Snow depth derived from Sentinel-1 compared to in-situ observations in northern Finland

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image by: Aleksi Rimali

Introduction:

Why to explore seasonal snow in northern Finland?

- Snow variations plays an important role in the northern regions, providing:

Water resources:

Consumption

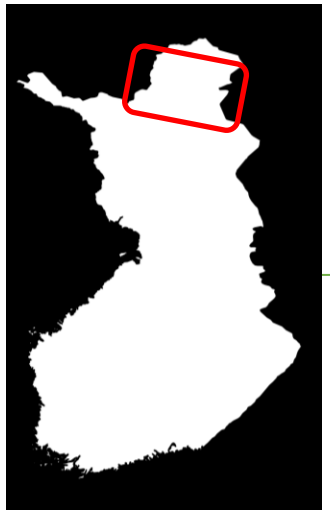
Hydropower generation

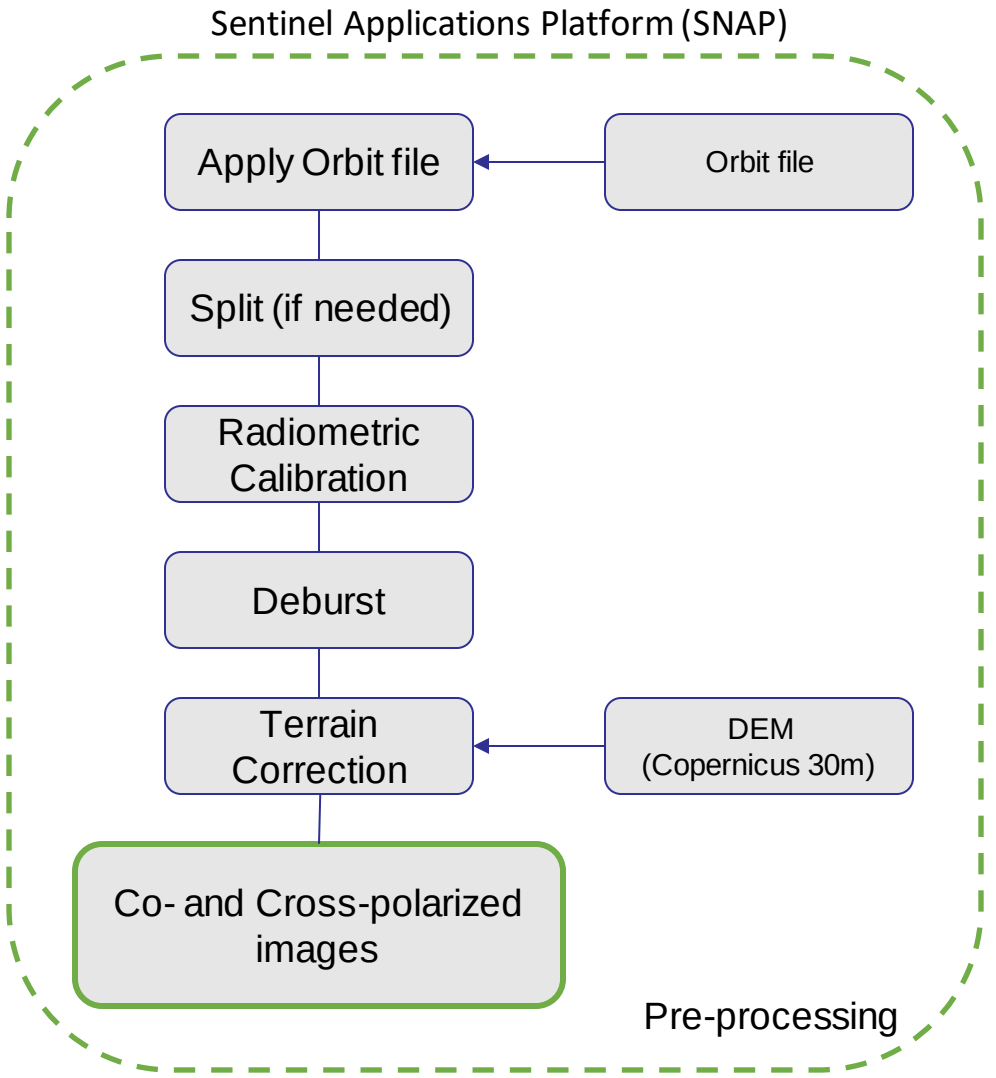
- Snow depth can exceed 1 m, impacting:
  - Local agriculture;
  - Vegetation;
  - Tourism;
  - Recreational activities

