Diffuse Aurora

Eric Donovan – Midway Utah – June 21, 2007

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3. *How do they become diffuse aurora*
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7. *Opportunities for future studies*
8. *Final thoughts*

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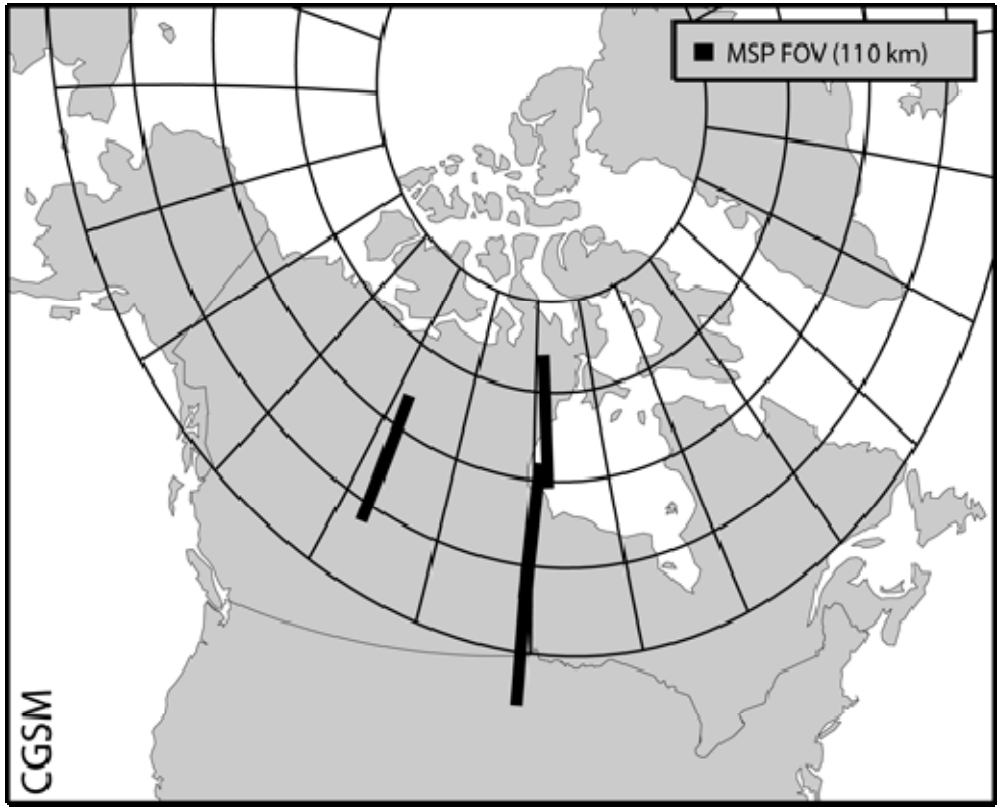
A Few Details

Images from rom http://spaceweb.oulu.fi/~jussila/aurora/

Diffuse Aurora



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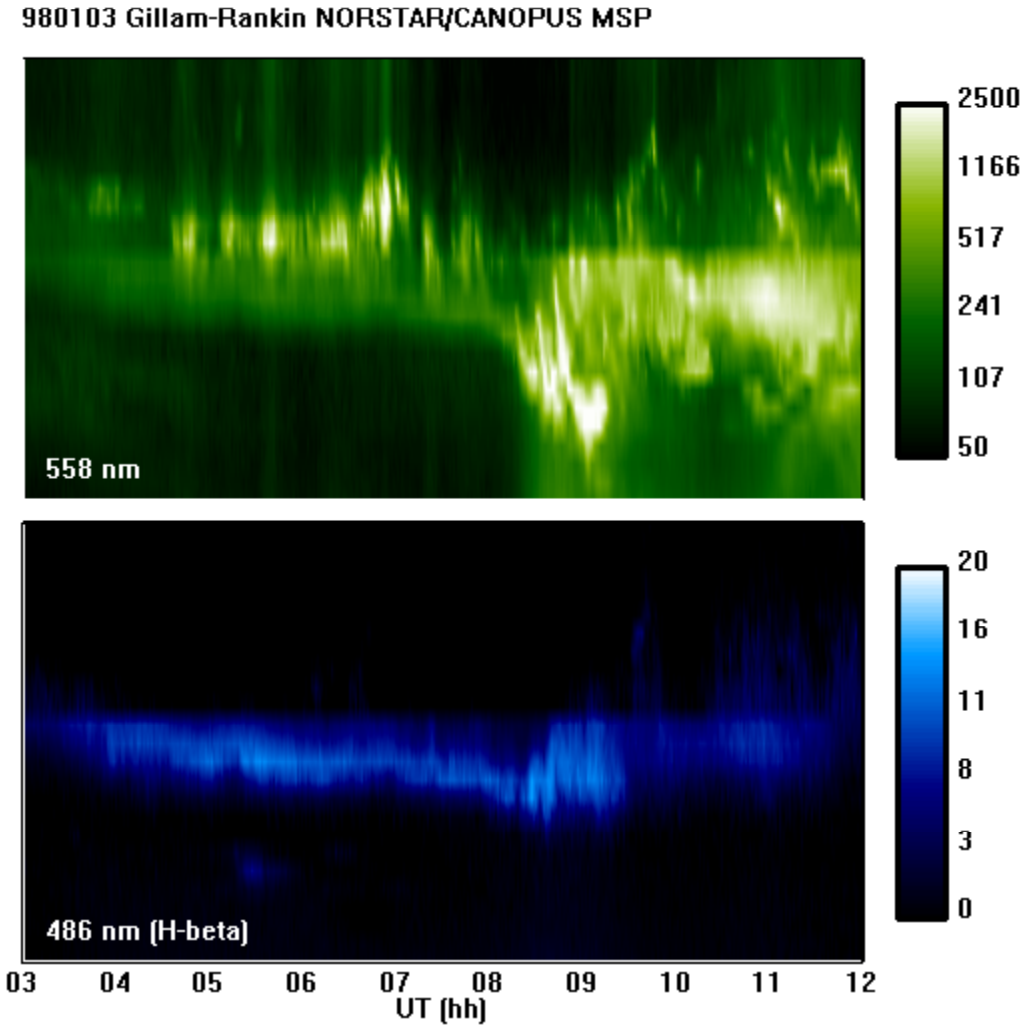

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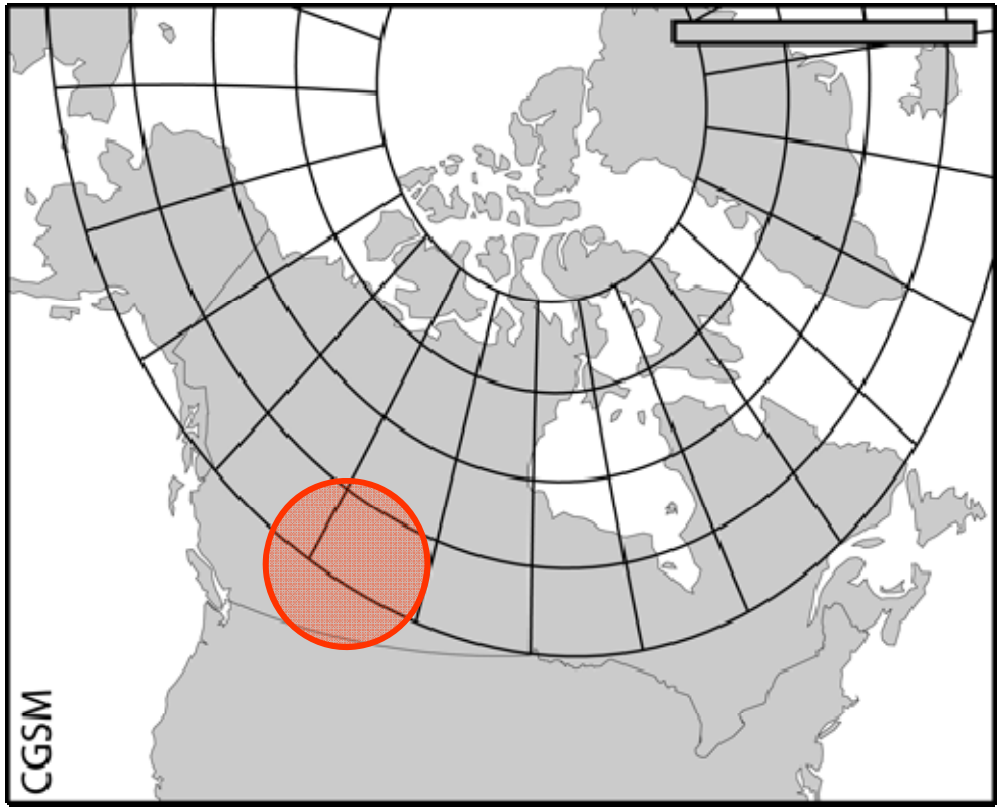

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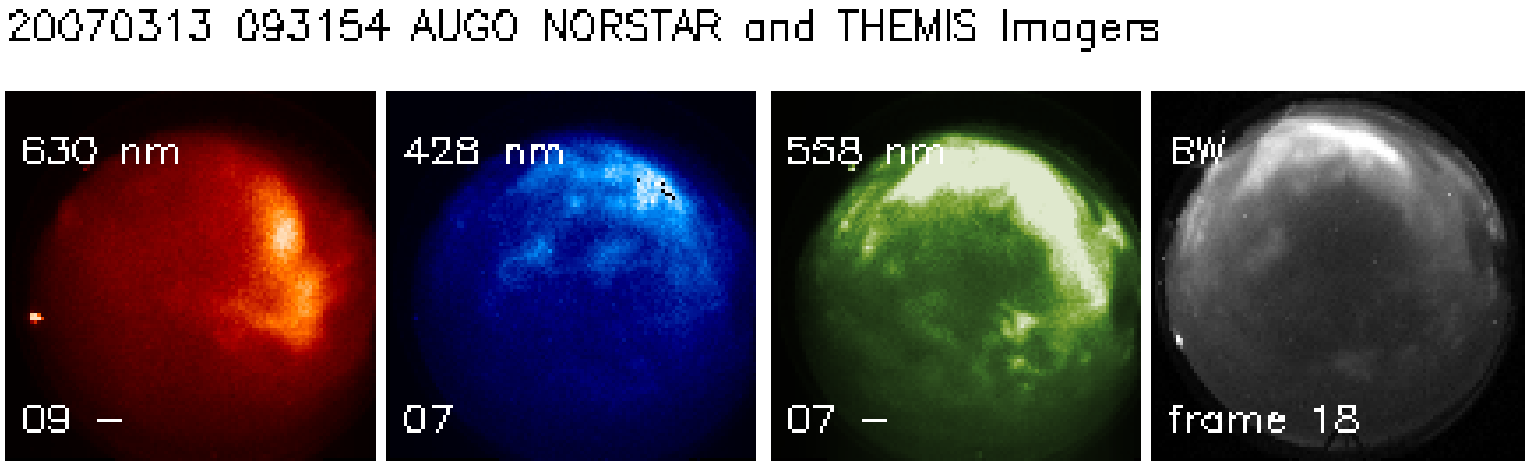

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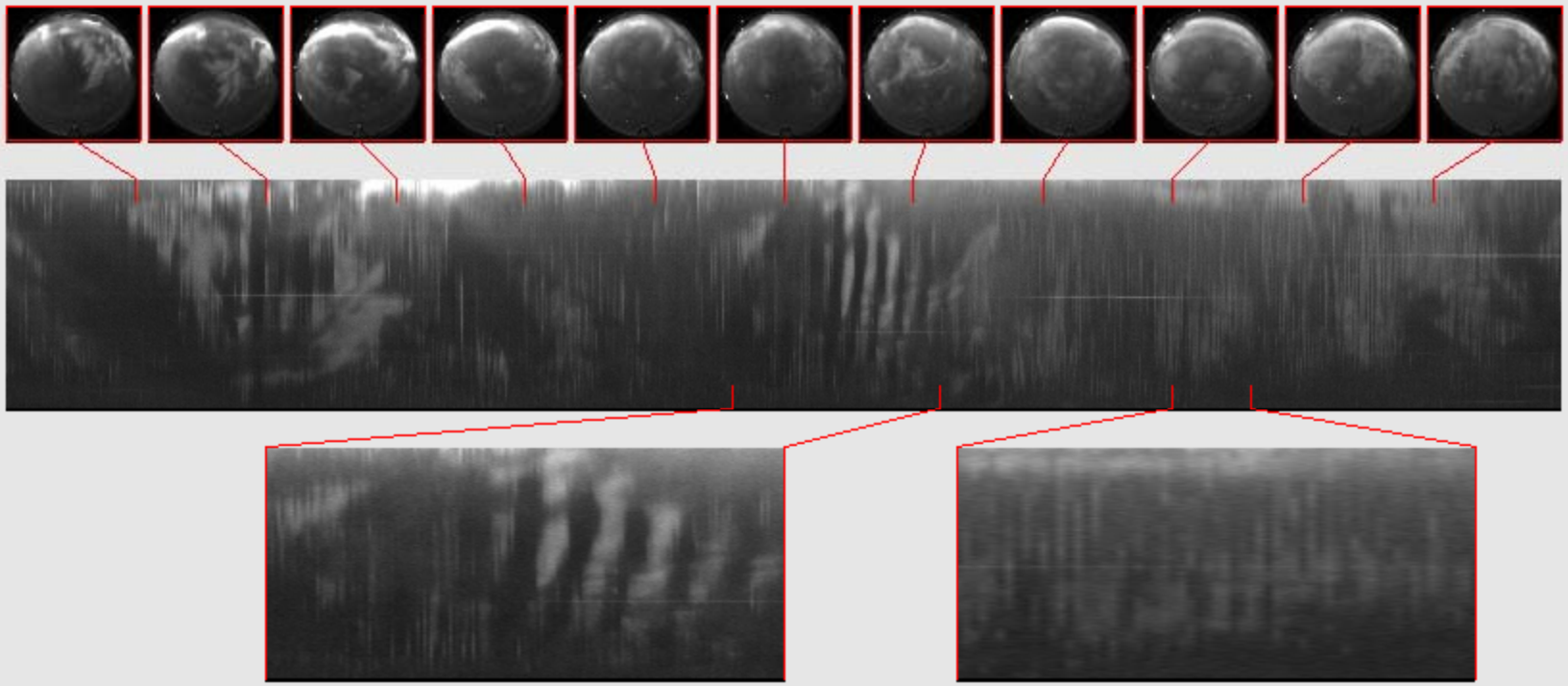

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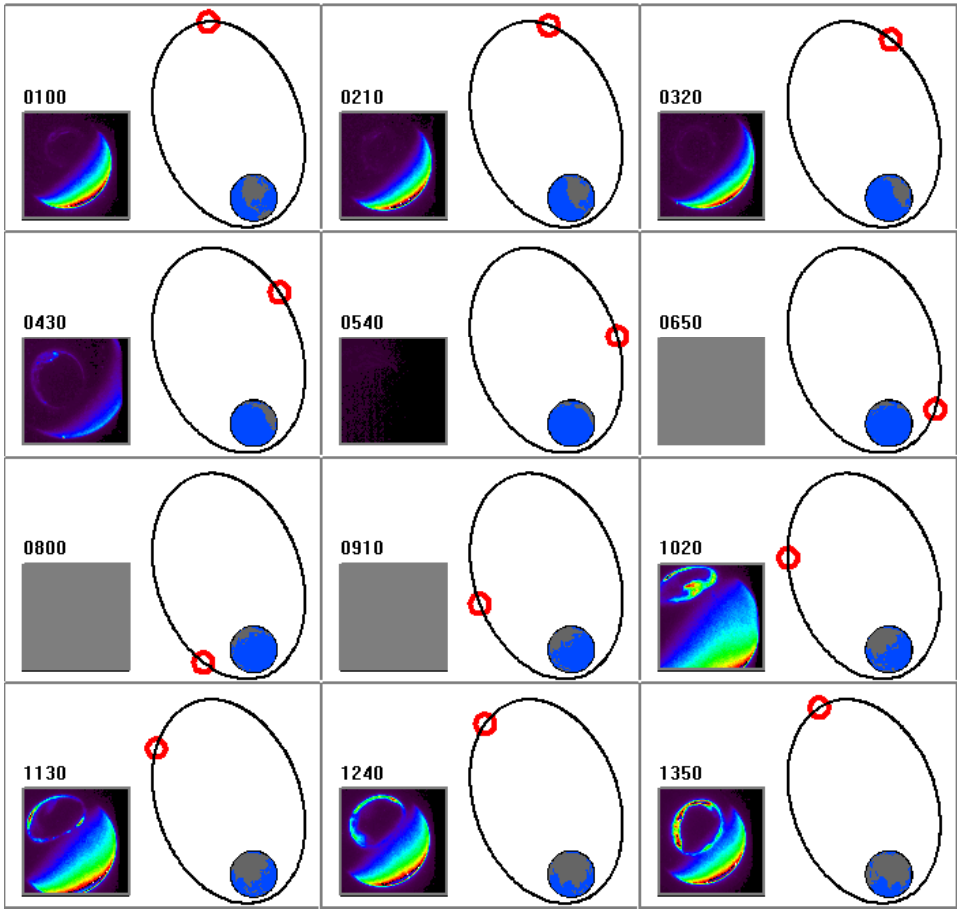

Introduction

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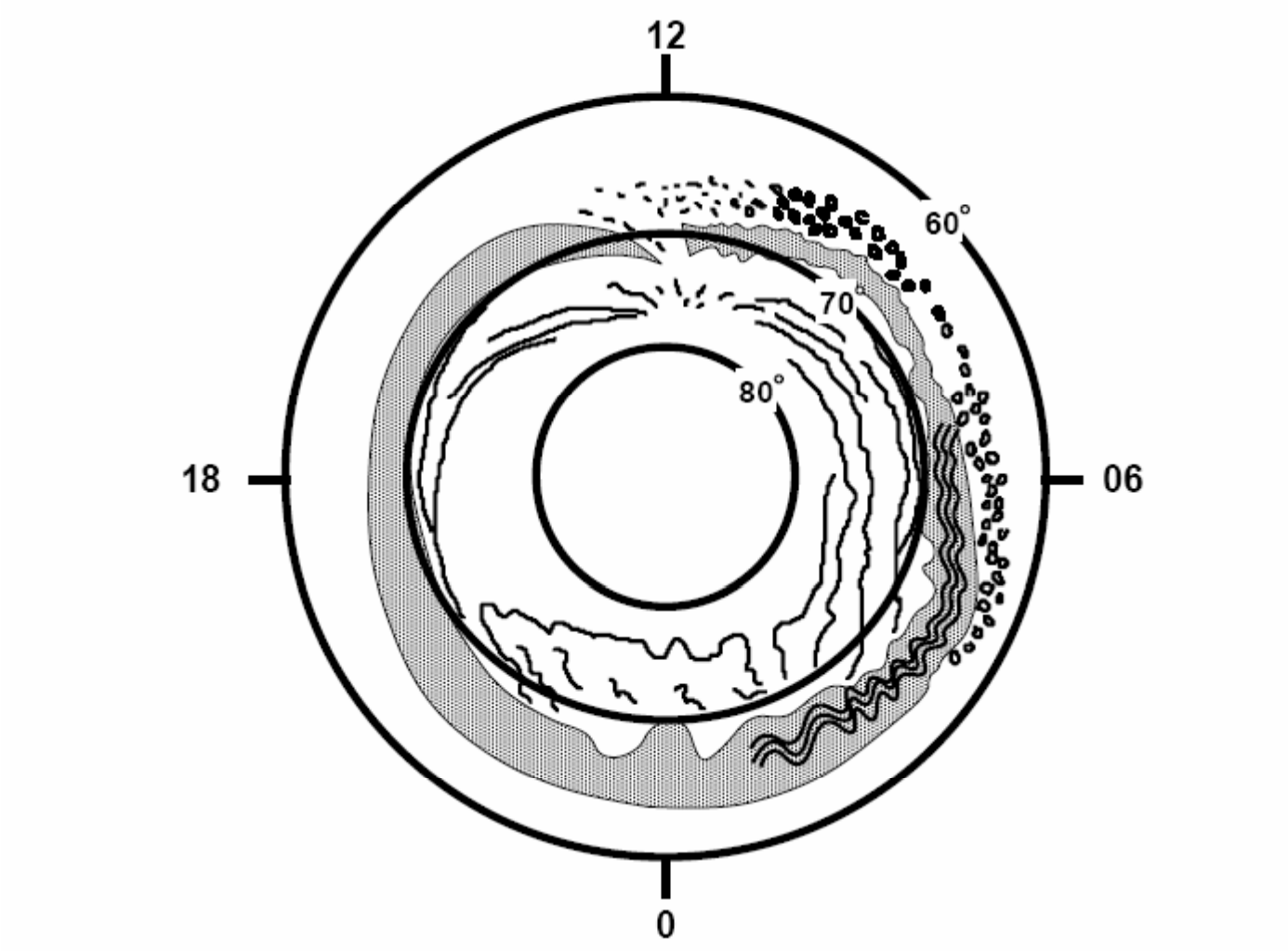

Fig. 1. Schematic of auroral distribution modified slightly from Akasofu (1966). Note that the original figure was constructed on the basis of ground-based observations made before global imaging from space was possible. As such, it incorporates a mixture of diurnal (local time) and temporal (universal time) variations.

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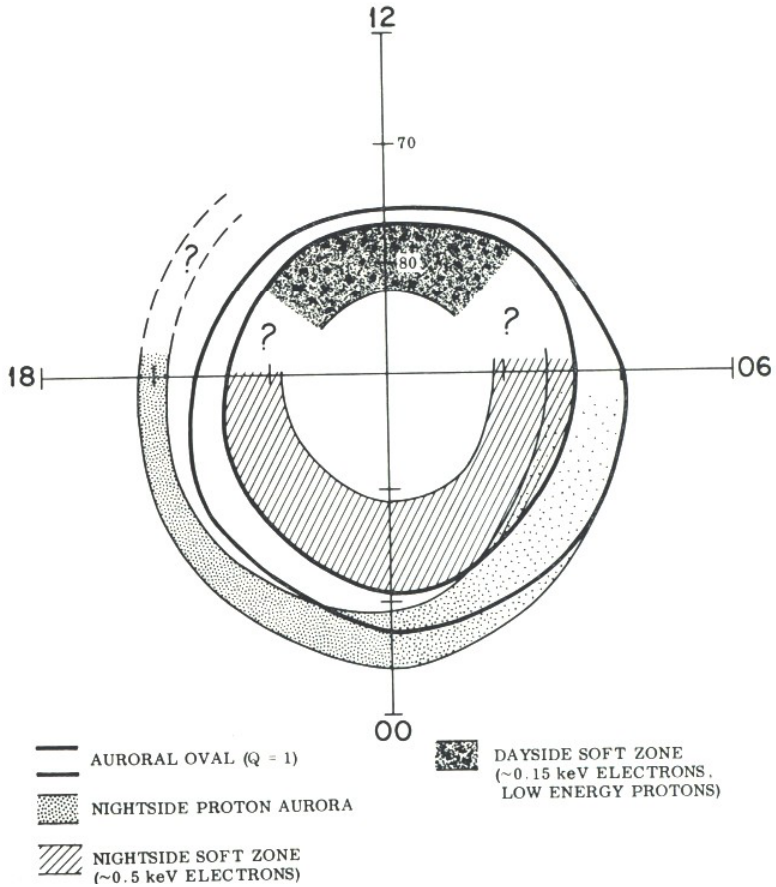

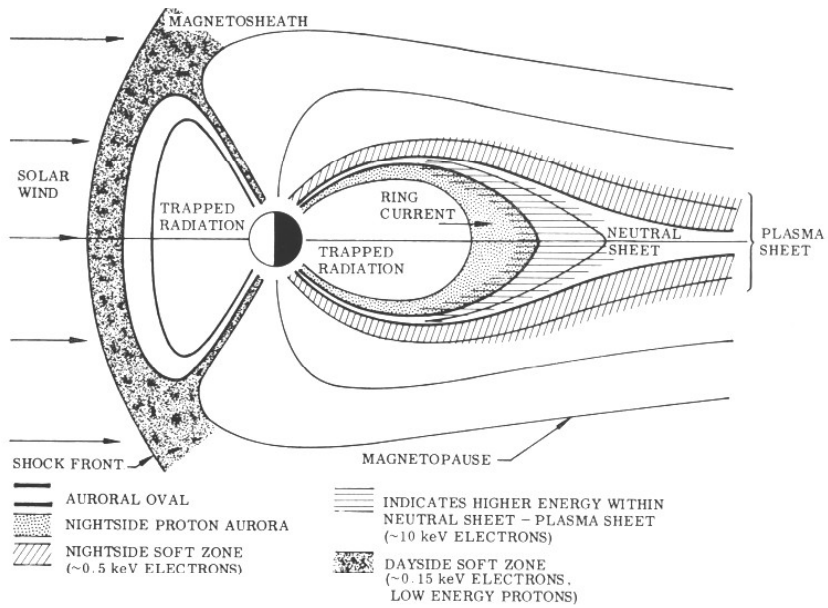

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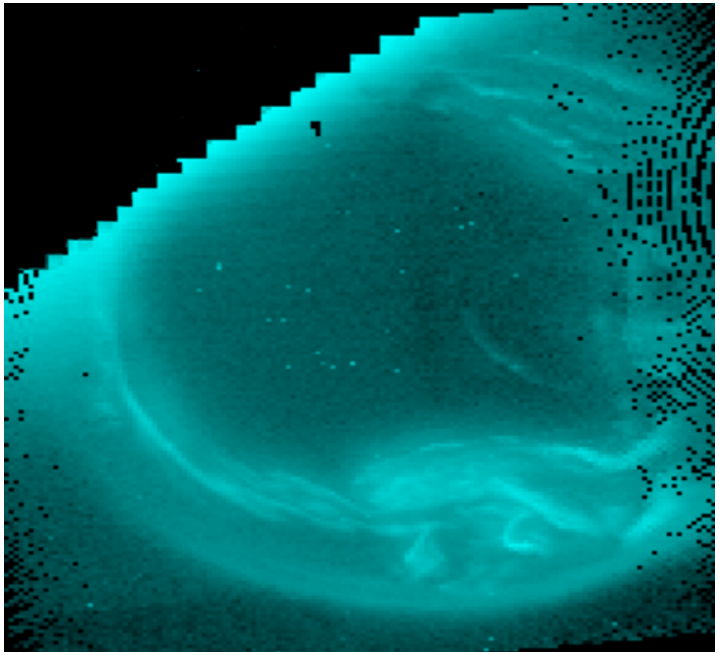

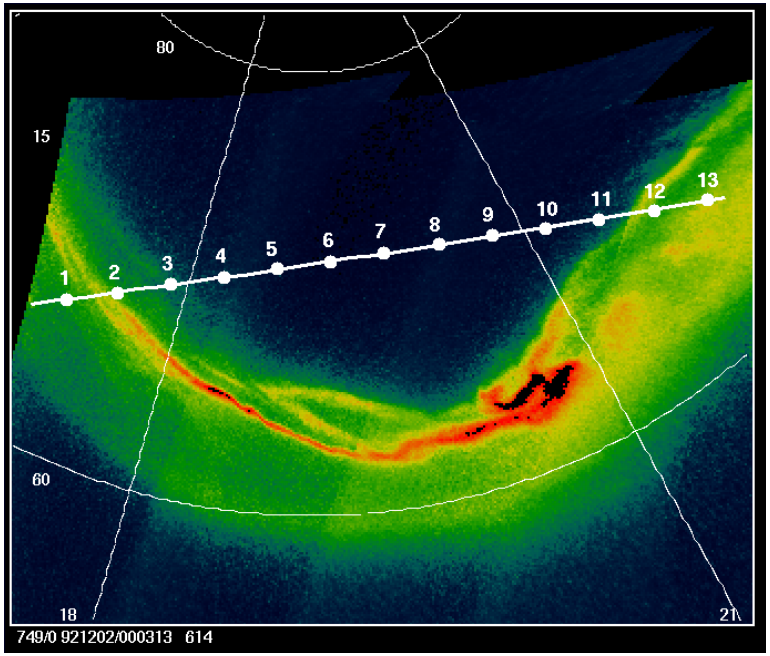

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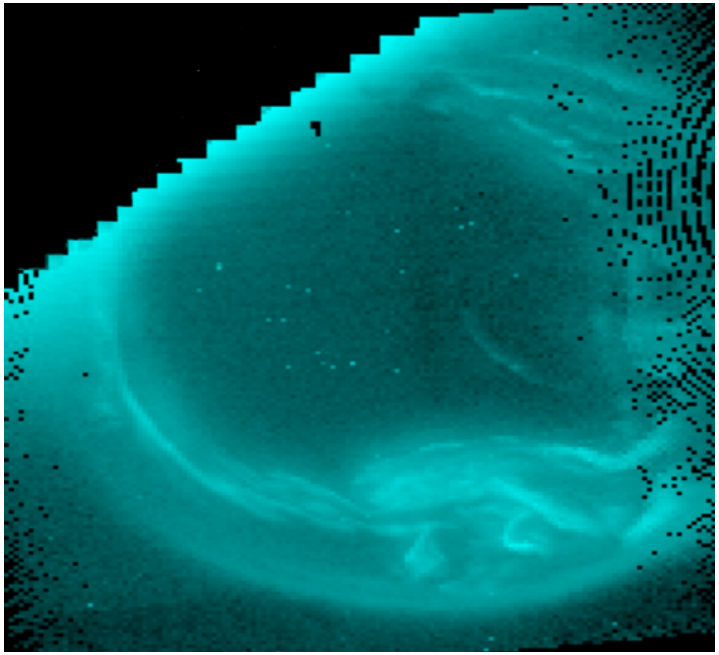

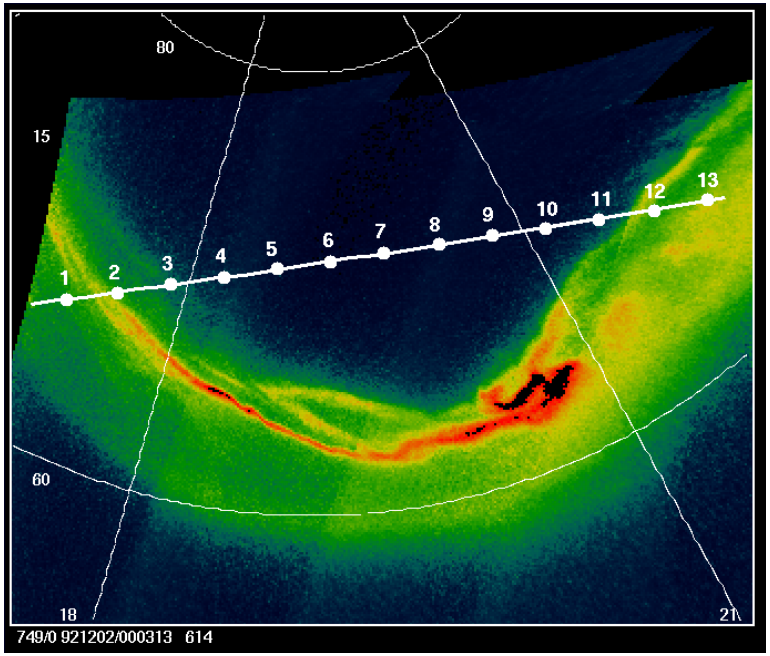

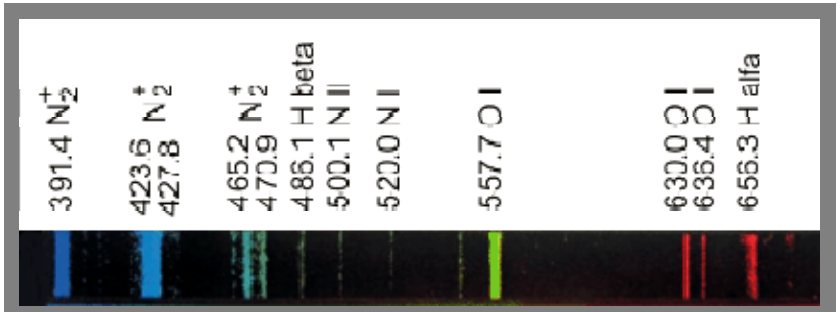

from - www.aldebaran.cz/actions/2002_aurora/start.html

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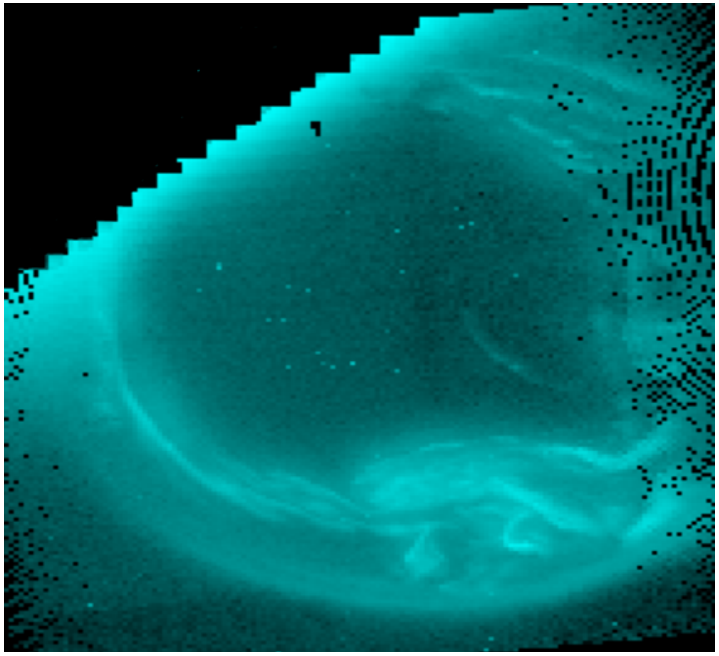

