Session Description

This session considers all the full range of effects that may corrupt GNSS signals or induce undesirable contributions in GNSS analysis results. We focus particular attention on those effects that may have been neglected before, are of most serious magnitude, may be particularly insidious in obscuring genuine geophysical signals (such as aliasing), or degrade the stability of the reference frame.

Questions concerning the quality of IGS products and future improvements have a platform in this session, too. This includes the correlation of orbit modeling deficiencies with apparent geocenter variations or causes for persistent biases between AC products as well as further improvements of the IGS products, e.g. for applications such as precise point positioning. Of interest for users of IGS products are discussions on the procedures promising the most precise and least biased results in the vast field of applications.

It is likely that significant technique-related errors (e.g. caused by near-field and far-field multipath) are sometimes being misinterpreted as geophysical effects. Therefore, it is critical that the IGS take a stronger role in identifying the sources of GNSS errors and in finding strategies to mitigate their effects. This will require new research activities to better understand some suspected error sources. All aspects of GNSS geodesy are potentially involved, from field observations through data analysis and interpretation.

Session Summary

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A position paper was prepared with a list of topics and questions that fit into the broad spectrum of effects that potentially induce undesirable contributions in GNSS analysis results. Not all of them could be adequately covered by the session, time was too short, but all deserve attention and further investigations. Topics that were covered by presentations in the session were: consistency of IGS products (Gendt), systematic errors of IGS Rapid orbits (Slabinski), SLR validation of GNSS orbits (Urschl), GPS/Galileo receivers and observables (Sleewaegen), systematic errors in GPS position estimates (Ray), modified sidereal filtering (Larson) and atmospheric mapping functions (Böhm). Several of the topics showed the close connections to other sessions, in particular to ABSA, GNSS, and OTHE.

The presentation of Gerd Gendt contained a large amount of information concerning quality and consistency of AC products. He compared ERP information from SINEX and from rapid and finals submissions and found prominent frequencies, e.g., at semi-annual and 14.2 day periods. Comparison of scales shows that each AC SINEX solution exhibits its own terrestrial scale while the orbit scales are very similar. Interestingly precise point positioning performs better with IGS rapid products than with final products due to more consistent clocks. This is a clear indication that the consistency of AC products needs to be improved.

Victor Slabinski shows using the well tried overhead projection technique – the only of the entire workshop – that systematic orbit overlap discontinuities exist for the IGS rapid as well as for the final orbits with sizes of a few up to some 15 cm in all three components. Possible causes could be radial biases originating from antenna phase centers or an unmodeled radial acceleration. The ACs should study the sources of the problem. In the discussion it was stated that the magnitude of the discontinuities are consistent with the claimed orbit accuracies. It was also indicated that orbit interpolation across day boundaries may be affected.

In an excellent presentation Claudia Urschl showed evidence for GPS orbit modeling deficiencies based on SLR validation results from four years. The variations of the residuals are strongly correlated with the position of the Sun with respect to the orbital plane and the satellite's position. Similar effects are observed also for orbits from different ACs, however not for GLONASS. It is, therefore, a must to have retroreflectors for at least each satellite type in order to independently validate the orbit quality and identify satellite-type specific orbit modeling problems.

Jean-Marie Sleewaegen reviewed in an informative presentation the expected Galileo signals, compared the observable types in terms of instrumental errors and biases, and mentioned also current Galileo activities and experimentations with GIOVE-A. Users of the new signals profit from better modulation, reduced tracking noise and multipath errors, and the presence of a pilot component promising better tracking perfomance. All measurements will be sampled at the same time, and biases are either small or non-existing.

Jim Ray presented three case studies and a large number of examples that show systematic errors in positioning estimates. An interesting result is the identification of a 350 days period signal in station coordinate residuals based on 10 years time series. The period corresponds to the Sun's repeat period with respect to the satellite constellation. The observed signal is thus very probably not of geophysical. Similarly changes of the character of coordinate time series are in many cases correlated with instrumental changes. The magnitude of day boundary clock jumps, too,

correlates with the size of vertical position residuals. Near-field multipath is a probable cause for the observed effects. Improvements may require major reference frame infrastructure upgrades. The best station configuration is, however, not yet well understood.

Christine Larson, in a paper presented by Geoff Blewitt, shows the correlation between 1Hz position time series between days, shifted by 255 seconds. The pattern does not repeat when different satellites are tracked or when different carrier phase biases have been introduced. In addition, the repeat times of satellites vary. Cross-correlation of position time series on two days can be used to estimate the optimal time shifts for a given time and site. The power spectrum of position time series significantly improves with sidereal filtering. Other solutions for mitigating multipath are the use of postfit residuals from previous days or residual maps. Indicative is also the signal-to-noise ratio.

Results presented by Johannes Böhm show systematic vertical height changes of up to 15 mm in the Antarctica between the Niell and the VMF1 mapping functions. Comparison with radiosonde data and validation using station coordinate repeatability shows increasing performance for the NMF, GMF, IMF, VMF1. Therefore VMF1, available for 650 GPS sites as well as on a grid, or GMF should be used for maintaining the reference frame and VMF1 for geophysical studies. In the discussion the construction of an empirical model for the hydrostatic delay and gradient was suggested.

In the session discussion the question was raised whether satellite PCV maps should be redone in view of the modeling issues identified. The consensus is, however, not to further delay the switch to absolute patterns and to compute new patterns in the course of the reprocessing. It is stated that with the switch to absolute patterns ACs shall also enable light deflection. Reprocessing results should be validated with SLR. The VMF1 should be checked for sub-diurnal periods in the troposphere. And finally it is stated again that at least one satellite of each type should carry a Laser retroreflector.

The main recommendation of the session asks that IGS stimulates research leading to a better understanding of the different error sources and technique related problem, in particular for not well understood effects such as near-field multipath, e.g., by organizing of dedicated workshops or sessions at conferences, or by initiating a special issue of Journal of Geodesy. Further recommendations request the ACs to improve consistency between their products and to verify the consistency with respect to the used IERS Conventions, and the IGS to intensify the interface to receiver manufacturers in order to agree on a common minimal tracking mode for IGS like activities.