Data and methodology used:

Sentinel-1 SAR images (2019−2022):

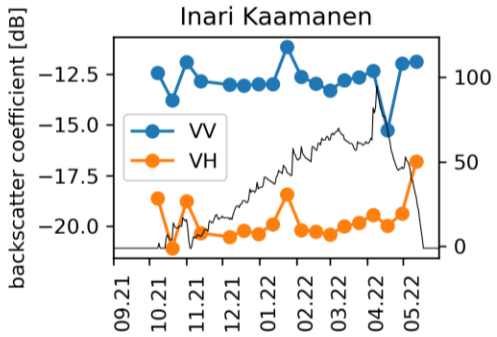
S1 images	Number of images
2019-2020 (Oct-May)	20
2020-2021 (Oct-May)	20
2021-2022 (Oct-May)	18

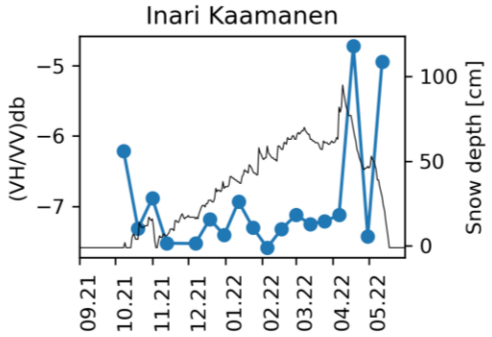




Data and methodology used:

- σ°_{vh} and σ°_{vv}



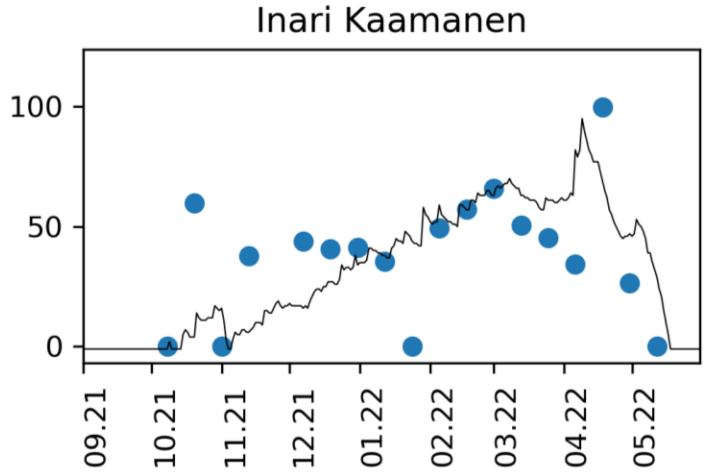


$$SD_{(t_i)} = SD_{(t_{i-1})} + [(\sigma^0_{vh} / \sigma^0_{vv})_{(t_i)} - (\sigma^0_{vh} / \sigma^0_{vv})_{(t_{i-1})}]$$

$$(\text{If, } SD_{(t_i)} < 0 \rightarrow SD_{(t_i)} = 0)$$

(Lievens et al., 2019)

