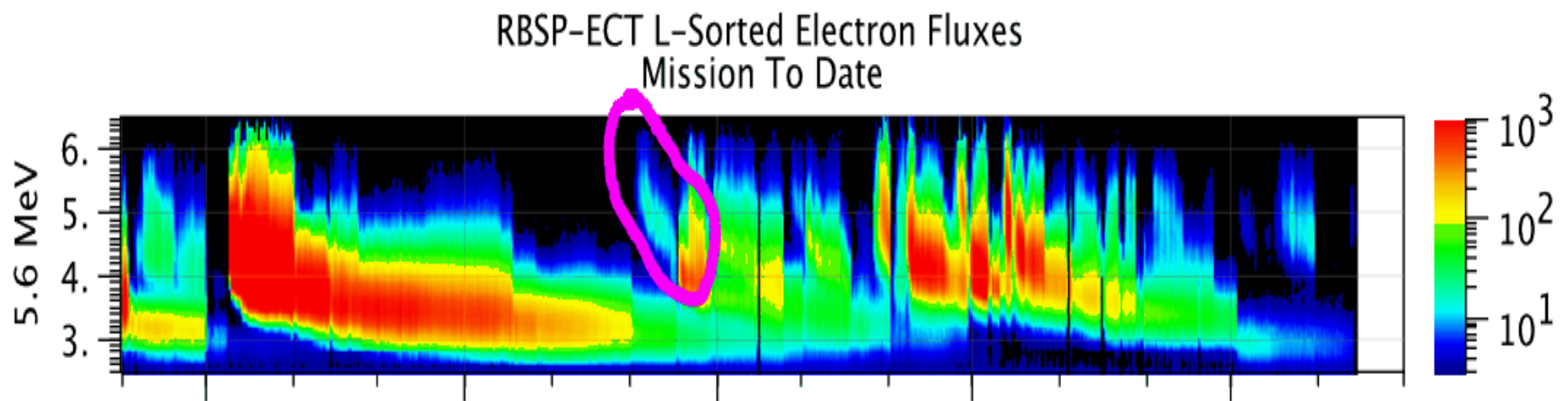


GEM M&V ULF Wave Challenge: Motivation

- Some events clearly show inward radial transport of energetic electron populations in the outer belt
 - 1-16 March 2013 (Li et al., 2014) - SLOW
 - March 17th 2015 (Jaynes, Monday) - FAST
- ULF waves can contribute to radial transport of energetic electrons.
- Global MHD models are capable of supporting ULF wave fields in the simulated magnetosphere [Claudepierre et al., 2008, Hartinger et al, 2014]
 - Is the MHD ULF wave power correct?
 - Is it sufficient to radially transport electrons this much, this fast?
 - How accurate do the ULF waves need to be simulated to reproduce radiation dynamics?

- 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?

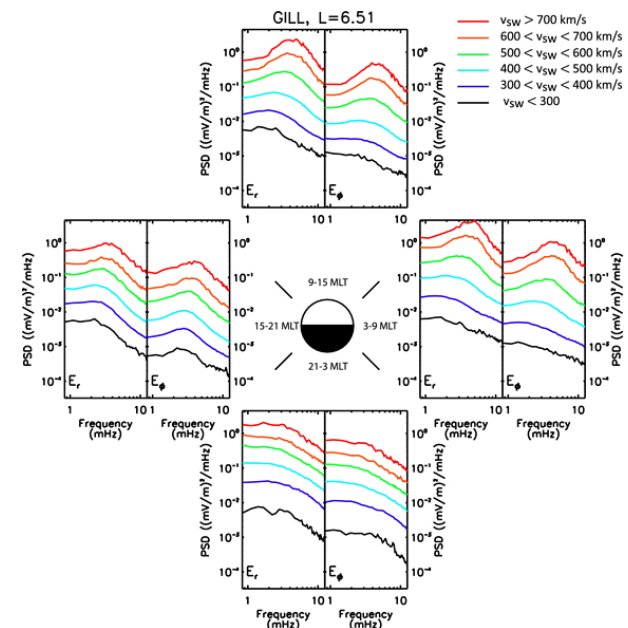
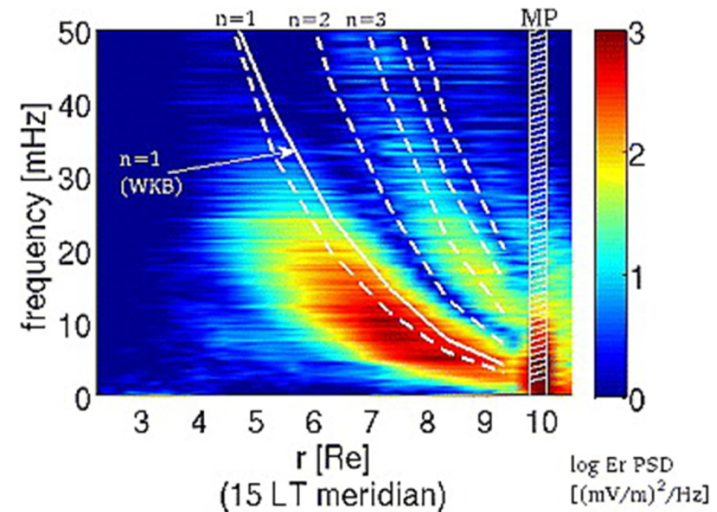


