Horizontal and Vertical Wind Measurements from GOCE Angular Accelerations

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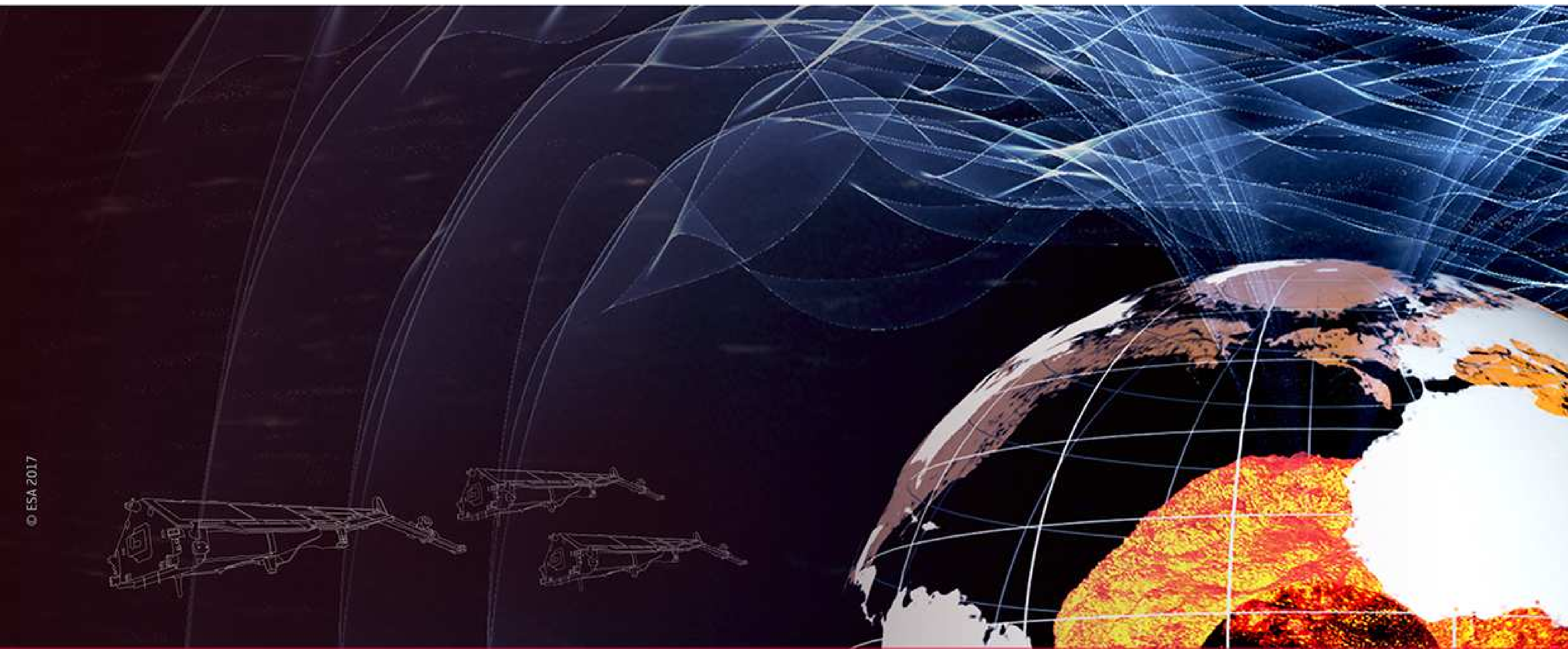
Publication date
2017

Document Version
Final published version

Citation (APA)
Visser, T., Doornbos, E., de Visser, C., & Visser, P. (2017). *Horizontal and Vertical Wind Measurements from GOCE Angular Accelerations*. 81-81. Abstract from 4th Swarm Science Meeting & Geodetic Missions Workshop, Banff, Canada.

→ FOURTH SWARM SCIENCE MEETING AND GEODETIC MISSIONS WORKSHOP

ESA's magnetic field and geospace explorer constellation mission widening the context



ABSTRACT BOOK

20–24 March 2017 | Banff, Alberta, Canada higher fidelity density estimates. An overview of achieved improvements and dataset comparisons will be provided together with an introduction to the next gas-surface interactions research phase.

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GPS-derived Density Data for the Swarm Satellites During the Declining Phase of the Solar Cycle

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After the detection of many anomalies in the accelerometer data, the development and production of GPS-derived acceleration and thermosphere density products for the three Swarm satellites has been intensified. In order to convert the range and phase information in the Swarm GPS measurements into accelerations, a precise orbit determination approach needs to be used, in which gravitational accelerations are modelled with a very high fidelity, but in which the non-gravitational accelerations are part of the parameters to be estimated. After initial tests with both batch least-squares and Kalman filter orbit determination approaches, a Kalman filter approach was tuned and selected for computing the acceleration data. The resulting GPS-derived accelerations currently serve as a baseline for the correction of Swarm C along-track accelerometer data. In addition, the GPS-derived accelerations for all three Swarm satellites are converted directly to thermosphere neutral density data. This GPS-derived density data can serve as a replacement for the originally planned accelerometer thermosphere density products, albeit at a much lower temporal resolution than the accelerometers would have been able to deliver. The accuracy at which accelerations, and subsequently densities, can be derived from the GPS range and phase observations depends on the parameterisation in the orbit determination process. In principle, a higher accuracy can be traded off against a lower temporal resolution. An additional source of error is the modelling of radiation pressure accelerations, which need to be removed from the estimated signal to arrive at the aerodynamic accelerations, which are used as a source to determine density. We have assessed the impact of the declining solar activity level on the currently available acceleration and density data, as well as the impact of various scenarios for the future evolution of the Swarm orbits. Most of the currently available data contains a significant signal well above 2 cycles per orbit revolution at high solar activity. At low solar activity this maximum significant frequency is reduced. A complicating factor is that it would not be very useful for the interpretation of the data to estimate the accelerations and densities above 1 but below 2 cycles per revolution. Currently, the Swarm satellites are still in relatively high orbits, while solar activity is getting lower. Our conclusion is that with the current level of error sources, and keeping the orbits at the current altitude or higher, as proposed in some scenarios, will make it very difficult to resolve latitudinal density variability at solar minimum, using Swarm GPS data.

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Horizontal and Vertical Wind Measurements from GOCE Angular Accelerations

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Because of the highly accurate accelerometers, the GOCE mission has proven to be a unique source of thermosphere neutral density and cross-wind data. In the current methods, in which only the horizontal linear accelerations are used, the vertical winds cannot be obtained. In the algorithm proposed in this paper, angular accelerations derived from the individual gradiometer accelerations are used to obtain the vertical wind speeds as well. To do so, the measured angular rate and acceleration are combined to find a measurement of the torque acting on the spacecraft. This measurement is then corrected for modeled control torque applied by the magnetic torquers, aerodynamic torque, gravity gradient torque, solar radiation pressure torque, the torque caused by the misalignment of the thrust with respect to the center of gravity, and magnetic torque caused by the operation of several different subsystems of the spacecraft bus. Since the proper documentation of the magnetic properties of the payload were not available, a least squares estimate is made of one hard- and one soft-magnetic dipole pertaining to the payload, on an aerodynamically quiet day. The model for aerodynamic torque uses moment coefficients from Monte-Carlo Test Particle software ANGARA. Finally the neutral density, horizontal cross-wind, and vertical wind are obtained from an iterative process, in which the residual forces and torques are minimized. It is found that, like horizontal wind, the vertical wind responds strongly to geomagnetic storms. This response is observed over the whole latitude range, and shows seasonal variations.

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