

Interactive comment on “Polar night retrievals of trace gases in the Arctic using the Extended-range Atmospheric Emitted Radiance Interferometer” by Z. Mariani et al.

Anonymous Referee #2

Received and published: 11 March 2013

Mariani et al. describe the retrieval and validation of trace gas column amounts for O₃, CO, CH₄ and N₂O from the ground-based FTIR emission spectrometer E-AERI over two measurement periods. The paper is logically structured and well written. The comparisons with various other instruments indicate that the presented dataset is sound. However, as described in more detail below, there are some serious issues regarding the applied data retrieval and error assessment which have to be substantiated before the paper can be accepted. Further, the reason for some seasonal dependent biases of the results of E-AERI compared to validation instruments could be illustrated in more detail.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Detailed comments:

Title 'Polar night retrievals of ...': Since the paper describes retrieval from E-AERI during the whole year, this part of the title appears a bit too restrictive.

P554L22 'so called "dirty window" around 400cm⁻¹ where much of the infrared cooling to space occurs': It should be specified which 'cooling to space' is referred to here - since it is not the cooling of the earth surface (which occurs in the IR-window) but of higher atmospheric regions.

P557L8 'While in solar absorption spectroscopy the right most term in Eq. (3) can be neglected': It should be made clear, that this statement strongly depends on the opacity of the atmosphere at distinct wavelengths. E.g. at optically thick regions of the atmosphere this term cannot be neglected.

P559L7 'uniformly shifted (increased/decreased)': What is fitted: a scaling factor or an additive offset?

P559L10 'to the lack of vertical sensitivity': I believe that profile information through the line shape is lost by the coarse spectral resolution. However, for broad windows with variable optical thickness there should still be information on the profile through different optical depths at different wavenumbers (like in IR nadir sounding from satellite). This is certainly the case for temperature retrieval in the 15 μm CO₂-band but also most probably for ozone in the 10 μm band and perhaps for CH₄ or N₂O. Could you comment on this?

P558L18 'Sa, which constrains the retrieval to the a priori, was set to 30% for each target gas': Why is it set so stringent? For a retrieval of only column amounts, i.e. where no vertical profile information is retrieved but only a scaling factor, I would expect that no constraint at all is needed. I would strongly urge the authors to perform retrievals without any constraint or at least with a very loose one (e.g. 1000% a priori error) to see the influence of the a-priori. Further, in Fig. 3 and Fig. 6 there are results at the

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper



very edge of the a-priori assumption. To see how much information comes from the measurement compared to the a-priori, e.g. the degrees of freedom should be shown.

P559L26 ‘The signal-to-noise ratio (SNR)’: How is SNR defined here? It is stated as a single value, however, in thermal emission sounding, it should be very different at different wavenumbers (e.g. very small where there are no emission lines). The use of SNR probably makes sense in case of solar absorption measurements where the signal is on a constant high level. But in case of thermal emission observations the NESR (which varies much less than SNR with wavenumber) should be the correct quantity to set up the S_{ϵ} matrix as it is standard e.g. for limb-emission sounding from satellite or balloon. Could you justify your choice?

P559L6 ‘This technique is described in more detail in Rodgers (2000)’: Could you specify more precisely where in the book of Rodgers (2000) this is described?

P559L26-P560L7: This adaptation of S_{ϵ} can be seen as the search for an optimum regularization parameter. However, in theory, S_{ϵ} should only contain the variance derived from the estimated NESR values. Any regularization is normally performed by adaptation of S_a . Could you defend your approach in that respect.

Sect. 3.1 general: Have there been any fit parameters apart from the profile scaling factors, like a baseline-offset to account e.g. for continuum of non-detected clouds? (The residual spectra in Fig. 2 are so nicely distributed around zero, that I’ve the impression that some wavenumber-constant offset has been jointly fitted.)

P560L23 ‘Table 1 lists the optimal miniwindow selected for each trace gas’: What is meant with ‘optimal’ in this respect? Has an optimization algorithm been applied?

P560L25, Table1 ‘and the typical RMS residual in the spectral fit’: Since radiances are fitted I would expect the RMS in radiance units. However, it is given in percent. So how is it defined? I would like to see it relative to the estimated NESR derived from calibration measurements (i.e. the χ^2) to be able to estimate the quality of the fit.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Fig. 2: The residuals e.g. in case of N₂O and CH₄ seem not only to contain spectral noise since these are rather variable with wavenumber. Could you elaborate on this? There is probably a problem connected to the instrumental line-shape (ILS). It is important to specify in the text how the ILS has been determined and how it is handled in the forward model. Has there been any kind of additional apodisation applied?

