DGFI Analysis Center Annual Report 2008

Manuela Seitz, Hermann Drewes, Volker Tesmer, Robert Heinkelmann

Abstract

This report summarizes the activities of the DGFI Analysis Center in 2008 and outlines the planned activities for 2009.

1. General Information

The German Geodetic Research Institute (Deutsches Geodätisches Forschungsinstitut, DGFI) is an autonomous and independent research institution located in Munich. It is run by the German Geodetic Commission (Deutsche Geodätische Kommission, DGK) at the Bavarian Academy of Sciences. The research covers all fields of geodesy and includes participation in national and international projects as well as functions in international bodies (see also http://www.dgfi.badw.de).

2. Activities in 2008

1. Homogeneously reprocessed VLBI and GPS height time series

   Homogeneously reprocessed VLBI and GPS height series from 1994 to 2007 were compared. The data analysis used fully adapted state-of-the-art models (such as VMF1 and a priori zenith delays from ECMWF) for the GPS (at GFZ and at TUM with Bernese 5.1) and VLBI (at DGFI with OCCAM 6.1, LSM) processing. The series were compared in terms of long term non-linear behaviour and harmonic and mean annual signals (derived by averaging the positions of all years into one "mean year"). The mean annual signals are quite similar for VLBI and GPS (Figure 1), if the VLBI data is available with an appropriate density. The two almost independent observing techniques show the same mean annual signals at nearly all co-located sites. Therefore we assume that the annual signals can be geophysically interpreted as integral vertical deformations.

   In order to study regional effects, the stations of one region (with a dimension of some thousand kilometers) with a similar mean annual signal are grouped into a cluster. Accordingly 55 clusters are defined. To illustrate the clusters, and how diverse the signals from clustered sites can be, the results for the European region are displayed in Figure 2. They confirm that the signals reflect regional deformations, not local or technical artifacts.

   The most important findings from this study are that (1) for most sites, an annual harmonic function is not a sufficent approximation and that (2) the variations of station heights are regional effects and are induced by mass load variations.

   For each of the 55 clusters, a regional average mean annual signal was computed. They can be used as a tool to validate geophysical models.

2. Atmospheric loading coefficients determined from homogeneously reprocessed GPS and VLBI time series

   VLBI and GPS long term observation series were reprocessed at DGFI and TU Munich. (See above.) The processing was done twice, once with the classical tropospheric modeling (**A**:

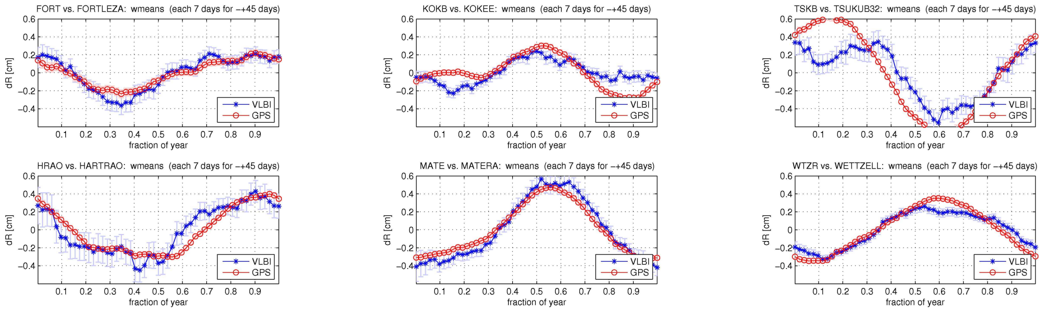

Figure 1. Mean annual behavior of homogeneously reprocessed VLBI (darker/blue asterisks) and GPS (lighter/red circles) height time series at co-located sites (column-wise, from left to right): a) Fortaleza (Brasil), b) Hartebeesthoek (South Africa), c) Kokee Park (Hawaii, USA), d) Matera (Italy), e) Tsukuba (Japan) and f) Wettzell (Germany).

