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Outstanding Student & PhD candidate Presentation contest

Latitude Variations of Cusp-Related Boundaries Dependent on Solar Wind Conditions and Dipole Tilt: MHD Simulations and Auroral Observations

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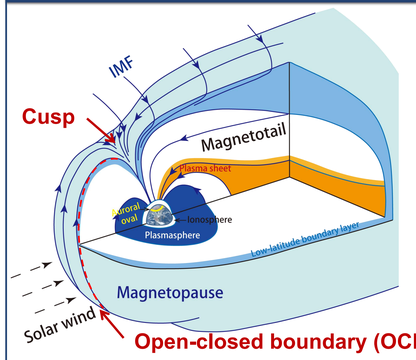
Introduction



➢ **Similar dependencies** of the cusp and OCB footprint latitudes on IMF B_z, solar wind dynamic pressure, and dipole tilt have been reported (e.g., Pitout et al., 2006; Bogdanova et al., 2006).

🔍 *However, a **comparative analysis** of the cusp and OCB footprint latitudes—alongside subsolar magnetopause motion—under different solar wind and IMF conditions is lacking.*

Data & Method

Global MHD simulations (SWMF model):

» **OCB:** the boundary of closed field lines (magnetopause on dayside)

» **OCB footprint: 2.5-R_E** boundary traced to ionosphere using Tsyganenko 2004 model

» **Polar cap boundary (PCB):** from simulated field topology

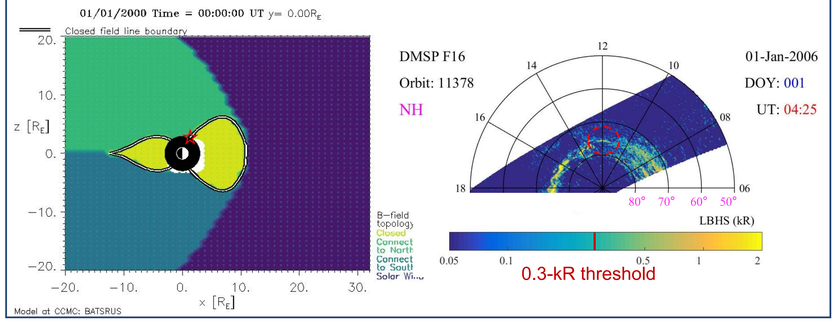
» **R1-R2 current boundary:** from simulated parallel current (J_{par}) between 11-13 MLT.

DMSP/SSUSI auroral observations (LBHS band):

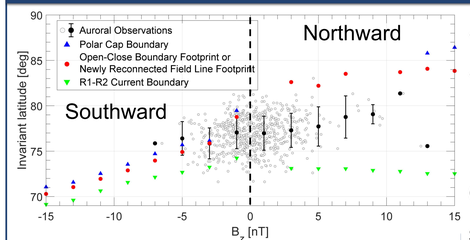
» **Cusp central latitude:** identified in the 11-13 MLT sector.

OMNI 5-min data:

» **Solar wind and IMF parameters:** 10-min time delay from bow shock nose to the ionosphere.



Results: IMF B_z and B_y dependence



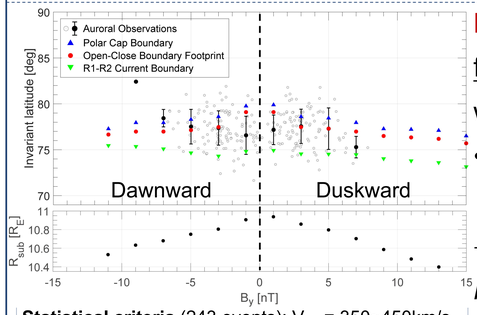
Statistical criteria (633 events):$|B_y| \le 2$nT, V_{sw}= 350 ~450km/s, ρ_{sw}= 2~7cm^{-3}, dipole tilt angle θ = -5~5°

Simulation settings: $B_x = B_y$= 0nT, V_{sw} = 400km/s

- Positive correlation with B_z
- Cusp and LLBL widths increase with increasing northward B_z

Consistent with previous studies.

→ *Validates the reliability of our method.*



Statistical criteria (243 events): V_{sw} = 350~450km/s, ρ_{sw}= 2~7cm^{-3}, θ = -5~5° , $|B_x| \le 1.5$nT, $|B_z| \le 1.5$nT

Simulation settings: $B_x = B_z$= 0nT, V_{sw} = 400km/s

New results ①: The OCB footprint shifts equatorward with increasing $|B_y|$.

