CCMC-AFIT Model Validation Projects

Lt Col Ariel Acebal

Department of Engineering Physics

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Outline

- Collaboration overview
- Collaboration results
- Summary

Collaboration Overview

- Initial discussions between AFIT and CCMC personnel
  - Topic depends on student
    - Weather officers need to choose topics from central "shopping list"
    - Other officers, free to select space physics topic

Collaboration Overview

- Student chooses topic
  - 18 (or 21) month program
    - 3 - 5 month part-time research
    - 4 month full-time research
  - Students range from:
    - Just having completed undergraduate degree
    - Flying job for the last 11 years

Collaboration Overview

- CCMC/AFIT interaction
  - Initial conference call to discuss research as a group
    - CCMC prepares models/student interface
    - Student completes relevant course work and literature research
  - Student visits CCMC and works with staff
  - During full time portion of research conference calls range from weekly to monthly; student/committee dependant

AFIT- CCMC Collaborations

•"Evaluation of Interplanetary Magnetic Field Tracing Models Using Impulsive SEPs", Brian Elliot, 2010

•"CME Ensemble Forecasting Using the Coned Model", Capt Dan Emmons, 2012

•"Auroral Oval Model Comparisons", Maj Cory Lane, 2012

Evaluation of Interplanetary Magnetic Field Tracing Models Using Impulsive SEPs

2Lt Brian Elliott

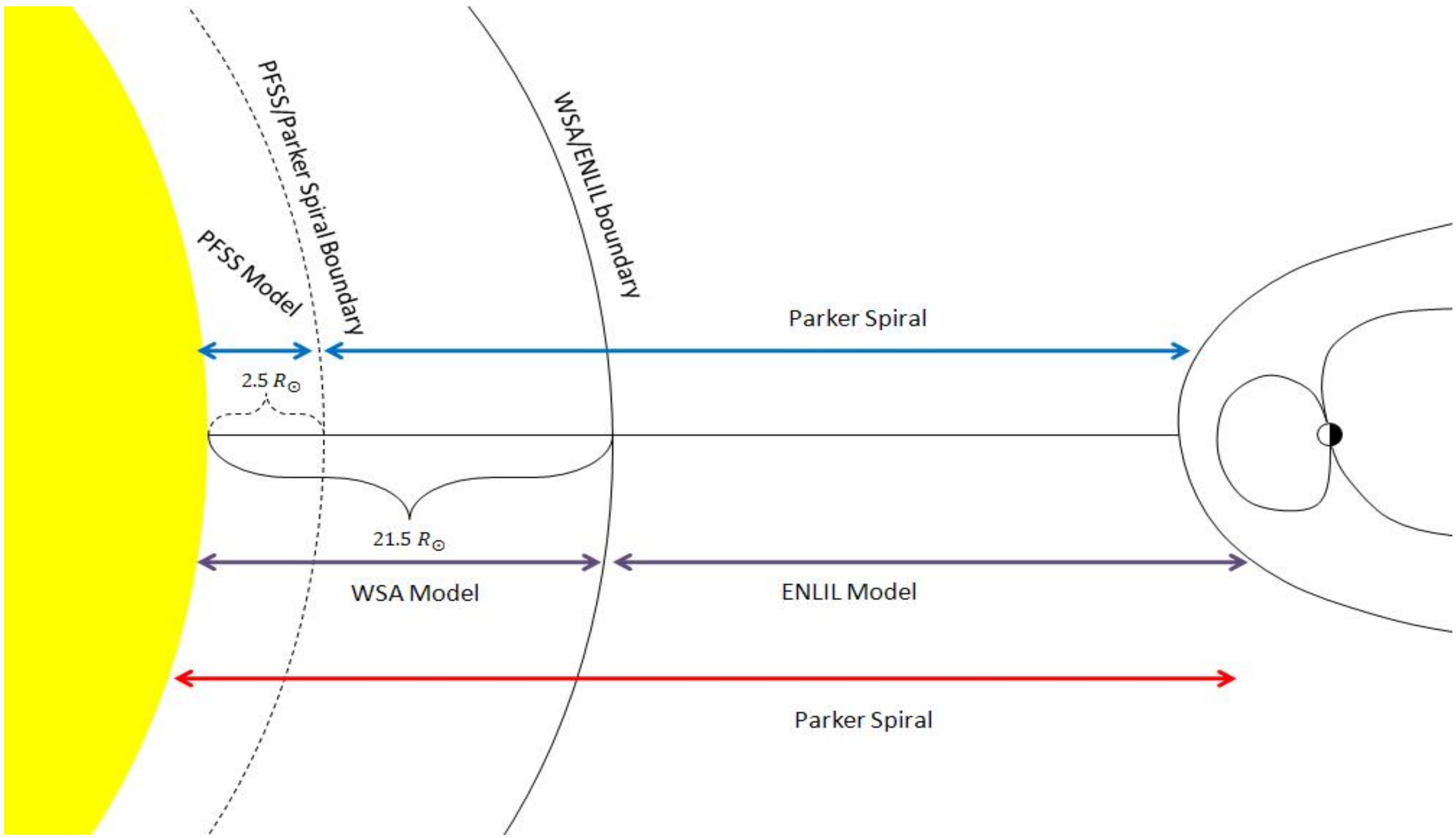
Mar 2010

Basics

- Purpose
  - Determine which model(s) accurately represent the magnetic structure within interplanetary space
  - Improve the ability to forecast SEP events for the DoD

