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HIRLAM experiments on energy balance at Vatnajökull

**Laura Rontu(FMI) Friedrich Obleitner (U.Innsbruck) Stefan Gollvik (SMHI)
Christoph Zingerle (ZAMG) Sander Tijm (KNMI)**

November 12, 2007

**CONCLUSIONS EDITED by LR and SG for
THE SURFACE DATA ASSIMILATION WORKSHOP
12-14.11.2007 AT MET.HU**



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What we can learn by comparing
fine-resolution NWP model simulations
with detailed observations over a glacier?

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MOTIVATION

What we can learn by comparing
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Fine-resolution model: HIRLAM

- New developments: “newsnow” surface scheme
- Need for detailed model-observation comparison

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Detailed observations: Vatnajökull

- Largest glacier of Europe, Iceland
- Observation campaign summer 1996

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- ⇒ **First step: Comparison of simulated and observed surface energy balance**

Can we rely on HIRLAM on a glacier? How to improve the model?

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⇒ **First step: Comparison of simulated and observed surface energy balance**

Can we rely on HIRLAM on a glacier? How to improve the model?

⇒ Next step: detailed studies of interesting cases (circulations, clouds ...)

⇒ Application: use of fine-scale NWP model output for glaciological studies

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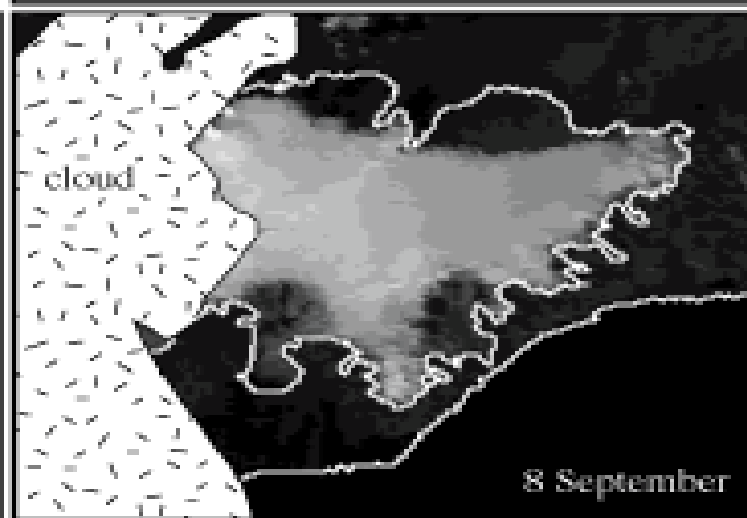
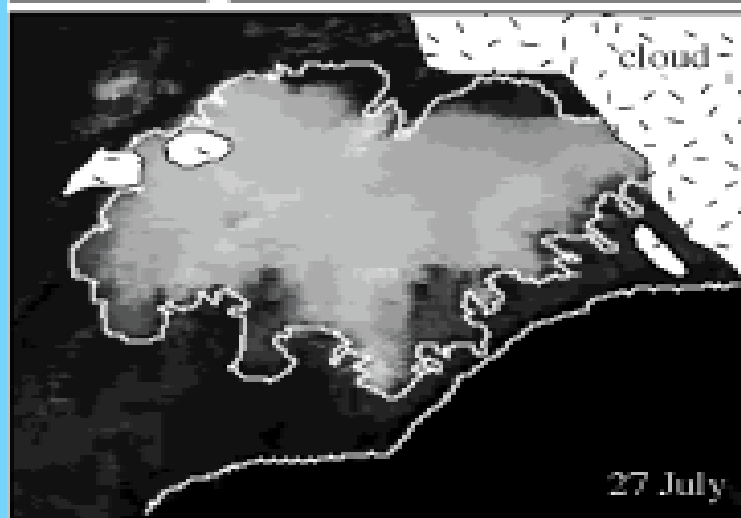
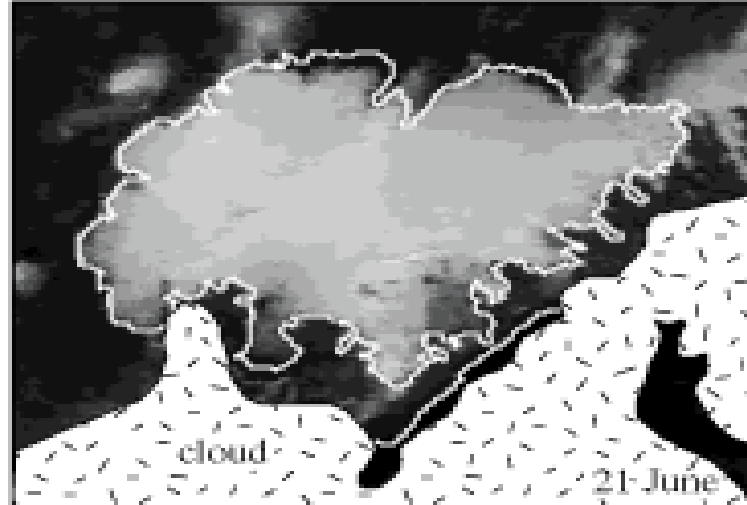
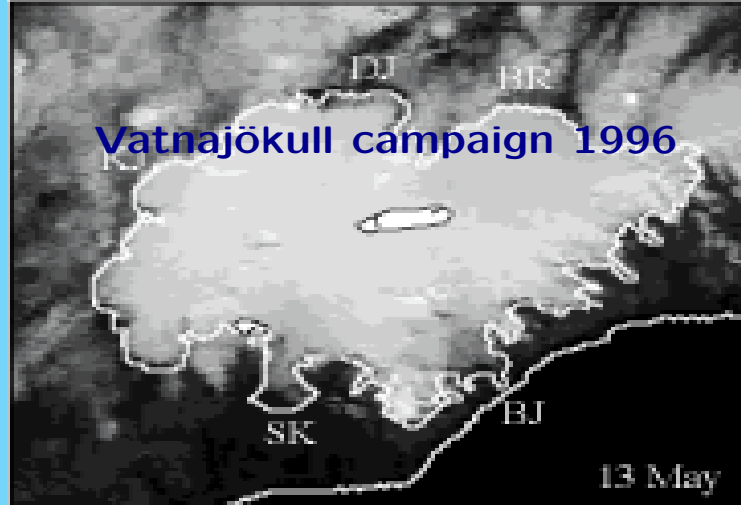
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Surface albedo

