High Latitude and Polar Processes

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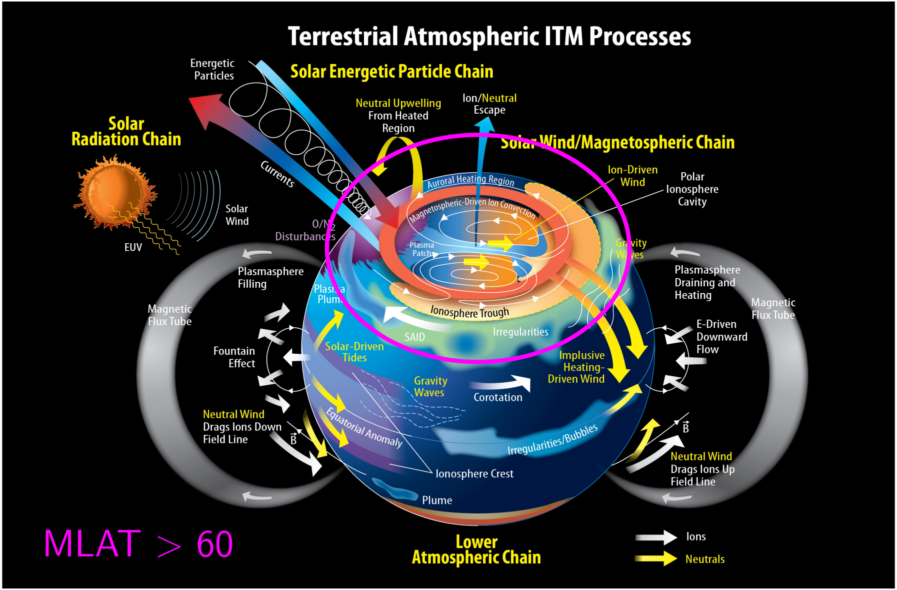
SRI International, Menlo Park, CA, USA

