PACIFIC CLIMATE IMPACTS CONSORTIUM

PCIC SCIENCE BRIEF: DYNAMICAL MODELS VERSUS STATISTICAL MODELS FOR EL NIÑO PREDICTION

This is part of a regular series of brief reports on recent climate science literature relevant to stakeholders in the Pacific and Yukon Region of Canada. The PCIC Science Briefs contextualize and explain the results and implications of important scientific findings.

A recent paper in the Bulletin of the American Meteorological Society shows that dynamical (physics-based) models are now better than statistical models at predicting El Niño. This is important for seasonal weather prediction in BC because El Niño has a strong effect on the weather in our region.

El Niño is a climate pattern characterized by warm sea surface temperatures of the Pacific Ocean, at the equator. Normally, trade winds blowing from the east to the west cause warm surface water to build up near Australia. As this surface water builds up, it draws up cool, nutrient-rich water from the deep ocean, off the coast of South America, supporting fisheries and ecosystems. Every three-to-seven years, these trade winds weaken and the warm surface water, no longer pushed toward Australia, covers the tropical Pacific Ocean. This is an El Niño event and it has effects on weather patterns, both regionally and globally.

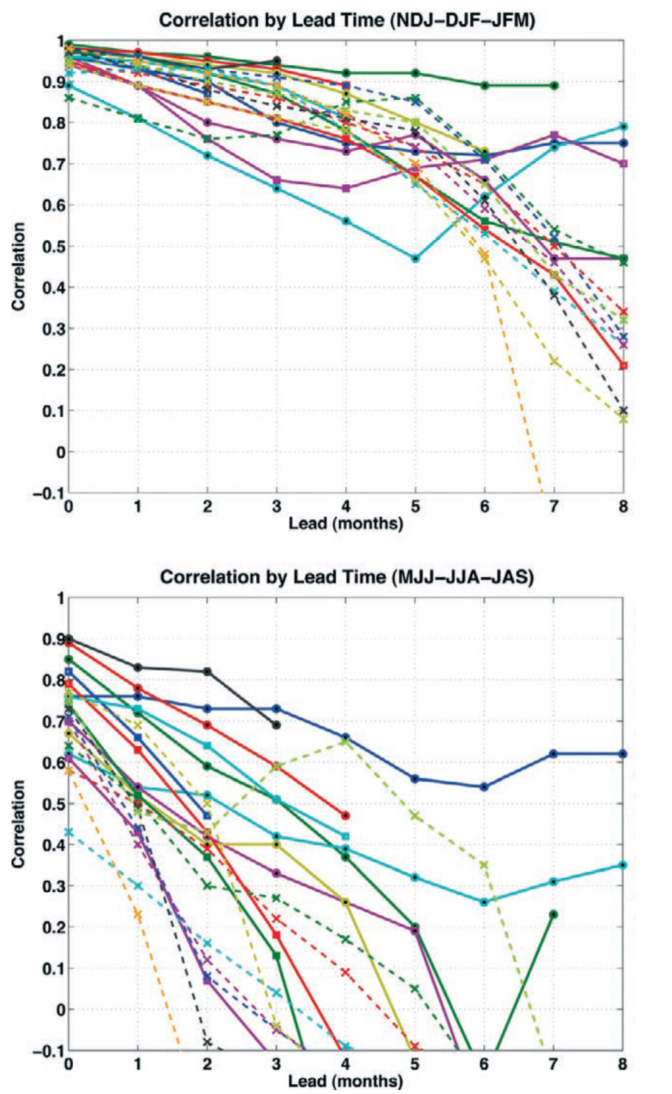
In British Columbia, winters during an El Niño event tend to be warmer than usual, with increased precipitation and storm activity in the southwest and decreased precipitation in the interior regions. Sectors as diverse as fishing, logging and auto insurance are impacted. Because of these and other impacts, it is desirable to improve El Niño predictions. Both statistical and dynamical models have been developed for this purpose.

Barnston et al. (2012) examined the El Niño prediction skills of twenty models (twelve dynamical and eight statistical) over the period of 2002-2011. The authors began by determining the relative El Niño variability[1] of the 2002-2011 period compared to a longer period. The variability of El Niño—and therefore the difficulty of making El Niño predictions—changes by the decade. So, if the 2002-2011 period wasn't typical, that fact must be accounted for in any comparison of newer models with older models. They found that 2002-2011 was a period of lower variability relative to the 30 years from 1981 to 2010, making El Niño predictions during this period more difficult. Because making El Niño predictions over the 2002-2011 period was more difficult, they argue that achieving comparable skill with newer models for earlier periods would effectively indicate skill improvement.

The authors then analyzed the skill of the models over the 30-year period and found that the modern models have greater skill. This highlights that gradual improvements in the models used to make El Niño predictions can be overshadowed by the varying difficulty, from decade to decade, of making El Niño predictions. Also as a result of the weaker variability in El Niño events, the models in the study tended to predict that El Niño events would occur sooner and end later than observations show that they did.

When they compared the statistical models to the dynamical models, the authors found that the skill of the dynamical models exceeded that of the statistical models for the May-September season (see figure above). Barnston et al. attribute this to the higher temporal resolution[2] of the dynamical models, and their more effective usage of information about the state of the ocean-atmosphere system. They further sug-

1. El Niño variability refers to both the number of El Niño occurrences in a given time period and the amplitude of those El Niño events.



These are correlations between model forecasts and observations for six sets of seasons: November-January, December-February and February-March (top); and May-July, June-August and July-September (bottom). The solid lines represent the forecasts of dynamical models and the dashed lines represent the forecasts of statistical models. Values closer to one (i.e. near the top of the graph) represent better forecasts than values that are less than one. Lead time is the period between the time when a forecast is made and the time at which the events in the forecast are to occur, here in months.
Image from Barnston et al. (2012).

gest that the differences between the model types is largely a result of funding policies which favour dynamical models. The authors note that, though dynamical models have advanced, there is still much room for their improvement in such areas as air-sea physics and the parameterization of small-scale processes.

The fact that dynamical models have surpassed statistical models is important because dynamical models reflect our knowledge of the physical system. The improvement of the dynamical models therefore indicates an overall improvement in our understanding of the physical processes underlying El Niño.

Methodology

In order to arrive at these results, the authors used observed sea surface temperature data from the equatorial Pacific Ocean and compared this with the sea surface temperature output of twenty models, of which twelve were dynamical and eight were statistical. The statistical models ranged from regression models to neural network models and the dynamical models ranged in complexity from intermediate complexity models to fully coupled models.

They first compared the time period that they selected, 2002-2011, against the longer period of 1981-2010, in order to determine if the shorter period had more or less variability, which could affect the results. The authors then applied a number of statistical tests to individual models to determine the skill of each and grouped these skill scores into the two model types, dynamical and statistical, to look at how each type of model performed.

Finally, the authors examined the range of model predictions from the runs that they had selected based on climate sensitivity and agreement with observations.

Barnston, A.G., M.K. Tippett, M.L. L'Heureux, S. Li and D.G. DeWitt, 2012: Skill of real-time seasonal ENSO model predictions during 2002-11. Bulletin of the American Meteorological Society, 93, 5, 631-651.

2. The dynamical models work by representing many of the physical mechanisms of the climate system as equations and calculating the values of those equations over given areas, spatial volumes and lengths of time. Models that use smaller areas and spatial volumes, and shorter lengths of time are said to have ' higher resolution.' For time, this resolution is called, 'temporal resolution.'

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