

Clouds enhance Greenland ice sheet meltwater runoff

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KU LEUVEN

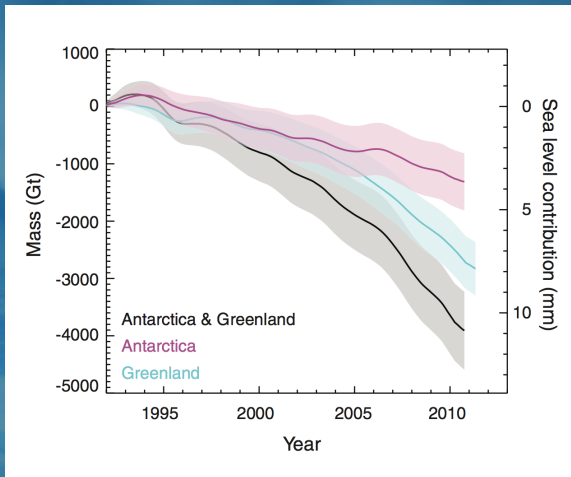
 **TU Delft**





Why?

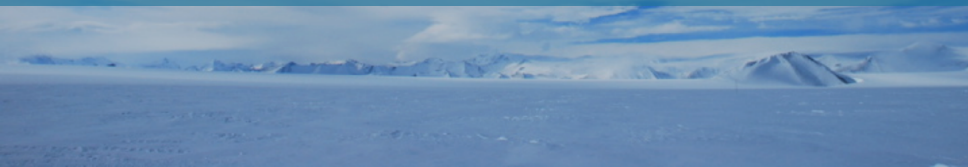
Effect on sea level



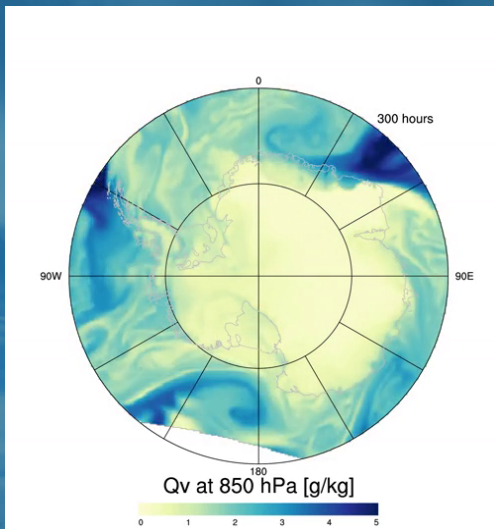
Shepherd et. al., *Science*, 2012

Two major uncertainties

- ▶ Clouds / precipitation
- ▶ Albedo feedbacks

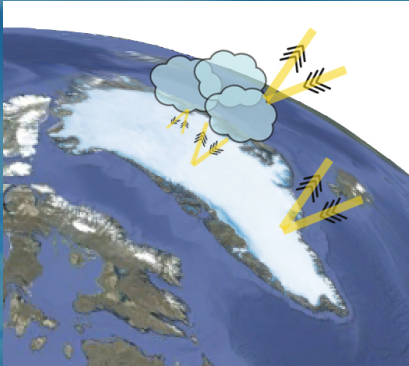


Clouds are a source of precipitation

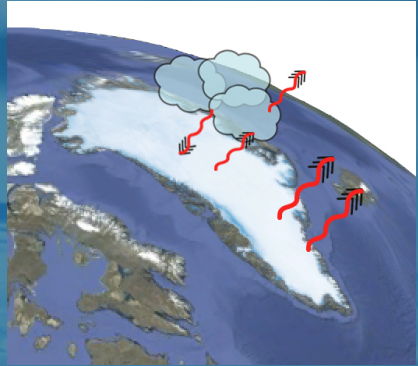


Clouds affect incoming radiation

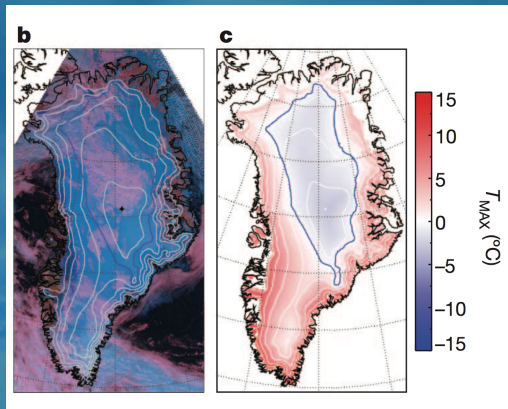
SW cooling



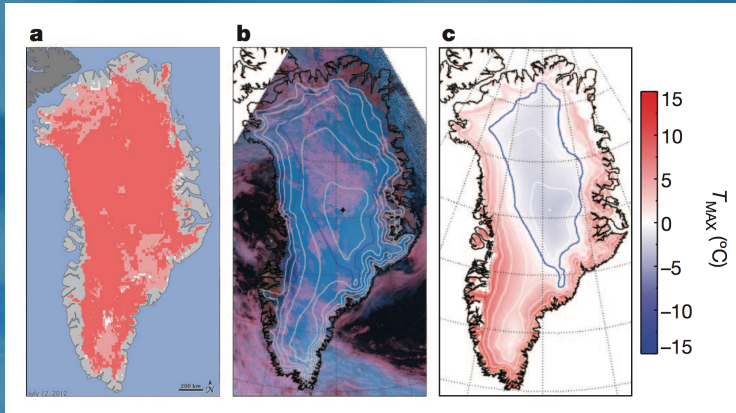
LW warming



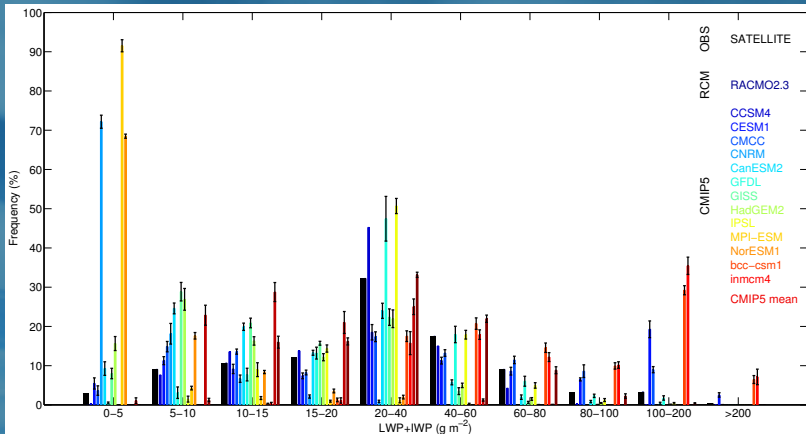
Importance of this forcing



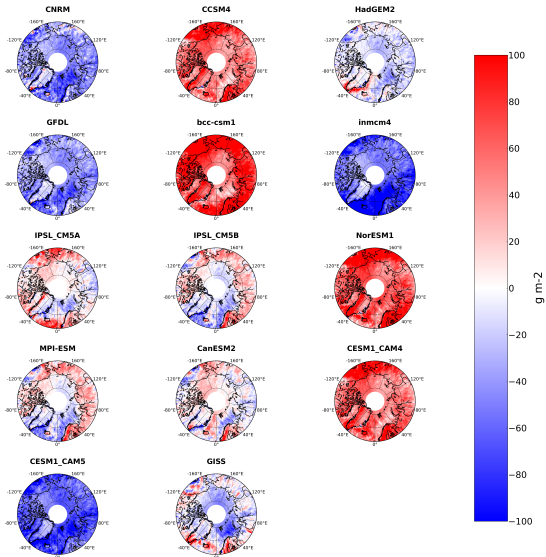
Importance of this forcing



Major uncertainty in models



Difference in Mean total water path between CMIP5 and SATELLITE



