The Effects of Carrier Phase Ambiguity Resolution on Jason-1

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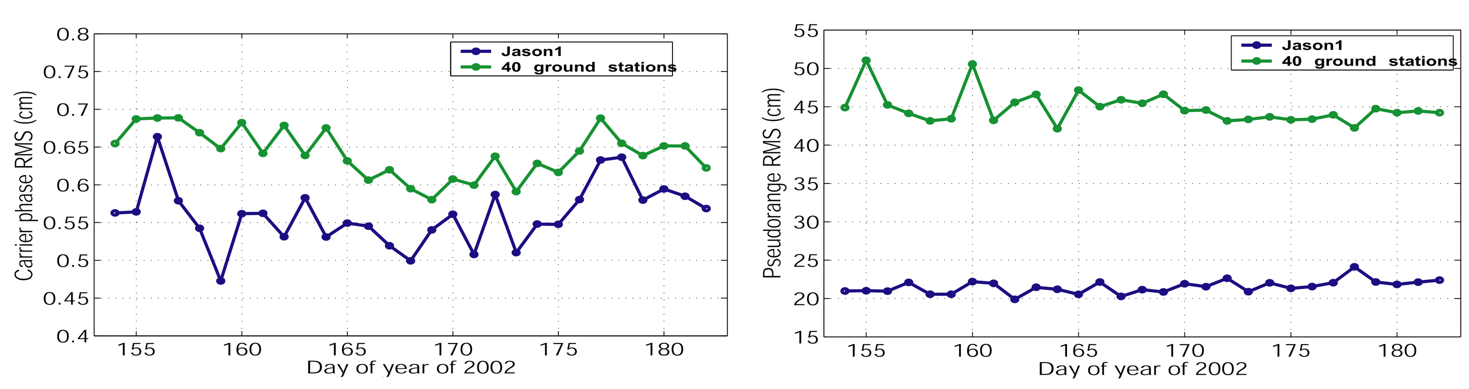
Abstract

The concept of GPS carrier phase ambiguity resolution has been applied to Jason-1 in an effort to achieve highly accurate orbit solutions. The wide-lane and narrow-lane approach is adopted and all double-differenced phase ambiguities that satisfy the user-defined criteria are resolved in a single iteration. When integer ambiguities are correctly resolved, the orbit accuracy for Jason-1 shows significant improvement. The results presented here demonstrate the influence of ambiguity resolution on the Jason-1 orbit overlap statistics and the geocenter shift in the Terrestrial Reference Frame. The quality of the orbit solutions are verified using SLR derived orbits and the sea surface height crossover residuals.

