Mapping of field-aligned currents in the ionosphere and bursty bulk flows in the magnetotail

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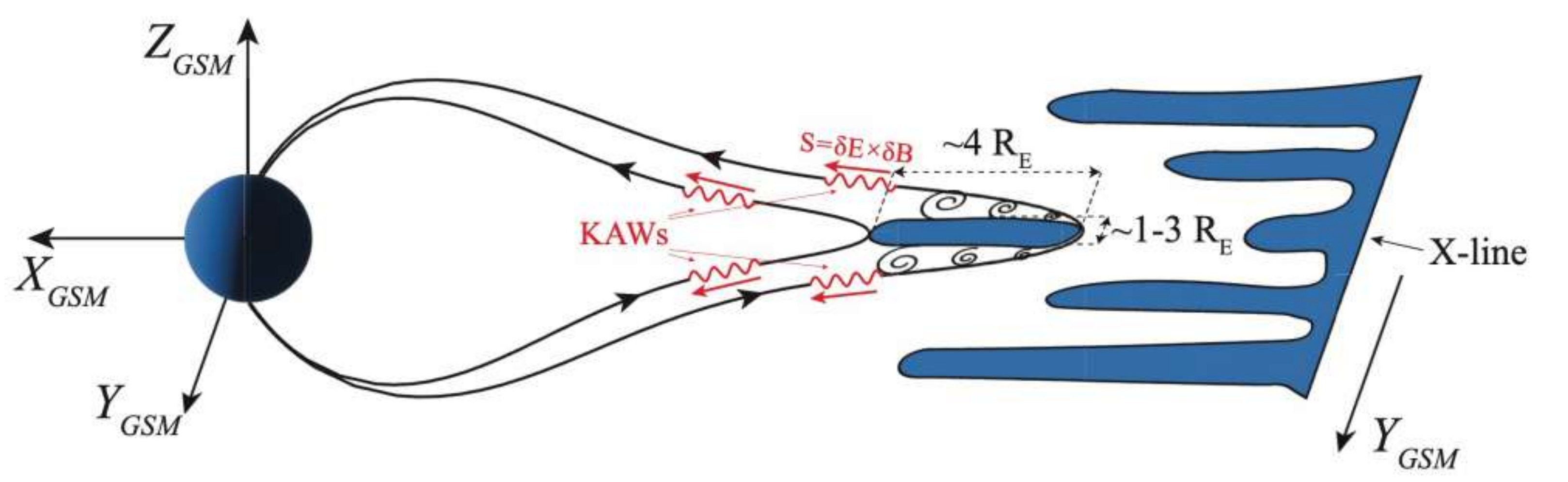
Introduction and objective

Substorm are usually associated with large ground geomagnetic disturbances at high magnetic latitudes and at the night as a consequence of changes in the ionospheric currents. During a substorm part of the energy in the magnetotail is transported towards the near-Earth by transient high-speed plasma flows, known as **Bursty Bulk Flows (BBFs)** that are coupled with the ionosphere via **Field-Aligned Currents (FACs)**. The **F-BURST** project aims to study MI coupling using multi-spacecraft observations



L. Richard, 2023. Adapted from Sergeev et al., 2000 and Duan et al., 2016.

We plan to combine long-term ionospheric and magnetospheric data such as Swarm, Cluster, and MMS observations

