Hydrological loading signal observed by GPS and GRACE in South America (SIRGAS)

Qiang Chen, Balaji Devaraju, Nico Sneeuw

Geodätisches Institut, Universität Stuttgart

Outline . . .

- *Motivation*
- *Datasets, methodology and filters*
- *Analysis and results*
- *Conclusions*

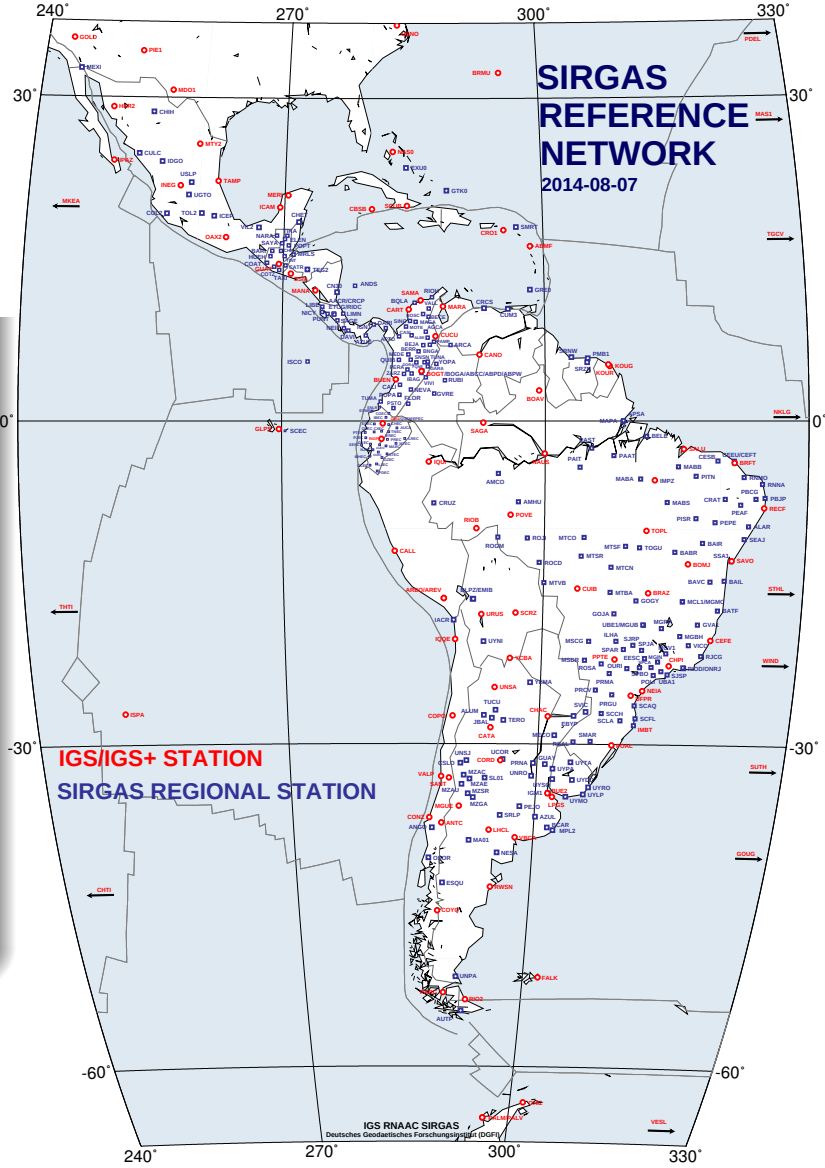
Motivation

- The SIRGAS GPS time series is not used yet for comparison with GRACE.
- King et al., (2006) studied the effects of the isotropic Gaussian filter with different smoothing radii on GRACE RL02 solutions by a comparison with GPS.
- Other studies, e.g. van Dam (2007), simply applied the isotropic Gaussian filter with a relative high smoothing radius (500 km).
- What about other filters? anisotropic Gaussian filter, destriping filter, DDK filters and so on.

Datasets

GPS dataset: SIRGAS GPS network

- Multi-year solution SIR11P01 from the SIRGAS GPS network (DGFI Report No. 87)
- 228 stations with time spanning from 2000 to 2011.29
- cleaned and detrended weekly time series

