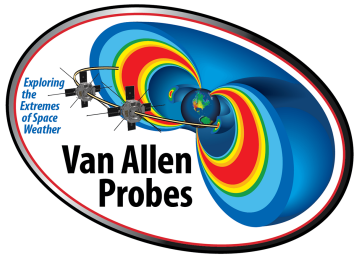

The Angular Distribution of Whistler-Mode Chorus and the Importance of Plumes in the Chorus-Hiss Mechanism

D. P. Hartley, *L. Chen, C. A. Kletzing, R. B. Horne, and O. Santolík*

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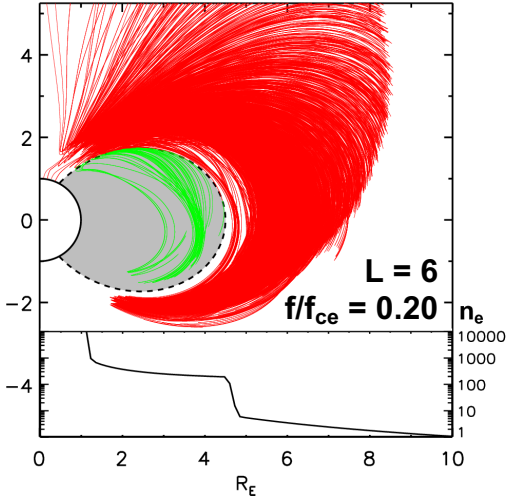
Ray Tracing: Chorus-to-Hiss Mechanism

Observations have shown strong correlation between chorus and hiss

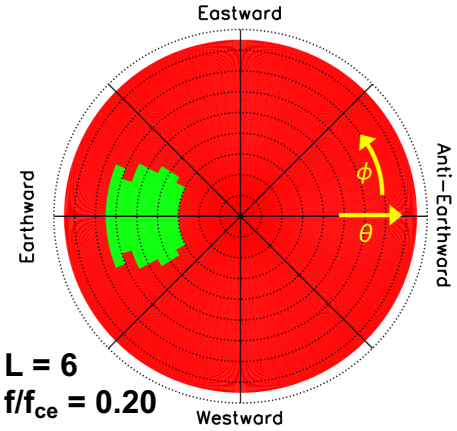
Ray tracing setup - waves launched from sources located at
L = {5, 6}, MagLat = {0°, 10°, 20°} with f/f_{ce} *= {0.10, 0.15, 0.20}*

Obtain chorus wave vector directions that enter plasmasphere from each source location (azimuthally symmetric density model)



Enters plasmasphere

Does not enter plasmasphere



Green wave vector orientations do propagate into the plasmasphere, red do not

Results show chorus can access plasmasphere, but only under specific conditions:

Polar wave vector angle, *θ, between ~ 60°* to *40° (oblique to background B)*
Azimuthal wave vector angle oriented approximately Earthwards
Sources within *~3* R_E of p/pause
Frequencies from *0.05 to ~0.25* f_{ce}

How often do we observe chorus with these required conditions?

Comparing Data to Ray Tracing Results

Produce statistical maps of chorus normalized wave power (NWP) from Van Allen Probes survey mode observations

Polar angle, θ, is the angle between k-vector and background B, azimuthal angle, ϕ, is the angle of the k-vector around the background B with respect to the anti-Earthward direction

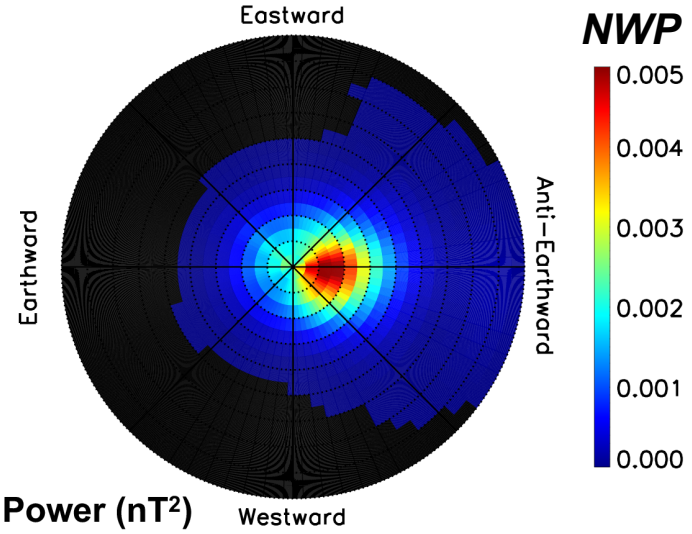
In all plots, the field-aligned direction is in the center, and the k-vector becomes more oblique towards the edge

