

Ocean loading and crustal deformation in Bretagne (France): an experiment involving differential GPS, gravimetry and tide gauges

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Abstract. Brest in west part of France, is a place where the oldest tide gauge data are available. A complete recording since 1807 shows the variations of the sea level height from it can be inferred the elevation of the mean sea level. More, with its geographic location, Brest is an ideal place to observe the sea tides (high tidal range). For this reasons, it has appeared very interesting to conduct gravimetric and geodetic measurements. This paper presents the first results on the ocean loading studies.

1. The experiment

One of the best locations to investigate the consequences of ocean loading on the solid Earth deformation is the Brest area in Bretagne; indeed, the tides of the Atlantic Ocean are known to be large and can lead to inland gravity changes of around 40 μ Gal (peak to peak). The gravity signal is generally phase shifted with respect to the solid tide. It involves a direct Newtonian attraction, and also a contribution due to the flexure of the crust which modifies the gravimeter altitude too.

In this study, we present a set of differential measurements obtained in Bretagne (at two sites; Brest and Mauron, Fig. 1) in 1998.

A Scintrex microgravimeter CG3-M was installed in Brest (EPSHOM point) for four months,

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Fig. 1 - Study area.

in order to estimate, accurately the ocean loading gravity, effect.

Various measurements were performed for a period of 4 to 7 days in March 1998, during the equinoctial spring-tide period. They involved absolute measurements from the gravimeter FG5 in

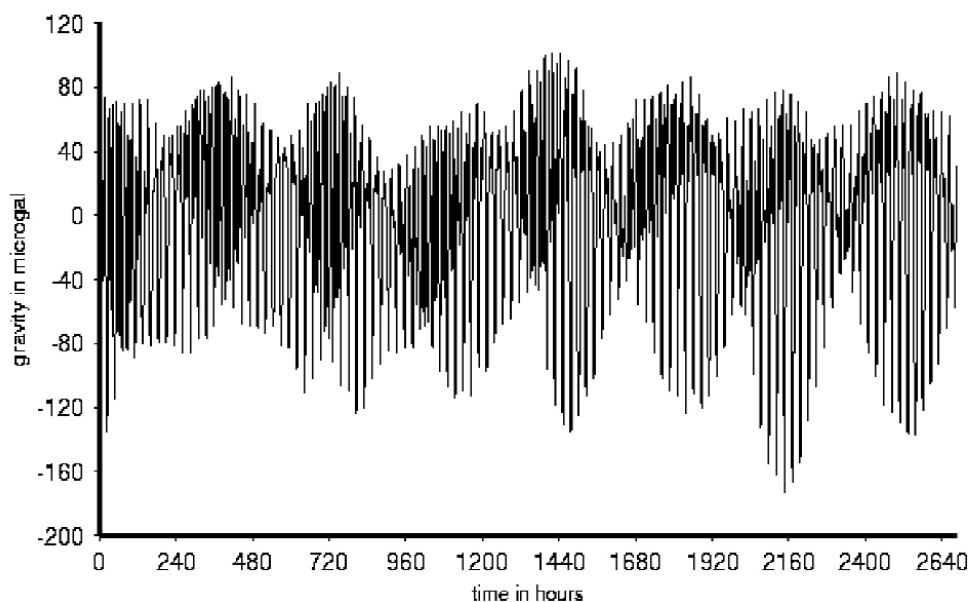


Fig. 2 - Scintrex CG3M records (drift corrected).

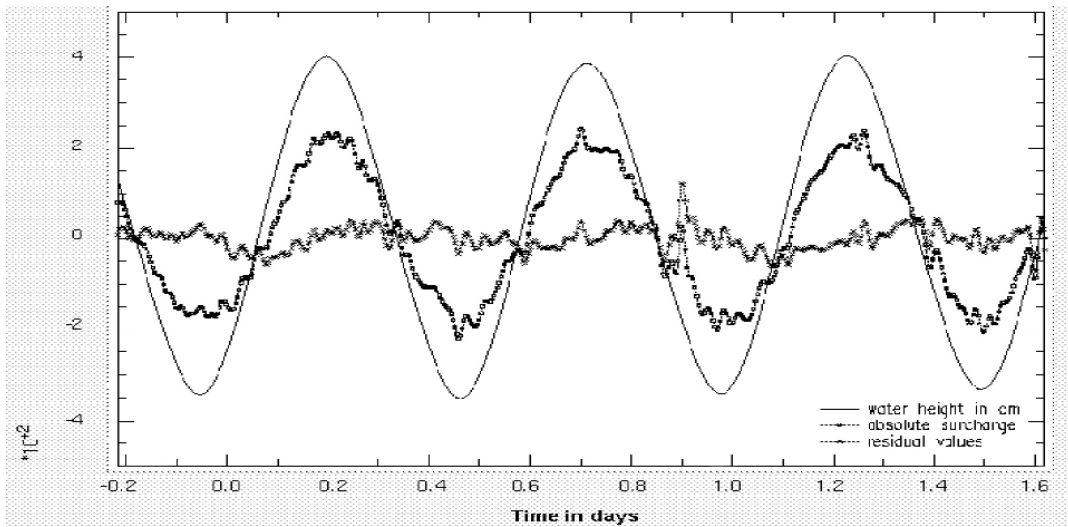


Fig. 3 - Absolute estimation of ocean loading versus water level tide.

