UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

12th CONFERENCE ON AIR QUALITY MODELING

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ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA

8:30 A.M.

Noteworthy
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A G E N D A

Presentations by EPA and Invited Panelists

PROCEEDINGS

MR. BRIDGERS: Welcome to Raleigh, RTP; welcome to EPA campus; and welcome to the 12th Conference on Air Quality Modeling. At this time, I'll officially call the public hearing to order. And the first official action I'd like to do is to extend our gratitude to everyone that's sitting in the room.

This conference is something that's very important to the EPA and it's your feedback that is what's valuable. All of you have taken time out of your schedule. You have taken the opportunity to miss work, spend resources and spend time away from your family to spend it with us, and so we thank you for that.

As I mentioned, it's a public hearing. The Clean Air Act has a Section 320 that requires that we hold this conference every three years. This is the 12th. You can do the math. We're pretty close. We're not right on spot, but we -- we do value the input that we get through these conferences. And I have tried to impress upon my colleagues that this is an opportunity for us to listen more and talk less.

The focus of this particular conference is on the latest features of the current and preferred air quality models and sort of looking forward on the potential revisions that we need to do to these models. And so that's why we've set the -- the format with a number of expert panels where we're going to be in the listening mode and hearing feedback and then have the public comments from the external community tomorrow.

All the proceedings are being transcribed and they'll all be placed in the docket. So that means anything you say will be seen again, but also all the presentations will be available in the docket as well and so anyone that's not here can go back at their leisure and look at them. And since this docket is not part of an official rulemaking, we're not making an announcement that we're doing a response to comments docket document, but, most likely, at some point in the future, we'll focus on having a summary of comments available.

So a couple of things real quick. Since this is a public hearing, I need to announce myself. My name is George Bridgers. I'm the Director of the Model Clearinghouse here at the EPA. I'm also an environmental scientist, and I'll be your master of ceremonies throughout the next few days and also your public hearing officer.

So far as logistics, most everyone is pretty familiar with the EPA campus. You went through two tiers of security to make it to this room, one on the external of the campus to make it on the campus and then one to make it inside the building. Security has asked for me to just impress upon all of you that the common areas down here and this meeting room, over at the bathrooms, in the café are all well and fine. But should you go up in Building C above the second floor or to any of the other buildings in the facility, you would need an escort. And as always, if you exit the building, even just to take a walk around the lake, you'll have to go through the full security protocol to get back in the building.

So far as bathrooms, if you exit the meeting room here on your side and go across the foyer, before you get to the bank of the elevators on the left are the -- the bathrooms. And snacks and lunches, most of you probably saw straight across the hall here is the cafeteria. They do have some snacks during the morning and afternoon and they'll have the full complement of lunch items. We did schedule an hour and fifteen minutes for lunch. It gets kind of busy over there, especially when we have a lot of people coming in. So I invite for the conversations to happen around the tables over there versus in here once we get to lunchtime.

The other thing is the emergency protocols. I think everybody understands if the emergency sirens go off that you'll exit the building, most likely. But, typically, in our building, there'll be a public announcement if the alarms go off and they'll give us further instructions. As such time if the alarm goes off, I'll give instructions to the room after those. Most commonly, we would exit out of the room, go up the main set of stairs and out to the small parking lot that's right out in front of the building. It's mostly handicapped parking now. But that would be our assembly area and then we would wait there until such time as we're given an all-clear to come back in the room.

As I said earlier with the air conditioning, you can see me. At any time during the conference, if you have any questions, have any needs, find me. There's other EPA folks up here in the front that you can find also that you'll see across the morning: Chris Owen, James Thurman, Clint Tillerson, Tyler Fox. But you can also send me an e-mail, you can slip me a note because I -- I do have those availabilities to -- to access your comments as we go along across the day.

And the last thing I would like to do, I started with recognitions of all of you, but I also need to recognize a few key people who have made this conference possible and, first and foremost, the staff that surrounds me. I -- I am very active in Boy Scouts and the mantra there is many hands make light work, and this is the same here. The names you see on the screen before you are my colleagues, and they're the ones that really made this conference possible.

And so I thank my immediate staff in the Air Quality Modeling Group, but, additionally, we have a number of regional office staff that will be presenting on the expert panel contextually from their background, from their experiences working with the states and applicants. And so it's a heartfelt thank you to the regions that traveled here today and are participating across the conference. We also have some ORD staff that will be presenting, and their efforts are well-noted. And, finally, we have a couple of Federal partners that will be participating. So to all of you, I say thank you on the front end of the conference and I will thank you again tomorrow.

I think, Tyler, without further ado, I would like to -- it's my distinct pleasure to invite to the microphone Tyler Fox, my manager, and the group leader of the Quality Modeling Group.

MR. FOX: Thank you, George, and welcome everybody to North Carolina and Research Triangle Park. It's a little hard to believe that we're approaching three years under the revised *Guideline*, but I think we all survived and we're flourishing still. What -- what I'd like to just kick off with is to -- to give an overview of the continuing work that -- that we're doing to continue the responsibility and obligation we have to improve -- to improve the models so that they can address the -- the many challenges that you-all have in using them to meet Clean Air Act requirements.

It, as George said, takes a number of hands. I don't know if it makes a light lift or not, but -- but it is a worthwhile endeavor and, as -- as evidenced by all your participation here, is something that -- that we all can agree on and -- and work towards.

I wanted to emphasize the -- the strengthening of our -- our federal partnerships. We've engaged much more so with our federal partners than we have in the past. It -- it's always been a long-standing relationship with the Federal Land Managers, but we're working with the Federal Highway -- FHWA and DOT and other parts of DOT, as evidenced by bring the BETA version of R-Line into AERMOD in the most recent release. That wouldn't be possible if not for the collaboration that we have with our Office of Research and Development; the wind tunnel facility, which is essential to our work; Dave Heist and Steve Perry, who -- and others who were working in -- in that area and -- and helping us to bring that BETA option and hopefully in -- in the near future a regulatory default option into -- into air modeling.

We're continuing to work with -- with our partners in BOEM and work towards an evaluation of OCD and bringing in those elements of OCD from a shoreline dispersion and platform downwash perspective into AERMOD for consideration in our next revision to the *Guideline* and update to -- to AERMOD. We're continuing to work with ORD, as well as the external community, on photochemical modeling. We brought ozone and secondary $PM_{2.5}$ analyses into the *Guideline*, provided guidance in order to address those plumes appropriately. Kirk Baker and others have continued to do excellent work. You'll see a lot of that work over the next couple of days and -- and even to the extent of making the information from the hypothetical source modeling that he -- he has done for the MERPs guidance more -- more accessible and more available to you-all and -- and bringing that into compliance demonstrations and the like.

We worked very hard, took a lot of years, but we got prognostic -- prognostic meteorological data into the *Guideline*. Chris Misenis and -- and others in the community have been working very hard both to run more and make those simulations and data available to applicants and -- and state and MJOs but also then working with the community to process those data and continue to deal with the challenges in using those data but broadening the -- the available information that can be used for these dispersion models to have more representative met, which was always a challenge. Still is a challenge, but, certainly, we have now more -- more to work with than we had to work with.

And there's many others. I could go on and on. In fact, all you have to do is look at the agenda and see all of the areas in which we're trying to focus on and prioritize as we move forward. And if it weren't for the efforts of you-all in this room and others outside of the room, we wouldn't be able to accomplish what we've already accomplished, but also set our sights high for what we need to still do in order to make the models appropriate and -- and to meet those challenges that you guys face in -- in, you know, meeting the requirements under Clean Air Act.

So without any further ado, thank you for being here and look forward to all the engagement and the interactions with the panels. Hopefully, we've set it up in a way that -- that will bring out feedback that we need because this is the feedback that we're going to then take and consider what we need to do in revising the *Guideline* and in the next, you know, year to eighteen months consider whether or not we go through a regulatory action to do so. So it's critically important and thank you for your participation.

MR. BRIDGERS: Thank you, Tyler. So if you look at your agenda -- you don't have to right this minute, but if -- if you were looking at your agenda, the next couple of presentations are sort of setting the stage as we head into a series of six expert panels. So I'm going to call to the podium Chris Owen, because I believe you have the first discussion, Chris. Chris Owen.

DR. OWEN: Good morning. I have a relatively short slide deck on the status of the AERMOD white papers. It is relatively short because we're going to hear a lot more about the details of the scientific, evaluative and developmental work that the white papers frame from the rest of the panels today and tomorrow. The white papers really form the basis of problem statements and set us off in the direction towards finding solutions to those problems, but the information that we're getting from the community today and in the future and other feedback mechanisms we have is really what shapes what we're doing moving forward.

So I'm just going to provide an update on where we're at in terms of updating white papers, where they're at, how did we get the evidence and other pieces related to AERMOD development. But we're not going to dive into what the panel is, because, certainly, the panel is going to provide much more detail than I can give you, or you can stand in one chunk for me right now anyway.

So -- so the first thing I'm going to tell you is where you can get the white papers. We do have an AERMOD development site now. It's been live for six, nine, twelve months; somewhere in that range. It's kind of hard to find because there wasn't a link to it off the -- the main SCRAM website. There was an announcement when we -- when we first posted it. I, of course, provided this link at other meetings as well. So if you haven't seen it, there it is. Please go there and see what we have to offer.

The development site has the original white papers that were released back in 2017. It also has the current white papers, and the current white papers is really the focus. These are living documents that are updated really at any time. We actually updated one in -- just in the last few days, and we'll have a new deposition one, I think, in the next few week.

And so these are living documents. It's a living site, and we're updating them as we have new updates to the model and there's new updates to the science. I want to emphasize that the white papers -- well, the ones that are up there have been written by EPA. We have developed this format so that we can get input from the community as well. And so there's a white paper template that I've provided. And it really outlines sort of the key pieces of what we see as being essential to outlining an issue via a white paper, and that's really the statement of the issue with the model.

The issue can't just be that concentrations are too high. You know, there needs to be an identified technical issue with the model. There needs to be some current scientific development or evaluative work that is ongoing by the community that the white paper should outline. There needs to be some considerations of implementation of a potential update in the model. There's a pretty broad spectrum of -- of how this is described in the current set of white papers, but the bottom line is we need to think about fixing this within the context of updates to the model.

So if you're interested in providing a white paper, send me an e-mail. I'll send you a template. You can grab any of the ones that are up there and you can probably figure out the pieces and send it to me and we will absolutely review those and consider those and revise as appropriate and post for the public -- post as appropriate for the public.

We actually had a penetrated plume white paper submitted in August and that's under review. And so, hopefully, we'll be able to move forward with providing that to the public in the near term as well.

So, just briefly, the white papers that we have available, of course, I have a white paper on low wind conditions. Probably the original white paper is our longest standing sort of developmental piece that's still in the model addressing low wind conditions. We, of course, updated AERMOD with ADJ_U* in 16216 with the Appendix W update, but we're continuing to look at improvements for low wind conditions via the LOWWIND keyword.

We have several white papers on downwash. There's multiple moving pieces, almost too many pieces to keep track of, but there's a lot of exciting and interesting and really important developmental work that's outlined in the white papers, and, of course, we'll hear about more of that today.

We have several white papers on NO_2 enhancements, and we probably need to break these out even a little bit more. These detail some of the field studies that have been happening, provide more databases for evaluation of NO_2 methods, describes the new Tier 3 method that's been under development for a few years, as well as the new Tier 2 method that we are scoping out and considering for future release in the model as well.

There's a white paper on mobile sources which right now is largely focused on -- on the R-LINE implementation into AERMOD, and, as Tyler mentioned, this is through significant collaboration with our federal partner in Federal Highway.

So these are -- these are the white papers that have had a lot of attention in the last few years or there's been a lot of developmental work even in the model. We have another set of white papers that are a little bit more forward-looking. We don't necessarily have updates in the model right now, but these are things that we're working on. In particular, there are several white papers on overwater issues, and so these are downwash effects with lattice structures that are unique to offshore platforms, shoreline and coastal fumigation issues, as well as the parameterization of the marine boundary layer.

And these have been addressed at different stages over the last few years, and the white papers provide the information and this background. We do have a -- an -- a interagency workgroup with the Department of Interior to continue to develop and push these issues forward.

Lastly, we have a white paper on saturated plumes. This either needs to be expanded, I think, to include a little bit more on plume rise in general or that we need some other white papers that address plume rise because we've seen plume rise be a topic of interest in a number of areas over the last few years, particularly with some model clearinghouse actions related to plume rise and some other interactions with industry on this topic. So there is one there and there's more to come.

So this is the ALPHA/BETA slide that you've seen in previous meetings, but I wanted to provide it again as we're talking about updates to the model and just provide a little bit more detail, actually, on the next slide on ALPHA and BETA options. ALPHA options are, of course, the experimental options. They're developmental and we're not intending those for regulatory use. We've adopted to coloring the ALPHA options in a red box, which means, stop, don't use them, please, at least for your permits. Please use them for your scientific development and evaluation work and please share that information with us as you look at those options.

And then, of course, we have the BETA options, which we have colored yellow, which means slow down, but you can possibly proceed with the appropriate approval. That approval is, of course, alternative model approval through your regional office in concurrence with the model clearinghouse. And, in general, we've been stating that the way to go from an ALPHA option to a BETA option is that you've met the requirements of Section 2.2 and Appendix W, and I'll actually provide more details on -- on the next slide.

And then our -- our -- our intent, generally, with the BETA option is that if it proves to be useful enough for the community in the next rulemaking that we'll graduate that to a regulatory option. Green means go and it will be there for you to use, as appropriate, without any additional approvals.

So I've had this question a lot, and so I thought we'd go ahead and -- and lay some of the details out, which are really just abbreviated quotes from Appendix W of what makes a BETA option, how does something move from an ALPHA to a BETA. I mentioned on the previous slide we've emphasized Section 3.2.2(e) that there is no preferred model and so there's a list of requirements to get alternative model approval. And, remember, if you're using the BETA option, that's what you're seeking, is alternative model approval. So these are the regulatory requirements for alternative model approval.

Over there in 3.2.2(e), there is no preferred model. And in that case, you have to have scientific peer review of a particular technique, and so we generally equate that to a published journal article in a peer-reviewed, refereed publication; technique is applicable on a theoretical basis; that there are databases available to analyze that option. Even if you have something that's theoretically applicable, you still need to evaluate that option, and those evaluations show that the technique is not biased to underpredict.

The last one here, protocol on methods, has been established as effectively saying that the information needed to run that model is available to the community to actually use that option. And so if you need the moisture content in an emissions from the stack to calculate the enhanced plume rise from condensation, then that information needs to be readily available in order to use that option.

So this is where we focused in the past, is sort of the 3.2.2(e), but there are lots of cases where even though there's a BETA option out there, there is already a preferred model. And so there are different requirements that you will have to meet as well.

So the best example for that is downwash. There is a model that accounts for downwash already. It's AERMOD. So if we're going to update the formulation of downwash in AERMOD, then we have a preferred model and we need to meet the requirements on alternative model demonstration when there is a preferred model.

In that case, we have to have a statistical performance evaluation that shows that the alternative model performs better than the default model. And this is the crux of a lot of the -- the development we have going forward, is that we can do a lot of work to peer-review something and we can put it in AERMOD and we can have protocols, but we have to have these evaluations that show that that change in the model does not decrease model performance.

So keep that in mind as we go through a lot of these talks this morning and this afternoon, that a key piece of moving this forward from ALPHA to BETA, or eventually moving it from BETA to regulatory preferred option, is that we need to have this performance evaluation that is generally applicable and generally shows model performance improvements.

And then I wanted to put up here also, as we're talking about moving forward from BETA to regulatory the requirements for a preferred model. And there are more than what I've listed here, but there's some overlap and I just wanted to emphasize again a preferred model has to have a complete test dataset in addition to the performance evaluation. And that dataset actually, according to the regs, has to be there available for release with the code.

The model must be useful for typical users. And so if we have a BETA option that really only applies to one facility out there, no matter how useful it may be, that may not be appropriate for a regulatory model option if it's not going to be widely useful to the community or has too many limitations on how it can be applied.

And so these are the things that makes the BETA option but ultimately makes a regulatory option as well. Again, a question I've had a number of times and I wanted to lay out our perspective here.

This is what's going to move -- Section 3.2.2(e) is what we think can move from ALPHA to BETA, but your alternative model approval may also require 3.2.2(b)(2), that there's a preferred model in those requirements as well.

All right. Last slide I have here, something we've been sharing the last couple of years. Just for a little fun, if you will, what -- what's been hot on SCRAM, so to speak. So George can run some analytics on -- on our -- our part of SCRAM and get some top ten downloads both for .zip files and -- and .pdfs. And so we've been sharing the stats periodically at -- at certain intervals. And so George ran this yesterday, got the number of -- of downloads from the model release on August 21st.

And so we've -- you can see here the number of -- of AERMOD downloads. part of the reasons we actually started looking at this was as we've been -- we've moved to 64-bit for default executable. We've also provided the 32-bit and we've been kind of keeping track on what the number of 32-bit downloads are. So it's -- it's not insignificant. And so we'll continue to provide that as that number is -- shows up on the -- on the radar.

But if you add up downloads of AERMOD.zip, AERMOD_source and AERMOD 32-bit, then you get 1240 downloads. This, of course, does not account for the fact that commercial vendors are distributing the executable through their own platforms. So these are just downloads from SCRAM. There's certainly a lot more users out there than what this indicates.

One thing that's always been a surprise is SCREEN3 has always made the top ten list.

MR. BRIDGERS: Top three.

DR. OWEN: Yeah. This time, it was in top three. And, you know, this isn't people using SCREEN3. I presume people already have it downloaded, so the fact that people are still downloading it I think is as much a surprise as anything. And so maybe we need to launch a committee to understand the importance of SCREEN3 to the community, not just to running it but downloading it as we release new versions of the model. SCREEN3, of course, has not been updated -- I don't know how many years, but decades, I would imagine.

MR. FOX: '96.

DR. OWEN: So if you've already downloaded SCREEN3, you're good with that going forward. You don't need to download it again. So maybe this will drop off our list and we can have a better understanding what's going on there.

The .pdfs are maybe a little less interesting, but it kind of helps us understand what the community is interested in learning about. And, hopefully, everybody got a hotel because there were 126 downloads of -- of hotel info. Not as many people as are in the room, but I think folks have been here before, so not everybody needed that.

But -- so that is my slide deck, and I'm going to transition over here to James and Clint and they're going to provide an update to the most recent version of AERMOD. And after that, we will launch into the panel discussions.

MR. THURMAN: So this will be a tag-team

effort by myself and Clint. I'll go over AERMET and then Clint will go over AERMOD updates. Updates to AERMET, there were no changes. We didn't make -- make -- have to change anything. AERMET, there were five bug fixes. AERMOD had nine bug fixes, four enhancements, one BETA formulation update, three ALPHA formulation updates. And then we'll talk about some bug reports we've received since the model was released and the workarounds for those.

So the AERMET updates, these are the five bug fixes. We made some changes in the PBL subroutine related to when you had ONSITE data with mixing heights but there were no available soundings for the day. There was a logic error. We corrected that in Stage 3. That only affects your ONSITE data or MMIF data.

There was a format stating the audit subroutine that was to allow larger values of total soundings reported. Does not affect your output. There was just a reporting bug.

I think one of the bigger changes was a check for missing station pressure in FSL data. If your -- the first sounding you were processing had a missing station pressure, AERMET would stop and say can't identify sounding type. But if that was not your first sounding, AERMET would merrily go on its way. So we took that check out because it didn't really seem to make sense. And there were also boundary checks on the station pressure. The lower level is 700 millibars. We lowered that even more -- to, like, 650 -- to allow for higher altitude stations. Obviously, it's not going to make a lot of difference most places. And that only affects the upper air data in the FSL format.

Another bug was for precip in the ISHD data. If you had an hour with duplicate observations, if the first observation had precip and then the second observation for the hour was one of the special observations and had zero precip, we didn't replace -- we changed it where it doesn't replace the precip. So if you have non-zero, it's not going to be replaced with zero. And this is only important if you're going to run wet deposition in AERMOD. Precip's not used for anything other than that. And that only affected the ISHD data from the Weather Service.

And then we modified the OSTEST subroutine to issue an error and abort AERMET if you were reading in temperature differences that you didn't specify the heights. Before, AERMET would issue an error but didn't abort, so you got to Stage 3 and you got crazy errors. So we changed it to where AERMET would abort, and that only affects ONSITE data. And when I say "ONSITE," that's either observed site-specific or MMIF data since that's usually ONSITE pathway.

So, I mean, for the most part, you may not have to reprocess data, especially National Weather Service data, but we listed what stages are affecting data types so people can make that decision.

Then we'll talk about some bug reports since the 19191 release. Actually, the first one, we got -- I'm sorry, the second one. The first one, we got right before the code was released, but we'd already locked the code down and there was a workaround. So we didn't change the code.

There's an error when you process subhourly ONSITE data and you're specifying your heights using the HT variable, the measurement heights are not correctly averaged. They're summed, but they're not averaged. Let's say you had a measured height of three meters for four observations for the hour. Your height that comes out of Stage 1 will be twelve, not three, because it sums them up and doesn't average.

The workaround is using the OSHEIGHTS keyword and specify the heights and then the HT variable is ignored in the ONSITE data. And we'll fix these in the next release.

And then another bug we got after the release was a format overflow when reporting missing variables for the upper air data message files in AERMET. This occurs very rarely. You've got to have a lot of levels in your sounding. It occurs when sounding has more than 99 levels below five kilometers, so it's not going to happen very often. And it only affects the messaging. The EXTRACT QA output file, QA output files are not affected. So the workaround there is just to ignore that error. It's -- you'll see it when you're running AERMET. You'll get these crazy Fortran errors on the screen. So you can go on about your -- the QAOUT files and EXTRACT files. And then, like I said, both of these will be corrected in the next release.

So now I'm going to turn it over to Clint to talk about the AERMOD updates.

MR. TILLERSON: There are quite a lengthier list, I guess, for -- for AERMOD than James had for -- for AERMET. So I'll -- I'll run through and probably won't mention every one or I'll kind of lump some together.

But for bug fixes, there was a correction to the background units. Whenever you were using an output format other than units of micrograms per cubic meter, then the background units were not changed to the correct format. So that was causing a problem. That's been fixed.

A correction to remove background concentrations to wet -- wet deposition output whenever you had background running wet and dry deposition, it would actually add the background units or background concentrations to the wet and deposition -- wet and dry deposition output.

Modify the scavenging ratio calculations for wet deposition when using Method 2 dry deposition. You'll actually see some more -- I think James has a presentation on deposition tomorrow. You'll see some more on the deposition and some of the issues with the Method 2 in particular and changes that we've made in the model in terms of the status of the Method 2 deposition option.

Imposed minimum release height of two meters and reference wind speed of one meter per second for buoyant line sources, because the algorithm for BLP was not really developed for, you know, low sources or low wind speeds, we imposed these limitations in AERMOD whenever you run a buoyant line source.

The next three or four there are just

corrections to the output summaries. They did not have anything to do with actual concentrations or changes in what you see in the concentrations or results but just in the messaging and some of the summary files that would be output.

And then the elevation unit keyword has now been applied to LINE and BUOYLINE sources. I think that it was implied, but you had to put your elevation units in meters. Now you can put them in feet and it will make the conversion for you.

So enhancements, the ARM2 has been enabled with BETA R-LINE and the ALPHA R-LINE. We'll talk more about that in a minute, those BETA and ALPHA options, but ARM2 has been enabled with those two options.

The EVENT processing has been enabled with BETA RLINE and ALPHA RLINEXT as well. And URBAN option processing has been enabled with BETA RLINE and ALPHA RLINEXT.

And so for the ALPHA and BETA formulations that had been added to the model, you've heard Chris talk about the source types. The RLINE source type and the R-Line model has been added as a BETA option. The RLINEXT source has been added as an ALPHA option. And when you use the -- the RLINEXT, you also have the option of depressed roadways and solid barriers. So just want to make sure that we point out that distinction, that RLINE is BETA, RLINEXT is ALPHA. And the RLINEXT really refers to RLINE Extended.

Building downwash options, we're going to have a panel later this afternoon on building downwash where we will talk more about this and we'll hear from some of the building downwash experts. But we have added three options that were developed by ORD, Office of Research and Development.

We've added three options that were developed -- developed by the PRIME2 subcommittee of the Air and Waste Management Association. And we've also released a draft of BPIPPRM as 19191 draft to help facilitate the evaluation of these options. So for the BPIPPRM draft, that is not out there to use in regulatory applications. It's -- the changes were very limited. They're very limited to simple, rectangular, one-tier -- single-tiered structures. But because of the work that ORD and the PRIME2 subcommittee did -- and their evaluations used either that BPIPPRM draft or a comparable method -- we felt like it was necessary to release that so that you can use that to duplicate/replicate those results. So we do want feedback on the BPIPPRM draft and the changes that were made to that as well as these -- these ALPHA options -- downwash options.

And I'll just say that, for the most part, these options can be combined, mixed and matched in different ways in the model. There are a few caveats to that and the model will stop you if you try to combine something that can't be combined. Again, the Method 2 particle and gas deposition has been changed to an ALPHA. It previously was a non-DEFAULT option. Some work that James has done now has led to making that -- and, again, you'll hear more about that tomorrow -- making that an ALPHA option.

And then the URBAN option processing has been enabled with the BUOYLINE source. But just to point out that URBAN option with the BUOYLINE source, the buoyant line source is an ALPHA option. So you can use the BUOYLINE source as a non-DEFAULT, but you have to use the ALPHA switch on if you want to use the URBAN option.

So bug reports, there's been one bug report since the release, and this had to do with the buoyant line source and the -- the order that you put your sources. And it's only applicable if you're running multiple source types and neither of those sources is an URBAN source, then the order that you have your sources listed does matter.

And there is a workaround, and the workaround is that the BUOYLINE source should be listed as the last source when no URBAN sources are modeled. And just so you don't get hung up on that, then if you just always make it a practice to list that source last, then that will -- that will take care of it and you won't have to worry about whether or not it's doing something that it shouldn't. And then that will be corrected in the next release. And then that's all I have.

MR. BRIDGERS: Thank you. Thank you, James. And also thank you, Chris.

Those that know me know I try to run a tight ship on time, and we're actually a few minutes ahead of schedule, which is great. What I'll tell you is we'll try to stay within our time blocks, and whatever we run early on, then we'll tack on to lunch so that you guys have a few more minutes for lunch.

I've been in the back of the room. It sounds like the audio is okay in the back of the room. I've also seen, much to my pleasure, that most of our seats are full. We set up 192 chairs plus this front row last night. That's about 40 more than we had registered. And so we're going to have a Hunger Games because there are six beautiful seats up here on the front row on the left. It would be to your right.

We're going to open those up if people want to spread out a little bit at the break and we'll try to get a few more chairs brought up because it's nice that we have a larger crowd than anticipated.

So now we're going to transition to the expert panel portion of our day. It will take me just a second -- I apologize -- to get the panels up. And each of the panels will be moderated by EPA staff, but then the actual panelists will be from academia, from the stakeholder community and from our Regional Offices.

I will note, and I think each of the moderators will also note, we're going to have some introductions and then each of the panelists are going to respond to a series of charge questions that we gave to them several weeks back. For your benefit, we printed those and those are on one of the handouts that you have so you can refer to them.

At the end of each session, we may have a few moments for some questions. Now, that being said, this is a public hearing. We're not going to get into a big back and forth. But if there are questions for the panelists of the EPA or clarification for anything that they said during their response to the charge questions, we might be able, if there's time, to entertain that. But, otherwise, if you have comments to the EPA, we'd offer that you give those tomorrow during the open session in the afternoon.

Without further ado, I'd like to introduce back to the podium Dr. Chris Owen. Come on up, Chris.

DR. OWEN: So I'll ask you to bear with us as we sort of feel out the -- the best way to -- to administer these panels. I'd certainly invite -- like to invite the panelists for the low wind conditions to go ahead and come up. George will be putting out a -- a nametag for you -- or a name card for you here at the front of the audience.

I'm going to give a -- a quick overview and then Clint's actually going to -- panelists, one's going to be over here. Other panelists who are coming later, we're going to tag-team. One of us will be down there to help with time management. The other one will be up here to help with slide show management. There is a clicker that we will give the panelists for those who have slide decks.

So I'm introducing the panelists before they sit down, apparently?

MR. BRIDGERS: Well, we're going to blank the

screen so it's not in Rick's eyes.
DR. OWEN: Oh, okay. Oh, once he's sitting?
MR. BRIDGERS: Once he's sitting.
DR. OWEN: All right. So they're going to wait for me, I guess, to do my spiel and then they will sit after we turn the screen off, although they have slides. So --
MR. BRIDGERS: We'll have to work it out unless they -- unless Rick wants to get blinded.
DR. OWEN: We could --
MR. BRIDGERS: I can put --
DR. OWEN: One's going to be up here.
MR. PAINE: We can sit here for a while.
MR. BRIDGERS: Yeah, that's fine. That's probably a good idea, Bob.
MR. PAINE: Yeah, let's do that.
DR. OWEN: All right. Low wind conditions. Let me get back to my -- so starting one minute early on the session and we have our panelists almost seated, so we're doing good.
All right. So, some background: I wanted to give just a little bit of high-level background on how AERMOD deals with low wind conditions that provides some of the context for where we're going forward.
AERMOD accounts for low wind conditions,

meander, by interpolating between basically two concentration fields. The first one is the Gaussian plume that we expect from the model that's directed along the wind direction and where we normally think about a Gaussian plume. The second one in it is the random plumes and one called the pancake plume, which is, really, just a circle when the concentration's decreasing with distance. And AERMOD basically averages these two fields.

So in the direction of the wind, you'll have a higher concentration from that coherent plume, but you'll also have concentrations upwind of that as that random plume provides some input to the final concentration field.

It should be noted, though, that meander has not been implemented for aerial sources, so for point and volume sources, meander's not available. The BUOYLINE source actually doesn't account for meander either. And so there are some limitations to how meander is accounted for in AERMOD. So, you know, as we talk about updates that we need to -- that can be done, it's important to consider how some of these features might affect either just a couple of source types versus all source types.

AERMOD 16216, of course, added the ADJ_U* option as a regulatory option, and this was designed to address issues with AERMOD, the tendency to overpredict from some sources under stable and low wind speed conditions.

ADJ_U* is based on two different papers, one with delta-T data and one without delta-T data, and we're pleased to have one of the authors of that paper to be on our panel here today to provide more insights on where it can go in the future.

We did extensive testing of u* during the rulemaking process. We tested ADJ_U* after comments we got focusing on site-specific turbulence data and whirlwind option. And so there's pages in the rulemaking text that preamble the details of the testing that we did on what was found in those evaluations. And, ultimately, we went with ADJ_U* and left the door open for some of these other potential updates.

This isn't totally disconnected from what's on the screens.

AERMOD 18081 introduced the LOW_WIND ALPHA option for addressing low wind conditions. And the low wind option has three primary features. It has the ability to adjust the minimum sigma-V value. There's a default in AERMOD of 0.2 liters per second, and then LOW_WIND1, 2 and 3 had several adjustments to this in the past, LOW_WIND1 was 0.5 and LOW_WIND2 and 3 used 0.3 liters per second.

We also allowed for the adjustment of the FRAN max, which is the maximum value for the fraction of the random plume. And so the default in AERMOD is one, although I don't think the model ever hits that in the formulation, but the default maximum is one for that value.

LOW_WIND2 sets up a 0.95 and you can adjust that and then your low wind option to reduce the amount of the random plume that's factored in for low wind conditions.