Compare ray tracing simulations to these statistical maps

Determine fraction of chorus wave power that exists with conditions required to propagate into the plasmasphere (in green region of ray tracing plots)

Repeat for all wave source locations and wave frequencies

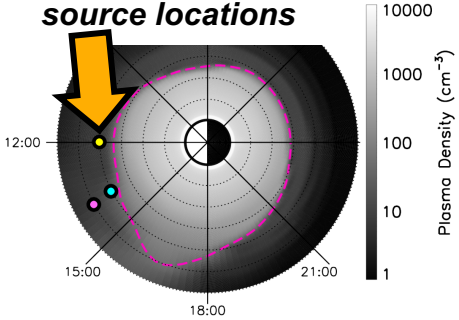
Less than 1% of wave power can enter plasmasphere for all source locations



	Wave Power	
	L = 5	L = 6
0.10 f_{ce}	0.91%	0.53%
0.15 f_{ce}	0.95%	0.38%
0.20 f_{ce}	0.87%	0.31%

Ray Tracing Near a Plume Structure

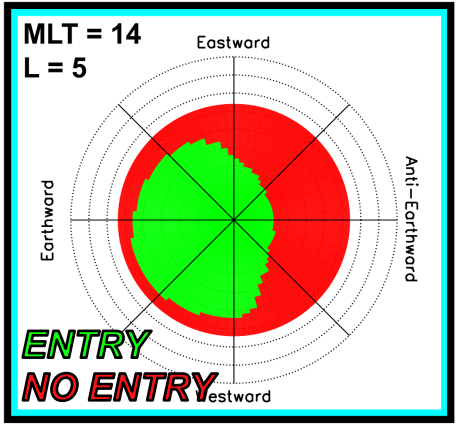
Plot borders are colour-coded to wave source locations

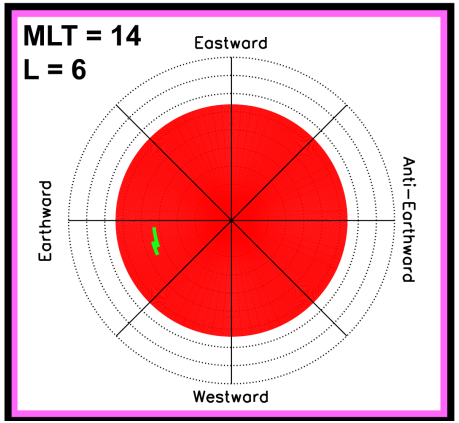


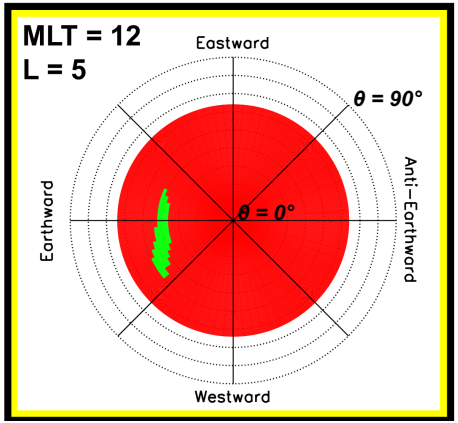
Ray trace from sources located near the plume

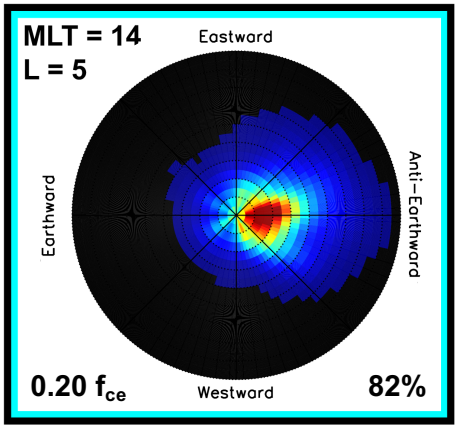
Plume expands range of wave vectors that can access plasmasphere (green area expands)

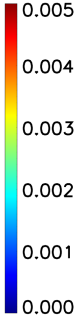
% of wave power that enters plasmasphere is very high near the plume, but drops off rapidly











