Improvements of the Swarm Accelerometer Data Processing

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Introduction

The Swarm satellites were launched on 22 November 2013 and carry accelerometers and GPS receivers as part of their scientific payload. The GPS receivers are not only used for locating the position and time of the magnetic measurements, but also as a scientific payload for the determination of gravity field models, non-gravitational forces acting on the spacecraft and the total electron content.

The accelerometers measure the non-gravitational forces acting on the spacecraft, at much finer resolution than the GPS receivers. On this poster we present the processing that we apply in order to transform the raw acceleration measurements into scientifically valuable thermospheric neutral densities. A first data set is released for Swarm C, May 2014 – June 2015. The extension to September 2015 is in progress.

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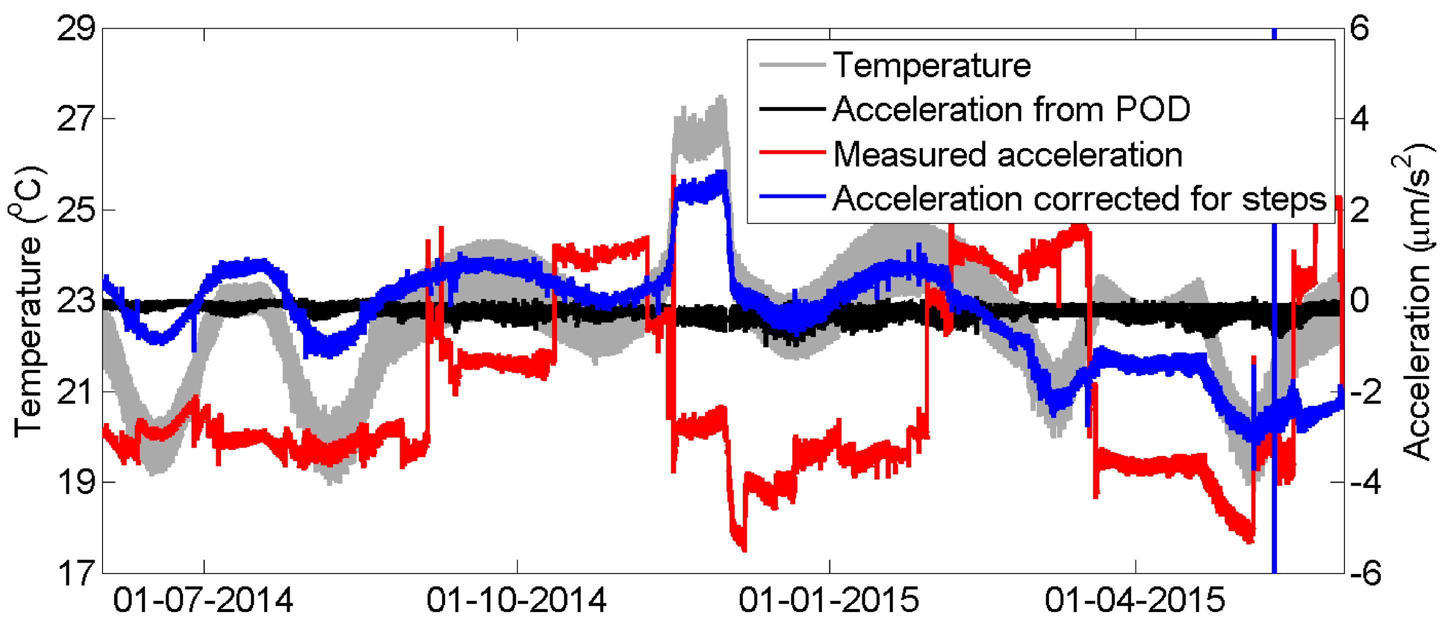
Step correction

The raw accelerations suffer from a large number of steps (red curve), which are corrected in a largely manual process using a dedicated software tool. The step-corrected accelerations (blue curve) show a high correlation to temperature (grey curve). The step correction is available in the ACCxCAL_2_ products.



Temperature correction

The temperature correction accounts for a delayed and dampened response of the accelerations to temperature variations.

