
Benefits from Homogeneously Reprocessed GPS Time Series



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Motivation

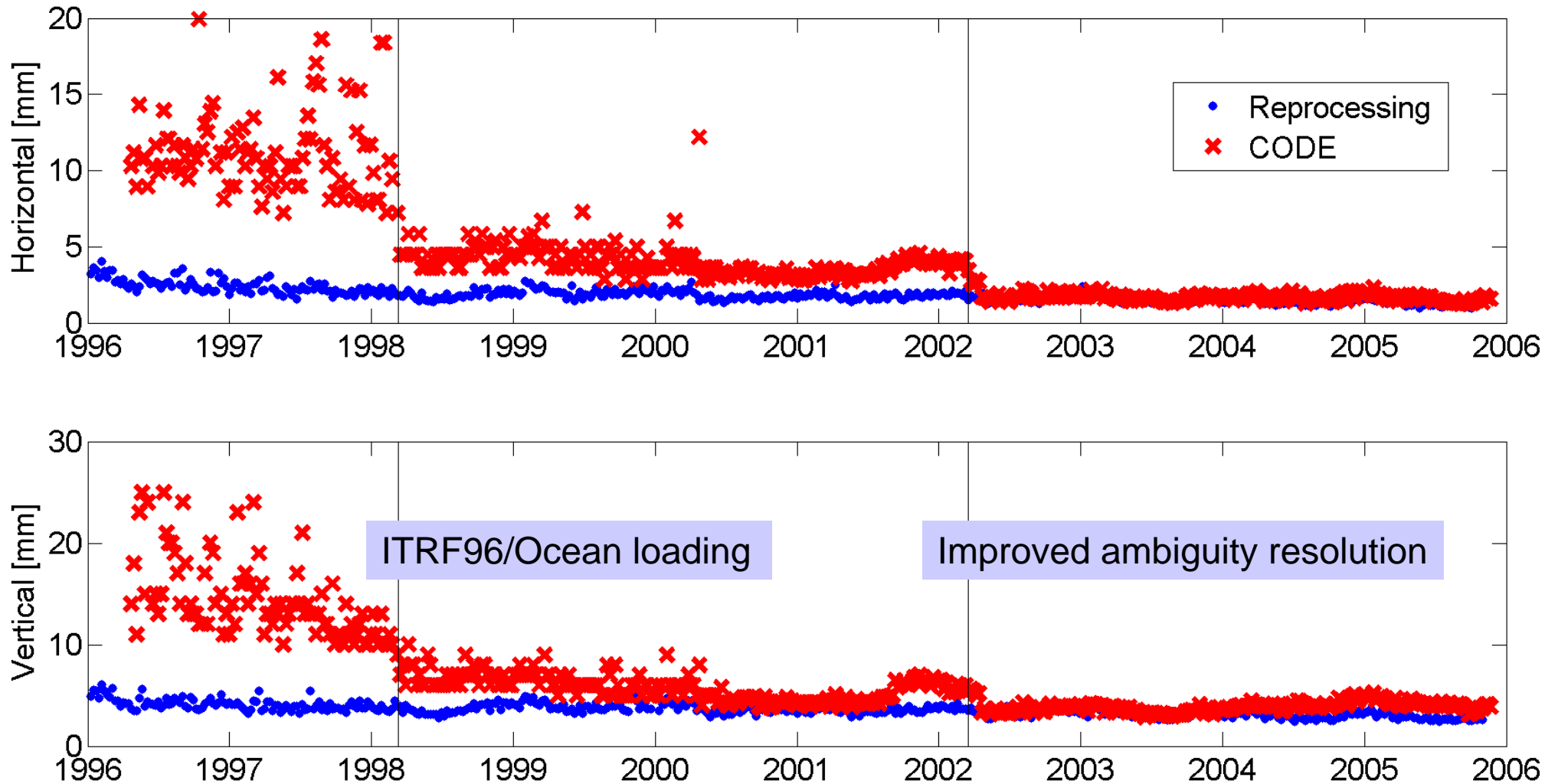
Significant improvements in modeling of global GPS solutions in the last decade:

- Orbit modeling
- Reference frame changes
- Changes of the cut-off angle and mapping functions
- Antenna phase center variations
- ...

