Ensemble forecast experiments of 'Yamase' that occurred on 31st July 2011

Hiromu Seko (Meteorological Research Institute), Yasumasa Kodama (Hirosaki University) and Toshitaka Tsuda (Kyoto University)

1. Introduction

'Yamase' is a cold northeasterly wind that produces cool weather in summer over northeastern Japan. The origin of the Yamase is the cool polar maritime air mass that develops over the North Pacific, including the Bering Sea and the Sea of Okhotsk. It usually accompanies a boundary layer cloud, the "Yamase cloud" (Kodama et al. 2009). 'Yamase' influences the agricultural crops when it continues for long time. It is needed to predict 'Yamase' accurately. In general, 'Yamase' was discussed as a climate problem. However, influences of Yamase can be mitigated by windbreak screens if accurate short range forecasts (1-2 days) are provided. In this study, ensemble forecasts of 'Yamase' were conducted by using the nested LETKF system. The comparisons with the observation data are shown in this report.

2. Outline of experiments

To reproduce the cold northwesterly flow and airflows over the eastern Japan, the nested LETKF system was adopted to the 'Yamase', which occurred from 30th to 31st July 2011. The nested system was composed of two NHM-LETKFs (Miyoshi and Aranami, 2006): Outer and Inner LETKFs. The horizontal grid intervals of Outer and Inner LETKF were 15 km and 1.875 km, respectively. In the Outer LETKF, the conventional data that was used in JMA data assimilation system was assimilated every hour. Although high resolution data, such as Doppler radar data, can be assimilated in the Inner LETKF, the conventional data was assimilated every 10 minutes in this study. Assimilations of the Outer and Inner LETKFs were performed from 09 JST 27th July and 09 JST 31st July, respectively.

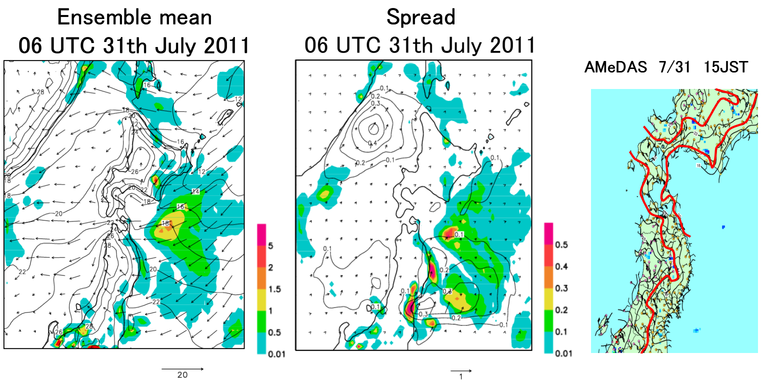

Fig. 1: (left and middle) Ensemble mean and spread at 15 JST 31st July 2011 obtained by Outer LETKF. (right) Temperature and surface wind observed by AMeDAS at 15 JST.

3. Results on ensemble forecasts of Yamase

Figure 1 shows the ensemble mean and spread of sea level temperature, horizontal wind at the height of 20 m and total cloud amount reproduced by the Inner LETKF. On the eastern side of the northern Japan, northeasterly wind was dominant and cold sea level temperature was reproduced. The expanded cloud regions on the eastern side of Japan were also reproduced. The contours of sea level temperature over the northern Japan was roughly similar to the observed ones, which were obtained by Automated Meteorological Data acquisition system (AMeDAS) of JMA, though the reproduced contours were smoother than the observed ones because of the smooth topography of numerical models.

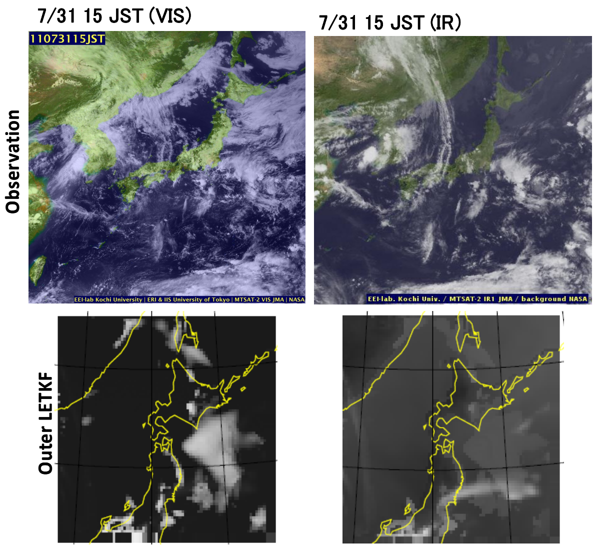

Fig. 2: (upper) Observed satellite images at 15 JST 31st July 2011. (lower) Cloud images produced from outputs of the Outer LETKF.

From the water substances of the Outer LETKF, the cloud images were produced. The cloud on the eastern side of the northern Japan was clearly seen in VIS images and obscure in IR images (Fig. 2). These cloud images indicate that this cloud region was composed of low-level stratiform clouds, which is known as the 'Yamase cloud'. There was the relatively fewer region of the cloud along the eastern side of the coastline (Fig. 3). This gap of cloud was reproduced in most of ensemble members.

The temperature and airflow distributions near the surface produced by the Inner LETKF were shown in Fig. 4. As mentioned in the explanation using the analyzed fields of the Outer LETKF, the contours of temperature and surface wind were similar to the observed ones, though the reproduced temperature was slightly colder. The clouds on the eastern side of the mountains and around the eastern coastal line were also consistent with the satellite images. Because these distributions reproduced by the Inner LETKF have small scale structures, the nested LETKF system has the potential to provide the information on temperature and wind speed of 'Yamase' in the inland area of the northern Japan.

