Newly derived thermospheric products for CHAMP, GRACE, GOCE and Swarm

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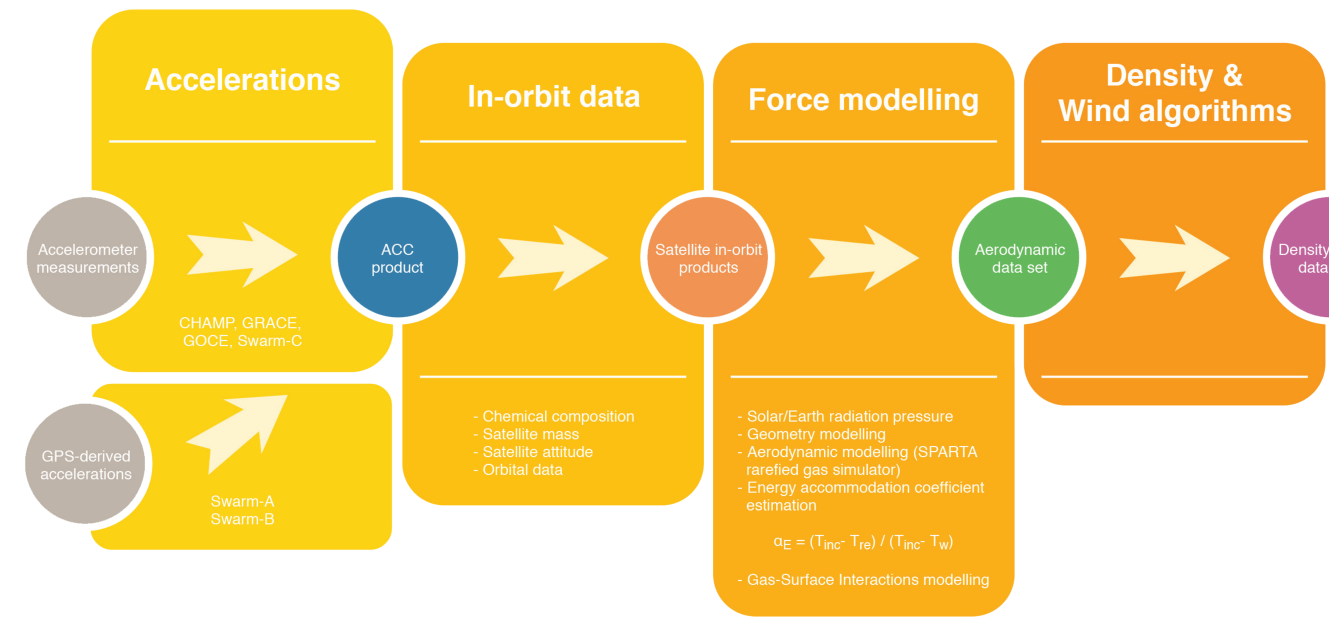
Density and wind from satellite accelerations

Accelerometers and GPS reveivers on satellites provide information about aerodynamic accelerations, which are controlled by density and wind in the upper atmosphere. With the help of high-fidelity satellite geometries and rarefied gas simulatons, we can retrieve this information from the satellite data. Currently, density data sets are available for the CHAMP, GRACE, GOCE and Swarm satellites. Horizontal wind estimations are available for the CHAMP and GOCE missions.

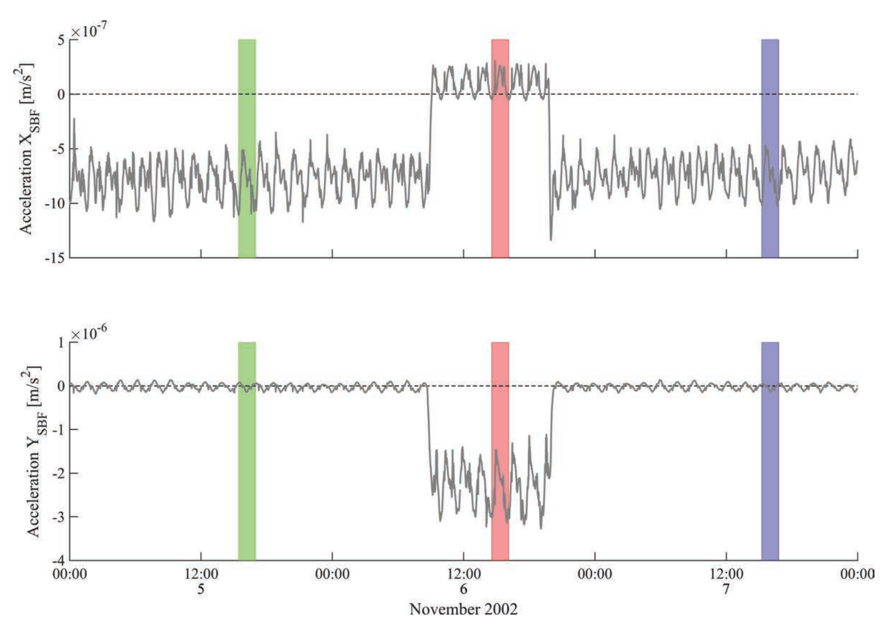
In order to enhance products fidelity, it is important to estimate the gas-surface interactions (GSI) parameters. One of these crucial parameters is the energy accommodation coefficient (α_E), which provides a tangibile value for the exchanged energy in the collisions between atmospheric particles and satellite surfaces.