Basics

- Models used



Basics

- Methodology
  - SEP event selection
    - 12 references listed 1153 events from 1979-2003
    - 88 events clearly identified as impulsive
    - Two or more references had to agree on source location
    - No change to proton flux in previous 24 hours
    - Ended up with 15 events
  - Traced SEP event back to source location on the Sun

Conclusions

- PFSS-Parker model performs the best trace for both longitude and latitude

Model	Longitude/ Latitude offset	RMS Values with all events
Parker Spiral	Longitude	32.77
PFSS-Parker	Longitude	21.87
	Latitude	18.50
WSA-ENLIL	Longitude	32.44
	Latitude	27.51

Findings

- Model Kink
  - Magnetic field lines are radial at the boundary between WSA-ENLIL and PFSS-Parker
  - This results in an unrealistic kink in the magnetic field lines at this boundary

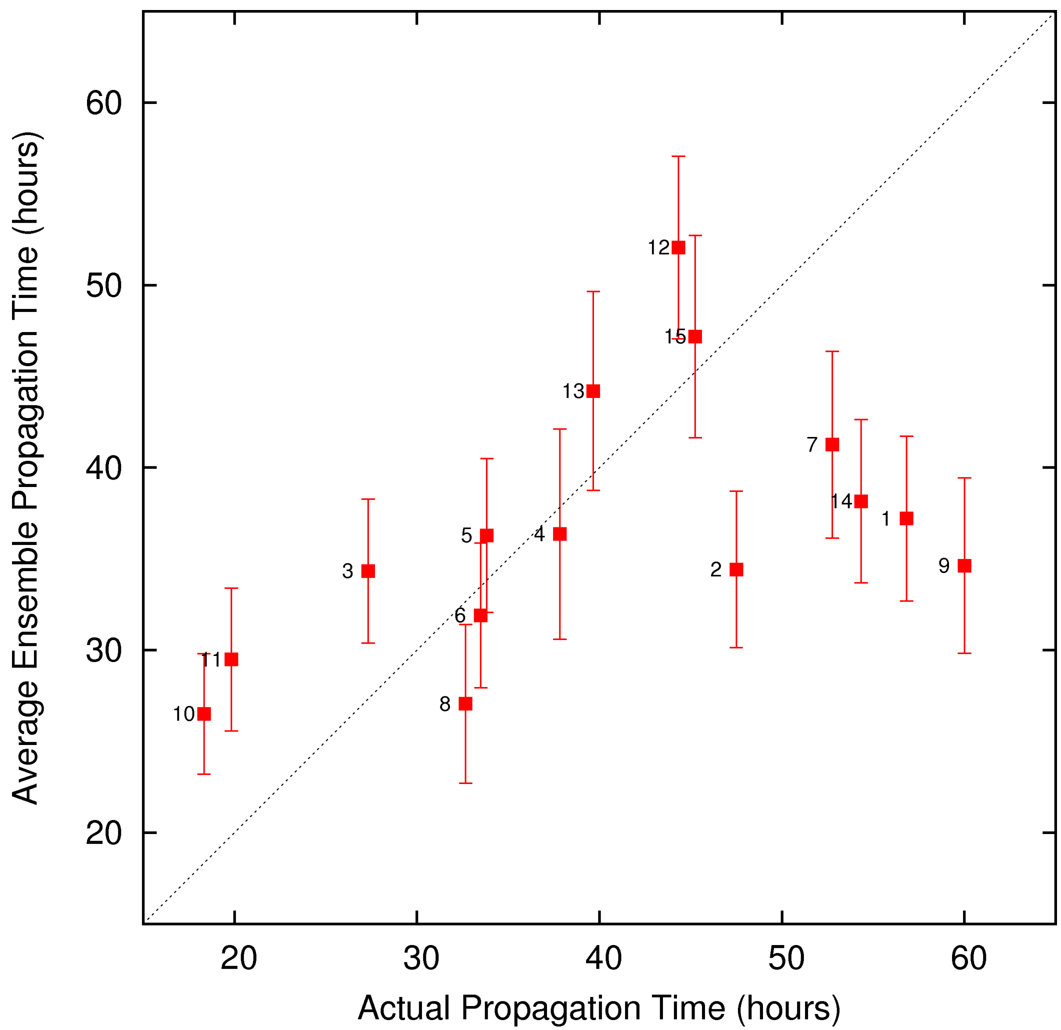
Ensemble Forecasting of Coronal Mass Ejections using the WSA-ENLIL with Coned Model

