Multivariate Ensemble Sensitivity for Typhoon Haiyan

Sijing Ren and Lili Lei
School of Atmospheric Sciences, Nanjing University, Nanjing, China

Background
- Univariate ensemble sensitivity ignores correlations across variables and often results in overestimations for sensitivities.
- Multivariate ensemble sensitivity proves to be an effective alternative, but lack of evidences from real cases.

Data
- The Typhoon Haiyan (2013) is selected because of great challenges in its intensity forecast.
- Ensemble forecasts of 80 members are produced using WRFV3.4 from 0000 UTC 4 November to 0600 UTC 9 November. Each member has two vortex following domains of 9km (D02) and 3km (D03), and one fixed parent domain at 27 km (D01).
- Simulations show significant underestimation of intensity and huge ensemble spread (Figure 1). Seeing that, ensemble sensitivity analysis on this problem can be a great challenge.

Results
- Consistent results are obtained from univariate (Figure 2) and multivariate (Figure 3) ensemble sensitivities that reducing of SLP forecast error and increasing intensity is associated with a moister deep convection region in mid-lower troposphere, a stronger warm core, an increased primary circulation particularly at maximum wind radius and an increased secondary circulation.
- Due to computational constraints, only the member closest to the ensemble mean is used for perturbed initial condition experiment. By applying a $\sigma$ increment of QVAPOR, T, RW or TW to the analysis that leads to the largest improvement of intensity change estimated by univariate ensemble sensitivity at different levels, and integrating the model forward, the actual forecast response can be obtained. The comparison between the univariate and multivariate ensemble sensitivity to the actual response is shown in Figure 4. Results shows that univariate ensemble sensitivity always overestimates the intensity change in this case. On the contrary, multivariate ensemble sensitivity can reduce the overestimation and has better agreement with the actual response.

Conclusions
- Univariate and multivariate ensemble sensitivities consistently indicates that increasing intensity is associated with a moister deep convection region in mid-lower troposphere, a stronger warm core, an increased primary circulation particularly at maximum wind radius and an increased secondary circulation.
- However, multivariate ensemble sensitivity behaves better in perturbation response estimation than univariate ensemble sensitivity that invariably overestimates changes.