Finally, we have an adjustments to the minimum wind speed in AERMOD. AERMOD has a default of 0.2828, which is maybe a little precise, but that is the number that's in there. But it's also important to note that that default wind speed is tied to the formulation of the model with respect to the minimum sigma-V as shown in the slide.

The minimum wind speed was not adjusted in the LOW_WIND packages, but because of the formulation connection with the minimum sigma-V value, we added the minimum wind speed as an adjustment as well.

I will say that current EPA testing of these

LOW_WIND options suggest reduced model performance. And this isn't final, but to the point of the comments that I made in the white paper slide that we have to show an improved model performance, we need to do more with low wind conditions to find a solution that does improve model performance across a variety of conditions really without reducing model performance in other conditions. It's something that's broadly applicable.

So that is my background. Somehow I'll get the slides to change. There we go. As I introduce our panel members -- and I guess they're going to continue to stay off to the side --

MR. BRIDGERS: They can come sit. I mean, Rick's the only one that's in the fire of the screen.

DR. OWEN: Yeah. I -- I guess I'll ask you to go ahead and --

[DISCUSSION OFF MICROPHONE]

DR. OWEN: Well, let me -- let me introduce our panel members and apologize for the -- the issues here with this light.

Rick Gillam is an environmental engineer who works with EPA Region 4 in Atlanta, Georgia. He's been with Region 4 for 27 years, including 19 years working in air quality modeling.

He currently serves as the Region 4 Air Modeling Team Lead, working with four other Region 4 modeling staff to manage air -- air modeling projects in the region, including PSD/NSR modeling, SIP attainment modeling, Outer Continental Shelf permit modeling, ozone and $PM_{2.5}$ photochemical modeling, regional haze, air toxics and wildland fire smoke modeling.

Rick has a B.S. in mechanical engineering from Ohio State University. Our second --

MR. GILLAM: Ohio.

DR. OWEN: Hmm?

MR. GILLAM: Ohio University.

DR. OWEN: Oh. Sorry. Had to make sure Rick was awake. Good job, Rick. You were listening.

Our second panelist is Mr. Bob Paine. He is a certified consulting meteorologist who has worked with AECOM for 44 years. Bob has a long history of working with EPA in the development of many approved regulatory models, including OCD, RTDM, CTDMPLUS and AERMOD. Bob was a member of the AERMIC committee and helped design AERMOD.

Bob has continued to contribute to AERMOD development on many topics and is specifically engaged with EPA on low wind conditions -- improvements to the low wind conditions in AERMOD since 2009.

Our final panelist is Dr. Akula Venkatram. He's a professor of mechanical engineering at the University of California in Riverside. His research is focused on the development and application of models for the transport and dispersion of air pollutants over urban and regional scales. He previously held positions as the Vice President of Air Sciences at ENSR Consulting and Engineering and the Head of Model Development at Ontario Ministry of the Environment.

Dr. Venkatram was a member of the team that developed AERMOD and was a principal contributor to the R-Line model as well. Dr. Venkatram received a B.S. degree in mechanical engineering from the Indian Institute of Technology and a Ph.D. in mechanical engineering from Purdue University.

So welcome, panelists. Thank you for your participation.

[DISCUSSION OFF MICROPHONE]

DR. OWEN: I'm not going to read the charge questions. We're going to have them up. They're also printed out. If you did not get one of the -- the packets with the bios and the charge questions, please do so at the next break so you can have those on hand.

But the -- to summarize the charge questions that we have, we're looking for feedback on the application of the current ADJ_U* option.

We're looking for feedback on the current LOW_WIND ALPHA options that we put out there, particularly any testing and evaluation that's been done with it.

We're looking for recommendations for additional formulation changes to AERMOD that haven't been said about the options for consideration.

Finally, we're looking for feedback on databases. And low wind databases are particularly hard to find that have all the appropriate inputs, and so we're hoping to identify new databases that can help us in testing the many new options going forward. So with that, I'll turn it over to Rick.

MR. GILLAM: Okay. Thanks, Chris. Can folks hear me all right? Okay.

Yeah. So, as Chris said, I'm with EPA Region 4 Regional Office. So I'll give you a regulatory perspective on these charge questions, and I'm going to focus my remarks on Questions 1, 2 and 4.

So jumping right in on Charge Question 1, experience with ADJ_U*, I guess my first point is that ADJ_U* is being used and it's being used a lot. At least, that's what we've seen in -- in our region, in Region 4.

As Chris had talked about earlier, with the Appendix W revisions, ADJ_U* was incorporated as a regulatory default option in AERMET. And in -- in our region, anyway, we looked back at some recent permitting actions that we've had over the last couple of years. We've looked -- we looked at over a dozen PSD permit analyses in the region, and in all cases, ADJ_U* was used as a regulatory default option in modeling.

And some -- in some cases, the permit application materials discussed the need for ADJ_U* for dealing with low wind conditions; in some cases, not. So in many cases, the -- the use of ADJ_U* is being approved without any additional justification and it's become, essentially, a presumptive default regulatory modeling option in -- in what we've seen in our states in Region 4.

Just some additional information to share, in Region 4, we have eight states. Six of those eight states have -- provide preprocessed AERMET data to permit applicants, and in -- in those situations, they're providing both the ADJ_U* and with and without ADJ_U* in most situations. Some states are only providing one or the other in a preprocessed format, but we have a couple of states that are providing both.

And I guess the one additional comment I have here is that the state of Alabama here in the Southeast is the only one that is requiring the applicants to provide some type of justification whenever they're proposing to use ADJ_U* in a permitting application, based on our research.

So, again, all of that information is focused on the eight states that we deal with in the Southeast. So I'd be interested to know how that compares to the rest of the country.

For Charge Question 2, we're talking about experiences with the ALPHA LOW_WIND options. I personally have no experience with the ALPHA LOW_WIND option. However, I do have some experience with the LOW_WIND2, LOW_WIND3 options that were part of the consideration for the regulatory change back when Appendix W was being evaluated.

And so I -- I'll relay a little bit of information based on that experience I had with that. There was a -- an SO_2 modeling project for a large chemical plant in Tennessee where the LOW_WIND2 and LOW_WIND3 options were evaluated in -- in addition to the ADJ_U* option.

We did -- my colleague here, Bob, did quite a bit of work on modeling to evaluate different options there. We in the Regional Office, working with Tennessee, also did many, many sensitivity runs to evaluate different options and we were essentially looking at that Section 3.2.2(b) improved performance condition for an alternative model. This was back in 2015 -- 2014, 2015 time frame.

And in this situation, it was -- it's pretty ideal for making that demonstration. There were actually five ambient monitors located around the source in different terrain conditions. There were site-specific meteorology that was collected over an entire year and we had hourly emissions data available.

So it was an ideal situation to evaluate model performance. And, actually, in June of 2015, we in the region approved an alternal -- alternative model request for use of ADJ_U* LOW_WIND2 with a 0.4 meter per second minimum sigma-V value based on improved performance over the default regulatory AERMOD settings.

Unfortunately -- and this is a -- a point I want to really stress to folks if you're going to go down this road. We later found out that there were quality assurance issues with monitoring the ambient monitoring data and there were questions about how accurate that data was. And it led us to having to retract that alternative model approval.

And so one thing I really want to stress is if you're going to be evaluating this, you need to have an approved quality assurance project plan and make sure that all ambient data is collected and meets all of the regulatory requirements in order to make this Section 3.2.2(b) demonstration for an alternative model.

I do have one other example I want to briefly touch on. It was, again, an SO_2 source in South Carolina where they proposed to use LOW_WIND options, the BETA option -- the LOW_WIND3 BETA option at the time. And in that situation, there was no site-specific ambient data available.

They tried to make the case for the 3.2.2(e) demonstration, and as Chris was talking about earlier, the information -- the peer review and all of that -- has -- has not been done to what EPA considers to be an acceptable level. So we were forced to deny that request for an alternative model in that situation.

Moving on to Charge Question 4, some remarks about the adequacy of existing databases and potential additional databases, again, I'll go back to the -- there is -- there is a significant potential, based on especially the SO_2 monitoring that has been deployed in the recent past and we have a -- a large number of sources around the country that are -- where additional SO_2 monitors have been deployed for the upcoming Round 4 designations for SO_2.

I've got a few stats here. There are 54 areas that include 71 sources and 75 monitors around the country where additional ambient monitoring was put out to characterize specific SO_2 emission sources. And so that's an opportunity for doing these additional model evaluation studies.

In some situations, there are multiple monitors around a single source. In some situations, a single monitor would assess multiple sources. But all of those details would need to be considered, but they're -- I think that's a -- an opportunity for folks to look at for additional model evaluation of the LOW_WIND options.

And related to that, ideally, for a model performance evaluation, it would be best to have multiple monitors nearby, like the situation in Tennessee where there were five, and then also having site-specific meteorology is -- is critical. You've got to have representative meteorology trying to do that based on a nearby National Weather Service MET station that may not be representative, may not give you really a quality analysis.

And then well-characterized SO_2 emission sources or the emission source that you're evaluating needs to be well-characterized. And, ideally, you would want to have hourly data from, like, a CEMS unit from a continuous monitoring unit. If -- if not that, then you would need to have a good way to -- to calculate the hourly varying emissions data.

So that's what I would see is -- it's the information you would need to look for for additional study databases. And then I'll hit again on the importance of for the monitoring, you need to make sure you have quality assurance project plans and evaluated and approved by a regulatory agency if you're planning to use this for an alternative model demonstration.

Again, I would reference back to a couple of examples we have in Region 4. This -- there's a large chemical plant in Tennessee. They are continuing to operate four monitors located near that source. They do have CEMS data. They don't currently have site-specific meteorology. That was only collected for one year on site. But one thing potentially to consider would be to look at prognostic MET data and the use of MMIF with WRF data. That's -- that would be an option. I would -- I would not rule that out.

And then we have another example in the state of North Carolina where there is -- it's an SO_2 source again as well where they have site-specific meteorology available and they have hourly emissions data and there is a SO_2 monitor nearby. So these are situations that are -- I would see as options for supplementing the existing databases.

There are definitely benefits of the existing databases, the tracer studies, the Oak Ridge study, Idaho Falls study, tracer studies that were referenced in the Appendix W updates. Those are all still useful and I -- I think we would support use of those, but there are options out there for additional studies. So that's the conclusion of my remarks.

[DISCUSSION OFF MICROPHONE]

MR. PAINE: Thanks for inviting me to this panel. I'm going to talk about the -- all four of the charge questions and provide some thoughts on those. And, basically, these -- these just repeat those charge questions, so I don't have to dwell on this slide too much.

It's providing experiences with the new option, the strategy with the LOW_WIND current option, should there be actually -- I'm going to talk about enhancements to that LOW_WIND option for further testing and then more discussion on evaluation databases.

Let's review why we're talking about low wind speed issues. One -- one issue is that when wind speeds are low, the dilution is low and you could have high concentrations. But you also are testing and challenging steady-state models because you're -- you're assuming that a plume goes in a straight line and could go up to 50 kilometers in one hour. And if you do the math, that takes a fairly high wind speed.

So the challenges with the low wind conditions are plumes don't go very far in one hour and the winds are not likely steady, which violates the -- the assumptions of the steady-state model. Now, you hope that the wind would maybe at the second hour go in the same direction, but with low winds, there's a lot of -- of wind shifting.

There's also the issue of the coherent plume versus the pancake plume, how do you weight those appropriately and do we parameterize the plume spreading in low winds correctly, even if you have observed turbulence.

So what we need to do for a -- a steady-state model like AERMOD is to, you know, not go too hot or too cold but just right in terms of combining a minimum low wind speed and a minimum turbulence so we have a reasonable dilution and turbulence that is well-tested and -- and can be used with confidence in permitting.

Now, just to review the ADJ_U* option, we found that in -- in formulating AERMOD, there were some wind speeds below which there was a quadratic equation that didn't have a real solution and we had to adjust the formulation for those low wind conditions. And so that, of course, was not extremely thoroughly tested when AERMOD was promulgated, and -- and with experience, we found that maybe some of those -- that friction velocity needed to be adjusted in those conditions.

Now, as you can imagine, when you increase the friction velocity, it was actually -- it turns out it was formulated to be too low in those conditions. You will get more mechanical turbulence. You will get higher mechanical mixing heights; therefore, a higher effective wind speed and lower predicted concentrations. And we found that in the promulgation of ADJ_U* option overpredictions were -- were mitigated with the use of this option. That's why it's popular, I -- I would imagine.

But in the implementation of -- of the ADJ_U* option, EPA decided if you had observed turbulence and you wanted to use the ADJ_U* option, you -- you couldn't do both of those. You basically had to select one option or the other. That's why the -- the non-use of ADJ_U* when you have observed turbulence is certainly something to seriously consider. And in some cases, we have opted for that, and I'll get into why that might be the case in further slides.

I also provide some comments on convective conditions. Low wind speeds are also present in convective conditions. Sometimes those result in the highest observed concentrations in flat terrain, so it's certainly worth mentioning it. And I'm going to also comment on cases when you do have turbulence measurements and when you do not.

So suppose you don't have turbulence measurements. In convective conditions, we see little difference in my experience when you turn on ADJ_U* or not because the convective turbulence dominates the mechanical turbulence. And when the winds are high, there's really no wind adjustment because the ADJ_U* fix is for low winds.

So the real issue where it comes in play is low wind stable conditions, where you don't have convective turbulence, all you have is mechanical turbulence. And this definitely plays a part, and you will get, as I mentioned before, a -- a higher turbulence level, a higher mechanical mixing height, more ventilation basically, and so you will get lower concentrations. Generally, if you don't have turbulence data when you use the ADJ_U*, then that's our experience.

Suppose you do have turbulence input. Now, turns out that we have found in convective conditions we do pretty well with the parameterized turbulence ignoring the turbulence data. In fact, I've been working with some current projects where if you override the parameterized turbulence in convective conditions with observed turbulence, you actually overpredict.

The -- the parameterized spreading of the plume is -- is larger than if you plug in the turbulence. There might be something wrong with the -- the formulation of how you compute sigma-Y and sigma-Z from sigma-W and sigma-V in convective conditions.

But on the other hand, in -- in the stable conditions, we find the turbulence data actually improves the model performance over that of ADJ_U* because in -- in stable low wind conditions, the turbulence -- observed turbulence is key to -- to the spreading of the plume.

So it's sort of like a dichotomy. We -- we don't really -- we aren't really helped by turbulence measurements in convective conditions, but we are assisted more in performance in stable conditions. And one thing to -- and I'm going to get into this in a few slides, that during the hour, the wind direction can shift.

Encapsulating those wind direction shifts into the hourly average of the turbulence data is important. The -- this 15-minute averaging is not going to -- to work.

Okay. Let's go into some of the low wind option components. Minimum sigma-V, it's one of the more important variables because it directly affects the horizontal plume spreading. And in written comments that we will provide through various entities, we're going to talk about research papers by, for example, Steve Hanna mentioning that a minimum sigma-V of 0.5 meters per second is giving good model results.

We also have an active model clearinghouse proposal to use that for a field study in the Laurel Ridge area of Pennsylvania that's been submitted to EPA Region 3 under -- currently under review because we have a full year of data with several monitors to evaluate that option.

For the minimum wind speed, it basically has to be reconciled with the instrument starting threshold, but, basically, a 0.5 meter per second seems to be a good choice. And for maximum meander -- this relates to the -- how the weighting function works between the coherent plume and the meander plume. I would say keep -- keep the 0.95 as a default for now.

But what to add? I would like to have EPA consider a minimum sigma-W option, because when you look at the meteorological debug output, if you ever want to look at that in AERMOD, you will see 0.02 meters per second for sigma-W above the mechanical mixing height. And I've seen data that is rarely as low as that. And if that's what we're putting into the model, that's really low. That's why I -- I would recommend to EPA to add another -- you know, an option for low wind to consider a minimum sigma-W. 0.1 meters per second, for example, is used in SCICHEM as well as 0.5 meters per second for sigma-V.

Also, AERMOD is very sensitive to the weighting scheme between the coherent plume and the pancake plume. Now, that option -- the option to -- to tweak how the -- that -- you know, that -- that dichotomy is done, how you -- how you parameterize the weighting, is not in low wind. We used to have a way to adjust this by the scale and time parameter; that is, the -- what is the time scale of random motions and that adjustment, that factor. And right now, it's set to 24 hours, but in LOW_WIND3, it was -- I think it was cut to 12 hours or something like that. It actually weighted the pancake plume more and now that's been retracted in LOW_WIND. I would like to have what they call BIGT, which is the -- the time scaling parameter for random motions put in as another option to readjust that part of the LOW_WIND calculation.

Some research findings indicate that there are -- there are low frequency mesoscale motions in low winds that make the wind direction often just abruptly change every half hour perhaps. Therefore, if you have, like, a ten-minute experiment, like

Prairie Grass, you might not see that. You might think that the wind direction is very steady. But if you have a full hourly average, you might see these wind shifts. And these researchers have indicated that the low frequency mesoscale motions become the most important factor for total variance when you have other turbulence disappearing, basically.

They also say that when you have a wind speed below a certain threshold, maybe even 1.5 meters per second, you're going to have these wind shifts and you can't really define with an hourly average a -- a steady-state wind direction. If you have wind oscillations every 30 minutes or so, your BIGT ought to be much lower than for 24 hours. And these low frequency mesoscale motions could be setting a lower limit for the horizontal wind variance component.

Now let's get into some research. NOAA knows how to build a wall and the Trump Administration should take notice. This was done for a roadside barrier experiment, and I hope that the people researching roadside barriers use this, because I think they found that there is a significant blockage of pollutants on the other side of that wall.

But when they did this experiment in Idaho Falls, they -- to their surprise, they saw -- they found that the -- the spreading of the plume was higher than the Prairie Grass experiments suggested. So they said, "Let's do some more tracer experiments," and so Project Sagebrush was born.

They -- they reset SF_6/SO_2 tracer release campaigns, one in 2013 and one in 2016. So this is basically Project Prairie Grass reborn. And they had -- in the first phase, daytime releases, eight -- that is five releases. And in the second phase, they did four daytime, four nighttime releases, many involving low wind speeds.

I would certainly invite the -- any -- any evaluations of low winds to include these new databases. This is the view of the sampling. You can see the -- this is, you know, Sagebrush, I guess. You know, obviously, very easy to -- to get around in these conditions, flat terrain, low level releases.

The monitoring network of the samplers were, you can see, one hundred -- 100 meter circle, 200, 400 and 800 for the Phase 2. I think the Phase 1 went out a little further. Obviously, they had to wait until the wind direction was from the southwest, more or less, to -- to get the measurements, but there was a lot of instrumentation for this. Definitely worth considering.

So now, what databases to consider. There -- there are several existing ones, including the one I just mentioned. Believe it or not, Three Mile Island -- remember that nuclear power plant disaster? Well, before they built that thing, they actually released SF_6 on the island, five trials, low level releases.

Idaho Falls, we've been looking at Idaho Falls and Oak Ridge for the previous ADJ_U* and LOW_WIND evaluations and those are still available. So these are, basically, low level release evaluation databases that could be reconsidered for any updates to AERMOD. There are several existing elevated release databases, plus, as Rick mentioned, the -- some of the SO_2 Round 4 campaigns might add some -- in fact, there might be a public presentation tomorrow about one that's come forth.

Lovett, for example, has been used in the AERMOD evaluation, one of the 17 databases available on the SCRAM website. Tracy had 14 days of SF_6 releases, mostly at night. So some of these are full year and some of these are very short term. Hogback Ridge was one of the -- Hogback Ridge has not been used a lot, but it's certainly worth considering. Eleven days from a two-dimensional ridge.

Cinder Cone Butte, 18 days from a crane toward a Gaussian-shaped hill in Idaho. Bull Run was an EPRI experiment. EPRI had a -- some very ambitious field studies in the early '80s. Bull Run and Kincaid are -- are two such experiments with very extensive data. Laurel Ridge is the one I mentioned that's being considered by EPA Region 3 which had four monitors, a full year of data.

So these are definitely databases to consider. I don't know if we really need to go out and take new data. We have a wealth of data already, plus the Round 4 SO_2 monitoring.

So other considerations would be -- I would -- I would advocate for turbulence data processing if you use turbulence data for these low winds and use the full hour averaging, not four 15-minute periods that capture the wind fluctuations. The current form of the parameterization for sigma-Y and sigma-Z might be underestimating the dispersion in the daytime. Tomorrow, I will be up here again to talk about the penetrating plume component, which Chris Owen had mentioned as a -- a -- a new wannabe white paper. It should -- it's a low wind issue I would consider for convective conditions.

And, also, when you -- when you evaluate tracer databases, you don't have that many hours, and you might want to -- since you have all these bag samplers, you know the wind direction that would get the plume to the peak impact area. You should -- you should actually modify the wind direction input to AERMOD to make the plume get there, rather than using -- since in low winds, the wind direction is somewhat uncertain, you might miss -- you know, the model might be seemingly underpredicting, but it really isn't because you didn't give it the right -- right wind direction.

Conclusions, the ADJ_U^* option has made a difference for low wind speed stable conditions, as it was designed to do. In convective conditions, I would think the formulation of plume sigmas using observed turbulence needs reconsideration because I think AERMOD works better with the parameterized turbulence. There's a problem with the penetrated plume, more on that tomorrow.

The LOW_WIND updates could include the adjustment of a meander fraction for a way to do that and adding a minimum sigma-W as well as a sigma-V. We have a lot of evaluation databases if we want to tap those and take advantage of tracer and full-year databases already in existence. And that's the end of my slides.

DR. VENKATRAM: First I'd like to thank Chris Owen and Clint Tillerson for inviting me to participate in this panel. So flying over from California was not exactly very comfortable to get up at 3:30 my time, but, anyway, thank you very much, because it gave me an opportunity to look back at what we did in 2000. I think the first modeling conference I attended was in 2000. Steve Perry just reminded me that's when AERMOD was conceived and what we believed that we could do it. We thought we could do it in one year, but it took us seven years.

So, anyway, the LOW_WIND option was a very important component of AERMOD mainly because we realized that concentrations were being overpredicted in the low wind conditions. So -- so in order to talk about that, I need to first address the four questions that Chris -- Chris sent to us.

One is to talk about experience with the ADJ_U* option, and what I'm going to do is actually talk about history, because at my age, history becomes very important. And then I'm going to talk about the LOW_WIND components very cursorily because I'm not familiar with all of them. One is sigma-V and wind speed. I think Bob and -- Bob and -- and Rick have done a good job addressing them, so I'm going to spend less time on it.

But I'm going to talk a lot more about the meander option because I think that's an extremely important component of the LOW_WIND option and without it, the LOW_WIND option doesn't really work. And then I'm going to talk about databases that are useful.

First of all, why did we get the ADJ_U* option? It turns out that especially for surface releases, the concentrations are inversely proportional to the friction velocity, and I think all of you have used AERMOD and you know what friction velocity means. Some of my colleagues don't know about friction velocity, so I'm going to say it's proportional to wind speed, is a measure of sheer stress, and it turns out that near the source, the concentrations are inversely proportional to u^*. So under stable conditions, if u^* -- if the wind speed goes to zero or close to zero, friction velocity also goes to zero so the concentrations are extremely high.

So we wanted to see whether did u^*, indeed, approach low values when the wind speed went to zero values. And so we looked at some data and I'm going to talk about the data. And I suppose some of the options are to have minimum values of wind speed and sigma-V. I don't like them very much, but I suppose we -- we are forced to do so because we really don't have any alternatives.

And then, of course, the most important option, I think, is to introduce meandering. And I'm surprised that the area source algorithm still doesn't have meandering in it. In fact, I think meandering has not even been used in AERMOD with PRIME close to the source. So -- but meandering is a very important component.

So let me give you a little history of the ADJ_U^* option. So this ADJ_U^* option was introduced mainly during stable conditions. Stable conditions mainly because u^* went to very low values under stable conditions and the concentrations turned out to be too high, so we had to do something about it. So a student of mine, Wendy Qian, worked on this problem. The numerator -- I'm responsible for the numerator and she is responsible for the more important denominator.

It turns out that -- that if you see the -- if you look at the figure very carefully, the green line is what we were predicting initially with the numerator, which is that one-plus exponential. And so if you look at it, you don't have to worry too much about the formula itself, but what you need to worry about or at least look at is the green line going to zero. So ADJ_U* basically -- actually is the red line to make sure that u^* doesn't go to low values at wind speed.

And what is this based on? It’s actually based on years and years of data from data collected in Cardington, England, and that was available to us. It was available only to academia, correct, for some unknown reason? So Bob one day called me and said, "Venky, send it to me."

"I will send it to you, Bob." Apparently, I get special permission for some unknown reason.

Okay. So the point is ADJ_U* did what it was supposed to do, which is increase u^*, and made sure that u^* didn't go to zero as fast as the wind speed went. So it solved the problem to some extent and I'm gratified that it's very popular. But, unfortunately, it doesn't solve the whole problem because we have had a lot of experience under low wind speed conditions and it turns out that we almost inevitably and always overpredict concentrations.

So we introduced meandering. And what is meandering? Meandering is -- it's a combination of the plume -- and this is my -- my attempt at being an artist, so forgive me. That's why I do basically -- I still haven't yet learned from my students how to draw things, and they do fantastic jobs making presentations. I notice even if the content is not very good, the presentations are always very, very good with animations and all that sort of thing.

So, anyway, the plume -- the plume -- so this is a combination of the plume and the -- the pancake. And the pancake basically says if the wind speeds go to low values, the plume spreads out all over the place. So the concentration should be a combination of the two.

So that would basically be interpolated between the two. So if you look at the equation down at the bottom, it basically says the horizontal is the usual square root of two Pi sigma-Y in exponential form. But this is basically the second line concentration and the second term is essentially the -- the plume going all over the place. So you're saying sigma-Y is essentially two Pi R, which is the circumference.

So this was an important addition to -- to the low wind speed case. And so the main thing is how do you weight them. And the weighting was -- if you -- if you look at the code -- the Fortran code, you find the weighting actually. It's called FRAN for some unknown reason, and it's -- it basically weights sigma-V squared, the energy in horizontal motion, with the effective wind speed.

And what you need to notice is the wind speed consists of two components. Effective wind speed consists of two components, the vector wind speed -- it's not the scalar wind speed. It's the vector wind speed and sigma-V. So -- so when the vector wind speed goes to zero, you get square root of two sigma-V that Rick talked about and Bob talked about. And so you need to -- the main problem with using this is that you have to estimate it using u^*. So u^* is low. Sigma-V is also low, so that's a problem.

And the other thing is under unstable conditions, ADJ_U^* really should not be used because it was never designed for it. So I don't know whether it's being used -- I don't think it's being used currently.

Bob, it's not used under unstable conditions, ADJ_U^*?

MR. PAINE: When you turn it on, it's on for everything.

DR. VENKATRAM: Oh, okay. Okay. Okay. Well, it was designed for stable conditions. Okay?

So -- so the -- and the main thing is it's --

sigma-V is a combination of u^* and w^*. The moral of the story is that if the u^* is low, it's not going to smear the plume. So you need to either use measured sigma-V, which is a problem. So we still haven't solved the problem for meandering and how do you weight it.

Recent experiments we did at UC-Riverside looked at the effect of barriers on roadside concentrations indicated that this FRAN factor needs to be much, much larger. It doesn't solve that under stable low wind conditions the -- or even unstable low wind conditions, the concentrations tend to be overestimated.

So I think the smearing effect is much larger than we think it is, so we need to do some experiments. So -- so -- so -- so one of the things we did was is smearing enough? So the question is is smearing enough in the horizontal direction.

We need to smear it in the vertical direction also. We need to do something about vertical dispersion also and that's something that we need to look at. Here is something that we did long ago. Again, my student, Wendy -- this is part of her Ph.D. thesis. She was -- so we went ahead and created concentrations using data from Idaho Falls, again with

NOAA. NOAA essentially did a whole bunch of fantastic experiments over the years, starting in the 1970s and they're -- they're still doing really good experiments. It's unfortunate that most of the people like me are close to retirement or have already retired. So somebody has to carry the flag so -- to do these tracer experiment.

It turns out that very few people know how to do tracer experiments. I can basically think about three people in this country can do tracer experiments, and that's really unfortunate.

So, basically, this -- this basically showed that if you use AERMOD with -- with meandering, you still ended up overpredicting concentrations. So what you see there is that -- hopefully I don't press the wrong button here. What you see here is still overpredicting concentrations, even with meandering.

So what we did was, okay, so let's basically switch off meandering from the model and use a numerical dispersion model without meandering and see what happens. The difference is marginal. So vertical dispersion -- so the moral of the story is vertical dispersion is doing something to -- to the concentration. So -- so we need to worry about not just horizontal smearing but vertical smearing to some extent.

So I'm not going to spend too much time with this slide, but what it says is if you combine meandering with better vertical dispersion -- again, the -- the point here is meandering is not sufficient. You need to do something with vertical dispersion. So the numerical model actually handles vertical dispersion much better.

So it turns out that if you handle both things like vertical dispersion and maybe -- Bob, minimum sigma-W might do the trick. Okay? So Bob is nodding his head. Okay? Maybe. Maybe, but I prefer a numerical model.

Okay. So if you put in meandering with better vertical dispersion, it tends to do better. So this needs to be accounted for.

So as far as some field studies, let me say a few things about field studies. We did a field study long, long ago, aeons ago -- and for me, lot of things are aeons ago.

So we did -- we did some dispersion experiment in our campus. We were looking at dispersion from urban sources and this was -- this was a trailer of the -- there really is a source on the top of it and we wanted -- what we wanted to see is how the concentration pattern behaved close to the trailer. So we had a whole bunch of samplers -- continuous SF_6 samplers and just the point of -- this was done -- this entire experiment was done by a guy called David Pankratz who retired -- who's retired about five years ago.

And so we did this new experiment that Chris is actually aware of that we actually collected tracer data to evaluate R-Line and we had to bring it out of -- bring him out of retirement in order to do this experiment because he's one of, I told you, just three people who can do these experiments in this country. So -- which is rather unfortunate, and I had to go all -- write a letter all the way to the chancellor to get him back because there are strict rules against employing retired employees.

So, anyway, the main point here is that we did the experiment. You notice there's a lot of meandering. If you look at the -- if you look at the bottom here -- if you look at the bottom here, you see that sigma theta data -- you can look at the bottom here.

Sigma theta becomes very large. It becomes as large as hundred degrees. So there's a lot of meandering that goes on because you've got to --

because you've got to release it from the top. The wind speeds become very low when there's meandering.

And so the question was how do we handle this. So we'd rather have -- so -- so this is a fairly extensive experiment. We published a paper and we looked at it. And the main results I want to present here is that if you just ran AERMOD PRIME, this is the concentration as a function of wind meander with respect to the mean wind speed.

So if you look at the concentrations, look -- observe it's pretty flat. It's smeared all over the place, concentrations as far as 150 degrees away from zero. So if you ran AERMOD PRIME -- I could be mistaken here, but AERMOD PRIME doesn't have a meandering component. But if you ran PRIME like so, next to the source, you do not find the smearing at all.

So that is a problem that needs to be solved. If you want to run PRIME next to an urban source and you want to include meandering to reduce concentrations, you need to somehow introduce meandering into PRIME. So if you just ran AERMOD and you simply ran AERMOD with meandering, it gives much better results. We switched off PRIME and we ran it.

So the main result here is that meandering works in a lot of cases, but be careful when using with downwash because the downwash algorithm with PRIME doesn't use with meandering.