Linearization of temperature

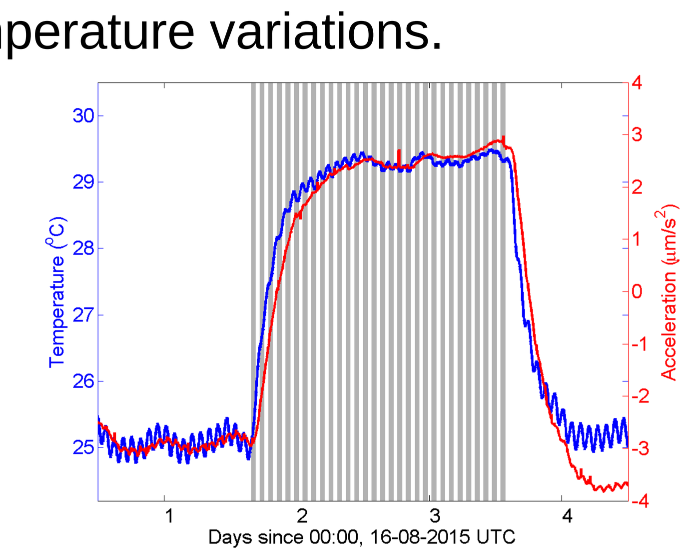
$T_B(t + \Delta t) = T_B(t) + \Delta t\, (dT_B/dt)(t)$

Heat flow

$dT_B/dt = P_{A\to B}/C$

Model for radiation heat flow

$P_{A\to B} = (T_A^4 - T_B^4)\, k$ T_A and T_B in Kelvin



Model for heat transfer

$T_B(t + \Delta t) = T_B(t) + \Delta t\, P_{A\to B}(t)/C = T_B(t) + \Delta t\, (T_A(t)^4 - T_B(t)^4)\, k/C$

Temperature correction

$b_{temp}(t) = c_A T_A + c_B T_B$ k/C, c_A and c_B are control parameters

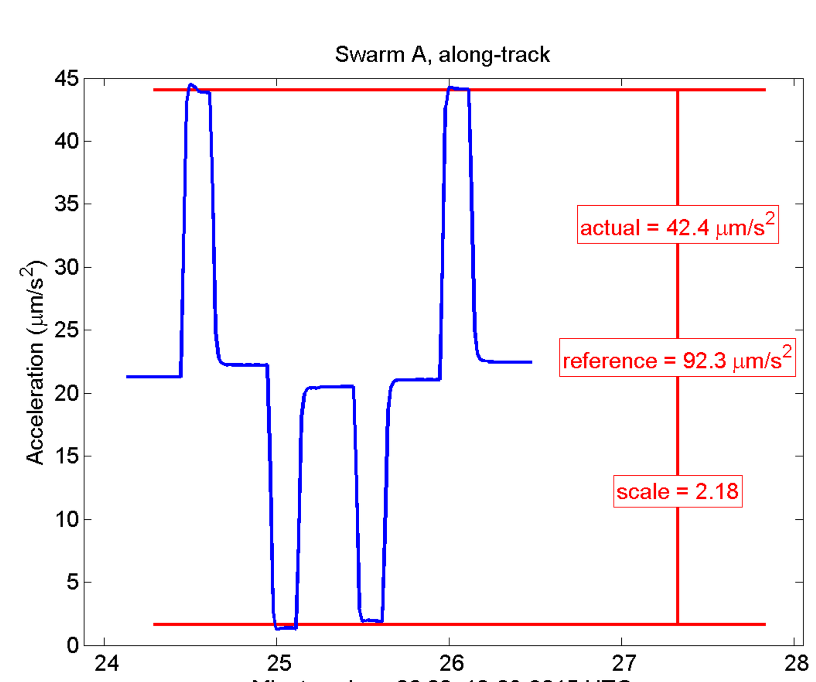
Calibration

The calibration model includes a scale factor, the temperature correction, and a slowly drifting bias, which is modelled by quadratic b-splines (all contained in the ACCxCAL_2_ products).

$$a_{cal}(t) = s(t) \times \left(a_{raw}(t) + a_{step}(t)\right) + b_{temp}(t) + b_{drift}(t)$$

