
Vertical deformations from homogeneously processed GRACE and global GPS long term series



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GPS Data

Time Period: September 2002 – April 2009

- Extended GGOS-D series, homogeneously reprocessed
- Rejection of stations with short observation span, large data gaps, and spurious signals
- Only stations with regionally coherent signals, verified by cluster analysis: 115 stations
- Trend removed, monthly means with formal errors of ~ 1.0 mm

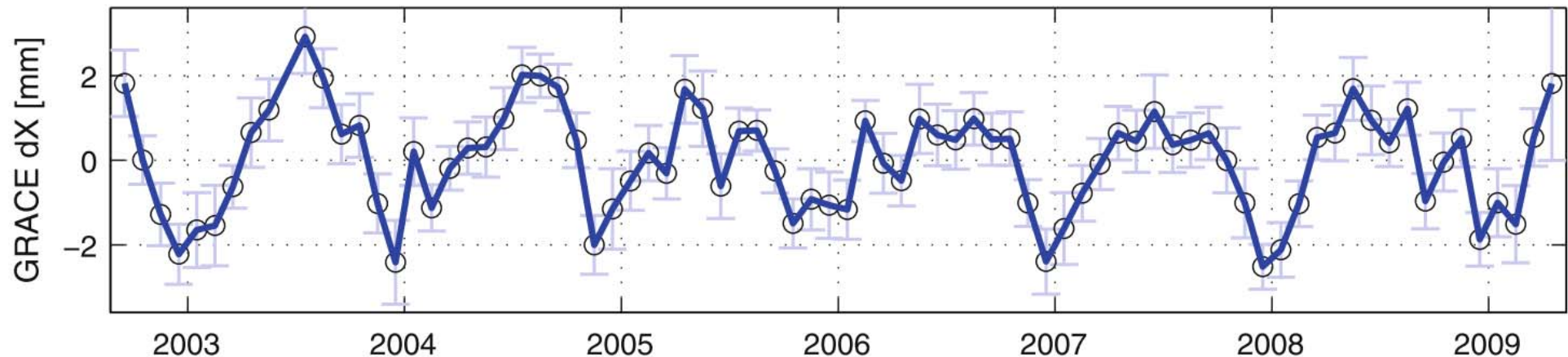
GRACE Data

Time Period: September 2002 – April 2009

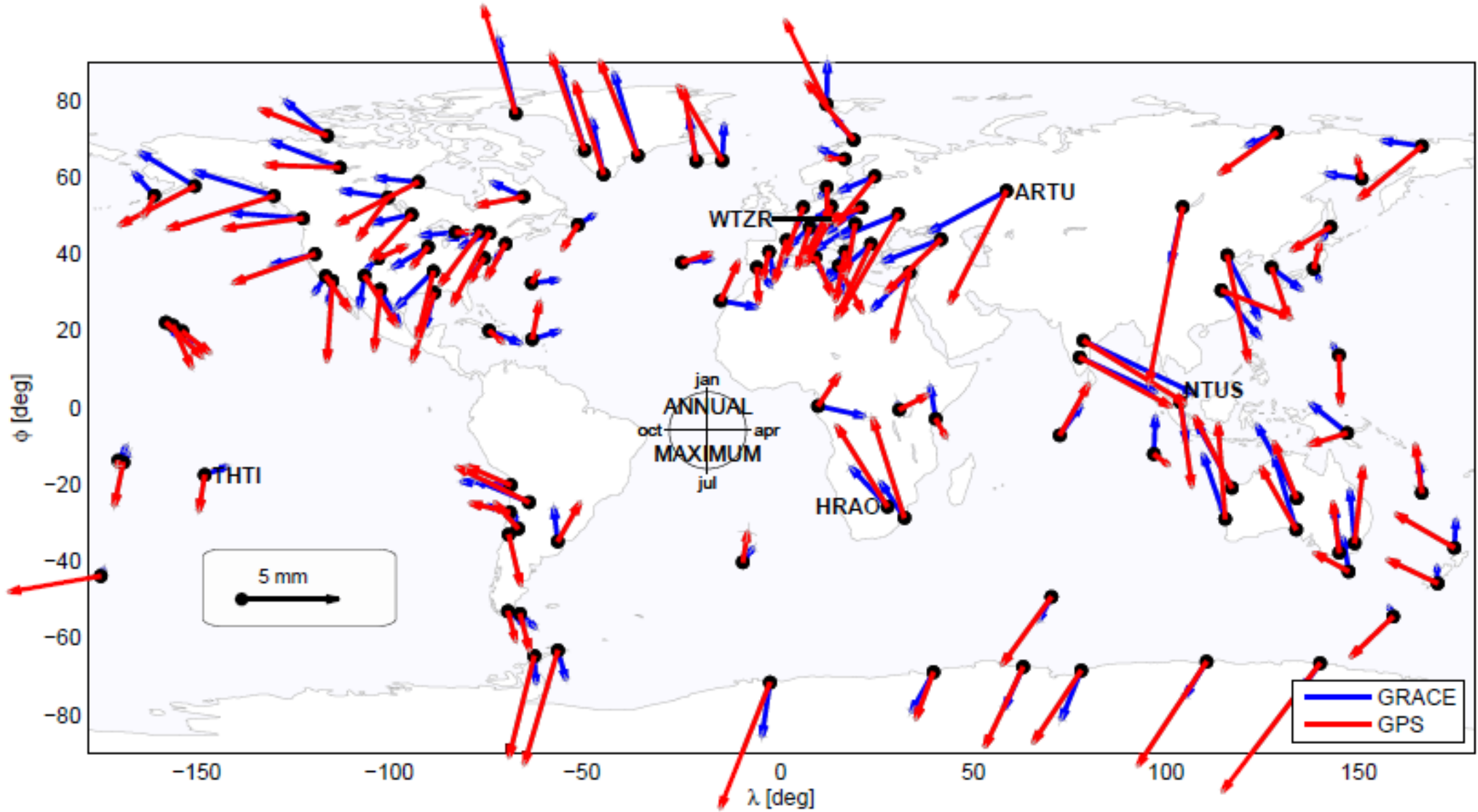
- CSR GRACE Level 2 monthly gravity fields, Release 04
- Added atmospheric and non-tidal ocean mass fields from AOAD1B
- C_{20} replaced by SLR estimates
- Vertical deformations according to Wahr et al (1998) with load love numbers of Han and Wahr (1995)
- Gaussian filter with 400 km radius
- Precision by comparisons with GFZ and JPL: ~1.2 mm

Translations between GPS and GRACE

- GRACE insensitive to degree-1 mean effects: $n=1$ set to zero
- GPS in CoF frame, translations removed by LSA with 53 datum stations
- Apparent degree-1 signals from surface displacements at datum stations: WRMS $X=1.1$ mm, $Y=0.7$ mm, $Z=0.6$ mm
- Adding GRACE-derived translations to GPS time series to ensure frame consistency



