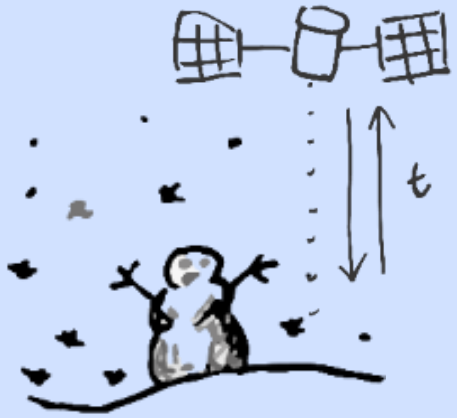
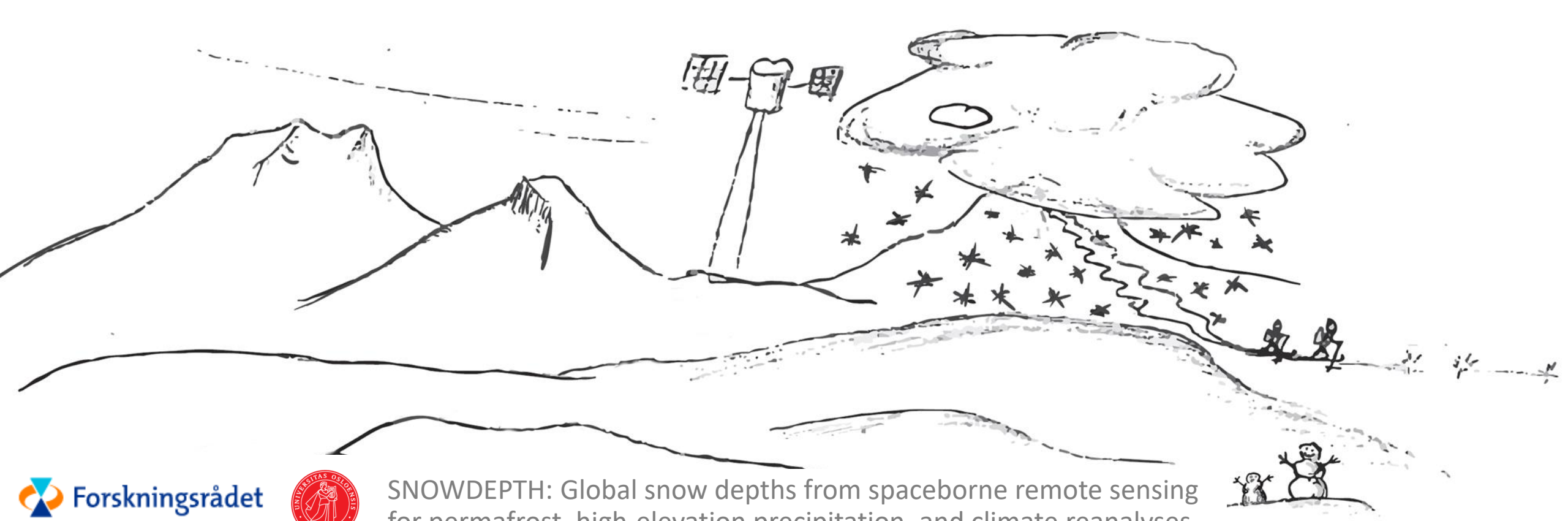


Spaceborne snow depth measurements from ICESat-2 laser altimetry

Désirée Treichler, Marco Mazzolini, Livia Piermattei, Clare Webster, Luc Girod,
University of Oslo, NO; Yves Bühler, SLF, CH



Forskningsrådet

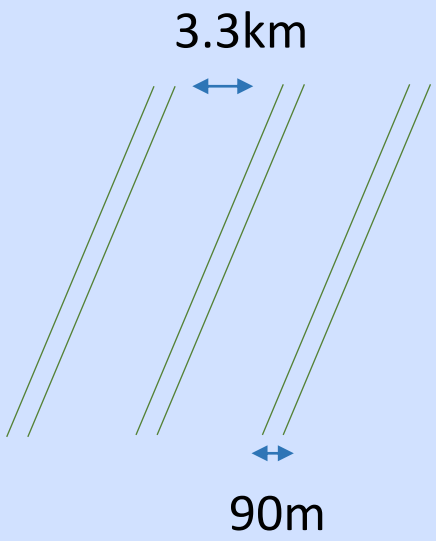
SNOWDEPTH: Global snow depths from spaceborne remote sensing for permafrost, high-elevation precipitation, and climate reanalyses

