Continental Hydrology Loading Observed by VLBI Measurements

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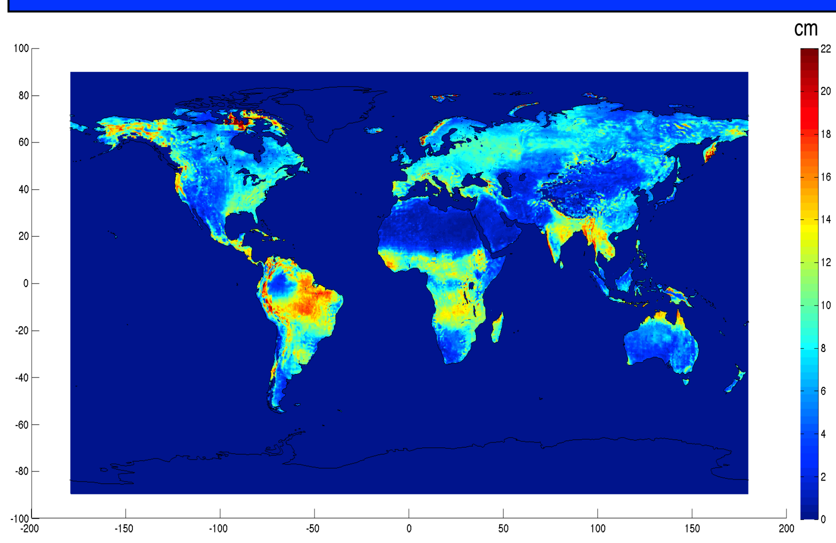
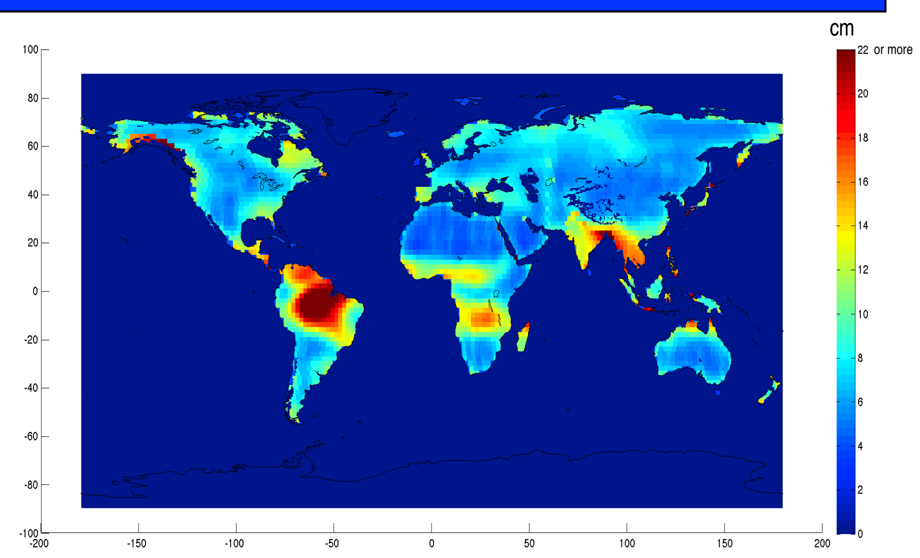
Introduction

Vertical deformation due to hydrological loading is large enough to be seen in VLBI geodetic parameter estimates. Typical peak-to-peak vertical variations are 3-10 mm at VLBI sites. The hydrological signal at VLBI sites generally has a seasonal character, but we also observe interannual variations. These variations are caused by temporal variations of the geographic distribution of surface mass. Here, we have calculated the mass loading derived from GRACE gravity measurement time series from 2003 to 2011. Specifically, we have evaluated the convolution of Farrell's loading Green's function with the global loading mass field, given by a global grid of equal-area GRACE mascons [Rowlands et al., 2005]. We compare hydrology loading series derived from GRACE with those computed using the GLDAS hydrology model by the NASA GSFC GLDAS team [M. Rodell et. al, (2004)]. We then investigate the reduction in baseline length and site position scatter when hydrology loading is applied in VLBI analysis.