P561L12 ‘Under this approach, the smoothing error (due to interpolation), S_s , and measurement error (due to noise), S_m , are added in quadrature with the forward model parameter errors and interference errors.’: 1.) As written e.g. by Rodgers (2000), p.49: ‘to estimate the smoothing error covariance, the covariance matrix of a real ensemble of states must be known’. Since for S_a a value of 30% has been used in general for all gases, the smoothing error which is given here seems wrong. It can only be correct if the real height-dependent covariance of the single gases would be used. 2.) Since S_ϵ has been determined like a regularisation parameter, the resulting S_m can also not be correct. For a correct determination of S_m the measurement NESR should have been used for S_ϵ .

P561L14 ‘The noise equivalent spectral radiance (NESR) quantifies the radiometric calibration error’: The NESR in emission spectroscopy normally quantifies the instrumental spectral noise while radiometric calibration is more a broadband effect with a relative (gain) and absolute (offset) error term. Could you explain your statement?

P561L21-26: It is not clear which temperature uncertainty has been used: Vaisala or ECMWF?

P264L1-17 ‘...of increased H₂O and scattered solar energy from aerosols during this season...’: In case the aerosols are smaller than about the wavelength, scattering can be neglected and the effect in the emission spectrum is primarily that of broadband continuum emission. Only for larger aerosols scattering becomes important. This should be mentioned. Further, it would be good to compare a fit in the summer with one in the winter since in presence of aerosols and/or H₂O continuum effects there should

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

be a baseline offset in the residuum (this is connected to the question whether there is some additional baseline/offset fit in the retrieval). From analysis it would be informative to see, like in Fig. 3, the broadband offset versus time in order to correlate with the apparently larger bias between HR125 and E-AERI in summer compared to winter.

P565L2: To prove this statement about the vertical sensitivity of E-AERI I would recommend to show e.g. the height-dependent averaging kernel of the retrieval for the different gases.

P565L3 ‘The day-to-day variability in the CH₄ and N₂O column is greatest in the summer’: I cannot really spot this in Fig. 2 when comparing polar winter to summer. Could you make it more clear.

P567L20 ‘Both of these amplitudes are larger than that in Oklahoma (40 %) (Yurganov et al., 2010), indicating a stronger 365-day seasonal cycle of CO at Eureka compared to mid-latitudes’: Given the larger bias of CO vs. the HR125 in the summer, this seasonal cycle may be overestimated. How large is it for the HR125? This should be discussed.

P568L8 ‘The additional error due to this removal is small (< 1 %) for all trace gases. The removal of the first 600m has a large effect on tropospheric trace gas species, such as CO, which are heavily concentrated within the first 600m (~20%) compared to stratospheric species, such as O₃ (~0.6% at Eureka).’: I don’t understand why the additional error should be small when in the next sentence it is stated that the effect of the removal is large. Since one does not know the altitude profile, I assume that the error for tropospheric trace gases could also be larger than 1%.

Fig. 6: For CH₄ and N₂O there is a clear positive bias in the summer compared to Fig. 3 and the HR125-measurements. Could you comment on this?

P579L11 ‘RMS residuals < 1.5 %’: 1.5% relative to what? Since there are small and large emission lines, as stated above, I think a relative value is not very sensible here. It could better be given relative to the NESR.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)

Fig. 7: In this scatter-plot the E-AERI column amounts of O₃ look kind of ‘binned’ i.e. the same value of E-AERI for different values of 125HR (and sometimes vice-versa). Are these different values of HR125 for the same E-AERI column? This should be stated at least in the caption. If this is the case, can such correlated pairs be used in the same way as fully uncorrelated ones for calculating the statistical parameters as given in the plots?

Technical comments:

P553L12: Since there are different definitions of resolution, please define which value this definition of resolution refers to (since sometimes $1/2L$ and sometimes $0.61/L$ (FWHM) is used).

P557L6 ‘of the layer’: Change to ‘from the layer’

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 547, 2013.

[Full Screen / Esc](#)[Printer-friendly Version](#)[Interactive Discussion](#)[Discussion Paper](#)