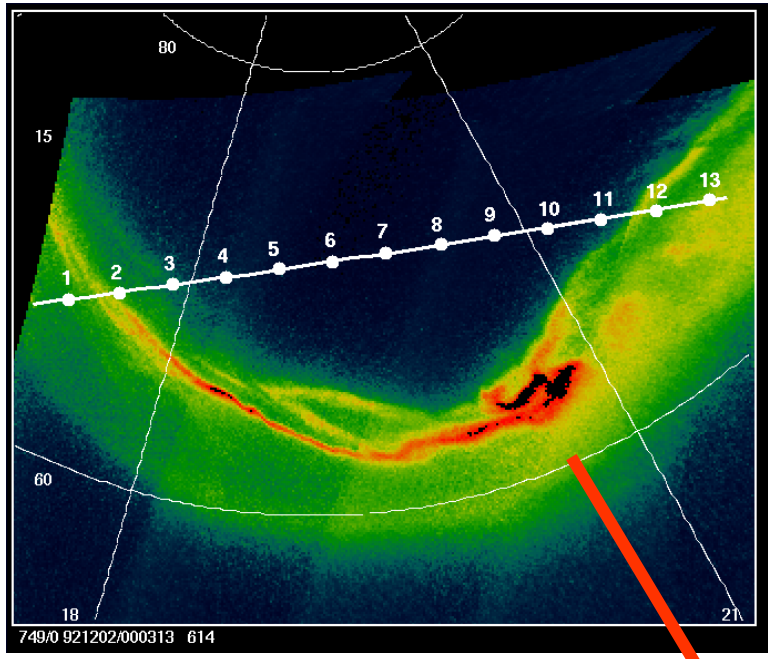

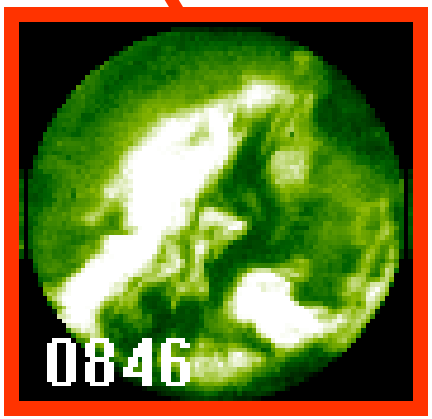

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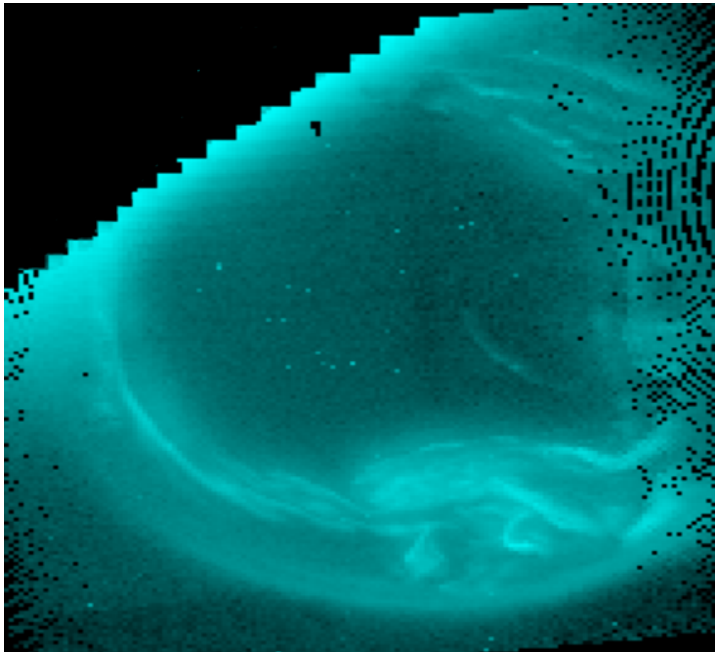
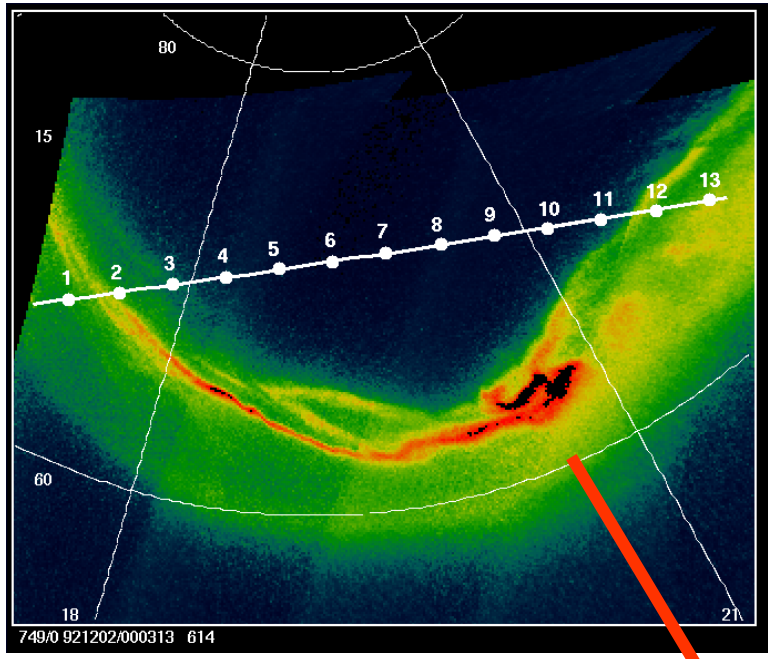
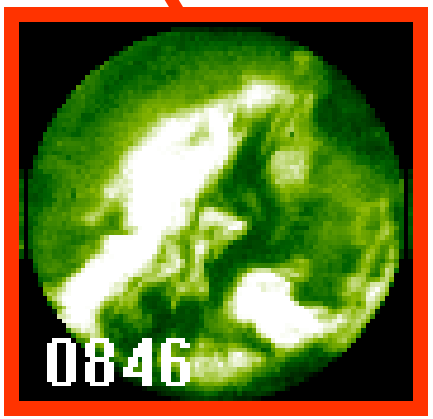
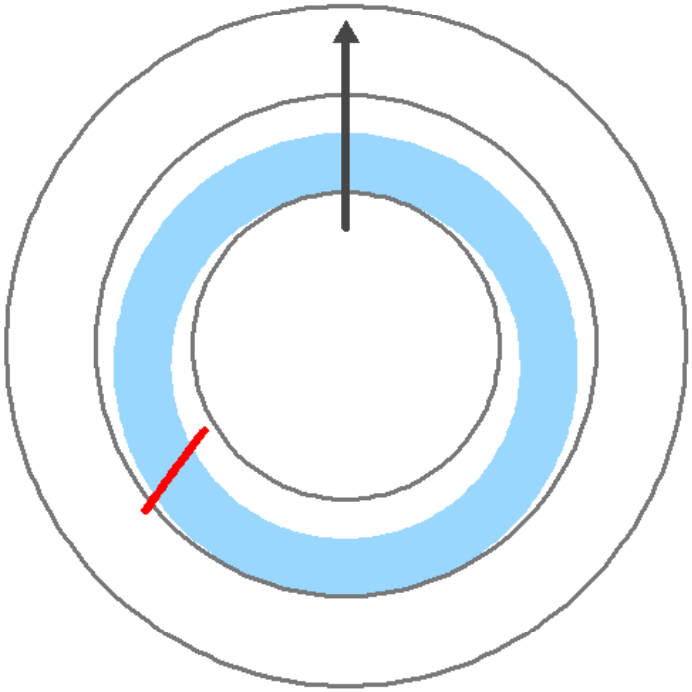


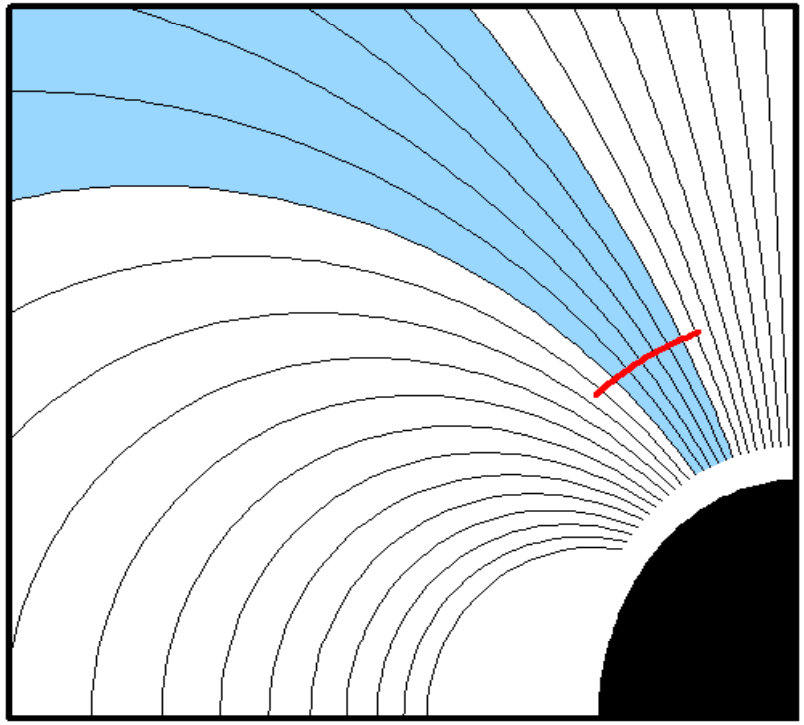




Show SNKQ Movie

Diffuse Aurora





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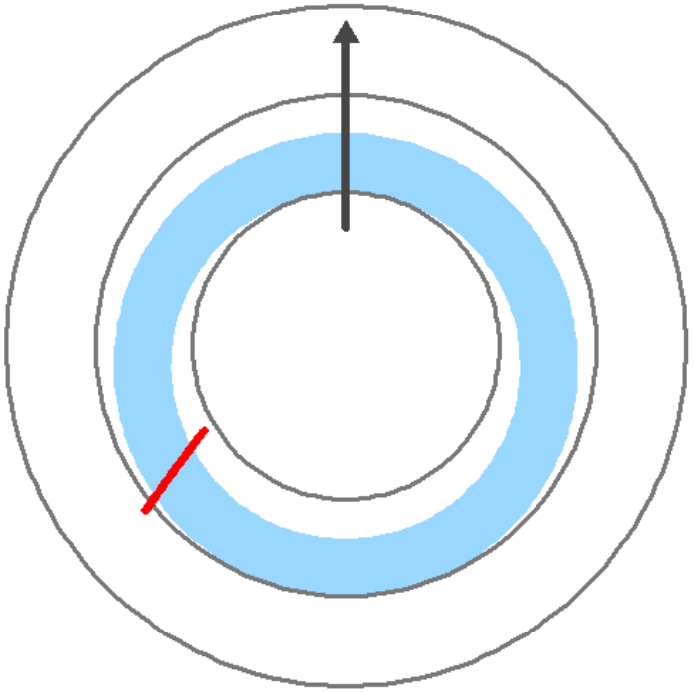

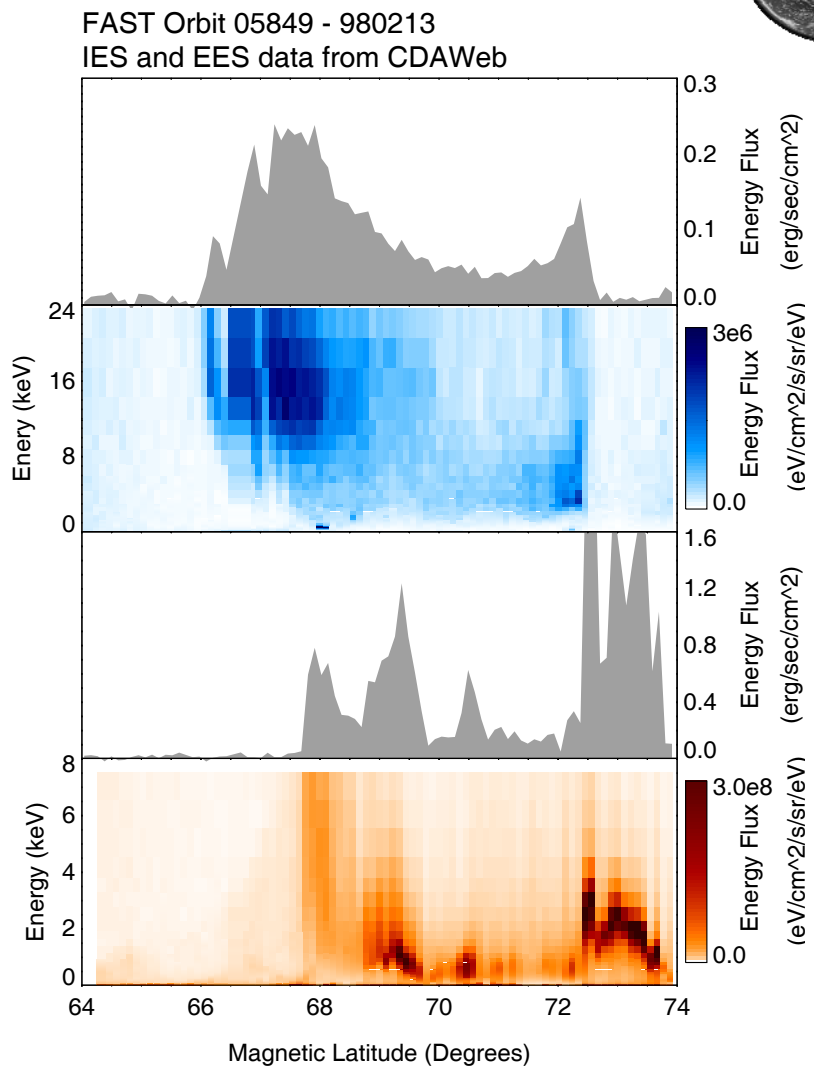

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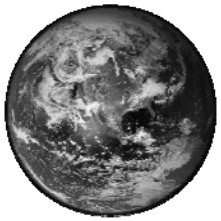
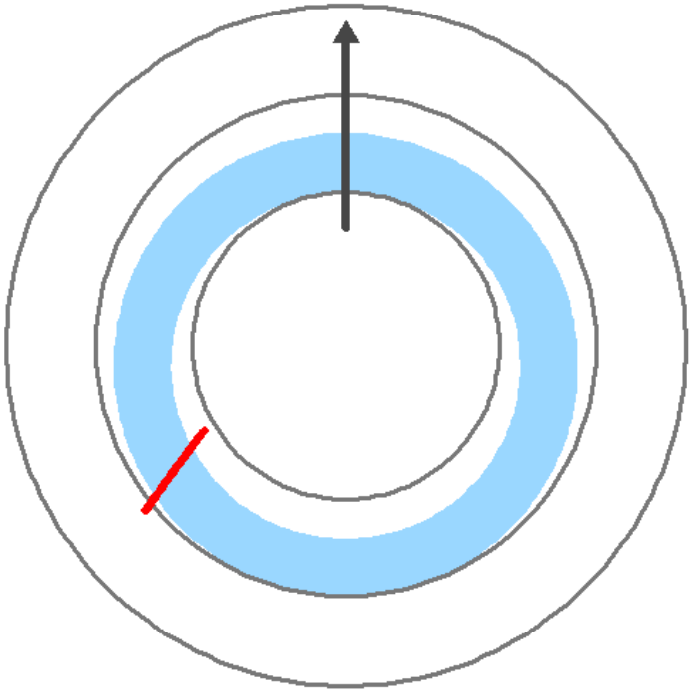
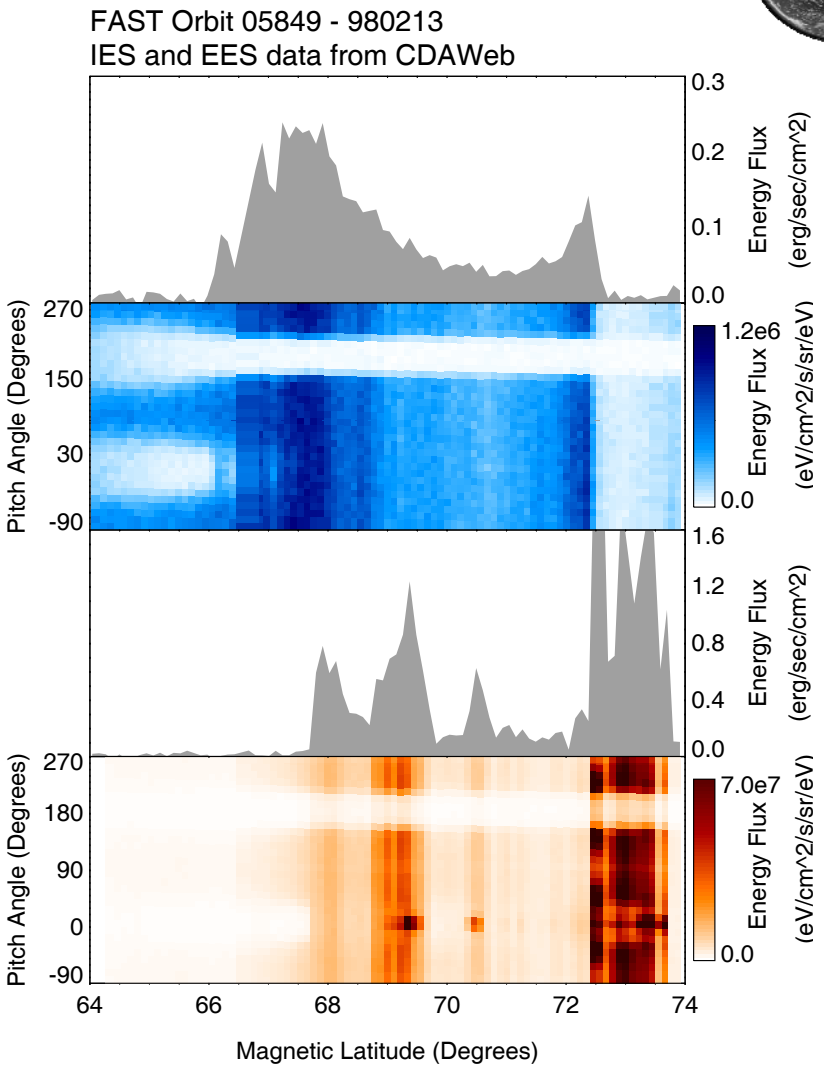
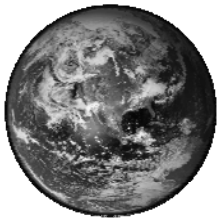


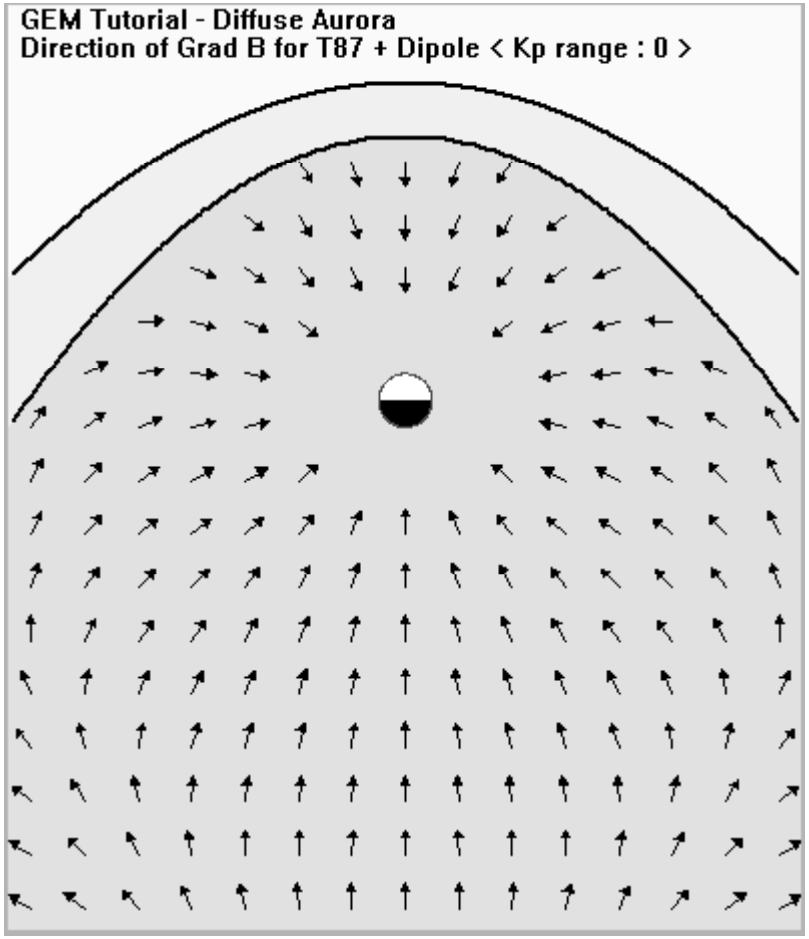


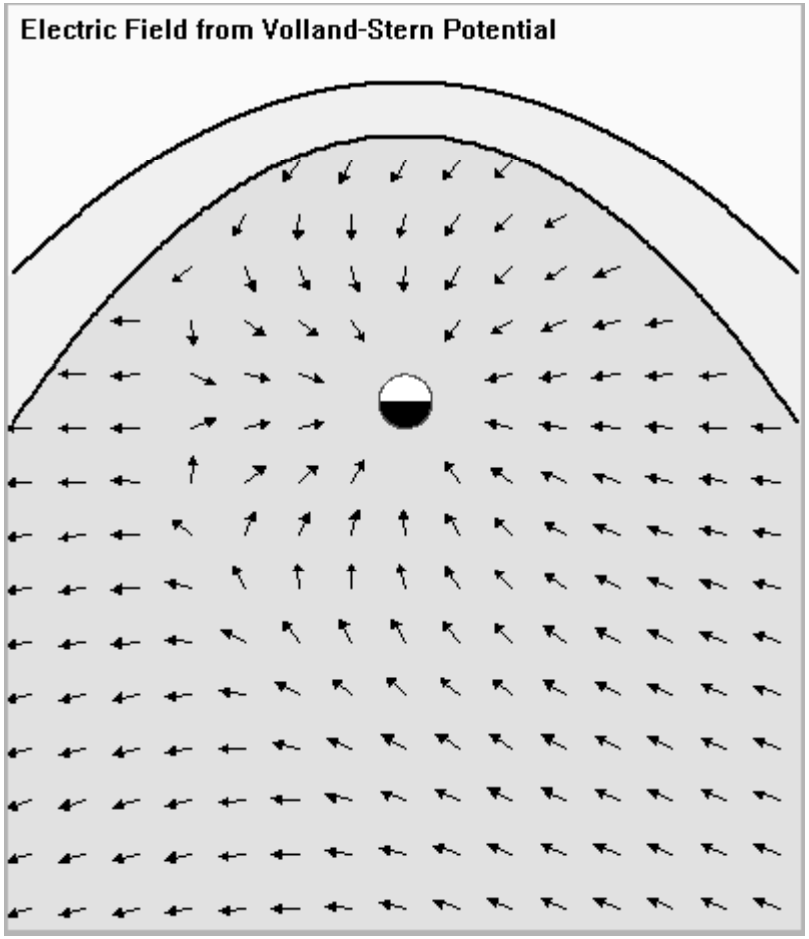




Where do the Particles Come From?

Diffuse Aurora





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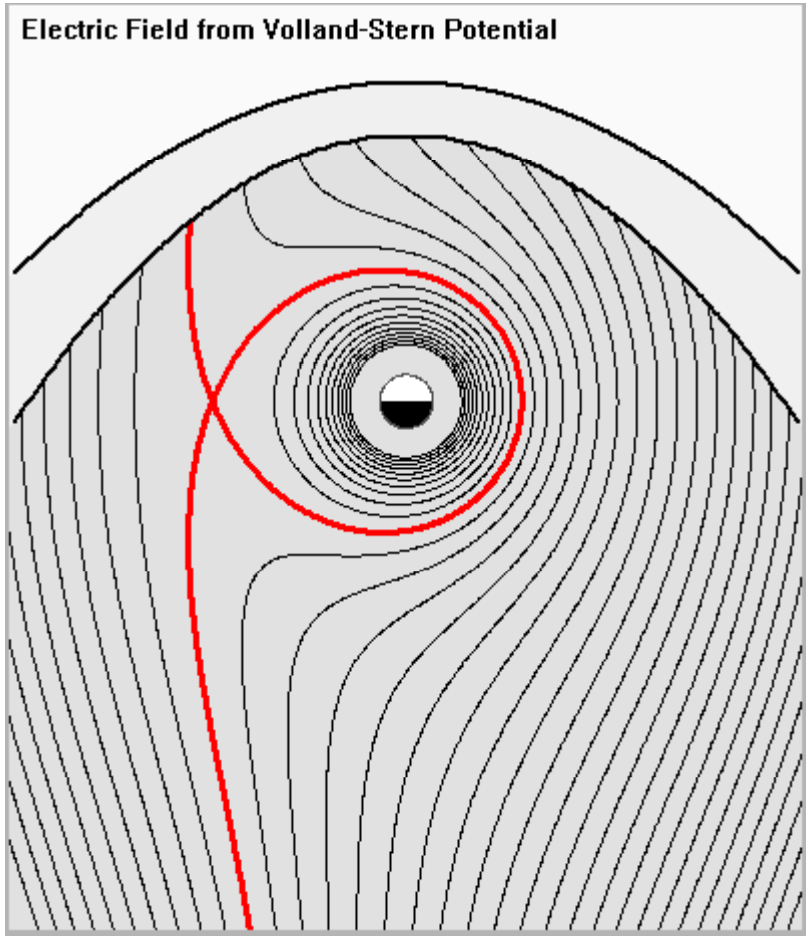

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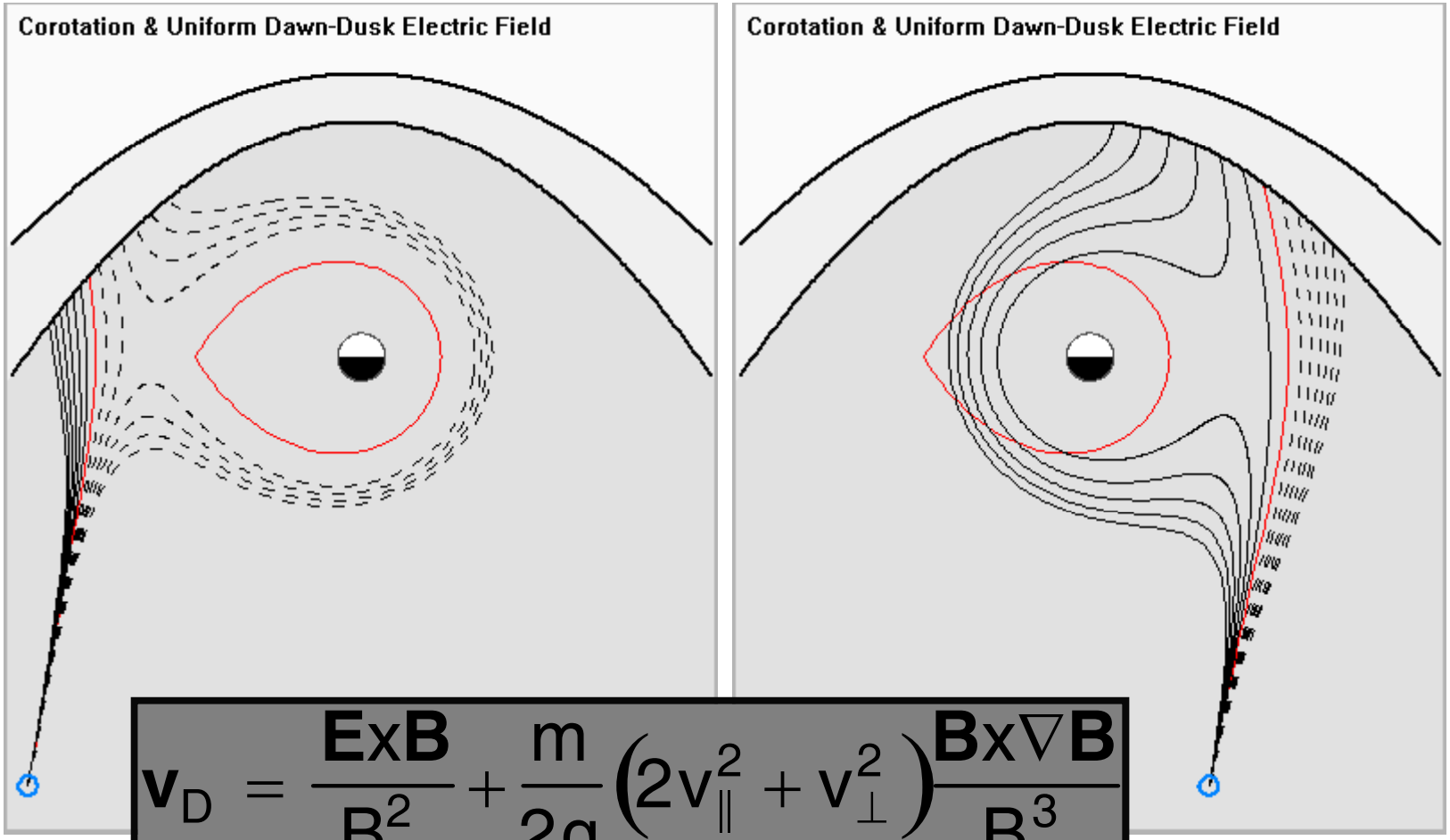
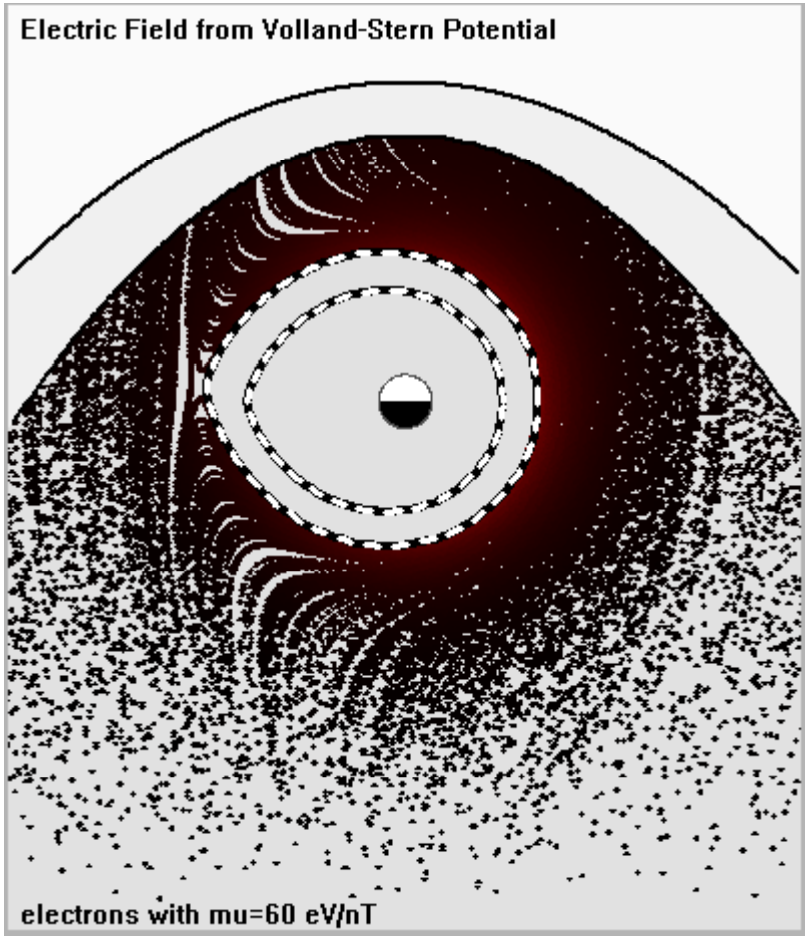
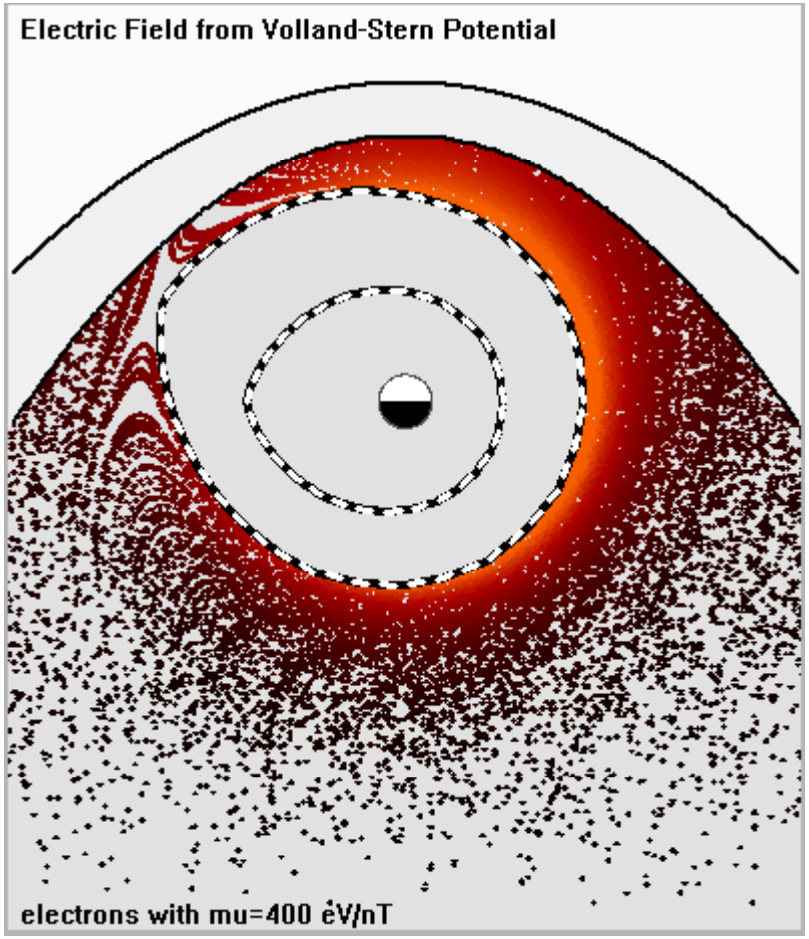


$$\mathbf{v}_D = \frac{\mathbf{E}\mathrm{x}\mathbf{B}}{B^2} + \frac{m}{2q}\left(2v_{\parallel}^2 + v_{\perp}^2\right)\frac{\mathbf{B}\mathrm{x}\nabla\mathbf{B}}{B^3}$$

