2014 Workshop: The Dynamic Polar Cap

Long title
The Dynamic Polar Cap
Conveners
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Description

Observations of polar cap outflows, polar cap patches, and Joule heating of ions and neutrals within the polar cap during magnetic storms have been reported and modeled. This workshop solicits short presentations on these and other polar cap phenomena with the overall goal of placing them into a unified framework of high-latitude dynamics. We encourage papers on observations from ground and space, models and theory. A round-table discussion will follow the presentations.

Agenda

Cusp:

Yvonne Dåbakk (University of Oslo) - Evaluation of possible generation mechanisms for Reversed Flow Events in the polar cusp Ionosphere. (pdf)

Cheng Sheng (UTA) – Correlation between Poynting flux and soft electron precipitation around the cusp region. (pdf)

Active Polar Cap:

Yanshi Huang (COSMIAC/UNM) - DMSP measured Poynting Flux during magnetic storms. (pdf)

Cheryl Huang (AFRL) - Polar cap heating during magnetic storms. (pdf)

Polar Cap Patches, Meso-scale flow channels and TOI:

Christer van der Meeren (Bergen) – GPS scintillation and irregularities at the front of a tongue of ionization in the nightside polar ionosphere over Svalbard. (pdf)

Cesar Valladares (Boston College) – polar cap patches, observations from Greenland. (pdf)

Michael Ruohoniemi (Virginia Tech) – polar cap patches on global scales with SuperDARN radars and GPS/TEC. (pdf)

Jeff Spaleta (University of Alaska, Fairbanks) – polar cap patches, McMurdo SuperDARN radar observations. (pdf)

Boyi Wang (UCLA) - Dayside connection of polar cap patches to PMAFs and intense meso-scale flow channels. (pdf)

Ying Zou (UCLA) - Mapping of meso-scale polar cap flow channels using a combination of radar flow observations and optical observations of patches. (pdf)

Round Table Discussion

Justification

The polar cap has historically been overlooked in studies of high-latitude dynamics which have traditionally focused on the nightside auroral zones. However, there is a growing body of evidence that places the polar cap as central to ion-neutral coupling, particularly during magnetic storms. Examples include direct observations of anomalously high neutral densities, electromagnetic energy input, and Joule heating in the polar cap. This topic is directly linked to the CEDAR Strategic Thrusts 1 and 2, and Scientific Goal #2 of the National Academy of Sciences Decadal Survey summary report.

Summary

The Dynamic Polar Cap workshop consisted of 10 presentations and was well attended, with between 30-50 attendees. The talks generated lively discussion and comment.

Yvonne Dåbakk (U. Oslo) presented observations made with the EISCAT radar at Svalbard of reversed flow events (RFEs). These occur about 16% of the time in the dataset, last an average of 19 minutes and are 100-200 km wide, and longer than the field of view (400-600 km). Flow within the RFE is in the direction opposite to magnetic tension imposed by IMF BY. During a sounding rocket flight, strong flows and plasma irregularities were detected. The RFEs represent velocity shears and backscatter, which lead to plasma irregularities and may be a mechanism for formation of polar cap patches.

Cheng Sheng (U. Texas at Arlington) presented correlated electron precipitation and Poynting flux observations from DMSP in and around the cusp during storm intervals. Using the cusp definition from Newell based on precipitating electron characteristics, they identified 24 cusp crossings. In half of these events, the cusp (as defined from electron precipitation) is co-located with the region of intense Poynting flux. In the other half, there is a separation between the cusp and the region of large Poynting flux which can be as large as 1^0 in magnetic latitude.

Yanshi Huang (U. New Mexico) presented observations of Poynting flux measured by DMSP during magnetic storms. In the storm in August 2011, Poynting flux clearly peaks inside the polar cap. This is not captured in widely-used models. The polar cap is defined as the region of anti-sunward flow. Using this definition, the Poynting flux measured in the Southern hemisphere maximizes inside the polar cap, poleward of 75^0 MLat at nightside local times during the August 2011 storm. Similar results were obtained for a storm in September 2011. Integrating the Poynting flux into regions poleward and equatorward of the convection reversal boundaries (CRBs) showed that at times the Poynting flux polewards of the CRBs is dominant.

