Heather Reese
Sr. Lecturer in GIS & Remote sensing
Department of Earth Sciences

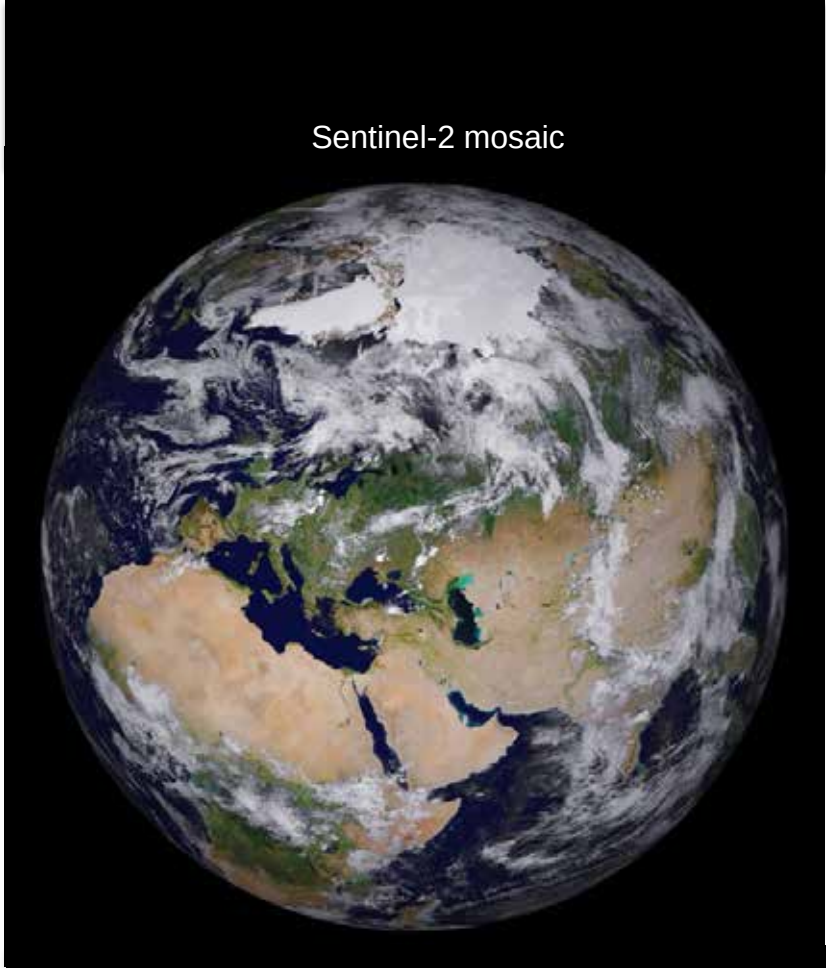
Remote sensing for Earth Sciences

HEATHER REESE, DELIANG CHEN, CÉLINE HEUZÉ, LEA POROPAT, AURORA PATCHETT, LU ZHOU, JULIA KUKULIES & ANDREAS JOHNSSON

Department of Earth Sciences

- 71 employees
  - Physical Geography
  - Biogeochemistry
  - Climate studies
  - Geology

- 14 PhD students
- 40 Bachelors and 20 Masters projects in Earth Science and Geography per year



Overview of selected projects

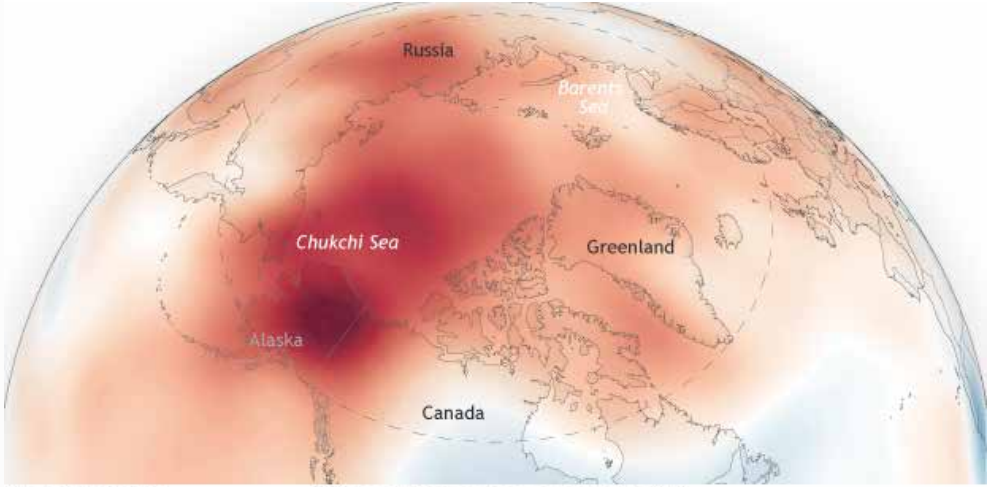
- 1. Thawing permafrost in a northern palsa mire
- 2. Small-scale Arctic browning
- 3*. Sea ice in the Antarctic
- 4. Sea level rise in the North Sea
- 5*. Understanding climate models over the Tibetan Plateau
- 6. Earth as analogue for Mars

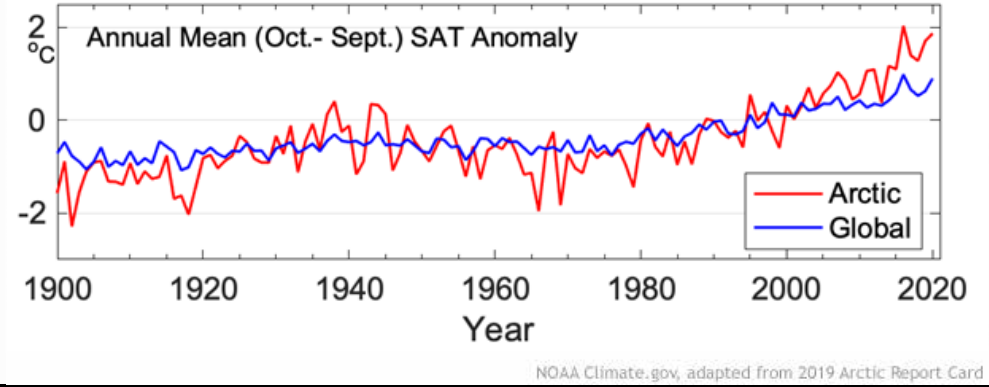
* Funded by
Rymdstyrelsen
Swedish National Space Agency

OCT 2019 - SEPT 2020 2nd WARMEST YEAR

The Arctic is warming at a rate three times the global mean

- Arctic Report Card 2021
https://arctic.noaa.gov/Report-Card/Report-Card-2021





NOAA Climate.gov, adapted from 2019 Arctic Report Card

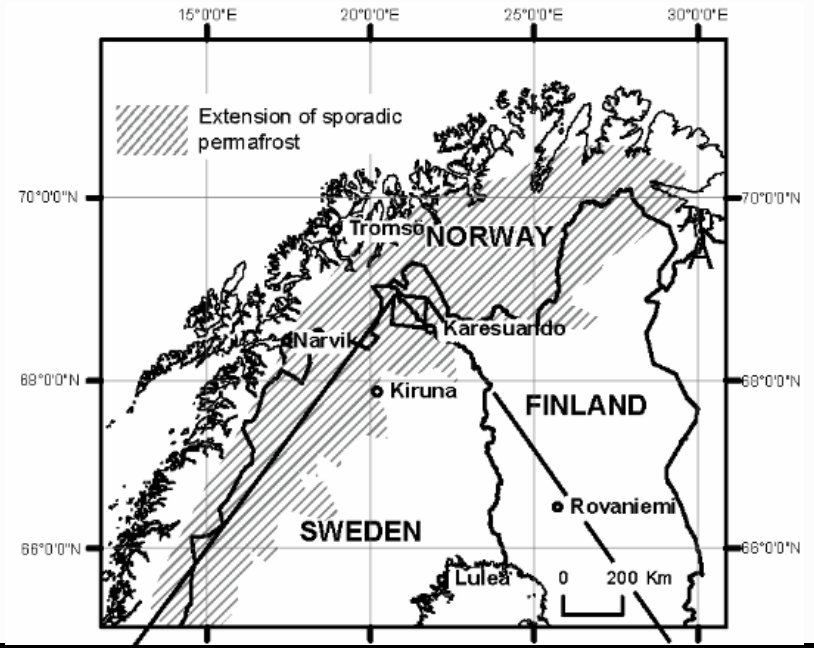
Project 1

Thawing permafrost in a northern palsa mire

Thawing permafrost in a palsa mire

Goal

Monitor changes and climatic drivers of change on Sweden's largest cohesive palsa mire (274 ha), Vissátvuopmi