Diffuse Aurora





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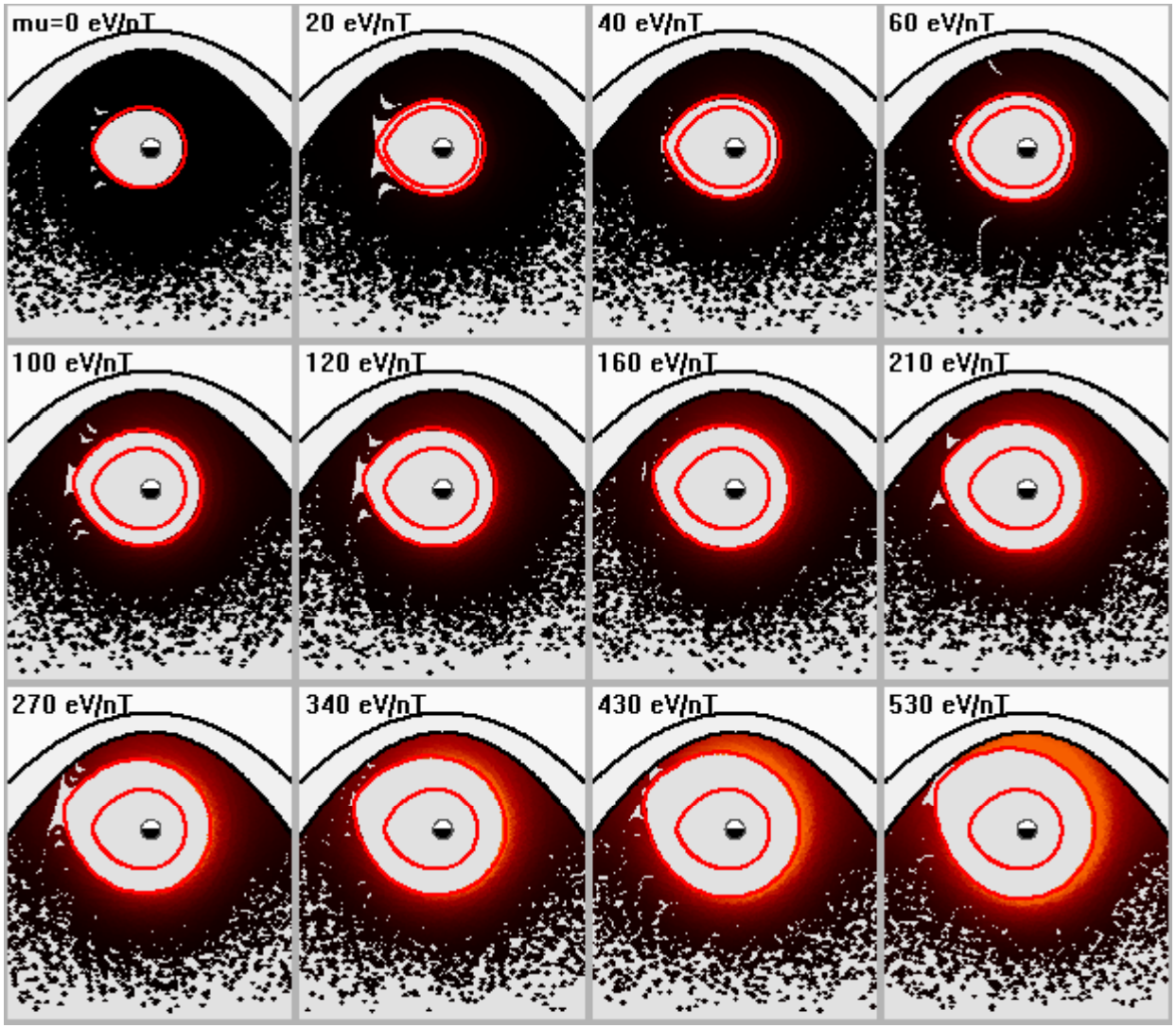

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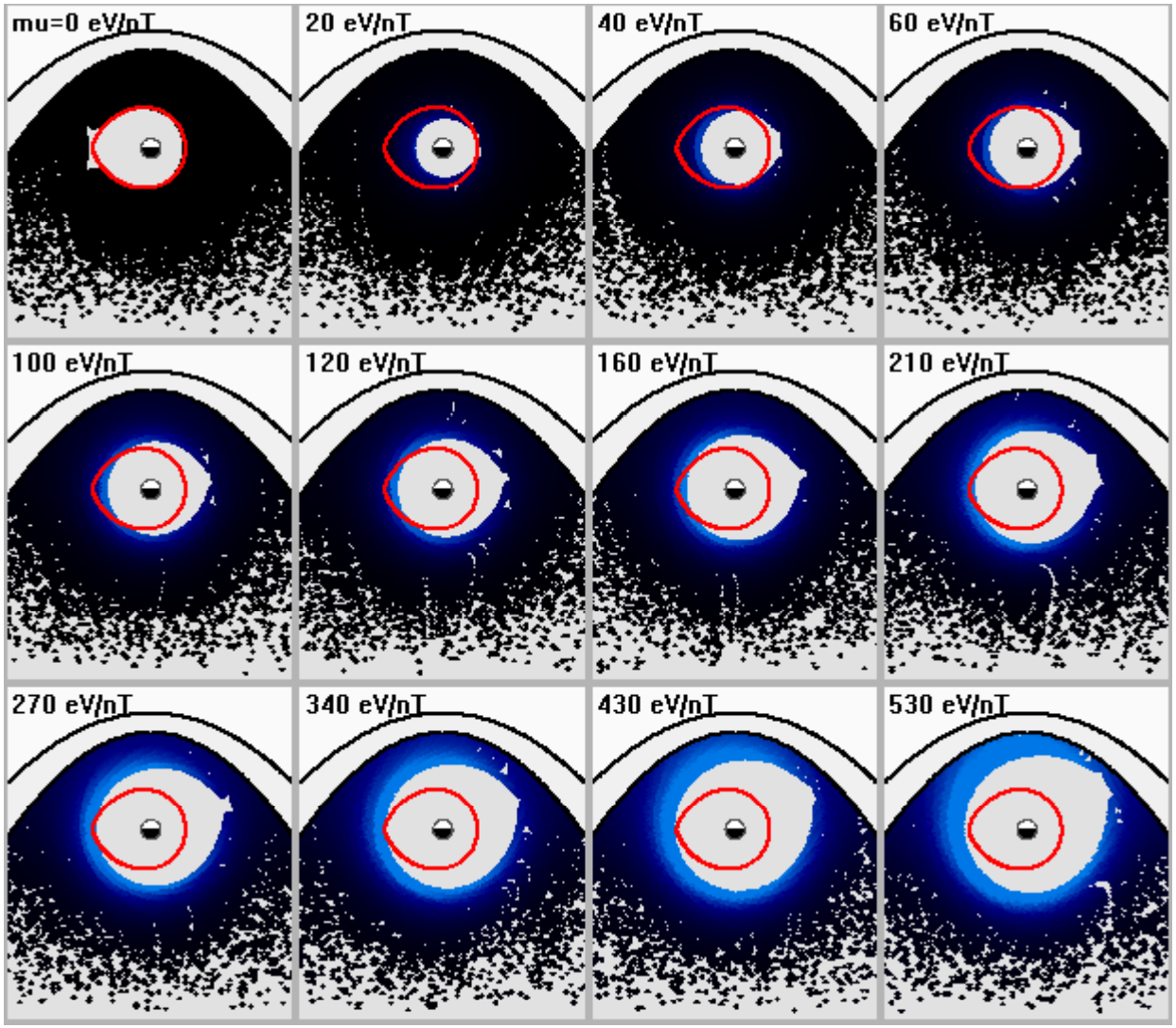
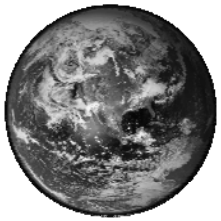
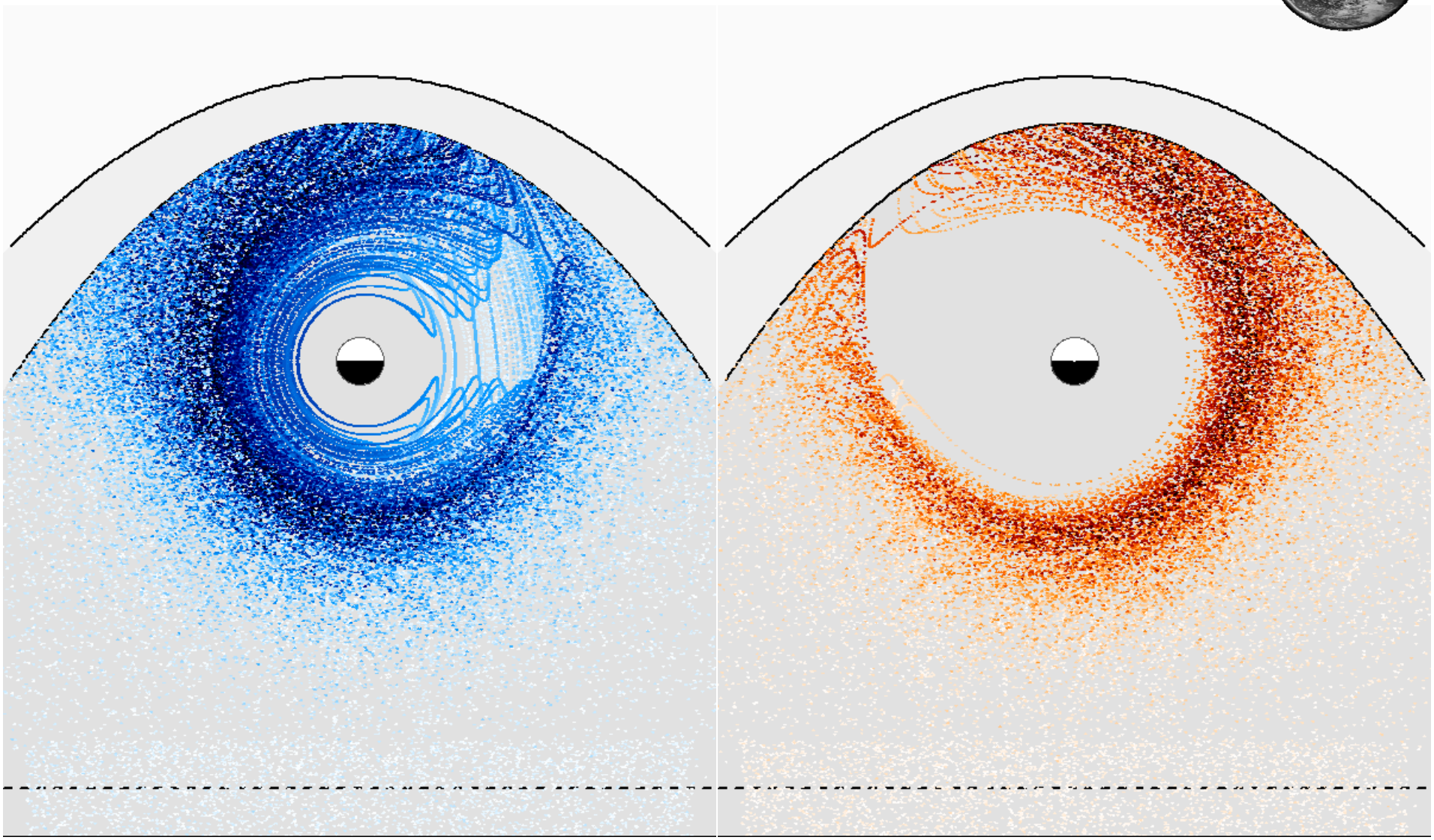




How does this become Diffuse Aurora?

Diffuse Aurora



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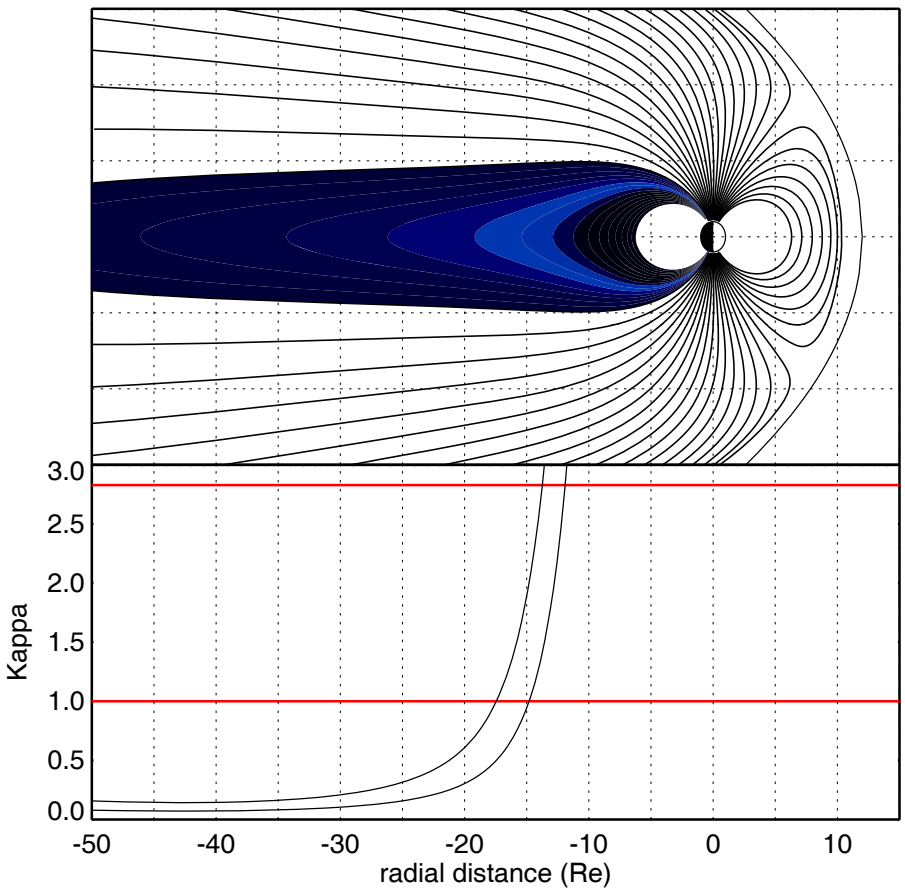

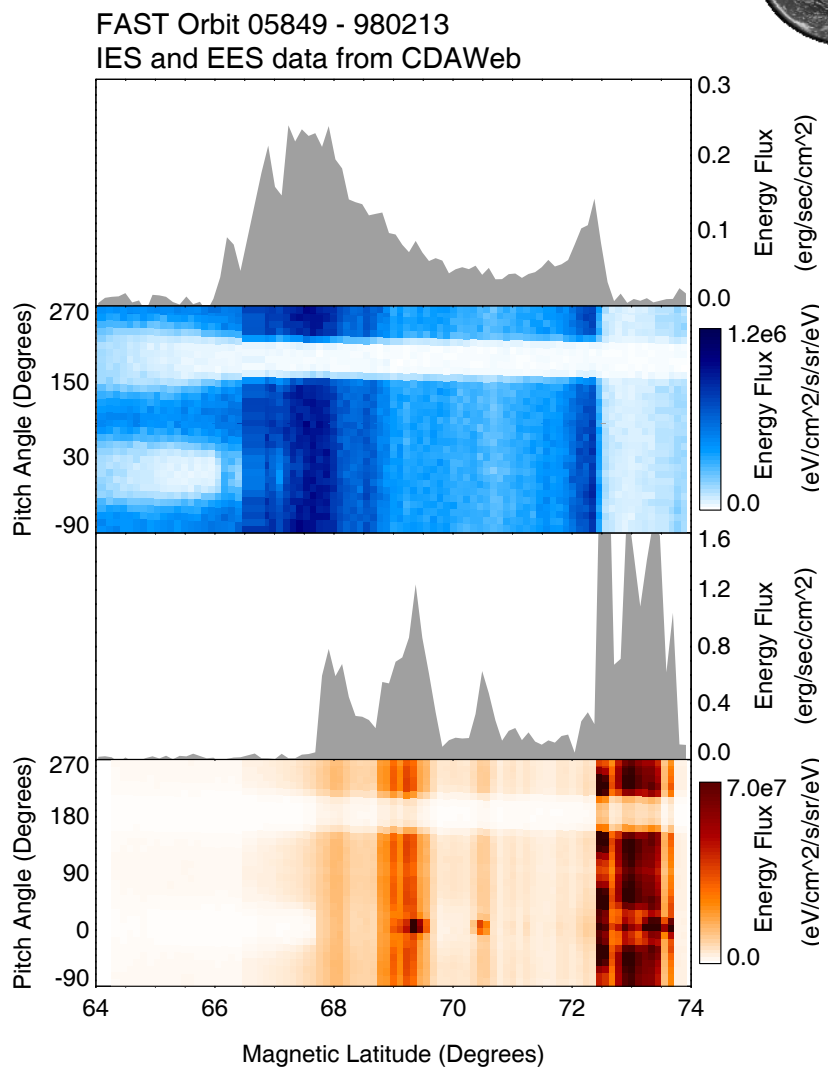

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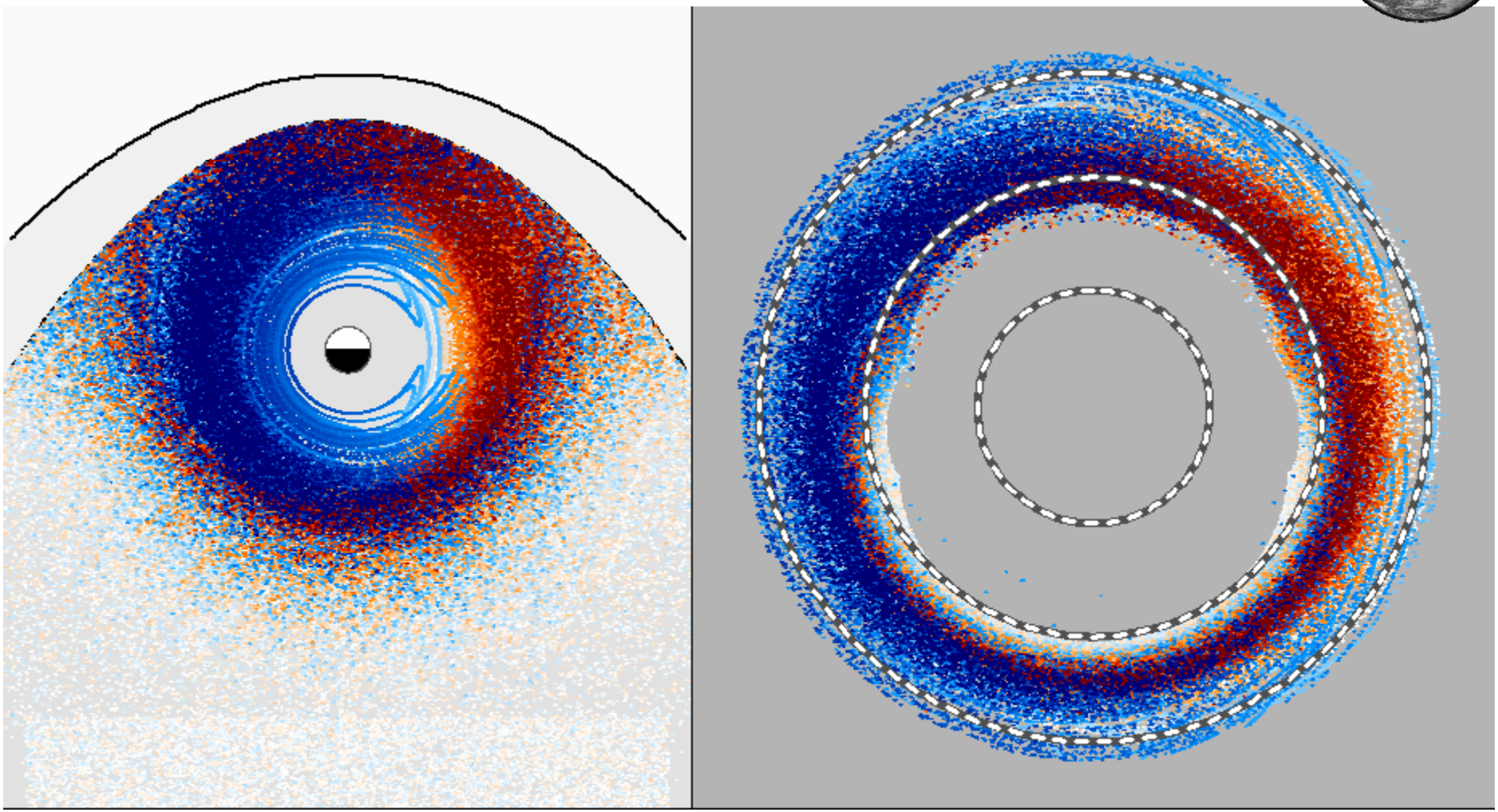

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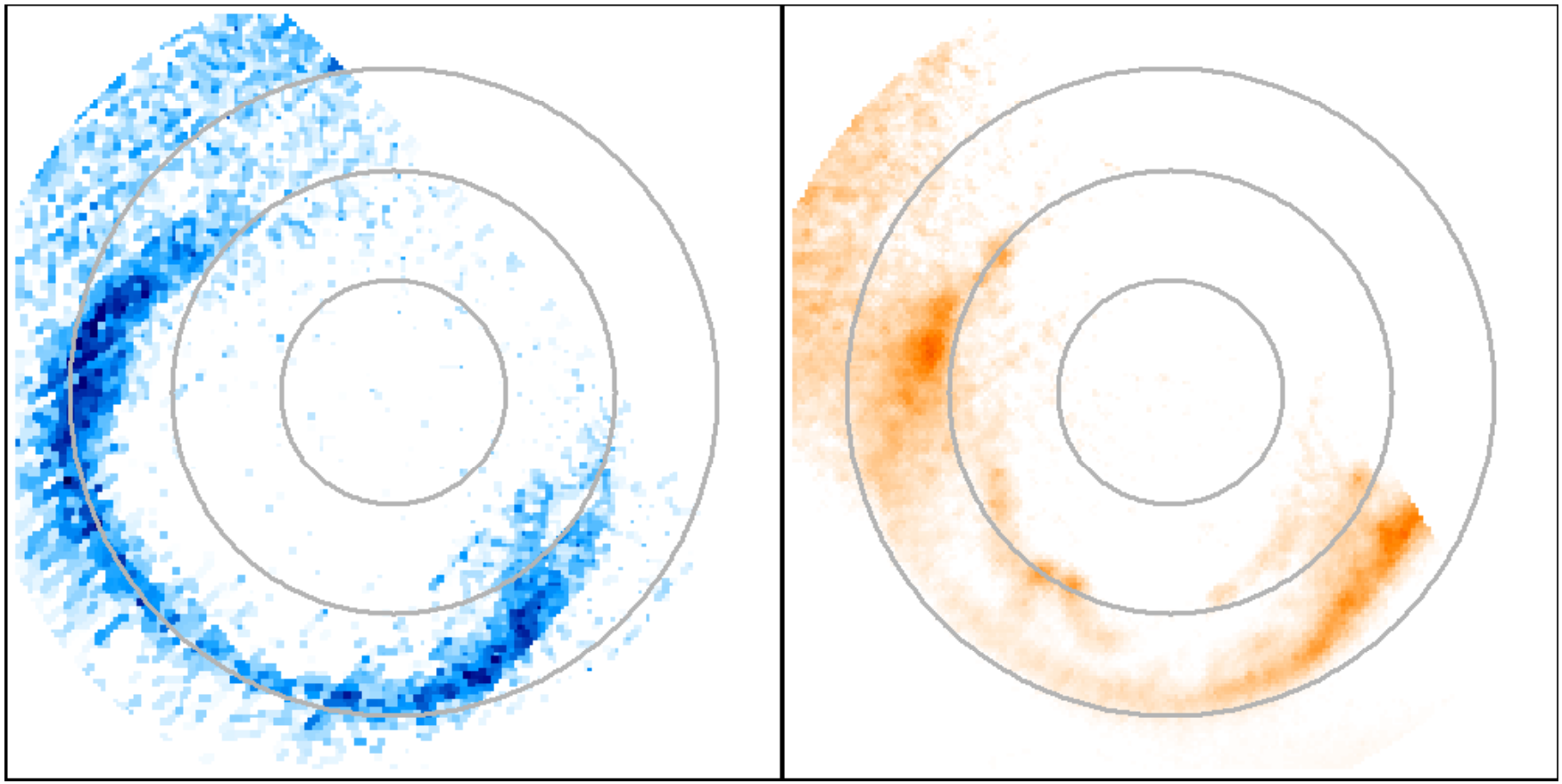

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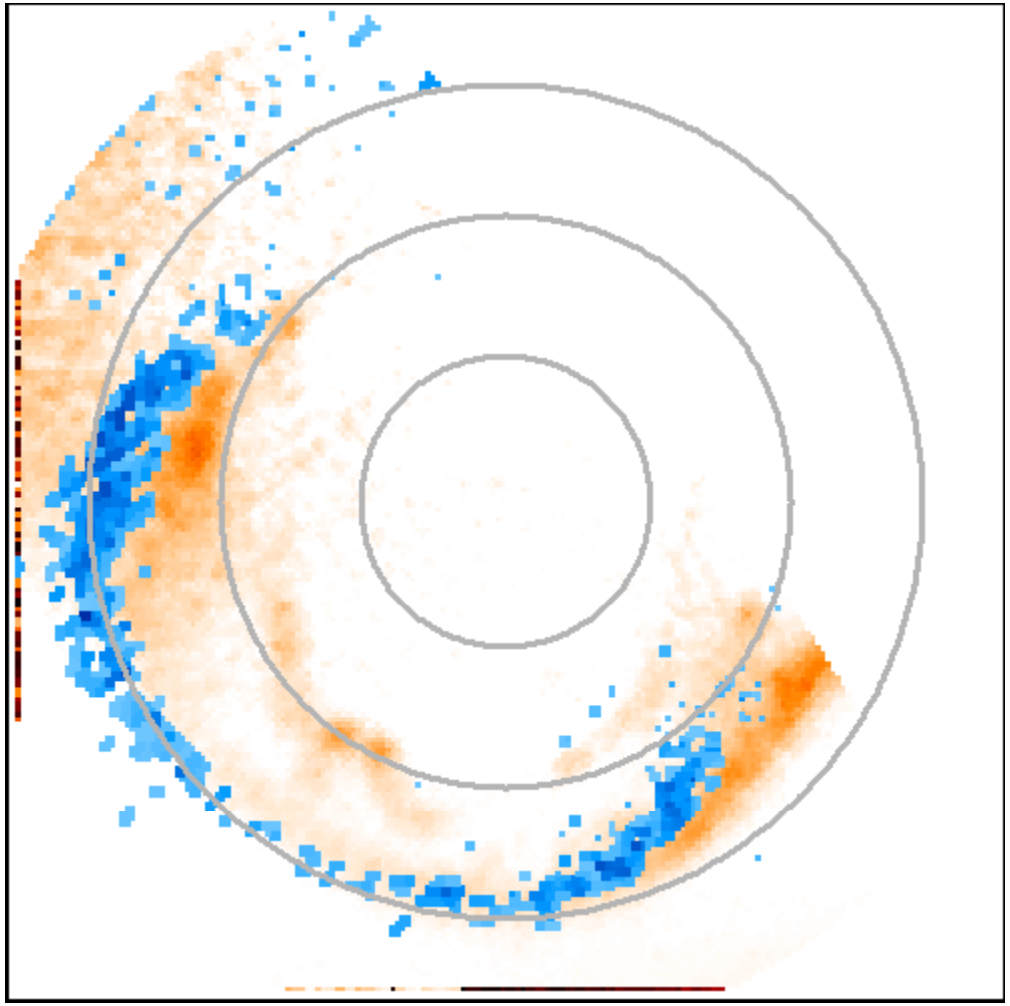

