SnowSat-An AI approach towards efficient hydropower production

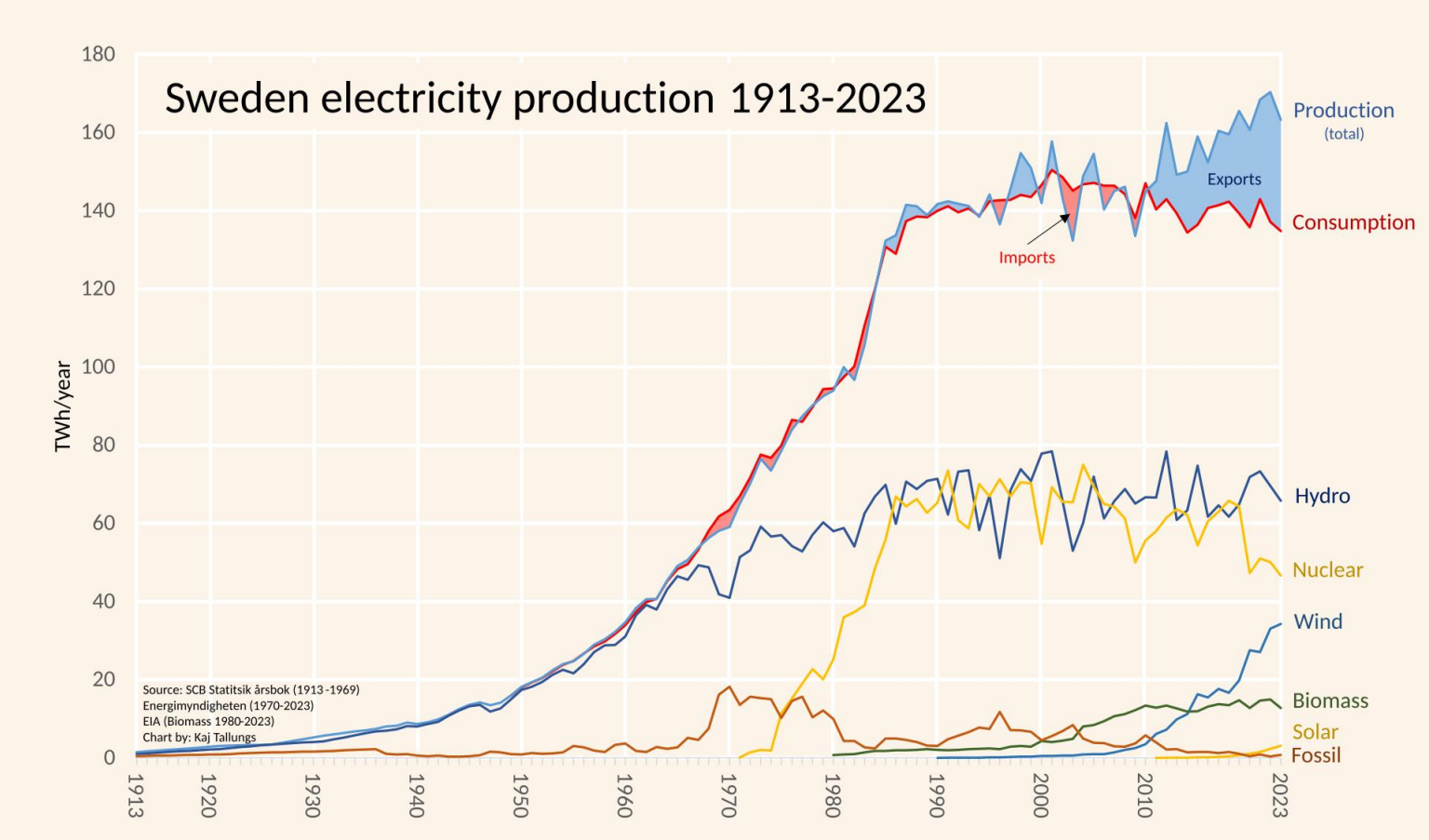
Jie Zhang, Björn Norell
on behalf of the SnowSat team

SnowSat is a Vinnova funded project led by Uppsala University (UU), and a collaboration among UU, Mälardalen University (MDU) and Vattenregleringsföretagen (VRF)

Project lead: Jie Zhang, jie.zhang@geo.uu.se
MDU lead: Pietro Elia Campana, pietro.campana@mdu.se
VRF lead: Björn Norell, bjorn.norell@vattenreglering.se