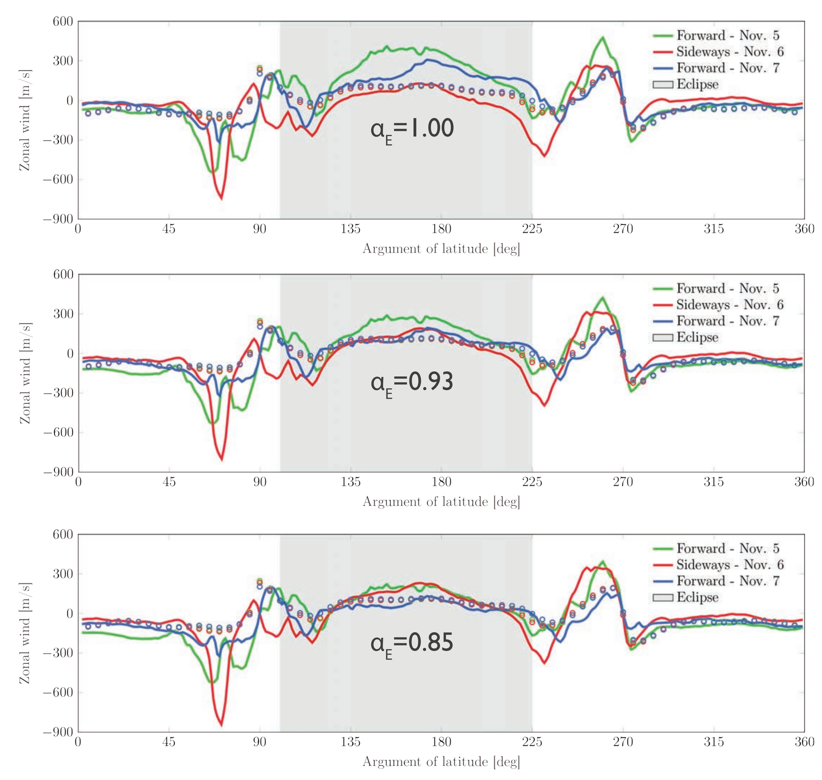
Within this study, an enhanced geometry and aerodynamic modelling with a better characterization of gas-surface interactions aims to reduce uncertainties. Long periods and attitude manoeuvres have been investigated in order to characterize the GSI modelling and to enhance the consistency of density and wind products.



CHAMP manoeuvre analysis

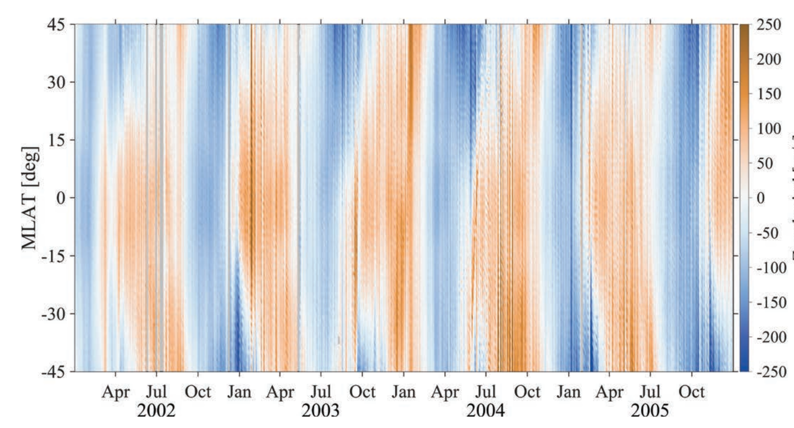
The CHAMP sideways manoeuvre occurred in November 2002 provides a great opportunity to investigate wind consistency as a function of the gas-surface interaction modelling. The results were inter-compared in a short time domain and with the HWM-14 wind model (drawn using open circles). Looking at the three different zonal wind plots, wide variations in wind between the three estimated subsets are obtained for accommodation coefficients of 1.00 and 0.93. The differences reduce for α_E=0.85. A further decrease of the accommodation coefficient brings back to larger discrepancies.



