IMPACT STUDIES AND SNOW-HYDRO VALIDATION PART I: ASSIMILATING HSAF DATA INTO A NATIONAL-SCALE SNOW-FORECASTING CHAIN

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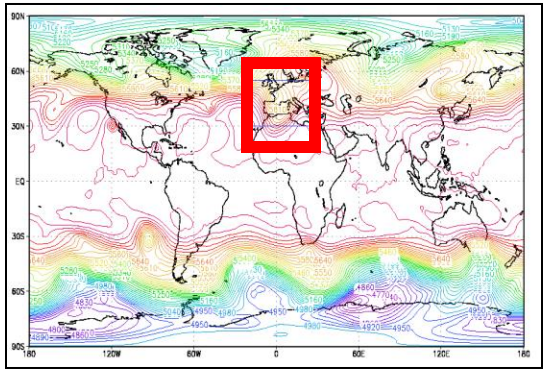
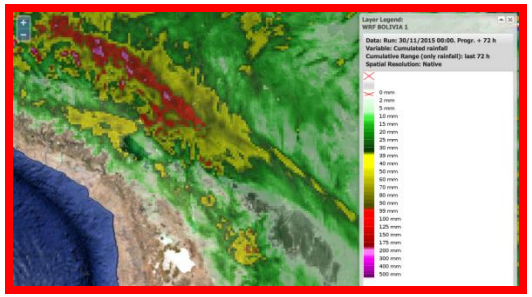
What is a "snow forecasting chain"?

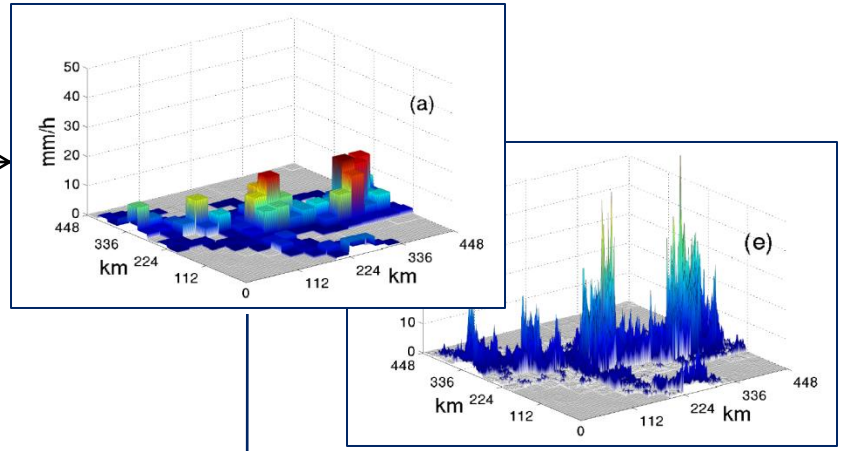
Global meteorological model



Limited Area Meterological model



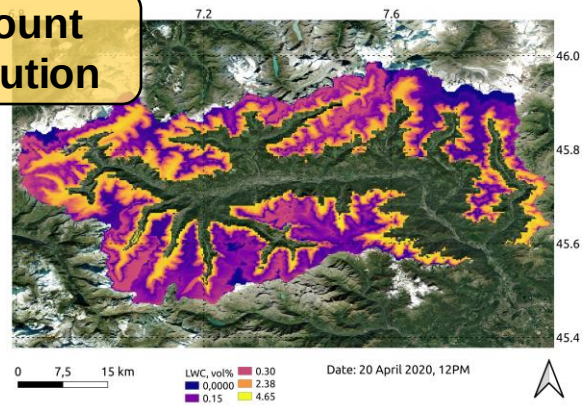
Downscaling



Cryospheric model

S3M
CIMA'S CRYOSPHERIC MODEL

Snow amount and distribution



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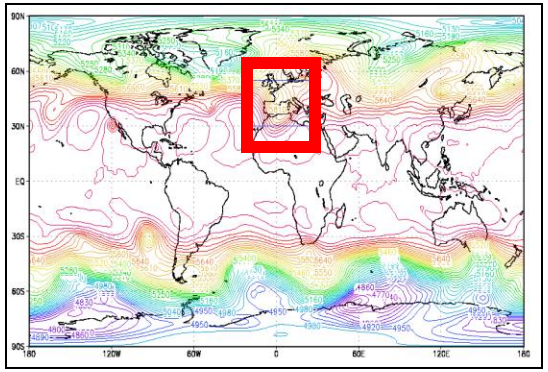

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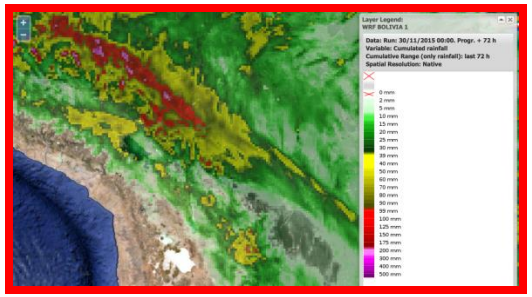

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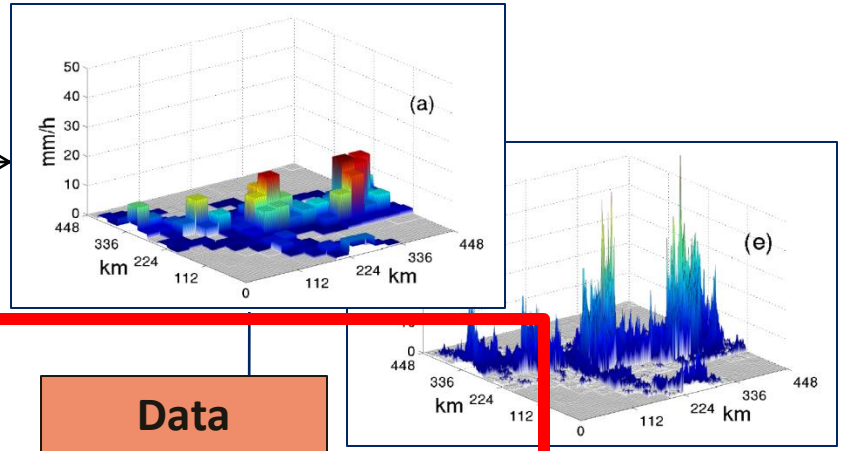
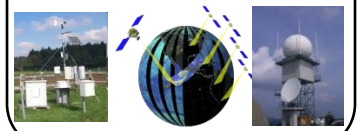


Real-time observations



Data assimilation

Cryospheric model

S3M
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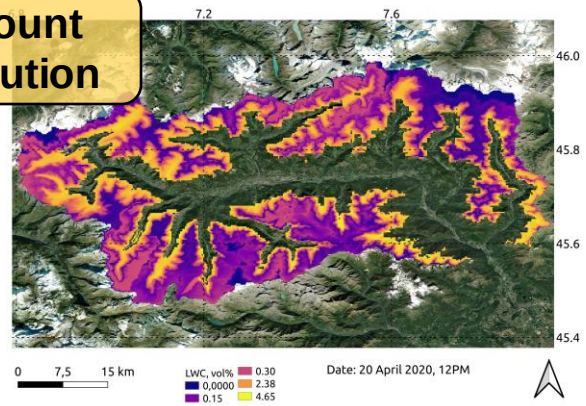
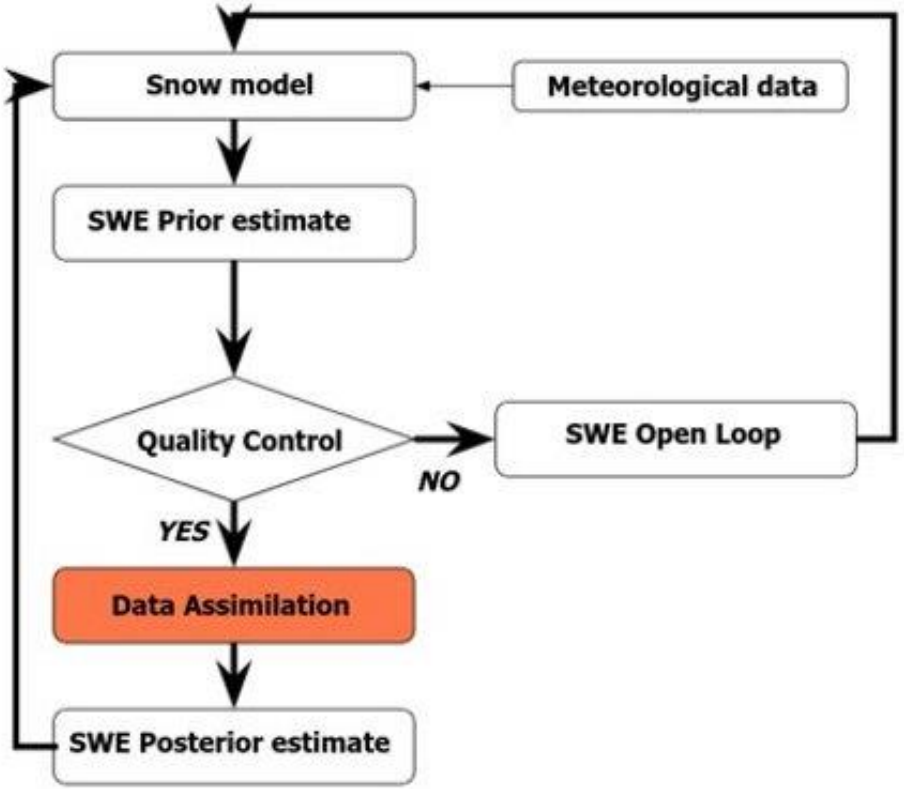
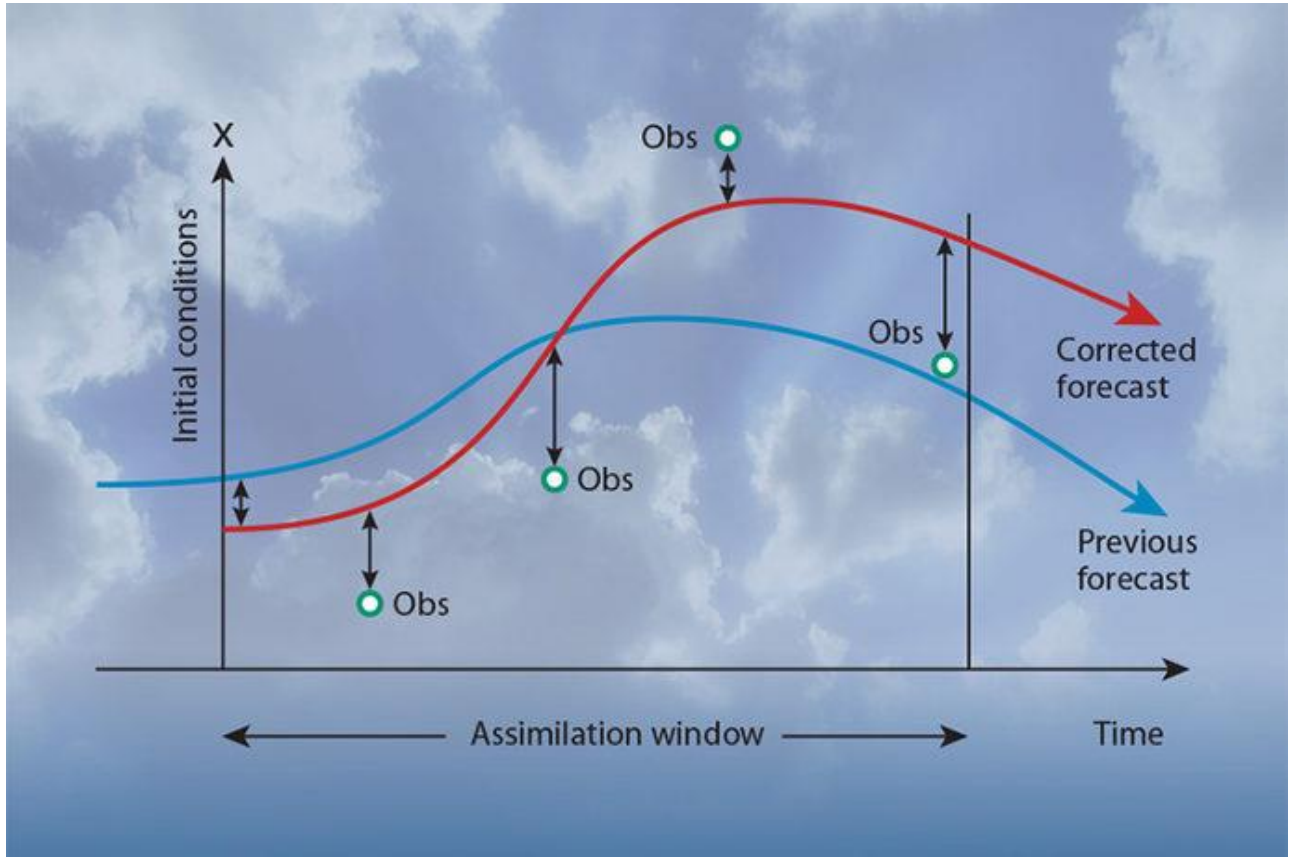


