



## Special issue "Swarm science results after 2 years in space"

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PREFACE

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# Special issue “Swarm science results after 2 years in space”

Nils Olsen<sup>1\*</sup>, Claudia Stolle<sup>2</sup>, Rune Floberghagen<sup>3</sup>, Gauthier Hulot<sup>4</sup> and Alexey Kuvshinov<sup>5</sup>

*Swarm* is a three-satellite constellation mission launched by the European Space Agency (ESA) on 22 November 2013. It consists of three identical spacecraft, two of which (*Swarm Alpha* and *Swarm Charlie*) are flying almost side-by-side in polar orbits at lower altitude (about 470 km in September 2016) with an East-West separation of 1.4° in longitude corresponding to 155 km at the equator. The third satellite (*Swarm Bravo*) is in a slightly higher orbit (about 520 km altitude in September 2016). Each of the three satellites carry a magnetometry package (consisting of absolute scalar magnetometer, fluxgate vector magnetometer, and star imager) for measuring the direction and strength of the magnetic field, and instruments to measure plasma and electric field parameters as well as gravitational acceleration. Time and position are provided by on-board GPS. The configuration of the various instruments on each of the three *Swarm* spacecraft is shown in Fig. 1. More information about the mission can be found at <http://earth.esa.int/swarm>.

The 21 articles collected in this special issue were stimulated by the Joint Inter-Association Symposium “JA4 Results from Swarm, Ground Based Data and Earlier Satellite Missions” at the 26th General Assembly of the International Union of Geodesy and Geophysics (IUGG) held in Prague in July 2015.

Tøffner-Clausen et al. (2016) report on the advanced calibration of the magnetometry package of the *Swarm* satellites. Finlay et al. (2016) and Olsen et al. (2016) present models of Earth's core magnetic field, while Thébaud et al. (2016) and Kotsiaros (2016) determine models of the lithospheric field. The importance of high-resolution magnetic field models for studying external magnetic

field contributions, in particular during geomagnetic quiet conditions, is discussed by Stolle et al. (2016).

Five contributions discuss the magnetic field produced by ionospheric and magnetospheric currents: Chulliat et al. (2016) present a climatological model of the ionospheric currents responsible for geomagnetic daily variations at non-polar latitudes, while the work of Laundal et al. (2016) concentrates on a consistent description of horizontal ionospheric and field-aligned currents in the polar ionosphere, in particular regarding their dependence on solar irradiation that controls ionospheric conductivity. A scheme for estimating the polar ionospheric currents that form the Polar Electrojets on an orbit-by-orbit basis is presented by Aakjær et al. (2016), while Tozzi et al. (2016) discuss unmodelled magnetic field contributions in satellite-based magnetic field models. Michelis et al. (2016) present a study of high-latitude magnetic field variations during the St. Patrick's Day Storm.

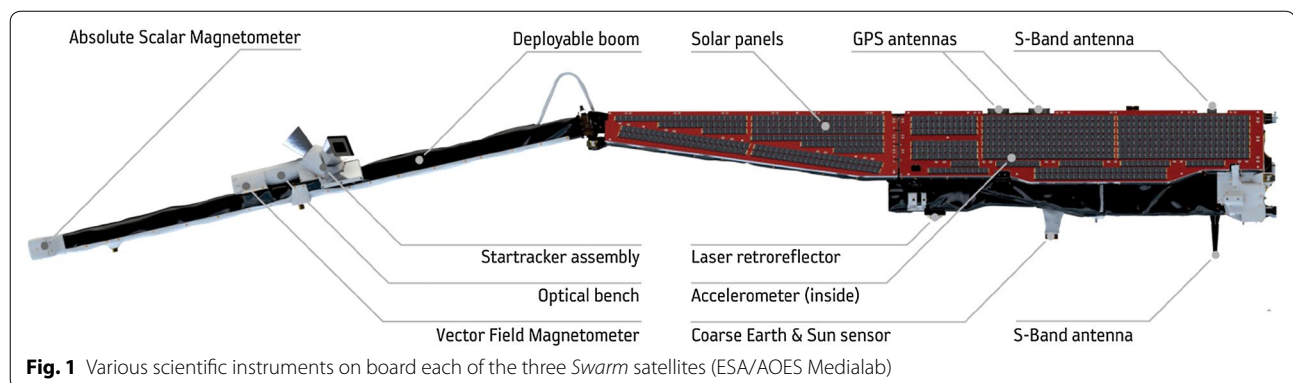
The same event is investigated by Pignalberi et al. (2016) using *Swarm* plasma density measurements, and by Cherniak and Zakharenkova (2016) using GPS data from ground and *Swarm*.

