Luleå University of Technology

Polar Atmospheric Physics

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EISCAT Space Weather

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1 Introduction

example MISC **exampleMISC**.
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2 GUISDAP software

In this section the raw EISCAT data is processed using the MATLAB software with the package GUISDAP. The data analyzed in this section was obtained with the 42m radar located in Svalbard, Norway. The time frame of the analyzed data corresponds to the 27th of October, 2016, from 15:00 to 21:00.

GUISDAP have several "experiment" methods. From the EISCAT experiments manual: "An EISCAT experiment is a set of instructions telling the transmitters, receivers and digital signal processing units what to do at what time". Meaning that depending on the object of interest of the experimenter, Some of the parameters that change between experiments are the code length in bits, baud length, smapling rate, the range span (measurable height), time resolution, etc. In this particular case, the experiment "ipy" was used.

With the help of GUISDAP, a few plots showing different parameters observed in the ionosphere at the time period mentioned above. The following parameters are used by the ipy experiment. One of the obtained parameters is the raw electron data. The data obtained with GUISDAP which is data measured from the EISCAT radar, was compared with data formulated using the IRI model in the following pictures.

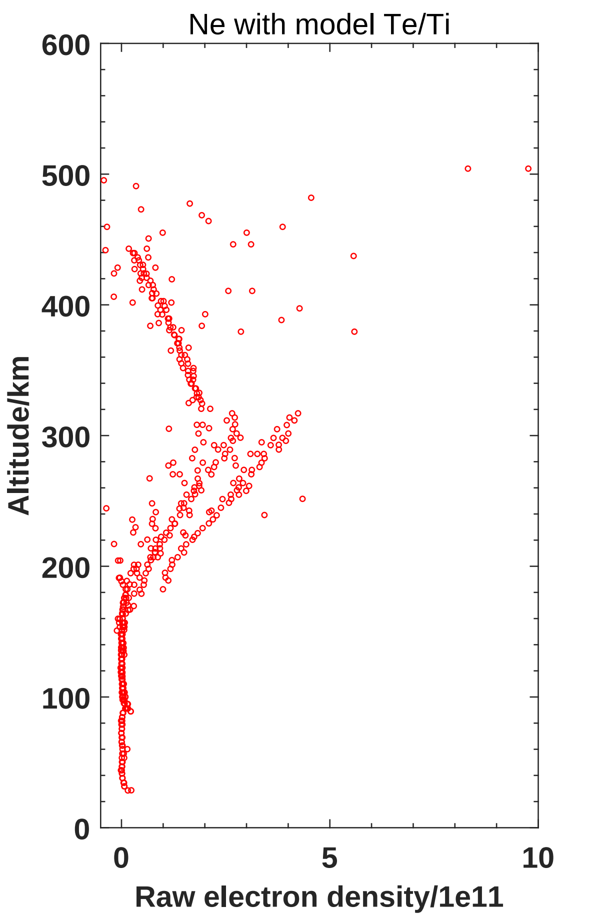


Figure 1: Electron density data obtained from EISCAT 2016-10-27.