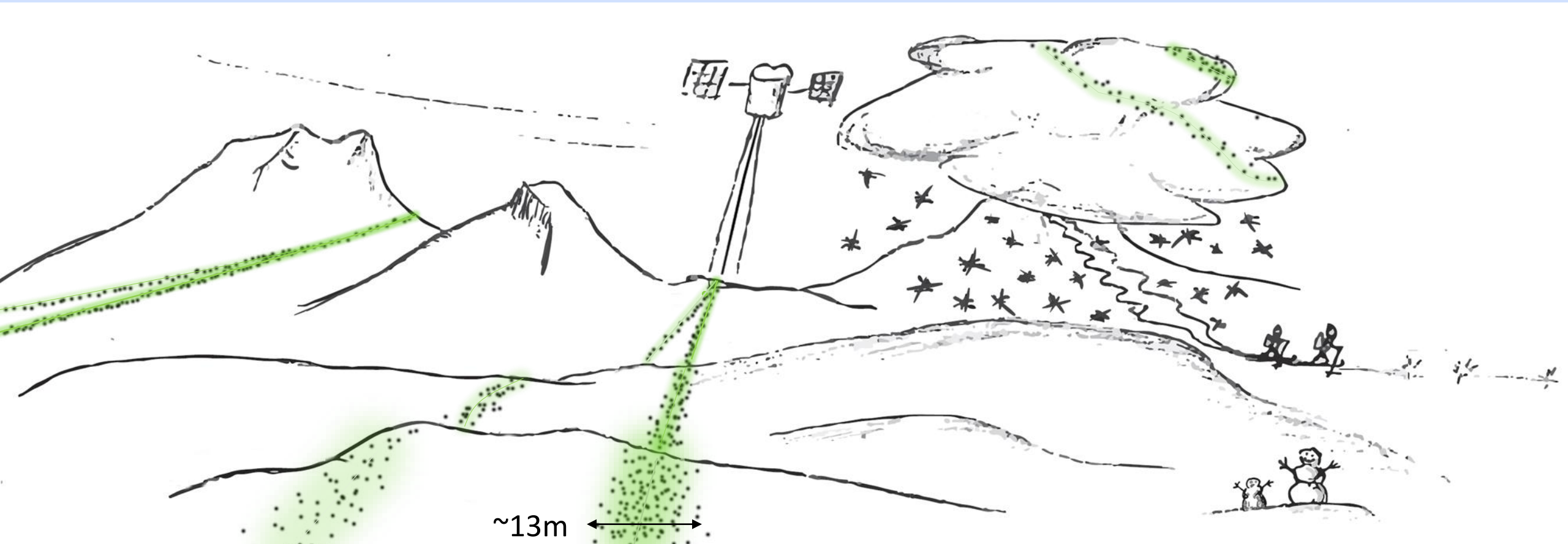
ICESAT-2 DATA

ATL03

ATL06

ATL08



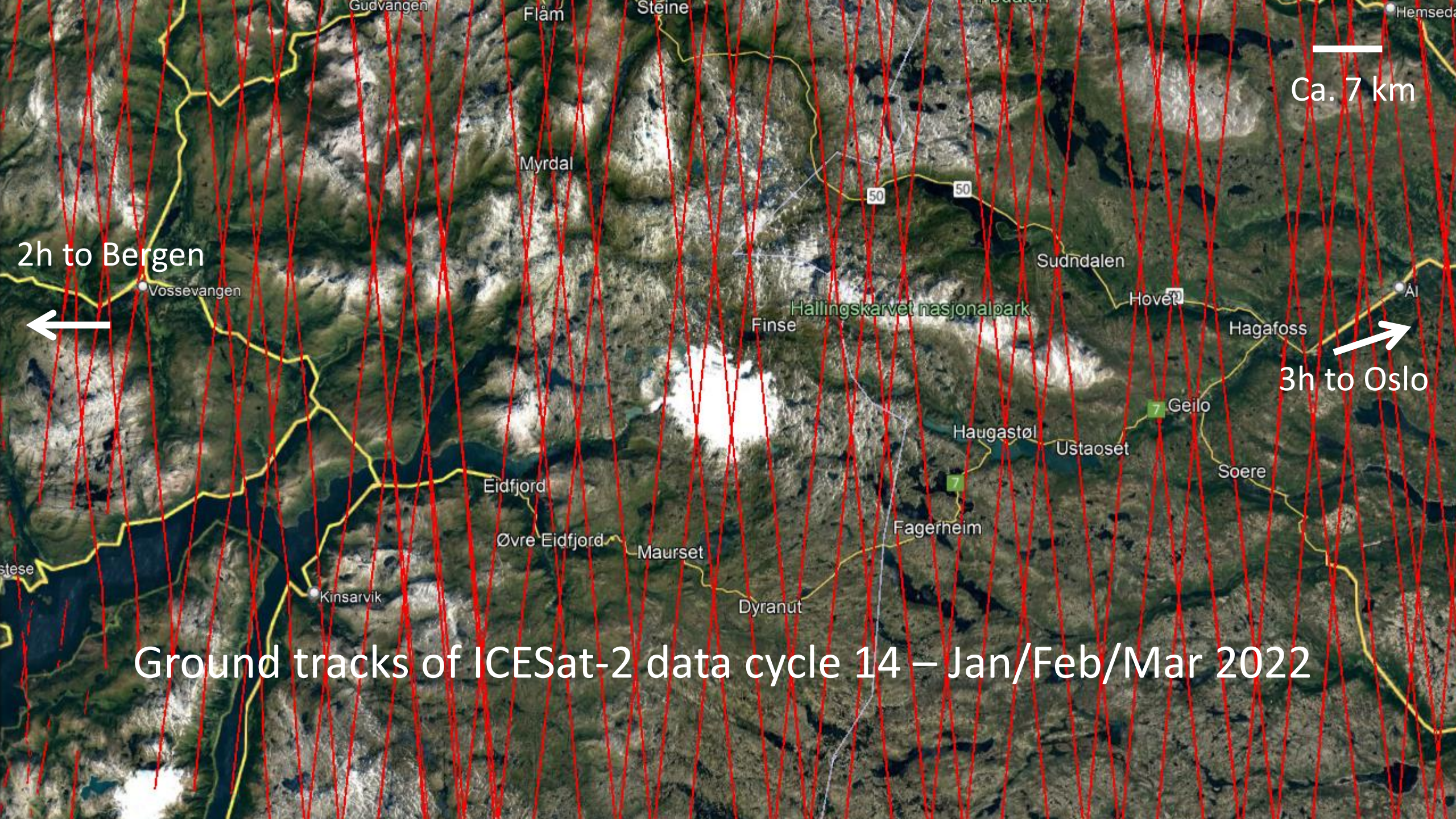


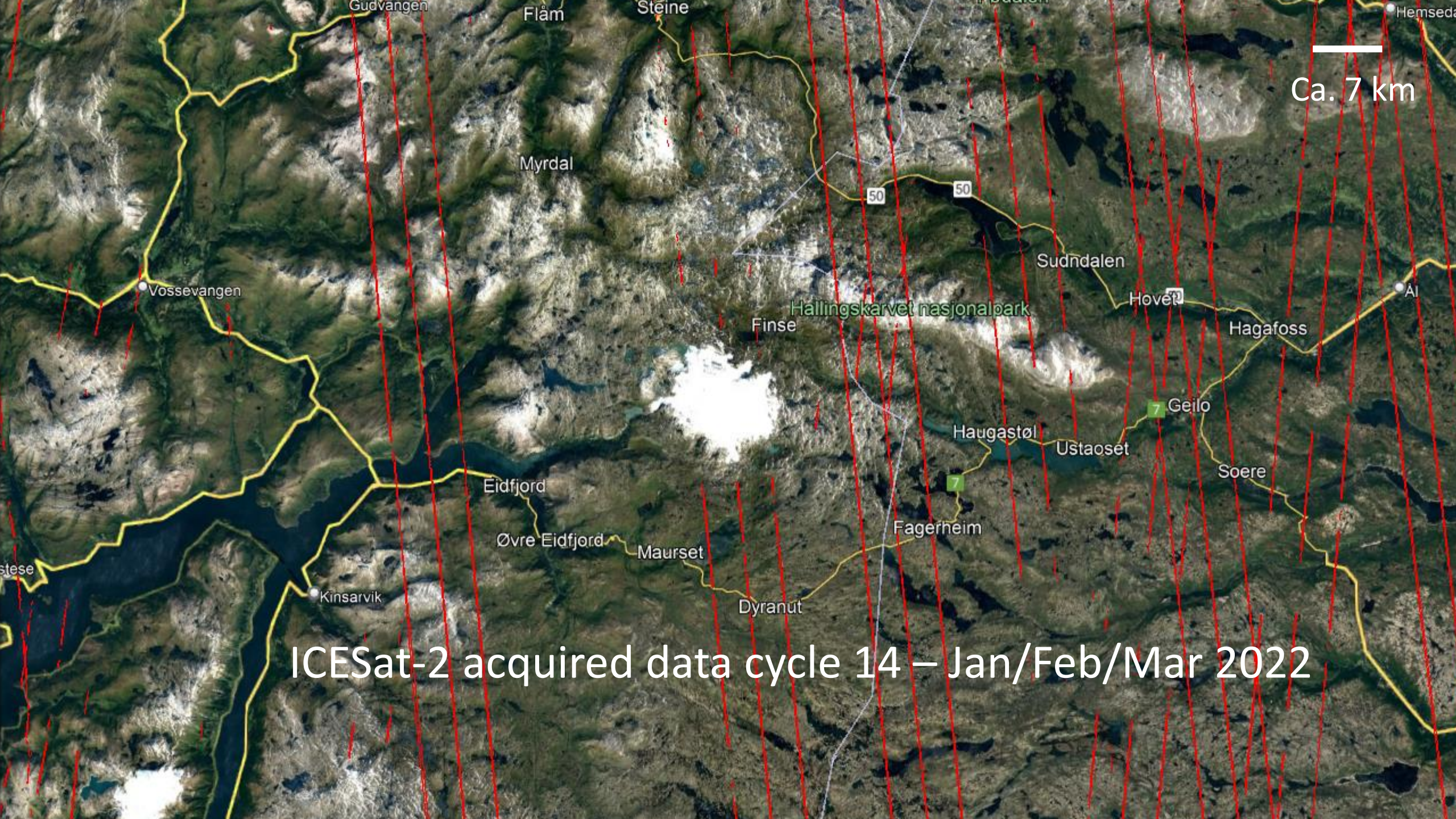
QUESTIONS

1. Can we use ICESat-2 data to get snow depths?
2. How accurate are these snow depths?

Comparison with UAV snow depths

3. Is this data useful for me?
4. How to move on from there ?


Ca. 7 km
2h to Bergen
3h to Oslo
Gudvangen
Flåm
Steine
Hemseda
Myrdal
50
50
Sudndalen
Vossevangen
Hallingskarvet nasjonalpark
Finse
Hovet
Hagafoss
Ål
Geilo
Haugastøl
Ustaoset
Soere
Eidfjord
Øvre Eidfjord
Maurset
Fagerheim
Kinsarvik
Dyranut
Ground tracks of ICESat-2 data cycle 14 – Jan/Feb/Mar 2022



