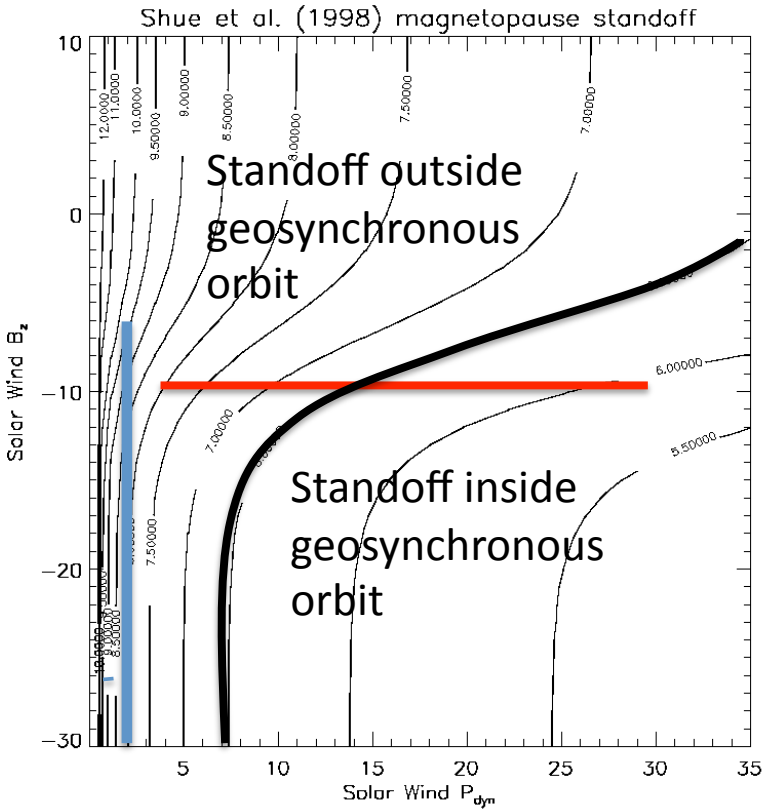
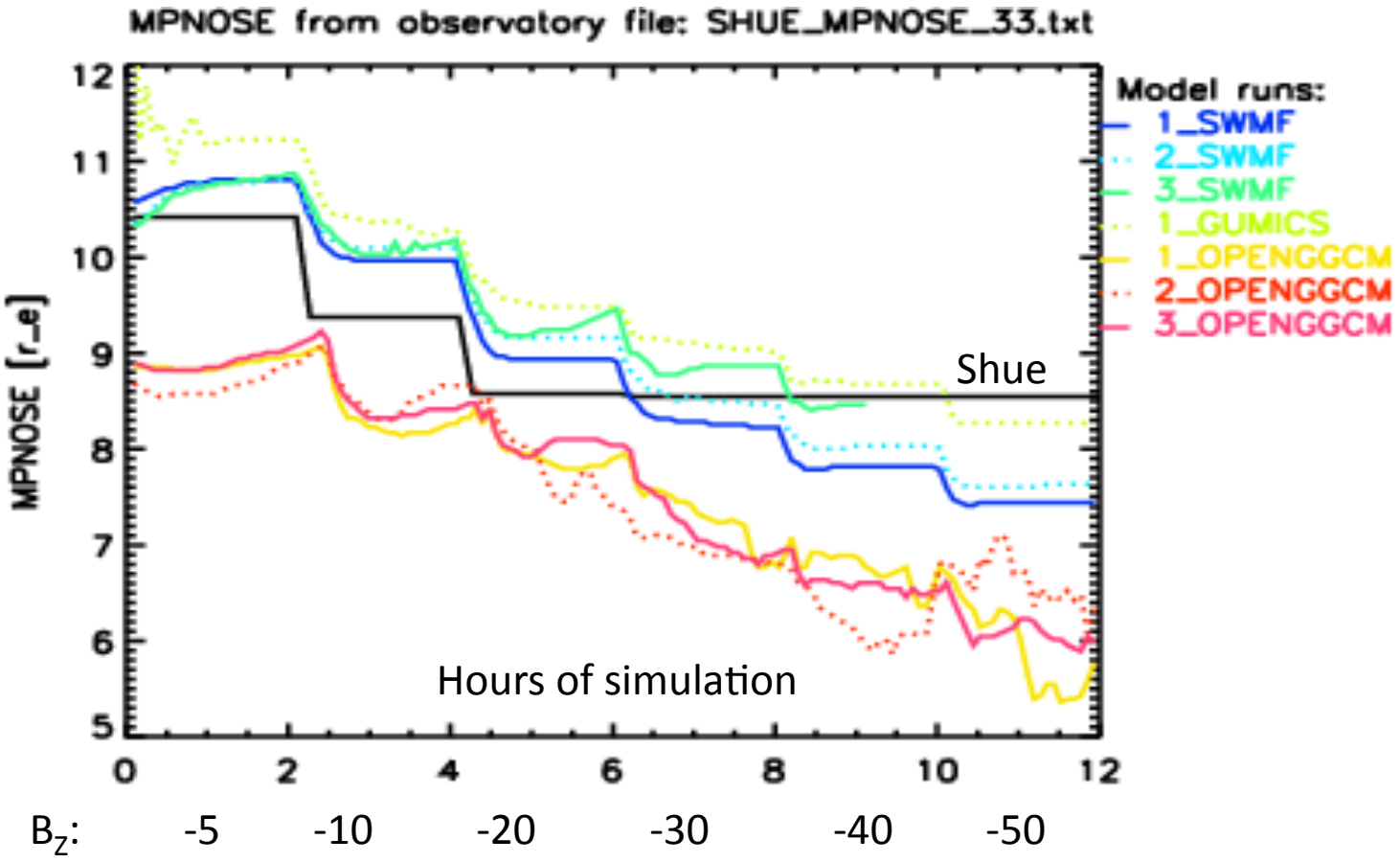
Magnetopause challenge

Artificial solar wind conditions,
Model runs were compared with Shue et al. (1998),
Standoff on Sun-Earth line.