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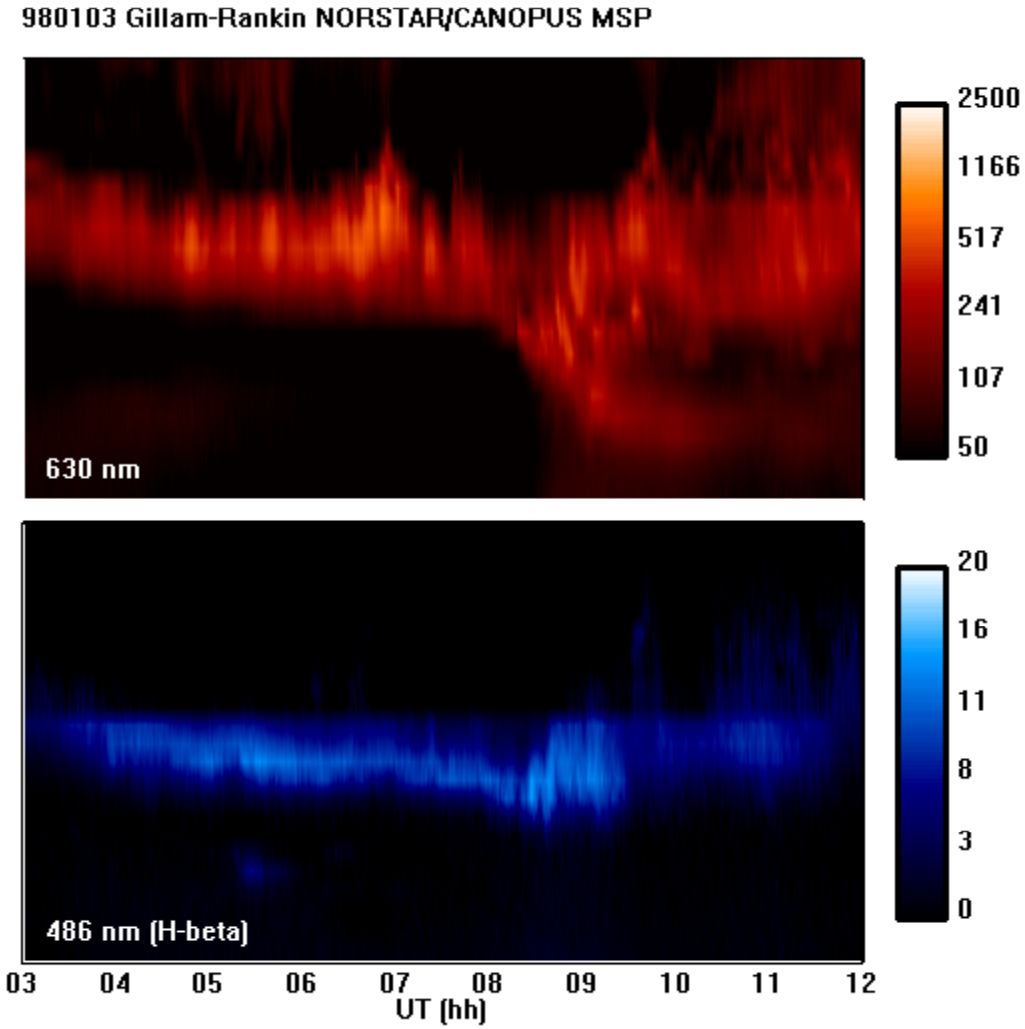

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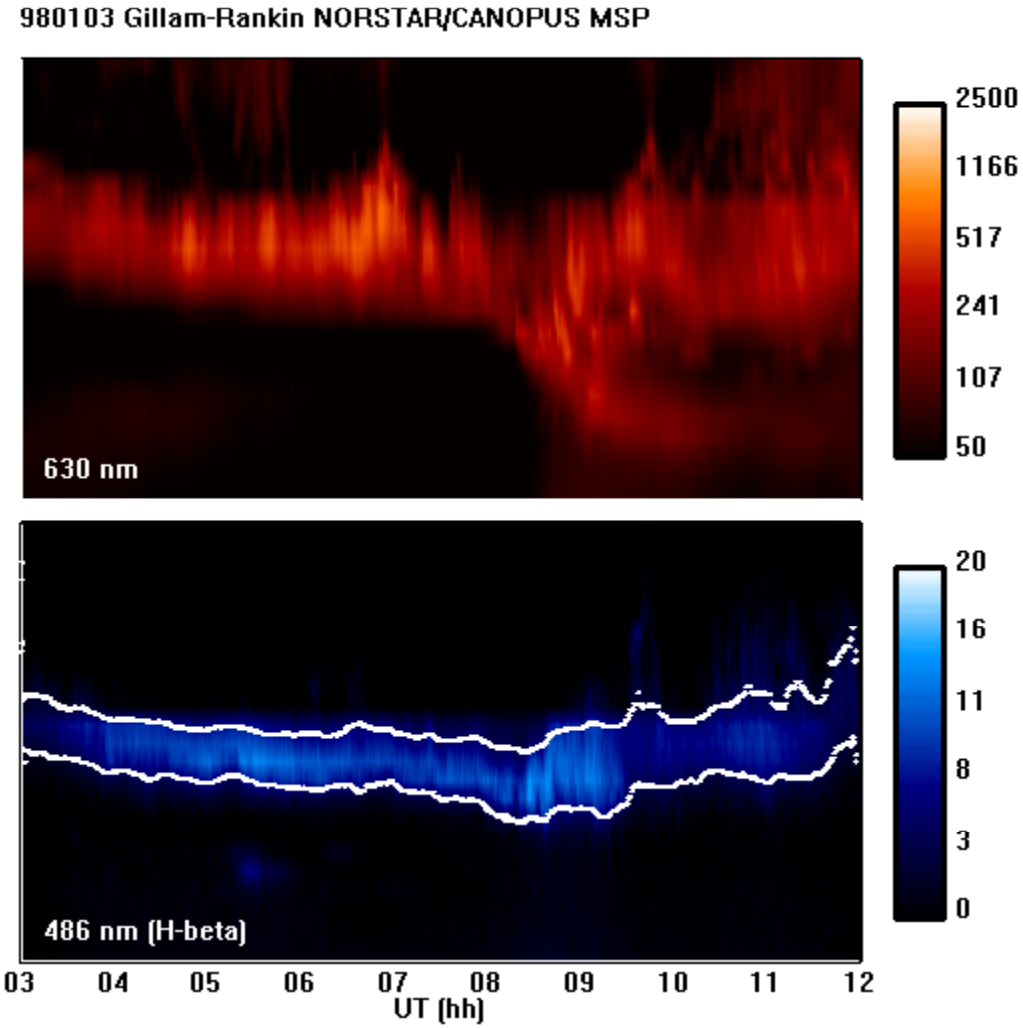

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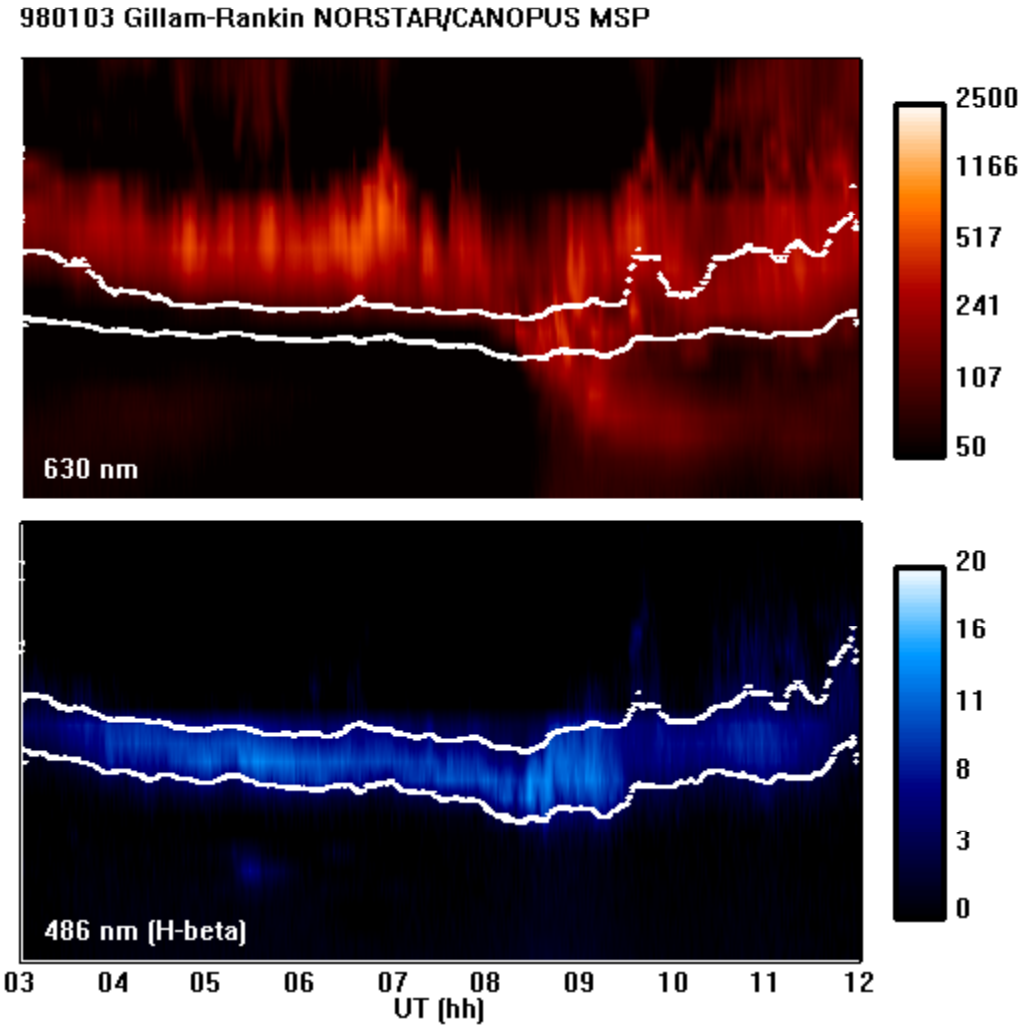

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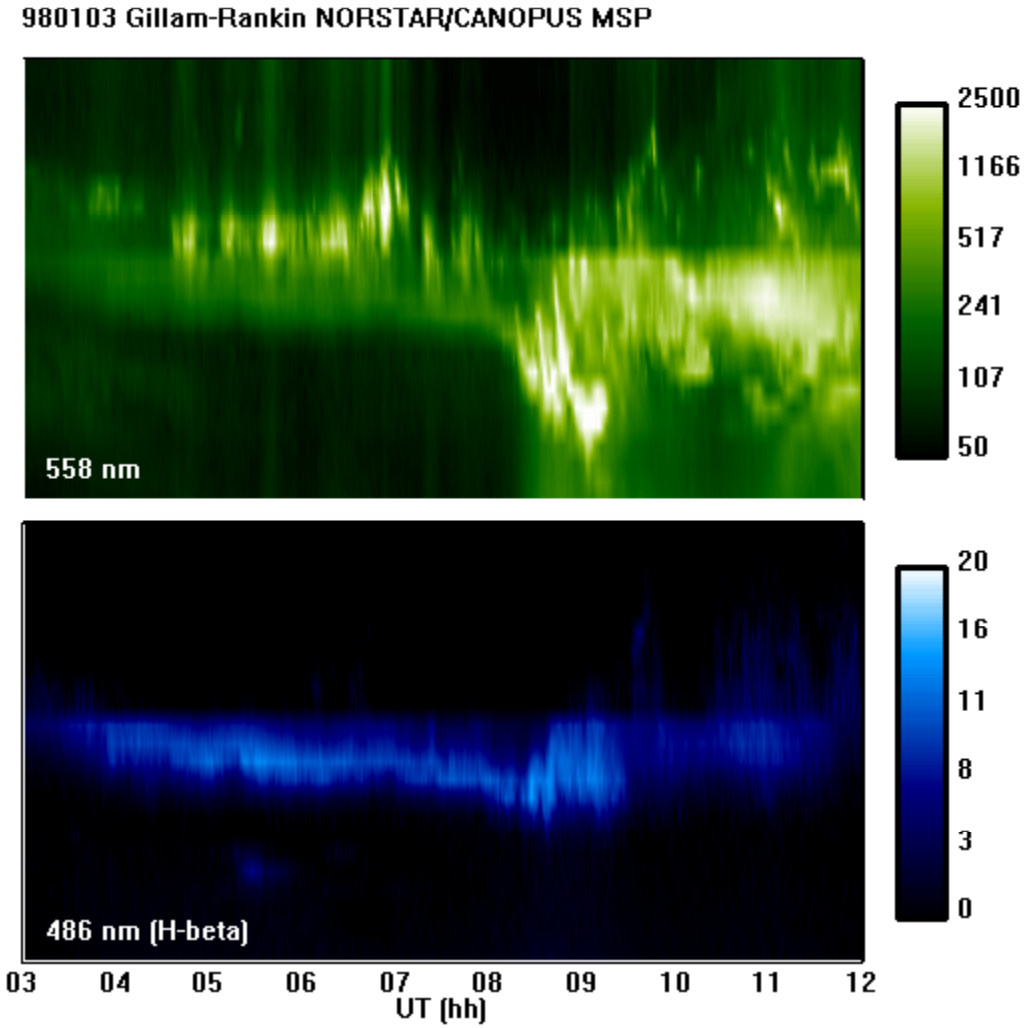

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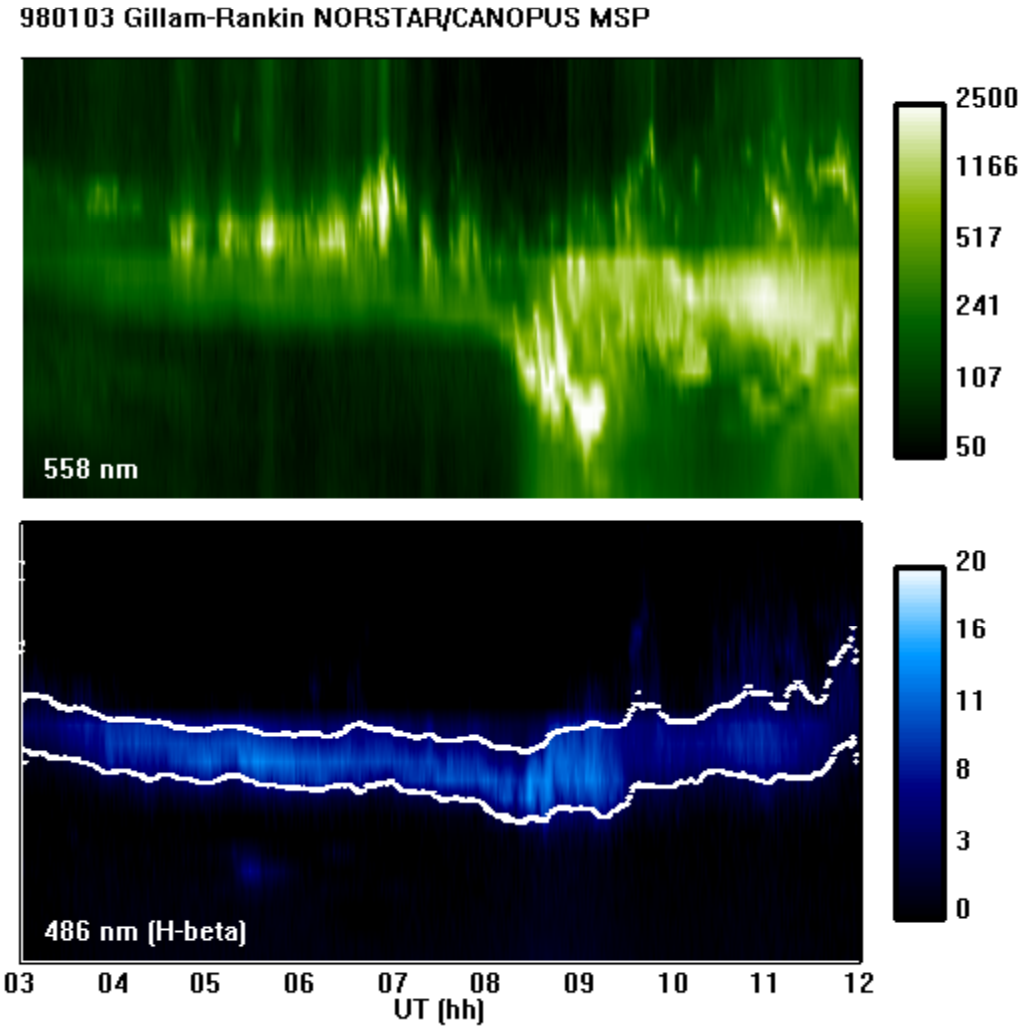

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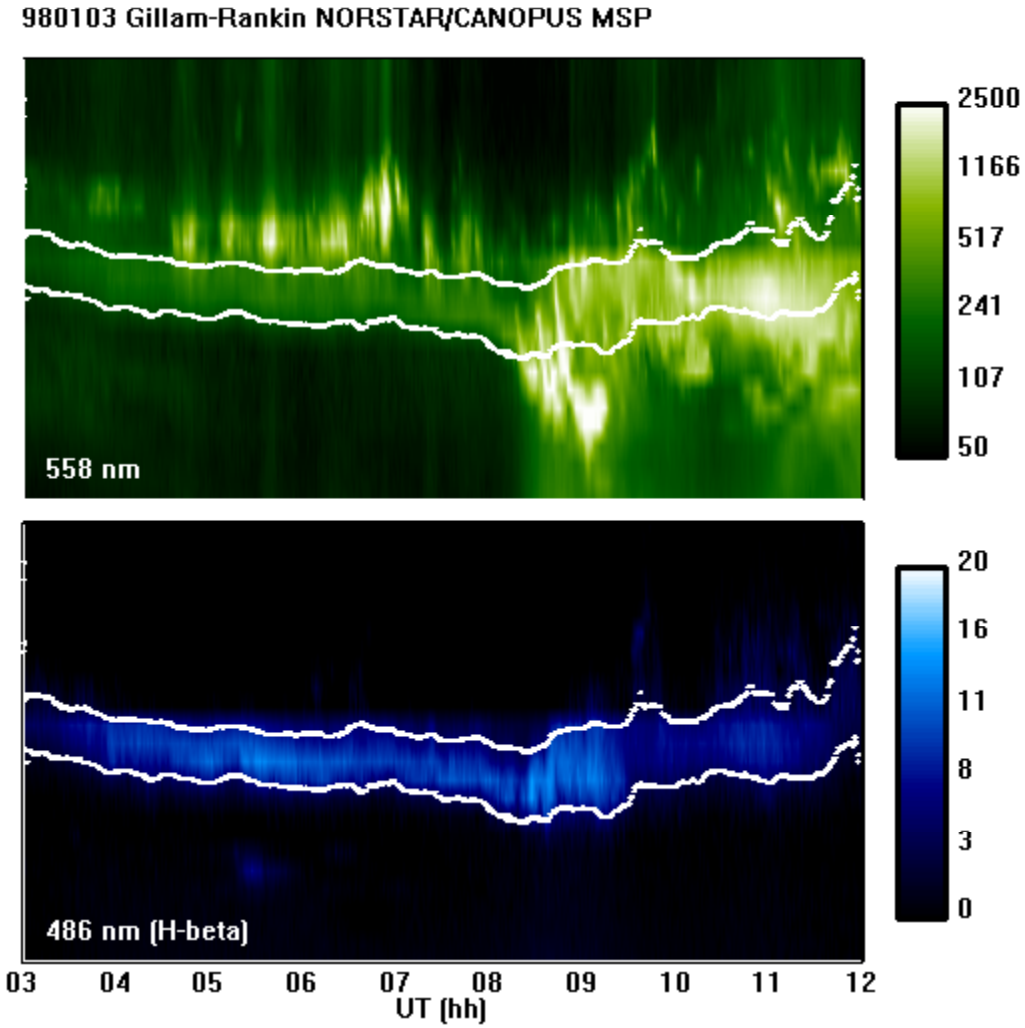

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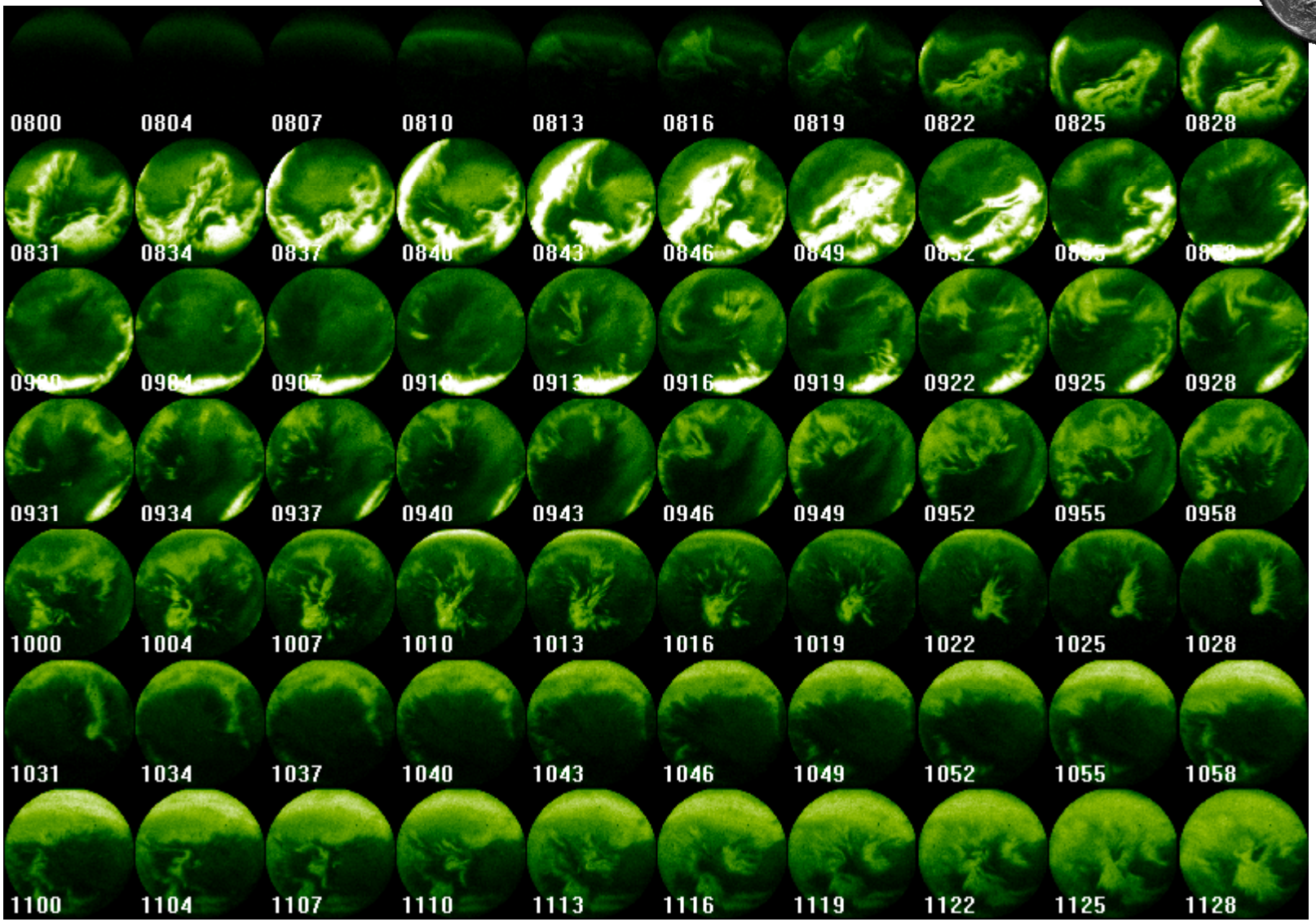

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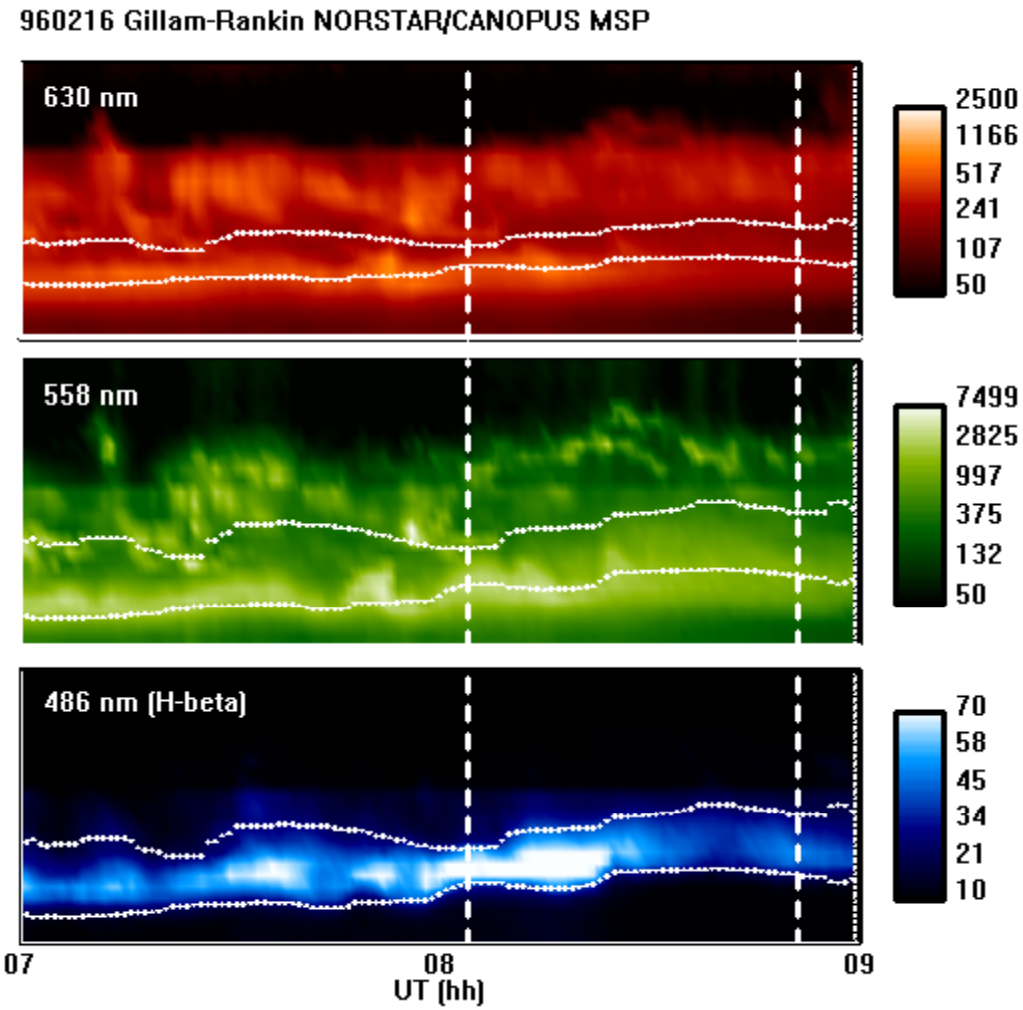

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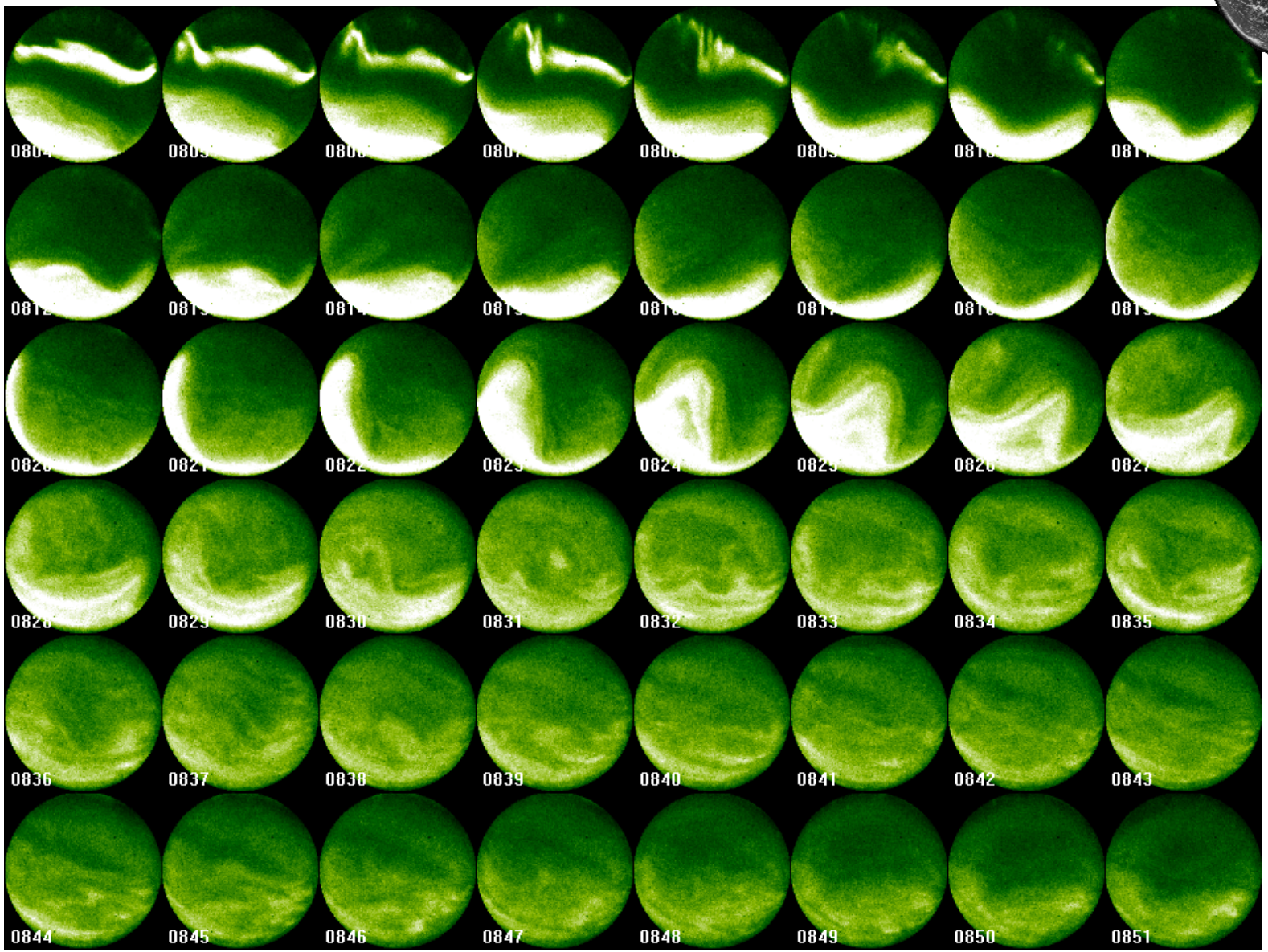
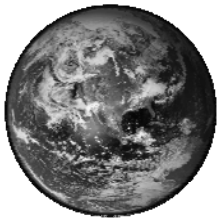
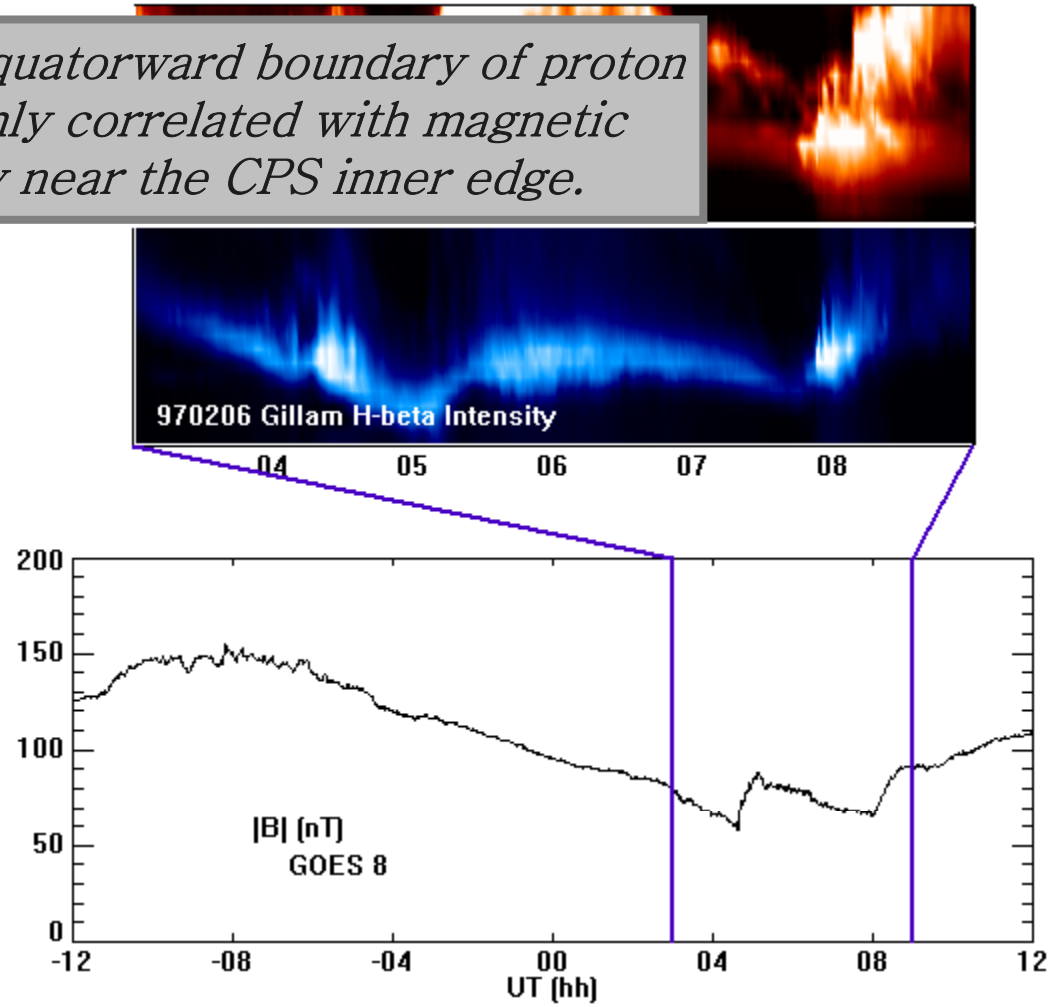




Remote Sensing the Magnetosphere

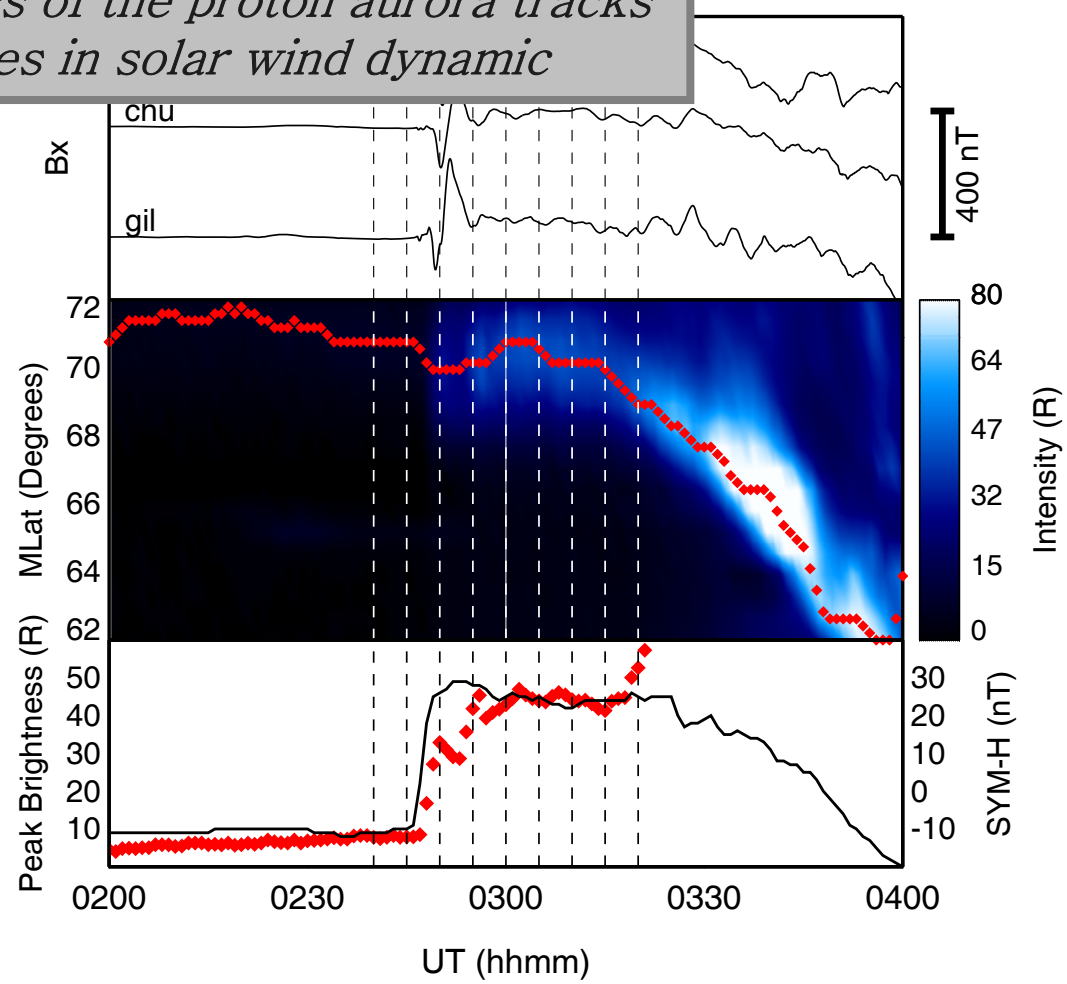
Diffuse Aurora

Latitude of equatorward boundary of proton aurora is highly correlated with magnetic field topology near the CPS inner edge.



