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# TCV-like event induced by positive-negative pulse pair of solar wind dynamic pressure

A.M. Tian, A.W.Degeling, Q.Q. Shi, Z.Y. Xing

Shandong Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, School of Space Science and Physics, Institute of Space Sciences, Shandong University, Weihai, Shandong, 264209, China.

Email: tamin@sdu.edu.cn

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# Outline

- Introduction
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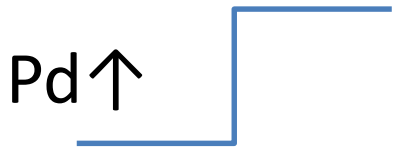
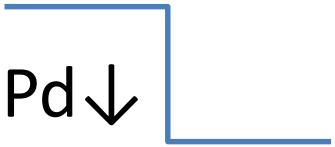
  - Radar
- Simulation results
- Summary and conclusions

# Introduction

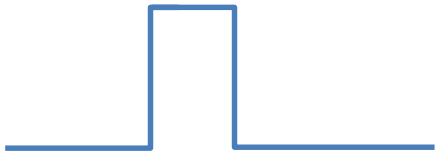
- Travelling Convection Vortex-like(TCV-like) events excited by **Step function-like increase/decrease** of solar wind dynamic pressure(Pd) have been reported and widely analyzed by observations and simulations[Tamao, 1964a, 1964b; Araki,1994; Fujita et al., 2003A, 2003b; Shi et al., 2014; Zhao et al., 2015; Sun, et, al., 2015; Kim et al., 2015; Tian, et, al., 2016].
- Interplanetary current sheets, HFAs, and sheath jets are frequently observed in the solar wind, near the bow shock and in the magnetosheath [Winterhalter et al.,1994, Zhang et al.,2009; Zhang et al., 2010; Wang et al., 2013; Plaschke et al.,2013]. All these phenomena may be accompanied with global or local **positive-negative pulse pairs** of dynamic pressure.
- How will the magnetosphere and ionosphere respond? Are the positive-negative pulse pairs related to TCVs?




[e.g. Tian et al.,2016]



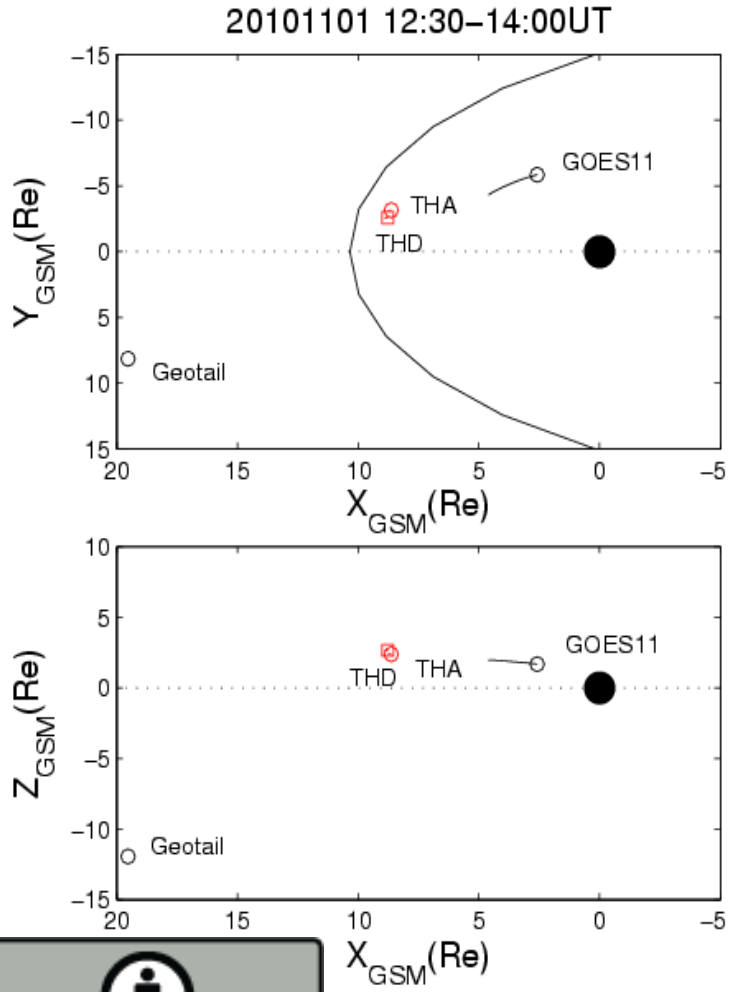

[e.g., Zhao et al., 2015]



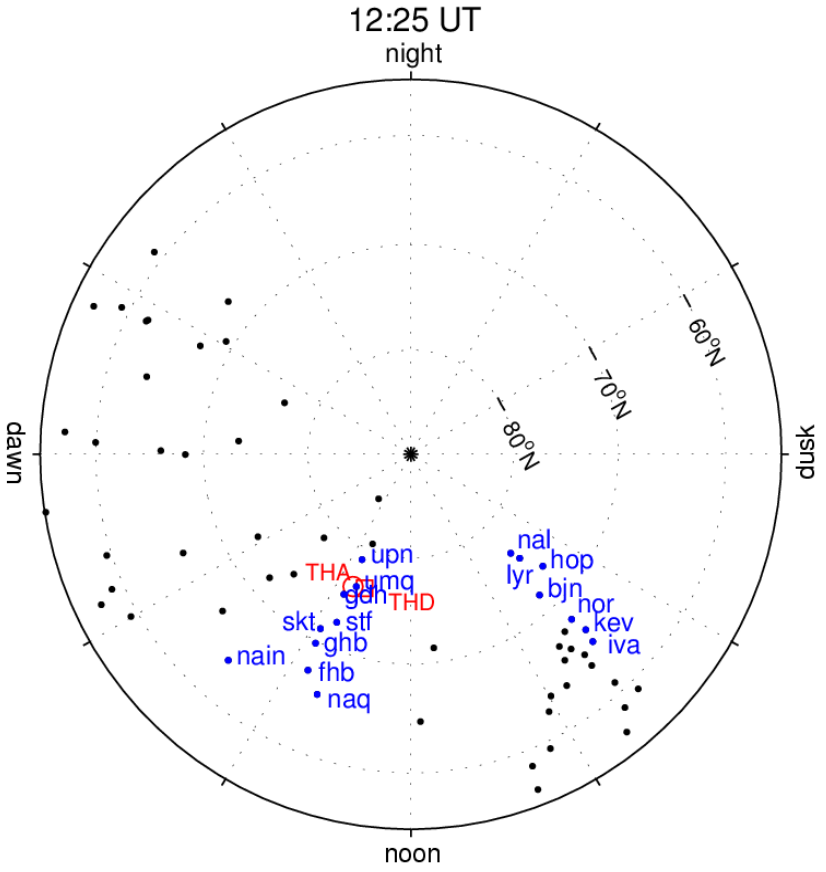
How response of **Pd positive-negative pulse pair**?