An aerial photograph of a dry, cracked desert landscape. The ground is light-colored and shows extensive cracking and erosion patterns. A large, semi-transparent teal circle is overlaid in the center of the image. Inside the circle, the text "Remote sensing of cloud effects" is written in white, sans-serif font.

Remote sensing of cloud effects



ARTICLE

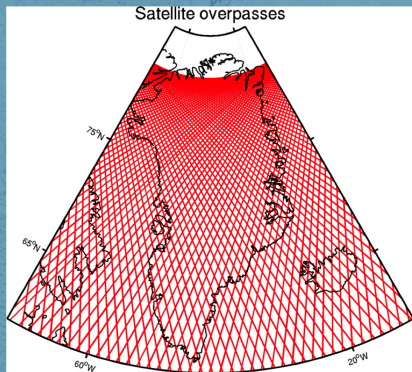
Received 26 May 2015 | Accepted 23 Nov 2015 | Published 12 Jan 2016

DOI: [10.1038/ncomms10266](https://doi.org/10.1038/ncomms10266)

OPEN

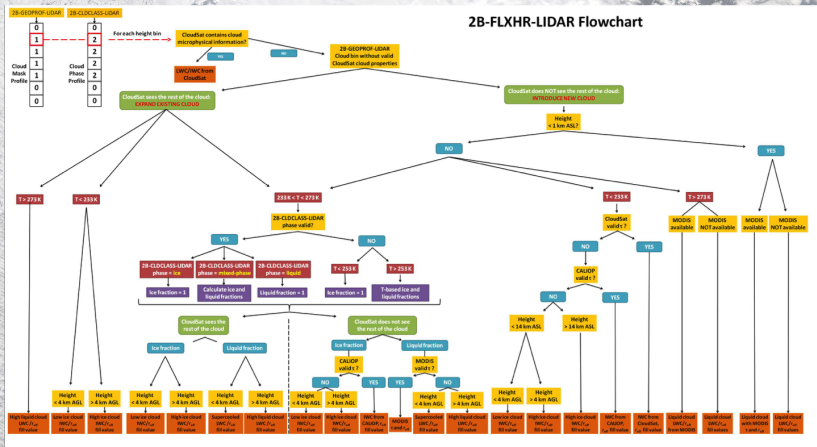
Clouds enhance Greenland ice sheet meltwater runoff

K. Van Tricht¹, S. Lhermitte¹, J.T.M. Lenaerts², I.V. Gorodetskaya¹, T.S. L'Ecuyer³, B. Noël², M.R. van den Broeke², D.D. Turner⁴ & N.P.M. van Lipzig¹

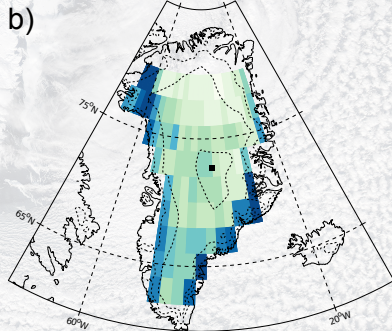
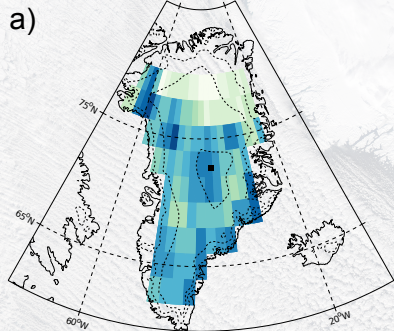
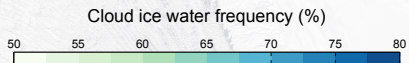


Cloudsat / Calipso

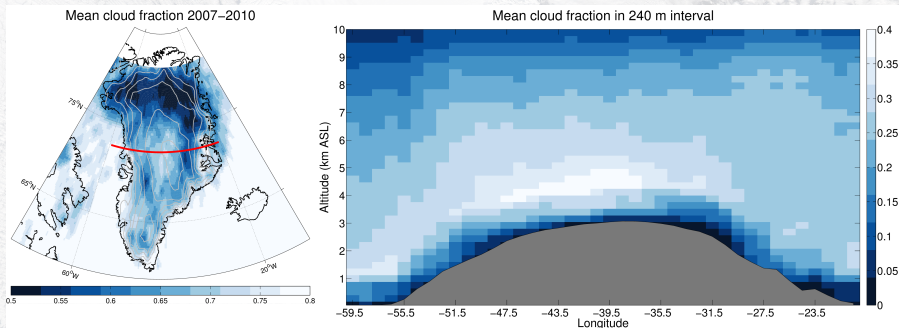
- ▶ GrIS
- ▶ 2007-2010
- ▶ 2x2° grid
- ▶ Cloud properties
- ▶ SW/LW flux products
2B-FLXHR-LIDAR.R04



