R&D item

5. Weather Prediction

Progress until FY2023

1. Outline of the project

Due to the recent progress of global warming, occurrence of heavy rainfall is becoming more frequent in Japan as well as various parts of the world. Against this background, the project "artificial generation of upstream maritime heavy rains to govern intense-rain-induced disasters over land (AMAGOI)" aims to reduce heavy rainfall on land downstream by artificially enhancing heavy rainfall over the ocean. Specifically, the idea is to generate rainfall upstream over the ocean to reduce the water vapor that serves as the seed for rain.

During the Baiu-season, the East China Sea upstream has an environment conducive to the development of cumulonimbus clouds due to evaporation from the warm sea surface and the transport of large amounts of water vapor from the southwest. In fact, one can see that precipitation tends to develop downstream, triggered by small islands west of Kyushu. Based on these facts, Item 5 "Investigation of Effective Intervention Operations for Generating Offshore Heavy Rain," considers that it may be possible to generate and enhance precipitation over the ocean with even a "small" human-induced stimulus. The goal is to clarify in which situations and with which methods effective interventions are possible. This involves reproducing heavy precipitation events with numerical weather models to test and confirm the effectiveness of "realistic" meteorological intervention methods.

2. Outcome so far

In this project, we have used numerical weather models to reproduce two specific heavy rain events and have introduced artificial intervention methods into these models (table 1) to evaluate the effectiveness of the interventions on the reproduced heavy rain events. First, method ① "Sprinklers" aims to lower the temperature by spraying seawater into the air to promote evaporation. While lifting water several hundred meters into the air is technically feasible with current technology, the temperature change within realistic power limits is about 0.1° C, and the resulting change in precipitation is about 1%. However, some simulations showed slightly larger impacts depending on how the water is sprayed, so we judged the potential of this method as neutral (△). Next, method ② involves "Seeding" ice particles to promote ice growth directly. Given that small aircraft can carry around 1000 kg at a time, the impact on precipitation was calculated to be less than 0.1%, leading us to judge the potential of this method as negative (×). Method ③, which involves direct heating and cooling, also resulted in an impact on precipitation of less than 0.1%. Therefore, unless the location and timing are finely tuned, we consider this method negative (×). For method ④, we modeled the placement of around 100 kite-like objects, each 300 meters high and 200 meters wide, over the ocean. This intervention simulates the natural development of precipitation systems triggered by small islands in the East China Sea. This method was found to be promising, with the potential to cause changes in precipitation of 5-10% and allow for downstream precipitation control. Finally, method ⑤, which involves reducing sea surface temperature (SST) through ocean mixing, was recognized as having a significant impact on suppressing precipitation. However, given that our estimates of realistic scale may be overly optimistic, we currently judge the potential of this method as neutral (△).

Table 1: Modeled Intervention Methods

	Method	Purpose	Feasibility
①	Sprinklers	Cold pool	△
②	Seeding	Ice growth	×
③	Direct heating/cooling	Updrafts and Downdrafts	×
④	Installation of obstacles	Frictional convergence	○
⑤	Ocean mixing	Reduction of SST	△

3. Future plans

Several promising intervention methods for "artificially inducing precipitation over upstream ocean areas" have been identified. However, it is necessary to demonstrate that these results are robust and to clarify under what conditions control is possible. In the future we plan to increase the number of numerical experiments to verify the robustness, to perform numerical experiments for other events, and to explore quantities that could serve as a good indicator of controllability.