# AIRGLOW MEASURMENTS WITH ASRONOMICAL DATA


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## WHY ASTRONOMICAL DATA?

Ground based astronomical facilities have been taking spectra for many years, leading to large data archives. With only a few seconds of exposure time, one can already detect airglow lines like NaID, OI, NI or different OH and $O_2$ bands. Astronomical data also cover a larger wavelength range than most spectrographs used by the geo-science community.

We make use of the Very Large Telescope operated by the European Southern Observatory in Chile. For our studies we choose X-Shooter, an echelle spectrograph with a resolution from 3 000 to 18 000, covering a wavelength range of 3 000 – 25 000 Å (see Fig. 1).

Our dataset spans a time range from October 2009 to March 2013 leading to > 6 000 observations suitable for airglow measurements. Everyday, new data becomes available to expand our dataset.

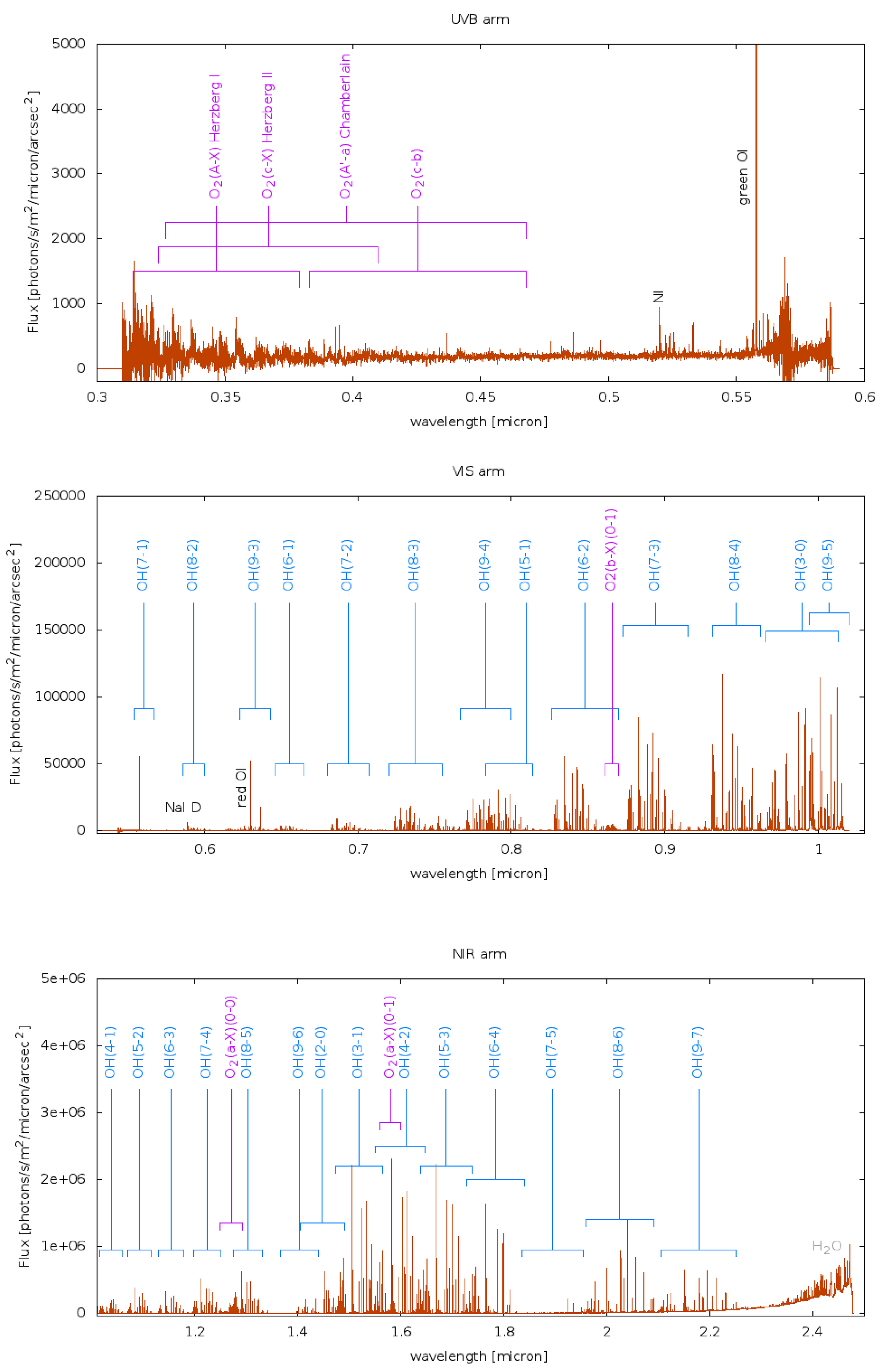


**Fig.1: X-Shooter Spectra**
Example of an X-Shooter spectrum of the plain sky, covering the wavelength range from 3 000 – 25 000 Å with the different airglow lines/bands labeled.
The spectrum is split into three arms:
UVB → 3 000 – 5 900 Å (uppermost panel),
VIS → 5 300 – 10 200 Å (middle panel)
NIR → 10 000 – 24 800 Å (lowest panel)

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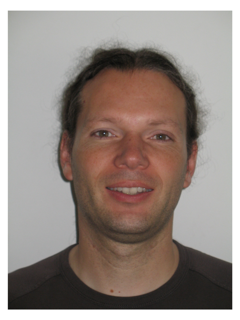

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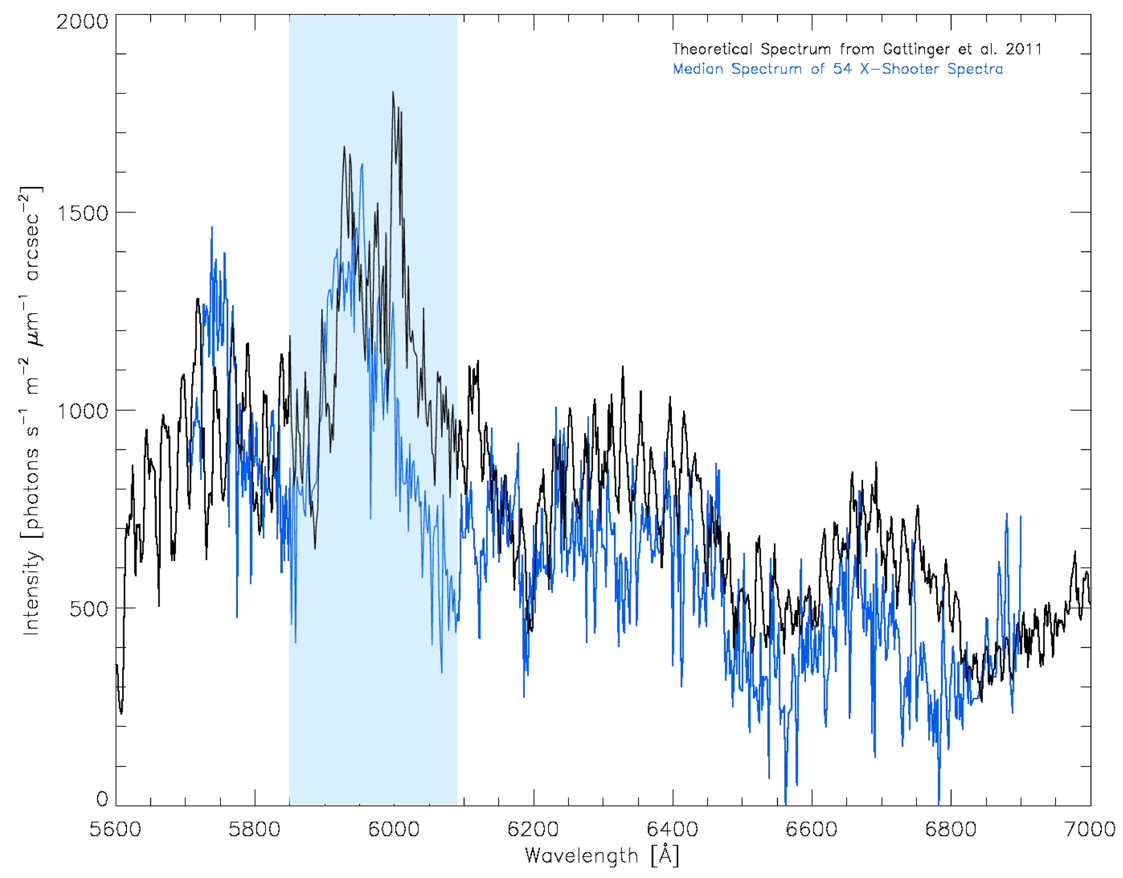