What does "assimilation" mean here?

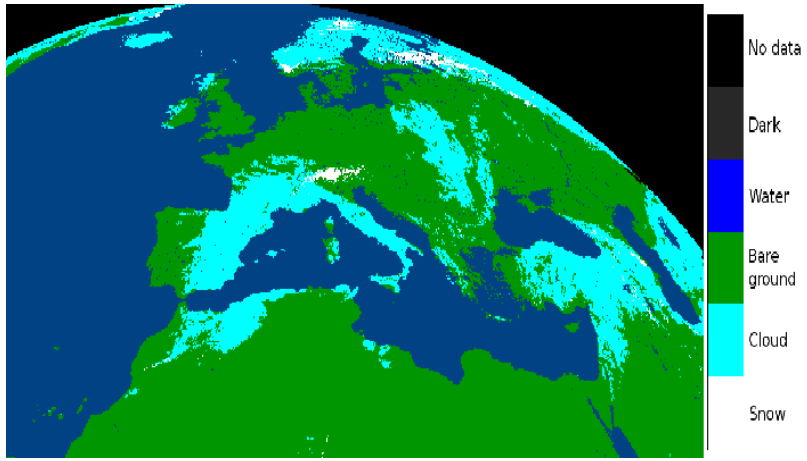




Source: ECMWF

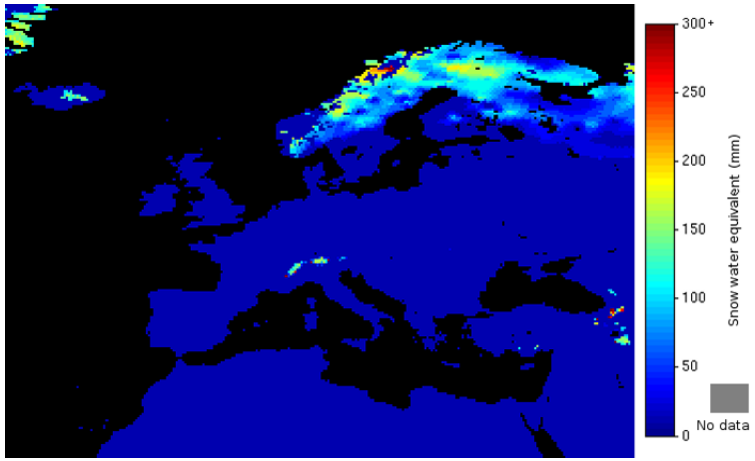
What information are we looking for?

Where?



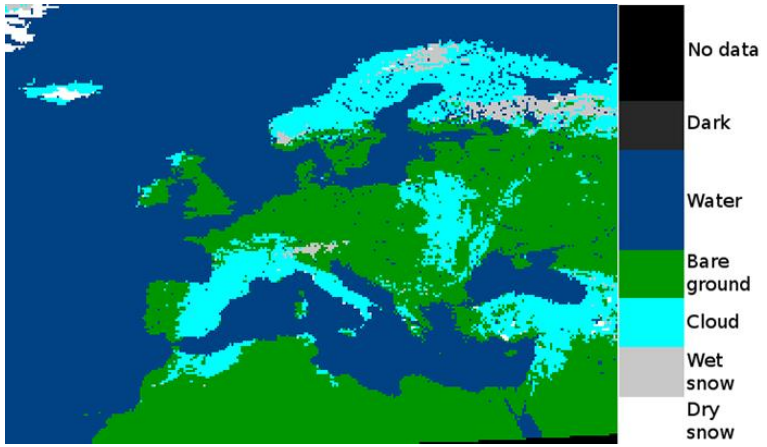
SE-E-SEVIRI (H10), FSC-E (H12), SE-D-SEVIRI (H31), SE-G-AVHRR (H32), SE-D-SEVIRI (H34), ESC-H (H35).

How much?



SWE-E (H13)

When?*



WS-E (H11)
* will it melt?

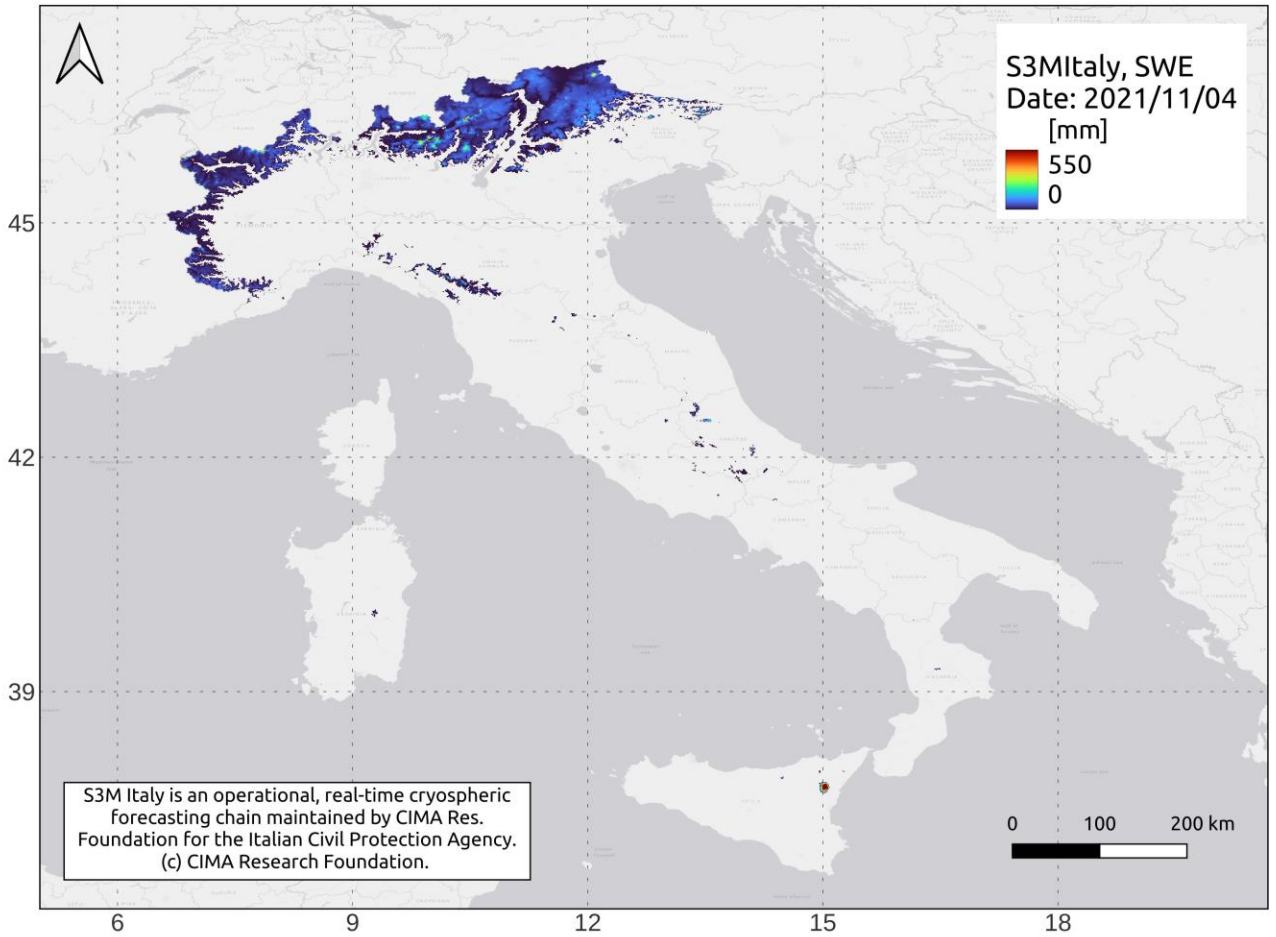
H10 & a real-world forecasting chain: S3M Italy

