MITC-9
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A Statistical Dependence of Ion-Neutral Coupling Rates on Geomagnetic Activity in the Nightside Auroral Oval

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Background & Motivation

- F-region neutral winds are crucial for redistributing density, momentum and energy across the I-T system
- Mesoscale neutral wind response time to changes in plasma flow is not well understood
  - Response time has a wide range of variability
  - Drivers (**ion-drag**, **pressure**, coriolis, viscosity, etc.) not well characterized
- The **e-folding time** (Killeen & Roble, 1984) has previously been used to estimate the neutral wind response time and is defined as $\tau_{in} = (V_i - U_n) / (dU_n/dt)$
  - Assumes ion-drag is the only driving force
- Joshi et al. (2015) compared a time-lagged correlation coefficient to the e-folding time
  - Limited to a nightly average

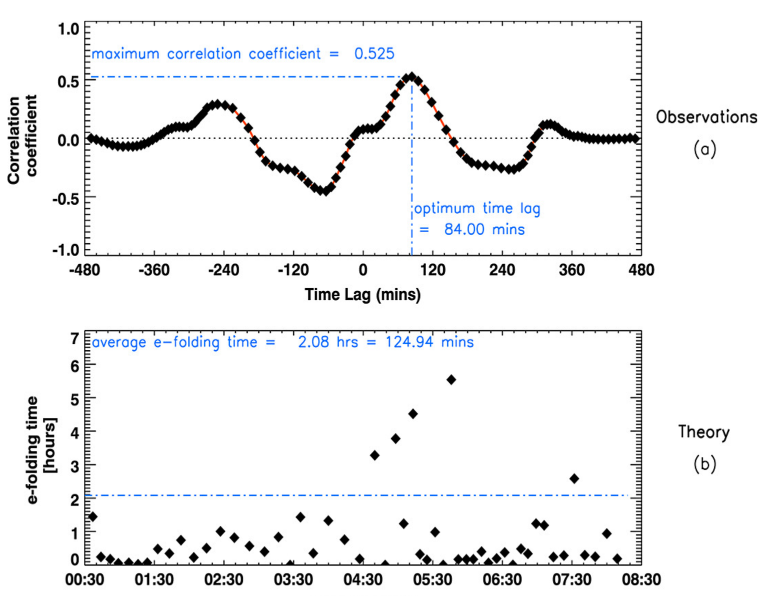

Figure 1. Time-Lagged Correlation Coefficient and E-folding Time from a geomagnetic storm main phase period, Joshi et al., 2015.

- We introduce a new methodology that provides a time-dependent neutral wind response time capable of analysis in the auroral region
- The new response times are compared to e-folding times for two case studies, then a statistcal comparison of the response times to the AE index is shown

Motivation

1) Develop a new method for analyzing the neutral wind response time in the high-latitude auroral region.
2) Use the comparison of these response times to geomagnetic indices to give insight to the dynamics of I-T coupling.

Methodology

Data/Instrumentation

- THEMIS All Sky Imagers (ASIs) for **auroral data**
- Scanning Doppler Imagers (SDIs) for **neutral winds**
- Poker Flat Incoherent Scatter Radar (PFISR) for **plasma flow**

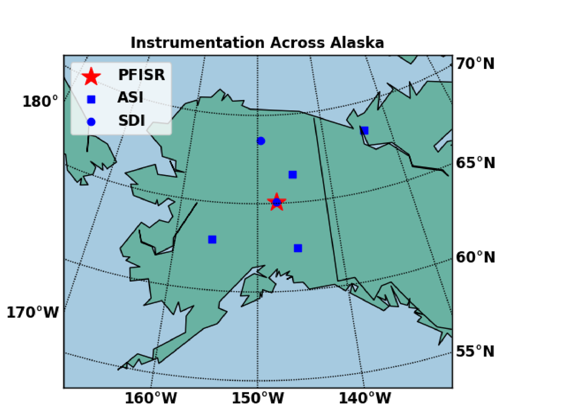

Figure 2. Instrument locations across Alaska.

Weighted Windowed Time-Lagged Correlation Analysis (Weighted WTLC)

- New time-dependent, observation based calculation of the neutral wind response time that takes all thermospheric drivers into account
- **Unweighted WTLC**: Event is split into two hour windows and performs the time-lagged correlation (TLC) of each window
- **Weighted WTLC**: Results of each window are weighted by full correlation curve

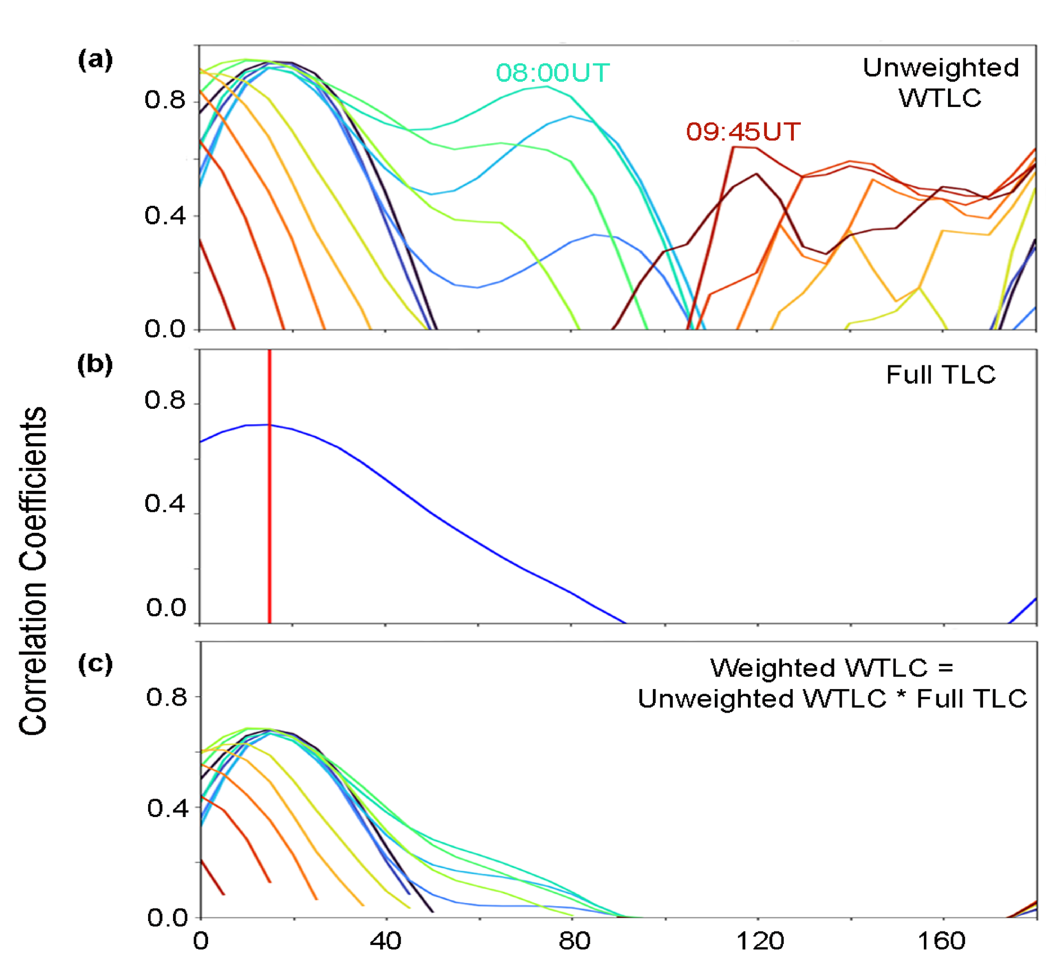

Figure 3. (a-c) Correlation coefficient vs. lag time plots of the unweighted WTLC, full TLC, and weighted WTLC on 2013 Feb 28.

Result 1 - Case Studies

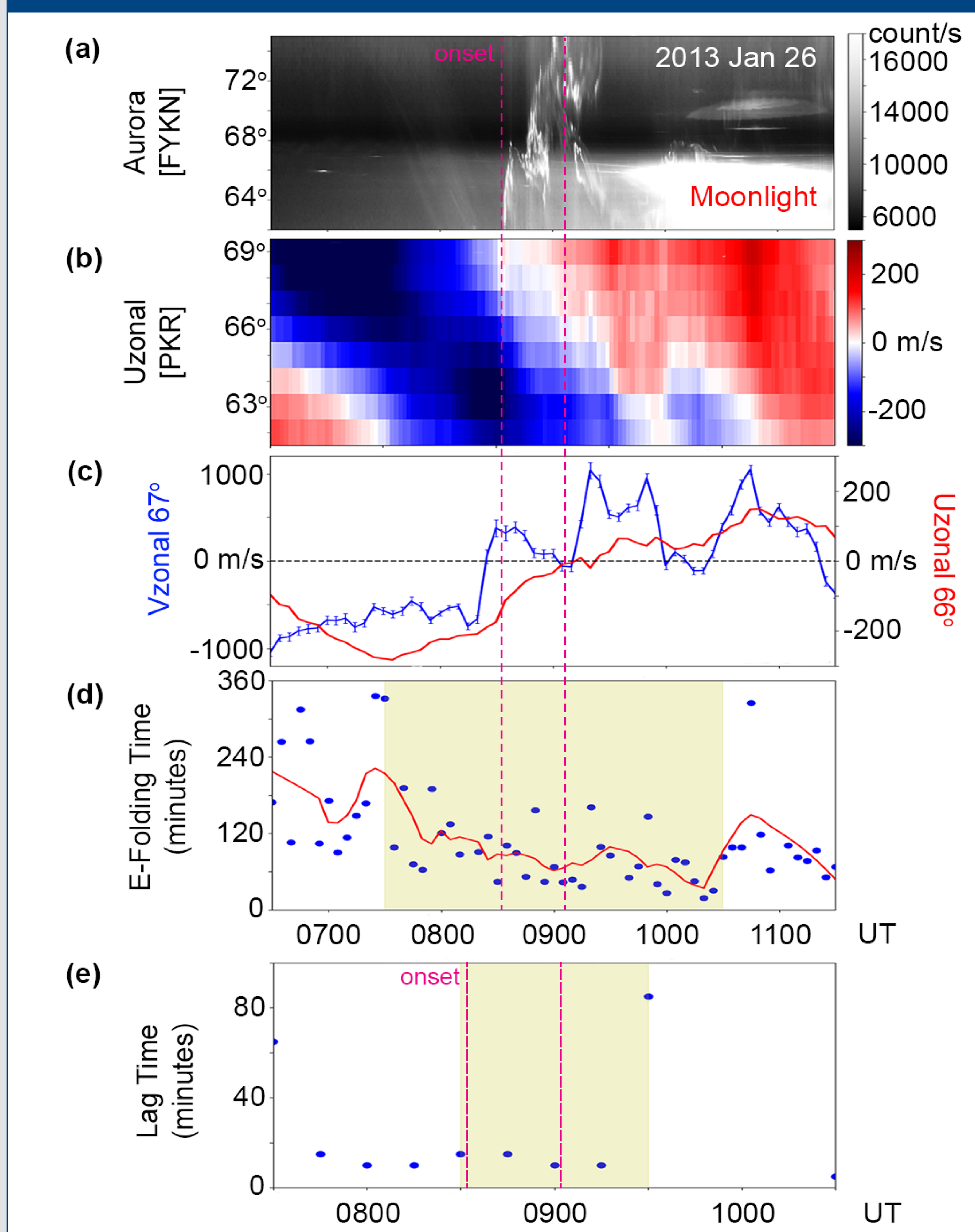

Figure 4. (a-e) Time series of AE index, auroral keogram, zonal plasma and neutral wind, e-folding time and weighted WTLC time on 2013 Jan 26.

- E-folding time ranges from 9 to 336 minutes, with a median response time of **93 minutes**
- Weighted WTLC time ranges from 5 - 85 minutes, with a median response time of **13 minutes**
- Difference in response time is **80 minutes**
- Both e-folding time and weighted WTLC time remain fairly steady throughout the event

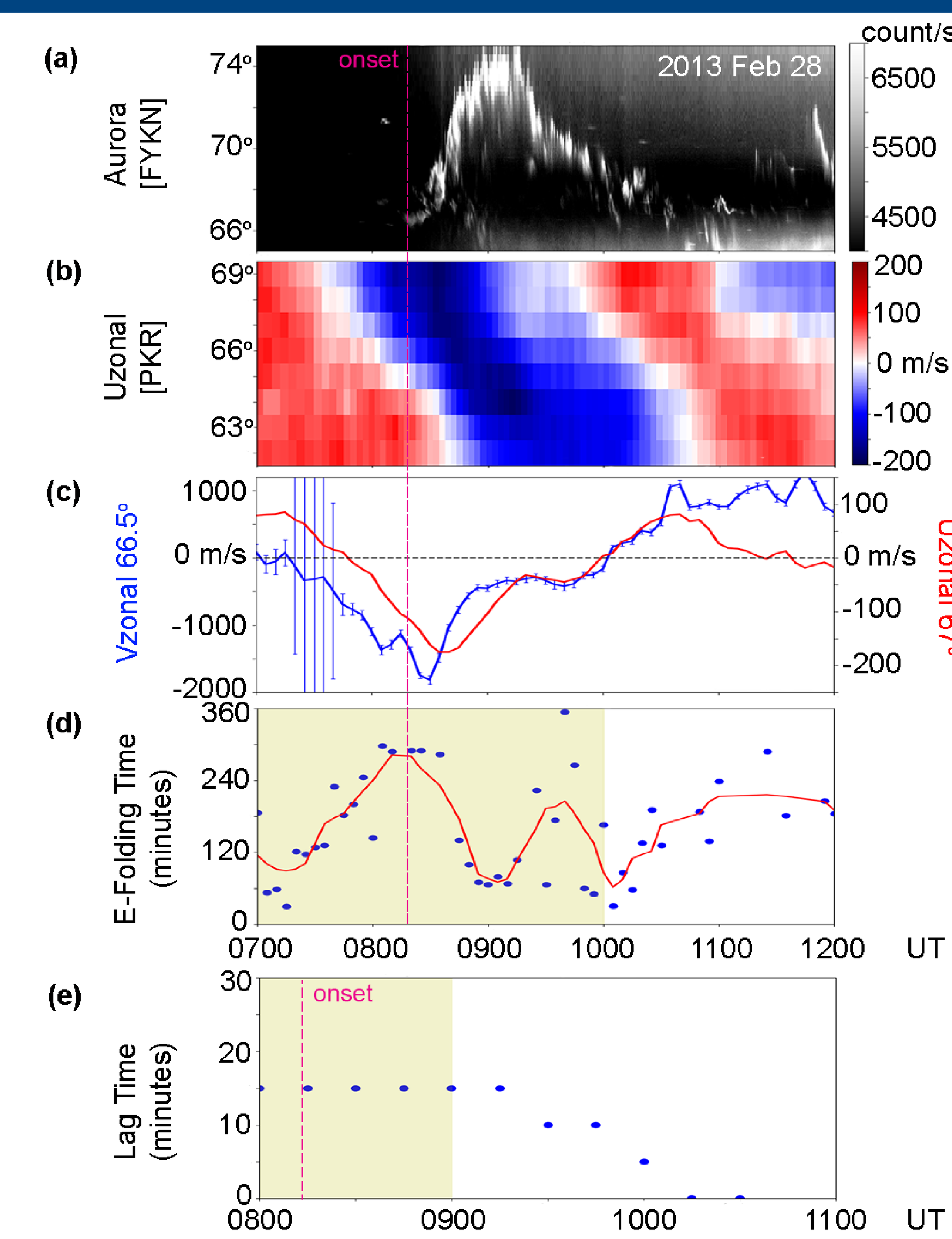

Figure 5. (a-e) Time series of AE index, auroral keogram, zonal plasma and neutral wind, e-folding time and weighted WTLC time on 2013 Feb 28.

- E-folding time ranges from 30 to 355 minutes, with a median response time of **142 minutes**
- Weighted WTLC time ranges from 0 to 15 minutes, with a median response time of **15 minutes**
- Difference in response time is **127 minutes**
- E-folding time is much more variable than weighted WTLC time

Result 2 - Statistical Study

Event Selection

- Used Newell and Gjerlov (2011) substorm list in 2013
- Substorm occurence between 07:00 - 14:00UT and 19 - 05 MLT
- Simultaneous operation of PFISR, SDIs and ASIs, with clear sky conditions in SDIs and ASIs
- Analysis window is chosen as 1 hr before and 2 hr after substorm onset

Results

- Event search resulted in 10 events from 2013
- E-folding time had a wider range of response times than the weighted WTLC time
- The dependence of response times on the AE index is weak, with a large scatter
- Lag time is consistently shorter than e-folding time, with the average difference being **86 minutes**, suggesting significant thermospheric forcing other than ion-drag
- However, Kiene et al. (2018) suggested that e-folding time could grow very large when coupling reaches a steady state

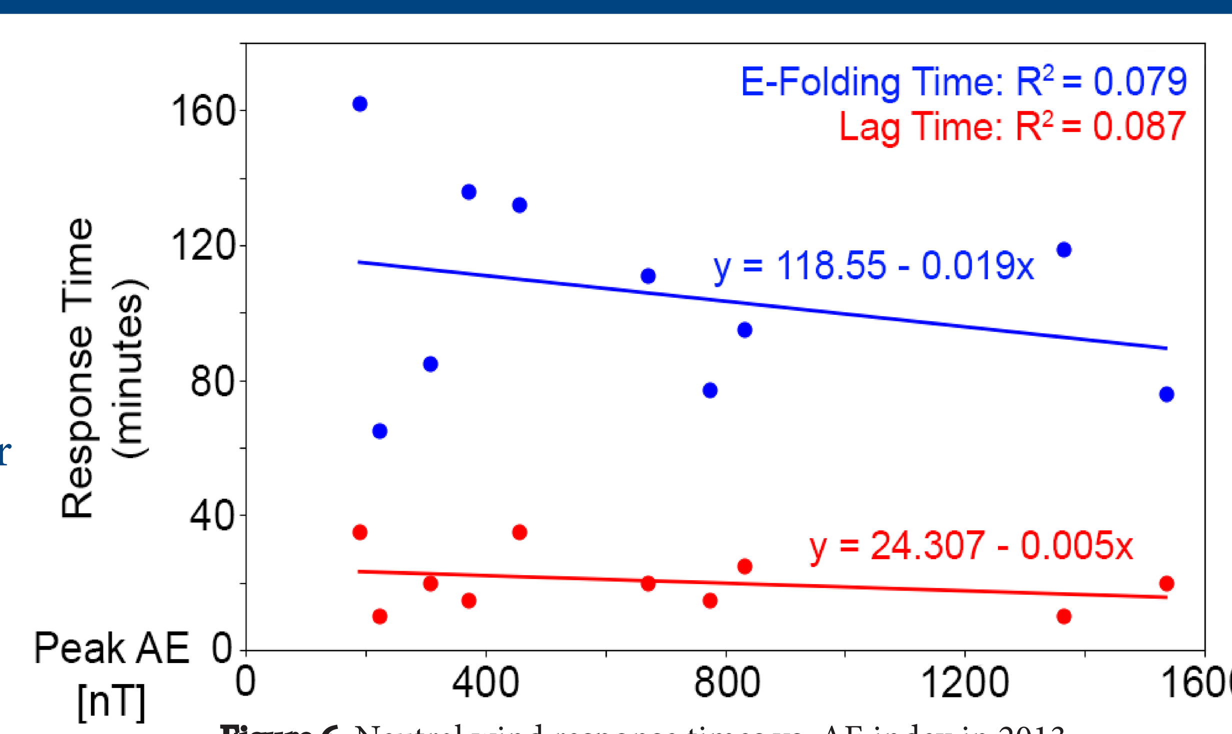

Figure 6. Neutral wind response times vs. AE index in 2013.

Conclusions & Future Work

- The new weighted WTLC method provides a time-dependent neutral wind response time that considers all thermospheric wind drivers
- Comparison of the weighted WTLC time and e-folding time for two case studies show that e-folding time is larger and more variable than the weighted WTLC time
- We also provide a statistical comparison of the two response times to the AE index
- Both the e-folding time and lag times vary little with increasing AE index, but more statistics are required to make conclusions
- Future work includes adding statistics from 2012
- Response times will also be compared to local geomagnetic indices, such as local magnetometer data and electron precipitation data from PFISR
- Our conclusions suggest significant thermospheric forcing other than ion-drag
- In order to further investigate the roles of thermospheric drivers, we are conducting a study using NCAR's TIE-GCM
- Various high-latitude drivers will be used to simulate thermospheric winds and compare to the observed SDI winds

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