Revisiting seasonal ionospheric conductivities at Saturn as derived from HST auroral imagery

Physics | Lancaster University

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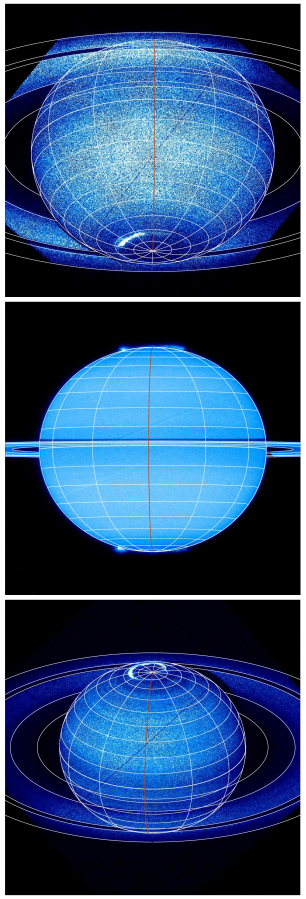
Introduction

Measurements of FUV auroral intensity can be used to derive estimates of Saturn's ionospheric Pedersen conductance [Gustin+ 2012], which can be enhanced above the solar EUV-driven background by up to 20 times following energetic auroral precipitation [Galand+ 2011].

Local time profiles of the auroral intensity reveal spatial and temporal variation in this enhanced ionospheric conductance in response to magnetospheric dynamics. Such profiles have previously been based on imagery captured by the Hubble Space Telescope during the Kronian southern summer [Lamy+ 2009].

Here we revisit multiple HST campaigns to investigate changes in the intensity response over Saturn's seasons. We apply a consistent pipeline process to the reduction and projection of STIS imagery, and extract local time intensity profiles from within the main auroral current latitudes.

The HST has observed Saturn since 1997, capturing views of the auroras at different phases of its slowly changing seasons.



2004 Southern summer.

2009 Equinox.

2017 Northern summer.

Source: APIS

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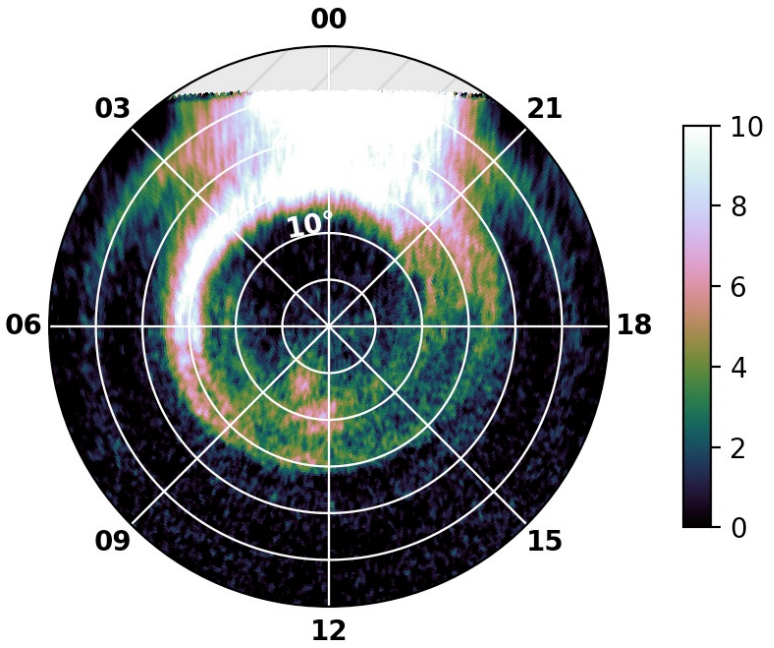
A revised and consistent pipeline process for the reduction of HST STIS imagery was applied (thanks to Jonny Nichols at Leicester), including:

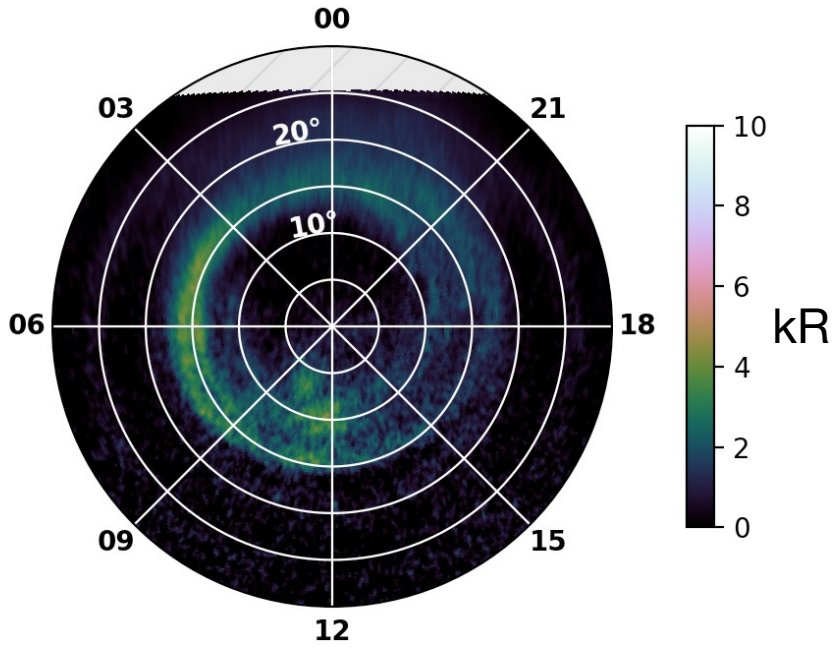
- planetary disc emission profiling & removal
- limb finding & projection
- geometric viewing angle correction

