Detecting the Auroral Oval through Swarm ionospheric magnetic field measurements and CSES-01 electric field observations.

E. Papini[1], **M. Piersanti**[2], **E. Qamili**[3], **G. Consolini**[1], **G. D'Angelo**[2], **D. Recchiuti**[4], **P. Diego**[1]

(1) Istituto di Astrofisica e Planetologia Spaziali, INAF, Roma, Italy
(2) Dipartimento di Scienze Fisiche e Chimiche, Università degli Studi Dell'Aquila, L'Aquila, Italy
(3) Serco for ESA - European Space Agency, ESA, ESRIN, Frascati, Italy
(4) Università degli studi di Trento, Trento, Italy

Email contact: emanuele.papini@inaf.it

SCIENTIFIC RATIONALE

We present the results of a study of the electromagnetic (EM) field properties in the high-latitudes top-side ionosphere under different geomagnetic conditions. We exploit magnetic field measurements taken by the Vector Field Magnetometer (VFM) onboard Swarm B [4] and electric field observations by the EFD instrument onboard the CSES-01 spacecraft [1,2]. Both satellites are Low-Earth orbiting at around 500 km of altitude.

We employ the Auroral Oval Detection (AOD) algorithm [3] (a new technique we developed that allows to detect the crossing of the auroral oval using in-situ measurements of electromagnetic fields) to detect latitudinal intervals of high EM activity. AOD has been succesfully applied to CSES-01 EFD data [3] to identify periods of high geomagnetic activity at auroral latitudes. We extend AOD application to magnetic field measurements taken by VFM (at a sampling frequency of 50Hz) onboard the swarm satellites.

We run the AOD algorithm over one year of (VFM) data from Swarm B [4]. For all the ~5000 orbits we succesfully detected crossing of the AO by the spacecraft on both hemispheres. Furthermore, we analyze the statistical properties of the magnetic and electric fluctuations in the detected intervals.

THE CSES-01 SPACECRAFT

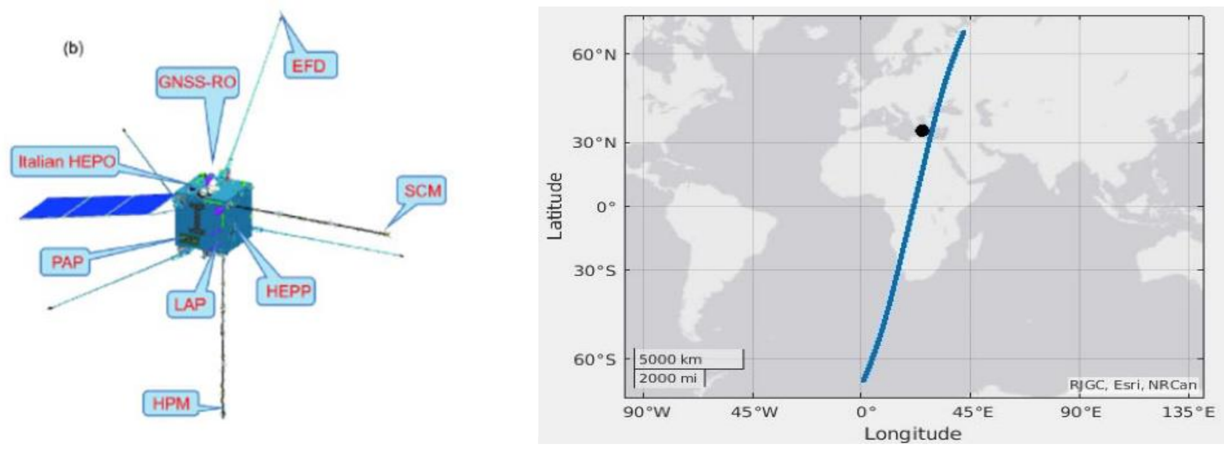

Fig. 1: Left: sketch of the CSES-01 spacecraft, together with the position of the scientific payloads. Top: example of a semi orbit of the CSES-01 spacecraft.

CSES-01 [1] is a chinese mission with an Italian contribution from ASI, INFN, and INAF, through the project Limadou.

CSES-01 orbits sun-synchronously at an altitude of ~500 km (F2-ionosphere)

- with an inclination of 97.4º, a 02:00 a.m. ascending-node local time, and a revisit period of 5 days;
- with an average speed of ~7.2 km/s;
- with an orbital period of ~94 minutes.

