Priority Subjects — **Establishment of Optimal Risk Management**

Development of a Prediction Method for Meteorological and Climatic Impact on Power Facilities

Background and Objective

Recently, natural disasters such as floods, heavy snowfall, strong wind and gusts have occurred frequently due to sever typhoons and bomb cyclones. It is necessary to secure the safety and reliability of the electric power distribution facilities, hydraulic power plants, and harbor facilities which have been exposed to natural external forces. The first purpose of this study is to improve the accuracy of the numerical weather prediction model for assisting the maintenance and operation of electric power facilities. The second purpose is to develop and improve the regional climate model in order to predict the climate change on the Japanese region in 20 to 30 years, and to make an impact assessment of the design wind speed or precipitation for electric power facilities.

Main results

1 Development of a short-term rainfall forecasting method using a meteorological radar

Our software for analyzing radar data is updated to handle data obtained from a variety of organizations including MLIT, JMA, and electric power companies. A method is also developed to assimilate radar data into our numerical weather forecasting and analysis system (NuWFAS). We investigated its usefulness to use together with a traditional nowcasting technique that is based on extrapolation of radar data with a high performance regarding 1-hour rainfall forecasting. Consequently, this hybrid method can work well for 3-hour heavy rainfall forecasting.

2 Windstorm simulation using the CRIEPI weather forecasting and analysis system

Windstorm simulations to evaluate turbulence characteristics, especially gust wind, provide important information for the wind-resistance design of electric power distribution facilities, such as transmission lines and towers. To simulate the turbulence characteristics of a windstorm, the CRIEPI weather forecasting and analysis system, NuWFAS, has been developed by adopting a large-eddy simulation (LES) technique for the turbulence model, which allows for very high-resolution simulation with a horizontal grid spacing of 50m (the value in the existing simulations are generally 2-5km). The performance of the model was verified through windstorm simulations for an event due to the passing of a bomb cyclone; simulation has a capability to represent the wind turbulence parameters (Fig. 1), such as gust factor, of a low pressure windstorm and a typhoon.

3 Weather pattern analysis of heavy rainfall in Japan's rainy season using a neural network

In addition to the rainfall forecast for the next several days, long-term change in the characteristics of local precipitation is important for disaster prevention and preservation of hydraulic power plants. To evaluate change, a classification technique which extracts spatial patterns of anomalous weather patterns in relation to heavy rainfall events during Japan's rainy season have been developed by using a neural network algorithm, so-called "Self-Organizing Map". This method picked up six weather patterns in relation to extreme high-precipitation events around western Japan (Fig. 2) from atmospheric variables and local precipitation of the past 31 years (1979-2009). The analysis enables us to easily understand the recent change in the frequency of precipitation-related weather patterns in eight hydrological-separated regions (Fig. 2b, 2c)(V12017).

4 Estimation of impact on precipitation over drainage basins in future climate

To evaluate the change in extreme meteorological events with global warming, a statistical downscaling method has been developed which enables estimations of climates of regional scale (several km) from the coarse (100-200km) data of a global climate model. The downscaling method was applied to estimate the precipitation over 20 basins with areas of 20 km^2 to 2300 km^2 in the Kyushu region of Japan, to compare current and future precipitation, when a global mean temperature increase by 1.1 K. The result indicates that heavy precipitations with 50-year return periods increase in all drainage basins, and the average of the increase ratio is estimated to be 20% (Fig. 3) (V12016). Such a projection of change in precipitation over drainage basins is required for estimation of the damage caused by heavy precipitation/flood with global warming.

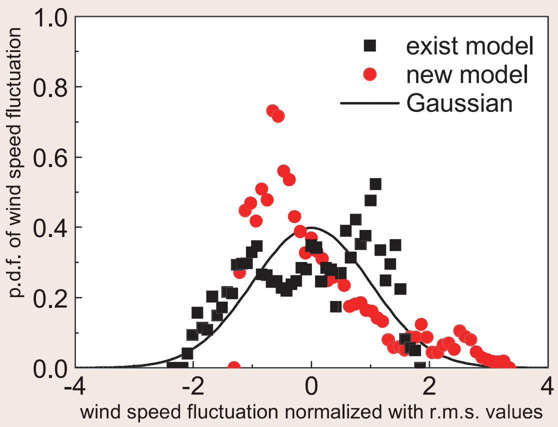


Fig. 1: Verification of turbulence simulations for windstorms with a passing bomb cyclone

The bomb cyclone, which passes through the Sea of Japan during the beginning of April 2012, yielded windstorms all over Japan; with maximum wind speeds recorded at the 75 meteorological cites. The windstorm in the Tohoku region was simulated with the existing and newly developed NuWFAS. The horizontal grid spacing was made finer with 6-nested computational domains, which achieves very high resolution grids with a spacing of 50 m. Fig. 1 shows a comparison of turbulence simulations results between existing and newly developed models. This figure depicts the probability density functions (PDF) of wind speed fluctuations normalized with r.m.s. values, σ, corresponding to the gust factor. The newly developed model with LES appropriately represents the occurrence of high-speed wind. The wind speed exceeding 2σ reasonably agrees with observations, whereas the PDF with the existing model tends to be negatively skewed.

