

13th Modelling Conference - Session 2

George Bridgers:

Welcome back everybody, I will formally reopen the 13th Conference for the afternoon session. It appeared as if lunch did not go as catastrophically as I thought it was, a lot more smoothly than the entrance into the building this morning. Again, I am not pressuring anybody, just letting everybody know that is a tablet, that if you did have problems getting in this morning, across the afternoon during the break, or at the end of the day. Put your name and some of the basic contact information. I'll make sure that you are in the Visitor Management System for tomorrow so you will not have trouble getting in.

I had a very popular question over lunch and had people asking over the morning break. As interesting as it appears on your phone that there's a guest Wi-Fi. The short answer is "No."

[laughter]

Slightly long answer is we would have to have a model number, the serial number, the MAC code of the device and your blood type and a couple of other things to then register to get you permission to use the guest Wi-Fi. And I might get an answer on that in 24-hours. So, that the short answer is "No.". I cannot figure out why a hotel can work out Wi-Fi, and we can't. But ours is sort of a secure guest Wi-Fi.

But for this afternoon, again, the afternoon session was structured, of Conference Day, to be forward looking. So, the next three talks are going to focus on different agreements and relationships that we've got with other federal partners, and activities that are going on. And first up we've got James Thurman to give us an update on the Federal Highways front.

James Thurman:

Just to introduce myself again, James Thurman, Air Quality Modeling Group. I do want to point out, as George mentioned in the comment period ends 22nd and my birthday. So, feel free to send me a birthday gift certificates.

[laughter]

The docket is one of those milestone birthdays [unintelligible] midlife crisis. If my wife says she supports it, then I [unintelligible] have it.

[laughter]

So, I'm going to give an update on the interagency agreement between EPA and Federal Highways Administration. I have a couple of Federal Highways folks back here, George and Chris, in the back. I kind of got into this earlier this year when Chris Owen in the Modeling Group moved to the ORD side. And he already did this work.

So, the history part, I'm not as well-versed in, but the upcoming I we're involved in. So, this is a brief history on -- don't worry. And then we have 20 minutes to, say, we'll take like five,

everybody who's -- there are people who are [unintelligible].

So, since 2017, EPA and FHWA have collaborated to further the state of the practice for mobile source modeling. This was after EPA replaced CALINE or CALINE3 dispersion model -- I forget which one -- with AERMOD in 2017. And so, EPA-FHWA reached an interagency agreement for 2017 to '23. This is in the federal employees. [unintelligible] before -- yes, whatever, but going now with the model. Everybody's been learning the new system that's being inside EPA.

Anyway, this first IA, research areas were integration of AERMOD's urban option with RLINE, obviously, work on RLINE itself, work on roadside barriers, [unintelligible]. You've got the different barriers, vegetative, solid barriers, hedge effects, but then also vehicle induced turbulence, if the vehicle instead of creates a wake. We did kind of account for that in AERMOD, now your initial sigma-z and sigma-y. So, looking at those in more detail to sort of learn more about the model.

So, what was the outcome of that collaboration that just ended? I was getting a reminder yesterday. Obviously, the integration of RLINE into AERMOD version 19191 is a beta option. And then this proposed as a mobile source type. And this updated the *Guideline*. We also -- originally, urban options were not integrated with RLINE, but it's been integrated with RLINE. And we'll talk more details about both of these tomorrow. So, this just gets you to want to come back tomorrow to hear more about RLINE. Those are the two main outcomes of the collaboration. I think there's still work going on the barriers and the turbulence.

So, the new work that just started technically in September, we entered a new IA agreement in 2023. The research areas, again, vehicle-induced turbulence where EPA's ORD wind tunnels were used to further look at vehicle-induced turbulence to better characterize those wakes behind different vehicle types and how they mix together behind those vehicles' emissions. And then this can help lead to better adjustments of the additional sigma-y, sigma-z terms in AERMOD when you're modeling these mobile sources.

What could be possible adjustments to what's in AERMOD now, and then adjustments to the inputs? We also look at special class configuration of roadways like depressed roadways, capped roadways. Those are my understanding [unintelligible] is the roads where, I think it's like an overpass, it sounds like it's actually -- they would put parks on top of the road, so stuff like that. Again, more work with the vegetative barriers and solid barrier and the hedge effects, working with FHWA tech on that.

And also, they developed methodology for modeling those roadways to AERMOD. And finally, looking at scoping out a field study for mobile sources, you know, protocol, possible locations, and test methods. So, now, I'll just say, yes, we literally just started last week or so. So, I think that's all I have on that.

That's it, five minutes.

[talking simultaneously]

George Bridgers:

Efficient. Sufficient. If you have questions about FHWA, I'll encourage you during break, which we might get to earlier, because he was efficient, to talk to James.

[laughter]

And if there are other questions that James doesn't have the answer to, some of the previous folks. Chris Own and others that were involved with this project before, can possibly answer questions during the break.

So, next up, and the first time that we have him on the floor today, is Matt Porter.

Matthew Porter:

Oh, perfect. Thanks.

George Bridgers:

Take your time.

Matthew Porter:

Oh, yes. Thank you, James, for helping me out there. As James' presentations are abbreviated, I can add a lot of words to my presentation. But it's a pleasure to join you all today. I'm Matt Porter with Air Quality Modeling Group. I've been with EPA, as of last week, for a year. And prior to this opportunity, I used to work for the North Carolina Division of Air Quality, in Air Quality Modeling. And my experiences before that were in consulting.

And I see familiar faces from state and in my consulting days. I see some new faces. And all I'm going to say to the new faces is, don't believe anything about the consulting[unintelligible] people say for sure. That's not true.

So, this work I'm going to talk about today is a collaboration with the FAA. They sponsored the work. Most of the work was conducted by UNC. The developers of the code, aircraft plume rise code, are here today, Dr. Gavendra, and, and Sarav Arunachalam. I'll do my best. But thanks for joining us today. And then there's also Dr. Venkatram, which I believe is at the University of California, Berkeley. But they beat my Cougars[unintelligible] over the weekend, so I'm not going to say much more about anything. Sorry. Next.

So, the work has been going on for over two years. So, they told me to work -- I took it over from Dr. Chris Owen last year. The work's transitioned to me exclusively now. But it's a collaboration between EPA, FAA, and then UNC. And the origins of this work are really FAA's tool for air quality, their sort of emission preprocessor, the Aviation Environmental Design Tool, AEDT, and its application under the Clean Air Act to dispersion modeling demonstrations.

AEDT preprocesses airport fleet emissions and parameters for input to AERMOD in the form of an hourly emissions file. These are inputs for aircraft plume rise [unintelligible]. Basically, these files, these hourly emission files with the area and volume sources that are included on the order of tens to thousands per hour, can get quite large, upwards of gigabytes for a one-week analysis

period for a very large airport, Chicago or Atlanta, LAX, for example.

So, the other motivation for this is refined source characterizations for PM_{2.5} and NO₂ demonstrations at airports, under general conformity, SIP planning, some attainment demonstrations. It's also, you know, AEDT -- preparing AEDT and AERMOD was called out in Section 10 of the *Guideline*.

So, let's talk about the implementation, the code in AERMOD that was changed and the ARISE [spelled phonetically] F module that was added. This is a significant achievement in that over 3500 new lines of code were introduced this alpha option. So, congrats, UNC, for getting that across the finish line, with a lot of testing involved with getting that code integrated with all the other Alpha updates.

And again, this introduces seven new aircraft plume rise parameters from AEDT, handed off to AERMOD for hourly emissions file. And here's a listing of them, I've scalped from the AERMOD user's guide. You'll find this in there. The fuel burn rates, the aircraft thrust, aircraft speed, air-fuel ratio, bypass ratio, and the rated power. Just seeing in parentheses there provide us a ratio for rated power.

There is a differentiation as far as the code logic between how plume rise is calculated, shaft-based and non-shaft-based engines, turbofans and the like, for both jet engines. I have some examples of those for y'all's reference later in the presentation. Source angle also gets tied into inputs, as far as the calculations, with respect to plume management, how it's [unintelligible].

This is a hard slide to get through. So, I'm going to try and gloss over the details. The notes on the left, well, the first one just kind of refers to the stuff to the right. That's what's going on AERMOD as far as the code logic of the mathematical formulations. But the second bullet, I'll read through that first, just to talk about where -- AEDT is generating this hourly emissions file based on sub-hourly aircraft or airport activities, whether it's, you know, runway or airborne, operating modes, and things like that.

All those types of activities across different aircraft types get baked into the time-weighted and fuel burn-weighted averages. And it's a function of aircraft operating modes, the number of aircraft, and the engine types, you know, the length of time [unintelligible] going through, the volume sources, the area sources, tens of thousands of area volume sources used to simulate all the activities from the different hour -- different hours, per day hour or hour of day and the day of the week for that simulation analysis period.

I can refer you to these equations in the paper that describes this theory -- calculations more in detail, which is one, two and three, these weighted average functions, some summation functions that are really narrating what AEDT hands off to AERMOD. Then as far as some of the key terms that are involved with the equations on the right part of the screen here, the total plume rise is just the buoyant and the moment flux plume rises, added together.

The formulation for the buoyancy-induced plume rise focuses mostly on the buoyancy parameter there. Let's in the upper right-hand panel there. And that's really one of the keys ingredients of

variables there is fuel burn rates. Then there's also the differentiation between, as far as thermal efficiencies for shaft and non-shaft based jet engines. And then the lower left-hand panel there is on horizontal jet momentum. That's only applicable to turbofan and turbo jet aircraft types. Lower right-hand panel puts that all together as a function of the initial plume radius in the -- as the plume radius grows, additions to the maximum plume radius at some -- down distance, effective down the distance.

And here's a nice graphic here I pulled from the supplemental material in the article [unintelligible] that kind of shows the collection of aircraft and engine types that this new feature of AERMOD and AEDT really [unintelligible]. I also pulled this graphic -- this table from the supplemental material from the paper just to kind of show folks, you know, what are the numbers of -- what do these airports look like typically, you know? How many turbojets and turboprops, turboshafts, aircrafts, or system on the aircraft are operating large, medium and small hubs?

There are definitely more piston-based aircraft operating out of the general aviation hubs. Then the large turbojet and turbofan, those aircraft engine types are definitely more prevalent in the other locations, and turboprops to a lesser extent.

And here are some schematics just for your reference. I didn't want to download the supplemental material. But there's the example of a turbofan jet on the left there. And on the right is a turboprop engine. Again, these are both going to include buoyance and momentum components of plume rise. And then the shaft-based engines, so turboshafts and this.

Now getting into some of the buoyancy flux calculations just to kind of idealize the buoyancy flux calculations. We have landing, taxi, take-off, and climb-outs. You know, the buoyancy flux values here are on the order of thousands for takeoff and climb-out. This is all plotted against fuel burn rates there. So, we're talking 10 kilograms per second. That's, you know, 2 to 3 gallons per second of jet fuel. So, that's quite a lot. So, they're operating in that mode, not often, but this is just kind of an isolated example of how to calculate for the buoyancy flux for the different thrusts that are better shown by color for different bypass ratios and different aircraft speeds.

And then, of course, the -- what stands in stark contrast, this is how much less things -- how much less buoyancy flux is cranked during taxi. And take-off and climb-out are pretty cool ones, relatively equivalent to one another. Oh, and that's turbine-based engines.

So, for shaft-based engines, we're talking about orders of magnitude less for all those operating modes, landing, take-off, climb-out, and taxi. There's certainly a lot more -- there's a lot more buoyancy flux associated with a high-rated power piston engine or turboshaft-based engine. This is exactly that. This is also pulled from the supplemental paper associated with the theory.

And going into what this really looks like, you know, in terms of either downward distance versus, you know, total plume rise, this is sort of just an isolated calculation here separate from what this -- the full breadth of the system of calculations that are going on in the model. This is particular aircraft during take-off, with thrust of 88,242 newtons. Buoyancy is on the order of 1800, above 1800. I stated, back a couple of slides ago, this is like a turbine-based engine profile.

There are three rows of panels in there. Each of these rows is representing the fact that wind speed -- 2 meters per second, 4 meters per second, and 8 meters per second, representing different aircraft velocities. You can see there's an inverse relationship with the aircraft velocities. The slower the aircraft is going; the more plume rise is realized for the different wind speeds and vice versa. So, the other thing I would call everyone's attention to is the total plume rises -- the line and then the dots, you know, on the top, you can't read that. But then, you know, the red line, the area below that, that's the point you see plume rise. So, that represents the lion's share to the plume rise, or what would conceivably represent a turbine -- turboprop, turbojet aircraft engine during take-off.

And now going to the same series of plots but instead, this time, we're looking at a typical aircraft during taxiing. For us to produce significantly more than an order of magnitude, buoyancy on the order of value of 50, yes, there's only tens of meters of plume rise [unintelligible] simulated at least the system of calculation that's in the model. And these figures are pulled from the main paper, the theory on the paper, so --

Just to summarize, the aircraft plume rise theory and code logic that's implemented in AERMOD. Just based on my current understanding of it, it's effectively dependent on this -- the number and distribution of hourly ground and airborne traffic counts, essentially, sub-hourly. Then types of aircraft engines, fleet burn rate hourly profiles, operating modes, whether it's landing, take-off, climb-out, taxiing. And, of course, there's a lot going on in AEDT as far as preprocessing and how it's developing profiles and segments and a list of other things to generate the hourly emissions file that's handing off to AERMOD.

Then of course there's meteorological, the wind speed, stability, and mixing heights. And it's that last bullet, just to kind of call this out, you know, from the paper, the plume rise, the maximum plume rise is limited by the mixing height and the standard deviation of vertical wind speed. So, that's it. There are the references to the papers in the presentation that I used for the formulation slide that shows slide 3 [inaudible]. So, that's it.

George Bridgers:

Thank you, Matt. We have one more Interagency Agreement presentation to present. It involves our partnership with BOEM, and Clint Tillerson is going to give us that update. Clint, you have ample amounts of time.

Clint Tillerson:

I do. I might take a little longer than James but not a lot longer than James.

Clint Tillerson:

So, yes, this is, as promised earlier, a short presentation on just the interagency agreement that we have with BOEM, Bureau of Ocean Energy Management.

And so, why interagency agreement? Well, I'm not going to read all of these words to you. But this was taken out of the interagency agreement itself, where it explains that BOEM is required under the Outer Continental Shelf Lands Act to comply with the National Ambient Air Quality Standards. And dispersion modeling is one way that they do that. And through that, they have to

comply with the guidelines in Appendix W. And so, BOEM, just like us, has need for sunseting OCD and replacing OCD with AERMOD.

