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FOR SPACE SCIENCE

Nightside dynamics influence on the dayside ionospheric current

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Objectives

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During substorms

1. Is the influence on the dayside ionospheric current present only during northward IMF?
2. Are there IMF By asymmetries in the ionospheric equivalent currents?
   - Do we observe removal of the asymmetry on the dayside?
   - Do we observe enhancement of the current system on the dayside?
3. What is the influence of different seasons on the dayside/nightside IMF By asymmetry?

Motivation

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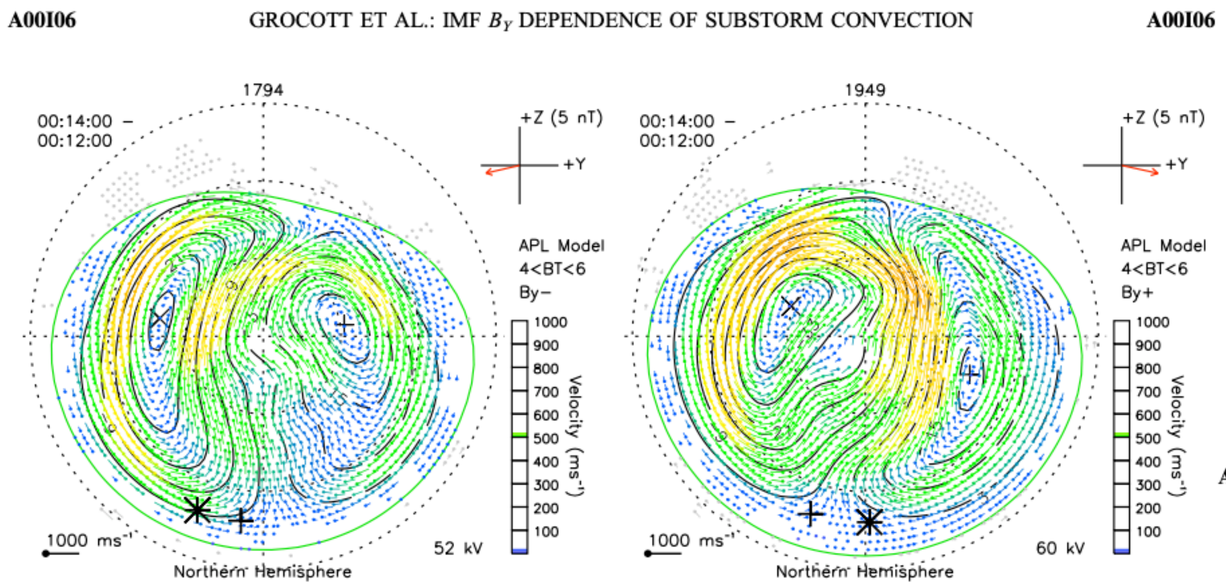
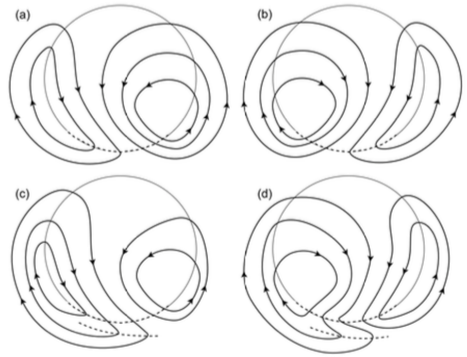
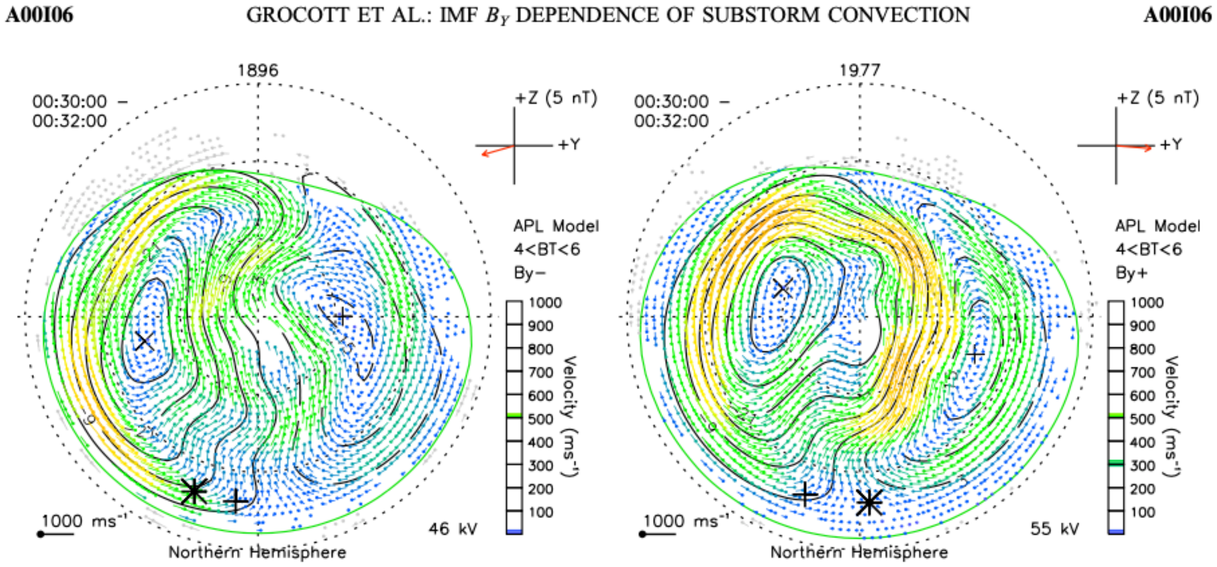
14 mins before substorm onset





The ionospheric convection pattern driven by tail reconnection during non-substorm (a and b), and (c and d) substorm times, at different IMF By orientations[1].

30 mins after substorm onset



Grocott (2010) examined how the substorm influences the asymmetry of the IMF By on the convection.
Motivated by his results, we investigate the influence of the substorms on the equivalent current under different IMF conditions.

Grocott, A., Milan, S. E., Sato, N., Wild, J. A., Yeoman, T. K., & Yukimatu, A. S. (2010). Superposed epoch analysis of the ionospheric convection evolution during substorms: IMF *By* dependence. *Journal of Geophysical Research*, *115*, A00I06. https://doi.org/10.1029/2010JA015728

Motivation

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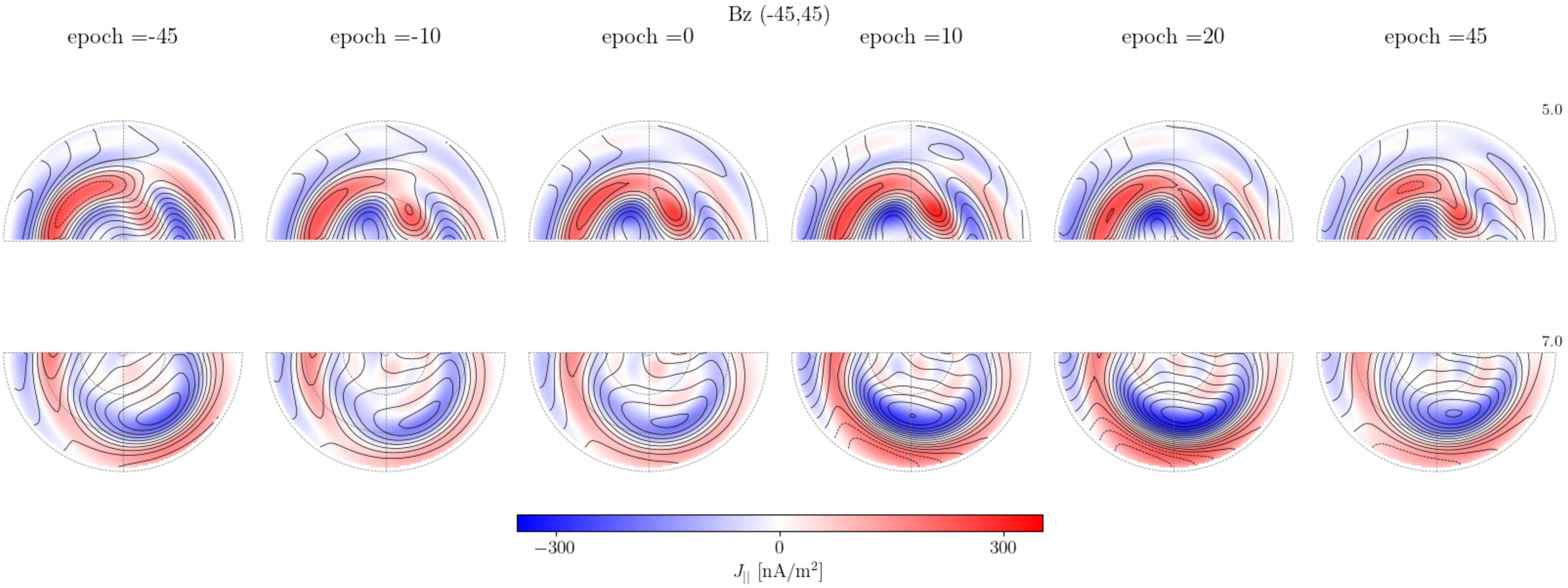
Substorms during northward IMF



-The magnitude of the dayside and nightside EFAC and EHIC increases with substorms taking place.

