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NWS Efforts to Improve Weather to Climate Based-Services

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1. Introduction

The promise of NWS operational climate monitoring and prediction improvement relies on research advancement and its successful transition to operation. This summary highlights recent advances identified by NWS that can improve weather-climate based services.

2. Embracing a unified weather-climate modeling strategy

a. Weather-climate connection in model prediction

In recent years, the development of seamless prediction has been increasingly praised, which advocates the importance of scale interactions between weather and climate. The NCEP Climate Forecast System (CFS) has been built on the operational weather forecast model in order to benefit from the weather model improvement. It is expected that the better the weather statistics is simulated by the model, the more reliable the climate prediction would be.

The significance of model climate improvement to advancing the weather forecast has not been taken seriously until recently, when outstanding researches (van den Dool 2012, Fan 2012) demonstrated that the foremost weather forecast error is not due to random processes, nor to local factors, but rather to large-scale climate biases (Fig. 1). The improved understanding of ocean-atmosphere interactions has also pointed out that ocean mesoscale eddies have a large influence on weather system development, and the improved hurricane and coastal weather forecasts can be achieved using a high-resolution model coupled with an eddy resolved ocean model. Evidently, the ocean influence on weather forecast should no longer be ignored. As a result, a weather-climate two-way truly unified modeling framework is recommended for mutual benefits and acceleration of model improvement.

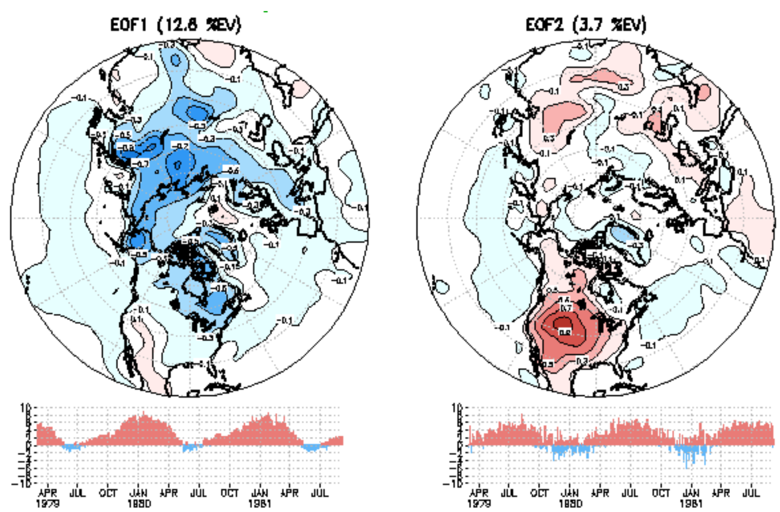

Fig. 1 The leading two EOF modes of NCEP Climate Forecast System (CFS) 975 hPa temperature 5-day forecast error (1979-12). (van den Dool, *CFS v2 Evaluation Workshop, May 2012*)

b. Cloud resolving vs. optimized physics ensemble

Due to increases in computational power, weather-climate model development has achieved more realistic representations of physical processes, thereby improving prediction skill.

Global cloud resolving model with modern turbulence parameterization and multi-scale framework explicitly formulates mesoscale organization without closure assumptions and triggers. It simulates