Departmental funding

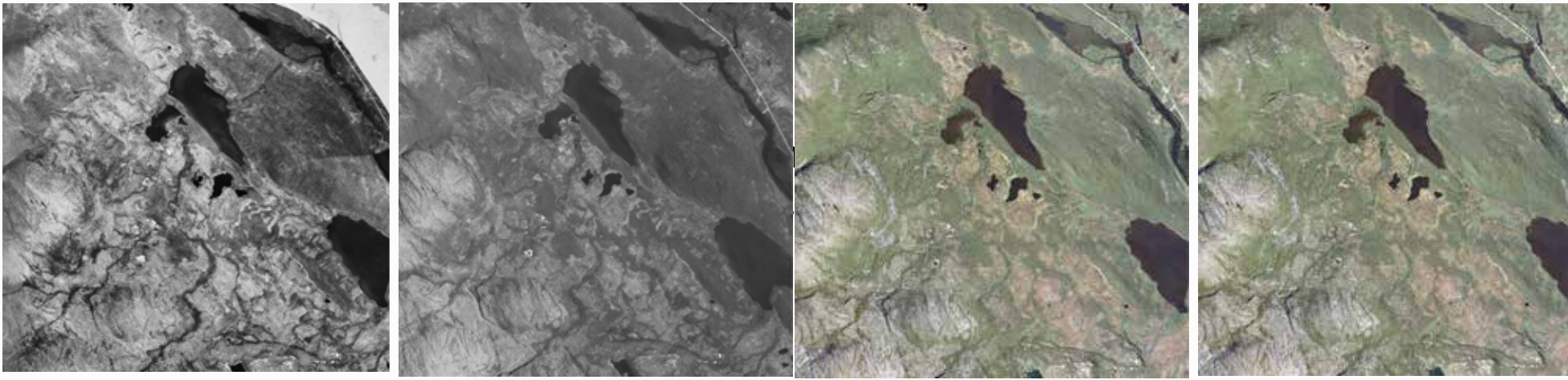
Thawing permafrost in a palsa mire

Foto Björn Holmer augusti 2016

Thawing permafrost in a palsa mire

Thawing permafrost in a palsa mire

Data: LM aerial photos, Drones, Lidar, Sentinel-1 & Sentinel-2 satellite data



1955 1986 1994 2010 2016

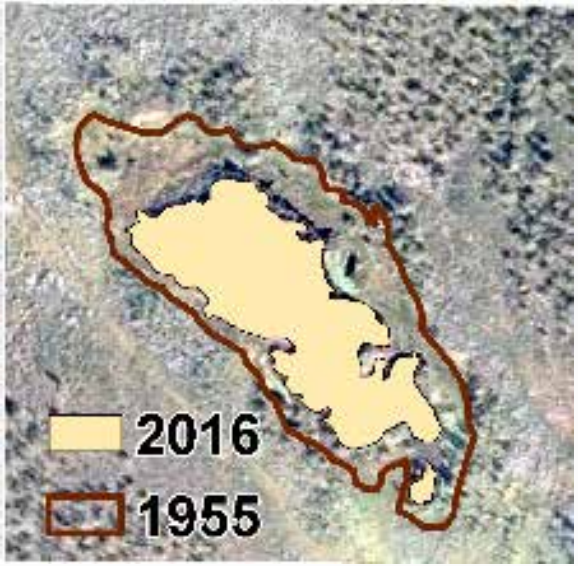
LATERAL DEGRADATION 1955-2016

30% of the
area degraded

70 -> 49 ha

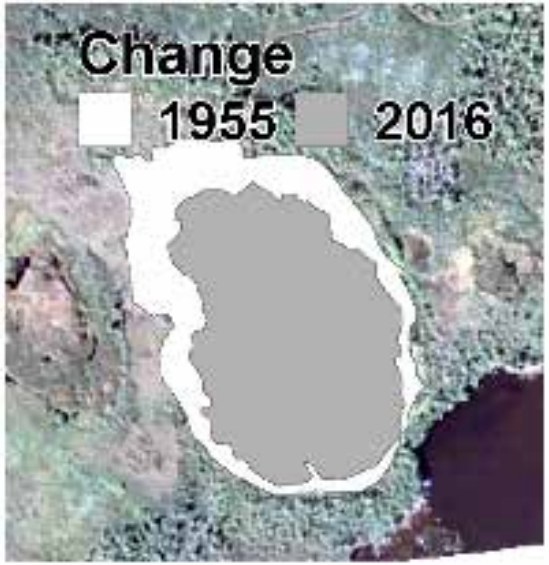
54% area degraded

250 m



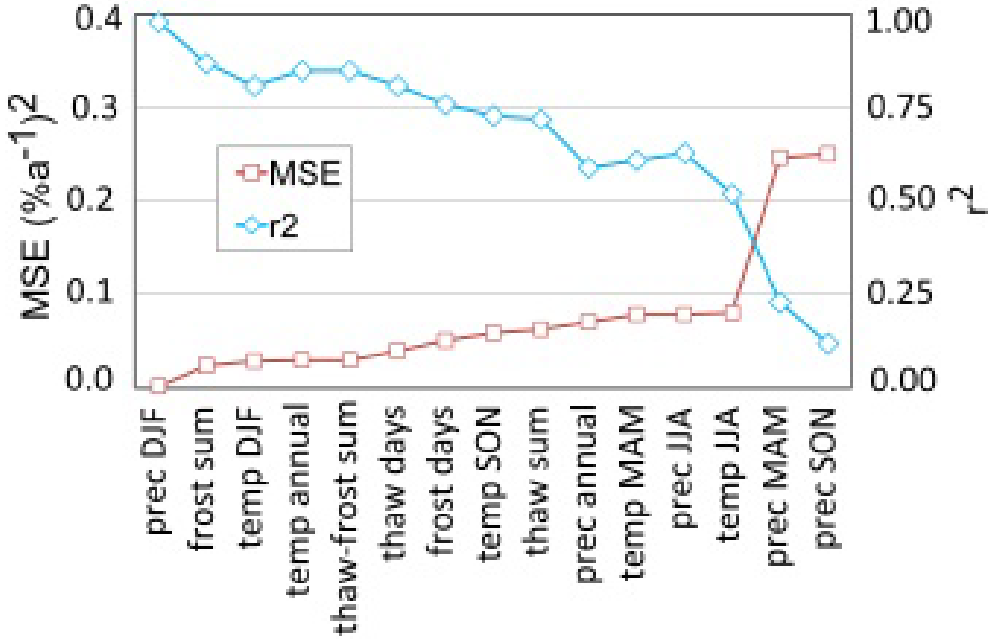
35% area degraded

300 m



AERIAL PHOTOS & CLIMATE DATA ANALYSIS- RESULTS

The role of different climate drivers on lateral palsa decay

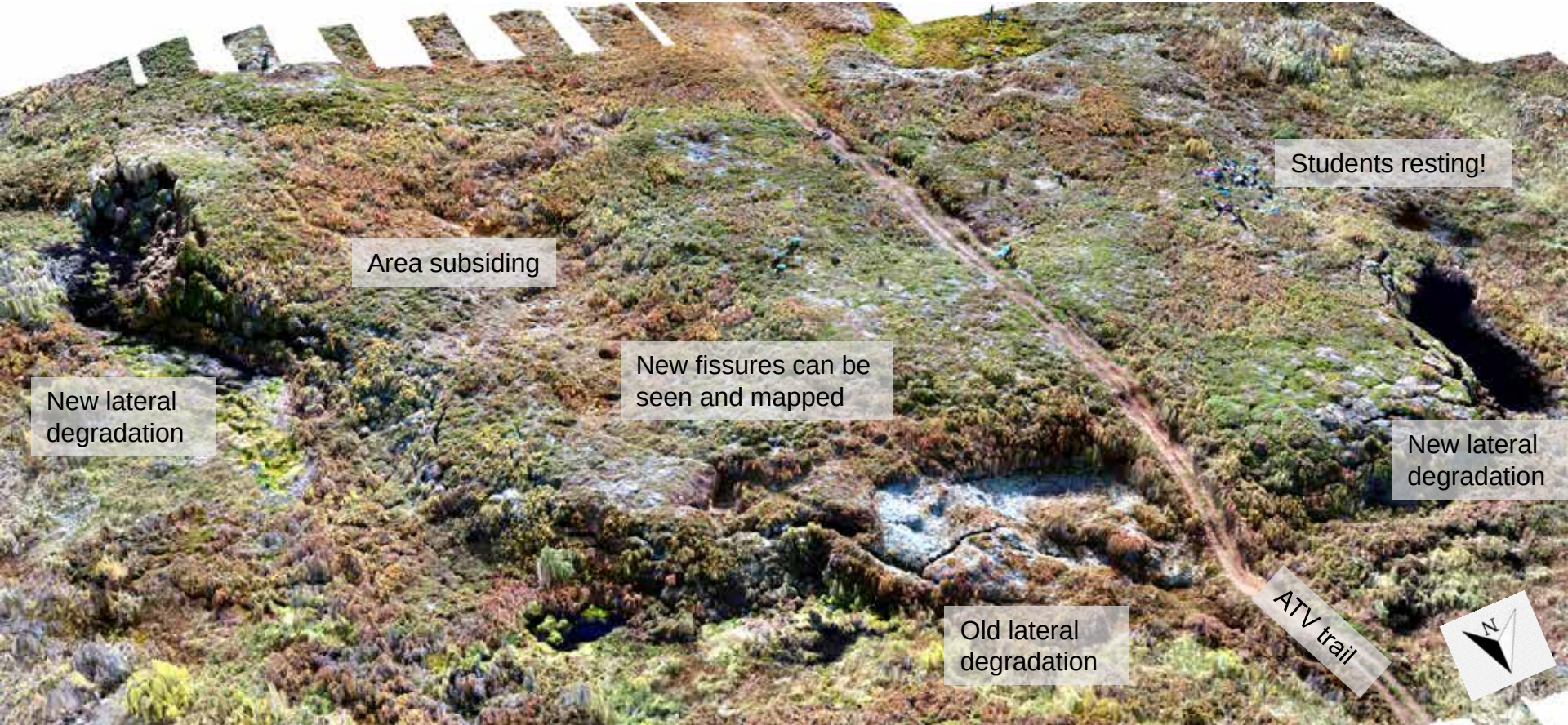


Ø Wetter, shorter and warmer winters are the main causes for the change in lateral-palsa extent.

