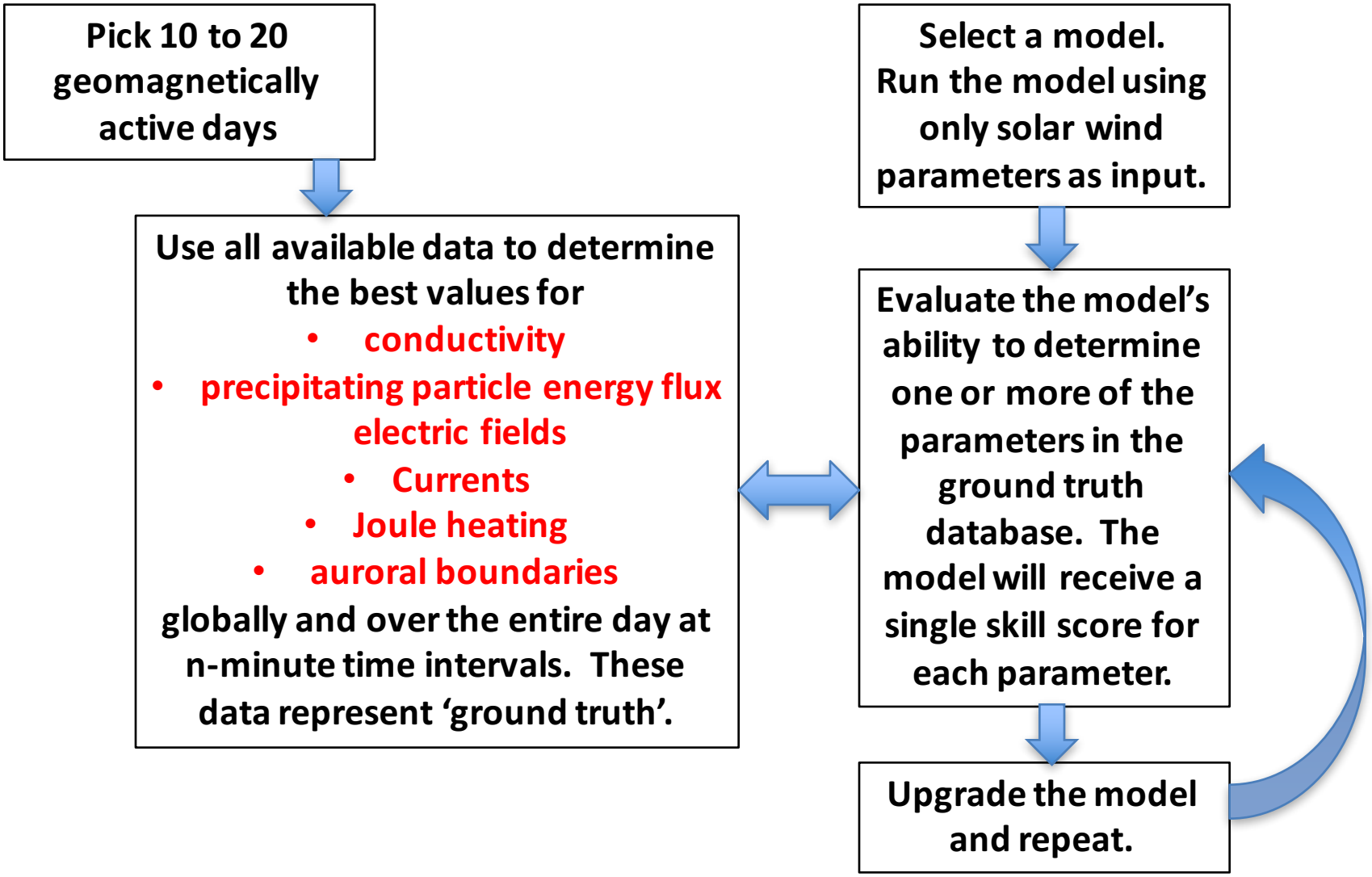
