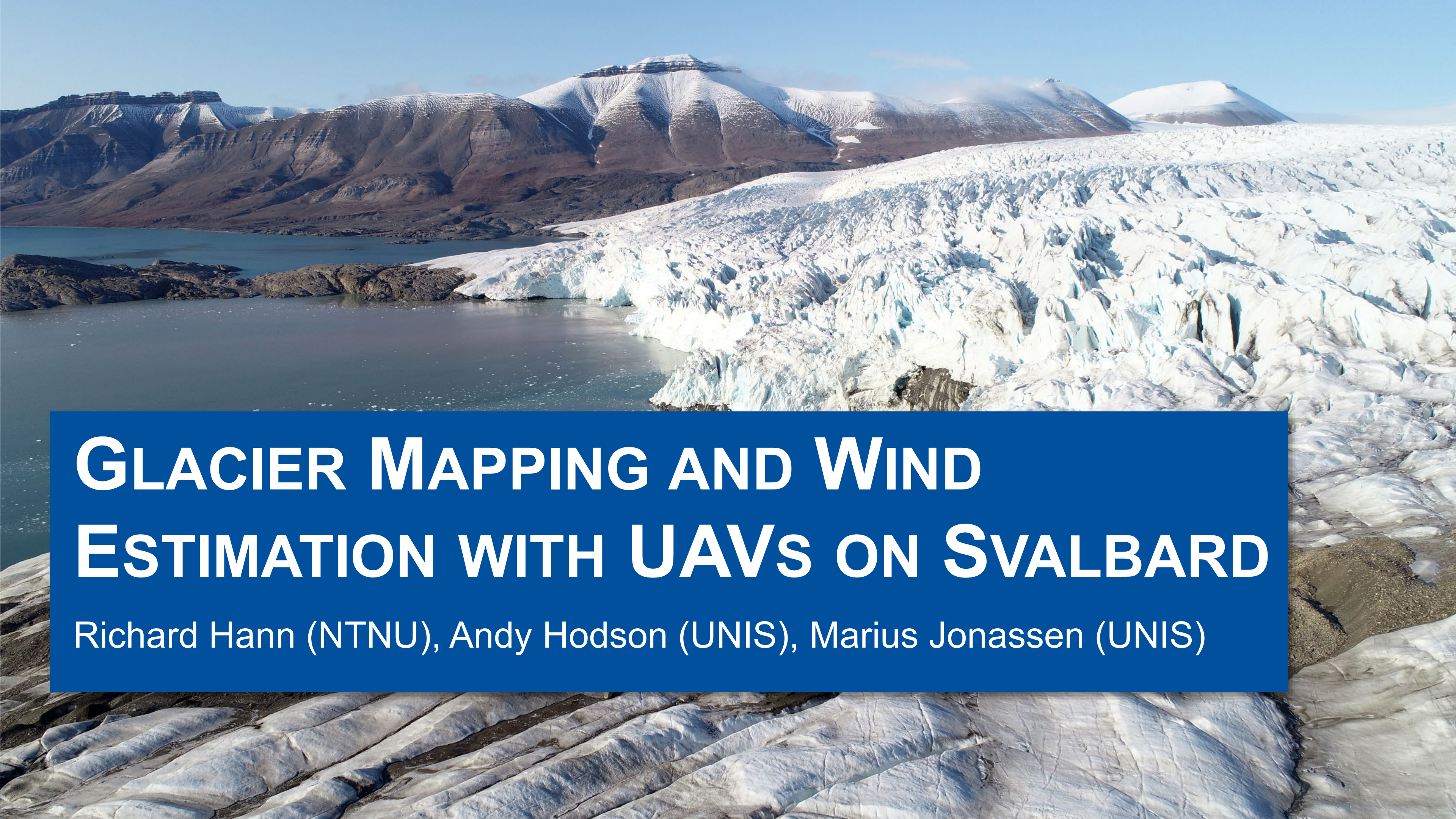


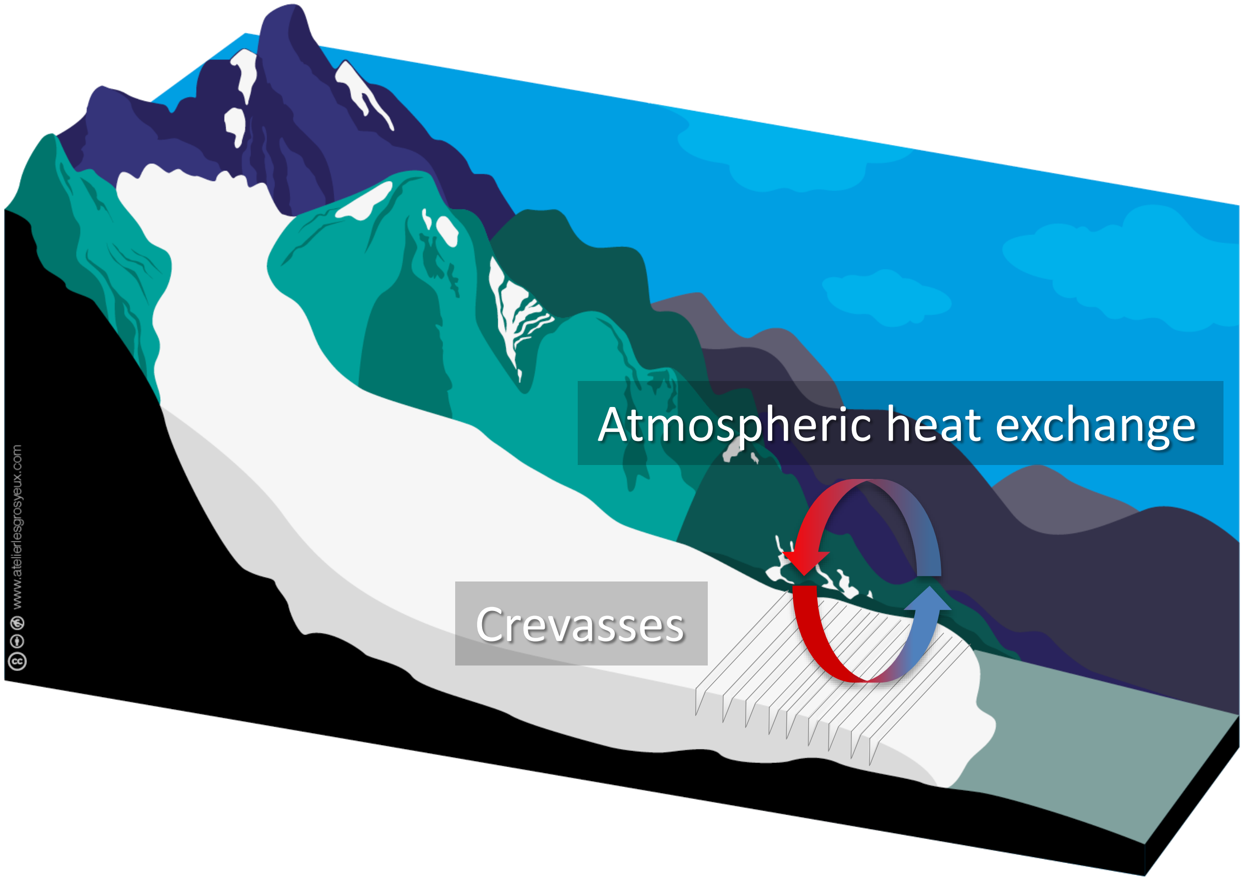
Glacier Mapping and Wind Estimation with UAVs on Svalbard

