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How to optimize the spatial resolution of GRACE data for studying mass anomaly trends of the Greenland and Antarctic Ice Sheets?

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Research questions

• How to obtain unbiased high-quality high-resolution estimates of mass trends within the ice sheets from GRACE data?
• How robust are the obtained estimates?
Primary input data

- **GRACE gravity field solutions:**
  - ITSG-Grace2016 (90x90)
  - (Degree-1, $C_{20}$): Y.Sun et al (2016)

- **Time interval:** 2003 – 2012
Mascon approach

- Synthesized gravity disturbances:
  - \( h = 500 \text{ km} \)
  - Point-to-point separation: \( 1^\circ \)
  - Buffer width: 300 km
  - Inspired by: Forsberg & Reeh (2007)
- Parameterization:
  - Many small equal-size homogeneous patches inside Greenland
  - 9 homogeneous patches around Greenland
- Inversion:
  - bounded above (trend < 10 cm/yr)
Major problem with high-accuracy data:
- Model (discretization) errors: actual mass anomalies are not constant within patches (J.Ran)

-> Dynamic patch approach: Let us average multiple estimates obtained with slightly different parametrizations
Parametrizations of the dynamic patch approach: a few examples

A set of ~100 alternative parametrizations is typically considered
Result of the dynamic patch approach (patch sizes 150 : 0.5 : 200)

EWH trend

(C) Wikipedia
Validation data

**Height trend**

- ICESat-based height trends:
  - Resolution: 20x20 km
  - Courtesy: B. Gunter

Correlation coefficients between ICESat-based and GRACE-based trends are estimated.
Dynamic patch approach: dependence on the patch size

150:0.5:200

Corr: 47.4%

250:0.5:300

Corr: 48.7%

350:0.5:400

Corr: 44.6%
Dynamic patch approach: dependence on the data area

- 300 km
- 500 km
- 700 km
Dynamic patch approach: dependence on the data area (cont’d)

Corr: 47.4%

Corr: 44.8%

Corr: 42.1%
Dynamic patch approach: dependence on the upper bound

- Less than 10 cm/yr: Corr: 47.4%
- Less than 30 cm/yr: Corr: 43.5%
- Unlimited: Corr: 0.1%

ICESat-RACMO

GRACE(DMT2)-ICESat-RACMO

(cm/yr EWH)
Conclusions

• Dynamic patch approach is a powerful tool to obtain high-resolution estimates of mass trends within the ice sheets from GRACE data.

• The obtained estimates show a noticeable sensitivity to the considered range of patch sizes and the chosen data area.

• Setting a reasonable upper limit of trend estimates is critical (particularly, when patch sizes are small).
Future outlook

- Usage of state-of-the-art GRACE/GRACE-Follow-On data
- Further refinement of data processing strategy (incl. refinement of geographical constraints)
- Further validation of the obtained results
- Application to other geographical areas
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