EPA Urban Heat Islands Webcast
November 12, 2008

Slide 38: Investigation to Mitigate Heat Island Intensity using Models and the National Urban Database and Access Portal Tools (NUDAPT)

Neelam Patel: I'd like to now introduce Jason Ching from EPA's Office of Research and Development, and he will be doing his presentation on some modeling tools and systems that can address urban heat islands. Jason Ching is a meteorologist and has been with EPA for the past 33 years. Initially he was involved with urban and regional air quality and acid precipitation studies. But in 1990, he initiated and was responsible for the development of the initial version of EPA's CMAQ, the Community Multiscale Air Quality modeling system. He is currently involved in developing advanced meteorological and air quality modeling tools and support systems, and fine-scale modeling methods designed to address current and future urban air quality issues. And with that, let's turn it over to Jason for his presentation.
Jason Ching: Thank you very much. I appreciate being on this webcast. My topic is on modeling tools as it might relate to mitigating heat islands intensities, and with the models, and also the National Urban Database and Access Portal Tools, a project called NUDAPT.

Slide 39: Presentation Roadmap

Jason Ching: I'll cover my topic in the following ways: I'll introduce the issue, and then bring us to the point where we are on the state of the science of urban meteorology and air quality modeling. I'll talk about NUDAPT a bit, and then provide an example from collaborations that we have had in NUDAPT on mitigation strategies, and end with some discussion of the future.

Slide 40: UHI Problem Statement

Jason Ching: So the problem statement as far as I can see is that heat islands are complex, and they're in response to urbanization and population growth. And when that happens, air quality is reduced and exposures are exacerbated either directly or indirectly with the heat island. And if you were to turn the problem around, you can reduce the heat island and can also get a benefit in reducing air quality problems; for example, ozone.

Slide 41: Approaches to Mitigating UHI

Jason Ching: Approaches to mitigating urban heat islands—now this is a community I am speaking to that is well-versed in this—so from my understanding basically we try to do this by partitioning the surface energy budget, or making your transportation sector more efficient, or finding ways to decrease energy consumption. There are now advances I think in models and data from about a decade ago, and I think these are advances that would be very useful as planning tools as we get to specific details—which I've heard already discussed today—in mitigating the heat island. So we'll talk about that in the rest of the presentation.

Slide 42: Modeling

Jason Ching: Let me turn now to modeling. I've claimed that there've been some advances, and they really have occurred in the last ten years maybe. And these advances with systems available to us – the Meso-scale Meteorological Model stayed at NCAR; the WRF model, which is the predecessor to MM5, the Weather Research and Forecasting model that brings together the applied and the research community. Again the WRF research is being supported by NCAR, the National Center for Atmospheric Research. In EPA, in an effort to advance dispersion modeling, that has come about in a model called AERMOD. And as you heard, I was involved with the development of the CMAQ modeling system.

Slide 43: Challenge for meso-to-urban scale modeling

Jason Ching: So what we have done in these last ten years is to try to bring our modeling to a focus on the details that we find in urban areas. In the past, we have [had trouble trying] to characterize the urban area, and we do classify it according to land use. But now we are able to remedy this deficiency or limitation with more details.

Slide 44: Models need and can now account for different scales & variations in types, composition of urban land features

Jason Ching: And this is now going to be a schematic. When we deal with trying to improve models, we first of all try to recognize that urban areas are unique: they differ between European, Asian, and U.S. cities. But typically they are configured with buildings and suburban areas; they are treed or not treed; paved, and so forth; they have different structures to their street canyons. They create perturbations to the flow, the meteorology, in terms of creating a boundary layer with a lot of structure to them. So we want to ensure that modeling tools can distinguish these unique features.

Slide 45: Introducing drag concepts to relating meso-urban and building scale features

Jason Ching: Here is a picture—this is downtown Houston—a digitized map of buildings in this 1- kilometer square area of Houston. And you can see that it's made up of buildings of all sorts of size, shape, and aerial coverage, and that these will impact the whole of the meteorology, not just the temperature field, but also the momentum—the wind field—as well.

Slide 46: High resolution morphological urban data can be derived from lidar mapping and photogrammetric techniques

Jason Ching: So as we proceed with trying to develop these modeling tools at a finer resolution, we find that data is required—data that allows us to recognize that individual cities are unique. Data now is being collected, and I guess because of 9-11, the information is being speeded up to get most of the cities in the U.S. into a database with one- to five-meter resolution.