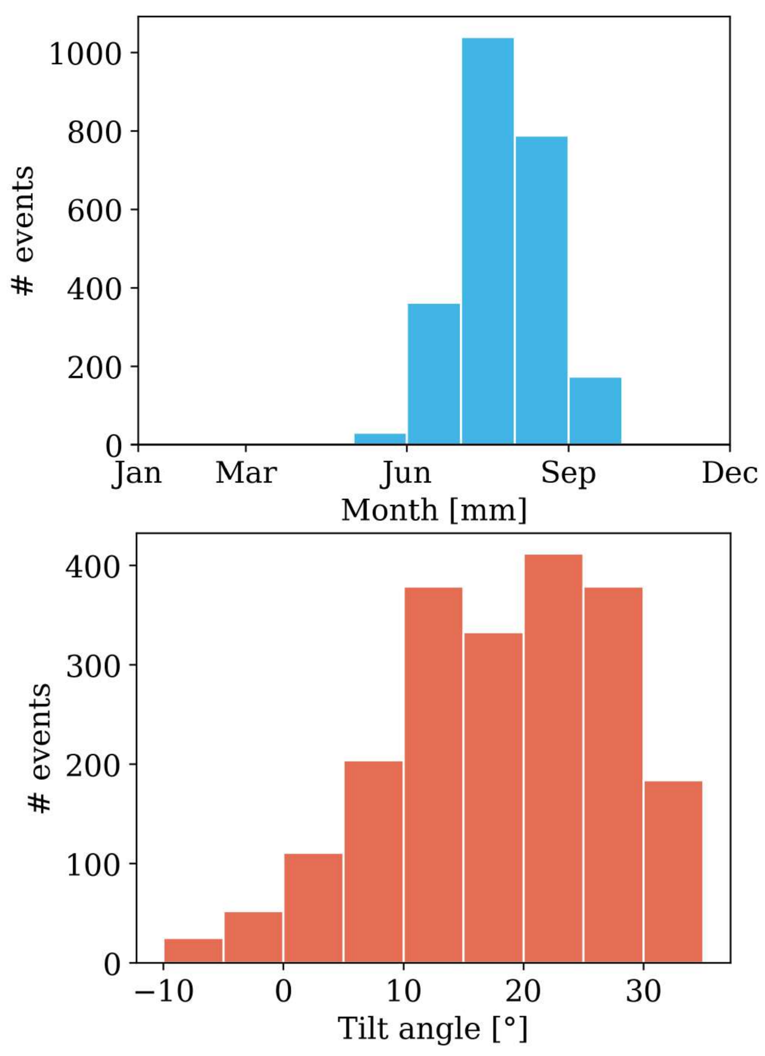
- Database of 2394 **BBF** in the magnetotail from MMS data performed by L. Richard et al (2022) https://zenodo.org/records/7528071
- We use **Tsyganenko** models to find the BBFs' footprint into the ionosphere
- Swarm is used to study the behaviour of **FAC** during BBFs

BBF Statistics

The **BBF** were detected during the magnetotail season of MMS (Jun-Sep)

- BBFs have a orbital coverage bias
  - Gaussian distribution centered at Z_{GSM} = 5.80 R$_E$ and Y_{GSM} = 2.55 R$_E$
  - Positive mean dipole tilt angle 18.1°
- The mean duration of the BBF is 3.49 minutes
- 89% of the events are Earthward directed
- ~75% of BBF occurs during calm geomagnetic conditions (kp < 3 and -25 nT < Sym-h < 5 nT)

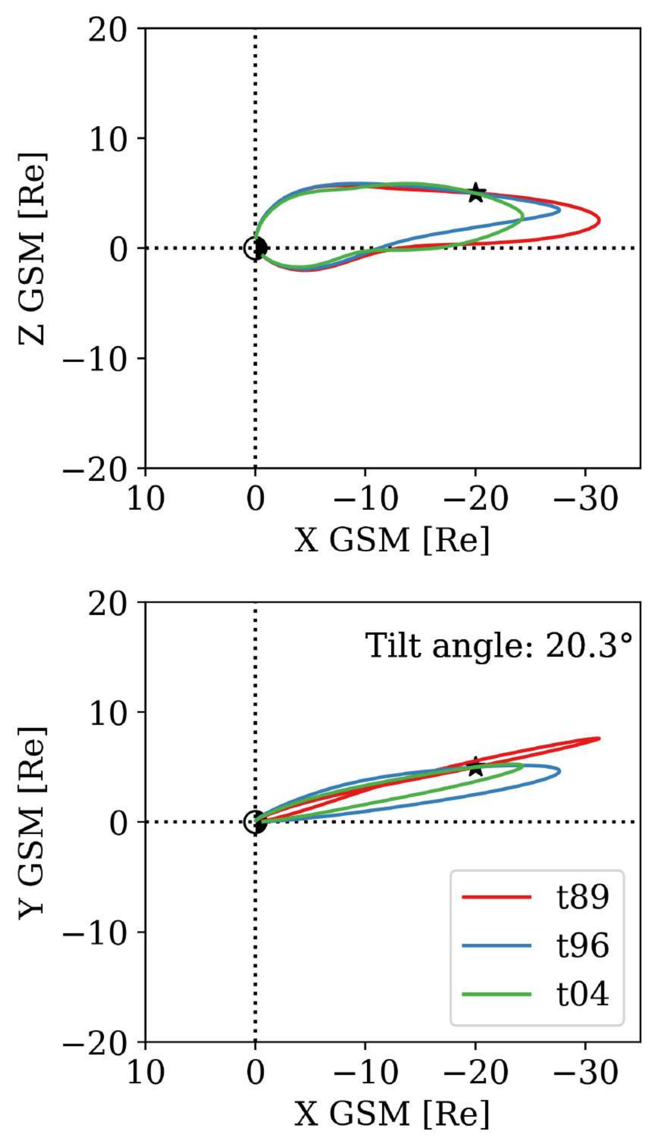
To reduce the orbital bias we plan to extend our database with BBFs detected by THEMIS and Cluster

