Norwegian Meteorological Institute

Snow

Mariken Homleid

ALADIN Workshop and HIRLAM ASM, 30 March 2020

Outline

- Ongoing **snow** related efforts in HIRLAM, CARRA, MetCoOp, AROME-Arctic, NORDSNOWNET....
- How do the presence of snow affect near surface weather - in reality and in our NWP models
- Snow status in current cycle of HARMONIE-AROME
- Snow related improvements in CARRA
  - On glaciers (permanent snow)
  - Use of satellite snow extent
- Next steps ... on our way to new cycles ...

«Winter night
in Rondane»
by
Harald Solberg

https://no.wikipedia.org/wiki/%C2%ABVinternatt_i_Rondane%C2%BB

Snow

- has low heat capacity
- isolates and prevents heat transport between the ground and the atmosphere
- emits as a black body

... properties that might contribute to rapid and strong cooling in stable conditions

«Winter day in Rondane» Photo by Jan Erik Haugen

Snow

- has high albedo and reflects most of the incoming radiation
- effects the wind speed and exchange of heat (effects that are parameterized through specific roughness lengths for snow)

«Melting» Photo by Hanneke Luitjing

The impact of snow on the ground is largest in the melting season; on sunny days

- with snow on ground will all available energy be used to melting, and the surface temperatures will not increase much above 0

Snow status in cycle 40 (38, 36)

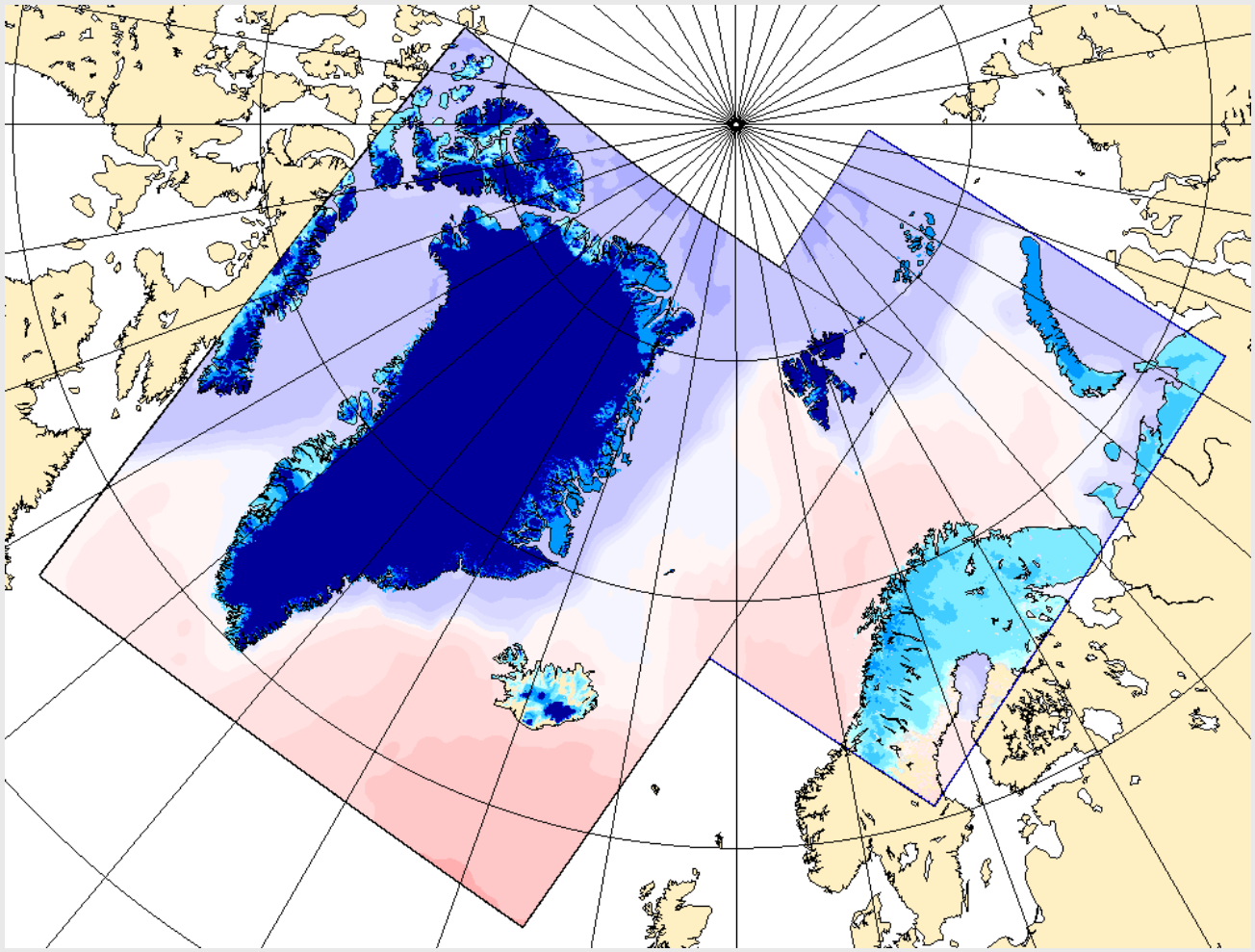
- **1 layer snow scheme** (D95, Douville et al., 1995)
  - gives realistic snow aggregation, but a slight delay of the melting, given that the forcing is realistic (highest sensitivity to precipitation and temperature)
  - gives too much snow in areas with too much precipitation (snow)

- **Snow analysis by Optimal Interpolation with CANARI** (Taillefer, 2002)
  - using **conventional snow depth observations**
  - the background error correlation includes a horizontal and a vertical term
  - quality control by a first guess check

- Good performance in regions with representative observations

- **Monitoring is important**, e.g. blacklisting of observations at SEA point, make sure that the observations not are rejected in First Guess check due to too narrow limits,..

CARRA – **C**opernicus **AR**ctic **R**e**A**nalysis



- 1997 – 2021
- HARMONIE-AROME cycle 40
- improvements related to cold surfaces; sea ice, **glaciers** and **snow**
- 2.5 km
- Partners are the meteorological services in the Nordic countries and Météo-France

https://climate.copernicus.eu/copernicus-arctic-regional-reanalysis-service

Glaciers in CARRA

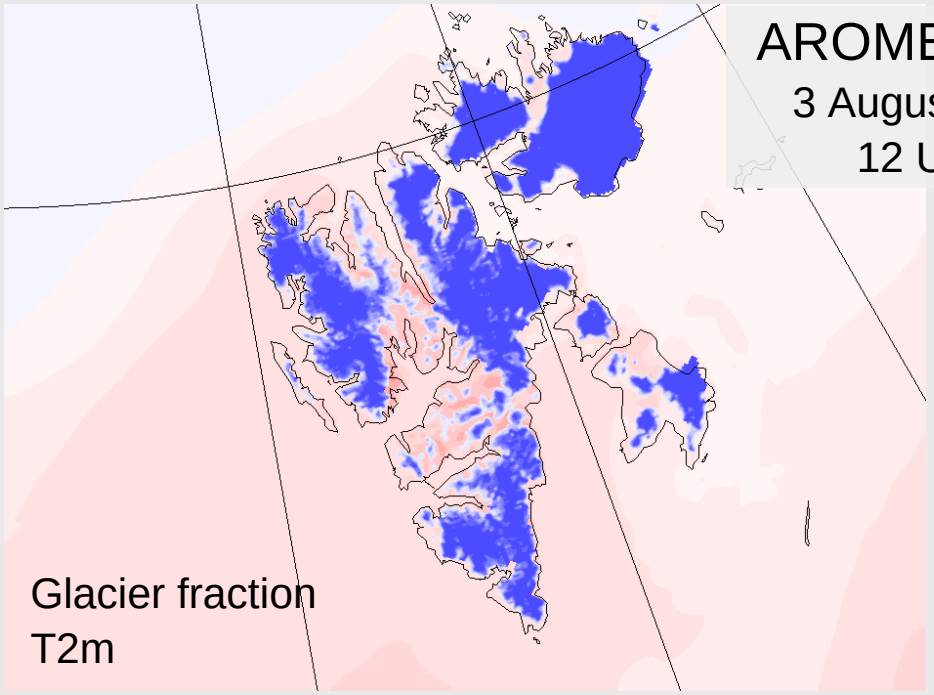
SURFEX glaciers

- are defined by a specific patch; PERMANENT SNOW
- no specific glacier model; the performance over the glaciers is defined by the 1-layer snow scheme (D95)