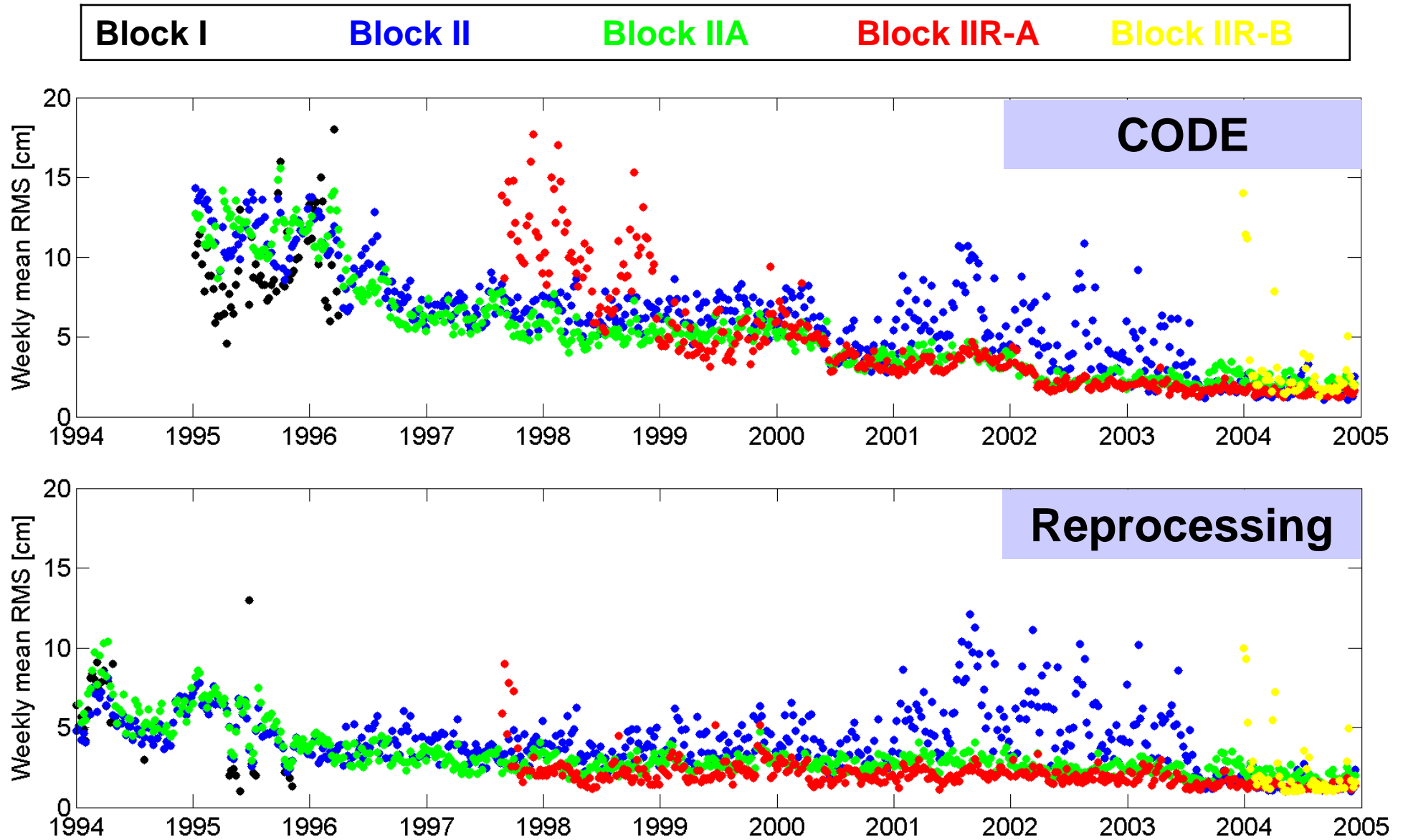
➔ **Inconsistent and inhomogeneous GPS time series**

Complete reprocessing of a global network of 202 stations by the Universities of Technology in Dresden and Munich covering the time interval from 1 January **1994** till 31 October **2005**

Coordinate Repeatability



Orbit Consistency



Advanced Modeling

Troposphere

- Niell 1996 Mapping Function
- + Isobaric Mapping Function (Niell, 2000)

Ionosphere

- 1st order effect eliminated
- + 1st order effect eliminated, **2nd and 3rd-order effect modeled**

Antenna Phase Center Variations

- relative PCVs for receivers only
- + absolute PCVs for receivers **and** satellites including radome calibrations

Troposphere Mapping Functions

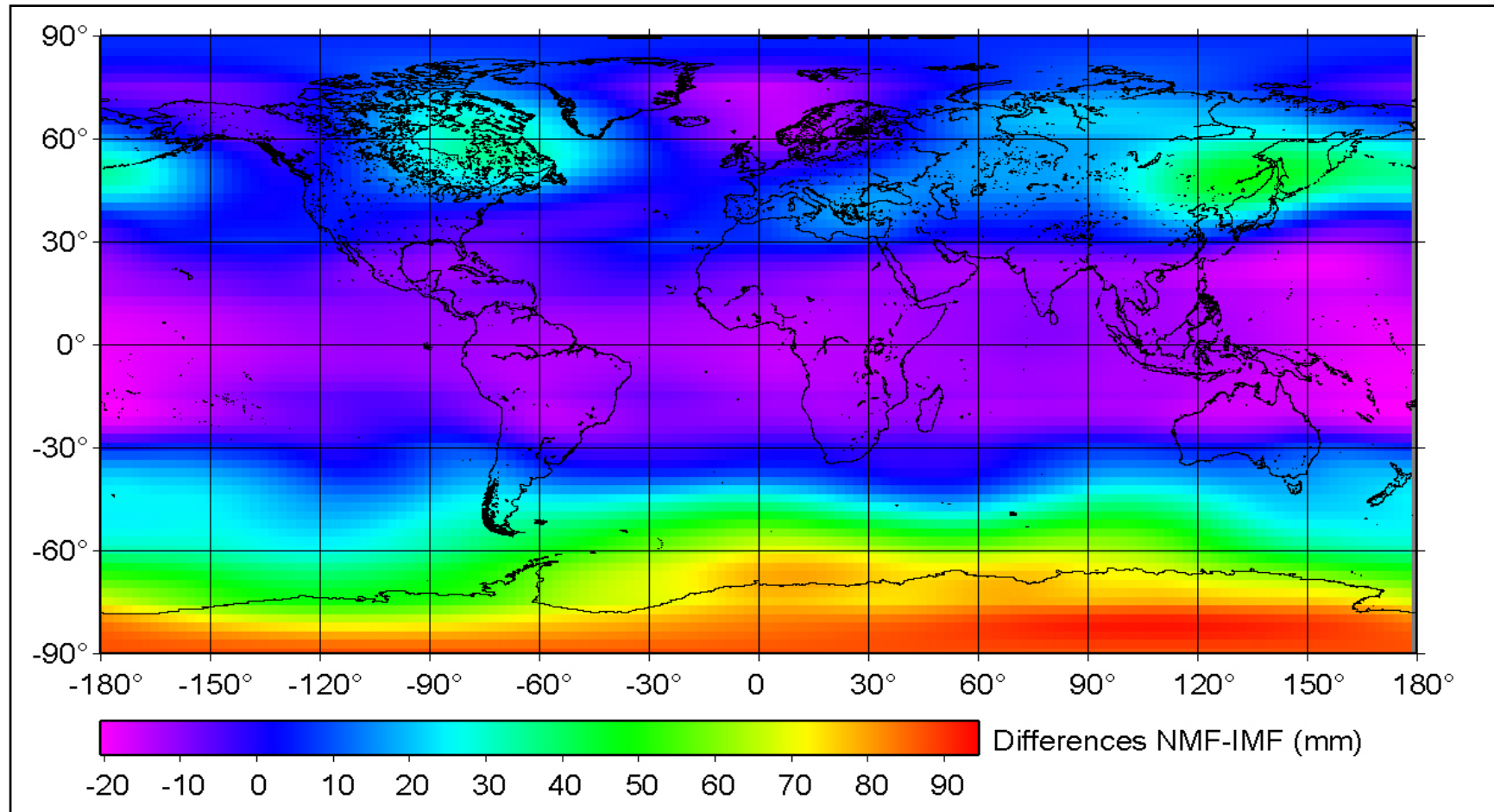
Niell Mapping Function (NMF)

