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Interactive Comment

Interactive comment on “Recipe for continuous monitoring of total ozone with a precision of around 1 DU applying mid-infrared solar absorption spectra” *by* M. Schneider and F. Hase

M. Schneider and F. Hase

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We appreciate all the comments made by the referees. Below they are answered in detail:

Comments in the Referee Quick Reports:
(1) In the Referee Quick Report one referee mentioned that Figure 2 is not informative enough. We agree. The problem is that it is very difficult to discern the small differences between the output and the input column amounts. Therefore, we decided to change Figure 2. Instead of the output column amounts the new Figure 2 shows the difference between the input and output column amounts (i. e. the errors) versus the

input column amounts. We think that now the Figure gives much more information about the magnitude of the different errors and their dependance on the input column amounts.

(2) In the same Report it was criticised that there is no plot that shows how the errors depend on solar elevation angle. We agree with the referee that the paper would widely benefit from such an additional error characterisation. Therefore, we decided to introduce an additional Figure (Figure 4) in Section 3. This Figure 4 is very similar to our new Figure 2. It shows the error (difference between output and input vertical column amount). In difference to Figure 2 it shows the error for the new retrieval method and versus the input slant column amount (and not versus the input vertical column amount like Figure 2). The slant column amount is proportional to the magnitude of the absorption signal in the spectra. Figure 4 shows how the errors depend on the slant column amount (i. e. on the magnitude of the absorption signal). We find that besides errors due to incorrect assumption of the solar elevation angle, errors produced by ILS uncertainties or wrong line parameters assumptions depend on the slant column amount.

Comments of Referee #1:
(1) The referee criticises the lack of an experimental check of our theoretical study. We agree: a theoretical claim calls for an experimental verification. However, our theoretical study is an important step towards ground-based high precision measurements and it is worth to be published in their own right. An extensive comparison of FTIR with Brewer data is under preparation.

(2) Strictly it should be a-priori of $^{48}O_3$. The a-priori of the other isotopologues are calculated from the $^{48}O_3$ a-priori and data from Johnson et al. (2000). We will change this in the manuscript.

(3) The $^{50}O_3$ profiles are determined by optimal estimation. This is already mentioned some lines before.

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(4) Here the temperature profile is still not part of the state vector. A-priori would always imply that it is a variable that will be improved by the measurement. This is only the case for our new method introduced in Section 3.

(5) New spectroscopic data always requires a detailed quality check before applying it for spectral analysis. Therefore, we do not apply always the latest HITRAN data.

(6) We will introduce all technical corrections into the final manuscript version.

Comments of Referee #2:

(1) Concerning the critics about the lack of an experimental proof please refer to answer (1) to Referee #1.

(2) Ok, we will read in the literature and adequately cite similar works done by satellite people.

(3) Ok, we will cancel the word 'continuous' in the title. However, the term 'recipe' should be maintained, since we list all the 'ingredients' that are necessary to achieve such a high precision (in Section 4). So we will change the title to 'Recipe for monitoring of total ozone with a precision of 1DU applying mid-infrared solar absorption spectra'.

(4) Ok, we will change it to: '[...] how climate change or ongoing emission of ozone destroying compounds will affect [...]'

(5) The applied windows are shown in Figure 1. These are 6 different windows between 780 and 1015 cm-1. On page 9096 these windows are described individually. We think that all this is clear enough from the manuscript as it is.

(6) We handle a weak interfering species by scaling an a-priori profile. In this case the inversion of a profile is ill-posed. For scaling the problem is well-posed and no assumption of a-priori covariances is needed.

(7) Yes, that would be correct, if we did not retrieve the O_3 profiles. However, optimal estimation of O_3 profiles means that we derive the O_3 distribution from our measured

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spectra. This is possible mainly due to the pressure broadening of the absorption lines. Only scaling a mean or a-priori profile would leave as with systematic errors.

(8) Our estimation includes simulations with solar elevation angles down to 5°. This will become evident from the new Figure 4 that will be introduced in the final manuscript version.

(9) Naturally, a wrong temperature affects the line intensity and the shapes. This produces the errors that we call errors due to uncertainties in the assumed temperature profile. A main message of our paper is that these are the main remaining errors if one applies a state-of-the-art instrumentation. We propose a method that nearly eliminates these errors, since we introduce a retrieval of the temperature from the measured spectra (Section 3).

(10) Yes, the absorption coefficients are calculated by applying the HITRAN parameterisation. They depend mainly on temperature and pressure. When no temperature retrieval is performed temperature and pressure will not change during the iterative procedure and it is sufficient to calculate this coefficients at the beginning. When the temperature is retrieved, it will change after each iteration step and the coefficients have to be recalculated.

(11) Derivative with respect to the spectrum. The inversion algorithm needs to know how the spectrum changes in response to changes in a given variable.

(12) The model levels are altitude levels (one could also use pressure levels). We will change 'altitude fixed model level' to 'altitude level of the model'.

(13) These terms sound quite technical but they are commonly applied in the remote sensing community (see e. g. Rodgers (2000)).

(14) NCEP: National Centre for Environmental Prediction

(15) The FTIR is installed on a mountain observatory. The temperature close to the mountain is higher than the temperature encountered by the sonde at the same altitude

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but above the sea in the free troposphere. This is due to the presence of the heated Earth's surface.

(16) We will introduce all technical corrections in the final manuscript version.

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