Background

- ❑ Hydropower is one of the top renewable sources in Sweden
- ❑ Swedish hydropower produces about 40% of national electric energy



Background

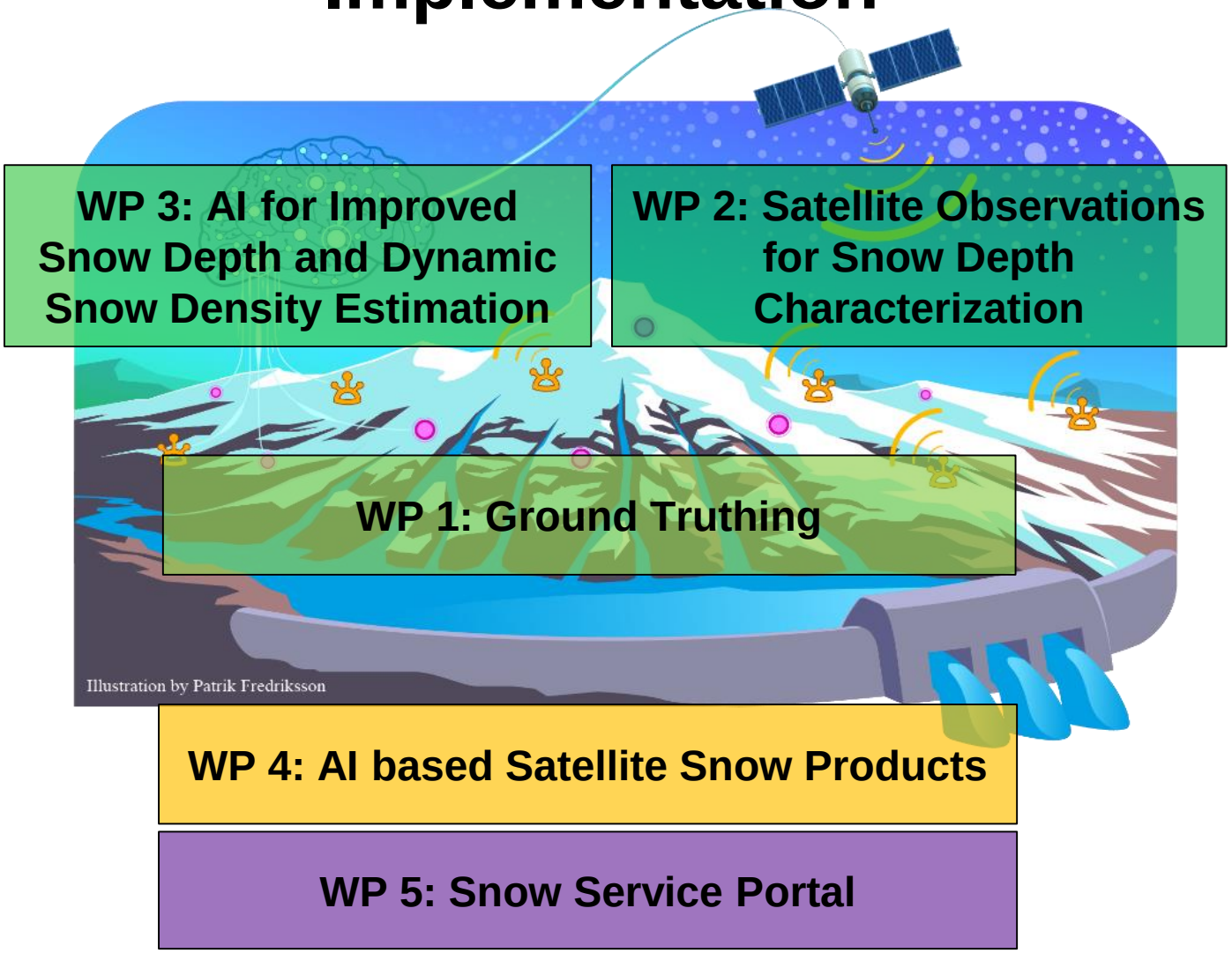
- Spatially distributed and temporally dynamic **snow information** are **highly valuable** for the **hydropower sector**
  - optimize production
  - avoid water spillage
  - ensure dam safety

