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Snow barrels based on H SAF snow extent products

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Snow seminar 2.2.2022

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Snow

Challenges with satellites

- Variability
  - Snow types and structures
  - Temporal variability (new snow, melting snow)
  - Spatial variability
    - Vegetation
    - Forests (tree density, tree species)
    - Small lakes and rivers
    - Solar angles, viewing angles
    - Shadows
- Difficulties in optical channels
  - Clouds and darkness

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Chaos!
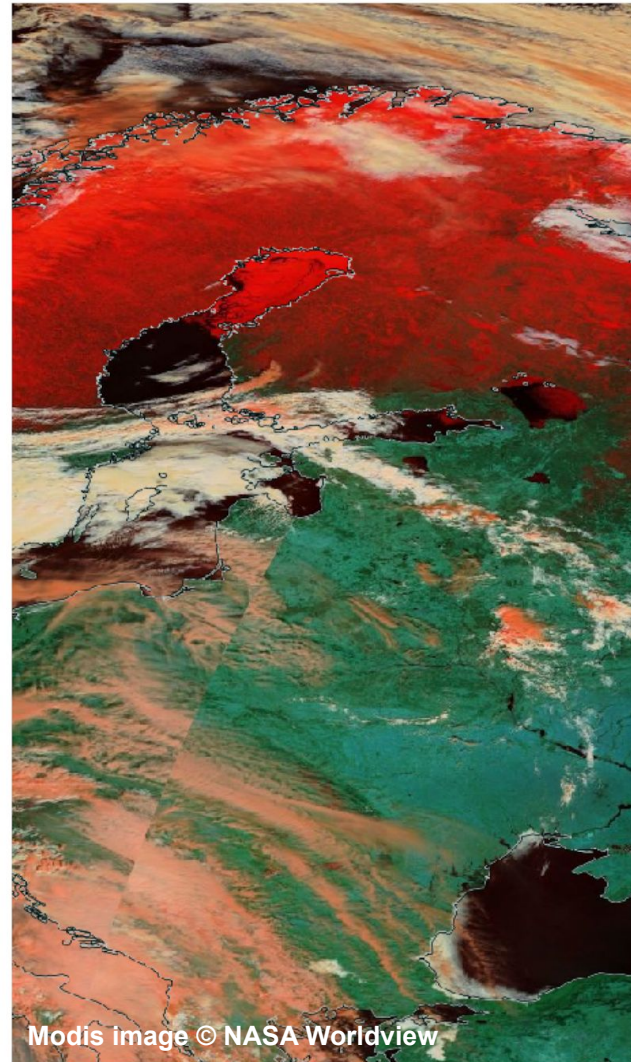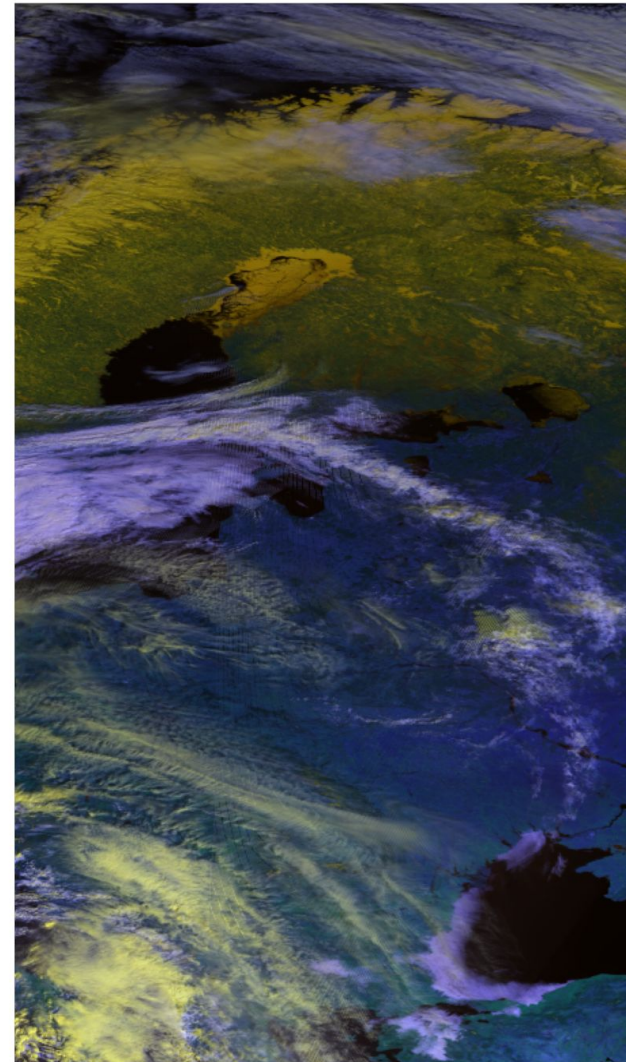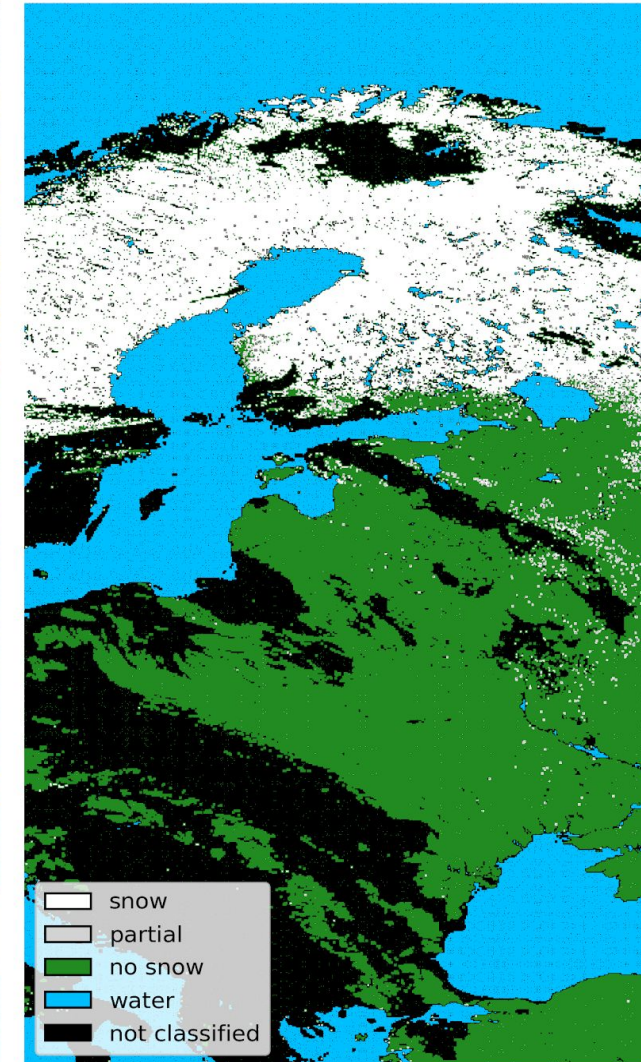
MODIS and
AVHRR
RGB