Capt Dan Emmons

Basics

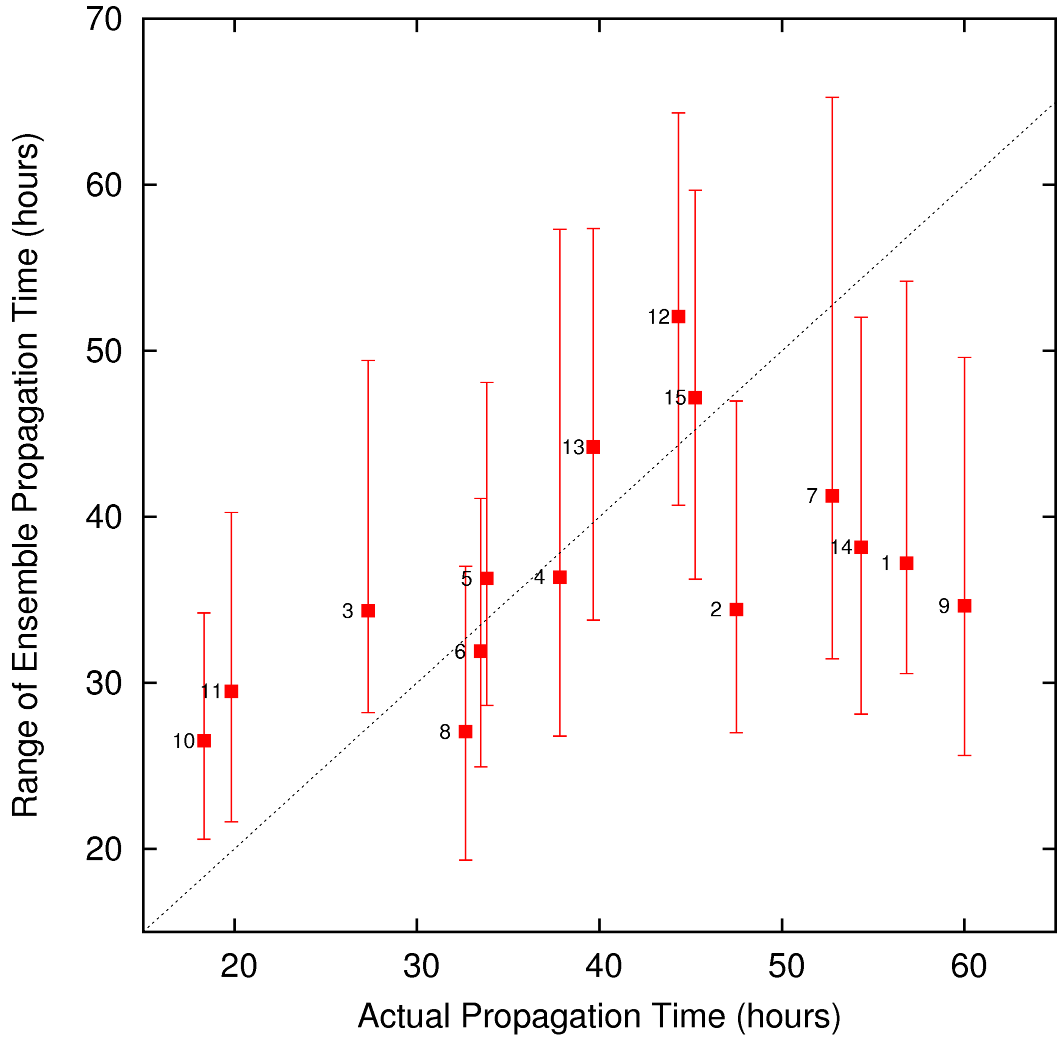
- Purpose
  - Determine accuracy of using an ensemble forecast method for estimating arrival of coronal mass ejections
- Models used
  - WSA
  - ENLIL
  - Coned model
- Methodology
  - Analyze LASCO imagery with Coned Model
  - Coned Model generates ensemble of CME observations
  - Run CME through WSA/ENLIL
  - Compare results with ACE data