2021-2022



Average snow depth estimates from Sentinel-1

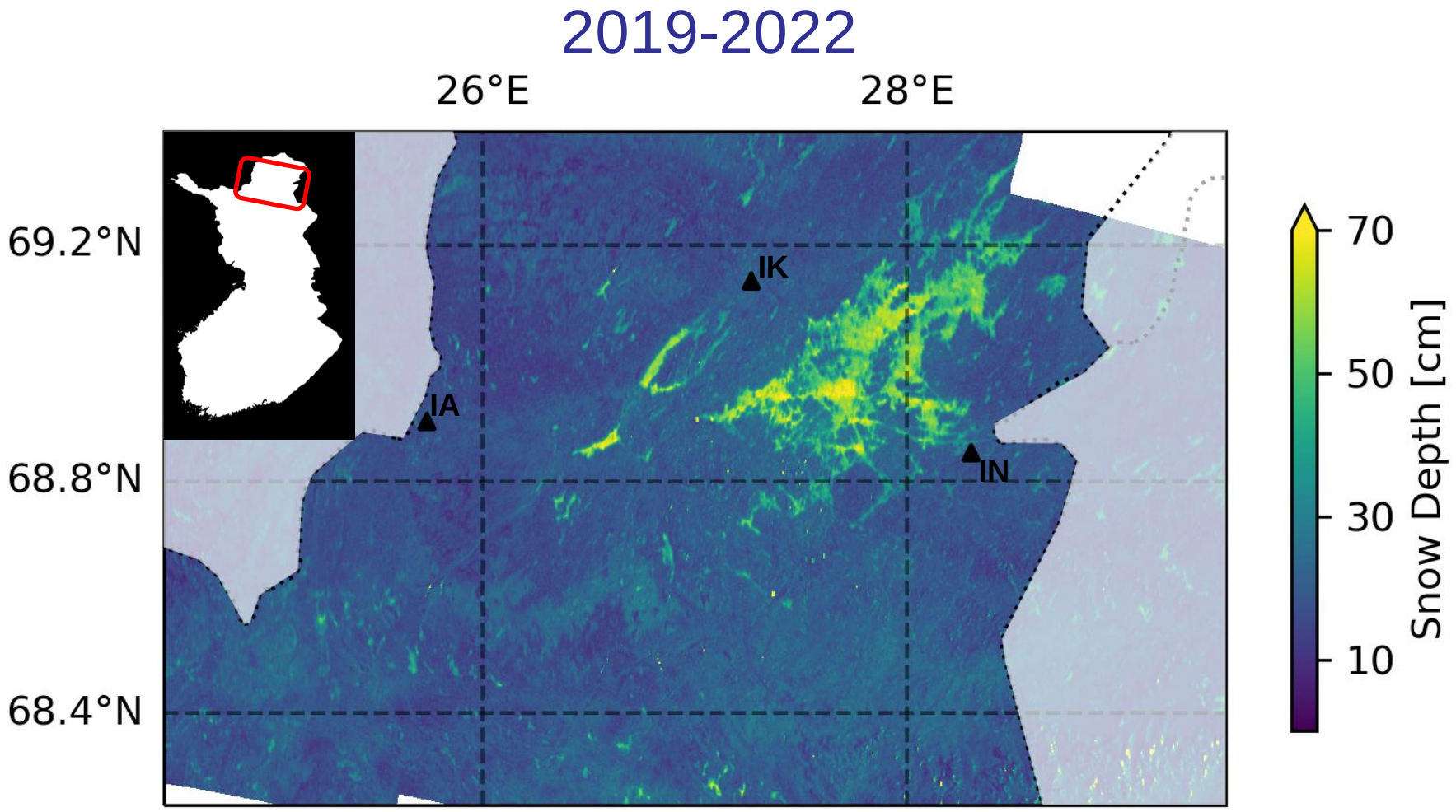


Figure 1: Average snow depth estimated from Sentinel-1 of the seasons 2019-2022 (between October and March). Black triangles indicate the automatic weather stations locations; Inari Nellim (IN), Kaamanen (IK), and Angeli Lintupuoliselkä (IA), respectively. The inset figure shows the study region in Finland.