Weather data interpolation

Snow-depth data interpolation (10 national snow domains)

Sentinel-2, MODIS, and **H-SAF** real time blending

Real time, operational snow simulations across 20 regional domains (200 m, 1-h latency)

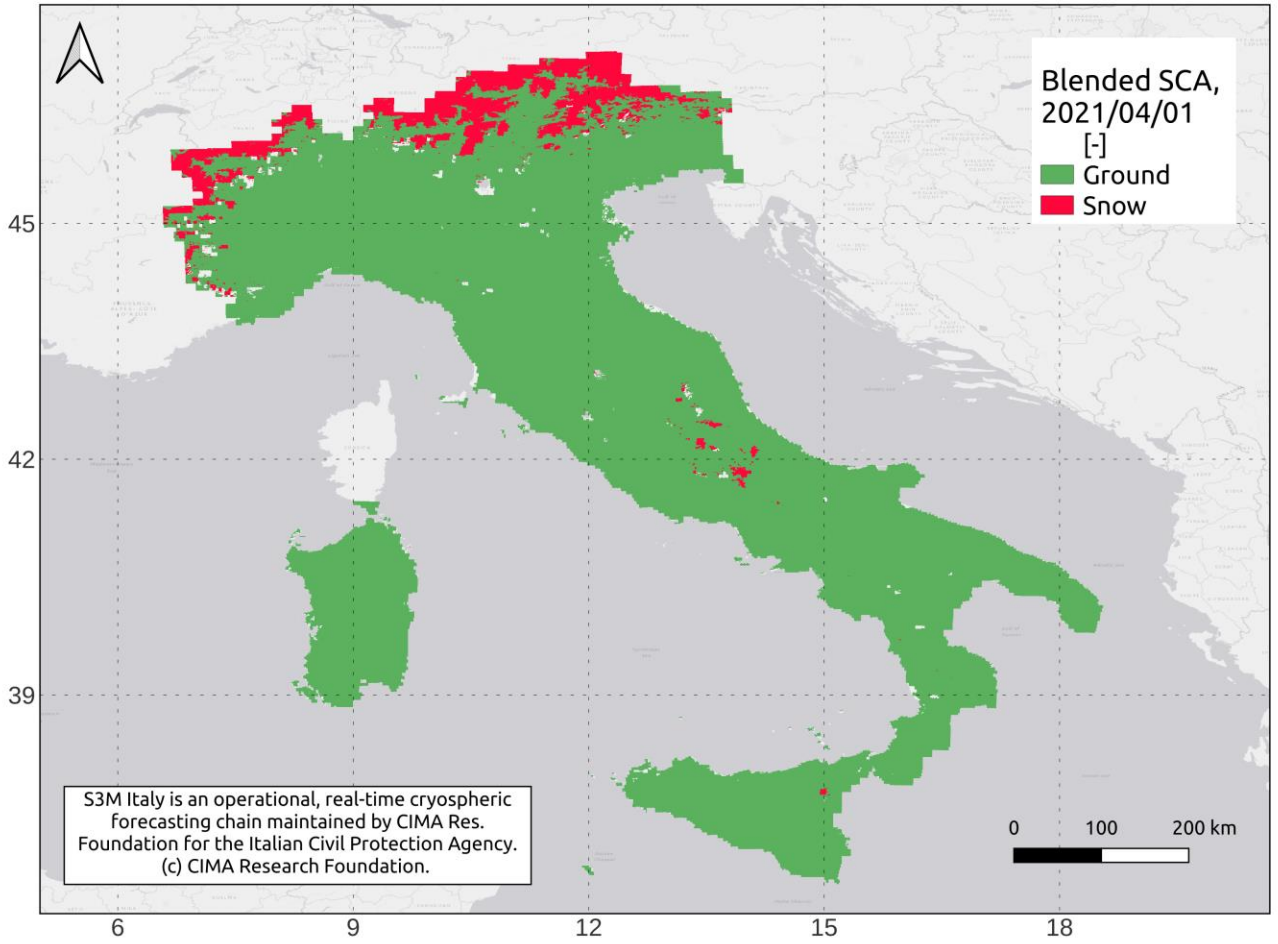


H10 & a real-world forecasting chain: S3M Italy

First guess: Sentinel-2 (due to spatial resolution)

Second guess: MODIS as a filler for NaN pixels

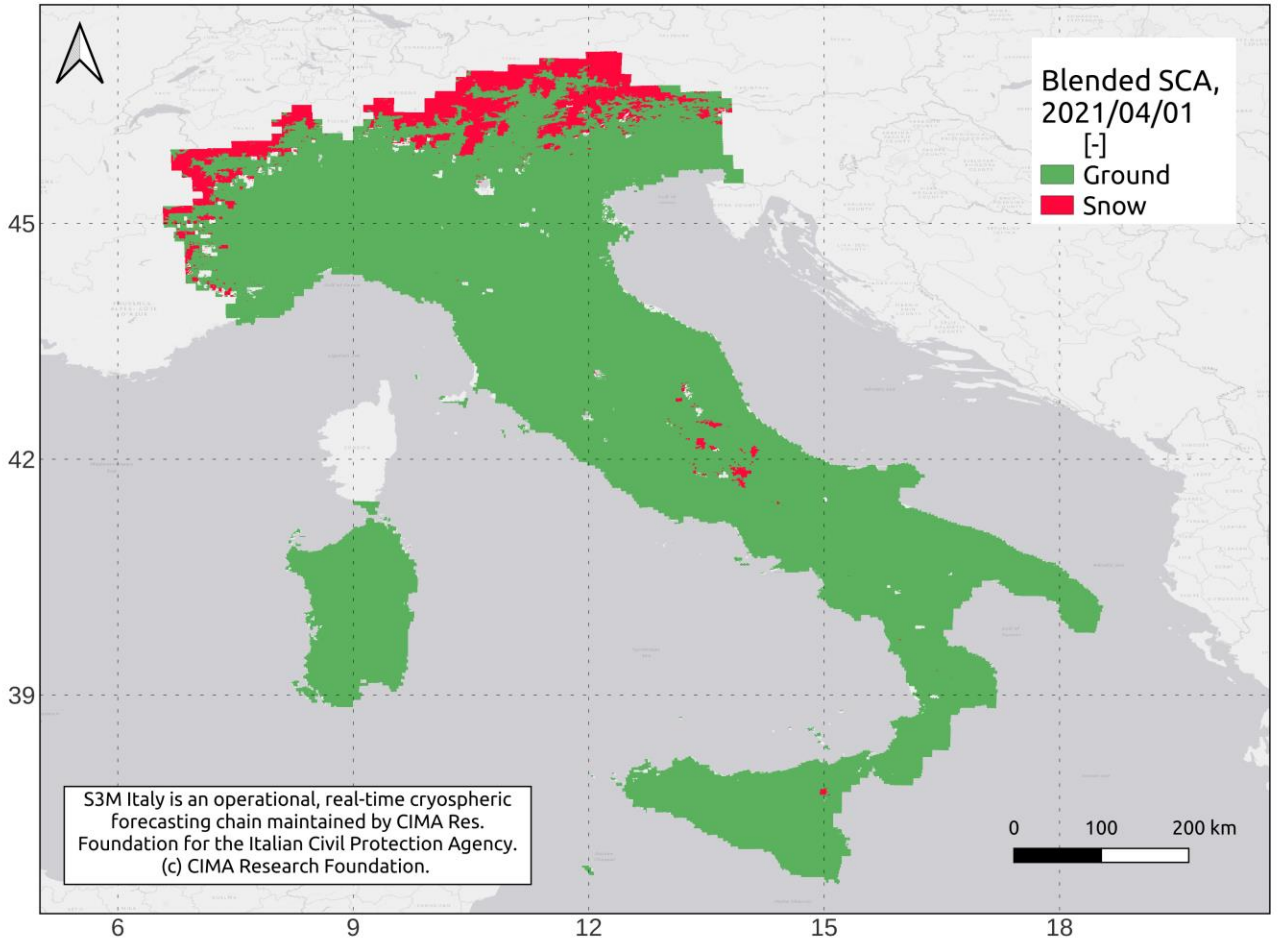
Third guess: **H10** as, again, a filler for remaining NaN pixels



H10 & a real-world forecasting chain: S3M Italy

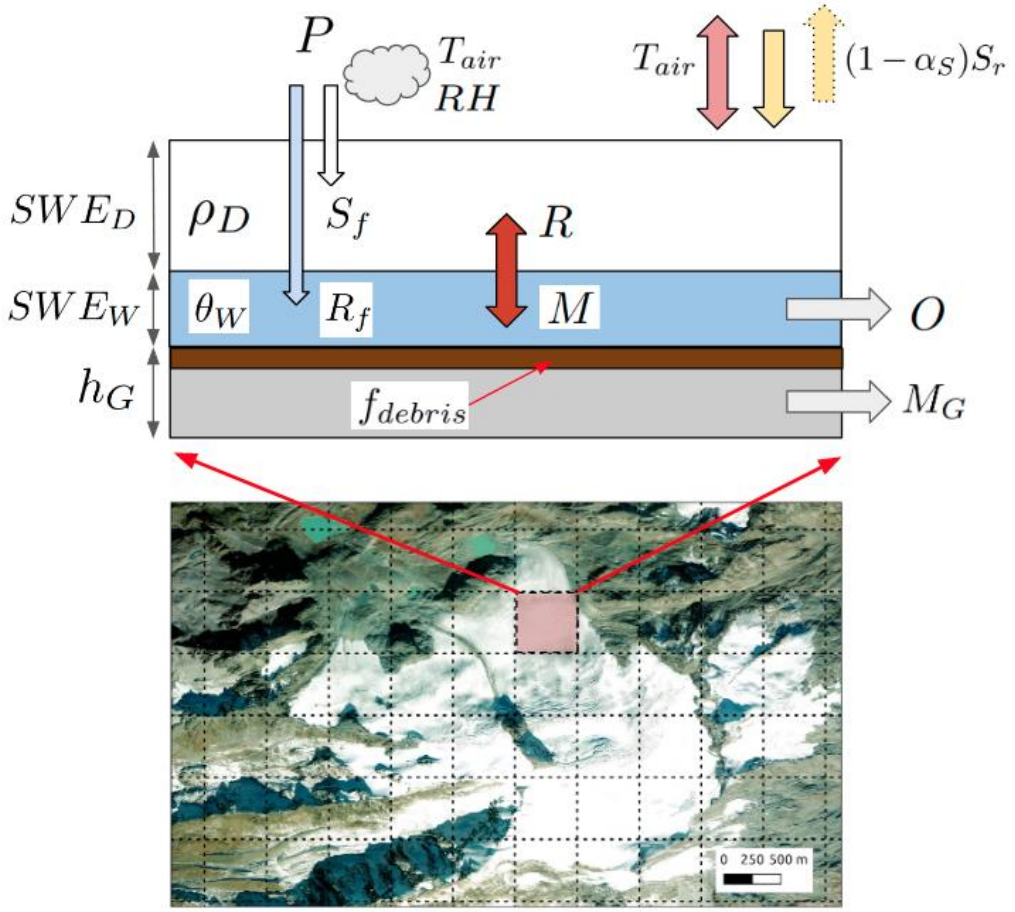
For the scope of this example:

First guess: H10



H10 & a real-world forecasting chain: S3M Italy

- *Dry and wet snow*
- *Snow settling*
- *Melt & Refreeze*
- *Snow (simplified) hydraulics*
- *Snowmelt based on a T-index approach with a separate component for incoming shortwave radiation*
- *Phase separation based on T air & Rel. Humidity*
- *Aging & Albedo*

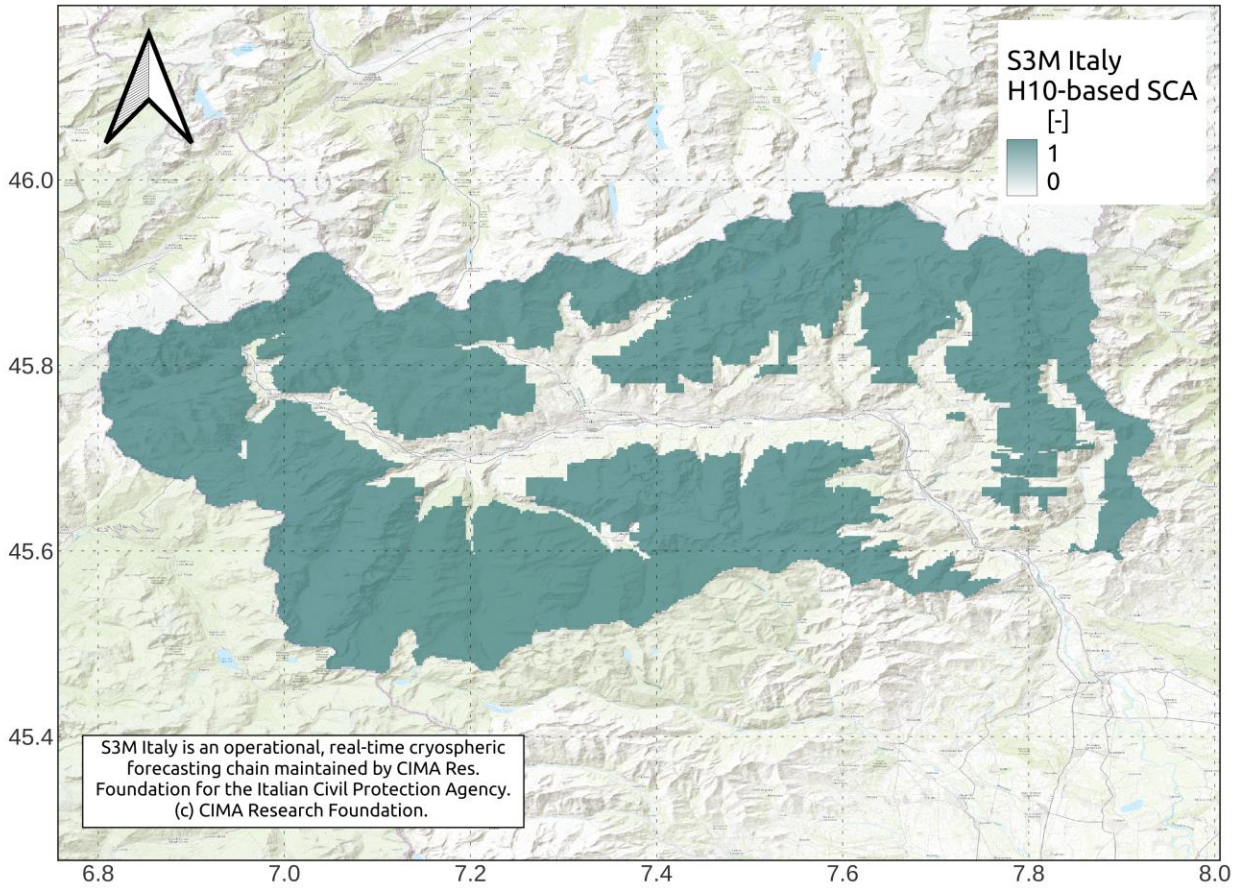


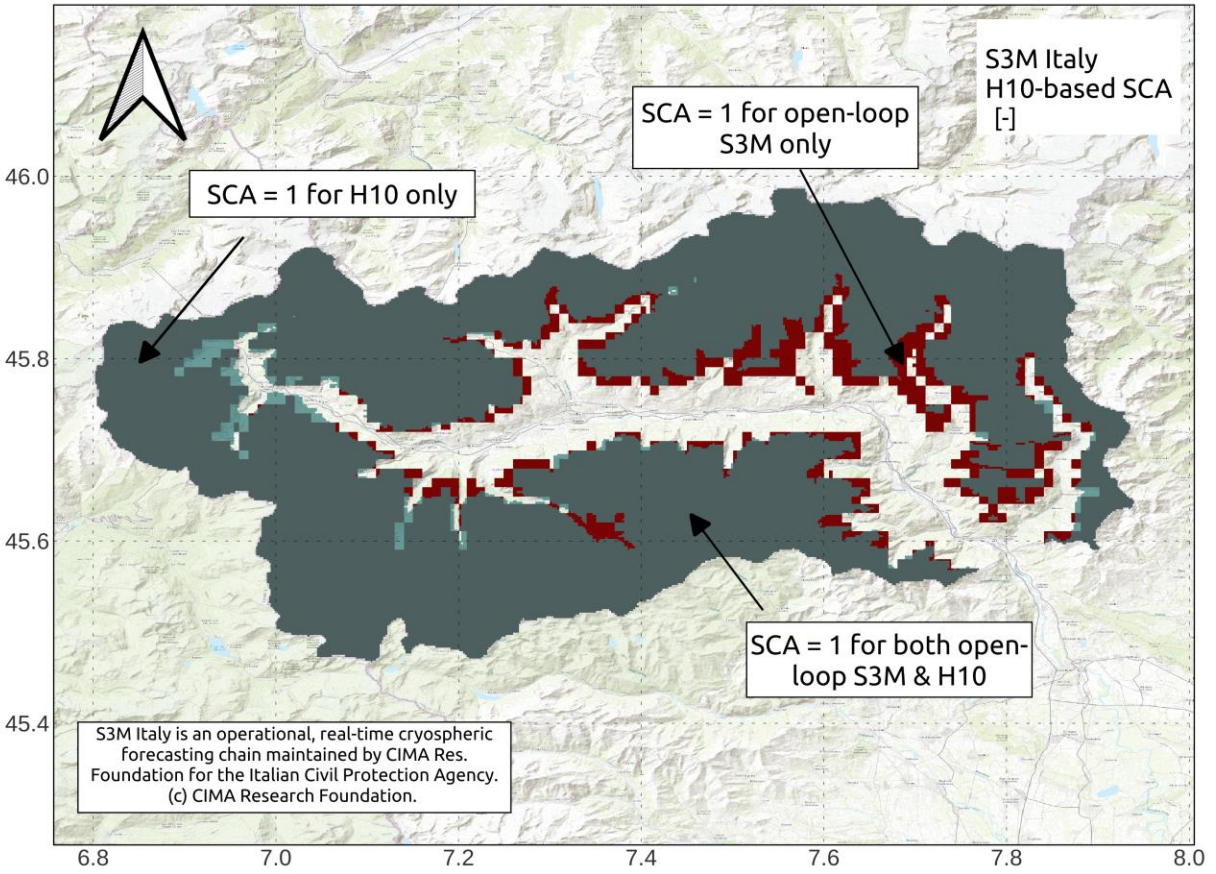
S3M 5.1: a distributed cryospheric model with dry and wet snow, data assimilation, glacier mass balance, and debris-driven melt

