Project Research — **Establishment of Optimal Risk Management**

Severe Storm Prediction and the Impact Assessment of Electric Power Facilities under Global Warming

Background and Objective

The influence of global warming might be gradually actualized in 20 to 30 years in the future, and there is a possibility that this will affect power industries in Japan. 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, such as delivery equipment and water power dams. The second purpose is to develop and improve the regional climate model in order to predict climate change in the Japanese region, and to make an impact assessment of electric power equipment under global warming.

Main results

1 Development of a Regional Climate Model to Predict Climate Change over the Japanese region

The numerical weather forecasting and analysis system (NuWFAS) developed by CRIEPI has been improved for application to regional climate prediction with a horizontal resolution of 5 km. The main improvements involve the setting and calculation methods of sea ice, sea surface temperature, soil temperature, soil moisture, snow depth, and lake surface temperature (Fig. 1) (N11009).

Using the improved model, we conducted 52 year-long weather reproduction from 1957 to 2008 and produced a meteorological dataset over the Japanese region with the horizontal resolution of 5 km and the temporal resolution of 1 hour. Extreme value analysis is applied to the wind speeds dataset, and we can evaluate 10 minutes of mean wind speed with a 50–300-year return period (Fig. 2). The estimated wind speed map for the entire Japanese region with a resolution of 5 km will be useful for the wind-resistant design of electric power delivery equipment and for the estimation of past cumulative fatigue damage. The regional climate model developed in this study is applicable to climate simulation over the Japanese region with a specific climate change scenario.

2 Development of a Climate Model to Predict Typhoon Activity under Global Warming

To simulate and evaluate typhoon activity in the future climate, a regional model was configured as a tropical channel model, which has a north and south boundary at the latitude of 60N and 60S, with a cyclic boundary in the east-west direction. This model configuration is applied to the period of 2003–2005, and the simulated results are compared with the observation of typhoons. The position of typhoon genesis and the tracks of typhoon movements are simulated very well, although the annual number of typhoons reproduced by the model is overestimated compared with the observation (Fig. 3).

3 Improvement of Meteorological and Ocean Models

Field measurements are carried out in order to estimate the momentum transfer from the airflow into the ocean, which is very important for the development of ocean waves and cyclones. Momentum fluxes estimated from the measured data are compared with those predicted by several bulk flux formulae in previous studies. The results show that the scaling with a saturation ratio of wind waves is preferred over other scalings (Fig. 4) (N11055). By using this formula, it is expected that the accuracy of ocean wave and sea wind speed forecasts by ocean and meteorological models will be improved.

4 Improvement of Short-range Precipitation Forecasts with Weather Radar

We developed a data processing system for X-band dual-polarized weather radar and improved the performance of the radar rainfall estimation method, especially in the case of heavy rainfall. We also developed a data assimilation method that brings the estimated radar rainfall into the numerical weather forecasting model. It is confirmed such that the developed method improves the short-range precipitation forecast.

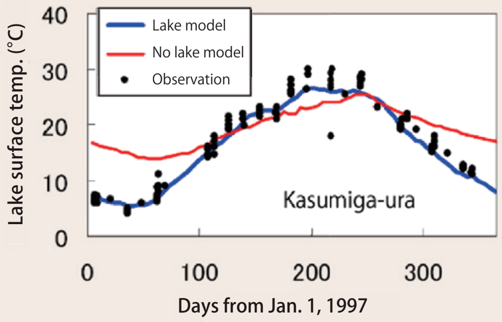
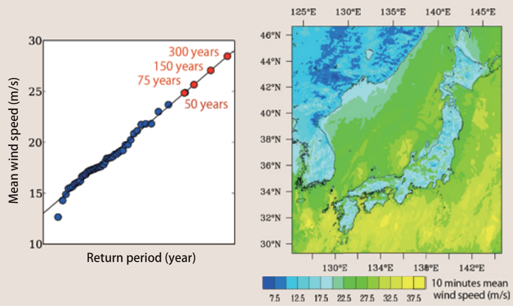


Fig. 1: Comparison between the observation and estimation of lake surface temperature

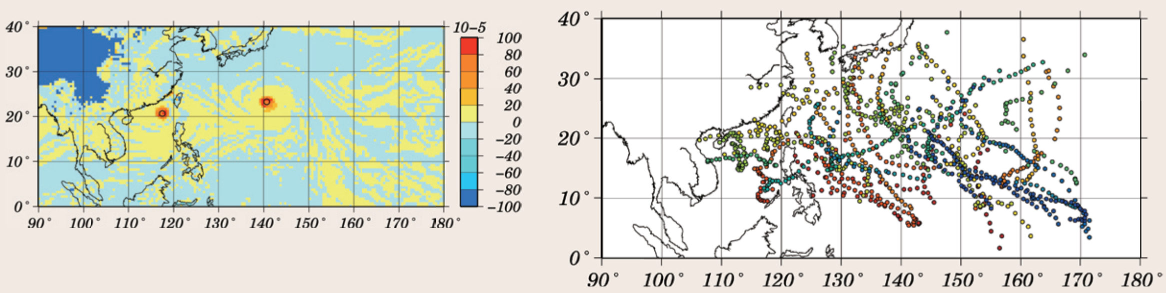
The lake surface temperature model developed in this study (blue line) shows good agreements with the observation (●), compared to the previous method (red line), which uses the sea surface temperature near the lake or at the same latitude. The lake model improves the air temperature information over the lake and near the lake.



(a) Extreme value statistics (b) 50-years return period

Fig. 2: Extreme values of mean wind speeds based on the 52 year-long dataset

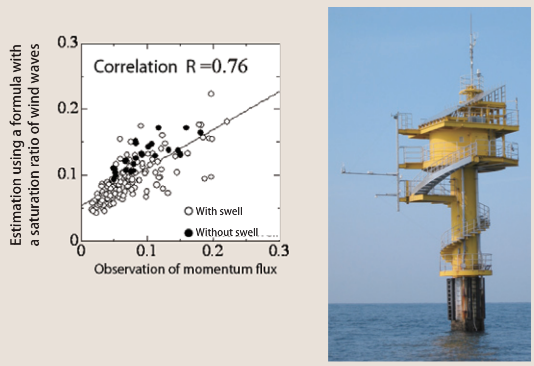
Using the 10-minutes mean wind speed dataset of a 52 year-long simulation with the temporal resolution of one hour, an extreme value statistical analysis is applied. The data samples at a grid point (● in Fig. [a]) are linear in the Gumbel probability paper, which shows that we can estimate the longer return period of wind speed properly. Fig. (b) represents a 50-year return period of wind speeds.



(a) Example of typhoon genesis in the model (b) Typhoon tracks simulated for 2004

Fig. 3: Typhoon simulation with the tropical channel model

The tropical channel model is free to generate its own weather, climate, and typhoons. Fig. (a), which is a relative vortex (1/s), represents an example of simulated typhoons in a model. Fig. (b) is typhoon track simulated for 2004. By using sea surface temperature under climate change, the model can predict typhoon activity in the future climate.



(a) Momentum flux comparison (b) Tower

Fig. 4: Observation of air-sea momentum transfer

Field measurements (Fig. [b]) of the air/sea temperature, wind speed, ocean waves are carried out to evaluate the momentum flux transfer between the atmosphere and the ocean.

The observed flux agrees well with the bulk flux formula with a saturation ratio of wind waves.