4D-Var Experiment of GPS Down-Looking Data Observed at the Top of Mt. Fuji into Meso-scale numerical Weather Model

Yoshinori Shoji[1]; Takuya KAWABATA[2]; Yuichi Aoyama[3]; Hiromu Seko[4]

[1] Second Lab of Forecast Dep., MRI; [2] MRI; [3] RASC; [4] Forecast Dep.,MRI,JMA

1.Introduction

The microwave from the GPS satellites are delayed and bent by an atmospheric refractive index. If a GPS receiver is set up at a few kilometers above the surface such as on a mountain or an airplane, we can obtain vertical information on the lower atmosphere up to the receiver altitude. This method is first advocated by Zuffada et al. (1999), and now called 'GPS Down-Looking (DL) Occultation Method'.

Meteorological Research Institute (MRI) and the Radio Science Center for Space and Atmosphere (RASC) of Kyoto University have been doing the experiment observation of the DL occultation method at the top of the Mt. Fuji in the summer from 2001.

Aoyama et al.(2004) succeeded to retrieve the profiles of temperature and relative humidity at the lower atmosphere around a typhoon, by using the observed DL data.

We are now developing the four-dimensional variational data assimilation (4D-Var) system to assimilate retrieved following elements into meso-scale numerical weather model (MSM) developed and operated by the Japan Meteorological Agency (JMA).

(1) Profile of temperature and relative humidity
(2) Profile of refractivity
(3) Signal bending angle
(4) Atmospheric delay

We report on some results that have been obtained.

2. Numerical Weather Prediction Model and assimilation technique

We adopted operational Meso-scale spectral numerical weather prediction Model (MSM) for our assimilation experiment. The model has a horizontal resolution of 10km and 40 vertical levels. JMA operates this model since March 2002 routinely with three-hour assimilation windows. So called the incremental approach is taken to save computational time. The control variables are the initial and boundary conditions of unbalanced wind, temperature, surface pressure, and specific humidity. The horizontal background error correlations are assumed to be homogeneous and of a Gaussian type to significantly reduce memory requirement. The forward model is a full-physics model, while physics of the adjoint model include moist processes, boundary layer processes, long-wave radiation and horizontal diffusion only.

Assimilated data are radiosonde, synop, ship, buoy, airep, wind-profiler and radar-AMeDAS precipitation data. With the adjoint codes of moist processes, the system can directly assimilate the precipitation amount data, which is useful to improve precipitation forecasts.

DL retrieved temperature and relative humidity from 20:14 to 20:19, September 2001, are added to other assimilate data and introduced into the 4-Dvar system as considered to be the data at 20 oclock. The observation error was assumed to be the temperature 1degree and 4% in relative humidity from the analysis of Aoyama et al.(2003). An initial value in 21ut was made by processing 4D-var with the assimilation window of three hours from 18 to 21ut, and then we executed forecast for 18 hours ahead.

3. Preliminary Result

We compared the following two forecast results.

(1)With DL: Start from the initial that DL retrieved temperature and humidity profile is assimilated.
(2)W/o DL: Start from the initial that DL retrieved temperature and humidity profile is not assimilated.

As a result, an essential difference was not seen by above two.

However, for 'with DL' case compared to the 'w/o DL' case.

Moreover, a little difference was caused for the forecast of precipitation. Total precipitation of 18 hours became to show good agreement with Radar-Amedas Precipitation analysis. It seems that it is reflected the changes in initial profile in the area on the windward side by assimilating the DL data.

4. Future Plan

Data assimilation of only one DL data shows the influences for the numerical weather forecast. We will investigate the impact when the DL data is increased. More over, we will try to assimilate refractivity profile, bending angle, and atmospheric delay. A bigger impact can be expected by using data with few degrees of the retrieval.