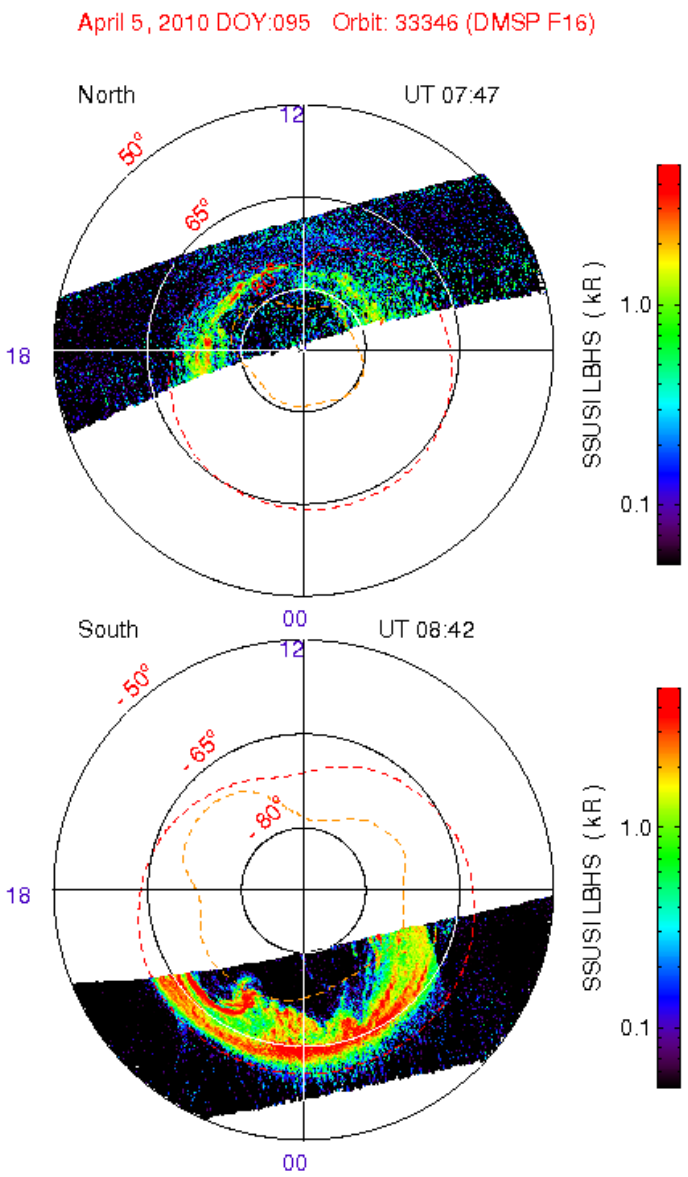
Metric Steps



