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Application of GPS Zenith tropspheric delay to numerical weather prediction

Nobutaka Mannoji[1], Ko KOIZUMI[2]

[1] CPD, JMA, [2] JMA/NPD

In order to improve the accuracy of weather forecast, precipitable water (PW) retrieved from zenith toropospheric delay (ZTD) data of GEONET is assimilated into a numerical weather prediction (NWP) model.

The accurate forecast of the heavy precipitation accompanying the mesoscale phenomena is required in order to prevent disaster by torrential rain. The fundamental data for weather forecast are made by NWP.

In order to predict heavy rain correctly by NWP, an improvement of an initial value as well as that of a model is important. Most reliable data are observed with radiosonde, which observes wind, temperature and humidity in the atmosphere up to several hPa. Since this observation is performed at the 200-300km interval horizontally every 12 hours (only a wind is observed every 6 hours) in Japan, the structure of a mesoscale phenomena is not captured. Rain and a wind can be observed by the radar or the wind profiler. As for water vapor, accurate PW with high resolution in time and space can be retrieved from ZTD observed by the GPS network which amounts to no less than 950 points over Japan operated by the Geographical Survey Institute (GSI).

Therefore, we investigate the effect of the assimilation of the GPS PW retrieved from ZTD on NWP.

As a first step, optimal interpolation (OI) method was used to assimilate GPS data. However, neither GPS ZTD nor PW can be assimilated directly with OI. Therefore, the following methods were used. GPS ZTD is converted into PW first. Surface pressure and mean temperature over the observational point are calculated from the objective analysis. Then, 2-dimensional objective analysis of PW is performed with OI, where GPS PW is used as observational value and PW calculated from objective analysis is used as the first guess. Finally, the specific humidity is multiplied with a constant value at each column to be in accordance with the analyzed PW.

PW of the first guess has to be compared with the observational value in the OI. At this time, there is a problem that the actual altitude at the GPS point differs from that of the topography used by the NWP model, because topography is averaged according to resolution of the model. Therefore, the difference of PW caused by the difference of altitude was rectified.

A forecast experiment with OI was conducted with the examples late in August, 1998. ZTD calculated operationally by GSI, that are the 3-hour averaged value analyzed with the precise ephemerides, were assimilated. The results show that the forecast has improved two of nine examples by assimilating GPS PW. The rest of them had the difference, but we cannot judge better or not.

Another experiment which assimilates GPS PW using a four-dimensional variational method was also conducted. PW data can be assimilated simultaneously with other observation data such as a wind and atmospheric pressure with the variational method. Moreover the observation with different time can be reflected in an initial value. 32 forecasts were conducted for eight days in June, 2001 when much rain was observed. Forecast of rain is improved very slightly by assimilating GPS PW.

There remained some problems to be solved in future :

(1) Making use of ZTD based on Ultra Rapid Orbit which can be obtained in near real time for operational weather forecast.

(2) Improvement of the NWP model which reflects the improvement of the initial condition of water vapour into the forecast of precipitation.

(3) Assimilation of zenith wet delay instead of PW. Moreover, direct assimilation of ZTD which includes zenith hydrostatic delay. Although this may be of little importance, this is a step to realize the next item.

(4) Assimilation of slant tropospheric delay to derive information of vertical distribution of water vapor