Testing the snow albedo sensitivity in HARMONIE-AROME

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Overview of presentation

1. Introduction
2. Snow albedo as used in AROME
3. Current operational results and observations
5. Coupled experiment
6. Concluding remarks

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Introductory remarks

The Greenland ice sheet albedo and the albedo of the other large ice caps and glaciers in the Atlantic Arctic and European Arctic are essential to model correctly, as their are few or no synoptic observations in these glaciated areas.

Experts at Meteo France advice that the current snow albedo parametrizations are optimized for French conditions.

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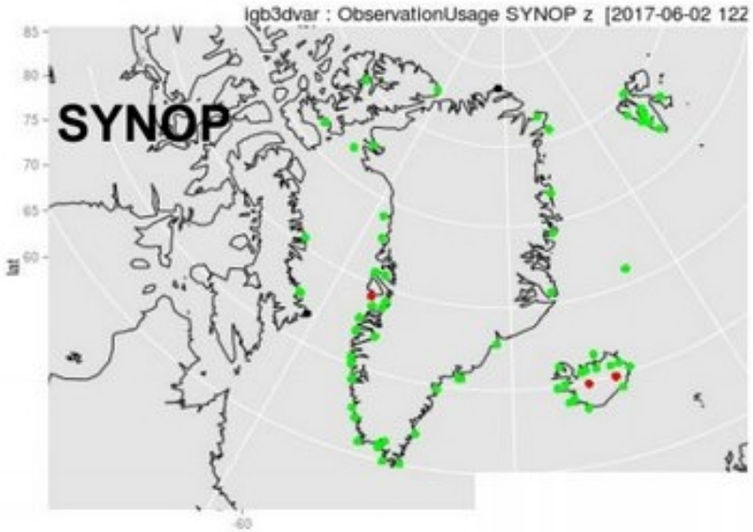

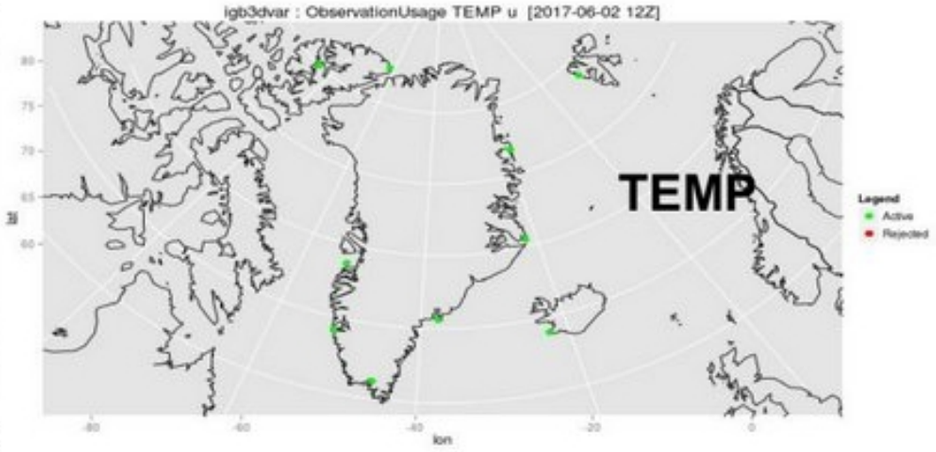

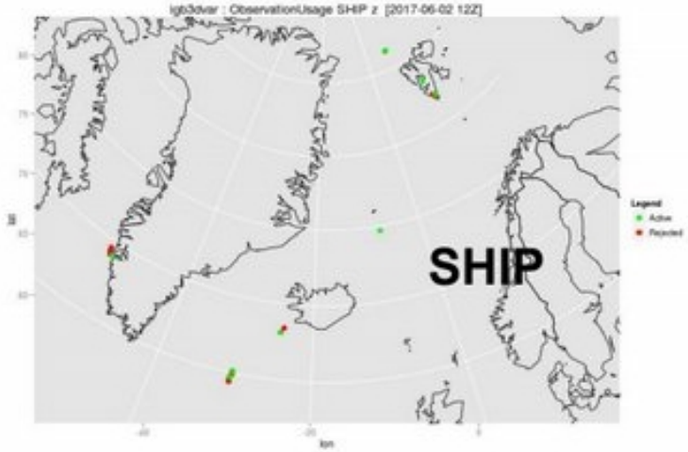

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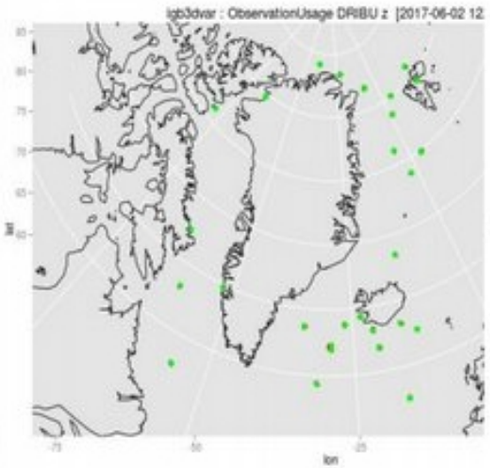

