Lost in translation: Bridging the gap between science and climate policy

Dr William Gutowski, a Professor of Meteorology in the Department of Geological and Atmospheric Sciences at Iowa State University, has focused his current research on the importance of atmospheric dynamics in climate, especially for applications at the local scale, and for the water cycle. His recent work aims to make the Community Earth System Model (CESM) more usable for practitioners in the water industry in the Denver region of the US.

Dr William Gutowski's current research aims to make Earth System Models (ESMs) more beneficial and relevant for decision-making. The EaSM project he is part of involves bringing together different users of model data to better understand what stakeholders need from scientists. Dr Gutowski and his collaborators have been working with partners in the water industry predominantly to ensure that their output is suitable for practical implementation.

THE EARTH SYSTEM

The term 'Earth system' refers to the various parts, or 'spheres', of the Earth, such as the atmosphere, oceans and other elements of the water cycle (the 'hydrosphere'), the living things across the planet (the 'biosphere'), or ice and snow at the poles and at high elevations (the 'cryosphere'), and the interactions between these. Earth system models are used to explore interactions between these different elements of the Earth system.

EARTH SYSTEM MODELS

Earth system models are idealised representations of the Earth system that allow scientists to explore these links and connections. Since we cannot perform experiments on the planet itself, we use models, like the Community Earth System Model (CESM) of the US National Center for Atmospheric Research (NCAR) that Dr Gutowski and his collaborators work with. Models are simplified, yet still very complex, computer simulations of the Earth that can be adjusted and tested to reveal the processes and mechanisms that are important in the real world.

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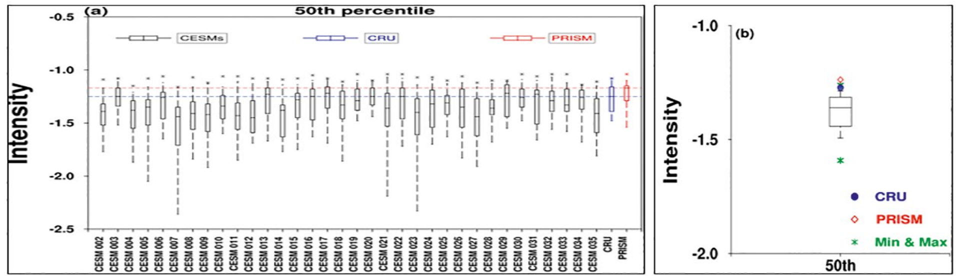


Boxplots of (a) 50th percentile intensity attribute of MODE drought objects for CESM-LE ensemble members and observation, and (b) the ensemble mean of CESM-LE ensemble members. The whiskers indicate 5th and 95th – percentiles, respectively. The asterisks indicate the minimum and maximum drought intensities.

USING MODELS

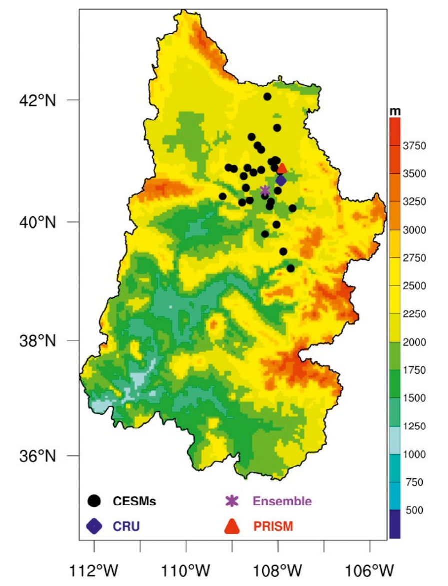
Models like the CESM are very useful tools for understanding the interactions between parts of the Earth system, and for making estimates (or 'projections') of the future. This makes them extremely useful for planning, decision-making and policy, particularly in areas that are sensitive to the effects of global environmental change, such as water resource management. The EaSM project, under the shared leadership with NCAR colleagues and Dr Gutowski, aims to increase the relevance of the CESM to end-users in the water industry, particularly to optimise the transfer of useful climate information.

