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VMF and IMF mapping functions based on data from the ECMWF

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Abstract

In recent years, numerical weather models (NWM) have been investigated to improve mapping functions which are used for tropospheric delay modeling in VLBI and GPS data analyses. The Vienna Mapping Functions (VMF; Boehm and Schuh, 2004) are based on direct raytracing through the NWM, and allow to exploit the full information provided in the NWM. On the other hand, the Isobaric Mapping Functions (IMF; Niell, 2001) use intermediate parameters calculated from the NWM. Pressure level data from ECMWF (European Centre for Medium-Range Weather Forecasts) are applied to determine the coefficients of the VMF and the IMF. Used for the analyses of IVS-R1 and IVS-R4 VLBI sessions, both mapping functions improve the repeatability of baseline lengths (by ~10% for IVS-R1, see Figure 1, and ~5% for IVS-R4) and height components compared to the Niell Mapping Functions (NMF; Niell, 1996). The Institute of Geodesy and Geophysics of the Vienna University of Technology provides the parameters for VMF and IMF since 1979 on a regular basis for all IVS stations. The IMF parameters are given on a global grid of 2.5° x 2.0°.

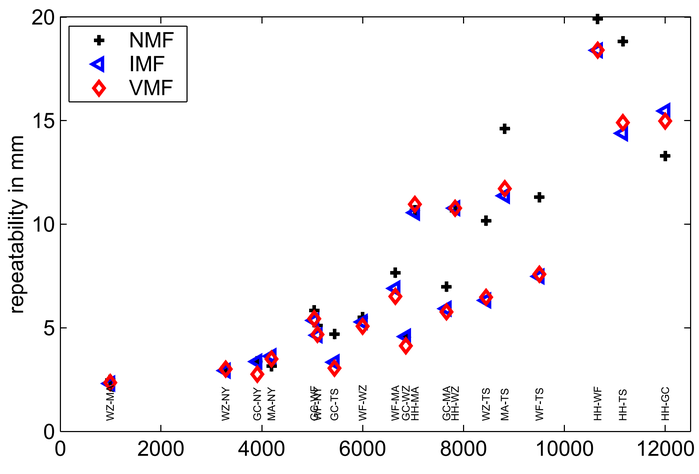

Figure 1. Repeatabilities of baseline lengths for the IVS-R1 VLBI sessions from Jan. 2002 until Sep. 2003. The relative improvement is ~ 10% with IMF and VMF compared to NMF, and it is especially high for the baselines with the station in Tsukuba (Japan, TS).

Principle of the Vienna Mapping Functions (VMF)

ECMWF provides temperatures, heights and humidities at 15 (21) pressure levels. Steps:

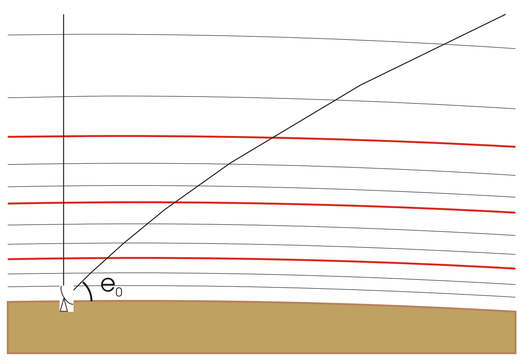

Figure 2.

1. Increase the number of pressure levels by inter- and extrapolation (15 ~1000).

2. Raytracing for an initial elevation angle e_0 = 3.3° yields the hydrostatic and wet mapping functions and the vacuum elevation angle e (~3°).

3. Inversion of the continued fraction form yields time series for the coefficients a_h and a_w for the hydrostatic and wet mapping functions.

$$mf(e) = \cfrac{1 + \cfrac{a}{1 + \cfrac{b}{1 + c}}}{\sin e + \cfrac{a}{\sin e + \cfrac{b}{\sin e + c}}}$$

from raytracing

b_h, c_h from IMF

b_w, c_w from NMF

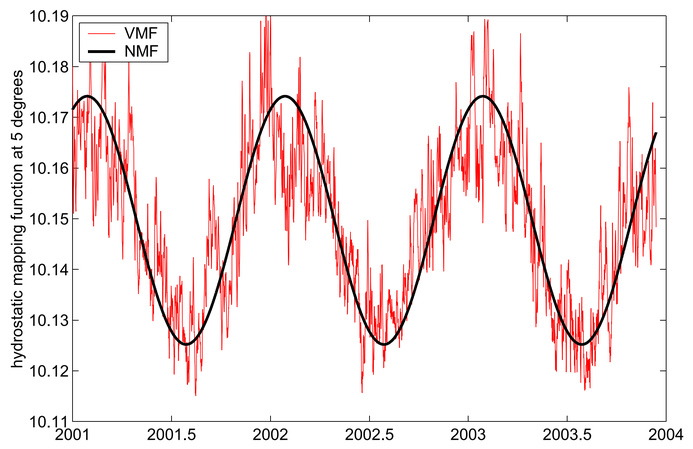

Figure 3. Hydrostatic mapping functions at 5° elevation at the station Wettzell (Germany) for NMF and VMF. If plotted, IMF would be very similar to VMF. The annual signal in NMF agrees very well with VMF, but NMF cannot account for shorter fluctuations.

Provision of mapping function parameters for IMF and VMF based on data from ECMWF:

www.hg.tuwien.ac.at/~ecmwf

Table 1. The Institute of Geodesy and Geophysics at the University of Technology in Vienna provides the parameters for IMF and VMF with 6 h time resolution starting with 1979 and updates them daily with a delay of 5 days. Whereas IMF is provided on a global grid, VMF is given for all VLBI stations. Since August 2003, VMF is determined from the ECMWF data with the highest resolution available.

	IMF (grid)	VMF (stations)
doy 1 in 1979 - doy 365 in 2001	2.5° x 2.0° ERA-40 reanalysis 15 presure levels	
doy 1 in 2002 - doy 238 in 2003	2.5° x 2.0° operational data 15 pressure levels	2.5° x 2.0° oper. data 15 pressure levels
doy 239 in 2003 - now		~0.3° oper. data 21 pressure levels

Conclusions and future outlook

- at sites with accurate NWM, the influence of VMF on station height accuracy is less than 3 mm with 5° elevation cutoff
- VMF exploits the full information of the NWM better NWM will directly improve VMF
- tests showed that the new mapping functions IMF and VMF will change the terrestrial reference frame (by up to ~3 mm in station heights)
- in future VMF will also be provided for IGS stations
- forecasting data can be used for real time applications

References

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