

Radar Polarimetry – Useful for Detection of Icebergs in Sea Ice ?

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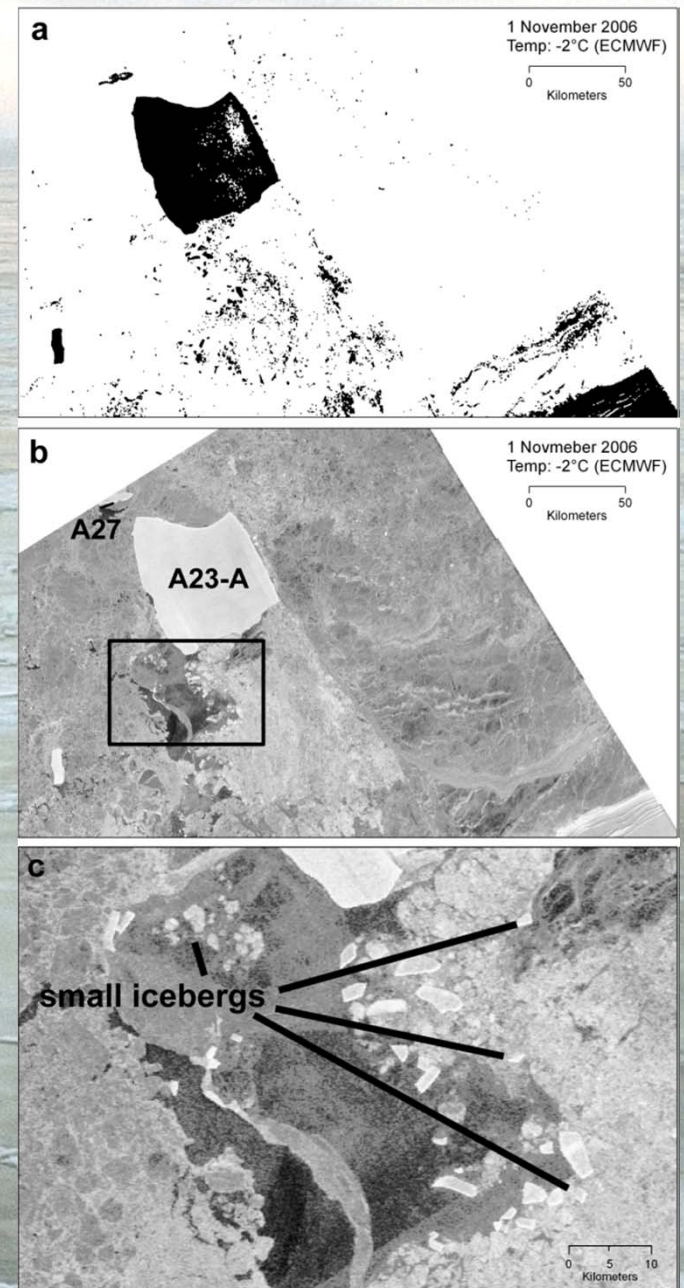
June 2012



Background

- Study: part of a project on *iceberg census in Antarctic waters*
- dealing with *iceberg detection and tracking, modeling of drift, and calving site classification*.
- Funded by the German Research Foundation (lead investigators: Wesche & Dierking)
- A recent study using *single-channel C-band SAR* revealed *difficulties to detect icebergs in heavily deformed sea ice*.