Data and Methodology

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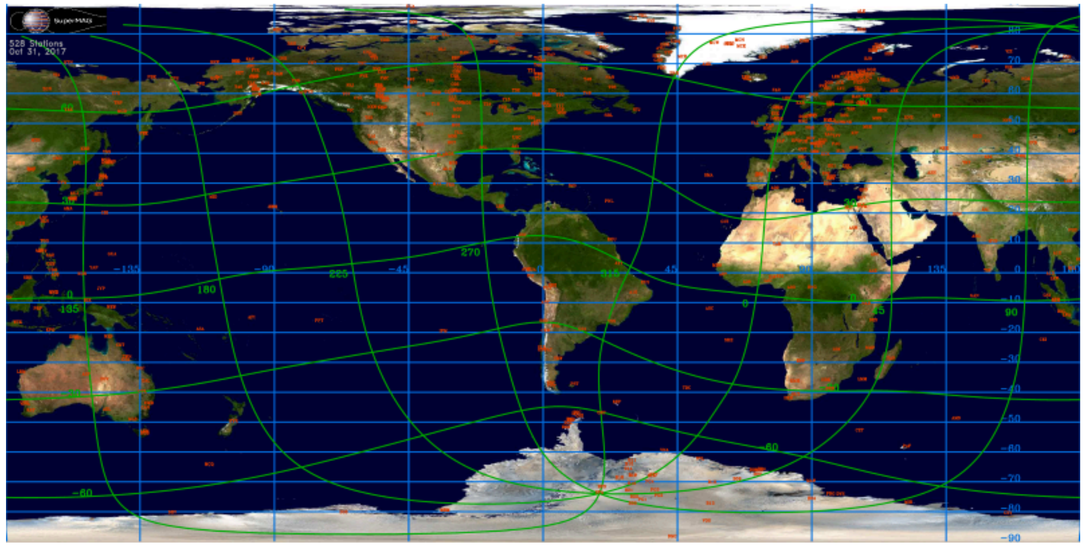
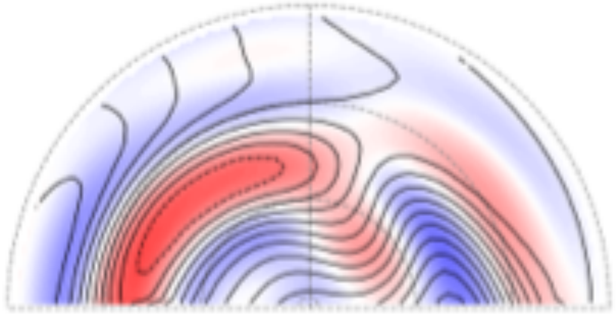
1.Ground based magnetometer data obtained from SuperMAG stations above 50° Mlat.
2. Newell and Gjerloev substorm list.
3.Solar wind data provided from OMNI data webpage.

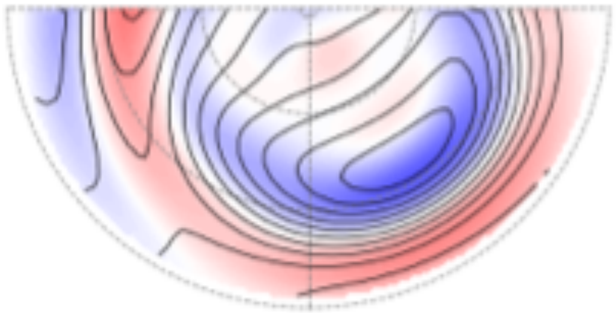


Geomagnetic map (isotropic projection). Blue lines are geomagnetic coordinates while green lines are geographic coordinates.

https://supermag.jhuapl.edu/info/?page=logos

Spherical
+Harmonic
Analysis





Data and Methodology

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We analyzed ground magnetic field perturbations from SuperMAG during substorms identified in Newell and Gjerloev substorm list between 1990 and 2019.
Superposed epoch analysis was applied to the data after these steps:

1- Selecting all ground-based magnetometer stations above 50° magnetic latitude.

2- Converting the magnetic field components to the quasi-dipole coordinates.

3- Sorting the data in an equal area grid in magnetic local time/magnetic latitude.

4- Applying different criteria to select subsets of the substorm lists.

5- The ionospheric currents are based on the ground observations of magnetic field perturbations using spherical harmonic representation.

6- The equivalent horizontal ionospheric currents (EHIC) is represented by the (black contours), and the equivalent field aligned currents (EFAC) by(red/blue) in the plotted maps.

- The numbers shown in the right side of each map are in kA to indicate the contour spacing for the EHIC

- Each figure has a black sector circle on the top, indicating the selected clock angle criterion for each case.

Results and Discussion

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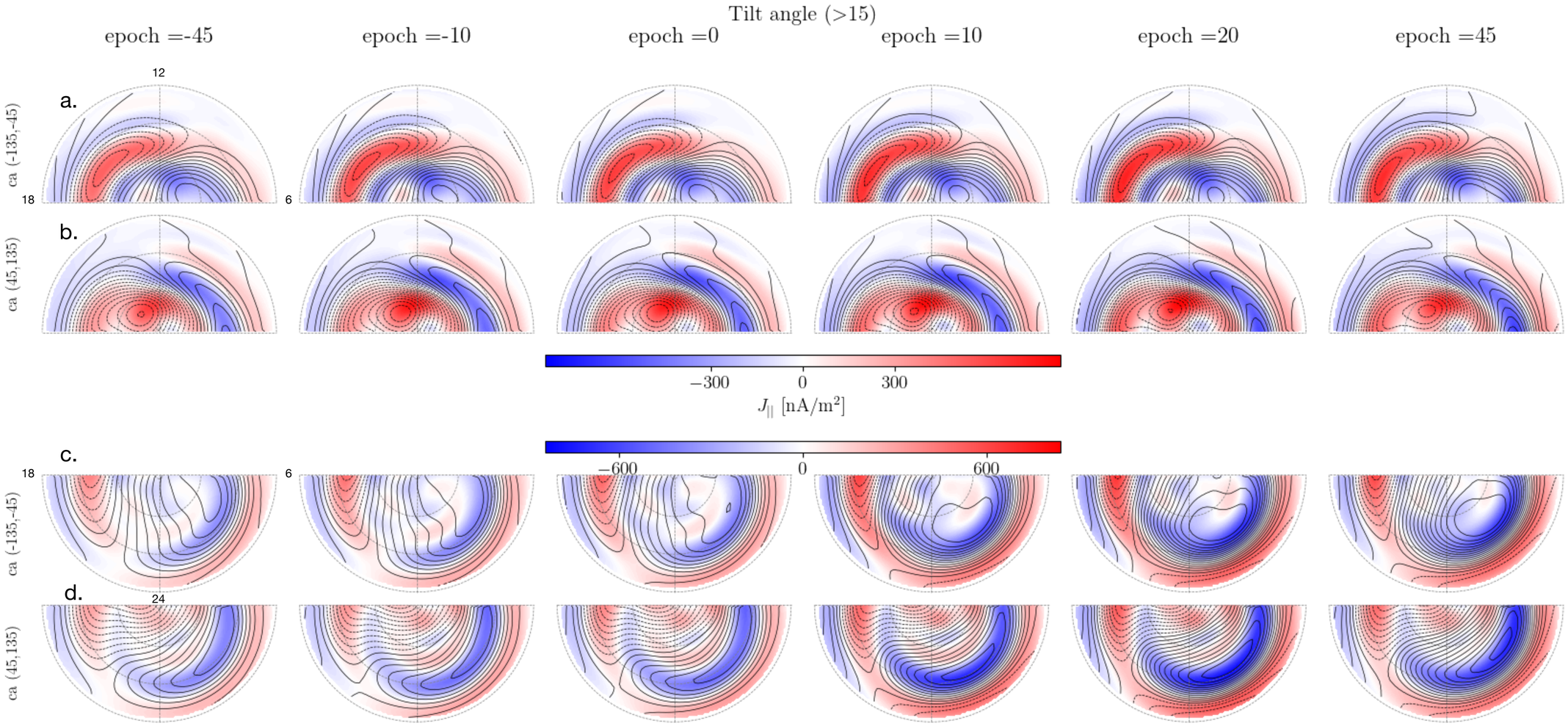
A Comparison between By negative and By positive substorms during summer