vs

H SAF H32
Metop/AVHRR
Snow Extent

MODIS 20180415

AVHRR 20180415

H32 20180415

Modis image © NASA Worldview

snow
partial
no snow
water
not classified

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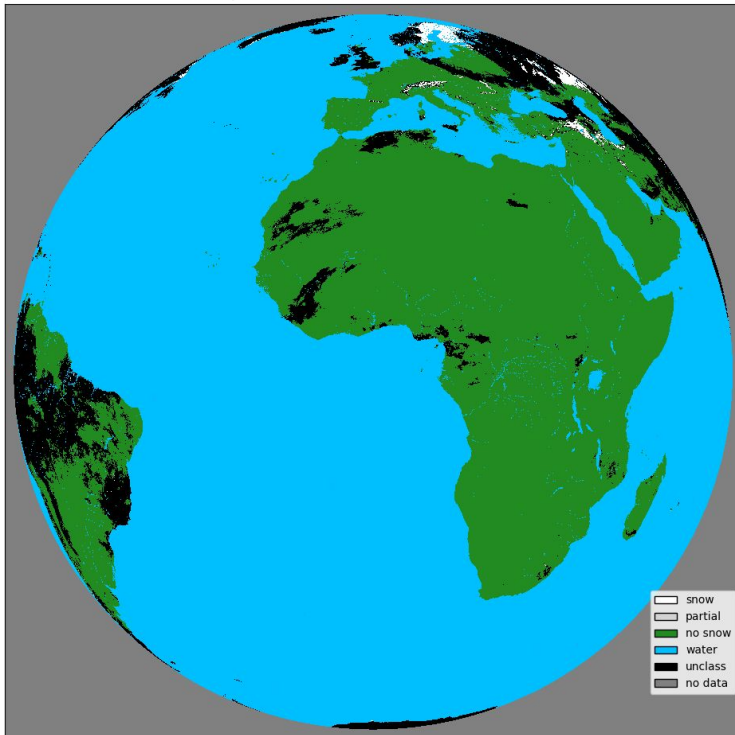
Empirical HSAF Snow Extent products

- Empirical approach employed
- Two snow extent products developed at FMI for the H SAF (earlier: LSA SAF)
  - Geostationary H SAF H31 (MSG/SEVIRI) snow extent, operational
  - Polar H SAF H32 (Metop/AVHRR) snow extent, operational
- Good or very good validation results
- Currently, H31 and H32 available from:
  - LSA SAF website: https://landsaf.ipma.pt/ (full archive)
  - H SAF products from: http://hsaf.meteoam.it/
  - EUMETCast

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H SAF H31 MSG/SEVIRI

MSG/SEVIRI snow cover 22.3.2019

snow
partial
no snow
water
unclass
no data

H SAF H32 Metop/AVHRR

Metop/AVHRR snow cover 22.3.2019

snow
partial
no snow
water
not classified
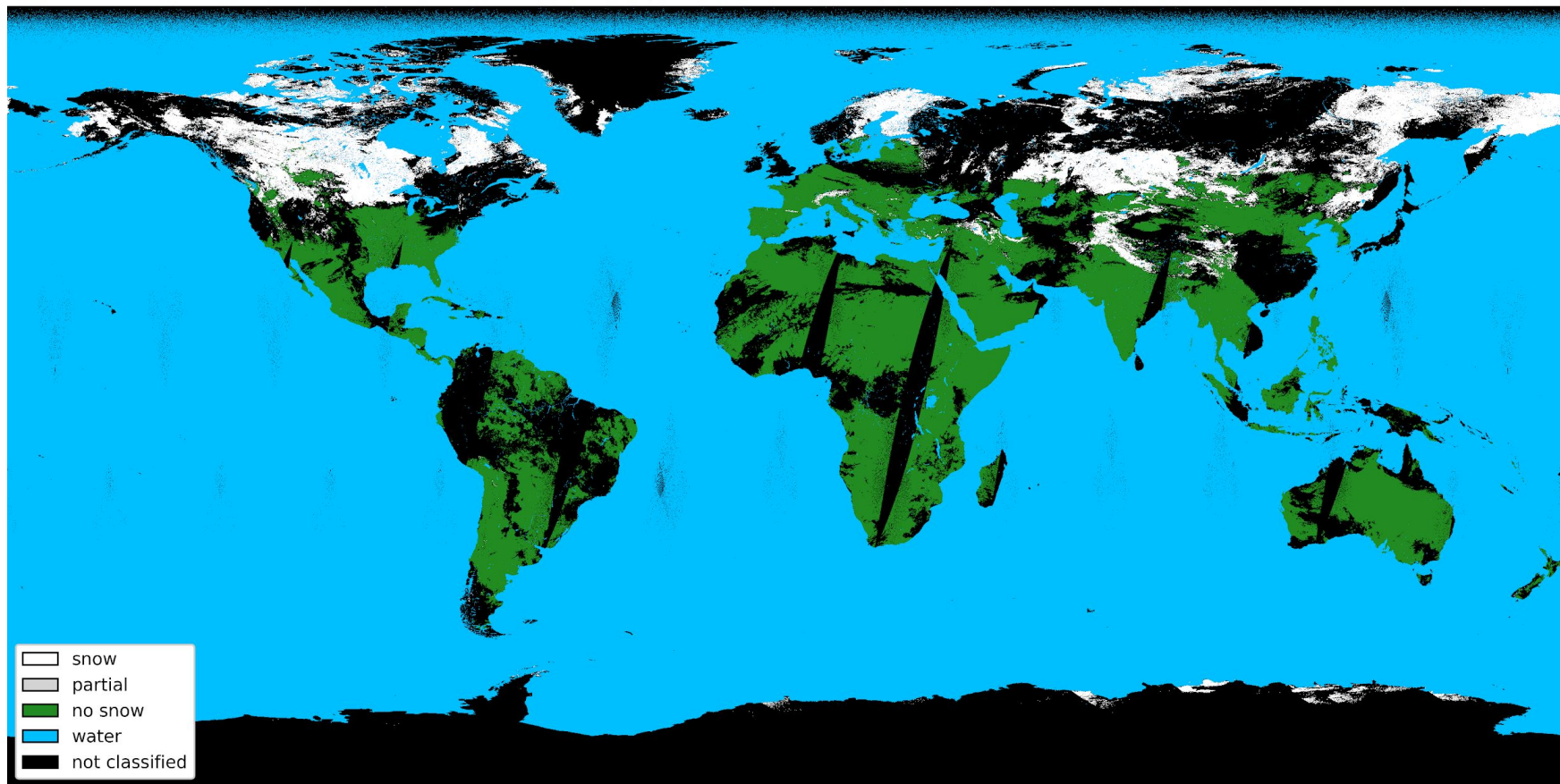
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Validation

