3.6.2.6 GeoForschungsZentrum Potsdam (GFZ)

Introduction

The IERS Combination Research Center (CRC) at GFZ performed most of the work concerning the combination of space geodetic techniques in the framework of the project GGOS-D. The major features of this project are the high degree of standardization of the modeling and parameterization between the software packages that were used, the consistent reprocessing of all observations and the exchange of datum-free normal equation systems (NEQs). Thus, the resulting time series of parameters are very homogeneous and a rigorous combination of the individual contributions is possible. The project GGOS-D has been financed by the German Ministry of Education and Research (BMBF) as part of the large program "Geotechnologien – Observation of the Earth from Space". More about the project GGOS-D may be found in the IERS Annual Report 2007, Section 3.7.2 "WG on Combination".

In the following a few of the results of this project will be shown:

- Assessment of the quality of local ties using Earth Rotation Parameters (ERPs)
- Assessment of the quality of local ties using troposphere gradients
- Atmospheric loading effects in VLBI and GPS height time series

More information about the project and its results may be found in Rothacher et al. (2011), more information about all the projects in the Geotechnologien Program is contained in the Springer book by Flechtner et al. (2010) and its predecessor by Flury et al. (2006). See also the references below for further publications in this context.

Assessment of the quality of local ties using Earth Rotation Parameters (ERPs)

The local ties forming the link between the station positions of the individual techniques play a crucial role in the inter-technique combination. As a criterion for a good selection of local ties the pole coordinates were considered. In a first step all available local ties were introduced into the combination, but the ERPs were not combined, i.e., for each observation technique (GPS, VLBI and SLR) an individual pole time series was estimated. Under ideal circumstances, all three pole time series should agree. Discrepancies between the pole time series could then be attributed to individual local ties that were then removed from subsequent computations. Figure 1 shows the iterative process for the selection of appropriate local ties between GPS and VLBI co-locations.

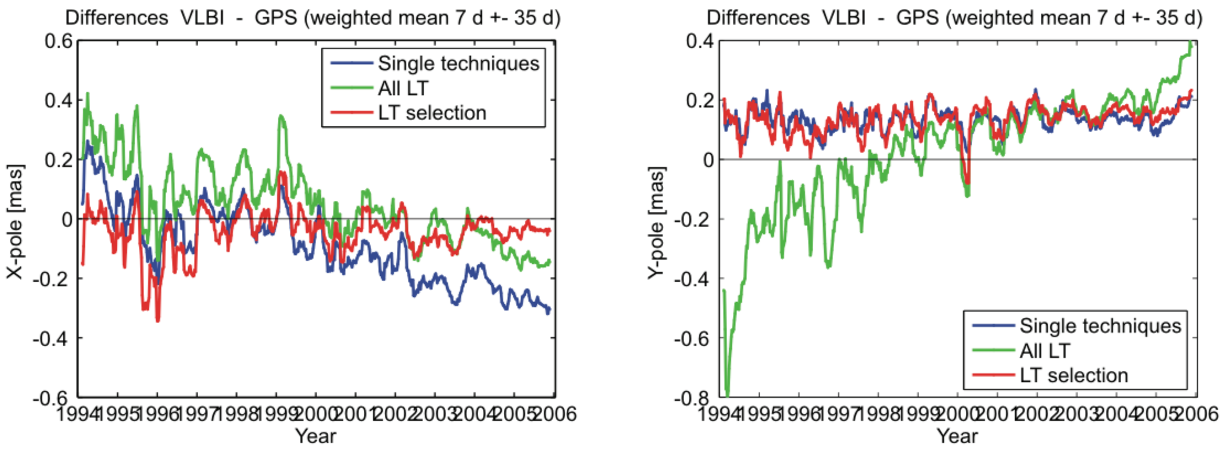

Fig. 1: *Differences in the pole coordinates as indication for the quality of the local ties used.*

Assessment of the quality of local ties using troposphere gradients

The known correlation between station coordinates and troposphere parameters may also be used to assess the local ties selected for linking the space geodetic techniques VLBI and GPS. Based on the data of the CONT'02 campaign these relationships were studied in detail. Figure 2 shows the troposphere gradients in the north direction for the station Kokee Park. If all local ties available between VLBI and GPS are applied in the combined solution (called „G+V: 8 LT“), the estimates of the troposphere gradients change for both, GPS and VLBI, compared to the estimates resulting from the two single-technique solutions („VLBI-only“, „GPS-only“). If, however, the local tie for Kokee Park is not introduced into the combination, („G+V: 7 LT“), the gradient estimates are almost identical to those based on the single-technique solutions. This is a clear sign that discrepancies are present between the local tie and the difference between the coordinate estimates for Kokee Park derived from VLBI and GPS data.