So, the advantages of OCD, we talked about this already today, but -- or some of it at least. It accepts multiple meteorological datasets. It accepts overwater and overland dataset to characterize the two boundary layers that are adjacent. It treats downwash from raised, open offshore platforms. And it also treats shoreline fumigation that results when the plume intersects with thermal internal boundary layer that develops first in the shoreline -- at the shoreline from ground heating.

So, just a couple of images there that you'll find, one out of the user's guide now that we have a platform downwash in AERMOD. It's an Alpha option. And then just a quick graphic that I found that shows just very simply what the shoreline fumigation is. And actually, in this particular image, we've got a stack that's sitting right there on the shoreline where we're talking about like offshore emissions.

So, disadvantages. Developed in the '80s. Last formulation update was 1989. Graphical user interface was developed in 1997 that you can no longer run on our modern computers. And I think during that time, there were not any new formulation updates. There was just graphical user interface that had just been working with the model to work with the interface. And then in 2000, there was a code correction. There was a very simple update. So, nothing since 2000 has been done to OCD.

As I mentioned earlier, it uses Pasquill-Gifford stability rather than similarity theory. It can't read the modern meteorological data files. As you know, AERMET reads a number of files. The integrated surface hourly data files are probably the format that most people use, if not everyone now. Outputs are not directly comparable to the current forms of National Ambient Air Quality Standards. So, this is a hurdle because it requires a lot of post-processing. If you have to run OCD then, generally, you have to do a lot of post-processing with the results to calculate the air design concentration in the form of the standard.

So, we had an interagency agreement that ran from 2019 to 2022, so three years. It was extended into 2023 just to complete the reports, which we're actually still working on, waiting for feedback at BOEM, in their reviews of the reports by their editors. So, we pretty much closed out that interagency agreement. We just started a new one.

The purpose of the first one was to assess the compatibility of OCD platform downwash. We already made the decision that, "Hey, this might be a quick path to get something in the AERMOD." They may not be the only option. Again, the A&WMA has been working on downwash. And at one point in time, they put some resources into platform downwash. BOEM had a wind tunnel study that was going on concurrently with the work that we were doing, looking at platforms, different types of platforms, and looking at flow around platforms. And we were able to use some of that data in our work to put the platform downwash algorithm into AERMOD.

And so, we put platform downwash into AERMOD as an Alpha option. We've done some testing

and evaluation. There's quite a bit more to do in terms of evaluation. And we performed a scoping study for shoreline fumigation algorithms, trying to figure out, "Okay, is there something out there already that we can use? Can we use what's in OCD? Is it appropriate?" Once again, to take that into AERMOD, it does require two meteorological datasets, which I think would probably be required in what we do because you've got to characterize those boundary layers.

So, we've still got some work to do to pick up on the study, to do some more work to try and figure out how to go forward. As far as the platform downwash, the testing evaluation that we've done really shows significant underprediction. So, we know there's work to do there. And then there's also work to add some things like angled stacks that AERMOD does not handle], in order to completely replace OCD with AERMOD.

So, now, we just started a brand-new interagency agreement. It was basically right around the beginning of the fiscal year. It will run for three years and further evaluate downwash in AERMOD, the platform downwash, and make some refinements. We're going to, as I mentioned, add additional capabilities to AERMOD that are needed to replace OCD with AERMOD. We're going to finish the scoping study, determine the best fit path forward to incorporate shoreline fumigation into AERMOD. Hopefully, through this interagency agreement, we will get that implemented in some form, probably as an Alpha option.

The initiative will take some work to get it integrated with alpha status through this interagency agreement. And then update the meteorological preprocessor, AERMET, if needed to support whatever meteorological changes in the process, as needed. So, we're just getting started. We haven't done any work. I think we've just gotten money obligated to the contract with WSP. So, they will be helping us with that. And that's it. Yes.

George Bridgers:

Clearly, from a planning perspective, we're running about 30 minutes ahead of schedule.

[unintelligible]

Anyway, I encourage everyone, and we're going to get to the break sooner, so I encourage everybody, find Matt, find James, find Clint, and talk to them during the break about those IAs. I think it's kind of unfortunate that all happened in 30 minutes, because there is a lot there. All three of those efforts are significant time syncs for the staff. We've got all the work that we're doing to support permitting and the issues that are going on in the Regions, all the work is going on with model development. Obviously, we're involved in the rule writing that takes time too, to go through that bureaucratic process. Then there's all this other work that's going on with our partner agencies.

Before we even talk about the other initiatives that we are working with different industrial sectors, with the industrial groups, on updates. So, this takes a significant amount of time. And I know that most folks in the room, they may not really care about aircraft plume rise. I am not belittling it. It is a great initiative that's going on with the FAA. And we hope to see that come to fruition very, very soon. As Clint said, with the BOEM initiative, we have a vested interest in

sunsetting OCD. And not that we're trying to make AERMOD the center of the universe, but it's our workhorse right now [unintelligible].

And then on the transportation side, we've had a long partnership with Federal Highways, and we're continuing to work with them. And it's a whole different set of customers, so to speak, when we start talking about the state agencies and the support we need to give to Federal Highways so they can appropriately support the transportation sector.

[unintelligible]

So, this is a matter of subtleties. So, up to this point in the day, we talked about aspects of the work that we have done, the work that's ongoing, the work that we have done with our federal partner agencies. We are going to do a transition. So, now we're going to have presentations by external stakeholders and members of the public. Actually, the first presentation and part of the second presentation we're getting ready to see are connected at the hip with us. So, we've got ORD that is going to give a talk -- and then WSP is going to give a talk with two things that we've been heavily involved with but from the perspective of, if you can appreciate the separation of, OAQPS and our operational support of AERMOD and then ORD and their research and development.

They're working on a bunch of things. And they're not going to present everything they've worked on, today. But there's a whole lot of initiatives that are going on that as they get to points of fruition then they can pass it over to us, although we're aware of what's going on. Then we can consider for putting those in operational parts of the model.

So, this is just kind of just a subtle differentiation. So, talks you're going to hear now are going to be talks on research and development and recommendations that are being offered to us and then we're taking under serious consideration for future incorporation into the model systems. And then a little later in the afternoon, we'll have comments and feedback that will be coming from, when I say, the general public, from the stakeholder community.

So, Chris, are you presenting first? So, Dr. Chris Owen is going to come speak in a second. And this is a reminder. We've kind of been slack on it, guys. We need to identify ourselves and get up here. So, Chris will do so when he gets in here. And anything that is presenting today, will be in the docket and put on SCRAM.

ORD, I guess it's appropriate, wins the contest for the largest presentation submitted. What was the original size?

[talking simultaneously]

100, 100 some megs, or 70 megs. So, hopefully, he can fill some time for us.

[laughter]

You have the floor.

Chris Owen:

Hi. Thanks for your time. My name is Chris Owen. I work at EPA's Office of Research and Development. I'm supposed to introduce myself. On the transcript, I'm going to present today on some work that I say we have been doing in ORD, because there's large team here that's been working on this topic for a number of years. So, I'm kind of the spokesman today. But really, most of this work has been done by my colleagues. In particular, I'm going to blame postdoc Jon Retter for the size of the slide deck. Just like, all the figures he makes are like 10,000 dots per inch or something like that. So, thanks, gentlemen, for helping us get out of the finish line. Over to George. There was one presentation that was [unintelligible] for computers.

[talking simultaneously]

Chris Owen:

All right. So, let's get started here. The disclaimer here, I'm going to joke about these aren't the EPA's policy. I didn't realize until a few minutes ago that I'm part of the public presentation. So, I guess I'm going to really go off record here and issue a disclaimer and just say whatever I feel.

[laughter]

So, I have a lot of trouble figuring out where to start here. It's kind of a huge topic. And I kind of decided to step back and just make a few simple statements about urban dispersion. That just said it's complicated. If you think about AERMET and AERMOD, they're really defined by field datasets that we have developed. Those models were largely rural in nature. And that's why we have the urban option in AERMOD. It's to adjust the meteorology for a different landscape.

That urban formulation that's in AERMOD is based basically off this paper by, I say, Oke. At least some of you know that's Oke. We've had this discussion. But I'll say Tim Oke. I'll say for the moment. He's been doing urban heat research his entire career. And so, this paper from 1973 is the touchpoint that AERMOD looks at, looking at temperature differences between urban and rural environments. It's the basis of the urban formulation. There's obviously a lot more to that as it feeds into the meteorology that AERMET produces, but that's kind of the touchpoint.

And there's obviously been a lot of ground covered since then. A lot of Tim Oke's work has been summarized in sort of what I would think of as a seminal book that was published in 2017. And all of that work, you know, has come a long way. So, I've kind of got a little bit of touchpoint here that that original paper was 11 pages, and that book now is 548 pages. So, just think about all the work that just that one individual has done. And that doesn't really account for some of the science here, basically, advances in meteorological technology, so ability to collect data, look at data in real time scales, that it's been something we've been -- that I mentioned here.

So, I have one other joke here. I actually asked George, originally, for 40 to 60 minutes. He gave me 40. And now I've got 90. So, thank you, George.

[laughter]

But I also -- just to kind of also look back in the past. Remember Roger's presentation on AERSURFACE. It also had quite a deck of slides. And I do actually have a slide here, a sample of Raleigh-Durham as well.

[laughter]

So, please remember that he started off the AERSURFACE looking at Raleigh-Durham. All right. So, just to talk a little bit about what AERMOD's urban option does, it actually does a whole lot of meteorology. If you haven't looked at it before, you'd be surprised at the number of variables that it modifies. So, it adds nighttime surface heat flux which is normally negative. It turns positive. And so, that creates basically a convective atmosphere at nighttime, by urban heating. So, that ends up modifying the boundary layer height.

It adds nighttime convective velocity scale which isn't present normally at night. It modifies the surface friction velocity. It modifies stability. And it also modifies the turbulence profiles due to surface heating and roughness. So, it does I. And it's, I think, overlooked. I think the number of things that are changed here and the number of places that we can look at brings that science forward from the '70s, from that original Oke paper. So, there's just a lot of room here, in general, to make some advancements on this topic.

So, the next couple of slides are really just -- this is a visual representation of what I just said. I'm not going to go over this because it's really a repeat. And these are the formulas that are employed in urban options. I'm not able to [unintelligible]. I'm just going to have this up here. [unintelligible] keep your eye on this presentation later. One of these might speak to you about AERMOD. I'm just going to section the discussion with the number of things that are modified. And the formulas here should kind of give you a sense of, roughly, the daisy chain of the inputs here.

If you start off with the urban option, the input there is a delta-T. From that delta-T, temperature difference from urban to the rural environment, that's what that whole paper really identifies, initially, its relationship to population-temperature difference. So, this delta-T here is sort of the kernel for some the work that we've got here from [unintelligible]. But I'm not going to try to walk through all these equations, but relationships there. But you've got it for reference if you like.

So, I do want to mention, you know, again, within the AERMOD space, how we've looked at the AERMOD performance, sort of the early launch years. One dataset that's been focused on AERMOD'S urban option is the Indianapolis database. It is a field study that covers several months. There were several hours that were many days over that several-month period where they released an SF6 trace on top of this pretty tall stack, basically in downtown Indianapolis that collected arcs of this tracer. So, it's really nice to have a trace so at least you know your emissions really well. And then you've got arcs of samples, which is really nice [unintelligible].

And you can see here on the right, a QQ of this database. These are, I think, arc maxes. You can see that the colors here are the different distances from that source. Before the urban option was implemented in AERMOD, you basically didn't see that plume at night from that source. The

monitor is capturing that data. We have concentrations going up, not several orders of magnitude, but the nighttime concentrations are on par with the daytime concentration. The model was missing that [unintelligible] option set.

Once the urban option was added, that plume then is able to mix down to the surface, impact the surface receptors in the model, which is happening. So, the urban option is a really important addition to the model in certain cases. Because otherwise, you might miss plume entirely.

And that's -- it's really interesting looking at the different meteorological variables that were changed here in the urban option and how they affected the Indianapolis database. The mixing height being one of the most important pieces here. That plume was able to below the mix of height for the urban options above, mix of height just [inaudible]. And as turbulence [unintelligible] mixed that down, so it then increased the impact of that source.

The current AERMET or, sorry, the current ORD take on urban dispersion [unintelligible] two conceptual pieces that ultimately kind of come back together. But we have sort of two platforms that we've been looking at data to understand the meteorology that's occurring. We have sort of a mechanical piece of this. The surface roughness really drives changes, turbulence, velocity profile. And then on the convective side to deciding how that's changing [unintelligible].

So, my talk here is basically in two parts. I'll be talking about mechanical first, talk about convective second. And this is just, you know -- this is some of the things that in ORD -- we mainly are talking about. This is not part of the Appendix W proposal. It's just that -- some research that we've been doing on this [unintelligible] future updates on.

As far as mechanical turbulence systems, largely focused on wind tunnel and LES modeling as it is. So, this is the requisite slide. If you work at ORD and the wind tunnel, then you have to show the wind tunnel. So, here's a wind tunnel. It's not quite a football field size. But it is facility several miles down the road from here, [unintelligible] actually. But I kind of realized -- and Dave is going to slap me for this later -- probably should have scheduled some tours.

[laughter]

Male Speaker:

Yes.

Chris Owen:

So, we'll see how that flushes out in the next day and a half. But it is relatively close by, and we actually give out tours as far as we go [unintelligible] lunch visitors. So, if you are interested in seeing the wind tunnels right here in ORD. You talk to me, and I'm going to try and set up later to see how [unintelligible]. Sorry.

So, the wind tunnel is -- was actually established in 1973. I think the property sticker on it indicates. So, it's one of EPAs' probably oldest pieces that's still operating and sitting there. But it's still producing data that's relevant for us to this day. So, a couple of the measurements that we make at the wind tunnel, we have sort of two measurements that we make, meteorological

measurements. So, velocity measurement is the focus here.

And up until the last year and a half, we used laser doppler velocimetry. LDV, on the left side of the slide, to measure the wind speeds. That can only give you a point measurement in the meteorological field and so have to move the probe around to get wind speed at different locations. If you want to alter components, [unintelligible] take turns. So, it's certainly time-consuming to do that.

