Multiscale Energetics of MI Coupling

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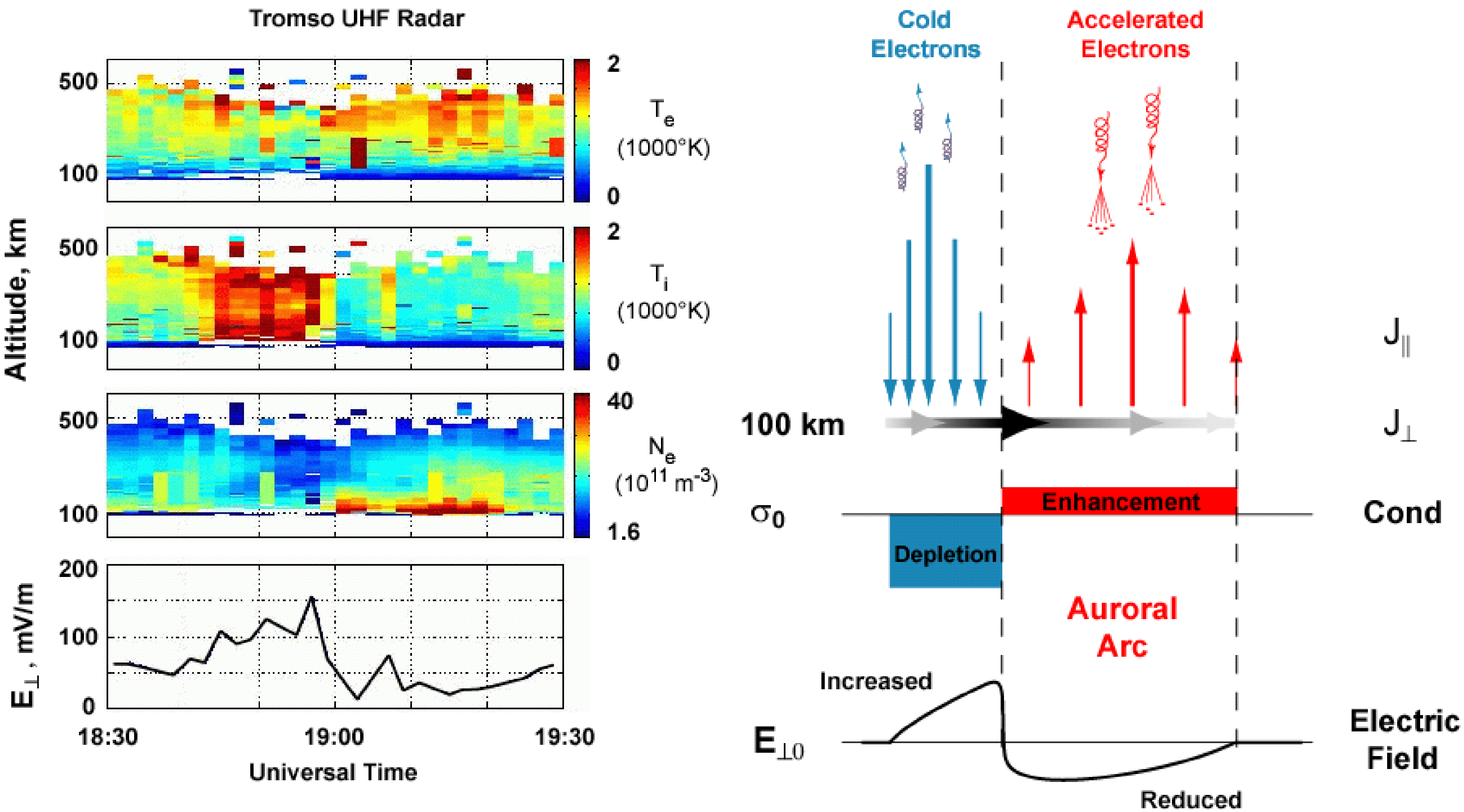
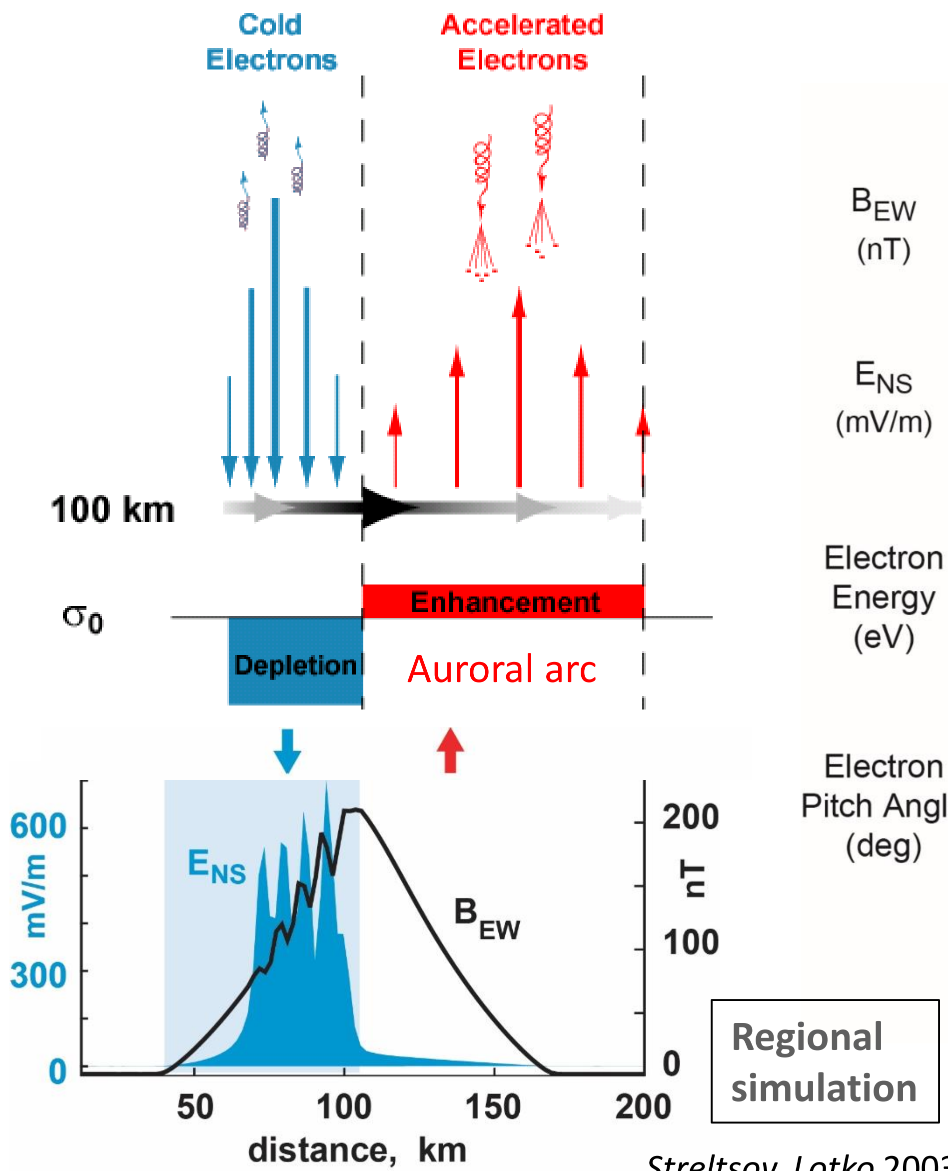
- **Ionospheric Alfven resonator**
  - Feedback instability diverts Poynting flux powering *E*-region Joule dissipation into *F*-region reactive power
  - Joule, Ohmic dissipation enhanced at IAR harmonics
- **Ionospheric feedback on magnetospheric drivers**
  - Hall conductance gradients | increase Joule dissipation
  - Auroral potential drops | decrease Joule dissipation

Active Ionization and Depletion

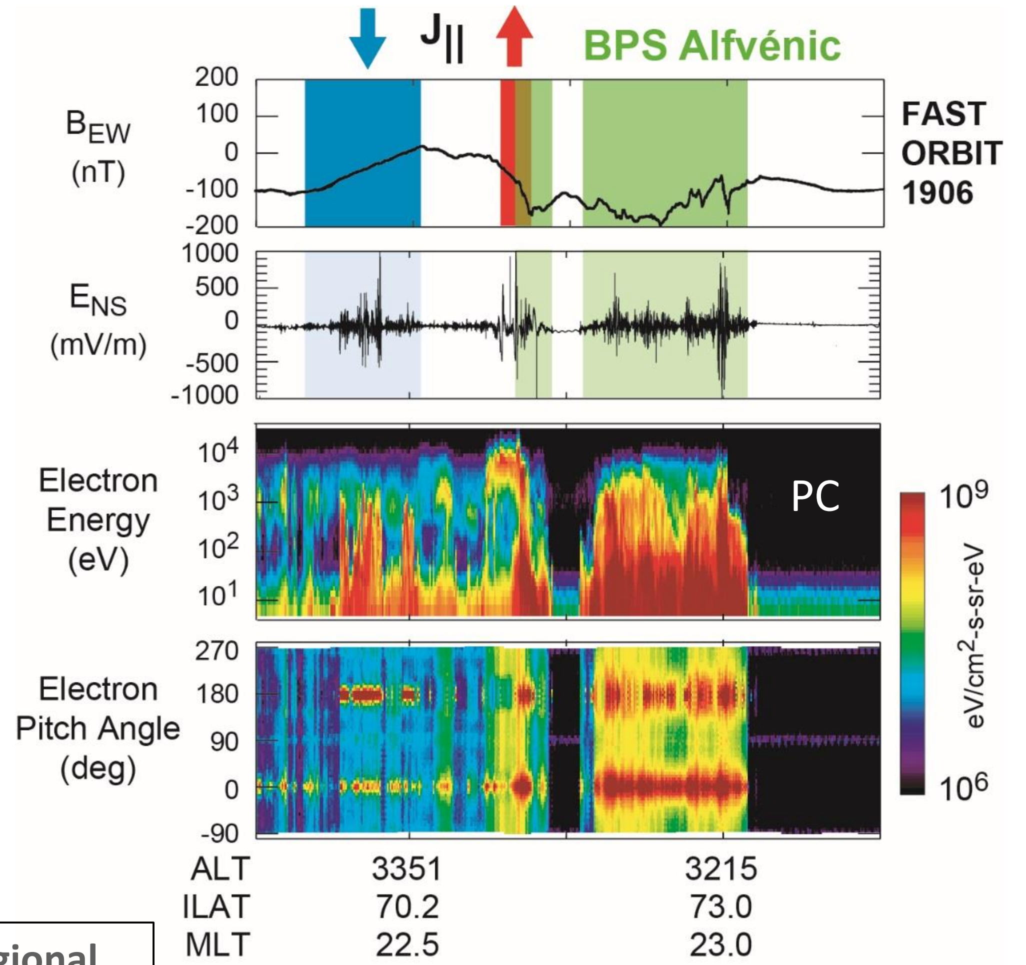


Opgenoorth et al. 2002 (also *Evans* 1977)

Spontaneous IAR (Feedback) Instability



Streltsov, Lotko 2003 (also *Lysak* 1991)



Paschmann et al 2003

Alfvénic I-T Heating: Pumped Resonator Modes

CUSP IONOSPHERE

Launch Alfvén waves at high altitude

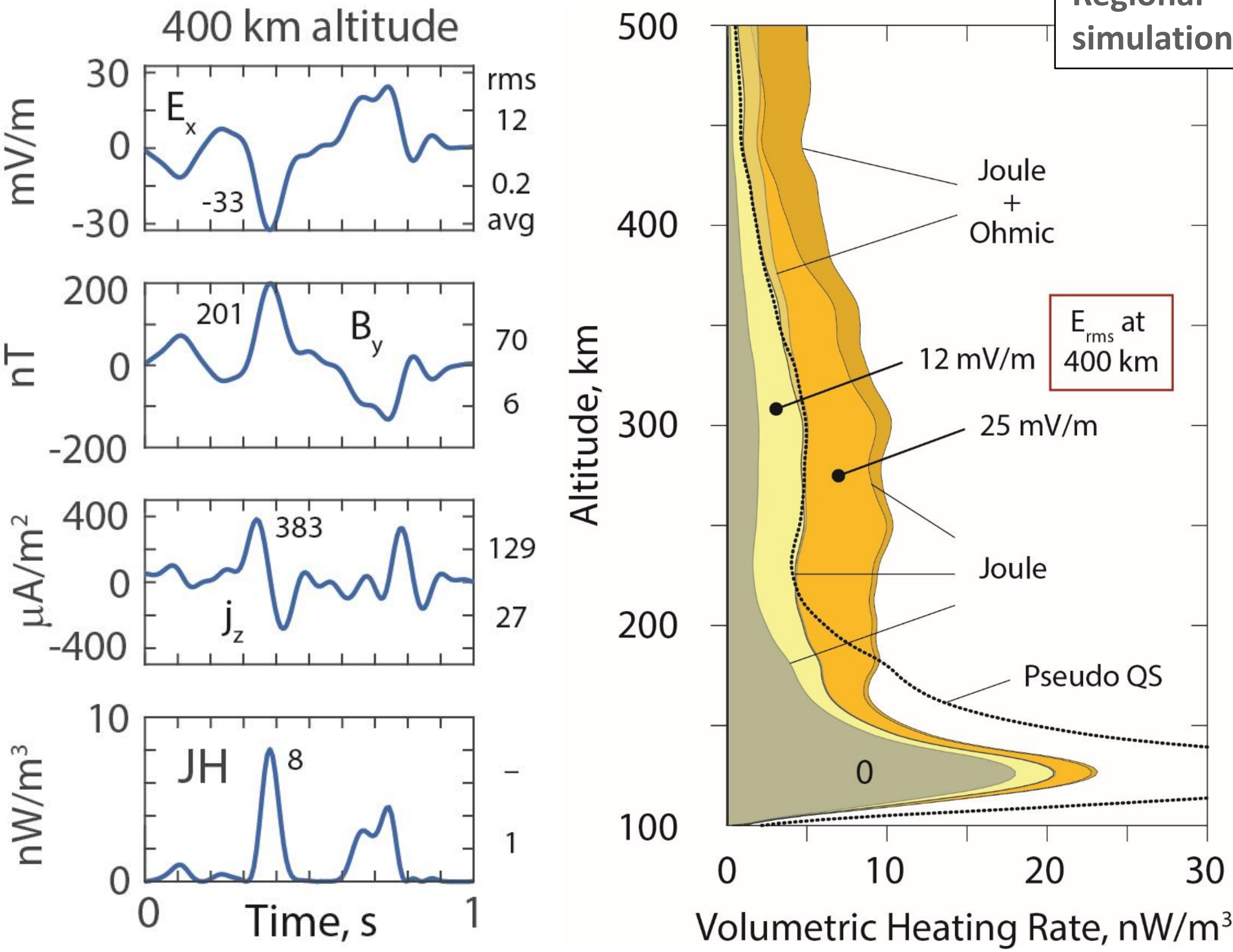
Diagnose interaction with ionosphere

1600 Modes

$0.05 < f < 2\text{Hz}$

$0.5 < \lambda_\perp < 20\text{km}$

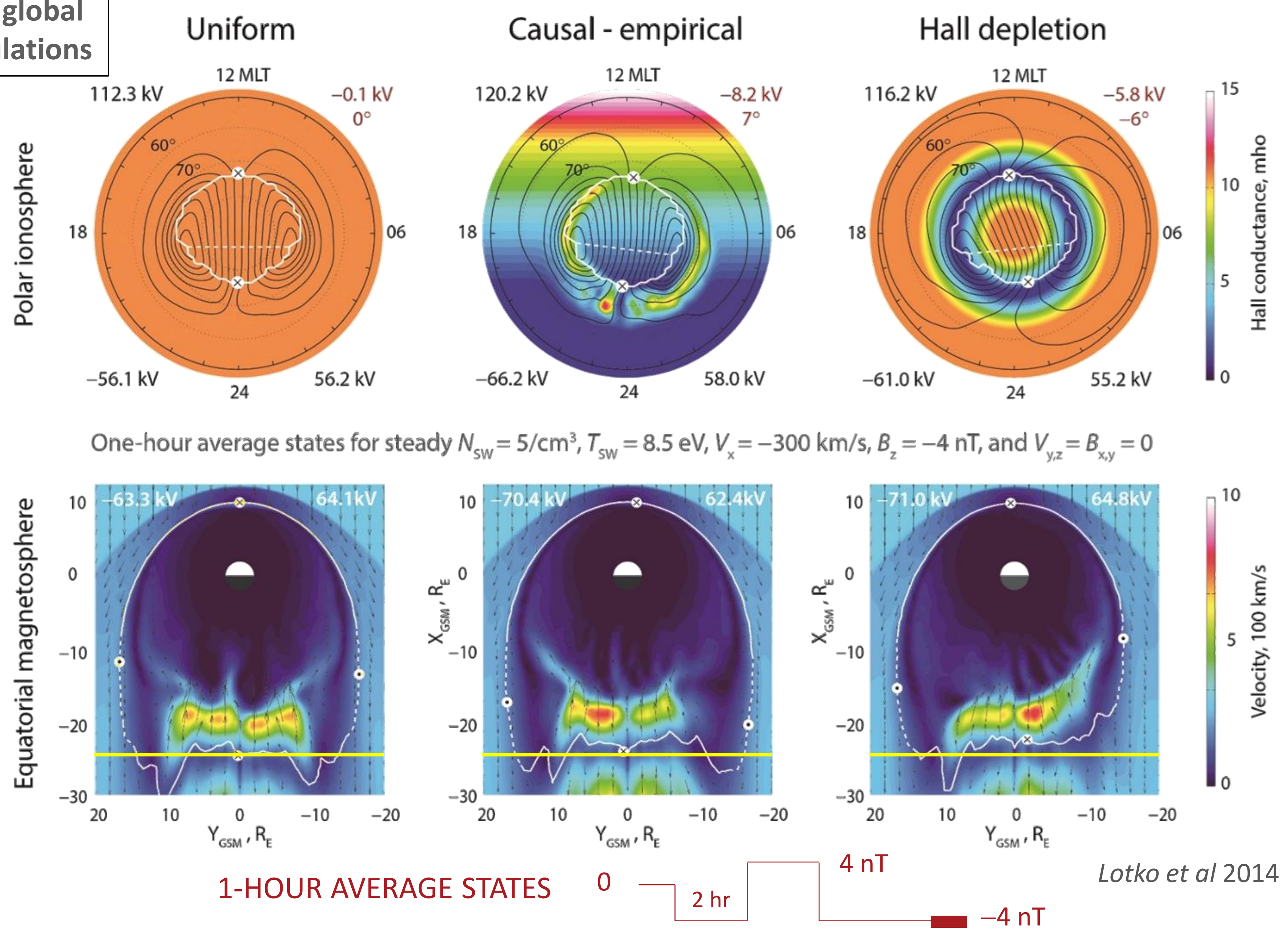
Regional simulation



Lotko, Zhang 2018

Effects of Hall Conductance Gradients on MI Coupling

LFM global simulations



Lotko et al 2014

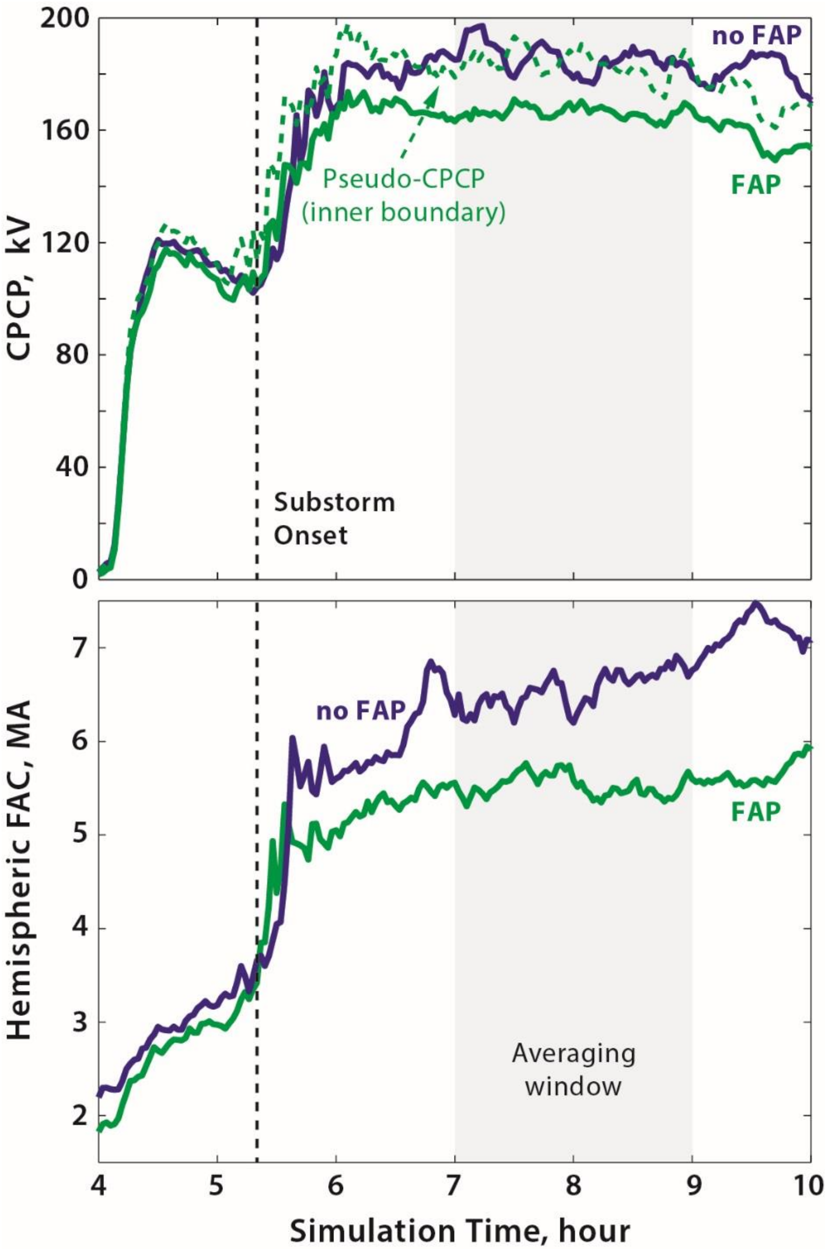
LFM global simulations

Ionospheric diagnostics

CPCP and FACs

Constant conductance experiment: $\Sigma_P = 5S$, $\Sigma_H = 0$ (*isolate effect of* $\Delta\Phi_{||}$)

- Dayside reconnection potential is the same with and w/o $\Delta\Phi_{||}$.
- Hemispheric FAC is lower with $\Delta\Phi_{||}$ because the effective resistance in the global circuit is larger.

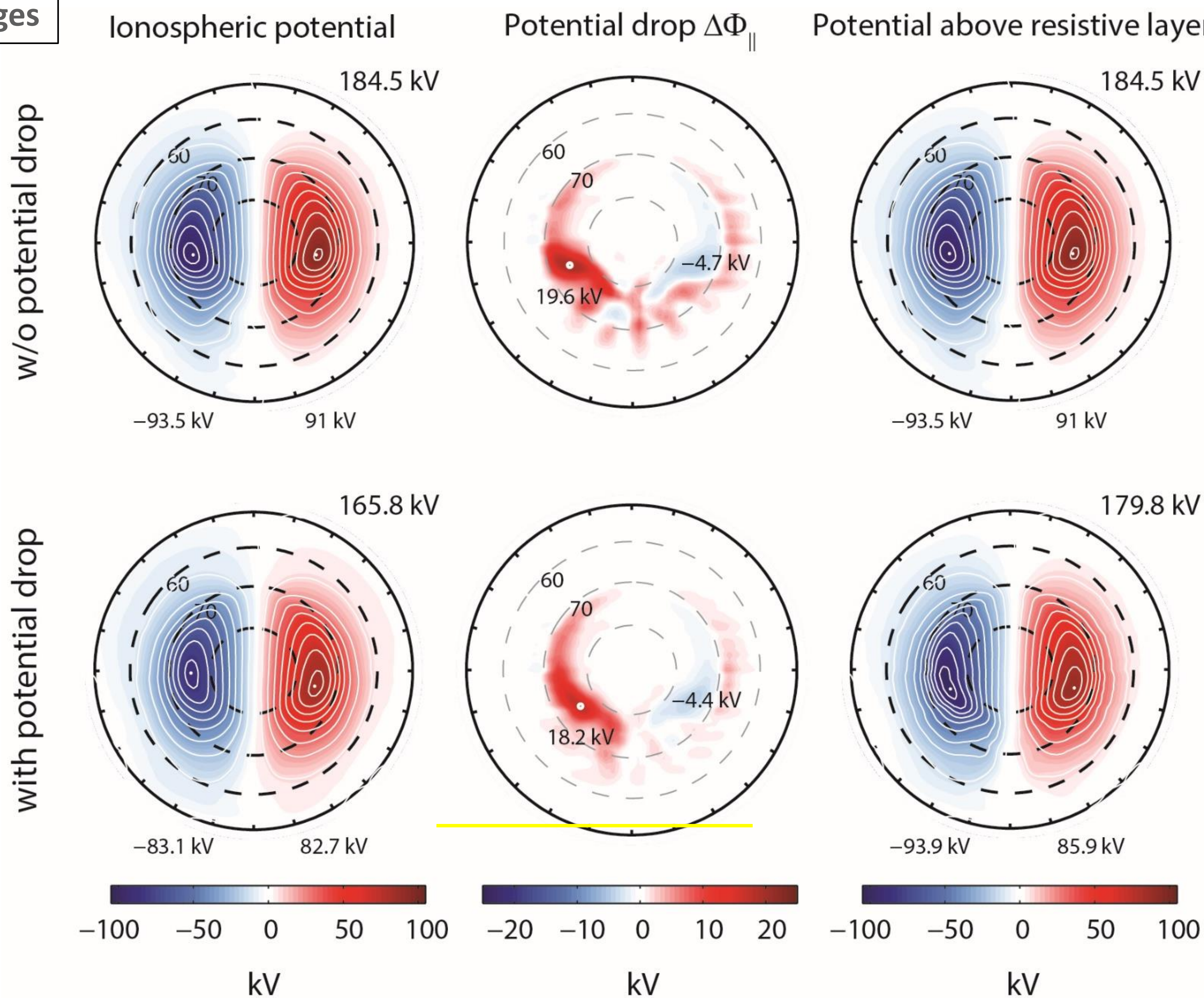


Xi et al 2016

Effects of Auroral Potential Drops: Ionospheric Convection

2-hr averages

$\Sigma_P = 5S$
$\Sigma_H = 0$

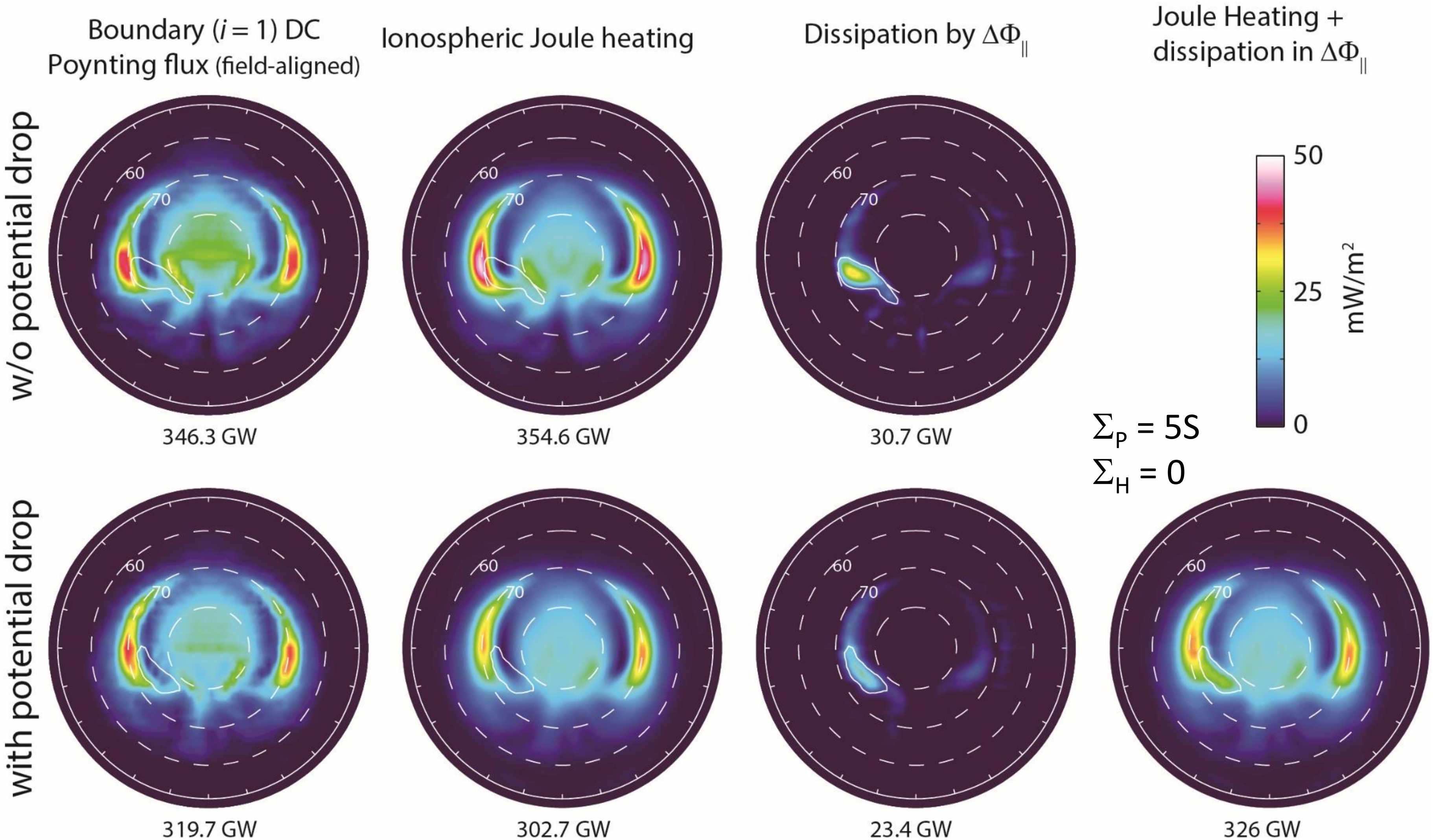


Xi et al 2016

Effects of Auroral Potential Drops: Joule Dissipation

$\Sigma_P = 5S \;\; \Sigma_H = 0$

2-hr averages

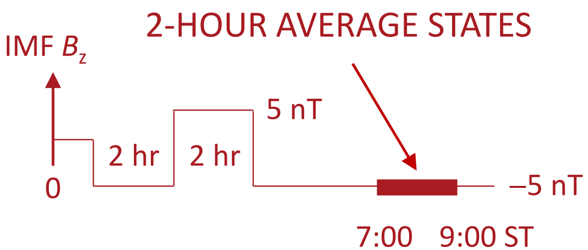


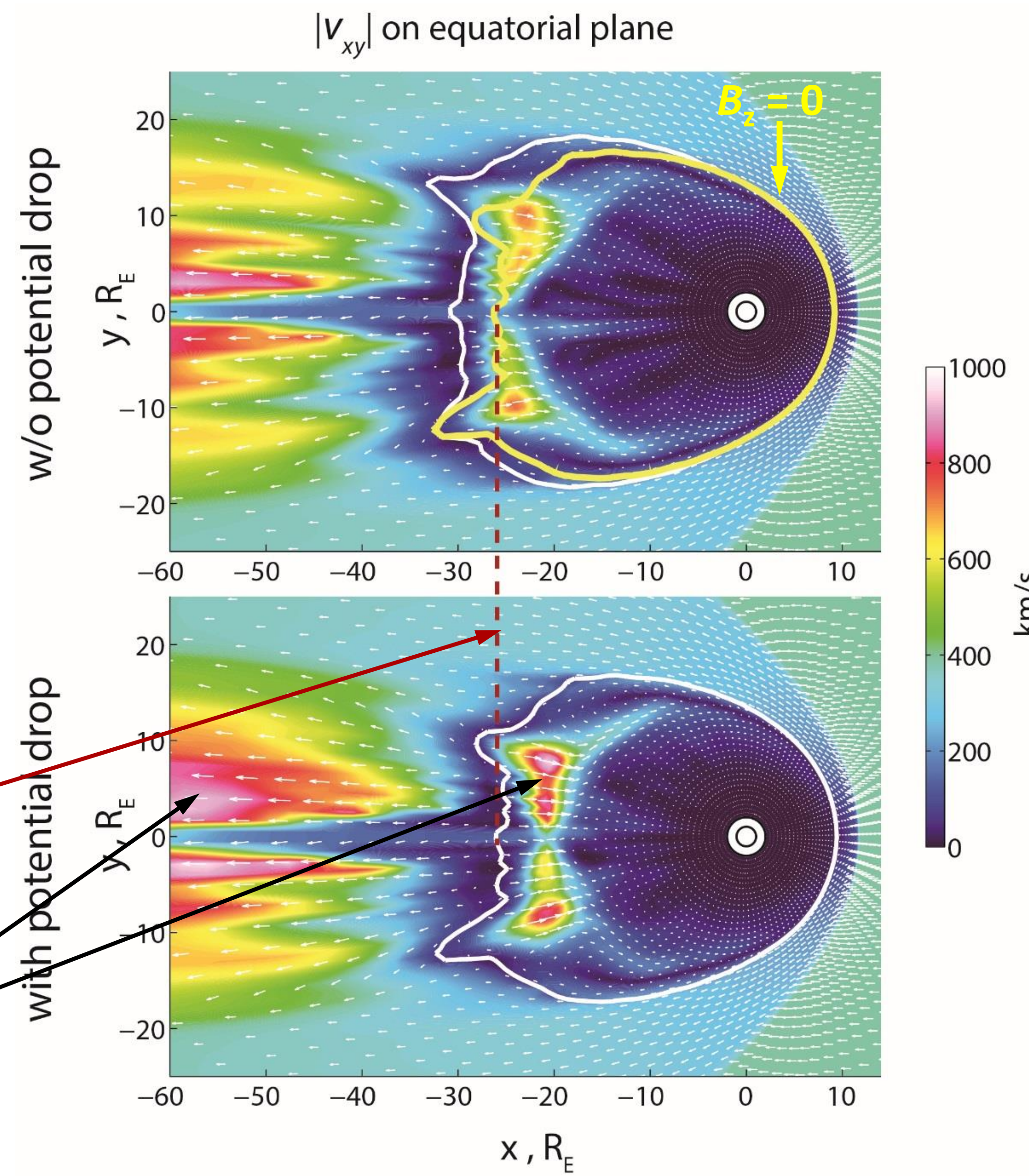
Xi et al 2016

Magnetospheric diagnostics:
X-line and flows

$\Sigma_P = 5S$
$\Sigma_H = 0$

2-hr averages





Xi et al 2016

With potential drops

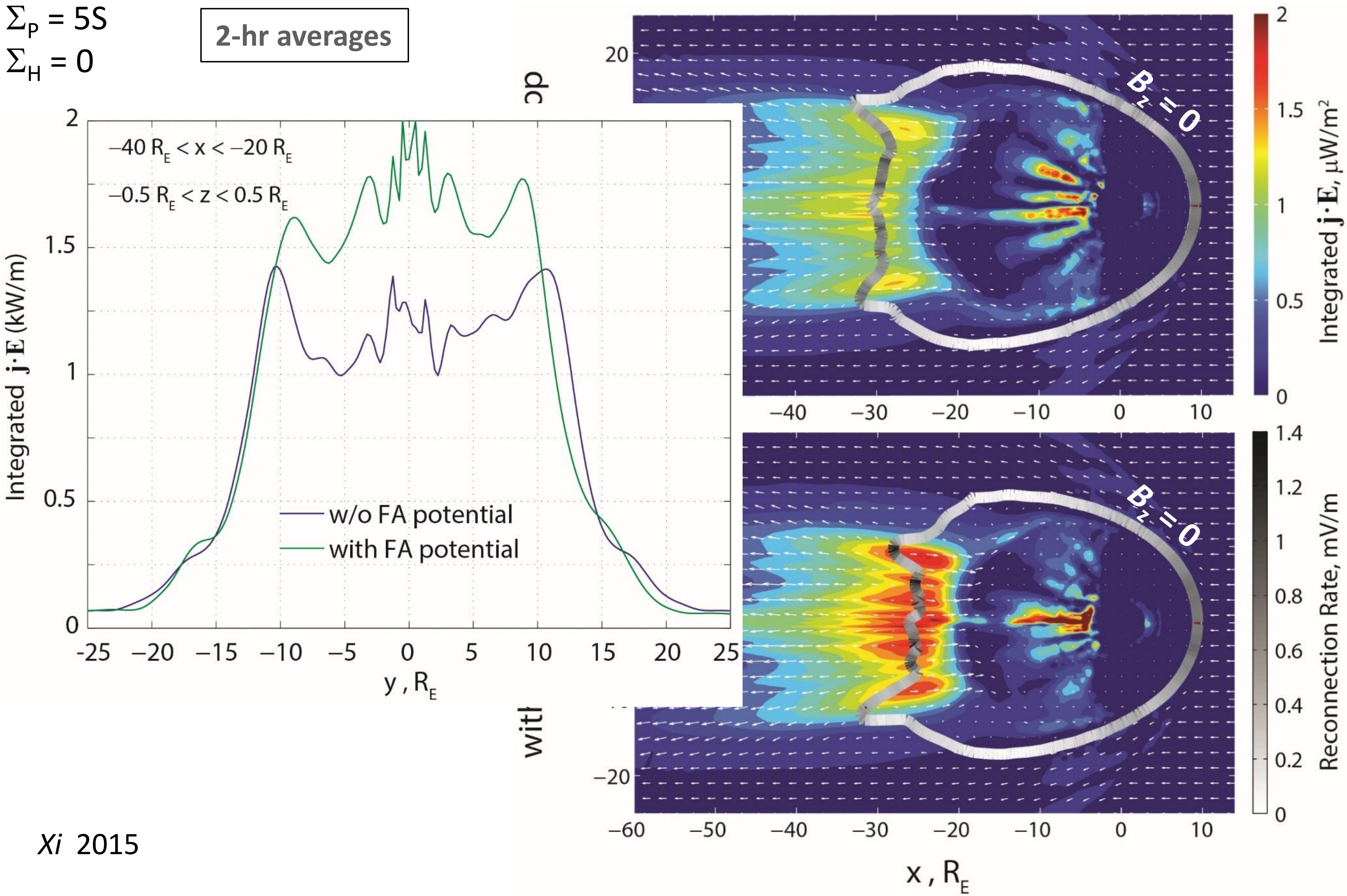
– *Tail x-line* moves earthward

– *Reconnection* exhaust flows increase

Effects of Auroral Potential Drops: Magnetotail J·E

$\Sigma_P = 5S$
$\Sigma_H = 0$

2-hr averages



Xi 2015

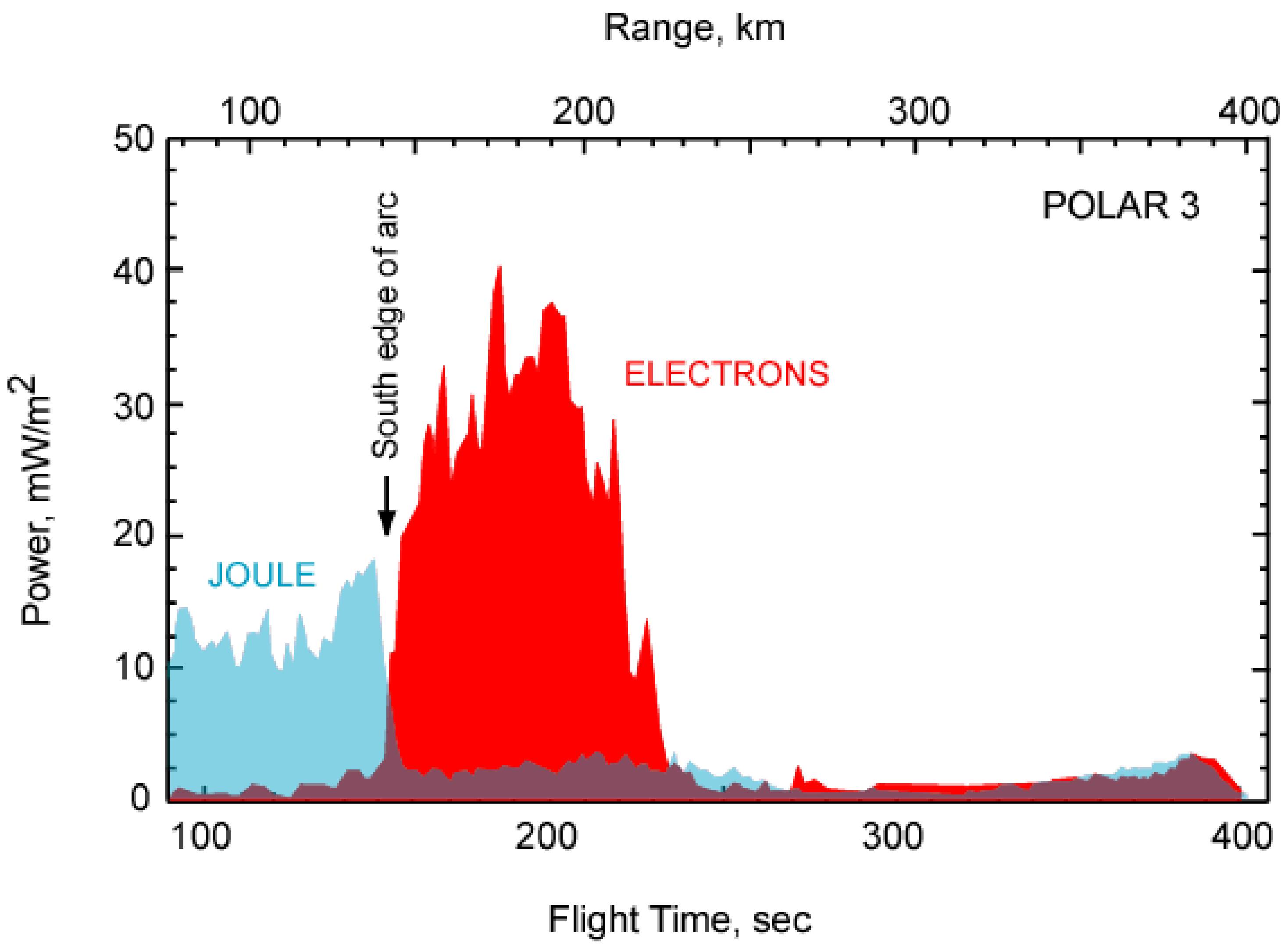
Summary: Multiscale Energetics of MI Coupling

- **Ionospheric Alfvén resonator**
  - Enhances Joule, Ohmic dissipation at resonator harmonics
  - Feedback instability (low Σ) diverts *quasistatic* Poynting flux powering *E*-region Joule dissipation into *F*-region *reactive* power
- **Ionospheric polarization at Hall conductance gradients**

  (e.g. due to enhanced precipitation) increases Joule dissipation and power supplied by magnetospheric dynamos | Moves reconnection line earthward, increases rate and exhaust flows
- **Auroral potential drops**
  - Reduce CPCP, hemispheric current and Joule dissipation
  - Move x-line earthward | Enhance reconnection rate, reconnection exhaust flows and magnetotail J·E

EXTRAS

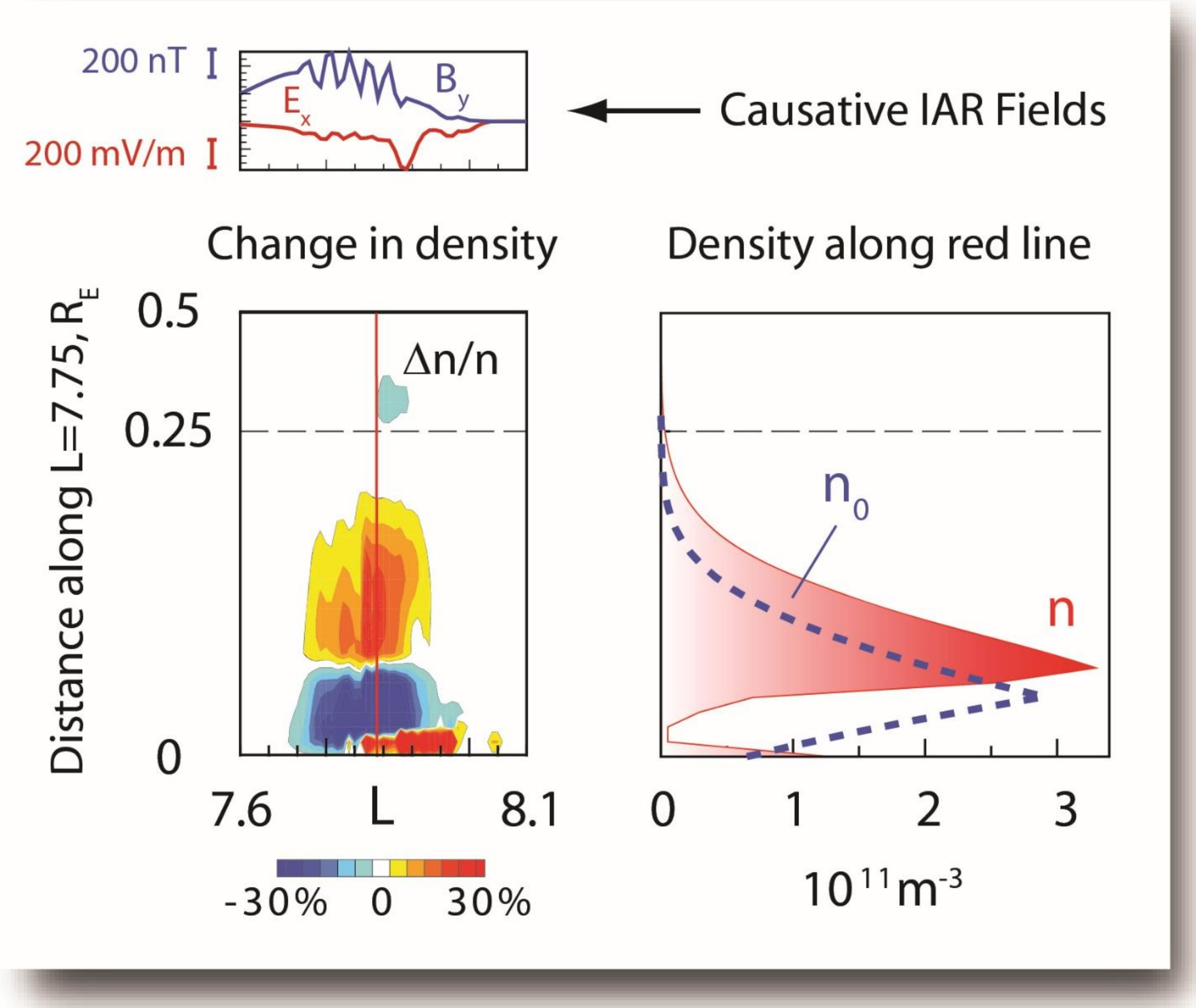
Precipitating Electron Power and Joule Dissipation



Evans 1977

Alfvénic Density Redistribution and Ionospheric Upwelling

Ponderomotive force of intense, HF IAR oscillations transports ionospheric plasma upward, creating a large-scale, bottom side density cavity. The upwelled plasma enhances the topside source of outflowing heavy ions.



Streltsov, Lotko 2008