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Uncertainties in the El Niño Response of Precipitation over the US West Coast

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1. Introduction

In this study, the possible reasons why the seasonal mean precipitation prediction skill over the US west coast during December-January-February (DJF) is low in the National Centers for Environmental Prediction (NCEP)'s Climate Forecast Systems version 2 (CFSv2) are explored. The analysis is based on the hindcasts and real-time forecasts from the North American Multi-Model Ensemble (NMME, Kirtman et al. 2014). We first examine how well basic features of the DJF precipitation in terms of its climatological mean, total interannual variability, and the mean response to ENSO SST are predicted across each of seven models in the NMME. We also assess the anomaly correlation skill and the signal-to-noise ratio (SNR) to validate whether the prediction skill of DJF precipitation over the west coast is low in general across the models. Then, we analyze the west coast precipitation response in individual models to anomalous ENSO SSTs during individual El Niño events to investigate to what extent the response during individual events differ from the composite response. Specially, it can be approached in two ways: 1) by analyzing the consistency of precipitation responses across El Niño events in a single model, and thereby, examine the influence of ENSO SST flavor and possible non-linearity in the response; and 2) by analyzing the consistency of precipitation responses across seven models for a specific El Niño event to examine if the consistency improves as the amplitude of El Niño events gets larger. In the final analysis, we also analyze the DJF precipitation for the regions of US southeast coast with the same ensemble forecasts from the same set of models. Over the southeast coast the precipitation prediction skill is higher, and therefore, provides a contrasting case study to the analysis over the west coast of the US.

2. Results

The results show that the simulated north-south variations in DJF precipitation climatology and its interannual variability, together with the linear response to ENSO is similar in generally to that in observations, but there are differences in details, particularly in the amplitude (Fig. 1). However, the prediction skill across all the models is unanimously low and is in close proximity of the skill for the CFSv2 (Fig. 2). It is noted that there does not seem to be a correspondence between the linear ENSO response and skill that be possibly due to non-linearity in the precipitation response to ENSO, sampling issues, or the model biases. Further, the SNR is low for all models, and there is a lack of correspondence between SNR

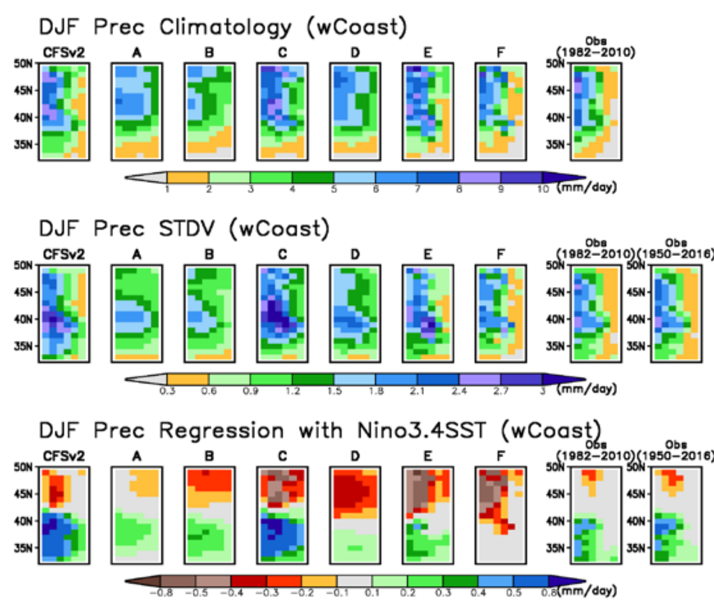

Fig. 1 The DJF Precipitation climatology (top row), standard deviation (middle row), and linear regression to Nino 3.4 SST (bottom row) for seven models (CFSv2, and models A, B, …and F) in the NMME (Kirtman et al. 2004) and observations (Chen et al. 2002) over the US west coast (wCoast). The US west coast area is aligned to an 8x21 degree longitude/latitude rectangle. The unit is mm/day for the climatology and standard deviation and is mm/day of unit standard deviation of Niño 3.4 SST index for the regression.

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and skill due to the biases in the model, small ensemble size, and the influence of sampling over short verification time period (Fig. 2).

The analysis comparing individual El Niño events and in individual models (Fig. 3) highlights the basic features: 1) the observed seasonal mean, which is a combination of both the response and the contribution from the unpredictable internal variability, clearly indicates that the event-to-event variability is much larger than the model ensemble mean response; 2) the consistency is better for stronger El Niño events, particularly over Southern California (SCA) where all models have above normal precipitation (except for the model A in 1982); 3) for some models the response is very consistent across different El Niño events. In contrast, the response for some other models shows much stronger non-linearity; 4) comparing precipitation response across models for the same El Niño events does not lead to definitive conclusions; 5) the spatial pattern of the El Niño composite, in general, has a good resemblance with the linear regression pattern indicating that non-linaerity in the response may not be a dominant factor; 6) for the strongest El Niño event of DJF2015/16, the precipitation response in the NMME ensemble mean has a good consistency with positive anomalies over the SCA, where the observed anomalies were negative.