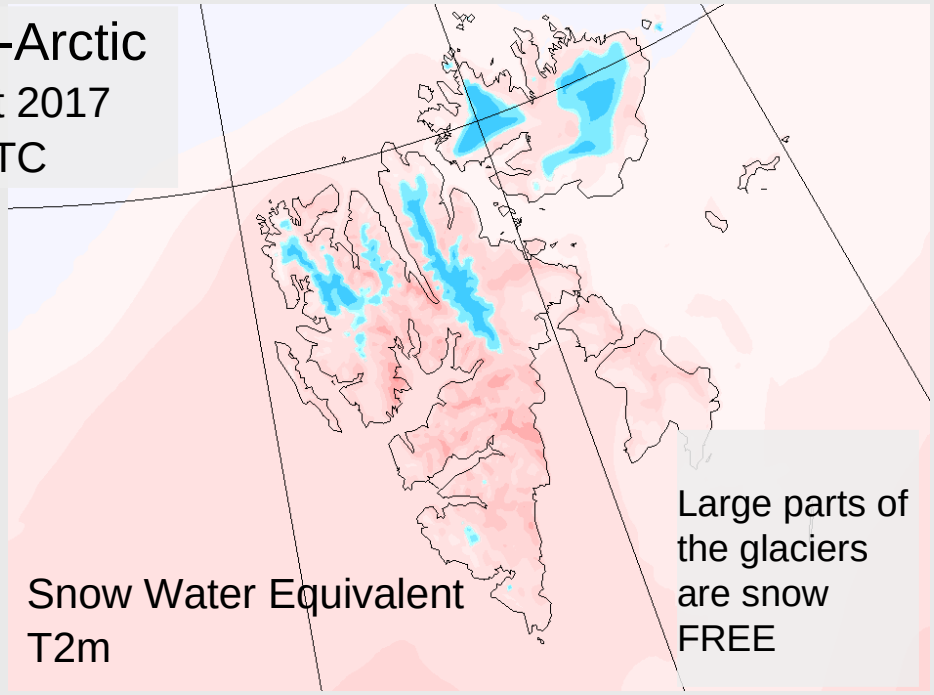
Glacier related improvements in CARRA

- new glaciers masks
- improved snow albedo calculations, and use of an external glacier albedo data set
- Snow Water Equivalent on the glaciers is reinitialized to 10 ton/m^2 every year, 1 Sep
- the snow analysis do not change the SWE on the glaciers
- snow free and HOT glaciers avoided by introducing a lower limit of SWE on PERMANENT SNOW (problem detected by Kristian, DMI, on glaciers in Greenland)