- **B_Z variation:** (-5 to -30 nT)
  P_{dyn}=1.33 nT, near left side of valid range
- **Density variation:**
  (V=600, N=5 to 50):
  Pdyn from 3.0 to 30 nPa.



Model runs compared to Shue et al.



SWMF (blue) and **GUMICS (green)** standoff larger than **Shue**, **OpenGGCM** (Version 3.1, **yellow**, **red**) below **Shue**.

Shue model (black) valid only for B_Z larger than -20 nT.

Problems with modeling challenge

- Models not compared to observation data.
  - Statistical model (Shue 1998) used as comparison.
  - Solar wind inputs (B_z < -20) beyond validity range of Shue model.
- Models driven with unrealistic (very strong) driving conditions.
- Time period between changes of B_z (2 hours) too short for models to reach steady state.

GEM, GEM-CEDAR challenges

- Use real events:
  - LANL plasma data, 4 spacecraft
  - GOES magnetic field (Bz<0 in dayside), 4 spacecraft
  - Events 1 and 2, 4 had multiple crossings

1. 2003/10/29 (doy 302) 06:00 UT – 2003/10/30 06:00 UT
2. 2006/12/14 (doy 348) 12:00 UT – 2006/12/16 00:00 UT
3. 2001/08/31 (doy 243) 00:00 UT – 2001/09/01 00:00 UT
4. 2005/08/31 (doy 243) 10:00 UT – 2005/09/01 12:00 UT
5. 2005/05/15 (doy 135) 00:00 UT – 2005/05/16 00:00 UT
6. 2005/07/09 (doy 190) 00:00 UT – 2005/07/12 00:00 UT

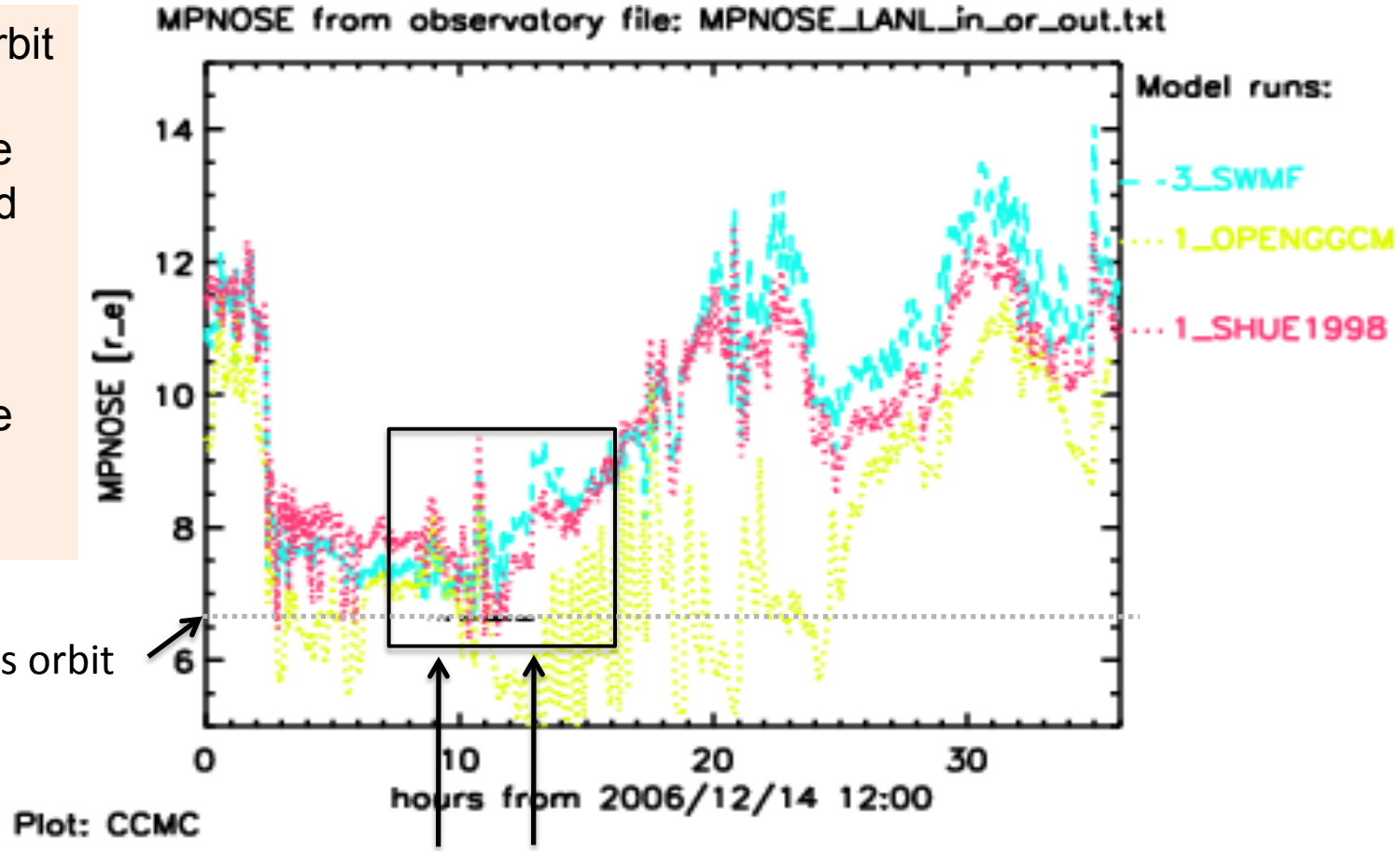
Real event comparisons

AGU storm (Dec. 14-16, 2006), Event 2 of 2008 GEM challenge

Use time series plotting and analysis developed for challenge.

MP crosses orbit only in strong events, i.e. the Halloween and AGU storms.