This makes the profiles as comparable as possible between campaigns.

Note: Auroral intensity is proportional to precipitating energy flux via the relation that 1 mW/m^{-2} produces an H_2 intensity of 10 kR [Gustin+ 2012].



2017 mean intensity in polar projection



Corrected for view angle brightening

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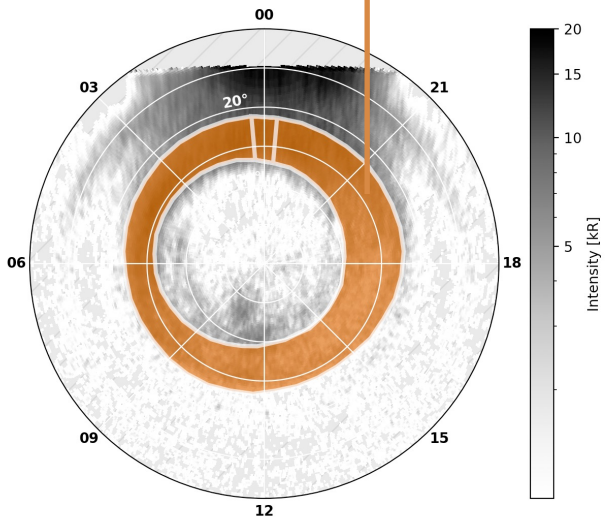
Extracting local time profiles from the main auroral current regions.

Considerations:

- exclude polar emissions
- capture main oval, encompassing ~1° location shift driven by PPO systems.

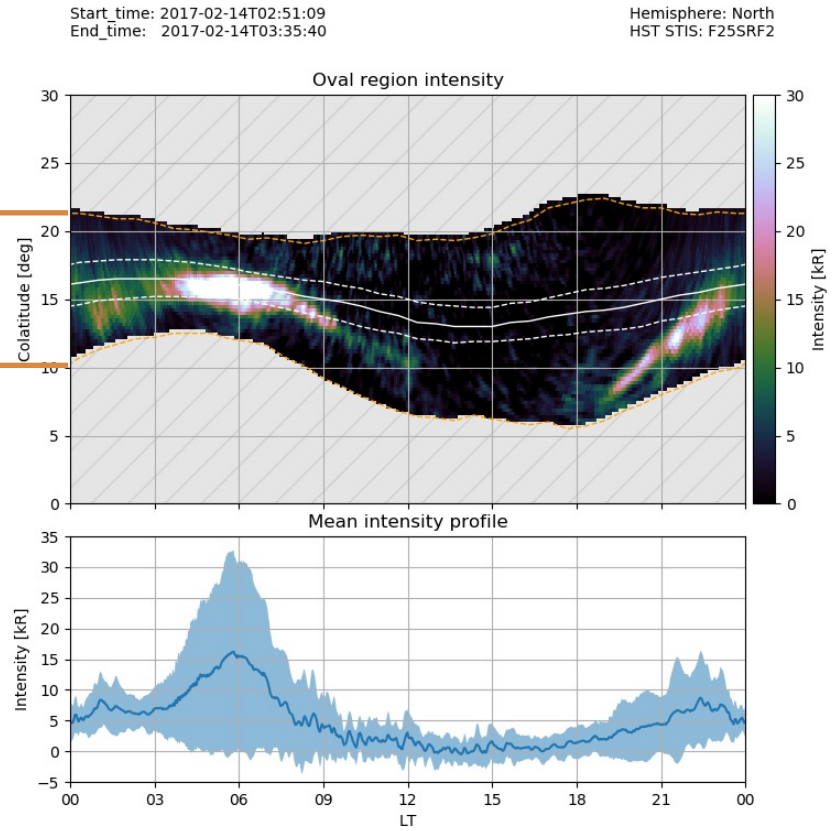
Solution:

Apply a polygon mask for median equatorward & poleward auroral boundaries, ± 3σ. Based on tens of thousands of Cassini UVIS sample points in each hemisphere {Bader+ 2019].



