Iceberg monitoring service by joint use of drift model, SAR and altimeter data

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Iceberg monitoring service

- An 24/7 Iceberg detection service delivered during
  - the Vendee Globe Challenge (2008-2009) a sailing race around the world, for single-handed, without any stopover
  - the Jules Verne Trophy (2010) record attempt with Groupama 3 skippered by Franck Cammas
  - the solo round the world (2011) of Sodebo skippered by Thomas Coville

- Service included
  - Preliminary iceberg detection by altimeter
  - Iceberg detection using SAR imagery
  - Iceberg drift forecast

- Further scientific/technical development
  - SIDARUS FP7 project
  - CITEPH program (sponsored by GEP – Total oil company, Doris, CGG Veritas …)
System and processing chains

- SAR Images
  - SARTool
  - SAR Icebergs
  - Drift Model
  - GIS
  - METOC data
  - Argos buoys
  - Icebergs positions
  - Altimetry
    - Altimetry data
  - Alti Algorithm
  - Altimetry Icebergs
  - End-User
System and processing chains

- Altimetry data
- Alti Algorithm
- Altimetry Icebergs

End-User
Spaceborne altimeter

- Area illuminated by the radar
  - 10-20 km on each side of the track
- Area that actively contribute to the leading edge of the waveform (beginning of the peak)
  - Not more than 5 km on each side of the track (depending on the sea state condition) useful for iceberg detection
Altimeter-based iceberg detection

- Cumulative approach over one month
Toward an efficient data acquisition strategy with altimeter detection

2008-2009: During Vendée Globe Challenge, 250 ENVISAT SAR images were used to monitor icebergs: Very efficient but the market is not ready today for such a high volume of SAR acquisitions.

2010 Jules Verne Trophy: 30 RS2 SAR scenes were programmed in short notice over pre-identified risky areas.

- Use of altimetry allows more efficient planning of SAR acquisition over risky areas
  - Risky areas can be identified and tracked well before the passage of the sailboat
System and processing chains

- SAR Images
  - SARTool
  - SAR Icebergs

- Altimetry data
  - Alti Algorithm
  - Altimetry Icebergs

SAR acquisition strategy

End-User
### SAR-based iceberg detection

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<th>Imaging mechanism</th>
<th>Possible detection methods</th>
<th>Comments</th>
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<tr>
<td>Double-bounce scattering</td>
<td>CFAR-like approach</td>
<td>Commonly used method, robust, good capacities except at steep angle or strong wind condition</td>
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<td>Shadowing, Specular reflection</td>
<td>Dark point-target detection</td>
<td>Observable with decametric resolution only</td>
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<tr>
<td>Effect of surrounding sea surface, Wakes</td>
<td>Segmentation, Hough transform</td>
<td>Strongly depend on sea condition</td>
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<tr>
<td>Shape</td>
<td>Image segmentation</td>
<td>Large icebergs only</td>
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<tr>
<td>Volume scattering</td>
<td>Multifrequency or polarimetric approach</td>
<td>Observable only with multi channel data, for sea surface only</td>
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- **SAR data**
  - Land masking
  - Pre-screening CFAR detection
  - False alarm discrimination
  - Geographical database
  - Ancillary data
  - Supervisory control
Current performance

- Over 218 ASAR WSM in HH channel from Vendée Globe 2008-2009 dataset
  - No ground truth but a systematic detection approach
  - Occurrences of detection wrt incidence angle, wind speed
  - Valid for WSM products only (150m resolution – 75 m pix. spacing)
    - medium (61-122m length), large (123-213m) and extra-large (> 213m) icebergs

- Incidence angle appears as a critical parameter.
  - Below 30°, the detection rate is particularly low

- CFAR algorithm: based on the supposedly high contrast between the iceberg and the ocean clutter
  - Increase of ocean backscattering (linked to incidence angle or wind speed) -> diminution of the overall detection accuracy.

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SAR-based iceberg detection

- Modeling of detection performance
  - Given incidence angle and wind speed (by ancillary data) -> a priori probability of detection

ECMWF wind field
A priori iceberg detection rate
Detected icebergs
SAR-based iceberg detection

WSM acquisitions in South Atlantic and Indian Oceans from Dec 2008 – mid-Feb 2009

Probability of iceberg detection

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System and processing chains

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- Drift Model
- METOC data
- Icebergs positions
- End-User

- Altimetry data
- Alti Algorithm
- Altimetry Icebergs
- SAR acquisition strategy
- Argos buoys
- Icebergs positions
MOBIDRIFT

Icebergs

Oil spill

Leeway

Container

Iceberg modeling with:
- advection
- thawing
- rolling over
- dislocation
- icebergs generation

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Example of Drift modelling and validation with B15N
B15N: Status Oct., 28 and Nov. 9, 2011
B15N: Drift simulation from Oct., 28 and until Nov. 9, 2011
Deterministic and probabilistic approaches

Probability of iceberg’s presence
> 50 % in red
> 68% in Orange
> 95% in Yellow
= 100% in White
Next challenges and perspectives

• Development of a complete prototype for iceberg detection and forecast
  – Use of altimetry: more efficient planning of SAR acquisition over risky areas
  – SAR data enable a reliable and well-controlled iceberg detection
  – Drift model for an Early Warning System

• Technical/scientific challenges
  – Complete integration of various data types (SAR, altimeter and metoc data)
  – Ensure a low false alarm rate with altimetry (waveform analysis)
  – Ensure a good SAR-based detection rate even in the icepack
    • Integration of SAR-based sea ice map -> toward an automated methodology?
    • Tune the CFAR-based method?

• Future demonstrations
  – the Vendee Globe Challenge (2012-2013)
  – An Early Warning System for oil platform, ongoing prototype demonstration for the Shtokman gas field in the Barents Sea

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