Abstract

The Japan Meteorological Agency (JMA) has operated global and regional atmospheric transport models (ATMs; JMA-GATM and JMA-RATM, respectively) to issue volcanic ash advisories (VAAs) and volcanic ash fall forecasts (VAFFs). The JMA-GATM is driven by the grid-point values of the global spectral model (GSM) and the JMA-RATM by those of the meso-scale model (MSM) or local forecast model (LFM) based on the nonhydrostatic model ASUCA. Under a research plan that began in April 2019, the Meteorological Research Institute (MRI) of the JMA is proceeding with a plan to unify the global and regional ATMs. In this Technical Report, we document the design and development of the new JMA-ATM.

The new JMA-ATM was designed from the point of view of robustness, promptness, flexibility and manageability. *Robustness*: To avoid any abnormal ends in operation, the JMA-ATM employs a Lagrangian description. *Promptness*: To issue VAAs and VAFFs immediately, the JMA-ATM is calculated offline. Moreover, the element conversion of grid-point values is executed during preprocessing, and the main ATM calculations are processed in parallel using a message-passing interface on supercomputers. *Flexibility*: ATM tracers are not limited to volcanic ash estimated from emission-source parameters as the initial condition, and the ATM coordinate system can accommodate beyond the input datasets of the GSM, MSM and LFM. *Manageability*: In order to review and share source code within the JMA, project management and version control systems have been implemented in the ATM development.

Considering these design principles, the offline Lagrangian model is the same as in the previous ATMs. Whereas the vertical coordinates of the JMA-GATM and JMA-RATM are the σ-p hybrid coordinate of the GSM and the hybrid terrain-following coordinate of the ASUCA, respectively, the JMA-ATM unifies the models by converting the grid-point values to identical z-coordinates. For readability, the JMA-ATM is written in Fortran in accordance with standard coding rules, and all subroutines are modularized. To ensure that dynamical and physical processes are commutative at each time step, the time tendency of tracer variables is calculated in each process and integrated at the last time step. A technical platform also provides visualization and verification tools. The JMA-ATM project is managed with Redmine and source code versions are controlled with Subversion.

As an operational model, a first objective of the new ATM, which is to maintain the accuracy of JMA-GATM and JMA-RATM predictions, has been achieved. To precisely predict atmospheric transport phenomena near ground surface, the next subject is a suitable treatment of the model terrain in the z-coordinate or transformation to a terrain-following coordinate. Furthermore, to improve the accuracy of JMA-ATM predictions, we are planning to implement aggregation and resuspension processes in addition to integrating a data assimilation system for volcanic ash.