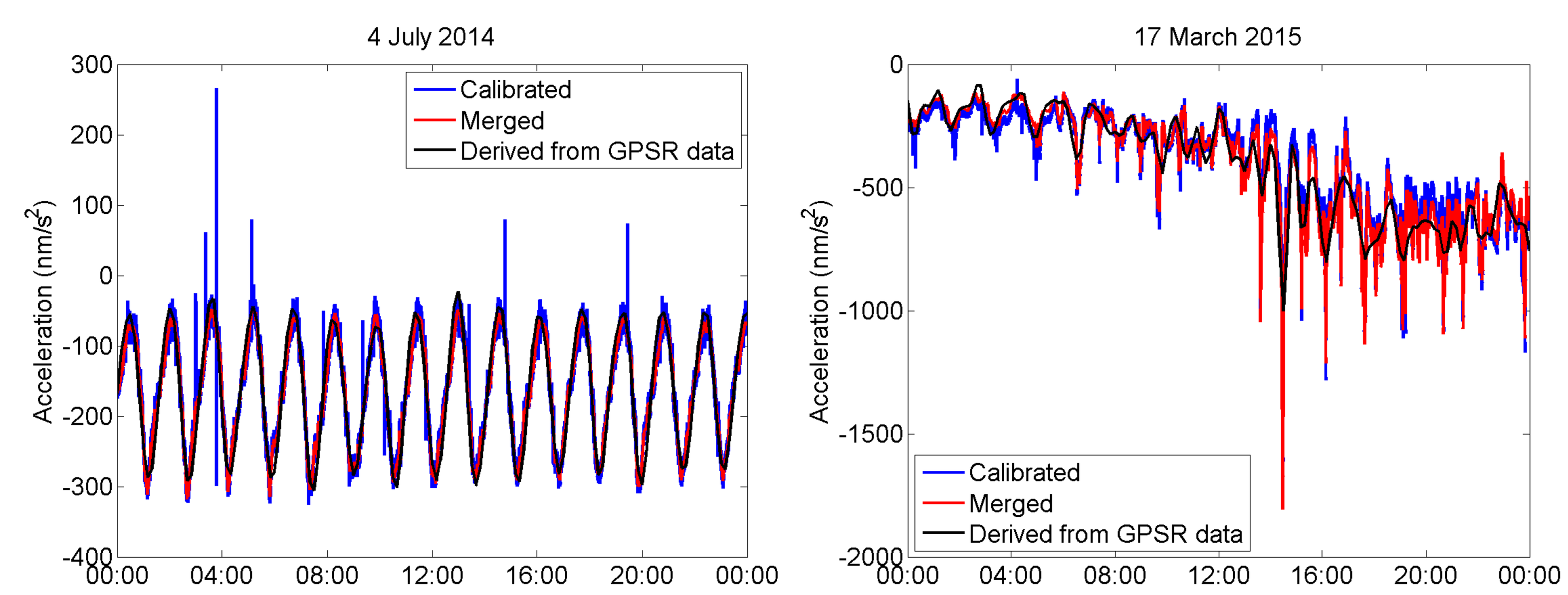
The parameters of the calibration model are estimated in a fit against accelerations estimated from GPS receiver data in precise orbit determination process (contained in the ACCxPOD_2_ products).

The scale factor is often derived from a dedicated calibration maneuver, where thrusters create a reference acceleration that is known with an accuracy of ~10%.



