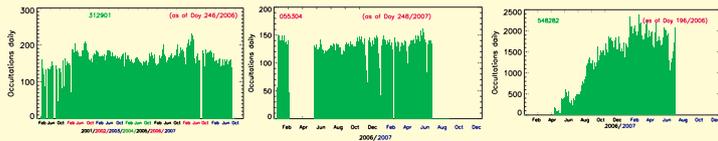


J. Wickert, G. Beyerle, C. Falck, S. Heise, R. König, G. Michalak, D. Pingel*, M. Rothacher, T. Schmidt, and C. Viehweg
GeoForschungsZentrum Potsdam, * Deutscher Wetterdienst

Overview

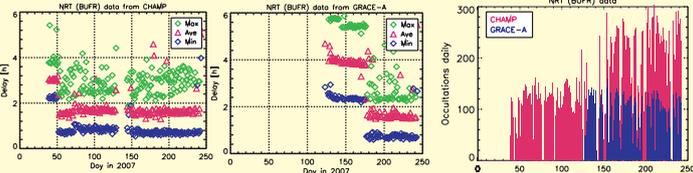
During the last decade ground and space based GNSS techniques for atmospheric/ionospheric remote sensing were established. The currently increasing number of receiver platforms (e.g., extension of regional/global ground networks and additional LEO satellites) together with future additional transmitters (GALILEO, reactivated GLONASS, new signal structures for GPS) will extend the potential of these innovative sounding techniques during the next years. Here, we focus to GPS radio occultation and present selected examples of recent GFZ results. The activities include orbit and atmospheric/ionospheric occultation data processing for several satellite mission (CHAMP, GRACE-A, SAC-C, and COSMIC), but also various applications.

Data sets from CHAMP, GRACE and COSMIC



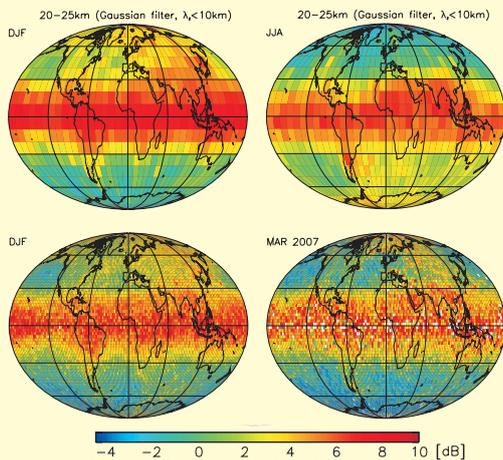
Number of daily available vertical atmospheric profiles, derived from CHAMP (left), GRACE (middle), and COSMIC (right, UCAR processing) measurements (note the different scale). COSMIC provides significantly more data compared to CHAMP and GRACE-A. The long-term set from CHAMP is unique (300 km orbit altitude expected in Dec. 2008).

Near-real time data from CHAMP and GRACE-A



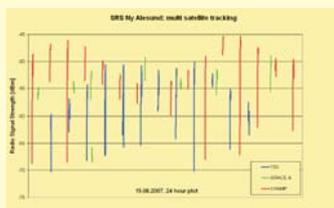
GFZ provides near-real time occultation data (bending angle and refractivity profiles) from CHAMP and GRACE-A using its operational ground infrastructure including 2 receiving antennas at Ny Alesund. The figure shows the time delay between CHAMP (left) and GRACE-A (middle) occultation measurements aboard the satellites and availability of corresponding analysis results at NRT ftp-server at GFZ. Red triangles indicate the daily mean of the time delay between measurement and availability of bending angle and refractivity profiles for all occultation events. Data are provided since February 2007 in BUFR format and are currently distributed also via the Global Telecommunication Service (right).

Gravity Waves, detected with GPS RO



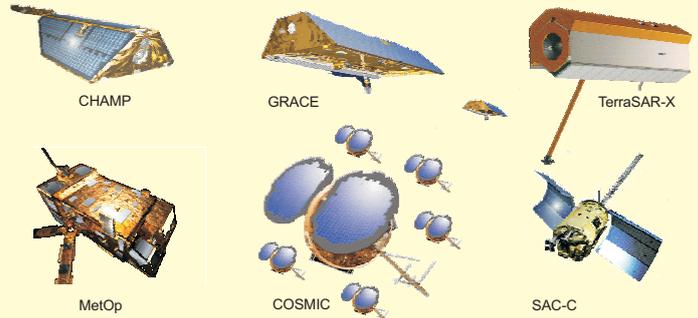
Above: Global mean potential energy E_{∞} between 20-25 km derived using a Gaussian filter for CHAMP/SAC-C/GRACE for northern hemispheric winter (DJF) and summer (JJA) based on the data from May 2001-June 2007. The latitude/longitude resolution represent 10x10 degree. Below: same as above, but using COSMIC DJF 2006/2007 and March 2007. The latitude/longitude resolution is 2.5x2.5 degree.