2022 CEDAR Workshop Student Day
Austin, TX
June 19, 2022

High Latitude Environment

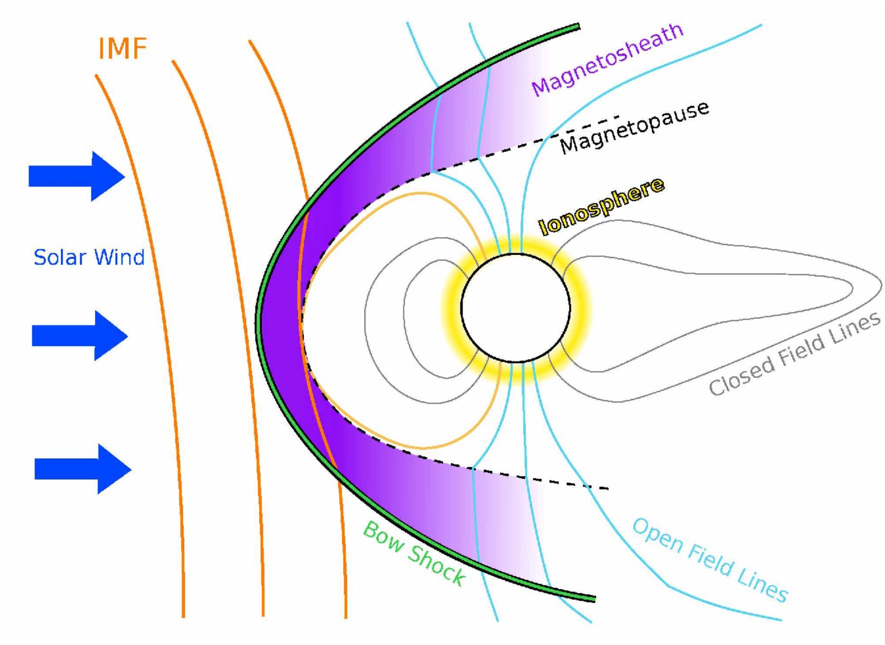


MLAT > 60

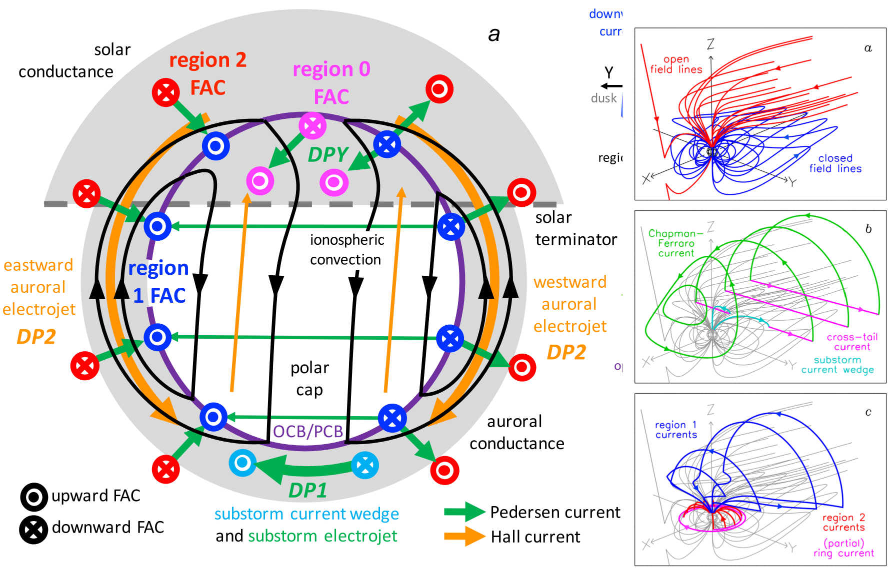
Overview

- Connection between the solar wind, magnetosphere, and ionosphere
- Major High Latitude Regions
  - Auroral Zone
  - Cusp
  - Polar Cap
- Common Phenomena
  - Auroral Arcs
  - Flow Chanels
  - Polar Cap Patches
- Plasma Instability Physics

Solar Terrestrial Environment

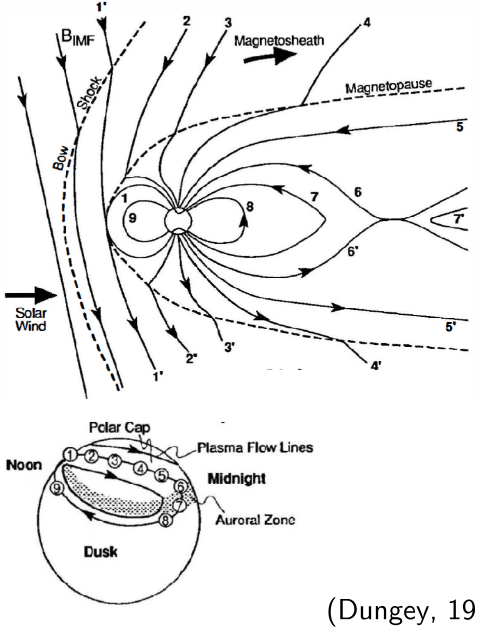


Magnetosphere-Ionosphere Current Systems

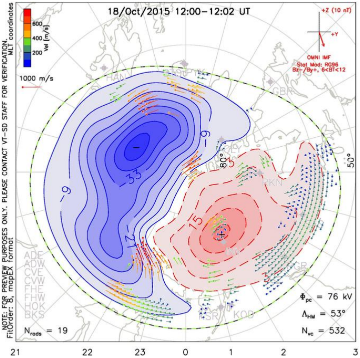


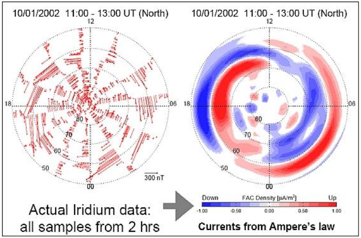
(Milan et al., 2017)