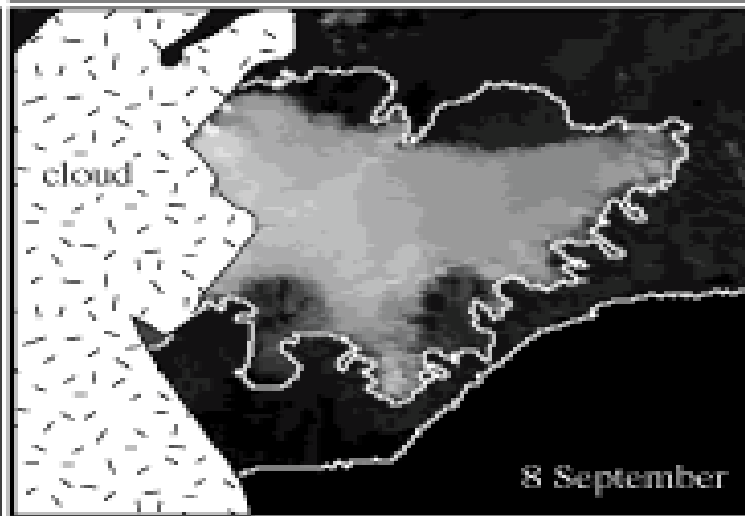
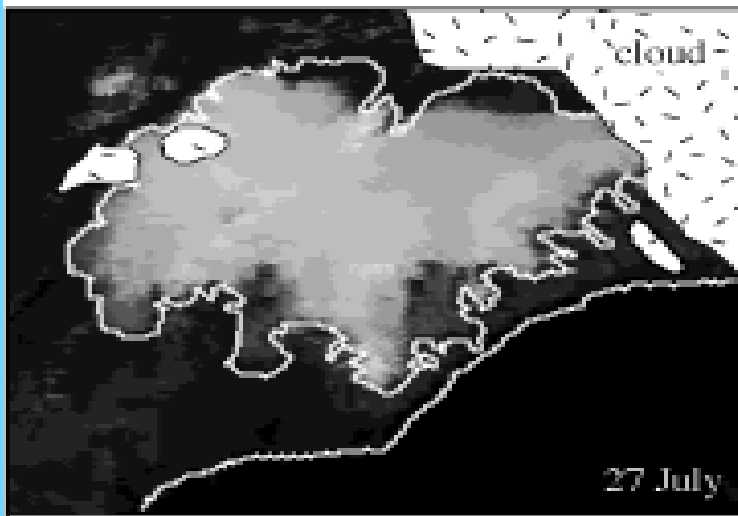
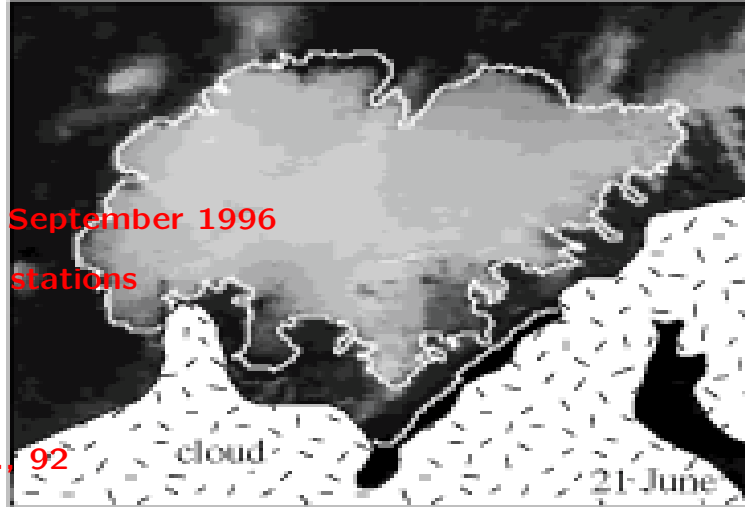
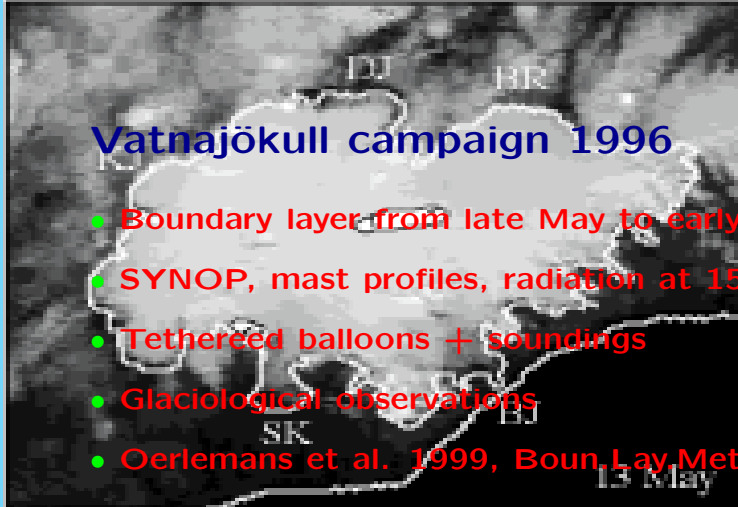


0 10 50 km



Vatnajökull campaign 1996

- Boundary layer from late May to early September 1996
- SYNOP, mast profiles, radiation at 15 stations
- Tethered balloons + soundings
- Glaciological observations
- Oerlemans et al. 1999, Boun Lay Met., 92



Surface albedo



0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

0 10 50 km





HIRLAM experiments

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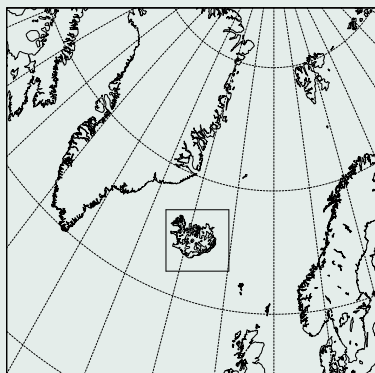
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HIRLAM experiments

- Double nesting with data assimilation:
ERA40/1.0 - HIRLAM/0.15 - HIRLAM/0.025
- In the finest resolution,
only surface data assimilation using conventional observations
- Period from 20 May to 30 June shown here



experiment	resolution	parametrizations
71b2	2.8km/60L	reference HIRLAM
71ns	2.8km/60L	newsnow basic
71ns1	2.8km/60L	newsnow tuned
71ns2	2.8km/90L	ns1 + small corrections

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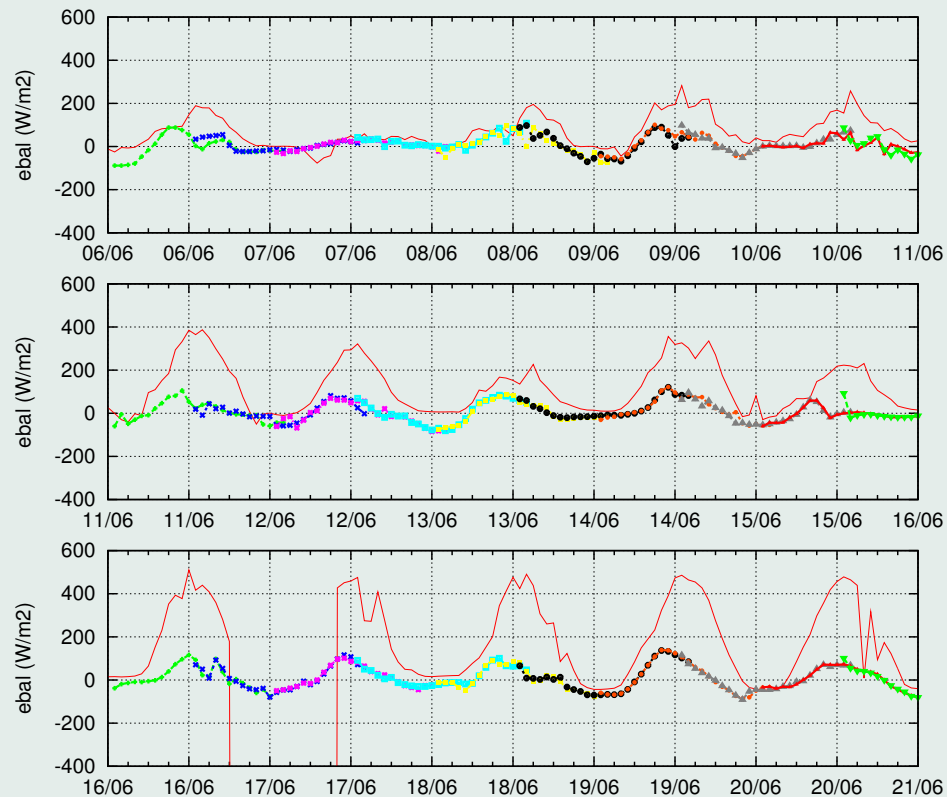
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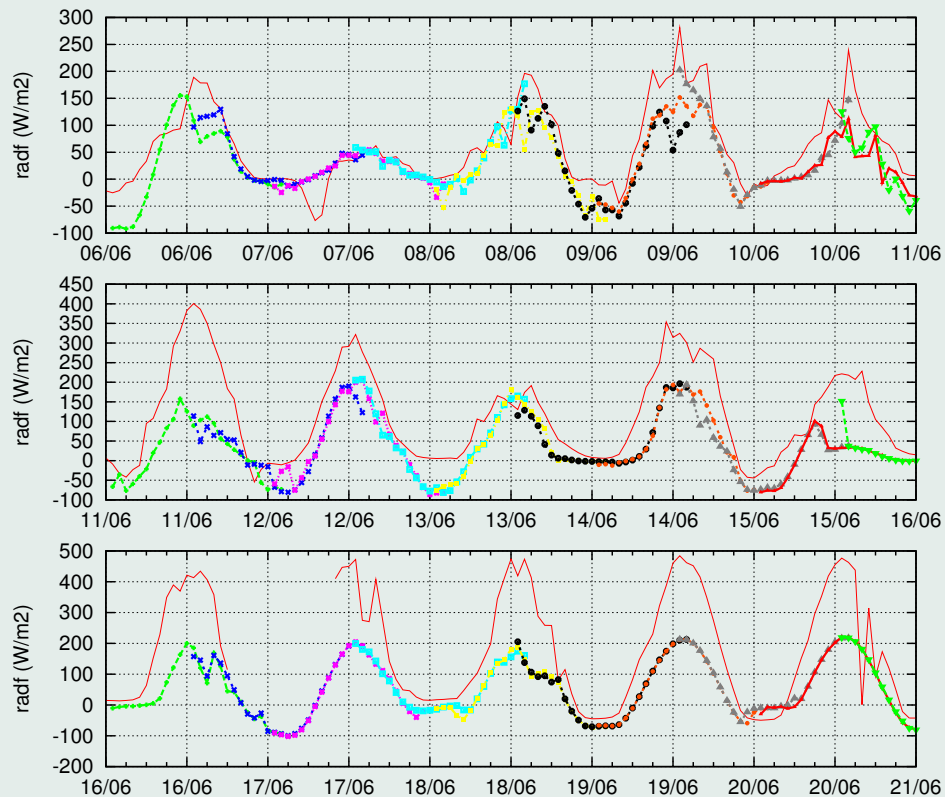
Energy balance, HIRLAM reference at station I6