THE PROBLEM WITH USING MODELS

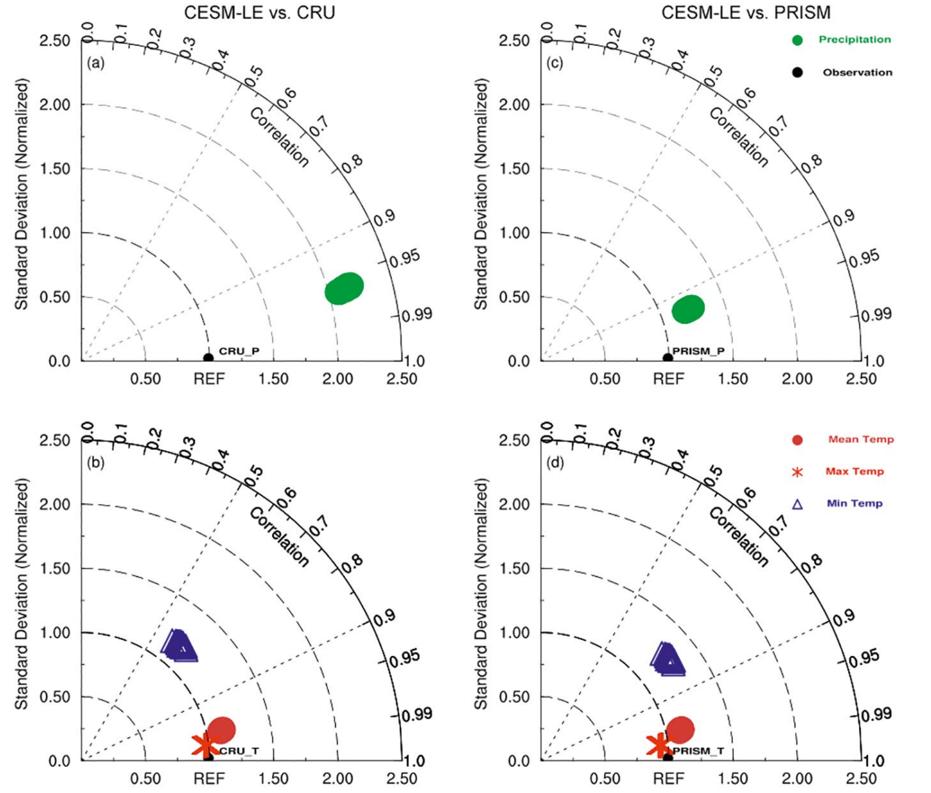
The problem is that CESM data are in a format that is difficult to understand and work with. This lack of user-friendliness means that that although the data are potentially very useful, the data that are produced do not get translated into practical application terribly well.

One reason for that is the different needs of practitioners and scientists who make use of the CESM. For instance, while water utilities generally need data on meteorological measures such as temperature, winds and rainfall, they are often more concerned with much more complex indicators, such as the number of weeks without rainfall after a winter season with above-average snowfall, than with something simple like air temperature.

A second reason is that the modelling and user communities operate on different spatial and temporal scales. Modellers often focus



Spatial distribution of mean of centroid location attribute of MODE drought objects for CESM-LE ensemble members and observations. The map shows the Upper Colorado River Basin (UCRB).



Taylor diagram of spatial correlation and relative magnitude of spatial variability between CESM-LE ensemble members and observations (CRU; left, and PRISM; right) for (a and c) precipitation and (b and d) temperatures (mean; brown, maximum; red, and minimum; blue) climatology over UCRB for the period 1950–2012. The observations provide the reference datasets. The closer the points are to 'REF', the better the agreement.

on long-term global consequences and processes, and non-academic users of the data, such as energy or water companies, are more interested in local and shorter-term effects.

In addition, the way CESM output has traditionally been supplied (a one-way street) inevitably leads to a loss of knowledge about the scenarios, methods and data used, because things get lost in translation. This therefore impacts policy-making and the implementation of solutions and adaptations to climate change.

INCREASING TRUST IN MODEL PROJECTIONS
Making sure that models are producing the right sort of estimates (a process called validation), is crucial to increasing trust in model projections across the board. Dr Gutowski's project borrows techniques from weather forecasting to determine when the CESM is accurately predicting measures like rainfall, and where it is getting it wrong. This is an essential step that also drives model development.

The project has already had a positive impact for scientists and practitioners"

It is hard to validate on the local (decision-making) scale. Model validation is usually performed using averages over time and space scales that obscure the local scale, so they are not relevant to practitioners. Since the things practitioners are interested in, such as predicting the onset or end of dry periods, are a product of the complex interactions between 'spheres', more sophisticated methods are required to validate these types of behaviour, identify uncertainty and extract information on a scale that resource managers can use.

