

→ POLINSAR 2015

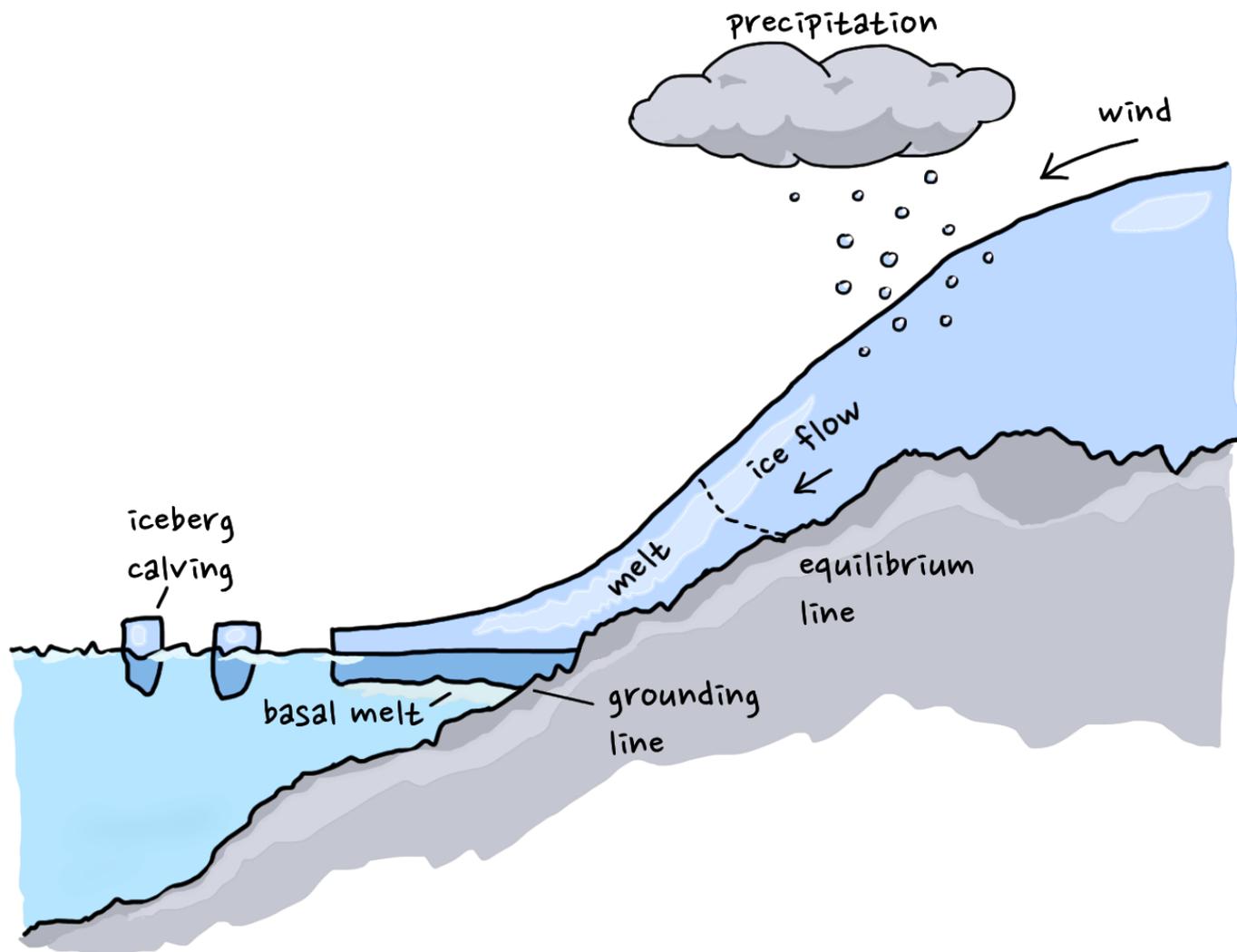
# What can polarimetric SAR data tell us about snow accumulation on polar ice sheets?

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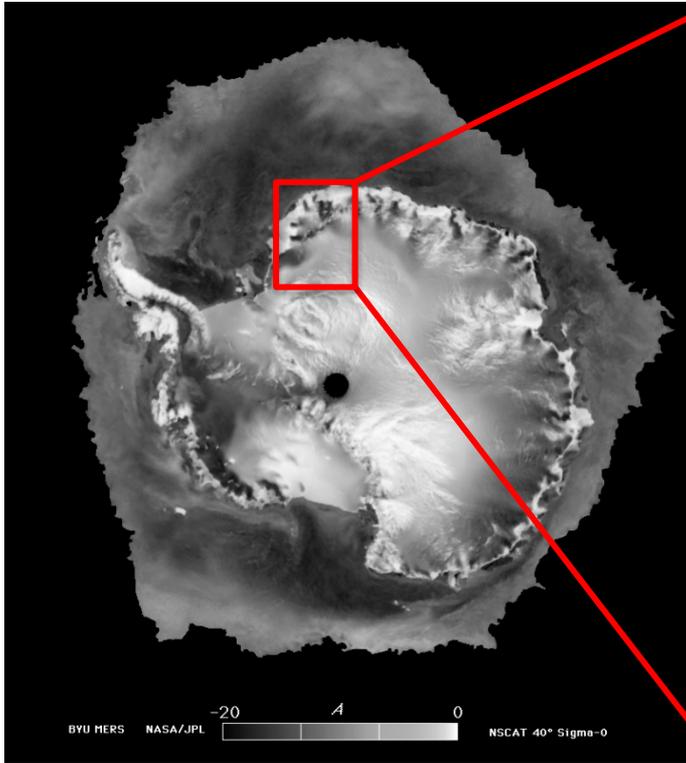
<sup>1</sup>Alfred Wegener Institute for Polar and Marine Research