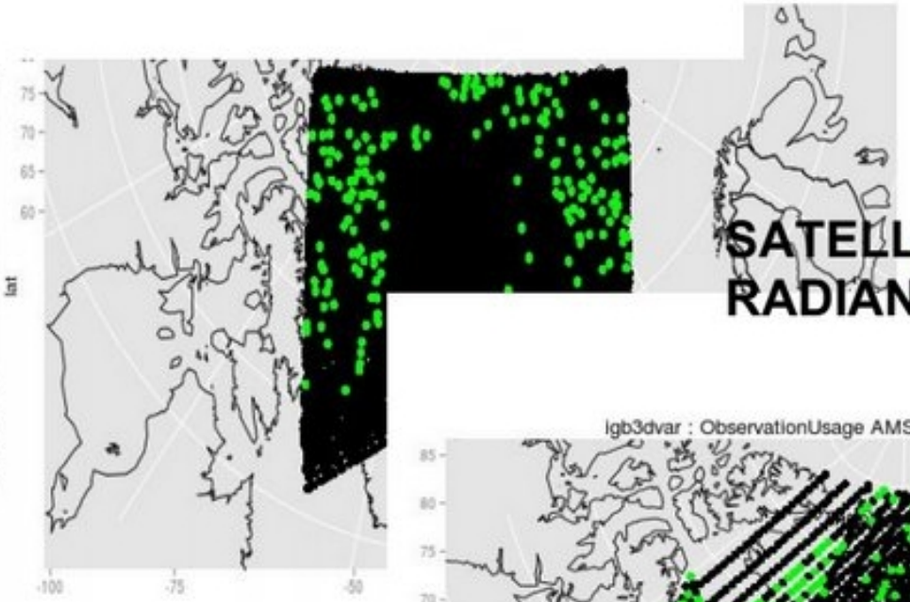

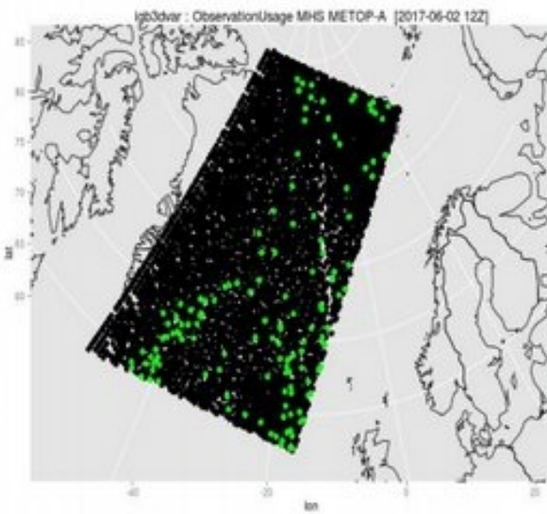

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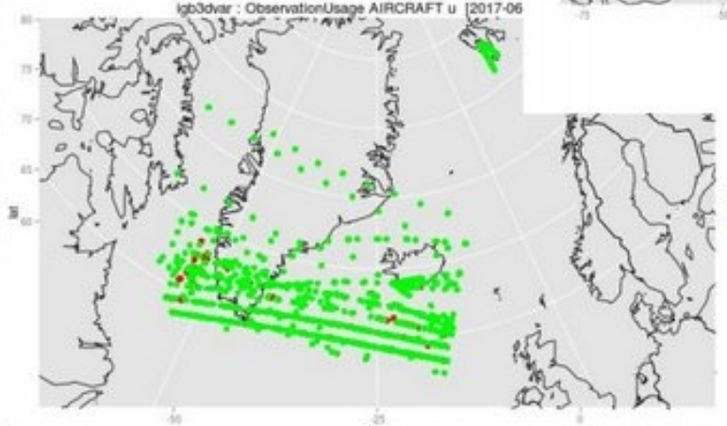
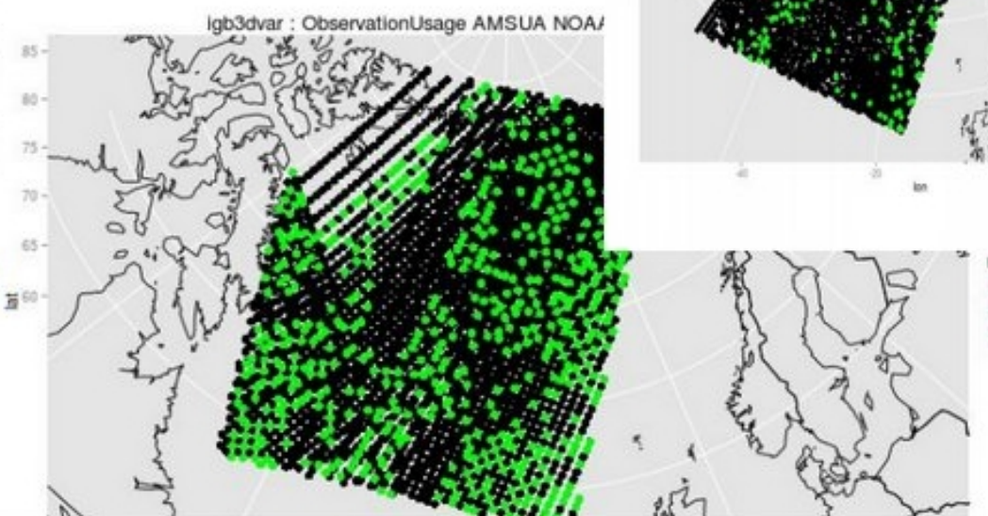


OBS data used in the current IGB-3DVAR



Snow schemes in AROME and SURFEX

1. Douville et al. (1995) "D95"
The default 1-layer snow scheme in cy40h.

2. Explicit Snow in SURFEX 8 "3-L"
(Boone & Etchevers 2001; Descharme et al. 2016)
Multi-layer snow scheme. Crocus surface albedo in SURFEX 8.

3. Crocus (Brun et al. 1992; Vionnet et al. 2012) "CRO" & "B92"
Snow scheme for avalance and detailed snow melt modelling.

4. Crocus-TARTES (Tuzet et al. 2017) "TAR/TA1/TA2"
Multi-spectral two-stream radiation scheme for Crocus.

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Change of snow albedo

D95: Includes separate albedos as a function of snow age for melting and dry snow. If LGLACIER is chosen a separate albedo for glaciers (cover type: "permanent snow") is also used.

Crocus (also used for albedo in the ES scheme): The albedo is calculated in 3 spectral bands as a function of snow density and age. Here, the age effect is related to pollution and optimized for the Alps. The spectral bands are fixed with **71%** assumed in the UV-VIS spectral band.

Crocus-albedo in the ES scheme with MEB: As above, but the albedo is calculated in 2 spectral bands with **48%** irradiance assumed in the UV-VIS spectral band ==> Lower snow albedo with MEB!

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We model the spectral bands with the IFS radiation scheme. Can we use them as input? - or would this cause a calibration issue?

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Snow albedo limits

D95: Maximum: 0.85; Minimum: 0.50.
With LGLACIER: Maximum: 0.85; Minimum: 0.80.

Crocus: Maximum: approx. 0.845; Minimum: approx. 0.5.
For glaciers: Maximum: approx. 0.845; Minimum: approx. 0.63.

Crocus+MEB: Maximum: approx. 0.81; Minimum: approx. 0.44.
For glaciers: Maximum: approx. 0.81; Minimum: approx. 0.54.

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Directional reflectance dependencies ...

Lambertian surfaces do not exist in the real world!

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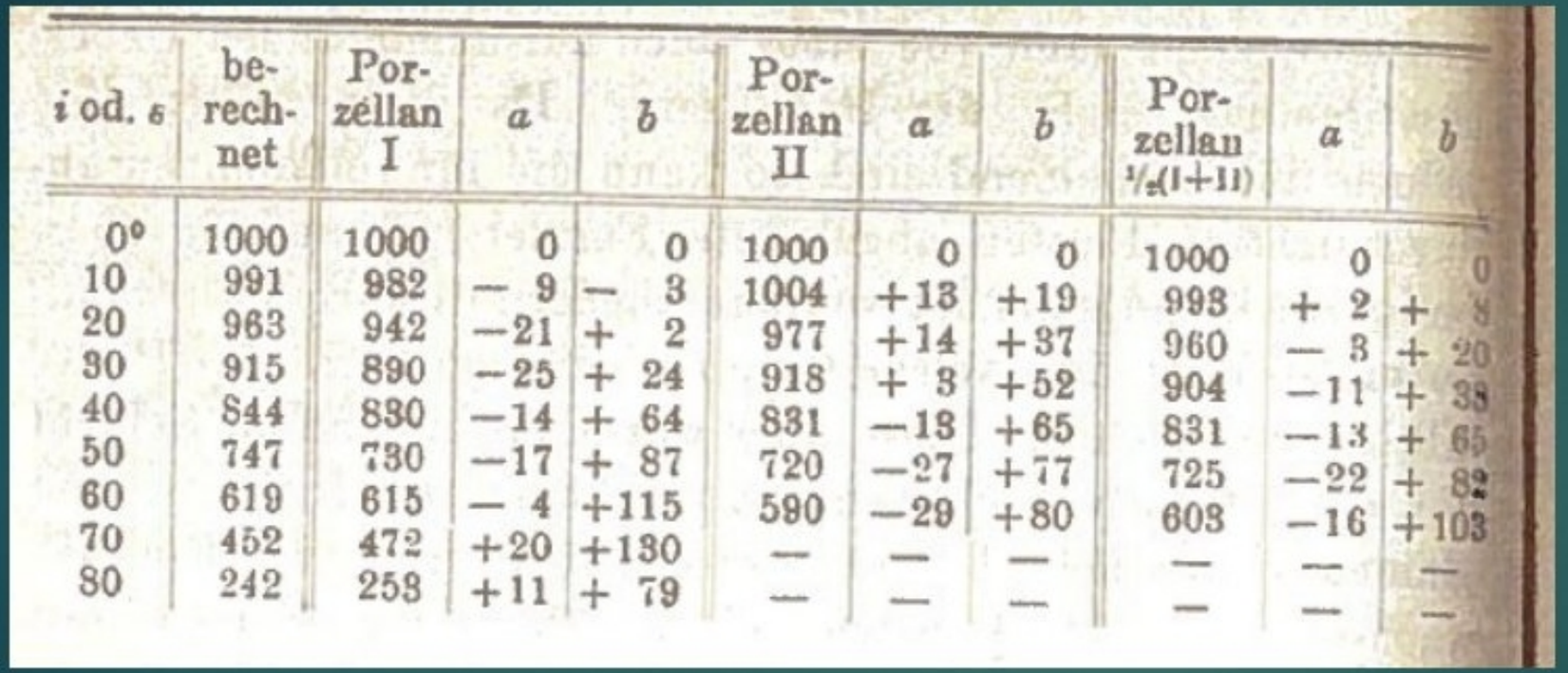
Should the term reflectance be used rather than albedo?



i od. ε	berechnet	Porzellan I	a	b	Porzellan II	a	b	Porzellan ½(I+II)	a	b
0°	1000	1000	0	0	1000	0	0	1000	0	0
10	991	982	− 9	− 3	1004	+13	+19	993	+ 2	+ 8
20	963	942	−21	+ 2	977	+14	+37	960	− 3	+ 20
30	915	890	−25	+ 24	918	+ 3	+52	904	−11	+ 38
40	844	830	−14	+ 64	831	−13	+65	831	−13	+ 65
50	747	730	−17	+ 87	720	−27	+77	725	−22	+ 82
60	619	615	− 4	+115	590	−29	+80	603	−16	+103
70	452	472	+20	+130	—	—	—	—	—	—
80	242	258	+11	+ 79	—	—	—	—	—	—

