Patchy accumulation and bedforms observed at Dome C by timelapse photography and laserscanning

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Questions

How much snow accumulates on the Antarctic ice-sheet is a major question.

Different approaches:
- SMB measurements
- Regional climate models and « alpine » snow models
- Remote sensing

...

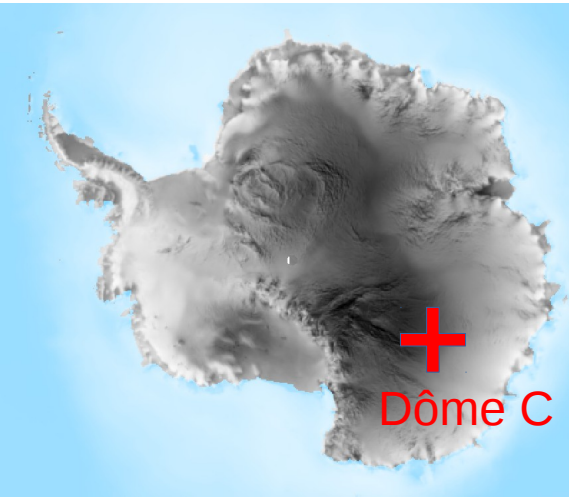
A different way to approach this question:

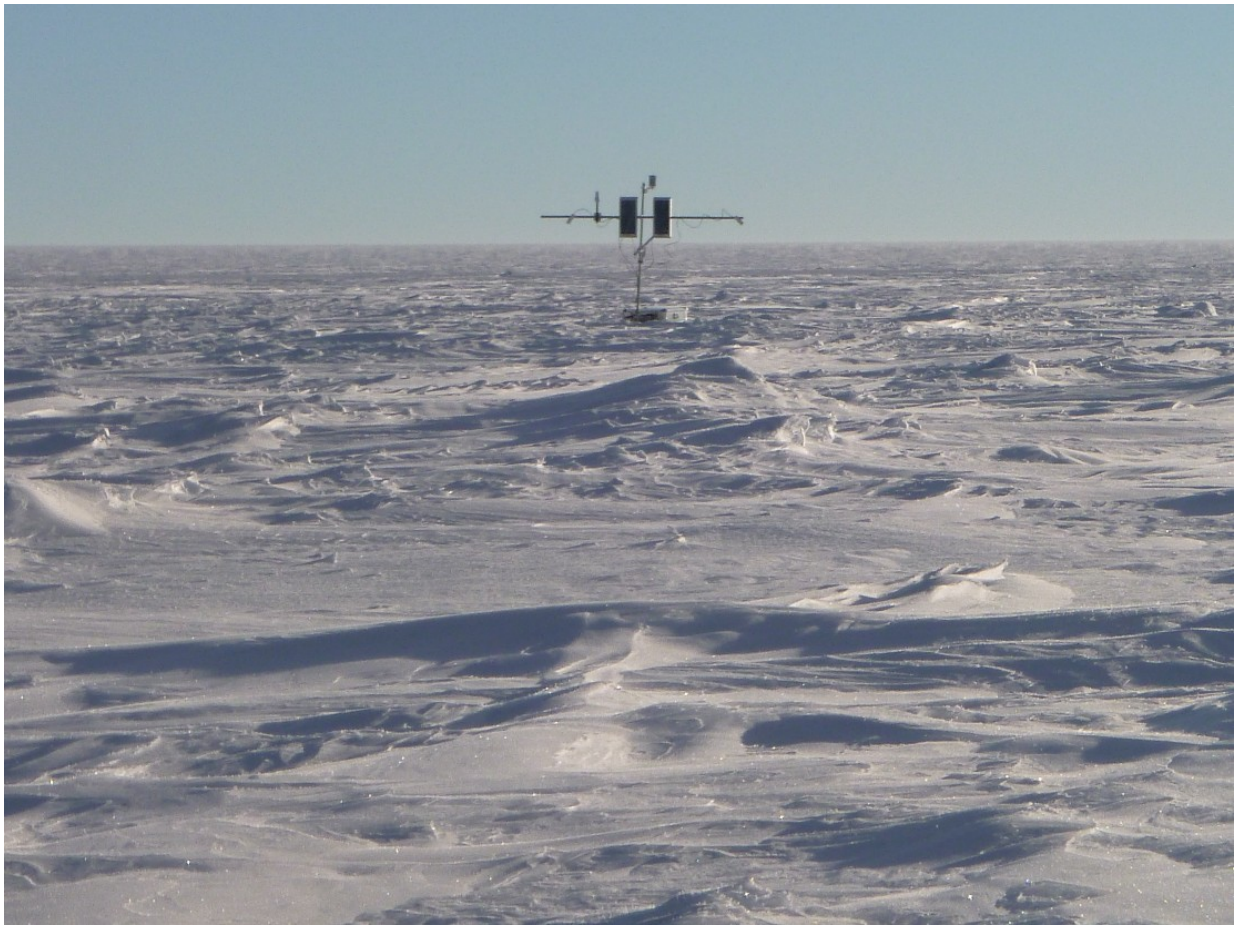
How does snow accumulate and settle on the Antarctic Plateau ?

Context

Dome C: **Annual accumulation < roughness height**

- Average **annual accumulation** is about 8-10 cm of snow
- Snow surface is **rough**: 20-30 cm high and more

