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Group delay variations of GPS satellite antennas and their temporal stability

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Motivation

Group delay variations (GDV) of transmitting and receiving GNSS antennas affect code pseudorange measurements. Concerning GPS, they can reach up to 1.0 m (3.3 ns) in the ionosphere-free linear combination of C1 and P2 for specific combinations of satellite and receiving antennas (Wanninger et al. 2017). The objective of this poster is to determine the temporal stability of GDV corrections. It focuses on the GDV of the GPS Block IIR and IIF satellite antennas.

Method

We analyzed the first week of observation data of each month in a period of one year (12/2015-11/2016) of 17 globally distributed stations of the IGS and NGS networks (Fig. 1). All stations meet the following requirements:

- identical antenna and receiver types, i.e. TRM59800.00 antenna and TRIMBLE NETR9 receiver, to avoid antenna- and receiver-specific effects,
- elevation mask set to 5° or lower to cover the whole elevation range and thus the nadir angle range from 0° to nearly 14°,
- low multipath (MP) level of <0.5 m RMS between 10° and 90° elevation,
- observation data available on at least 5 of 7 days in all 12 weeks.

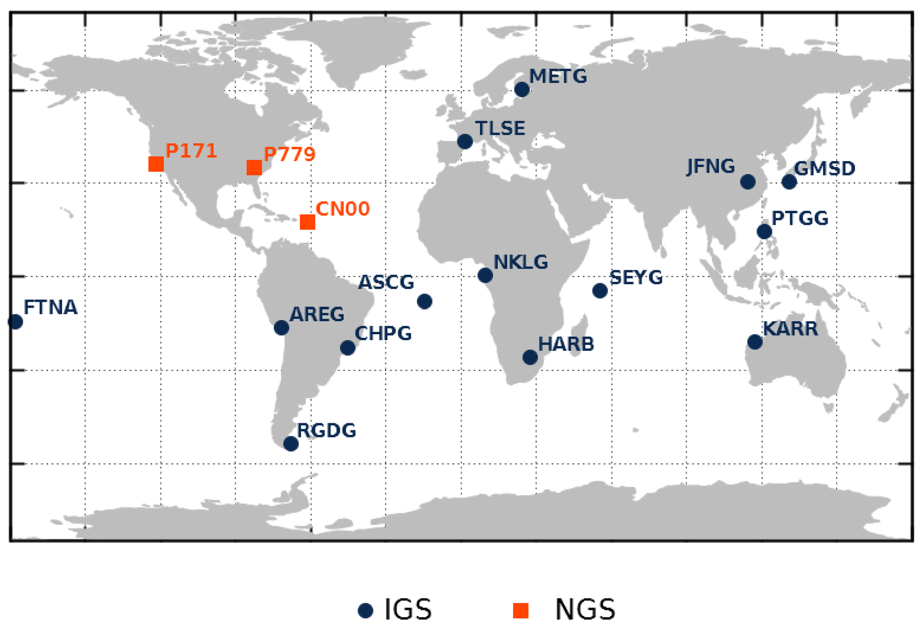

Fig. 1 Network of 17 stations in the IGS network (blue dots) and NGS network (orange squares) with identical antenna and receiver types (TRM59800.00 and TRIMBLE NETR9)

Our GDV analysis is based on the MP linear combination

$$MP_i = C_i - \Phi_i + 2\lambda_i^2 \frac{\Phi_j - \Phi_i}{\lambda_j^2 - \lambda_i^2}$$

where C_i, Φ_i and λ_i are pseudorange, phase and wavelength of one signal, while Φ_j and λ_j are phase and wavelength of a second signal with different frequency. MP_i is a geometry-free code-phase difference corrected for ionosphere delays (Simsky 2006). It is dominated by high-frequent code multipath but also contains information on the low-frequent GDV.

We modeled the MP observables piece-wise-linear as a function of the nadir angle at the satellite in steps of 1°. Thus, in the examined year, we derived 12 GDV model parameter sets per GPS satellite and frequency band C1, P2, and for their ionosphere-free linear combination. These parameter sets were statistically analyzed and compared to the earlier findings of Wanninger et al. (2017).