Wesche & Dierking , J.Glac. 58(208), 2012



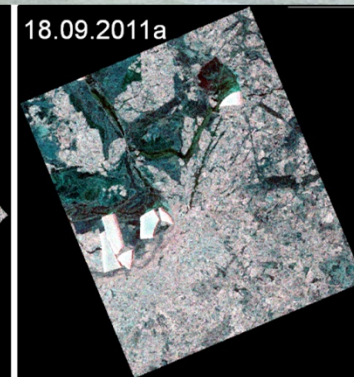
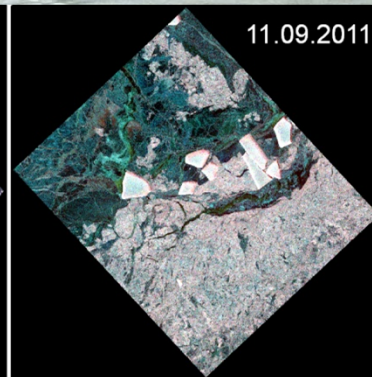
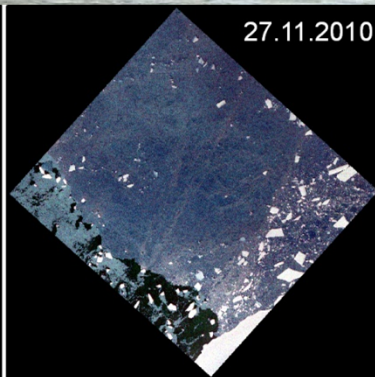
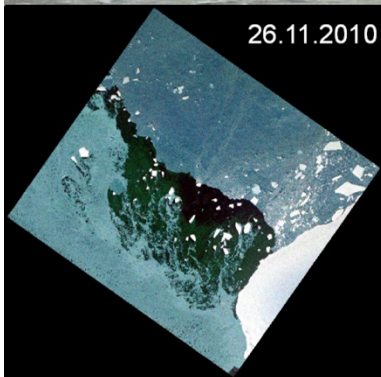
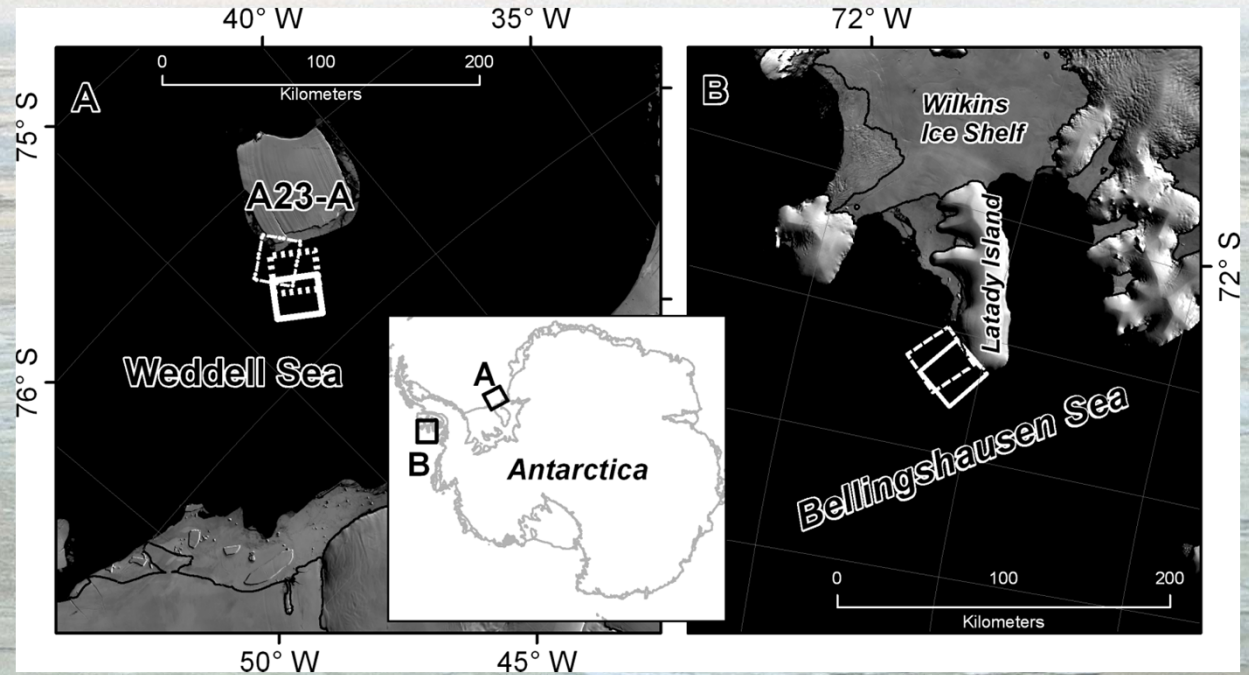
Study Areas and SAR Images

Test sites:

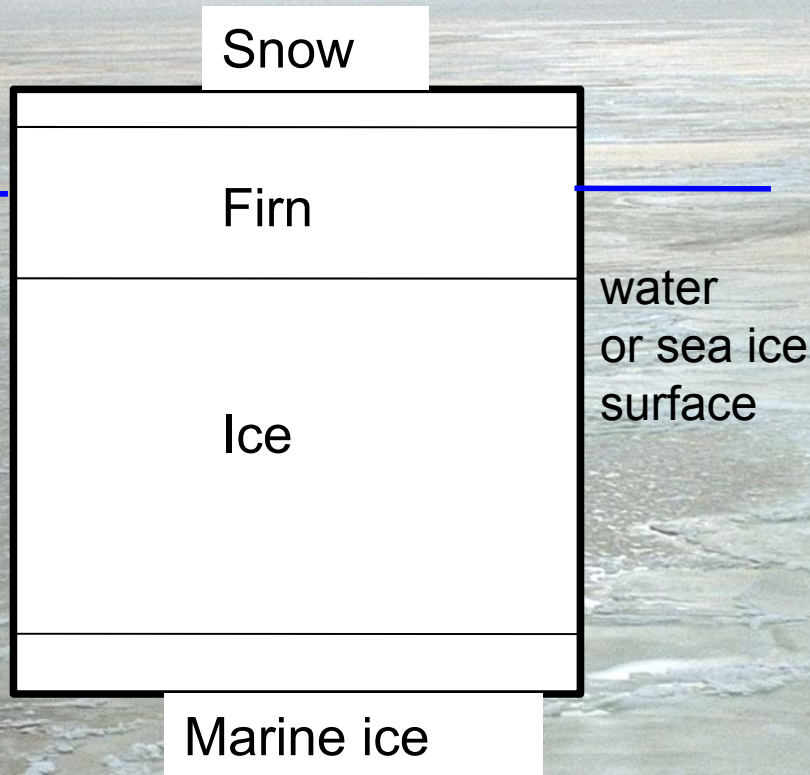
Bellingshausen (BS)
and Weddell Sea (WS);

Data: Radarsat-2

Fine Quad.-Pol. images;
2 from Nov. 2010 (BS),
Incidence $40-50^\circ$;
3 from Sep. 2011 (WS),
incidence $18-24^\circ$.