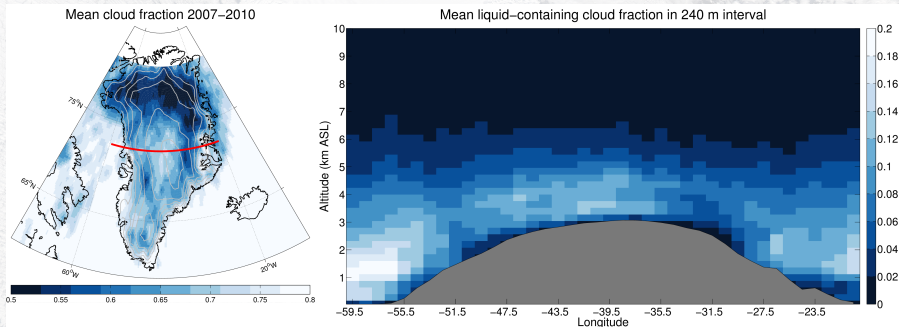
Cloud macrophysical properties



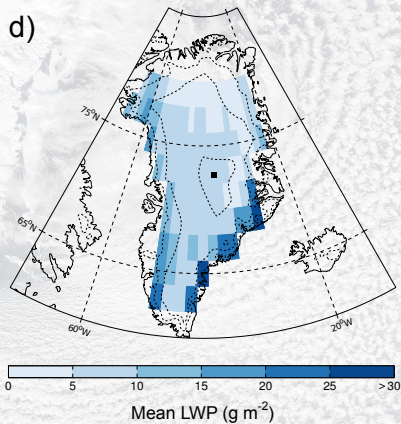
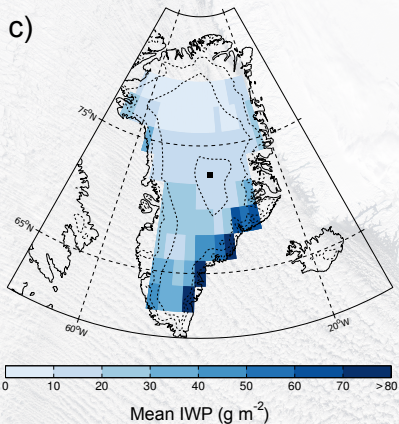
Cloud macrophysical properties



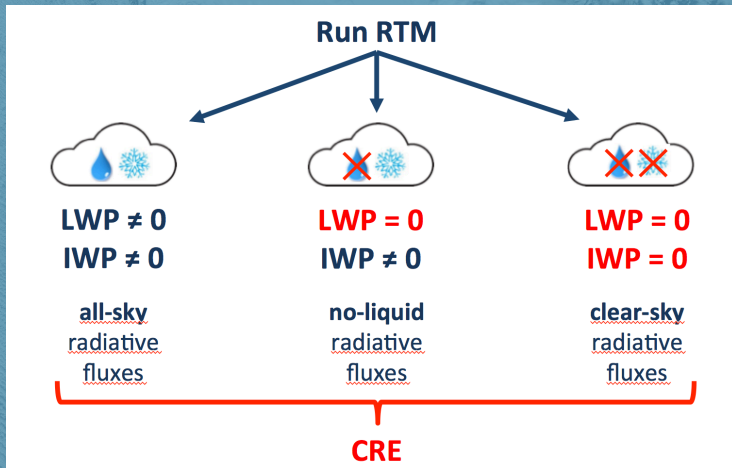
Cloud macrophysical properties



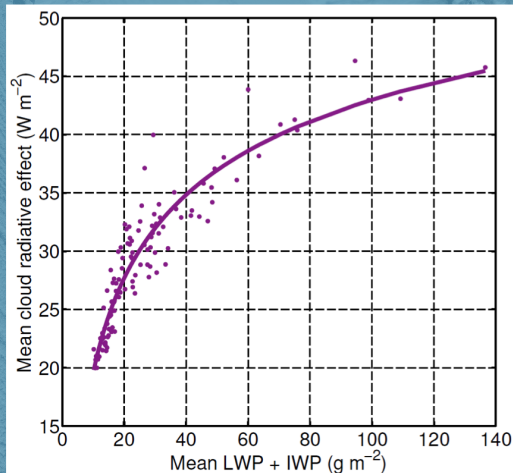
Cloud microphysical properties



Cloud radiative effect



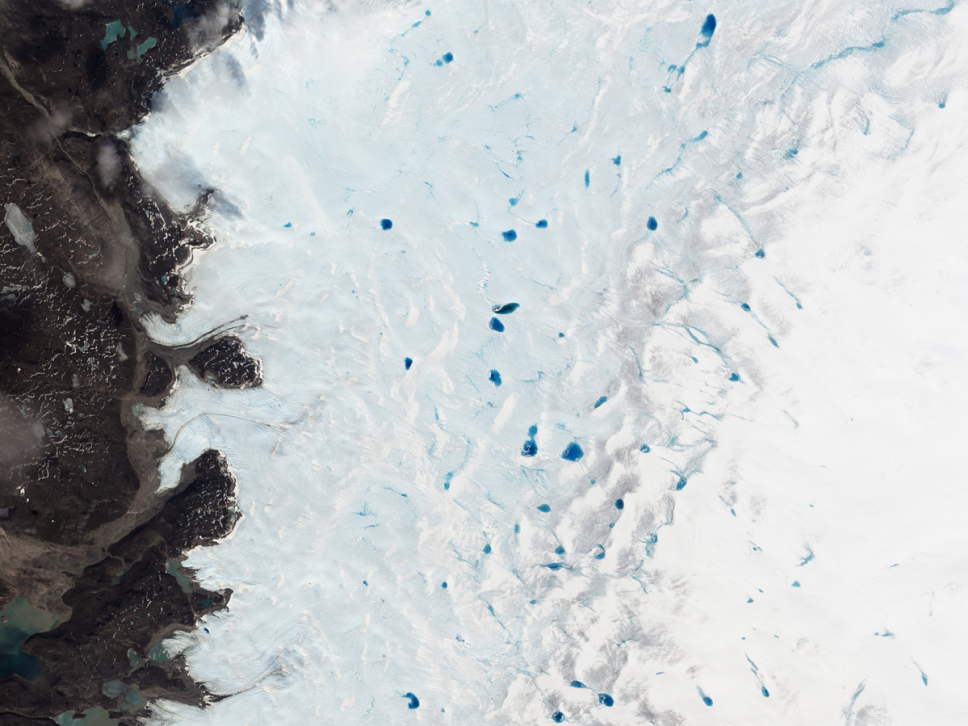
Satellite based cloud forcing



$$CRF = 29 \pm 5.2 W/m^{-2} \text{ or } 90 Gt/yr$$

A satellite image of Earth showing a mix of dark brown landmasses on the left and white, grey, and blue cloud patterns over the oceans. A large, semi-transparent blue circle is centered over the image, containing the title text in white. The background image shows a high-contrast view of the planet's surface and atmosphere.

Cloud-surface interactions





But how?



spatial resolution



temporal resolution



cloud-related uncertainties

**Climate
models**

But how?



