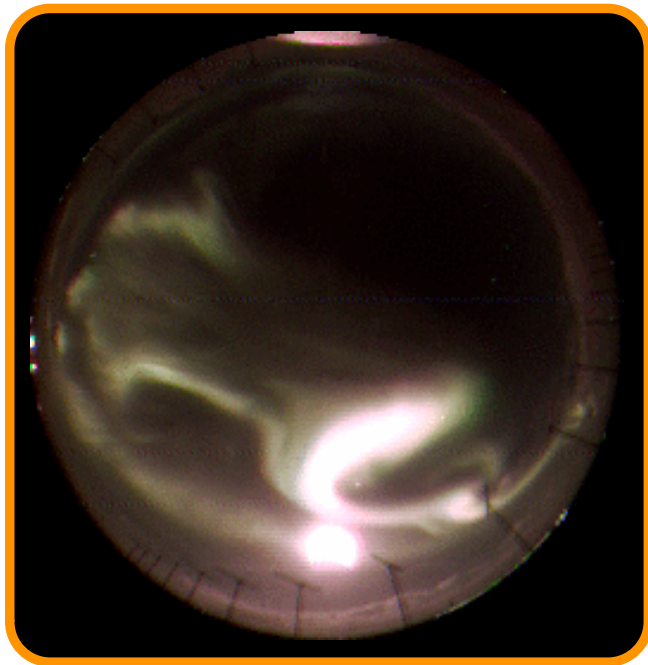


# The Influence of Magnetospheric Substorms on SuperDARN Backscatter



Moonlight and aurora captured by the new Rainbow ASI at the Pykkvibær SuperDARN radar, Iceland on 20 Nov 2007.

J.A. Wild<sup>1</sup> & A. Grocott<sup>2</sup>

1. Space Plasma Environment and Radio Science Group, Dept. of Communication Systems, Lancaster University, UK.
2. Radio & Space Plasma Physics Group, Dept. of Physics & Astronomy, University of Leicester, UK.



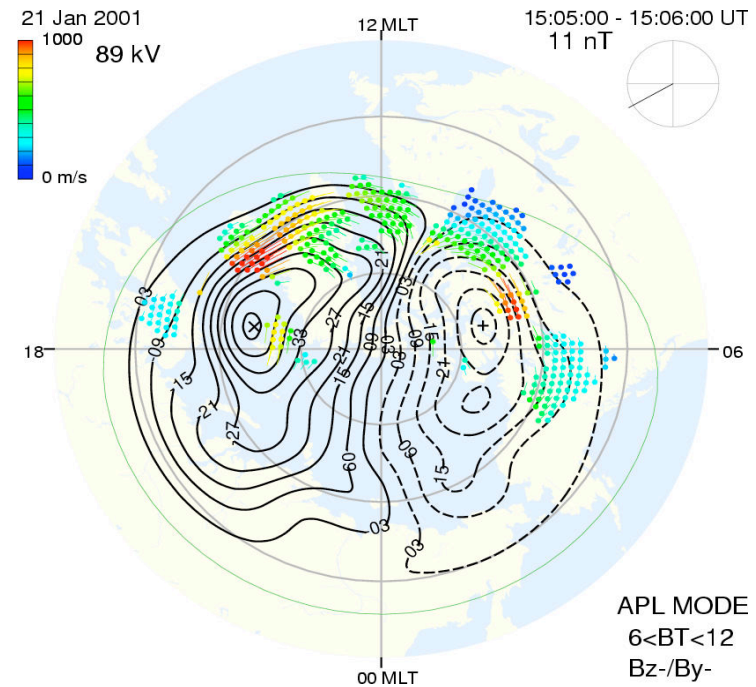
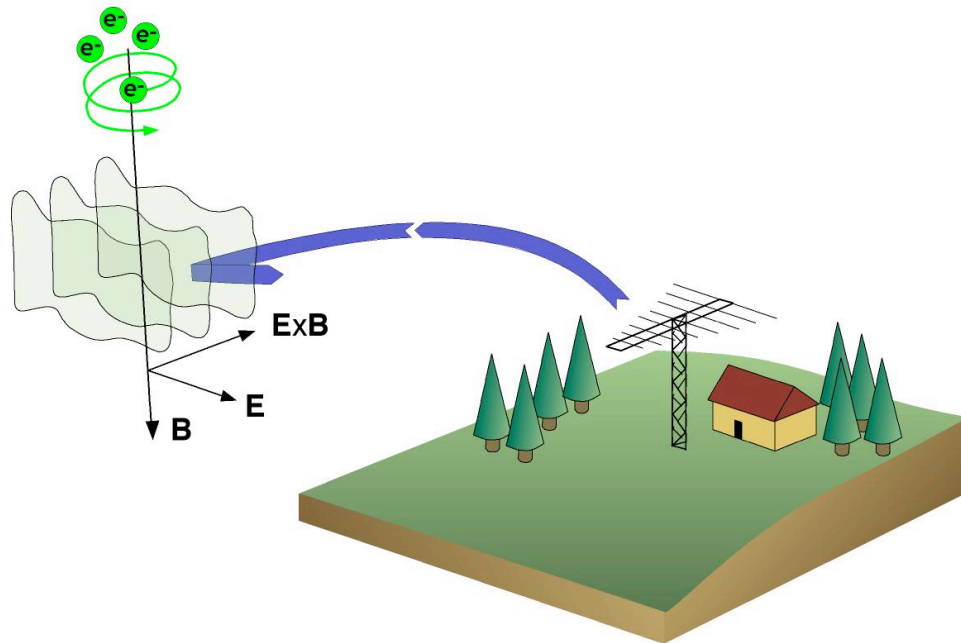
**Department of**  
**Communication**  
**Systems**

LANCASTER  
UNIVERSITY



# SuperDARN

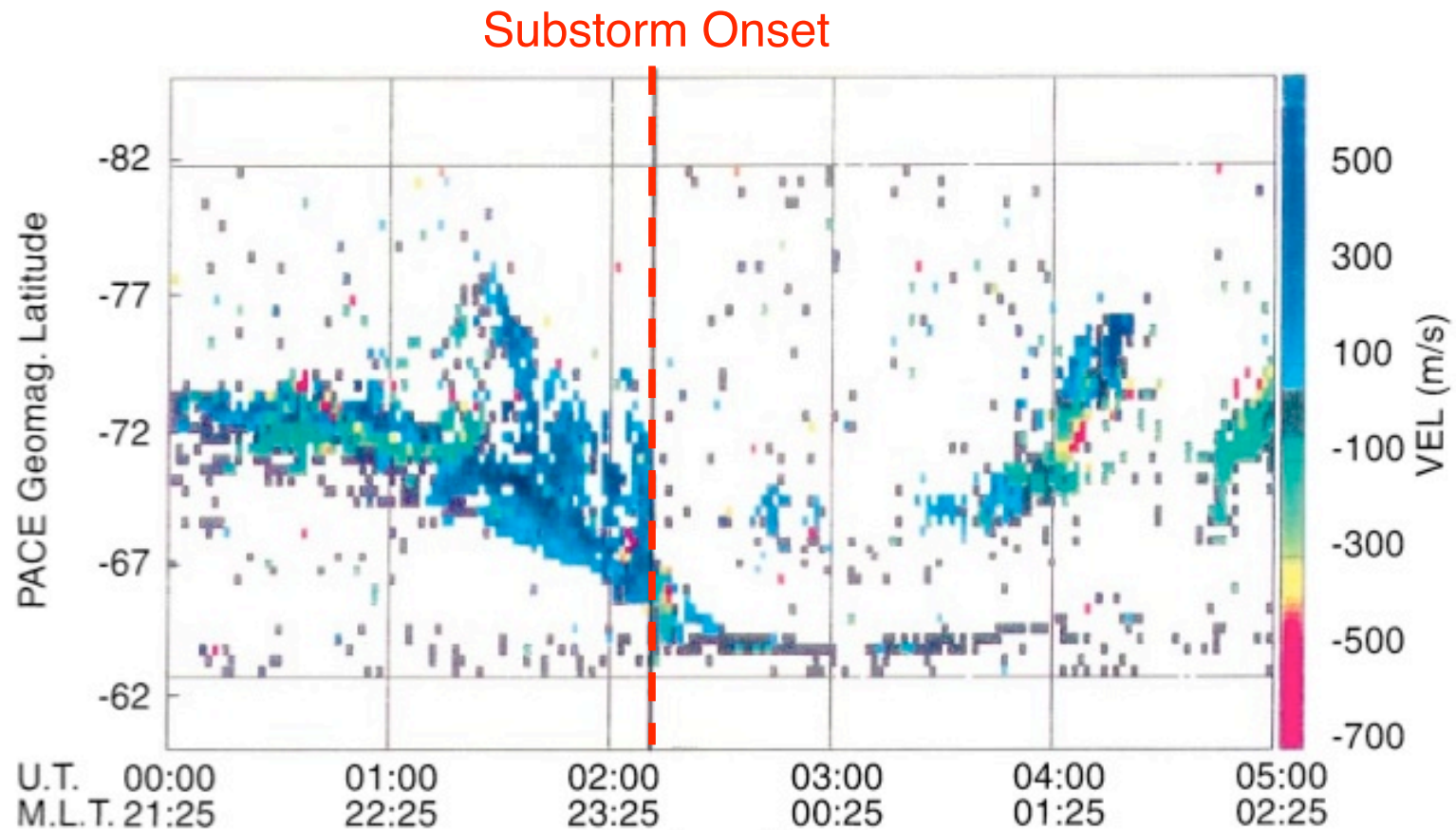
A network of 19 coherent-scatter HF radars



In order to detect backscatter...

- Irregularities must exist
- Radar signal must propagate to/from irregularities
- Signals must be orthogonal to irregularities

# BACKGROUND & MOTIVATION

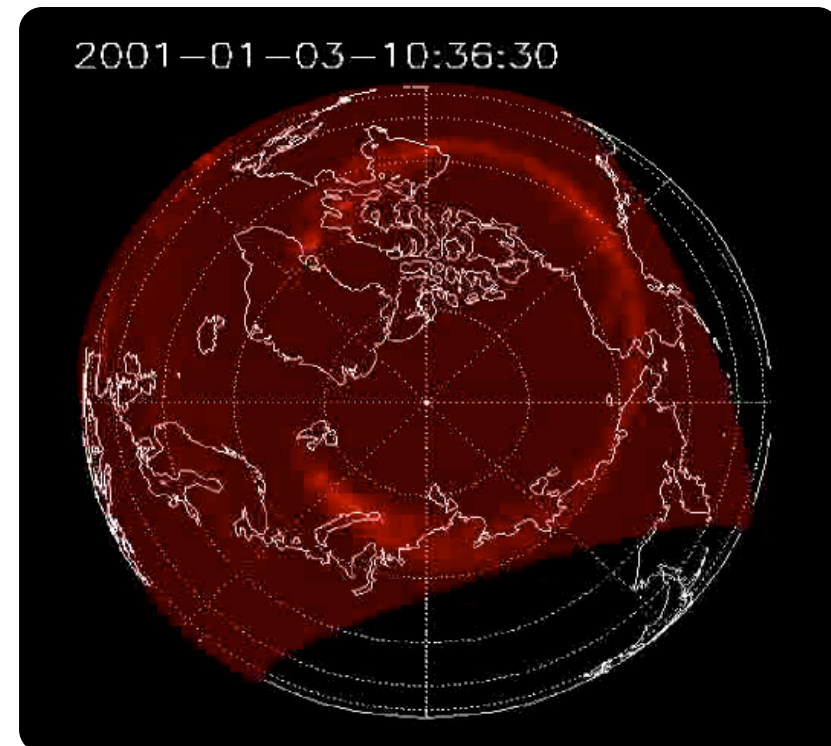


From Lewis et al., 1997.

# IDENTIFYING SUBSTORMS: IMAGE

Prime data source were the WIC images (SI-13 images were used when WIC data were unavailable).

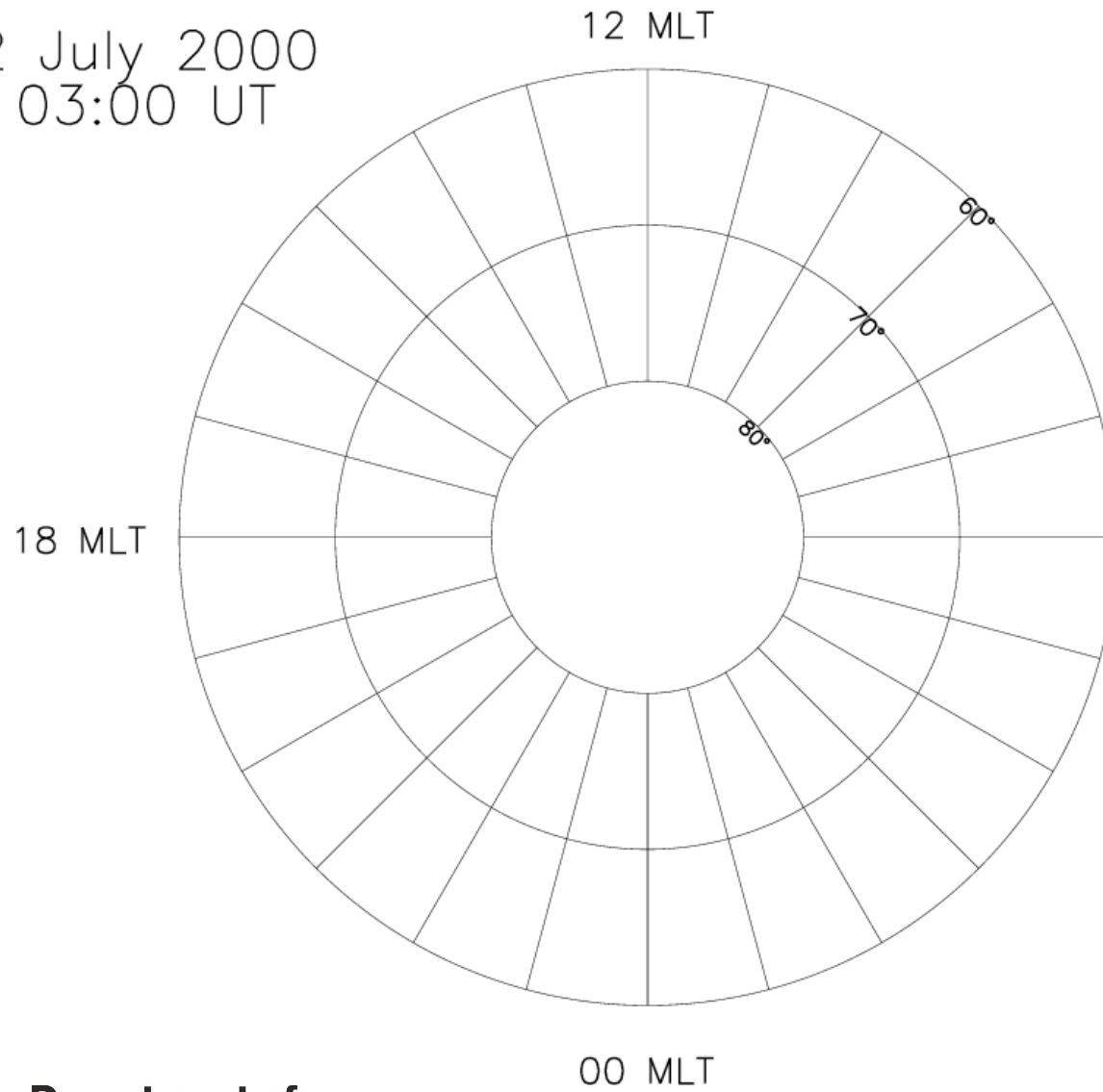
- a clear local brightening of the aurora has to occur
- the aurora has to expand to the poleward boundary of the auroral oval and spread azimuthally in local time for at least 20 min
- a substorm onset was only accepted as a separate event if at least 30 min had passed after the previous onset



# SUBSTORM DATABASE

Frey et al. (2004) IMAGE WIC May 2000- Dec 2002	2437 substorms
IMAGE WIC May 2000- Dec 2005	4193 substorms
Exclude events within $\pm 2$ hours of another event	3005 substorms