Olvmo et al., 2020. Scientific Reports

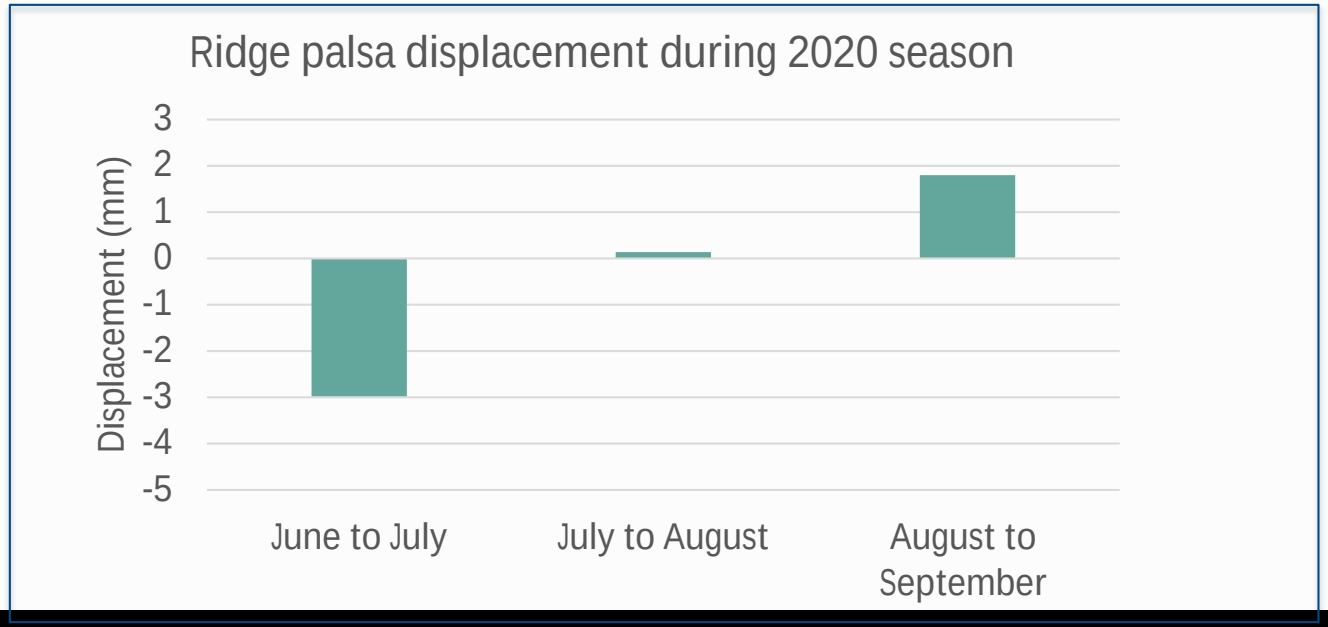
VERTICAL SUBSIDENCE

3D model from drone photogrammetry



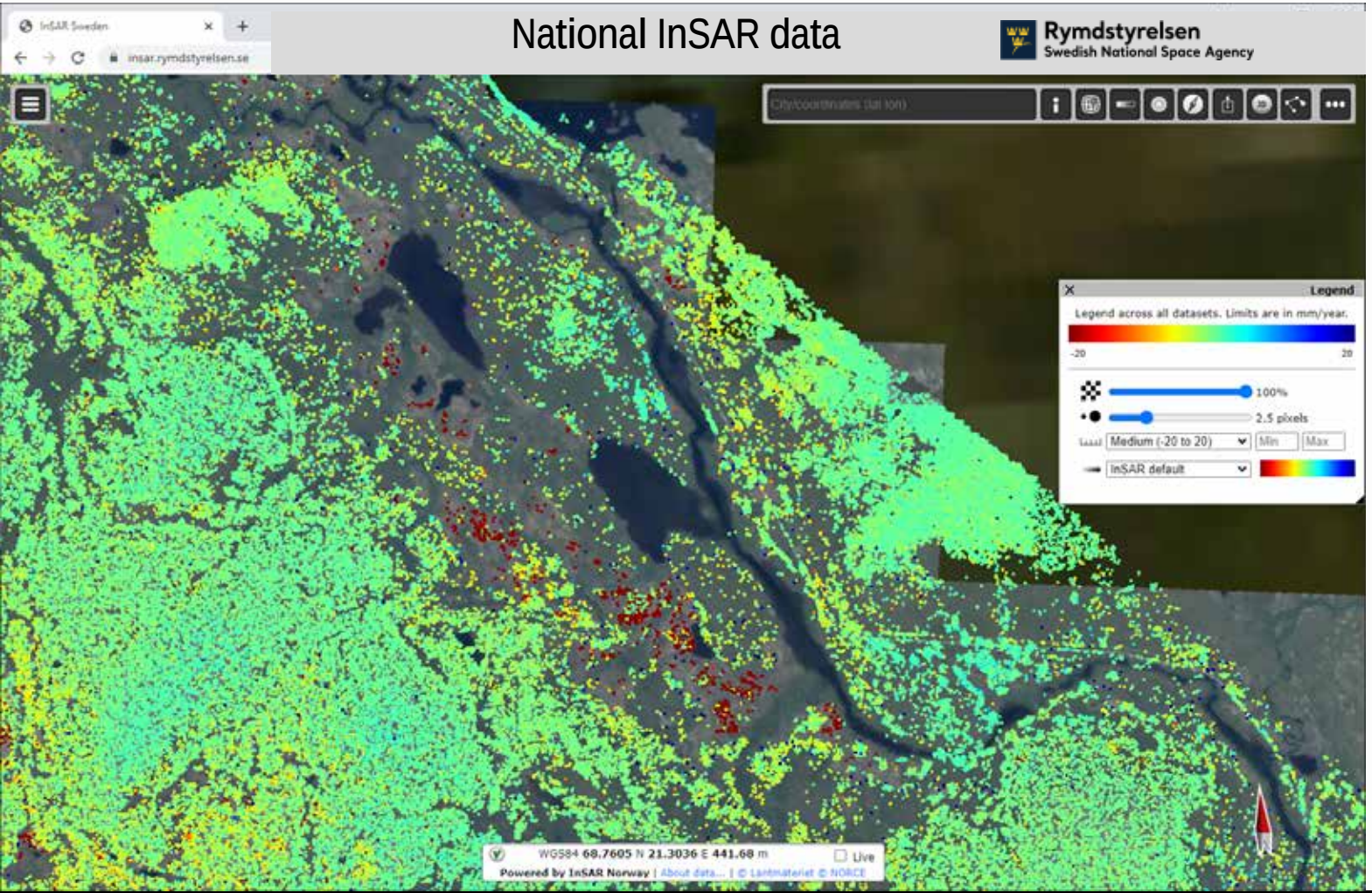
Sentinel-1 InSAR to monitor vertical subsidence

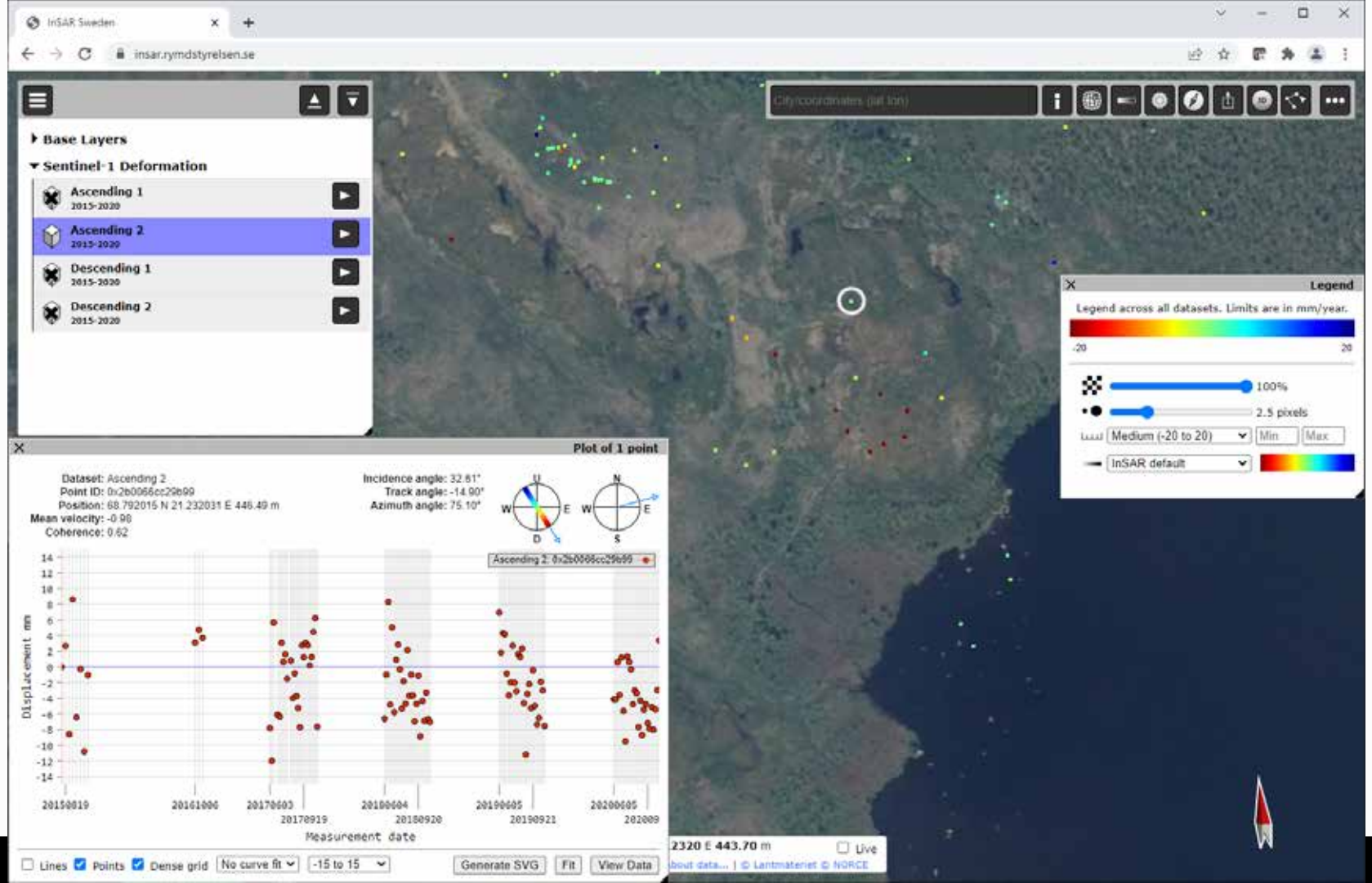
- Do we see seasonal elevation changes in palsas?
- What are the annual elevation changes (2017-2021) in palsas?