Slide 47: LIDAR Profiling to obtain building and vegetation data

Jason Ching: We can get this kind of data either through photogrammetric methodologies or by using airborne methods with systems called LIDAR. Basically what happens here is that the aircraft will fly over a city in transects and emit light and the return signal is recorded. And the ground, by way of a return signal, and obstacles, by way of their return signals – you subtract the two signals and you will get the definition of the obstacle—in this case here, a tree, or in urban area, buildings and so forth. And it can be done with existing technologies to give you 1-5 meter resolution at this point in time.

Slide 48: Introducing canopy features into MM5

Jason Ching: We take this kind of data, we take theoretical formulations that recognize these features, and then craft the model to handle this information. But we do it in an official way, and I'd like to go through that a little bit. Typically in a roughness approach, mentioned earlier, you don't have details picked out or captured other than through some kind of roughness or information about the materials or so forth, as related to its land use. In these more current approaches, we introduce either canopy layers to capture the information better, or a single layer that tries to capture the features. And this is what we have done, in a conceptual way, in MM5.

Slide 49: Implementation of canopy concepts and urban morphology parameters for improved modeling

Jason Ching: Now when you take a gander at a city, you note that it is made up of a lot of distribution of buildings and trees. And if you try to aggregate this—as I showed you in Houston, this one kilometer area, and generalize it to the whole area—you will composite that information into what the models can use. Parameters such as roof area density (the tops of the roofs, which might be wide here, or narrow here), the building plan area density, the frontal area density (the front of the building facing the wind), and a couple ones for vegetation—so these are height-dependent parameters.

Slide 50: Selected Urban Canopy Parameters per 1 km^2 cells for Harris County, TX

Jason Ching: Here is a modeling domain for Harris County—and this is Houston, in Harris County. And you see these 1-kilometer cells that we did in the model—and each of these cells contains what I call urban canopy parameters. And we set these parameters, such as plan area density of the building, the frontal area index, and so forth. So each particular grid would have its own set of parameters, and I'll show you a list of those parameters and run the model in a moment.

Slide 51: NUDAPT: strategic tool kit for advanced urban model implementation and applications

Jason Ching: Now let me switch gears from the modeling that is now in place, to the database that can support such models. We've been working with the AMS (American Meteorological Society) and the Office of the Federal Coordinator for Meteorology. And earlier on in this decade they really tried to encourage moving forward with implementation of new models and databases. EPA supported our proposal to develop a prototype of a database that would, in principle, be a facility for the nation and beyond. And this first venture is the NUDAPT: it's a

two-year project that EPA sponsored, and it could not have been made successful without a lot of contributions from collaborators.

Slide 52: NUDAPT supports more robust model applications

Jason Ching: We're going to talk about urban heat island intensity applications, based upon modeling and on the NUDAPT prototype. So here's some background on NUDAPT. In this two-year effort, we've conducted model sensitivity studies, and what it has shown is that significant responses to the meteorology do occur when you can introduce data into the characterization of the urban surfaces and models, even to the point where we can address urban heat island mitigation concerns. NUDAPT, we know now, can be adapted to handle MM5 applications and WRF applications, and we even had collaborators from Canada and other government agencies that were interested. We've added, for custom applications, information on population and anthropogenic heating, which I think is very relevant for urban heat island intensity studies.

Slide 53: Prototype Implementation – The NUDAPT Framework

Jason Ching: In the prototype implementation, we're focusing clearly on urban modeling. In the prototype implementation we were adopting a community modeling system paradigm: what this means is we are taking advantage of portal technology. And if you ask me a question about it, I can go into more detail about it, but let me go on to say that this database has the ability—for the 133 cities that are legislated to have data collection—to have a complete set of the parameterizations needed for the advanced model that are urbanized at urban grid scales. It will have the ancillary data. The portal of the system is able to take our base data and re-grid them for others to use a customized approach. And it can also be used to change the map projections, which is a big deal. But it is able to take the gridded data we have generated and put it into different projection systems, and we've used Houston as our developmental prototype.

Slide 54: UCPs in NUDAPT (& growing)

Jason Ching: I mentioned that each grid that was shown earlier in the model will contain parameterizations. And these are a list of the parameters that are now in MM5 and in WRF. In the case of WRF, it is a single layer model that represents all of the urbanization. And MM5 is a multi-layer model. I should mention that WRF is now being implemented with a multi-layer model, much as in MM5, as we speak.

Slide 55: Gridded Anthropogenic Heating

Jason Ching: I indicated that anthropogenic heating data was included in NUDAPT, and here is a slide that displays the heating gridded at 1 kilometer. In this case here, it is an example of August, the 20th hour of that month—it's just the average for the whole month. We would have hourly-specific, day-specific information for each grid. Here is, for example, the time signature on an hourly basis for the heating per grid.