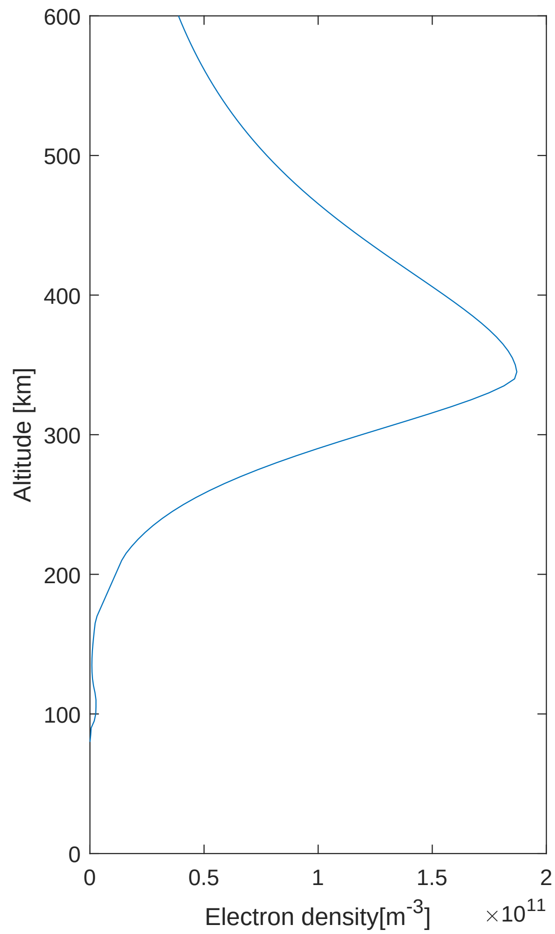


Figure 2: Electron density data from the IRI model 2016-10-27

In these two images, the electron density from 0 to 600 km was plotted in order to compare the IRI model to the measurements from EISCAT. Both are showing the electron density distribution at around 18:00 hours. While both the model and measurements agree on where the maximum occurs, the model underestimates the amount of electrons by about a factor of 3. More on the IRI model will be discussed in a later chapter.