TerraSAR-X



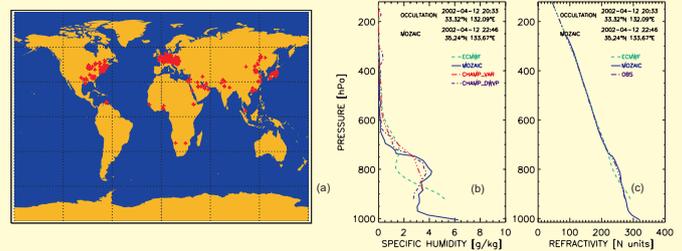
The German TerraSAR-X satellite (artist's view, left) was launched on June 15, 2007 with a Dnepr-1 from Aerodrome Baikonur. The main science instrument aboard is a new generation X-band radar (9.65 GHz) for Earth observation with up to 1-2 m resolution (spotlight mode). GFZ (together with University Texas) is operating an IGOR GPS receiver. Operational activation of occultation is planned for late autumn 2007. The right plot shows a real scenario of parallel data reception from CHAMP, GRACE-A and TerraSAR-X at the Ny Alesund receiving station.

Current GPS occultation missions



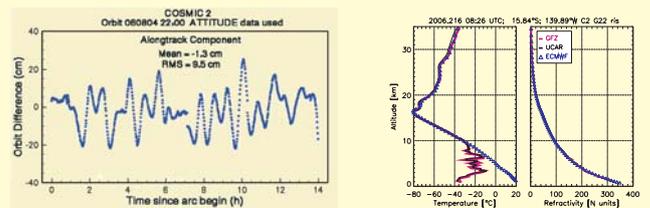
Current GPS radio occultation missions: CHAMP (launch July 15, 2000), GRACE (March 17, 2002), TerraSAR-X (June 15, 2007), MetOp (October 18, 2006), COSMIC (April 15, 2006) and SAC-C (November 21, 2000).

Validation of CHAMP with MOZAIC aircraft data



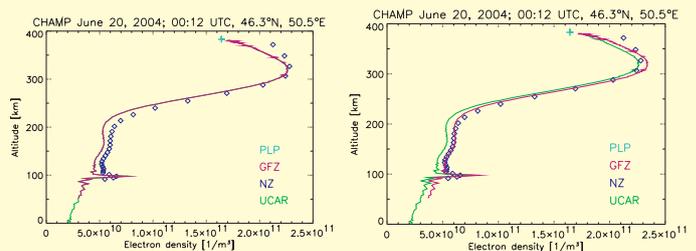
The MOZAIC (Measurement of Ozone and water vapour by Airbus Inservice airCraFt) programme includes five aircraft performing up to 2,500 flights per year. These data are not assimilated to ECMWF analyses and consequently provide a unique opportunity to assess whether GPS RO data could provide significant additional meteorological information compared to ECMWF data without assimilating RO. (a) Global distribution of coincidences of CHAMP and MOZAIC (during aircraft ascent and descent) from March 2001 until March 2006 (coincidence criteria: 3 h, 300 km). Comparison of vertical specific humidity (b) and refractivity (c) profiles derived from CHAMP (1DVAR and DWVP) retrieval with MOZAIC and ECMWF data. Example for April 12, 2002, 20:33 UTC, 33.32°N, 132.09°E (Heise et al., subm. 2007).

COSMIC data analysis



Example from initial results of the Precise Orbit Determination for COSMIC at GFZ. All 6 satellites were processed for a 3 day period using attitude data. The left plot shows the difference of the along track component between the 14h GFZ arc and corresponding operational UCAR orbits for COSMIC 2 satellite (August 4/5, 2006). The mean of the differences is -1.3 cm and RMS is 9.5 cm. The right plot shows the first rising occultation, which was successfully processed with GFZ inversion software using UCAR excess phase data.

First ionospheric profiles from GFZ



First vertical profiles of electron density (red) from CHAMP, completely derived using GFZ analysis software. The data are compared with processing results from UCAR (green) and DLR Neustrelitz (NZ, dark blue diamond) and in-situ data from the PLP (Planar Langmuir Probe, light blue cross). A sporadic E-layer was observed at ~100 km altitude. The GFZ profiles are derived using 2 different scale heights to estimate the TEC (Total Electron Content) above the orbit altitude (scale height for exponential decrease of the electron density 182 km, left; and 98 km, right).

Acknowledgements:

We thank all engineers and scientists of the CHAMP, GRACE, COSMIC/Formosat-3, and TerraSAR-X teams for their great work. We are grateful to UCAR, especially Doug Hunt, Bill Kuo, Chris Rocken, Bill Schreiner, Sergey Sokolovskiy, Stig Syndergaard, and NSPO for support and early access to COSMIC/Formosat-3 data.