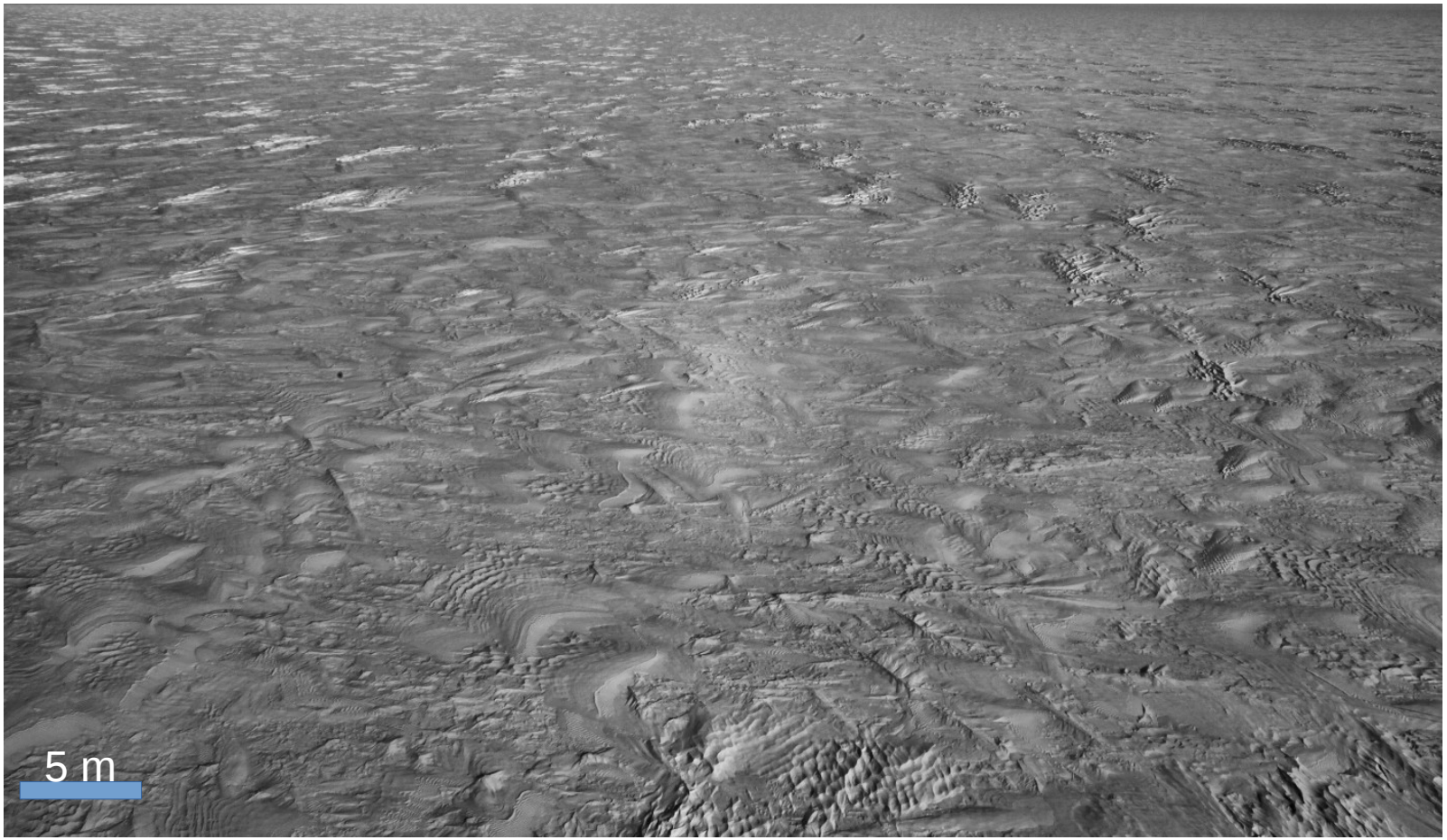




Spring 2013

Context

Dome C: **Meter-scale roughness is semi-organized:** dunes, ripples, sastrugi, ...



Context

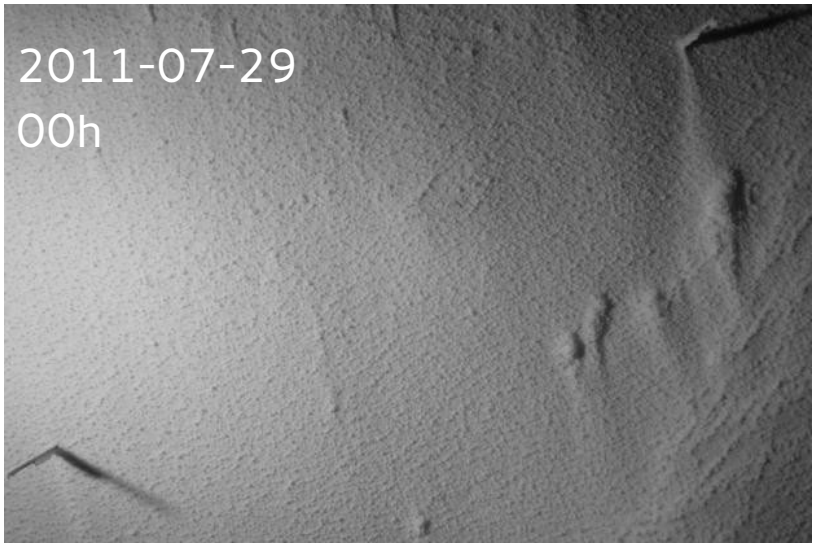
Layer by layer accumulation of snow, as it is common in the Alps is not adequate to describe snow accumulation in Antarctica.

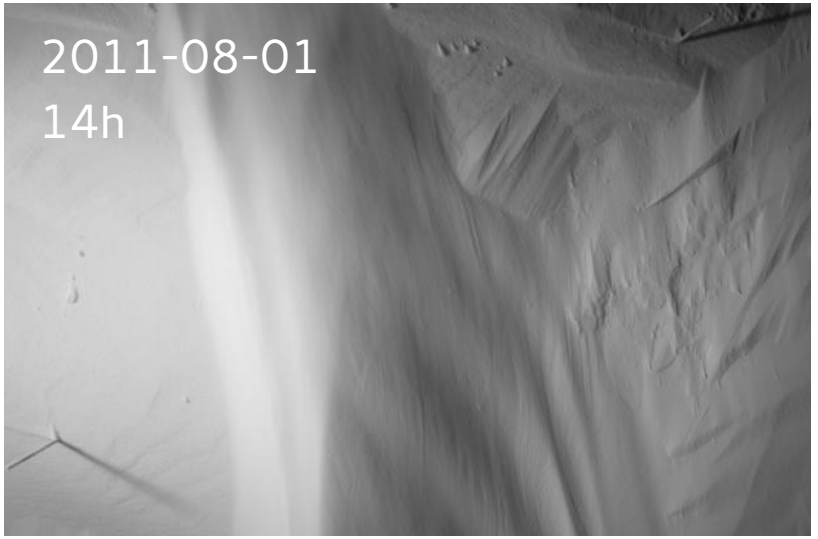
Time-lapse photography

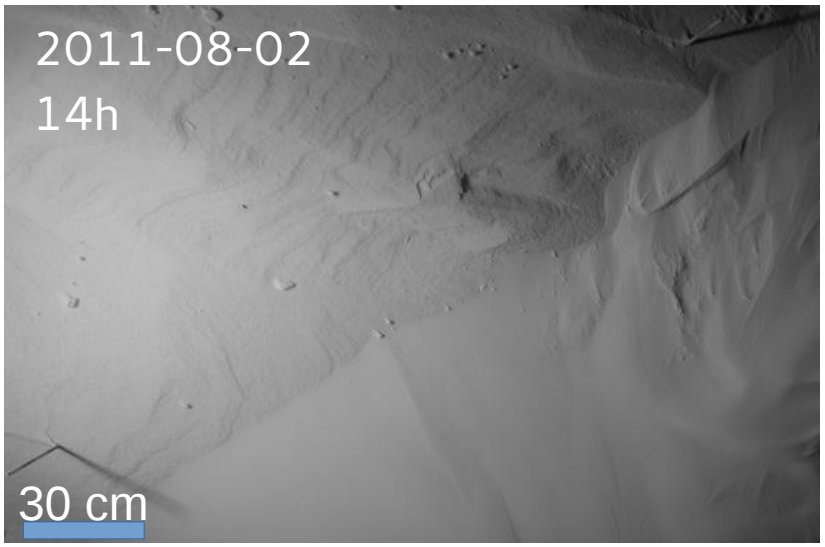
Different systems installed since **2009**: near-infrared Canon 5D and conventional webcam → about 120,000 photographs

