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ScienceDirect
Advances in Space Research 45 (2010) 39–44
ADVANCES IN SPACE RESEARCH (a COSPAR publication)
www.elsevier.com/locate/asr

Dynamics of the dayside Aurora Australis

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Received 24 December 2008; received in revised form 18 August 2009; accepted 19 August 2009

Abstract

Current dayside optical studies of Aurora Australis from the Amundsen-Scott Research Station at the South Pole (74 degrees magnetic latitude) show some striking differences from optical results reported from Svalbard. A 6-channel meridian scanning photometer operating during the past three austral winters shows, in particular, the 630 nm emission is much lower, on average, than the Arctic dayside aurora and very weak on some days. The 558 nm intensity is higher relative to 630 nm suggesting the incoming electrons have a higher average energy. There are notable differences in auroral forms, giving further evidence of asymmetries in the two dayside ovals.

Keywords: Aurora; Auroral conjugacy; Dayside; Optical aurora

1. Introduction

Optical studies of dayside Aurora Australis began at the South Pole in 1973 (see Eather et al., 1979; Eather, 1984, 1988) and they have been pursued intermittently since that time (see e.g. Rairden and Mende, 1989; Mende et al., 1998; Ebihara et al., 2007). At a magnetic latitude of 74 degrees, cusp aurora is often overhead, and within view nearly every day. That is perhaps the best accessible location in the world, from the standpoint of darkness and clarity of skies, for such optical studies. It has been recognized to be conjugate to the Aurora Borealis, from aircraft and satellite imagery, and extensive observations have been conducted to detect any differences in form or location (see e.g. Ostgaard et al., 2004; Sato et al., 2005).

Arctic dayside auroral studies have been much more extensive, with early ones from the Canadian Arctic (Shepherd et al., 1976; McEwen, 1985), and a continuous program since 1978 from Svalbard (Gilmer, 1981; Sandholt et al., 2002).

Comparisons of auroras occurring simultaneously in the two hemispheres can rarely be made directly (except in particular cases from two satellites) due to the opposite dark seasons. But with the extensive data from Svalbard from over two decades, it appeared possible to consider comparisons with a similar extensive body of optical observations from the South Pole.

We initiated a study in 2006 at the South Pole station, with a view to examining in detail the dynamics and morphology of dayside aurora, in comparison with, or contrast to, the similar studies from Svalbard over the past decades. Some results are reported here.

2. Instrumentation

We have operated a 6-channel meridian scanning photometer (MSP) at the Amundsen-Scott research station at the South Pole through the 2006 and 2007 Austral winters, and continuing through 2008. The emissions at 630, 589, 557.7, 486.1, 427.8 nm and a background region around 500 nm are monitored with a threshold sensitivity of around 5–10 R. The MSP scans approximately along the magnetic meridian at 108 degrees azimuth, repeating a 180 degree scan each 40 s. It has a one-degree field of view

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doi:10.1016/j.asr.2009.08.032

and steps one degree each 0.2 s. This instrument has had a long history of airglow and auroral measurements in the Arctic since 1980 (see e.g. McEwen, 1994) The MSP was upgraded and modified in 2005 and installed beneath a hemispheric dome on the roof of the Aeronomy laboratory near the South Pole station in January, 2006.

3. Results

The MSP has operated at the South Pole (Magnetic Latitude 74 degrees) since the Austral winter of 2006 (beginning about April 20 and ending about August 31 each year). For dayside aurora, the major emission is the OI 630 nm, and those intensities are examined here. The corresponding 558 intensities recorded in the scans give additional details of dynamical effects, and average energy of the incoming electrons. Some illustrative typical data are shown here.

Fig. 1 shows a MSP recording on May 23, 2007 which was a rather active day. The 630 nm emission intensities from 00 to 24 h UT are displayed in grey scale as a function of magnetic latitude. These have been converted from 0 to 180 degree elevation scans using an assumed emission height of 180 km, based on earlier comparisons between optical and polar satellite overpass particle data (Zhang et al., 2000). The dayside aurora can be seen through Magnetic Local Noon (15:30 UT) reaching a peak intensity of 1 kR.

