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A multi-physics ensemble approach for short-term precipitation forecasts at convective permitting scales based on sensitivity experiments over southern parts of peninsular India

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The southern peninsular India is characterized by unique climatology with rainfall processes throughout the year from land–ocean contrasts. In addition, the complex terrain induces localized effects causing huge spatial and temporal variability in the observed precipitation. This study aims at evaluating the sensitivity of the high-resolution Weather Research and Forecasting (WRF) model (4 km) to multi-physics parameterizations, 3D variational data assimilation, and domain configuration, in the study domain covering southern peninsular India. Furthermore, the study focusses on the formulation of an ensemble method to improve the simulation of precipitation across seasons. A total of 120 experiments were set up across four crucial rainfall events, of varying spatial extent and duration, dominated by different rainfall generation mechanisms. The assessment of the experiments shows that the model's cumulus and microphysics schemes have the highest impact on the location, intensity, and spread of the simulated 4-day long Quantitative Precipitation Forecasts (QPFs). Applying cumulus schemes at all domains represented the variability in the QPFs, across space and time, for the precipitation events dominated by convective activity. The cases without cumulus schemes at the convective scale domain (4 km), captured the higher intensity rains during organized cyclonic circulations in the north-east monsoon period. Hence, a 10-member multi-physics ensemble approach including members with and without cumulus parameterization at the fine resolution domain was adopted. The preliminary results demonstrate that the mean from the suggested ensemble approach (n-MPP) performed well in capturing the dynamics of QPFs across the rainfall events, as opposed to a single-member deterministic simulation and mean from larger member conventional multi-physics ensemble approach (c-MPP) without cumulus parameterization at the convective scale. The rank histogram, delta semi-variance plots, and outlier statistics at various lead times clearly showed that the suggested n-MPP was able to capture the high-intensity rainfall, increasing the spread of precipitation forecasts and consequently reducing the occurrence of outliers.

Keywords. Convection-permitting scales; multi-physics ensemble; physics parameterization schemes; WRF model sensitivity; southern peninsular India; quantitative precipitation forecasts.

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