LARGE-SCALE CIRCULATION AND ITS VARIABILITY IN THE SOUTH INDIAN OCEAN FROM SATELLITE ALTIMETRY

Y.H. Park, L. Gambéroni
(Muséum National d'Histoire Naturelle, France)

In our recent study on the circulation of the south Indian Ocean [Park and Gambéroni, 1995], we processed the first 18 months of TOPEX/POSEIDON (T/P) data. The data were previously validated using tide-gauge measurements acquired off Amsterdam Island and in the equatorial Atlantic Ocean at São Tomé [Verstraete and Park, 1995]. The results are excellent: the difference is on the order of 2 cm, with a correlation of 0.8 to 0.9 at low frequencies, for periods over 60 days. Our recent validation at São Tomé with the new version-C T/P data shows a marked improvement in the results (rms difference of 1.8 cm; correlation of 0.95), demonstrating the exceptional quality of T/P data.

The altimetric mean sea surface height relative to the present geoid only allows us to describe the dynamic topography at scales greater than some 2000 km, with an uncertainty of the order of 10 cm. Adequate spatial filtering is thus needed. We applied a Gaussian filter with a cut-off length of 1000 km at mid-latitudes. The results (Figure 1a) unmistakably show the effectiveness and power of T/P altimetry, which can now satisfactorily describe the ocean circulation at synoptic scales from 1300 km out in space. Notice the Antarctic Circumpolar Current (ACC), with its north-south slope the most marked right across the southern Indian Ocean,; the anticyclonic subtropical gyre, enclosed and centred on the Crozet Basin, two sub-polar cyclonic gyres, separated by the Kerguelen Plateau.

The two subpolar gyres, well supported by the Fine Resolution Antarctic Model (FRAM, Figure 1b) and by historical tracking of icebergs, are somewhat unexpected, as the hydrography does not clearly show them. The subpolar gyre stretching out to 60°E to the west of the Kerguelen Plateau is in fact the eastern end of the Weddell Gyre, although many authors using hydrography set its eastern boundary at around 20° to 30°E. This difference between the hydrography and the altimetry is due to the extremely weak baroclinic shear in the Antarctic Zone, and because the circulation there is dominated by the barotropic signal, invisible to the conventional dynamic method. Thanks to the T/P altimetry, we have shown the significance of the barotropic signal in the Southern Ocean and confirmed the existence of subpolar gyres on either side of the Kerguelen Plateau.

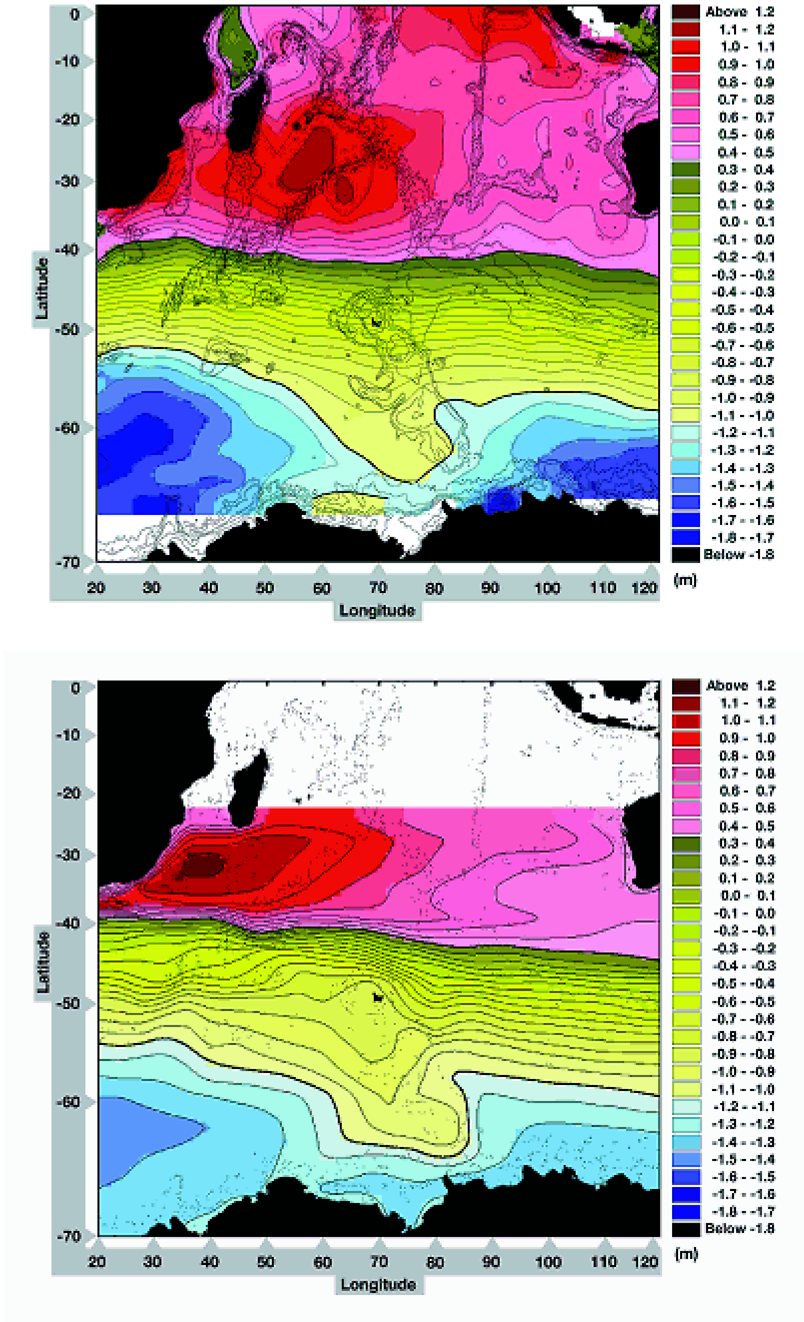

Figure 1

Dynamic topography (in m) in the south Indian Ocean, from (a) T/P altimetry and (b) FRAM output.