ICESat-2 acquired data cycle 14 – Jan/Feb/Mar 2022

SITES

1./2./4. Hardanger-vidda: Alpine

5. Davos: Alpine

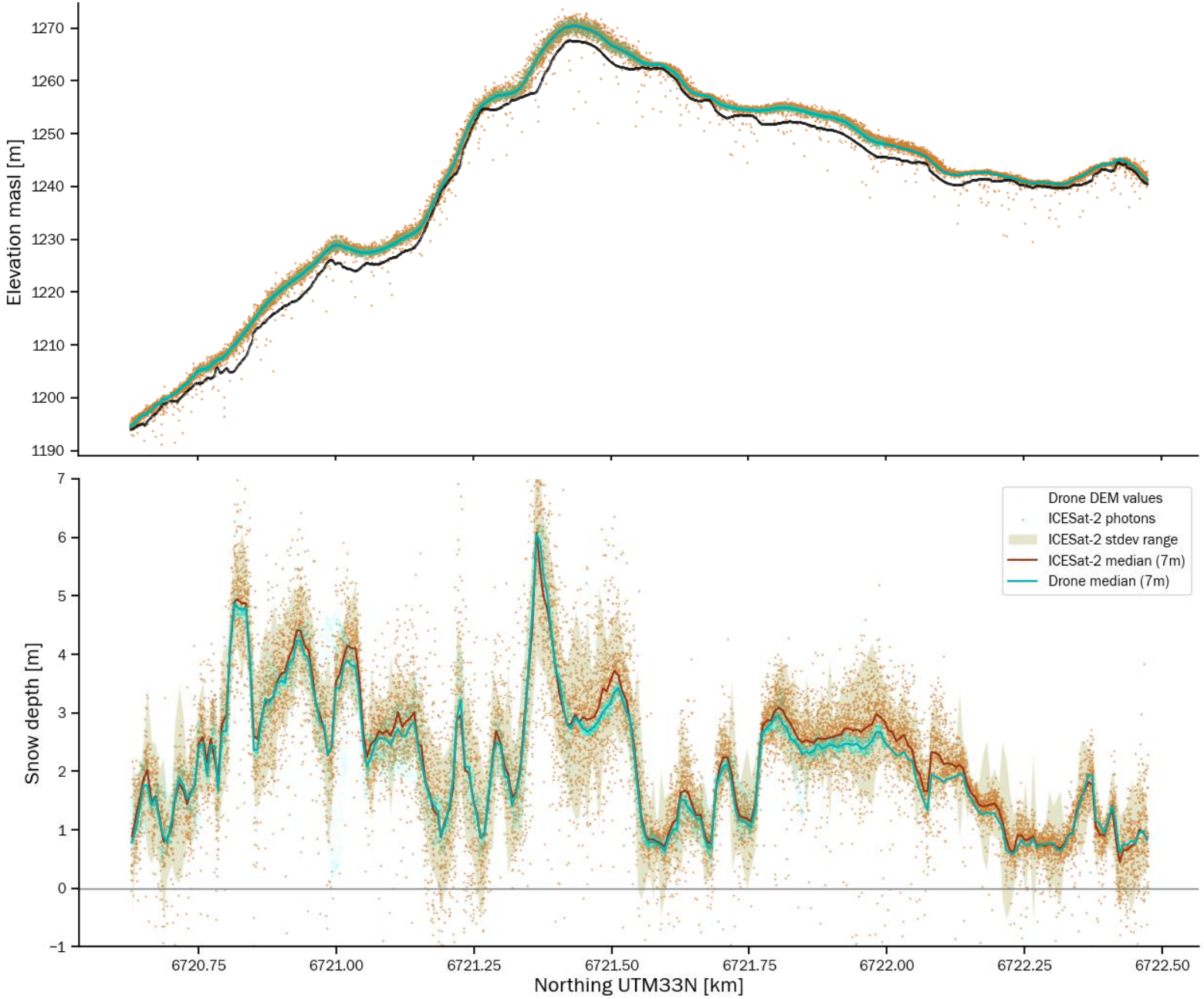
3. Sodankylä: Open forest

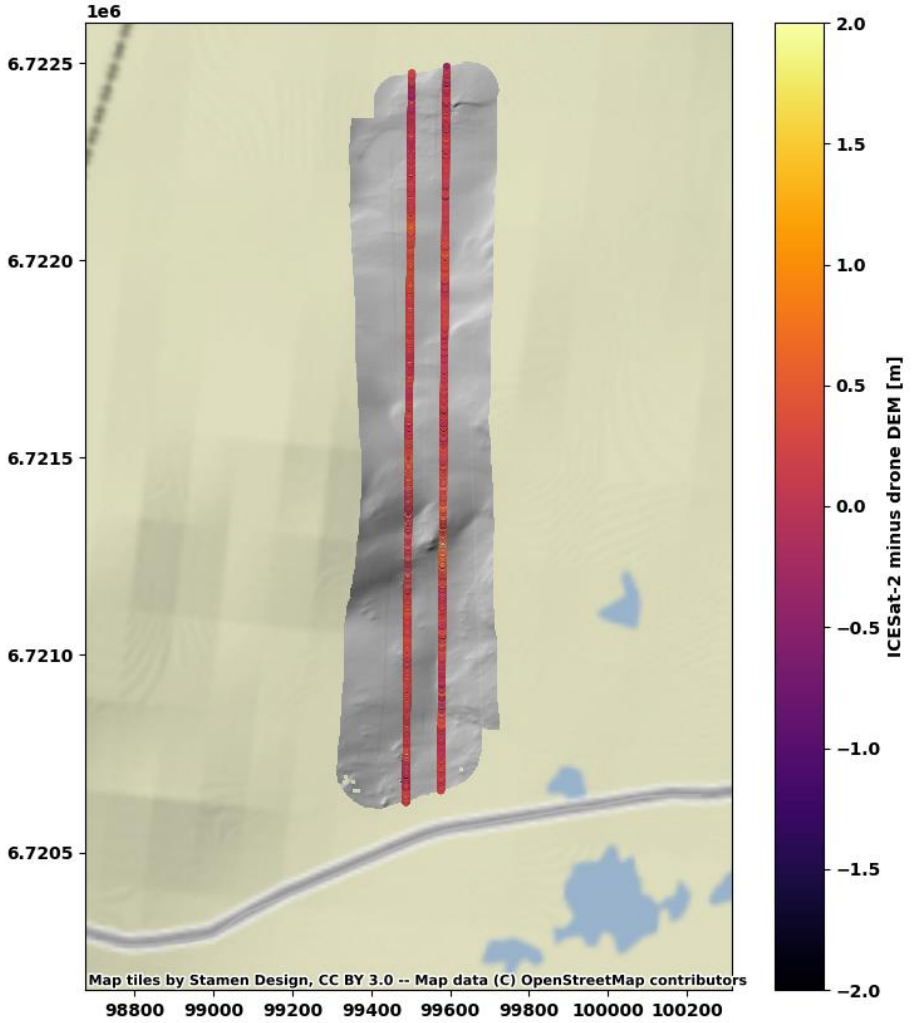
1./2. HARDANGERVIDDA EAST

ICESat-2: 5. March 2022
Lidar UAV: 11. March 2022

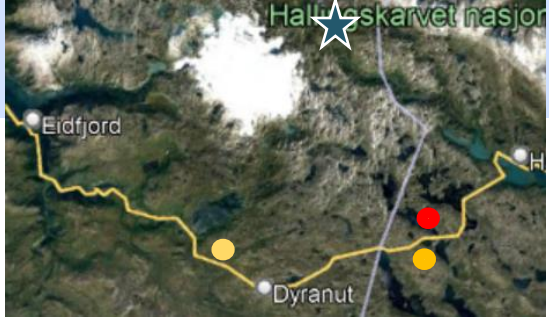
Photo: Eivind Torgesen

1. HARDANGERVIDDA EAST - NORTH

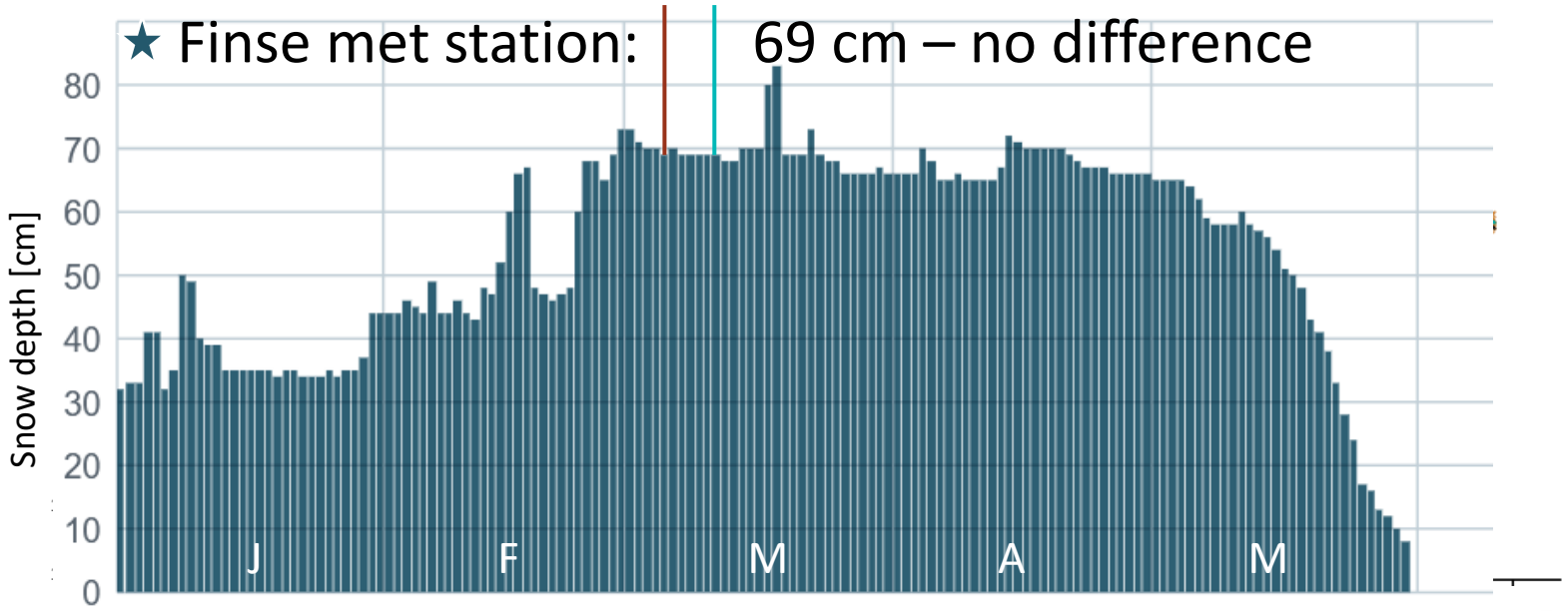


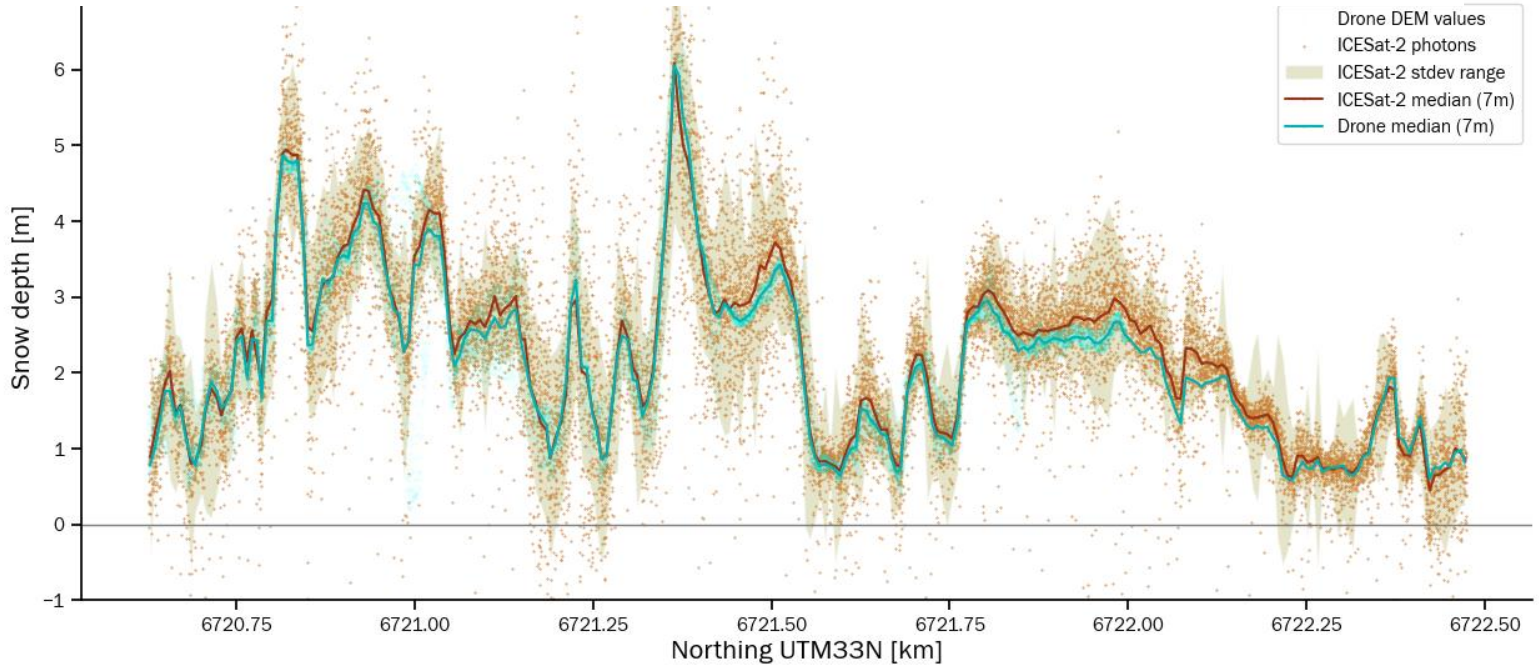


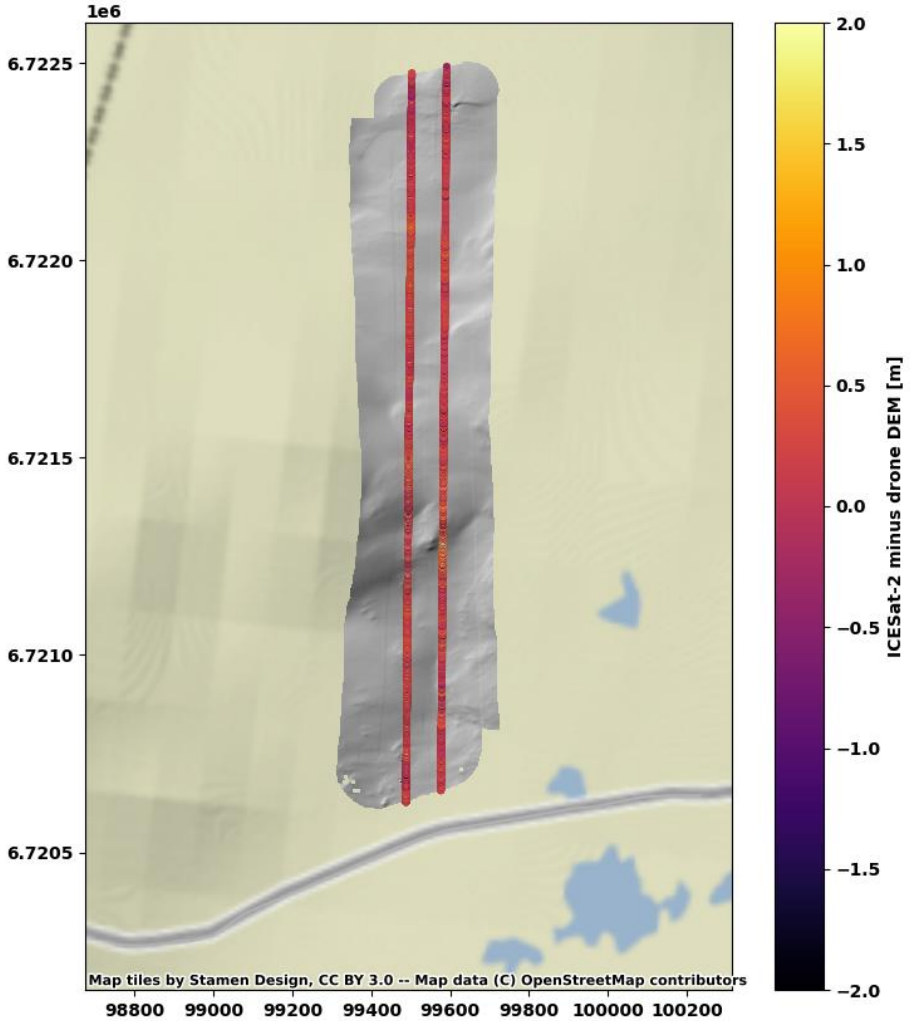
1. HARDANGERVIDDA EAST - NORTH



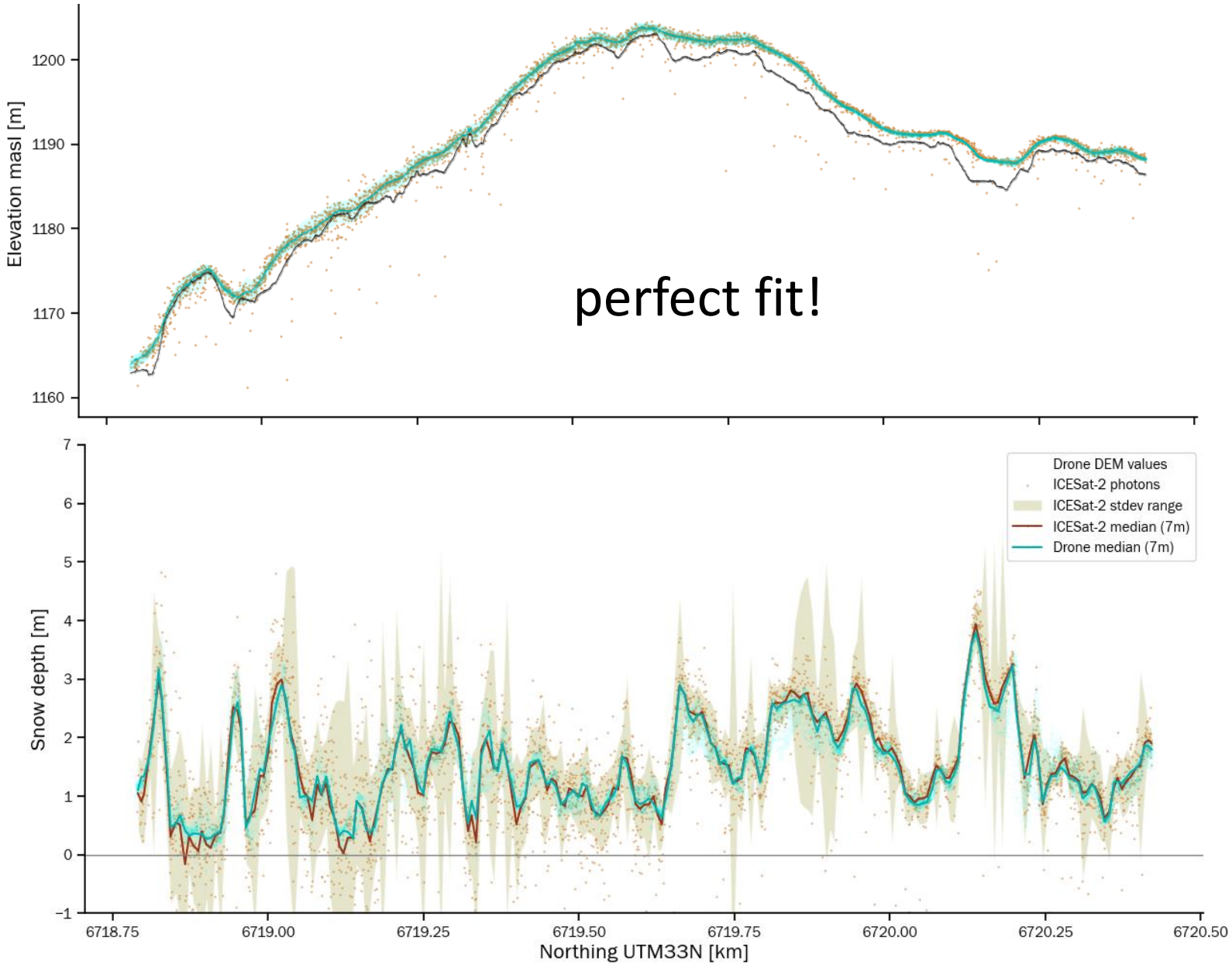
★ Finse met station: 69 cm – no difference

