Near-real time generation of ENVISAT ASAR level-2 Wind and Waves products:
Presentation of the system and preliminary achievements

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SAR Ocean Wind, waves and Currents
presentation of the project

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• Main objectives of the SAR Ocean Wind, Waves and Current project
  – To develop and validate novel processing methods
    • for wind vector retrieval from ASAR image mode and wide-swath mode
      (with a view to their rapid incorporation into operational products)
    • for wave spectrum retrieval from ASAR image mode and wide-swath mode
  – To consolidate understanding of the geophysical contribution to SAR Doppler residuals

• Consortium
  – BOOST Technologies, GKSS, NERSC, NORUT, University of Hamburg, Atlantis and Vexcel UK (Microsoft)
SAR Ocean Wind, waves and Currents presentation of the project

• Phase 1: From R&D to Validation of prototypes
  – Period: February 2005 to December 2006
  – Achievements
    • Development of L2 SAR wind and waves prototypes
    • Validation using in-situ measurements
    • Technical support for the generation of Doppler grid now made available by ESA on ASAR Wide Swath products
    • Geophysical analysis of the concept of the Doppler anomaly
    • Suggestion for L3 products
    • Recommendations
SAR L2 wind products

- Characteristics of the software prototype (ver. 2.0)
  - Bayesian approach based on
    - Neural network implementation of CMOD-IFR2
    - A priori local distribution of wind given by NWP model
      - NRT 6-hourly predictions of ECMWF winds (0.5 x 0.5°)
      - RMS error of predictions: 2 m/s (speed), 20° (direction)
    - Spatial resolution of 1 x 1 km
SAR L2 waves products

- Input products:
  - ASAR SLC and Wide Swath Single (WSS) look complex products

- General breakthrough
  - Use of the full range resolution of WSS products
  - Wave inversion in shallow water
  - First high resolution wave field product.

- Major achievements
  - Composite look formation for WSS products
  - Non wave signature removal
  - New removal method of the non-linear imaging mechanism
  - Spectral partitioning of the Wave spectrum

<table>
<thead>
<tr>
<th></th>
<th>Bias WM</th>
<th>Bias IM</th>
<th>Bias WSS</th>
<th>RMS WM</th>
<th>RMS IM</th>
<th>RMS WSS</th>
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<td>$H_s$ [m]</td>
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<td>0.09</td>
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<td>0.28</td>
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<td>0.76</td>
<td>1.1</td>
<td>0.87</td>
<td>0.94</td>
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<tr>
<td>$\phi$ [deg]</td>
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<td>10</td>
<td>-4</td>
<td>N/A</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>
recommendations of Phase 1

• SAR level-2 wind/waves products must be brought into end-users’ notice
  ⇒ NRT Demonstration at European scale of systematic production of wind/waves SAR products

• Definition of specific permanent validation “Super Sites”
  – Systematic acquisitions over
    • Gulf Stream and the region of Agulhas current
      – very strong mesoscale current variability signatures
    • The Norwegian Coastal Current and the west tip of Brittany.
      – Unique validation facilities (HF-radar, in situ wave sensors)
  – To improve knowledge on complex dynamic processes and surface interactions
  – To progress towards integrated wind/wave/currents retrieval approach

• Technical recommendations
  – For experimental Wave mode acquisitions campaigns in other modes
  – For the production SAR wind/waves products
Phase 2: New products demonstration
- Period: September 2007 to March 2009
- Objectives
  - To improve algorithms for wind & wave retrieval
  - To increase scientific understanding of the Doppler anomaly
  - To develop algorithms for combined wind & wave retrieval
  - To demonstrate the production of the Level-2/3 SAR wind & wave products.
  - To demonstrate an ocean swell tracking service.
  - To produce a clear set of recommendations for the Envisat and Sentinel-1 missions.
SOPRANO
Sar Ocean Products demonstration

• http://soprano.boost-technologies.com/
description of the processing chain

ESA Rolling Archive

Acquisition and processing chain of SAR L1 products

Indexation of SAR L1 products over
Europe
Super-sites

Processing of downloaded L1 products
Wind vector retrieval
Swell spectrum retrieval (SLC only)
Roughness map
Surface radial velocities retrieval (WSM only)

