We thank the reviewer for very thorough and constructive comments. The quality of the manuscript has been improved by these comments and suggestions. Below are our responses to the comments. The response (in *blue*) follows each comment.

Reviewer #3 (amtd-7-C192-2014):

General comments:

This paper focuses on a description of measurements of O2 A-band spectra in directly and diffusely transmitted sunlight using a high-spectral resolution ground-based spectrometer, called HABS. In addition a comparison with computed spectra is performed, and differences are shown. The HABS instrument is a very interesting development for research, because of its high spectral resolution and its capability to measure the Stokes parameters I, Q and U (only V is not measured).

The application of these HABS measurements to get profile information of aerosols and clouds is mentioned several times but not investigated. Please reduce the repeated mentioning of the application without showing it. Showing results of the application is not essential in the present paper, but it should be clarified what the aim is of the paper.

The topic of the paper fits well into AMT. The text reads well and the figures are clear. However, several clarifications are needed. The paper could be accepted after several major and minor modifications, mentioned below, are performed. The paper contains quite some typos; please correct the text carefully.

Specific comments:

1. The main finding of the paper is the comparison between the measurements and the model results for a few cases. The differences are 5-9 %, in direct and diffuse radiation. What would be important to add is a deeper discussion of the cause of these differences: is it purely instrumental, or also an oxygen cross-section problem? From this discussion the readership could benefit.

Answer: We have added more discussion of the cause of these differences into the revised paper. We have added more comments into the revised paper as suggested.

"Currently, to some extent, relative difference between measurements and model simulation always exists for both direct beam and zenith diffuse radiance. To reduce the difference between observation and simulation, further studies as follows are needed: (1)

develop different types of high-resolution O2 A-band spectrometers, use their measurements to cross validate the accuracy of observation; (2) perfect the data base about the oxygen cross section parameters; (3) perfect the related radiative transfer model and improve the accuracy of model parameters setting; (4) further assessments of instrument slit function and performance;(5) consider other issues, such as Raman scattering effect."

2. The abstract and introduction are quite confusing regarding applications of the O2 A-band for aerosols and cloud profiling. What should be added to the paper is a discussion of the (fundamental) difference between O2 A-band observations from space, in reflected light, and from the ground, in transmitted light, which is the topic of this paper. The cloud/aerosol profile information content of space-based observations is much larger than of ground-based observations, due to the difference in atmospheric penetration depth of weak and strong lines for reflected light.

The abstract starts with: "The pressure dependence of oxygen A-band absorption enables the retrieval:": this is an unclear sentence. For profile retrieval from reflected light, no pressure dependence of the oxygen cross-sections is needed; the depth of the lines is determined by the level at which scattering takes place. Please clarify the formulation.

Answer: We have added some discussion of the fundamental difference between O2 A-band observations from space, in reflected light, and from the ground, in transmitted light. The discussion is shown in Section 5 (Discussion and future work based on HABS) in the revised paper. One of the important potential applications of HABS is validating the satellite measurements (e.g., O2 A-band spectrum from OCO).

3. Are the solar Fraunhofer lines included in the calculated spectra, and if so which source was used?

Answer: Yes, we have considered the Fraunhofer lines when we use the database of solar radiation at top of the atmosphere. The data source is **FLUXATLAS2005,** downloaded from http://kurucz.harvard.edu/sun.html
http://kurucz.harvard.edu/sun/fluxatlas2005/
We have added the comments and reference into the revised paper.

Reference:
Chance, K., & Kurucz, R. L. (2010). An improved high-resolution solar reference spectrum for Earth's atmosphere measurements in the ultraviolet, visible, and near infrared. *Journal of quantitative spectroscopy and radiative transfer*, *111*(9), 1289-1295.

4. There are many references to publications of the authors but missing are relevant references from European groups observing and modelling O2 A-band spectra from space and ground. Papers to be referred to are e.g.:

- Stam et al., 1999, on modelling the polarization of the O2 A-band
- Boesche et al., Applied Optics, 2005, and Boesche et al., JQSRT, 2006, on measuring and modelling the polarization of the O2 A-band
- Koelemeijer et al., 2001, on GOME O2 A-band measurements
- Kokhanovsky et al., 2006, on SCIAMACHY O2 A-band measurements

Answer: We have added all the above references into the revised paper as suggested.

