REGIONAL VALIDATION IN THE MEDITERRANEAN

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The usefulness of results from space oceanography missions depends on how accurately we know the geodetic parameters: the orbit and its error spectrum, the gravity field, the geodetic network, altimeter calibration and its drift over time, measurement corrections, and so on. This means the parameters need determining and their quality monitored over time. Such was the aim of the regional validation exercise described below.

Calibration

Determining the calibration bias on the TOPEX and POSEIDON altimeter radars, and monitoring it over time, has turned out to be a crucial space geodesy exercise for the interpretation of altimeter measurements in terms of sea surface height and trend in mean sea level. It requires, if possible, orbit calculation to within a centimetre, at least at local scale. Our work in this area has highlighted the very important role of the short-arc orbit technique and Satellite Laser Ranging (SLR) systems. Together with absolute altimeter calibration, these are determining factors in 1-2 cm level local orbit enhancement [Bonnefond et al., 1995]. But error budgets (ERS1 published in recent years for Venice, and T/P for Lampedusa) will only improve as a result of high-quality instrument data, i.e. with SLR calibration bias per pass of no more than 1 cm. However, Lampedusa, the only dedicated site with a laser station, showed how troublesome the system was to implement, hardly worth it for the meagre results [Ménard et al., 1994].

With the 1-cm calibration challenge of the Jason mission, the important issues include:

- can the cost of absolute calibration at a dedicated site be reduced?
- what role should neighbouring SLR stations play?

To attempt a response to these questions, a pilot experiment was conducted in Corsica from October 1996 to February 1997. The site was Aspretto, near Ajaccio. The ultra-mobile French Transportable Laser Ranging System (FTLRS) was used routinely for the first time; so too were a DORIS beacon, a GPS receiver for geodetic tying-in, and two tide-gauges (see figure 1). The station reference point has now been located, and the geodetic collocation experiment is over. The coordinates are estimated to be accurate to within 1-2 cm, despite no work being done using the Lageos satellite. Instrument noise from the laser is 2 cm, with a major bias variation of 3 cm on average between passes [Stoufs, 1997]. The altimeter calibration value is being calculated. Due to bad weather, only six passes are being used, taking the error budget of the calibration value to be 3 cm. We now expect immediate progress, both from enhanced FTLRS instrument technology and from a better tide-gauge site. The Italian island of Capraia, right on a T/P crossover point, already has a tide-gauge, and is a potentially useful site [Bonnefond et al., 1997a].

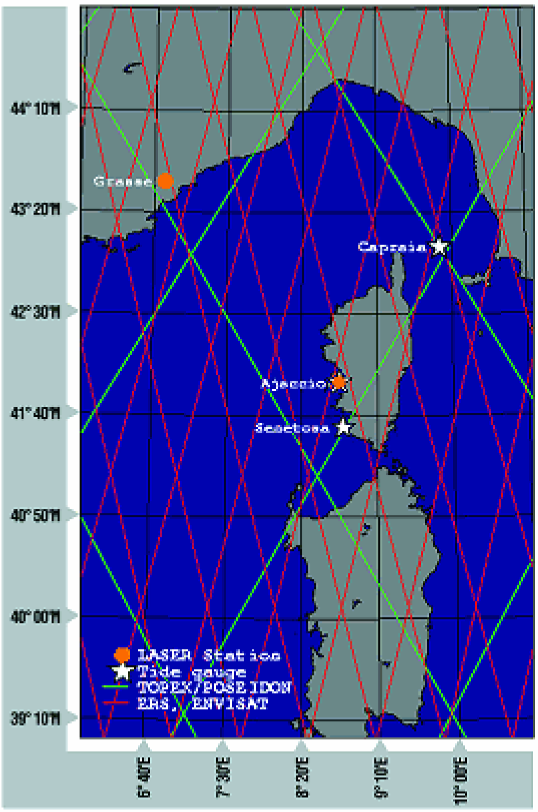

Figure 1
experiment in Corsica, France.
T/P satellite tracks in green, ERS in red.

Mean surface

After application at purely local scale at Lampedusa, we then showed that it is possible to remove T/P radial error at the 1-2 cm level over sea areas such as the Mediterrean, satisfactorily covered by European SLR systems [Bonnefond et al., 1995]. However, the temporal coverage of SLR systems does not permit regular monitoring of the trend in Mediterrean sea level and does not provide a major improvement, i.e. less than 1 mm/year, at regional scale. On the other hand, short arcs make it possible to establish space-time control points for the orbits and to improve the altimetry error budget. This work, in cooperation with Anny Cazenave [Cazenave et al., 1997], is part of the broader European Union SEa Level Fluctuations II (SELF II) project. It should make it possible to provide global, interannual validation of the variations in mean sea level in the Mediterranean, in particular via comparisons with tide-gauges installed or tied in by the community [SELF II, 1997].

Effect of gravity field

The global dynamic method used routinely by CNES and NASA [Nouel et al., 1994; Tapley et al., 1994], has provided more and more accurate ephemeris, thanks to improved models and numerical techniques [e.g. Barotto et al., 1996]. Radial error is now down to 3-4 cm [Marshall et al., 1995]. Thus, using the long-term stability of the T/P ephemeris, we calculated the trend in radial orbit corrections supplied using the short arc method in Europe and the U.S. over three years [Bonnefond et al., 1997b]. Thanks to the geometrical nature of the method, completely independent of the dynamics, it has been possible to characterise T/P radial orbit error over time and, to a lesser extent, space. Thus, the geographically-correlated error arising from use of JGM-2 and -3 accurate ephemeris was deduced. This confirmed a theoretical study of orbit error based on an analytical solution of perturbed circular motion expressed in spherical coordinates [Exertier and Bonnefond, 1997]. The results were also confirmed by comparing them with the reduced-dynamics solution from GPS data [Haines et al., 1995]. This type of analysis, based on laser residuals, is an integral part of the assessment of orbit accuracy, so important for oceanography.

Influence of tracking data quality

The quality of the laser terrestrial reference frame is closely related to the technological state of the art at SLR stations. If calibration range bias is disregarded at the stations, the orbit or the fit of the station coordinates needs modifying. The geometrical method is particularly sensitive to this. Applied to T/P regional orbitography, it makes it possible to examine the direct and indirect effects of data quality.

Analysing three years of data was also an opportunity to supply an accurate error budget on the SLR measurements and the terrestrial reference frame. We can say today that the biases observed on laser instruments in Europe and the U.S. from T/P orbit analysis are 3 cm and 1 cm on average respectively [Marshall et al., 1995; Bonnefond et al., 1997b]. In five years, from 1992 to 1997 some biases have varied by more than 1 cm, especially in Europe. This trend is thus likely to change the interpretation of orbit determinations, and thus the altimetry interpretation. The terrestrial reference frame also has an influence on the long-term orbit calculation, according to whether it accommodates vertical drift in the station positions, even if only weakly.

Conclusion

Our work on validating the TOPEX/POSEIDON satellite altimetry system, and the ERS missions, has a metrological and geodetic control component. It is associated with many studies on error budgets, without which any scientific use of the altimeter data could be misleading and dangerous. Currently, the global error budget for T/P on sea level height is 4.3 cm, spread near-equally between orbit (3 cm) and measurements (3 cm). With Jason-1 in mind, we are working today to reduce the budget by a factor of two, if possible. We are also looking for potential sites for regional validation in the western Mediterranean, such as Corsica, Capraia, or Ibiza.

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