Average snow depth estimates from Sentinel-1

2019-2020 2020-2021 2021-2022

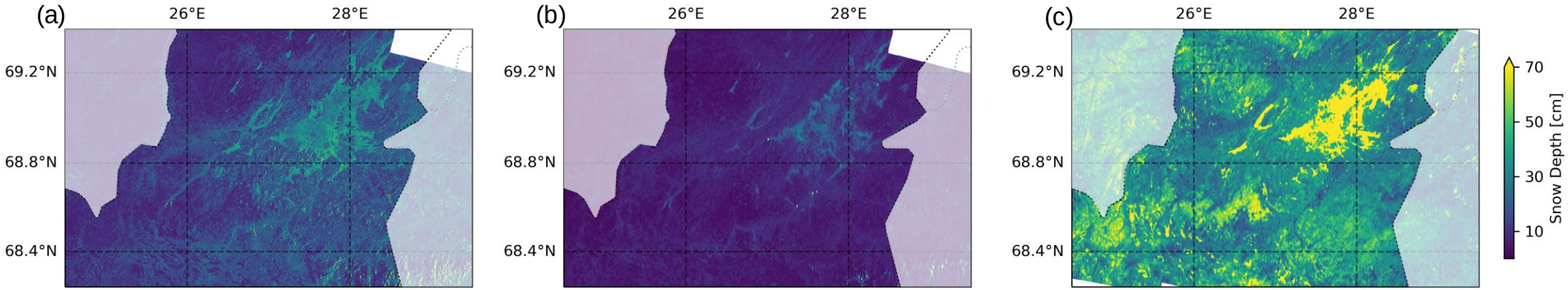


Figure 2: Average snow depth estimated from Sentinel-1 during the seasons of 2019-2020 (a), 2020-2021 (b), and 2021-2022 (c), respectively.

Maximum snow depth estimates from Sentinel-1

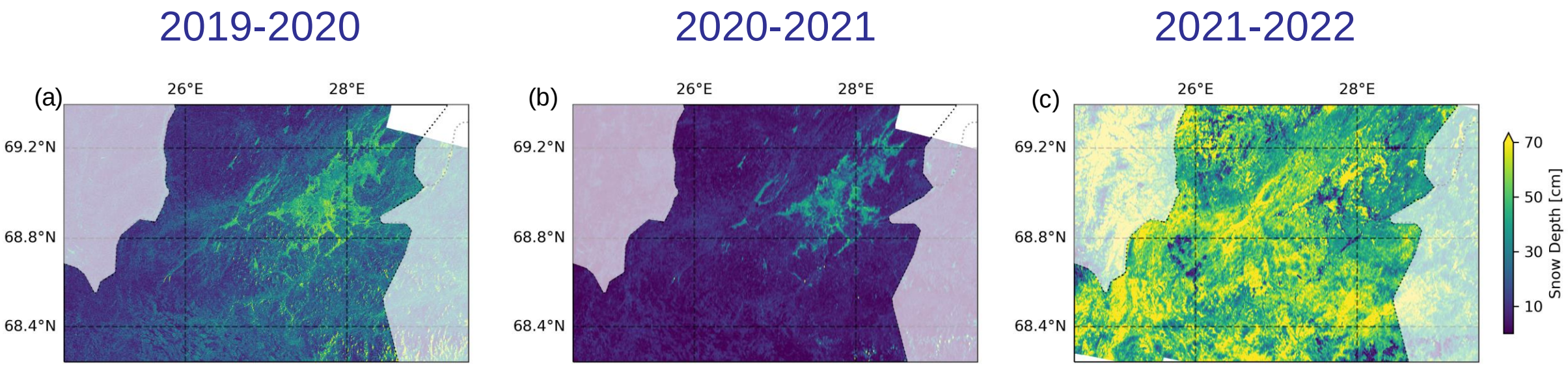


Figure 3: Maximum snow depth (March average) estimated from Sentinel-1 for each season of 2019-2020 (a), 2020-2021 (b), and 2021-2022 (c), respectively.

