Ensemble Configurations for Typhoon-related Rainfall Forecasts

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Typhoon-related precipitation forecasts are investigated in this study utilizing three ensemble configurations. The ensemble configurations are the multi-analysis (MA), the multi-convection (MC), and the multi-model (MM). Each configuration comprises a set of six members with a common component. The MA components are obtained from the assimilation of five different rainfall algorithms (FERRARO, OLSON, SSMI/TMI, TURK and TMI2A12) into initial analyses within the FSU physical initialization and prediction system. The MC configuration is devised by incorporating six cumulus parameterization schemes (FSU, NCEP/SAS, GSFC/RAS, NRL/RAS, NCAR/ZM, and EMANUEL) into the FSUGSM. The set of MM ensemble members is provided by five operational center forecasts (BMRC, JMA, NRL, RPN, and NCEP) in addition to an FSU control forecast.

In the deterministic ensemble forecast, three ensemble means are employed to intercompare the predictability of the above configurations. These are regular ensemble mean, individually bias-corrected ensemble mean (BCE), and superensemble (SE). In the SE method, the a priori weighting statistics is computed using the dynamic linear model method (Shin and Krishnamurti, 2003). Thirty-one cases are identified from Typhoons Damrey, Kirogi, Kai-Tak, Jelewat, and Ewiniar occurred in 2000. TRMM satellite rain rates are treated as our benchmark observation and used in forecast verifications.

The MA and the MM ensemble members produced the smallest and the largest spreads, respectively, in the typhoon track forecasts. The average variances of latitude were larger than those of longitude due to the direction of typhoons studied. The best ensemble mean track forecasts were made by the MM configuration.

Figure 1 visualizes the skill differences of the BCEs for the MA, MC, and MM configurations. The 5-day average skill scores of the MM with respect to the MA and MC are approximately 34% and 17%, respectively.

The skill of MM SE forecast almost always surpasses those of any combination of ensemble configurations and means. The MM SE rainfalls for days 1 to 5 are compared to the observed rainfall estimate in the left side of Fig. 2. These are 24-h accumulated precipitation forecasts at the end of days 1 to 5, all valid for August 16, 2000. The panel (a) presents the observed precipitation field based on satellite microwave instruments. The accuracy of forecast continues to slowly deteriorate as forecast lead time increases. The RMSEs and correlation coefficients are respectively 5.90/0.78, 7.11/0.66, 7.13/0.65, 7.64/0.57, and 8.82/0.35 for days 1 to 5 forecasts in this example. This figure exemplifies a key role of SE approach, compared to other ensemble means.

Panels (b), (c), and (d) in the right hand side of Fig. 2 illustrate day 3 MA, MC, and MM probability of precipitation (POP) forecast maps for 10 mm/d of precipitation threshold, respectively. The associated event occurred is shown in the panel (a). The probability higher than 0.5 is shaded in panels (b), (c), and (d). In comparison of probability maps for the MA, MC, and MM, we can notice that there is a good correspondence with each other. However, the BSSs are -8.71, 3.20, and 23.66 respectively. As the skill scores said, there is more disagreement between the POP and event occurred in the MA and MC than in the MM. Although the skill for the MA forecast is less than zero, there exists a recognizable agreement between the POP forecast and observation. It is unreasonable to say, therefore, that climatological forecasts based

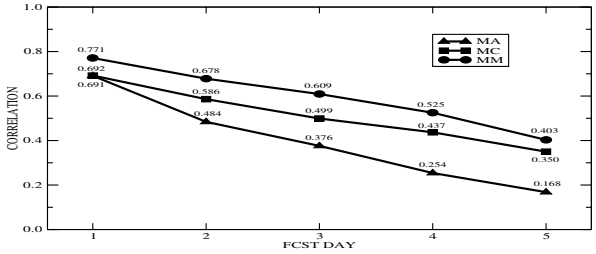

Figure 1:

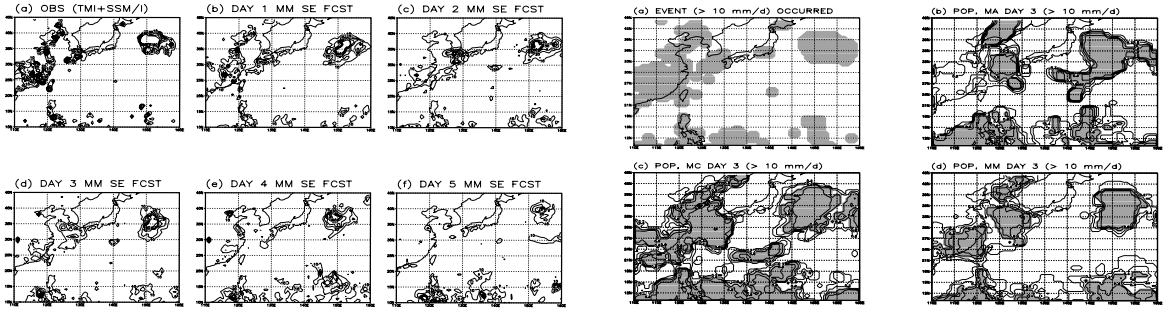

Figure 2:

on observational uncertainty are better than the MA ensemble forecast system. At the least, state-of-the-art NWP models predict rational signals for precipitation events. But, they have inherent deficiencies in making forecasts of the proper magnitude and location of those events. Overall, the above result clearly verifies that the medium-range POP forecast contains a fair amount of skill with a properly prepared ensemble system.

In summary, typhoon-related precipitation systems are best predicted by the MM configuration from both deterministic and probabilistic viewpoints. The single model ensemble setups (MA and MC) contain more biases than the MM setup. A weighed ensemble, the so-called superensemble (SE), technique shows a slight increase in forecast skills, compared to the bias-corrected ensemble.

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