AROME-Arctic
3 August 2017
12 UTC

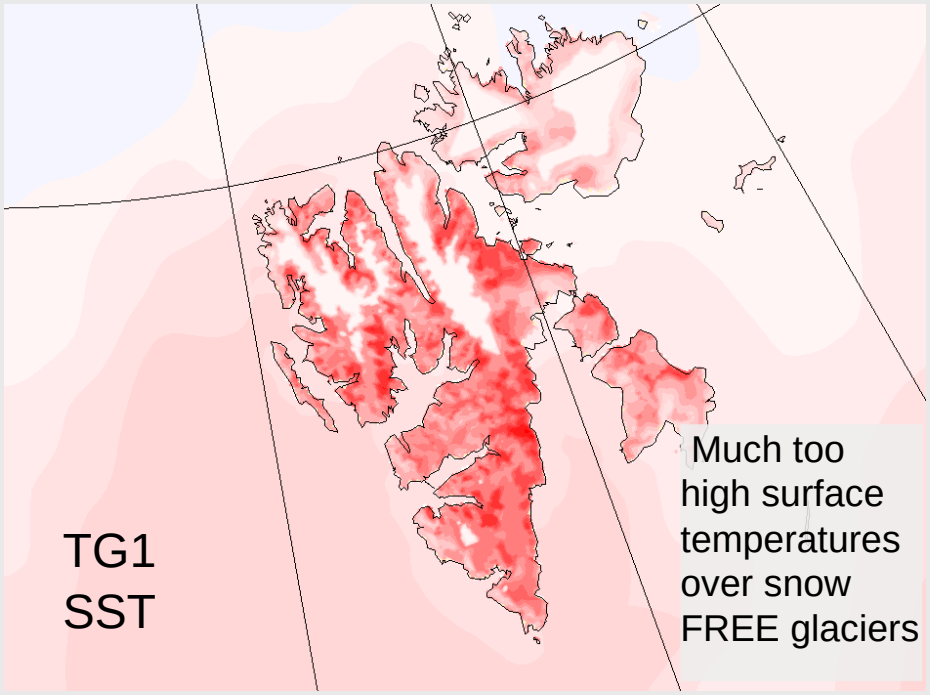


Glacier fraction
T2m



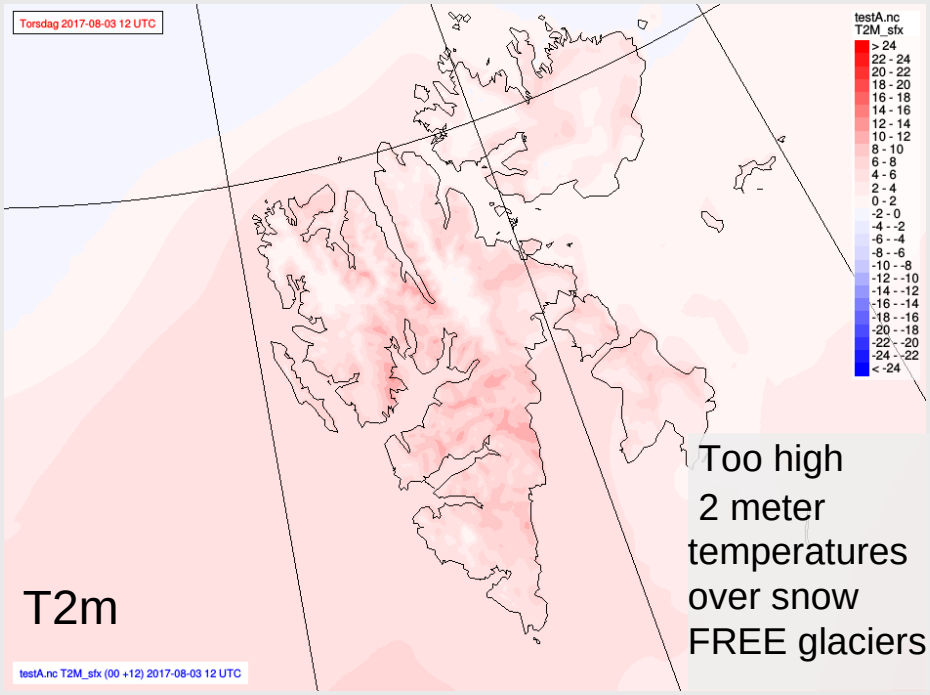
Snow Water Equivalent
T2m

Large parts of the glaciers are snow FREE



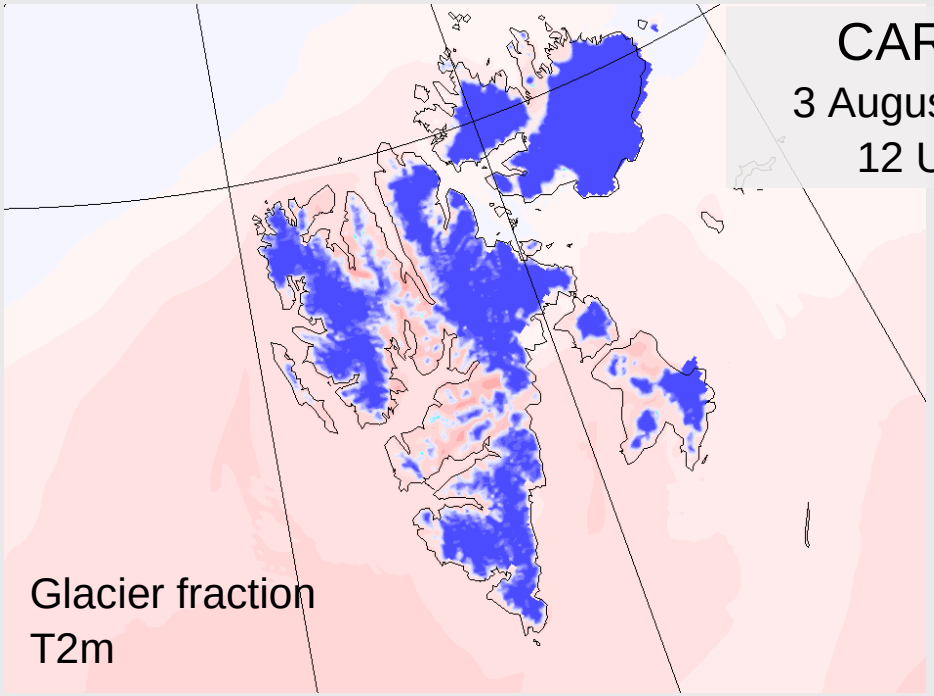
TG1
SST

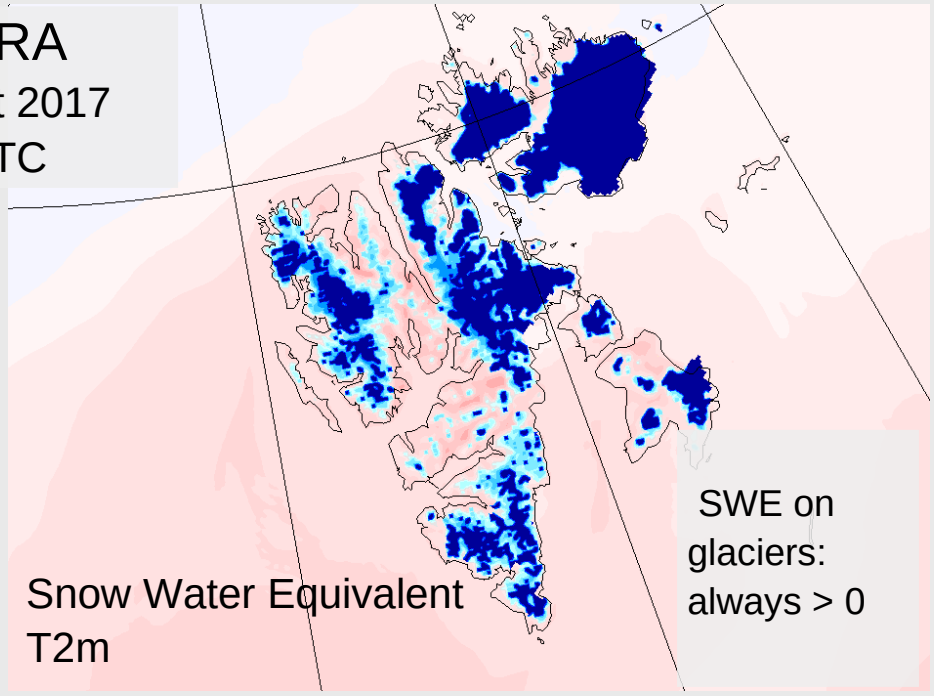
Much too high surface temperatures over snow FREE glaciers

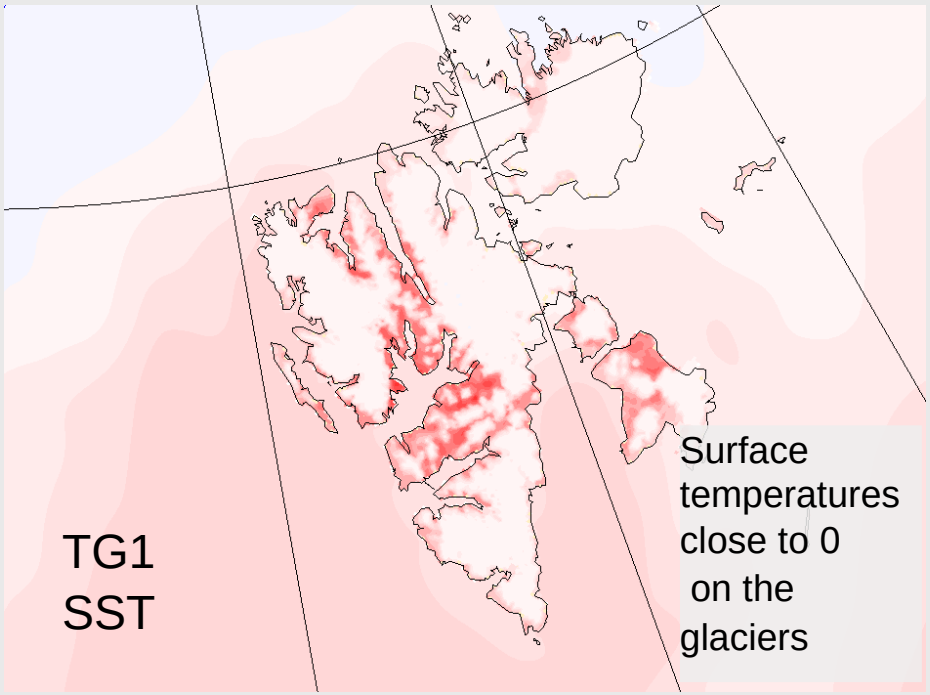


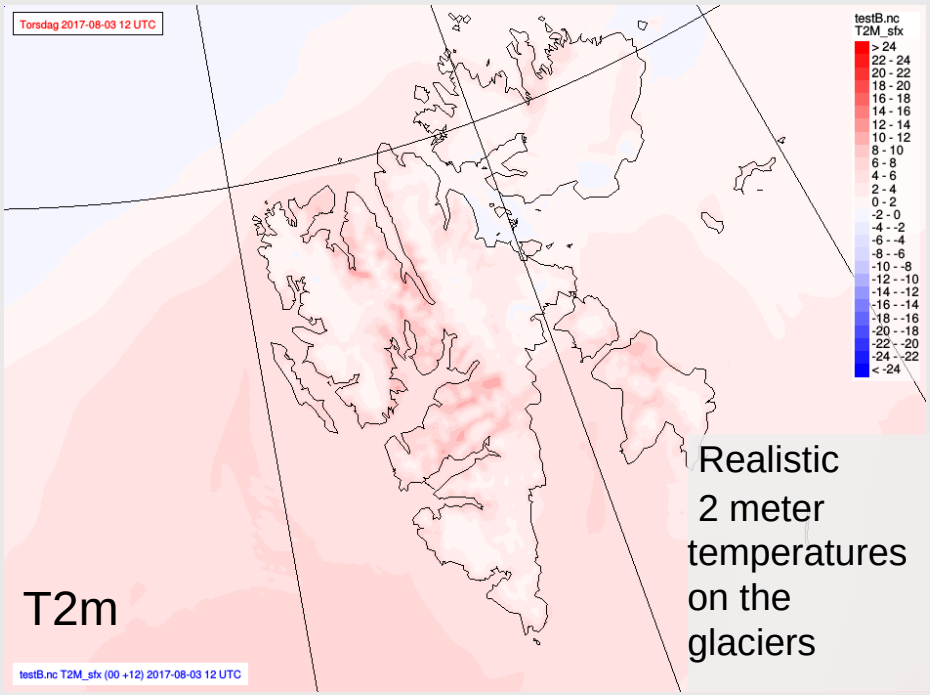
T2m

Too high 2 meter temperatures over snow FREE glaciers


CARRA
3 August 2017
12 UTC
Glacier fraction
T2m


Snow Water Equivalent
T2m
SWE on
glaciers:
always > 0


TG1
SST
Surface
temperatures
close to 0
on the
glaciers


Torsdag 2017-08-03 12 UTC
testB.nc
T2M_sfx
> 24
22 - 24
20 - 22
18 - 20
16 - 18
14 - 16
12 - 14
10 - 12
8 - 10
6 - 8
4 - 6
2 - 4
0 - 2
-2 - 0
-4 - -2
-6 - -4
-8 - -6
-10 - -8
-12 - -10
-14 - -12
-16 - -14
-18 - -16
-20 - -18
-22 - -20
-24 - -22
< -24
T2m
Realistic
2 meter
temperatures
on the
glaciers
testB.nc T2M_sfx (00 +12) 2017-08-03 12 UTC