So -- so I'm going to go to the conclusions. Estimating concentrations at low wind speeds requires adjusting the micromet variables like u^* and sigma-V. We really don't know how to do it really well. We have -- we have some adjustments that seem to work.

Horizontal meandering, I personally believe that it -- it needs to be much, much larger. That is, the FRAN factor needs to be much larger. We need to make it -- we need to smear much rapid -- much more rapidly. That's the basic concept here. Because it doesn't turn out to be -- I show you some results. It doesn't -- data indicate that the plume doesn't -- doesn't have a Gaussian shape most of the time.

So I think we need to do some sort of meandering. In fact, the Three Mile Island experiment that Bob was talking about, it showed very clearly that concentrations are well predicted only when you did -- you smeared it over the entire angle. So if you did use a Gaussian plume and you smeared it over the entire sector, you've actually found much better performance.

Then about vertical meandering -- of course, I just put that down there and put a question mark because I didn't know what the hell I was talking about.

So -- so vertical meandering is basically -- we need to do something about vertical dispersion. And there are some databases that people have collected in -- in Italy, a whole bunch of experiments that talk about meandering. They've written a lot of papers on meandering.

What you see here is that the horizontal -- horizontal turbulence fluctuations can be ten times greater than u^*. It's not 2.5 or 1.9. It could be ten times u^*. So the low horizontal meandering and the low wind speeds I know -- I know for a fact that we really haven't deciphered that figure, but it doesn't matter.

Okay. So, in fact, I found it very difficult understanding the figure. Now, if you notice, a lot of papers have a lot of these figures, beautiful color pictures, usually 20 of them and they don't mean a thing. But the color is supposed to impress you. So -- so that's a new thing that -- this guy didn't have color, so I shouldn't be saying that.

So -- so the main thing is potential databases. Bob already talked about Project

Sagebrush. I think that's an extremely useful database. They collected excellent database, but they don't have any funding to -- to analyze the data and that's important. And most of the people involved in the experiment have retired, so that's a major problem. But this -- but this database is available. It's -- anyone can get it.

So Bob talked about there's a hundred -- talked about this -- excellent databases. This group has collected extremely good tracer databases with lot of instrumentation with horizontal wind speeds and everything and wind velocities, vertical velocities and everything else that you need.

And the main thing about it, if the plume is not Gaussian -- one of the things I want to point out, notice how flat it is. The concentration is extremely flat and then it falls off very rapidly. So this is what I call smearing in the -- in the horizontal. So it's not like a horizontal in a graph of a Gaussian plume. So -- so this needs to be accounted for in doing low wind.

And another result that they got was that sigma-Y that they were getting from the data was much, much larger. The horizontal spreading was much, much larger than what AERMOD was predicting. So that needs to be accounted for.

So, again, that's it. Thank you very much.

DR. OWEN: All right. We have 15 minutes and we're supposed to have a break. And so first I want to say thank you again to the panelists. Very insightful information. I do want to say that in the last couple of months I've gotten the Project Sagebrush data. Turns out Dave Heist was hoarding it over at the -- the wind tunnel facility. But we have that now and we hope to do some work with that in the coming year.

But I wanted to first give the panelists the opportunity to see if they have any questions -- clarifying questions for each other on any of the topics that were brought up.

MR. PAINE: I don't think so.

DR. OWEN: Okay. And so we did want to give the audience the opportunity, again, if there are clarifying questions for the comments that were provided by the panelists. We're not opening up the floor to discuss AERMOD in general. But if something the panelists said you'd like them to clarify, we'll give you the opportunity to do so.

MR. KIM: Rick, I have a question for you about how it is that the data points came to the database. You mentioned that it may be used for the one-hour modeling. And did you guys have any -- at one point, there are 75 substitution cases where you have to substitute the SO_2, I guess, data with much more conservative data when you have a missing hours.

DR. OWEN: Okay. Just to put in the context of clarifying your statements, Rick.

MR. GILLAM: Okay. Yeah.

DR. OWEN: Any further reaction or otherwise.

MR. GILLAM: All right. So I -- I think that's a good question, Beyeond. In terms of a definite answer on it, I don't think I can give you a definite answer at this point. But I would say that that's definitely something that should be brought up if you're looking at an alternative model demonstration and you're relying on the emissions data that would be reported in the -- yeah. My initial thought is you might want to exclude that data, but that's just a -- just an initial thought.

MR. GARRISON: My question was looks like the -- the studies have been done in, you know, certain ideal conditions with, like, low roughness and large fetch and stuff like that.

What -- do y'all have any insight as to what happens with the meander, the pancake versus the plume, during maybe higher roughness conditions?

DR. VENKATRAM: I can respond to that. If you look at one of the first plume studies we conducted -- can you hear me?

The first plume studies we conducted was in an urban setting with a lot of roughness. If you notice, it was a -- it was a trailer with -- with buildings in the background. So it was a fairly -- fairly representative of an urban condition.

And what we found there was meandering actually played a much bigger role than we had anticipated because the wind was going all over the place. So the point I'm trying to make is that quite often, you can get away with predicting concentrations assuming that it's all over the place, that it is essentially -- the horizontal spread is two Pi times the distance.

And then we did an experiment -- we had just finished an experiment next to the university and looking at collecting data for -- to evaluate R-Line. And Chris is involved in supervising the project. We found that, again, on the low wind speed -- low wind speed conditions -- and this is under urban conditions. Meandering was extremely important. We overpredicted concentrations by a factor of two with the current treatment of meandering; that is, using measured sigma-V. We had actually measurements of horizontal turbulence.

So when we put in the horizontal turbulence into AERMOD, or a version of AERMOD that included R-Line, it turned out that the concentrations were still being overpredicted. So we essentially increased the fraction to close to one and then the concentrations were fine.

So -- so the basic concept is, yeah, there's a lot more meandering in urban areas.

MR. PAINE: I wanted to add something to that. I noticed at the -- this year's EPA modeling workshop, a bullet on a Monin-Obukhov length to account for the source structures because in AERMIC, we were struggling with what do you do when you have a -- an anemometer in a low roughness area, which has to be the case because of siting requirements, but your source has buildings around it. How do you account for that additional mechanical turbulence? Right now, there's no easy way to do that, but I think there's an issue of maybe having a way to incorporate a minimum Monin-Obukhov length to account for surface roughness and -- and those types of things that we never really have solved.

DR. OWEN: Thanks, Bob, and Venky. Any other clarifying questions?

MR. BRIDGERS: So I think we should give the panel -- I don't want to take your job from you, Chris -- a round of applause.

And, Bob, I was going to give you an opportunity if you want to make a quick announcement.

MR. PAINE: At previous modeling workshops, we had a -- a colleague who's no longer able to be present with us, Joe Scire, who was the -- formulated the CALPUFF Model. He extended his efforts to do marathons too far on October 12th, 2014, and collapsed a half a mile from the finish line, was not attended to for a few minutes and, therefore, suffered brain damage.

He is basically at home, but does appreciate and can acknowledge notes from colleagues and -- and appreciates those. So we have outside this room on a table, you know, blank note cards if you want to write a note inside, I will then take those home and -- and ship them to his house. So those are available outside here.

MR. BRIDGERS: And with that, we will take our first morning break. And let's just go ahead and make it a long break. We'll still have plenty of time for lunch. So the time to restart will be 10:45 and this will give you a few minutes to do some networking if you'd like, but I'll suspend the public hearing until 10:45

[BREAK - 10:21 A.M. TO 10:45 A.M.]

MR. BRIDGERS: So I will reopen the public hearing after the break here. We're still waiting for one of our panelists. And so without further ado, it's my pleasure to introduce Clint Tillerson, who's going to moderate the Overwater Modeling Panel.

MR. TILLERSON: Thanks, George. Okay. Just a real quick background slide here because this is somewhat new work that we're encroaching on, something that we know needs to be done, have known that it needs to be done. Now we have some mechanisms in place now to -- to really dive into this.

So over -- overwater -- overwater modeling doesn't go away. It seems to be coming more prominent. People are looking at whether they can use AERMOD. They still have to use OCD. That seems to be coming up more and more these days and so we know that there's some area -- this is an area that we need to address.

So, currently, the Offshore Coastal Dispersion Model, OCD, is still the preferred model for offshore coastal modeling applications. But OCD, you know, has been around for a very, very long time and it relies on older dispersion science. It does not contain the post-processing routines for the more recent one-hour NAAQS or screening options for NO conversion to NO_2.

And so we've been considering replacing OCD with AERMOD. There are a few things that have to happen that will take some time in order for that replacement to take place. In particular, we need to be able to handle marine-based meteorology. We need to be able to handle coastal shoreline fumigation. And we also need to be able to handle offshore platform downwash.

These are all things that are a part of OCD that have not yet been incorporated into AERMOD, and so they're all key issues, key features that will need to be integrated into AERMOD in a way that will give us that -- that range to be able to do offshore modeling, nearshore modeling, dealing with coastal fumigation and -- and a mix of marine-based and terrain-based meteorology.

So we have a panel of four here today, and so I welcome you. I guess I need to stay close to here. I thank you for your participation today. And so I'm going to go through and introduce them and then they'll each, just like the last panel -- oh, thank you. Is it on? There we go. Is that on? Got it?

MR. BRIDGERS: Should be. Try again. It's on.

MR. TILLERSON: Okay. Okay. Thanks.

They'll -- they'll each come up and have 10 or 12 minutes to go through the charge questions, and we'll put the charge questions up.

So we have Dr. Bart Brashers. He did a post-doc with EPA group developing CMAQ from 1998 to 2001, working on dry deposition. He returned to Seattle and has been with the same group for 18 years, though there have been four different names on the door -- most recently Environ and now Ramboll. He runs WRF, supports MMIF and has done model intercomparisons both onshore and offshore.

We have Mrs. Holli Ensz, a physical scientist with emphasis on air quality with the Bureau of Ocean Energy Management, Headquarters Region, in Northern Virginia. Since the mission of BOEM is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way, Holli conducts air studies regarding impacts assessments of OCS oil and gas activities on air quality, including emissions inventory and modeling studies. She is also assisting with the drafting of BOEM's Air Rule. Before working in Headquarters, Holli worked in BOEM's Gulf of Mexico Region in New Orleans for 14 years in a similar position.

We have Dr. Jay McAlpine, a boundary leader -- pardon me, boundary layer meteorologist and Regional Modeling Contact at EPA Region 10 in Seattle; member of EPA's overwater dispersion modeling group. He holds a Ph.D. in atmospheric science from the University of Nevada, Reno, Desert Research Institute and a B.S. in atmospheric sciences from the University of Washington. Jay has 18 years of experience in air quality modeling, working in air quality consulting and modeling research prior to joining the EPA.

And again on this panel, we have Dr. Akula Venkatram, professor of mechanical engineering at University of California, Riverside, California. His research is focused on the development and application of models for the transport and dispersion of air pollutants over urban and regional scales. Previously, he held positions as the Vice President of Air Sciences at ENCR [sic] Consulting and Engineering and the Head of Model Development at the Ontario Ministry of Environment. Dr. Venkatram was a member of the team that developed AERMOD and was a principal contributor to the R-Line model. Dr. Venkatram received a B.S. degree in mechanical engineering from the Indian Institute of Technology and a Ph.D. degree in mechanical engineering from Purdue University.

So we have -- we have three charge questions. Again, we will not -- I will not read these, but they are printed in your -- in your handout. And they, essentially, focus on the replacement of OCD with AERMOD and what are those most important features that EPA should be concentrating on focusing on so that we can better apply the models to these overwater and near coastal situations.

So with that, we're going to have Jay come up first and present.

MR. McALPINE: Hello, and thank you. So I'd like to start by just first mentioning -- as the representative of EPA, just to put this into context where we are at right now with the overwater developments. And I want to say one of the first big developments was the development of the AERCOARE model, and I will be talking about that in a little bit -- few minutes here.

Also, we, in cooperation with BOEM and Federal Land Manager Agencies -- with the other agencies, we developed the inter-agency workgroup on overwater air quality modeling which I was involved with. That just began end of last year, so there's been some preliminary work with that group.

Also, we have the internal overwater group, which focuses on modeling but also other elements of overwater air permitting and some of the issues. We have a monthly call and that involves many of the regional modelers and also staff from OAQPS.

One of the purposes of the internal group is to help inform and facilitate -- oh, sorry about that. We don't need that up right now. Facilitate the development of the model and the integration of overwater features into AERMOD eventually.

So saying that, so one of the questions that was originally up in the air was should we integrate an overwater modeling system into AERMOD or perhaps provide a modern update to OCD. And as is -- is obvious, the -- the goal at this time is to attempt to integrate everything into AERMOD as the main regulatory near source -- near field model under EPA.

And there's many -- it's very obvious why we want to do that. It prevents the doubling of the workload by having to update both models at the same time and also the new AERMOD development process, again using ALPHA and BETA models, having everything in one package is ideal.

With that being said, I -- and there's a world of difficulty that arises when we start talking about having an offshore system in AERMOD because there are some big fundamental differences between OCD and AERMOD, and I'll go into some of those and -- and why integrating everything that OCD can do into AERMOD will require a fairly substantial update to AERMOD and go somewhat beyond the original structure of the models.

So I see three big pieces of work that need to be done for this update, or have been done I should say. First, Part A, the overwater meteorology. This is the -- the -- in my opinion, was the biggest piece. And I have to say that we -- we are there already, more or less.

The development of AERCOARE was spearheaded by my predecessor, Herman Wong at Region 10, in cooperation with BOEM and Dr. Brashers' group in Seattle. And it incorporates pretty much the state of the art of overwater meteorological parameterization at this time. And the -- the COARE models itself were developed using not only the COARE experiment measurement data but a host of other overwater meteorological datasets. So my understanding and what I've seen in the literature is that the model is -- is very robust.

We also -- Region 10 went through an alternative model approval process for an air permit in Alaska a few years ago where AERCOARE was approved for that project and used. So -- so I can say at this point AERCOARE is essentially a BETA-equivalent model. And thinking of the ALPHA/BETA scheme, it's not officially in AERMOD as a BETA model, per se, but it has the potential to be considered a BETA-equivalent model at this time. So saying that, we're pretty much there at the point where AERCOARE could be accepted as an overwater meteorological model at this point.

That being said, there's features in AERCOARE that -- well, AERCOARE on its own cannot be -- it cannot do everything that we need for overwater modeling. It doesn't bring all the features of OCD into AERMOD, those core features that are missing.

So using AERCOARE right now, we could use AERCOARE directly as a regulatory model, in my professional opinion, now, but only for overwater receptors. When it comes to the plume moving from the overwater boundary layer onto shore, air -- the AERCOARE/AERMOD combination can't account for the transition of the boundary layer along the shoreline in -- in what's referred to as the -- the thermal internal boundary layer. AERMOD doesn't have the capabilities of accounting for that yet.

Another big piece which a lot of development has recently been focused on, I understand, through BOEM is the platform downwash piece. The integration of that into AERMOD involves some development of BPIP and then the PRIME algorithms. And the earlier wind tunnel work that was used in OCD, that alone could be moved forward, but I understand there is a lot of new -- some wind tunnel work and I believe measurement studies that are being conducted by BOEM which will be really -- really great. I'm sure Holli's going to be discussing that in length here.

So my understanding is that we're not too far away from having those pieces put into the AERMOD modeling system. Most of the work for AERCOARE when the coding is finished on the technical side, the platform downwash piece is going to take a little bit more work because of integrating that into BPIP and PRIME.

So the last of the three big pieces of work here -- and I -- I mentioned it a little earlier -- is -- will involve a pretty big step in -- in -- in alteration to how AERMOD works is the treatment of the thermal internal boundary layer. So the transition of the plume when it goes from the marine boundary layer to an overland boundary layer.

So right now, AERMOD -- the AERMOD system just is fed with one set of meteorology. If we're moving to an overwater case where we have inland receptors, we're going to need both the overwater meteorology and then the on-land meteorology integrated into there. Technically, I could see just instead of putting AERCOARE into AERMOD, AERCOARE could still stand on its own and we'd model two sets of meteorology and then the handling of that would be done in AERMOD, more or less, as -- that's a suggestion.

But once that information is in AERMOD, the -- accounting for the plume interaction with the boundary layer is going to be tricky, mostly because that's highly dependent on the distance of the receptor from the shoreline. And to do that, each receptor will have to be assigned a distance from the shoreline under each wind direction that's being modeled. And so that will require some development. First of all, you need some preprocessors to calculate those distances possibly, and I'll -- you know, similar to AERMAP. And I could key the term AERSHORE or something like that. I don't -- I upset George by saying that.

But a lot of the fundamental algorithms involving fumigation and then interaction with the -- I'll say TIBL, they have been developed and I believe we need to -- the EPA needs to spend time reviewing those algorithms and seeing if they need to be brought up to date, if there's some refinement of those models using newer studies. That will be a focus of our work also. So that's generally my response to the -- the first question there.

I'll read -- the second question was, "In your opinion, what is the most immediate need in terms of coastal modeling issues?" And I also want to expand slightly into overwater permitting issues that relate to the modeling.

So I think one of the most difficult pieces of overwater modeling is finding a good dataset of temperature difference. Buoy data -- your temperature difference involves measuring temperature in the air and then usually a monitor -- you know, a meter or -- within a meter of the sea surface itself.

Well, the algorithms that are being used in AERCOARE and OCD are very sensitive to that temperature difference, so if there's any error at all -- if there's even the possibility of the flipping of a sign of -- of Monin-Obukhov, so erroneously forecasting -- or erroneously modeling a stable condition instead of unstable, or vice versa.

Well, saying that -- where do I want to go with that? So buoy data itself is often lacking, and when we do have it, the temperature difference is not usually a -- a key -- it's not really measured that well. But, you know, the -- I'll say the temperature probes aren't essentially linked for calculating temperature difference. So it's a big area of error that can result in poor performance of the model. I see that as a -- as an issue.

A possible alternative is using -- well, first of all, prognostic modeling somewhat solves that because it will be using the sea surface temperature data; hopefully a high-resolution dataset that's provided in the satellite data. So -- and I see most overwater modeling will likely, I assume, be using prognostic data. I'm sure Dr. Brashers will be touching on that possibly.

One option I can see is maybe using those sea surface temperature datasets as a parameterization of inputs so that we don't have to rely on buoy data where the temperature's taken a meter below the surface, because it's really that difference at the -- at the very surface, the skin of the water that -- that decides the flux of -- of moisture and heat to the atmosphere.

And I did mention air permitting. Some issues that my colleagues in Region 1 and 6 are -- are work -- dealing with, some of the challenges in offshore permitting anyway is, (a), concentration data, getting -- assigning the background concentration data that's representative. So -- and then also dealing with a PSD increment. And I just want to quickly wrap up with my -- talking about the -- the last question, do you envision priorities related to your division priorities.

And it's -- instead of a forecast, I want to say that it's more of a now-cast of -- of what we need. I guess we're seeing a lot of offshore wind development, especially in Region 1, but I could see that expanding to other regions. And there's a lot of offshore modeling needs for permitting of those projects and -- and also offshore oil and gas development. I see growth in that. We're already some work in the Cook Inlet in Alaska which will require updates in modeling. So thank you.

MS. ENSZ: Hi. I'm Holli Ensz. I'm with the

Bureau of Ocean Energy Management. We're an agency under the Department of Interior. And before I get into the charge questions, I wanted to talk a little bit about our agency. A lot of y'all probably don't know a lot about our agency.

So our mission, as was stated in my biography, is to manage development of the U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way. The Clean Air Act actually gave BOEM air quality jurisdiction on the OCS, which is federal waters, in the Gulf of Mexico region west of 87.5 degrees longitude. So if you take the Florida panhandle and the state line with Alabama and go straight south, west of that in federal waters is BOEM air quality jurisdiction. East of that is EPA air quality jurisdiction. And then, of course, the states have the state waters.

The Consolidated Appropriations Act of 2012 gave BOEM air quality jurisdiction on the OCS on the North Slope Borough of Alaska, which is the Chukchi and the Beaufort Seas.

So BOEM has this air quality jurisdiction and we also have the statutory responsibility that's listed in the Outer Continental Shelves [sic] Lands

Act, Section 5(a)(8), which states that we should prescribe regulations for compliance with the NAAQS to the extent that activities authorized under OSLA significantly affect the air quality of any state. So any activity that we're going to authorize, we have to make sure that that activity will not impact the air quality of any state.

We also do impact analysis to support NEPA for our five-year program for environmental impact statements, any kind of environmental assessments we need to do. So we do these impacts assessments a lot.

Our regulations for air are codified in 30 CFR Part 550. Our regs state that the operators -- when they have to conduct modeling, that they need to use EPA's Appendix W. Therefore, our agency, even though we have this air quality jurisdiction, we need to work closely with EPA because if we do need to conduct modeling, we have to use Appendix W.

And as I mentioned, EPA has air quality jurisdiction in the eastern Gulf of Mexico, and they also have jurisdiction for air in the Pacific, Atlantic and other areas in Alaska. So, again, the coordination between EPA and BOEM is -- is -- is important.

So why is there a need for offshore dispersion modeling for our agency? It's pretty obvious, but we have several programs. Jay mentioned a couple, but I'm going to start with our oil and gas program. BOEM reviews air quality plans submitted by the operators prior to exploration, installation and/or development. This is the oil and gas program.

We -- in the plan that is submitted to us by the operator, we have an air quality section. And in that air quality section, we review the estimated potential emissions. The plan's estimated potential emissions are calculated using EPA emission factors and calculations. And if it's -- if those potential emissions are over a threshold that BOEM has decided that could impact the air quality of any state, then we require the operator to conduct further air quality assessment, and that usually includes modeling.

So I wanted to mention, though, that our process is a little bit different than EPA's. We don't actually issue an air permit. What we do is we either approve the plan or deny the plan. So we can approve the plan; we can improve it with mitigations.

If we think that data will possibly impact the air quality of any state, we can mitigate their fuel usage. We can require controls. So we have options, but we either approve or deny a plan. We do not issue a permit.

In the Gulf of Mexico region, BOEM reviews approximately 300 oil and gas plans a year. Those aren't initial plans. Those are revised and supplemental as well as initial. And seven percent, approximately, of those plans require modeling and 15 percent require Fish and Wildlife Service review. We have Breton, which is a Class I area right off the coast of Louisiana, so we do coordinate with Fish and Wildlife Service when needed. So that's the Gulf of Mexico program.

Alaska, we just have Liberty project. It also needed modeling. And then in the Pacific, we have approximately 20 platforms that will need to be decommissioned in the upcoming years. Lastly, BOEM's five-year program is currently on hold, but the initial proposal opened up the whole Atlantic region, along with a lot of other regions, for oil and gas development. It's -- like I said, it's on hold, but if that opens up, then we could potentially have oil and gas development on the Atlantic, which, again, is EPA's jurisdiction, but we need to have this model ready to go. So that's our oil and gas program.

We also have a renewable program, which Jay kind of mentioned a little bit about. It's the wind program. We actually have leases from -- extending all the way from Massachusetts to North Carolina for wind development. And -- and what would happen is the wind company would come to BOEM for the lease for the -- for the actual wind lease, but since it's EPA's jurisdiction, they would go to EPA for the air quality permit under that scenario.

We also have this marine minerals program that not a lot of people know about. It's our sand and gravel program. And we have completed over 45 coastal restoration projects and we're still expanding.

So, basically, if a hurricane wipes out a beach, the city, state, locals want to replenish that beach, a lot of times they will use federal sands to replenish the beach. And like I said, we've completed 45 of those projects to date. So we think there is a need for overwater modeling based on what I just said, not only for BOEM but for EPA.

So the charge questions, what are -- what is my thoughts or BOEM's thoughts for replacing OCD with AERMOD. OCD is very outdated and has not been updated, whereas AERMOD has been continuously updated. AERMOD can read modern meteorological files. AERMOD, the outputs are directly comparable to the NAAQS.

So, therefore, BOEM, because of our need to assist our mission and our regulatory mandate and because AERMOD has been updated continuously, we strongly support replacing OCD with AERMOD.

Jay also mentioned that BOEM is working with EPA on an overwater workgroup, IWAQM overwater workgroup. And through that workgroup, we have -- hopefully soon will be entering into an interagency agreement with EPA to improve AERMOD for overwater modeling.

This inter -- interagency agreement, hopefully, will look at the OCD platform downwash algorithms and try to incorporate those into AERMOD, if it's compatible, and test those and evaluate those. We also hope through this interagency agreement that the coastal fumigation algorithms get incorporated, tested and evaluated into AERMOD as well.

Another project that BOEM was doing which -- Jay stole all my thunder -- that he also mentioned is a wind tunnel study. We -- and this will probably be for fiscal year '20, so starting soon. Since OCD was developed, the type of facility offshore has changed significantly. We no longer have just these -- just the shallow water platforms, jack-up type rigs. You have these MODUs, which are, like, mobile drilling units. You have FPSOs, which are huge floating production storage and offloading boats. Basically, they do it all on a boat. If a hurricane comes, they can drop the well down and they can leave the whole site and then come back and reconnect to it.

You have deepwater spars. You have tons of different types of facilities now that we didn't have before. And so we hope through this wind tunnel study that we can look at all the different types of downwash scenarios and make sure in the future that AERMOD incorporates all the facility types that we need.

So for question two, our immediate need, we need it all. We want it all now. So, obviously, like I said, we support meeting all the necessary needs to replace OCD with AERMOD and we hope to get a good start on this through the EPA interagency agreement and this wind tunnel study.

We have generated -- we have a study that's just recently completed which is a -- a major study. It was the air quality modeling in the Gulf of Mexico region study. And we generated a five-year meteorological dataset. ERG, Ramboll and Alpine Geophysics were our contractors. And it's a 2010 through 2014 CALPUFF and AERMOD WRF/MMIF dataset and it's for the whole Gulf of Mexico region. It's available on the GCOOS website, G-C-O-O-S, the Texas A&M University website.

But development -- we definitely want to support future development of the meteorological, AERCOARE, anything that we need to do our modeling and get the correct impacts assessment.

Our other need, which wasn't mentioned in the list, is up to this point, you've been talking about modeling -- dispersion modeling less than 50 kilometers. We also need modeling greater than 50 kilometers as we go further and further into deepwater. Currently, we use CALPUFF, but it's delisted. So, you know, based on what Fish and Wildlife Service and some of the other federal land managers do, BOEM will have to consider how we're going to go forward. But we are bound to use Appendix W. So we'll have to work with EPA on not only these less than 50 kilometer but greater than 50 kilometer scenarios.

The other need is, as I mentioned earlier, the deepwater technology has changed a lot and they have subsea wells now. So you don't have tons of point sources. You have these subsea wells and you have a lot of mobile sources, so support vessels coming in and out. So any modeling that we do for overwater needs to include and incorporate these support vessels coming in and out to help with that development.

The third question, do you think the priorities will shift in the next five years, no. With all of our -- all our multiple programs -- the oil and gas program, the wind, the renewable, the sand and gravel -- we think that there's a definitely a need for offshore models for not only BOEM but EPA.

There's approximately 1842 platforms in the Gulf of Mexico currently and they keep adding more daily. So those are going to be out there. We're going to have to eventually decommission those, but they're going to be active for many years to come.

I did want to say something that you had mentioned about -- with the marine boundary layer. BOEM has proposed a tracer study that -- they haven't done tracer study in the Gulf in a long, long time. So we're -- we're -- we're hoping to do that in fiscal year '21. But this year, we're going to try to focus on the -- the interagency agreement and the wind tunnel study and then in 2020 maybe do a tracer study in the Gulf of Mexico. That's it.

DR. BRASHERS: I'm sorry. I forgot my notebook. I'll have to read off my phone. My name is Bart Brashers. It's pretty clear to me what I'm supposed to be representing here, which would be -- so we have EPA, BOEM and academia, so I'm representing applicants.

But I'm -- so much of the work that I've done has been switching hats back and forth. Sometimes I work for applicants and sometimes I work for BOEM. Most notably, we've done some -- I've done some pretty big WRF modeling jobs and some overwater tracer study evaluations comparing OCD to AERMOD and CALPUFF. And those were based on the 2005 or 2006 work by the -- by Joe Scire and his team that started evaluating CALPUFF. So we just carried CALPUFF along with that.

And I guess the -- the big open secret in the room is that CALPUFF performed just about as well as OCD and AERMOD for all those tracer studies. Makes people a little bit nervous when I say that.

So switching hats back to the applicant side, because most of the work that I have done has been for deepwater or deepwater platforms in the western Gulf of Mexico and also for PSD projects in the eastern Gulf of Mexico, so on the other side of that bright line there at 89 -- 87 and a half degrees West.

Most of the -- those sources have been so far from shore that I don't see platform downwash as being a really huge issue. I suppose that if you really had a situation where you had to, say, repermit a platform that was close to shore or if there was a new platform or for perhaps the dredging things -- I did work on a dredging project once and we just used AERMOD with -- with an onshore meteorological dataset because it was so close to the shore that we figured that was good enough.

So for downwash, I don't see it as being all that huge of an issue. If you really come up with a situation where you need platform downwash, you could, I suppose, do a Section 3.2.2 demonstration and say -- even after OCD is delisted, you could still do an equivalency demonstration and say, "Oh, we could use OCD." That is, if you really enjoy running OCD. Most of us who have dealt with it don't.

Or I suppose you could try to do a Section 3.2.2 equivalence for CALPUFF which does have the platform downwash in there. So I think for certain isolated situations, CALPUFF would be an appropriate model to use, even in the near field for -- to be able to get the -- the platform downwash correct.

I think, similarly, the coastal fumigation part -- my career has probably not been as -- not -- not such a collection of really weird projects as Bob Paine's perhaps. I have a fair collection of weird projects, but not quite as many as his. And -- so for -- in my experience, coastal fumigation has not really come up and been a very important issue in the -- the permitting or plans that we've done, especially offshore of the Gulf of Mexico.

Almost all the new development is so far away that the plumes have essentially filled the boundary layer and they're well mixed within the boundary layer anyway. The -- the platforms are not quite as tall and, thus, they're -- the emissions are not as hot as, say, a typical power plant. So it's not, you know, getting above the boundary layer and moving all the way in to be mixed down once you get there.

And so almost all the time, the highest concentrations are going to be right at the shoreline or even, potentially, at the state seaward boundary, if that's what you choose as your evaluation point, the edge of the state. So I -- I don't think coastal fumigation or platform downwash are super-duper important. I think it would be nice to see those in there.

And I'm going to kind of blend into question two as what do I see as the most immediate need. And that would be the -- the overwater surface layer parameterization. But it's a really slippery slope.

If you try to just take the COARE, C-O-A-R-E, the Coupled Ocean-Atmospheric Response Experiment -- if you try to take that formulation of the Monin-Obukhov similarity theory layouts, it's based on the Liu, Katsaros and Businger, LKB, which came out of the University of Washington.

If you try to just take that and cram it into AERMET's current formulation, it's not going to work. COARE was developed specifically based upon the typical kinds of measurements that you get over water. You have sea surface temperature. We have an air temperature. Because we have a sea surface temperature, we can assume that the air right next to that sea surface is saturated with -- at the temperature of the sea. So you have a mixing -- rich water vapor mixing ratio right there.

Then if you measure relative humidity, then you have two layers of mixing ratio and two layers of temperature and two layers of wind speed, because we assume that the wind speed right there at the surface is zero, and you can solve the full Monin-Obukhov similarity theory.

