Microwave remote sensing of firn properties in Antarctica

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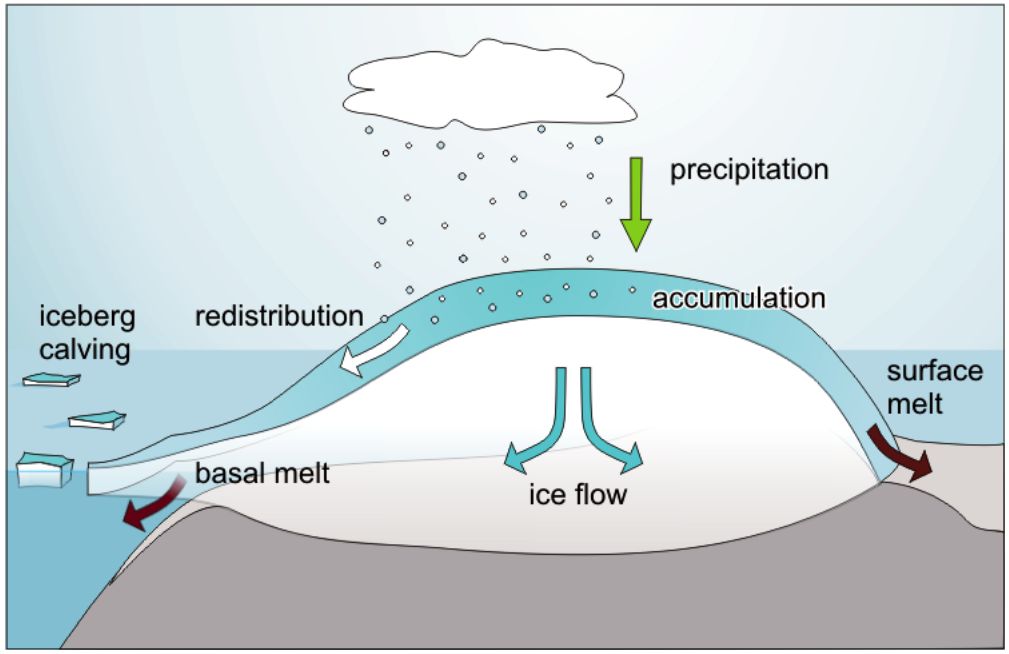

Ice sheet mass balance:

- mass gain vs. mass loss
- can be modelled, but models need observations for validation