Richard Hann (NTNU), Andy Hodson (UNIS), Marius Jonassen (UNIS)

Abstract

- This study focusses on the application of unmanned aerial vehicles (UAVs) to study crevassed glaciers on Svalbard (RIS-ID: 11148). Drones have several advantages for this type of research. They offer a possibility to investigate crevasses from a safe distance, without the hazards of glacier travel. Drones can take high-quality aerial imagery and are mostly independent of cloud coverage, which is an advantage compared to conventional remote sensing satellite data.
- Three tidewater glacier fronts on Svalbard have been mapped using a DJI Phantom 4 Pro drone: Tunabreen, Fridtjovbreen, and in Mohnbukta. For each location, we have generated high-resolution digital elevation models (DEMs) using a photogrammetry method. We use these DEMs to study the influence of surface roughness on atmospheric heat exchange. The aerodynamic surface roughness parameters, which are enhancing heat transfer rates, are strongly linked to the size, depth, orientation, and the number of crevasses. The aerodynamic surface roughness can be identified from the DEMs and is used in thermodynamic models to estimate the heat transfer rates. In the context of rising atmospheric temperatures due to climate change, crevasses may be an important factor for glacier mass balancing.
- Furthermore, we have tested a novel approach to use a multirotor drone for wind measurements based on the UAV inertial measurement unit (IMU) data. Pitch angle, yaw angle, and thrust variables can be used to estimate wind speed and wind direction while the drone is holding its position. To calibrate the method and to find the estimation functions, the drone is flown next to a wind measurement mast near Longyearbyen. Once a function between the IMU data and the wind speed has been established, the drone was used to take vertical wind profiles up to altitudes of 120m above ground.

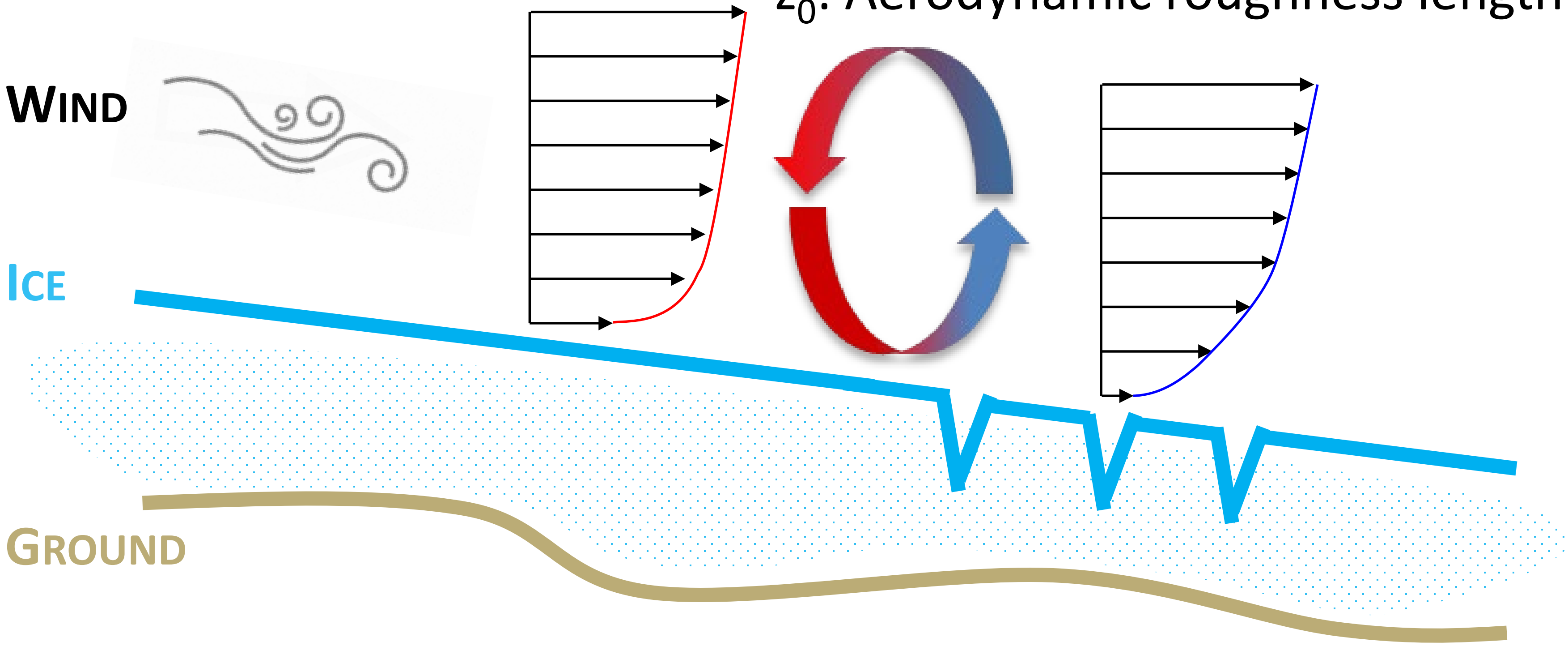

Richard Hann
- 3rd year PhD at NTNU
- Aerospace engineer
- UAVs for Arctic Applications