Global, MSG/SEVIRI, partial = no snow

Global, Metop/AVHRR, partial = no snow
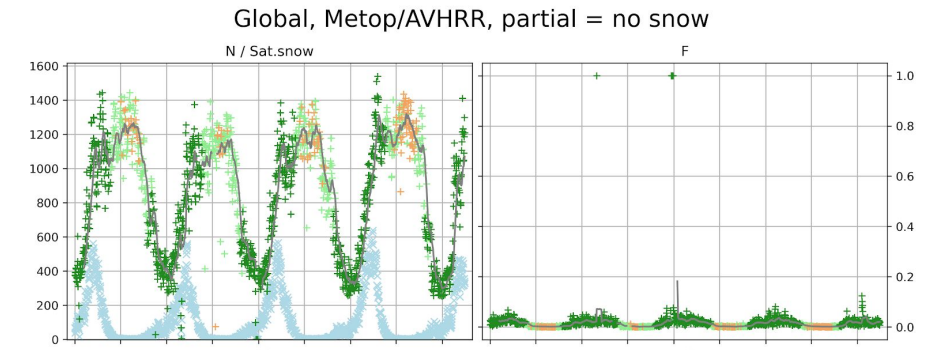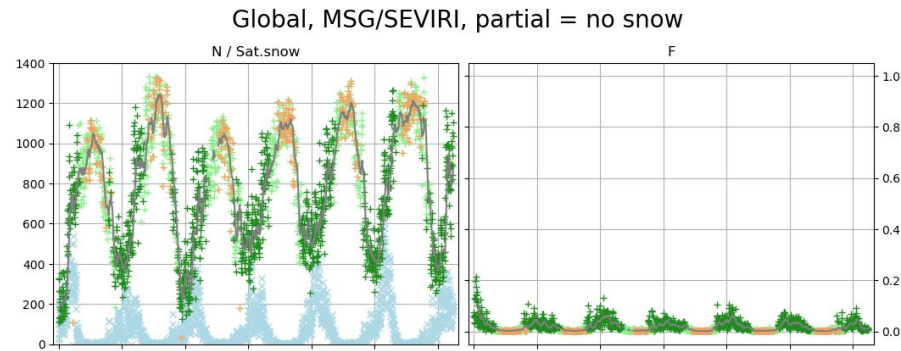
More information about these products and validation:

Siljamo, Niilo, Otto Hyvärinen, Aku Riihelä, and Markku Suomalainen. "MetOp/AVHRR Snow Detection Method for Meteorological Applications", Journal of Applied Meteorology and Climatology 59, 12 (2020): 2001-2019, https://doi.org/10.1175/JAMC-D-20-0032.1

Siljamo, Niilo. "Empirical Approach to Satellite Snow Detection", Finnish Meteorological Institute Contributions 171, (2020), PhD Thesis, https://doi.org/10.35614/isbn.9789523361201
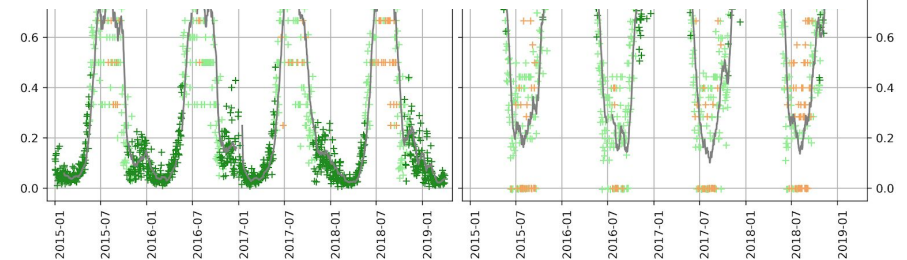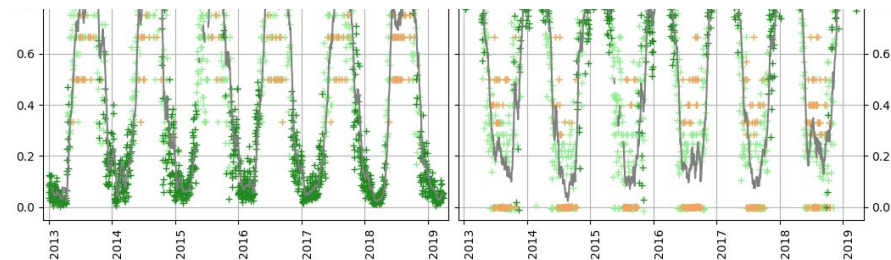
Satellite snow in NWP

Know your users! Ask!