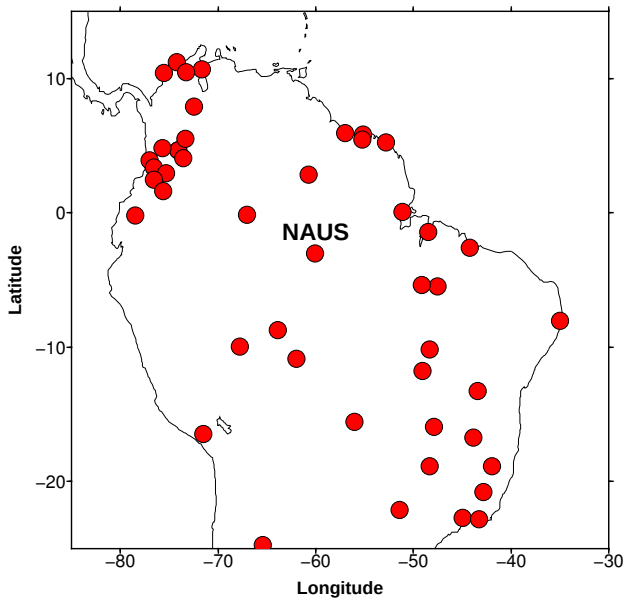


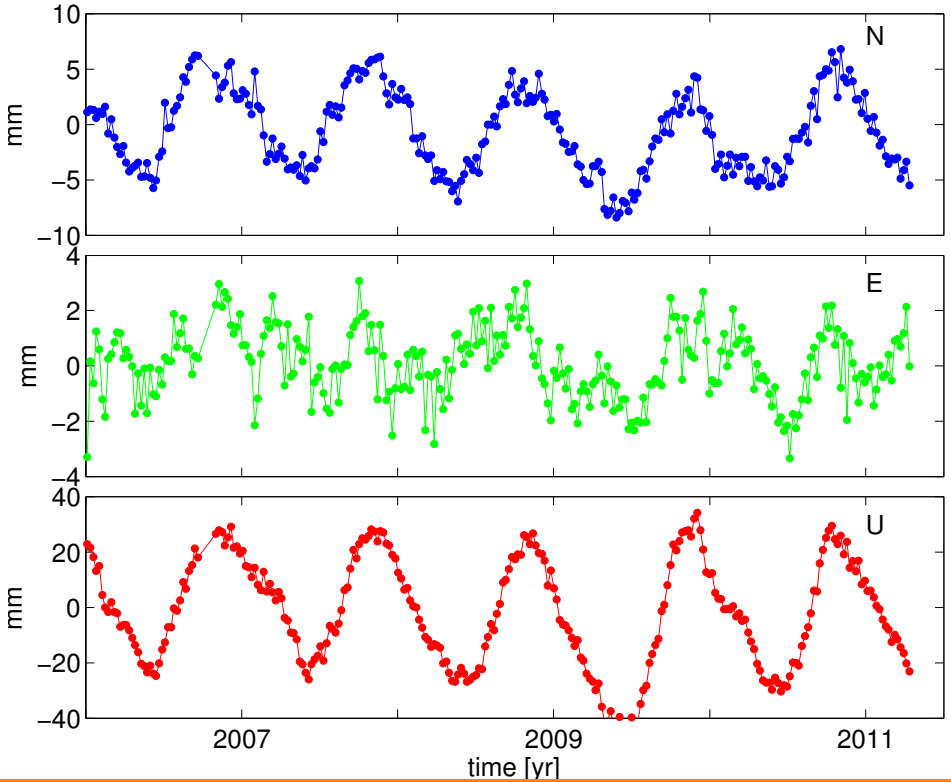
http://www.sirgas.org/index.php?id=15

Selected GPS time series

Selection criteria

- overlapping with the GRACE time frame more than 3 years
- stations inside or around the Amazon basin and its nearby basins





GRACE datasets and the filtering schemes

GRACE datasets

- GRACE RL05a monthly solutions from GFZ (2003.1-2010.12)
- DDK filtered datasets downloaded from ICGEM
- Replacing C_{20} term with the SLR solution

Filters used in this comparison

Filter type	Variable parameter
Isotropic Gaussian filter	$r_g = 200, 250, 300, 350, 400, 450, 500, 600, 800, 1000$ km
Anisotropic Gaussian filter	$r_0 = r_g$, $r_1 = 2 \times r_0$
Destriping filter	$p = 2$, $l = m = 8$
DDK filter	$\alpha = 10^{14}, 10^{13}, 10^{12}, 5 \times 10^{11}, 10^{11}$

- DDK 1 filter corresponds to $\alpha = 10^{14}$ (strong smoothing) and DDK 5 corresponds to $\alpha = 10^{11}$ (weak smoothing)

Deriving displacement due to loading

Spherical harmonics approach

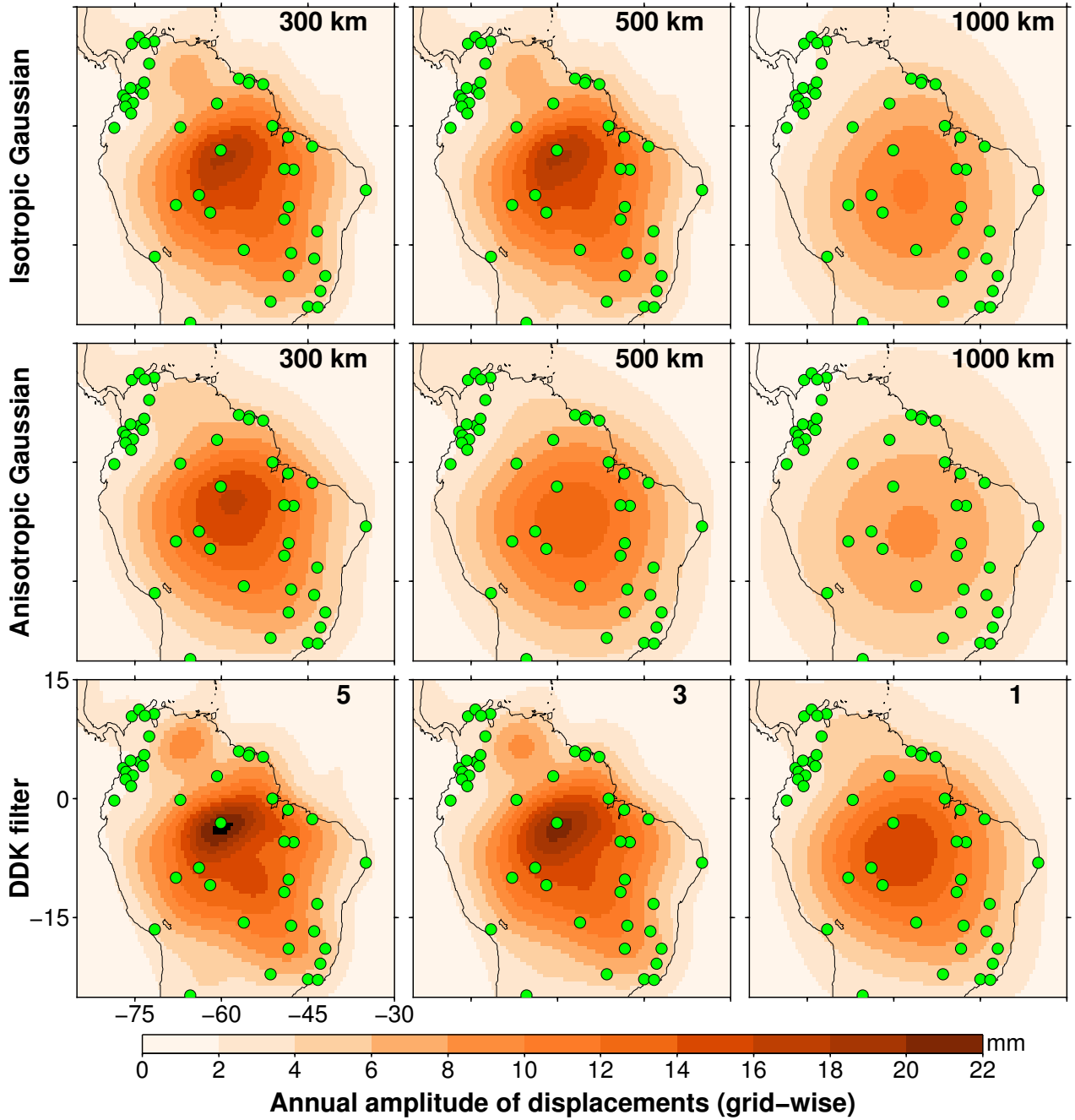
$$du(\theta,\lambda) = R\sum_{l=1}^{\infty}\sum_{m=0}^{l}\tilde{P}_{lm}(\cos\theta)\cdot(C_{lm}\cos(m\lambda)+S_{lm}\sin(m\lambda))\frac{h'_l}{1+k'_l}$$