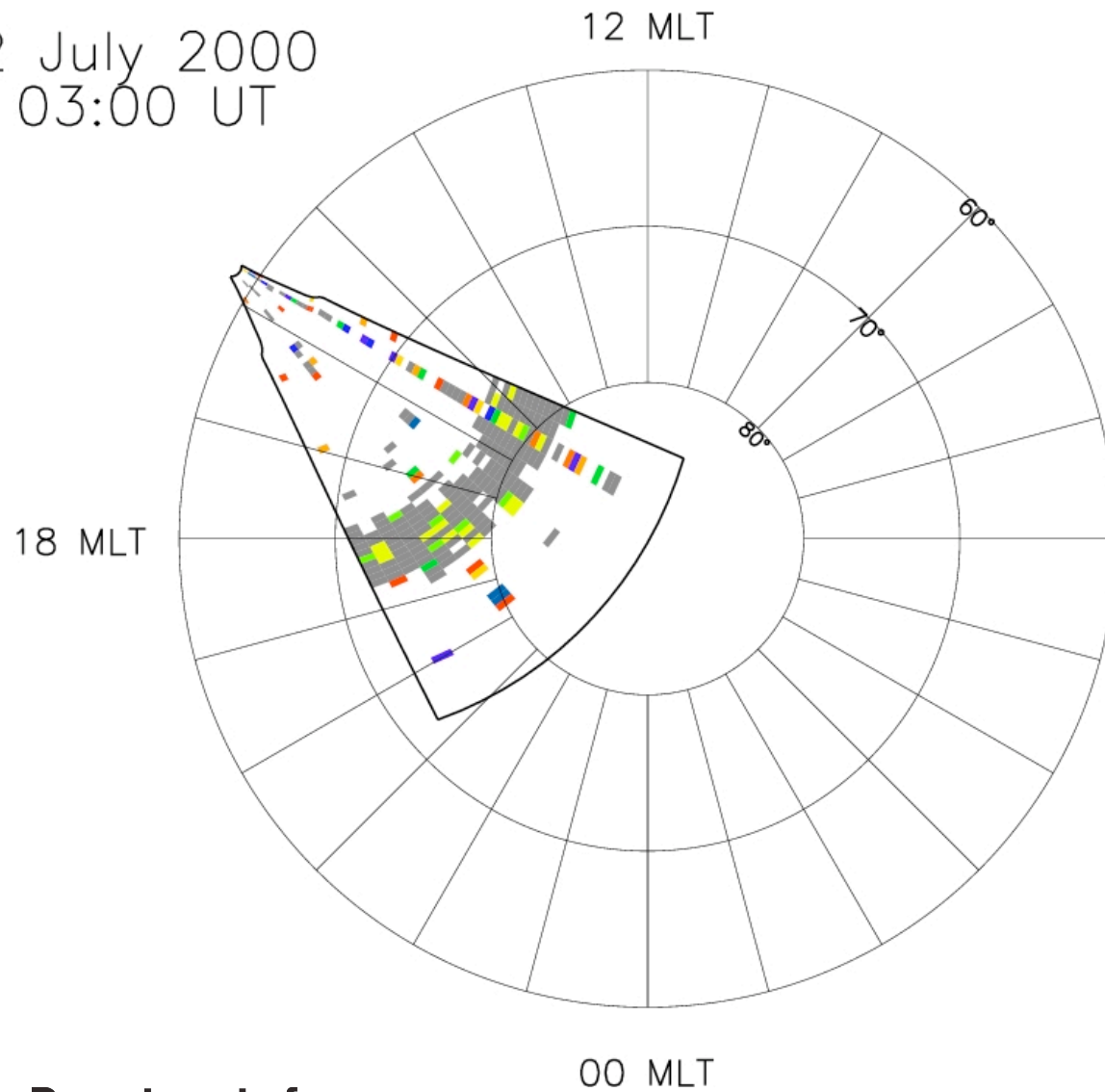
2 July 2000  
03:00 UT



06



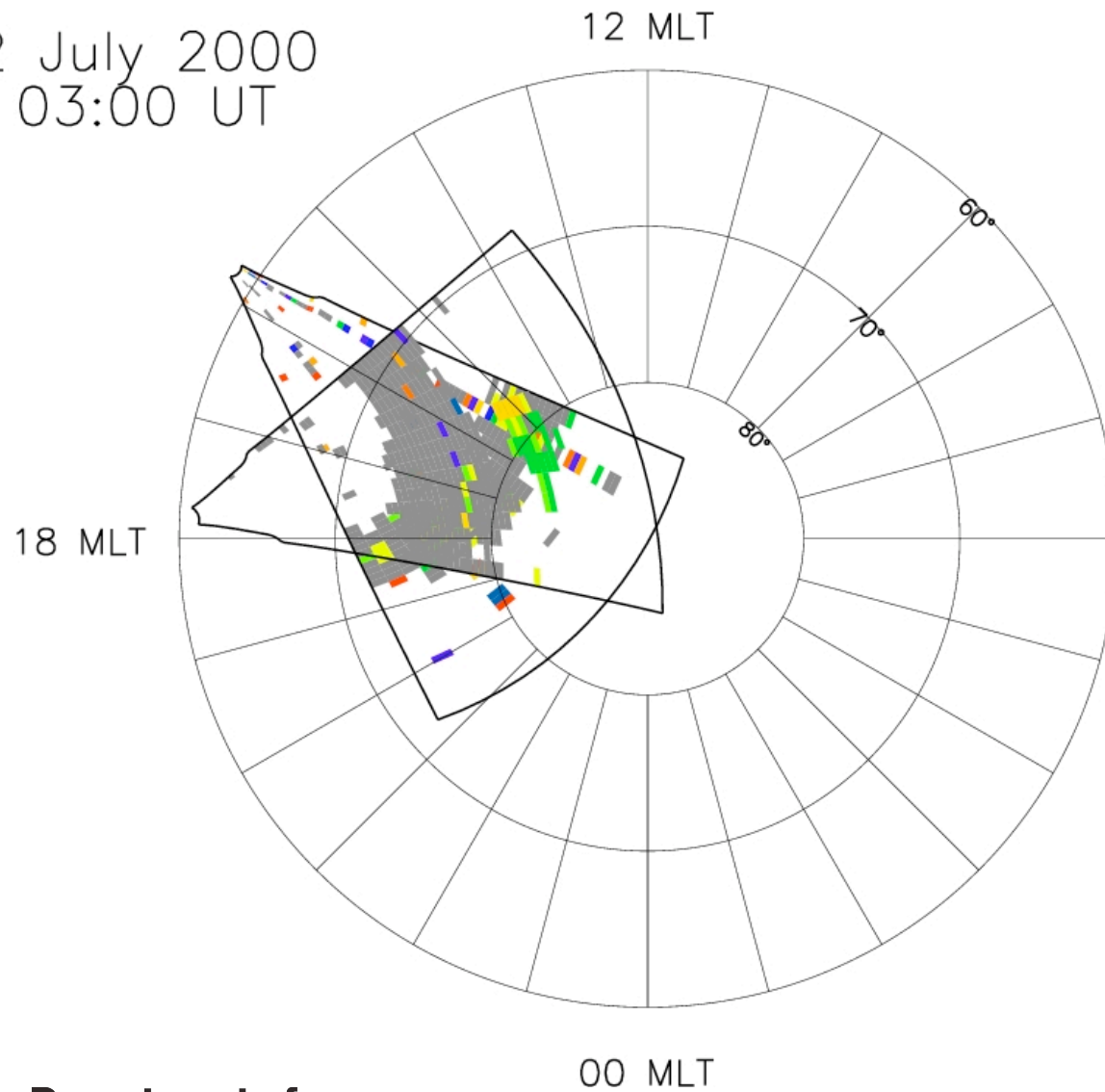
2 July 2000  
03:00 UT



06

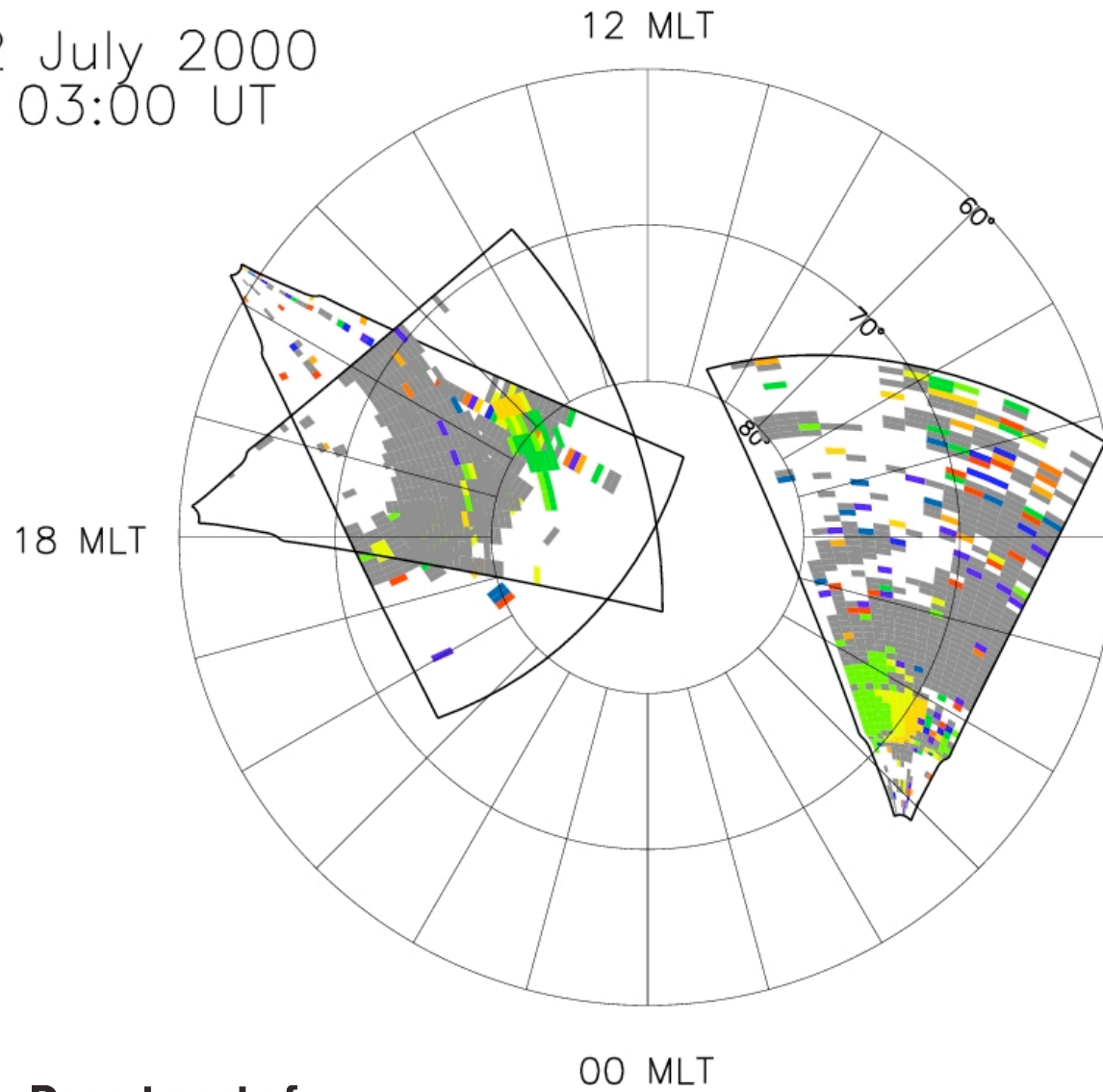


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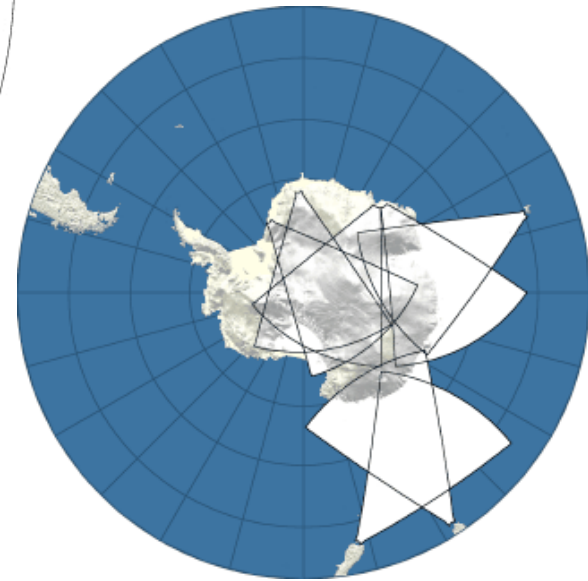




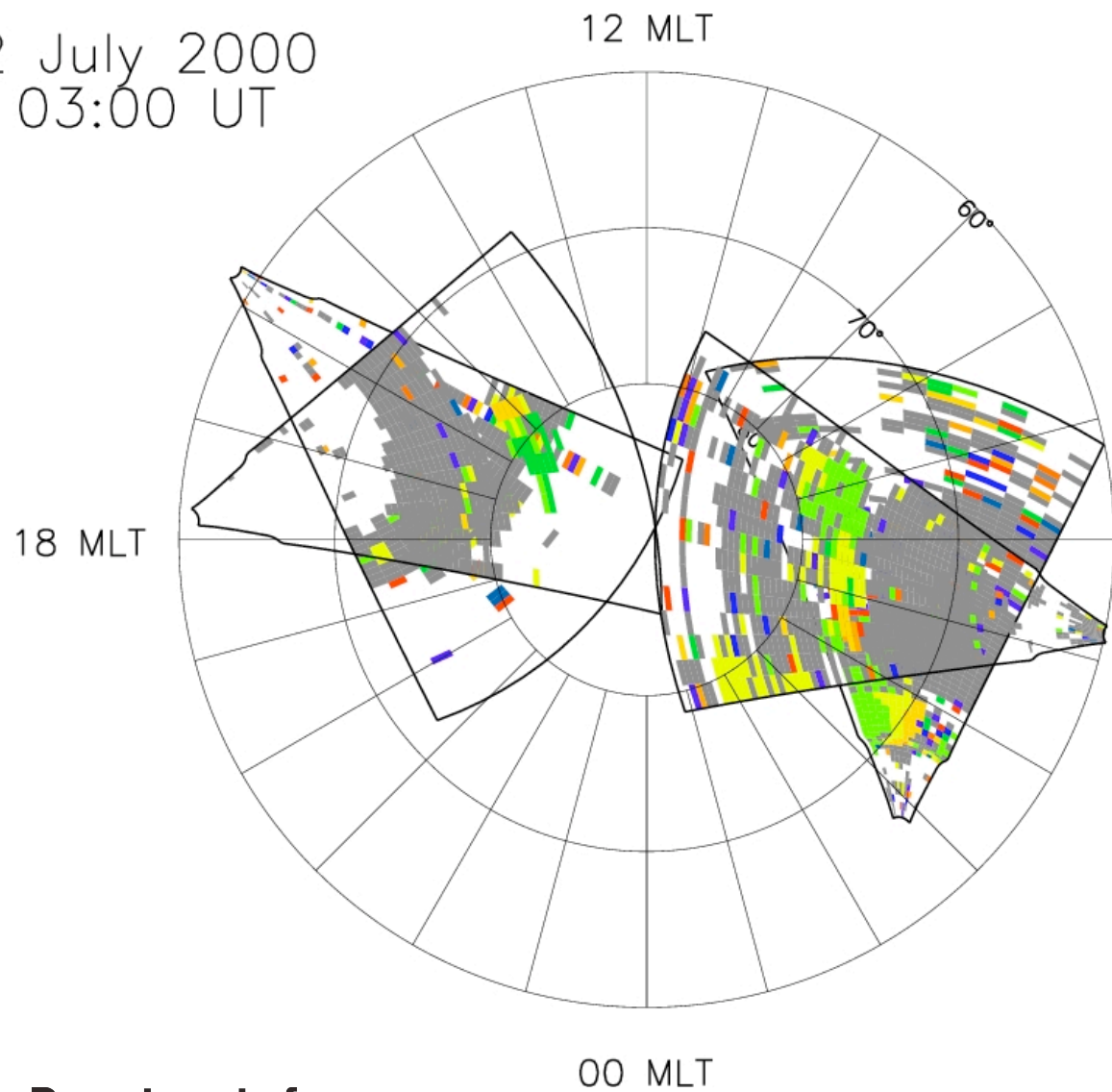
2 July 2000  
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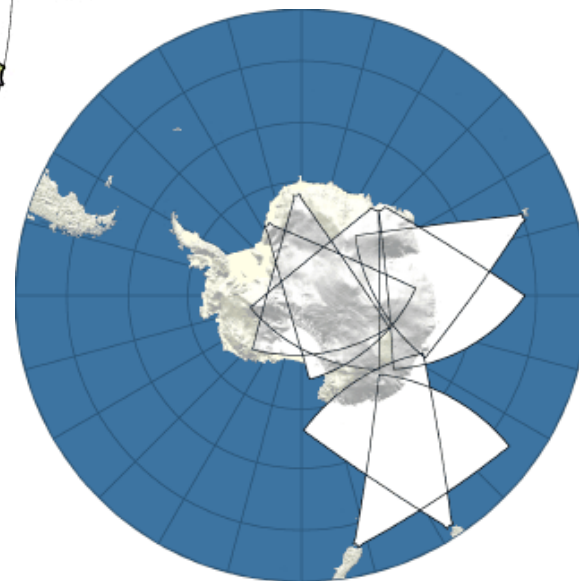
06



