

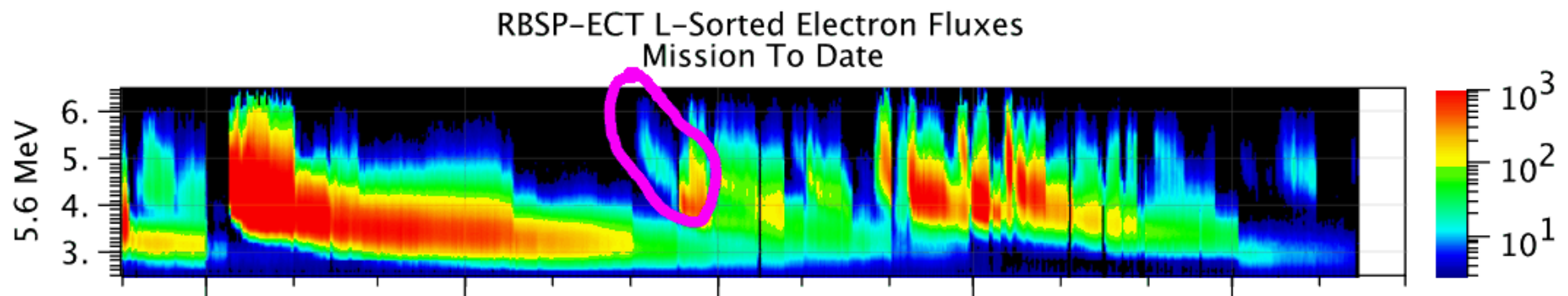
# ULF Wave Modeling Challenge – Motivation

- Presently lots of interest in the radiation belts
- Some radiation belt dynamics are governed by ULF wave fields in the global magnetosphere.
  - Outstanding questions
    - Local time range of ULF wave power?
    - SW driven (dayside) or KH driven (flanks/nightside)?
    - Relative contribution of each?
- Modular “GGCM’s” ideally suited to contribute here
- Is the ULF wave field sufficient to radially diffuse relativistic electrons?
  - Is it steady or episodic?
  - Do these dynamic fluctuations integrate to “diffusion”? How?

# Potential science questions

- Idealized runs
  - Can the model magnetosphere support FLRs?
    - Over what range of frequencies?
  - How does the plasmasphere/ring current change these FLRs?
  - How does grid resolution and numerical resistivity change the FLRs?
  - What is the modeled local time distribution of FLRs?
    - Does that agree with empirical models or observations?
  - ...
- 1-15 March 2013 interval
  - What ULF frequencies are supported in the magnetosphere from 1-15 March 2013?
  - Are they directly driven from the solar wind?
  - Continuously driven or episodically driven?
  - How are the ULF waves from 1-15 March different from other intervals?
  - Is the wave power sufficient, and for long enough, to radially diffuse energetic electrons?
    - Can coupled simulations reproduce this 1 Re diffusion in 2 weeks?
  - ...

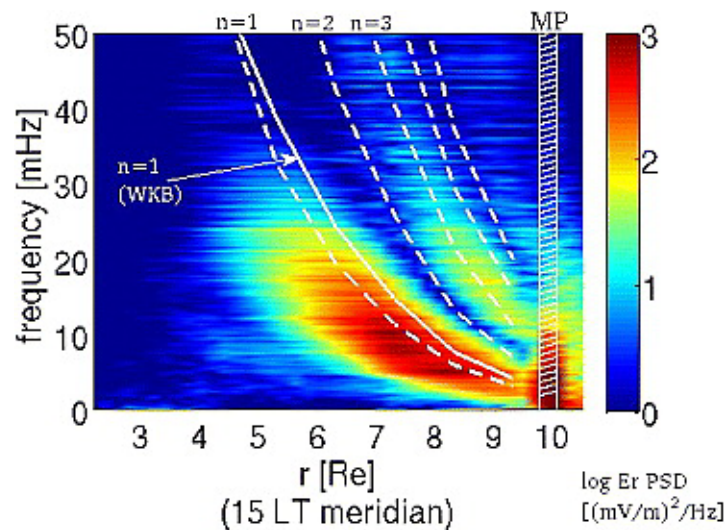
- We're organizing a modeling challenge to investigate the ability of global models to reproduce ULF wave fields in the magnetosphere, and ultimately if those ULF fields can radially diffuse an existing electron population from  $L \sim 5.5$  to  $L \sim 4.5$  in two weeks. To get there, we can split the question into two distinct ones:
  - 1. Can global models of the magnetosphere reproduce the observed persistent, solar wind driven, low mode number ULF wave fields in the magnetosphere? and...
  - 2. Are those waves capable of producing the observed energetic radiation belt population evolution observed during the first two weeks of March 2013 as observed by Van Allen Probes?