where $du(\theta,\lambda)$ is the displacement of the Earth's surface in the vertical direction, h'_l andk'_l are the loading Love numbers of degree l, $\tilde{P}_{lm}$ are normalized Legendre functions of degree l and order m, and C_{lm} and S_{lm} represent the GRACE spherical harmonic coefficients.

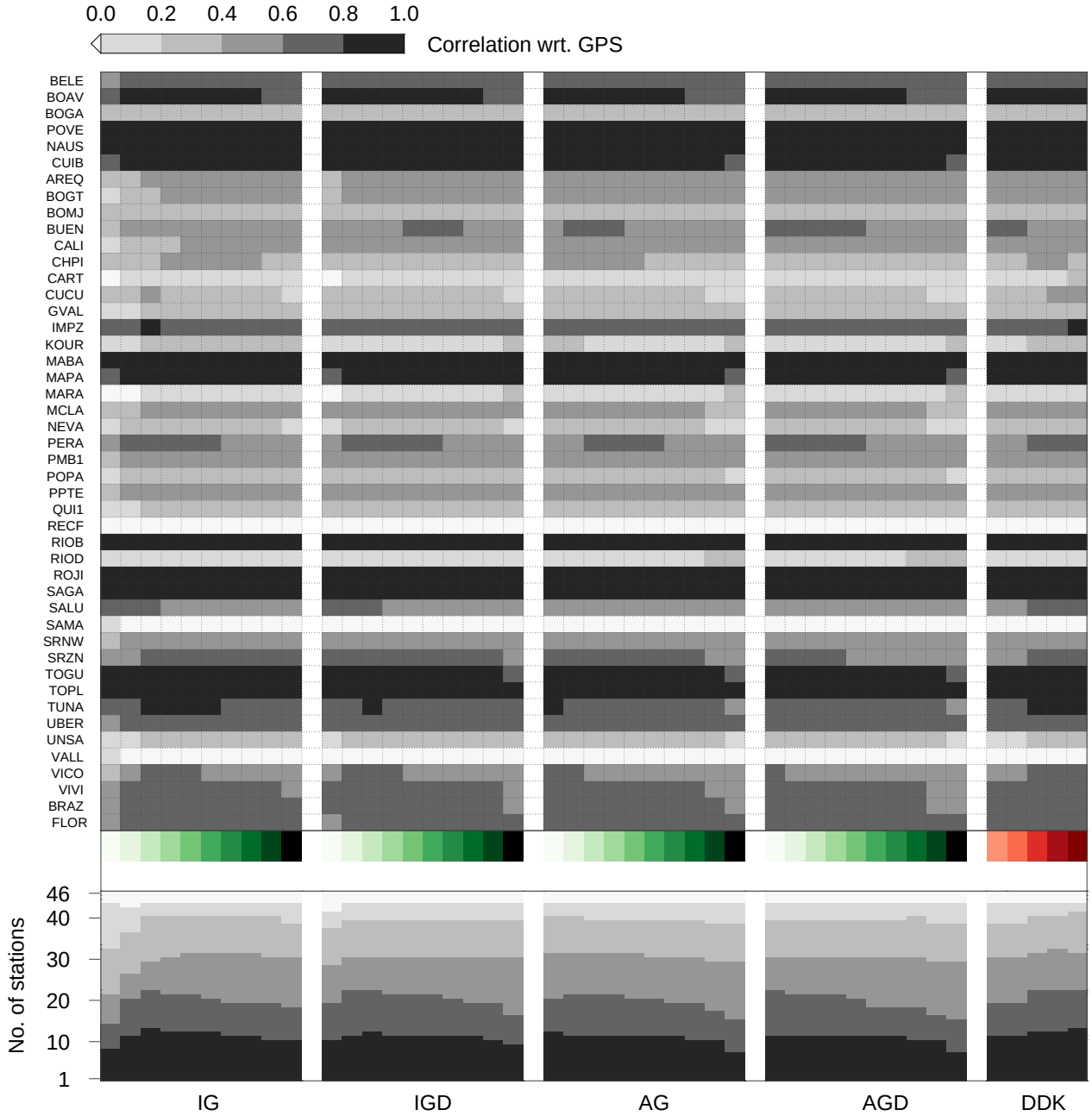
Issues regarding consistency between GPS and GRACE