Dungey Cycle



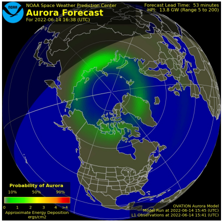
(Dungey, 1961)

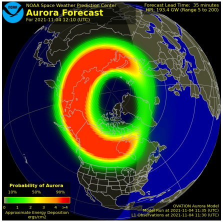




Auroral Zone

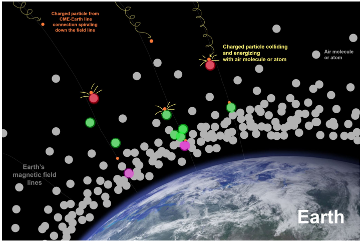
- Characterized by aurora and energetic particle precipitation
- Typically between 60–70 MLAT
- Expands and contracts based on magnetosphere/solar wind behavior
- Auroral zone in the ionosphere connects to plasmasheet in the magnetosphere
- Auroral features are the “footprint” of many complex magnetospheric processes

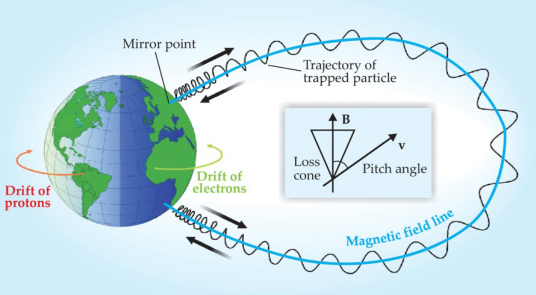


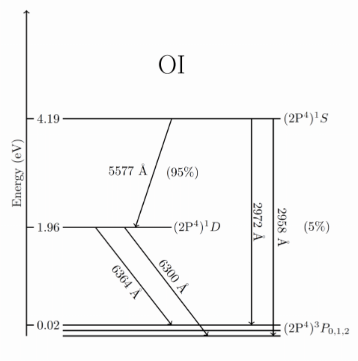


Auroral Emission Process

1. Solar wind particles become trapped in the magnetosphere
2. Particles are scattered/accelerated and escape magnetic mirror
3. Energetic particles collide with particles in the upper Atmosphere
4. Excited particles produce specific emissions



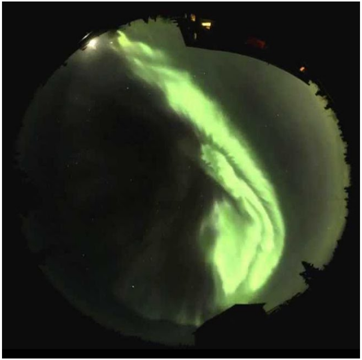




Types of Aurora

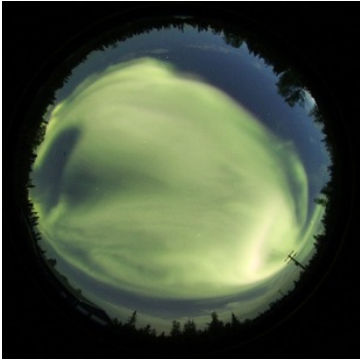
Discrete Aurora

- Magnetic field-aligned electric fields accelerate electrons far above the ionosphere
- 1–10 keV electrons
- Structured forms, including arcs, sheets, rayed forms



