Towards a Tracking of Small Scale Eddies Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery

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Workshop on Sub-Mesoscale Processes
Hamburg, June 15th, 2012
Outline

- The DTeddie project
- Marine surface films as tracers
- Challenges and results on the mesoscale
- Sub-mesoscale challenges
- Future work
The DTeddie Project

Detecting and Tracking Small Scale Eddies in the Black Sea and the Baltic Sea Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery

supported by the Canadian Space Agency CSA and the German Space Agency DLR by means of the announcement CSA-DLR-2010, project OCE0995
Regions of Interest

- Central and Southern Baltic Sea (TSX only)
- Gelendzhik / Black Sea (Russian territory)
Data Requirements of DTeddie

- High-resolution SAR data (1m – 50m p. pixel)
- Spatio-temporal *near* images
- Visibility of trackable objects and eddy-like structures
- Ground Truth w.r.t. real measurements
- Good radiometric quality
- Best geographic quality
Data Processing

- Generic and independent preprocessing chain

- Sea surface current estimation

- Validation and interpretation of results by means of other (e.g. in-situ) measurements
RADARSAT-2 UltraFine SLC

11.10.2011 03:37 UTC   VV-pol.   3m res.
RADARSAT-2 UltraFine SLC

11.10.2011 03:37 UTC  VV-pol.  3m res.
RADARSAT-2 UltraFine SLC

11.10.2011 03:37 UTC  VV-pol.  3m res.
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Eddies at the Baltic Sea (ENVISAT)

(b) 25.04.2009 9:09 UTC
**Resumée**

**Surface films as tracers**

- Biogenic or anthropogenic
- Algae blooms → biogenic films
- Signatures in SAR images are visible under certain (wind) conditions
- Signatures look dynamic due to frontal / morphological „history“
- **Attention**: They provide *no* information about the *instantaneous or future* sea surface current
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Approaches for motion estimation

- Origin of most motion estimation algorithms: Video analysis
- Differential or feature-based methods
Challenges on the mesoscale

Comparison with video analysis

- Mesoscale SAR image sequences:
  - Different sensors
  - Larger temporal distance between images
  - Larger spatial distance between image items
  - Larger Images
  - Require advanced preprocessing

- Signatures of surface films:
  - High morphodynamic variations of tracers
  - Changes in NRCS* not only caused by movement of tracers but e.g. by changing wind conditions

* Normalized Radar Cross Section
California (ENVISAT)

2003/09/27
18:01 UTC
Resolution: 12.5m

United States of America
California
Mexico

2km
California (ERS-2)

2003/09/27
18:30 UTC
Resolution: 12.5m

United States of America
California
Mexico
Local minima below a given value of NRCS*

* Normalized Radar Cross Section
matches with a correlation $> 0.5$

Matched via a fast NCC*

Global motion model estimated

* Normalized Cross Correlation
Resumée

Motion estimation on the mesoscale

- Most of the issues have been solved
- Some approaches yield promising results

![Diagram showing time between frames vs. spatial coverage with video data and medium resolution SAR-data points.](image)
Outline

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Challenges below the mesoscale I

- Different spatial but nearly same temporal resolution
- Different imaging properties of high resolution SAR (?)
Challenges below the mesoscale II

- Higher resolution → larger spatial distances of the tracers
- Differences of signatures at C- and X-Band
- Data availability for strongly requested platforms like TerraSAR-X and RADARSAT-2
- Validation of complete ROIs becomes harder
RADARSAT-2 UltraFine SLC

11.10.2011 03:37 UTC   VV-pol.

2km
First results

Matches with a correlation > 0.6

Matched via a fast NCC on arbitrary features

Global motion model not yet estimated
Comparison with in-situ measurements of IKI

Overlay of field studies and computed currents
Conclusions

- Similar imaging properties for both sensors
  - X- and C-band
  - HH- and VV-polarisation
- Improvable first results
  - Optimize feature detection
  - Adopt motion model estimation
- Further acquisitions → Eddies
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Future work

- Acquisition of further data
- Detection:
  - More expert-interpretation of SAR images
  - Improve semi-automatic detection of surface film signatures in hi res. SAR images
- Tracking:
  - Start improvement of (already adopted) algorithms
  - Validate with in-situ measurements
Outlook

• Collect more in-situ data (Black Sea):
  • Field study in June
  • Field study in ~ September
• Finally, implementation of semi-automatic processing chain, consisting of:
  • Preprocessing,
  • Detection and
  • Tracking
Thank you for your attention!

