Dayside auroral precipitation

Introduction

The dayside auroral precipitation consist of magnetosheath related boundary layer precipitation, and plasma sheet related BPS/CPS precipitation (extensions of the nightside precipitation regions). The boundary layer and BPS precipitation regions form the so-called **dayside zone of soft precipitation**. The general softness of the high-latitude dayside precipitation means that the prevailing emission line is 630.0 nm (red).

It is important to note that, although the low-altitude ionization and visible auroral emissions are created mainly by precipitating electrons, these signatures are not useful in identification of the different plasma regions around the dayside cusp. For example, the much lower fluxes from the LLBL region when compared to the cusp are compensated by the bidirectional electron beams found in the LLBL: the precipitating energy fluxes in the LLBL and the cusp are not that different. Measuring the precipitating electron fluxes directly is more useful, but even that suffers from the variability of the electron signatures. Thus, **it is mainly the low energy ion (mostly proton) fluxes that are used in defining the different source regions**.

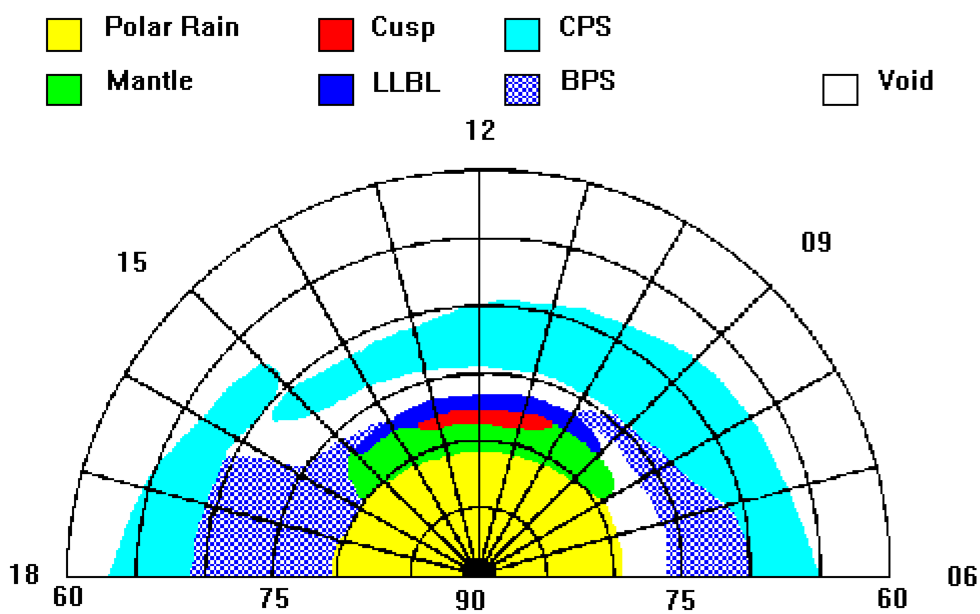
The use of higher energy particles as tracers for different regions is somewhat problematic, for a number of reasons. First of all, it seems that the plasma from the magnetosphere is able to escape into the magnetosheath quite easily. Because of this one can see magnetospheric particles also in the cusp region. Secondly, the interaction of both magnetosheath and plasma sheet ions with the magnetopause current layer is most likely important. It leads to the violation of the first adiabatic invariant, and thus to pitch angle scattering and acceleration of ions.

Note that we won't discuss the very high latitude polar cap precipitation, i.e., polar rain, here.

Low-altitude observations

Using the 32 eV - 30 keV particle characteristics from low-altitude (about 830 km) DMSP satellites, the dayside precipitation has been summarized like this:

1. Magnetosheathlike boundary layer precipitation
   - directly through the cusp and plasma mantle
   - indirectly along low-latitude boundary layer (LLBL) field lines
2. Plasma sheet precipitation
   - extension of the nightside BPS/CPS precipitation to the dayside
   - dayside BPS is stronger on the afternoon sector, and CPS on the morning sector



Dayside auroral distribution according to the precipitating plasma parameters: 'less than reality, but more than a cartoon' (from Newell and Meng, GRL 19, 609-612, 1992)

Note that, in this scheme, names for the low-altitude boundary layer regions (cusp, mantle, and LLBL) refer directly to the corresponding magnetospheric region:

- there is no need for a separate 'cusp proper' definition, since the cusp is thought to map directly to the exterior cusp
- the magnetospheric boundary layer called the 'entry layer' is not needed
- the term cleft (low-altitude LLBL) is not used

The LLBL is distinguished from cusp by higher average particle energies, while the mantle region is recognized by lower energies when compared with the cusp. The cusp itself is showing the most magnetosheathlike plasma characteristics (according to its definition). The following figure displays ion spectra from the low-altitude LLBL region, and compares it with in situ measurements of high-altitude magnetosheath, LLBL, and plasma sheet spectra. Although the measurements are not simultaneous, it is evident that **1)** the LLBL ions are heated with respect to the magnetosheath ions also at high-altitudes, and that **2)** the LLBL ion spectra measured at high- and low-altitudes are in good agreement.