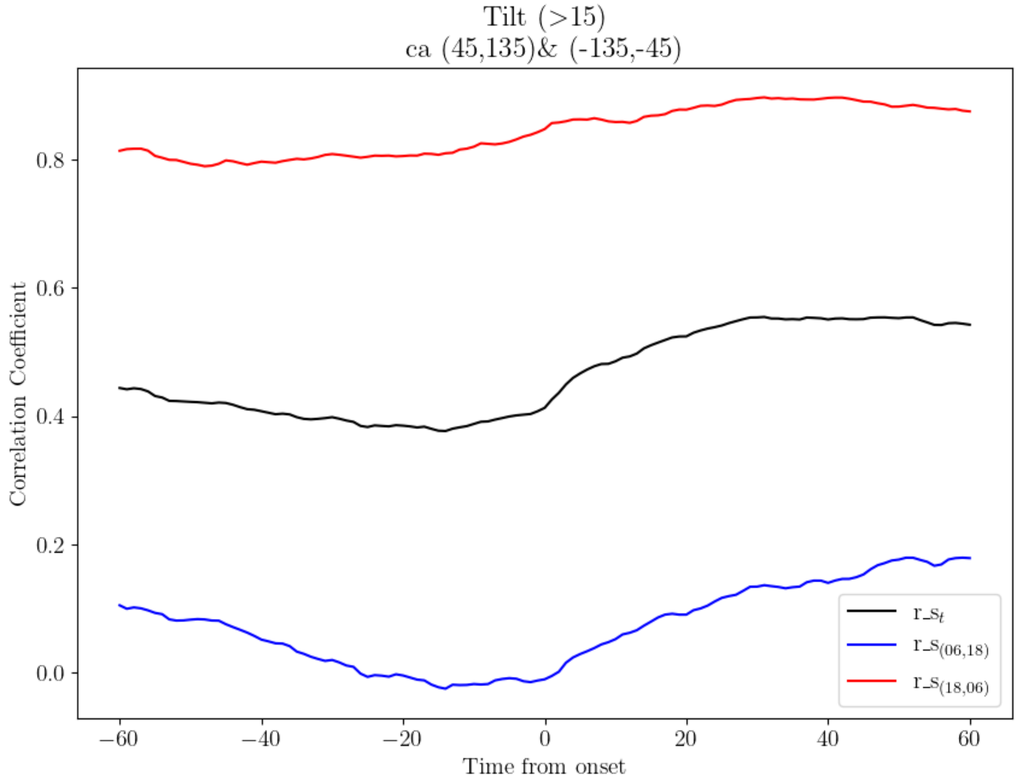
In this figure, By$^-$ substorms are plotted in panels (a, c) and while By$^+$ substorms are shown in (b, d).

- Only one lobe cell is observed for each case with increase in the magnitude of the dayside and nightside currents.
- The asymmetry observed in the dayside continues after substorm onset occurs, while the nightside asymmetries are reduced.

Results and Discussion

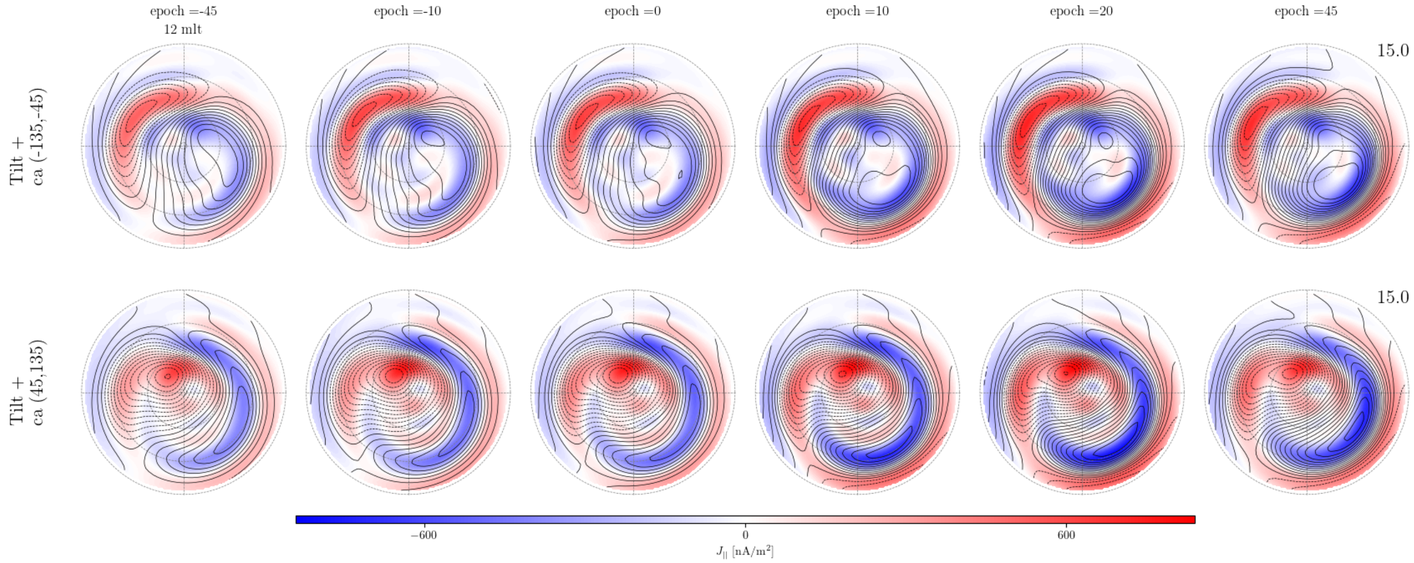
BIRKELAND CENTRE FOR SPACE SCIENCE

A Comparison between By negative and By positive substorms during summer



We found that the correlation is higher on the nightside than the dayside. As the onset takes place, the correlation increases, but since the correlation has high magnitude on the nightside even before the onset takes place, the correlation didn't change so much.

During summer, for (By + and By -) to evaluate if the asymmetries decrease after onset takes place, we plotted EFAC and EHIC maps of the time series of (-60 min prior to onset to +60 min after onset) — showing 6 epochs only—. From these maps, in the figure to the left, we correlated using spearman's correlation, the nightside of the maps represented by the red line for the MLT (>18 or <6), the blue line presents the dayside (MLT<18 and >6). The black line presents the whole map.



Results and Discussion

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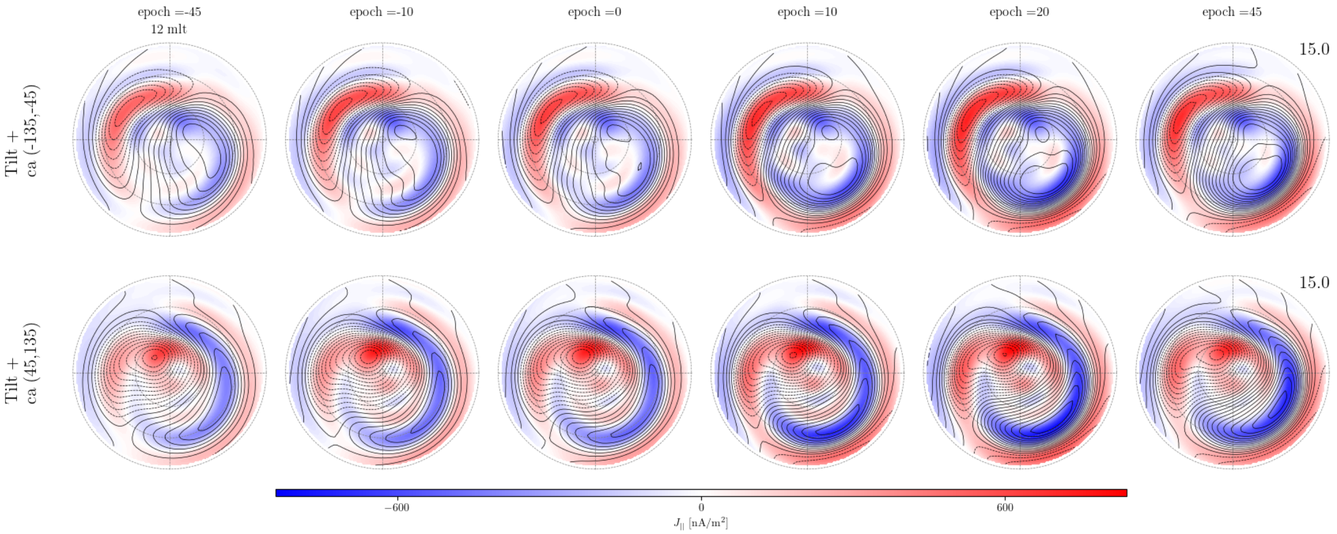
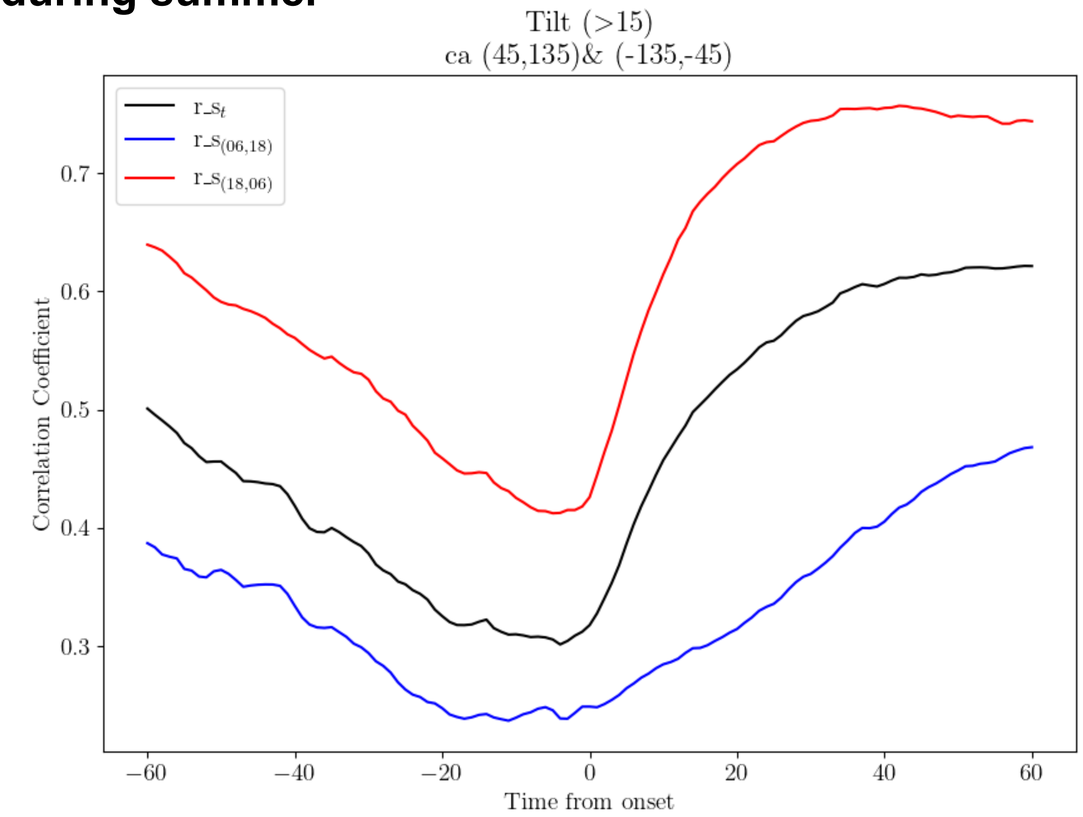
A Comparison between By negative and By positive substorms during summer