Software
IDL prototype
Linux environment

Hardware
Bi-Xeøn 5148 dual-core processor
4Gb DDR2 RAM
2 x 400Gb HD configured in RAID1

Posting on the web

Output products
L2 wind field
L2 swell field
Sea Surface Roughness
Surface radial velocities

SAR Products
ENVISAT ASAR WSM ERS-2 SLC
presentation of the Web interface

- **http://soprano.boost-technologies.com/**

- The 5 last SAR products overlapping the selected geographical area are

- Use the pages manager to view previous results

- When mouse is over a row, the coverage of the SAR scene is displayed
Select time window
Default is from 3 months ago from today

Dates can be changed using time window menu

Geographical area
Default area of interest is Europe.

Click "set" button in the area menu to define a new area of interest

While "set" button is red, a rectangular area of interest can be drawn the map.

click on the "submit" button on top right of Google Map to query the database

Use the "permalink" button, to save query as bookmark
SOPRANO
Sar Ocean Products demonstration

• http://soprano.boost-technologies.com/
access to SAR wind product information
SAR L2 wind products description

- Low level of expertise:
  - Geo-referenced map with land mass (if applicable)
    - PNG format (or Google Earth file)
  - Information
    - Date and time of acquisition
    - SAR mission and L1 product
    - 10-m height neutral wind speed
    - Wind direction (arrows)

- High level of expertise
  - NetCDF format (standard CF 1.0)
  - variables:
    - float longitude(az_size, ra_size) [degrees_east]
    - float latitude(az_size, ra_size) [degrees_north]
    - float wind_speed(az_size, ra_size) [m/s]
      - description: Wind speed
    - float wind_direction(az_size, ra_size) [Degree (meteorological convention)]
      - description: Wind direction
    - float sigma0(az_size, ra_size) [m^2/m^2]
      - description: Normalized Radar Cross Section
    - float incidence_angle(az_size, ra_size) [Degree]
      - description: Incidence angle
    - byte mask(az_size, ra_size) [0 for valid cells]
      - description: Mask of data

- High level of expertise (Cont’)
  - Common global attributes:
    - PROCESSING_LIMIT_SOUTH = 47.56732f
    - PROCESSING_LIMIT_WEST = -6.103677f
    - PROCESSING_LIMIT_NORTH = 48.73192f
    - PROCESSING_LIMIT_EAST = -4.450198f
    - SOURCE_FIRST_NEAR_LAT = 48.53462f
    - SOURCE_FIRST_NEAR_LONG = -4.450198f
    - SOURCE_FIRST_FAR_LAT = 48.73192f
    - SOURCE_FIRST_FAR_LONG = -5.789707f
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    - SOURCE_LAST_NEAR_LONG = -4.790926f
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    - SOURCE_LAST_FAR_LONG = -6.103677f
    - SOURCE_ACQUISITION_UTC_TIME = "20071111112211.367718"
    - SOURCE_PLATFORM = "ERS"
    - SOURCE_PRODUCT = "IMS_1P"
    - SOURCE_PRODUCT_REF = "SAR_IMS_1PXASI20071111.111212_000000 16A131_00180_65665_0059"
    - SOURCE_START_DATE = "20071111111212.375891"
    - SOURCE_ACO_DURATON = 16.5337264537811
    - SOURCE_ABS_ORBIT_NUMBER = 65665
    - TRACK_ANGLE = -167.298f
    - POLARIZATION = "VV"
    - SWATH_NAME = "IS2"
    - GROUND_RANGE_PIXEL_SIZE = 19.88792f
    - AZIMUTH_PIXEL_SIZE = 19.86677f
access to SAR swell product information
SAR L2 swell products description

- **Low level of expertise:**
  - Geo-referenced map with land mass (if applicable)
    - PNG format (or Google Earth file)
  - Information
    - Map of significant wave height
    - Dominant direction
    - Wavelength (size of arrow)

