Fast determination of surface water mass changes using regional orthogonal functions

Guillaume Ramillien (1, 3, 4), Lucia Seoane (2, 3, 4) and José Darrozes (2, 3, 4)

Guillaume.Ramillien@get.omp.eu; Lucia.Seoane@get.omp.eu

1. Centre National de la Recherche Scientifique (CNRS)
2. Université Paul Sabatier (UPS)
3. Géosciences Environnement Toulouse (GET)
4. Observatoire Midi-Pyrénées (OMP)

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We propose a representation method that maximize the information inside a domain by construction of a finite set of regional orthogonal functions known as Slepian functions (Simons 2009)

(*)& modified from Freeden & Schreiner 2008
Examples of regional Slepian functions: cases of Africa & Congo basin
Recovery of WaterGap Global Hydrology Model (WGHM) maps by Kalman Filtering estimation

\[ s(\theta, \lambda) = \sum_{K=1}^{K_{\text{max}}} \text{slepian}(\theta, \lambda)^{(k)}a^{(k)} \]
Inversion of real GRACE data – First results (1/2)

Recovery of the first modes from GRACE-based geopotential differences

First modes versus time by KF estimation

<table>
<thead>
<tr>
<th>Coefficient amplitude (m of Equivalent Water Height)</th>
<th>( K=1 )</th>
<th>( K=2 )</th>
<th>( K=3 )</th>
<th>( K=4 )</th>
<th>( K=5 )</th>
<th>( K=6 )</th>
</tr>
</thead>
</table>

| | \( K=10 \) | \( K=20 \) | \( K=30 \) | \( K=40 \) | \( K=50 \) | \( K=60 \) |
| | \( K=90 \) | \( -0.25 \) | \( 0 \) | \( 0.25 \) | \( 0.5 \) | \( 0.5 \) |

Inversion of real GRACE data – First results (2/2)

Recovery of the first modes from GRACE-based geopotential differences

![Maps showing geopotential differences for different months and Kmax values](image)
Highlights

A promising approach based on orthogonal Slepian functions has been successfully developed to invert GRACE satellite geopotential difference data and map continental water storage changes.

It is possible to follow the evolution of the GRACE Slepian coefficients adjusted by Kalman Filtering (KF).

Perspectives

Numerical optimization of the computation of Slepian coefficients of higher orders (K ~ 7000) would permit to reach better spatial resolutions in continental hydrology.

Multi-year series of coefficients estimated from real GRACE (-FO) data would enable spatio-temporal analysis and characterization of water mass processes.