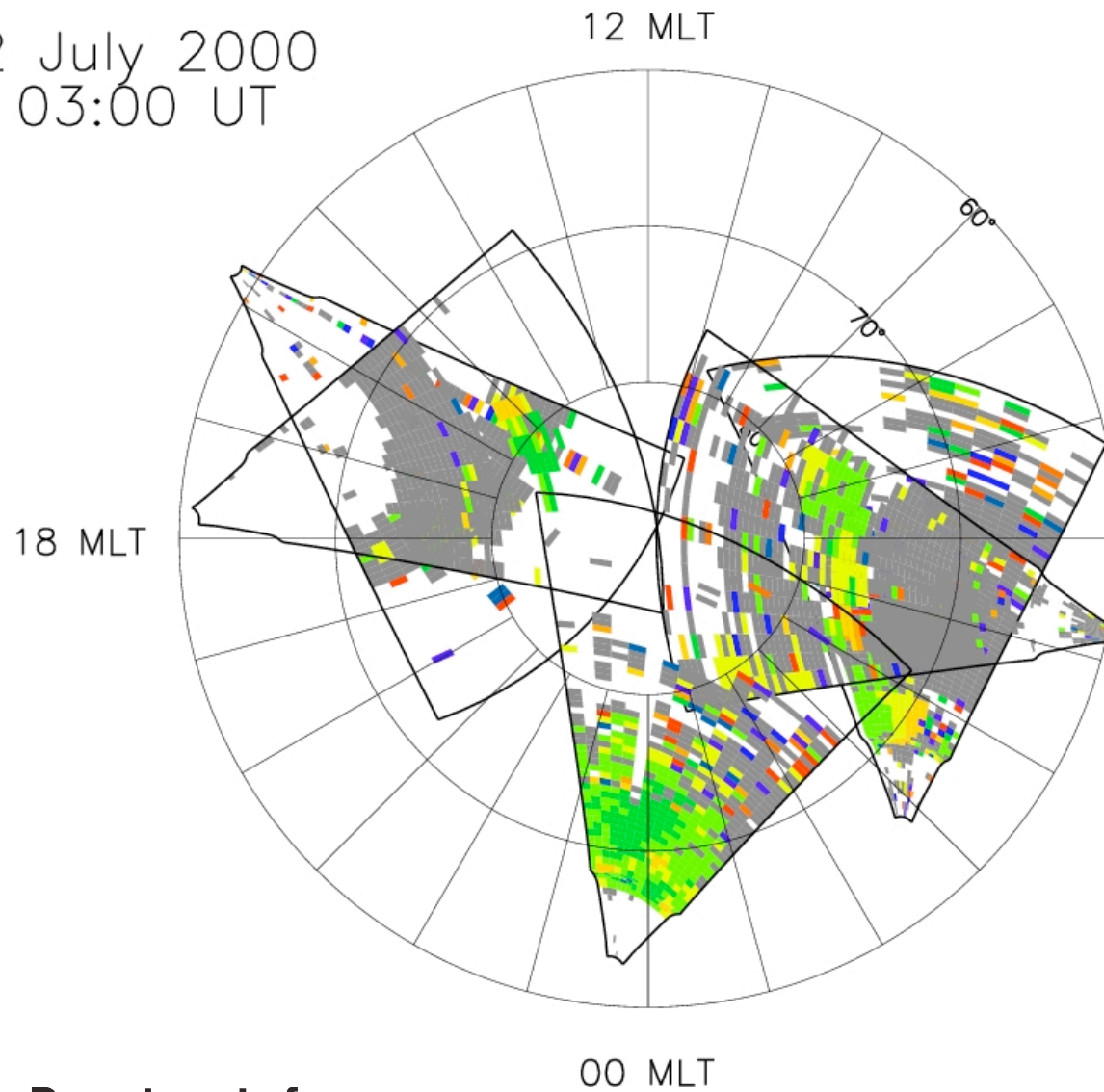
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06



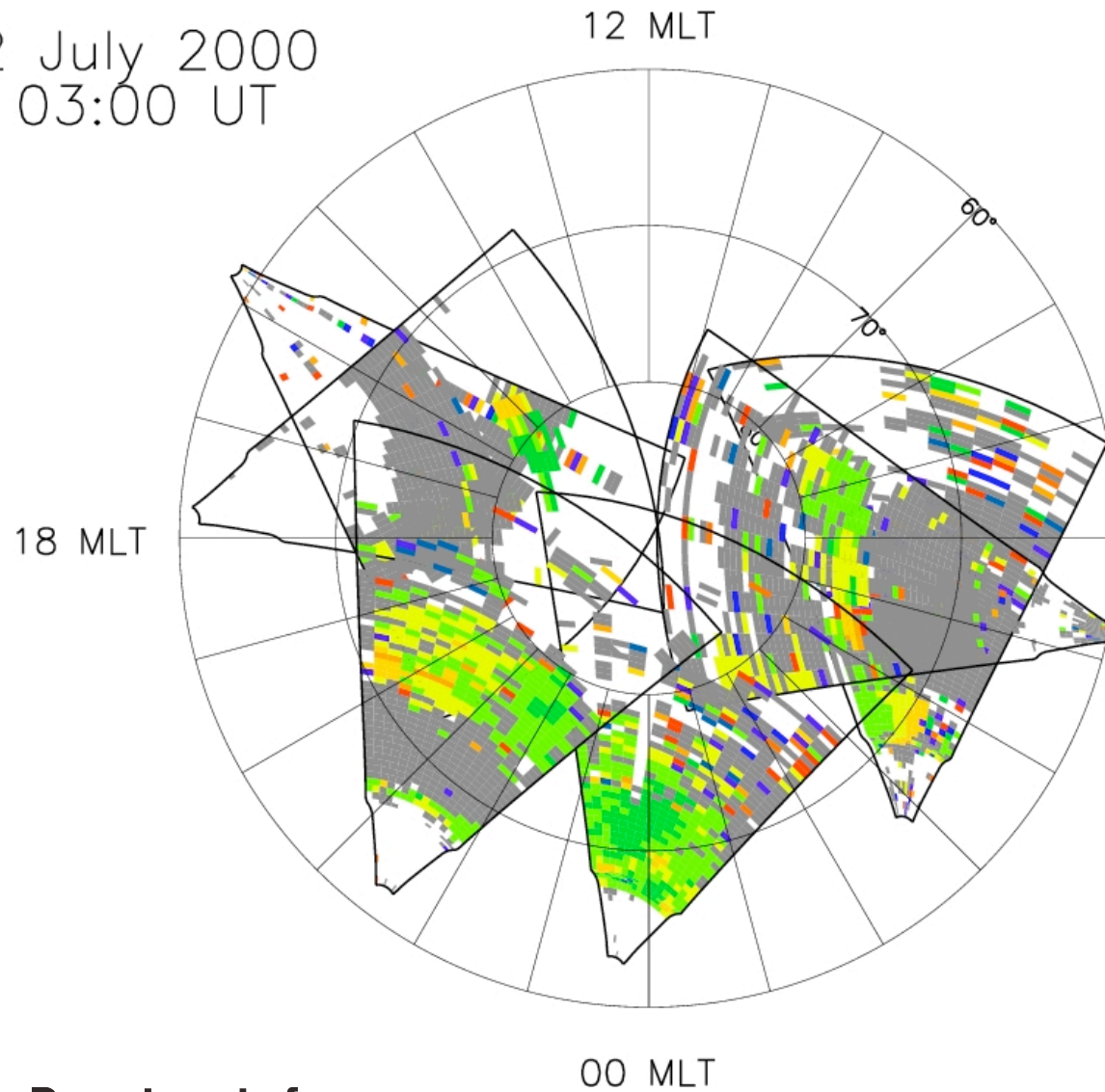
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03:00 UT



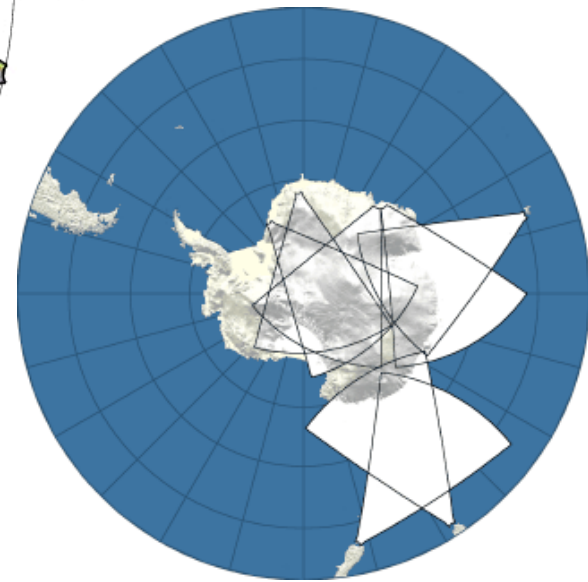
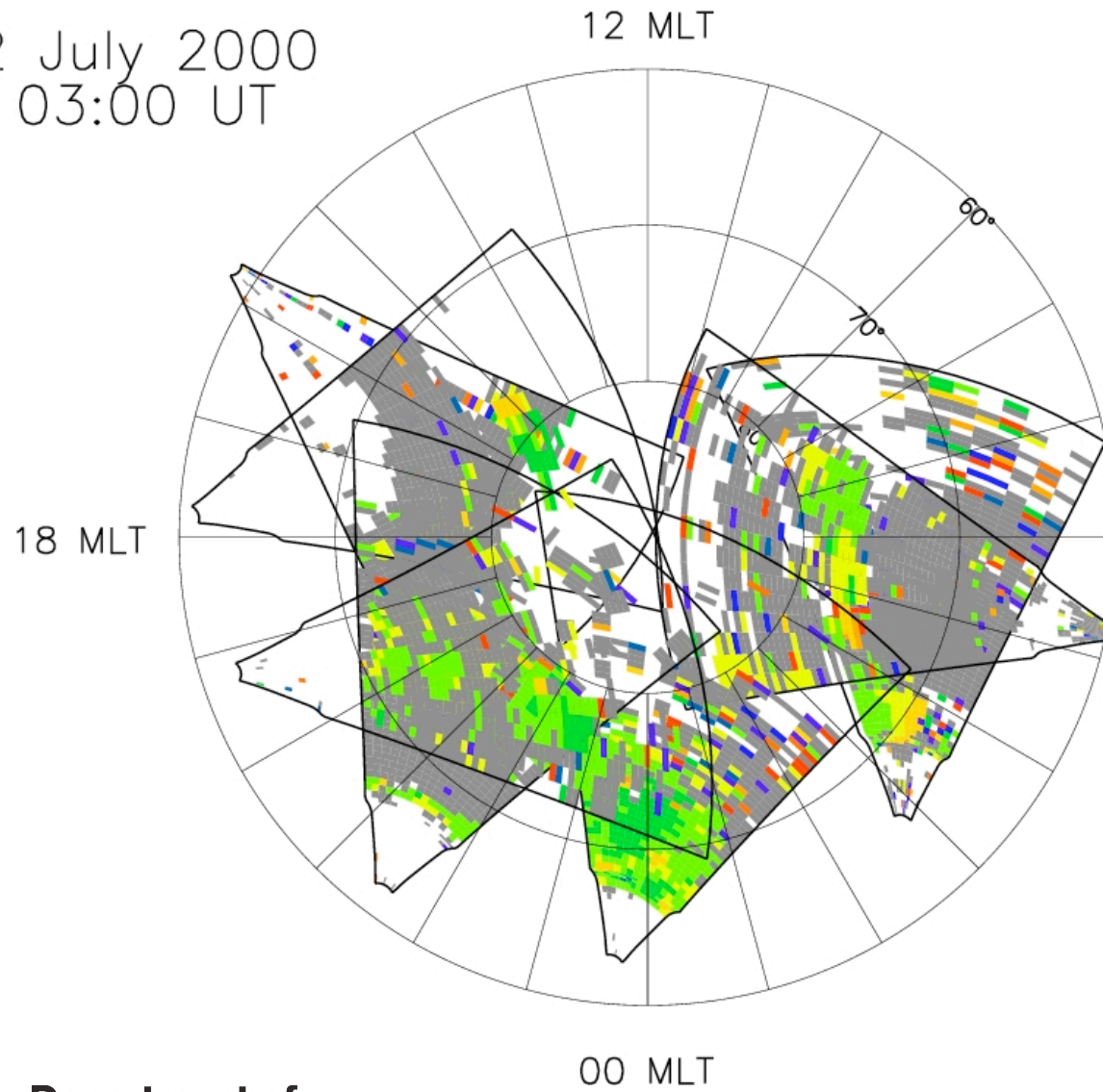
06