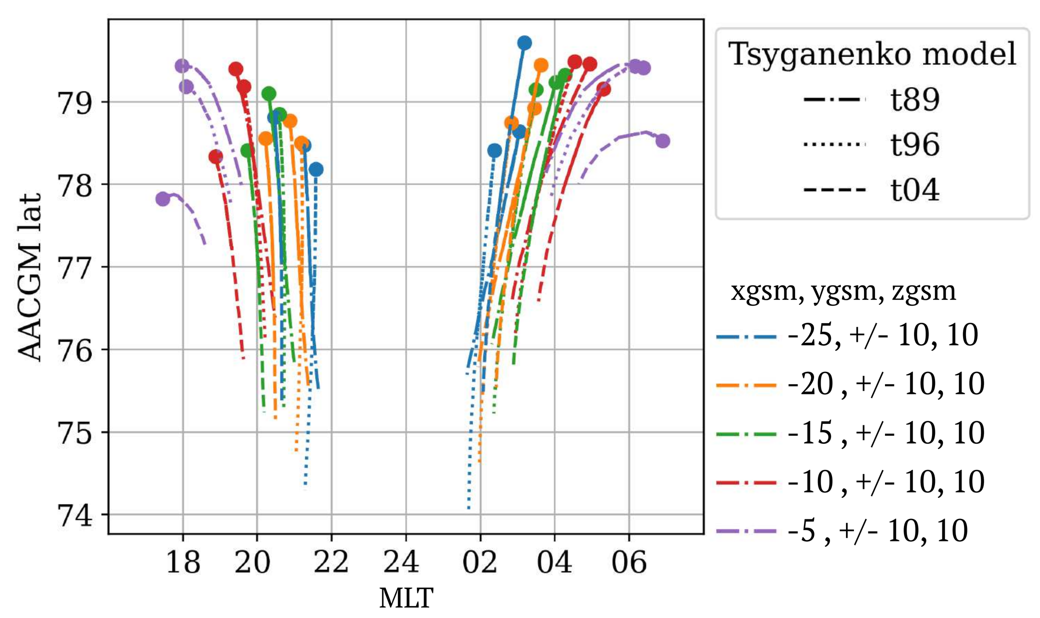


BBF mapping with Tsyganenko models

We use the **Tsyganenko models** (T89, T96, T04) to find the footprint of the BBF

- T01 is not included because 66% of the BBFs are located X_{GSM} > -15 Re
- The differences between the models depends on the position, the solar wind conditions, and tilt angle
- We will study the differences in the footprints for each model under different conditions





