Response of Arctic sea level and hydrography to hydrological regime change over boreal catchments (RASLyBoCa)

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RASLyBoCa Project

- Hydrological regime change over Boreal Catchments → response of Arctic Sea Level and hydrography
- Focus on continental discharge into the Arctic Ocean, as it may significantly influence the regional dynamics
- A wide range of observation techniques is used, such as
  - in-situ data
  - satellite altimetry data
  - satellite gravimetry data
  - numerical simulations with forward and “adjoint/dual” models

(Holmes et al., 2015)
Satellite crossings along the Mackenzie river

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Repeat track [days]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Envisat</td>
<td>35</td>
</tr>
<tr>
<td>Jason-2/3</td>
<td>10</td>
</tr>
<tr>
<td>Saral/Altika</td>
<td>10</td>
</tr>
<tr>
<td>Sentinel 3A/B</td>
<td>27</td>
</tr>
</tbody>
</table>
Densification

Combining measurements in time and space
Estimating water levels at
  - Any place
  - Any time
Least squares collocation (LSC)

Observation equation:

\[ y = Ax + s + n \]

- \( y \) - measurement
- \( Ax \) - functional term
- \( s \) - stochastic signal
- \( n \) - noise
LSC- Method

\[ y = Ax + s + n \]
\[ y - Ax = s + n \]
\[ Q_{ee} = Q_{ss} + Q_{nn} \]

Linear equation model

\[ \hat{x} = (A^T Q_{ee}^{-1} A)^{-1} A^T Q_{ee}^{-1} y \]
\[ \hat{s} = Q_{ss} Q_{ee}^{-1} (y - A\hat{x}) \]
\[ \hat{n} = Q_{nn} Q_{ee}^{-1} (y - A\hat{x}) \]

Estimation step

\[ \hat{s}_d = Q_{s_d} \hat{s} Q_{s_s}^{-1} \hat{s} \]
\[ \hat{y}_d = A_d \hat{x} + \hat{s}_d \]

Densification in time

y – measurement
s – signal
Ax – functional term
n – noise
e – residuals
LSC – Results and Outlook

Densified Jason-2 track 223 with in-situ data

RMSE between densified time series and in-situ is 0.49 m
AWI - Introduction

• Global simulations with analysis focus on Arctic
• Lat-lon-cap (llc) grid with nominally 1° resolution (40km in Arctic), 50 vertical layers
• Forward sensitivity experiments: force model with different run-off data sets to explore the effect of improved run-off data
• Prototype simulation with climatological seasonal run-off vs. interannual run-off in preparation for improved run-off data
Methods to adjust freshwater flux

freshwater budget = \( E - (P + \Delta FW) - R \)
Comparison to observations

Results: climatology vs. interannual runoff

**CORE II datasets**

Aug 2010: sea level differences are small but salinity difference have accumulated over time.

(Church and White, 2011)
Conclusions

GIS
• First densification tests show motivating results
• Conducting LSC in time and space
• Include long-/no-repeat altimetry missions like CryoSat-2

AWI
• Insufficient freshwater forcing data sets require adjustment.
• Not yet addressed:
  higher resolution (1/3°) and adjoint simulations
Thank you very much for your attention!
Reference