Use of satellite snow extent in CARRA

- motivated by the lack of conventional snow depth observations in parts of the domains, e.g. Greenland, Svalbard, Iceland

- satellite products considered for use
  - HSAF snow extent produced operationally since autumn 2017 by N. Siljamo, FMI, available on https://landsaf.ipma.pt/en/
  - CryoClim produced at MET Norway available 1982 – 2015
  - HSAF and CryoClim are based on AVHRR data and gives “probability of snow” or “snow extent” in cloud free regions

- Comparisons of HSAF and CryoClim performed in the CARRA project by K. Kouki, FMI, show
  - good agreement between the to data sets in most cases
  - some differences (and potential for improvements of the products)

- CryoClim was chosen for use in CARRA because the data were already available for most of the CARRA period

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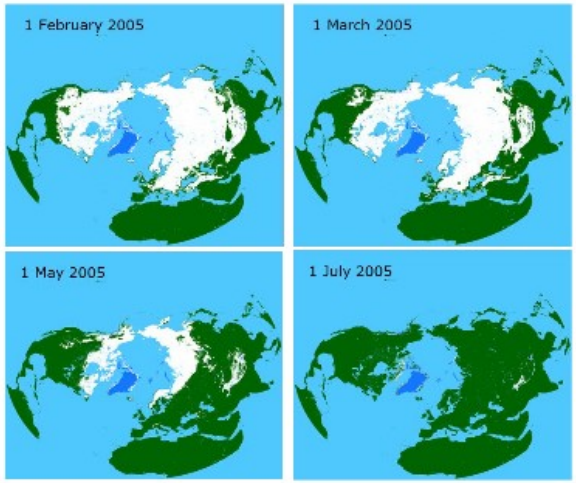
Note

Advancement of global snow mapping in CryoClim

Sentinel4CryoClim Phase 1, Deliverables 1-6



Note no. SAMBA/10/17

Authors Rune Solberg, Øystein Rudjord, Arnt-Børre Salberg (NR)
Mari Anne Killie, Steinar Eastwood, Lars-Anders Breivik (MET)

Date 28 March 2017

CryoClim 1982-2015

- Global, optical snow product
- 5 km resolution
- Based on historical AVHRR GAC data (A2 FCDR)
- Bayes approach is used to combine information from optical and infrared AVHRR channels
- Extensive, manual collection of training data
- Each swath is processed individually
- In a second step are the individual swaths gridded and averaged to a daily product

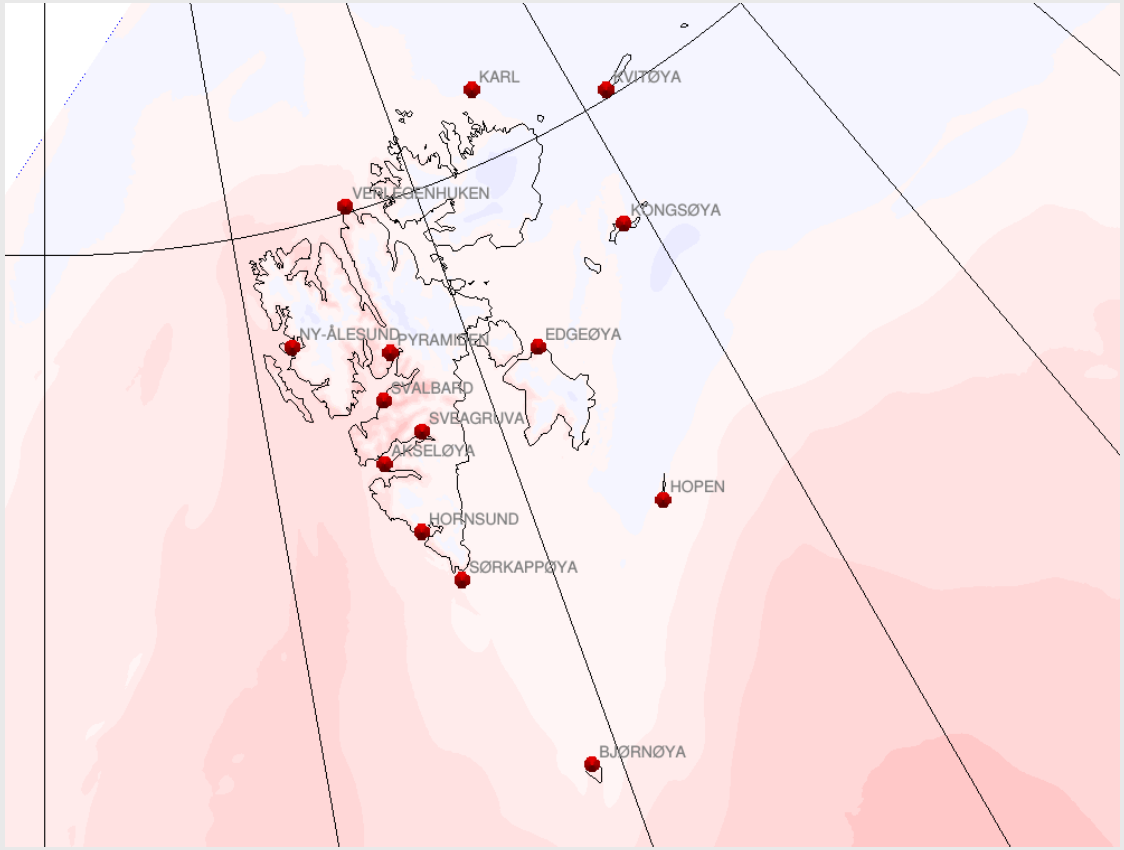
How satellite snow extent is used in CARRA

- satellite data is used in combination with conventional snow depth observations
  - the snow depth observations to improve SWE
  - the satellite data helps to discriminate between snow free and snow covered ground
- the satellite data is
  - used with 5 km resolution on Iceland and Svalbard, but thinned to 10 km resolution else where to avoid significant increase in computation time in CANARI
  - assumed to have uncorrelated errors
  - «no snow» values are used as 0
  - «snow» are used only when 1.guess < 28 kg/m², and set to 28 kg/m²
- the satellite data is given less weight than conventional snow depths

- the satellite data has a small positive impact, both on the snow cover and on surface temperatures, particularly in the melting season

- the implementation in CARRA is based on cycle 37 experiments performed some years ago, presented on ASM in Reykjavik in 2013, and documented in MET report 06/2013 Homleid and Killie: HARMONIE snow analysis experiments with additional observations, available on https://www.met.no/publikasjoner/met-report/met-report-2013