**Fig.2: Theoretical spectrum vs. observed spectrum**
The light blue region indicates the area that was used to measure the FeO* intensities.

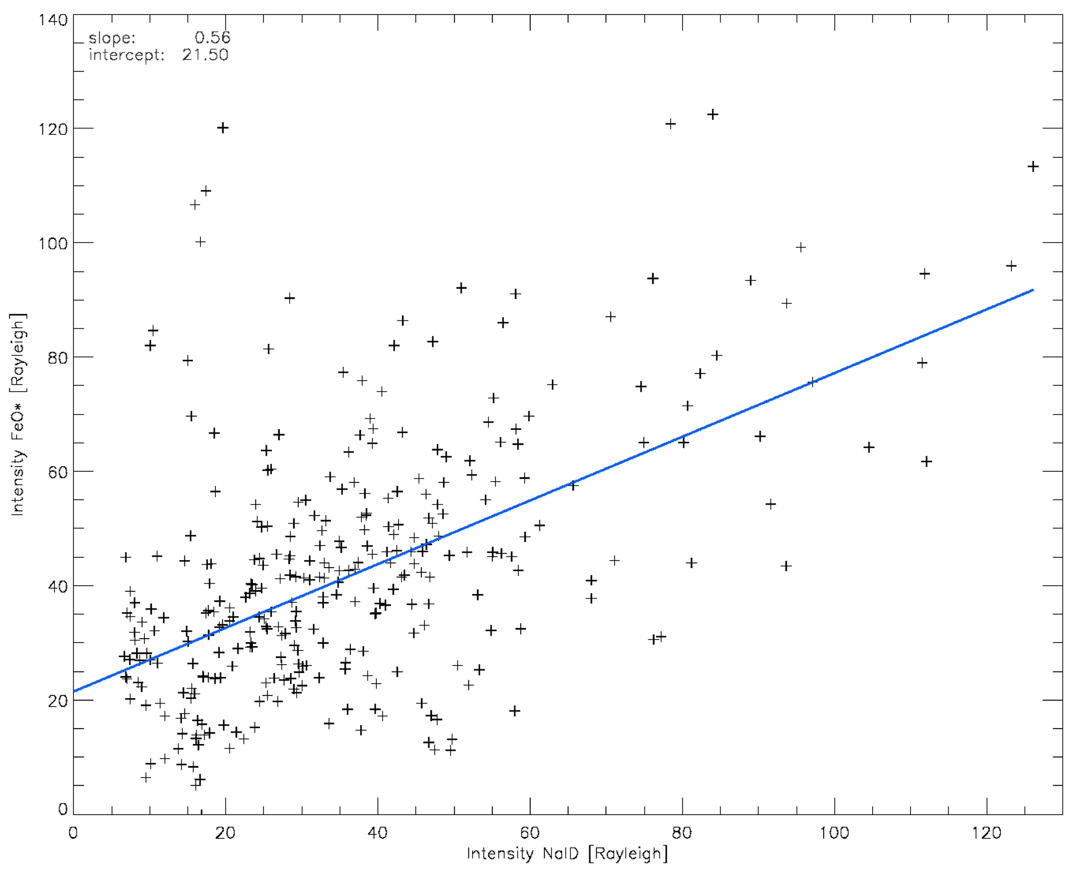


**Fig.3: NaID vs FeO***
Intensity measurement of NaID and FeO* in the same spectra.

## FEO*

Lab studies of [5] showed the presence of a FeO* band between 5 500 and 6 800 Å. The first detection of FeO* in the mesosphere was published by [1]. This paper was quickly followed by [2] who modeled a theoretical spectrum of this molecule. The biggest study so far contained data from nine nights ( [4]).

Detecting FeO* in a plain sky spectrum is not a trivial task, as it is a faint feature in a region of bright and well known airglow lines (eg. NaID , 5 892 Å and OI, 6 300 Å ). Furthermore, it is contaminated by other sources contributing to the continuum like zodiacal light or the Moon. All of these features were taken into account by the sky model described in [3].

To be able to compare our X-Shooter spectra to the model of [2], we produced a median spectrum of 54 spectra. These spectra represent the upper 15% of our sample with respect their intensity (see Fig. 4). The overall pattern of the theoretical spectrum (black) and the median spectrum (blue) agree very well. However, at the main peak (light blue shading in Fig. 2), one can see a clear discrepancy. One of the questions that needs to be answered is how accurate is the theoretical spectrum. Probably there is a need for more parameters to be taken into account. Another question would be how a further improved reduction of the data will influence the measured spectrum.

Furthermore, X-Shooter allows us to study this newly detected airglow feature over a long time span. Studies on its properties could not be carried out yet. With our dataset, described in the panel below, we are able to test different hypotheses such as the source of FeO*. It is suggested, that FeO* is replenished by meteors like NaID. In addition other studies [4] state that both emissions are the result of a reaction with $O_3$. Hence one would expect a correlation of NaID and FeO*. We tested this suggestion in Fig. 3 and find a correlation between both emission features. To have an approach as robust as possible towards airglow line subtraction and variance at the other peaks of the FeO* signal, we decided to just use the light blue shaded region of the FeO* emission in Fig. 2.

## DATASET FOR MEASURING FEO*

Focusing our analysis on FeO* we took 462 spectra that have an exposure time of at least 10 min. This cut was done due to the faint nature of the feature.

Fig. 4 shows the intensity of the main peak of the FeO* feature at ~5 900 Å (see light blue shaded region in Fig. 2) as a function of time.