- **Accurate depiction of snow amount** in the mountainous regions **remains a big challenge**
  - lack of ground monitoring network
  - large spatial heterogeneity
  - complex snow process

Goal

- Use **Artificial Intelligence (AI)** and **Internet-of-Things (IoT)** for improving the estimation of snow water storage in Sweden from **satellite observations**
- Improve management of the hydropower sector, increase hydropower production, and enhance preparedness to extreme weather events

Implementation

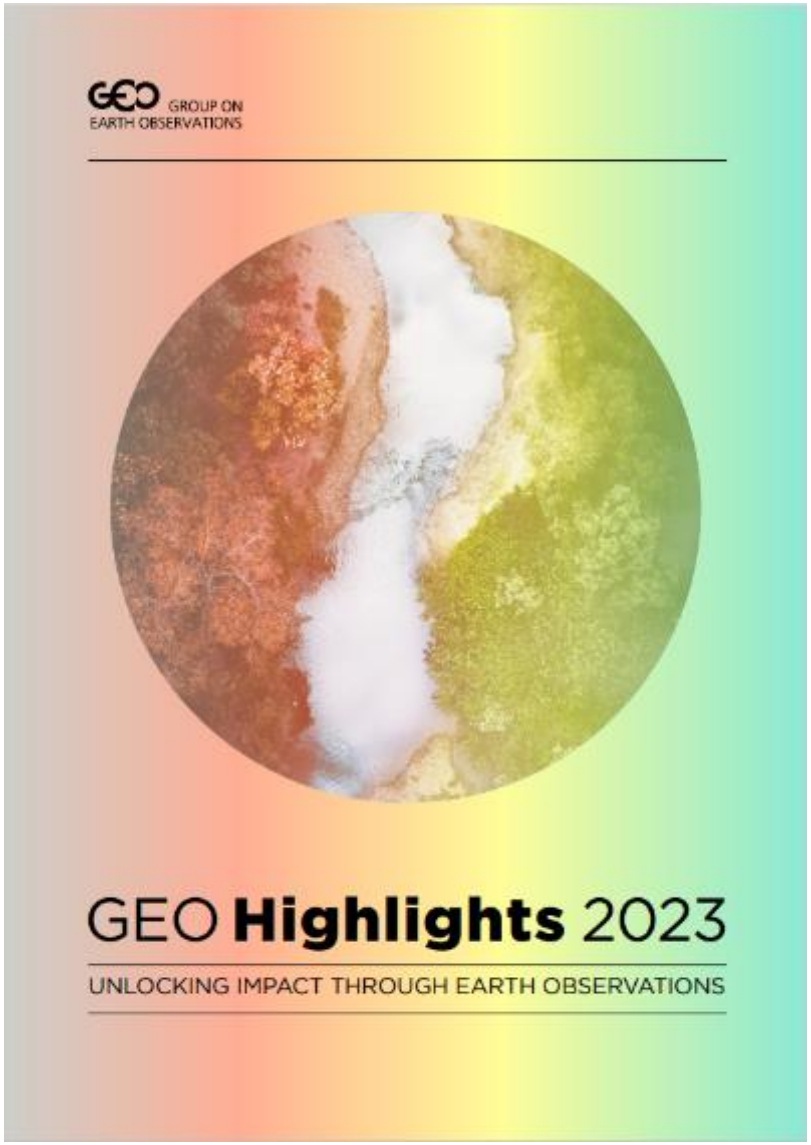


UU: Satellite observations, AI algorithms and snow product

MDU: IoT network, AI algorithms and snow portal prototype

VRF: Field measurements

GEO 2023 Highlights



An AI approach towards efficient hydropower production in Sweden

PROJECT:
Earth Observations Data for Water-Energy-Food Nexus

LOCATION:
Sweden

Snowmelt is a very important source for hydropower, which accounts for about 40% of the total electricity production in Sweden. One significant challenge in the hydropower sector is the water spills during snow-melting periods due to inaccurate quantification of the snow storage upstream of hydropower dams. This leads to significant losses of potential hydraulic energy. For instance, in 2015, water spills in Umeälven, a major hydropower producing river in Sweden, led to an economic loss of between 1 to 6 million Euros.