Calibration of the electric field instrument of *Swarm* is presented by Fiori et al. (2016). A combination of electric, magnetic, and TEC observations has been used by Astafyeva et al. (2016) to investigate the magnetic storm of 22–23 June 2015. Aoyama et al. (2016) combine ground magnetic data and *Swarm* TEC observations to study possible ionospheric effects of the 2015 eruption of a volcano in Chile, Zakharenkova et al. (2016) used GPS and *Swarm* plasma observations to study equatorial plasma density irregularities in the topside ionosphere, and Xiong et al. (2016) performed a scale analysis of equatorial plasma irregularities.

van den IJssel et al. (2016) describe improvements of *Swarm* GPS antenna settings to enhance high-precision positioning of the spacecraft, and da Encarnação et al. (2016) discuss various attempts to determine monthly

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snapshot models of the large-scale part of Earth's gravity field from *Swarm* GPS observations.

Finally, the processing of the *Swarm* accelerometer data is described by Siemes et al. (2016).

The work reported in this issue could not have been achieved without the unfailing support of our deeply regretted friend and colleague Gernot Plank (Fig. 2), to which we wish to dedicate this special issue of *Earth Planets Space*. Gernot has been one of the major contributors to the success of the *Swarm* mission. With great enthusiasm he played a considerable role in the establishment of *Swarm* SCARF, the *Swarm* Level-2 data processing facility. *Swarm* SCARF was key to the project and all scientific results presented in the present special issue (as well as in a previous issue, see *Earth Planets Space*, Vol. 65, Issue 11) heavily rely on the success of this facility. Gernot's

energy and enthusiastic spirit, from beginning to end of even the most intense meetings, was extremely appreciated. He had a remarkable ability to help solve problems and convince anyone to do the right thing in the interest of the project and science, sometimes even very late in the evening, and always in his unique and particularly cheerful way, whatever the circumstances.

Gernot passed away in March 2016 after a lengthy, hard, and unfair fight against cancer. He, and his legendary laugh, will be sorrowfully missed by his friends and colleagues.

#### Authors' contributions

All authors of this article served as guest editors for this special issue. All authors read and approved the final manuscript.

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#### References

- Aakjær CD, Olsen N, Finlay CC (2016) Determining polar ionospheric electrojet currents from Swarm satellite constellation magnetic data. *Earth Planets Space* 68:140. doi:10.1186/s40623-016-0509-y
- Aoyama T, Iyemori T, Nakanishi K, Nishioka M, Rosales D, Veliz O, Safor EV (2016) Localized field-aligned currents and 4-min TEC and ground magnetic oscillations during the 2015 eruption of Chile's Calbuco volcano. *Earth Planets Space* 68:148. doi:10.1186/s40623-016-0523-0
- Astafeyeva E, Zakharenkova I, Alken P (2016) Prompt penetration electric fields and the extreme topside ionospheric response to the June 22–23, 2015 geomagnetic storm as seen by the Swarm constellation. *Earth Planets Space* 68:152. doi:10.1186/s40623-016-0526-x



