GEM Challenge 2008 Magnetic fields and plasma properties in the inner magnetosphere

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Contents

- Data and Preparation
- Analyses and initial results:
  - Magnetopause crossing of LANL satellites
  - Magnetic field on GOES satellites
  - LANL MPA particle densities
- Summary

Data

Satellites in Geosynchronous orbit

- LANL: magnetopause crossings (LANL-90, LANL-91, LANL-94, LANL-95, LANL-97, LANL-01, LANL-02, as applicable) provided by M. Thompson.
- GOES: magnetic field measurements (GOES-8, GOES-10,GOES-11,GOES-12, as applicable) available through CDAWeb.
- LANL plasma data available through CDAWeb.

Selected storm events:

1. October 29, 2003 06:00 UT - October 30, 06:00 UT.
2. December 14, 2006 12:00 UT - December 16, 00:00 UT.
3. August 31, 2001 00:00 UT - September 1, 00:00 UT.
4. August 31, 2005 10:00 UT - September 1, 12:00 UT.

Model run data at CCMC

For each of the events (runs at CCMC):

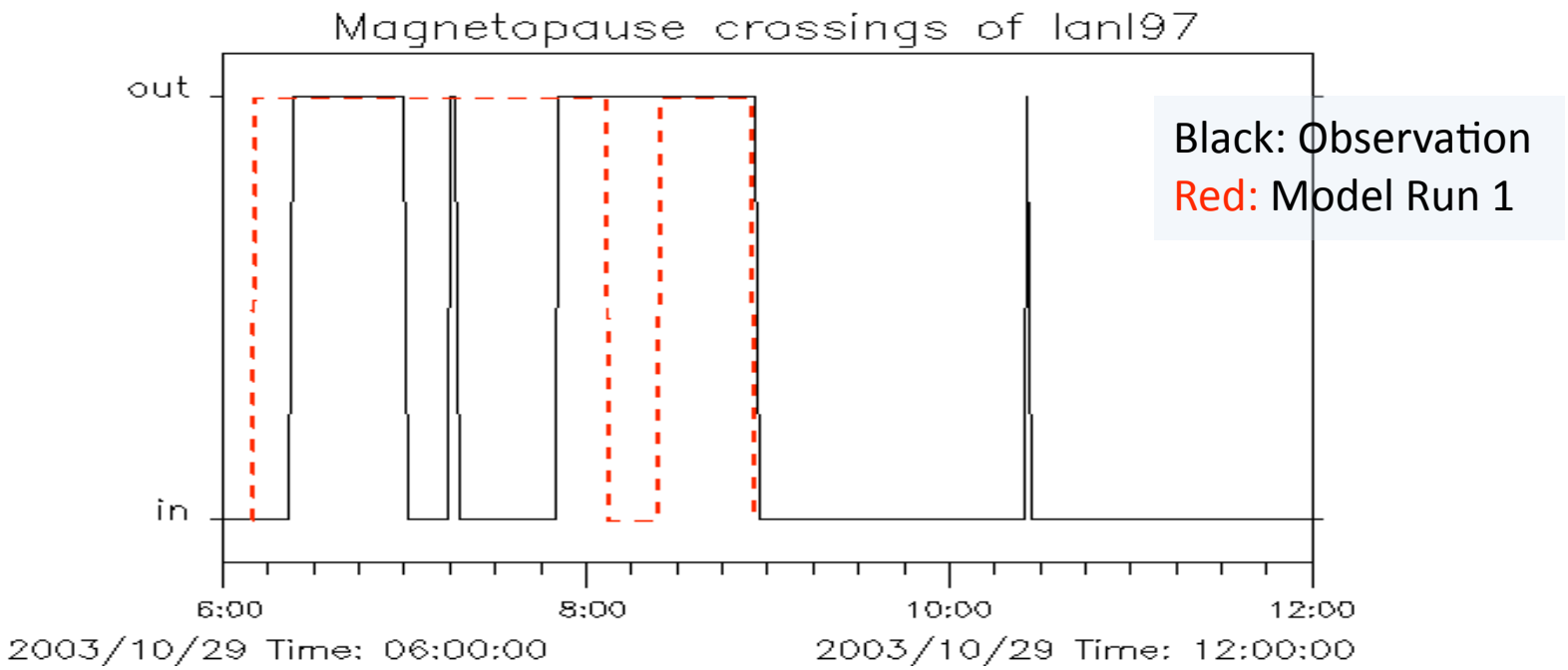
- Run 1: BATSRUS v. 7.73, 700 000 cells
- Run 2: BATSRUS v. 7.73, 2 million cells
- Run 3: BATSRUS v. 8.01, 2 million cells, w. RCM
- Run 4: OpenGGCM, 3 million cells