Time-lapse photography

Near-infrared **nadir** looking series: http://gp.snow-physics.science/pauto/
Used by Champollion et al. 2013, TC for the surface hoar dynamics





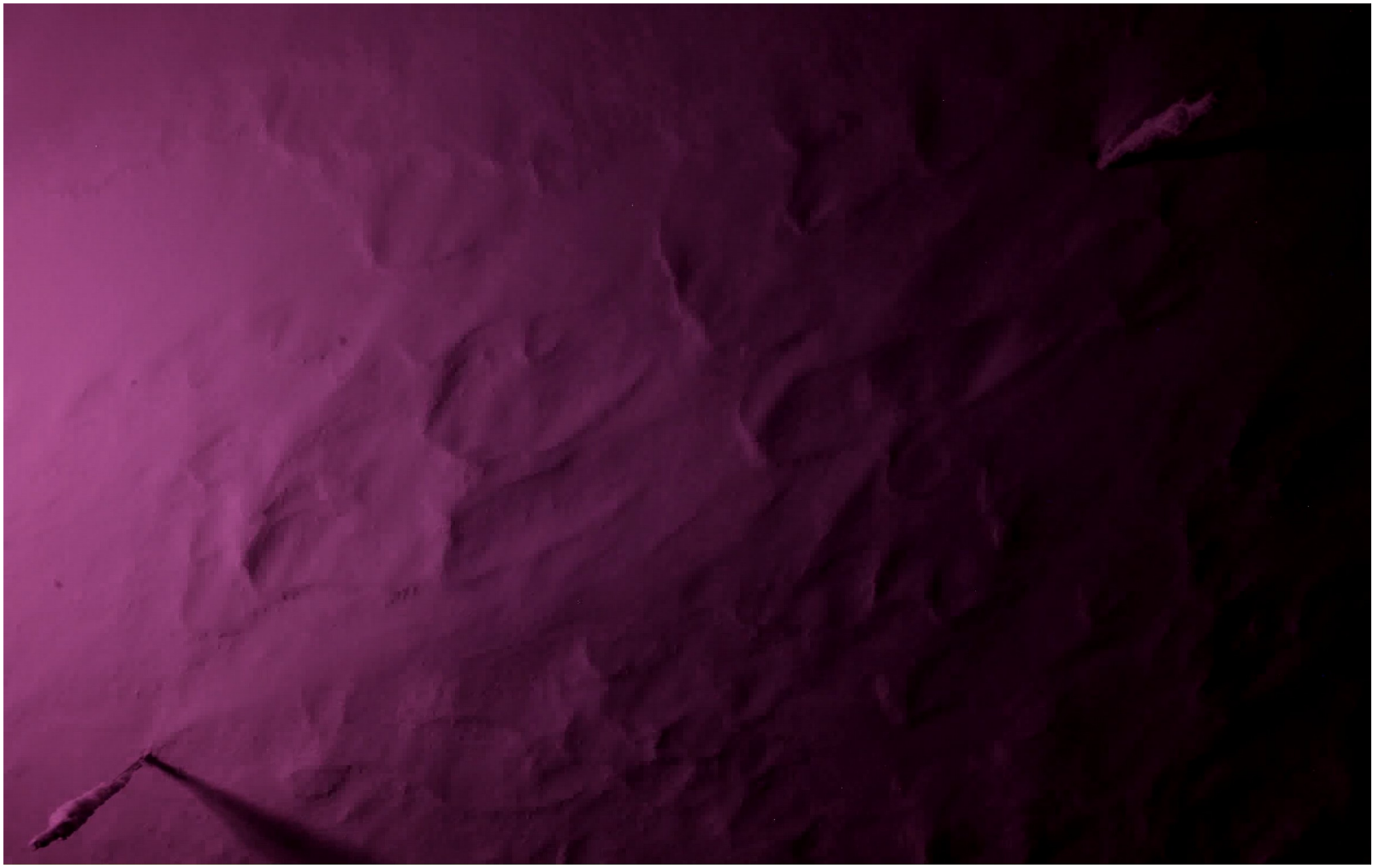


Major changes are relatively rare (a few events per year).

Time-lapse photography

~6 years of hourly pictures (with gaps!)