# Observations: 2010-10-01 event

## Spacecraft trajectory

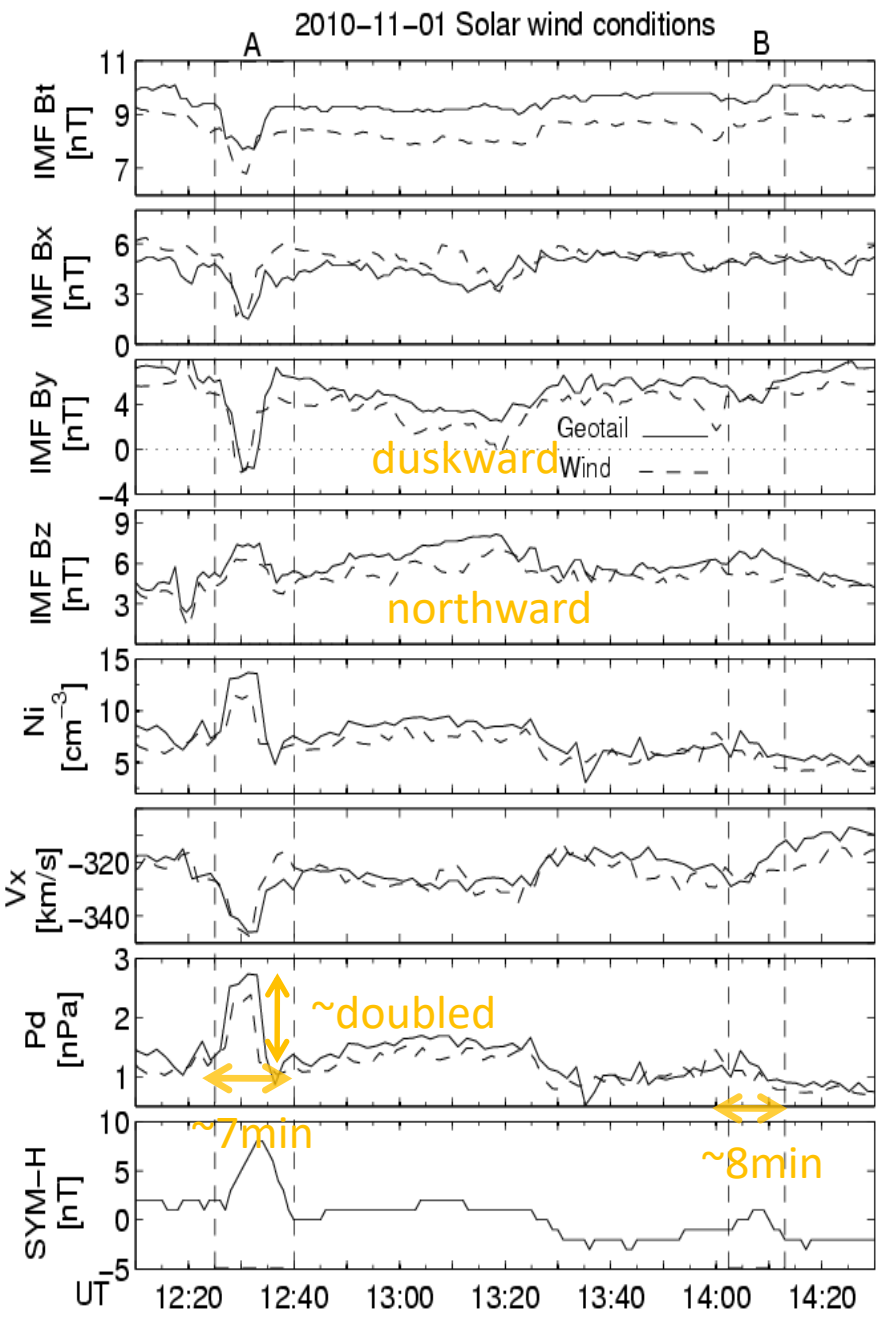


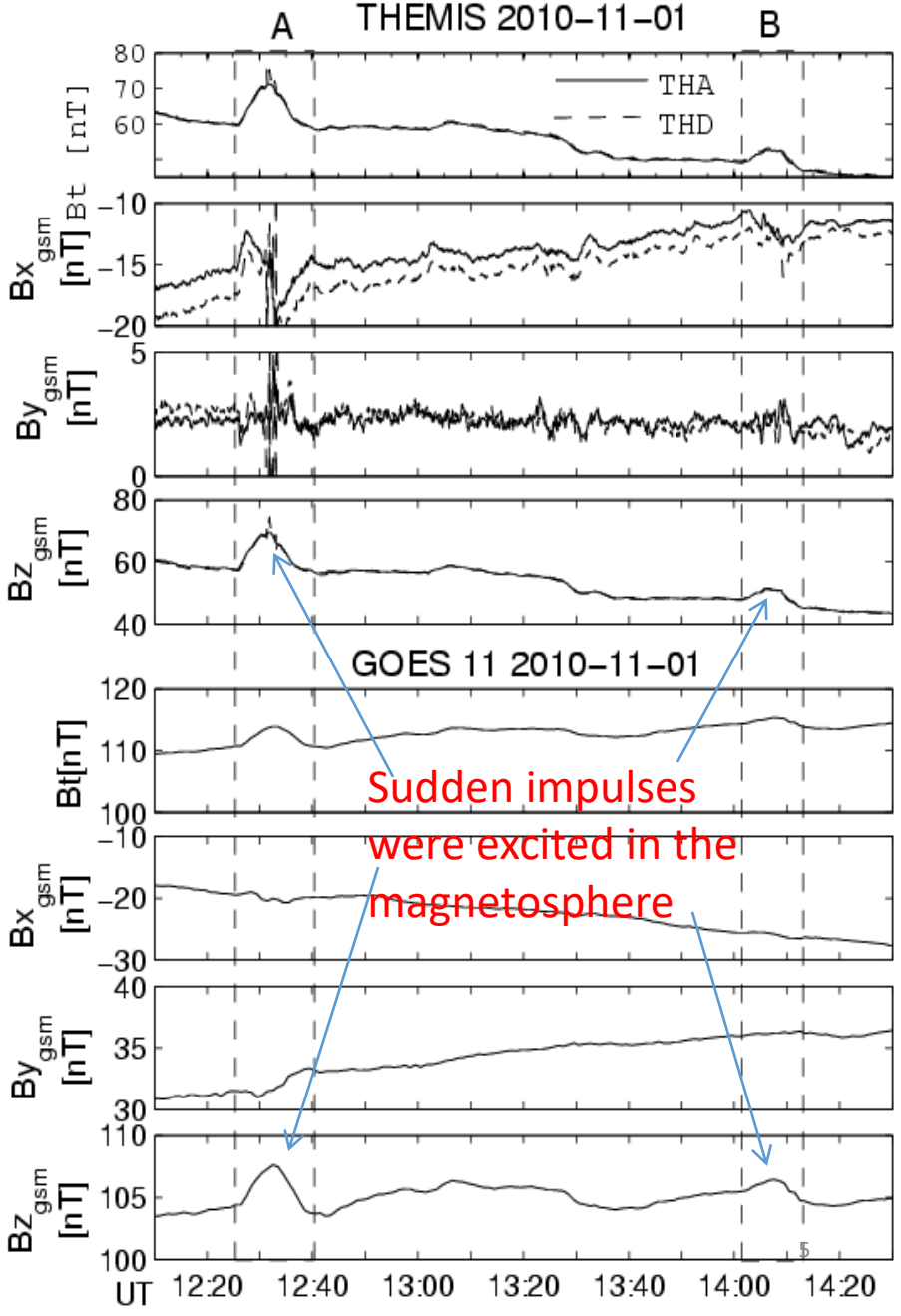

## geomagnetic stations




63 geomagnetic stations used to infer the time-dependence of EIC patterns