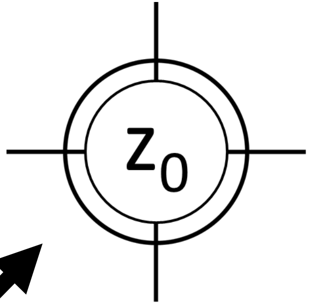

Atmospheric heat exchange
Crevasses
www.atelierlesgrosyeux.com

Heat transfer intensification

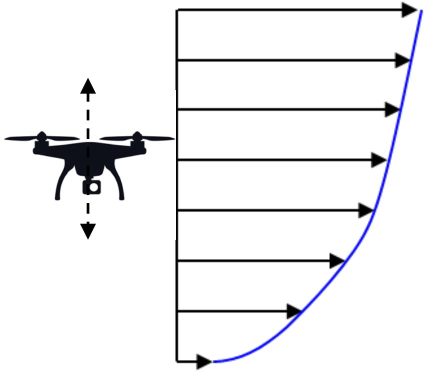
Log wind profile ~ $f(z_0)$

z_0: Aerodynamic roughness length

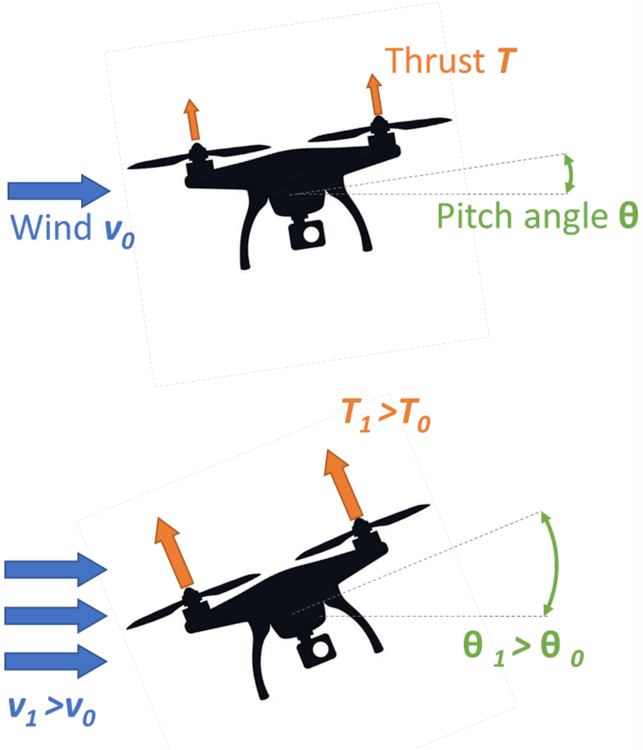




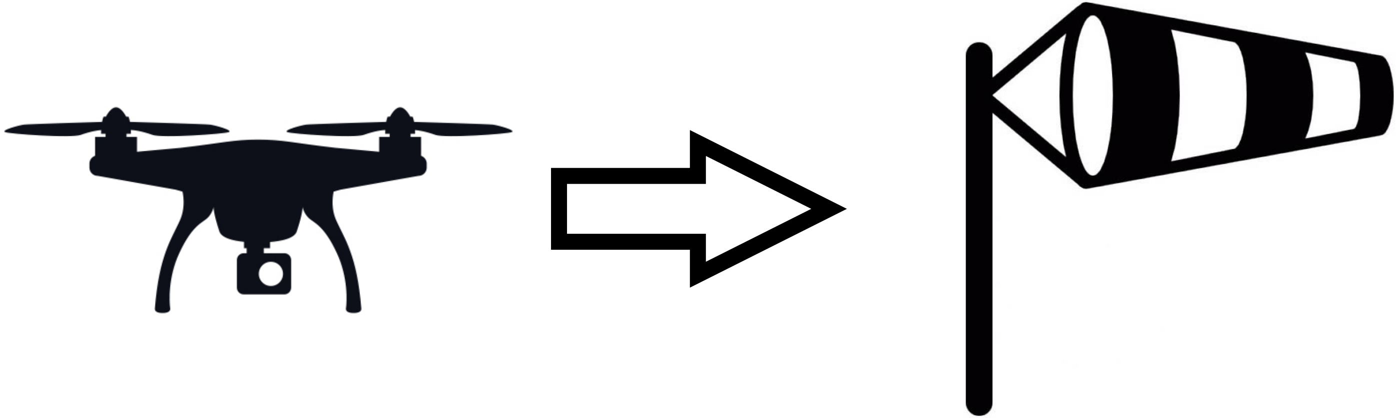
Direct Measurement

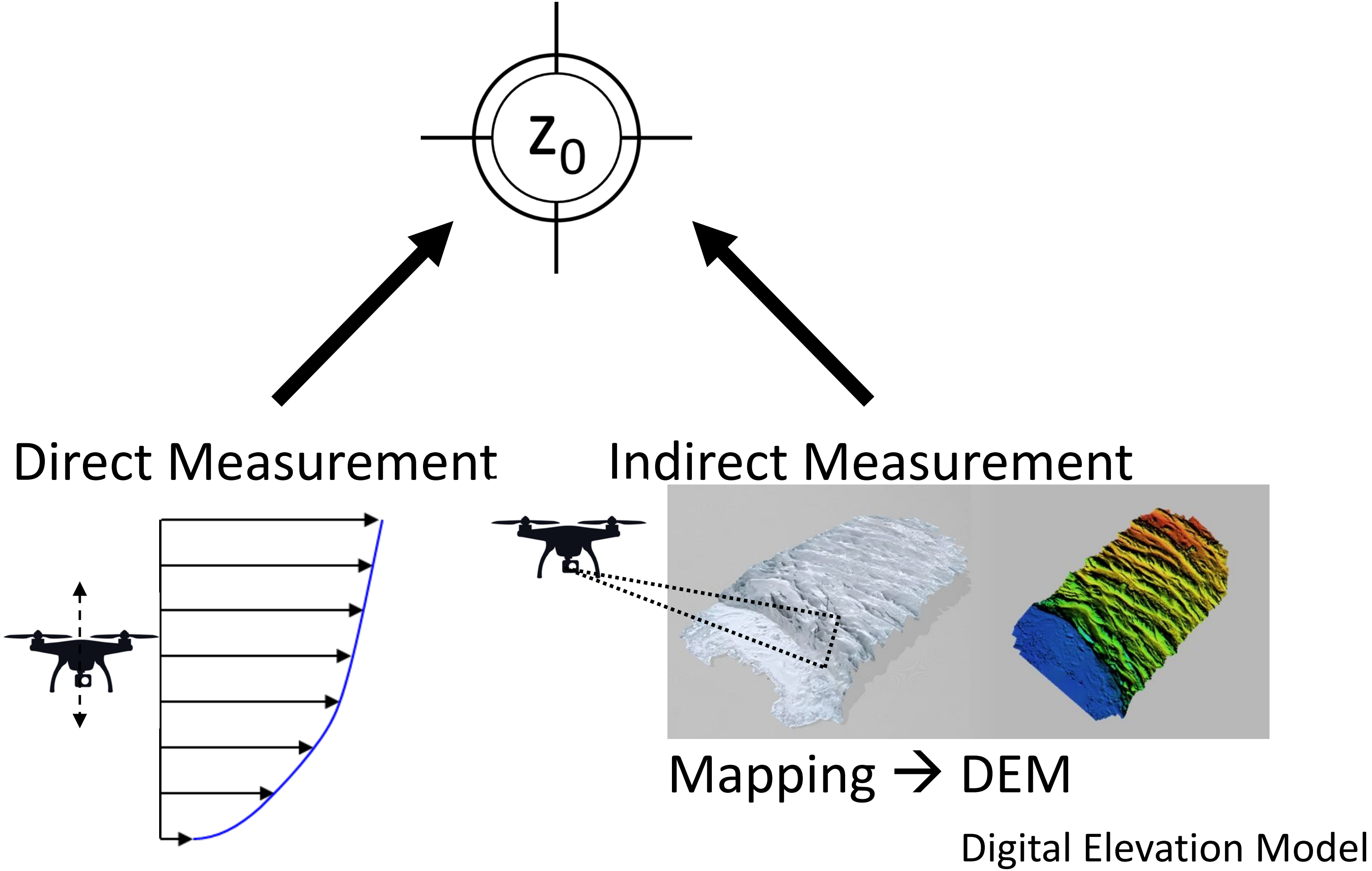


Wind Estimation with UAVs



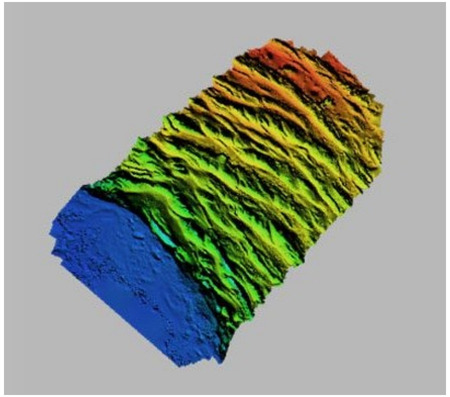
