A Novel Forecasted Zenith Hydrostatic Delay / Weighted Mean Temperature Model for Rapid PWV Retrieval and Its Application in Extreme Rainfall Event

Luohong Li[1,2,3], Hongxing Zhang[1], Yunbin Yuan[1], Aichinger-Rosenberger Matthias[3], Benedikt Soja[3]

[1] Innovation Academy for Precision Measurement Science and Technology (APM), Chinese Academy of Sciences (CAS); [2] University of Chinese Academy of Sciences (UCAS), China; [3] ETHZ, Switzerland

1 Introduction

- **ZHD** and T_m are two key parameters for real-time GNSS PWV retrieval
- **a more convenient approach** to obtain **ZHD** and T_m for real-time GNSS-PWV retrieval to monitor the water vapor when there are no nearby meteorological data;
- **the NWP forecasts** have been accessed for **ZHD** and T_m with improved quality and horizontal resolution and provided for free;
- **HDTM model** is proposed to provide hourly **ZHD** and T_m forecasts based on NWPs, such as NECP-GFS and ECMWF-IFS.

2 Data and Methodology

Data Collection

Table 1. The characteristics of data and products used.

Item	Time Interval/ Horizontal resolution
HDTM(NCEP-GFS)	1 hour/1° × 1 °
HDTM(ECMWF-IFS)	1 hour/1° × 1 °
VMF3(TUW)	6 hour/1° × 1 °
ERA5	1 hour / 0.25° × 0.25°
Radiosonde	12 hour
GNSS-ZTD	30 min
Pressure	30 min
GNSS-PWV	30 min

$$PWV = \Pi \cdot ZWD = \Pi \cdot (ZTD - ZHD)$$

$$\Pi = \frac{10^5}{R_w \frac{k_3}{T_m} + k_2'}$$

Establishing of HDTM model

- Hourly **ZHD** and T_m are calculated by numerical integration of the pressure, humidity and temperature profiles from NCEP-GFS or ECMWF-IFS forecasts provided at 1°×1° resolution.
- We distinguish HDTM products as **HDTM(ECMWF-IFS)** and **HDTM(NCEP-GFS)** according to the NWP data used, respectively.

3 Results

Overall performance of ZHD and T_m over China

Accurate ZHD and T_m:

- Biases and STD of ZHD: within -2 mm and around 1.6 mm
- Biases and STD of T_m: within -1 K and around 1 K

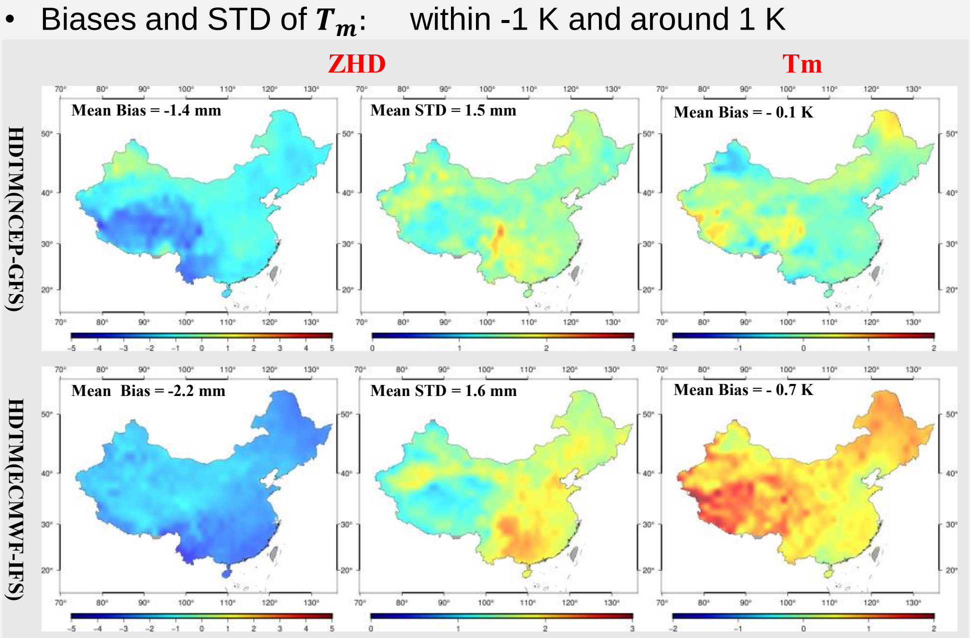

Figure 1. The spatial distributions of biases and STD of ZHD and Tm from HDTM with respect to ERA5.

