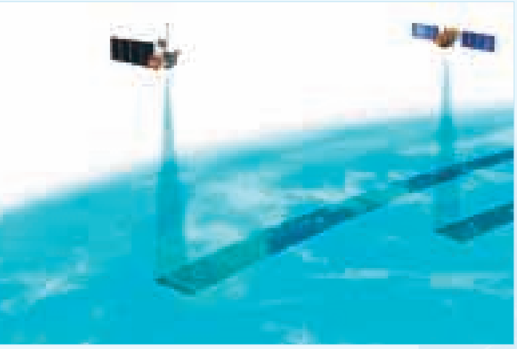


Two altimetric satellites

minimum are needed for ocean observation and forecasting

V. Rosmorduc, F. Hernandez - CLS, France
Vinca Rosmorduc - E-Mail: vinca.rosmorduc@cls.fr

After 10 years in the same orbit, on August 15, 2002 Topex/Poseidon was moved to a position midway between its original repeating ground tracks. With the launch of Jason-1 in late 2001 and Envisat in early 2002, Topex/Poseidon on its new orbit, ERS-2 still in service, and GFO launched in 1998, we today, for the time being, have a uniquely rich constellation of altimetry satellites in operation.

Figure 1. Topex/Poseidon and Jason-1 are on parallel orbits 158 kilometers apart.

The orbit of an altimetry satellite like Jason-1 or ERS is a tradeoff between revisit frequency and spatial resolution. In other words, if we want to observe a spot more often, then measurements will be spaced further apart, and vice versa. For example, during the 168-day geodetic phase of its mission, ERS-1 ground tracks were only eight kilometers apart at the equator, whereas for its three-day ice-observing phase the spacing was increased to 909 kilometers.

One way to combine frequent observation data with sufficient coverage of the Earth's surface is to use several satellites. Combining ERS and Topex/Poseidon (T/P) data significantly improves spatial and temporal resolution (figure 3), thereby enabling us to see and track ocean circulation more clearly at a scale of 100 kilometers (figure 2). T/P and Jason-1 pass over the same spots on the ocean fairly often (every 10 days) to observe ocean variations at scales of 100 to 300 kilometers (mesoscale), but their ground tracks are 315 kilometers apart at the equator, which means they cannot resolve an average-sized ocean eddy. On the other hand, ERS and Envisat passes are spaced no more than 90 kilometers apart at the equator, but they only see the same point on the globe every 35 days. These complementary features mean

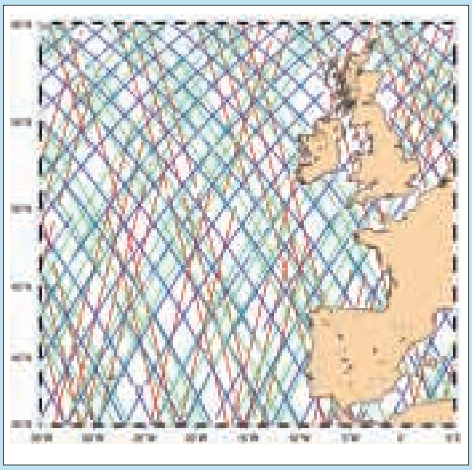
Altimetry satellites today

There are no less than five altimetry satellites currently in service, a constellation that should not last for long:

- Two satellites—Topex/Poseidon and Jason-1—with a relatively short repeat cycle (10 days), able to observe the same spot on the ocean frequently but with relatively widely spaced ground tracks (315 kilometers at the equator). They are now operating in similar, parallel orbits 158 kilometers apart at the equator.

- Two satellites—ERS-2 and EnviSat—with a longer repeat cycle (35 days) but a tighter ground track spacing (90 kilometers at the equator).

- An “intermediate” satellite—GFO—with a repeat cycle of 17 days and 160 kilometers between ground tracks at the equator, in the same orbit as its predecessor, GEOSAT.



T/P (blue), ERS-2 (red) et GFO (green) over 10 days (14 to 23 December 2000)

