Examining the relationship between the plasmapause and the equatorward auroral boundary

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Does the plasmapause align with the equtorward auroral edge?

★ We compare the statistical location of the plasmapause ionospheric footpoint with the equatorward auroral boundary location from FUV auroral images.

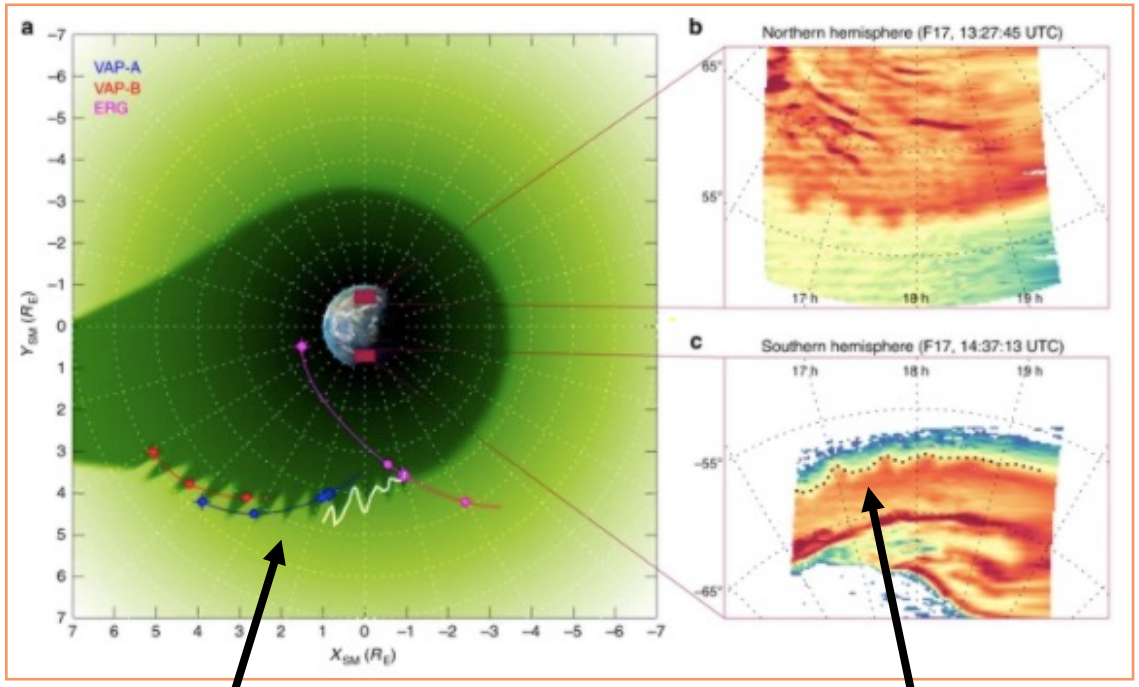
★ On average, the plasmapause ionospheric footpoint is located 4 – 8° equatorward of the auroral boundary location on the nightside and 8 – 11° equatorward on the dayside.

★ As geomagnetic activity increases, the separation between the two boundaries decreases in the nightside sectors.

1. The Plasmasphere

- The plasmasphere is a torus of cold (< 1 eV) ions and electrons that co-rotate with Earth which extends between 3 – 6 R_E.
- Recent studies have found that giant undulations and waves in the aurorae are linked to waves, instabilities and plasma injections at the plasmapause (e.g. Motoba et al., 2015; Henderson et al., 2018; He et al., 2020; Forsyth et al., 2020).

  ➢ Can we use the aurora to locate the plasmapause?
  ➢ Does the presence of the cold plasmaspheric population prevent auroral precipitation at lower latitudes?



In-situ observations of a plasmapause surface wave.

And coincident undulations on the equatorward edge of the auroral oval in the same local time sectors.