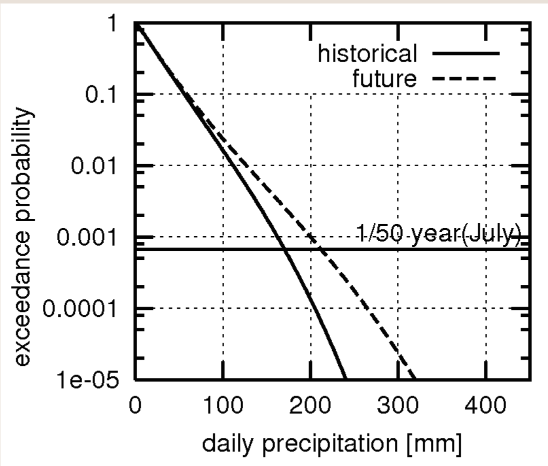
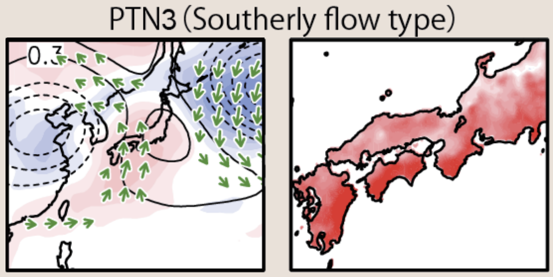


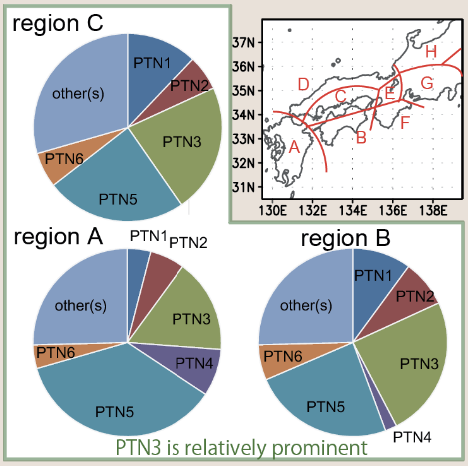
Fig. 3: Change in precipitation over a drainage basin with global warming

The proposed statistical downscaling model is applied to estimate climatological probability density function (PDF) of precipitation over drainage basins in the Kyushu region of Japan from the data of global warming projection by a climate model with 120-km resolution. The solid and broken lines indicate the probability of exceedance calculated from PDF under historical and future climates respectively (increase in the global annual mean temperature of 1.1K).
It is shown that such an increase in temperature will cause an increase in the probability of heavy precipitation in July over the drainage basin with an area of 491km^2. For 20 basins, the average increase ratio in precipitations with 50-year return periods is estimated at 20%.

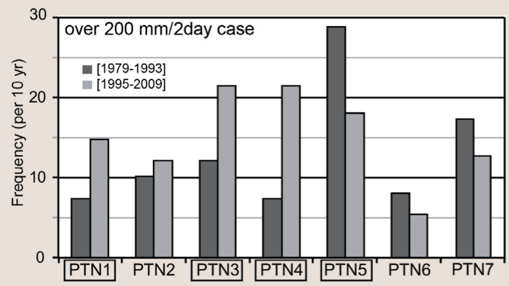


(a) One example (PTN3) of the weather patterns in relation to the extreme high-precipitation

The patterns are the differences from the climatological state of average years. (Left) Color shade exhibits 850-hPa equivalent- potential temperature, with the red shade implying relatively unstable atmospheric condition. Green vectors exhibiting 850-hPa wind are strong around the southern coast of Japan. The black line shows 200-hPa geopotential height. (Right) Color shade exhibits local precipitation pattern, with the red color implying relatively high-precipitation.



(b) Rate of the precipitation pattern frequency of the top 50 rainfall events in the region A-C.



(c) Long-term change in the frequency of precipitation-related weather patterns.

Fig. 2: Regional characteristics of the weather patterns and long-term change

We simultaneously analyzed five atmospheric variables (equivalent-potential temperature, zonal and meridional wind, geopotential height and local precipitation of western Japan) of the past 31 years (1979-2009), and picked up six weather patterns (PTN1-6) in relation to the extreme high-precipitation events (Fig. 2a). Rate of the precipitation pattern frequency in the eight regions enables us to easily understand the difference in the regional dependence between each weather pattern and heavy rainfall (Fig. 2b). Comparison of the pattern frequency between the first and second half of the past 31 years exhibits the increase in the frequency of weather patterns which relate to the heavy precipitation around Kyushu and Shikoku (Fig. 2c). Boxes in the horizontal axis exhibit statistically significant change in the patterns.