# Solar wind positive-negative dynamic pressure pulse pairs

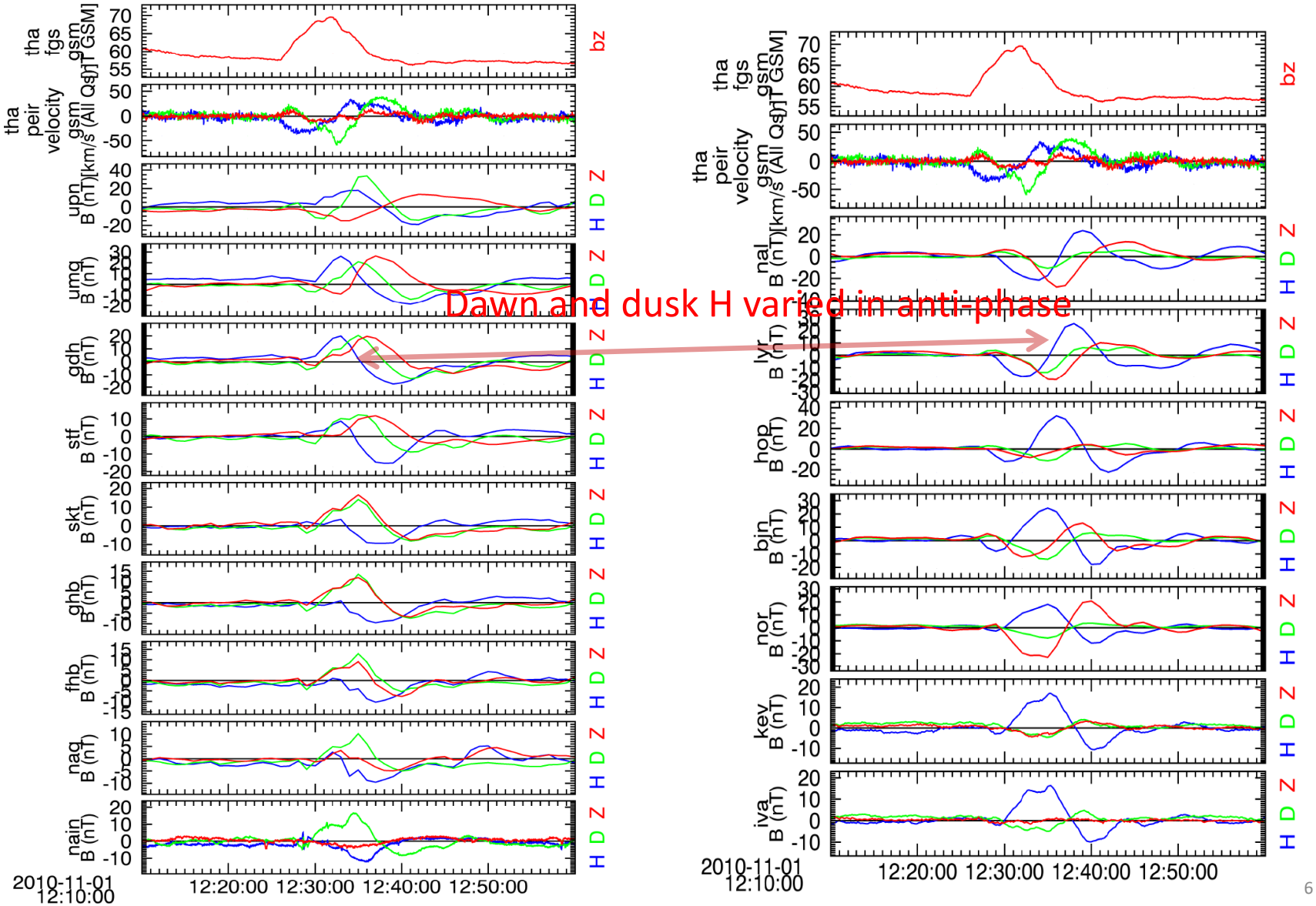


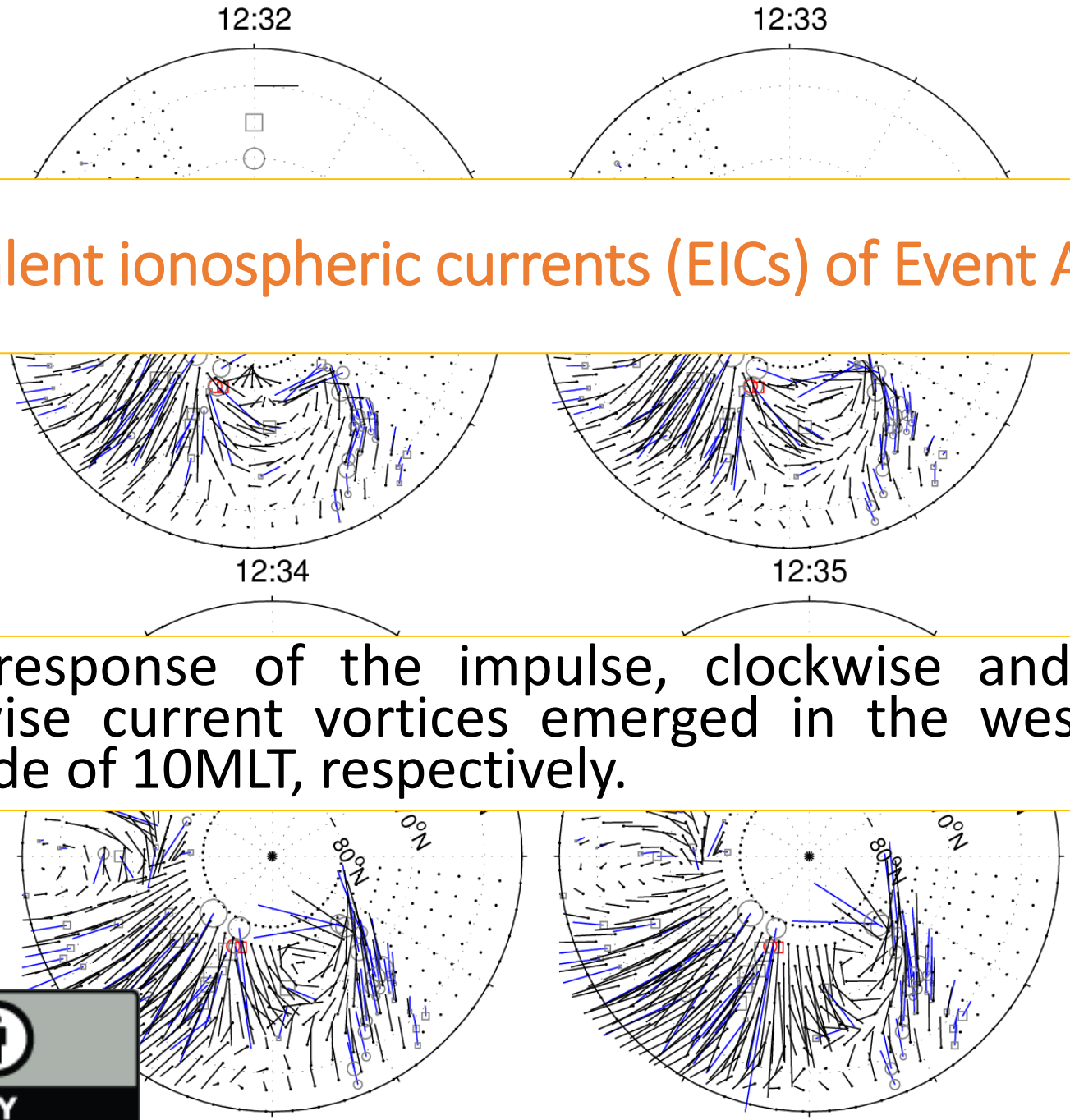
# TCV-like events

Stations around 10MLT

Stations around 15MLT

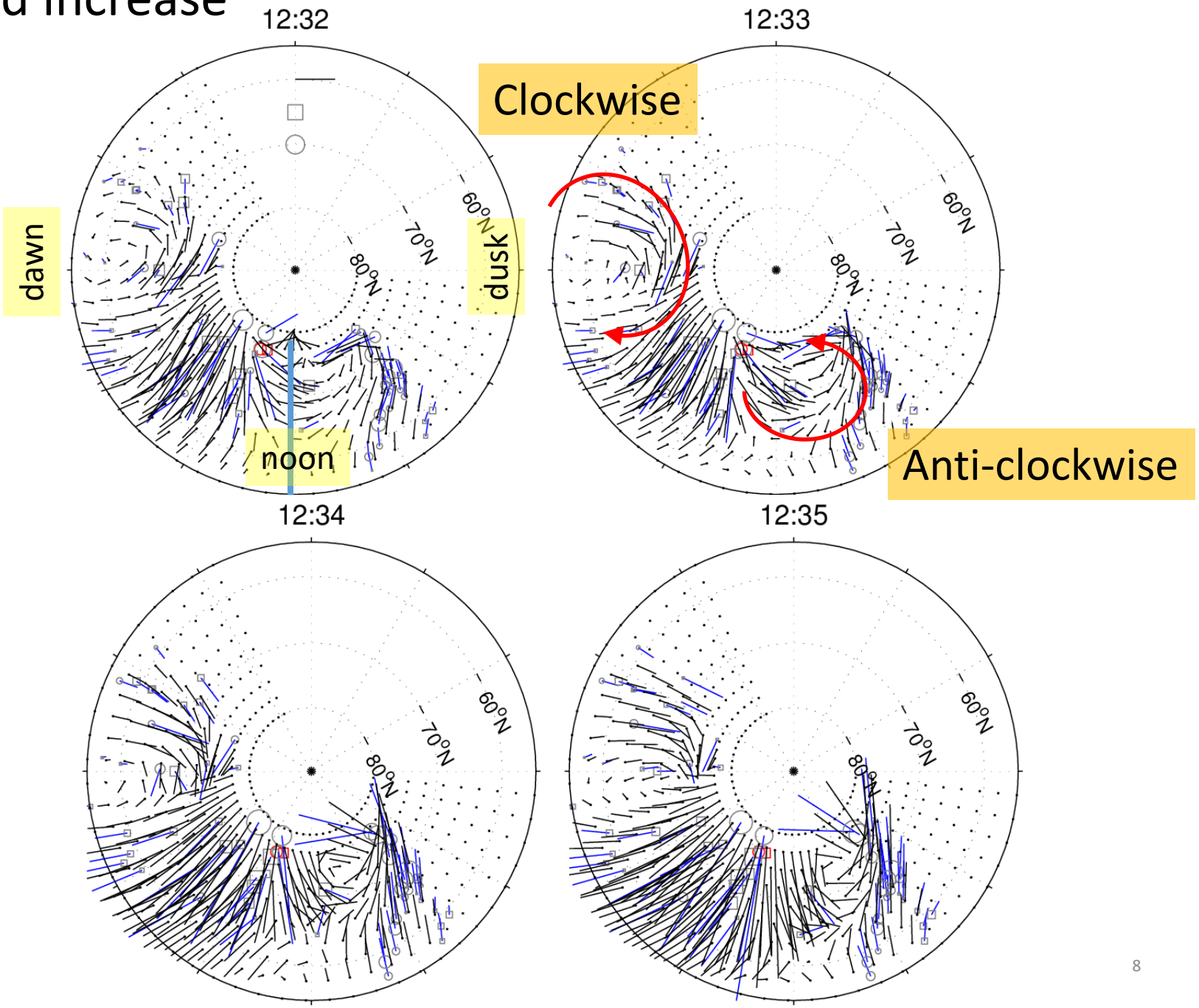


