U.S. NAVAL RESEARCH LABORATORY

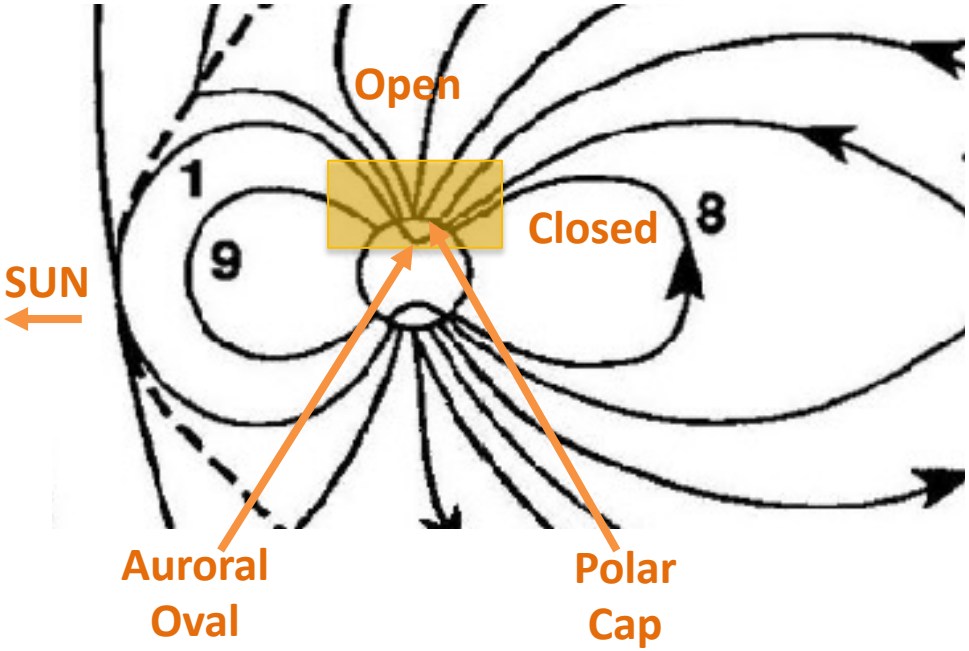
High-latitude Ionosphere

Dr. Meghan Burleigh
Naval Research Laboratory

M. Burleigh's research is sponsored by the Office of Naval Research

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere

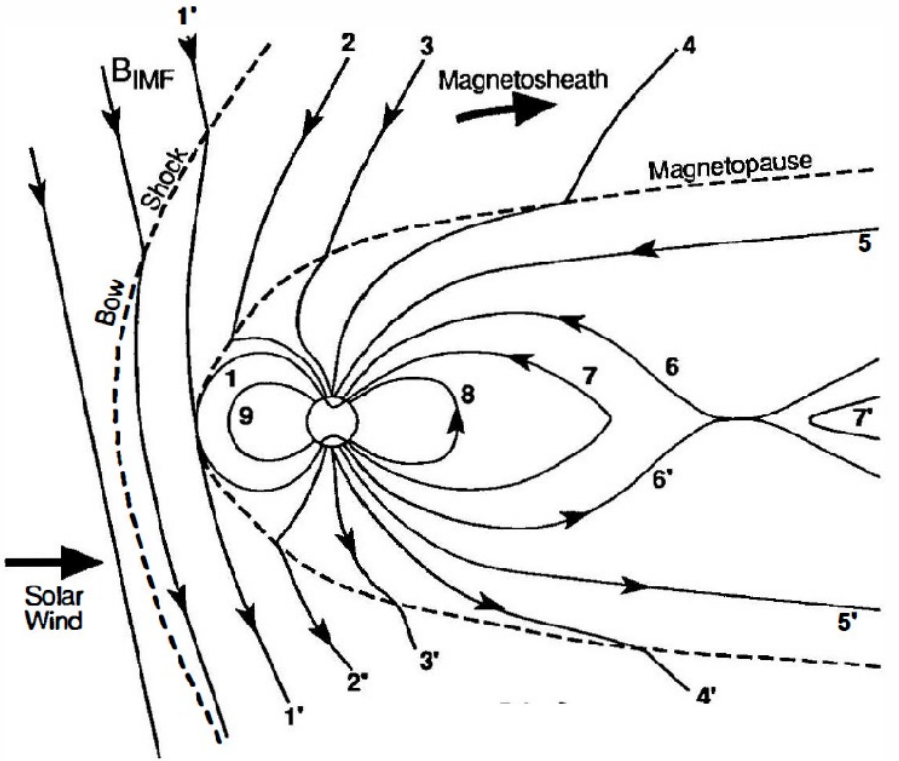


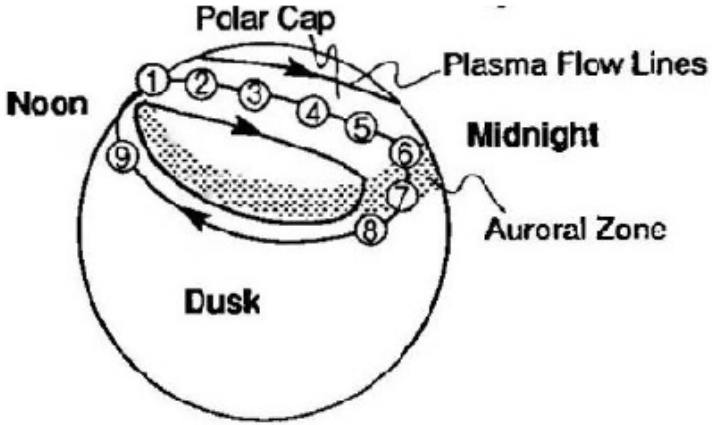
High-latitude ionosphere:

- Typically >60 deg. Latitude
- Regions of open and closed magnetic fields lines
- Open - allows ions and electrons to escape from the ionosphere via polar wind in the polar cap
- Closed - facilitates interhemispheric transport
- Auroral oval contains precipitating energetic electrons
- Widely changing conditions as ions drift into the different regions