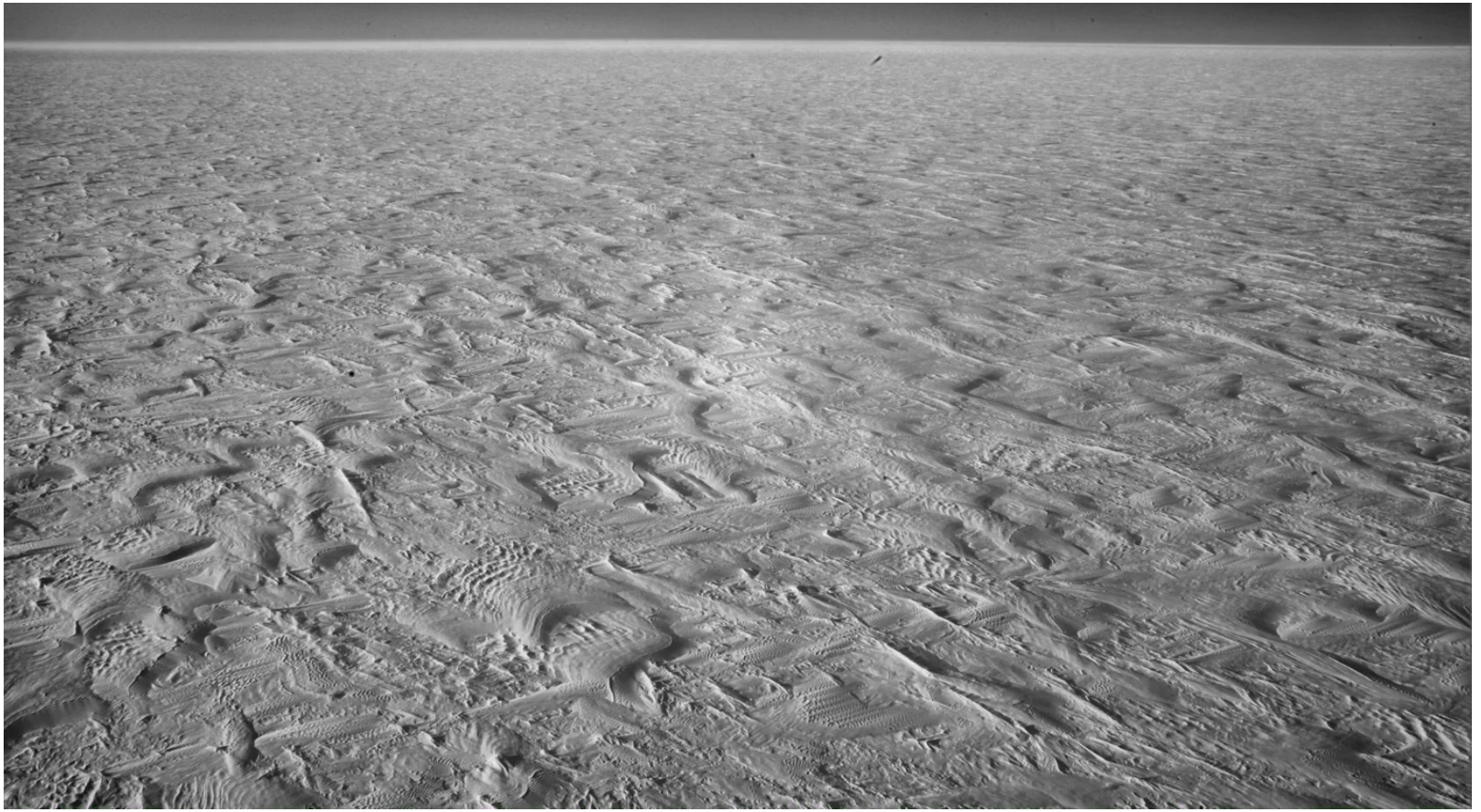
E.g sequence: June 2012



30 cm

Time-lapse photography

Since January 2017, at 20m height on the American tower



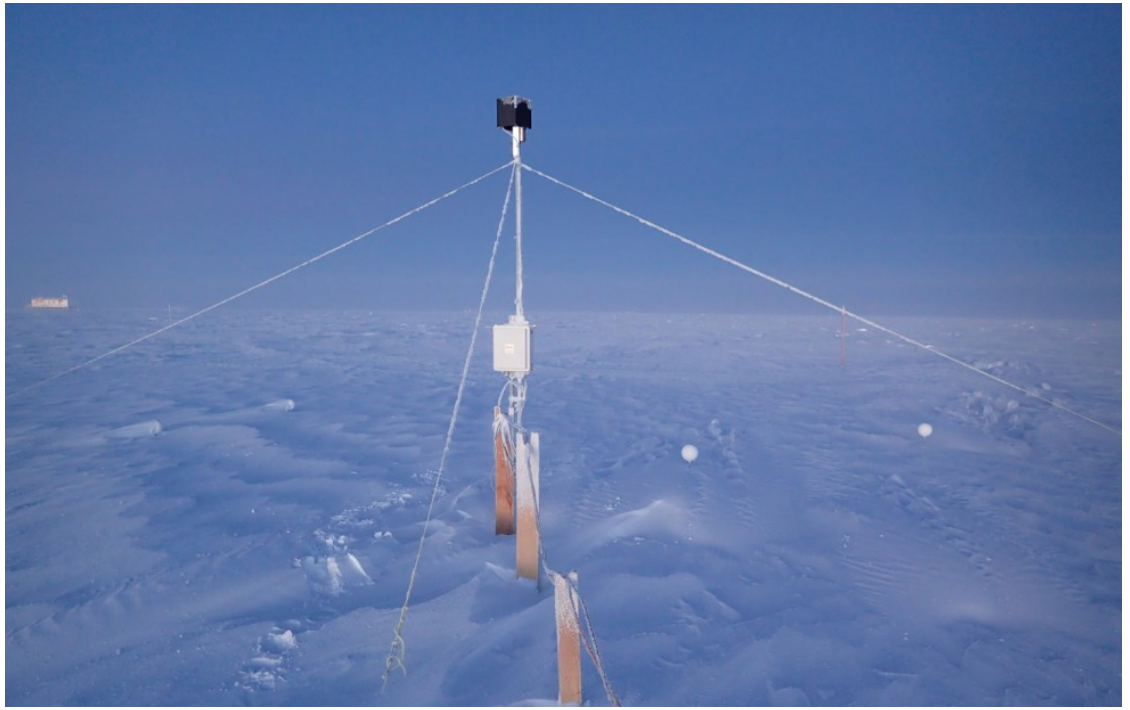
In general: Each wind/precipitation event only affects a small fraction of the surface

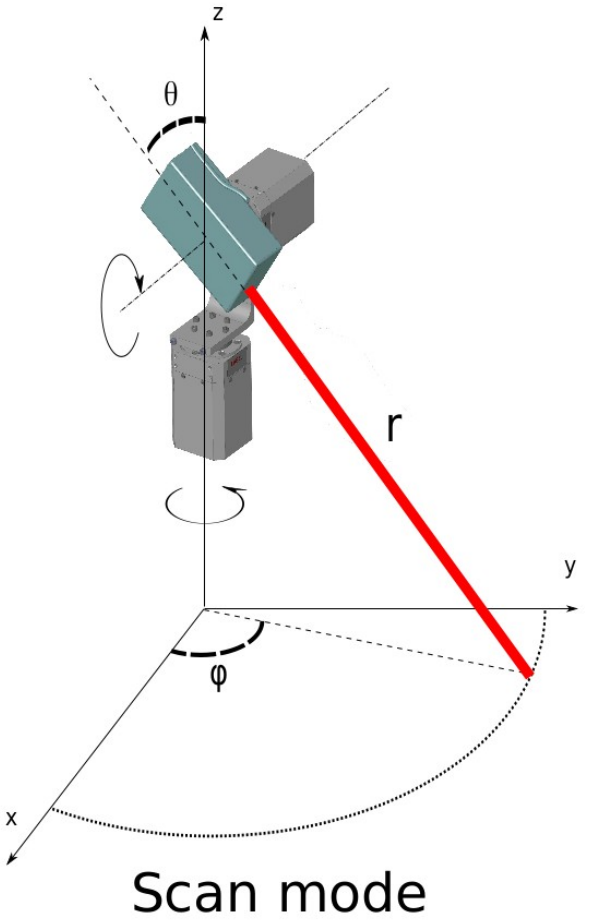
→ **patchy accumulation**

Time-lapse laserscanning

Development of the low-cost “rugged laser scan” (RLS)

- Commerical lasermeter known to work in Antarctic
- A specially designed 2-axis rotating mount





