Evaluation of a new snow albedo scheme for the Greenland ice sheet in the regional climate model RACMO2

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RACMO2.3p3: A new version of the regional climate model RACMO2

For what has RACMO2 been used?

- Surface processes of major ice sheets and ice caps. In this study: Greenland
- Present-day climate, future climate projections and much more…

What is new?

- Spectral snow albedo
- Radiation penetration
- Subsurface heating and internal melt
- Updated bare ice scheme
- Updated firn model

What modules do we use?

- Two-streAm Radiative TransfEr in Snow model (TARTES, Libois et al., 2013)
- Coupled with: Spectral-to-NarrOWBand ALbedo (SNOWBAL) module (Van Dalum et al., 2019)

Libois, Q., Picard, G., France, J. L., Arnaud, L., Dumont, M., Carmagnola, C. M., and King, M. D.: Influence of grain shape on light penetration in snow, Cryosphere, 7, 1803–1818, https://doi.org/10.5194/tc-7-1803-2013, 2013.

Van Dalum, C. T., Van de Berg, W. J., Libois, Q., Picard, G., and Van den Broeke, M. R.: A module to convert spectral to narrowband snow albedo for use in climate models: SNOWBAL v1.2, Geoscientific Model Development, 12, 5157–5175, https://doi.org/10.5194/gmd-12-5157-2019, 2019.

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Question: How well does the new albedo scheme perform
and what impact does it have on the Greenland ice sheet?

Evaluation with:

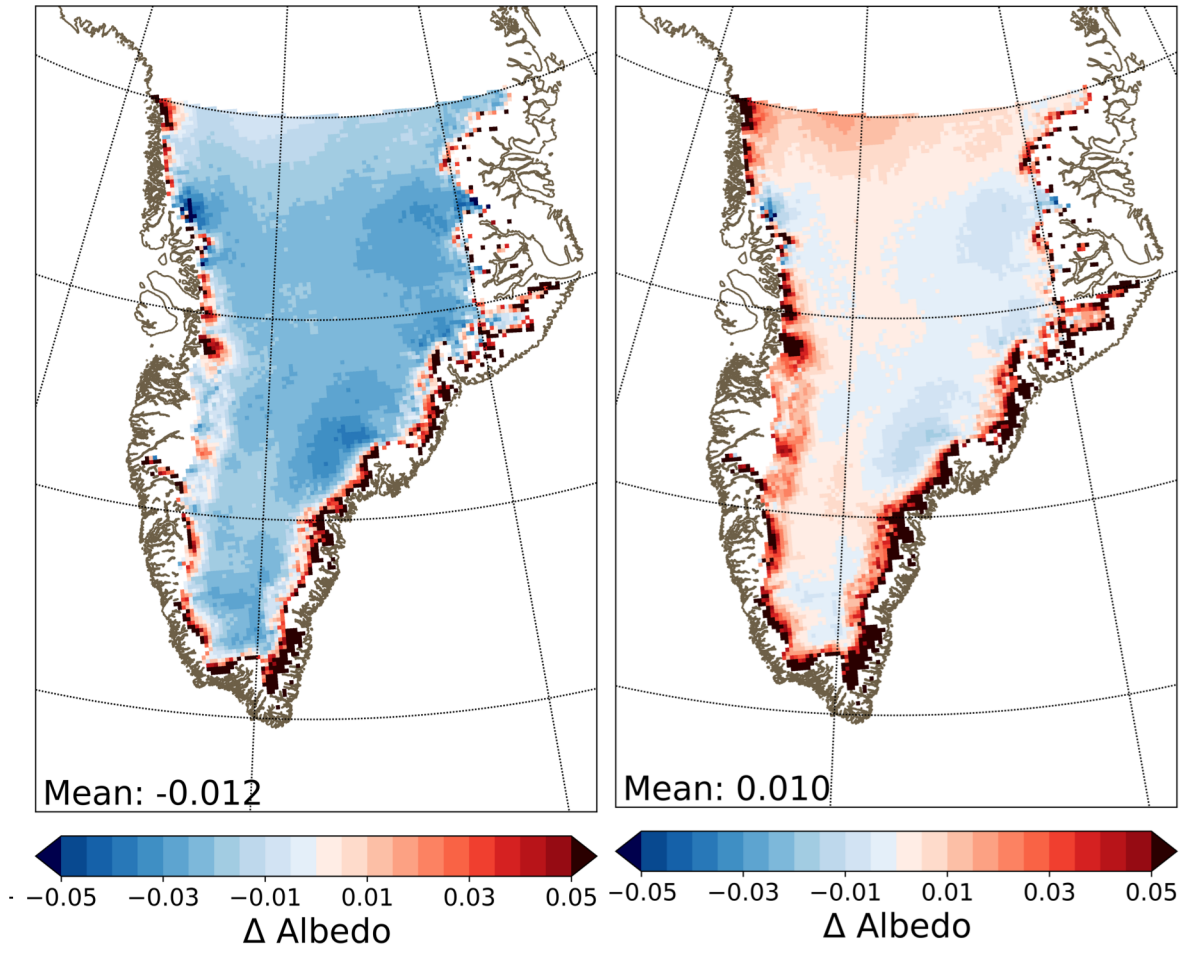
- MODIS MCD43A3 remote-sensing albedo product: broadband and its seven bands.
- K-transect and PROMICE automatic weather station data
- K-transect and PROMICE stake measurements
- Subsurface temperature observations

