Flood Modeling Uncertainties

Panel Members

David Ford, Moderator
Joe Countryman
Mike Dettinger
Justin Ferris
Michael Mierzwa
Kathy Schaefer
Ron Stork

Introduction

Gary Estes, Symposium Coordinator: As part of putting together the Symposium this year, because of the conversation that has been held internally amongst various participants, Dale Cox said, "You know we need to have a panel discussion where we can have some of these ideas and some of the controversies and some of the frictions, and instead of it just being the hydrologists in the back of the room and the emergency managers, let's open it up to a larger community because all of you work in that environment." The group can sometimes come up with a much better solution than the individuals sitting in the cubicle by themselves.

With that in mind, I asked David Ford if he would undertake this effort of moderating the panel. Some of the speakers who you heard earlier today, like Mike Dettinger and Kathy, will be on the panel. But we decided we'd bring in some other folks who had been working on this or who have insights. So, Joe Countryman was invited from MBK Engineers to be on the panel. And Justin Ferris with the US Geological Survey is working on also hydrology on this topic. And Michael Mierzwa from DWR, because his role – he just got a change of assignment – but his previous responsibility was Chief of the River Forecasting Section. He understands the interplay between all the different modeling aspects from precipitation to hydrology to hydraulics. And Ron Stork with Friends of the River … Ron served on the California Floodplain Management Task Force that the Governor appointed, and so he has a broad understanding and has been doing this for many, many years, and helps keep me focused.

I'd like to invite all these participants to come up and continue the discussion of "Flood Modeling Uncertainties."

Discussion

FORD: Have you been watching the World Cup? Did you know the US won today? And I bring that up because if you've watched the World Cup and the coach on the sideline, you can understand what my job is. My job is to try to keep these people all pointed at the same goal, to remind them of the time, and also to encourage them to pass the ball around and not hold onto it. So, we'll see how successful we can be with that.

I think Gary just introduced the panel members, but let me just run down the table, and I'll start on the opposite end in case you don't know the folks. Let's see … who's down there. Joe Countryman, MBK Engineers. Kathy Schaefer you just heard. Ron Stork from Friends of the River. Mike Mierzwa, DWR. Justin Ferris from the Water Science Center, USGS, in Sacramento. And Mike Dettinger you heard earlier.

I want to start out by referring back to something that Professor Weber said in her presentation. When she was talking about her work, she said that one of the things that we should do is elicit information about people's level of concern. And since we're talking about uncertainty in flood modeling here, what I'd like to do is just go down the table, and I'll start with you, Joe, and work this way, and ask you how much you are concerned about uncertainty

in flood modeling in general and, maybe even more specifically, how much you're concerned about uncertainty in flood modeling as it reflects, or as it pertains to the ARkStorm exercise.

COUNTRYMAN: Well, the ARkStorm presentations kind of left me wondering because there seemed to be a lot of science going into moving the moisture in and generating the rainfall, and then there was a click and floodplains instantly appeared that had absolutely nothing to do with the storms that were generated. So it's hard for me to respond to the ARkStorm analysis. It seems like the flood maps could have been developed without the storm from what I heard.

But there's no doubt that we have significant floodplains. There's uncertainty as to the extent that the levee system that we have is effective and I think the maps certainly demonstrate that. There's uncertainty as to the level of protection that we have because of the levee system. But the overwhelming uncertainty, both in forecasting and in studies, is the rainfall. There's huge uncertainties that come in.

I don't want to get too far off track here, David, but with our current requirements to look at uncertainty and parameters, you know, you've got to run your hydraulic model five different times looking at different roughness values, different timing values, all kinds of things. Well, these are miniscule changes compared to the uncertainty in the rainfall, the distribution of the rainfall, the intensity of the rainfall, the assumptions that go into that. And it seems to me that we're wasting a lot of time and energy looking at a lot of these little uncertainties when we have this overwhelming uncertainty facing us.

I had a couple of slides that I wanted to present just showing the uncertainty in a study. This isn't in forecasting; I think there's more uncertainty in forecasting. But in doing a study and trying to estimate the 200-year flood value and 90% confidence limits with that. And just the uncertainty associated with which probability distribution function that somebody would use, there's huge differences in answers that you would get. And the confidence bounds … there are huge differences. And there's even a question: Can you use confidence bounds or not? We have a lot of uncertainty in the work that we're doing. I think we're starting to try to address it in a responsible way, but I think we're just beginning.