<sup>2</sup>Gateway Antarctica, Center for Antarctic Studies and Research, University of Canterbury, New Zealand

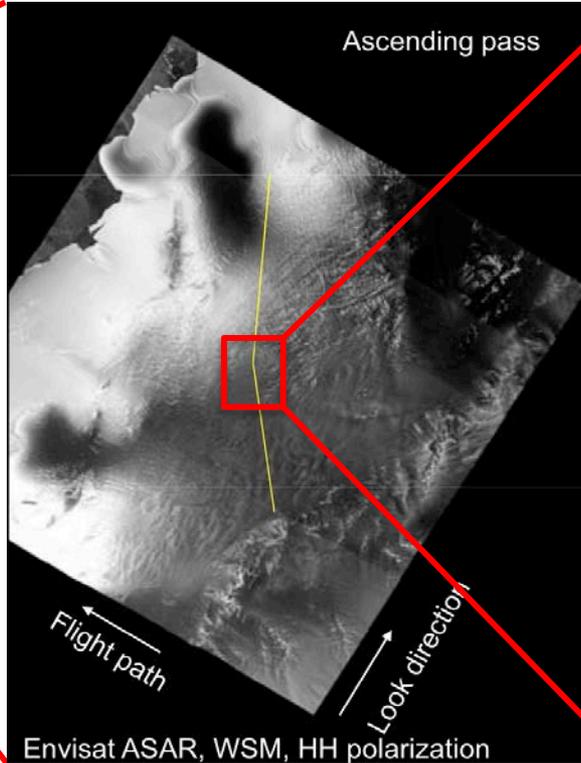
# Ice sheet mass balance



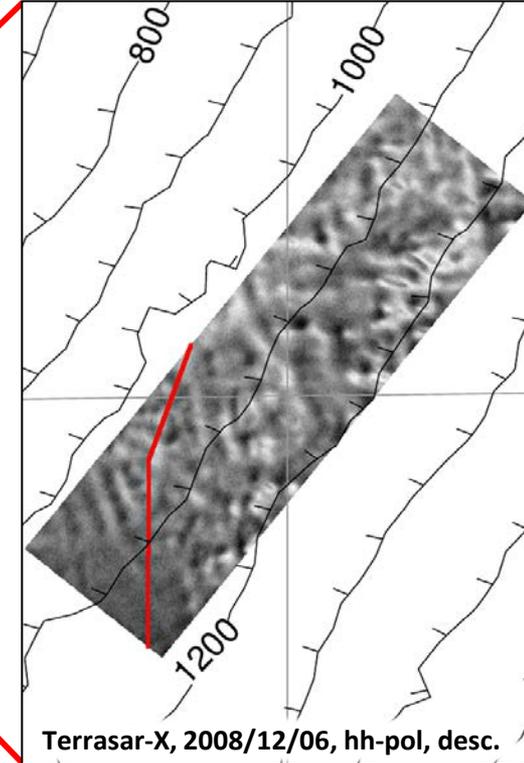
# Spatial scales



Scatterometer (50 km resolution)