Ground-truth: Energetic Particle Precipitation

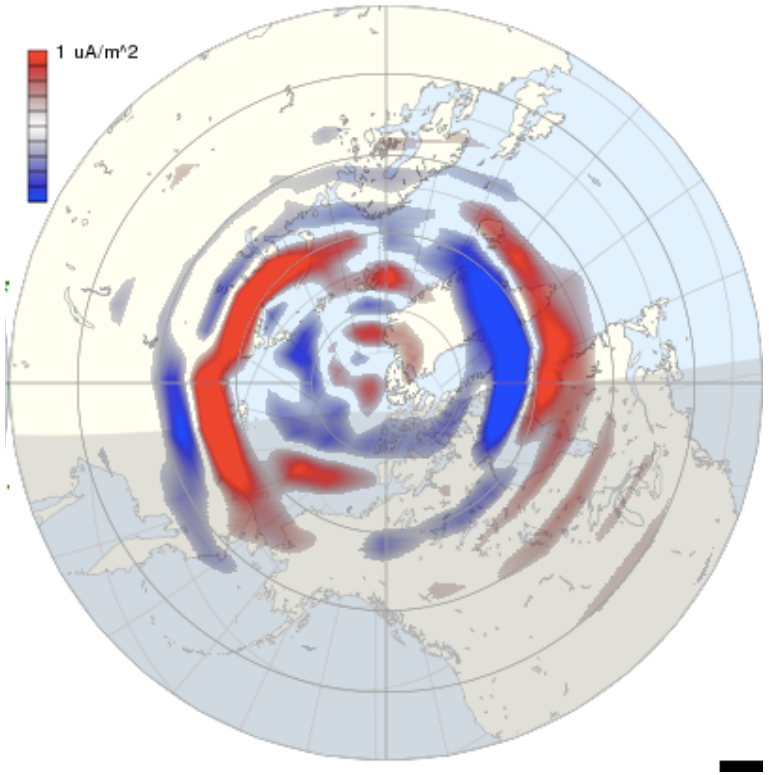


Use TIMED GUVI Far Ultraviolet observations to infer energy flux and mean energy of precipitating electrons and protons

Ground-truth: Conductivities

- Infer conductivities from the average energy and energy flux from GUVI observations
- Validate the conductivity values using incoherent scatter radar
- Develop an inversion methodology for conductivities produced by protons
- Validate conductivities with Ovation-Prime and ground-based magnetometer measurements

Ground-truth: Electric fields



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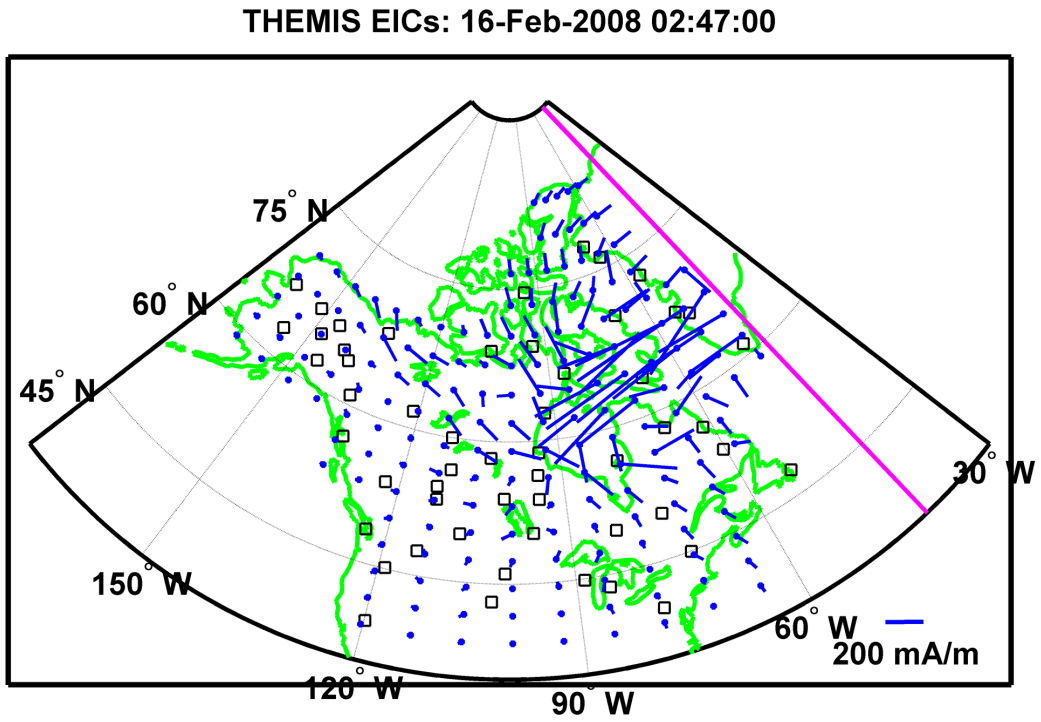
- Combine conductivities with field-aligned currents to solve for electrostatic potential
- Use incoherent scatter radars and SuperDARN to validate electric fields