Figure 1: *Figure from He et al. (2020) showing simulation of the wave detected at the plasmapause by the Van Allen spacecraft and the coincident wave activity observed in the diffuse aurora by DMSP.*

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2. Identifying the Plasmapause

- The extreme ultraviolet (EUV) imager onboard the IMAGE satellite (2000 – 2005) took the first global observations of the plasmasphere.
- Goldstein et al. visually identified the plasmapause in ~ 3000 EUV images between 2000 – 2002. These matched very well with the plasmapause location from in-situ observations (Goldstein et al., 2003).

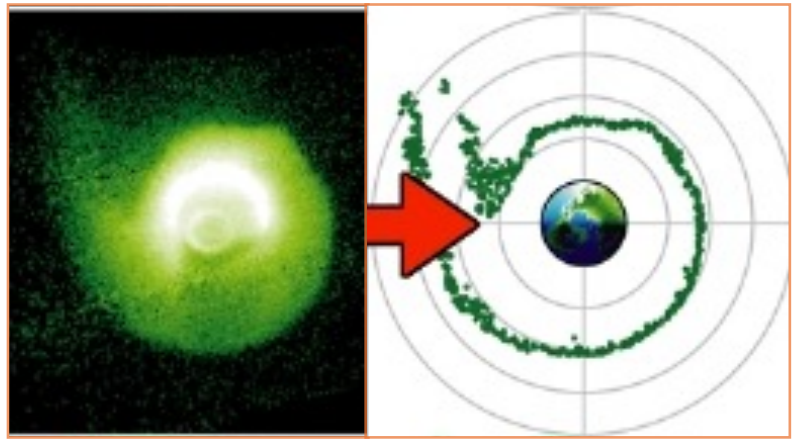

Figure 2: *EUV observation of the plasmasphere by IMAGE satellite (left), plasmapause visually identified by Goldstein et al. (right).*

3. Identifying the Auroral Boundary

- The IMAGE satellite also took far ultraviolet (FUV) images of the auroral oval between 2000 – 2005.
- Longden et al. (2010) use an automated technique to define the poleward and equatorward luminosity boundaries of the auroral oval between 2000 – 2002.

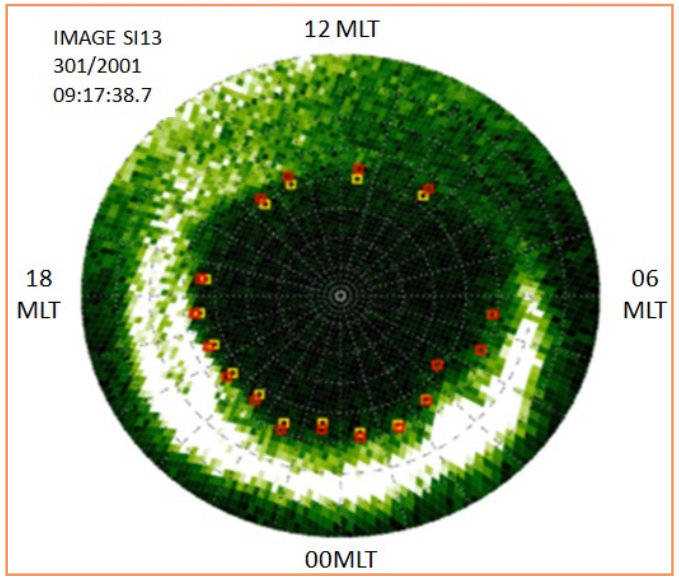

Figure 3: *An example of the poleward auroral boundary location in the northern hemisphere identified from IMAGE data (adapted from Longden et al., 2010).*

4. Comparing the Boundary Locations

- We compare the average location of the plasmapause mapped to the ionosphere using the T96 model to the equatorward boundary of the auroral oval.
- On average, the nightside boundaries are within 4 – 8° with overlapping distributions, while the dayside boundaries are separated by 8 – 11° with distinctly separate distributions.