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Net radiation, HIRLAM reference at station I6

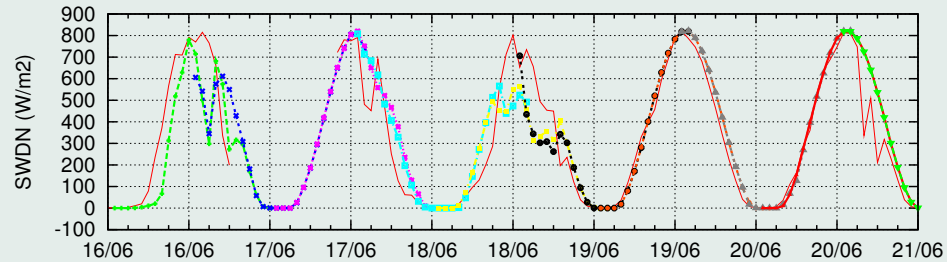

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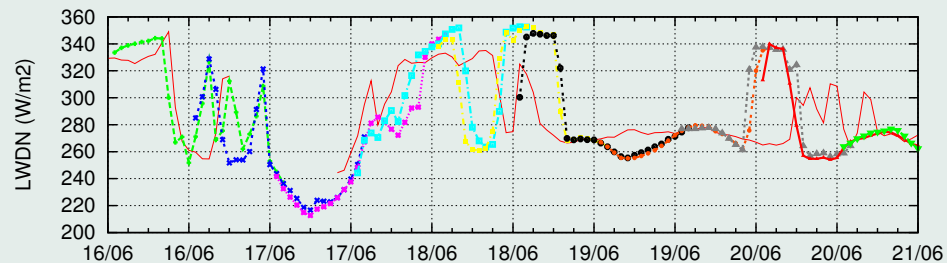
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SWDN and LWDN, HIRLAM reference at station I6

Downwelling shortwave radiation 16-21 June



Downwelling longwave radiation 16-21 June



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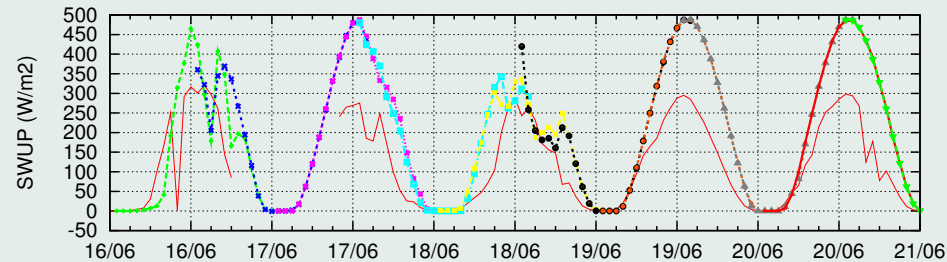
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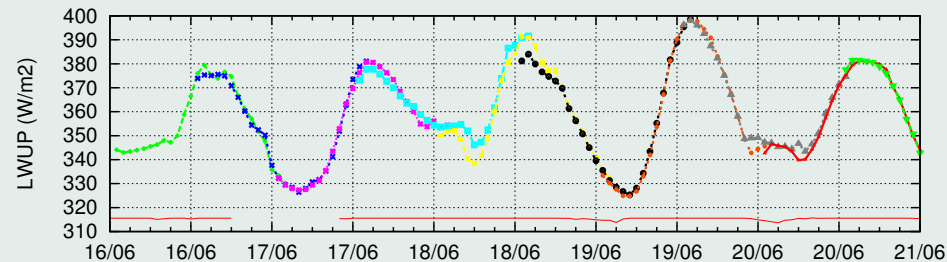
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SWUP and LWUP, HIRLAM reference at station I6

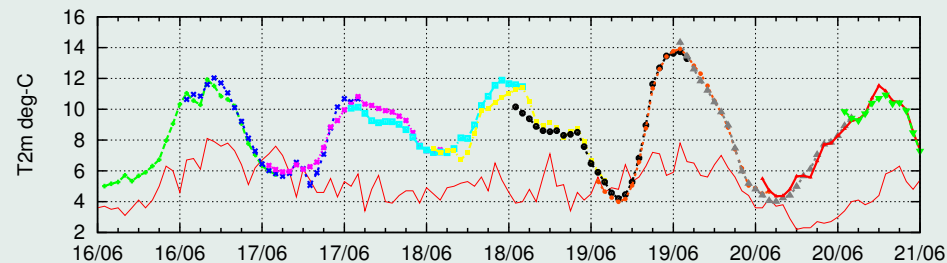
Reflected shortwave radiation 16-21 June



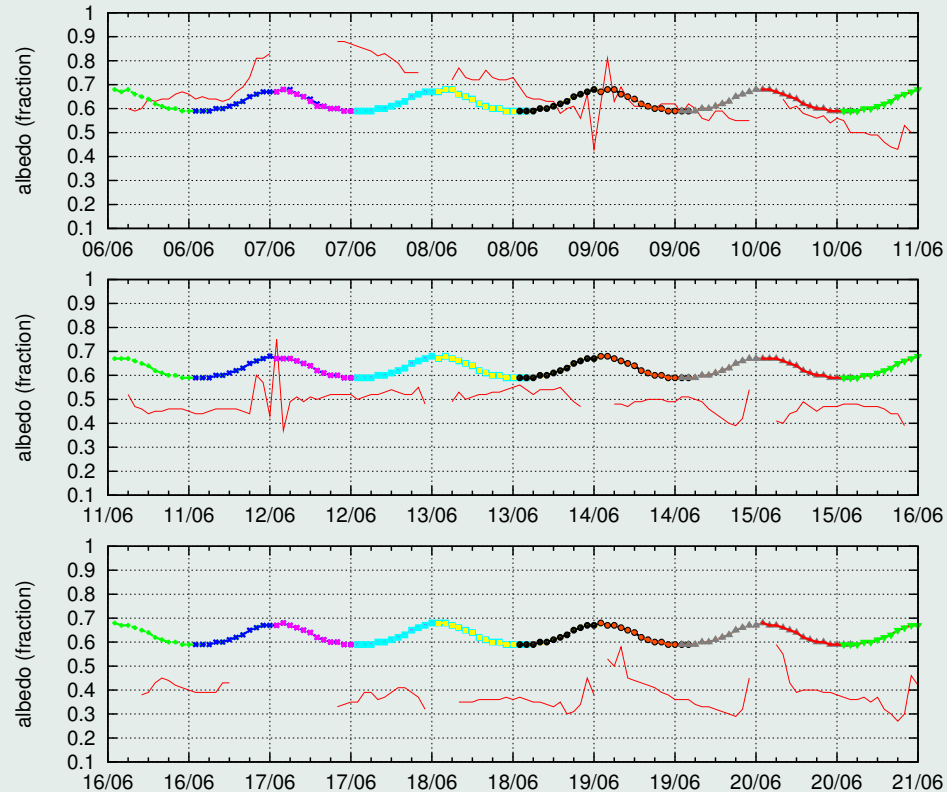
Upwelling longwave radiation 16-21 June



Screen-level temperature 16-21 June



Albedo (prescribed in model), HIRLAM reference at station I6



Thus, SWUP understood.

But what is wrong with the upwelling longwave radiation (LWUP)?