Wind Estimation with UAVs



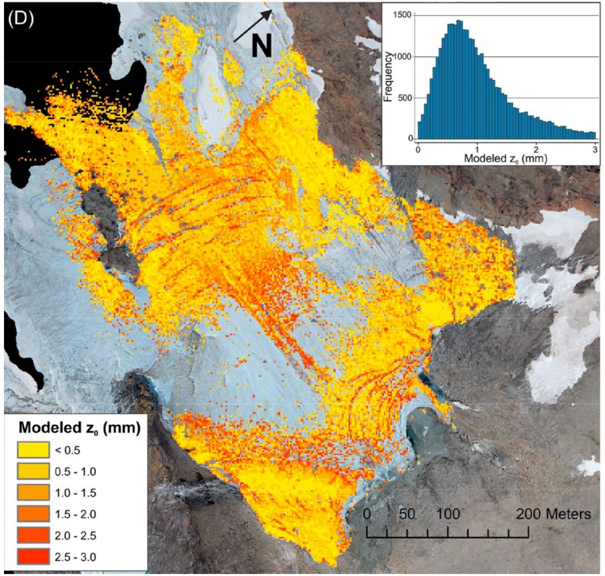

z_0
Direct Measurement
Indirect Measurement
Mapping → DEM
Digital Elevation Model

DEM

Digital Elevation Model



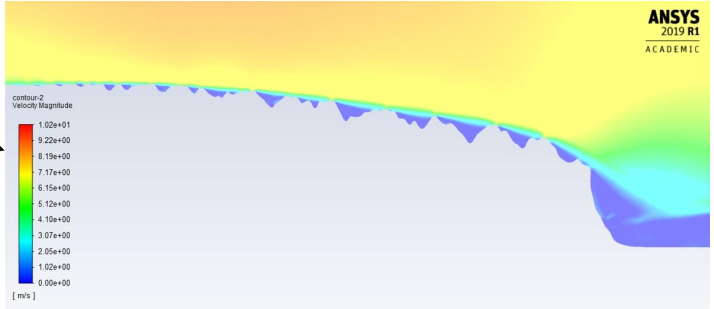
GIS Evaluation*



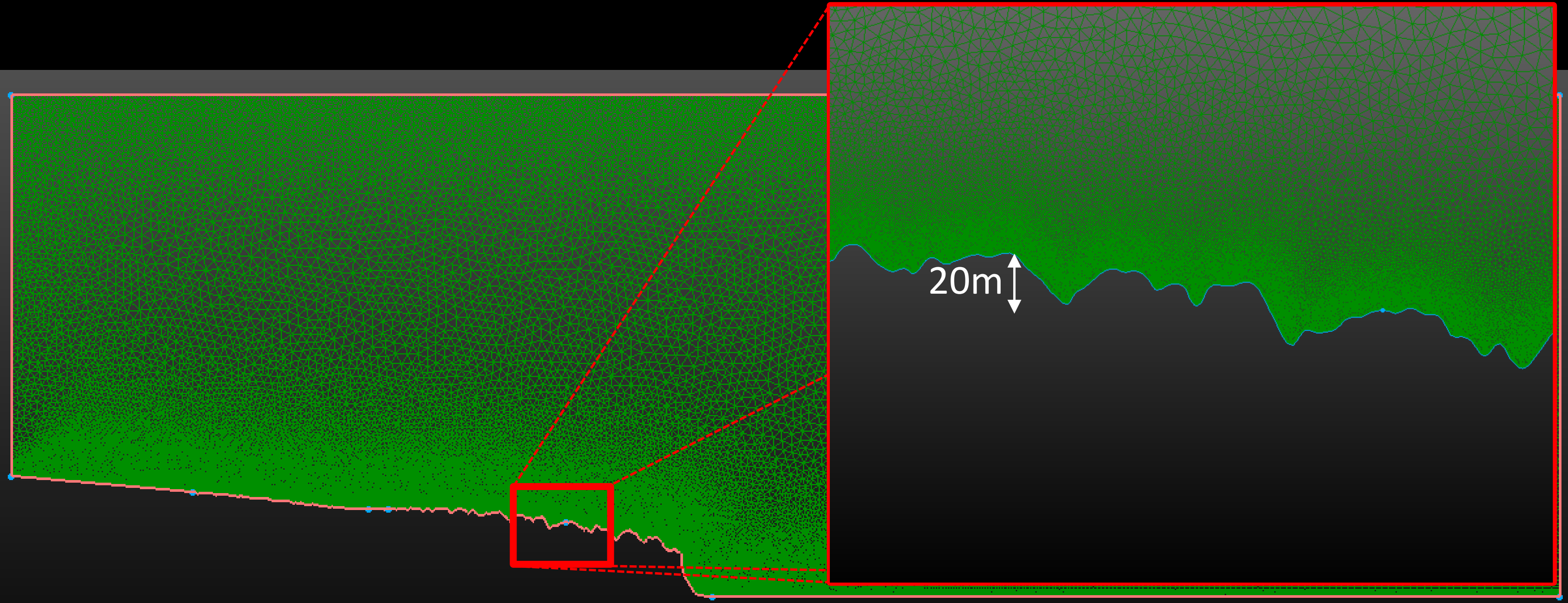
*Smith et al., (2016): **Aerodynamic roughness of glacial ice surfaces derived from high-resolution topographic data**. JGR: Earth Surface

