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Jürgen Müller and Helmut Hornik

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Nuisance Effects in GNSS

L. WANNINGER¹, S. SCHÖN²

Introduction

Observations of the signals from satellites of one of the GNSS (the US-American GPS, the Russian GLONASS, the future European Galileo and quite a few planned regional systems) are influenced by several factors which adversely affect the accuracy and reliability of the positioning results. The most important influences are ionospheric and tropospheric propagation delays, multipath from the surroundings of the receiving antenna, and antenna phase centre variations (PCV) of both the receiving and the transmitting antennae (cf. SEEBER 2003).

Ionospheric and tropospheric propagation delays can be reduced considerably by relative GNSS using a single reference station or even better a network of reference stations surrounding the observation site. Multipath and PCV, however, are station and antenna dependent effects. They are dealt with in the measurement procedure or by calibration.

During the past four years a considerable amount of research work has been carried out in the field of nuisance effects affecting GNSS observations. A selection of key publications is given in the text. A more extensive list is included in the references.

Ionospheric propagation delay

First-order effects of the ionospheric propagation delay are successfully removed by using dual-frequency observations (ionosphere-free linear combination). Higher-order effects are typically ~0-2 cm at zenith, larger for lower elevated satellites, but at the same time smaller for relative positioning applications. Nevertheless, corrections for the higher-effects can easily be obtained and may improve positioning results (FRITSCHET et al. 2005, MAINUL HOQUE, JAKOWSKI 2007).

Relative ionospheric propagation delays influences the reliability and success rate of ambiguity resolution even in case of dual-frequency observations. The pre-processing of the observation data of networks of reference stations does not only provide improved ionospheric real-time correction models but can also produce valuable information on the size of ionospheric residuals which will affect baseline processing (CHEN et al. 2003, WANNINGER 2004).

Tropospheric propagation delay

There are several approaches to reduce the influence of tropospheric propagation delays which mainly affect the height component of the positioning results; application of standard tropospheric corrections, relative positioning, estimation of tropospheric delays as additional unknowns etc. In practice these approaches are combined to yield precise positioning results.

Research work dealt with standard tropospheric models for Galileo (POSFAY, 2003, KRUEGER et al. 2004), comparison of tropospheric mapping functions (VEY et al. 2006) and radiometric measurements for validation studies (HAFELE et al. 2004). Tropospheric modelling based on GNSS observations from moving platforms has been studied by SCHÜLER (2006a).

Multipath mitigation

The ability to discriminate between direct and reflected signal in the measurement process largely depends on the signal characteristics. New signals structures were analysed regarding their multipath performance in order to select appropriate signals for the Galileo system (IRSIGLER et al. 2004, PANY et al. 2005, ÁVILA-RODRIGUEZ et al. 2006).

An alternative approach for permanent stations or identical antenna set-ups is multipath calibration. Calibration of carrier-phase multipath effects caused by signals reflected in close vicinity (… 10-20 cm) of the antenna has been performed by WÜBBENA et al. 2006b. In-situ multipath calibration of an antenna and its surroundings has been published by DILSSNER et al. (2006).

Uncorrected multipath effects may cause an apparent height shift of up to approx. 1 cm in case of an antenna exchange. This phenomena has been observed e.g. in the German SAPOS network of permanent GPS-stations (KLEIN, KLETTE 2005, WANNINGER et al. 2006). It illustrates the unresolved difficulties precise height determination still faces.

Antenna phase centre variations

Many research groups contributed to a better understanding of the antenna phase centre variations (PCV) of both the receiving antennae and the transmitting antennae on-board the GNSS satellites. Receiving antennae are calibrated either in the field using the original GNSS signals (MENGE

¹ Lambert Wanninger: TU Dresden, Geodätisches Institut, D-01062 Dresden, Germany, e-mail lambert.wanninger@tu-dresden.de
² Steffen Schön: Leibniz Universität Hannover, Institut für Erdmessung, Schneiderberg 50, D-30167 Hannover, Germany, e-mail schoen@ife.uni-hannover.de
The data processing of regional or global GNSS-networks made use of so called relative PCV corrections until recently. Although it had been shown for several years that absolute corrections would be required (MENGE 2003, VOLKSEN 2005) it lasted until 2006 to change the processing procedures of these large-scale networks. The processing of these networks also requires PCV corrections of the GNSS satellites. These corrections are estimated from the ground observations as additional unknowns in the adjustment procedure (SCHMID et al. 2003, SCHMID et al. 2005).

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