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Interactive comment on "Satellite observations of peroxyacetyl nitrate from the Aura Tropospheric Emission Spectrometer" *by* V. H. Payne et al.

Anonymous Referee #2

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The article "Satellite observations of peroxyacetyl nitrate from the Aura Tropospheric Emission Spectrometer" by Payne et al. presents a novel look at the potential for tropospheric observations of PAN from the TES instrument. This work presents tropospheric PAN observations, an important addition to the study of the nitrogen cycle. The observations complement the established upper troposphere and lower stratosphere measurements of PAN made by limb-viewing instrumentation.

The paper presents a detailed look at an optimal estimation approach to invert TES measurements into PAN partial columns and makes a fairly convincing case based on simulations. Although, as the authors mention, in-situ measurements of PAN are sporadic, they do exist. I understand that the paper aims to convince the reader of the quality of the PAN data through simulations but I believe the paper could be improved if

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even a limited number of comparisons to aircraft measurements was made, for example the 2011 BORTAS campaign. Overall, the paper is fairly well presented and I'm happy for the paper to be published once the specific comments are addressed.

Specific comments

P5348 L5: It would be useful to mention which pressure/altitude range at which TES measurements are most sensitive to PAN. Even though you mention one degree of freedom, most information appears to come from the mid-troposphere looking at the averaging kernels.

P5351, L18: what are the advantages in using a natural log retrieval for the retrieval. Are you not falsely constraining the retrieval to have positive values rather than allowing negative values which, although physically impossible, are mathematically correct. Does using a log retrieval also mean that Gaussian statistics are still applicable?

P5352, L6: The meaning of Sa is not clear. I understand Sa to mean the a priori covariance matrix. Could you please clarify.

P5352, L8: how do you quantify what is "relatively linear"?

P5352, L13: did the authors try to perform their own retrievals of P/T, H2O and the other important contributing gases within the PAN microwindows themselves? This could be done using the level 2 data as the initial state, meaning that the PAN retrieval isn't just fitting residual noise or another gas that hasn't been retrieved such as CFC-12.

P5352, L20: Is it possible to verify that the surface emissivity varies linearly across the PAN spectral region? Is this not dependent on surface type? Have verifications been made against databases such as version 2 of ASTER (http://speclib.jpl.nasa.gov/) which compiles over 2400 spectra of natural and man-made materials.

P5353, L4: The authors state that the PAN signal is relatively weak compared to the noise. Have the authors attempted to co-add spectra over areas with similar emissivity, to reduce the noise on the spectrum? Or does the surface temperature and

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atmospheric variability make this unfeasible?

P5354, L9: Why was the initial guess profile set to a single value of 0.3 ppbv throughout the troposphere? The GEOS-Chem model results in Figures 3 and 4, for example, show a large variability in PAN with altitude. Wouldn't an average model profile, with associated variability provide a better starting constraint?

P5354, L12: Could the authors please explain "null-space" within the text.

P5355, L12: The work of Allen et al. shows that PAN has many absorption bands across the IR range. Would extending the retrieval to these other bands improve information on the vertical structure?

P5356, L11: As biomass burning is a very large source of PAN, a useful application of the dataset would be to observe these events. Would TES PAN retrievals be possible within wildfire plumes (generally cloud-free, but high optical depth)? P5356, L16 makes a qualitative assessment of the capability of PAN retrieval in higher optical depths, but is not explored. Could the authors make a more quantitative assessment? Siberia would be a good test case, as an area with high PAN (based on the model) and a large number of wildfires at that time of year.

P5357, L20: Are surface temperature and surface emissivity important components of the total error?

P5359, L23: I am slightly concerned by the assumption of CFC-12 being very well-mixed, particularly as Figure 1 shows that both CFC-12 and PAN have similar broad spectral shapes across a similar wavenumber range. Have the authors looked at the difference in the PAN retrieval with and without inclusion of CFC-12? Does changing the assumption of tropospheric CFC-12 vmr significantly affect the retrieved PAN vmr? What is the variability of the CFC-12 vmr shown across the NOAA Halocarbons & other Atmospheric Trace Species Group (HATS) surface sites (http://www.esrl.noaa.gov/gmd/hats/combined/CFC12.html) for April 2008?

P5360, L10: This sentence is repetition of section 3.4.

P5360, L17: Would BORTAS aircraft measurements from summer 2011 provide suitable validation data?

P5361, L21: The authors note a large number of retrievals over the Arctic, with some of the largest vmr. Can the authors please characterise any problems with the Arctic retrievals. In particular, does ice cause issues in terms of emissivity or characterising surface temperature? Does this impact your error estimate on the Arctic PAN data? Do you get the same sensitivity to PAN over the Arctic as for mid-latitudes (i.e. do the averaging kernels appear similar)?

Technical comments

Figures: Figure 1: Please change "F12" to CFC-12, as this is how the gas is referred to in the text. Also, N2O and NH3 are similar colours and so it is not easy to see which is most important within the figure.

Figure 5: The font size is very large compared to the text. Please reduce the font size.

Figure 8 & 9: The colours for East Asia do not appear to match, between figures. Please rectify this.

P5348 L2: does the algorithm have a name? This would be useful for future papers on TES PAN retrievals.

P5356, L5: This sentence is jumbled and repeats "here", please rectify.

P5356, L25: Please change to "uncertainty"

P5359, L1: Again, please correct the spelling of "uncertainty"

P5360, L1: Please change to "uncertainties"

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 5347, 2014.