# Iceberg Detection and Drift Simulation

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## *Problems?*

- SAR images:
  - detection of small icebergs
    (Titanic: 15-30 m freeboard, 60-120 m length)
  - detection of icebergs in deformed sea ice

- Iceberg drift forecasting

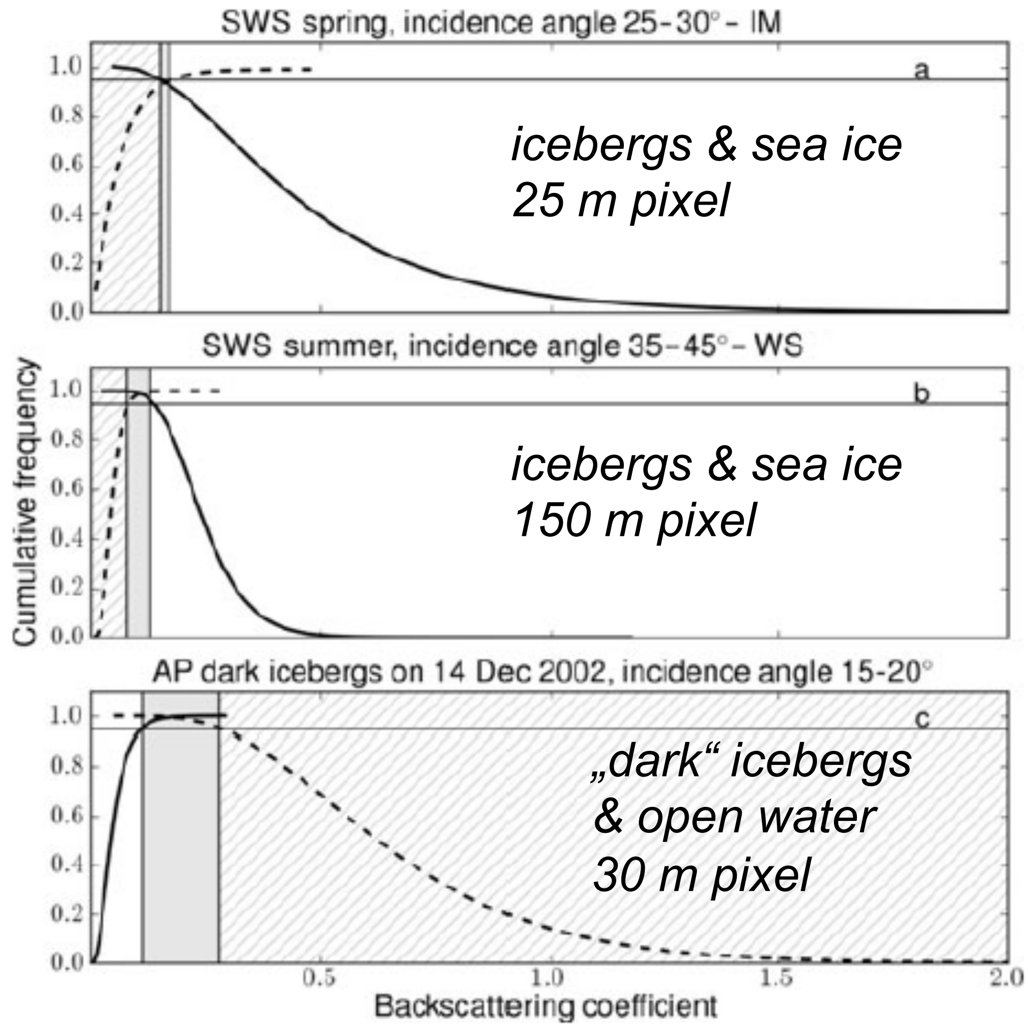
## Motivation for drift forecasting

- marine safety
- limit search area for new iceberg position in satellite images
- reduce ambiguities in identifying particular bergs