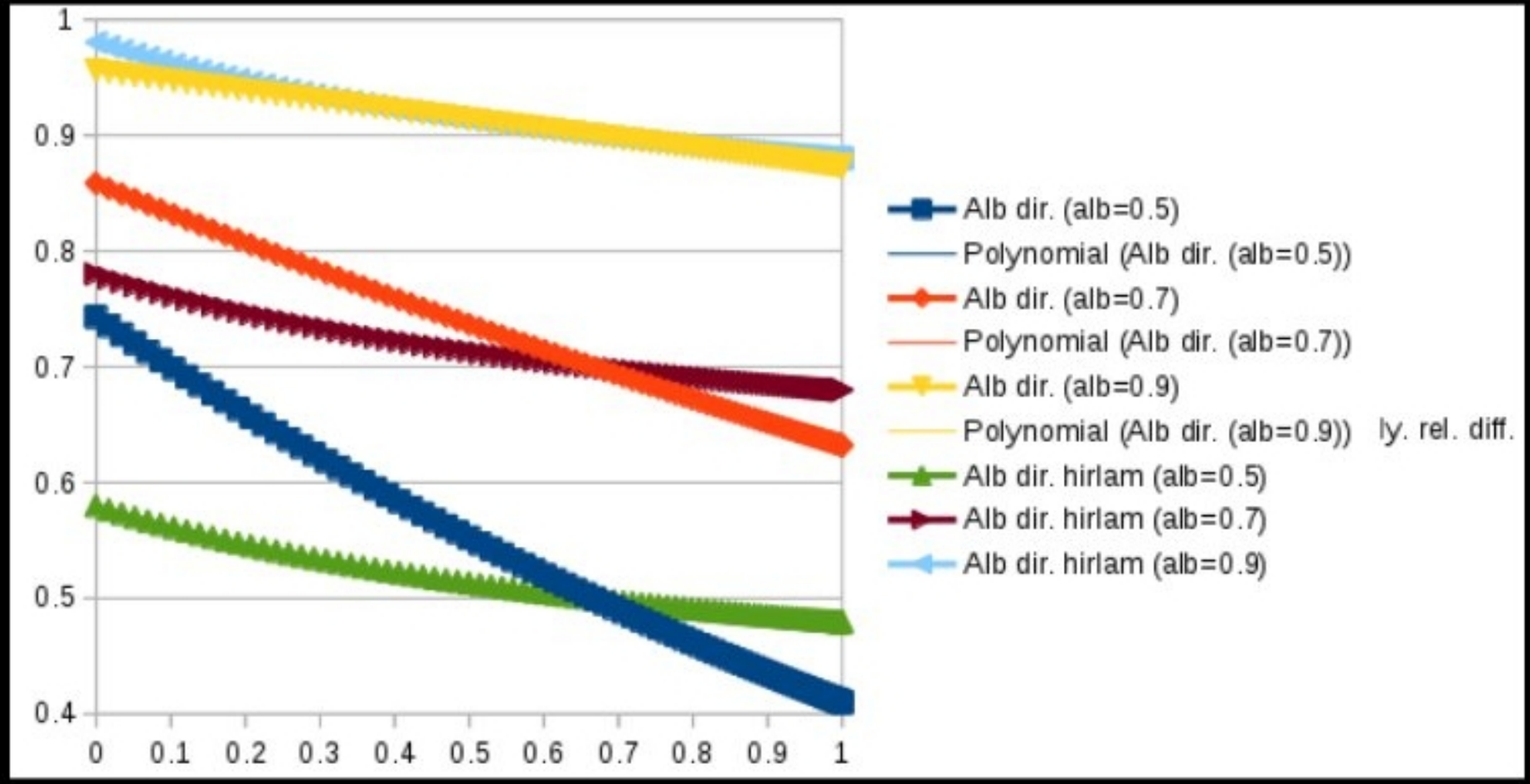
Table from Lommel (1889) that in the columns labelled ‘b’ shows the errors in tenths of percent of assuming an”albedo” that only varies with the cosine factor for the reflectance of porcelain for a constant viewing angle (I) and a constant illumination angle (II) as a function of the other angle.

The columns labelled ‘a’ show the same for Lommel’s own reflectance model.

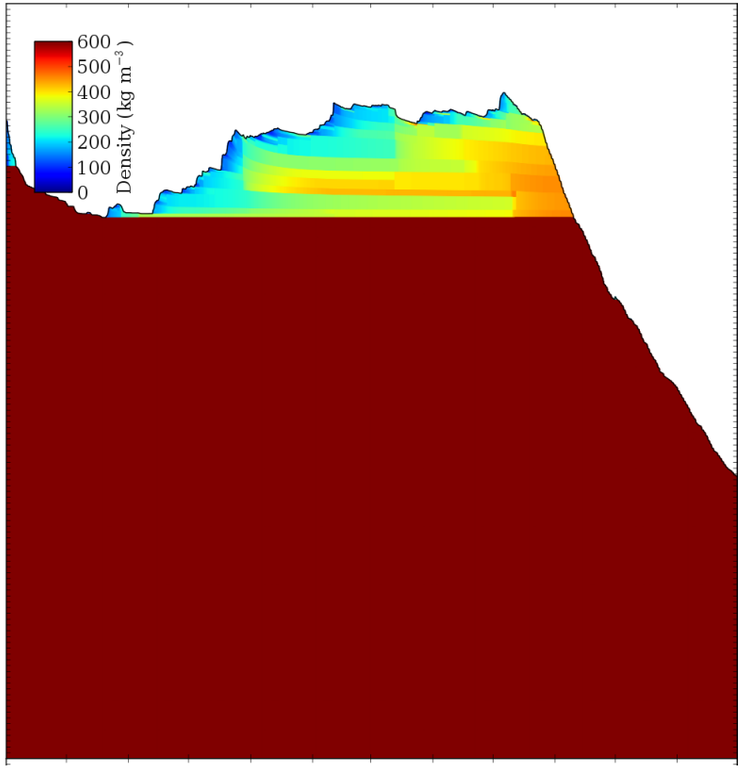
Albedo dependence on solar zenith angle

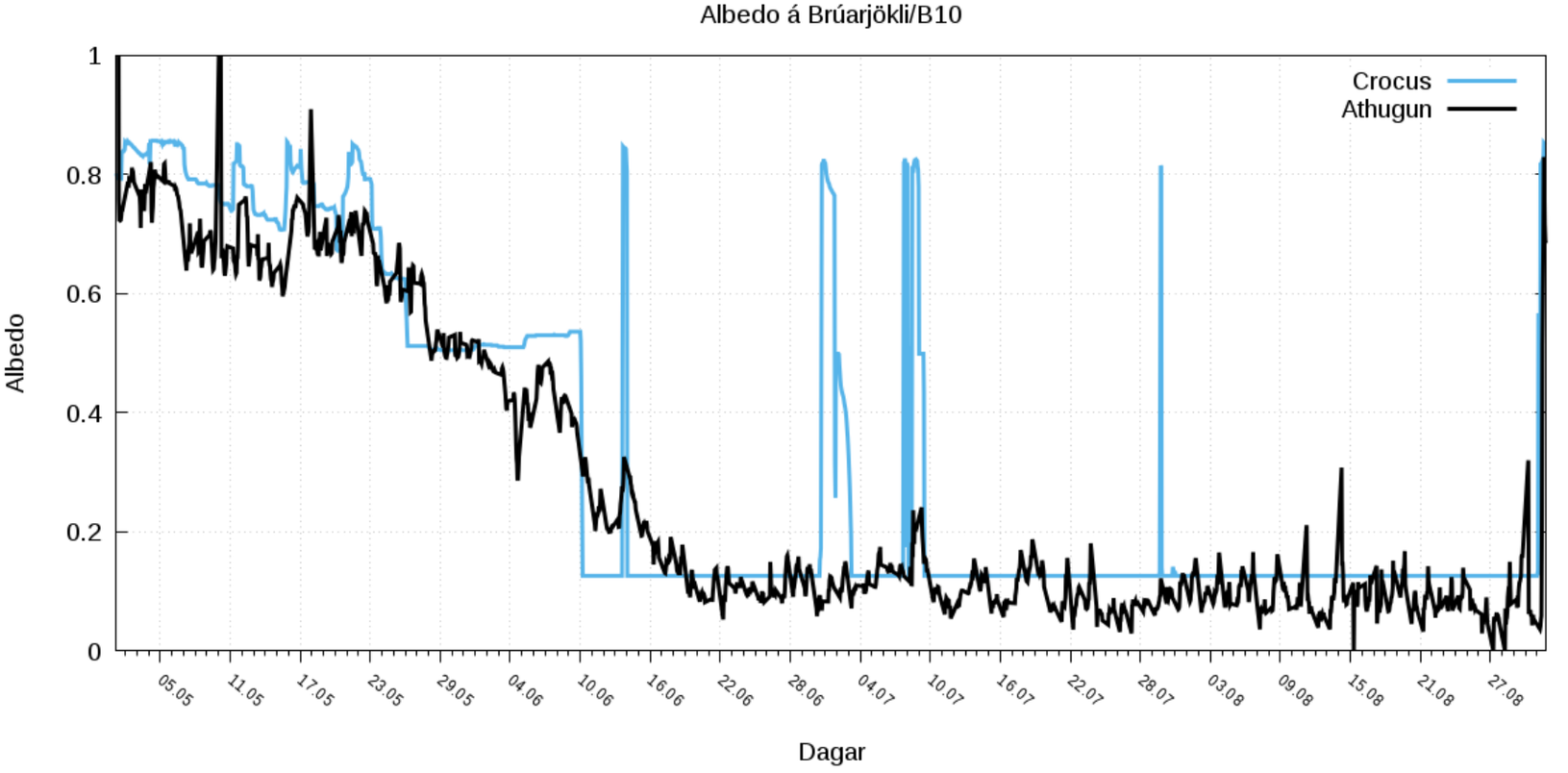
Direct or "black sky" albedo as a function of cos(SZA)

Kokhavnoski & Sege (Appl. Opt. 2004)



Crocus test for Brúarjökli





Figures and analysis by Bolli Palmason. The glacier layer albedo is predetermined.