RACMO2 settings:

- Resolution: 11 km
- 2006-2015, with spin up from September 2000-2005
- Lateral boundaries: ERA-Interim

Average clear-sky albedo difference: RACMO2.3p3 - MODIS

- In general: small albedo difference with MODIS, especially after bias correction
- Interior: mean corrected bias is 0.000
- South-eastern margin:
  - Inadequate resolution in RACMO2
  - Large uncertainty in the MODIS product



No bias correction

MODIS bias corrected

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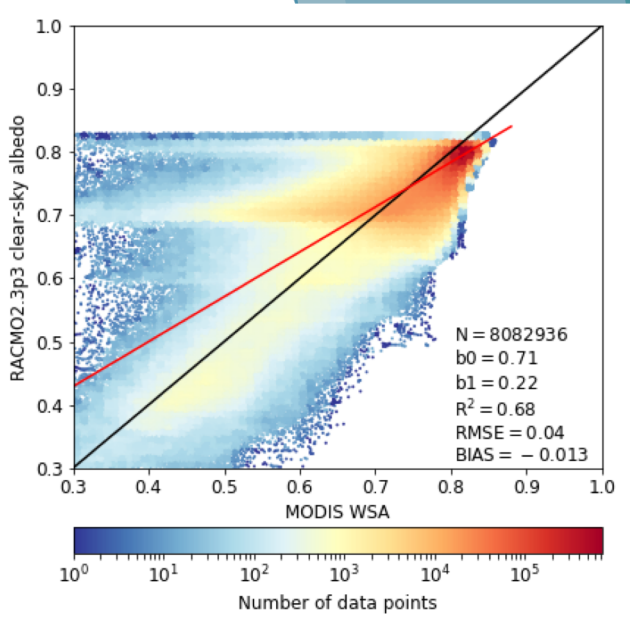
RACMO2.3p3 albedo

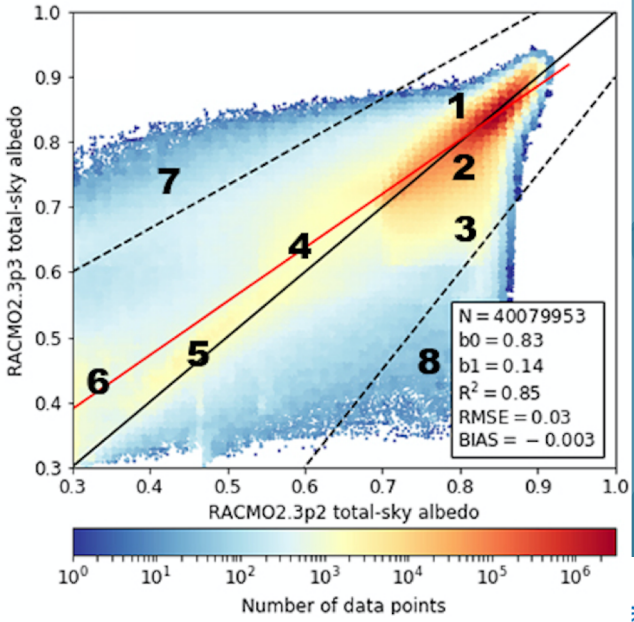
Every point represents data for a grid point on 15:00 UTC for a day between 2006 and 2015

We compare RACMO2.3p3 albedo with MODIS white-sky albedo (WSA) and the previous RACMO2 version: 2.3p2



