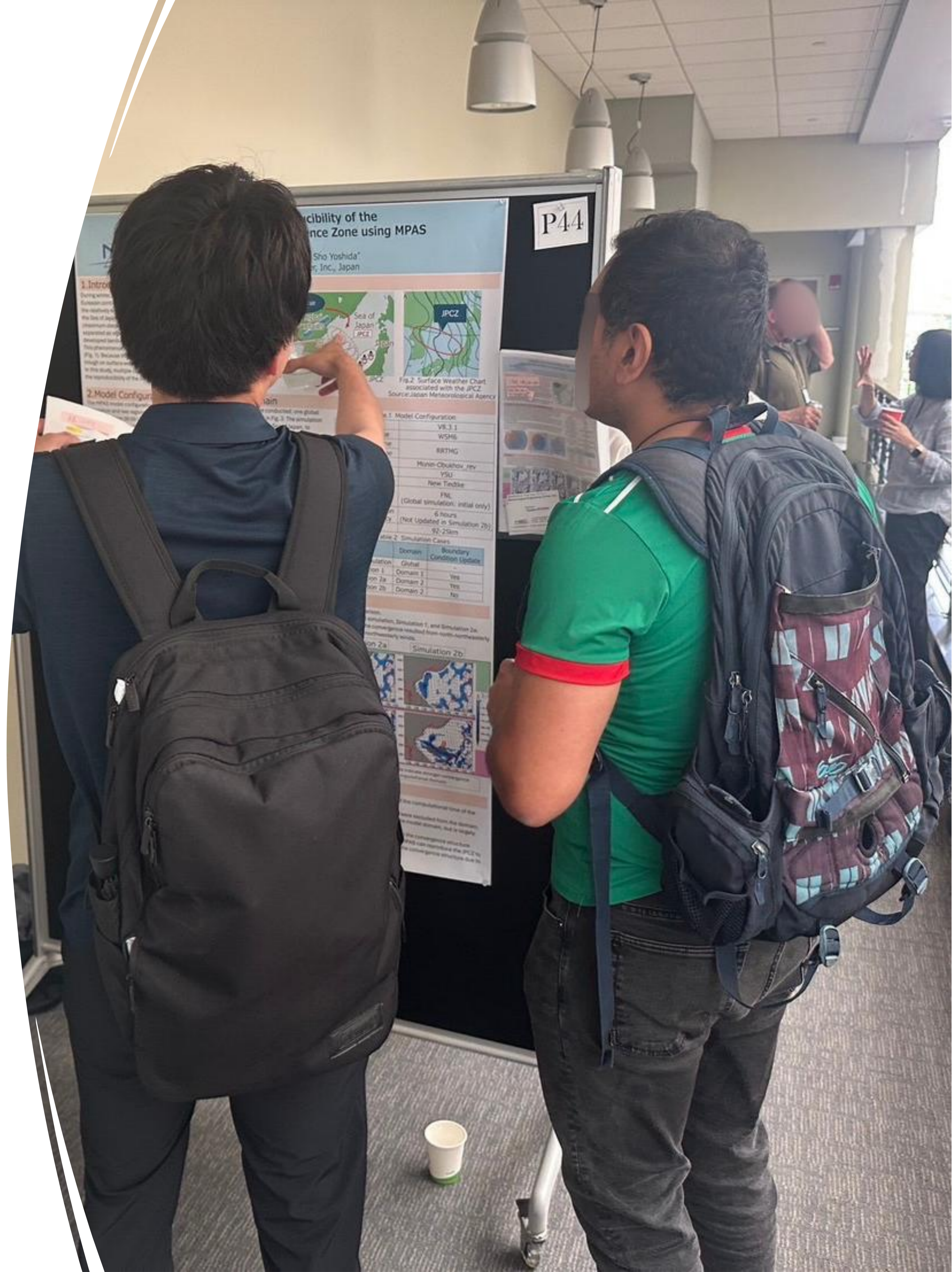


Evaluation of the Reproducibility of the Japan Sea Polar Air Mass Convergence Zone using MPAS

(当社社員 発表風景)



Evaluation of the Reproducibility of the Japan Sea Polar Air Mass Convergence Zone using MPAS