# Equivalent ionospheric currents (EICs) of Event A

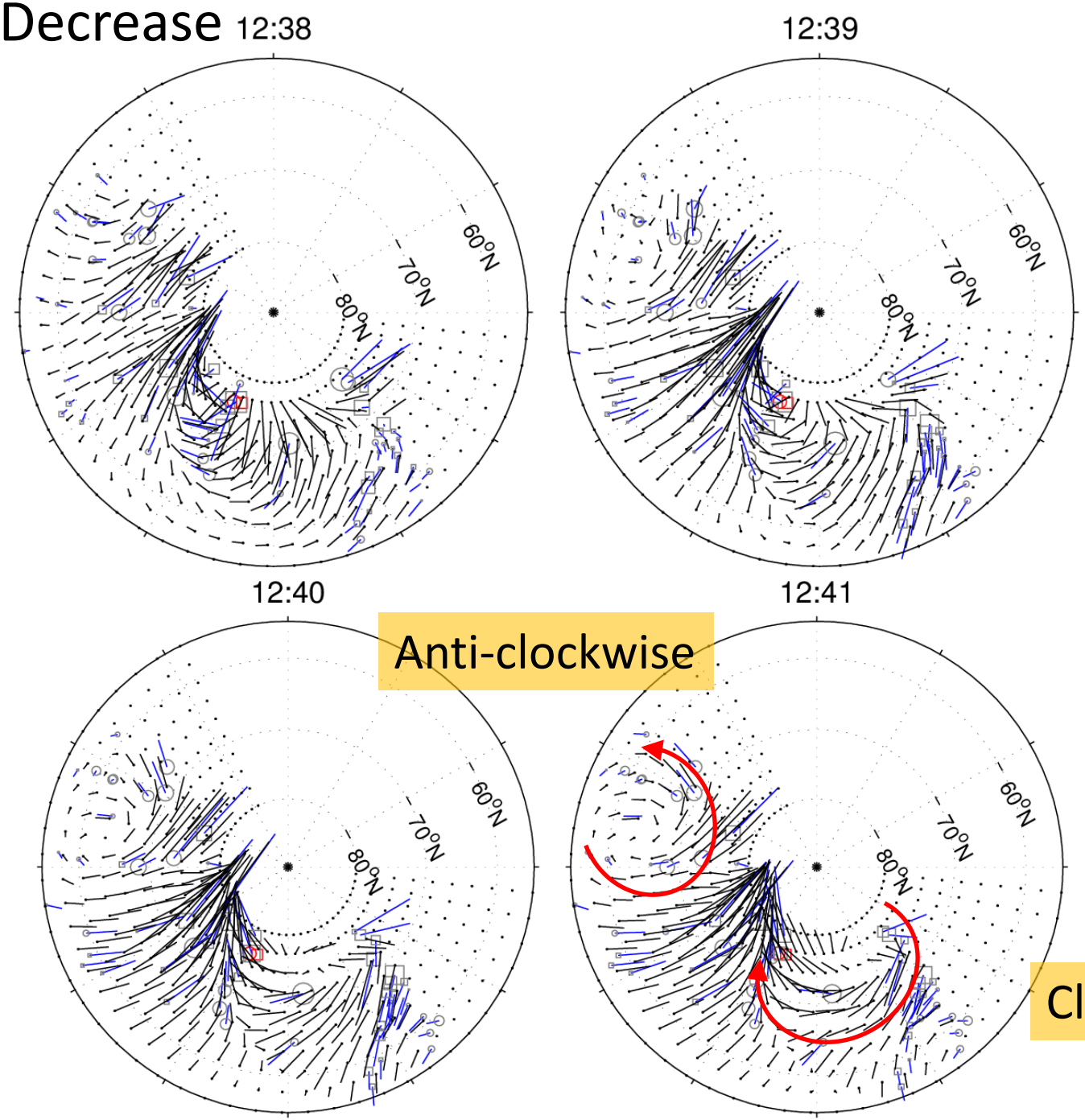



As a response of the impulse, clockwise and anti-clockwise current vortices emerged in the west and east side of 10MLT, respectively.

