DORIS DIODE on-board Jason-3 and Sentinel-3: real-time pole coordinates and USO frequencies

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DORIS Auxiliary Data

• New TM format containing on board estimates
  – Pole coordinates and drifts
  – Beacons and satellites USO frequencies and drifts

• Will be available for Jason3 and Sentinel3
  – Available in Near Real Time (typically 3h)

• Goals
  – Deliver real-time pole estimates with a good accuracy
  – Deliver a real-time monitoring of the beacons network frequencies

• Ground activation for Cryosat2, HY2, Jason2, Saral
Pole coordinates and drifts

• DIODE estimation strategy
  
  Satellite positions-velocities
  On-board and on-ground frequency biases
  Hill along-track, Cross-track Drag
  Upole Vpole ...

• Variation model for period < 1 day
  – Described in IERS conventions

• Outputs
  – Smoothed mean pole coordinates
  – Mean pole drift
Simulation

• Measurement simulation:
  – Dynamical orbit
  – Variable pole: IERS Bulletin B + sub-diurnal variation model

  Amplitude variation of the model for a day: ~ 1mas

  Pole U (arcsec)  Pole V (arcsec)

  – Modelled measurements

• DIODE restitution (orbit and pole)
Simulation results

• Physical pole coord. comparison: (after convergence)

<table>
<thead>
<tr>
<th></th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
<th>MEAN</th>
<th>ST DEV</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLE_U</td>
<td>-2.340E-04</td>
<td>2.220E-04</td>
<td>-0.103E-03</td>
<td>8.678E-05</td>
<td>0.135E-03</td>
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<tr>
<td>POLE_V</td>
<td>-1.190E-04</td>
<td>1.730E-04</td>
<td>0.028E-03</td>
<td>8.116E-05</td>
<td>0.086E-03</td>
</tr>
</tbody>
</table>

• IERS Bulletin A prediction error: < 0.1 mas
Pole: inter-satellite comparison

• In theory, same pole for all the satellites

• Ground activation with the last DIODE version
  – On a calm period without maneuver or event

Cryosat2  HY2  Jason2  Saral
Pole: inter-satellite comparison

- Mean pole comparison: DIODE – IERS bulletin B

### Cryosat2
- \text{POLE\_U} = 1.499E-03
- \text{POLE\_V} = 1.597E-03

### HY2
- \text{POLE\_U} = 1.427E-03
- \text{POLE\_V} = 1.491E-03

### Jason2
- \text{POLE\_U} = 1.223E-03
- \text{POLE\_V} = 1.099E-03

### Saral
- \text{POLE\_U} = 1.242E-03
- \text{POLE\_V} = 1.384E-03

**RMS (arcsec) on the converged period**
The four poles estimates are mixed: composite value

<table>
<thead>
<tr>
<th>Pole</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>ST Dev</th>
<th>RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLE_U</td>
<td>-1.874E-03</td>
<td>1.472E-03</td>
<td>-0.151E-03</td>
<td>6.023E-04</td>
<td>0.621E-03</td>
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<tr>
<td>POLE_V</td>
<td>-1.635E-03</td>
<td>1.651E-03</td>
<td>-0.121E-03</td>
<td>4.621E-04</td>
<td>0.477E-03</td>
</tr>
</tbody>
</table>
Frequencies and drifts

• DIODE estimation strategy

- Satellite positions-velocities
- On-board and on-ground frequency biases
- Hill along-track, Cross-track
- Drag
- Upole Vpole

• Outputs
  - Smoothed on-board and on-ground frequency estimations
  - On-board and on-ground frequency drifts
Frequencies and drifts

- On-board and on-ground allocations are differentiated thanks to the Time and Frequency Beacons:
  - TF-B are tied to atomic clocks => long-term stability
  - Their USO is in a highly controlled environment => mean-term stability
  - During passes over TF-B, Doppler biases are allocated to on-board USO

- Beacon frequency determination is a part of the DREAM (DORIS REal-time Autonomous Monitoring) function
  - Network survey from space
  - Warnings sent to the integrity team
Smoothed on-board frequency

- Comparison to T2L2 on Jason2

Results presented in next JASR issue

- On-board Sentinel 3: GNSS receiver for direct comparison

Compliance: $1.2 \times 10^{-12}$
Frequencies: inter-satellite comparison

- On-board frequency depend on the satellite
- But same beacon frequencies for all satellites

Good consistency at first sight (One estimate per pass)
Frequencies: inter-satellite comparison

- DIODE frequency drift used for extrap. between two passes

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**Frequency comparison: DIODE - MOE**

- **◆ Cryosat2**
  - Mean: \(-0.149E-12\)
  - RMS: \(1.635E-12\)

- **▲ HY2**
  - Mean: \(-1.477E-12\)
  - RMS: \(2.264E-12\)

- **■ Jason2**
  - Mean: \(0.813E-12\)
  - RMS: \(1.898E-12\)

- **✖ Saral**
  - Mean: \(-0.754E-12\)
  - RMS: \(1.610E-12\)

**Statistics \(\frac{\delta f}{f}\) on the converged period**

- Futur REGINA GNSS receivers for direct comparison

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New frontiers of Altimetry – Lake Constance, Germany - October 2014
Conclusions

• Poles coordinates: results are promising
  – RMS of mixed solution: ~0.5 mas
  – Need parameters optimization (Kalman filtering)
  – Information can be reduced to one point every 3h/6h

• Smoothed frequencies
  – RMS on-board as on-ground: < 2.0 \times 10^{-12}
  – Further investigation for short/mid-term frequency estimation
  – Useful for integrity survey