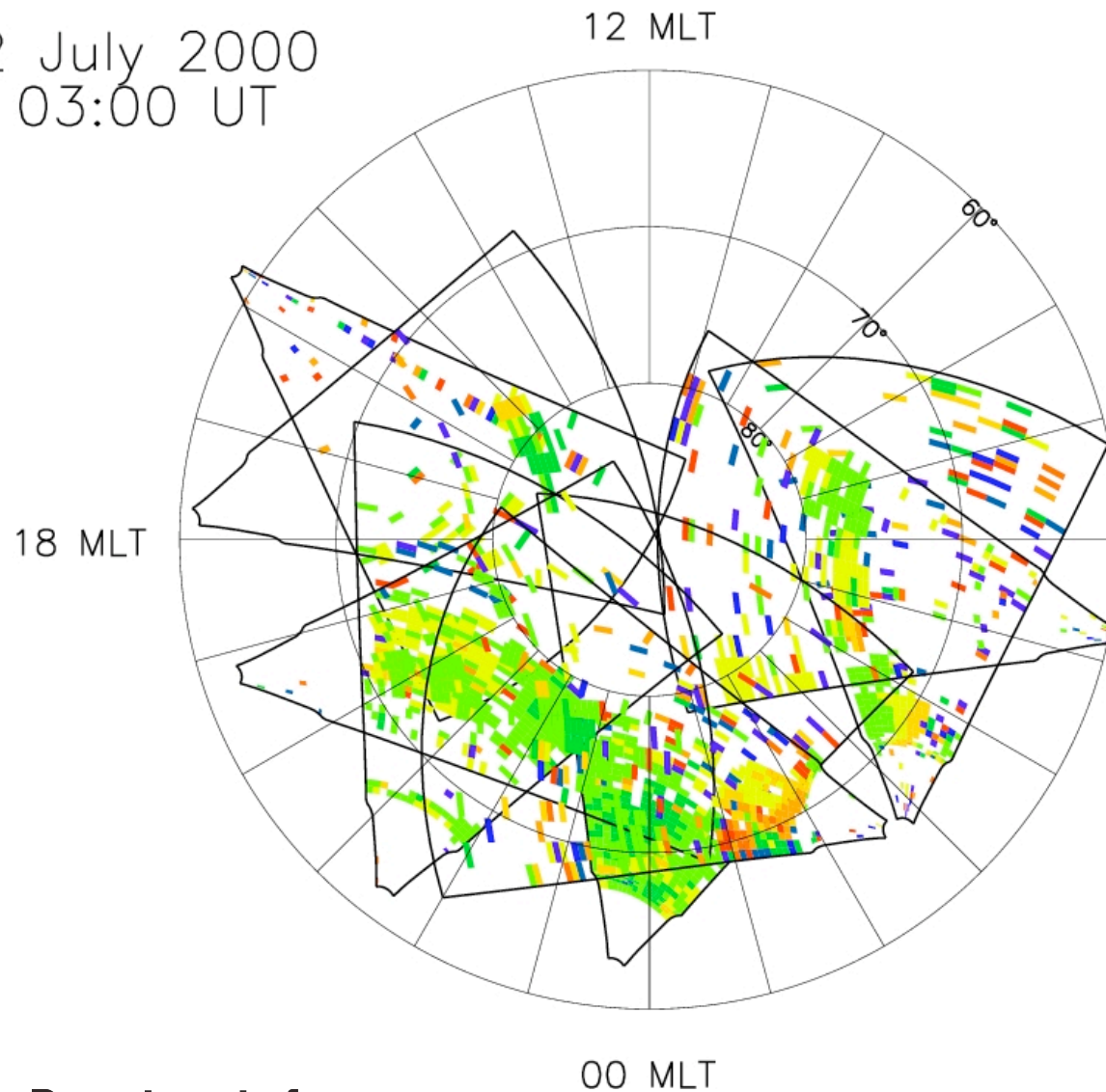
2 July 2000  
03:00 UT



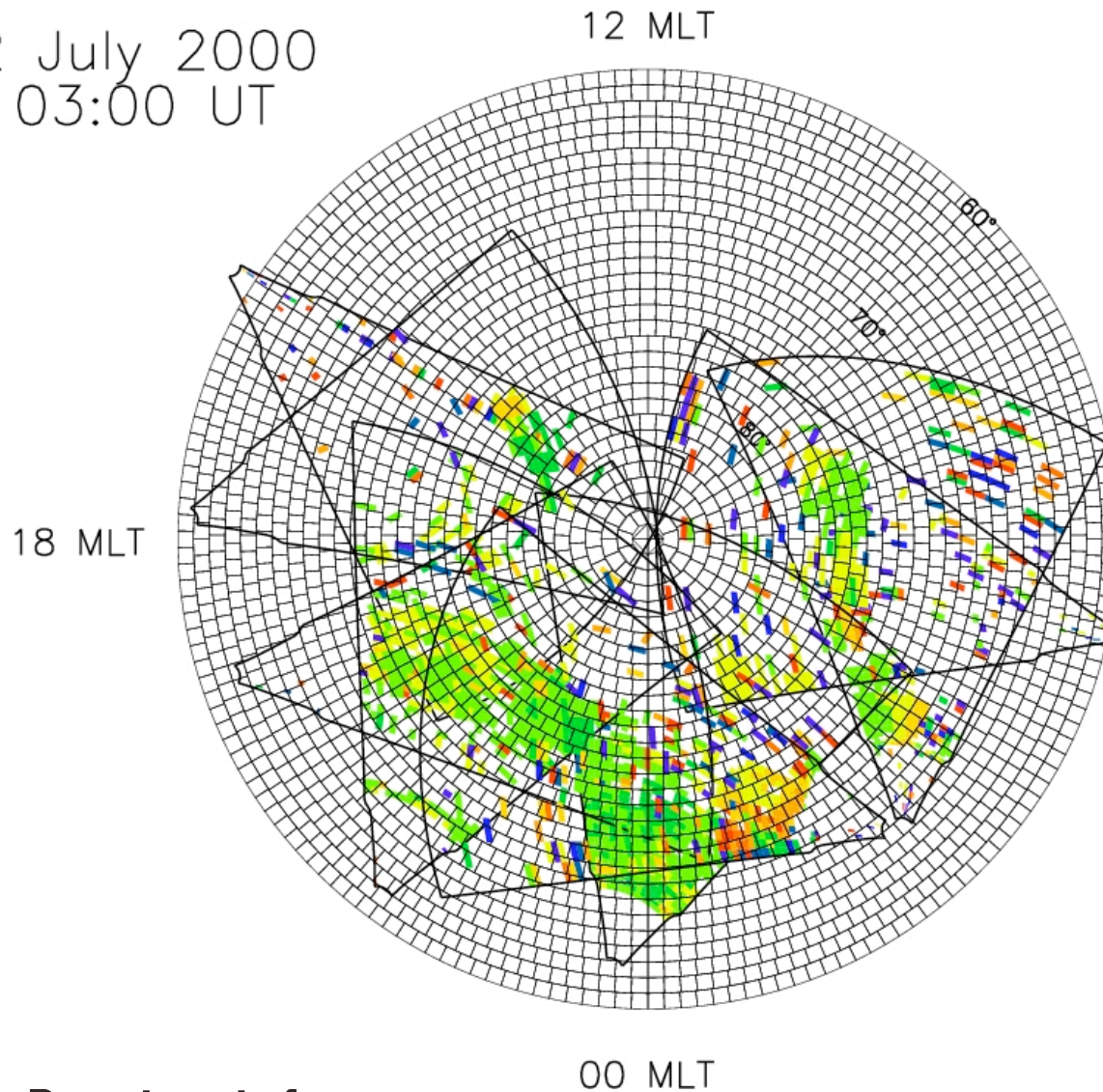
2 July 2000  
03:00 UT



2 July 2000  
03:00 UT



2 July 2000  
03:00 UT



Data are gridded in cells

- 1° in latitude ( $\approx 111$  km)
- $\approx 111$  km longitude

Same as SuperDARN  
“potential-mapping”  
technique

06

Gridded data span 2 min  
intervals  $\pm 90$  min from  
onset

No spatial averaging

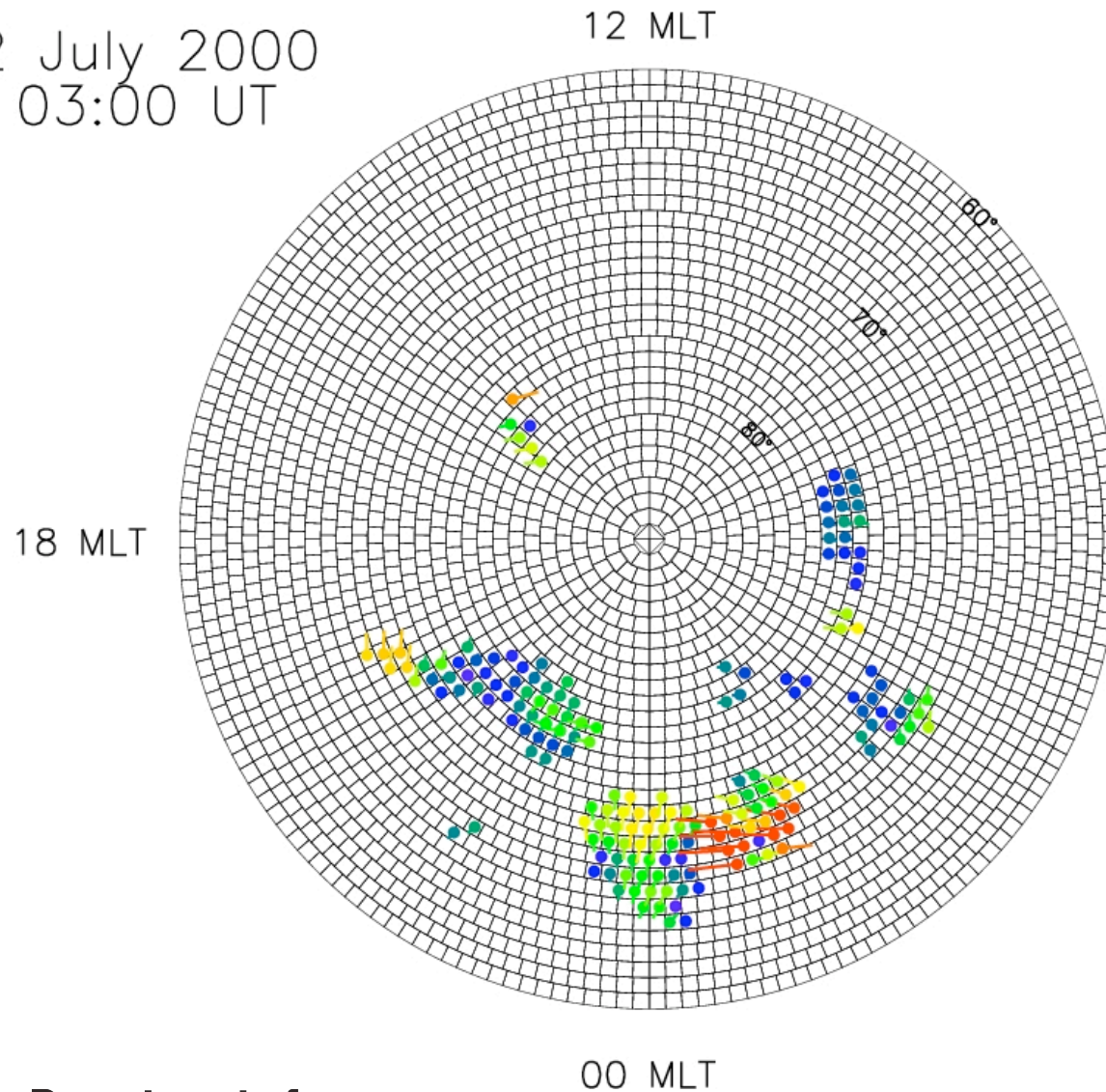
No temporal averaging

Ground scatter excluded

Noise removed

SuperDARN Workshop 2008

2 July 2000  
03:00 UT



Data are gridded in cells

- 1° in latitude ( $\approx 111$  km)
- $\approx 111$  km longitude

Same as SuperDARN  
“potential-mapping”  
technique

06

Gridded data span 2 min  
intervals  $\pm 90$  min from  
onset

No spatial averaging

No temporal averaging

Ground scatter excluded

Noise removed

SuperDARN Workshop 2008



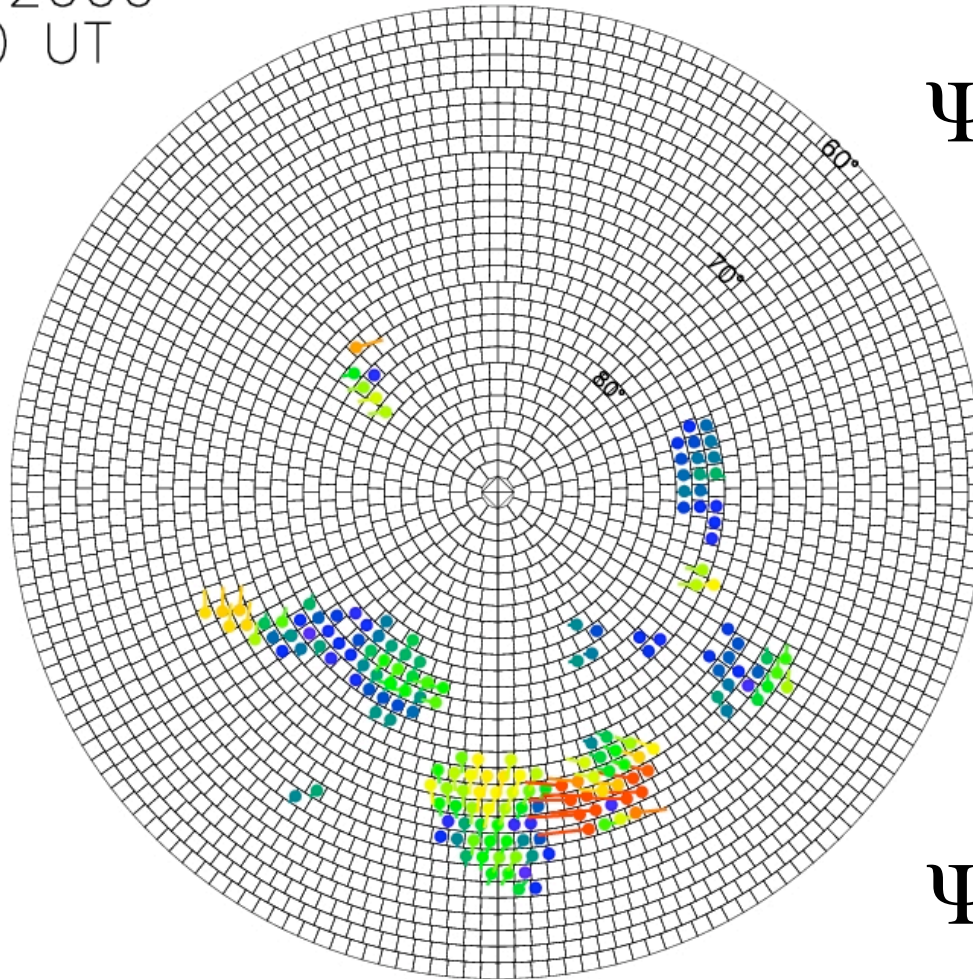
2 July 2000  
03:00 UT

12 MLT

Compute a backscatter parameter:

$$\Psi(t) = \frac{n_{scatter}(t)}{n_{radars}(t)}$$

18 MLT

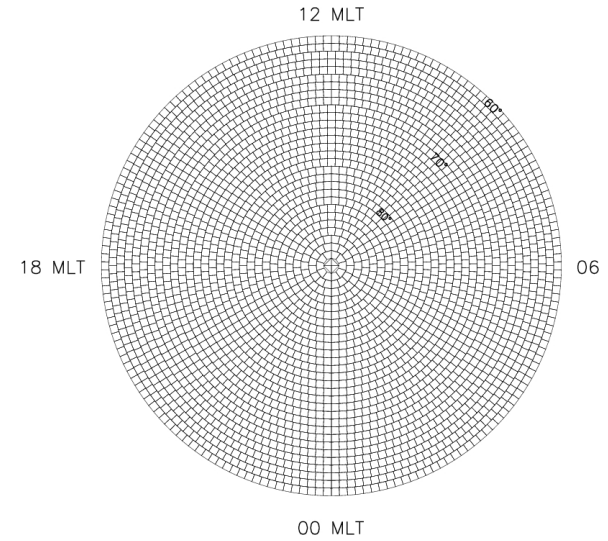
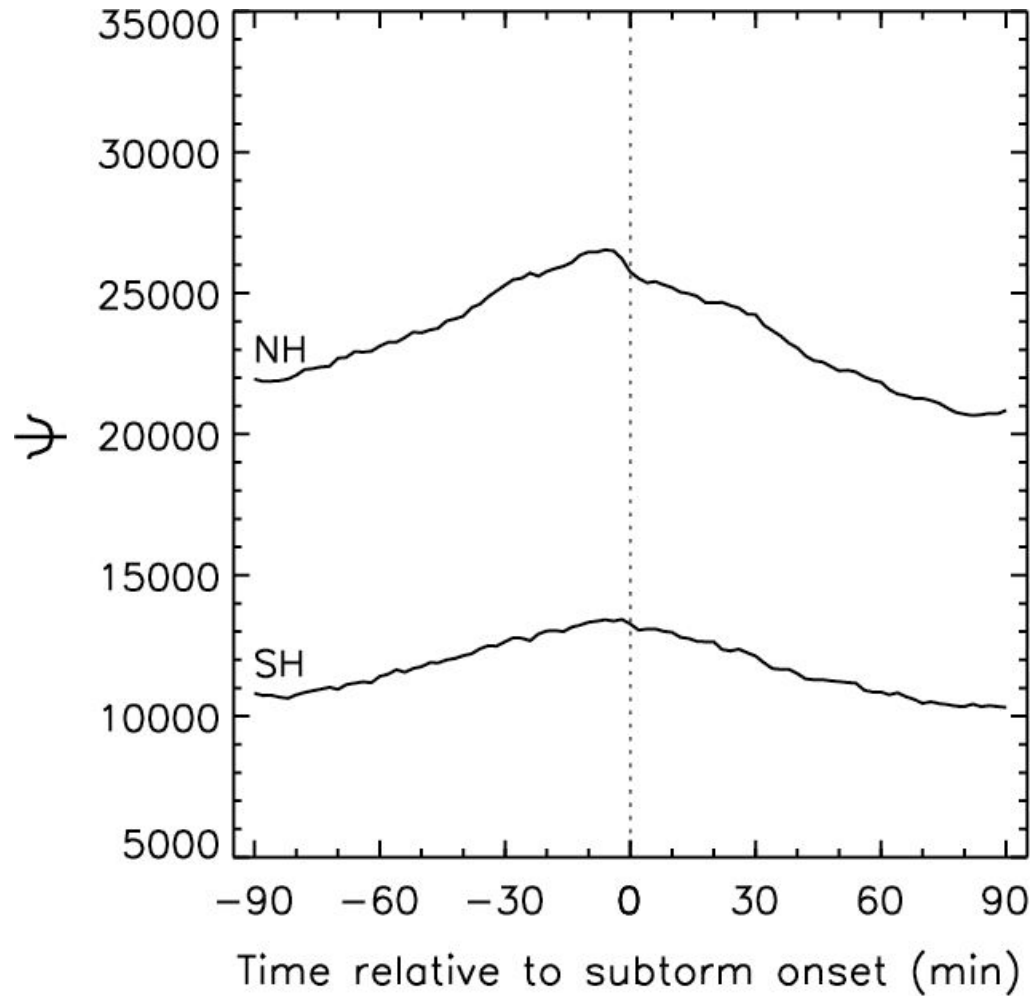