Orbit Estimation

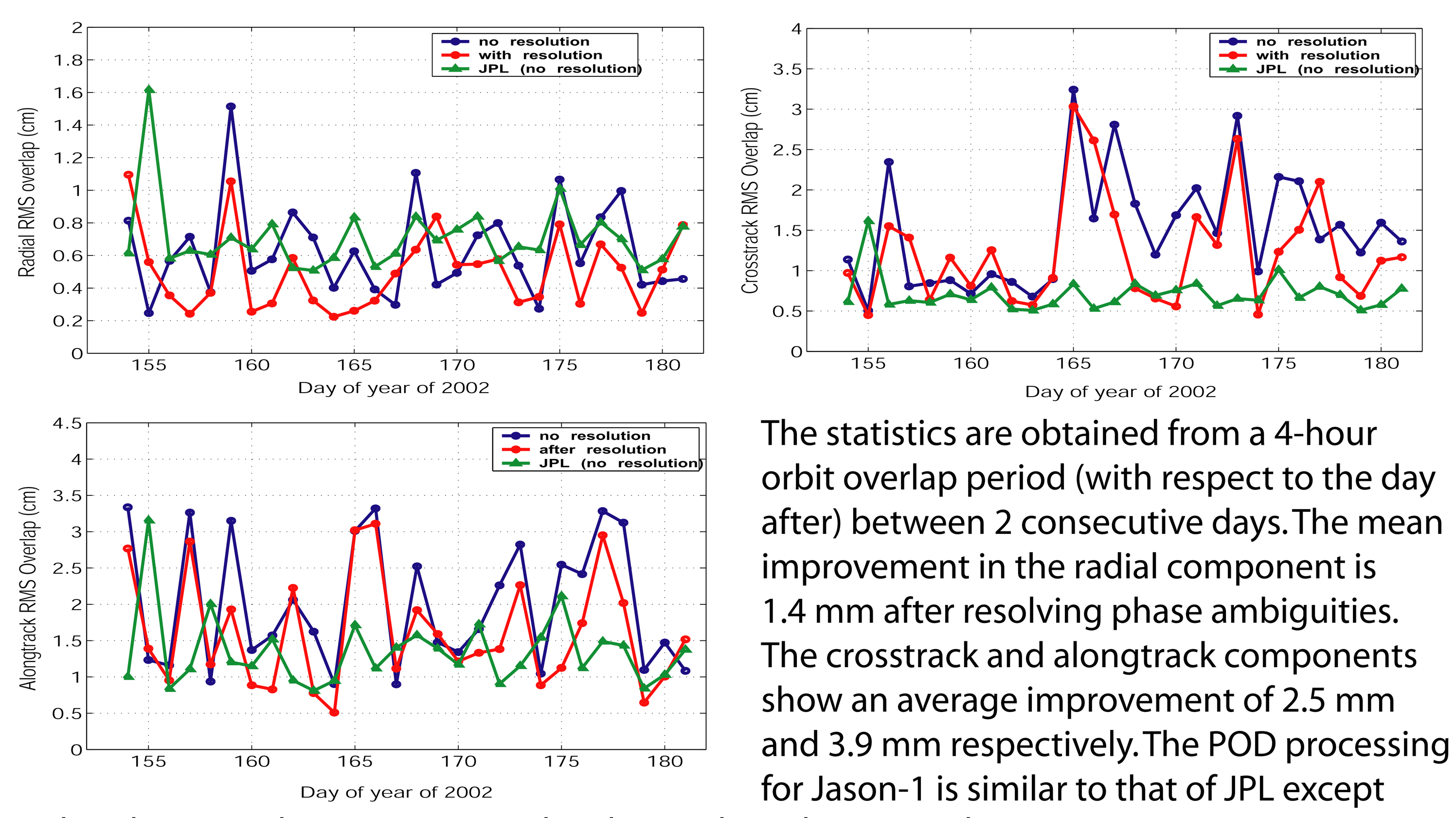
- Used a network of 40 globally distributed ground stations. Only the Y-codeless ground receivers are considered in the processing. The satellite-based pseudorange bias corrections are applied to ensure the network of mixed receiver types can be used together consistently.
- 29 days (June 3, 2002 - July 1, 2002) of Jason-1 and ground data have been processed. Daily orbit arc length spans 30 hours and data are decimated to 5-min intervals for processing. The pseudorange is carrier-smoothed.
- GPS and Jason-1 orbits estimated simultaneously. Antenna calibration maps for Jason-1 are used. Note that the maps used in generating these results were produced in March 2003. JPL currently has a newer version of the phase and code maps.
- GPS orbits are produced using JPL's 'Quick-Look' POD method. Jason-1 orbits are obtained using the reduced-dynamic orbit determination strategy.