- Widely used within the geodetic community
- Temporal resolution: 1 day, spatial resolution 15° in latitude, no longitude dependency
- Three major deficiencies:
 - seasonal behavior of the southern and the northern hemisphere is the same
 - equatorial region from 15°S to 15°N is described by the 15°N latitude profile
 - polar regions with latitudes larger than 75° are described by the 75°N latitude profile

Isobaric Mapping Function (IMF)

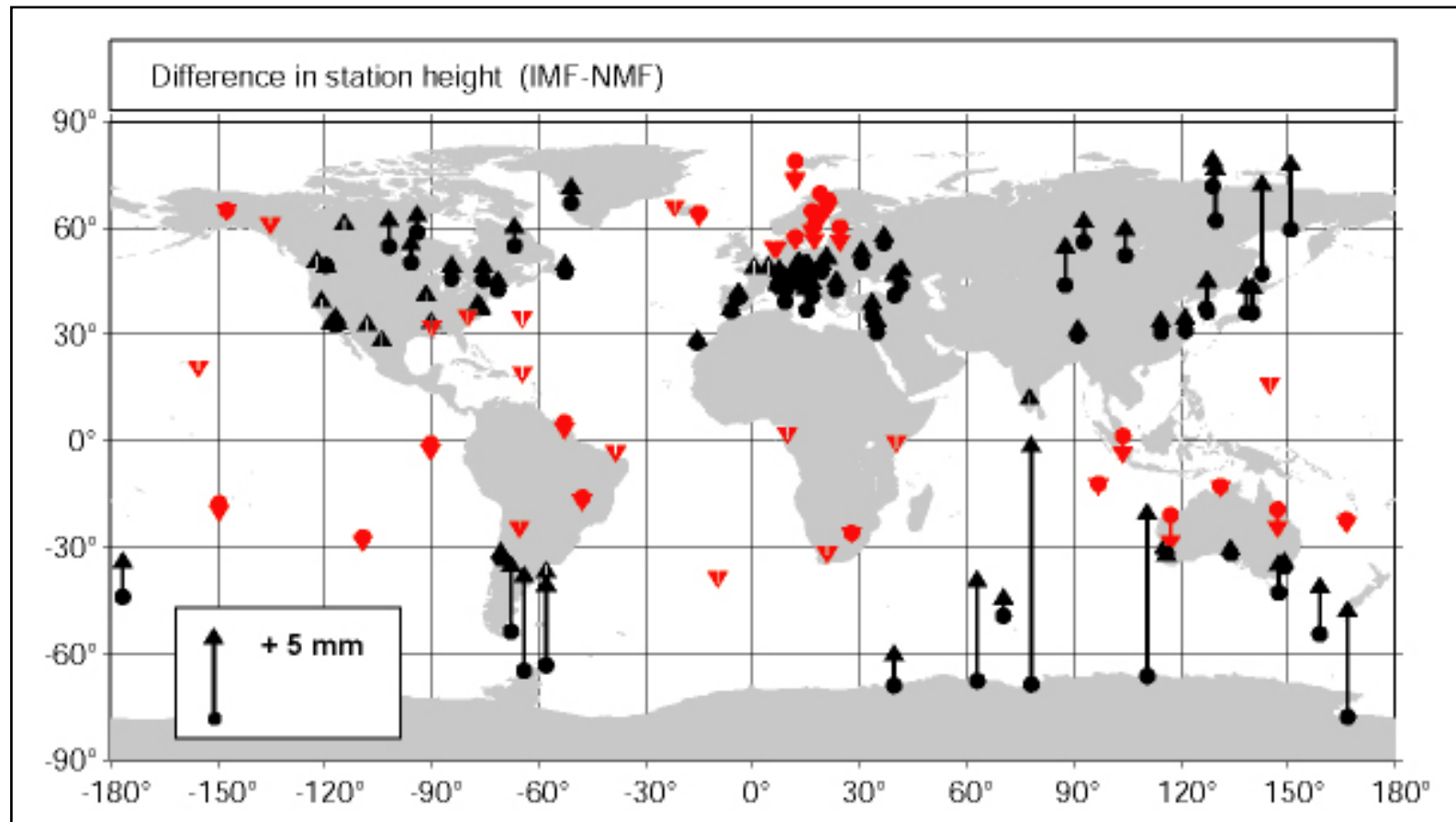
- Based on numerical weather model data: height of the 200 hPa pressure layer
- Resolution depends on the weather model, e.g. ECMWF: 6 hours temporal and $2^\circ \times 2.5^\circ$ spatial resolution
- more realistic modeling of the atmosphere

