# Upgrade of the GOCE Level 1b Gradiometer Processing

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## Introduction

The electrostatic gravity gradiometer onboard GOCE is the first instrument of its kind, consisting of three pairs of three-axis accelerometers. The gradiometer processing, being a part of the GOCE Level 1b processor, transforms accelerometer and star sensor measurements into gravity gradients. Based upon the experience with this new kind of data, an effort was undertaken to improve the gradiometer processing. On this poster we present the planned upgrade of the gradiometer processing and the impact on Level 1b and Level 2 products.

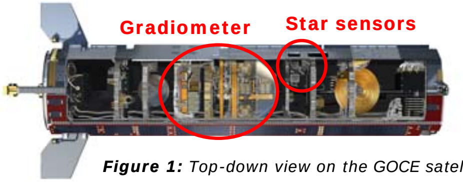


***Figure 1:*** *Top-down view on the GOCE satellite.*

## Calibration of accelerations

The calibration parameters are retrieved from data recorded during a dedicated satellite shaking procedure. Since the beginning of the nominal operations the satellite shaking procedure has been executed approximately every two months. The results show that the calibration parameters linearly drift over time, which is confirmed by the monitoring of the calibration parameters. Therefore, it is planned to linearly interpolate the calibration parameters.

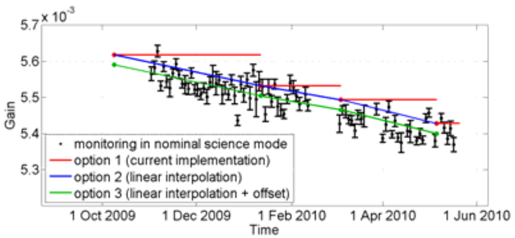


***Figure 3:*** *Evolution of calibration parameter ds25y.*

## Combination of star sensors

The attitude measured by a star sensor is ten times worse about the star sensor's boresight than about axes in the focal plane. Since GOCE has three star sensors onboard which are pointing into different directions (see Figure 1), the weak boresight component of one star sensor is a strong focal plane component of another star sensor. Thus, the combination of star sensors yields the attitude with only strong components.

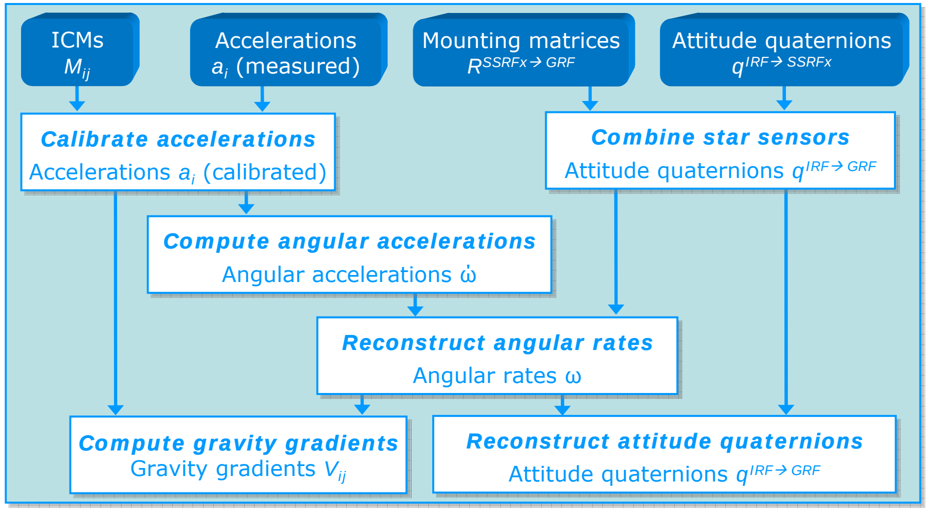


***Figure 2:*** *Data flow in the upgraded GOCE Level 1b Gradiometer Processing. The upgraded components are: calibration of accelerations, combination of star sensors, reconstruction of angular rates, reconstruction of attitude quaternions.*

## Angular rate reconstruction

The angular rates are reconstructed from the attitude measured by the star sensors and the angular accelerations measured by the gradiometer. The first step in the reconstruction is to differentiate the attitude and to integrate the angular accelerations, both in time, for obtaining angular rates of the star sensor and the gradiometer.

