Progress until FY2023

1. Outline of the project

Develop a control system that combines observation, prediction, and decision-making to effectively suppress heavy rains by implementing multiple engineering methods at different times and stages. Additionally, the control system would be designed to intervene at multiple stages to course-correct when an unexpected deviation occurs. Furthermore, our goal is to implement multiple types of interventions at various stages to increase the regulatory effect. Specifically, we aim to develop a decision-making support system that can derive optimal solutions by combining multiple control methods in real-time by (1) simplifying the time evolution model for heavy rain events and constructing an ensemble prediction method, (2) constructing monitoring methods for regulation, (3) setting appropriate objective functions based on the output of ELSI/RRI research, and (4) optimizing algorithms.

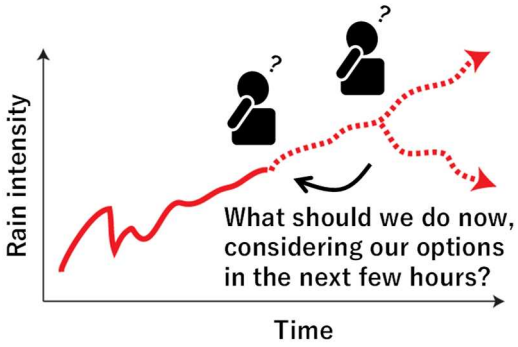

Figure 1. Schematic diagram showing decisions being made at multiple points in time and at multiple stages

2. Outcome so far

① Formulation of a decision-making problem for heavy rainfall control

The objective of R&D Theme 2 is to develop a system capable of deriving optimal solutions for operations in real time. This system integrates knowledge from Theme 1 on various operational methods and from Theme 3 on the evaluation of impacts on floods, water resources, and human societies.

Collaborative discussions were held with Themes 1,3 to identify the four essential elements required to formulate a decision-making problem: the objective function, constraints, possible interventions, and random phenomena. The proposed engineering solutions—seeding, offshore curtain, and offshore wind turbines—were developed by considering their spatial impact on weather phenomena associated with heavy rainfall and the temporal scale from the initiation of control measures to the manifestation of their effects.

Moreover, a policy was formulated to categorize the impacts of heavy rainfall control into two groups: those that should be included in the objective function and those to be considered as constraints. The decision-making problem focuses on optimizing the timing and magnitude of engineering interventions to maximize the objective function within these constraints. Although there is considerable flexibility in determining which items should be included in the objective function or constraints, current considerations include human and economic losses in the objective function and impacts on water resources, ecosystems, and the global environment in the constraints.

②Elucidation of heavy rainfall mechanism for control

Furthermore, sensitivity experiments using numerical simulations were conducted to determine the most probable pathways or conditions that facilitate the transport of water vapor to isolated localized linear convective systems, which frequently result in heavy rainfall inland. The findings demonstrate that higher atmospheric stability promotes the convergence of water vapor between landforms, enhancing the inland transport of water vapor.

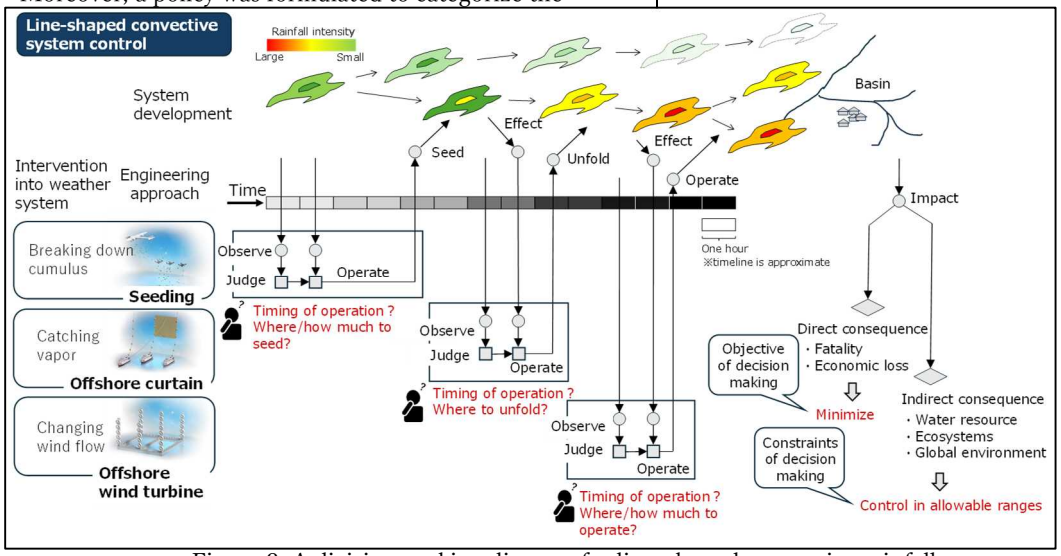

Figure 2. A dicision-making diagram for line-shpaed convective rainfall

3. Future plans

Our objective is to develop a decision-making framework based on the characteristics of control methods, the relationships between the effects of control (i.e., impacts related to heavy rains and social impacts), and the scope of the decision-making problem.