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The Relative Contribution of Internal and Model Variabilities to the Uncertainty in Decadal Climate Predictions

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Decadal climate predictions, which are initialized with observed conditions, are characterized by two main sources of uncertainties–internal and model variabilities. The former is due to the sensitivity of the models to the initial conditions, and the latter is due to the different predictions of different models. There is not much that can be done to reduce the internal variability; however, there are several methods for reducing the model variability–for example, using an ensemble weighted according to the past performance of the models rather than an equally weighted ensemble. Quantifying the contribution of each of these sources can help in assessing the potential reduction of the total uncertainty of these climate predictions.

We used an ensemble of climate model simulations, from the CMIP5 decadal experiments, that includes different climate models and several initializations for each of the models, to analyze the uncertainties on a decadal time scale. Time series of the monthly and annual means of the surface temperature and wind components were established for the variability analysis. The analysis focused on the contributions of the internal and model variabilities and the total uncertainty.

We found that different definitions of the anomaly resulted in different conclusions regarding the variability of the ensemble. However, some features of the uncertainty were common to all the anomalies we considered. In particular, we found that (i) over decadal time scales, there is no considerable increase in the uncertainty with time; (ii) the model variability is more sensitive to the annual cycle than the internal variability (this, in turn, results in a maximal uncertainty during the winter in the northern hemisphere); (iii) the uncertainty of the surface temperature prediction is dominated by the model variability, whereas the uncertainty of the surface wind components is determined by both the model and the internal variabilities.

Analysis of the spatial distribution of the uncertainty reveals that the surface temperature has higher variability over land and at high latitudes, whereas the surface zonal wind has higher variability over the ocean. The relative importance of the internal and model variabilities depends on the averaging period, the definition of the anomaly, and the location. These findings suggest that several methods should be combined in order to assess future climate prediction uncertainties. In addition, the significant contribution of the model variability suggests that weighting of the ensemble members may reduce the uncertainties.