2024 Workshop: What is a Patch?

Long title
Plasma Structuring in the Polar Cap - Definition, Generation Mechanisms, and Properties of Polar Cap Patches
Conveners
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Description

Polar cap patches (or just "patches") have been ubiquitous in discussions of dynamics and structuring in the polar cap for decades. These have traditionally been defined as F-region plasma density enhancements that are at least double the background density, often with the assumption that these are structures on scales of ~100 km. Recently, there has been a significant amount of debate over whether this traditional definition is accurate, or even if it is appropriate to consider all "patches" one single phenomena. There are a number of processes that could cause localized plasma density enhancements, including but not limited to soft precipitation, waves like Traveling Ionospheric Disturbances (TIDs), and Tongues of Ionization (TOIs). It is possible that many of these "other" phenomena have been routinely misidentified as patches in the polar cap. There is further debate about the extent to which observational biases (i.e., under-resolving or limited viewing geometries) impact how we describe patches. These plasma structures are important as they are known to be connected to a variety of physical processes, such as trailing-edge gradient drift instability that drives small-scale structuring or off-great-circle HF propagation.

This session welcomes open discussion of the questions “What is a patch?” from a variety of modeling, theory, and observational perspectives. This includes both debate over the technical definition of patches, as well as details about their generation mechanisms and properties, as it is likely these will be integral to describing the phenomena. The session will consist of several talks to give background on the issue and an extended discussion period. We welcome submitted presentations with specific results that contribute to the discussion of what is (or is not) a patch in the polar cap, but encourage authors to reach out to conveners early with their topics as there will be a concerted effort to keep the session focused. Students and early-career researchers are highly encouraged to participate in this session as changing consensus will impact how the polar cap is viewed and studied in the future.

Agenda

13:30 : Introduction/Welcome - Lindsay Goodwin

13:40 : Background on Patch Observations - Toshi Nishimura/Shasha Zou

13:55 : Topical Presentations

- Katrina Bossert
- Shunrong Zhang
- Roger Varney
- Kasia Beser

14:30 : Open Discussion

1. Properties of Patches
    - What are the properties of patches (e.g., generation mechanism, propagation and decay patterns)?
    - How are these distinct from other density enhancements in the polar cap?
2. Definition of Patches
    - How should we define polar cap patches?

    - What is the density threshold to define a patch?
    - How are the background density level and edges determined?
    - How are density enhancements in the oval, polar cap arcs, and TIDs excluded?
3. Impact of Patches
    - How do patches as observed from different modalities (e.g. ISR, TEC, in-situ, ASI and SuperDARN) compare to each other?
    - What are the impacts of patches in the M-I-T system?
    - What are the space weather effects of patches? What is their societal impact?

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Justification

Descriptions of polar cap patches have percolated high-latitude literature for 75 years. However there has recently been debate over whether the terminology, or even the idea of patches as an unique and unambiguous phenomena, is appropriate. Effectively, it is unclear the extent to which the term “patch” has been used to describe potentially unrelated phenomena (convoluting processes that occur within, above, and below the ionosphere), or traditionally discrete phenomena. For instance, an argument could be made that many plasma structures that would typically be described as patches could be more similar to wave-like structures, such as TIDs. Similarly, there is debate as to the extent that patches and TOIs are actually independent phenomena vs the same thing observed with different techniques or at different stages in its life cycle. This session aims to bring together experts not only in polar cap structuring, but also waves and other high-latitude phenomena to see

evidence of similarities and differences in different identified structuring in the polar cap and come to some consensus about whether or not present categorization makes physical sense, or if it should be reconsidered.

Summary

This session was focused around plasma structuring in the polar cap, specifically things that could be identified (either intentionally or not) as polar cap patches. In recent years there has been debate about whether the traditional definition of polar cap patches is adequate, or even if thinking about these structures as a single phenomenon is scientifically helpful. There were several presentations that introduced the issue and showed recent results and observations, as well as extensive discussion. The following summarizes some of the most significant points.

- There are many phenomena that could generate a density enhancement over twice the background (the traditional definition for polar cap patch).
- Different studies have all used slightly different variations on this definition, which creates some ambiguity of what exactly is being studied.
- Different instruments/observation modalities may require different definitions.
- More attention should be paid to neutral and wave-like activity (ie, are there gravity waves or TIDs in the polar cap that are traditionally not considered and may be misidentified as patches).
- Modern numerical models currently have not been able to produce distinct, cross-track elongated patches.
- The details of high resolution convection patterns may be critical to understand how patches separate and evolve in time.
- An operational definition for patches that only identify the largest density enhancements that are likely to cause significant scintillation and off-great-circle HF propagation may be useful for some applications.
- The threshold between “patch” and “not a patch” (traditionally twice the background) is challenging to justify physically and adjusting it may be appropriate in some cases.

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Keywords
polar cap, patches, mesoscale, plasma density structures

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