Twangs: Charge Re-distribution due to Atmospheric Influences

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The GRACE (Gravity Recovery and Climate Experiment) satellite mission observes Earth' gravity field since 2002 with unprecedented accuracy in it's temporal component. However, not all signals within accelerometer data are clearly resolved yet and it remains uncertain whether they have an impact onto the gravity field models built upon GRACE's observations.

In our study we focus on so-called twangs which describe a sudden, yet strong, signal in the accelerometer data having its main impact on the radial component. Twangs can be characterized through a high frequency, often consisting of two or three peaks, which may be followed by an oscillating decay.

We managed to separate twangs into two main types of twangs (cf. Fig. 1), whereas we believe subtypes exist. One type (Fig. 1 left) consists of 2 peaks, but the pattern up-down or down-up of the peaks may vary. The other type (Fig. 1 right) consists of 3 peaks – here also the pattern may vary and the signal length for the 3 peaks is about as long as for the prior introduced type. Both types may occur with an oscillating decay and are comparable in accelerometer data of both GRACE satellites.

These twangs appear to be repetitive and we are now able to build models for these two types of twangs and some of their subtypes by superimposing accelerometer data reflecting the same twang found via cross-correlation.

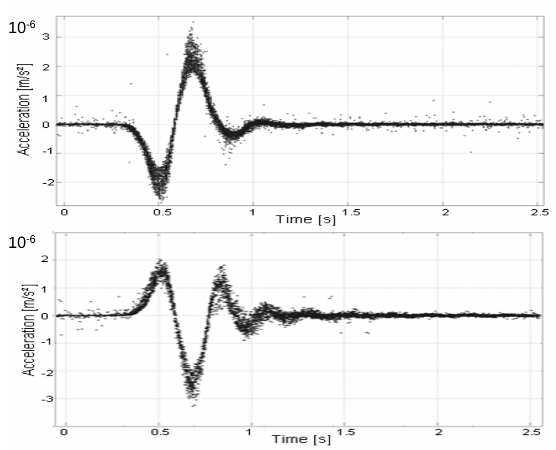
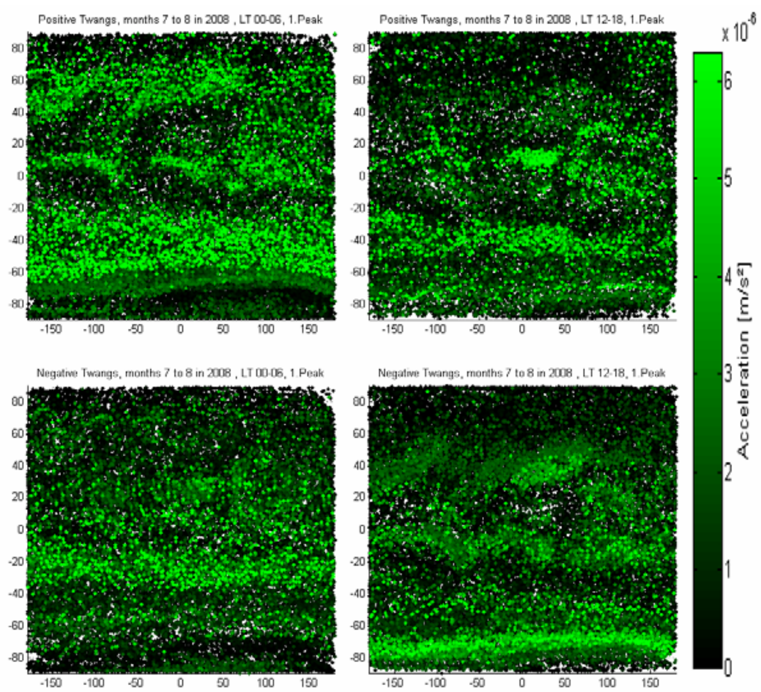


***Fig.1:** Two main types of twangs found in accelerometer data*

Spatial distribution and temporal variability of twangs



When local time is set to a specific time globally, patterns formed by twangs reveal correlations to Earth' magnetic field as well as to ionosphere. These distributions may change by either season (respectively orbit) or local time.

In Fig. 2 the spatial distribution of twangs found in accelerometer data of GRACE B during the months July and August of year 2008 are displayed. It is obvious that the twangs appear to follow very distinct patterns that are apparantely geographically correlated.

For the upper left and the lower right image the distribution of twangs appear to form the Auroral Oval concerning the magnetic pole of the southern hemisphere. This is a strong indicator for an impact of the ionosphere on GRACE accelerometer data as the ionosphere shows up to have a very high density in the Auroral Oval regions.

Also at other times a distribution of twangs concerning the Auroral Oval, i.e. the radial component of the Earth' magentic field, can be observed. In the wintermonths of the northern hemisphere the twangs are aligned to these structures tightly.

Also other patterns can be observed in Fig. 2 and it becomes clear that a mechanism from the outside must be the trigger for a twang to happen. Yet, not all patterns could be clearly correlated to strict ionospheric structures. Moreover it becomes clear, that distribution is strongly depending on the local time, i.e. solar impact. The distribution of twangs between the local times between 00-06 (left column) and 12-18 (right column) is visible.

Although not all twangs could be clearly linked so far, further investigations might contribute to a better understanding of how ionosphere is composed and densities are distributed in altitudes commonly used for geodetic space missions.

***Fig. 2:** Global distribution of twangs in accelerometer data of GRACE B in July/ August of 2008 at a local time between hours 00-06 and 12-18. The dots represent the amplitude of the first peak of the twang.*

Hypothesis: Re-Distribution of Charges

GRACE satellites planes consist of non-conductive material, quartz for the solar array planes and a teflon-foil on the nadir side of the satellite. Due to ionosphere, ions or electrons may be stuck on these planes, building up a potential between the charge on the outside and the satellites ground. This charge can be re-distributed over the entire satellite if the material gets conductive or the break-through voltage is attained. Coffey and Nanevicz showed that teflon and fused quartz can get photoconductive if the material is exposed to x-ray radiation (cf. Fig. 3).

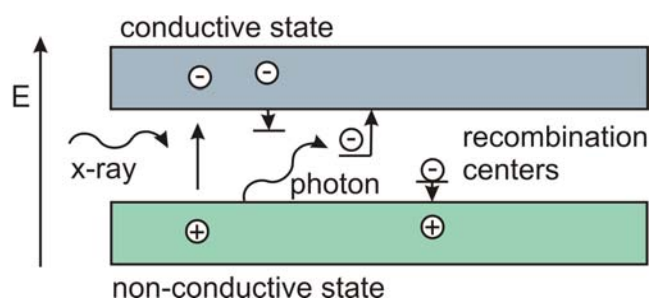


***Fig.3:** Schematic overview about x-ray induced photoconductivity of the material Teflon as used for the nadir site of the GRACE satellites.*

References

Coffey, H.T.; Nanevicz, J.E.; "Photoconductivity of high voltage space insulating materials: Measurements with metal electrods" interim Technical NASA Report, 1974 – 1975.

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