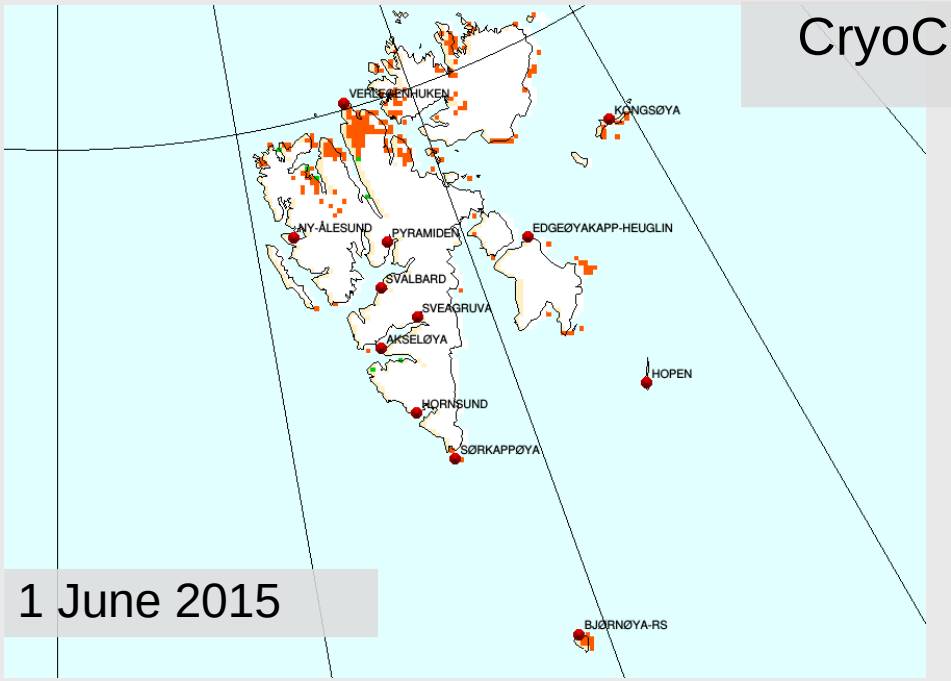
Snow analysis experiments with CryoClim Svalbard - results



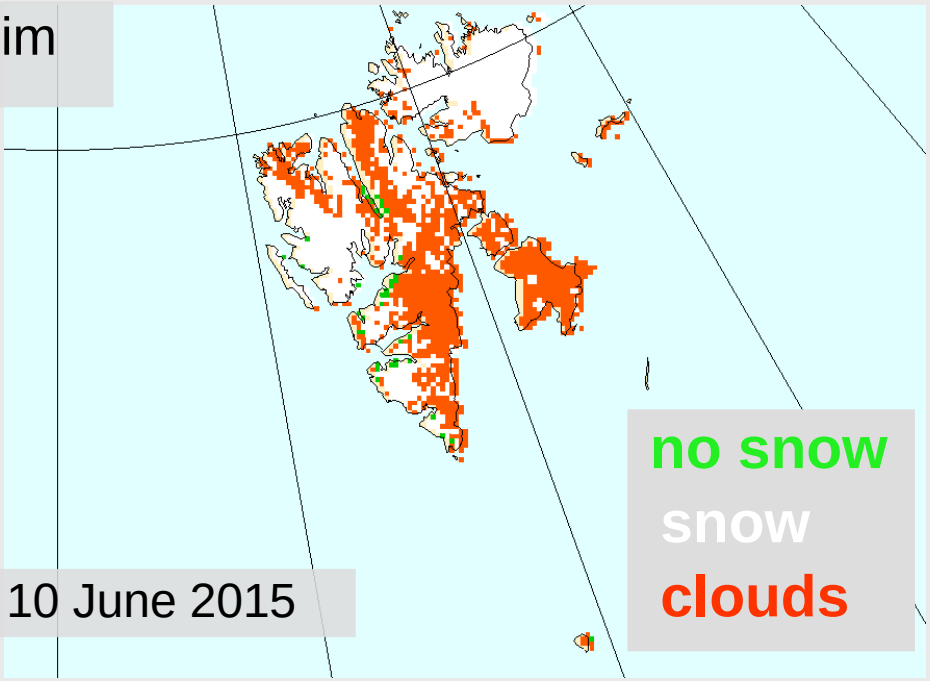
- It is **possible** to demonstrate positive impact, but not **easy,** because the summary scores of e.g. T2m is calculated on synop stations, which also have conventional snow depth observations that are used in the snow analysis

- Svalbard has more than 10 synop stations, reporting T2m, …, but only a few reporting snow depth