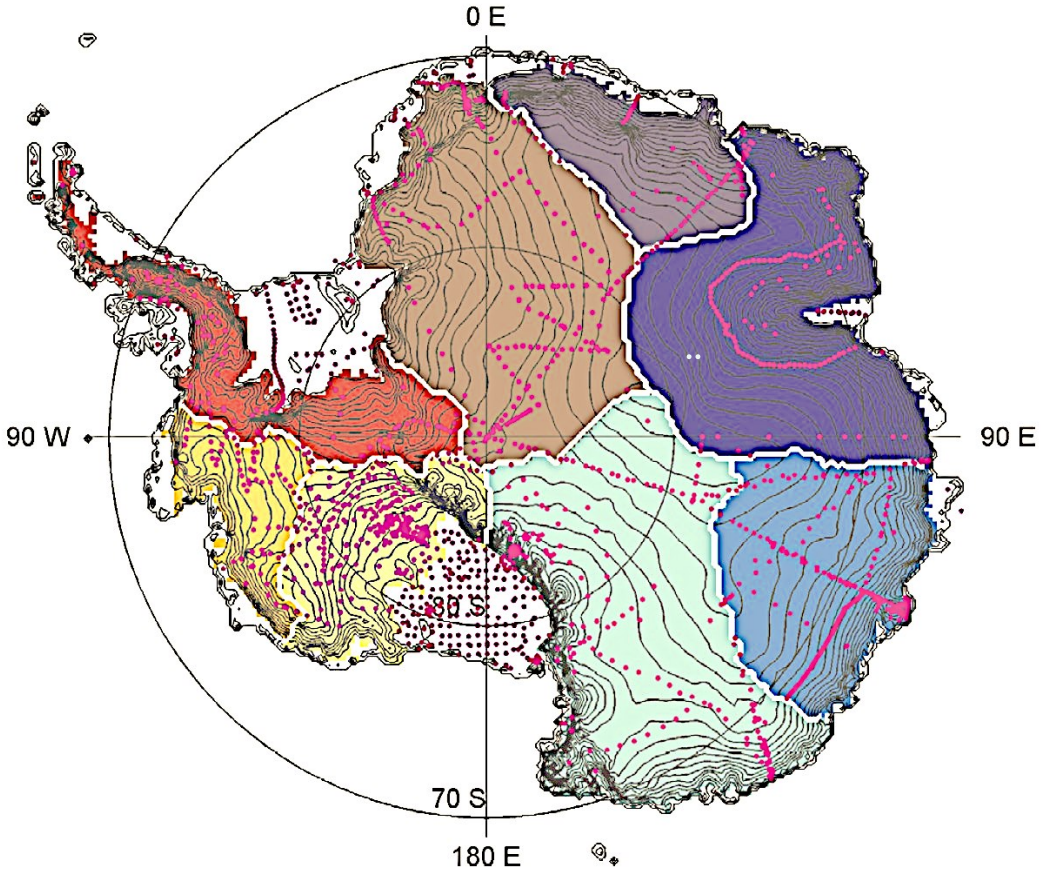

Figure: Arthern et al., 2006

Ice sheet mass balance:

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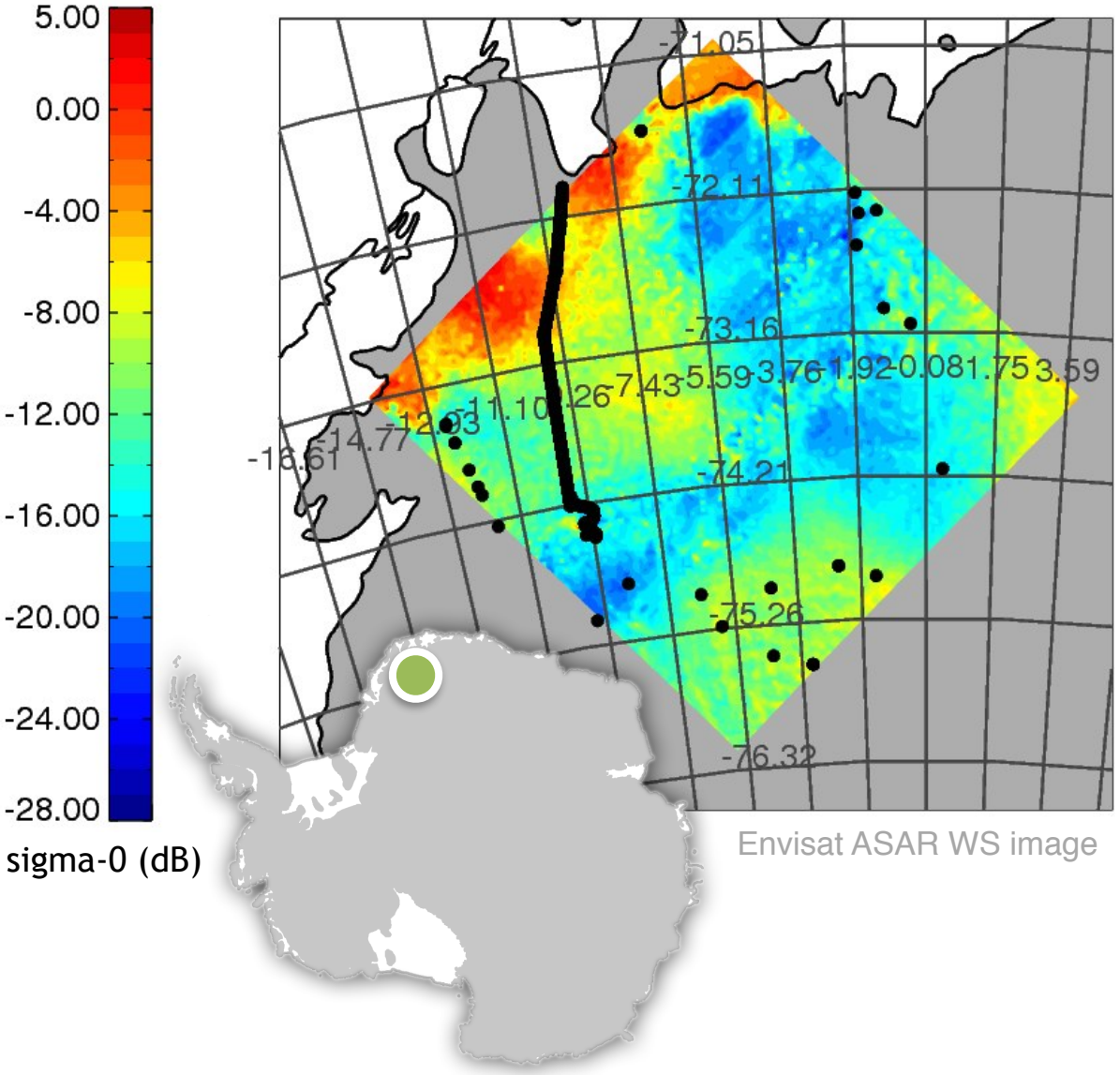
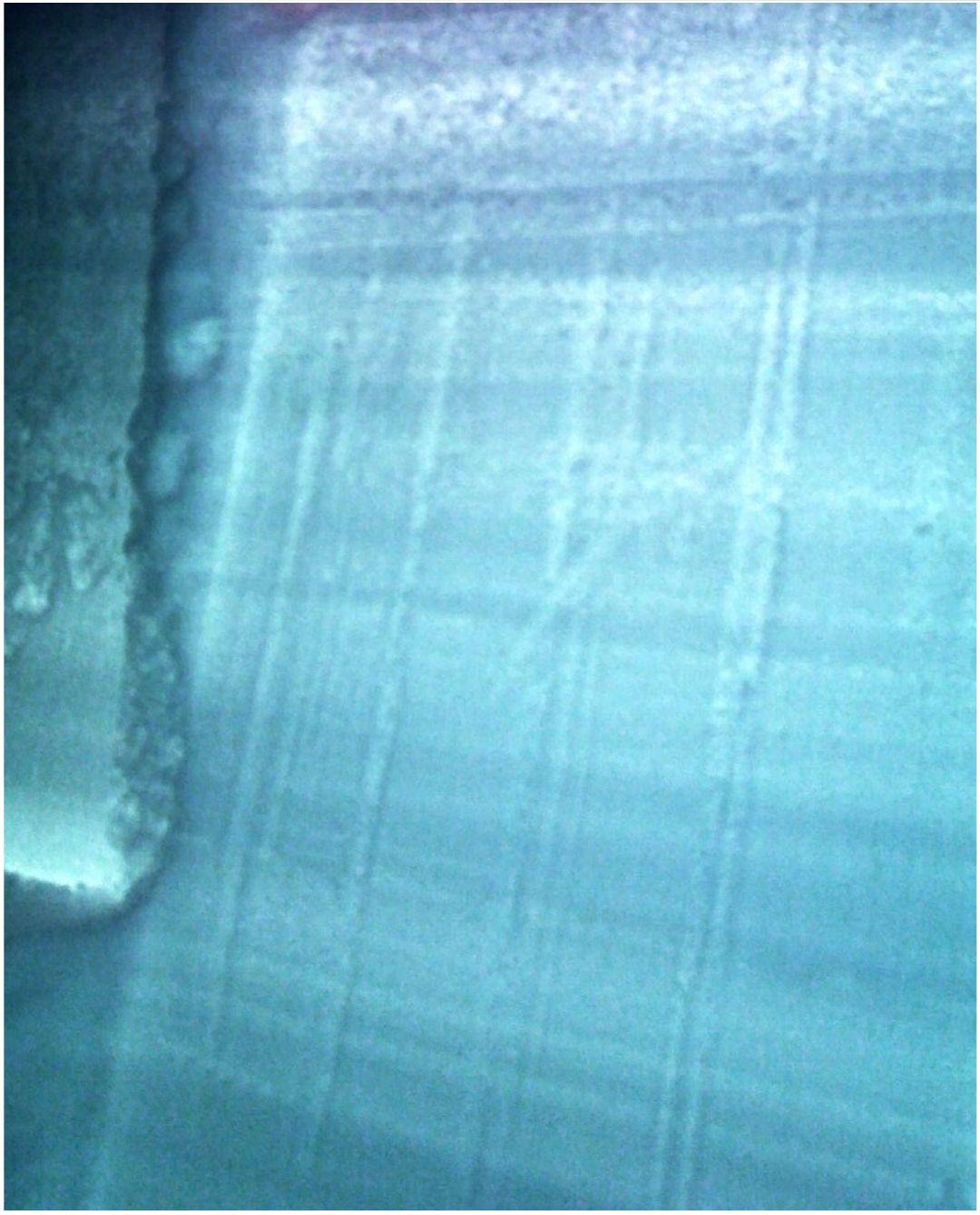
Observations:

- field observations (challenging logistics)
- remote sensing data (passive and active instruments)



How is the microwave signal generated?

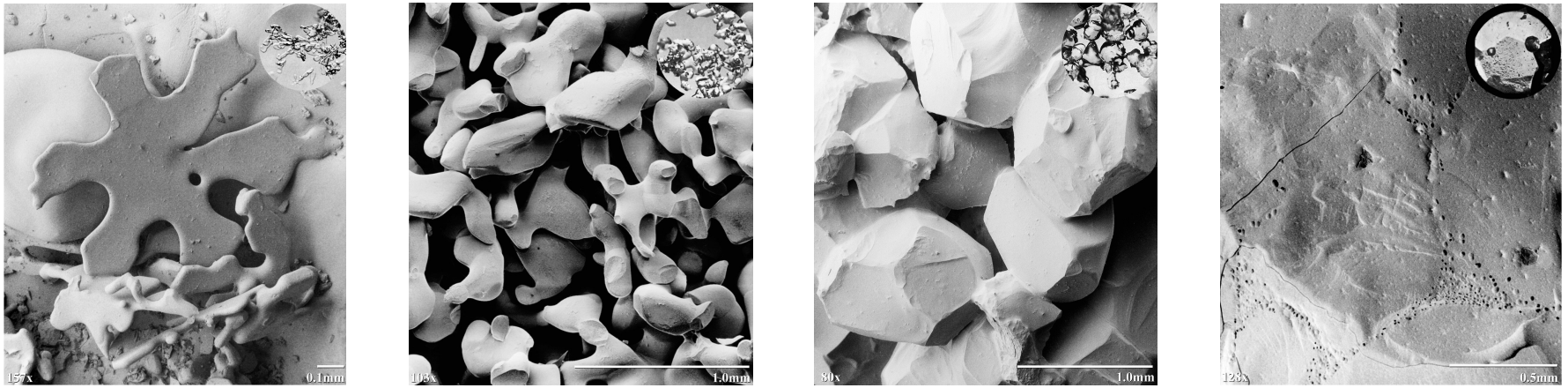
- integrated signal over the firn volume under dry snow conditions
- signal penetration depth is frequency dependent, in the microwave range between a few cm and hundreds of meters



What is polar firn?