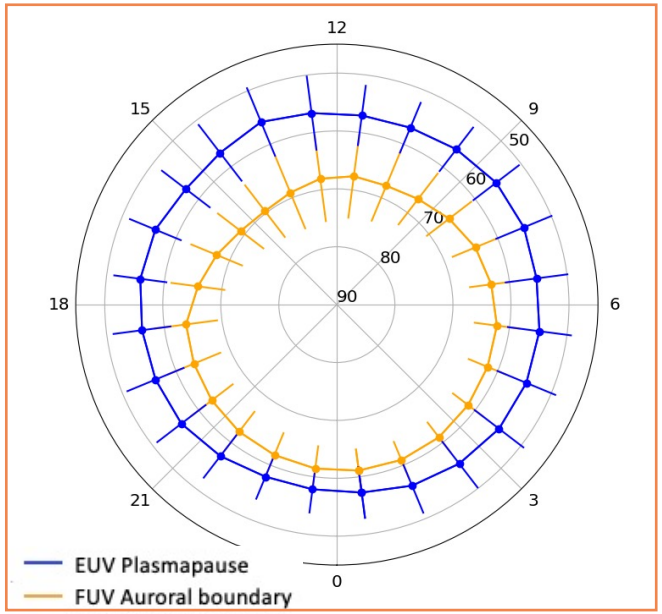

Figure 4: *Statistical mean location of the mapped plasmapause (blue) and the equatorward auroral boundary (orange).*

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5. The Effect of Geomagnetic Activity

As geomagnetic activity increases, the nightside boundaries are more closely aligned, particularly in the dusk to post-midnight (MLT 18 - 03) sectors.

Nightside Local Time Sectors

- As geomagnetic activity increases, equatorward auroral boundary gradually moves to lower latitudes but the plasmapause location is fairly steady at 55 – 60° magnetic latitude for Kp ≤ 6.
- This indicates that the source of the auroral moves towards the plasmapause with increasing geomagnetic activity.
- At very high levels of Kp > 6, the plasmapause boundary moves equatorward to ~ 50° which could indicate plasmaspheric erosion during very high levels of geomagnetic activity.

Dayside Local Time Sectors

- The dayside auroral boundary is located at higher latitudes than on the nightside, between 65 - 70° magnetic latitude.
- The dayside auroral boundary also expands to lower latitudes as the level of geomagnetic activity increases, however the equatorward motion in the dayside boundary is not as significant as in the nightside sectors.