We evaluated the asymmetries in the EHIC, by correlating the EHIC maps during the summer of (By + and By -) each minutes between (-60 min prior to onset to +60 min after onset) using spearman's correlation. The red line represents the correlation on the nightside of the maps for the MLT (>18 or <6), the blue line presents the dayside (MLT<18 and >6). The black line presents the whole map.

EHIC



We found that the correlation is higher on the nightside than the dayside. As the onset takes place, the correlation increases.

Results and Discussion

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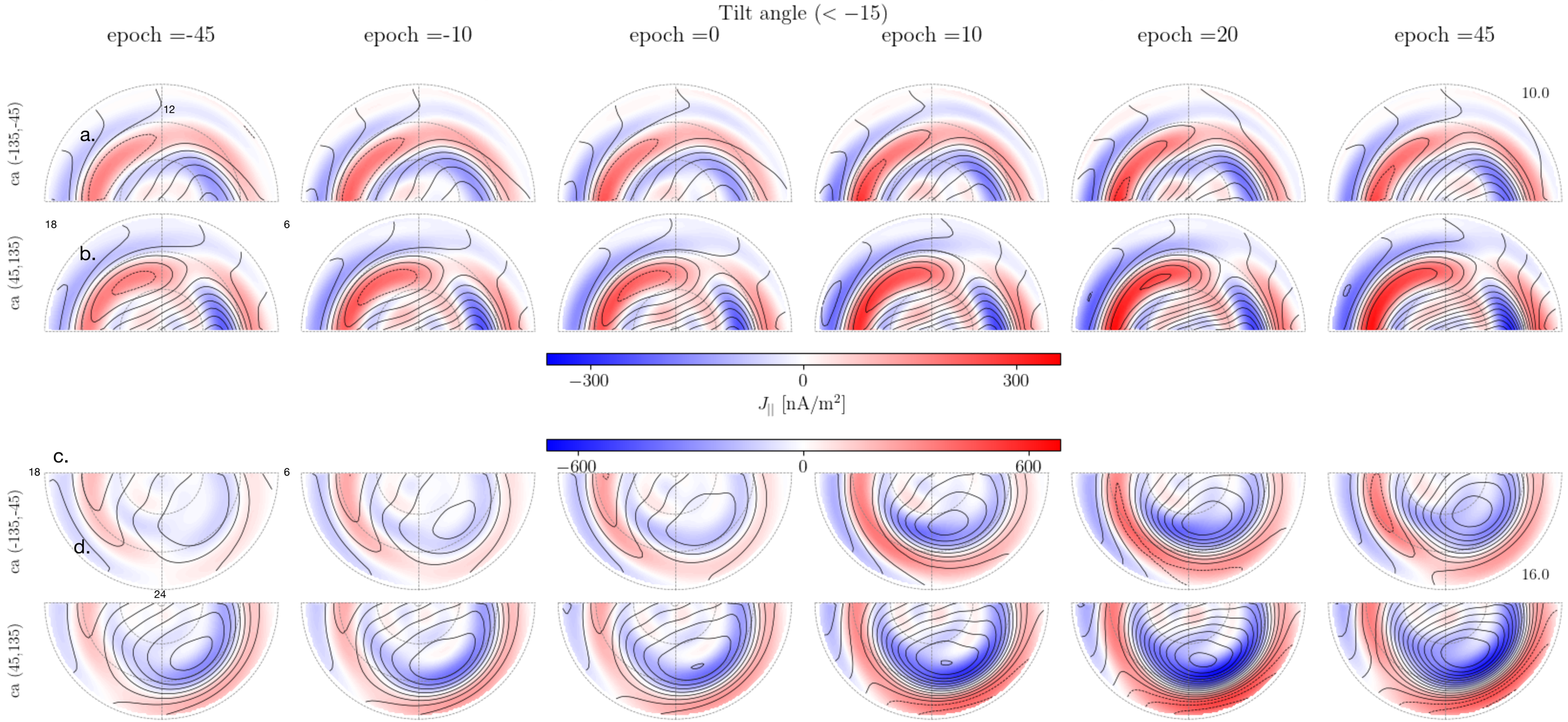
A Comparison between By negative and By positive substorms during winter



Similar to the summer, By$^-$ substorms are plotted in panels (a, c) and while By$^+$ substorms are shown in (b, d).

- The asymmetry observed in both the dayside the nightside are reduced as substorm takes place.