1 Hydrology Data



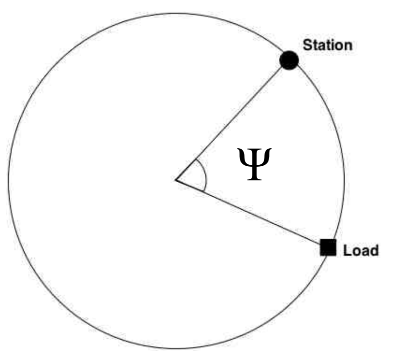
Standard deviation of GLDAS NOAH hydrology parameters in centimeters of water



Standard deviation of the GRACE Mascons in centimeters of water

Vertical and horizontal hydrology loading is computed using the GLDAS NOAH model and the NASA GSFC GRACE Mascons. In our analysis we use a monthly average of the GLDAS NOAH model. Since the GLDAS model does not account for ice sheet processes, areas with permanent frost are masked out. Another problem with the GLDAS NOAH model is that it is not designed to model groundwater, which is a significant part of the hydrology system.

2 The Green's Function Approach

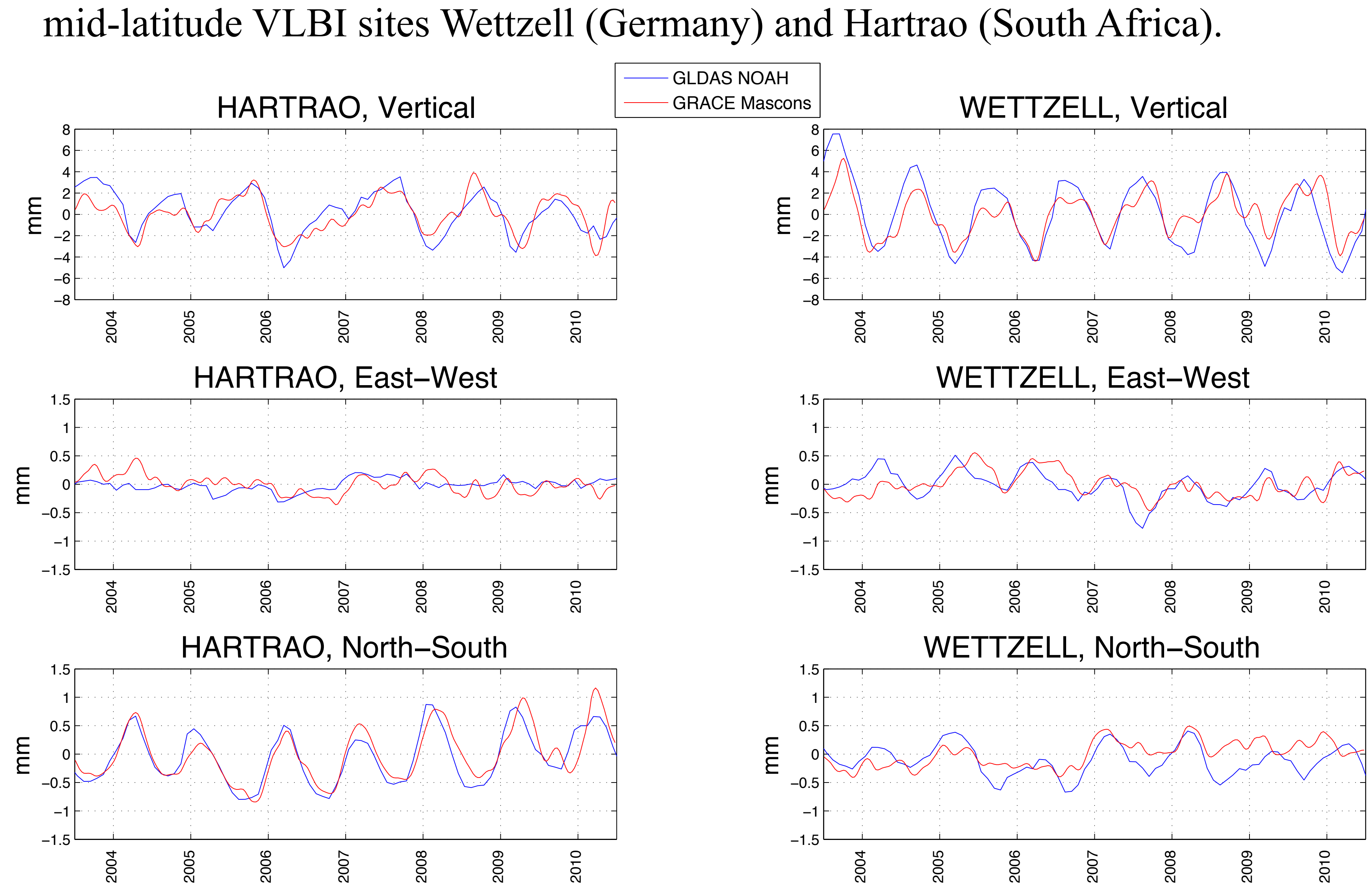


Ψ is given in degrees

The loading Green's function is the response at the station due to a mass load at an angular distance ψ from the station. The closer the mass is to the station, the larger the response. By integrating over the surface of the earth, we will get the total adjustment of the station position caused by the surface mass distribution. The loading contribution is dominated by loading near the station as well as any large coherent regional loads far from the station.

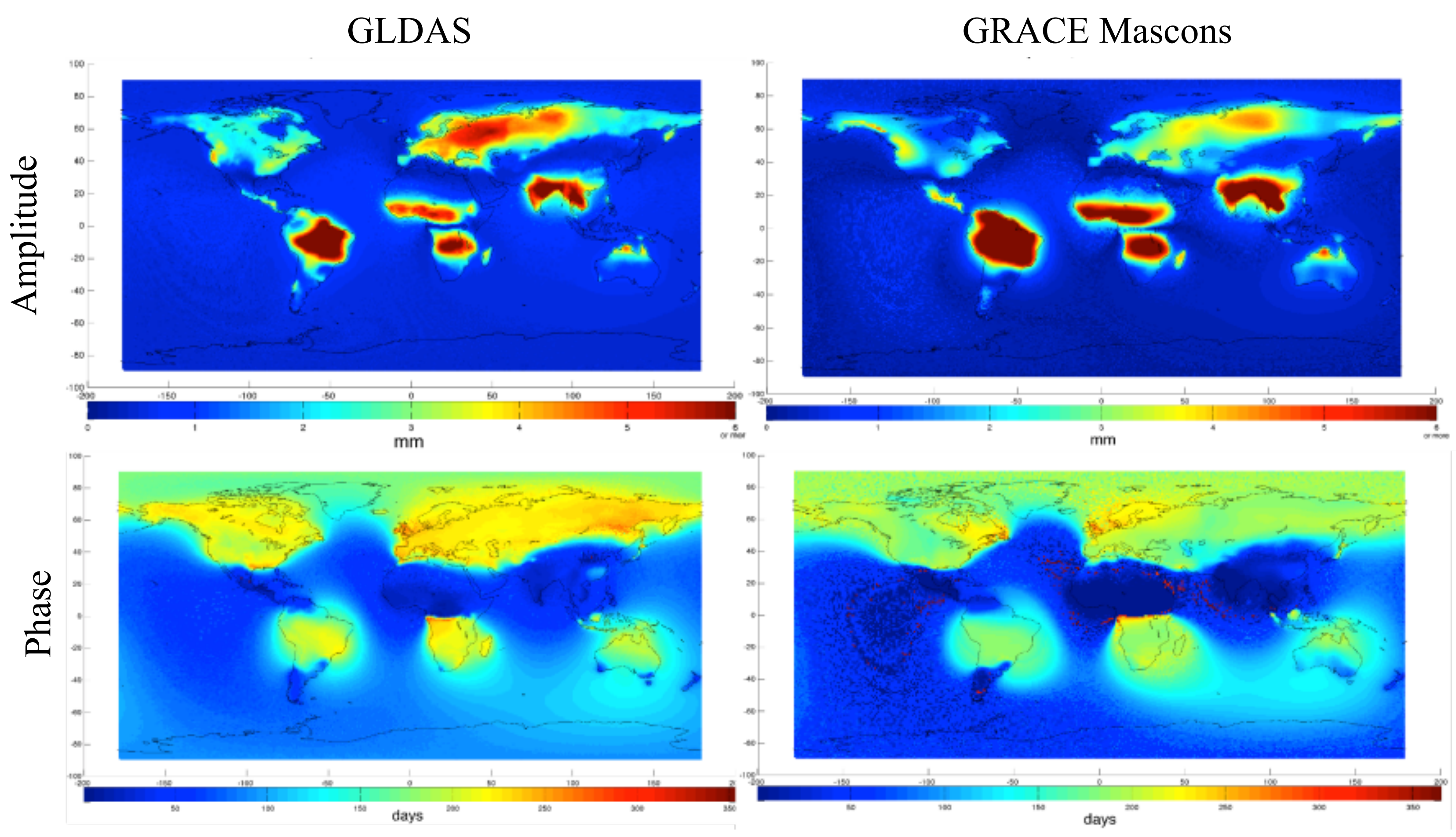
3 Characteristics of Loading Displacements