Propagation Time



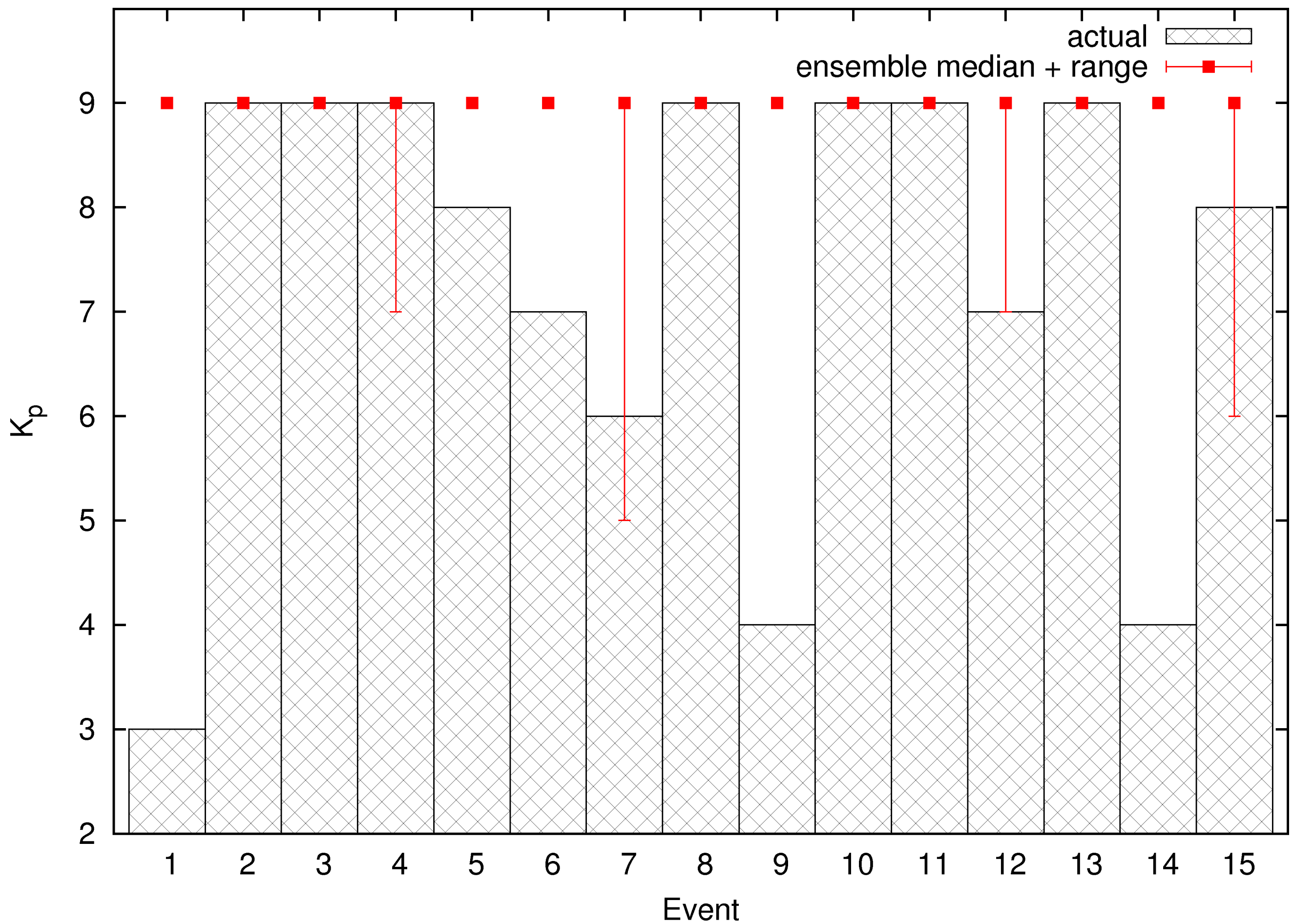
- Error bars = 1 stdev
- 5 of 15 events have actual prop-time inside avg ± 1 std
- All 5 between 30 and 46 hours
- Forecast is bad after 46 hours

Propagation Time



- Error bars = Range
- 8 of 15 with actual prop-time inside range

Maximum Kp



- Forecasts Kp = 9 for all events
- 10 of 15 with actual Kp inside range
- 7 of the 10 had actual Kp = 9