Over the last year and a half, again, thanks to postdoc that's working with us right now, Jon Retter, has helped us to implement particle image velocimetry and how we can make these velocity measurements in a plane rather than a single point. So, in some ways, it's an infinite increase in update in a fraction of the time. So, that's really helped us think about some of the analysis that we can do with this dataset. I want to sort of emphasize that this is advancing in terms of the science that we're doing at that facility.

The other thing that we measure with the wind tunnel is concentration, right? We release wind or, sorry, neutrally buoyant hydrocarbon tracer. And then we do measurements of that tracer in the wind field. This is [unintelligible]. You can see, this is what we call the rake here. And so, this will collect six different measurements of that tracer at any time. But we also have to move that around to get samples across the meteorological field are insufficient [unintelligible]. So, we focus off on meteorology, which is important for us. And we also focus on the concentrations for dispersion.

As far as the urban work that we're doing, our current inspiration is sort of based on the suburban neighborhoods typical in Detroit, where they have a very regular grid of streets. Having lived in a Detroit suburb, you know, I can tell you that 13 mile is one mile away to a 14-mile road.

[laughter]

So, it's a lot easier to navigate than it is some places are up here, where it's like, you know, [inaudible]. So, these neighborhoods have a very regular grid in terms of blocks. A lot of these neighborhoods have effectively sort of the same sized- and shaped-houses for blocks. So, these are what are called a uniform grid. So, you would model these in the wind tunnel. Of course, some of these neighborhoods have apartments and other things like that. The velocity is going to be the same size buildings. That's the main part.

So, this is a suburban or not quite into the urban scale. If you can come [unintelligible] you see are all -- they're ascending and definitely is urban. And I can't say that we got measurements in that -- with that model that we could apply to the current. But maybe we can put that back in and see [laughs].

All right. So, this is what this looks like when we take that idealized suburban morphology and put it in the wind tunnel. This is the uniform grid. You can see we've made good space blocks for houses in the wind tunnel, and we have multiple blocks. We can have the development of that boundary layer. [unintelligible], we call are zero-degree and see the wind that's perpendicular.

Then when we want to change the wind angle, we have to take the model out. We have to cut some of those pieces off, rotate them physically, rearrange them, and we talked to David about that jigsaw puzzling since it's his favorite activity [unintelligible]. [laughs] [unintelligible]

[laughter]

And this is what our nonuniform model looks like. We actually put this on turntables so that we can rotate correctly. And this is our first foray into 3D printing so that most of these buildings are 3-d printed at the wind tunnel. But before I give you an idea of what this looks like from that sort of conceptual neighborhood, what we're doing with the wind tunnel and then the measurements that we're taking around these.

So, now that you've seen the models and the measurements that we take, let's sum this together with data. This slide sort of preps a comparison of those two different velocity field measurements, so PIV versus LDV. One of them is a sheet. One of them is a point. So, you can imagine when we're having to move the probe to each of these black points to get a different measurement versus the single measurement represented by the colored data. There are gaps in the sheet where we can't necessarily take a measurement of velocity, but it's a much more complete data than velocity gain in the point measurements.

So, that really is actual once this is set up, [unintelligible] some additional velocity measurements. Like, yes, I'll do that in half a day, something that used to take a couple of weeks for us to do. So, it's really a significant improvement.

So, here's a comparison of some of the wind speed data that we can collect, again, comparing the two techniques. And we've also added the LES model here as well. One of the things we always like to do when we're using the LES, we like to have physical model in the wind tunnel. But we have the equivalent model in the LES to make sure that we're getting similar results. There's not a bias there. So, this comparison of wind speed is typical comparison to the [unintelligible]. There's no bias between the two. And this is just an example of wind speeds, taking it to several different places within the physical model.

So, we've got one set of measurements here on the top row that are in sort of this main street, so relatively opened-up wind fetch. We've got several measurements that are in between the buildings. And then measurements upwind and downwind in the spaces between the buildings. Now, you can see the velocity profiles here are significantly affected by these buildings. But the remarkably, unaffected in the kind of open-up space where the streets are. So, this is the data that we're looking at to collect and understand better some of the meteorological profiles that will occur in an urban area.

This is an example of the LES data and sort of the reason I have this up here is to, again, take that stuff, why do we do the LES? Because we can get a much greater sampling field with the LES than we can from the wind tunnel. Even when we're taking that sheet of velocity measurements, we have to take sheets from lots of different locations and still get the same sort of density of measurements in LES.

The LES data also is just in a couple of places. It's also relatively easy to rotate the winds in the LES versus what I described before of having to physically take that model apart, rotate it, and get it aligned to do that additional wind directions data collection with the physical model. So, we use these as much as possible together where we have some common models that we'll put in those systems and then be able to branch out with LES to get additional data.

So, the other thing I want to mention here, talking about velocity profiles, actually, wind speed being one of the most important things in your model concentrations. But we're also collecting turbulence data. And I think this has been particularly enhanced by the new velocity measurements that we're making. So, I've got some examples of u^* calculations that we're making with the wind tunnel, you know, the next couple slides. And I think it's kind of interesting to tie this together with what we did in 2015 with the last Appendix W update that we made, update. One of the things that we did update there was u^* turbulence formulations there.

And so, the fact that we were able to collect new data and think about these different morphologies is really encouraging to me. So, this is an example of -- at the top, we've got wind speed profiles from the uniform building array. And at the bottom, we have our turbulence profiles as well. So, if you think about this in the AERMOD space, there's wind speed profile that AERMOD uses. There's also the turbulence profile that AERMOD uses. And these are velocity data and might have form adjustments to those that will be specific to those urban areas.

Same plot for non-uniform. And there's not really a specific takeaway other than it gets rather complicated as soon as you start changing buildings here. Take a look at the turbulence profiles from uniform building array. You can imagine the ground rise to some extent, not a lot of fun. But once we have the non-uniform building arrays, it starts to become much more complicated. And so, this kind of goes back to my intro slide, urban environment is difficult to model.

I do have a note about concentration influence. As I mentioned, we are taking those, and that will help us look at, for example, sigmas on plumes to consider with different urban morphologies. But I did just want to make a note about concentrations. In a lot of cases, we think about urban environments to produce lower concentrations because of increased turbulence. We've got more mixings. And this is for folks to keep in mind, for example, the Indianapolis dataset right, the model wasn't seeing the emission at all as soon as we have these urban environments with their increased concentrations.

So, for surface releases, you will have plumes bigger, mixed out, not mixed out, [unintelligible] probably increased concentrations. With surface releases, that idea of additional turbulence generally will decrease concentration, except when you have channeling. So, the figure on the right here shows an example of data collected between buildings and see the increase in the measured concentrations and the deviation in the Gaussian. That would estimate to our sources you can have higher urban concentrations.

This is something that's probably outside the scope of AERMOD development. But some of the folks that work with us at the wind tunnel were looking at emergency response models. So, in that arena, we think about really high-time resolution and very, very location-specific times when there might be higher concentrations in the urban model. So, this is something that we're

talking about what happened, trying to think how we can improve some of those models.

All right, last slide on the mechanical portions of the [unintelligible]. Where are we going with all this data? So, these are just some sort of recent thoughts about where we're going with this. I think there are several other issues that I mentioned with respect to wind speed profiles, turbulence profiles we can think about. But right now, I think the things that LES are talking about, the concept is not here, but something that's really obvious in the data that we're collecting is actually the displacement height.

The displacement is an AERMOD in some places. But it's not maybe as prevalent as it could be in the urban environment. So, we're trying to characterize and incorporate displacement heights, just the heights themselves, but also look at large meteorological profiles for [unintelligible]. And then as I mentioned, we're working turbulence profiles, having to think about updating its turbulence estimates based on the data in the collection.

Again, it's messy over here on the right. These are from both uniform and non-uniform, so wind directions. And you can see there's a lot going on there. It will be difficult to figure out how to capture that in a way that's operable based on the evidence.

All right. So, I'll transition to the convective model, the discussion here. This really bugs me about some of the data work that we've been doing. But as far as a little bit of concept here, when we think about the urban and rural temperature differences, there's kind of three different surfaces that we've considered in our research. So, the first one, on the top here, the blue, is the urban atmosphere, so that air temperature. Second one, in the middle, the green is the surface temperature. And then below the surface, there's the sub-surface. That's when heat sinks into the ground.

So, all three of these pieces, that temperature profile in the urban environment, are [unintelligible] fully about the changes in [inaudible] urban. So, these are all parts that we've looked at. We're trying to think about how to put together in a way that we use the data that we got to work with and how to make some data useful on the urban models versus the rural. So, yes, [unintelligible] how do we better relate those types of information to the urban space?

So, one of the questions that we really just started off with is: what are the urban heat fluxes? I mentioned earlier that the urban option is primarily a function of nighttime meteorology. So, this figure here shows a comparison of typical heat flux profiles diurnal flux profiles from several urban areas versus several rural areas. And so, this all is the data that goes into these average lines that are shown here on the right-hand side.

You can see that at nighttime, there is a pretty consistent -- for the particular cities that are examined here -- difference in the nighttime heat flux, about 50 watts per meter squared. And the rural environments have a negative heat flux. This is what AERMOD normally sees at night. And that's the rural environments [unintelligible], and the urban environments stay positive, which is what the urban option does in terms of nighttime positive looks.

But there's also heat flux during the day that can be talked about as well. But it's just

[unintelligible] greater the effects in the total heat flux in the daytime than there is at night. The other thing that we tried to figure out here is how they get things at the right scale. And AERMOD has one set of meteorology each hour. So, the exception here is that when you turn the urban option on, you get a second set of meteorology. And that's going to represent the entire urban area.

We know really clearly that both the wind speed profiles and the temperature differences across the urban area are not continuous, but there's a technique actually in the urban area as you leave it. But what we're working with right now is sort of, we have to have one set of disturbance for that urban area versus having a sort of gradual change across the urban landscape.

So, we have to think about the data that we have in a way that will calculate sort of an average over an area. So, where we settled on for this is looking at satellite data. In particular we decided to use the GEOS satellite data. It has a spatial resolution of 2 kilometers, temporal resolution of roughly one hour, so you can get data for each hour of the day. And so, we have collected five years of this data and done a lot of analysis with it that I'll show you in a couple of minutes.

I will say that we considered some other satellite products. There are satellite products that can get me like 5- to 10-meter resolutions as opposed to kilometer resolution, but those are polar augers. They pass over a location, once or twice a day. So, you get a very, very short window of what's happening in a location at very high resolution versus a larger spatial resolution where you have data 24 hours a day. Wow. This is why this slide is so big. I didn't realize this was in here.

[laughter]

When I compressed it, I thought, "We only went down 30 megabytes." It's like, "What is going on here?" It's because we've got this really nice video in here. So, this is something that Jon is showing that sea surface temperature from the GEOS data.

All right. So, the pros to using this data is that we do have an hourly resolution so that that matches the AERMOD in terms of we've got something for each hour. We prepared about [unintelligible]. We've got a single satellite data product, and we've got a consistent measurement technique. It's easy to process, just one data file that covers CONUS and sources pieced together from multiple products. And then we have the spatial resolution that's continuous across that surface as well.

In general satellite products have a limitation of clear sky only. So, we've made this a bit of a bias in that [unintelligible] cloud cover a certain surface to get that data. Of course, we talked about spatial resolution. And then, you know, when I introduced this topic, it's air temperature, surface temperature, and subsurface temperature.

So, this data is giving us the surface temperature. And we really would have liked to have had air temperature in addition to surface temperature. We did a lot of legwork for the dataset that didn't match the satellite data in terms of informing both of those. But it became very laborious to try to get data. And then we have a couple of measurements in an area that you very quickly mismatch

that spatial representation where you've got a couple potential methods here, there. Whereas the satellites give you this nice average. So, we focused really on satellite data. Although, we certainly looked at temperature data.

How am I doing on time?

George Bridgers:
You're doing perfect.

Chris Owen:

The thing that really -- I really like about the approach and the way [unintelligible] is the whole concept here is you've got air, cool air, upwind rural environment that blows its way into more urban area. But what if upwind is another urban area? And that's what this slide here represents. What if upwind is a great lake? And so, if you don't take into account those directional differences, you're not really going to see the picture of what's relevant for that particular meteorological scenario. You assume that every upwind stretch is a rural fetch and has a single upwind temperature differential. And you're going to miss a lot of the details that should be there [unintelligible] that center this dataset.

So, how have we calculated these differences? So, we've just taken the U.S. Census boundaries to represent urban areas. We talked about several other methods to characterize urban areas, including just, kind of satellite data to indicate heat islands. But there's a lot of work around using census boundaries. I think it's also very easy to have it laid in terms of communication and finding your area of what is and not is. So, it's really easy to just use census boundaries.

So, we started this when the 2010 data was out, 2010 census data was out. Jon, is the 2020 out yet or are we still [unintelligible], haven't looked in a while?

Jon Setter:
[inaudible]

Chris Owen:
All right.

George Bridgers:
Can you repeat the answer?

Chris Owen:

So, I think the 2020 census boundaries are out, but not when we last processed this data. There are 497 census boundaries. There are 481 in CONUS. So, for each U.S. census area, we defined eight upwind sectors, sort of shown here, the satellite block here. So, we've calculated temperature differences in each of those fetches, getting the temperature data, upwind – in different directions -- upwind fetch, the direction, and air temperature.

We've also done some work to correlate these temperature differences on land cover data, which we use land cover data in every AERMOD run with the surface roughness, albedo, and Bowen

ratio. And so, we felt like it would be important to understand the correlation between land surface types and the typical changes that we're seeing. And the short answer is that there is significant dependence over the expected area of these [unintelligible].

The other part of this is that the original dataset we had was land surface temperature. As I mentioned, maybe it matters to be on water upwind as well. So -- and fortunately, the satellite collects sea surface temperature as well. Unfortunately, it's a separate product and more work to get it out. But we have lots of sea surface temperature as well. So, then we've got places like here in Florida where half of your upwind fetch is over water that you can also get [unintelligible].

And so, you know, it's actually, to us, wind direction was important, you know. But was there other data out there to support this? So, you can see here that these figures are a little hard to interpret entirely, but on the left here is basically a heat rose akin to a wind rose, the pollution rose. And we see the possible winds are coming from the stretch under, so a reasonable distribution of heat. This middle plot, which I am not going to be able to fully explain, it's just showing how much of a difference there is between the urban and rural environment.