CFD

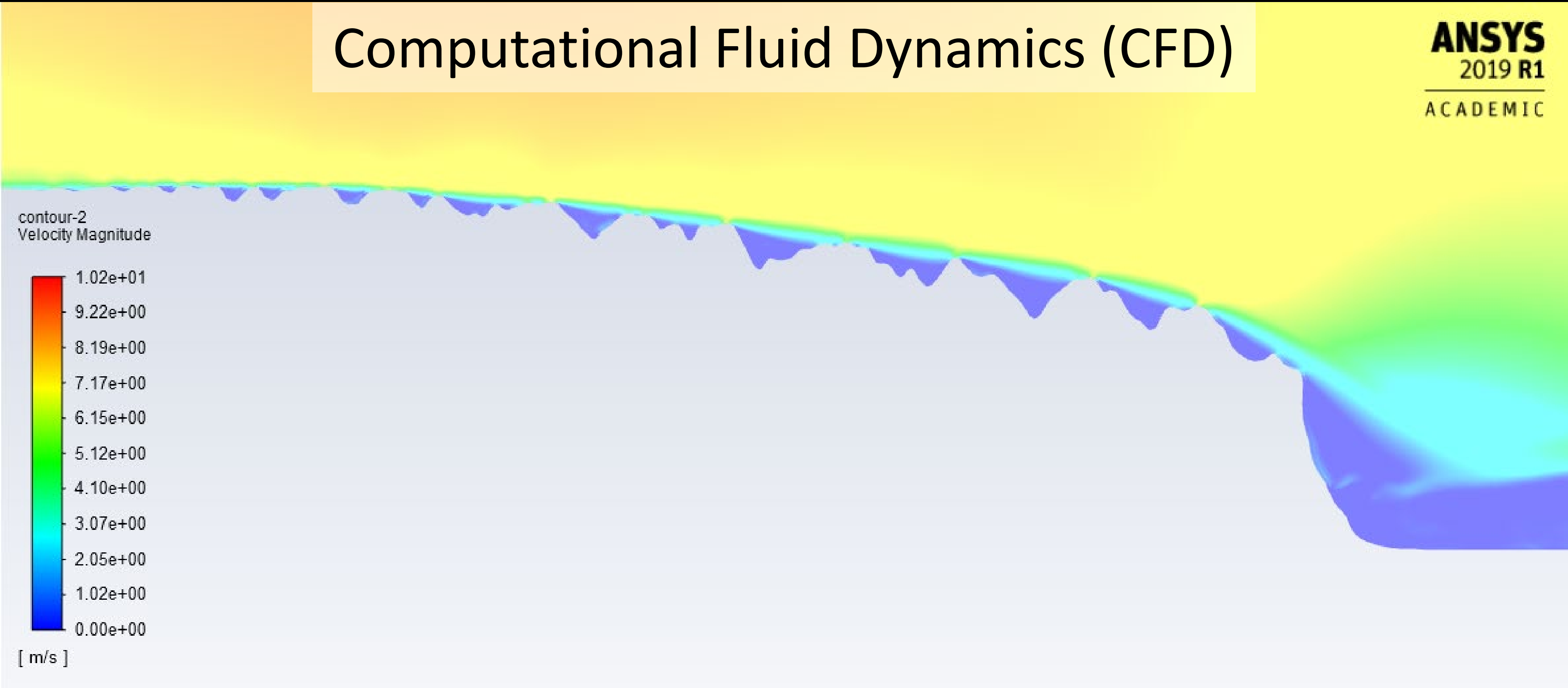
Computational Fluid Dynamics



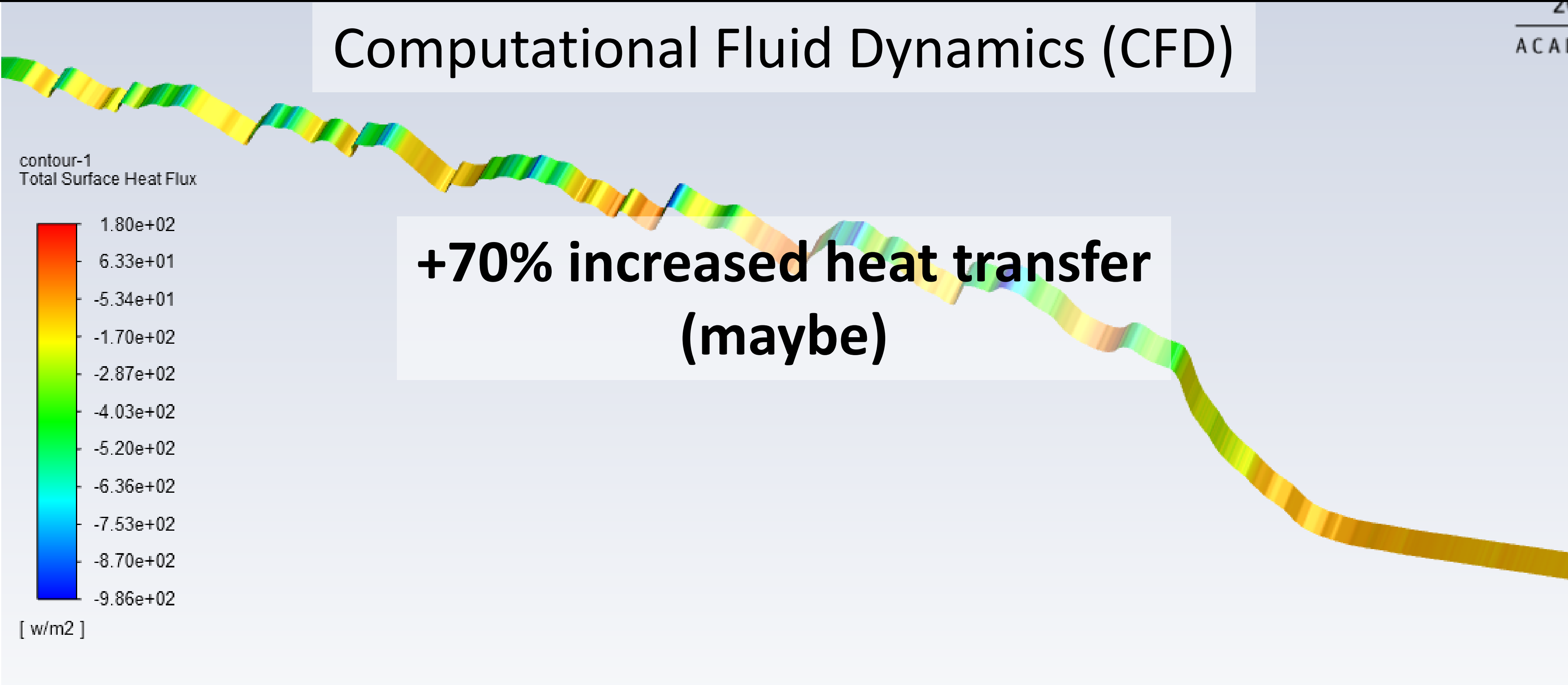
Computational Fluid Dynamics (CFD)



Computational Fluid Dynamics (CFD)