Results and Discussion

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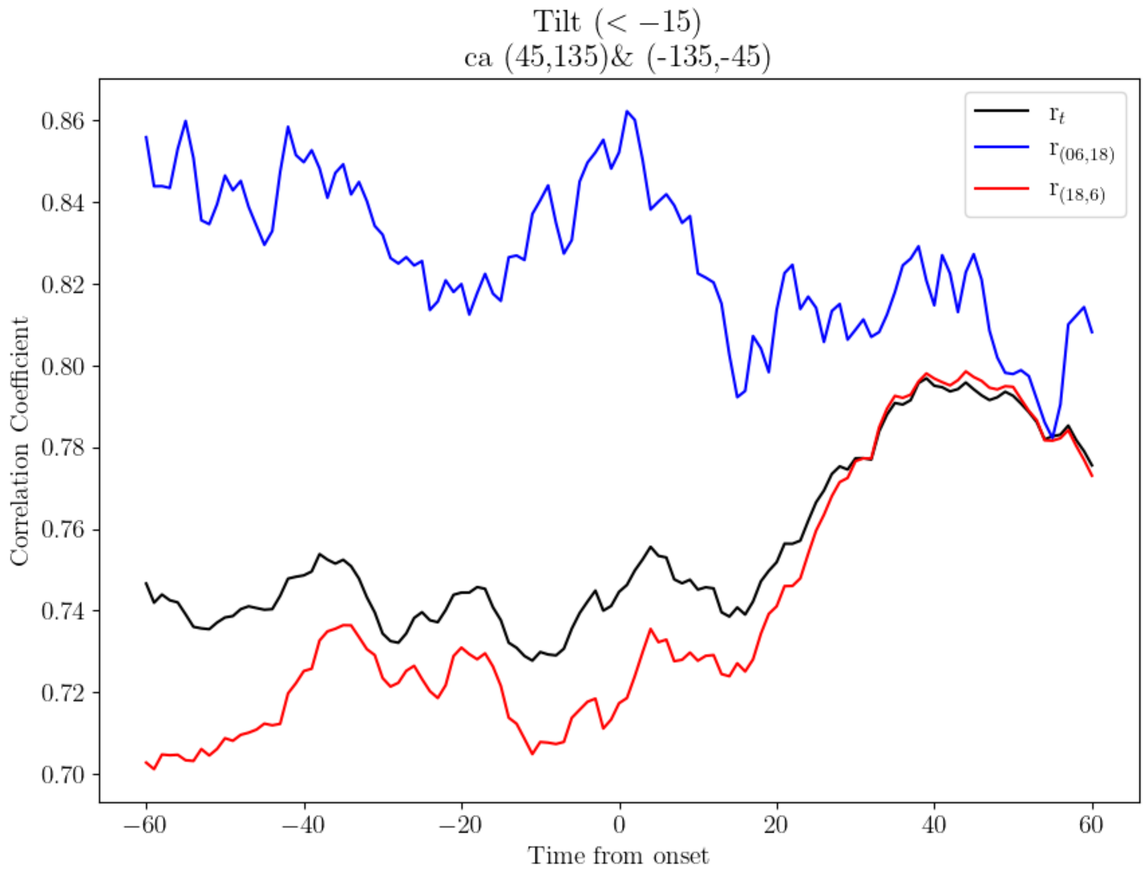
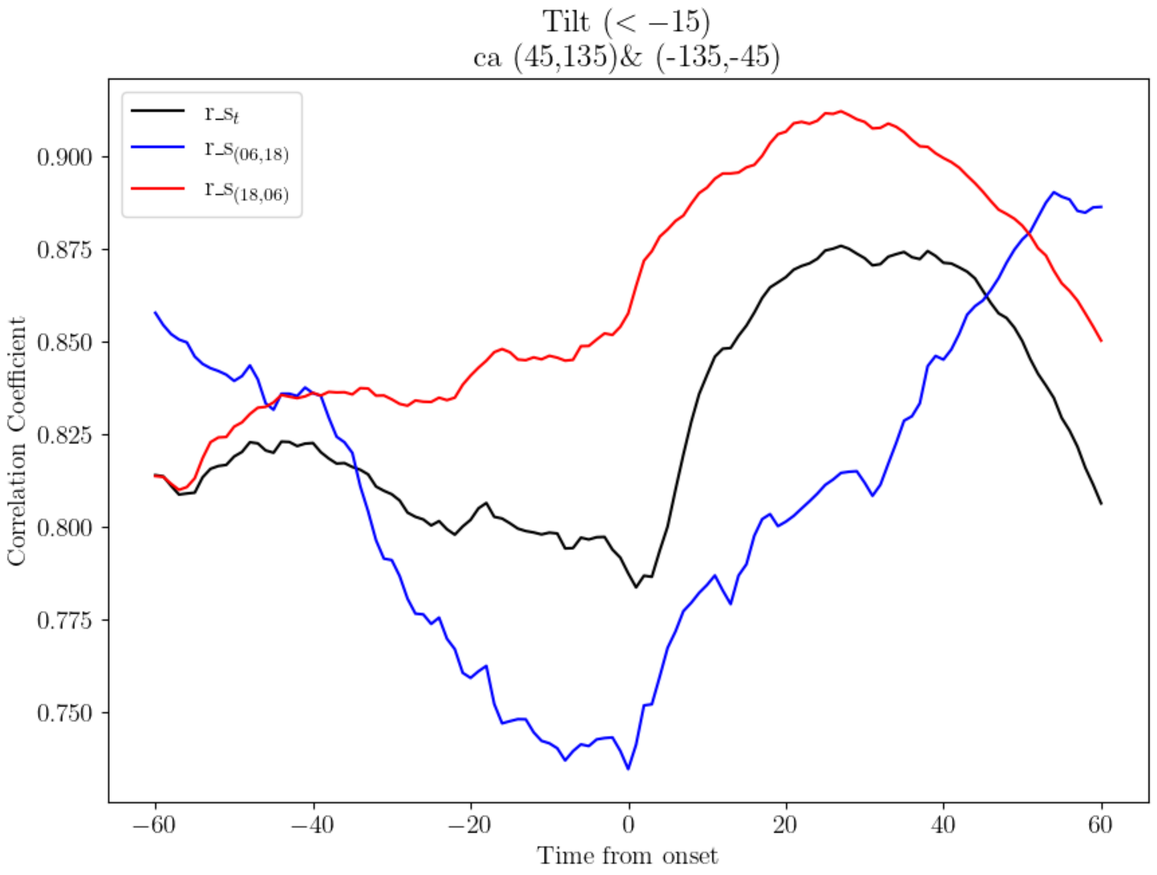
EFAC



EHIC



On onset time, the asymmetry reduction in the EHIC is clearer than the EFAC.

Results and Discussion

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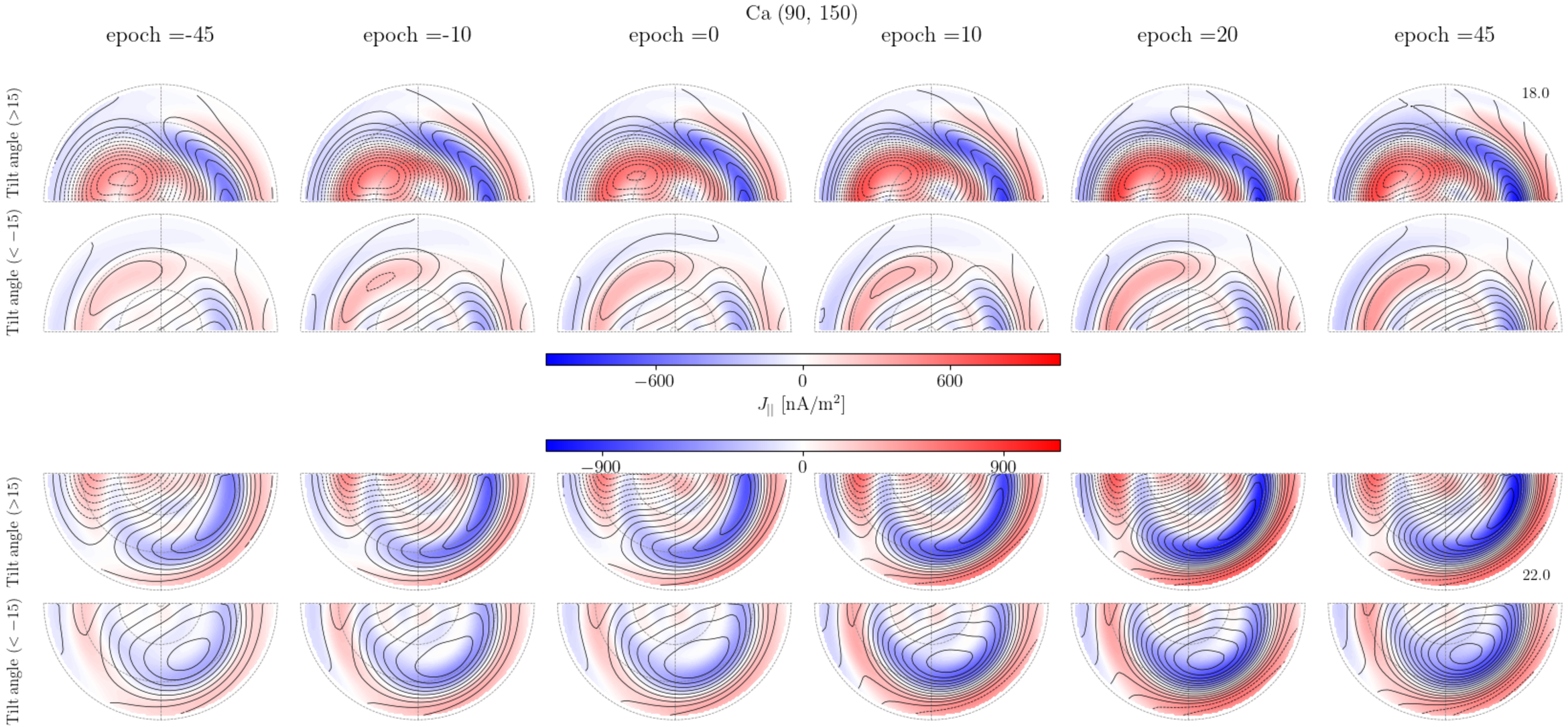
A Comparison between By positive and Bz negative substorms during summer and winter



- During summer, the magnitude of the current is generally higher than the currents in the winter time.