CSES-01 carries a full suite of instruments for measuring the ionospheric electromagnetic fields and plasma properties. Here we use electric field measurements from the Electric Field Detector (EFD) [2] instrument in the ELF (0÷5 kHz) band.

DATASET AND METHODS

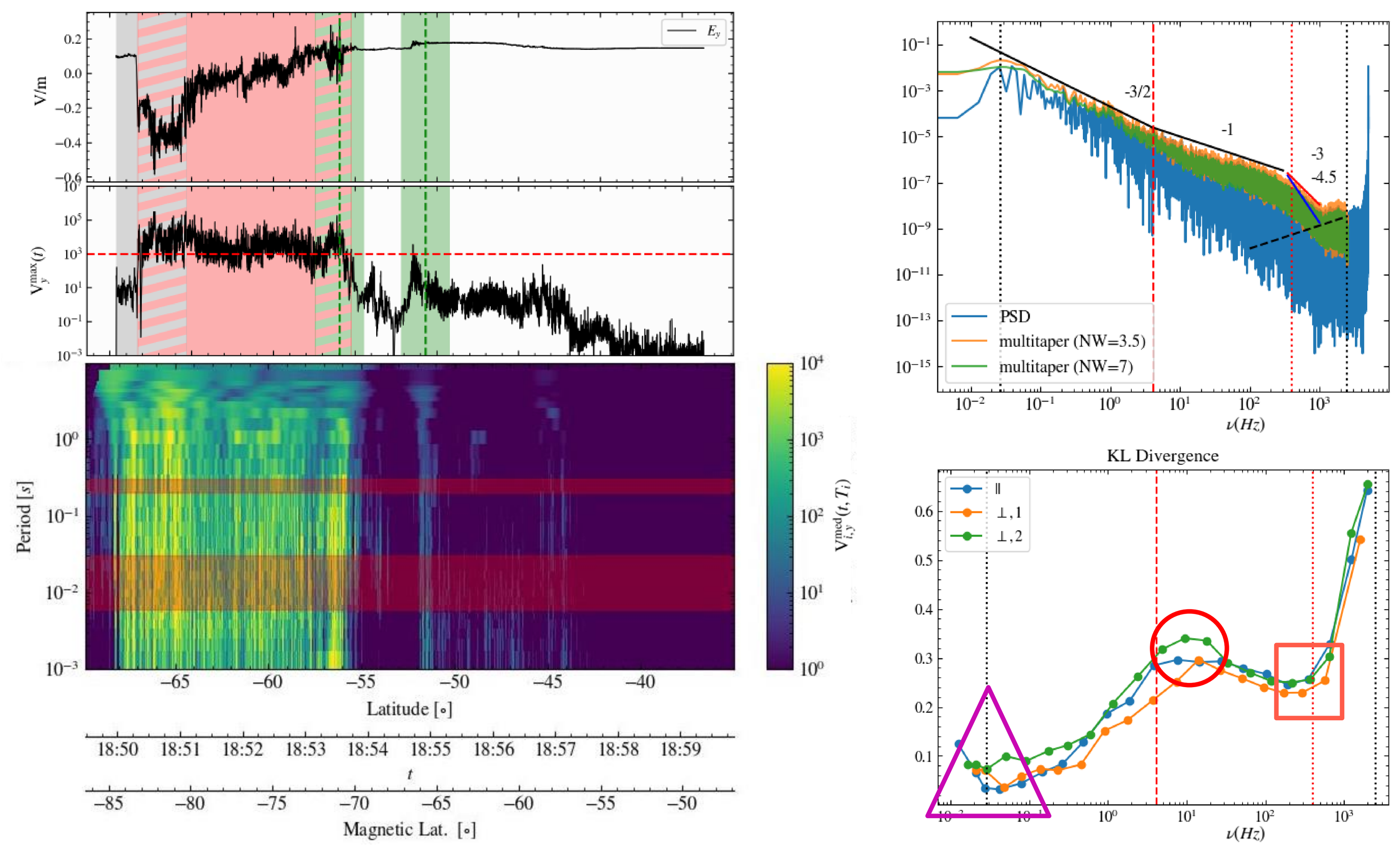

Fig. 2: Left: example of AOD detection results for the electric field measured by EFD. The red area denotes the active interval detected. Upper right: Power Spectral Density (PSD) of the y component of the electric field for the active interval. Lower right: Kullback-Leibler (KL) divergence of the electric field for the same interval.