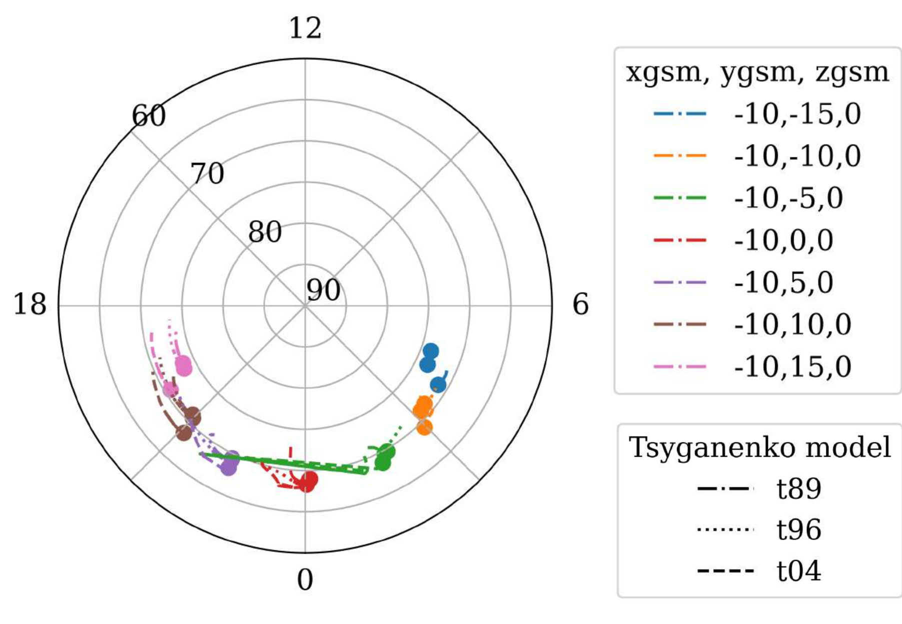
Tilt angle [-8, 28]°

BBF footprint

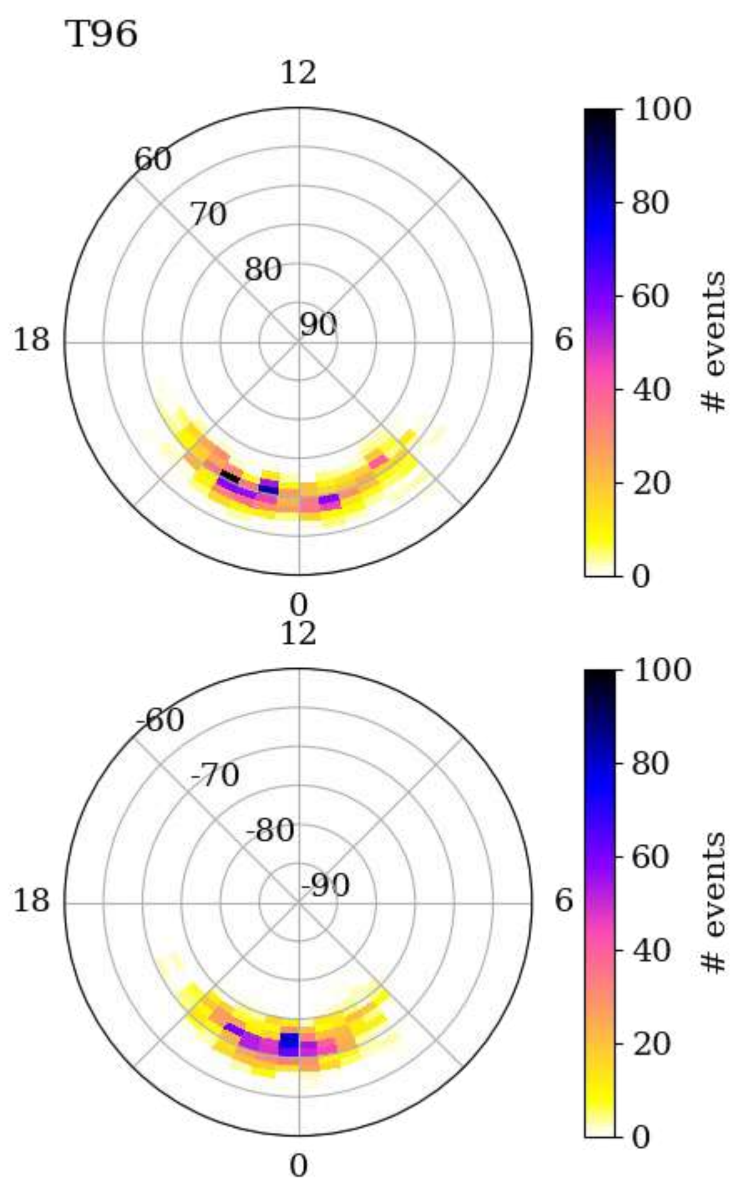
Histogram of the **BBFs footprint** for all Tsyganenko models shows similar characteristics:

- Footprints are mainly clustered between
  - MLT 21-03
  - AACGM latitude 65-75°
- Maximum at pre-midnight

The footprint at pre-midnight is directly related with the BBF position at Y_{GSM} > 0