Other GEM events provide few or no comparisons.



geosynchronous orbit

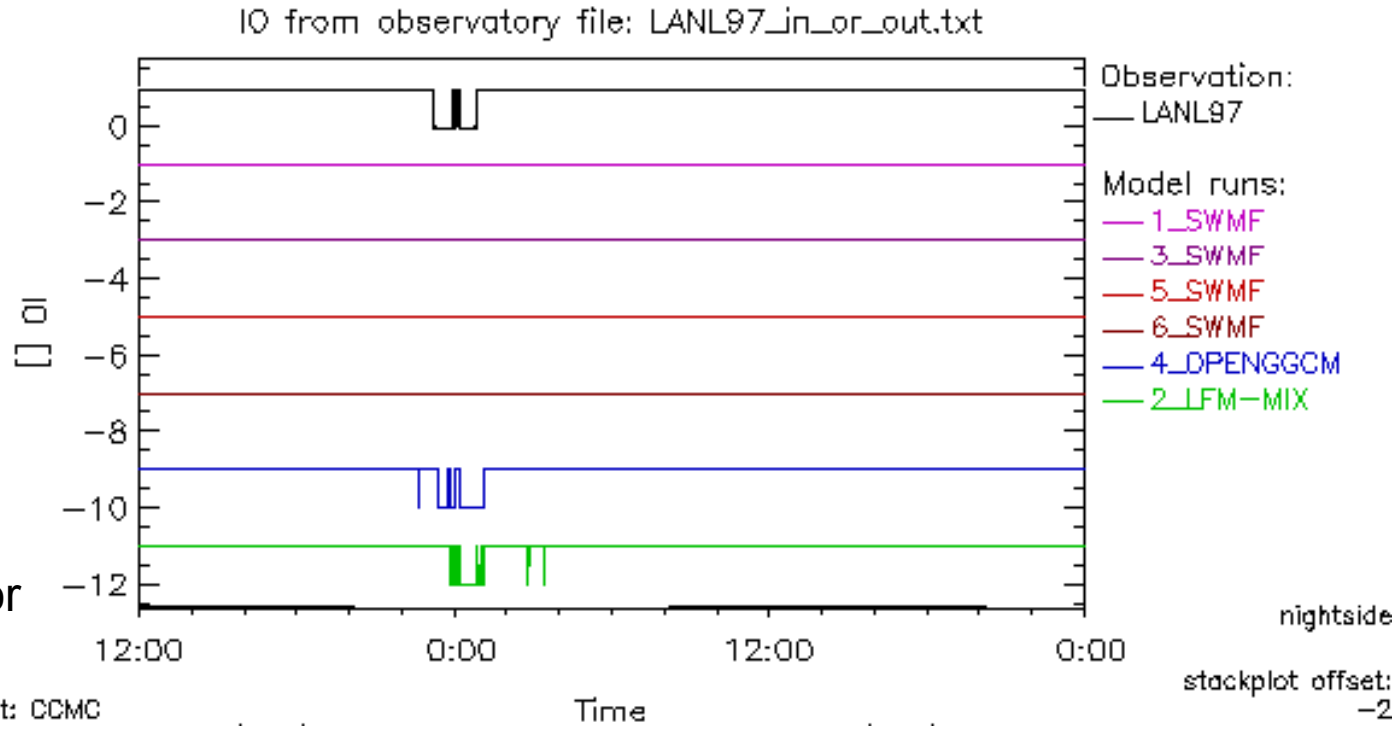
Observed MP crossings of LANL satellites

New approach to visualization of magnetopause crossings

Time line plotter and skill score calculator at CCMC

New for plotter:

- Stackplot option
- Nightside indicator



Magnetopause crossing challenge:

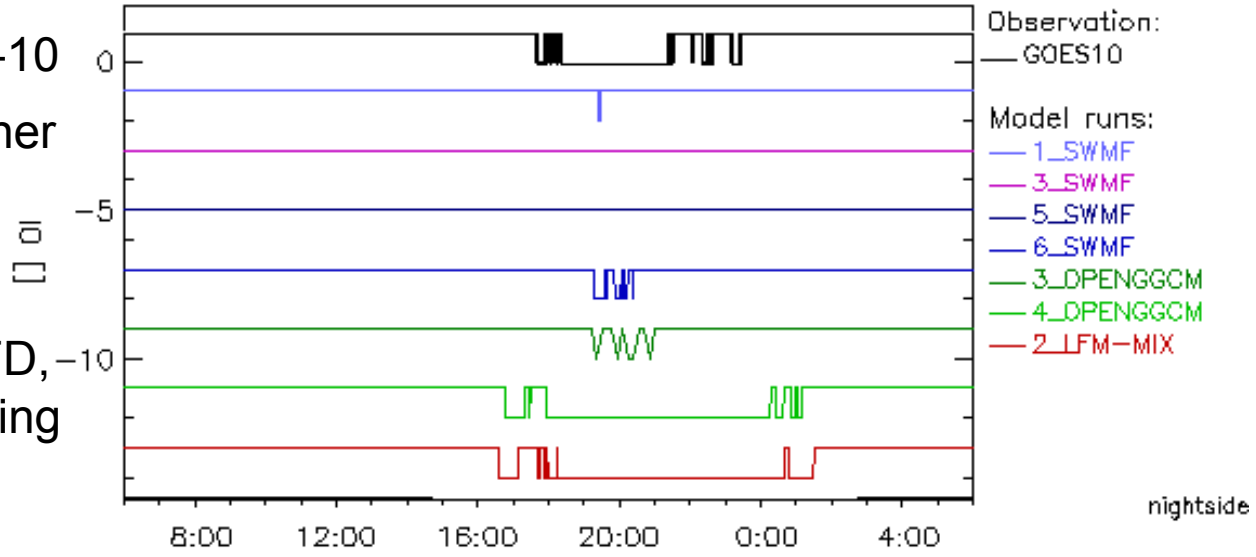
- Binary information (inside or outside) recast into time series files (models and observations): 1-minuite cadence
- Analysis done for each LANL or GOES satellite separately

Halloween storm (2003/10/29-30)

GOES-10

Use experience from other studies (e.g., dBH/dt):

- Event-based contingency table to calculate POD, POFD, …, Heidke skill (here using 20-minute windows).



