JMA's Total Energy Singular Vector Sensitivity Guidance for Adaptive Observations during T-PARC 2008

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1. INTRODUCTION

The Japan Meteorological Agency (JMA) performed sensitivity analyses and supplemental observations of tropical cyclones (TCs) as a part of the THORPEX Pacific Asian Regional Campaign (T-PARC). The observations were conducted with the aim of improving numerical weather prediction (NWP) performance, especially for TC track forecasts. The supplemental observational data included dropsonde deployment by manned Falcon aircraft, enhanced radiosonde observations by research vessels and fixed observation stations, and MTSAT rapid-scan operations. To provide guidance for the observations (referred to as adaptive observations), sensitivity analyses were performed using the singular vector (SV) method with the moist total energy (TE) metric evaluated at the initial and final times of the optimization time interval (TESV).

2. JMA'S SENSITIVITY ANALYSIS SYSTEM

For effective decision-making in adaptive observations using information from sensitive areas, a two-day lead time is necessary to plan each observation. Accordingly, sensitivity analysis was performed for the forecast fields (T+24 h and T+48 h) of the operational Global Spectral Model (GSM) at TL959L60 resolution. In the calculation of TESV, four target areas were defined in the western North Pacific. Three of these were fixed target areas (referred to as GUAM, TAIWAN and JAPAN) for daily analysis, and the other was an adaptive target area (referred to as MVTY) in the vicinity of the TC location. Figure 1 illustrates the four target areas for a typhoon. The fixed areas were useful for intercomparison between different providers, while the adaptive target area was more adequate for each TC case. The MVTY target region was automatically defined according to the TC position forecasted by the operational GSM. The norm used for measuring the amplitude of perturbations at both the initial and final times was based on moist TE as described by Ehrendorfer et al. (1999). The SVs calculated for all target areas were often defined as moist SVs because moist processes – including large-scale condensation and deep convection – were implemented in the tangent linear and adjoint models at T63L40 resolution for the global domain. The specifications of the sensitivity analysis for T-PARC are shown in Table 1.

3. SENSITIVITY GUIDANCE AND ADAPTIVE OBSERVATIONS FOR TYPHOON SINLAKU

The adaptive observations were performed for Typhoon Sinlaku, the 13th named tropical cyclone in the western North Pacific of 2008. Figure 2 indicates the supplemental observation points overlaid on the sensitive area for the MVTY region that was calculated from the two-day forecasted field valid at the time of special observations at 00 UTC on 11 September 2008. The highly sensitive area was defined as a region of large vertically integrated TE normalized by the maximum value of TE in the global domain.

To estimate the usefulness of TESV structures, sensitive areas from two- and one-day forecast fields were compared to those of the analysis field using the similarity index (Buizza, 1994). This index is equal to 1.00 when the two TESVs are identical. Table 2 denotes the results calculated for the observation at 00 UTC on 11 September 2008 (shown in Figure 2). The value between the leading TESV from the two-day forecast field and that of the analysis field is 0.85, indicating good usability for the TESV provided in advance.

The T-PARC observational data were distributed through the Global Telecommunication System to enable their use in operational NWP systems worldwide. Figure 3 outlines the results of the extra observational data denial experiment; it shows that, without special observation data assimilated into the NWP system, GSM failed to adequately forecast the recurvature of Sinlaku. In the interests of natural disaster reduction and mitigation, good forecast skill for TC recurvature as seen in this example is of great importance to people living in Pacific basin countries, including Japan. Other results of the data denial experiments are described by Yamashita et al. (2009).

Table 1. Specifications of the sensitivity analysis system for T-PARC

Forecast domain	Global			
Method	Singular vector			
Inner model resolution	Spectral triangular truncation at 63 wave numbers (T63), 40 levels (from surface to 0.4 hPa)			
Norm	Moist total energy			
Target area	GUAM (05 – 25N, 135 – 155E)	TAIWAN (18 – 30N, 117 – 140E)	JAPAN (25 – 45N, 120 – 150E)	*MVTY
Optimization time interval	48 hours			24 hours
Physical process	**Full physics			

*The MVTY target region is automatically defined in the vicinity of each TC position forecasted by the operational GSM.

**Full physics: Initialization, horizontal diffusion, surface turbulent diffusion, vertical turbulent diffusion, gravity wave drag, long wave radiation, large-scale condensation and deep convection

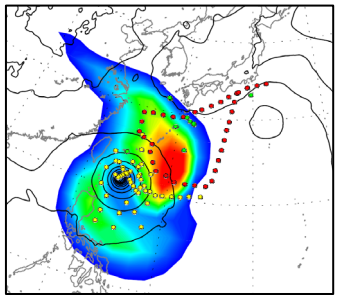

Figure 2. The sensitive area (shaded) calculated from the two-day forecasted field valid for special observations at 00 UTC on 11 September 2008. Extra observation points for upper-soundings by JMA research vessels and ground observatories (green points), dropsondes released by Falcon aircraft (red) and those released by other planes (yellow) are overlaid on the sensitive area.

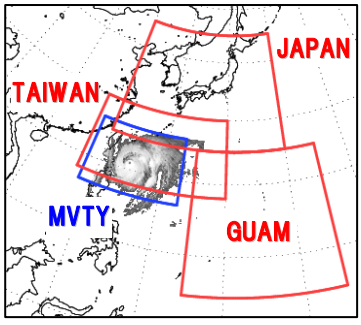

Figure 1. Schematic map showing the four target areas (defined in Table 1)

Table 2. Similarity index for the leading SV

Similarity	Two-day lead time	One-day lead time	Analysis
Two-day lead time	1.00	0.88	0.85
One-day lead time		1.00	0.93
Analysis			1.00

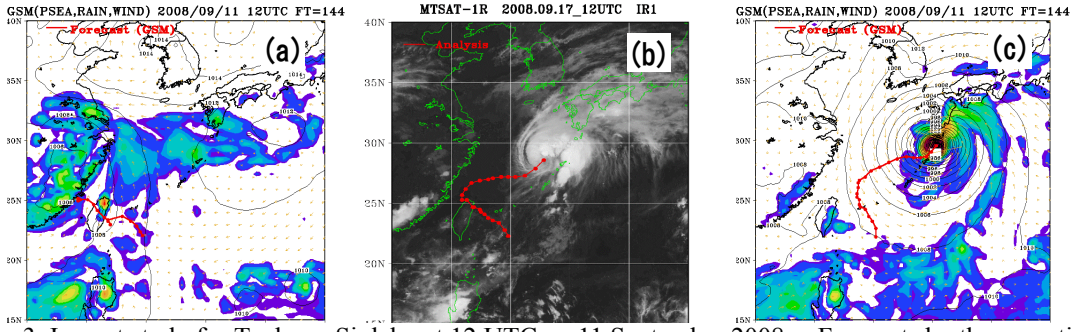

Figure 3. Impact study for Typhoon Sinlaku at 12 UTC on 11 September 2008. Forecasts by the operational GSM with and without supplemental observations are shown by the red lines (typhoon tracks) and shaded areas (rain fields) in (a) and (c), respectively. The track analyzed by the RSMC Tokyo-Typhoon Center is plotted on the MTSAT image in (b).

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