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Variations in global climate model performance for different regions, seasons, variables, and climate regimes

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We examine the behavior of two AGCMs for which ensembles of multiple realizations are available for the period 1950-1994: the ECHAM3 (V 3.6, MPI) and the NCEP (MRF9, NCEP) models. Both models are forced by reconstructed observed SST. The data from seven runs of the ECHAM3 model and thirteen runs of the NCEP model are examined. Observed fields are based on the NCEP-NCAR reanalysis.

Four variables (zonal and meridional component of wind, stream function and velocity potential) were analyzed at four levels (850 hPa, 700 hPa, 500 hPa and 200 hPa). Area-averaged 45-year time series were made by averaging the data over each of 81 regions of 20 latitude by 40 longitude over the globe. The subsequent analysis was performed for each of these regions, to emphasize the variation of performance for different regions in the world. The analysis is based on the simultaneous temporal anomaly correlation coefficients (CCs) between area averaged time series of seasonal mean model responses and reanalysis data. We use these CCs as a simple indicator of model "skill".

The influence of seasonal variations is examined through seasonal (3-month) anomaly CCs calculated for the whole 45-year period (1950-1994). The comparison of these CCs, in each 20 latitude by 40 longitude region, shows if there is a season in which there is clearly a better skill of the models. A similar procedure is followed to verify whether there is a particular best simulated circulation parameter or whether circulation anomalies are best simulated at a particular atmospheric level. Finally the in-

terdecadal variation of the models' performance over the globe is assessed through the computation of simultaneous seasonal CCs between 11-year running series of the observed data and model output, in each region.

The influence of seasonal variations on model skill is shown for the zonal wind at 200 hPa. The best correlations for all seasons occur in the tropics and subtropics, particularly in the subtropical region of the Northern Hemisphere (NH) (10N-30N). The best overall performance for both models occurs in JJA. The performance is not that good in the subtropical region of the Southern Hemisphere (SH) (10S-30S), where the best performance occurs in DJF. Therefore, summer is the season with best skill for upper-level zonal wind in the subtropics of both hemispheres. In the equatorial belt (10S-10N) there is no strong seasonality. In the SH extratropics the correlations are significantly positive only in spring and winter.

The performance of the models is strongly parameter dependent and shows some dependence on the level. On the average, the best-simulated parameter at 200 hPa is streamfunction. In the tropical belt (30S-30N) the zonal wind is the best-represented parameter on the average, while the streamfunction is best represented outside this belt. The zonal wind is better reproduced at 200 hPa than at other levels, on the average, especially in the subtropics of both hemispheres (10-30 N and S).

The skill of the models undergoes interdecadal variations, which are coherent with well known interdecadal fluctuations of SST anomalies. Several causes for these variations are discussed, but it seems that the best model "tuning" for one phase of an interdecadal oscillation might not be the best one during the opposite phase. The interdecadal variation of the models' performance is also clear from the analysis of their response to ENSO throughout the period analyzed. As these models are used in seasonal climate predictions and similar models in projections of future climate change, the long-term variations in their performance may have implications for the regional reliability of climate projections, which may depend on the time slice in which the output of the model is analyzed.

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