Variable: IO Observatory file: GOES10_in_or_out.txt

Model_Setting	T	OY	ON	H	F	M	N	A	B	POD	POFD	FAR	CSI	TSS	MTSS	HSS
1_SWMF	72	16	56	1	0	15	56	0.792	0.062	0.062	0.000	0.000	0.062	0.062	-0.875	0.094
3_SWMF	72	16	56	0	0	16	56	0.778	0.000	0.000	0.000	-NaN	0.000	0.000	-1.000	0.000
5_SWMF	72	0	11	0	0	0	11	1.000	-NaN	-NaN	0.000	-NaN	-NaN	-NaN	-NaN	-NaN
6_SWMF	72	16	56	5	0	11	56	0.847	0.312	0.312	0.000	0.000	0.312	0.312	-0.375	0.414
3_OPENGGCM	72	16	56	5	0	11	56	0.847	0.312	0.312	0.000	0.000	0.312	0.312	-0.375	0.414
4_OPENGGCM	72	16	56	16	10	0	46	0.861	1.625	1.000	0.179	0.385	0.615	0.821	0.565	0.672
2_LFM-MIX	72	16	56	16	11	0	45	0.847	1.688	1.000	0.196	0.407	0.593	0.804	0.511	0.645

N_Windows (T)	number of windows considered to create events (T = Plot Interval Length / Event Window Length)	
Events (OY)	number of windows where at least one observation falls below threshold	
NoEvents (ON)	number of windows where observation does NOT fall below threshold	
Hits (H)	number of windows where model and observation fall below threshold at least once	
FalseHits (F)	number of windows where model does fall below threshold but observation does not	
Misses (M)	number of windows where model does not but at least one observation falls below threshold	
NoForecast (N)	number of windows where model and observation do NOT fall below threshold	
Accuracy (A)	(H+N)/(M+N+H+F)	Range: [0,1], perfect score: 1, no skill: 0
Bias (B)	(H+F)/(H+M)	Range: [0,+Inf], perfect score: 1
POD	probability of Detection H/(H+M)	Range: [0,1], perfect score: 1, no skill: 0
POFD	probability of False Detection F/(F+N)	Range: [0,1], perfect score: 0
FAR	False Alarm Ratio F/(H+F)	Range: [0,1], perfect score: 0
CSI (TS)	Critical Success Index (Threat Score) H/(H+M+F)	Range: [0,1], perfect score: 1, no skill: 0
TSS	True Skill Score POD-POFD=H/(H+M)-F/(N+F)	Range: [0,1], perfect score: 1, no skill: 0
MTSS	Modified True Skill Score (H-M)/(H+M) - 2F/N	Range: [0,1], perfect score: 1, no skill: 0
HSS	Heidke Skill Score 2(H*N-M*F)/[(H+M)*(M+N) + (H+F)*(F+N)]	Range: [-Inf,1], perfect score: 1, no skill: 0

Extend Challenge

1. Perform all calculations with the runs and events we used for dB/dt study, Dst, K index validations and related studies.

<u>Define New Events:</u>

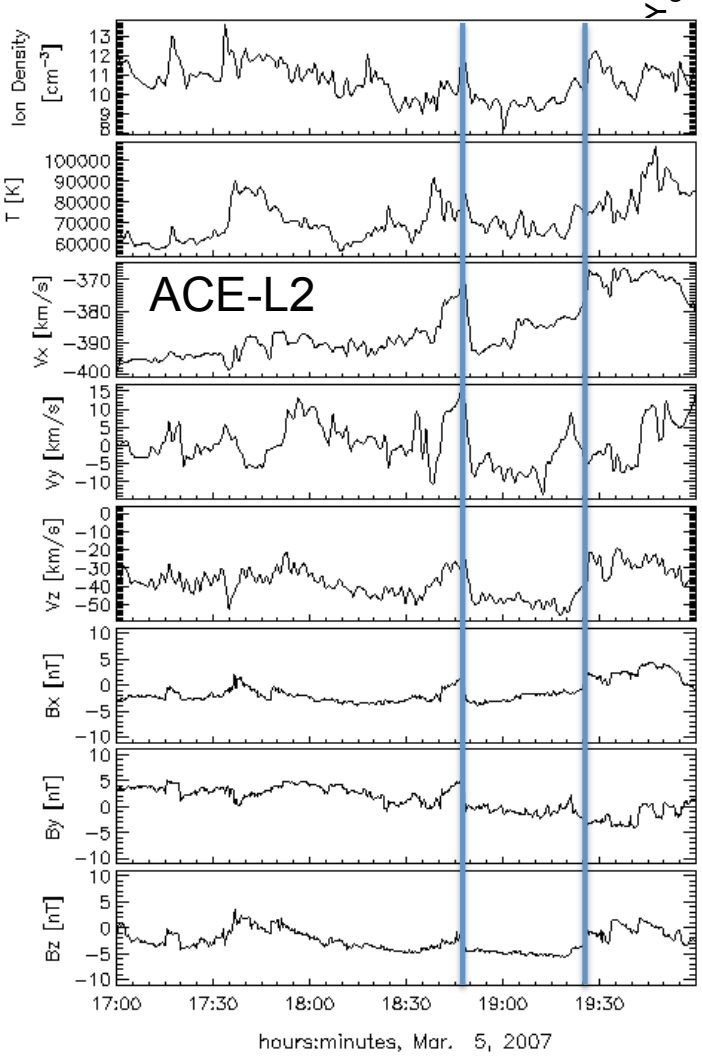
2. Near-stationary solar wind conditions.
   - Multiple satellites cross magnetopause at different local times (not only near Sun-Earth line),
   - All crossings to occur within the interval of stationary solar wind
   - Average solar wind conditions within validity of Shue et al. and other statistical models.