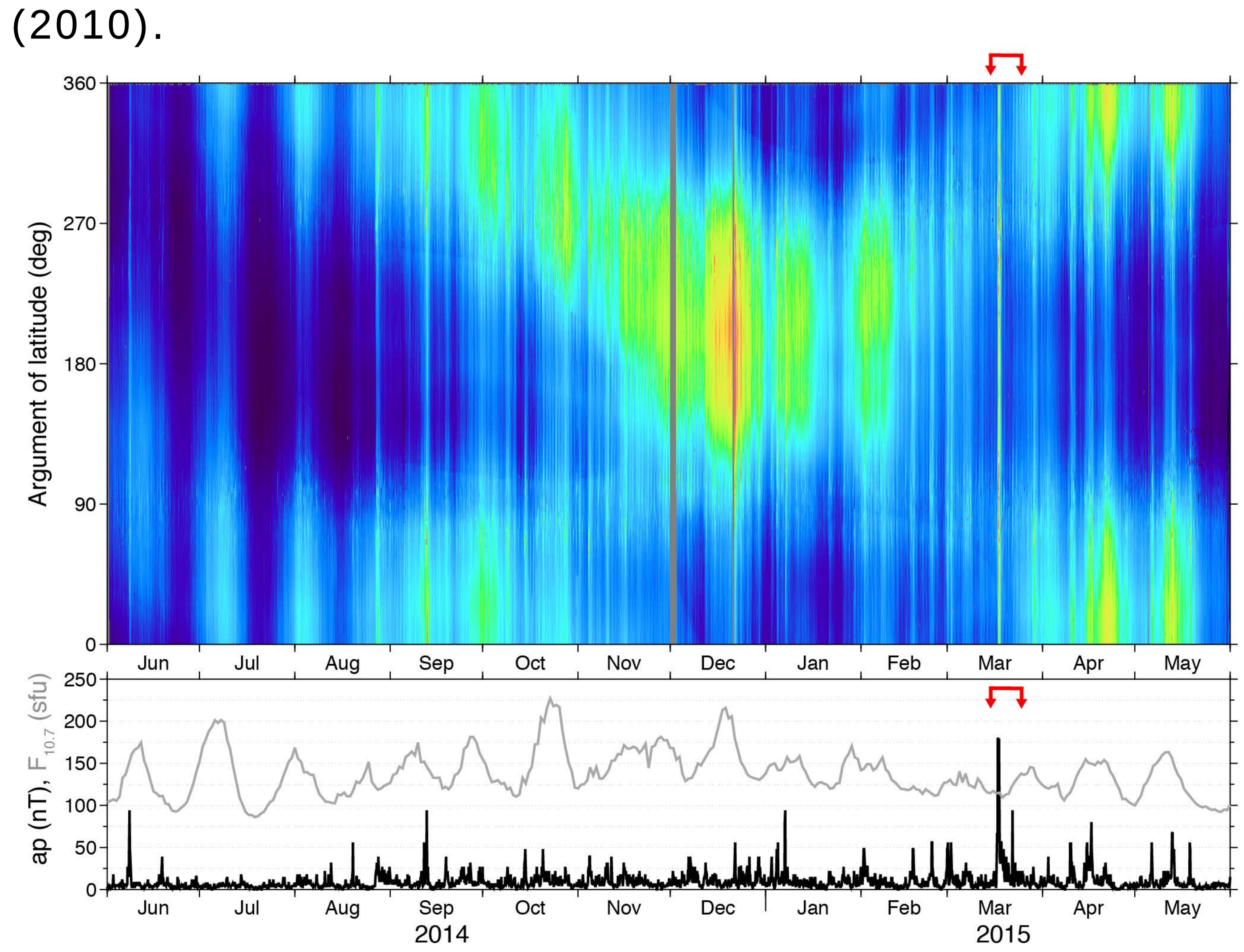
Frequency slicing

The frequency slicing merges calibrated accelerations (blue curve) with accelerations derived from GPS receiver data (black curve) by taking a weighted average in the spectral domain. In this processing step, we replace the drifting bias of the calibration model, which is perceived as an empirical parameter needed for estimating the other calibration parameters correctly. The merged accelerations (red curve) and final bias are contained in the ACCx_AE_2_ products.



Aerodynamic accelerations and thermospheric neutral density

The merged accelerations are transformed into aerodynamic acceleration by subtracting radiation pressure from the Sun, Earth's albedo and Earth's infrared radiation (contained in the ACCx_AE_2_ products). The aerodynamic acceleration is then transformed into thermospheric neutral density (contained in the DNSxWND_2_ products) following Doornbos et al. (2010).



References

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E Doornbos, J van den IJssel, H Lühr, M Förster, G Koppenwaller (2010) Neutral density and crosswind determination from arbitrarily oriented multiaxes accelerometers on satellites. Journal of Spacecraft and Rockets, 47(4):580-589.