Improved orbits and reference frame stability from GPS tracking of TOPEX/POSEIDON and Jason-1 to support basin scale sea level studies

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This investigation plans to carefully analyze the Jason-1 orbits determined with the precise Global Positioning System (GPS) receiver. For TOPEX/POSEIDON (T/P), the GPS orbits are arguably the highest accuracy in terms of measuring variations in the orbit, but exhibit some unexplained biases which potentially degrade the large spatial scale oceanographic interpretation of sea level variations. We intend to investigate any similar orbital biases for Jason-1, and to minimize them through the experimental application of advanced GPS processing techniques such as carrier phase ambiguity resolution.

The TOPEX/POSEIDON (T/P) mission has contributed significantly to our understanding of the large scale variability of sea surface height. To satisfy the mission science objectives, tight restrictions have been placed on the knowledge of the radial component of the T/P (and hence Jason-1) orbit. Meeting these restrictions requires both precise modeling and estimation of the dynamic forces acting on the spacecraft as well as stability of the reference frame in which the orbits are expressed. For T/P, a combination of satellite laser ranging and DORIS Doppler data has provided the orbits and defined the reference frame in which to study sea surface variations. However, T/P also carries a precise Global Positioning System receiver which has operated well under non-Anti-Spoofing conditions. There is some evidence that the GPS orbits provide slightly better radial orbit knowledge as measured by altimeter crossovers and overlaps. There has been, however, an unexplained translational offset in these precise GPS ephemerides relative to those of SLR/DORIS, which corresponds to a shift along the terrestrial z-axis (along the Earth's rotation axis) of several centimetres. There is also some variability about the mean value of this translation. This offset and its variations can degrade both estimates of large-scale circulation and sea-level variability. Particularly sensitive are observations of the change in global mean sea level and estimates of basin and hemispheric-scale variations in sea level stemming from seasonal and longer period changes. Since GPS tracking is potentially superior otherwise, and will likely be a significant or primary tracking type for future altimetric satellites, understanding the source of this reference frame uncertainty is important. We propose that a major cause of this z-shift is the poor sensitivity of GPS to the location of the z-axis due to the estimation of real-valued phase ambiguities for all satellite-station pairs. We have preliminary evidence that resolution of phase ambiguities in GPS solutions significantly reduces this weakness, and plan to re-evaluate T/P and Jason-1 GPS orbits with this improved strategy. We can see from table 1 the significant improvement in orbit quality (as measured by daily overlaps), and in the daily stability of the orbit origin when ambiguities are resolved. It is this improvement that gives us reason to believe that the T/P z-shift may be reduced or eliminated by a combination of ambiguity resolution for the GPS s/c and for T/P and/or Jason-1. We will also attempt to resolve ambiguities involving Jason-1, and we plan to implement all required Jason-1 specific dynamic and measurement models and produce GPS based orbits (with ambiguity resolution attempted) for at least a subset of the first two years of the Jason-1 mission and carefully compare them to DORIS and SLR based orbits as well as non-bias-fixed GPS orbits. We believe that explanation and elimination of the z-shift affecting GPS tracking of T/P is possible, and moreover that this work will lead to improved interpretability of large scale variations in the sea surface, regardless of tracking type.

The work proposed has two main thrusts. The first will examine the effect of ground-GPS phase ambiguity resolution for reducing the observed z-shifts, an approach which has already met with some success in preliminary tests.

The second effort will be to resolve phase ambiguities directly for the low Earth orbiter (T/P, CHAMP, Jason-1) to GPS links.

Case	Orbit Overlap (3D, cm)	X orbit origin repeatibility (mm)	Y orbit origin repeatibility (mm)	Z orbit origin repeatibility (mm)
No ambiguities resolved	14	19	14	40
Ambiguities resolved	10	8	10	15

Table 1: Effect of Ambiguity Resolution (Ground sites - GPS s/c)

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