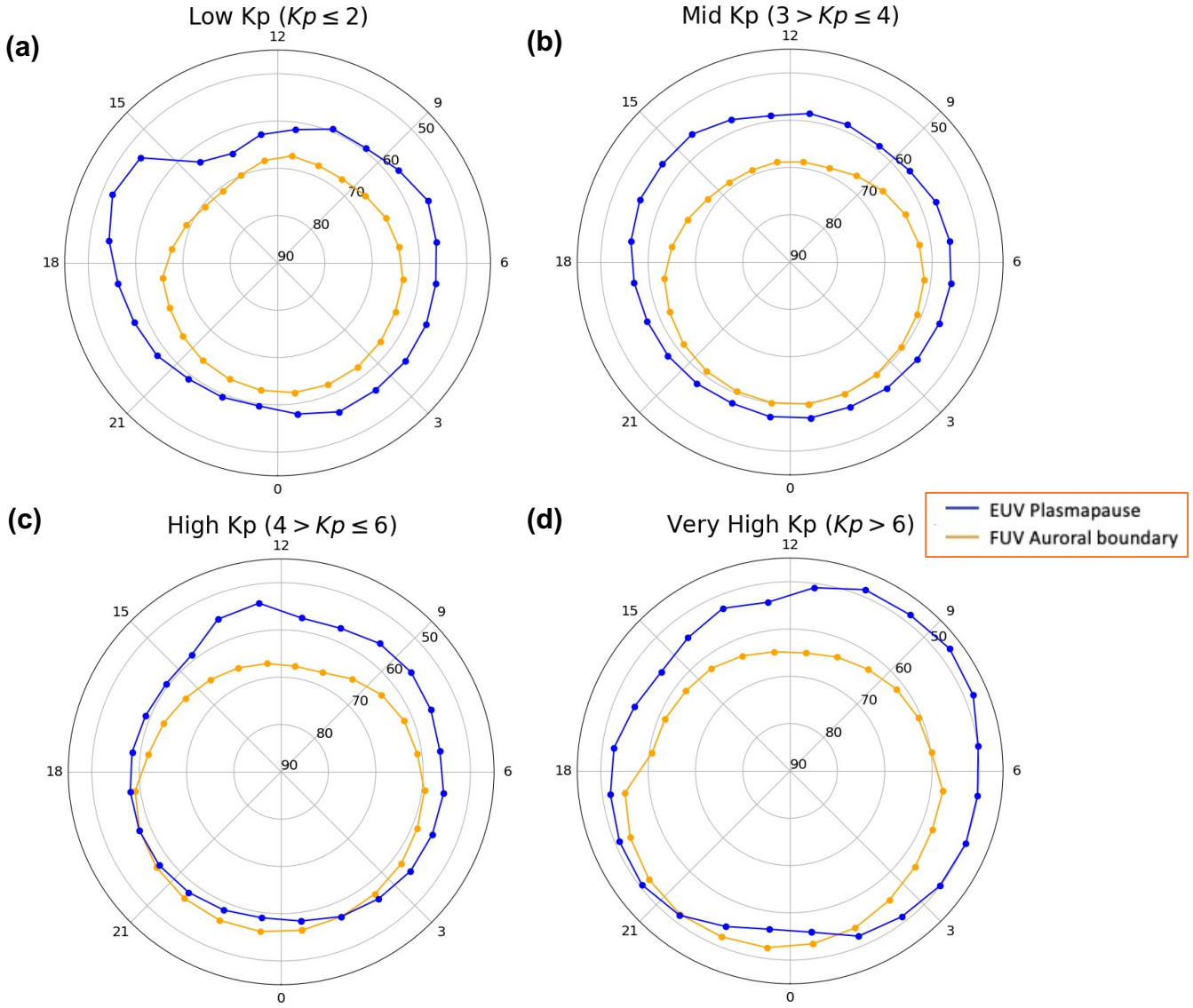

Figure 5: *Statistical location of the mapped plasmapause boundary (blue) and the equatorward auroral boundary (orange) during periods of (a) low, (b) mid, (c) high and (d) very high levels of geomagnetic activity.*

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6. Conclusions

Can we use the aurora to locate the plasmapause?

- Case studies (e.g. He et al., 2020) have shown good agreement between the two boundaries, however this does not hold in all local time sectors or under all levels of geomagnetic activity.
- On average, the mapped plasmapause lies 4 –11° equatorward of the auroral boundary location. As geomagnetic activity increases, the separation between the two boundaries decreases, particularly in the dusk to post-midnight (18 - 03) sectors.

Does the presence of the cold plasmaspheric population prevent auroral precipitation at lower latitudes?

- In most local time sectors, there is a gap between the cold plasmaspheric particles and the source of the higher energy precipitating auroral particles so, it does not seem likely that the plasmaspheric population has any impact on the precipitating auroral particles.

7. Relevance to SMILE

★ The upcoming SMILE mission will host a similar ultraviolet instrument onboard to obtain global auroral images and may be able to provide limited, simultaneous images of the plasmasphere using the Soft X-ray Imager to enable comparisons between the plasmapause location and the edge of the auroral precipitation.

★ SMILE suite of instrumentation will also include the Light Ion Analyser for complementary in-situ particle measurements.

8. Acknowledgements and References

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Plasmapause boundary data was determined by J. Goldstein and provided by the Southwest Research Institute (SWRI) based on EUV observations from the IMAGE satellite (https://enarc.space.swri.edu/EUV/)
Goldstein et al. (2003), doi: 10.1029/2002JA009475; Forsyth et al. (2020) doi: 10.1007/s11214-020-00665-y; He et al. (2020) doi: 10.1038/s41467-020-15506-3; Henderson et al. (2018) doi: 10.1002/2017JA024472; Motoba et al. (2015) doi: 10.1002/2014JA020863; Tsyganenko et al. (1996) doi: 10.1029/96JA02735

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