Mapping function parameters derived from Numerical Weather Model data in global GPS network analyses - a comparative study

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Motivation:

- One major part in the GPS error budget is the inaccurate modelling of the elevation dependence of tropospheric path delay.
- As part of the strategy optimization for an ongoing GPS reprocessing project we compare two different mapping techniques: (1) the commonly used Niell hydrostatic mapping function (NMFh) and (2) the Integrated hydrostatic mapping function (IMFh).
- IMFh proposed by Niell (2000) requires just one meteorological input parameter in contrast to other algorithms based on ray tracing in numerical weather fields (Rocken et al., 2001). For global network analyses we therfore prefere IMFh.

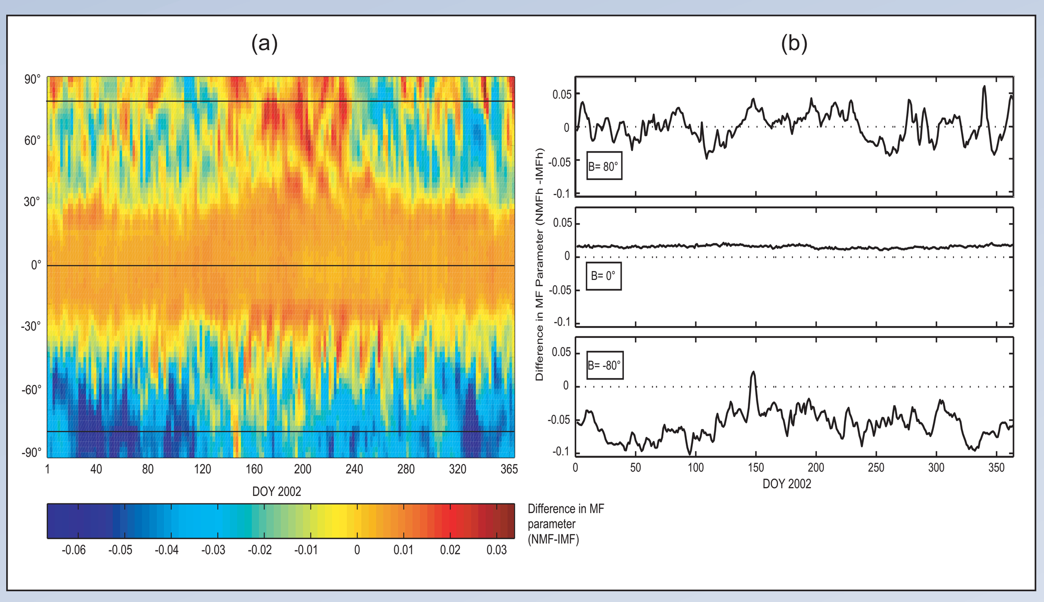

Fig.1: Time and latitudinal dependence of the model difference (NMFh-IMFh), a) for all latitudes b) for selected latitudes (Mapping function differences are shown for an elevation angle of 5°)

Model differences:

	NMF	IMF
based on:	raytraces of the US standard atmosphere	numerical weather fields
resolution: (spatial)	15° in latitude homogenous in longitude	2.5° x 2.5°
(temporal)	1 day	6 hour

Differences NMFh-IMFh are composed of:

- **offset:** (1) large dependence on latitude (differences are larger at higher latitudes and more important for the southern than the northern hemisphere, see Fig.1), (2)dependence on longitude (differences are correlated with areas of permanent high or low pressure areas e.g. Siberia, see Fig.3)
- **periodical signal:** seasonal dependence (differences are smaller in winter than in summer, see Fig.2)
- **short term variations:** (3) strong time dependence, see Fig. 2