The smaller discrepancies between the zenith total delays derived from GPS and VLBI, when an accurate common reference frame is used, also show the high correlation between station coordinates and troposphere parameters (here heights and troposphere zenith delays), that can be exploited to assess the quality of the local ties used.

Atmospheric loading effects in VLBI and GPS height time series

In this study, a simple but very direct approach was used for the modeling of deformations caused by atmospheric loading. The changes of the local pressure values (Δp) are multiplied by a coefficient (coef) that is valid locally, in order to obtain the corresponding change in the height component: Δh = coef * Δp. The changes in the local atmospheric pressure were computed from ECMWF pressure fields by a bi-linear interpolation.

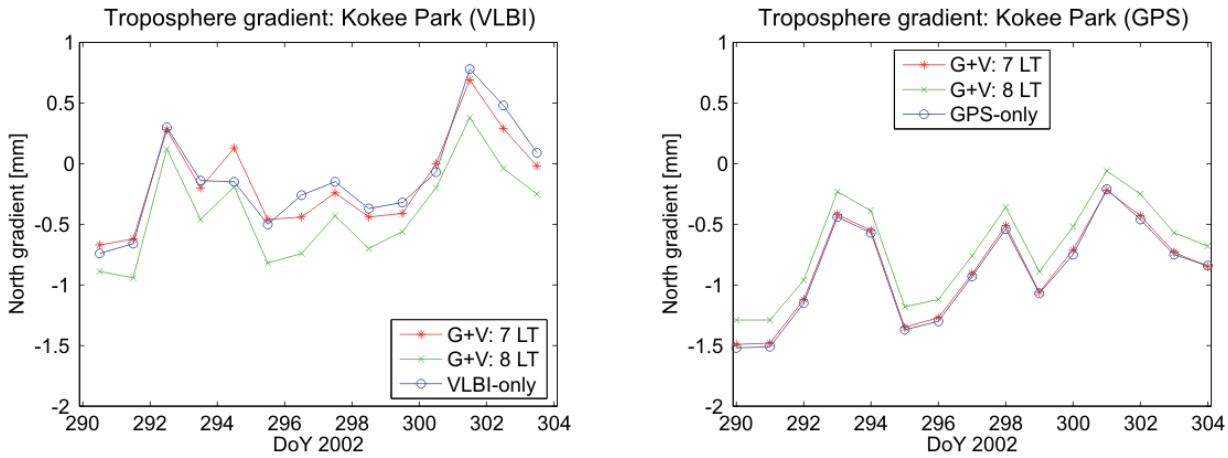

Fig. 2: *Influence of problematic local ties on the troposphere gradients of GPS and VLBI for the station Kokee Park.*

Using the height time series of individual stations, a coefficient was estimated for each station using the method of least squares. These coefficients, estimated for each station, indicate how strongly the Earth surface deforms at the measurement stations in the case of pressure variations. If a station is located, e.g., close to the coast, almost no effect (coef ~ 0) will be expected, whereas noticeable effects (coef < 0) are to be expected in the interior of continental plates.

An analysis has been performed, whether the state-of-the-art GGOS-D reprocessing solutions indeed deliver variations in the height time series that can more adequately be interpreted as deformations caused by atmospheric loading than variations in height time series that are, as usually done, generated using simpler modeling approaches. This would theoretically be expected, because, when using the simple, common approaches with, e.g., constant a priori zenith delays, part of the atmospheric loading signals might be absorbed into the tropospheric parameters.

The VLBI height time series generated by DGFI and the GPS height time series generated at GFZ with the Bernese GPS Software were considered here. Both series were produced twice:

(1) once using the simpler common modeling approaches like the NMF (Niell Mapping Function) and a priori zenith delays (ZD) that are constant in time, and

(2) a second time using the best possible models according to the standards defined within the GGOS-D project, as e.g. the VMF1 (Vienna Mapping Function 1) and a priori ZD computed using atmospheric models of the ECMWF derived from real meteorological data.