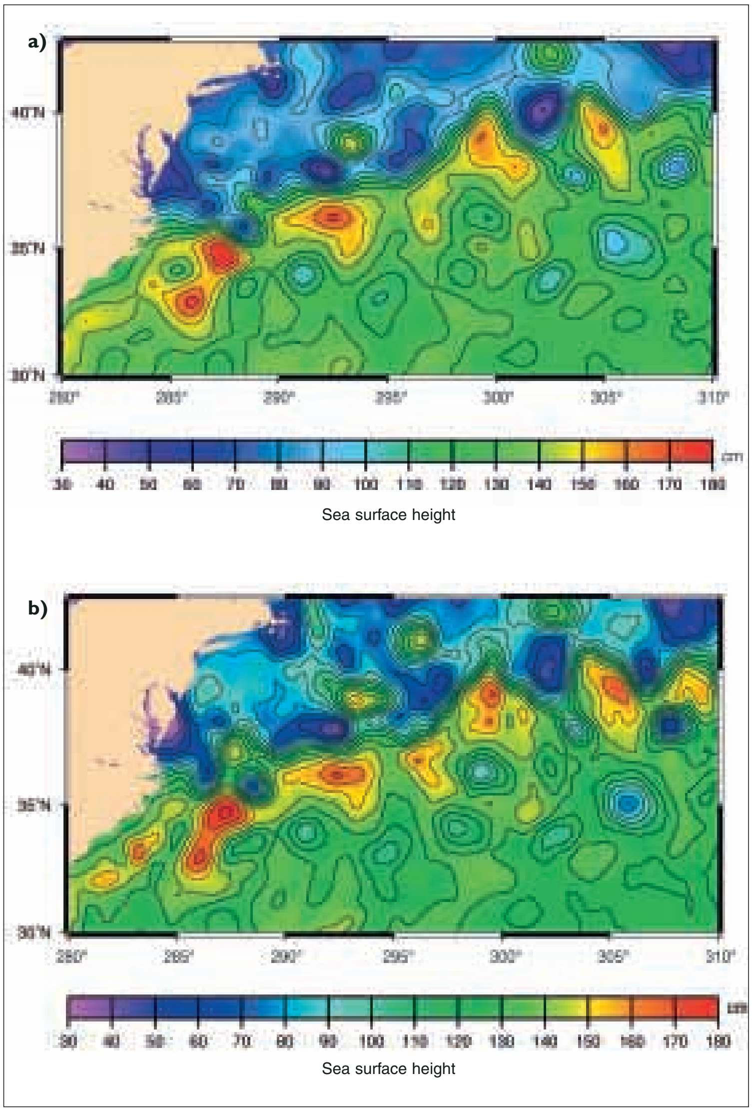


Figure 2. Sea surface height in the Gulf Stream, December 5, 1999: a) Topex/Poseidon data, b) Topex/Poseidon + ERS-2. The many eddies in the Gulf Stream are visible at much higher resolution

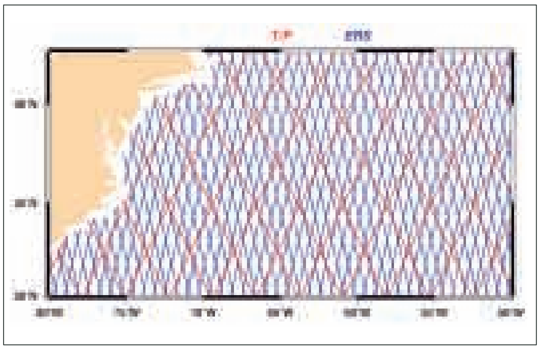


Figure 3. Superimposed Topex/Poseidon and ERS-2 ground tracks

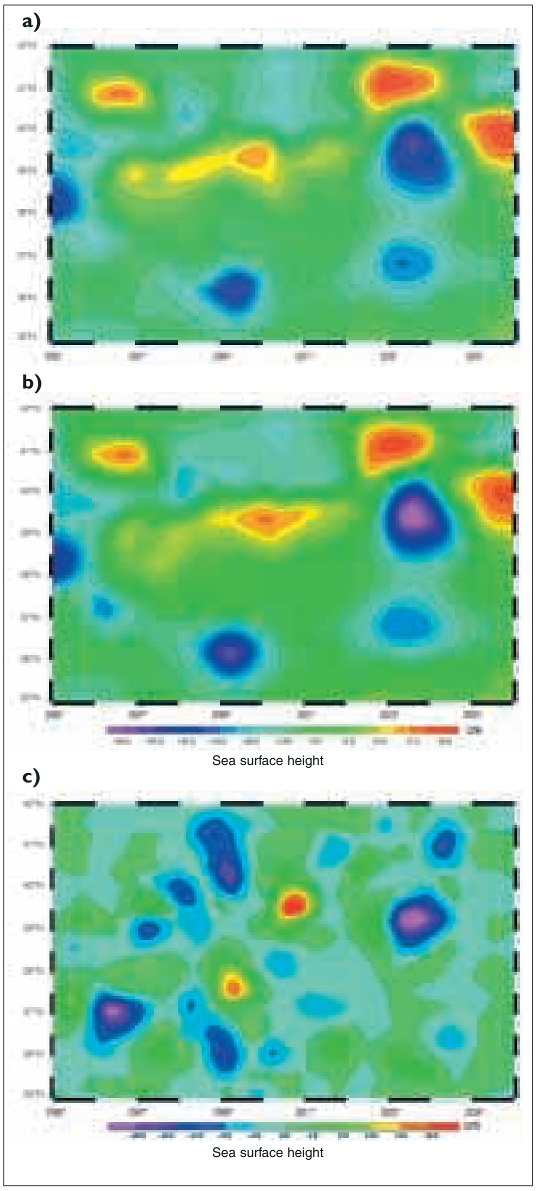


Figure 4. Absolute sea surface height computed from T/P+ERS-2 (b) and T/P+ERS-2+GFO (b), on December 20, 2000 in the Kuroshio region; (c) T/P+ERS-2+GFO minus T/P+ERS-2 sea surface heights (in cm)

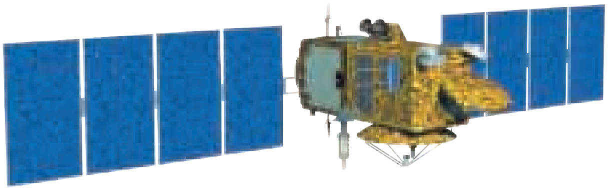
that operating ERS in tandem with Topex/Poseidon, and Envisat with Jason-1, proves very valuable.

