

Magnetospheric flux throughput in the Dungey cycle during 2010

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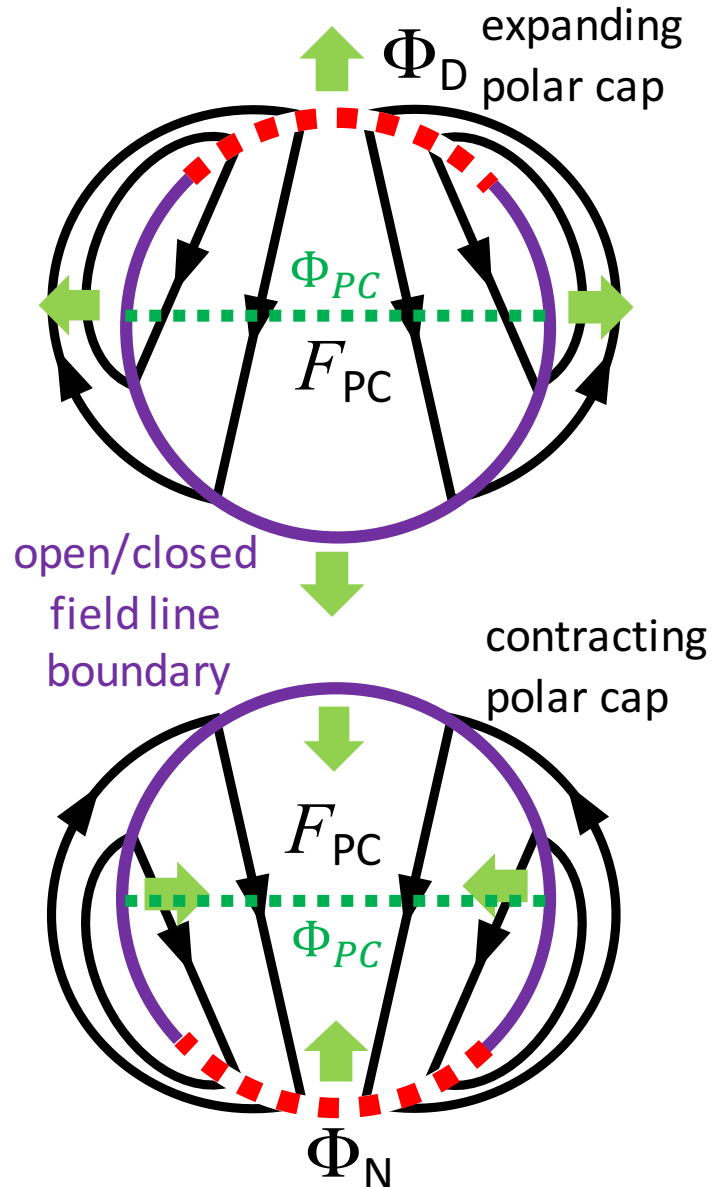
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The ECPC made easy-peasy

Expansion and contraction of the polar cap and strength of convection are controlled by dayside and nightside reconnection:

$$\frac{dF_{PC}}{dt} = \Phi_D - \Phi_N \quad (\text{exact})$$

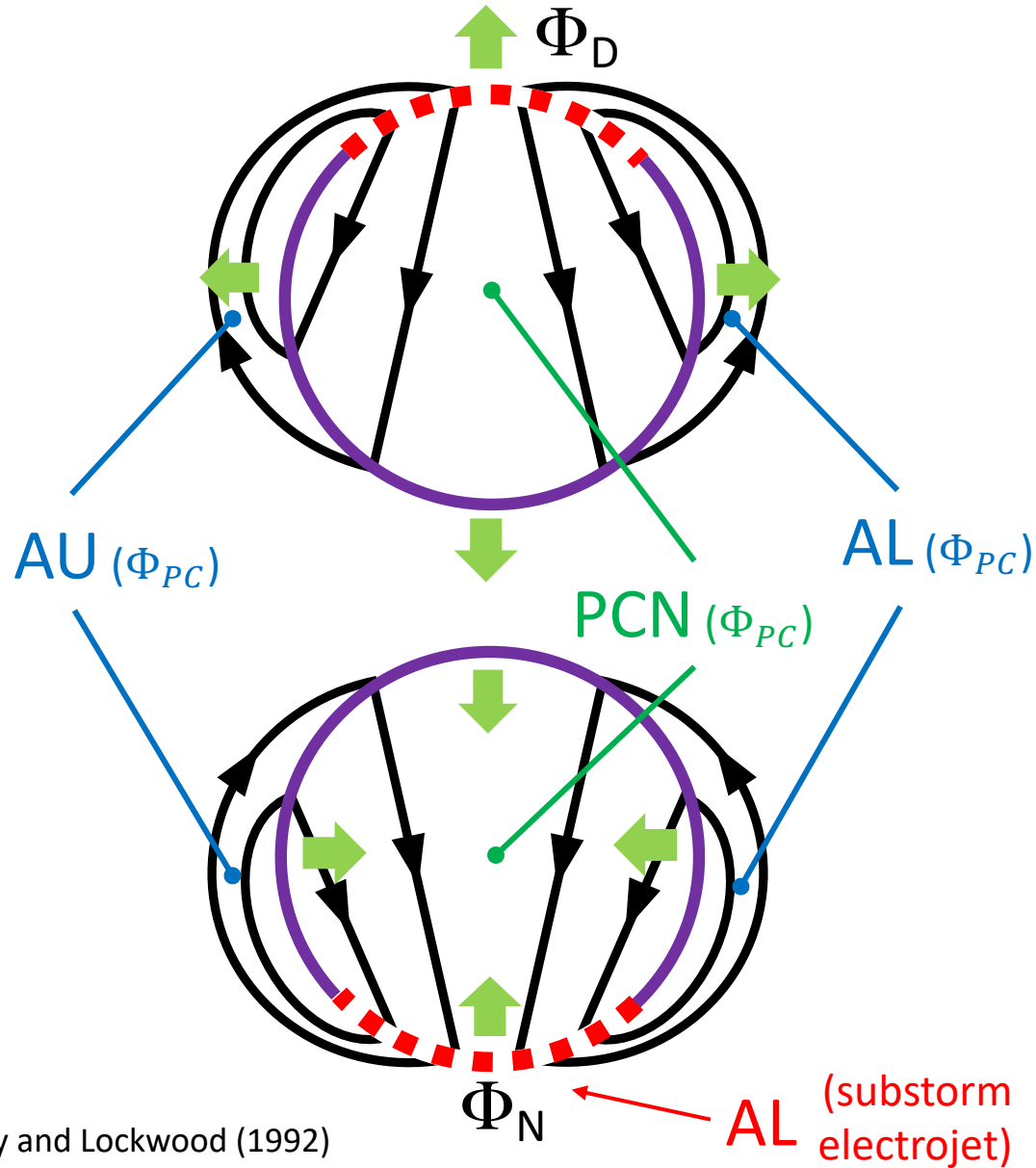
$$\Phi_{PC} = \frac{1}{2}(\Phi_D + \Phi_N) \quad (\text{approximate})$$

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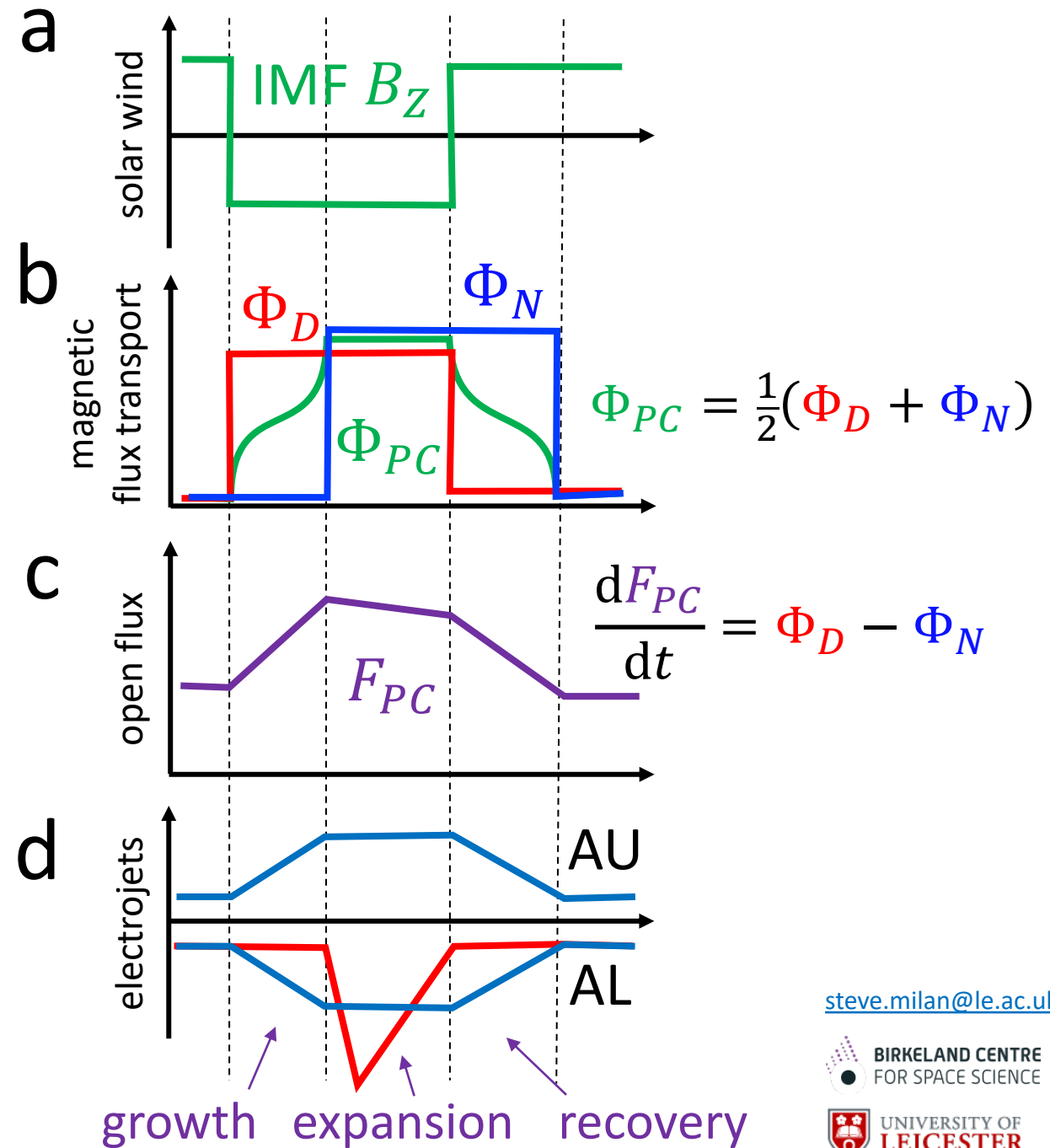


Cowley and Lockwood (1992), Lockwood and Cowley (1992)

Substorms in the ECPC



Cowley and Lockwood (1992)
Lockwood and Cowley (1992)



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Convection state definitions

- Quiet
- Weak activity
- Growth phase
 - $\Phi_D > 0$
 - $\frac{dF_{PC}}{dt} > 0$
- Expansion phase
 - Substorm bay in AL
- Recovery phase
 - $\Phi_D \approx 0$
 - F_{PC} decreasing
- Driven phase
 - $\Phi_D > 0$
 - $\frac{dF_{PC}}{dt} \approx 0$

Proxies: F_{PC}

Φ_D

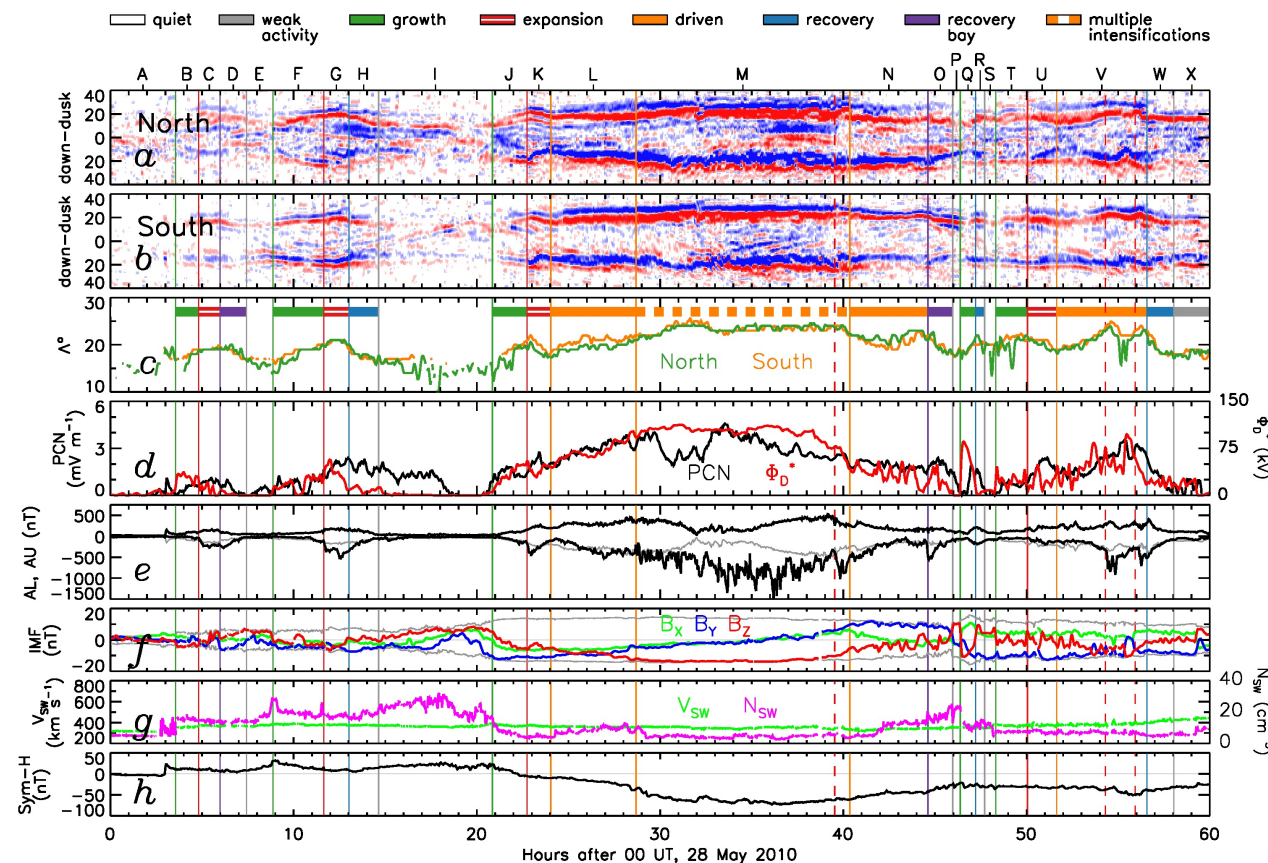
Φ_{PC} polar cap index, PC-N

latitude of the R1/R2 FAC rings as measured by AMPERE (Anderson et al., 2000; Milan et al., 2015)

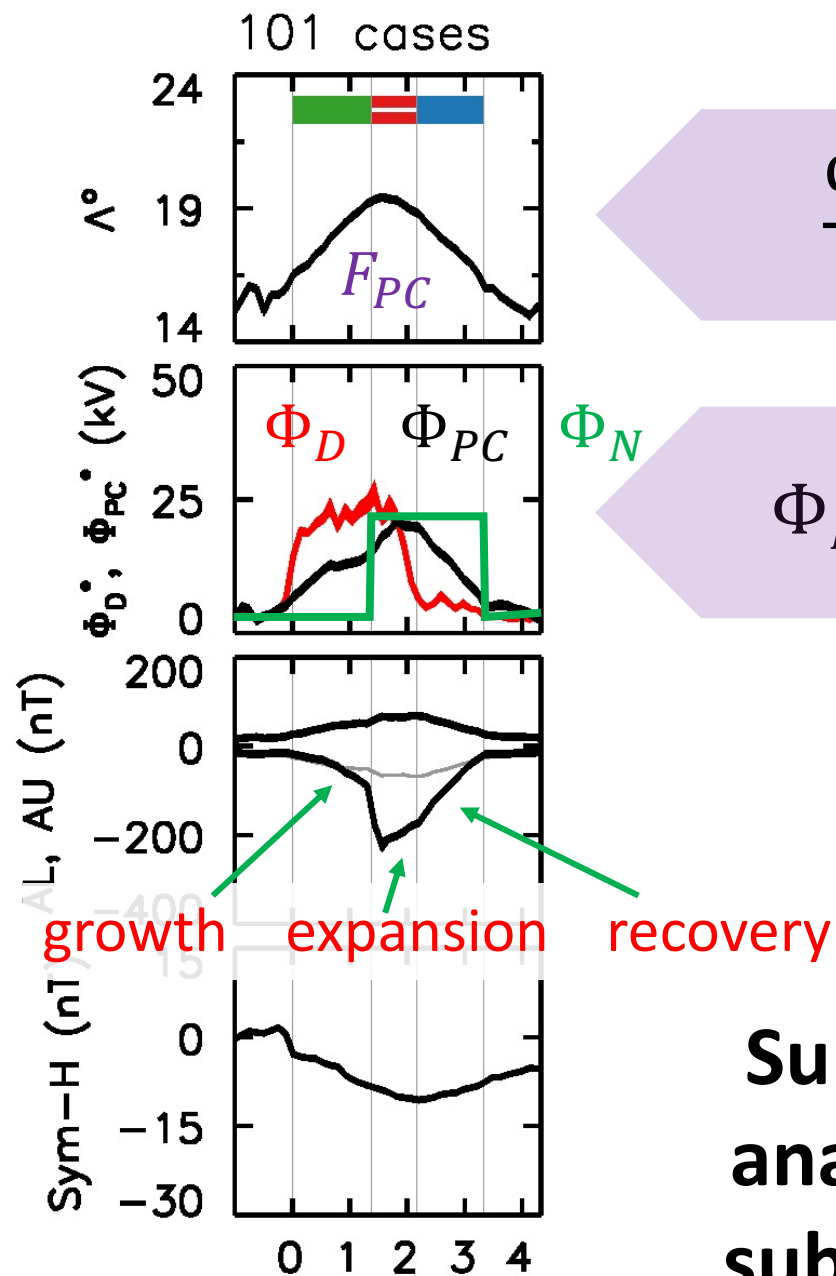
coupling parameter dependent on upstream parameters (Milan et al., 2012)

Sequenced the magnetospheric convection state for the whole of 2010 (approximately 4000 “phases”)

Searched for particular sequences and performed superposed epoch analyses (e.g. growth-expansion-recovery, growth-expansion-driven-recovery)



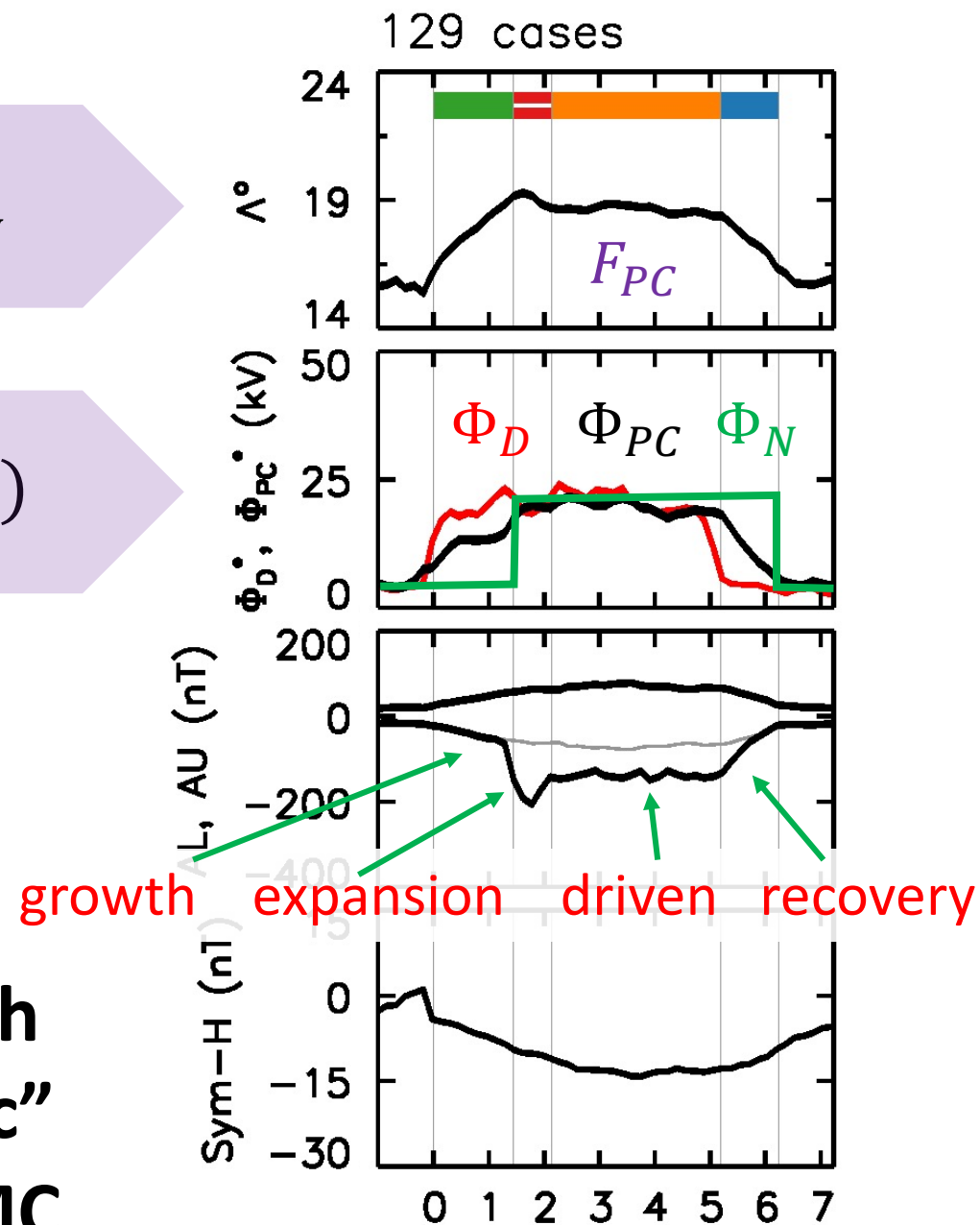
Milan et al. (2021)



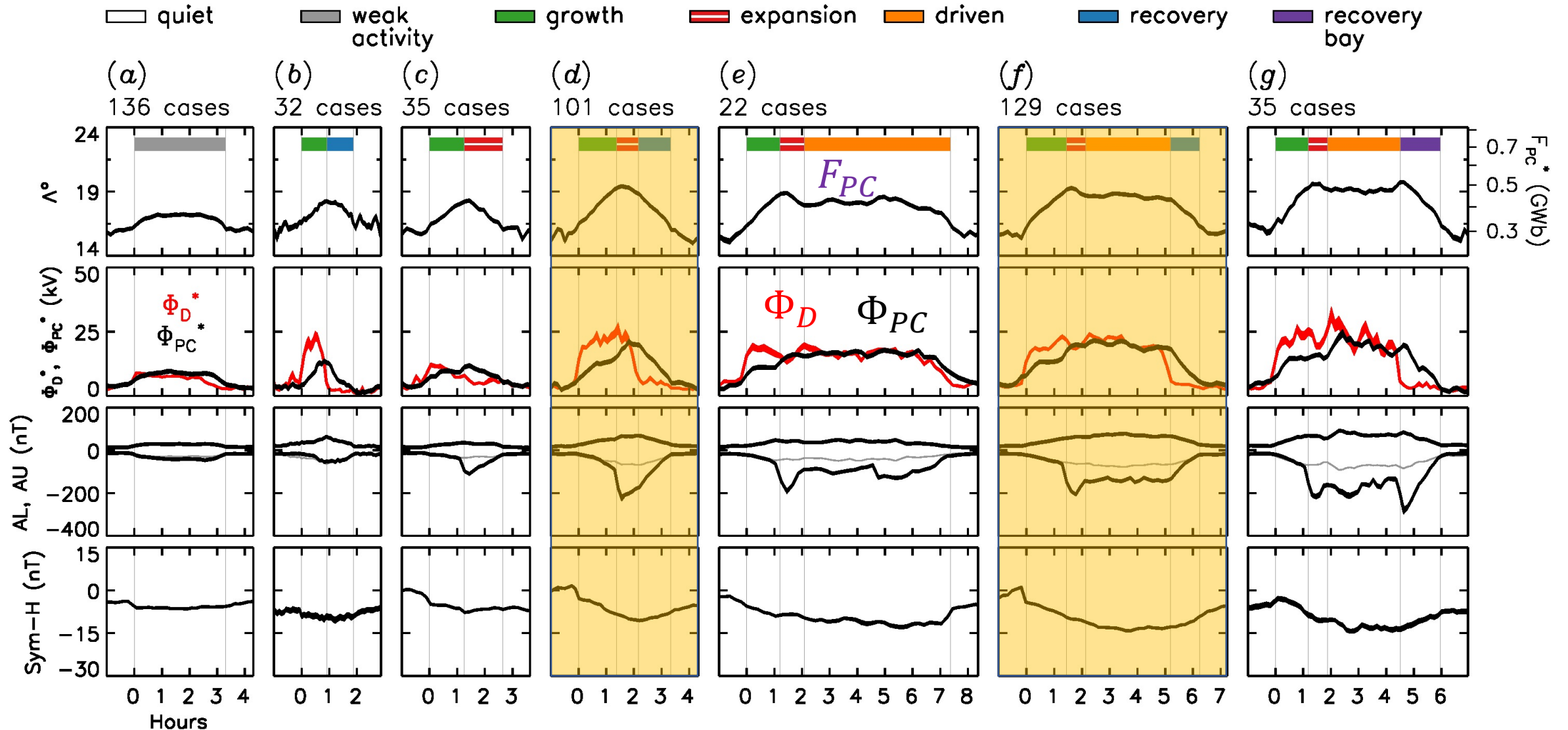
$$\frac{dF_{PC}}{dt} = \Phi_D - \Phi_N$$

$$\Phi_{PC} = \frac{1}{2}(\Phi_D + \Phi_N)$$

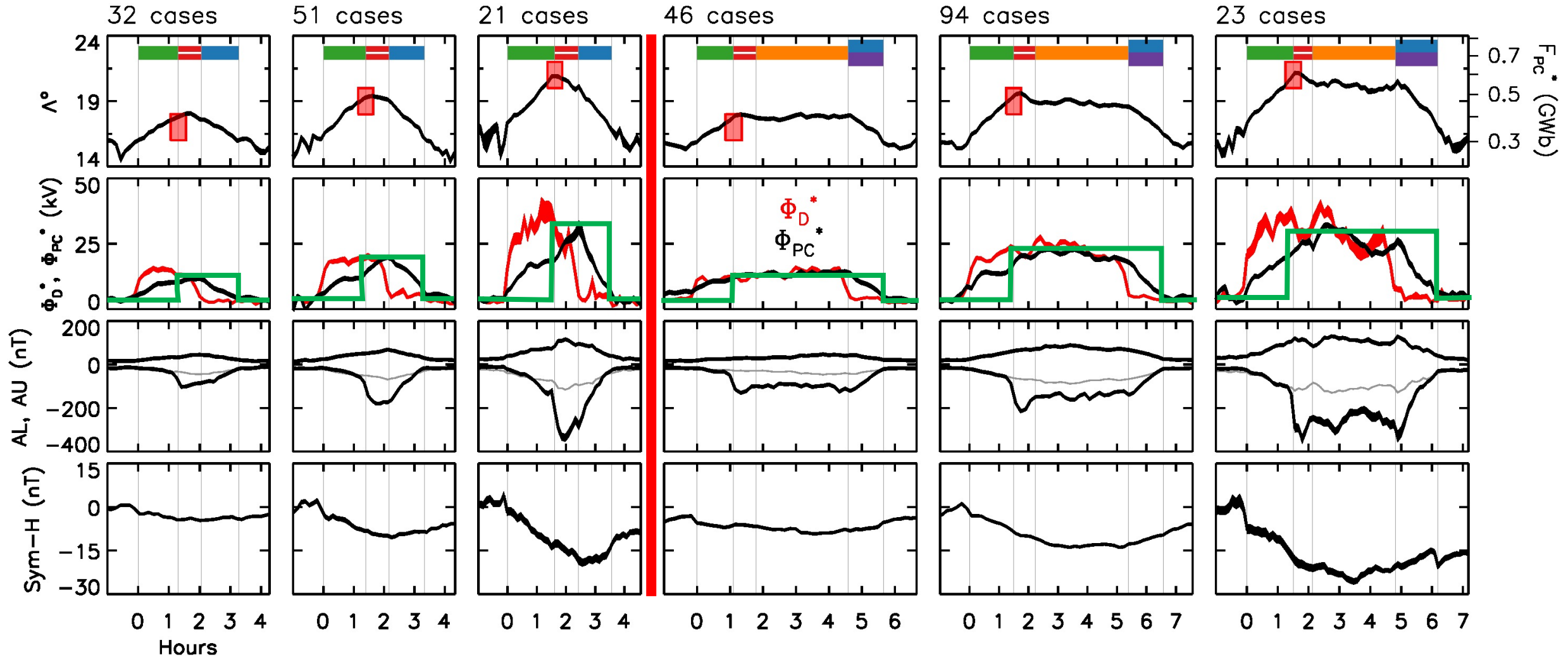
**Superposed epoch
analysis of “classic”
substorms and SMC**



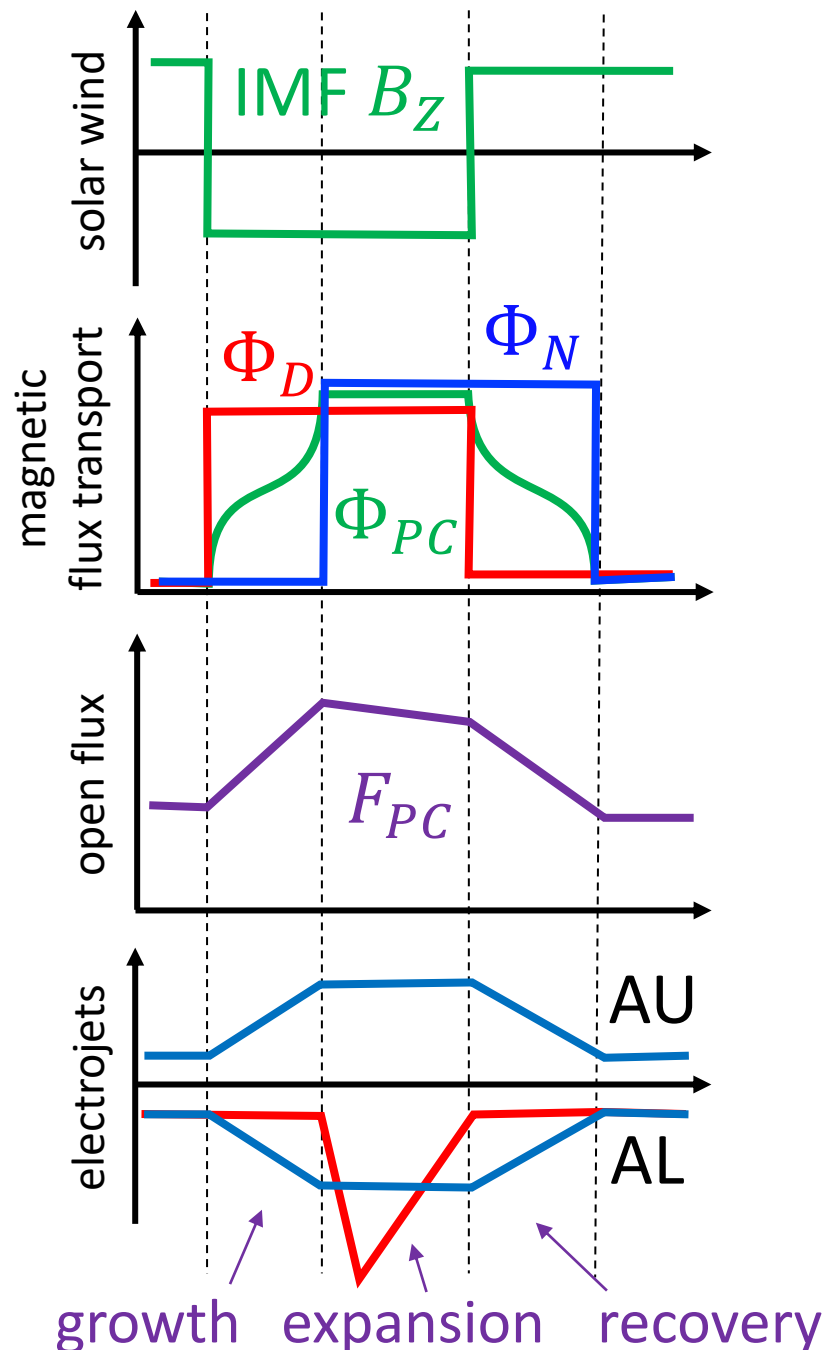
Superposed epoch analysis of other sequences



What determines substorm onset latitude?



Lower-latitude substorms (higher F_{PC}) are associated with higher dayside and nightside reconnection rates, more intense electrojets, and enhanced ring current; however, what is controlling onset latitude is not clear



Conclusions

- At substorm onset, magnetotail reconnection tends to initiate at the same rate as ongoing dayside reconnection
- Substorms and SMC are the same; the behaviour after substorm onset depends on subsequent IMF variations
- Key question remains: what determines the time (and hence F_{PC}) of substorm onset?

Paper: Milan, S. E., J. A. Carter, H. Sangha, G. E. Bower, & B. J. Anderson (2021). *Journal of Geophysical Research: Space Physics*, 126, e2020JA028437.

<https://doi.org/10.1029/2020JA028437>

Dataset: Milan, S. (2020). Magnetospheric Geonome Project 2010 University of Leicester. Dataset.

<https://doi.org/10.25392/leicester.data.12571307.v1>

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