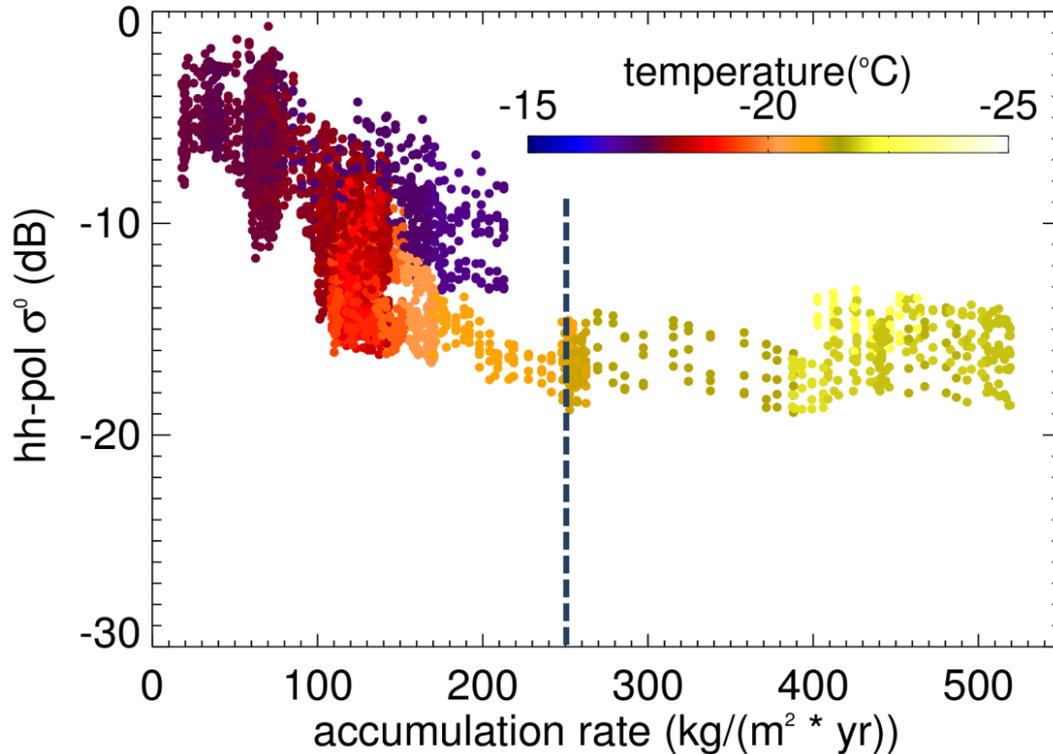
SAR (75 m resolution)



SAR (10 m resolution)

- SAR data: 6 Radarsat-2 FQP scenes, 18 TSX scenes (HH+VV) along Kottas Traverse
- 543 point measurements of snow accumulation + ECMWF temperature and wind

# Accumulation rate retrieval



accumulation rate retrieval:

firn microstructure model



SAR backscattering model



accumulation rate inversion

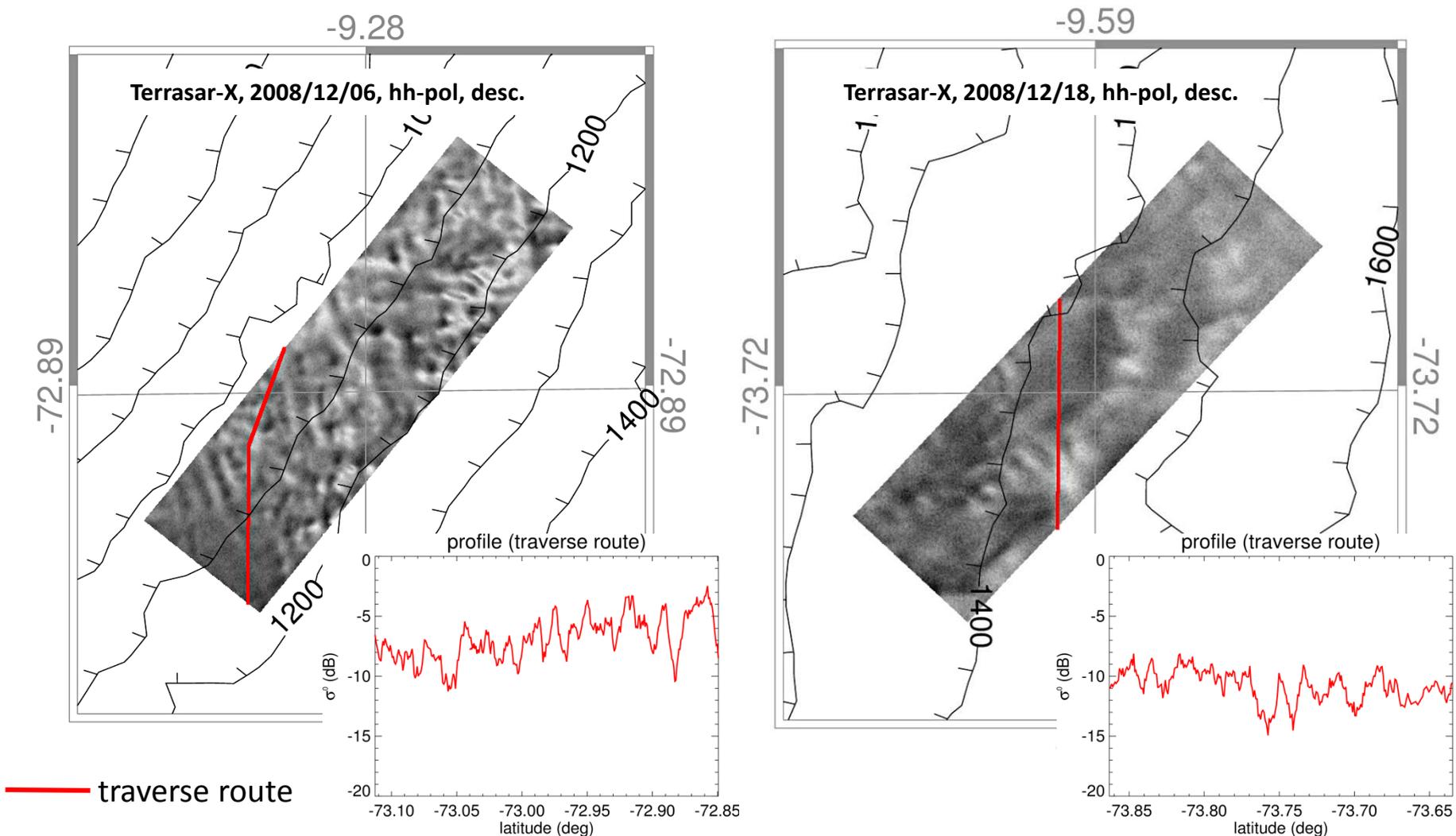


SAR + temperature data

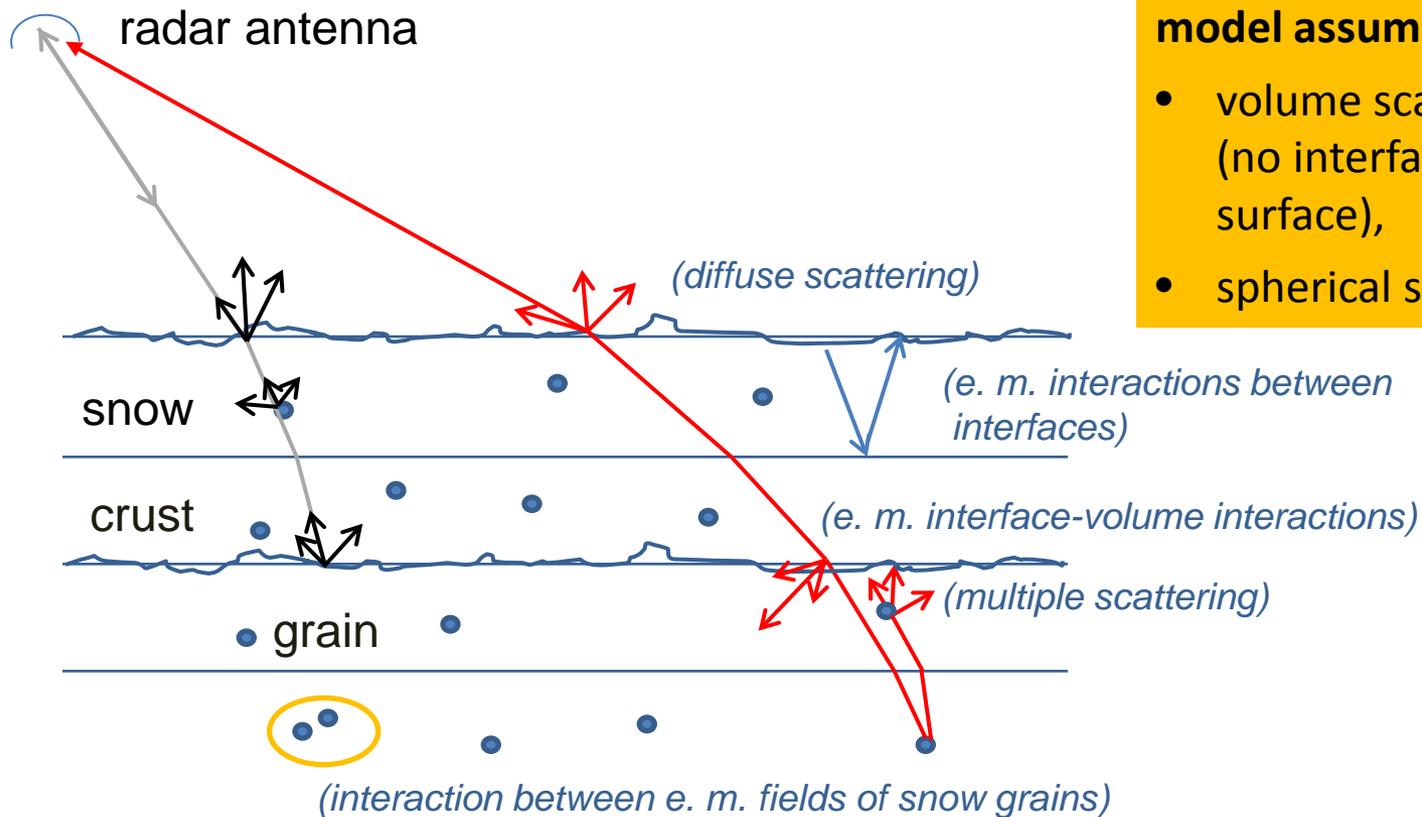
**SAR is sensitive to accumulation rates up to  $\approx 250 \text{ kg}/(\text{m}^2 \cdot \text{yr})$  – roughly 90% of Antarctica**

- large scatter in  $\sigma^0$  values not only due to SAR speckle – geophysical reasons?

