Ensemble downscaling prediction experiment of summertime cool weather in northeastern Japan caused by local wind “Yamase”

Shin Fukui, Weiming Sha, and Toshiki Iwasaki (Tohoku University)

1. Introduction

Yamase, a northeasterly from the Okhotsk high, brings cool and cloudy summer days at the Pacific coast of northeastern Japan (Fig. 1). The anomalous low temperature and sunlight deficiency cause serious damage on the crops harvest. Yamase exhibits small-scale localized features because its shallow structure can be heavily affected by complex terrain. It calls for high resolution modeling in the medium-range forecast.

This study is to evaluate the performance of medium-range ensemble downscaling prediction of Yamase events. We aim to improve the forecast accuracy of dynamical downscaling, using global ensemble forecasting data as lateral boundary conditions.

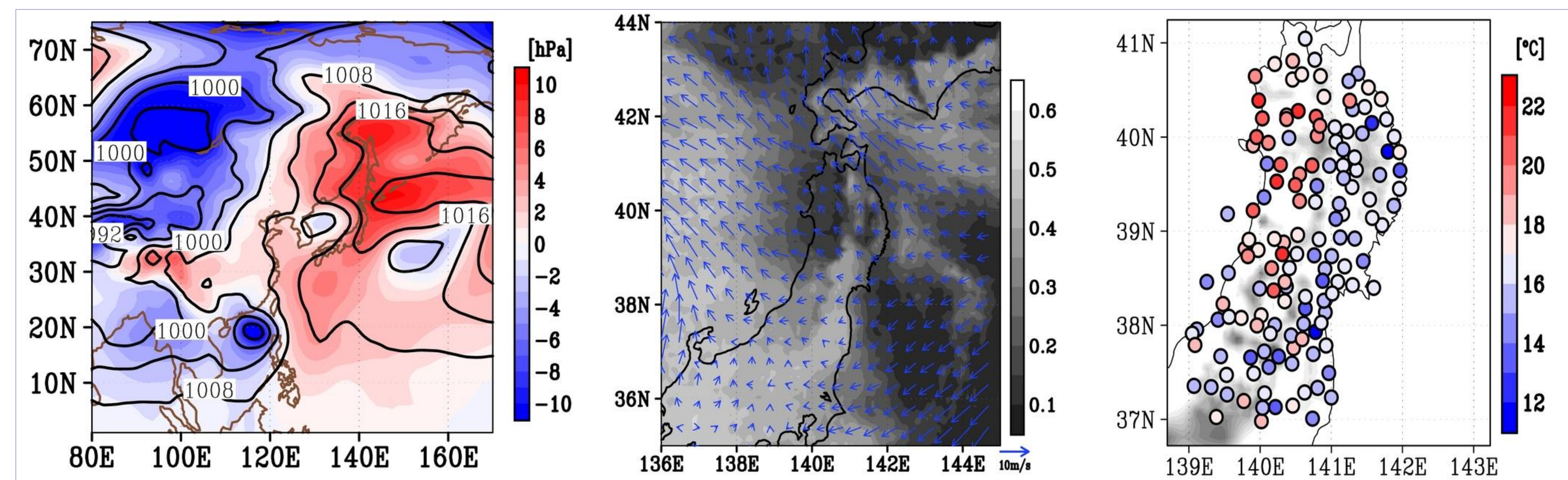

Fig. 1 A typical Yamase day (23 July 2003). The left shows sea level pressure (contours) and its anomaly (shade) from JRA-25. The middle shows albedo (shade) observed with GOES-9 and surface wind from the meso analysis data by JMA (arrows). The right shows daily mean of surface temperature observed at AMeDAS.

2. Ensemble downscaling prediction system

2.1 Downscaling model

From nine members of global ensemble forecast, we implemented the dynamical downscaling using the Japan Meteorological Agency’s nonhydrostatic model (NHM ; Saito et al. 2007). The 1-month ensemble hindcast data (resolution of ~125km) are used to make downscaling at higher resolution of 25km and 5km. Eight cases of downscaling are chosen; each has a forecast time of 14days. The initial time was set to 20 June, 30 June, 10 July and 20 July in 2003 and 2004. Fig. 2 shows the domain, and Table 1 gives detailed settings.

