Multi-model Forecast Quality Assessment of CMIP6 Decadal Predictions

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Extended Abstract

A. Introduction

Decadal climate predictions are a new source of climate information for inter-annual to decadal time scales (filling the gap between seasonal predictions and climate projections), which is of increasing interest to users. The external forcings (natural and anthropogenic) and the internal climate variability (natural slow variations of the climate system) provide predictability on these time scales. However, due to chaotic characteristics of the climate system, it is not possible to predict its exact evolution. Thus, decadal forecasting provides large ensembles of predictions that, besides predicting the average anomalies based on the ensemble mean, are also used to obtain probabilistic information about the likelihood of certain event types.

Forecast quality assessment is essential to identify windows of opportunity (e.g., variables, regions, and lead times) with skill that can be used to develop a climate service and inform users in specific sectors. Besides, it can help to monitor improvements in current forecast systems. The forecast quality assessment needs to be carried out over a long enough period in the past (when observations are available to compare against) to achieve robust results that can be used as an estimate of how well the forecast system may perform in simulating future climatic anomalies. Thus, retrospective decadal forecasts (also known as hindcasts) are performed with the same forecast systems used to predict future climate variations. For this, the forecast systems are utilized to simulate the evolution of the climate system from our best estimate of the observed initial state, which is referred to as forecast system initialization and the predictions also incorporate information about the external forcings. The hindcasts are also used to apply calibration techniques to partially correct systematic biases of the predictions.

The Decadal Climate Prediction Project (DCPP [1]) of the Coupled Model Intercom-parison Project Phase 6 (CMIP6 [2]) now provides the most comprehensive set of retrospective decadal predictions from multiple forecast systems. The increasing availability of these simulations leads to the question of how to best post-process the raw output from the forecast systems so that the most useful and reliable information is provided to users.

B. Data and Methods

This work evaluates the quality of deterministic and probabilistic forecasts for spatial fields of near-surface air temperature and precipitation generated from all the available decadal predictions contributing to CMIP6/DCPP-A (169 members from 13 forecast systems). The analysis focuses on the predictions for the average of forecast years 1 to 5 during the 1961-2014 period, using the 1981-2010 period as reference for computing the climatology and probabilistic categories. In addition to decadal predictions, the retrospective climate projections (i.e., the uninitialized historical forcing simulations; 195 members from the same forecast systems) are used as benchmark to estimate the impact of model initialisation.

The quality of the deterministic forecasts is estimated with the Anomaly Correlation Coefficient (ACC), while the Ranked Probabilities Skill Score (RPSS) is used to evaluate the probabilistic forecasts (created for tercile categories, i.e., below-normal, normal and above-normal conditions).

C. Results

The DCPP multi-model generally shows high skill in predicting temperature, particularly over land regions (Figure 1). The skill is more limited for precipitation, being significant over some regions like Central Africa and parts of Asia. Also, the comparison against the climatological forecast (defined as equal probabilities for all the categories) shows an added value of using the decadal predictions for temperature.

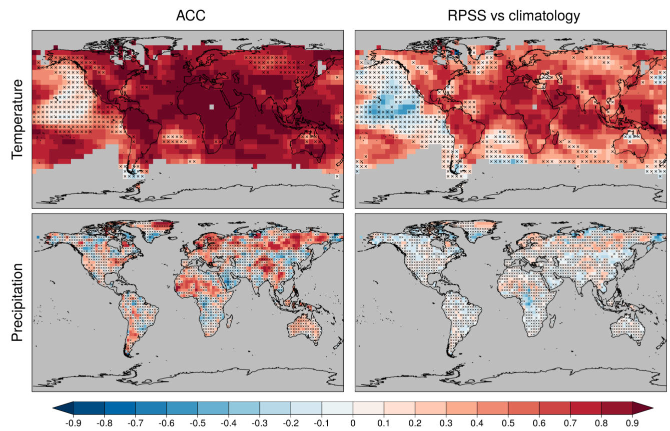

Fig. 1. DCPP multi-model forecast quality for the forecast years 1-5.