	L = 5			L = 6		
	MLT 10	MLT 12	MLT 14	MLT 10	MLT 12	MLT 14
0.10 f_{ce}	<0.01%	0.16%	94%	0.03%	0%	4.9%
0.15 f_{ce}	0.02%	1.1%	86%	0%	0%	<0.01%
0.20 f_{ce}	0.04%	0.42%	82%	0%	0%	<0.01%

Plumes are an important access region for the chorus-to-hiss mechanism

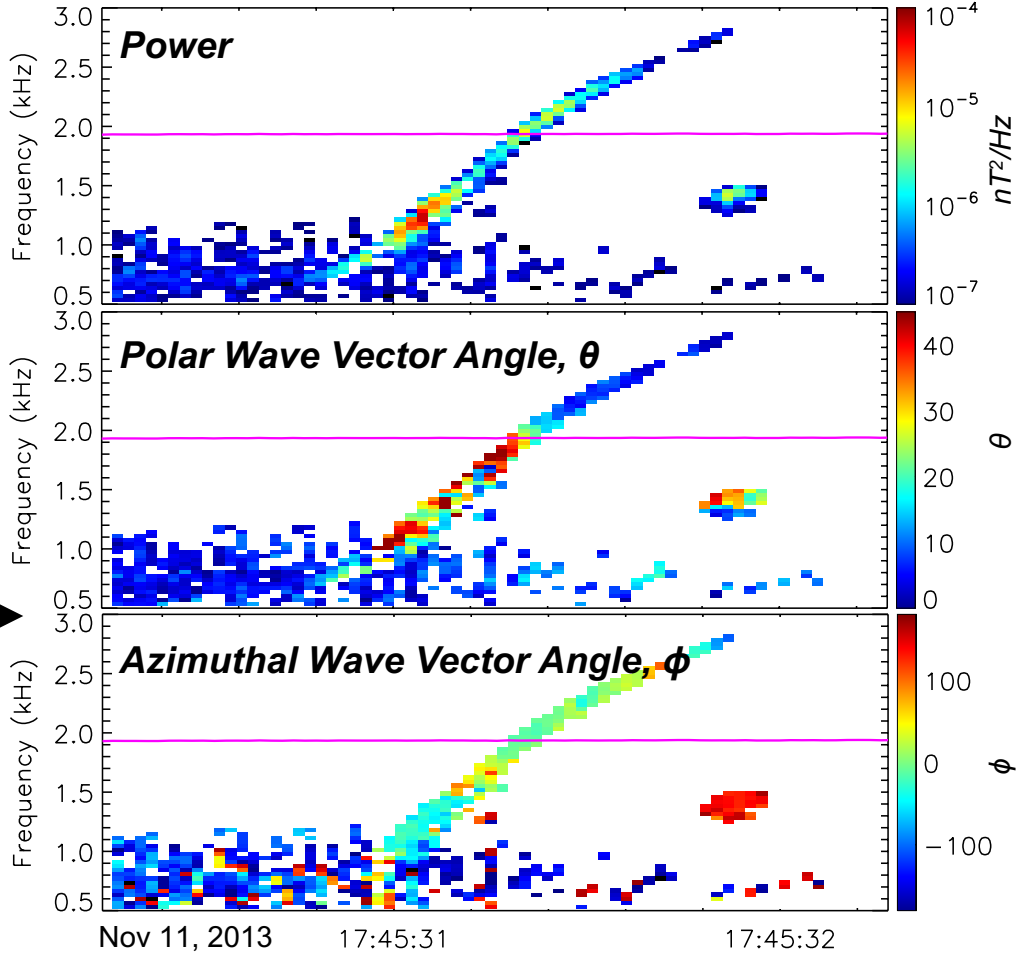
Short Timescale Chorus Variations

So far, angular wave power distributions are constructed using survey-mode data, but chorus wave vectors have been shown to vary on much shorter timescales that cannot be resolved by survey mode observations

The instantaneous wave vector direction can change by tens of degrees within a single chorus subpacket (*Santolik et al., 2013*)

Wave vector can also vary throughout the time-frequency structure of a chorus element (both polar and azimuthal angles)

How do these short timescale variations affect the survey mode statistics?