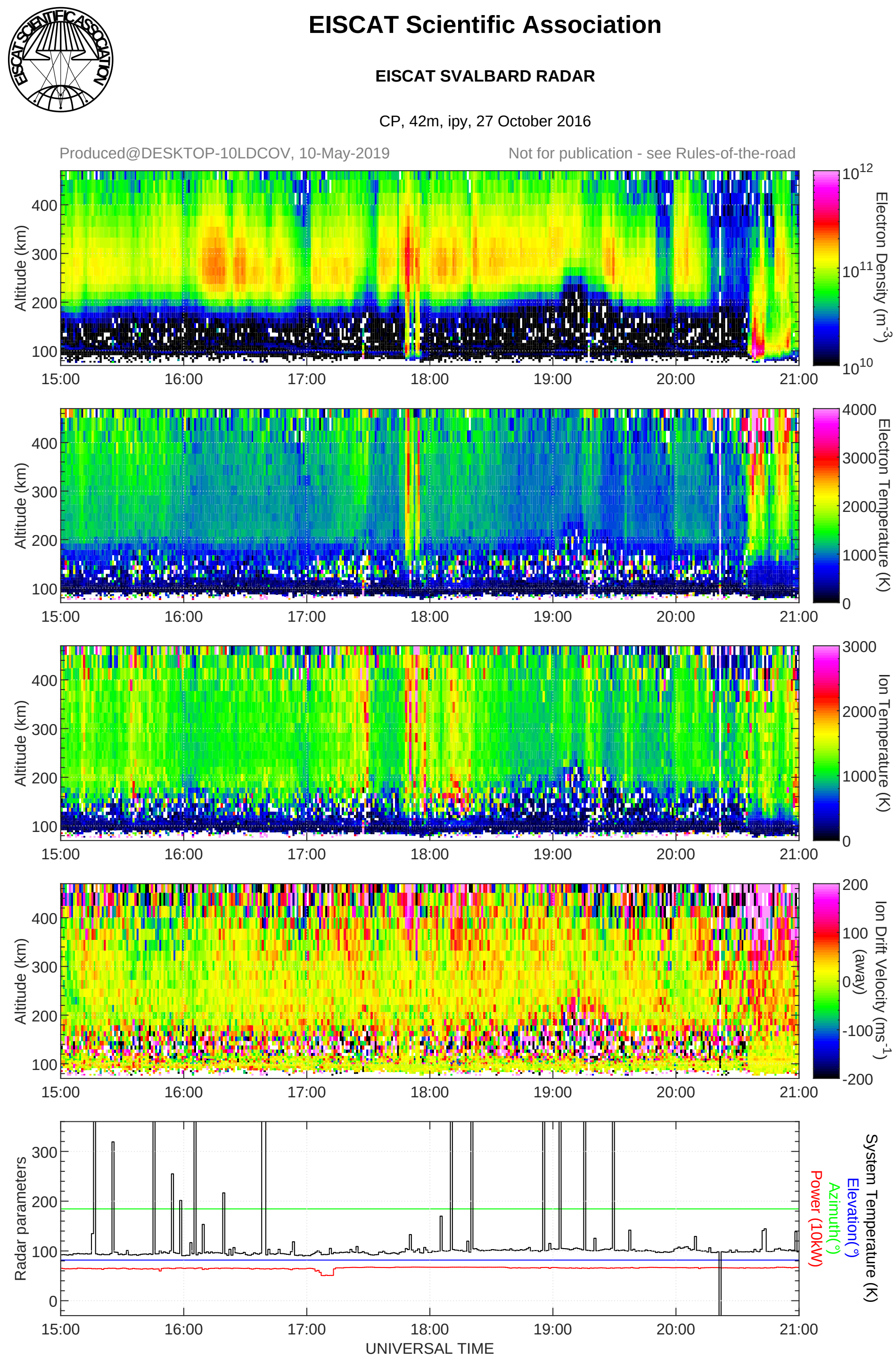


Figure 3: Plot produced analyzing raw data from EISCAT with GUISDAP

Figure 3 shows the results of analyzing 6 hours of data obtained by EISCAT from 15:00 to 21:00 on the 27th of October 2016. In the first row, we can see the electron density which matches with the plots on figure 1 and figure 2, showing a maximum around 300 km of altitude. The second row shows the electron temperature, with respect to each altitude, it is interesting to note that most of the times the variation is smooth and small, except for a small band right before 18:00 and a larger band around 20:30. The third row row shows the ion temperature, again, this one is more or less constant along time with a few exceptions around 17:30 and 18:00. The fourth row showing the ion drift velocity, most of the values look like a more or less random noise, meaning that this drift velocity is not consistent. On the fifth and final row we see the data of the antenna within the time range of the data analyzed.

3 Space weather event

In the rest of this document preprocessed data is used from the Halloween 2003 space weather event. This event took place from the 28th up to the 29th of October, with the main two peaks at 11:10 (28-10-2003) and 20:50 (29-10-2003) **goes˙x-ray˙archive**. This solar weather event consisted of a series of solar flares and coronal mass ejections. The solar flare with the most energy was measured at 10:16:53 UCT. With an energy of $6.9 \cdot 10^{25}$ Joule and a mass of $1.6 \cdot 10^{10}$ gram **CME˙list**, one of the strongest ever measured by GOES.

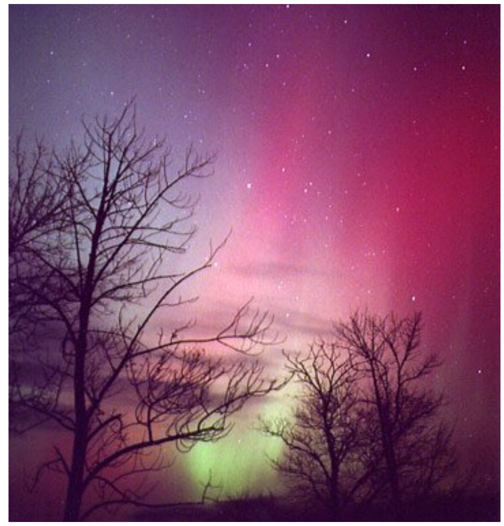


Figure 4: Geomagnetic storm/ Aurora on the 29th of October **spaceweather**.

Satellite-based systems and communications were affected, as well as the instruments onboard **swpc-noaa**. Aircraft were advised to avoid high altitudes near the polar regions, and a one-hour-long power outage occurred in Sweden as a result of the solar activity. Auroras (figure 4) were observed at latitudes as far south as Texas and the Mediterranean countries of Europe **wiki˙halloween˙solar˙stroms**.

3.1 Solar flares

On the 28th 12:18 UCT one of the most powerful solar flares in years erupted, this eruption, that caused a intense geomagnetic storm, is shown in figure 5.The solar flares erupted out of 486 giant sunspots. It was measured X17 on the Richter scale of solar flares. This means that the peak had an energy above $7 \cdot 10^{-4}\,\mathrm{W/m^2}$. It was also classified as a S3 storm, which means it has a flux of more than 10^3 with $\geq 10\,\mathrm{MeV}$ particles. **spaceweather**.

3.2 GOES

In figure 6 the space weather data from GOES10 (10th Geostationary Operational Environmental Satellite) over the month October is shown. In figure 7 the data from the same satellite is shown over the month of November **ngdc-noaa**.

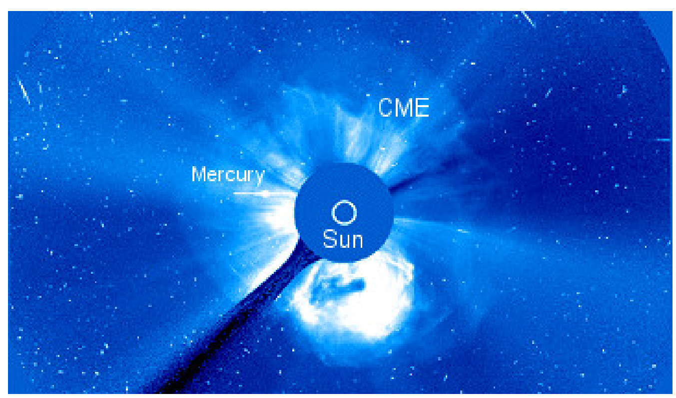


Figure 5: Solar image of a CME using a cronagraph**spaceweather**.