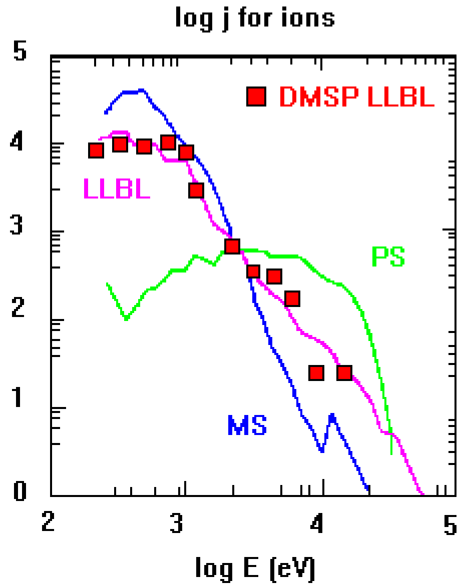


Figure: Direct comparison of high- and low-altitude LLBL ion spectra (red dots and line, respectively; from Newell et al., GRL 96, 21013-21023, 1991).

The LLBL has also few times smaller ion densities than the cusp, and the mantle even smaller than that. However, the densities can vary dramatically with solar wind density, making the average energy more reliable indicator for different regions.

One important feature seen in the precipitation distribution is the **wide longitudinal extent of the mantle precipitation region**. The scheme for the formation of the high-altitude plasma mantle due to direct plasma entry from the cusp cannot explain this. According to it, only the region directly poleward of the cusp, so-called **cusp plume**, should show mantle precipitation. However, also observations of the mantle current indicate longitudinally much wider mantle than cusp. Although not seen from the figure, the precipitation is indeed much stronger inside the cusp plume. This indicates that an **additional, weaker direct entry is taking place at field lines further away from the noon**. It is considered unlikely that the additional precipitation would be return flow from the distant tail.

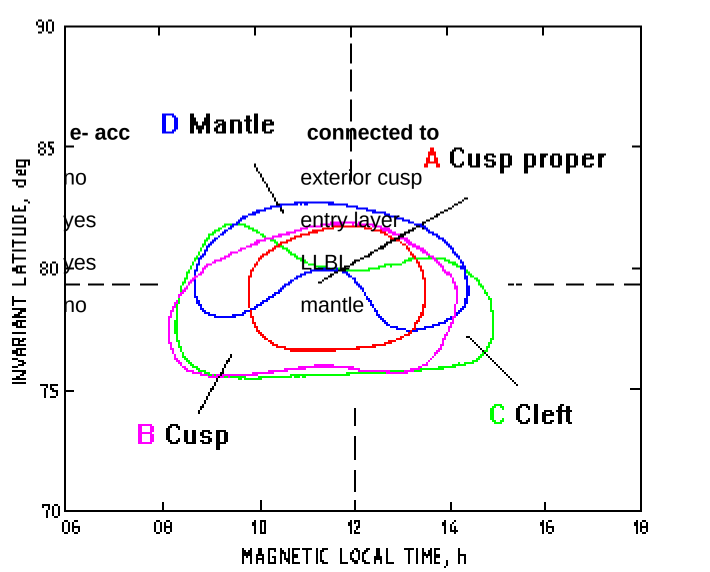
The distribution of the LLBL precipitation is also surprising, indicating that this precipitation would be more often seen pre-noon than post-noon (not seen in the map above). It is thought that this is due to a fault in the automated identification algorithm used, brought by the field-aligned potential acceleration events inside the intense upward region 1 current between 1400-1600 MLT (**the 1400 MLT 'hot spot' aurora region**).

An important point to note is that the distribution map above has been generated**without any ordering of the data according to geomagnetic activity and solar wind/IMF conditions**. Because the position of the regions, especially that of the cusp, depend heavily on these parameters, this may introduce some additional spread into the results.

Midaltitude observations

There are also midaltitude measurements of the cups region by the VIKING satellite. They divide this region into four parts according to the low energy magnetosheathlike particles:

	part	p+	e-	e- acc	connected to
A	Cusp proper	yes	yes	no	exterior cusp
B	Cusp	yes	yes	yes	entry layer
C	Cleft	no	?	yes	LLBL
D	Mantle	yes	no	no	mantle



These results differ somewhat from the those of DMSP at lower altitudes.

Optical aurora

As mentioned before, the general softness of the high-latitude dayside precipitation means that the prevailing emission is the red 630.0 nm, and a strong contribution from the green 557.7 nm indicates typically BSP precipitation. The boundary layer precipitation is typically diffuse kind, discrete precipitation being found occasionally inside the LLBL and mantle. The latter finding is interesting, because it indicates field-aligned acceleration on open field lines. Some interesting auroral types found in the dayside region are:

- the 1400-1600 MLT 'hot spot' aurora
- dayside breakup events
- pre-noon sector auroral fans