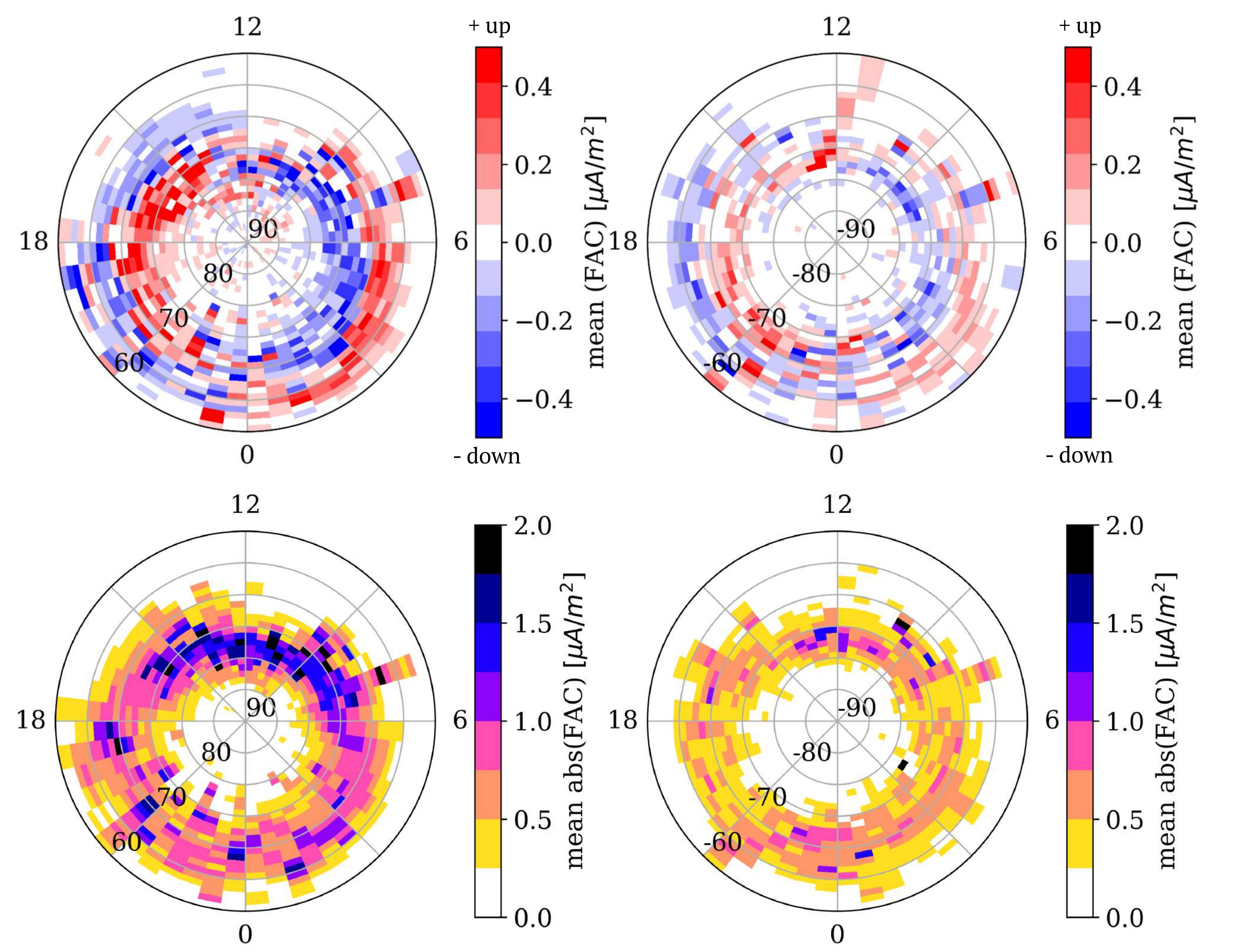
Tilt angle [-8, 28]°



SWARM Field-aligned currents

We use **Swarm FAC** from single spacecraft at the moment of the BBF observation plus 15 minutes.

- The signed mean value shows the usual pattern of R1 and R2 currents.
- Due to the orbital bias in summer season we observe:
  - Mean absolute value larger in north hemisphere than in the south hemisphere
  - Larger magnitudes in the midday sector due to higher conductivity of the ionosphere in the illuminated side.



- The seasonal and diurnal effect should be taken into account. We will focus in the region defined by the footprint

Future plans

- Include a set of **BBF** detected by Cluster and/or THEMIS
- Estimate the difference in the footprint location from different **Tsyganenko** models
- Use SwarmFACE package https://zenodo.org/records/7361439 to study the behaviour of **FAC** during BBFs

References:

Richard, L., et al. (2022). Are dipolarization fronts a typical feature of magnetotail plasma jets fronts? *GRL*, doi: 10.1029/2022GL101693

Blagau A and Vogt J (2023) SwarmFACE: A Python package for field-aligned currents exploration with Swarm. Front. Astron. Space Sci.. doi: 10.3389/fspas.2022.1077845

SWARM 10 YEAR ANNIVERSARY SCIENCE CONFERENCE
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