This in the middle here, this circle, it's one. That's about the average. And so, if you're above one, you've got much greater differences in these temperatures based on that direction. And you can see where the largest temperature differential, that largest heat differential, is from the southeast. And, you know, that will show up if you're just looking at the rows itself, but most of the winds are coming from southwest. It doesn't seem like that's a very important sector. But if you have winds coming from there, you're going to have a much greater difference, that temperature difference, in urban-rural environments.

So, George, this is the Raleigh-Durham plot that I mentioned earlier. I thought I'd start off with a familiar site to explain this complicated plot. And I'm only going to take a minute, explain the plot, and then I've got a couple examples that I also will show. In terms of data product, we've looked at it or reduced this data product in two ways. We have calculated a diurnal profile for each urban area that is directional and seasonal.

So, for every month, we have a single diurnal profile that covers eight different directions. So, that's what you're seeing here in these plots, are these aspects of this. So, on the left, we've got the seasonal profile. The average of that season is the solid black line. There are daytime and nighttime differences also shown here. And we've got the different directions [inaudible].

So, what's interesting here, right, is that around here, our average temperatures, both nighttime and daytime, come out to be roughly zero. But when you look at any particular direction, you get something that's either greater or less than zero. I hope you can see that. So, it really depends on the wind direction that you're getting. Because upwind in Durham, you might have Raleigh. Or upwind in Durham, you might not have Raleigh. You've got a rural environment or something. So, that's what these plots are showing on the left.

And on the right-hand side, it's showing that diurnal plot, also broken out and colored by lot, but it's focus on black and clear. [unintelligible] So, it's also interesting, as you're working these plots, to look at these diurnal differences. And so, for Durham, when you now look at the diurnal

profile, well, it is on average, zero, up until about noon. And then there does become a bit of a temperature difference gap in the [inaudible].

So, this isn't actually a terribly interesting plot. It's for the other ones but it's [unintelligible]. So, the next example we have is Erie, Pennsylvania. And the thing that draws my eye on this slide here is a diurnal difference, where you have almost no temperature difference -- differential, on average, during the nighttime. But in that daytime period, you actually have quite a large temperature difference. And then when you look seasonally, there's actually a pretty strong seasonality as well. So, in the spring and in the summer, you have a much larger average temperature profile.

Then we look at some of these outliers relative to those lines. So, circle is daytime, right? This is where we see bigger difference in daytime. Next example is Springfield, Massachusetts, again, this really strong daytime average temperature differential. And so, what I want to put in your mind about these two sites is, you know, East Coast, deciduous forests, lots of -- it's not desert. It's a lot of green space in these areas. Versus when you get to some other parts of the country, Amarillo, Texas, now, the opposite, complete opposite, at least looking at the diurnal profile behavior at nighttime. Now we have a very significant nighttime temperature difference, almost in the negative. It is in the negative on average, daytime. And so, location matters, direction matters, time of year matters.

So, if we're able to have satellite data help support early relations to [unintelligible], spatial, temporal resolution are much more represented to describe this temperature differential. And then all of that to be informed by this. Here's another area. So, Ames, Iowa, to me, honestly, Iowa, kind of green, but I mean, really? I mean, you know, it's not East Coast. It's still relatively dry. And so, when you look at the average diurnal. You still have that nighttime, positive 2 differential. You actually have a daytime positive two but, man, look what happens in the seasons, right? Completely different patterns. So, being able to represent that annual cycle is just as important as diurnal.

So, the other question that we kind of come up with is: what if the temperature differential can suddenly get a zero, or it's negative? So, there's a number of other things that you could do. But temperature relationship is data driven either by climate, geography. And so, there are lots of times, this dataset or the delta-T you're getting is zero or is negative. So, probably one more area to grab Raleigh-Durham, right? And so, some of our easy answers to this is, well, you know, there's not that strong urban-rural difference from that wind direction. So maybe you don't need to modify it.

So that's one of the things that we considered. And this is now starting to creep into the AERMOD space, how we start applying this [unintelligible] to thinking about how we can apply this potential dispersion model scenario. So, a couple of examples of what happens when you consider bringing in some of this temperature data from this dataset into sort of the current formulations of our AERMOD and adjusting some of these temperatures, some of those heat flux values. You see a really drastic difference to their profile-- in Indianapolis, which we kind of pull in because that's their database model valuation.

This is a lot of stuff. So, down here at the bottom, you see dashed is rural. And then solid is where you've turned on the urban option. Sort of, urban option is going to do the math. So, that urban option is going to have these kind of high heat fluxes at night, of course, zero during the day because urban options isn't applied during the daytime. Whereas, if you use the satellite data, you get a really different result. And it's going to vary by city effects rather than having positive data heat flux.

And then Phoenix is another. Again, this is where we saw different climate areas response from the satellite data. So, again -- so, we kind of get into like, how much [unintelligible] the model space. And we've even done some work to make these data files in the way that people could potentially use them in the future. So, we kind of work towards this, you know, maybe one way to do this, you have an urban option, and you just specify one of these data files, these temperature differences.

Again, this is just stuff that we've sort of ballparked on the ORD side. And how can we make this data available? It's a good way to ask this in talking about a web face -- web interface. The nice thing about something like that is you're able to sort of look at your urban area. And maybe even visually, they could say, "Yes, I see a heat area around my city. And so, maybe I need to consider this." And then maybe if you look at your other census block, "Oh, there's not really that much to consider in my area. Maybe I don't need to use this model."

So, this is kind of what our current iteration just looks like. So, for each month, we've got 12 different hourly averages that we compete in. And that's eight different directions. So, it's a pretty small datafile. As we've talked about the mechanical parts of this, we've talked about, how do we describe the cityscape and the roughness that's associated with that, the building morphology. So, there are some datasets out there that describe, like, the surface area of the buildings. We said, "We can put some other things in the header file placeholders to address some of those mechanical pieces in the future." So, this is just one vision that we have, how we can take some of this data to potentially make useful to the modeling community in the future.

So, we put it all together. So, this is where I come back now to the Indianapolis urban database, kind of showing what happens when we plan for these visual [unintelligible]. What's interesting about Indianapolis database is that there actually were four meteorological sites that were part of the field study. The evaluation used the airport data. There's other met data to sort of look at and validate, basically, obviously, these urban options, that we can calculate an urban versus rural temperature differential, so the rural sites, suburban sites, urban sites. So, we have met data to calculate for those temperature differences. And there's also MET data that could potentially be used with this Indianapolis database to do additional modeling evaluation.

I'm not going to have this up here to talk about any of those. So, remember the slide where I showed all the equations? Well, we came back down and said, "Well, here's all the equations. Here, tweak one or tweak the other." When you put it in, like I said, if you get that negative delta-T, how do you incorporate that? If you got a daytime heat flux, how do you incorporate that? So, this is one of the iterations of what we've looked at on ORD side. And these are the equations that I think apply to some of the stickers I'm going to show here.

So, this is application Minneapolis database. This is just the met side of it. So, now, as I said, we've got rural, suburban, urban. So, we've got on-site data that actually has the heat flux. You can see, depending on where you're at, it's about a zero-nighttime influx in Indianapolis and positive daytime heat flux.

The GEOS, this lighter green here, that actually is under -- the satellite is underestimating a little bit. And so, getting that simulation, Jon, kicking in earlier, but he's got a bunch to talk about why there's -- the satellite data isn't quite matching real data. And then the delta-T values as well. Again, just kind of a bias between the GEOS data. And there actually was a good reason for it that I apologize, I cannot remember at the moment. But I can talk to you about it probably [unintelligible].

And then when you run the model. So, this is the original urban option. This is all data that's stable hours, convective hours, and they mainly apply to stable. So, kind of just look at this middle row. This is the current urban option. And these are several iterations of us messing with stuff. Unfortunately, all of our messing with stuff makes this model performance worse. So, it is what it is. That's why it's research, and we can have results that are better. [unintelligible] But we do think there's some science that's worth looking at here that's not necessarily showing improvements in the model evaluation.

So, here's another example of Indianapolis. This is not field study. This is 2019 airport data. This is as you process it through AERMET and current AERMOD. So, to get this in the -- where a solid line is urban option. Dashed line, that's -- I apologize, but center yourself for, in terms of dashed and solid. I just kind of want to show you what satellite data does on this. So, the temperature differentials in particular, you get temperature differentials when applied to that 2019 satellite of data, between zero and one at night. They actually get relatively high temperature differentials a day. And that's as far as you can get out of this calculated value. So, we won't worry about the rest of it. So, I'll pull out this plot, but I'll try to [unintelligible].

So, I'm going to finish here with a request. I asked this earlier in the year at a Regional, State, Local modeling workshop. We're trying to find more data. I mean, this is really all about data. It's [unintelligible] all data. It's about field data. It's about satellite data. And we know that there's a lot of met data out there. There's a lot of sonic near monitors that are operating out there. But they are just data [unintelligible], just looking at u^* , looking at w^* .

And so, we do know that there are some databases that are maybe going to come online. There's one in particular that was supposed to go online with [unintelligible] waiting for that. But if you have any datasets that you think would be useful or any sites in your state that are operating a sonic, we can tap into that. It's important to get some of that data. You know, if it's the right location and it's taking the right measurements, I think that we'd be really interested in getting that information.

So, I think that's where we're going to end. I may just disappear after a break here. So, if you did want to talk about any of this stuff, I'm going to point you in the back to David Heist and Jon Retter. And if you guys did raise your hand, find them, talk to them, they will be here.

[unintelligible]. Appreciate your time, let's just talk about the extra time. I couldn't have done it in my 10 minutes. I'm taking a long time and also finishing [unintelligible]. Thank you. Appreciate it.

George Bridgers:

Thank you, Dr. Owen. I wasn't sure if we were looking at Rorschach imagery there, with a few of those, but it was interpretative. But obviously, well, obviously, there was a reason that a put that distinction there between ORD and OAQPS. ORD, obviously, a lot of research and development is going on. It's great. These guys can focus your time and energy. They don't have a lot of the distractions we have with Program office.

So, up next, we have another presentation and then that will take us to our break. And Michelle, I believe. This is another area where I put it in the public comment section because we have been doing a bunch of work back and forth. But we did want to kind of draw that distinction because at some point, this will probably be a recommendation to us. So, Dr. Snyder, welcome. Go ahead and present yourself when you're up there.

Michelle Snyder:

Thanks, George. Michelle Snyder, I work at WSP and worked on the extension of AERMOD'S AREA source algorithm to include low wind meander. This was done through our AERMOD Maintenance and Support contract. And a lot of that funding came from EPA's OTAQ office. So, I want to give a shout-out to them. This is an important topic for transportation-related applications. And a shout-out to my two co-authors. Laura Kent who left six or eight months ago. But she was really instrumental in getting this into the model and Chris Owen who we just heard from who kind of pushed us forward on this effort.

Before I start, I wanted to apologize for any flashbacks of your Calculus Class during these slides. I promise it will only last maybe six slides, but it has lasted in my head at least a year and a half. So, consider yourself lucky. All right. So, the outline here is I'm just going to talk about a history of the areas of algorithm in AERMOD, then an example application. Why is this important to you guys? And then we'll talk about the Gaussian POINT solution since everything that we do for AERMOD is kind of based on a Gaussian POINT solution.

And I'll be talking a lot about meander and coherent plumes [Slide #2, figure in bottom right]. Meander plume is a low wind speed random plume that kind of emanates in every direction from its source, they call it pancake plume. Then a coherent plume follows the wind direction. So, that's a little snapshot of the model. Then I'll talk about the way that the AREA source is currently implemented and the extension that we just added to include this low wind meander. Then I'll revisit that example application with the adjusted code. And I'll talk about future work. And I have anticipated a few questions, since I was told that you guys could not ask me any questions. So, I anticipated a few answers for you.

[laughter]

So, first slide [Slide #4], the history of area source algorithm in AERMOD. So, before 1997, ISC was the model that predated AERMOD, and they used a finite line solution to estimate the

AREA source. And then this Atkinson paper in 1997 describes a new numerical approach that was implemented in ISC. And that revision to the AREA source algorithm was literally copied, line for line, into AERMOD as it appears today.

There's a graphic on the right shows you their kind of new estimation where they've numerically integrated, which is more efficient at the time. This is buried in the appendix of the Atkinson paper. Just a warning, it's not in the actual paper itself, which is called "Improvements to the EPA ISC Model". So, this AREA source algorithm was like an afterthought, in the appendix, but hopefully informative for this effort.

And in 2005, of course, AERMOD's promulgated, and like I said before, the algorithm remains unchanged from ISC. I did find a record in our project files that at WSP. Before WSP we were called a few different things, Roger Brode actually came out of the group –and Jim Paulmier served a little bit with us. But I found some notes from the AERMIC committee, and they identified the lack of meander in the AREA source algorithm as a priority topic for future development. So, here we are 17 years later.

And then in 2019, there were low wind options that were added to AERMOD. And in part of the white paper, they definitely emphasized, although not very, like, bright lights emphasized. They did say that adding the meander, to the AREA source algorithm was a future development topic. So, our goal here today is to extend AERMOD's AREA source algorithm to include low wind meander.

So, our example application [Slide #6] this is important to you guys. What I did was I generated a simple LINE source. So, a LINE source uses those AREA source algorithms. It's one long LINE source. I'm just running FLAT. I don't care about terrain right now. And I used the hot spot guidance for a light-duty vehicle. So, it's a one lane road light-duty, it's 3.7 meters wide, 1.3 meter release height, and 1.2 meter initial sigma-z. And then I placed receptors, 50 on either side of the roadway, just along the x-axis, east west, putting 5 to 1,000 meters log spaced. So, there's a hundred or so receptors. They're all at $y = 0$. I just put them all on that line perpendicular to the middle of the source.

And I use meteorology from RDU 2018. This was pre-processed by the NCDEQ. I just pulled it off their website. The most recent one they have is 2018. And it was running with "wet," not that this matters a whole lot, but it was 99.5 percent complete. And you can see the wind rose shown there at the bottom right [Slide #6]. It's kind of a range of the meteorological variables for this year-long meteorological set.

So, results for this, okay. So, first, I took, and I found the normalized concentration. So, I took the concentration over my emission rate, and I looked at one-hour, eight-hour, and 24-hour averages. And you can see that the AREA source, when you look at the average concentration compared to the VOLUME source, they're pretty close for one-hour, eight-hour, and 24-hour [Slide #7 figure on left; left column]. But when you look at those max one-hour concentrations, and the max eight-hour, and then even 24-hour. You see a significant difference that AREA source really has a lot higher concentrations for these one-hour and eight-hour concentration averages [Slide #7 figure on left; right column]. So, AREA has higher maximums averages. But

the AREA source will still give you a similar average over that entire year concentration as the VOLUME source.