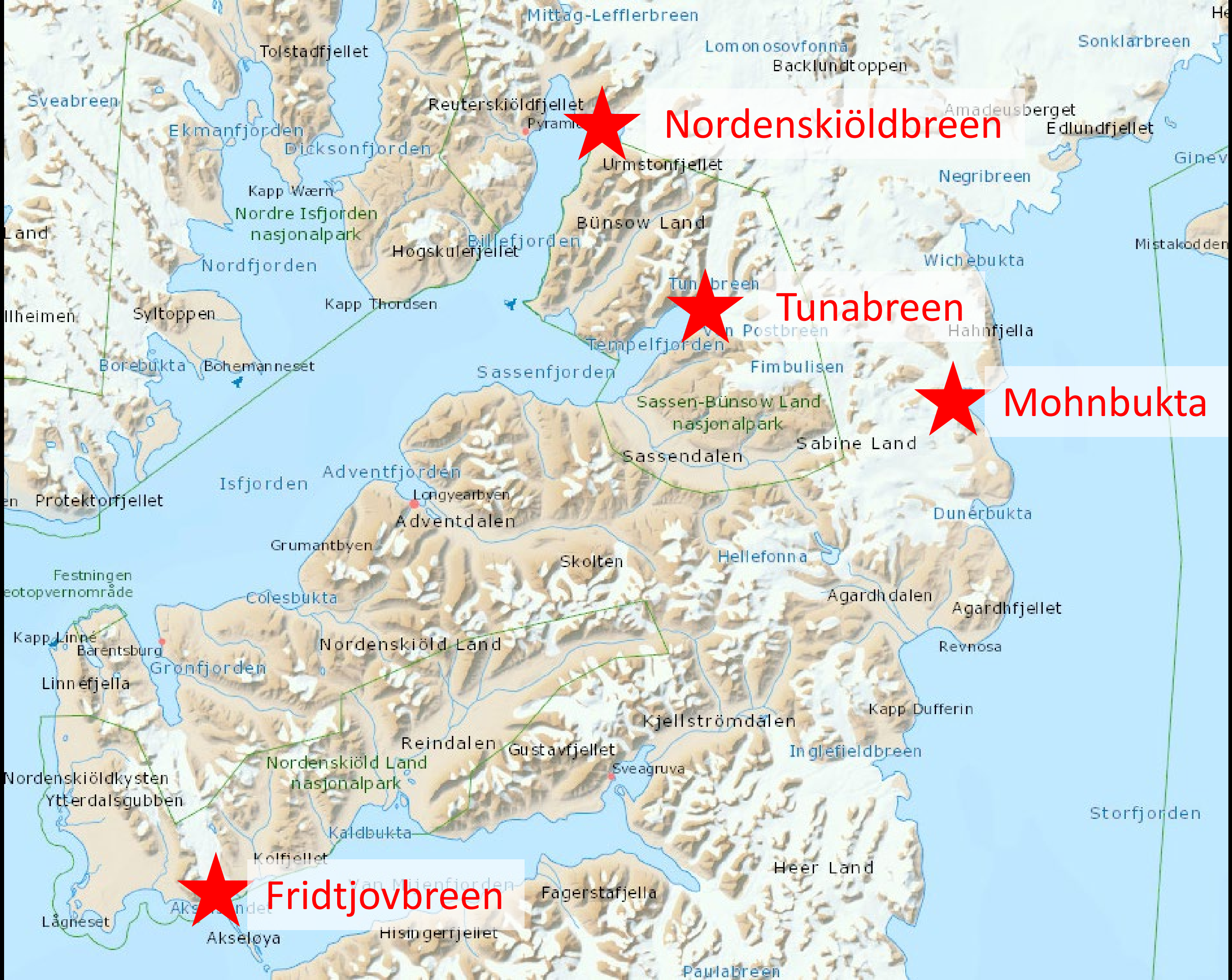


Computational Fluid Dynamics (CFD)



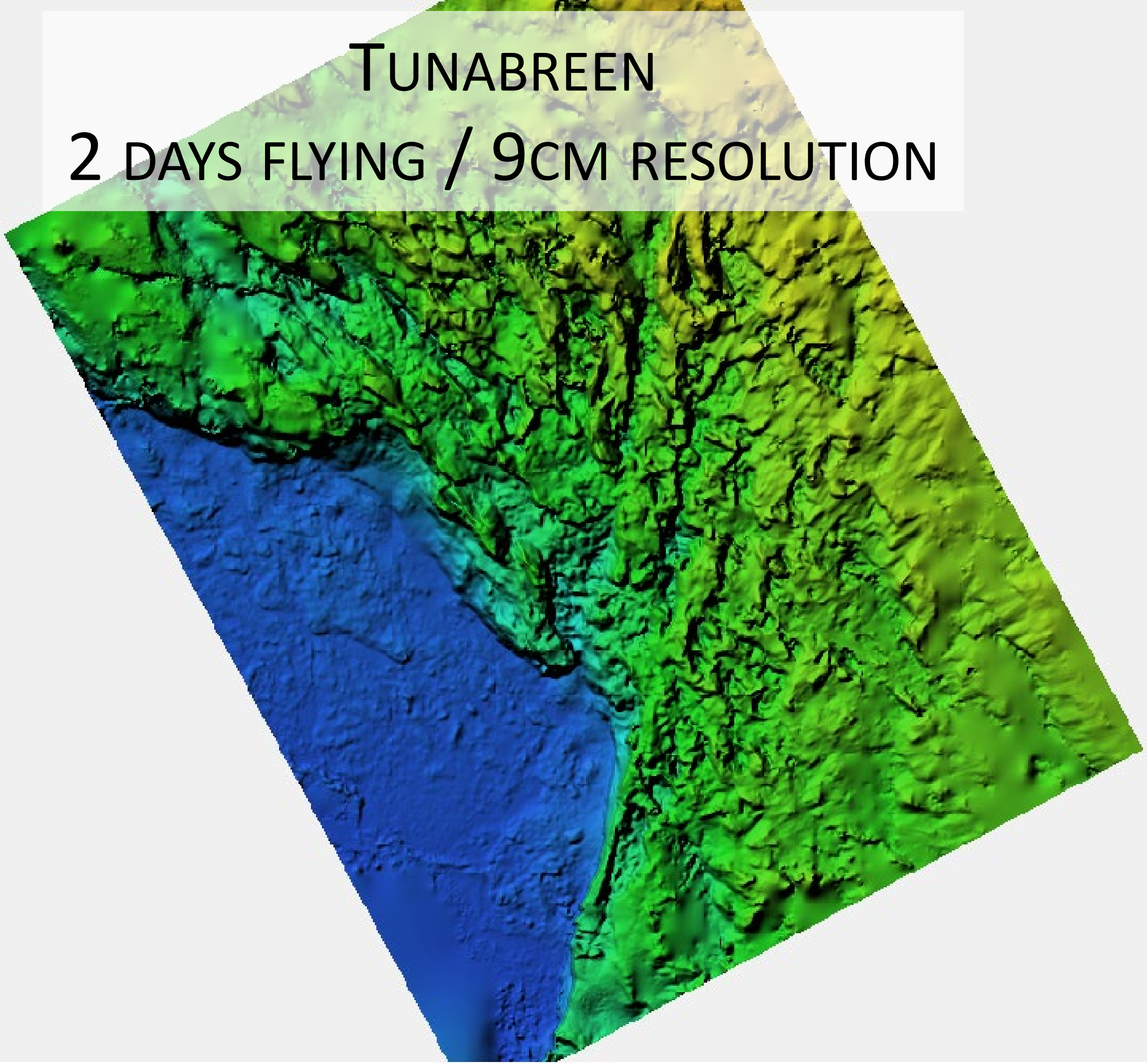
+70% increased heat transfer (maybe)