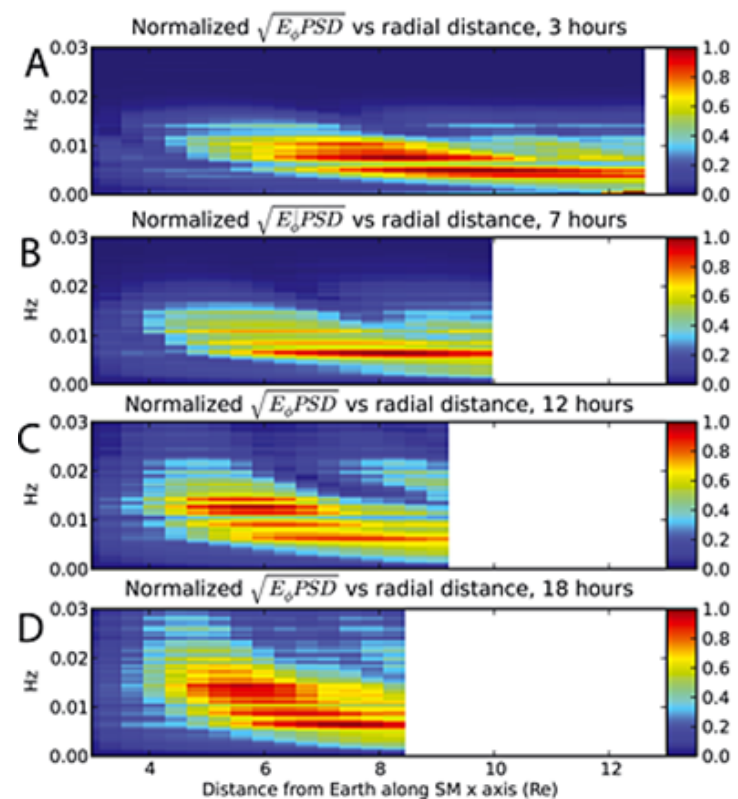
- The figure above is the REPT flux from [http://www.rbsp-ect.lanl.gov/science/LTPlots/RBSP-ECT\\_LT\\_Mission\\_plot.pdf](http://www.rbsp-ect.lanl.gov/science/LTPlots/RBSP-ECT_LT_Mission_plot.pdf) with the interval I mentioned circled in pink. Tick marks in time (x-axis) are one month in duration. The modest electron belt which starts out at  $L \sim 5.5$  seems to diffuse inward a whole  $L$  in two weeks. A key aspect of these questions which MHD models could uniquely constrain is the fraction of the diffusion which is accomplished by solar wind driving alone.
- The 1st question above may be divided into two basic ULF wave challenges dealing with (Level 0) a idealized continuum of solar wind frequencies [i.e. Claudepierre et al., 2010, Paragraph 12] and (Level 1) the real solar wind input from 1-16 March 2013.

# Proposed “Metric” for model/model comparison

Claudepierre et al., 2009



Hartinger et al., 2014



Journal of Geophysical Research: Space Physics

Volume 115, Issue A11, A11202, 5 NOV 2010 DOI: 10.1029/2010JA015399

<http://onlinelibrary.wiley.com/doi/10.1029/2010JA015399/full#jgra20604-fig-0007>