# Polar firn in SAR images

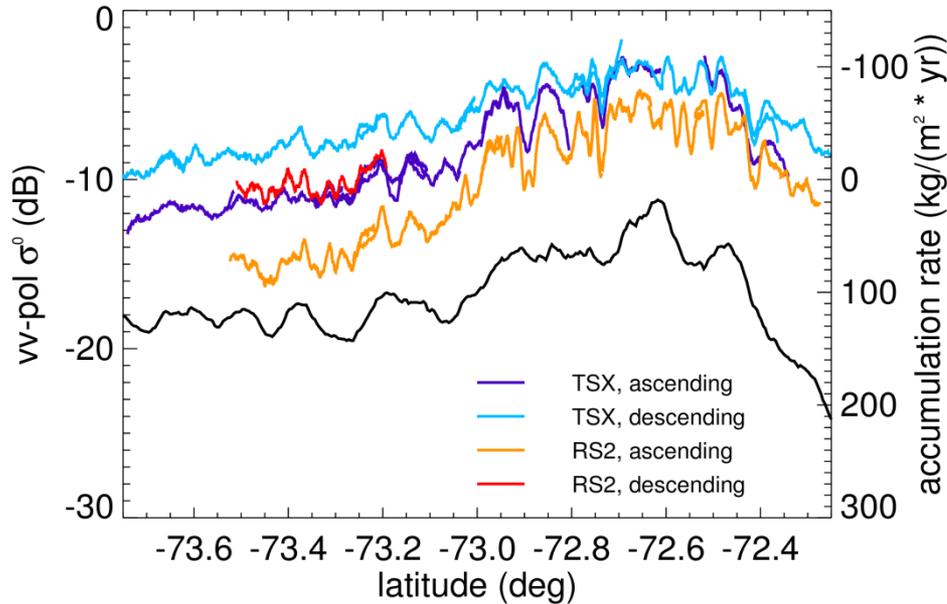


# Firn-microwave interaction

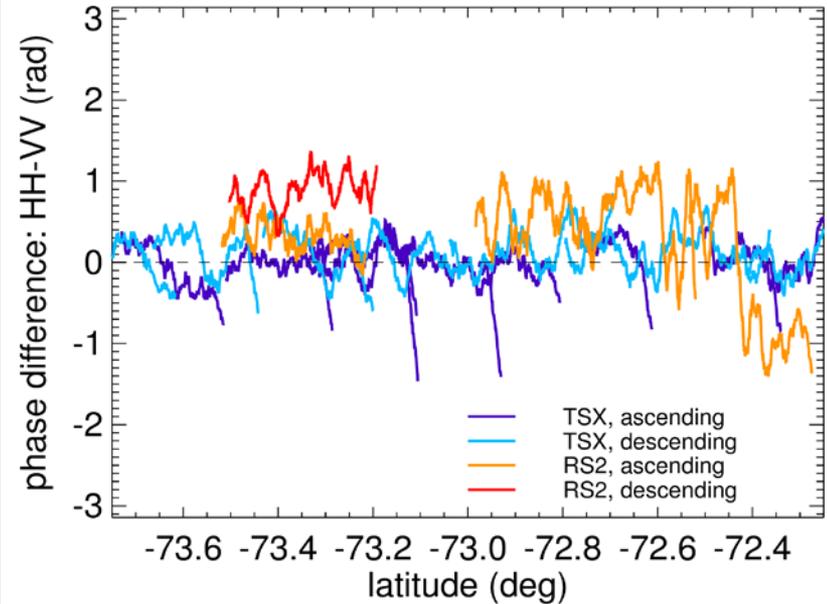


- model assumption:**
- volume scattering (no interfaces / surface),
  - spherical scatterers

# Anisotropy



- $\sigma^0$  approximately follows accumulation rate, but differences in asc. / desc. orbits
- **surface contribution?**