The special observation was conducted at the Shimokita peninsula by the Kyoto University and the Hirosaki University (Kodama et al. 2011). In the special observation, sonde, wind profiler and lidar etc. were used to observe the vertical structure of 'Yamase'. When the structure reproduced by the Inner LETKF was compared with the observed ones, the boundary of northerly and southerly winds and the large gradient layers of θe were similar to the observed ones, though the wind speed of the lower layers was weaker.

The vertical structure of 'Yamase cloud' was shown in Fig. 5. 'Yamase cloud' existed at the heights from 1000 m to 1500 m on the eastern side of the northern Japan. The relative humidity below the height of 1500 m exceeded 90 % and temperature of cloud region was colder than the other areas. It is deduced that this cold regions were caused by radiation cooling. The intense northeasterly wind existed mainly below this cloud.

To improve the atmospheric profiles over the sea, the radio occultation data observed by COSMIC was assimilated in the Outer LETKF. Because the refractive index was function of temperature and humidity, the improvements of cloud distribution are expected. Figure 6 shows the distribution of tangent points observed by COSMIC. Even if all COSMIC data in Fig. 6 was assimilated, the improvement of cloud region was not significant (Fig. 3). It is one of reason why the improvement of the cloud regions was small that the positions of COMIS data were far from the cloud regions.

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Reference

Miyoshi, T. and K. Aranami, 2006: Applying a four-dimensional local ensemble transform Kalman filter (4D-LETKF) to the JMA nonhydrostatic model (NHM). SOLA, 2, 128-131.

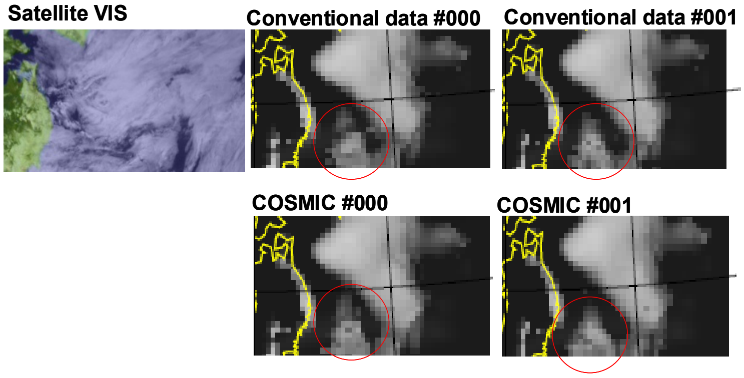

Fig. 3: (left) Observed satellite image (VIS) at 06 UTC. (right) Cloud images obtained from the analyzed fields that were obtained by assimilation of (upper) convectional data and (lower) conventional data and COSMIC data.

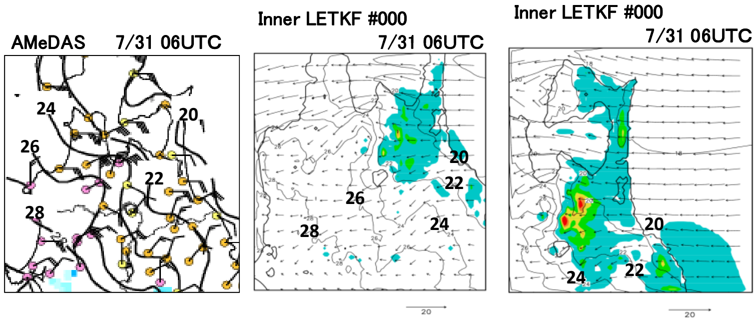

Fig. 4: (left) Temperature and horizontal wind at 15 JST (06 UTC) observed by AMeDAS. (center and right) Temperature and horizontal wind reproduced by the Inner LETKF.

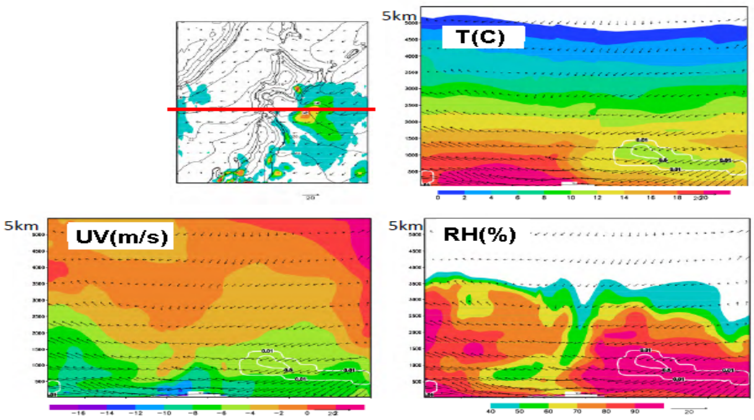

Fig. 5: Vertical cross sections of temperature, wind velocity and relative humidity along a red line.

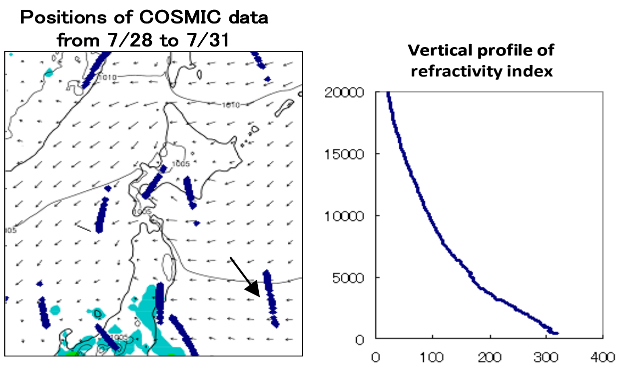

Fig. 6: (left) Positions of tangent points of COSMIC data from 28th to 31st July. (right) Vertical profile of refractivity index. Position of this profile data was indicated by a large arrow.