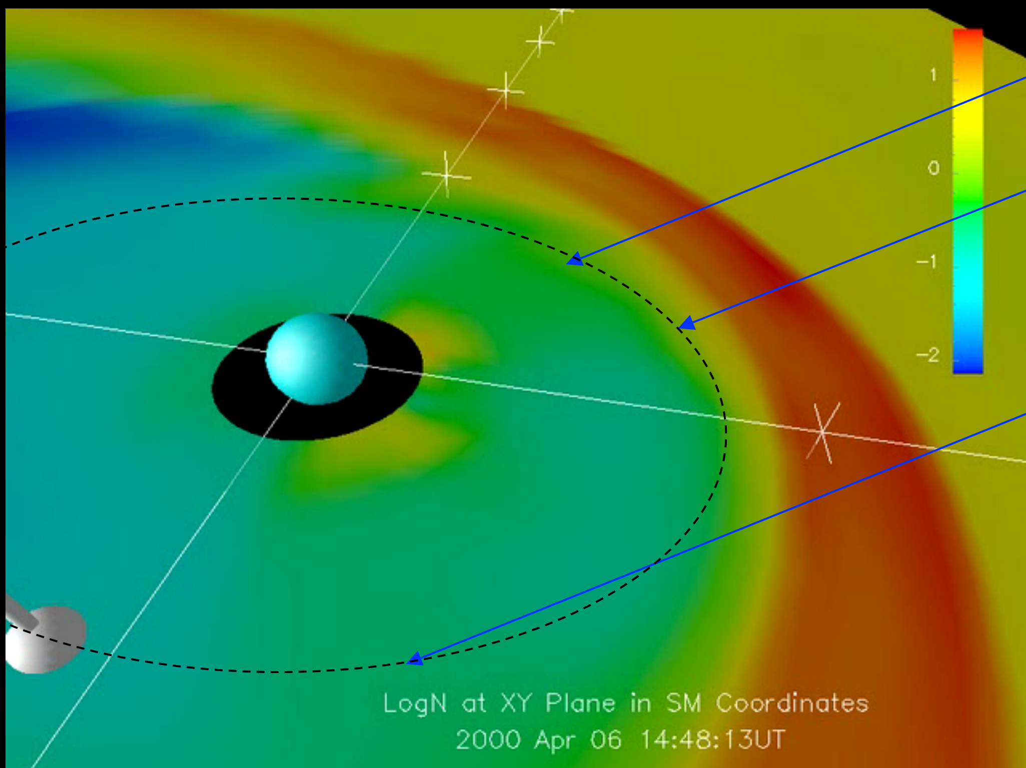
Magnetopause position in LFM

M. Wiltberger
NCAR/HAO

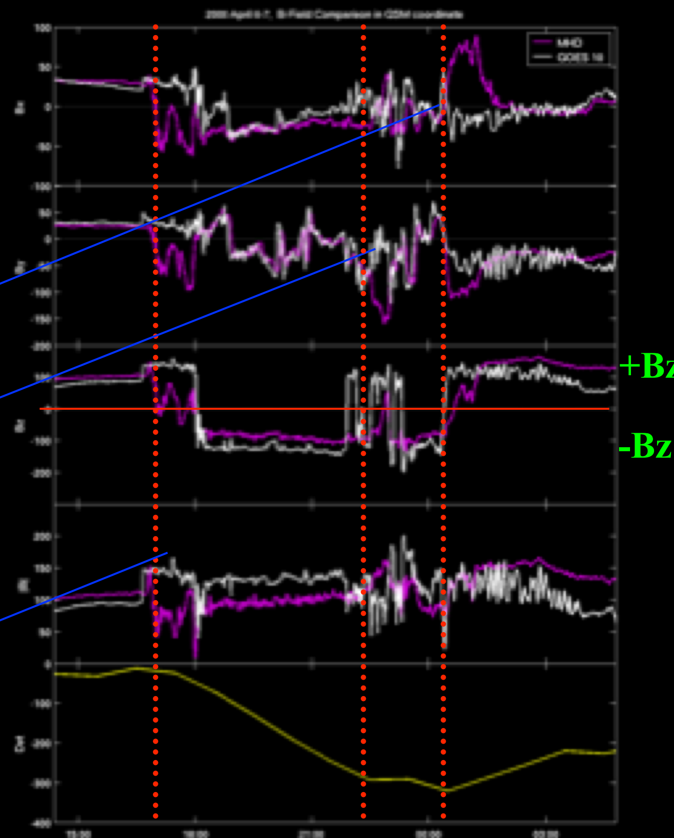
Collaborators include K .S. Garcia Sage, V. G. Merkin, R. E. Lopez, J. G. Lyon,

