Sensitivity Analysis using the Mesoscale Singular Vector

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In September 2008, a sensitivity analysis experiment using the mesoscale singular vector (MSV) was performed by MRI/JMA to support the THORPEX Pacific Asian Regional Campaign (T-PARC). The mesoscale singular vector method has been developed for the use of the initial perturbation of mesoscale ensemble prediction at MRI/JMA. MSVs are calculated using a tangent linear model (TLM) and an adjoint model (ADM) of the JMA non-hydrostatic model variational data assimilation (JNoVA) system (Honda *et al.* 2005). In TLM and ADM, some parts of the nonlinear model are simplified, such as large-scale condensation and moist convective adjustment used in moist processes. To solve the eigenvalue problem the Lanczos algorithm with Gram-Schmidt re-orthogonalization is adopted. To define the perturbation growth, the total energy norm is used, considering a moisture term.

The model domain and the targeted area of this experiment appear in Fig.1. The targeted area is fixed to the 27.5-42.5N, 125.0-145.0N, which is independent of a typhoon position. The horizontal resolution is 40 km and the optimization time is set to 12 hours to ensure the validity of the tangent linear approximation. In the near-real time operation, the 24-hour forecast of the JMA Global model (GSM; TL959L60) is used for initial condition to calculate MSVs, so that leadtime of about 14 hours is kept prior to the observation time of T-PARC.

Here a result for the case of TY0813 (SINLAKU), which caused a torrential rainfall at Kyushu district, is introduced. MSVs-based sensitivity areas for the typhoon were located in the right side to the moving direction of the typhoon, which was dominated by the potential energy components in the mid-lower troposphere (Fig.2). Compared with Global singular vectors (not shown), MSVs reflect the small scale structures which affect mesoscale disturbances rather than synoptic events including the track of tropical cyclones.

To examine the validity of the sensitivity analysis based on MSV, a data denial experiment over sensitivity area was conducted. This experiment systematically excludes all observations in the sensitivity area. Data assimilation and forecast experiments were performed using JMA Meso-4DVar and NHM. Figure 3 shows the difference of analysis field between the denial experiment (DENIAL) and the control experiment (CNTL). The denial experiment changed the water vapor fields over sensitivity area, which is similar to SVs, especially 4th SV (Fig.3(c)). Figure 4 shows the subsequent model forecast results using DENIAL and CNTL analysis as initial fields respectively. The data denial experiment shows that the exclusion of observations over the sensitivity region has an impact on forecast fields, however deterioration of forecast accuracy was not large because the difference of analyzed moisture fields with and without the data was small in this case. The difference of forecast fields at FT=12 in data denial experiments is conspicuous near the typhoon center, which does not necessarily consistent with the locations of final MSVs (not shown). This discrepancy is probably attributable to the track error (about 100 km) in the GSM 24-hour forecast used as the initial condition to calculate MSVs. To further assess the propriety of the MSV-based sensitivity region, OSSE on water vapor fields around typhoon center is necessary.

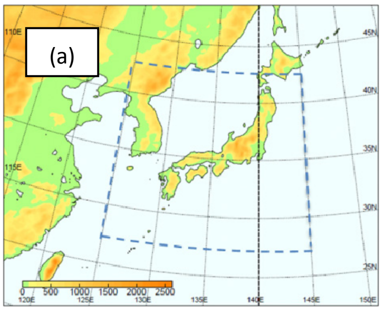

Fig.1. Model domain and the target area (broken line).

