Superposed epoch analysis of vertical plasma flow and its relationship with FACs as observed by DMSP and CHAMP: IMF $B_y$ and $B_x$ dependence

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**Observations:** Mar/2001-2005 (Northern Hemisphere)
- DMSP F13 and F15 data [http://cindaspace.odallus.edu/]
- IMF data [http://omniweb.gsfc.nasa.gov]
- Total magnetic field, $B_z$
- IMF $B_x$, $B_y$, and $B_z$ components
- Vertical plasma flow, $V_N$
- Large-scale field-aligned current (LSFAC)

**Vertical Plasma Flow:** $-1.2 < B_z < 1.2, \pm B_y$

$V_N$ threshold values: $(0.2, 0.4, 0.6, 0.8, 1.0, \text{and } 1.2) \times 10^{14} \text{ m}^2\text{s}^{-1}$

**Vertical Plasma Flow:** $B_z < -1.2, \pm B_y$

$V_N$ threshold values: $(0.2, 0.4, 0.6, 0.8, 1.0, \text{and } 1.2) \times 10^{14} \text{ m}^2\text{s}^{-1}$

**Discussion:** Schematic patterns of the plasma flow, $B_z < 0$

**Conclusions and Summary**

Vertical plasma upflow, taken together from both DMSP satellites, shows no dependence on IMF $B_z$, $B_y$, and $B_x$ orientation. Its amplitude is slightly decreasing towards local summer in the Northern Hemisphere.

Large-scale FACs show a clear dependence on local season and IMF $B_z$, $B_y$, and $B_x$ orientation, but these dependences differ depending on IMF component and its orientation.

Northward IMF $B_z$: large-scale FACs show no regular pattern for both orientations of IMF $B_x$ and $B_z$. The amplitude of large-scale FACs increase towards local summer for positive $B_x$ and are weaker in local winter for negative $B_x$. Generally, the amplitude values are larger in the Northern Hemisphere for negative $B_x$ for both $B_z$ orientations.

Southward and around zero IMF $B_z$: large-scale FACs show clear regular pattern for both orientations of IMF $B_x$ for all seasons and threshold values. The amplitude of large-scale FACs increase towards local summer. In case of negative IMF $B_x$ the peaks of large-scale FACs for downward (upward) and upward (downward) cases are shifted equatorward and poleward from the reference point, respectively.

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**Seasonal subdivisions**

- CHAMP needs <130 days to visit all local times
- The seasonal subdivision example (Northern Hemisphere)

**SEAF Method**

- Superposed epoch analysis (SEA)
- MLat-MLT coordinate frame
- $(V_N, V_Z)^p \equiv (V_N, V_Z)^{poch}(\text{SEA})$

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**Motivation**

We present results of a superposed epoch analysis (SEA) method applied to vertical plasma upflow (ion density times vertical velocity) and large-scale field aligned currents (FACs) in the Northern Hemisphere cusp region. Our study is based on DMSP (F13 and F15) and CHAMP satellite observations during the years 2001-2005.

The dependence on Interplanetary magnetic field (IMF) $B_x$ and $B_z$ component orientation is investigated, while the absolute amplitude of IMF $B_z$ is selected to be less than 1.2 nT. Seasonal variations are also investigated.

The reference time and location for the SEA method are taken from the vertical plasma upflow peaks detected by DMSP. Our analyses were performed in the magnetic latitude (MLat) and local time (MLT) coordinate frame.

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**Vertical Plasma Flow:** $-1.2 < B_z < 1.2, \pm B_y$

- $B_z$: Average temporal variations: no difference
- Amplitude change: depends mostly on $B_z$
- $B_x$ and $B_y$: Symmetry in absolute values: Parker solar wind spiral
- $B_z$: Half an hour before velocity peak: increase (decrease) for positive (negative)
- $B_x$: About zero: mostly negative (> -0.5 nT)
- $B_y$, $B_x$, and $B_z$: no systematic sign change

**Vertical Plasma Flow:** $B_z < -1.2, \pm B_y$

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<tr>
<th>$V_N$ threshold values</th>
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**Data**

**IMF Components:** $-1.2 < B_z < 1.2, \pm B_y$

Dependence on the $B_z$ orientation: no evidence (figures are not presented here)

**Vertical Plasma Flow:** $B_z > 1.2, \pm B_y$

$V_N$ threshold values: $0.8 \times 10^{14}$, $1.0 \times 10^{14}$, and $1.2 \times 10^{14} \text{ m}^2\text{s}^{-1}$

**Conclusions and Summary**

Vertical plasma upflow, taken together from both DMSP satellites, shows no dependence on IMF $B_z$, $B_y$, and $B_x$ orientation. Its amplitude is slightly decreasing towards local summer in the Northern Hemisphere.

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