Cheryl Huang (AFRL) presented observations of plasma temperature (Ti) measured by DMSP during selected magnetic storms. Motivation for the study is evidence of Joule heating of neutrals inside the polar cap from observations made by CHAMP, GRACE and GOCE. As primary energy input is electromagnetic, there must be transfer of Joule heat from ions to neutrals to account for heated neutrals. In five storms, Ti measured by DMSP was observed to increase mainly in the polar cap, suggesting that IT coupling and energy dissipation occurs at polar latitudes during storms.

Christer van der Meeren (U. Bergen) presented observations of GPS scintillation and plasma irregularities associated with a Tongue of Ionization (TOI) over Svalbard in October 2011. Phase scintillation was reported at the leading edge of the TOI, no significant amplitude scintillation, and no scintillation after the gradient. Comment by Gary Bust: the phase scintillation does not imply plasma irregularities, but may be due to the gradient itself. Further, the scale size may be related to the drift of the TOI and not to the size of the irregularity.

Cesar Valladares (Boston College) reported on TEC from a network of 55 GPS receivers in the polar cap. These can be correlated with all-sky imagers at Qaanaaq in the center of the polar cap to trace polar cap patches back to the time they cross the open-closed field line boundary. Results were presented for periods on 16 December 2009 and 20 November 2003.

Michael Ruohoniemi presented coordinated measurements from GPS, SuperDARN and 630nm all-sky imagers of polar cap patches during a moderate magnetic storm on 22 January 2012. Imagers at Resolute Bay (RSB) and Longyearbyen (LYR) provided images of 630nm; radar observations from Inuvik and CUTLASS were used to provide overlapping coverage, and GPS TEC in 1^{0} x 1^{0} cells at 5 minutes were used in this study. The GPS TEC and 630 nm airglow which are often used as proxies for F region electron densities are in good spatial agreement. The imagers show fine structure of patches at 2 km and 4 km resolution. HF backscatter from radar correlate with the airglow images, showing structure on scales of tens of kilometers.

Jeff Spaleta (U. Alaska) presented observations of plasma density structures in the polar cap using the McMurdo SuperDARN radar. They have developed a new technique to extract plasma densities from SuperDARN autocorrelation function phase data. The technique requires dual frequency operation and a new algorithm used in analysis. They demonstrate results of this analysis for patches on 6 September 2013 which compare well with GPS TEC measurements.

Boyi Wang (UCLA) presented coordinated measurements of dayside polar cap flows using all-sky imagers and DMSP data. The polar cap flows/patches penetrate into the polar cap. Examples were shown of patches which occurred near the dawnside on 4 May 2011, 15 April 2008. Flows were detected of comparable width to the patch width of 390 km, with average flow speeds of 776 m/s against a background flow speed of 100 m/s.

Ying Zou (UCLA) presented observations of localized flow enhancements over the polar cap. The airglow patches associated with localized polar cap flow enhancements have comparable widths and speeds. Using the criterion that the flow enhancement be > 200 m/s above background, and > 10 minutes in duration, a database of 93 patches which occurred during January-March and October

–December of 2008-2012. 67% of the patches has localized flow enhancements. These were most likely associated with IMF BY. The cross polar cap potential associated with the flow enhancements can account for 10 – 40% of the total cross polar cap potential.

Discussion: There was discussion both after each presentation and after all presentations were over. Patrick Newell objected to the characterization of the polar cap as the region of anti-sunward flow, as plasma in the low-latitude boundary layer which is partially on closed field lines, flows antisunward. Cheryl Huang replied that the results which were described as being in the polar cap were generally well poleward of the convection reversal boundary, and were unlikely to be LLBL events.

Gang Lu thought that the conclusion that energy at high latitudes occurs in the polar cap 50% of the time not generally true. This should be reworded to say that energy entering the high latitude IT system can occur at polar latitudes 50% of the time along the DMSP orbit.

A figure showing Sondrestrom radar data for a storm in August 2011 was shown, together with the results of Gary Bust’s IDA4D TEC map for the time period. In IDA4D, high density electron densities form a Tongue of Ionization (TOI) which moves from approximately 14 LT into the polar cap, stops near the pole, then disappears. The radar data for the period show high ion flux moving away from the Earth at this time, appearing to be an ion outflow from the pole. This observation was confirmed by DMSP measurements almost directly overhead. This result appears to be contrary to RISR observations reported in an earlier CEDAR workshop by Shasha Zou.

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