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Hypotheses and actions

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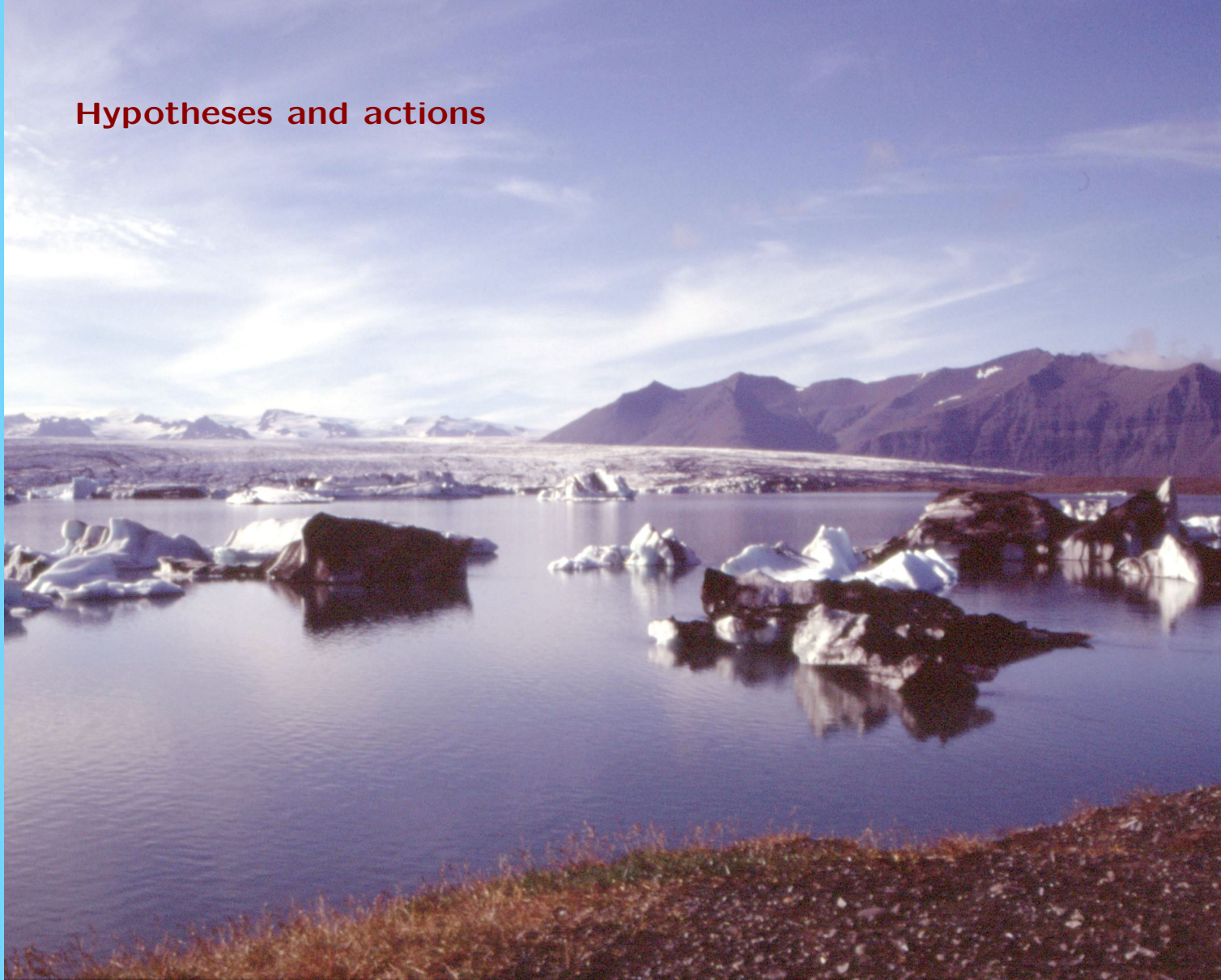
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Hypotheses and actions

Wrong **energy balance** and **surface temperature**

from the middle of June at a station at Breidamerkursjökull

is due to

⇐ wrong **albedo** and wrong **surface temperature**

⇐ wrong **heat flux from below**

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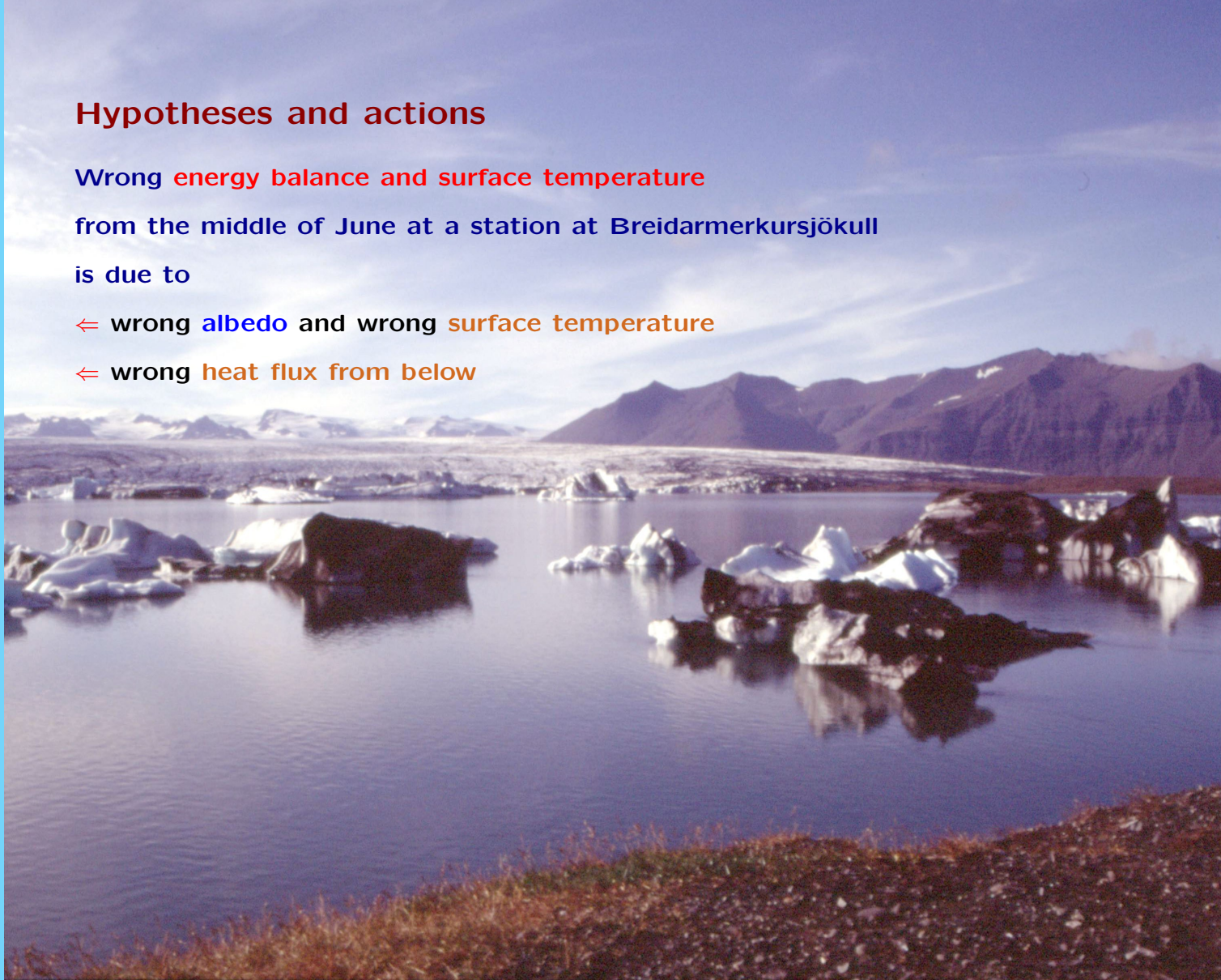
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Hypotheses and actions