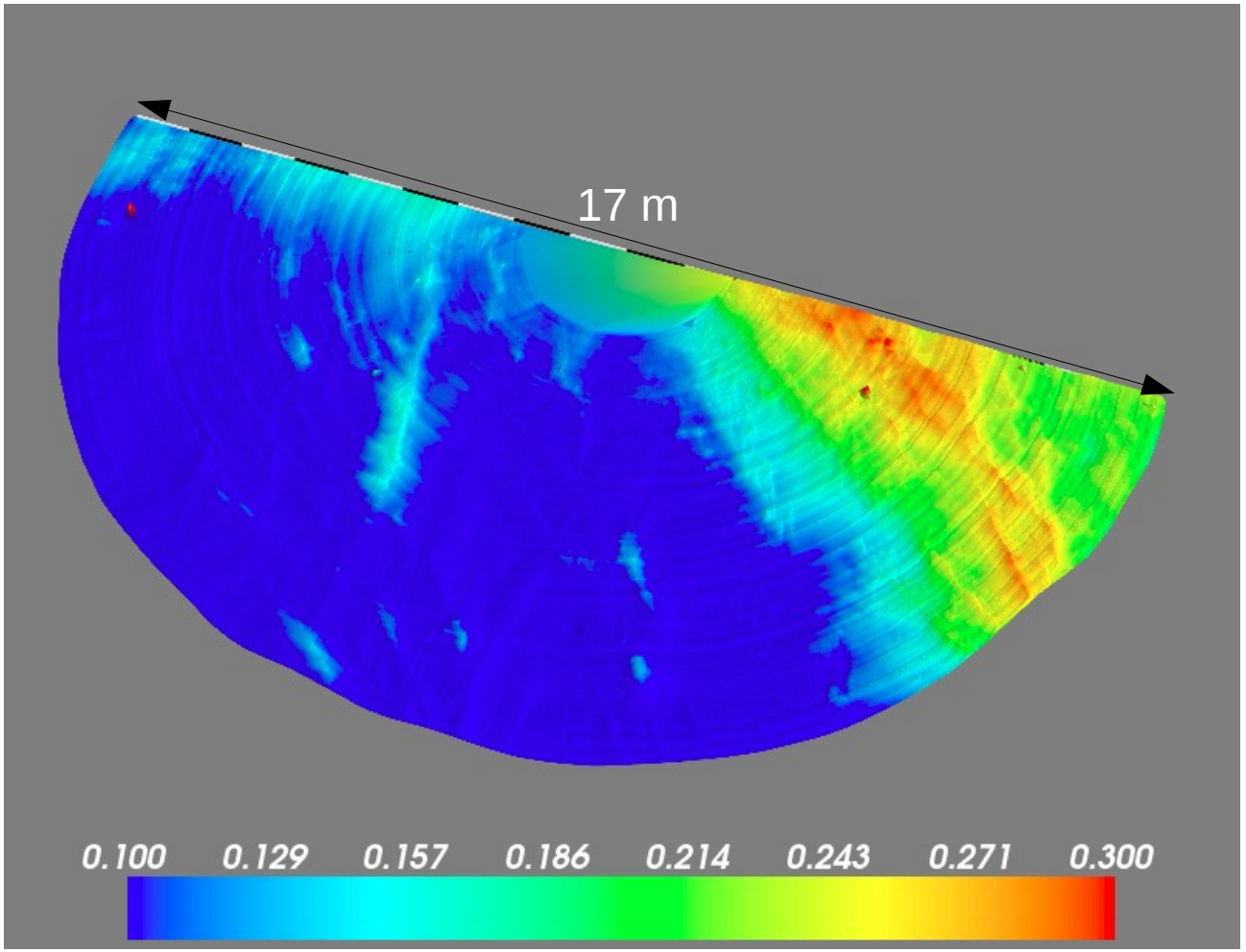
Scan mode

- Work by -80°C

Picard et al. 2016 TC

Time-lapse laserscanning

E.g. of scan (16 February 2017)

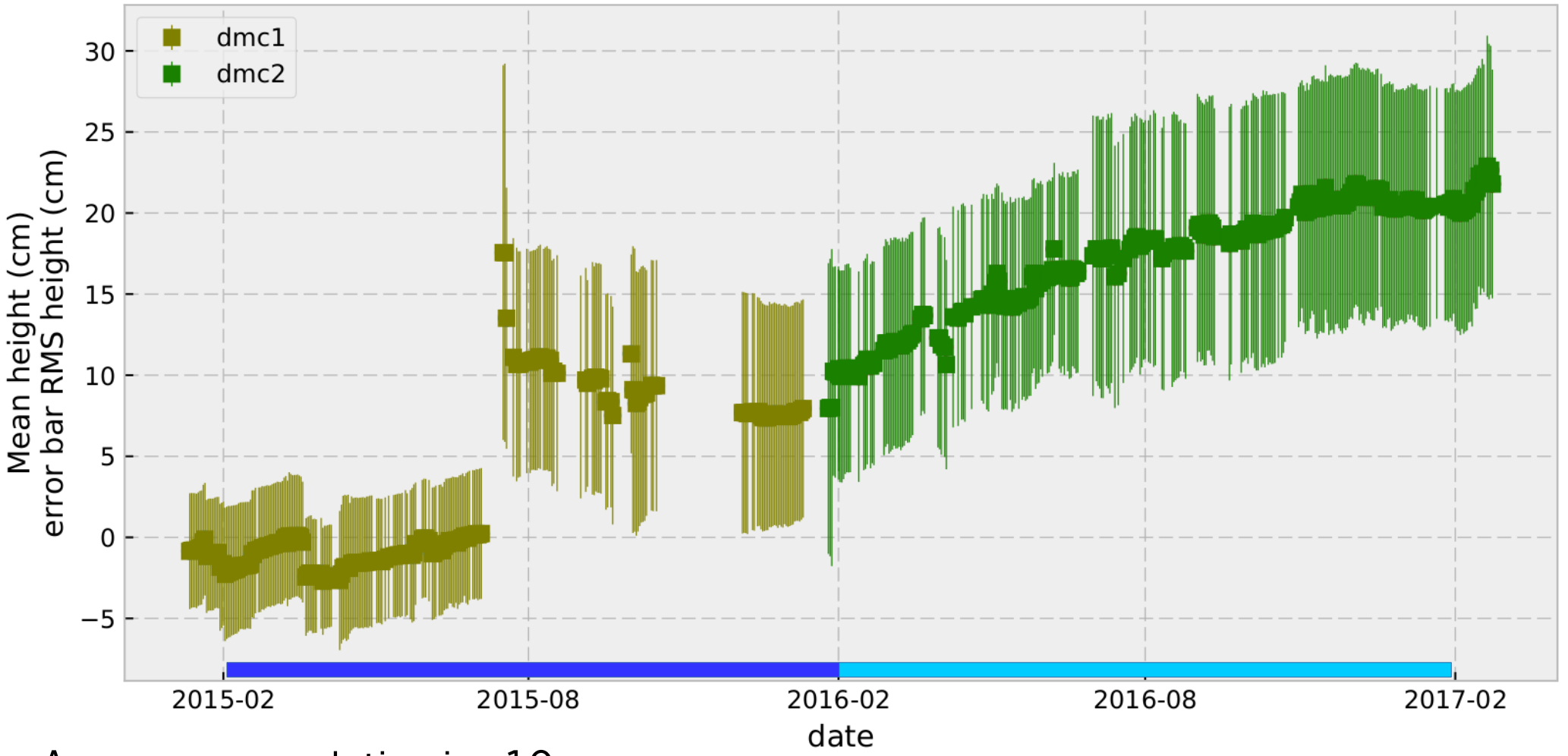


- Duration of scan acquisition: 4h
- Resolution is ~5cm. Vertical accuracy is better than 5 mm

