

Atmospheric data assimilation which accommodates weather descriptions as observations of solar radiation: Evaluation of performance with a modern one-year case

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To acquire information about climate before the beginning of instrumental observations, we can use documentary records written by people in addition to natural objects such as tree rings. In particular, many diaries that contains descriptions of daily weather are available in Japan. On the other hand, data assimilation systems have so developed that they can incorporate such observed quantities that are not prognostic variables of the forecast model. Thus, we expect that we can know space-time distribution of meteorological elements of the times without instrumental observations by taking weather descriptions as input to atmospheric data assimilation systems.

In this study, we apply the method to a time period with instrumental observations, and examine how weather phenomena in the real world can be reproduced.

As the atmospheric model, the NCEP GSM (Global Spectral Model) of the version used for seasonal weather forecasts till 2004 is used. The spatial resolution is T62 (grid spacing ca. 250 km) and 28 layers. As for the assimilation scheme, LETKF (local ensemble transform Kalman filter) of Miyoshi (2011, Monthly Weather Review) is used. The sea surface temperature given as a boundary condition is based on monthly mean NOAA OISST, interpolated to daily time steps.

As present-day data which mimic weather descriptions in diaries, the general weather conditions ("tenki gaikyo") of Japan Meteorological Agency is used. 18 stations are chosen so that each station corresponds to one grid box of the GSM. We classify the daytime general weather condition of every day into three categories, "fine", "cloudy", and "rainy and snowy", and convert it into the daily amount of global solar radiation by the method of Ichino et al. (2001, "Tenki"; 2018, "Chigaku Zasshi"). Then we re-scale it into 6-hourly values and gave them to the assimilation system as observations of the downward shortwave radiative flux at the surface of the earth. In addition, we give zero as the observed amount of precipitation if and only if no rain or snow in daytime was documented in the general weather condition of the day. We call this the "weather assimilation experiment." As for comparison, we also conduct the "no-observation experiment" where no observations are given to the assimilation system.

The period of the experiments is one year of 1995, from 1 January to 31 December. The number of members of the ensemble of LETKF is 30.

Among the results of assimilation, we mainly look at the ensemble average analysis fields of sea level pressure, and additionally those of vorticity at 850 hPa and of precipitation. As for information on the real situation, we use JRA55 and surface weather charts.

When extra-tropical cyclones pass Japan in the actual situation, low pressure systems often appear in our "weather assimilation experiment" in positions similar to the real situation, over Japan as well as over oceans to the east of Japan. However, correspondence of their strengths are not always good. Since the position of troughs does not match the actual condition at all in our "no-observation experiment", we consider that assimilation of weather information is effective. Tropical storms are not well reproduced. We consider that this is partly because that the spatial resolution of our atmospheric model is insufficient, and partly because that the time span of overlapping between the course of a tropical storm and the spatial coverage of observations is short. The meteorological situations of the Baiu are not well reproduced, either. In terms of seasons, the performance of this technique seems good in spring and autumn.

Keywords: climate in historical times, data assimilation, weather records in diaries, extratropical cyclones