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Multi-Model Super Ensemble Based Advanced Approaches for Monsoon Rainfall Prediction

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Abstract : Traditionally, monsoon forecasts have encountered many difficulties that stem from numerous issues such as lack of adequate upper air observations, mesoscale nature of convection, proper resolution, radiative interactions, planetary boundary layer physics, mesoscale air-sea fluxes, representation of orography, etc. Uncertainties in any of these areas lead to large systematic errors. Global circulation models (GCMs), which are developed independently at different institutes, each of which carries somewhat different representation of the above processes, can be combined to reduce the collective local biases in space, time, and for different variables from different models. This is the basic concept behind the multi-model superensemble and comprises of a training and a forecast phase. The training phase learns from the recent past performances of models and is used to determine statistical weights from a least square minimization via a simple multiple regression. These weights are then used in the forecast phase. The superensemble forecasts carry the highest skill compared to simple ensemble mean, bias corrected ensemble mean and the best model out of the participating member models. This approach is a powerful post-processing method for the estimation of weather forecast parameters reducing the direct model output errors. Although it can be applied successfully to the continuous parameters like temperature, humidity, wind speed, mean sea level pressure etc., in this paper, this approach is applied to rainfall, a parameter quite difficult to handle with standard post-processing methods, due to its high temporal and spatial variability. The present study aims at the development of advanced superensemble schemes comprising of 1-5 day daily precipitation forecasts from five state-of-the-art global circulation models (GCMs), i.e., European Centre for Medium Range Weather Forecasts (Europe), National Center for Environmental Prediction (USA), China Meteorological Administration (China), Canadian Meteorological Centre (Canada) and U.K. Meteorological Office (U.K.) obtained from THORPEX Interactive Grand Global Ensemble (TIGGE), which is one of the most complete data set available. The novel approaches include the dynamical model selection approach in which the selection of the superior models from the participating member models at each grid and for each forecast step in the training period is carried out. Multi-model superensemble based on the training using similar conditions is also discussed in the present study, which is based on the assumption that training with the similar type of conditions may provide the better forecasts in spite of the sequential training which is being used in the conventional multi-model ensemble (MME) approaches. Further, a variety of methods that incorporate a 'neighborhood' around each grid point which is available in literature to allow for spatial error or uncertainty, have also been experimented with the above mentioned approaches. The comparison of these schemes with respect to the observations verifies that the newly developed approaches provide more unified and skillful prediction of the summer monsoon (viz. June to September) rainfall compared to the conventional multi-model approach and the member models.

Keywords : multi-model superensemble, dynamical model selection, similarity criteria, neighborhood technique, rainfall prediction
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