Impact of orographically-induced winds to the offshore wind resource around northern Japan

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Wind resource assessments have shown high potential for wind energy in northern Japan. In regions where large wind resources are estimated, previous studies suggest that orographically-induced winds often occur. However, more observational studies are necessary to obtain detailed pictures of the orographically-induced winds and understanding of generation mechanism is required. With an increase in development of offshore wind energy and installation of offshore wind power plants, meteorological studies are increasingly required to estimate offshore wind resource, to understand the variation in the wind energy, and to predict the wind power output. Therefore, this study presents the orographically-induced winds around northern Japan and their occurrence mechanisms, and discusses contribution of the orographically-induced winds to regional wind resource.

Keywords: offshore wind, wind energy, northern Japan, satellite observation

Estimation of photovoltaics power generation in consideration of both its installed capacity and satellite-estimated solar irradiance

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Recently, in Japan, large photovoltaics (PV) power systems have been penetrated after feed-in-tariff (FIT) in 2012. PV power generations have large variability in both temporal and spatial scales beacause PV power depended on solar irradiance (or downward shortwave radiation). Solar irradiance has also impact from both clouds and aerosols distributions.

PV power generation from roof-top PV power system on residences, industrial manufactures and small-, mediam- and large-scale solar plants have not directly been monitored even by electrical power companies in Japan because monitorying instruments have not been installed even in distributing substations and residences. This is a problematic situation for safty control of electric power grid, because accurate PV power generation from PV power system under various weather conditions were not grasped. Accurate monitoring of PV power generation could be important data for a safety electric power control of power grid in energy management system.

Thus, PV power generation estimation using satellite-estimated solar irradiance data in consideration of PV syetem capacity for city-wide scale are conducted in Japan in this study for the first time. Furthermore, installed PV power system capacity for each area and future status of PV power will be also discussed.

Keywords: photovoltaics power generation, Meteorological satellite, PV power estimation

Evaluation of Cloud locations with Stereo Observations for predicting solar PV temporal variation

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Photovoltaic (PV) power generation is one of important renewable energy, and it has been getting more poplar and numbers of both mega-solar PV and small scale solar PV systems have been rapidly increasing these days. While the solar PV is a common renewable energy source, it is difficult to predict temporal variation of power generation accurately depending on weather conditions. Especially it has been reported that passing of patchy clouds makes the prediction more difficult (Itagaki et al., 2011, 2012). The difficulty is from both weather forecast and observation issues. Because the grid interval of current weather forecasting is the order of 1 km, it has not been able to resolve sub-km scale cloud distributions which can affect variation of local solar PV power generation. The typical spatial resolution of geostationary satellites, such as Himawari-8, is 500m - 1km size, which is also not enough to resolve the small-scale cloud structures.
To have better spatial resolution for cloud observation, we have planned to develop a cloud monitoring system constructed with multi (more than three) wide field of view (FOV) cameras, the interval of each camera is a few hundred meters. The interval allow us to measure cloud locations with a stereo estimation method for the clouds from several km to ten km altitudes. In addition, current wide FOV cameras allow to resolve cloud position with a smaller resolution than 100m.
In this study, to demonstrate the stereo measurement can work for clouds at the first step, we set two cameras with ~400m interval and took images which satisfied stereo condition for several to ten km altitude clouds. The camera orientation and the amount of tilting were measured with star position measurement in the camera images, which is a common technique for determining a satellite attitude in space with less than 0.1 degree accuracy, and it takes no additional cost. From the stereo measurement, we have successfully resolved cloud positions whose altitudes were from 1,300m –2,500m, and also we have resolved cloud motions from sequential observation images. In this presentation, we will introduce our approach for measuring three dimensional cloud positions and its results, and we will discuss predicting temporal variation of solar PV power generation with the cloud positions and the cloud motions.

Keywords: Solar photovoltaic power generation, Stereo measurement, Clouds

Detection of forecast busts of regional surface solar radiation using ensemble spread with multi numerical weather prediction centers

