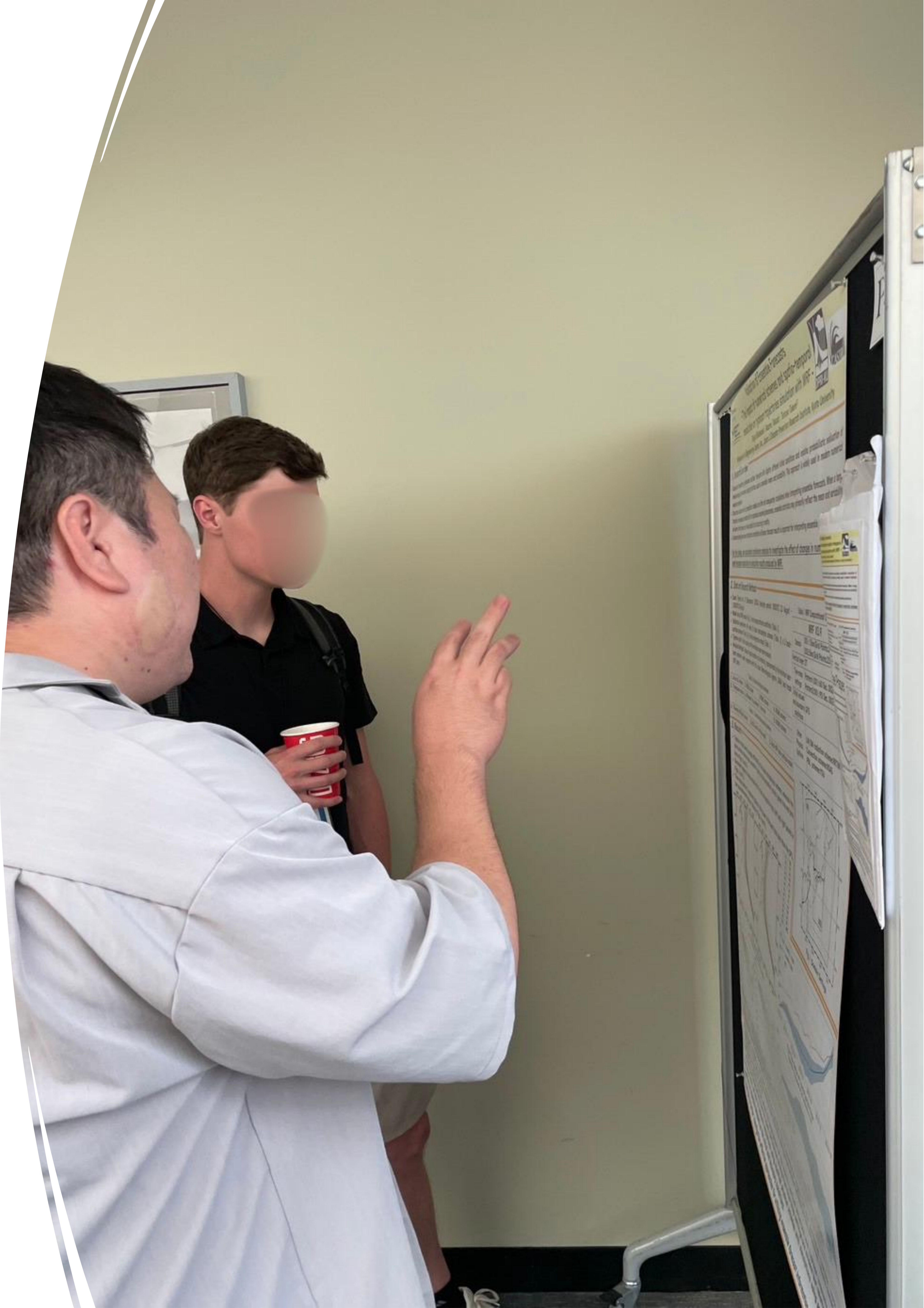


# Validation of Ensemble Forecasts - The impact of numerical schemes and spatio-temporal resolution on typhoon trajectories simulation with WRF -

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### 1. Research Overview

- Ensemble forecasting generates multiple forecasts with slightly different initial conditions and enables probabilistic evaluation of meteorological phenomena using statistics such as ensemble mean and variability. This approach is widely used in modern numerical weather prediction.
- Structural uncertainties in prediction models are often not adequately considered when interpreting ensemble forecasts. When a large fraction of ensemble members fail to reproduce observed phenomena, ensemble statistics may primarily reflect the mean and variability of events that have a very low probability of occurring in reality.
- Understanding how model structural uncertainties influence forecast results is important for interpreting ensemble predictions.
- ✓ In this study, we conducted a preliminary analysis to investigate the effect of changes in numerical schemes and temporal resolution on simulation results produced by WRF.