- NWP preferences:
  - Accuracy over coverage (do not force classification, avoid misclassifications)
  - Single-source data (satellite data only, do not smuggle in other data)
  - Directness: Avoid redundant steps (such as cloud masking and interpolations)
  - Availability: Operational products
- Satellites provide more data, especially where weather station data has gaps

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NWP system

- NWP model predicts snowfall and snow on ground [SWE, kg/m^2]
- Model's surface parametrizations contain a prognostic snow scheme
- Forecast snow cover is corrected by assimilating observations
- Snowfall prediction is independent of snow observations
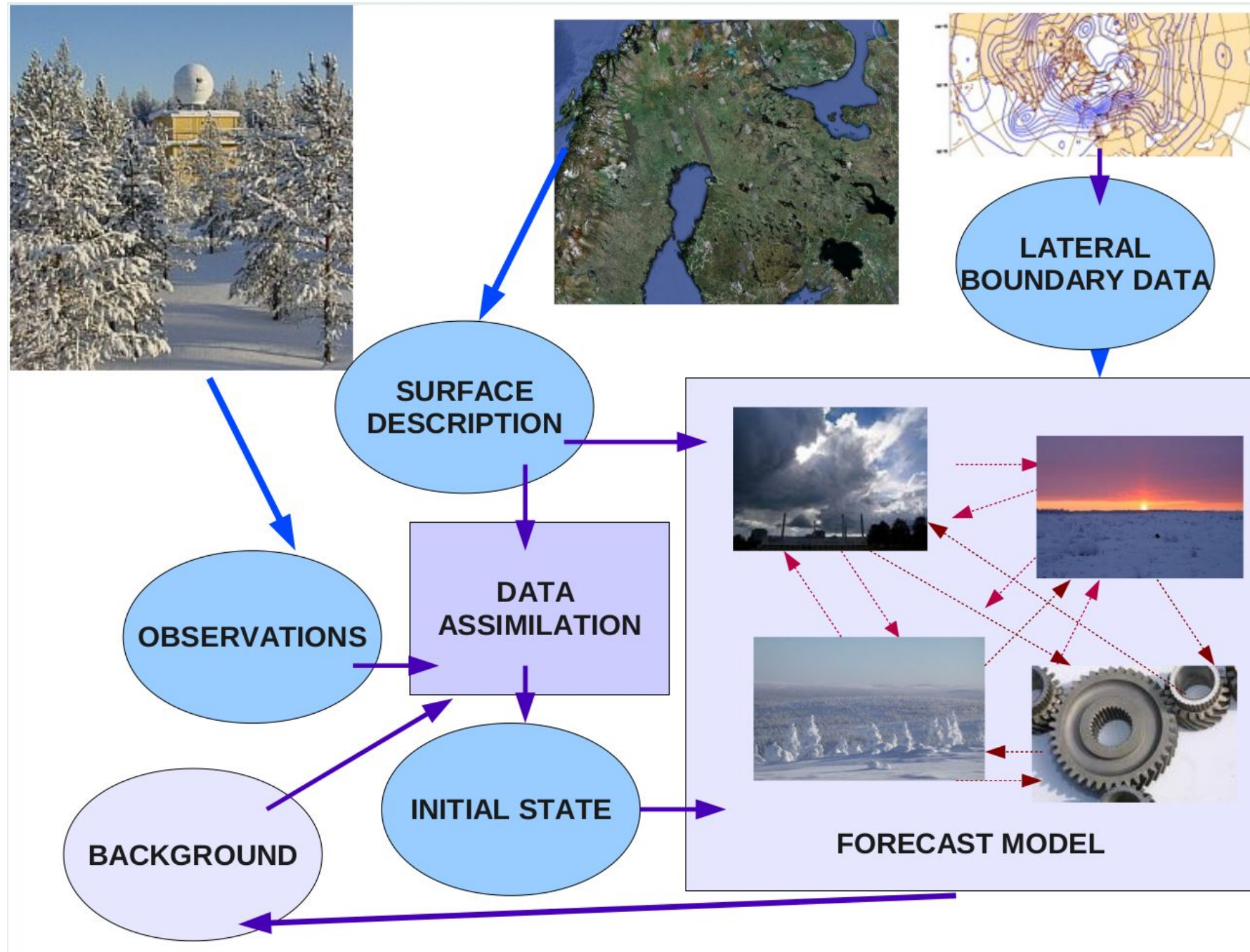
SURFACE DESCRIPTION

LATERAL BOUNDARY DATA

OBSERVATIONS

DATA ASSIMILATION

BACKGROUND

INITIAL STATE

FORECAST MODEL

While sitting in a meeting with NWP experts:
1) "Too much data"
2) "Thinning"
3) "Especially in polar areas…"
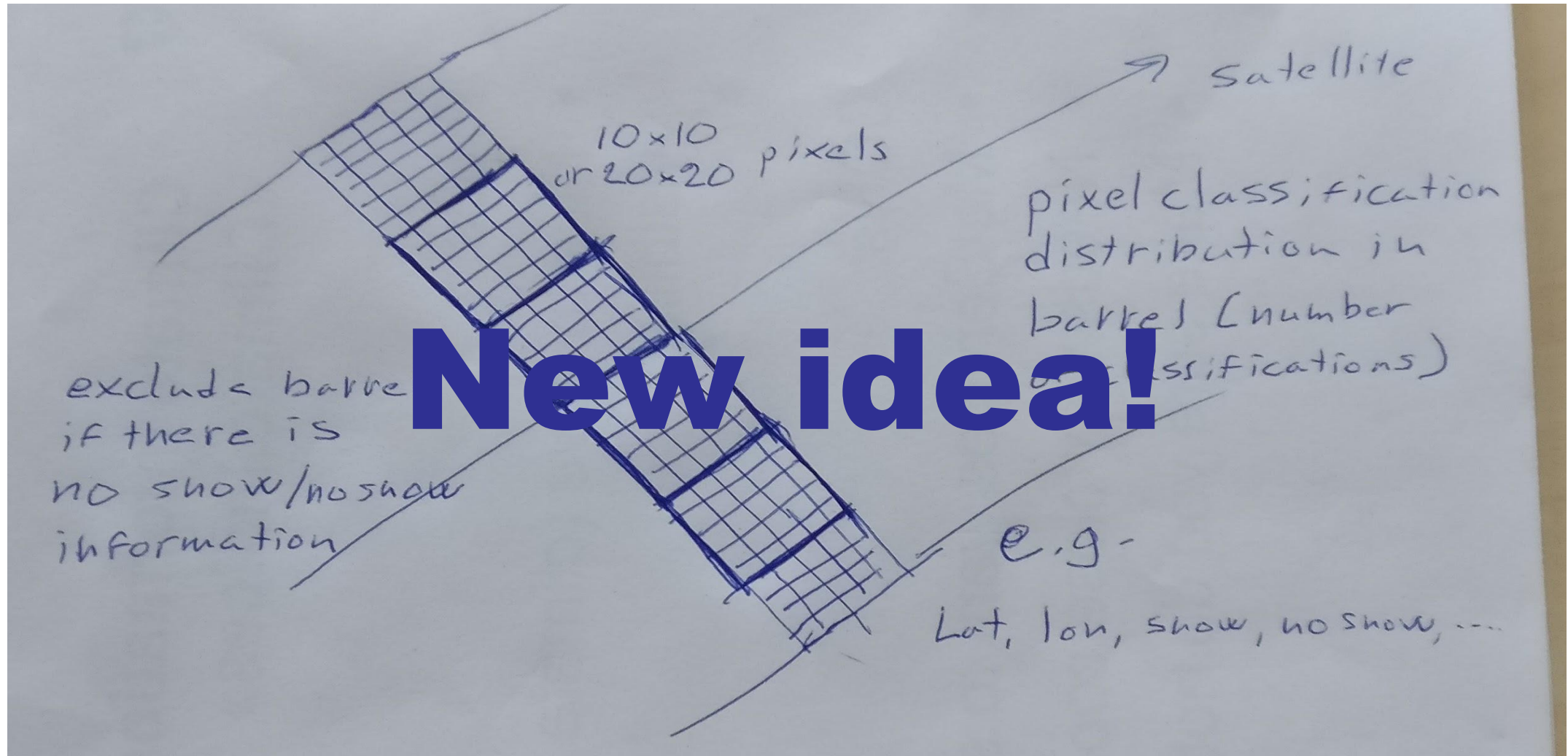
While sitting in a meeting with NWP experts:
1) "Too much data"
2) "Thinning"
3) "Especially in polar areas..."