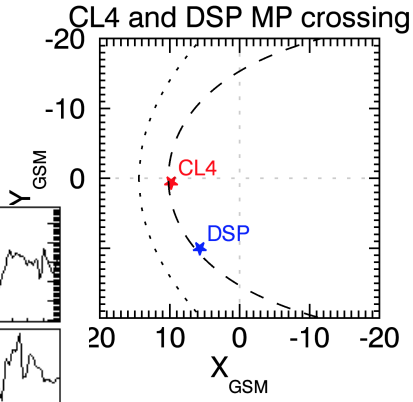
   Yari Collado-Vega's talk (coming up)

3. Consider dynamic solar wind events (e.g., Zhang et al, 2009):
   - THEMIS (CLUSTER, other) satellites arranged at different distances may capture motion of magnetopause.
   - Satellites may not cross the magnetopause but their presence could impose constraints on the magnetopause position.

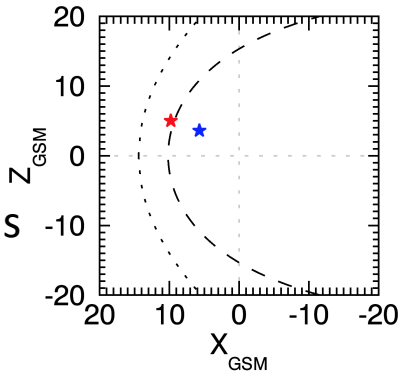
05 March 2007

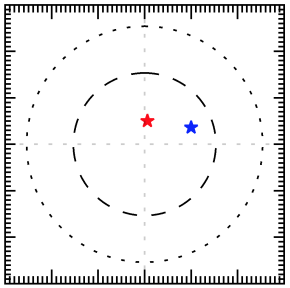
05 March 2007,
18:30 – 19:50 UT



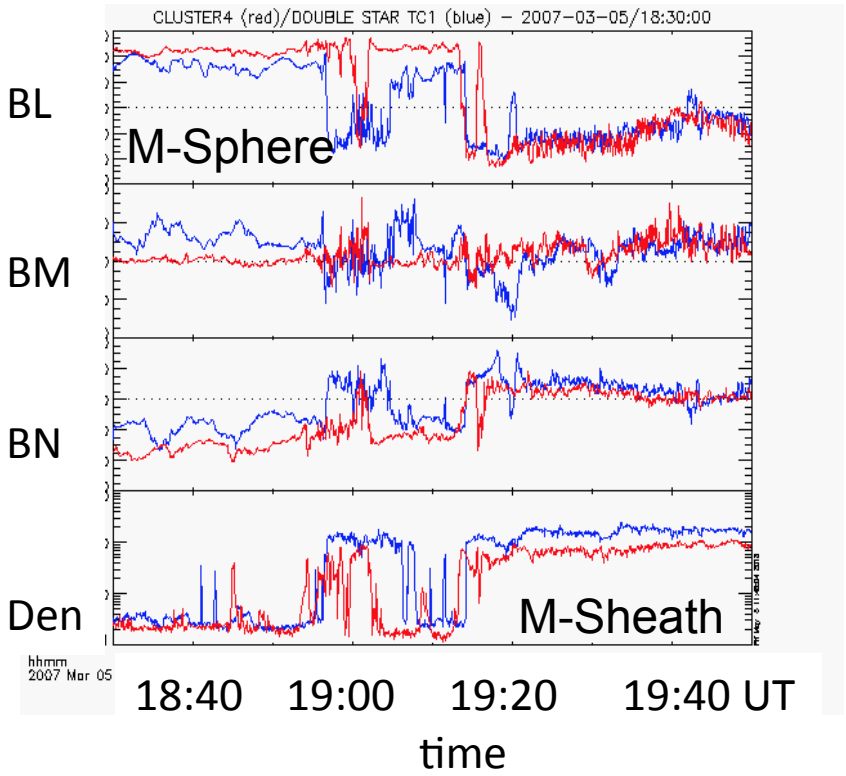


CL4,
DS-P
positions



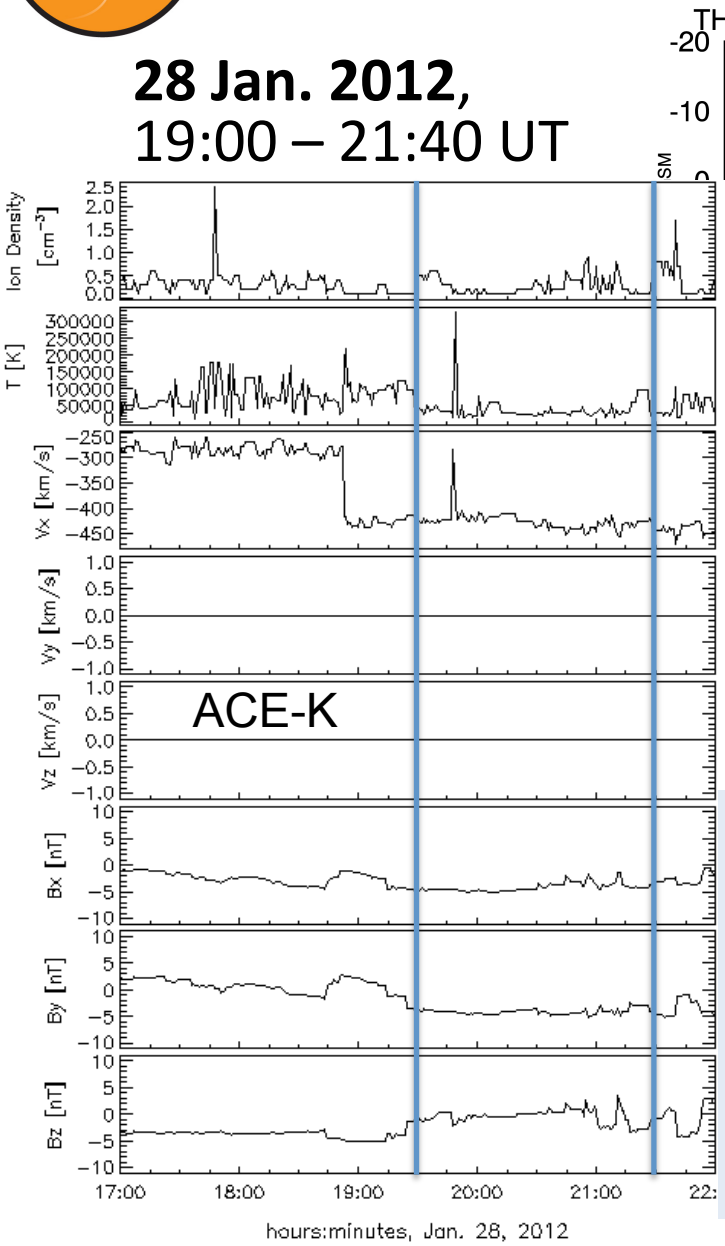


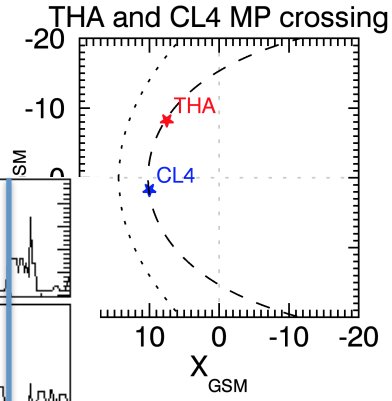
Solar wind:
N ~ 10 - 11
Vx~-380 ..-390
Vy~ -5 .. +5
Vz~ -40 ... -50
Bx~ -2 .. 0
By~ 0
Bz~-5