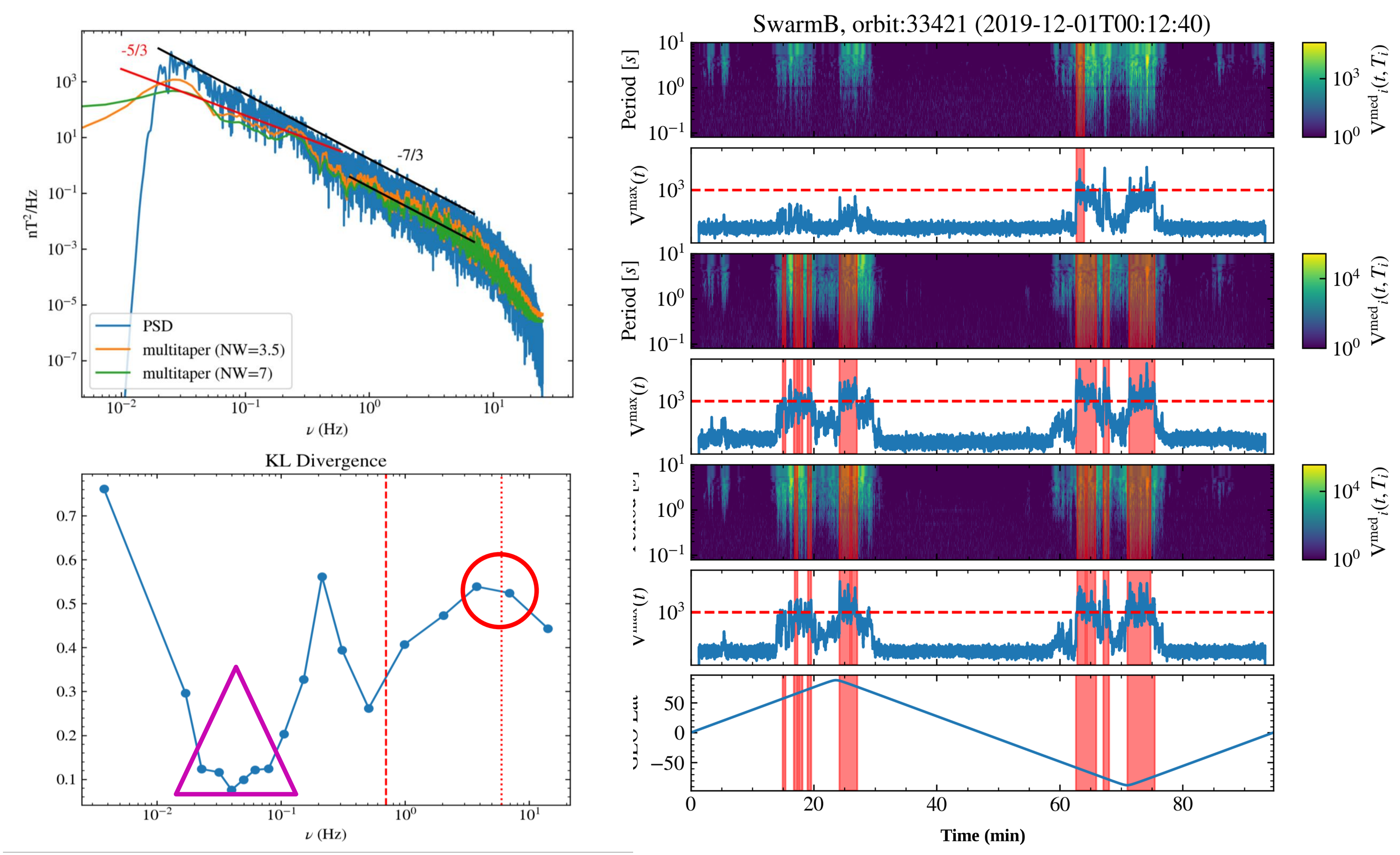

Fig. 3: Right: example of AOD detection results for the magnetic field measured by VFM. Upper left: Power Spectral Density (PSD) of the y component of the magnetic field for one of active intervals. Lower left: Kullback-Leibler (KL) divergence of the magnetic field for the same interval.