# Detection: Thresholding

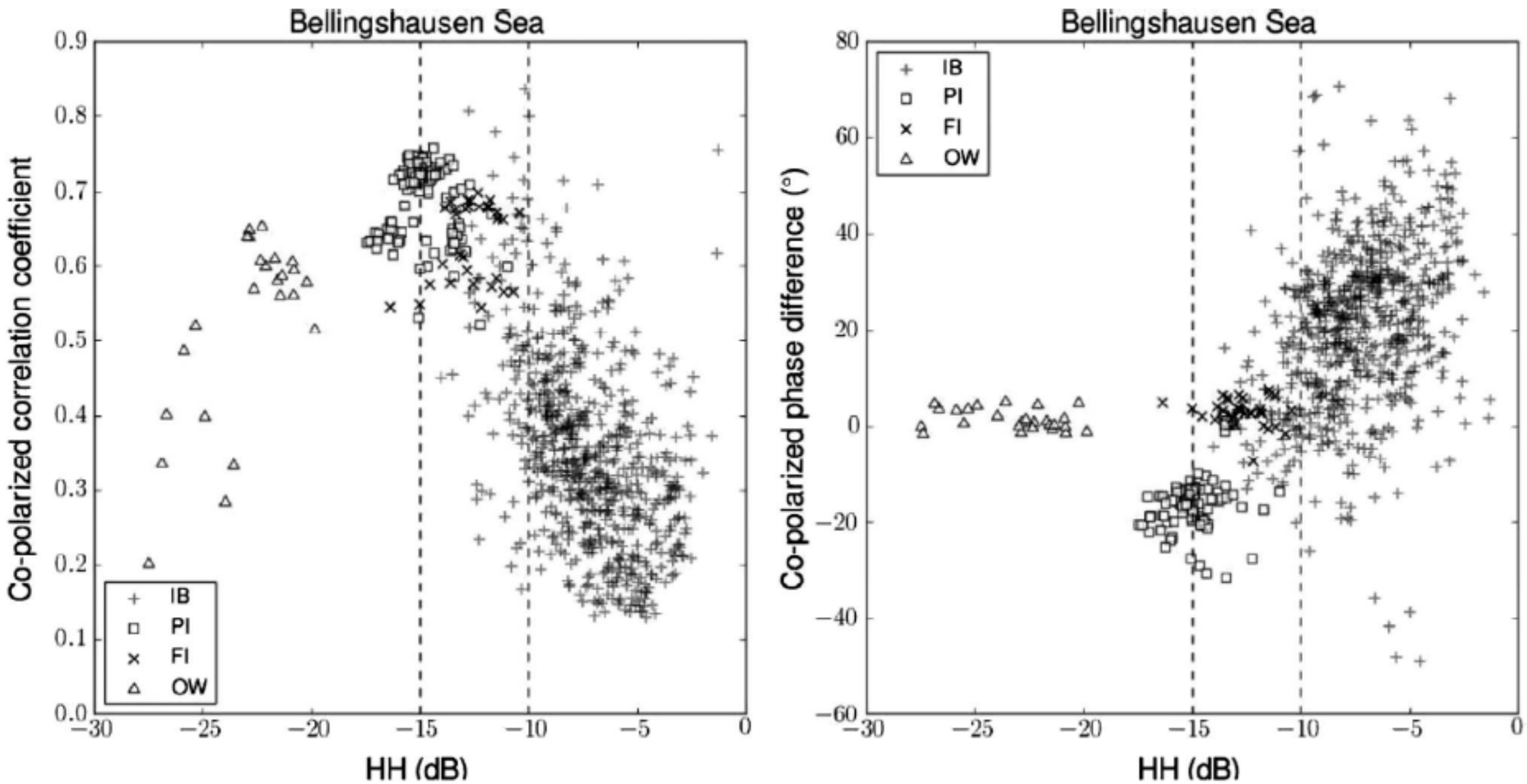
WESCHE, C. and W. DIERKING, "Iceberg signatures and detection in SAR images in two test regions of the Weddell Sea, Antarctica". Journal of Glaciology. 2012, vol 58 (208), p. 325-339

- single-polarized images ERS-2 & Envisat ASAR
- icebergs in open water and in sea ice
- success of detection is determined by pre-processing
- dependence of thresholds on wind/ice conditions
- problems in deformed sea ice



# Detection: Quad-Pol. Data

*Dierking, W., Wesche, C. (2014),*"C-Band radar polarimetry – useful for detection of icebergs in sea ice?", *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 52, No. 1, 25-37




Use of polarimetric parameters improves discrimination between icebergs and sea ice only in some cases!

# *Detection: Dual-pol incoherent Data*

Marino, A., Rulli, R., Wesche, C., Hajnsek, I. (2015) “A New Algorithm For Iceberg Detection With Dual-polarimetric SAR Data” Proc. IGARSS 2015, Milan, Italy.

- icebergs present an **enhanced volume scattering** compared to sea ice and ocean surface (dual-pol. analysis)

- new detector focuses at anomalies/increases of volume scattering.

