The ICNet REU Freeze-Thaw Research Project:
Climate Scientist Outreach Synopsis

Summer 2015

Approach

During the summer 2015, a small group of ICNet REU students team conducted a research study on the potential impacts of climate change on pavement freeze and thaw dynamics. As part of the study, we sought the expertise of climate scientists in order to refine the methods for using and interpreting climate model output.

We timed our interactions to best capitalize on the climate scientists' input. Prior to contacting the climate scientists, we had downloaded climate model output, conducted preliminary analyses baseline checks and were early in the analysis phase. Before speaking with the climate scientists and receiving their feedback, our proposed approach was to compare the model output to historical data using a suite of statistical analyses, use the results of those analyses to filter out poorly performing models, and then use the remaining models to examine future pavement freeze and thaw dynamics.

We contacted the ICNet members who had experience with climate model output in order to ensure that our approach would be comprehensive and follow methods that had been vetted by the climate community. We prepared and presented a powerpoint presentation, which can be found with the collection of documentation for the case study, to seven climate scientists. The meetings were conducted in conference calls, screen-shared online chats (gotoMeeting), or in person. Each meeting took between 30 minutes and 2 hours.

Expert Input Summary

After the climate scientist meetings, our team compiled their input and adjusted our research plan. This section presents the input that was generally agreed upon by the experts.

1. *Most climate experts thought the baseline model comparison was unnecessary. Based on their input, we reduced this aspect of the study and only used box plots and probability density functions (PDFs) to compare engineering model results using climate model output to engineering model results using observed data. We decided not to eliminate the baseline comparison because the research engineers wanted to ensure that the models could reasonably replicate the present and also to develop an understanding of the typical variation across models and observations for the baseline period.*
2. *The climate experts strongly suggested that we include all of the climate models. Their reasoning is thate using a larger number of models increases the overall variability of the ensemble. Some suggested that if we needed to narrow down the number of models, we should do so in a way that incorporates a variety of extremes. For the future, they suggested that we experiment with dynamical downscaling. Based on their input, we expanded our model list to include all available models.*
3. *Some of the scientists suggested that our timeline was too long (2000 to 2099) and recommended breaking it into 20- to 30-year periods during the analysis. In the analysis we included figures that captured the entire period as well as summary graphics for current, mid-century, and end-of-century periods.*
4. *Climate scientists suggested that for future analyses, we include multiple runs per model to compensate for the internal variability of the models. This was beyond the scope of the summer work, but will likely be completed in the future.*
5. *Many climate scientists touched on the importance of documenting our process and communicating our findings. They suggested simple and to-the-point communication, with a focus on three or four highly important visuals. We followed their advice regarding visuals. After creating the final figures, we also followed up with several of the climate scientists and revised the figures based on their suggestions.*

Individual Meeting Summaries

Seth McGinnis (UCAR), Mari Tye (UCAR), and Anne Stoner (Texas Tech University)
After presenting our data collection and analysis process to the climate scientists, they offered input on sources, source reliability, and data collection strategies. They believe that the Bureau of Reclamation site provides enough reliable CMIP5 data. They also think that our baseline analysis is excessive because the data have already been bias corrected. However, eliminating models based on their performance with historical data would be to judge the models based on random variance. We would lose compensational variance by picking out specific models. They think that if we must pick models, we should pick based on a variety of extremes. However, they recommend using all 19 models if time and resources allow. They also suggest that we expand our future analysis to include all of the models, as well as to further analyze based on regional modeling through dynamical downscaling, if possible. Dr. Tye suggested that for comparisons, we should use Cumulative Distribution Function (CDF) charts in addition to histograms and boxplots to look at the overall distributions compared to each other. Lastly, they gave us some topics from other sectors that we can investigate to help guide our research, such as the drought severity index and growing degree-days.

After the discussion, our team decided to cut down on our baseline analysis and only to compare box plots and CDFs. We also decided that looking at regional modeling would be useful and interesting, but there is not enough time or resources to do this during the summer. We will include all of the models. To get a better understanding of how other teams have tackled this type of research, we will look into the other sectors that these scientists suggested.

Cameron Wake (University of New Hampshire)
Dr. Wake provided us with input on our data analysis and presentation. In his opinion, the time spans for our historical data (1950-1999) and future data (2000-2099) are too long. We will not be able to compare year-to-year without smoothing out the variations. Breaking the span into 20- to 30-year periods will allow us to see a good amount of variation. He also suggested that we continue to compare the model baselines to the observations but not omit any of the models. Dr. Wake pointed out that a very important part of our process is how we present our data and findings to others. He suggested that we keep the information that we present short and sweet, selecting a main message and one key question that we are answering. He suggests that the REU students meet with specialists from the ICNet at the end of July with a brief presentation of the information prepared by that point.

Muge Komurcu (University of New Hampshire)
Dr. Komurcu provided input about data collection and resources. She suggested that we use a model with a higher output frequency as well as more options with model output (e.g., soil temperature, moisture, relative humidity, etc.). She showed us the model that she is currently using for research. It is dynamically downscaled output of the northeastern United States to a 3 km by 3 km grid and outputs information hourly, but it only works with RCP 8.5 because it is expensive to run. Though this kind of data may be unnecessary for our relatively simplified project, she is still going to send us the other options for data sources to possibly compare to the statistically downscaled output in the future.

Bruce Anderson (Boston University)
Dr. Anderson gave us a great deal of input on our baseline and future analysis. He said that our baseline output credibility check is redundant because the models have been designed to replicate the historic data and thus should fit. He suggested that the number of models that we choose is based on our own discretion, and there is no real statistical choice to it. If we want more output then there is no harm in that. He has concerns about our future analysis because we were only doing one run per model. He said that there is too much internal variability of a model to do only one run, but if we do multiple runs, the average will compensate for that. He also pointed out that if we start calculating the freezing or thawing indices for only an abbreviated portion of the year, in the future that thawing may start outside of that window and cause inaccurate results. His overall advice on our process was to stay in constant contact with climate scientists and to receive their feedback so that our framework is “bulletproof.”

Linda Mearns (UCAR)
Dr. Mearns gave input on our data collection and on the presentation of our findings. She liked the simplicity of the question given the timeframe and suggested that we look for examples of similar projects. She said we should spend less time evaluating our models because it is not very useful and instead dedicate our time to looking at all of the models to "get a feel for the total scatter." She also recommended using multiple runs of the models to get better variety. In terms of analyzing and presenting the results from the output, she noted that we might have problems with the extremes. According to Dr. Mearns, bias correction is not as successful when you are working with a specific threshold, because model variability makes it difficult to tell when a variable exceeded a certain number. For example, we use the CFI > 280 threshold. She also suggested that we consider that there are specific socioeconomic and demographic conditions that are associated with the different climate scenarios. For example, if there is a decrease in population in an area, there will be a decrease in the volume and loadings on those roads, which may change the implication of the output.

Conclusions

The REU team had an extremely positive experience working with the climate model experts. We found it insightful and instructive to be able to have an open discussion. Though we asked specific questions at our meetings, the conversations tended to be free flowing. Most of the climate scientists gave similar feedback, which was reassuring because we received consistent advice. Modifying our process based on their feedback was uncomplicated and significantly improved our study. We highly recommend working with experienced climate scientists when working with climate model output – this is critical for first time climate change and infrastructure researchers and valuable even for subsequent studies.