Prediction as a Technology

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Why is Weather Prediction Possible?

Weather prediction are routinely used by decision makers with the result being actions that save lives and permit more efficient day to day economic decisions, such as airline routing and electric power allocations. These forecasts represent a successful application of science to the practical needs of society.

The reason for this success is that thousands of observations of temperature, humidity, pressure and winds are made every day. This information is inserted into numerical weather prediction models, which use the physics of the atmosphere to forecast weather over the next couple of weeks. By sampling the atmosphere, the beginnings of a winter storm, for example, can be seen, and the models are able to realistically simulate its further development and movement. This sampling of the atmosphere in order to provide information to insert into numerical weather prediction models is called "initialization". This initialization provides a real world constraint on what the models forecast. On the shortest forecast time periods, the model relies heavily on the observed values that are inserted into the model to provide skillful forecasts. These observations are inserted into the model such that the physics of the atmosphere is preserved. Millions of forecasts have been made with the numerical weather prediction models, where they have been tuned such that they provide accurate weather forecasts most of the time

What are the Limits of Weather Prediction?

The further into the future that a model forecasts, however, the more that the atmosphere model "forgets" these initial conditions. The model then must rely on the physics within the model to provide skillful predictions. Atmospheric physics are complex, however, which results in the forecast weather deviating significantly from the real world weather with time. The models lose most of their skill at forecasting the future day to day weather after a week or two.

What about Multi-decadal Climate Prediction?

Climate prediction shares many similarities with weather prediction, except of course that forecasts are made for decades into the future. Many scientists believe that climate prediction is different than weather forecasts because, they argue, accurate long-term predictions depend upon the large-scale forcings in a climate model, which they call boundary conditions. However, other scientists (including the lead author of this essay) believe that climate model predictions are in fact just as sensitive to initial conditions as are weather forecast models. This scientific debate can be difficult to resolve based on the actual behavior of the climate system because the predictions are made for so far into the future. However, resolving this scientific debate is important for understanding the proper role of climate predictions in climate policy decisions.

What is Necessary for Accurate Multi-decadal Climate Prediction?

A necessary condition for accurate multi-decadal climate predictions, however, is that all of the important climate processes and all of the important land, atmosphere, ocean and continental ice processes be accurately included in the climate models. Currently, however, all of the important climate forcings are not included in the models. Climate scientists, for example, have a very low level of scientific understanding of the role of small atmospheric particles (called aerosols) on cloud and precipitation processes, as well as their influence on “global warming”. The scientists also do not adequately understand the role of the vast human alteration of the land on the climate system. These limitations in climate science mean that accurate forecasts of average weather conditions in Italy or elsewhere, decades into the future are not yet possible.

What is an Alternative for Decision Makers since Skillful Multi-decadal Climate Prediction are not Possible?

An alternative approach to provide useful information to policymakers is to assess the range of risk to important societal and environmental resources. By determining the threats associated with each resource, decision makers can determine the most appropriate mitigation and/or adaptation approach that best reduces the risk, and can work to reduce these threats even if we are unable to accurately predict the future. Rather than relying on the limited range of conditions predicted by the multi-decadal climate prediction models, the evaluation of the spectrum of threats is inclusive and can cover the entire range of possible threats.

Financial resources can then be more effectively spent to benefit society and the environment. For example, what is the most effective approach to insure adequate water supplies for agriculture, industry and direct human consumption? Similarly with food and energy, what policies can be implemented that provides adequate supplies to these essentials?

The methodology to assess these risks includes scenario studies where past extreme climate events, such as long term drought, are evaluated with respect to their impact if they reoccurred today (or in the next several decades) with the current local, regional and global society. If we protect ourselves against these threats, we will be better able to reduce the risk of serious impacts on the society of the 21st century.