National InSAR data

Rymdstyrelsen
Swedish National Space Agency



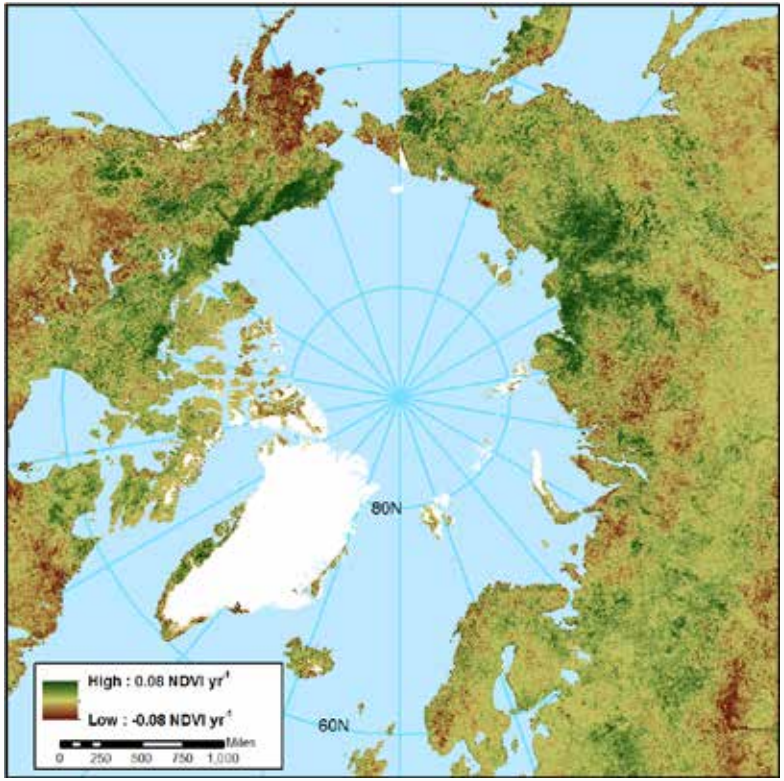

InSAR Sweden
insar.rymdstyrelsen.se
City/coordinates (lat lon)
Base Layers
Sentinel-1 Deformation
Ascending 1
2015-2020
Ascending 2
2015-2020
Descending 1
2015-2020
Descending 2
2015-2020
Legend
Legend across all datasets. Limits are in mm/year.
-20
20
100%
2.5 pixels
Medium (-20 to 20)
Min
Max
InSAR default
Plot of 1 point
Dataset: Ascending 2
Point ID: 0x2b0066cc29b99
Position: 68.792015 N 21.232031 E 446.49 m
Mean velocity: -0.98
Coherence: 0.62
Incidence angle: 32.61°
Track angle: -14.90°
Azimuth angle: 75.10°
Ascending 2: 0x2b0066cc29b99
Displacement mm
Measurement date
20150819
20161006
20170603
20170919
20180604
20180920
20190605
20190921
20200605
202009
Lines
Points
Dense grid
No curve fit
-15 to 15
Generate SVG
Fit
View Data
2320 E 443.70 m
Live
© Lantmäteriet © NORCE

Project 2

Arctic Browning

The Arctic is greening … but it is also “browning”

NDVI trends 1982-2012 from AVHRR



(från GIMMS 3g dataset, AVHRR)

Greening – NDVI increases

Browning – NDVI decreases over 3 years in a row

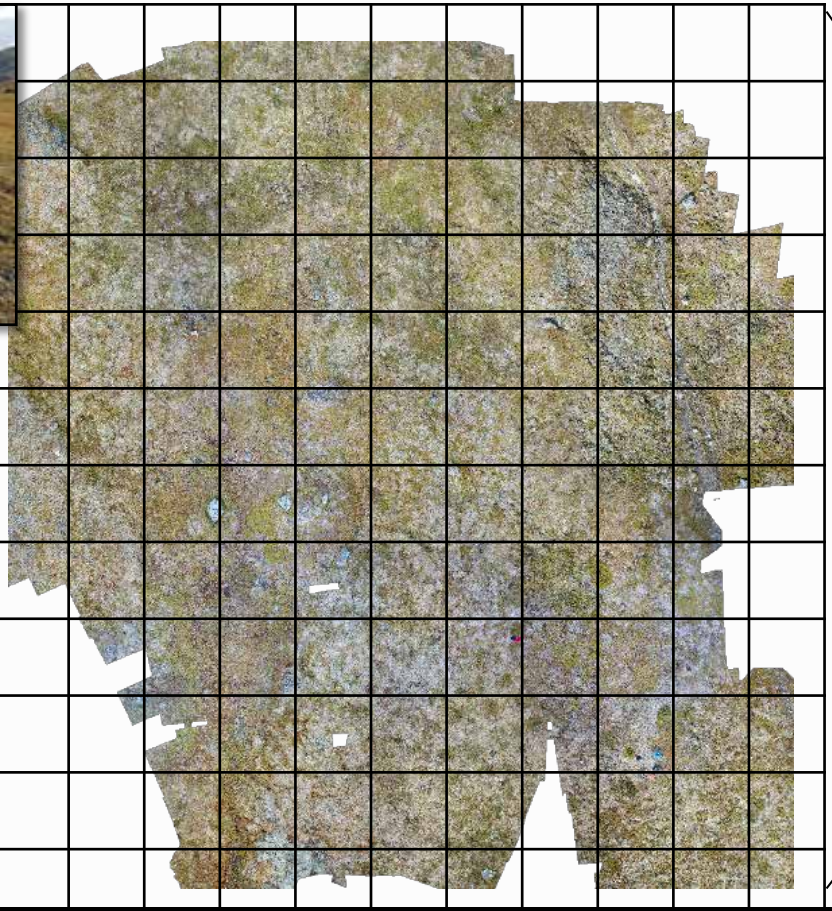
Reason for browning differs, but may be due to frost damage

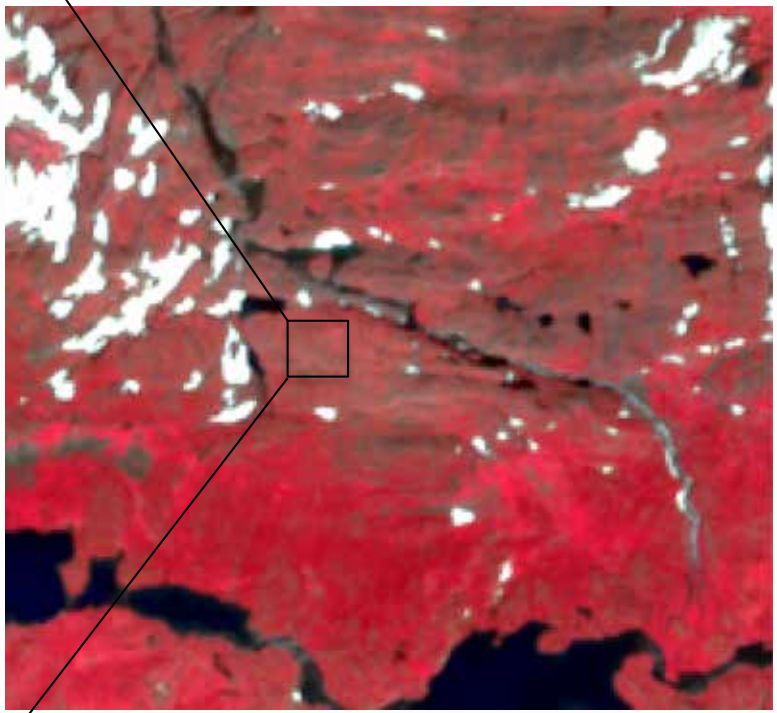
Can Sentinel-2 data be used to see small areas of Arctic browning?

- Cold and low snow cover in 2014 led to browning with dead *cassiope tetragona* and *empetrum nigrum* at Latnjajaure (west of Abisko) = “Browning”
- Data: Drone and Sentinel-2 data
- PhD student Aurora Patchett

FINANSIÄR: BECC PROGRAMME (STATLIG FORSKNINGSPROGRAMME)

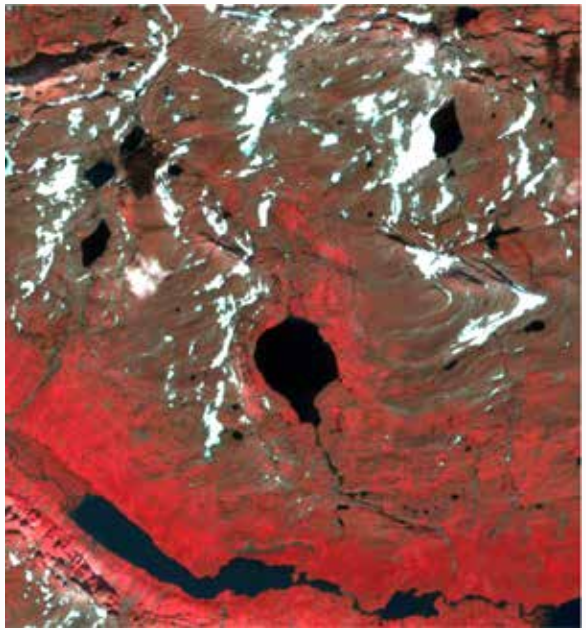
Can we quantify browning in Sentinel-2 pixels using drone data as reference?