# After Pd increase



# After Pd Decrease



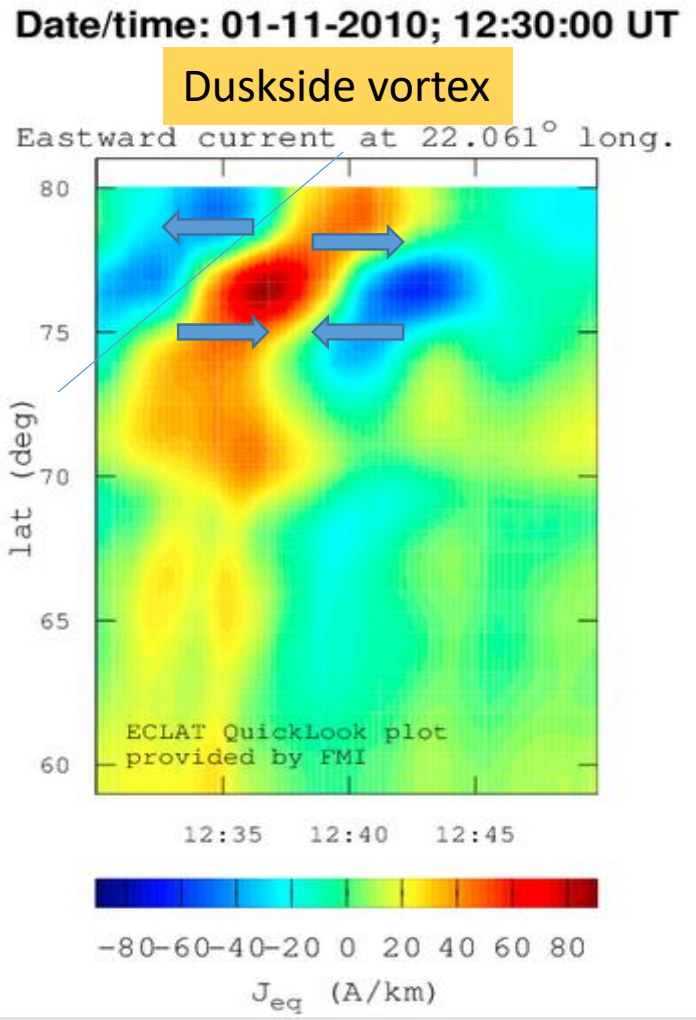
# Current vortex scale and intensity

## 1. Duskside vortex

- 12:35UT:
  - ~1000×2000km, anticlockwise(upward FAC)
  - Centered at ~ 14:00MLT, 75MLAT
  - ~1.65km/s poleward moving
  - Current density: several 0.01μA/m$^2$
- 12:41UT:
  - Similar scale, movement but with opposite rotation direction

## 2. Dawnside vortex

- Across more than 6MLT, in opposite rotation sense to the duskside vortex

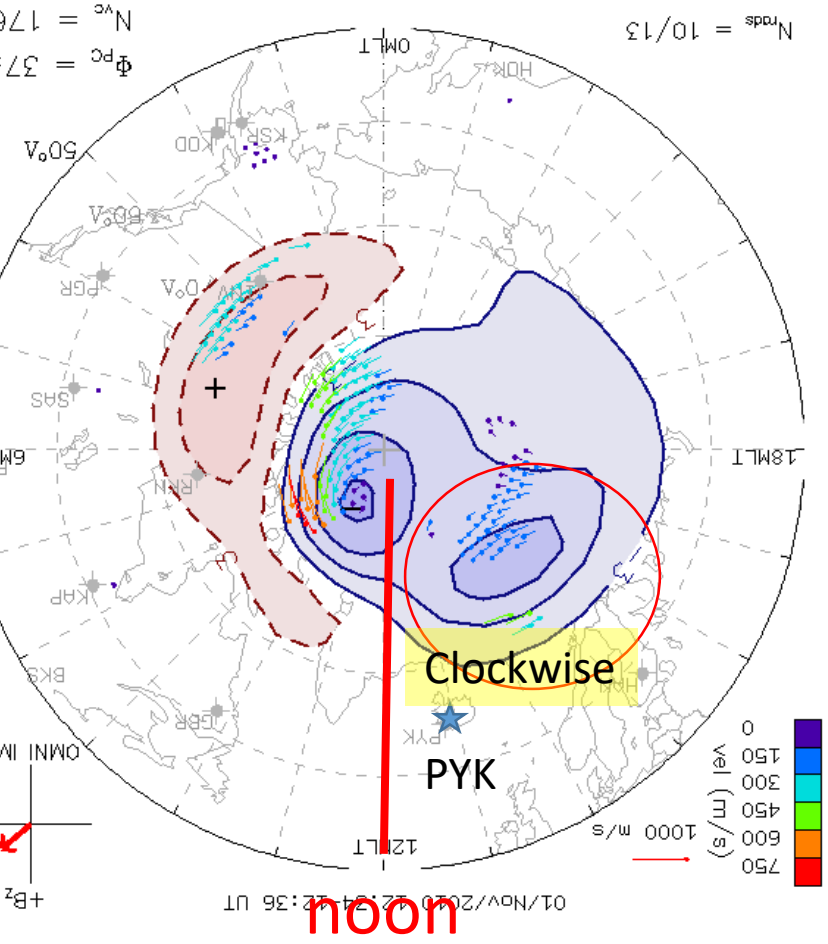



2D equivalent current plot(eastward) provided by the IMAGE Network

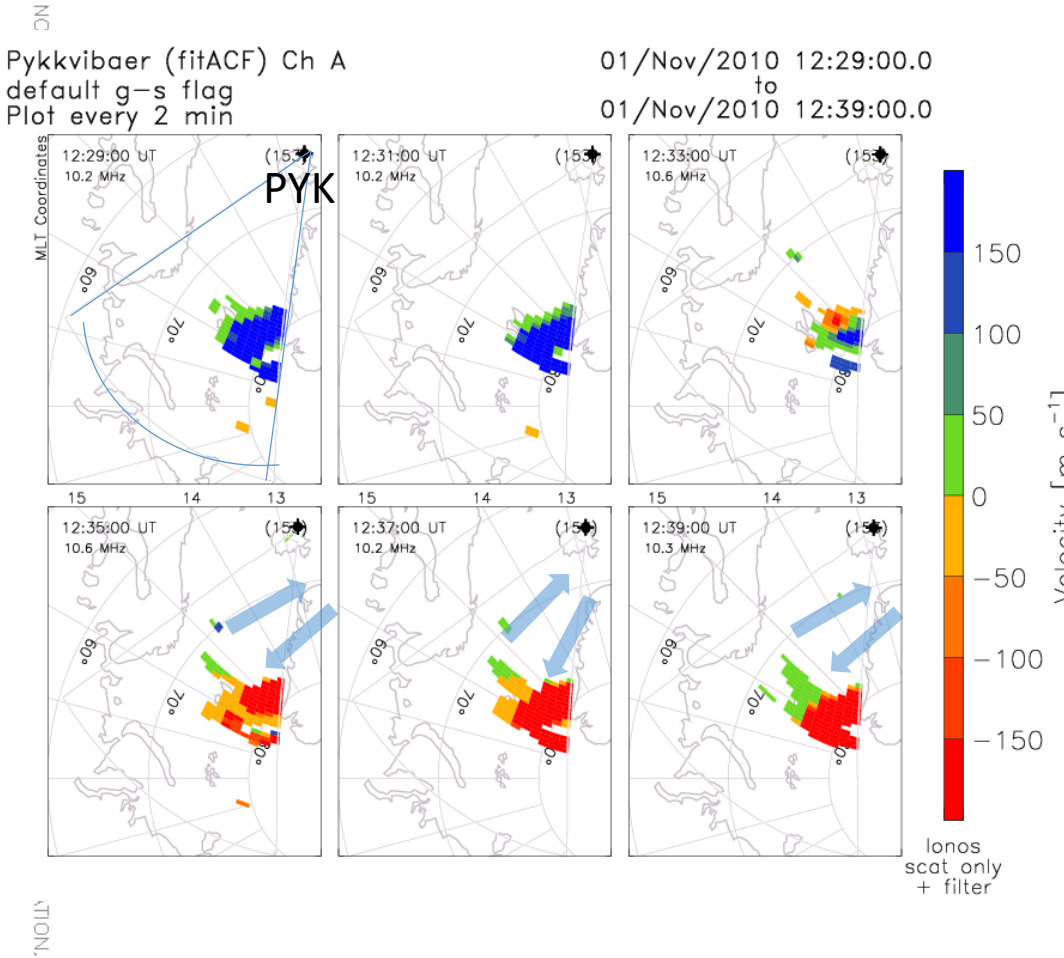
From http://space.fmi.fi/MIRACLE/iono_2D.php