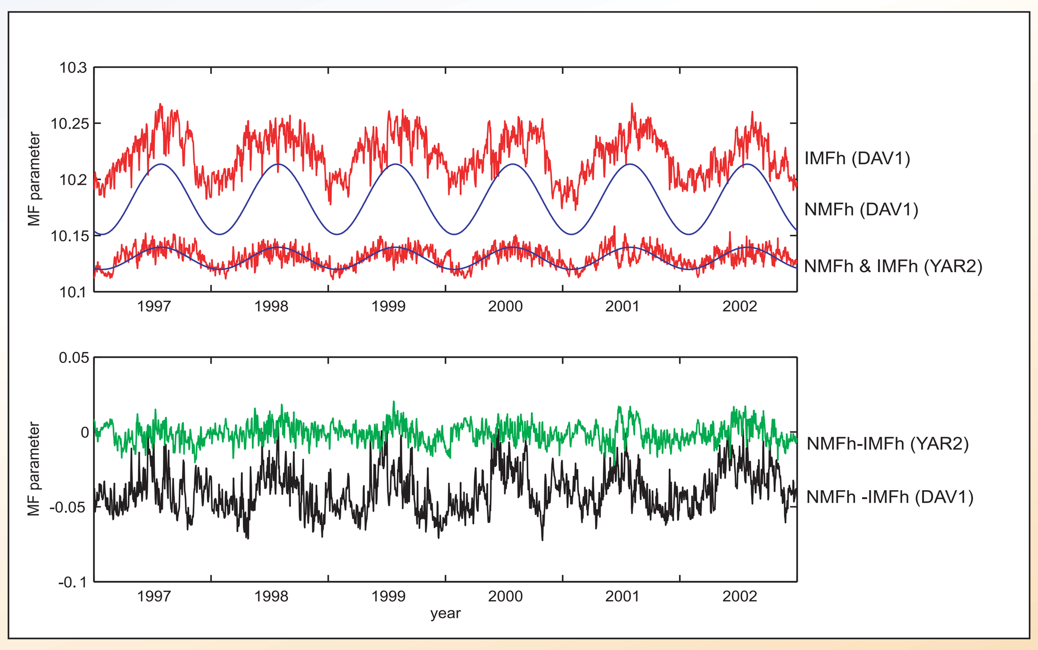

Fig.2: Differences in mapping function (MF) parameters for an elevation angle of 5° at station DAV1 (Davis, Antarctica) and YAR2 (Yaragadee, Australia) over a period of 6 years

GPS Data Analysis:

- Implementation of IMFh in the Bernese Software Version 5.0
- Derivation of the height of the 200 hPa surface (z200) from the numerical reanalysis model of the National Center for Environmental Prediction (NCEP)
- Estimation of 2 GPS solutions which use the same analysis strategy (e.g. 3° Elevation cut off) besides different MF
- Analysed datasets: (1) global network of 161 stations, 3 month of data (day 285-365 of 2002)
  (2) baseline DAV1-YAR2, 1 year of data (2002)

Results:

Influence on GPS height

- small impact in equatorial regions, see Fig.3
- very important changes in polar regions, especially Antarctica (offsets up to 13 mm, additionally temporal variations up to 15 mm), see Fig.4
- amplitude of height variation during one year is reduced in the IMFh solution, see Fig.6

Influence on repeatability of weekly GPS height

- repeatability of the IMFh solution is smaller in many cases, but sometimes also larger depending on location and time, see Fig.5

Influence on Troposphere Parameters

- large impact on zenith total delay (ZTD) at high latitudes
- offset in ZTD up to 6 mm, variations in ZTD up to 7 mm, see Fig.3
- effect on precipitable water vapor estimates up to 2 mm