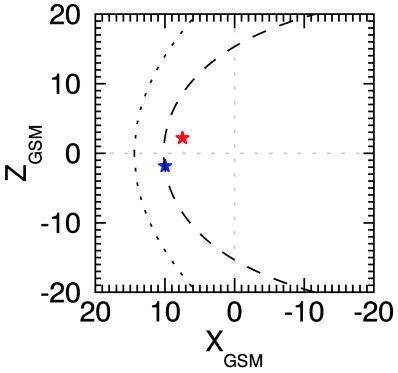


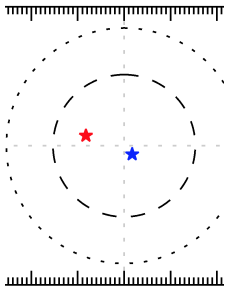
28 Jan. 2012

28 Jan. 2012,
19:00 – 21:40 UT







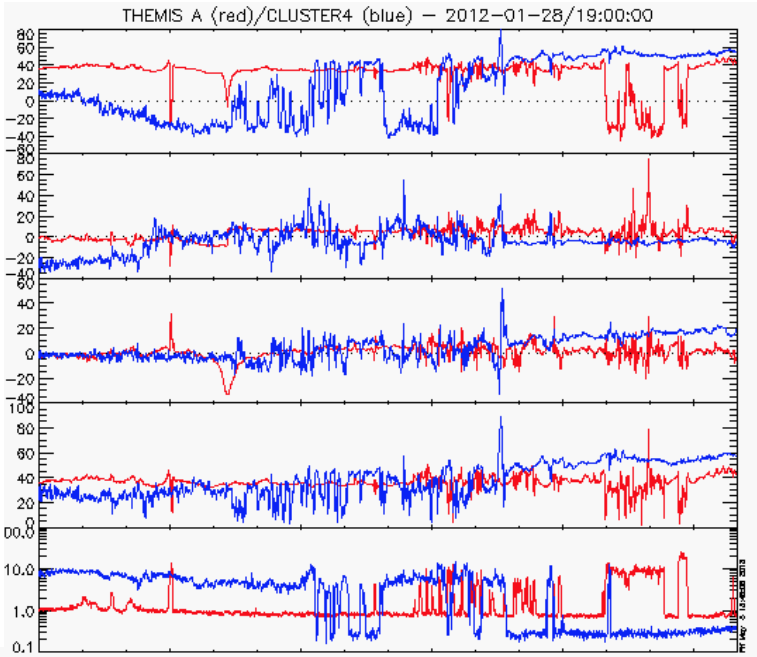


BL

BM

BN

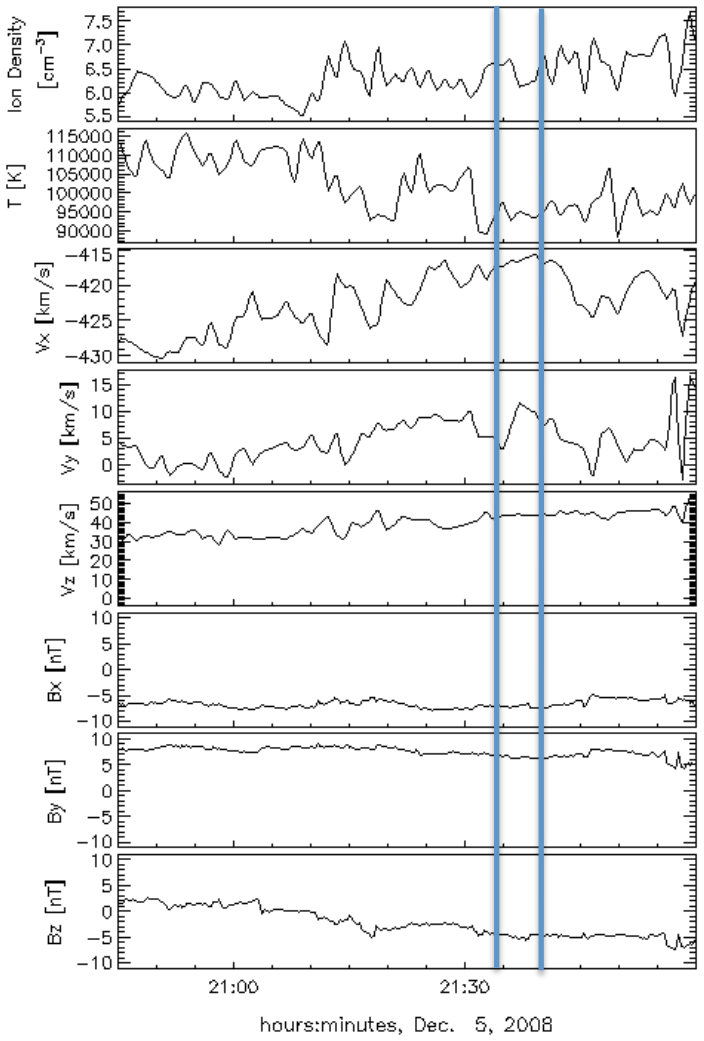
Den



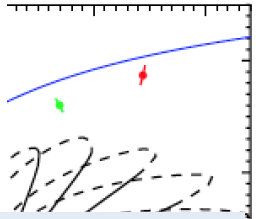
Solar wind:
N~0.5
Vx~-420
Vy~N/A
Vz~N/A
Bx~-5
By~-5
Bz~-1

5 Dec. 2008, 21:10 – 22:00 UT