# Duskside vortex confirmed by SuperDARN data(1)

First vortex: clockwise, 12:34-12:36UT



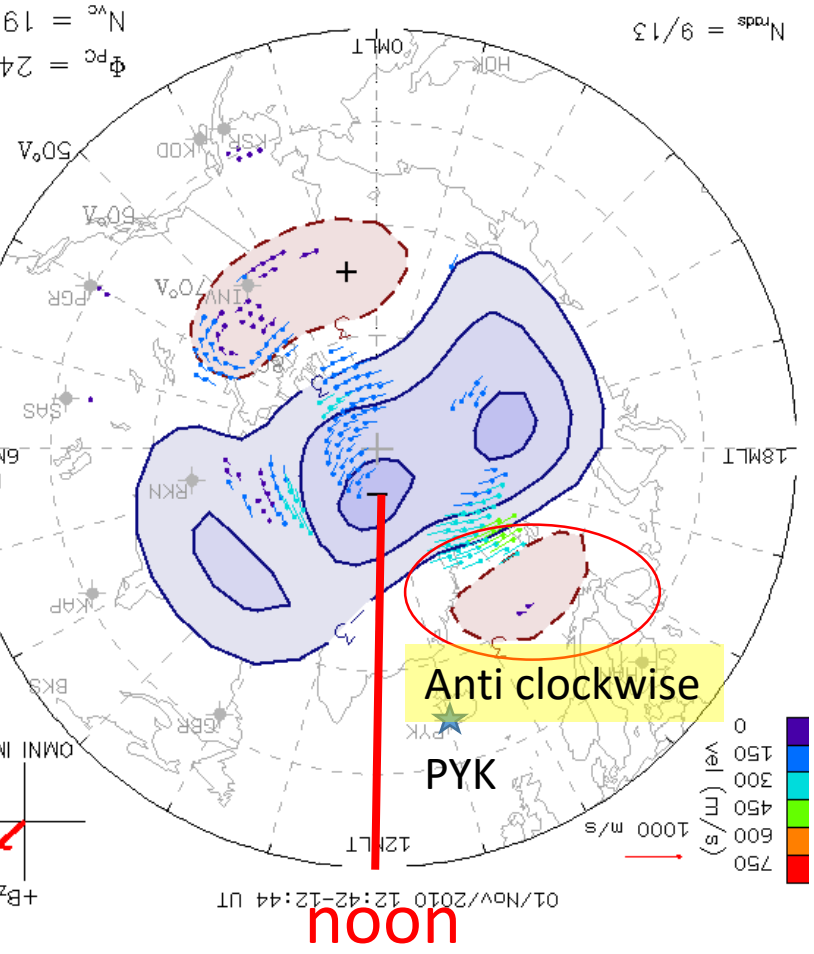

PYK observations

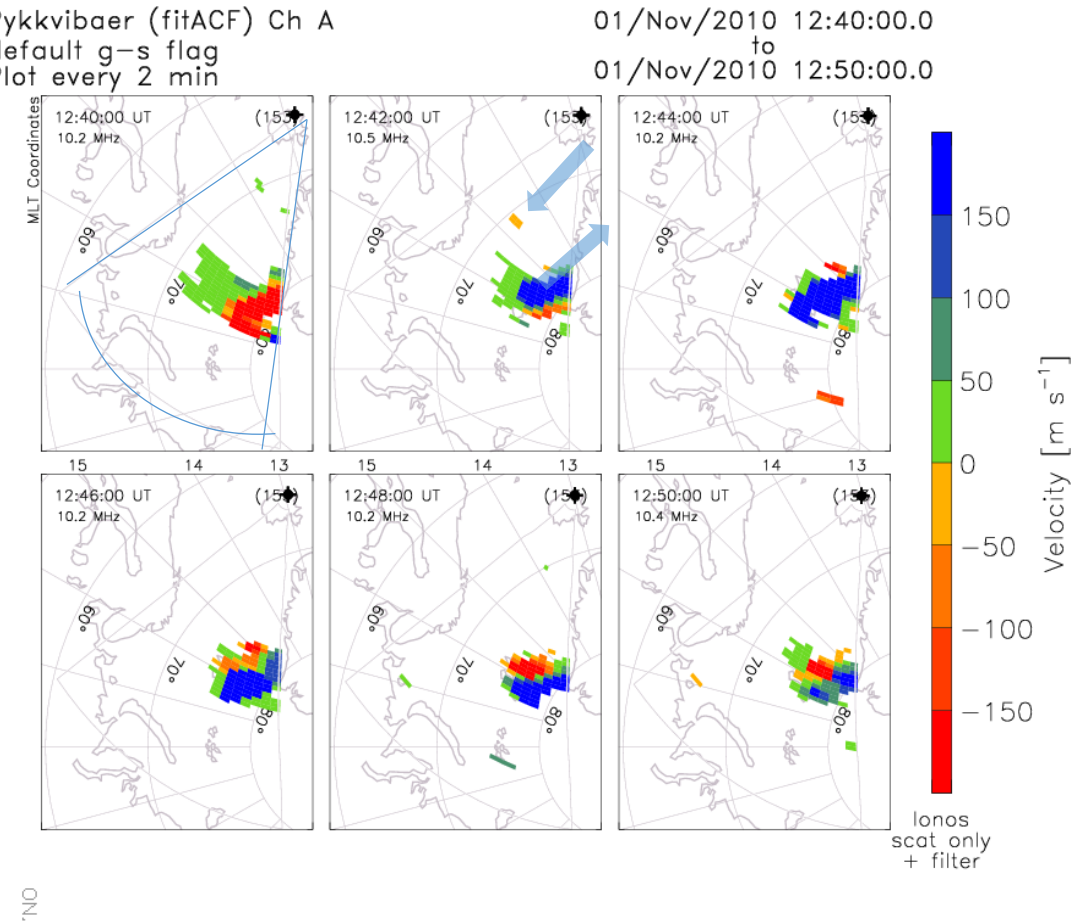


# Duskside vortex confirmed by SuperDARN data(2)

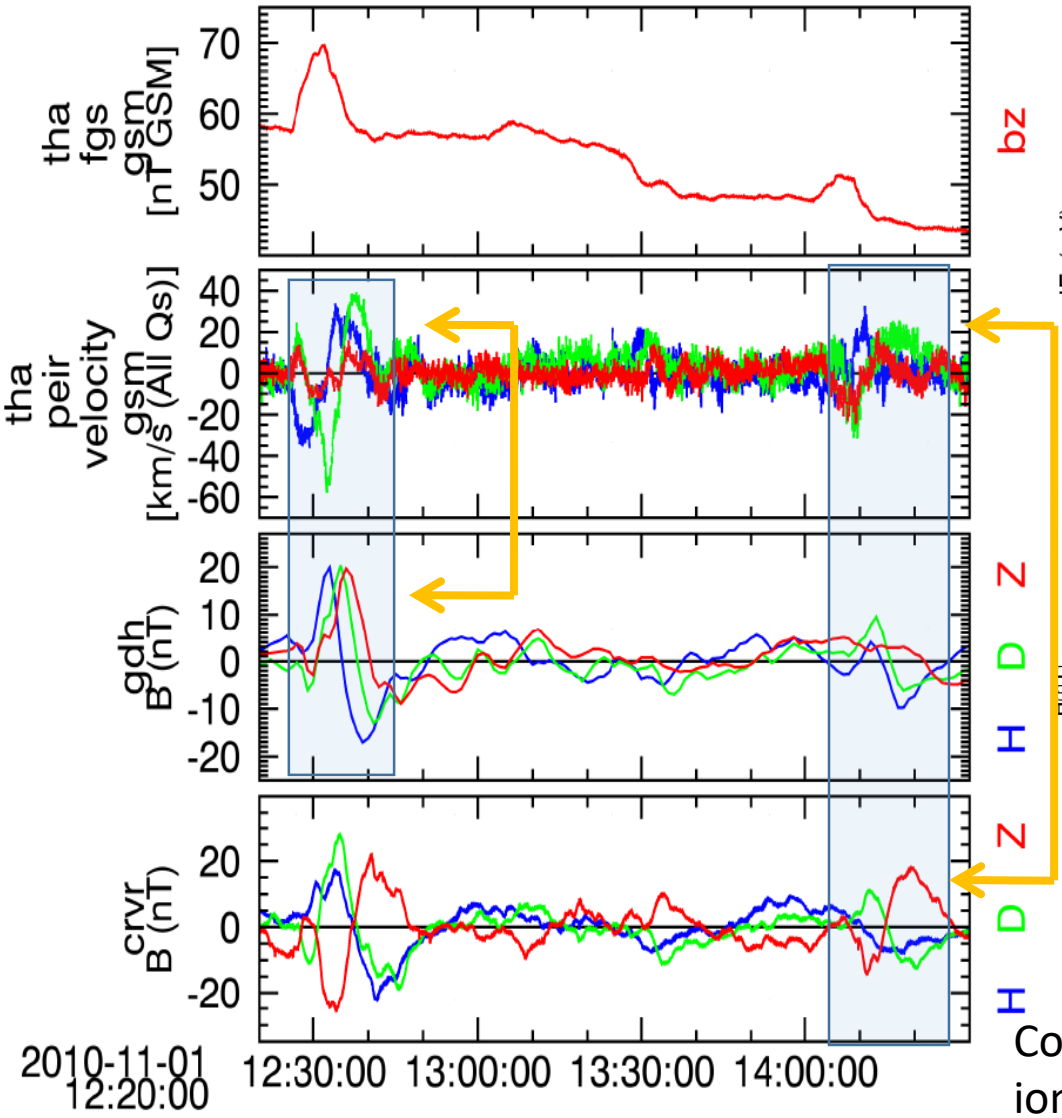
**Second vortex: anticlockwise, 12:42-12:44UT**

