ESA's second SWARM Meeting

Thermospheric density responses to the interplanetary magnetic field from CHAMP accelerometer data

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Introduction

- The thermospheric density is important:
  1) for predicting the atmospheric drag in the context of satellite ephemeris prediction, and
  2) in understanding the thermosphere-ionosphere coupling process

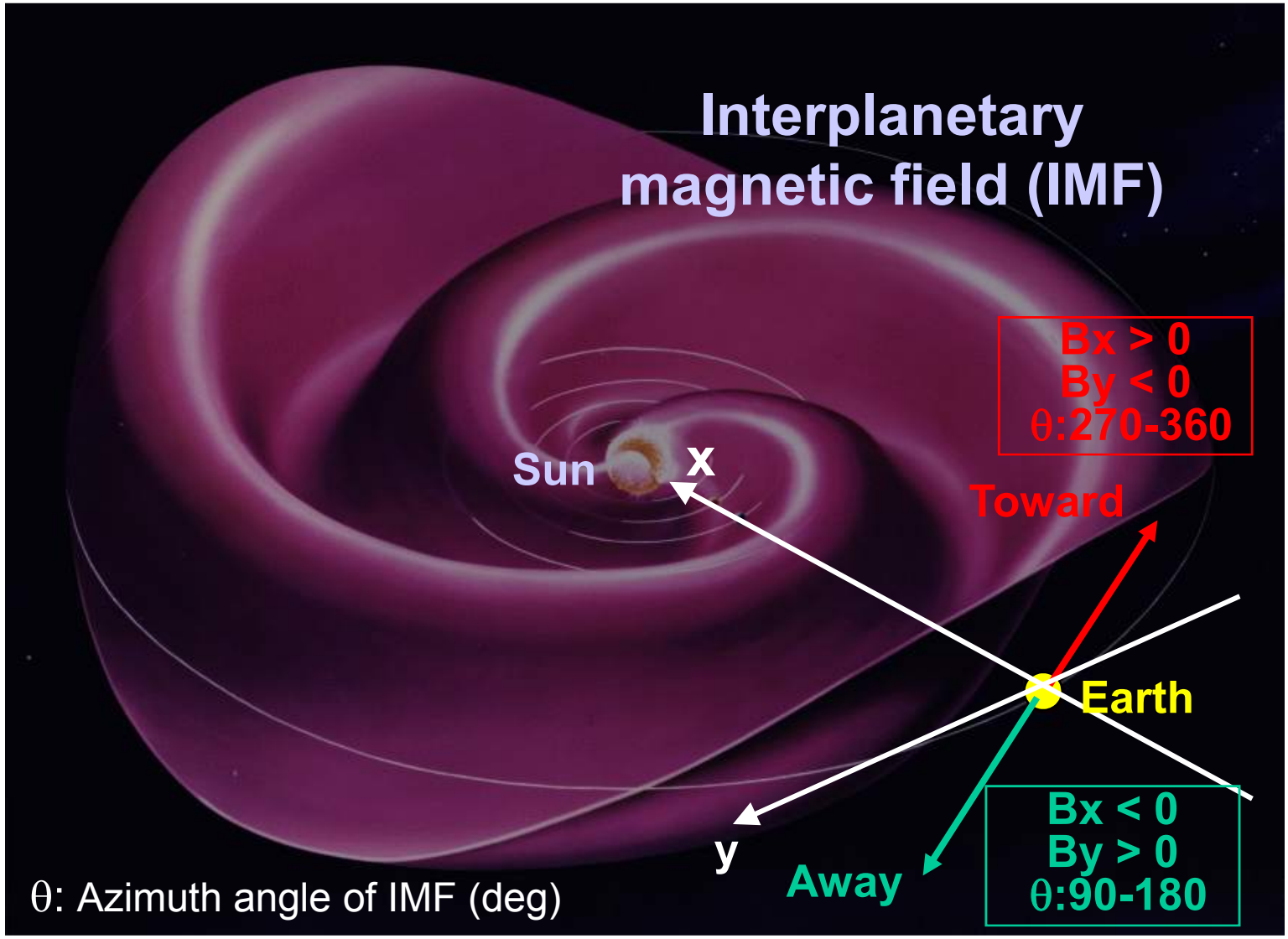
- Thermospheric density variations are controlled by various sources directly or indirectly associated with the direction and/or strength of the interplanetary magnetic field (IMF) [*Kwak et al.,* 2007a,b].

  → There is an intimate relationship between IMF variation and thermospheric density variation [*Kwak et al.,* 2009].