Slide 56: Sensitivity Study based on WRF-Noah UCM Temperature differences

Jason Ching: In one of the sensitivity studies, we have been able to look at the role of the heating data from NUDAPT, contrasting that with the default standard table lookup. And here in WRF, the sensitivity of using the NUDAPT-type data is shown here. Differences on the order of one degree can show up.

Slide 57: 250m Gridded Population for Central Houston, Texas

Jason Ching: I mentioned that population information was an important thing to have—in my mind—in NUDAPT for applications of exposure assessments, or homeland security issues, or whatever. We've had a wonderful collaboration from the Los Alamos National Laboratory, and they provided us gridded fields of daytime population as well as nighttime population. You will remember that nighttime population is the data you get from the Census. Daytime population is where people actually reside or work or go to school. In this case it is all the worker population.

Slide 58: Population

Jason Ching: Los Alamos has been very gracious and generous in providing to NUDAPT a database for the entire nation at 250 meter resolution of the gridded data and nighttime population, so that's part of NUDAPT.

Slide 59: Custom Collaborations

Jason Ching: The collaborations that we have had in these past two years have been primarily focused on MM5 and WRF, but we've had collaborators also involved with other meteorological systems. The data—we now have about 40 cities of the 130 cities that we've collected, and we're collecting more from the National Geospatial Agency. We have the gridded parameterized fields, what we call UCPs, for Houston. And in Arizona, Arizona State has developed customized UCPs for Phoenix. And there is Haider Taha for Sacramento, and I believe Haider is on this webcast. The day-night population and the anthropogenic heat is available—the heat rate is for Houston, and of course you saw the ones at the national level. While we have the prototype in Houston, we have collaborations and different levels of effort in Phoenix, Atlanta, and possibly a European megacity.

Slide 60: Urban Heat Island Mitigation Study

Jason Ching: So how about the urban heat island. Well this next set of slides does come from Haider Taha, and Haider, you might want to help me out if I don't do justice to these slides. When mitigating heat islands, we'll get the benefit of reduced cooling energy required, and subsequently we reduce the emissions generated from power plants. By reducing emissions—such as NO_x, VOC, CO_2—from anthropogenic sources, it also reduces some of the sources in a biogenic way. These reductions or cooling effects slow down the photochemical production of air pollutants, and they improve the air quality, mitigating the heat island of course, and reduce the pollution, and reduce mortality. The urban heat island does impact the meteorology and convective precipitation that can occur with additional heat and moisture that is produced in the city. So again, at this point, how might we use the tools that we are talking about? By increasing the albedo, by increasing the canopy coverage, by decreasing the anthropogenic heat flux, by

greening the city, changing thermal properties, changing the degree of imperviousness, seeing the effects of air on the moisture and the runoff—these are effects that can be dealt with.

Slide 61: Examples of uMM5 applications

Jason Ching: Again, back to the collaboration. Here you see Haider Taha is providing the experience on the subject. He's done the work in the Houston area, and he's also performed studies of the sort in the Sacramento, California area.

Slide 62: Simulating UHI and mitigation potential (cooling) of the air and at the surface as a result of increased urban albedo

Jason Ching: In the study for Sacramento, let me go through this in a little bit of detail. It's a nested domain—a mix of the version of MM5—it's his customized version. He's taken MM5 from 12 kilometers to 4 kilometers to the domain for Sacramento, in which this simulation was done at 1 kilometer using the night system. And here, you see the wind field as well as the temperature difference for simulated temperature changes resulting from urban albedo changes. And, if you look on the right-hand side of this, this inset shows you one of the many fields that are urban canopy parameter fields used in this urbanized MM5. Now if you take any one of these grids—in this particular case, Haider has selected the point here in the red circle—to look at the time signature over some 4 days or so, what happens when you change the albedo or the canopy (the vegetation, etc.) by a certain amount? And when you apply them individually, you come up with the resultant heat island or change in the temperature from a base case. Again here, only at this red dot, it's his time signature. And so if he changed the canopy, the vegetation materials, you will get this kind of response from the model in red. If you change the reflectance, or what's called albedo, you get this change shown in blue. And of course if you do a combination, you'll amplify both signals. So this is what can be done; in this case here, I think the simulation was done for flat-out change in albedo, percentage-wise, or in the canopy. You're permitted to do this, you're allowed to do this, you can exercise the model in any way wish, by changing the composition of the albedo and the canopy grid by grid. So there's a lot of flexibility you're allowed in these models.

