On improving the topside ionospheric modelling by selecting an optimal electron density profiler

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Outline

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2 Data & method

3 Results
- Influence of external drivers
- Correlation with other characteristics

4 Conclusions

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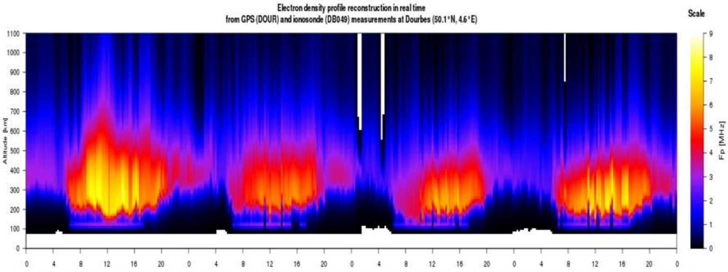
Context for this research

Our motivation to investigate the topside profilers comes from the LIEDR model (Local Ionospheric Electron Density Reconstruction), developed for near real time reconstruction of the electron density profile.



Produces full height electron density profile from: 1) ionosonde parameters [Lowell Digisonde-4D], 2) TEC maps [provided by ROB], 3) empirical model for UTL [I. Kutiev *et al.*], 4) procedure to select topside profiler.

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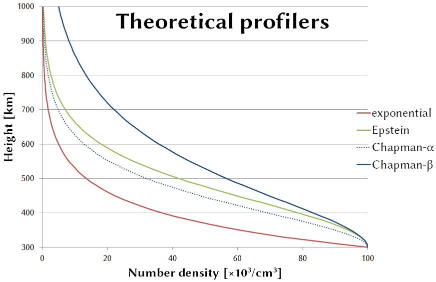
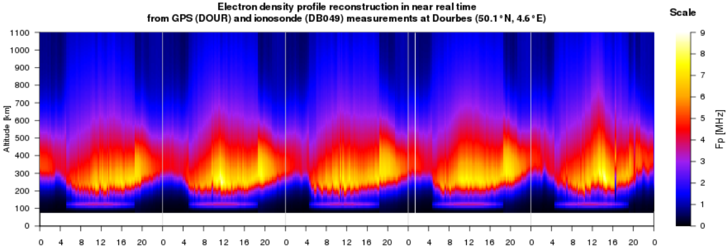
Topside profilers

Several topside profilers are used in literature: exponential, Epstein, and α- & β-Chapman. Choosing a more appropriate profiler clearly improves the LIEDR model.





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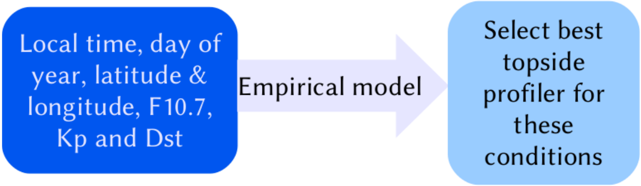
The ideal goal

The selection of topside profiler has to be further improved. Ideally, a model for this should be based on all relevant drivers of the ionosphere.



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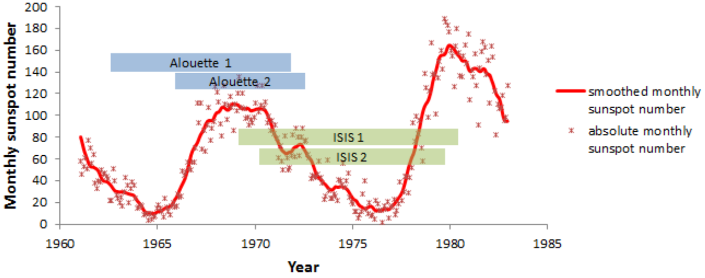
Topside sounder data

Database with 170000+ topside electron density profiles available from NSSDC, obtained from measurements by Alouette-1 & -2 and ISIS-1 & -2. Covers the whole globe, all days and times, as well as a wide range of solar and geomagnetic activity levels.



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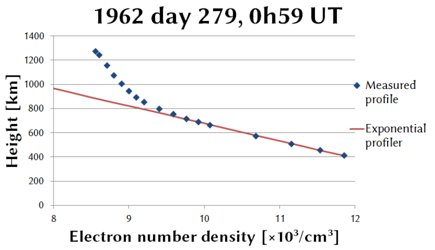
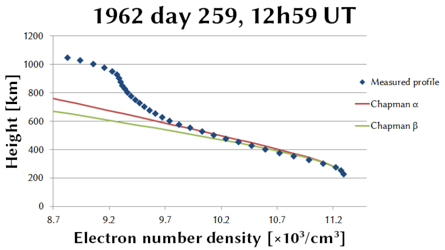
Method of analysis

Electron density profiles are fitted with all four profilers. Integrated errors, from F_2 to UTL, are computed.





Unfortunately, this requires profiles to go up to UTL. This makes many profiles unsuitable for our analyses.

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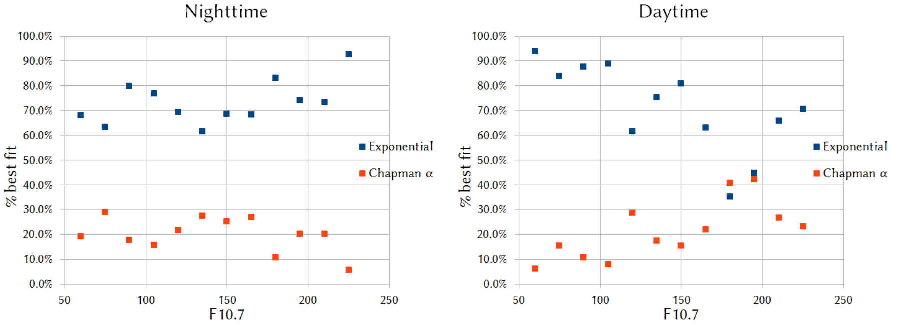
Correlation with external drivers



Percentages of profiles best fitted with an exponential or Chapman-α profiler, as a function of F10.7. Influences of local time and solar activity are visible.