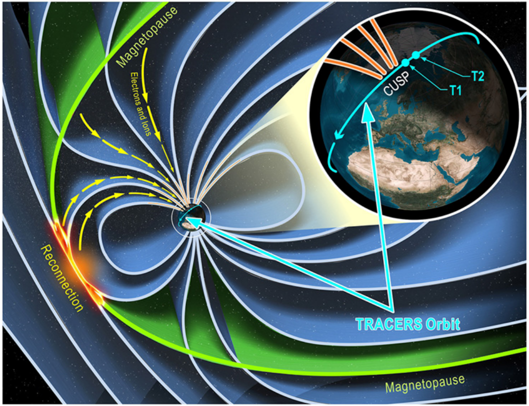
Diffuse Aurora

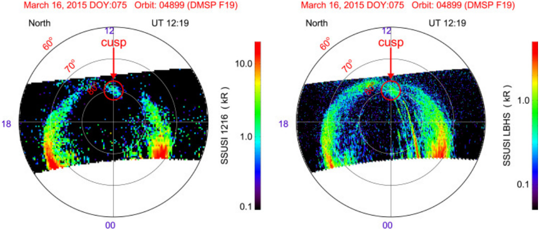
- Direct precipitation into loss cone through wave-particle interactions (i.e. whistler waves, elctron cyclotron waves)
- $>$ 10–100 keV electrons
- Very little structure



Cusp

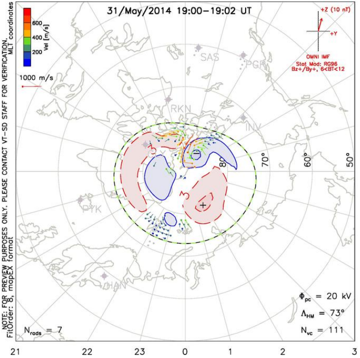
- Connected to the reconnection region between the Earth's magnetosphere and the IMF at the magnetopause
- Very small region (couple of degrees in MLON/MLAT) on dayside near auroral oval
- Characterized by strong precipitation and flow channels, which give important information about magnetic reconnection

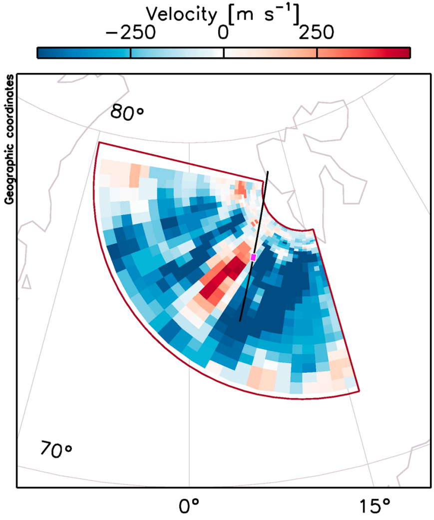




Flow Channels

- Flow shears or Reverse Flow Events (RFE)
- Cusp phenomena associated with flux transfer events
- Certain convection patterns also support fast flow channels

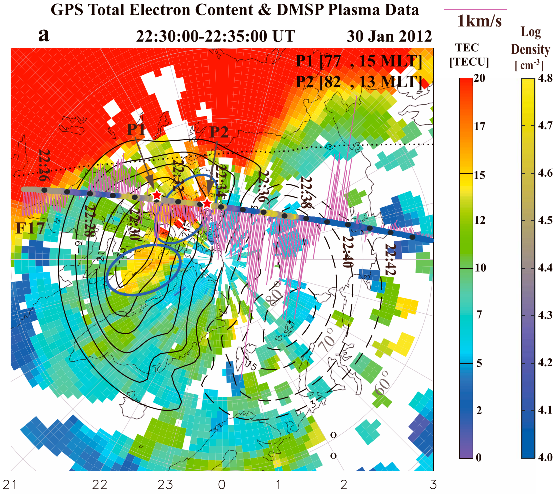




(Spicher et al., 2016)