Results

Typical examples of GDV model parameters are shown for one selected satellite (SVN 56) in Fig. 2. For the ionosphere-free linear combination, the maximum variations between 0° and 14° nadir angle reach up to 80 cm. No temporal systematic biases or trends can be identified. RMS values w.r.t. an annual mean GDV model do not exceed 2 cm for C1 and P2, and 6 cm for the ionosphere-free linear combination for nadir angles larger 1°. The variations are larger for nadir angles smaller than 2° due to the low number of observations in the corresponding elevation range above 80°.

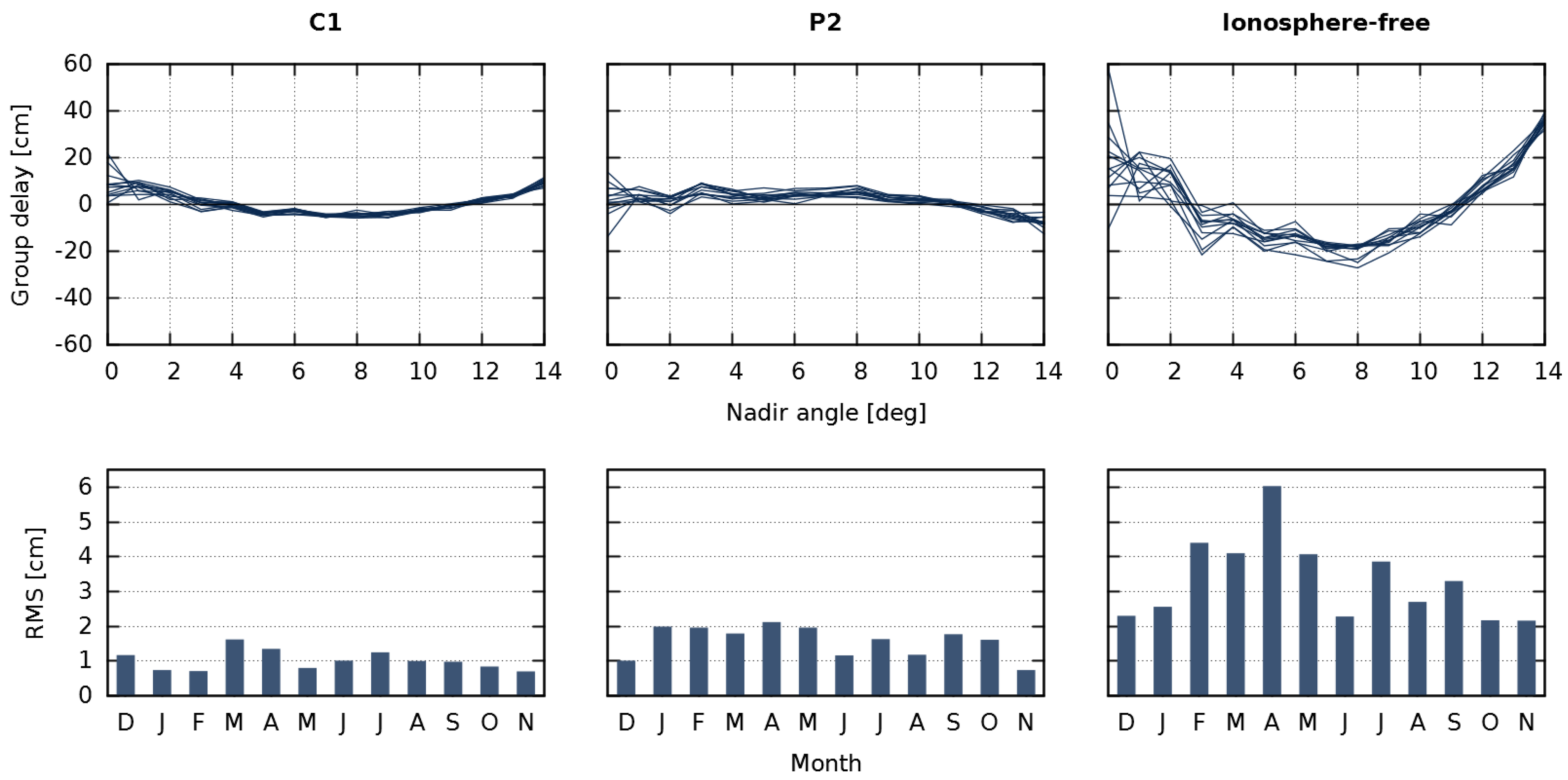

Fig. 2 Results for GPS Satellite SVN 56. Upper panels: GDV models for C1, P2, and ionosphere-free linear combination. Lower panels: RMS w.r.t. mean model parameters (12/2015-11/2016)