- phase difference  $\neq 0$
- **anisotropy in firn microstructure?**

# Evolution of polar firn

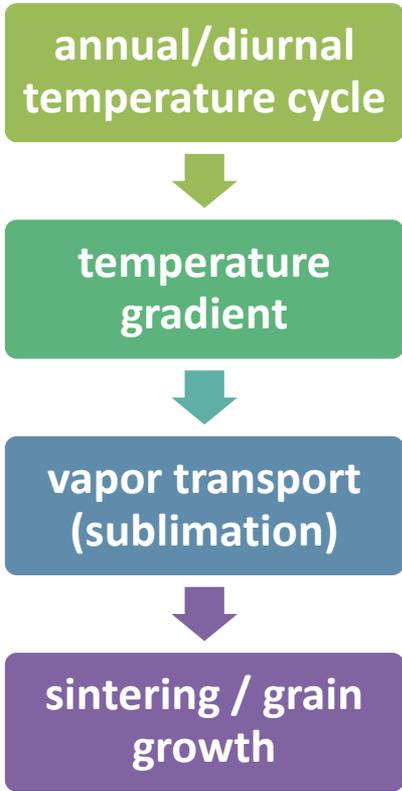
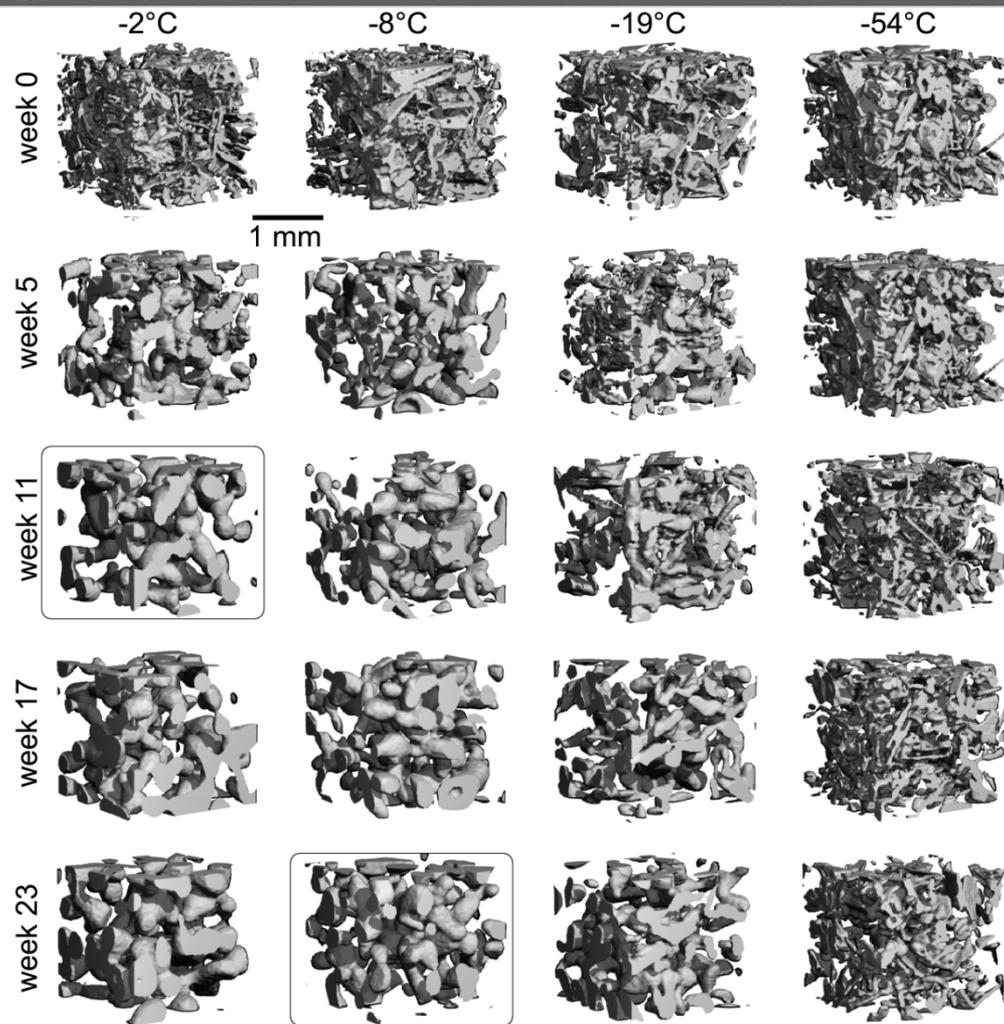
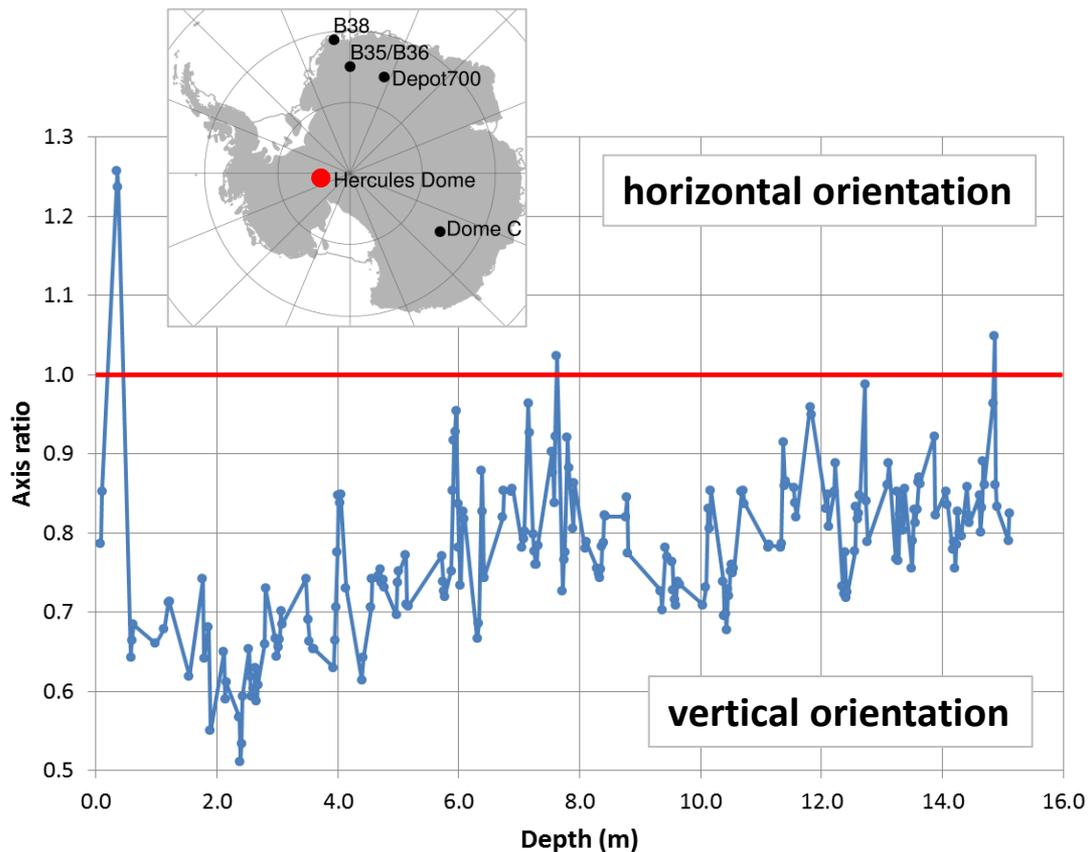