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1. Introduction

During winter, cold air associated with the East Asian winter monsoon flows from the Eurasian continent over the Sea of Japan. Sensible heat and water vapor supplied from the relatively warm sea surface promote the formation of longitudinal snowbands over the Sea of Japan. Furthermore, the cold air is divided by the Changbai Mountains (maximum elevation: 2,744 m), located at the northern part of the Korean Peninsula. The separated air streams subsequently converge over the Sea of Japan, forming a well-developed band-shaped snow cloud that is stronger than the surrounding snowbands. This phenomenon is known as the **Japan Sea Polar Air Mass Convergence Zone (JPCZ)** (Fig. 1). Because the JPCZ is associated with relatively low pressure, it appears as a trough on surface weather charts (Fig. 2).

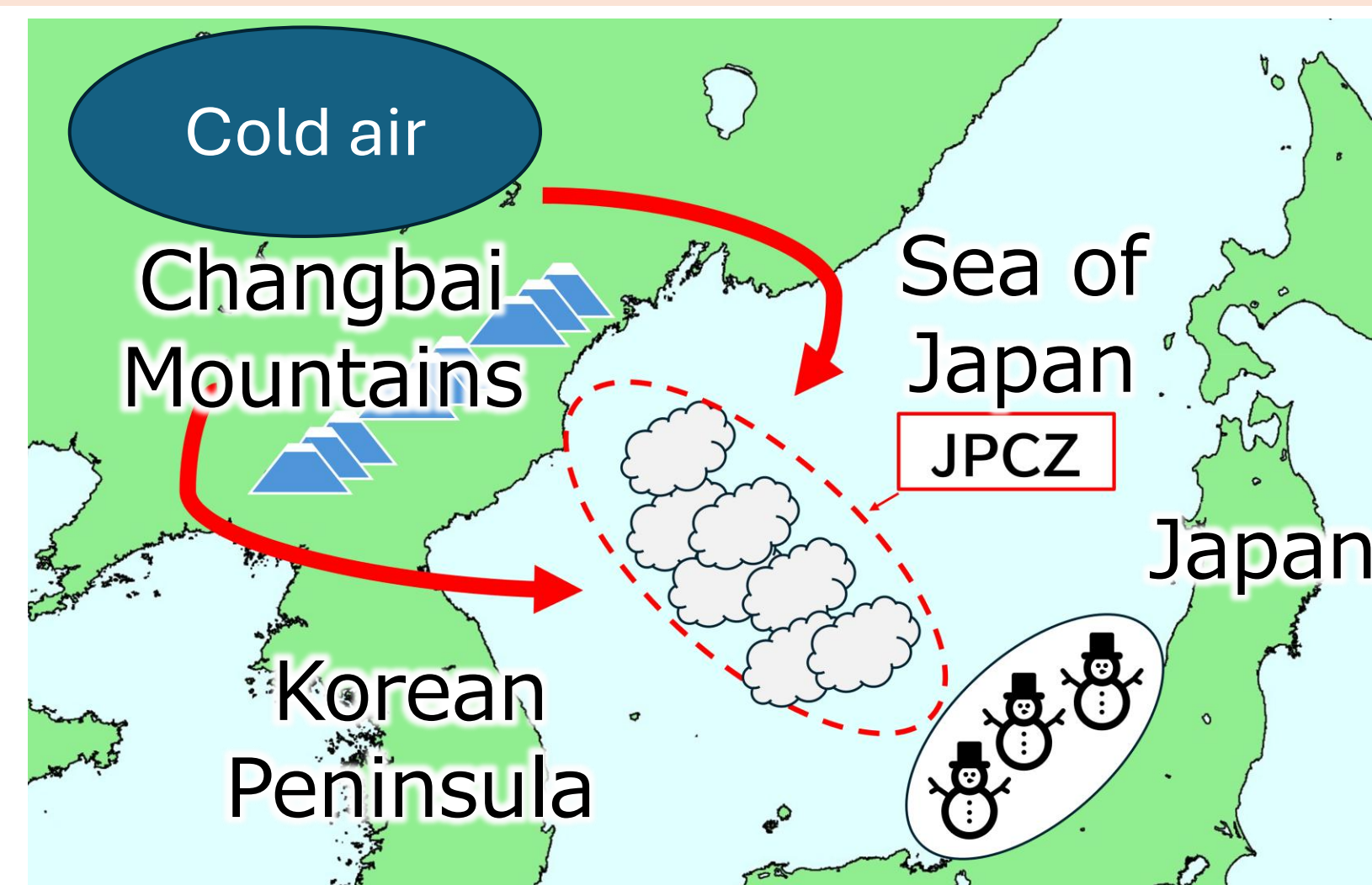


Fig.1 Schematic of the JPCZ

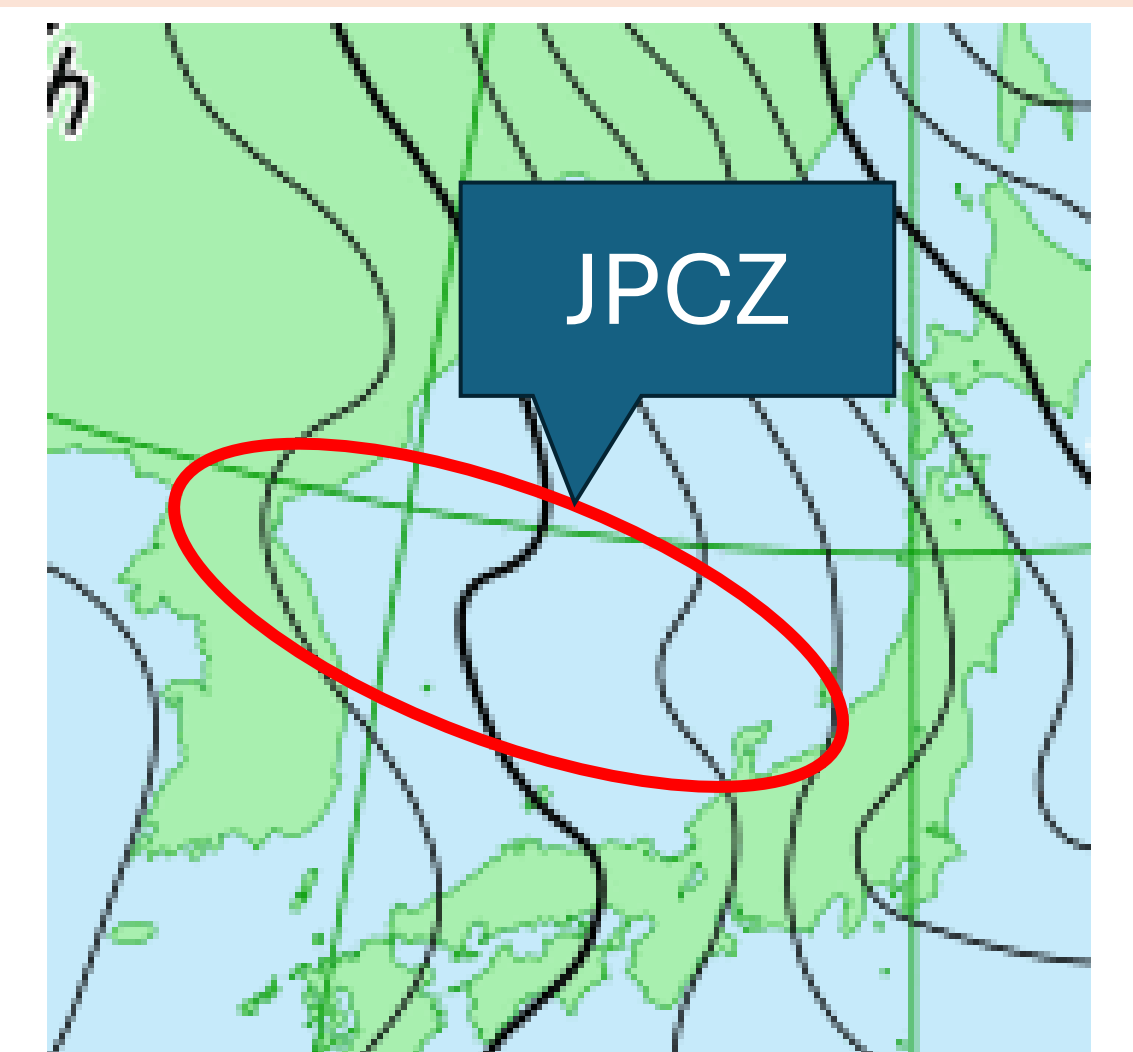


Fig.2 Surface Weather Chart associated with the JPCZ
Source: Japan Meteorological Agency

In this study, multiple computational domains were designed and compared to evaluate the reproducibility of the JPCZ in the Model for Prediction Across Scales (MPAS).