- temporal resolution
  - averaging weekly GPS solution into monthly solution
- reference frame issue
  - adding degree-1 from Swenson et al., (2008) back into the GRACE GSM solution
- non-tidal atmospheric and oceanic effects
  - adding the AOD1B RL05 products back into the GRACE GSM solution

- Derived displacements from GRACE GSM

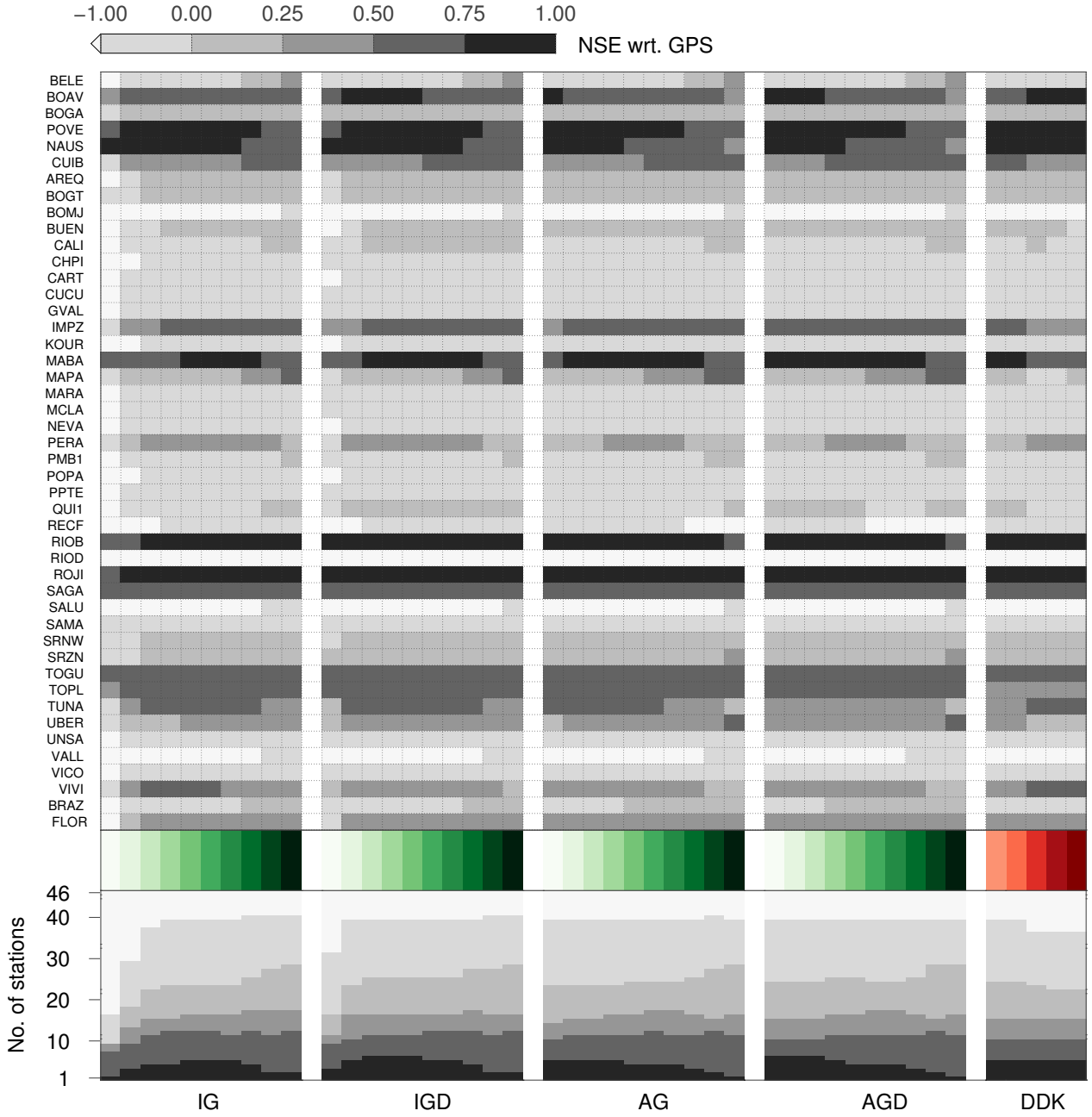


- Comparison with GPS: correlation



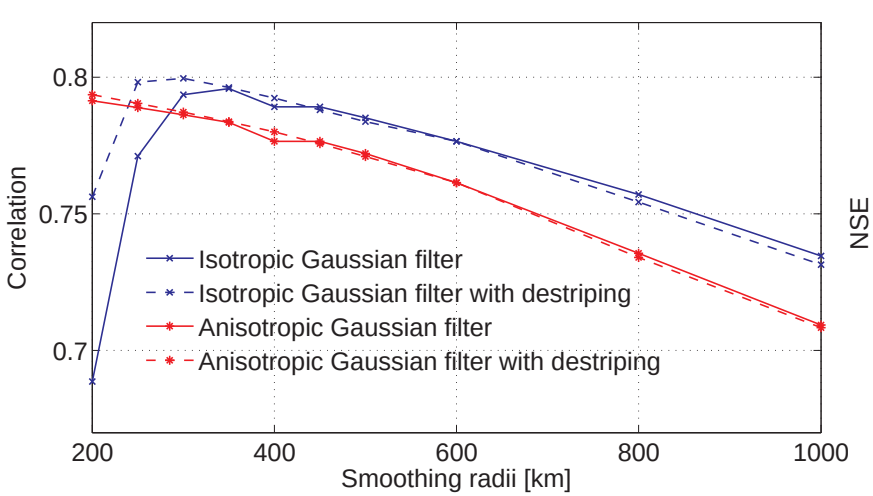
- Comparison with GPS: Nash-Sutcliffe efficiency

