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Contribution of bursty bulk flows to the global dipolarization of the magnetotail during an isolated substorm

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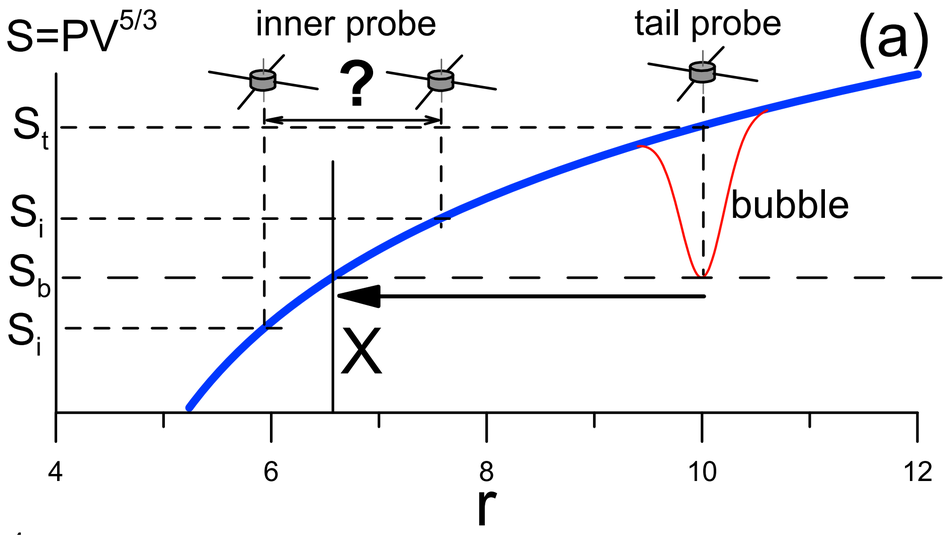
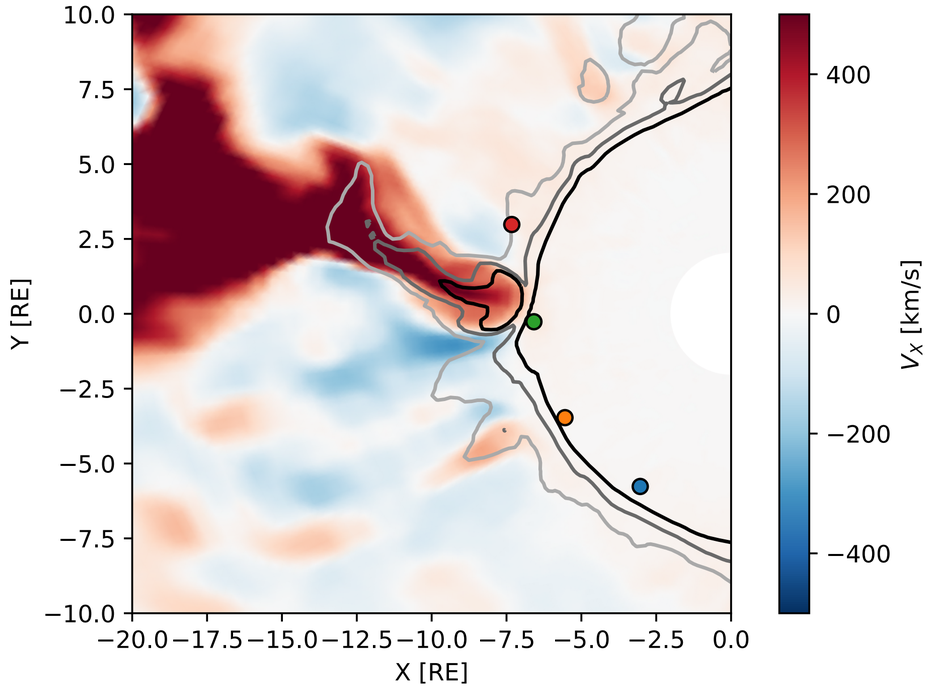
Motivation

- Bursty bulk flows major contributors to flux circulation in the magnetotail (Dungey cycle)
- Resolve “pressure catastrophe”
- Efficiently transport and energize particles from tail to ring current (e.g., Ukhorskiy et al., 2018)
- Ring current injections spatially localized (Van Allen Probes; Gkioulidou et al, 2014)
- Suggests relationship to BBFs but not confirmed observationally. Most BBFs stop at ~10 Re.
- If they do penetrate to geosynchronous, what is the BBF contribution to a global dipolarization of the inner magnetosphere?
- Is the substorm current wedge made of wedgelets?

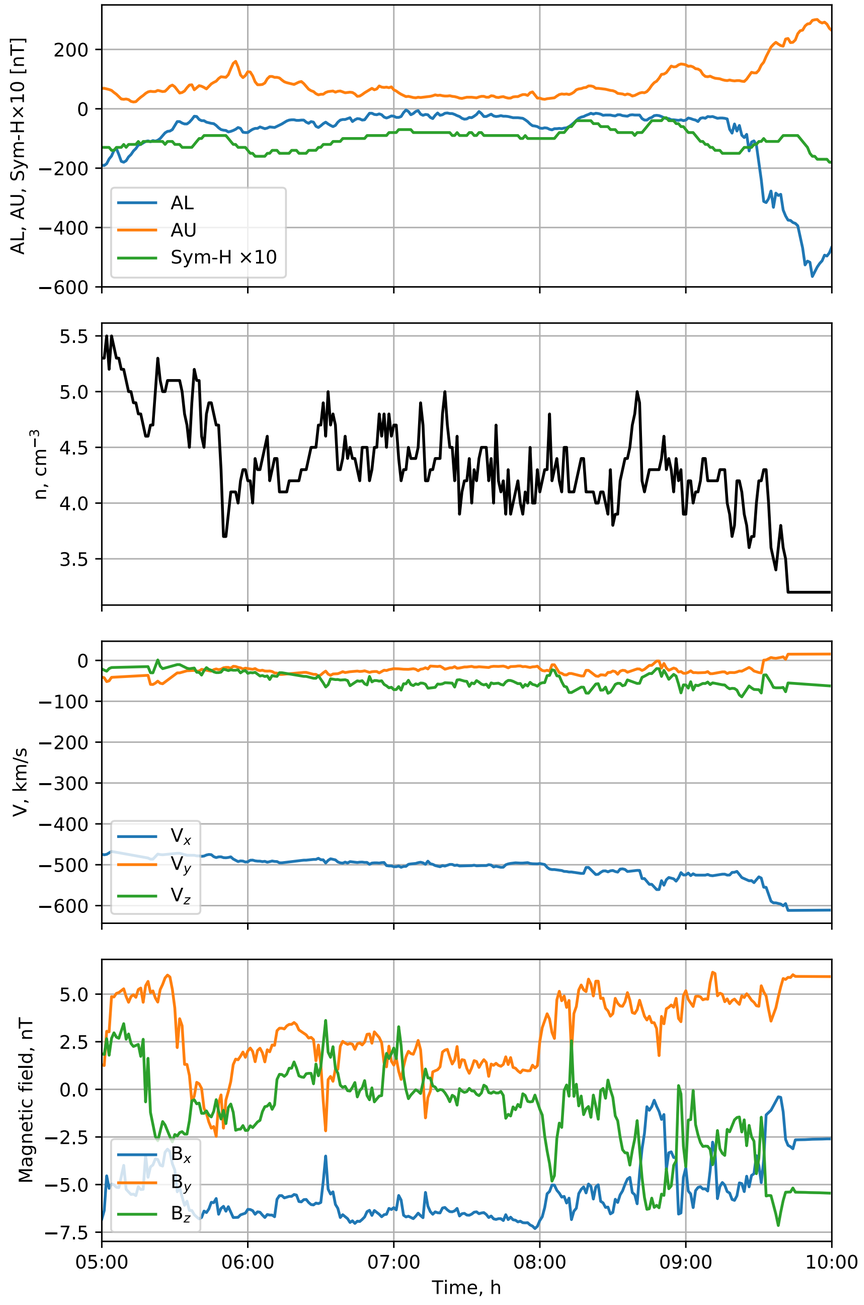
Dubyagin et al., 2011





Numerical experiment

- Isolated substorm 09 August 2016
- Run high-resolution global MHD model (~600 km in central plasmasheet)
- Lyon-Fedder-Mobarry code
- Correctly reproduces loading-unloading cycle at least at CCMC (Gordeev et al., 2017)
- Quantify magnetic flux transport in inner magnetosphere



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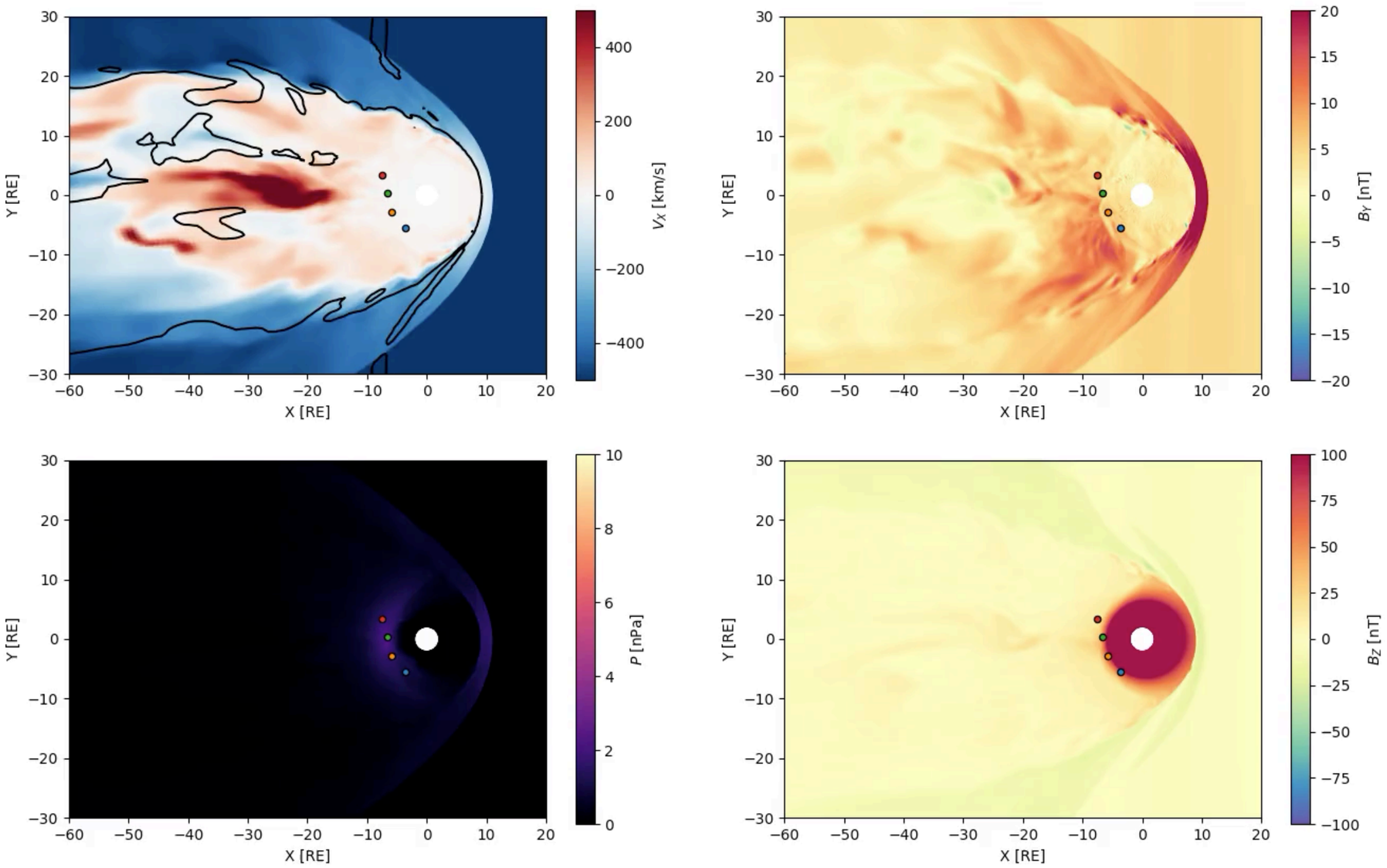

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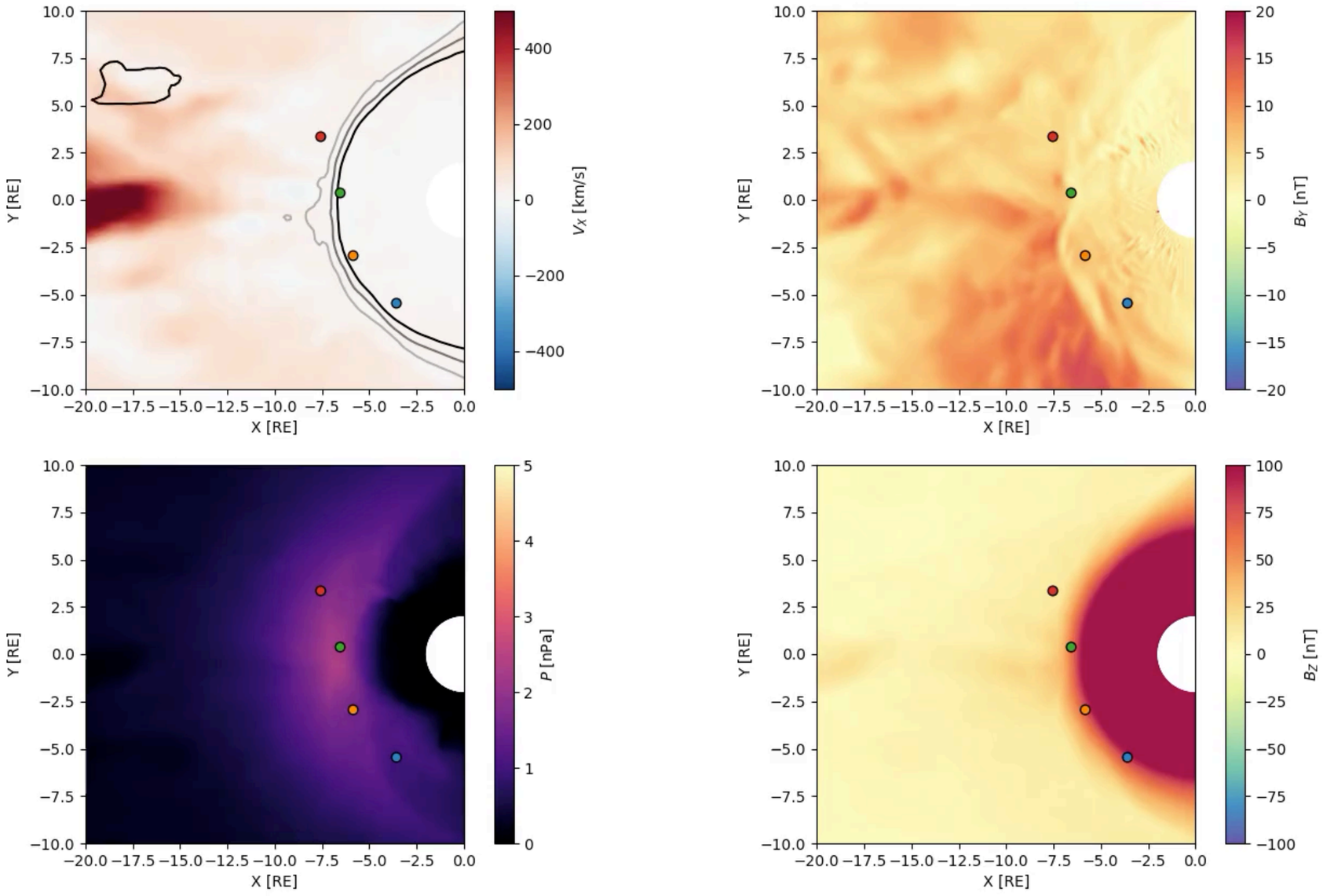
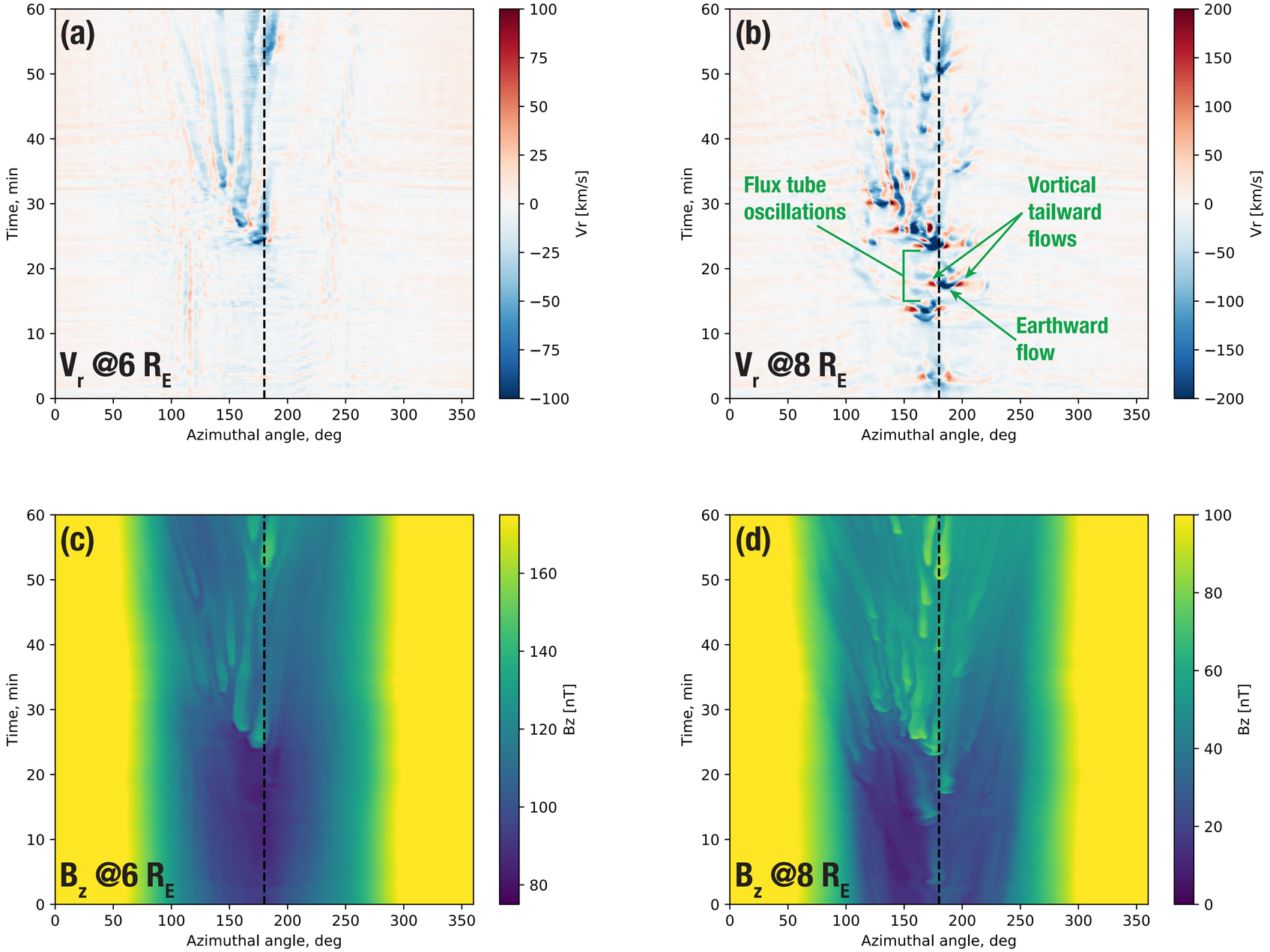


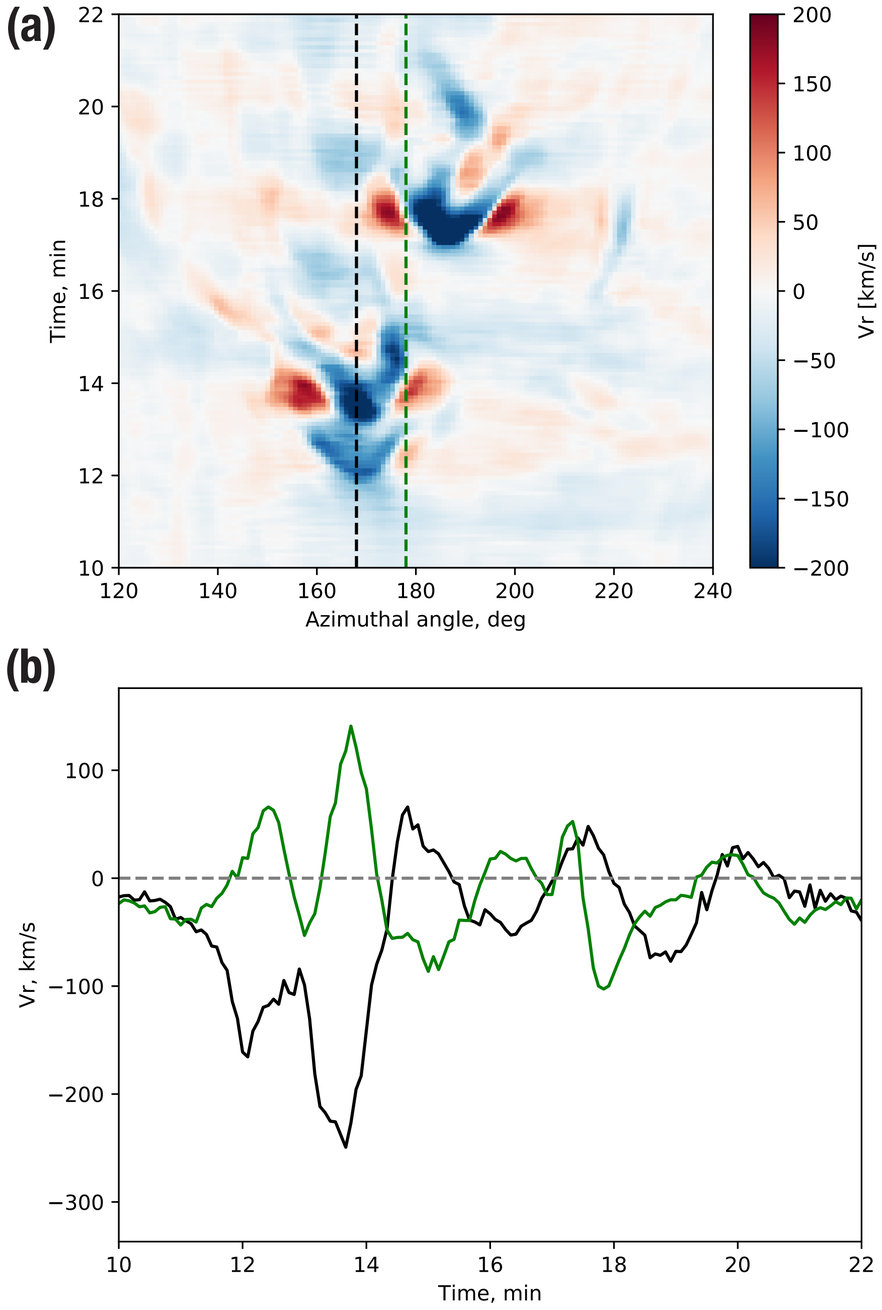
BBF penetration to GEO

- Occasional BBFs prior to onset; do not penetrate to GEO
- After onset, penetrate to GEO, avalanche-like global (in MLT) accumulation of magnetic flux
- Flux tube oscillations (as observed)



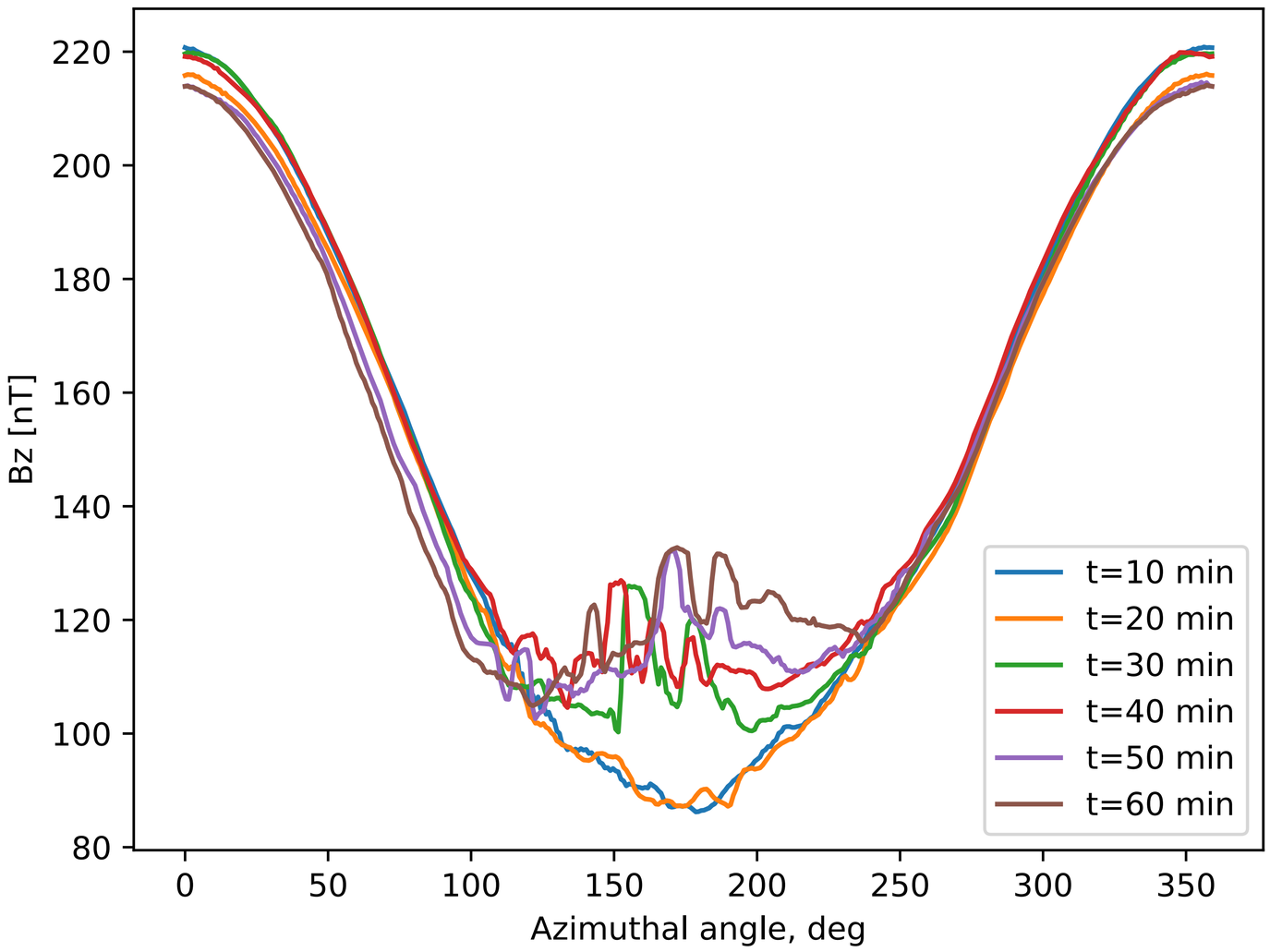
Flux tube oscillations

- Occasional BBFs prior to onset; do not penetrate to GEO
- After onset, penetrate to GEO, avalanche-like global (in MLT) accumulation of magnetic flux
- Flux tube oscillations (as observed)
- Requires fortuitous s/c location



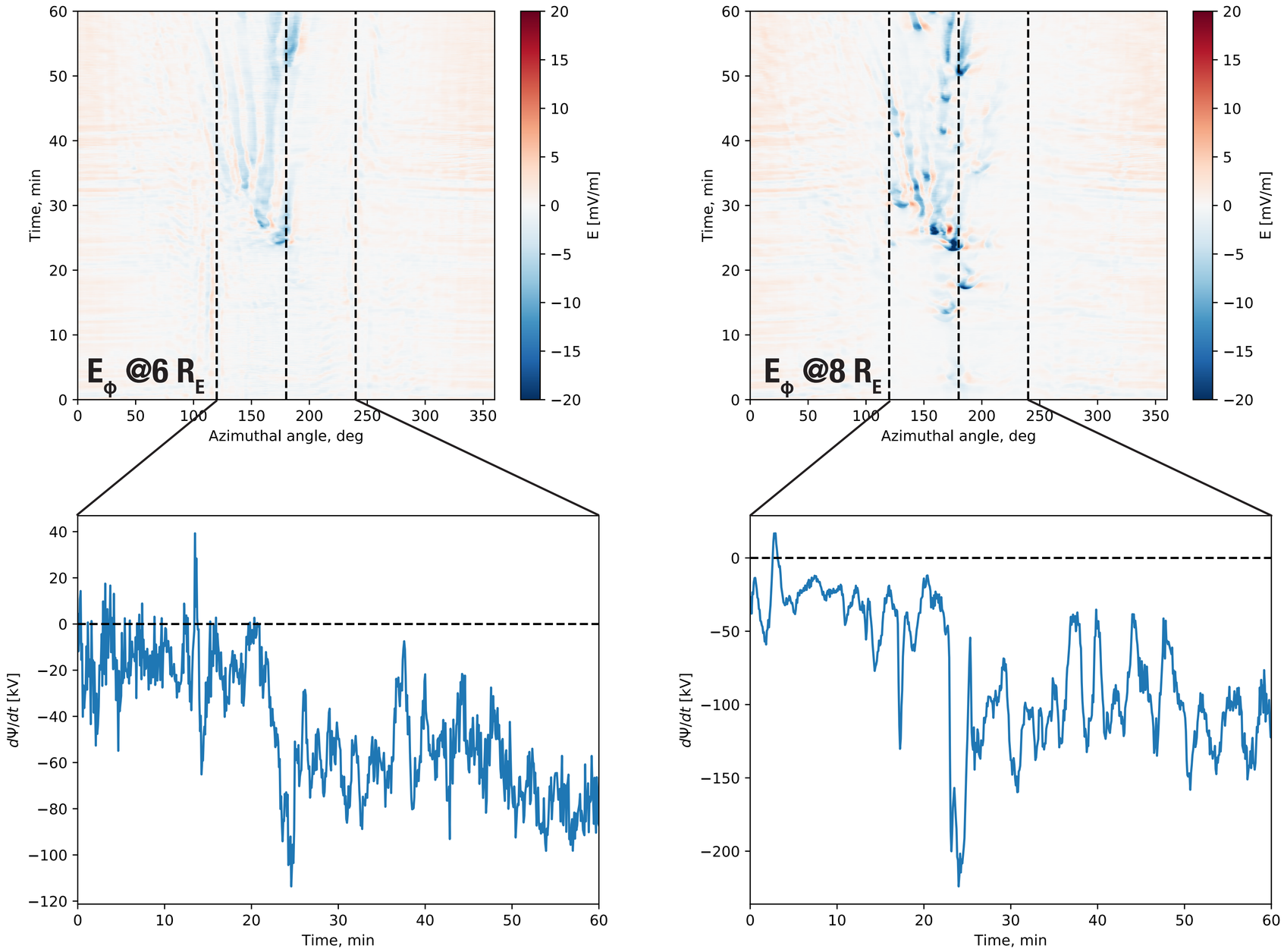
Magnetic flux accumulation at 6 RE

- Accumulation is global
- Sharp increase at onset
- Gradual azimuthal expansion afterward



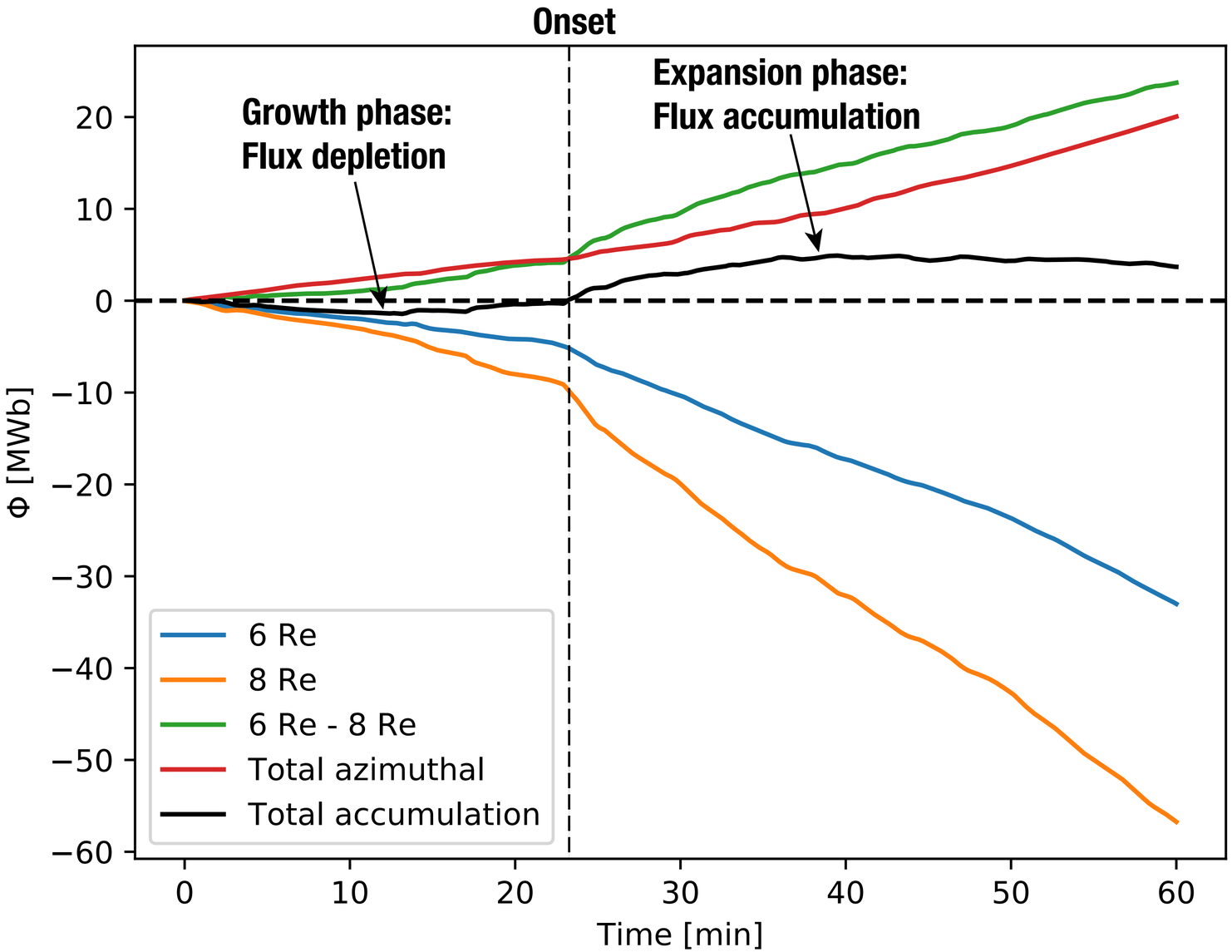
Magnetic flux transport

- Within 8Re transport occurs exclusively in azimuthally localized flow channels
- Integrated flux transport is all earthward, but bursty
- Sharp intensification at onset



Where does the magnetic flux go?

- Most accumulation inside GEO
- Growth phase characterized by flux depletion
- Expansion phase, by flux accumulation
- Total flux between (6 and 8Re, and 20 and 04 MLT) goes through zero at onset



Conclusions

- During an isolated substorm all magnetic flux transport into the inner magnetosphere occurs via azimuthally localized earthward flows
- Substorm onset is characterized by an abrupt increase in the number of such flows penetrating to the geosynchronous orbit
- Properties of simulated bursty bulk flows/dipolarization fronts are similar to those observed including flux tube oscillations and rebounds

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