WHAT IS SHOWN HERE!

DISCUSSION / INTERPRETATION

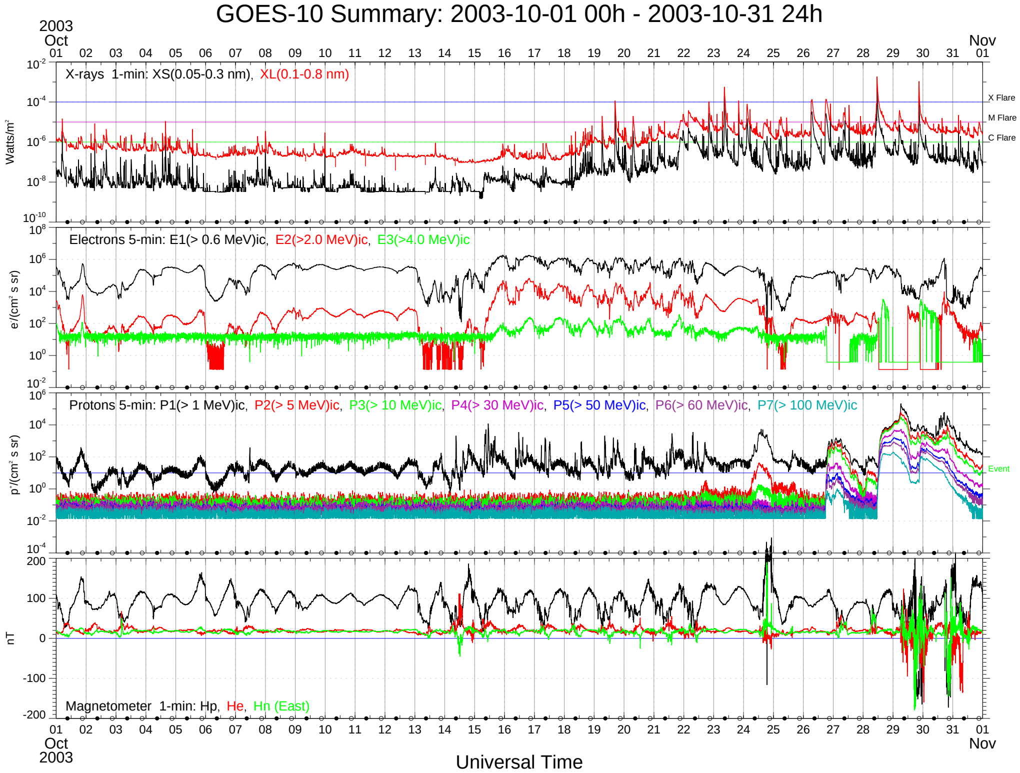


Figure 6: **ngdc-noaa**.