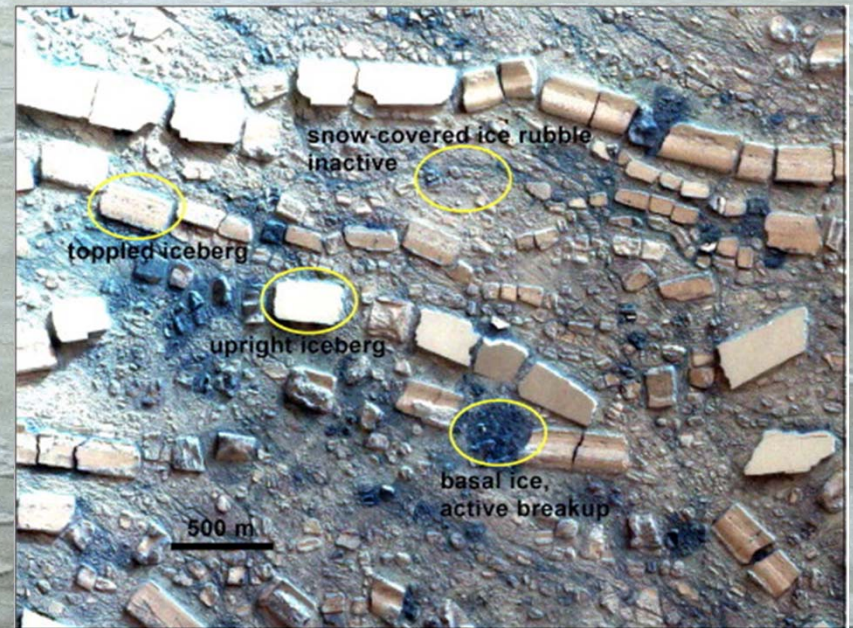
Iceberg Structure



To the left:
The ideal situation

Up and down may change:
iceberg turnover!

Scambos et al., 2009



Polarimetric Analysis

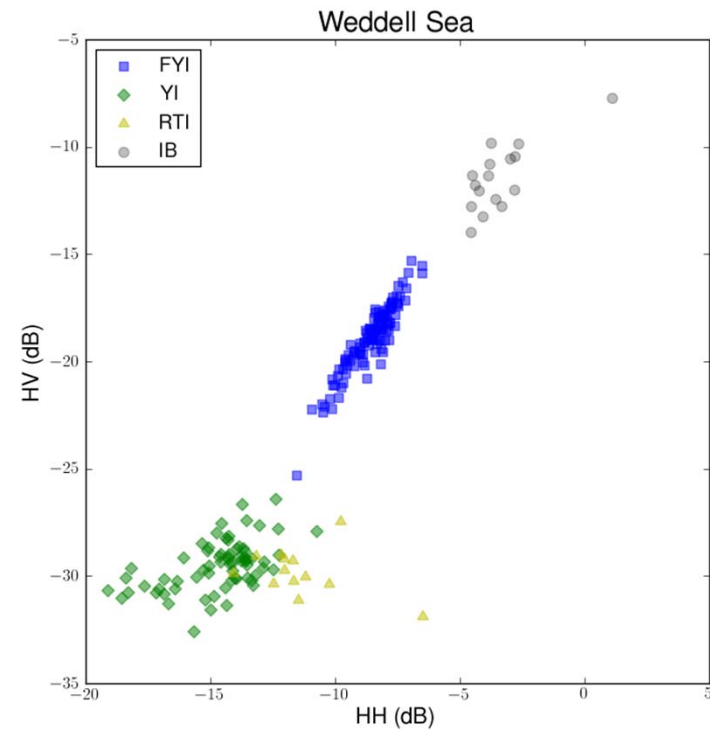
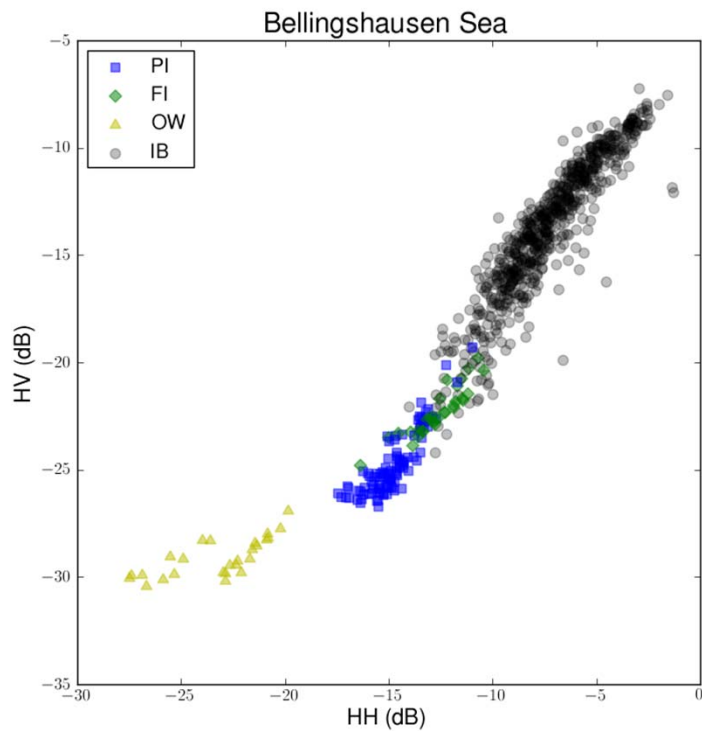
Investigated polarimetric parameters:

- intensities at like- and cross-polarization
- co- and cross-polarization ratios;
- phase difference and correlation HH-VV;
- entropy, alpha, anisotropy