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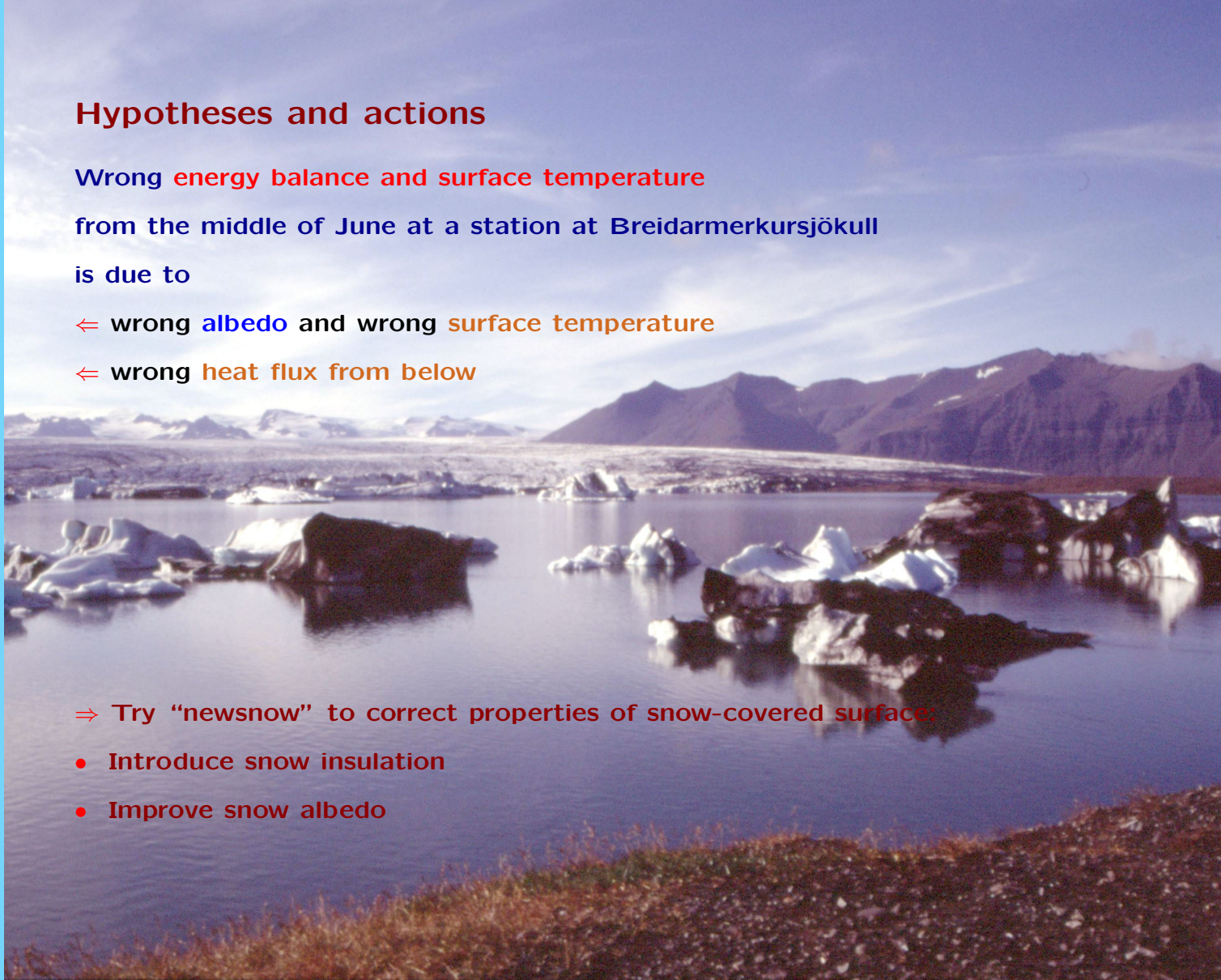
is due to

⇐ wrong **albedo** and wrong **surface temperature**

⇐ wrong **heat flux from below**

⇒ Try “newsnow” to correct properties of snow-covered **surface**:

- Introduce snow insulation
- Improve snow albedo



Hypotheses and actions

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from the middle of June at a station at Breidarmerkursjökull

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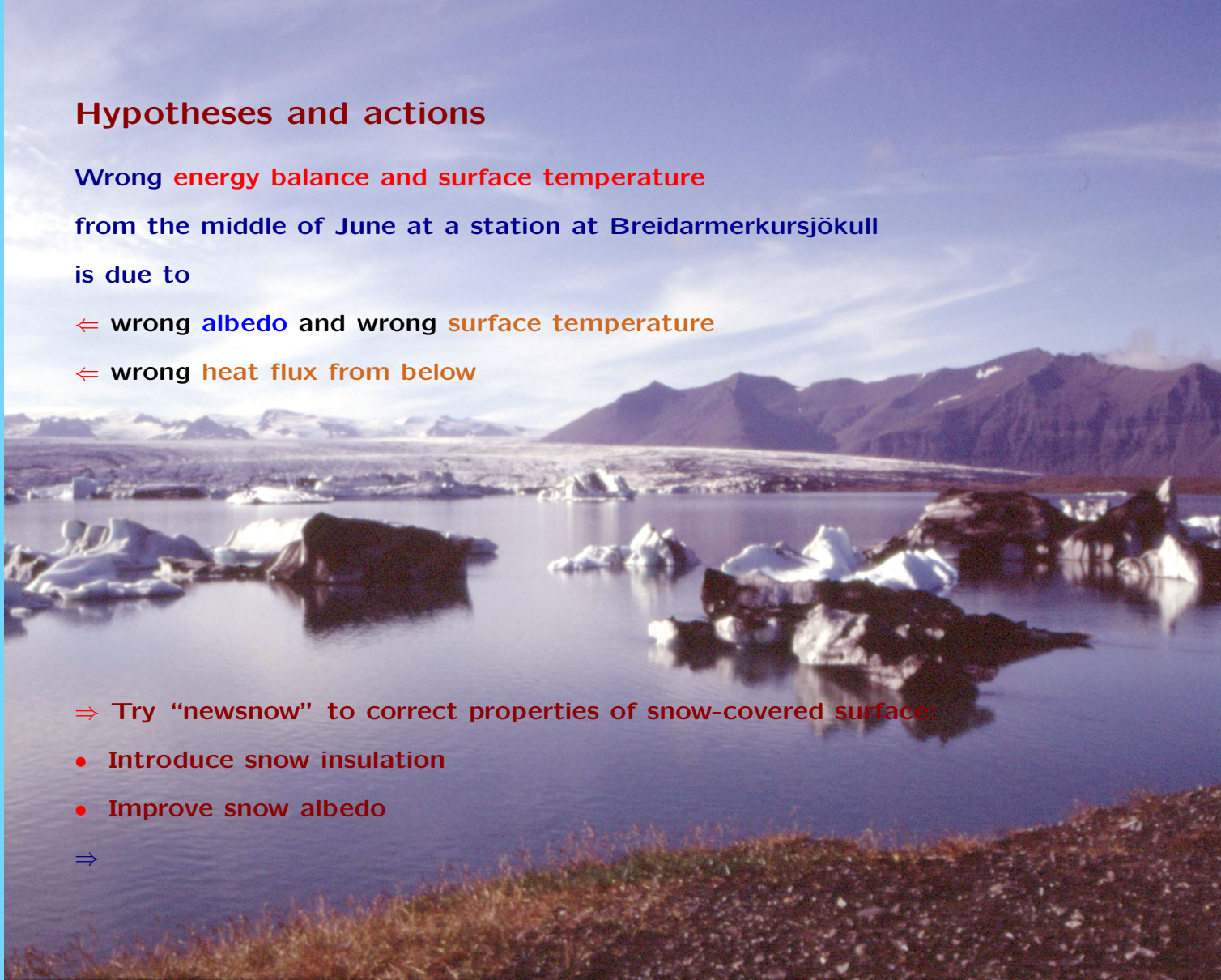
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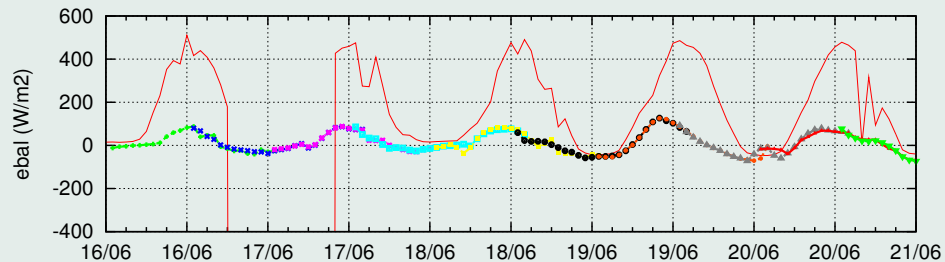
- Introduce snow insulation
- Improve snow albedo