Fieldwork Sites


Nordenskiöldbreen
Tunabreen
Mohnbukta
Fridtjovbreen
Mittag-Lefflerbreen
Lomonosovfonna
Backlundtoppen
Sonklarbreen
Tolstadfjellet
Sveabreen
Ekmanfjorden
Dicksonfjorden
Reuterskiöldfjellet
Urmstonfjellet
Amadeusberget
Edlundfjellet
Negribreen
Kapp Wærn
Nordre Isfjorden nasjonalpark
Bünsow Land
Billefjorden
Høgskulefjellet
Nordfjorden
Wichebukta
Mistakodden
Kapp Thordsen
Syltoppen
Tempelfjorden
Hahnfjella
Fimbulisen
Borebukta
Bohemanneset
Sassenfjorden
Sassen-Bünsow Land nasjonalpark
Sabine Land
Sassendalen
Isfjorden
Adventfjorden
Longyearbyen
Adventdalen
Protektorfjellet
Dunérbukta
Grumantbyen
Skolten
Hellefonna
Festningen
Colesbukta
Agardhdalen
Agardhfjellet
Kapp Linné
Barentsburg
Nordenskiöld Land
Revnosa
Grønfjorden
Linnéfjella
Kjellströmdalen
Kapp Dufferin
Reindalen
Gustavfjellet
Sveagruva
Inglefieldbreen
Nordenskiöld Land nasjonalpark
Nordenskiöldkysten
Ytterdalsgubben
Storfjorden
Kaldbukta
Kolfjellet
Heer Land
Fagerstafjella
Lågneset
Akseløya
Hisingerfjellet
Paulabreen