T/P's new orbit, midway between its original ground tracks (figure 1) now occupied by Jason-1, also affords new capabilities. Paired operation of these two dedicated satellites with the same design, cross-calibrated, yields data every 10 days, acquired from parallel orbits 158 kilometers apart at the equator. The two satellites deliver equivalent performance and their orbits are synchronous.

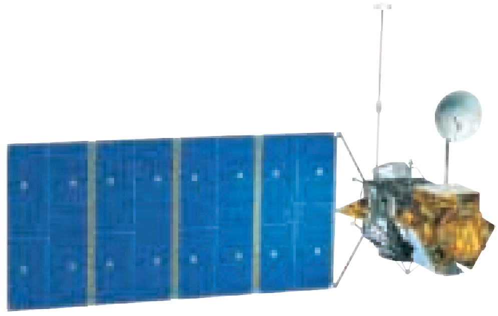
Other combinations are possible. For example, combining GFO data with data from T/P and ERS-2 significantly improves the description of the ocean mesoscale (figures 4 and 5), and provides a continuous worldwide coverage.

The intention now is to sustain this system in the long term, and if possible to enhance it, by always having at the very least two altimetry satellites operating at the same time.

In the medium term, consideration is now being given to altimetry missions capable



Jason-1



Topex/Poséidon

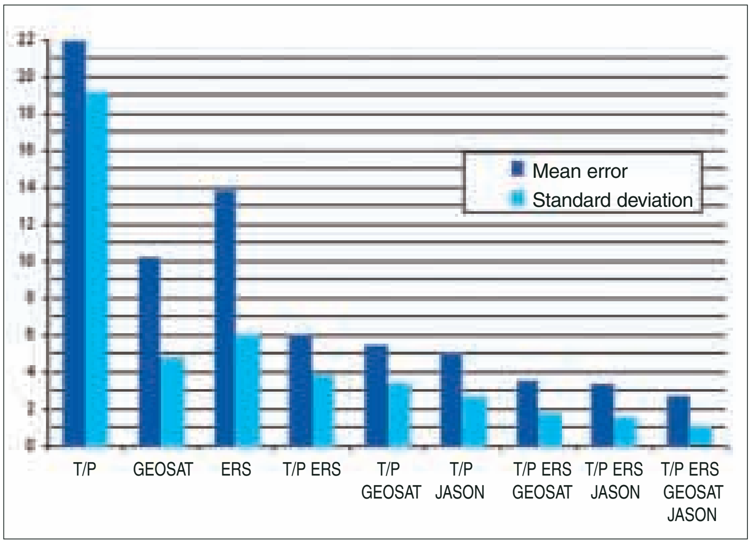


Figure 5. Improvement of mesoscale restitution by combining several satellites. Note that T/P orbit, very wide-spaced, is not well adapted to resolve these signals

of "scanning" the ocean surface to acquire data at scales of a few tens of kilometers, passing over the same spots every few days. Other projects on the drawing board are based on constellations of dedicated, low-cost microsatellites (AltiKa, Wittex).

Jason-1's successor is thus expected to carry an experimental altimeter/interferometer called WSOA (Wide Swath Ocean Altimeter) in addition to the operational instrument, a Poseidon altimeter. WSOA will in fact comprise two altimeter antennae mounted on masts to acquire measurements simultaneously, providing continuous coverage of large areas (200-km swath). Envisat follow-on is under study. Looking further into the future, the goal is to monitor relatively rapid ocean variations with a period of less than 10 days at scales below 100 kilometers.

Beyond 2010, "conventional" operational missions are still envisaged. NOAA and US Department of Defense are planning an altimeter mission in the framework of the future NPOESS oceanographic and meteorological program.

High-resolution measurements are a necessity for many applications:

- To observe ocean phenomena that vary in amplitude, scale, and frequency from one zone to another. For example, eddies are smaller at high latitudes, so we need a spatially dense observing grid. Conversely, wave phenomena in the Tropics have shorter periods and therefore require more frequent observations.
- To yield insights into phenomena caused by wind and changing atmospheric pressure, and give us a better understanding of transient phenomena, especially near coastlines.
- To study sea ice and continental glaciers.
- To monitor sea states.
- To measure tides.

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