Diffuse Aurora

The brightness of the proton aurora tracks sudden changes in solar wind dynamic pressure.



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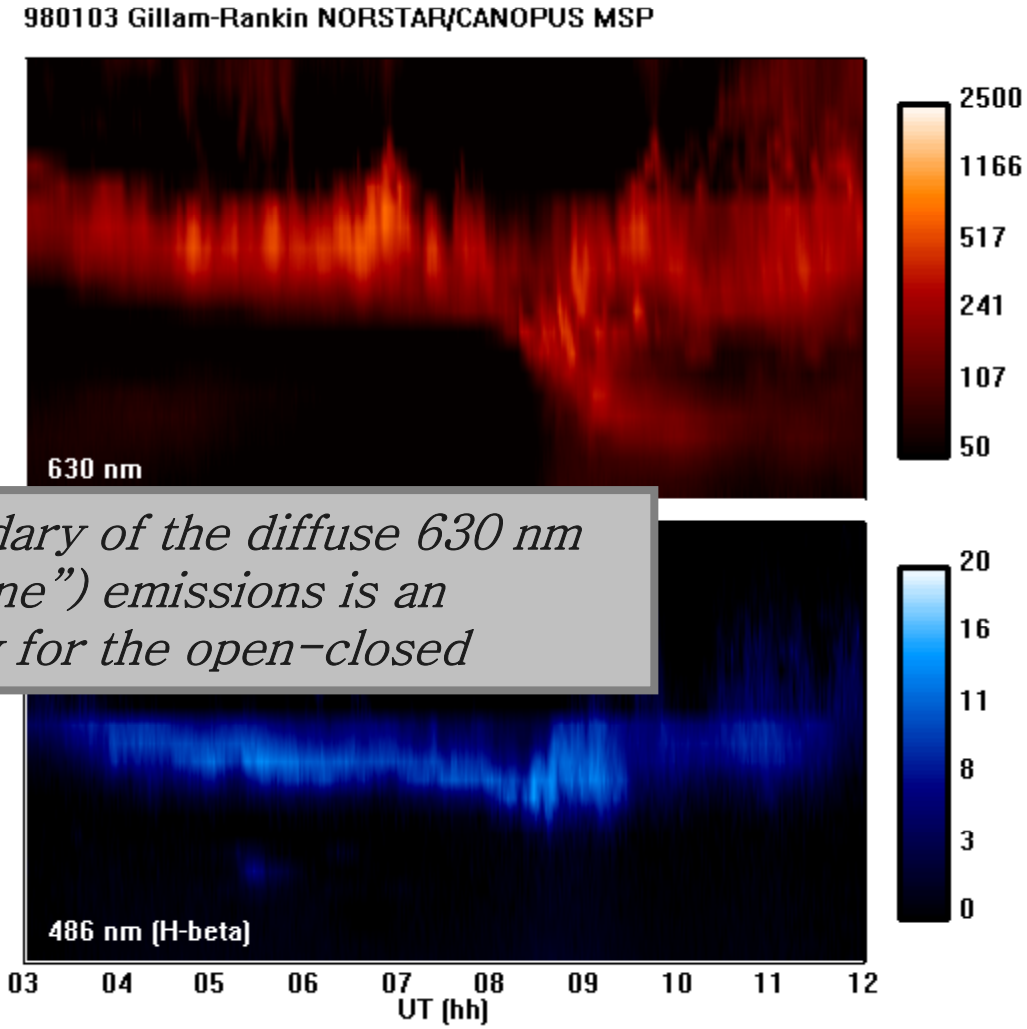
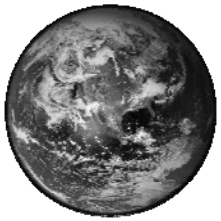


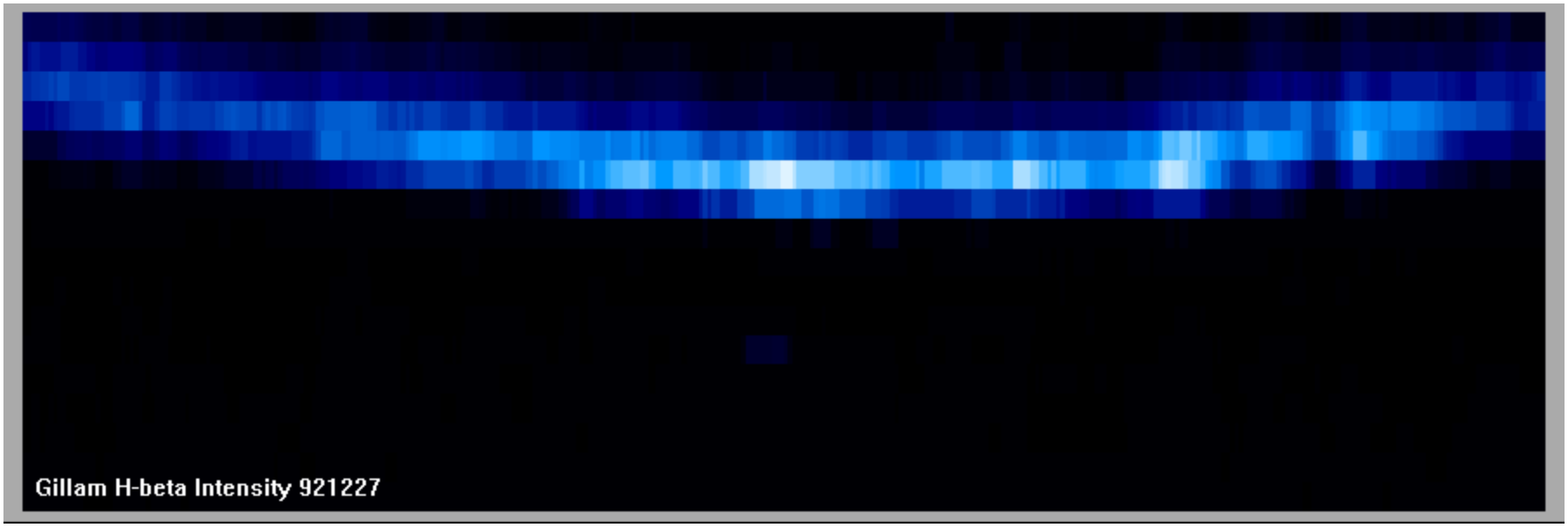
Poleward boundary of the diffuse 630 nm (Oxygen "Redline") emissions is an excellent proxy for the open-closed boundary.



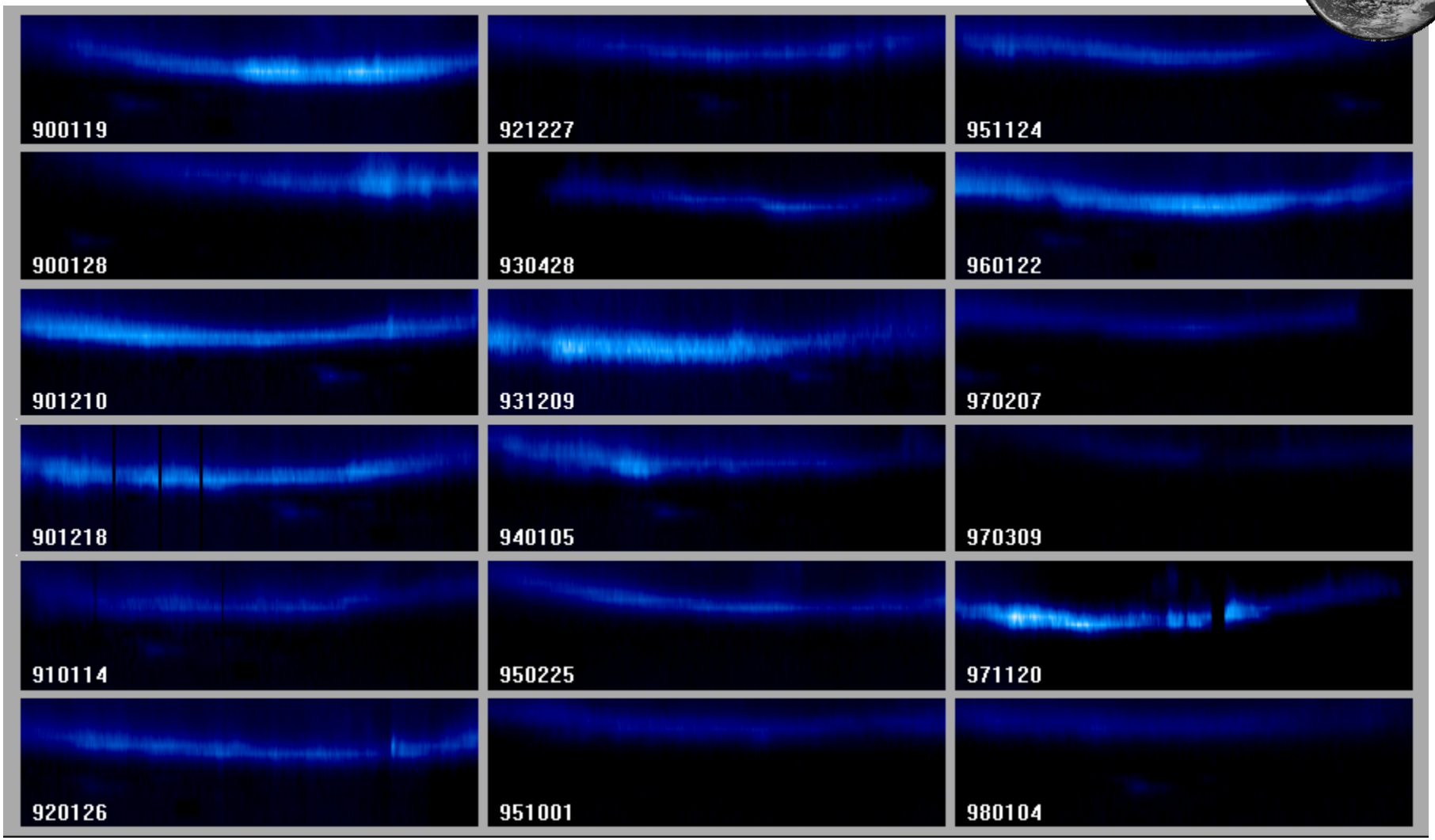
Unstructured Quiet Time H+

Aurora

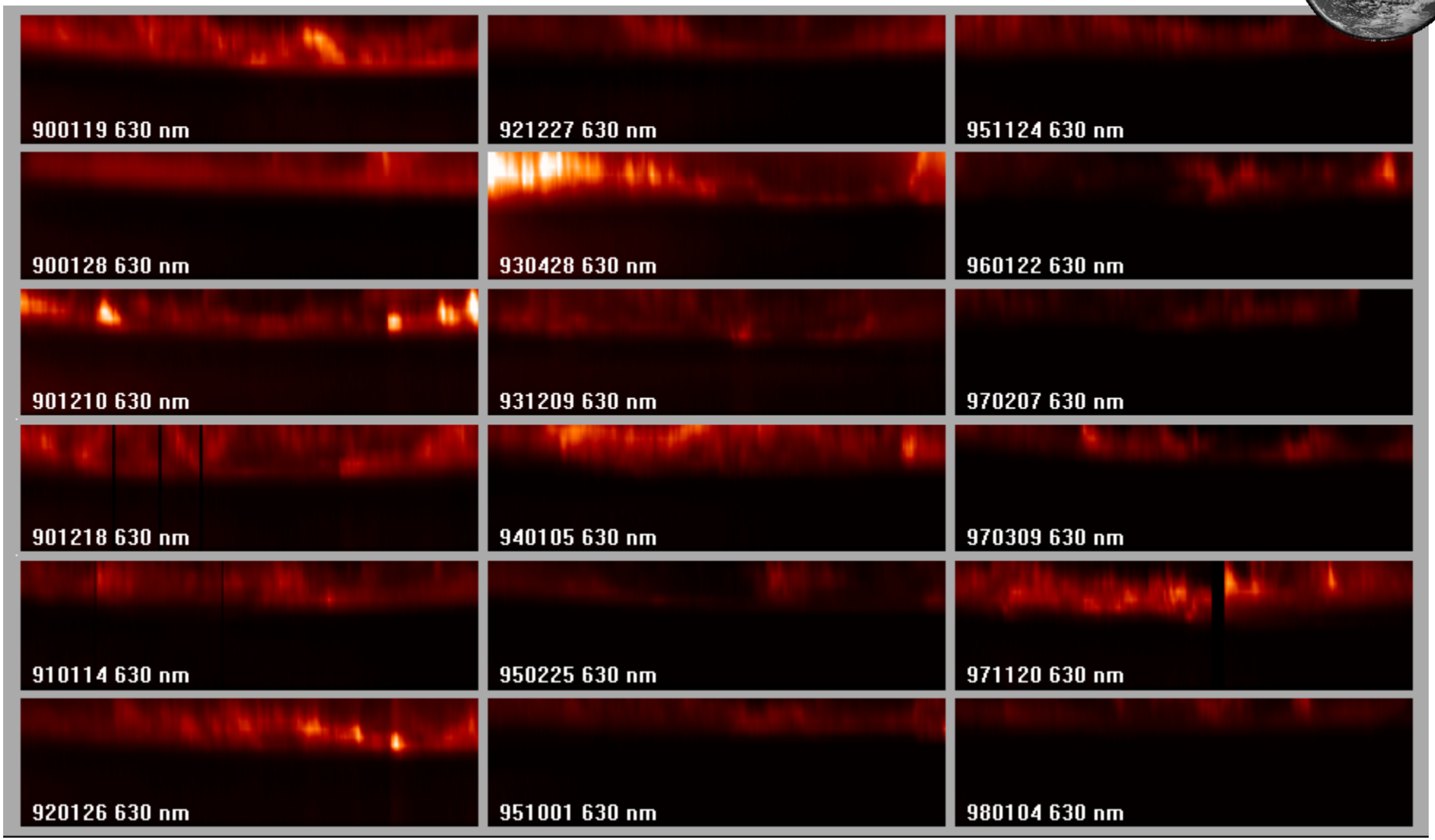
Diffuse Aurora



Diffuse Aurora



Diffuse Aurora



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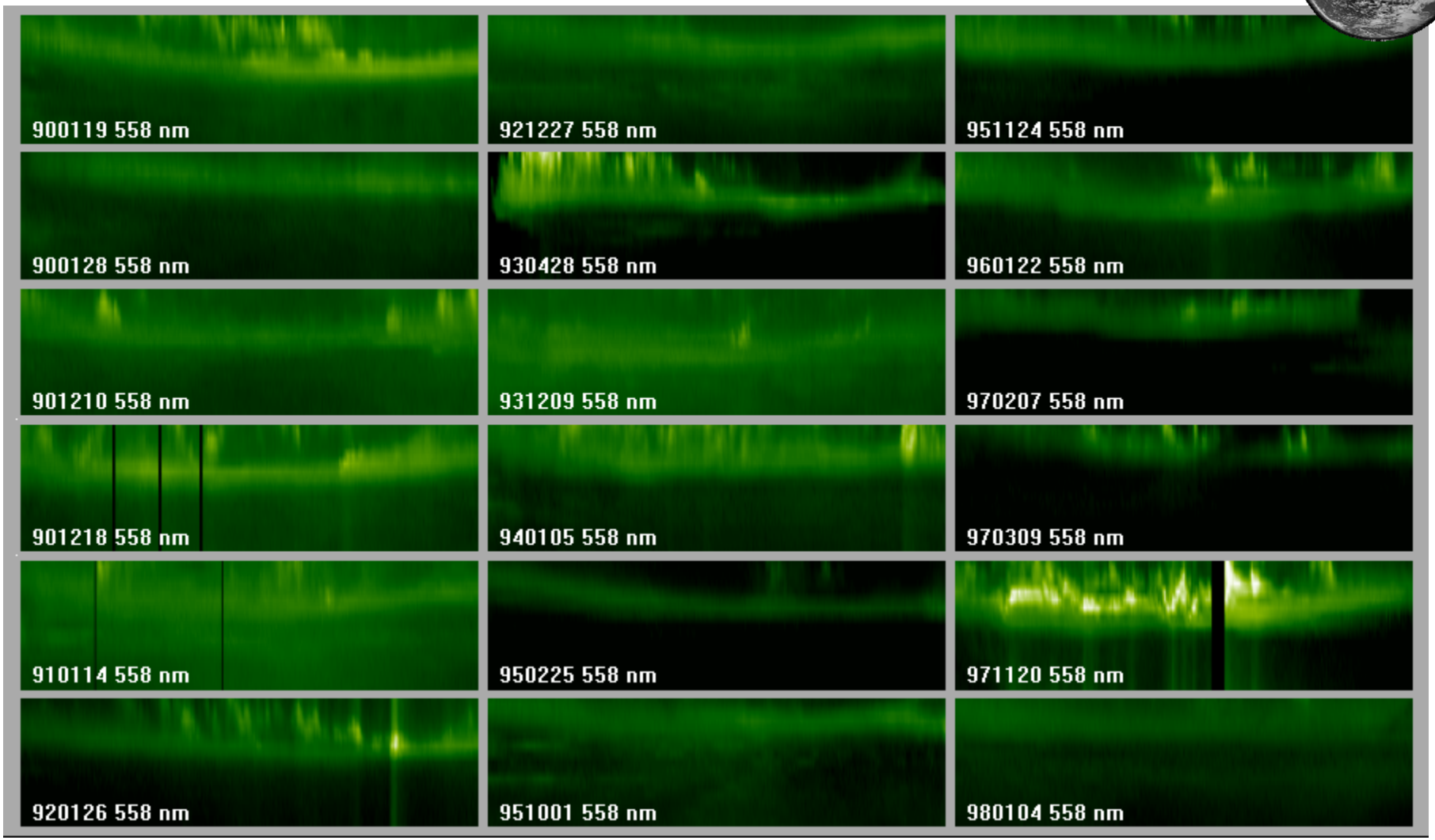
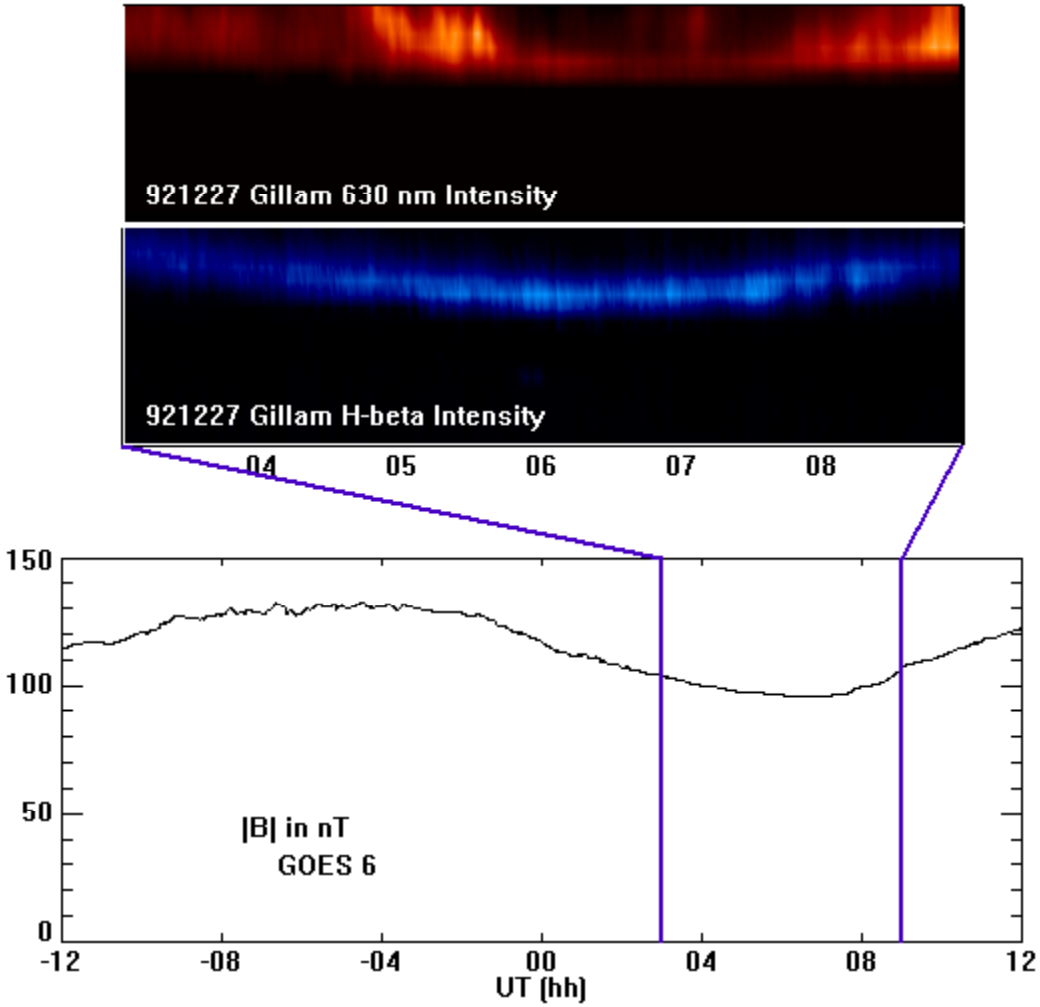


Diffuse Aurora



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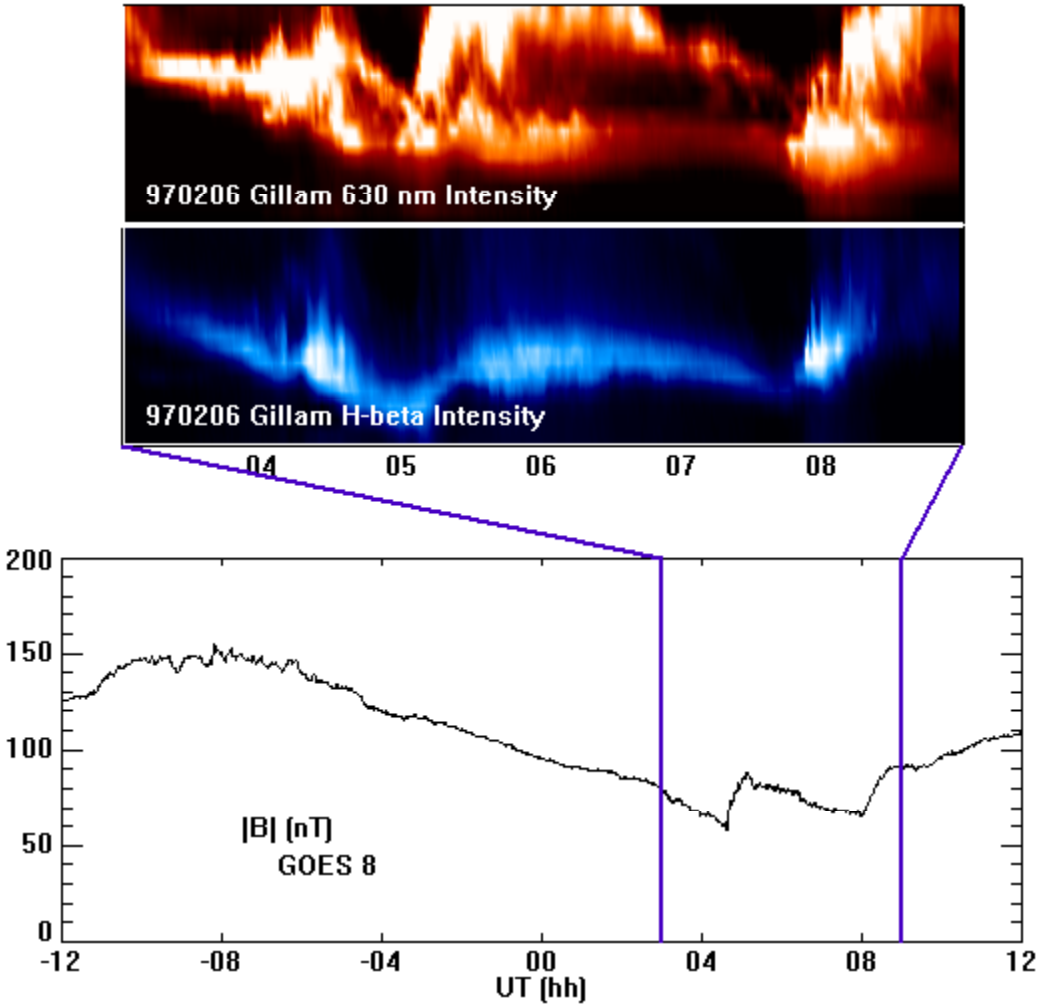
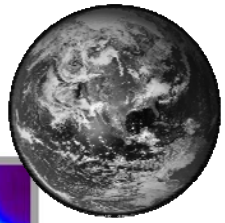
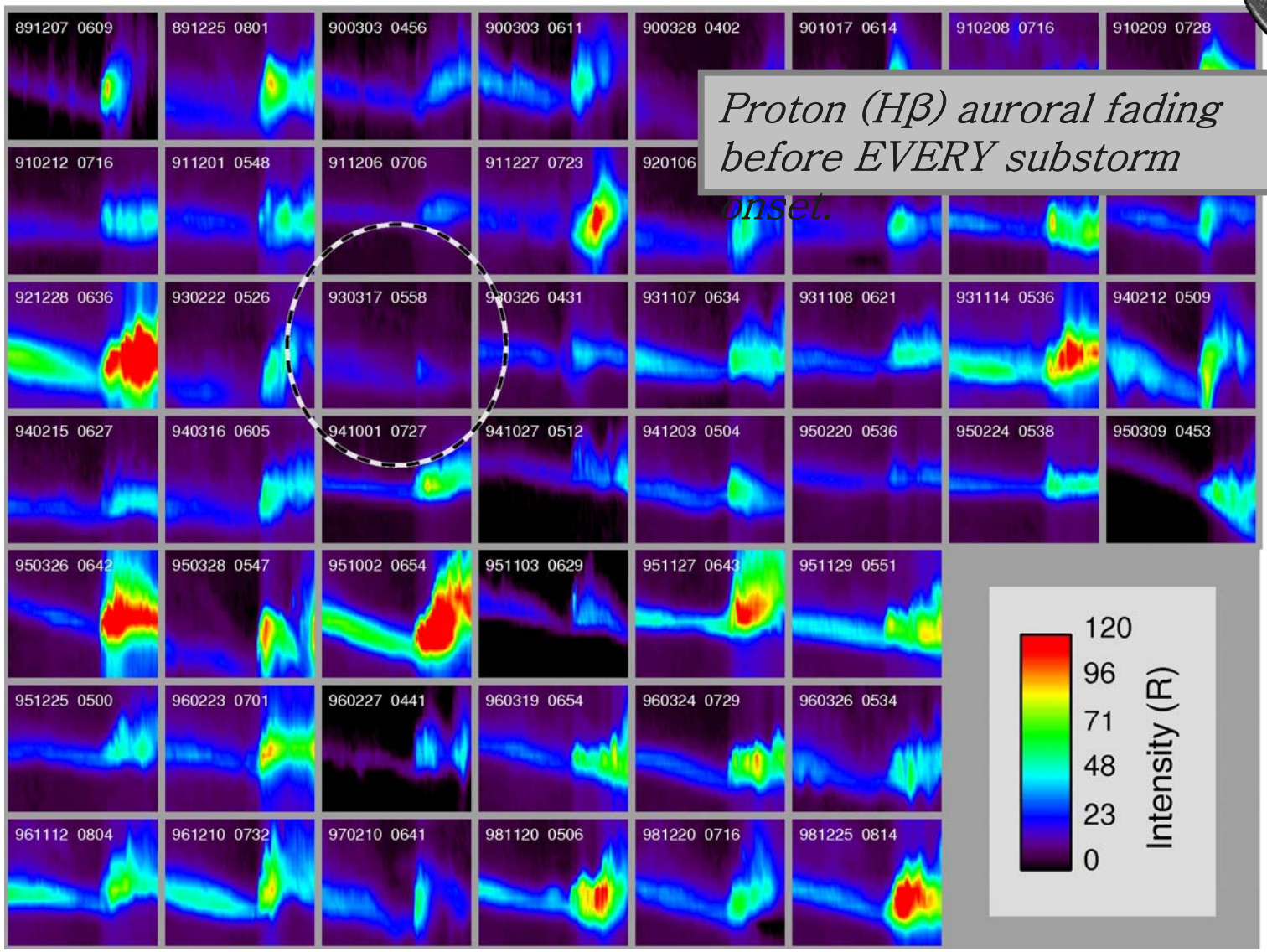


