Improving the local ionospheric electron density reconstruction model

Solar-Terrestrial Centre of Excellence

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Abstract

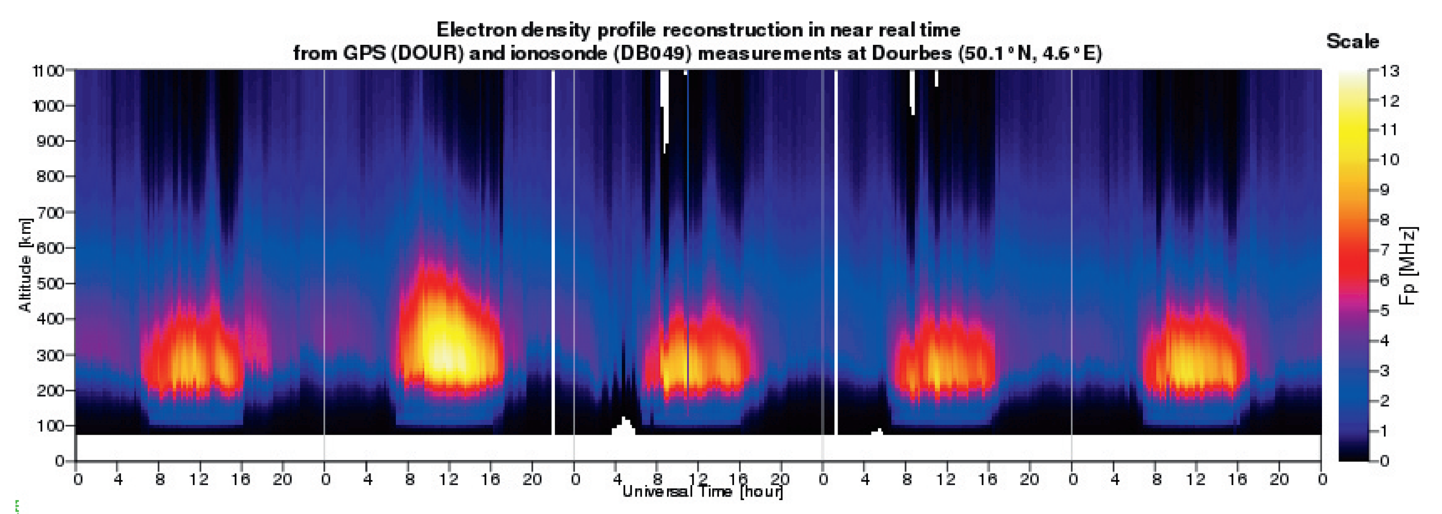
The RMI Local Ionospheric Electron Density profile Reconstruction (LIEDR) service was developed with the purpose of monitoring the local ionosphere in real time, using digital ionosonde and GNSS measurements in combination with empirical models. Several improvements have been made to the model for the selection of an appropriate topside profiler by using topside sounder data. Also, data from new GNSS-receivers and a new ionosonde (Digisonde-4D) have been incorporated into the services to obtain a higher time resolution and better data quality.