Event 3 only (runs done elsewhere):

- Run 5: LFM-MIX, 53x48x64 grid; ¼ R_E resolution
  data submitted by M. Wiltberger

Magnetopause crossings

Graphical comparison



Time period of multiple magnetopause crossings seen by LANL97 within first 6 hours of event simulation.
BATSRUS model runs underestimate magnetopause crossings.

Metrics computations
Magnetopause crossings

- Test satellite position in model data every minute.
- Create matching 1-minute samples of periods inside and outside of magnetopause for LANL satellites.
- Use contingency table (for Event/No Event data):

Forecast \ Observ.	Yes	No
Yes	**H**it	**F**alse
No	**M**iss	**N**ull

Magnetopause Crossings: Metrics

Example: Event 1, Halloween storm (Oct. 29-30, 2003) LANL 97

LANL97	Run1	Run2	Run3
H (HITS)	89	87	56
M (MISS)	59	61	92
F (FALSE)	19	18	17
N (NULL)	1273	1274	1275

A	0.946	0.945	0.924	Detection ratio (1 perfect); large with many NULLS
B	0.730	0.709	0.493	Bias (1 perfect); models underestimate occurrences
POD	0.601	0.588	0.378	Prob. Of Detection (1 is perfect)
FAR	0.176	0.171	0.232	False Alarm Ratio (0 is perfect)
POFD	0.015	0.014	0.013	Prpb. Of False Detection (0 is perfect)

Ranges and perfect scores:
green: range=[0,1], 0 no skill, 1 perfect yellow: range =[0,+inf], 1 perfect
purple: range=[0,1], 0 perfect

Metrics after Lopez et al., Space Weather **5**, S01005, (2007)

Magnetopause Crossing Metrics
(continued)

	Run 1	Run 2	Run 3	
TS	0.533	0.524	0.339	Threat Score (1 is perfect)
TSS	0.587	0.574	0.365	True Skill Score; good for frequent events
MTSS	0.173	0.147	-0.270	Modified True Skill Score; penalizes false alarms
HSS	0.666	0.659	0.471	Heidke Skill Score; excludes random HITS, NULLS

blue: range: [-1,1], 0 no skill, 1 perfect

red: range [-inf,1], 0 no skill, 1 perfect

No data for Run 4 for this event.

GOES magnetic field (B)

