Calculation of local wind speed near surface by using 4DVAR

Jiro Yoneda, Ryohji Ohba, Kazuki Okabayashi
Mitsubishi Heavy Industries, Ltd., Japan

Hirohiko Ishikawa
Kyoto University, Japan

Kenichi Tatsumi
Tokyo University of Agriculture and Technology, Japan

ABSTRACT

In Japan there are about 1300 surface observation stations of JMA (Japan Meteorological Agency) called as AMeDAS (Automated Meteorological Data Acquisition System). Most of AMeDAS stations measure 10 minutes averaged wind speed every hour. The AMeDAS data are available from JMA near-real time. Therefore in this study, we tried to incorporate these surface wind data in addition to the NCEP reanalysis data for the better reproduction of local wind field near the surface using 4DVAR technique. As the result, both initial condition and prediction accuracy were improved at several observation sites. However the wind field was unrealistically twisted at some other areas. These may be caused since the input data are too much affected by local topography which are not reflected in the model topography. Therefore it is important to select the represented data for application of 4DVAR using AMeDAS.

1. Introduction

After Fukushima Daiichi Nuclear Power Plant accident on Mar 2011, emergency response systems to predict the wind and dispersion intended for the larger scale (more than 100 km square) is required. However, it’s not a good way that the grid size is simply set large to calculate large domain, because emergency response systems needs the quick and accurate prediction. The prediction accuracy strongly affected by the initial condition. Then it is expected to increase the prediction accuracy by optimizing the initial condition.

In Japan, there are about 1300 surface observation stations of JMA called as AMeDAS. Most of AMeDAS stations measure 10 minutes averaged wind speed at 10 meter height every hour. The AMeDAS data are available from JMA near-real time. Therefore in this study, we tried to incorporate these surface wind data in addition to the NCEP reanalysis data for the better reproduction of local wind field near the surface using 4DVAR technique or WRF.

2. Calculation

In this study, the back ground error for 4DVAR was made by using the NMC method during 1 month of Mar 2011 as model case. By using this back ground error covariance, the calculation with 4DVAR was run from 0:00 3/11/2011 to 18:00 3/11/2011 (6 hours), then calculate 6 hours after 18:00 3/11/2011 as prediction.

The 43 AMeDAS data, which were used to update the back ground error during the period of 4DVAR, was plotted to Fig. 1 (Red diamond). The other 3 AMeDAS data, which were described as black symbols of Fig. 1, were used as comparison data. The other conditon is listed as Table.1.

Table.1 Calculation conditon

Version	WRF ver.3.3.1 WRFVAR ver.3.3.1 WRFPLUS ver3.3.1
Obserbation data	AMeDAS (see Fig 1)
Period of 4DVAR	3/11/2011 0:00～18:00
Period of making background error	3/1/2011～3/30/2011
Time window	6 hours
Method	NMC
Initial/boundary condition	NCEP Final analysis data
Grid number	70×70×40 (Horizontal grid size: 5km, Vertical grid size at surface : about 20m)
Geogrid resolution	30 seconds
Domain	1

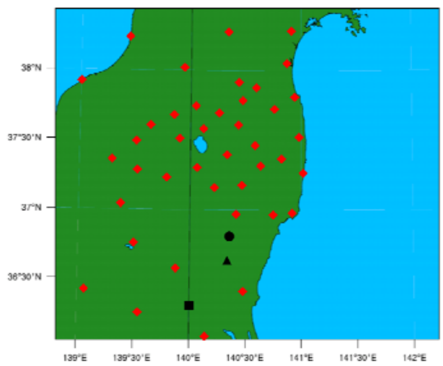

Fig.1 Location of AMeDAS
(Red circle: Used point for 4DVAR,
Black symbols: Compared point)

3. Result

Fig.2 shows the wind field at 18:00 3/11/2011 with/without 4DVAR cases. The local wind change was reproduced by using the 4DVAR. It means that the initial condition was modified as including the local effect. Fig.3 shows the comparison with AMeDAS data not used to 4DVAR. Fig.4 shows the RMSE (root mean square error) during the prediction period.
The RMSE is calculated as follows.

$$RMSE = \sqrt{\frac{\sum (x_m - x_o)^2}{n}}$$

Where x_m is calculation value, x_o is observation value, n is number of comparison data.

It is difficult to judge as good effect by using the 4DVAR for initial condition (18:00 3/11/2011) for all calculation area. Even in the prediction period from 19:00

3/11/2011 to 0:00 3/12/2011, some part time period of Daigo and Shimodate was changed as better by using 4DVAR, the total trend of calculation was not corresponded to AMeDAS. As shown in Fig.4 even the RMSE of wind direction at Daigo was improved by 4DVAR, the RMSE of wind speed at Daigo was not improved by 4DVAR.