Measurement Postfit Residuals



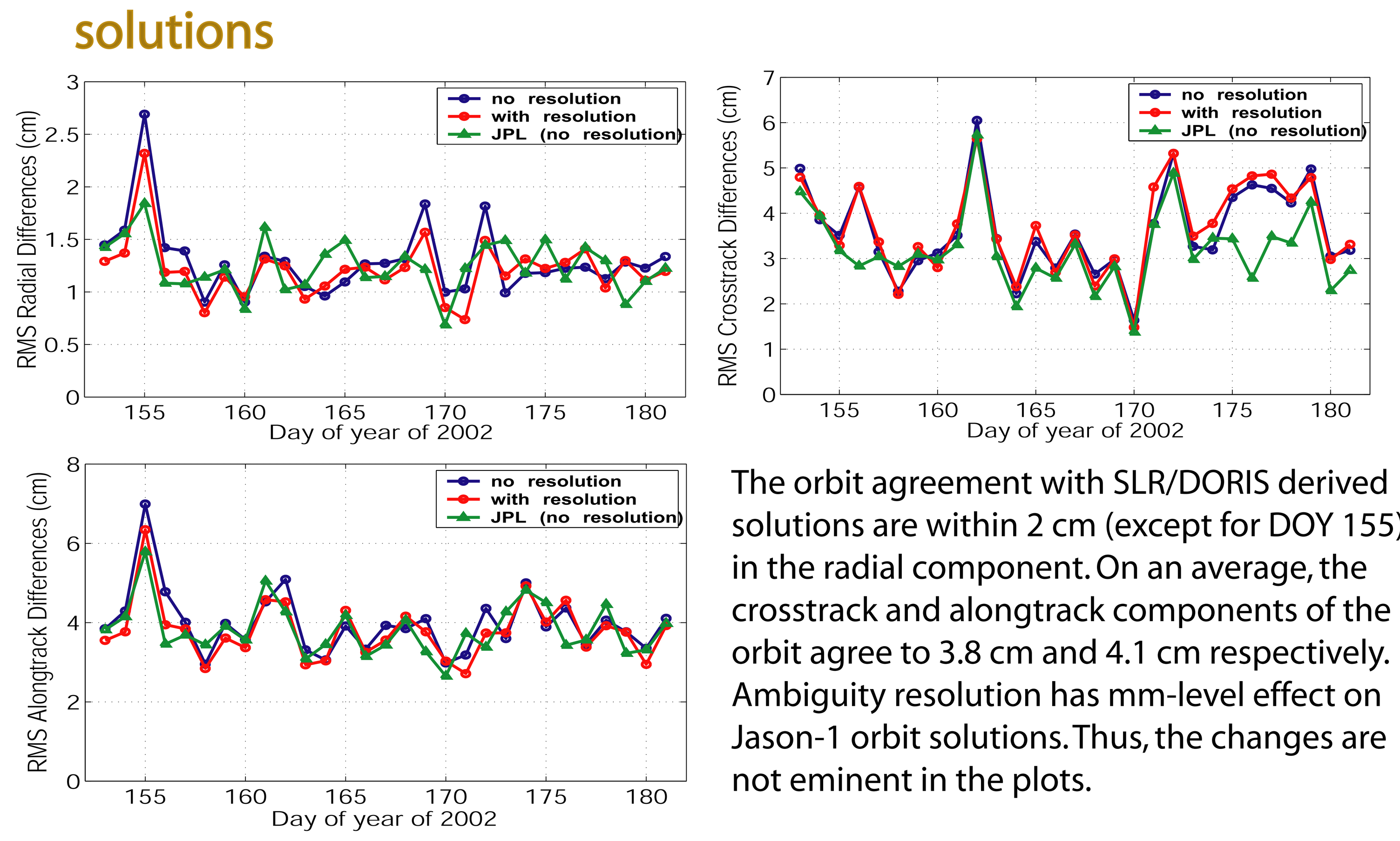
The orbit fit for Jason-1 has an average RMS of 5.6 mm and 21.5 cm for the pseudorange and carrier phase respectively over 29 days. The ground station measurements show an average RMS of 6.4 mm for the phase and 44.9 cm for the pseudorange.

Jason-1 Orbit Overlap Statistics



The statistics are obtained from a 4-hour orbit overlap period (with respect to the day after) between 2 consecutive days. The mean improvement in the radial component is 1.4 mm after resolving phase ambiguities. The crosstrack and alongtrack components show an average improvement of 2.5 mm and 3.9 mm respectively. The POD processing for Jason-1 is similar to that of JPL except that the GPS orbits are estimated in this study and JPL uses the FLINN precise GPS solutions. This may have caused the higher fluctuations in the crosstrack and alongtrack components.