Over land, the -- we don't have a really good way, given the current measurements, to estimate things like latent heat flux. Over the land also, we -- we believe that something like 90 percent of the incoming solar radiation turns into sensible heat flux and latent heat flux doesn't play a huge role. Over the water, it's more like 70 to 80 percent of this incoming solar radiation going -- goes into evaporation like heat flux. So it plays a huge part of the role there, pretty important.

Over land, because of the kinds of data that were being taken, that the model was designed to -- was formulated to take advantage of, the role of q^* and latent heat flux has been greatly diminished and reduced out of this thing, out of the AERMET formulation.

So just taking -- you can -- you can kind of argue that the AERMET's formulation of the Monin and Obukhov similarity theory is a -- a simplified version. I mean, we have -- the Bowen ratio idea is a pretty simple way to approach our latent heat flux. So it's a simplified version and the -- just cramming the COARE algorithm into that is not going to particularly work very well.

You'd have to rewrite all of AERMET and reformulate all of AERMET to be more general and then apply it both towards the -- you make the simplifications that are appropriate for over land and simplifications that are appropriate for over water.

And I know James -- James Thurman is working on a -- a rewrite of AERMET, but I believe that your rewrite is not supposed to be about introducing new features into AERMET. It's only replicating the existing model formulation of AERMET.

I'll talk about this a little bit later on in the prognostic thing -- prognostic panel, but AERMET's formulation, I believe, has not been really looked at in a good bit of time here, hasn't been updated like some of the prognostic models have been updated. So -- but we'll -- we'll talk about that later -- later on today.

I think in the meantime, we do have AERCOARE. AERCOARE is useful if you have measured meteorology, though one of the other big secrets is that the data retention rates for a lot of offshore buoys, especially in the Gulf of Mexico -- even in the Gulf of Mexico, where it's -- you know, except for hurricanes, it's a pretty benign type of situation there. The data recovery rates are still pretty poor, 75 percent. So it's not PSD quality measurements that we're using -- that you're using there.

And AERCOARE doesn't produce anything about the mix layer height. In fact, if you were trying to just use the AERMET formulation as is right now, you'd have to really look very closely about the mix layer and about the whole assumption that sunlight hours are convective and ark hours are stable, because over the ocean, stability has a lot more to do with cold or warm invection.

When the wind's blowing from warmer sea surface temperature towards cooler sea surface temperatures -- like, when it's going north in the Gulf of Mexico, the southern part of the Gulf of Mexico is warmer and it's going from hot air -- it's bringing hotter air over cooler sea surface temperatures, it actually gets stable, even though it's 80 degrees temperature -- water temperature. So that had -- that would have -- would have to be looked at, too. So rewriting AERMET would be a huge slippery slope, I think.

Question three about the priorities for the next years, we do have the AERCOARE, which we could probably use for most of the time. We do have air -- let's see. We could use WRF and MMIF in direct mode, so you skip writing -- skip using AERMET and you write it directly.

There's no regulatory framework for doing that right now. The regulatory says that we have to use

AERMET. So either you have to then change the regulations to accept AERCOARE and run MMIF data through AERCOARE, even though the Monin-Obukhov similarity formulation in WRF and in AERCOARE are mighty similar. They're pretty much the same thing. You don't really need to use AERCOARE, but that will get us by for another couple of years.

Since you opened the door, from an applicant perspective, there are a few other things that are -- that we would like to say would -- would be really cool to see. Like, if you rewrote the AERMOD COARE to turn the pollutant ID from single element to a vector, a list, you know, then you can do multi-pollutant AERMOD. It doesn't seem like it would be that hard to do in one run. You know, we always have to do four AERMOD runs, five AERMOD runs at the very least. It'd be nice to have to do fewer of them. It's easy, I think -- well, I hope it's easy.

Or how about a parallel version of AERMOD? There's other people who have done parallel versions of AERMOD. It doesn't like it should be impossible to do as well. That's all for me.

DR. VENKATRAM: Thank you very much again. You must be wondering why I'm back again. If you have been around as long as I've been in the community, you're involved in everything.

So here are the questions, OCD model, they want to replace it, so what do you do about it and what is immediate need and what are the priorities. So I'm not going to repeat the questions and talk about it. Just let me say a few words about OCD itself.

OCD was developed in 1985, quite a long time ago -- what, 20 plus 15 -- 35 years ago. And it is for offshore releases. If you notice the picture -- if you look at the picture, it just shows an offshore release.

Fumigating, I'm told now that fumigation is not that much of a problem. I suppose it's not. I don't know. That -- but that was the original. OCD does have that and it does have some other features that I'm going to talk about in a few minutes.

Steve Hanna, Lloyd Schulman, Paine and a whole bunch of people put it together, and I think it's still being used. So one of its features, it uses Briggs formulas for dispersion based on stability classes that are keyed to Monin-Obukhov lengths, and it uses an AERMOD formula type for very stable conditions because at that time, in 1985, we were doing CTDM, the complex terrain dispersion model, and we had come up with a vertical dispersion algorithm that was then adapted -- or adopted in OCD.

Then we had a thermal internal boundary layer line [sic] that allowed for fumigation. It assumes a linear growth with distance. Then we have dispersion over land, again, Briggs formulas for stability -- keyed to stability process [sic]. Then we had RTDM for complex terrain. We had some linear chemistry features.

I think one of the outstanding features of the OCD model, it handles the complex geometry relative to the sources. I think it's something that we should consider adopting. Then it had been evaluated with databases -- a limited evaluation with databases and seems to -- to work.

So what do we do now to replace this with more modern formulations? First thing is I think AERCOARE is a -- is a viable processor that can be adapted for AERMET. I'm not as pessimistic as Bart was about getting down the slippery slope that is -- which is what he called it. But I think -- I think we can do things to account for overwater dispersion.

Right now, it uses Monin-Obukhov similarity. That's based on temperature differences, but maybe we can use energy balances rather than temperature differences. It meets -- it accounts for water vapor, the role of water vapor. You need to worry about virtual temperatures and saturation features. It also accounts for roughness of the water. It uses -- which, again, you're calculating surface friction velocity. You calculate roughness. It's no longer keyed to land surface type.

What I like about the fact is when they did the evaluation, the boundary height that worked best was the empirical equation I put together -- put together years ago, so I like it very much. U* to the power three by two, apparently, that worked the best.

So we have a viable alternative for meteorology. Maybe I'm exaggerating that. Maybe this is much more difficult than my cursory examination showed, but there is something there that we can work with.

The second thing is over land, what do we do? The first thing is the internal boundary layer. And the reason I put this slide up was this is the very first paper I ever wrote. This was aeons ago, 1976 or 1977. I remember very clearly when it was accepted I ran around the office saying, "My God, this is the first paper I wrote and it was actually reviewed by James Deardorff, who was one of the gods of meteorology. And James -- Deardorff actually wrote to me.

So, anyway, the main -- main reason we did this was in this -- all this coastal fumigation was extremely important because power plants were located next to -- next to the shoreline. So fumigation was a major issue, so we needed to know where it fumigated.

So we came up with the equation to predict the height of the internal boundary layer or the thermal boundary layer. And what is important about this equation is that h grows as distance to the power of half and not linearly. So I never liked the linear equation, even though Steve proposed it.

So I said it should be more like x to the power of half. So we decided that had we now had this -- notice it again has some temperature differences. It's got the temperature over the land, the temperature of the water. You need to know the potential boundary to gradient over -- over the water, a whole bunch of variables that you might not have access to.

So how do we get around this? So one of the things you want to do when you're coming up with a dispersion model is you want to have the least amount of dependence on these variables you can never measure. Okay?

The second thing is you want to make it robust. You want to make it work under a lot of circumstances. So what we did was, okay, let's come up with an equation of the following form. Just bear with me.

It basically says the height of the internal boundary layer is what it was over the ocean plus -- plus a term that accounts for the fact that after it undergoes transition from over the water to land, it has to be equal to the boundary layer over land. So why not basically have a square root dependence between ocean and land?

And zi over land is predicted by AERMET. AERMET actually predicts the zi over land. So -- so what I basically said was we came up with the formulation in 1986 suggesting a robust way of doing it which basically says h is proportional to x to the power of half at small x over the land. And then it achieves the equilibrium at large x. So that's basically what I'm suggesting; that it's not really difficult to do, fairly simple to implement in AERMET because you really don't have to have temperature differences.

If you know what the boundary layer height is over the ocean and you know what the boundary layer height is over the land, you can essentially interpolate using x to the power of -- using this type of equation that I've suggested.

And then the second thing I want to talk to you is people who are aware of what w^* means, you know, you -- you see that equation basically depends on the surface heat flux. It depends on the mixed layer height and if Zi is the boundary layer over the land where it is x to the power of half. You get an equation in which the convective turbulence, which is the turbulence that controls dispersion over land, is actually very insensitive to the distance. It's x to the power of one-sixth. So you can get away with simply using AERMET w^*.

You can simply say, well, AERMET is going to work because it's -- you really don't have to be -- worry too much. And notice it's also proportional to the heat flux to the power of one-third. So you can make big mistakes in the heat flux and still get away with it.

So what I'm saying is you can still use zi over land. Okay? So -- so I'm being optimistic here. I'm saying, look, things can actually work. You can actually adapt AERMET with small modifications.

And then I want to talk about dispersion. First thing I did was talk about meteorology. I'm optimistic AERCOARE perhaps can be adapted, perhaps don't worry about temperature difference, worry about energy and maybe you can -- you can get around using variables that we don't measure.

And here is a paper that looked at fumigation by a guy called Misra. Again, it was done years ago. It's surprising that I'm still talking about these things. But it was done -- again, this is coastal fumigation and we came up with very elaborate models to look at coastal fumigation where we accounted for the fact that fumigation occurred over distances along the thermal internal boundary layer.

But what is -- what I want to point out here is these formulas for sigma-Y and sigma-Z, all it basically says is you've combined something that happened over the stable boundary layer with something that happened over the unstable boundary layer. And we know how to do both of them. We know how to do dispersion over the stable -- stable boundary layer.

So I don't think it's that difficult as long as you know where the plume intersects, the thermal internal boundary. You can actually compute -- compute these plume spreads. So -- so my -- my basic message here is AERMOD can include offshore sources without major modifications. Of course, I could be completely wrong.

So -- so AERMET has to be expanded. I think AERCOARE is a good candidate. And I also believe that TIBL behavior can be incorporated into AERMOD. And you don't have to be extremely accurate about it, because as I showed, a lot of the parameters are not very sensitive to how precisely you do it. Thank you. That's all.

MR. TILLERSON: George, we got time for questions?

MR. BRIDGERS: If there needs to be questions.

MR. TILLERSON: Does anyone have any clarifying questions that they would like to ask any of the panelists?

MR. PAINE: Sure. Basically, on the hard-to-measure meteorological parameters, such as the air-to-sea temperature difference and the overland that you see at the top of the TIBL, I would recommend -- maybe you can comment on this -- if you find some really good observational MET towers or buoys where you could compare a prognostic model to these measurements, I would recommend you consider that.

For example, nuclear power plants on a shoreline. In Massachusetts, they have a 60-meter tower. This has decades of data, delta-T. You should consider calibrating a MET model against that type of measurement, opportunistic measurements.

Maybe, Venky, there's some data from those studies on the shore of Lake Erie that could be used in testing a model for shoreline power plants.

Just one other -- couple of things. Platform downwash, if ambient air doesn't extend out way over the ocean, maybe we don't have to worry about it. But some -- some jurisdictions require predicting out of the top of a -- you know, the water surface concentrations within 500 meters, and there you do need platform downwash.

MR. SZEMBEK: So following up on Bob's question, is -- could satellite data be used to augment and perhaps even be used as a form of measuring observations, whether it's in how you develop the prognostic data or even how it's used indirectly in developing meteorology in AERCOARE?

DR. BRASHERS: I suppose there are a few satellite sources of wind speed. I'm not sure if an SSMI is still flying, but you could use that to do -- find the wind speed offshore. I don't know that you would be necessarily more accurate or more unbiased than if you ran a meteorological model, a prognostic model, and used that. I think you would be probably on the same order.

The difference, I suppose, would be that when you're running a prognostic model, you're creating terabytes of data, as opposed to downloading terabytes of data to your server. It's not --

MR. SZEMBEK: You also have the sea surface temperature, so --

DR. BRASHERS: Yes. Sea surface temperatures are -- high resolution sea surface temperatures are normally an input to any prognostic meteorological modeling.

MR. SZEMBEK: Used from the satellites?

DR. BRASHERS: Yes.

MR. SZEMBEK: Okay.

DR. VENKATRAM: I concur with what he said. I think we can use sea surface temperatures from satellites, and I'm told that satellites can even give you ocean current speeds, which can ultimately give you surface friction velocities, which perhaps would work.

But my -- my feeling is I think you should -- we should construct a model that's robust in the sense that it doesn't -- it's not very sensitive to inputs. That's what we did in AERMOD. We tried our best to make sure things were not sensitive but, at the same time, be realistic.

Two things: one, it had to be robust, not sensitive to inputs; at the same time, provide a realistic value. So I feel that if it depends so much on temperature differences, we should avoid temperature differences and solve the problem. All right?

We should then rely on energy as do in -- incoming solar radiation, something about evaporation. Maybe it can be done. I really don't know. But I think the robustness is a very important consideration.

And this is in response to even what Bob said. Bob was worried about temperature differences. And then if -- then if that's sensitive to temperature differences, it's going to be very difficult to come up with a model. Even though in reality it does, but maybe you can do something that's sort of approximate, which is exactly what I want. It's not accurate in every set, but it's robust and realistic, what AERMET does.

MR. TILLERSON: All right. We are running into our lunch time here, so I would like personally to thank each of you for your participation, and I believe that we should all give them a round of applause.

MR. BRIDGERS: And as we break, I am going to suspend the public hearing until 1:00. Again, 1:00, we'll get started on time and I hope everybody has a great lunch.

If there are any other questions or things about the facility and logistics, please come find me. Thank you.

[LUNCH BREAK - 11:47 A.M. TO 1:01 P.M.]

MR. BRIDGERS: I would reopen the public hearing for the afternoon session, where we've got a series of expert panels again this afternoon. And we're going to start off with mobile sources. I will turn it back over to Dr. Chris Owen.

DR. OWEN: All right. Thank you, George. So mobile sources. I know that we don't have a lot of stakeholders from that group in the group today, but I think it's a particularly useful topic for us to learn more about and how we're dealing with that, because it's our first BETA option to come out of our new ALPHA/BETA paradigm. So hopefully we'll learn some useful things about how we got to BETA, to the point I made earlier this morning on the white paper set of slides.

So a little bit more background, in case you haven't been following what's been going on with modeling mobile sources from the study perspective. With the 2017 update to Appendix W, we specified AERMOD as the preferred model for mobile sources. This replaced CALINE3 for refined modeling. Just a caveat asterisk there, you can still use ALPHA QHC for screening for CR analyses, but for refined analysis for PM, your hotspot for performing analysis and similar analyses, AERMOD will be the preferred model and that will go into effect in January of 2020. That's the end of that grace period.

The replacement of CALINE3 with AERMOD was based on a 2013 paper from ORD that compared AERMOD, R-LINE, ADMS, which is the UK's online dispersion model, as well as the CALINE models; actually, CALINE3 and CALINE4. That analysis found that the modern, basically, Monin-Obukhov-based models -- AERMOD, R-LINE and ADMS -- all had fairly similar performance and there's a pretty big performance gap between CALINE3 and CALINE4 with the more modern models.

Some other info here, we actually entered into an interagency agreement with Federal Highway -- we've mentioned this a couple of times already today -- to integrate ORD's R-LINE, R-dash-LINE, model -- and that's how ORD specifies this moving forward. If you see R-dash-LINE, that's referring to ORD's stand-alone R-LINE model. If you see RLINE as just one phrase, that's referring to what we have in AERMOD.

In spring 2017, so shortly following publication of the study, we entered into this interagency agreement to integrate R-LINE into AERMOD. R-LINE is a steady state Gaussian model and it's designed to simulate emissions from line sources. And it was developed specifically to look at surface releases along with emission sources. And earlier, we -- Bob showed a picture of the Idaho Falls barrier study. And so those datasets were used in the development of R-LINE as well as some algorithms within R-LINE.

Some of the advantages or some differences, I guess, in R-LINE and the other parameterizations that are in AERMOD for modeling mobile sources. R-LINE includes meander. Just like point and volume sources and VOLUME sources are an option, it has meander sources. But the inputs are fairly easy to use. Like the LINE source, you just hit a button and a single x1 and y2 line and x2, y2 and you just put your end points in and put the roadway. And so it's a reduced pathway to put your inputs into the model and still get the advantage of having meander in your model simulation.

It also runs a whole lot faster than VOLUME sources. If you try to do roadway analysis with VOLUME sources, you may note they take quite a while. And so you can get the advantage of having meander considered in your modeling with simplified inputs and much shorter run times compared to some of the other options as you combine those two.

The R-LINE model also has additional parameterizations with formulations of barriers, so solid noise barriers specifically and depressed roadways. And so those are important and frequent nearby features that are -- cannot necessarily be modeled right now in AERMOD using the LINE source and the VOLUME source options.

So in AERMOD, 19191 -- of course, Clint and James covered this already, but a little bit more details. We added two new source types that are based on the R-LINE source from ORD.

The RLINE source has been added as a BETA and so this has the new dispersion characterization of the LINE source. The inputs for that RLINE source are identical to the LINE source inputs. And so if you want to test RLINE, you can simply change model simulation as the LINE source in it and put an R in front of that LINE and you can run RLINE and see how that affects your model simulation.

We've also added the RLINEXT or R-LINE extended source as an ALPHA option. In the RLINEXT, the basic dispersion curves are the same. If you input the source coordinates identically between the two and -- and don't use the barriers or depressed roadways, you'll get identical concentrations. So they are the same. The RLINEXT gives you a pathway to access the solid barrier algorithms and those depressed roadway algorithms. And the barriers and depressed roadway algorithms are an ALPHA part of this that were developed in testing.

There are some limitations to RLINE. There's lots of developmental work to do still here. Both sources are limited to FLAT terrain right now. RLINE was developed basically in flat terrain, and so there is no processing for differences in elevations. As I mentioned, we need more research and development for the barrier and depressed roadway algorithms. Field studies are an important piece of -- of being able to continue that evaluation.

And then there's more practical needs for moving RLINE forward for the community, which is being able to account for two barriers, so a roadway segment and then a barrier on each side of the roadway. At barrier edge effects, we need parameterizations for those.

We also added the URBAN option for both the RLINE and RLINEXT sources. As Clint mentioned earlier, that URBAN option is ALPHA, whether you're using the RLINE or the RLINEXT. So we need more evaluation about the limitation of the URBAN option as well.

So that's the -- the background information I have. I'd like to introduce our panelists, if y'all wouldn't mind coming up now and we can get going with our session.

Our first panelist is going to be Dr. David Heist. David is a research scientist at EPA's Office of Research and Development for the last 16 years. He earned his Ph.D. in mechanical engineering from Cornell University in fluid dynamics. Davis performs wind tunnel experiments on flow and dispersion at the EPA's Fluid Modeling Facility and works to further develop the Agency's dispersion models.

Our second panelist is Dr. Michelle Snyder.

She is an atmospheric scientist at Wood Environment & Infrastructure Solutions, LLC. So if you see Wood on her nametag, there's more -- more to it than just Wood. She also worked at UNC's Institute for the Environment and she's also worked for the EPA's Office of Research and Development. She specializes in atmospheric dispersion, numerical model development and air quality data analysis. She's also one of the main developers of the R-LINE model when she was at ORD.

And our last panelist, Mr. Christopher Voigt, is a Senior Environmental Engineer with the Virginia Department of Transportation Environmental Division. He's served a number of roles with the American Association of State Highway and Transportation Officials, as AASHTO as you may know them. He's currently the Vice Chair of the CES Air Quality Committee -- the CES Air Quality, Climate Change and Energy Subcommittee. Sorry.

So I'd like to thank our panelists for being here. And then just briefly, the questions that we have for our panelists today, just to summarize, we're seeking comment on what we have done recently with integration of R-LINE and what are the priorities for moving forward with the developmental needs from that implementation.

Other than the RLINE framework, what other developmental needs are important for the mobile source community, and then, finally, what do you envision as the priorities changing in the future and -- and how we need to consider those going forward. So I'll turn things over to David Heist.

DR. HEIST: Thanks for the chance to speak on opportunities and challenges in modeling dispersion for mobile source emissions. We at ORD's Fluid Modeling Facility began working on mobile source-related dispersion issues about ten years ago, when we did some initial experiments looking at the way roadway configurations affect near source dispersion.

We looked specifically at solid roadside barriers, depressed roadways and various combinations and variations on those -- those configurations. It was also during this time that we began working on the R-LINE, R-dash-LINE, dispersion model as a way of testing out some ideas about how to improve modeling of near ground level dispersion from roadway emissions.

We used R-LINE as a kind of laboratory to test out our -- test out our ideas, developing dispersion curves, barrier and depressed roadway algorithms, maintaining a separate model to avoid confusion -- confusion with EPA's regulatory model, AERMOD.

Along the way, various field and laboratory databases became available for development and evaluation of various aspects of near ground level dispersion for mobile sources, which we worked to make the best use of. So now that -- now as parts of R-LINE are mature enough, the ALPHA/BETA structure in place for testing algorithms within AERMOD comes at a good time.

Some aspects of R-LINE have been peer-reviewed enough to be ready for inclusion as BETA options. These include the basic methodology for converging solution with a sufficient number of point sources distributed along the roadway; the algorithm to account for lowering meander; and revised dispersion curves based on new analysis focused on near ground level dispersion.

Other aspects of R-LINE, like the barrier and depressed roadway algorithms, still need more development and evaluation and, therefore, are being designated as ALPHA options at this time.

So, in my opinion, the ALPHA options we need to focus our development effort on include, of course, the -- the near road barrier algorithms. The current version included in AERMOD in the recent release is an early version of the barrier algorithm that was released when we released R-LINE in 2013.

Since that time, several new developments have been made modeling the effects of solid roadside barriers. For example, in 2014, Schulte, et al., published a paper describing an algorithm for a barrier on the downwind side of the roadway that produces concentrations that are well-mixed over the height -- over a height roughly proportional to the barrier height, accounts for increased turbulence intensity in the wake of the barrier and lofts the pollutant plume over the top of the barrier.

Then in 2016, Ahanger, et al., published further improvements to account for a barrier on the upwind side of the roadway and for barriers on both sides of the roadway. One additional concern which we're currently working on is edge effects; that is, what happens when the plume approaches the end of a barrier and has the potential to disperse around the edge of the barrier.

To that end, in coordination with Federal Highways and OAQPS, we've performed a series of wind tunnel experiments to quantify these edge effects for varying wind directions and distances from the barrier and for a variety of barrier configurations. We are in the process of analyzing that data and developing modifications to our barrier algorithms to account for those edge effect phenomena. So all of that work -- the improved barrier algorithm, the algorithms to account for the upwind barriers and barriers on both sides of the roadway and the edge effects -- have been and continue to be focuses of ours for model development.

In addition, as new field datasets become available that address these issues, they'll be useful for evaluation of these algorithms as well.

So the second question about what EPA has not already identified is a little hard for me to answer since I work for EPA. But I guess I would say that there are some important development areas with respect to AERMOD that haven't been the focus of as much discussion.

The first thing that comes to mind are the barrier edge effects, which we just talked about. But in addition, another topic that has been receiving a lot of discussion lately is vegetative barriers. The topic of mitigation of air pollutant effects is multifaceted and important, but even for the special case of roadside vegetative barriers, the variety of possible configurations makes the problem very challenging.

Some of those challenges include the density of the vegetation, the height, the thickness, whether it's deciduous or not, how complete or uniform the blockage presented by the vegetation is, the vegetation's effectiveness for aerosol deposition and the possibility that the vegetation could be used in combination with solid barriers.

A number of field studies have been performed and a few wind tunnel studies and there is a fairly rich literature on the use of windbreaks and shelter fences for agricultural purposes, but much further work is needed, including distilling all of that known information on vegetative effects down to an algorithm that can be introduced into the AERMOD platform that would begin to account for the mitigation potential.

And while it is a -- quite a complex effect, going about developing algorithms, we need to be mindful not to unduly increase the -- the burden of the model by requiring an excess amount of inputs to describe a vegetative barrier. So there's a lot of things to consider.

With respect to changes in mobile source modeling issues over the next five years or so, one of the primary things that I'll be looking for is more datasets available for analysis, both for further development of the modeling approaches and for evaluation of relevant algorithms.

High quality tracer field experiments are particularly valuable because the emission rate of a pollutant is well controlled and measured. This alleviates the challenge of estimating emissions from vehicle activity.

I know we alluded to it earlier. There's a study underway in California right now designed to characterize the effects of solid barriers, including the edge effects. I'm looking forward to seeing how that experiment and others like it add to the literature on mitigation strategies.

Another area to watch in the next five years is the use of vegetation as a mitigation method, as I already mentioned. This is an area of active research, and as more information becomes available, this can improve our understanding of the complex interactions. However, there have been cases that demonstrate that vegetation can have a negative impact by trapping emissions, say, for example, in a street canyon and increasing potential exposure. So carefully planning how to deploy such strategies is important.

In addition, there may be advances in understanding health effects related to exposure to mobile source emissions that will inform modeling priorities and approaches. And as technology evolves and fleet -- vehicle fleets turn over, the emission profiles for mobile sources may change. This again may inform modeling approaches and priorities.

New and innovative mitigation options may be developed using different roadway configurations, different combinations of vegetation barriers, depressed roadways and other ideas and this may change the kind of scenarios that are important to characterize and understand and eventually model.

And, finally, as computational methods develop and computer speeds increase, modeling tools may evolve to make better use of those changes and so we'll need to keep an eye on that.

And that's the end of what I have to say, but I'd like to just thank you for the opportunity and for your attention.

DR. SNYDER: All right. My name's Michelle Snyder. I currently work for Wood Environment & Infrastructure. And so thank you, Chris, for allowing me to speak today. Roadways are one of the things I really like to do and think about all the time.

So thank you, Dave. You stole most of my material. But I do want to say that I -- I did do a significant amount of work in including R-LINE into the AERMOD model. It was a challenge, and so a lot of my comments are going to be in that respect.

The -- the idea of two source types -- I know it's kind of novel for AERMOD to have it this way, but it was kind of essential to make a LINE source easily compatible with an R-LINE source so that you could really test the difference in the model dispersion formulations. That's one of my concerns as well, is that we have two models now that -- two source types that model the same thing pretty easily.

So how do -- how do we address that and do that moving forward, because you do have two different ways for kind of modeling the atmosphere and so which one is kind of scientifically right. And so I think that's -- that's another question we need to address maybe with all source types. I think that we need something common between all of them. So my -- my suggestion would be to have one LINE source -- source type.

But that also comes with a few obstacles, and those being that roadways are really hard to model. Like Dave said, you have a lot of configurations that are unique to roadways. You have barriers, vegetative barriers. You have roadways and depressions. All of those things make it complex to model the -- this source type.

So whereas you would -- in building downwash, you would use, you know, one building that influenced your source, well, you might have a vegetative barrier and your roadway might be in a depression. And so you have multiple things that are really influencing your roadway source type and that makes it really difficult to input into your model because you have multiple things going in.

You also have a lot of different algorithms and adjustments to dispersion algorithms that need to occur for each of those complexities. And so the inputs become tedious and overwhelming. I could imagine a case where you have a very urban area with lots of roadway sources. Of course, roadways are very important in urban areas because that's the source that people are standing next to as they're on the street, walking their dog. You know, they -- there's -- there's a lot of exposure to these types of sources.

So what you want to do is model these really well and include all of their complexities. So I -- this situation where you have lots and lots of sources in an urban area means you have a lot of run time for your dispersion model. You also have barriers and other buildings that influence each of these sources. So it becomes kind of a nightmare to tackle and track all these different things that influence this version on your sources. So the inputs become very, very hard to do. I would describe it as a nightmare to try to put that in the model as it currently exists.

So what I would say is it's -- we have -- now we have an urban option that's ALPHA. We have a depressed roadway option and a barrier option that are ALPHA. I would say all of those need further research. I kind of questioned putting in an urban option to begin with because R-LINE was developed with urban databases and the parameterization of R-LINE and its dispersion curves was done in an urban setting, so why do we need to make a further adjustment for urban options?

For a depression, I feel like there's not -- there's not a lot of field studies. I know I was in the wind tunnel facility with Dave and Steve back there when we looked at depressed roadways. And then

I know that there was the Las Vegas near road study where the roadway was in a depression, but there were some other complexities going along with it -- with that. And it's just hard to get a pure dispersion of a depressed roadway field study. So that's definitely -- definitely needed.

Barriers is coming along. There's a few studies coming along that people have mentioned before. But, again, like Dave said, you have one barrier, you have two barriers, you have a barrier with vegetation. You might have a barrier that starts and stops; it's not continuous. It just becomes very complex in terms of the inputs that you're putting in.

The more complex your inputs, the slower your run times are going to be, no matter what model you use. So that's definitely a consideration. So I feel like EPA should focus on the wind profiling and dispersion curves, as I mentioned before.

I also think that double barriers is -- happens a lot. We should focus on those kinds of things. One thing that has not been mentioned yet is intersections at interchanges. That's currently addressed in the CALINE model, although the CALINE model hasn't been updated in a while.

So it -- to me, intersections at interchanges become an emissions issue. How do you really characterize starts and stops of vehicle emissions? Those become difficult.

Bridges and elevated roadways are not addressed at all currently. And so those occur also all the time and those would have some effects because, obviously, there's roadways that are omitted and there's emissions on these roadways. And when you have them elevated, they disperse a little bit quicker. So you may be actually overpredicting if you model them as flat.

Prognostic models and representative meteorology has been touched on in a few cases in a few panels. I agree. Mobile sources have the same issue. If you're -- if you're getting airport meteorology, it might be kilometers and kilometers away and that might not be necessarily be totally representative of where your receptor is and the location that you're at. So I think that some focus needs to be put in that area and maybe some way to kind of take your airport meteorology and get some kind of adjustments to where you actually are.

A lot of these airports are in suburban areas and so that's not really representative of a roadway in an urban area. So these are things that -- that I think EPA should consider and think about.

I also would add a plug in for adding meander to AREA and LINE sources would be beneficial.

So, again, emissions and the source characterization of these R-LINE or mobile source roadways is very difficult and challenging and we would need to think about that moving forward in terms of the AERMOD model.

Future priorities, I -- I echo what Dave said in that as computers get faster, we can put more and more things into our model and we can compute more things. But, like, how much is too much and what things make a difference? And you want to focus on the things that make the most difference, not the things that make a little bit of difference, even if they are there.

The model is somewhat limited in the term -- in terms of inputs and sources that it currently has in its model setup, and the complexity of a road -- road network is very burdensome on computational resources, inputs, databases and data generation. I'm sure databases exist out there of some barriers in some places, but whether there's a widespread uniform database -- I don't know of it, but there could be. It would be very large and very tedious and cumbersome to use as an input to the model, even if you were to break it down into the area that you had.

So those are the end of my comments. I will now let Chris have the floor.

MR. VOIGT: Good afternoon, everyone. I thought I'd start with a poll, Chris Voigt with Virginia DOT, working with AASHTO. I saw maybe three people in here that I recognized from a transportation agency and I know Akula Venkatram has worked on mobile sources, working on tracer studies right now.

Is anybody else in the room working on transportation besides our panel? Three, four, five -- okay, maybe ten. That's good. More than I thought.

