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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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_y and B_x 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.

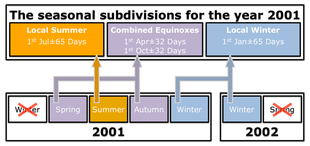
Data

Observations: Mar/2001-2005 (Northern Hemisphere)

- **DMSP F13 and F15 data**
  http://cindispace.utdallas.edu/DMSP
  - vertical plasma flow, V_zN_i
- **CHAMP data**
  - large-scale field-aligned current (LSFAC)
- **IMF data**
  http://omniweb.gsfc.nasa.gov
  - total magnetic field, B_t
  - IMF B_x, B_y, and B_z components

Seasonal subdivisions

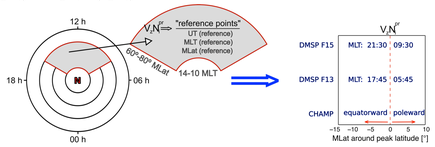
- CHAMP needs ~130 days to visit all local times
- The seasonal subdivision example (Northern Hemisphere)



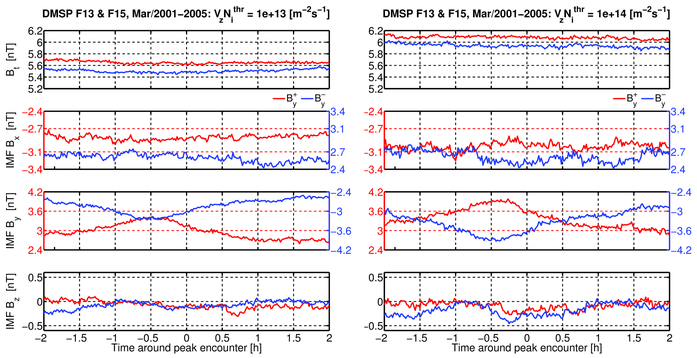
SEA Method

Superposed Epoch Analysis (SEA)

- MLat-MLT coordinate frame
- $(V_zN_i)^{pr} \equiv V_zN_i > (V_zN_i)^{thr}$



IMF Components: -1.2<B_z<1.2, ±B_y



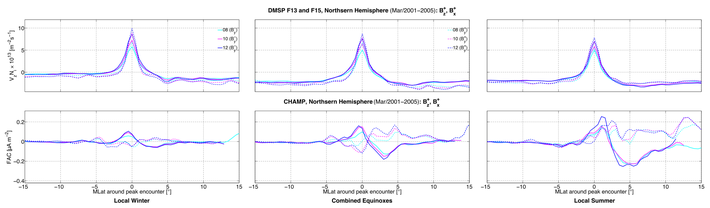
- **B_t**
  - Average temporal variations: *no difference*
  - Amplitude change: *depends mostly on B_y*
- **B_x and B_y**
  - Symmetry in absolute values: *Parker solar wind spiral*
- **B_y**
  - Half an hour before velocity peak: *increase (decrease) for positive (negative)*
- **B_z**
  - About zero: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

IMF Components: -1.2<B_z<1.2, ±B_y, ±B_x

Dependence on the B_x orientation: no evidence (*figures are not presented here*)

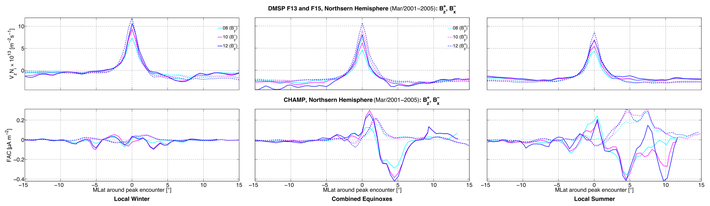
Vertical Plasma Flow: B_z>1.2, ±B_x, ±B_y

V_zN_i threshold values: 0.8•10^{14}, 1.0•10^{14}, and 1.2•10^{14} [m^{-2} s^{-1}]



IMF B_x > 0

- **Vertical plasma upflow**
  - Seasonal variations: *slightly decreases towards local summer*
  - B_y orientation: *no significant variations*
- **Large-scale FACs**
  - Seasonal variations: *increases towards local summer*
  - B_y orientation: *no regular pattern*



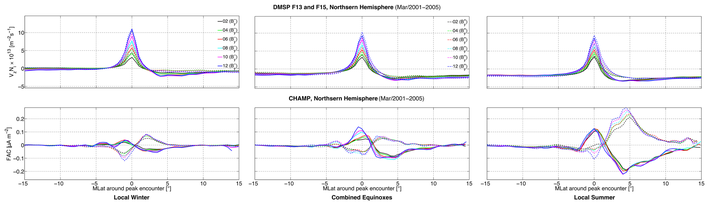
IMF B_x < 0

- **Vertical plasma upflow**
  - Seasonal variations: *slightly decreases towards local summer*
  - B_y orientation: *amplitude variations*
- **Large-scale FACs**
  - Generally stronger
  - Seasonal variations: *weaker in local winter*
  - B_y orientation: *no regular pattern*

Negative B_x: amplitude values are larger (*as expected*)

Vertical Plasma Flow: -1.2<B_z<1.2, ±B_y

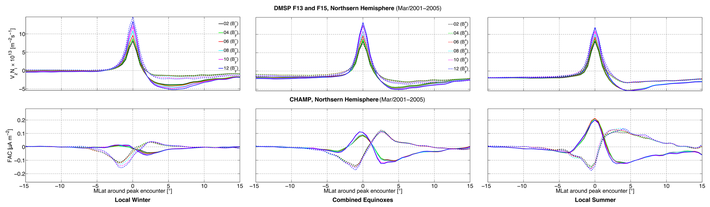
V_zN_i threshold values: (0.2, 0.4, 0.6, 0.8, 1.0, and 1.2)•10^{14} [m^{-2} s^{-1}]



- **Vertical plasma upflow**
  - Seasonal variations: *slightly decreases towards local summer*
  - B_y orientation: *no significant variations*
- **Large-scale FACs**
  - Seasonal variations: *increases towards local summer*
  - B_y orientation: *regular pattern for all seasons and threshold values*

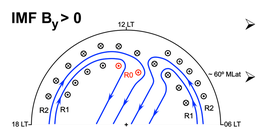
Vertical Plasma Flow: B_z<-1.2, ±B_y

V_zN_i threshold values: (0.2, 0.4, 0.6, 0.8, 1.0, and 1.2)•10^{14} [m^{-2} s^{-1}]

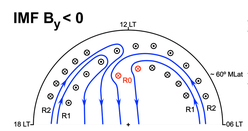


- **Vertical plasma upflow**
  - Seasonal variations: *slightly decreases towards local summer*
  - B_y orientation: *practically no variations*
- **Large-scale FACs**
  - Seasonal variations: *increases towards local summer*
  - B_y orientation: *very clear regular pattern (with shifted peak values) for all seasons and threshold values*

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



- **Two-cell convection pattern**
  - dusk dominating
- **Plasma drift in cusp region**
  - westward



- **Two-cell convection pattern**
  - dawn dominating
- **Plasma drift in cusp region**
  - eastward

CONCLUSIONS AND SUMMARY

Vertical plasma upflow, taken together from both DMSP satellites, shows no dependence on IMF B_x, B_y, and B_z 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_x, B_y, and B_z 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_y. 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_y orientations.

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