⇒

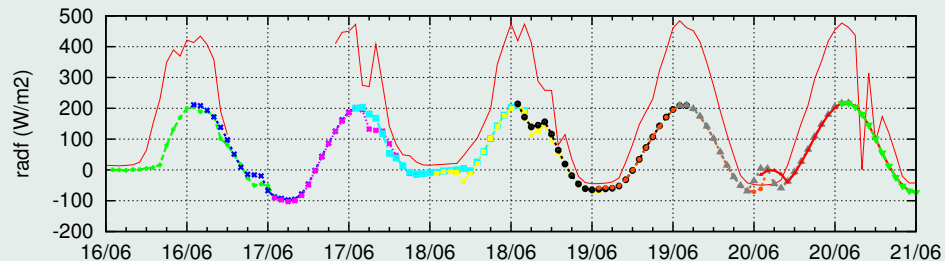


Trying HIRLAM “newsnow” at station I6

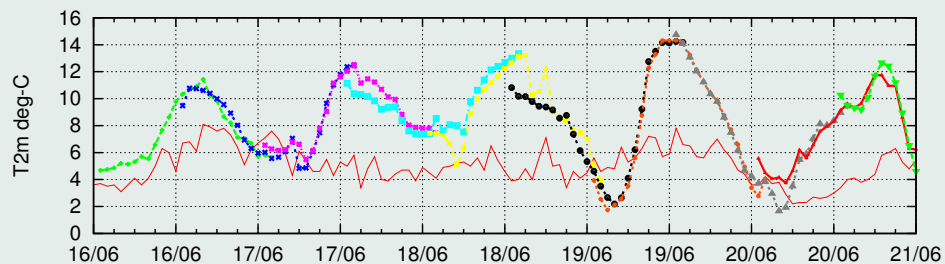
Energy balance 16-21 June



Net radiation 16-21 June



Two-metre temperature 16-21 June


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Further actions

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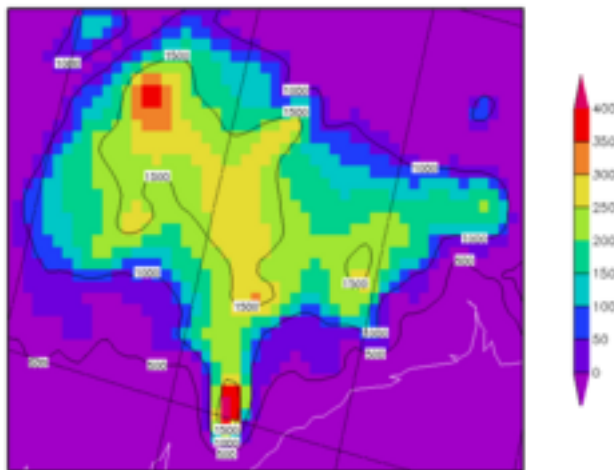
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Further actions

So it was not that simple ...

... maybe because (in HIRLAM), there is no snow on ice at I6!



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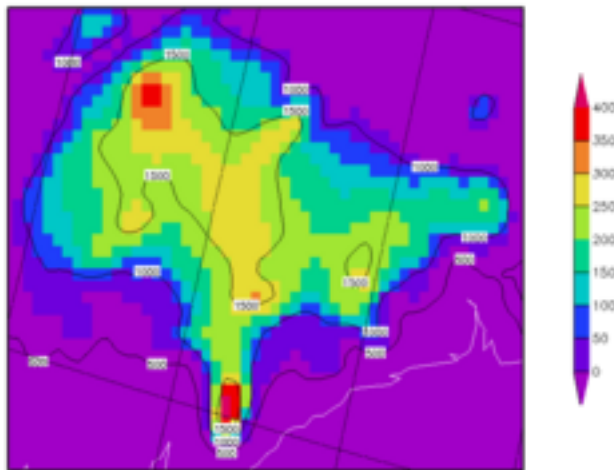
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Further actions

So it was not that simple ...

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⇒ Try to correct properties of underlying ice:

- Introduce locally the albedo of dark ice
- Correct heat conduction in ice

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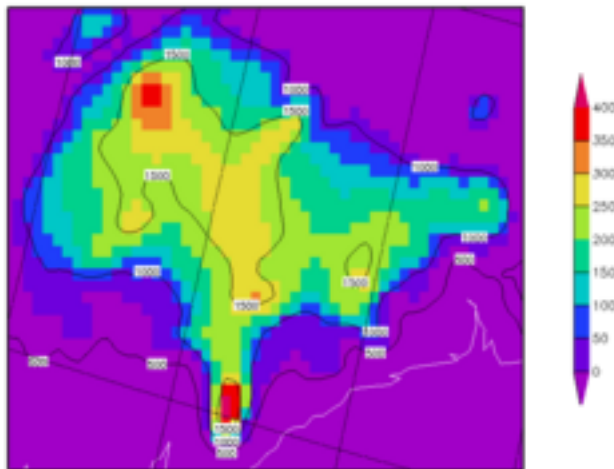
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⇒

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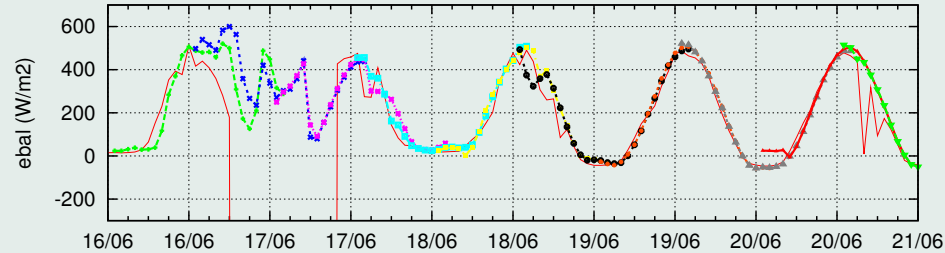
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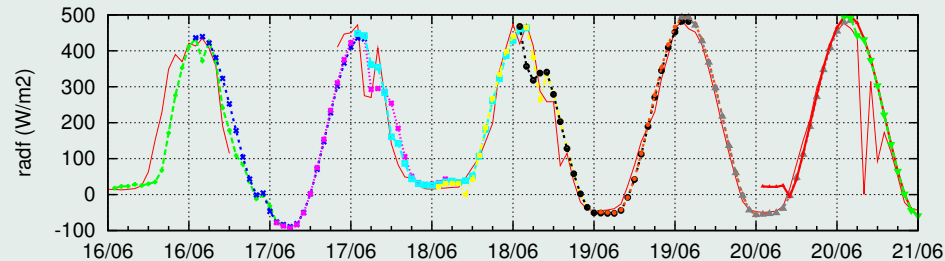
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Tuning HIRLAM “newsnow” at station I6

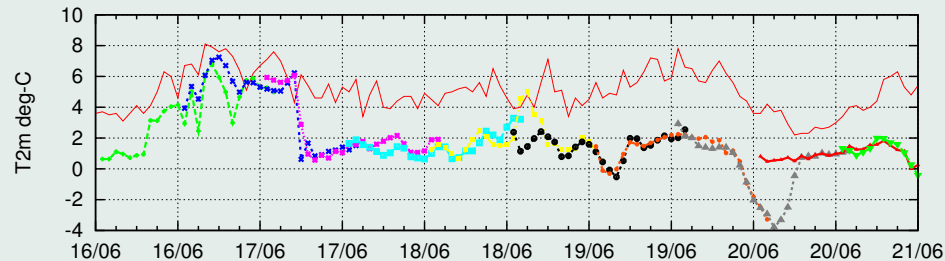
Energy balance 16-21 June



Net radiation 16-21 June



Two-metre temperature 16-21 June



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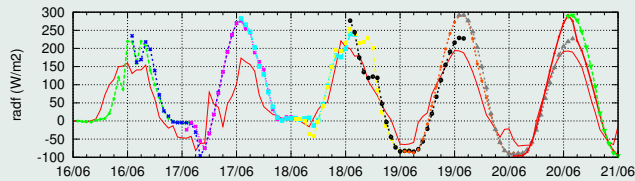
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Reference and tuned "newsnow" at station U7