Structure in the Diffuse Aurora

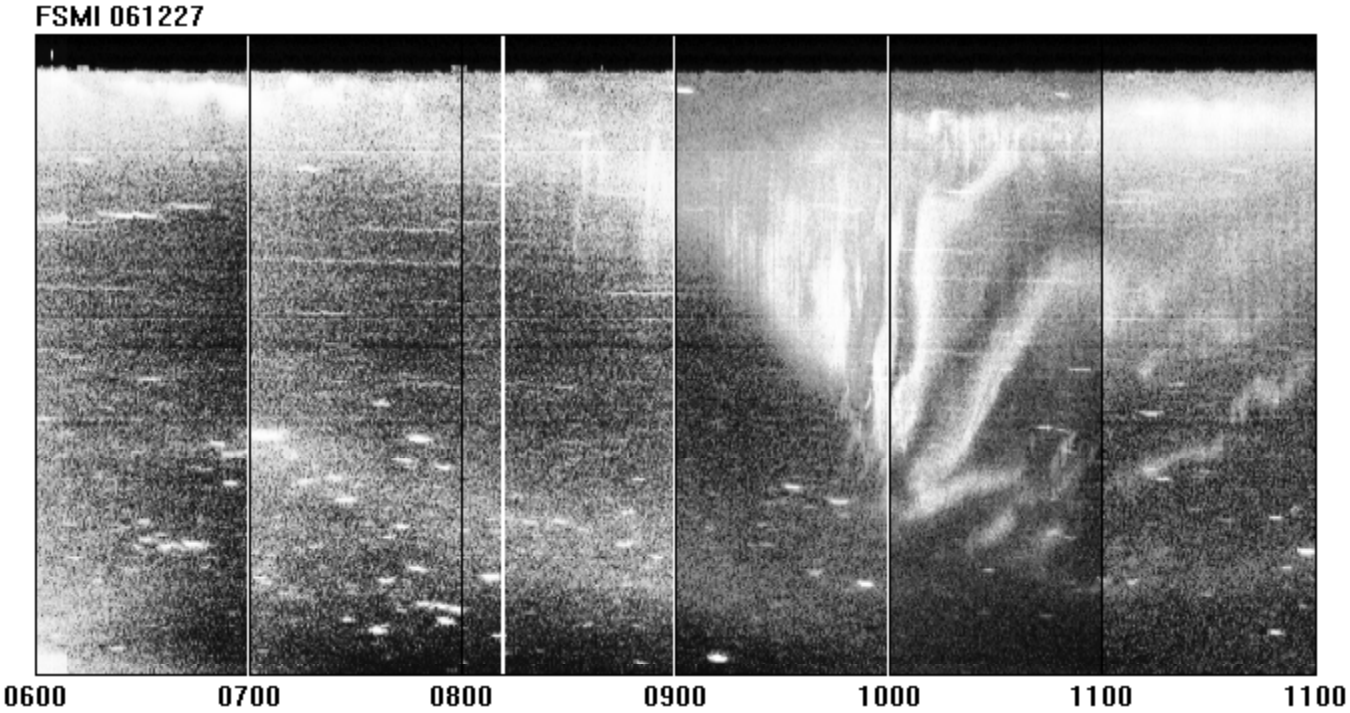
Diffuse Aurora



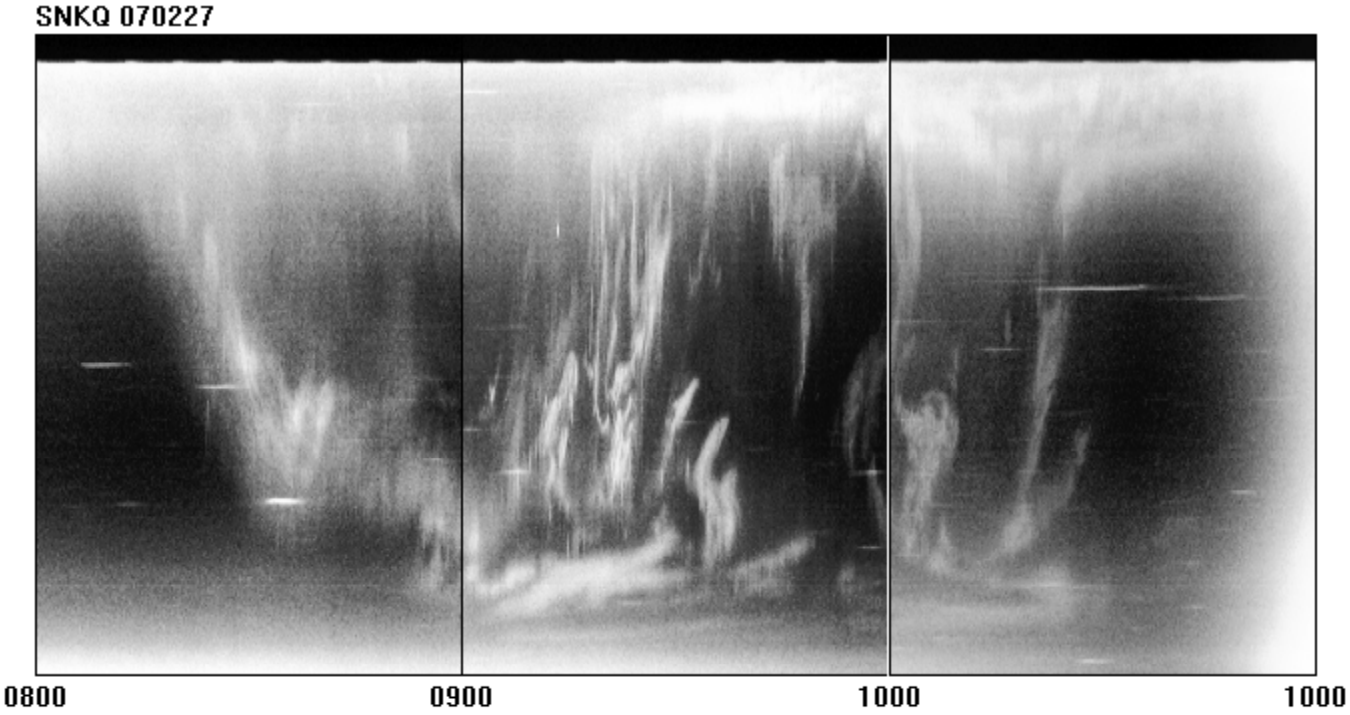


Proton (Hβ) auroral fading before EVERY substorm onset.

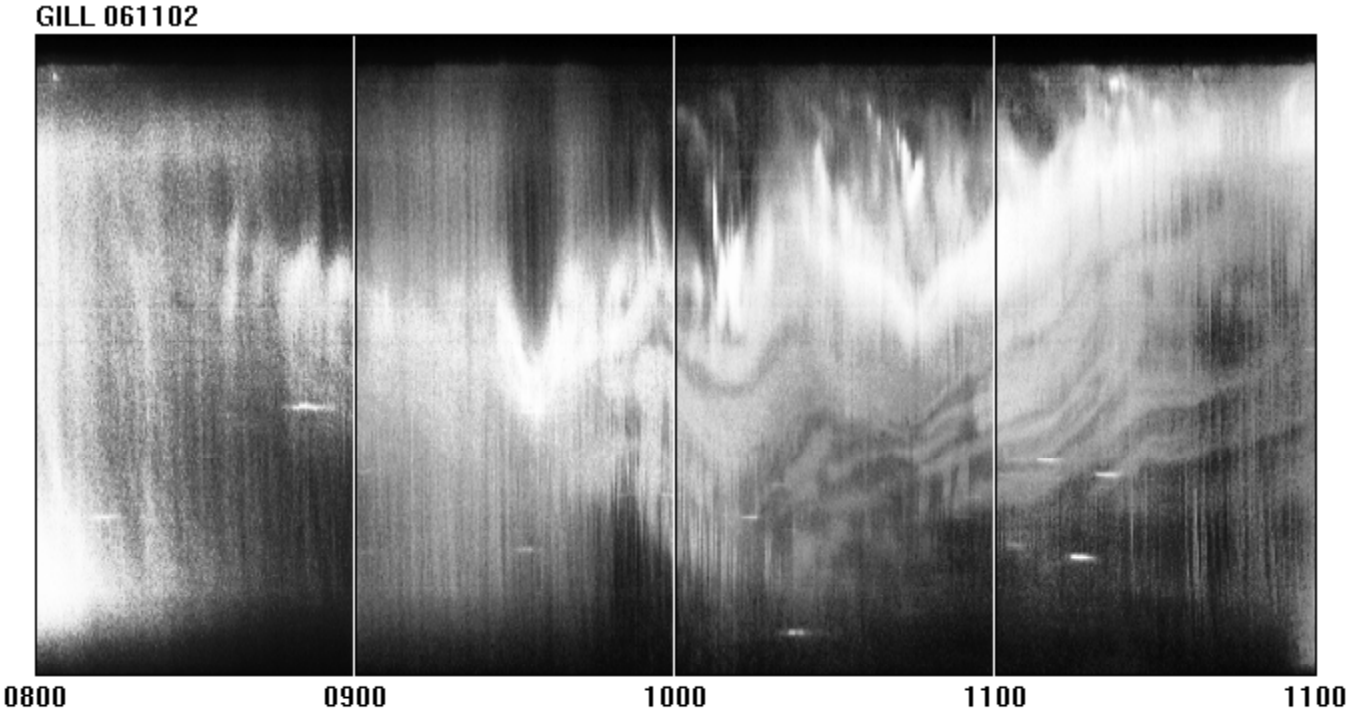
Diffuse Aurora

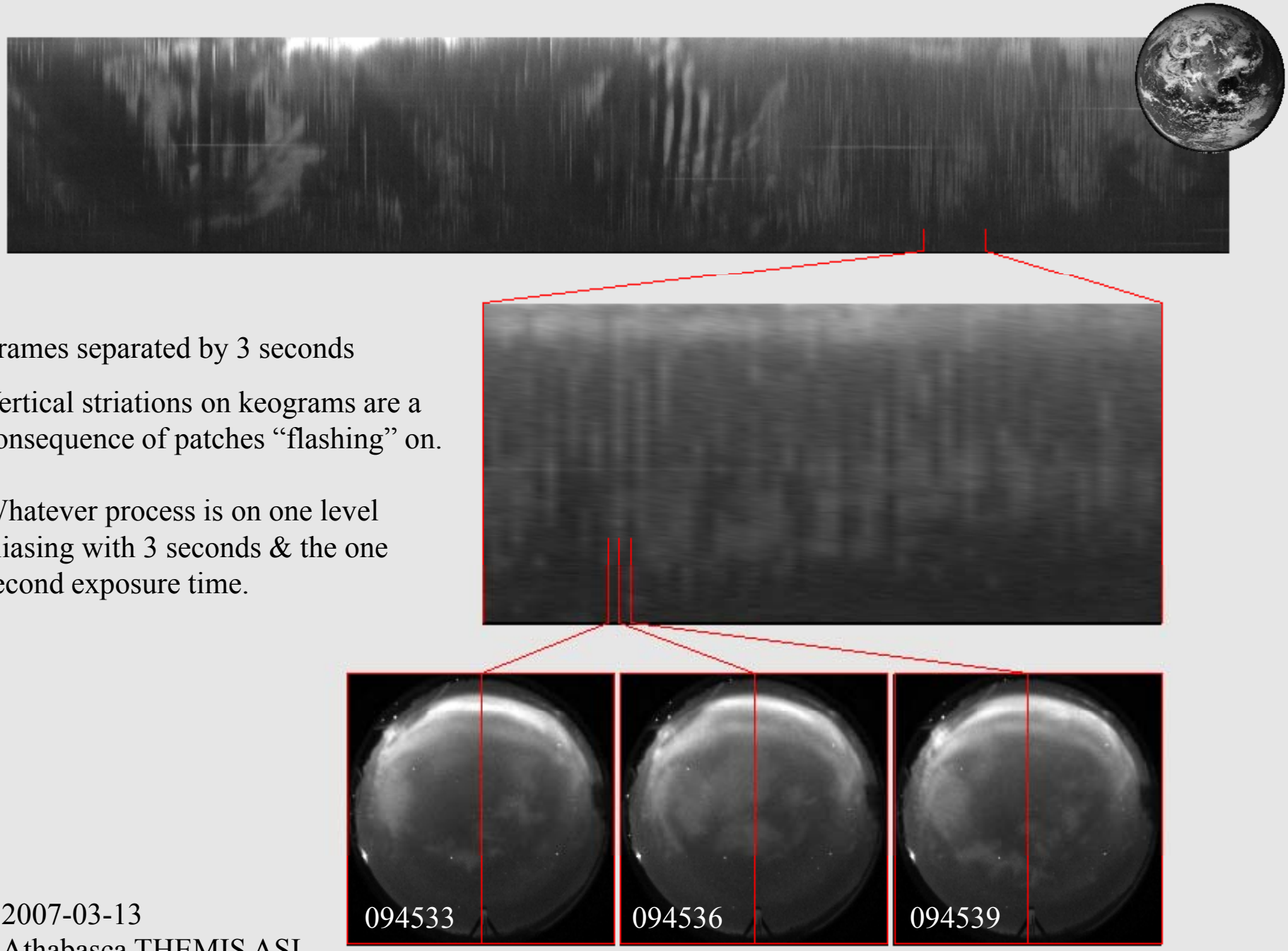


Diffuse Aurora



Diffuse Aurora





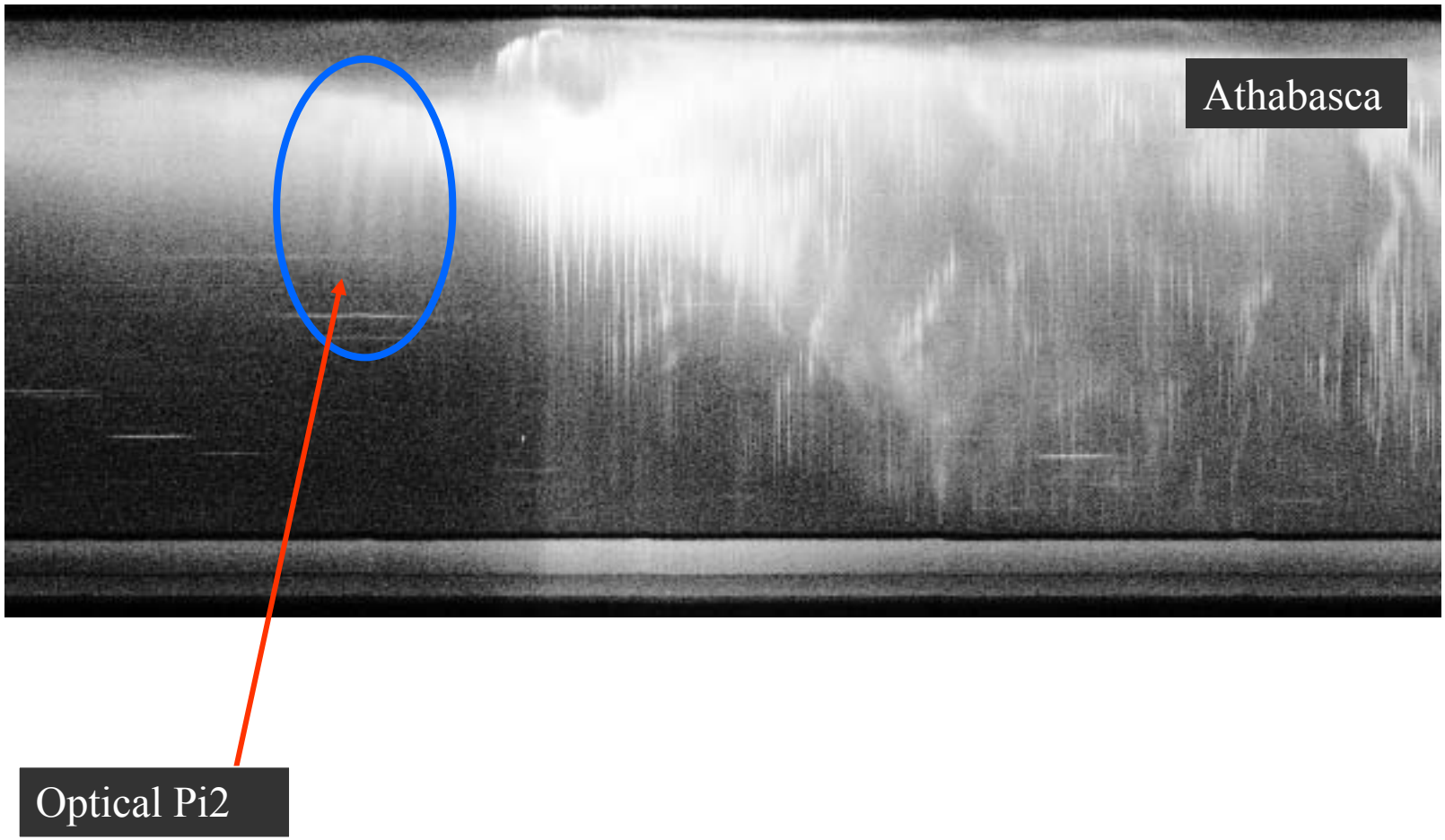
Frames separated by 3 seconds

Vertical striations on keograms are a consequence of patches “flashing” on.

Whatever process is on one level aliasing with 3 seconds & the one second exposure time.

2007-03-13
Athabasca THEMIS ASI

Diffuse Aurora



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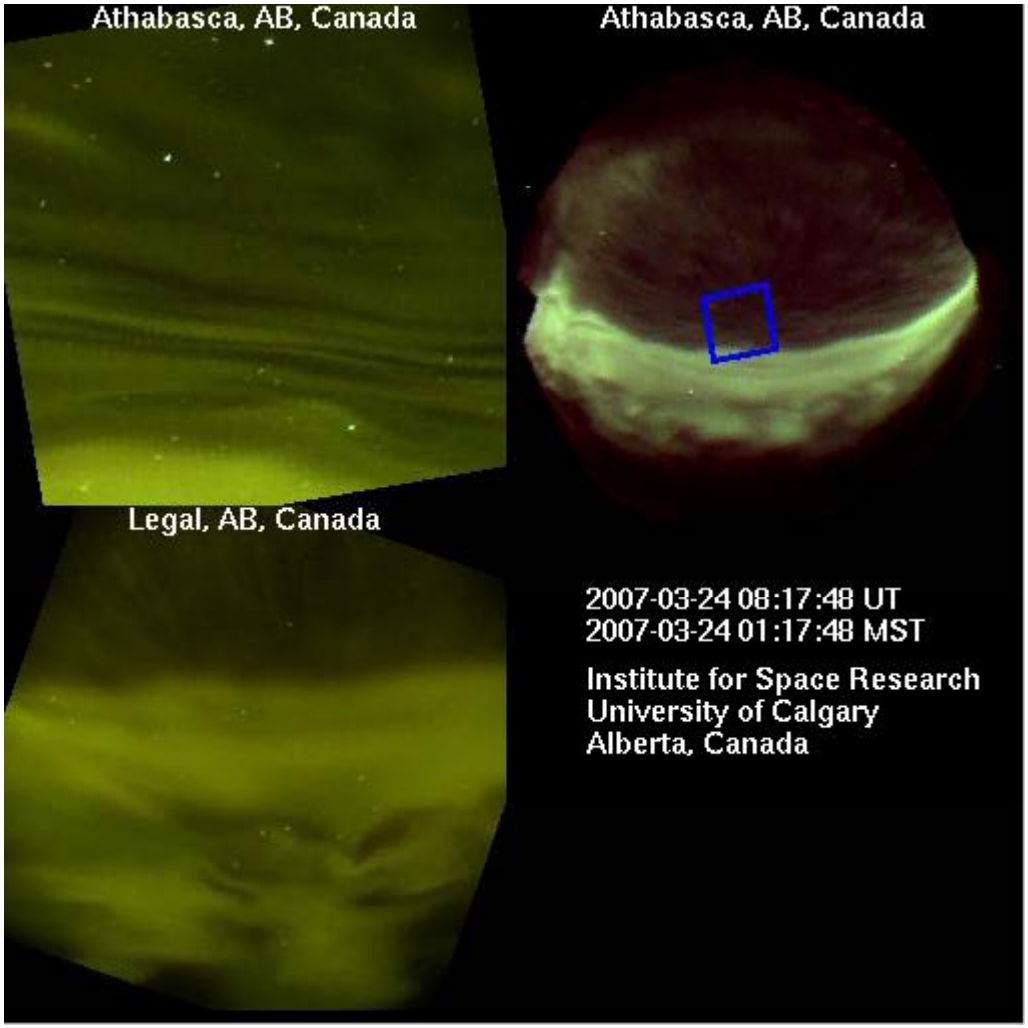

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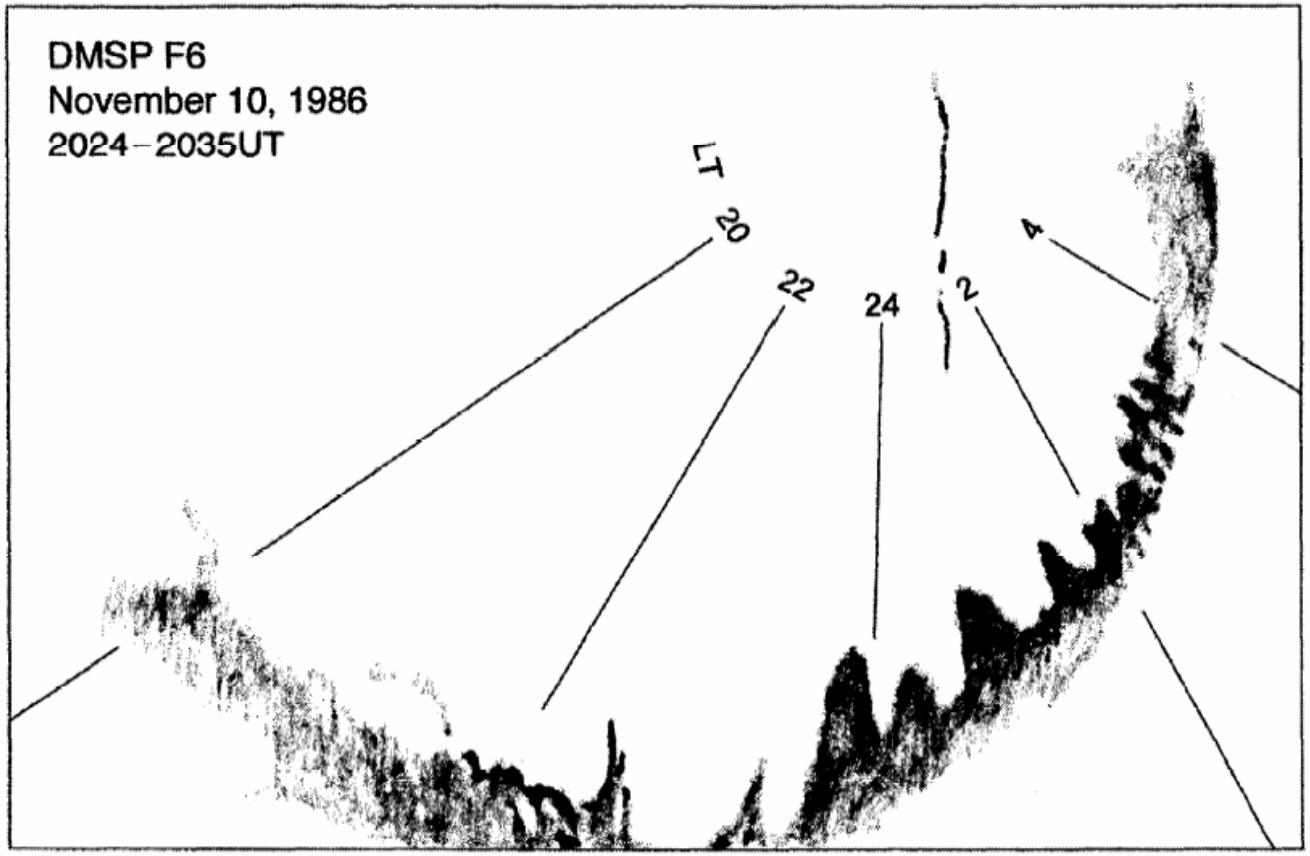
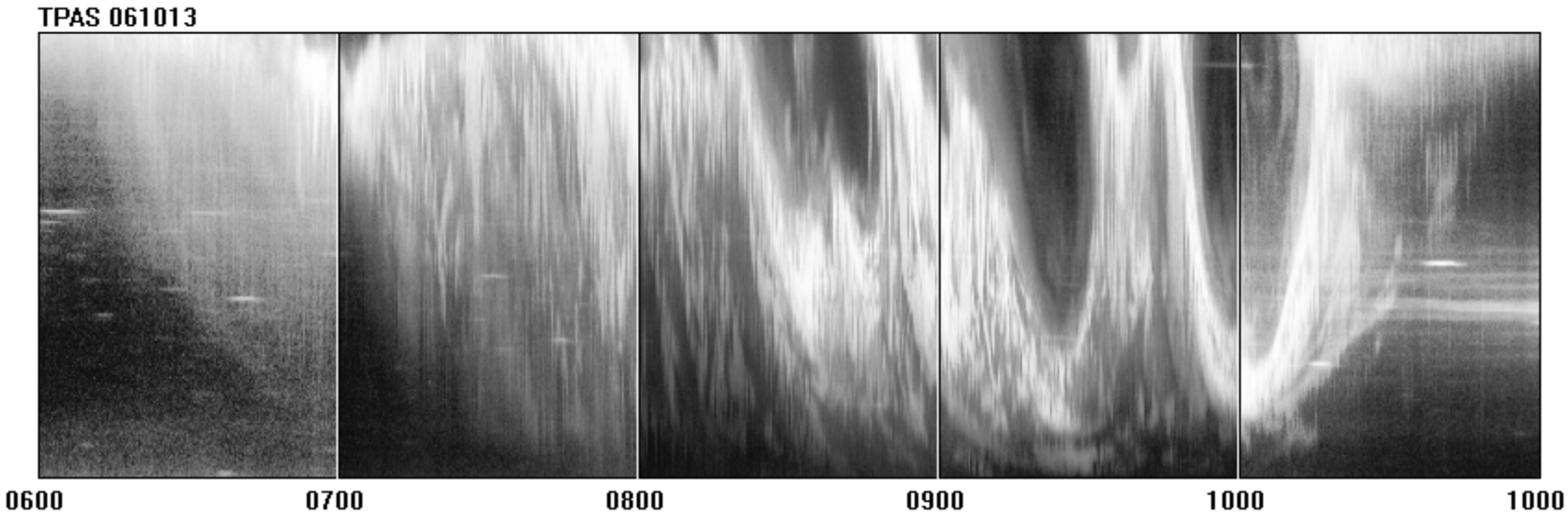
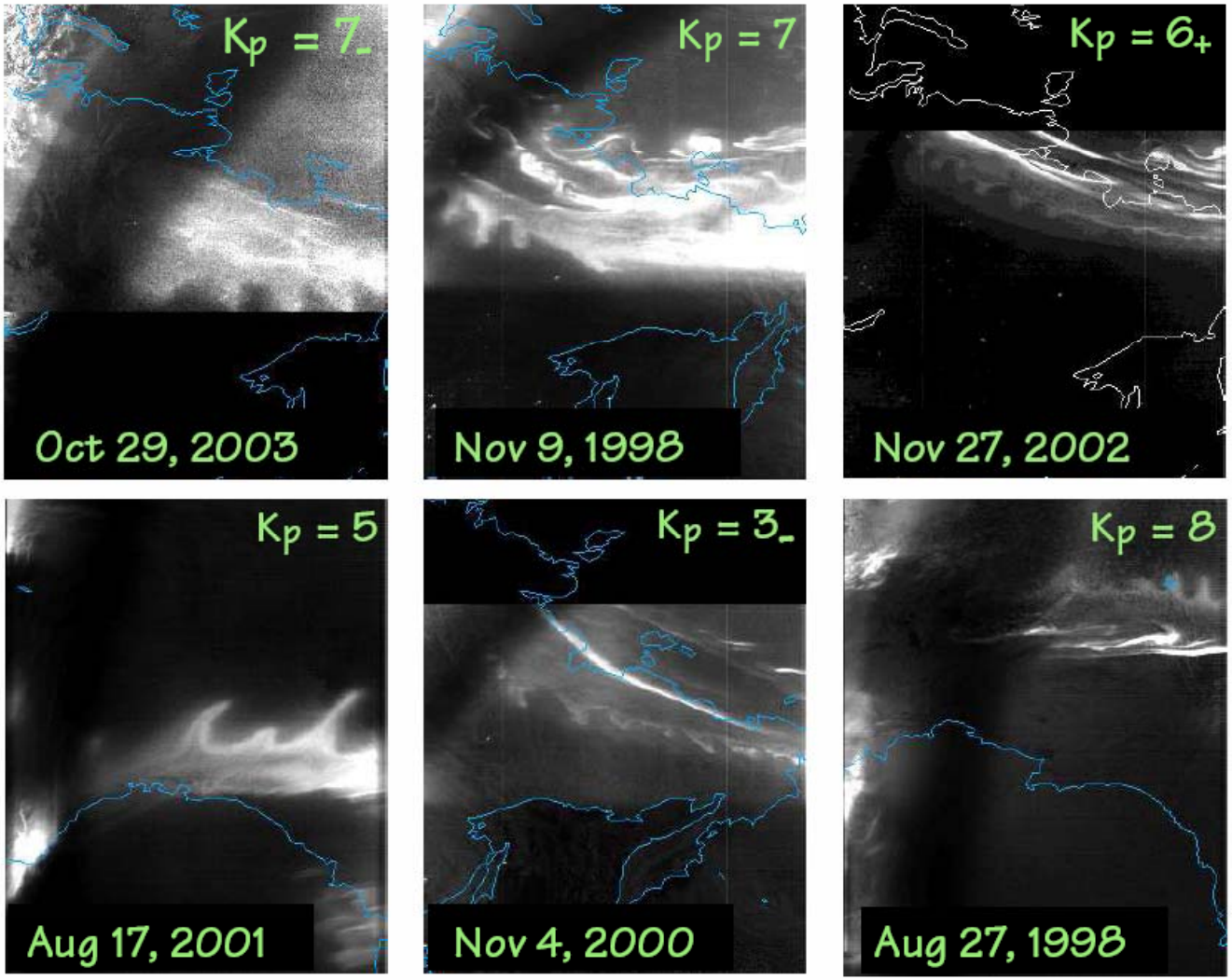


Reproduced from Figure 10 in Yamamoto, T., S. Inoue, and C. Meng, *Formation of auroral omega bands in the paired region 1 and region 2 field-aligned current system, JGR, 102*(*2531-2544*)*, 1997.*

Diffuse Aurora



Diffuse Aurora



Opportunities for New Studies

Diffuse Aurora

Questions that need answering!