3 Results

Diurnal variation of ZHD and Tm

Better diurnal variations. Consistency with less than 2 mm in RMS was found between ZHD from HDTM and in-situ pressure-derived ZHD while the better T_m was obtained by HDTM than the traditional methods, reaching an RMS of 0.8 K in T_m.

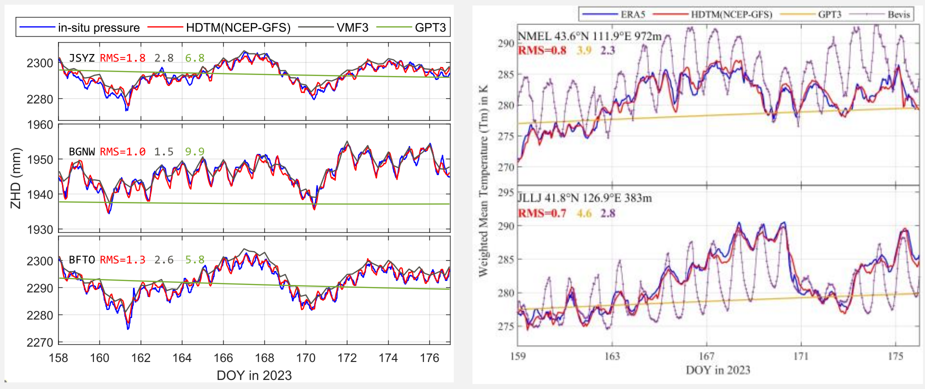

Figure 2. The diurnal variation in ZHD(mm) and Tm(K) of HDTM model and other models.

HDTM-based PWV retrieval in a heavy rain event

- **Works accurately** in heavy rain events and supports hourly PWV retrieval, showing an RMS of ~1 mm, which is comparable results with PWV from in-situ data
- Has **significant advantages** in capturing water vapor changes before, during, and after heavy rainfall.
- **PWVs at 6-hour intervals are insufficient** to monitor short-term water vapor changes in extreme weather.

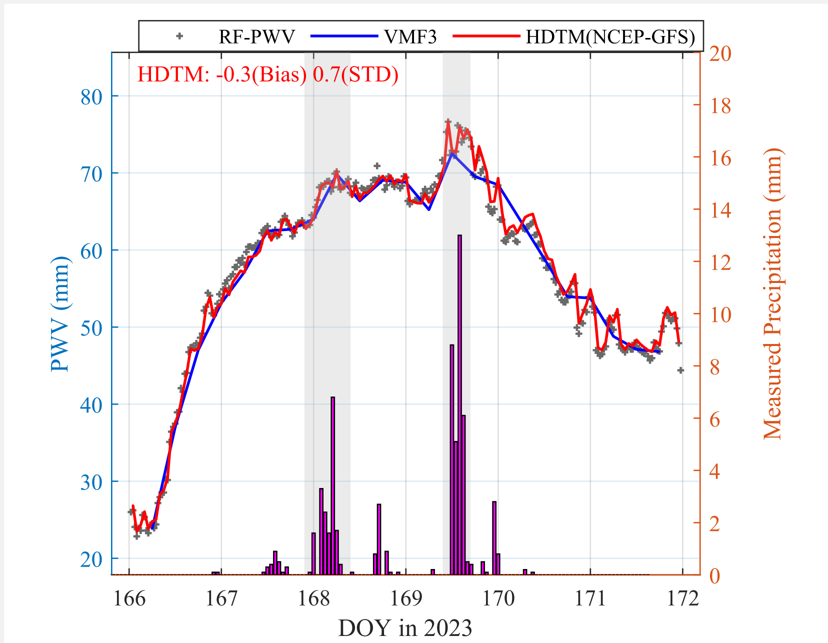

Figure 3 The relationship between real-time GNSS PWV (mm), including the RF-PWV, GNSS-PWV(HDTM) and GNSS-PWV(VMF3),and measured precipitation(mm) at BTCD station during an extreme heavy rain event. RF-PWV (30-min) is calculated based on the in-situ pressure and temperature.

4 Conclusion

- A novel NWP-based ZHD and T_m model was developed to provide forecasts and a real-time PWV retrieval over a large area.
- HDTM can provide accurate hourly ZHD and T_m forecasts based on NWP in real-time and outperform traditional models in their diurnal variation, as well as work accurately even in severe weather.
- HDTM is a more accurate and convenient approach to enhance the implementation of real-time GNSS water monitoring for weather forecasting and contribute to GNSS meteorology.