2. Model Configuration and Computational Domain

The MPAS model configuration is summarized in Table 1. Three simulations were conducted: one global simulation and two regional simulations. The computational domains are shown in Fig. 3. The simulation period was from 00:00 UTC 12 December 2022, when no JPCZ was present over the Sea of Japan, to 00:00 UTC 14 December 2022, when a JPCZ had developed over the Sea of Japan.

The simulation cases are listed in Table 2. To investigate the impact of lateral boundary condition updates on JPCZ formation in the regional simulations, two experiments were conducted for Domain 2: one with boundary condition updates and one without them. NCEP FNL (Final) data were used for the initial and boundary conditions.

Note: Because boundary-condition updates cannot be completely disabled in MPAS regional simulations, Simulation 2b was run until 12:00 UTC 14 December 2022 with a boundary update interval of 60 hours. Consequently, no boundary updates were applied before 00:00 UTC 14 December 2022, which was regarded as a no-update experiment.

Table.1 Model Configuration

Version	V8.3.1
Microp_Scheme	WSM6
Radt_Iw_Scheme	RRTMG
Radt_sw_Scheme	
Sfclayer_Scheme	Monin-Obukhov_rev
Pbl_Scheme	YSU
Convection_Scheme	New Tiedtke
Initial and Boundary Conditions	FNL (Global simulation: initial only)
Boundary Condition Update Frequency	6 hours (Not Updated in Simulation 2b)
Meshes	92-25km

Table.2 Simulation Cases

Case	Domain	Boundary Condition Update
Global Simulation	Global	-
Simulation 1	Domain 1	Yes
Simulation 2a	Domain 2	Yes
Simulation 2b	Domain 2	No

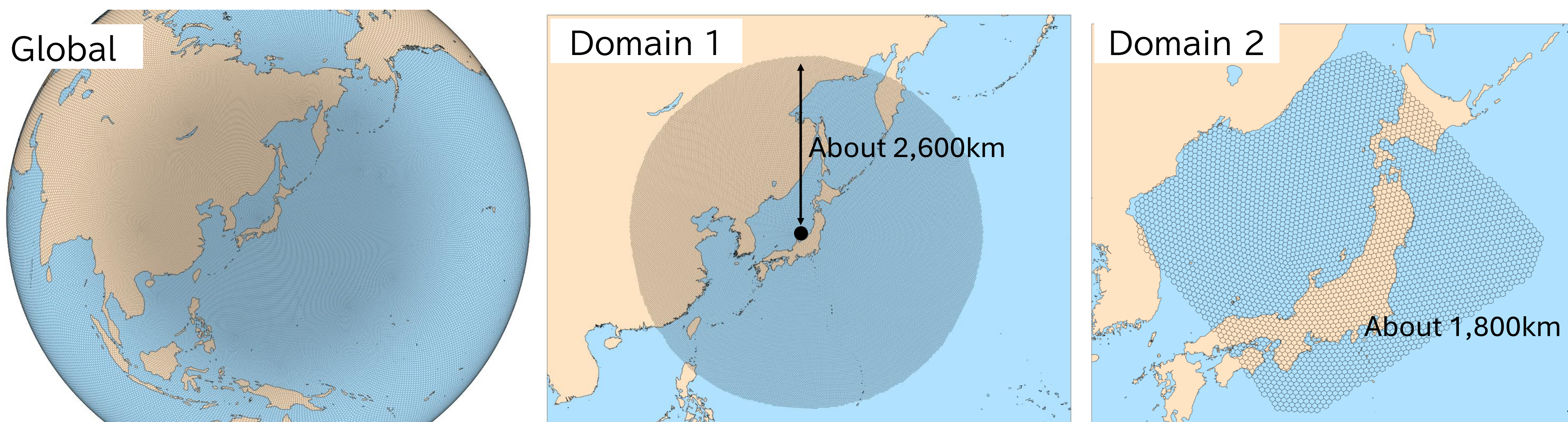


Fig.3 Three Computational Domains

3. Result

- Fig. 4 shows the simulation results. The JMA/GSM (JMA's Global Spectral Model) objective analysis was used for comparison.
- The JPCZ that developed over the Sea of Japan at 00:00 UTC 14 December 2022 was generally reproduced in the global simulation, Simulation 1, and Simulation 2a.
- Although a JPCZ-like convergence zone was reproduced in Simulation 2b, its structure differed from the other cases. The convergence resulted from north-northeasterly and west-northwesterly winds, whereas the other cases showed convergence between north-northwesterly and west-northwesterly winds.