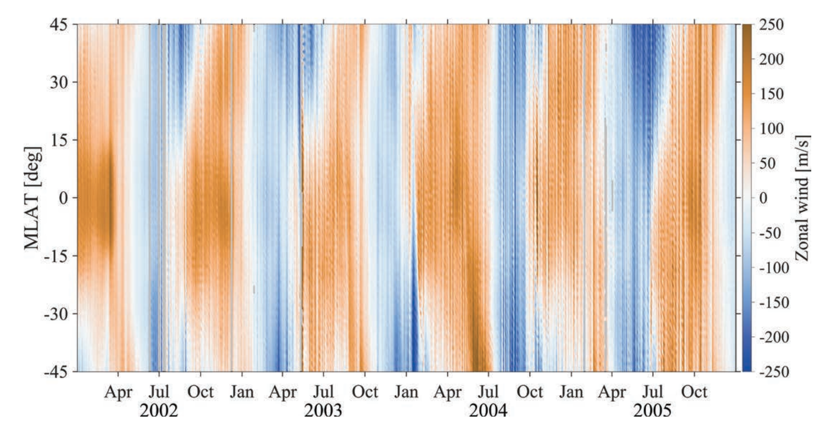


Decreasing the accommodation coefficient from the fully diffusive case (α_E=1.00) a minimum in the difference between the three subsets of zonal winds can be detected. Selecting all the possible orbits within the manoeuvre and comparing the results with the previous and following day data, a better consistency is achieved for α_E=0.85.

For this optimal value, the zonal wind can be processed between 2002-2006 as follow. Zonal wind as a function of the magnetic latitude (MLAT) can be illustrated for ascending (left) and descending (right) orbit sectors.



