The Harvest experiment

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Every ten days, the Jason-1 satellite will directly overfly an oil platform (Harvest) off the coast of central California. Data from specialized instruments on the platform will be used to verify the accuracy of the Jason-1 sea-level measurements.

The *Arguello Inc.* Harvest Oil Platform (figure 1) is located about 10 km off the coast of central California near Point Conception. An impressive structure, the platform is attached to the sea floor and sits in about 200 m of water near the western entrance to the Santa Barbara Channel. Conditions at Harvest are typical of the open ocean and the seas can be quite heavy. Ocean swell and wind waves average about 2 m, though waves over 7 m have been experienced during powerful winter storms. Prevailing winds are from the northwest and average about 6 m/s (15 mph). The platform is served by helicopters from the Santa Maria, California, airport, and is regularly visited by supply boats. Operational since 1991, Harvest has produced over 44 million barrels of oil (as of July, 1997).

In addition to its primary mission to drill for oil, Harvest is a "calibration site" for the Jason-1 (2001 launch) and TOPEX/ POSEIDON (1992–) missions. As such, The platform is an important international resource for the study of sea level from space. A consideration in designing the TOPEX/POSEIDON (T/P) orbit was a requirement that the satellite pass directly over Harvest on a regular basis. Traveling in excess of 7 km/s at an altitude of 1335 km, T/P flies over the platform every 10 days en-route to tracing out its global pattern of sea-level measurements. Observations recorded with instruments attached to the platform are used to verify the sea-level readings from T/P taken at the instant of the overflight. After its own launch this summer, Jason-1 will be placed in the same orbit, bringing it over Harvest in formation flight with T/P.

Why is Harvest such a good calibration site? For one, it is located sufficiently far offshore so that the area illuminated by the altimeter's radar pulse is covered entirely by ocean when the satellite is directly overhead. At the same time, the platform itself is small enough so that it cannot influence the reflected radar signal. The platform's location in the open ocean also implies that the altimeter missions are monitored in conditions under which their measurements systems are designed to best operate. Finally, the platform is located in proximity to important tracking stations in California and the western US, data from which contribute to measuring the positions of the satellite and platform through space-based surveying techniques.

Figure 1: The Arguello Inc. Harvest oil platform.

The fundamentals of the calibration technique are well established from previous missions. Attached to the platform are "tide gauges" that continuously measure variations in the sea level relative to the platform. These variations may be due to the effects of fluctuating ocean currents and atmospheric pressure in addition to astronomical tides. Any sinking or rising of the platform structure itself will also affect the tide-gauge measurements. As oil is pumped from the underlying deposit, for example, the sea floor supporting the platform structure subsides by almost 1 cm each year. This is measured using data from a global positioning system (GPS) receiver on the platform. Also computed with the GPS data is the absolute height of the platform relative to the Earth's center.

Combining the tide gauge and GPS results gives the local sea-surface height (SSH) relative to the Earth's center, the same quantity measured by the radar altimeter when it flies over the platform. By looking at the mismatch of the two SSH readings (Jason-1 vs. Harvest) at the overflight times, the errors in the respective measurement systems will be exposed. Errors in the platform measurements are minimized by using redundant systems, and through careful monitoring and routine maintenance of the Harvest instruments. Drawing on our experience with T/P, we expect the agreement between the instantaneous sea-level readings (Jason-1 vs. Harvest) for a typical overflight to be 2–3 cm or better. A multi-year time series of these overflight comparisons beginning with the launch of Jason-1 will serve as a vital performance record for the mission.

The value of the Harvest experiment was amply demonstrated with results from the T/P mission. Shortly after the satellite launched in 1992, results from Harvest showed that the TOPEX sea-level measurements were too high by almost 15 cm [Christensen et al., 1994]. The bias is now recognized as a consequence of an error in the software used to produce the TOPEX data for the mission scientists [Nerem et al., 1997]. As T/P continues its successful run, attention has turned to improving estimates of measurement-system stability in order to verify the emerging record of global sea-level change [see also Mitchum, 1998].

The T/P experience has proven to be excellent preparation for Jason-1. We expect even greater success for Jason-1, owing to improvements in both the platform and satellite systems. In addition, during the first few months of its mission, Jason-1 will pass over Harvest in formation flight with T/P. Because the ocean scene at Harvest cannot change appreciably in the few seconds separating the T/P and Jason-1 overflights, many sources of measurement uncertainty will cancel. This cancellation will significantly benefit cross-calibration of data from the two satellites. Jason-1 will also benefit from the ongoing minimization of systematic errors in the platform measurement system. Particular emphasis is being placed on monitoring the platform vertical position and velocity with GPS at the 1 cm and 1 mm/yr levels respectively. We will also exploit the thorough instrumentation at Harvest in order to lend insight on the source of the potential errors in the Jason-1 data (e.g., atmospheric delays, range anomalies). Throughout the Jason-1 mission, we will work closely with other Jason-1 investigators overseeing additional regional calibration sites, as well those performing drift calibrations using global tide gauges, to reach a consensus on the application of calibration corrections to the global mean sea level record.

References

Christensen E.J. et al., l994: Calibration of TOPEX/POSEIDON at Platform Harvest, *J. Geophys. Res.*, 99, C12, 24,465-24,485

Mitchum G., 1998: Monitoring the stability of satellite altimeters with tide gauges, *J. Atmos and Oceanic Tech*, 15(3), 721-740.

Nerem R.S., et al., 1997: Improved determination of global mean sea level variations using TOPEX/POSEIDON altimeter data, *Geophys. Res. Lett.*, 24(11), 1331-1334.

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