### 2. Data and Research Methods

- Case: Typhoon No. 10 (Shanshan) (2024); Analysis period: 1800UTC 23 August - 1200UTC 28 August
- Model setup: WRF domain (Fig. 1) and computational conditions (Table. 1).
- Validation experiments: 48 runs; 8 cloud microphysics schemes (Table. 2) x 3 land-surface schemes (Table. 3) x 2 time integration steps (Table. 1).
- Typhoon path: Track location of the minimum sea-level pressure.
- Analysis Methods: Typhoon track location and intensity, represented by the minimum sea-level pressure, were compared with the Japan Meteorological Agency (JMA) best track (BT) data.

Table.2 8 cloud microphysics schemes

1. Lin et al. scheme	2. WSM3 scheme	3. WSM5 scheme	4. WSM6 scheme
5. Thompson scheme	6. Milbrandt-Yau scheme	7. Morrison	8. WDM6 scheme

Table.3 3 land surface physics schemes

A. Thermal diffusion scheme	B. RUC land-surface model	C. Noah-MP land-surface model
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Table.1 WRF Computational Conditions

WRF V3.9	
Domain	D01:15km(Grid Points:200×230) D02:5km(Grid Points:232×277)
Vertical layer	27
Time-step settings	Pattern1:D01:60 Sec. D02:20 Sec. Pattern2:D01:90 Sec. D02:30 Sec.
Initial values and boundary conditions	GFS
Other Physics Options	LW/SW radiation scheme:RRTMG Convection scheme:NSAS PBL scheme:YSU

### 3. Results

- Typhoon tracks were strongly affected by the cloud microphysics scheme, whereas the land-surface scheme had a smaller impact on the simulation results (green line and pink line in Figs. 2 and 3).
- Simulated typhoon tracks varied with the time integration step (left and right panels in Figs. 2 and 3).
- Time-step pattern 2 produced typhoon track closer to the best track data than the GFS, but overestimated typhoon intensity (Figs. 4 and 5).

