R&D Theme

Development of an Atmospheric Simulation Model and Evaluation Methods to Improve the Accuracy of Probability Estimation

Progress until FY2022

1. Outline of the project

In weather control, selecting the optimal control method requires highly accurate estimates of the probability associated with properties of phenomena, such as location, time, and intensity. In probability estimation, imperfections in the atmospheric simulation model can be an obstacle to accurate estimation. Solving this problem requires qualitatively different approaches rather than an extension of traditional computational methods. Atmospheric simulation models are composed of multiple subcomponents. In this research, we will develop new computational methods for some of the components that are thought to contribute significantly to the decline in the accuracy of probability estimation and build new atmospheric simulation model using these methods.

When developing a new model, it is necessary to confirm the validity and usefulness of the model. Therefore, in addition to developing a new model, this research will also work on developing validation methods to objectively demonstrate that the model improves the accuracy of probability estimation. In this way, we aim to ensure the reliability of the new model and clearly demonstrate its usefulness.

2. Outcome so far

We have designed mathematical models and implemented them in program codes for the following four new calculation schemes. Each scheme has been fundamentally validated through numerical experiments.

- Surface layer turbulence scheme using a new formula that eliminates the assumption of spatio-temporal uniformity and accounts for turbulence of the order of 1 m.
- Fluid dynamic scheme that achieves both high computational efficiency and high accuracy by employing the discontinuous Galerkin method
- Lagrangian particle-based cloud microphysics scheme, superdroplet method, that computes cloud behavior by calculating the motion of water droplets and ice particles
- Lightning scheme that explicitly calculates charging due to collisions between cloud particles within clouds and lightning strikes

We have also developed validation and factor analysis method to objectively evaluate the accuracy of probability estimates from simulations.

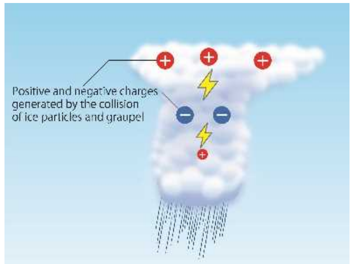

Diagram of intracloud charging as calculated by the lightning model.

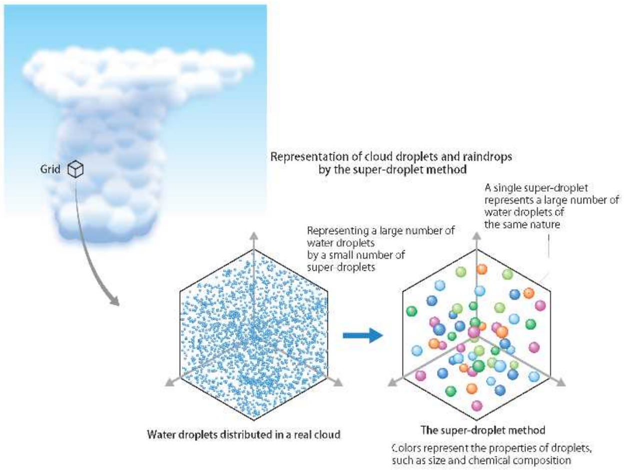

Diagram of how cloud particles are represented in the superdroplet method.

3. Future plans

We will verify the validity of the calculation schemes under development from various perspectives and make improvements based on the results. We will also develop a new atmospheric simulation model that incorporates these calculation schemes to simulate the real atmosphere. Furthermore, in order to objectively demonstrate that the new simulation model improves the accuracy of probability estimation, we will further advance the methods for evaluation and analysis.

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