Slide 63: Simulating changes in ozone to UHI reduction scenarios

Jason Ching: And Haider has taken results of the temperature changes that he can achieve into an air quality simulation. And in this case here, you have a 4 kilometer grid domain providing information, a nested domain here, for Sacramento. And here is the base-case air quality simulation for ozone shown here. Downtown Sacramento here—this is a domain for Sacramento being simulated at 1 kilometer. If you apply the urban heat island mitigation strategy, this is the kind of air quality improvement you can achieve in this kind of simulation. In here, downtown Sacramento seems to appear to have anywhere from 1-10 mitigation for ozone, so that's a benefit you can get from using this type of tool.

Slide 64: CMAQ (1 km grid model ozone in Houston, 2100 GMT)

Jason Ching: To return back to Houston, this is a simulation with MM5 and with CMAQ. CMAQ driven by MM5, without NUDAPT. When you look at NUDAPT, you get this simulation of CMAQ, and if you take the difference—while we cannot at any point evaluate the magnitude of the difference in the structure, you can see that there are significant differences if you were to bring on board NUDAPT into these advanced systems.

Slide 65: Overall summary NUDAPT provides

Jason Ching: So, in summary, specifically NUDAPT, it's my impression that it was a very successful venture. It is a platform that we have demonstrated can accommodate new modeling systems, new sets of parameterizations. We've demonstrated that it can be used for urban heat island modeling guidance. The community framework—more and more I think that a lot of us are feeling a lot more comfortable with the idea of community—this was built, the community concept was a basic part of the framework. It is urban focused. We have tools in the system which we can't talk about today, but we can certainly do regridding and remapping, which will be very helpful. Prototypes: we've got the prototypes here for urban heat islands, as we've demonstrated in Houston and Sacramento. What it means is that if it can be demonstrated in these cities, it can be demonstrated or used in any other city as well. The data—cities do change, and NUDAPT can certainly accommodate changes in the data.

Slide 66: Suggestions, Options, Levels of Collaboration

Jason Ching: I'd like to promote the idea of collaboration, because I think that advancing models and methodologies becomes possible with a collaboration among modelers. Among those that are involved with a policy or applications, that's also possible. We'd love to see additional data become available to NUDAPT, and therefore then to the community. We're looking to see moving to a NUDAPT that could be a community decision support system with the idea of performing heat island mitigation analyses as a focus possibly, either within the NUDAPT system or as a collection of systems.

Slide 67: Final Remarks

Jason Ching: So again I want to say that in my opinion, this was a highly successful prototypic development. It is ongoing—by that I am saying that we have funding that allowed us to continue this development just for one more year. After the end of FY '09, we're going to have to find other means to support NUDAPT. Currently, for fiscal year '09, the system is at the University of North Carolina at the Institute for the Environment, in the section called CMAS. I'm exploring having NCAR (the National Center for Atmospheric Research) host NUDAPT as a permanent facility. They are receptive to the idea, so that discussion will continue. It makes sense because NCAR is the developer and supporter of the research version of WRF. So stay tuned for any further developments on that. The NUDAPT is flexible, and it is powerful. But there is going to be a journal article; in the Bulletin of the AMS that describes the system briefly. But I think the point is that it's got the power in the modeling database to stress urban heat island mitigation strategies; it's based on science that is improving, and getting better all the time. And so my last point is I encourage collaboration in the development or enhancing of this set of tools.

Slide 68: NUDAPT Collaborators

Jason Ching: And I guess I do have a last slide which shows the list of collaborators that helped make this two-year prototype a success.

Slide 69: Thank you for your time and interest. Questions?

Jason Ching: Ok, that's the end of my presentation.

Neelam Patel: Thank you Jason. Do we have any questions for Jason on the prototype and the tools?

Lauren Pederson: There was one question that came in. Please briefly review again the various potentials for collaboration and how one might get involved?

Jason Ching: The portal does allow for specific collaborations. In the portal we set aside rooms, and groups who would like to collaborate can contact me, and we can set up a special room specifically for that collaboration. It could be an applications collaboration, it could be a model evaluation collaboration, it can be a whole host of possible activities. It's a room dedicated to those who are going to be the collaborators: they can share what they're doing through the Web, they can use a tool to help them facilitate collaborations. We really don't have a whole lot of experience to make this happen, other than our Houston study, but we do know that such a mechanism within the portal does facilitate collaboration. So I guess maybe that's a short answer to that question.

Neelam Patel: Thank you Jason. Are there any other questions for Jason on the application of this prototype? Okay, well then I'd like to open up the conversation to participant updates. I know that there were some upcoming meetings that people wanted to mention. Or if there are any other questions on the Sustainable Skylines Initiative, or any other programs that we've mentioned?