So question one asks -- I want to say right off the bat on behalf of the AASHTO Air Quality Subcommittee -- and AASHTO is the American Association of State Highway and Transportation Officials, so, basically, state DOTs. And we do a lot of work in association with each other, and so I'm a vice chair of that committee and been working on these issues for a number of years and working a lot on just the background on reviewing and improving research proposals for NCHRP funding, National Cooperative Highway Research Program funding.

So we very much appreciate the invitation to come speak to you today and -- and talk about the issues that -- that we see. We strongly support all the R&D efforts to improve regulatory models. So on the specific question of the relative priority for solid barriers for depressed roadways, we don't -- I tried doing a quick survey of state DOTs before this meeting. Didn't get very much in the way of response. I did get feedback from one large state on the West Coast and they said solid barriers have the priority now -- quote/unquote, now. So take that how you want.

I think, in general, the priority is really going to be solid barriers and berms over rail-covered depressed roadways as the barriers are just more prevalent and so the potential benefits to state DOTs doing project-level analyses is just greater.

We -- in the presentation that we saw from EPA on -- on this new RLINE option with AERMOD, we didn't see an overview of the benefits of the program in terms of reduced concentrations or lower design values. And so we'd like to see something like that before we can make a decision what the benefits would be for us.

We do have a recommendation that EPA work with FHWA and state DOTs to develop representative case studies and use typical cost data from -- for barriers from DOTs and to develop cost effectiveness ranges. And -- but the typical costs vary by state, so you're -- you'd have to allow for a range of costs. It could include vegetation, as I've heard mentioned by the other panelists as an option if RLINE can be modified to do that.

Let's move on to the second question: What’s the most important development area? This is my most detailed answer, so I'll spend a little bit more time on this one.

There's two points that state DOTs I think would support. One is model evaluation for the intended regulatory purposes of -- of the models. That's all transportation facility types, configurations and operating conditions for which we are required by regulation to do analysis. So that's sort of the trust but verify. We want to see the data. You want to see the model is proven.

We'd also like to see it done for the regulatory tests, the NAAQS, National Air Quality Standard, tests and Build/No Build tests. And then -- so that's sort of the long-term view.

In the near term, in order to be able to achieve that long term, we need to have tracer data to be able to do the model evaluations. A critical first step is the first domino to fall. So to be able to do that, we need to look at funding options, and some may be doing EPA and FHWA and state DOTs and maybe some other organizations. We need to pool funding and -- and get some tracer studies done. I think that's the highest priority in the -- in the near term.

So I have -- the next couple of slides deal with why we put the -- put this as the highest priority and then what out of all we'd like to see in the way of model evaluations.

The first point is AERMOD is not, to our knowledge -- I should back up a second. State DOTs have been not -- not been using AERMOD until about 2010, when it first came out. So we don't have a lot of experience with it. We use consultants to do the work. And so we're coming up to speed now with -- with some of the issues -- underlying issues with AERMOD.

And one of the things that we've identified with AERMOD is, due to the lack of tracer data, it has not been validated for all these different transportation facility types that we are required to model. And to us, that's a large gap.

And the facility types include highways, interchanges and intersections, as Michelle noted, bus and truck terminals and whatever else might come up, port operations, that sort of thing. The -- the tracer studies are cited in the last update to Appendix W to address all these types. And, basically, due diligence requires that we do test the model and validate it for all these types.

The second point -- and this is in reference to recent studies -- one was just presented earlier this week, on Monday -- concerning AERMOD might overestimate design values for transportation projects, at least in specific cases.

So we had a consultant working in the Pooled Fund study look at a couple of case studies, one in Providence and one in Indianapolis. In both cases, they identified -- or the modeling chain -- the traffic, emissions and dispersion modeling chain resulted in an overestimate by a substantial margin of the near road concentrations as measured at the near road monitors.

And they concluded that this is likely dominated by the emissions and dispersion model components. They did not put the blame on either one. It's kind of spread. But we need to do more research to know how -- precisely where -- where things are going wrong and what needs to be done.

DOTs are required to model CO and particulate matter for the EPA conformity regulation. We model other pollutants as well, but of all the things that we model, $PM_{2.5}$ seems to be the biggest challenge. And the reason for that is the background concentrations are so high relative to -- to the annual primary NAAQS that it becomes a challenge sometimes to meet -- to show that your project meets the NAAQS and it raises questions about how accurate is the model really for that particular application; is the model accurate enough to do that.

It's one thing to do -- to assess models to model evaluation, to compare AERMOD to CAL3 or whatever other models there might be and say AERMOD is the best. That's a different question than asking is AERMOD accurate enough for this particular application. And so the concern is really -- that's where concerns really arise.

That leads to the next point. From the state DOTs and the regulated community point of view, we don't want to -- we appreciate you need to do the work to compare the dispersion models that's been done for Appendix W. We'd like to see that extended to address the regular -- regulatory tests, the NAAQS and

Build/No Build tests.

And so the first question that comes up to us -- and bear in mind we've only been doing this for the last -- less than a decade -- where has this been done in the past; who's -- who's done a study looking at uncertainties with the model and how that affects the determination of compliance with the NAAQS and Build/No Build tests. And so that question arises in part because of the uncertainty identified in the Pooled Fund study I mentioned on the last slide.

And also -- you may not -- may or may not be aware, when we do air quality studies for transportation projects, we're doing them for purposes of NEPA or EPA's conformity regulation applies, or to incorporate it into the NEPA study.

NEPA requires -- has an emphasis on transparency or disclosure. So if there's an issue with the science or how it's -- something's being assessed, we're supposed to address it. Typically, in NEPA studies, for at least high volume roadways, we address something called mobile source air toxics. That’s just an emission analysis and Build/No Build comparisons. There’s no dispersion modeling. But I mention it because it includes, developed by FHWA staff and a great help to state DOTs, a section on the uncertainties, what -- the limitations of the science. And so that satisfies our need to be transparent to disclose all the issues what we know about limitations of our modeling.

We don't have that right now for CO or PM. For CO, it's not really an issue because the margin is so wide nobody really cares. But for PM, it -- it's an issue. We really would like to be able to address that and we're not really doing it at all right now.

So for NAAQS tests, the issue -- the -- the general question applies, how should uncertainty be addressed or considered in determining compliance with the NAAQS. And so that's both the modeling chain, traffic, emissions, dispersions and dispersion modeling output. It's also the background concentrations and -- and that's a huge issue because there can be a lot of, shall we say, uncertainty in determining what the appropriate background concentration is because you can have a monitor in the area, but it not -- might not be representative of your site. So you just might not have good data is what it comes down to.

For Build/No Build tests, the -- what seems to us to be the more awkward question, what if the traffic -- emission chain conversion modeling uncertainty is greater than the difference in the Build/No Build model concentrations? That could happen and how do we address that?

So those are the -- that's -- these are the -- the issues that give rise to our recommendations for model evaluation for transportation. And these recommendations I'm going to go over right now are generally consistent with the report that came out in 2007 from the National Research Council called "Models in Environmental Regulatory Decision-Making." We really like this study. You know, it doesn't apply to air quality specifically since it covers various issues including air quality. I don't think it really addressed project-level -- level air quality.

But in reviewing this -- this study and its recommendations, there are several that jumped out to me that would be helpful to talk about in project-level analysis for conformity and for NEPA.

We'll start with life cycle model evaluation. There's four points here. This is generally includes accuracy, uncertainty, quality -- quality assurance and quality control. So we would like to see -- our recommendation is model evaluation against exhaust-based tracer data -- so the kind of data that's being developed by Caltranss with Akula involved in that study -- for all facility types, configurations and operating conditions for which modeling is required under the EPA conformity rule.

If you're going to make us do modeling and we're going to end up with go/no go decisions on a project because of this modeling, we want the models to be validated to the extent possible to the limits of the science.

So some evaluation's been done for a low volume highway and tracer data collection is in progress or planned for a higher volume freeway with or without noise walls. That's the Caltranss study. But we still need tracer data for all the other facility types -- interchanges, intersections, truck and bus terminals, et cetera -- configurations -- depressed or elevated -- and operating conditions -- so congested versus uncongested, basically, where you have more turbulence possible.

One of the major recommendations of the NRC report that is consistent with the NEPA requirements is to quantify and communicate uncertainty. Maybe or maybe not we can quantify the uncertainty, but we definitely need to address it, to address the topic at least in a qualitative way. And so one of the recommendations we have here is EPA working with FHWA and -- and AASHTO is to look at funding a comprehensive assessment of uncertainty for the traffic emission dispersion modeling change. That would be the starting point for doing something on uncertainty.

If it's already been done and it's in the literature and we just haven't seen it, then please let us know. But we think that's something that hasn't been done and needs to be done.

I overshot here. Okay. Continue with the model evaluation. We want to test for the intended purpose. So that's the facility types I already mentioned and the regulatory tests. We specifically want to know that the NAAQS and Build/No Build tests can be met with statistical confidence or with what level of confidence for all facility types or by facility type or what limitations need to be specified.

So it requires consideration of the uncertainty in the modeling chain and also in the background concentrations. The last point there, the fallback option -- for those of you that are not completely current on what the detailed requirements are of the EPA transportation conformity rule, it's this provision that applied before 2010 when the models came out. It's basically when quantitative analysis methods are not available, you fall back on qualitative.

That's always our fallback. But we'd rather just come up with here's a set of criteria for when models can be applied and outside this, you know, we have some qualitative tests.

The other point made by NRC -- and the intended purpose I put in quotes because that's something emphasized in the NRC study. So we're just picking up on it, so it's -- it's something we would put a high value on.

Peer review -- and so this is -- we're all stakeholders, but from our perspective, we want to see that with federal and state communities. We haven't been too involved in the model evaluation process with the EPA. Like I said, it's only something in the last ten years. We appreciate the invitation to come here and speak to you today about this obscure and cryptic topic to you-all. And so we'd like to see this continue on an ongoing basis.

And as part of that process, as we get into model evaluation studies, one of the things I've heard is sometimes people have had trouble getting access to all the data and information that's being used in the analysis. It's like people do this data and then go away, hide in their offices and whatever. They don't share the data.

I think the process that DOTs would like to see is a more transparent and open process where everybody access -- has access to all the data throughout the process. It's just like -- how we like to work things.

The other point -- they had another section in the NRC report on model development, talked about model management and other things. But the point I'd like to highlight is their call for model parsimony as a design objective. And I have a quote: "Models used in the regulatory process should be no more complicated than is necessary to inform the regulatory decisions." So that's really tying back to making sure the models are designed for their intended regulatory application.

It applies to all models with a specific role for transportation, for screening models, relative to refined models. So for screening for CO -- we -- we never fail a CO test, or I haven't heard of a project ever failing a CO test. There's such a wide margin in the NAAQS, but the controlling NAAQS is nine ppm. Background concentrations are under two. So it's basically impossible.

We've done a lot of studies where we used worst-case assumptions. And for the worst-case assumptions, we'll assume level of serve E traffic and then you compare that to the actual test conditions, stop and go conditions. We compare that to the actual traffic forecasts and -- you know, we can do 50 percent higher, 100 percent higher, 200 percent higher, 300 percent higher, 500 percent higher and we still pass the CO test. So we don't ever see the need to do refined modeling for CO. So we need to maintain a good simple screening criteria or screening model for CO. And CAL3 may not be -- it might not be the most accurate model, but accuracy isn't a critical design objective from our perspective.

And I've talked about -- model parsimony just sounds sounds so obscure. I've used the term "model proportionality," not making things more complicated or difficult than they need to be for the task at hand and the concurrent need for efficiency and streamlining. EPA seems to like DOS-based models. The transportation side, we have models that are not DOS-based, that have graphic and user interfaces that are so nice. It makes it a lot easier to do modeling, to do scenario management, do quality control. And --

and so that -- that would actually -- I'll just hit that point while I'm -- for CO analysis, that was -- you know, having that graphical interface makes things -- you get the analysis done in an afternoon, basically.

For AERMOD, it's a bit more complicated with the graphical user interface, the quality control and the context-sensitive help. It just not only streamlines the process but reduces errors, especially for users that are maybe not experts, unlike the folks in this audience.

All right. So going to the last question -- and I've already actually hit those points, so I'll be really quick. Future change is that EPA's policy assessment for $PM_{2.5}$ came out a couple of weeks ago -- three weeks ago, I think. And they're considering concentrations as low as eight micrograms. The current annual primary NAAQS is 12. So they -- they talk about assessing it as low as eight or as low as ten. Either way, that would greatly reduce the margin. Background concentrations are usually between nine and ten right now.

That has the potential to make it just that much harder for us to do $PM_{2.5}$ analyses. This puts more of a premium on the need for accuracy, which puts more of a premium on the need for model evaluation and then more premium on the need for tracer studies to do that model evaluation. So I'm kind of rehashing, getting back to our original recommendation that we need to look at funding more tracer studies. That's it.

DR. OWEN: All right. Thank you, Chris, Michelle, David. So we have more than a few minutes. Do we have any questions from the audience for our panelists?

MR. BRIDGERS: Or questions from the panelists.

DR. OWEN: Panelists, do you have questions for the other panelists? Yeah, go ahead.

MR. VOIGT: The only question that would occur to me is -- is getting feedback from you on -- on doing the tracer studies. Is that something you're interested in supporting and can we work together on that, or what are your thoughts on that?

DR. OWEN: Well, I'll just restate what -- what I said in my opening presentation, that we have a great need for databases, and -- and David reiterated that as well. So we will be more than happy to help the community identify and -- and design field studies as appropriate for different conditions.

MR. PAINE: Have you considered the role of computational fluid dynamics in helping to assess how to deal with these complex roadway emission configurations?

DR. HEIST: We have used CFD, particularly in large eddy simulations near barrier dispersion to help us in model development to try to understand the phenomenon that we're trying to distill into a more simple algorithm to include in R-LINE. We've done that work more for building downwash than we have for roadway sources, but we have done a little bit of work in that area and it's very useful.

It's time-consuming and expensive, as so much is, but, yeah, it's a useful tool

MR. PAINE: Well, it might be better than going out in the field.

DR. HEIST: Different, yeah. You get a lot more information but maybe less confidence in it.

MR. PAINE: Well, I guess one follow-up question is on the vegetation barriers, you might consider a parameter like velocity. Obviously, the height and maybe the width of the vegetation but also the -- how much open space there is as a -- as a parameter to define how you would give it some sort of control efficiency.

MS. NEUMANN: The cost effectiveness comment was pretty interesting for the roadway barriers. Were you considering also including -- although it's not really quality related, but as a consultant, you know, they tell us to do it all -- so noise effects of the barriers in the cost effectiveness analysis?

MR. VOIGT: I think that would -- that would have to be part of the -- the consideration. For state DOTs, the -- it's almost a hypothetical question. It's a charge question given to us. That's why I mentioned it. If you really wanted an answer, you'd need the cost effectiveness.

But I think in a lot of cases, you know, noise barriers are built for different reasons than air quality. Depressed roadways might be a -- you know, a design consideration, not really an air quality driven consideration. Hypothetically, if you want to compare the two, we'd want to look at the cost effectiveness. But in reality, I think what we're looking at is if you're modeling a roadway that has road -- near road barriers or it happens to be depressed, we want to be able to account for that.

In some locations where the margins are very small and meeting the NAAQS might be very difficult, then people might think of putting up a wall or a barrier or vegetation and it might be useful in that more extreme limited case.

DR. OWEN: I do have a clarifying question as well, I guess. Michelle made this comment -- but it may be between Michelle and David because it relates to R-LINE development -- about the urban nature of the development or R-LINE. And so I'm familiar with Idaho Falls, which is definitely rural. Caltranss has done a million datasets with the suburban wind tunnel.

I presume it's set up more in the rural-type setting, but I don't have those details in my collection. So I was wondering if both or one of you can expand a little bit on that particular aspect of the R-LINE development and the urban option and what we might need to look at further going forward.

DR. SNYDER: Okay. Yeah. So when we developed R-LINE, we also used the Raleigh study. And we found good performance with R-LINE in the Raleigh study. I -- the year was maybe 2006 -- I can't remember the year. But it was -- it's definitely an urban area. And so my comment was -- was generating from that in that R-LINE performed well in that case even though we had developed the surface dispersion curves for Idaho Falls which were rural.

So in my mind, it seemed like we had enough meteorological parameters to also characterize the urban environment without the need for the urban option adjustment as it is in AERMOD.

DR. HEIST: I would just add that a lot of times when we do the wind tunnel experiments, we don't necessarily have an urban setting, but we develop the boundary layer to represent suburban kind of roughness length scales. And even the Raleigh study is sort of urban, but it's in a suburban or approaching urban. We haven't done a lot of work with urban dispersion.

DR. SNYDER: And I -- I would just like to add that it's -- it's really difficult when you have -- when you look at highly urban areas, you start having buildings right next to roadways. And when people hear buildings and AERMOD, they think downwash, but that's not the case. Your actual emissions source is in between those buildings.

So it's really hard to have a good analogy between a building downwash and having an urban area where you have blocks and blocks and blocks of these urban structures and you're looking at measuring concentrations within that surface roughness element. You're looking at making a measurement kind of below that surface roughness that was developed and input as an input to -- it's developed in AERMET and put into

AERMOD.

DR. VENKATRAM: We are involved in the Caltrans experiment, the huge study. I think the urban option might be necessary because we never found stable conditions even during the late evening when the sun had set and early morning. It was still convective. So the urban option might make sure that it is convective because of convection recorded along the surface.

I was very surprised, actually. We never found -- maybe a couple of hours at the most it was stable. Otherwise, it was convective.

DR. OWEN: Okay. Last call on additional questions.

All right. Well, I'd like to thank our panelists.

MR. BRIDGERS: Thanks, Chris. You know, one of the challenges with putting together a conference, especially when you have expert panels, is trying to figure out how much time to allocate, because you want to have a generous amount of time for everybody to talk, but you also don't want to make things run on too tight of a ship.

So don't think that you're going to get a break early. We're going to stay the course. We're going to take about a couple of minutes here to change over for the panel.

But in the interim, as I was walking in this morning, I happened to be walking alongside a former colleague -- or a colleague of mine, and he was mentioning that he was at the first conference back in the late '70s. And so since we have a minute or two to, air quote, kill, is there anybody in the room that was at the first conference back in -- I think it was 1977?

How about the second? I'm not going to go all the way to the 12th. But, yeah, I was a -- I was a little impressed that someone that's still with the Agency was -- was there.

Are we set up here for our panel? Well, rolling right along -- and this may allow us to have a few extra minutes at the end of the day -- we will transition to the building downwash panel, which may or may not take a whole lot of time. But this is one that I -- I really do think that there's a lot of energy that's been in the community over the last number of years, and so I think there's going to be a lot of exciting conversations.

So, Clint, without further ado, I will let you have the podium and I'll sit down.

MR. TILLERSON: Yeah, if the panelists want to come on up front, I'll start into my introduction here and just kind of set the stage as to why we're having this panel.

There's been a lot of activity around building downwash in the last couple of years. Just to give you a little bit of background, it's -- downwash point sources in AERMOD is handled by the Plume Rise Model -- Enhancements Model and that algorithm in AERMOD has not been updated since AERMOD was promulgated in 2005.

And there's been a lot of research here in the last five or ten years that has shown that the PRIME algorithm in -- in AERMOD will both overpredict in some situations and underpredict in other situations. Some limitations that have been identified with the PRIME algorithm as it's currently implemented are buildings assumed to be rectangular and solid.

We talked this morning about a draft version of the BPIPPRM that's been put out there to evaluate some of the ALPHA options in AERMOD. That -- that program takes whatever building configuration you give and for each wind direction, it comes up with a single solid structure that is representative, or tries to be representative, for that wind direction to represent a building that building downwash then is treated for. It considers a single building or a tier for each wind direction.

Turbulence is constant in the near wake or the cavity and then approach roughness and stability are not considered. So these are all things that have been integrated into the research that has been done recently and has been incorporated as ALPHA options into AERMOD.

So as I said this morning, AERMOD Version 19191 includes ALPHA options that represent formulation changes to the current PRIME downwash algorithm. So the PRIME that has always been PRIME is still there. You have to use the ALPHA flag on the model ops keyword to implement or to -- to utilize any of these ALPHA options.

And this is just basically a restatement of what we had this morning. There have been two research initiatives that we have collaborated on, one with the Office of Research and Development, that have put three ALPHA options in the -- separate individual options into AERMOD, and then there have been the PRIME2 subcommittee of the Air & Waste Management Association that include new equations for building wake turbulence and velocity deficit with special --

and specialized treatment for streamlined -- streamlined buildings.

So you'll see these options in AERMOD. We have a white paper out there that describes these options, as -- as Chris talked about this morning, and then also just another mention of the BPIPPRM that's out there that is really just a draft version to use with these ALPHA options for evaluation.

And so with that, I'll invite our panelists up and stay here at the mic. You'll notice a bit of a difference in who we have listed here and who we have in the agenda. We had Ron Petersen who had agreed to come and serve as a panelist, and he has been very active and led a lot of the work for the PRIME2 subcommittee. But he started not feeling well and was afraid to travel. And so we have a fill-in. We have Sergio Guerra, who is also very active with the PRIME2 subcommittee, who at the last minute stepped in. So just wanted to point that out because -- first because that's a little bit different than what you see in the handouts that you have.

So we have Dr. Steven Perry, who is a research physical scientist with US EPA's Office of Research and Development in RTP. Dr. Perry received his Ph.D. in meteorology from the Pennsylvania State University and has over 34 years of experience development many of the Agency's regulatory dispersion models, including AERMOD, CTDMPLUS and AgDRIFT. He is a senior scientist and co-lead at the EPA's Fluid Modeling Facility, which houses the Agency's meteorological wind tunnel that is used for flow and dispersion studies in support of regulatory model development and specialized homeland security applications.

As I said, we have Dr. Sergio Guerra. He's a lead senior and air quality engineer at GHD. He has over 19 years of experience in air quality working as a researcher, a regulatory -- a regulator in the state of Kansas and then as an environmental consultant assisting clients around the country. Sergio's expertise in research regulations and consulting gives him a unique insight into the interaction of the theoretical and practical aspects of air quality. His research has been published in peer-reviewed journals and conference proceedings. Sergio holds a Ph.D. in environmental engineering from the University of Kansas and currently serves as the Vice-Chair of the Atmospheric Modeling and Meteorology Committee, APM of the Air & Waste Management Association.

And then we have Dr. Max Zhang is a professor at Sibley School of Mechanical and Aerospace Engineering at Cornell University. He received his Ph.D. in mechanical engineering from UC-Davis. Dr. Zhang's research areas reside on the nexus of energy and environmental system engineering and currently focus on dispersion modeling, passive mitigation of air pollution, renewable energy planning and sustainable heating solutions in cold climate. Dr. Zhang has a visiting -- was a visiting scientist to then US EPA Atmospheric Modeling Division in 2000 and 2002 through 2003.

And so I will ask Steve Perry to come up and start us off. Sure. They can just come up as they -- as they talk. That'll be fine.

DR. PERRY: Thanks, Clint. I'm Steve Perry, as he just said, EPA ORD. I'm going to start by apologizing. I have no slides. So you have my permission to take out your phones and look at something interesting. I don't like to stand up without slides. You need slides.

So, yes, we're talking about building downwash again. Building downwash is the bad penny of dispersion modeling analysis. So I've said -- I say that a lot and then I said, well, maybe I should look up what bad penny means. So I did. I just looked it up.

It says that it's a thing that is unpleasant, disreputable and otherwise unwanted and appears at inopportune times. So, yeah, building downwash is a bad penny.

Seriously, though, building downwash has been a significant dispersion modeling issue for a lot more years than I've been at this agency and I've been here for 35 years.

In fact, one of the very first laboratory experiments that was conducted at EPA's Meteorological Wind Tunnel Facility back in the 1970s was to look at the flow and dispersion around a cubical building with a smokestack nearby. And it was that study, along with several other studies in the '70s and '80s, that formulated the foundation for the Agency's stack height -- good engineering practice stack height regulation. It was also the -- the foundation of the original downwash algorithms in the old industrial source complex short-term model, ISCST.

So, further, it was a combination of field studies and wind tunnel studies that also formed the basis for the original PRIME downwash algorithm. And I need to make a side note right here. You can blame me for a lot of things in AERMOD. I was part of that group that formed that model, but I had nothing to do with the PRIME model. We brought that in lock, stock and barrel, as we were asked to do, and put it into AERMOD, but we did not change the model at that time.

So somewhat driven by the adoption of the new one-hour SO_2 and NO_2 standards for -- we -- people started looking at the downwash algorithms again because it became one of the reasons that people were having trouble meeting those standards. So over the past decade, we, and many other people, have performed combinations of wind tunnel studies and computational fluid dynamic studies to support improvements to the AERMOD PRIME model, and that's what we're discussing today.

I know it sounds like an advertisement I'm -- I'm doing here for wind tunnel studies, but let's face it, I always do that. I have to say wind tunnel at least 12 times on every talk, so you'll hear me say that a few times. But, actually, it's more to the point that -- that these studies are very important in -- in advancing this difficult modeling issue. If -- if we really -- they really do put any changes that we -- they and the field studies and the computational flow dynamic studies really put the changes that we're proposing, I think, on very solid footing scientifically.

So to that point, we have made a serious effort in our recent -- recent laboratory studies in CFT modeling to look at the downwash algorithms that people have identified and we have identified as inadequacies in AERMOD.

So with that said, let me take a stab at the questions that Clint has asked. A couple of years ago, while we at EPA were in the midst of examining the algorithms in AERMOD. We were asked to participate in a -- a collaborative effort with AWMA -- the Air & Waste Management Association's PRIME2 subcommittee that Sergio's going to talk about here in a minute -- so that we could share our research findings with them and they could share their findings with us.

They -- they are funded by an industry group and -- and we felt like this would be, obviously, an appropriate thing to do, both working on similar things, but it -- it would be productive and -- although very limited because we didn't have a whole lot of time to work with on them, but we felt like it would be very productive activity as far as advancing and understanding their work and their -- and them understanding ours. So we did do that.

Let me see. What was I going to say about that? Anyway, I just want to point out that I feel that that was a worthwhile effort and I would highly recommend future efforts in other subject matter relative to modeling on -- on -- when people in the industry are working on an issue. I know it's frustrating sometimes to -- to -- to work really hard on issues, submit it to EPA and then it's -- you -- it seems like it sits there. So I think having communications along the way, if possible, is -- is worthwhile.

As for the ORD ALPHA options, for some time now, we've been examining the primary issue of how AERMOD PRIME accounts for long narrow buildings, and in particular when those buildings are not perpendicular with the incident wind, as AERMOD requires. So as anybody who's used the model is aware, the current algorithms do require the effective buildings at each angle to be perpendicular to wind.

However, in testing the model from our wind -- with our wind tunnel data, we started with a perpendicular case, figuring, okay, this is one where AERMOD will hit a home run. No. We found problems.

So rather than continue tackling the issue of the long buildings at an angle, we decided to tackle these issues of perpendicular buildings first. And the ALPHA options that you're going to -- that you'll see in the white paper, that are talked about in the white paper, are actually for cases when the building is perpendicular to the wind.

This was a surprise to us. The model actually underpredicted significantly very near to the building and -- in the cavity and just beyond the cavity. So I'm not going to get into a bunch of details about those options. They are covered in the white paper and the white paper also references the journal article that -- that describes them in -- in a lot of detail.

But, basically, we focused on improving the models unexpected underprediction. The ground level concentrations very near the wake -- very near the building or the cavity and to try to bring those PRIME algorithms more in line with how AERMOD does business.

As I said, when we put PRIME into AERMOD back in -- well, before 2005, we were sort of forced as a -- as a workgroup to make sure that we didn't change it. It was -- they wanted it to stay the same. So at that point, we didn't make too many efforts to make it blend nicely with -- with AERMOD as far as the -- the -- the approach that the models take. Now we have to do a little bit more of that.

The -- the algorithms that -- the options -- I'm sorry -- that we are proposing are basically in three areas. PRIME basically breaks the plume up into three parts. It has the primary plume as deflected down but doesn't get into the cavity. It's the part that gets into the cavity is the second one. And then what is re-emitted from the cavity is the third part of the plume.

So what we found was there was a discontinuity in dispersion between what was happening inside the cavity and what was happening in the part that was re-emitted from the cavity. So we fixed that discontinuity. That was the first thing.

The second thing was AERMOD -- one of our mantras in the development was that we were using effective parameters. We didn't like the idea of having a wind speed at the stack top or -- or -- or any other parameter measured just at stack top. So we used what's called effective parameters, where you would look at more of a layer average.

Well, PRIME was using just the stack top wind speed to do its calculations for the -- for the primary plume. So we corrected that to use the effective wind speed.

The third change was the original turbulence algorithms in PRIME were based on the work of Jeff Weil from the '90s. And in there, there was a turbulence intensity limit, a maximum value, that was, for some reason, was not set at what Jeff wanted it to be. It was slightly different. So we did correct that.

The fourth thing -- well, okay, let me say this. When we put those into the model and compared it against the wind tunnel data, it significantly relieved the underprediction problem, so they really did show an improvement.

Let's see. So we continued our research on the issue of elongated buildings at -- after these ALPHA options were included, and we're looking at now what we originally started to look at, which was when you have obtuse angles between the wind and the -- and the building.

And our first recommendation was it's an approach that was not dissimilar to one that was first suggested by our colleague Roger Brode from OAQPS where, instead of BPIP, the building preprocessor for AERMOD -- instead of BPIP taking this angled building and then saying the affected building was just the size of the corners, we looked at just how long the building is in the along wind direction and used that dimension. That is as simple and uncomplicated as what that change is.

But in -- in compare -- when you compare the model with the other three changes and the BPIP change to our wind tunnel, we found that the -- for those cases, the normalized means for error was cut in half for the -- for the concentration estimates on the ground and the fractional bias was reduced by two-thirds.

So that simple change in the building preprocessor had that much of an effect -- well, with those other changes had that much of an effect. So that proposed BPIP change is just the start. We've been focusing most recently on how the building wake and the associated plume material can be shifted laterally.

So when you have a building at an angle, you don't get a nice uniform wake behind the building the way that AERMOD would model it because it has a perpendicular building. You get a distorted wake. You have a tendency for plume material that gets caught in the cavity to be shifted laterally different than the -- the mean wind direction. And so this can have a significant effect on the magnitude and location of the ground level concentration, and in this way, we are definitely reconsidering how the model re-emits the plume from the cavity.

Now, this is preliminary work. We -- we are just in the process of -- of testing that now and we hope to have a journal article out in the next few months describing that work so we can get a little peer review on it.

So just a quick comment on the PRIME2 group. I'm not going to take any of Sergio's thunder. We -- we are aware of the wind tunnel studies that they've performed and understand that -- what their findings are and we know that the model is somewhat challenged in how it defines the velocity deficit and the turbulence profiles in the cavity wake.

Now, it also -- we also realize that the model doesn't do well for streamlined and porous structures. Now, that -- the latter is not surprising. The model was not originally designed for that, so we can't get too mad at it for not handling it well. But we do support their efforts to find ways to account for these differences. And as with the ORD proposals, we're anxious to see how they perform by the public.

We want the -- these model -- these changes in the model to be challenged and to be used in a lot of -- in a wide variety of applications because we realize that when you have new formulations in any model and if they involve empirical parameters or any empirical nature to them, extrapolation of the applications to beyond the development regime is a true test of the model.

So the final question, where should EPA be going. As Dave Heist said, I'm -- I work for EPA. I'm a little uncomfortable on this, but not really. If you know me, I'm not really because I'm retiring soon.