Magnetopause Validation

LFM, rendered with CISM_DX, identifies dayside magnetopause crossings quite well, with an accuracy commensurate with code's spatial resolution



- ***G10** = orbiting white dot – arrow indicates direction of **B**: measured **-Bz** (arrow "down") means s/c is in m'sheath*
- ***LFM** m'pause is located at steep gradient in plasma density*



GOES10 and **LFM** magnetic field variations recorded at geostationary orbit as a function of time during a magnetic storm

Thanks to C. Huang and S. Herndez

Contingency Table

Observed

Forecast	Yes	No	Total
Yes	***Hits***	***False Alarms***	***Forecast Yes***
No	***Misses***	***Correct Negatives***	***Forecast No***
Total	***Observed Yes***	***Observed No***	***Total***

Simple Ratios

- Accuracy
  - *A = (hits + correct negatives)/total*
  - *Range 0 to 1 with 1 perfect*
  - What fraction of forecasts where correct?
  - Can be misleading since its heavily influenced by most common category
- Bias
  - *BIAS = (hits+false alarms)/(hits + misses)*
  - *Range 0 to infinity with 1 perfect*
  - How did forecast freq of 'yes' events compare to observed frequency of 'yes' events?
  - Tells whether system has a tendency to underforecast (<1) or overforecast (>1) events. Doesn't measure how well the forecast corresponds to observations.
- False Alarm Ratio
  - *FAR = (false alarms)/(hits + false alarms)*
  - *Range 0 to 1 with 0 perfect*
  - What fraction of predicted 'yes' events actually did not occur?
  - Very sensitive to climatological frequency of event

Probability of …

- Detection
  - *POD = (hits)/(hits + misses)*
  - *Range 0 to 1 with 1 perfect*
  - What fraction of observed ‘yes’ events were correctly forecast
  - Sensitive to hits, but ignores false alarms so it can be artifically improved by issuing more ‘yes’ forecasts
  - Should be used in conjunction with FAR
- False Detection
  - *POFD = (false alarms)/(correct negatives + false alarms)*
  - *Range 0 to 1 with 0 perfect*
  - What fraction of the observed ‘no’ events were incorrectly forecast as ‘yes’?
  - Sensitive to false alarms, but ignores misses so it can be artifically improved by issuing fewer ‘yes’ forecasts