What if:
1) Satellite grid
2) Classifications:
   a) no snow
   b) snow (partial snow too?)
   c) water (sea/lakes/rivers)
   d) unclassified (clouds/dark/etc)
3) Count number of different cases in 10x10 pixel area, not just percentage

Snow Barrels!

- Snow classification distribution in predefined area, e.g. 10x10 pixels in **satellite grid**
- Benefits: no interpolation or thinning
- Best for polar orbiters, avoid problem of meridian convergence in LON-LAT coordinates

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Current work

- FMI: development and testing
- Global barrels since mid-October 2021 available
  - Based on HSAF H32 intermediate SC1 (Phase 1) product
- In FMI tests: impact seen in tests, important when snow appearing
- February - March: continue testing in spring conditions.

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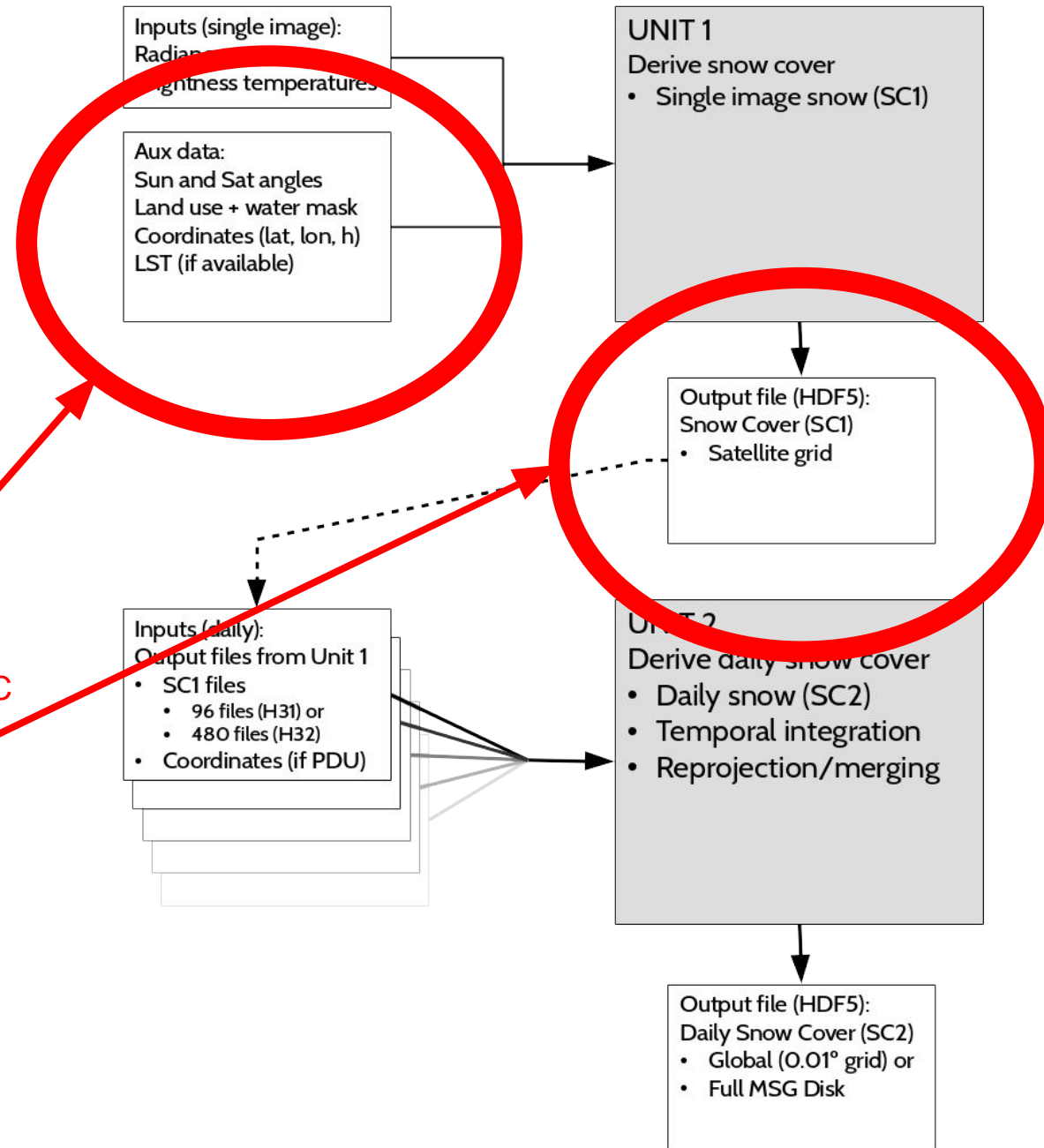# Flow chart of the H32 snow extent algorithms