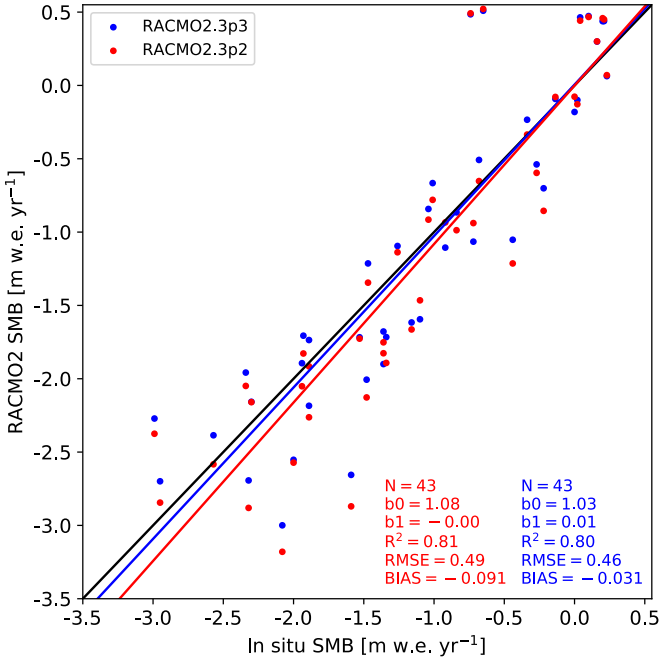
The following can be observed:

- 1. In general: close to the 1-1 line
- 2. Slightly stronger snow metamorphism in RACMO2.3p3
- 3. Radiation penetration: subsurface darker ice or firn alter the albedo
- 4. A slower firn-ice transition
- 5. Bare ice is often modeled similarly
- 6. Edge errors in RACMO2.3p2 and clouds
- 7. Newly modeled snow
- 8. Radiation penetration: subsurface bare ice alters the albedo