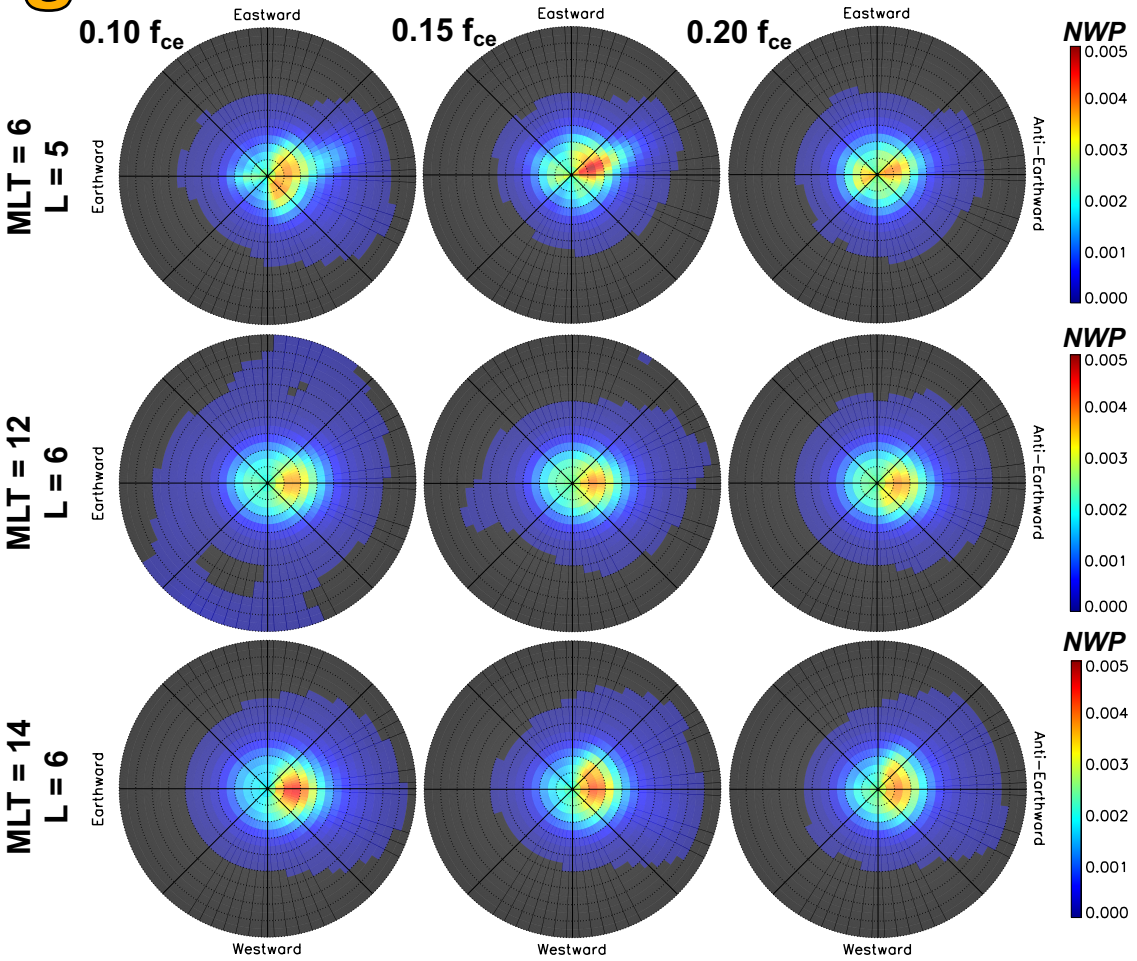
Burst-Mode Angular Power Distribution

RBSP-A continuous-burst mode chorus data, 3,982 different hourly files from Nov 2012 to Sept 2017