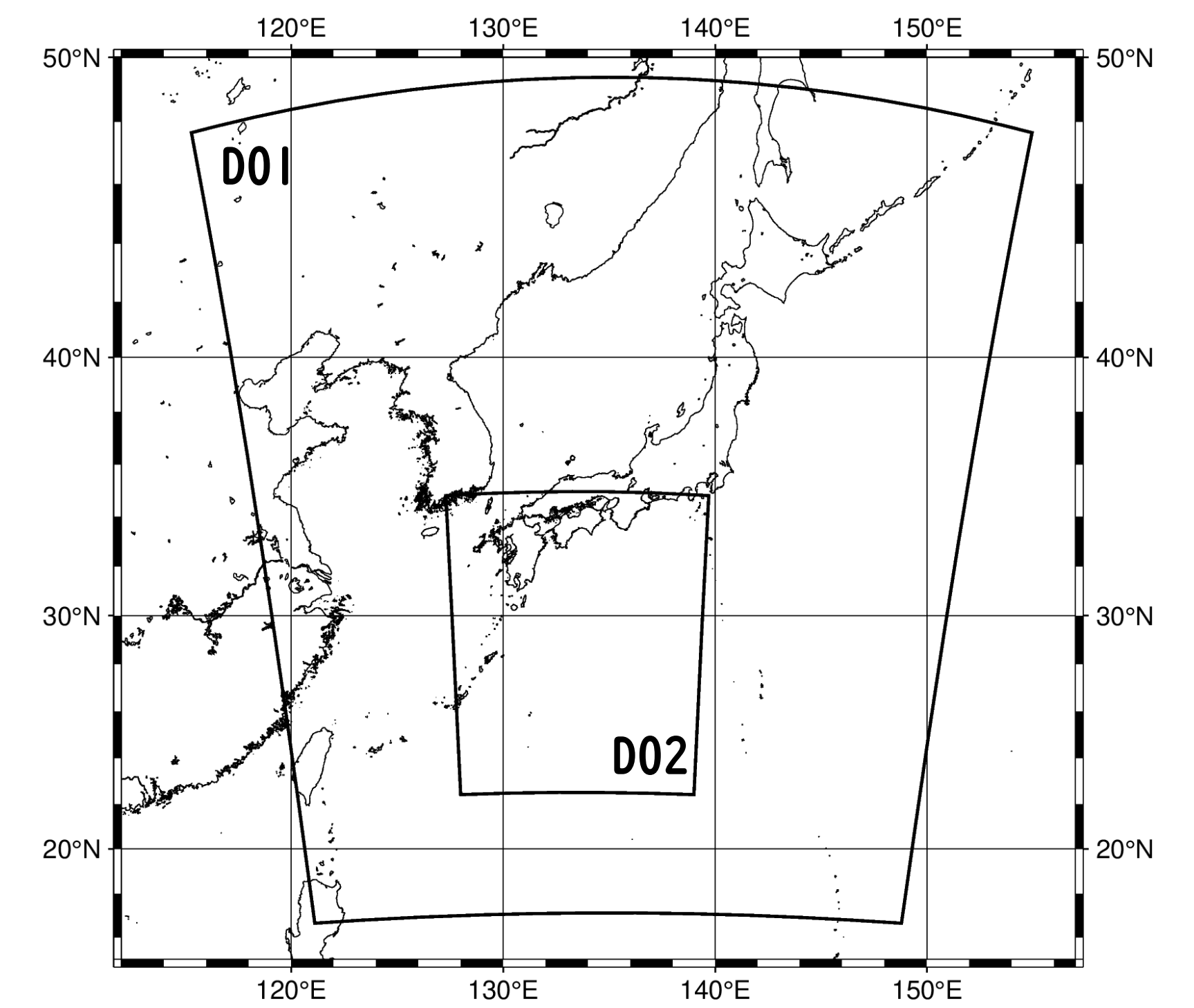


Fig.1 Domain Settings

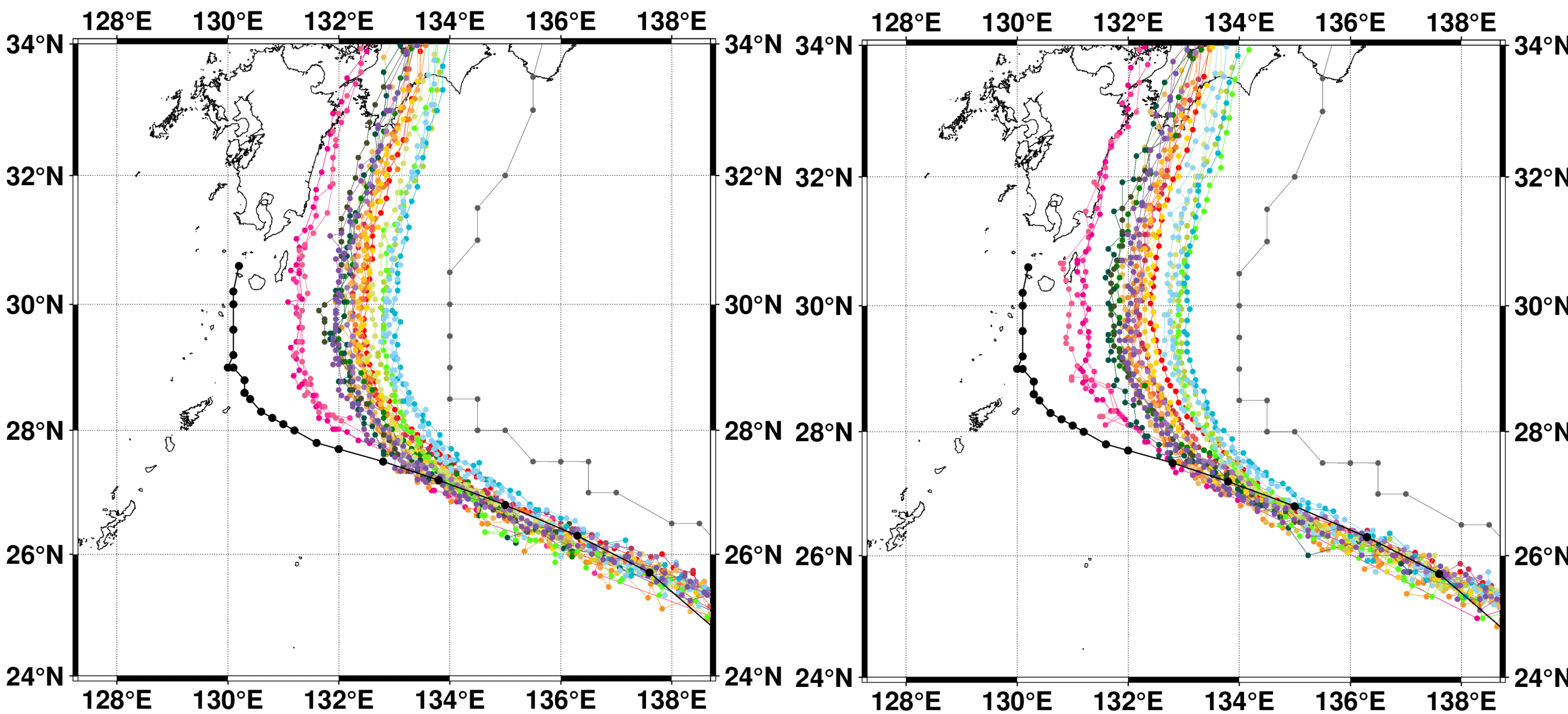