Polarimetric Analysis

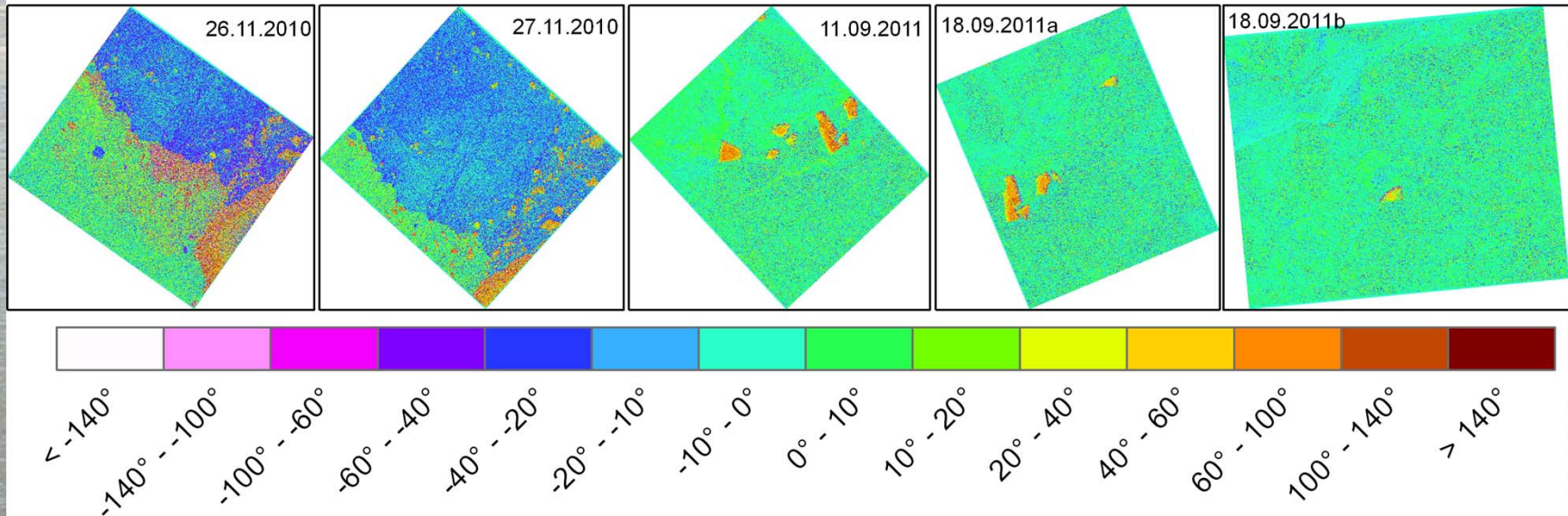
Intensities:

- icebergs: like- and cross-pol. $\sigma^0 > \sigma^0_{\text{noise}}$ (-36 dB)
- overlap between $\sigma^0_{\text{sea ice}}$ and $\sigma^0_{\text{icebergs}}$ at like- and cross-pol.

