In-Situ Calibration
Results from Bass Strait

Christopher Watson
Neil White
Reed Burgette
Richard Coleman
Paul Tregoning
John Church
Jason Zhang

1 University of Tasmania
2 CAWCR and CSIRO CMAR
3 Antarctic Climate and Ecosystems CRC
4 The Australian National University
Bass Strait is an absolute calibration site that adopts a purely geometric technique. The method is centred around the use of GPS buoys to define the datum of high precision ocean moorings.

Mooring SSH also used to correct tide gauge SSH to the comparison point.

Altimeter vs mooring SSH and tide gauge SSH to determine absolute bias.
1. The comparison point has been moved further offshore to avoid land contamination of the radiometer.
2. Different buoy design, longer deployment duration.
3. New tide gauge and collocated CGPS.
4. New inland CGPS site on bedrock (~5km from the gauge).
5. New episodic GPS at Stanley to minimise baseline length to GPS buoys.
6. Three new ocean moorings (two consecutive six month deployments and one twelve month deployment spanning the previous two).
7. FTLRS campaign (assess benefit of additional southern hemisphere SLR).
Bass Strait Calibration Site

- Comparison Point A: Moorings & GPS buoys
- Comparison Point B: Moorings & GPS buoys
- Stanley GPS (STLY)
- Rocky Cape GPS (RKCP)
- Table Cape GPS (TBCP)
- Burnie GPS (BUR2, RHPT)
  - Tide gauge, FTLRS

Key:
- TIP - Jason 1 - Jason 2
- Descending Pass 088

Map showing positions along Bass Strait with GPS locations and distances.
Instrumentation:

**Tide Gauge**

- Tide gauge is part of the Australian baseline array, provision for a radar gauge to be installed later in 2009. Run by the Australian National Tidal Centre (NTC).

- Collocated CGPS at TG.

- Bedrock CGPS ~5km away at Round Hill (RHPT).

- Data from both GPS sites archived at Geoscience Australia.
Ocean Moorings

- Two ocean moorings deployed January 2008 in ~50 m water depth (Mooring 1 and 2). On retrieval of Mooring 1, Mooring 3 was deployed. Final retrieval February 2009.

- Instrumentation includes high accuracy pressure gauges, Seabird TS meters and current meters.

- Local atmospheric pressure determined using high resolution Australian LAPS model.

- Final mooring SSH time series determined using all three mooring datasets.

- The datum of the mooring-derived SSH is determined using episodic GPS buoy deployments.
Instrumentation:

GPS Buoys

• Moved on to Mk III wave rider buoy design. New design lifts antenna above water level whilst minimising tilt. Design prevents loss of lock caused by breaking waves as experienced with the Mk II design.

• Two buoys deployed at comparison point, tethered horizontally to anchored boat.

• Episodically deployments, 8 in total, each for 8-10 hours duration. Data at 1 Hz with final deployment 2 Hz.

• Buoys used to solve for mooring datum, NOT purely for alt bias or geoid determination.
Instrumentation: FTLRS

- Part of our NCRIS/AUSCOPE project has been to trial the FTLRS in Burnie during 2007/08.

- French and Australian Campaign ran from 01-Dec-2007 to 17-Apr-2008, observing a total of 660 over flights from 10 different satellites.

- Site was located in the city of Burnie, ~10km from the tide gauge site. FTLRS co-located with temporary GPS.

- Has been an important project to further build Australian SLR capability.

- Results to date show limited improvement to GDR orbits with the inclusion of FTLRS data – perhaps due to the proximity of the Mt Stromlo tracker?
1. Summary statistics: GPS buoy SSH / Mooring SSH / Tide gauge SSH

2. Verification Phase: Jason-1 GDR-C (239-259), Jason-2 GDR-C (000-020)
   Absolute biases, relative bias, differences in corrections

3. Jason-1 GDR-C (001-259)
   Absolute bias, impact of compensating for SSB

4. Jason-1 GDR-C with/without JMR update (228-259)

5. OSTM/Jason-2 IGDR-C (000-034)

6. OSTM/Jason-2 GDR-C with/without AMR update (000-026)
Results:

**GPS Buoy / Mooring / Tide Gauge**

- Our reference frame is defined by daily global analyses of 2x40 station networks of CGPS stations in GAMIT software, with ITRF2005 realised using GLOBK and a well defined set of stabilisation sites. We consider this analysis state-of-the-art within GAMIT (VMF1, ECMWF ZHD, non tidal ATML).


- Eight GPS buoy deployments completed to define the datum of the mooring (~8-10 hours each – 2 buoys deployed each time). Kinematic processing of 1 Hz buoy data in Track and Grafnav. Subsequently smoothed for comparison against mooring.
Results:

GPS Buoy / Mooring / Tide Gauge

• **Between buoy comparison (B1 and B2 from 8 deployments):**
  - Typical separation between buoys ~10-20 m.
  - Mean (B2 SSH – B1 SSH) ~ 5 mm, std dev ~ 5 mm.