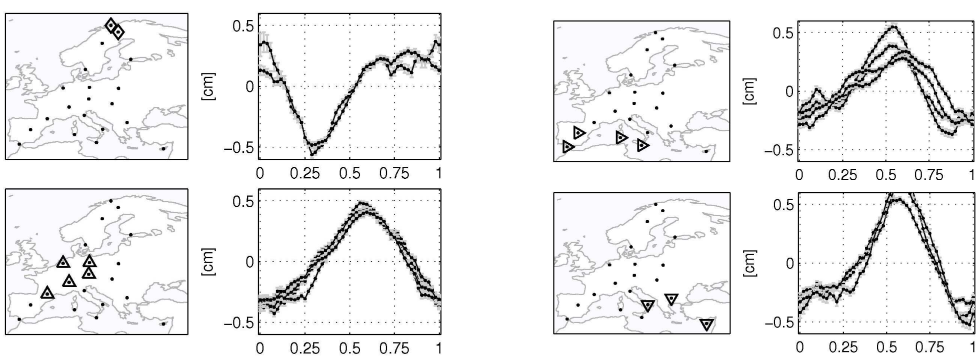

Figure 2. Mean annual signals for the defined four European clusters: a) KIRU, TROM, b) KOSG, POTS, TLSE, WTZR, ZIMM, c) CAGL, NOT1, SFER, YEBE, d) MATE, NICO, SOFI (up down, left right). The figures illustrate 50 days moving weighted means and their formal errors, computed each 7 days from the daily height estimates (weighted mean values removed).

NMF and constant a priori zenith delays) and once with advanced models (**B**: VMF1 and a priori zenith delays from ECMWF). Theoretically, station position time series resulting from approach **B** should display the atmospheric loading deformation better because shortcomings of both the mapping function and the constant a priori ZD of **A** induce parts of this signal to be absorbed by tropospheric parameters. In order to verify this effect, the height time series of GPS and VLBI stations were compared between **A** and **B**. The results were then used to investigate two questions:

Question 1: Can position time series be improved using state-of-the-art models?

Using approach **B**, the agreement of harmonic annual signals of homogeneous VLBI and GPS height series improves compared to approach **A**. (The WRMS of the VLBI–GPS differences of the harmonic annual signals are 2.2 mm for **A** and 1.8 mm for **B**.) This is significant for the atmospheric loading coefficients, which were estimated from these series using local ECMWF pressures and linear regression: the WRMS of the differences (GPS–VLBI) is 0.134 and 0.083 mm/mbar for **A** and for **B** respectively. See Figure 3. Additionally, the agreement of the coefficients with those provided by GGFC (Global Geophysical Fluids Center, http://www.ecgs.lu/ggfc) improves significantly using **B**. The WRMS's of the VLBI–GGFC differences are 0.301 and 0.154 mm/mbar, and the WRMS's of the GPS–GGFC differences are 0.232 and 0.161 mm/mbar (for **A** and for **B**, respectively).

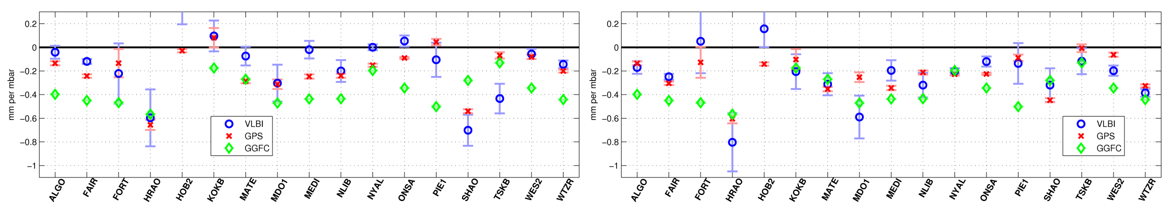

Figure 3. Atmospheric loading regression coefficients and their formal errors, determined from VLBI- (blue circles) and GPS- (red crosses) height time series, and from coefficients provided by the GGFC (green diamonds). Left: **A**, right: **B**.

Question 2: Can a simple regression approach for modeling the site-specific atmospheric loading signal keep up with the corrections computed from global models?