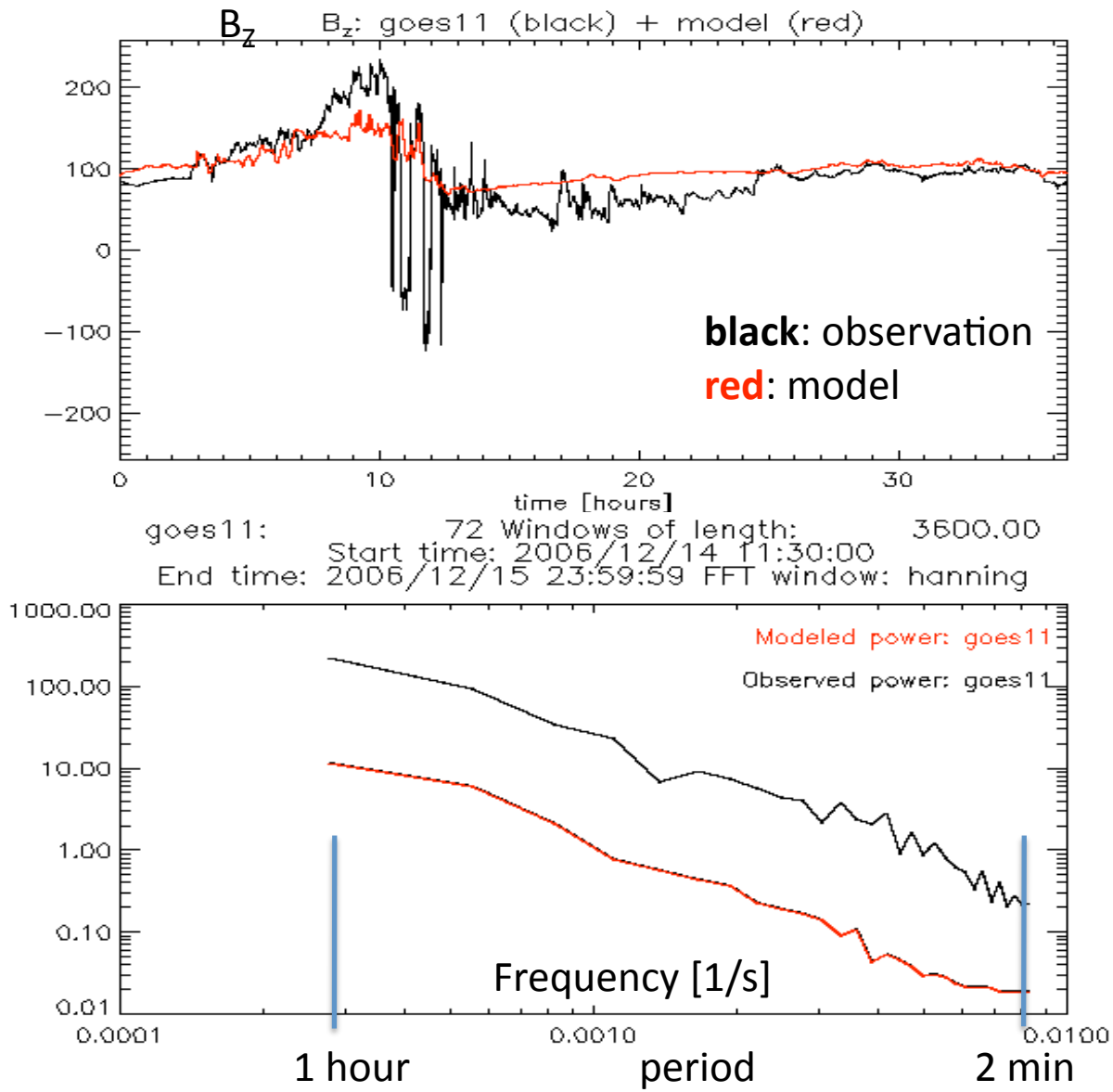
BATSRUS v.7.73: Event 2, GOES-11

Realtime grid

MP crossings not seen.

Power spectrum (all comp. of B):

Modeled power lower than observed.