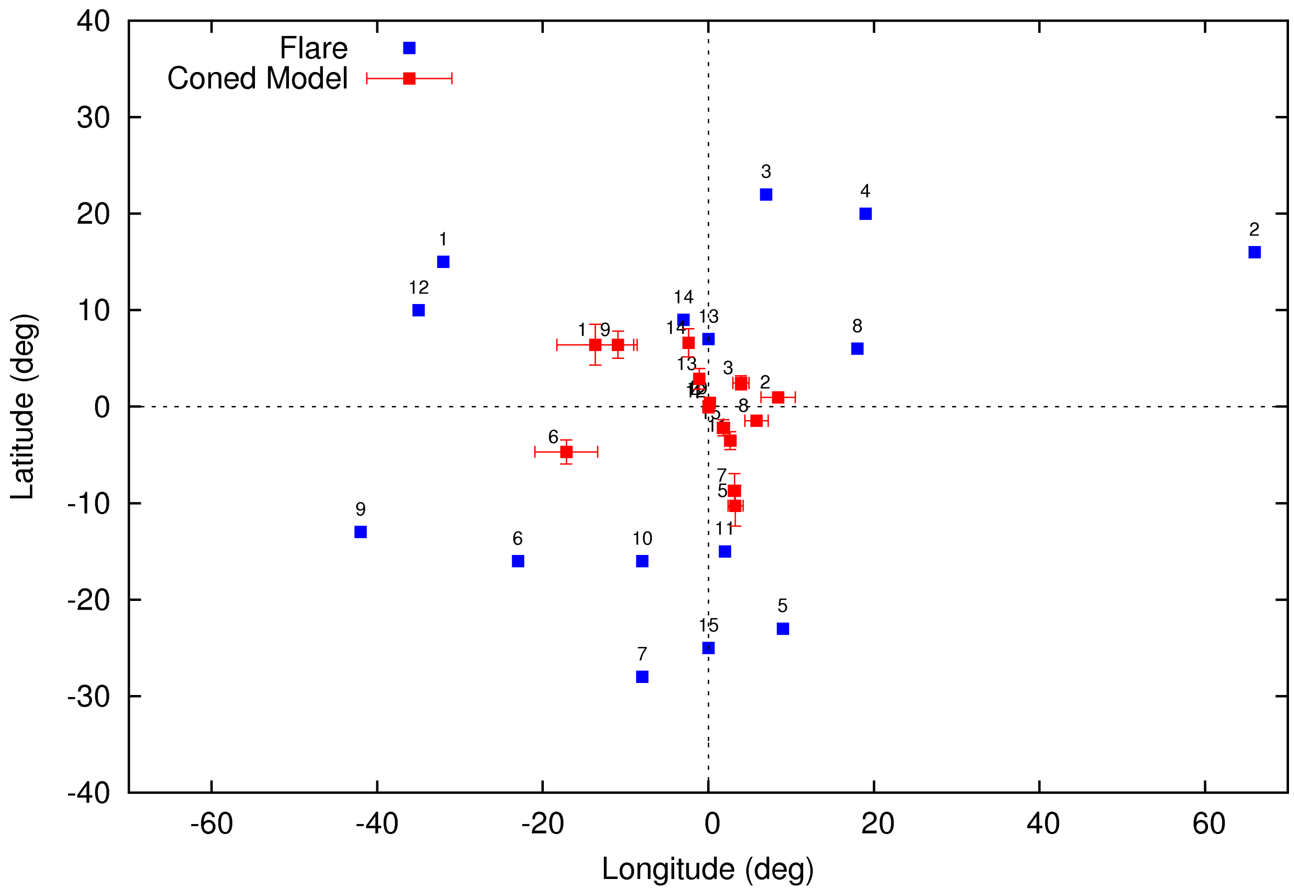
Conclusions

- Propagation time mean absolute forecast error = 9.1 hours
  - Greater than 6.9 hours for Analytical Cone Model [*Taktakishvili et al., 2011*]
  - Less than 11.2 hours for Coned Model Single Run [*Taktakishvili et al., 2011*]

Conclusions

- Maximum Kp forecast was overestimated for most CME's
  - Forecast Kp = 9 for all events when assuming magnetic field completely south
  - 10 of 15 events with actual Kp inside of forecast ± range

Findings



- Coned Model pushes propagation axis towards Sun-Earth line
- Could be a cause of large forecasting errors

Findings

- Analyze forecast change due to varying
  - Ensemble Size
  - Input images for Coned Model
  - Magnetogram source location
  - Magnetic field scaling factor
- Overall, the ensemble forecast using the WSA-ENLIL with Coned Model was robust with respect to changes in input parameters
  - Less than a 5% change in the forecast for all variations
  - Did cause large changes in the propagation time ranges for varying LASCO images and ensemble size

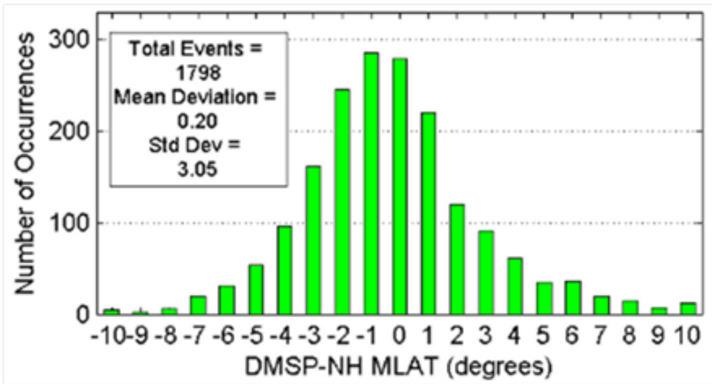
A Comparative Statistical Analysis of Auroral Models