So, then I looked at a scatter plot [Slide #7 top right] and a Q-Q plot [Slide #7 middle right], and you can see here that AREA is on your y axis, VOLUME is on your x. So, I'm kind of treating the VOLUME here as my measurement. VOLUME has low-wind meander and a coherent plume treatment. So, what you see in the AREA sources are giving you a lot of concentrations that are above that one-to-one line, closer to that two-to-one line. They're all in kind of that mix and the majority of those are in the low-wind meander conditions, below 2 meters per second.

And if you make that a Q-Q plot on the bottom, you kind of see that, yeah, if the AREA source is really overpredicting when you're looking at these hourly concentrations, when you're comparing it to a volume source. And these receptors closest to the source are the most overpredicted. So, that's when we really think that low wind speed meander makes a big difference in your AREA source concentrations.

So, again, our goal here was to extend the area source algorithm to include low-wind meander. So, here's your calculus coming back, Gaussian point source solution [Slide #9]. So, this is kind of where it all starts, right? Your concentration is your horizontal times your vertical component. Your horizontal component is how much your plume spreads in the outward direction. And your vertical is how much it spreads in that up and down vertical direction.

And it's all controlled by this f here, this is your f or your meander component. Clint mentioned this –as part of the options with your low-wind options [See AERMOD Modeling System Development Priorities presentation by Clint Tillerson], you can adjust what that f is. I left it as it was traditionally. Where it's kind of a ratio of your random to your horizontal wind energy. It may not make sense, your random is that kind of meandered when your horizontal is how much is transmitting across following your wind direction.

So, an example here with my little graphic [Slide #9 top right] was if you have a low f value, you have a low f , most of your emissions are in your coherent plume. And that's kind of that darker plume[coherent], it's following your wind direction. But if you have a low wind speed and a f value like .75 where you have most of those emissions go into that meander plume, which is the plume that spreads radially outward [Slide #9 bottom right].

So, your total here I've expanded so that you have both a horizontal and vertical component of both your random and coherent plumes. The vertical components are a function of x and they're the same for both of those plumes. The horizontal distribution functions are really where the difference is between that meander and the coherent plumes. That meander random plume is defined by the equations you see here. The coherent plume is defined by the other equation, both of which are found in the Model Formulation Document for AERMOD. And I've colored the [equation] numbers appropriately comparing plumes [in the graphics].

So, the current AREA source implementation. All right. Here's your total point source [solution]. So, what you're going to do is use the figure Atkinson's provides [Slide #11 right], where it has a wind direction and a rectangular AREA source. And what we're going to do is concentrate on

what's the concentration of a single line from Y1 to Y2 [red line in figure]. And to approximate the concentration from that line and the AREA source, we're going to use lines perpendicular to the winds. Again, your wind is blowing in your X direction.

So, we use that point source solution to iterate over all the lines to approximate that AREA source. So, you're going to integrate over your X and Y directions; you notice that an area popped up under that Q. That's because when you integrate over an area, you end up getting the area of the source out. So, those areas canceled and just get Q. So, that Q over A is the reason why the AREA source and LINE source, you have to put your emission rate in as grams per second, per meter squared. That's here, where the area comes in. And it's because this integration is being done in the AERMOD code.

So, the current area source algorithm ignores this meander portion and just looks at the coherent portion. This coherent portion I've reorganized and colored so that the red portion represents that single red line in the graphic on the right, from Y1 to Y2. And you can just solve for that because has all those points along the line have the same downwind distance. In the X direction, that red line, all of those have the same X component. So, now, that inner portion of the integral is only dependent on the Y coordinate in the line approximation.

Recall that your horizontal distribution function for the coherent plume is that $F(yCh)$ -- again, in the Model Formulation Document, Atkinson does use u-substitution here, and he solves. This is the coherent solution for that single red line represented from Y1 to Y2. That u-substitution gives you a defined solution for that concentration.

So, now we're going to go back to that whole integration over the entire AREA source [Slide #12]. So, we're plugging in that solution we just found for the single line. And we're going to integrate over all lines that are perpendicular to the wind direction. And so, that's why you can say that the AREA source is just an integration of those lines perpendicular to your wind direction. And that's true. That's a great way to describe it.

The way that AERMOD does this is it picks an X coordinate. Remember, that's along wind direction. And then it integrates stepwise, depicts a single X direction, draws the line, integrates across line. Draws the next line, integrates across that line, draws the next line integrates across that line. And that's done step wise. So, a rectangle is shown here. And this is applicable to all AREA sources. It's easier to describe as a rectangle. But there is intelligent algorithms in AERMOD which will draw these lines. Even if you have a convex kind of shape or circle, it draws from one boundary to the next at the same X direction. It's going to take that line -- all of those X distances. It takes the line to approximate.

So, now I'm going to extend this solution to include meander. So, we have that initial concentration of a point to your random and coherent points [Slide #15]. Again, you can see the Atkinson figure [Slide #14 right]. This time, I'm going to look at the meander component. So, I'm not going to ignore the coherent term and I'm going to look at the meander term. Remember that you can also reorganize this so that you have your meander term representing that single line from Y1 to Y2 in red at a single X distance.

So, the same way this horizontal distribution function is defined in the AERMOD Model Formulation Document. And this has a defined solution as well. You can integrate that single line perpendicular to the wind. And the solution for that single line from Y1 to Y2 is listed here in red. That's the exact solution for the term in the middle of that integration. So, that's for a single X distance. Then again, I'm going to extend this to get all X distances representing my AREA source. I substituted in and I get a concentration for that random plume. So, now we've solved this meander portion of our AREA source. And again, we're going to use that same integration.

I tried to keep the same integration steps and pieces for the meander solution as we have the coherent solution in AERMOD [Slide #16]. Trying to do the least amount of change possible, while still getting representation. So, here's our figure again. So, in total, we have a solution for both the meander and the coherent portions of the concentration. Where we've done that u-substitution where we have B for the coherent plume. And then I've come up with my own function called V , which is the solution for the meander portion. Again, some step wise to integrate the entire area source to get the approximation.

So, let's revisit our example [Slide #18]. Okay. Remember we have a simple line source. Now, I'm going to look at the area, the area with meander and the volume source concentrations. Again, you have the average on the left-hand side, left hand column, and you have the maximums on the right-hand column [Slide #18 figure on left]. So now, again, your average AREA and VOLUME sources are similar, but your AREA with meander ones are lower. This is due to no upwind concentrations in the average. This means AREA with meander option is only going to get you down in concentrations. And that's a choice that was made by the coherent plume in the initial algorithm, and I left it as it was. And we'll get into that, why I do that later.

But now you'll see those one-, eight-, and 24-hour short term averages are on top of each other for the AREA meander and the VOLUME source. We've reduced that overprediction in those low wind speed short time maximums. So, recall the scatterplot that I showed a few slides ago where we had AREA without meander. Now, compare it to the scatterplot that you see on the right-hand side on the top [Slide #18]. And the AREA and the VOLUME source, those high concentrations are now on the one-to-one line.

If you look at the plot down below [Slide #18 bottom right], remember that the AREA source I initially showed does not have low and speed meanders in green. And you can see that those Q-Q plots kind of tend towards that two to one line. You have high overpredictions with their short-term averages. But now with meander, you're on the ones -- one line with a Q-Q plot as well. So, low winds are now close with that volume source. And the receptors closest to the source are no longer overpredicted when you're using AREA meander.

So, we're going to revisit that example. We have a runtime and the statistics here. Remember that I was using normalized concentrations. So, your runtimes here, I just ran the AREA source, and it stands right now, and then I added that meander option. You notice that the runtime is longer while you're doing a meander integration and you're doing a coherent plume integration. So, you're doing the integration twice. That's why you have higher runtimes.

But your statistics are greatly improved as well. I just compared the VOLUME and AREA source. And then I have a ratio of the AREA to the VOLUME and then AREA with meander and AREA without meander. And you can see now your maximums are like .99 percent. It might be a little bit of a rounding error or something on the end where it's a 100, but it's pretty darn close.

Future work [Slide #21]. I alluded to some of this earlier, but I need to optimize the way that the algorithms are doing this integration. So, the way it's currently happening, like I told you, you have an integration on the top line. That's your meander and you're in the integration of your coherent plume. If you notice, those really have the same integration bounds. So, you can reorganize this to have both meander and coherent inside those integration bounds. You can just see the integration a single time. I didn't do that because I wanted to try to leave the regulatory AREA source option as intact as possible at this point in time.

I will or would or perhaps like to add upwind concentrations. That will, you know decrease runtimes by optimizing integration. But I'm going to increase them a little bit to add upwind concentrations. Again, I did that because I wanted to leave the AREA source as it was right now intact. Where the very first thing that happens in the AERMOD code is that it says, "What's my downwind distance?" So, the downwind distance is less than zero, it just set your concentration to zero and moves on. And I left that as it was. So, you're just going to get AREA meander concentrations for those downwind receptor points to zero.

I'd like to improve the debug for the AREA source so that it would include these meander-related components. So, currently, when you run this, it's not going to distinguish between your meander and your coherent portions. It's just going to give you this and all. I also need to implement and test this with -- I call it "*AERMOD options*" with the quotes because we need test to make sure that this is the area with -- that the AREA source with meander compared to the VOLUME source also translates into the NO_x chemistry, the MAXDCONT options, deposition and even processing.

And finally, I'd like to publish this work with some additional evaluations. So, these are the questions you may ask.

[laughter]

I'll give you a few. [Slide #23]

"How do you use this ALPHA AREA Source with Meander Option?" You use it under MODELOPTs keyword. You need ALPHA because it's not a regulatory option, and you need the AREAMNDR keyword.

"Does it work with FASTALL or FASTAREA?" No. I'm not sure that's totally needed. Those FASTALL and FASTAREA are kind of screening options. And as you can see that a lot of that coherent plume you're getting, some of those higher values, especially when you're looking at the long-term averages.

"Does it work with the new ALPHA Aircraft Plume Rise option?" Yes, it does.

“Can you get the meander and the coherent portion separately.” This goes back to the point that I said I wanted to work on the debug file. You can get them separately if you run using the low-wind FRANmax and FRANmin options to get both the meander and coherent portions of those plumes. Remember, you are running as ALPHA anyways, so you can use the low-wind options.

So, thank you. I think that's all I have. I think the AREA source with meander is a good option to be considered in the model. It definitely stems from Gaussian POINT solution. It's just an extension of that, plus the VOLUME. So, I think that AREA has some advantages. One of which is no exclusion zones. The VOLUME sources have exclusion zones. And the AREA source will run faster than running hundreds of volume sources, especially for some of these transportation-related applications where you have long line-like segments Thanks. Thanks for letting me be here.

George Bridgers:

Absolutely. Thank you, Dr. Snyder, I appreciate that. And I appreciate, Chris is still sitting back there. Chris and Michelle, thank you guys for getting us back on schedule somewhat. We are about 10 minutes fast. That's fine. That's not a problem.

I'm going to make the executive decision that we're going to take a 25-minute break instead of a 20-minute break because I feel it would be a good time for some networking. We had some data rich, research rich slides there. So, let's take until 3:15 p.m. Then we'll reconvene.

And then in the afternoon or the last session, we're going to have a series of four or five presentations that I will absolutely classify as external public presentations. And then if the spirit moves anybody, we do have a microphone and we'll have a time for additional public comments. So, we attend to that. I'm going to suspend the Conference until 3:15 p.m.

[CONFERENCE AFTERNOON BREAK]

George Bridgers:

Thank you, everybody. We are going to have the last session of the first day of the 13th Conference now. The next three or four talks are absolutely external stakeholder comments that are being made to us. These are presentations where people are requesting time to speak. After these presentations, there'll be a time that anybody who wants to talk, and comment can turn the microphone on and then we'll break for the day. So, without further ado, Tony, are you presenting?

Tony Schroeder:

Yeah, I think so.

George Bridgers:

I'll call Tony to the mic. Tony, you, like everybody else, you know the drill.

Tony Schroeder:

All right. Good afternoon, everyone. As already mentioned, my name is Tony Schroeder. I'm

with Trinity Consultants. I'm going to be speaking on behalf of Air & Waste Management Association Atmospheric Modeling and Meteorology Committee or APM. As the slides here say. I am the concurrent chair of the APM committee. And just to recognize the other current officers, Travis Hicks from Southern Company is the vice-chair, and Mary Kaplan with AECOM is the current secretary.

So, by way of introduction, if you're not familiar with the APM committee, we're a technical committee for air quality modeling and meteorology issues at Air & Waste Management Association. We have approximately 150 committee members. I think we are the biggest technical committee within the AWMA. And our objectives are to provide technical support for the AWMA annual meeting. Support especially conferences and workshops, contribute to different technical programs, and also offer constructive technical comments and review on regulatory issues related to modeling.

So, the -- what we call the Ad Hoc Review Committee is our committee -- subcommittee that provides a lot of support to review different regulatory proposals and guidance documents. And provide what we hopefully view as constructive comments and support on those proposals. So, these are the current ad hoc committee or subcommittee members. The three officers, as well as Michael Hammer, which is the current -- who is the current ad hoc chair. And then several folks over here plus others who weren't able to attend the conference this year.

Okay. So, I'll move on to our comments on the AERMOD system development. We will have a second presentation tomorrow with more specific comments on Appendix W. But today's comments are more tailored to comments that we received from the committee on different issues that could be considered by EPA for AERMOD system development. I will just mention that, you know, we did solicit comments throughout the AWMA APM committee. And this is kind of a consolidation of all those comments that were received back from the committee.

So, building downwash is one issue that was mentioned in a couple of presentations this morning. So, we feel that there's been considerable progress made with enhancements to PRIME both with the AWMA and ORD options. We're appreciative of EPA's collaboration with AWMA for improving model performance. But there are some issues that APM committee members felt -- remain such as comparisons of wind tunnel studies, plume meander under low winds, and then consideration of complex buildings.

So, a little bit about each of those. Using some wind tunnel comparisons, there's been some recent peer-reviewed wind tunnel studies which are listed in the bottom of the slide here, that have confirmed improved model performance using PRIME2 compared with the existing PRIME. Generally, better predictions for wake velocity, turbulence and dispersion. But the PRIME2 committee is still working on improvement on sigma-y and sigma-z.