In contrasting to the case over the west coast, the precipitation ENSO response over the US southeast coast (seCoast) shows lower variability and similar amplitude of response indicating larger SNRs, consequently, the higher skills for the precipitation prediction. Further, the same models that had difficulties in replicating interannual precipitation variability along wCoast have a better performance in seCoast. The possible dynamical basis for differences in SNR for the precipitation variability along the wCoast and the seCoast is that precipitation variations over swCoast (seCoast) is less (more)

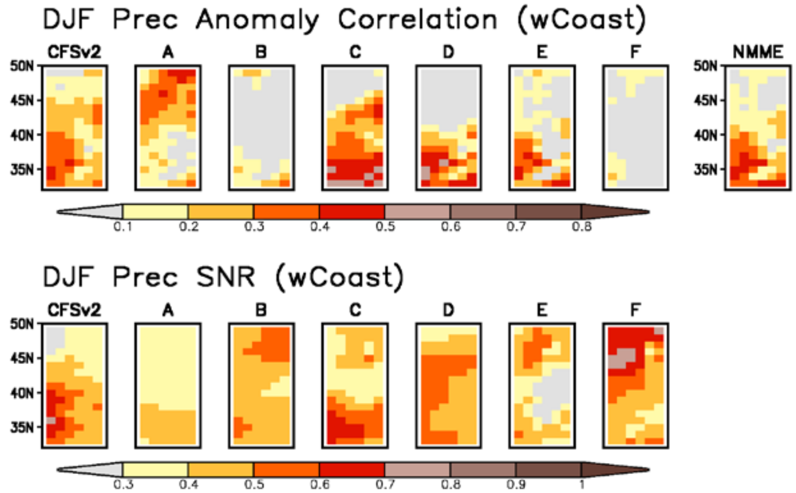

Fig. 2 The DJF precipitation correlation skill and SNR for the seven models over the wCoast. Correlations (SNR) below 0.1 (0.3) are not shown. The area average AC for each model and NMME (going from left to right) is 0.24, 0.22, 0.00, 0.26, 0.14, 0.16, -0.02, and, 0.20 and the area average SNR is 0.46, 0.38, 0.46, 0.47, 0.48, 0.38, and 0.52.

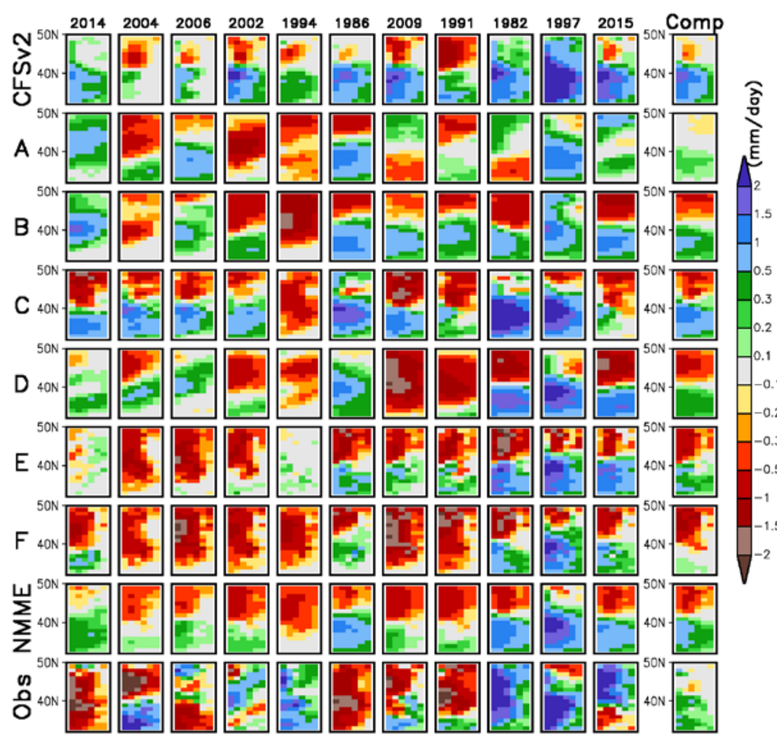

Fig. 3 The DJF precipitation ensemble means during each of 11 El Niño events arranged from the weak to strong event (from the left to right columns) for each models, multi-model average (labeled as NMME), and observation over the US west coast. Unit is mm/day.

constrained by ENSO SSTs and is influenced more (less) by internal variability resulting in lower (higher) SNR. A lower (higher) SNR, in turn, will result in smaller (larger) skill in seasonal prediction.

3. Concluding remarks

In summary, various analysis approaches based on the extensive dataset in the NMME from seven seasonal forecast models show that low skill in predicting seasonal mean precipitation along the US west coast is due to inherent predictability associated with a low signal-to-noise (SNR) regime. In contrast, for the same dataset, analysis over the US southeast presents a different paradigm of a higher SNR regime having a higher prediction skill. Another side of the analysis is that it did not provide answers to the questions like the sensitivity to different SST flavors in the ENSO response (non-linearity) for the precipitation over the US west coast, even though the analysis was based on a large multi-model dataset such as NMME. Such difficulty in itself may indicate it is in a low SNR regime, and a higher level of effort is required for extracting the signal above the noise and drawing robust inferences gets harder, for example, requiring larger ensemble sizes.

References

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