Ground-truth: Currents



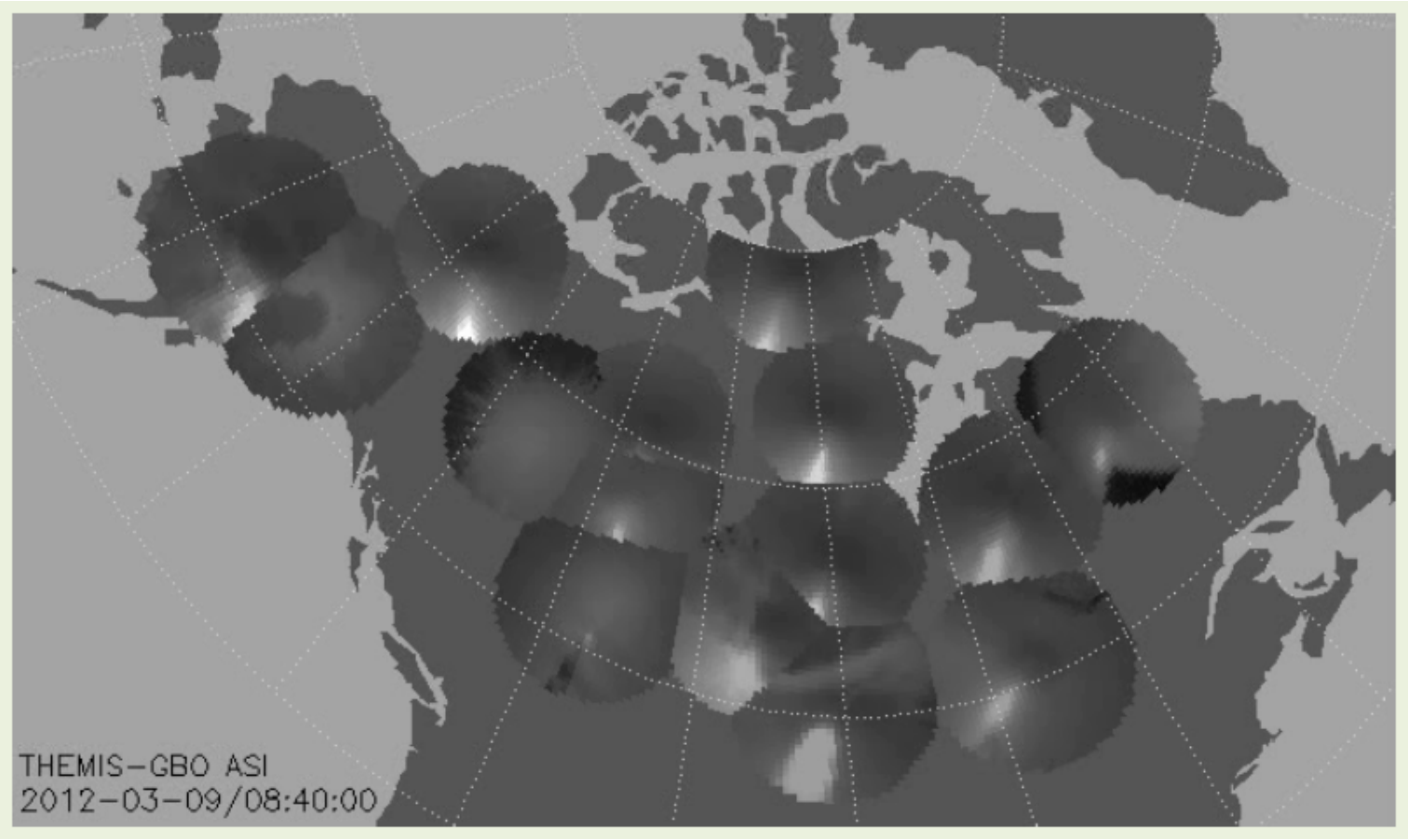
- Use electric fields and conductivities to calculate horizontal ionospheric currents
- Validate currents using ground-based magnetometer measurements

Ground-truth: Joule heating

- Use validated electric field and conductivities
- Use validated currents and electric fields
- Validate and selected locations using incoherent scatter radar

Ground-truth: Auroral Boundaries

- Use GUVI imaging data, ground-based optical images, AMPERE, ground-based magnetometers, Aurorasaurus, and Ovation-Prime



How to Evaluate Auroral Model Output

Property	One-D Form	Two-D Form
Auroral Conductivities	HPI	Map
Energy Flux from Precipitating Particles	HPI	Map
Electric Fields	CPCP	Map
Currents	AE	Map
Joule Heating	JHPI	Map
Auroral Boundaries	RMS difference summed at 24 MLTs	N/A