HARMONIE-AROME albedo animation

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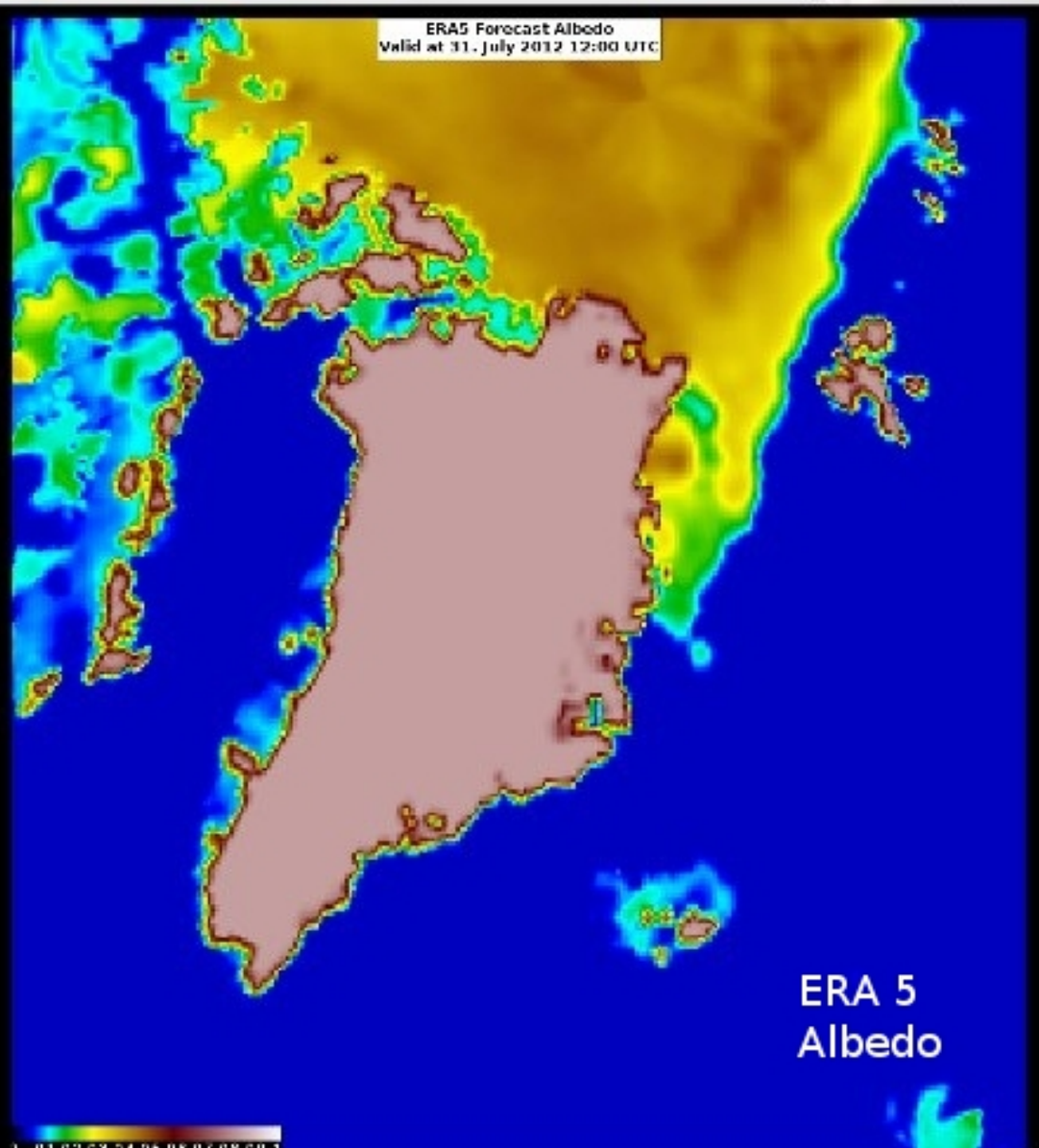
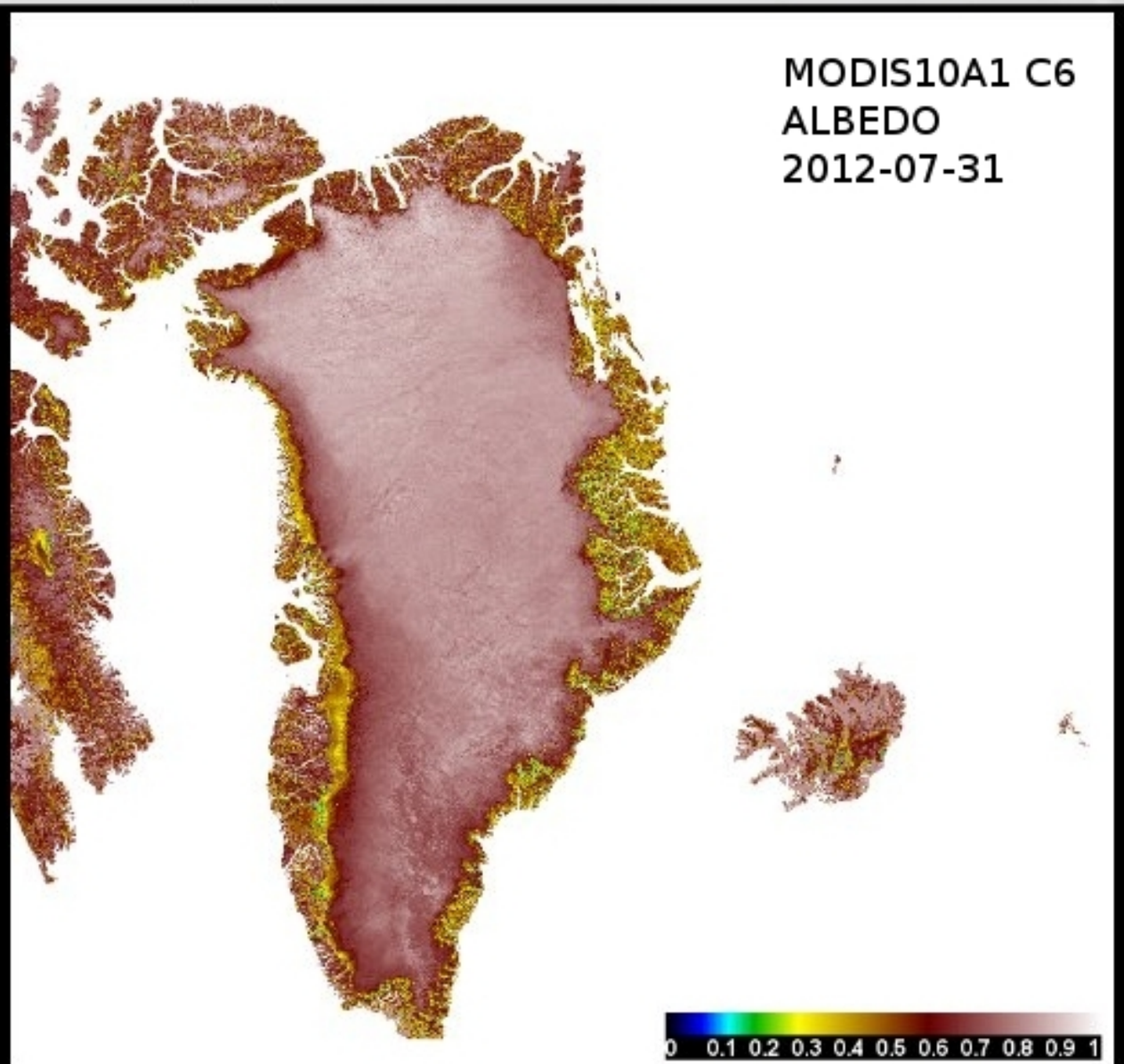
Albedo comparison