spatial resolution



temporal resolution



cloud-related uncertainties

**Climate
models**



spatial resolution

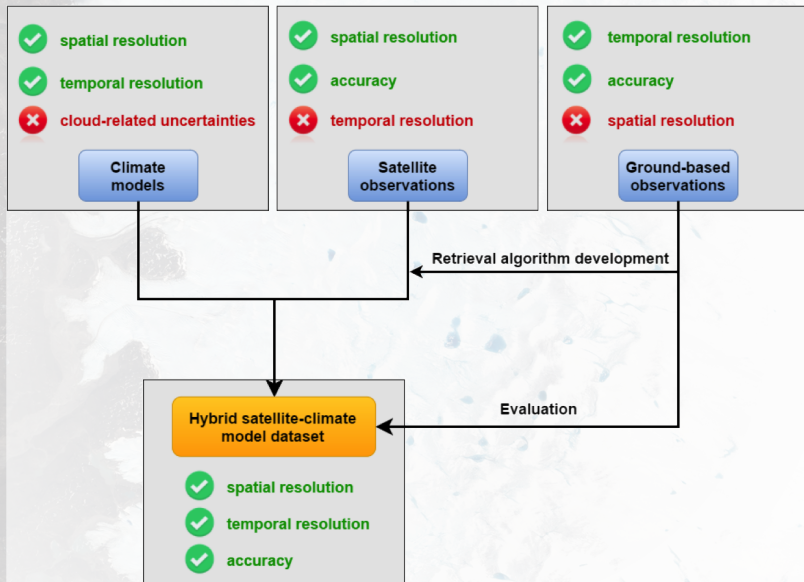


accuracy

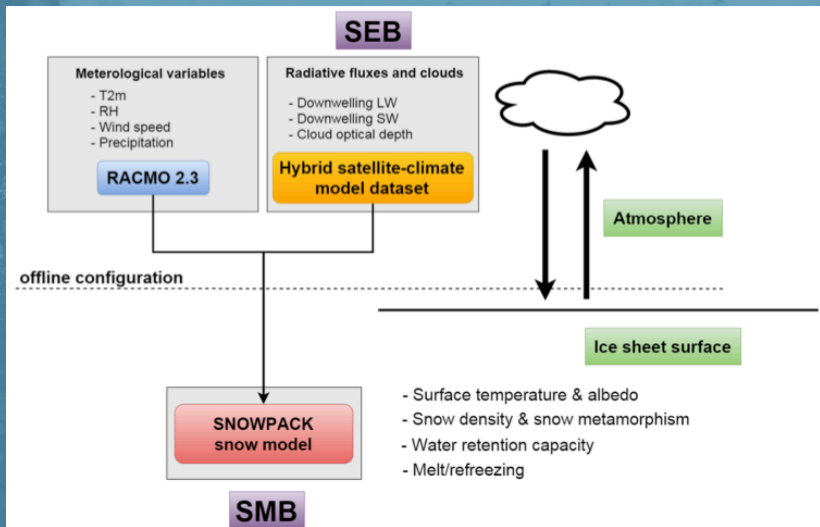


temporal resolution

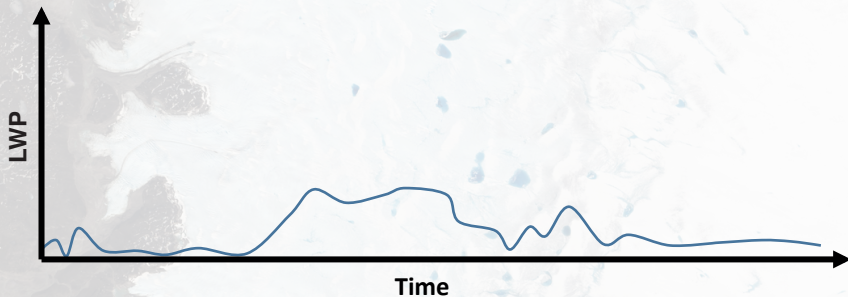
**Satellite
observations**



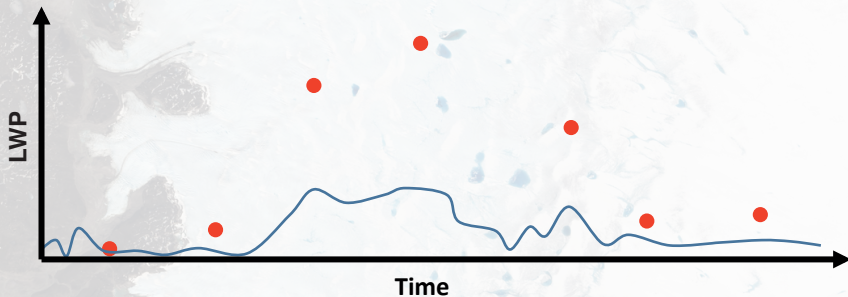
Cloud-surface interactions

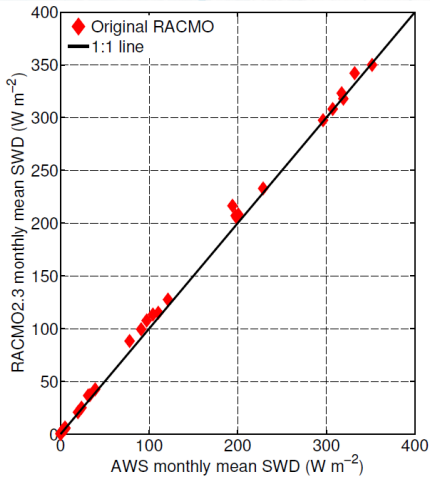
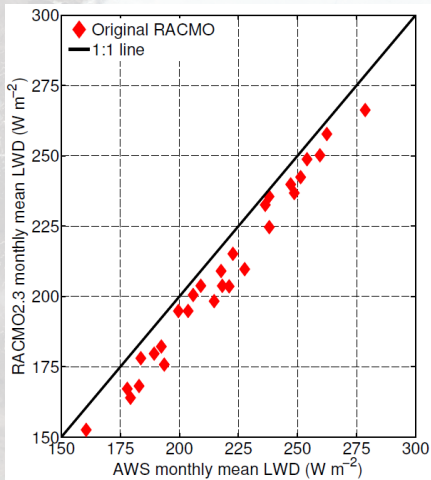