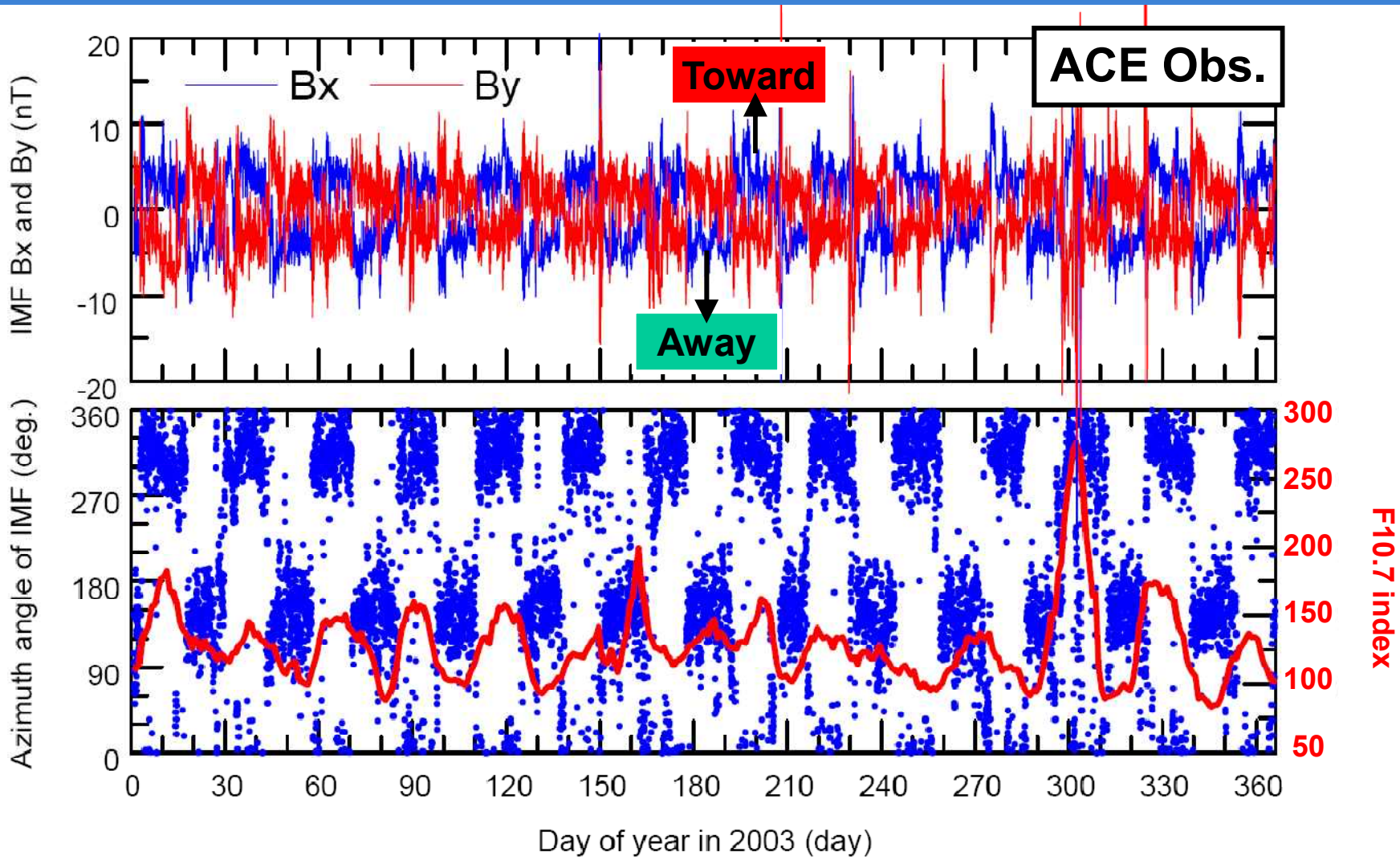
- The IMF in 2003 exhibited a well-defined sector polarity change.

- We discuss whether the thermospheric density changes with the IMF sector polarity by using total mass density around 400 km, derived from the high-accuracy accelerometer on board the Challenging Mini-satellite Payload (CHAMP) spacecraft.