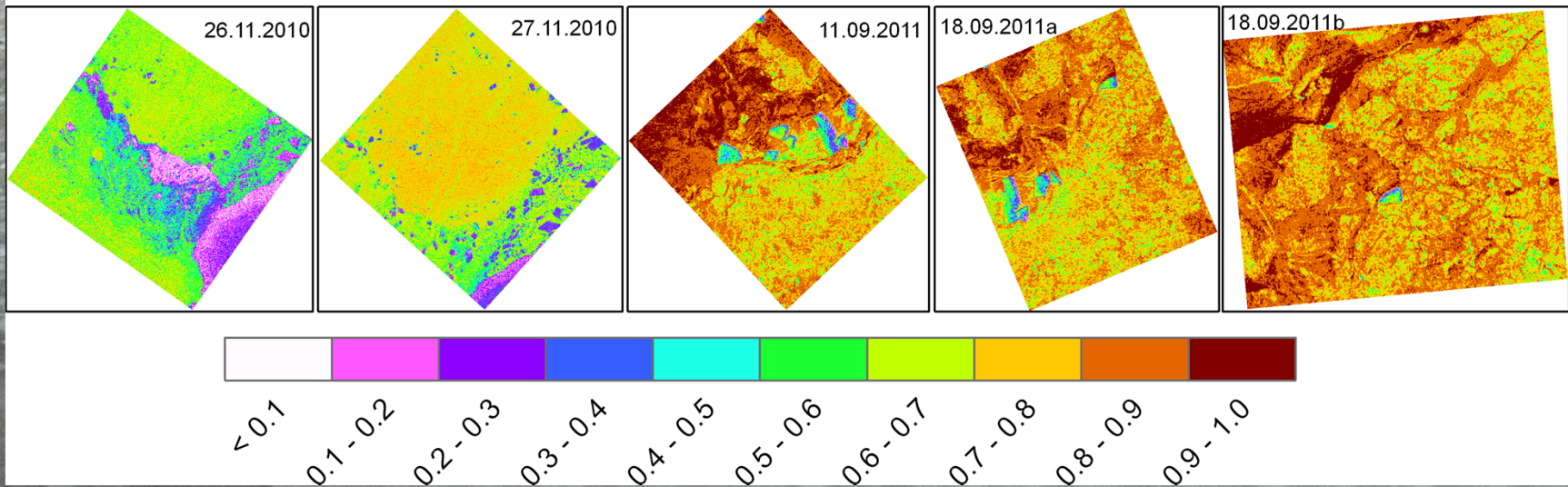


Polarimetric Analysis

Phase difference

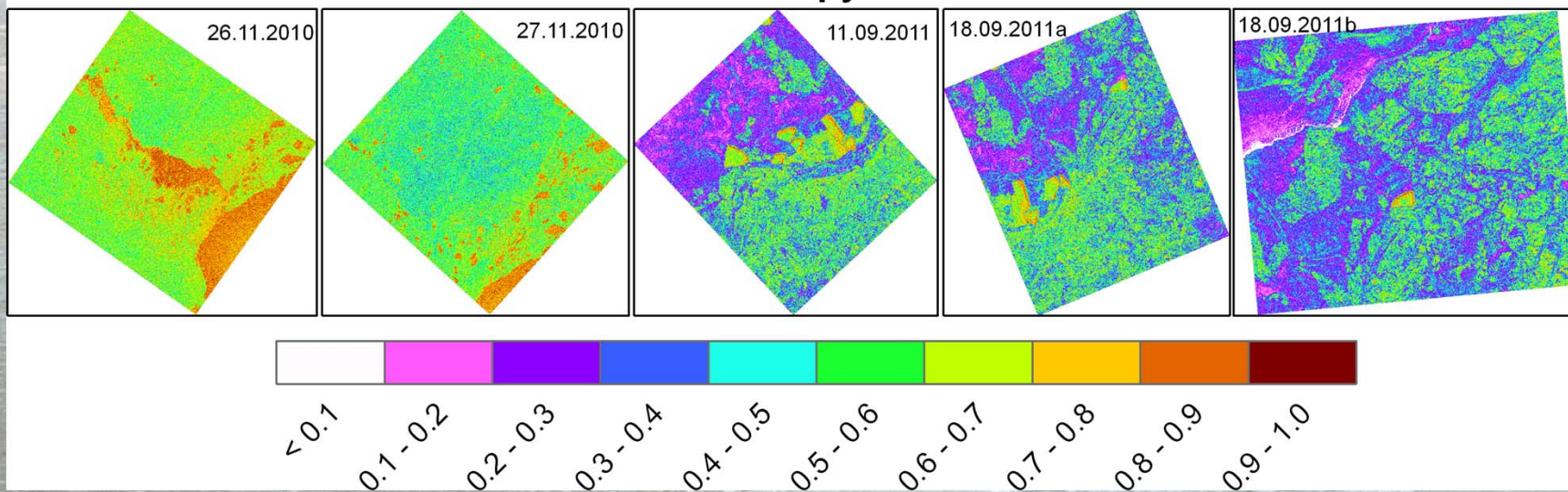


Correlation coefficient

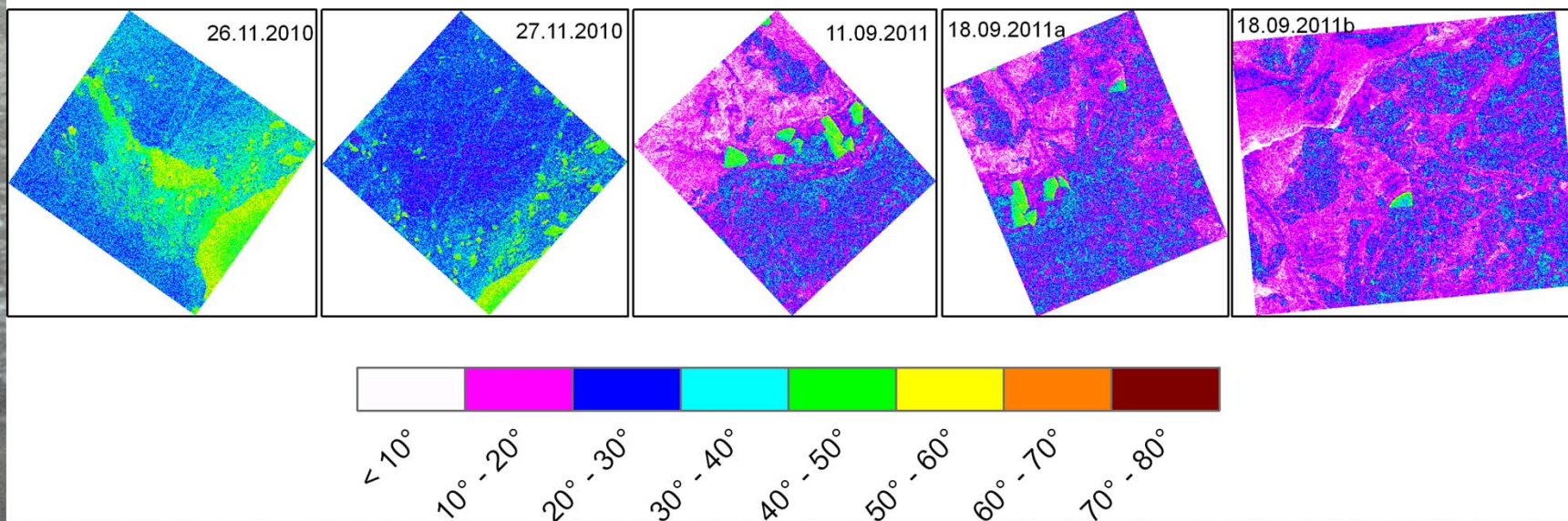


Polarimetric Analysis

Entropy



Alpha

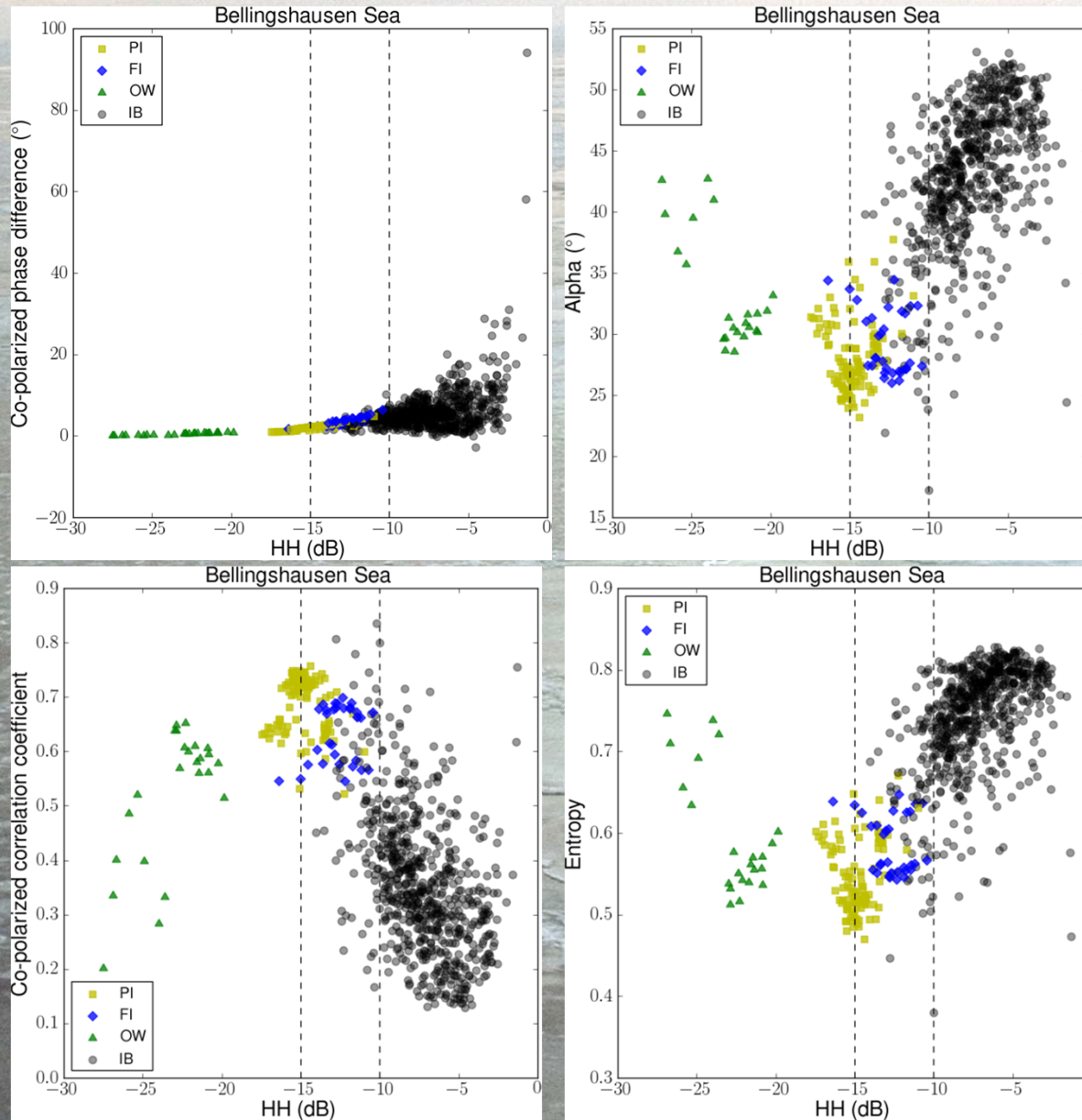


Interpretation of Radar Signatures

Iceberg radar signatures at C-band:

- complex mixture of different scattering mechanisms
(*dependent on ice properties, iceberg shape, meteorological conditions, incidence angle*)
- $\sigma^0_{XY}/\sigma^0_{XX}$, $\rho + \phi_{HHVV}$, H/α indicate strong contributions of volume scattering (icebergs: low salinity)
- ϕ_{HHVV} indicates anisotropy of? → permittivity
- reflections from the deeper volume and bottom?
→ not realistic: penetration depths 3-15 m at C-band