Differences between NMF and IMF



Slant delay differences between NMF and IMF at 5° elevation (mean of 2002)

Effects of Mapping Functions on Station Heights



Mean station height differences between solutions with IMF and NMF for the year 2002

Vey et al.: Influence of mapping function parameters on global GPS network analyses - comparisons between NMF and IMF, GRL (accepted for publication)

2nd and 3rd-order Ionospheric Effects

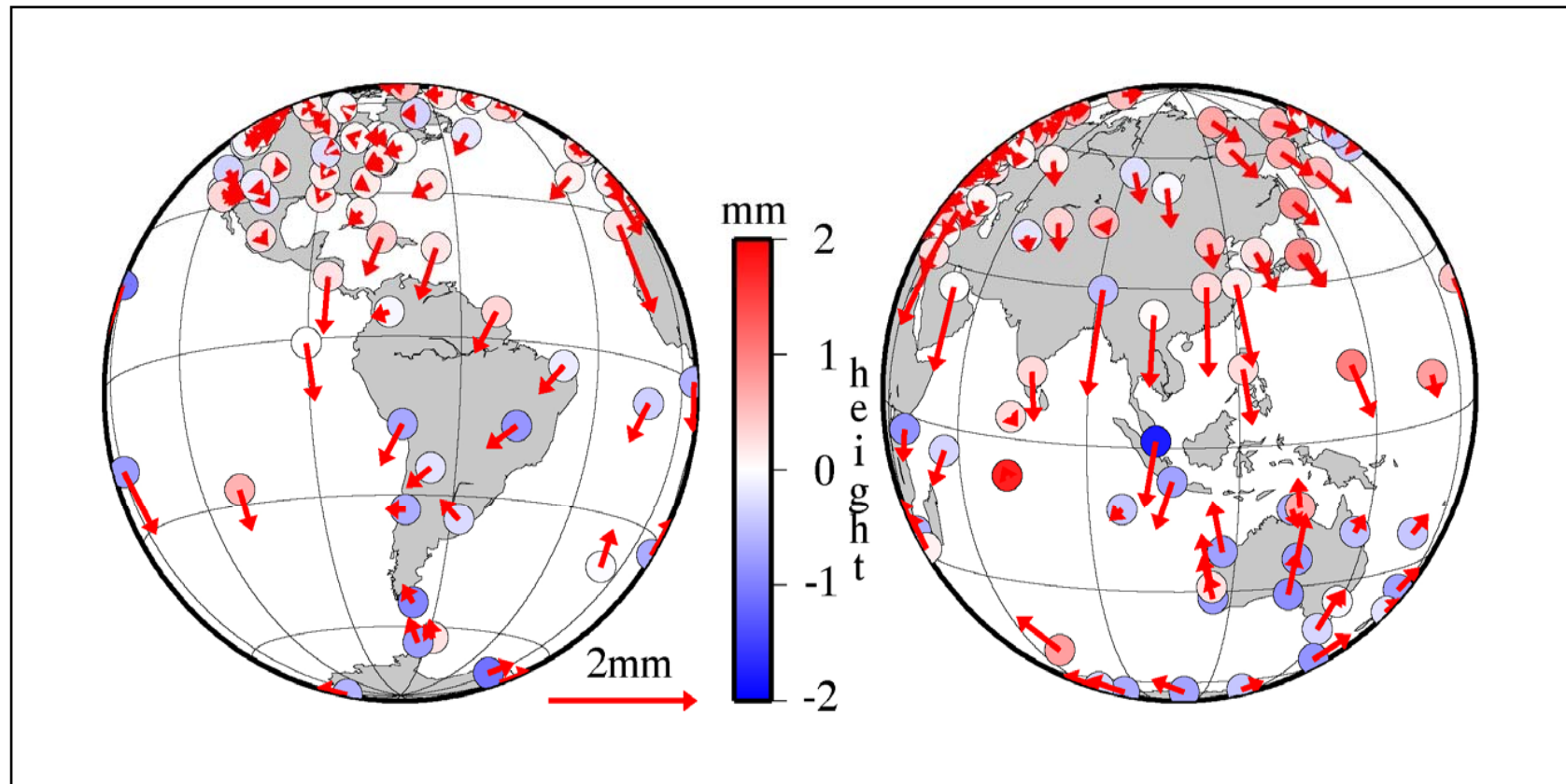
$$L_i = \rho - \frac{q}{f_i^2} - \frac{1}{2} \frac{s}{f_i^3} - \frac{1}{3} \frac{r}{f_i^4} + \dots + n_i \cdot \lambda_i$$

2nd-order term $\frac{s}{f_i^3} = \Psi(f_i, \mathbf{B}_0, \mathbf{k}, \text{TEC})$