The LIEDR model

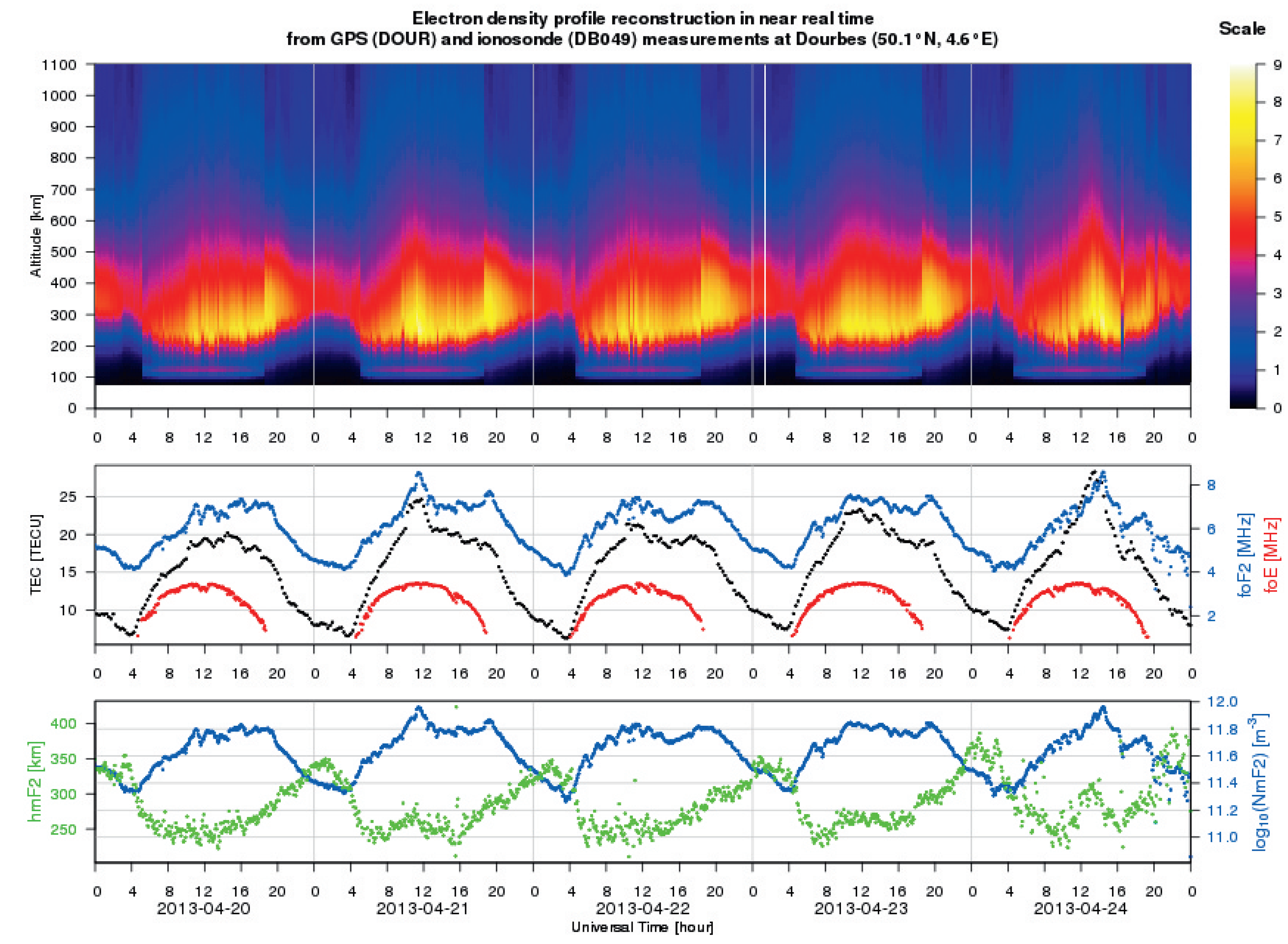
The LIEDR model has been developed to monitor, in near real time, the electron density above an ionosonde station. There are three principle inputs to the model:

1) characteristics of the bottom side ionosphere, obtained from the ionosonde (h_mF_2, f_oF_2, etc.),
2) total electron content, from TEC maps provided by the Royal Observatory of Belgium,
3) empirical model for the height of the upper transition level.

The output of the model is an electron density profile between 80 km and 1100 km altitude. Note that the topside scale height is calculated as output, whereas most model require this as an input.



The old version of LIEDR, showing several failures to produce a consistent reconstruction.



The LIEDR model for a five day period during April 2013. The top panel shows the electron density profiles (given as plasma frequencies) between 80 km and 1100 km. The middle panel shows the critical frequencies for the F_2 and E layer as well as the TEC. The bottom panel shows the height and density of the F_2 peak. See http://swans.meteo.be/ for real time profiles.