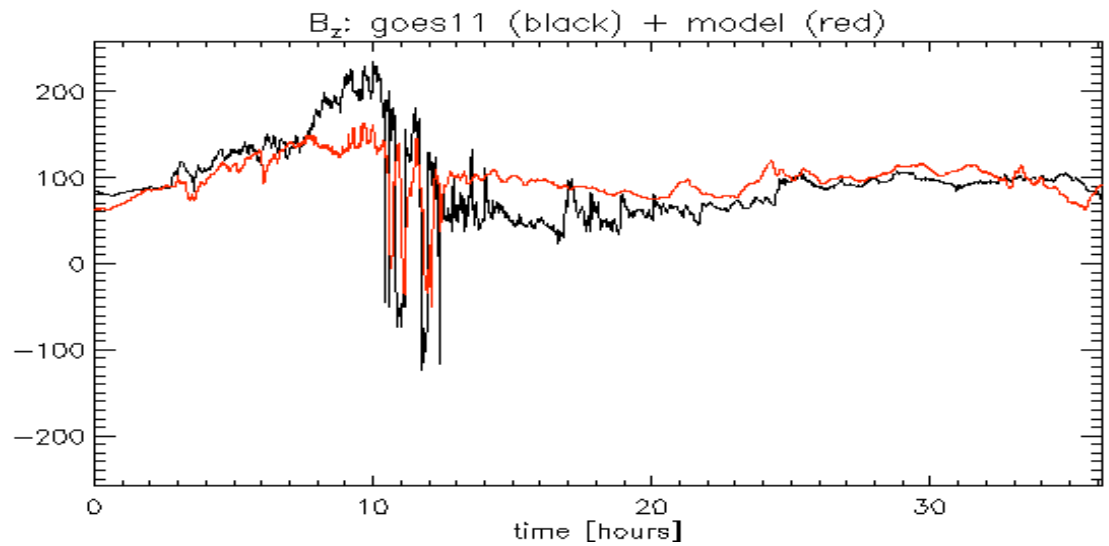
GOES magnetic fields

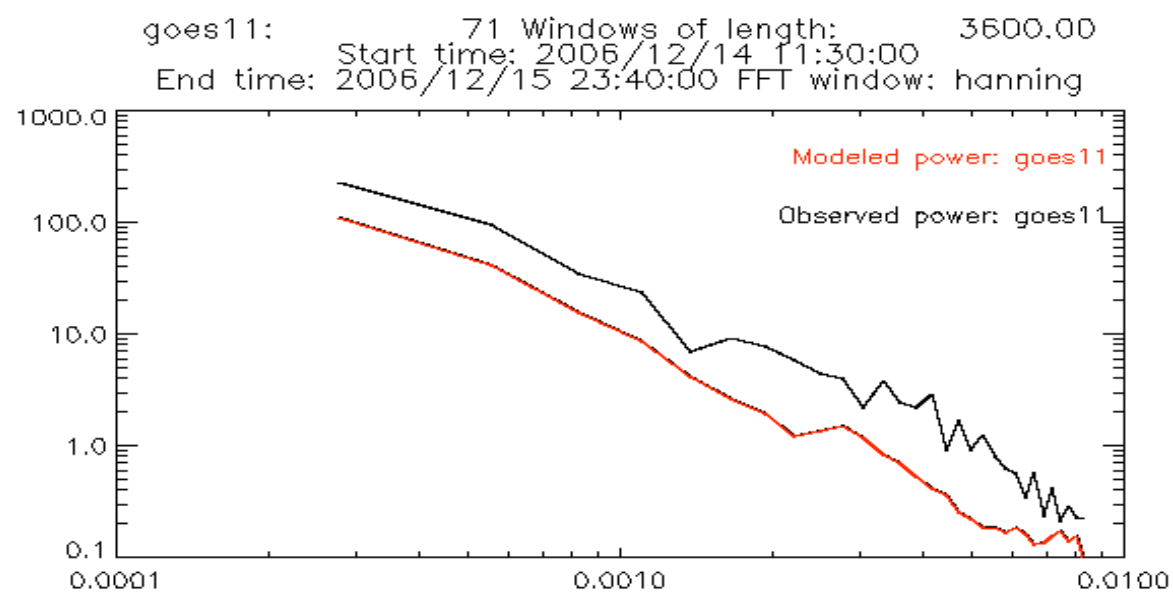
OpenGGCM

Event 2,
GOES-11

MP crossings seen.

Power spectrum closer to observation.





