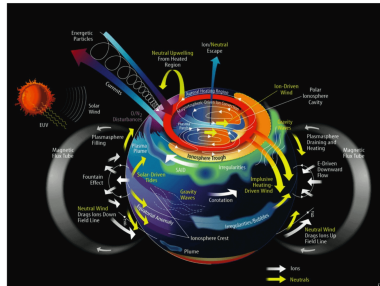
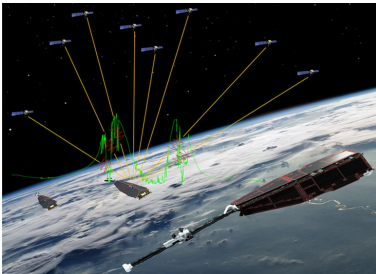


# Swarm Satellite mission and the data sets for space weather and ionospheric studies

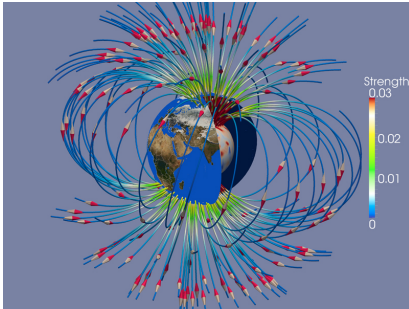
Stephan Buchert (scb@ifu.se)



Space Weather and Upper Atmospheric data analysis training workshop for East African Community, Online/Muni University, September 28, 2023

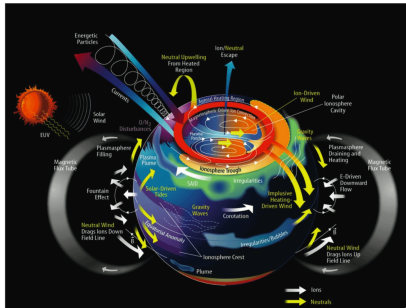


# Introduction

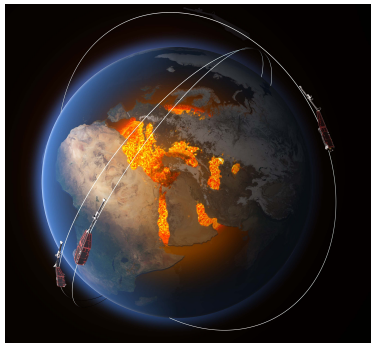


## The geomagnetic field

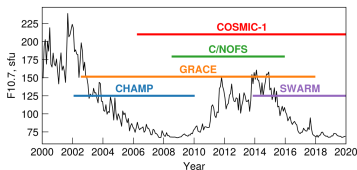
- ▶ originates from the Earth's core and lithosphere,
- ▶ corresponding to the *core* and *crustal* fields,
- ▶ and has also external, dynamic contributions
- ▶ from currents in the ionosphere and space,
- ▶ i.e. is affected *spaceweather*



# ESA Swarm Mission



- ▶ 3 satellites in circular orbits,
- ▶ the lower pair A and C early in 2023 at  $\approx 433$  km height;
- ▶  $\approx 426$  km at the equator,  
 $\approx 455$  km near the poles;
- ▶ but have now been pushed up to  $\approx 500$  km,
- ▶ re-entry  $\sim$  year 2032??
- ▶ this would be about 1.5 solar cycles of magnetic field and plasma data;
- ▶ Swarm B has also been pushed up,
- ▶ still fuel stock, potentially lasts longer.



# SwarmPublications

An advice:

- ▶ before starting with the data
- ▶ read publications!

Web Page with all Swarm publications at

<https://earth.esa.int/eogateway/missions/swarm/publications>

[Swarm](#) / [Science](#) / [Publications](#)

## Swarm Publications

The following is a list of publications released featuring the Swarm mission.