06

$$\Psi = \frac{181}{7} = 25.86$$

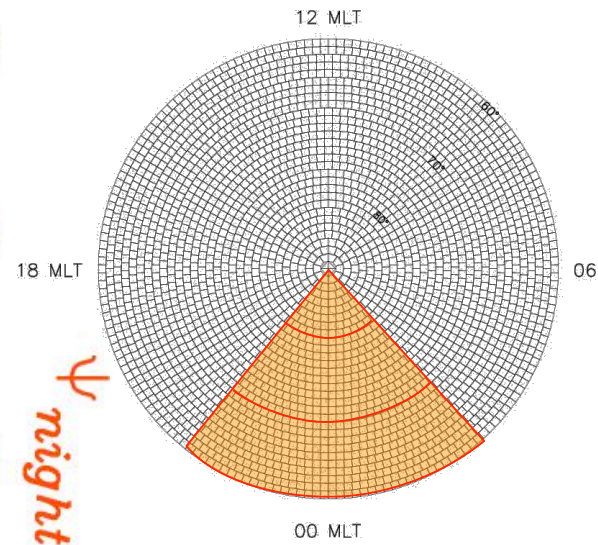
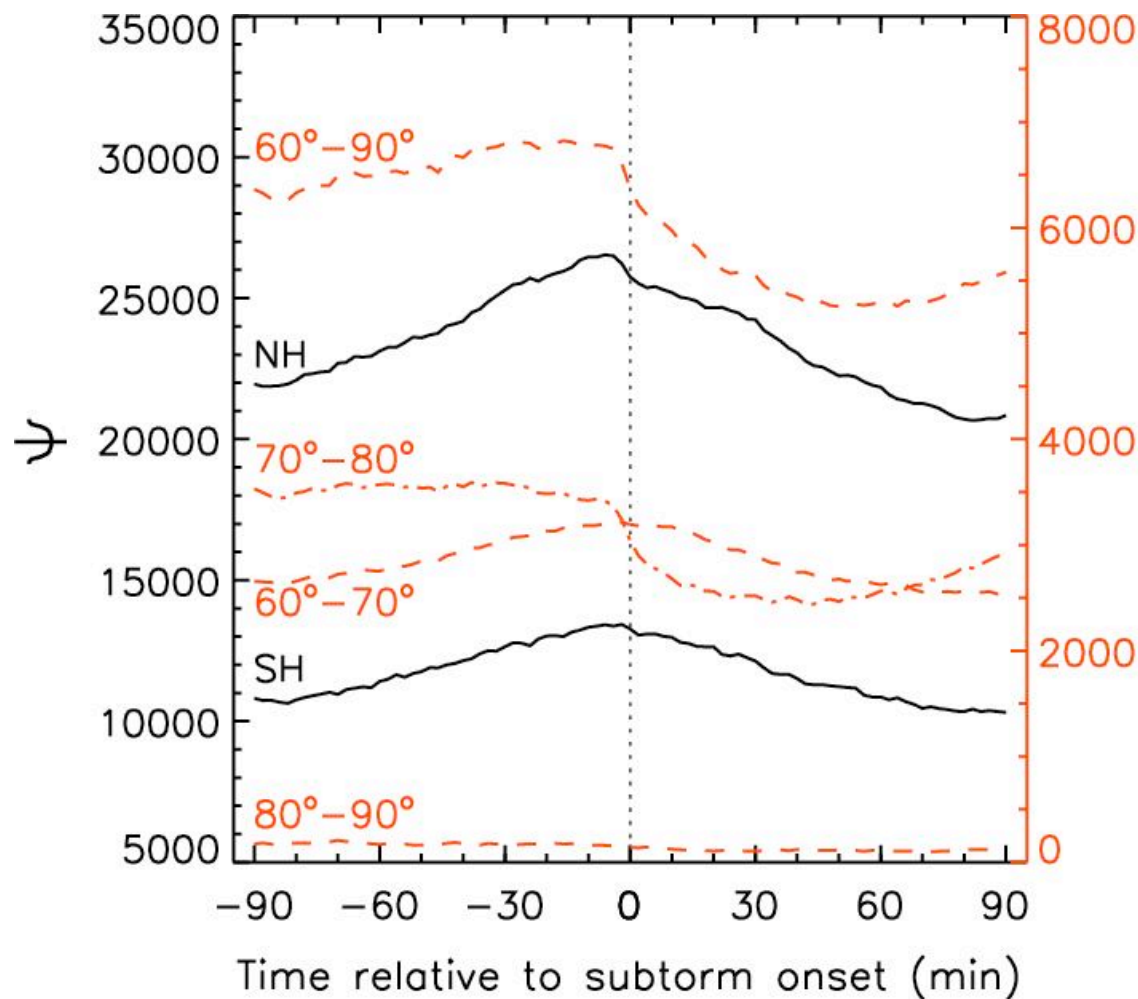
00 MLT

# BACKSCATTER VARIATIONS DURING SUBSTORMS



$$\Psi(t) = \frac{n_{scatter}(t)}{n_{radars}(t)}$$

# BACKSCATTER VARIATIONS DURING SUBSTORMS



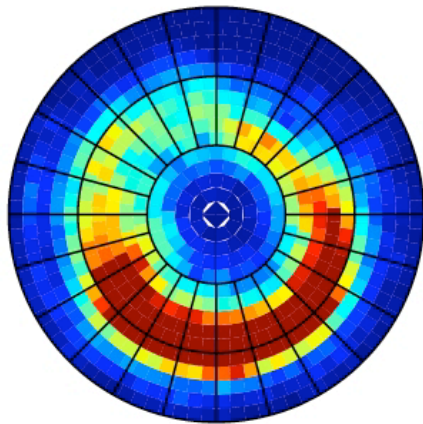
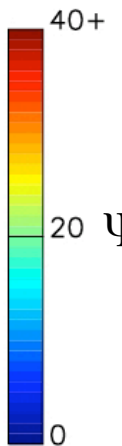
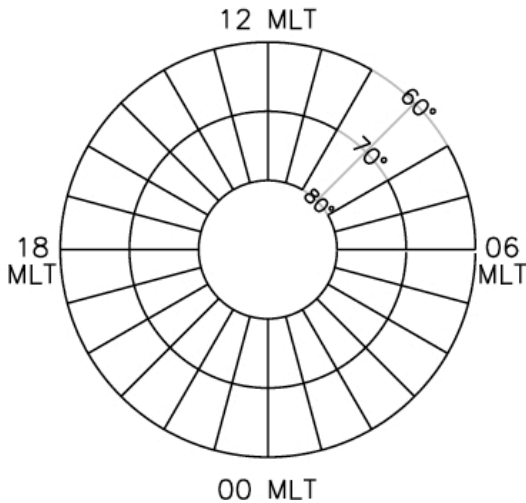
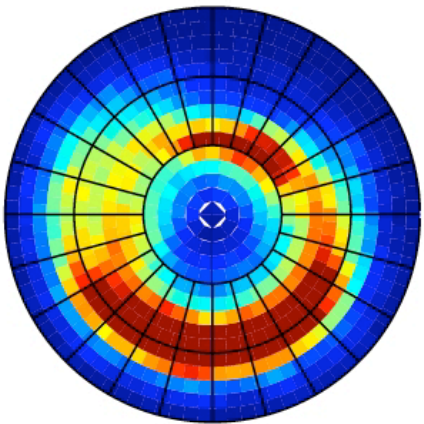
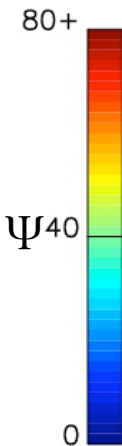
$$\Psi(t) = \frac{n_{scatter}(t)}{n_{radars}(t)}$$