In Situ dataset vs S1

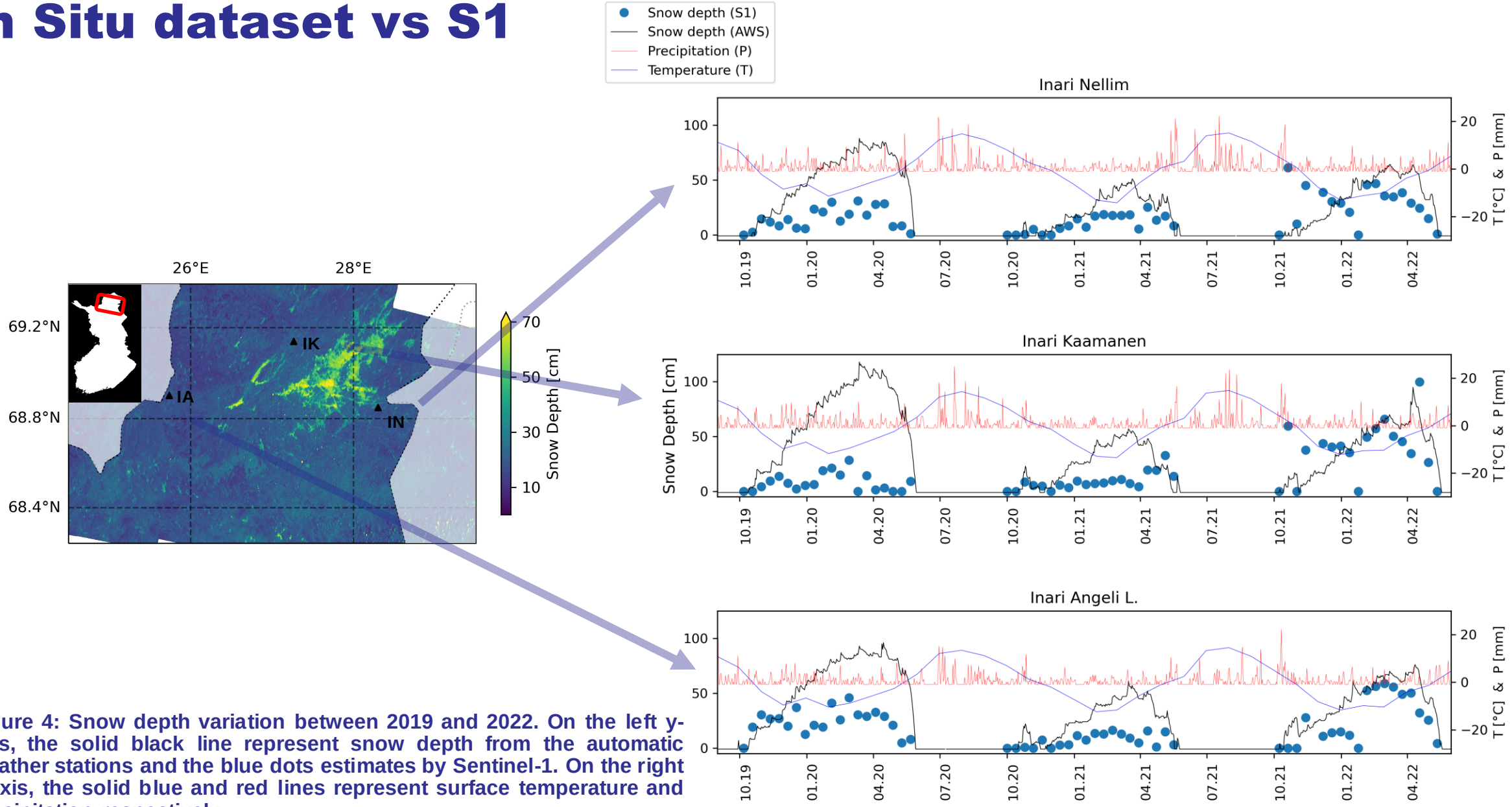


Figure 4: Snow depth variation between 2019 and 2022. On the left y-axis, the solid black line represent snow depth from the automatic weather stations and the blue dots estimates by Sentinel-1. On the right y-axis, the solid blue and red lines represent surface temperature and precipitation respectively.