• **Defining the datum of the mooring:**
  - The mean of (buoySSH – mooringSSH) defines mooring datum
  - Final std dev of (buoySSH – mooringSSH) = 21 mm. N = 840.
  - Assuming independent estimates each hour, N = 70, std err of mean = 2.5 mm.

• **Transforming the Tide Gauge onto the mooring datum:**
  - Std dev of difference (mooringSSH – tgSSH) = 102 mm.
  - Difference dominated by tidal diffs at M2 (amp=126 mm) and N2 (amp=29 mm).
  - Non-tidal residual has std dev = 37mm.
  - Tide gauge can be transformed onto the mooring datum by adding a tidal prediction of the difference (mooringSSH – tgSSH).
Results: VERIFICATION PHASE

J-1 GDR-C vs OSTM/J-2 GDR-C

Jason-1 and OSTM/Jason-2 Absolute Bias

Jason-1 GDR-C: Mean Bias: 107.4mm Median Bias: 103.1mm
N: 20, Std Dev: 22.5mm Std Error: 5.0mm
(SWH: 0.82 σ: 0.57m)
(SSB: -44.2 σ: 26.2mm)

Jason-2 GDR-C: Mean Bias: 159.5mm Median Bias: 164.2mm
N: 15, Std Dev: 33.0mm Std Error: 8.5mm
(SWH: 0.98 σ: 0.61m)
(SSB: -53.8 σ: 29.1mm)

dd/mm/yy and Cycle
Results: VERIFICATION PHASE

J-1 GDR-C vs OSTM/J-2 GDR-C

Relative Bias: Jason-2 GDR-C - Jason-1 GDR-C

- Δ Iono: N=14 Mean: +10.0mm σ: 5.6mm (less delay for J-2)
- Δ Dry: N=14 Mean: -0.0mm σ: 0.1mm
- Δ AMR-JMR: N=14 Mean: -3.0mm σ: 4.0mm (more delay for J-2)
- Δ SSB: N=14 Mean: -3.5mm σ: 7.9mm
- Δ CTGrad: N=14 Mean: -3.1mm σ: 3.1mm
- Δ Orb-Rng: N=14 Mean: +52.5mm σ: 24.5mm (shorter range for J-2)
- Δ SSH: N=14 Mean: +45.5mm σ: 32.0mm (higher SSH for J-2)

Date Range: 05/07/08 to 19/01/09
Results: ENTIRE JASON-1 MISSION

J-1 GDR-C cycles 001-259

Absolute Bias Jason-1 GDR-C 001-259

Jason-1 GDR-C Absolute Bias (001-259):
Mean: 98.9mm Median: 97.2mm
N: 212, Std Dev: 40.5mm Std Error: 2.8mm

(SWH: 1.00 σ: 0.58m)
(SSB: -53.5 σ: 27.1mm)

dd/mm/yy and Cycle

18/01/02 12/11/02 05/09/03 29/06/04 22/04/05 13/02/06 08/12/06 01/10/07 25/07/08

SWH

SSB
Results: ENTIRE JASON-1 MISSION

J-1 GDR-C cycles 001-259 – Bias vs SWH

Absolute Bias (including SSB correction) vs SWH

Mean Bias = 98.9 mm
Bias(mm) = -10.802 SWH + 109.7
Std dev of residuals: 40.0 mm
Results: ENTIRE JASON-1 MISSION

J-1 GDR-C cycles 001-259 – Bias vs SWH

Absolute Bias (NOT including SSB correction) vs SWH

Mean Bias = 45.4 mm
Bias(mm) = -56.472 SWH + 101.8
Std dev of residuals: 41.0 mm
Results: JASON-1 MISSION

J-1 GDR-C with/without updated JMR

Jason-1 (std JMR) and Jason-1 (updated JMR) Absolute Bias

Jason-1 GDR-C (std JMR): Mean Bias: 104.6mm Median Bias: 102.8mm
N: 30, Std Dev: 26.4mm Std Error: 4.8mm

Jason-1 GDR-C (updated JMR): Mean Bias: 102.8mm Median Bias: 101.7mm
N: 30, Std Dev: 26.5mm Std Error: 4.8mm
Results: JASON-1 MISSION

J-1 GDR-C with/without updated JMR

Relative Bias: Jason-1 GDR-C (updated JMR) - Jason-1 GDR-C (std JMR)

Mean: -1.7mm  Median: -1.5mm
N: 30, Std Dev: 1.7mm  Std Error: 0.3mm
Relative Bias: Jason-2 GDR-C (updated AMR) - Jason-2 GDR-C (std AMR)