Sun's rotating B field: Parker spiral

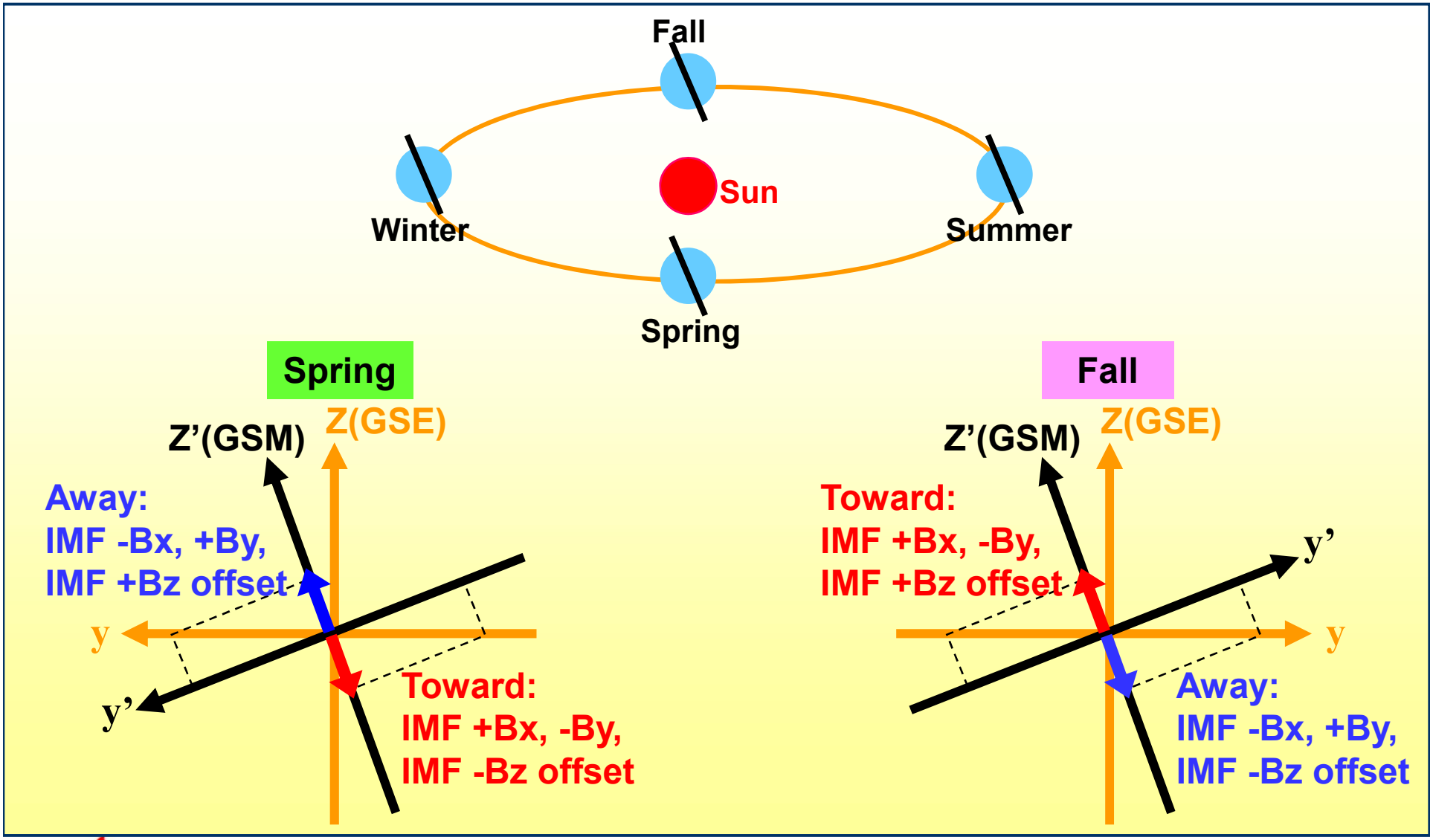


IMF conditions and F10.7 in 2003

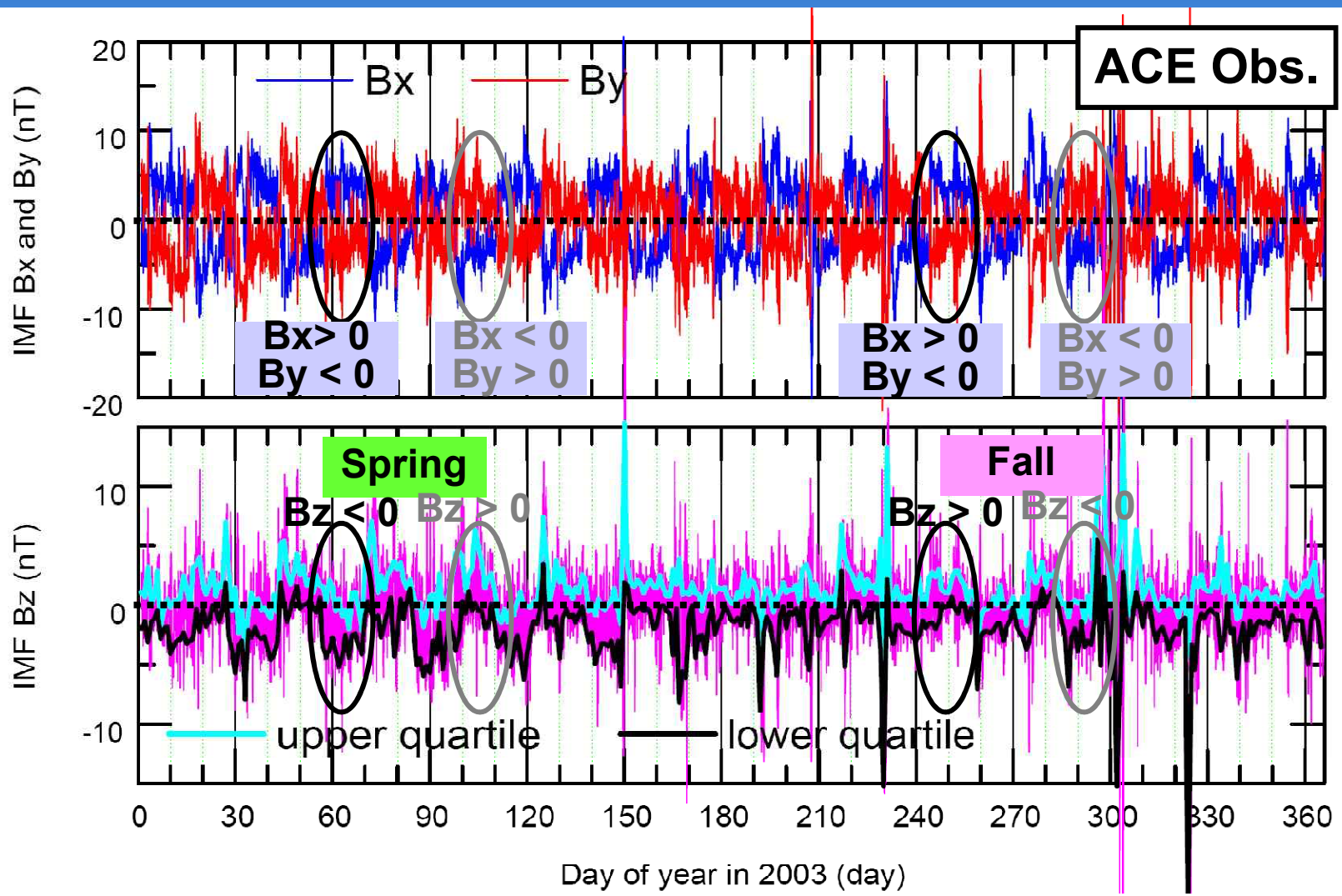


The IMF in 2003 exhibited a well-defined sector polarity change; directed toward the Sun (+Bx, -By) and away the Sun (-Bx, +By).

