Lulea Technical University ,Department of Computer Science, Electrical and Space Engineering

E7017R Space Physics

PRACTICAL 1: AURORA BORIALIS

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1 Abstract

The aim of this work is to classify northern lights displays from two pictures according to their characteristics, and to investigate the methods of forecasting these displays. In section 2 the characteristics of the aurora is classified into five main groups: condition, structure, form, brightness index, and color. In section **??** the methods of aurora forecasting are discussed.

2 Polar Lights Classification

The polar lights are not the same and each one of them has a classification based on its characteristics. The first display under study is shown in fig. 1a, which is considered to be classified as qm3HA2c aurora. The reasons behind this classification are as follows: First, considering the form of the display, we can see a band-like form of the A (Arc) sub-category. The upper edge is diffuse, while the bottom is very sharp. The lower boundary can be seen as a curving arch extending through the entire sky without any irregularities. The qualifying symbol is consider to be m3 (Multiple 3). It is multiple because several parallel arcs can be seen crossing the entire panorama. These arcs are diffusing across the sky,and we can see three main arcs that are decreasing on luminosity. The display structure is consider as H (Homogeneous) because the internal structure is uniform. We don't see rays or stripes, the lower boundary is diffuse and several levels can be seen and it looks like the brightness is decreasing through the aurora.As we're just discussing a static picture, we don't have any idea about the dynamics of the display. Even though HA are usually quite. The brightness index is 2 because brightness could be compared with a slight moonlit not too shine but enough to be distinguish and at the same time some green color could be seen on thru the aurora. Finally, the color class is c because we see a slight part on green on the top of the aurora with mostly white in the middle of it and the bottom near the horizon is yellow.

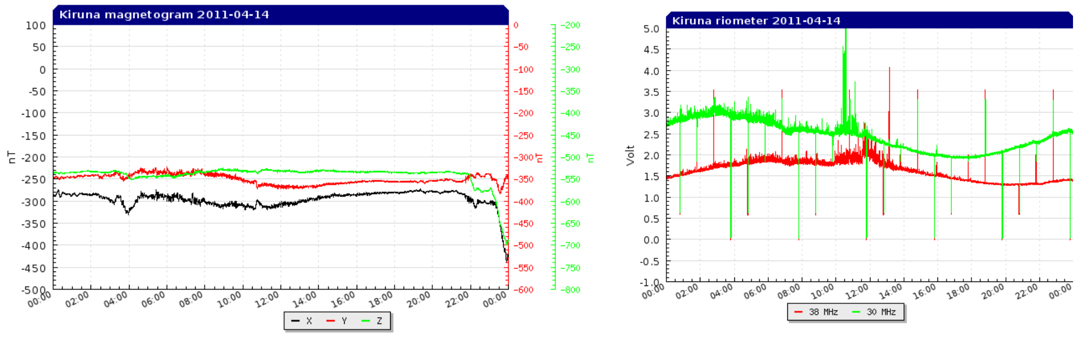
Figure 1. (a) Three parallel homogeneous arcs auroral display, (b) Rayed drapery aurora

The second display under study is shown in fig. 1b. We can see a red aurora with green emissions at the lower altitudes. It is considered as rayed drapery: $a_4 f R_2 B 3e$. The reasons behind this classification are discussed below.

We can see that the display is a highly rayed band where the rays are long. This long length of the rays make the display look like a gigantic drapery or a curtain. The lower border is not regular and the intensity of aurora varies with the altitude, where we have the peak intensity at the lower altitudes.Again we cannot judge the condition of the display from the static picture, however, band are frequently active. We can see the green color at the bottom of the display with some reddish rays at higher altitudes. It is comparable with a bright moonlit cumulus clouds.