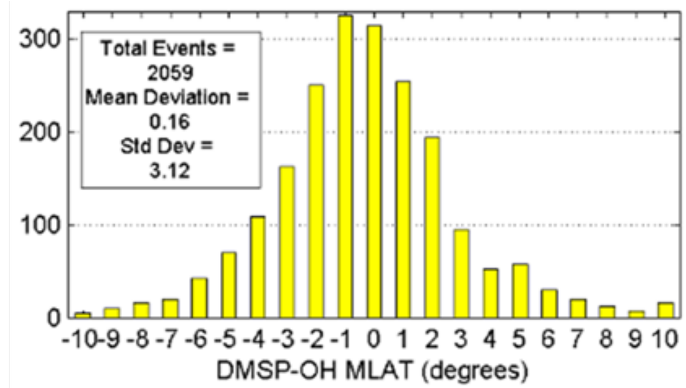
Major Cory Lane

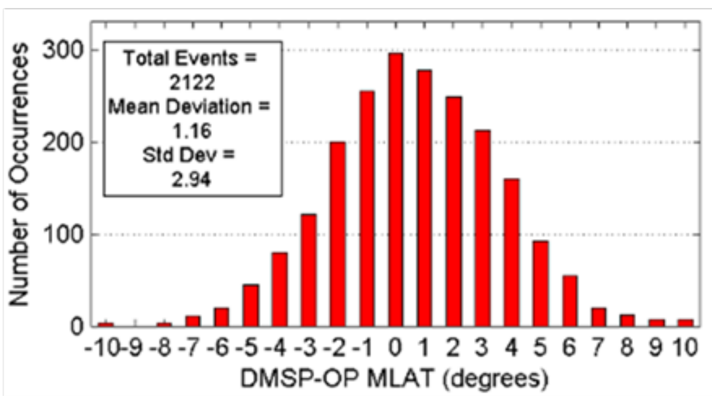
Basics

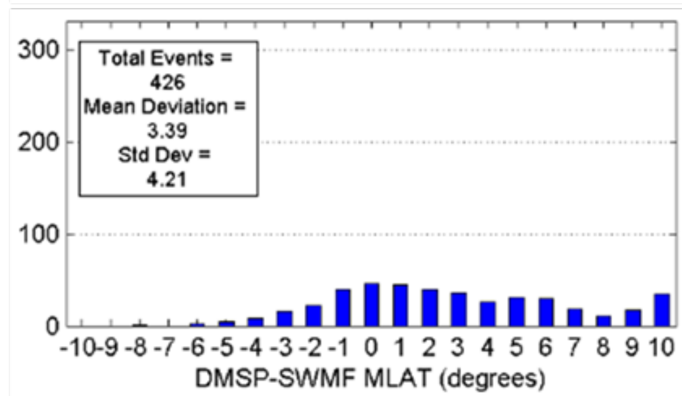
- Purpose
  - Compare DMSP energy flux (in situ) measurements of the auroral oval's equatorward boundary to the outputs of five auroral precipitation models
- Models used
  - Hardy and New Hardy
  - Ovation Prime
  - SWMF with Fok Ring Current
  - AMIE
- Methodology
  - Select events with CCMC input
  - Run models
  - Compare results with DMSP data