CryoClim

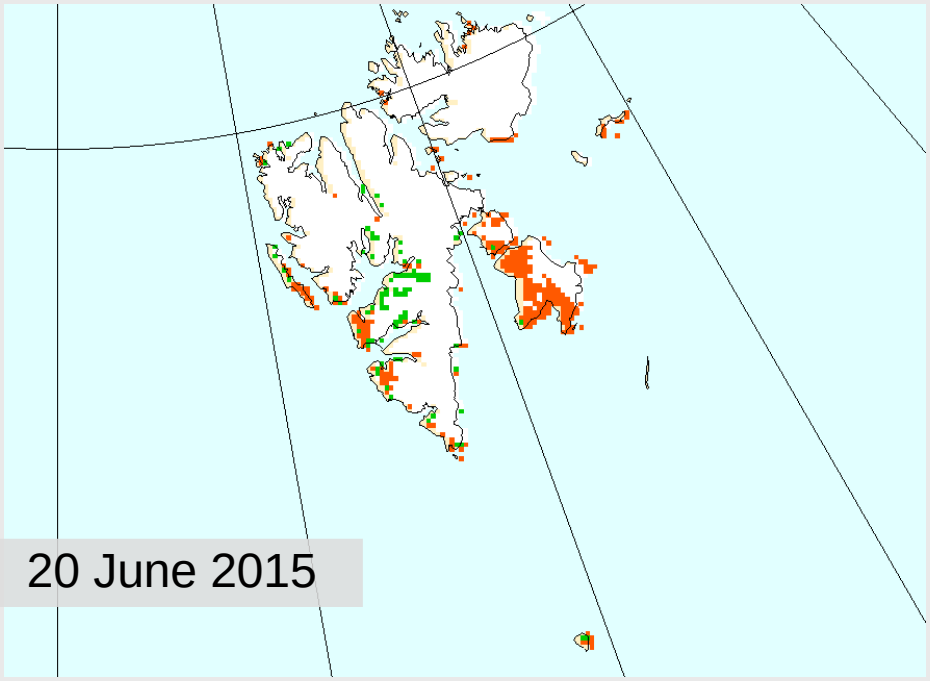


1 June 2015

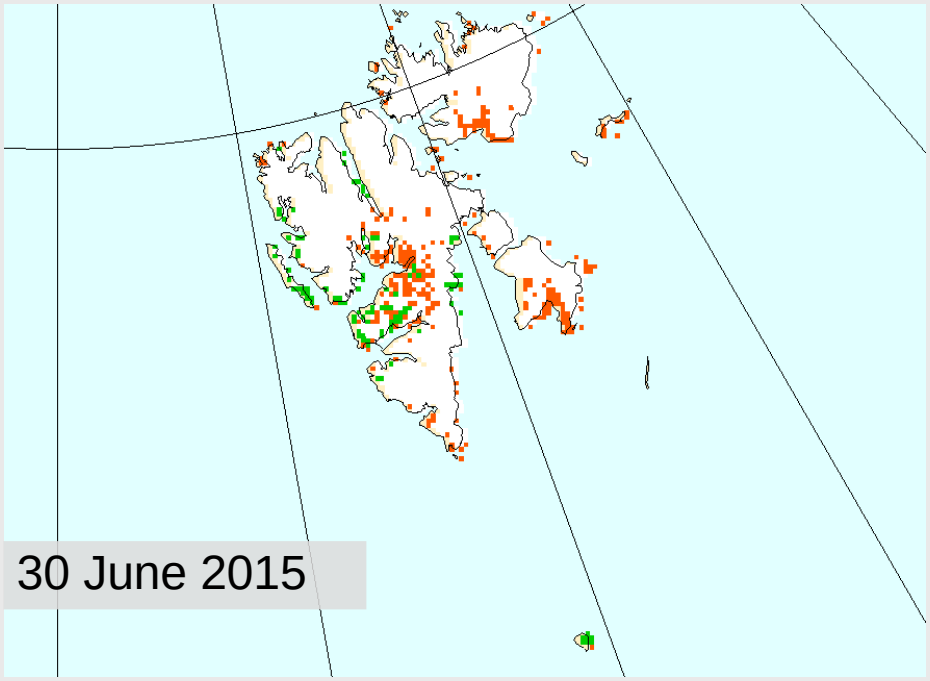


10 June 2015

no snow
snow
clouds

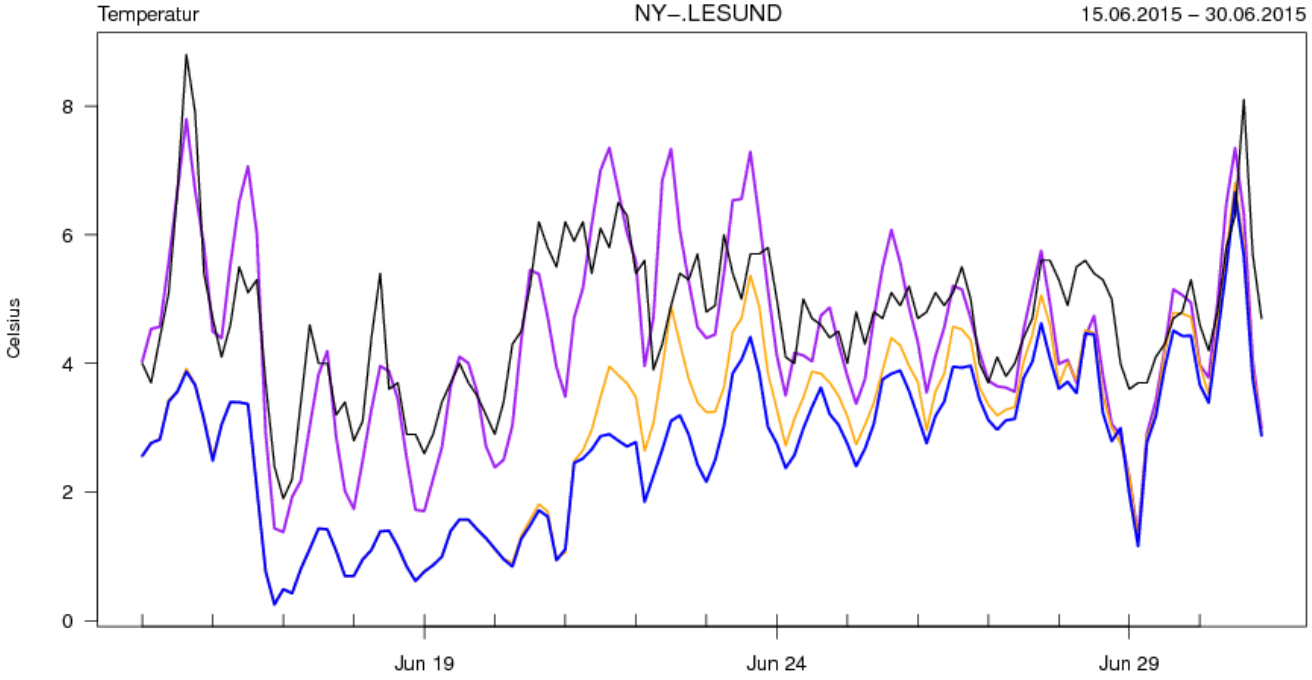


20 June 2015



30 June 2015

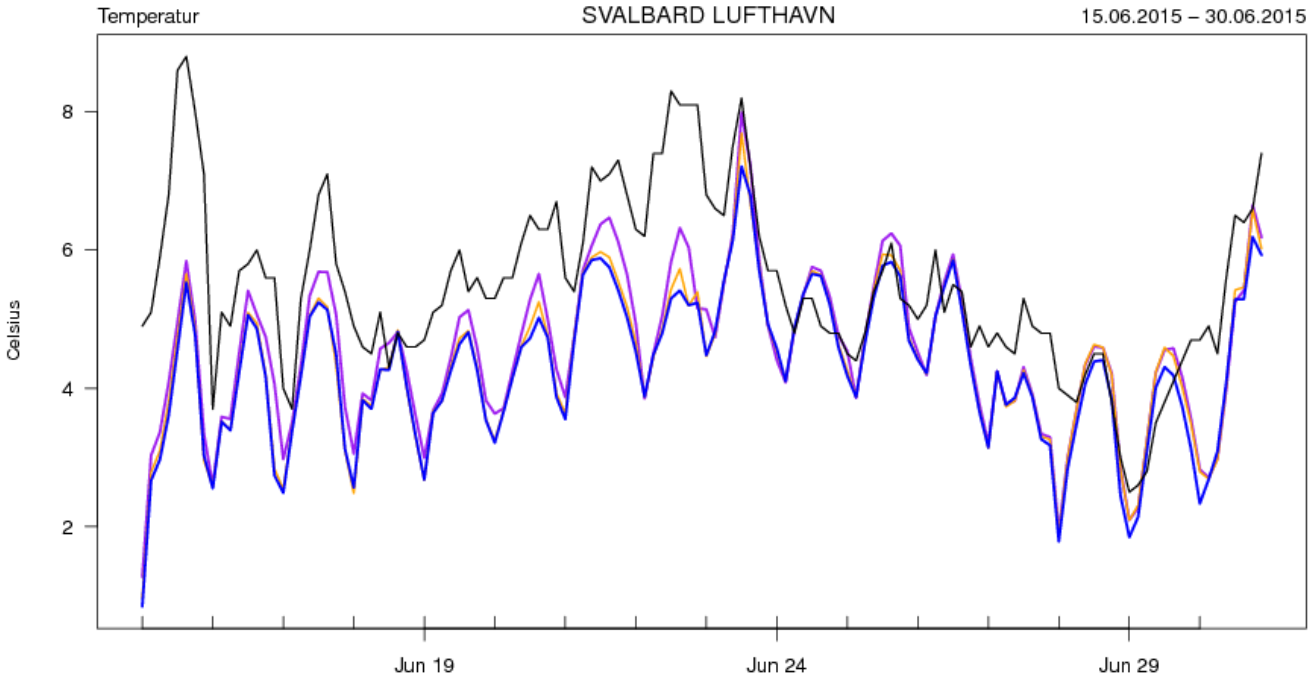
2 meter temperature OBS **REF** **CryoA: 10 km** **CryoB: 5 km**



	Min	Middel	Maks	Std	N
synop: 00,...,21 /3	1.9	4.7	8.8	1.1	128
SvalbardCryoB: 00+3,...,+24 /3	1.3	4.4	7.8	1.5	128
SvalbardCryoA: 00+3,...,+24 /3	0.3	3	6.8	1.4	128
SvalbardREF: 00+3,...,+24 /3	0.3	2.7	6.7	1.2	128

	Middelfeil	Std.feil.	RMSE	MAE	Maks.abs.feil	N
SvalbardCryoB – synop	−0.3	0.9	1	0.8	2.7	128
SvalbardCryoA – synop	−1.7	1.1	2.1	1.7	5.1	128
SvalbardREF – synop	−2	1	2.3	2	5.1	128