FORD: What about you, Kathy? Are you concerned about uncertainty? I could have inferred from what you said about ARkStorm is that maybe it's not so important there. Is it more important in other aspects of the work that you're doing, or is it not important in either one of them?

SCHAEFER: I think it is important in the work we're doing. The challenge that we face is that we have a hard enough time trying to explain to someone, at least in the FEMA flood insurance rate map business, that they have to buy flood insurance because they're within a certain boundary. Internally, we've had discussions about producing maps that show the uncertainty that we all know exists. But can you imagine trying to explain to a homeowner … "well, I'm 50% confident that you're within the 1% annual chance flood event, and therefore you need to buy flood insurance"? That's the challenge. The other part is we could make FEMA maps reflect the uncertainty and have the insurance rates somehow correspond with that, but again we have a hard enough time with three rates. We have a high rate, a moderate rate, and a preferred risk rate. That's confusing enough. If I said, you know, we went to, "well, we're 50% confident that you're in the 1% annual chance, and so if you're in the 50% confidence, your rate is this, as opposed to if you're in the 70% confident area." So, it's a compromise.

I think as we, as a society, become more sophisticated about risk and about odds and chance and some of the tools, it will be better, but I share a lot of the same concerns in day-to-day stuff about how do we convey the uncertainty that exists.

FORD: So what do you think, Ron? From the perspective of someone involved in public policy, are you concerned about my uncertainty about the flood models and flood modeling?

STORK: Sorry, David. No, I'm not terribly concerned about your uncertainty. If you look at the maps that FEMA has developed, most of the acreage in the state that's been mapped into

the 1% annual risk floodplain are low-lying grounds that have historically been subject to flooding. They may or may not be protected by flood control systems. The question … I think the biggest uncertainty, as Joe says, in any particular flood scenario, what is likely to actually flood? As in you route the flood and you find a failure here, and of course a failure in one part of the system can affect all kinds of other parts of the system. To the extent that the public understand that this ARkStorm scenario is an emergency management exercise tool, a public awareness tool, that's a good thing. Because I think that is, indeed, the essential focus of this. I am certainly more than capable of quibbling with the details of how the ARkStorm is routed and which levees you fail and which you don't. But as long as we don't claim that our precision is equal to our accuracy, it's OK. It's a good planning effort; it's a good public awareness effort. And fundamentally, anybody that is living in low-lying ground that has significant amounts of water visiting from time to time is susceptible to flooding. And though we all aren't going to flood in the same flood necessarily, at least with ARkStorm which is semi-realistic, we should all take some awareness of our risk that I don't think is shared.

Most people don't really understand their fundamental hydro-geographic reality. And to the extent that this program advances that, that's a good thing.

FORD: So, Mike, you've just changed hats. But you still have "hat hair" from your job as forecaster, so I'm going to ask you first to address this question from the forecasting perspective because it's a different question. What is your level of concern about uncertainty in forecasting? And then, you can switch hats if you want to, and talk to me about communication and FloodSAFE. What's your level of concern about uncertainty in that program?

MIERZWA: OK, thanks David. I had a few levels of concern. Starting off with the ARkStorm scenario, I was actually one of the ones who, when they first brought out this idea, initially enthused like, "Oh, this is a great idea. A great opportunity for us to raise the awareness of some of these flood risks and bring our work – our area of expertise – into the public eyes." Then I asked, "well, when is this going to happen?" And then I'm like, "what?" 2011, even 2010 at some point in time was discussed. And it just seemed way too soon. I know there are a lot of planning activity's going on, both in the emergency response community and in the general flood management community, and so the timeline seemed really rushed. So I was one of those voices advocating that we really need to be involved, but at the same time we need to have this process go parallel and not interfere with our other activities.

The thing that really cooled me down, and Mike mentioned it four times in his morning presentation, so I was really happy to hear this, is he was stressing this was not a prediction, this is a scenario. This is an exercise. And as I have gone through – as an emergency responder we go through, multiple times each year, and do emergency exercises – each one is different, but you're really practicing the same thing. And if you're asked to sit there and stare at a card that's red and it's really blue, you pretend it's red and you act from there. The exercise is really designed to find how you respond to that particular emergency. And I think that the ARkStorm scenario is going to succeed in that.