Potential science questions

- Idealized runs
 - Can the model magnetosphere support KHI, FLRs?
 - Over what range of frequencies?
 - How does the plasmasphere/ring current change these ULF waves?
 - How does grid resolution and numerical resistivity change the ULF waves?
 - What is the modeled local time distribution of ULF waves?
 - 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 or KH on the flanks?
 - Continuously driven or episodically driven?
 - How are the ULF waves from 1-15 March different from other intervals, specifically March 17th 2015?
 - Is the wave power sufficient, and for long enough, to radially transport energetic electrons?
 - Can coupled simulations reproduce this 1 Re diffusion in 2 weeks?
 - Can coupled simulations reproduce faster diffusion in March 2015?

Proposed Model/Data comparison?

- Comparison to empirical maps of ULF PSD?
 - Made from ground?
 - Made from space?
- This is a different kind of “validation” in frequency domain.



Challenges/Issues/Lessons Learned

- ULF waves simulated in global MHD: KHI, toroidal FLR, cavity/waveguides, shock compressions, magnetopause surface eigenmodes
- ULF waves not simulated: ring-current driven, non-MHD driven, poloidal ULF
- Boris correction
- Numerical dissipation
- Grid effects in solar wind driving
- Role of plasmasphere

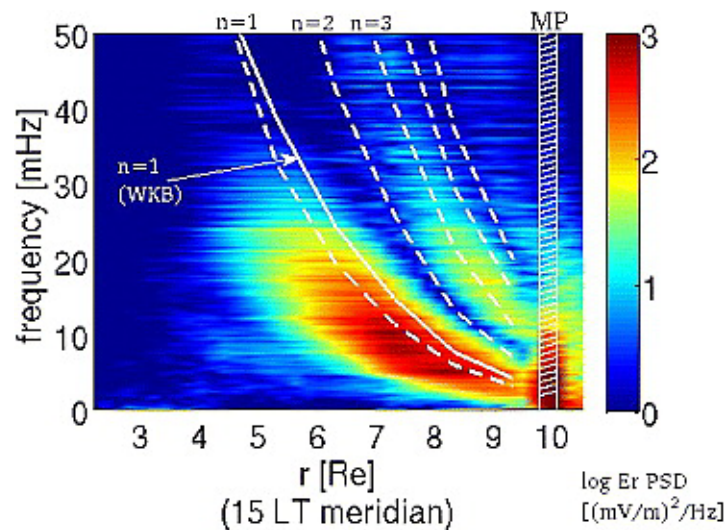
Agenda

- Observations
 - Ian Mann: Preliminary challenge time periods based on ground magnetometers
 - Peter Chi: Global distribution of ULF power from ULTIMA, and in-situ observations of poloidal waves
 - Ashar Ali: From Van Allen Probes E & B measurements to radial diffusion coefficients.
 - Chih-Ping Wang: Observations (RBSP, THEMIS, Geotail) and simulations (LFM) of a 2-hour ULF wave interval.
- Simulations
 - Lutz Rastaetter: Newly developed CCMC analysis tools supporting the ULF Challenge, and initial results
 - Colin Komar: ULF power in the BATSRUS model and resonance conditions with electrons
 - Bob Lysak: ULF waves in local MHD model
 - Slava Merkin: ULF waves in the LFM.
 - Scot Elkington: Mode structure calculations
 - Qianli Ma: Radial diffusion model of March 2013 interval