Hybrid satellite-climate model dataset

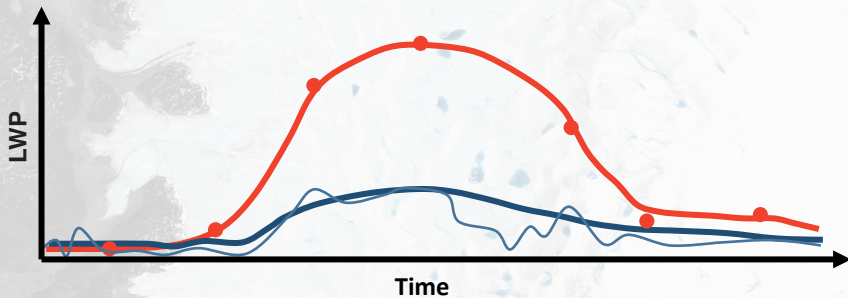


Hybrid satellite-climate model dataset

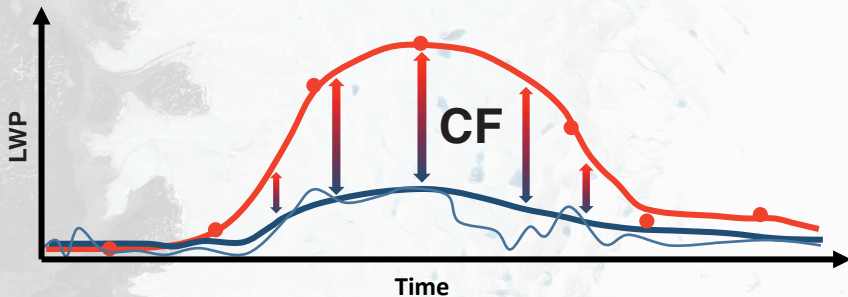




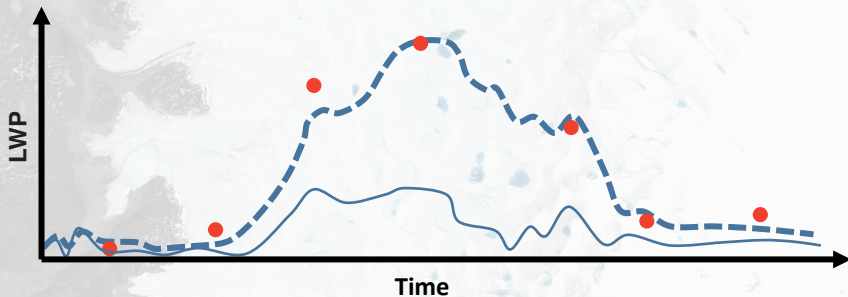
Hybrid satellite-climate model dataset



Hybrid satellite-climate model dataset

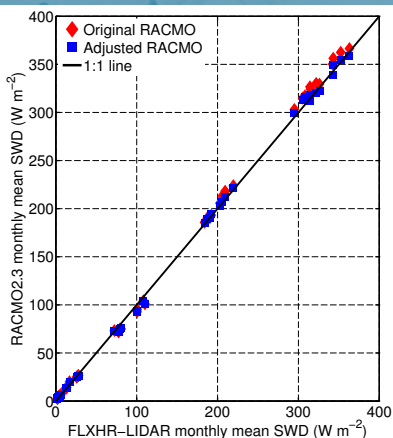
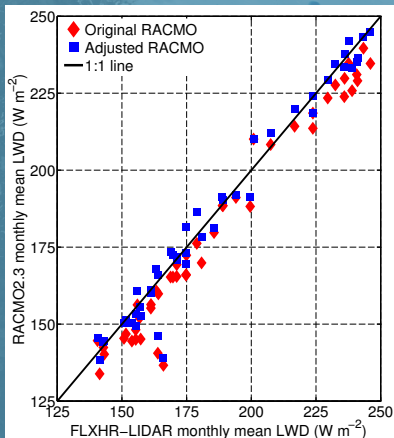


Hybrid satellite-climate model dataset



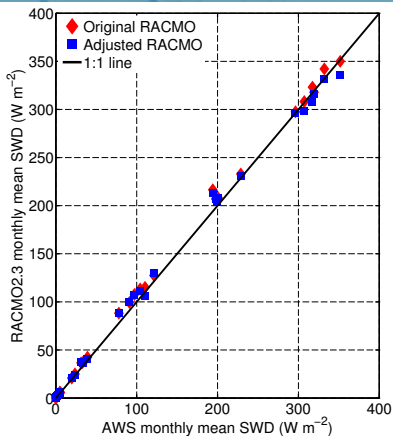
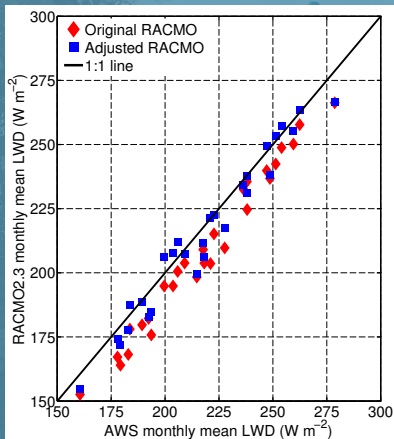


Hybrid dataset: better correspondence with satellite fluxes





Hybrid dataset: better correspondence with AWS fluxes

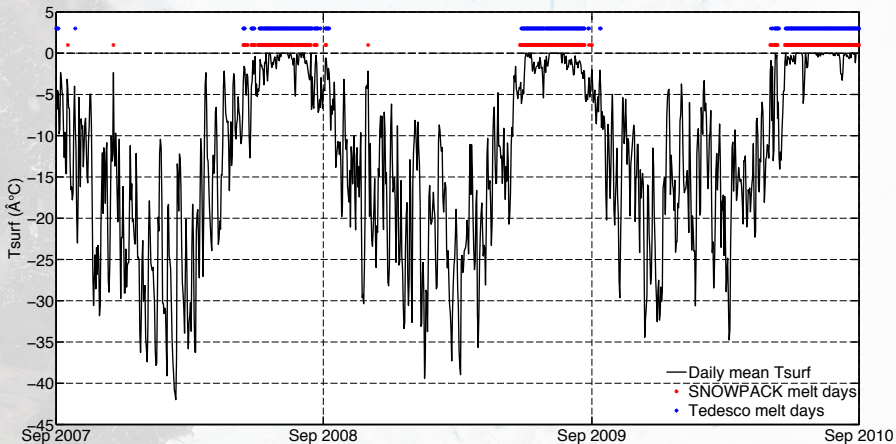


A satellite image of Earth showing a large blue circular overlay in the center. The text "Surface snowmodel" is written in white inside the circle. The background shows a mix of white snow, blue oceans, and brown landmasses.