The APM recommends using PRIME2 wake theory and updating wake height and width equations. As far as low wind meander goes, there are some -- been field studies indicate significant PRIME overpredictions in low wind stable conditions. One example is the AGA model performance database, as well as recent SO₂ monitoring studies near industries with considerable heat releases. Other models such as the Danish OML account for intermittent

downwash by applying a fractional scaling factor for any given receptor. And that might be an approach that could be considered for inclusion in the AERMOD PRIME moving forward.

Complex buildings are another potential area for improvement. There's currently a potential to neglect interaction between multiple buildings. And that can be a key deficiency in PRIME and BPIP. So, a possible solution could be equivalent building -- an equivalent building demonstration approach. This approach employs numerical pre-processors that can simulate interactions between multiple structures resulting in equivalent simple structure that has a similar concentration result compared to the full actual building set.

So, moving on to the next item after PRIME is the highly buoyant plume source type. So, APM commends EPA for adding that as an option into AERMOD latest version. Appreciate the consideration of previous comments that have been submitted. And this option provides a refined treatment to hot plumes that penetrate the top of the convective mixed layer. The default treatment can produce counterintuitive results, such as the plume that penetrates the elevated stable layer can mix before the plume is intercepted with the mixing height in the current configuration.

So, then a peer-reviewed recent paper that evaluates multiple field databases and shows improved model performance with the highly buoyant plume option. Members of the committee felt that it satisfies the conditions for alternative models that are outlined in the *Guideline*. And with the fact that there's a peer-reviewed study, APM would like to recommend promotion to BETA status for the next version of AERMOD release expected in 2024.

Other current challenges and potential areas for research and development in AERMOD that are remaining are low wind challenges. There's been an overprediction bias that's been well documented for over a decade. Non-default options have been developed. And they've been mentioned earlier today, the different low wind options. But so far, none have gained regulatory status. There are options focused on lateral turbulence intensity, plume meander, and minimum wind speed. And we encourage additional research into these options and these potential approaches to reducing overprediction during low-wind speeds.

Another remaining potential option or issue is that the formulation of vertical wind profile remains unaddressed. And that there's no scaling of winds above mixing height. This can present a challenge for met data developed from single ground level measurements such as standard ASOS. And it can be compounded at sites that experience low-level jets. So, we encourage further research and investigation.

And one example of an issue with this is, you know, if you have a mixing height that is only 10 meters under stable conditions at night, that can be that the vertical wind speed profile remains constant at a height of just 10 meters above the ground, which can be, you know, not necessarily representative of real world conditions, as can be shown in the figure in the corner of the presentation here.

This shows the AERMOD using 10-meter wind speeds versus AERMOD wind speeds using the full wind speed at 300 meters. You can see that using the 10-meter tower, the wind speeds are

capped at 5 meters per second. Whereas at the higher elevation, above-ground level, the wind speed is typically much higher indicating that there can be an underprediction for speeds using the current formulation.

On modeling technique advancement, you know, again we commend EPA on the development of additional options into and rolling out to the public the availability of ALPHA options as well as BETA options. By our count, there's 17 ALPHA options included in the latest version of AERMOD. But some of these are documented in peer-reviewed papers and have performed well in field evaluations.

So based on, you know, the definition of a BETA option, we encourage this iteration of some of these ALPHA options that have peer-reviewed studies behind them to be elevated to the BETA option status. So, they can still be, you know, reviewed on a case-by-case basis, but kind of have an additional level of potential usability in regulatory applications.

One item here is that there's not necessarily an obvious method for public input to the advancement process. It will encourage potential acceleration of options that seem really particularly good at predict -- or good at representing an atmosphere from the ALPHA or BETA as a regulatory option potentially through the R/S/L modeler's workshop.

Looking toward future development, we certainly appreciate the initial release of the AERMOD modeling system development and update plan. The document it looks like on the current SCRAM website says it'll be available in the future but it's not yet available. You know, we are curious if it will be updated in the near future and if there are any new or updated white papers planned. It looks like the latest updates were published in 2019. So, they're getting to be a few years old. I know EPA has a lot of different priorities, but these white papers, I think, are very helpful to the public and the modeling community to kind of see the research and help push it -- push the research forward amongst various stakeholders within the modeling community.

It may also be helpful to have a long-range outline for future regulatory modeling. AERMOD inherently does have some limitations, the steady-state approach applicable to only one-hour transport. There's no accommodation for 3D wind fields, and no or very little chemistry capability. So, there was some talk at the last EPA or AWMA specialty modeling conference two years ago, now, if I remember it correctly where, you know, AERMOD planning began over 30 years ago, and the model is approaching 20 years of regulatory approval.

And we encourage EPA to continue to develop and publish long-range plans for if there's a potential for replacing AERMOD at some point in the future as, you know, AERMOD begins to become a lot of different -- basically, a model that has a lot of different uses and pulls a lot of things together. There might be a need to kind of fundamentally overhaul the regulatory modeling system moving forward into a more state-of-the-art modeling system.

Okay. With that, on behalf of APM members, we're grateful for the opportunity to work with EPA and to present at the conference today.

George Bridgers:

Thank you very much, Tony. But I think it's probably time to mention -- we were talking right before this session, the distinction between today and tomorrow. And one of the reasons why we were trying to make this distinction on the comments that have been made today from the external stakeholders, ORD, WSP, and then those tomorrow that are connected to the rule making. And one of the subtleties that I did not announce this morning is response to comments[unintelligible]. So, anything that is absolutely connected to the rule, then we will have to do a response to comments on. We typically do not do response to comments on the Conference but they're on record.

And it's important that they're on the record, because Tony, I appreciate the -- if you want to call this the response to comment. I appreciate the AWMA's point about our Model Development Plan and the White Papers. Because there's a point that things that need to be updated. The Model Development Plan should be available on the web but it's not. And White papers absolutely should be updated. And you're right, they serve an important function. It's not lost on me or anybody here in the front of the room. And I know that Tyler came in and came out, he's upstairs right now. It's not lost on Tyler. We just need to find the time to, honestly, to devote to get those updated. Because it would be helpful to the community and also for us.

So, many of the points that you made are very well -- they're very poignant and very well appreciated. So, I'm doing that because you won't see that response to comment. I want to make sure that we are appreciative. Honestly, agencies such as, AWMA, or other organizations that will present today are keeping us honest. So, thank you.

Speaking of keeping us honest, next up is Ryan Gesser.

[laughter]

I can't help that he might support a school that I don't support, Georgia Tech.

[laughter]

Ryan Gesser:
Or Virginia.

George Bridgers:
Or Virginia. Yeah, that's right. Chet was here earlier.

Ryan Gesser:
Yeah. We connected over lunch.

[talking simultaneously]

George Bridgers:
Well, without further ado, Ryan Gesser.

Ryan Gesser:

Hi. I'm the industry stakeholder. My name is Ryan Gesser. I'm an air permitting practitioner at Georgia-Pacific where I manage regulatory permitting and modeling for more than 100 industrial facilities, manufacturing paper and tissue consumer products, residential and commercial building products and consumer and recyclable packaging. Working in 35 states and nine out of the 10 EPA Regions. I appreciate the opportunity to participate and speak here at this week's conference and take a few minutes to offer my observations and suggestions about what EPA proposes in this revision of Appendix W. And perhaps more importantly, or less importantly, what EPA hasn't proposed.

I have this scripted down to the word when I thought that I -- just to prevent rambling when I thought I only had 10 minutes.

[laughter]

So, I'll probably still read from my notes, but I can take the pitch and the pace down two notches. So, thank George for the time allowed here today. Observations on the current state of Appendix W are informed by experience in roughly the last 15 years. Which if you think about it was a very momentous decade and a half. EPA ended the PM₁₀ Surrogacy Policy and implemented the PM_{2.5} NAAQS for the first time. EPA implemented brand new NAAQS for one hour sulfur dioxide and one hour nitrogen oxide using novel probabilistic forms of standards and new modeling techniques to evaluate.

And now, EPA is about to implement a revised likely significantly more stringent PM_{2.5} NAAQS that will continue to push the boundaries of current modeling policies and techniques. Now, me as someone who stood up at this conference in 2012 -- it was the 10th modeling conference, and worried about whether the sky was falling when the last PM_{2.5} NAAQS provision was proposed.

[laughter]

I have to first express appreciation for collaboration among all the stakeholders in the modeling community. And for EPA in addressing some -- many of our concerns from that time through consequential changes to modeling techniques, and implementation policies. I'm not going to name them all. I'm thinking of things like ADJ_U* and low wind dispersion. And I will note even seemingly minor changes, like implementing input schemes for horizontal and unobstructed point sources are important and used by industries like ours in the forest products industries.

And establishing -- as well having the same reasonable guidance for variable background concentrations for short term standards was a reasonable and crucial approach to facilitate attainment demonstrations that remain conservative relative to actual conditions, and protective of human health and welfare. These efforts aren't and haven't been simple and easy. And I'm probably not the first person but not, in general, to say that permitting and modeling is only becoming more challenging as standards become more stringent.

So, these days, I'm focused almost entirely on how the revised PM_{2.5} NAAQS will be implemented. And based on our experience, and that of about three dozen PSD permit applicants summarized on this slide, which I realized is probably not legible to all in the room. There is

reason to be concerned that we may be assuming ask some regulatory models to do things that they're not currently equipped to do. Or perhaps they are, but they aren't enabled to be used under current guidelines for regulatory analysis. And that creates a heightened sense of urgency to continue through the representativeness of regulatory modeling analyses in ways that are more realistic yet remain protective.

So, as ambient standards in general become more stringent, we need to be confident that the regulatory models we rely on for decision making about our permits for economic growth have the right answer for the right reasons. And to the extent there's margin for error and some conservatism in today's modeling techniques and policies, it's already a small margin. It's decreasing or vanishing when standards like the PM_{2.5} NAAQS are revised. So, I don't mean to say the sky is falling -- about to start falling again when the new standard is implemented.

But for example, among this survey of three dozen recent PSD permits, 50 percent of them would not successfully model attainment with the upper range of the proposed annual standard. And 78 percent or 20 out of these 36 projects could have been permitted with the modeling results they presented if the standard ends up with the expected lower range for the annual standard. At least 36 projects spanning 20 states and a dozen critical industries for infrastructure, clean energy and transportation, and consumer products investing in new and modernized facilities, minimizing emissions using best available control technology.

And if you look closely, they provide a sense of direction on where modeling techniques and policies urgently need continued improvement. So, one example from that survey the recent PSD permits shown here, where an existing major source evaluated annual average PM_{2.5} in a cumulative analysis. And calculated a model design concentration, MDC appears on here of 11.7 relative to the annual PM_{2.5} NAAQS, 12.0 micrograms per cubic meter. Now the fact that a large industrial manufacturing facility modeled the design concentration at about 98 percent of the current standard, it's not necessarily surprising. But it is informative to understand what exactly the model told us.

Now, most of -- everyone understands that for PM_{2.5}, the background concentration is already near the level of the current status. And that's about to become more acute when the standard is lower, as what we generally refer to as shrinking headroom between the NAAQS and background concentration in the vicinity of the project. But let it not go without saying that the PSD increment through the annual PM_{2.5} that essential quantity meant to prevent its significant deterioration is about to become practically obsolete when the standard is revised.

In this case, the monitor designed value was 8.3 micrograms per cubic meter. But on closer inspection, this is one of the many continuous federal equivalent method or FEM monitors with instrumentation that appears to exhibit a bias. And in this case, that value is about 1.1 micrograms per cubic meter above the co-located federal reference method or FRM instrument is based on EPA's comparability assessment tool and published monitoring data.

So, this tells us that it's critical to accurately characterize the background concentration, as required by Appendix W and related guidance. And we're going to be challenged to practically implement permitting requirements for revised PM_{2.5} NAAQS until this bias is corrected and

historical data is reconciled to be used in the future analysis. The next element of this model results in the nearby sources in the vicinity of the project contribute 0.20. It is not that much, but it's significant in the sense that EPA's recommended significant impact level is 0.2. So, we will say that one or more of the nearby facilities are contributing significantly to the MDC for this project.

This tells us that it's important that EPA continues to evaluate how nearby sources are selected and simulated in the analysis. And we can be confident that such sources are not double counted as part of the background concentration. The largest permitting sources at this facility -- three large industrial boilers, firing gas, and solid fuels contribute level 0.3 to the model design concentration. These emissions are from tall stacks, but it's not simply that the solution to pollution is dilution.

These boilers were originally subject to best available control technology emission controls, now also must meet even more stringent maximum achievable control technology standards, which limit particulate matter emissions as a surrogate for HAPs from large combustion sources, the kind that are operated in most large manufacturing facilities. And most of the PM_{2.5} precursors are emitted from these boilers. Thousands of tons per year of NO_x and sulfur dioxide which contribute only 0.05 to the MDC is estimated using the MERCs in EPA's screening tools.

So, this tells us that the highest emitting sources when well controlled and properly characterized in the model in terms of emissions and dispersion, can be reasonably simulated. And that EPA's guidance to account secondary formation in PM_{2.5} can be successfully implemented, at least for the annual average here. Now, the process sources from this example, characteristic of this type of facility contribute most of the model design concentration of 1.8 micrograms per cubic meter. These emission units are the subject of this application emit at the best available control technology level, lower in terms of total mass on the combustion sources.

Their emission rates are uncertain because these are the kinds of sources that have moist exhaust with condensable particulate matter for which reference tech test methods are uncertain and prone to bias or simply can't directly measure the PM_{2.5} emission rate. So, we're using conservatively high emission rates that we have to assume to be able to permit. These sources are modeled at their maximum emission rate continuously and simultaneously throughout the year, even though their operation is variable. And the collection of sources rarely operates at the peak production rate for sustained periods.

Now finally, this particular facility is located in a state where the regulatory agency expects and requires simulating fugitive emissions from haul roads within the facility. And despite using site-specific sampling and emission calculations procedures from EPA's AP-42 emissions guidance and modeling in conformance with the EPA's recommendations for haul roads, the impact of 1.1 micrograms per cubic meter for the final design concentration seems disproportionate relative to the total admission rate of only about two and a half tons of PM_{2.5} owing to poor dispersion from ground level fugitive sources and proximity to the ambient air boundary, which in this case is the receptor of the public road in which no one lives or works or occupies continuously. So, coincidentally, that contribution of 1.1 from the road is roughly equivalent to the observed bias in the FEM monitor used to represent the background concentration.