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Convection



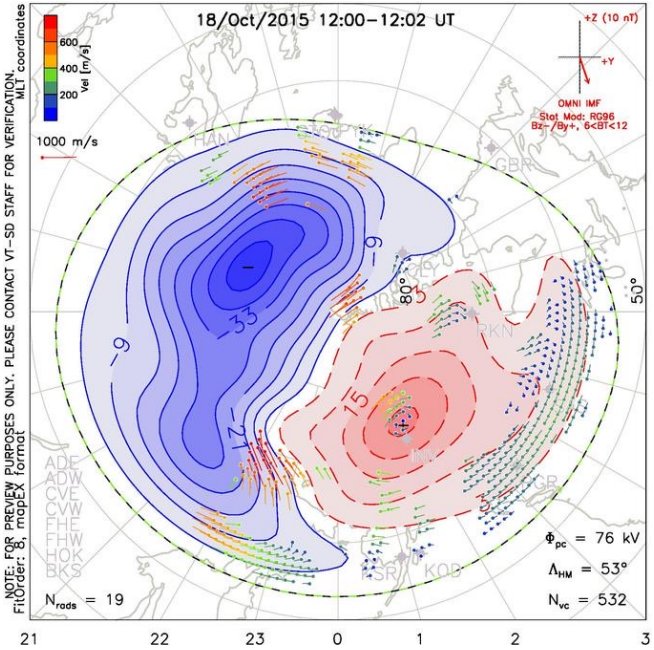


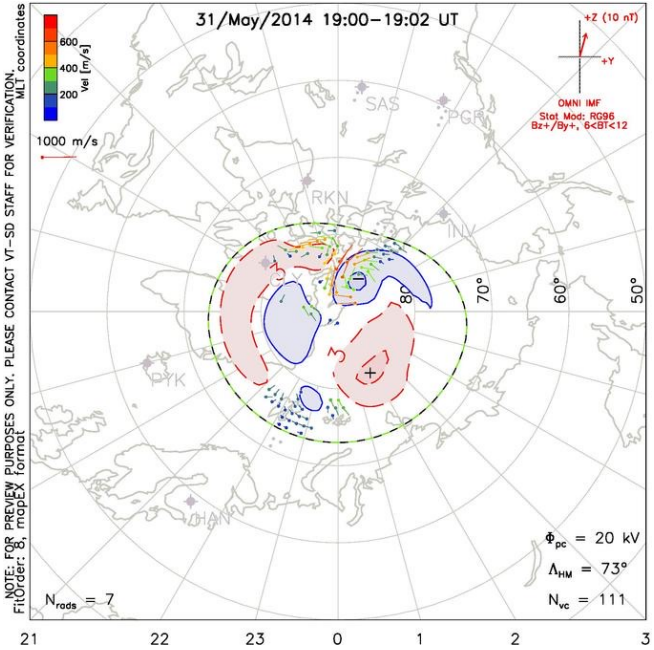
- Solar wind-magnetosphere interactions
- Two-cell plasma convection pattern
- Antisunward flow over the polar cap
- Return flow equatorward of the auroral oval
- This flow can reach speeds as high as 4 km/s

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Convection

Ionospheric convection pattern determined from SuperDARN radar observations





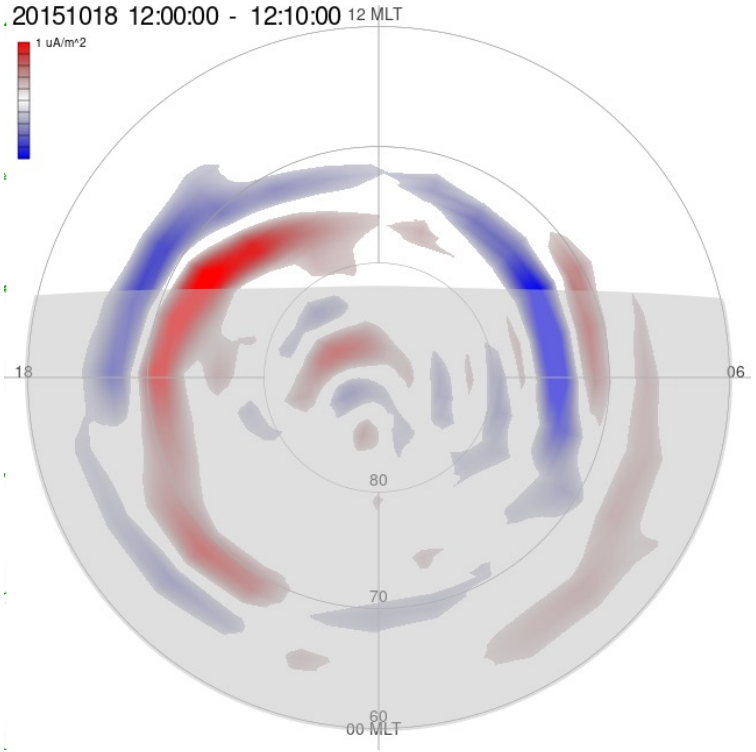
- Convection pattern isn't always neat and tidy
- Strength and expansion in latitude coverage depends on solar activity and IMF orientation