Image from: Kaempfer and Schneebeli, JGR 112, 2007

# Firn anisotropy

## CT firn anisotropy at Hercules Dome



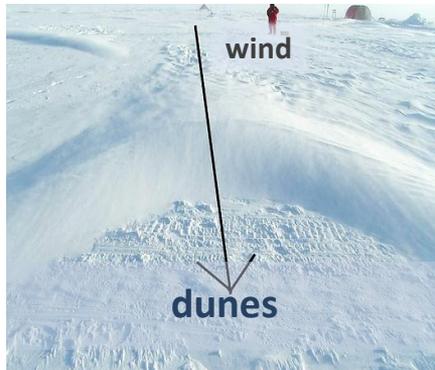
Data from Hörhold et al., J.Glaciol., 55, 2009

Hörhold et al., 2009:

- microstructure shows anisotropy
- anisotropy depends on duration of exposure to large temperature gradients
- low accumulation = large anisotropy

# Surface features

...are shaped by the wind



km

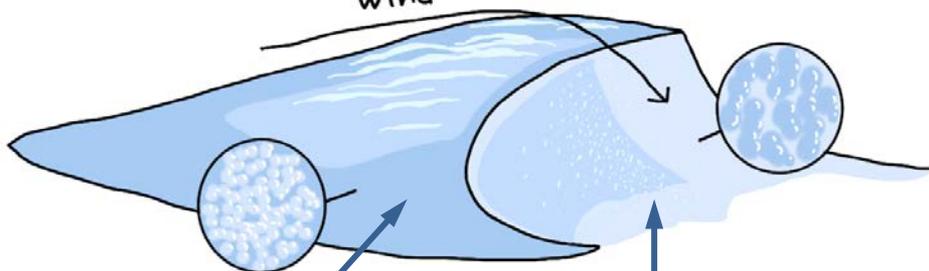
cm

Images: a) NASA, b) Birnbaum et al., J. Glaciol., 56, 2010, c) A. Light, d) S. Tronstad, NPI

# Wind / deposition

snow dune

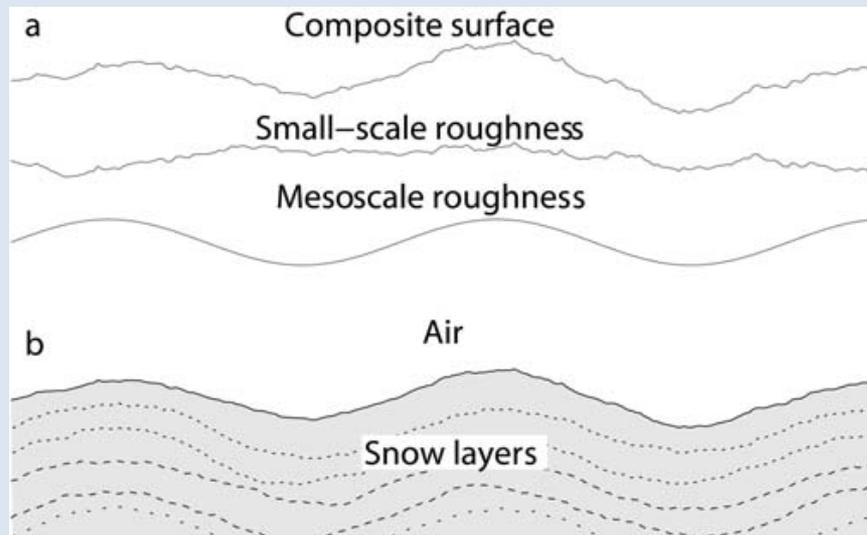
wind



- sastrugi
- small snow particles
- (relatively) low accumulation

- no sastrugi
- large snow particles
- vertical anisotropy
- (relatively) high accumulation