Iceberg detection



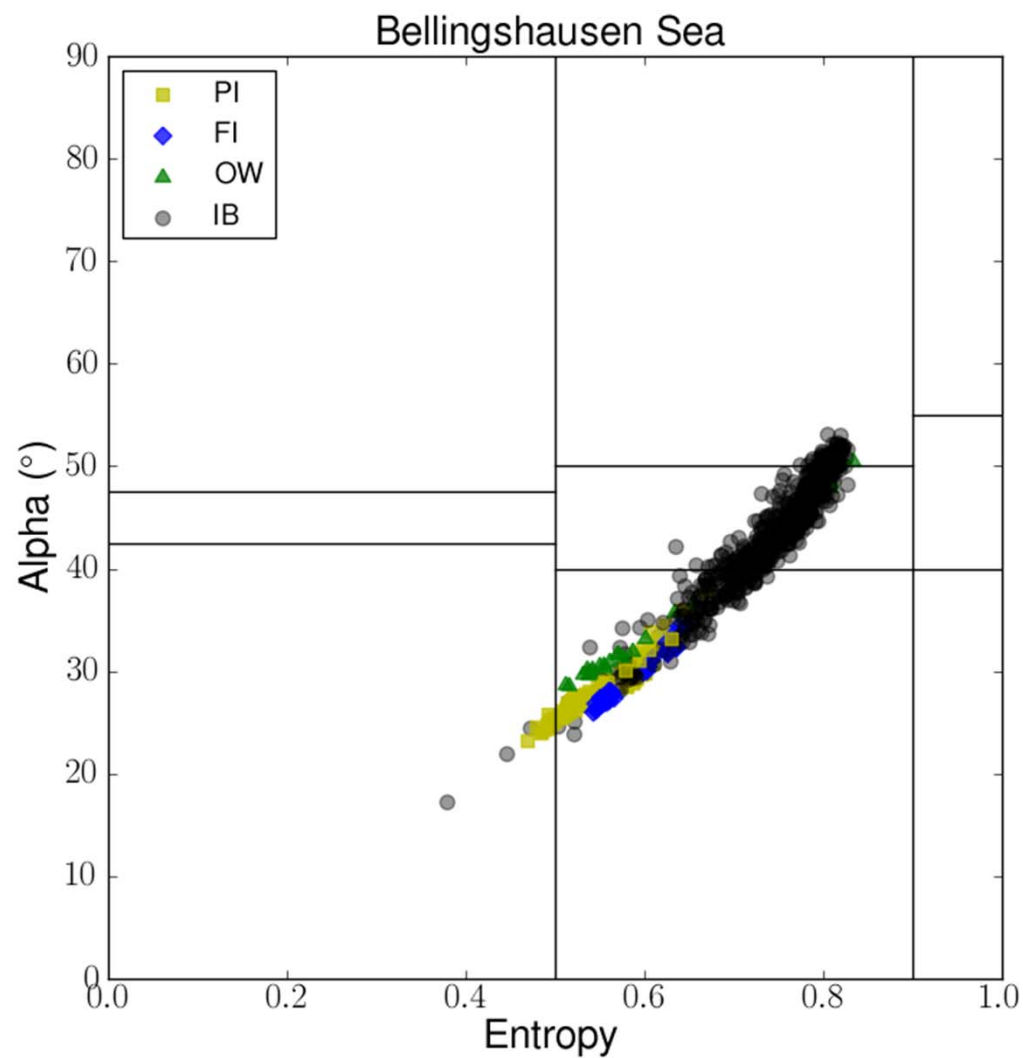
Problem: limited data set with "easy" sea ice conditions

In some cases: overlap of $\sigma^0_{\text{icebergs}}$ with $\sigma^0_{\text{sea ice}}$

BS: overlap at $-15\text{dB} < \sigma^0_{\text{HH}} < -10\text{dB}$

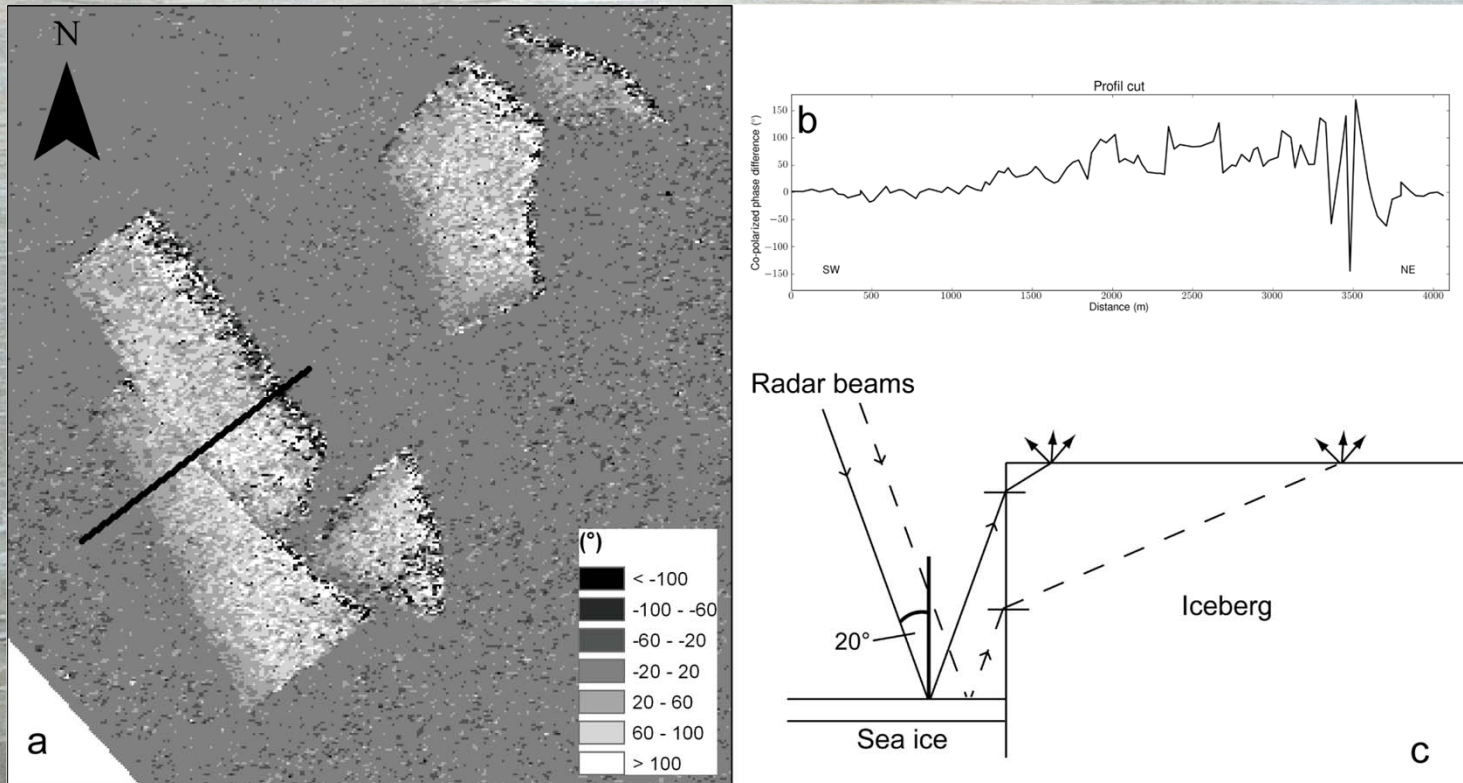
Overlap also when using polarimetric parameters (although partly different)