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Datasets comparison

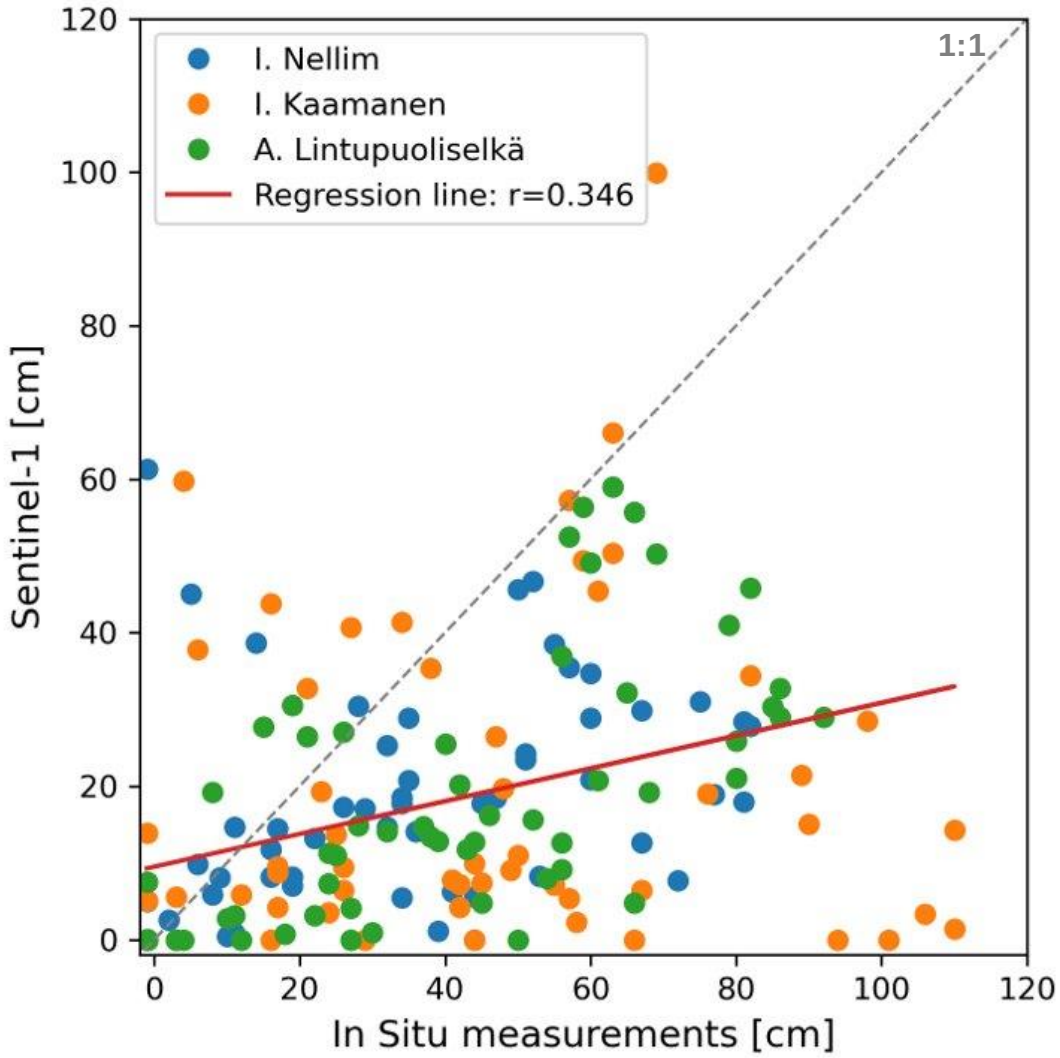

Figure 5: In situ measurements compared to Sentinel-1 estimative. Different colours represent the different automatic weather stations, and solid line represents linear regression for the entire dataset.