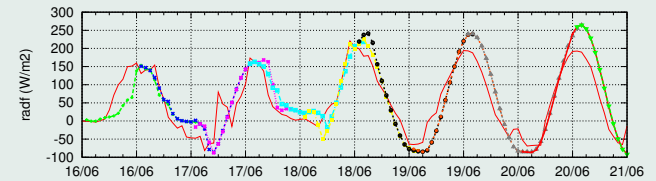
Net radiation

reference

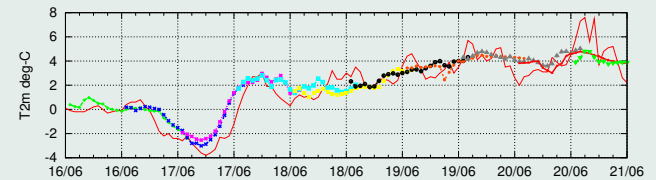
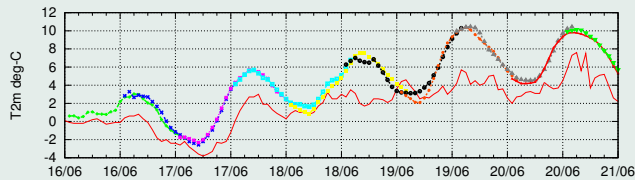


newsnow1

U7 on snow-covered ice



Two-metre temperature



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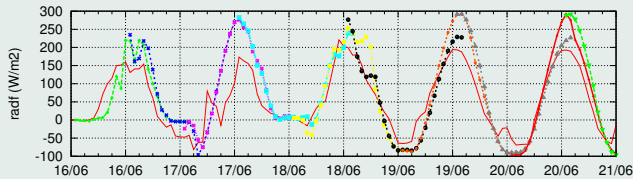
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Reference and tuned “newsnow” at station U7

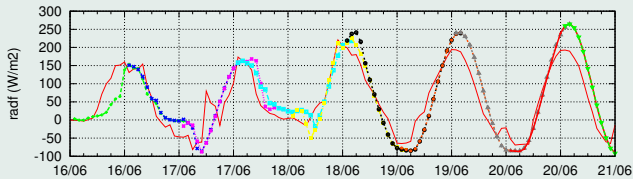
Net radiation

reference



newsnow1

U7 on snow-covered ice



Two-metre temperature

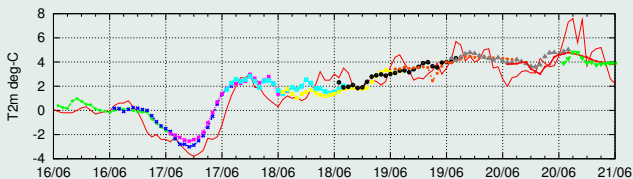
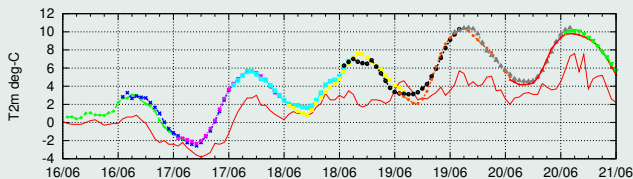


Table 1: Impact of the HIRLAM modifications at different stations

Stn	Elev. (m)	Ice		Snow		T _{2m} quality		
		Nature	HIRLAM	Nature	HIRLAM	reference	newsnow	tuned ice
U7	1530	yes	yes	yes	yes	fair	good	good
I6	715	yes	yes	partly	no	poor	poor	good
U2	50	no	yes	no	no	poor	poor	improved



What did we learn from this exercise? (1)

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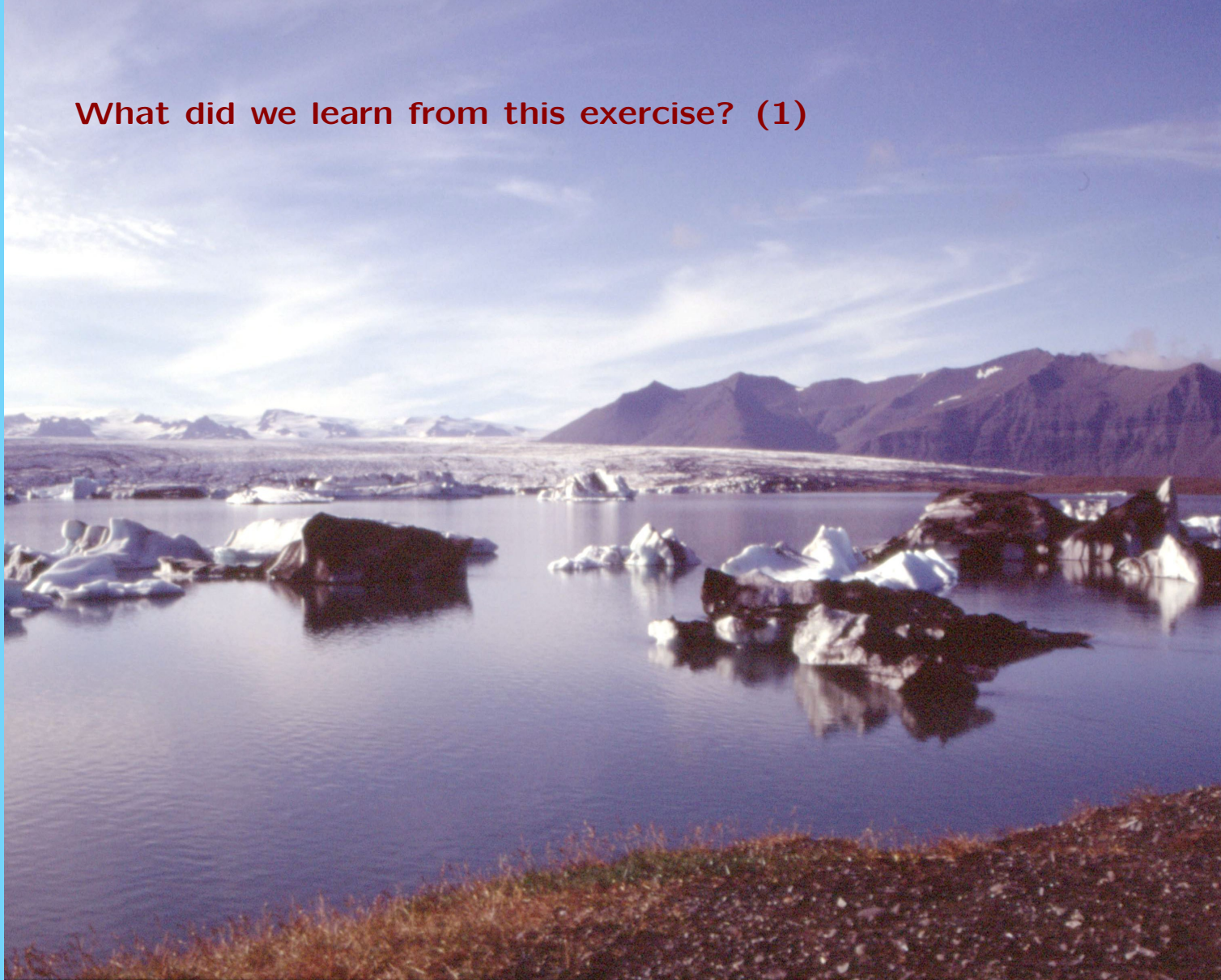
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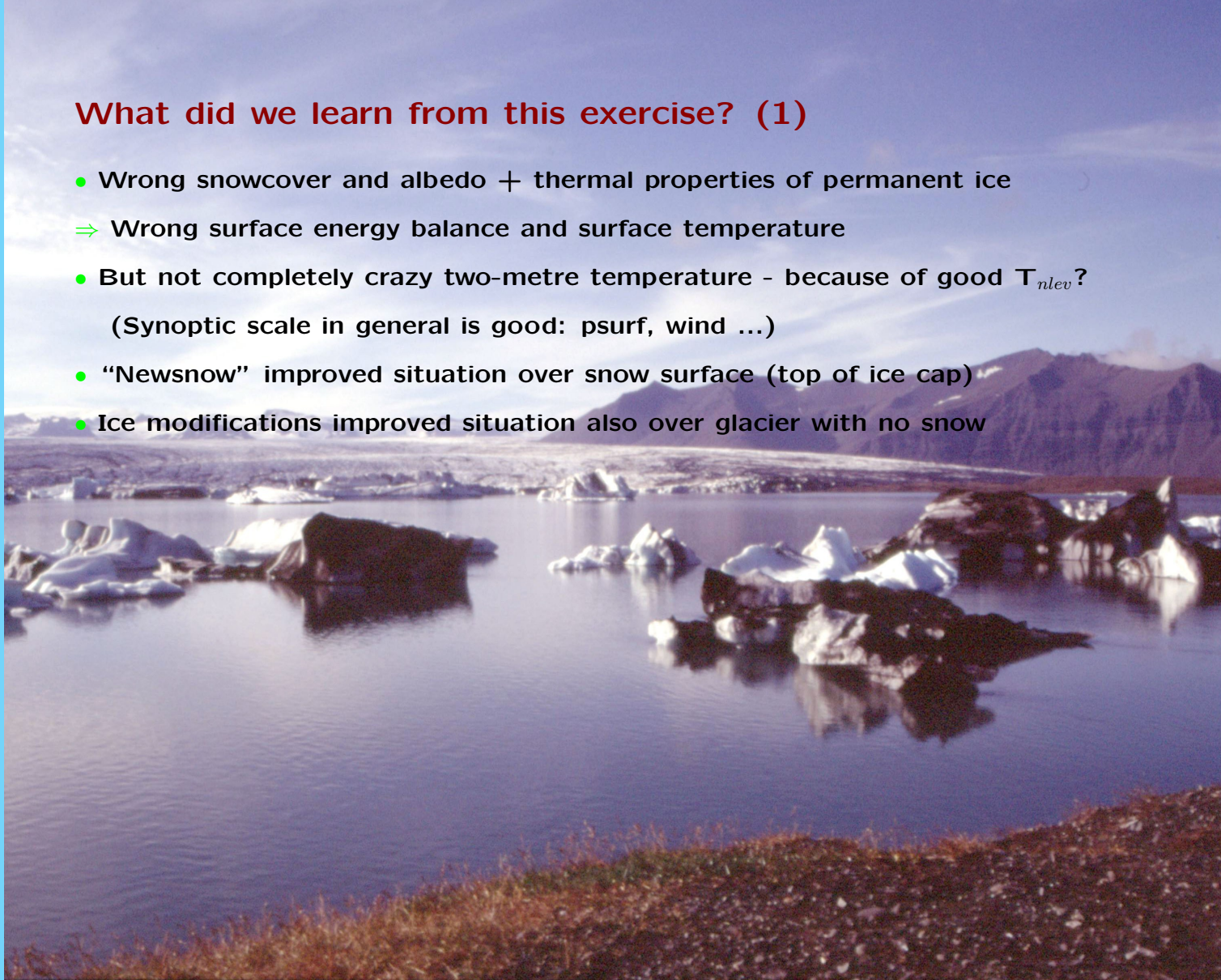
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What did we learn from this exercise? (1)