3 Polar Light Forecasting

There is a correlation between the occurrence of auroral displays and various solar and geophysical phenomena. The displays correlate with the sun activity that affects the near Earth environment. The coupling is done through the solar wind and solar ejections that significantly affect the magnetosphere. With increased sun activity, the magnetosphere dynamics exhibits rapid changes and disturbances that leads to magnetic sub-storms. The interactions between the magnetosphere and the ionosphere leads to the auroral displays. Thus, the occurrence of the aurora can be related directly to several solar and magneto-spheric phenomena. As an example of solar dependence, we have higher probability to encounter aurora displays after 27



(a) Magnetometer readings

(b) Riometer readings

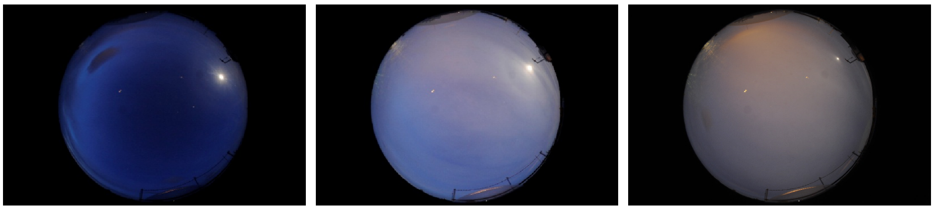
Figure 2. Weather data from the IRF-Kiruna observatory on April 14, 2011
http://www.irf.se/Observatory/?chosen=observatory

days from an active recorded display (period of sun rotation). This is related to the sun spots which are stable for several rotations. The sun spot number is an indication of the sun activity for long-term variation (indication of the 11 years solar cycle).

The first geophysical parameter that correlates with aurora displays is the disturbances in the geomagnetic field.The disturbances, which is a global phenomena, are observed on different places on Earth's surface using magnetometers. Magnetometers can track both absolute the short-term variations in the geomagnetic field at Earth's surface. Observation of disturbances in the magnetic field indicates an increased probability of an auroral display. The magnetic disturbance level is measured by the logarithmic planetary index K_p with a scale from 0 to 9 for increasing disturbance. The index is updated every 3 hours. The index a_p is also used, which is just the linear representation of K_p. The daily average of a_p is A_p.

The second geophysical parameter is the absorption of radio-noise from the stars in the ionosphere. A Riometer is used to track the noise level and observe any decrease relative to the quite-day level. Any relative decrease is an indication of high-energy charged particles penetrating the ionosphere increasing the ionization. Trying to catch aurora on February 14th, we took a look at the real-time data available from the observatory web page of the Swedish Institute of Space Physics in Kiruna. The magnetometer and riometer readings of that day are shown in figure fig. 2. As can be seen the situation was quite. The weather was good, and we tried to go out in a dark place trying to find if we can detect any aurora displays in the sky. But as was expected from the readings we didn't find any auroras that night. The magnetometers didn't detect any disturbances in the K_p, or in the ionoshpere cosmis-noise absorption. To verify that, we also reviewed the pictures taken by all-sky camera that night. See fig. 3

On February 21st, 2011, there were bright aurora displays. The observatory readings from that night are shown in fig. 4. We can see that the magnetometer readings detect disturbances

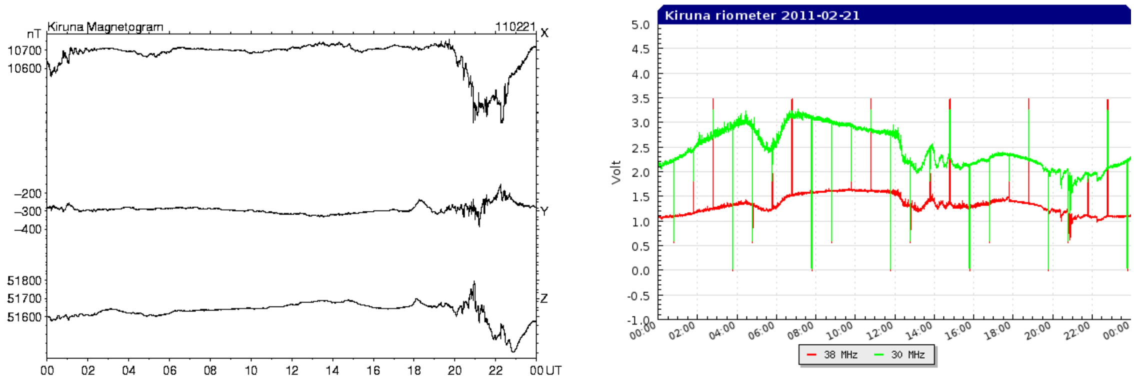


(a) 20:30 (b) 21:00 (c) 21:30

Figure 3. IRF-Kiruna All-sky camera pictures on April 14, 2011. Picture orientation: right is south geomagnetic pole (N magnetic polarity), and down is geomagnetic east