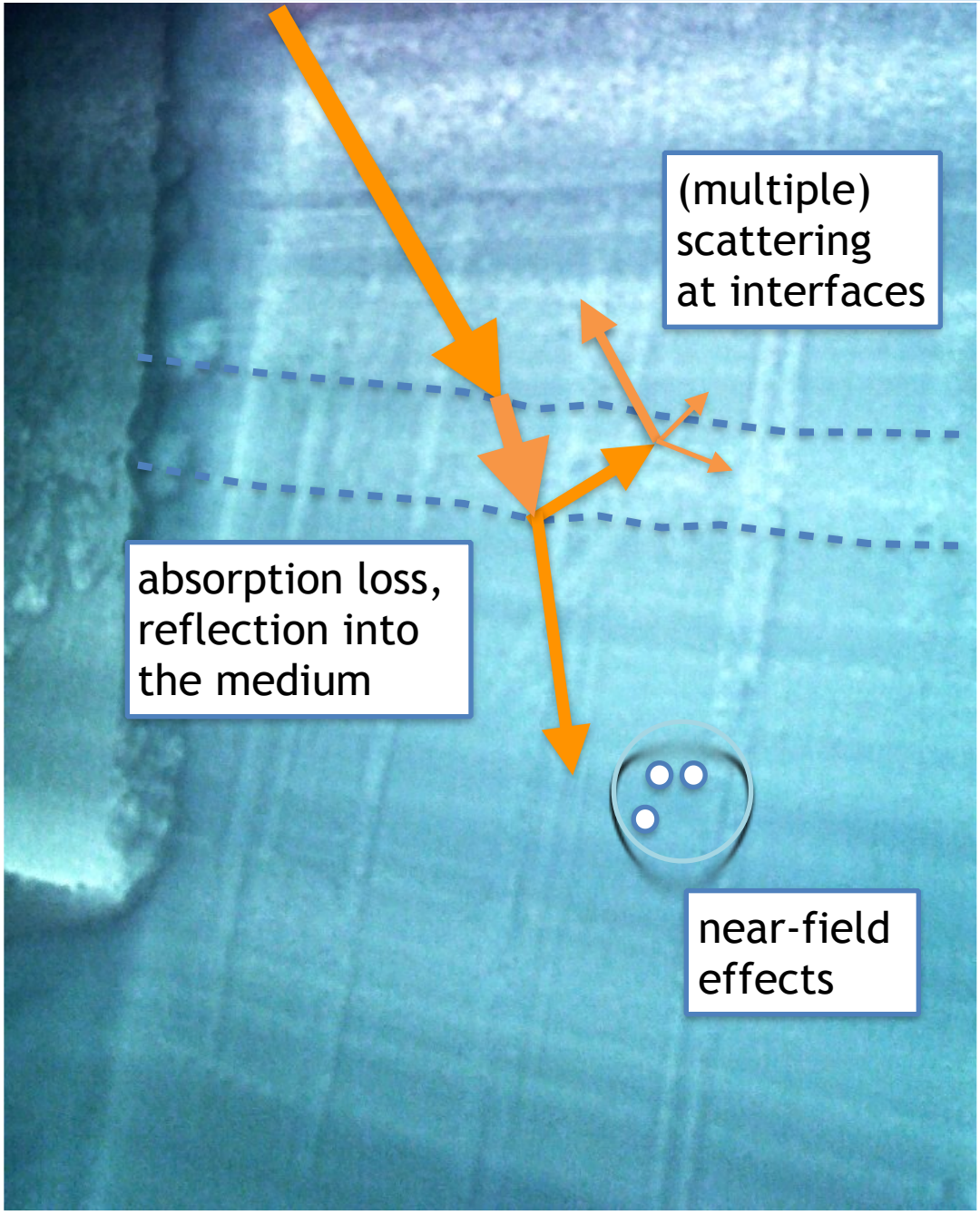
Layering

- deposition, metamorphism
- different electromagnetic properties depending on density and grain size