Fig. 3a shows mean annual GDV models of the ionosphere-free linear combination for all GPS satellites. They are more pronounced for Block IIR than for Block IIF satellites. But both are stable on the level of 5 cm RMS during the examined year, see Fig. 3b. However, compared to earlier findings of May 2015 in Fig. 3c, the RMS of SVN 55 clearly exceeds the RMS values of the other satellites, which could indicate a temporal variation.

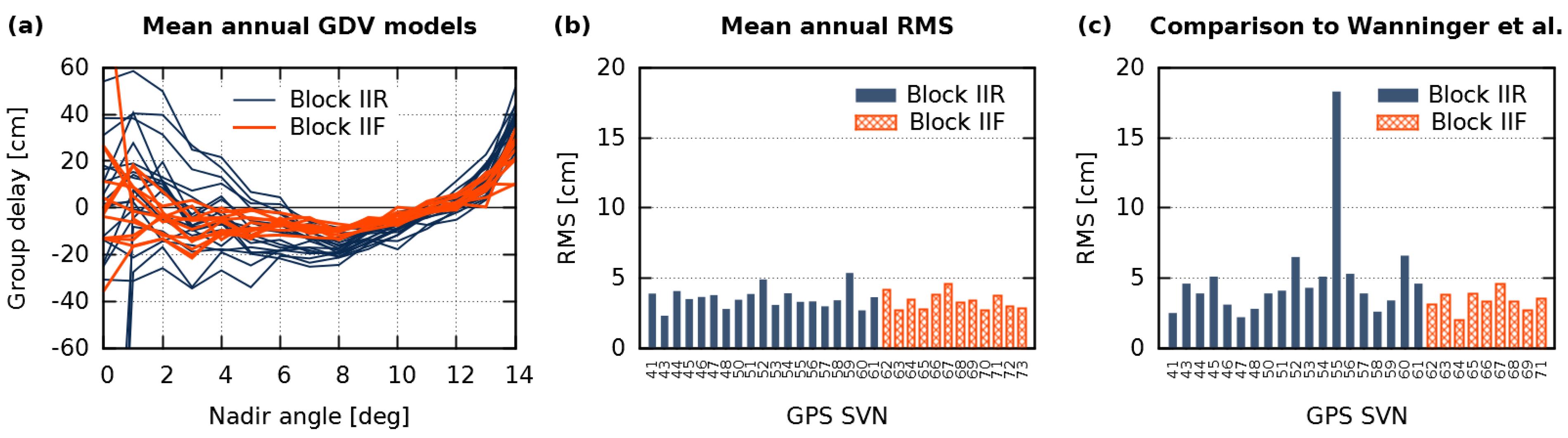

Fig. 3 Results for ionosphere-free linear combinations and different GPS satellite blocks: (a) annual mean of GDV models, (b) mean RMS w.r.t. mean annual GDV models, (c) RMS of differences to the findings of Wanninger et al. (2017)

Conclusion

GPS Block IIR satellite antennas are more affected by GDV than those of Block IIF.

During the examined year, the GDV of GPS Block IIR and IIF satellite antennas are stable on the level of 2 cm RMS for C1 and P2, and 5 cm for the ionosphere-free linear combination.

The GDV models of GPS satellite SVN 55 differ from earlier findings, which could indicate a temporal instability.

Challenges

The estimation of reliable GDV model values for nadir angles smaller than 2° is difficult because of the low number of observations for elevations above 80°. A denser network of equally equipped stations could help.

The available number and distribution of stations providing observation data on L5 was not yet sufficient to estimate GPS GDV models for C5.

Acknowledgements

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References

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