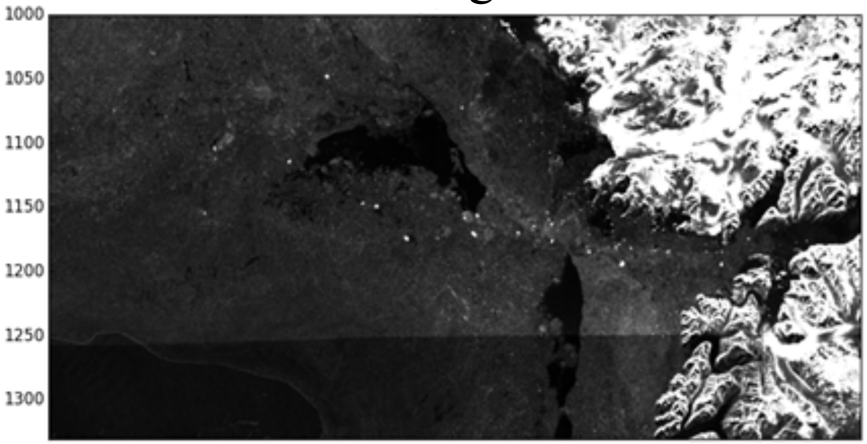
$$\Lambda = \frac{|\langle |HV|^2 \rangle_{test} - \langle |HV|^2 \rangle_{tr}|}{\langle |HH|^2 \rangle_{tr}} > T_\Lambda.$$

- Specifically the detector will be **higher than 1 if there is an increase in HV intensity and depolarisation ratio**. Both are indicators of volume scattering.

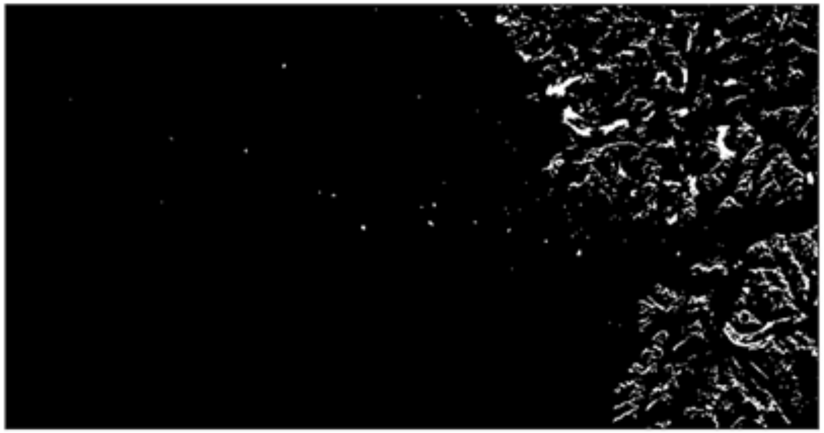
# Detection: Dual-pol incoherent Data

Sentinel-1 EW HH HV (05/04/2015). East Greenland (Fram Strait)
Window used: Test = 3x3; Train = 101x101.