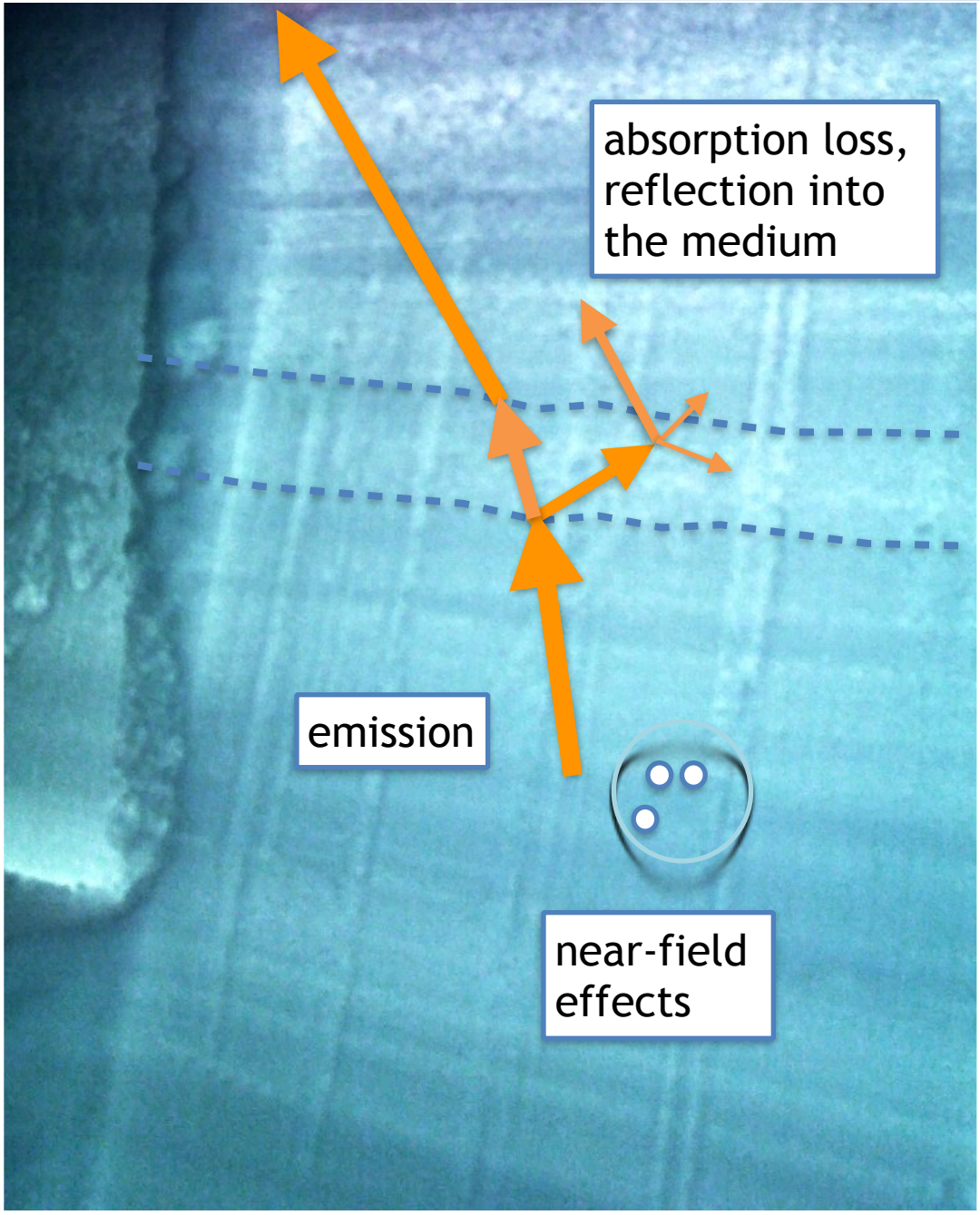


- dry snow metamorphism (grain growth, densification) depends on temperature and accumulation rate
- microwave scattering is sensitive to variations in density and grain size
- if there is a link between climate and scattering properties, we should be able to invert the climate signal

Images: Electron and Confocal Microscopy Laboratory, Agricultural Research Service, U.S.D.A.