EO4WEF convenes researchers in the remote sensing fields to develop tools for large-scale and dynamic snow monitoring. SnowSat is one tool which combines Earth observations with AI algorithms and Internet-of-Things (IoT) to improve the estimation of snow water storage in Sweden. By developing a high-quality snow accumulation dataset and prototyping a snow service system, SnowSat supports the optimal planning and management of hydropower reservoirs. Consequently, it mitigates water spills and thus increases hydropower production. The developed snow service also provides risk assessments for snow-induced hazards, which can be used in flood prevention/preparedness, forest management and in the planning of ski and insurance industries.

To date, SnowSat has actively involved the local Sami community in the project design and ground snow measurement. The industrial partner, Vattenregleringsforetagen, the hydropower company managing the water in the river, is already using the information gathered by the distributed IoT stations to take informed decisions. The information from the IoT stations and the planned service could also be used by the local Sami community for reindeer herding.

Although the SnowSat service is still in the developmental phase and hasn't been fully deployed, its preliminary results have shown promising potential to revolutionize the management of hydropower systems dependent on snowmelt. Through its ability to offer more precise assessments of upstream snow water storage, it promises to minimize water spills, enhance dam safety, optimize reservoir operations, and ultimately elevate the efficiency and sustainability of hydropower solutions significantly.

PARTNERS: Mälardalen University, Uppsala University, Vattenregleringsforetagen, Vinnova

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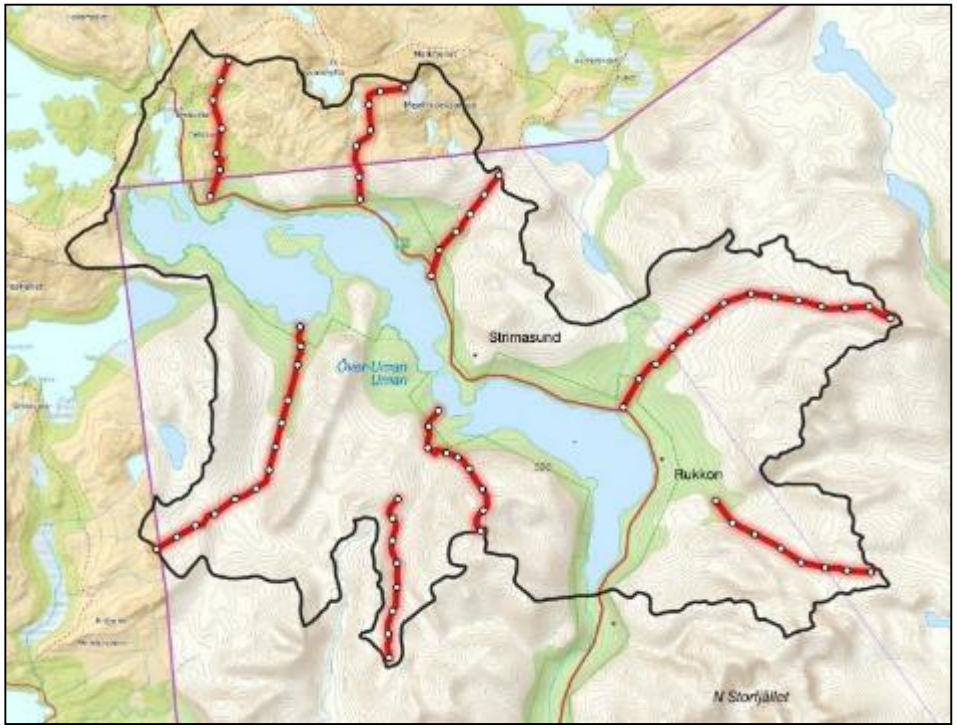
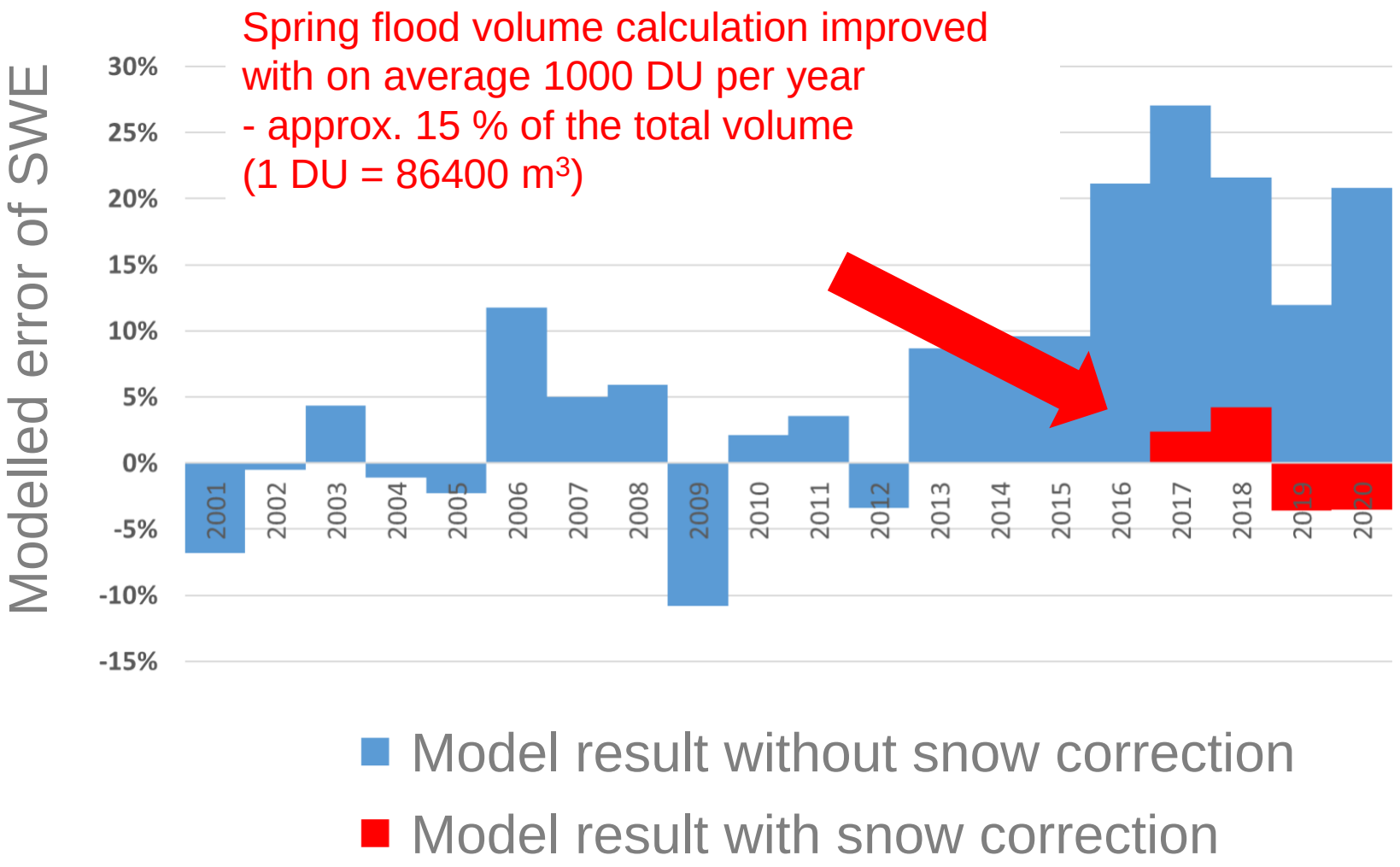
Ground Truthing - GPR measurements