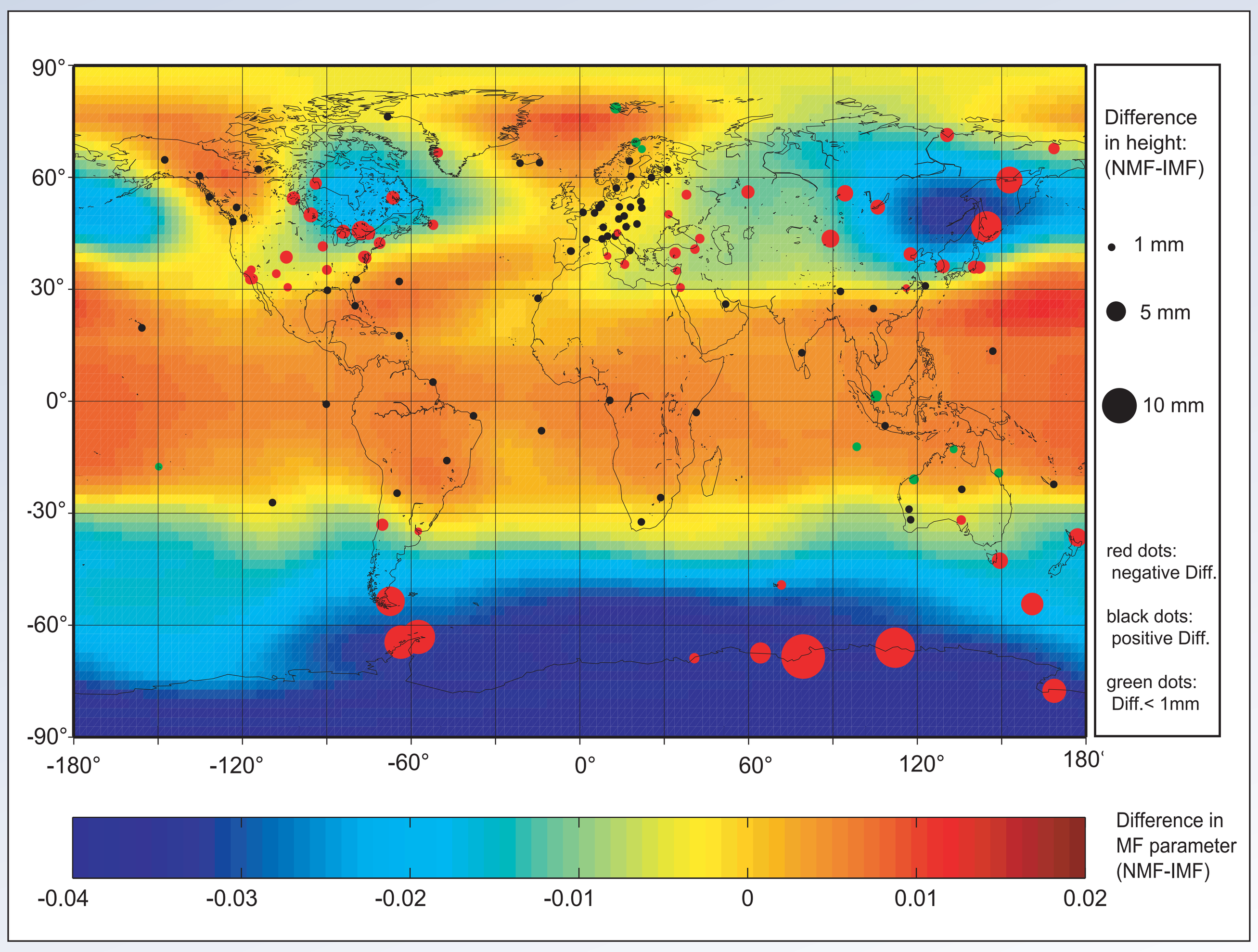

Fig.3: Mean height difference (NMFh-IMFh) over a period of 3 month (doy 285 to 365, 2002), colour code shows difference of mapping function parameter (at 5° elevation) as mean over the 3 month period.