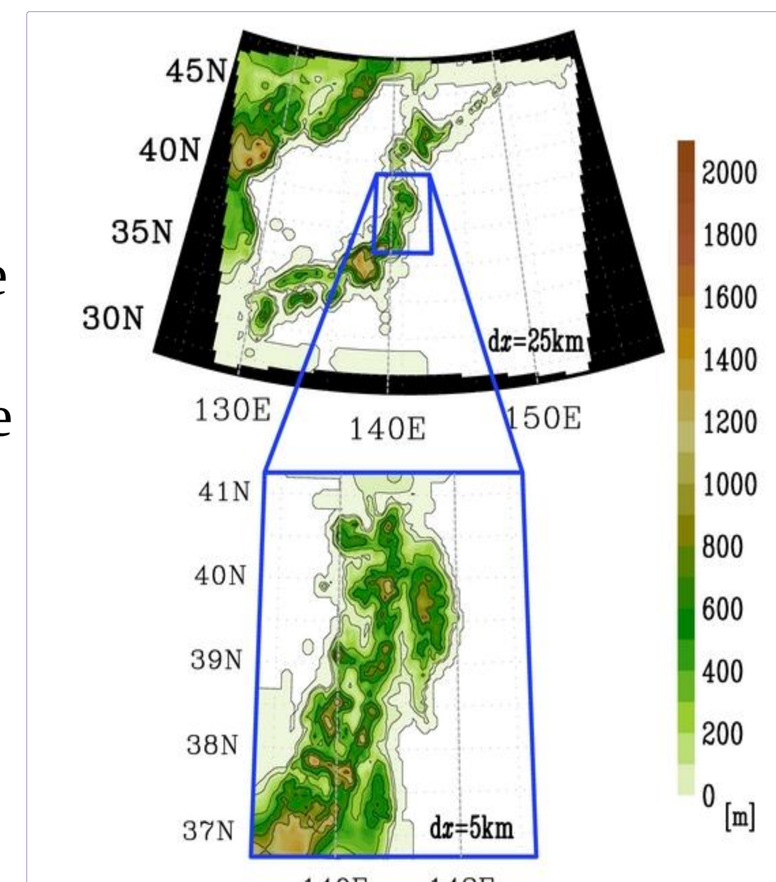

Fig. 2 The domain for the experiments. Shade indicates elevation in the model [m].

Table 1 Specifications

Model	NHM (Saito et al. 2007)	
Horizontal mesh	25km (100×80)	5km (80×100)
Initial & Lateral boundary conditions	1-month ensemble hindcast (dx = 1.25°)	result of downscaling (dx = 25km)
Number of members	9	
Vertical coordinate	generalized hybrid coordinate 50 levels (20 - 840m)	
SST	NGSST (dx=0.05°; Guan and Kawamura, 2004)	
Land surface	MRI/JMA Simple Biosphere (MJ-SiB)	
Convection	Kain-Fritsch scheme	
Turbulence	Improved Mellor-Yamada Level3 (Nakanishi and Niino, 2004, 2006)	

2.2 Bias correction

To estimate the downscaling bias, we carried out the perfect boundary downscaling using Japanese reanalysis data (JRA-25; resolution of ~ 125km) as initial and boundary conditions. The results were averaged from 20 June to 31 August in 2003 and 2004, consider as the climatic data. They were interpolated to the surface observation sites, the Automated Meteorological Data Acquisition System (AMeDAS). The downscaling bias is defined as the temperature difference between forecast and observation at each site. The surface temperature at 25km (5km) downscaling exhibits a warm bias of 1.9K (1.3K), as shown in Fig.3. We corrected the downscaling forecast by subtracting these bias at each site.

