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Separation of GRACE observations into individual mass variations of atmosphere, oceans, and continental hydrosphere

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The identification of individual mass signals in the Earth's subsystems atmosphere, oceans and continental hydrosphere remains one of the challenging problems in satellite gravimetry. This contribution presents an approach for separating mass signals from GRACE observations by means of base functions derived from geophysical models. In general, for the representation of a signal an infinite number of base function systems can be chosen. To select an appropriate system, various aspects can be considered. Principal component analyses (PCA) are performed for geophysical models of the atmosphere, oceans and continental hydrosphere leading for each subsystem to a complete set of Empirical Orthogonal Functions (EOFs) and associated Principal Components (PCs). These EOFs can be taken to estimate by a least squares process new PCs that explain the integral GRACE gravity observations. A closed loop simulation proves that the separation (the reconstruction of individual PCs) is possible although (1) the atmospheric mass variations overlay mass variations of both, oceans and continental hydrosphere and (2) there is leakage from ocean to land and vice versa.
The separation works with real, unfiltered GRACE observations and a limited number of EOF base functions for the individual subsystems. The residuals of the GRACE observations as well as the correlations of the unknowns show that mass signals in the Earth's main subsystems atmosphere, oceans and continental hydrosphere can be clearly separated