- Two phases
- Phase 1: Single image product (SC1):
  - Satellite grid
- Phase 2: Daily product (SC2):
  - Merge SC1 products (e.g. one day)
  - Lan-lon grid (Metop/AVHRR)
  - Slight smoothing
- Deliver + archive daily SC2

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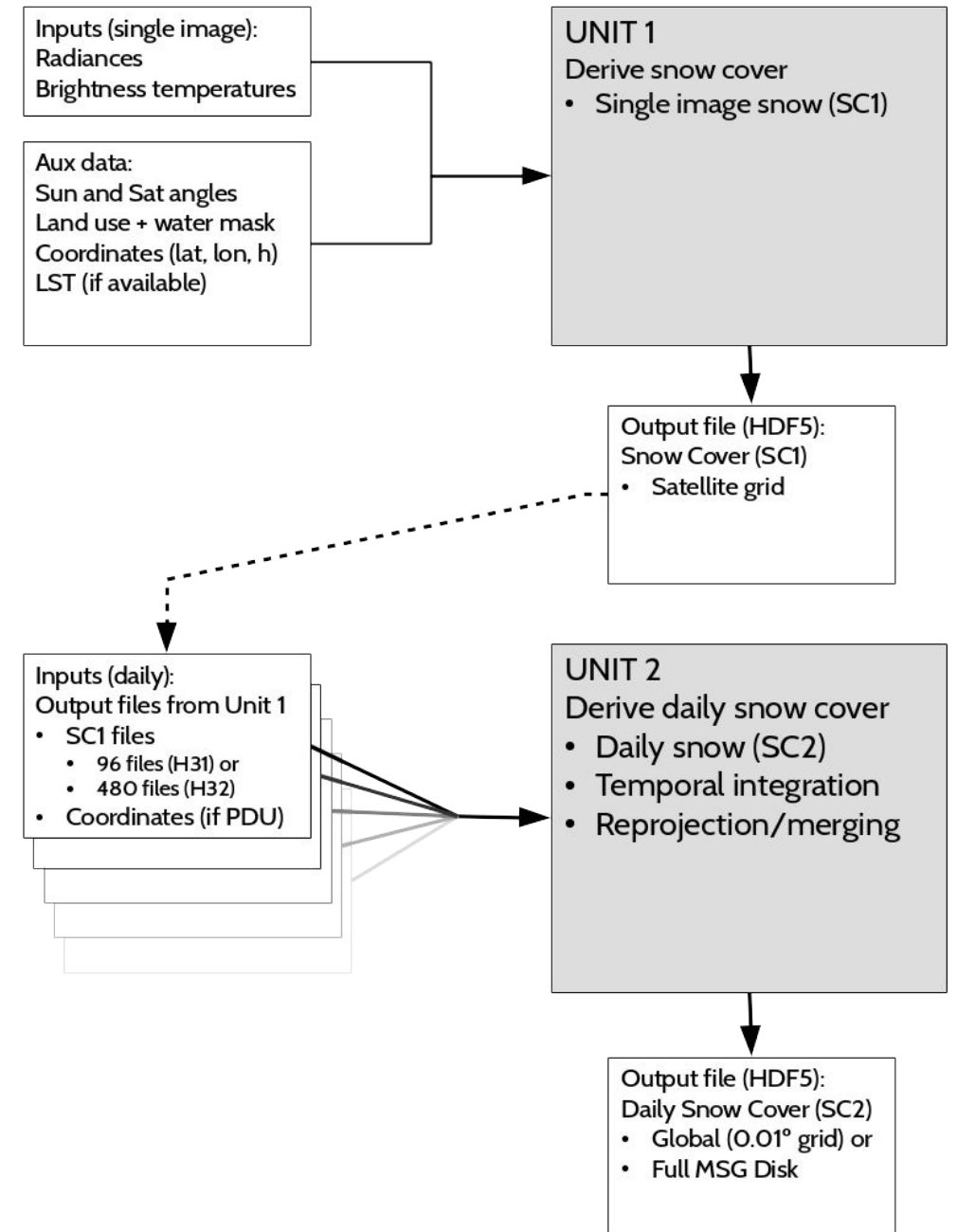
Barrel inputs from HSAF production chain

- Intermediate data available NRT from LSA SAF
  - Single image SC product (SC1)
  - Coordinates (LAT, LON)
- Only land pixels
➡ Barrel production scripts

Inputs (single image):
Radiance
Brightness temperatures

Aux data:
Sun and Sat angles
Land use + water mask
Coordinates (lat, lon, h)
LST (if available)

UNIT 1
Derive snow cover
- Single image snow (SC1)

Output file (HDF5):
Snow Cover (SC1)
- Satellite grid

Inputs (daily):
Output files from Unit 1
- SC1 files
  - 96 files (H31) or
  - 480 files (H32)
- Coordinates (if PDU)

UNIT 2
Derive daily snow cover
- Daily snow (SC2)
- Temporal integration
- Reprojection/merging

Output file (HDF5):
Daily Snow Cover (SC2)
- Global (0.01° grid) or
- Full MSG Disk

LAT, LON

SC

Snow barrel inputs

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Barrel data are used when they contradict first guess snow

NWP model variable is snow water equivalent (SWE), not snow extent (SE)!

Spatialization method is optimal interpolation, that treats barrels as pseudo observations