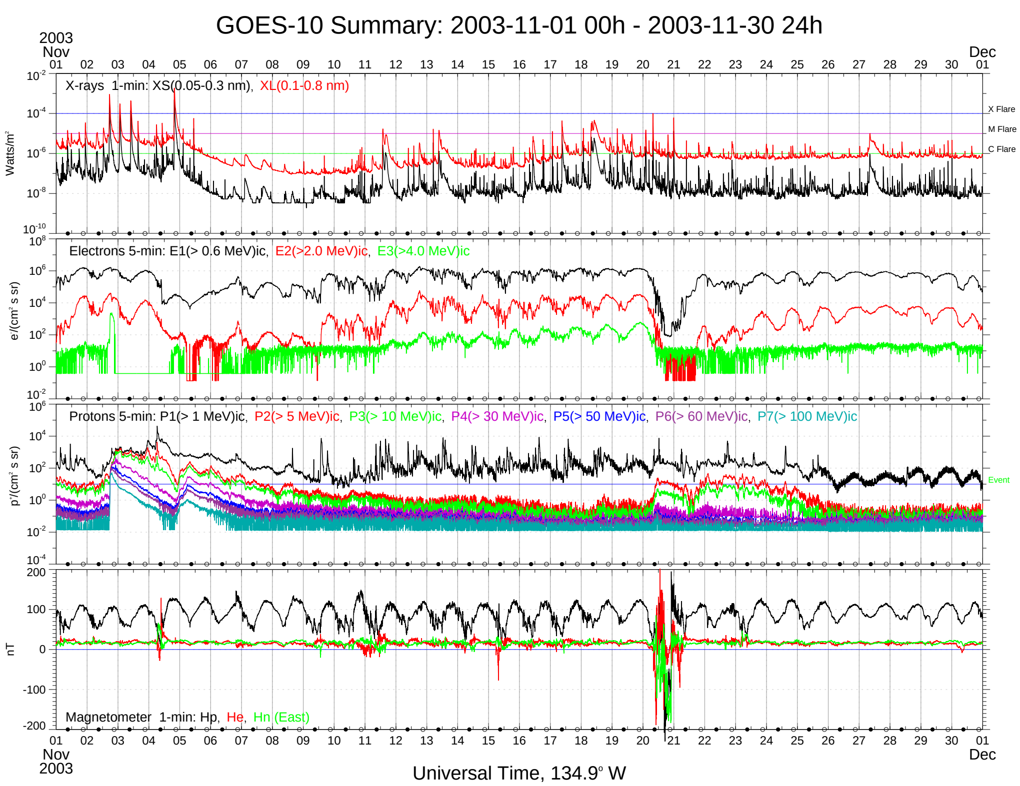
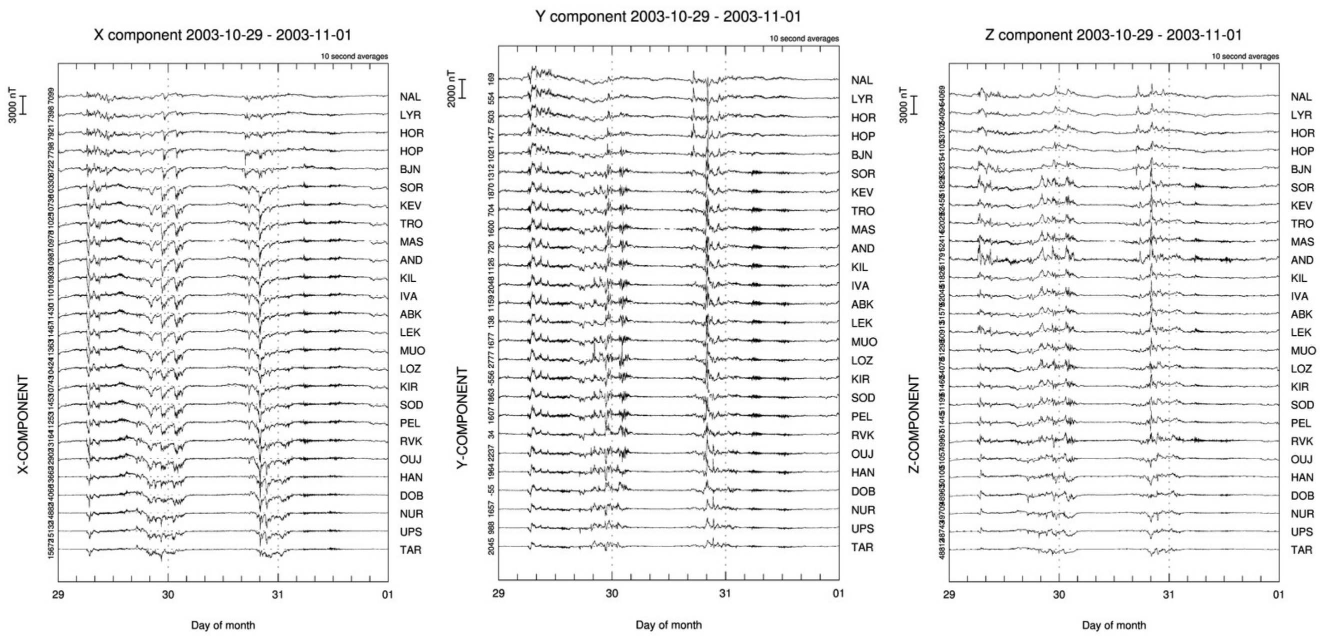


Figure 7: **ngdc-noaa**.

3.3 IMAGE

text/ explanation



(a) **image**.

(b) **image**.