Proton Diffuse Aurora

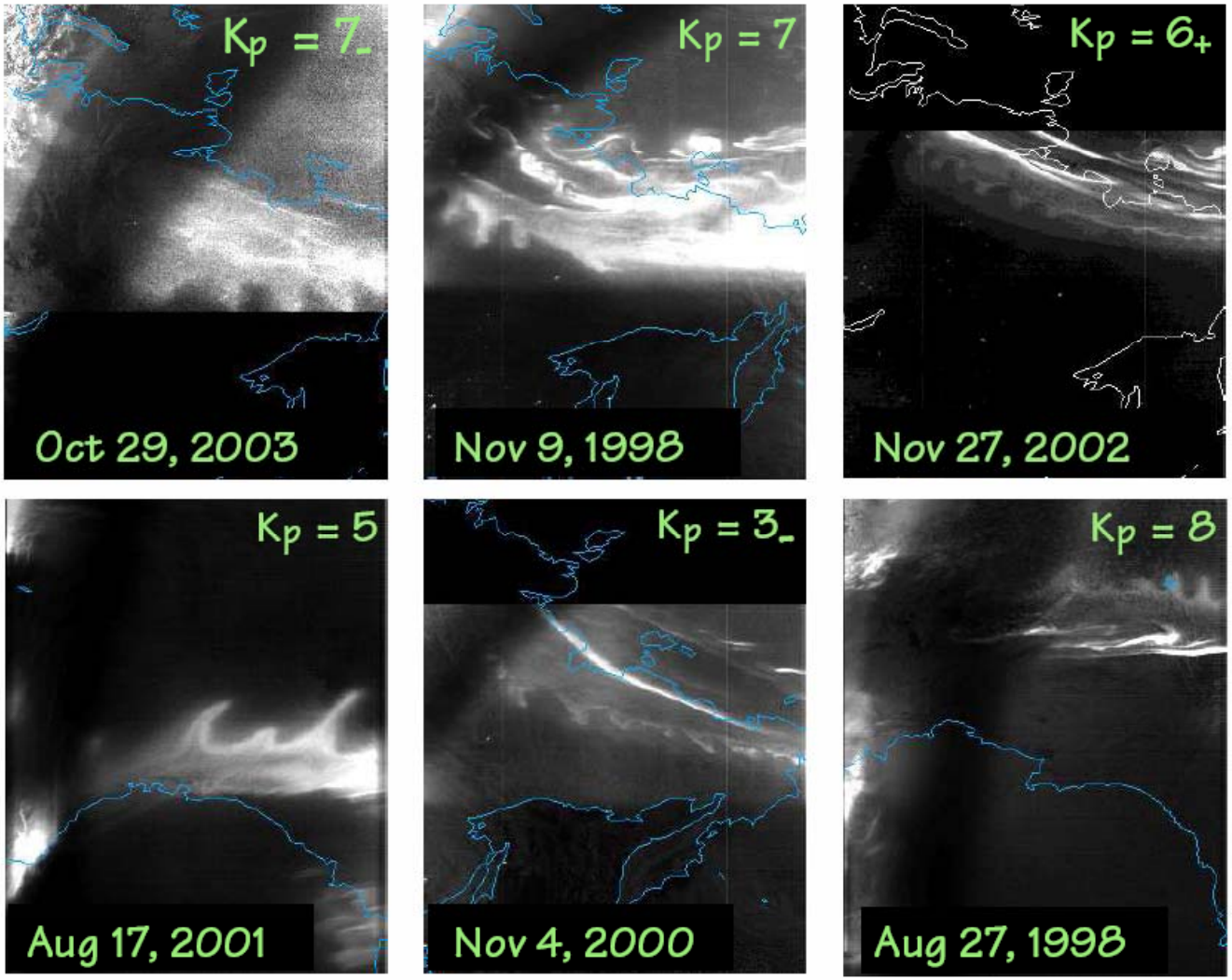
Why does proton auroral fading occur in the 20 minutes prior to onset?
Is proton diffuse auroral precipitation structured?
What are the relative contributions of the various causes of proton precipitation?
Are inductive electric fields important in proton auroral precipitation near onset?
Are all discrete electron auroral arcs embedded in the proton aurora?
Is there such a thing as a discrete proton auroral arc?

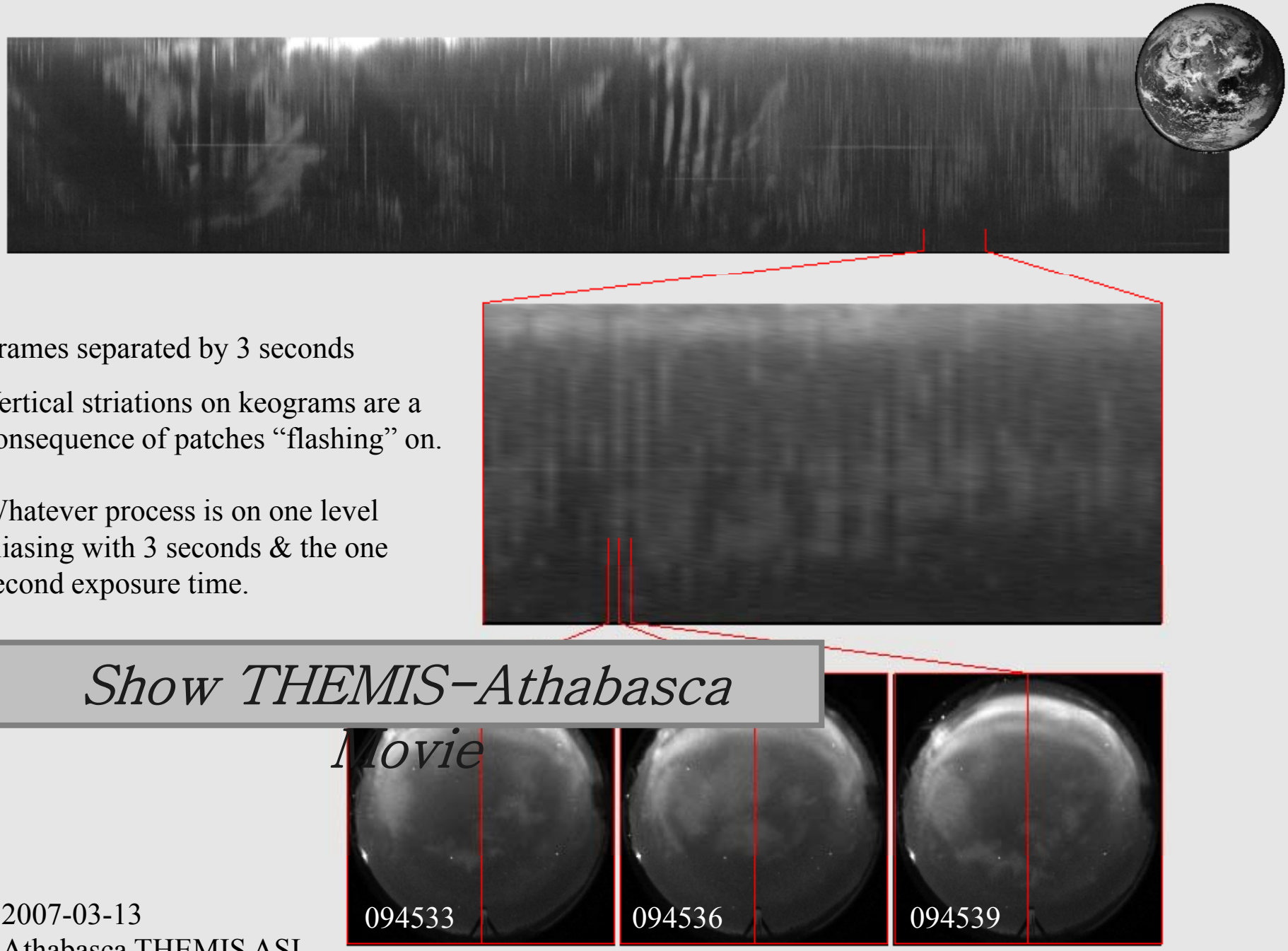
Electron Diffuse Aurora

What determines structure in the electron diffuse aurora?
What is the role of CPS turbulence in diffuse auroral structure/brightness?
Develop a relationship between CPS conditions and electron auroral brightness.
Do processes such as BBFs play a role in diffuse auroral brightness?
Is there a diffuse auroral signature of mid-tail reconnection?
Develop a relationship between CPS conditions and electron auroral brightness.
What are the relative contributions of the various causes of electron precipitation?
Why is the poleward boundary of the diffuse electron aurora sometimes so sharp?
Is the redline poleward boundary always a good proxy for the separatrix?

Diffuse Aurora

Questions that need answering!





Frames separated by 3 seconds

Vertical striations on keograms are a consequence of patches “flashing” on.

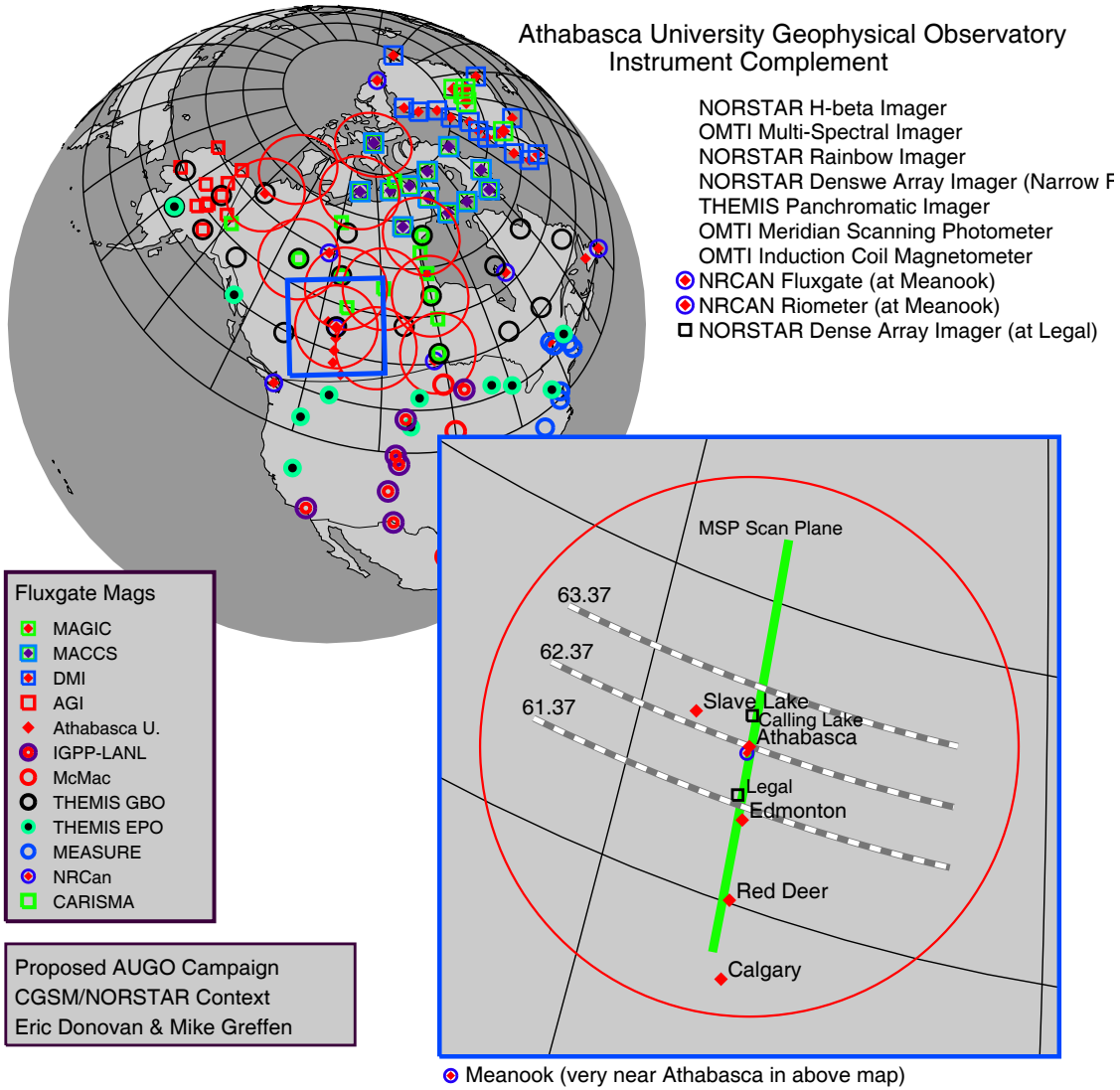
Whatever process is on one level aliasing with 3 seconds & the one second exposure time.

Show THEMIS-Athabasca Movie

2007-03-13
Athabasca THEMIS ASI

Diffuse Aurora

Plasma physical mechanisms of DA precipitation



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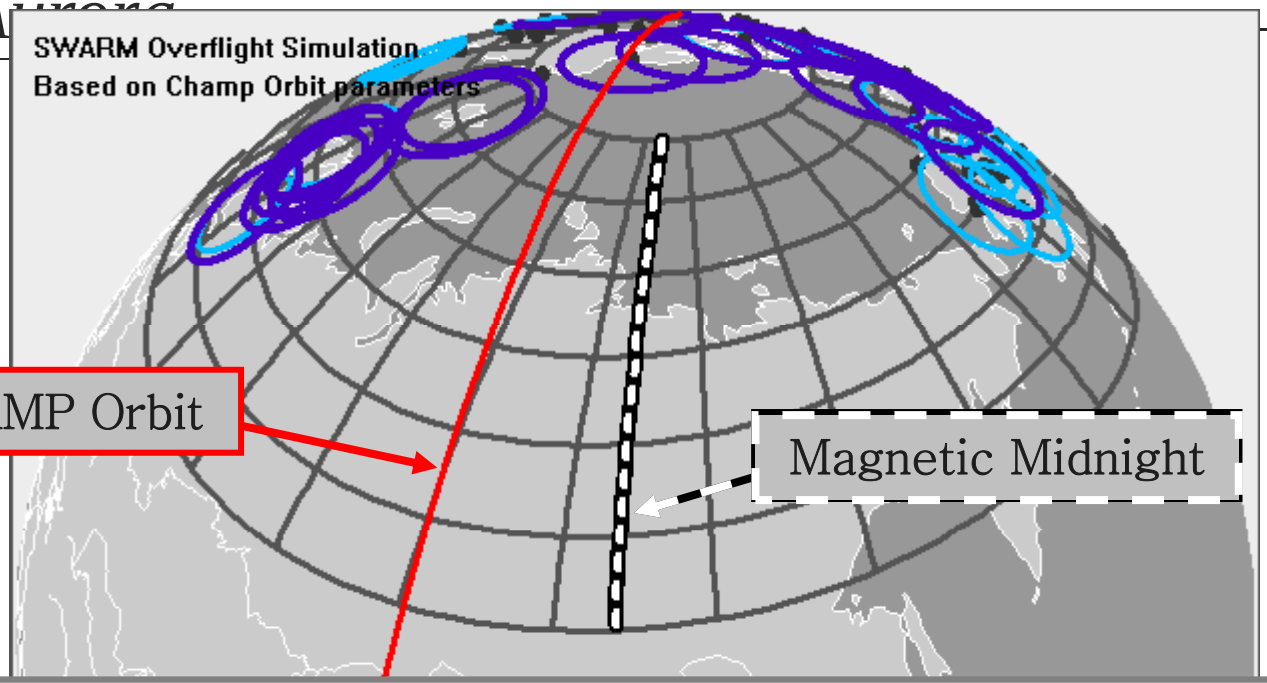


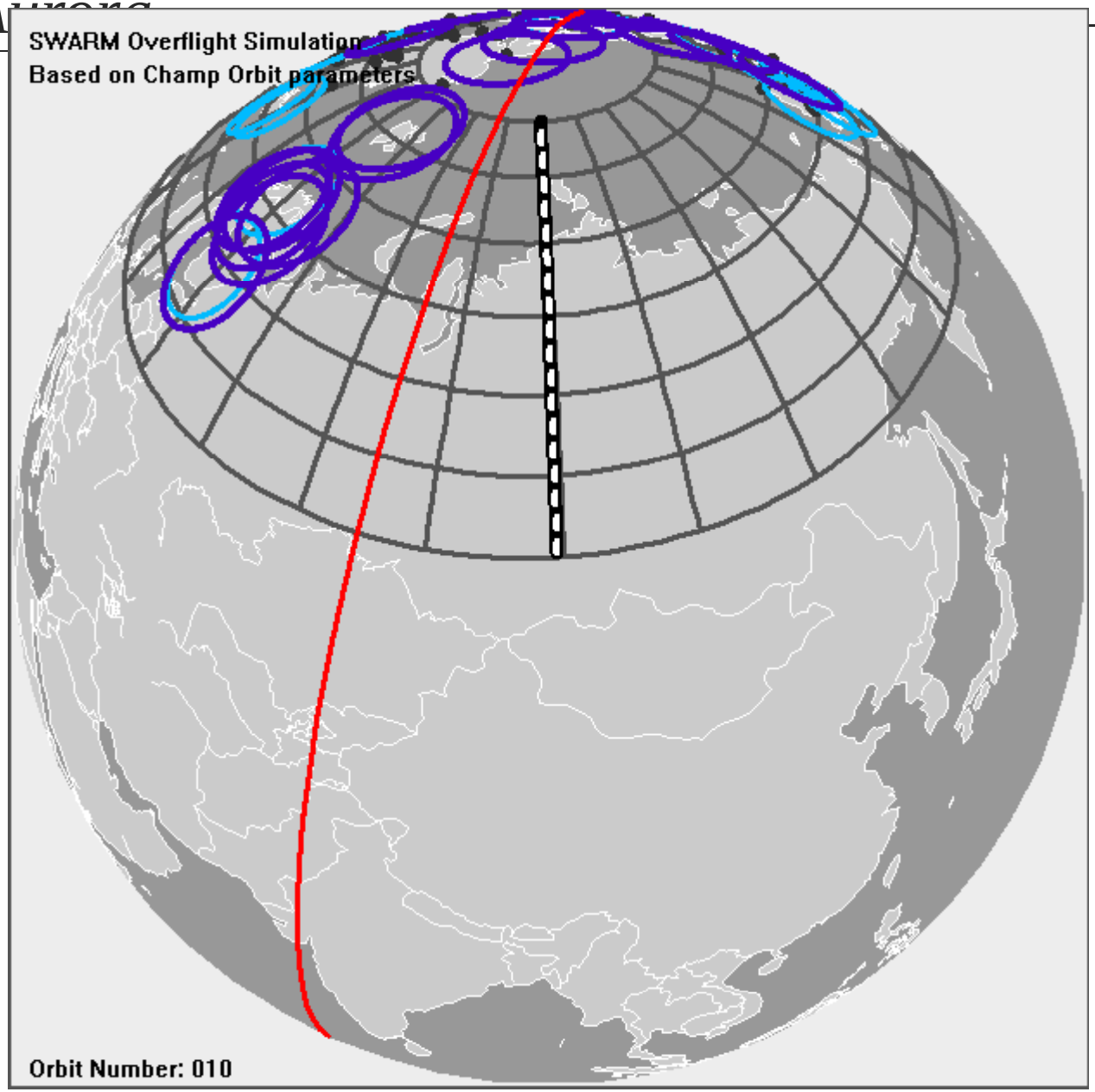
In the following plots I am stepping forward one orbit at a time starting from an orbit where the satellite passes through the night side over eastern Russia.

The contours show constant PACE latitudes from 50 to 80 degrees and longitudes separated by one hour of local time.

The orbit is shown in red (projected geographically to the surface which is not too bad for the orbit we are talking about. Magnetic midnight is indicated by the dashed white thick line from 50 to 80 degrees PACE.

The black dots indicate fluxgate mags in North America and

Diffuse Aurora



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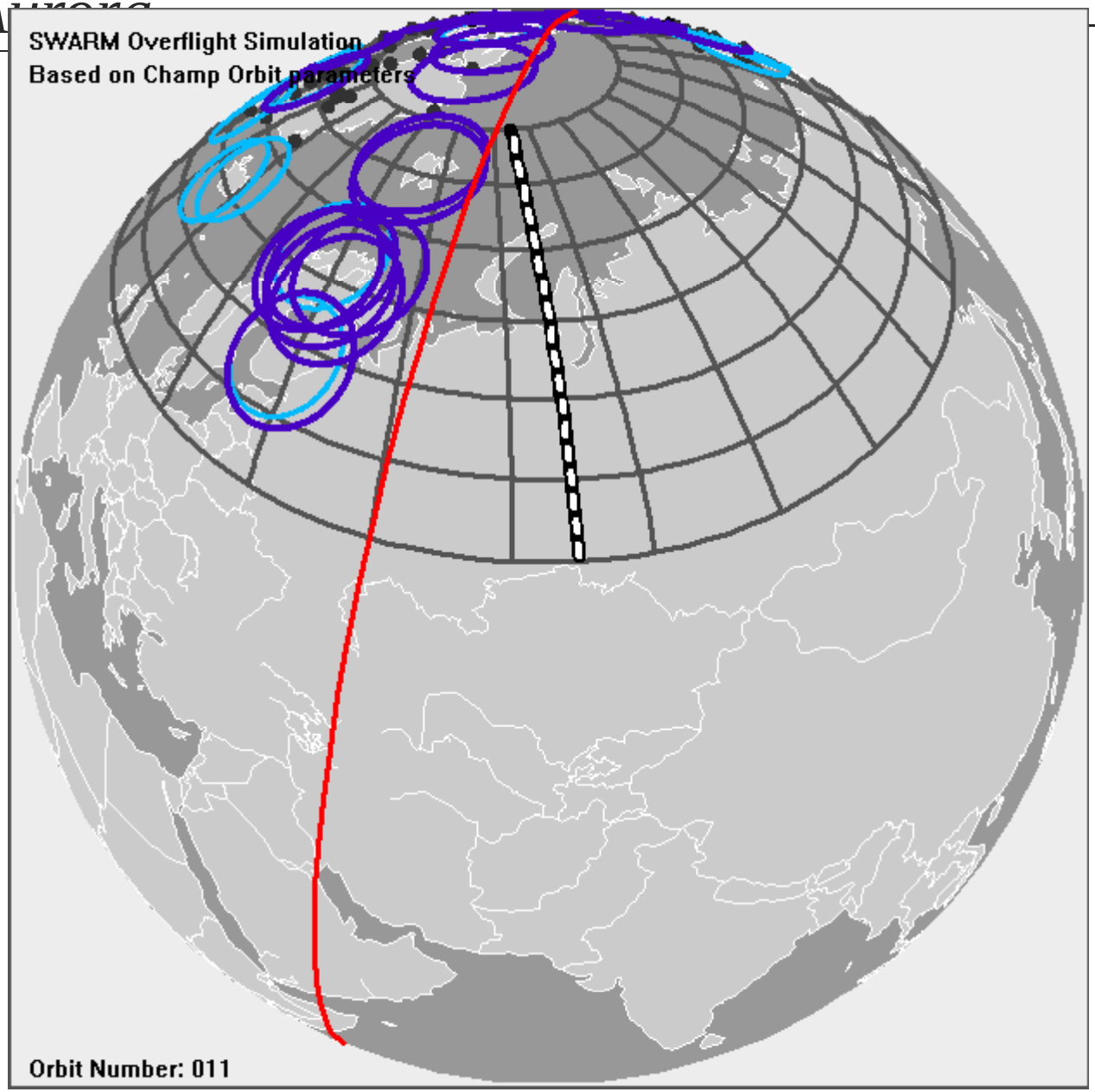

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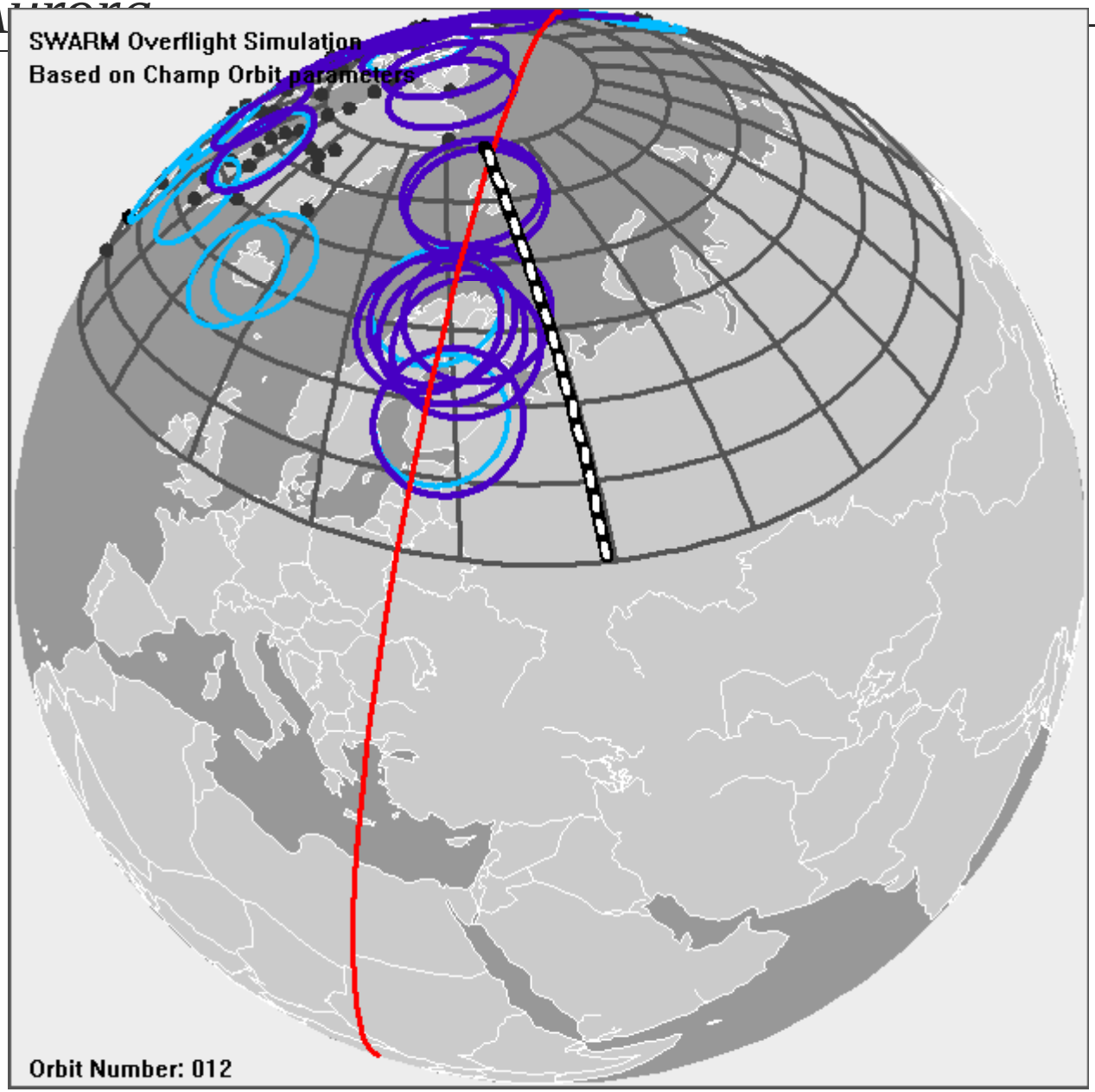

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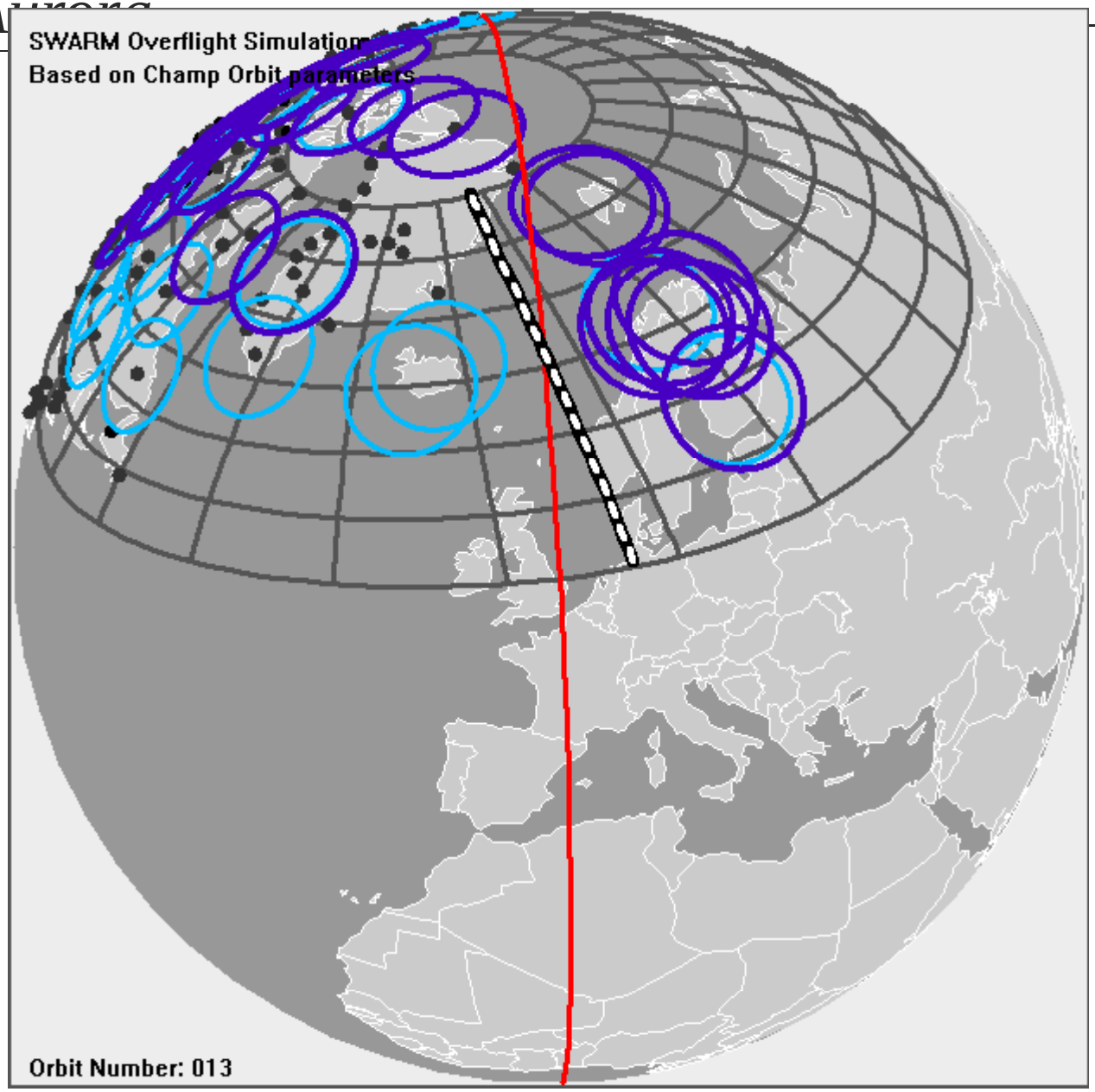

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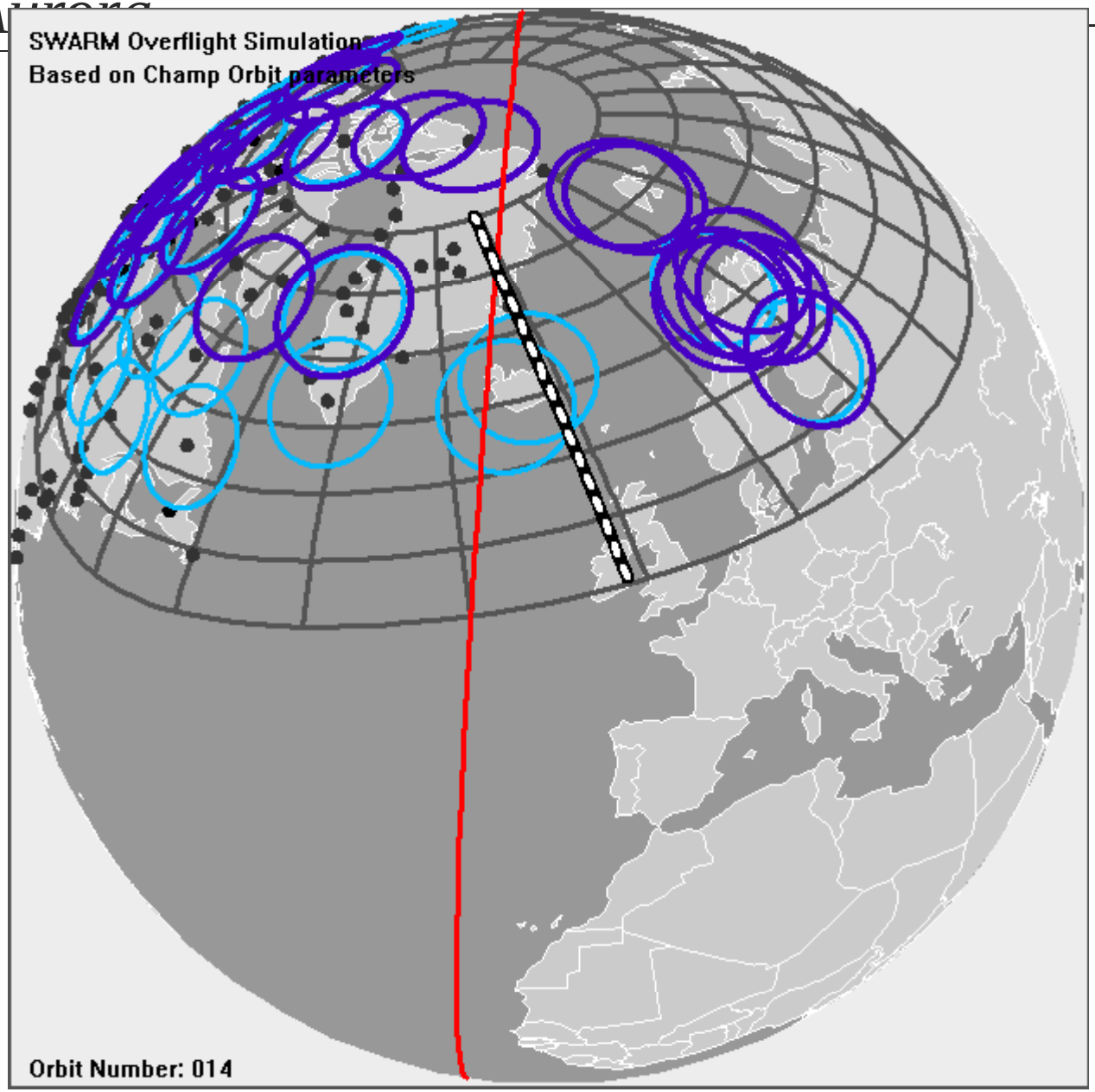

