

Interactive comment on “Water vapor total column measurements using the Elodie Archive at Observatoire de Haute Provence from 1994 to 2004” by A. Sarkissian and J. Slusser

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1) Editor’s comment c265 top line,
...preliminary results showing a decrease during 10 years seems to contradict the expectation from a climate science perspective

In the new manuscript,

Chapter 5 p1083 line 11 Sentence

A negative trend of $-0.44 \pm 0.24 \times 10^{22} \text{ molecule} \times \text{cm}^{-2}$ per 10 years is obtained after
C273

removing the sine fit.

will be replaced by

A negative slope of $-0.44 \pm 0.24 \times 10^{22} \text{ molecule} \times \text{cm}^{-2}$ per 10 years is obtained after removing the sine fit, indicating a not significant trend because it is larger than two times its error. This is in agreement with the review of measured trends over Europe made by Morland et al.. This negative slope might be introduced by the high summer values in 1994 and 1995. We believe that more detailed trend calculation, including seasonal trends calculations, could be made after we extend this analysis to the full Elodie Archive and to the Sophie Archive.

2) Absorption cross section and description of the method

Astronomers use the term of line list. A description of the basic concept of our method will be added in the new manuscript, as also recommended by the referees. In fact, I believe that adding an overview of the analysis method in chapter 2 just before the chapter cross-section will help for a better understanding of this paper.

3) new chapter 2 (preliminary)

1 Spectral Analysis: Overview

The spectral analysis has been specially developed for water vapor removal for future astrophysical use of the spectra. The authors’ initial objective was to develop a spectral analysis to search water vapor signatures in external sources like exoplanets and bod-

ies of the solar system. First analysis shows that water vapor signature in the visible in exoplanets is so tiny (optical thickness of 10^{-9} at most) that its detection is not possible with existing techniques, but in the infrared, water vapor, ozone and carbon dioxide absorption can reach a significant percentage, justifying development of this technique.

In atmospheric research, most spectrometric instruments use solar light as the source. The differential optical absorption spectroscopy (DOAS) method is used commonly for tiny absorptions and because of geometrical considerations, using scattered light (zenith sky light at twilight) increases the path length up to 20 air masses (Sarkissian et al., 1995). Here, because the source is not always the same, the DOAS method cannot be applied and an absolute method had to be developed for Elodie. An example of a spectrum of the Elodie archive is presented in Fig. 2. The spectral range around 592 nm is displayed in Fig. 2. Not all astronomical spectra have as many visible absorption lines that are proper to solar type stars, here 51 Peg of spectral type G2. Some astronomical objects have only broad or a few lines visible, like hot O stars, or sometimes emission lines like nebulas. The wide range of sources make the spectral analysis more difficult, as we will discuss in the section 5. If I_0 is the spectrum of the astronomical object outside the atmosphere, and taking into account the absorption by water vapor only, the Beer-Lambert law gives

$$I_{observed} = I_0 \times e^{-\tau_{H_2O}}, \quad (1)$$

where $I_{observed}$ is the intensity of the observed spectrum and τ_{H_2O} the water vapor optical thickness in the observed spectrum. We called here our analysis an absolute method compared to the DOAS one because we compensate water vapor signature in the observed spectra adding a negative absorption (i.e. equivalent to an emission) at intensity levels instead of doing it at differential intensity level,

C275

$$I_{0,calculated} = I_{Elodie} \times e^{+\tau_{H_2O}}, \quad (2)$$

where I_{Elodie} is the intensity (in counts) of the spectrum observed by the Elodie spectrometer, $I_{0,calculated}$ the spectrum calculated without water vapor signature and $+\tau_{H_2O}$, the measured water vapor optical thickness in the observed spectrum. Absolute methods are often used when signal-to-noise ratio of observation is so low that differentiation will generate too much noise for use. Because of the very high quality of spectra needed in astronomy, most spectra (up to 96.5 %) were used in the analysis. Then, the amount of water vapor molecules in the line-of-sight of the observation, n_{H_2O} , is obtained by

$$\tau_{H_2O} = \sigma_{H_2O} \times n_{H_2O}, \quad (3)$$

where σ_{H_2O} is the water vapor absorption cross-section, often provided as a line list (Fally et al.) and to be adapted to fit with instrumental and observational characteristics, as presented below.

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C276