Datasets comparison

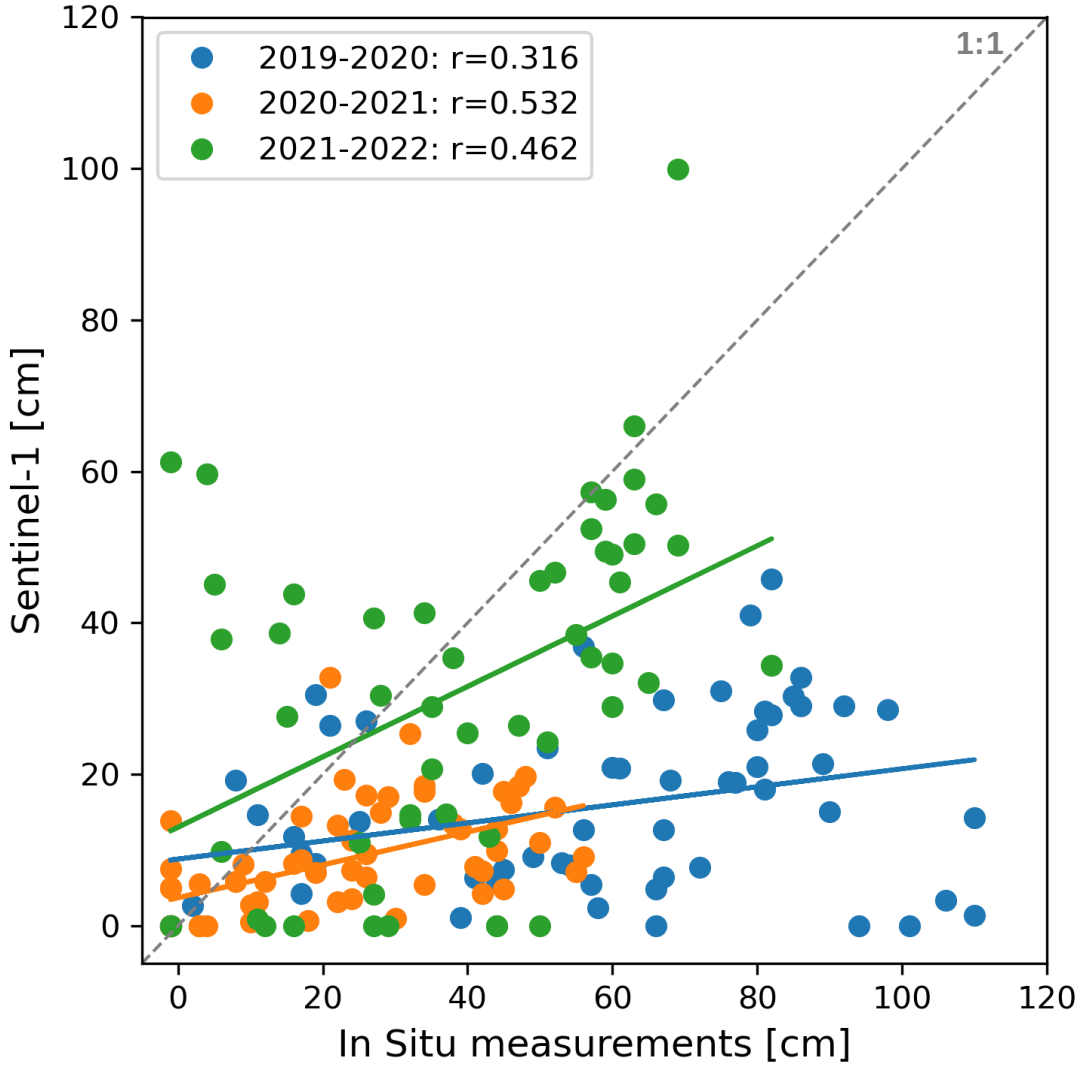

Figure 6: In situ measurements compared to Sentinel-1 estimative. Different colours represent different years, and solid lines represent linear regression for each year.