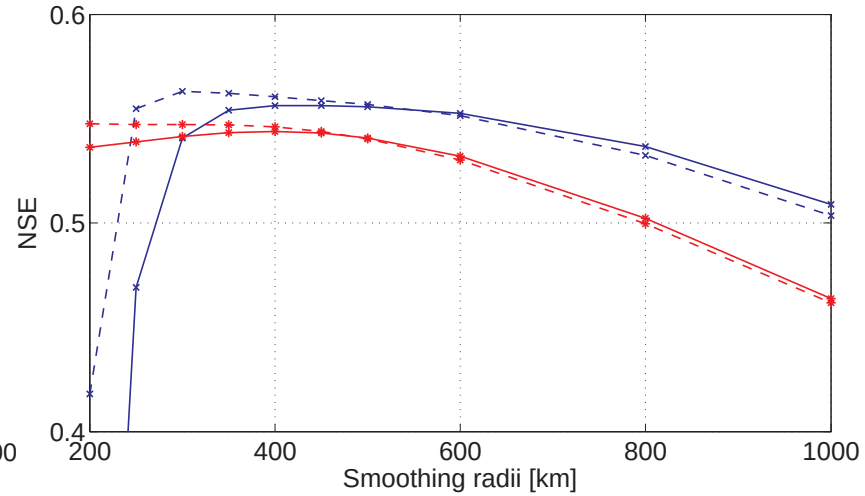
$$E = 1 - \frac{\sum_{i=1}^{n} (\mathrm{GPS}_i - \mathrm{GRACE}_i)^2}{\sum_{i=1}^{n} (\mathrm{GPS}_i - \overline{\mathrm{GPS}}_i)^2}$$



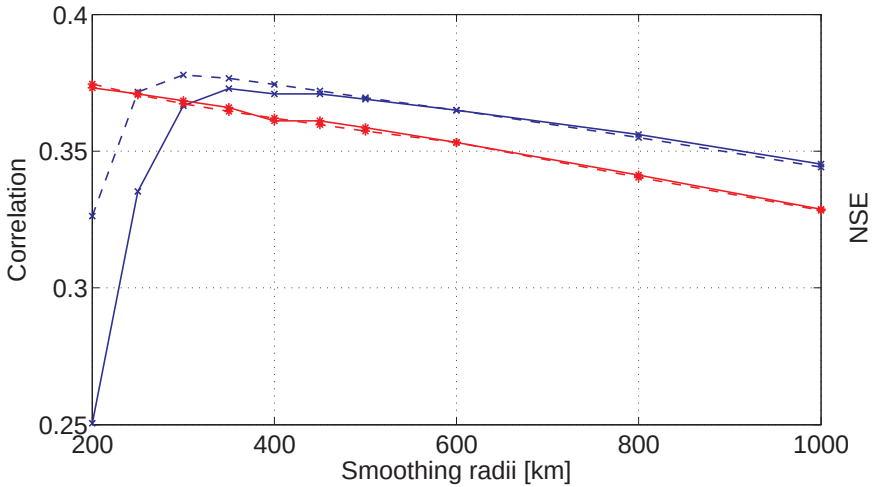
Mean: deterministic filters

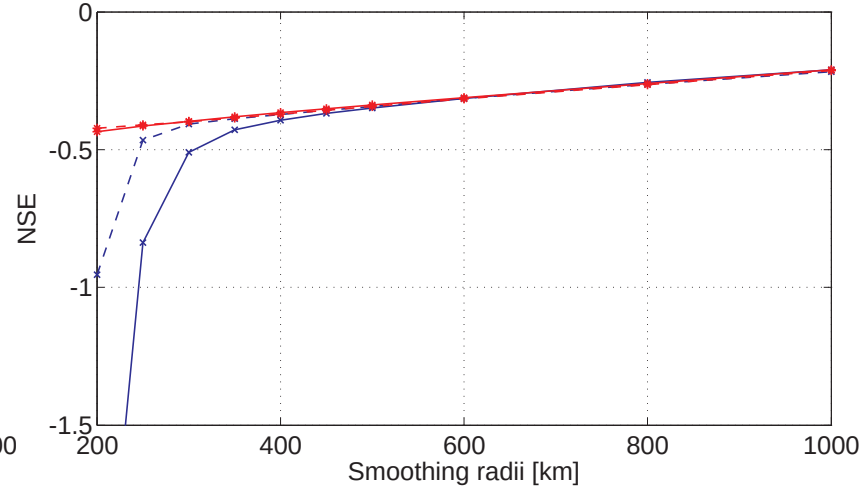
GPS stations inside the basin (17 stations)





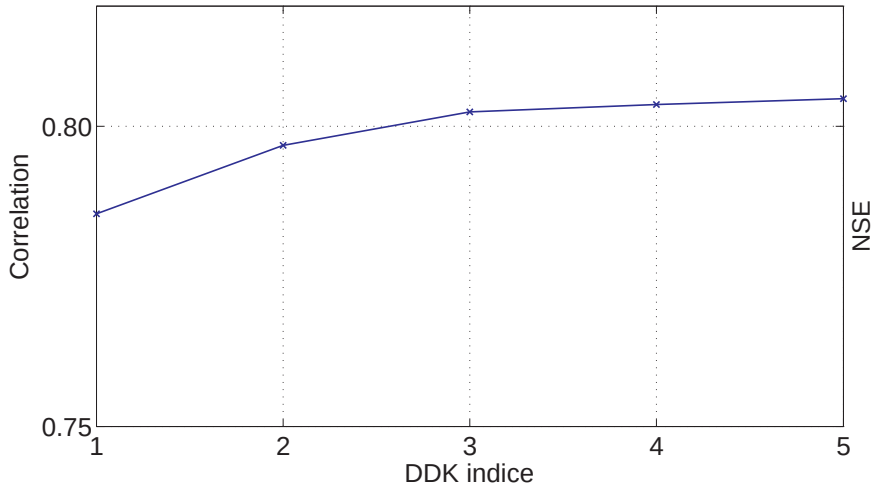
GPS stations along the coast (29 stations)