The height corrections due to atmospheric loading computed using the coefficients estimated before were compared to the corrections described by Petrov and Boy (2004) (Petrov, L., J.P. Boy: *Study of the atmospheric pressure loading signals in very long baseline interferometry observations.*J. Geophys. Res., Vol. 109, B03405, doi:10.1029/2003JB002500, 2004).

For some stations, e.g. Gilmore Creek, Alaska (USA) or Hartebeesthoek (South Africa), the series are in good accordance regarding the annual domain. (See Figure 4.) However, there are many stations, such as Kokee, Hawaii (USA) and Ny-Ålesund (Norway), which show a quite bad agreement. Possible reasons for the disagreements are (1) a linear regression model with local pressure is physically not sufficient, (2) VLBI- and GPS-estimated coefficients additionally contain other signals, (3) the modeled crustal displacements are not good enough in some regions.

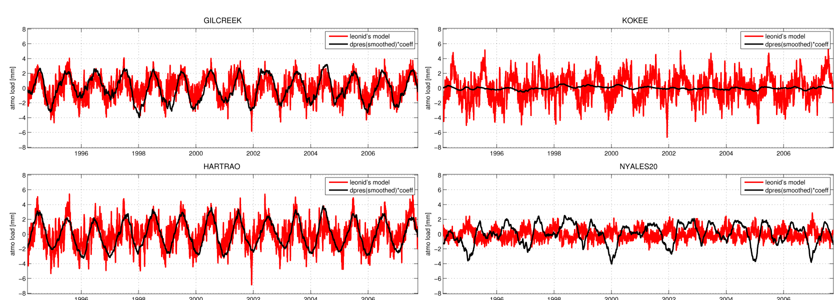

Figure 4. Comparison of smoothed "pressure times coefficient" series (thin black line) and modelled crustal displacement series (red) for the stations Gilcreek, Hartebeesthoek (Hartrao), Kokee Park and Ny-Ålesund (Nyales20) (top to bottom, left to right).

3. DGFI contribution to the second realization of the ICRF (ICRF2)

   DGFI takes part in the IVS Working Group for the second realization of the ICRF (ICRF2) by submitting all types of results necessary in this context. DGFI computes ICRF solutions, realizing the datum of ICRF by using no-net-rotation conditions, to enable a non-deformed CRF solution. The computation is based on, all together, 3131 sessions between January 1984 and August 2008, and it contains the coordinates of 2835 radio sources.

4. IVS Operational Analysis Center at DGFI

   DGFI was promoted from an associated analysis center to an operational analysis center in September 2008. DGFI routinely processes the standard IVS sessions (R1 and R4) supplemented by other sessions and delivers the resulting datum free normal equations to the IVS in SINEX format. In the case of relevant software updates, the VLBI normal equations are fully reprocessed and provided to the IVS. The latest update was the implementation of the Vienna Mapping Function (VMF1), where the complete time series (3131 sessions between 1984 and August 2008) was reprocessed and submitted to the IVS data server.

5. IVS OCCAM Working Group

   The most important goal for DGFI as an IVS AC is to maintain and refine the VLBI OCCAM software to current requirements in close collaboration within the IVS OCCAM Working Group, chaired by Oleg Titov, Geoscience Australia (Canberra, Australia). Other members are scientists from the Vienna University of Technology (Austria), the St. Petersburg University (Russia), the Institute of Applied Astronomy (Russia), and DGFI. During the past year the work concentrated on the development of software for subsequent processing of the OCCAM results.

3. Staff

The DGFI IVS AC is operated by Manuela Seitz and Robert Heinkelmann.

4. Current Status and Activities

In 2008 DGFI received two new functions within IVS. DGFI became an operational IVS Analysis Center, and it was appointed together with BKG as an IVS Combination Center.

Dr. Volker Tesmer left DGFI at the end of August 2008, and Dr. Robert Heinkelmann (formerly of TU Vienna) followed in his position. We are very sorry for Dr. Tesmer's leaving the DGFI; nevertheless, we wish all the best to him and much success at his new position!

5. Plans for 2009

For 2009, we plan to continue the IVS AC activities and the work within the ICRF2 Working Group. Together with BKG, DGFI will start the IVS Combination Center. We will install the DOGS-CS software for the combination work and develop and implement an appropriate strategy.