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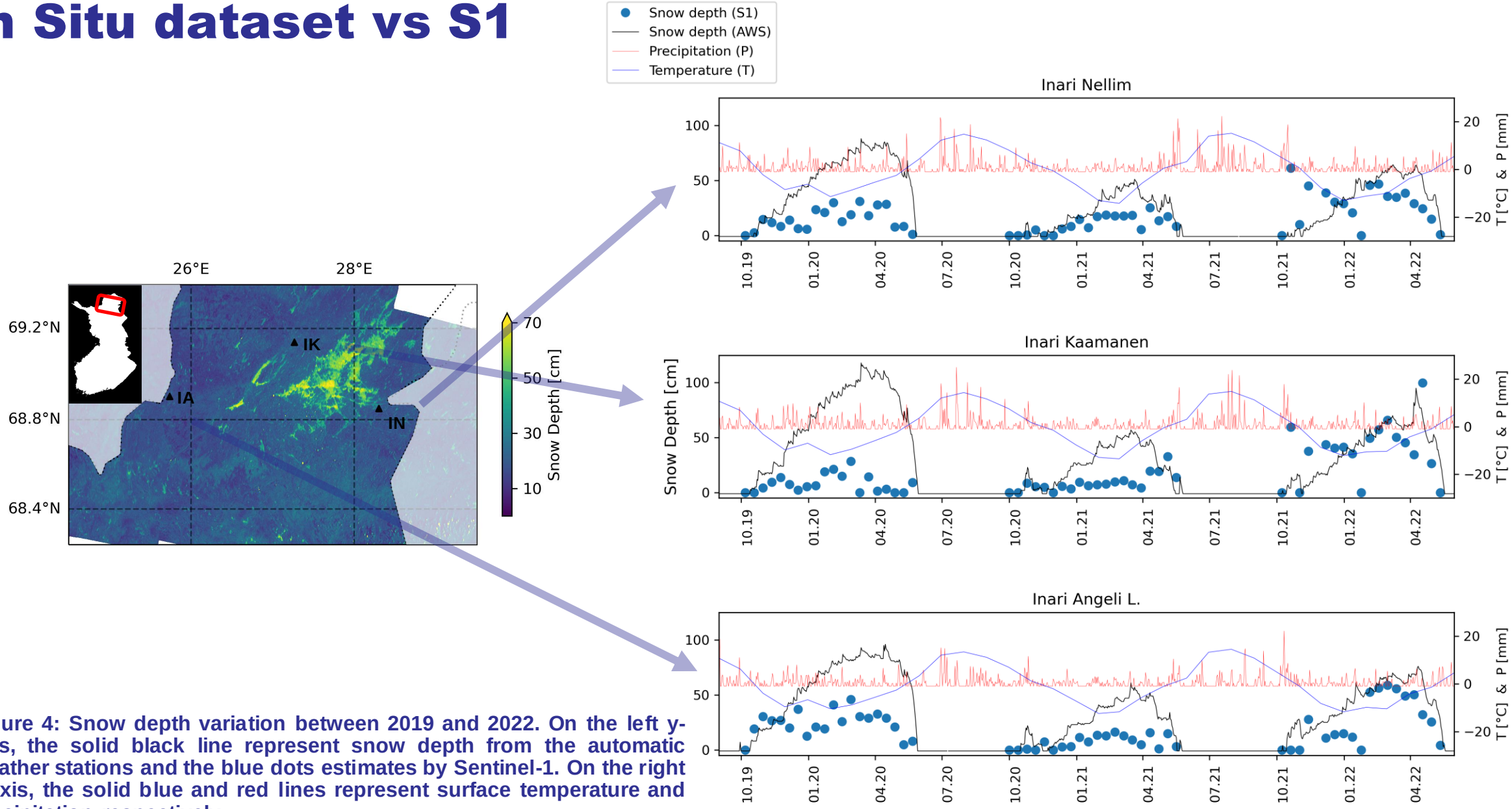
In Situ dataset vs S1



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