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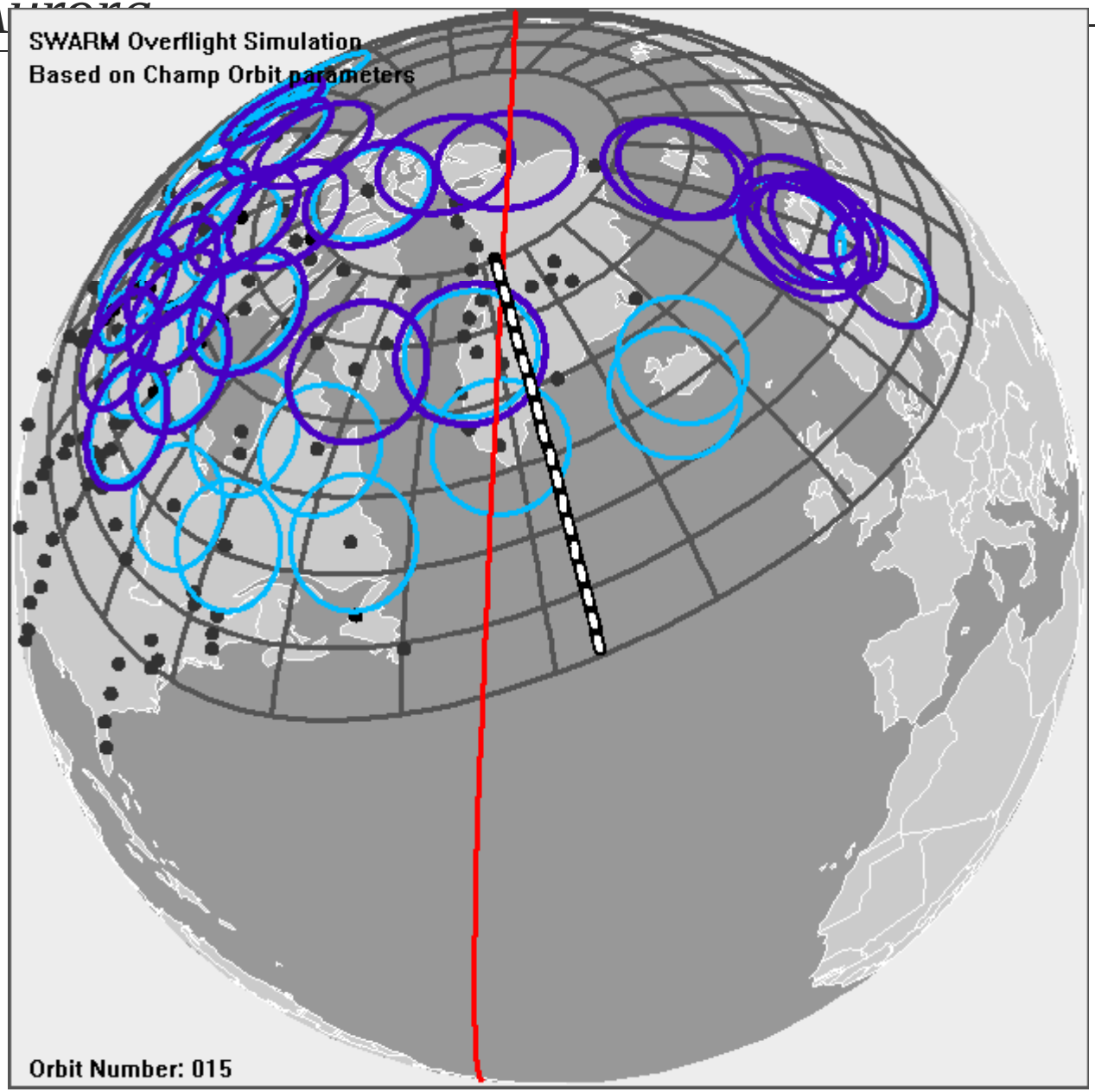

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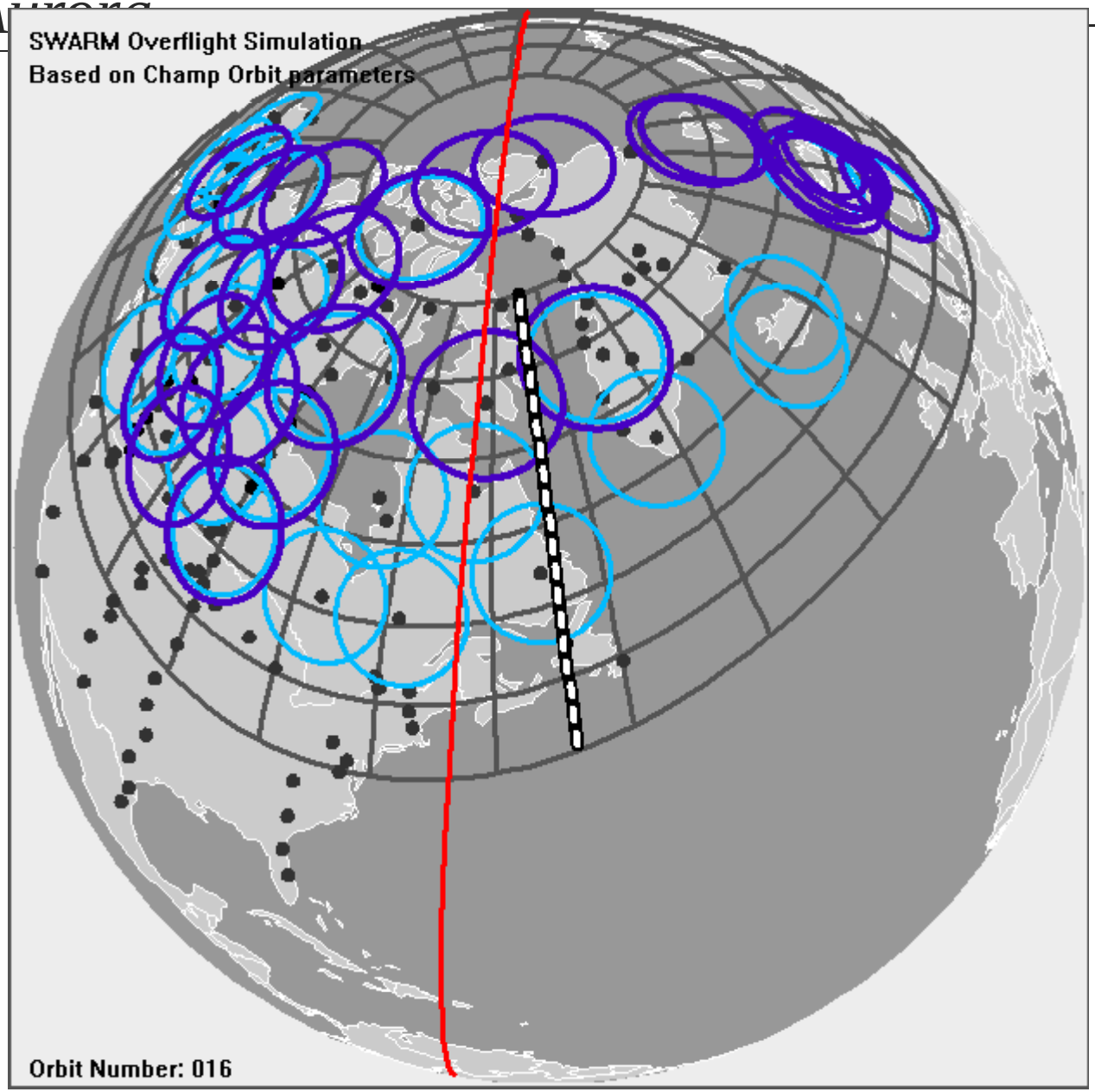

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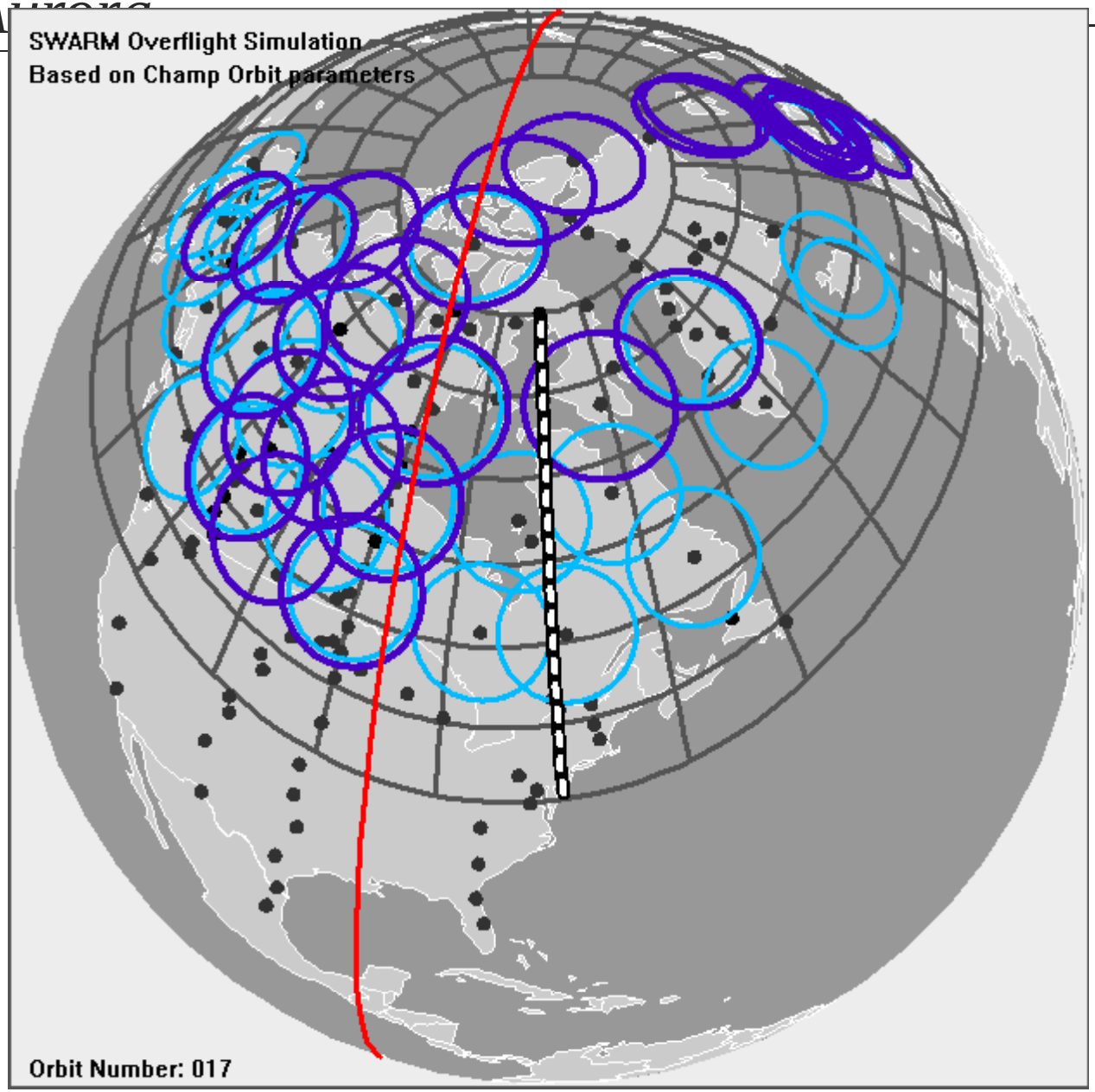

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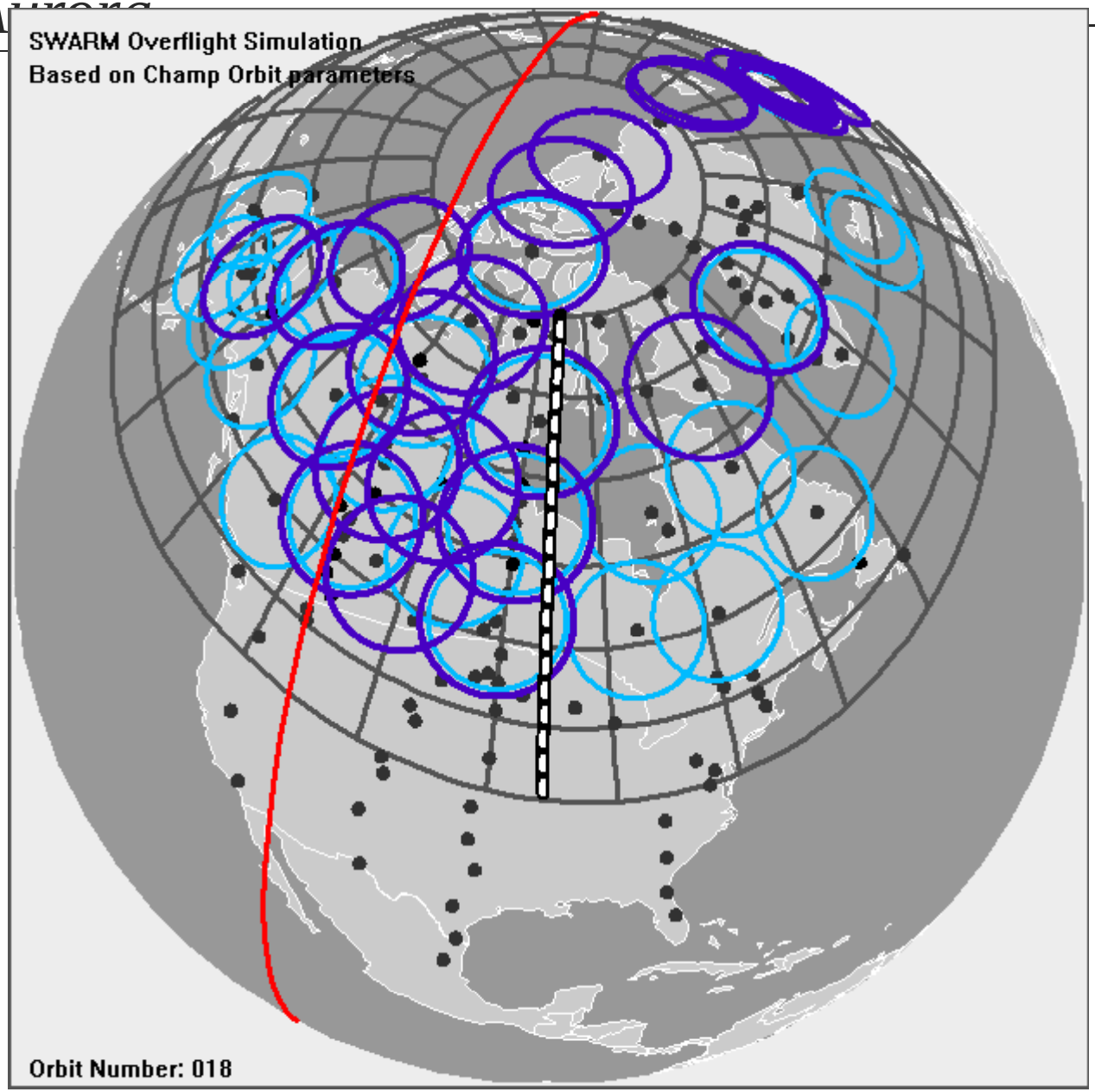

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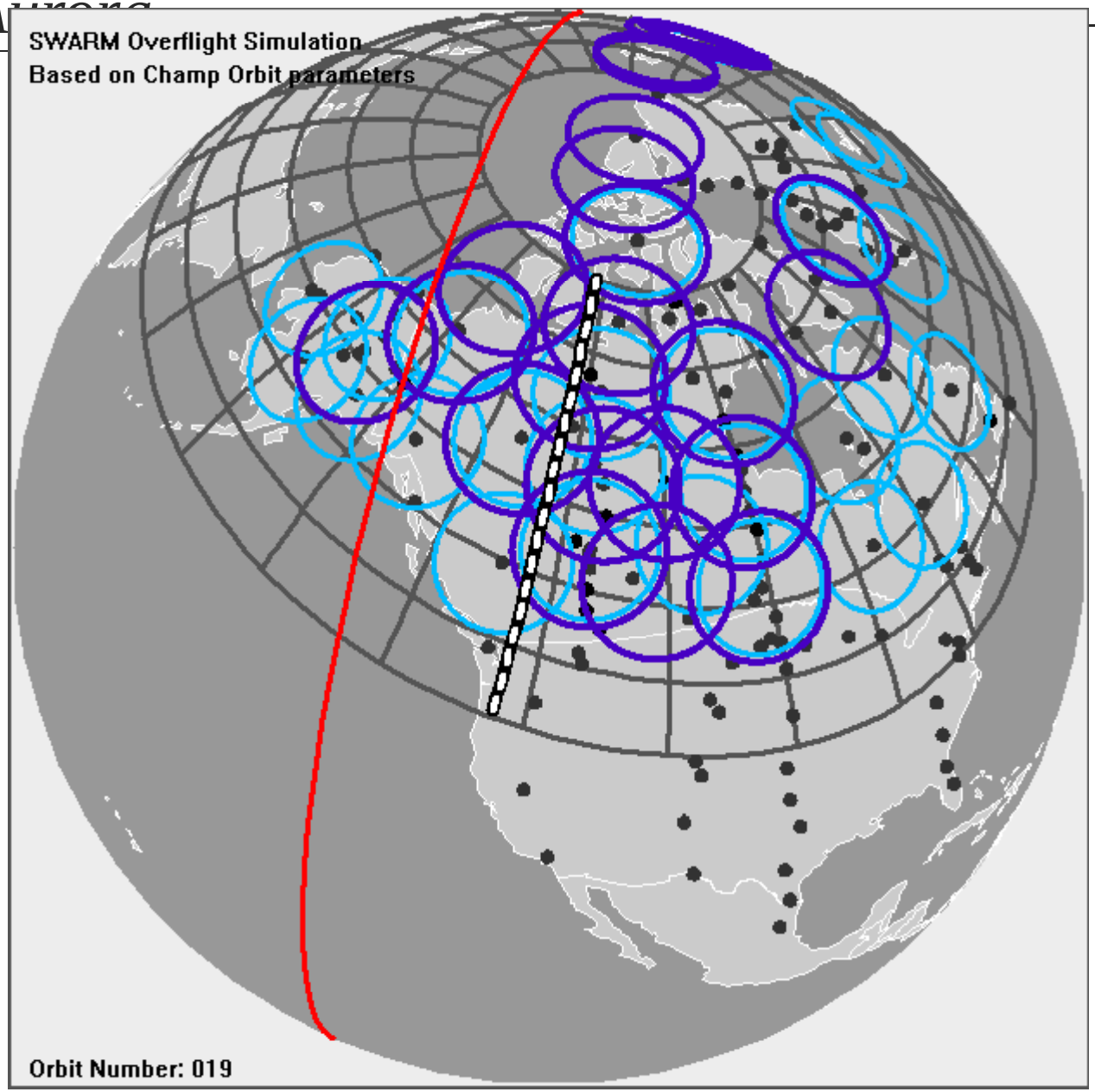

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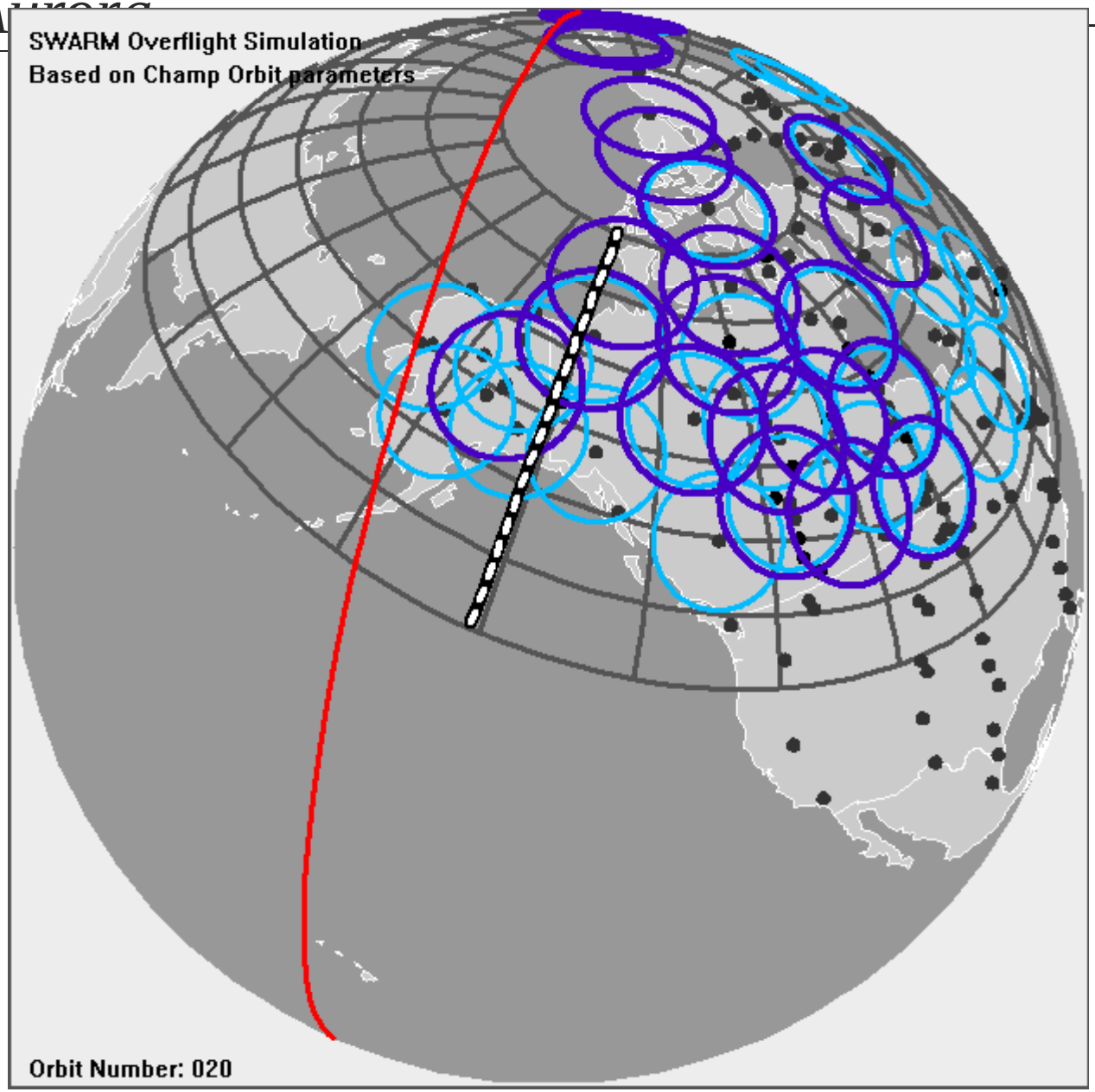
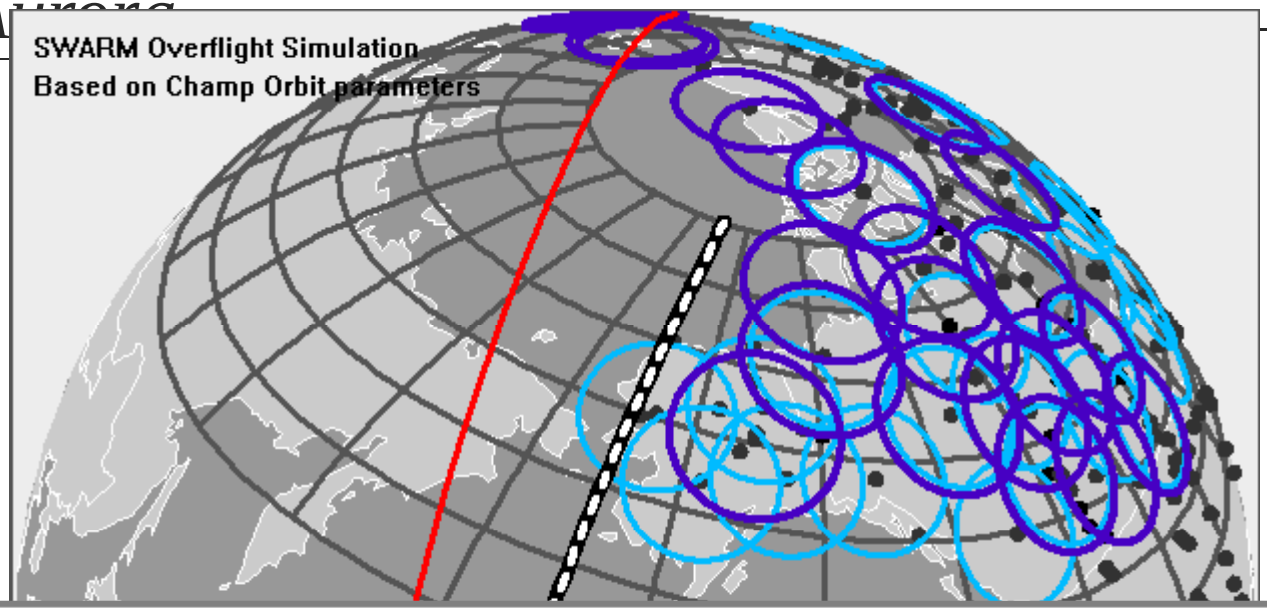


Diffuse Aurora



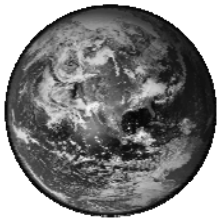
Considering just this <u>one day</u> in 2002, had all of the ASIs been operating that I expect will be operating by 2009 been running….

Champ would have passed though the FOVs of roughly 50 ASIs with one pass having continuous optical coverage from 55 degrees mlat (NORSTAR) to the magnetic pole (CHAIN) and passing though the FOVs of AMISR and PolarDARN.

WE can expect this number of conjunctions for all three SWARM satellites during most times of year. With three satellites and the quality of E and B observations that SWARM will provide this will be an unprecedented opportunity for studies of auroral eledctrodynamics.

Final Thoughts

Diffuse Aurora



Plasma Physics	Geospace Remote Sensing	Role in Dynamics
What causes the precipitation??	What can we infer about geospace from the diffuse aurora?	Is the diffuse aurora "important"?

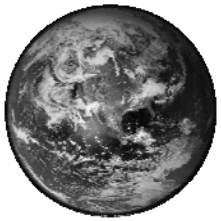
ECH
Chorus
EMIC
Turbulence
Potential Difference
FL Curvature
MASER
⋮

OC Boundary
E- CPS inner edge
H+ CPS inner edge
Stretched-dipolar trans
Stretching
H+ pressure
Presence of MHD waves
Presence of waves
⋮

Loss of low E e-
Loss of high E e-
Loss of low E H+
Low of high E H+
Direct role in currents
Conductivity effects
Role in wave generation
⋮

References

Diffuse Aurora



High Points

Discovery & Early Exploration of the Diffuse Aurora

Rees, M., A. Belon, and G. Romick,
The systematic behvior of H emission in the aurora, PSS, 5, 87-91, 1961.

Petschek., H., and C. Kennel,
Tail flow, auroral precipitation, and ring currents., Trans. Am. Geophys. Union, Volume 47, 137-138, 1966.

Lui, A., P. Perreault, S.-I. Akasofu, and C. Anger
The Diffuse Aurora, PSS, Volume 21, 857-861, 1973

Eather, R., and S. Mende
Airborne Observations of Auroral Precipitation Patterns, JGR, Volume 76, 1746-1755, 1971.

Fukunishi,H.,
Dynamic relationship between proton and electron auroral substorms, JGR, Volume 80, 553-574, 1975.

Mende, S., and R. Eather,
Monochromatic all-sky observations and auroral precipitation patterns, JGR, Volume 81., 3771-138, 1966.

Diffuse Aurora

High Points

Properties of the major relevant plasma populations (mostly the CPS)

Frank, L., *Relationship of the plasma sheet, ring current, trapping boundary, and plasmapause near the magnetic equator and local midnight, JGR, 76(2265-2275), 1971.*

Wing, S., *Central plasma sheet ion properties as inferred from ionospheric observations, JGR, 103(6785-6800), 1998.*

Friedel, R., *Airborne Observations of Auroral Precipitation Patterns, JGR, 76(1746-1755), 1971.*

Diffusion mechanisms

Kennel, C., and H. Petchek, *Limit on stably trapped particle fluxes, JGR, 71(1-28), 1966.*

Sergeev, V., E. Sazhina, N. Tsyganenko, J. Lundblad, and F. Søraas, *Pitch-angle scattering of energetic protons in the magnetotail current sheet as the dominant source of their isotropic precipitation into the nightside ionosphere, PSS, 31(1147-1155), 1983.*

Diffuse Aurora

High Points

Inferring things from diffuse auroral boundaries

A. Lui, C.-I. Meng, and S. Ismail, *Large amplitude undulations on the equatorward boundary of the diffuse aurora, JGR, 87(2385-2400), 1982.*

W. Imhof, *Fine resolution measurements of the L-ependent energy threshold for isotropy at the trapping boundary, JGR, 93(9743-), 1988.*

V. Sergeev and B. Gvozdevsky, *MT-index: a new index to characterize the configuration of the magnetotail, Ann. Geophys., 13(1093-1103), 1993.*

G. Blanchard, L. Lyons, J. Samson, and F. Rich, *Locating the polar cap boundary from observations of 6300 Å auroral emission, JGR, 100(7855-7862), 1995.*

E. Donovan, B. Jackel, I. Voronkov, T. Sorirelis, F. Creutzberg, and N. Nicholson, *Ground-based optical determination of the b2i boundary: A basis for an optical MT-index, JGR, 108(doi:10.1029/2001JA009198), 2003.*

Rae, Kabin, Rankin, Fenrich, Liu, Wanliss, Ridley, Gombosi, and De Zeeuw *Comparison of photometer anf glbal MHD determination of the open-closed field line boundary, JGR, 109(doi:10.1029/2003JA009968), 2004.*

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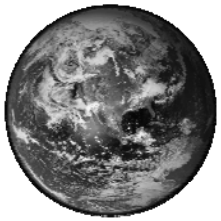

High Points

Papers from which I learned the most

M. Ashour-Abdalla, and C. Kennel,
Diffuse auroral precipitation, in Auroral Processes, C. Russell Ed., 1977.

V. Sergeev, E. Sazhina, N. Tsyganenko, J. Lundblad, and F. Søraas,
Pitch-angle scattering of energetic protons in the magnetotail current sheet as the dominant source of their isotropic precipitation into the nightime ionosphere, PSS, 31(1147-1155), 1983.

D. Fontaine and M. Blanc
A theoretical approach to the morphology and dynamics of diffuse auroral zones, JGR, 88(7171-7184), 1983.

D. Fairfield and A. Viñas
The inner edge of the PS and the diffuse aurora, JGR, 89(841-854), 1984.

P. Newell, Y. Feldstein, Y. Galperin, and C.-I. Meng,
Morphology of nightside precipitation, JGR, 101(10737-10748), 1986.

Frey, Mende, Carlson, Gérard, Hubert, Spann, Gladstone, and Immel
The electron and proton aurora as seen by IMAGE-FUV and FAST, GRL, 28(1135-1138), 2001.