Figures by Bolli Palmason (IMO)





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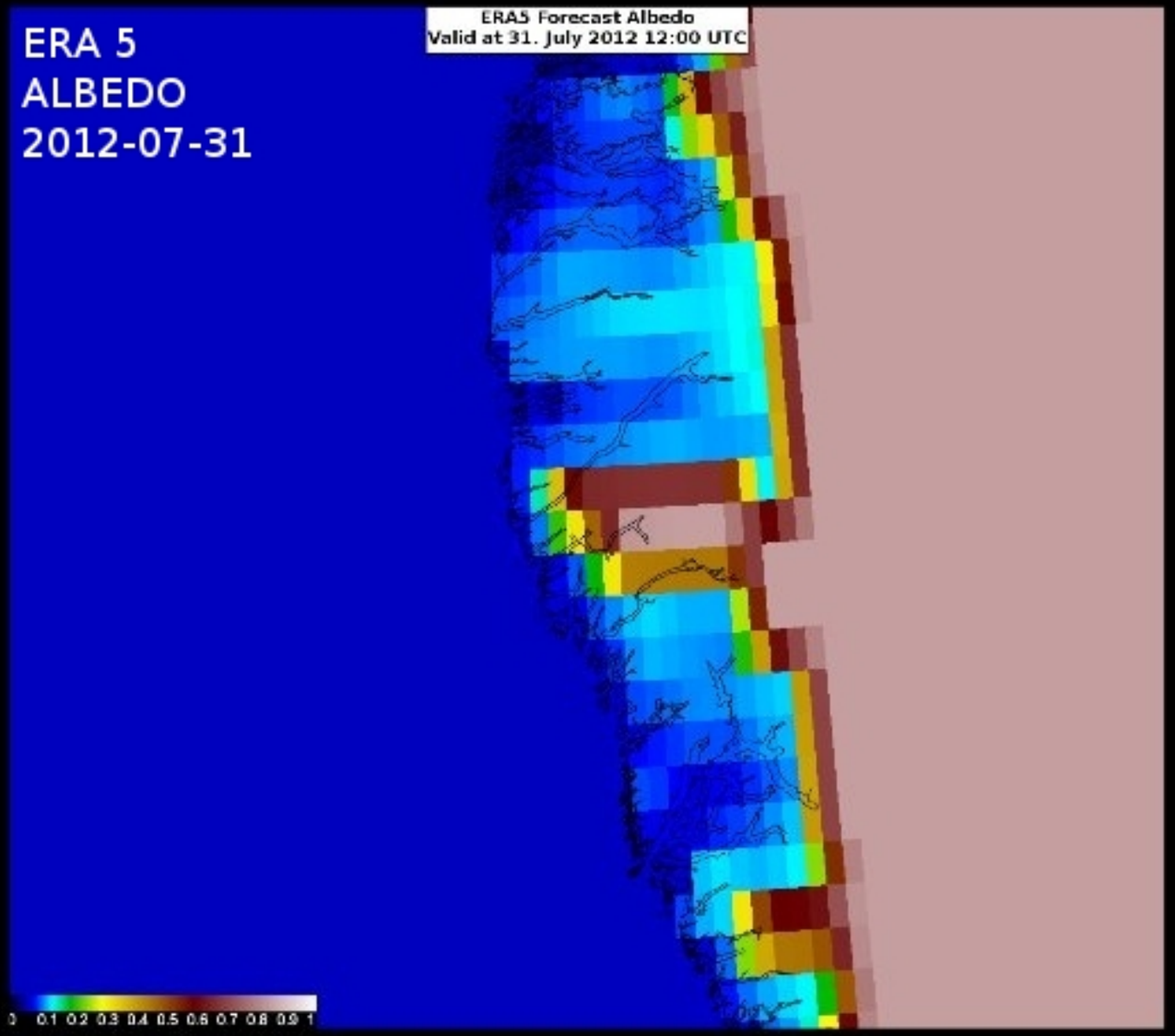