The Dome C collection: 2 years, 660 scans

Time-lapse laserscanning

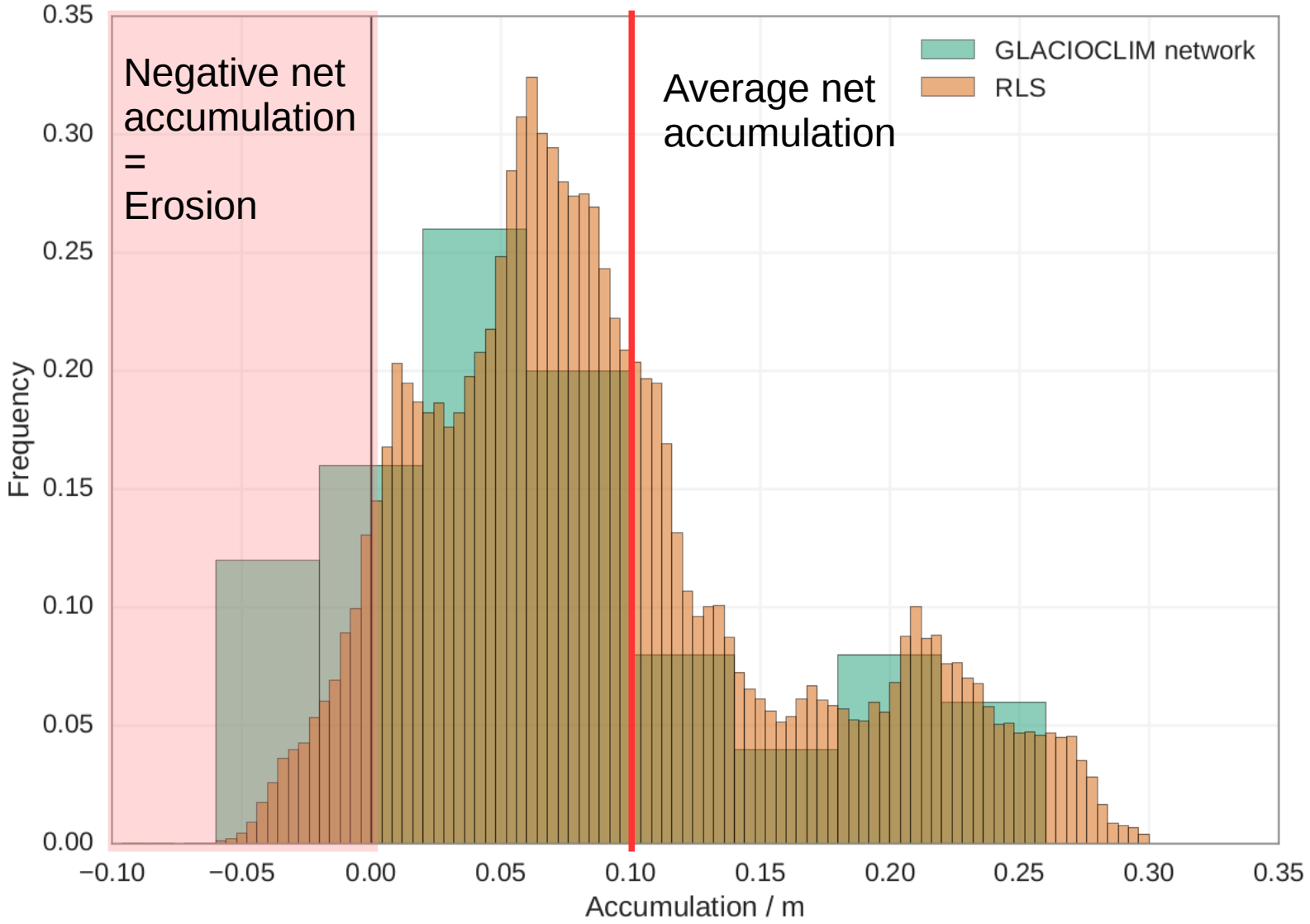
General trend: Average surface height and RMS height



- Average accumulation is ~10 cm per year
- First year: most of the accumulation occurred in one event, second year: relatively regular accumulation
- Increase of the surface RMS height, i.e. roughness

Time-lapse laserscanning

Histogram of annual accumulation



Annual accumulation in a point is:

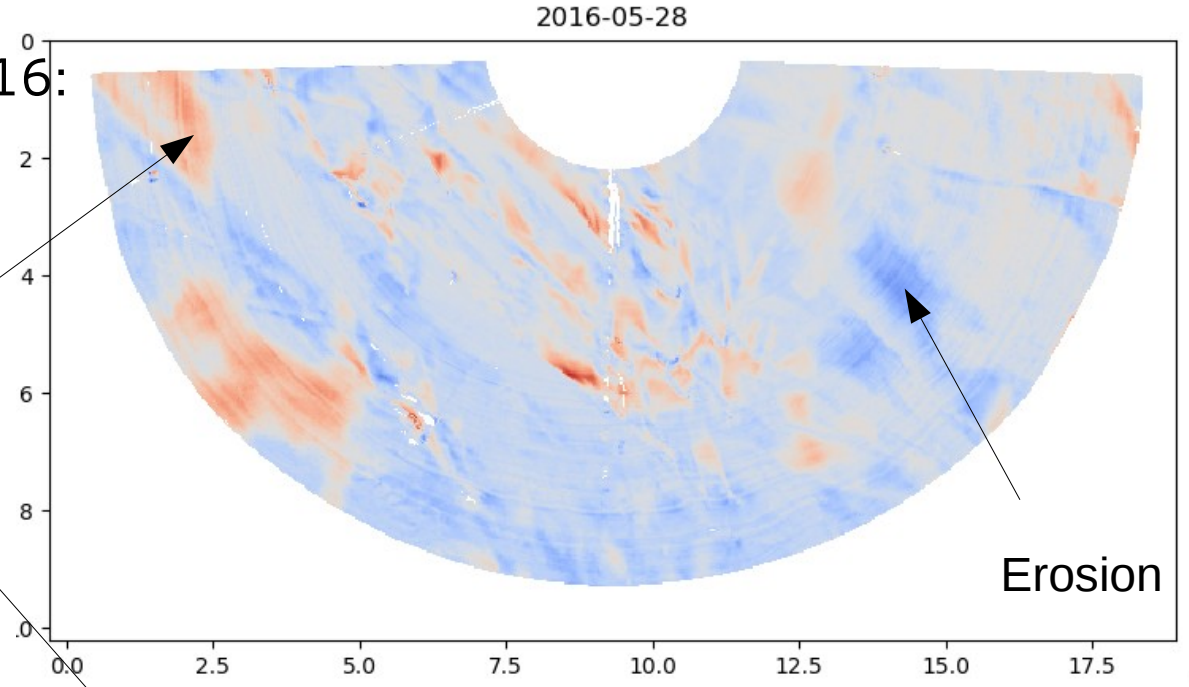
- negative in 13% of the case
- can be negative and up to 3x the average annual accumulation