3rd-order term $\frac{r}{f_i^4} = \Psi(f_i, \text{TEC})$

L_i	Phase observation of frequency f_i
ρ	Distance satellite - receiver
q, s, r	Ionosphere-related integrals along the signal propagation path
$n_i \cdot \lambda_i$	Ambiguity term
\mathbf{B}_0	Magnetic field vector
\mathbf{k}	Signal propagation unit vector
TEC	Total electron content

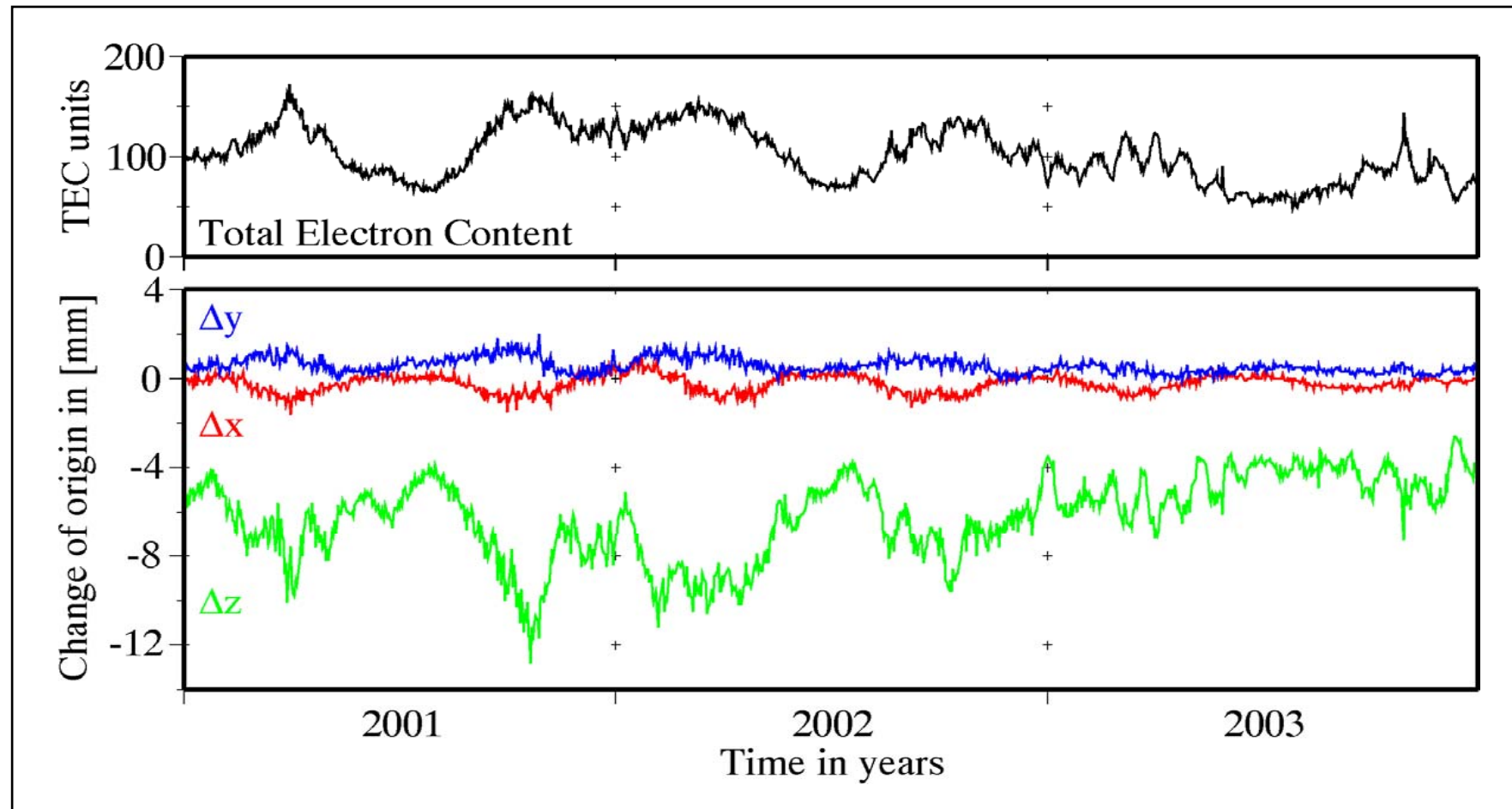
Mean Coordinate Residuals



Residuals of 1-year solutions with and without modeling of the 2nd and 3rd-order ionospheric effect

Fritsche et al.: Impact of higher-order ionospheric terms on GPS estimates, GRL (accepted for publication)

Origin of the Reference Frame



Effects of the 2nd and 3rd-order ionospheric corrections on the origin of the reference frame

Antenna Phase Center Variations

	PCVs	z-offsets	Radomes
Relative Model	Receivers only	block-specific	not considered
Absolute Model	Receivers + Satellites	satellite-specific	partially calibrated

