Radar Altimeter Data Corrections and Editing in Coastal Regions

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with contributions from

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and others

Coastal Altimeter Workshop
Silver Spring, Maryland, 5–7 February 2008
Issues

- **Are corrections sufficient for coastal applications?**
  - Are corrections for open oceans only?
  - Can they be applied in coastal areas?
  - What corrections are particularly affected?
  - Are there alternatives?
  - Are alternatives available on the products?

- **Can we use standard edit criteria?**
  - Can we use edit criteria that are tailored to open oceans?
  - Do we need to restrict edit criteria?
  - Do we need to relax edit criteria?
  - Is all information available for editing the data?
Jason-1 and Envisat Editing
Jason-1 and Envisat Editing

-60...5 cm

-60...0 cm
Jason-1 and Envisat Editing

Dual-frequency iono correction

-40...4 cm

-40...4 cm
Jason-1 and Envisat Editing

Quality of dual-frequency measurement
Jason-1 and Envisat Editing

FES2004 ocean tide model

Remko Scharroo – Coastal Altimeter Workshop – Silver Spring, Maryland – 5-7 February 2008
Jason-1 and Envisat Editing

WebTide shelf model
Jason-1 and Envisat Editing
Jason-1 and Envisat Editing

Number of 20-Hz range measurements

17...20

16...20
Jason-1 and Envisat Editing

Std dev of range

0...40 cm

0...17 cm
Jason-1 and Envisat Editing

-0.5...8 m

0...8 m
Jason-1 and Envisat Editing

Backscatter coefficient

6...27 dB
<table>
<thead>
<tr>
<th></th>
<th>TOPEX</th>
<th>TOPEX(TDM)</th>
<th>Jason-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total SSH measurements</td>
<td>145948</td>
<td>42345</td>
<td>72270</td>
</tr>
<tr>
<td>Rejected SSH</td>
<td>29896(21%)</td>
<td>11137(26%)</td>
<td>20811(29%)</td>
</tr>
<tr>
<td>Orbital altitude, GCM02C(m)</td>
<td>161</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>TMR wet tropospheric corr (m)</td>
<td>8058(5.5%)</td>
<td>2823(6.7%)</td>
<td></td>
</tr>
<tr>
<td>JMR wet tropospheric corr (m)</td>
<td></td>
<td></td>
<td>118 (&lt;1%)</td>
</tr>
<tr>
<td>Dual-freq ionospheric correction</td>
<td>7950(5.5%)</td>
<td>2450(5.8%)</td>
<td>1000(1.4%)</td>
</tr>
<tr>
<td>Sea State Bias, Chambers,BM4</td>
<td>826(&lt;1%)</td>
<td>102(&lt;1%)</td>
<td>1619(2.2%)</td>
</tr>
<tr>
<td>Hs-Ku outside the range {0,8}[m]</td>
<td>7125(4.9%)</td>
<td>2161(5.1%)</td>
<td>374 (&lt;1%)</td>
</tr>
<tr>
<td>Sigma-0 Ku outside {6,27} [db]</td>
<td>3125(2.1%)</td>
<td>690 (1.6%)</td>
<td>151(&lt;1%)</td>
</tr>
<tr>
<td>Std of range(10HzKu) : {0,0.15}[m]</td>
<td>11504(7.9%)</td>
<td>3303(7.8%)</td>
<td></td>
</tr>
<tr>
<td>Std of range(20HzKu) : {0,0.15}[m]</td>
<td></td>
<td>1204(1.7%)</td>
<td></td>
</tr>
<tr>
<td># of 10Hz Ku range meas: {8.5, 10.5}</td>
<td>15898(11%)</td>
<td>4595(10.8%)</td>
<td></td>
</tr>
<tr>
<td># of 20Hz Ku range meas: {15.5, 20.5}</td>
<td></td>
<td></td>
<td>3664(5.1%)</td>
</tr>
<tr>
<td>Engineering flags</td>
<td>29339(20%)</td>
<td>10964(25.6%)</td>
<td>17647(24.4%)</td>
</tr>
<tr>
<td>Std of Hs(10Hz-Ku) outside {0,0.09}[m]</td>
<td>7642(5.2%)</td>
<td>1996(4.7%)</td>
<td></td>
</tr>
<tr>
<td>Std of Hs(20Hz-Ku) outside {0,0.09}[m]</td>
<td></td>
<td></td>
<td>1526(2.1%)</td>
</tr>
</tbody>
</table>
SSHA without tides (i.e. tide correction applied) map scaled to min=−0.2; max=0.2
NEW PROCESSING STRATEGIES FOR ALTIMETRY IN COASTAL AREAS

Laurent ROBLOU
In collaboration with:
Jérôme BOUFFARD, Stéfano VIGNUDELLI, Florent LYARD, Matthieu Le Hénaff, Julien LAMOUROUX
Satellite altimetry in the coastal domain

Is satellite altimetry possible in the coastal domain?