Time-lapse laserscanning

The main asset of RLS: shortest time-scales

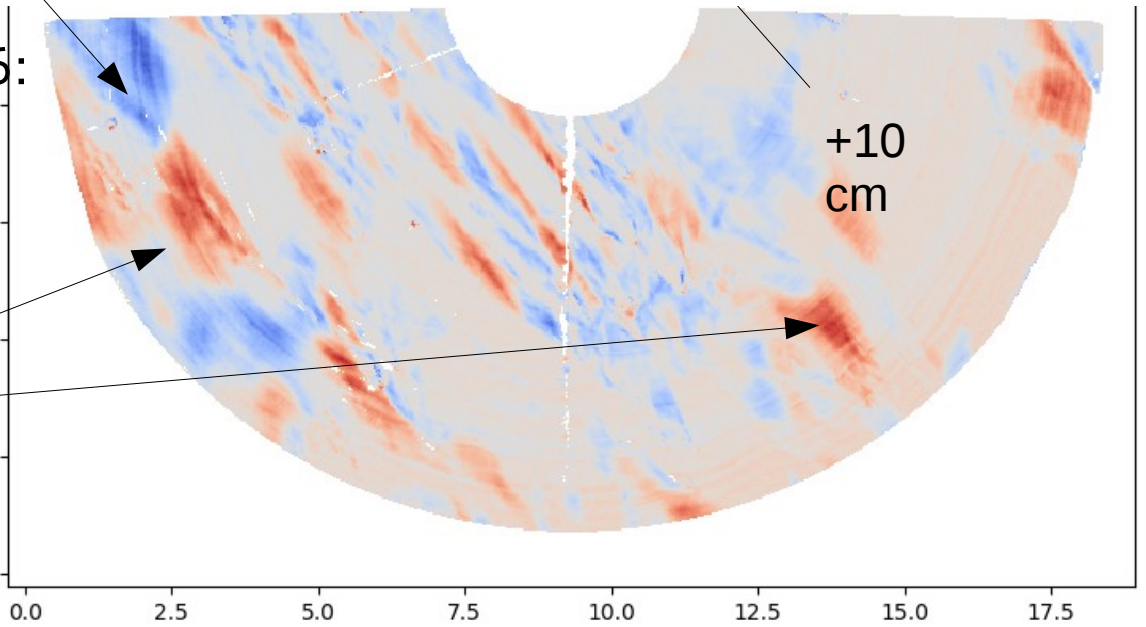
Accumulation 28-29 May 2016:

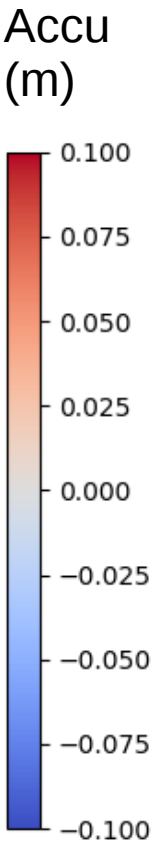
Patch deposited and removed the day after



Accumulation 28-29 May 2016:

Patches deposited and persisting the following days



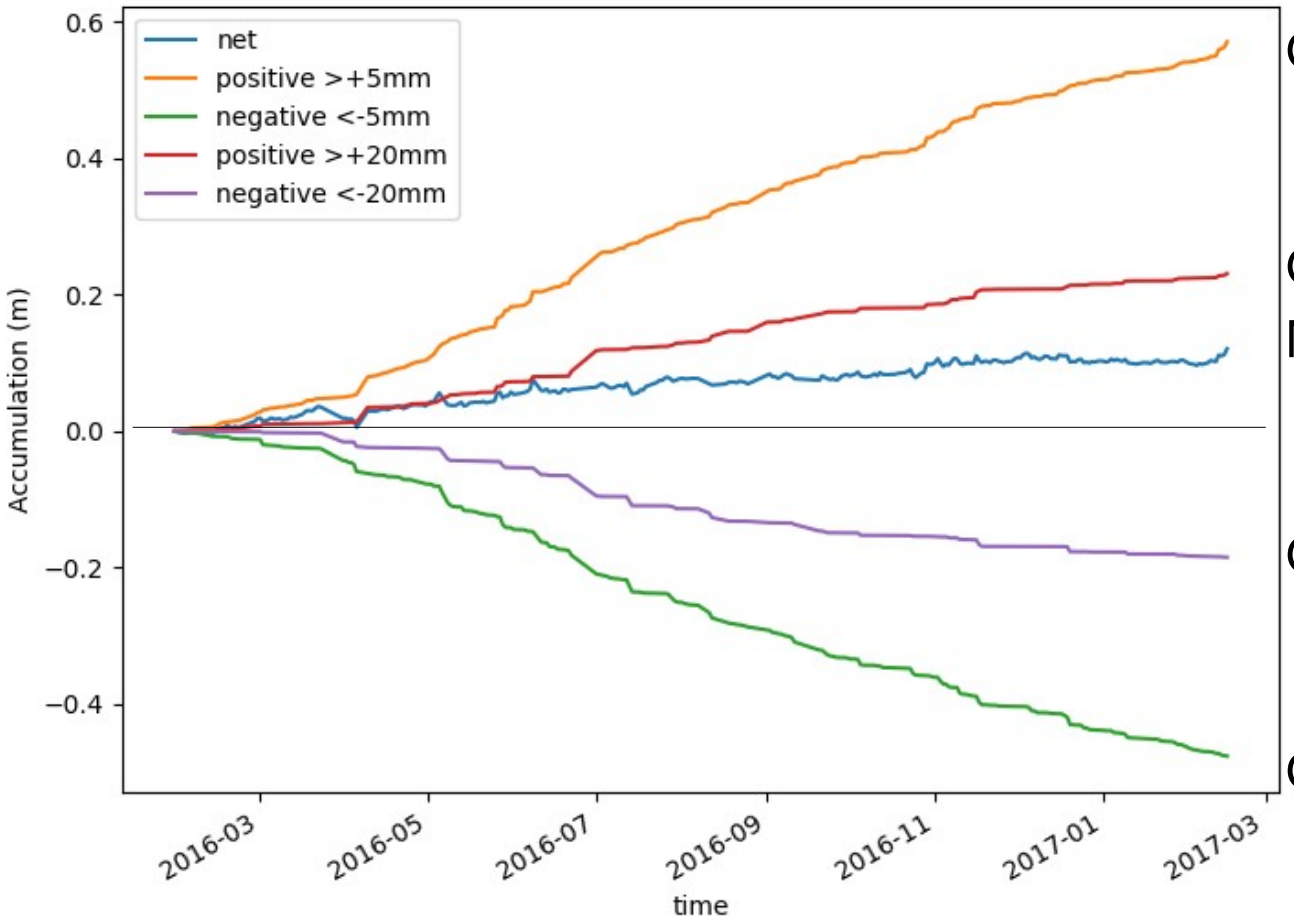


The surface is changing often !

Time-lapse laserscanning

The surface is changing often !

Every point experiences many accumulation/erosion cycles in a year



Cumulative positive accu. ~57 cm

Cumulative patchy (>2 cm) accu.