[2023](#) [2022](#) [2021](#) [2020](#) [2019](#) [2018](#) [2017](#) [2016](#) [2015 and earlier](#)

### 2023

1. Sabbagh D, Ippolito A, Marchetti D, Perrone L, De Santis A, Campuzano SA, Cianchini G, Piscini A (2023), "Satellite-based electron density background definition at mid-latitudes and comparison with IRI-2016 model under different solar conditions", *Advances in Space Research*, 72, 1183-1195,  
[DOI: 10.1016/j.asr.2023.05.029](https://doi.org/10.1016/j.asr.2023.05.029)
2. Aoi S, Buchert S, Jura E, Sorriso-Valvo L (2023), "Spectral properties of sub-kilometer-scale equatorial irregularities as seen by the Swarm satellites", *Advances in Space Research*, 72, 741-752,  
[DOI: 10.1016/j.asr.2022.07.059](https://doi.org/10.1016/j.asr.2022.07.059)
3. Park J, Min WK, Eastes RW, Chao CK, Kim H-E, Lee J, Sohn J, Ryu K, Seo H, Yoo J-H, Lee S, Woo C, Kim E-J (2022),

# Review of Ionosphere Science with Swarm

[Home](#) > [Space Science Reviews](#) > [Article](#)

## Variability of Ionospheric Plasma: Results from the ESA Swarm Mission

[Open Access](#) | Published: 23 August 2022 | 218, Article number: 52 (2022)

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[Alan G. Wood](#) , [Lucilla Alfonsi](#), [Lasse B. N. Clausen](#), [Yaqi Jin](#), [Luca Spogli](#), [Jaroslav Urbář](#), [James T. Rawlings](#), [Jan C. Whittaker](#), [Gareth D. Dorrian](#), [Per Høeg](#), [Daria Kotova](#), [Claudio Cesaroni](#), [Antonio Cicone](#), [Jan Miedzik](#), [Ewa Gierlach](#), [Paula Kochańska](#), [Paweł Wojtkiewicz](#), [Golnaz Shahtahmassebi](#) & [Wojciech J. Miloch](#)

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### Abstract

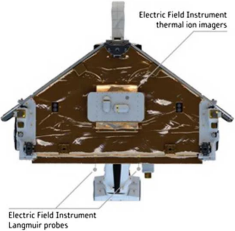
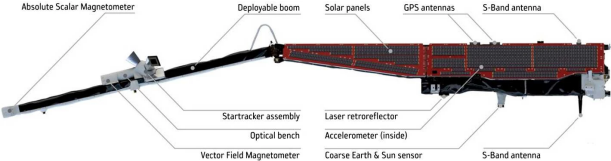
Swarm is the first European Space Agency (ESA) constellation mission for Earth Observation. Three identical Swarm satellites were launched into near-polar orbits on 22 November 2013. Each satellite hosts a range of instruments, including a Langmuir probe, GPS receivers, and magnetometers, from which the ionospheric plasma can be sampled and current systems inferred. In March 2018, the CASSIOPE/e-POP mission was formally integrated into the Swarm mission through ESA's Earthnet Third Party Mission Programme. Collectively the instruments on the Swarm satellites enable detailed studies of

Open access review at <https://link.springer.com/article/10.1007/s11214-022-00916-0>

## How to obtain Swarm data?

1. by downloading files with FTP or HTTP (browser), or
2. with a graphical UI at <https://vires.services/>, or
3. programmatically via a HAPI <https://github.com/hapi-server/data-specification> interface, for example using Python

# Instruments



## Swarm data types

- ▶ L1b:
  - ▶ more or less as measured by each instrument
  - ▶ in physical (SI) units,
  - ▶ also S/C position and attitude,
- ▶ L2:
  - ▶ products derived from L1b,
  - ▶ example: sTEC and vTEC from the GPS receiver;
- ▶ Advanced:
  - ▶ special data only available as file download,
  - ▶ example: 16 Hz density estimates (faceplate);
  - ▶ EFI ion velocity components,
  - ▶ ASM burst mode.