The figure above shows some typical loading series from the GRACE period (2003-2010). The loading series shown are for two representative mid-latitude VLBI sites Wettzell (Germany) and Hartrao (South Africa).



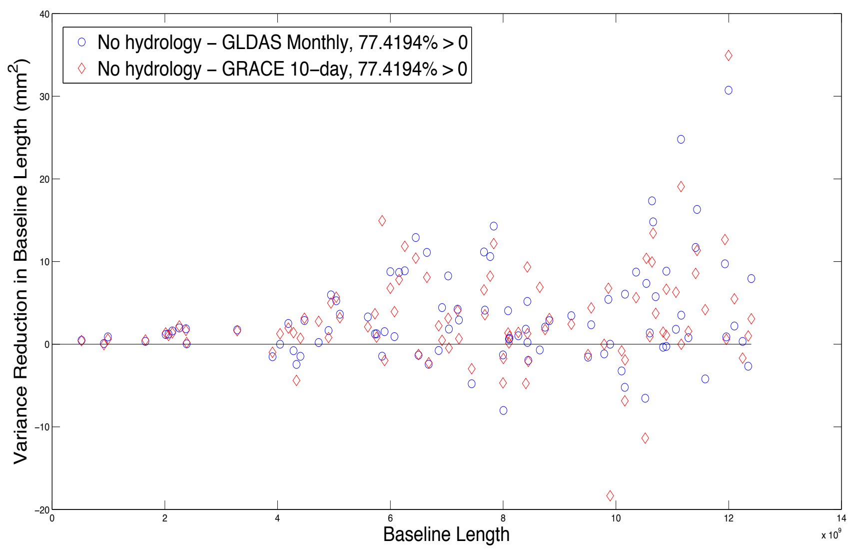
4 Annual Variation of Vertical Loading on a Global Grid