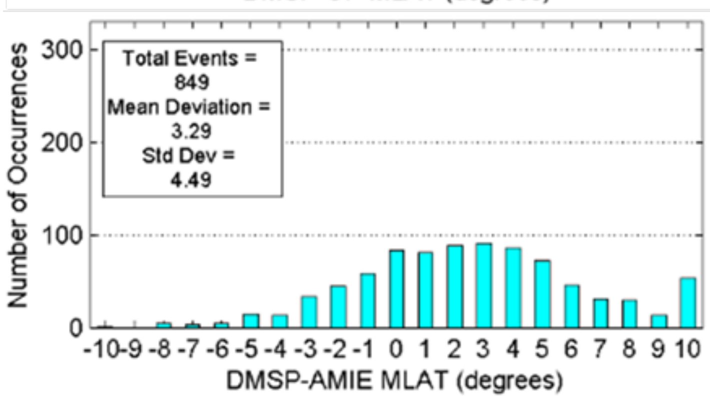
Model Deviations





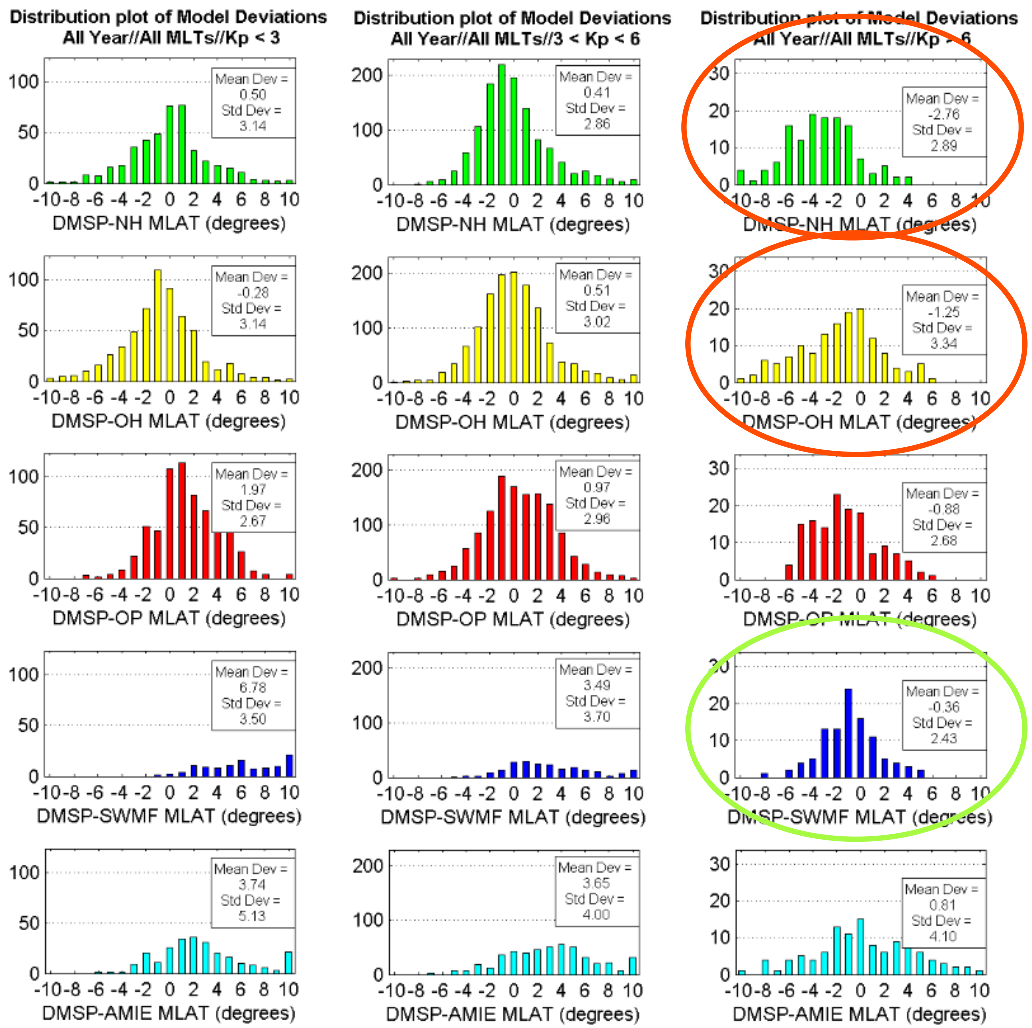






Conclusions

Kp Grouping

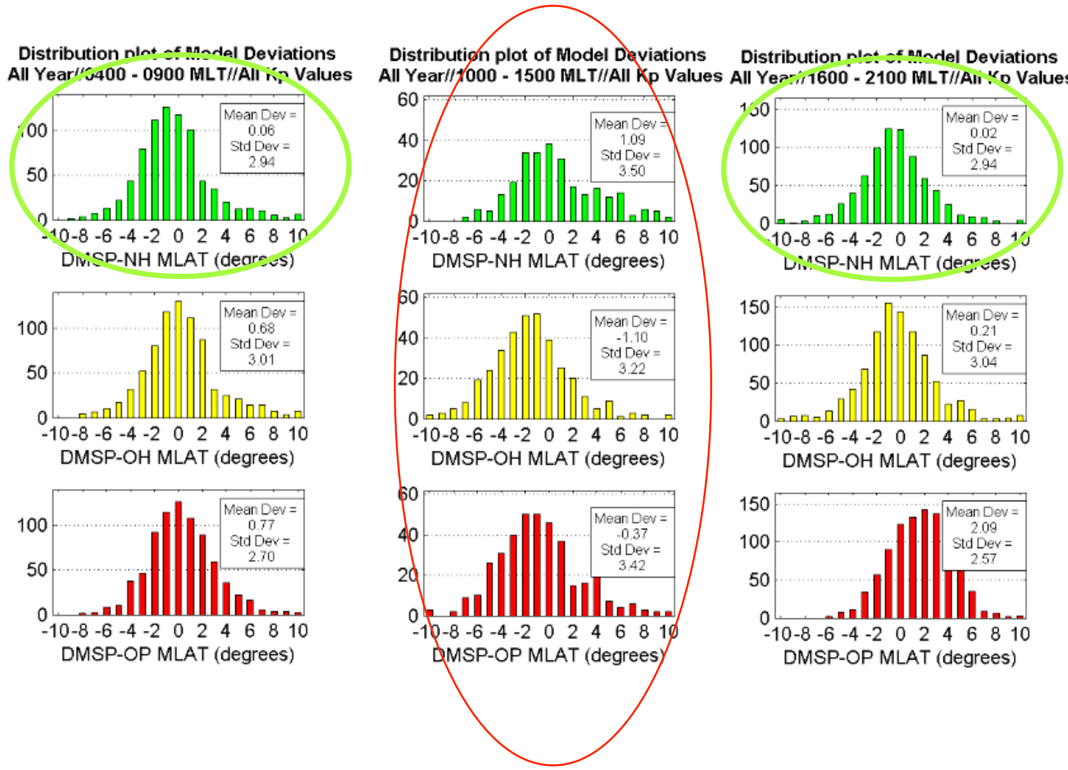


Reduced performance: NH & OH during High Kp conditions

Better performance: SWMF during High Kp conditions

Conclusions

TOD grouping

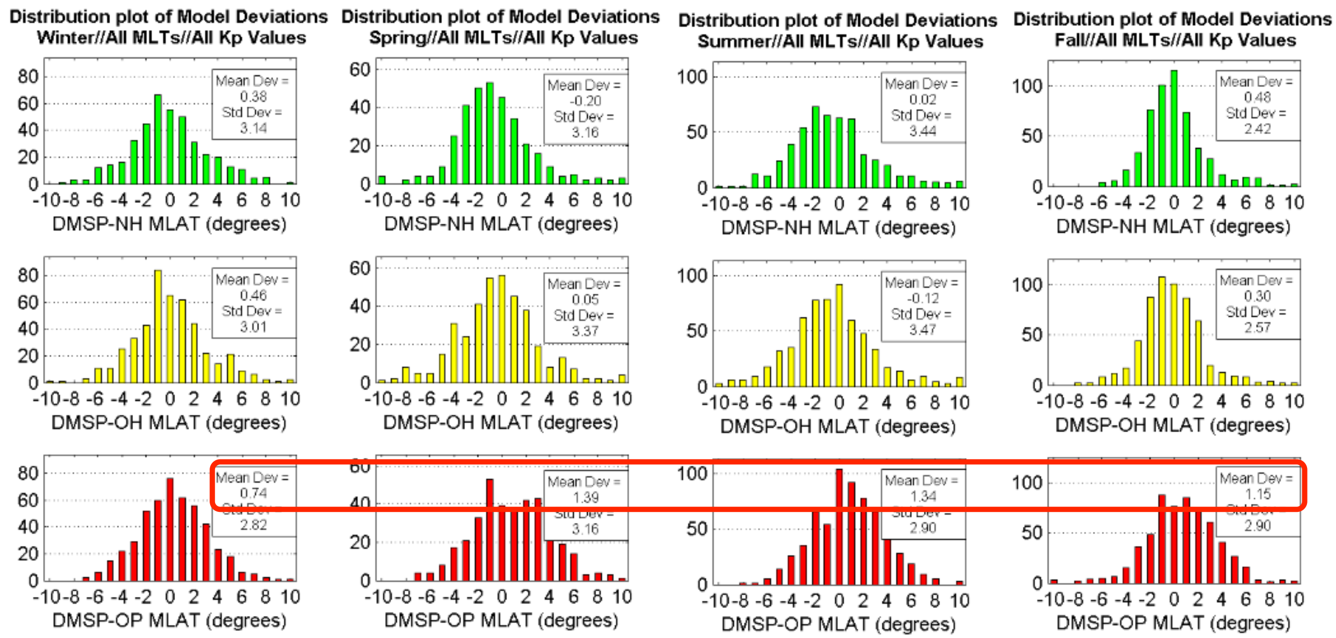


Strong NH performance during dawn and dusk

Modeling difficulty between 10-15 MLT for all models: larger variances observed

Conclusions

Seasonal Grouping



Reduced performance: OP equatorward bias

Conclusions

Prediction Efficiency @ 0.4 $erg/cm^2/s$

MLT	Kp	NH	OH	OP	SWMF	AMIE
04-21	All	0.45	0.51	0.55	--	--
04-21	High	--	--	0.13	0.29	--
	Mod	0.32	0.31	0.30	--	--
	Low	0.22	0.34	0.37	--	--
04-09	High	--	--	--	0.32	--
	Mod	0.19	0.05	0.30	--	--
	Low	0.19	0.06	0.10	--	--
10-15	High	Insufficient Data				
	Mod	0.06	0.21	0.12	--	--
	Low	--	0.40	0.38	--	--
16-21	High	--	--	0.15	0.25	--
	Mod	0.39	0.35	0.19	--	--
	Low	0.07	0.36	0.37	--	--

- OP: Best PE overall
- Kp groupings: No best choice
- Dawn sector: No best choice
