Morphology of the ionospheric convection pattern during time-dependent solar wind and magnetospheric driving

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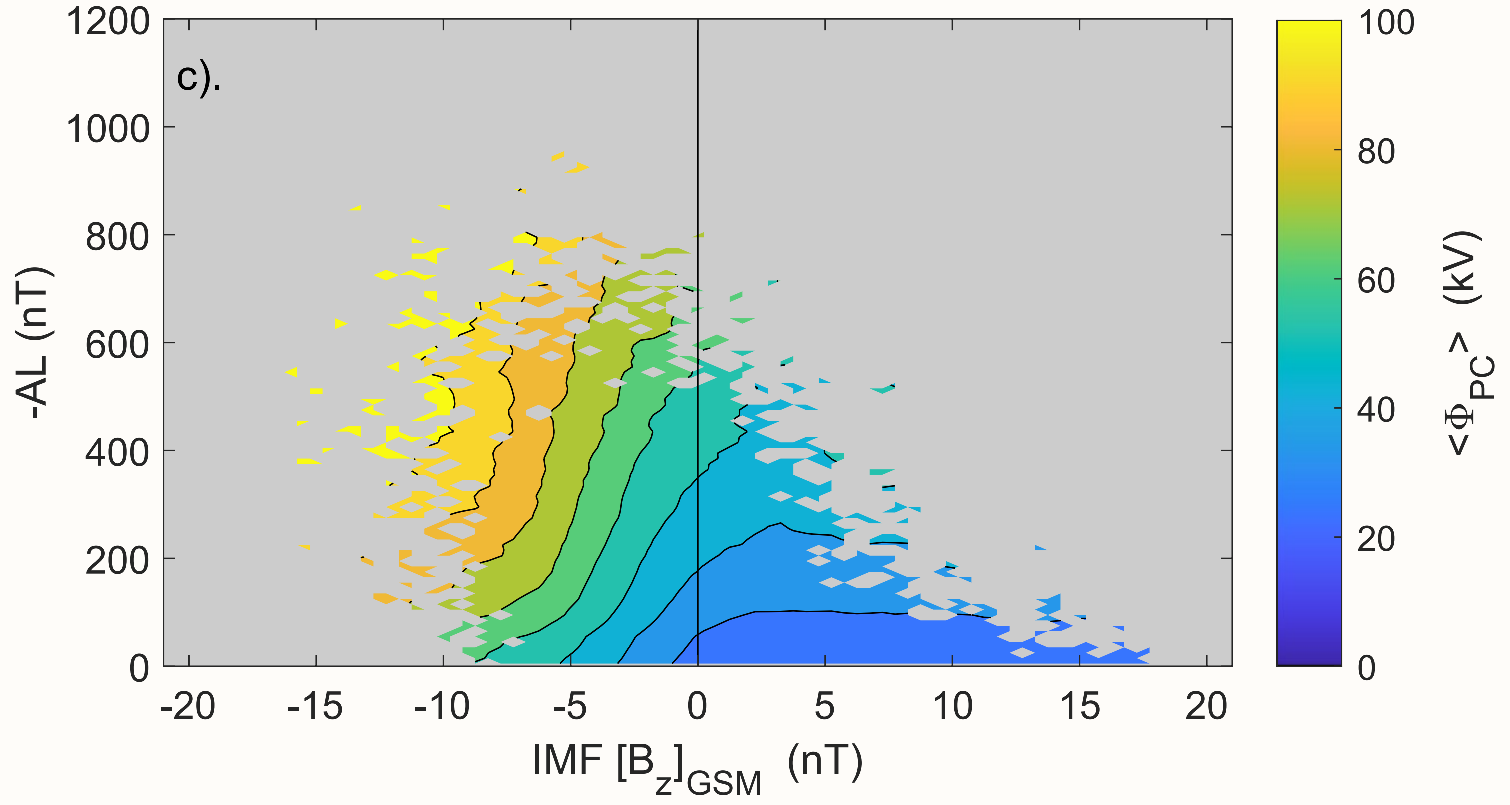
Introduction

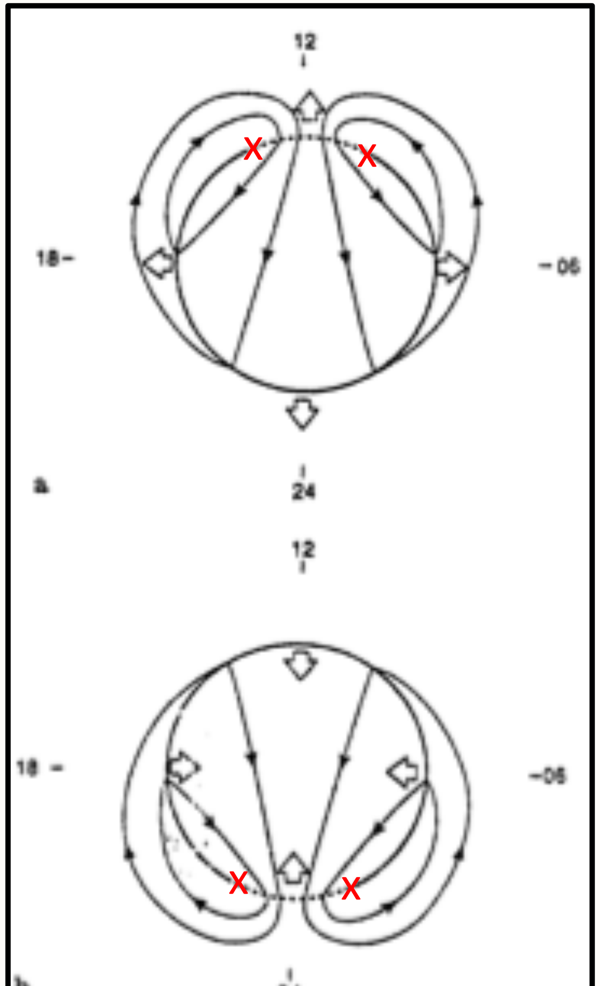
- Expanding-Contracting Polar Cap (ECPC) model requires unbalanced dayside and nightside reconnection to each drive a polar cap voltage (Cowley and Lockwood, 1992; Milan et al., 2021).
- Evidenced by the observation of solar wind (e.g. Ruohoniemi and Greenwald, 1998) and substorm (e.g. Grocott et al., 2002) driven enhancements to V_{PC}.
- Demonstrated statistically using IMF B_Z and the AL index as proxies for dayside and nightside reconnection, respectively (Lockwood and McWilliams, 2021).

Lockwood and McWilliams (2021)



- For a fixed AL, increasingly negative B_Z is associated with increased V_{PC}.
- For a fixed (but not strongly) negative B_Z, increasingly negative AL is associated with increased V_{PC}.

Introduction



Cowley and Lockwood (1992)

- The ECPC model also dictates that dayside and nightside reconnection should drive independent components of the convection pattern.

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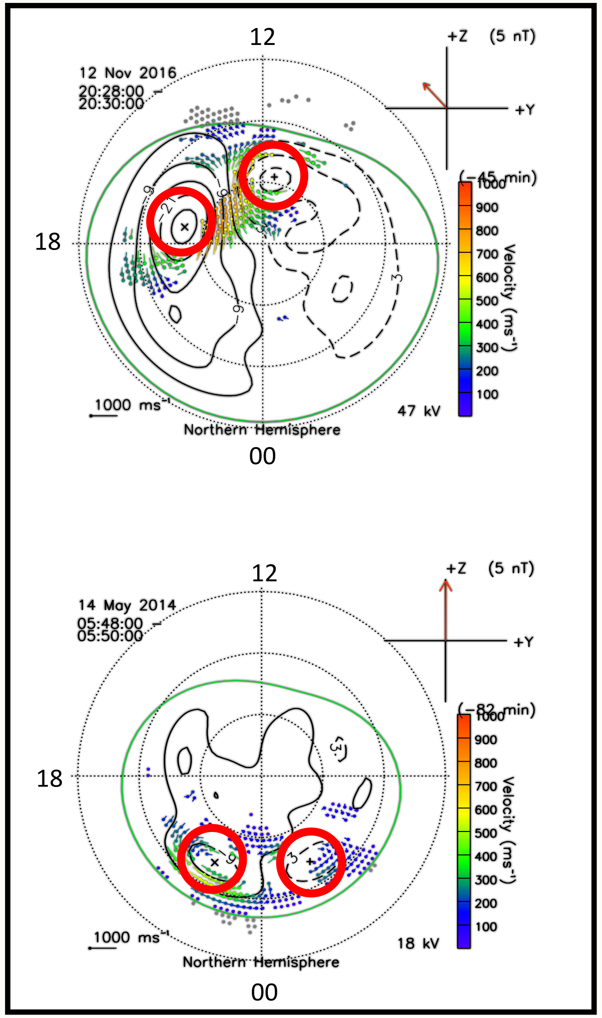
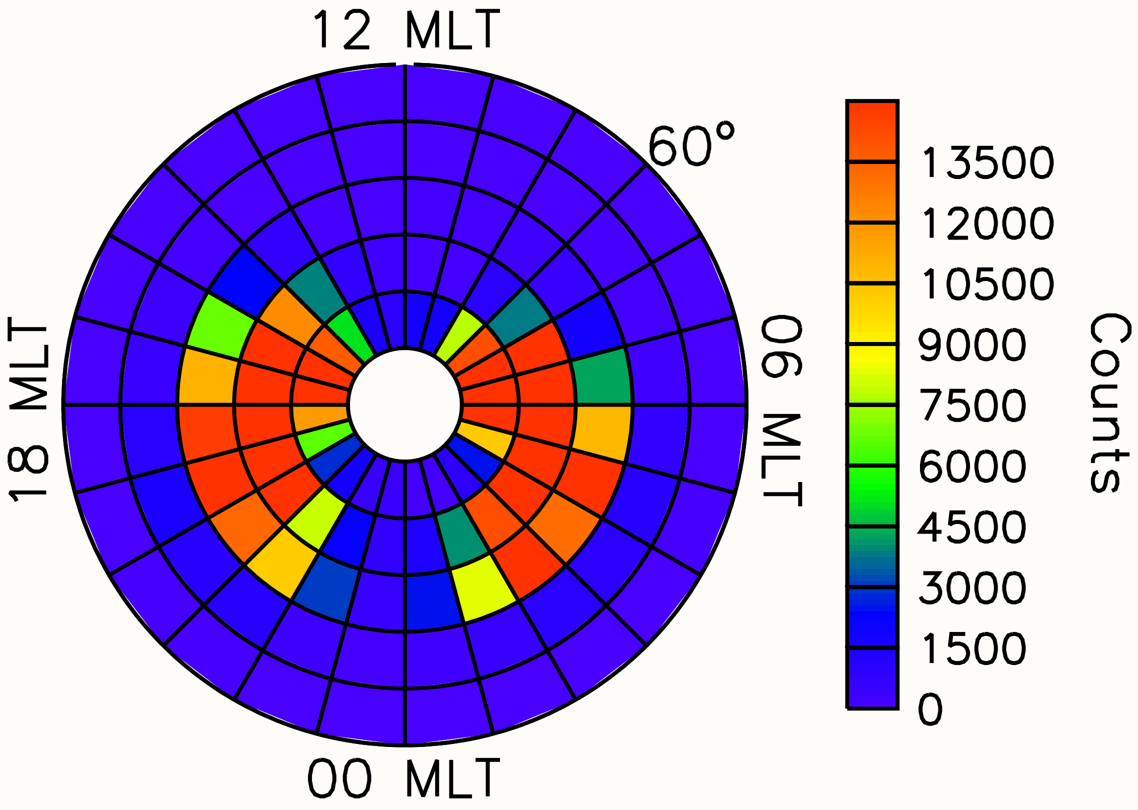


- The ECPC model also dictates that dayside and nightside reconnection should drive independent components of the convection pattern.
- In this study we use an archive of SuperDARN data to investigate these two components based on the locations of the foci of the twin vortex convection.
- We use SuperDARN convection maps (Ruohoniemi and Baker, 1998) that satisfy:
  - $n_{vecs} > 250$
  - $MLT\Phi_{min} > 12$ and $MLT\Phi_{max} < 12$

Overview of Foci Locations

- Wide spread of foci locations, particularly on the nightside
- Typically 75° – 85° latitude on the dayside (within 2 hrs MLT of the dusk-dawn meridian).
- Typically 70° – 80° latitude on the nightside (within 4 hrs MLT of the dusk-dawn meridian).
- 98% of map foci fall within these limits.



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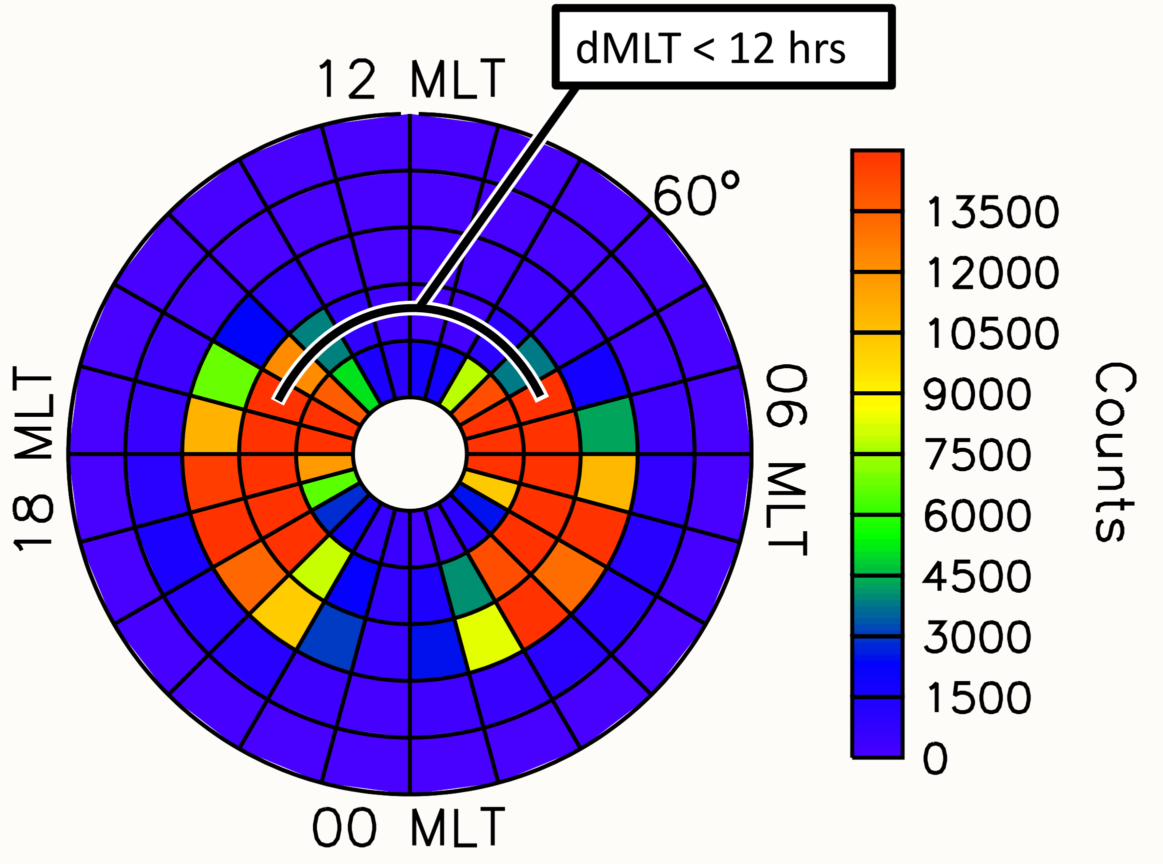
- Define: $dMLT = MLT\ \Phi_{min} - MLT\ \Phi_{max}$



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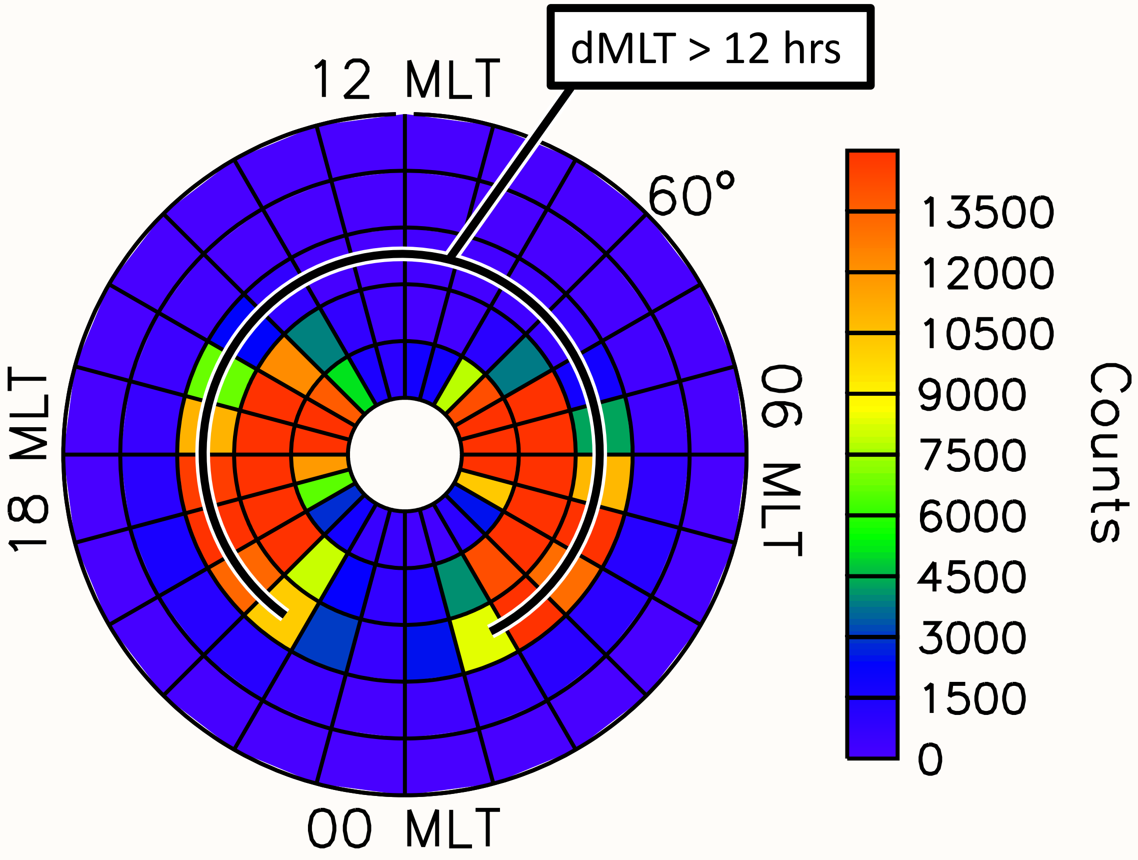

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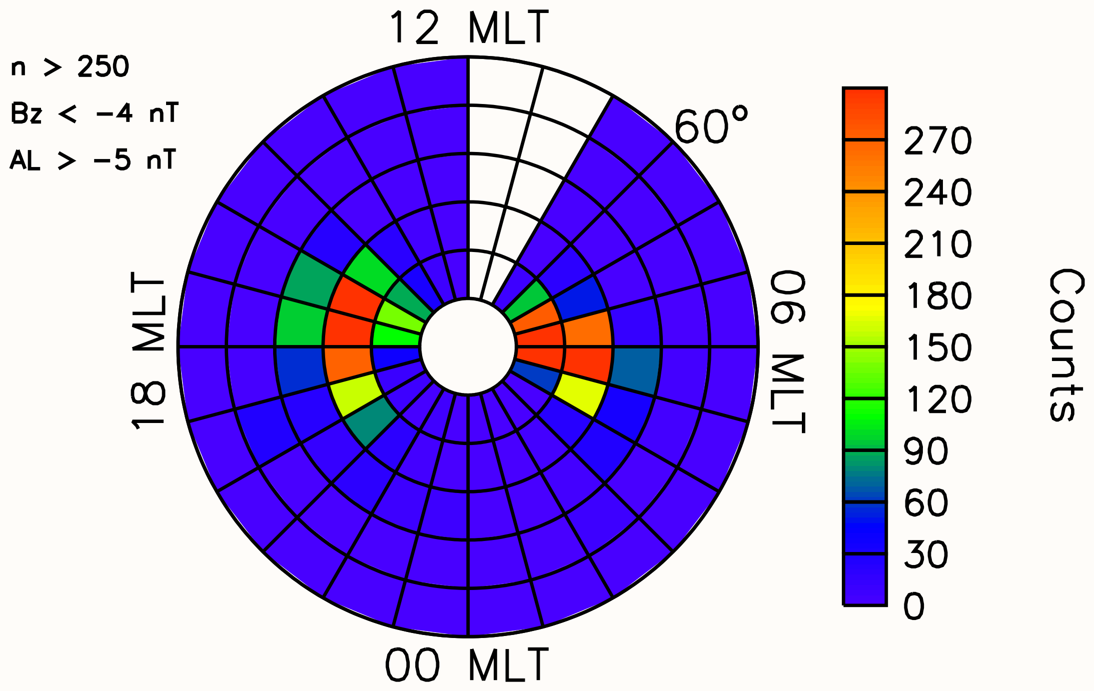
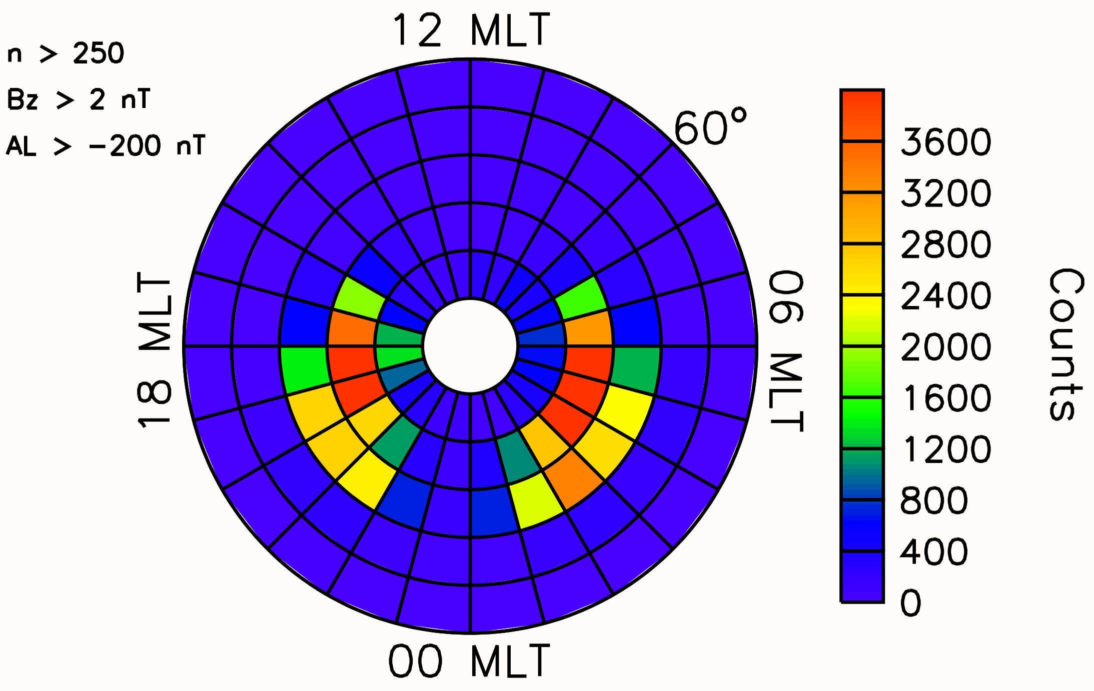
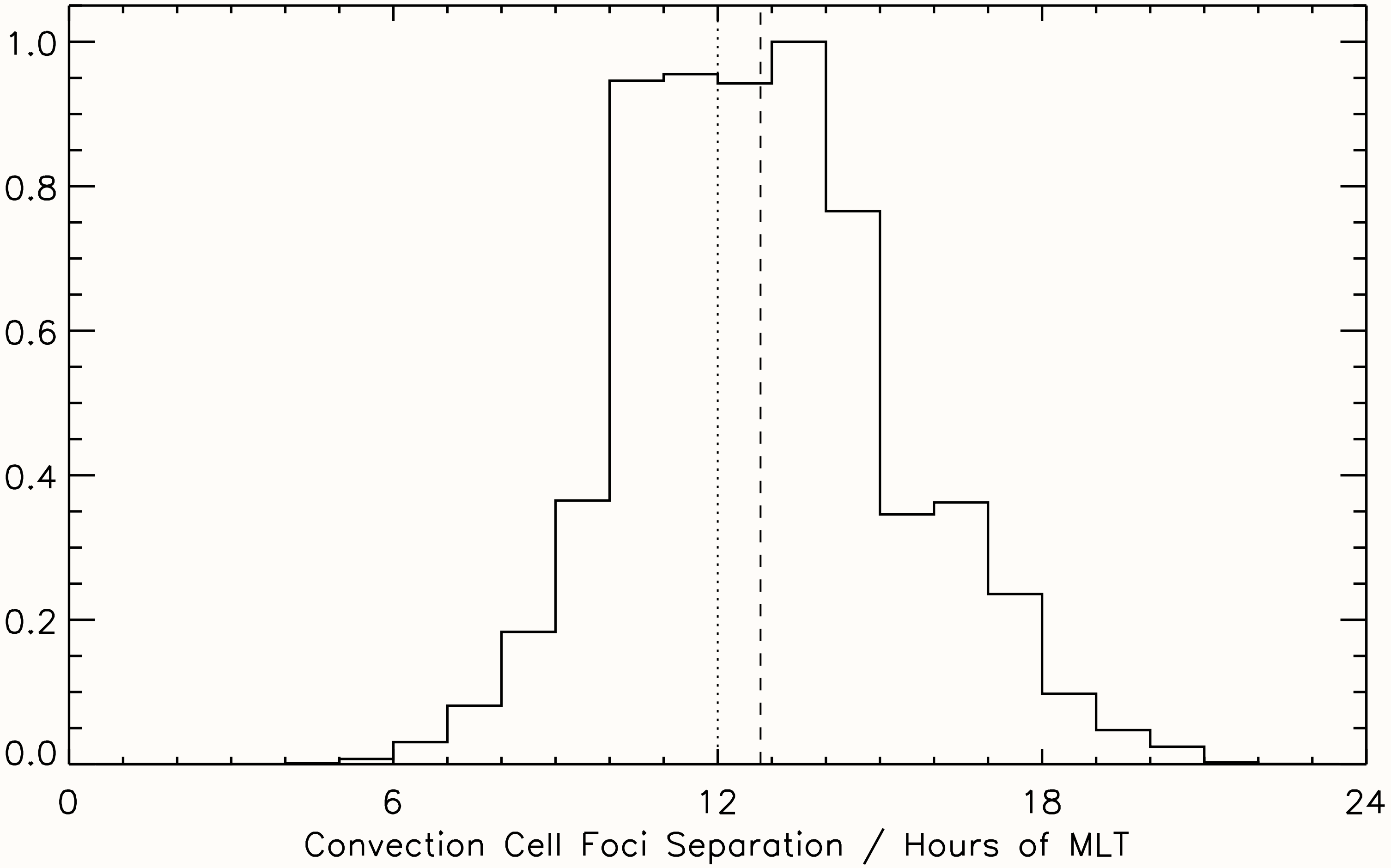




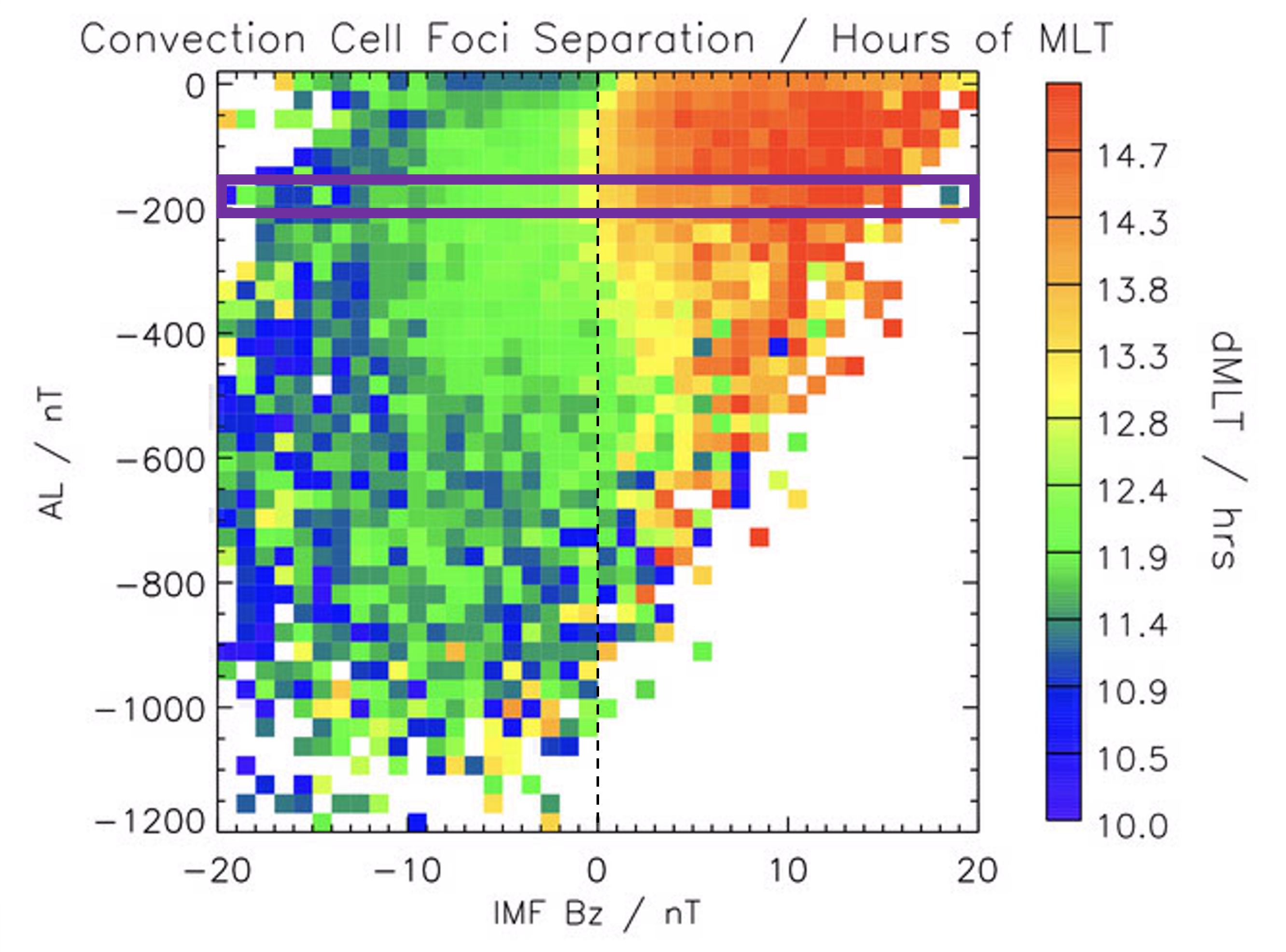
- Filtering by IMF and AL there are clear differences.
- Peak occurrence on left is slightly pre-dusk, but also slightly pre-dawn, higher latitude.
- Peak occurrence on right is post-dusk and pre-dawn, extending to lower-latitudes.
- Greater spread for nightside foci.

Foci Separation



- Foci separation has a mean of 12.8 hrs.
- Minimum separation is ~4 hrs.
- Maximum separation is ~20 hrs.

Foci Separation vs. IMF B_Z and AL



- At fixed, modest AL, see a clear Bz dependence of dMLT
  - Stronger $-B_Z$ → dayside foci

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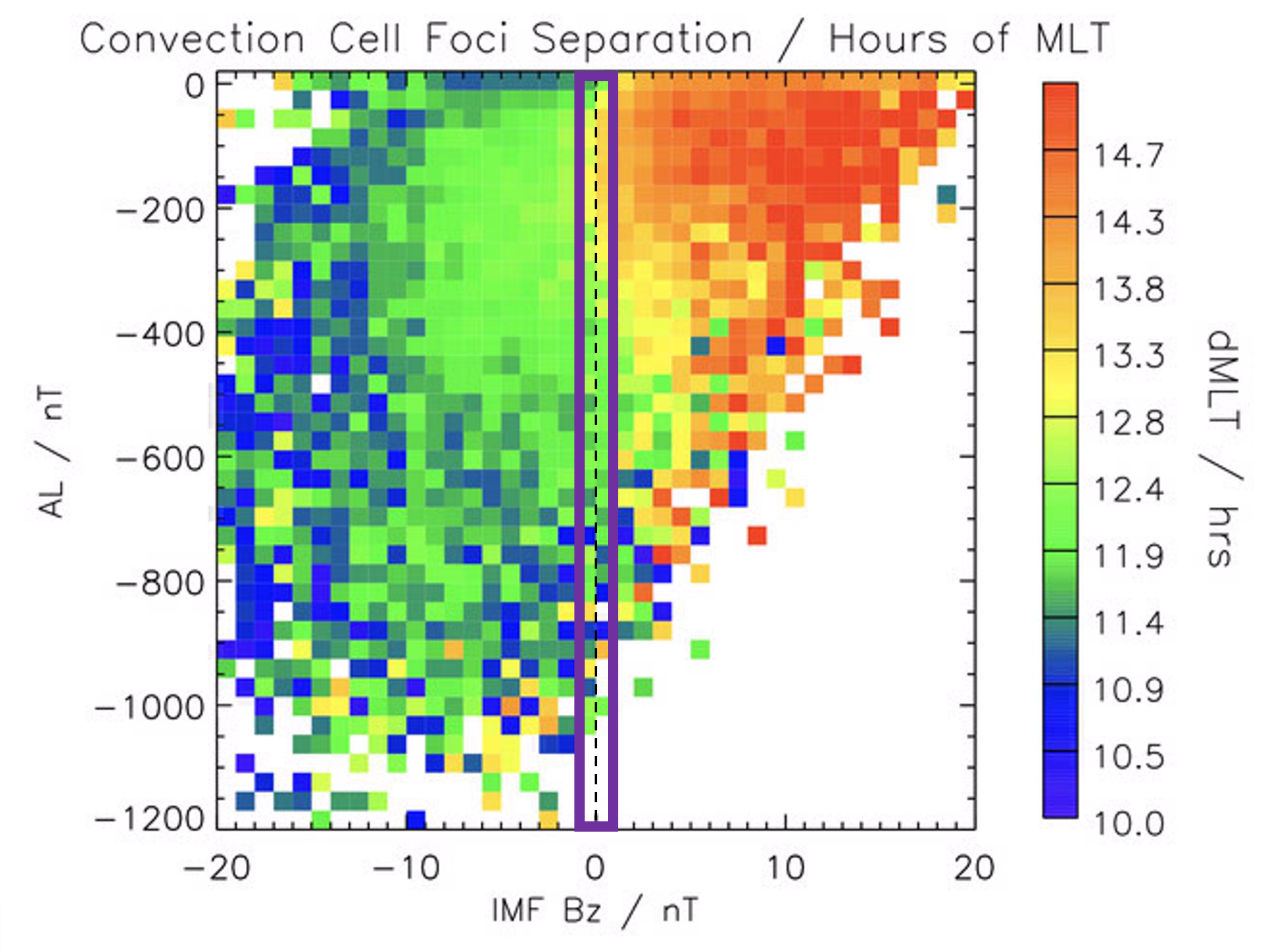

- At fixed, modest AL, see a clear Bz dependence of dMLT
  - Stronger $-B_Z$ → dayside foci
- At fixed, zero Bz, also have a dependence of dMLT on AL
  - Stronger AL → dayside foci

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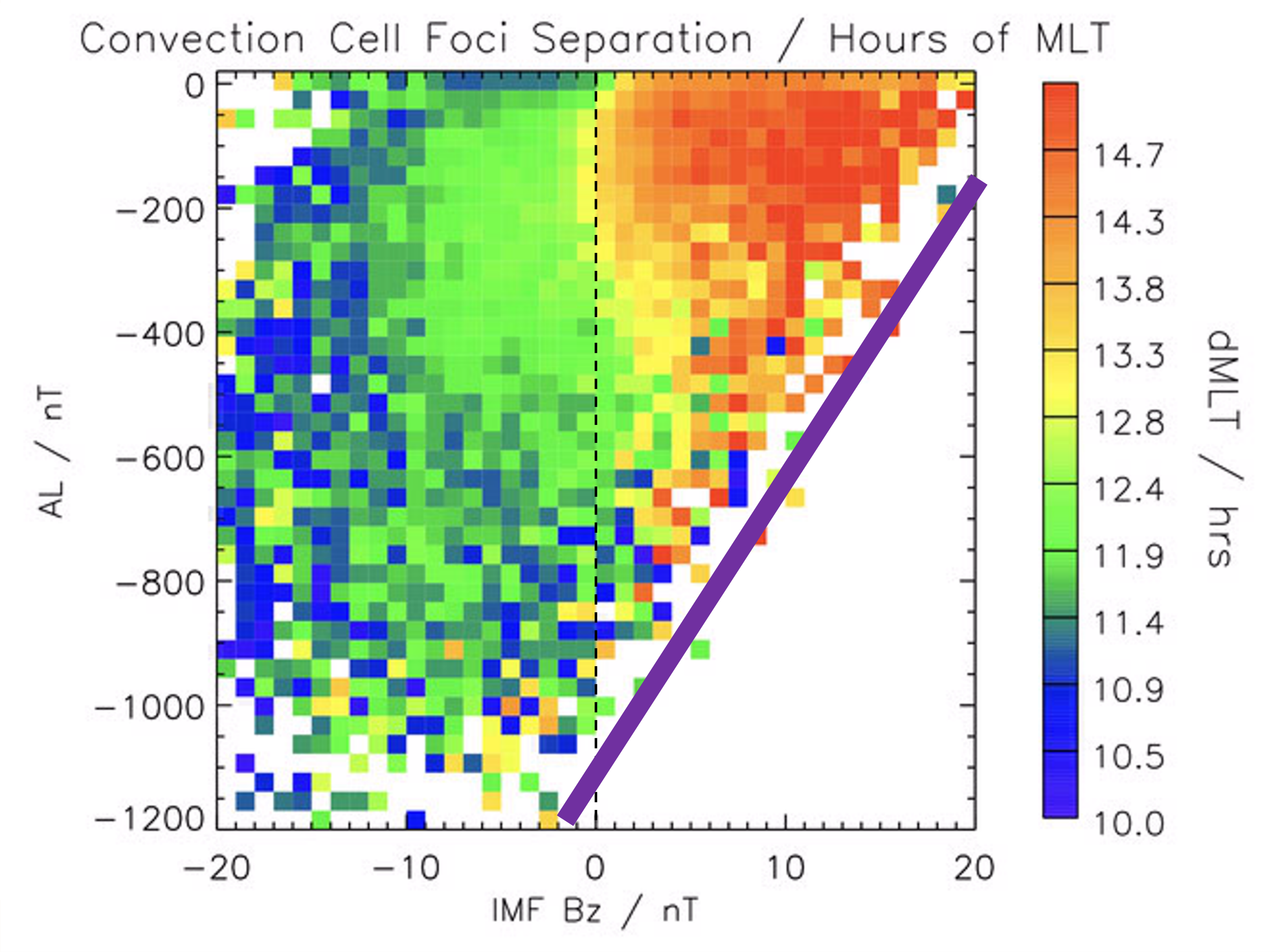

- At fixed, modest AL, see a clear Bz dependence of dMLT
  - Stronger $-B_Z$ → dayside foci
- At fixed, zero Bz, also have a dependence of dMLT on AL
  - Stronger AL → dayside foci
- Strong AL requires strong dayside driving

Foci Separation

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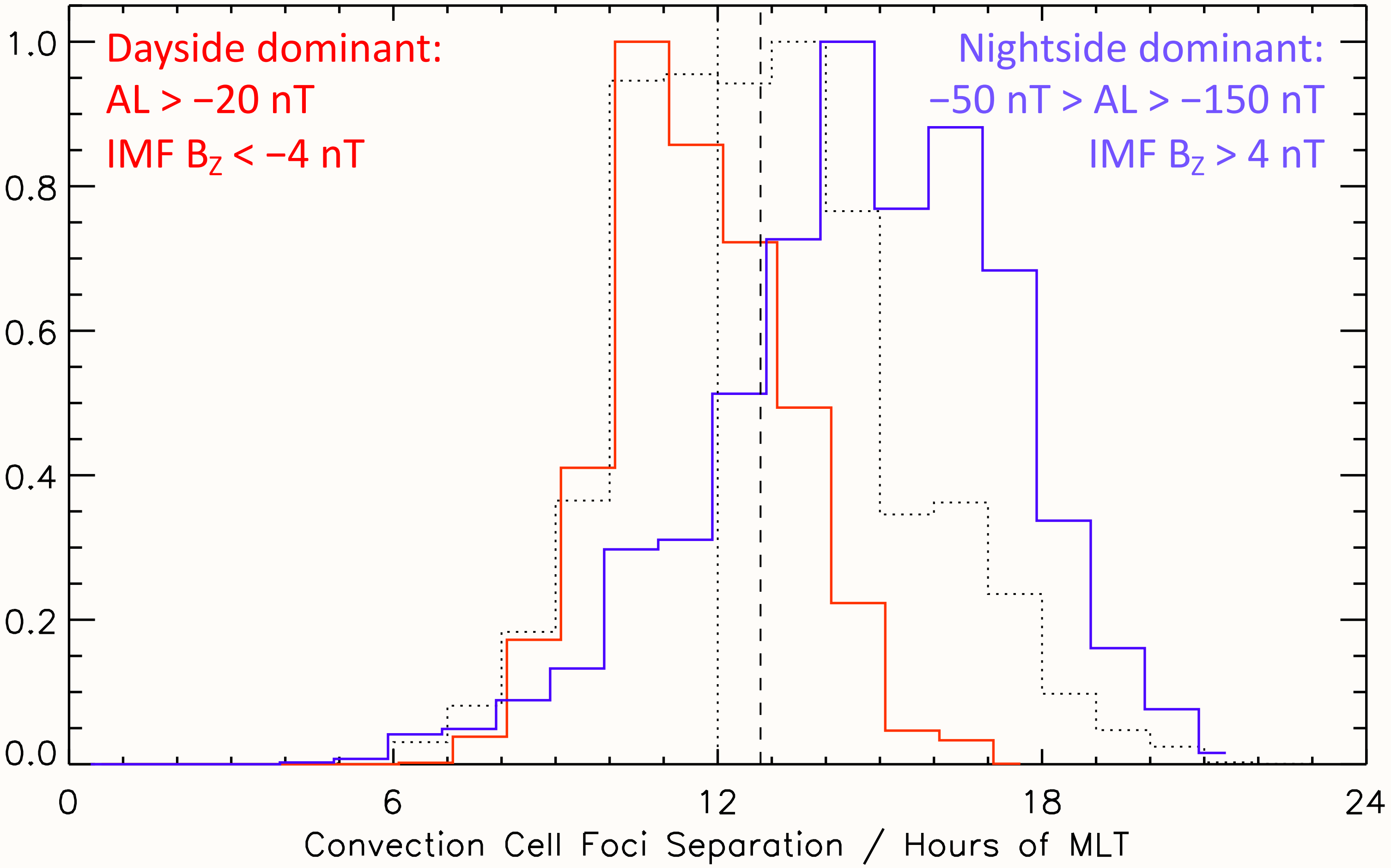


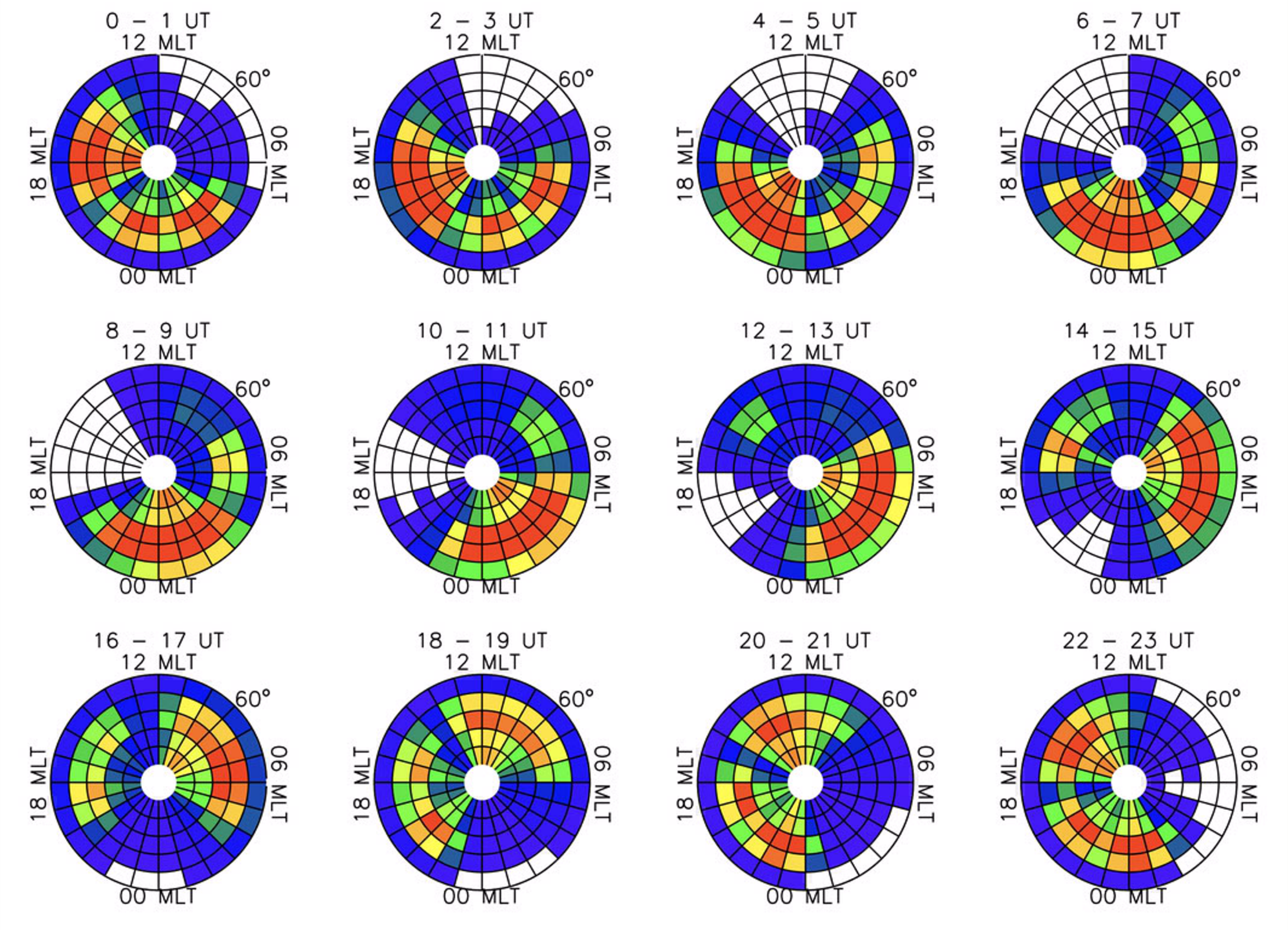
Results

- Dayside reconn. dominant: mean dMLT = 11.5 ± 1.6 hrs
- Nightside reconn. dominant: mean dMLT = 14.7 ± 2.7 hrs

Conclusions

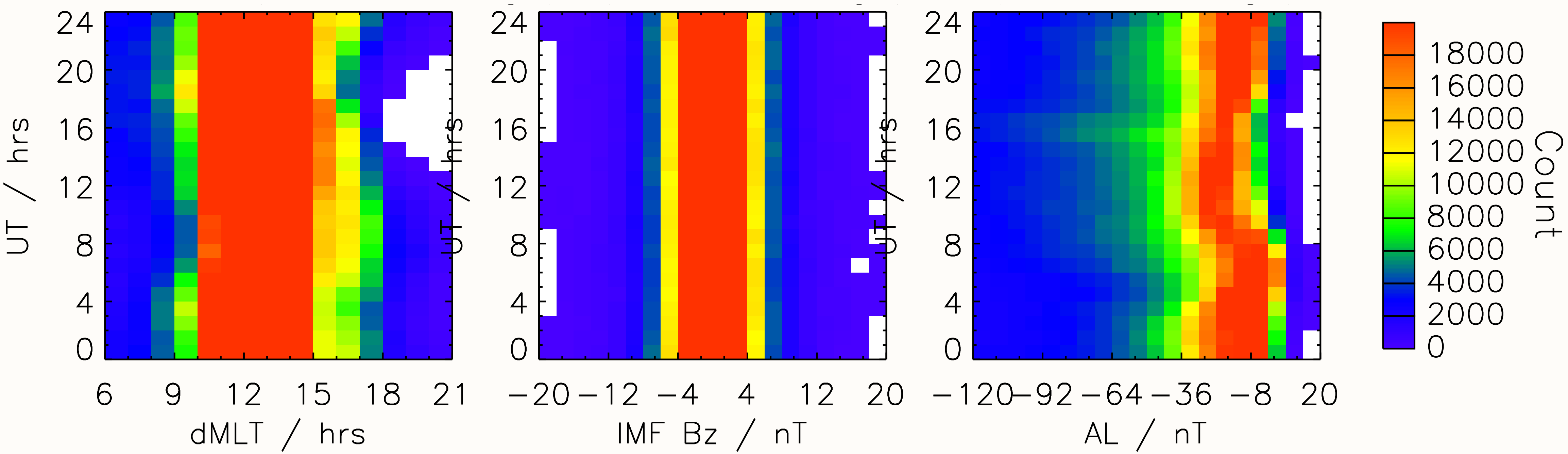
- Results agree with ECPC model
- Overlap in the distributions due to AL dependence on B_Z

Average SD Data Coverage



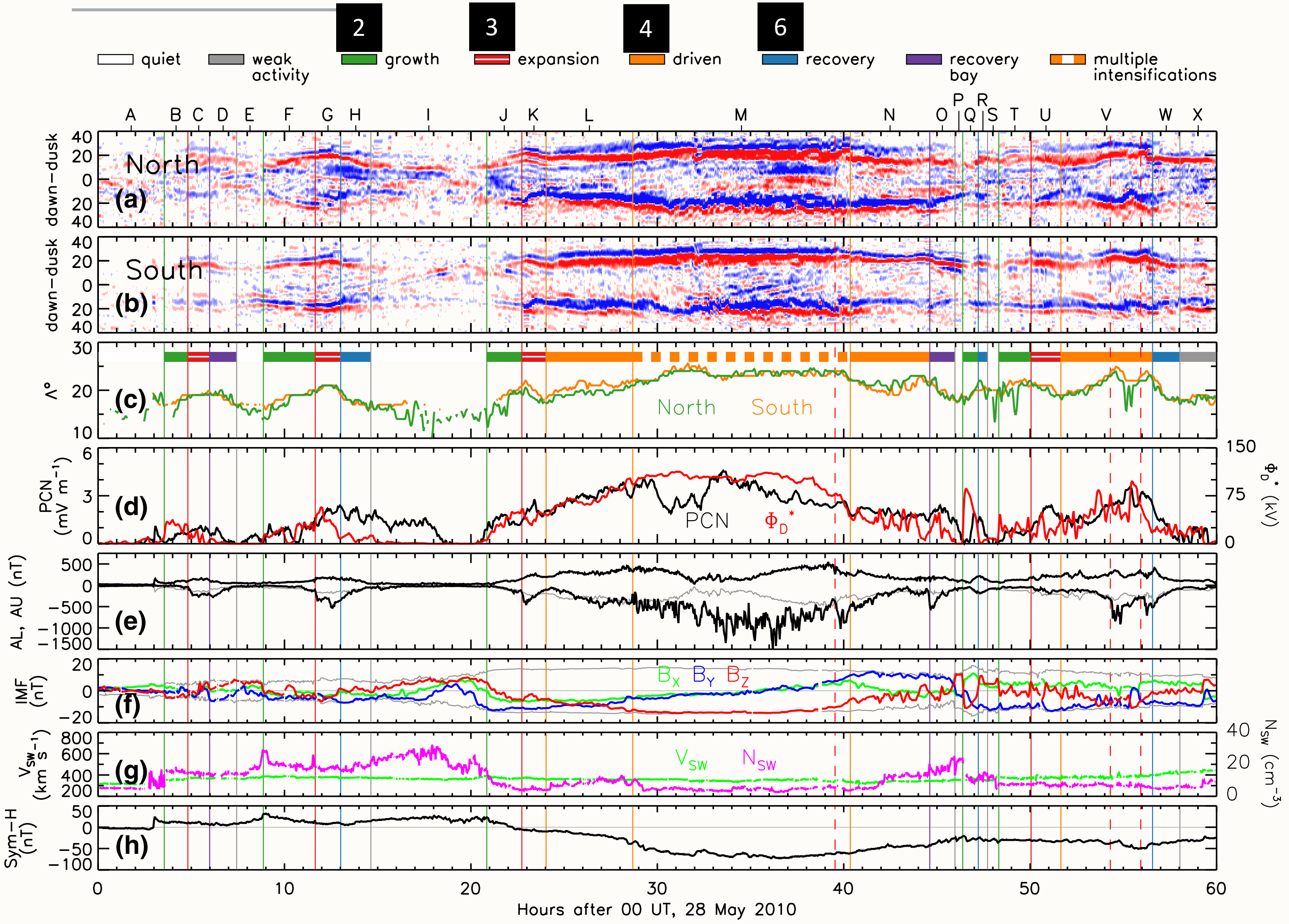
- Average SuperDARN data coverage is shown for different Universal Times
- Non-uniform locations of the radars gives some UT-dependence of the coverage
- With a coverage filter to remove low (n<250) maps….
- Better highlights how the coverage gap rotates with UT.
- Q: Is this responsible for the observed foci displacements?

UT dependence



- Very weak UT dependence of dMLT
- No UT dependence of IMF B_Z (as expected!)
- Weak UT dependence of AL (station asymmetries?)

Comparison with ECPC model



- Milan et al. (2021) characterized the ECPC phases for 2010.
- Average values of dMLT for 4 of their states:

2	11.8 hrs
4	12.1 hrs
3	11.7 hrs
6	12.7 hrs

- Inconclusive…

Conclusions

- The two-component convection pattern discussed by Cowley and Lockwood (1992) is apparent in the SuperDARN convection maps, with a ±1.5 hr displacement of the cell foci for dayside and nightside driven flow.
- It is harder to isolate the dayside component, because strong dayside driving produces a strong tail response.
- The nightside component persists following a northward turning, so is more readily apparent.
- Further work is looking at 1. asymmetries in the dusk and dawn foci locations and 2. comparison with known intervals of polar cap expansion and contraction.