Ascending mean zonal wind

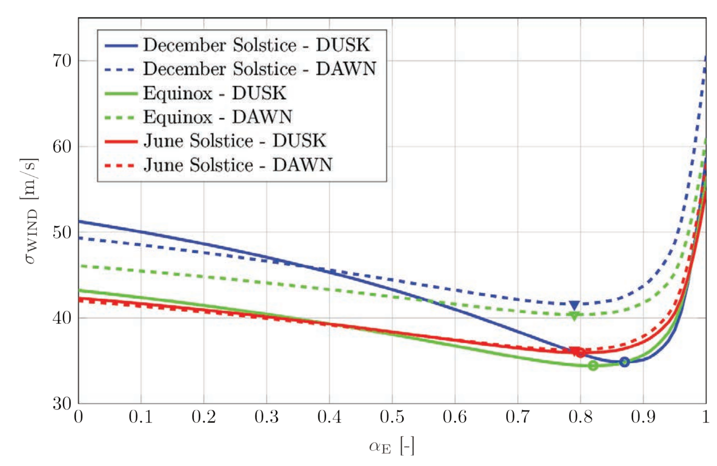


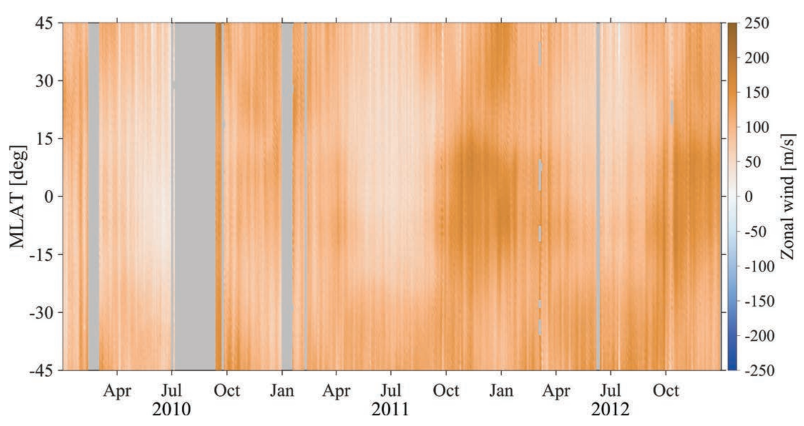
Descending mean zonal wind

Horizontal wind from GOCE

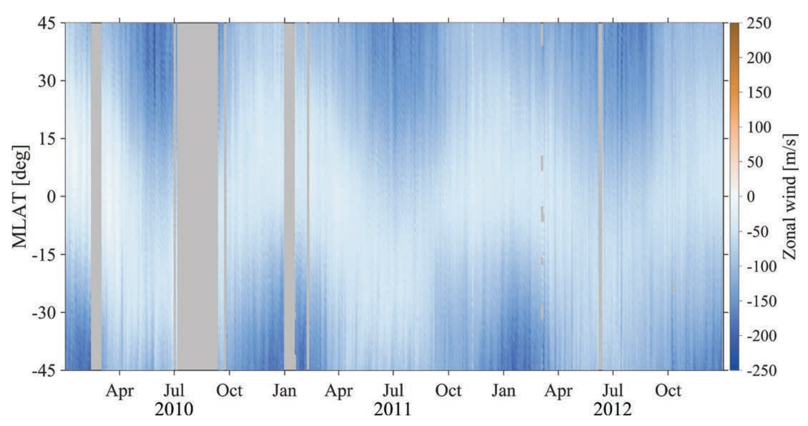
The observed wind can be subdivided into three seasonal bins. Each bin includes four months of data: December solstice (between November and February), Equinox (March, April, September, October) and June solstice (between May and August). In order to investigate the GSI features to get more consistent data, the standard deviation of the zonal wind observations (σ_{WIND}) is analyzed.

For the GOCE satellite these values are between 35 and 70 m/s. Minima in standard deviation are below the previously adopted α_E value of 0.93. Depending on the seasonal bin the optimal value for α_E converges to an average of 0.82, which is currently used in the V2 GOCE density and wind processing as part of the official ESA production.