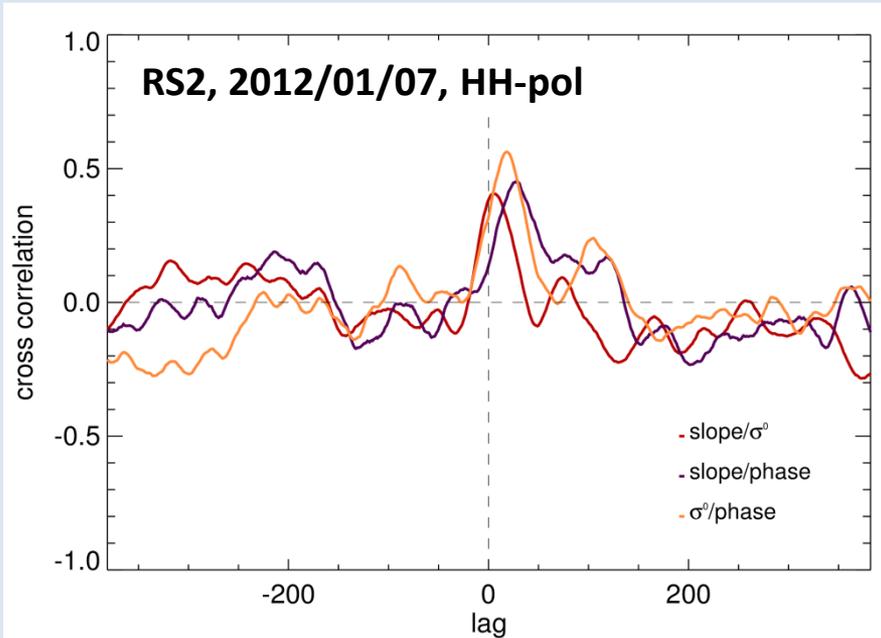
a surface roughness model:



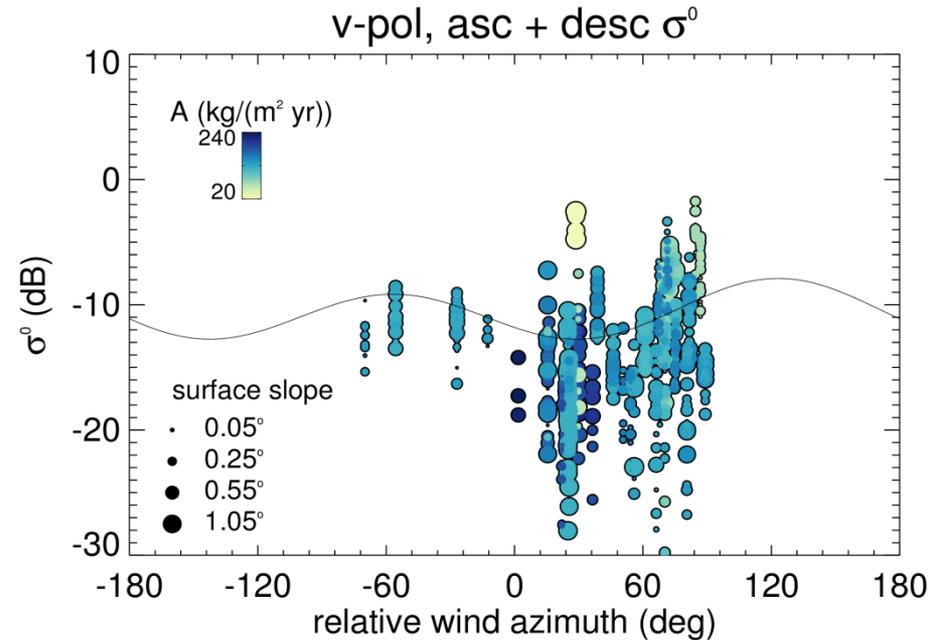
From Ashcraft & Long, J. Glac., Vol. 52, No. 177, 2006

- quantification of different roughness scales?

# Local topography



- correlation between topography and observed parameters  $\sigma^0$  and phase difference



- surface contribution: orientation of surface structures from azimuthal modulation of  $\sigma^0$

# Summary



Current model assumptions	SAR observations	Field observations	Model changes
SAR backscatter from the volume only	$\sigma^0$ depends on orbit direction (ascending $\neq$ descending)	sastrugi / dunes (wind and surface slope)	include surface / interface contribution
spherical scatterers	phase differences between HH and VV	anisotropy in firn microstructure (temperature gradient, accumulation rate)	different description of microstructure

# Outlook



- accumulation rate retrieval from SAR data can be improved
- complex deposition processes caused by wind need more focus
- consider grain size anisotropy / microstructure description in models