Russell-McPherron Effect



Seasonal variation of IMF Bz offset



For IMF toward (away) sector in spring, there is IMF -Bz (+Bz) offset.
For IMF toward (away) sector in fall, there is IMF +Bz (-Bz) offset.

CHAMP/STAR thermospheric density

- **Study period:** **January 1, 2003 – December 31, 2003**
- **CHAMP/STAR(Spatial Triaxial Accelerometer for Research)**

  : A near-circular (~390-470 km) high-inclination (87°) orbit, precessing in local time at a rate of 5.6 min per day and providing approximate measurements of total mass density along the orbit with 10-s (~80 km) resolution

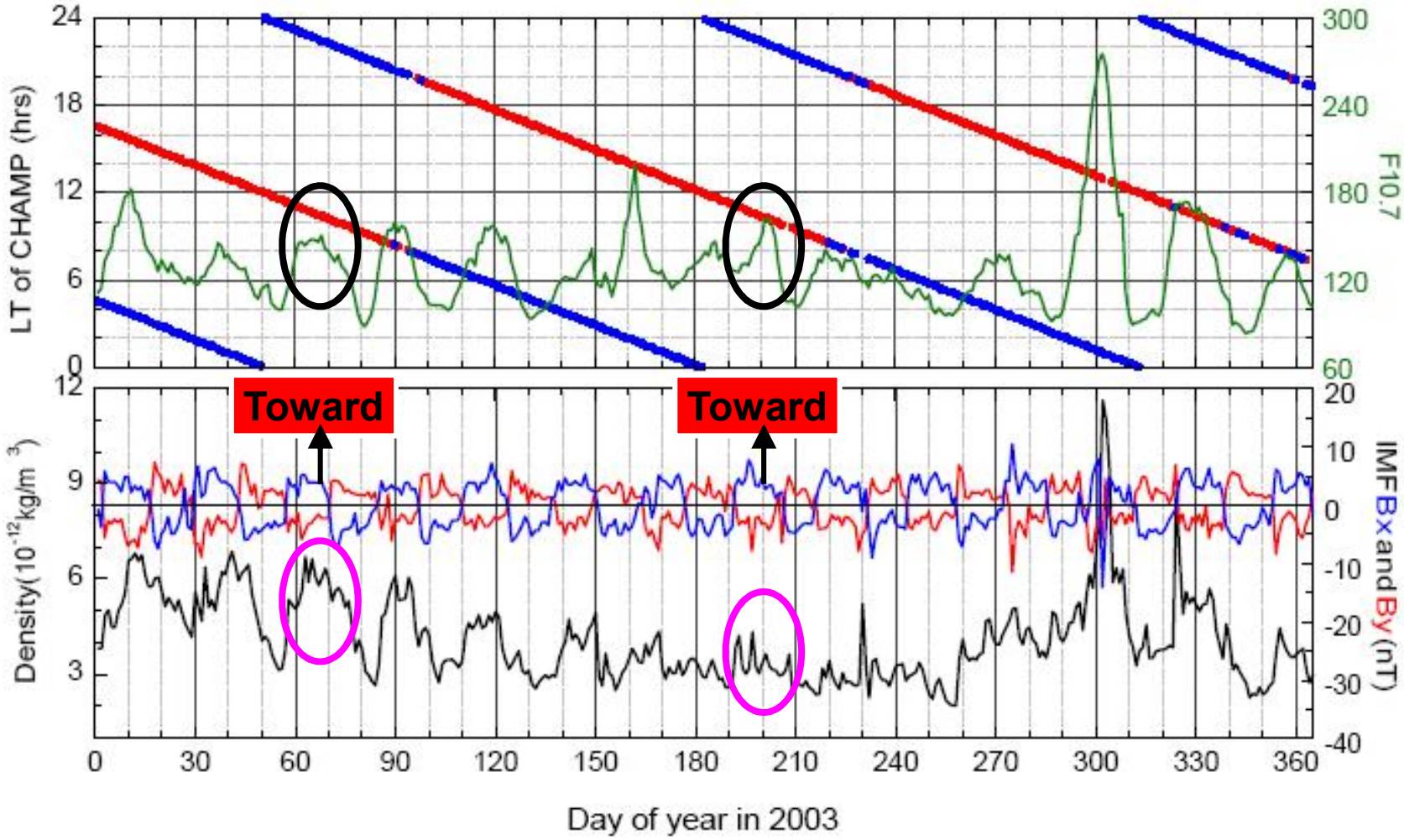
- **Density calculations from CHAMP:** ρ_{STAR}

$$\rho_{STAR} = \frac{-2m(\vec{a}_{STAR} - \vec{a}_{SR} - \vec{a}_{ALB}) \cdot \hat{x}}{\sum_{i=1}^{13} [A_i C_{Di} (\vec{V}_{rel} \cdot \hat{ni})(\vec{V}_{rel} \cdot \hat{x})]}$$

[Sutton *et al.*, 2007]