This tells us the modeling low level -- low emitting fugitive sources, especially including all roads, remains a quite vexing problem despite EPA's best efforts to offer guidance for emissions and modeling a decade ago. And that continuing focus on improving simulation of low wind and other poor dispersion coefficients is imperative. I'd also note for this project that if I could have waved a magic wand and eliminated the FEM bias by simply relying on the federal reference method, and just making the whole road impacts to go away, that reduces the cumulative impact by 2.2 down from 11.7 to 9.5. Which will attain the -- at 95 percent of the new annual $PM_{2.5}$ NAAQS, if it lands at 10. The upper end of the range at which it was proposed but would still be over the new annual $PM_{2.5}$ NAAQS if it lands at 9.0, or lower.

So, in situations like this, when the applicant complains the modeling doesn't pass, that doesn't necessarily suggest that there are high concentrations everywhere. More often than not, I think the situation resembles what hopefully is depicted well enough in this image, consider the colors hot to cold, hot being higher concentrations, hotter than simulation. That the preceding model designed concentration we were examining represents just the one receptor with the highest concentration.

And that's usually at a near fence line, perhaps only one or a handful of receptors. And then the rest of the modeling domain has lower concentrations quickly approaching background with -- within a relatively short distance from the property boundary and the ambient air boundary. And in this situation -- and we expect this -- to encounter this much more frequently as the $PM_{2.5}$ NAAQS is revised. We revisit the inputs to the model and the multiple layers of conservatism to try to find a solution in how we're stimulating the operation of the source.

We're confronted with our guidelines that require us to simulate new and modified emission units emitting at the maximum allowable rate simultaneously and continuously for the full duration of the standard, even for an entire year. With other onsite and nearby unmodified units operating or emitting at a representative actual emission rate that is greater than measured actual dimensions at every offset interceptor regardless of the likelihood, frequency, and duration of exposure, considering things like roads and railways.

During the worst-case dispersion conditions, obviously around short-term standards or yearly years of conditions for annual standards. Added to a background of concentration that we are depending on being free from bias and its measurements, plus an estimate of secondary $PM_{2.5}$ information from precursor emissions, we assumed to occur at the same time and place.

[talking simultaneously]

There's an objectively and demonstrably low likelihood of each of these things happening individually, much less collectively. So, when we can trim any more fat from the model inputs, we're compelled to look at the basis for them. Though I suggest that accounting for emissions variability, especially for the annual standards, is perhaps the next frontier where formulation of the model inputs and simulation of ambient concentrations would be improved.

The conventional approach of assuming continuous maximum emission rate simultaneously from

all sources guarantees that we're going to compute model design concentration under the worst-case meteorological dispersion conditions. But in reality, the maximum allowable emission rate may be a statistical outlier or an infrequent or unlikely condition. That's going to be increasingly likely, I think, if policies to consider startup shutdown and malfunction emissions require quantifying and modeling those emission rates.

Emission units may be emitting less than the maximum allowable during worst-case meteorology and dispersion conditions over whatever timeframe those are taking place. Maximum emission rates may be significantly different for different averaging periods. In other words, annual average emission rates may be considerably lower than maximum one-hour or 24-hour emission rates. Emission variability doesn't always look the same. But in our experience, wherever we look for it, we usually find it.

And we find significant differences in the computed model design concentration, depending on whether the maximum sub-maximum or actual admission rate is simulated. So, obviously, this overestimation relative to actual emissions is compounded by the number of sources in the analysis. And that's usually more than a few, often more than a dozen. So, again, I suggest that regulatory modeling guidelines accounting for emission variability would provide an opportunity to significantly improve representativeness by simulating more realistic conditions profiles, yet still result and protect the best estimates of ambient air quality relative to increasingly stringent standards.

So, our company is a member of American Forest and Paper Association and a technical partner in National Council for Air and Stream Improvement, committed to continuing to collaborate with EPA and the modeling community on this specific issue among several others to urgently address this aspect of regulatory modeling.

So, I'll conclude by summarizing what I hope are the next steps that the modeling community and especially EPA can focus on urgently in the near future. Continued emphasis on the source types that remain challenging for models, including but not limited to fugitive particulate matter sources, and doing that by addressing deficiencies and improving the quantification of emissions and simulation of dispersion.

I think it's crucial to consider how emissions variability can be accounted in regulatory modeling. And as I said, there are many of us who are highly motivated to support that effort by providing data and ideas for implementation for permitting a modeling policy. If not urgently through interim guidance and -- or even a supplemental Appendix W revision, then by the 14th Modeling Conference and routine revision in three years from -- right now.

So, now coincidentally, the trade organizations that we support and participate in has suggested that the revised PM_{2.5} standard should be implanted with an effective date of three years to align implementation for PSD permitting with the infrastructure set milestone. To ensure that the technical deficiencies and modeling techniques along with key implementation problems for source measurement and ambient measurement are resolved to enable successful implementation.

And finally, everyone in the room who knows me and has seen me before and knows I'm not going to step away from microphone before mentioning ambient air policies.

[laughter]

So, among other relative policy and guidance beyond Appendix W that affects when our regulatory and even non-regulatory modeling is practiced. We continue to believe that policy about the selection of model receptors simulating ambient air exposure is consistent with the duration, frequency, and likelihood of exposure aligned with each standard remains crucial to revisit, especially for PM_{2.5}, in light of the pending revision to the annual standard.

As well as EPA's 2022 PM_{2.5} modeling guidance that can require or expand modeling for minor projects that increased directly in 2.5 emissions by an insignificant amount even zero if the precursor emission increases -- would increase by significant -- or possibly inconsequential amount as well as other initiatives that may require modeling for minor sources and to characterize air quality in environmental justice communities.

The time is now to improve modeling techniques and guidance in ways that promote the overarching objective of the Clean Air Act, which is to protect and enhance air quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population. So, thank you once again for the opportunity to speak.

George Bridgers:

Thank you, Ryan. I had to double check, I had to go in your LinkedIn to see. I know there was connection to Georgia Tech. That was for your undergraduate?

Ryan Gesser:

Yeah.

[talking simultaneously]

George Bridgers:

But the meteorologist in me wants to say, Ryan, that under high pressure, the sky is always falling.

[laughter]

[inaudible] But your points are well taken, and Ryan, I appreciate that. One thing, Ryan, I would encourage you that if there's any part of that that you want to submit that -- you know, the industry that you're representing wants to comment on or wants to see in response to comments, make sure you submit them to the docket. So, if you had it all typed up, and it looks like you had all your notes, so you could probably just submit that to the docket.

[unintelligible]

So, we have a couple more presentations. The next one, Carlos Szembek is going to come on

behalf of a project that EPRI funded. Carlos.

Carlos Szembek:

All right. Thank you, George. So, I'm here to discuss the development and evaluation of the streamlined Travel Time Reaction Method. So, TTRM for NO₂ applications. I'd like to also thank my colleagues and co-writers. Bob Paine retired whom I was on the phone with this past Saturday at 10:00 p.m.

[laughter]

Chris Warren, Jeff Connors, Joshua Molvar at AECOM. And as George mentioned, this is research that was conducted with funding from EPRI under sage guidance of Eladio Knipping. So, grateful for that as well. Just an overview, so I'm going to give just a broad review of the Travel Time Reaction Method. And then discuss these updates to the TTRM. And I just want to make a distinction here. This is a proof of concept and enhancement for any future implementation into AERMOD. So, it's a possible implementation in the future. So, it's not the version that's currently in 23132.

I'll proceed then with the model evaluation for the Colorado drill rig. In this presentation, there's an appendix for second sites, Balko, Oklahoma that is also -- will also be included. And then just our results and conclusions. Okay. So, for the Travel Time Reaction Method, TTRM, it's a refined option to supplement the Tier 2 and Tier 3 methods and this excludes GRSM that already takes this into account.

So, what this is focused on is the NO₂ that -- the NO to NO₂ conversion by simulating NO titration during the travel time in the near fields. And travel time being a function of both wind speed and distance. So, the full reaction of ozone with NO can be represented with this expression here. And what TTRM focuses on is just forward reaction. And to generate this NO₂ - fractional NO₂ scaling factor. Where here, you can see that it's a function of ozone concentration and travel time, which again is with the speed and distance dependent. And then this reaction rate which in itself is a function of ambient temperature.

So, off to the side -- off to the side over there is a table that shows increasing travel time and increasing ozone concentrations and the calculated NO₂ fractions for each of those combinations. So, the TTRM is capped at about -- or is capped at 0.9. And what this is -- the fraction is doing is it will allow you to calculate what the final NO₂ concentration is of the hour against the available or remaining NO and NO₂ in the atmosphere after in-stack conversion.

And so, in AERMOD, it's simplified by -- it's calculated by using the relevant distance and effective wind speed based on the dominant plume type and treatment. So, this distance is based on the coherent or the random plume type, and for point/volume and point -- as well as area sources and -- we've now added in buoyant line sources. And the selection of whether it's the coherent or the random plume, so that for the pancake plume I was showing earlier is based on what these plume treatment types, sort of in the model formulation plume treatment figure.

You see in the model formulation figure, what type of plume treatments for every hour is

relevant. And so, for stable hours, you have the Gaussian plume and or indirect plumes, direct plumes, penetrated plumes. And then for the near field, any downwash. So, whichever of those is dominant is used for the effective wind speed. So, in this version that was based -- that was built on 22112, there were three updates that were made. And some of these were done also in discussions with EPA initially off way back when --and then implemented.

So, first is just a simplified user setup -- right now, it's a little mixed. There are some multiple steps and multiple keywords that need to be used to trigger the hybrid TTRM. And so, now there's a single word and though it's a little bit of alphabet soup of terms, but TTRARM2, TTROLM, TTRPVMMR - it is sort of like what you set down. And by using those, it triggers these hybrid methods. So, but then regardless, the user is still required to then provide appropriate inputs for these methods.

The second update was just streamlining TTRM. Previously, at every receptor for every hour it was calculating the TTRM values, even at far distances. So, in this enhancement, it only calculates within a limited distance based on the hourly winds and from the distance from the source. And in which NO₂ fraction is less than 90 percent. So, that reduces the -- it can significantly reduce the model runtime.

And finally, as I mentioned, where I actually spent about 40 percent of my time -- just figuring out cryptic messages and comments in the code. But now, it is implemented, actually, for the buoyant line sources. And as I say here in 22112, as I looked in the 23132 model formulation, it still appears the same -- EPA has only implemented ARM2 for buoyant line sources. So, the way that the [streamlined] TTRM has been configured in the code is that if and when the Tier 3 methods are implemented for the buoyant line sources that it would activate the TTRM option as well. So, we didn't perform model evaluations on the buoyant line sources. All we did was stability testing using EPA's AERMOD BLP implementation test case.

All right. So, I'm going to discuss the one site, the Denver-Julesburg, Colorado in the model evaluations. I should say that for these two sites, these were selected primarily based on proximity of the monitors to sources. And then there were some other factors that will come into play. So, for the Colorado drill rig study, this site, the location is north-northeast of Denver, Colorado, with a study period of October to November 16, 2014, about 160 hours. There are two well pads. And the twelve air quality monitors about 100 meters from each of the two different sites, and so, placed around them. And then the in-stack ratios of between 0.04 and 0.09.

This is showing -- so, how at each of these different monitors a value was selected. So, in this case we have November 12, 2014, hour one. And all the values for the different monitors are shown here. And then the peak value was selected to be used in the evaluation, and then the relevant AERMOD receptor was then used as well. Okay. So, for the -- for this evaluation of the key differences of these modeling approaches is the conversion of NO to NO₂. Such that the NO₂ ratio should be the focus of the evaluation here. Because if the NO_x is underpredicted, then NO₂ is going to be underpredicted. We're going to see that in a second.

So, as -- and this use of the NO₂ to NO_x ratio will be sort of -- be a more or less biased metric for evaluating. So, the evaluation results are given for each pad separately due to the different model

performance for the NO_x predictions. The use of one observation, as I mentioned in prediction, for each plume capture hour is paired for the peak plume capture monitor location. With -- such that the hourly values are ascribed to a single downwind peak receptor. Then finally, for the meteorological options, the cloud cover, no turbulence, and use of the low wind optimization were employed.

Okay. So, here, what we're showing are the NO_x [Q-Q] plots initially with -- observed on the X axis and predicted on the Y axis. And, you know -- I'm sorry. So, then with -- obviously, along with the one-is-to-one line showing perfect prediction. And what we're seeing at Pad 1, is that it was nearly unbiased. So, that we have the values perfectly running along the one-to-one line, but pretty much clustered around it. Whereas over on Pad 2, there is distinct underprediction. So, the underprediction was probably due to some topographical features that I'll mention later.

Okay. So, here moving on to the NO₂ Q-Q plots, what we're seeing on the left-hand side with Pad 1, the right-hand side is Pad 2. The top row is showing the different NO to NO₂ modeling options without TTRM. And the bottom is showing with the inclusion of the streamline TTRM. With the -- at the top here, the dark blue is ARM2. The -- over here, the gray is PVMRM. And then the yellow is OLM. And then here is the GRSM [in light blue] performing quite well here. And I just want to note that this GRSM is using AERMOD 23132, and with reprocessed meteorology using AERMET 23132.

What we can see here is that adding in in Pad 1, the TTRM for the three options really brings it much closer to one-to-one prediction particularly for the OLM and PVM options. Over in Pad 2, where if you recall, the NO_x was showing under prediction, we have GRSM quite underpredicting at the one-to-two line -- underprediction line. And now, adding in the TTRM, we can see it that now -- everything out -- all the other options now also are underpredicting but not quite as much as GRSM.

All right. So, then here now, we move over to the -- to the NO₂ to NO_x ratios compared against the observed NO_x concentrations. So, we have NO_x concentration on the X, NO₂ -- NO_x on the Y, and the observed is in orange and the predicted are in blue. We have in the top row the methods without the TTRM. The middle row is showing the methods with TTRM, and on the bottom is GRSM.

So, the goal of this -- or the aim of this metric is that by adding in TTRM, we converge on to the observed NO₂ to NO_x ratios while still remaining slightly above them. And in this case, you can see in Pad 1 that there actually is -- there's a reduction in variability between -- in adding TTRM. And that they are well sort of aligned with the observed here, particularly again with TTRO above the OLM [TTROLM] and the TTMRM with TTRM [TTRPVMRM]. The GRSM also is performing very well at Pad 1.