- **High level of expertise**
  - NetCDF format (standard CF 1.0)
  - Global attributes:
    - TITLE = "SAR waves field (WVF)"
    - WNF_PROCESSING_UTC_TIME = "20080117T132429.000065" 
    - WVF_PROCESSING_CENTER = "BOOST Technologies"
    - WVF_PROCESSING_SOFTWARE = "SAR2WVF V1.3"
    - WVF_CELL_SIZEX = "2023.65 m"
    - WVF_CELL_SIZEY = "5085.99 m"
    - WVF_SUBCELL_SIZEX = "1011.83 m"
    - WVF_SUBCELL_SIZEY = "2542.95 m"
    - WVF_CELL_SIZEPIXELX = "256"
    - WVF_CELL_SIZEPIECELY = "128"
    - WVF_SUBCELL_SIZEPIXELX = "128"
    - WVF_SUBCELL_SIZEPIXELY = "640"

- **High level of expertise (Cont’)**
  - Variables:
    - float longitude(az_size, ra_size) [Degree (decimal)]
    - float latitude(az_size, ra_size) [Degree (decimal)]
    - float k(nr_size) [rad/m]
    - float phi(na_size) [rad]
    - float area(nr_size) [m^-2]
    - float polSpec(na_size, ra_size, nr_size) [m^-2]
    - float Hs(az_size, ra_size, n_partitions) [m]
    - float Wl(az_size, ra_size, n_partitions) [m]
    - float Dirmet(az_size, ra_size, n_partitions) [degrees clockwise from north]
    - float snr(az_size, ra_size) [adimensional]
    - float nv(az_size, ra_size) [adimensional]
    - float wind_speed(az_size, ra_size) [m/s]
    - float wind_direction(az_size, ra_size) [degree clockwise from north]
    - float depth(az_size, ra_size) [m]
    - float land_coverage(az_size, ra_size) [%]
    - float incidence_angle(az_size, ra_size) [Degree]
    - float landflag(az_size, ra_size) [boolean]
    - float valid(az_size, ra_size) [boolean]
    - float land_coverage(az_size, ra_size) [boolean]
    - float landflag(az_size, ra_size) [boolean]
    - float incidence_angle(az_size, ra_size) [Degree]
access to sea surface roughness information
parallel on-going activities

• Scientific activities
  – Geophysical understanding of the Doppler anomaly
    • Doprim model + Global analysis using wave mode products
  – Wind retrieval
    • Statistical description of a priori wind vector distribution
      – Rice +direction distribution, etc
    • Study on polarization ratio using wave mode test campaigns

• Long term validation
  – http://validation.boost-technologies.com/ (restricted access)

• Demonstrators
  – Swell tracking using ENVISAT ASAR L2 wave mode
future developments

• Integrate other L2 products for demonstration purpose such as:
  – Ocean surface radial velocities field
  – Combined wind/wave product

• Maintain the demonstration platform over a 2-year period
  – To generate long time series of SAR L2 products (to experiment L3 products)
  – Upgrading L2 products when retrieval algorithm have been improved and duly validated
towards wind/waves L3 products

• The production of long time series of SAR L2 wind & waves products will open the way to the definition of L3 products
  – L3 wind products
    • (Seasonal) maps of wind speeds statistics (mean, weibull shape parameters, etc)
    • Risk maps of dangerous locations (based on percentile)
    • Roses of SAR wind vector distributions / identification of wind regimes

  – L3 Ocean Swell products
    • Probability of cross seas occurrence
    • PDF of joint significant swell height and dominant period further classified depending upon dominant direction
conclusions

• This SAR Ocean wind, waves & currents offers unique opportunity
  – To investigate and experiment advanced methods to generate (unique) L2 SAR ocean products
  – To improve knowledge on complex dynamic processes and surface interactions (Super-sites)
  – To consider as well practical implications of pre-operational production
  ⇒ For the whole benefit of Sentinel-1 missions (and others), GMES services, etc

• The NRT demonstration of SAR Ocean Products (SOPRANO) has two main objectives
  – Promoting the capabilities of such high resolutions products to end-users
  – Building a long-term database for the proposal and definition of L3 products
    http://soprano.boost-technologies.com/

• Comments, suggestions on the SOPRANO demonstration web site are more than welcome