Radiative transfer into polar firn - radar scattering



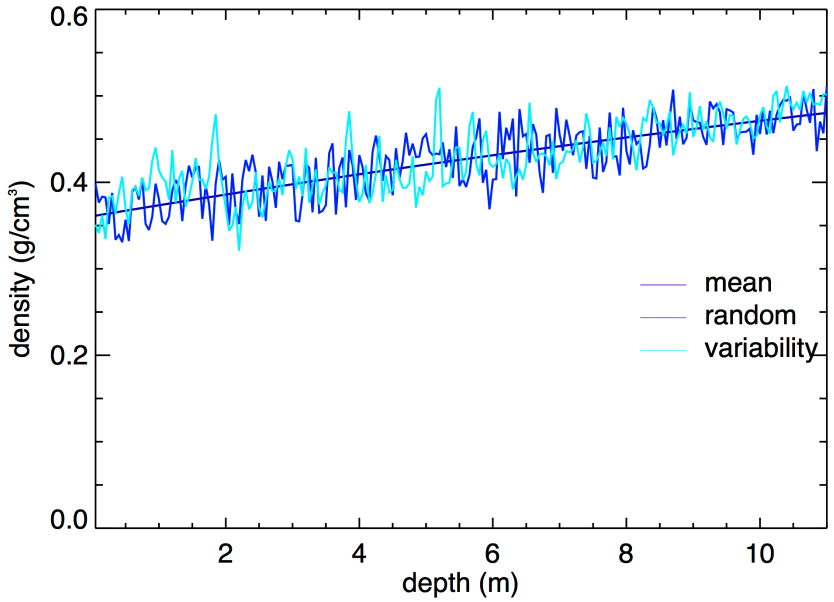
Radiative transfer into polar firn - microwave emission

Simplifications

- spherical, spatially separated snow grains
- no roughness at layer interfaces

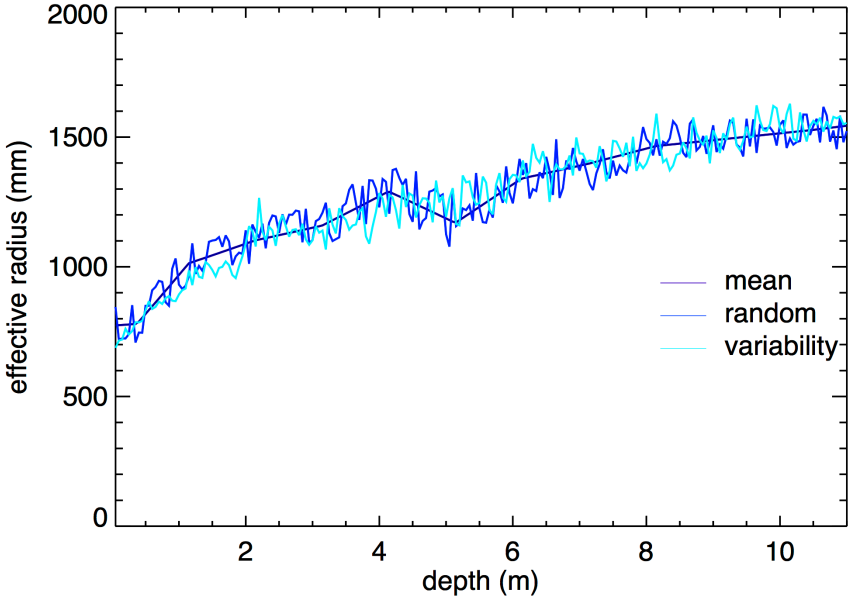
Impact of firn layering on microwave emission