Slide 70: International Association for Urban Climate

Mel Pomeranz: Yes, Neelam, if I may. This is Mel Pomeranz of the Lawrence Berkeley National Lab, and I wanted to bring to the attention of the participants an international conference on urban heat islands. It's called the Second International Conference on Countermeasures to Urban Heat Islands. You very kindly put it on the EPA Resources calendar, but it is way down at the bottom because it's in September of 2009, when it will actually take place in Berkeley near our lab. But I wanted the participants of this webcast to be reminded of it. In fact, we're going to extend the deadline for applications or abstracts—we originally thought it would be November 15, but since this webcast is so close to that date, we are happy to extend the deadline of abstracts to December 1. And much of the work we heard about today would be excellent at that meeting. People are going to be coming from all over the world to present their work, and some of this sounds just perfect for our meeting. So I would encourage people to take a look at our website, it's http://heatisland2009.lbl.gov/, where you can get more information, and a general outline of the meeting, and the kind of topics we're going to cover, which are very similar to

what we've heard today. Thank you very much for the opportunity to mention that and remind people about our meeting, which should be very exciting.

Neelam Patel: Thank you Melvin, and also, in the handouts section we've included a brochure about the conference. You can download that for more information. I just want to make a quick distinction. On your screen you may see a slide about another international conference on urban climate; that is a different than what Melvin just described. Melvin's conference is in September of '09 in Berkeley, California. And if we have Dr. Brazel still on the line?

Dr. Tony Brazel: I guess you have the first slide up there—there are two things. One is the meeting, which is the second slide. But the first one shows that there is a newsletter that people can, if you haven't gotten a chance—get on that website http://www.urban-climate.org, and you get to a newsletter of this organization, which contains what you see on that first slide: upcoming conferences, articles, student information and opportunities, reviews of various climate work around the world in different locations.

Slide 71: Call for Papers: The 7th International Conference on Urban Climate (ICUC-7)

Dr. Tony Brazel: And the second slide gives you details of this meeting: before the LBL meeting in September, you can go to Yokohama in June and July, and attend this international conference on urban climate. And there are several links there on the second slide that you can take a look at if you would like to attend that. Abstracts for the meeting are due December 15th. Thank you.

Neelam Patel: Thank you Dr. Brazel. Are there any other announcements or updates that people would like to share? Okay, well in that case, I would like to thank everyone for joining us for the Urban Heat Island webcast. And again, I encourage you to contact me, Neelam Patel, with any ideas or presentations for future webcasts. And again, I thank you for joining us.

Demetra McBride: Neelam, is it too late—I had a question? This is Demetra McBride again. For Dr. Brazel: are there any other prominent health impacts other than heat-related stress impacts and cardiopulmonary related impacts to human beings from urban heat island effects?

Dr. Tony Brazel: Wow, big question. I think the answer is yes. And I think there might be information at that AMS meeting if you look through the whole list of papers related to different aspects of health. There's disease vectors and all kinds of things that urban areas might affect. I know here in Phoenix we're worried about asthma and valley fever, and how the urban area distribution of land cover and climate relates to all of that down here in the Southwest. I'm sure that other people can speak better to that than me for what's going on in the rest of the world.

Mel Pomeranz: If I could make a comment—this is Mel Pomeranz again—someone actually did a very interesting highlight study of air pollution and how that can affect land values, like smog and visibility, things like that. That's another thing that—well, I don't know if I should talk about it, with the mortgage crisis as it is. Nonetheless, air pollution can actually affect people's views and the value of their property—another side issue; actually it was numerical values that have been estimated in the past.

Neelam Patel: Thank you Melvin for describing those studies to us. I just wanted to respond to Demetra's earlier question about how to deal with resistance by private landowners in addressing their landscapes, making them hardscaped. Demetra, I also wanted to refer you to the Urban Heat Island Community Actions Database that has information on projects. You might find some resources there. And also on EPA's Clean Energy Local Government website, there's a database that may have additional information for you as well.

Demetra McBride: Excellent, thank you. We were trying to avoid regulation, and that was the only thing.

Neelam Patel: And I think, just in terms of convincing those corporations, it may be helpful to point out that these things are being instituted because there are benefits.

Demetra McBride: Great, thank you again.

Neelam Patel: Any other questions from any other participants?

Jason Ching: I wanted to ask if Haider had any comments on the use of the tools that I talked about, relative to the heat island demonstration. I don't know if Haider is still on the line?

Neelam Patel: I don't think he is. With that being said, we are running over, it is 3:45. So I do want to thank everyone again for participating in the webcast. And our next one will be coming up in the Spring—late Winter/early Spring—so we can connect that, and of course we have our Urban Heat Island Listserv as well.