Fig.2 Typhoon Track Map

Left: Time-step-pattern 1, Right: Time-step-pattern 2

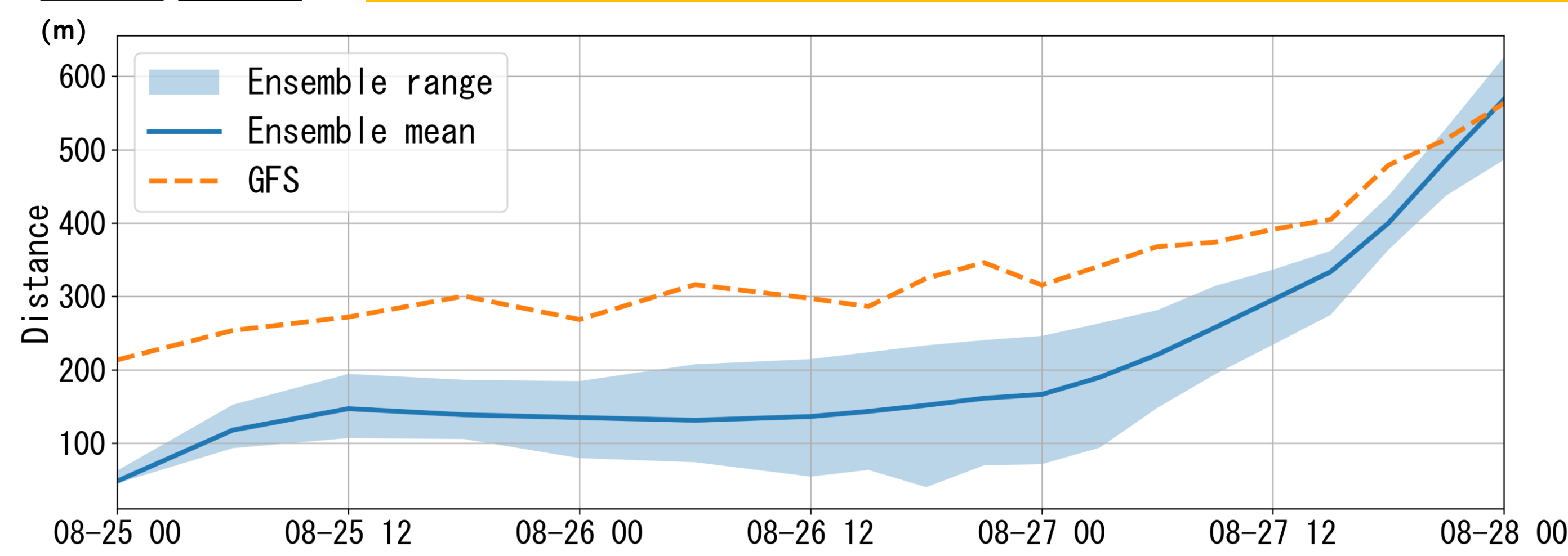
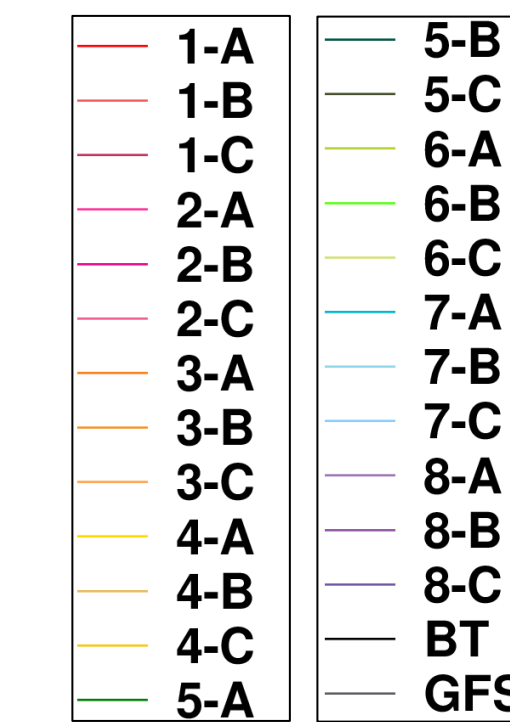