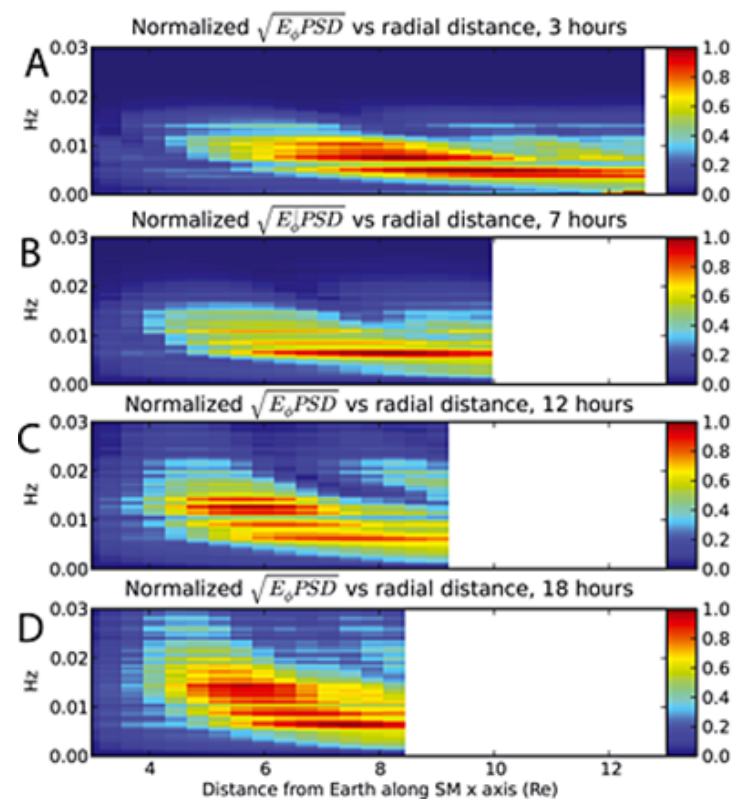
BACKUP

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

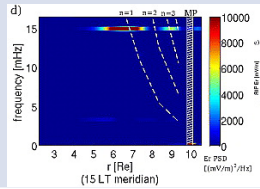
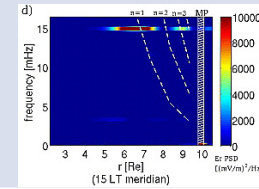
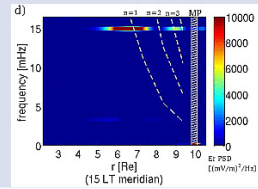
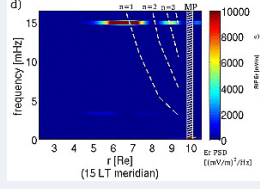
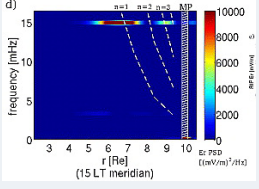
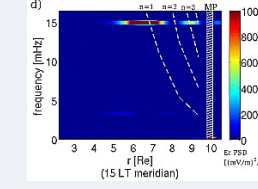
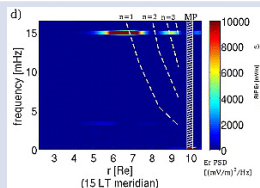
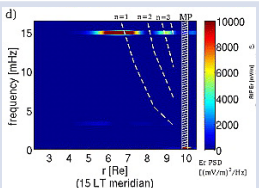
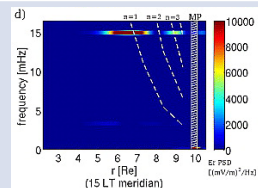
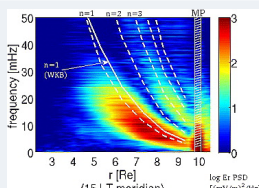
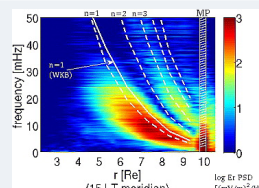
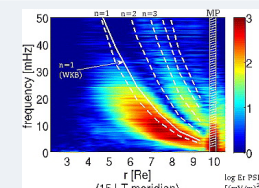
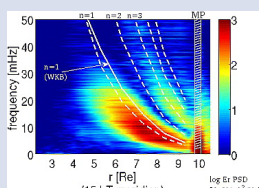
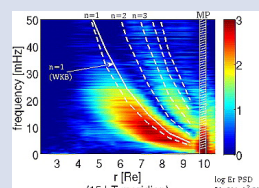
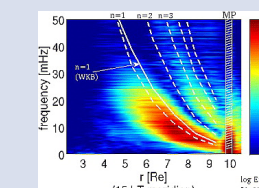
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<http://onlinelibrary.wiley.com/doi/10.1002/2014JA020401/full#jgra51354-fig-0003>

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? ☺