Threat Scores

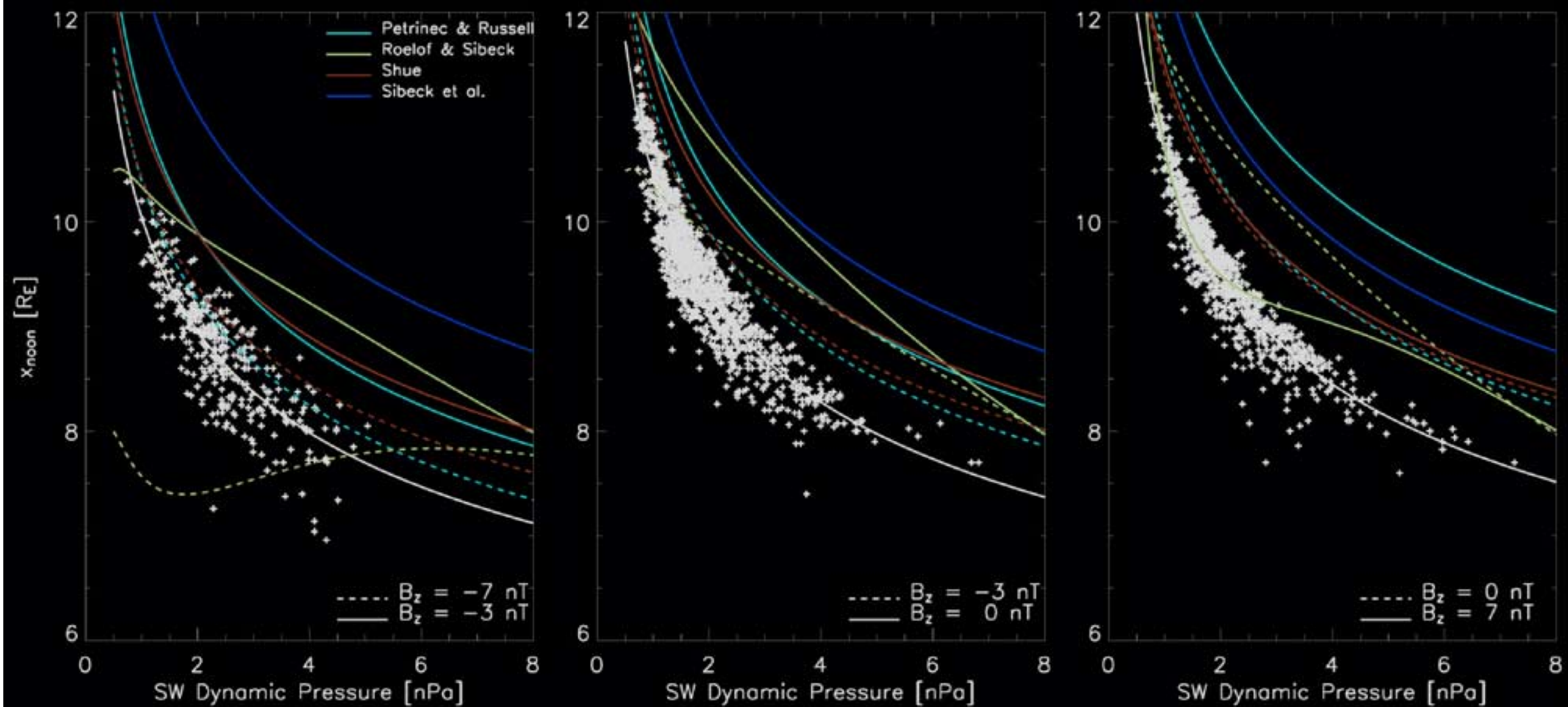
- Threat Score (Critical Success Index)
  - *TS = CSI = hits/(hits + misses + false alarms)*
  - *Range 0 to 1 with 1 perfect and 0 no skill*
  - How well did the forecast 'yes' events correspond to the observed 'yes' events?
  - Measures the fraction of observed and/or forecast events that were correctly predicted.
  - Can be thought of as accuracy when correct negatives are removed from consideration
- True Skill Statistic (Hanssen and Kuipers Discriminant)
  - *TSS = (hits)/(hits + misses) – (false alarms)/(false alarms + correct negs)*
  - *Range -1 to 1 with 1 perfect and 0 no skill*
  - How well did the forecast separate the 'yes' events from the 'no' events?
  - Can be thought of as POD - POFD
  - Uses all elements of the contingency table.
  - For rare events its unduly weighted toward the first term
- Modifed True Skill Statistic
  - *TSS2 = (hits-misses)/(hits + misses) – 2*(false alarms)/(correct negs)*
  - *Range -1 to 1 with 1 perfect and 0 no skill*
  - First term is POD remapped to -1 to 1
  - Second term peanlizes a forecast for large area for rare event

Metric Assessment

	LFM	RS	PR	SA
A	0.95	0.93	0.85	0.93
B	1.18	1.28	1.35	1.09
POD	0.92	0.90	0.72	0.81
FAR	0.22	0.30	0.47	0.25
POFD	0.048	0.069	0.12	0.050
TS	0.73	0.65	0.44	0.64
TSS	0.87	0.83	0.60	0.76
MTSS	0.73	0.64	0.18	0.52
HSS	0.81	0.74	0.53	0.74