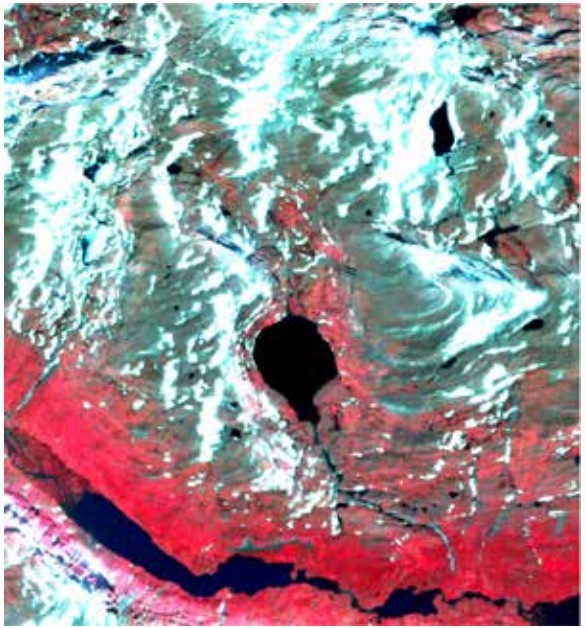


FINANSIÄR: BECC PROGRAMME (STATLIG FORSKNINGSPROGRAMME)

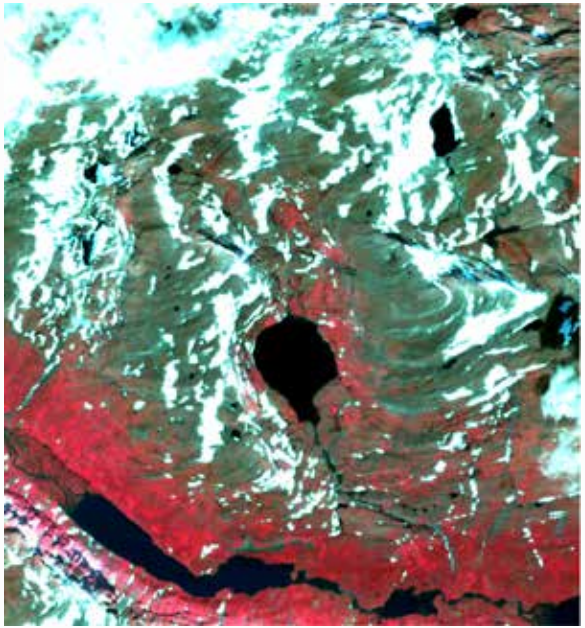
Using a Recurrent Neural Network and Sentinel-2 time series to detect new browning sites



July 2018



July 2019



July 2020

FINANSIÄR: BECC PROGRAMME (STATLIG FORSKNINGSPROGRAMME)

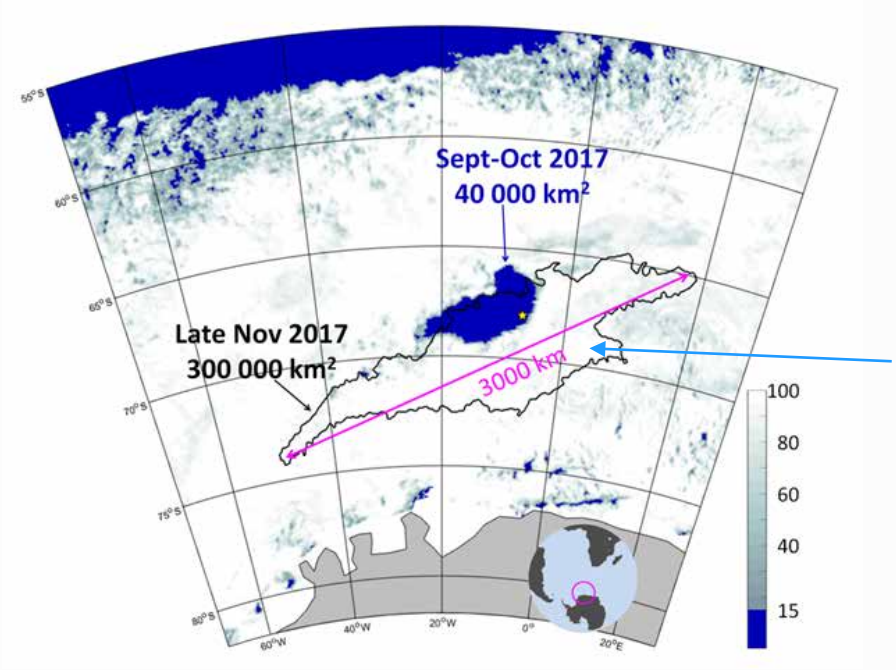
Project 3

Antarctic Sea Ice

Forecasting appearance of the Weddell Polynya

- Goal: To forecast when the Weddell Polynya may appear

Céline Heuzé



Weddell Polynya

Rymdstyrelsen
Swedish National Space Agency

Funder: Rymdstyrelsen (dnr 164/18)

Forecasting appearance of the Weddell Polynya

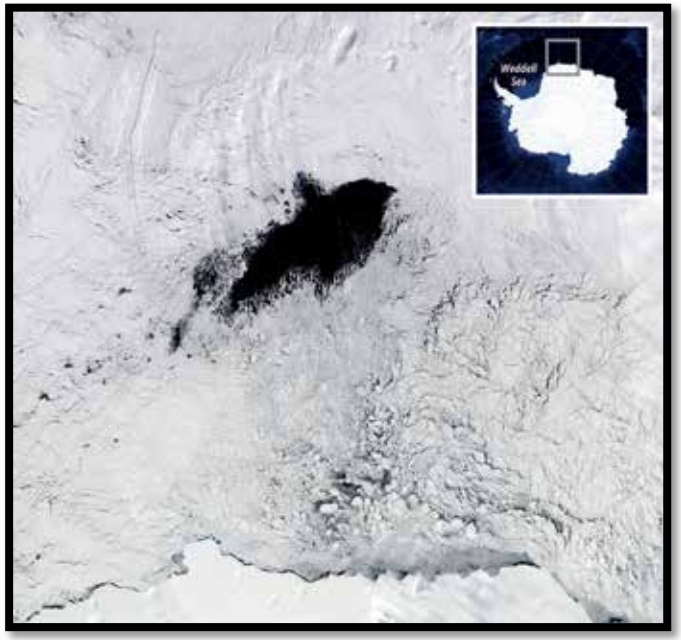
Satellite data from 1982 to present:

- AVHRR Polar Pathfinder, daily temperature brightness data as proxy for upwelling of warm water and presence of leads

Reference data

- ERA-5 Reanalysis + some *insitu* data

Heuze et al., 2021. The Cryosphere



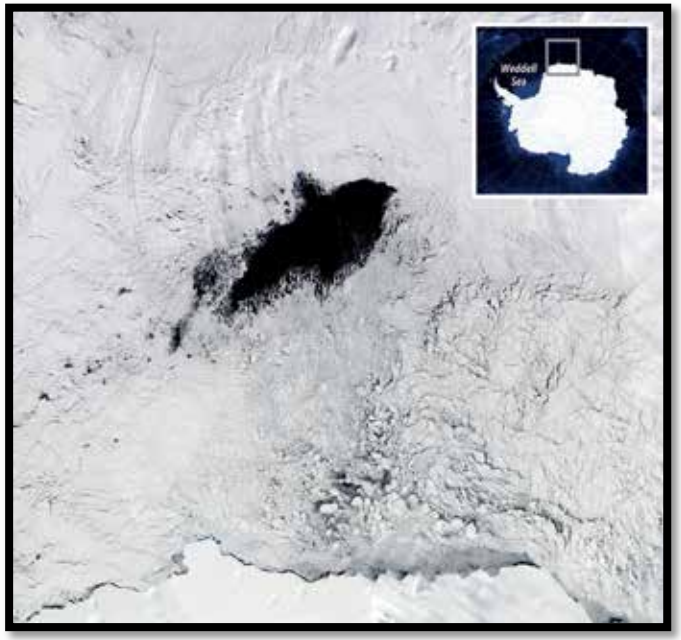
NASA Sept. 25, 2017

Funder: Rymdstyrelsen (dnr 164/18)

Forecasting appearance of the Weddell Polynya

- Can predict the event up to 15 days ahead of time
- There have been 30 Weddell Polynyas since 1982
- AVHRR could be used to indicate whether the polynya opened in response to upwelling or a lead

Heuze et al., 2021. The Cryosphere

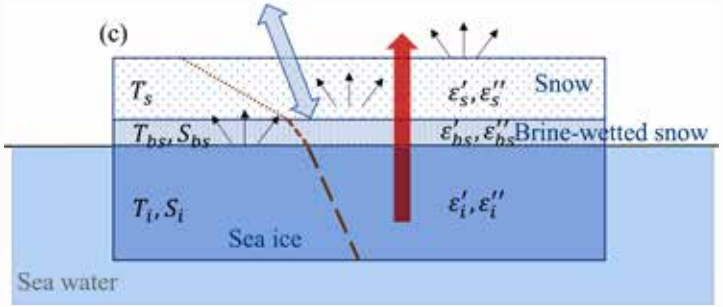


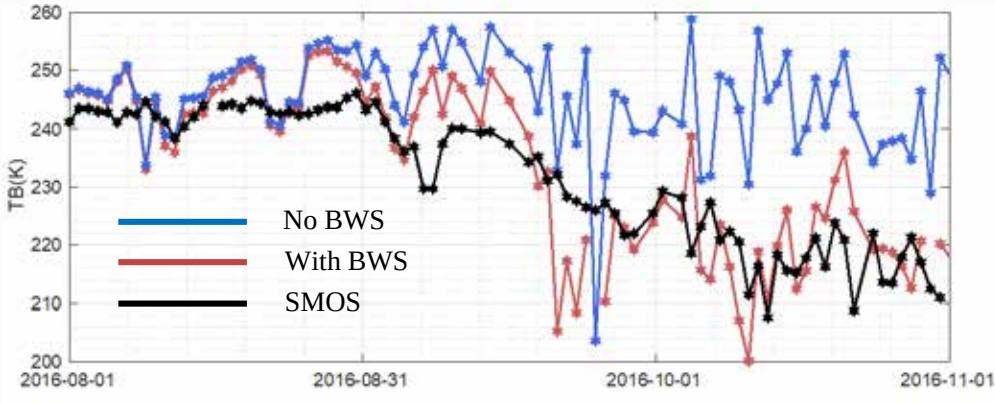
NASA Sept. 25, 2017

Funder: Rymdstyrelsen (dnr 164/18)

Improving Antarctic sea ice thickness models

- Previous model used ERA-5 data only
- Improved model uses ERA-5 data + SNOWPACK data which includes data on brine-wetted snow
- SMOS/SMAP satellite data are used to evaluate the model
- Find that brine-wetted snow (BWS) has large influence on Antarctic sea ice thickness estimates





Zhou et al. 2022.