in the local K-indices around 20:30 which indicates activity in the dynamics of the magnetosphere structure. As described above, we have a correlation between the K_p disturbances and occurrence of aurora displays. The riometers readings also indicates increase in absorption of the cosmic-noise at the same time, which also correlates with aurora display events. To show this correlation, we compare this observations with the pictures taken by IRF-Kiruna's all-sky camera, fig. 5, in the period from 20:54 to 21:02 of February 14th, 2011, which we believe to be an indication of a geomagnetic substorm. The pictures are recorded each one minute, which is the best resolution available from the archive. As expected by the readings, the all-sky camera detected bright aurora displays during this period. Development of auroral substorm can be see in the pictures. First, we can see brghit quite arc moving equatorward (expansion of auroral oval) fig. 5a,b and c. From the magnetometer readings in fig. 4, the substorm onset is at 20:59 UT and is indicated by the sharp decrease in the northward (x) component of the magnetic field. This is also shown in the riometer data by the sharp increase in the absorption at 20:59 UT. This is indicated in fig. 5f, where we see aurora over entire sky and from the picture sequence indicate rapid movements of the display. In the last three pictures, we see rapid poleward motion in high intensity arcs, which then starts to be more diffuse.

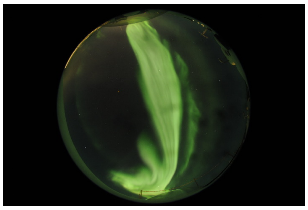
4 Conclusion



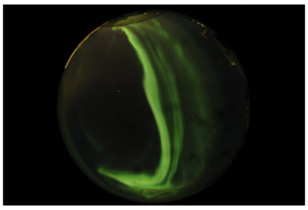
(a) Magnetometer readings

(b) Riometer readings

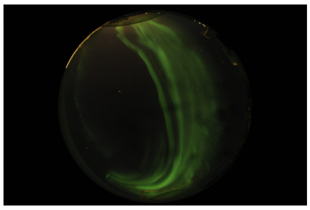
Figure 4. Weather data from the IRF-Kiruna observatory on Feb 21st, 2011
http://www.irf.se/Observatory/?chosen=observatory



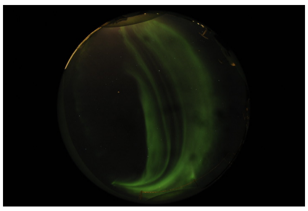
(a) 20:54



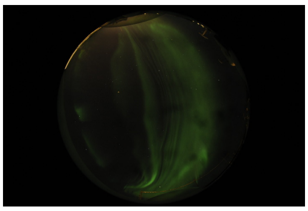
(b) 20:55



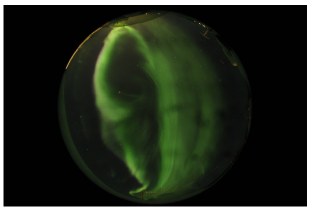
(c) 20:56



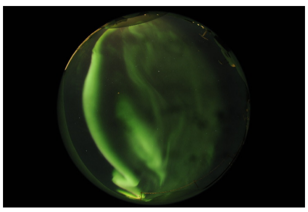
(d) 20:57



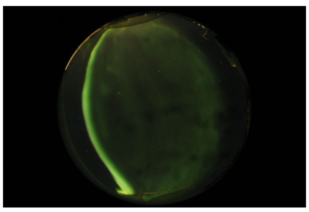
(e) 20:58



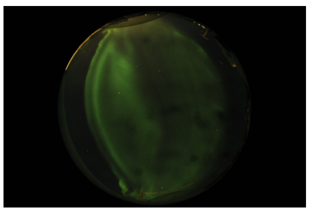
(f) 20:59



(g) 21:00



(h) 21:01



(i) 21:02

Figure 5. Aurora displays recorded by ALIS on February 21st, 2011. Picture orientation: right is south geomagnetic pole (N magnetic polarity), and down is geomagnetic east