Inter- and intra-calibrations of TOPEX/POSEIDON and Jason-1 with inferences for decadal basin-scale sea-surface variability

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Tied orbit computations of TOPEX/POSEIDON and Jason-1 during the overlap mission will be used to inter-calibrate the respective altimetric data sets. In-situ data, in the form of tide gauge time series, will subsequently be used to monitor stability of the altimetric range measurements and thus allow a seamless transition between the altimetric data sets from the 1990s with the new missions from 2001 onwards. The high accuracy of TOPEX/POSEIDON and Jason-1 altimetry will permit detailed examination of the long-wavelength spatial distribution of sea-level variability to quantify decadal basin-scale sea-surface change from 1991 onwards.

Orbit computations during the overlap mission

The first objective of the study is to undertake an inter-calibration of the TOPEX/POSEIDON and Jason-1 missions to assist in the production of seamless altimetry data sets from 1992 to 2001 and beyond. Initial studies of Jason-1 altimetry will concentrate on calibration/ validation of the product including orbit, sea-state and altimetric biases, and other geophysical corrections. The overlap mission of TOPEX/ POSEIDON and Jason-1 will parallel the ERS-1 and ERS-2 tandem mission (Moore et al, 1999), but with the advantage that the time difference between the repeat pass measurements will be reduced to a few minutes. We will connect TOPEX/POSEIDON and Jason-1 altimetric data sets through tied orbit computations using the *FAUST* software, with its multi-satellite capability, and repeat pass data during the missions' overlap. Simultaneous orbit determination for TOPEX/POSEIDON and Jason-1 will be particularly informative as the dual satellite repeat data will be effectively free of oceanographic signals and indeed all altimetric corrections except for the altimeter and sea-state biases. Orbit computations of Jason-1 and TOPEX/ POSEIDON using SLR, DORIS, dual satellite crossover and repeat pass data to connect the two missions will thus provide fundamental insight into the different performances of the altimeters onboard TOPEX/ POSEIDON and Jason-1. Analyses of residuals will identify any spatial and temporal deficiencies within the altimetric data sets, with correlation studies pin-pointing the likely causes. The tied orbit methodology will also yield orbital positioning for TOPEX/POSEIDON and Jason-1 that is derived in a consistent manner with the possibility of a link between the DORIS pass parameters common to both satellites. Furthermore, as gravitational forces will be identical on both satellites, orbital computations will quantify deficiencies in non-gravitational force modeling for the two satellites.

Inter- and intra-calibrations of the altimetric range stability

Intra-calibrations will be undertaken for Jason-1 and TOPEX/POSEIDON over longer time periods. Long-term stability of the altimetric range will be considered by comparison against in-situ tide gauge data [Mitchum, 1998; Moore, 2001] over the lifetime of the missions. Tide gauges provide the invaluable ground truth from which non-oceanographic signatures in the altimetric data sets can be quantified. To date this methodology has excluded local land movement at the tide gauge, relying on global averaging to reduce the total effect. With continuously operating GPS installed at several UK tide gauges, and others worldwide, the uncertainty in local movement can be drastically reduced for the Jason-1 timeframe for a subset of the tide gauges. During the 1990s, TOPEX/ POSEIDON was used as a benchmark for inter-calibrations for the ERS satellites [Moore, 2001] and, more recently, the GFO missions, using dual satellite crossovers with the TOPEX/POSEIDON signature removed by the aforementioned intra-calibration using tide gauges.

For 2001 and beyond, Jason-1 will take over this role. In particular, the highly accurate Jason-1 data will enable cross-calibration of the European mission, ENVISAT, due for launch in June 2001. The overlap period will thus link Jason-1 to TOPEX/POSEIDON and hence to GFO and the two ERS missions. TOPEX/POSEIDON and Jason-1 are clearly the most accurate oceanographic missions, but improved spatial distribution of oceanographic signatures, and reduction in aliasing by high-frequency effects, can be achieved by considering satellite altimetry in different repeat orbits. Residual signatures in the dual crossover data will thus supply an important quality check on the independent altimetric data sets.

Inter-calibrations of the various missions will provide a consistent altimetric data set from 1991 onwards. An important additional goal is to connect the less accurate GEOSAT altimetry (1985-1989) to the 1990 data set, thus enabling sea-level change studies to extend to nearly two decades. A major problem here is the accuracy of the GEOSAT orbit as computed from TRANET Doppler data and the apparent centre-of-figure offset between the respective tracking networks. The recent availability of GFO altimetry will enable dual satellite crossover data with TOPEX/POSEIDON and Jason-1 to be used to enhance the gravity field for satellites in the GEOSAT/GFO orbit. Using this approach, the geographically correlated errors of gravitational origin for GEOSAT/GFO can be drastically reduced. With the availability of an enhanced gravity field, dual crossovers across the decade between GEOSAT and TOPEX/POSEIDON and Jason-1 can be used to tie the TRANET tracking network into the ITRF reference frame, thus enabling GEOSAT altimetry from 1985-1989 to be more easily connected with the post 1990s data sets.

Decadal basin scale sea-surface variability

Comprehensive analysis of any drift signature in the altimetric range is a precursor to sea-level change studies. The high accuracy of TOPEX/POSEIDON and Jason-1 altimetry will permit detailed examination of the long-wavelength spatial distribution of sea-level variability to quantify decadal basin-scale sea-surface change from 1991 onwards. Crucially, the Jason-1 mission will correspond to the timeframe of the GRACE (Gravity and Circulation Experiment) dedicated gravity field mission. GRACE will provide monthly gravity field solutions from which temporal variability (at the longer-wavelength spatial scales) will be interpreted as a mass redistribution in the Earth's gravity field. Integration of altimetry and gravity field temporal signatures is one of the goals of the consortium financed by the UK NERC Research Council to investigate high-frequency aliasing of the GRACE signal.

References

Mitchum G.T., 1998: Monitoring the stability of satellite altimeters with tide gauges, *J. Atmos. Oceanic Tech.*, 15, 721-730.

Moore P., 2001: The ERS-2 altimetric bias and gravity field enhancement using dual crossovers between ERS and TOPEX/POSEIDON, *J. Geod. (to appear)*.

Moore P., S. Carnochan, R.J. Walmsley, 1999: Stability of the ERS altimetry during the tandem mission, *Geophys. Res. Lett.*, 26, 373-376.

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