# SPATIAL BACKSCATTER VARIATIONS

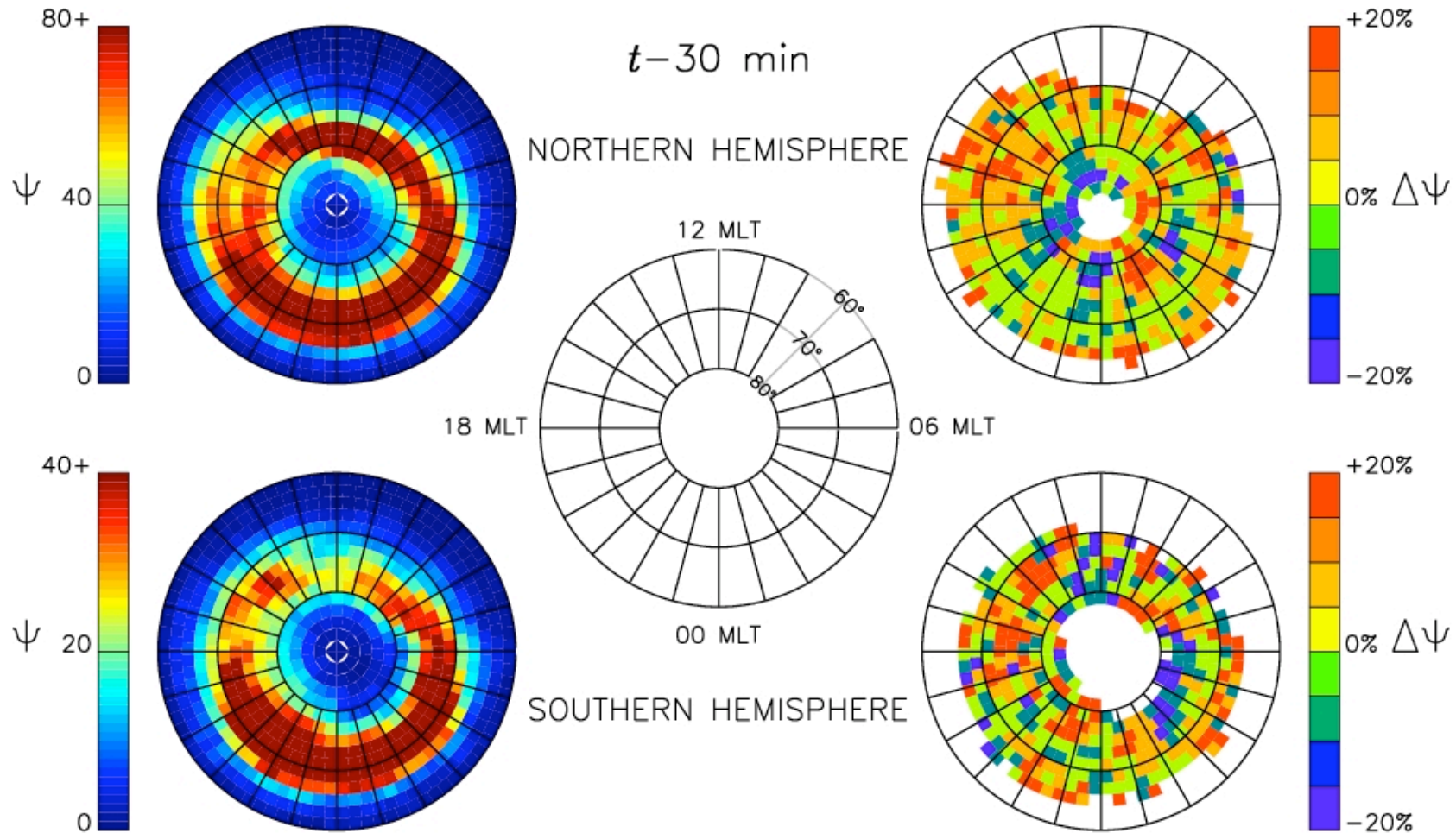
NORTHERN HEMISPHERE

$t-90$  min

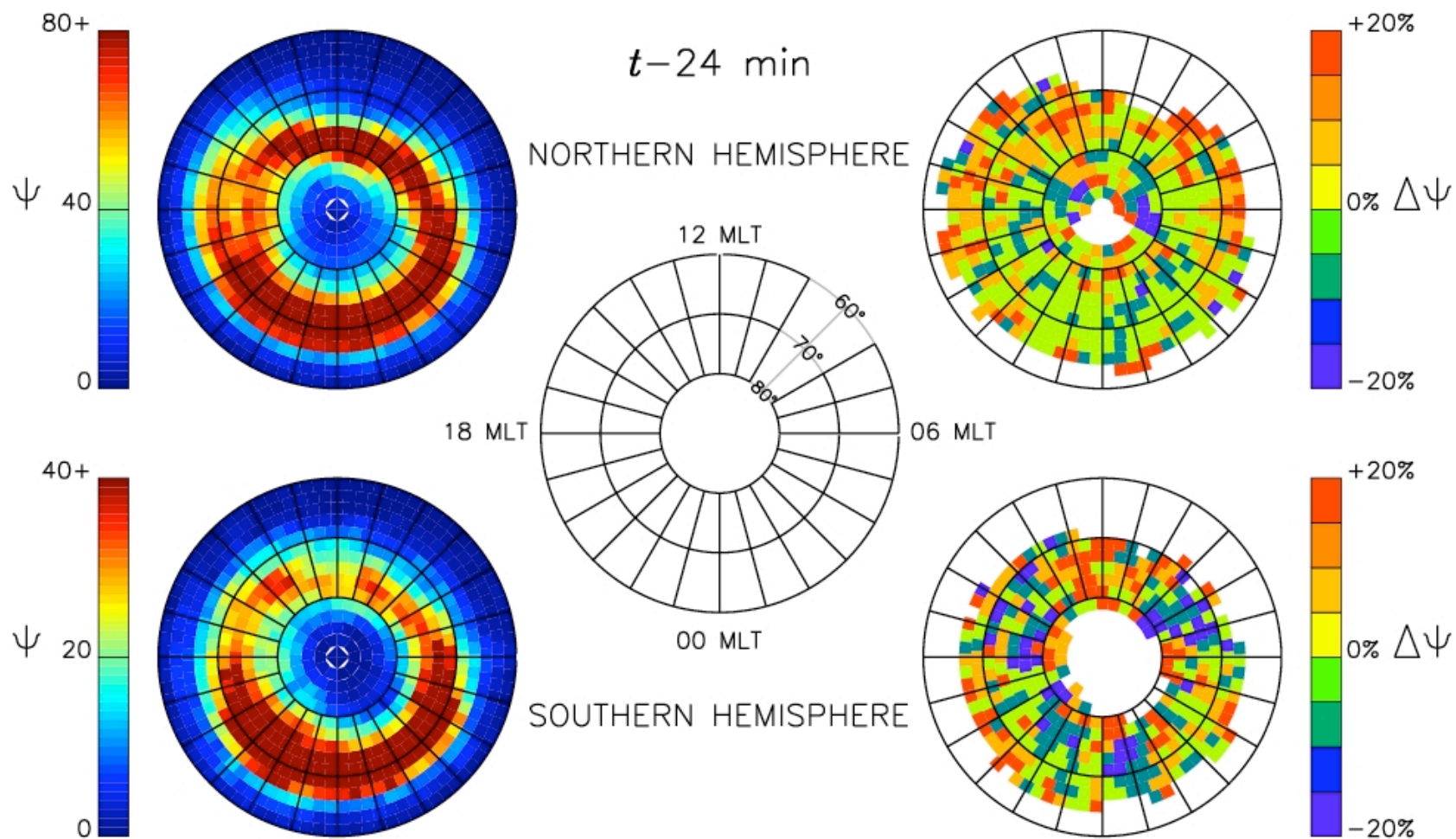
SOUTHERN HEMISPHERE



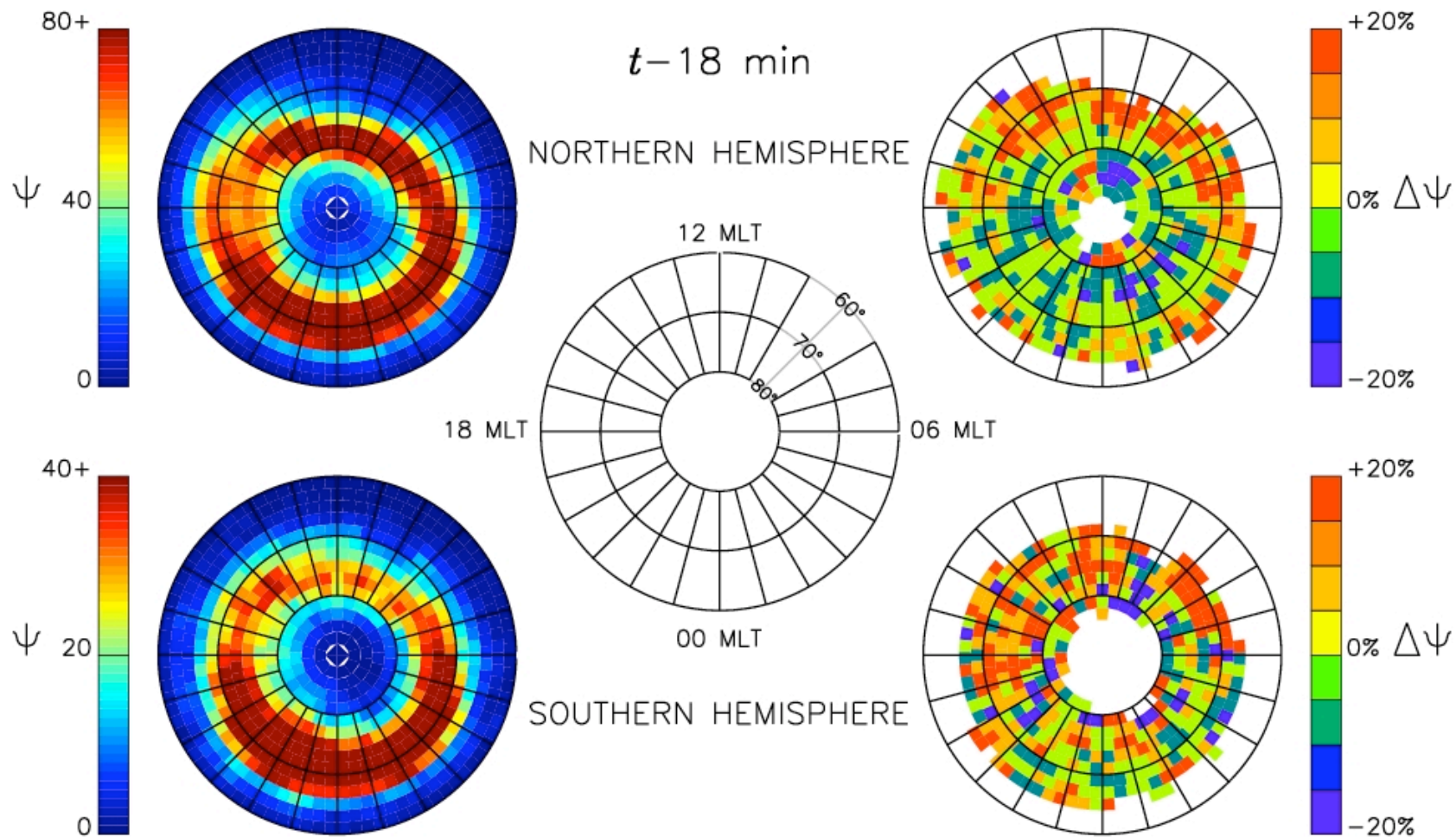
# SPATIAL BACKSCATTER VARIATIONS



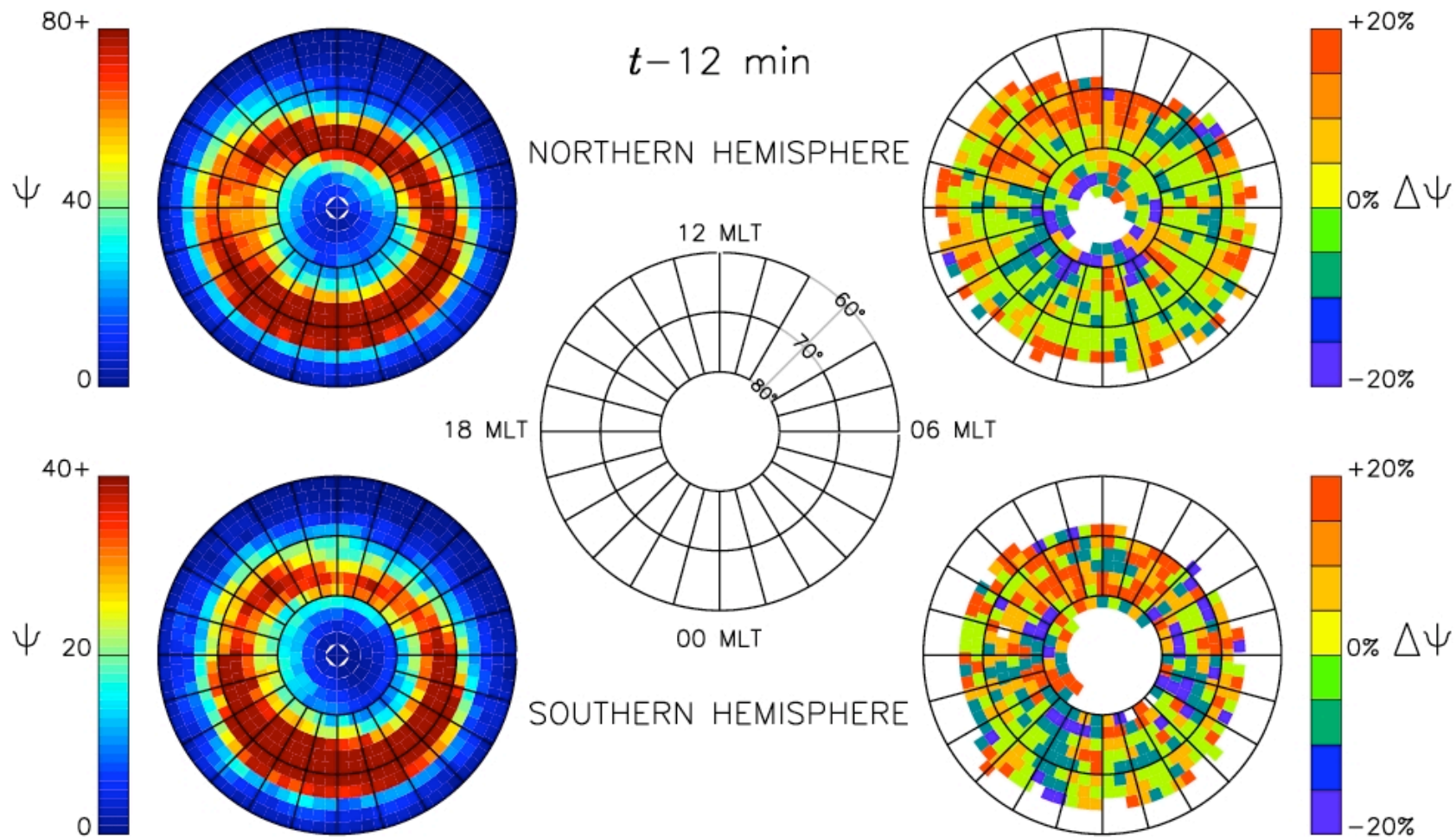
# SPATIAL BACKSCATTER VARIATIONS



# SPATIAL BACKSCATTER VARIATIONS

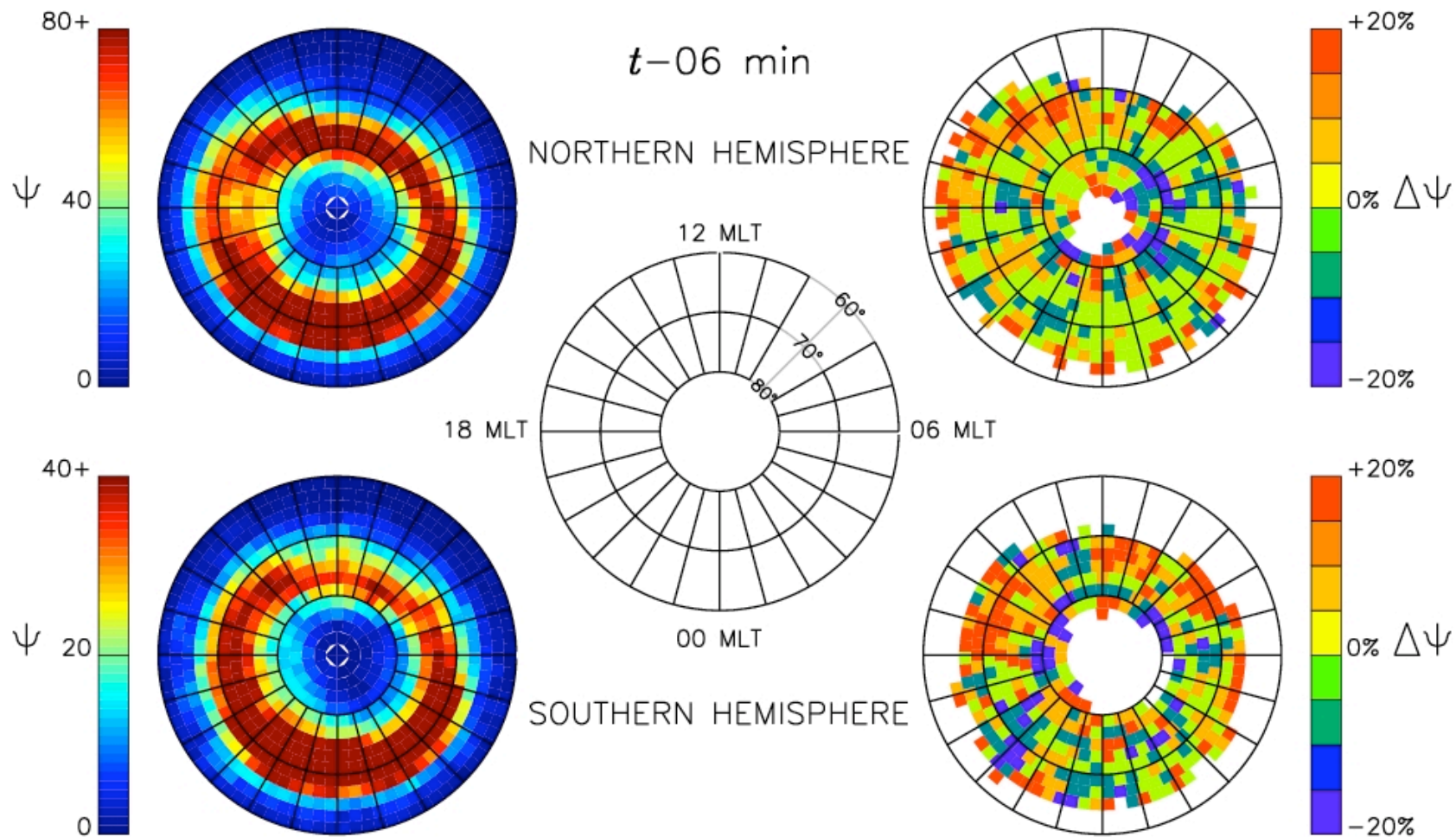


# SPATIAL BACKSCATTER VARIATIONS

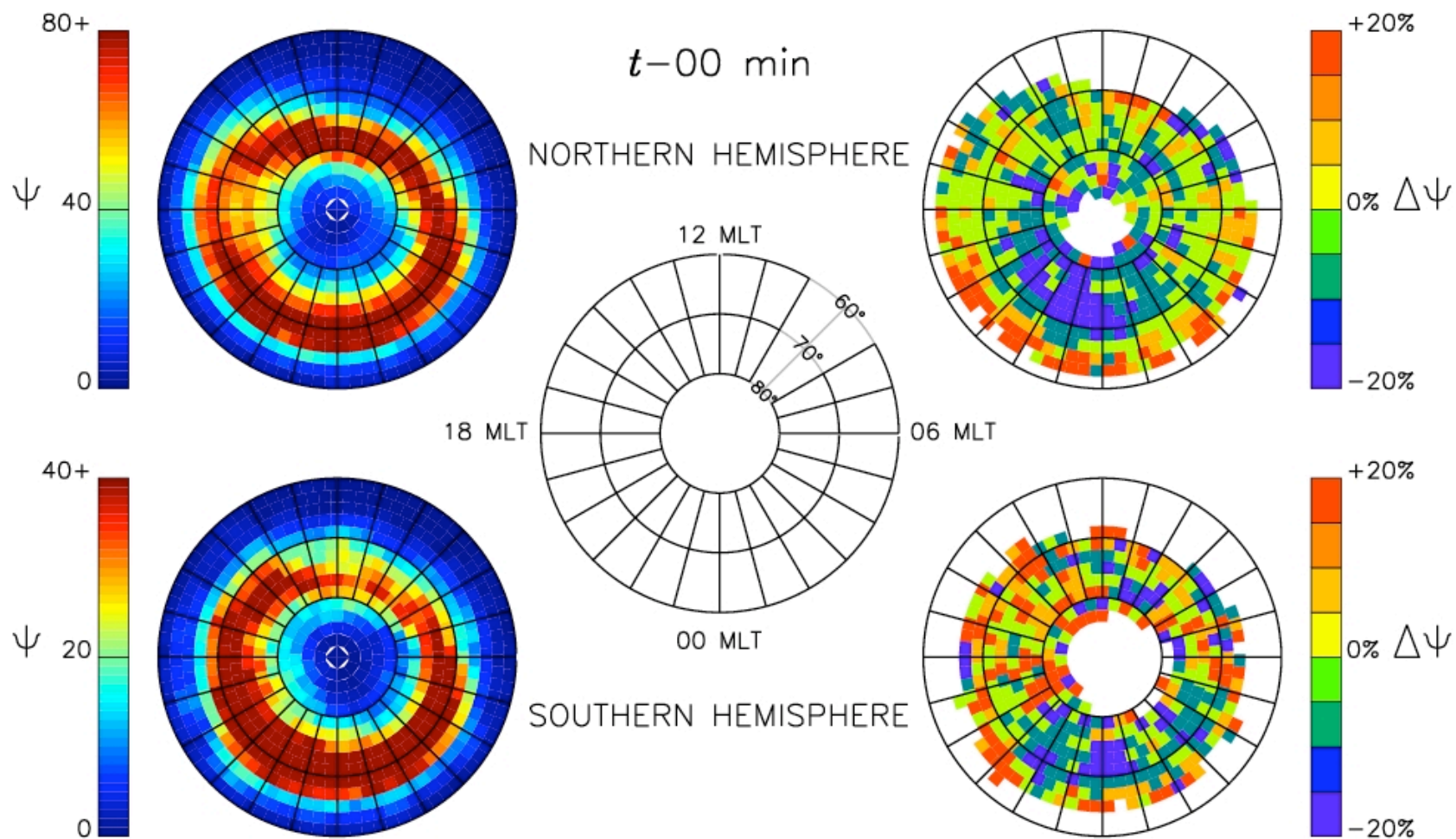