So, for Pad 2, this was the one that had the underprediction. What's nice about using this NO₂ to NO_x ratio is that this has been focusing on just the NO_x. It's sort of bypassing the underprediction. And what we're still looking for as a sign of good performance is that it converges upon the observed NO₂ to NO_x ratios. And in this case, you actually see that across the three -- Tier 2 and Tier 3 methods, that particularly from when you view them without

TTRM to the addition of TTRM, they are all performing quite well, particularly at the higher concentrations. And yet, when looking at GRSM, there's actually a slight underprediction here. And if you recall, it's the lowest of the four options.

All right. So, then in summary of the Colorado evaluation study, the AERMOD NO_x predictions are relatively unbiased for Pad 1, underpredicting in Pad 2. The reasons for underpredicting in Pad 2 was still unclear, but it's possible -- possibly due to downwash or topographic issue. And there's 2-meter elevated berm issue there with respect to the monitor placement that wasn't accounted for in the in the modeling.

So, the key performance metric here is the predictive ratio of NO₂ to NO_x. The default and BETA options, so no TTRM, GRSM performs best against the default Tier 2 and Tier 3 options. ARM2 overpredicts more than OLM and PVMRM. But the addition of TTRM, TTROLM and TTRPVMRM perform comparably with GRSM. So, with TTRM showing some improvements over ARM2, but still overpredicting. So, this improved performance due to the monitor was due primarily to monitor's proximity as well as increased wind speeds within the distance limit of incomplete titration of NO to NO₂.

Finally, in conclusion. TTRM is optimized for improving model performance at reduced travel times, which is a factor of both distance and wind speed. Model evaluation show a marked improvement in field studies particularly for near-field impacts with reduced travel time yielding incomplete titration of NO to NO₂ with TTROLM and TTRPVMRM performed comparably to GRSM. TTRM has also been shown to transition to the predicted values of the Tier 2 and Tier 3 methods at the farther distance beyond that limit of incomplete titration. Finally, while not quantified with a stopwatch, but it was quite noticeable reduction in the model runtime. And as previously before I said, it now also includes the buoyant line features.

That's about it. And again, like I said, afterwards is the whole of the study [included as an appendix in the presentation] can be also looked at.

George Bridgers:

Do you mind just identifying yourself just for the record?

Carlos Szembek:

Oh, my gosh. Okay, sorry. Yeah. So, the person who was talking was – Jesus...

[talking simultaneously]

[laughter]

So, Carlos Szembek, senior atmospheric meteorologist at AECOM.

George Bridgers:

Thanks.

[talking simultaneously]

Okay, Carlos. We are trying to get AERMOD to model over water.

[laughter]

I actually introduced you, Carlos, when you came up. So, you were square, but I just want to make sure they're hearing your voice and not mine. So, we have one more presentation but not by Jesus.

[laughter]

[talking simultaneously]

[inaudible]

But before I call Sam up to the podium, I did want to say one thing to the character of Sam. I can do this on the record, and it will be transcribed. So, I don't know that the rest of the industry stakeholders will know, but the state and local folks will know that we have for decades had the State and Local Modeling Representative that we work with exclusively to communicate with the states and locals. Now we rely in Headquarters, a lot on the Regional Offices to communicate to the states and locals. So, this is a direct pathway that Headquarters can get information out to the states and locals.

So, for a number of years, there's actually former state and local modeling people in the room that I will not mention [unintelligible], but they now work for the agency. But these are people that go out of their way and take time, out of their state time, their local time to help us in the agency. And we put an all call out every time that we have somebody that retires or moves on to a management position and can no longer fill that role. And Sam, a year ago -- about a year ago step up to that role. So, Sam is our State and Local Modeling Representative.

And if Annamaria Coulter was here, or Colecchia now. Years and years and years ago, when the RSL Workshops were just Regional Office only, the only other person that comes to the RSLs were -- was the State and Local Modeling Rep. And so, that's a vast time difference now, we have stakeholder days, and all the state locals are there. But anyway, I wanted to give a shout out to Sam for stepping up and filling that role, because no one else did.

[laughter]

Thanks Sam, and the floor is yours.

Sam Sampieri:
Thank you.

George Bridgers:
Introduce yourself.

Sam Sampieri:

I'll try.

[laughter]

Hi, everyone. My name is Sam Sampieri from Connecticut. I'm senior modeler down in Connecticut Department of Energy and Environmental Protection. And so, a lot of my job now lately is in training new staff. And also, I've been kind of in charge lately updating our guideline in Connecticut of managing impact guideline. And then with the update coming to Appendix W, I took a look at everything, and I noticed that it is still referencing our revision EPA screening procedures.

So, I looked at it and "Oh, this is 1992 all over again." But to go back a little bit further, a little bit of history here. Just kind of like looking at some of what was going on back in those days. I remember starting out as a junior modeler back in 1992, '93. And you can see that these three here that I wrote down, and there are just a couple of screening models. Used to take days and weeks to run a dispersion model with 400 receptors. No internet, used to have to go to a UNAMAP as a predecessor to the TTN BBS brand and now the current SCRAM when everything is so updated in the computers.

And, you know, used to have to request the latest version of UNAMAP following a call, receive a mag tape from Computer Products - National Technical Information Service. And then through the 90s, Screen 2, Screen 3 user guide, code and documents, and you still had to call in to the technical transfer net or a BBS via modem. So, I'm going to go back here. I took a -- I went way back into the archives. I saw Screening Procedures for Estimating the Air Quality Impact of Stationary Sources. Well, who wrote it, by Roger Brode. So, this is a memory of Roger Brode. And the acknowledgement there, you can see I've put it in red in that.

And I'm actually getting choked up a little bit. Roger Brode, I got to experience to meet him and talk with him over the last 15 years since I've been with the Connecticut Department of Energy and Environmental Protection. And it's just -- it's a shame that he passed away so soon after -- at that time. It just so he wasn't -- just really -- I'm kind of speechless about this. So, I'm going to move on here.

So, the original guidance was released on August 4 of '88. The purpose was to replace certain old screening procedures. The big update is to transition from hand calculating impacts of basic dispersion equations to a "SCREEN" computer model. And then SCREEN replaced PTPLU, and could see the rest of them, PTMAX, PDIS. I didn't even know any of these. Anybody who's been in here [unintelligible] around sure have run these models and, of course, familiar with it.

So, here's the current document that is referenced in Appendix W. It's the 1992 version. And so, my proposal is it's time for EPA to update this since that time. It's been over 30 years. And don't ask me why, it will be obvious. Thirty-one years, science technology, 2005 - big advancement with AERMOD replacing ISCST since the late 80s. 2011 - AERSCREEN replaced SCREEN3. And so, proposing -- you just put everything that's been in the language over the last 15, 16 years since 2005 in the AERMOD's formulation, and all the documents and users guides, it's basically just replacing all that and putting in like the AERSCREEN users guide. Put all that in a new

document in the overhaul, this screening of a document.

And to deploy boundary layer meteorology, stability instead of [unintelligible] on and off cost land. Many more worst-case met conditions, now you can actually execute MAKEMET to create site-specific worst-case screening met conditions. AERSCREEN GEP analysis, of course, you're incorporating PRIME. And so, basically, you just fill in all the AERSCREEN screening modeling. And also, you now can run screening modeling with all types of terrain. From simple, flat to a complex terrain. Before you used to run screen and then you would have to run an old model.

If you remember RTDM, then CTDM Plus, well, CTDM Plus is still the *Guideline* model, CTSCREEN. But now, I think it's been employed in AERMOD AERSCREEN, and I just think it would be more appropriate now that we're updating Appendix W. Why not update the screening procedure within Appendix W to reorder the sections and chapters, add appendices, references, basic equations, AERMOD formulation and replace old dispersion curves, and EPA's AERSCREEN user's guide link and reference everything electronic versus hard copy.

So, basically, you just take everything and reformat source data. If you go back and read the document, '92 document. You know, Section 1, we enter the basic modeling concepts. So, screening based on AERMOD modelling system formulation, AERSCREEN. Then you go to Section 2, talks about all the source data types. Now, you're going to add in more source types from AERSCREEN. And then it can, again, replace the old met data discussion and tables with the AERSCREEN worst-case met conditions and the mention of the MAKEMET subprogram defaults for onsite -- or for site specifics too.

Section 4, removal of specific topics. What do they have to do with GEP? So, maybe you can reformat it to talk about GEP and downwash and that kind of screening analysis like you do with AERSCREEN. Section 5 is combining everything into one section, analysis, methods inputs, outputs. Results, compare impacts to all applicable NAAQS and increments. Maybe a quick discussion if the source passes screening. Bu if fails, perform refine single and cumulative modelling. So, it's sort of what we do with Connecticut and so, most of you - most of the states and different areas do the same thing. And basically, the other update, you can put all the basic dispersion equations in reference, again, everything in the AERMOD formulation.

That's it. Just a very simple -- take an old document and update it to the 21st century. It's no real - you know, it's not rocket science here. It's just a quick revision to the update -- update the Appendix W. We update the model formulation all the time, and it's time to update the screening procedures. This is sort of as a basic framework for all states and all local regions to utilize and work with. That's it. Thank you.

George Bridgers:

Sam, we'll make a deal. Actually, we'll have to do a little trade-a-rue, here. So, we'll do the Screening Guidance.

Sam Sampieri:

Okay.

George Bridgers:

Then, we'll get around to the Met Monitoring Guidance for Regulatory Applications from some time ago [unintelligible] and then we'll get to the Model Development Plan

[laughter]

How about that?

[talking simultaneously]

George Bridgers:

Thank you for your comments, Sam. And I'm sure you're probably one of the few people who has even looked at this guidance.

[laughter]

Sam Sampieri:

Sorry.

George Bridgers:

Keep us honest. So, if you look on your [unintelligible] schedule. You would see that there is another for presentation. Officially, before the end of the requests to present, the state of Minnesota had submitted -- I should say to the record, a presentation that they want to present. But they had no way to travel here. So, I decided just for ease of people being able to see what Minnesota wanted to present, sort of just throw it into the docket [unintelligible] but regulations.gov is where it is.

I put this -- it'll be part of the linkable presentations for the Conference. And so, they've done a ton of work looking at it and updating rules in the state of Minnesota or guidance around nearby source selection. Because it is germane to what we'll talk about tomorrow, I thought it was appropriate to have it there for you guys to reference. I am not going to step through their slides, because it's not a content that I created. But, it is there. So, that is what you will see after I post everything on SCRAM, and we'll will have clickable links on the agenda. And you'll be on here and go, "I don't remember seeing Minnesota present." But Minnesota did submit this, and I wanted to bring this in front of everyone. So, if it's there, it's a PDF, and it's on the order of [unintelligible] 51 slides. So, it is a report. I don't think that's what they intended to present, but it's there.

That then brings us to the point of the afternoon, the spirit can move us. And so, we have depleted all of the reserved speaking times. But this is the opportunity that if anybody across the course of today, or they came to this Conference and wanted to provide comment to us. Again, I want to try to be careful here, specific to ongoing and future directions for the agency on model development and not things specific to the rulemaking. Because if it is specific to the rulemaking, if you can save for tomorrow, that way, it kind of lines up with how we are doing

those response to comments.

And so, this is where I stop and I get really, really quiet and I wait to see if the spirit moves anyone to go speak at the microphone. And just to be clear—if you go to the microphone, just like we asked all other presenters today, identify yourself, who you're affiliated with, and the you're welcome to make comments.

Any takers?

Steve Nelson:

Steve Nelson with [unintelligible]. I, very briefly wanted to emphasize the presentation from [unintelligible] and the probabilistic nature of actually what happens in terms of production facilities and in plant. And it's just thinking that if we got the probabilistic performance of the standards that seems to match up with probabilistic evaluation of facility operation, which then drives towards additional development of the Monte Carlo types of methodologies for demonstrating compliance.

George Bridgers:

If you do not mind, can you just -- I had to move my microphone a step closer, could you just, reidentify your name and your affiliation.

Steve Nelson:

I'm Steve Nelson with Cold Creek Environmental Associates, out of the Seattle area.

George Bridgers:

Thank you. I just want to make sure the transcriptionist will get that.

I feel like I'm wearing something that's out of place, because of the way that everyone is looking at me.

[laughter]

While we're waiting for spirit to move others, I will mention that I didn't go through, and everybody that had trouble getting in this morning. –I went ahead and if they identified you attending the Conference, and me as a host, I have put you in for tomorrow's piece [unintelligible]. And some of you that had problems getting in today, shouldn't have. Bill, you should not have had any problem [unintelligible]. Sorry about that.

I will mention while we wait. also, this isn't your only opportunity to speak or provide comment. I understand that some people would prefer to provide a written comment. You are more than welcome to submit to the docket. I would ask if it is more forward looking and not specific to the rules, just put up at the top, "This a comment for 13th Conference," versus a comment specific to the rule. That will just help us differentiated and make sure that we do respond to comments correctly.

Seeing as I don't see anyone running to the mic and it will save the awkward pause between us.

And I will say that we're going to suspend the Conference -- closing the Conference session. Because, when we readjourn we will start the public hearing for the rule. I know that there were a number of questions today. A few people came up during lunch saying that we didn't talk much about background concentrations. Well, Alyssa has got a presentation on that tomorrow. And the guidance... the draft guidance that we put out that is interconnected with the rule. And then we have had a lot of teasing for GRSM, for the COARE in AERMET, and the RLIN work. All of that would be outlined in the morning and there will be an opportunity for more public comment late in the morning and into the afternoon.

Just, I guess, I will suspect you will have travel plans tomorrow and an afternoon flight, you probably won't miss it. Because I kind of have a guess that we'll probably be done by 1:30 p.m. or 2:00 p.m. tomorrow. If I just had to guess. We'll have to wait and see. I will have to open session after lunch just because it is a public hearing, but I imagine it will be much like today where will have one or two comments and then we will adjourn.

I wanted to finally thank everybody for making an effort to come. I'll reiterate what Chet said, it's a testament to your character, for the character of all the organizations to sponsor people to be here in the state agencies and help to travel here, if you are with a state or local, to come to this Conference. We appreciate it. The feedback is very valuable. And even though you might think it goes on deaf ears. It really is very helpful. So, I hope everyone has a pleasant evening and can find some food. In the morning, hopefully security will go a little better. But you may want to arrive a few minutes early, just to be sure. So, with that, I will call adjournment for today, and we'll start back tomorrow at 8:30 a.m. Thank you.

[CLOSE OF CONFERENCE FOR THE DAY]

[end of transcript]