Funder: Rymdstyrelsen (dnr 164/18)

Project 4

Sea level in the North Sea

Will the “Northern European Enclosure Dam” really protect Sweden from sea-level rise?

Goal: quantify sea-level dynamics over time for better prediction of flood risks in northern Europe

- Where are regions of coherent sea level variability?
- What are the drivers of sea level variability in each region?
- Can we predict long-term regional sea level changes?

Funder: FORMAS

Will the “Northern European Enclosure Dam” really protect Sweden from sea-level rise?

Lea Poropat
Postdoc

Data

Sea level drivers

- sea surface temperature
- evaporation
- precipitation
- mean sea level pressure
- 10 m wind
- runoff
- sea ice area fraction
- Greenland ice sheet runoff and discharge
- ocean potential temperature
- ocean salinity
- Fram Strait sea ice transport
- NAO, EAP & Niño 3.4 index

Target

- in situ monthly mean sea level observations from Smögen

1958 – 2014 monthly

Evaluation data

Copernicus Global Ocean Sea Surface Heights from merging altimeter data from

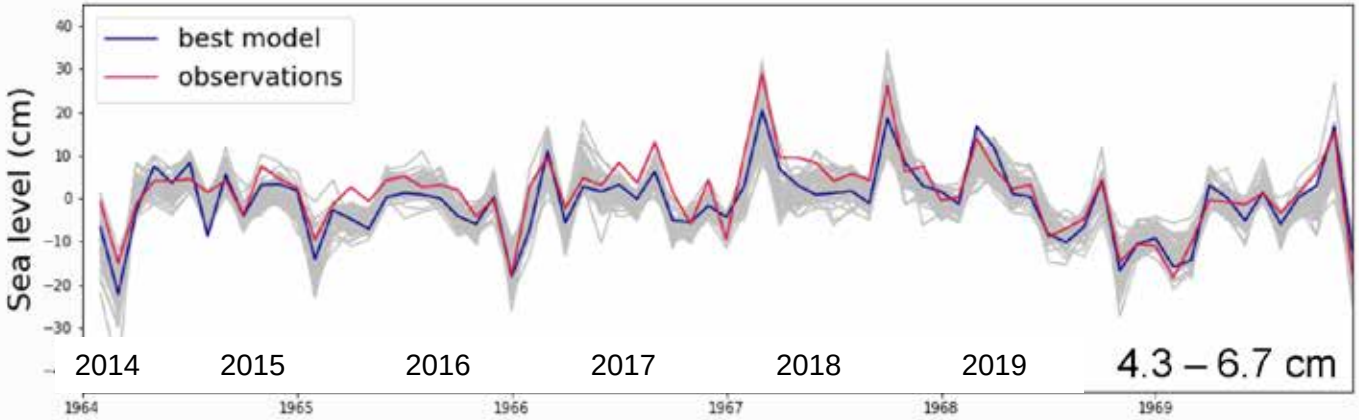
- Jason-3, -2 & -1
- Sentinel-3A
- HY-2A
- Saral/AltiKa
- Cryosat-2
- T/P
- ENVISAT
- GRACE-FO
- ERS1/2

Funder: FORMAS

Will the “Northern European Enclosure Dam” really protect Sweden from sea-level rise?

Method

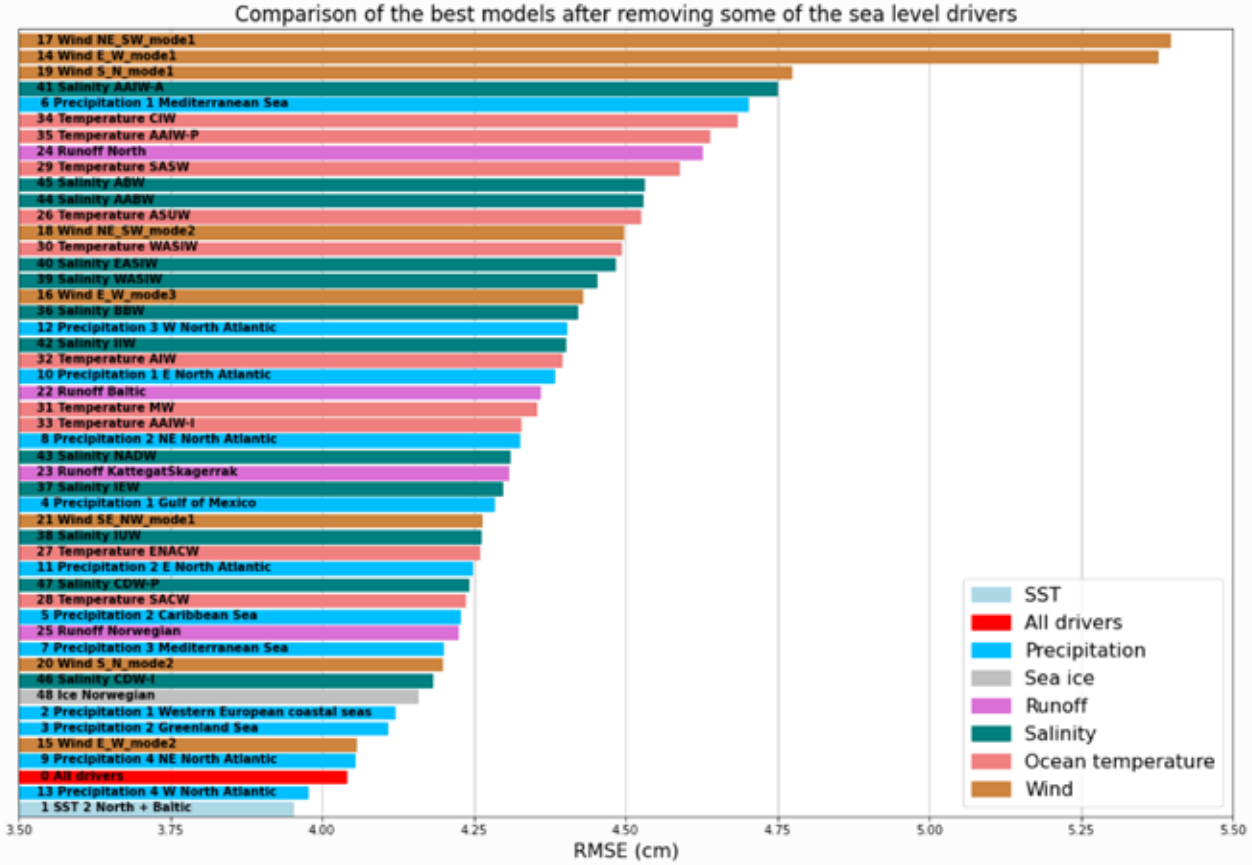
Long-Short Term Memory (Recurrent neural network)



LSTM
L = 2
n = 1

Funder: FORMAS

Results



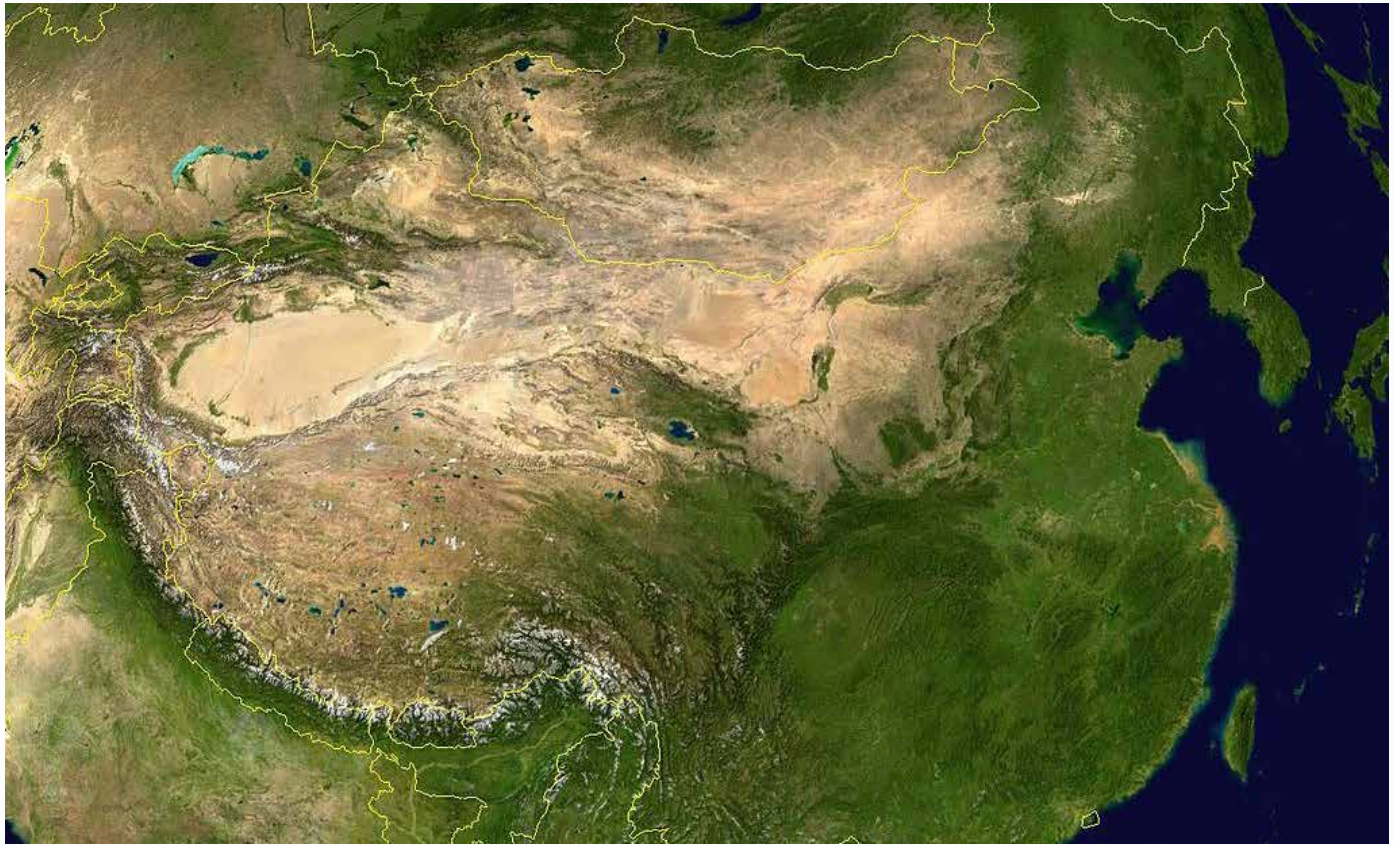
Which drivers contribute to sea level prediction?