Relative

phase center variations relative to the Dorne Margolin T antenna



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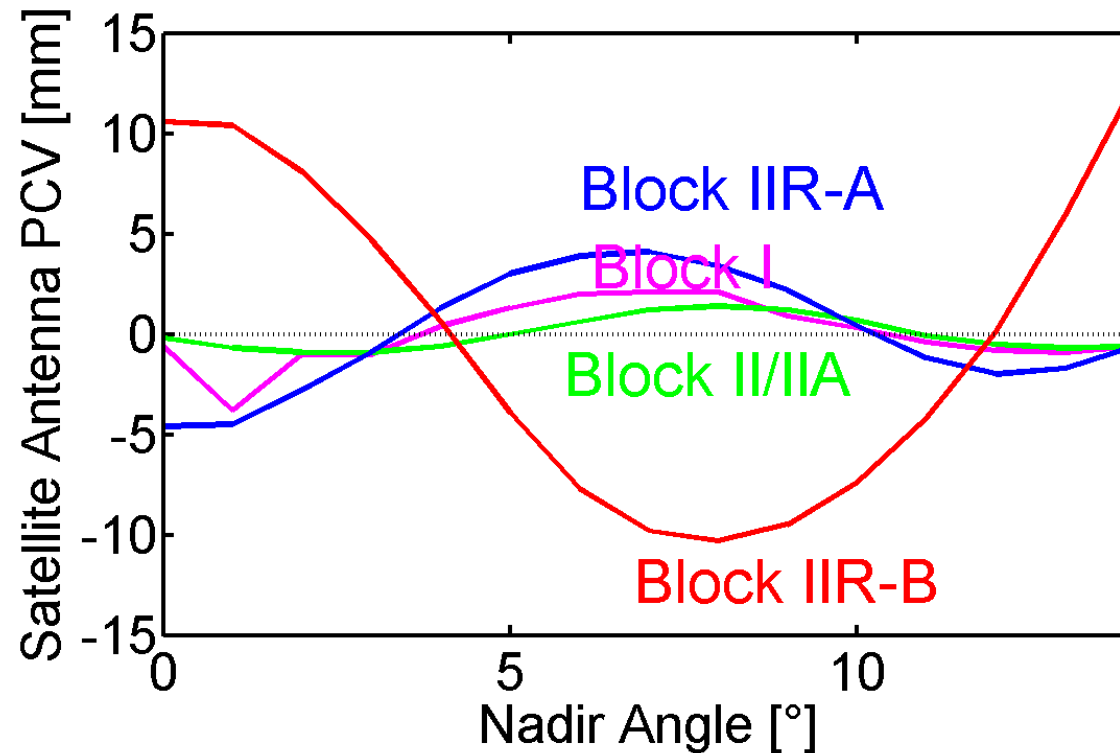
Absolute