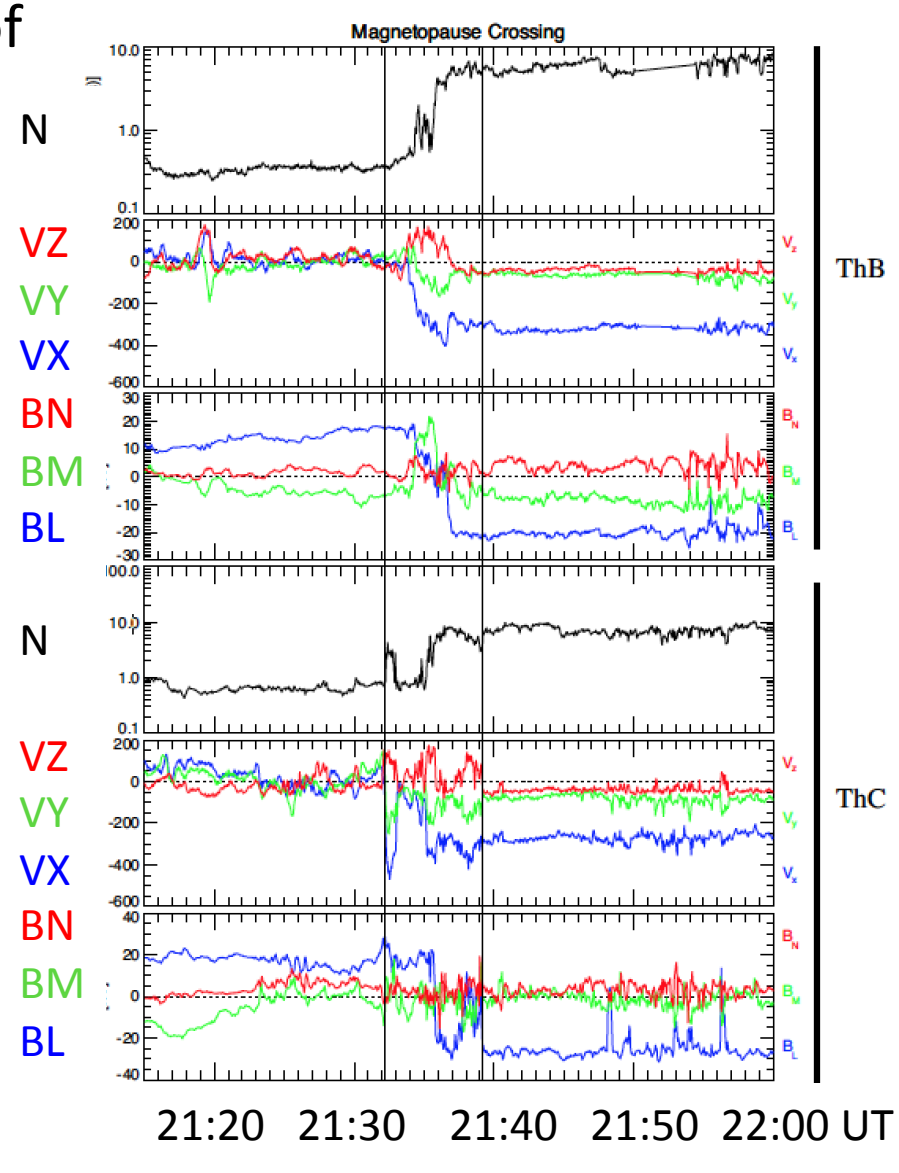
Simultaneous dawn flank crossing of **Themis B** and **Themis C**, 7 RE apart



: 2008



Solar wind:
N~6.5
Vx~-415
Vy~+10
Vz~+40
Bx~-6
By~+6
Bz~-5



New Event Summary

- 3 events with different satellite alignment
- Nearly stationary solar wind during MP crossings
- Short simulation intervals (<2 hours)