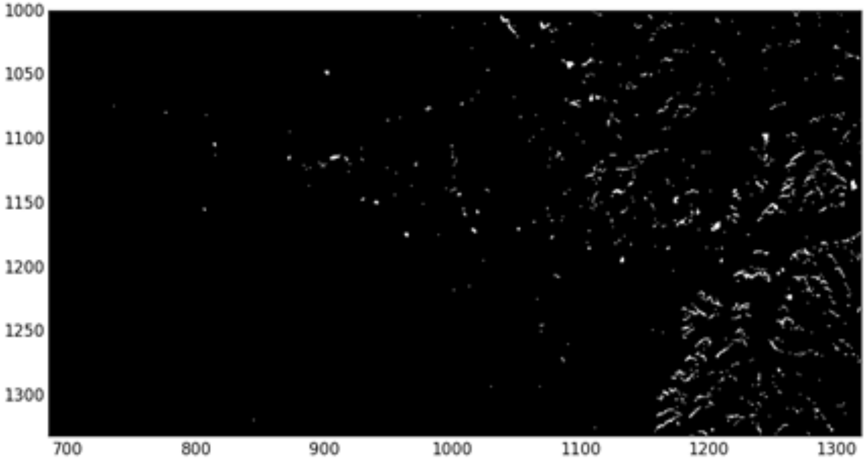
HV Magnitude




Volume Anomaly Mask

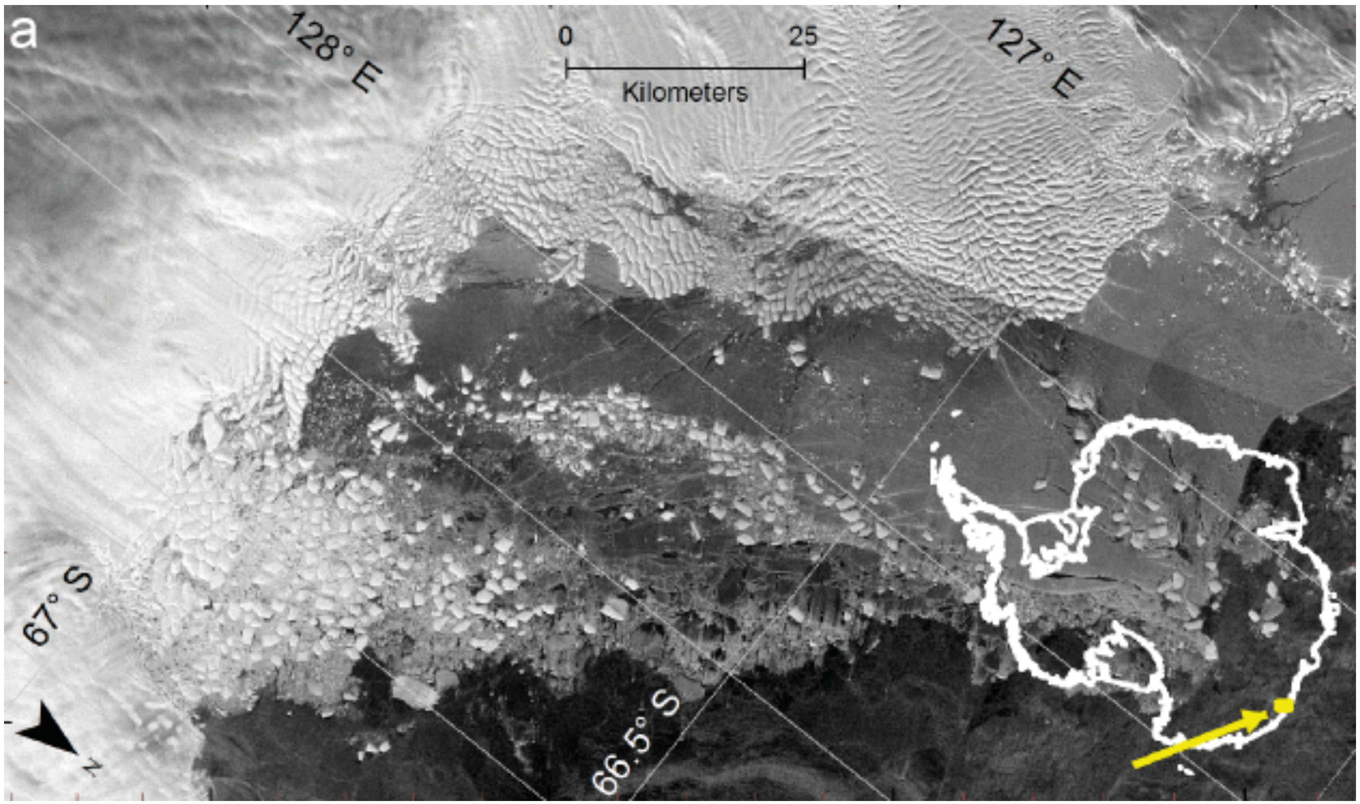


CA-CFAR



# *Iceberg Calving: Monitoring Source Locations*

*Wesche, C., Jansen, D., and Dierking, W. (2013)*, “Calving fronts of Antarctica: Mapping and Classification”, Remote Sens. 2013, 5 (12) pp. 6305-6322