Metrics:
GOES-11 magnetic fields Event 2

Log-spectral distance from perfect agreement of fourier transform of B components:

$$M_s(\tilde{b}_{obs},\tilde{b}_{mod}) = \sqrt{\sum_{\omega}\left(\log\frac{\left|\tilde{b}_x\right|_{obs}+\left|\tilde{b}_y\right|_{obs}+\left|\tilde{b}_z\right|_{obs}}{\left|\tilde{b}_x\right|_{mod}+\left|\tilde{b}_y\right|_{mod}+\left|\tilde{b}_z\right|_{mod}}\right)^2}$$

Sat.: goes11

Run 1 2.208 Runs 1 -> Run 2:

Run 2 2.266 results slightly worse

Run 3 2.063 RCM improves results

Run 4 0.841 OpenGGCM “sees” crossings

LANL-94 plasma density
(high-energy protons from MPA)

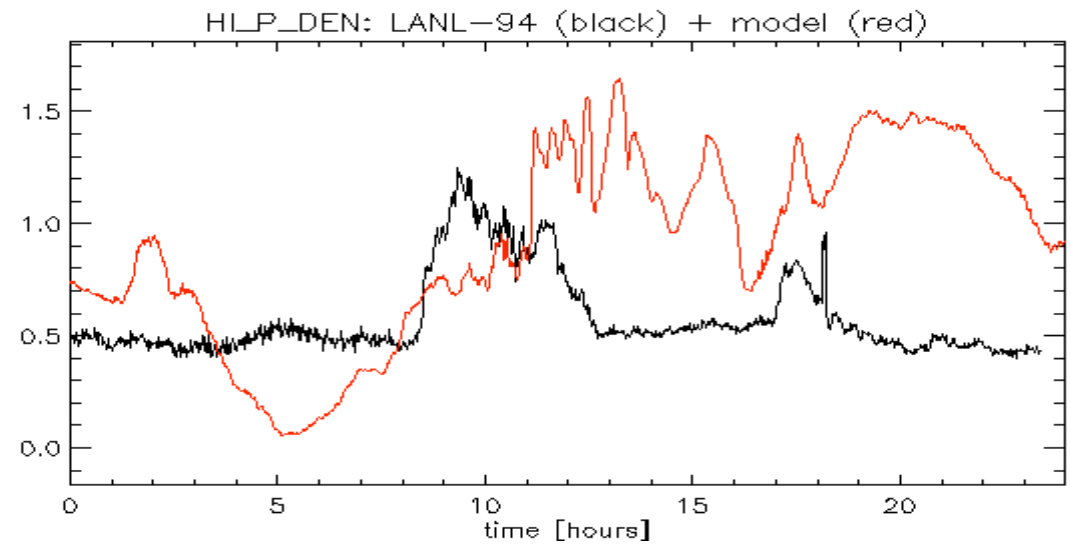
Event 3 (2001/8/31 2001/9/1)