robot calibrations or anechoic chamber measurements



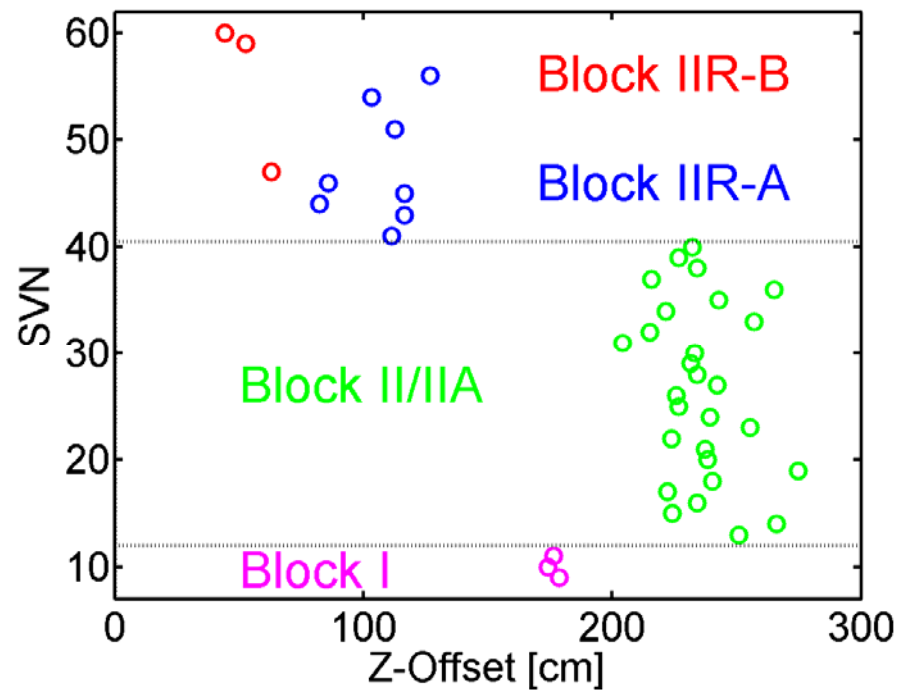
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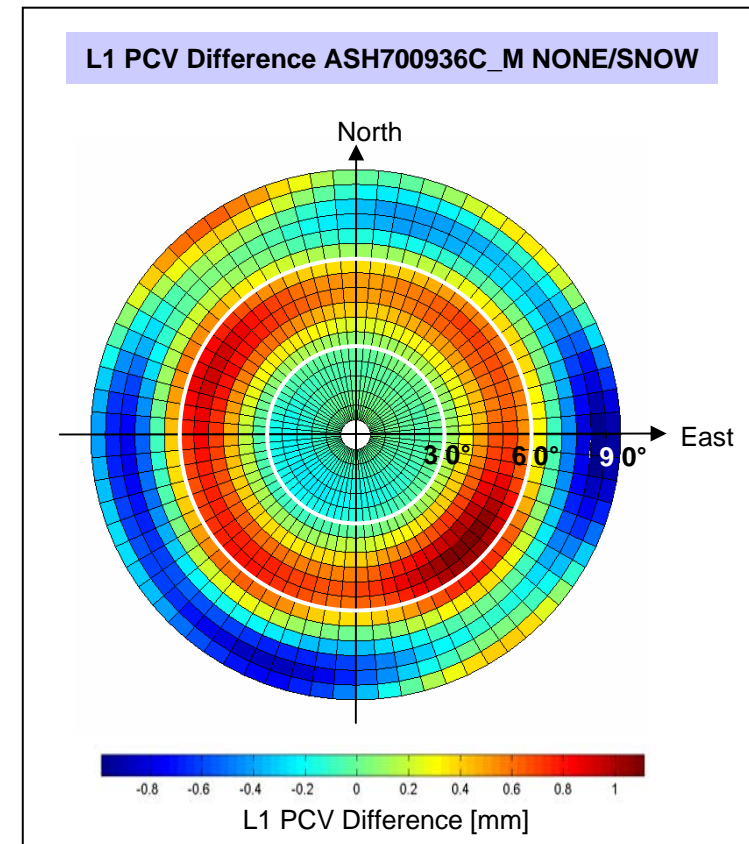
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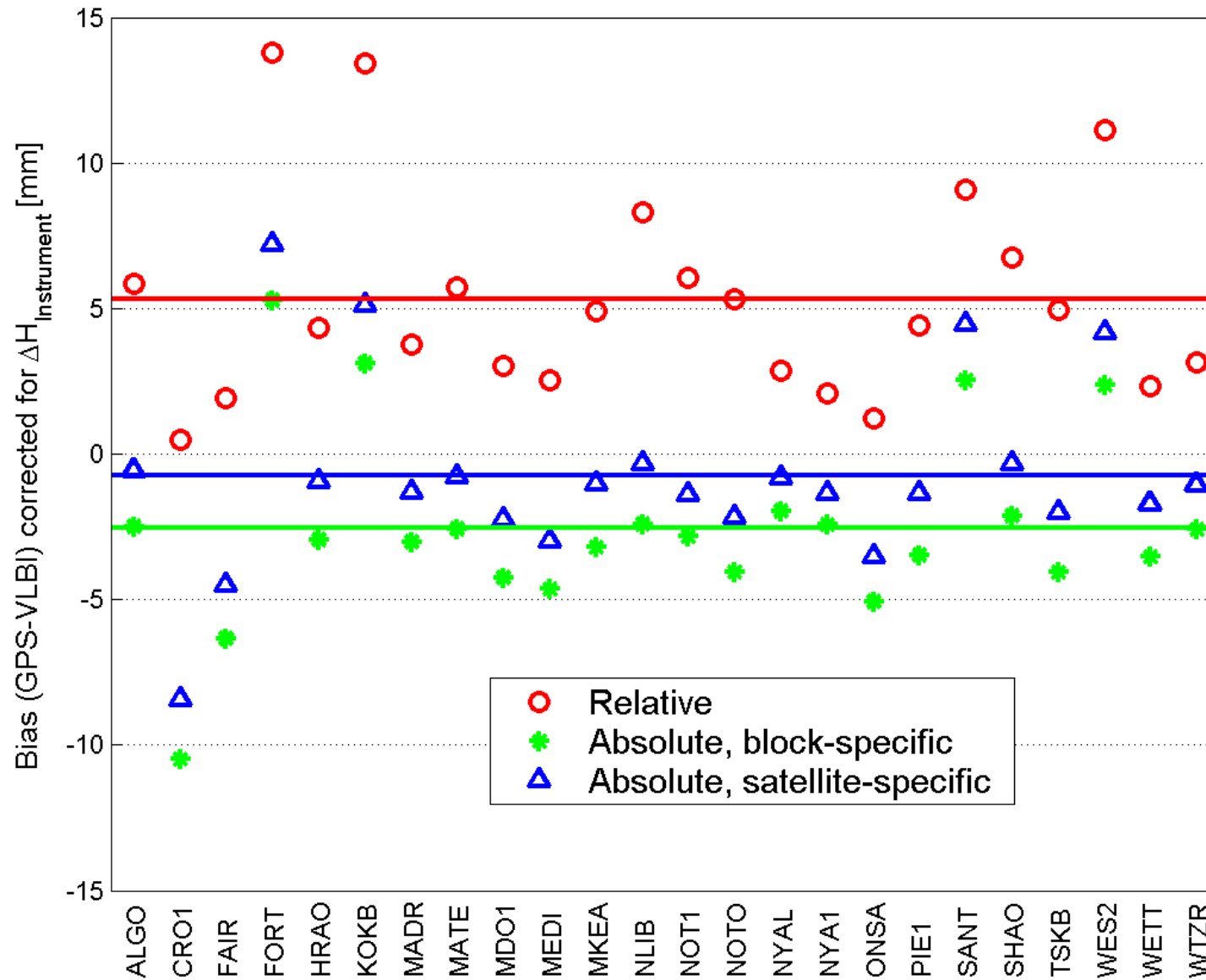


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Troposphere Parameters: Comparison with VLBI