First and foremost, as long as AERMOD is the workhorse near field dispersion model for regulatory applications, the Agency should continue to ensure that the building downwash algorithm in that model performs well. So for areas where it has already been recognized as somewhat deficient, such as elongated buildings or streamlined porous structures, I do encourage continued effort.

I -- I do not consider AERMOD PRIME to be -- this was a question that was specifically asked that do consider that the model is based on out-of-state -- out-of-date science. I do not believe that. I -- I think that it's on firm scientific ground. But that is not to say that there isn't always more science or reconsideration of old science that can be -- can be looked at to -- to improve the model or to expand the applications that it's appropriate for, such as streamlined buildings and porous buildings.

I also expect that Max Zhang will -- will have some interesting thoughts on the subject of other approaches. And I'm not -- I'm not saying that we should -- we have to stay with PRIME, although I -- as difficult as it can be and as hard it is to get into the code and figure out how it all works, I'm -- I'm -- I'm not against keeping that model and making it better.

But I think Max will -- you know, may -- will have some -- probably have some ideas. And if we can demonstrate better ways to do building downwash other than PRIME, I would certainly be in favor of that as long as whatever we do is compatible with the overall AERMOD framework. I think that's important to say, unless we're going to get rid of AERMOD at some time.

So for going forward, I'd recommend a parallel path. On one side, continue looking at the AERMOD PRIME or other options and improving those with these ALPHA-type approaches. But at the same time, I think the Agency needs to also take a hard look at how AERMOD does urban dispersion in general. Not to suggest that -- I almost think of building downwash as a -- as a source characterization, what's happening right at the source. But I think we need to somehow start thinking a little more generally about urban -- there is an urban approach in AERMOD. I think it has a lot of merits, but I think it has a long way that it could -- a long way to go and it can be improved.

Let's see. So, really, in summary, my -- my final comments would be let's keep -- let's continue to improve AERMOD PRIME or some substitute, if that's where we go eventually, but let's definitely go after the -- the overall urban approach in AERMOD. Thank you.

MR. TILLERSON: And while Sergio's coming up, I'll just ask Max if he wants to come -- come on up and have a -- have a seat so he'll be up front.

MR. ZHANG: I can -- I can see here.

MR. TILLERSON: Oh, you're right there. Okay. All right.

MR. BRIDGERS: Does Sergio have slides?

MR. TILLERSON: Yes, he does. Thank you.

DR. GUERRA: Thank you. So, yeah, Ron really wanted to be here. Of course, he didn't feel well. We've been working on the presentation for some time now. You know, obviously, we've been working over the last three years in getting this off the ground and -- and up and going, so we're very happy to share some of what has been going on.

And, again, our plan was not just to address downwash, but we wanted to basically implement some type of collaboration within the different groups. And I think that's what we're seeing here today, where we have, like, academia; we have industry; we have research; we have consultants. We're all working toward the same goal, so that's what helps us continue to do a lot of work and continue to put long hours into things that maybe are not a high priority for some of our employers. But we definitely think that downwash is something that, like Steve mentioned, can be improved, and we would like to be part of that. And the more we collaborate, the more we -- we find ways to connect those links, I think the better it will be.

So to start, I mean, the first question has to do with what do we think about this collaborative effort. And I think everybody understands that whenever you have different groups coming from different perspectives, you have this synergy that allows you to do more than what you could do individually as the sum and of the parts. So I think that's what we have been doing with this.

And to understand this, like Steve mentioned, we had a lot of issues with compliance. We had the one-hour standards. At that point, we decided that one area that the -- the -- was the only thing that had been looked at. So we opened up a Pandora's box. And, really, it was a black box. When Ron and I started to look at it, we said, "Okay. Well, we -- we know what there -- these are the problems in the model and I think we'll just address those problems and then everything will be nice and rosy."

That was not -- not the case, and -- and I think, like, anyone that deals with model evaluation will know that this is very difficult. You know, like, we -- we're really trying to match the atmosphere and -- the dispersion within the atmosphere for many different types of sources into one single model. So that's how the PRIME2 subcommittee came about.

We had two main goals in mind. Of course, we wanted to deal with downwash and update some of the algorithms to address some of the issues, but we also wanted to establish a mechanism so that we could implement new science into the model.

Up to that point, like it was mentioned

earlier, like, there would be a big project done maybe funded by industry. It would work independently of EPA, and then all of a sudden, it'd be like this big thing, this three-ring binder, "Here it is, EPA. I want you to approve this." And -- and on the other hand, like, EPA was also doing their own research and then they were implementing those updates to the model also.

So we wanted to basically bring in all the parts together. And by doing that, we believed that we could benefit not only building downwash but many other updates that are needed in the model.

So at that point, we actually obtained industry funding from the Electric Power Research Institute, the American Petroleum Institute, the American Forest and Paper Association and the Corn Refiners Association. We then basically asked everyone and said okay, "We know there are issues with the model like that. We need some research money so we can look into them and we can update them." So these were the four funding members that funded the -- the project as it comes to doing the wind tunnel studies, doing the evaluations and doing a lot of work and that is still ongoing -- been going on.

We presented a lot of this at the RSL

conference in 2016, at least our initial findings, and we published a journal article. So -- so the idea was that -- in -- in the journal article that we did at the AWMA, we outline all of our objects -- all the -- the problems that we -- we found in the model as it comes to downwash.

And then in 2017, the EPA released the white papers for -- it was a list of different projects that were priority for EPA. And we were very glad to see that building downwash was one of those.

And then as we did the wind tunnel study, we made sure that we dealt with -- we parameterized all the data that we collected into -- into new equations that had a lot to do with -- with what was mentioned earlier; like, velocity deficit and turbulence intensity. Parameters are very important when it comes to dispersion. And then we submitted that to a journal, the *Journal of Wind Engineering*, so that it could be part of this process of peer review. We wanted to make sure that we provided what was necessary to make this part of more or less a regulatory option.

The enhancements of the PRIME2 project have been that the wake effects decay rapidly back to ambient levels on top of the building. This is something that right now doesn't happen. It's the same type of wake effect even up to the height of the wake, which is -- is much higher than the height of the building. This is incorrect.

And then we also found that the lateral turbulence enhancement in the wake is less than the vertical turbulence enhancement. Again, as we're going through the research, we start to find new things and we try to incorporate those into the new science.

And then the approach turbulence and wind speed are calculated at a more appropriate height, an effective height that we're proposing. And also, we found that wake effects for streamlined structures are reduced. I guess this is something that maybe is intuitive, but, again, we wanted to test it in the wind tunnel. And also, we found out that wake effects increased with increasing surface roughness if you model the site around water, it is different than if you model a site around, like, a large forest or an urban area. So these were all aspects and -- and variables that we put into our equations.

I knew that Steve wasn't going to have any slides, so I did this for him.

DR. PERRY: Thanks, buddy.

DR. GUERRA: So this is what Steve was talking about, the mismatch between going from the cavity to the re-emitted plume. That's the fix number one, the one in the top right, and -- and, yeah, that was something that definitely when we looked at it there was an underprediction really close to the building and this definitely helps a lot.

The second one has to do with what wind speed you use for your calculation. So the current values is the stack top and the fix number two that ORD is proposing is using the average of the height of the plume and the height of the receptor, which is, I think, more consistent with the way AERMOD works. And then the third one is kind of like -- this is like a small typo.

And then, speaking of collaboration, we had a downwash summit here in this building. So we were very glad to participate. The APM subcommittee on PRIME2 was here. I know Bob Paine and Mark Garrison were here. We basically had Office of Research and Development, OAQPS and PRIME2 committee. We sat down for whole day. We went through all the updates that we're doing, what we're proposing, how we're justifying them and we figured out a path forward.

And so we thought that that was very, very beneficial. I think that was very useful so that instead of just communicating through e-mail or through phone calls, like, to kind of sit down and make sure that we were on the same page, that we were in agreement with what we wanted to do.

And then in that meeting is where this new concept of ALPHA options was first introduced to us, and this is something pretty novel. Of course, we have the BETA options that are approved on a case-by-case basis and then they graduate to be a default option once it goes through rulemaking process or once -- I think it would be prior to the rulemaking process. But this is kind of like a pre-BETA option, an alternate is put out there so that everyone can use it and try to see how it performs in different -- different projects.

So I think this is where -- this is a real exciting part of the project because now everyone here and every user that -- of the user community can go in and test these options. You can go in and say, you know, I have a building with downwash. Let me try these options. Now let me try Option 1 and 2; how does Option 1 and 2 play with the other ones. The other ones are not compatible at the effective wind speed because we are proposing a different wind speed than what ORD is proposing, but you can, basically, otherwise mix match -- mix and match all the other options.

So this is something that really empowered the whole community so that we can come together, figure out where these options work well, where they -- there's additional research needed and then together can -- we can collaborate and try to update the model in the best way possible.

And then in order for the ALPHA option to become a BETA option, it's my understanding that we have to go through the Appendix W Section 3.2.2 of alternative models, and that's where we get into implementation. I think that the first three steps have already been accomplished, and number four is -- kind of has been accomplished in the case of the evaluation databases that we have.

There are cases where it works really well and there are cases where it overpredicts and -- and underpredicts. So that's -- really, it's a mixed bag, but I think we're working to figure out what's making those differences in different databases. And I think we're making very good progress on that, but -- but, again, many of these aspects have already been addressed. So we hope that we -- as we continue to work on some of these enhancements, we'll be able to graduate these ALPHA options into BETA options.

And then on May 3rd, 2018, there was a meeting also with Petersen Research and EPA to discuss the PRIME2 ALPHA options. Ron retired from CPP, so now he has his own company. He never going to stop working on building downwash. It's his passion. I'm very fortunate to be part of that.

And in that meeting, it was understood that these different options, like, were going to be put into AERMOD so that we could -- they could be evaluated by the user community.

And then on October 3rd, 2018, there was a submittal to EPA with those switches for them to be included in the next version of AERMOD.

And then March 26 of 2019, the PRIME2 committee met with EPA to talk more about the ALPHA options in PRIME2. There was a small bug that was addressed by EPA and then we also talked -- well, in this case, Ron and -- and the -- the rest of the -- the group talked to EPA about what are the future updates that are needed to the model.

So we already talked about it, the platform structures. The streamline structure probably needs a little bit more work just because we don't have databases out there that are located next to a monitor or something like that. But, again, the work has been done in the wind tunnel. So we just need to verify it and -- and improve it as -- as needed.

And then, obviously, Office of Research and Development is working on this elongated building and then also an update in BPIP. So I think that's going to be a big, big improvement once we have a new BPIP that corrects that effective length that tends to overestimate this condition in the PRIME version.

And then August 21st is when we had the release of AERMOD, and this new release has these options. So, again, I encourage everyone here to try them out and give your feedback to -- to EPA, to any of us. We definitely want to know what -- what you find; you know, like, where it works well, where it's not working well or if it doesn't make any difference. You know, we want to make sure we understand these options as -- as best as we can.

So as it comes to the conclusions of this first question on -- on collaboration, we think the research to get this new theory was actually pretty quick, 13 months. And then getting to the implementation of PRIME2 ALPHA took about ten months from EPA, so from time that we gave it last year until the time that it was released.

And we thought that the interactions with EPA along the way were very useful, and -- and definitely we felt that they were valuable for the project.

As it comes to recommendations, one thing that we found is that there are certain improvements that can be made to the code that we provided, but the code is already undergoing this process of being implemented into the -- the next release. So what we want to know is how can we implement these changes perhaps outside of that platform so that we can start to evaluate that. And I'm going to show a few slides that talk about that -- that same point.

Yeah. So, currently, any output that you want to do on something that is in here as an ALPHA option would have to go again through the process. You know, so, again, it took about ten months here. So I think we can update that a little bit more.

One thought that we had is that maybe we can work on these pre-ALPHA options outside of the framework of EPA, maybe release them through github or something like that. I know that SCIHEM uses that platform. And that way, we can make these versions available quicker for the user community to evaluate them to find out what -- I mean, what -- what options may be there.

So that's -- that's one thought that we had as we through this process. Again, we understand that, obviously, EPA's not only working on building downwash, but there are many other things that are happening at the same time and -- and the release cannot happen as soon as everyone would like it to. So I think this was a way we could expedite some of that -- that improvement -- continuous improvement of the model.

And then as it comes to the evaluation, one thing that we've noticed is that even when we changed from ISC to AERMOD, the evaluations were done for various databases, and in some cases, the database evaluations didn't look that good. And that's -- if you look at the Duane Arnold Energy Center, if you look at the Millstone Power Plant -- Nuclear Plant, the evaluations don't look that good. So the system has heavy reliance on the Alaska North Slope and also on the Bowline Point databases. But even the AERMOD that we're using right now has certain biases depending on which database you're using.

So I guess we would like to understand better how we can graduate these ALPHA options to BETA options and eventually into a default option.

There -- and I know that there will be other databases that will become available -- hopefully, soon -- and at that point, we'll be able to test those as well.

Question number two has to do with what should be the priorities as we address building downwash. We do have a long list. As I mentioned, this is a black box. Once we opened it, we found that there were definitely a lot of things to be addressed. The first one is BPIP, BPIPPRM. And I think one that has already been addressed is this projected length that is too long when you have an elongated building and you have wind at an angle. It creates this extremely long building.

So that has been addressed already by the BPIP draft. So our comment would be that we should make that one a regulatory option. I do not see anything to preclude us from doing that. And that's a -- an improvement that will help us because it basically will state where the start of the building is and where the end of the building is. So the wake would be starting at the right location and it would decay also at the right location.

So I think that's a -- a much-needed improvement that needs to be brought into -- I'm not sure if we're going to do a BETA BPIP or -- or something like that, but it needs to go back into -- it should be available for regulatory purposes.

The other aspect of BPIP that needs to be evaluated that -- like Steve mentioned, there was never enough time to evaluate all these options. We need to figure out the formulation that is inside BPIP that merges buildings, that grabs certain buildings at a distance of 5L and things like that. We need to make sure that we're comfortable with the way that that's being done. Because, again, everything that you put into your modeling is going to be summarized into one single square building. So we need to make sure that that is done properly and that we feel comfortable with the way that's being done. That -- that's something that, to my knowledge, hasn't been done to this day.

We believe that the wake turbulence and wind speed calculations that we developed through the PRIME2 research should be made valid. So it should be brought to the next step, the BETA option. And we would like to, as I said, evaluate the streamline equation in PRIME that we developed, and also we need to spend more time evaluating the plume rise predictions in PRIME.

And number five, the corner vortex, that's something that in specific cases can actually show the model underpredicting quite significantly. So this is something that definitely needs to get addressed at some point.

Upwind terrain wakes, right now you do enter terrain elevations, but your terrain is not considered, as opposed to -- as it comes to downwash effects. You have a hill upwind of your site, that hill is going to create some downwash effects.

And then platform and porous structures, that's definitely something that we've started working on the porous structures, but it's a complicated one. It's a little bit like the vegetation barriers that we're talking about. You have to look at porosity. You have to look at different places that may be more solid than others. So it's -- it's definitely a challenging type of -- of project.

And then the rotated elongated building and lateral plume shift, I think that Steve has covered.

Cavity plume rise issues, there's mismatch in the sense that instead of having the -- what happens in the cavity building is that the -- the plume is kind of drawn to the middle of the building. So -- I'll show a figure that shows some of that, but that needs to be addressed as well.

And then we need to figure out which wind speed to use for computing concentrations. Concentrations are very, very dependent on the wind speed that you use.

And then other areas that need improvement has to do, as I mentioned, with plume rise evaluation. And -- and Ron has done some updates and some work on this. I already showed that. It seemed like the plume rise equation in PRIME is underpredicting. So that definitely will create some of the issues that we've seen with some of the evaluations that we've done so far.

And then number two is the -- oh, yes. The way that the code was done more than 10, 15 years ago, we're not able to get the wind speed at a specific receptor like we need for this -- this type of model. We're doing the best with what is given within the model, but to understand, the way the model is giving like that, we're not able to get the wind speed of each one of the locations of the -- of the receptor. So that's something that -- that needs to be fixed somehow. We understand that it's a major overhaul effort, but that's something that will definitely create more accurate results.

And, currently, what we're using is the

minimum for the final Briggs momentum plume rise or the -- the wind speed that comes from PRIME, not at the first receptor location used.

And then number three, the equation for the height of the wake versus downwind distance needs to be evaluated based on PRIME2 research results. This is what I was talking about when I say that PRIME is underestimating. This is from a wind tunnel study. And the -- the -- as you can see there, the yellow line is from PRIME as it comes through the -- the plume rise elevation. And then -- but then you see that the plume is actually higher than that. So this is something that definitely needs to be addressed and this would create higher concentrations than normal.

Here is what we're talking about the wind speed. So the wind speed is used to compute concentrations. Currently, PRIME uses the height of the stack. Option 2 from ORD is using the average from the height of the plume and the height of the receptor. What we're using is the minimum from the final momentum plume rise and the first plume rise variable comes out of PRIME. So, again, depending on which one of those wind speeds you use, you're going to get a very different answer as it comes to concentrations.

This is a study that Ron did. Let me see. So we have the -- the green line is PRIME2 as it is right now in the code. And then the blue line is current AERMOD with the current PRIME. So you can see that it can underpredict. And this is a bowline point receptor one. It's underpredicting, but it's still within the two time underprediction. So it's still an unbiased model, at least when you calculate the robust highest concentration with the 25 highest values.

But you can see that here it does go outside of that region of the overprediction of two times. And, historically, you always worry about maximum concentrations for compliance with the NAAQS. This hump over here is quite significant because it's showing that the model is overpredicting at those locations at those receptors. And if you're doing a SIL analysis or if you're doing a culpability analysis, this could be quite significant as well.

So instead of using the minimum from the final momentum plume rise and the plume rise from PRIME, if you use the maximum from those two, you get the -- what is it -- the red line, which shows a lot more agreement as it comes to concentrations. It's more -- it's closer to the one-to-one line of a perfect model. So this is one preliminary analysis I guess that was done on bowline point. The same analysis is done also for the Receptor 3 and we see the same thing.

With this difference in using the maximum as opposed to the minimum plume rise, the final plume rise and the plume rise in PRIME, we're able to get better agreement. In this case, there was highest concentrations that are pretty close to one in all cases because they all converge here at the maximum concentrations. When you look at the rest of the distribution, this update does help it have better performance. Again, more work needs to be done, but this is how we started it.

This is a slide from Bob Paine where you have a stack in the middle of a building and you have, for example, here 2800 micrograms. Well, something interesting happens here. The wind is coming from left to right. You put the stack at the end of the building, well, your maximum is still inside the cavity, 2802. It should probably be downwind from the stack.

And then if you move it away, it still kind of pulls in -- and, again, we're talking just in the cavity region. It still had to show the maximum concentration inside the cavity region, but it's at a wrong location. This is very relevant if you have two stacks at the end of a building because, basically, both plumes are going to overlap over each other. So you're going to have significantly higher concentrations than what you would expect otherwise.

The last question has to do with how much energy should go into maintaining the PRIME algorithm or replacing it altogether, and also any insights into short-term and long-term.

Well, I -- we're in complete agreement with what Steve mentioned. We think that there's a very solid basis right now in AERMOD and in PRIME. There are definitely some updates that need to be made, but I think that we need to continue to -- to identify the issues and go after them and -- and fix them that way. But we don't think that PRIME should be done away with altogether.

I think that would be wishful thinking, but I don't know that there will be enough research money and that there will be enough people at EPA that will have the time, I guess, to work on that. So I think being a little bit realistic, we think that PRIME is -- is good enough as it is and as we work on improving certain aspects of it, we'll get it to work even better.

So here's one thing that over the period that we're talking about. You know, the current PRIME theory, as soon as that -- the -- the U -- the delta-U is the same up to the height of the wake and the same thing for the sigma-W.

As far as we could tell, we could not find how this was justified, but, basically, this means that the downwash are all the same in this region. What we find in the wind tunnel is that once you get above the height of a building, these effects start to diminish and we see something like this. The turbulence intensity -- when it goes back to one, it means that it's the same as upwind but you don't have a building.

So, yeah, when -- when you have a building, I mean, there's definitely an effect of turbulence intensity, but that effect is exponentially lower as you get higher into the building. And that's how -- this is quite significant because, again, right now, AERMOD would assign turbulence intensity up to the height of the wake when, in reality, that's not something that -- that is justifiable.

So this is my last slide. So how can we expedite research? I think what we've been doing is we've been trying to find sponsors and research groups and we -- we've been communicating as much as we can and we can only benefit from open communications with the different groups that are working on building downwash.

So a lot of work has been done thanks to the industry sponsors, and we thank them a lot. One -- the idea that we're floating is perhaps a nonprofit organization with crowd funding. So that way, like, you can not only test them out, but everyone could also contribute to -- to make all these changes. And that's something that -- that we're evaluating as well.

I think Ron already got some commitment of 15,000 to get started on it. But, basically, what we want is to make sure that any research that we're doing is available to everyone and that we're able to work on things on a continuous basis instead of kind of like this stop and go. And the advantage of doing this is also that we won't have to wait, you know, because already certain groups are recent, but then there will be some limitations as it comes to the availability of the data. You know, so I believe that that's slowing down a little bit the progress that we could be making if otherwise like that we could just make it open to everyone; like, hey, this is what we're getting. These are the improvements we're making and then someone else can come and kind of help out with -- or identify something and ask that that need to be addressed.

But, again, the main thing that has come from the PRIME2 subcommittee has been the collaboration between all these different groups. We're very thankful to the openness of EPA in doing this. It has been very key in making this happen and we look forward to continuous work and collaboration together.

And, honestly, as I said -- as I said earlier, like, everyone here and every user of AERMOD can be part of this now with the ALPHA options. So as you use them, make sure to let us know how they work for you. Thank you.

DR. ZHANG: I want to guarantee you this is your last downwash talk of the day.

So I want to acknowledge a few folk here. So some students, also Margaret at the New York State Department of Environmental Conservation. I don't think we have anybody from New York coming except me. They already asked me to -- to report back to the folk, you know, back home.

Also folk from NYSERDA and NESCAUM, you know, have very -- you know, valuable discussion here. Also, you know, we want to thank, you know, Steve -- you know, Steve Perry and David Heist. We had a -- this conversation for about probably a year now. Also, we had a call with, I guess, Chris and, you know, a few folks to pitch an idea.

Also Wei Tang -- I don't know if she's here, but, you know, she's, like, a -- providing the computational support for Steve group. We have a -- you know, she has, you know, been very generous in sharing data, so -- and sort of funny to report -- funny to work.

So the first question is -- it's quite long, right? My first reaction is, you know, good for you. I'm not part of it, you know. And -- but I do acknowledge this -- you know, but, again, I thank again for EPA support; you know, the – you know, all the help and data sharing. I really – I think I wouldn't be here without that. And also I commend, you know, AWMA and EPA collaboration on this. And, you know, I -- I always learn so much about, you know, downwash by, you know, standing there for, like, you know, half hour.

And -- so but I -- you know, I'm -- I -- I wish, right, so, you know, this -- this can be more open process; you know, maybe, like, people like me and my group can be part of that conversation. You know, I made so many assignments already.

Anyway, so, but I think a -- what I think we do agree a collaborative approach definitely is the way to go.

Okay. Now, the second question here -- I like to show some visual. You know, I think here it is -- you know, look, so I learned so much already, right? So, you know -- you know, Steve told me -- you know, taught me about bad penny. That's another cultural -- you know, cultural reference – that’s another cultural reference, you know, Max Zhang was not aware of, you know, before this talk. But I do want to emphasize it's a bad penny, but it's a very important, very critical bad penny.

So -- and so those are, you know -- those photo taken for the project in New York. You know, I -- you know, I came from very cold -- cold area. So, you know, a lot of emission sources in the Northeast in general are associated with heating. So -- and so, actually, this a -- you know, you can recognize building -- the type building. It's actually a school. For -- for some reason, they received the federal funding to add a biomass boiler. And this is -- this is original stack.

So the state actually, you know, helped them to -- you know, this is a -- you know, someone had to -- you know, to -- you know, to rise up early to take the picture, right? But those -- you know, this is a classical downwash condition and temperature inversion. And, you know, the State of New York actually gave them additional funding to -- to increase the height, the height of the property here. This is not a -- it’s not a boiler. This is actually a biomass combined heat and power on a campus. So, you know, surrounding are very tall buildings, right?

So -- and this is -- this is the stack of the -- this small source and this is the main air intake. So -- but again, it's a bad penny, but I think it's really a critical bad penny, right? So it doesn't make our life more meaningful to improve -- you know, improve the downwash algorithm.

So this actually one of the -- this from my town. This is from my town. Actually, I took this photo. You know, this is in downtown Ithaca. This -- you know, for that particular section of the town, you know, those two houses are right next to each other, right? So this is the wood stove stack of one neighbor and, you know, the plume -- and, actually, I took a video. So, you know, this is what's coming out from the stack, right? So that can -- almost can head directly to other neighbor’s window. So that's not right.

Once again, this is very important topic, right, especially for the cold climate. So if history repeat herself, as it always does, I can run out of time, right? So I just want to get my point out, right? So, you know – you know, when the time come, you can -- so Clint is just going to remove me from the podium.

So I -- I want to talk about three -- basically three different approaches. We have spent a lot of time on BPIP PRIME. I'm not going to repeat any more. I do have a question, I think. Bob Paine mentioned about computational fluid dynamic approach. I do like this approach, but I do acknowledge the limitation. And, you know, my group have been working on CFD approach for -- for many year now. I feel more comfortable about our capability, but at – at same time, I do acknowledge it computationally expensive.

Actually, I think the biggest -- biggest problem I see for CFD approaches is really -- are difficult to standardize, right? So if, you know, Steve run for one -- you know, same condition, if Steve run the CFD and I run CFD, we got, you know, different results, right? So, because, you know, how we do the mesh, how we run two different parameters, you know, subject to your professional discretion.

So and I think that will be -- you know, what I see, that's the biggest obstacle for the CFD approach to be a regulatory model. And -- but at same time, right, so I do see there's, you know, a positive side for the CFD approach. You know, for example, you know, Steve group, you know, have -- Wei have been, you know, working for -- with Steve and David for -- for many year running downwash, you know, CFD simulations. My group was also working on it. We do believe that well-configured CFD models can produce pretty good results.

And, you know, once you sort of -- you vary the model and you get a reasonable result, then basically, the -- the rest become easier, right, and do -- you know, how, you know, change the configuration, you know, there are many things you can do with the well-configured configure model.

But my -- but my -- my real point here is -- last one, right? I want to present an alternative, right? I have a slightly different opinion on the third question. So -- so the whole idea here is, you know, we want to take advantage of CFD simulation, right? So -– and so it’s -- there's a -- we want to propose a parameterization -- an alternative parameterization approach. We call it a Mixture model. I'll tell you what Mixture model is, but the idea here, it can be assisted by CFD simulation.

And also, another point here, we not just have downwash. You know, when you have a -- especially when you have, you know, oblique wind condition, not perpendicular to a building, you -- you actually have what we call, you know, sidewash, right? You know, what I'm saying, you can’t really find this term in the dictionary or something. We -- I think we probably -- you know, I'll show you.

I think if you want to capture the oblique wind condition, you really have to capture both the downwash and sidewash in order to do that. And so I'll show you.

And by doing that, we think we can -- you know, this is actually a proof of concept, right? So I think we can address the discontinuity in the transition zone. I think, you know, Steve mentioned that, but also I think we can handle the oblique wind conditions problem, so -- and potentially more, especially -- it's a CFD assisted approach, right?

So if you -- the promise here is you can run a whole lot of the CFD simulations on different configurations while evaluating so you can make your parameterization much more robust in the future. You know, of course, for this occasion, it’s -- you know, I present a proof of concept.

So I will -- you know, so my student, Bo, who did all the work, somehow got a photo from Steve and David at some point. I don't even remember now. So this is a -- you know, for our current study, it was based on this particular experiment that, you know, Steve and David group have been -- collected and generously shared with us, right?

So, you know, it's more or less representing a low buoyant -- you know, neutrally buoyant and low momentum, low stack conditions, right? So this is the building. This is the source, right, more or less a cartoon version. You know, because when I first saw it, I said that's really good, right; very relevant to the environmental problem I'm concerned about, you know, those low – you know, small source for heating purposes, right? You want to extract heat from your plume, right? So that's – the buoyancy is not particularly strong, right?

And, you know, working -- you know, we -- actually, we came out with this idea -- this approach at the same time; you know, independently embedded large eddy simulations, right? So, you know, with -- you know, with Steve and David group. But the idea here is there's a -- you know, two type of the simulation technique. One called large eddy simulation is much more computationally intensive, but it can resolve the flow pattern better. The other is, you know, Reynolds-averaged Navier Stokes. So the RANS model is slightly more efficient, but it's not as accurate. So you basically want to marry both, right?

So you have -- near source, you have the LES simulation and you transition to the RANS. So, you know, lot of -- because once again, it's CFD-assisted approach, so this is the basis of our simulation.

So I -- I don't have a lot of slides to show the graph. We are having a paper under review right now, but, in general, I think we get a embedded -- embedded LES, right? So we've got a reasonable good, you know, adequate, you know, agreement with the wind tunnel measurement.

Okay. Once again, we go back to our reference point. So I think, you know, this is really my -- this really is the story of my life in some way. We decided to -- you know, when I first approached the problem, I thought it would be a quick and easy project. And the first approach, you know, we try to understand how PRIME works, right?

So my understanding is PRIME is – PRIME, you know, was based on the wind tunnel -- wind tunnel experiments, right? So -- and they have two pieces. You know, the first is to parameterize the flow field and then -- then try to -- based on the flow field, then parameterize the concentration field. If you look at the flow field parameterization, right, so here is the -- you know, this is the advantage of having a good CFD simulation. You can see a lot of stuff, right.

So we see here a very nice vortex here. And this is PRIME's -- this is an envelope -- so-called envelope. It’s -– actually, it’s 3D envelope of the PRIME parameterized results, right?

I can see here it's -- it's amazing. You know, I was -- to be honest, I was surprised when I first see this, right? So I expect PRIME even for this condition to perform bad. But, actually, as you can see here, the PRIME performance really -- I was really surprised.

But once we go to the oblique wind, right -- so oblique wind means, once again, the wind is not perpendicular to the -- to the building. Now you can see the flow pattern is much more different now, right? So -- and then, you know, I think both Steve and Sergio, I think, mentioned that what the PRIME approach is that the BPIP will give a projected building. So based on -- basically, this is a -- this is real building and this is the projected building, right?

And then you basically just run PRIME on the projected building, right?

And then -- and then this is the -- the envelope of the cavity zone, right, predicted by PRIME? And you can see there -- you know, that doesn't work well, right?

And the ORD approach -- you know, approach here, my understanding here is -- let me go back. Why is not showing here?

All right. I will come back. I have another slide and will come back later. So we can shorten this and kind of narrow this projected building, right? But still, once again, wind is still perpendicular. So this is a beautiful conversation. I will go back to this point, right?

So that approach, still the wind -- your projected building is still perpendicular to the wind. And then your cavity zone is still -- you know, is still more like this, right? Going to be slightly different but is shaped, more or less, like this.

Okay. You know, moving to the concentration field, like -- once again, it’s been repeated many times. There's a -- three components. There’s PRIME source; there's cavity source; and then there's re-emitted sources, right? So there's -- for any – for anywhere in the -- you know, in downwind, the concentration is a combination of -- of those -- of those three, right, you know, with different contributions.