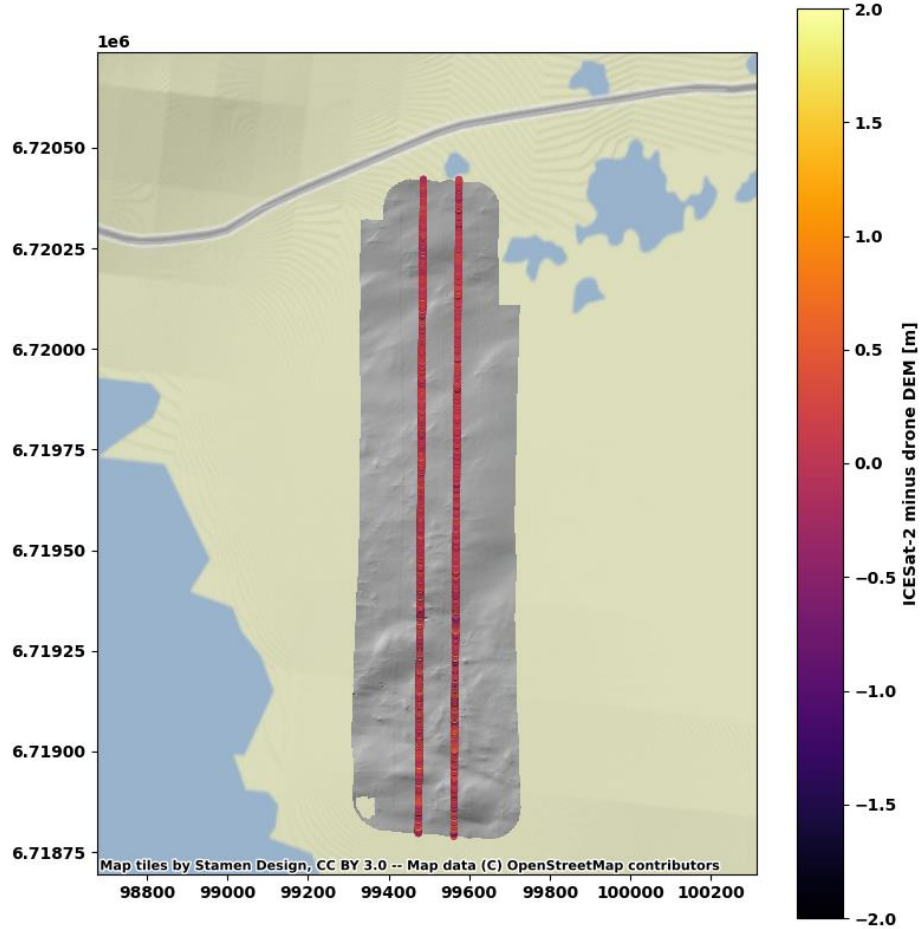






2. HARDANGERVIDDA EAST - SOUTH



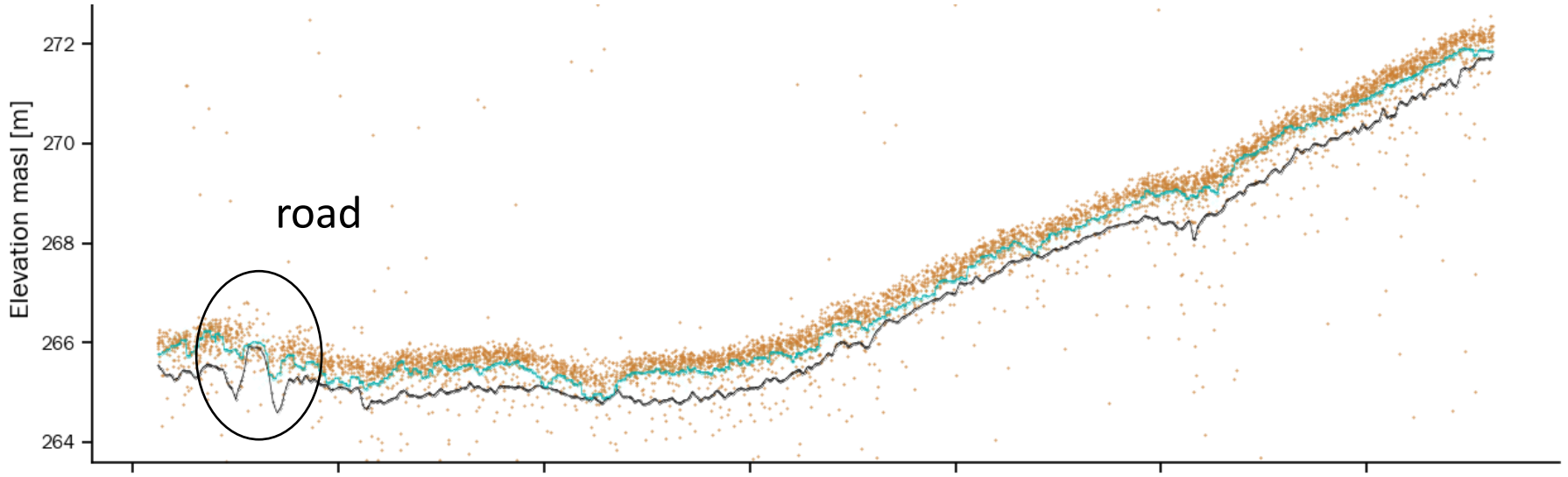


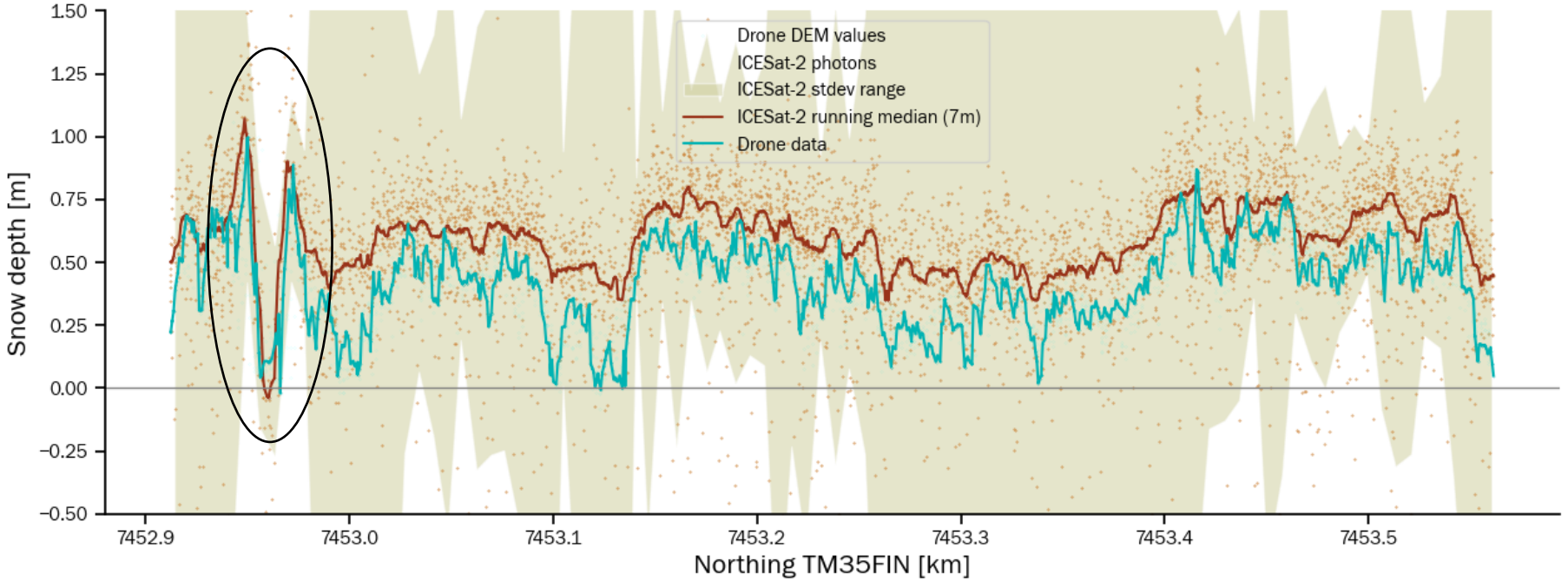
3. SODANKYLÄ

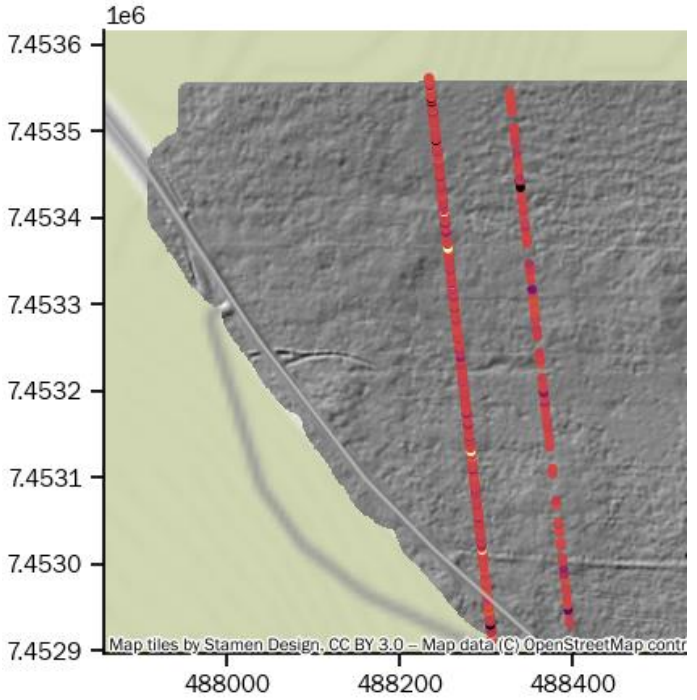
ICESat-2: 19. April 2022
lidar UAV: 24. April 2022

