R&D Theme

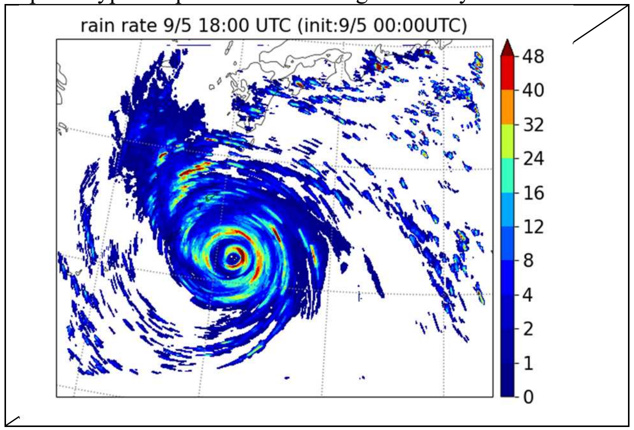
Meteorological Approach

Progress until FY2022

1. Outline of the project

We will develop a more accurate numerical prediction model that represents the internal structure of typhoons in detail, and that can be used to control typhoons effectively. Specifically, methods to control typhoons by seeding, lowering sea surface temperatures, weakening surface winds and changing wind direction by placing barriers and wind turbines on the sea, etc., will be considered to change typhoon intensity. We also consider methods to change typhoons with continuous weak intervention. Assuming seeding from aircraft, we will conduct laboratory experiments to investigate the details of cloud physics in convective clouds.

We will select cases that have the potential to cause disasters by predicting them in advance and assimilate aircraft and ship observation data into a data assimilation system based on a high-resolution model to improve the accuracy of prediction to the extent that the effects of human intervention can be judged and to improve typhoon predictions with high accuracy.

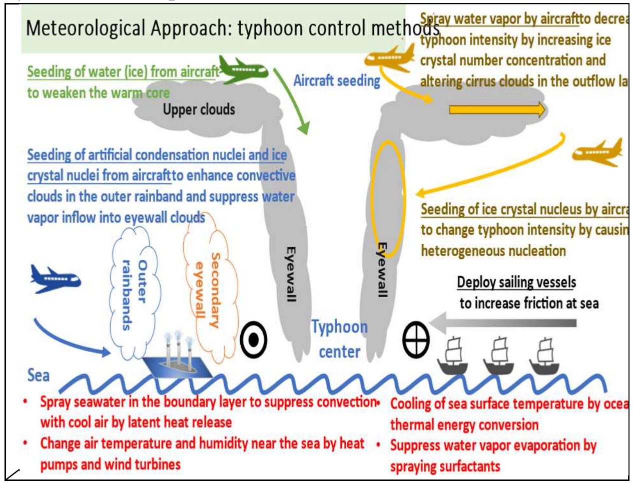


An example of the 1-km-mesh numerical experiment of Typhoon Haishen in 2020, reproducing the double-eyewall structure of the northward-moving typhoon over the ocean south of Kyushu.

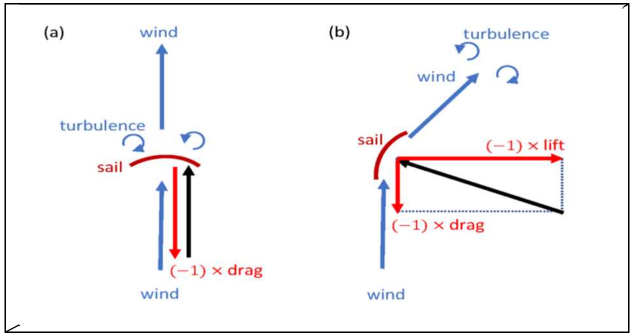
2. Outcome so far

In FY2022, we promoted studies on typhoon control methods, the development of a high-resolution numerical model to represent typhoon structure in detail, laboratory experiments of cloud microphysics in convective clouds, a data assimilation system based on a high-resolution model, and the construction of a detailed analysis of typhoons using aircraft data to improve typhoon forecasts.

We investigated possible control methods affecting typhoon intensity. Candidate methods are summarized in the figure: changing convective clouds by seeding from aircraft, reducing sea surface temperature and evaporation from the sea surface, and changing wind speed, temperature, and humidity near the surface by unmanned ships or other means.



Schematic diagram of a typhoon cross-section and possible control methods. The gray areas extending diagonally from both sides of the typhoon's center are the eyewall and upper clouds. The anti-clockwise winds are at the lower level near the eyewall cloud. Possible typhoon control methods to weaken the strong winds are designated in the figure.



An example of a theoretical study of a specific control method: Horinouchi and Mitsuyuki (2023). The typhoon intensity is varied by placing many sailboats on the sea under strong typhoon winds. The direction of the sailboat (sail) relative to the wind's direction determines the drag's strength and direction. Quantitative evaluation of the effect of sails on the atmosphere shows that deploying 400 large rigid-sail vessels in a 100 km square area can reduce typhoons' maximum potential intensity by about 10%. The challenge is investigating the effectiveness through realistic numerical simulations and more efficient methods.

3. Future plans

We will promote theoretical studies and conduct numerical simulations with specific typhoon cases to systematically investigate the relationship between the strength of external forcing and its impact on typhoon intensity. We will explore methods that can be artificially intervened to obtain significant typhoon intensity changes (around 5 m/s at maximum wind). Identify issues in improving the accuracy of typhoon forecasting in numerical models. Elucidate the mechanisms of changes in the internal structure of typhoons that cause changes in typhoon intensity, such as eyewall replacement and formation of rain bands. We also promote mathematical research to produce large effects with small external forces.

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