- Wrong snowcover and albedo + thermal properties of permanent ice
⇒ Wrong surface energy balance and surface temperature
- But not completely crazy two-metre temperature - because of good T_{nlev} ?
(Synoptic scale in general is good: p_{surf} , wind ...)
- “Newsnow” improved situation over snow surface (top of ice cap)
- Ice modifications improved situation also over glacier with no snow



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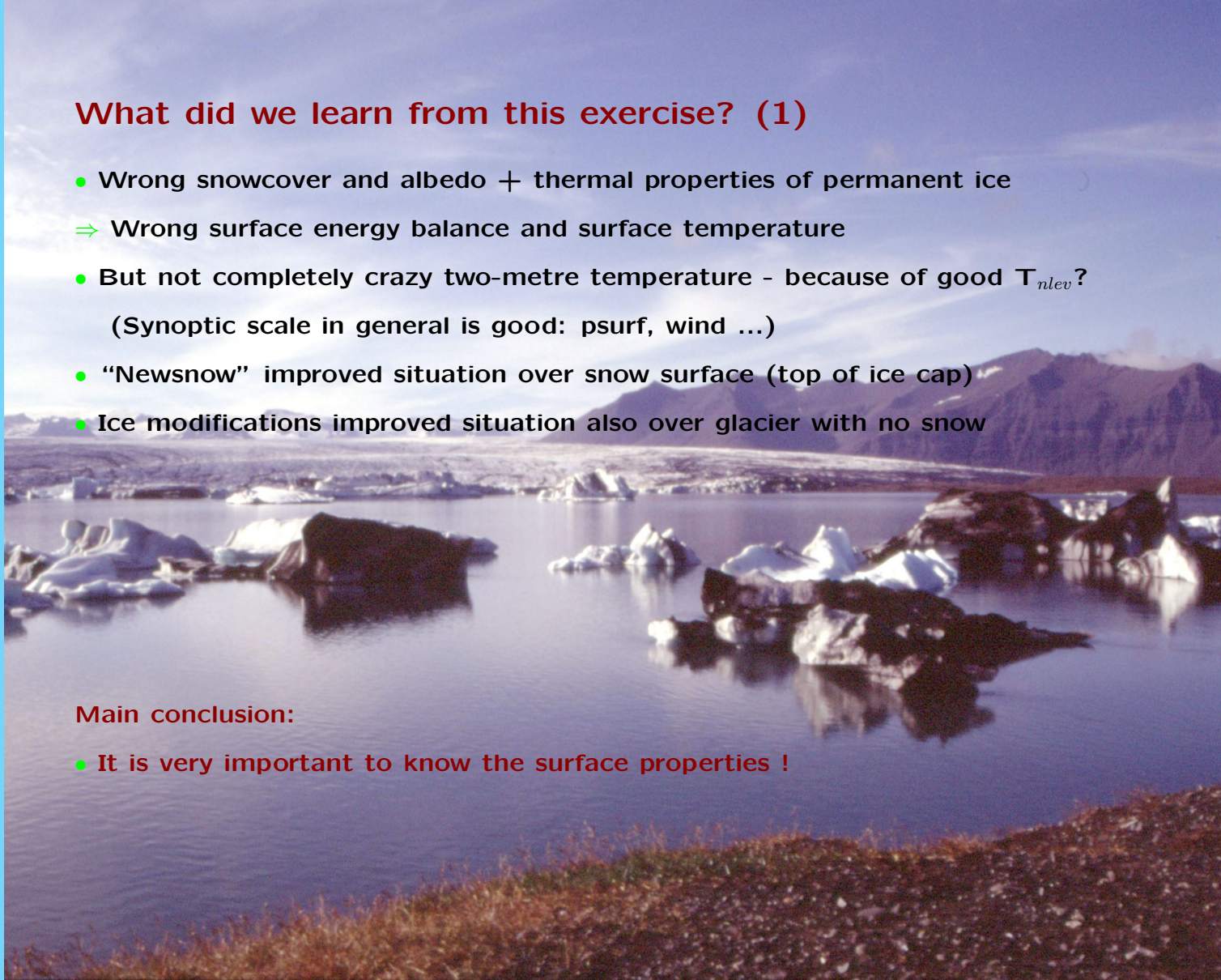
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Main conclusion:

- It is very important to know the surface properties !





What did we learn from this exercise? (2)

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What did we learn from this exercise? (2)

Vatnajökull energy balance correct/incorrect depends on prescribed and analysed surface properties

- What is the surface elevation (physiography)
- Is there a snow cover on ground? (analysed)
- Is the ground rock or continental ice (physiography)
- How are the ground thermal properties defined (physiography/parametrizations)
- How are the surface albedo/emissivity/roughness defined (physiography/model)



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Good atmospheric background + good physiography

+ reasonable parametrizations would provide good energy balance



What did we learn from this exercise? (3)

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What did we learn from this exercise? (3)

We run the experiment without upper air analysis
but even surface analysis did nothing useful

- Too sparse regular (SYNOP) observations
- Not easy to take extra observations in \Rightarrow not used
- Soil moisture/temperature analysis in ice not relevant
- Ice albedo was artificially modified instead of snow analysis



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Prescribed albedo, ice and snow

- Heat flux from below was the main factor
- Surface albedo is important for the melting of snow/ice
- How to analyse satellite albedo and use it ? First guess ?
- Snow in ECOCLIMAP 10-day (satellite-based) data?



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- In model, they are related to the temperature gradient



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We did not look carefully at the turbulent fluxes

- In model, they are related to the temperature gradient

At Vatnajökull we did not have

- Vegetation or conventional soil
- Forest would be more complicated!