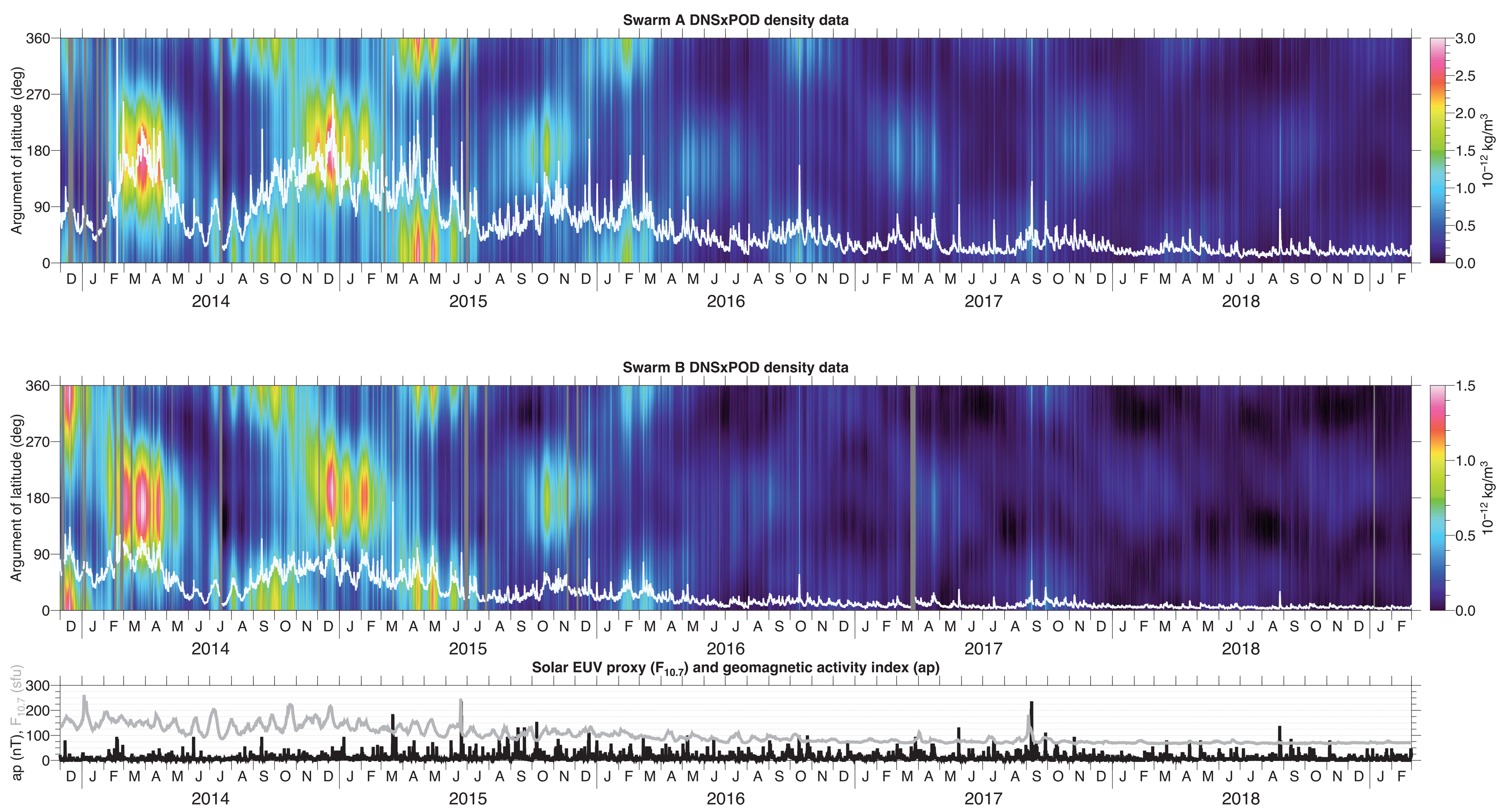


Ascending (Dusk) mean zonal wind



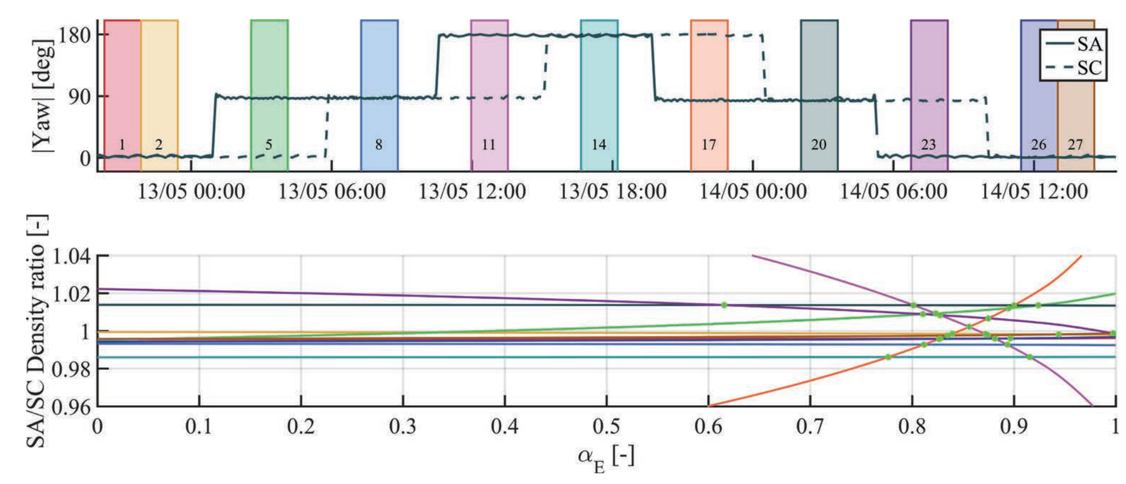
Descending (Dawn) mean zonal wind

Swarm neutral density



Accelerometers onboard of the Swarm satellites provided data with many anomalies. The development and production of GPS-derived accelerations has been necessary for density processing. Currently, the ESA neutral density data (L2 DNSxPOD products) uses the high-fidelity geometry and an energy accommodation of 0.93.

Similarly to CHAMP, the manoeuvre in May 2014 suggests an optimal α_E around 0.85. This value might be included in the processing for the next data dissemination.



Conclusions and future work

The accommodation coefficient turned out to have a relevant impact on density and wind products. A lower value with respect to the currently adopted one is suggested for having a higher level of consistency in thermospheric density and wind.

A better estimation of thermospheric density and wind products can be achieved with an improved solar radiation pressure modelling. This is especially valid for satellites with high altitudes like Swarm-B and GRACE.

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