Fig.4 Time Series of Track Position Error

Ensemble is composed of 48 validation runs.

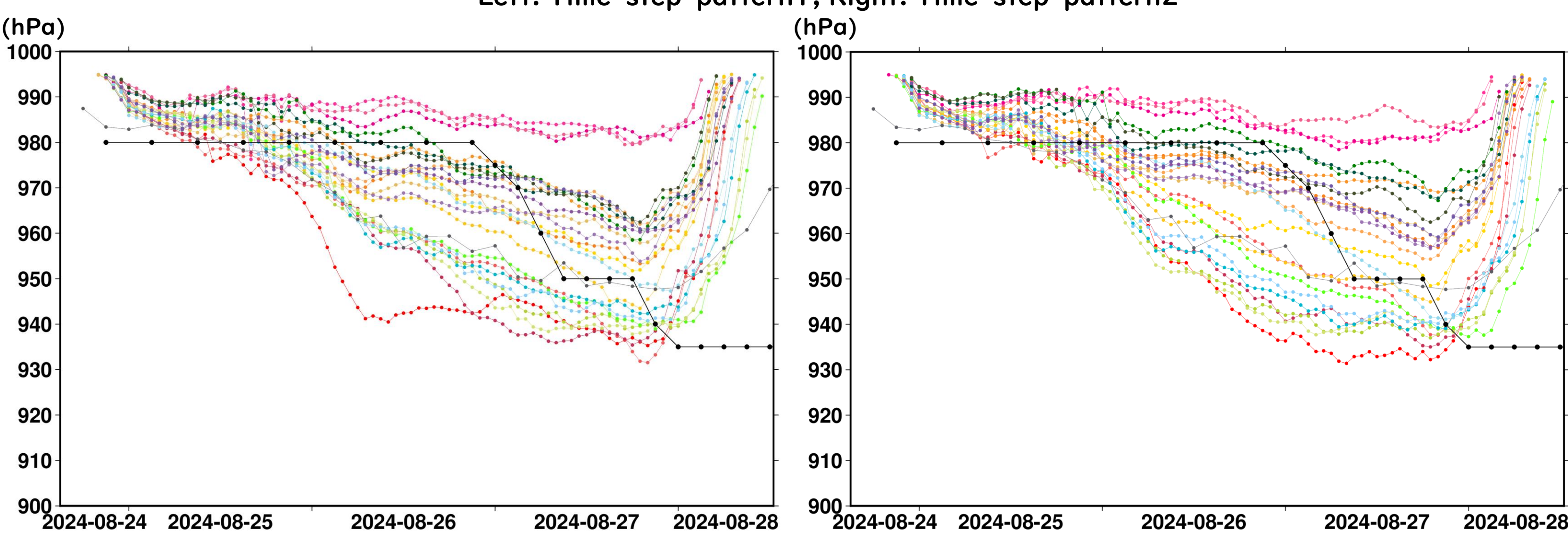


Fig.3 Time Series of Minimum Pressure During the Typhoon

Left: Time-step-pattern 1, Right: Time-step-pattern 2

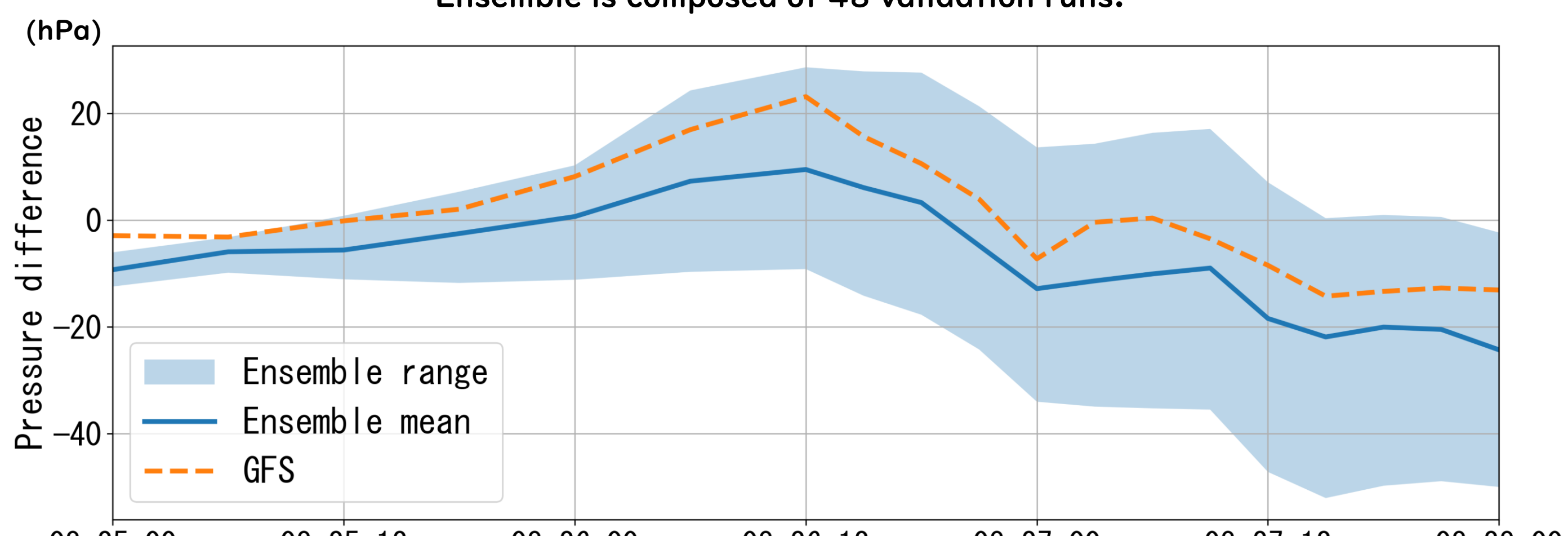


Fig.5 Time Series of Minimum Sea-Level Pressure Error

Ensemble is composed of 48 validation runs.

### 4. Summary and Future Works

- In this case, changes in the cloud microphysics scheme had a substantial impact on the simulated typhoon track. In contrast, modifications to the surface physics scheme and time-step settings had smaller effects on the simulation results compared with changes in the cloud microphysics scheme.
- Microphysics schemes strongly affect the development of the storm's vertical structure and typhoon intensity, whereas land surface schemes have limited effects over the ocean. Differences arising from time-step settings are evident but relatively small.
- In future work, we plan to compare simulations using modified physical schemes with simulations using perturbed initial and boundary conditions or ensemble datasets as the initial and boundary conditions.
- We would like to further investigation effective approaches for utilizing ensemble forecast information.