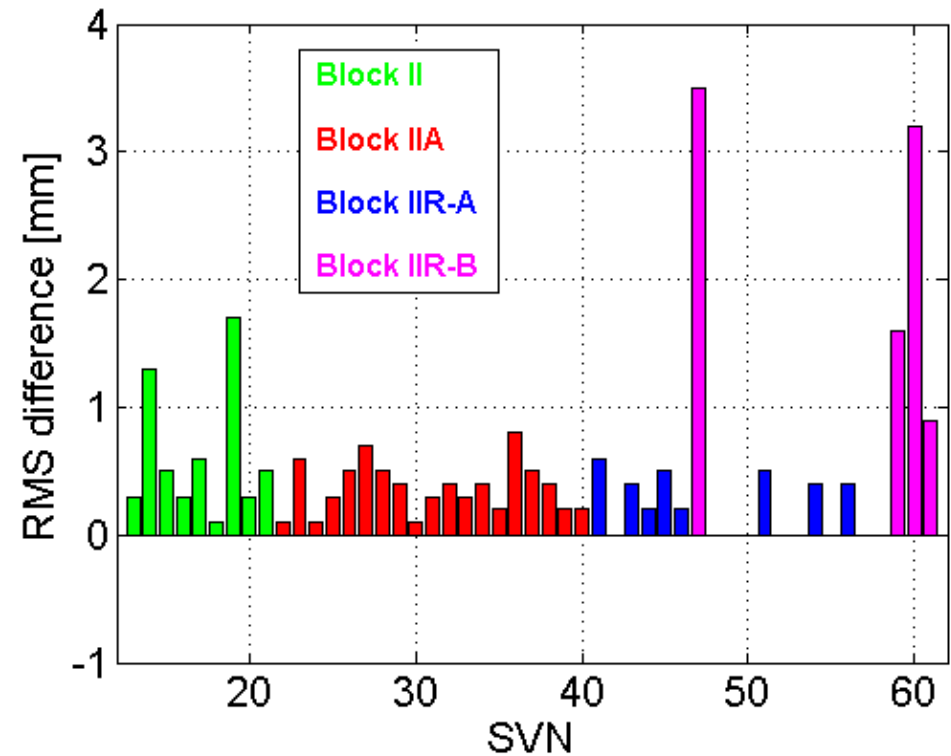
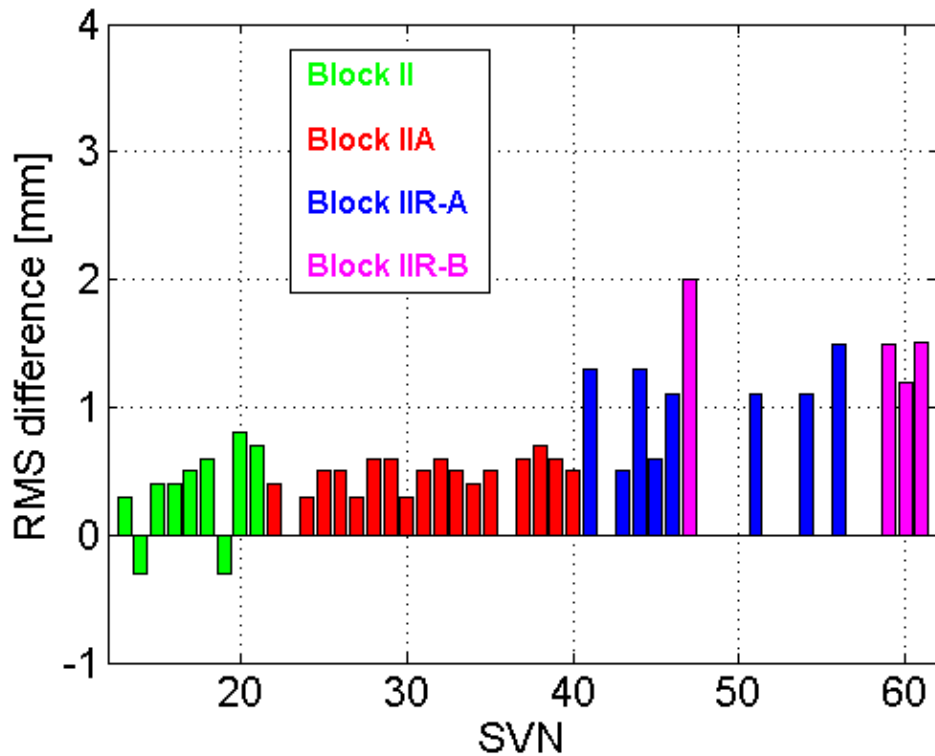
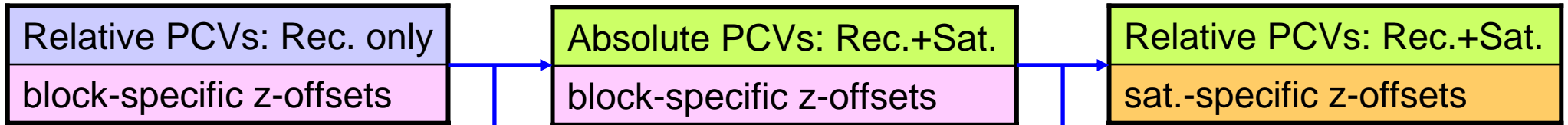
Mean Biases

5.3 mm

-2.5 mm

-0.8 mm

Orbit Consistency: RMS Reduction of 3-day Fits



Conclusions

- A **complete GPS reprocessing** significantly improves the quality and homogeneity of the estimated parameters
- **Mapping functions** based on numerical weather models like IMF allow for a more realistic modeling of the troposphere
- **Higher-order ionospheric corrections** are on the millimeter level and should be considered for global high-precision GPS applications
- **Absolute PCVs** reduce the bias in the troposphere parameters compared to VLBI and improve the orbit consistency
- Transition from relative to **absolute PCVs** within the **IGS** planned for 2006
- **IGS Reanalysis** project also planned for 2006