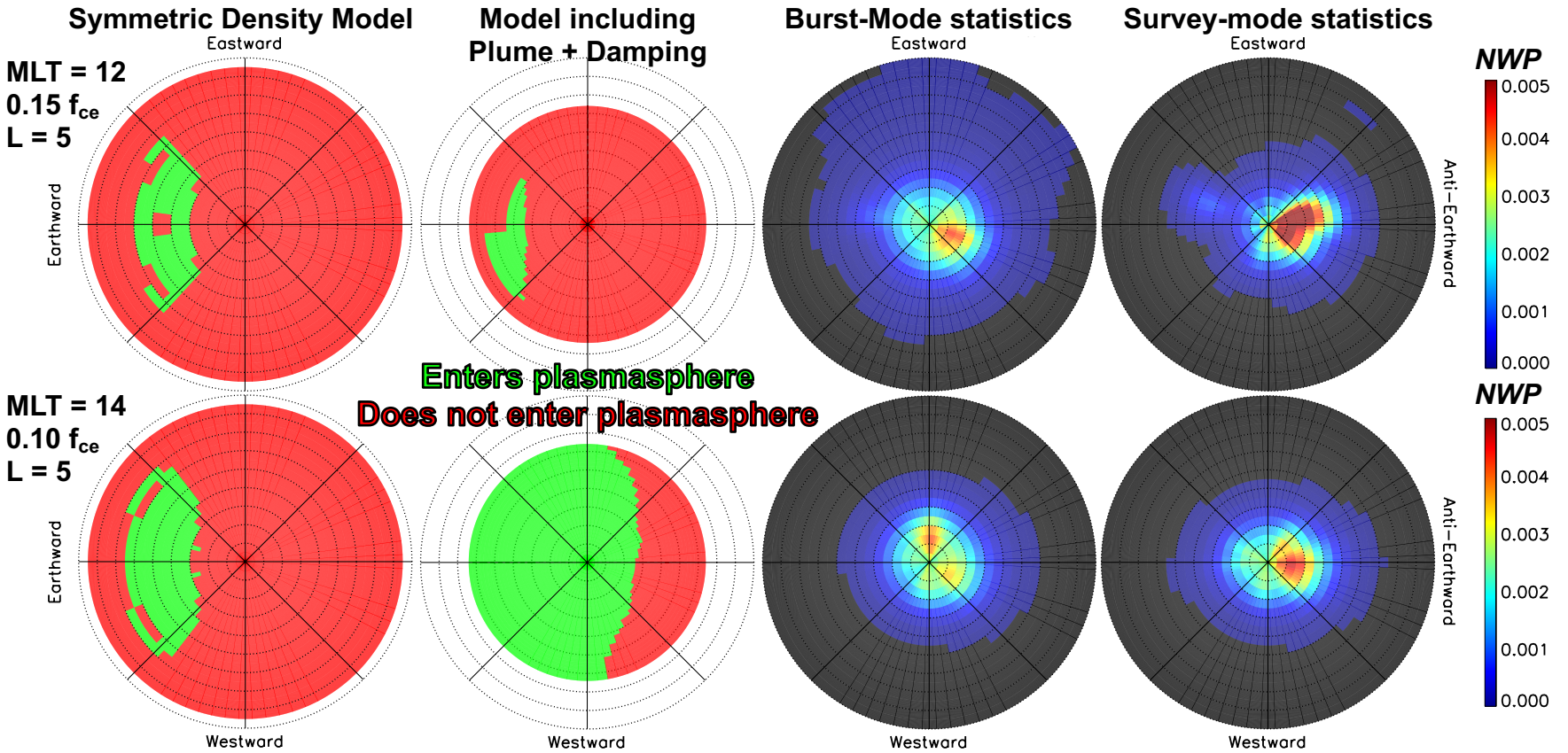
Continuous-burst mode data is biased towards active periods

Statistical burst-mode maps show majority of wave power is oriented almost parallel to B and slightly anti-Earthward: very small fractions oriented both oblique and Earthward for all f, L, and MLT ranges

Some East/West asymmetries, but these seem to reduce as more continuous-burst data is added



Burst-Survey Comparison Statistics



Burst/survey distributions are largely consistent, only small variations in wave power distributions

It is plume presence and proximity that dictates how much chorus can access the plasmasphere

Burst-Survey Comparison Statistics

	Percentage of Wave Power That Can Enter Plasmasphere: BURST (*SURVEY*)					
	L = 5			*L = 6*		
	MLT = 10	*MLT = 12*	*MLT = 14*	*MLT = 10*	*MLT = 12*	*MLT = 14*
0.10 f/f_{ce}	0.019% (*0.0005%*)	0.75% (*0.16%*)	96% (*94%*)	0.15% (*0.34%*)	0% (*0%*)	8.0% (*4.9%*)
0.15 f/f_{ce}	0.0017% (*0.020%*)	1.3% (*1.1%*)	95% (*86%*)	0% (*0%*)	0% (*0%*)	0.080% (*0.0058%*)
0.20 f/f_{ce}	0.0005% (*0.037%*)	0.61% (*0.42%*)	92% (*82%*)	0% (*0%*)	0% (*0%*)	0.015% (*0.0013%*)

Wave power percentages are consistent between burst and survey-mode observations: generally a little higher for burst-mode (accounting for short timescale WNA variations)

Plumes are identified as an important access region for chorus waves to enter the plasmasphere based on both burst and survey-mode analysis

Future work: Directly evaluate angular distribution of chorus waves near plumes, study how it varies with separation distance from the plume, and further ray tracing comparisons