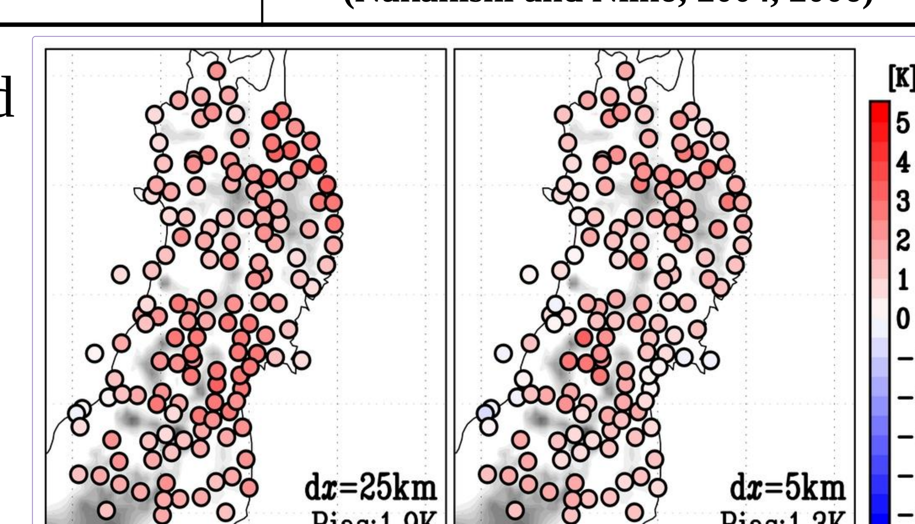

Fig. 3 The bias of surface temperature after downscaling. The left shows that for DS_25km. The right shows that for DS_5km.

2.3 Filtering based on EOF

To extract reliable signals, we propose a filtering based on EOF. The relationship between product of EOF eigenvector and observation/forecast is estimated. (The EOF eigenvector is obtained by EOF analysis for the observation at AMeDAS.)

3. Results

Fig. 4 and Fig. 5 show that the 1st EOF mode of surface temperature represents an overall warming or cooling, while the 2nd mode displays a west-east difference pattern. The correlation coefficient between the EOF component of downscaling forecast and that of observation illustrates what extent the spatial patterns of the mode are captured, while the regression coefficient highlights how large their amplitudes of the mode are forecasted. It seems clear in Figs 4-5 that the downscaling forecast at higher resolution of 5km give a better reproduction of the distribution pattern and amplitude of the EOF modes.