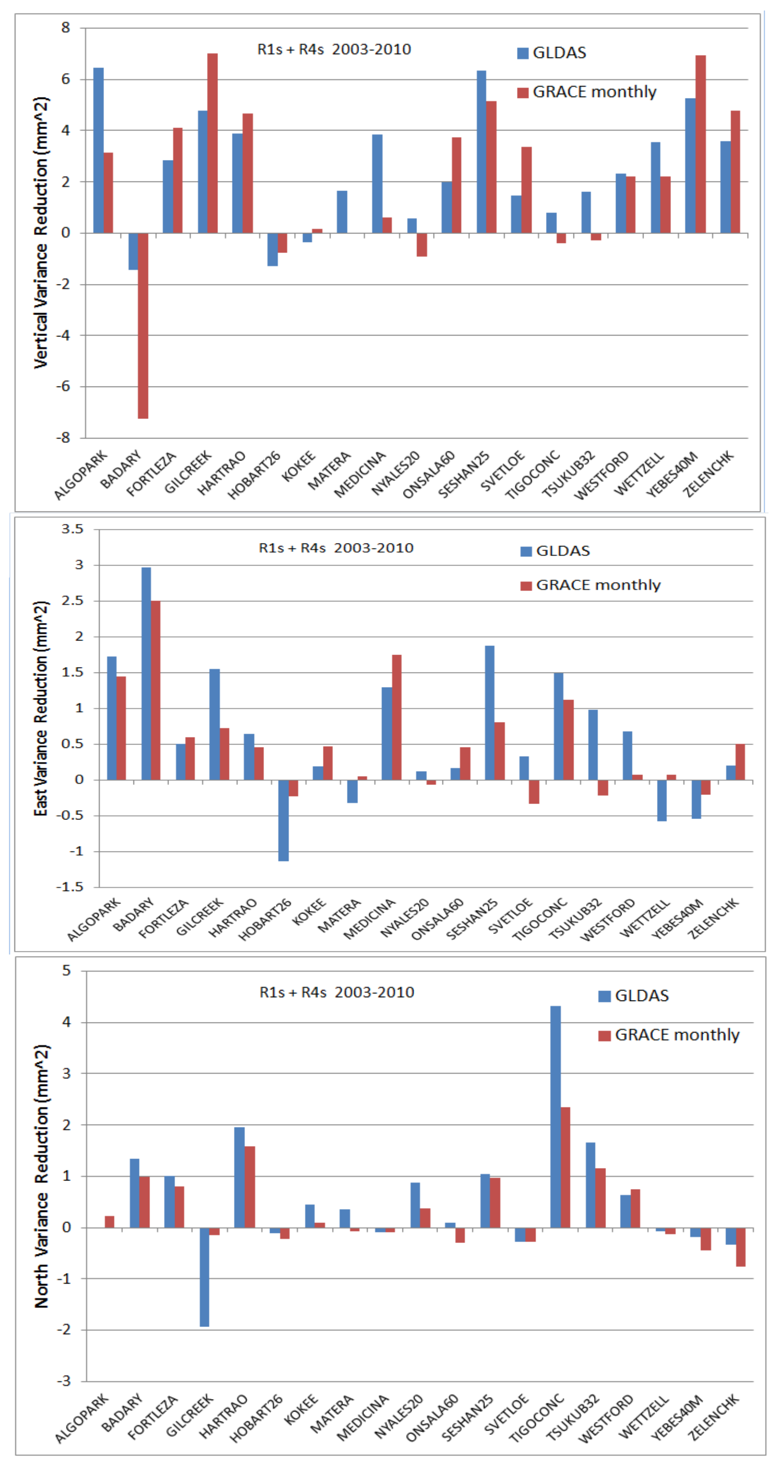
A 1° x 1° global grid with amplitudes and phases estimated from the hydrology loading series.



5 Improvements in VLBI Analysis

We applied our loading series in standard Calc/Solve VLBI analysis to determine whether site postion estimates were improved. We ran three solutions (without loading and then with each loading correction) to estimate daily site positions for the sites in our weekly operational R1 and R4 networks.





- Variance reduction in baseline length: 80% of the baselines are improved.
- Variance reduction in the UEN position estimates: We get improvement for most stations where the hydrology signal is strong.
- Applying GLDAS and GRACE hydrology loading series reduce VLBI vertical and horizontal scatter.

NASA GSFC Hydrology Loading Service

We have a loading service **http://lacerta.gsfc.nasa.gov/hydlo/** where we provide loading series computed from the GLDAS NOAH model.

References

Rodell, M., P. R. Houser, U. Jambor, J. Gottschalck, K. Mitchell, C.-J. Meng, K. Arsenault, B. Cosgrove, J. Radakovich, M. Bosilovich, J. K. Entin, J. P. Walker, D. Lohmann, and D. Toll, The Global Land Data Assimilation System, *Bull. Amer. Meteor. Soc.*, 85(3), 381-395, 2004.

Rowlands, D.D., S.B. Luthcke, S. M. Klosko, F.G. Lemoine, D. S. Chinn, J. J. McCarthy, C. M. Cox, and O. B. Andersen,(2005), Resolving mass flux at high spatial and temporal resolution using GRACE intersatellite measurements," *Geophys. Res. Lett.32* (L04310), 2005.

Farrell, W. E., Deformation of the earth by surface loads. *Rev. Geophys. and Spac. Phys.*, 10(3):761–797, 1972.

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