Geoscientific Model Development

GitHub

Some example outputs





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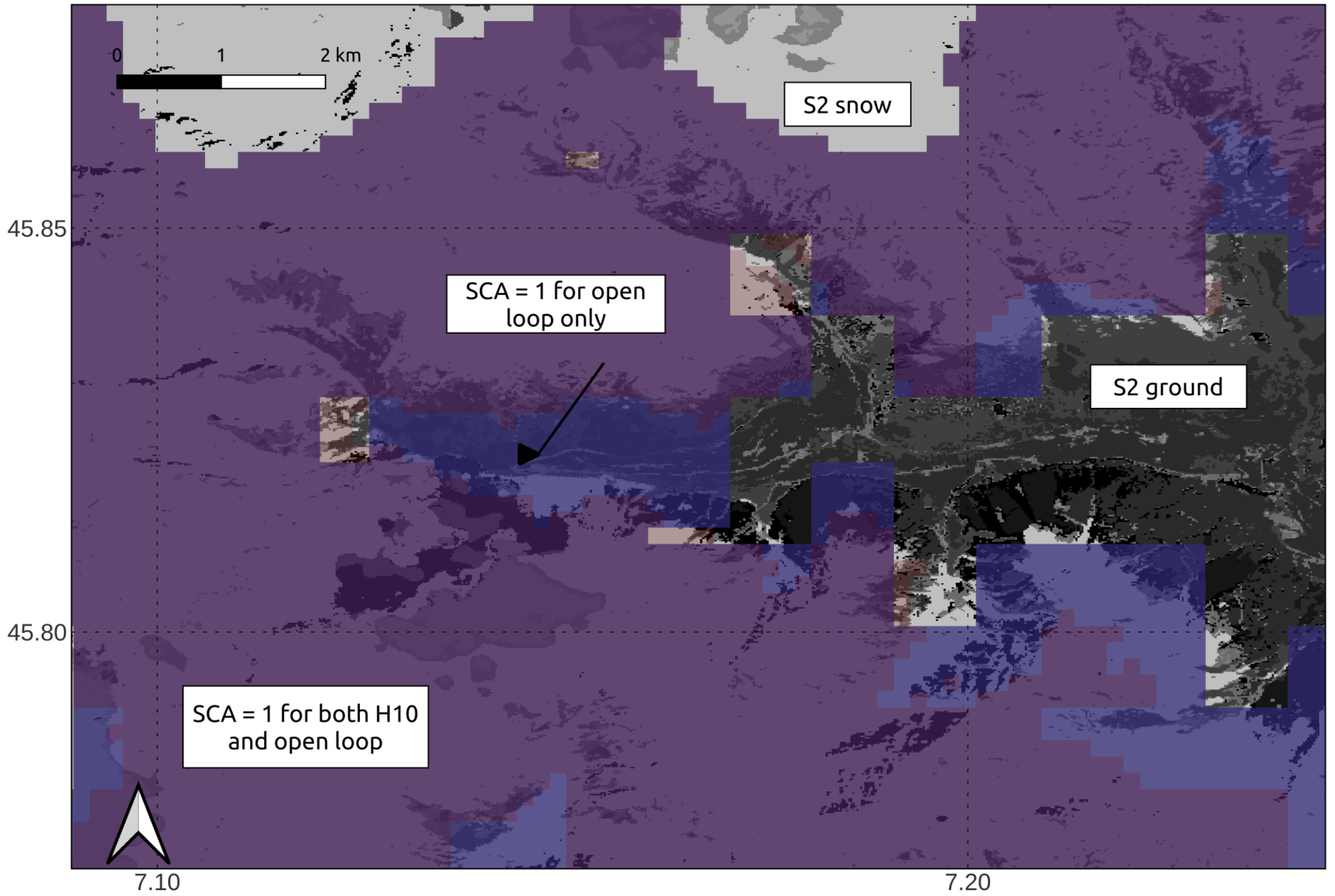
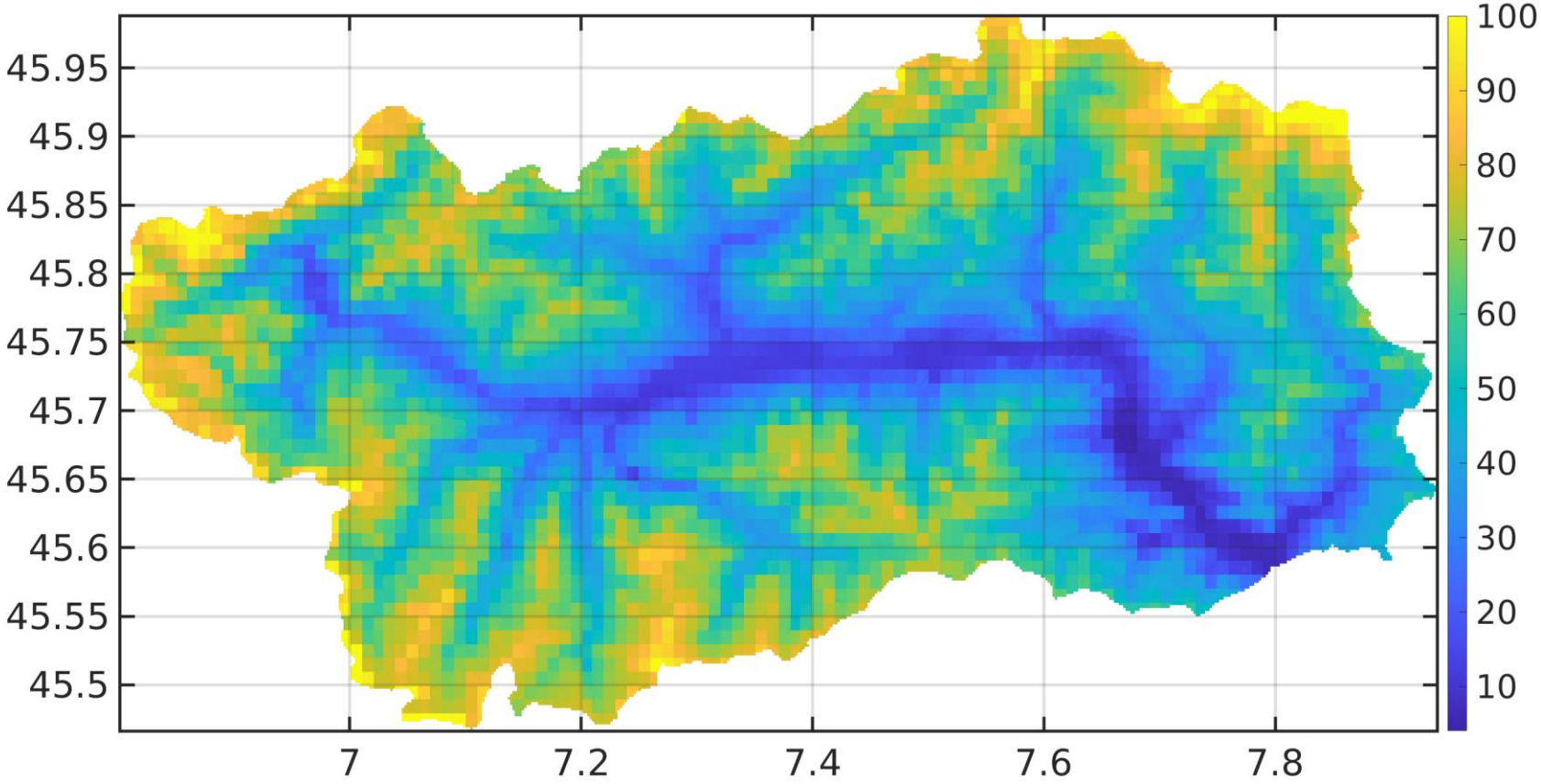
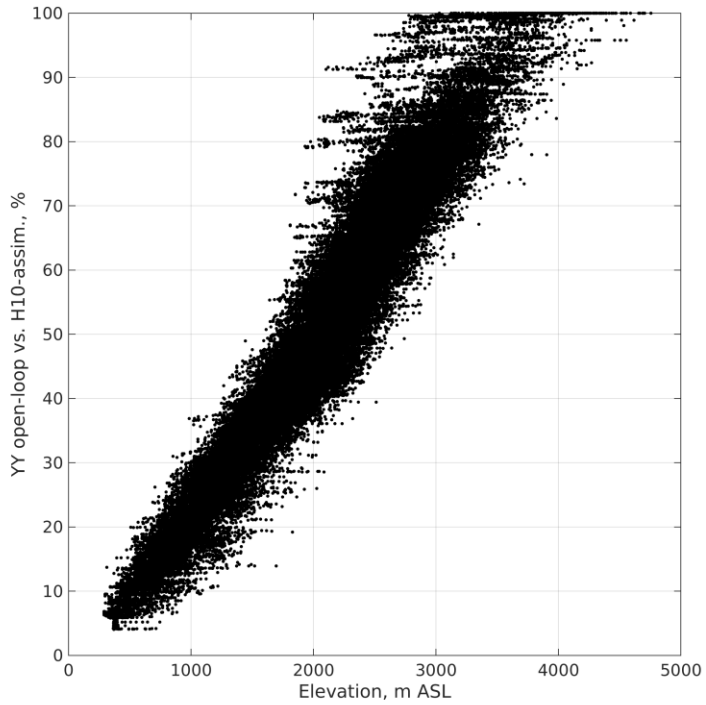


Open-loop vs. H10-assim.: % of positive agreement (YY)
Period: September 2019 – August 2021