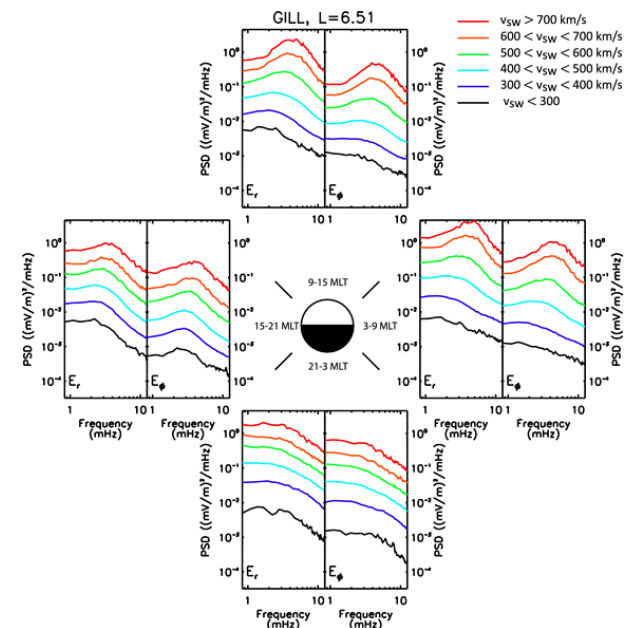
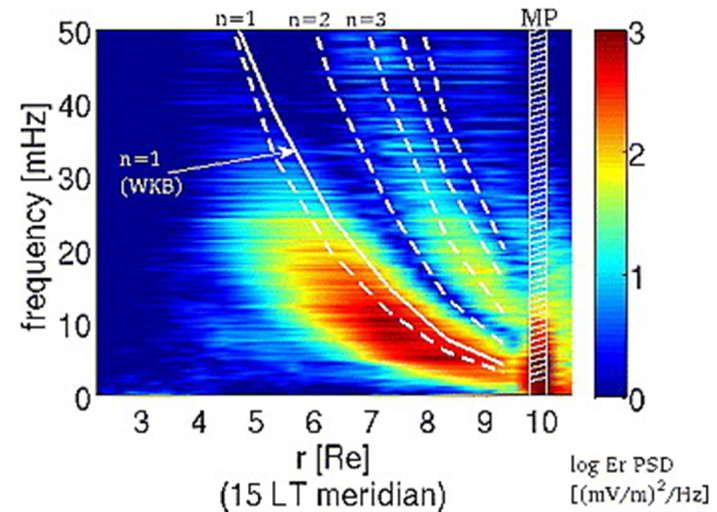
Journal of Geophysical Research: Space Physics

Volume 119, Issue 10, pages 8212-8227, 16 OCT 2014 DOI: 10.1002/2014JA020401

<http://onlinelibrary.wiley.com/doi/10.1002/2014JA020401/full#jgra51354-fig-0003>

# Proposed Model/Data comparison?

- Comparison to empirical maps of ULF PSD?
  - Made from ground?
  - Made from space?



# What we need

- **Observations**

- Remotely sensed ULF wave fields from magnetometers (U. Alberta)
- Space-based ULF wave power from March, 2013 (Sarris/Schiller)
- EMFISIS wave fields from Van Allen Probes (who?)
- ...