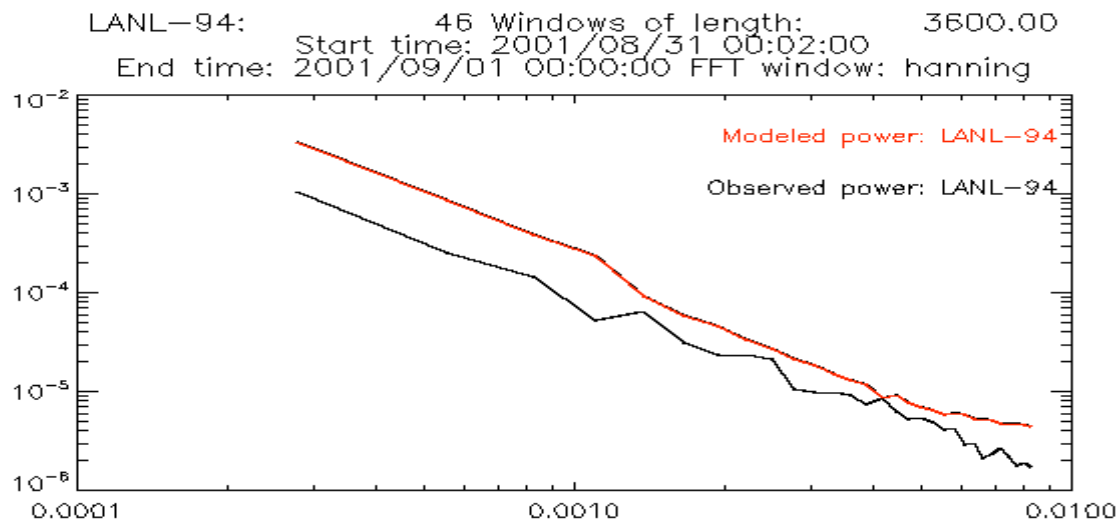
Submission for LFM-MIX

(M. Wiltberger)

Are we comparing the right thing?

Modeled activity higher than observed.