Comparison with UT/CSR Jason-1 SLR/DORIS derived solutions



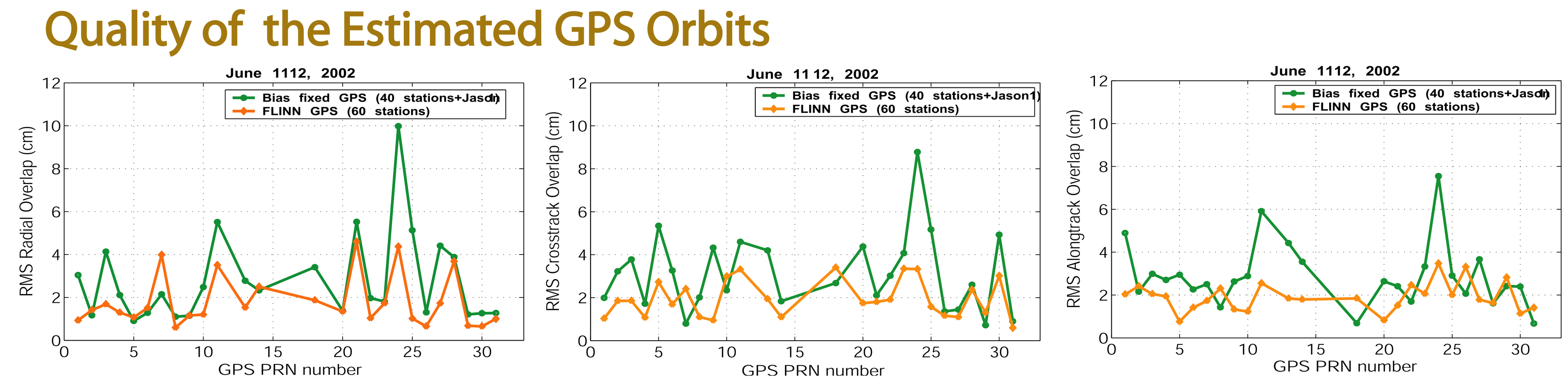
The orbit agreement with SLR/DORIS derived solutions are within 2 cm (except for DOY 155) in the radial component. On an average, the crosstrack and alongtrack components of the orbit agree to 3.8 cm and 4.1 cm respectively. Ambiguity resolution has mm-level effect on Jason-1 orbit solutions. Thus, the changes are not eminent in the plots.

Ambiguity Resolution

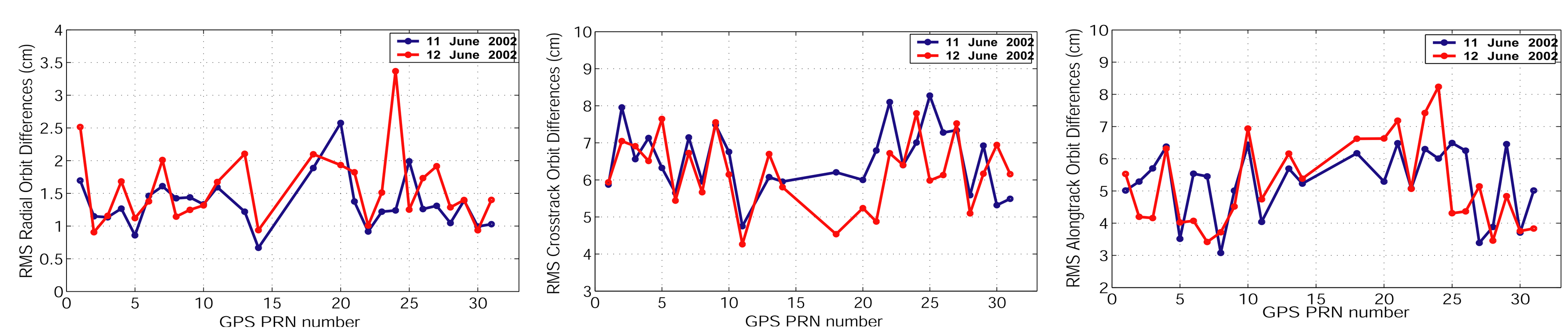
- Two sets of double-differenced phase bias combinations are resolved:
  - 2 ground receivers + 2 GPS satellites
  - 1 ground receiver + Jason + 2 GPS satellites
- Used wide-lane and narrow-lane approach. The wide-lane phase biases are resolved using the pseudorange approach. Narrow-lane phase biases are resolved using the ionosphere free method.
- The wide-lane biases are obtained from the pseudorange and wide-lane combination, and are constrained to their integer values based on the defined confidence criteria.
- The narrow-lane phase biases are constrained using the ionosphere free double-differenced phase bias obtained from the parameter estimation process and the resolved wide-lane bias.
- Phase biases that satisfy the criteria (shown in table below) are fixed simultaneously. The ionosphere free phase biases are then re-adjusted based on these constrained values.