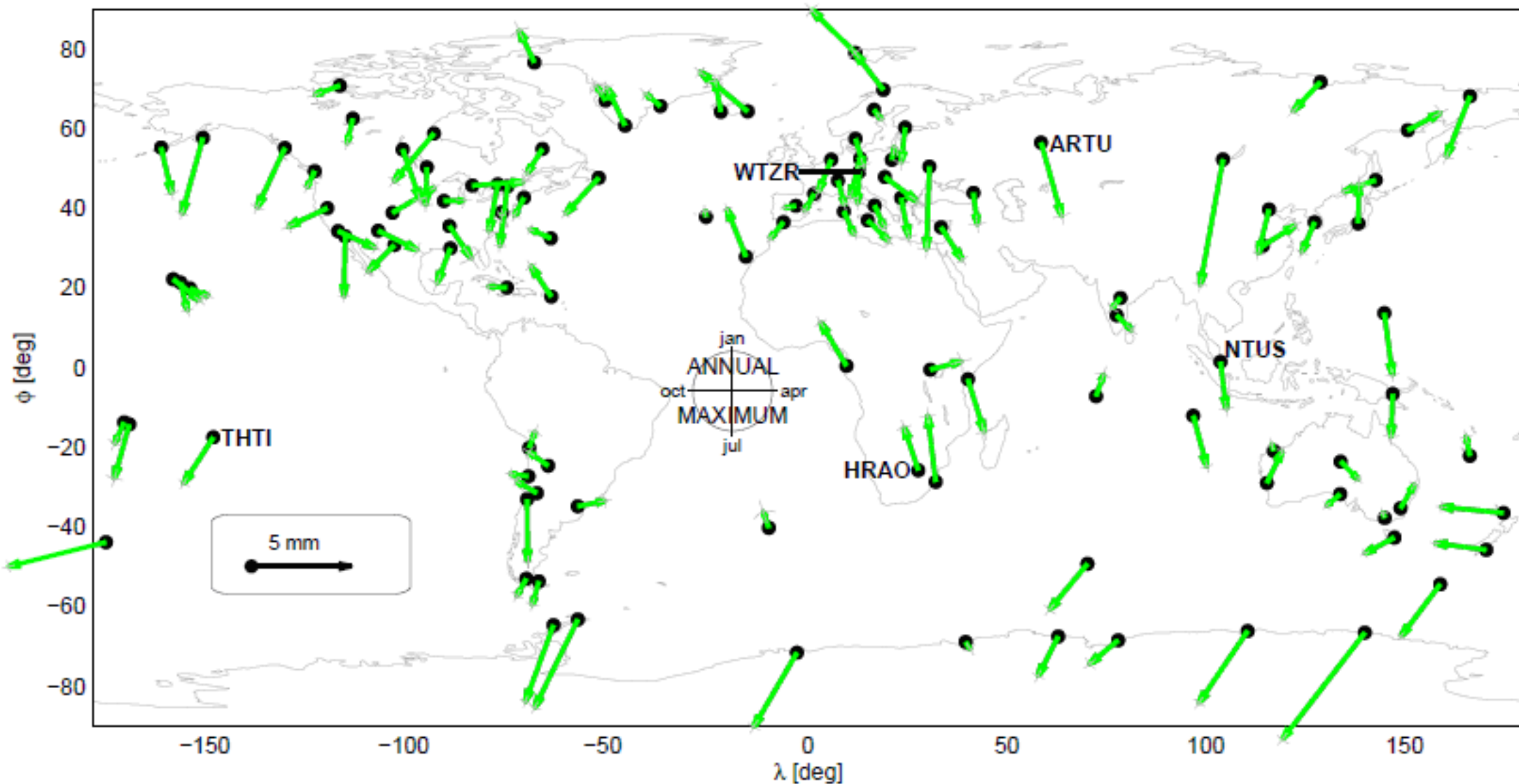
Annual Height Signals



Mean phase difference: 10°

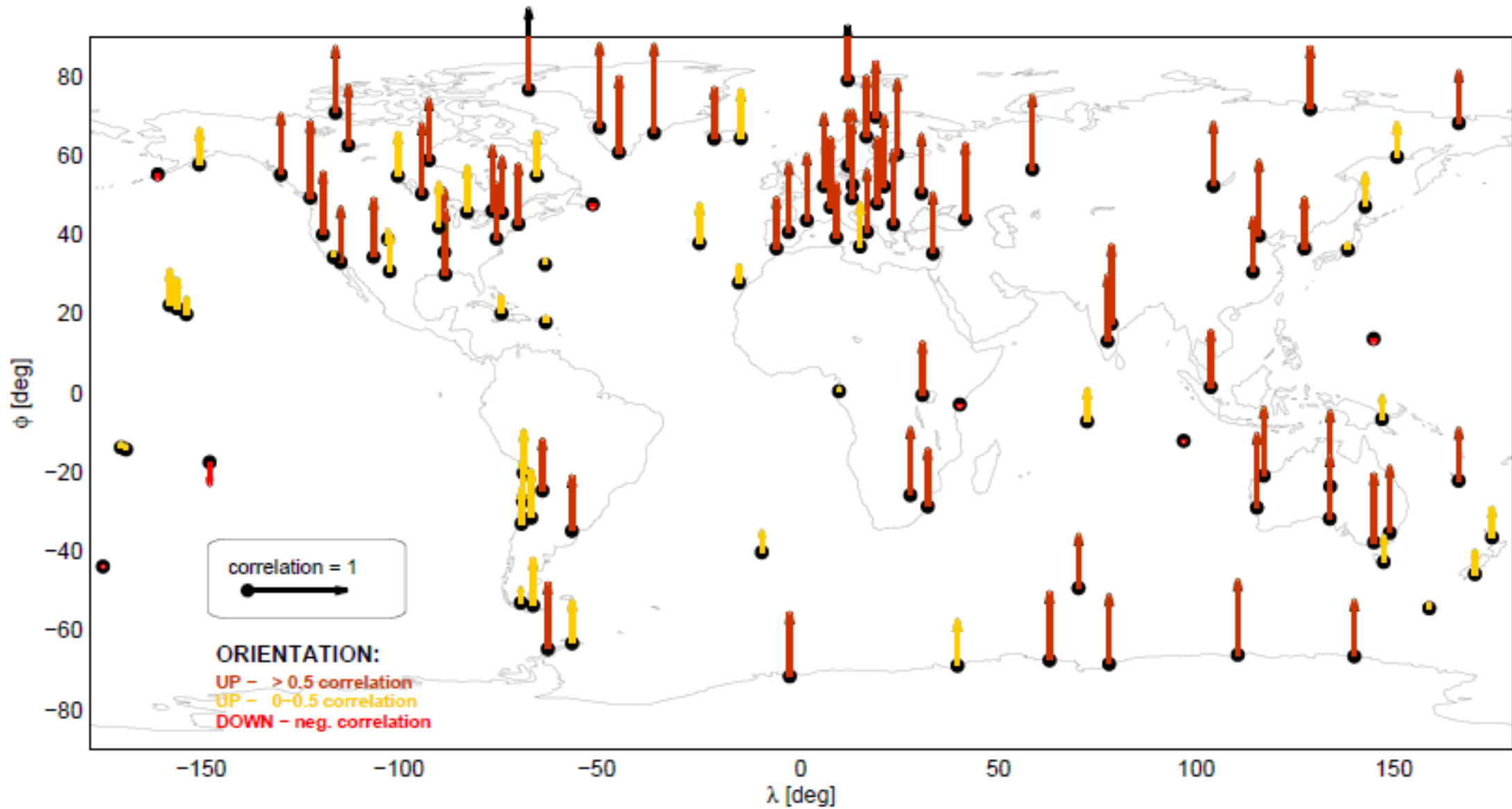
