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Signal separation: the quest for independent mass flux patterns in geodetic observations

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Today, the analysis of the Earth's time-variable gravity field and land and ocean surface plays a key role in geodetic Earth system research. The GRACE and GPS observables provide, together with satellite altimetry, an almost direct measurement of the amount of mass that is redistributed at or near the surface of the planet by oceanic and atmospheric circulation and through the hydrological cycle.

With reprocessed data sets, it is now widely accepted that GRACE gravimetry and GPS loading inversion see the same mass flux signals, although at different spatial and temporal scales. The same goes for GRACE and ocean altimetry, when steric effects in the sea level are taken into account. This has lead to promising approaches that combine these techniques, e.g. in order to improve geocenter estimates or to estimate ocean heat storage. However, in the view of the authors, the biggest challenge in data analysis is the problem of signal separation. This problem is three-fold: 1) separation of signal and noise stemming from the measurement systems, 2) separation of mass flux patterns originating from different compartments of the Earth system (trends in continental hydrology vs. GIA, the leakage problem in ice sheet mass balance from GRACE), 3) identification of physically dependent and independent signals within the same compartment (sea level contributors, teleconnections in the hydrological cycle).

In this contribution we will first review different techniques that have been suggested for signal separation using multi-sensor data, including the joint spherical harmonic analysis, the 'fingerprint' inversion method and various methods rooted in the assumption that physically independent processes generate uncorrelated or statistically independent observations. The, results obtained by our group in jointly analysing global GRACE, GPS and altimetry data sets will be presented.