Surface snowmodel

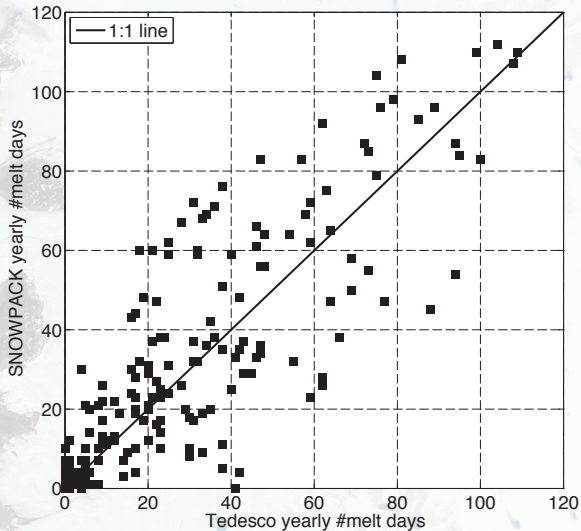


Snowpack performance: melt



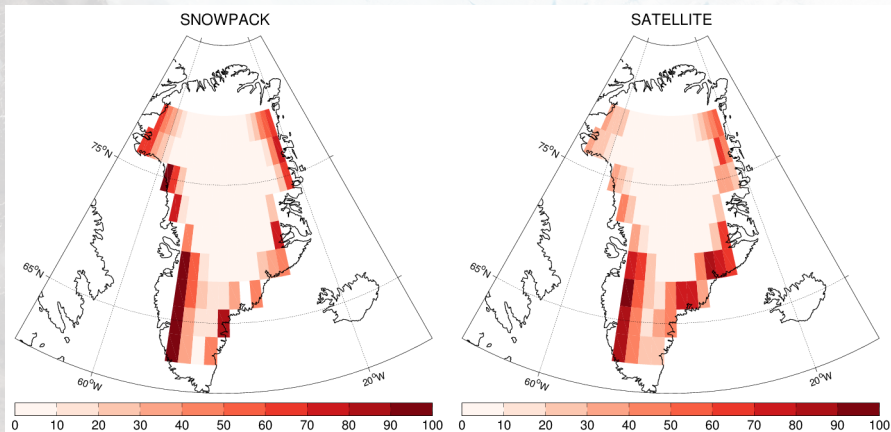


Snowpack performance: melt



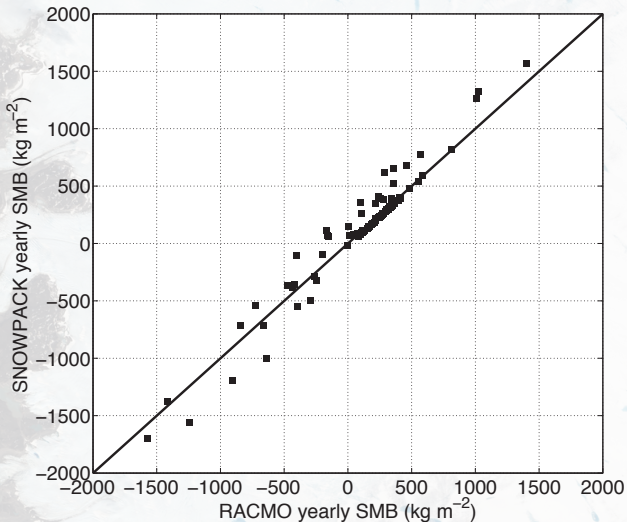


Snowpack performance: melt





Snowpack performance: SMB

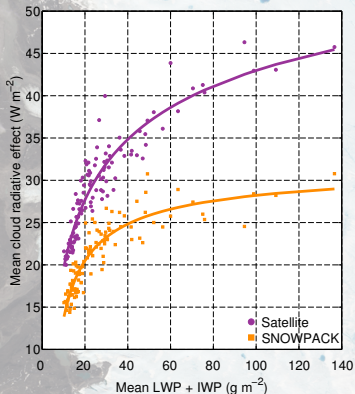


An aerial photograph of a glacier system, showing a large, dark, rocky area on the left and a vast, white, snow-covered area on the right. A large, semi-transparent blue circle is overlaid on the center of the image. Inside the circle, the text "Ice sheet response" is written in white, sans-serif font.

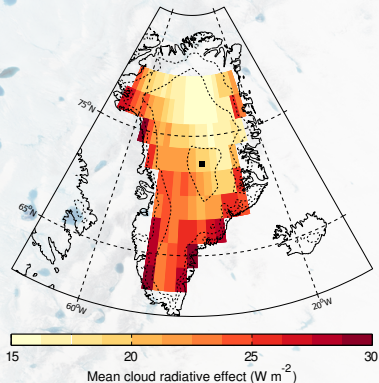
Ice sheet response

CRE is 30% less

a)



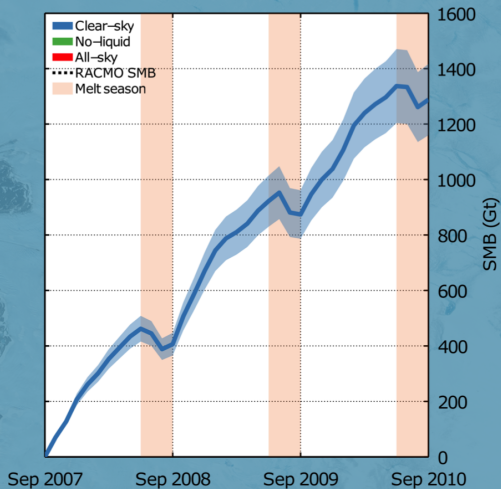
b)