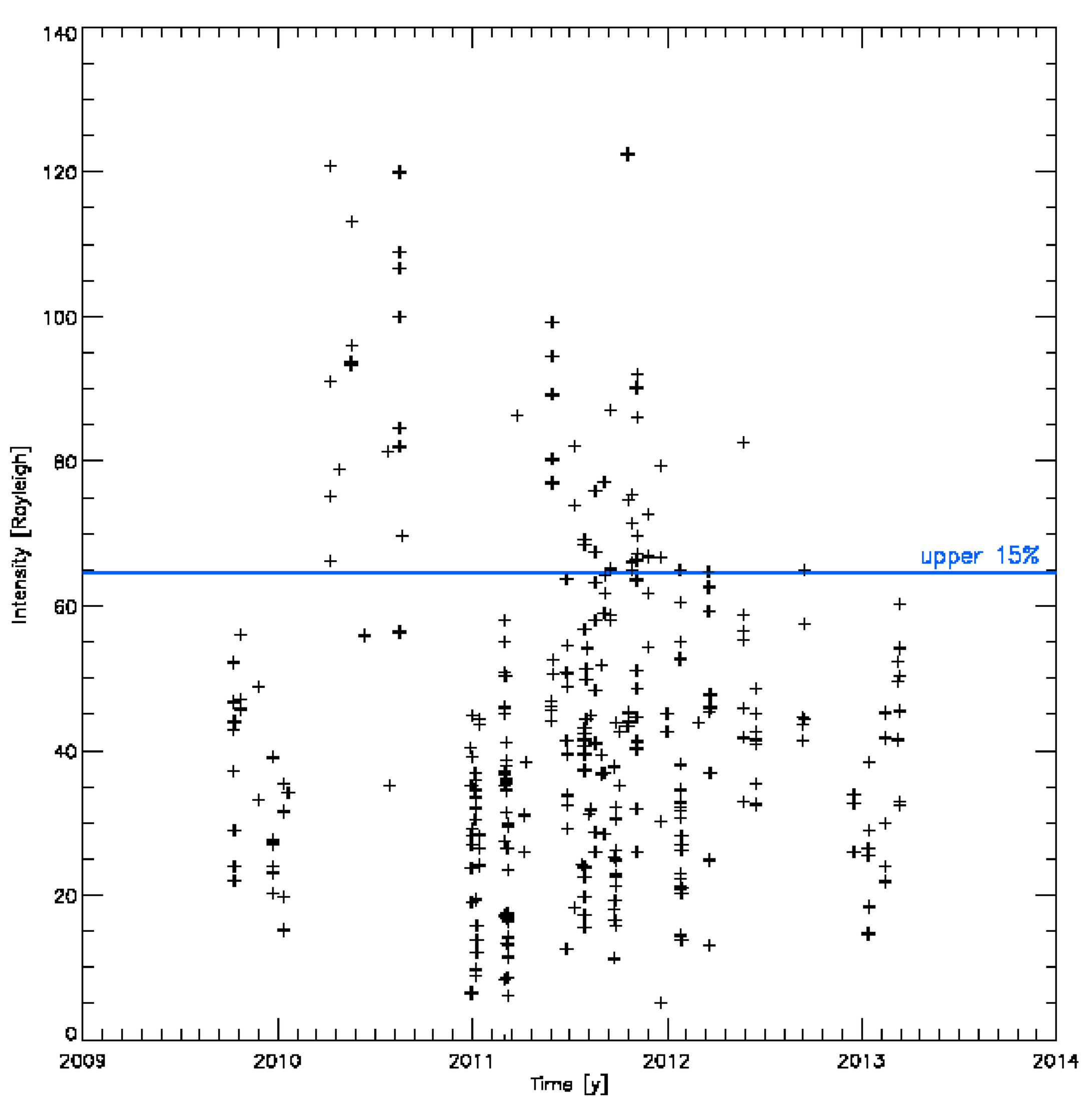


**Fig.4: Time Coverage of the Dataset**
The intensities measured refer to the intensities of the main peak in the FeO* feature at 5900 Å. In Fig.3 you can identify that region by the light blue shaded region.

## CONCLUSION AND OUTLOOK

Using X-Shooter data, we have a large sample of spectra at hand, covering a time range from October 2009 until March 2013. X-Shooter is a frequently used instrument and hence our sample will continue to increase.

We showed that our median spectrum fits well with the expected one from [2]. Discrepancies may result from missing information for the model in [2].

In Fig. 3 we presented a correlation between NaID and FeO* emission. The trend may become clearer using the whole emission of FeO* (5 500-7 200 Å) for comparison. Further improvement of the airglow subtraction will help to reduce the uncertainties in the FeO* measurements

Next steps will be the inclusion of UVES data (see EGU2014-12008).

Furthermore, we will investigate the variation of FeO* with respect to different causes such as variation during nighttime, seasons or by solar activity


**References:**
[1] Evans et al, Geophysical Research Letters, Vol. 37, 2010
[2] Gattinger et al , Can J Phys Vol. 89: 239-238, 2011
[3] Noll et al, A&A, Vol. 543, 2012
[4] Saran et al, Journal of Geophysical Research, Vol. 116, 2011
[5] West & Broida, Journal of Chemical Physics, Vol. 62, No7, 189