Results and Discussion

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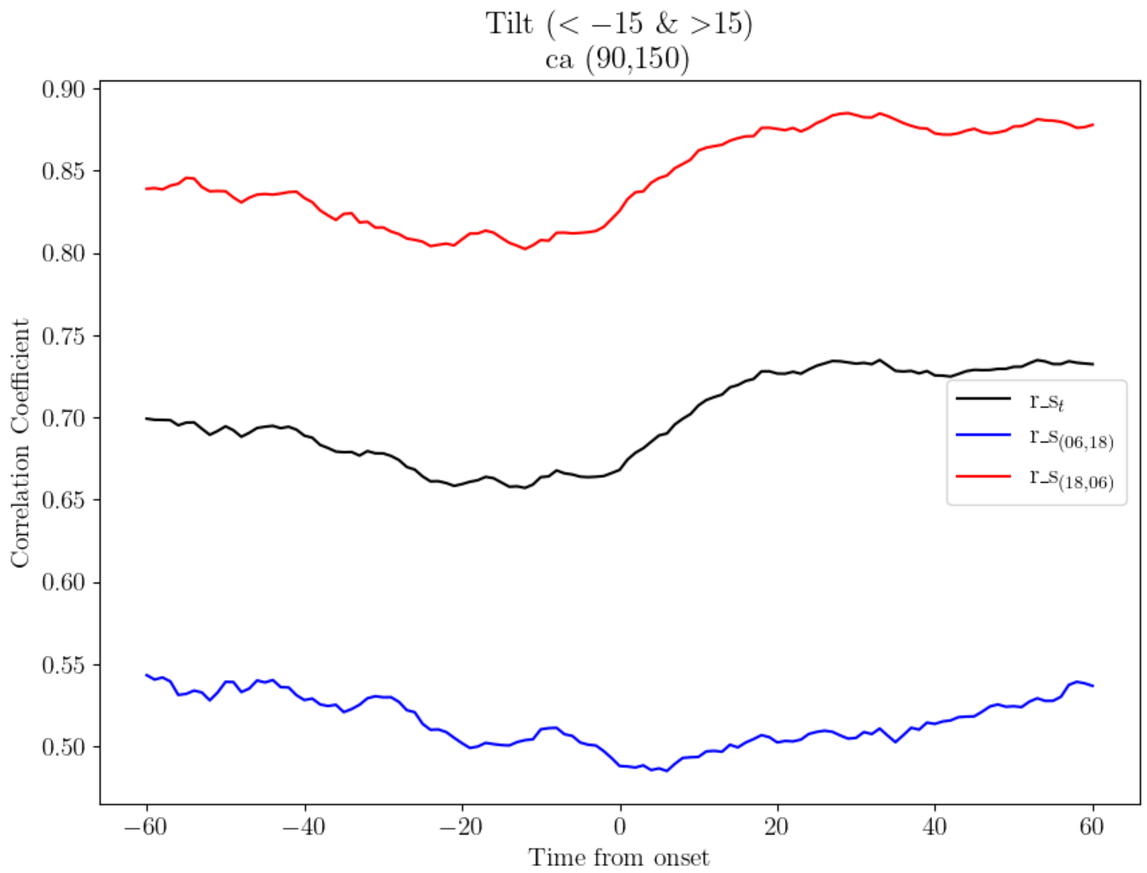
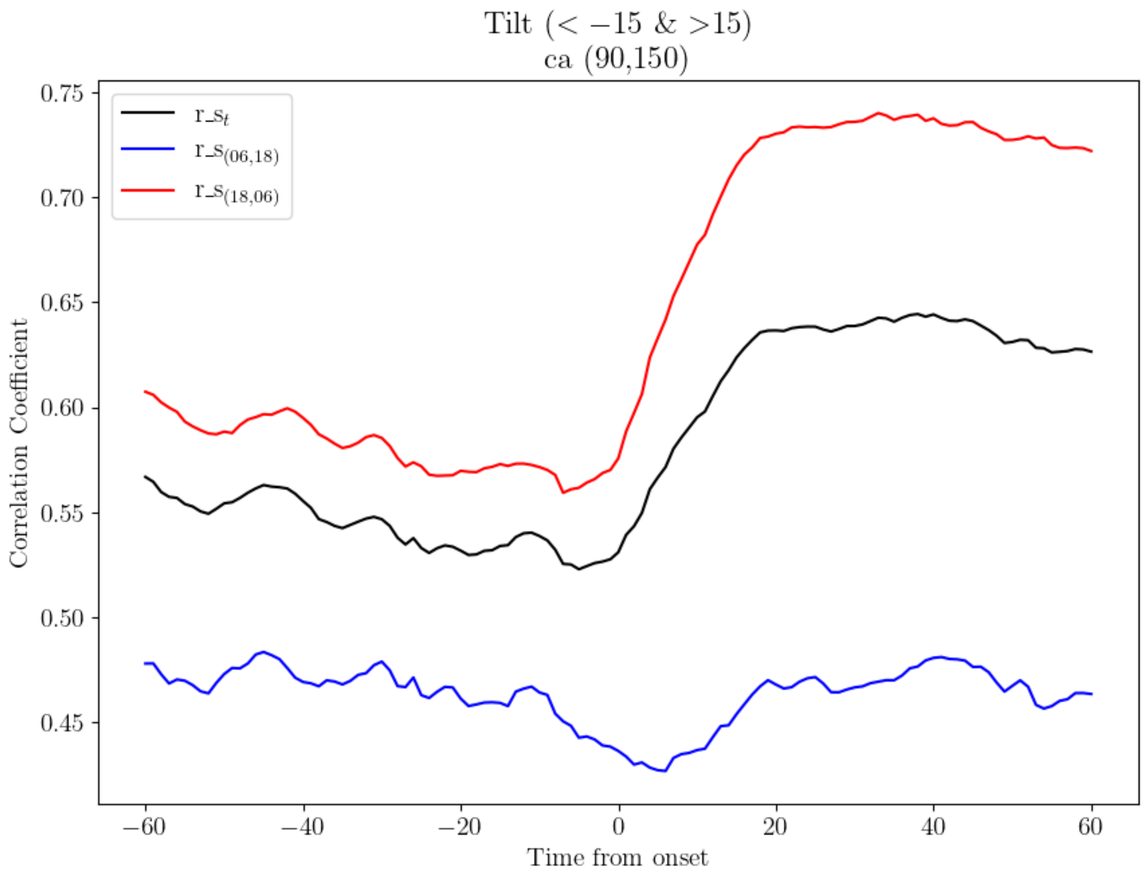
EFAC



We found that the correlation is higher on the nightside than the dayside. As the onset takes place, the correlation increases.

EHIC



On onset time, the asymmetry reduction in the EHIC is clearer than the EFAC, even though the values of correlation coefficients are higher in case of EFAC.

Results and Discussion

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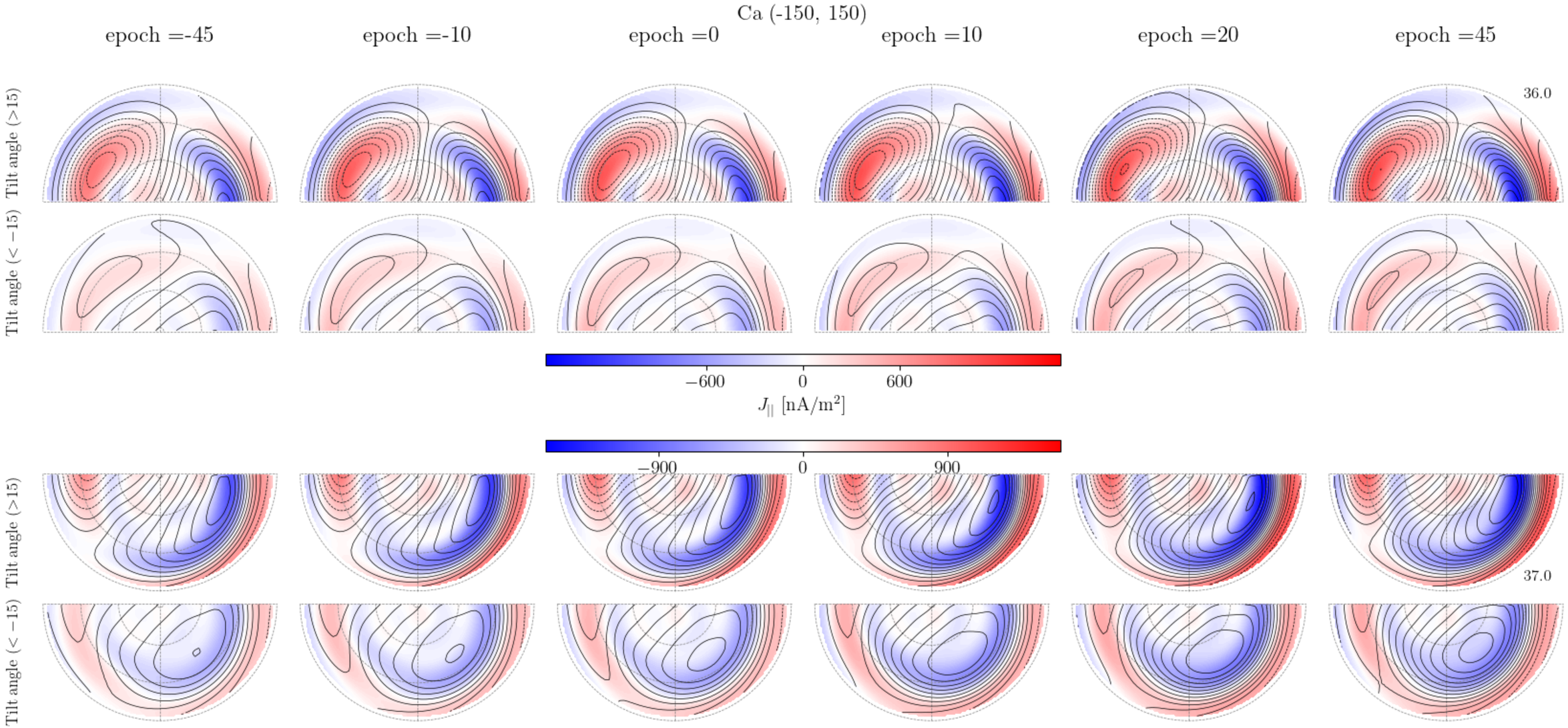
A Comparison between Bz negative substorms during summer and winter



- During summer, the magnitude of the current is generally higher than the currents in the winter time.