So then, once again, we can visualize this. So here, you know, wind is -- this is one additional concentration field proposed from oblique wind. So the -- I think Steve mentioned this, you know, discontinuity in the transition zone. Basically, between this cavity room here -- basically, you know, between D and DPRIME, right? So PRIME -- PRIME, PRIME. So PRIME formulate a linear -- linear combination of those two based on parameter lamda.

So -- and then what's the result here? I want you to focus on this transition zone here. And then, you know -- okay. So once again, the circle here is the wind tunnel, red is PRIME and this line is the -- our CFD simulation here.

So I can see here in transition zone, PRIME will give you not just discontinuity but also I'll say unphysical, right? So the trend is wrong, right? The trend is -- instead of going up, it's going down, right. So -- for both conditions; both, you know, conditions. So it's not just discontinuity but also unphysical trends.

Move to the oblique winds. So then, we basically, you know, try to visualize this important -- you know, this is a -- the building, right, perpendicular wind. The same building, if you orient it to 45 degree with wind, this -- you know, if you trust the CFD model, this would be the concentration field, right?

And this one -- we say this one -- this is what the PRIME would be, right, because PRIME try to project into a -- you know, try to create a projected building and -- and is then treated as a perpendicular cased, right? I can see here these two, right?

So this is the PRIME approach. This is, more or less, where we're at. But even more important, I think, if you look at the ground level concentration -- actually, the high concentration, comparing those different cases.

High concentration actually happens at the oblique wind conditions, right, you know, compared to the perpendicular and oblique. The oblique wind gives you the highest concentration. Peak concentration actually occur during the oblique wind. That's my -- my point, right?

So I think oblique wind is the important characteristics that we have to captured in order to make -- to capture the highest peak; you know, peak concentration.

So back to question two, right? So I know this is the good part for being the last speaker on the panel. So I agree with everything Dr. Guerra said. So my answer is going to be short, right? So -- but I do want to add, you know, I do, you know, hope that EPA, right, in the PRIME development can focus on, you know, among many other things -- you know, I learned so much, you know, this morning, even though I had no idea about the overwater -- you know, dispersion also has downwash issues. So it’s good to be here.

But I do want to emphasize that, you know, one is distributed generation, right? So I think that, you know, in many part of the country, there's a movement toward a more distributed resources, right, compared to the central power plant, right? So I do see there's a need for the PRIME. You know, I think I gave some examples at the beginning, right? So also, there's, you know -- you know, like, a heating-related emissions with short stacks. Those are conditions.

I think, you know, the PRIME has a -- you know, the downwash algorithm has a lot of audiences for those type of sources. I think it's important.

In terms of the physical mechanisms, you know, I -- you know, I'm not really self-promoting here, but I do think, you know, resolving this discontinuity and oblique wind is important, right? So, you know, hopefully, you know, through my example, you can agree with me.

For the third question, this is my version, my minority opinion. I do believe that PRIME -- even though I do agree there's a pretty solid theoretical background for PRIME, I do -- you know, but, you know, for the perpendicular wind case, I was really surprised by the performance for that -- for that particular condition. However, my theory so far here -- I have not been convinced, based on PRIME's current formulation, it can really capture the oblique wind well.

I just see -- you know, I tried. I'll show some of my effort. I tried, but I just, like, couldn't really make it work. So that's why I think if you -- if you -- you know, if you are with me that oblique wind conditions are important, then I don't think PRIME -- I think PRIME had some fundamental problems. That's -- you know, that's me; you know, what do I see here as a cautious man. I think we should have -- you know, have open door to -- to alternative approaches to the problem.

And once again, you know, I -- I mentioned when I first work on this project, I thought it’s going to be a quick, easy project, right? So -- because I thought, well -- you know, I think -- I don't know if I can do the -- you know, set up the simulation well and then we can visualize this, right?

So while the oblique wind conditions -- well, even though PRIME didn't -- couldn't capture it well, but, however, we can visualize -- maybe we can develop some formulas to capture this shape and then, you know, send it back to the PRIME and then PRIME can work well, right?

So, you know, we spent lot of time seeing how can parameterize the cavity room like this, right? So we tried many different ways. Just, you know, at some point, said, “Well, we give up. Maybe we should try something different,” right? So that's -- you know, I did try, you know.

Actually, this is different from my original proposal, actually, to the project. But, you know, we do see there is value, right, for the CFD simulations. Once again, I think I was really -- you know, we really want to spend our time, you know, just looking at exactly what is the plume shape, the vortex, you know.

So by looking at this -- so that's what gave rise to the idea of you have this downwash -- downwash, right? So we'll call it downwash effect. But at the same time, you can tell if there's -- actually, there's another sidewash, right, because of the oblique wind condition.

So that's -- in order to -- so this is for the velocity, so you can see the vortex. And then in terms of concentration here, we feel like there's almost, like, a combination of a main plume and a shift -- a shift -- a shifted plume, right? So -- so that's what gave us some idea to pursue this approach, called a mixture, right; a mixture of different plumes, right?

So, you know, here we're trying to make it simple, two plumes -- two Gaussian plumes. But at the same time -- you know, at the same time, you know, this can be -- lead to more plumes. We try to keep the model as simple as possible. So this really was, you know, sort of the motivation for our model.

Anyway, I -- so the idea here is – high-level idea is it going to be a mixture of two plumes, right? So both are Gaussian plumes and we simplified the component even more to reduce number of parameters and then we -- based on the CFD study, we -- I'll skip here result and conclusion here. And we tried to simplify this and test it on the -- on the -- on the data we have.

So speaking of the training and testing, right -- so training is solely based on the CFD simulations. So we didn't touch anything about the wind tunnel data, wind tunnel -- we try to see, you know, what -- try to do this way just to see whether it work, right?

So the training, it -- you know, I can see here the CFD study -- you know, CFD simulation doesn’t match perfectly, but -- so -- but as in training -- internal parameterization is solely based on the CFD study -- CFD results. But when we test it, we test on the wind tunnel, right? So also test conditions and training are different, right? So we try to figure out, you know, some more rigorous way. You know, you can argue this is not as rigorous as you would hope for, but we try to, you know, do what we can here.

So some -- just some quick results here, so for the longitudinal -- longitudinal means along the x direction, right? So here -- basically, what I see here is the PRIME gives you this discontinuity, right, in transition zone and -- and this is the wind tunnel data. This is the mixture -- mixture results, right? So, of course, it's not one-to-one observation, as every modeler hopes to see, but as to how we avoid it, we sort of resolve this, you know, discontinuity issues. Also, unphysical trends, right? So, you know, the trend become more physical.

On the vertical -- on the -- on the lateral, basically, you're seeing whether it can capture this, you know, lateral shift, right, because of the oblique wind, right? So -- you know, so this is my point, right?

So as long as you -- whatever you do, as long as you still, you know, use BPIP and make your wind perpendicular to the building, you will never capture the lateral shift, right? So how would you if the wind is still perpendicular to the building?

But I think this mixture approach -- you know, sometimes it's subtle and sometimes it's more obvious. For example, we do capture the shift in the lateral direction, which is encouraging. And on the vertical distribution, we -- I think we -- we sort of more or less capture the -- the peak concentration, right, because it's an elevated source. The peak concentration is elevated, so we capture, you know, more as this Mixture model approach captures the peak concentration.

You know, in -- in general, we basically capture the main plume trajectory, right, the plume centerline so that we can capture the plume peak concentration.

So this is -- you know, put everything together, you know, we do see improvement, right, in terms of comparing to PRIME. I know we -- I didn't show here, but, you know -- you know, because I think that’s a -- you know, more useful for the offline conversation, but we do compare -- I do receive the PRIME2 and the PRIME ORD from EPA. We do test it. I think it -- you know, we see improvement, but not as significant improvement as we -- we hope for.

So I think this will -- so that's why I still think this is still a worthy approach at this time. So, I mean, that's my -- that's my last slide, basically saying we see a good promise, right? And, you know, good promise, I think, in terms of two -- two aspects.

One is I think by this downwash/sidewash perspective or angle, right -- so I think we can -- we are able to make this model formulation more rigorous to capture the oblique wind condition. The second aspect here is this is also a CFD-assisted approach, right? So I think even though we want to test on the wind tunnel condition here, but at same time, we are working on -- you know, actually, right now, we're working on the Millstone dataset.

But the promise here is, you know, a well-configured CFD simulation will allow you to have many different configurations and make your parameterization -- parameterization much more vigorous, right?

Once again, as a proof of concept, we do acknowledge our model has limitations, right, but at same time, I do think this approach can allow us to do better if we have more time and resources in the future.

Thank you. Am I out of time or --

MR. TILLERSON: You're good.

DR. ZHANG: All right. Thank you.

MR. TILLERSON: So we do have some time for questions. If anybody has any clarifying questions they'd like to ask the panel or if the panelists have questions for the other panelists, we'll take them now.

MR. PAINE: A question on CFD, could a complex set of buildings or a oblique angle approach be done with CFD and then you could impose a perpendicular approach to mimic the same -- you know, the characteristics and then put that perpendicular building into PRIME? Is that -- is it possible to do that, keep PRIME but -- but putting CFD on the picture?

DR. ZHANG: I think that question directs at me.

MR. PAINE: Oh, you -- why not?

DR. ZHANG: I think short answer is we should talk. I haven't -- you know, like I said, I tried, but I just haven't been very -- you know, we spent a lot of time but haven’t been very successful, I mean, how we do that. You know, because that's our first -- that's our first objective, is if we can keep the PRIME just somehow parameterized better, that would be the best approach so that we -- you know, we tried, but it just -- the shape is too complex to be reasonably captured in a -- you can use machinery model to have a black box model to capture that, but I don't think that's good for a regulatory model. So -- but I do want to -- want to hear more about your opinion. I do appreciate it.

DR. GUERRA: And I have something to say to that. I think that we can bring the CFD, but the problem is going to be how do we deal with that side -- sidewash, you know, because that hasn't been parameterized yet. So I think that maybe the work that Steve and Dave Heist are doing, you know, like, that -- that might help us in that, to marry the -- the two concepts. You know, CFD with the current.

You could put some in a little bit better, you know, but we still have to deal with this other parameterization that hasn't been addressed yet.

DR. PERRY: Bob, in terms of the multiple buildings, I think it's a little more difficult. In essence, you're asking the question can we use CFD the way we use the wind tunnel to come up with -- what’s the term I want to --

MR. PAINE: Equivalent building.

DR. PERRY: Equivalent building as a direct if you had multiple buildings. But in the case of the, say, elongated building that's rotated, the oblique winds, we obviously believe you can make a difference there and stay within the formula of PRIME because that's what we're doing.

That's what we've been doing for the last year or so. I'm not saying that we're going to have some magical result when we're finished that will -- that will cover every scenario, because I do believe that it's very sensitive to where the source is on the building, especially when you rotate the building.

But -- but we are working on a parameterization approach, Max, that -- that we hope will -- will be successful in -- in at least -- and I'm not adopting the term "sidewash." I just want to say that, although I --

MR. ZHANG: You know, feel free to.

DR. PERRY: You take bad penny and I'll take sidewash. But it, in essence, is primarily looking at how the material that gets down in the cavity on a rotated building gets laterally or sidewashed out.

And we actually found the same thing that Max found in looking at our CFD and wind tunnel work, sort of a -- a double Gaussian kind of plume. It just looks like you have the -- the primary plume is coming down without being deflected so much laterally and stuff in the cavity is deflected. And so you get kind of this double plume approach.

And if you -- you then just have to figure out where that other plume is going. And so we are working on that approach. Hopefully, we'll be successful. So I would say some hope on -- on the single building approach.

MR. TILLERSON: Any others?

MR. PORTER: I have -- for the Mixture model that you presented, was that evaluated or the comparisons at different time scales in the course of an hour, three hours, 24-hour averaging, that type of thing? I imagine that the shape of the sidewash versus just the regular downwash would -- would fluctuate and vary with time?

DR. ZHANG: So we're not -- we're not there yet, but we are now looking on the -- on the Millstone dataset, you know, hopefully to address the question just raised here. But, you know, so far, we've just looked at the wind tunnel dataset that's, you know, Steve and Dave have collected, you know, in 2014.

By the way, our -- you know, our goal here is, yes, I do -- or, you know, we -- you know, I do believe in order to make this work, hopefully at some point an ALPHA or BETA version, if possible, we do need to go through this -- you know, test more field datasets. But I think -- but the approach can be very similar. We're still going to run CFD simulations and then see how we can parameterize the model, you know, with help from the CFD. I'm -- you know, I'm optimistic about this approach and hopefully will let you know.

MR. SADAR: You said this is going to be published. It looks like it's under review. Can you tell us where it's going to be published, first question? Maybe you can’t.

But in the paper, your current work, are you considering other than the neutral -- or, I'm sorry, other than the, yeah, neutral conditions, the unstable?

DR. ZHANG: First question is I would -- I would like to have your card, when it published, yes.

The second question is -- that's another good question. You know, once again, you know, so far, we positioned the first paper as a proof of concept, right? So we only use wind tunnel, which means it's neutral condition.

So -- but, you know, my -- the same answer here is I -- I don't -- I don't see that as a limitation. And, you know, I -- I do see the model can be extended to other, you know -- other stability conditions, right? So we -- we're just not there yet because, you know, we're not really inviting the plume -- the Gaussian plume equation. We're just saying a different way to formulate -- you know, use a Mixture model to -- to capture the, you know, downwash and sidewash.

So, you know, a lot of what's -- we already learned from -- you know, from the -- how the stability affects dispersion model can be done -- you know, can be used in this formulation. I'm not -- we're not inviting a disperse model. We are just seeing, like, a different way to use it at this point.

DR. VENKATRAM: Steve and others have been working on this. I think Hoster (phonetic) started the game and then you took it over and worked on it for years and years. And you've used the term "bad penny" and "sidewash" and all pejorative terms. And --

DR. PERRY: Be nice, Venky. Be nice.

DR. VENKATRAM: Is it possible that the problem is so complex that the best you can do is not go terribly wrong? I mean, it seems to me that you'll be working on this -- I mean, you really can't capture all the situations of downwash because the buildings are so complex. The surrounding buildings are complex. So I think the best you can -- in my opinion -- of course, this could be -- but the best you can do is actually not make big mistakes. That's all.

DR. PERRY: I think that -- that -- this is the way I look at building downwash. If it's a single building, I -- I think of building downwash as a source effect, okay, just like plume rise is, just like any other source effect.

So get it right in the -- and you'll -- and you'll be okay for downwind. This is why I think the Agency needs to also look at the urban approach overall in AERMOD. So if you have a complex or industrial complex of buildings, you can consider, as you say, in some more general sense what's going on in this group of buildings. But we're never going to get exactly where that plume is going to go down and certainly not on an -- on an one-hour or multi-hour average did it go down this street canyon, did it go down that street canyon.

But if we can sort of get what -- we can sort of treat this as a source effect, get that right, then model it correctly in a -- in a -- by getting the urban meteorology and the urban dispersion overall correct, I think we have hope to make improvements.

MR. TILLERSON: One more in the back.

MR. MONIRUZZAMAN: So I have a question about when height is low and [indiscernible] and if the terminal height is, say, [indiscernible].

DR. PERRY: No.

MR. MONIRUZZAMAN: If your source height is far lower than the building height.

DR. PERRY: Are you -- you're asking if the source height is -- source height is many building heights above the top of the building?

MR. BRIDGERS: Below.

DR. PERRY: Oh, below?

MR. MONIRUZZAMAN: Yes. Is that, like -- like, idling aircraft in a -- in an airport, if source height is, say, two to --

DR. PERRY: I -- there's an echo in here. I'm not sure I got the whole question. You're asking about what -- what about sources below the top of the building.

MR. MONIRUZZAMAN: Yes.
DR. PERRY: So if it's near the ground --
MR. MONIRUZZAMAN: Near surface, near surface.
DR. PERRY: Near surface. Right.
MR. MONIRUZZAMAN: Yes. And the -- the building height is -- is very high, like airport terminal, terminal building.
DR. PERRY: Yeah.
MR. MONIRUZZAMAN: And we see idling aircraft in -- in the terminals. So therein makes a lot of pollutants. So in that case, [indiscernible] is likely to be caught near the -- near the buildings. So -- but can PRIME model those conditions?
DR. PERRY: Okay. First of all, for an individual building where the source is near the surface, PRIME was actually developed with that -- those actual cases in mind. So it actually works pretty well for those cases. That's the plume -- especially the sources downwind of the building, or even if it's not downwind of the building because a lot of the plume is actually captured in the cavity.
And so it's -- a lot of the problem that PRIME has is getting it right, how much of -- if it's an elevated stack how much of it gets captured in the cavity and how much doesn't get captured, does it get

treated properly in the streamlines.

So for a surface release, that's -- it does very well. Okay? You're talking about a case where there are other buildings around, where the plume can be trapped between buildings or -- or -- or -- what is it that's trapping the pollutant that you're asking?

MR. MONIRUZZAMAN: Trapping -- trapping in the terminal buildings, in the terminal in the airports.

DR. PERRY: Oh, inside the building?

MR. MONIRUZZAMAN: No. Outside.

DR. PERRY: Oh.

MR. MONIRUZZAMAN: Outside.

DR. PERRY: Yeah. I -- I don't know. I'm not sure how well the model would do for that.

MR. TILLERSON: Do you have another idea?

DR. GUERRA: Well, I know that the Dwayne Arnold Energy Center has a similar case where you have a one meter release next to a very tall building that's maybe 20 meters, something like that.

I can't remember how the evaluations look, but that case would be very similar to what you're describing. You know, but, again, we get into the same thing, that in an airport you would have very complex type of structures that would have an effect on how the wind flow patterns would react. So -- so be -- it would be a complex type of result, but I guess you could get an answer, and -- and AERMOD has been tested under similar conditions.

DR. PERRY: And -- and oftentimes, when you have a very tall building and a surface release, that's actually a good situation because the pollutant will be -- on the downwind side of the building, the pollutant can be drawn up the building very rapidly out and away from the street level.

DR. ZHANG: So I have -- I have a question here related, but is that a -- still a PRIME problem?

DR. PERRY: Is this a what problem?

DR. ZHANG: Is it still a PRIME -- the problem for PRIME or is it just an AERMOD surface release problem?

DR. PERRY: I would assume this is a downwash problem or a building effects problem. I hope I answered some of your question.

MR. MONIRUZZAMAN: Thank you.

MR. TILLERSON: All right. We will conclude then. I want to again thank our panelists and Sergio for stepping in at the last minute.

MR. BRIDGERS: So before we take break, Steve, you're going to need stay right where you're at. You don't get to leave.

So we were talking about something generational just a minute ago and you had to look up bad penny on the Internet. I happen to be of a different generation -- I don't know if you can tell --

MR. TILLERSON: Wait a minute.

MR. BRIDGERS: -- but there's a local brewery here that also serves a beer called Bad Penny and it's actually a pretty good brown ale. With that, you don't have to worry about sidewash. You have to worry about backwash. And I will offer when we're not officially on the record and officially on EPA campus to buy you a Bad Penny.

But the other thing, Steve, you mentioned just a minute ago that you're about to sunset yourself from the EPA. And as many know, Steve's on staggered retirement. And when -- when's the date, Decemberish -- ish?

DR. PERRY: Yeah.

MR. BRIDGERS: So right now, all the members of the AERMET committee that are -- that are in attendance, can you guys come up? And, Roger, that includes you. Steve, you're going to have to stand up because, one, I want to get a picture of all you guys. But I also wanted to offer if Akula or if Roger or if Bob wanted to say any words. I think I also tell you, Steve, that Bob put me up to this a little bit.

DR. PERRY: I'm sure he did. You just wanted them to see all our faces so they could have --

MR. BRIDGERS: Oh, target practice?

DR. PERRY: Where do you want it?

[DISCUSSION OFF MICROPHONE]

MR. BRIDGERS: So, Bob or Akula or Roger, do you want to say anything?

MR. BRODE: I appreciate Steve's plug on my suggestion about the elongated building.

DR. PERRY: I appreciate you, Roger. Thank you.

DR. VENKATRAM: Yeah. Yeah. I've known Steve for umpteen years. I -- you want to say something, Bob, first?

MR. PAINE: No. No.

DR. VENKATRAM: Yeah. I think I started with my tenure with the complex training project and that was in the 1980s. And Steve was involved with it. And Steve came up with CTDM Plus. They're not -- does the model still exist?

DR. PERRY: Yes, it does. Ask Randy Robinson.

DR. VENKATRAM: So I -- so I was in all of that project, so I worked with Steve on that. And then in 2000, I think, we started the AERMOD project and --

because Steve championed it. That was in 2000, I know. But this was a modeling conference and we said we'll do this in one year because we're so excited about changing everything. And he's excited about changing things about PRIME.

So we decided, okay, let's do it in one year and Joe take part and the head of OAQPS was sitting at the back -- and I don't remember who all stood in front with Steve championing it, and I think you had -- held the flag, right?

DR. PERRY: [Indiscernible] AERMOD.

DR. VENKATRAM: Yeah, and you said we would do it and it took us seven more years. But the way we worked at it was actually what created the dispersion model view. We would actually come here to US EPA once -- what, once in four months and then get together in a room and work for three days continuously. Of course, it was interspersed with fantastic dinners and lunches and C_2H_5OH. So it was -- it was fun.

But during those three days, all of us worked intensely writing equations and programming. This was pro bono, by the way. I just want to --

DR. PERRY: They were paying me, Venky. I don't know --

DR. VENKATRAM: They were not paying us. So

Steve was -- he played a very major role in that. And then after that, I think I started working with Steve again over the next ten years on R-LINE. R-LINE was another project. And, of course, he handled this [indiscernible] and just been absolutely invaluable. Steve, we're going to miss you. Maybe Dave Heist -- he can -- you can do a good job, right?

DR. PERRY: Probably better. Probably better.

DR. VENKATRAM: So, Steve, you're going to retire, but do you really want to retire? It's not clear to me that you want to retire, because in academia, we don't have anything called retirement. We just go from faculty positions to something called emeritus. So maybe you want to think about that. In fact, I'm also retiring, but I'm doing it from an emeritus. So you really don't retire. You just draw much smaller salary.

But, anyway, Steve, you've been a fantastic colleague, a great friend, and I'm sure -- sure you're going to make major contributions even after retiring. That's all I have. Thank you.

DR. PERRY: This is the whole truth and nothing but the truth. I have made 35 years of my career successful for one and only one reason. I surround myself with extremely talented, extremely bright, very good people and they make me look good -- sometimes.

MR. PAINE: Thanks. Steve, you know, I do remember the CTDM days when we delivered a model, but it only worked for half the hours of the year and you had to make it a plus. It was a very ingenious acronym you added there.

And so we had to work together on that, and then, of course, AERMIC and downwash. I would like to provide you with a -- a flow chart of how models are really developed, and I have a copy for you, too.

DR. PERRY: Oh, good God.

MR. PAINE: Basically, I don't know if I want this to be publicized because it has some of the sausage-making aspects of models.

DR. PERRY: I'm not sure I can show this to my grandchildren.

MR. PAINE: Anyway, anyone that wants to see it can address -- come up to these individuals. Thank you very much for all your help along these years. You've been a great friend.

DR. PERRY: Thank you.

MR. BRIDGERS: This is all on the record. This is just by coincidence. I picked up my AMS bag this morning, so you've got the AMS, EPA, AERMIC and -- if I can get it out of the bag. So, Steve, this is on --

this is on behalf of us. This is just a certificate of appreciation to Steve for the years of dedicated service and his contributions to AERMIC.

So, Steve, on behalf of us, thank you and godspeed on your retirement.

DR. PERRY: I'm not used to people saying nice things about me. I guess you have to retire to get that.

MR. BRIDGERS: And I have been informed by the weather gopher it's 94 to 95 degrees outside. So I know it was a little cool in the back of the room, but I -- I think it's better than we have outside.

We're still five minutes ahead of schedule, but I know that last session -- actually, the last two sessions were pretty long. I saw some long faces in the room. So we're going to go ahead and take a 20-minute break versus a 15-minute break. We'll still finish easily on time and get you guys out of here by 5:00 or thereabouts.

But I feel like 20 minutes is what we need to stretch our legs, get some drink, some water and whatnot. So I'm going to suspend the public hearing until 4:05 and that's when we'll get going again.

[BREAK - 3:45 P.M. TO 4:05 P.M.]

MR. BRIDGERS: So in the interest of time and the fact that I think a lot of us probably want to get out of here at 5:00, I'm going to call the meeting back to order. So the public hearing is back open.

I appreciate everyone bearing with us and holding through the long session there. We have just this one session to go and then we can go try those Bad Pennies.

So now I'll invite to the podium Chris Misenis so that Chris may conduct the prognostic meteorology panel.

MR. MISENIS: Thank you, George. Knowing that I'm all that stands between you and a few beverages, we're going to move this right along.

So just a little background on prognostic meteorological data, we put that in as an option for meteorological inputs a few years ago. I think it was one of the most sought after changes that we've made.

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Preference for meteorological data but remains site-specific, site-representative data. National Weather Service data, then prognostic meteorological data. And since we've allowed the use of it, we've received several applications using simulated meteorology. Region 6, Region 10, Region 1. There have been a -- maybe there's some others, but those are the ones that come to mind right now.

And we thought we kind of nailed stuff down when we put out the guidance for how to use MMIF or how to run it and do everything, but we knew we were going to miss a few things. But in the course of reviewing those applications, some issues came up, mainly applicants asking if they can blend prognostic and observed data, the number of observation sites used in the comparison. We actually did scare away one applicant when we said, yes, you do have to use more than one point to compare to your WRF data and also determining representativeness.

So there's some questions that we knew we had to flesh out over time, so today's panel's sort of focused mainly on getting to issues that we see may be a problem, things that are good about what we're doing now with prognostic met, things that may need to be changed and what we see may be needed in the future.

Our panelists today will be Ashley Mohr, from EPA Region 6; Bart Brashers from Ramboll; Bret Anderson from the U.S. Forest Service. And I'll ask them to come up and sit at the table if they want. If they want to stand and glare, yeah, menacingly at me, that's fine, too.

While they're coming up, I'll give you a little bit about each one. First we'll talk about Ashley.

She's an environmental scientist in EPA in Region 6 in Dallas. She joined EPA in 2010 and currently works in the Air Permits Section, where she serves as the Region 6 contact on air permit modeling. As the Region's air permit modeler, she coordinates activities related to the Region's oversight and review of ambient air analysis conducted in support of state-issued New Source Review permits. She is also the lead for reviewing ambient air analyses submitted by permit applicants to EPA Region 6 in support of EPA-issued construction permit applications. Ashley also serves as the EPA Region 6 state coordinator for the Arkansas air permitting program. Ashley has a master's and a bachelor's both from North Carolina State University; a master's in atmospheric sciences, a B.S. in meteorology.

Mr. Bret Anderson is a physical scientist with the USDA Forest Service. Previously, he was the lead regional modeler for EPA Region 7 and started with the Nebraska Department of Environmental Quality. His technical experience is in permit modeling, meteorological and photochemical modeling, long range transport modeling and smoke transport modeling. Pretty much any kind of modeling, this guy right here does it. Mr. Anderson is a graduate of the University of Nebraska, Lincoln, with a B.S. in geography and has an M.S. in computer information systems from Bellevue University.

Dr. Bart Brashers did a post-doc with EPA developing CMAQ from 1998 to 2001, primarily working on dry deposition. He returned to Seattle and has been with the same group for 18 years, though there have been four different names on the door; most recently, Environ and now Ramboll. He runs WRF at multiple scales and regions, supports and updates the MMIF tool under the guidance of EPA and has done significant work on model development and evaluation.

I'll slide -- I'm going to leave the charge questions up here and we're going to start with Bret.

MR. ANDERSON: No, we're not.

MR. MISENIS: Yes, we are.

MR. ANDERSON: Well, I did not prepare a presentation. I'm sure most people are glad of that. I did want to offer, you know, in relation to the three charge questions a slightly different perspective, and that's the land management community, which is what I represent.

And we've been very happy about the EPA's formal adoption of MMIF. You know, it's a personal thing for me, obviously, as the original developer of it. And Bart can talk about the continued development of it.

But, anyway, we've -- we've made a conscious decision within the land management community to transition away from -- we continue to use CALPUFF as our preferred model for, you know, doing, you know, air -- air quality related values modeling. And, you know, the backbone for meteorology coming up through the years has been CALMET meteorology.

So with the advent of MMIF and EPA's formal adoption of it, we're transitioning towards recommending the use of MMIF in lieu of CALMET for the development because it promotes -- promotes -- you know, from our understanding, it promotes traceability protocol because, you know, there are very few switches associated with -- you know, with MMIF.

So it promotes general consistency in the development of meteorology and then also it is -- it provides an advantage because it means there is a dynamic consistency of the original prognostic fields, you know, that can get disrupted when you're using objective analysis techniques. And so the -- those are what we, you know, view as the positives for, you know, EPA's move, you know, towards prognostic modeling.

The challenges, you know, I -- I talked about the challenges previous, you know, I think -- I think at the 10th Conference I talked about the challenges related to the adoption of prognostic met. And they remain largely the same, from my observation standpoint. You know, I see a little bit -- I get involved in, you know, a few of the PSE permits where MMIF was being used for the near field component of it.

But we still -- still see the same questions being asked either in the near field or in the far field. And so that speaks to what John Irwin talked about at the 7th Modeling Conference back in 2000, you know, which was, you know, kind of ensconced in the IWAQM Phase 2 guidance that talked about there was a general consensus that as the community moved toward with these -- you know, with the use of these products that there would be a greater awareness of it.

But we still haven't seen that awareness develop to its -- you know, to its maturity there, and that remains the single greatest challenge. It -- in every aspect of the use of prognostic met, we just see a general lack of awareness in the -- particularly in the permit modeling community about where it comes from, how it's run, how do you evaluate it and all of these sort of things. And so that creates a challenge.

You know, so you mentioned -- Chris mentioned the PSD project in EPA Region 10. Bottom line, the -- you know, one of the commenting agencies that was involved in that absolutely refused to accept prognostic met because there was no way that it could, you know, work in complex terrain, even though it was run at a very high resolution, was run with good -- you know, with good thought into the physics packages and everything else.

And -- but just absolutely were convinced that it couldn't do what -- you know, what we were saying. And so that is the consistent -- you know, we see that -- that consistency in the resistance, the lack of understanding. And that -- that remains, I think, probably the single greatest challenge to the continued use of -- you know, promotion and use of prognostic met.

The one thing that we do see an awful lot of is still a general lack of adherence to, you know, Section 8452 of the *Guideline*, which is -- deals specifically with the performance evaluation section. And people just don't want to do it.

You know, when I worked for EPA Region 7, we asked somebody to do a performance evaluation on the MM5 data that was being used for the BART runs that they were doing, and they absolutely flat-out refused to do it, even though it was in the regulations. It says that you have to do -- you have to justify use of this meteorology. They refused to do it. They said, "We're not going to pay for a research project."

And so that remains -- that remains a consistent thing that we see, is that people just don't -- they don't understand what -- you know, what the elements of a proper performance evaluation are, how to document it; you know, what -- what statistics to focus on, do I separate observations from simple terrain to complex terrain and segment the analysis that way.

There's a lot -- there's a lot of things that we can do as a community to continue to augment the understanding, because the key -- the key here is, you know, you're not going to be the ones that are running the meteorology. You know, it's very -- it's a very -- you know, very few people in this community are actually the ones -- the end-user of the product of it. But they still have to justify its use.

And as such, the performance evaluation becomes the critical element in providing that justification. And that -- that's something that we as a community need to work on, is doing that.