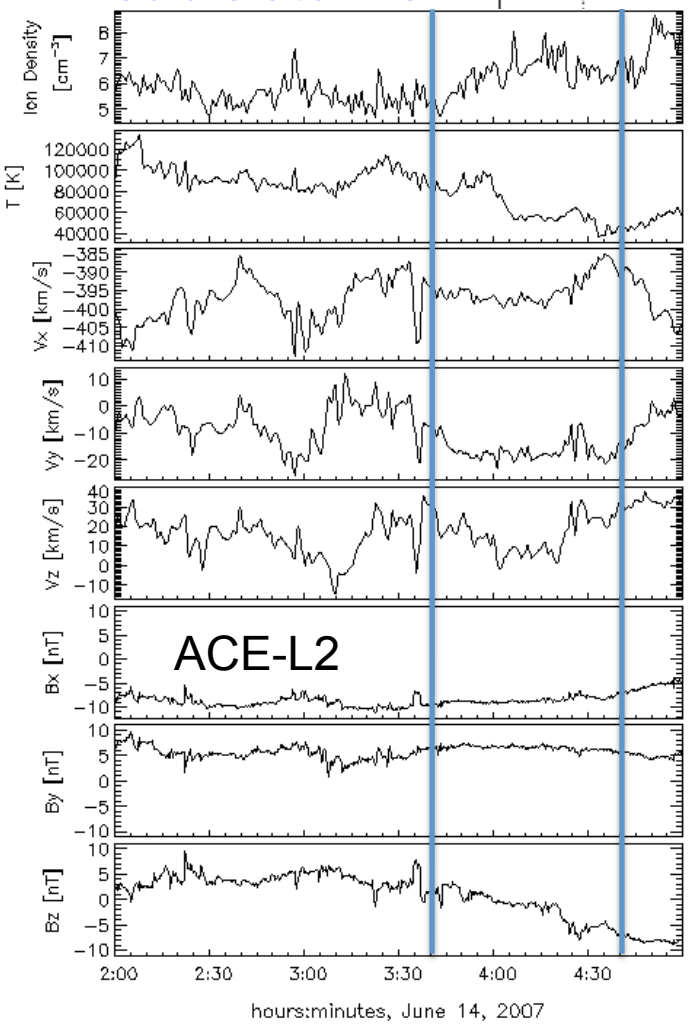
Next phase:

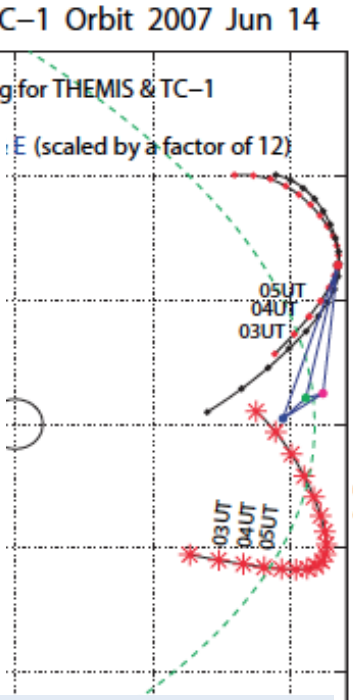
- Dynamic events:
  - FTE or reconnection events, MP at same location
  - changes of the MP position

14 Jun. 2007, 03:00 to 05:00 UT

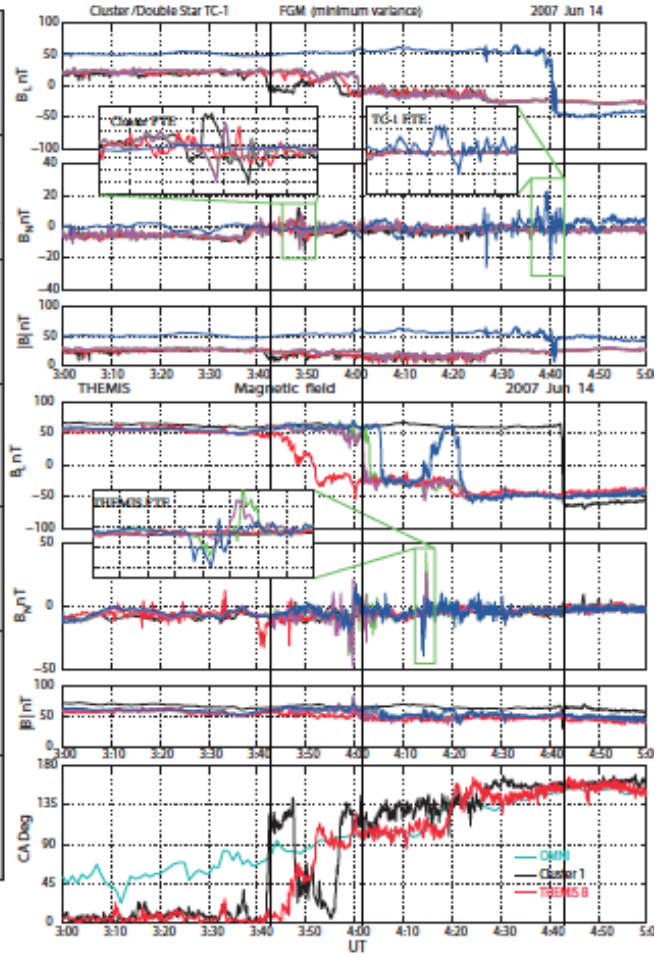
FTEs observed (Dunlop et al. Ann. Geophys. 2011)

5 THEMIS,
4 **CLUSTER**,
Double Star TS1





Solar wind:
N ~ 5 - 7
Vx~ -395…-390
Vy~ -20
Vz~ 0 ..30
Bx~ -9 … -7
By~ 5
Bz~ 3 … -5



BL (CL, DS)

BN

|B|

BL (TH)

BN

|B|

CA (CL1,THB, OMNI)

3:00 3:30 4:00 4:30 5:00
time

13 Jan. 1996, 20:15 – 21:30 UT

Reconnection observed (Phan et al. GRL, 2006)

- GEOTAIl, WIND, IMP-8 (in sheath only)
- Solar wind?
  IMF: southward B_Z, and duskward B_Y.
- Reconnection was observed
  If reconnection were resolved by models, how would MP position change in models?