Photo: Cassie Lumbrazo

3. SODANKYLÄ

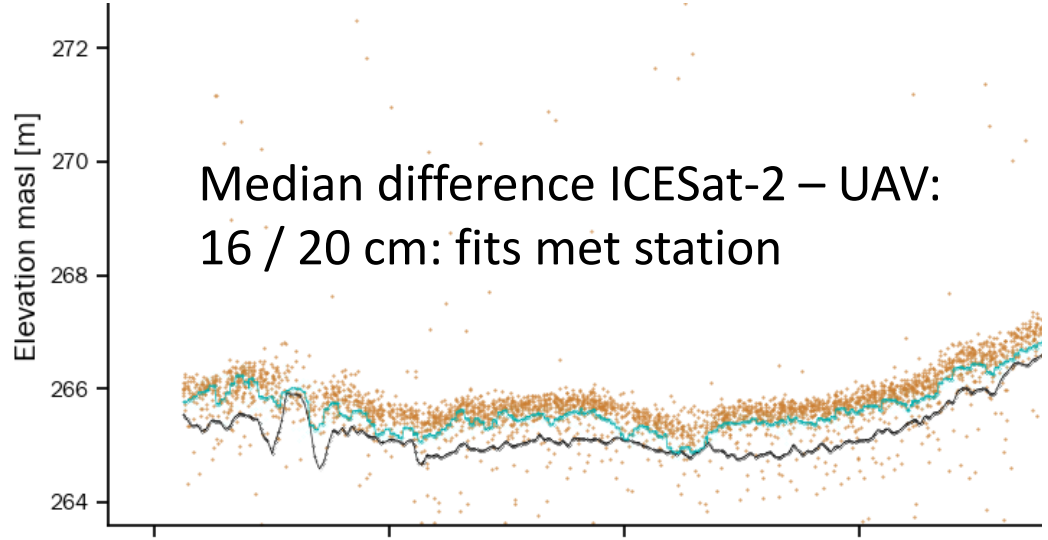

Elevation masl [m]
272
270
268
266
264
road

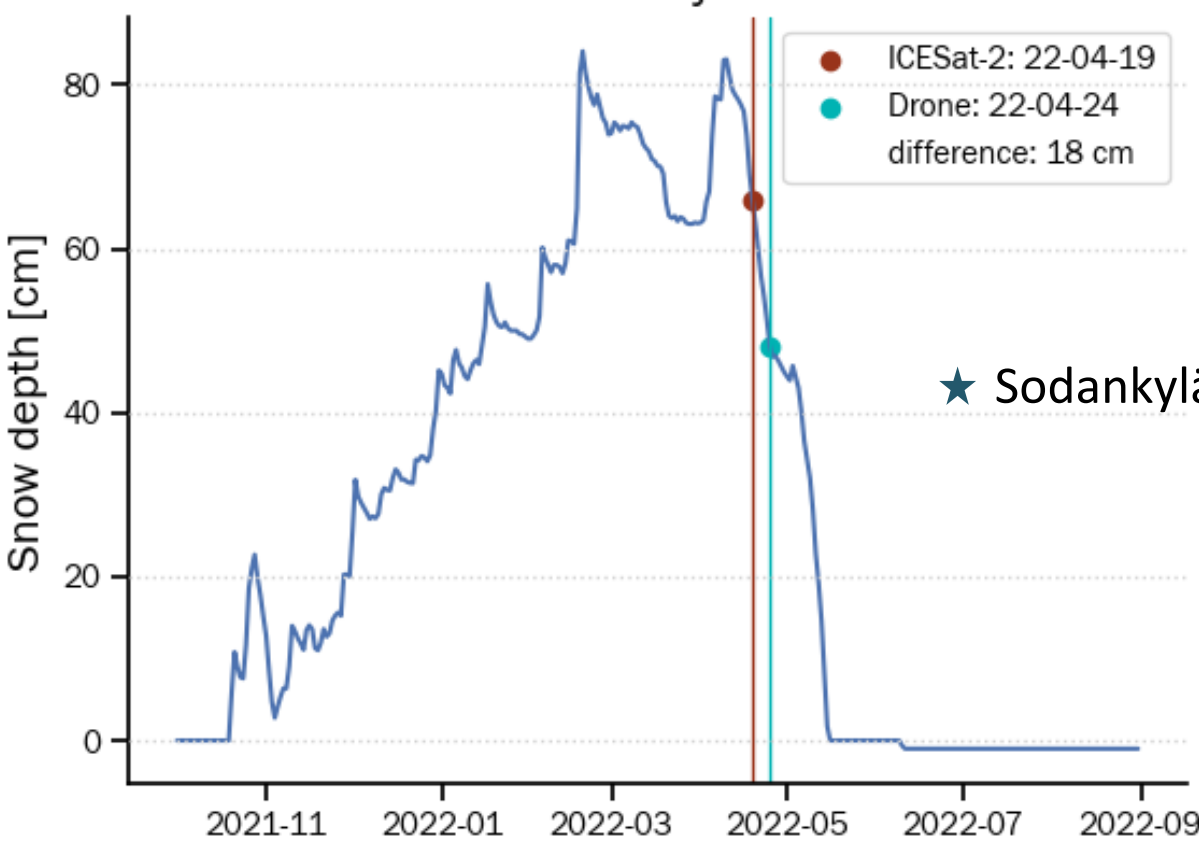

Snow depth [m]
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
Drone DEM values
ICESat-2 photons
ICESat-2 stdev range
ICESat-2 running median (7m)
Drone data
7452.9
7453.0
7453.1
7453.2
7453.3
7453.4
7453.5
Northing TM35FIN [km]


1e6
7.4536
7.4535
7.4534
7.4533
7.4532
7.4531
7.4530
7.4529
488000
488200
488400
Map tiles by Stamen Design, CC BY 3.0 – Map data (C) OpenStreetMap contr

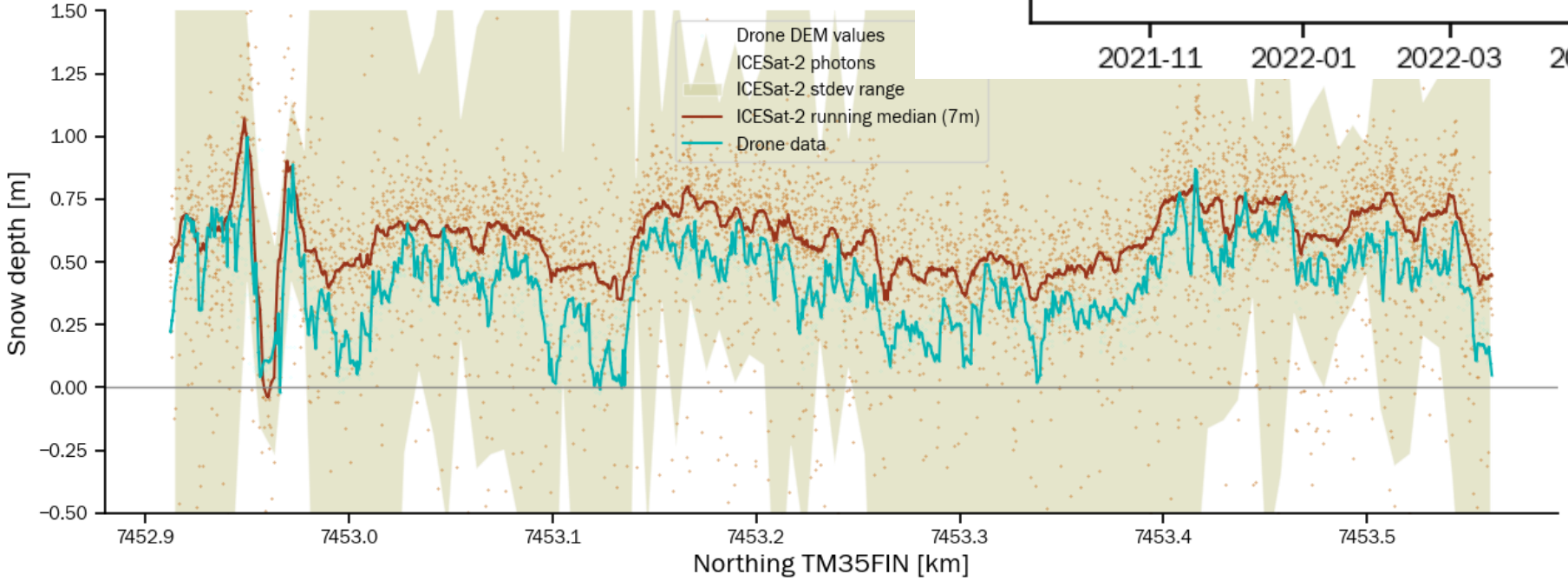
3. SODANKYLÄ

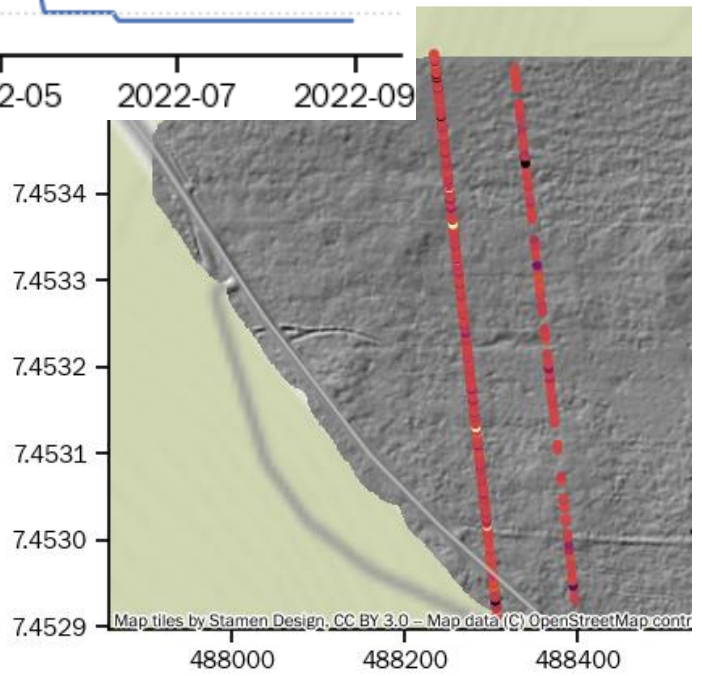
Median difference ICESat-2 – UAV:
16 / 20 cm: fits met station