http://vt.superdarn.org/tiki-index.php?page=DaVIT+Map+Potential+Plot

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Field Aligned Currents

Ionospheric field aligned currents (FACs) from AMPERE measurements



Region 1 FAC – poleward
Region 2 FAC – equatorward

Return current – red
Downward current – blue

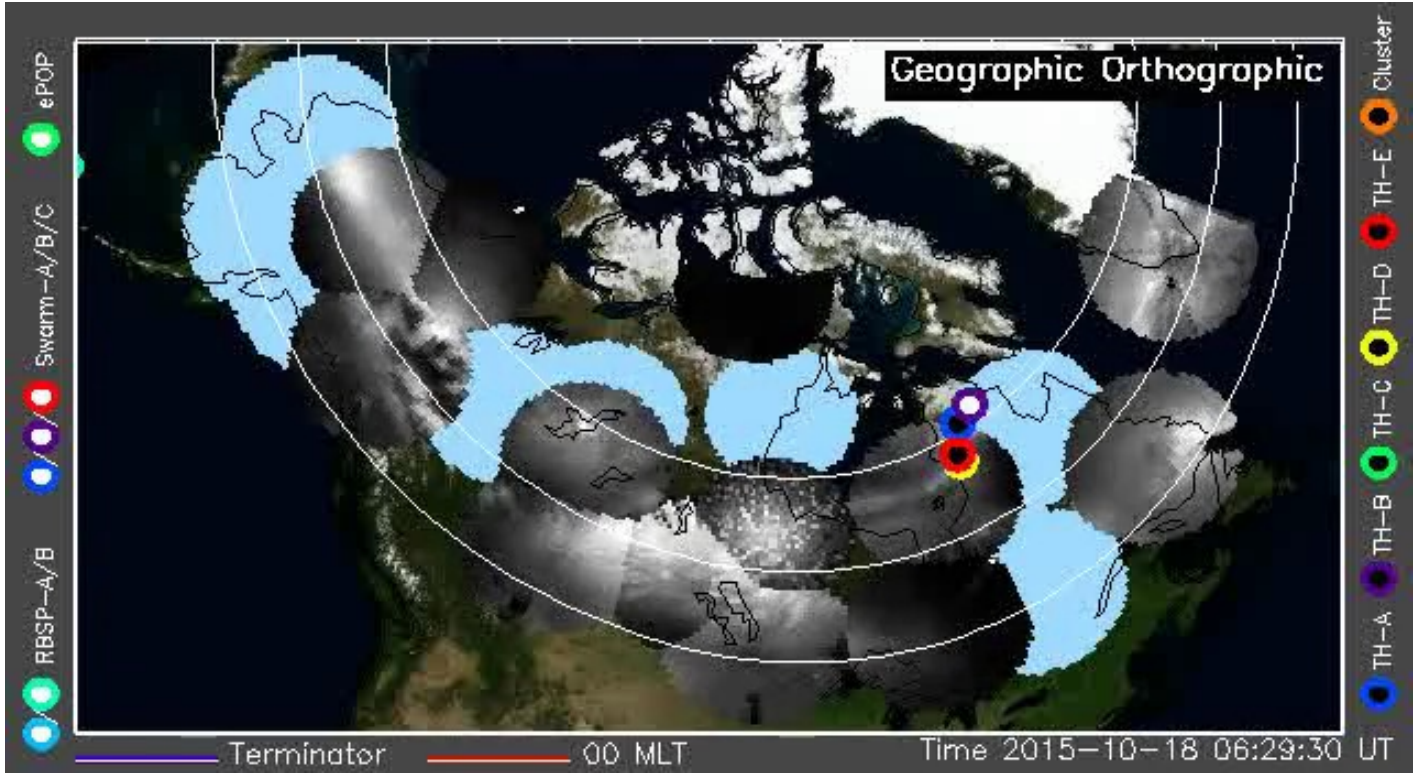
FACs close via Hall and Pedersen currents which are dependent on local densities

https://ampere.jhuapl.edu/products/

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Aurora

Aurora as seen from THEMIS All Sky Imagers



Auroral precipitation ionizes the atmosphere increasing ion densities

Increased ion densities = increased conductivity which influences how and where FACs close

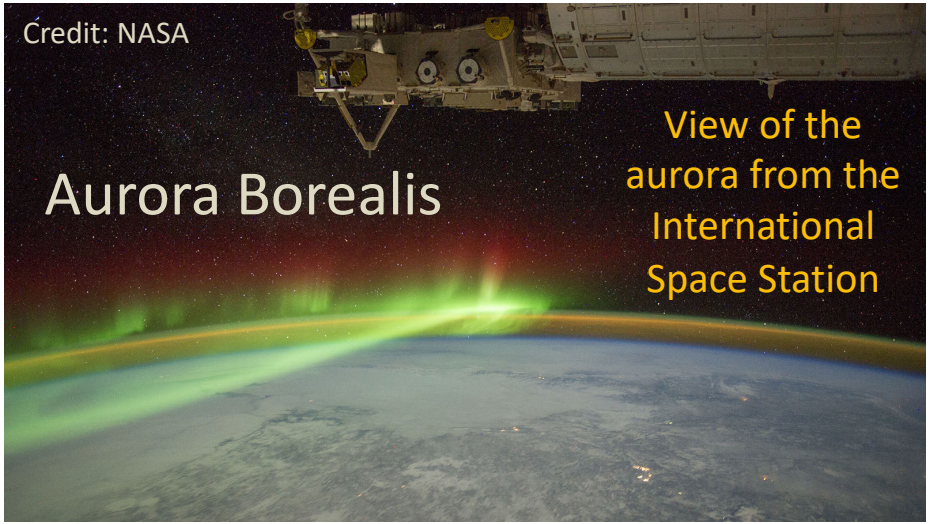
Auroral features indicate what the magnetosphere is doing