Moving on to my newer hat as head of the FloodSAFE communications with the Department of Water Resources, there are some opportunities here and there are some challenges. And it's not just to the ARkStorm scenario, but how we categorize the uncertainty associated with risk. When you get into the emergency operations … again Joe had pointed out, and I agree with him … that there's a lot of uncertainty associated with the rainfall. And it's not just the how much; it's the where and the when. And that where and when can be huge. And that has a lot to say, historically, why our flood management system, both the structural and non-structural, has developed the way it has.

Into the longer-range planning, though, I think some of when we get into these detailed modeling issues – the connectivity from the rainfall, the watershed runoff, to the actual hydraulic routing – is less uncertain than some of the land use planning decisions that we're

actually getting those cost/damage functions in the future. Or, more importantly, something we don't talk about: the budget uncertainties. Are we going to have the resources to maintain the operations and maintenance of these structural and non-structural systems? Are we actually going to have the ability to buy the billions or tens of billions of dollars worth of improvements that we need to get this risk reduction? So, the important here really is, saying that this is again an opportunity to go to the public … there is a risk out there. But this isn't the only risk out there and we're going to discover some other risks as we're really addressing some of the needs of today.

FORD: Thanks, Mike. Justin, I'm going to ask you and Mike Dettinger the same question. From your perspective, sort of at the core of the ARkStorm activity, what are your levels of concern, or what are your greatest concerns about the uncertainty in your activities?

FERRIS: Well, I'll go ahead and let Mike address the rainfall. As far as the actual runoff scenario we've designed, for me at least, the runoff scenario is one possibility out of many, many different possibilities that could occur. It is, by no means, the only solution, nor do we present it as the only solution. Would I have loved to have numerical modeling, to be able to take Mike's data and plug it into a nice numerical model for the state? Absolutely. Does anyone in the audience have a complete hydrologic and hydraulic numerical model that I can use for free?

That was the problem. It's not a failure of any agency. We all have unique roles. One of the things that I think has been very beneficial of ARkStorm is it showed, perhaps, areas where we could work together better, areas where we can address certain shortcomings. They're building a nice model for the Central Valley now, but what about beyond that? What about moving towards having common input and output files, common language, and making the source code open so instead of every agency or academia all having a set or pet model, we can use or interchange models. These are some of the ideas that have come from ARkStorm because of some of the needs we've run into.

We could not find a numerical solution. And in that regard, I would have preferred it. I usually agree with most everything Joe has to say; I think it was a little disingenuous to say we clicked a button and boom, we had flood zones. There was some transfer of information from what Mike made into our HUC zones and floods. It wasn't by numerical model. I would have preferred it that way, but I am comfortable with what we did.

FORD: Mike, go ahead.

DETTINGER: I'd just like to reiterate what Justin just said. If you look at the handouts, there's the map with the HUC basins on it. All of the texture there, which admittedly amounts to probably a page's worth of lists somewhere (if you took it off the map and made a list), all of that texture was coming specifically from a combination of what folks know about likely inundation times and depths and the ARkStorm meteorology that's run through the VIC hydrologic model. In particular, that step was a desperate attempt on our part not to simply have generated – we spent a lot of time on that meteorology to have it suddenly disappear at a click and another map shows up that has no bearing.

A few points. In terms of uncertainty about precipitation, the good news is this is a scenario. We defined the scenario in terms of what came out of the WRF (pronounced,'warf") model, so I have no uncertainty about the precipitation in this scenario. We defined it. That's the nature of a scenario. In terms of prediction, yes, you can spend an awful lot of time running around in circles and if you aren't getting precipitation forecasts and the like right, all that time is largely wasted. So I agree with Joe on that point in a forecast sort of framework.

One thing I'm not sure that most of the people in this audience are aware of – and you will be if you hang in there for a couple more hours – is that the goal of ARkStorm wasn't to get to a flood inundation map. I know that's central to a lot of interests here. But you'll find out in the next couple of talks that a big part of the goal was to push beyond. When you think about

these major storms and major floods, there's a tendency to picture the guy sitting on his second-floor veranda wishing he had had a boat, or something like that. I think what you'll find in some of the talks is that the damages, the inconveniences to people, extend well beyond the immediate floodplains. And that's a huge part of what ARkStorm is about, is getting those interconnections. How it impacts not just the people who are literally heading for the hills, but also the people who were in the hills to begin with. So hang in there a little bit.