Brest, placed near the microgravimeter.

One of the GPS sets was installed in Brest at the VLBI point, and the other one in Mauron, a little town 160 km from Brest, to estimate the height variation between the two sites.

Another Scintrex microgravimeter was made to work in Mauron during the few days of the spring equinox.

2. Preliminary results

Data from the FG5 absolute gravimeter and CG3-M gravimeter are in good agreement (Figs. 2 and 3).

The record for the longest period (around 4 months) of the CG3-M gravimeter was studied

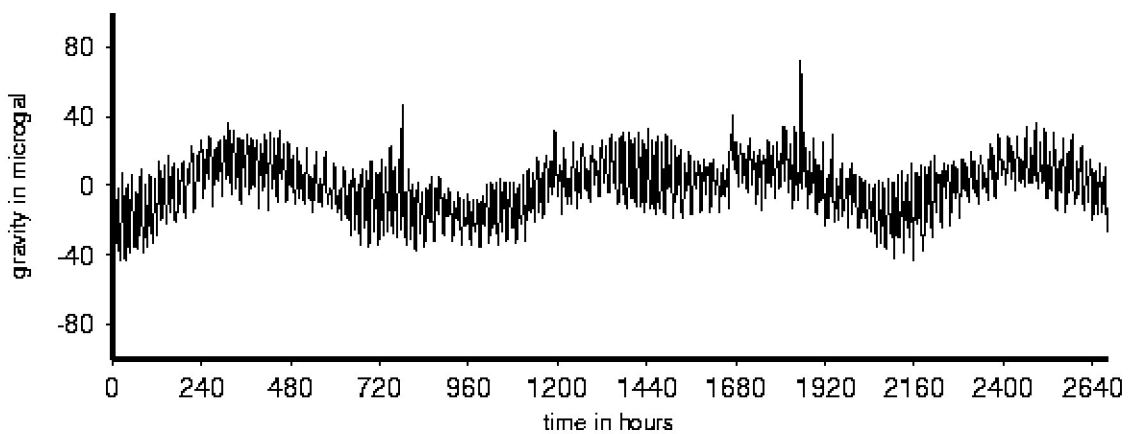


Fig. 4 - Residual signal after Earth tide corrections.

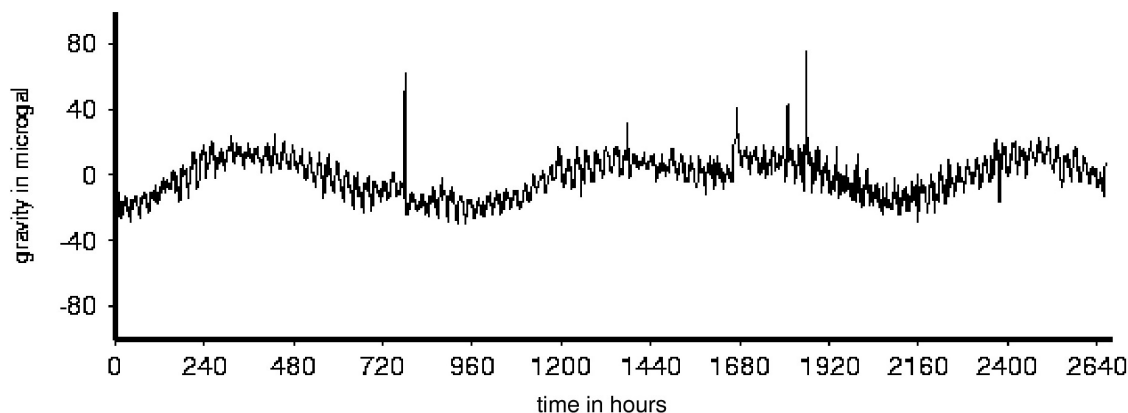


Fig. 5 - Residual signal after Earth tide corrections and oceanic loading deduced from measurements.

with the harmonic analysis method and compared with the water levels measured at the tide gauge. As expected, the signal exhibits the diurnal and semi-diurnal Earth tide waves. But the ter-diurnal waves are noisy.

After correction for solid Earth tide (Fig. 4), the residual signal presents two distinct parts:

- a semi-diurnal term in phase with the sea tide. This is interpreted as the ocean loading effect (Fig. 5). Its range reaches $40 \mu\text{Gal}$ for the main spring equinoctial tide. For comparison, oceanic loading models provide lower values in coastal areas (about $30\text{-}34 \mu\text{Gal}$);
- a diurnal term which could be due to natural or human causes.

A simple relationship then appears between the water level and the gravity ocean-loading changes. It can be expressed with a proportionality factor equal to $0.059 \mu\text{Gal/cm}$ for the region of Brest. This result is significant especially for correcting microgravity surveys close to the tide gauge.

3. Conclusions

Further studies will be conducted to explain, above-all, the residual loading signal. GPS data will also be analyzed to estimate, precisely, the height differences between the two stations related to our results.