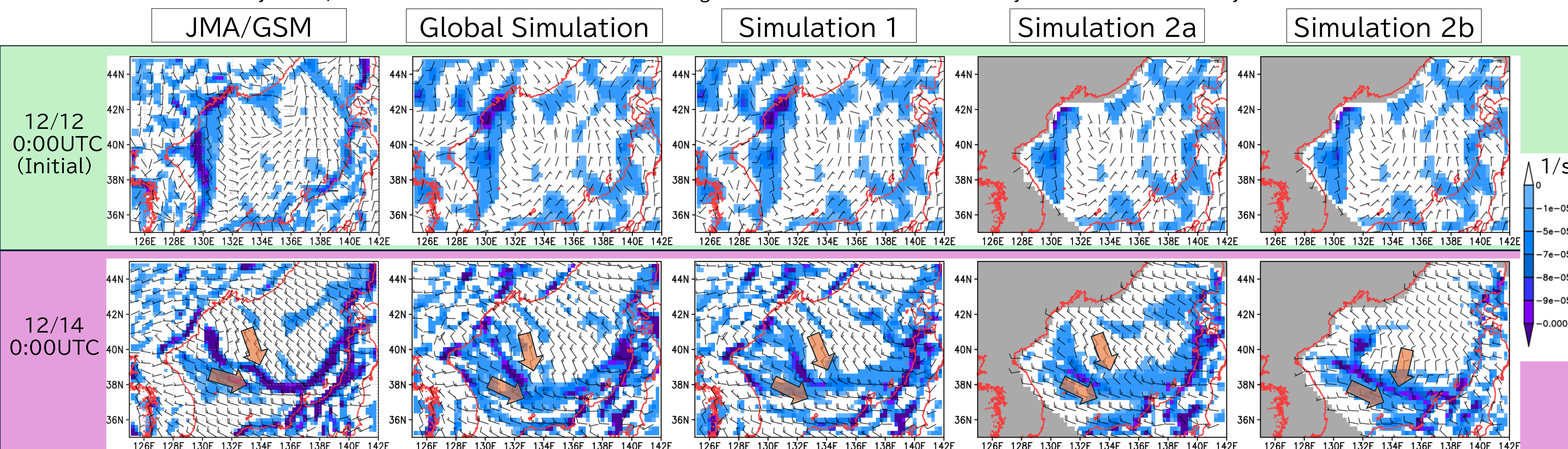


Fig.4 Distribution of 10-m wind vectors and convergence
From left to right: JMA/GSM, Global Simulation, Simulation1, 2a, 2b
Top:12/12 0:00UTC, Bottom:12/14 0:00UTC

Colors closer to purple indicate stronger convergence
Gray: Outside the computational domain

4. Conclusion

- The JPCZ was successfully reproduced in MPAS using a Domain 1-scale regional domain. Simulation 1 required about one quarter of the computational time of the global simulation, indicating that regional simulations are an efficient and cost-effective approach for JPCZ reproduction.
- In Simulation 2a, results comparable to the global simulation and Simulation 1 were obtained even though the Changbai Mountains were excluded from the domain. This is likely because the FNL boundary conditions already include their influence. Thus, the JPCZ is not primarily generated within the model domain, but is largely imposed through the boundary forcing.
- In Simulation 2b, boundary conditions were not updated, yet the JPCZ was still reproduced at 00:00 UTC 14 December 2022, although the convergence structure differed from the other simulations. This suggests that boundary condition updates are not essential for JPCZ reproduction, and that MPAS can reproduce the JPCZ to some extent using initial conditions from about two days earlier. However, the lack of boundary updates likely caused differences in the convergence structure due to the absence of evolving synoptic-scale forcing.