Could we/should we do the flood modeling for this? Clearly, with more time we would have more options. And I would just note the two big ones.

Number one is: with more time we would be in a position to hopefully draw in a lot of you folks. You know, local agencies and the like who have their own ways of going from a certain level of storm – you define how you want to describe that level – to flood risks and inundations and the like. Because there are many local models and a lot of hydraulic engineers (which I'm not one), who know a lot more about how to make that connection than we do in any given location in the state. To that I would just note, you know, our meteorology is now approved by the Survey and report that describes it. And so anyone who wants to play along and would like to see what this ARkStorm scenario would do in your system, shout out – not right now – but, shout out. I'd love to provide any … it's all public domain information … I'd love to share it with anyone who wants to run it through real good flood models, presumably at a local stage unless somebody really does have the statewide model or state scale model that Justin mentioned.

And that's my final comment. It seems to me that ARkStorm certainly brought us to a stage where we would dearly love to be able to take this scenario or another scenario and actually have a place where we would go and turn it into flood information that was somehow integrated across this large scale, most-of-the-state landscape. It seems to me that's not a unique desire. We've got the Central Valley Flood Protection Plan program rolling now and a key point of that is to get flood management up and down the Central Valley all sort of clicking together. There's a need to really pull together a nearly state scale vision of flood routing and flood management. For that, the Water Plan is calling for much better integration of water management and flood management. Again, these sorts of things really do call out for that large scale vision of a model that deals at something like the state scale, or at least is integrated from place to place to place to give a coherent picture across the landscape. My sense – not a hydraulic engineer, but talking to folks – is that we probably can make real headway with that with some dedication of people and resources, and maybe a little bit of new kinds of model development. But I think we have a lot of that in hand.

For me personally, if ARkStorm helps to motivate some real pushes in that direction towards a very large scale, geographically-extensive flood modeling capability for the state, I would call that a success for my part.

FORD: So Mike, I'm going to take the ball from you and pass it back down to Joe because … Joe, I think I would argue, and you and I have had these conversations a lot, that knowing how to assess and include uncertainty in our flood modeling is really difficult, but not doing it is absurd. So, how are we going to do it? Who's doing it right and what do you think we should do? And we'll just come back down the table. Let's start with you, Joe.

COUNTRYMAN: I'm hesitant to say the truth here, but part of the truth is we've got to walk away from our statistical approach to this. We have spent, since the 1950's, a lot of effort fitting different probability distribution functions to data, extrapolating those functions, and making estimates of certain return intervals. And then we go to the public and tell them, here's a 100-year event, here's a 200-year event. And when we calculate the confidence bounds on our estimate, we find out the confidence bounds are actually wider than the estimate. So if the estimate is 100,000 we see the confidence bounds on 100,000 is 125,000. What kind of confidence is that? There's no confidence.

It's a flawed procedure. Even a high-school science student will tell you that if you fit a curve to data, the curve's not any good past the data. And yet we routinely extrapolate these curves

past the data and pretend like it's real. That's one of the big problems that we have. We have a lot of uncertainty, but our procedure is flawed, I think, David, and I think that needs to be addressed.

And I think the ARkStorm – I hope I didn't sound too critical – I guess I just sound like a critical person. I actually like the ARkStorm concept because I think what we need to do is tp get back to basics and back to physics. Right here at UCD with some of their atmospheric modeling and runoff stuff, they are going back to basics. They are getting away from the statistics. And there's some papers that are going to be coming out soon that I think are going to completely undermine the whole idea that the statistical approach to estimating these events is valid. Because what it's going to show is that you can only get so much moisture out of the atmosphere in a certain amount of time with storms coming in. And I wish I had my plots here that didn't make it. Right now we're extrapolating frequency curves to infinity, like there's no limit on the amount of rainfall that can occur to generate these flows. And it's just not true. And I think, as our modeling sophistication becomes greater which they're doing here at UCD right now, we're going to see that that's a fact, and it's going to change our whole approach.