In order to assess the benefits and drawbacks of using a multi-model forecast, the multi-model ensemble is compared to the individual forecast systems. To do this, the skill of all forecast systems is first computed. Then, the systems that provide the highest and the median skill are selected for each grid point. The best system usually provides the highest skill (Figure 2). However, the multi-model ensemble is more skilful than at least 50% of the individual systems (not shown). Thus, the multi-model is a reasonable choice for not selecting the best system for each particular variable, forecast period and region, making a potential operational forecast generation more straightforward.

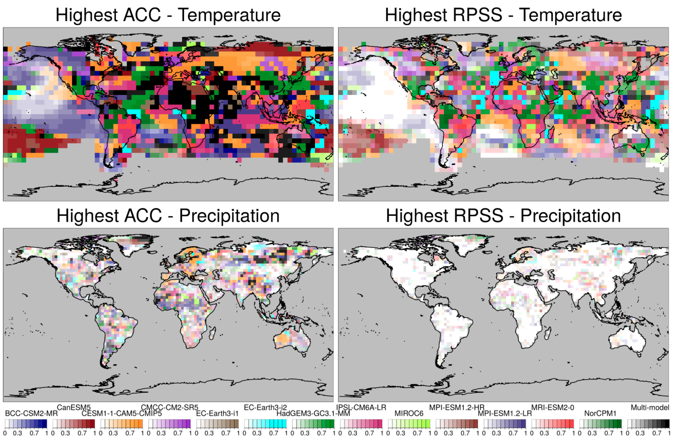

Fig. 2. Highest skill among the individual forecast systems and multi-model for the forecast years 1-5.

The decadal predictions are also compared to the uninitialized historical climate simulations (HIST) to estimate the impact of initialization. For the deterministic forecasts, an added value is found for temperature over several ocean and land regions (Figure 3). For precipitation, the added value is found to be more reduced, although the residual correlation shows significant positive values over several regions meaning that the decadal predictions capture more observed variability than the uninitialised historical simulations. For the probabilistic forecasts, the North Atlantic Ocean is the region that shows the highest added value for temperature.

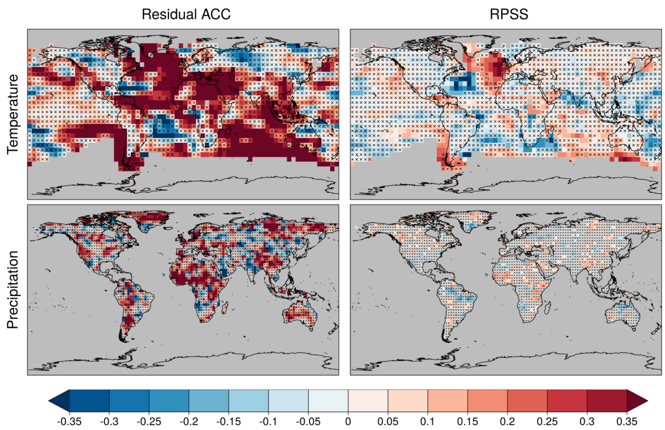

Fig. 3. DCPP multi-model forecast quality in comparison to the HIST multi-model ensemble for the forecast years 1-5.

D. Conclusions

The CMIP6/DCPP multi-model ensemble shows generally high skill in predicting temperature, being lower for precipitation. The comparison between the multi-model ensemble and the individual forecast systems indicates that the best system provides the highest forecast quality for a particular region, variable and forecast period, which would be the best option for a specific climate service. Yet, the multi-model ensemble shows higher skill than, at least, 50% of the systems, which makes it a reasonable choice for operational forecast product generation. The decadal predictions show an added value with respect to the uninitialised historical forcing simulations for temperature and precipitation over several regions.

A paper on this study has been accepted for publication in Journal of Climate [3], in which the impact of calibrating the raw predictions is also assessed, and the comparison of two multi-model ensemble sizes. Besides, the results are also shown for the forecast of the Atlantic Multidecadal Variability (AMV) index and Global Surface Air Temperature (GSAT) anomalies.

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Author biography

Carlos Delgado Torres is a PhD student at the Climate Prediction and Earth System Services Groups of the Earth Science Department. He received a BSc degree in Physics and a MSc degree in Meteorology and Geophysics at the Universidad Complutense de Madrid. His work focuses on the applicability of decadal predictions for climate services.