- Time between frames [min]
  - Video data
  - Medium resolution SAR-data
  - High resolution SAR-data

Spatial coverage [km²]

You are here
Literature


RADARSAT-2 Image Modes I

Data taken from CSA-brochure, ©2012 CSA
# RADARSAT-2 Image Modes II

<table>
<thead>
<tr>
<th>BEAM MODE</th>
<th>APPROXIMATE INCIDENCE ANGLE</th>
<th>NOMINAL SWATH WIDTH</th>
<th>APPROXIMATE RESOLUTION</th>
<th>NUMBER OF LOOKS</th>
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<tbody>
<tr>
<td>Selective Polarization</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>transmission H or V</td>
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<tr>
<td>receive H and/or V</td>
<td></td>
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<tr>
<td>Fine</td>
<td>37° - 49°</td>
<td>50 km</td>
<td>10 x 9 m</td>
<td>1 x 1</td>
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<tr>
<td>Standard</td>
<td>20° - 49°</td>
<td>100 km</td>
<td>25 x 28 m</td>
<td>1 x 4</td>
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<tr>
<td>Low Incidence</td>
<td>10° - 23°</td>
<td>170 km</td>
<td>40 x 28 m</td>
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<tr>
<td>High Incidence</td>
<td>50° - 60°</td>
<td>70 km</td>
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<tr>
<td>Wide</td>
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<td>150 km</td>
<td>25 x 28 m</td>
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<tr>
<td>ScanSAR Narrow</td>
<td>20° - 46°</td>
<td>300 km</td>
<td>50 x 50 m</td>
<td>2 x 2</td>
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<tr>
<td>ScanSAR Wide</td>
<td>20° - 49°</td>
<td>500 km</td>
<td>100 x 100 m</td>
<td>4 x 4</td>
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<tr>
<td>Polarimetric</td>
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<tr>
<td>transmit H and V on alternate pulses</td>
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</tr>
<tr>
<td>receive H and V on any pulse</td>
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<tr>
<td>Fine Quad-Pol</td>
<td>20° - 41°</td>
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<td>11 x 9 m</td>
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<tr>
<td>Standard Quad-Pol</td>
<td>20° - 41°</td>
<td>25 km</td>
<td>25 x 28 m</td>
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<td>Selective Single Polarization</td>
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<tr>
<td>receive H or V</td>
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<td>Ultra-Fine</td>
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<td>Multi-Look Fine</td>
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<td>11 x 9 m</td>
<td>2 x 2</td>
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</tbody>
</table>

1. Ground range by azimuth

Data taken from CSA-brochure, ©2012 CSA
TerraSAR-X Image Modes I

Data taken from infoterra-brochure, ©2012 infoterra
## TerraSAR-X Image Modes II

<table>
<thead>
<tr>
<th>Imaging Mode</th>
<th>Standard Scene Size [km]</th>
<th>Maximum Acquisition Length [km]</th>
<th>Slant Range Res. [m]</th>
<th>Azimuth Res. [m]</th>
<th>Polarization</th>
<th>Full Performance Range [°]</th>
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<tbody>
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<td>HighRes SpotLight (HS)</td>
<td>10 x 5</td>
<td>5</td>
<td>1.2</td>
<td>1.1</td>
<td>Single (VV or HH)</td>
<td>20° to 55°</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1.2</td>
<td>2.2</td>
<td>Dual (HH &amp; VV)</td>
<td></td>
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<tr>
<td>HighRes SpotLight 300 MHz (HS300)</td>
<td>7-10 x 5</td>
<td>5</td>
<td>0.6</td>
<td>1.1</td>
<td>Single (VV or HH)</td>
<td>20° to 55°</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Dual (HH &amp; VV)</td>
<td></td>
</tr>
<tr>
<td>SpotLight (SL)</td>
<td>10 x 10</td>
<td>10</td>
<td>1.2</td>
<td>1.7</td>
<td>Single (VV or HH)</td>
<td>20° to 55°</td>
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<td>1.2</td>
<td>3.4</td>
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<td>StripMap (SM)</td>
<td>30 x 50 single pol</td>
<td>1.650</td>
<td>1.2</td>
<td>3.3</td>
<td>Single (VV or HH)</td>
<td>20° to 45°</td>
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<tr>
<td></td>
<td>15 x 50 dual pol</td>
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<td></td>
<td>Dual (HH &amp; VV, HH &amp; HV, or VV and VH)</td>
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<td>ScanSAR (SC)</td>
<td>100 x 150</td>
<td>1.650</td>
<td>n/a</td>
<td>18.5</td>
<td>Single (VV or HH)</td>
<td>20° to 45°</td>
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</table>
Tool for Image-Series Acquisition

[Image: Tool interface with satellite list and date range input]