Results and Discussion

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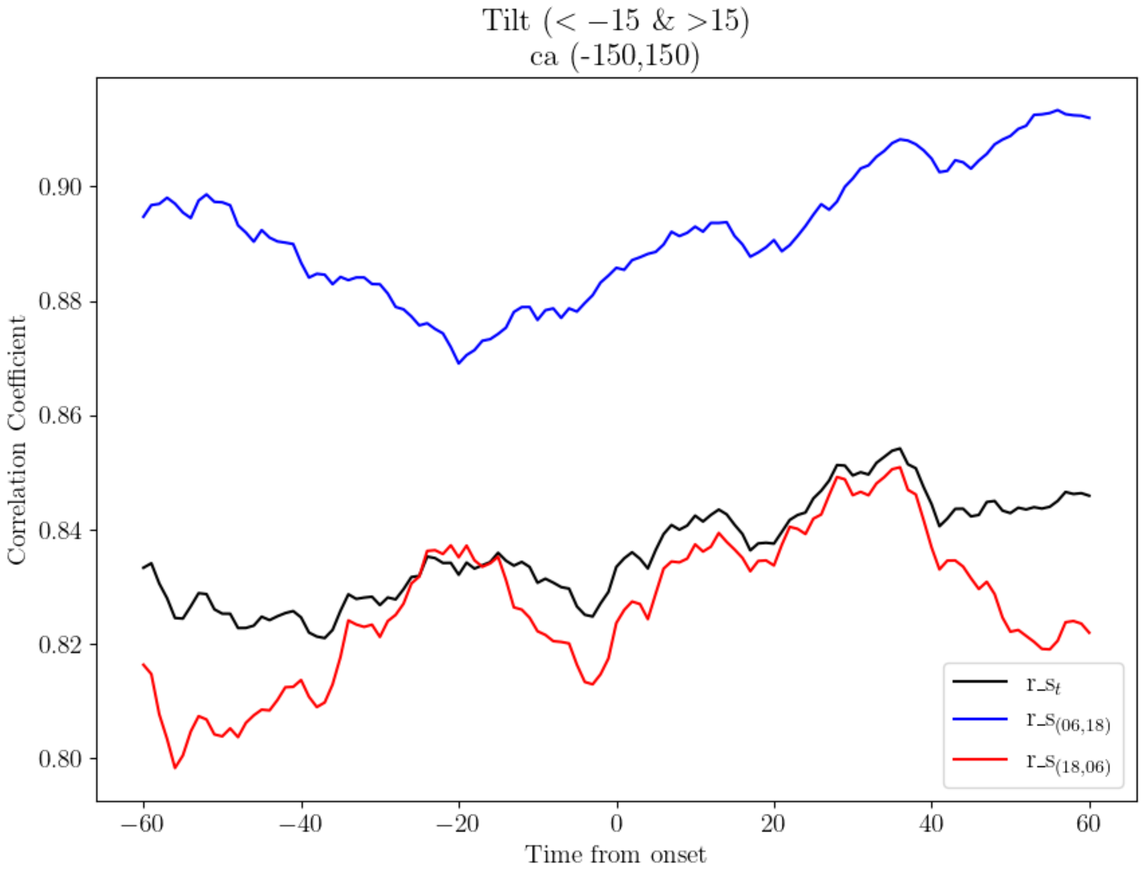
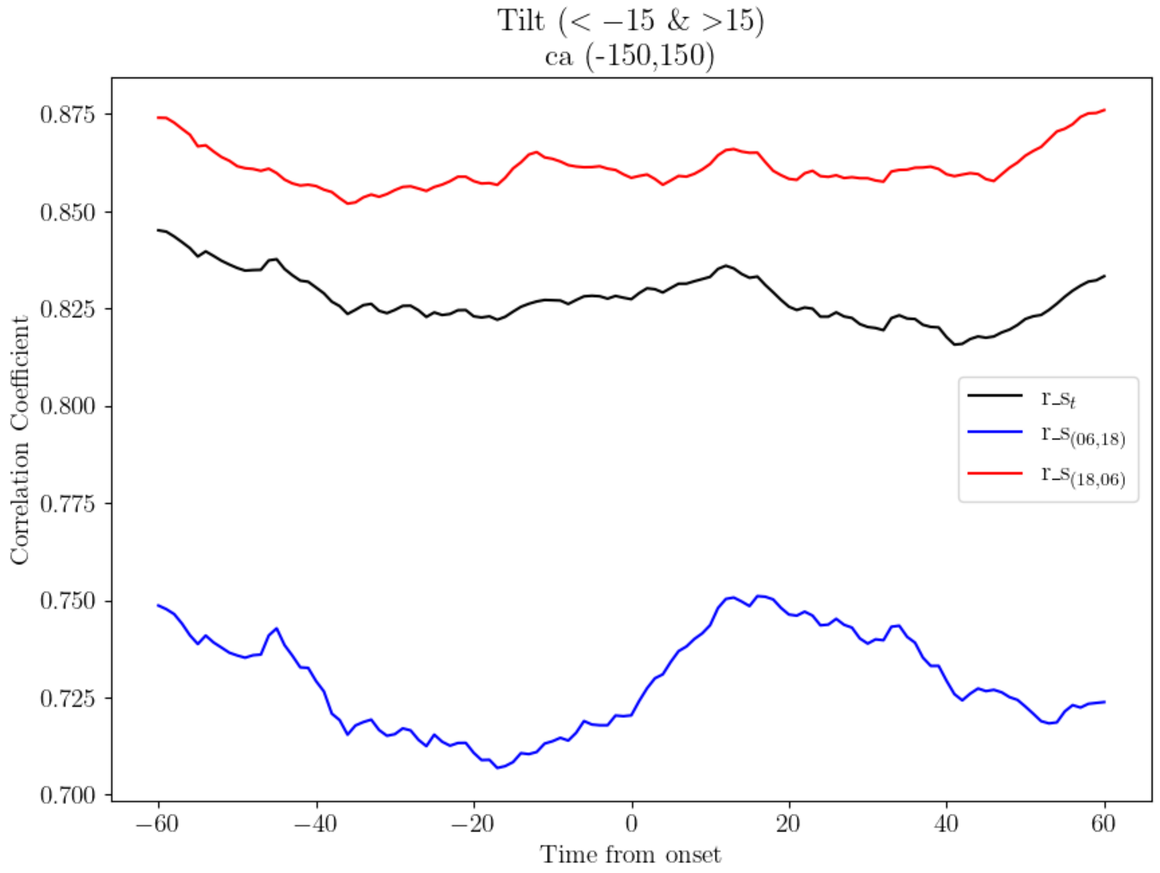
EFAC



EHIC



On onset time, the asymmetry reduction is not clear in both the EFAC and the EHIC.