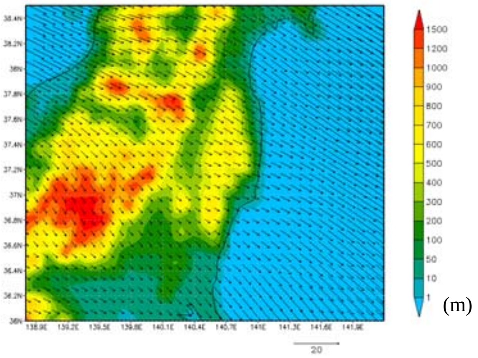

Fig.2 (a) Wind at 10m height (m/s) (without 4DVAR) (3/11/2011 18:00) (Contour: Terrain (m))

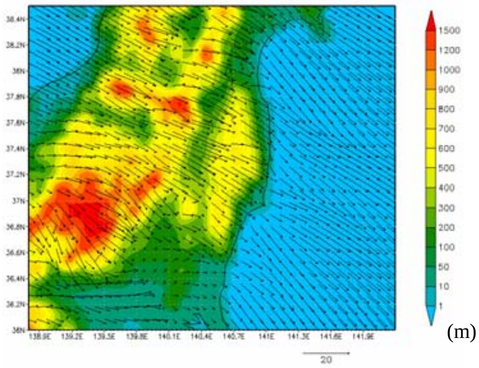

Fig.2 (b) Wind at 10m height (m/s) (with 4DVAR) (3/11/2011 18:00) (Contour: Terrain (m))

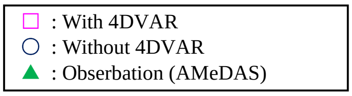

Fig.3 Time series of wind direction and wind speed

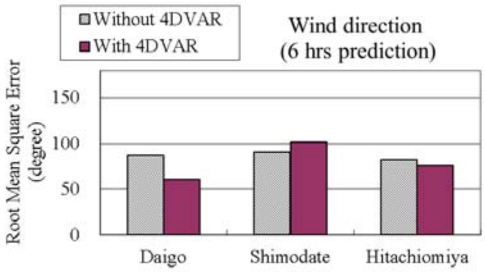

Fig.4(a) RMSE of wind direction (From 19:00 3/11/2011 to 0:00 3/12/2011)

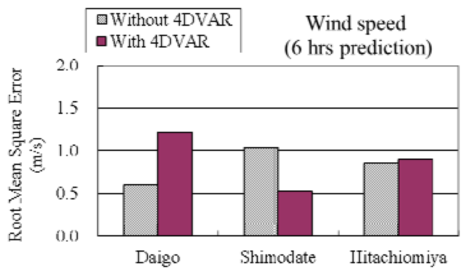

Fig.4(b) RMSE of wind speed (From 19:00 3/11/2011 to 0:00 3/12/2011)

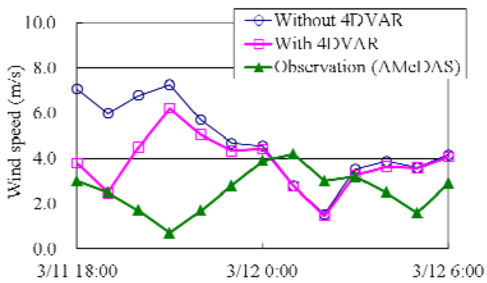

Fig.5 Time series of wind speed at Tsukuba (140.125E, 36.057N)

Fig.5 shows the comparison at Tsukuba, which is used to 4DVAR. At the initial condition (18:00 3/11/2011), the effect of 4DVAR is appeared, however that effect decrease depend on the calculation time, the wind speed with 4DVAR become to same to without 4DVAR. It means that the effect of 4DVAR included in the initial condition for calculation of prediction decreases due to the same boundary condition.

4. Conclusion

Both initial condition and prediction accuracy were improved at several observation sites by using 4DVAR. It is possible to include the local affect by using the observation data of local scale for 4DVAR. However, the local data like AMeDAS may mislead the large scale balance because the input data are too much affected by local topography which are not reflected in the model topography Therefore if some observation point is used for 4DVAR, the prediction accuracy of other points may decrease. It is important to find the useful way to use 4DVAR to optimized initial condition. It is needed to study especially the following things, kind of data, how to choose from many data (representativeness of data).