How quantitative assessments against ground-truth values will be done

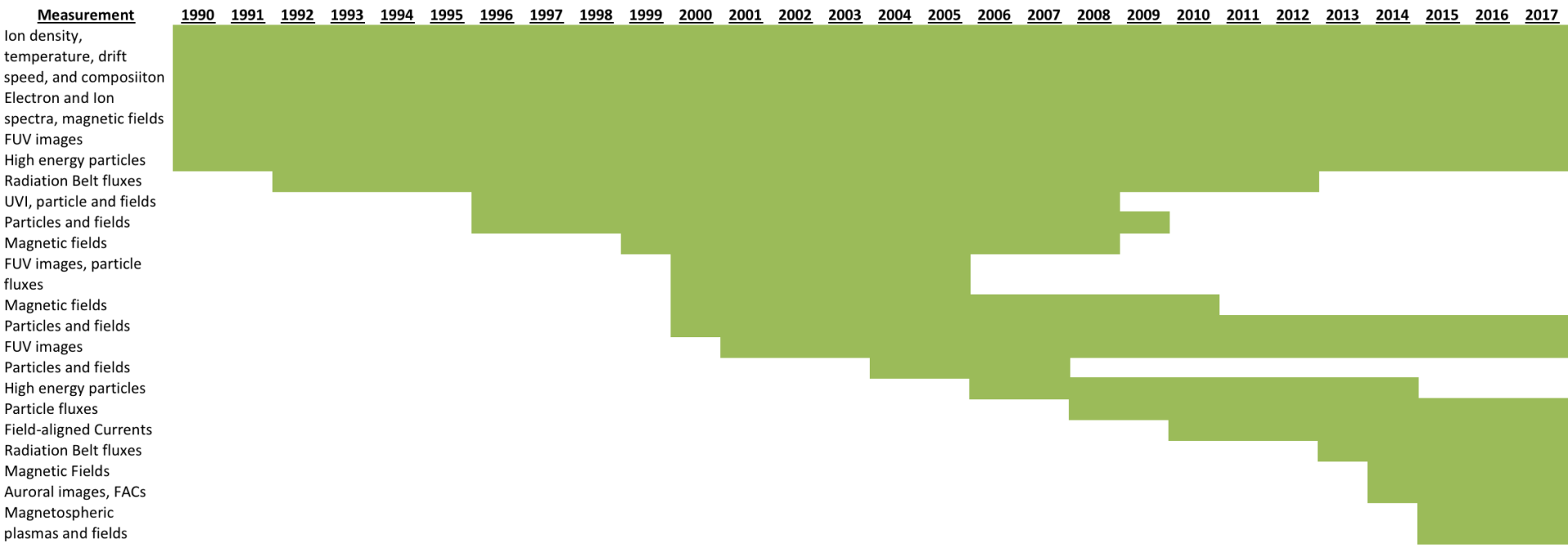
- Calculate either one-D or two-D correlation coefficient
- Shift in time and space to account for spatial or temporal shifts
- Assessment should only be done on validated ground-truth data over the regions where the data are valid
- Or: Use OTS Pattern Recognition Software
- All groups should use the same methodology for metrics-based validation assessment

EVENT SELECTION

- So far based on events identified in GEM conductance challenge
- Three in common with events selected by Geomagnetic Index Group
- Availability of ground-truth data sets has not been looked at yet

The SWPC events:
Oct 29-31, 2003
15-Dec-06
31-Aug-01
31-Aug-05
5-Apr-10
8/5/2011 (GEM event also)
Plus:
3/17/2013 (GEM event also)
3/17/2015 (GEM event also)
November 9-10, 2004
April 6-7, 2000
July 22-27, 2004
17-Sep-11
9-Mar-12
1-Mar-11
31-Mar-01
14-May-05
Other GEM Conductance Challenge Days
2016 Oct 13-15
2010 Apr 4-6
2015 Jun 21-24
2015 Dec 19-21
2016 Jan 20
2016 Mar 6-8
2016 May 7–8
2016 Oct 13-15
2011 April 27-May 4
2012 May 7-14