Mean amplitude difference: 2.3 mm

Annual Height Signal Differences



Amplitude scale factor of 1.7, partly due to smoothing of GRACE data

GPS/GRACE Correlation Coefficients

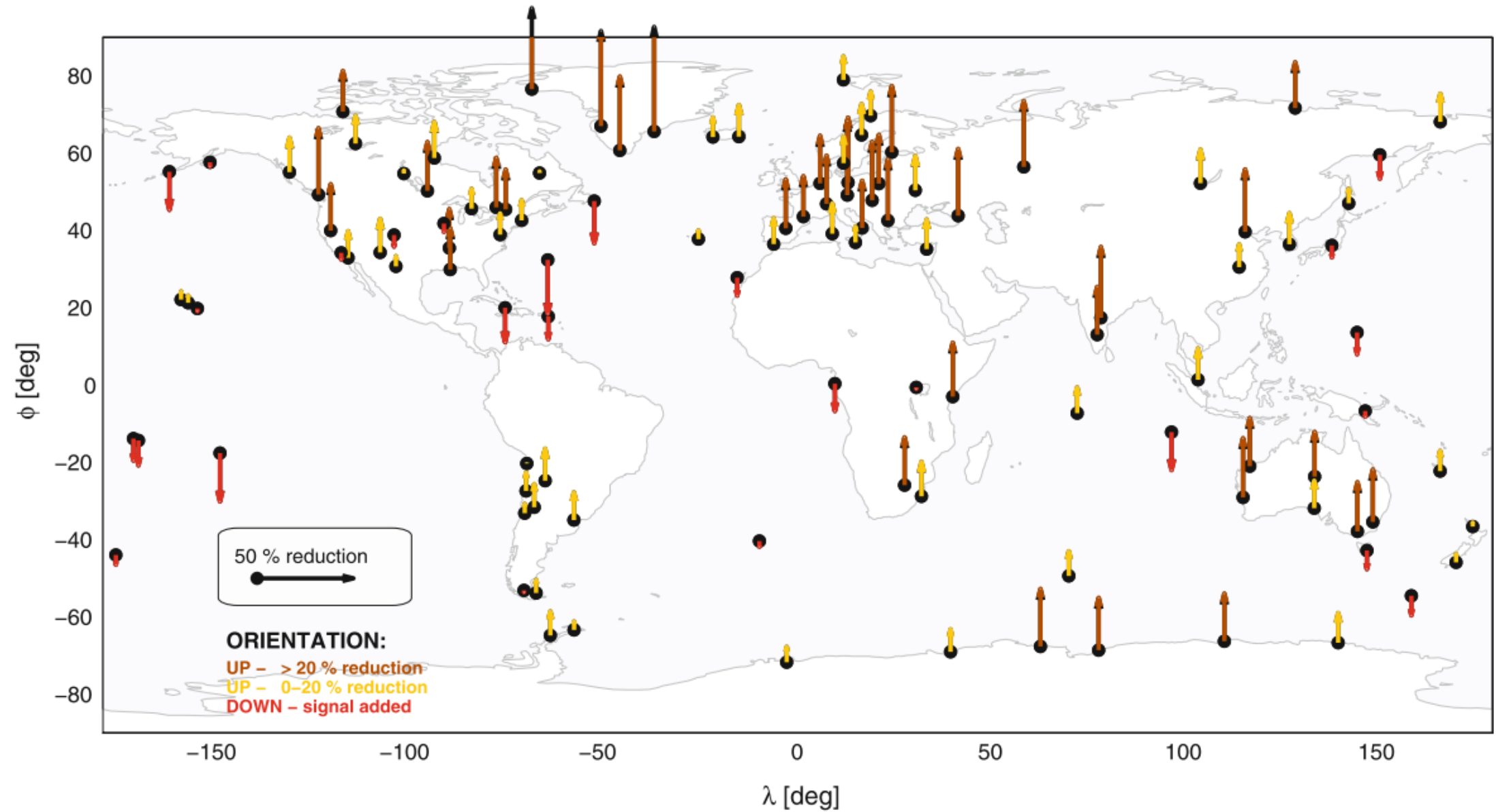


60% stations > 0.5

34% stations 0.5-0.0