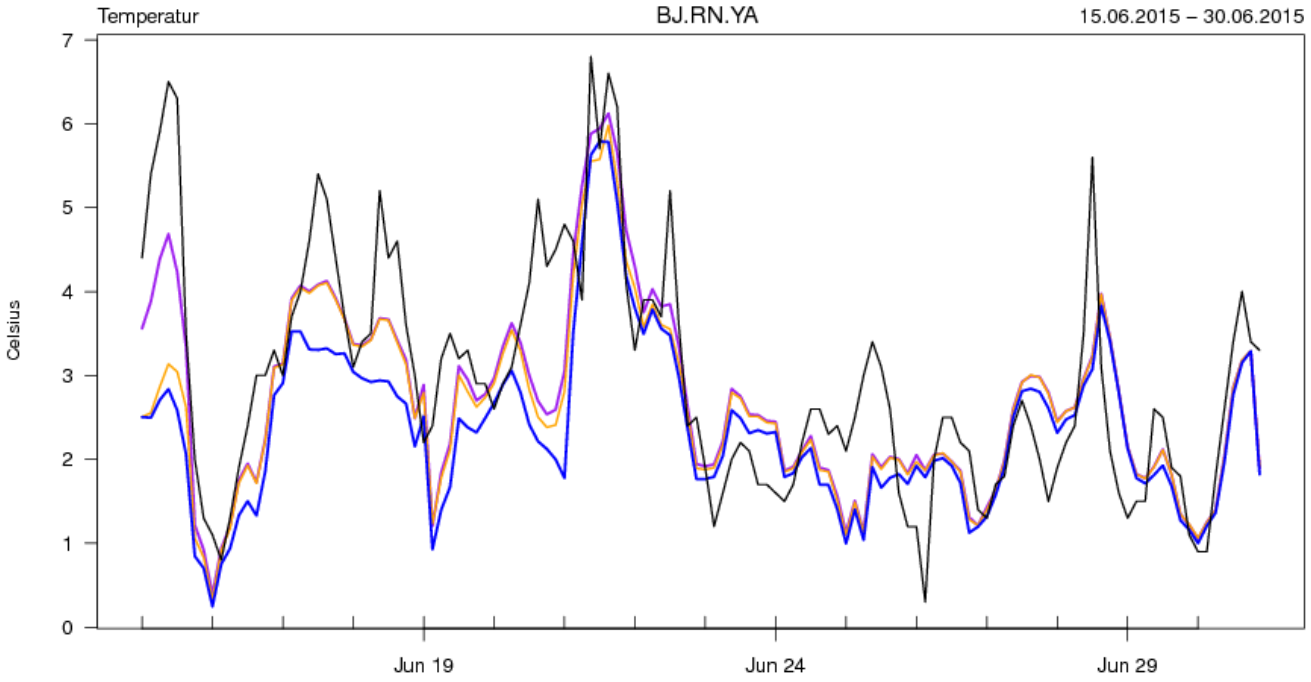
2 meter temperature OBS **REF** **CryoA: 10 km** **CryoB: 5 km**



	Min	Middel	Maks	Std	N
synop: 00,...,21 /3	2.5	5.5	8.8	1.3	128
SvalbardCryoB: 00+3,...,+24 /3	1.3	4.6	8	1.1	128
SvalbardCryoA: 00+3,...,+24 /3	1	4.4	7.7	1.1	128
SvalbardREF: 00+3,...,+24 /3	0.8	4.3	7.2	1.1	128

	Middelfeil	Std.feil.	RMSE	MAE	Maks.abs.feil	N
SvalbardCryoB – synop	−1	1	1.4	1.1	3.8	128
SvalbardCryoA – synop	−1.1	1	1.5	1.2	4.1	128
SvalbardREF – synop	−1.2	1	1.6	1.3	4.1	128

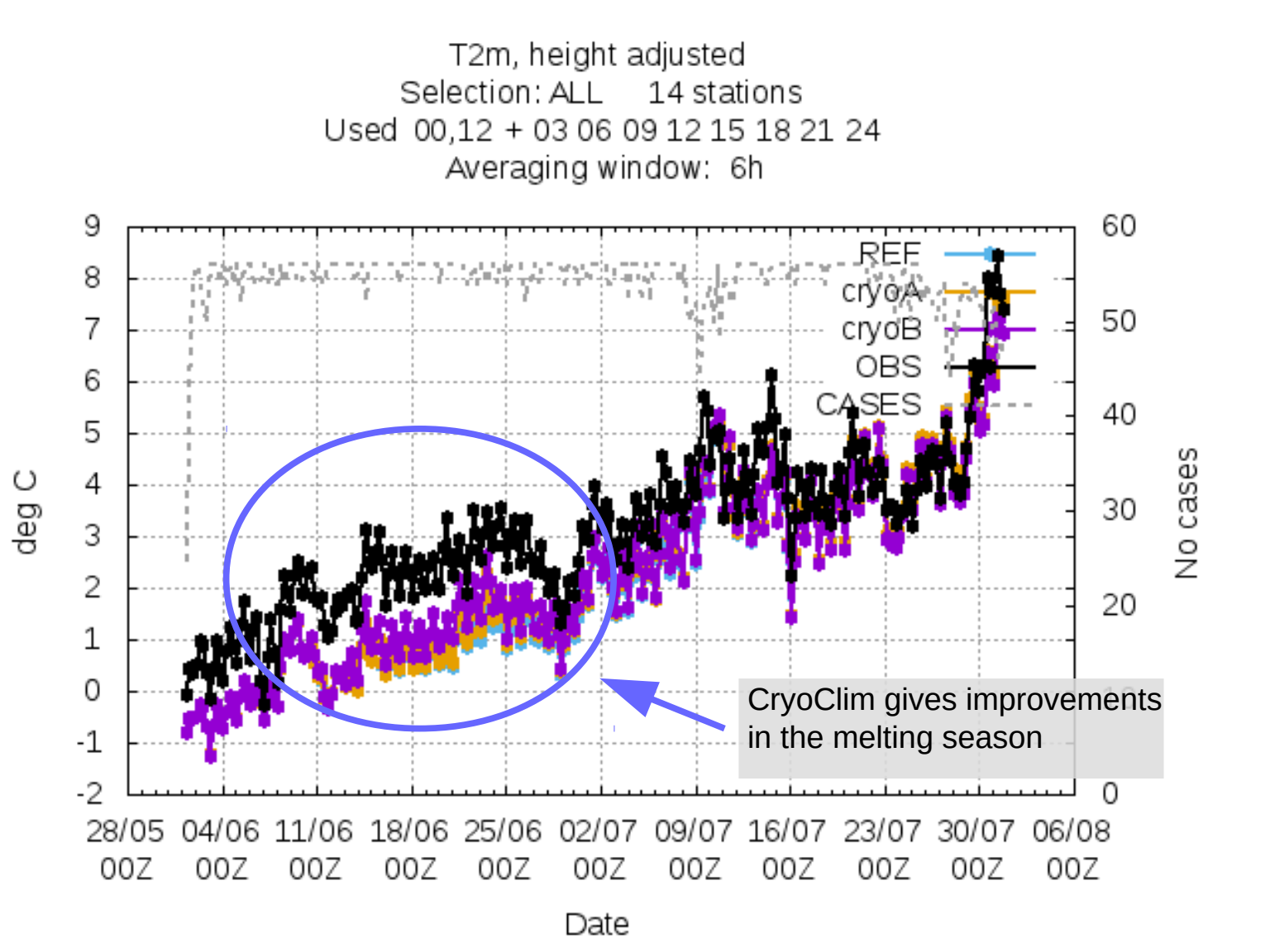
2 meter temperature OBS **REF** **CryoA: 10 km** **CryoB: 5 km**



	Min	Middel	Maks	Std	N
synop: 00,...,21 /3	0.3	3	6.8	1.4	128
SvalbardCryoB: 00+3,...,+24 /3	0.4	2.7	6.1	1.1	128
SvalbardCryoA: 00+3,...,+24 /3	0.3	2.6	6	1	128
SvalbardREF: 00+3,...,+24 /3	0.2	2.4	5.8	1	128

	Middelfeil	Std.feil.	RMSE	MAE	Maks.abs.feil	N
SvalbardCryoB – synop	−0.3	0.8	0.9	0.7	2.4	128
SvalbardCryoA – synop	−0.4	0.9	1	0.7	3.4	128
SvalbardREF – synop	−0.6	1	1.2	0.9	3.7	128

2 meter temperature OBS **REF** **CryoA: 10 km** **CryoB: 5 km**



Next steps … on our way to new cycles ...

- Introduce CARRA's "snow" improvements in cycle 43 ...
  - always snow on the glaciers
  - assimilation of satellite snow extent
    - code changes - done
    - thinning/aggregation into "barrels" or a grid
    - obsoul or bufr?