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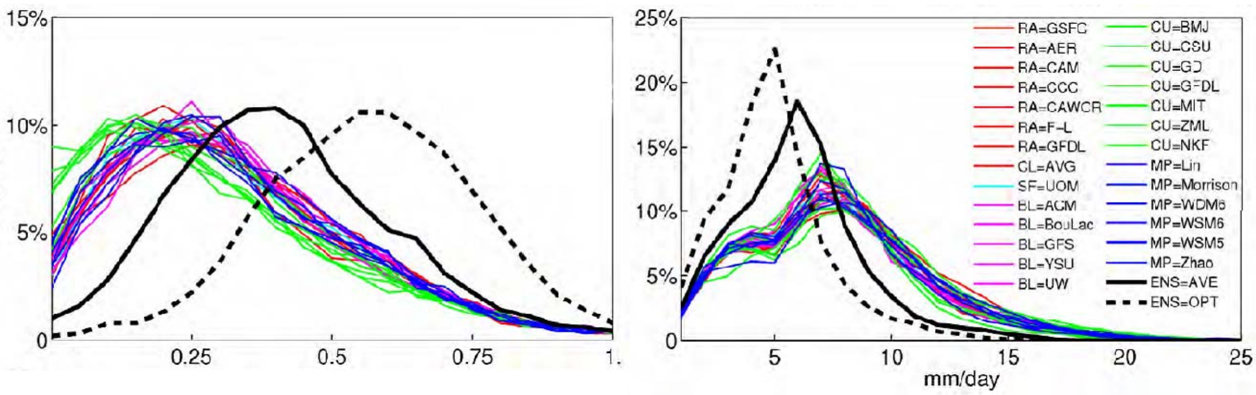

Fig. 2 Spatial frequency distribution of correlations (left) and RMS errors (right) between CWRF and observed daily mean rainfall variations in summer 1993. Each color line depicts a specific configuration in a group of key physical processes. The ensemble result is the average of all runs with equal (AVE, black solid line) or optimal (OPT, black dashed line) weights. (Liang, *Climate Prediction Center Seminar, June 2012*)

variability more realistically, *e.g.* the memory of delay in convective response, and shows tremendous potential (Randall 2012). The progress has also been made in developing multiple physics ensemble configuration, which incorporates a comprehensive list of alternative parameterization schemes for key physical processes. Since individual physical parameterization scheme has predictive ability depending on the weather or climate regime as well as the application, no single scheme performs uniformly well under all circumstances. Figure 2 shows superior skill of multiple physics ensemble over those using a single model configuration (Liang 2012).

3. Accelerating research to operations

a. Prediction of 2010-2011 "double dip" La Nina

During 2010-11, the tropical Pacific experienced prolonged cooler-than-normal conditions. More than 20 models have been used to make real-time forecasts of equatorial Pacific SST (see details at the IRI website http://portal.iri.columbia.edu). Most models failed to forecast Niño 3.4 SST from June 2010 initial conditions. However, one intermediate coupled model, UMD/ESSIC ICM, made a good prediction of the 2011 cold SST conditions in the tropical Pacific (Fig. 3).

To understand why, the relationships among various anomaly fields were analyzed. It was found that the thermocline feedback, which was explicitly represented by the relationship between the temperature of subsurface water entrained into the mixed layer and sea level, was a crucial factor affecting the second cooling in 2011. Sensitivity experiments showed that second cooling in 2011 would not occur if the intensity of thermocline feedback was underestimated below certain levels in the UMD/ESSIC ICM (Zhang 2012).

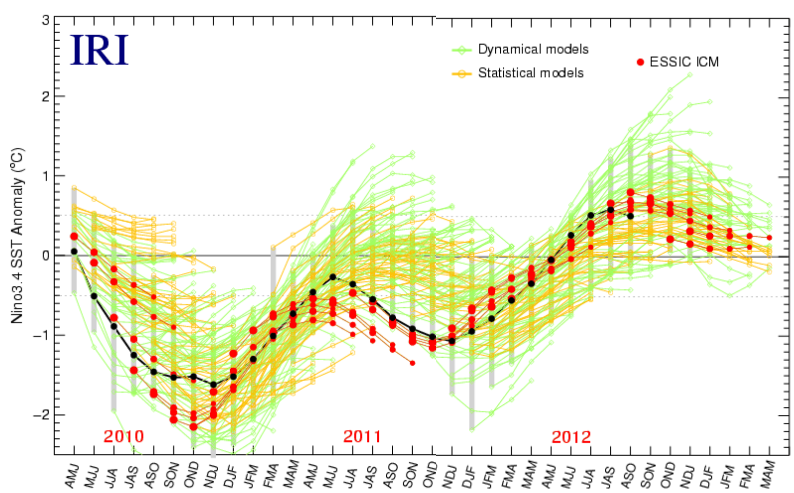

Fig. 3 UMD/ESSIC ICM performance of Nino 3.4 SST predictions (red) in comparison with performances of dynamical models (green) and statistical models (yellow). The observation is plotted in black. (Xue, *CPC Ocean Briefing, 2012*)

b. Representation of daily mean surface air temperature

Hourly (from minute) observations have become popular since the

Automated Surface Observing System (ASOS) deployed in 1991. There are many potential benefits of automated measurements that have not been realized.