Ice stream (IS) pattern

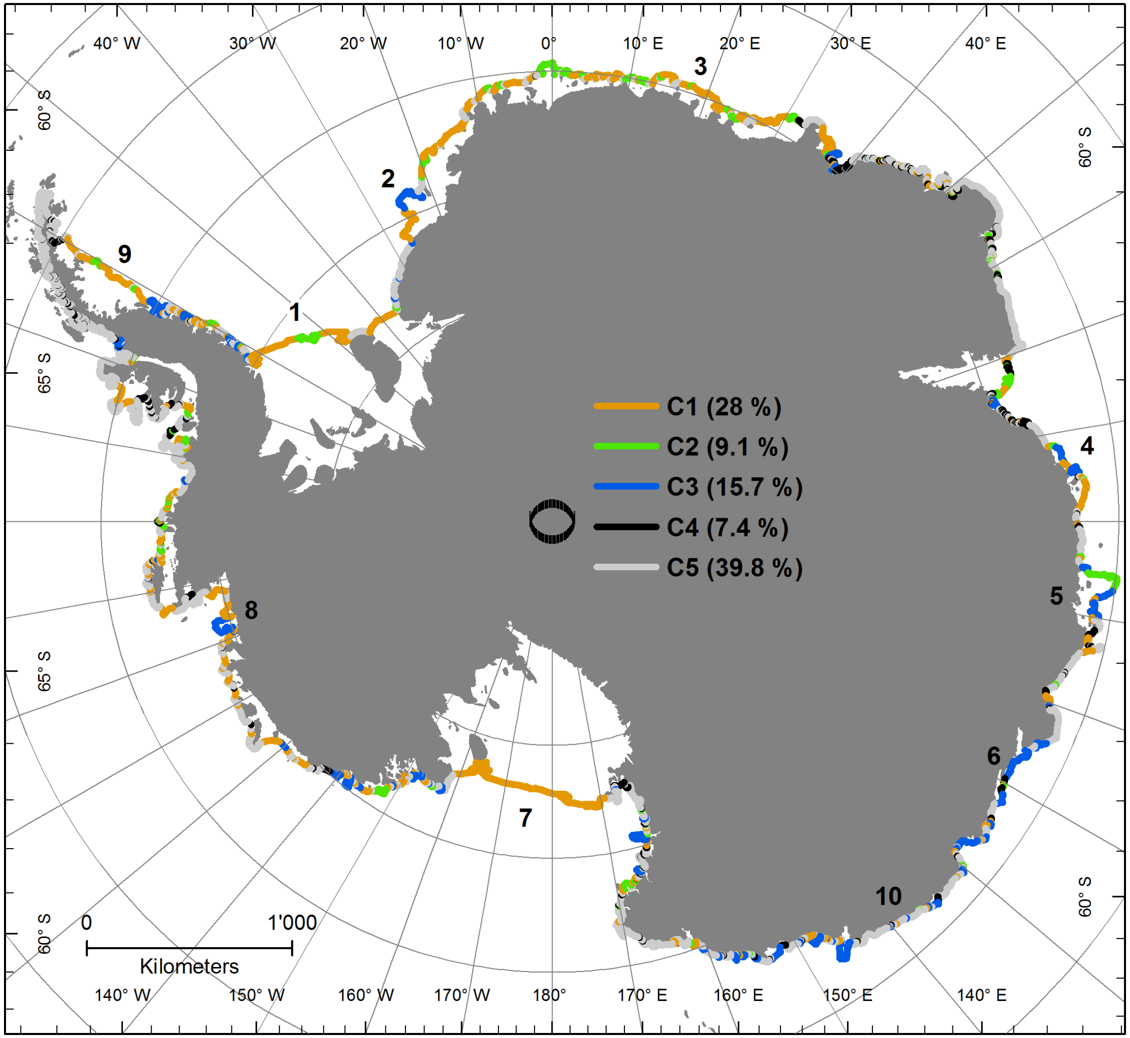
Surface structure of calving sites determines dominant iceberg shapes and sizes.