Criteria	Jason-ground-GPS	ground-GPS
Cumulative prob. confidence		
Wide-lane bias	90%	99.8%
Narrow-lane bias	93%	99.98%
Minimum visibility window	10 mins	1 hour
Max deviation from integer bias	0.17 cycles	0.05 cycles
Max baseline length	8000 km	8000 km

Quality of the Estimated GPS Orbits



The estimated GPS orbits in the POD processing are compared to JPL FLINN precise (final) GPS solutions. The orbit overlap statistics for period June 11 and 12, 2002 show that the estimated GPS orbit quality is within 6 cm in all directions except for GPS PRN 24. The statistics for all other days are of similar quality.



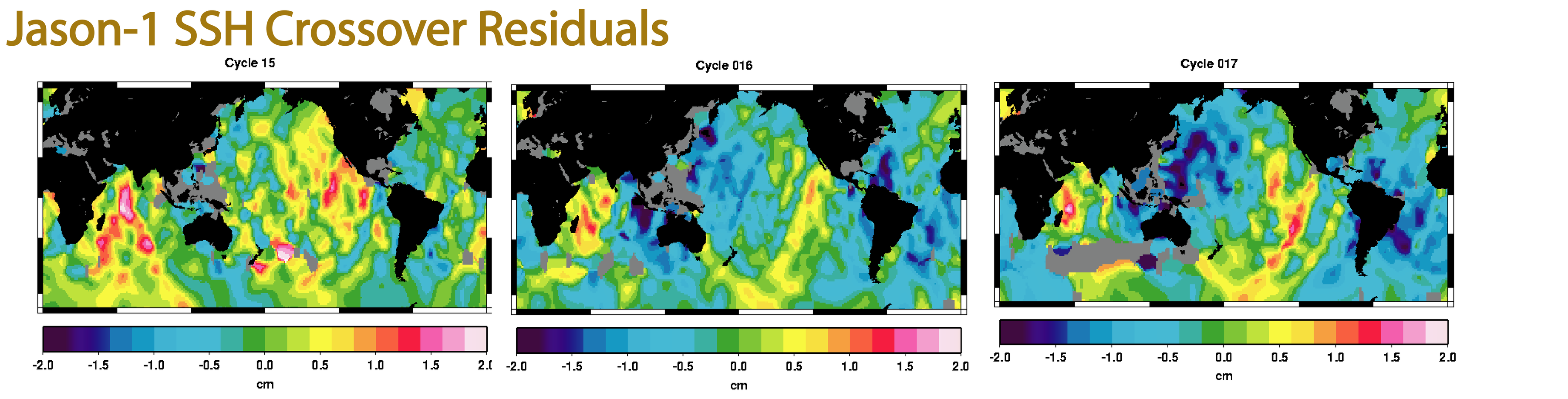
The above 3 plots are RMS orbit differences between the estimated GPS bias fixed orbits and the FLINN GPS precise solutions. The mean orbit agreement for both days is approximately 1.5 cm, 6.4 cm and 5.3 cm in the radial, crosstrack and alongtrack respectively.

The Geocenter Location

Cycle	No resolution DX	No resolution DY	No resolution DZ	With resolution DX	With resolution DY	With resolution DZ
	(mm)			(mm)		
15	-6.3	-4.7	-6.4	-5.2	-2.5	-5.0
16	-5.6	-6.5	-4.4	-2.9	-3.4	-0.8
17	+0.4	-0.5	-12.7	+0.7	+3.5	-9.7

Resolving phase ambiguities for Jason-1 seemed to have caused a positive shift in the location of the geocenter. The z-axis offsets for the 3 cycles show closer agreement after ambiguity fixing with an average improvement of 2.4 mm over 3 cycles. A longer time series of the offsets is required to deduce the influence of phase ambiguity resolution on the geocenter. Note that incorrectly fixed phase ambiguities occur occasionally and can have major influence on the orbit solutions.

Jason-1 SSH Crossover Residuals



The above sea surface height (SSH) residual representations show the magnitude of the ocean signals that are removed after ambiguity resolution.

Cycle	RMS SSH Residuals (cm) No resolution	After resolution	JPL
15	6.10	6.04	6.12
16	6.21	6.18	6.10
17	6.05	5.92	5.99

The RMS SSH residuals show improvement after resolving phase ambiguities. The effect is approximately 0.67 mm, in the RMS sense, on the SSH crossover residuals over 3 cycles. Apparently, estimating the GPS orbits has less than 2 mm (RMS) radial orbit error projected on the SSH residuals.

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