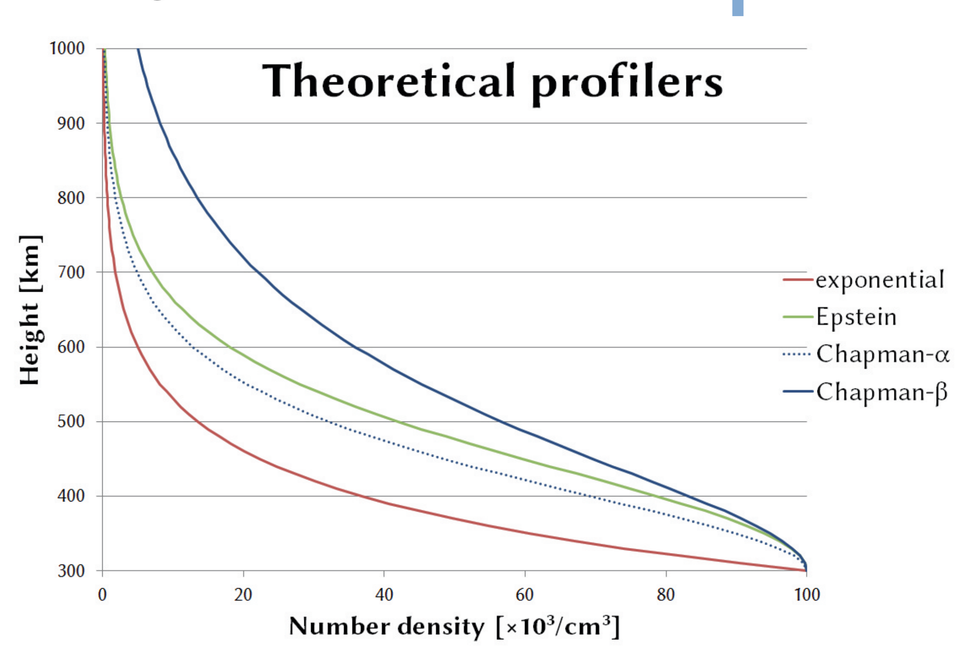
Recent developments & improvements

Better ionosonde inputs

In April 2011 the newest generation of digital ionosondes was installed at Dourbes: the Lowell DPS-4D. This has brought several improvements. The time resolution for the bottom side parameters is down to five minutes. Missing parameters can be taken from a previous sounding. The autoscaling software has also been improved. In general the bottom side characteristics are now very reliable, except when blanketing sporadic layers occur.

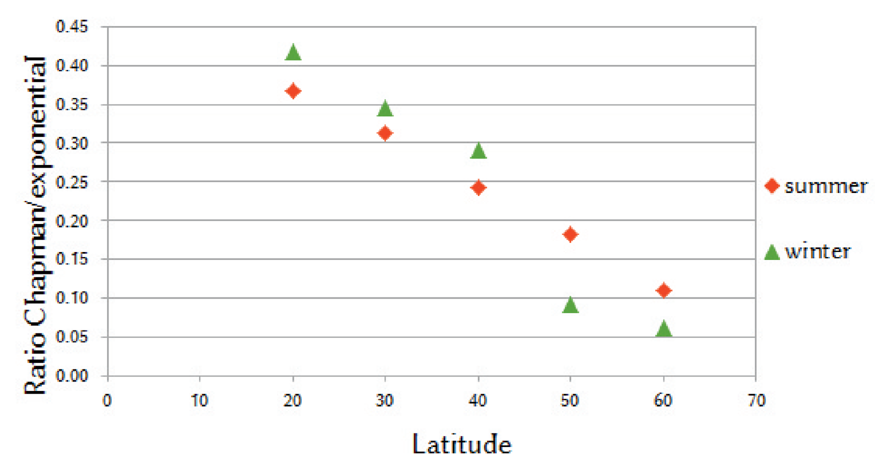
Selection of appropriate topside profiler

One of the main problems in the model is selecting a profiler for the electron density distribution in the topside, since only the TEC is given as an input. In the literature, exponential, Epstein and Chapman profilers have been used. The original LIEDR model assumed an Epstein distribution, causing occasional failures to produce a reconstruction. Based on the analysis of some *in situ* data the new LIEDR uses different profilers for day and night. However, this remains the main topic of further development.