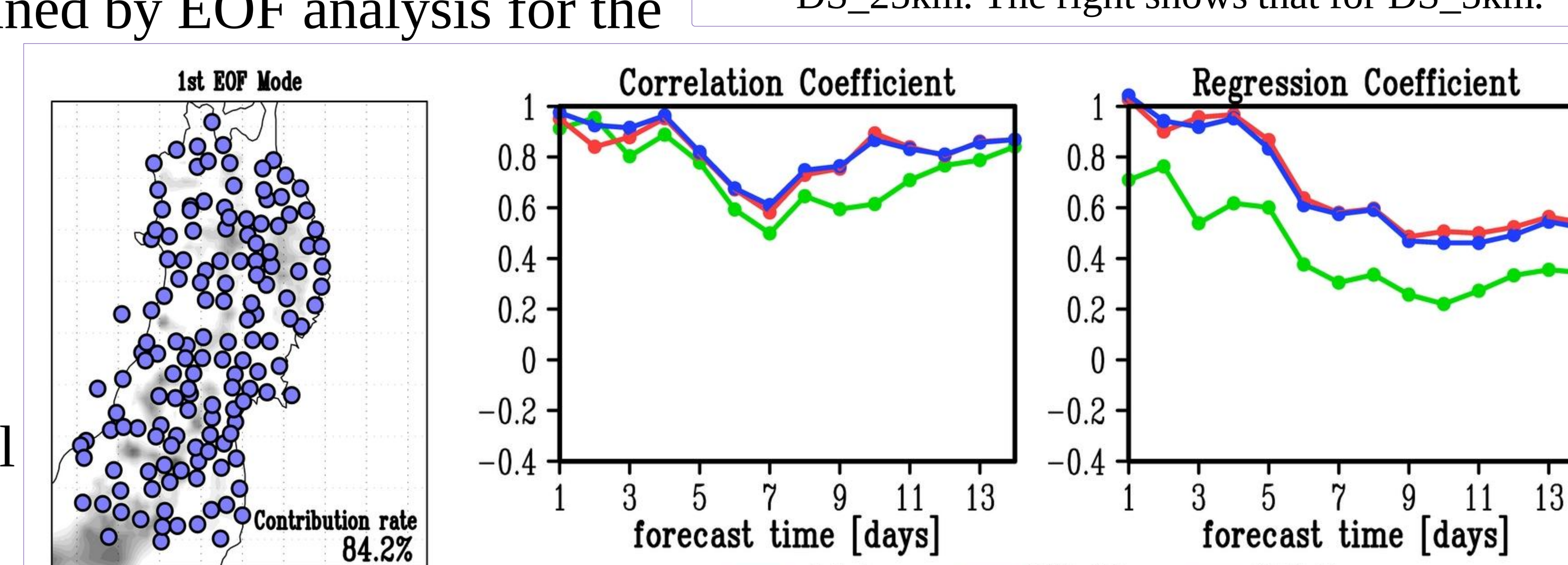

Fig. 4 The relationship 1st EOF mode component of the temperature anomaly of observation and that of the ensemble downscaling result.

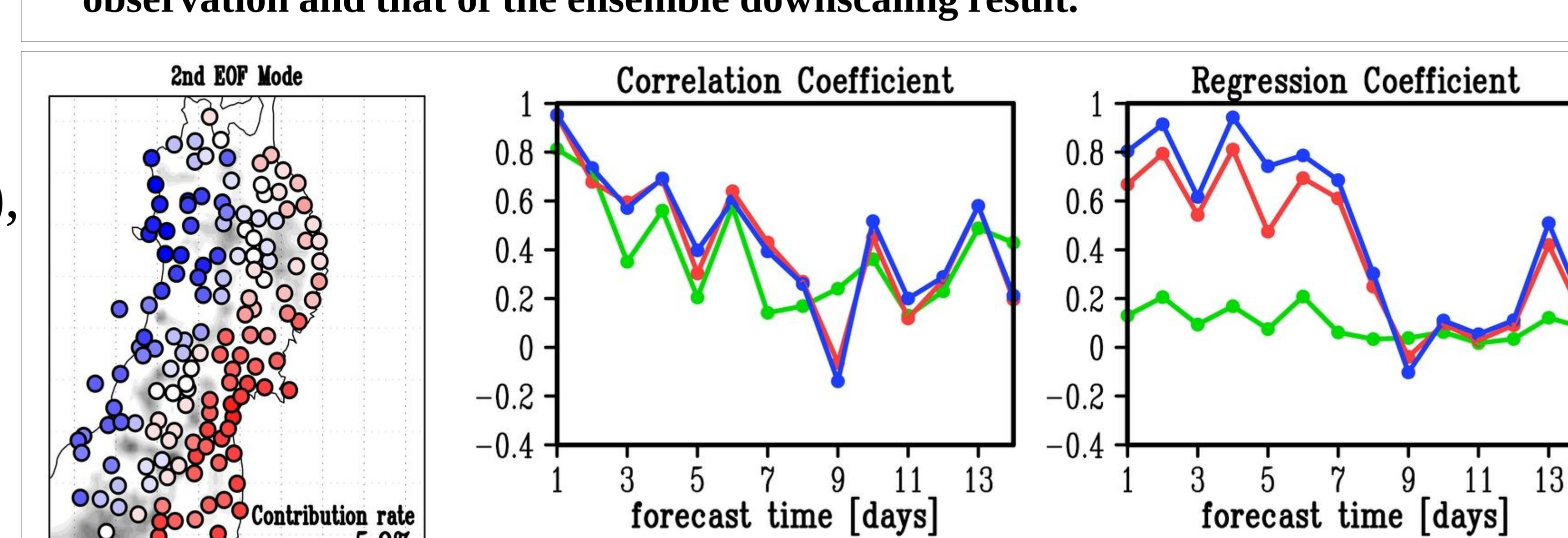

Fig. 5. As in Fig.4 but for 2nd EOF mode

Figure 6 shows that the ensemble mean of downscaling forecast (middle column of Fig 6), compared with no-perturbed control run (left column of Fig 6), appears to reduce the RMSE of temperature distribution especially in the localized anomaly. The downscaling forecast at higher resolution gives a larger spread as shown in the right column of Fig 6. This indicates that the locality can be better captured using ensemble downscaling forecast.