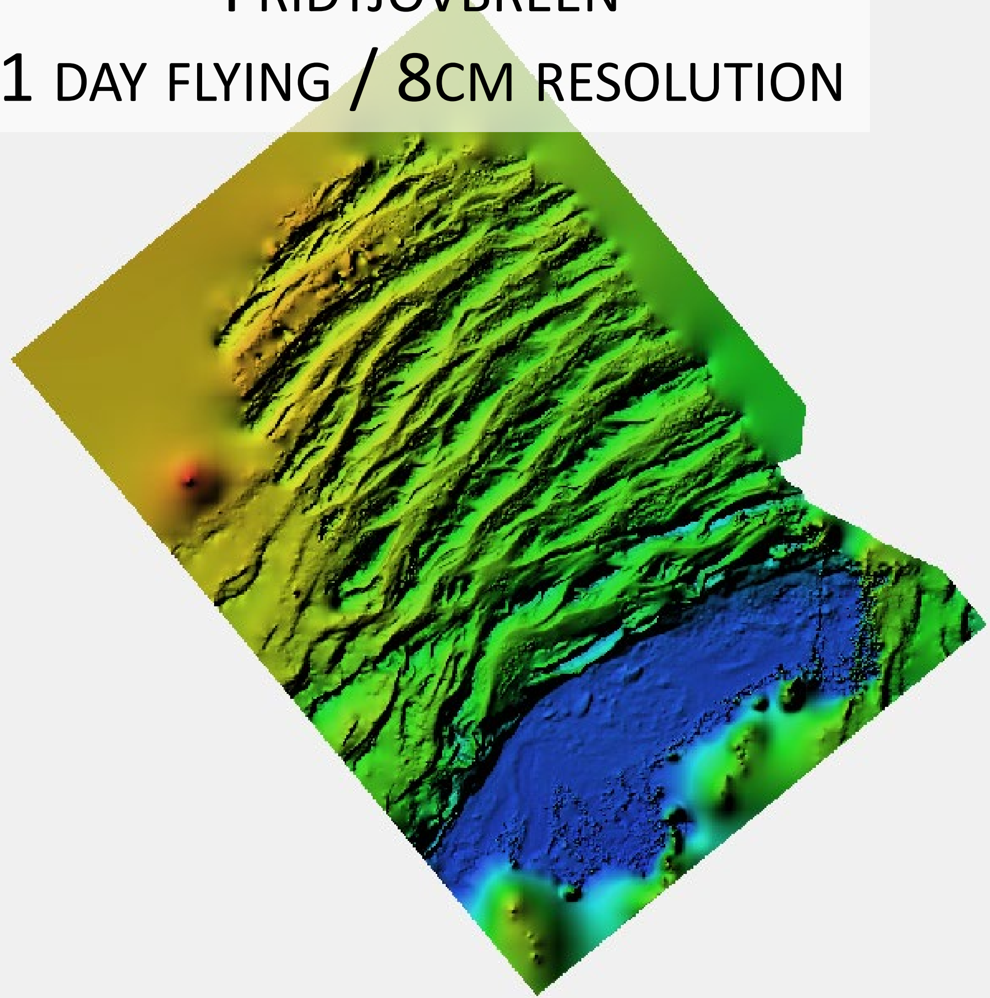

TUNABREEN
© Richard Hann

Tunabreen
2 days flying / 9cm resolution



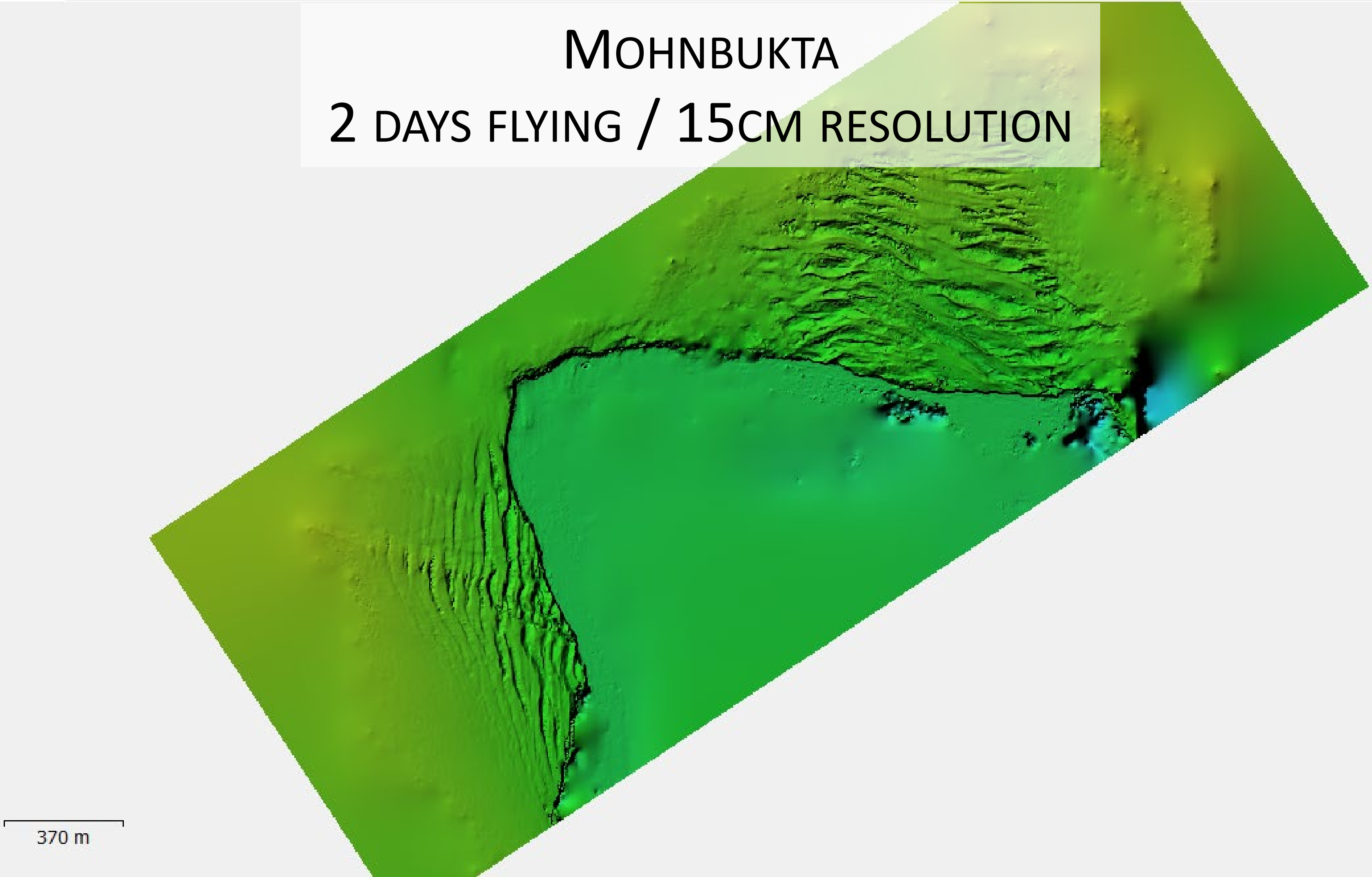

FRIDTJOVBREEN
© Richard Hann

Fridtjovbreen
1 day flying / 8cm resolution



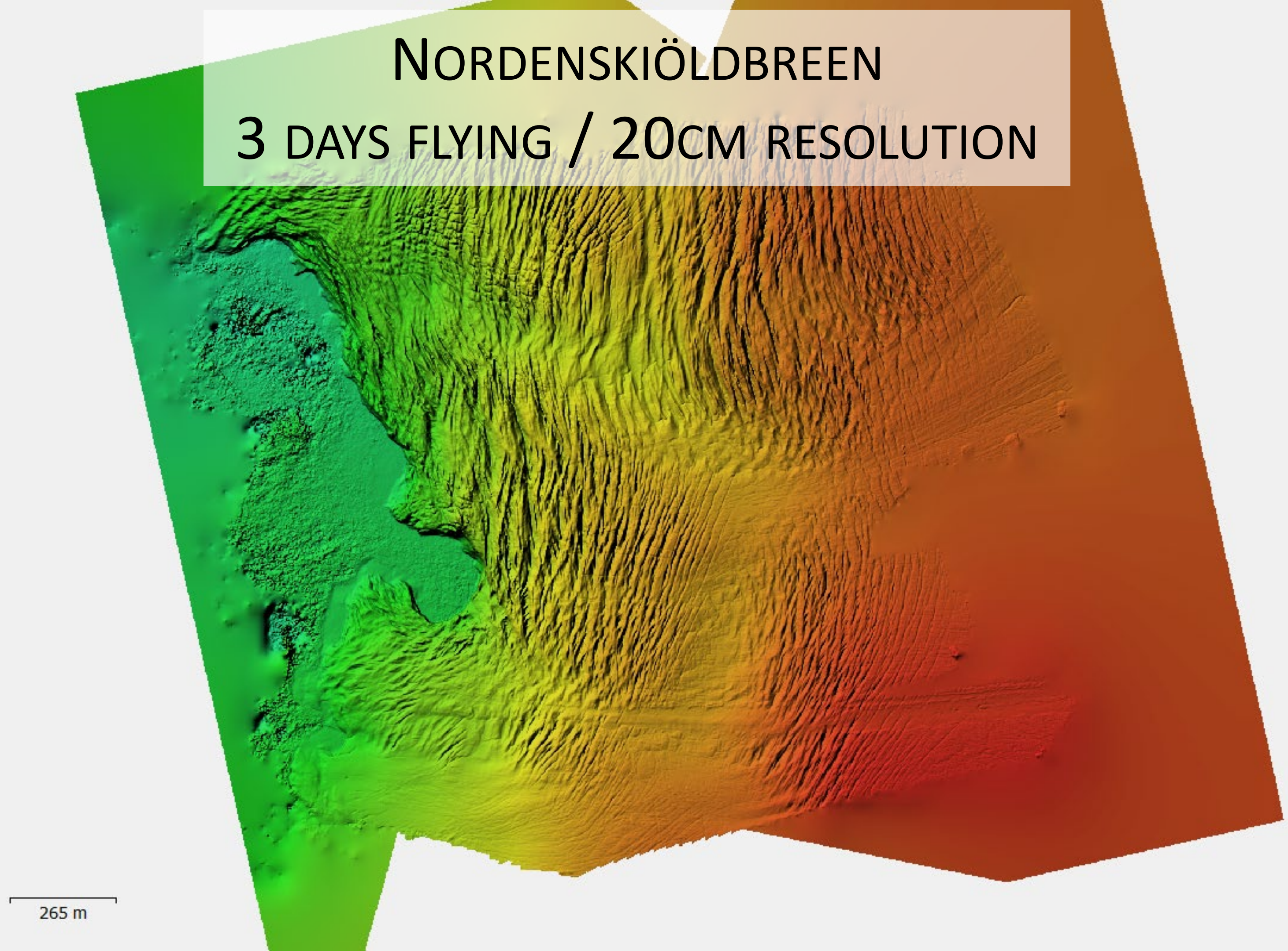
MOHNBUKTA

MOHNBUKTA
2 DAYS FLYING / 15CM RESOLUTION




NORDENSKIÖLDBREEN

Nordenskiöldbreen
3 days flying / 20cm resolution



Experiences

- Bring 5-7 Batteries
- Keep them warm
- Fly overcast days
- Find a good vantage point
- Keep away from birds
- Pray for no magnetic interferences…

References