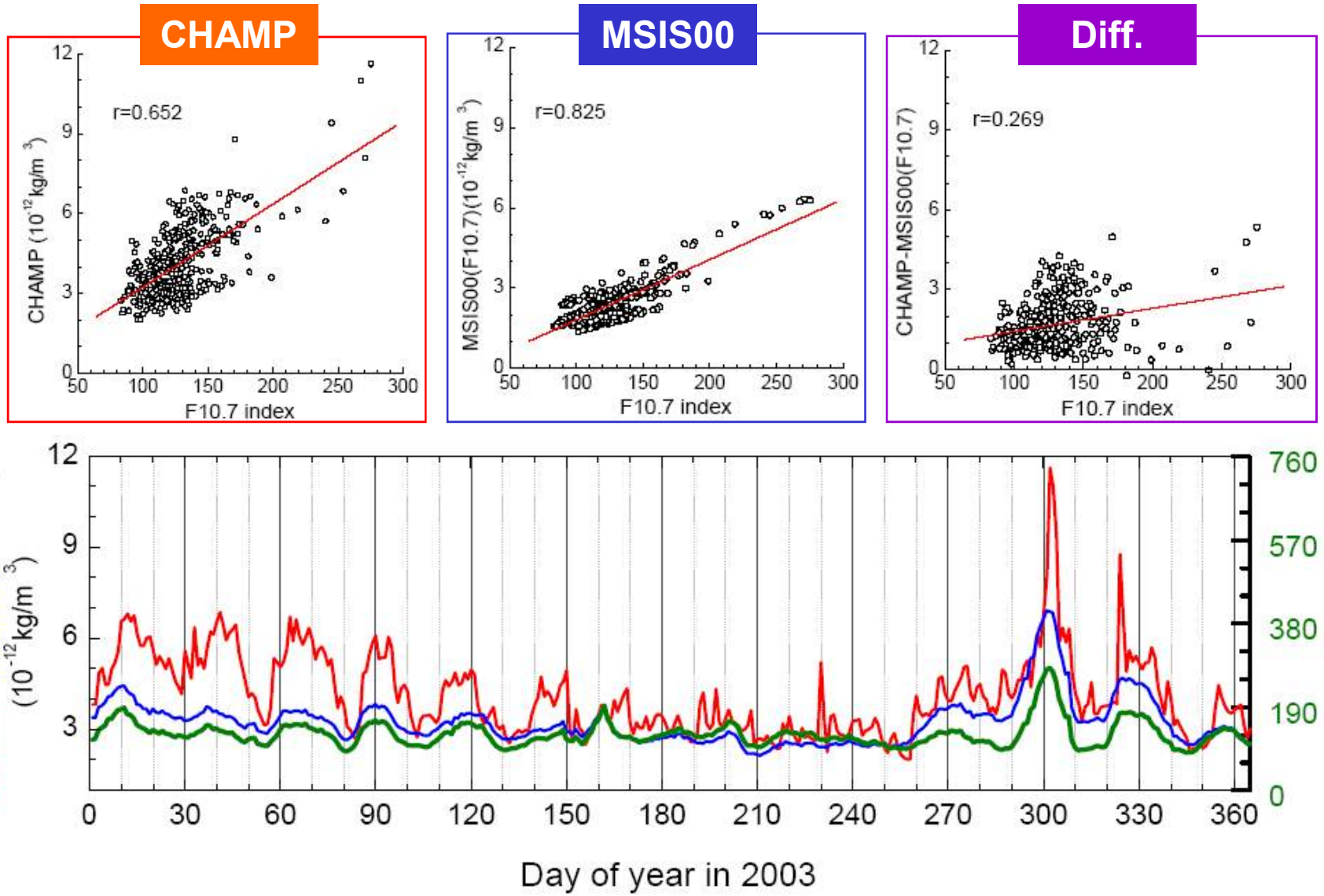
m	Satellite mass
$\vec{a}_{STAR}$	Acceleration measured by the satellite
$\vec{a}_{SR}$	Acceleration caused by solar radiation pressure
$\vec{a}_{ALB}$	Acceleration caused by earth radiation pressure
$\hat{x}$	In-track axis
i	Number of plate of the satellite
A_i	Plate area
C_{Di}	Coefficient of drag for the plate
$\vec{V}_{rel}$	Satellite velocity with respect to a corotating atmosphere
$\hat{ni}$	Unit plate normal