Fig. 7 shows that spread of the low-level cloud amount on a typical Yamase day appears at the east part. Through downscaling, it can be specified to the east slope of central mountain range. The relationship between low-level cloud and surface temperature needs to be clarified in the future work.

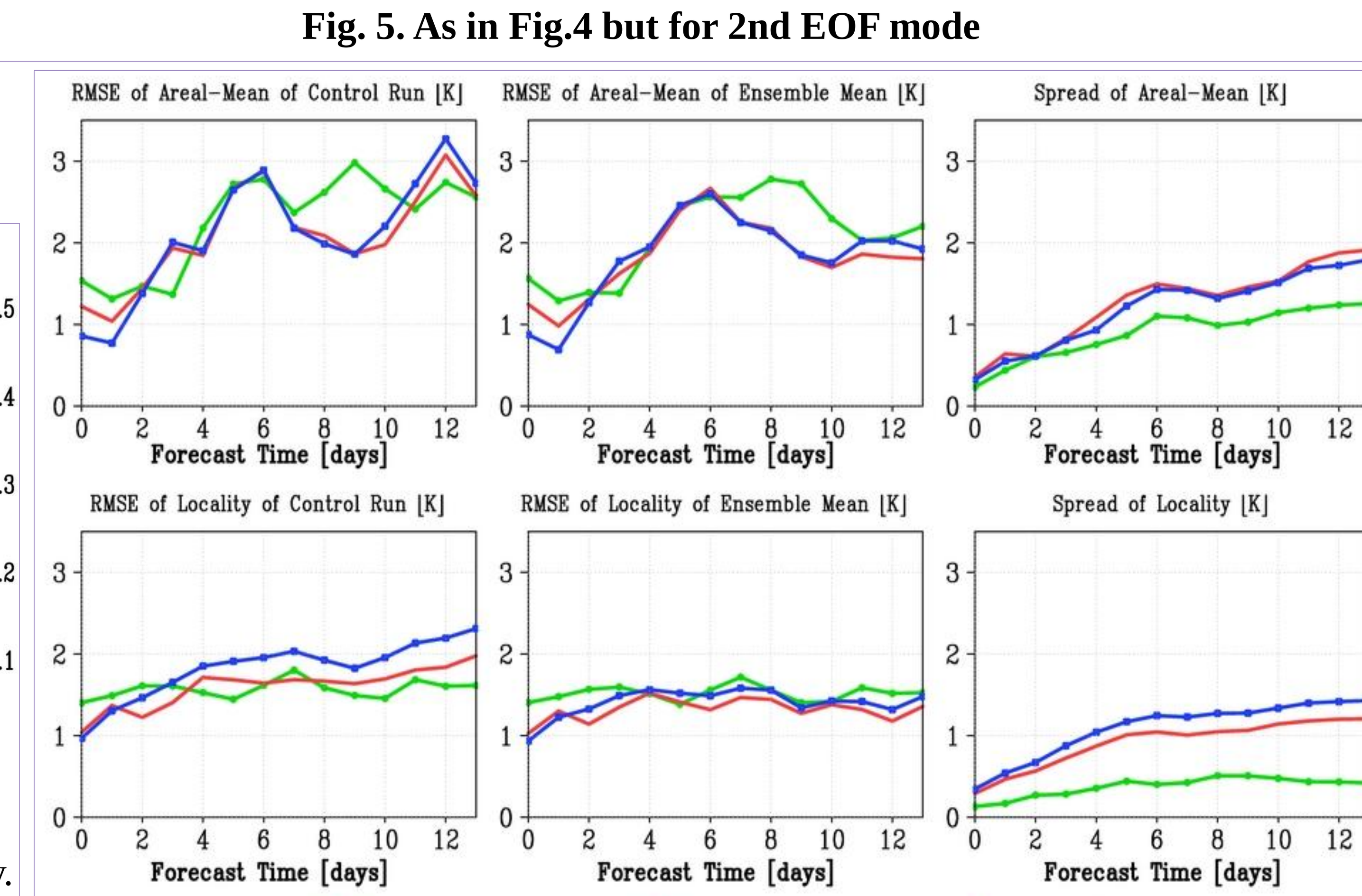

Fig. 6 RMSE and spread for temperature anomaly for 8 summer cases. The top raw shows those for areal mean component. The second raw shows those for locality component (the difference from areal mean). The left column shows the RMSE of control run. The middle column shows the RMSE of ensemble mean. The right column shows the spread.

4. Conclusions