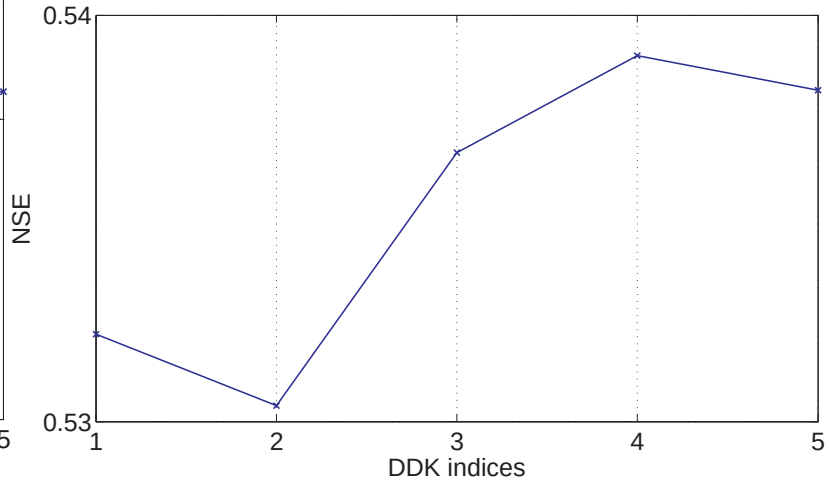




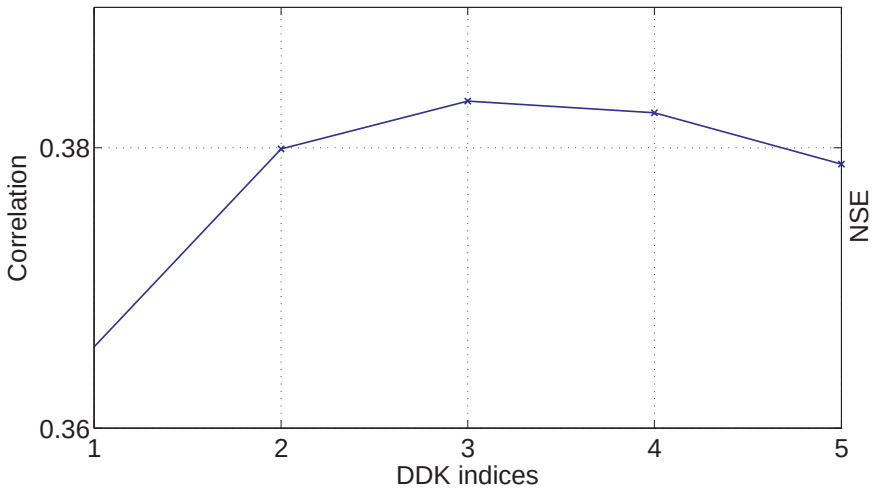
Mean: DDK filters

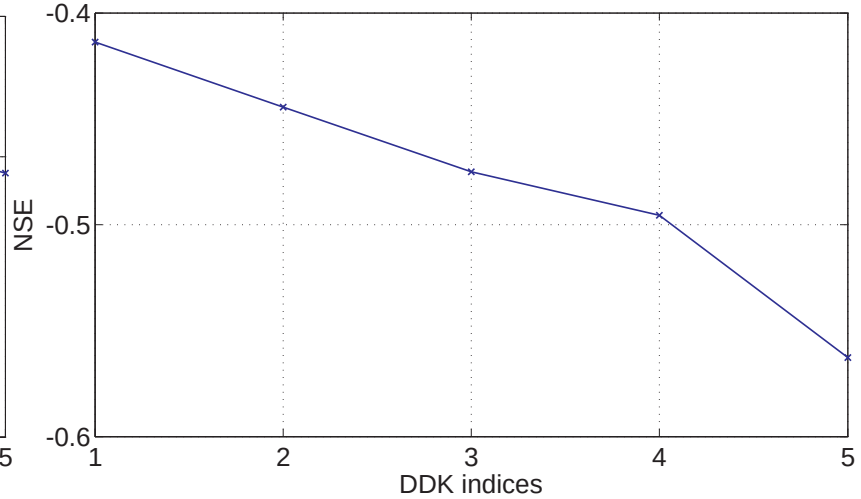
GPS stations inside the basin (17 stations)