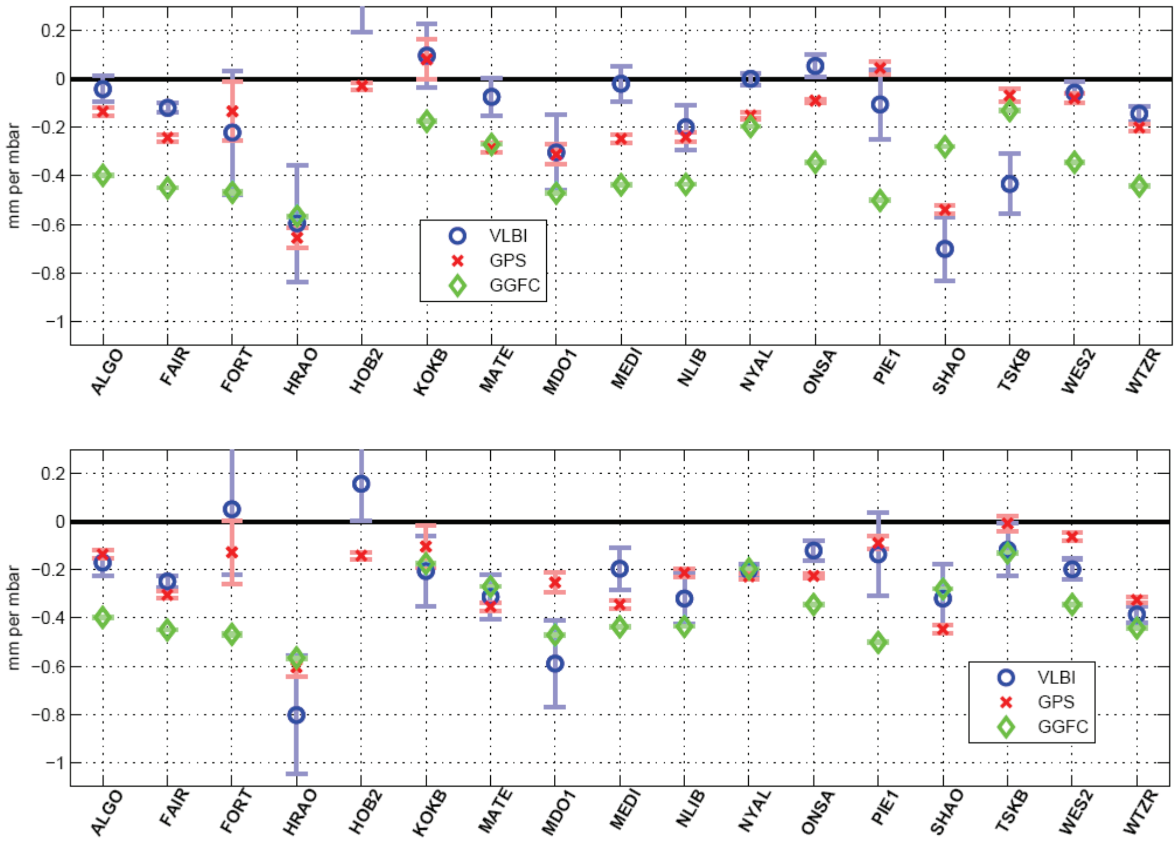

Fig. 3: Atmospheric loading coefficients and their a posteriori RMS values estimated from height time series derived from VLBI (blue circles) and GPS (red circles), for solution types 1 (left) and 2 (right), and, for comparison purposes, the coefficients available at the GGFC (Global Geophysical Fluids Center) (green diamonds).

The coefficients derived from the VLBI and GPS height time series are shown in Figure 3. In addition, coefficients computed in exactly the same way, i.e. using the regression equation Δh_{GGFC} = coeff * Δp_{NCEP}, but using the height time series made available by the Global Geophysical Fluid Center (GGFC), are displayed in Figure 3 for comparison purposes. Δp_{NCEP} is thereby the change in the local air pressure from 1980 to 1997 according to NCEP and Δh_{GGFC} is the crustal deformation computed using the local air pressure changes, the convolution with Green's functions and the assumption of an inverted barometric behavior.

Figure 3 shows that the modeling approach used for the generation of the second GGOS-D solution labeled (2) is better than that of the first solution (1): first of all, the coefficients derived from VLBI and GPS time series are clearly in better agreement for approach (2) (the WRMS of the differences is 0.134 and 0.083 mm/mbar for solution type (1) and (2), respectively). Secondly, with approach (2), also the agreement with the coefficients available at the GGFC is considerably improved: the WRMS values for the differences VLBI-GGFC amount to 0.301 and 0.154 mm/mbar for approaches (1) and (2), respectively, and 0.232 and 0.161 mm/mbar for the differences GPS–GGFC.

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