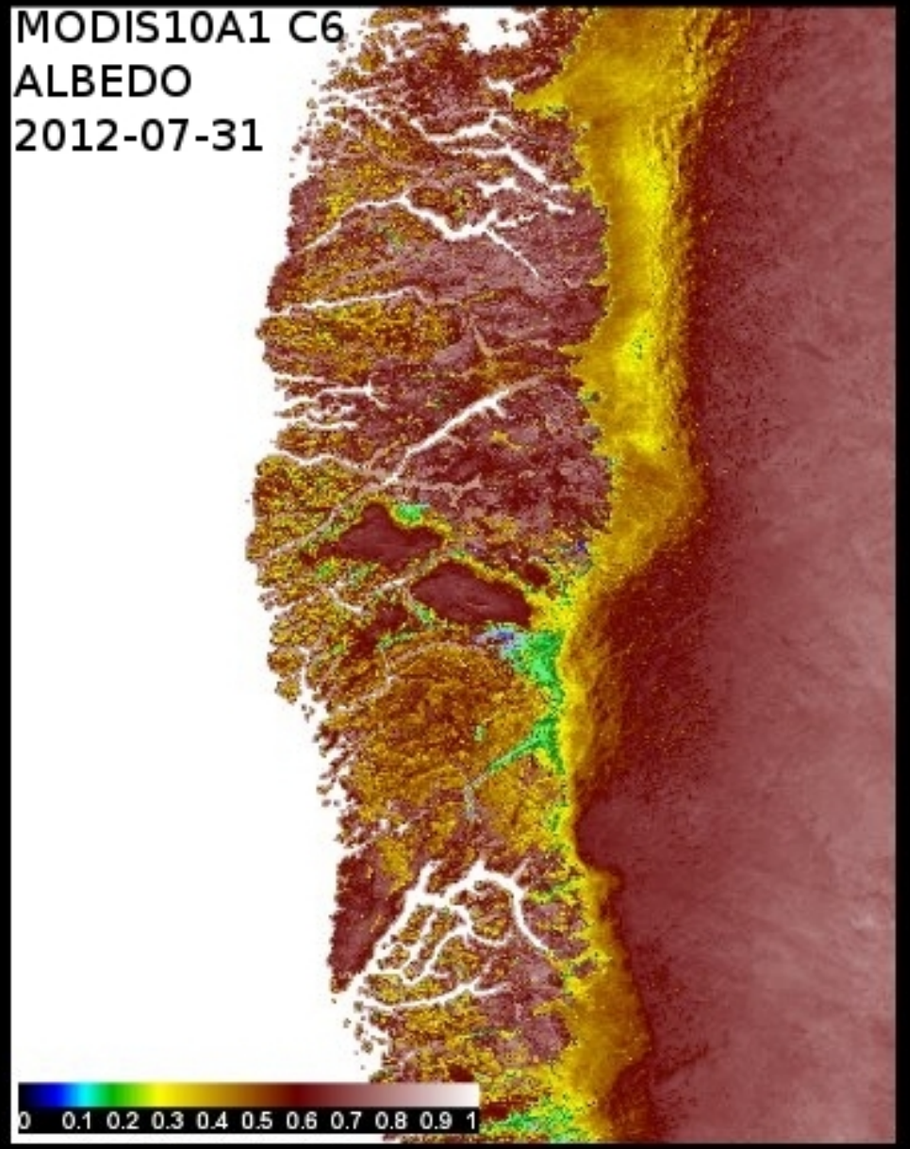

MODIS10A1 C6 albedo animation

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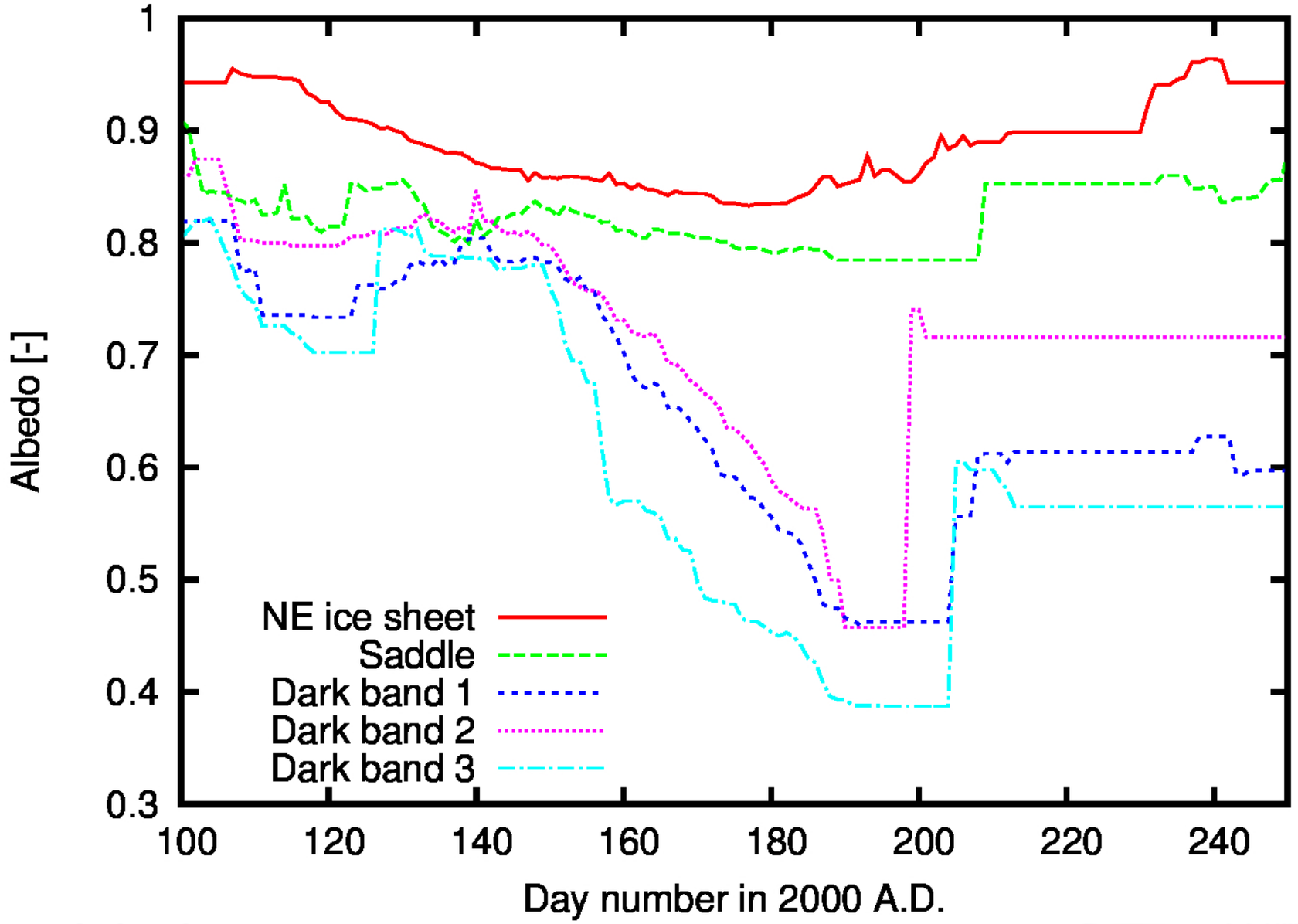
MODIS10A1 C6 albedos of specific points



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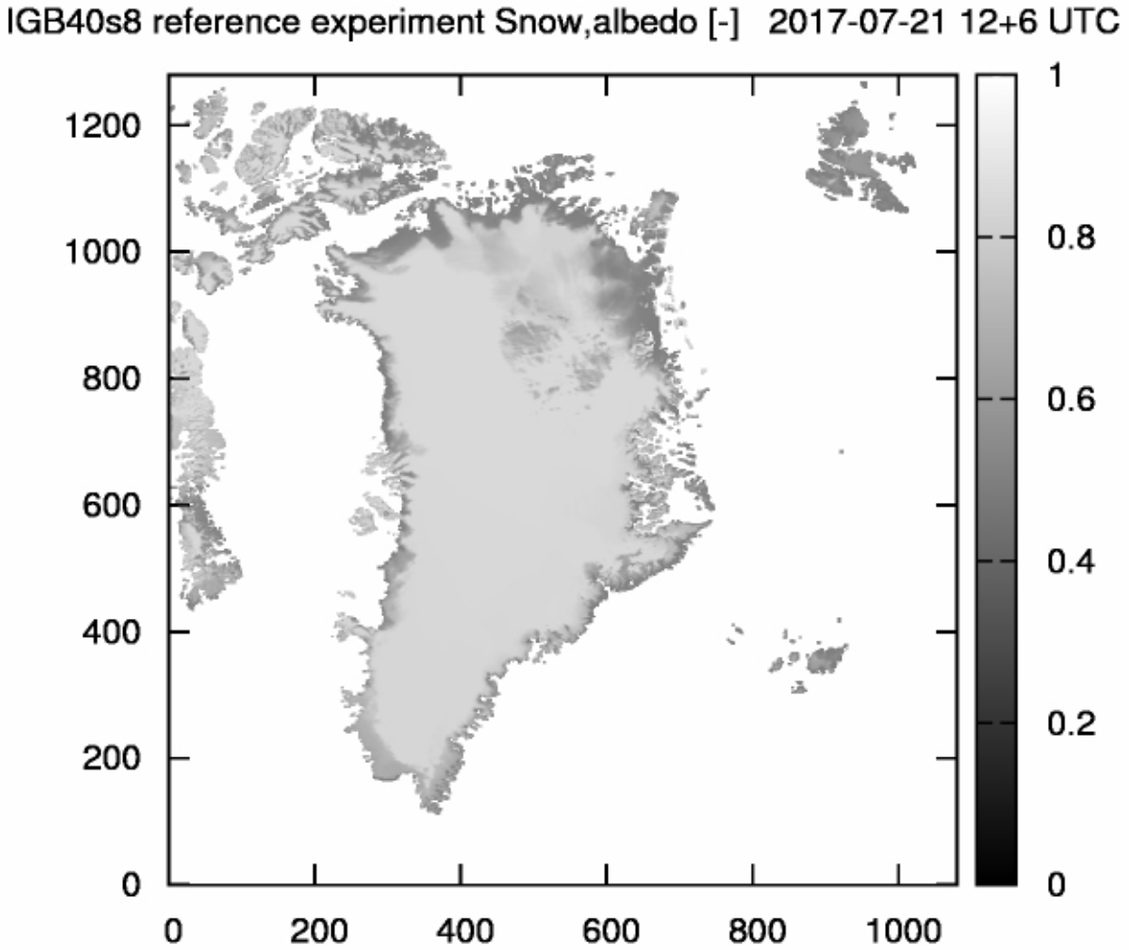
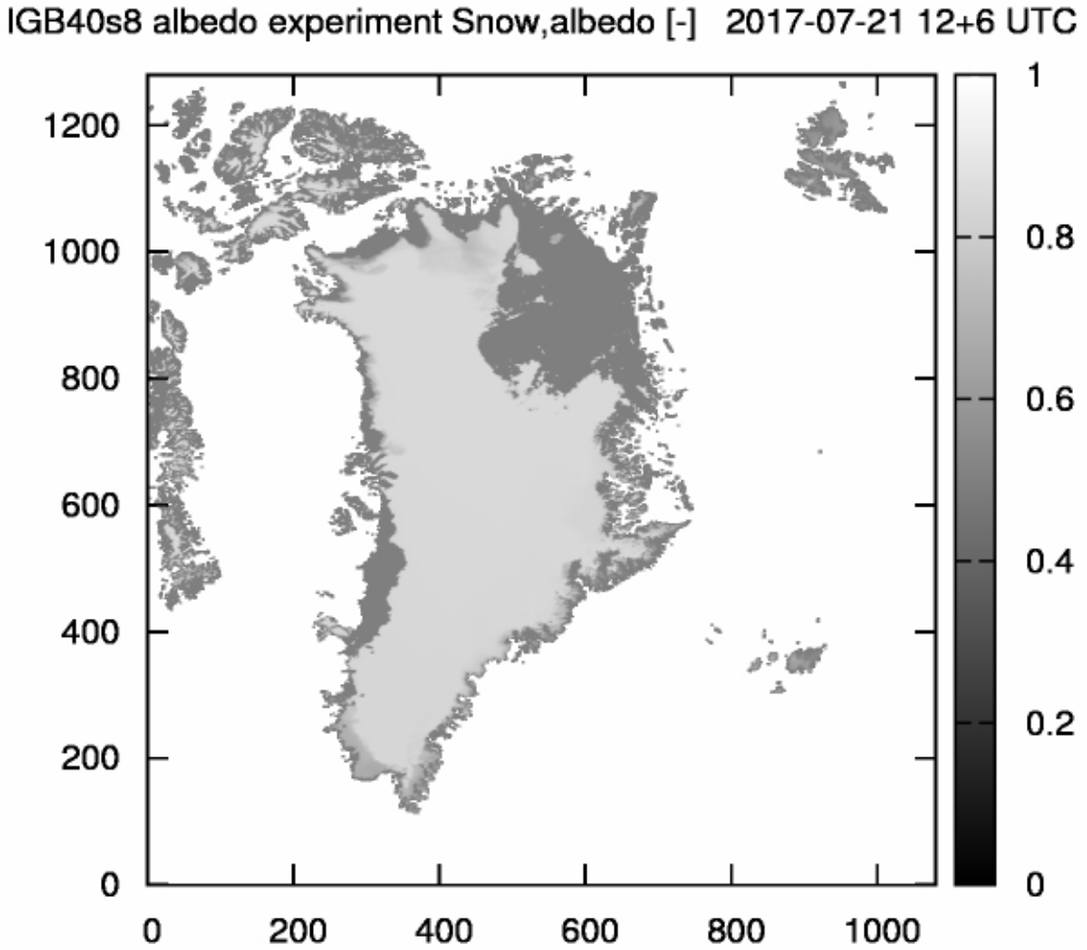
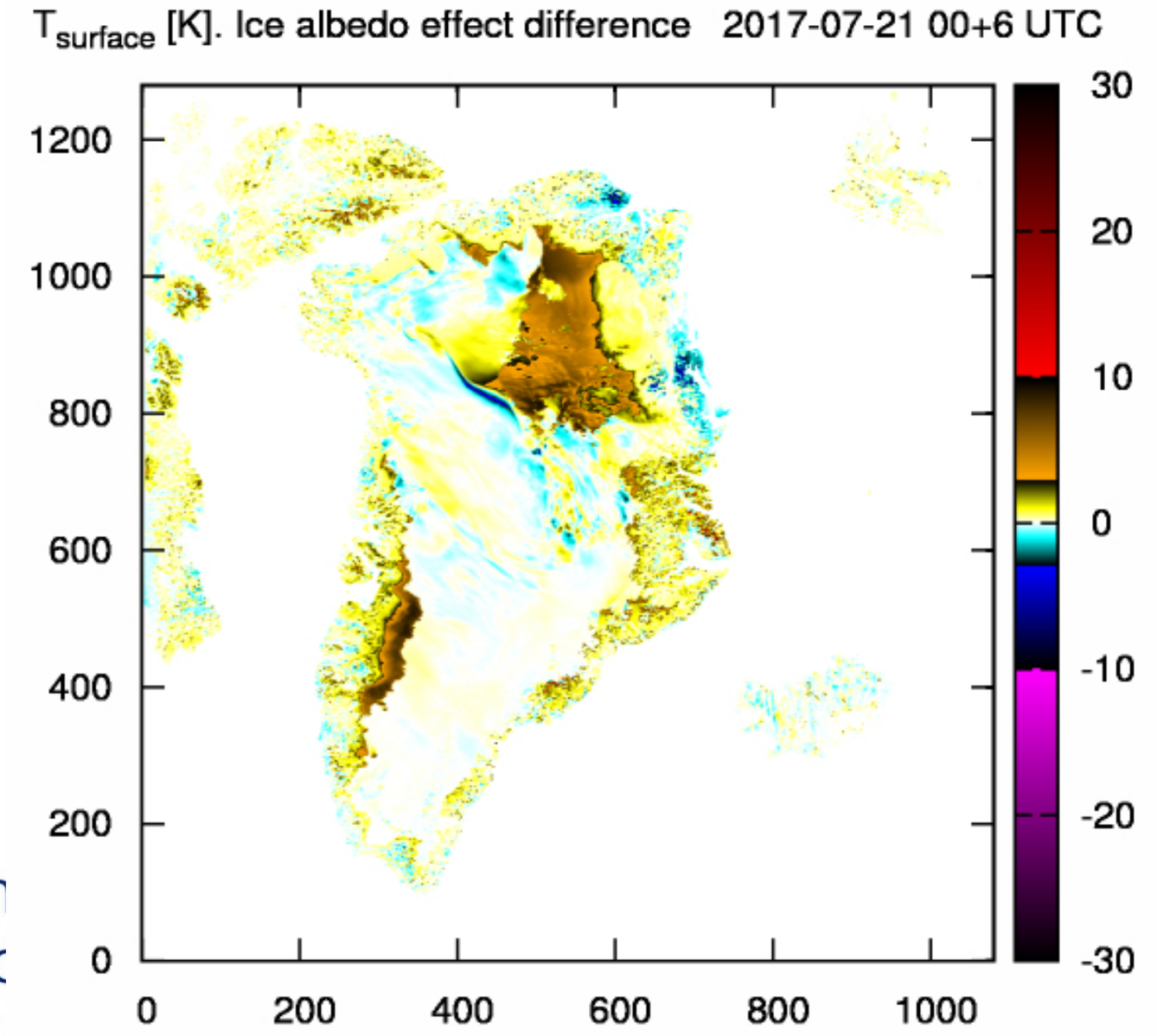
Coupled experiment