Ensemble downscaling prediction system gains larger spread and smaller RMSE than single downscaling forecast.

With bias correction and filterling based on EOF, it is valid for extracting the reliable localized forecasting information. Further studies are need to clarify the cause of warm bias in this system.

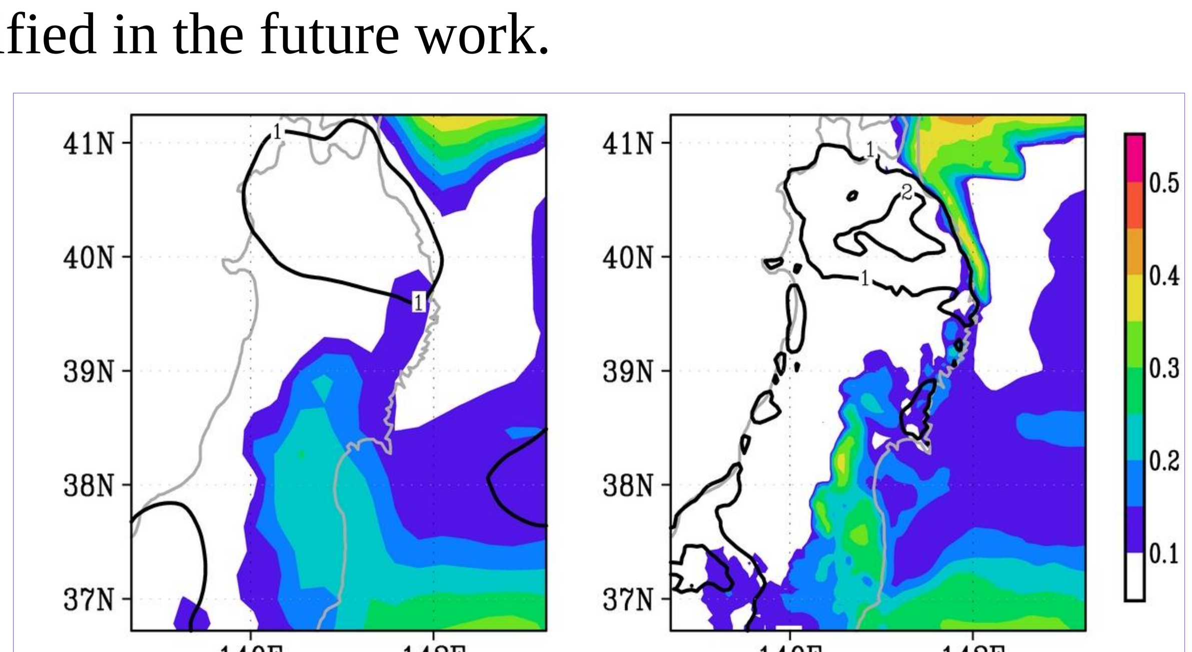

Fig. 7 The spread for the amount of low level cloud (shade) **and the surface temperature** [K] (contours). on a typical Yamase day. The left shows that for DS_25km. The right shows that for DS_5km. (averaged 00~06 UTC 23 July 2003; . ft=3days)

Acknowledgements

We thank Climate Prediction Division Japan Meteorological Agency for allowing to use 1-month ensemble hindcast data.