★ Sodankylä met station

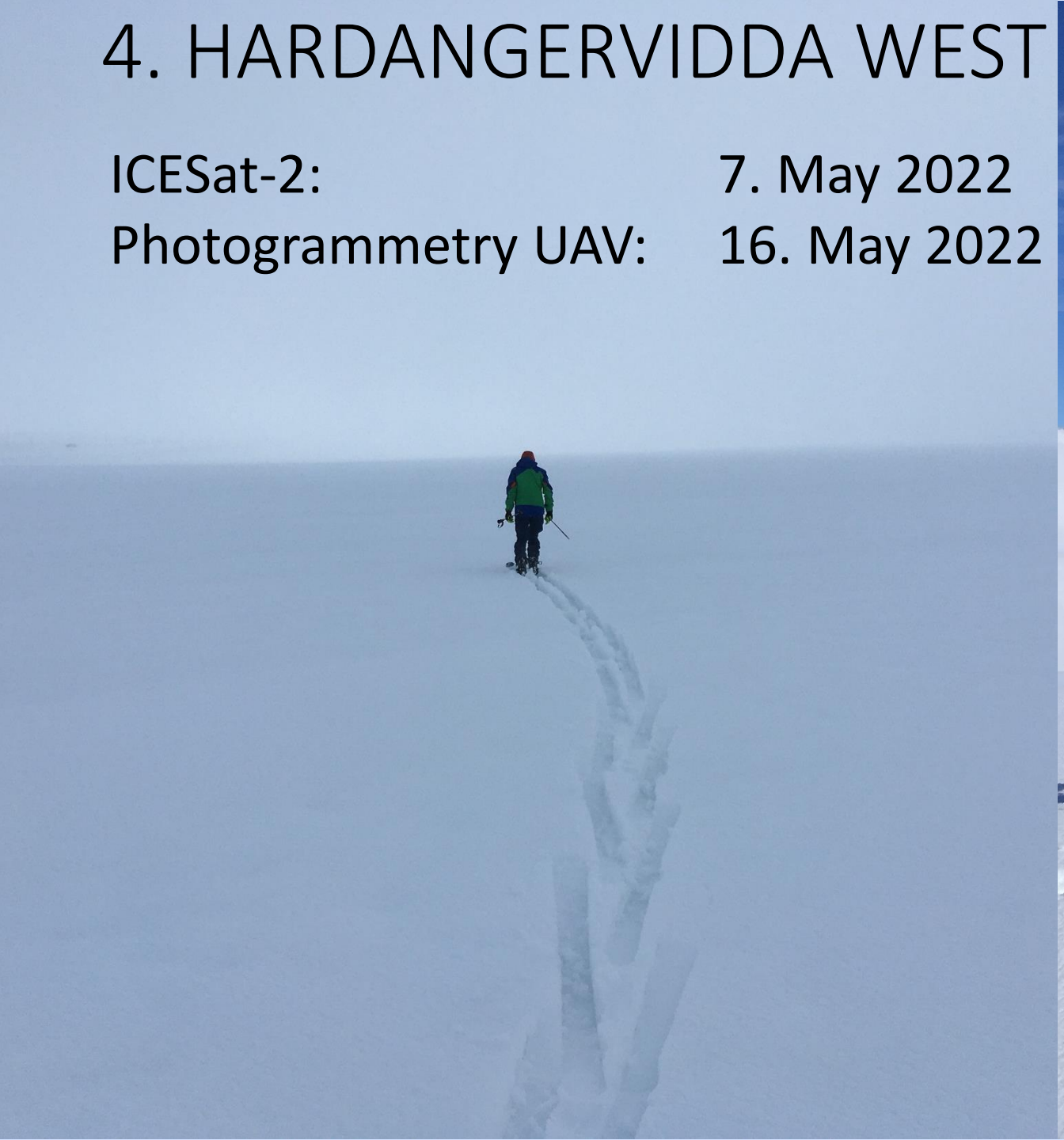


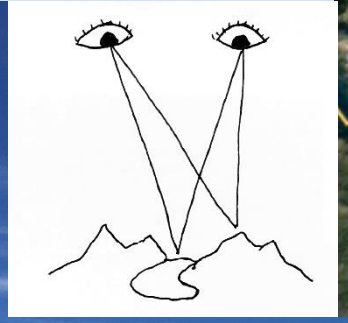


4. HARDANGERVIDDA WEST

ICESat-2: 7. May 2022

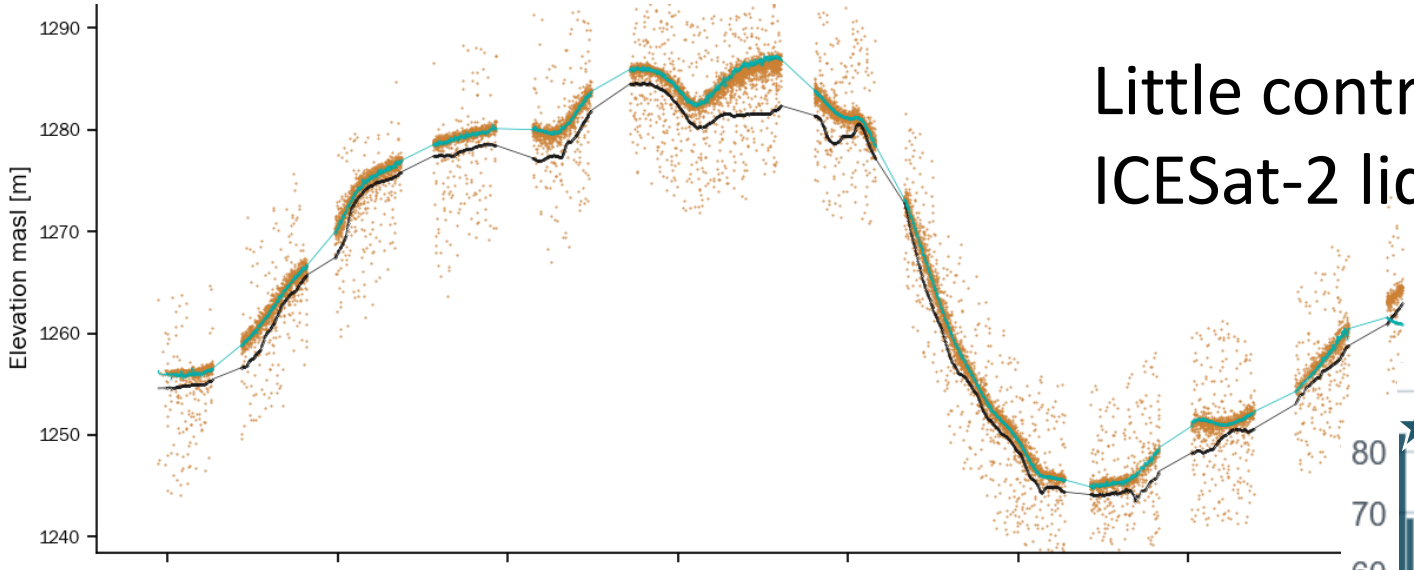
Photogrammetry UAV: 16. May 2022



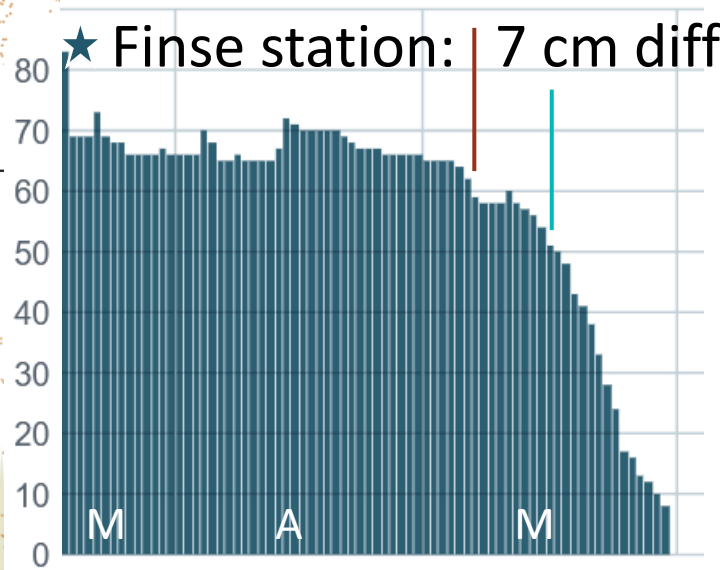


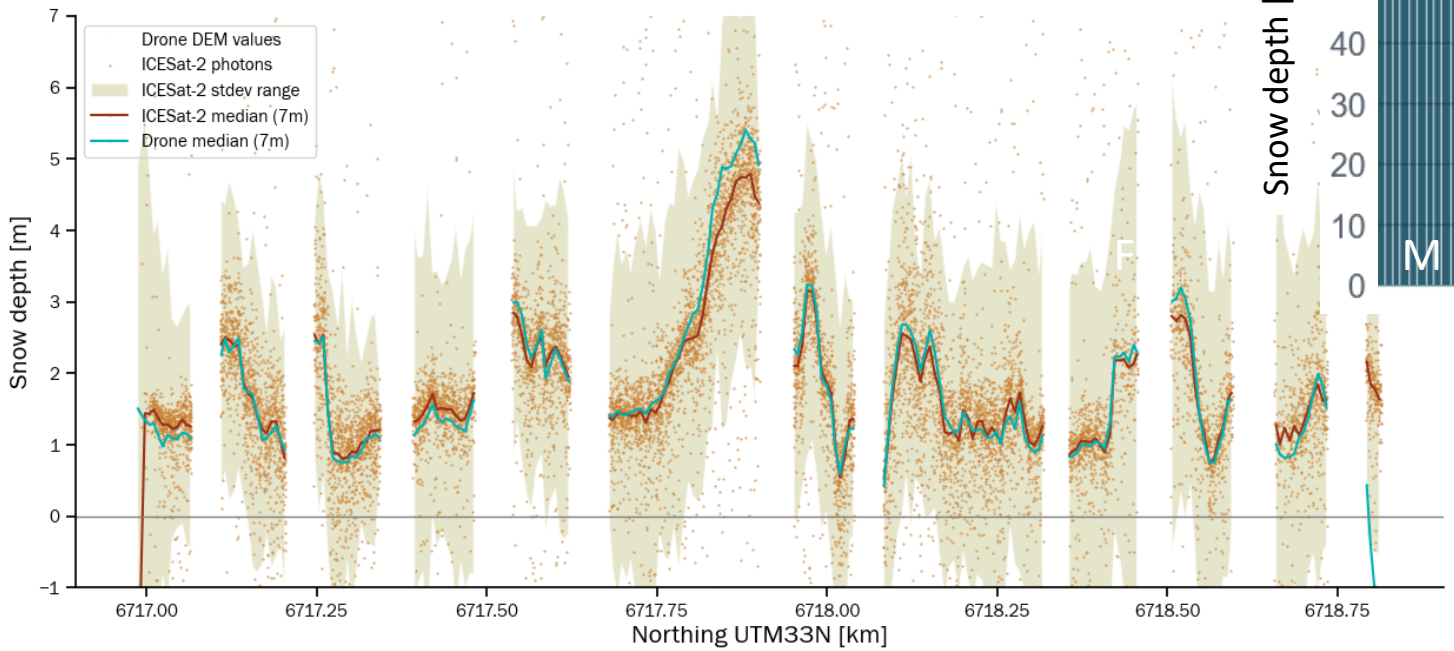
4. HARDANGERVIDDA WEST

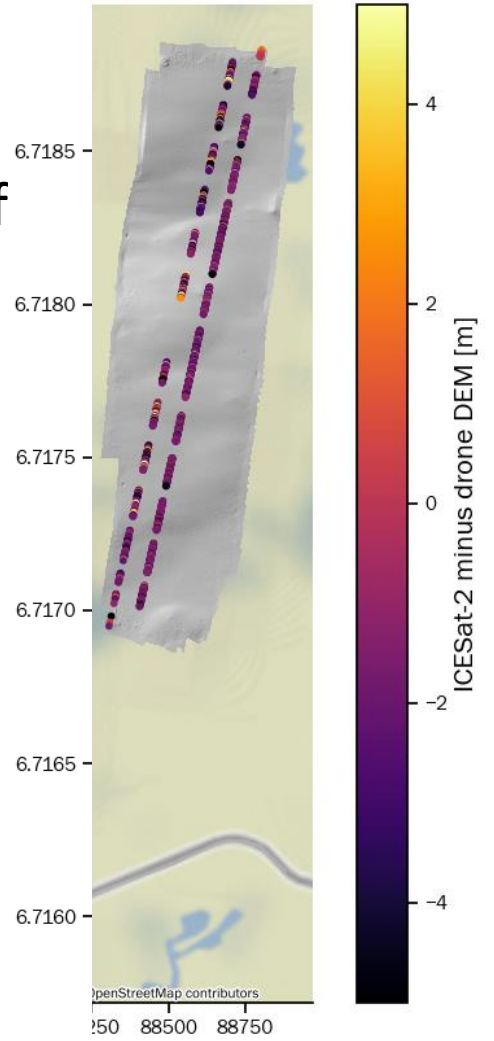
Little contrast in pictures –
ICESat-2 lidar better