IMF sector polarity vs. Thermospheric density

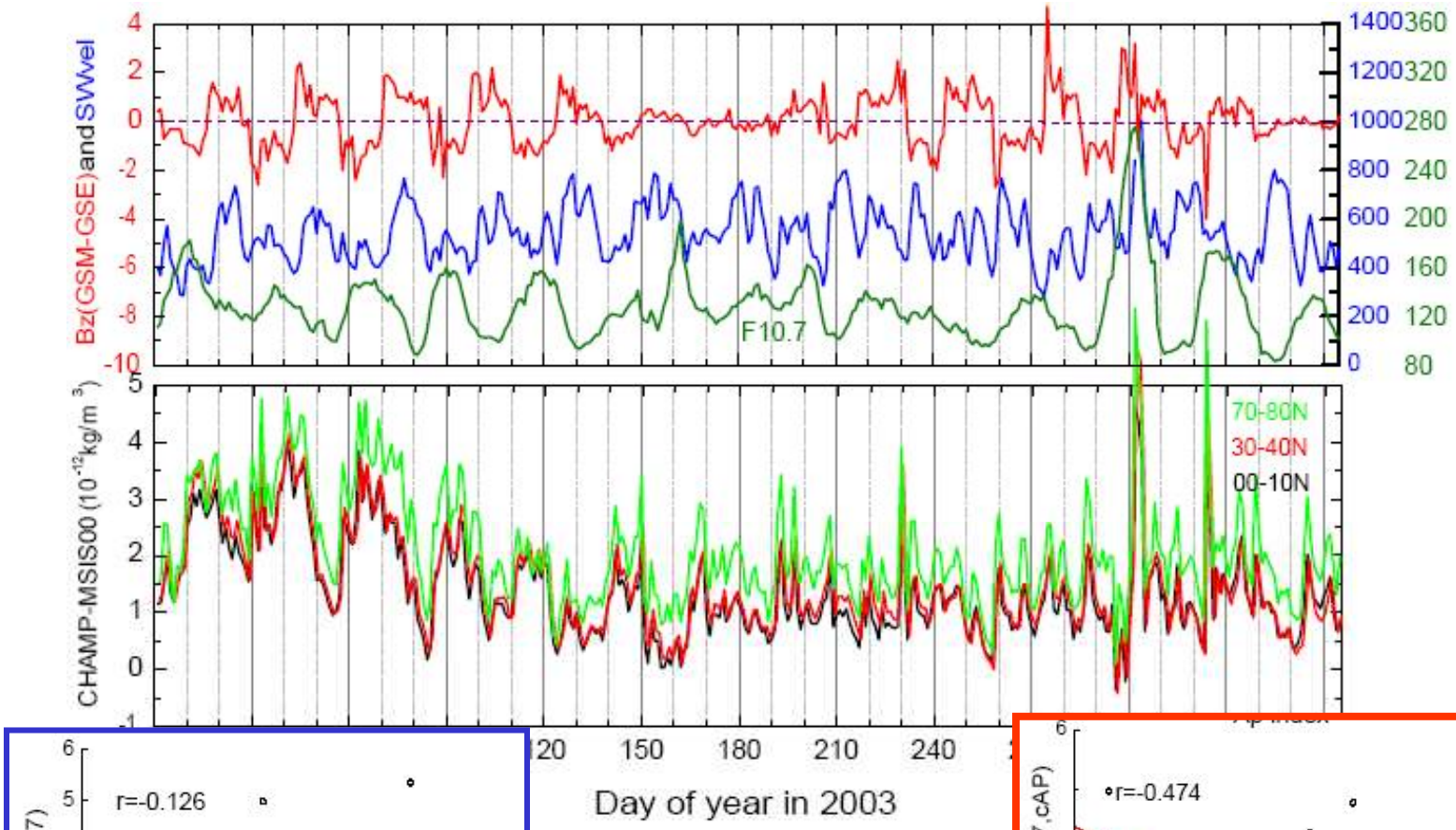


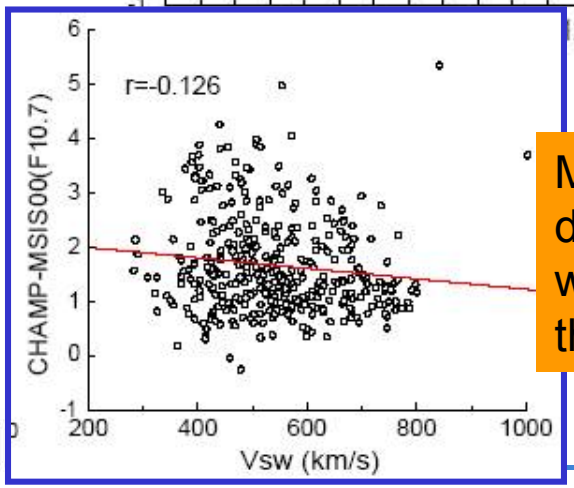
At same LT for same IMF polarity sector, thermospheric densities are not under tendency of F10.7 variation.

Non-solar radiation effect on mass density (1)

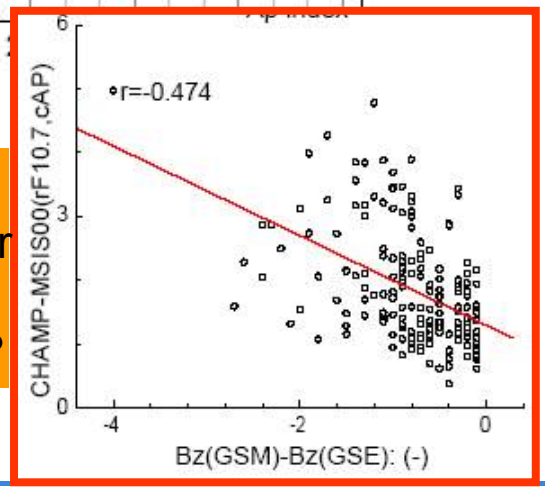


Non-solar radiation effect on mass density (2)