Polygon mask envelope

2017 single image example



Northern auroral intensity plotted in cylindrical projection in LT versus colatitude, within the statistical main oval region (top). Derived LT intensity profile and standard deviation (bottom).

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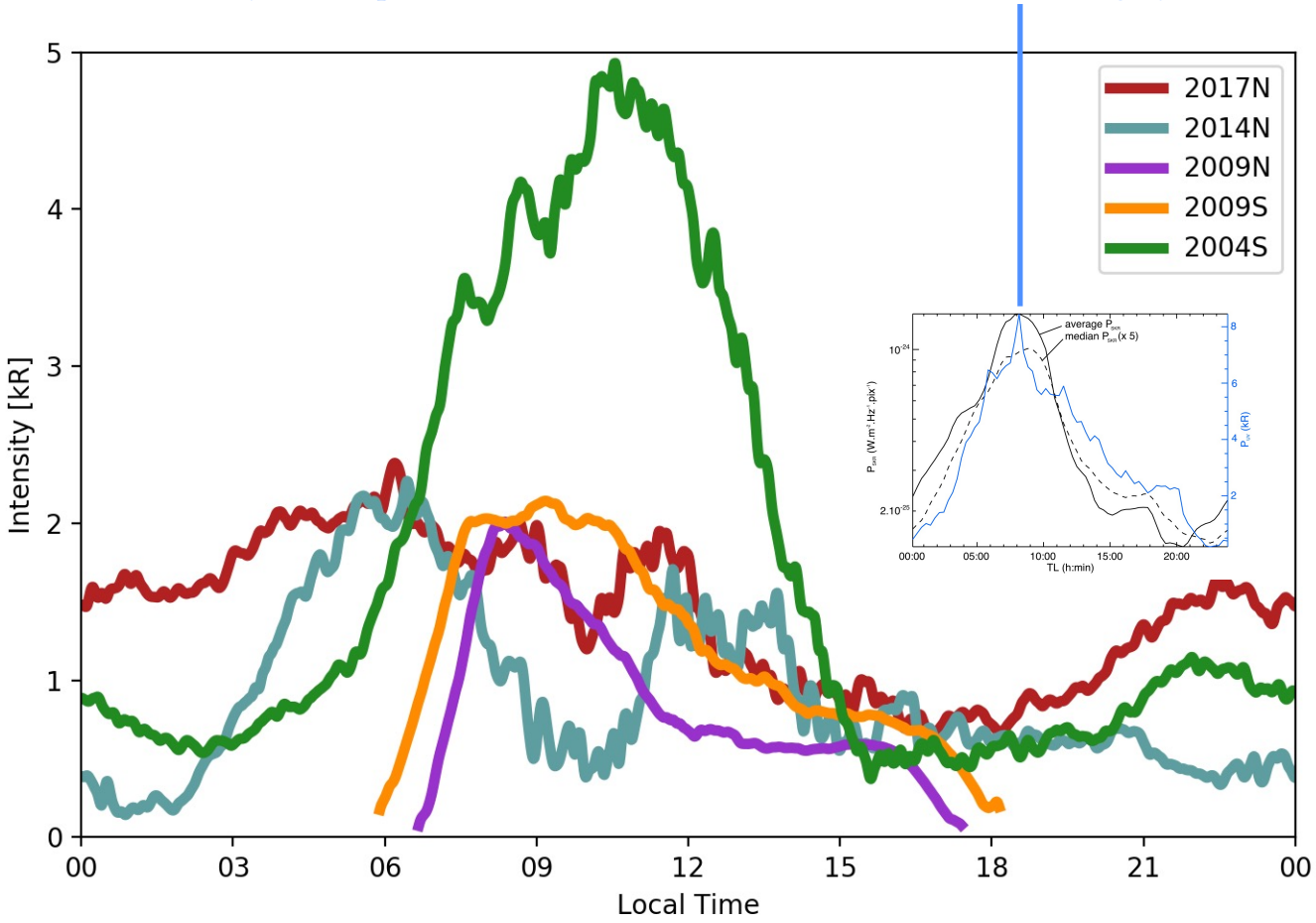
Summary

- Re-processed past HST campaigns using a consistent pipeline process, across various stages of Saturn's seasons.
- Extracted average local time intensity profiles in the main auroral emission regions.
- Dynamic morphology such as dawn storms – combined with sparse sampling – obscures observable seasonal or hemispheric asymmetry effects, which appear minor compared to the influence of precipitating particles.
- Previous estimates of LT variation in conductivity – based on auroral intensity pre-equinox (see inset) – may not reflect those in other seasons.

Future work

Cassini images may refine these local time profiles, particularly in the winter hemisphere (not observable by the HST).

Inset: Lamy+ 2009 profile based on 2004 & 2007 southern HST imagery



Mean LT-intensity profiles from HST campaigns across southern summer, equinox, and northern summer.