Research demonstrated that current daily mean surface air temperature (T_a) defined by (T_{max}+T_{min})/2, which could be strongly affected by transient factors (*e.g.*, cloud cover *etc.*), is distinctly different from the true daily mean of 24-hour average (Fig. 4). The difference has a significant impact on applications, *e.g.* model-data comparisons, trend assessment, *etc.* It is recommended to archive 24-hour average Ta, as well as daily maximum and minimum T_a, to produce the monthly mean T_a for the climate data record (Zeng 2012).

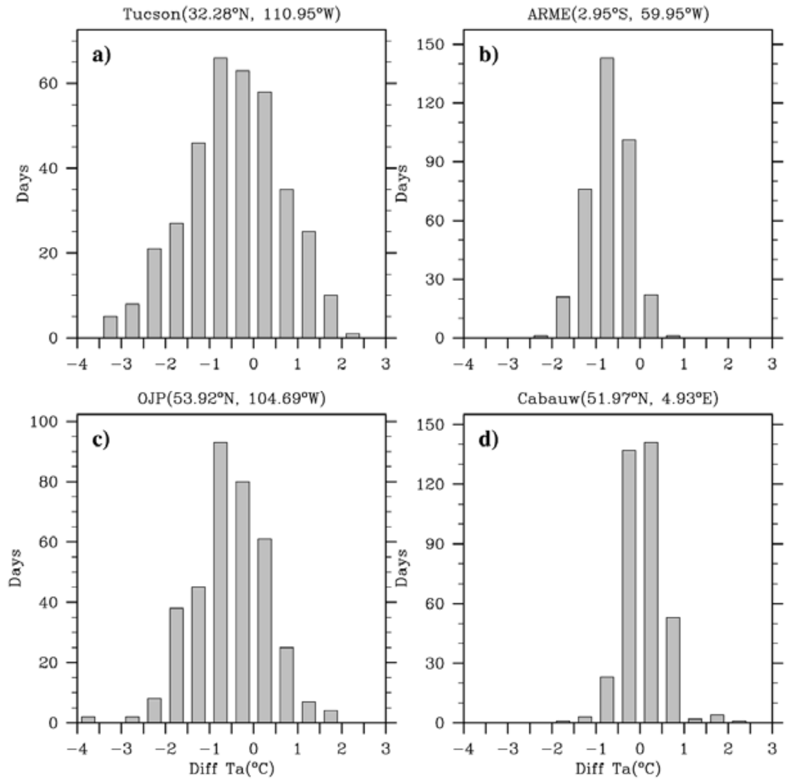

Fig. 4 The statistics of daily differences between 24-hr average and (T_{max} +T_{min})/2 at locations of distinct climatologies. (Zeng, 4th *WCRP International Conference, May 2012*)

4. Climate information and user needs

An analysis of scenario planning approaches employed by national climate assessment demonstrated all science information can be "actionable" (Hartmann 2012).

The science oriented top-down approach, which focuses on characterizing uncertainties based on modeling studies, identifies climate system sensitivity to the external forces, resulting in different adaptation options for probable futures that are hardly actionable for stakeholders.

The community bottom-up approach, which puts emphasis on reducing uncertainty through participatory processes, shares values, goals and visions and builds preparedness toward one probable future. The results are more relevant to and actionable for stakeholders but less reliable for a range of possibilities.

More recent advancement in scenario planning calls for embracing uncertainty. Due to long-term uncontrollable external forces and limited predictability, the new development incorporates the advantages of above two approaches by using them interconnectively to maintain a multi-dimensional view, looking for common elements on various pathways, meanwhile incrementally implementing options close by to meet strategic adaptation challenges.

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