Convection, currents, and cool aurora are all interconnected at high-latitudes

https://data-portal.phys.ucalgary.ca/archive/themis/mosaic_movies

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Aurora



U.S. NAVAL RESEARCH LABORATORY

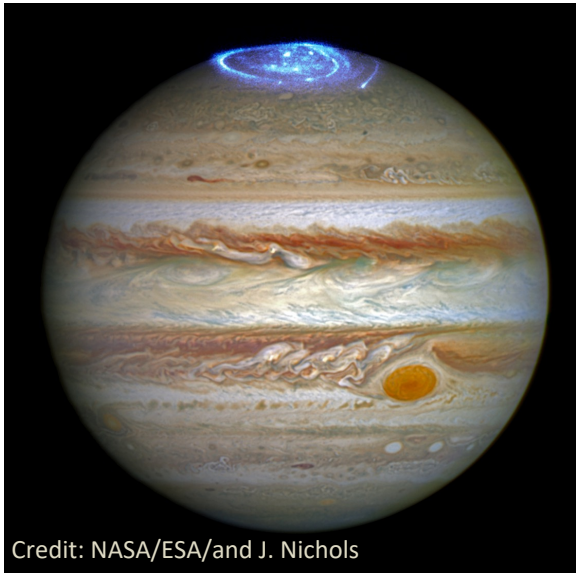
The high-latitude ionosphere: Aurora

- Field-aligned electric fields far above the ionosphere accelerate electrons
- 1–10 keV electrons
- Structured forms, including arcs, sheets, rays, etc.

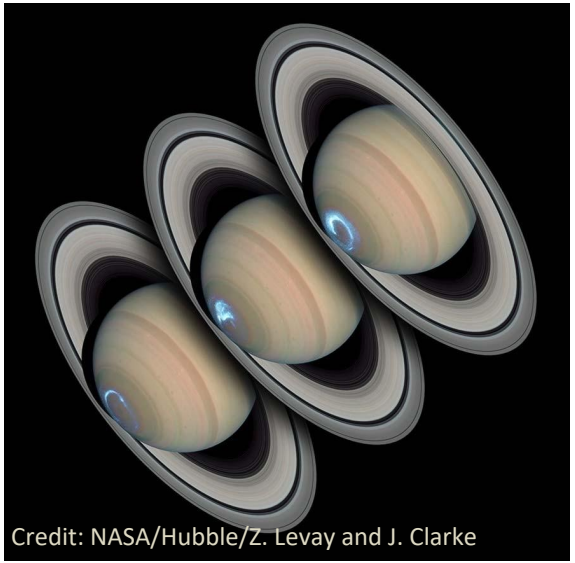
- Direct precipitation into loss cone through wave-particle interactions (i.e. whistler waves, electron cyclotron waves)
- > 10–100 keV electrons
- Very little structure

U.S. NAVAL RESEARCH LABORATORY

The high-latitude ionosphere: Aurora

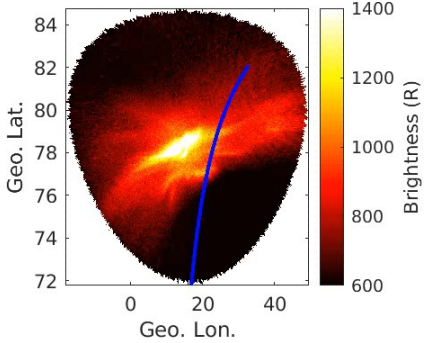


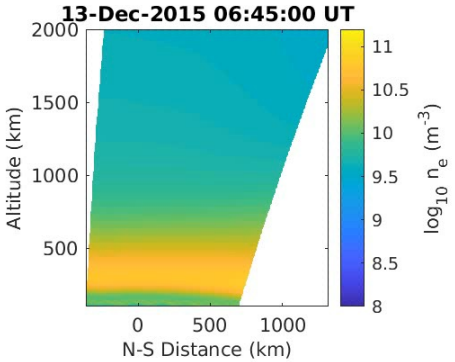
- Far-ultraviolet images from Hubble
- Aurora covers areas bigger than the Earth and hundreds of times more energetic
- Generated by solar wind and the moon Io