So, to get back to your question about the uncertainty, surely, yeah, we need to look at the uncertainty. We used to call it sensitivity testing with the models and the things that we do. Essentially that was a way of doing uncertainty. Part of the problem is, I think, some of the methods, for instance, the Corps is developing requires you to place information about … in other words, we used to do sensitivity testing. OK, let's increase the channel roughness 10 or 20 percent and decrease it 10 or 20 percent and get the range. See what that'll do. Now what's happened, with the new requirements of uncertainty, they say, "OK, we want you to assign a standard deviation to that." Well, what's the basis for that? OK, I increase the channel roughness 10%, I decrease it 10%, now I'm assigning it the standard deviation. What scientific data do we have that says that's the standard deviation of the error of the roughness? And we see all through this uncertainty approach that's being done, we're assigning standard deviations to the uncertainty. What's the basis? It's really just a sensitivity analysis that's being done, and then overlaying it is some statistical stuff that's added to it to dress it up and provide an analysis. I don't think ….

FORD: Kathy, what do you think about that? Is there too much statistics in uncertainty analysis?

SCHAEFER: Well, I think one of the challenges that we face is that a lot of all of this is driven by the FEMA 1% annual chance requirements. And I think that it was a good solution 30 years ago when we were all trying to figure out a way to make flood insurance economical for everyone. But I do think it is driving a lot of bad behavior. But if we stay with the current system, I don't know that there's another way out.

For example, I often make the comment that FEMA maps are "you must, you must" maps as opposed to "you should, you should." So the maps that DWR is coming out with on the behind-levee mapping, those are "you should, you should" maps. You should buy flood insurance. You should be aware of your risk. But they don't require the homeowner to do anything specific. The FEMA map, on the other hand, if you are within that special flood hazard boundary and you have a federally-backed mortgage, you must buy flood insurance or you must, if you're going to redevelop your home, you must elevate your home. So, in order to do that we have to establish a number. We can't say, "Well, you must elevate your home." We have to say to what. So there's been an attempt to put a number on a piece of paper that allows everyone to move forward with the regulations.

And there's a good intent on them. Elevating homes and all the things we've done over the last 30 years have reduced flood risk. But it's that process of going from "you should, you should" to "you must, you must" that we run into difficulty with our statistics.

The other thing that we have is this, I think everyone will agree, is having a uniform requirement for the 1% annual chance across the entire spectrum of our risk categories is also a bit absurd. It is absurd that a highly-urbanized area like Sacramento should have the same level of protection, if you will, as a small rural community. Both deserve a certain amount, but the potential infrastructure losses and the potential risk that comes with something happening to downtown Sacramento is totally different than something happening to a small community of 50 people or whatever. So there are some structural changes, I think, with the NFIP program that need to occur. Hopefully, our legislators will find a way and hopefully this discussion will ensue. I think it's been a good program for the last 30 years. I think in many respects it still is a good program. But we now have better tools, better understanding, and new ways that we should revisit the whole thing.

FORD: What do you think, Ron? Too much statistical hand waving?

STORK: The discussion on uncertainty here has to go back to what's the purpose for the uncertainty analysis. Some of you may know what we're talking about and others may say, "What the hell are you talking about?" Uncertainty, as we're discussing up here, has to do with how FEMA tries to figure out what the 1% annual risk flood is, and how the Corps assesses its statistical damage estimates based on probabilities in the context of trying to put together a national economic development analysis to try and figure out what the federal interest is in a federal flood control project.

So, these are rather important discussions to the Corps. And they are rather important discussions to FEMA and to local communities, because the way in which FEMA works is, essentially, they're defining the floodplain at least with regard to the way local communities look at it.

The legislature, in its infinite wisdom a few years back, tried to respond to the recommendations of the state's Floodplain Management Task Force and say, "We ought to ask a larger question which is: What are the areas that are actually at risk of flooding and how deep might they be?" Those are questions that are not the same question as what FEMA asks or what the Corps asks. And they are fundamentally a more common sense question and perhaps a more important answer is required there.

Believe me, this is an important discussion. But I don't think the ARkStorm scenario is dependent that much on the arcane statistical issues associated with uncertainty. There they define, essentially by fiat as if they were God, what storm is arriving and then choosing by whatever crude means they wish to try and define the areas that might be flooded. If we understand that that's indeed what's the program, it's a very useful program. To the extent that we see these precise predictions and expect them to be accurate in the sense of meaningful to the kinds of storm experience that we might experience in the future, we're kidding ourselves.