Problems

✓ Increased space/time sub-sampling:
  ➢ Shorter horizontal scales
  ➢ Amplified high frequencies
✓ Increased error budget
✓ Increased loss of data

Solutions

✓ New sensors
✓ Multi-mission approach
✓ Improve data post-processing
Data post-processing: example of the X-TRACK processor

The objective of the X-TRACK processor is to improve both the quantity and quality of altimeter sea surface measurements in coastal regions:

Features:

✓ redefining the data editing strategy to minimize the loss of data during the correction phase
✓ using improved local modelling of tidal and short-period atmospheric forcing
✓ Using an accurate mean sea level consistent with the coastal data set
X-TRACK historical playground: NW Mediterranean Sea
X-TRACK features: a new data editing strategy (1)

- The X-TRACK processor adopts a new data screening strategy and filtering techniques allowing to recover data that would otherwise be flagged as bad.

- De-flagging and re-interpolation of each single correction yields a reconstructed level profile.

Circles: uncorrected sea level anomalies (SLA) and original corrections from the AVISO Geophysical Data Records (GDR).

Brown line: SLA after application of the standard corrections from the GDR.

Purple line: the new SLA profile computed with X-TRACK processor.
X-TRACK features: a new data editing strategy (2)

number of T/P cycles exploitable

AVISO DT-(M) SLA product

X-TRACK SLA product

Cal/Val sites
X-TRACK features: a new data editing strategy (3)

- More altimeter data near to and far from the coast
- Coherent behaviour for ascending/descending passes
- Time series are longer (+10%) and less noisy (-7%)
X-TRACK features: regional de-aliasing corrections (1)

Issues:

✓ Aliasing of the tides and short-period ocean response to meteorological forcing is a major problem when estimating the seasonal or longer time scales oceanic circulations in altimeter data.

✓ Because of their insufficient spatial resolution that implies unresolved rapid changes in tidal features and an incorrect frictional dissipation, current global model cannot represent tides over continental shelves below a decimetre error level.

Solution: defining regional modelling of tides and ocean response to atmospheric forcing.

✓ T-UGO 2D model (Mog2D model follow-on) for both processes.
X-TRACK features: regional de-aliasing corrections (1)

LEGOS regional models

Caspian Sea

Amazonian shelf

New processing strategies for altimetry in coastal regions

Roblou et al. 06/02/2008
X-TRACK features: regional de-aliasing corrections (2)

Mog2D tidal regional models

M2 mean error: 1.3 cm rms (TG), 0.8 cm rms (ALT)
K1 mean error: 1.0 cm rms (TG), 0.9 cm rms (ALT)

Roblou (2003)

M2 mean error: 28.4 cm (TG), 5.3 cm (ALT)
K1 mean error: 1.7 cm (TG), 1.2 cm (ALT)
M4 mean error: 5.7 cm (TG), 1.2 cm (ALT)

Letellier (2004),
X-TRACK features: regional de-aliasing corrections (3)

Comparisons to tide gauges data:

- Gain vs IB: 46%
- Gain vs Mog2D-G correction: 5%

Similar results w.r.t altimetry (Bouffard)
X-TRACK features: an accurate mean sea level (1)

- Until accurate estimates of the geoid small- and meso-scales undulations become available, the dynamic topography of the ocean is not fully accessible in the altimeter measurements.
- Thus, the ocean mean sea surface provides an alternative reference surface, suitable for the observation of the ocean variability.
- Standard MSS products are not accurate in coastal regions

Solutions:
- ✓ Higher resolution MSS (including across-track effects) computed from an inverse method
- ✓ MSS consistent with the improved altimeter products
X-TRACK features: an accurate mean sea level (2)

MSS products comparisons

Sea level anomalies versus latitude

SLA=SSH-MSS CLS01
SLA=SSH-MSS X-TRACK
Difference

New processing strategies for altimetry in coastal regions

Roblou et al.
06/02/2008
X-TRACK work in progress: orbit error reduction

**Time evolution of the mean along-track SLA, GFO 074**

![Graph showing steps in processing strategies for altimetry](image)

- **Step 1:** Raw signal vs Low Frequency (LF) signal,
- **Step 2:** Localization and elimination of the outliers: 3σ filtering of the High frequency signal,
- **Step 3:** Re-building of the total corrected signal: linear regression.
X-TRACK work in progress: high rate data stream

Averaged along-track spatial spectrum, T/P track 146.

Small scale dynamics

Noise Level

Bouffard et al
Corrections

• **MWR correction**
  – MWR correction breaks down close to the coast
  – Jason-1 has particularly large footprint
  – Envisat MWR land flag leaves land affected data

• **Models**
  – Beware of land effects in dry tropo, wet tropo and MOG2D models

• **Recommendations**
  – Data bases should attempt to incorporate MWR extension near coast
  – Land effects in model atmospheric corrections should be avoided by using pressure and total water vapour to sea level
• **Flags**
  – Open ocean flags can generally be used
  – Use MWR land flag with caution; use it to transition to model

• **Edit criteria**
  – Open ocean edit criteria can generally be used in coastal regions
  – Keep zero and “negative” SWH (calm seas)

• **Multi-Hertz data**
  – Given the footprint size, sampling distance, measurement noise and typical length scales of ocean dynamics, multi-Hertz data are not very useful for coastal purposes

• **Recommendations**
  – Data bases should recommend editing criteria tailored to coastal regions