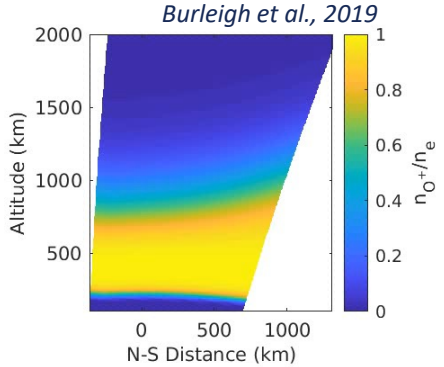


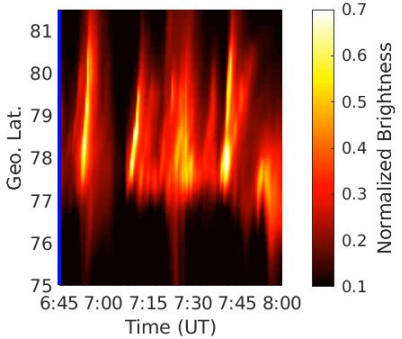
- Ultraviolet images from Hubble
- Day to day variability
- Excited hydrogen – pink, purple, red

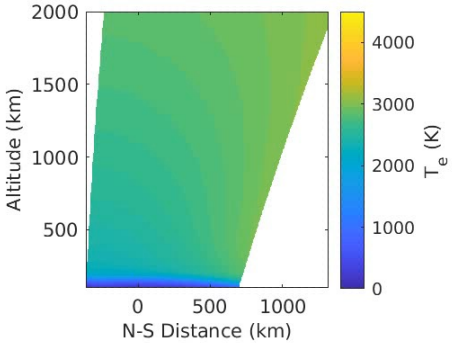
The high-latitude ionosphere: Dynamics

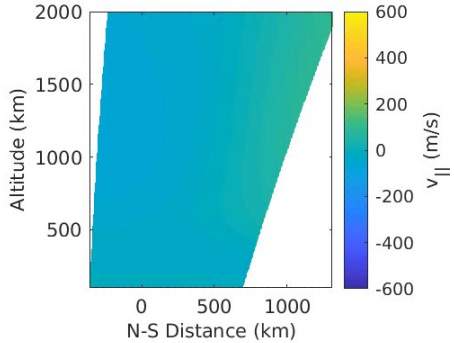












- Brightness keogram from along RENU2 rocket trajectory
- Small convection (not shown) so minimal frictional heating
- Soft precipitation from the discrete aurora elevates electron temperature
- Results in a stronger ambipolar electric field
- Which enhances the field-aligned upflow of plasma
- Cumulatively drives more O^+ to higher altitudes

Auroral motions, and changes in intensity, generate significant variability in the ionosphere

U.S. NAVAL RESEARCH LABORATORY

References, Data, and Photo Locations

https://www.nasa.gov/image-feature/aurora-australis-lights-up-the-sky
https://solarsystem.nasa.gov/news/1127/10-things-to-know-about-the-ionosphere/
https://www.nasa.gov/feature/goddard/2016/hubble-captures-vivid-auroras-in-jupiter-s-atmosphere
https://solarsystem.nasa.gov/resources/12369/saturns-auroras/
https://www.jpl.nasa.gov/images/pia17668-saturns-colorful-aurora
http://vt.superdarn.org/tiki-index.php?page=DaViT+Map+Potential+Plot
https://ampere.jhuapl.edu/products/
https://data-portal.phys.ucalgary.ca/archive/themis/mosaic_movies
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018GL081886