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Atmospheric Measurement Techniques Discussions

Interactive comment on "Spatial Heterodyne Observations of Water (SHOW) from a high altitude airplane: Characterization, performance and first results" *by* Jeffery Langille et al.

Anonymous Referee #2

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General Comments

The manuscript details water vapor measurements made with a Spatial Heterodyne Spectrometer (SHS) from an ER-2 high altitude aircraft and compares retrieved water vapor densities with coincident radiosonde measurements. My overall impression of the manuscript is quite positive. It provides sufficient context and the detailed descriptions provided make it quite easy to follow. The agreement between the SHOW and the radiosonde water vapor densities is remarkable, particularly given the complexity of the L0 to L1 processing required in the analysis of the SHOW data. Given the quality of the manuscript, my specific and minor comments below are to be considered as advisory

to the authors and not requiring another detailed review.

Specific Comments

The manuscript details a series of steps required to remove instrumental effects from the level-0 data. The most complex of these stems from the combination of aliasing due to the passband of the interference filter spanning the Littrow wavenumber and a vertical fringe frequency tilt of the interferometer. The result is a row-dependent spectral modulation seen near left edges of Figures 7c and 7d and require that a detailed instrument model be in integral part of the retrieval. Although it's implicit in the discussion, I think it is important to point out that the difficulties and uncertainties associated with correcting for this effect could be eliminated by using a filter with passband shifted slightly to the red that blocks all light at wavelengths on the opposite side of Littrow. To simplify the analysis is there a plan to replace the interference filter for future flights of the instrument?

There are numerous places in the processing where a fitted high-order polynomial is subtracted from the data in an effort to assess the noise from the residual. It would be helpful to indicate the order of the polynomial used. Clearly with a very high order polynomial fit, some of the noise will be fit and the noise in the residual will be underestimated while fitting with a polynomial of too low an order will result in signal in the residual. How was the decision as to the order of polynomial used made?

Although not ultimately used in the analysis due to optical depth issues I found the description of the cloud artifacts evident in the lowest rows of Figure 12a and 12b somewhat lacking. If the entrance optics are anamorphic and aligned properly, they should completely defocus spatial information in the horizontal direction. Why then does the modulation in rows 0 to $\sim$30 in Figure 12a tilted? Could this possibly be a fringe due to a spectral line very close to the Littrow wavenumber?

It appears that amplitude spectra where used throughout in the analyses. If proper phase correction is performed the spectral information can be isolated to the real part

of the Fourier Transform only thereby reducing the shot noise contribution from the imaginary part and reducing the shot noise contribution by roughly the square root of two. That said, I suspect that the dominant source of uncertainty is not shot noise so perhaps this improvement is not worth the substantial effort required.

Connected to the previous comment, the error bars shown for the SHOW measurement in Figure 19 appear to be quite small. Do these error bars include the systematic effects associated with uncertainties in the retrieval or are they simply an indication of the photon shot noise component of the noise? It would most illuminating, if the systematic uncertainties could be quantified.

In general, I would suggest making a clearer distinction between statistical sources of noise (photo, dark, CCD read noise, etc.) and systematic sources of uncertainty (errors in the uniformity correction, uncertainties in the retrieval parameters, etc.). In various places in the manuscript all of these effects are referred to as "noise".

To understand the instrument, it would be helpful to add a short section and perhaps a figure describing the anamorphic optics that feed the interferometer and the optics between the interferometer and the detector.

Technical Corrections

Section 5 second paragraph, second sentence: Missing "to"

Section 6 third paragraph: N in the SNR equations should be defined

Equation 4: Define Ij and σj.

Section 7, second sentence: Figure 3 reference should be Figure 2

Section 9.4, end of first paragraph: LightMachinery should be more completely referenced (e.g. LightMachinery, Inc., Ottawa, Ont).

Figure 9a: The black background makes it very difficult to read

Section 10, second paragraph, second sentence. "quiet" should be "quite"

Section 10, third paragraph: Acronym AFRC should be expanded

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