In the Crozet basin, the T/P altimetry also shows a band of strong variability, coinciding with the eastward extension of the Agulhas Return Current as well as the confluence of this subtropical current and the ACC (Figure 2). The areas of maximum variability are mainly confined to the deep basins, just downstream of the major topographic features. This indicates that the strong variations in sea level are due to perturbations in strong current flows produced by interaction with the marked bottom relief. With Geosat data we have, for the first time, identified Rossby waves propagating westward in the weak current zone, and eastward in the ACC core [Park, 1990; Park and Saint-Guily, 1992]. The maximum energy of westward-propagating waves corresponds to waves with periods of about 6 months and wavelengths of 400 to 600 km; for eastward-propagating waves, the periods are 2 to 4 months and the wavelengths shorter, centred on 300 km. The westward-propagating waves are baroclinic Rossby waves modified by the bottom topography of the basin, while those propagating eastward are due to the effect of the mean current on the Rossby waves, such as the Doppler shift and the change in phase speed. These results are consistent with the conclusions by Hugh [1995], who analysed the FRAM outputs and T/P data.

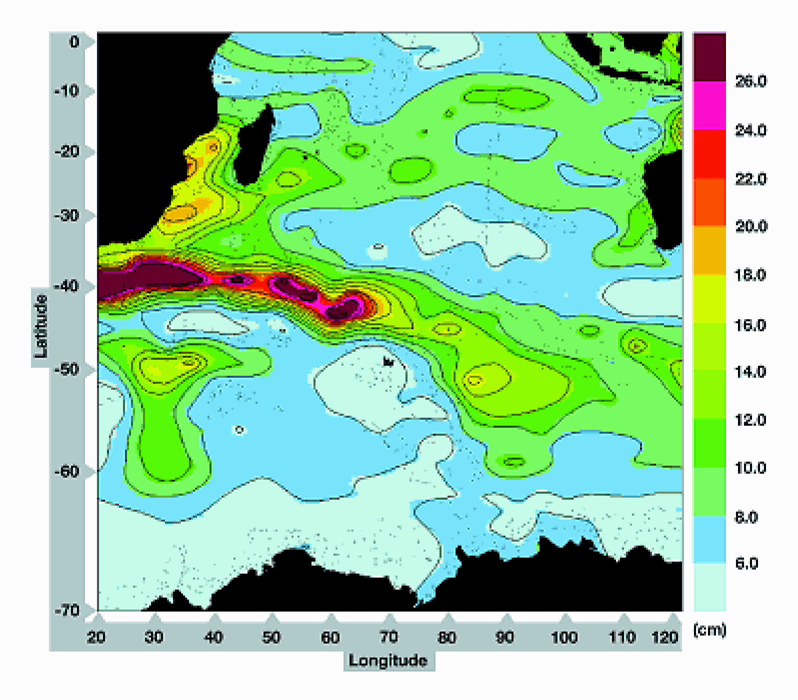

Figure 2
Sea level variability (in cm) from T/P data, from October 1992 to March 1994.

Currently, our research activities in altimetry are focused mainly on interannual variability in the Southern Ocean, and in the equatorial band of the three major oceans. Our aim is to detect and monitor climate variations in these areas, as well as any relationship there might be with El Niño Southern Oscillation (ENSO).

References :

- Hughes, C. W., 1995: Rossby waves in the Southern Ocean: a comparison of TOPEX/POSEIDON altimetry with model predictions, *J. Geophys. Res., 100*, 15,933-15,950.
- Park, Y.-H., 1990: Mise en évidence d'ondes planétaires semi-annuelles baroclines au sud de l'Océan Indien par altimètre satellitaire, *C. R. Acad. Sci. Paris, t.310,* II, 919-926.
- Park, Y.-H. and B. Saint-Guily, 1992: Sea level variability in the Crozet-Kerguelen-Amsterdam area from bottom pressure and Geosat altimetry, in Sea Level Changes: Determination and Effects, *Geophys. Monogr. Ser., vol. 69,* edited by P. L. Woodworth et al., pp. 117-131, AGU, Washington D.C.
- Park, Y.-H. and L. Gambéroni, 1995: Large-scale circulation and its variability in the South Indian Ocean from TOPEX/POSEIDON altimetry, *J. Geophys. Res., 100,* 24,911-24,929.
- Verstraete, J.-M. and Y.-H. Park, 1995: Comparison of TOPEX/POSEIDON altimetry and in situ sea level data at Sao Tome Island, Gulf of Guinea, *J. Geophys. Res., 100,* 25,129-25,134.