# *Iceberg Calving: Monitoring Sites*

Antarctica

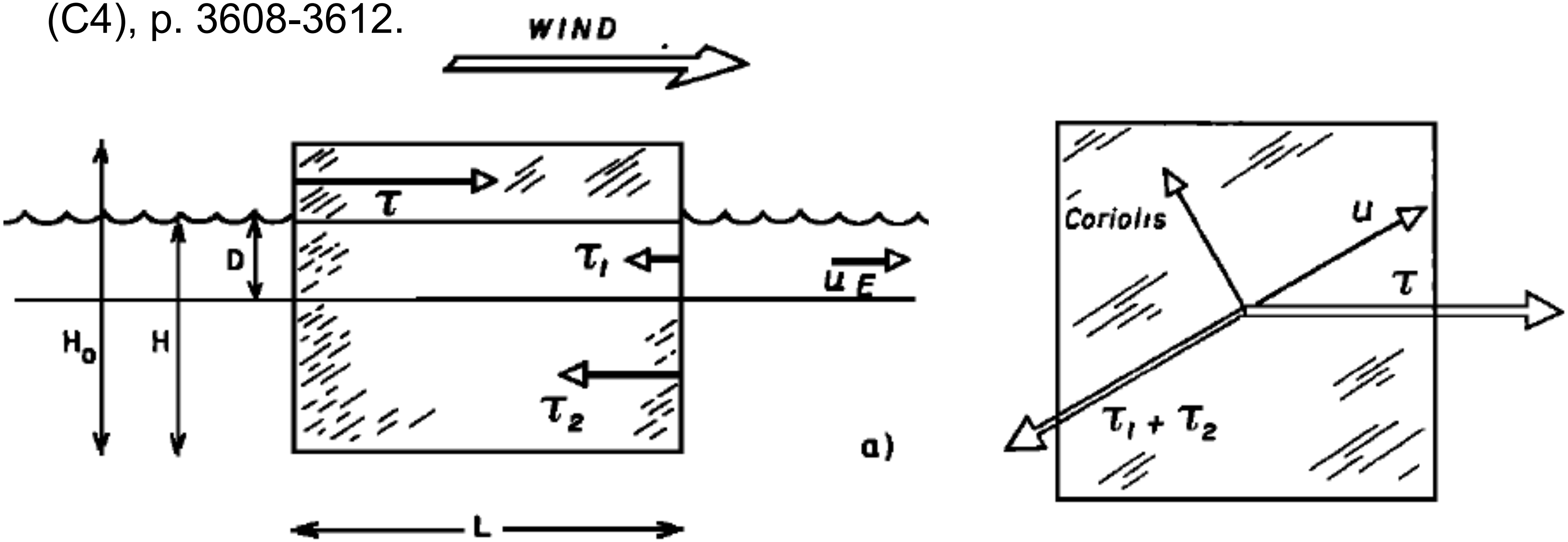
three different calving site surface structures:

C1 – parallel
C2 – orthogonal
C3 – IS
C4 – no crevasses
C5 – grounded ice



# *Drift Simulation: Test of a simple model*

CRÉPON, M., HOUSSAIS, M. N. and SAINT GUILY, B. "The drift of icebergs under wind action". Journal of Geophysical Research. 1988, vol 93 (C4), p. 3608-3612.




- Forces to be considered: air & ocean drag, water pressure gradient, Coriolis force, wave radiation or sea ice stress
- mixed layer: wind drag
- layer below: geostrophic => velocity proportional surface slope

# *Drift Simulation: Input Data*

"literature", typical values

- densities ice, water, air
- drag coefficients: air-water, air-ice, ocean-ice,
  tangential air-ice + ocean-ice
- mixed layer depth
- wind speed and direction (NCEP Reanalysis)

"from the field"

- iceberg dimensions (assuming a cuboid)

| | |
|---|---|
| lengths | 370 – 7000 m |
| widths | 100 – 4000 m |
| heights | 116 – 304 m |

- iceberg starting position

# *Drift Observations & Test Sites*

Drift patterns were retrieved from position data of GPS-buoys on 11 icebergs in different regions:

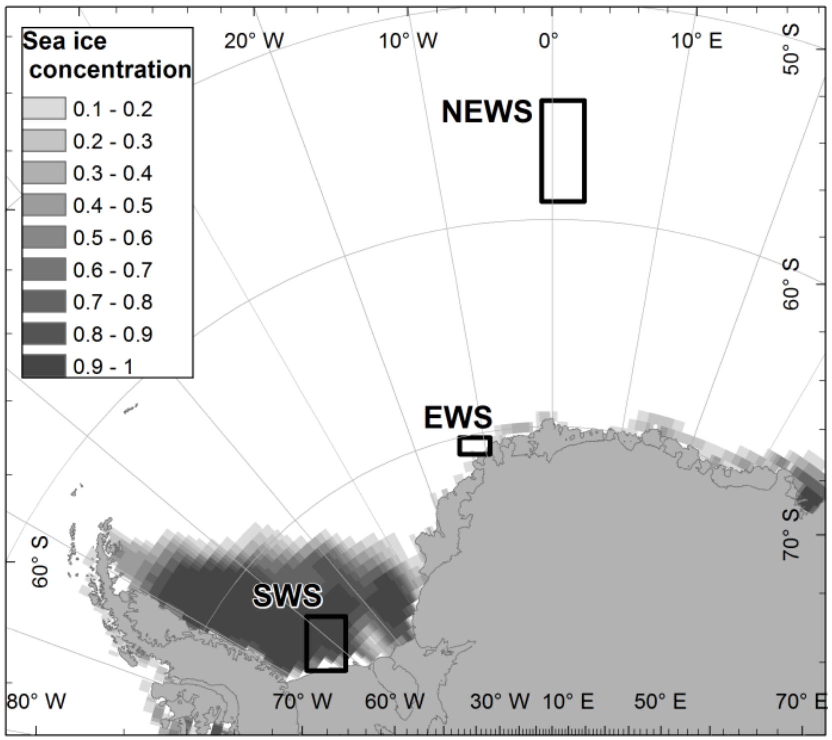
*Southern Weddell Sea SWS (model modifications)*
SIC ≈ 100%, SIT ≈ 1.0-1.5 m;  Weddel Gyre