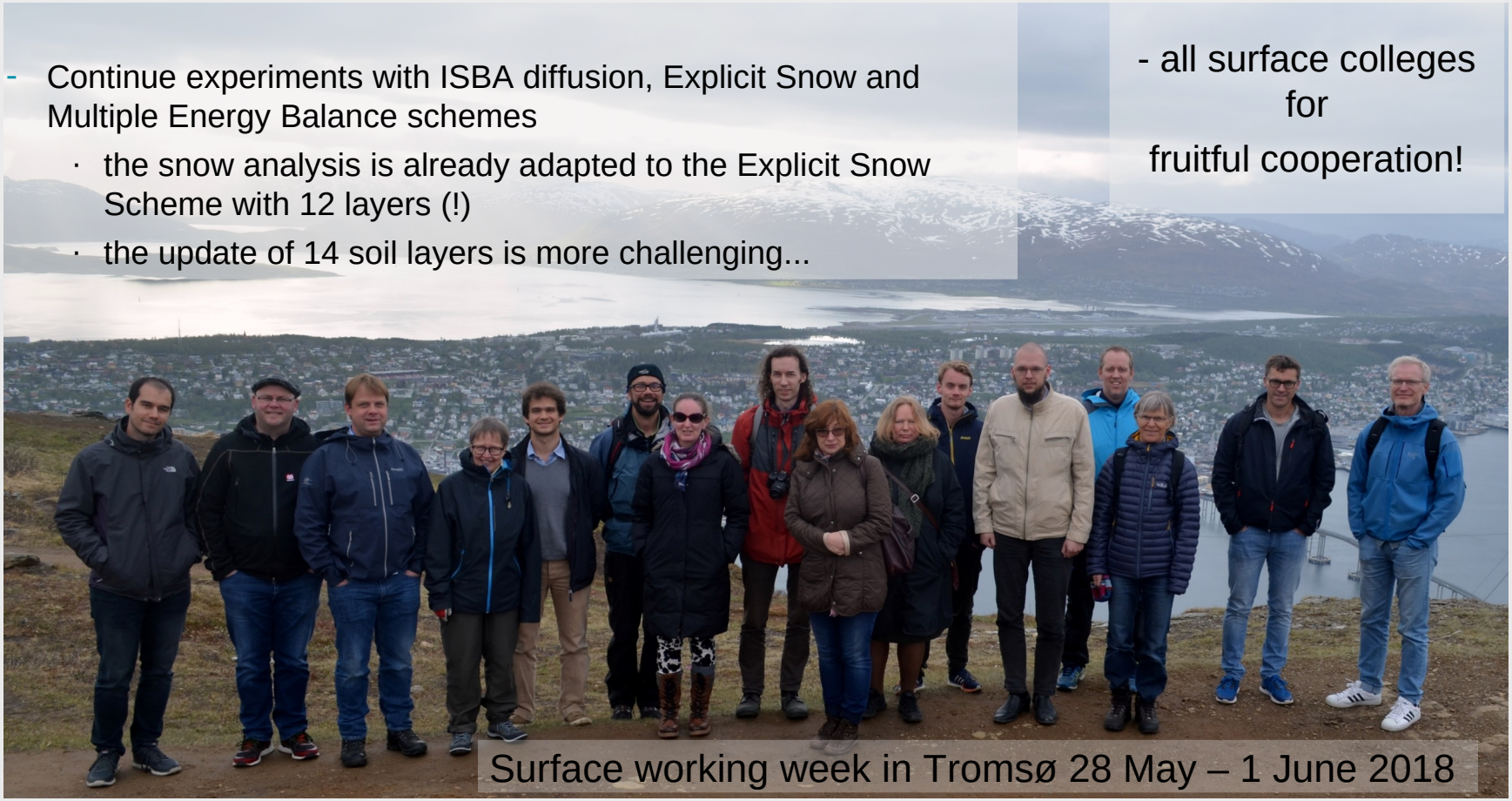
- Continue experiments with ISBA diffusion, Explicit Snow and Multiple Energy Balance schemes
  - the snow analysis is already adapted to the Explicit Snow Scheme with 12 layers (!)
  - the update of 14 soil layers is more challenging...

Thank you

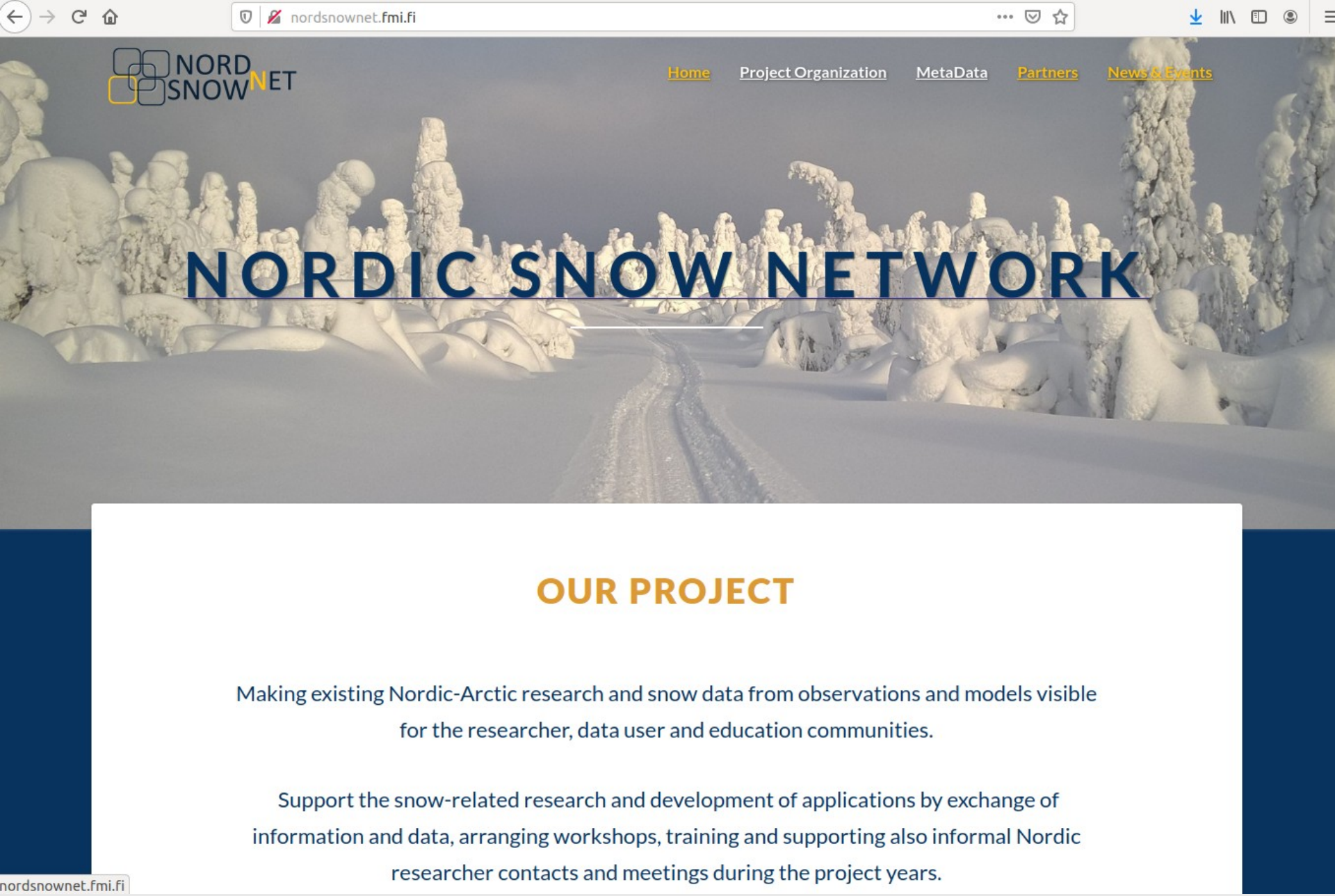
- all, for your attention!

- all surface colleges for

fruitful cooperation!



Surface working week in Tromsø 28 May – 1 June 2018



First project meeting 30-31.3.2020 (Tele-conf) at FMI in Helsinki-Finland