PYK observations



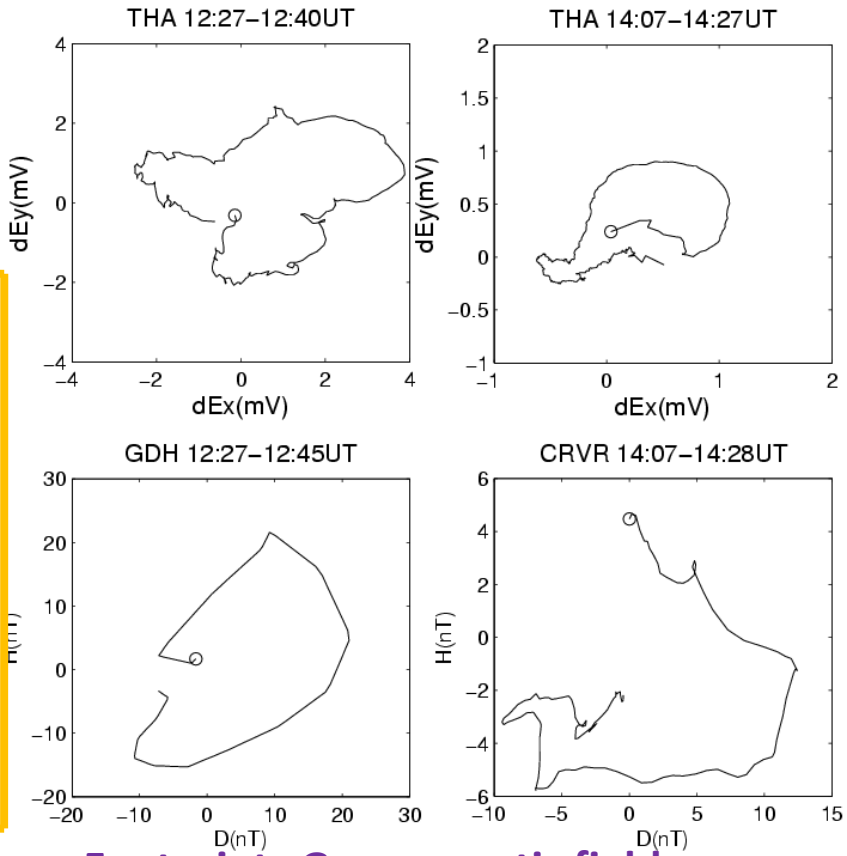



# The link between TCV-like event and magnetospheric convections




**Magnetosphere flow(THA):**

Anticlockwise circular polarization

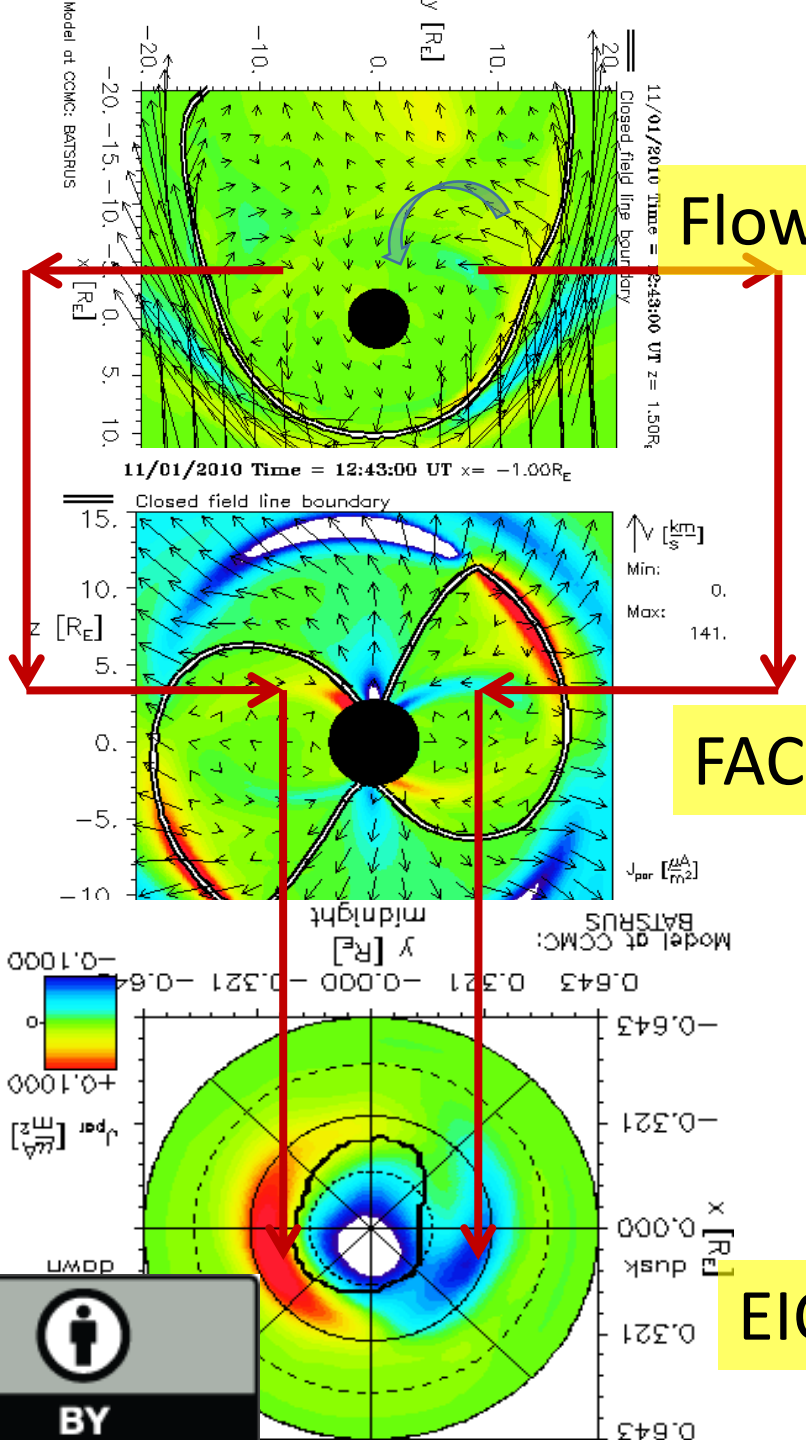



**Footprints Geomagnetic field:**

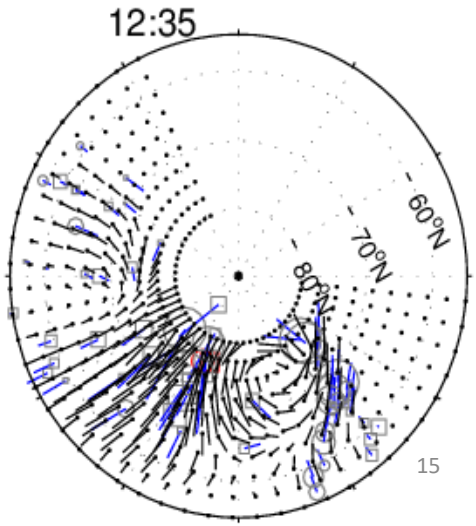
clockwise circular polarization

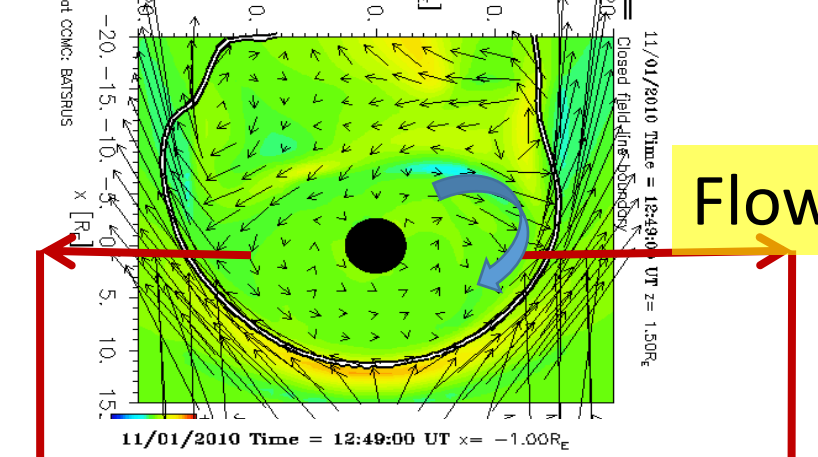
Convections in magnetosphpere and ionosphere **are connected** by magnetic field lines.

# Simulation results by BATSRUS model



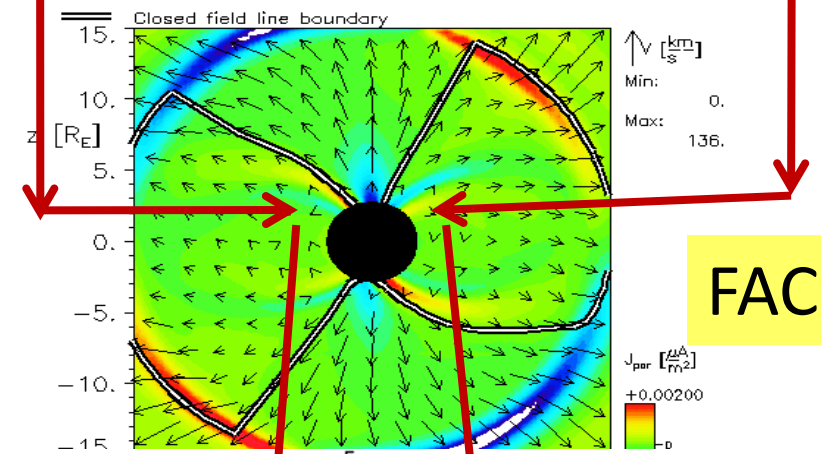

Positive pulse associated vortices



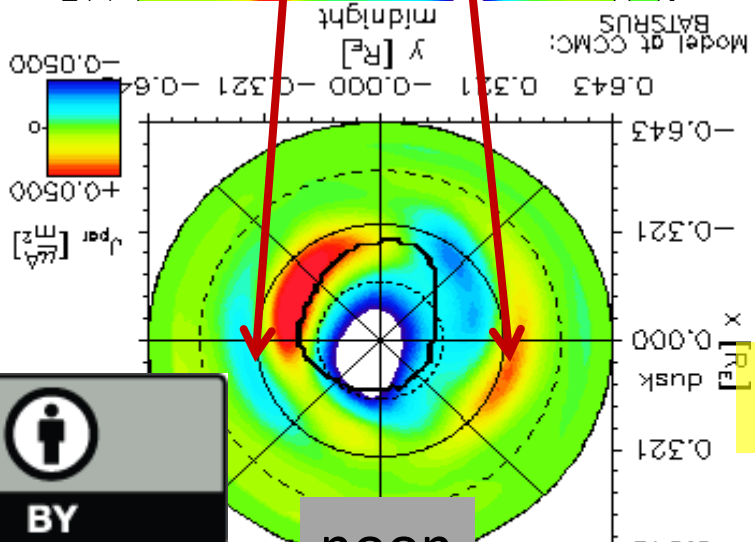



Flow vortex

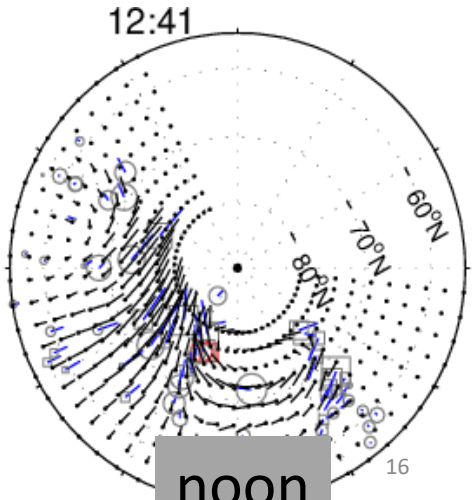
Negative pulse associated vortices




FAC




EIC vortex



# Summary and Conclusions

In this work, geomagnetic data, radar data and satellite data as well as global simulation are used to study the response process of the ground/ionosphere to an positive-negative dynamic pressure pulse pairs in detail.

- It shows that an ionospheric TCV-like event with a duration time of 6-7min was induced by a solar wind dynamic impulse with the same duration time. The TCV-like event consist of two pairs of ionospheric vortices： the first pair of vortices rotate clockwise in the dawnside and anticlockwise in the duskside; the second pair of vortices rotate anticlockwise near the noon sector and clockwise in the duskside.
- Global simulation generally reproduced the observed response process:
  - Compression→ magnetosphere dawn/dusk flow vortices → ionosphere dawn/dusk current vortices.
  - Expansion → magnetosphere dawn/dusk flow vortices in opposite sense of rotation → ionosphere dawn/dusk current vortices in opposite sense of rotation.

This study provides a way to understand how the momentum and energy injects to the ionosphere after spike-like dynamic pressures striking on the magnetopause.

Thank you!