*Eastern Weddell Sea EWS*
SIC < 10%, SIT < 0.5 m; Coastal Current (->west)

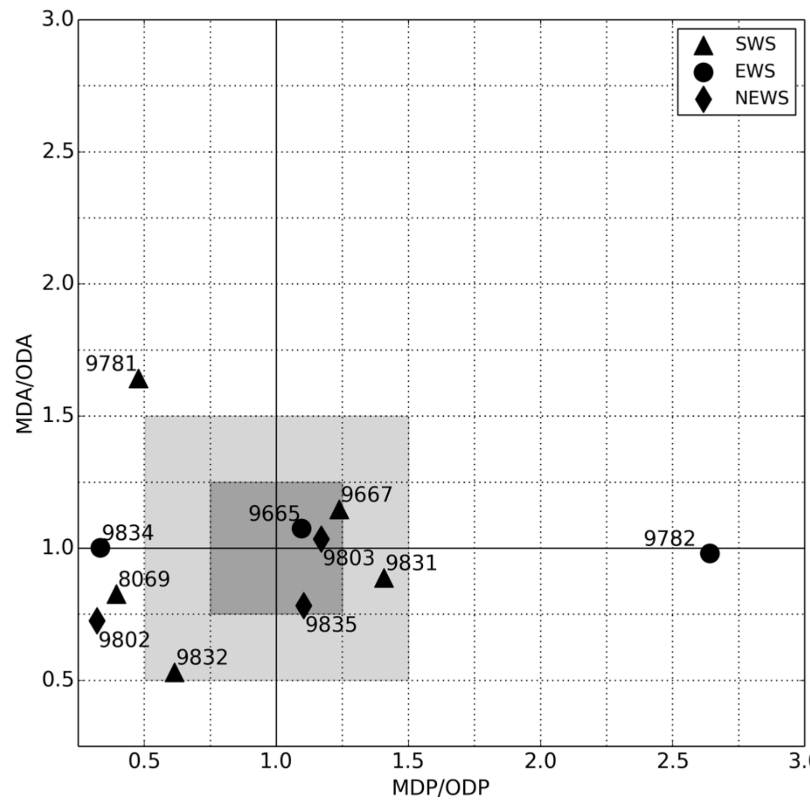
*North Eastern Weddell Sea NEWS*
SIC = 0%, ACC

# *Drift Simulation: Results <=> Observations*

WESCHE&DIERKING, Estimating iceberg paths using a wind-driven drift model, 2015, submitted manuscript