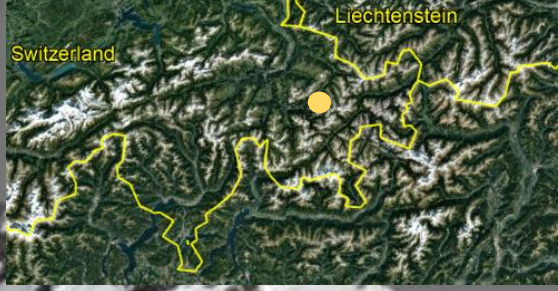
★ Finse station: | 7 cm diff







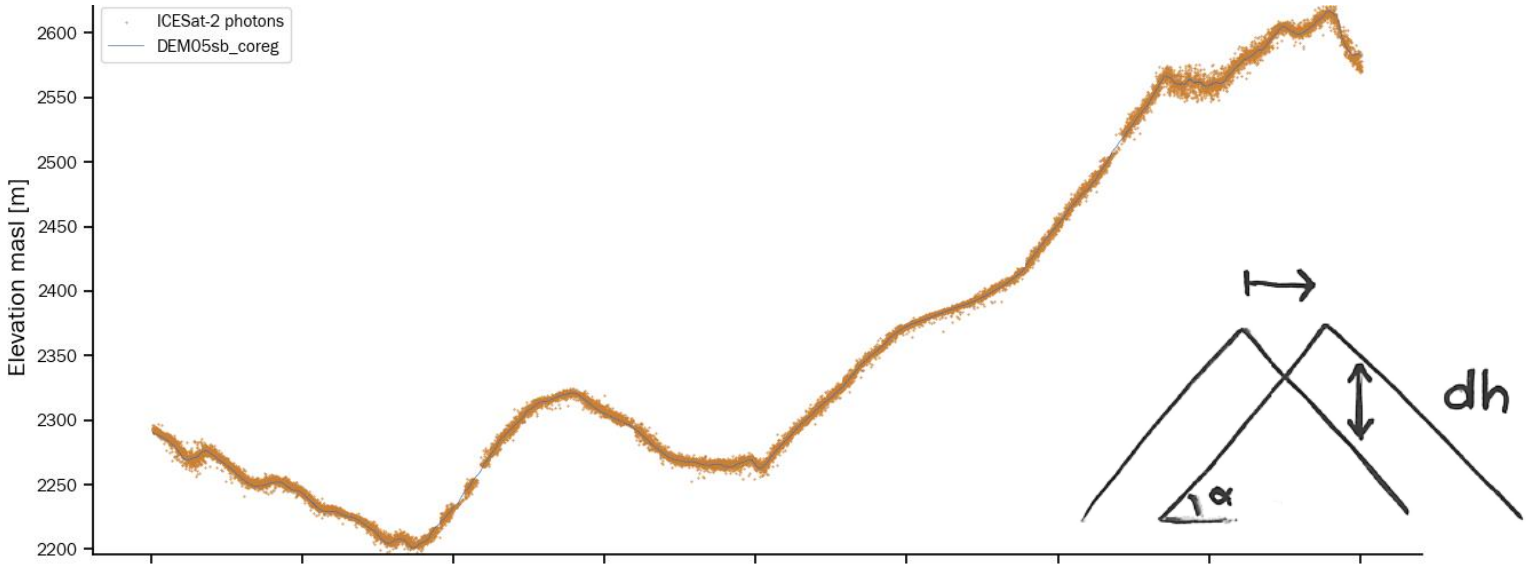
5. DAVOS: LATSCHÜELFURGGA



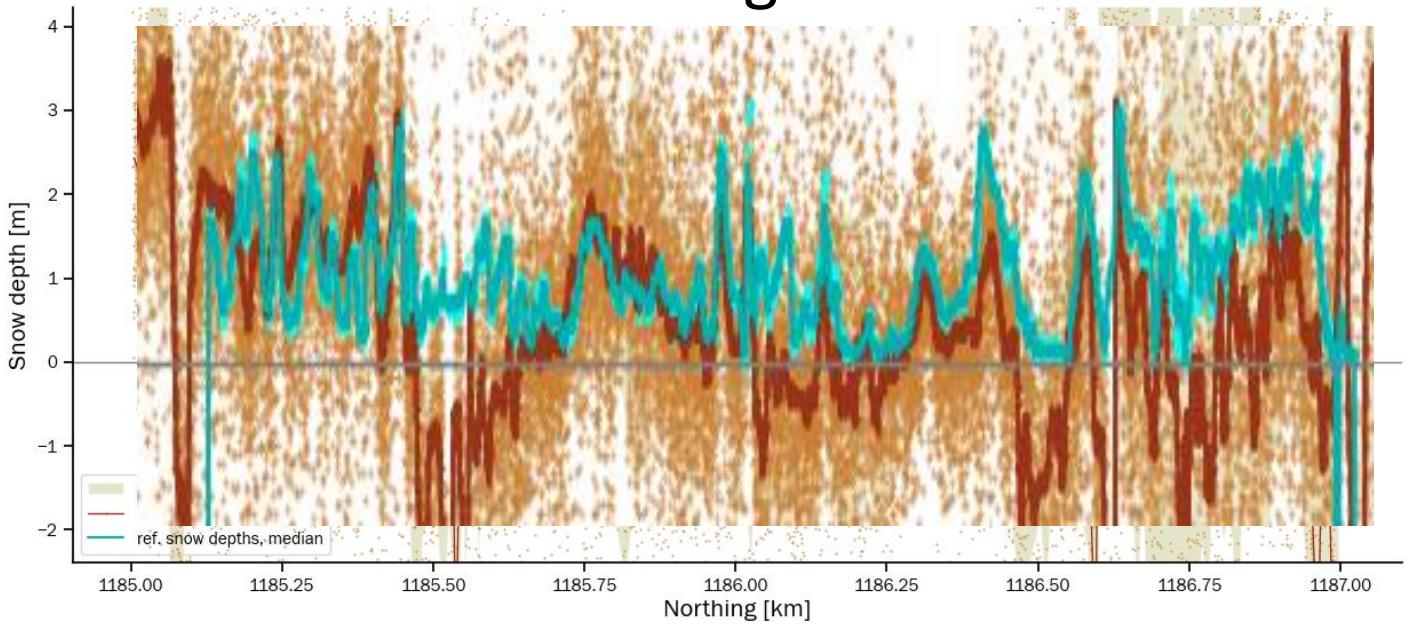
ICESat-2: 4. February 2022
Photogr. UAV: 9. February 2022