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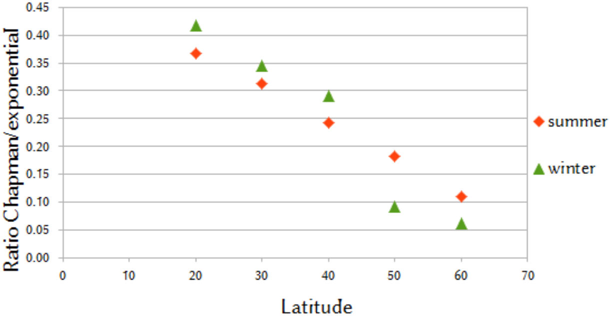
Correlation with external drivers



Ratio of number of Chapman-α profiles to exponential ones, as a function of latitude. A relation is clear, but this is not usable for the selection of a profiler.

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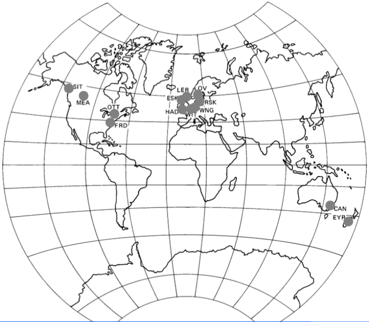
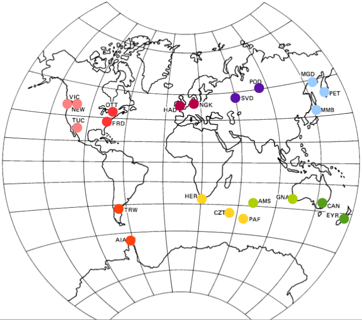
The problems with using external drivers

There are two main reasons why the correlations with external drivers are not very clear:

1. Irregularities in the data coverage, and associated artificial correlations and biases.
2. Solar and magnetic activity indices are not suitable to describe quick and local variations in the ionosphere.

For example: K_m could be used instead of K_p:





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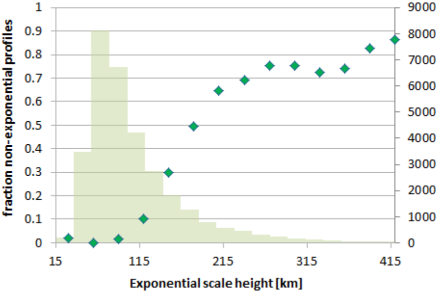
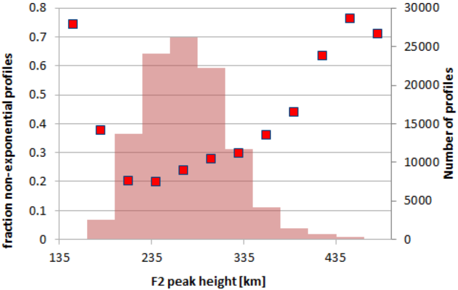
Correlation with ionospheric parameters

Instead of using the external driver directly, a topside profiler can be selected based on other characteristics of the ionosphere.





The usefulness of these selection criteria in a model depends on what parameters are known.

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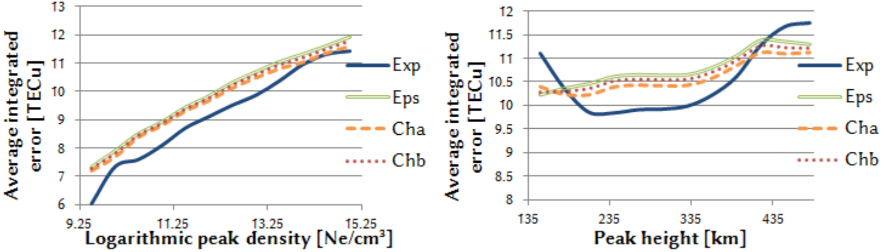
Correlation with ionospheric parameters



The relation between the best fitting topside profiler and the F_2 peak height is the most clear.

Relation to variable scale heights

It is possible to vary scale heights to such extend as to transform a Chapman profile into an exponential, or *vice versa*:

$$
\begin{aligned}
H_{CH\rightarrow EX}(h) &= \left(\frac{1 + W\left(1 + \frac{h-h_p}{cH_p}\right)}{h - h_p} + \frac{1}{cH_p} \right)^{-1} \\
H_{EX\rightarrow CH}(h) &= \frac{1}{c}\left(\frac{1}{H_p} + \frac{e^{-\frac{h-h_p}{H_p}} - 1}{h - h_p} \right)^{-1}
\end{aligned}
$$

If the variation in scale heights looks like this, it is better to use another profiler.

On the other hand, there are physical reasons to expect scale heights to vary. Therefore, variable scale heights should be combined with selecting an optimal profiler.

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Conclusions

1. Modelling the topside ionospheric electron density profile is still an important problem.
2. Selecting a profiler based on external drivers is difficult (this might be feasible when new topside sounders are available).
3. Choosing a profiler based on characteristics of the ionosphere can give better results, depending on the known parameters.
4. Ideally, selecting an appropriate profiler should be combined with the use of variable scale heights.

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The end, thank you!

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