Coupled experiment: Surface temperature difference



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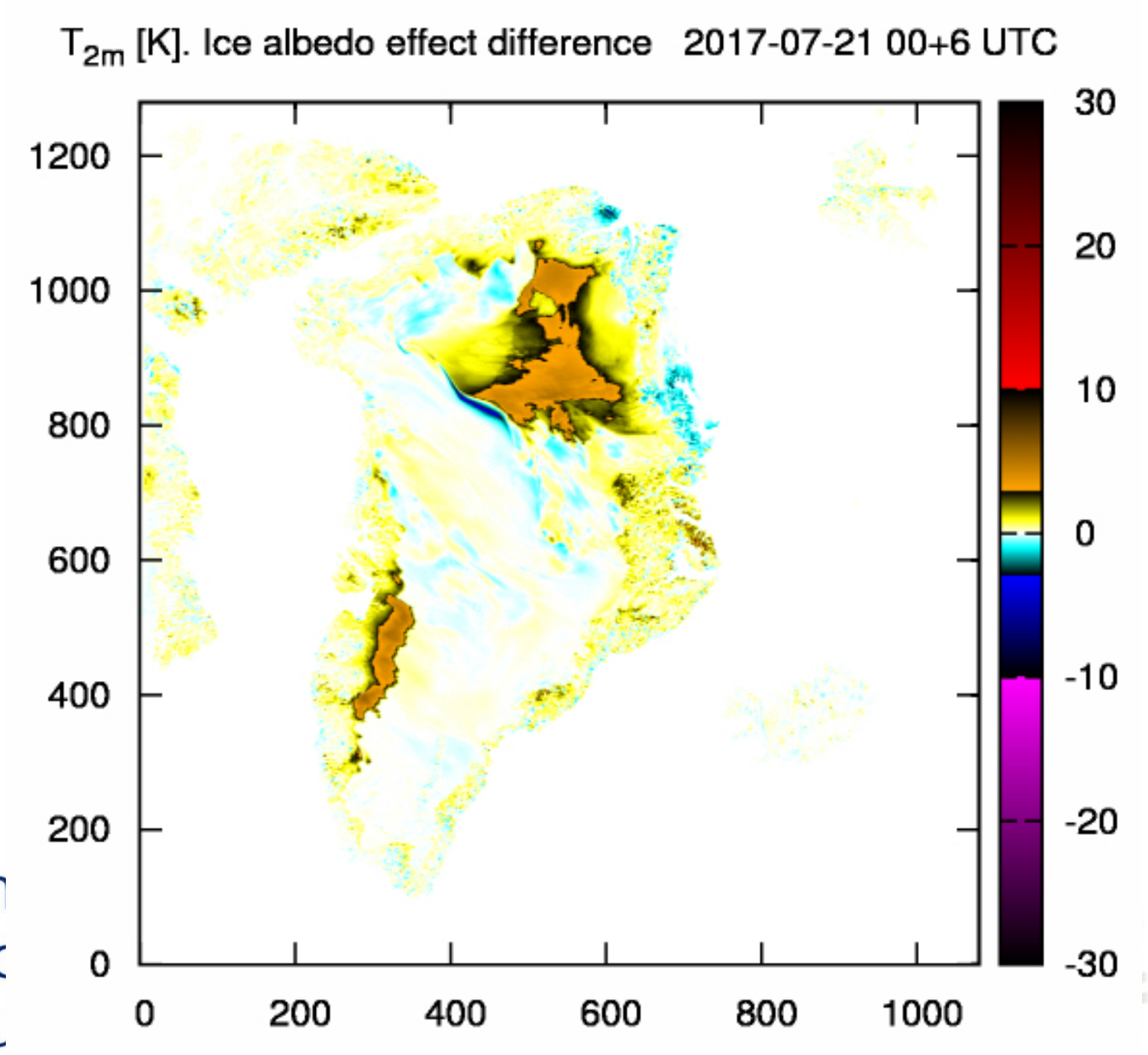
Coupled experiment: 2-metre temperature difference