J-2 GDR-C with/without updated AMR

Results: OSTM/JASON-2 MISSION
Results: OSTM/JASON-2 MISSION

J-2 IGDR-C vs GDR-C

OSTM/Jason-2 GDR-C vs IGDR-C Absolute Bias

- **Jason-2 GDR-C:** Mean Bias: 158.0mm, Median Bias: 160.0mm
  - N: 16, Std Dev: 32.4mm, Std Error: 8.1mm
  - (SWH: 0.90 σ: 0.59m), (SSB: -49.7 σ: 28.7mm)

- **Jason-2 IGDR-C:** Mean Bias: 170.8mm, Median Bias: 164.7mm
  - N: 21, Std Dev: 34.5mm, Std Error: 7.5mm
  - (SWH: 0.81 σ: 0.58m), (SSB: -45.4 σ: 27.9mm)

(Extent of Mooring Data)

dd/mm/yy and Cycle

- 05/07/0825/07/0814/08/0803/09/0822/09/0812/10/0801/11/0821/11/0811/12/0831/12/0819/01/0908/02/0928/02/0920/03/09
Results: OSTM/JASON-2 MISSION

J-2 IGDR-C vs GDR-C – relative bias

Relative Bias: Jason-2 IGDR-C - Jason-2 GDR-C

Mean: 8.4mm  Median: 2.6mm  
N: 21, Std Dev: 33.8mm  Std Error: 7.4mm

dd/mm/yy and Cycle
Results: OSTM/JASON-2 MISSION

J-2 IGDR-C vs GDR-C – relative bias

Relative Bias: Jason-2 IGDR-C - Jason-2 GDR-C

- Δ Iono: N=21 Mean: -0.1mm σ: 1.2mm
- Δ Dry: N=21 Mean: +0.0mm σ: 0.1mm
- Δ Wet: N=21 Mean: -5.1mm σ: 3.1mm (more delay for J-2 IGDR)
- Δ SSB: N=21 Mean: +0.5mm σ: 1.7mm
- Δ CTGrad: N=21 Mean: +0.0mm σ: 0.2mm
- Δ Orb-Rng: N=21 Mean: +3.4mm σ: 25.0mm (shorter range for J-2 IGDR)
- Δ SSH: N=21 Mean: +8.4mm σ: 33.8mm (higher SSH for J-2 IGDR)

dd/mm/yy and Cycle
Conclusions

Future Tasks:

1. Investigate other ways to improvement our ability to transform the tide gauge SSH to the comparison point (i.e meteorological forcing etc).

2. Further investigate altimeter bias with and without Burnie FTLRS data used to determine orbits. Do we see geographically correlated effects?

3. SSB effects – results from Storm Bay.

<table>
<thead>
<tr>
<th>Data</th>
<th>Cycles</th>
<th>N</th>
<th>Mean Bias</th>
<th>Std Error</th>
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<tbody>
<tr>
<td>Jason-1 GDR-C</td>
<td>001-259</td>
<td>212</td>
<td>+98.9</td>
<td>2.8 mm</td>
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<td>Jason-1 GDR-C</td>
<td>239-259</td>
<td>20</td>
<td>+107.4</td>
<td>5.0 mm</td>
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<td>Jason-2 GDR-C</td>
<td>000-020</td>
<td>15</td>
<td>+159.5</td>
<td>8.5 mm</td>
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<tr>
<td>J-2 GDR-C – J-1 GDR-C</td>
<td>as above</td>
<td>14</td>
<td>+45.5</td>
<td>8.5 mm</td>
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<tr>
<td>Jason-1 GDR-C (std JMR)</td>
<td>228-259</td>
<td>30</td>
<td>+104.6</td>
<td>4.8 mm</td>
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<tr>
<td>Jason-1 GDR-C (updated JMR)</td>
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<td>+102.8</td>
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<td>Jason-2 GDR-C (std AMR)</td>
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<td>+164.5</td>
<td>9.1 mm</td>
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</tbody>
</table>
Future Plans
Storm Bay

OSTM/Jason-2 pass 088 over SE Australia
Future Plans

Storm Bay

Storm Bay site (April 2009 to March 2010)

- Hobart
- Moorings

Blue line: Jason-2 pass 088 nominal ground track

Contours: bathymetry (metres)
Questions?

Christopher Watson¹
Neil White²,³
Reed Burgette¹
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Paul Tregoning⁴
John Church²,³
Jason Zhang⁴

¹ University of Tasmania
² CAWCR and CSIRO CMAR
³ Antarctic Climate and Ecosystems CRC
⁴ The Australian National University

Jason-1 and OSTM/Jason-2
OST Science Team
Updated Results
Seattle OSTST Meeting
June 2009