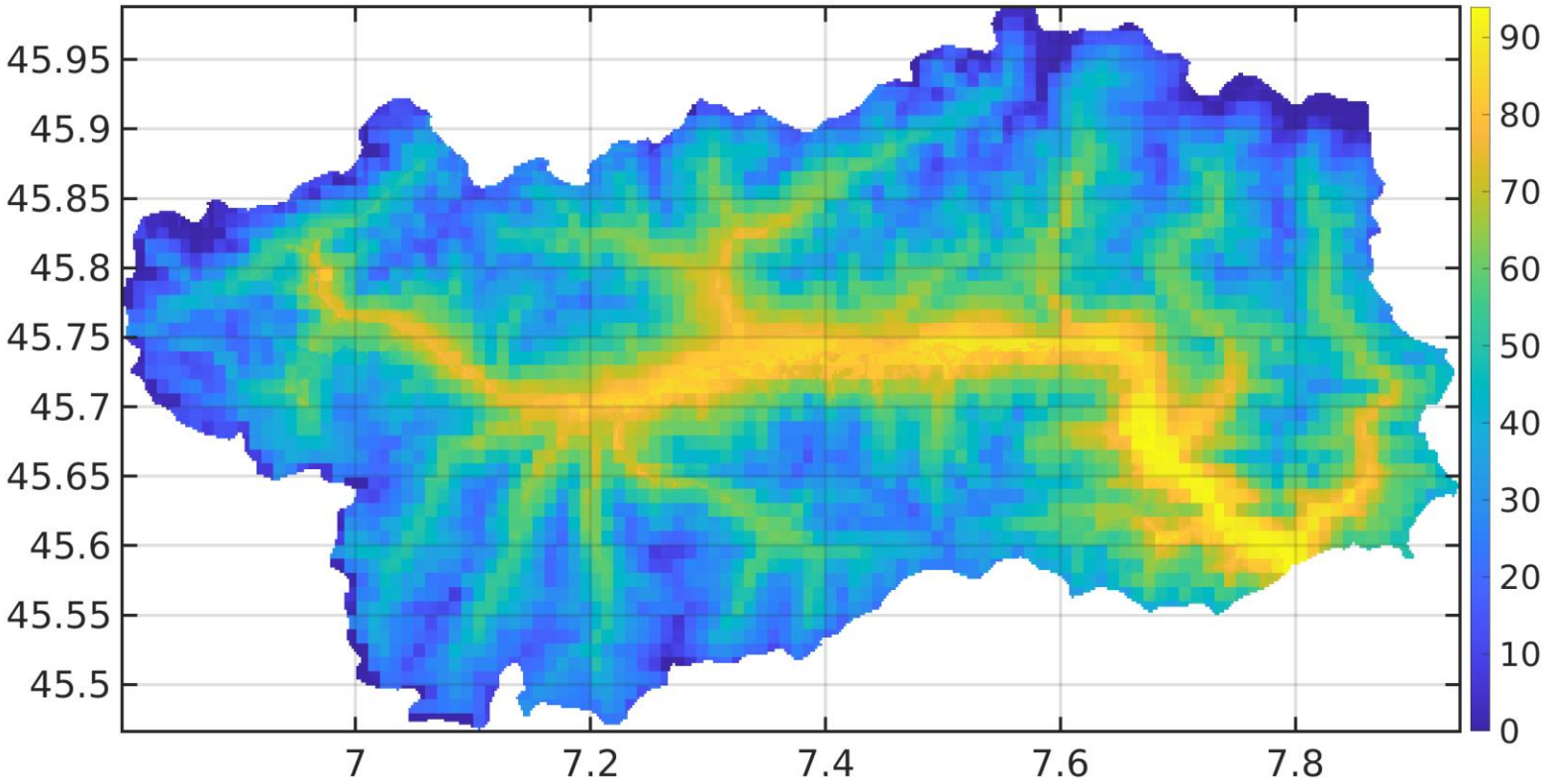


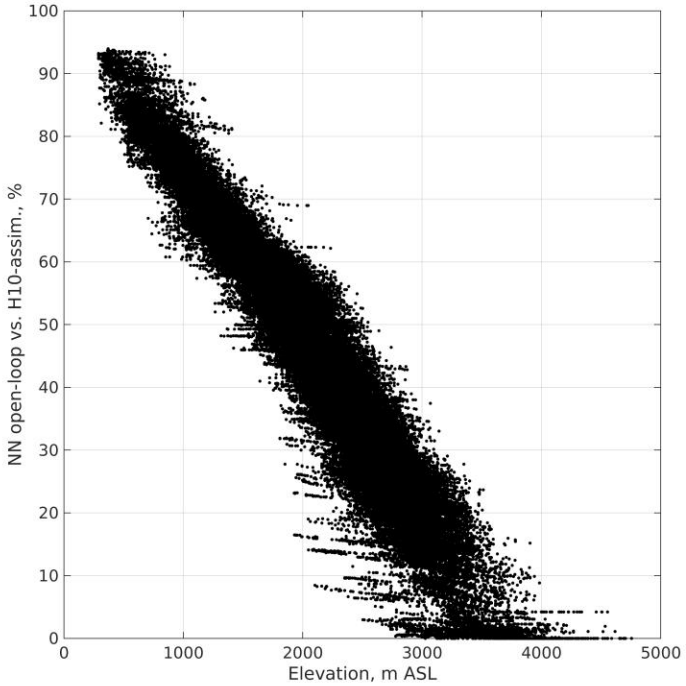


Agreement between an open-loop and a H10-assimilated simulation increases with elevation…

Bottom line: assimilation particularly important at low-to-mid elevations!

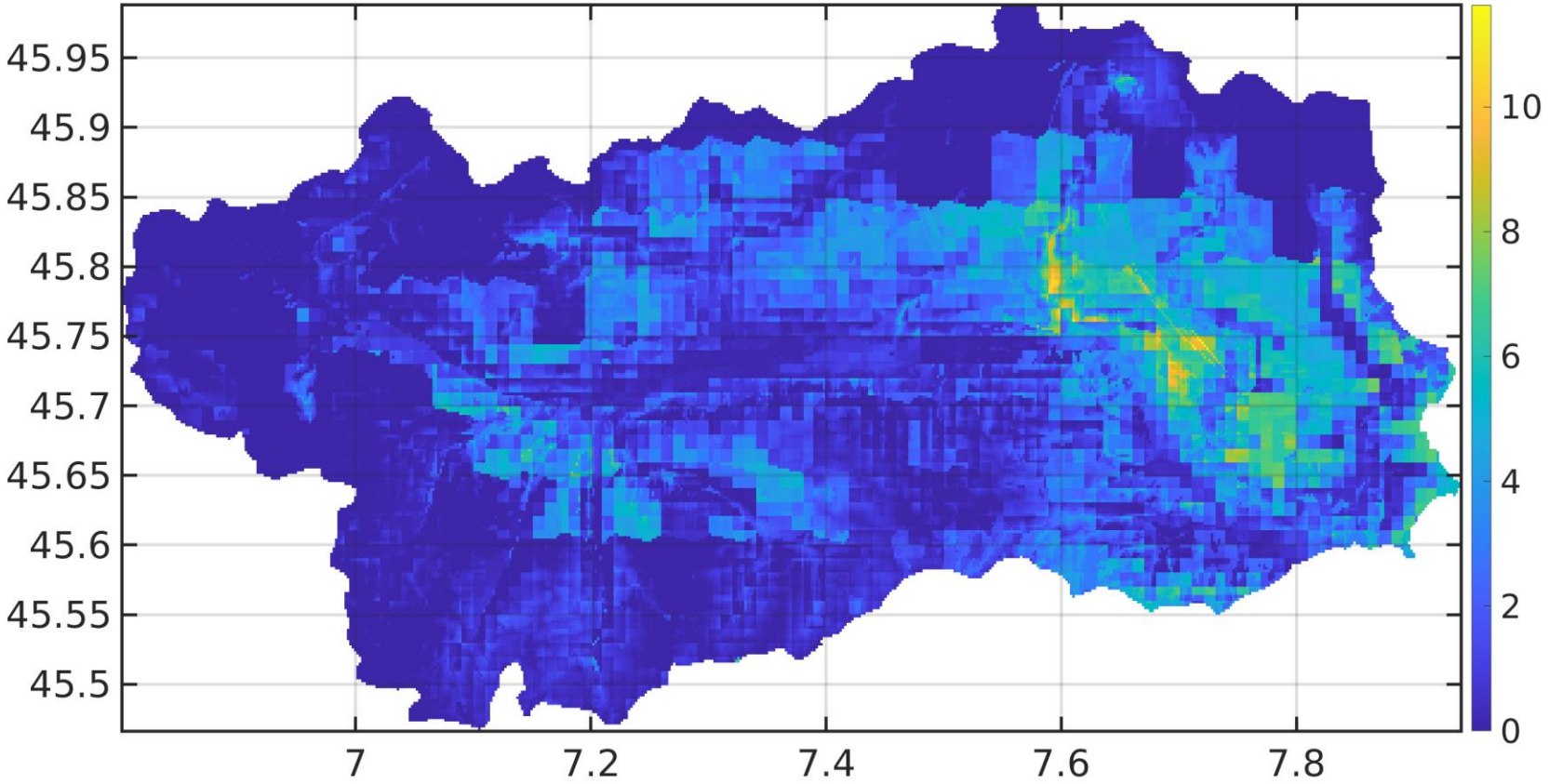
Open-loop vs. H10-assim.: % of negative agreement (NN)
Period: September 2019 – August 2021

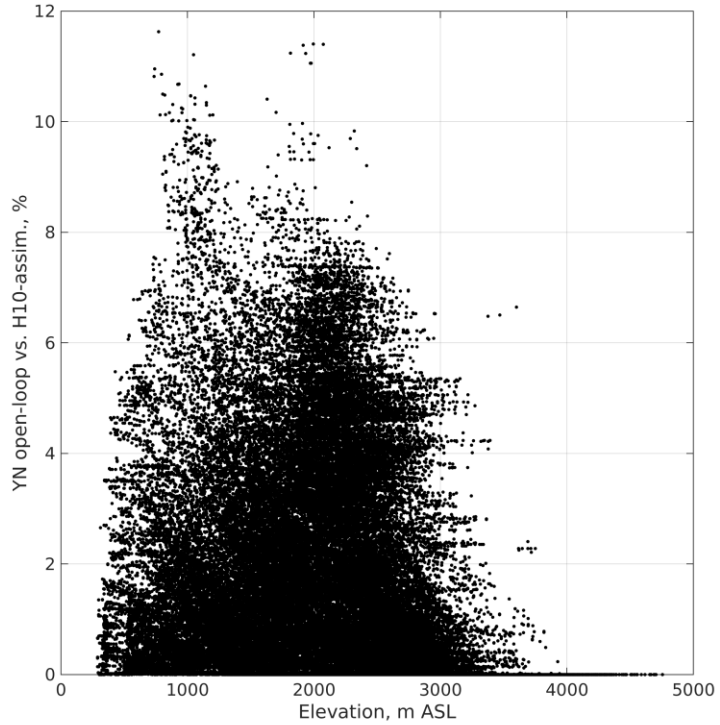




Opposite trend, same bottom line: assimilation particularly important at low-to-mid elevations!