And so, finally, you know, to talk about, you know, where -- where do I see, you know, moving forward advancements, I'm not going to so much speak about what I see advancement's going to be. I'm going to talk about my wish list moving forward, and that has a lot to do with we need to come up with better guidance on the -- you know, for the document -- how to document a performance evaluation and also do a -- you know, do a more thorough job of actually documenting how -- you know, how a performance evaluation gets done.

And, you know, there's -- you know, it's, like, if we're going to allow people to use these -- you know, these data products, you know, there -- there has to be an expectation that they can -- you know, they can do a cogent performance evaluation to justify it. And with that, when I keep talking about justification, always remember that, you know, in the land management community, we are a Section 30b commenting or reviewing agency. So we have -- when you're doing the AQRV modeling, we do have -- we do have purview to determine whether or not, you know, the prognostic datasets are acceptable. That's not just a -- it's not just an EPA decision at that point. You know, that's my sales pitch for the day.

But -- so, you know, one is -- you know, coming up with better guidance on performance evaluations. And I think as we move forward, I think another thing that we need to think about is because, you know, one of the attractiveness features of prognostic met is, you know, we -- it's a selling point, its complex terrain; you know, being able to do that.

So -- but the majority of the evaluation metrics and techniques are really for -- they were designed for urban settings back -- you know, dating over 20 years. And so there's been very little thought that has went into developing, you know, techniques that are -- or metrics or these different values of metrics that, you know, would be deemed, quote/unquote, acceptable for areas of complex terrain. You know, there's been -- I think Dennis McKeown (phonetic) came up with some extended statistics for a few wind -- you know, for wind and things like that or what is called more complex terrain.

But people -- you know, generally, you don't see people using that. So there -- there needs to be greater thought about -- you know, because this is an area where we're using, you know, the prognostic met, is where we don't have observations. We need to -- you know, we need to focus on, you know, what is -- what is accept -- what is kind of an acceptable criteria in urban application or in ozone or $PM_{2.5}$ implementation plan may not be the same thing. You know, we may have to, you know, have a little bit more relaxation of expectations because in areas of complex terrain, it's not going to do as well as we would hope for. So there's that.

One of the things as far as the land management community goes is that sometime -- you know, hopefully long after I retire -- we will actually come out with a new version of FLAG, you know. And I can't say when that is. I've been talking about that for a number of years, too. But there's a general interest in the -- incorporating the concept of critical loads into the AQRV matrix to kind of get a better handle on deposition.

You know, it's like the DATS are not a -- not a very effective measure of much of anything. And so there's been -- there's been a push inside the land management community, you know, for incorporating critical loads into that concept.

And that brings on an entirely new focus on techniques for evaluating precipitation, because wet deposition is obviously a critical component, you know, getting into that. And I think that's one of the areas that is probably the poorest evaluated of all the, you know, components of it, is precipitation. You know, it's simply -- you know, people are generating month -- you know, monthly average plots and comparing them against prism data, as an example.

There has to be -- there has to be a better way of -- you know, of getting at episodic conditions when we're talking about dealing with precipitation patterns. You know, not all of the stations give us precipitation patterns, but also the timing of it. You know, those are -- those are important aspects that we overlook.

And then the last thing is the evaluation of the vertical. You know, we have for years developed the techniques around surface observations and incorporating those. And there are very few -- I think AMET's the only one that has the capability of, you know, comparing against the actual sound. But that's -- that's a monstrosity of a system to try to use. And so the more simple tools, like METSTAT or MMIFSTAT, you know, and things like that are focused on surface observations.

And so we have no understanding of how well the model is doing above the surface level. And so that's another area that I would like to see, you know, that there'd be expansion in terms of not only technique but also guidance on -- just focusing on upper air evaluations as well. Thank you.

DR. BRASHERS: Hello again. Like I -- like I said, my name is Bart Brashers. Hold on one second. I took over the evaluation -- or the -- the -- we should talk about some history of met, I suppose, a little bit.

Bret put together the very first proof of concept and it had an unfortunate acronym that Bret Anderson reformatted, so we had to rerun that. I took over development from my colleague, Chris Emery, back at Version 2.0. So I've been working on it for a number of years now.

As far as the questions go, the most significant advantage is -- there's lots of obvious advantages: using it in complex terrain or in remote areas. And you'd be surprised at what people now consider to be remote areas; like, northeastern Washington; you know, 60 kilometers from the nearest meteorological site, or I've done a few in -- a few model performance evaluations in Pennsylvania, which have been similarly, like, 50, 60 kilometers from other meteorological sites.

You know, before MET, it -- I was -- always kind of took a very practical approach to things; like, which of these two meteorological sites is the most representative of my site, not whether it was representative or not, because I didn't have any choices. I have this site or that site, which do I pick.

But now you have a third choice, which would be if neither of those are sufficiently representative, you can run WRF or find somebody else who has run WRF for that area and do a model performance evaluation and off you go for using it for permitting purposes.

One of the places where MMIF has been surprisingly useful is offshore. We talked a little bit about that this morning, but you'd be -- all be surprised at how low quality, low percentage of the available hours that buoys are actually measured. So it's difficult to use buoy measurements to run offshore dispersion modeling when you only have 60 or 70 or 80 percent completion rates.

Another interesting aspect about it, which I think all of the consultants in the room will understand, is not only is using MMIF cheaper than installing a meteorological tower, probably about a third as cheap, maybe a little bit less -- maybe a lot less, and -- but it also goes a whole lot -- heck of a lot faster than installing a meteorological tower, right? To get a PSD quality met tower usually takes five quarters before you -- you have a year's worth of data.

And all of the consultants in the room have all had clients who are in a really big hurry. I see you nodding and some chuckles at least. So the speed is perhaps the most surprising part that I've found as part of this. We all know that the engineering of the PST project goes a lot faster than the PST permitting of the PST project.

So people say, "I don't need to decide the -- the size of this emergency generator. I won't know until two months before construction or even the day of construction, when we finally size everything about what we're going to do. Then I can size that emergency generator." But, oh, no, we have to tell EPA a year ahead of time what generator that's going to be.

As far as Question 2, challenges, I have met some states or agencies that just have been skeptical of -- of whether or not prognostic model can actually do a good job at -- at simulating the meteorology. Some of them were just slow to learn about the -- these changes in Appendix W. Some just had some sort of, like, gut-level reaction to meteorology.

And when I drilled down farther and really pressed them on the question, it's, like, it ends up being a feeling, like, "Oh, for this hour, the wind was 90 degrees off from that hour. And then I looked at another hour and it was -- it was 180 degrees off. The wind was going in the wrong direction in your model, so it can't be right."

But then I try to point out to them that they're working with AERMOD, which is also not advertising itself to be good at predicting a particular hour's concentration at a particular point. It predicts distributions, and so do meteorological prognostic models. They predict distributions of winds. As long as they get the distribution correct over the time frame, then we should be able to use them.

Another -- another challenge often for me is sometimes there's a lack of good quality meteorological studies that you can use for your model performance evaluation. There's -- especially in really complex terrain in really remote areas. There's nothing there that you can compare in a -- in a statistical sense with your work to make sure that it actually works, that you're actually -- that the WRF run is -- is accurate enough. And that -- I don't know if I have a solution for that myself.

The very first WRF/MMIF AERMOD model performance evaluation that we did -- I can give you a quick aside about it. Not only was it the WRF performance evaluation that was kind of following the $PM_{2.5}$ guidance for regional modeling, which was really aimed more towards CMAC or KMEX modeling. So it did a typical, like, period in time statistics and, as Bret pointed out, the monthly average rainfall compared to prism plots. And we did qualitative analyses looking at some soundings.

But the problem is that I always use the soundings as inputs to WRF. So I'm comparing outputs to inputs and I don't think it's a fair statistical comparison. So I don't think -- so I don't do it. I need some independent -- you know, some independent upper air observations.

And then -- so not only was it the meteorological part, but then for each of the nearby meteorological stations that we could find, we ran AERMOD with observations and we ran AERMOD with MMIF. And we compared the outcomes from AERMOD itself. So it was an AERMOD evaluation and said these outcomes from AERMOD were similar.

The first one was for a very controversial PSD project in Region 10, and I know that Region 10 has been distributing that as a -- as an example and perhaps one of the challenges going -- in the future would be to scale that down a little bit to be something that is something more reasonable for a less controversial PSD project, given that in Region 10 almost all PSD projects these days are probably controversial, but not in all regions.

We did a similar MPE using the WRF data that we ran for Tony and the Allegheny County, Pennsylvania, SO_2 segment. And we ran that for a -- and redacted the NPE. So it was a no-name power was the name of the power plant. And we distributed that, given that to Region 3, I think. And I don't know if they have used that as a template elsewhere.

But I don't think that the cost of generating an MPE, model performance evaluation, is a significant chunk of -- it's really not a significant chunk of the total budgets for any PSD project that I've ever done. So I don't think it's a huge hardship.

Moving forward, I think that's -- that's probably the -- the part that I'm going to get on the tallest high horse about. I spoke this morning about how the AERMET model formulation was designed really around the types of meteorology that you can measure and the types of physics that you can try to estimate using that measured meteorology. So its formulation is really centered on what you can measure over layers. And that formulation -- I don't believe that has been revisited in a number of years, at least 10, 15 years; something like that.

Well, at the same time, according -- as you see on the Question 3 here, the prognostic models, WRF and soon MPAS, M-P-A-S, the model for prediction across scales. That was -- that's the next generation that's on its way up the scales through the National Center for Atmospheric Research.

Those models are undergoing constant development. So we're having a little chat after the morning session here about how we could better feed the things that WRF can calculate, and that we believe that it calculates reasonably well, into AERMET more directly without having to go simplify it or dumb it down to match what things people could normally go out and measure in the real world.

For instance, the latent heat flux from soil is extremely difficult to measure. You have to get a sonic anemometer and a high -- high frequency temperature and relative humidity sensor to do direct -- any correlation measurements. Nobody wants to do that. Well, I think it'd be fun, but not many people are willing to do that for a project.

But WRF can -- can calculate that just fine. It has a -- it has a well-defined ground surface temperature and an air surface temperature and ground surface moisture and air surface -- air moisture. I can calculate all those -- all those things. So the ability to feed those to -- into AERMET I think is going to be the biggest challenge for the future and figuring out how much we need to validate those WRF outputs before we can trust them enough to put them directly into AERMET. I think that could be a big challenge.

Probably the biggest challenge, though, for

AERMET would be it still has that fixed idea that any daylight hour is convective. And converting that to be triggered by a sine of the fluxes, as Venky said, it seems possible to do, but I think that would require an AERMET reformulation, which would require rulemaking. So now we're talking years down the future here. So nobody hold your breath, please. I think that's it for me.

MS. MOHR: So, again, I'm Ashley Mohr from EPA Region 6, in the Dallas office. I'd like to thank Chris for inviting me to participate on this panel. I did not confer with Bret on my comments beforehand, but you're going to hear some repetition. But I have to give a little bit of a regional perspective from EPA's side at least on kind of what we've seen by way of implementation using MMIF, using prognostic met data, projects that we've kind of encountered, applicants that we may have scared away. I'm going to let Chris take that on there.

But, again, since kind of coming out with the MMIF and using prognostic data, we've seen the advantages, obviously, just the flexibility of being able to identify appropriate meteorology for a given project, some of these PSD permitting projects, some of these designation projects that we've worked on.

So there are kind of three main scenarios, kind of key terms that we've already kind of touched on. The idea that facility is located in complex terrain, so you either don't have a met station located nearby or -- quote, nearby, or one that is nearby has a major topographic feature that stands between it and the facility, so you're not getting the wind flow that you'd expect captured at that met station that you are actually seeing at a facility or techs see at a facility.

Similarly, you may just have a -- you may not have a met station that is close enough to be considered representative. I'll give examples from a Region 6 perspective for each of those.

And then, finally, I'm talking about observation monitors that have large periods of missing data. And our example on that is the offshore stuff, because there's a lot of offshore -- those projects are very hot in Region 6 right now, so we've -- we've been talking with a lot of consultants and industry on that and addressing that particular problem.

I'm just kind of going down those three examples. I guess that's Scenario 1, talking about complex terrain, we had one of our state agencies --

it's actually a state-issued permit that they were looking at -- at a facility that was located in complex terrain. And they had concerns that the -- the met station wasn't representative, wasn't capturing the fact that this facility was located in a valley and the wind flow that was associated with that.

Ultimately, they did not go by way of using WRF/MMIF. They actually went towards the more expensive option of installing an on-site met station. For their purposes, that company decided that was the way for them to go. This is kind of early in the rollout of WRF/MMIF.

The second case, that was for a designations project that we worked on in Region 6. There was a met station I think within, like, 50 -- 50, 60 kilometers. But, again, there was a reason that they didn't feel that that particular airport met station was representative of the facility. There was a closer met station to the facility, but it had missing data, a lot of comm hours that were giving them a lot of problems. And so they approached Region 6 and the option of, you know, prognostic met data's out there; how can we use this, does it provide an option for us.

That's actually one that we did work with that particular state with that project. They went through the full -- they did -- they did use the EPA WRF, the 12-kilometer grid WRF run, but they did their MPE using some of the examples that were given by headquarters and then by the region itself.

That model performance evaluation actually focused on both the regional scale, so we asked them to look at statewide, how is the model performing statewide, not just within the particular area that they were looking at the designation; and once they had a handle on how the model was performing at that larger scale, then looking also at the local performance. And I believe that they did use METSTAT and AMET for some of that MPE work that they did.

The third scenario was just kind of the -- the more common one that I've been involved with lately, is the offshore permitting. As Bart mentioned, I -- it was not known to me, and so getting involved in these projects, the availability, number one, of buoy data is -- relative to the -- where these facilities are located. And when you start looking at the met data, large periods of time where either all observations are missing or specific parameters that you need to feed into the model are actually missing.

So, initially, the applicant came to us with the idea of, like, you know, we're looking at using the buoy data, but we are interested in prognostic met data; you know, what does that involve; you know, how can we get the actual WRF data and then look at doing the model performance evaluation.

Ultimately, that was -- for that particular project, they decided to go with the buoy dataset and do some pretty intense data substitution based on the observed data that was out there, and they did not go by the way of doing the actual WRF/MMIF from a segmented approach.

And that kind of lends itself into, you know, these are -- these are three scenarios, at least in Region 6 perspective, that WRF does give us -- the WRF prognostic met data gives us an advantage. These are areas where there is a need. Obviously, the community has, like, identified these needs and -- and we're willing and we would like to work with the community to kind of be able to generate more opportunity for using this met data because of the flexibility that it does provide. But it does blend into, you know, well, why -- the two or three examples I just gave you, the -- those folks walk away and install a tower or try to piece together very incomplete buoy data. So that talks about just the -- the challenging aspects.

I know something that hasn't really been touched on, kind of initially the challenge was the idea of, like, how do we get WRF datasets that exist; specifically, the EPA's dataset. So early on, folks were asking how can we get that data, where do we go to get that data. Headquarters heard that concern and they did develop a methodology and procedure where, you know, you have a single point -- there are single points throughout the country where applicants can go. So that -- that was an initial challenge that we faced, but -- but, like, the -- what's in place now has been working for folks to address that challenge.

So kind of moving into the existing challenges, the ones that we still feel like that we're facing, one is just the level of familiarity or comfort of the dispersion modeling community when you start talking about prognostic meteorology.

The idea it's -- it's the same world, but it's two very different sides of the world at times. And I speak from experience. My master's degree was in more prognostic modeling. I was doing 3D chemical -- or photochemical modeling. I went to consulting and they started talking about dispersion modeling in AERMOD and it was a totally different world for me. So there was a learning curve for me to make that adjustment from using photochemical modeling, 3D modeling to dispersion modeling.

So I think a lot of times now when we are talking with industry, applicants or even, like, states who might be skeptical, it's -- they're just not familiar with it. And so the idea is, like, there's a learning curve there. Like, even if they're not going to do the modeling themselves, there's a learning curve to understand what is actually -- you know, how is the model set up, what -- what do the outputs look like; you know, later on, how do we evaluate how the model is performing.

And for a lot of the projects that we're facing, that learning curve -- that's more time. That's more resources that for projects that are very time-sensitive, while it may not in the long run take as long as some of the alternative approaches, at the time, it's just an additional hurdle that some folks just feel is too much to overcome. And a lot of that has to do with being the first or second or third person out of the gate of doing something that is truly new to them.

A kind of similar challenge in the way to do that is just the perceived introduction of uncertainty. And this really centers around the model performance evaluation piece and the idea of, like, you know, what is that, what does that require, how do we do it, what are the tools, how do we get access to those tools. And so a lot of folks are -- are asking do you have a go-by, do you have an example, is there a guidance document out there that I can -- that I can, you know, refer to. Because, you know, based on experience, like, you know, when we're doing permit modeling in particular, states have guidance that they use for permit modeling. EPA has guidance as well, but it's related to permit modeling. So folks are really looking for that type of a guidance document, especially for something that is, you know, new to them.

The model performance evaluation is -- on its own is perceived as an additional step in the process to even get to the point of doing the modeling. So they're trying to generate this met data, but to do that, you have to show that the model is performing well enough and is appropriate in your scenario. So the question is what if we go through this, quote, research project, which a lot of them, you know, think that it might become, and the answer is the model's not doing very well.

So then they feel like, well, now we're back at square one. So instead of being at square one, we want to invest our time, our resources into putting in an on-site met tower or we want to invest our time and resources in having discussions with the permitting authority to determine is there a way that we can stitch together a dataset that is representative of our particular facility.

So, again, the last two challenges are really additional time and resources. I think a lot of that is just because there isn't a lot of information out there about what really is involved and there's kind of a misunderstanding of what -- the additional step and it takes. So I think that kind of -- and, again, this is something that's been touched on, especially by Bret. You know, moving forward, the idea of, like -- I think a big piece in improvement is more guidance; you know, more examples, which I think with time will come and more folks will be able -- you know, will do these types of evaluations. There will be -- like, in Region 6, our applicant was very interested in what Region 10 was doing because that was the first, you know, tangible document.

This is what an MPE looks like. This is what I need to do. So in time, we'll get that. But in the meantime, until we have those scenarios and have those additional examples, I really do believe that, you know, additional guidance on how to actually perform that model performance evaluation is an important piece, because in our experience in Region 6, we don't have a lot of interest in folks that are actually running the model. They're not looking to create their own scenario and re-run WRF and then come up with their own model and scenario to then evaluate and feed their modeling. They want to use the off-the-shelf stuff that's already out there and then evaluate it to justify it for their use.

I think as part of that, something to keep in mind is also making ways to standardize or streamline that evaluation. While it -- while it can't be black and white and it certainly shouldn't be black and white, yeah, you have the steps that are taken. It would be beneficial, I think, to all the stakeholders in the process -- obviously, those doing the work, but on the flip side, the permitting authorities, whether it be the state or local level, or, in our case, when we're looking at offshore, we are the permitting authority for that at EPA.

You know, knowing that, you know, the applicant followed this standardized methodology that was, you know, provided in guidance is a helpful starting point because you kind of know that you're coming -- you're coming at something that is -- that is standardized, is something that you have at least somewhat of a starting point of where they -- they began their evaluation. So I think, again, that -- that will help with the overall implementation for all stakeholders.

I just want to touch on Eric Snyder in Region 6. We were talking about this. We have -- one of our states actually has a model performance web-based tool. It's not related to this in any way. It's for their ozone modeling, but on their website, they can, you know, choose an episode, choose a site location and it produces statistics there. It has graphs. It has a map that's interactive. And so something like that just makes kind of that burden of trying to do a statistical analysis, you know, more -- more user-friendly.

So, again, that's -- that's kind of the Region 6 EPA perspective on, you know, where we stand, what we've experienced and kind of where we would like to see it go forward.

MR. MISENIS: Thank you. We've got time for questions. Anybody? You folks ready to go to Bad Penny?

MR. ANDERSON: I have a -- I have a question for EPA. And this is a -- this is a real-world scenario here. And it's, like, there are -- we had an EA -- you know, for those that are familiar with the oil and gas world, you know, it's, like, you get a lot of small projects, you know, where we have -- that don't rise to the level of doing a full environmental impact statement.

And so these small projects are what we call EAs, an environmental assessment. But it's all part of a NEPA project. And we had one particular case in southern Colorado where we had the -- the issue that Ashley described, was that we had airport data at Durango, but the area that we were modeling and where the development was occurring was, you know, two mountain passes over from there. And so it was not likely that the Durango airport data was very representative of this.

And so I had approached the EPA regional office about using MMIF data in lieu of, you know, observational data, and the response I got back was a bit frustrating to me from the perspective that, you know, we had -- they insisted we had two years of nonconsecutive four kilometer data in the area, but we didn't have a third year. So the question becomes is it -- at what point does the -- does the regulatory -- even though this wasn't technically under the auspices of Appendix W, you know, we -- we try to follow Appendix W to the extent practical, you know, in -- in the NEPA world.

Does the -- does EPA look at relaxation of the requirement for three years of data, you know, to treat it more like -- you know, it's like you're actually extracting the meteorology at the location where the development's occurring. Could it -- could it philosophically be treated as on-site data and, you know, thereby, you know, having the one year -- because at that point, we just -- when we were told we had to have three years of consecutive, you know, prognostic data, we had to abandon because we weren't -- the off-the-shelf data was available, we just didn't have -- we didn't have a three-year dataset that was consecutive. So we just had to abandon it altogether.

And so to me, it was a -- to me, that's a lot. You know, that's an area I think, you know, that we could explore in terms of future regulatory development; is, you know, philosophical, you know, sidebar on that. You know, it's like, you know, what -- is this a -- is this potentially a -- an impediment to actually getting an environmental analysis done with something that is representative of that area, but because of -- because the regulations prevent, you know, we don't have that full data, that full template dataset available to us that the regulations got in the way of actually doing the analysis.

And so, you know, I'm throwing that to EPA as, you know, is that something that you guys would be willing to think about, you know, as far as your relaxing -- you know, relaxing the -- that requirement, you know, as a computer extracting, you know, for the area where you're modeling, or are you going to insist on three years?

MR. MISENIS: I'll give it to the boss man.

MR. FOX: The current *Guideline* is the current *Guideline*. So to make any changes to that would require regulatory process. So you're -- you're fully aware of that.

MR. ANDERSON: Yeah. I'm just asking --

MR. FOX: I think from a -- from a broad standpoint, I mean, our -- our job and -- and the first realization of getting these data available for use was to -- to do just that. And so as we look forward in terms of what -- what should the, you know, temporal nature of these data be for future considerations, I think we're open for discussion and evaluation and looking at those things and recognizing the strengths that some folks may have.

At the same time, I think it is an incentive or, you know, drive -- driver for people to be developing these datasets across the country at levels -- you know, resolution that would be appropriate. So at the same time, over time, a lot of these questions or these issues hopefully will resolve themselves because there is an incentive for these data to be available, broadly speaking.

We've got 12-kilometer data across the entire community that we are providing, but I realize in the West, you know, there's a lot of need for more resolve information. So from a -- from a Clean Air Act standpoint, programmatic standpoint, the *Guideline* is what it is, but I think the conversation can go on and should go on to think about ways in which we should consider use of appropriate data when they're obviously, you know, more appropriate than an alternative, which is what you're putting forward.

In -- in the NEPA context, that, to me, again, is -- is a tougher context. It's not under the Clean Air Act, and so the *Guideline* is a benchmark or something to -- to look to. And so from that standpoint, I -- I would have thought there would have been maybe some consideration of using those data, even though it's only two years, because the general standpoint is that the *Guideline* is there for a reference or consultation purpose, but it is not enforcing in the context of NEPA. At least, that's my understanding.

MR. ANDERSON: No. That's -- that's a very good point.

MR. FOX: And -- and NEPA is not listed under the *Guideline*. NEPA's a separate act. And, again, you know, in terms of dynamics of -- of NEPA, EPA comes to the table as the participating agency and provides information and requests recommendations as to how air quality should be treated. And I would -- I'm surprised to hear that -- that in a situation where you might have better resolve and more appropriate data those data weren't used and -- and rather be stuck with the -- a less representative situation.

In those cases, I think we have flexibility, you know, because that's not under the formal *Guideline* under Clean Air Act.

MR. MISENIS: Anybody else? I think you've asked a question every panel, Bob. I should have just come and stood by you.

MR. PAINE: No. That's okay. I have the question about the -- the skeptic. Are these databases real, how do they compare to real towers or profilers. So has there been an extensive evaluation done on -- against real towers and real situations or NOAA profilers so we can get an idea of other biases? Depending on how you run WRF, what's the resolution needed to be confident of the met data? So I think that would be helpful.

DR. BRASHERS: I can start out with a quote that I heard many years ago comparing observations to model. No one believes the model except for the modeler. Everyone believes the observation except for the guy who took it.

It's hard to measure stuff anyway. But there are a number of profilers out there that one could use. And I have personally not done that. I think that very few of my domains were in the area and in the time period when those profilers were operational, because NOAA shut down a bunch of those profilers in about 2015 or so, or they started to drop off and not become available.

We did do some work for Allegheny County with a RASS, was it? It was a RASS, radio-assisted sounding system. And, you know, that was a mixed bag because of that same quote that I said. It's really hard to actually measure stuff.

MR. PAINE: I guess the follow up is that you -- if you apply -- if you have this WRF data developed for a place that you have no data to check it against except for surface data, how do you -- how do you know whether it's right aloft?

DR. BRASHERS: Every WRF model is a series of nested grids. So the innermost nest is probably the one you're going to use to run AERMOD with. And there are outer nests which feed their boundary conditions to the inner nest. So impose their will upon their -- the inner nests. So there's always some soundings that are -- or some sounding locations that are within at least some of your outermost grids. And we can believe that the physics of WRF is the same for all grids; therefore, we believe that the profile was the same. And we can always extract the profile from the innermost nest and say, "Oh, yeah, that looks about the same as the hour from the outermost -- outer grid."

MR. SADAR: It actually was a sonar, but we -- we are now operating a sonar RASS and we just hopefully got good valid data last week using a radio sonar and validation. And hopefully we'll have at least a year, maybe two years' worth, of sonar RASS data on a large main industrial site that will be very helpful.

DR. BRASHERS: Perhaps you're in the next set.

MR. SADAR: Yes, exactly.

MR. MISENIS: Any others?

MR. MALONE: To both of you gentlemen, Bret, did you consider the four kilometers a small enough grid cell size for your project? I'm assuming you're talking about somewhere up in the Sandlin Mountains.

And, two, to your comment about you want to get the distribution right, my concern is -- is a little bit further north, along I-70, right now it's pretty quiet, but in the past, it's -- they had lots of gas development and it's expected at some point in the future they will again where the valleys are 500 meters across at best. If you have a distribution that is still going to ping up against the sidewall, how do you model that without getting impacts that are unbelievably high?

DR. BRASHERS: Higher resolution pretty much. I mean, if -- if you figure that -- well, it's kind of consistent with the idea of how closely you -- you space your receptors downwind of the Gaussian plume. You want to have three to five points across the Gaussian distribution, right?

So if you figure a -- a valley is something like an upside Gaussian distribution, you might have at least three points across the valley. So if it's on -- if it's a tight enough valley, it's 500 meter resolution, you should probably go put in a met tower.

MR. MALONE: That's what I currently argued, but I just wanted to hear other people's opinion.

DR. BRASHERS: It's -- it's pretty hard to get WRF to run at 100 meter resolution. I've done it at 300 meter resolution for Norwegian fjords and that was pretty challenging.

MR. MALONE: I got some hope from Allegheny County. A couple of years ago a representative showed some stuff and -- along some river valley and that was much more representative than up until that point I thought was possible. But -- so I was curious, Bret, was the four kilometer good enough?

MR. ANDERSON: I -- I can't answer that question because we never got to use it. So we never got to the point of actually doing a -- you know, an evaluation of it. But I -- I think philosophically I would -- you know, I'd like to address -- because similar to Bart, we had a -- we had a court case that we were working on in northern Arizona a number of years ago where we had -- and Lyle Chinkin in the audience knows what I'm referring to here. And it's, like, you know, we had a really bad -- you know, it was a SNOTEL site that was being used to drive AERMOD to deposition work. And we had, you know, large chunks of missing data that were out of the observed dataset. So we ended up having to run -- we ended up running WRF at 200 meter resolution for an entire winter ski season and were doing, you know, deposition modeling on the face of a ski resort.

And, anyway, we -- we faced that same challenge that you were talking about in terms of getting -- getting the appropriate resolution but also how do I evaluate -- how do I know if this is good enough, because I -- if I had observations, I'd use them. Since I don't have observations, there's a reason why I'm running WRF.

And we -- you know, what we did was we came up with a -- came up with a kind of philosophical paradigm of saying, first of all, we would -- we would compare the outer domains. So, you know, we started off at, like, a 16 kilometer outer domain and worked our way down to a 200 meter resolution at the finest domain over a 20 kilometer area. And in the areas where we -- we had -- we had a sufficient number of observations in the outer domains -- you know, the three outer domains. And so we compared performance at each of the three inner -- you know, outer domains against not only the observations but we also compared that in this -- against other modeling runs of both MM5 and WRF that had been done for the same area for the same time period and looking at -- you know, looking at how they statistically performed; you know, how they -- how they compared from one study to the other to kind of get us a benchmark of, you know, are we in the ballpark of sanity in doing those sort of things. And is -- that's one of the -- one of the things that you have to -- you know, in transitioning towards the use of prognostic data, it's probably a little less of an issue when you're talking about 3D, like, with -- you know, using a three-dimensional model. But it -- it's really -- conceptually, it's difficult to get a handle on when you're trying -- when you're talking about using meteorology for a single site and, you know, how do I -- how do I -- what grid resolution do I use, are the physics options I'm using appropriate and things like that. It's a kind of a -- you know, you're really focusing on --

you're focusing on the microseal and you're extracting for a single site and doing it that way. And so that -- there's a lot more consideration that has to go into, you know, if you're modeling in areas of complex terrain and you're extracting for a single site. To me, that -- that imposes an even bigger challenge on the person that's actually developing the meteorology in that area. I know that doesn't answer your question, you know, but there isn't -- there isn't a good way to evaluate these things because, just like I said, it's kind of a -- it's kind of a Catch-22 argument. If I had the observations, I'd be using them, but I don't have it, so I have to -- I have to rely upon a lot of sound judgment, like what Bart was talking about, is making sure that I have a -- you know, that resolution is sufficient to resolve the, you know, terrain feature, the graphic feature that you're concerned about and that you have the appropriate selection of physics packages, you know, that you're concerned about, you know, stable nighttime boundary layer. You know, there are certain options that you would choose inside the prognostic model to do that versus, you know, if you were running, you know, at a 12 kilometer conus where you were, you know, worried -- they're generally concerned about, you know, just, you know, model speed in order to produce a solution rather than focusing on, you know, the -- the microclimate of a particular environment and selecting physics packages tailored to what -- you know, what the issue of concern is. And so I'm done babbling.

MR. MISENIS: Thank you. He was trying to run out the clock. Any other questions?

No. Well, please join me in showing our panel --

MR. BRIDGERS: So as promised, we kept the time. And thank you to everyone across the day for your attention. We thank all the panelists again for their insight and their comments. We will start again tomorrow at 8:30. We have one more panel. It will be an exciting panel, I think, on near field and long range transport-related evaluation criteria. And then we have a few more presentations by the EPA before we have the rest of the public hearing.

And so with that, I will close the public hearing for the day and see everybody back at 8:30.

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