FORD: So, Mike, you've got maybe the last word here because Gary's throwing stuff at me. Let me twist the question a little bit. Are we going to address uncertainty in the FloodSAFE program and do it right?

MIERZWA: That's a no-brainer. We are going to be addressing it through the Central Valley Flood Protection Plan, and then Mike had mentioned that there needs to be a statewide plan that really addresses flood management. And actually there is. We're going to be really in the early stages of that later this fall and it will be a multi-year plan that'll be tied into the Water Plan that'll be a separate effort that we'll be looking at characterizing flood risks throughout the state. This will be our effort to really advocate for how do we bring more resources in to improve the system.

Now addressing uncertainty, I did come up with nominations for a gold, a silver, a bronze, and an honorable mention for agencies that I thought actually have addressed the uncertainties associated with flood modeling efforts. And I gave my gold aware to the National Weather

Service. They have now, where you can actually go in and view, their actual historical forecasts. You can compare what happened versus the forecast, and in doing so as a local, you can develop your own internal skill set or, sort of, confidence intervals based on their forecast and procedures. It's very transparent; it's open; it's easy to use; and you can do it on an event-by-event basis. They've been promoting an ensemble Stream Flow Prediction program that'll be going through some time in the future – I don't know when – but that'll be really building those confidence bands into short-term forecasts. So you can look and see what are the ranges of possibilities on this river of it getting high to where I have some property that is at risk. They also have that Advanced Hydrologic Prediction Service that allows you to go through and look at different confidence intervals in your neighborhoods where there are some maps that have been put online. You can see if your house is in that mapped-in area where there's a flood coming through or not. But it really brings it home. And what they've done is that they're bringing tools that someone with a non-technical background can see that there's some variability both in time and space and in various locations. So they get the gold.

I gave the silver to the Department [of Water Resources], so maybe that's a little self-serving there. But what we're going is that we're promoting that there isn't one level of protection. You've heard about a 200-year urban-level protection, and we just have another level of protection that we're in negotiation with, with everybody out there. So, you the audience, we're asking you to come to the Central Valley Flood Protection Plan meetings to talk to us about what these variable levels of protection should be. What should our investment be? And that's how we want to address the uncertainties, really, in the hydrologics, is also tied back into the damages … what's happening on the back side.

And then I gave the Army Corps [of Engineers] a bronze. And the reason I gave them a bronze is they are promoting a Corps water management system where they're trying to bring tools together. HMS is going through and addressing some of the rain on snow events we were talking about, where they're trying to bring in these other physical processes. But the Army Corps has had a long tradition of having very easy-to-use models which builds transparency, which allows local communities and consultants to go through, use these tools, and come up with different answers. And it's through the discussion of different answers that we really become aware that there are uncertainties in the work that we're dealing with.

And then I actually gave the Rookie of the Year, or my honorable mention to Apple: the iPhone. If you'll look online you'll see that there are a number of applications coming in that actually address flood risk. And as more of these come out, you'll see variability in their approach, the audiences they reach …. So, bottom line, it'll be the non-technical community that'll be out there actually as our front people, bringing the next generation of scientists, water managers, risk managers, etc. into the fold.

FORD: So, Justin, we've come to the final seconds of the game and the ball is with you and Mike Dettinger is asking you to pass it him. So I'll leave it up to you to decide whether you do that or not.

FERRIS: (Passed the ball to Mike Dettinger.)

DETTINGER: Yeah, I'd just like to note … a couple of obvious things. And one is that we've come this far with the combination of physical and statistical approaches and I can't imagine that we're not going to rely on both in the future. I would note that, at least from my perspective, physical modeling and the like, you know, the capacity to do it growing all the time, in both the computational level and the kinds of data resources that are available to characterize landscapes and structures and all that. And so, it's got to be something that we strongly explore.

And again, not to totally dis the statistical side of things, but I do have to note that one of the problems we face is at least potential for climate change. Whether you believe it or not, any statistic right now, until we really can sort this out and be absolutely sure that we're seeing climate change, any statistic that you've got right now that's based on the historical record is

somewhat suspect. We've got this other source of uncertainty that we typically haven't dealt with in the past that we either have to blow on past by determining that all this climate change stuff was a bunch of hooey, or else we've got to figure out how we're going to do a statistical approach in a world in which the climate is changing.

FORD: Join me in thanking the panel for their comments.