How much of GPS noise refers to hydrology loading? An insight from GRACE-assimilating hydrological modeling

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RESEARCH DESCRIPTION

Research question:
Does GPS (Global Positioning System) detect the short-term hydrology-related deformations?

Data:
GPS vertical displacements from a set of 221 European EPN (EUREF Permanent GNSS Network) stations.

Methods:
To separate deterministic part from the short-term changes:
(1) We use predictions of vertical deformations from a GRACE (Gravity Recovery and Climate Experiment)-assimilating land surface model (CLM-DA).
(2) We use conventional harmonic functions approach with pre-defined annual and semi-annual periods.
For the stochastic parts associated with two methods, the noise parameters (spectral indices and amplitudes of power-law noise) are estimated using the Maximum Likelihood Estimation (MLE).

Results:
(1) Annual and semi-annual frequencies are significantly explained by the hydrological model, resulting 60% reduction on average in amplitudes.
(2) The GRACE-assimilated model can remove the effect of high-frequency hydrological deformations, producing residuals with spectrum closer to the white noise process.
(3) Many oscillations at periods between 15 and 90 days are well-explained by GRACE-assimilating deformation model.
(4) Using GRACE-assimilated model as a deterministic part of GPS displacement time series, we provide a totally new estimates of uncertainty of GPS velocity for European sites.

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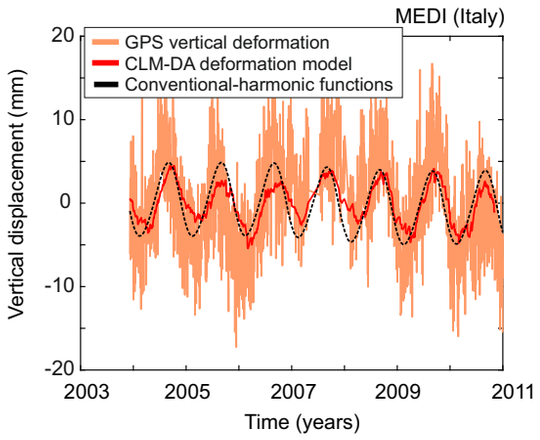

Fig. 1 Vertical displacements for MEDI EPN station. The GPS displacements (orange line) are plotted with two deterministic models: CLM-DA deformation model (red line) and conventional-harmonic functions approach (black line).

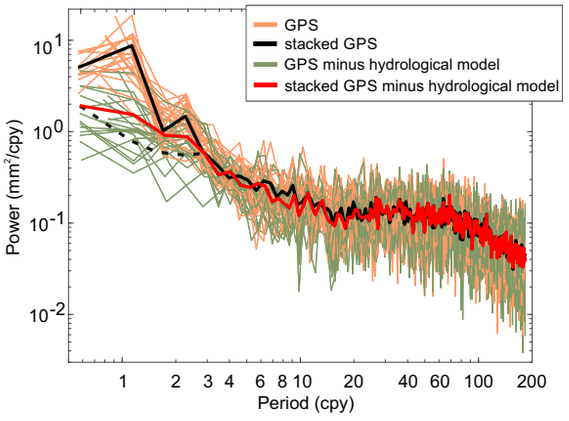

Fig. 2 Comparison of power spectral densities estimated for original GPS height time series (orange line) and those, but reduced for hydrological loading using the CLM-DA deformation model (green line). Stacked spectra are provided for both datasets in black and red lines. Stacked spectra are also shown for the conventional harmonic functions approach (black dashed line).

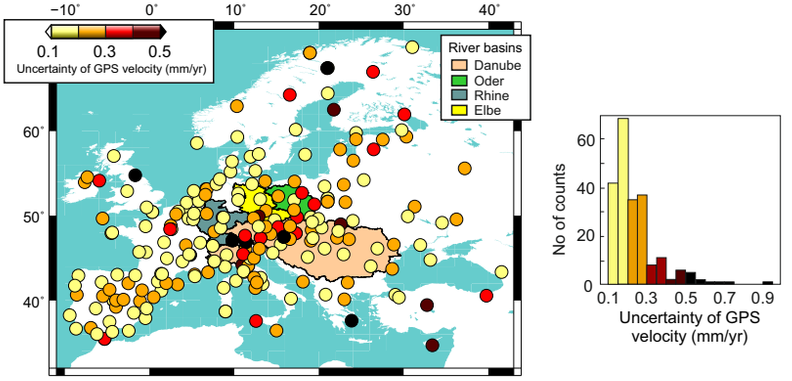

Fig. 3 Uncertainties of GPS velocity estimated for GPS height time series using the CLM-DA deformation model as a deterministic part of the time series. Right: histogram of these estimates is provided.