ACE Interplanetary Magnetic Field (IMF) data show Bz and By both strongly negative (−15 nT) prior to 14 UT and the cusp aurora is located below 70 degrees magnetic latitude; then Bz and By both go strongly positive to +15 nT by 16 UT and the cusp aurora moves sharply poleward approaching 80 degrees. One can see in detail the dynamical nature of the dayside emissions through the mid-day. Many transient forms can be seen, mostly drifting or expanding poleward.

Fig. 2 shows a similar plot of auroral activity on June 2, 2008.This day was moderately active with the IMF Bz about +15 nT and the cusp is located around 78 degrees. There are major fluctuations in the dayside auroral forms with frequent transient poleward expansions. The maximum 630 nm intensity is again about 1 kR, as in the Fig. 1 illustration.

These two full day 630 nm records show the dayside aurora as viewed from beneath at the South Pole with the perspective of the whole 24-h oval. We will now focus on 11:00–17:00 UT (encompassing magnetic local noon at 15:30 UT), showing the dayside region in more detail.

Fig. 3 shows a dayside aurora on April 28, 2007, with the IMF Bz and By both about −5 nT. The cusp is stationary about 75 degrees latitude through the mid-day, with a peak 630 nm intensity of 600 R. Some enhanced transient forms are seen with an apparent poleward motion toward the afternoon sector.

Fig. 4 shows the cusp on May 24, 2007, with the IMF Bz oscillating between plus and minus 5 nT; By is negative

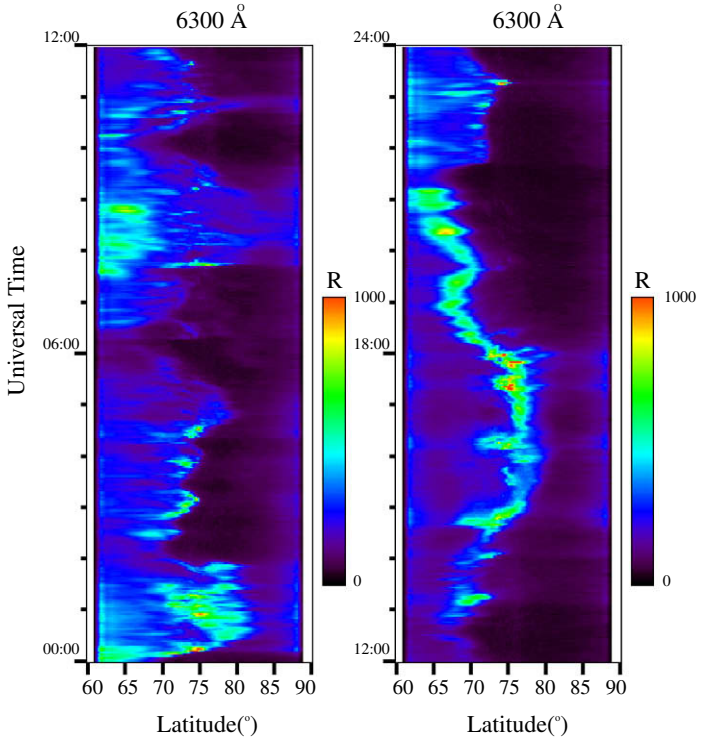

Fig. 1. The 630 nm OI auroral emissions recorded by the MSP at the South Pole on May 23, 2007 showing continuous aurora through all time sectors – a sequence of substorms expanding poleward through local magnetic midnight (03:30 UT), and very active dayside aurora (12–18 UT). Local magnetic noon is at 15:30 UT. Intensities are indicated by the grey scales on the right. The dayside aurora reached a peak intensity of 1 kR.