Communicating uncertainty is critical for climate policy. To make good planning decisions, decision-makers must understand the probability of different future scenarios occurring. Understanding uncertainty is essential to separate emerging climate signals from existing regional variability. To increase trust in model output, the EaSM project makes clear estimates of uncertainty and engages with practitioners on the subject.

BRINGING MODELLERS AND MANAGERS TOGETHER
Dr Gutowski's project is a collaborative and interdisciplinary activity that aims to bring together the various users of the CESM to find out how to meet their needs. This involves sharing knowledge about the way model data is generated and about the uncertainty inherent within future projections. It also involves dialogue with users of model data to understand their requirements, so these can be considered when producing data and tools, as well as learning from their experience of actually using model data.

The scientific discourse around climate change has moved on from "climate change is happening" to "here's how we can adapt to climate change". The water sector is likely to be one of the most affected, therefore Dr Gutowski's research group has focused on the water industry during this project. They have partnered with a regional water utility, Denver Water, to make model data relevant and useful for end-users in the water sector, while still preserving the integrity and capability of the model. They aim to develop a "best practice" process that delivers high quality, yet usable science.

To do this, Dr Gutowski and his collaborators have identified metrics that incorporate the needs of scientists and resource managers. This makes the predictions that they generate more specific and quantitative,

Q&A

What was your primary motivation for this project?
We had two motivations: (1) to adapt successful analysis techniques from weather forecasting to evaluation of climate simulations and (2) to improve the information flow from climate simulations to decision makers who could use it. We were especially interested in analysis techniques that make the information more accessible to users, something the weather forecasting community has worked on developing.

How difficult (or easy) is it to communicate with non-academics about climate model data?
The challenge is not so much communicating on the data itself (e.g., it will be warmer by X degrees on average) but on the assumptions that were involved with producing the simulations. These might involve approximations or estimates of input data that might be plausible, but which also are part of the uncertainty in the information provided. When translated into terms that reflect the weather experiences of the users, such as changes in hot days or the frequency of severe-storm systems, then the communication can become clear.

What was the most surprising thing you have learned about model users' needs?
An important surprise has been learning that the users are often interested in weather features that the model developers have not considered, as the article discusses. There may also be key thresholds, such as droughts exceeding a specific time length that trigger responses by water managers, which model developers usually do not consider when analysing their own models.

How many more people or groups now use your model output as a result of this project?
That is difficult to say, as people are motivated to access the CESM data archive and use its output for multiple reasons that could include our work. What we can say, however, is that we have developed a good dialogue with Denver Water that has been to their benefit for understanding climate projections and to the modellers' benefit for gaining new perspectives on how the CESM performs.

What can industry partners do to guide the development of models?
They can engage in dialogue with the modelling community to determine what simulated weather and climate processes are most important to the industry partners, assess how well those important processes are simulated and determine what that assessment means for the climate change information relevant to the industry partners.

so they can directly improve decision-making. This also benefits the climate modelling community because feedback from the resource managers can improve models' reliability and make greater use of their outputs.

POSITIVE OUTCOMES OF THE RESEARCH
The project has already had a positive impact for scientists and practitioners. For example, their platform to visualise model output makes data easily accessible to a variety of groups and organisations. The 'dashboard' condenses all the relevant information that a user needs into a single, digestible page. This makes it easier for non-scientists to implement and use CESM output.

By making the project application-focused, Dr Gutowski and his collaborators have interacted with end-users of climate model output, such as water utilities and decision-makers. This collaboration has benefitted everyone involved. Together, the scientific and user communities have evaluated the model against certain metrics, such as drought episodes, which stress water systems, to assess their usefulness from different perspectives.

The project will continue to develop, building on the experiences of users and tailoring the model further for practical use. This will allow the CESM to be used more and more, and to have a greater impact as time progresses.

Detail

RESEARCH OBJECTIVES
Dr Gutowski's research concentrates on the role of atmospheric dynamics in climate, especially the dynamics of the hydrologic cycle and regional climate. The EaSM project Dr Gutowski is part of, is attempting to integrate the needs and understandings of both the users of climate information, such as the water resources community, and the climate modelling community that continues to advance the complex Earth System Models (EaSMs).

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BIO

William Gutowski received a PhD in meteorology from the Massachusetts Institute of Technology in 1984. His research includes regional modelling of Arctic, African, and East Asian climates and involves collaboration with scientists in these regions. He was a Lead Author for the 2013 IPCC Fifth Assessment Report.

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