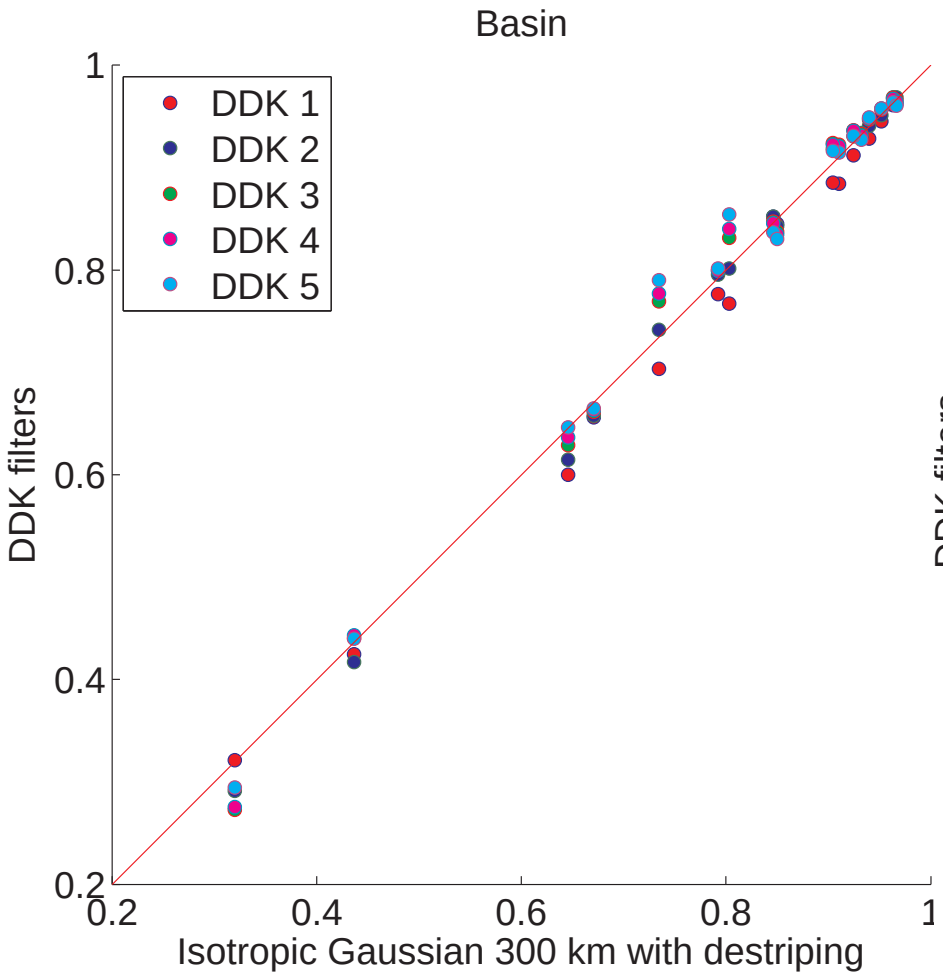


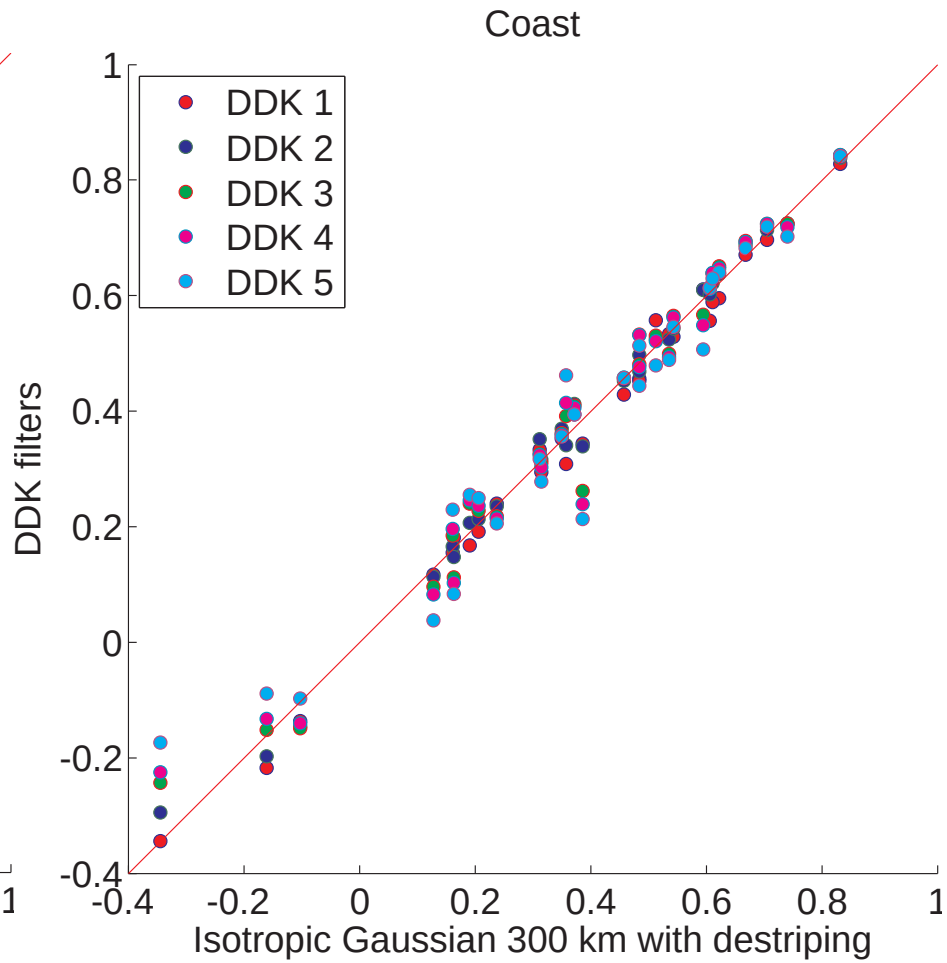
GPS stations along the coast (29 stations)