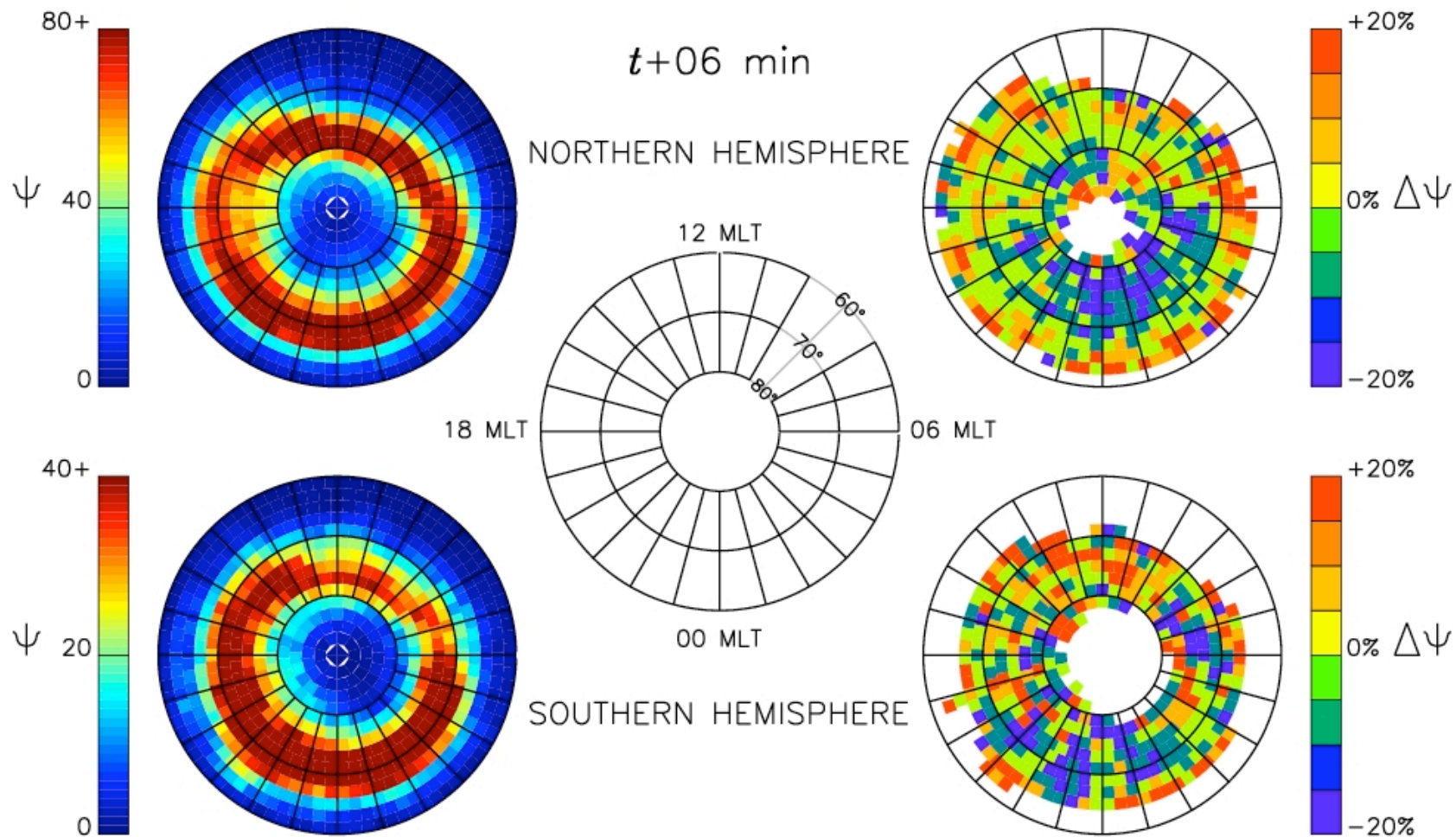
# SPATIAL BACKSCATTER VARIATIONS



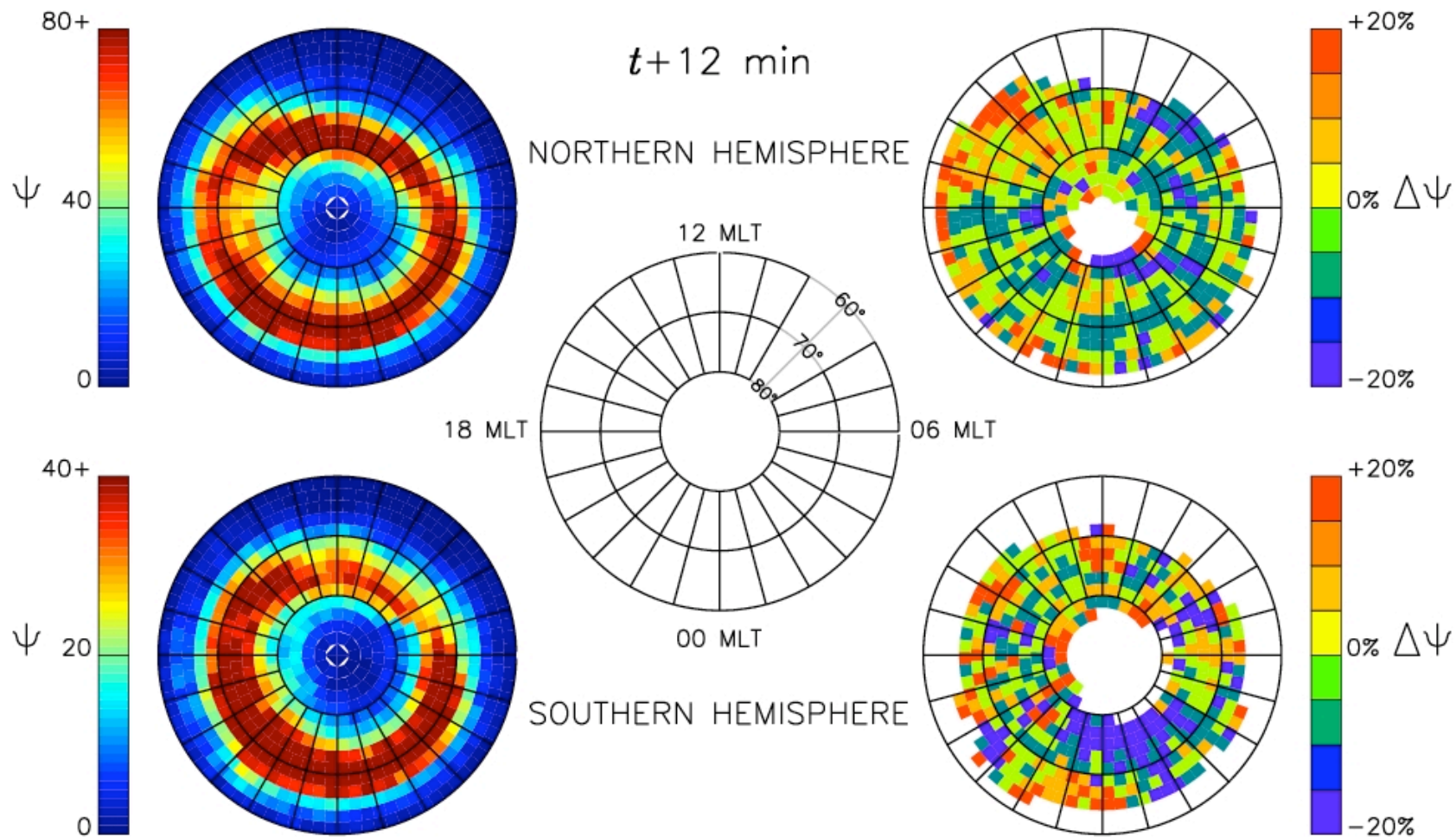
# SPATIAL BACKSCATTER VARIATIONS



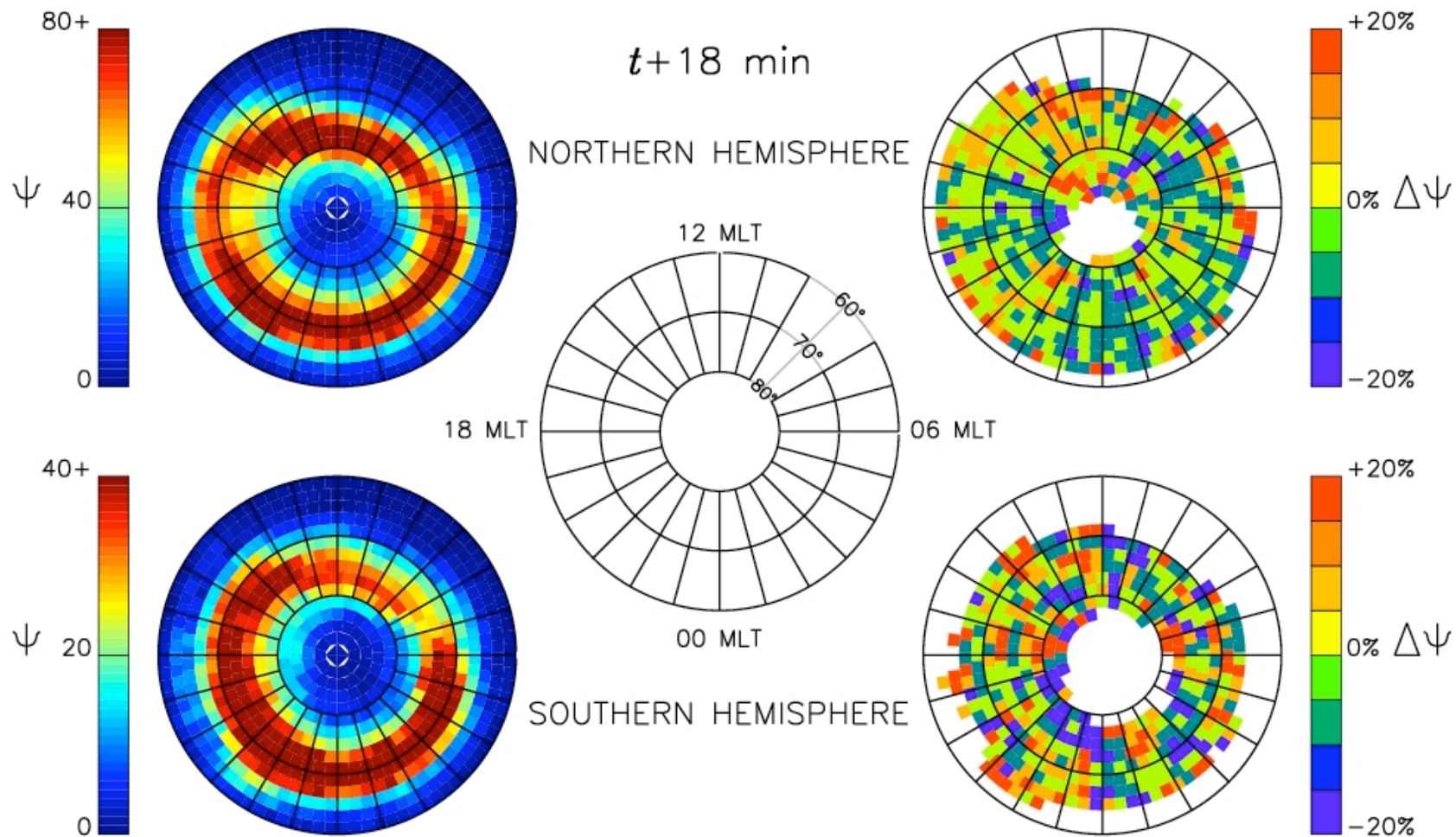
# SPATIAL BACKSCATTER VARIATIONS



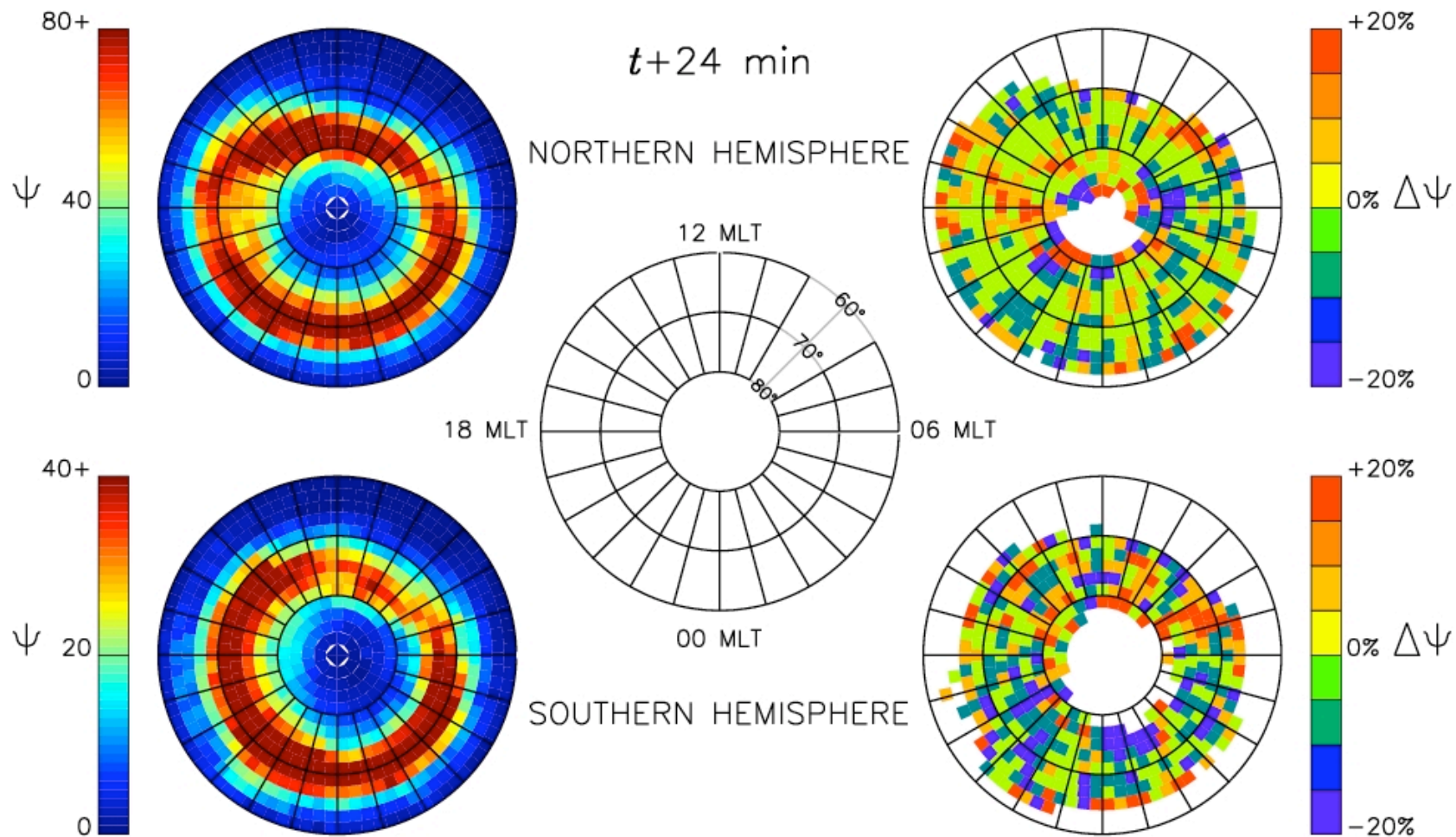
# SPATIAL BACKSCATTER VARIATIONS



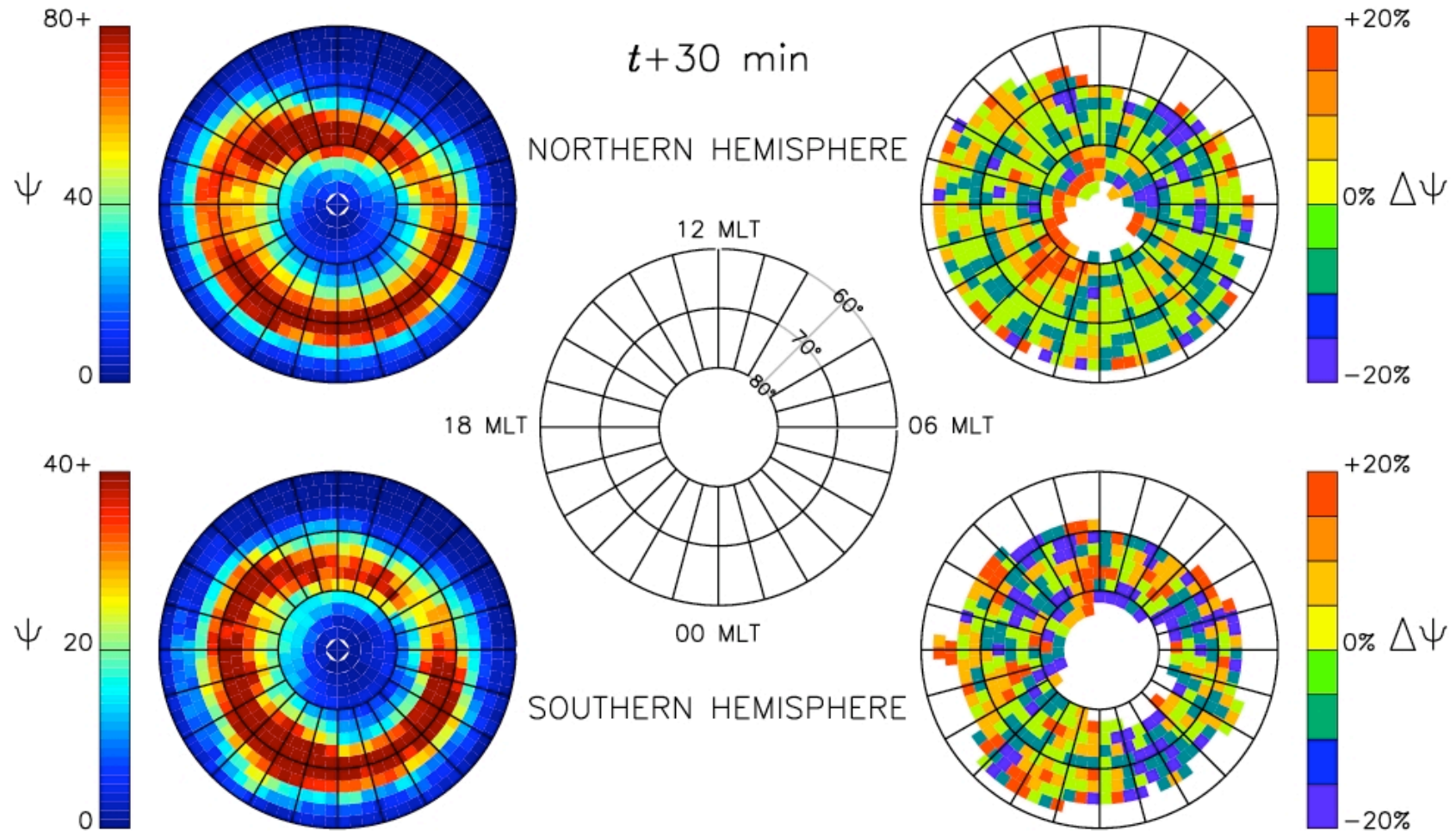
# SPATIAL BACKSCATTER VARIATIONS



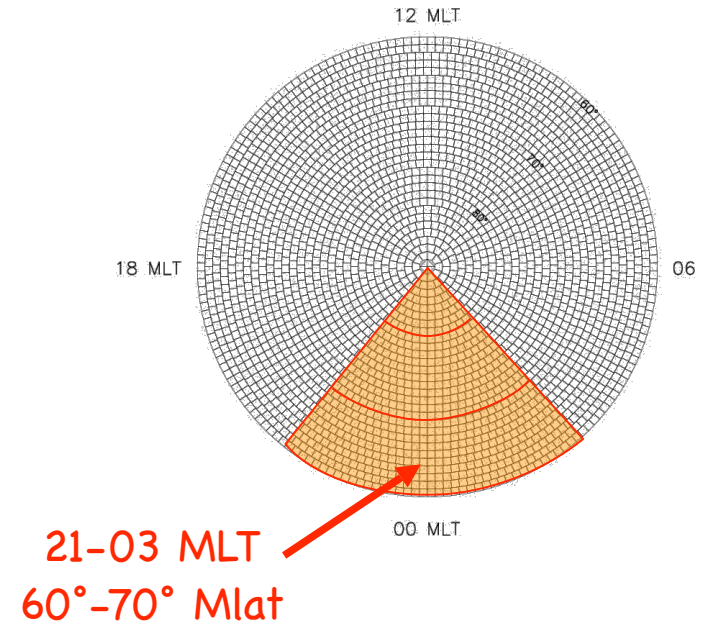
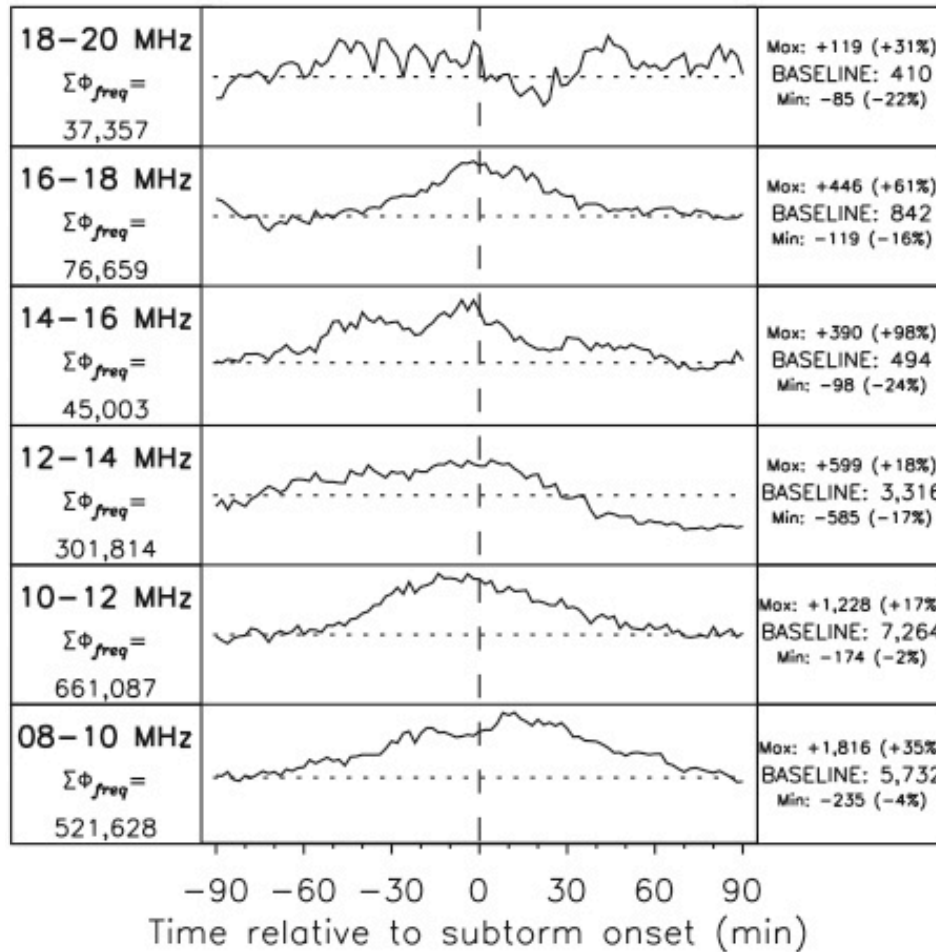
# SPATIAL BACKSCATTER VARIATIONS