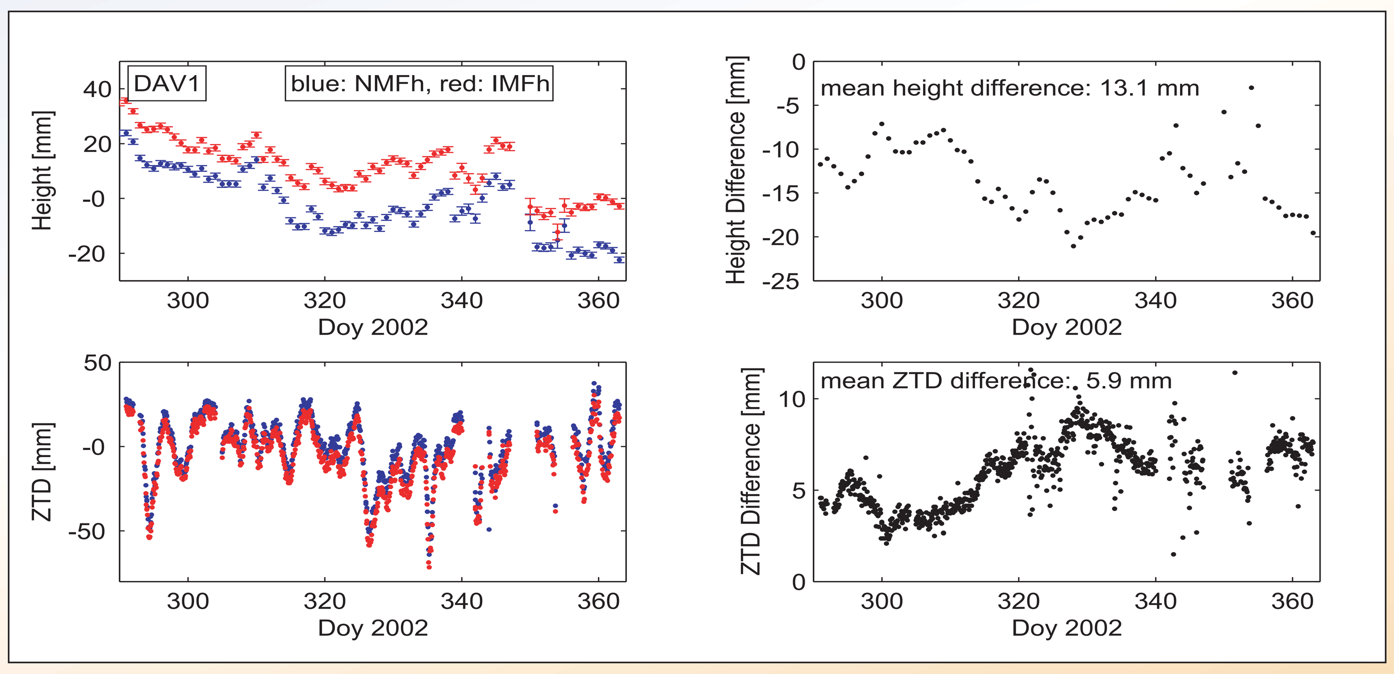

Fig.4: Time series of height and zenith total delay (ZTD) derived for solutions NMFh (blue) and IMFh (red) at station Davis, difference (NMFh-IMFh) in GPS height and ZTD is shown in black