Step 2: creating pseudo-obs by converting barrel SE to SWE*

| no snow in HSAF |
| snow in NWP |

→ 0 cm snow in pseudo-obs

| snow in HSAF |
| no snow in NWP |

→ 5-10 cm snow in pseudo-obs

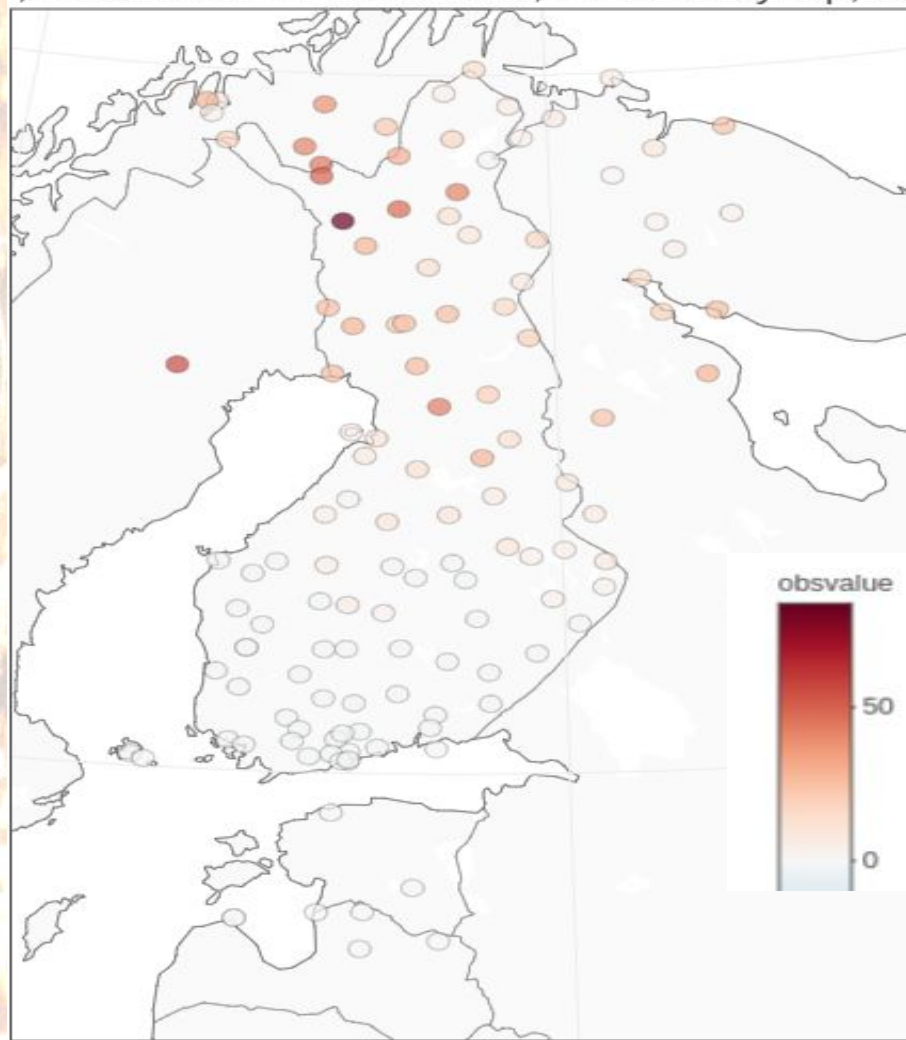Step 3: optimal (statistical) interpolation

| SYNOP obs |
| pseudo obs from HSAF |
| NWP background field |

→ gridded SWE analysis = initial conditions for the next NWP forecast

* via snow depth as in SYNOP observations

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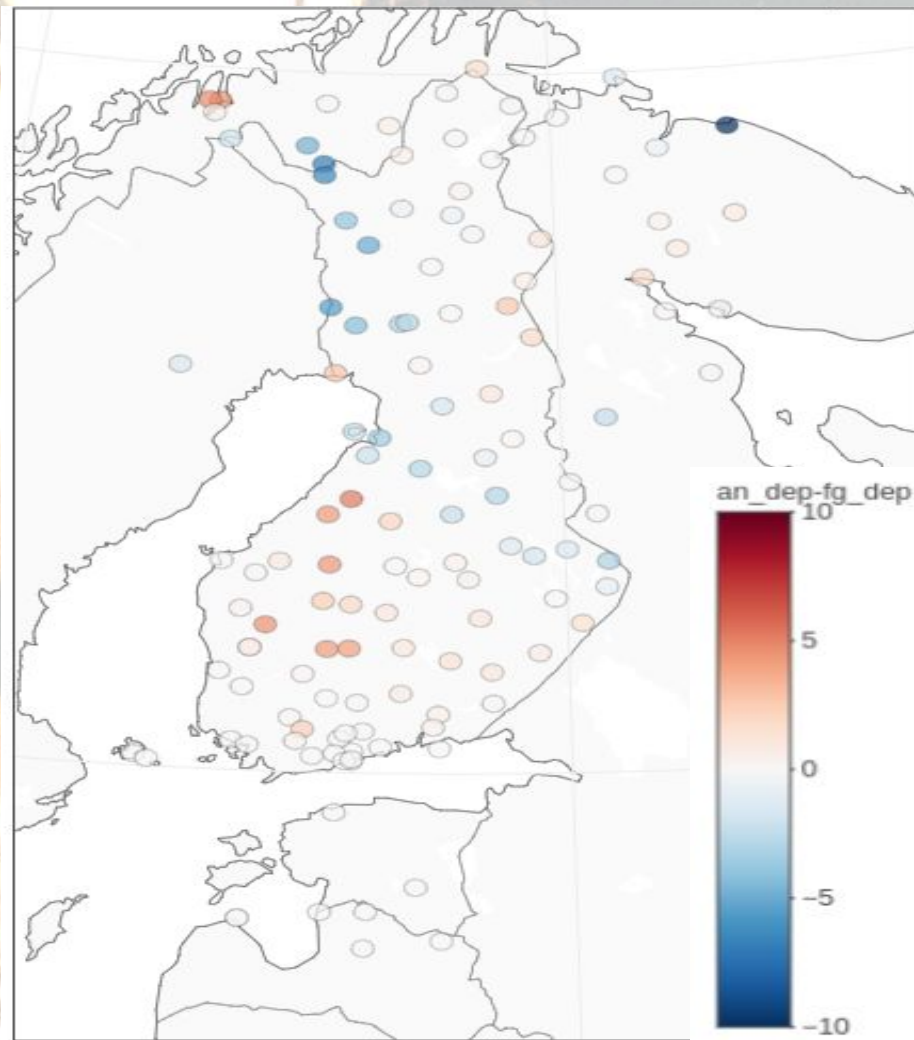METEOROLOGISKA INSTITUTET
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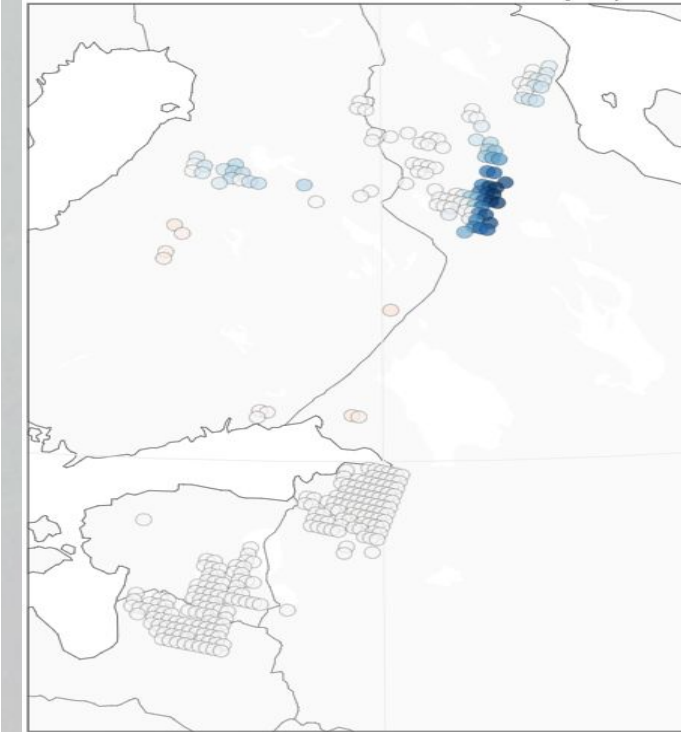**Harmonie-Arome experiment over Finland**