- Wind
- Temperature of upper ocean
- Salinity of upper ocean
- Regional run-off

Project 5

Understanding climate change over the Tibetan Plateau

Climate change in the Third Pole region (Tibetan Plateau)



Deliang Chen

Julia Kukulies
PhD Student

Climate change in the Third Pole region (Tibetan Plateau)

Deliang Chen

Rymdstyrelsen
Swedish National Space Agency

Dynamics and importance of convection for precipitation in the Third Pole region: Satellite and ground-based observations versus model simulations

Julia Kukulies
PhD Student

WCRP CORDEX
Coordinated Regional Climate Downscaling Experiment

High resolution climate modelling with a focus on mesoscale convective systems and associated precipitation over the Third Pole region

Dynamics and importance of convection for precipitation in the Third Pole region

Goal

Use satellite observations to improve understanding of mesoscale processes and dynamics that control sub-seasonal precipitation regimes

Input data

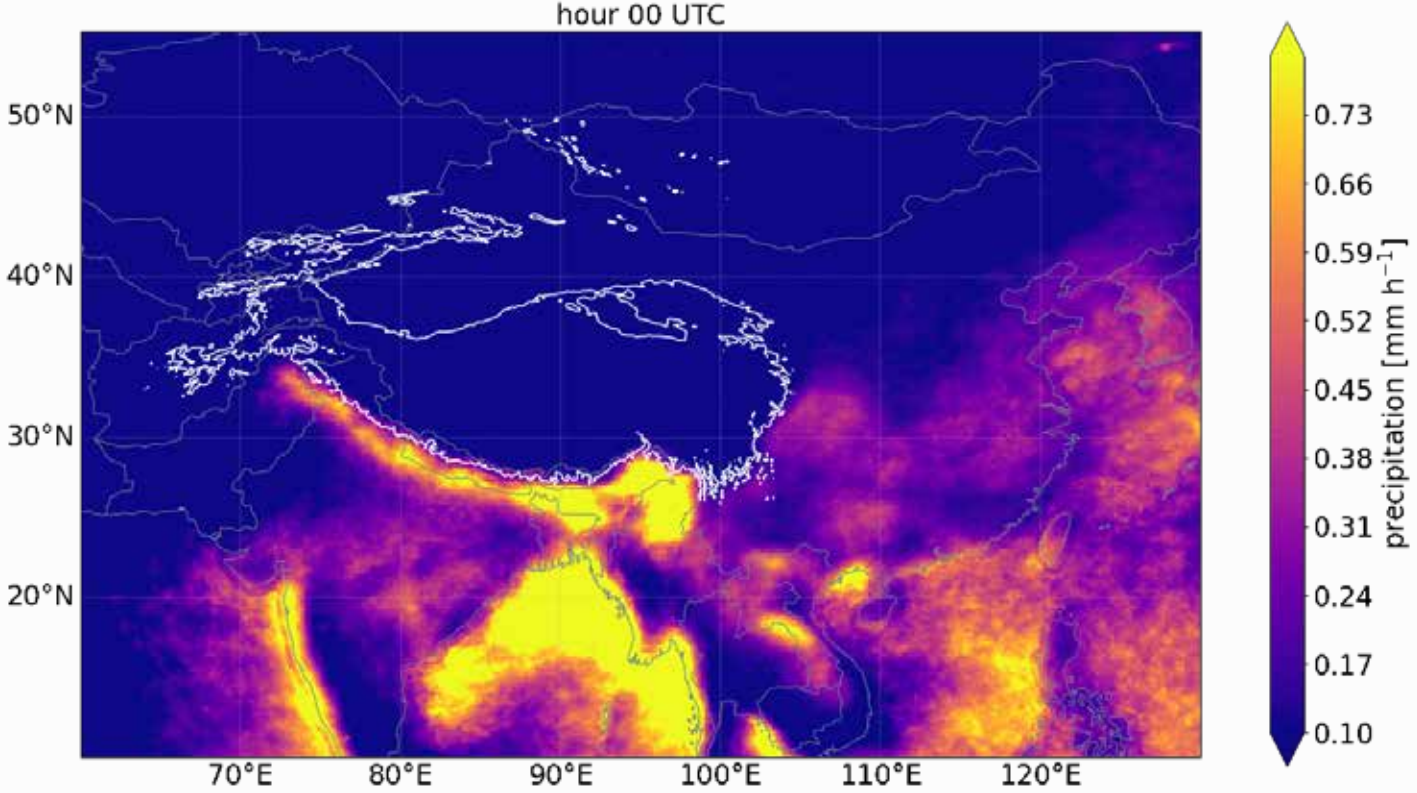
Global Precipitation Measurement from IMERG which includes

- TRMM satellite (2000 - 2015)
- GPM satellite (2014 - present).

Rymdstyrelsen
Swedish National Space Agency

Courtesy Julia Kukulies

The diurnal cycle of precipitation from GPM IMERG



Kukulies et al. (2020): International Journal of Climatology

Rymdstyrelsen
Swedish National Space Agency

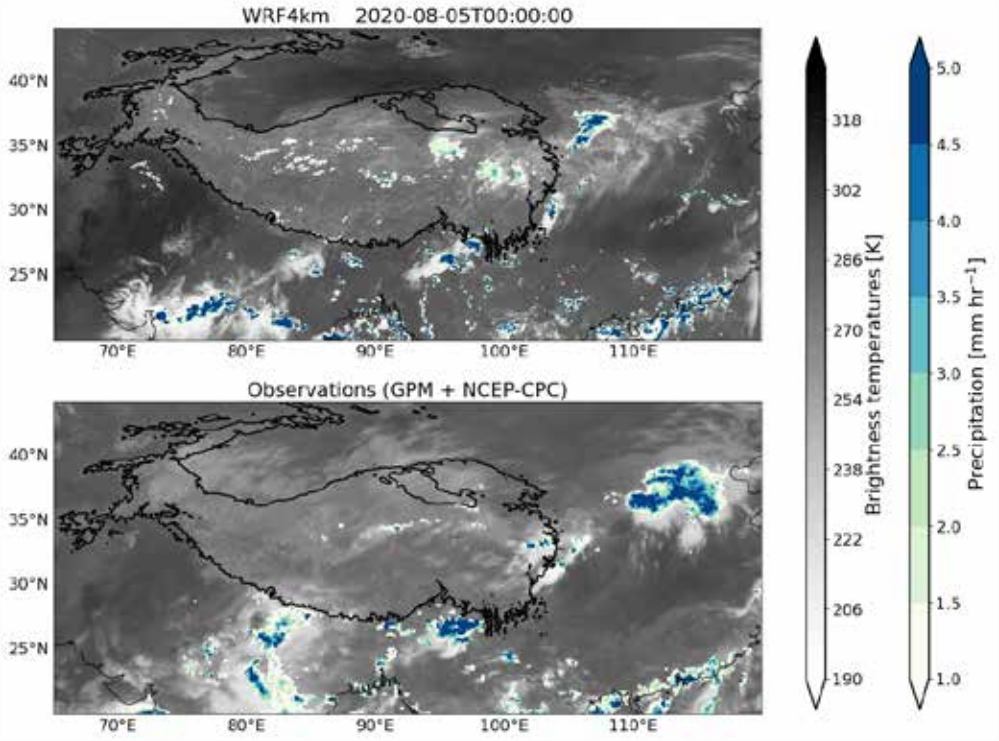
Courtesy Julia Kukulies

High resolution climate modelling with a focus on mesoscale convective systems and associated precipitation over the Third Pole

<u>Goal</u>

Model realistic characteristics of convective storm systems

Evaluate models using satellite observations (GPM-IMERGE and NCEP-CPC) at convective-permitting (~ 2- 4 km) scales