- **Models**

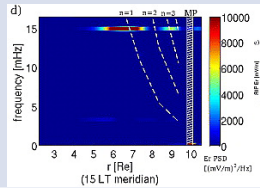
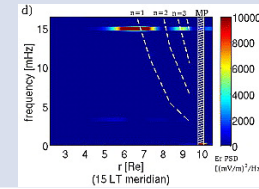
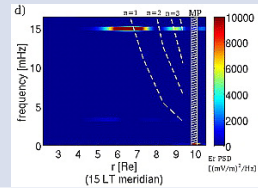
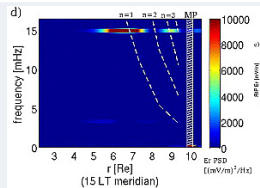
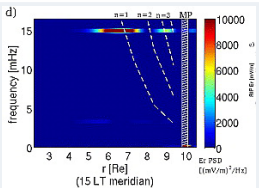
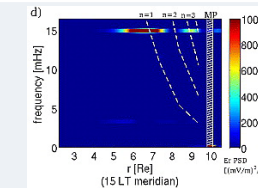
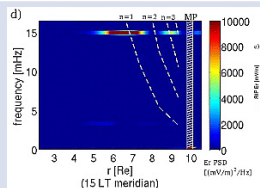
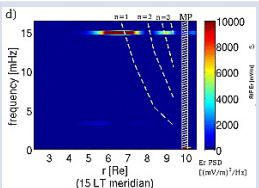
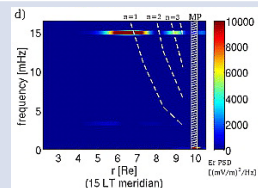
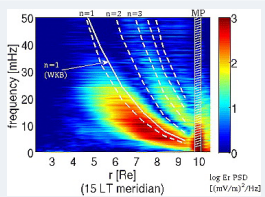
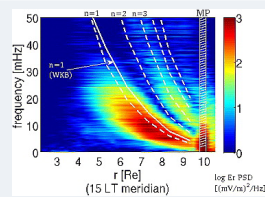
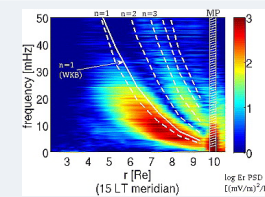
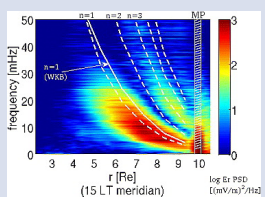
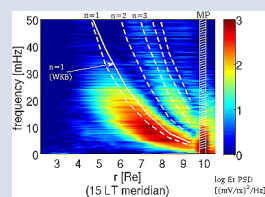
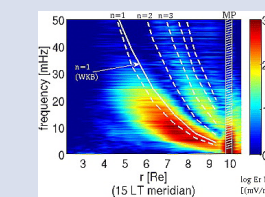
- LFM (Claudepierre)
- BATS-R-US (Hartinger)
- Radial diffusion models coupled or not (CCMC?)
- ...

- **Coordination**

- CCMC for runs/analysis (Lutz with Claudepierre & Hartinger tools)
- What should we compare first?
  - Idealized runs at CCMC with Alberta empirical PSD?
  - March 1-15 runs at CCMC with which data?

**BACKUP**

# Proposed run matrix

SW driver	Stand-alone MHD	+ plasmasphere	+ plasmasphere + ring current	Verification/validation
10 mHz upstream driver				FLR at the upstream frequency
20 mHz upstream driver				FLR at the upstream frequency
30 mHz upstream driver				FLR at the upstream frequency
Continuum				Ozeke et al., 2012?
1-15 March 2013 solar wind				Ground based measurements?

Thinking about “ensemble modeling” yet? ☺



- From: Howard Singer <howard.singer at noaa.gov>,
- Lutz Rastaetter <lutz.rastaetter at nasa.gov> and
- Tim Guild <timothy.guild at aero.org>
- 
- The Metrics and Validation Focus Group will hold one session at the
- Mini-GEM workshop at the Westin San Francisco on Sunday, 12/14, at
- 12PM in the Cornell room. While we welcome any and all contributions
- which address the Metrics and Validation focus group goals, we will
- discuss two topics in particular.
- 
- Magnetopause challenge: Models have been shown to differ strongly in
- the magnetopause location for the same solar wind conditions. We know
- that nightside (magnetotail) activity may result in considerable
- changes of the magnetopause in the day side. We are looking for
- events that have two or more spacecraft in the day side that crossed
- the magnetopause at nearly the same time and events where the solar
- wind conditions do not change but the dayside magnetopause was found
- passing spacecraft.
- 
- ULF Wave Modeling Challenge: We're organizing a modeling challenge to
- investigate the ability of global models to reproduce ULF wave fields
- in the magnetosphere, and ultimately if those ULF fields can radially
- diffuse an existing radiation belt electron population from  $L \sim 5.5$  to
- $L \sim 4.5$  in two weeks. We can split this overarching question into two
- distinct ones:
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- persistent, solar wind driven, low mode number ULF wave fields in the
- magnetosphere? and...
- 2. Are those waves capable of producing the observed energetic
- radiation belt population evolution observed during the first two
- weeks of March 2013 as observed by Van Allen Probes?
- 
- We encourage contributions from modeling, observations, and
- informative validation techniques which can inform us of shortcomings
- in our knowledge of the geospace environment, contributing to the GEM
- goals. In the spirit of GEM, we welcome brief, spontaneous
- presentations, but to help with planning, if you would like to speak
- on one of the topics listed, or anything else related to M&V, please
- send a note to Tim Guild with your name and a title for your
- contribution.