Net Accu. ~ 10cm

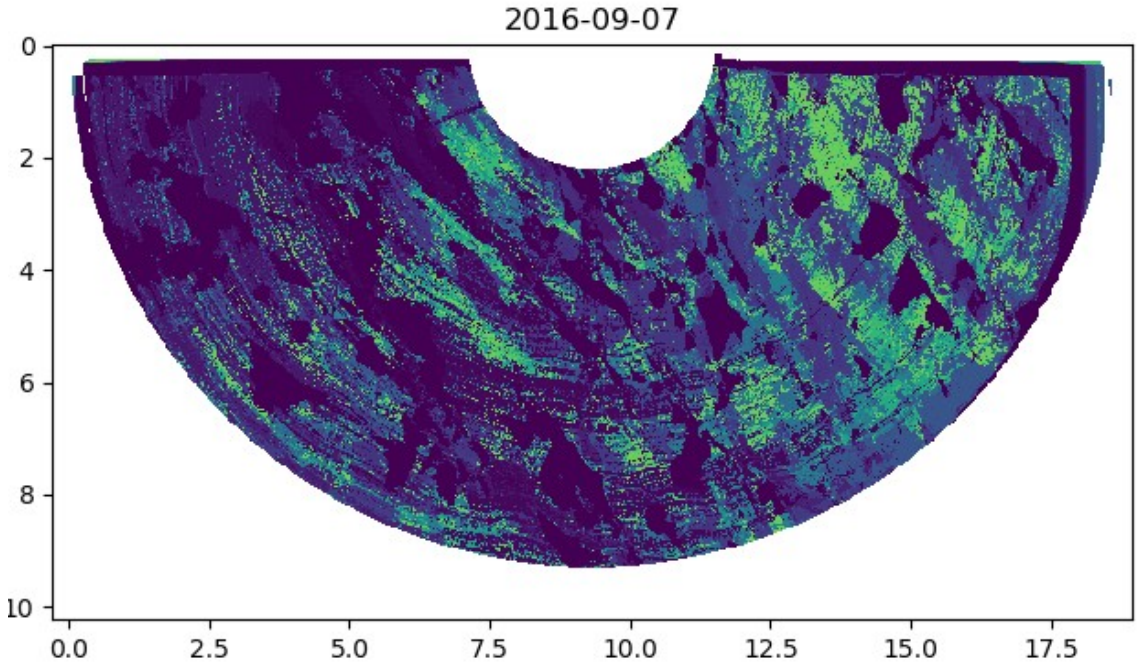
Cumulative patchy erosion

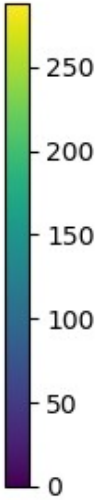
Cumulative erosion ~ 47 cm

Not shown: Patch detection, geometric characteristics, alignment w/r wind

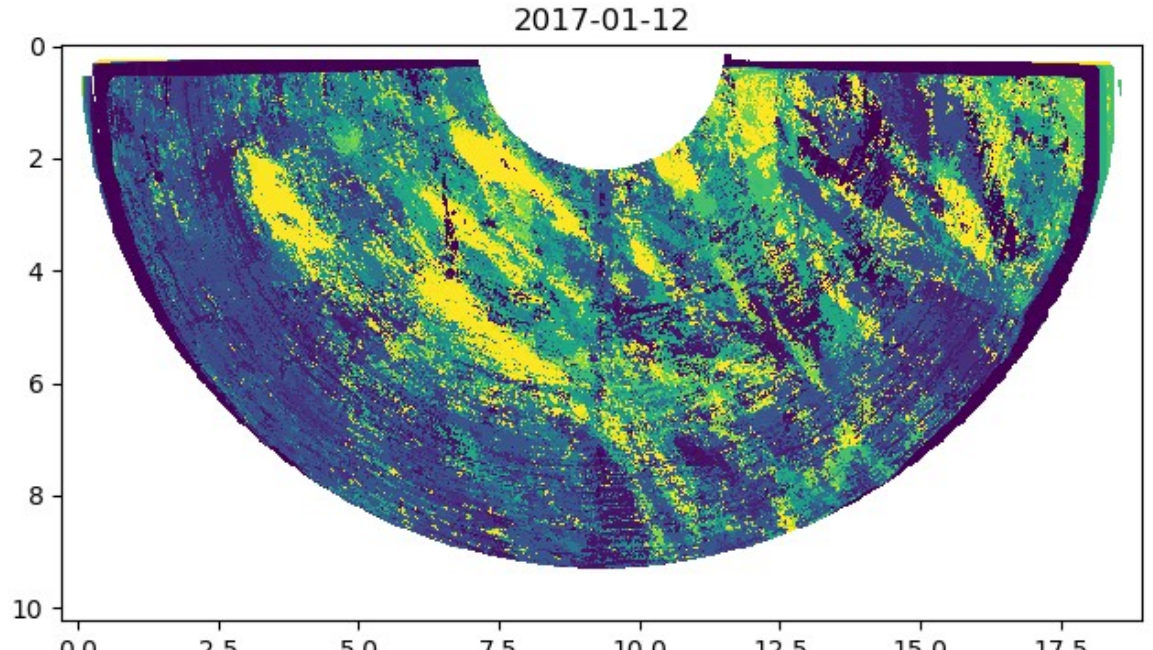
Time-lapse laserscanning

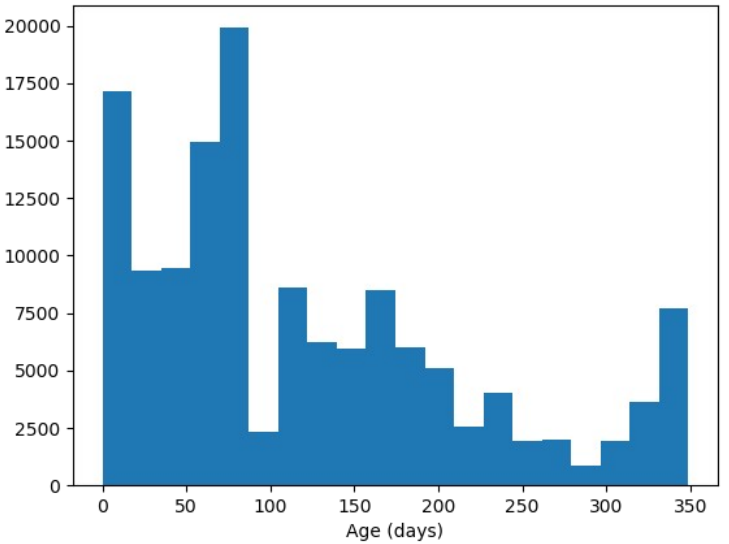
Algorithm : daily scans → the **age of snow on the surface** (and of each layer)





day





Conclusion

Time-lapse photography and laserscanning provide:

- Clear and multiple evidences that snow is accumulating **by patches** on the Antarctic Plateau.

- Phenomenological and **statistical information** on the processes

- They tell what an Antarctic snow models should be able to predict but do not tell (yet) how to build such a model.

See also Talk on Wednesday (morning).