DORIS System Time Bias: Envisat-1 and Jason-2

Ramesh GOVIND
Frank Lemoine
Doug Chinn
Nikita Zelensky

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Overview

• Rationale
  – DORIS and SLR orbit results
    • Envisat
    • Jason-2
• DORIS Time Bias estimates
• Effect of Time Bias on DORIS Orbits
• Discussion
Rationale

• For altimetry applications the measure of orbit accuracy is expressed as the RMS of the radial component

• However, for geodetic applications – reference frame, estimates of geocentre location etc. -- the accuracy of other components is of importance

• Multiple data types DORIS, GPS and SLR provide opportunity for verification, validation and calibration of orbit quality
Rationale

• DORIS and SLR determined orbits show differences in orbit trajectories in the along track component for identical force modelling

• Basic premise is that if all is equal the results of the two observable types should produce similar results for all parameters
DORIS and SLR data processed

Envisat July 2002 – July 2010

Jason-2 July 2008 – July 2010

• 7-day arcs

• Identical force modelling
Envisat

WRMS DORIS Data (mm/sec)

WRMS SLR Data (cm)
Envisat
Jason-2

WRMS DORIS Data (mm/sec)

WRMS SLR Data (cm)
Jason-2

SLR-DORIS Mean Radial Differences (cm)

SLR-DORIS Mean Along Track Differences (cm)

SLR-DORIS Mean Cross Track Differences (cm)
Measurement Errors

- Differences in DORIS – SLR orbit trajectories imply measurement errors due to:
  - DORIS – SLR network inconsistencies – mapping into the respective orbits
  - CoM offset (and attitude model) inconsistencies between DORIS antenna and SLR RRA
  - DORIS antenna “phase centre variation”
  - SLR RRA “depth” in error
  - Refraction corrections
Measurement Errors

- DORIS receiver clock error

  - Oscillator – Doppler Measurement Biases – estimated pass by pass

  - Time Keeper – Observation Time Tags – Time Bias

*Since the largest differences are in the along track component – effect of time bias is examined initially – satellite cannot be in two places at the same time*
Envisat -- DORIS Time Bias
Envisat Orbits – DORIS Time Bias applied
Envisat Orbits – DORIS Time Bias applied

- SLR-DORIS RMS Radial Differences (cm)
- SLR-DORIS RMS Along Track RMS Differences (cm)
- SLR-DORIS RMS Cross Track Differences (cm)
- SLR-DORIS TB Applied DIFF-RMS Along Track (cm)
Envisat Arc Differences

SLR-DORIS Radial Differences (m)

SLR-DORIS Cross Track Differences (m)

SLR-DORIS Along Track Differences (m)

Arc080916 TB=1.08μs delta = 8 mm

Arc080923 TB=-0.43μs delta = -3 mm
Jason-2 – DORIS Time Bias

DORIS Time Bias Microsecs

MJD
Jason-2 Orbits – DORIS Time Bias applied

WRMS SLR Data (cm)
Envisat Orbits – DORIS Time Bias applied

SLR-DORIS RMS Radial Differences (cm)

SLR-DORIS RMS Along Track Differences (cm)

SLR-DORIS RMS Cross Track Differences (cm)

SLR-DORIS TB Applied DIFF-RMS Along Track (cm)
Jason-2 Arc Differences

SLR-DORIS Along Track Differences (m)

Arc100516 TB=1.42\,\mu s delta \sim 15\,\text{mm}

Arc100530 TB=-1.63\,\mu s delta \sim -5\text{ to } -15\,\text{mm}

SLR-DORIS Cross Track Differences (m)

Arc100516 TB=1.42\,\mu s delta = -33\text{ to } 34\,\text{mm}

Arc100530 TB=-1.63\,\mu s delta \sim -42\text{ to } 44\,\text{mm}
Discussion

• The estimated time biases per 7-day arc are small at the microsecond level results in along track orbit trajectory differences at the sub-centimetre level – significantly smaller than the actual orbit differences.

• Does this imply that the effect of DORIS time biases are inconsequential to the orbit quality?
Discussion

• The **no** case:
  – 7-day estimates of time biases is too sparse and is non-representative – it represents a long term mean
  – Require a higher resolution of time bias estimates
    • Once per revolution – which will also provide the geographical correlation in terms of the behaviour of the clocks in space – the effects of general relativity
      – Gravitational potential
      – Satellite velocity
      – Can be achieved by “overlaying” exact repeat tracks spatially
  – Requires sufficient SLR data per arc to estimate time bias (importance of SLR tracking)
Discussion

• The yes case:

  • DORIS – SLR Network inconsistencies need to be addressed
  • CoM offsets for the DORIS antenna and SLR RRA need to be examined
  • DORIS antenna phase centre modelling
  • SLR RRA “depth” value checked