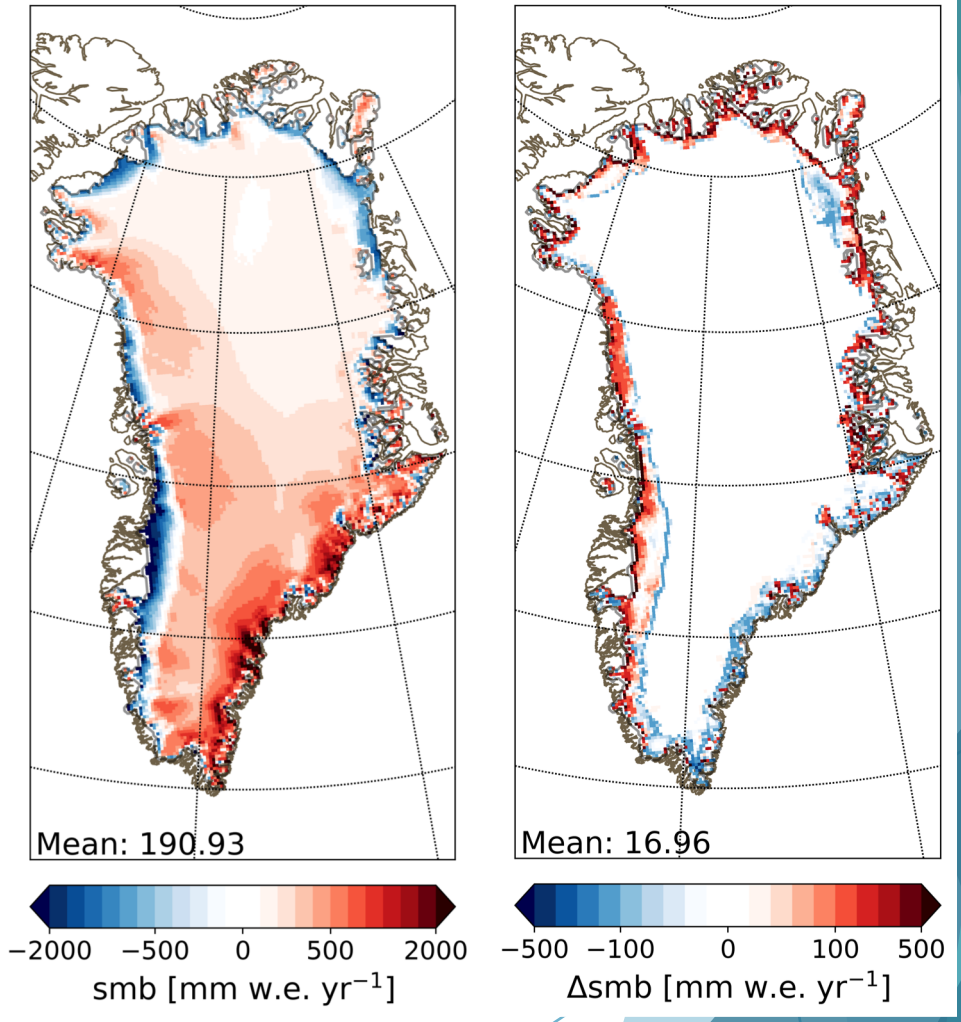


Surface mass balance (SMB)

- In the interior, almost no SMB change
- Tundra albedo contamination at the margins in RACMO2.3p2 → Higher SMB
- SMB compares well with observations



K-transect and PROMICE observations



RACMO2.3p3 RACMO2.3p3 – RACMO2.3p2

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Subsurface temperature

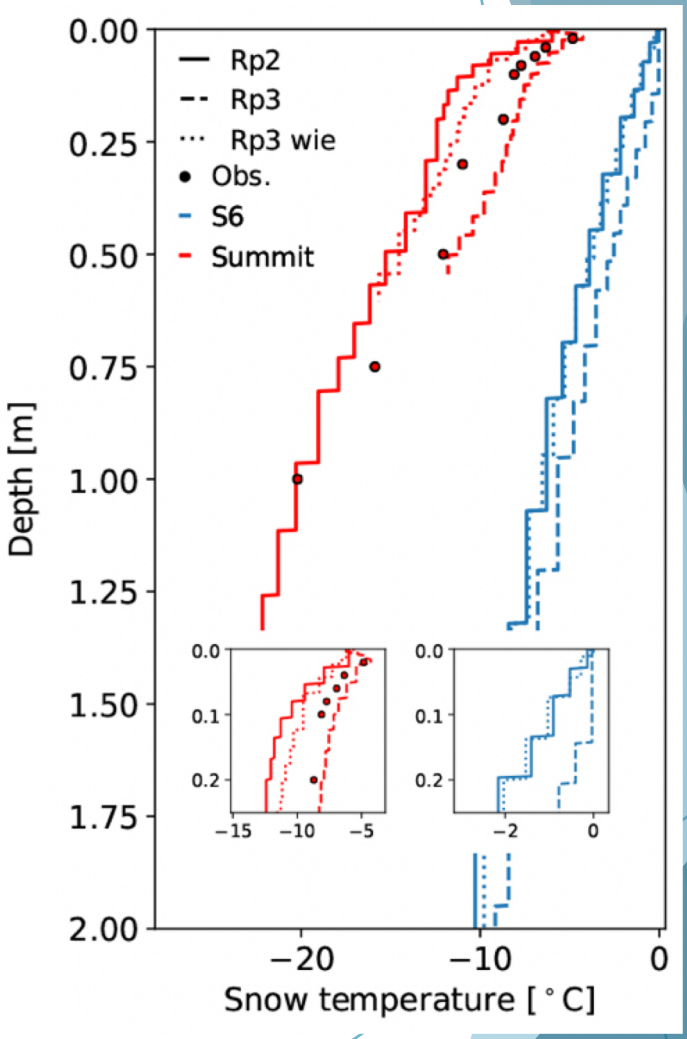
- Temperature profile for Summit (in the accumulation area, red) and S6 of the K-transect (in the ablation area, blue) for 10 July 2007, 15:00 UTC.
- RACMO2.3p2 (Rp2), RACMO2.3p3 (Rp3) and RACMO2.3p3 without internal energy (wie) absorption are considered
- Each step is a modeled snow layer, upper 20 layers are shown

For Summit:

- Internal energy absorption leads to a better temperature profile
- Higher vertical resolution in RACMO2.3p3

For S6

- Melt extent is increased in RACMO2.3p3



Summary

- RACMO2.3p3 snow and ice albedo compare well with observations
- Differences between the albedo of RACMO2.3p3 and the previous version can be explained by physical processes

- SMB correlates well with observations
- SMB differences with the previous RACMO2 version are generally small, except for some regions around the margin

- Subsurface energy absorption improves the internal snow temperature profile and extends melt to deeper layers.