- OH: Best 10-15 MLT
- Dusk sector: No best choice

Season	Kp	NH	OH	OP	SWMF	AMIE
Winter	High	--	--	--	0.30	--
	Mod	0.38	0.46	0.45	--	--
	Low	--	0.03	0.29	--	--
Summer	High	--	0.45	0.28	0.08	--
	Mod	0.30	0.28	0.49	--	--
	Low	0.28	0.34	0.46	--	--

- Winter: SWMF, OH, OP
- Summer: OP, OH

Conclusions

PE Scores using 0.6 $erg/cm^2/s$ threshold

MLT	Kp	NH	OH	OP	SWMF	AMIE
04-21	All	0.44	0.41	0.58	--	--
04-21	High	--	--	0.16	0.24	--
	Mod	0.31	0.29	0.39	--	--
	Low	0.14	0.11	0.47	--	--
04-09	High	--	--	--	0.55	--
	Mod	0.16	0.07	0.31	--	--
	Low	0.11	--	0.20	--	--
10-15	High	Insufficient Data				
	Mod	--	0.12	0.40	--	0.21
	Low	--	0.17	0.58	--	--
16-21	High	--	--	0.29	0.16	--
	Mod	0.37	0.40	0.32	--	--
	Low	--	0.13	0.40	--	--

OP demonstrates better PE scores at higher thresholds

Conclusions

- Model performance is highly dependent upon parameters of interest
- Operationally, OP may still be the most useful because it is the most conservative

Summary

- Looking forward to more joint projects
- Have 4 students that will start their research in April
- Looking for projects