6% stations < 0.0

WRMS Reduction

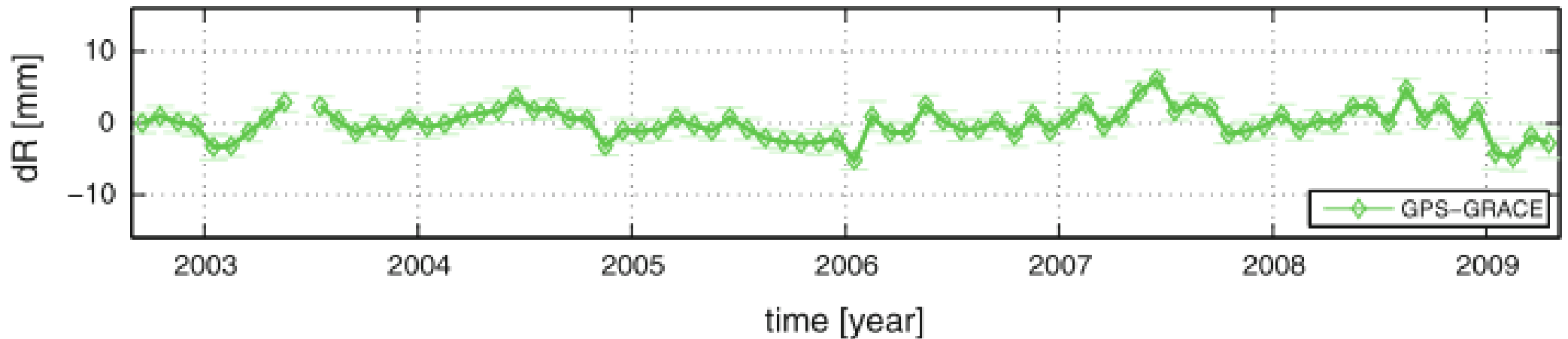
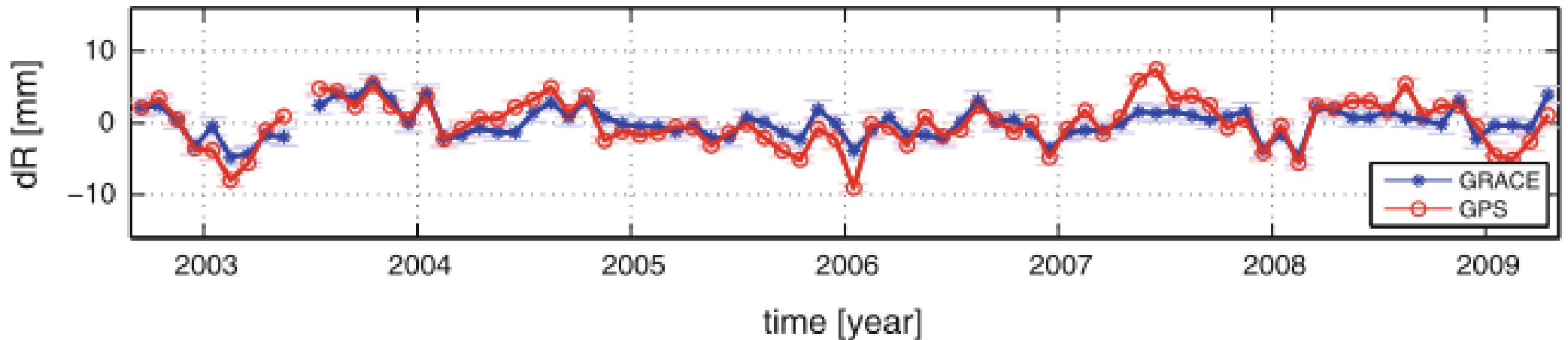


