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

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  • Radar
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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?

\[
Pd \uparrow \quad \text{[e.g. Tian et al., 2016]} \quad \text{Pd} \downarrow \quad \text{[e.g., Zhao et al., 2015]} \quad \text{How response of } Pd \text{ positive-negative pulse pair?}
\]
Observations: 2010-10-01 event

**Spacecraft trajectory**

20101101 12:30–14:00UT

**Geomagnetic stations**

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

CC BY
Solar wind positive-negative dynamic pressure pulse pairs

Sudden impulses were excited in the magnetosphere.
TCV-like events

Stations around 10MLT

Stations around 15MLT

Dawn and dusk H varied in anti-phase
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

- Dawn
- Noon
- Dusk

Clockwise

Anti-clockwise
After Pd Decrease 12:38

Clockwise

12:39

9

Anti-clockwise

12:40

Clockwise

12:41
Current vortex scale and intensity

1. Duskside vortex
   • **12:35UT:**
     - \(\sim 1000 \times 2000\) km, anticlockwise (upward FAC)
     - Centered at \(~ 14:00\) MLT, 75MLAT
     - \(~1.65\) km/s poleward moving
     - Current density: several \(0.01 \mu\)A/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

From http://space.fmi.fi/MIRACLE/iono_2D.php
Duskside vortex confirmed by SuperDARN data (1)

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

PYK observations

[Map and diagram with velocity vectors and arrows indicating clockwise movement]
Duskside vortex confirmed by SuperDARN data (2)

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

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 magnetosphere and ionosphere are connected by magnetic field lines.
Simulation results by BATSRUS model
Positive pulse associated vortices

Flow vortex

FAC

EIC vortex
Flow vortex
Negative pulse associated vortices
FAC
EIC vortex
noon
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 $\rightarrow$ magnetosphere dawn/dusk flow vortices $\rightarrow$ ionosphere dawn/dusk current vortices.

- Expansion $\rightarrow$ magnetosphere dawn/dusk flow vortices in opposite sense of rotation $\rightarrow$ 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!