Polar Cap

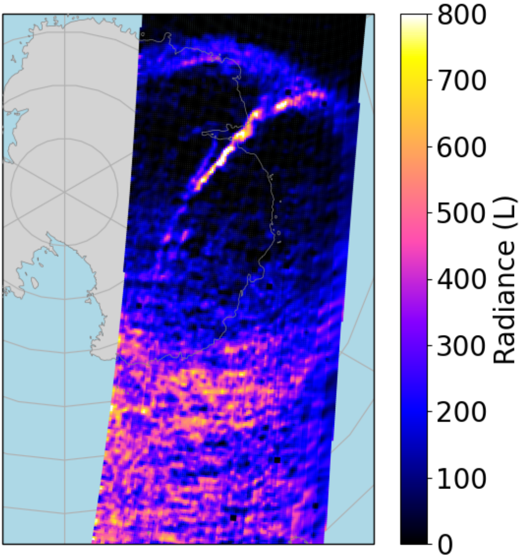
- Region of open magnetic field lines where the magetic field is connected directly to the IMF and can be traced back to the sun
- Generally > 75 MLAT, but expands/contracts following auroral oval
- Frozen-in plasma follows convection pattern driven by the Dungy cycle



(Zhang et al., 2017)

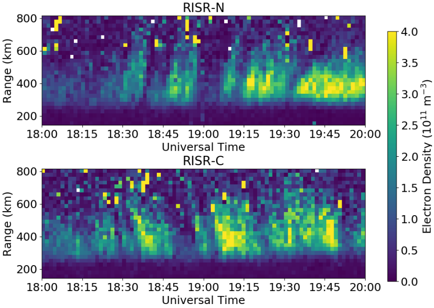
Polar Cap Auroral Arcs

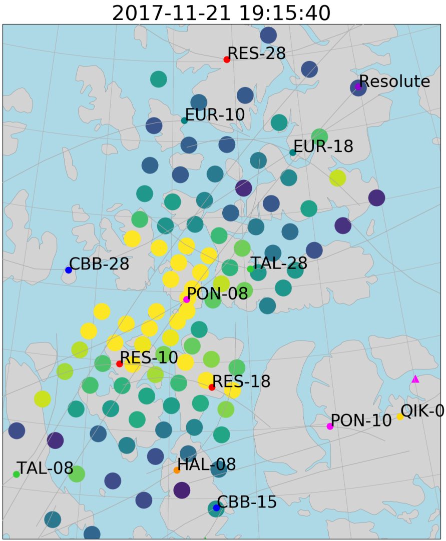
- Discrete auroral forms in the polar cap (Zhu et al., 1997)
- Sun-aligned arcs, transpolar arcs, polar cap arcs, horse-collar aurora, theta aurora
- Energetic particles deposit energy in the atmosphere, resulting in both emissions and enhanced plasma density at low altitudes
- Often associated with northwards IMF and/or fast flows



Polar Cap Patches

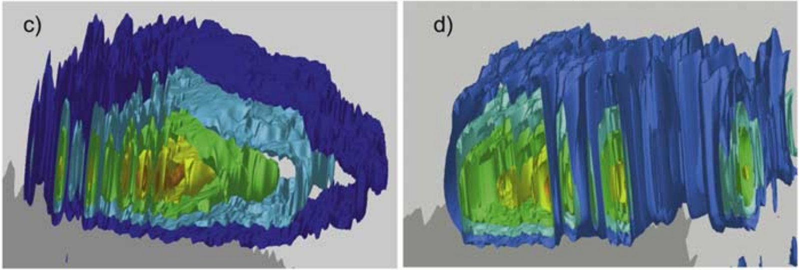
- Plasma density enhancements 100s-1000s km across (Weber et al., 1984)
- Move across the polar cap with the background plasma convection





Plasma Instability Physics

- Gradients in plasma density, velocity, temperature, or pressure can be unstable and lead to smaller scale structures (Tsunoda, 1988)
- Cascade of plasma structures from large to small scales is important to understand cross-scale coupling
- Some instability mechanisms in the linear regime can be studied analytically by deriving growth rates from plasma dispersion relations, but most quickly become highly nonlinear and require sophisticated numerical models (Gondarenko and Guzar, 2004; Zettergren and Semeter, 2012)



Funding Acknowledgments and References

- NSF Grant AGS-1452191
- NASA Grant 80NSSC21K0458 (H-ECIP)
- NASA Grant 80NSSC21K1354 (LWS)
- NASA Grant 80NSSC21K1318 (LWS)

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