34% stations > 20%

43% stations 20-0%

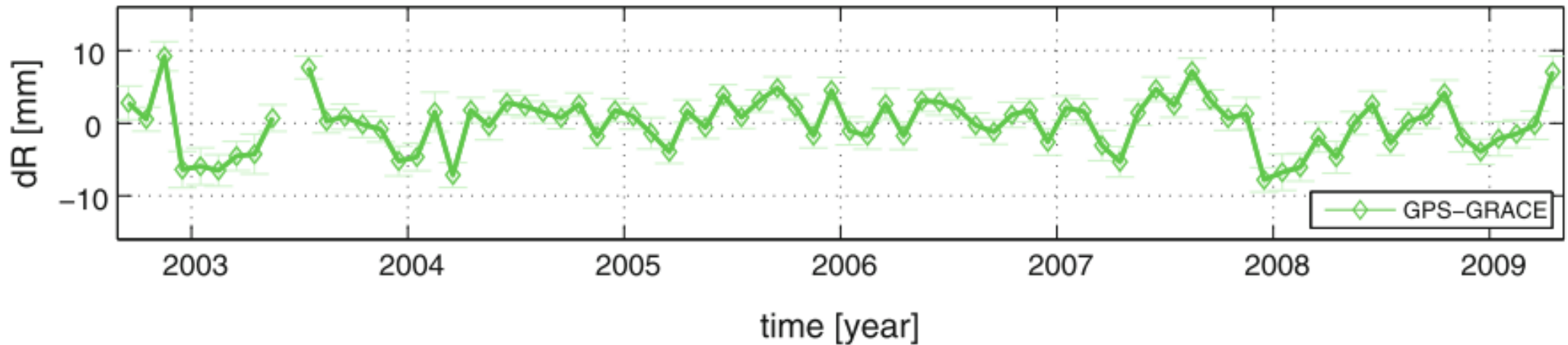
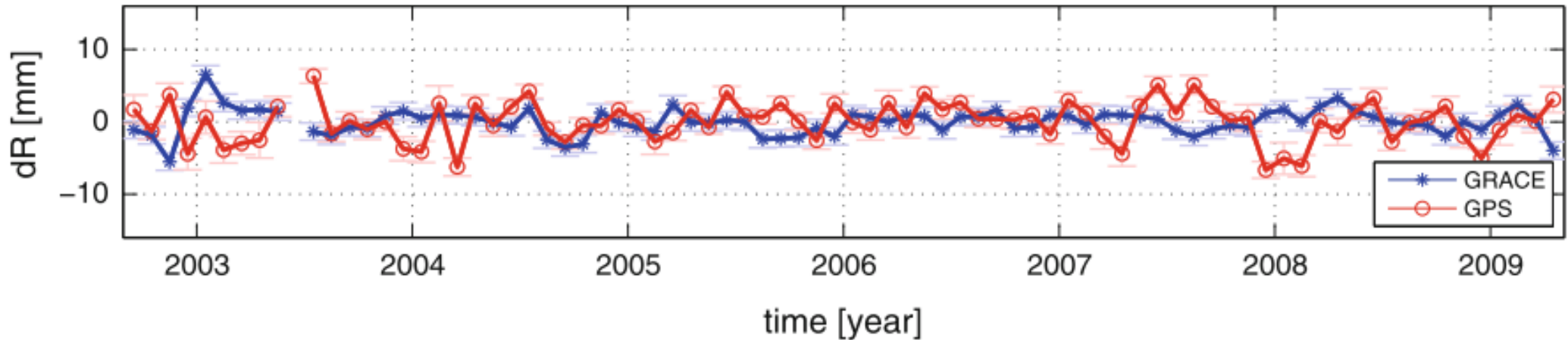
23% stations: increased

Time Series: Wettzell (Germany)



GPS signal WRMS	3.4 mm	Reduct. of GPS signal WRMS	38%
Correlation	0.76	GPS/GRACE signal WRMS	2.1 mm

Time Series: Papeete (Tahiti)



GPS signal WRMS	2.7 mm	Reduct. of GPS signal WRMS	-25%
Correlation	-0.23	GPS/GRACE signal WRMS	3.4 mm

GPS Error Sources

- Local effects, e.g. snow coverage of antennas
- Subaily EOP model
- Ocean loading coefficients
- Atmospheric S_1 and S_2 tides
- Troposphere mismodeling, correlations zenith delay/height
 - Comparison of GPS-GRACE residuals with zenith delays
 - Anti-correlation only for half of the stations
- Thermal deformation (volume changes only seen by GPS)
 - Comparisons of GPS-GRACE residuals with NCEP temperature data
 - Test of different time lags and regression coefficients
 - Positive correlation only for 55% of the stations

GRACE Error Sources

- Assumption that Earth's crust reacts homogeneously to a change of mass loading
- C_{20}
- Spatial filtering
- Background models, aliasing

Summary and Outlook

- Improved agreement between GPS- and GRACE-derived vertical deformations compared to earlier studies
 - Homogeneous reprocessing with state-of-the-art models
 - Stations selection based on cluster analysis
 - Consistent reference frame
- Systematic errors in both techniques still present
- More recent data products:
 - CODE GPS + GLONASS reprocessing with IERS2010, IGS08, igs08.atx
 - Daily GRACE solutions (ITG-Grace2010 with Kalman smoothing)
- Study secular mass changes

Tesmer, V.; Steigenberger, P.; van Dam, T.; Mayer-Gürr, T.: **Vertical deformations from homogeneously processed GRACE and global GPS long-term series**; Journal of Geodesy, Vol. 85, Nr. 5, pp 291-310, Springer, ISSN 0949-7714, DOI: 10.1007/s00190-010-0437-8, 2011