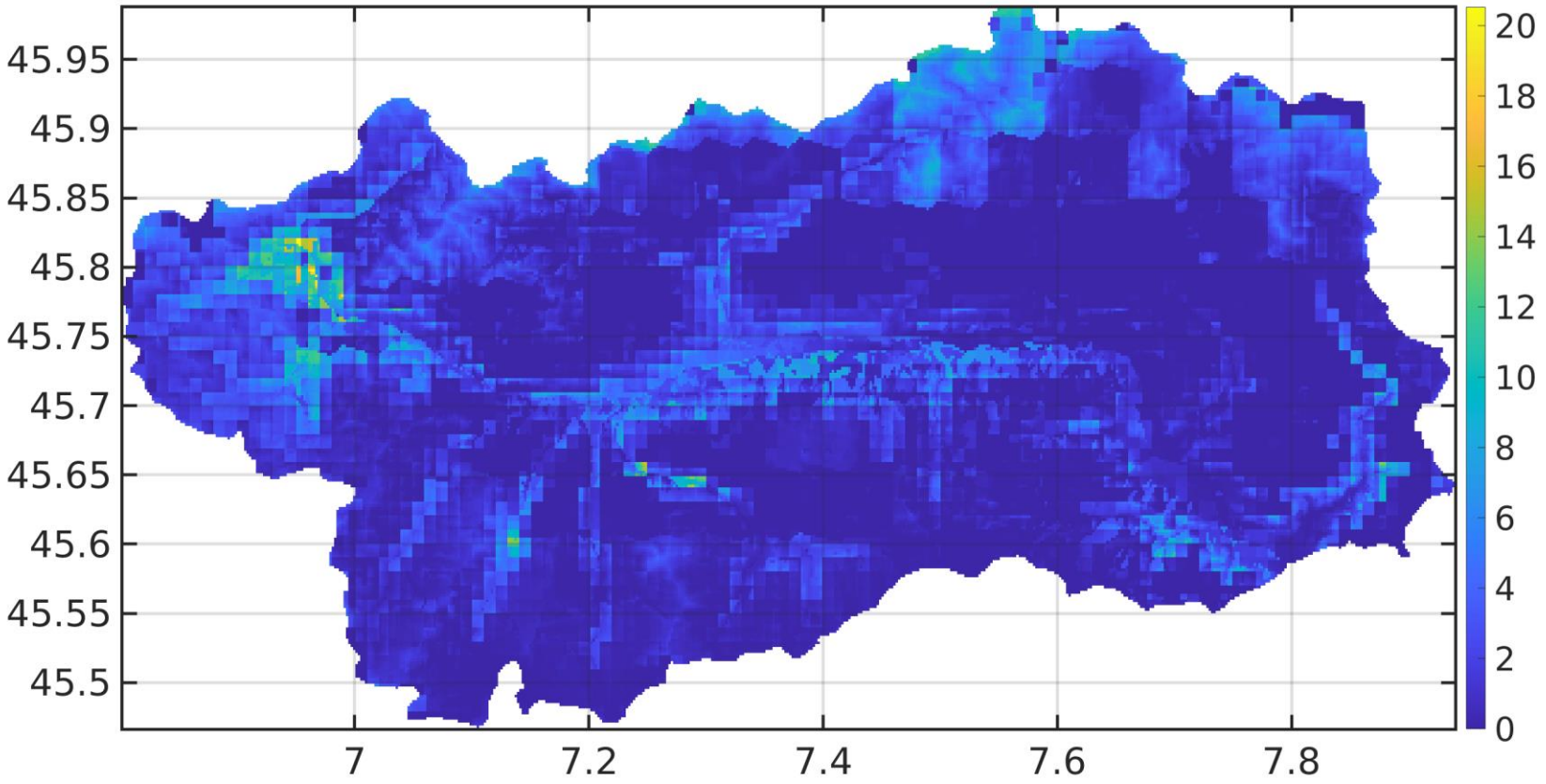
Open-loop vs. H10-assim.: % of disagreement (YN)
Period: September 2019 – August 2021

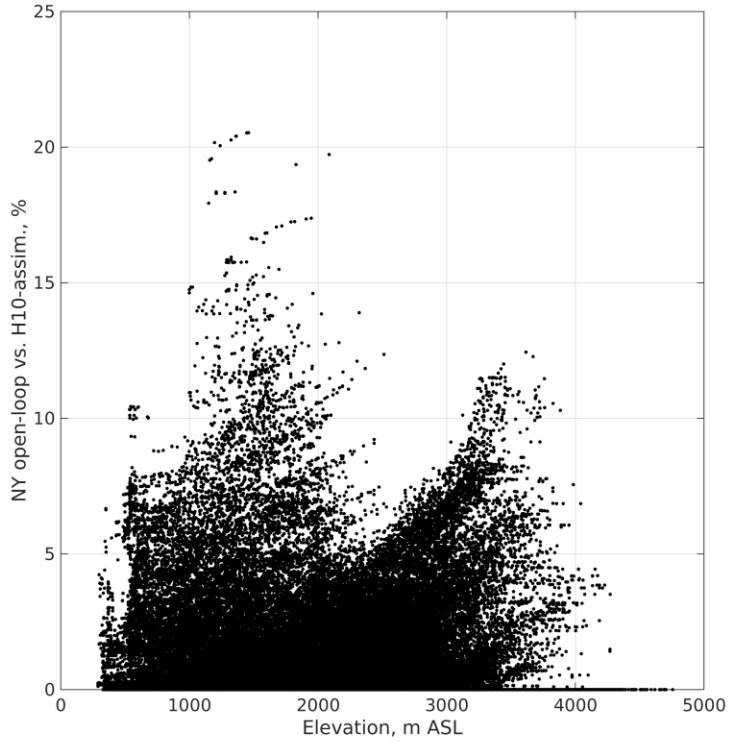




Instances of disagreement are particularly frequent at low & medium elevation, as expected!

Open-loop vs. H10-assim.: % of disagreement (NY)
Period: September 2019 – August 2021





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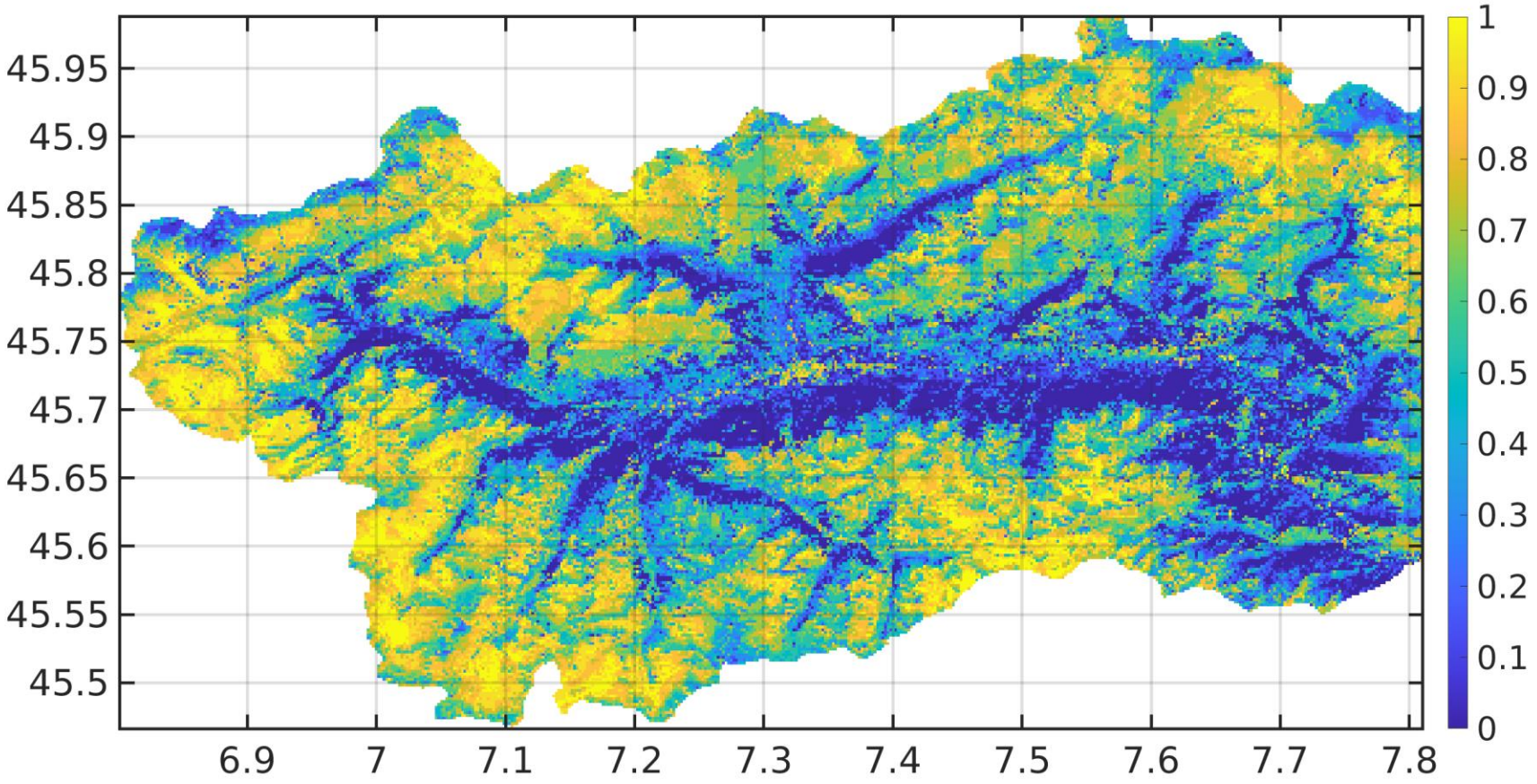
H10-assim vs. Sentinel 2
13 images, 2019-20, less than 20% clouds, tile 32TLR



Comparatively high accuracy of H10-assimilated simulations vs. Sentinel 2 images!