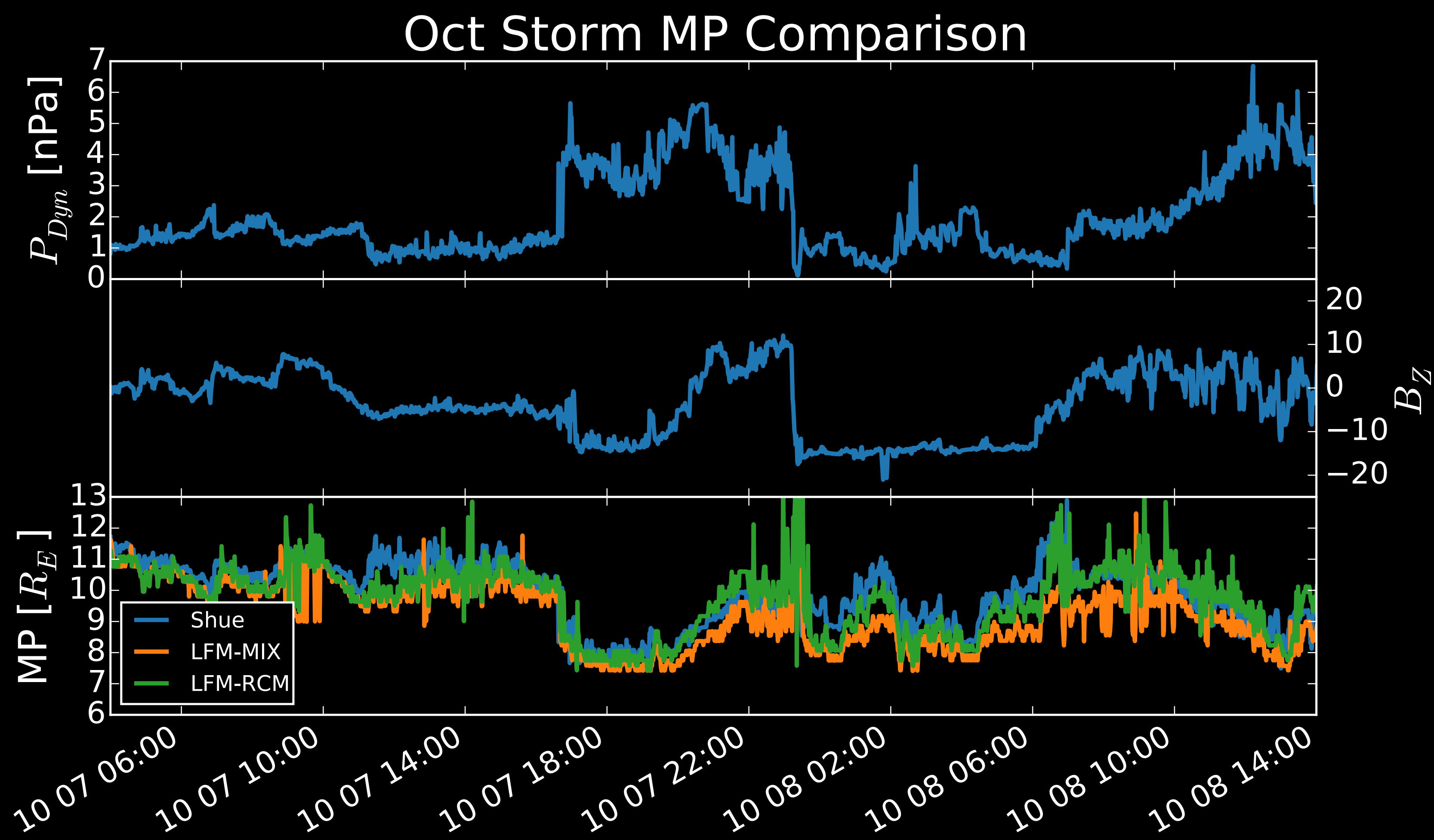
- We have computed ratios, probabilities, and skill scores for LFM and several empirical models which show that the LFM is slightly better at capturing the MP crossing during these extreme conditions
  - This may reflect the lack of training data for the empirical models

Statistical MP Comparison



- Garcia et al. 2007 compared LFM MP position determined during idealized SW runs several empirical MP models

MP Improvements with LFM-RCM



Conclusions

- Dichotomous metrics and related skill scores are good choice for assesssing model performance for MP
- LFM does quite well during extreme events at predicting the location of the MP
- LFM-RCM is better than LFM-MIX at predicting MP position
  - Yields better radiation belt forecasts

References

- García, K. S., and W. J. Hughes (2007), Finding the Lyon-Fedder-Mobarry magnetopause: A statistical perspective, *J. Geophys. Res.*, *112*, 06229, doi: 10.1029/2006JA012039.
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- Lyon, J. G., J. A. Fedder, and C. M. Mobarry (2004), The Lyon-Fedder-Mobarry (LFM) global MHD magnetospheric simulation code, *J. Atmos. Solar Terr. Phys.*, *66*, 1333, doi:10.1016/j.jastp.2004.03.020.