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No clear forecast for climate change

How global warming would affect climate is a question that matters to everybody, says S.Ananthanarayanan.

That the weatherman cannot be relied upon to say if the rest of the day is good as the morning is a slur which the weather forecast community has become used to. But still the weather is vital to commerce and industry and it is thanks to the weatherman’s watch that international shipping, the airlines, power supply and food production are able to function. And, by extension, the survival of social and ecological systems of the earth would depend on making the right moves in response to global warming.

Predicting the whether is difficult because of the huge number of factors. The ‘***butterfly effect***’, a concept in ***chaos theory***, is a case of how a very slight action (a butterfly flapping its wings) could have enormous effects on the whether at the other end of the world. And still, the world’s weather watchers collect and share wind and temperature data of almost the whole globe, to get the right trends, and help bustling citizens get through the day. But doing the same thing to predict the climate of a region a century from now not only has more uncertainty but would also have more serious consequences. Pedro DiNezio of the University of Hawaii and Jessica Tierney of Woods Hole Oceanographic Institution, Massachusetts report in the journal, ***Nature Geoscience***, their work to verify which of the current models of climate change fit the changes in climate during ups and downs in the earth’s geological past.

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DiNezio and Tierney consider the behaviour of the body of warm water stretching along the equator from the Indian Ocean, through the waters off Sumatra, Java, Borneo, and New Guinea, to the western Pacific Ocean – an area called the ***Indo-Pacific Warm Pool*** (***IPWP***), the weather dynamo that dominates the tropics. The surface temperature in this area is now at a warm 28˚C and it sustains ocean and wind currents that make for ample rainfall and low salinity, hence density. And variations, which bring about effects like the ***El Niño*** or the ***Southern Oscillation***, have impact on climate worldwide.

This balance, which has established in the IPWP, is likely to change under external forcing, such as global warming. What these changes may be and how it would affect world climate is of evident importance. There are many ways of considering what the changes may be. One of the features of IPWP, and a driving force for much of the world's weather, is that the warm surface temperature creates a 'temperature slope' and cool water is pushed down, to 'well up' at other places. This effect is likely to get stronger with global warming, or weaken with cooling. But studies have shown that it is not that simple and there are other factors of equal importance. Different rates of change in rainfall and moisture as a result of warming, for instance, would weaken the sea-water circulation, to keep the balance. On the other hand, rainfall may increase in areas which are moisture rich, as a result of warming – a case of 'wet-get-wetter'.

These are the geology-weather features that are all made use of in modeling the climate behaviour, both of past periods as well as the futures. But they remain conjectures, as none of them has been tested because historical records do not have the extent of data to observe and pinpoint the difference in changes brought about by forcing, such as warming or cooling.

DiNezio and Tierney made use of the data of the ***Last Glacial Maximum***, a period between 25,000 and 19,000 years ago, when the ice sheets covered much of the continents and there was dramatic drop in sea levels. Naturally, this resulted in more land being exposed and there was profound impact on climate. Data regarding water levels, salinity and temperature, during the period is captured in geological or biological records – the so called ***proxy data*** – which allows testing of the different climate models. Land based proxies used included ***speliothems***, which are mineral deposits in caves, charcoal, the abundance of plant material, lake levels or the nature of beds of dried lakes, The content of radioactive oxygen in these snap shots of the periods when they were formed indicate the level of the isotope in sea water and in rainwater, to show relative abundance. Salinity levels were assessed by derivation from seawater data or from plankton fossil data. The collection of data resulted in a network of 53 land locations representing 61 proxy records of rainfall and 54 locations of the sea, representing 66 proxy records of sea surface salinity.

Using the pattern of changes recorded in the ***proxies***, DiNezio and Tierney tried out how well they compared with the results of the 12 recognised models of the Last Glacial Maximum climate changes. Rigorous statistical methods were necessary, as also careful selection of what simplifications to make in the comparisons. A method to see how well the model and the data of the proxies compare is the ***Cohen kappa statistic***. This method is used, for instance, to see how equally two examiners rate a given performance. Given sufficient data, agreement of the ratings in a good number of cases would validate the process. This could be used, for instance, when different examiners are needed to rate a large numbers of samples, like student projects. With a sample of projects that are given to two or all examiners, one could check for uniformity of the rating, or even decided on a factor by which to equalize their standard of marking.

The result of the exercise, remarkably, or perhaps, significantly, was that only one of the 12 models corresponded with the data of the proxies. This model was the HadCM3, or the Hadley Centre Coupled Model No 3, a ***coupled atmosphere-ocean general circulation model*** (AOGCM) developed at the Hadley Centre in the U.K. The result of the HadCM3 simulation is that with the effect of a land mass that was exposed with falling sea level, it was the sea level, and that means the ice sheet extent, which was the first driver of climate. The result has its importance not in this fact – for the mechanism is not transferable to a global warming picture and we do not expect that it is sea level variation that will be the driver of tropical circulation change. But the value of the result is that it brings home the fact that mechanisms at work are not simple and, in the words of the authors, “the fact that only one out of the twelve models simulates a response in Last Glacial Maximum hydroclimate in agreement with the proxies presents a clear challenge for model simulations of tropical climates, both past and future, and also reflects the fact that both proxies and models are highly uncertain renditions of climate history. A multi-proxy, multi-model approach is arguably the most effective way to both understand past climates and improve future climate change projections.”