Assimilation of GNSS zenith total delay in the weather research and forecasting model: a case study

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Poster Section ps04 - troposphere

Introduction

Numerical weather prediction is an initial value problem, and its forecast quality is strongly depend on the initial state. Lack of precise and continuous water vapor data is one of the major sources of error in short-term forecasts of precipitation. As a cost effective technique, Global Navigation Satellite System (GNSS) can provide troposphere products with high spatial and temporal resolution. Assimilation of GNSS zenith total delays (ZTDs) into the numerical weather model is one of the focuses of GNSS meteorology and has demonstrated a positive impact on short-range precipitation forecasts. In this study, the experiment of GNSS ZTD assimilation is made by using the weather research forecast (WRF) model. Three scenarios are analyzed to investigate the impact of assimilating GNSS ZTDs in the weather research and forecasting (WRF) model. In addition, the effect of the period of cycle assimilation is analyzed.

Data and Case Description

Case Description

In this paper, a period of two days (from Aug 21, 2017 to Aug 23, 2017) is selected to conduct the data assimilation. During this time, the typhoon Hato passed through Hong Kong and heavy rainfall were brought. As shown in Fig 1, three nested domains are determined, and the central latitude and longitude of the domains are 22.64N and 113.92E, respectively.

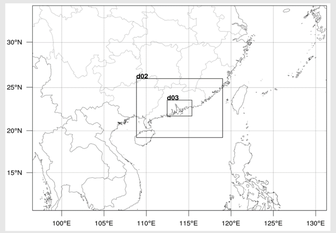

Fig. 1 *Map of the domains.*

GNSS observations processing

Observations from 17 stations of the Hong Kong Continuously Operating Reference Stations (CORS) are applied to derive ZTDs based on the precise point positioning (PPP) method. Fig. 2 shows the time series of the ZTD at station hkkt on DOY 234. It is obvious that the fast-changing ZTD is associated with the rapid change of the atmospheric water vapor.

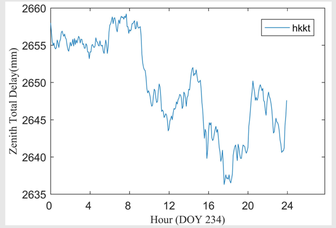

Fig. 2 *ZTD series at station hkkt on DOY 234,2017.*

Experiment Design

A rapid update cycle assimilation system based on the 3DVAR method has been established to investigate the potential benefit in the WRF system of utilizing GNSS ZTDs. Fig. 2 shows the basic procedure. A number of parallel data assimilation and forecast experiments have been carried out. In the baseline experiment, the GNSS ZTDs are withdrawn from the observation data. In the remaining two experiments, we assimilate the ZTD into the system with a cycle period of three hours and six hours, respectively. After the data assimilation is complete, we conduct a six hours forecast.

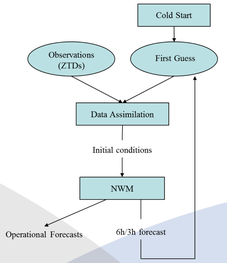

Fig. 3 *Flow chart of cycling data assimilation.*

Result and Analysis

The Fig. 4 shows the histograms of background and analysis departures for ZTD from experiment (cycle period is three hours). Compared with the left figure (observation minus background, OmB), the distribution of the observation minus analysis (OmA) is closer to Gaussian curves. The mean value is -5.54 mm before and -0.56 mm after the analysis. The standard deviation is 11.60 mm before and 6.70 mm after analysis. This indicates that the assimilation has changed the model state, mostly in terms of humidity field, closer to GNSS ZTD observations.

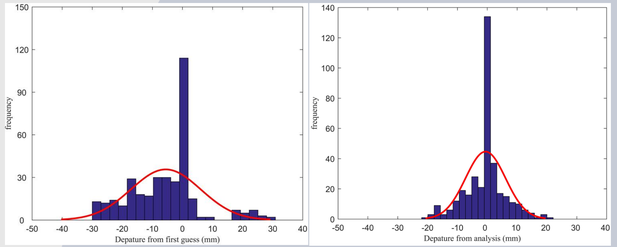

Fig. 4 Histograms of background (left, observation minus background) and analysis (right, observation minus analysis) departures for ZTD from experiment

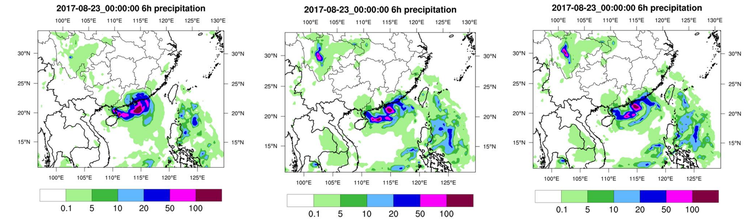

Fig. 5 six hours accumulated precipitation in mm. left (withdraw GNSS ZTD) , middle (include GNSS ZTD with a cycle assimilation period of 6 h), right (include GNSS ZTD with a cycle assimilation period of 3 h)

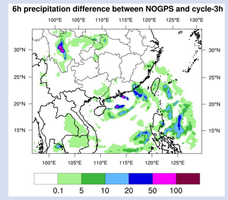

Fig. 6 The difference of precipitation between NOZTD scenario and cycle-3h scenario

The results of three scenarios are presented in Fig. 5. It is obvious that the accumulated precipitation is changed through assimilating GNSS ZTD into the WRF model, especially the area near Hongkong. Compared to the assimilation with a cycle period of 6 hours, the assimilation with a cycle period of 3 hours only has a little change. Meanwhile, some new rainfall centers has emerged, as shown in the figure above, there is a new rainfall center in Sichuan province, it may be created by the boundary conditions, and further validation is required.

Conclusions

In this paper, we have performed an impact assessment of the assimilation of GNSS ZTD into the WRF model. Experiments have been undertaken during a typhoon event. It is worth mentioning that the GNSS ZTD contribute in a positive manner to the analyses and to the forecast, especially during extreme weather conditions. In addition, more experiments should be carried out to further explore its capability.

References

Mahfouf J F, Ahmed F, Moll P, et al. Assimilation of zenith total delays in the AROME France convective scale model: a recent assessment[J]. Tellus Series A-dynamic Meteorology & Oceanography, 2015, 67.