(c) **image**.

Figure 8: Pictures of animals

sdfa

4 International Reference Ionosphere (IRI)

This model has been developed by an international collaboration sponsored by the Committee on Space Research (COSPAR) and the international Union of Radio Science (URSE). The development started in the late sixties in order to create a standardized model of the ionosphere by compiling empirical data from the available sources at the time. this model has been updated several times in order to keep it up to date with current measurements. The data of IRI comes ionosondes, incoherent scatter radars, satellites and sounding rockets.

A comparison was made between the data from the IRI model and the data obtained with EISCAT's incoherent scatter radar in Svalbard, Norway. This comparison takes data at around 21:01 hours on the 30th of October of 2003, as part of the Halloween solar storms.

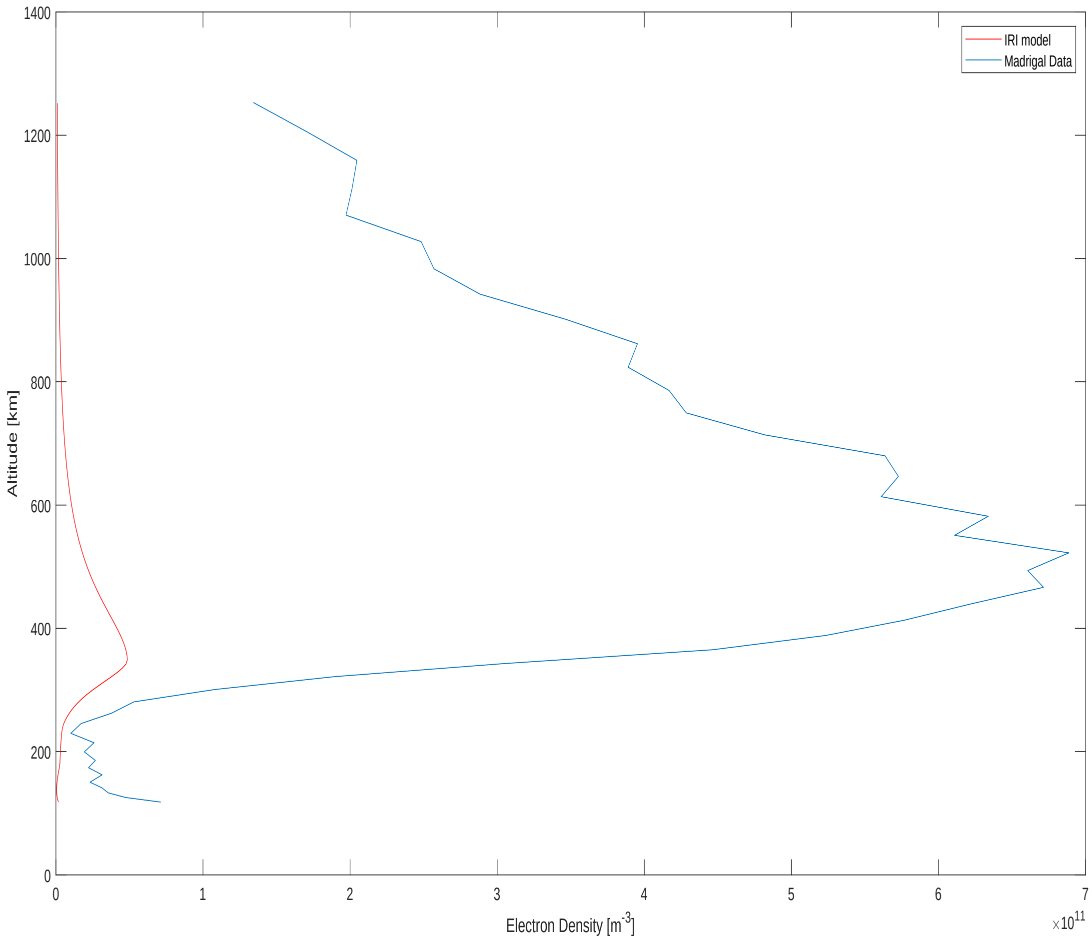


Figure 9: Comparison of the IRI model data (red) and the one obtained from EISCAT through the Madrigal system (blue).

While both sources more or less agree where the maximum of electron density occurs. There is a big discrepancy in the values shown, of about one order of magnitude.This can be attributed to the fact that the IRI model uses a monthly average to display the electron density of a particular time and date.