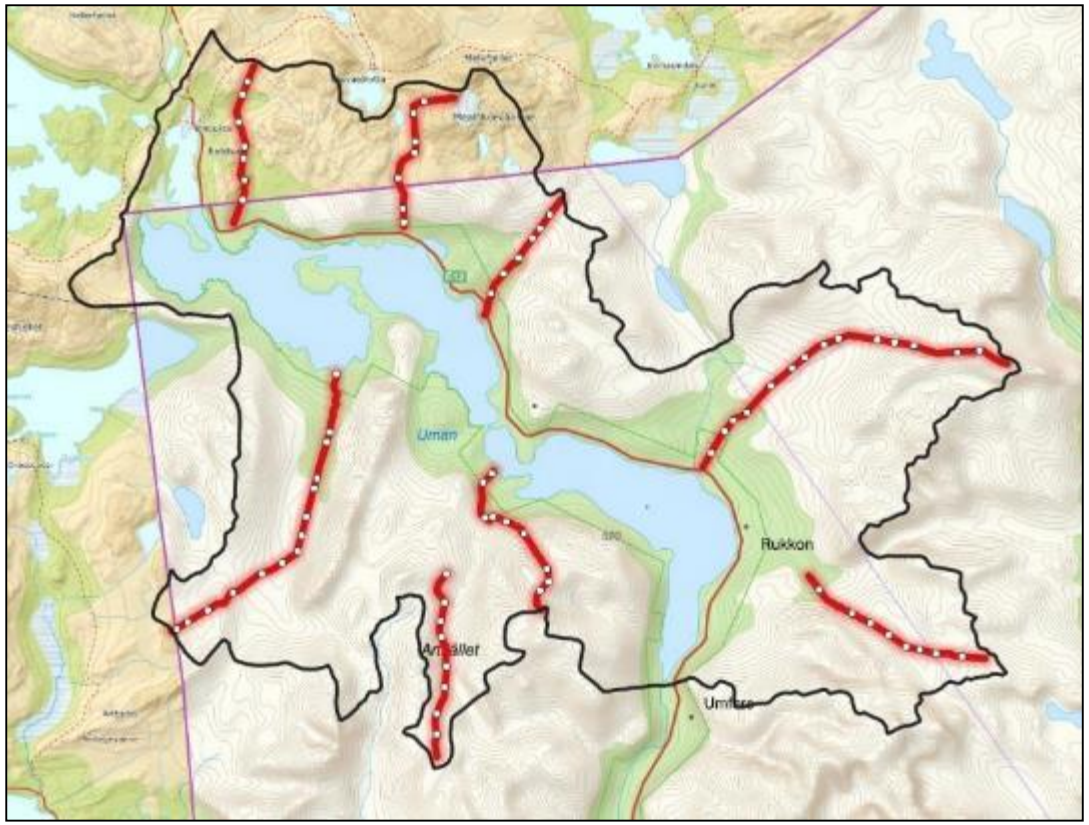
- Measurement system by Sweco Norge
- 8 snow courses (in total 74 km) with terrain parameters representing the total catchment
- Snow depth and density measurements with 1 km equidistance
- The result has been used for correction of the inflow model prior to the spring flood forecasts