Kukulies et al. (2021): *JGR Atmosphere*

Courtesy Julia Kukulies

10+ Years of Monitoring Svalbard as a Mars Analogue

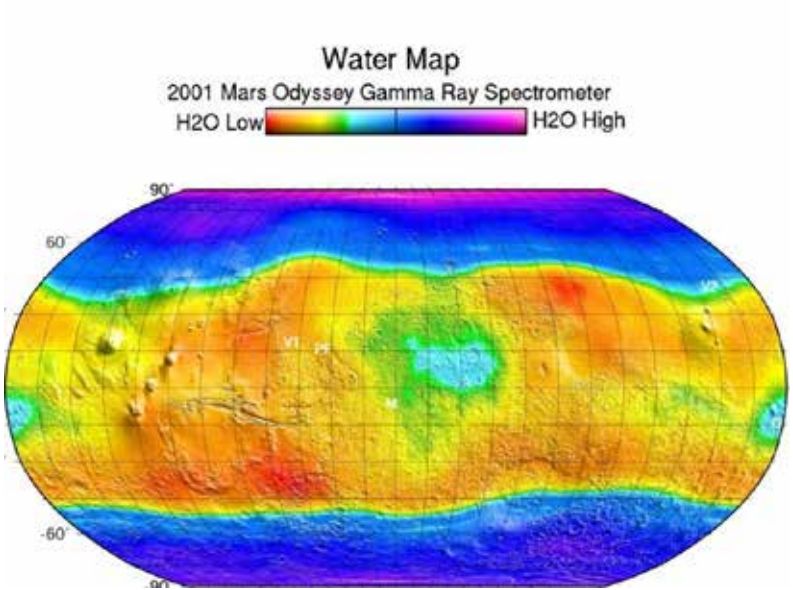
A. Johnsson, E. Hauber, H. Hiesinger, C. Sassenroth*, M. Desjardins*, N. Schmedemann, F. Ellermann*

*Student members

Svalbard as an analog to Mars

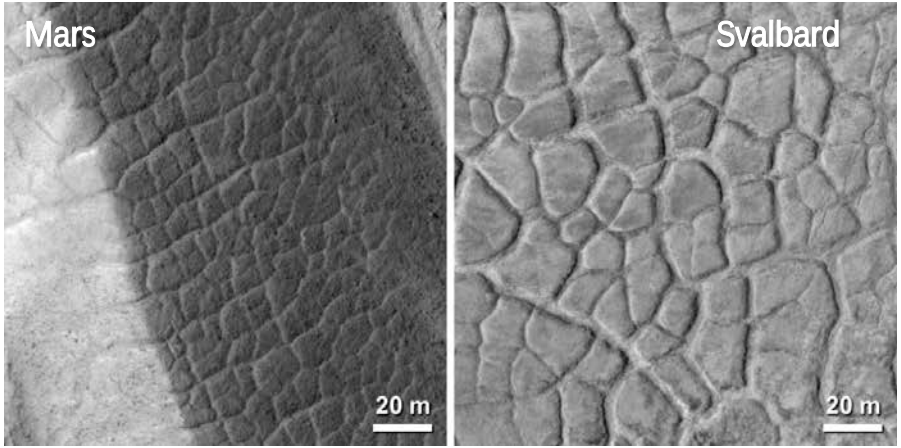
Motivation

Mars is a permafrost planet!
e.g., Hauber et al. (2011)

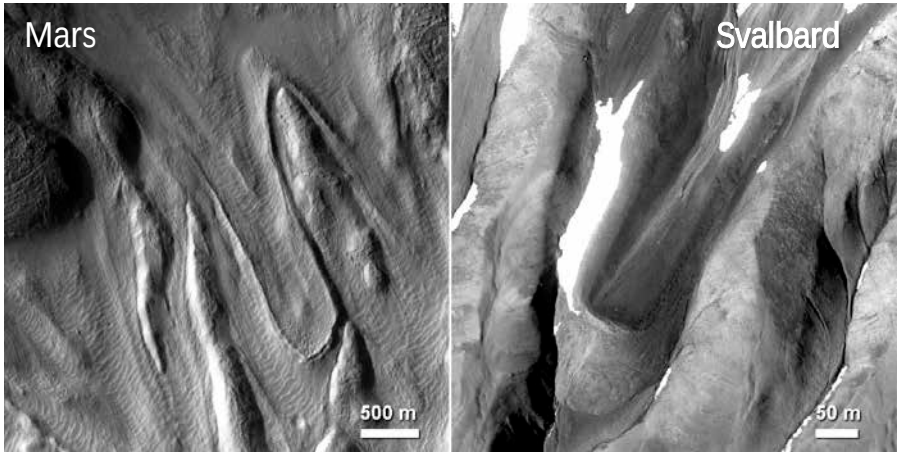


[Boynton et al., 2002; Feldman et al., 2002 ; Mitrofanov et al., 2003]

Permafrost polygons



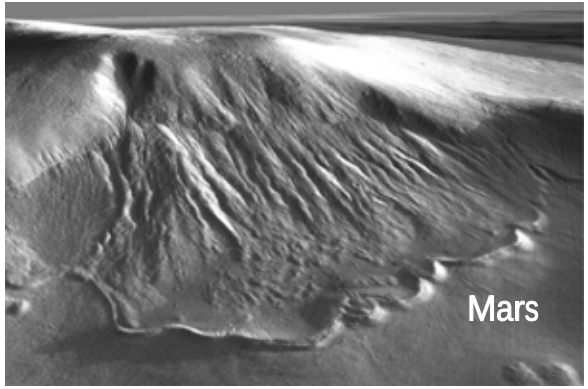
Rock glaciers

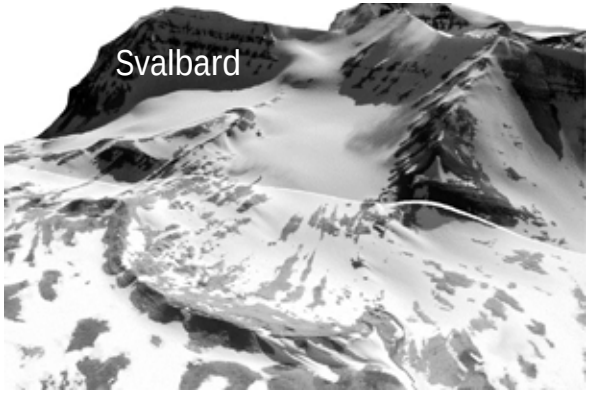


The glacial domain on Mars shares many components with glacial landscapes on Earth

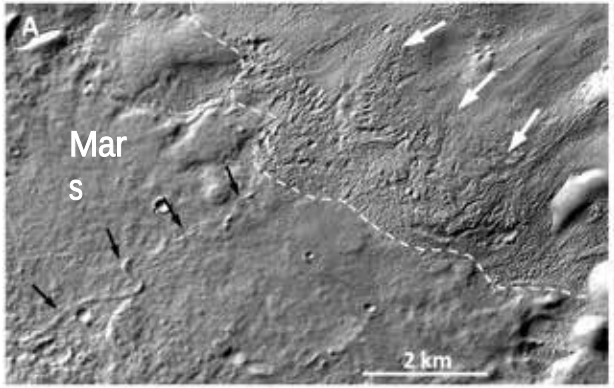
- Earth analog studies guide us in reconstructing the late glacial stages on Mars.
- Glacial erosional and depositional landforms provide clues on glacial dynamics, past extents, hydrology etc.
- Habitability?
- Important for in-situ resource utilization (ISRU).
- Important for the upcoming International-Mars Ice Mapper mission.

Moraines





Eskers (subglacial hydrology)

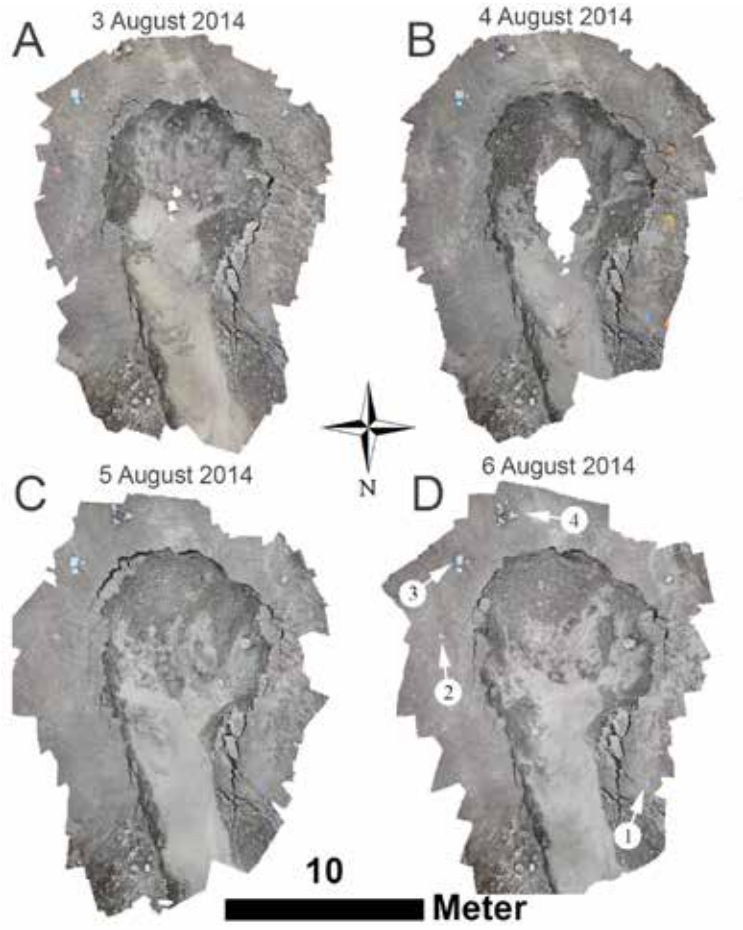


Thaw slumps on ice-cored moraine

- Svalbard features analogous to **debris-covered ice on Mars**
- Ice-cored moraine (Kongsvegen glacier)
- Sediment redistribution due to ice melting
- e.g., daily kite monitoring of active thaw slumps

DGPS

Kite imaging



Borisov et al., Geomorphology (in revision)

Thank you!

VISIT US AT
gu.se
gvc.gu.se

ESA och AI Sweden öppnar rymdlabb i Göteborg

AI Sweden och europeiska rymdorganisationen, ESA, ska öppna ett labb för avancerad teknikutveckling, Φ-lab Sweden (uttalas som grekiska bokstaven "phi"), för AI i nya rymdapplikationer och användningsområden för jordobservation. Labbet är först ut som ett spjutspetslabb inom ett stort europeiskt samarbete om rymdinnovation och kommer invigas under våren.