H10-assim vs. Sentinel 2
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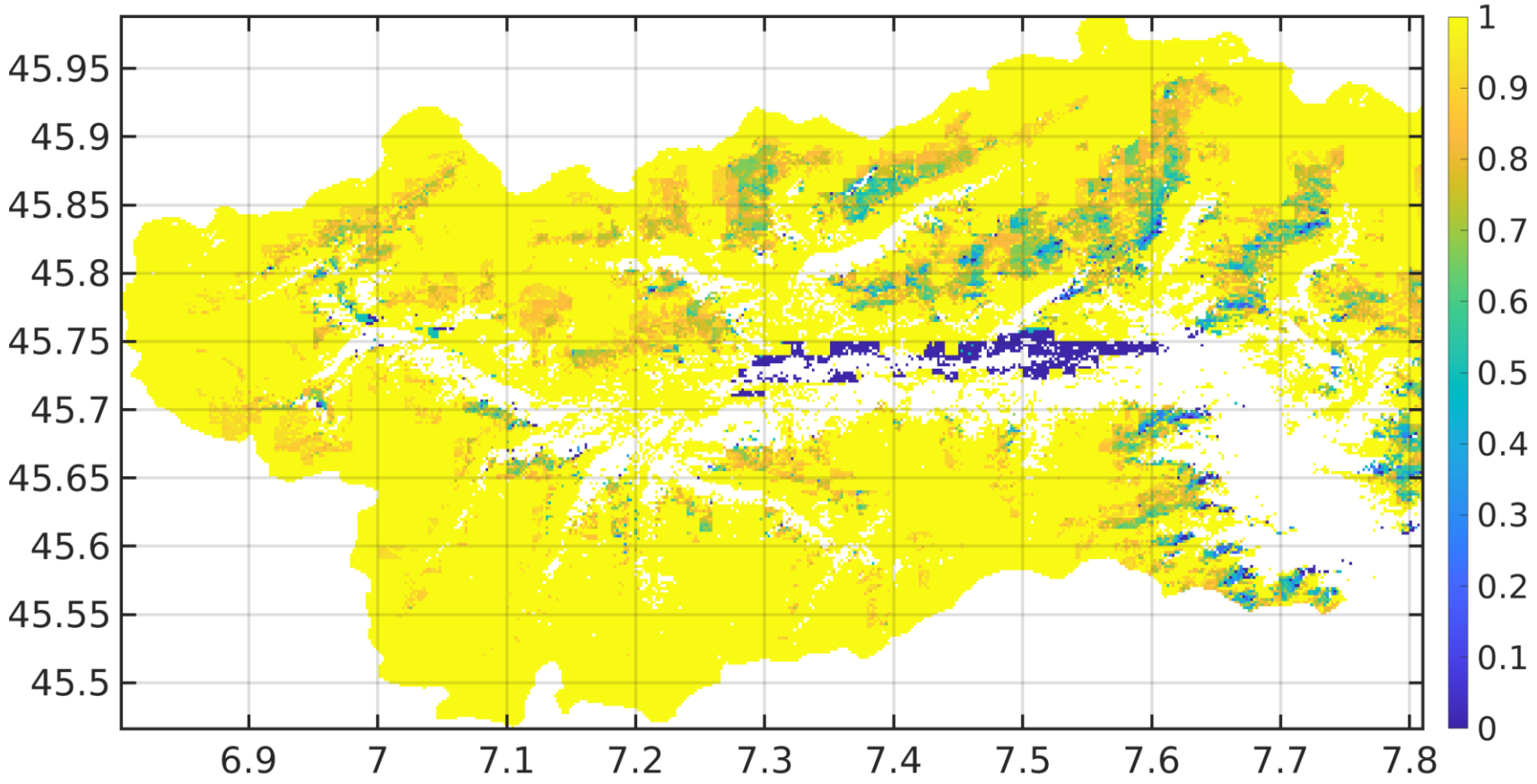
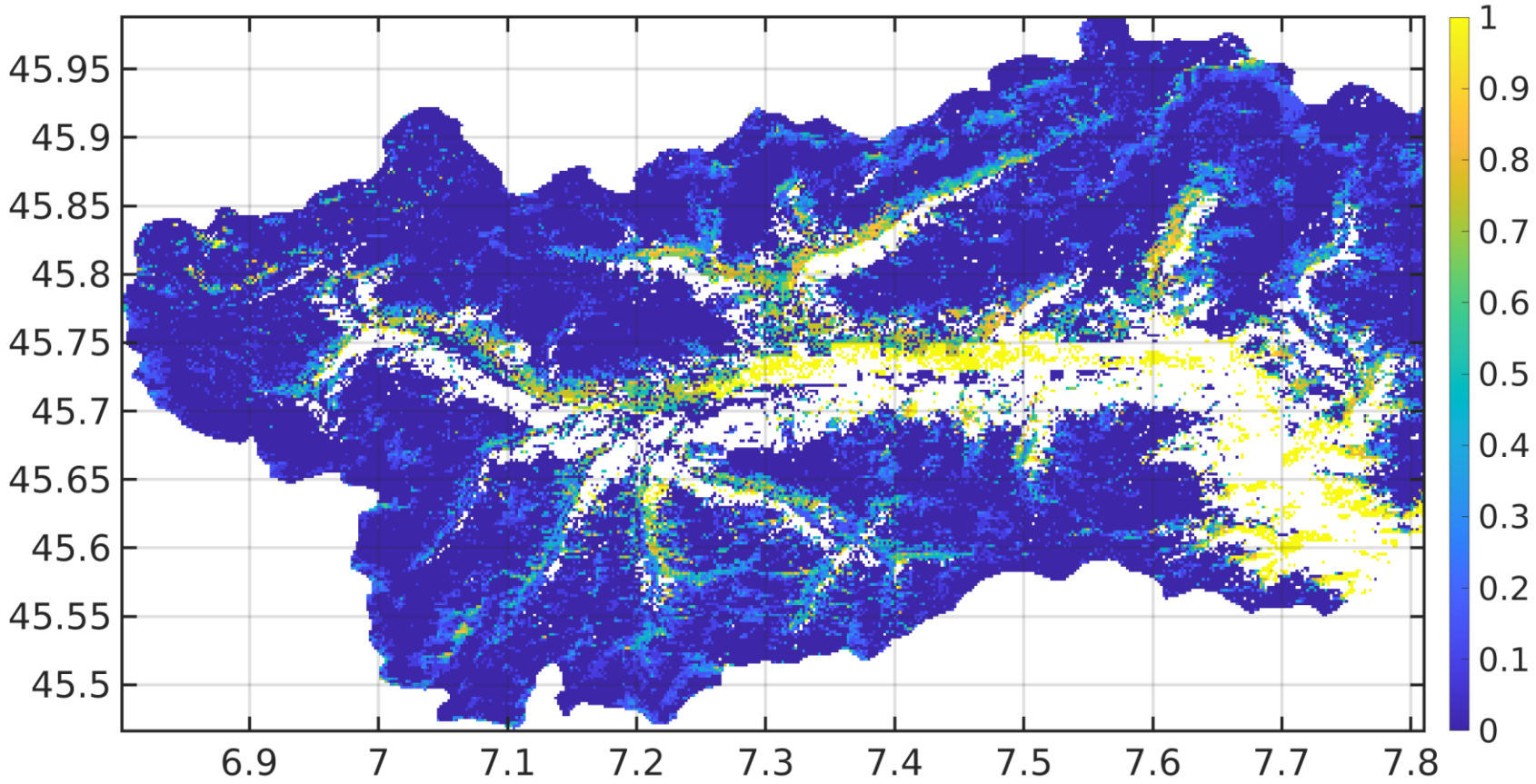


The probability of detection increases with elevation, with a decline in mid-elevation regions that might present high forest density.

Open-loop vs. H10-assim vs. Sentinel 2
13 images, 2019-20, less than 20% clouds, tile 32TLR



The False Alarm Ratio of H10-assimilated maps vs. Sentinel 2 is comparatively low across the whole study region.

Open-loop vs. H10-assim vs. Sentinel 2
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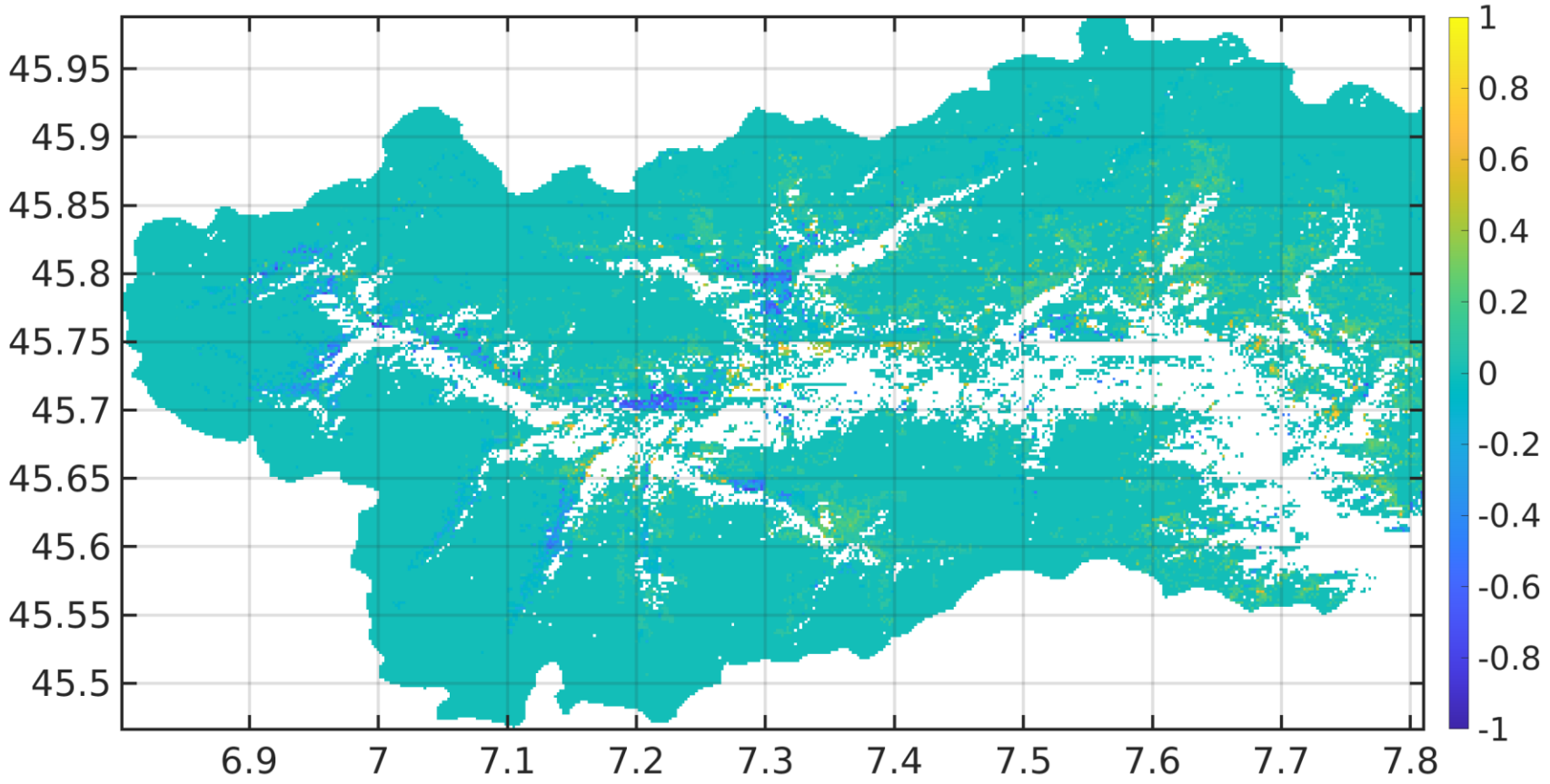

Differences in False Alarm between an open loop and an assimilated simulation are large at the snow transition line.

Three take-home messages

HSAF snow products answer recurring questions in operational snow hydrology and so support real-world decision making.

HSAF snow products are timely, and as such we are using them in forecasting chains with national relevance.

Optionally blended with other satellite products, HSAF snow products help delineating the snow line and so monitor snow presence at the critically important snow transition zone.