Then, the star sensor's and gradiometer's angular rates are combined using a Wiener filter implemented in the time domain. The spectral weights $W^{GRAD}$ and $W^{STAR}$ of the Wiener filter are chosen according to

$$W^{GRAD}(f) = P^{STAR}(f) \,/\, (P^{STAR}(f) + P^{GRAD}(f))$$
$$W^{STAR}(f) = P^{GRAD}(f) \,/\, (P^{STAR}(f) + P^{GRAD}(f))$$

where $P^{STAR}$ and $P^{GRAD}$ are model PSDs for the star sensor and gradiometer noise. Finally, the coefficients of the Wiener filter in the time domain are computed from the spectral weights by a discrete inverse Fourier transform.

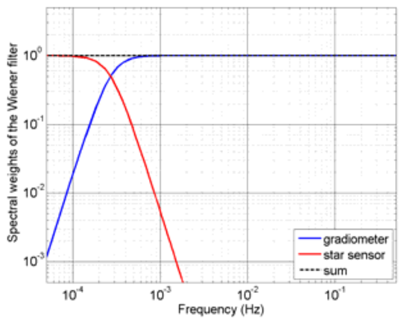


***Figure 4:*** *Spectral weights of the Wiener filter.*

## Attitude reconstruction

The attitude is reconstructed from the attitude measured by the star sensors and the reconstructed angular rates. The first step is to compute integrated quaternions. This is performed by rotating an initial attitude quaternion by the reconstructed angular rates. Then, the integrated quaternions are combined with the quaternions measured by the star sensor using the same Wiener filter as in the angular rate reconstruction.

## Impact on Level 1b Products

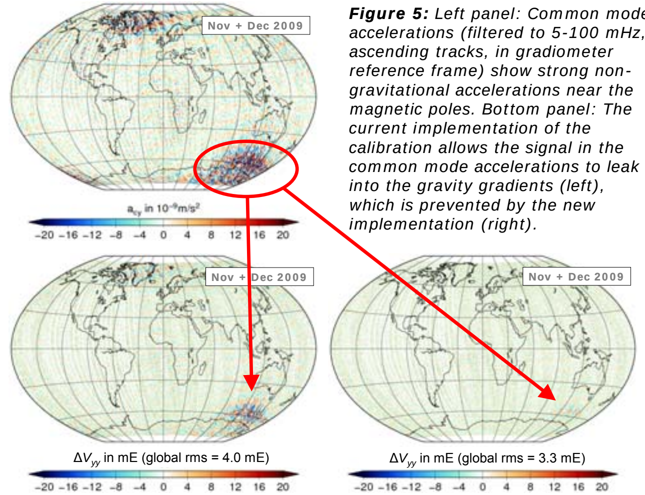


***Figure 5:*** *Left panel: Common mode accelerations (filtered to 5-100 mHz, ascending tracks, in gradiometer reference frame) show strong non-gravitational accelerations near the magnetic poles. Bottom panel: The current implementation of the calibration allows the signal in the common mode accelerations to leak into the gravity gradients (left), which is prevented by the new implementation (right).*

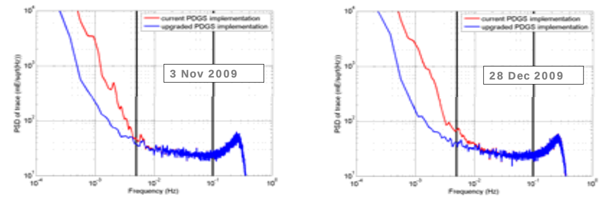


***Figure 6:*** The trace of the gravity gradients improves significantly bellow 20 mHz due to the upgraded gradiometer processing.

## Impact on Level 2 Products

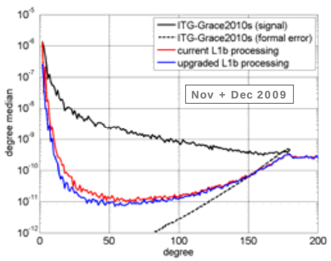


***Figure 7:*** Degree median of differences to ITG-Grace2010s.

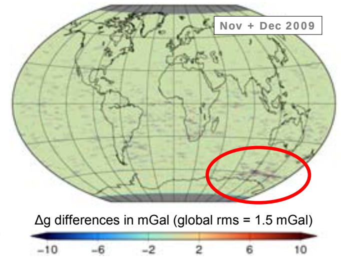


***Figure 8:*** Gravity anomaly differences due to upgraded processing (degrees 50-200).