# SPATIAL BACKSCATTER VARIATIONS



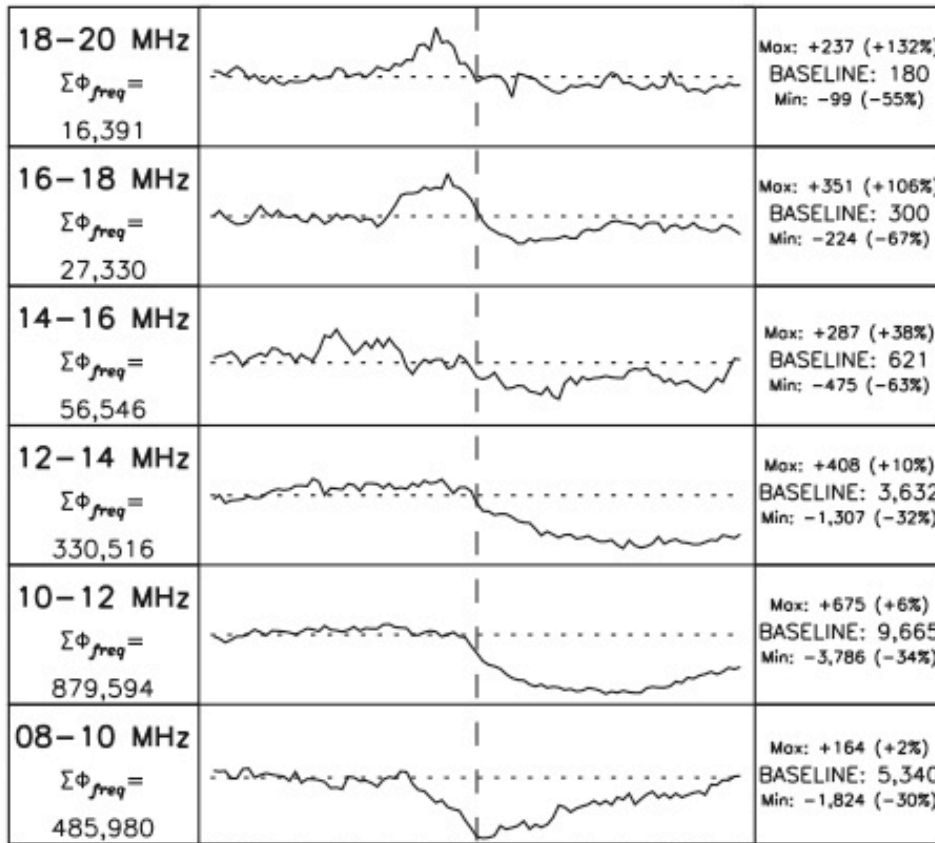
# BACKSCATTER-FREQUENCY BEHAVIOUR



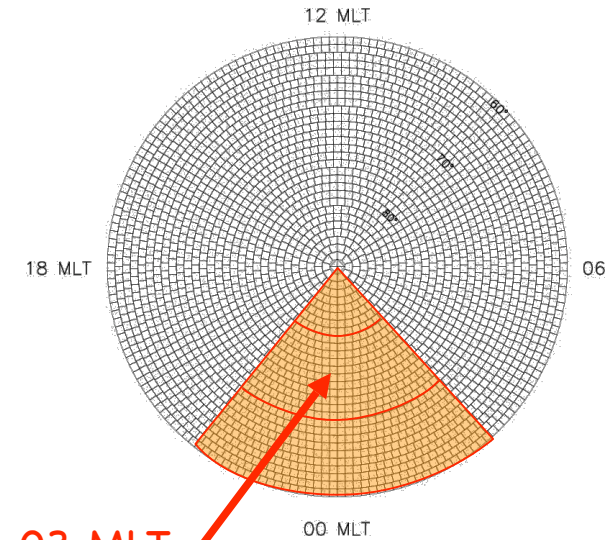
$$\Psi(t, \nu) = \frac{n_{scatter}(t, \nu)}{n_{radars}(t, \nu)}$$



# BACKSCATTER-FREQUENCY BEHAVIOUR



-90 -60 -30 0 30 60 90  
Time relative to substorm onset (min)

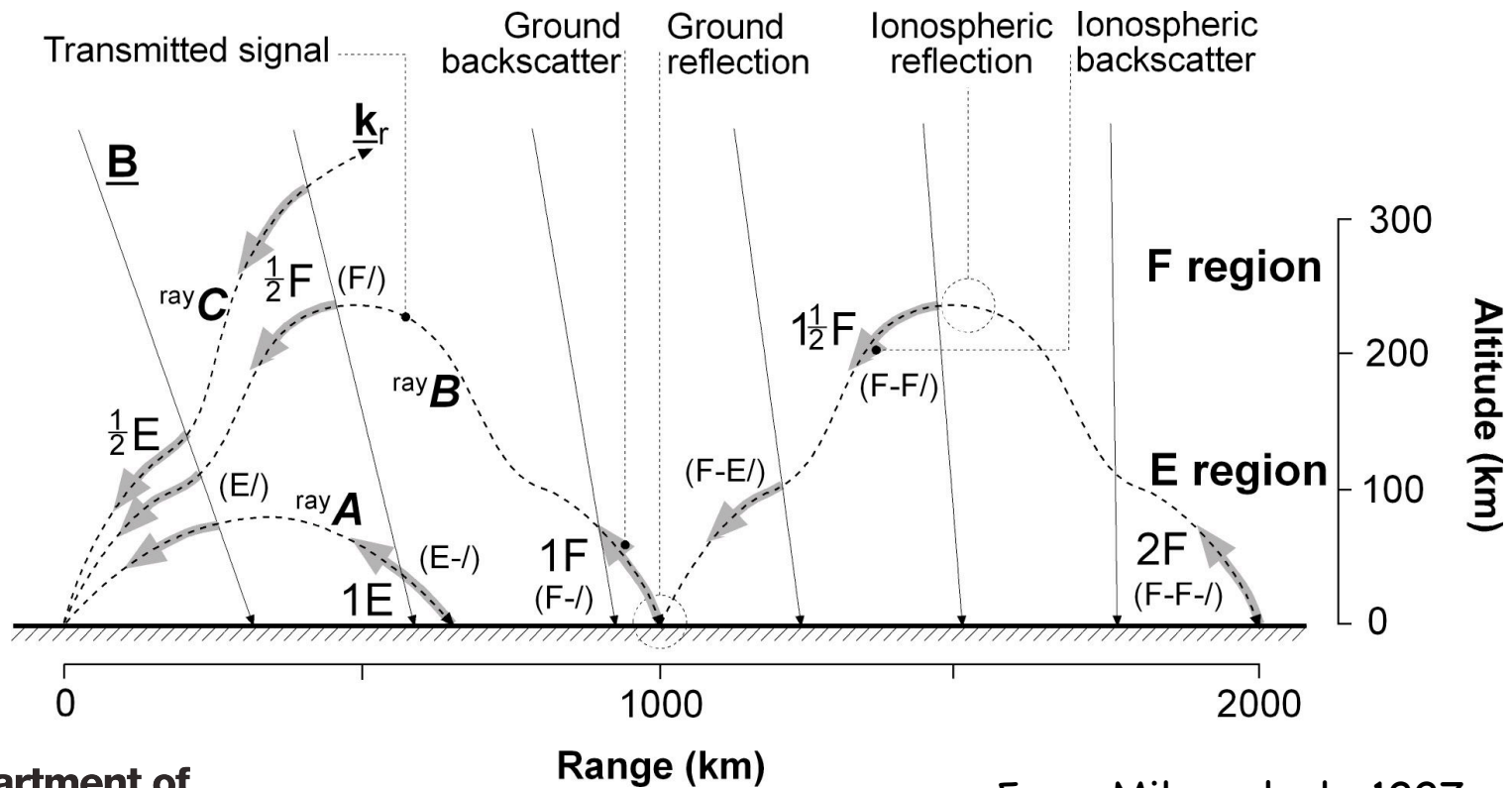


21-03 MLT  
70°-80° Mlat

$$\Psi(t, \nu) = \frac{n_{scatter}(t, \nu)}{n_{radars}(t, \nu)}$$

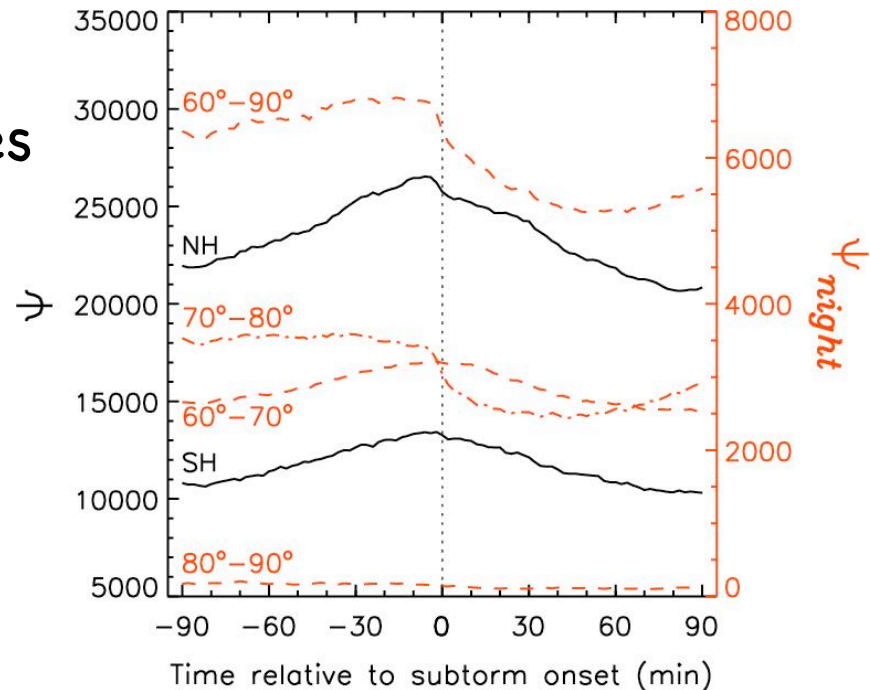
# FINDINGS

- NH radars observe approx twice as much backscatter as SH radar



# FINDINGS

- Globally, the amount of backscatter observed by SuperDARN peaks a few minutes prior to expansion phase onset
- In the nightside ionosphere:
  - Scatter falls overall
  - Reduction at 70° - 80° Mlat
  - Increases in at 60° - 70° Mlat
  - Equatorward motion of backscatter



- Possible to use “stereo” developments of SuperDARN system to maximise scatter at different latitudes?

# FUTURE DEVELOPMENTS

- **This work published recently**

“The Influence of Magnetospheric Substorms on SuperDARN Radar Backscatter”

Wild & Grocott, JGR, 2008.

- **Follow on work looking at flows**

“The influence of Magnetospheric Substorms on High-Latitude Ionospheric Convection”

Grocott, Wild, Milan & Yeoman

- Poster presented at this meeting
- Submission expected shortly

- **Coming soon...**

Large scale analysis of SuperDARN Doppler spectral width during these 3005 substorms and comparison with IMAGE WIC optical data.

## The influence of magnetospheric substorms on high-latitude ionospheric convection

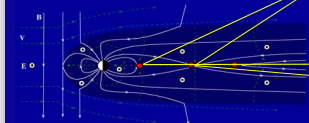
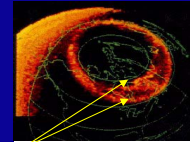
Adrian Grocott<sup>1</sup>, Jim Wild<sup>2</sup>,  
Steve Milan<sup>1</sup>, Tim Yeoman<sup>1</sup>  
<sup>1</sup> University of Leicester; <sup>2</sup> Lancaster University

### Why do we want to know?

Substorms are a global process

THEMIS will make unprecedented in-situ observations but these will still be local point measurements

The high-latitude ionosphere can tell us about the dynamics of the entire magnetosphere



### Introduction

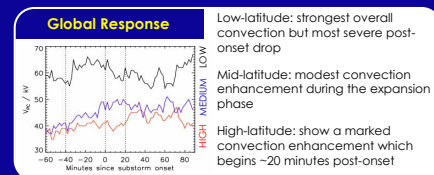
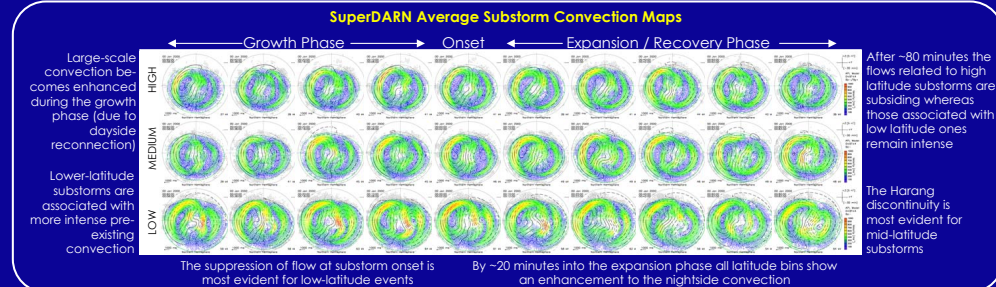
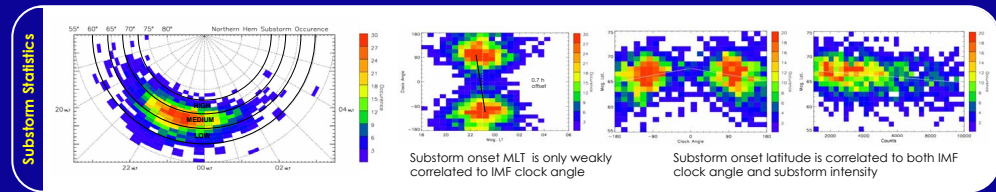
A number of statistical studies have attempted to determine the ionospheric convection response to substorms (e.g. Provan et al., 2004; Bristow and Jensen, 2007)

These studies have involved a limited number of substorms such that all events had to be artificially combined into a single substorm coordinate system

Here we analyse SuperDARN radar data from 1979 northern hemisphere isolated substorms that were identified in IMAGE FUV satellite data (Frey et al., 2004; Wild and Grocott, 2008)

The substorms have then been grouped according to onset latitude using similar criteria to Milan et al. (2008) in their discussion of average substorm auroral evolution

The local and global influence of substorms on the average SuperDARN convection patterns has then been studied

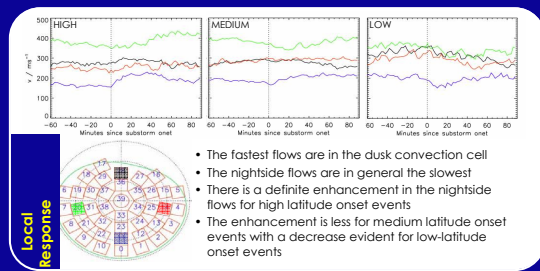


**Conclusions**

**Low-latitude substorms:** are generally of larger intensity and are associated with intervals of stronger convection, BUT more noticeably suppress the flow immediately after onset

**Mid-latitude substorms:** have a more significant effect globally than high-latitude substorms but do not produce a very large enhancement in the flows locally

**High-latitude substorms:** are slower at producing a large-scale convection response but produce the most noticeable enhancement to the flow in the locally disturbed region



Bristow and Jensen, A superposed epoch study of convection during substorms, J. Geophys. Res., 112, 2007.  
Frey et al., Substorm onset observations by IMAGE-FUV, J. Geophys. Res., 109, 2004.  
Milan et al., A superposed epoch analysis of auroral evolution during substorms, ICS-9, 2008.  
Provan et al., Statistical study of high-latitude plasma flow during substorms, Ann. Geophys., 22, 2004.  
Wild and Grocott, The Influence of Substorms on SuperDARN Backscatter, J. Geophys. Res., in press, 2008.