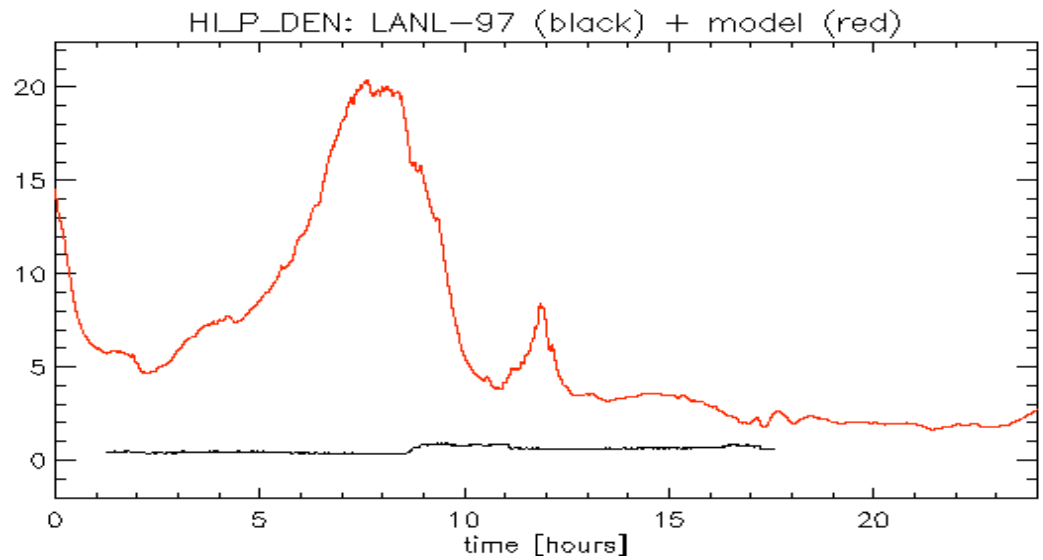




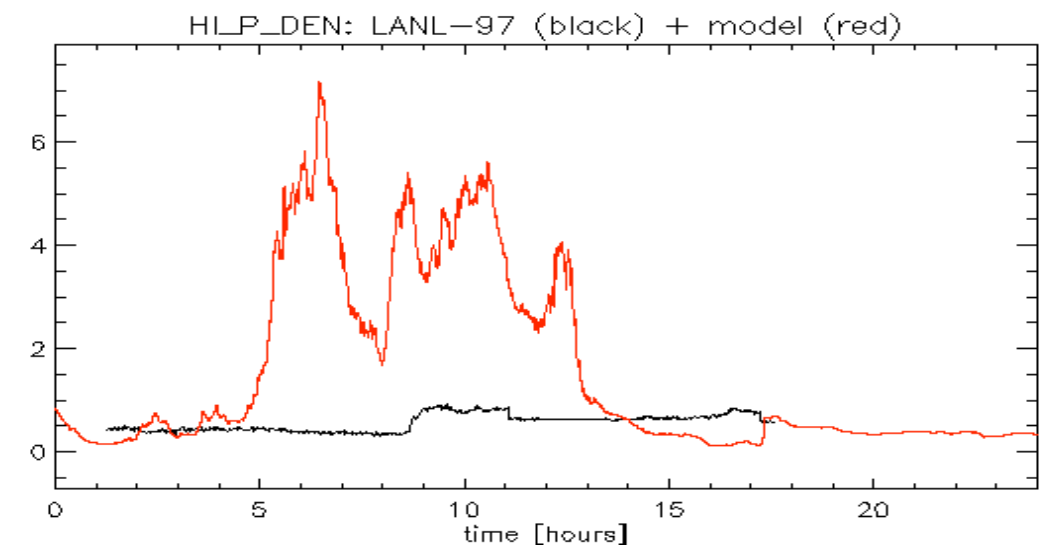
LANL-97 Plasma Density

SWMF

Higher modeled activity also for SWMF and OpenGGCM

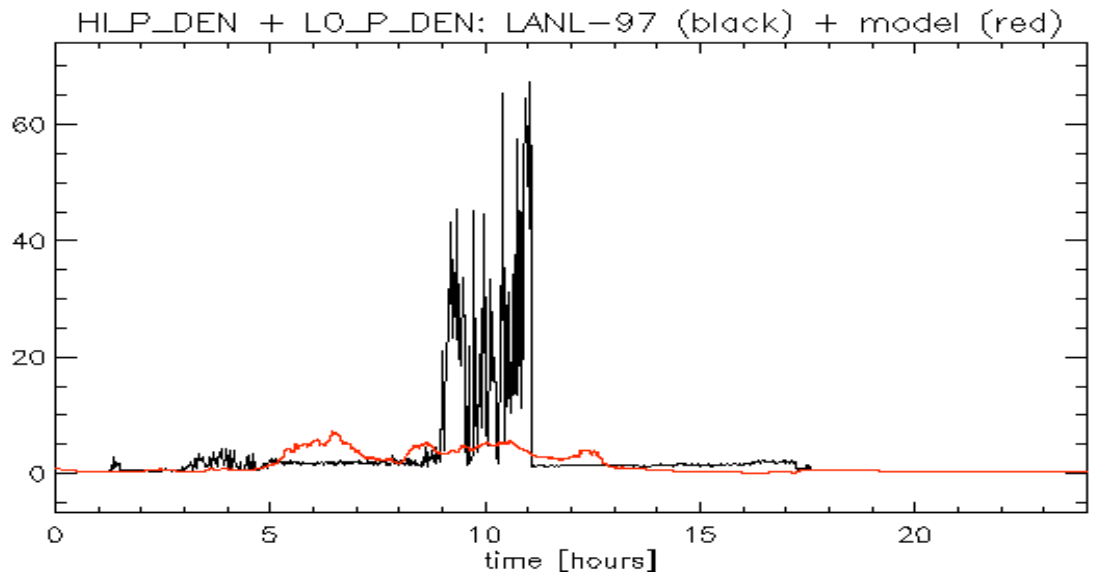


OpenGGCM



LANL – all energies

Example:
SWMF on
LANL-97 track



Sum of low and high energy protons at times much higher than modeled density.

LANL-MPA data sensitive to Plasmasphere background and other influences requiring careful analysis. Data not always available.

Summary

- Metrics show value of models – improvements are possible
- SWMF/BATSRUS (Runs 1 through 3): Grid improvements did not always improve results. BATSRUS v. 8.01 with RCM improves results.
- OpenGGCM fared well when run completed successfully (run may fail, however).
- LFM fares well in GOES comparison for Event 3.
- LANL density comparisons hard with MHD models.

Metrics: GOES B, Event 1

GOES B, log-spectral distances

Sat.:	goes10	goes12	
Run 1	2.521	2.315	Runs 1 -> Run 3:
Run 2	2.650	2.352	the metrics results
Run 3	2.752	2.519	seem to get worse
Run 4	no data for this run; model run failed		