RESULTS

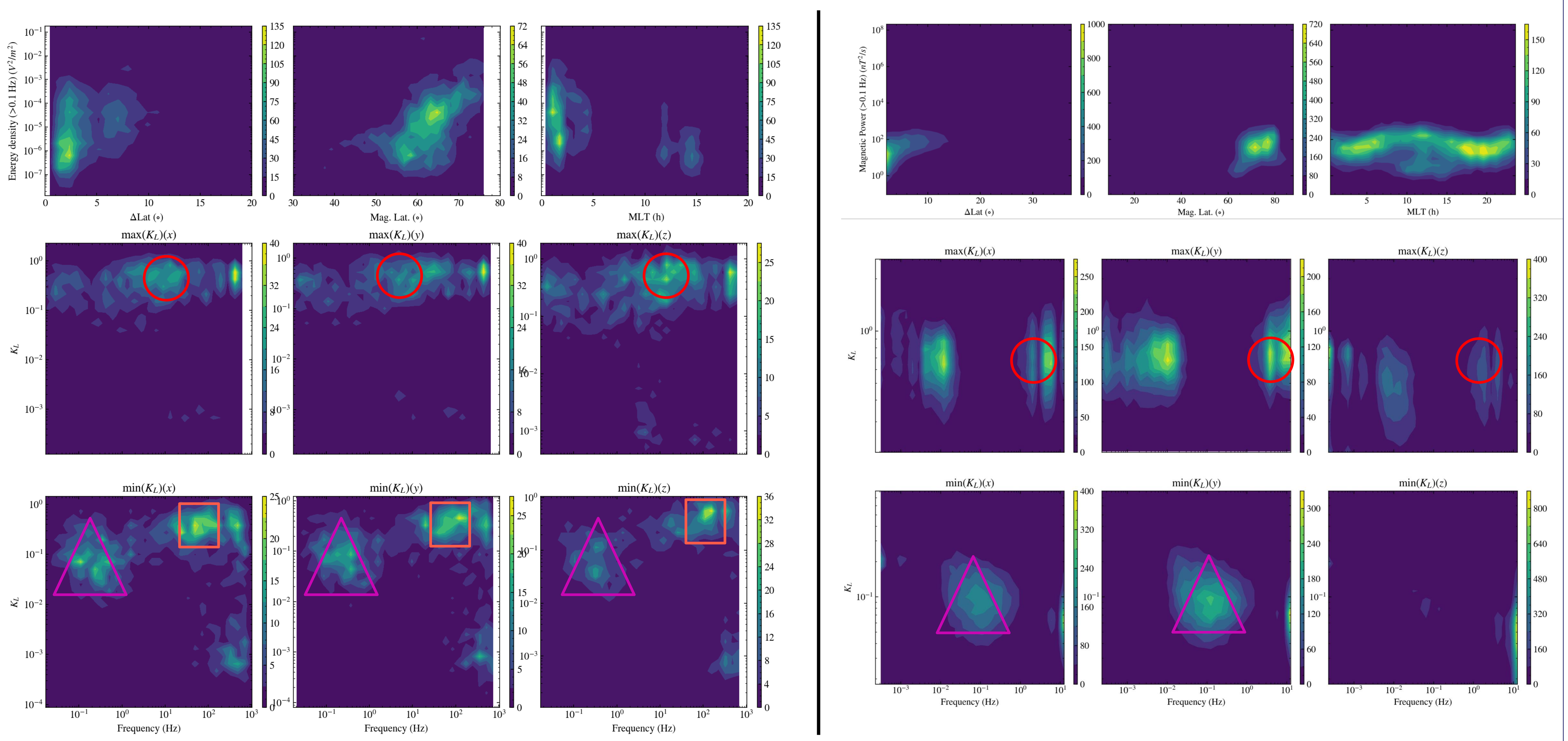

Fig. 4: Left: Upper panels: [EFD] Electric Power distribution of active intervals vs. their Latitudinal extension, Magnetic Latitude position, and MLT position. Lower panels: distribution of KL divergence values of relative maxima (top) and minima (bottom) vs. their frequency locations. Right: Same as left but for Magnetic field measurements taken by VFM.

DISCUSSION

The distribution of maxima and minima in the active intervals detected in EFD and VFM data shows several similarities and differences.

1. A dependence of the power with magnetic latitude is present in both VFM and EFD data.
2. Concentration of the latitudinal extension at around 1 degree (real due to AO size?).
3. There are preferred MLT locations for EFD and a modulation for VFM.
4. Location of minima in KL divergence between EFD and VFM data are compatible. The location of the maxima is at the edge of VFM frequency resolution.

Location of maxima and minima may be related to O+ and electron characteristic length scales. In this respect, this study open to the possibility to determine O+ and electron densities directly from EM field measurements.

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