Illustration credit: SLF

5. DAVOS: LATSCHÜELFURGGA

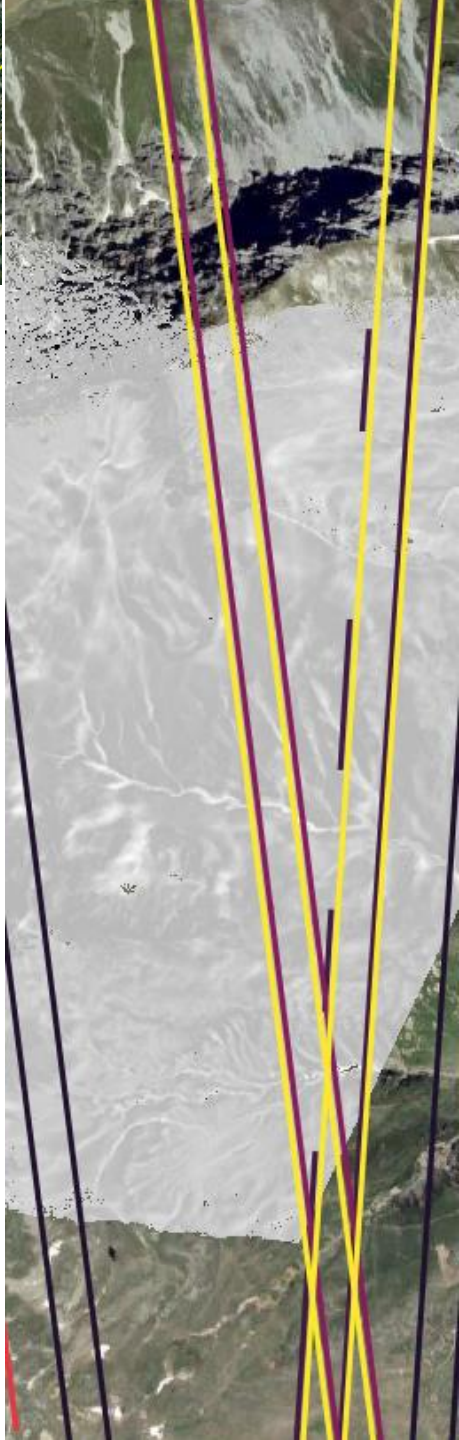


strong beam



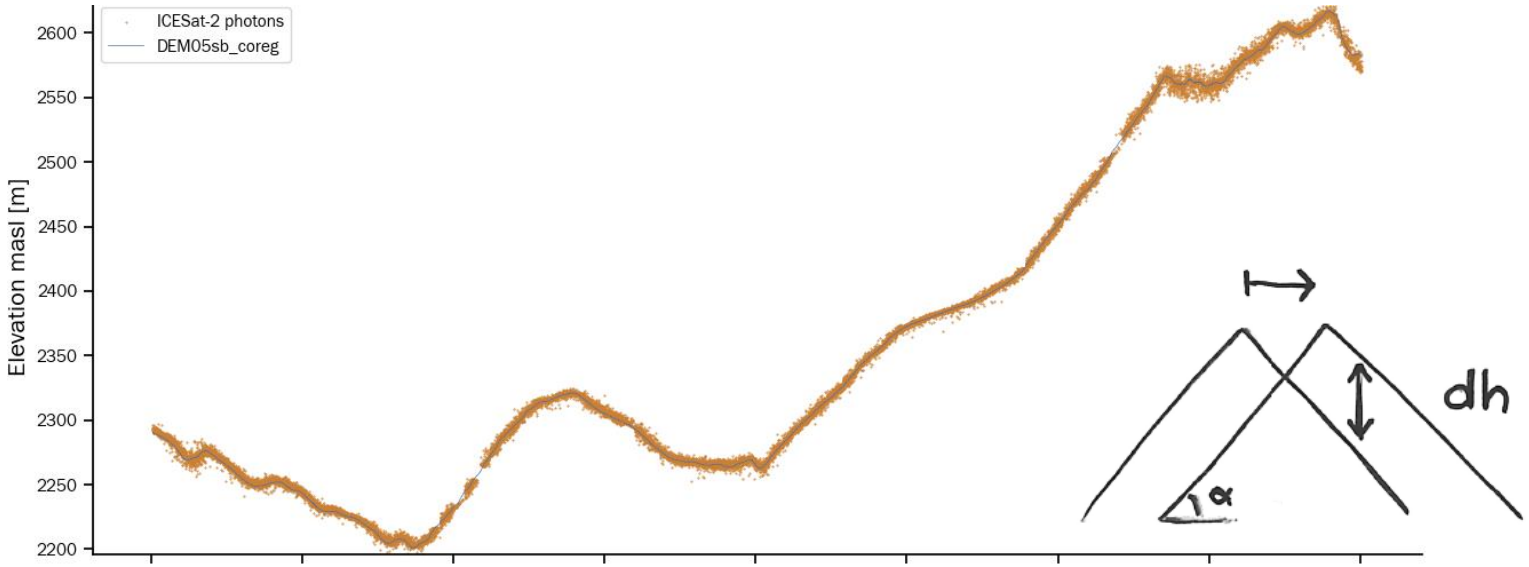
Feb 2022

Nov 2019
-> ideal co-registration base

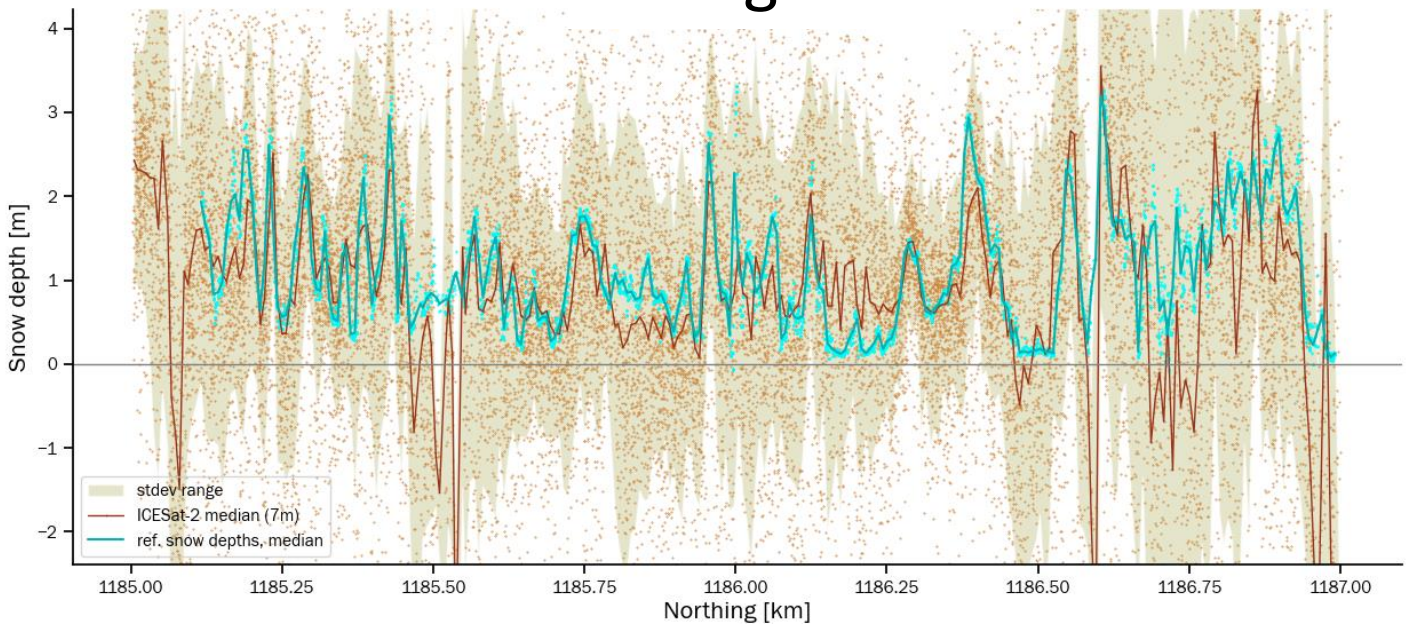


«standard processing»: terrible

5. DAVOS: LATSCHÜELFURGGA

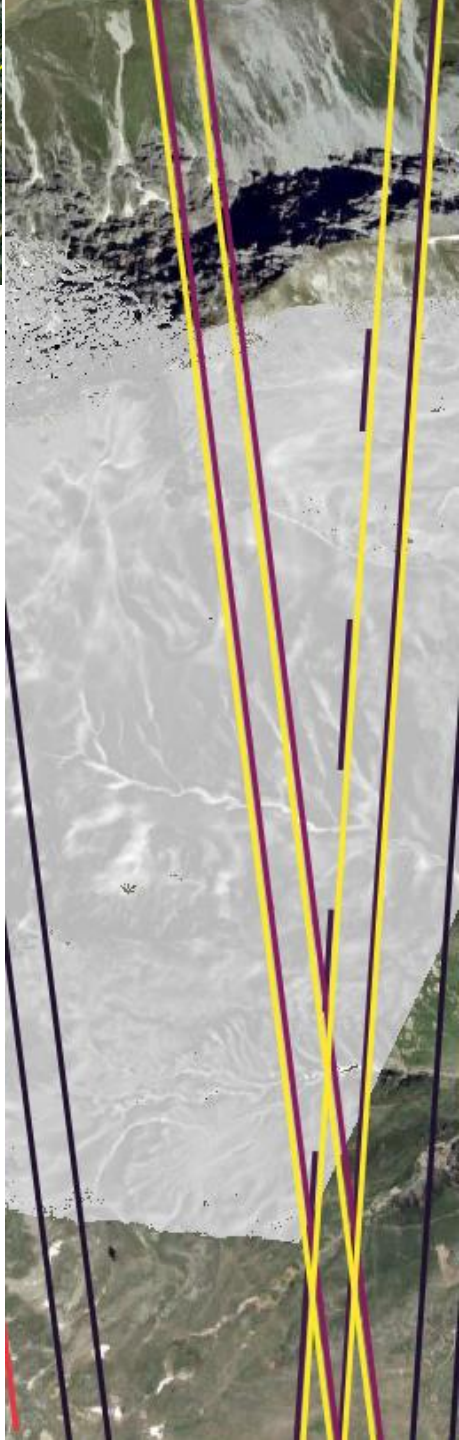


strong beam



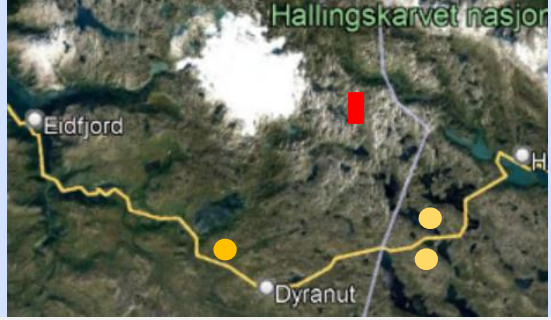
Feb 2022

Nov 2019
-> ideal co-registration base



Somewhat better after coregistration of individual beam

THE SNOW-OFF REFERENCE



ICESat-2 photons
Old NO stereo DEM (10m)
New NO stereo/lidar DEM (2m)
Arctic DEM (2m / 10m)

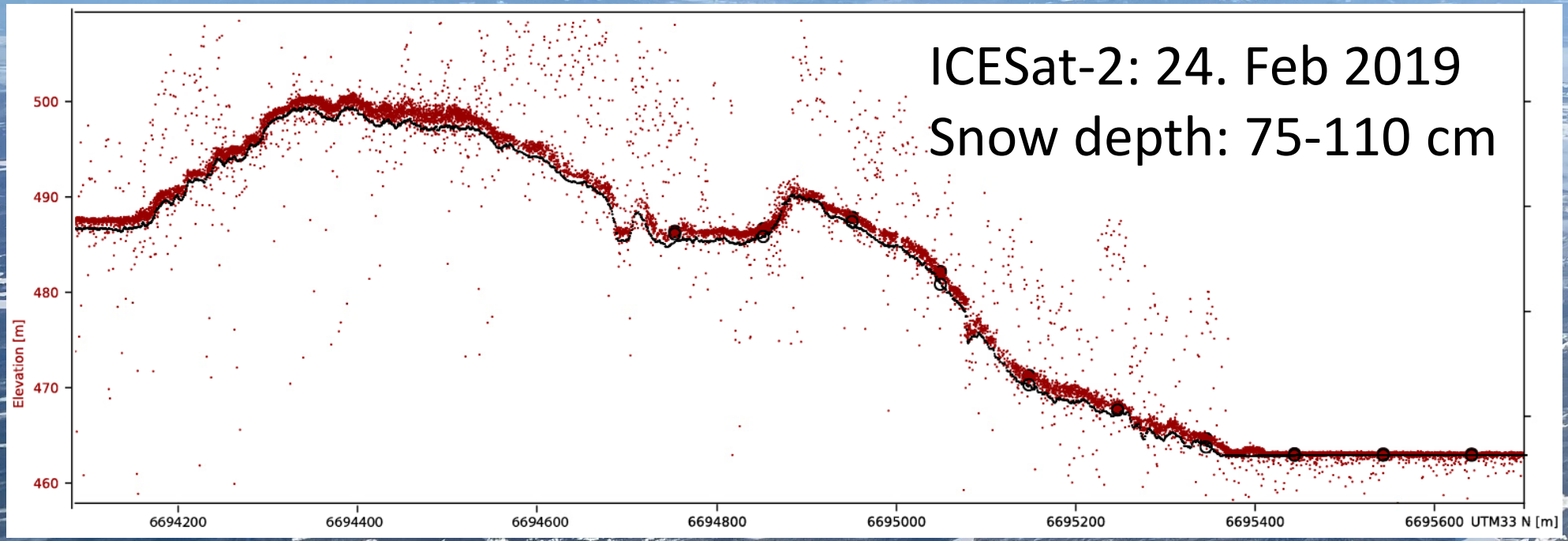
Elevation [m]
1470
1465
1460
1455
1450
1445

6.739
6.7391
6.7392
6.7393
6.7394
6.7395
6.7396

Northing, UTM 33N [m]
$\times 10^6$

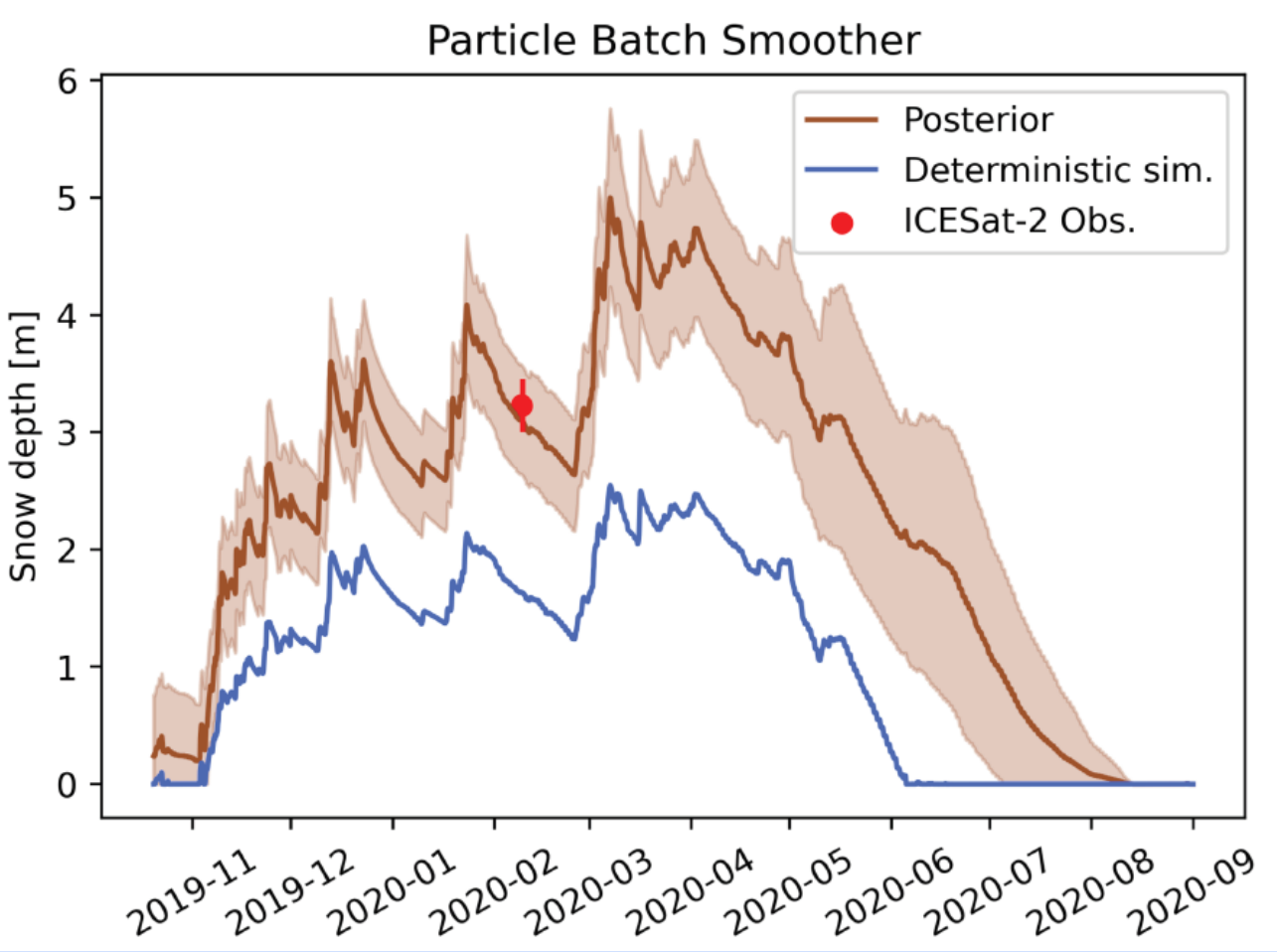
SNOW IN FORESTS

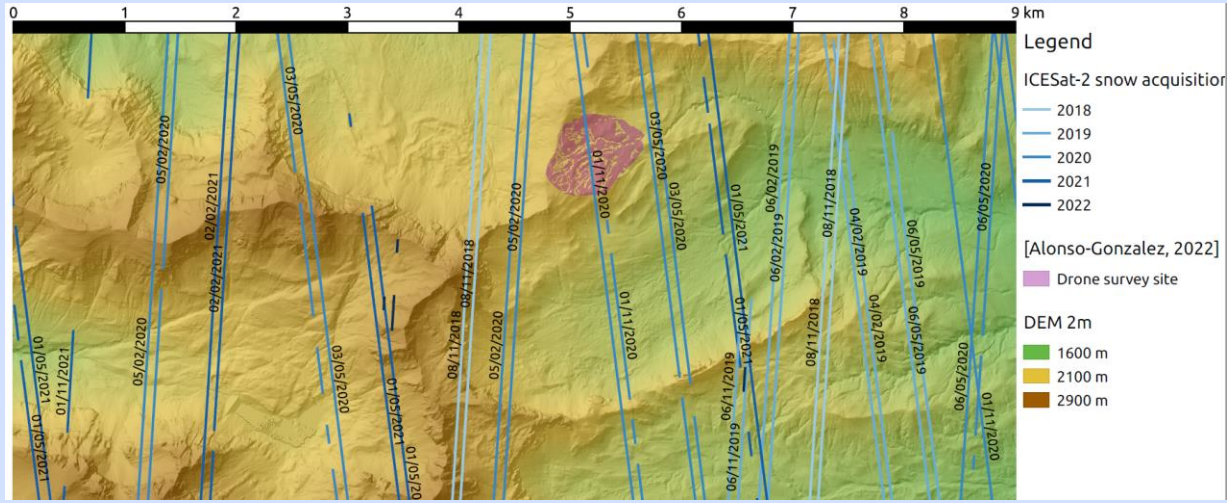
SNOW IN FORESTS



GETTING MAPS – FROM DATA ASSIMILATION

Modelled SWE improves if snow depth data is assimilated





Challenge: spatial propagation of information from sparse tracks

Marco Mazzolini; Izas catchment, Pyrenees

CONCLUSIONS & OUTLOOK (1/3)

1. Can we use ICESat-2 data to get snow depths?	Yes (mostly…?)
2. How accurate are these snow depths?	Comparable to UAV lidar data
3. Is this data useful for me?	Depends on what you are doing:
➢ *I have a 1 km^2 catchment:*	*no*
➢ *I want to do operational stuff:*	*no – data is ~3 months delayed*
➢ *I want snow depths in (dense) forests:*	*seems to work out*
➢ *I only have an inaccurate snow-off DEM:*	*acquire a better DEM*
➢ *I have little data in my large/remote area and want to combine/assimilate it with other data:*	*looks promising*

CONCLUSIONS & OUTLOOK (3/3)

desiree.treichler@geo.uio.no

4. How to move on from there ?

Forests – this winter's field work

Upscale processing (photons: ☠)

Spatial propagation of snow depth profile information in DA / ML framework

Exploit the data for other uses: