

# Supporting Information for High Latitude Ionospheric Electrodynamics During STEVE and Non-STEVE Substorm Events

V. Svaldi<sup>1</sup>, T. Matsuo<sup>2</sup>, L. Kilcommons<sup>2</sup>, and B. Gallardo-Lacourt<sup>3,4</sup>

<sup>1</sup>Mechanical Engineering Department, Colorado School of Mines, Golden, CO, USA

<sup>2</sup>Ann & H.J Smead Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA

<sup>3</sup>Goddard Space Flight Center, National Aeronautics and Space Administration, Greenbelt, MD, USA

<sup>4</sup>Universities of Space Research Association, Columbia, MD, USA

## Contents of this file

1. Figures S1 to S5
2. Tables S1

## Additional Supporting Information (Files uploaded separately)

1. Captions for Movies S1 to S3

**Introduction** The supporting information presented in this document primarily seeks to provide supplemental information that was omitted in the main document for the sake of brevity. In this document additional figures displaying the superposed epoch analysis results and reconstructed electrostatic potential maps for all 32 STEVE events centered at the STEVE optical onset time are provided as well as table providing the specific STEVE event dates that had weak dawn cell extension observed in the global ionospheric convection patterns produced by AMGeO. This document also contains superposed epoch analysis results and correlation matrices between principal component coefficients, geomagnetic activity indices, and solar wind parameters for 10 STEVE and 10 non-STEVE substorm events. Movies for events including the STEVE event occurring on March 26, 2008 and on April 5, 2010 and the non-STEVE substorm event occurring on September 14, 2015 are also included.

**Text S1: Description of Figure S1-S5 and Table S1** Superposed epoch analysis of time-varying PC coefficients and cross-polar cap potential are shown in the pink colored box-plots in Figure S1 shown for a 3-hour duration centered at the STEVE optical onset. Superposed epoch analysis of AL-index, AU-index, IMF By, and IMF Bz are included to examine the relationship of global modes of ionospheric convection evolution to solar wind drivers and overall substorm evolution indicated by geomagnetic indices. Figure S2 displays reconstructed electrostatic potential distribution maps and median PC coefficients times series at three key time frames at 30 minutes before and after as well as at time of STEVE optical onset. The superposed epoch analysis results for 10 STEVE and 10 non-STEVE substorm events, selected based on SML minimum values, are shown

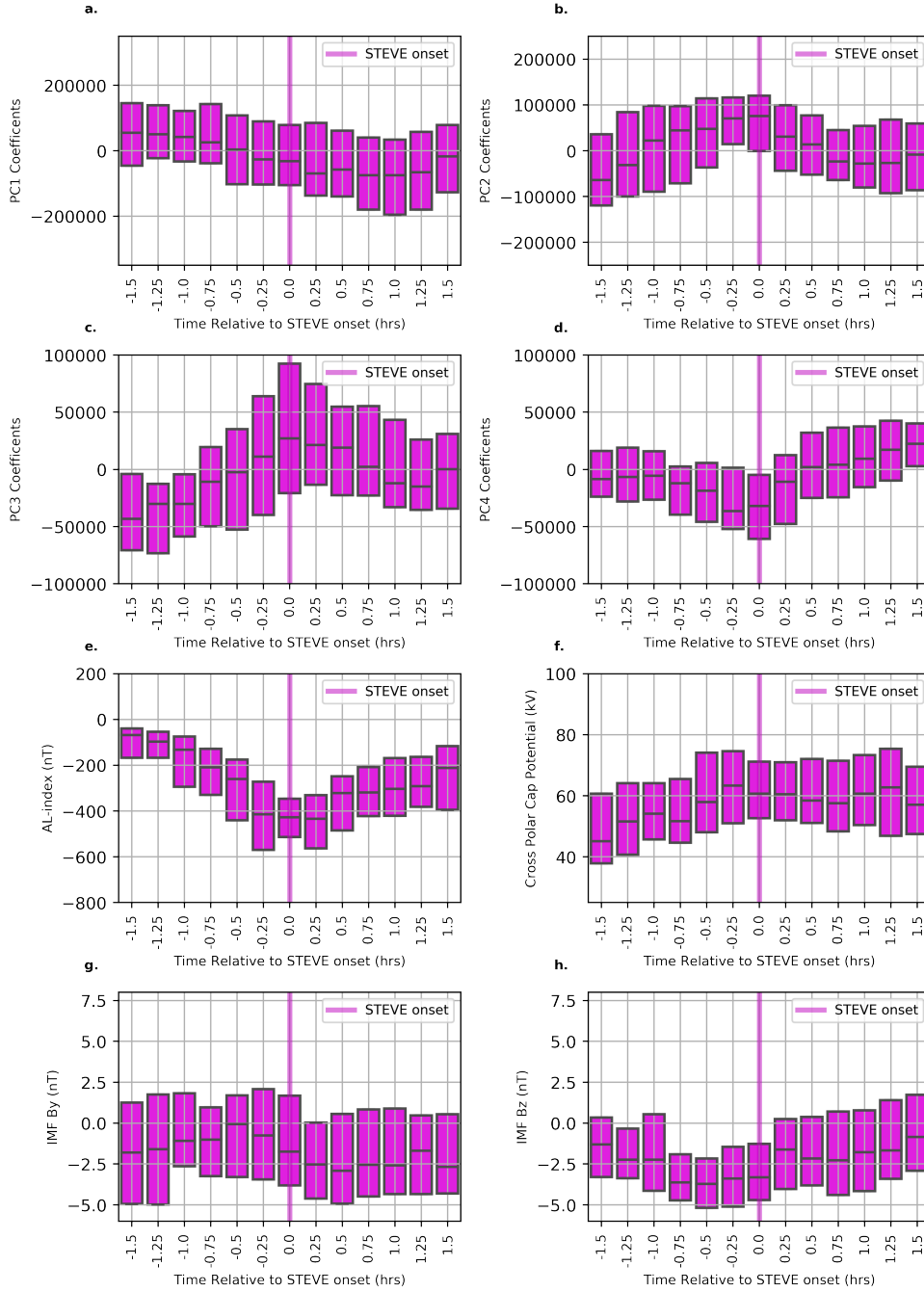
in Figure S3 and Figure S4, respectively. The related correlation matrices for these events are displayed in Figure S5. Table S1 provides a complete list of four STEVE event dates that did not conform to the majority of the 32 STEVE events investigated in this study with a weak or atypical dawn cell extension observed in AMGeO maps.

Movies showing 5-minute resolution AMGeO maps for a 3-hour duration for the STEVE event occurring on March 26, 2008 and April 5, 2010, and the non-STEVE substorm event occurring on September 14, 2015 are also included.

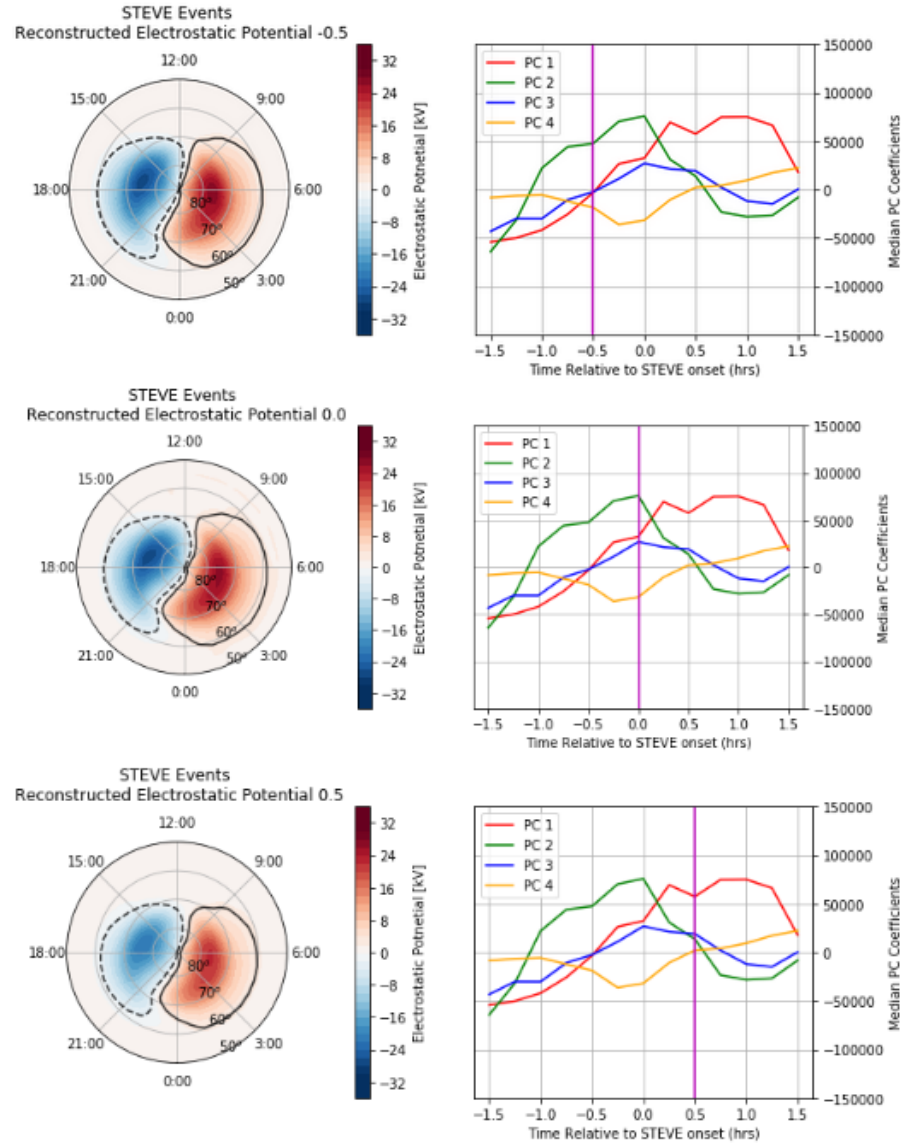
**Movie S1.** Movie displaying 5 minute resolution AMGeO electrostatic potential distribution maps generated for case study STEVE event occurring on March 26, 2008 occurring from 6:00 to 9:55 UT. Movie can be viewed at: DOI 10.17605/OSF.IO/F3VUT

**Movie S2.** Movie displaying 5 minute resolution AMGeO electrostatic potential distribution maps generated for case study non-STEVE substorm event occurring April 5, 2010 from 4:00 UT to 8:25 UT. Movie can be viewed at: DOI 10.17605/OSF.IO/F3VUT

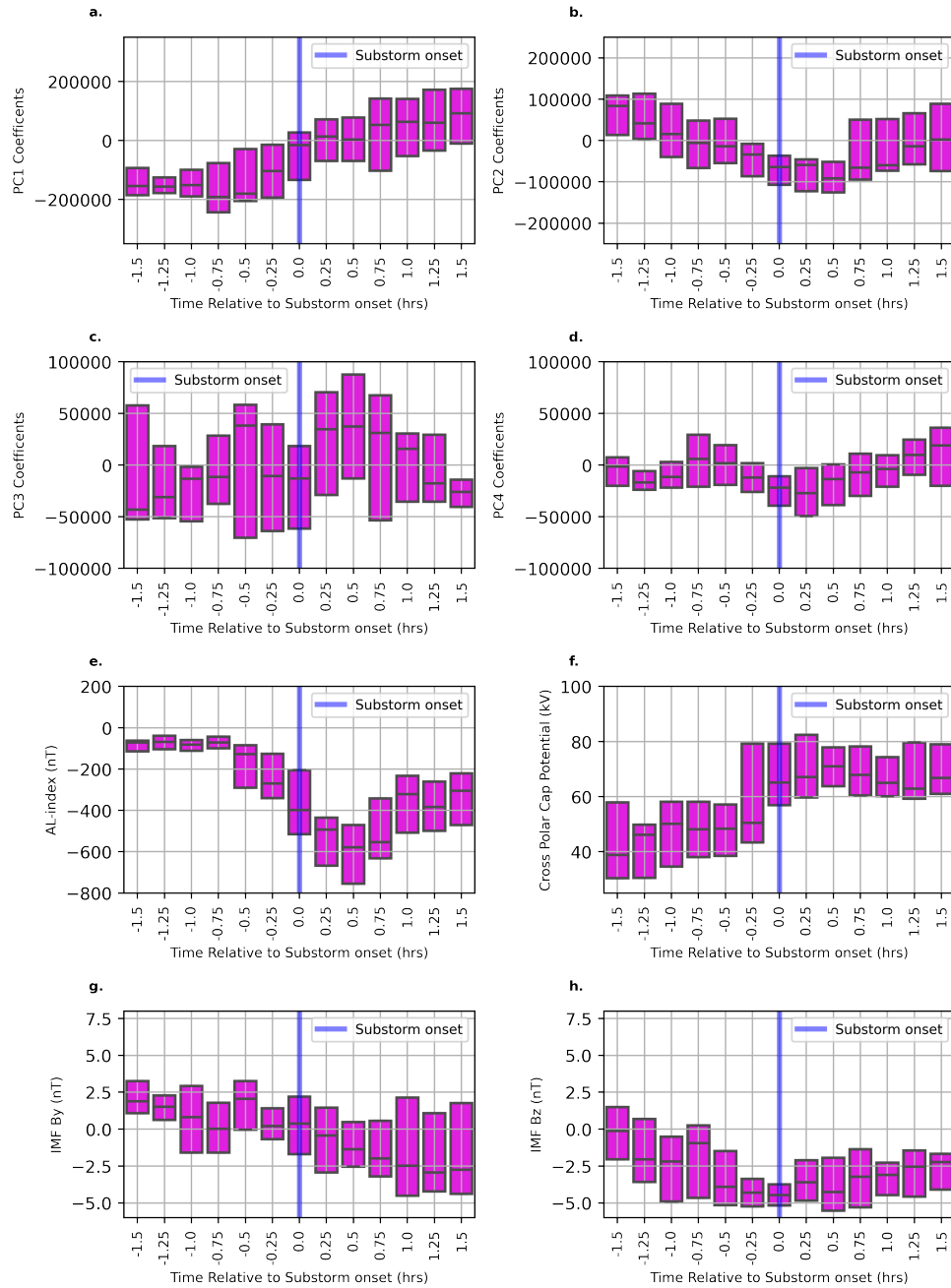
**Movie S3.** Movie displaying 5 minute resolution AMGeO electrostatic potential distribution maps generated for case study non-STEVE substorm event occurring on September 14, 2015 from 14:00 UT to 17:15 UT. Movie can be viewed at: DOI 10.17605/OSF.IO/F3VUT



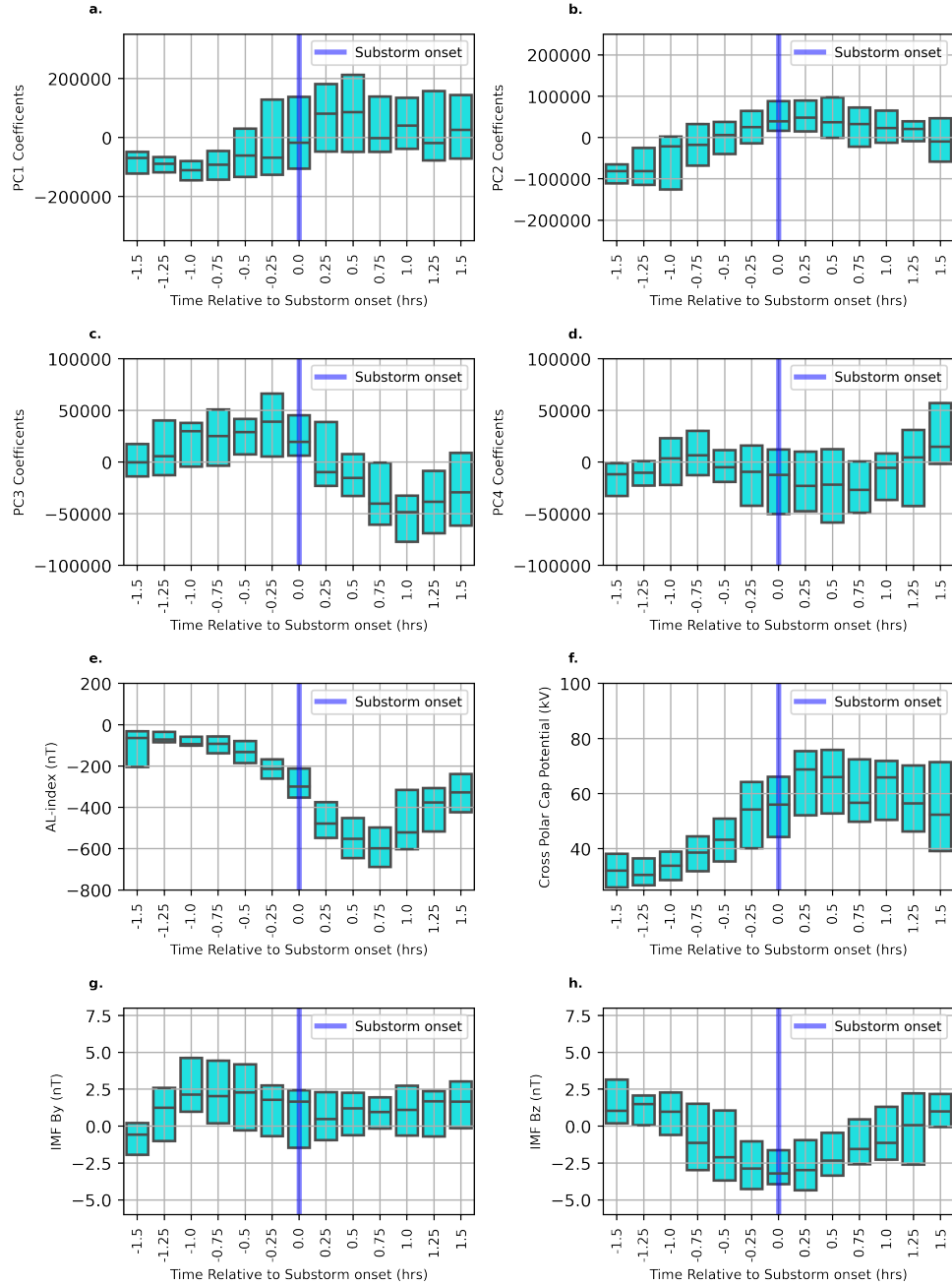
**Figure S1.** Superposed epoch analysis for all 32 STEVE events for a 3 hour duration centered at STEVE optical onset (1.5 hour prior and 1.5 hour post STEVE optical onset time). Displays the coefficients of the first four PCs, AL-index, AU-index, IMF By/Bz, and cross polar cap potential.



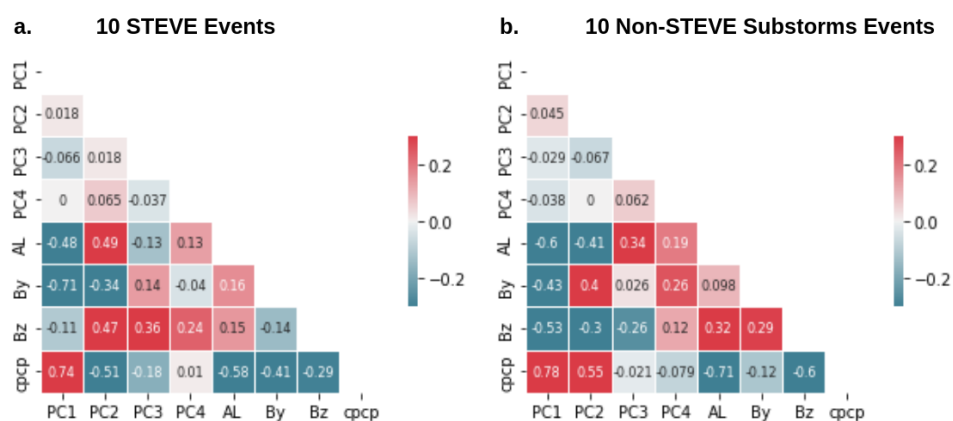
**Figure S2.** Reconstructed electrostatic potential spatial maps derived from PCA median coefficients for 32 STEVE events and time series of PCA median coefficients for three key times from top to bottom displays maps at 0.5 hour prior to STEVE optical onset, at the STEVE optical onset, 0.5 hour post STEVE optical onset.



**Figure S3.** Superposed epoch analysis for 10 STEVE events (events selected based on SML minimum values) for a 3-hour duration centered at substorm onset (1.5 hour prior and 1.5 hour post substorm onset time). Displays the coefficients of the first four PCs, AL-index, AU-index, IMF By/Bz, and cross polar cap potential.



**Figure S4.** Superposed epoch analysis for 10 non-STEVE substorm events (events selected based on SML minimum values) for a 3-hour duration centered at substorm onset (1.5 hour prior and 1.5 hour post substorm onset time). Displays the coefficients of the first four PCs, AL-index, AU-index, IMF By/Bz, and cross polar cap potential.



**Figure S5.** (a) Correlation matrix of PC coefficients, AL-index, AU-index, IMF By, IMF Bz, and cross-polar cap potential for 10 STEVE events. (b) Correlation matrix of PC coefficients, AL-index, AU-index, IMF By, IMF Bz, and cross-polar cap potential for 10 non-STEVE substorm events.



**Table S1.** List of specific STEVE event dates that had weak or idiosyncratic dawn cell extension observed in the global ionospheric convection patterns produced by AMGeO.

Event	Date	STEVE Onset
1	8-03-2010	5:40
2	6-23-2011	7:15
3	9-13-2013	8:30
4	7-29-2016	5:20