Research and development theme 1 (development of engineering methods based on numerical computations)

Progress until FY2022

1. Outline of the project

Develop a numerical weather model that can express heavy rains from when it occurs, and examine interventions to reduce heavy rains using a weather-based approach combining numerical weather models, field observations, and laboratory experiments. Develop multiple feasible engineering methods based on these examinations, while monitoring the scale of sudden heavy rains and linear convective heavy rains. Additionally, focus on the causes and early stages of heavy rain occurrence, and suppress the intensity and frequency of heavy rains.

Regarding physical quantities that can be manipulated step-by-step during cumulonimbus cloud formation, first, an offshore air-bubble curtain will be used to reduce water vapor, followed by the use of a fan to diffuse heat and air current vortices. Furthermore, wind farms will be used to weaken the convergence of wind, and finally, seeding will be employed to change the cloud and rain particle formation. These processes constitute a multi-stage manipulation technique.

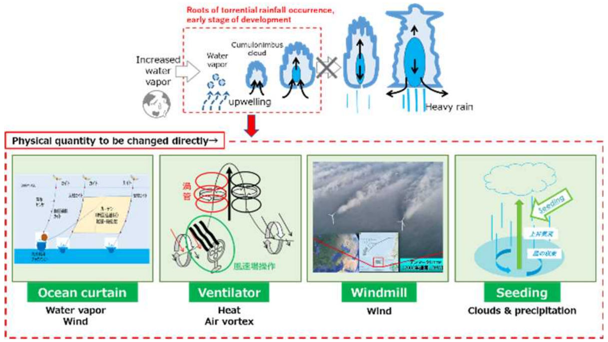

Figure 1. Heavy rain development stages and manipulation aims

2. Outcome so far

①Effects of exhaust heat in cities on atmospheric instability

Exhaust heat from buildings is a cause of the heat island effect in cities, which affects rain patterns due to thermally unstable atmospheric conditions in cities that experience warming because of the heat island. The effects of turbulence generated by exhaust heat in cities and the density and height of buildings on heat transfer were examined. Studies have shown that exhaust heat from buildings and the ground near Osaka Station caused intense turbulence downwind of buildings.

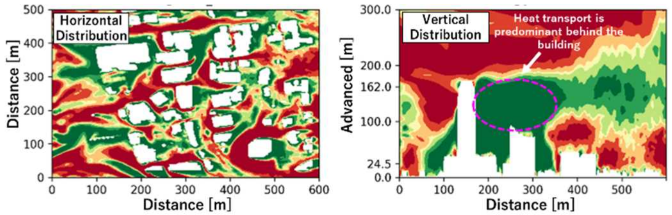

Figure 2. Heat transfer around Osaka Station.
Green colors indicate areas where heat is transferred to the atmosphere.

②Effect on the strength of sudden heavy rains and its reduction by changing wind field

To suppress eddy currents, which are a cause of sudden heavy rains, simulations were created to assess whether weakening the wind near the ground would change heavy rains. A simulation based on the sudden heavy rains in Togagawa, Kobe City, in FY2008, showed that weakening the wind near the ground weakened the rain by 27%. This was because the upward current caused by the air vortex decreased, reducing the convergence of the wind with abundant water vapor that was blowing into the center of the upward current.

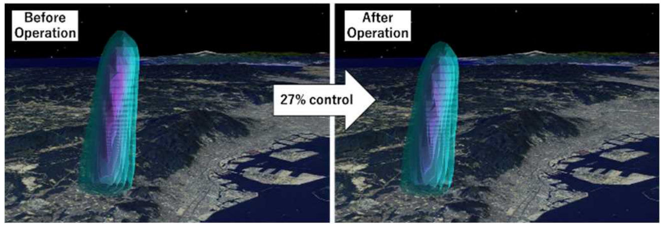

Figure 3. Three-dimensional distribution of heavy rain. Suppressive effect of wind field manipulation.

③Suppressing linear convective heavy rains by spraying dry ice

We focused on controlling cloud formation by scattering dry ice on clouds. The suppression of linear convective heavy rains was simulated by hypothetically increasing the formation of ice nuclei by scattering dry ice. Simulations based on the July 2020 heavy rains showed that by using this technique, the 24-hour maximum cumulative rainfall could be suppressed by 15%.

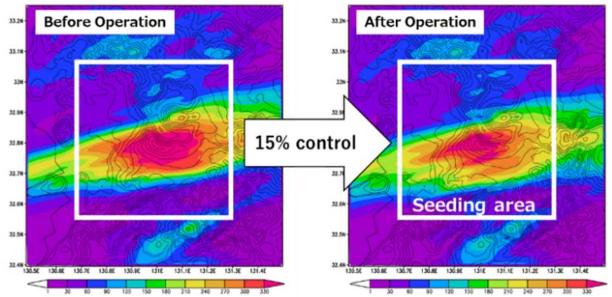

Figure 4. Accumulated precipitation. Suppressive effect of seeding.

3. Future plans

Our goal is to not only continue to further develop numerical weather models to control sudden heavy rains and linear convective heavy rains, but also to suppress the development of heavy rains with small-scale interventions.