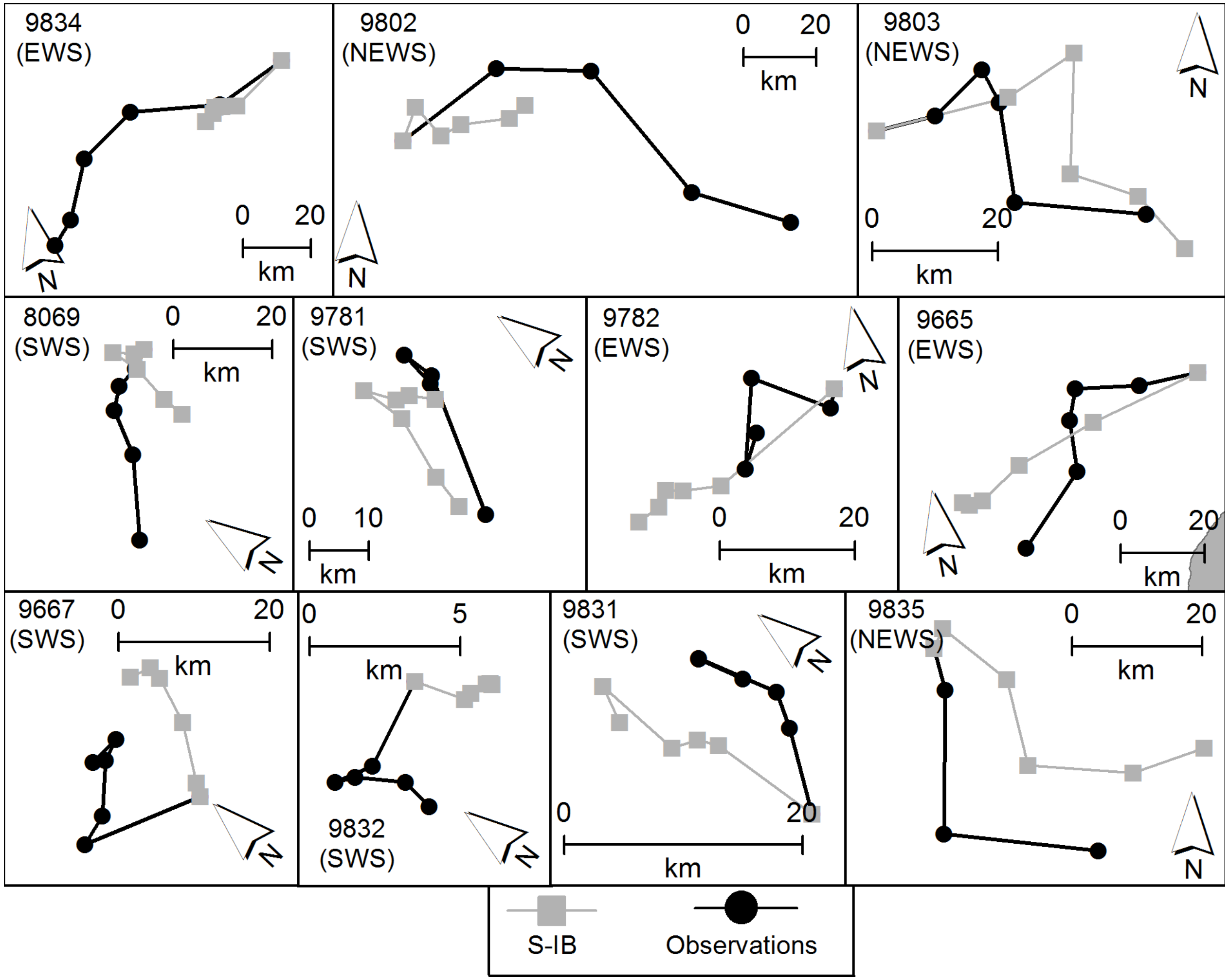



Different test sites




Differences of drift angles and magnitudes after 5 days

# Drift Simulation: Results <=> Observations




5-days iceberg paths

"Forecasts" would be acceptable for guiding image positioning (wide-swath scenario)

# *Drift Simulation: Results <=> Observations*

Why differences?

- *simplifications of the drift model used*
  (local ocean currents are not considered, idealized mixed layer=> Ekman spiral)
- *coarse spatial and temporal resolution of forcing data*
  *(example: near-coast: influence of topography on local wind patterns)*
- *influence of iceberg shape not adequately considered*
  (assumption: iceberg shape = cuboid)
- (tests with more complex models do not reveal significantly better results!)

# *Interesting study => "operational on-site"*

*I. D. Turnbull, N. Fournier, M. Stolwijk, T. Fosnaes, D. McGonigal, Operational iceberg drift forecasting in Northwest Greenland, Cold Regions Science and Technology 110, 1-18, 2015*

- support of coring campaign, NW Greenland
- operational model, near real-time input of metocean parameters, iceberg drift and size, tidal currents, weather forecast
- estimation of air and water form drag by matching observed and hindcast iceberg trajectories

# *Conclusions*

- Iceberg monitoring over larger regions should include observations of calving sites + drift forecasting
- Iceberg drift models: more complex ones do not necessarily deliver more accurate data!
- Largest problem of forecasts of iceberg drift:
  *in most cases input parameters cannot be provided with required accuracy*
- Local (“on-site”) operational monitoring possible with more or less detailed information about input parameters (high logistical effort)