Updated Results from the In Situ Calibration Site in Bass Strait, Australia

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Methods Recap

- Primary site is located on Pass 088 in Bass Strait. Contributing bias estimates to the SWT/OSTST since the launch of T/P.
- Secondary site along track in Storm Bay
Methods Recap

- We adopt a purely geometric technique for determination of absolute bias.
- The method is centred around the use of GPS buoys to define the datum of high precision ocean moorings.
- Outside of available mooring data, all available mooring SSH data are used to correct tide gauge SSH to the comparison point.
Tide Gauge and CGPS

- Tide gauge part of the Australian baseline array, located in Burnie.
- Vertical velocity not significantly different from zero.
- CGPS time series shows a quasi-annual periodic signal (amplitude ≈3-4 mm). Current investigations point towards this being dominated by a (spurious) GPS draconitic annual period (~351 days).

Watson et al. (2011)
Instrumentation:

Ocean Moorings & GPS Buoys

- Mooring 2008-09 shifted onto absolute datum using 8 GPS buoy deployments, each ~8 hr duration.
- Mooring 2011 shifted onto absolute datum using 2 ~50 hr buoy deployments.
Instrumentation:

Ocean Moorings & GPS Buoys

Datum comparable with altimeter

Mooring 2008-09

Mean offset + dAmp + dPhase + dAP

Tide gauge Local chart datum

Mooring 2011

Tide gauge 1992 -
Instrumentation: Ocean Moorings & GPS Buoys

- Tidal difference between mooring and tide gauge is dominated by M2 (amp = 0.126 m, and N2 (amp = 0.030m).
- Non tidal differences are reduced by modelling the differential effect of the modelled air pressure between the mooring and tide gauge.
- The RMS of the final non tidal residual (mooring – tide gauge) is ~22 mm.
- The corrected tide gauge dataset enables us to compute cycle by cycle estimates of absolute bias.
• 1 Hz GPS Buoy SSH time series is filtered prior to comparison with the mooring SSH (5 minute estimates).
• The residual time series (Buoy SSH – Mooring SSH) shows a typical RMS of ~18-20 mm.
• Conservative estimates of independence every 3 hours, yields a standard error about the mean of ~ 3 mm.
Example 1 Hz GPS Buoy Data

- Our current evolution in GPS buoy enables extended deployment for up to 3 days.

- Deployed in pairs, tethered individually via horizontal floating tethers attached to surface floats, which are then anchored to the sea floor.

- Deployment typically limited to relatively calm conditions (good results in up to ~3.5 m peak to trough waves at Storm Bay).

- Swell signals are readily extracted from 1 Hz data at both sites.
1. TOPEX Side A and B, Jason-1 and OSTM/Jason-2
   - All available cycles (OSTM/Jason-2 up to cycle 112)
   - **TOPEX**: GSFC orbits, corrected TMR, Chambers et al SSB.
   - **Jason-1**: GSFC orbits, enhanced JMR.
   - **OSTM/Jason-2**: GSFC orbits, enhanced AMR.
Bass Strait Absolute Bias Record

<table>
<thead>
<tr>
<th>ALTIMETER</th>
<th>MEAN (mm)</th>
<th>$\sigma$</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOPEX Side A</td>
<td>-8.1 ± 1.9</td>
<td>26.8</td>
<td>195</td>
</tr>
<tr>
<td>TOPEX Side B</td>
<td>+1.8 ± 2.9</td>
<td>30.7</td>
<td>114</td>
</tr>
<tr>
<td>Jason-1 GDR-C</td>
<td>+105.1 ± 2.4</td>
<td>37.0</td>
<td>234</td>
</tr>
<tr>
<td>OSTM/Jason-2 T/GDR</td>
<td>+169.7 ± 3.6</td>
<td>36.1</td>
<td>98</td>
</tr>
</tbody>
</table>
Absolute Bias Periodic Energy

Lomb Normalised Periodogram: TOPEX Side A and B Absolute Bias

~62 days
~434 days

Lomb Normalised Periodogram: Jason-1 Absolute Bias

~62 days
~116 days
~365 days

Lomb Normalised Periodogram: OSTM/Jason-2 Absolute Bias

~33.5 days
~116 days

Days
Both the ~62 d and ~434 d period signals are in phase between TOPEX A/B.