Conventional SYNOP observations

SYNOPs suggest both addition and removal of snow
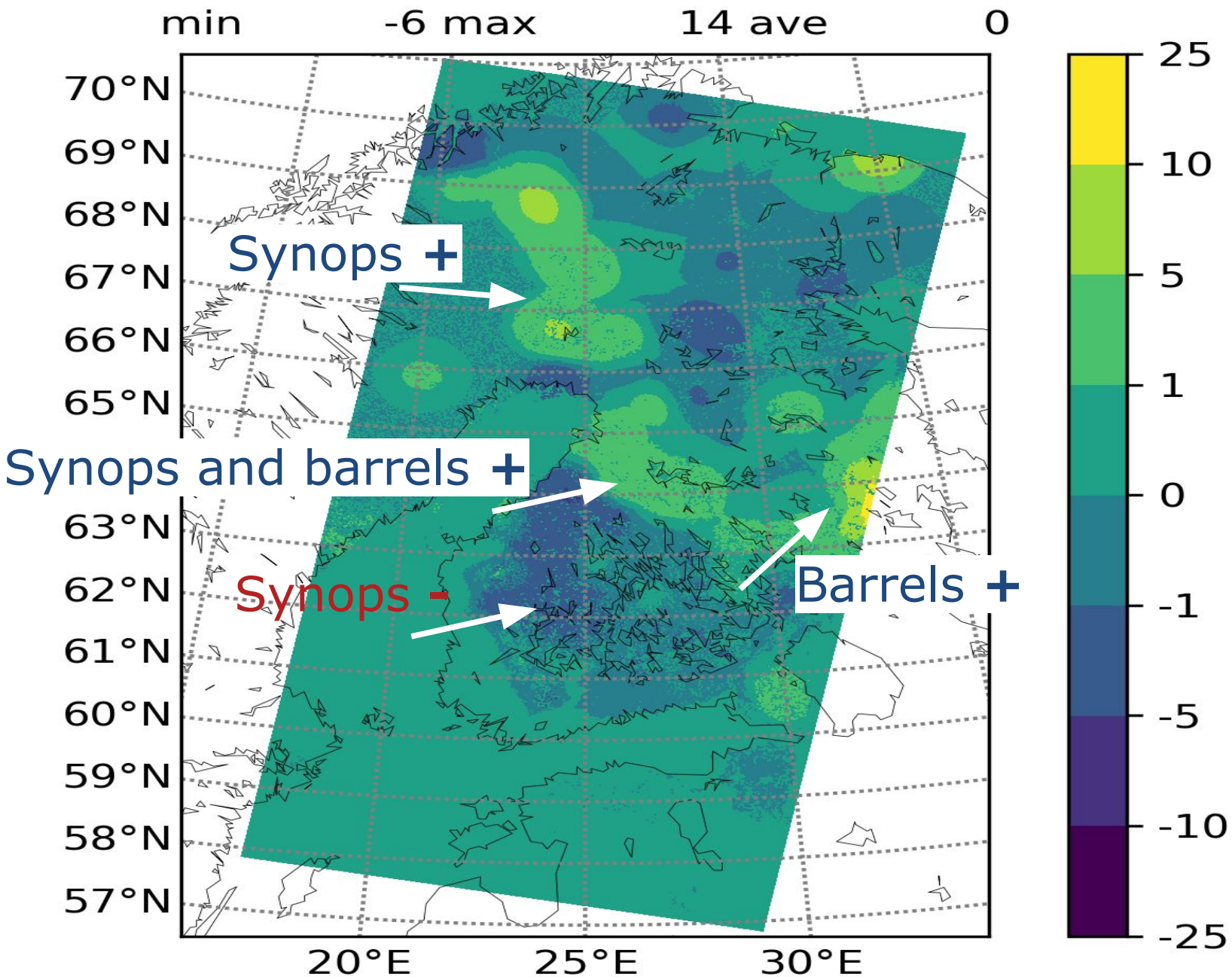
Barrels suggest addition of snow

Snow water equivalent [kg/m^2 or mm of water]
This time of year, 10 mm might correspond to a new snow layer of 5-8 cm on ground

Resulting analysis increment 2021102506

This is how the HARMONIE surface analysis changed SWE compared to the model background.

Both SYNOPs and barrels contributed to addition of snow in this case, SYNOPs also to removal in the Southern Finland.

Future: new snow products

- Several new snow extent products in development for MTG/FCI and Metop-SG/METimage in the H SAF
  - H43 (Day-1 product for MTG/FCI)
    ➡ H243 (Day-2 version)
  - H85 (Day-1 product for Metop-SG/METimage)
    ➡ H285 (Day-2 version)
- Operational snow barrel product?

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Summary

- Currently, H SAF produces two operational empirical approach based snow extent products: MSG/SEVIRI H31, Metop/AVHRR H32

- New EUMETSAT weather satellites (MTG, Metop-SG)
  ➡ New snow extent products

- "Snow barrels" for NWP under active development and testing

- Promising results

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