**Fig. 2** Gernot Plank (1967–2016)

- Cherniak I, Zakharenkova I (2016) High-latitude ionospheric irregularities: differences between ground- and space-based GPS measurements during the 2015 St. Patrick's Day Storm. *Earth Planets Space* 68:136. doi:[10.1186/s40623-016-0506-1](https://doi.org/10.1186/s40623-016-0506-1)
- Chulliat A, Vigneron P, Hulot G (2016) First results from the Swarm dedicated ionospheric field inversion chain. *Earth Planets Space* 68:104. doi:[10.1186/s40623-016-0481-6](https://doi.org/10.1186/s40623-016-0481-6)
- da Encarnação JT et al (2016) Gravity field models derived from Swarm GPS data. *Earth Planets Space* 68:127. doi:[10.1186/40623-016-0499-9](https://doi.org/10.1186/40623-016-0499-9)
- Finlay CC, Olsen N, Kotsiaros S, Gillet N, Tøffner-Clausen L (2016) Recent geomagnetic secular variation from Swarm and ground observatories as estimated in the CHAOS-6 geomagnetic field model. *Earth Planets Space* 68:112. doi:[10.1186/s40623-016-0486-1](https://doi.org/10.1186/s40623-016-0486-1)
- Fiori RAD, Koustov AV, Boteler DH, Knudsen DJ, Burchill JK (2016) Calibration and assessment of Swarm ion drift measurements using a comparison with a statistical convection model. *Earth Planets Space* 68:100. doi:[10.1186/s40623-016-0472-7](https://doi.org/10.1186/s40623-016-0472-7)
- Kotsiaros S (2016) Toward more complete magnetic gradiometry with the Swarm mission. *Earth Planets Space* 68:130. doi:[10.1186/s40623-016-0498-x](https://doi.org/10.1186/s40623-016-0498-x)
- Laundal KM, Finlay CC, Olsen N (2016) Sunlight effects on the 3D polar current system determined from low earth orbit measurements. *Earth Planets Space* 68:142. doi:[10.1186/s40623-016-0518-x](https://doi.org/10.1186/s40623-016-0518-x)
- Michelis PD, Consolini G, Tozzi R, Marcucci MF (2016) Observations of high-latitude geomagnetic field fluctuations during St. Patrick's Day Storm: Swarm and SuperDARN measurements. *Earth Planets Space* 68:105. doi:[10.1186/s40623-016-0476-3](https://doi.org/10.1186/s40623-016-0476-3)
- Olsen N, Finlay CC, Kotsiaros S, Tøffner-Clausen L (2016) A model of earth's magnetic field derived from 2 years of Swarm satellite constellation data. *Earth Planets Space* 68:124. doi:[10.1186/s40623-016-0488-z](https://doi.org/10.1186/s40623-016-0488-z)
- Pignalberi A, Pezzopane M, Tozzi R, Michelis PD, Coco I (2016) Comparison between IRI and preliminary Swarm langmuir probe measurements during the St. Patrick storm period. *Earth Planets Space* 68:93. doi:[10.1186/s40623-016-0466-5](https://doi.org/10.1186/s40623-016-0466-5)
- Siemes C et al (2016) Swarm accelerometer data processing from raw accelerations to thermospheric neutral densities. *Earth Planets Space* 68:92. doi:[10.1186/s40623-016-0474-5](https://doi.org/10.1186/s40623-016-0474-5)
- Stolle C, Michaelis I, Rauberg J (2016) The role of high-resolution geomagnetic field models for investigating ionospheric currents at low earth orbit satellites. *Earth Planets Space* 68:110. doi:[10.1186/s40623-016-0494-1](https://doi.org/10.1186/s40623-016-0494-1)
- Thébault E, Vigneron P, Langlais B, Hulot G (2016) A Swarm lithospheric magnetic field model to SH degree 80. *Earth Planets Space* 68:126. doi:[10.1186/s40623-016-0510-5](https://doi.org/10.1186/s40623-016-0510-5)
- Tøffner-Clausen L, Lesur V, Olsen N, Finlay CC (2016) In-flight scalar calibration and characterisation of the Swarm magnetometry package. *Earth Planets Space* 68:129. doi:[10.1186/s40623-016-0501-6](https://doi.org/10.1186/s40623-016-0501-6)
- Tozzi R, Manda M, Michelis PD (2016) Unmodelled magnetic contributions in satellite-based models. *Earth Planets Space* 68:108. doi:[10.1186/s40623-016-0484-3](https://doi.org/10.1186/s40623-016-0484-3)
- van den Ijssel J, Forte B, Montenbruck O (2016) Impact of Swarm GPS receiver updates on POD performance. *Earth Planets Space* 68:85. doi:[10.1186/s40623-016-0459-4](https://doi.org/10.1186/s40623-016-0459-4)
- Xiong C, Stolle C, Lühr H, Park J, Fejer BG, Kervalishvili GN (2016) Scale analysis of equatorial plasma irregularities derived from Swarm constellation. *Earth Planets Space* 68:121. doi:[10.1186/s40623-016-0502-5](https://doi.org/10.1186/s40623-016-0502-5)
- Zakharenkova I, Astafyeva E, Cherniak I (2016) GPS and in situ Swarm observations of the equatorial plasma density irregularities in the topside ionosphere. *Earth Planets Space* 68:120. doi:[10.1186/s40623-016-0490-5](https://doi.org/10.1186/s40623-016-0490-5)

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