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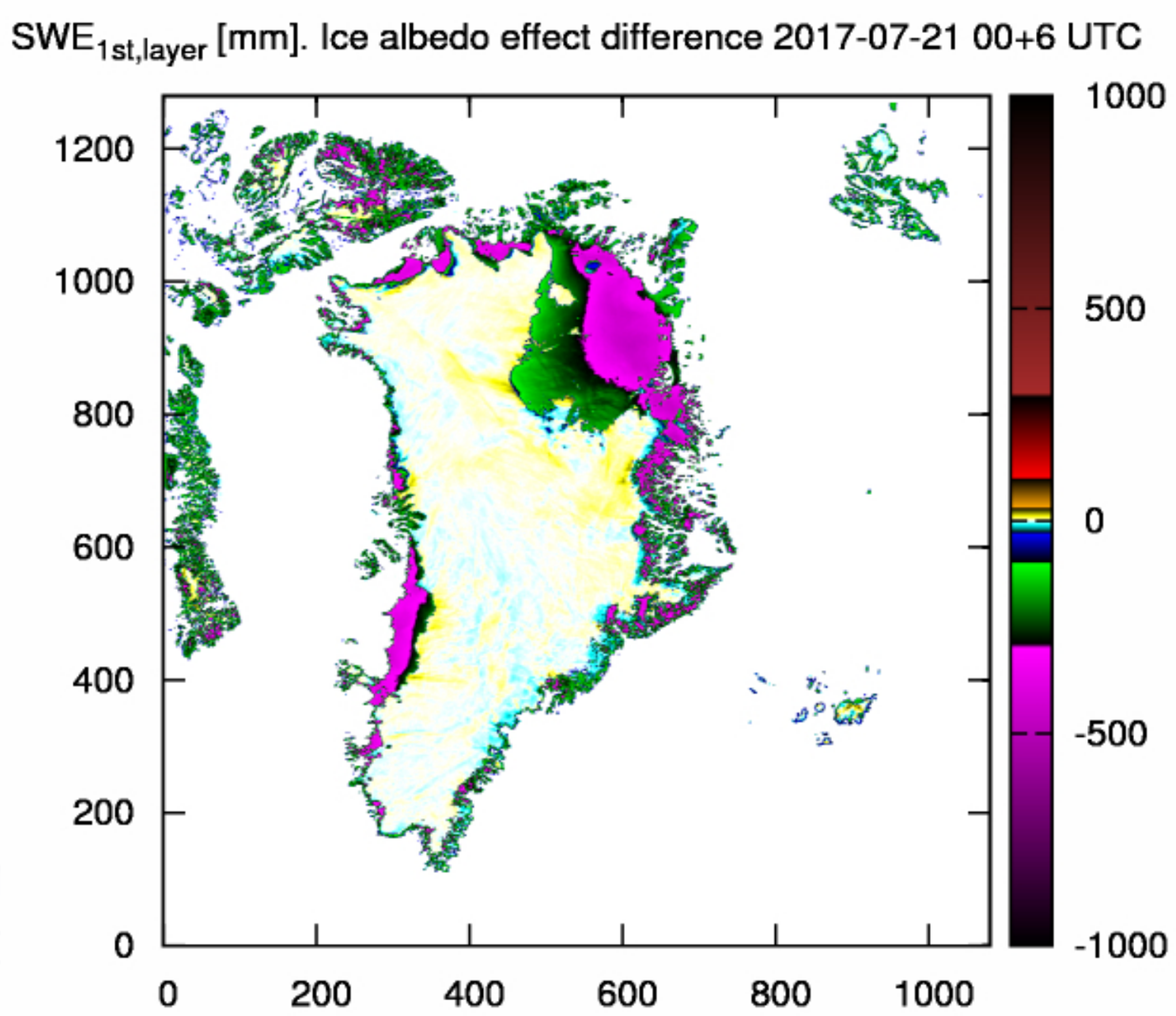
Coupled experiment: Snow water equivalent difference



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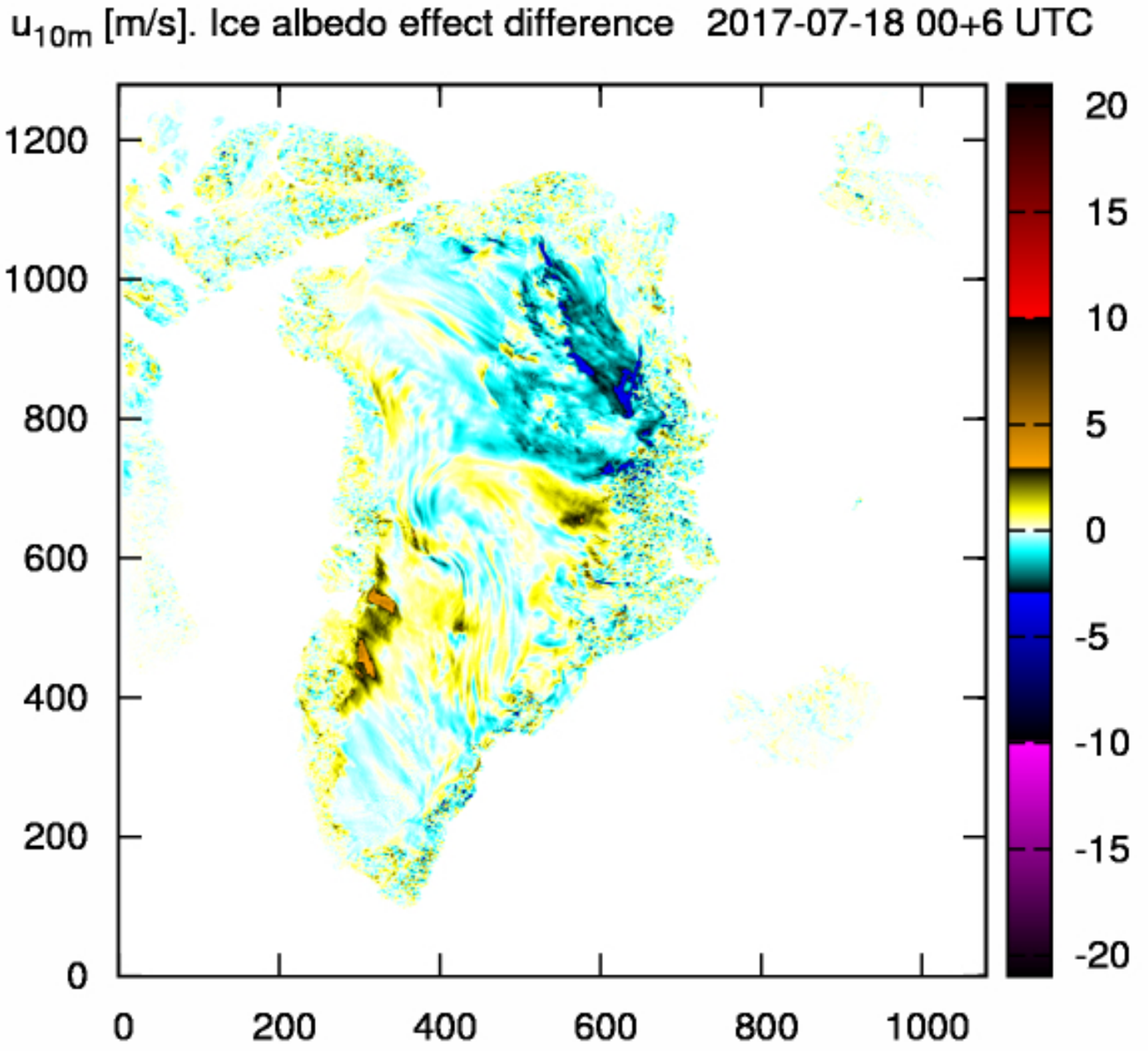
Coupled experiment: Zonal wind difference



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Concluding remarks

Can we use satellite albedos in HAMONIE-AROME cy40h?

A better IFS radiation scheme SURFEX coupling in AROME is needed.

Work is required on the snow and ice glacier albedo . . .

. . . in particular with utilizing SURFEX snow schemes in AROME.

Coupled experiments are essential!

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Thank you for your attention!
Contact: kpn@dmi.dk