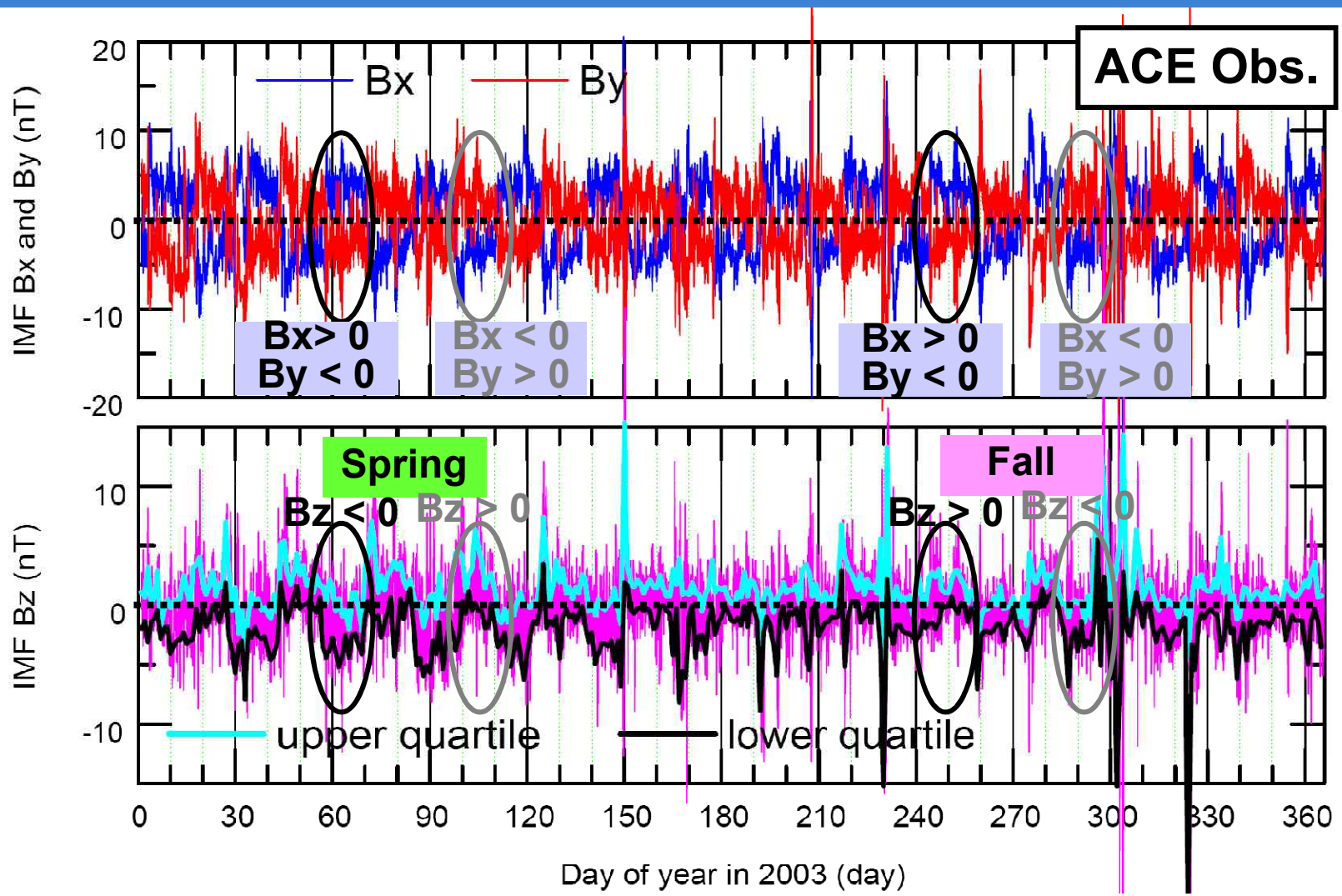




Modulations of observed densities don't follow solar wind velocity. Where are these modulations from??