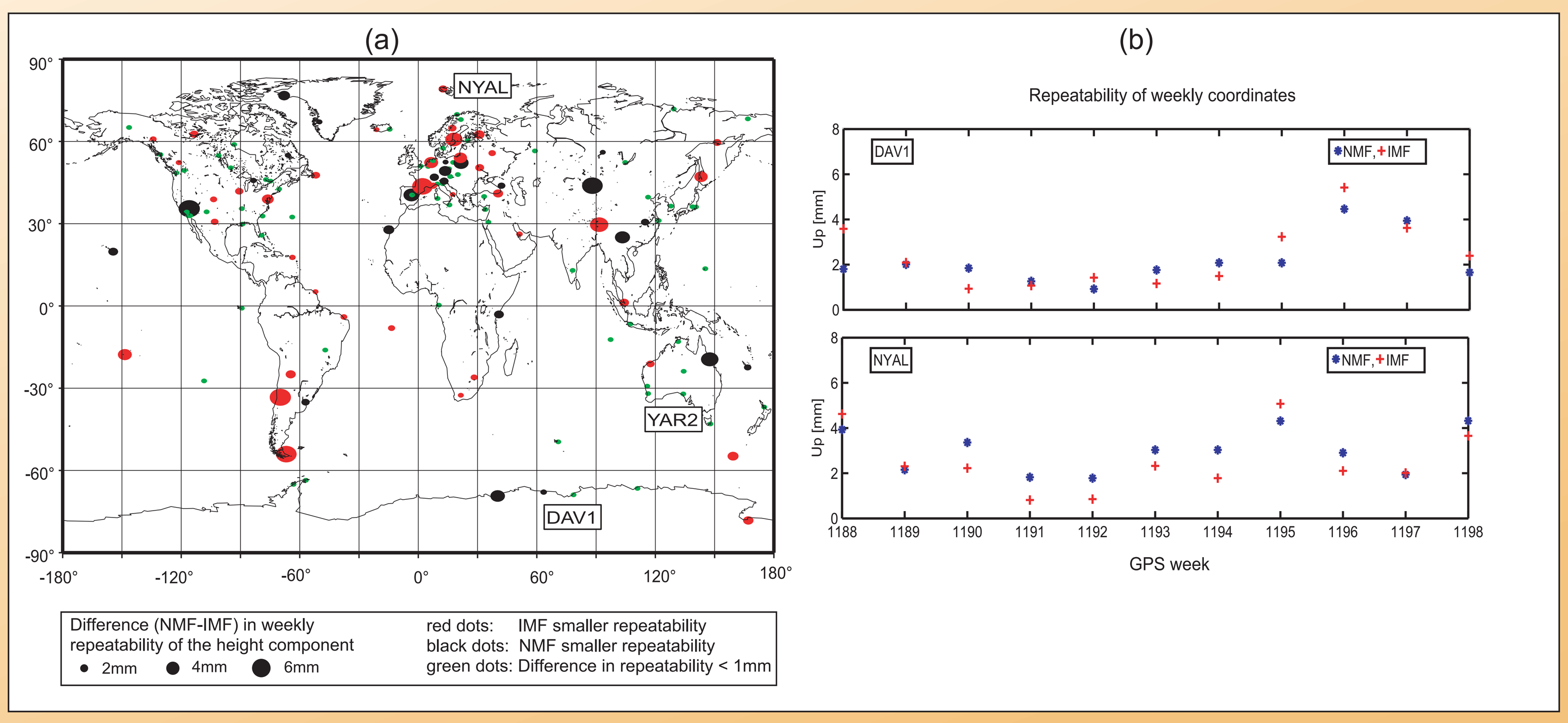

Fig.5: Repeatability of weekly GPS height solutions, a) globally for GPS week 1198, b) at station DAV1 (Davis, Antarctica) and NYAL (Ny Alesund, Norway) for a period of 11 weeks (doy 285-365, 2002)

Conclusions:

- NMFh captures atmospheric constitution only roughly.
- Time series of GPS height and zenith delay from the NMFh solution contain constant and periodical signals related to insufficient mapping of the atmospheric delay.
- IMFh reduces those signals, because of its direct relation to meteorological data and higher temporal and spatial resolution.
- The largest impacts of IMFh on GPS heights and zenith delays were found in the polar regions.
- For an analysis of long GPS time series in a global scale we recommend the use of a mapping function based on meteorological data, especially if GPS observations of low elevation angles are included.
- IMFh has proven to be an effective algorithm with regard to memory and computation time.

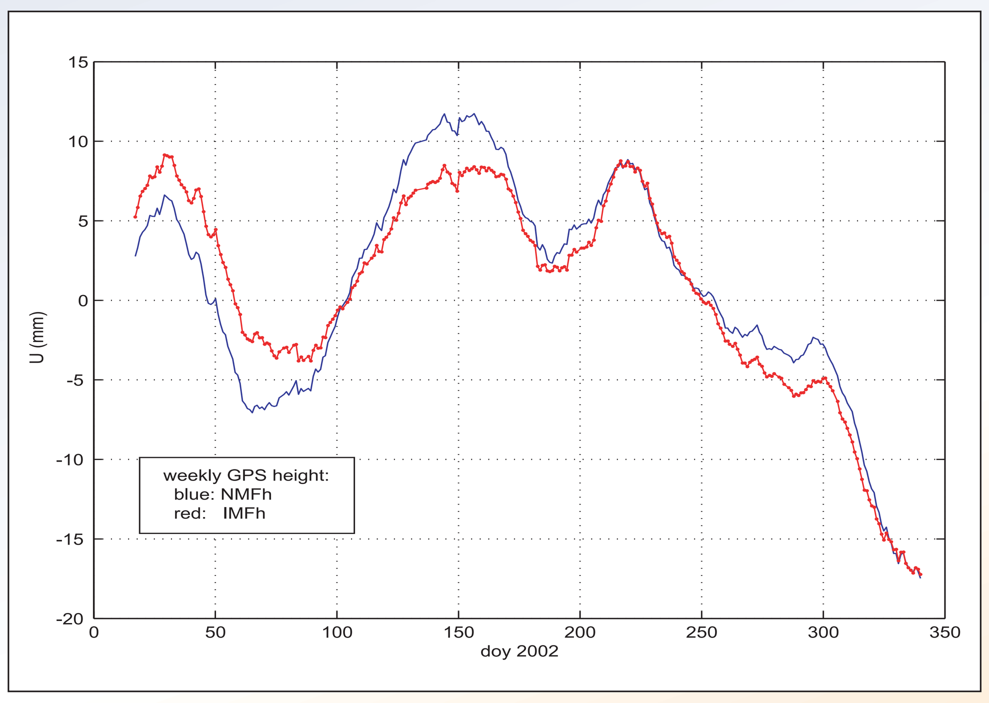

Fig.6: Comparison of one year of weekly GPS height derived from the NMFh and IMFh solution for baseline DAV1-YAR2, see also Fig.2

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