Ground-based Monitoring of the Plasmasphere: EMMA

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EMMA is the acronym for the European Meridional Magnetometer Array established in 2012 by involving the Geological and Geophysical Institute of Hungary, University of L'Aquila, the Finnish Meteorological Institute the Polish, Slovak and Hungarian Academy of Sciences, and the University of Zagreb. The Conrad Observatory joined EMMA recently in 2015. Now EMMA consists of 25 stations from North Finland to Italy. The primary aim of the network is the continuous monitoring of geomagnetic field line resonances. These observations are used to derive the plasma mass density along the field lines, which is expected to be one of the key parameters of future space weather reports.

The plasmasphere is the cold dense (few 100 to few 10000 particles per cm^3) plasma surrounding the Earth and corotating with it. Its outer boundary is called the plasmapause. The plasmasphere is filled with plasma from the underlying sunlit ionosphere, while at night the plasma flows back along the field lines to the ionosphere. During geomagnetic storms the plasmasphere is eroded as the plasma on its outer shells is swept away by the increased convection in the outer magnetosphere.

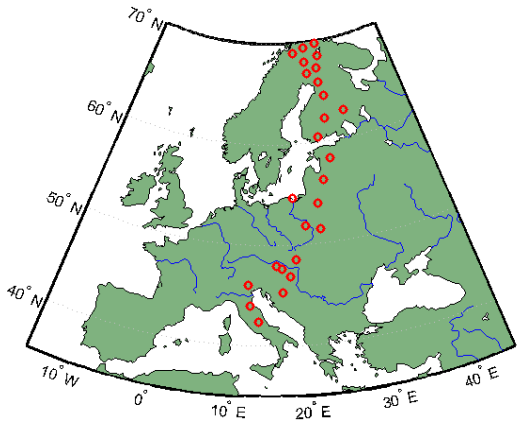

Figure 1: The current status of EMMA (31 Jan, 2016)

The plasmasphere is rather unexplored by satellites. Most of our knowledge on it comes from ground observations (VLF whistlers) and sporadic satellite missions (CRRES, IMAGE, VAP). ULF waves (with a few 10 s period) yield a unique tool for continuous monitoring of the dayside plasmasphere. The ULF technique makes use of the dependence of the field line eigen-frequency on the density along the field line. Using proper models the observed resonance frequency can be inverted to obtain the plasma mass density at the equatorial point of the field line. The method requires a station pair meridionally separated by some 100 kms. So, to be able to monitor the plasma at different heights, one needs a meridional chain of station pairs.

EMMA (the European Meridional Magnetometer Array) was established to unify and extend existing European networks making the monitoring of the whole plasmasphere possible (Figure 1). The Conrad Observatory joined this initiation in 2015 providing its high quality, and uniquely low noise data in near real time.

EMMA observations are processed in near real time to find the local resonance frequencies, and to infer the plasma mass density along the field lines observed by EMMA. The process can be monitored at:
http://geofizika.canet.hu/plasmon/.

A typical daily product of EMMA is shown in Figure 2 as a map of plasma mass density in the magnetic equatorial plane. This example shows clearly the day time filling of the plasmasphere from 06 UT (bottom right) to 18 UT (top centre) as the darkening of reddish tones. The colour scale is logarithmic, blue area depicts densities below a few 100 particles per cm^3, i.e. outside the plasmaspause.

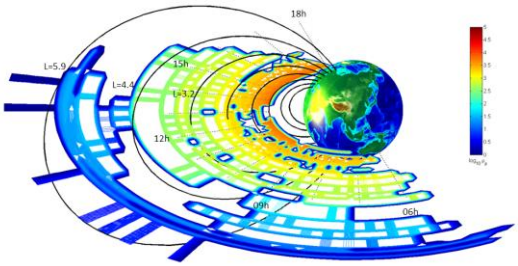

Figure 2: A daily map of the equatorial plasma mass density inferred from EMMA observations

Plasma mass density data produced by this project are a key parameter for the study of various magnetospheric processes (e.g. wave propagation, growth rate of instabilities, etc), as well as a key input for several space physics models.

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