Seasonal variation of IMF Bz offset



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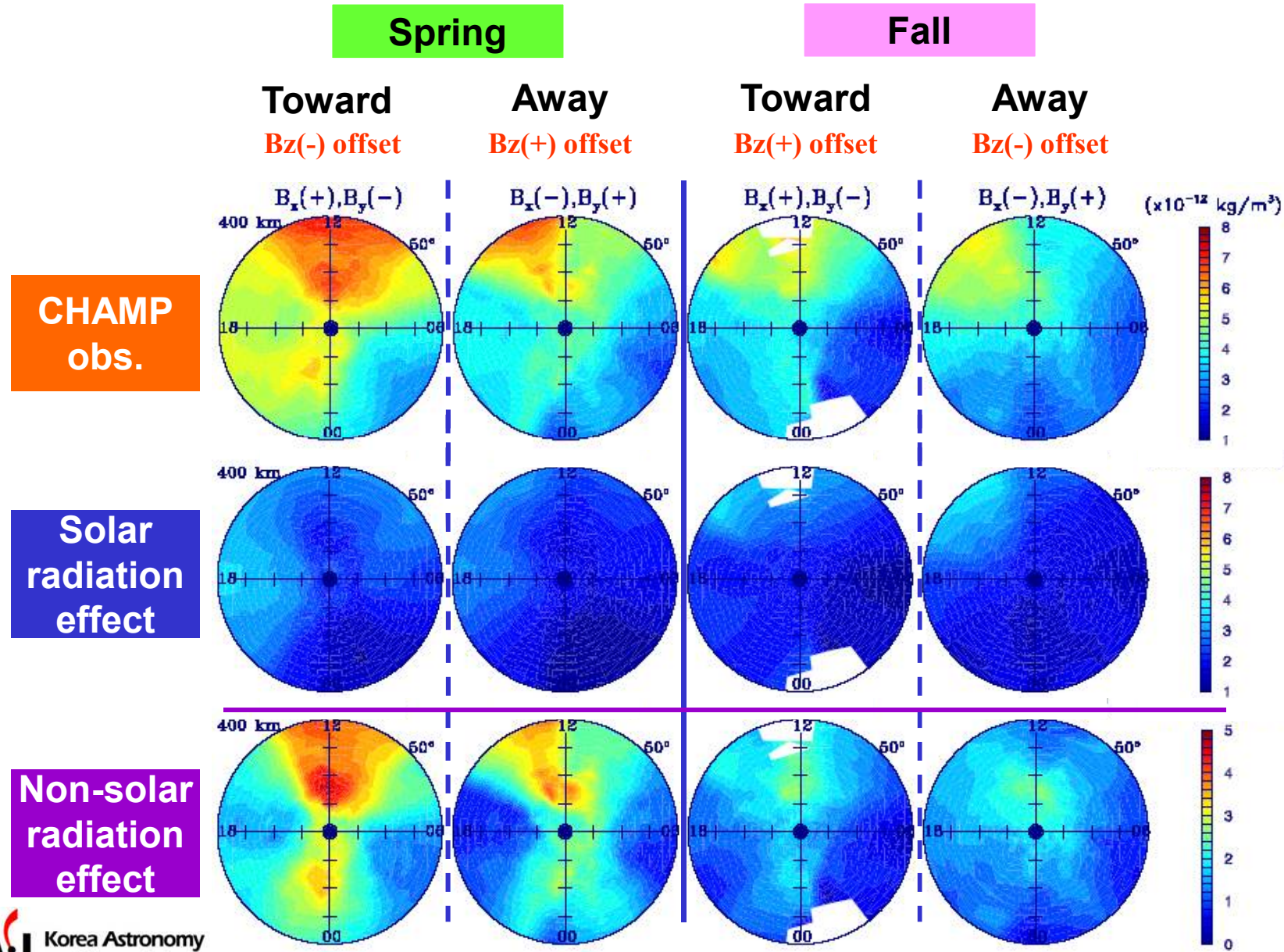
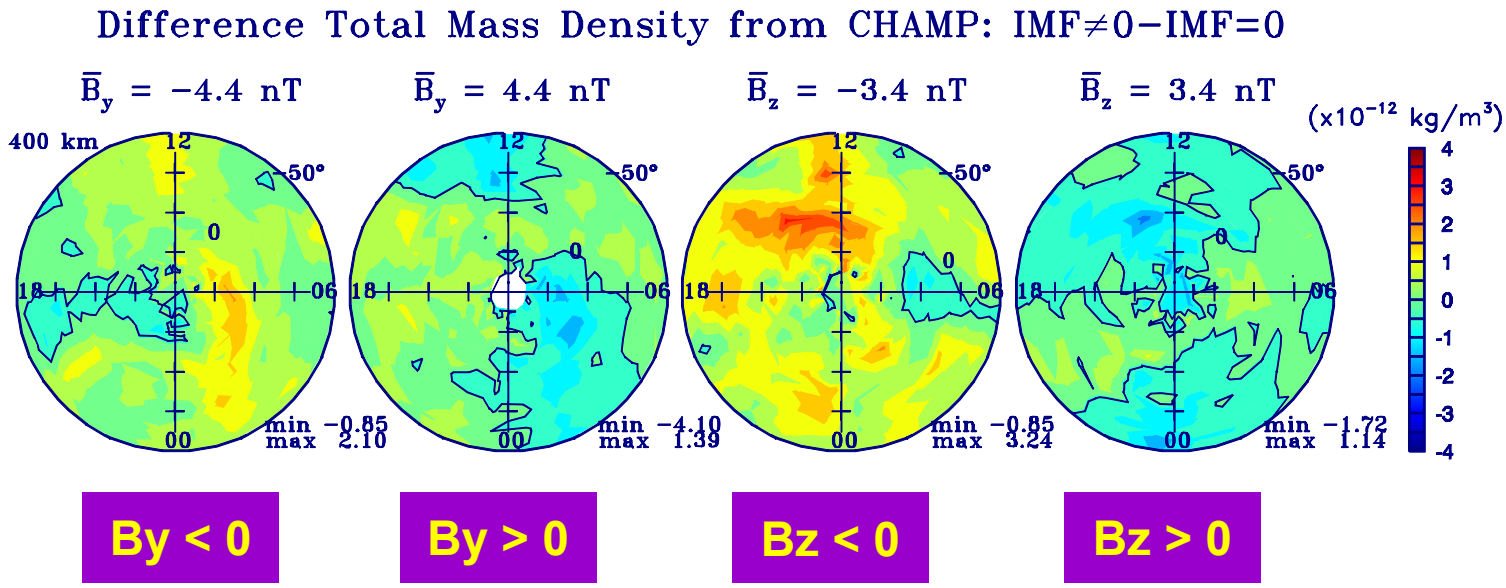
Density responses to IMF sector polarity - NH



IMF influences on mass density

CHAMP Obs. at 400 km (Nov. 2001-Feb. 2002)



By < 0 | By > 0 | Bz < 0 | Bz > 0

[*Kwak et al.*, JGR, 2009]

Summary

- The IMF in 2003 exhibited a well-defined sector polarity change: directed toward the Sun (i.e., +Bx and –By) and away the Sun (i.e., -Bx and By).

- Thermospheric mass densities response to the IMF Bz offset associated with IMF sector polarity:

  ► IMF Bz offset is stronger in equinox than in summer.
  → Thermospheric density variations are stronger in equinox than in summer.

  ► In spring, for toward (away) the Sun, thermospheric densities are influenced on the negative (positive) IMF By and the negative (positive) IMF Bz offset.
  → stronger (weaker) thermospheric density variations.

  ► In fall, for toward (away) the Sun, thermospheric densities are influenced on the negative (positive) IMF By and the positive (negative) IMF Bz offset.
  → similar thermospheric density variations in toward/away sectors.