Iceberg detection



Increase of Phase Difference HH-VV

Weddell Sea icebergs: increase of ϕ_{HHVV} from near- to far-range



ice crystals with preferred orientation \rightarrow dielectric anisotropy \rightarrow birefringence \rightarrow V- and H-polarized waves with different phase velocities

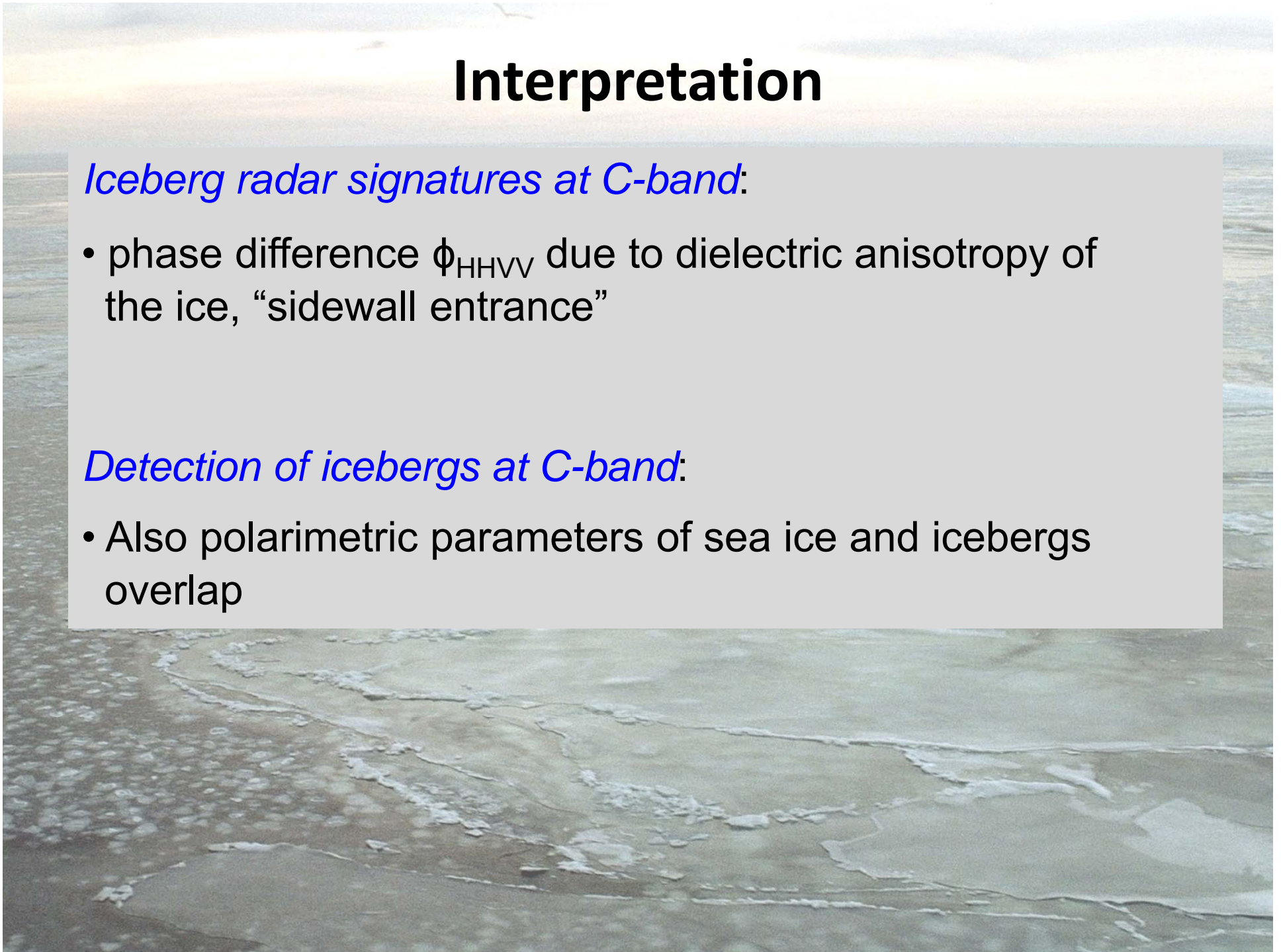
Interpretation

Iceberg radar signatures at C-band:

- phase difference ϕ_{HHVV} due to dielectric anisotropy of the ice, “sidewall entrance”

Detection of icebergs at C-band:

- Also polarimetric parameters of sea ice and icebergs overlap



Conclusions

- most icebergs reveal indications of volume scattering
- if not: turnover? (marine ice on top?)
- phase difference HH-VV because of dielectric anisotropy
- using polarimetric parameters reduces the overlap between sea ice and iceberg signatures to a certain degree, but not completely