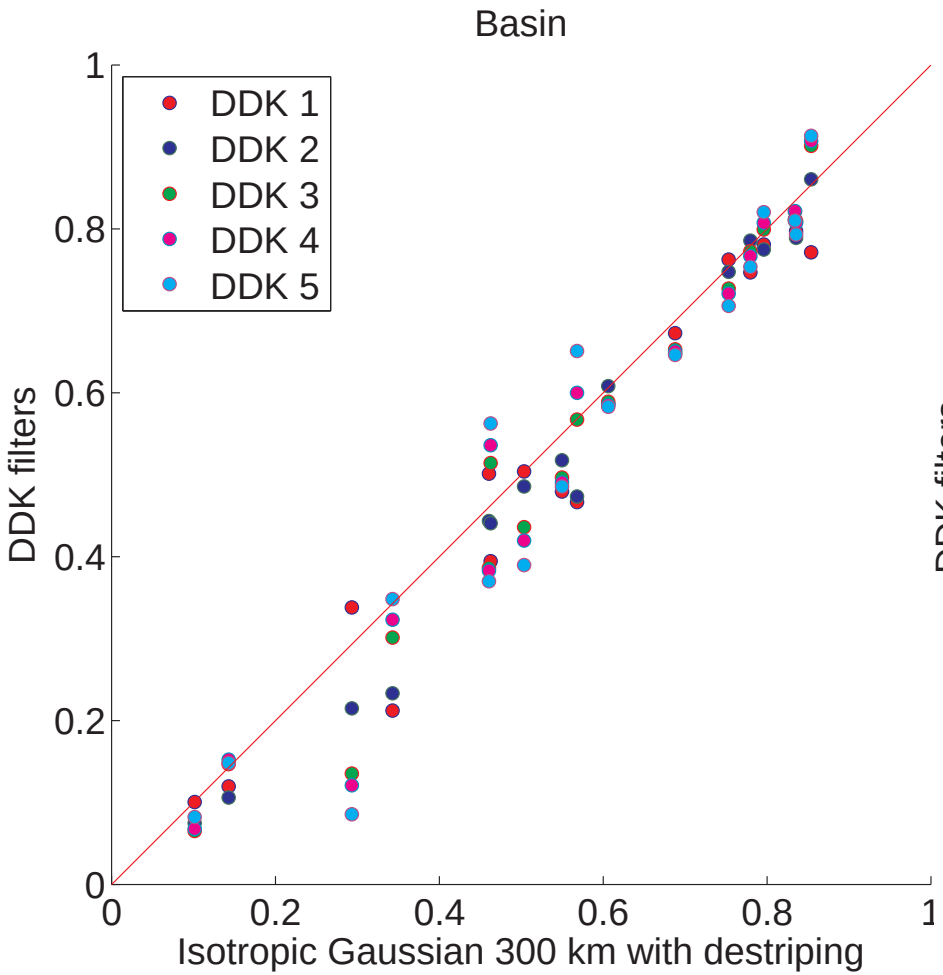


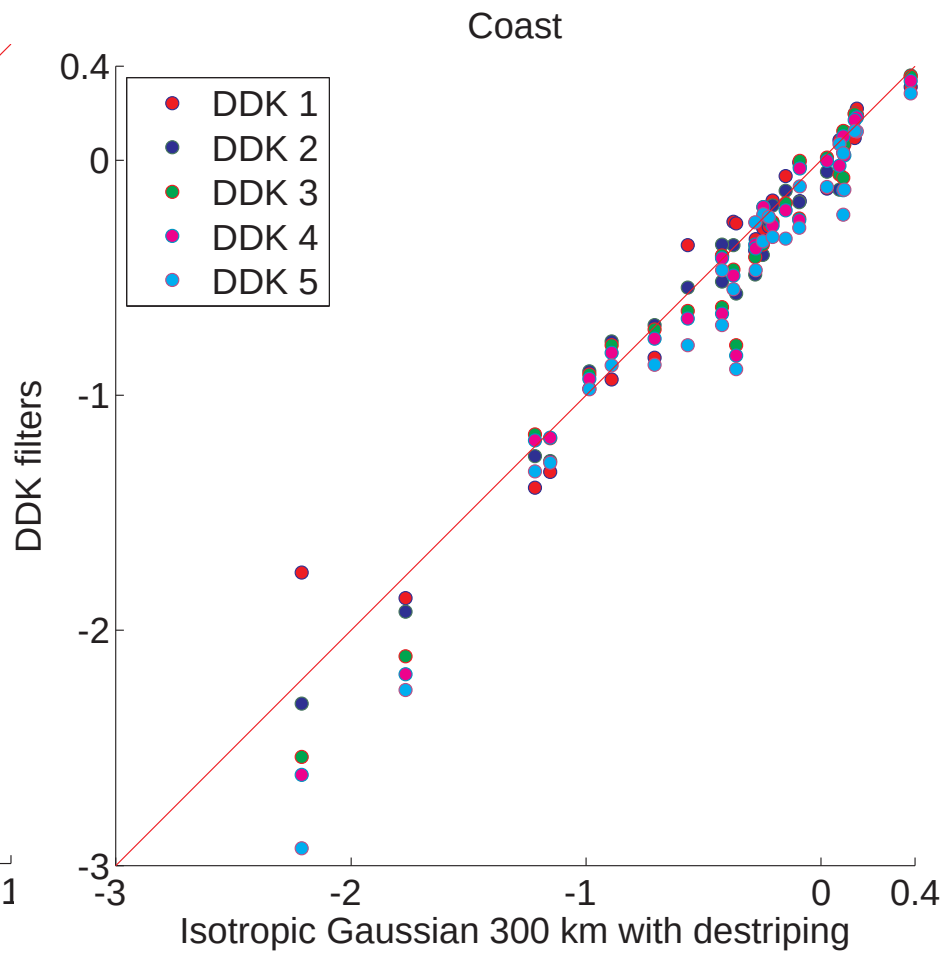
Deterministic filters vs DDK filters: correlation





Deterministic filters vs DDK filters: NSE





Conclusions

- Within the selected GPS stations, only those stations inside the continent show good consistency between GPS and GRACE. Stations along the coast display very bad consistency.
- No filter shows consistent good performances over all the selected stations. Nevertheless, we found the destriping filter is helpful in combination with the isotropic Gaussian filter at low smoothing radii.
- Anisotropic Gaussian filter does not improve the performances with respect to the isotropic Gaussian filter.
- In this study, isotropic Gaussian filter of the radius of 300 km with destriping outperforms other filtering schemes in the deterministic filter group. This filtering scheme seems to perform even slightly better than DDK filters over the study area.

Thanks for your attention!

Contact: qiang.chen@gis.uni-stuttgart.de

Acknowledgements:

Laura Sánchez (DGFI) is appreciated for providing the SIRGAS GPS time series. We also acknowledge GFZ for providing GRACE RL05a products and GSM coefficients filtered by the DDK filters.