Model	POC	Institution	Model Type	Input	Output							
					Auroral Precipitation Properties	Conductivities	Electric Fields	Horizontal Currents	Field-aligned Currents	Joule Heat	Poynting Flux	Ground Magnetic Perturbations
CMIT/LFM-MIX	John Lyon, Wenbin Wang, Slava Merkin, Mike Wiltberger, Pete Schmitt, and Ben Foster	Dartmouth College/NCAR-HAO/JHU-APL/CISM	Physics-based MHD	SW data, EUV, tides, AQ, AS, AT, AU			■	■	■	■		
OpenGGCM	Joachim Raeder, Timothy Fuller-Rowell	Space Science Center, UNH	Physics-based MHD	SW data			■	■	■	■		
SWMF/BATS-R-US with CRCM	Tamas Gombosi et al., Mei-Ching Fok et al., Gabor Toth et al.	CSEM	Physics-based MHD	SW data			■	■	■	■		
BATS-R-US	Dr. Tamas Gombosi et al.	CSEM	Physics-based MHD	SW data			■	■	■	■		
GUMICS	Pekka Janhunen et.al.	FMI	Physics-based MHD	SW data			■	■	■	■		
AMIE	Richmond, Lu	HAO NCAR	Data Assimilation	Multiple sources	■	■	■	■				
RCM	Stanislav Sazykin	Department of Physics and Astronomy, Rice University	Physics-based	Magnetic field model, plasma density	■	■	■	■	■	■	■	
Ovation Prime 2013	Tom Sotirelis	JHU APL	Statistical (from DMSP data)	Solar Wind and IMF data	■							
Cosgrove-PF	Russel B. Cosgrove	Center for Geospace Studies, SRI International,	Statistical (from FAST data)	Solar Wind, AL Index							■	
Weimer	Daniel R. Weimer	Virginia Tech	Statistical	Solar Wind, AE, AL			■					
AMPERE-Derived Electrodynamic Parameters	Robinson	CUA	Specification	AMPERE data		■	■	■	■	■		■
Fang Parameterization Model	Xiaohua Fang	U. of Colorado	Parametrization of full transport codes	Electron and proton fluxes		■						
GLOW	Stan Solomon	NCAR	Transport Code	Electron Fluxes		■						
GUVI auroral model	Yongliang Zhang	JHU/APL	Empirical			■						


Measurement
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2013
2014
2015
2016
2017
Ion density, temperature, drift speed, and composiiton
Electron and Ion spectra, magnetic fields
FUV images
High energy particles
Radiation Belt fluxes
UVI, particle and fields
Particles and fields
Magnetic fields
FUV images, particle fluxes
Magnetic fields
Particles and fields
FUV images
Particles and fields
High energy particles
Particle fluxes
Field-aligned Currents
Radiation Belt fluxes
Magnetic Fields
Auroral images, FACs
Magnetospheric plasmas and fields

Instrument/Facility	Measurement
Intermagnetic	Ground DB
SuperDARN	E-fields
Incoherent Scatter Radars, Millstone, PFISR, RISR, Sondrestrom	Precipitating energy flux, mean energy, conductivity,
Poker Flat Research Range	Auroral images
Canadian Geospace Monitoring	Auroral emissions, images, ground DB
European Observatories: Kjell Henriksen Observatory, Tromso Geophysical	Auroral emissions, images, ground DB
CANMOS/CARISMA/CANOPUS	Ground DB
MACCS	Ground DB/Pulsations
MIRACLE (Finland)	All-sky cameras
THEMIS/Ground	Auroral images
Mid-continent Magnetoseismic Chain (McMAC)/FALCON	Ground DB/Pulsations
STEP (Japan)	Ground DB/Pulsations
SuperMAG	Ground DB
Aurorasaurus	Auroral images

Next Steps

- Further event selection taking into account data availability
- Select one event to test methodology for creating a ground-truth database
- Select a model for testing the test procedure
- Run the model and assess the output using standardized, quantitative comparison methodologies
- Write up the results