Contribution from laser, GPS, and absolute gravimetry to the study of seasonal effects on vertical positioning

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The study of the temporal stability of the geodetic stations is of great importance to better understanding the positioning time variations for the new representation of the terrestrial reference frame. For this, the comparison of different techniques is essential to de-correlate the geodynamical signal from instrumental and processing effects, and then to compare the observations to geodynamical models.

We present an example of the contribution of different collocated techniques to monitor the vertical displacements of the Grasse fundamental geodetic observatory, located in the Southern Western French Alps on an ~1270 m high karstic plateau. This study concerns the comparison of the time series of 3 independent geodetic techniques: Satellite Laser Ranging (SLR), GPS, and Absolute Gravimetry (AG) on a 6-year period spanning 1998-2003.
We summarize for each technique the observations and the analysis method used to compute the different time series considered in this study. Then, we present the results and discuss the observed seasonal signals that appear on both SLR and GPS time series of the vertical component. The good agreement between the two independent techniques suggests a true physical annual vertical displacement of 5 to 6 mm in amplitude. The repeated AG measurements also exhibit a clear annual signal of several microGals amplitude. We discuss the impact of the Newtonian effect and the impact of the GPS and SLR data processing methods on the annual signal. We analyze local GPS baselines to separate local from regional effect contributions to the whole signal. Finally, we show a comparison between the observations and global geodynamical models of the different loading effects (atmosphere, ocean, and hydrology) to better understand the annual signal.
At Grasse, we showed a good agreement between the seasonal variations observed by each technique and the loading models, even if some discrepancies exist. The annual signal is mainly explained by large scale geodynamical phenomena and in particular by hydrological loading. To go further in this study, some other points have to be considered, such as the impact of the IB or non-IB hypothesis for the Mediterranean Sea or the effect of the local topography in the loading model computations since the Grasse station is located close to the sea (~20 km) on the southern extent of the French Alps (strong altitude variations over short distances). The topography effect should be non negligible on the time series computed from models, and particularly for the gravity variations.

This study shows that strong seasonal variations exist, mainly on the vertical positioning (6 mm at Grasse for the annual component for instance) which are non negligible for the new representation of the reference frame in terms of time series. The amplitude of the signal is close to the accuracy of each individual technique which makes more delicate this realization. It shows that the temporal stability study of the geodetic stations is very important for the terrestrial reference frame realization. The comparison of different techniques is thus essential to isolate the geodynamical signal from instrumental and processing effects. For this, it is of great importance to have several sites with different collocated techniques and to combine different techniques to fully exploit the potential of each individual technique. Moreover, AG measurements offer the unequalled advantage of being absolute and not reference system dependent, and provide an independent way to constraint the long term stability of the geodetic sites.

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