1. mean profile
2. mean profile + random noise
3. measured variability



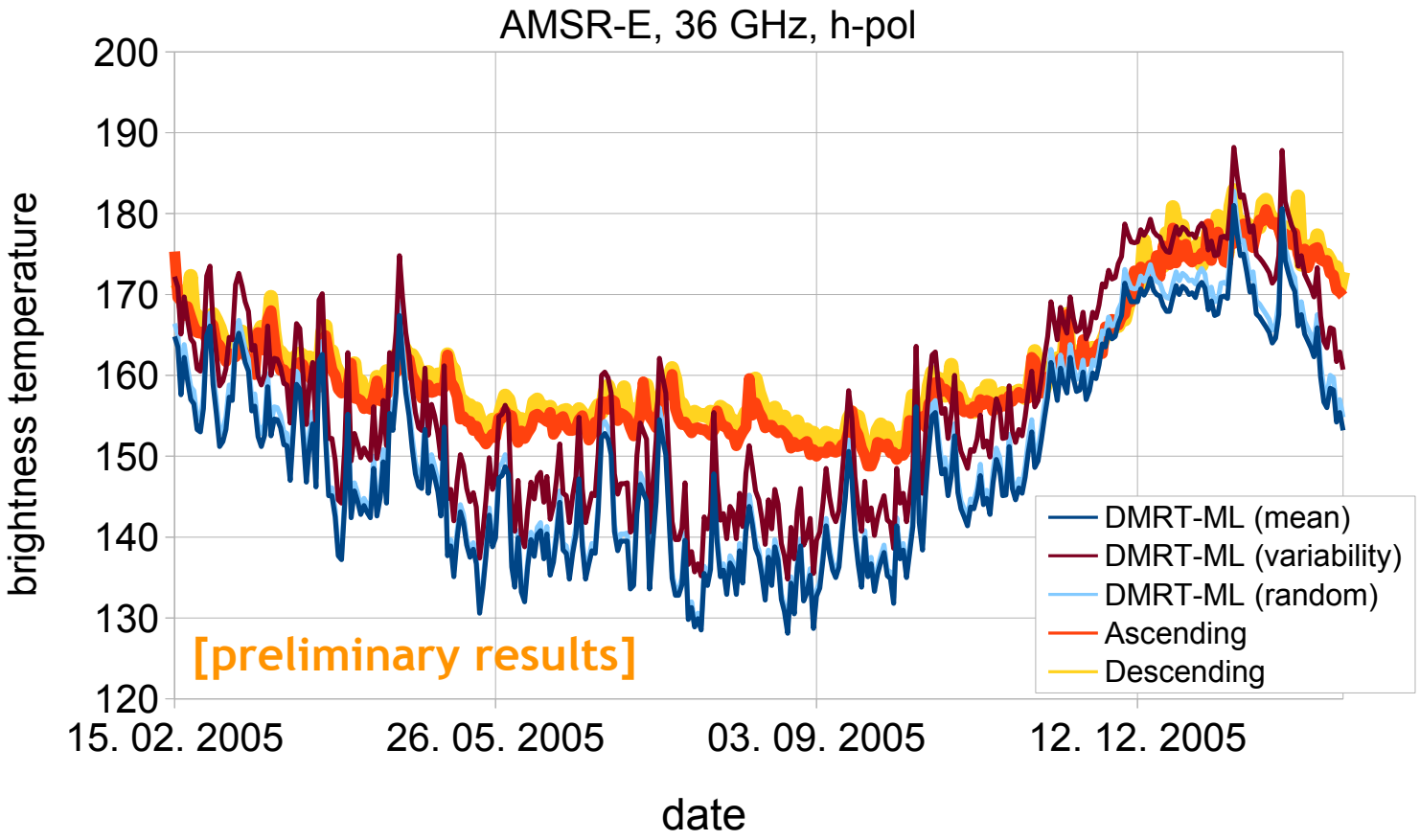
Example: B36

- 75°S, 0.068°E
- accumulation rate: 0.067 m w.e./year
- mean annual temperature: -44.6°C
- available measurements: high-resolution density and grain size



Setup

- DMRT/ML emission model
- physical temperatures from ECMWF reanalysis data (year)
- different layering properties (mean / random / data)
- 12 m firn profile
- calculated microwave emission at 36 GHz (signal penetration depth!)
- comparison to AMSR-E time series (2005/02/15-2006/02/14)



- seasonal cycle of brightness temperature can be modelled realistically
- discrepancies between model results and measurements due to unrealistic temperature propagation and grain size parametrisation issues
- realistic firn parametrisation seems important

- interpretation of the microwave signal can be difficult, and it is sometimes necessary to pay close attention to the very small scales
- ongoing and very active development of microwave radiative transfer models and better representation of firn microstructure properties
- polar climate properties (e.g. snow accumulation rates) can be inverted from microwave remote sensing data, with more accurate tools at hand