- Match an **earthward subsolar magnetopause** → *Dayside component reconnection* under large B_y shifts **the OCB and cusp equatorward boundary**.
- Cusp central latitude increases with $|B_y|$.

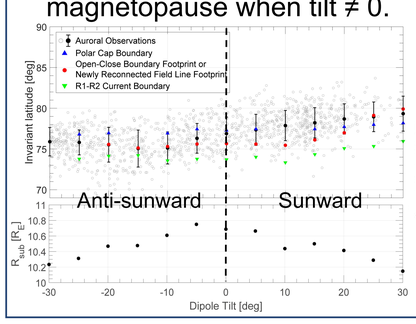
→ *High-latitude antiparallel and dayside component reconnection*

Consistent with **double cusp** and a **widened precipitation** region (Wing et al., 2001).

Results: Dipole Tilt dependence

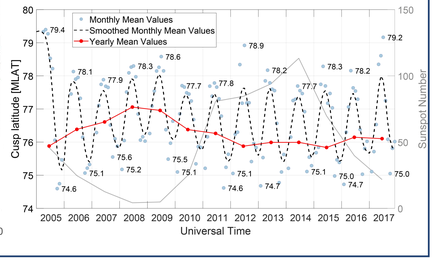
② OCB footprints shift poleward with sunward tilt.

- Despite earthward subsolar magnetopause when tilt ≠ 0.

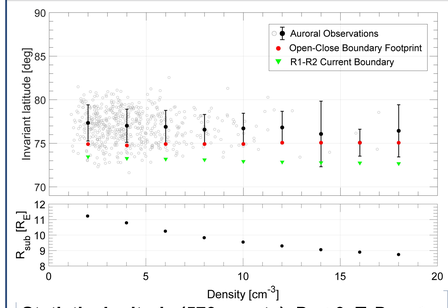


③ Periodic variation of cusp central latitude:

- **seasonal + solar cycle**
- **negative** correlation with sunspot number

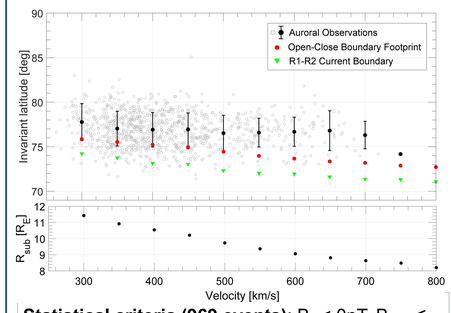


Results: ρ_{sw} and V_{sw} dependence



Statistical criteria (570 events): B_z < 0nT, $B_{total} \le$ 5nT, V_{sw} = 350 ~ 450km/s, θ = -5 ~ 5°

Simulation settings: B_x = -2nT, B_y = 2nT, B_z = -4nT



Statistical criteria (969 events): B_z < 0nT, $B_{total} \le$ 5nT, ρ_{sw}= 2~7cm^{-3}, θ = -5 ~ 5°

Simulation settings: B_x = -2nT, B_y = 2nT, B_z = -4nT

④ No clear dependence of cusp or OCB footprint on **solar wind density (ρ_{sw})**.

- **Not match** an **earthward** subsolar magnetopause

→ *ρ_{sw} affects **only** the OCB location most likely through compression.*

- Cusp and OCB footprint shift equatorward with increasing **speed (V_{sw})**.
- **Match** the **earthward** subsolar magnetopause

→ *V_{sw} affects the OCB location, cusp boundary and precipitation via combined effects of compression and enhanced reconnection.*

Conclusions & Future Work

We combined global MHD simulations with DMSP/SSUSI observations to systematically investigate the latitudinal responses of cusp and OCB-related boundaries under varied IMF (B_z, B_y), solar wind (ρ_{sw}, V_{sw}), and dipole tilt conditions.

Our results show:

1. **Cusp precipitation latitude** is also critically dependent on **the OCB location**, shifting in concert with the OCB footprint across most regimes dominated by dayside reconnection.
2. **Solar wind speed (V_{sw}) effect** on both compression and reconnection, modulating cusp and OCB locations.

Future Work: the mechanism behind the dipole tilt dependence.

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