Clouds warm the surface by 1.2° and lower albedo

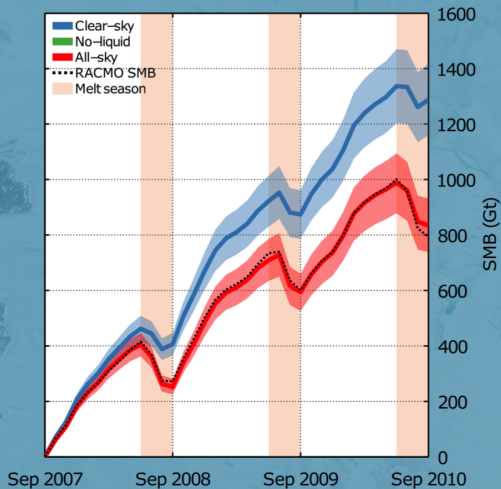


Effect on SMB

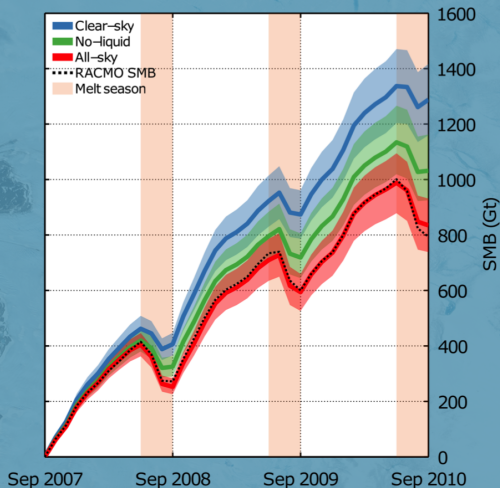




Effect on SMB

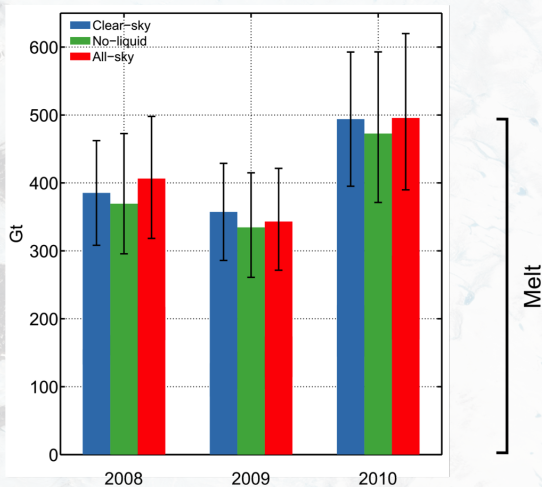


Effect on SMB

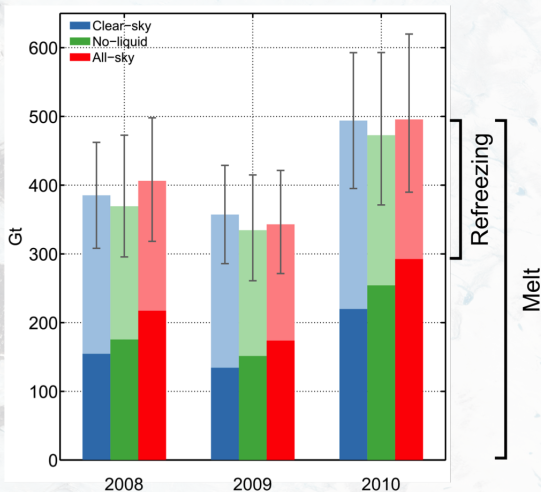


$56 \pm 20 \text{ Gt/yr}$; ice = 25 Gt vs. liq = 31 Gt

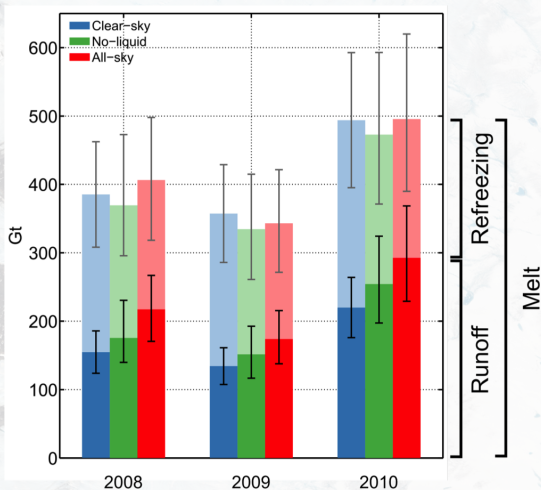
What is the driving process?

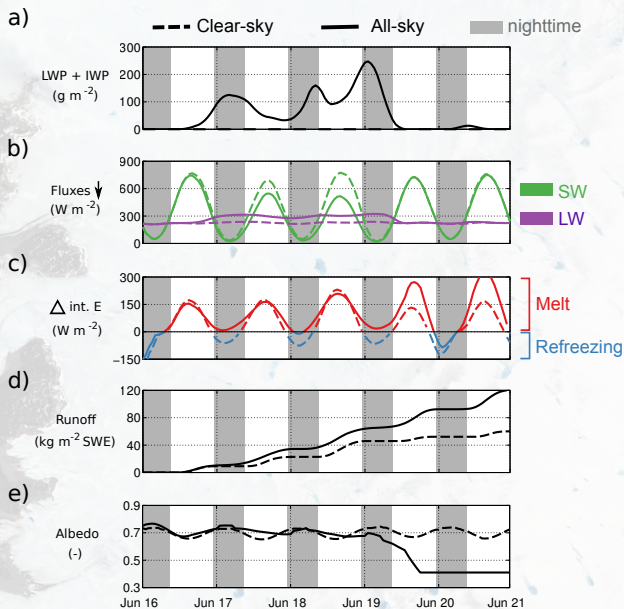


Not melt, but refreezing



Lack of refreezing creating runoff



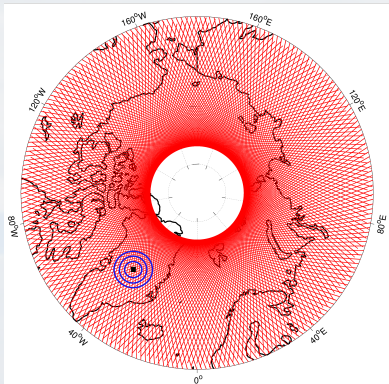


A photograph of a snowy landscape under a clear blue sky. In the foreground, a weather station is mounted on a tall pole, with a wind vane and other sensors. Two red flags are planted in the snow. The scene is overlaid with a large teal circle containing the text "Time space trade-off".

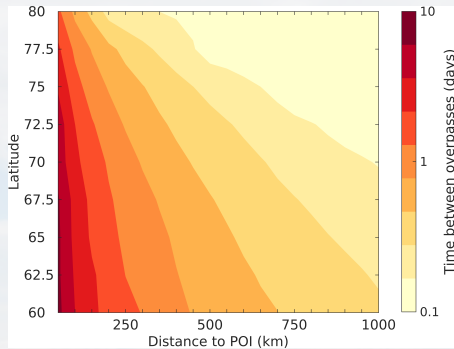
Time space trade-off

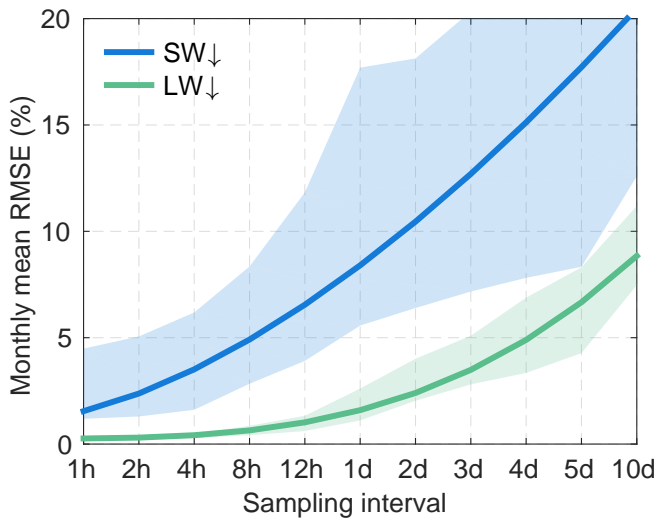
What's the trade-off between time and space?

