CRIRES Science Verification Proposal

Determining the atmospheric precipitable water vapour content from near-IR H_2O lines

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Abstract:

We propose to measure the precipitable water vapour (PWV) content over Paranal by determining the equivalent widths of 7 carefully selected unblended atmospheric H_2O lines in absorption and several additional lines in emission in the near-IR. This will demonstrate a potentially very powerful tool to quantitatively measure an atmospheric parameter which is crucial for IR astronomy. We will make comparison with VISIR data and remote sensing satellite data.

Scientific Case:

Atmospheric precipitable water vapour (PWV) is one of the crucial parameters in infrared (IR) astronomy. A methode suitable to undertake efficient and reliable routine measurements of the PWV content will be highly valuable for operations of CRIRES, and other IR instruments. Moreover, PWV will be an important criterion in the selection of a site for an European Extremely Large Telescope (ELT).

We propose a new methode that uses the equivalent widths of atmospheric H_2O lines imprinted onto the spectra of early type stars. For quantitative measurements the lines have been selected to have a minimum dependence of their absorption coefficient on temperature around 300 K. A paper by Brault et al. (1975, JQSRT 15, 549) describes a total of 8 unblended lines suitable for this purpose. One of these is located at 694.5 nm and is being used in the site testing program for the Giant Magellan Telescope (GMT). In a related effort we plan to make use of the ESO archive to extract suitable spectra taken with UVES and FEROS to investigate this line in the visual over a baseline in time of several years.

All of the remaining seven lines are located well within the spectral range of CRIRES and cover a substantial range of the near-IR (1086 - 2422 nm). Three of them can be observed in a single CRIRES setting. Validation of the near-IR line for PWV measurements will greatly enhance the value of this approach because more suitable lines are available than in the visual.

We propose to observe all seven near-IR lines during one night in two stars and repeat the setting with three H_2O lines on three more nights with one star. Although we expect the above method to be accurate, it is based on absorption spectroscopy and therefore relatively time-consuming, as it requires pointing and acquiring a target star. An alternative, very fast and efficient method is to use emission lines - as done with VISIR (project by A. Smette). Such an approach would be better suited for routine measurements. However, as shown by VISIR and by simulations, emission lines appear more sensitive to changes in temperature and pressure profiles. We therefore will add two settings with several emission lines for comparison with the absorption lines, as well as with the results from VISIR measurements and remote sensing data from the GOES satellite. This will allow us to fully assess the validity of the methods; we should be able to determine how accurate the temperature and pressure profiles need to be, in particular, whether temperature and pressure profiles provided by meteorological institutes for a given time are indeed suitable.

If the feasibility of quantitative PWV measurements in the near-IR can successfully be demonstrated such observations could be routinely used to characterize the quality of a given night for IR observations. This would be a important innovation in order to optimise the use of ESO's instrumentation.

Required observing time

Target	RA	DEC	Wavelength Band	Magnitude	DIT	NDIT
HR 8998	23 44 12.1	-18 16 37	1070-1096	J=5.38	3	20
HR 8998	23 44 12.1	-18 16 37	1483-1516	H=5.42	3	20
HR 8998	23 44 12.1	-18 16 37	1724-1766	H=5.42	3	20
HR 8998	23 44 12.1	-18 16 37	2174-2221	K=5.38	3	20
HR 8998	23 44 12.1	-18 16 37	2399-2458	K=5.38	3	20
HR 845	02 49 54.2	-27 56 30	1070-1096	J=5.33	3	20
HR 845	02 49 54.2	-27 56 30	1483-1516	H=5.34	3	20
HR 845	02 49 54.2	-27 56 30	1724-1766	H=5.34	3	20
HR 845	02 49 54.2	-27 56 30	2174-2221	K=5.27	3	20
HR 845	02 49 54.2	-27 56 30	2399-2458	K=5.27	3	20
HR 845	02 49 54.2	-27 56 30	2174-2221	K=5.27	3	20
HR 845	02 49 54.2	-27 56 30	2174-2221	K=5.27	3	20
HR 845	02 49 54.2	-27 56 30	2174-2221	K=5.27	3	20
sky	00 00 00.0	-00 00 00			60	5
sky	00 00 00.0	-00 00 00			60	5

We request a total observing time of 1.5 h. The individual exposures will be very short, a S/N of 100 is achieved in 2 min based on the current CRIRES ETC. Hence the observations are dominated by the overheads. We plan to observe all seven lines (5 settings) in two stars during one night and to repeat observation of the one setting with three lines on three more nights in one star. Observations of a star in five settings requires about 20 min. Observations of a star in a single setting requires about 10 min. Hence we obtain a total of 70 min observing time for absoprtion spectroscopy and an additional 20 min for emission line studies.

Notes:
a) We have got a list of 16 stars with very similar magnitudes and spectral type close to AO. Therefore we can use any RA slot during the night for these observations.
b) The lines used in absorption cannot be used in emission as they are too faint.We have added a pair dummy settings which will be defined later.
c) The analysis tool is already written and would just need minor adjustments to be adapted to the CRIRES specifics (format, FF, etc...).