## Metric Steps

Pick 10 to 20 geomagnetically active days

Use all available data to determine the best values for

- conductivity
- precipitating particle energy flux electric fields
  - Currents
  - Joule heating
  - auroral boundaries

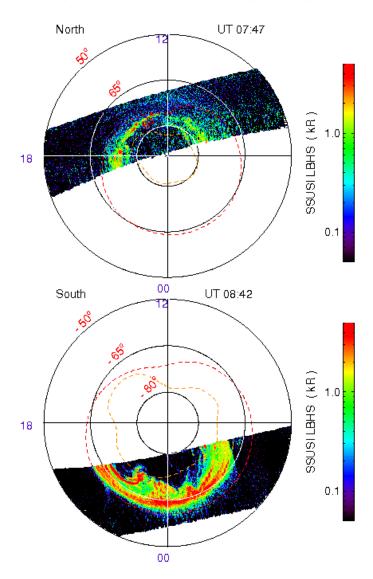
globally and over the entire day at n-minute time intervals. These data represent 'ground truth'. Select a model.
Run the model using only solar wind parameters as input.

Evaluate the model's ability to determine one or more of the parameters in the ground truth database. The model will receive a single skill score for each parameter.

Upgrade the model and repeat.

### **Ground-truth: Energetic Particle Precipitation**

April 5, 2010 DOY:095 Orbit: 33346 (DMSP F16)

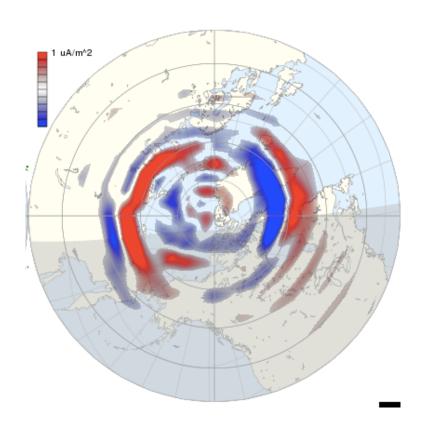


Use TIMED GUVI Far
Ultraviolet
observations to infer
energy flux and mean
energy of
precipitating
electrons and protons

#### **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

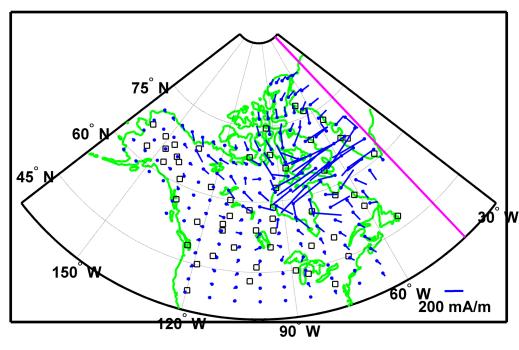
#### **Ground-truth: Electric fields**



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

## **Ground-truth: Currents**





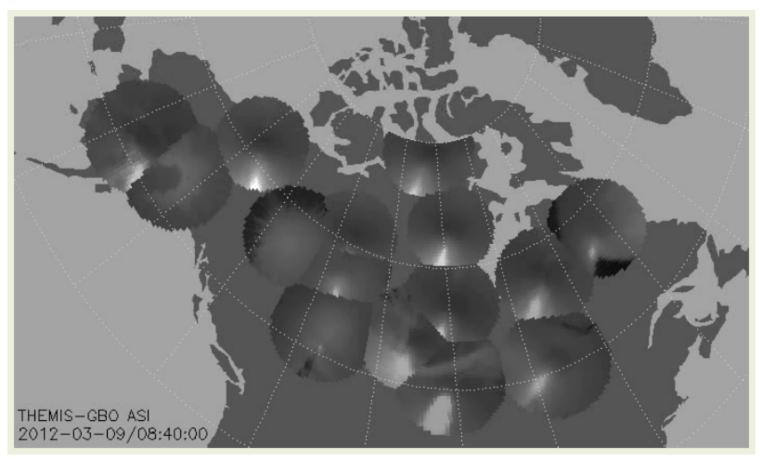
- Use electric fields and conductivities to calculate horizontal ionospheric currents
- Validate currents
   using ground-based
   magnetometer
   measurements

# 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	Мар
Energy Flux from Precipitating Particles	HPI	Мар
Electric Fields	CPCP	Мар
Currents	AE	Мар
Joule Heating	JHPI	Map
Auroral Boundaries	RMS difference	N/A
	summed at 24 MLTs	

# 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

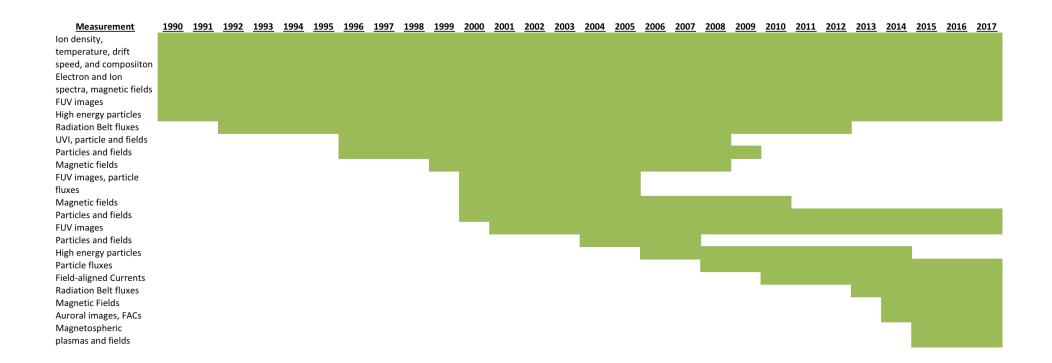
#### **EVENT SELECTION**

- So far based on events identified in GEM conductance challenge
- Three in common with events selected by Geomagnetic Index Group
- Availability of groundtruth 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

<u>Model</u>	POC	Institution	Model Type	<u>Input</u>	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 GUVI auroral model	Stan Solomon Yongliang Zhang	NCAR JHU/APL	Transport Code Empirical	Electron Fluxes								



Instrument/Facility Intermagnetic	<u>Measurement</u> Ground DB	<u>1990</u>	<u>1991</u> 199	<u>1993</u>	<u>1994</u> <u>1</u>	1995 <u>1996</u>	<u>1997</u>	<u>1998</u> <u>199</u>	<u> 2000</u>	<u>2001</u> <u>2</u> 0	<u>002</u>	<u>2003</u> <u>20</u>	<u>04</u> <u>2005</u>	2006	2007	2008	2009	<u>2010</u>	<u>2011</u>	<u>2012</u>	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>
SuperDARN	E-fields																								
Incoherent Scatter Radars, Millstone, PFISR, RISR, Sondrestrom Poker Flat Research Range	Precipitating energy flux, mean energy, conductivity, Auroral images																								
Canadian Geospace Monitoring	Auroral emissions, images, ground DB																								
European Observatories: Kjell Henrikse Observatory, Tromso Geophysical	ground DB																								
CANMOS/CARISMA/CANOPUS	Ground DB																								
MACCS	Ground DB/Pulsations				П																				
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