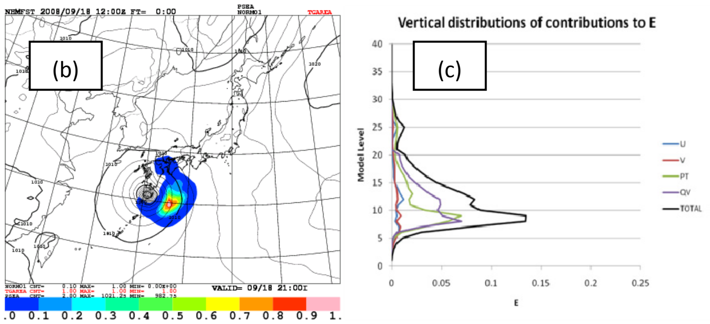

Fig.2. (a) Horizontal distribution of 1st MSV, (b) Vertical distributions of contributions to total energy norm. Observational time is 12 UTC on 18 September 2008.

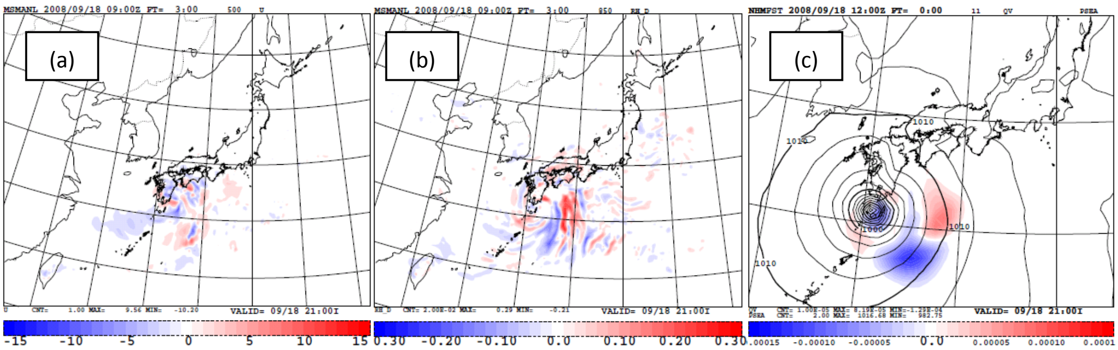

Fig.3. (a) Difference of analysis field between DENIAL and CNTL, zonal wind at 500hPa, (b) Same as in (a) but relative humidity at 850hPa, (c) QV of 4th MSV (z=1.46 km).

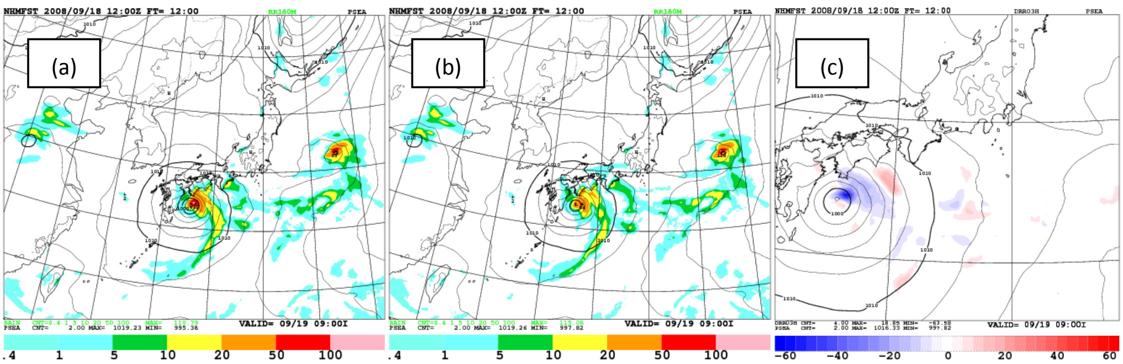

Fig.4. 3-hour accumulated precipitation (color) and SLP (contour) at 00 UTC on 19 September. (a) CNTL, (b) DENIAL, (c) difference of 3-hour accumulated precipitation between DENIAL and CNTL.

References

Honda, Y. et al., 2005: A pre-operational variational data assimilation system for a nonhydrostatic model at Japan Meteorological Agency: Formulation and preliminary results. *Quart. J. Roy. Metor. Soc.*, **131**, 3465-3475.