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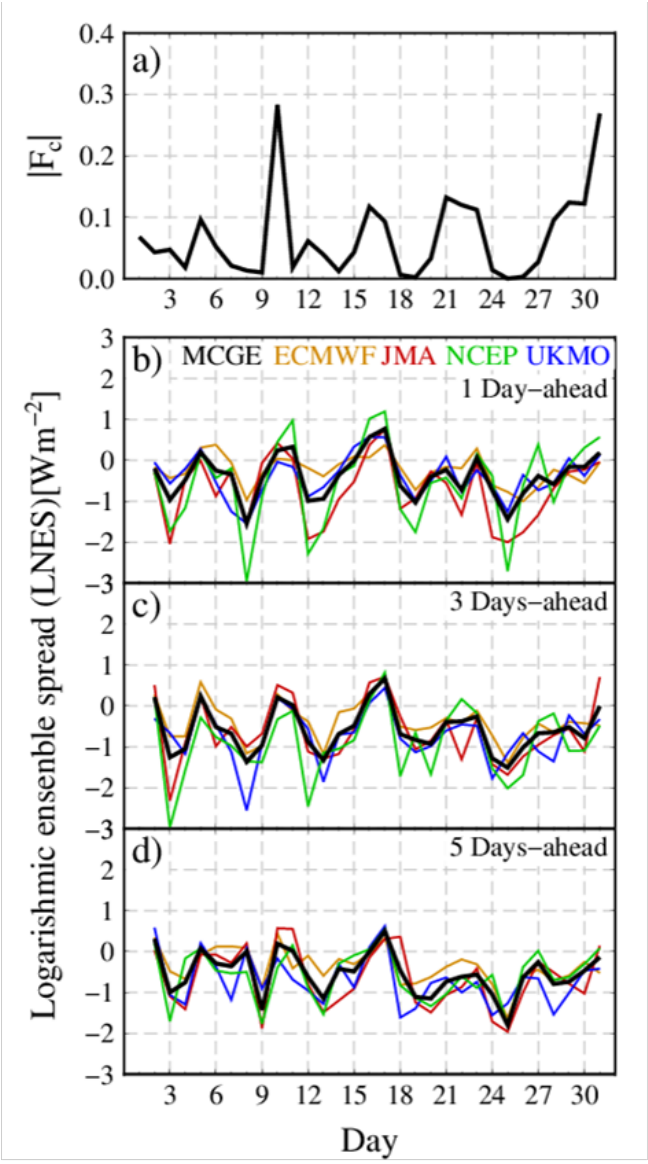
Energy management using weather forecast of numerical weather prediction (NWP) center is exposed to blackout risks and production of excessive surplus power owing to the large forecast errors (forecast busts) of NWP models. The detection of forecast busts is important for stable electricity provisions. Dispersion of ensemble forecast (ensemble spread: ES) relate to forecast skill. Multi-center grand ensemble (MCGE) has higher forecast skill than single-NWP center ensemble forecast. It is considered that the ES and ES of MCGE (ES_g) can be used as the predictor of the forecast busts. We investigate the detectability of forecast busts on operational regional forecast predicted by Japan Meteorological Agency (JMA-MSM) using lognormal ES (LNES) and ES of MCGE ($LNES_g$) in Kanto Plain, Japan. One- to six-day ahead global forecast at four leading NWP centers (European Centre for Medium-Range Weather Forecasts: ECMWF, Japan Meteorological Agency: JMA, National Centers for Environmental Prediction: NCEP, and Met Office, UKMO) were used to detect of daily surface solar radiation of regional forecast in 2015.

Root mean square error for the ensemble mean of MCGE (EM_g) and 5km regional forecast of JMA-MSM are 27.6 and 28.6 Wm^{-2} for the one-day ahead forecast, respectively. The forecast skill of the EM_g was found to be comparable with that of the JMA-MSM. In October 2015, the correlation between the absolute value of forecast error coefficient (|Fc|) on the operational regional forecast and $LNES_g$ for the one-, three-, and five-day ahead forecasts are 0.68, 0.63, and 0.45, respectively (see Figure). The correlation for one- and six-day ahead forecast was found to have statistical significance at ten and seven months, respectively. The $LNES_g$ can be, therefore, a valuable predictor for detection of forecast busts in the regional forecast.

Keywords: Ensemble forecast, Forecast busts, TIGGE, Surface solar radiation



Figure, Time series of Fc in JMA-MSM and ensemble spread in October 2015. (a) |Fc| in JMA-MSM one day-ahead forecast, and (b, c, d) LNES and $LNES_g$. in one (b), three (c), and five (d) day-ahead forecast. Colored thin lines indicate the LNES each NWP centers as shown in the legend. Thick line indicates $LNES_g$ in MCGE.

Probabilistic Weather Prediction for Power Demand/Supply Operation Management under the High Penetration of Renewable Energy Power

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Renewable energy power, such as from photovoltaics and wind, is volatile partly because of natural variability in weather conditions. Electric power companies have to manage the balance between supply and demand. Management of the volatility of renewable energy power is a key factor in minimizing the cost of integrating renewable energy power into electric grid systems while maintaining the required high level of reliability. For this purpose, probabilistic weather prediction for renewable energy power is one of the most cost-effective and easily implemented tools available to system operators.
In this study, we developed a regional ensemble prediction method using the Weather Research and Forecasting (WRF) model to a predict probabilistic weather. To obtain dynamically consistent perturbations with a synoptic weather pattern, both initial and lateral boundary perturbations were determined via differences between the control and an ensemble member of the Japan Meteorological Agency (JMA)'s operational one-week ensemble forecast. This method provides multiple ensemble members for Japan area with a horizontal resolution of 15 km for 75 hours at 30-minute interval outputs by downscaling the JMA's operational global forecast along with the perturbations. The predictions were able to represent various features of the high-resolution spatiotemporal distribution of precipitation affected by the intensity and location of extratropical cyclones in each ensemble member. Although the ensemble prediction method showed model bias in the mean values and variances for certain variables such as irradiance or wind speed, it has the potential to provide probabilistic information regarding the uncertainty of weather prediction.

Keywords: Renewable energy, probabilistic prediction, ensemble