Improved spring flood forecasts in Överuman



Ground Truthing - Representative points

- Selected through analyses of GPR data
- Possibility to perform more measurements per winter
- Cost per survey approximately 1/10 of a GPR survey

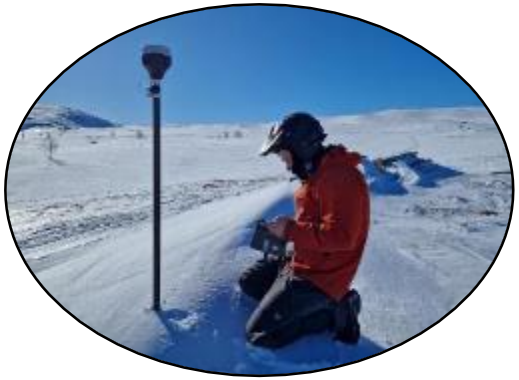


Ground Truthing - RTK positioning

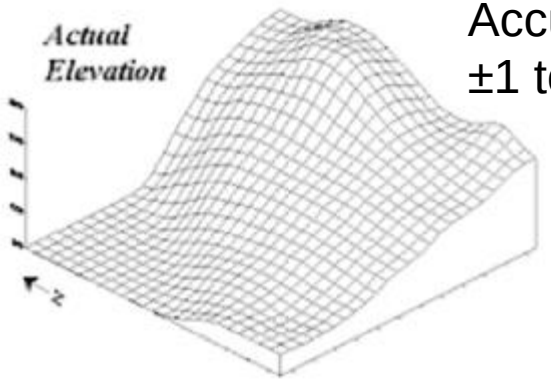
RTK rover on snow mobile sled

Accuracy
±1 cm

RTK base station



Lantmäteriet Terrain Model grid 1+
based on the National Elevation model



Accuracy
±1 to 10 cm

Snow density measurements

Ground Truthing - IoT Network

ARDUINO + ThingSpeak™ etm

Up to now, 7 IoT snow monitoring stations have been set up in Överuman

- 2 above tree line
- 2 at tree line
- 3 below tree line

Summary & Outlook

Summary

- Unique snow ground truth
  - Manual/GPR/RTK measurements
  - Drone surveys
  - IoT stations
- Collection of satellite signals sensitive to snow amount
- Benchmark of AI algorithms for snow depth estimation

Moving forward

- Expand mountain snow IoT monitoring network
- Produce a high-quality snow product
- Prototype a snow service portal

Thanks for your attention!