Topside profilers & further development

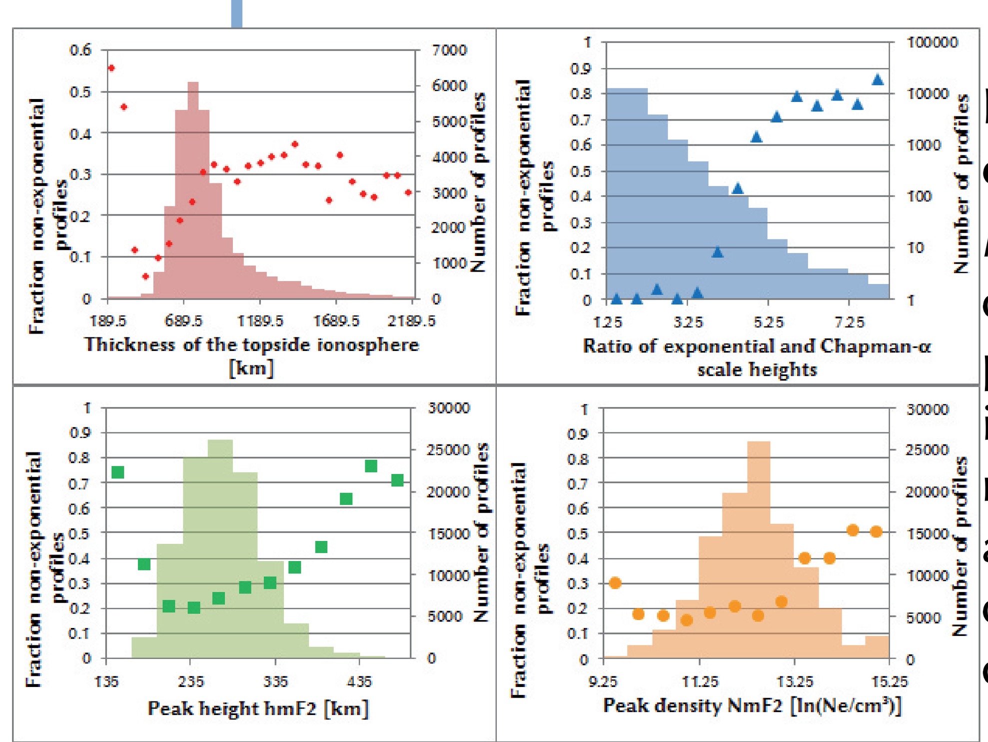
Improving the selection criteria for the topside profilers is the most important further development. In order to study the topside ionosphere, the NSSDC database of topside ionograms from Alouette-1 & 2 and ISIS-1 & 2 was used. All profiles were fitted with each of the four profilers in order to determine the best fitting shape under all circumstances.



Correlation between topside shape and latitude, for summer and winter.

Influences of external drivers

Ideally, we would like a model to select the appropriate topside profiler based on latitude and longitude, local time, season and solar and magnetic activity indices (Dst, K_p and F10.7). However, while influences of these external drivers can be seen, they are unsuitable for the selection of a profiler.



Correlation with other ionospheric characteristics.

Relation to other ionospheric characteristics

Much more promising is the selection of a topside profiler based on other parameters of the ionosphere. For instance, clear relations between the most usable profiler and the height and density of the F_2 peak have been observed. Selection based on other characteristics seems possible as well.

References

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