Results and Discussion

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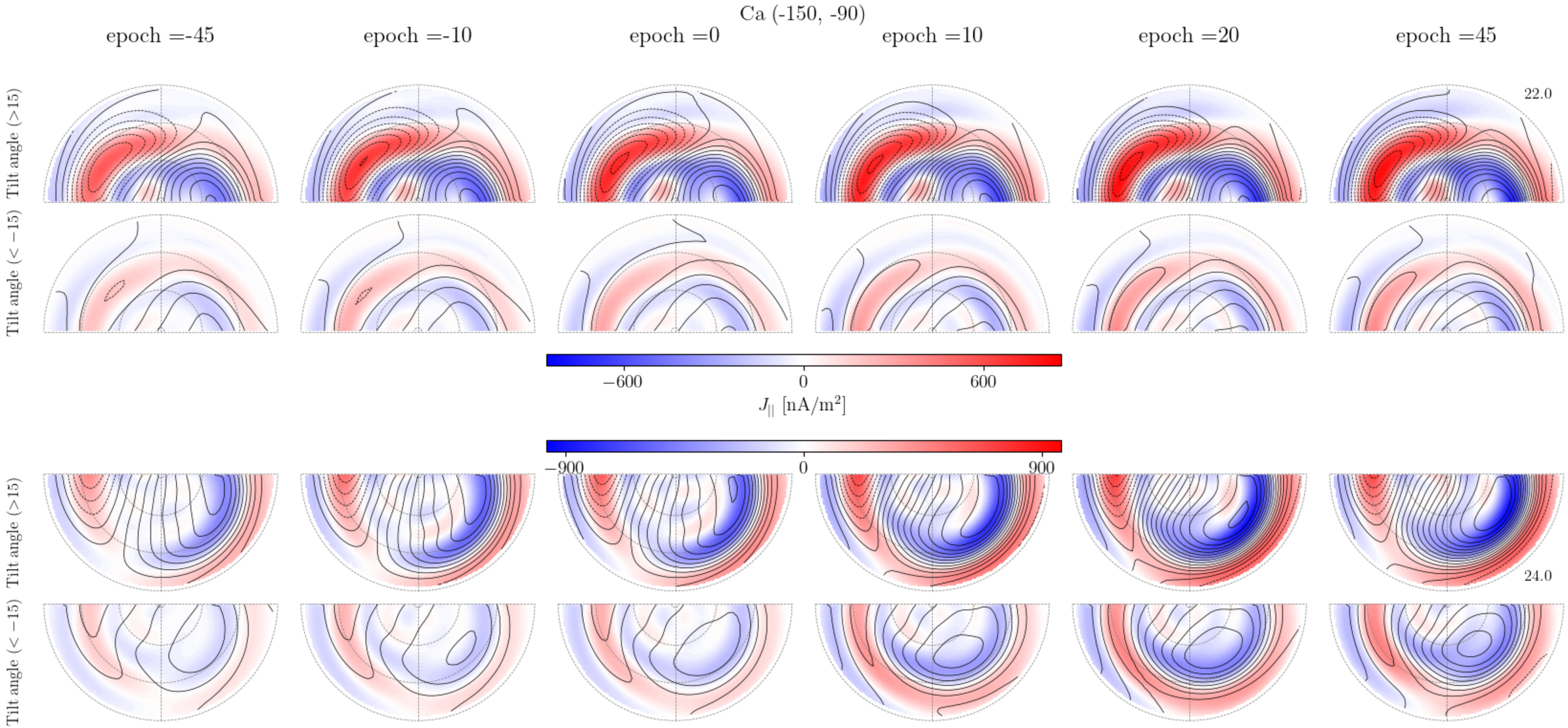
A Comparison between By negative and Bz negative substorms during summer and winter

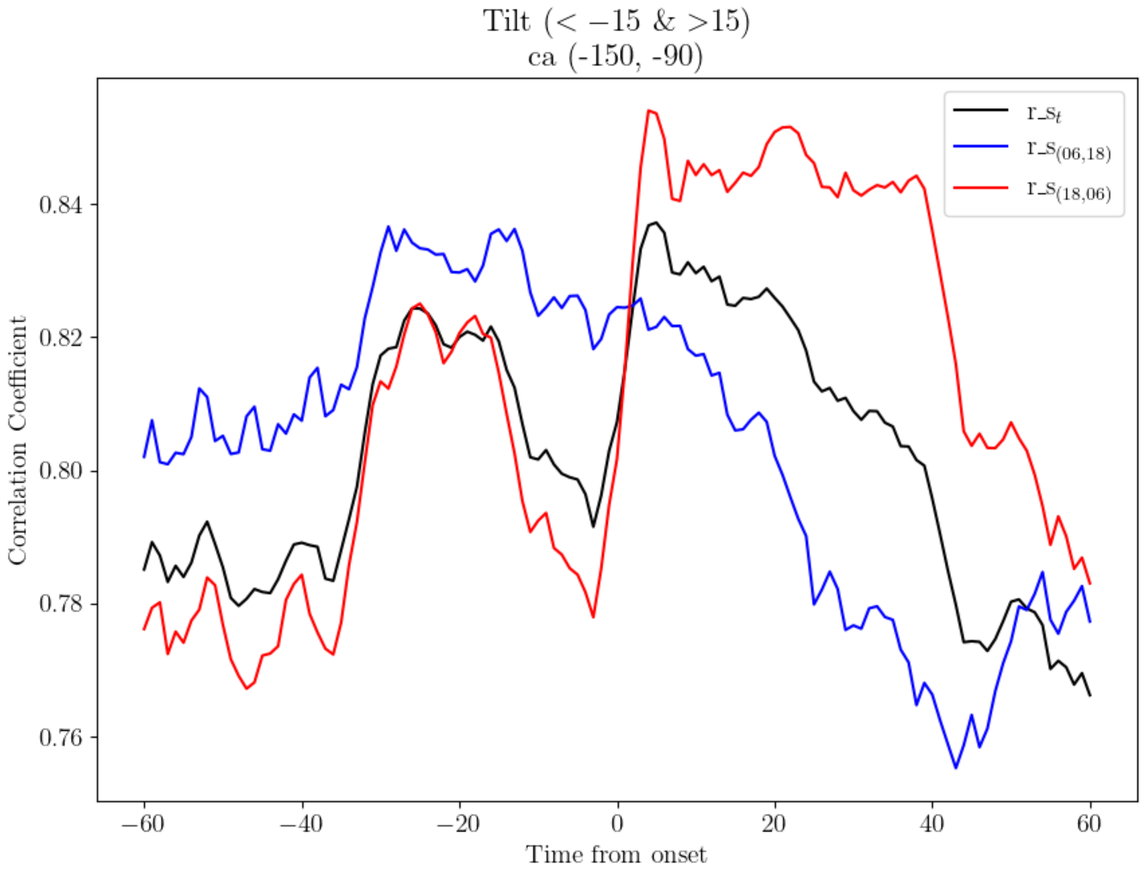


- During summer, the magnitude of the current is generally higher than the currents in the winter time.

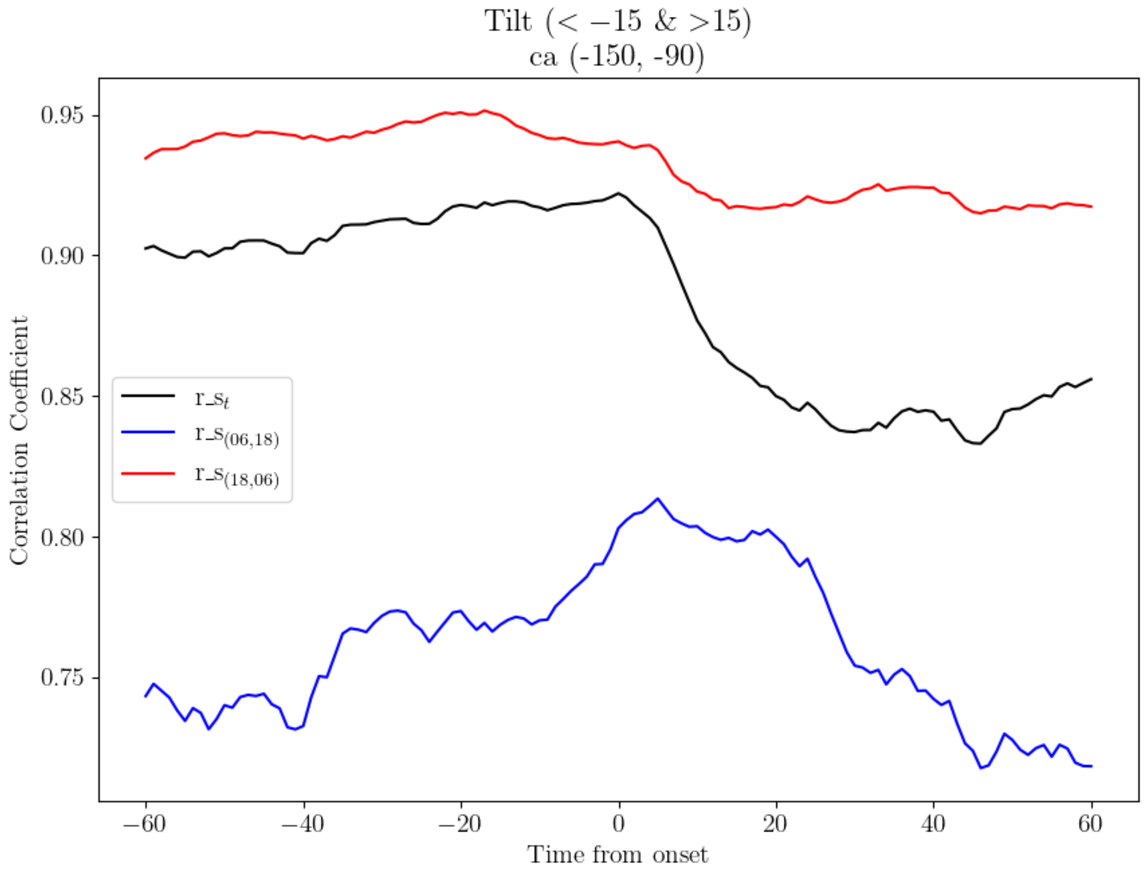
Results and Discussion

BIRKELAND CENTRE FOR SPACE SCIENCE

EFAC



EHIC



On onset time, the asymmetry reduction is clear in the EFAC, while it seems to increase in the EHIC.