

ICEBERG DETECTION IN OPEN WATER FROM ALTIMETER WAVEFORM ANALYSIS

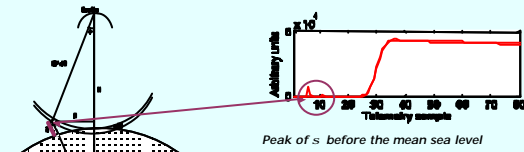
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Small icebergs, (typically < 1 km²) are difficult to detect using satellite borne sensors (Vis., IR and SAR)

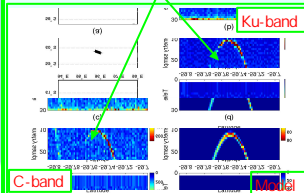
NEW DETECTION METHOD BASED ON ALTIMETER WAVEFORM ANALYSIS

PRINCIPLE

- Targets emerging from the sea : detectable signature in the noise part of Altimeter WF [Tournadre, 2008]
- **Works only in open water**



EX. signature of single iceberg (Jason WF)



- Simple parabola in telemetry sample/Time space:

$$\frac{d^2s}{dt^2} = -g + \frac{1}{2} \frac{a + H}{aH} g^2$$

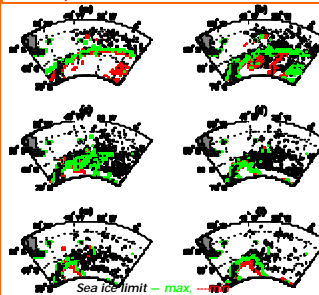
- δ target height, d distance from nadir A: earth radius H: satellite height
- Backscatter of a target of σ_1 backscatter and surface A

$$\sigma_{\text{iceberg}}(\delta) = \frac{\sigma_1}{2a^2 H^2} \left(1 + \frac{g^2}{2H^2} \right)^{-1} \frac{1 - \cos(\theta)}{2a^2}$$

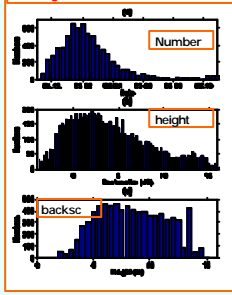
RESULTS

- Analysis of 1 year of Jason-1 WF;
- More than 8000 icebergs signatures detected south of 40°S.

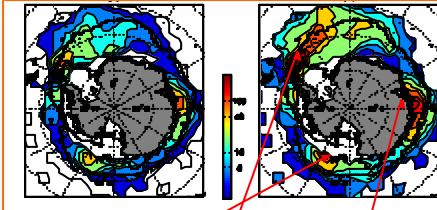
Icebergs detected off the Antarctic Peninsula by 2-month period N-D, J-F, M-A, M-J, J-A, S-O



Characteristics of detected icebergs south of 40°S



Density of icebergs on 250x250 km² regular polar grid uncorrected (a) and corrected (b) for undersampling

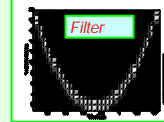


Strong tri-pole structure, good agreement with previous studies, maxima off Antarctic Peninsula, West Ice Shelf, and Ross Sea.

Automatic Detection Method

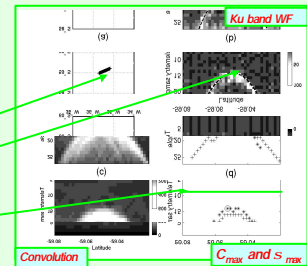
Analysis of the thermal noise part of WF: detection of parabola

- Computation of the convolution product **C** between WF (gates 5 to 28) and a filter computed from modeled WF.
- Determination for each WF of the maxima of **C** and σ_1
- Detection of the WF for which the maxima are larger than given thresholds

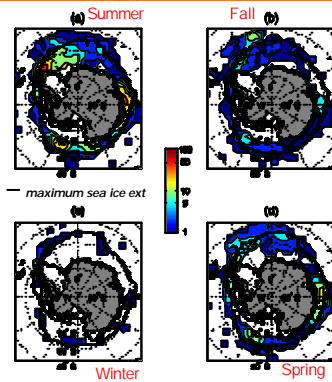


Estimate of

- location, (lat,lon)
- backscatter (σ_1) related to iceberg surface
- minimum height

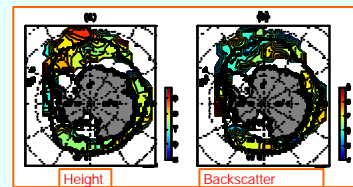


Seasonal distribution of icebergs



- Release of iceberg in open water starts in Spring.
- Maximum in summer
- Northwards propagation in the South Atlantic in Fall
- Some icebergs in Winter in South Atlantic
- Good agreement with previous studies

More tentative



- Iceberg height distribution higher berg in the S. Atlantic, higher ones propagate further north (north of sea ice max extent).
- Smaller bergs in S. Atlantic than in S. Pacific and S. Indian ocean.

CONCLUSION & PERSPECTIVE

- **Demonstration that Altimeters** are powerful tool to detect small icebergs
- The method can be applied to the waveforms of any altimeter
- **Perspective and future work:** analysis of the archive of Topex/Poseidon, Jason and ERS-1/2 for climate studies, detection in sea ice, large icebergs detection (data loss)

References

- Tournadre, J.: 2007, Signature of lighthouses, ships, and small islands in altimeter waveforms, J. ATMOS. OCEANIC TECH., 24, 1143-1149
- Tournadre, Jean Whitmer, Kirk Girard-Arduin, Fanny, 2008, Iceberg detection in open water by altimeter waveform analysis. J. GEOPHYS. RES., C08040S0