a

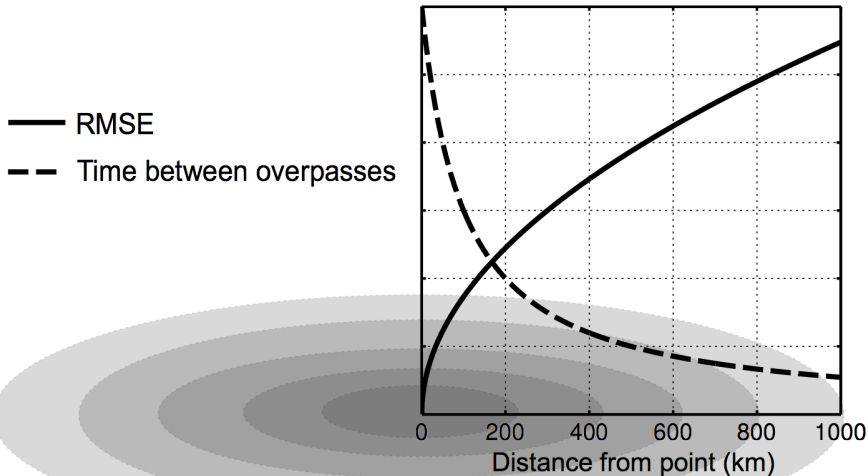


b





Trade-off vs. error



The Cryosphere Discuss., doi:10.5194/tc-2016-103, 2016

Manuscript under review for journal The Cryosphere

Published: 26 May 2016

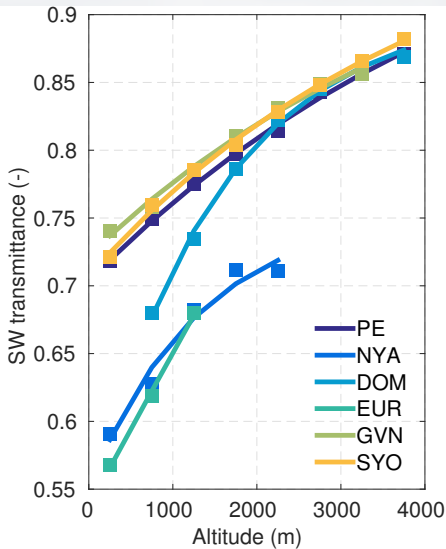
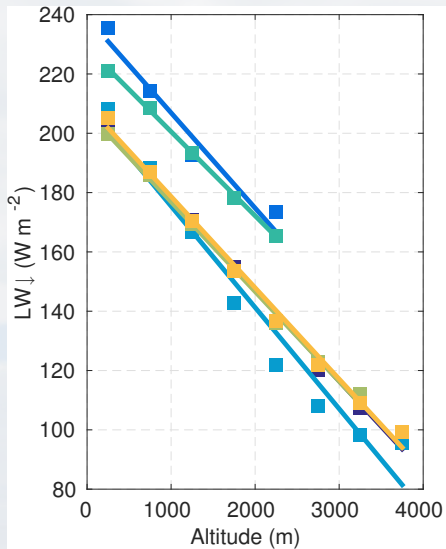
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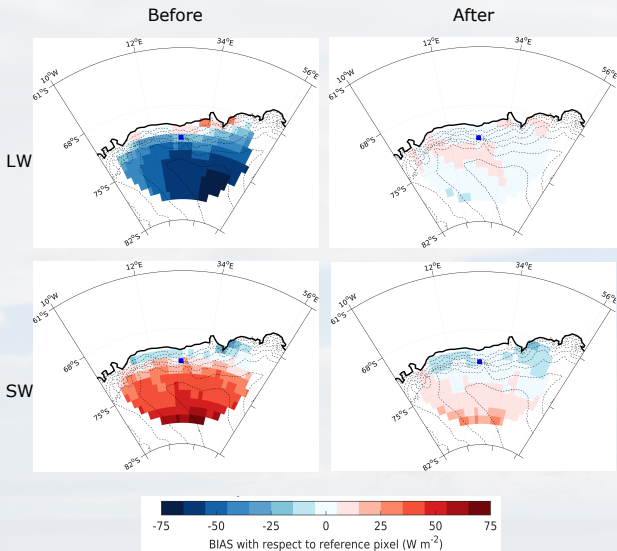


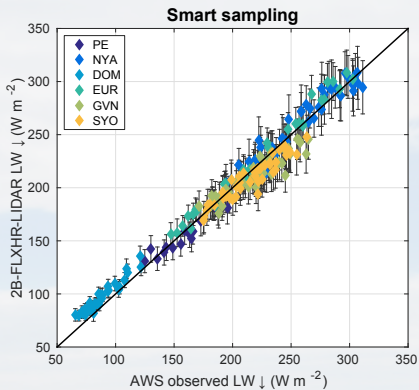
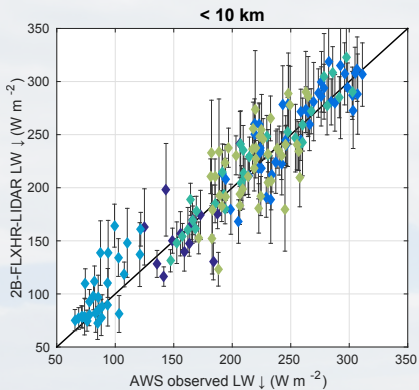
Improving satellite-retrieved surface radiative fluxes in polar regions using a smart sampling approach

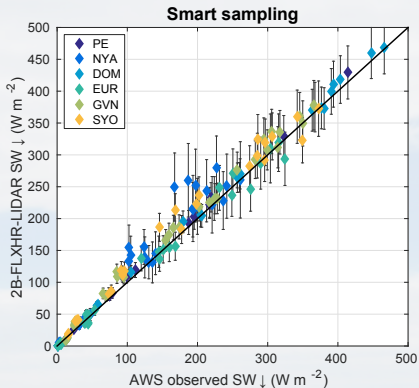
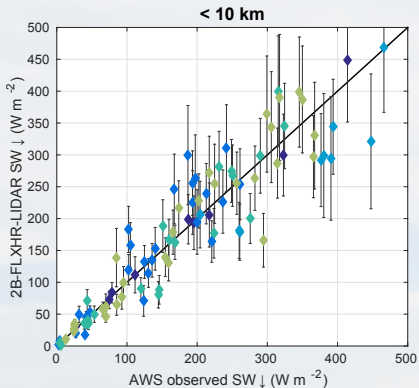
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¹KU Leuven - University of Leuven Department of Earth and Environmental Sciences, Celestijnenlaan 200E, Leuven 3001, Belgium





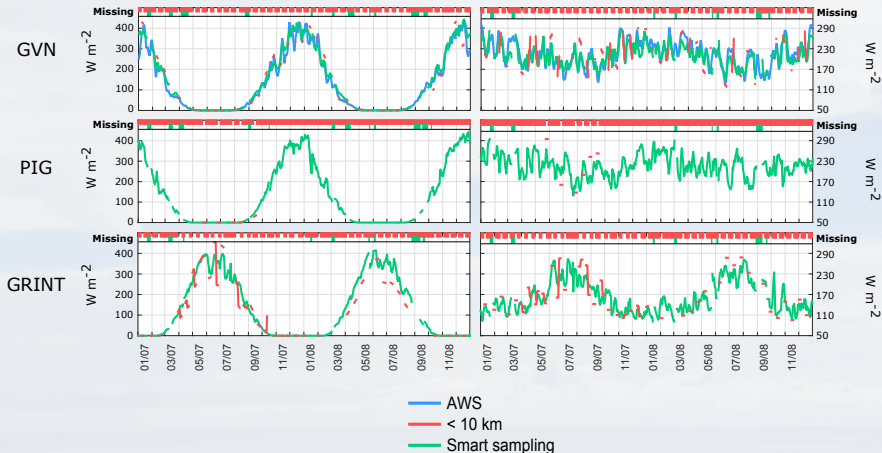




Get the fluxes anywhere, anytime

SW↓

LW↓





Conclusions

- ▶ Cloudsat/Calipso for model evaluation/tuning
- ▶ Importance of understanding the surface response
- ▶ White over white may turn dark