Linear rate:
- TOPEX Side A: +1.8 ± 1.0 mm/yr (10%)
- TOPEX Side B: +1.2 ± 2.6 mm/yr (27%)
- Jason-1: +2.6 ± 1.0 mm/yr (29%)
- OSTM/Jason-2: -11 ± 4 mm/yr (20%)

Variance exp:
- TOPEX Side A: 10%
- TOPEX Side B: 27%
- Jason-1: 29%
- OSTM/Jason-2: 20%

Residual RMS:
- TOPEX Side A: 25 mm
- TOPEX Side B: 26 mm
- Jason-1: 31 mm
- OSTM/Jason-2: 32 mm

Periodic terms:
- TOPEX Side A: 62d + 434d
- TOPEX Side B: 62d + 434d
- Jason-1: 62d + 116d + 365d
- OSTM/Jason-2: 34d + 116d
Results:

OSTM/Jason-2 Absolute Bias

2. OSTM/Jason-2

- Closer look at bias record cycles 001-112.
- Influence of T/GDR AMR vs enhanced AMR
- Influence of GSFC orbit vs GDR orbit
Results:

OSTM/Jason-2 Absolute Bias: Bass Strait

- Using the enhanced AMR product increases the bias by 3.1 mm (standard deviation of the difference time series is 4.1 mm).
Results:

OSTM/Jason-2 Absolute Bias: Bass Strait

- Using the T/GDR orbit over the GSFC orbit increases the bias by 2.1 mm (standard deviation of the difference 15.2 mm).
Results:

OSTM/Jason-2 Absolute Bias: Storm Bay

- Preliminary bias estimates from Storm Bay, using the only available mooring data, show a comparable bias to Bass Strait (c.f 169.7 mm)
- Detailed comparison requires additional mooring data, ongoing analysis and refinement of datum.
## Conclusions

<table>
<thead>
<tr>
<th>Data</th>
<th>Cycles</th>
<th>N</th>
<th>Mean Bias ± Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOPEX Side A</strong> (GSFC Orbits, corrected TMR, Chambers SSB)</td>
<td>001-235</td>
<td>195</td>
<td>- 8.1 ± 1.9 mm</td>
</tr>
<tr>
<td><strong>TOPEX Side B</strong> (GSFC Orbits, corrected TMR, Chambers SSB)</td>
<td>236-365</td>
<td>114</td>
<td>+ 1.8 ± 2.9 mm</td>
</tr>
<tr>
<td><strong>Jason-1 GDR-C</strong> (GSFC Orbits, enhanced JMR)</td>
<td>001-259</td>
<td>234</td>
<td>+105.1 ± 2.4 mm</td>
</tr>
<tr>
<td><strong>OSTM/Jason-2 T/GDR</strong> (GSFC Orbits, enhanced AMR)</td>
<td>001-112</td>
<td>98</td>
<td>+169.7 ± 3.6 mm</td>
</tr>
</tbody>
</table>

- Decrease by ~10 mm if using GDR JMR
- Increase by 2.1 mm if using GDR orbits

- Recall that non-time averaging systematic error contributions likely dictate that the “absolute” error is ~15 mm for these estimates.
Questions?

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Spares...
We derive a precise SSH time series, directly at the altimeter comparison point using two deployments of moored oceanographic instruments (high accuracy pressure gauges, Seabird TS meters and current meters).

Mooring deployments 2008-09 (1 year), 2011 (6 mths).

Unfortunately, 6 months of mooring data following the previous OSTST was lost due to technical issues with SBE26 pressure gauges.

The datum of each mooring-derived SSH series is determined using episodic GPS buoy deployments. (Datum shift = GPS SSH – Mooring SSH)

Outside the mooring deployment window, the tide gauge data can be tidally corrected to best fit the ensemble mooring series.
GPS Buoy vs Mooring SSH: Storm Bay

- Slight improvement in the precision at Storm Bay due to improved GPS network geometry.
- Note increased water depth at this site (~101 m vs ~53 m at Bass Strait).