5. It would be worth mentioning the GOSAT satellite, which has an FTS onboard with a similar spectral resolution as HABS, namely 0.015 nm (Kuze et al., Applied Optics).

Answer: We have added the comments about FTS and the related reference into the paper as suggested.

6. p. 1032: equation 4 should be removed since the HABS instrument is not measuring V. So in equation 5, V should be removed. Then DOP becomes the degree of linear polarisation. Please refer to Van de Hulst 1957 for the definition of the Stokes parameters.

Answer: For equations 4 and 5, we think although the HABS instrument is not measuring V, keeping equation 4 and V in equation 5 in the paper will make the analysis about polarization measurement more completed. We have revised the related reference to the revised paper as suggested.

7. p. 1034, l. 15: this statement is not true: the O2 A-band lines are not individually resolved by HABS. This could be seen by comparison with a line-by-line calculation using e.g. HITRAN.

Answer: Due to the limited spectral resolution (although it is high), the resolution of HABS measured O2 A-band lines cannot be as high as the simulated spectrum through line-by-line calculation using HITRAN. We have revised this statement as follows: *"It is clear that the primary absorption lines are clearly resolved."*

8. p. 1034: l. 16-18: this is an unsubstantiated claim. Please remove this sentence.

Answer: We have removed it as suggested.

9. p. 1038: l. 2-3: this is quite vague; please explain.

Answer: We have revised it as follows: "*In this study, we used the same method as Li and Min (2012), which has been proven to have the ability to make an accurate fitting calculation: the shapes and wavelength positions of the absorption lines from simulated spectra and observed spectra are well consistent with each other .* "

10. p. 1038:l. 21: how is the relative difference defined, and what is the unit of the difference (percentage or fraction)?

Answer: The relative difference is defined by comparing the normalized radiation of observed spectrum and simulated spectrum through the equation: (Observation-Simulation)/Observation. The unit is fraction. We have added some explanation into the revised paper.

11. p. 1040, l. 11-14: how do you explain the fact that the direct beam radiance differs this much and in the same amount as the diffuse radiance, while the latter is expected to be more difficult to model than the direct radiance?

Answer: Yes, the simulation of diffuse radiance is more complex than the direct radiance. In this study, we only focus on the radiation closure, thus we only use the cases under clear sky condition to do the analysis. Compared to the cloudy condition, the simulation error under clear sky condition is much smaller. We think the error from the model simulation itself may not be the dominant one. The main difference between observation and simulation could be from other common error sources, such as model setting error (e.g., temperature, pressure, aerosol extinction), limited SNR near the absorption line centers, wavelength registration error, etc. Thus the relative difference for direct beam and diffuse radiance are similar here.

12. p. 1040, l. 18 until end of Sect. 5: this part does not belong in the summary but in the introduction. Please remove here.

Answer: We have removed them here and moved them into another section (Section 5 in the revised paper: Discussion and future work based on HABS).

13. Figures:
Captions: GMT > UTC

Answer: We have revised GMT to UTC as suggested.

Fig. 10: how are the spectra normalized? What is the unit of the difference spectra?

Are the oscillations in the difference spectra caused by a spectral shift? Could you shift the spectra to reduce the oscillations?

Answer: If we look through the whole O2 A-Band spectrum, at the wavelength range around 759.4 nm and 768.8 nm, the absorption of O2 is ignorable. Based on these measurements without O2 absorption, we can obtain the spectrum baseline by using linear fitting method. Divided the whole O2 A-band spectrum with the spectrum baseline, we can get the normalized spectra. We have added the following comments into the revised paper.

"…To better indicate the absorption characteristics in O2 A-band, the spectra are represented as normalized radiance. The normalized radiance is calculated by dividing the original measured/simulated radiance with the spectrum baseline. The latter is derived by the measured/simulated radiance at the shoulders of the O2 A-band (without oxygen absorption), e.g., at about 759.4 nm and 768.8 nm, which have the best SNR and are insensitive to spectrum shifting. They are only impacted by the column integrated atmospheric optical depth, and less sensitive to the vertical profiles of aerosol and cloud optical properties."

The difference spectra show the relative difference between the simulated spectra and observed spectra, thus they have no unit.

The noise could be caused by a spectral shift or the error of the wavelength registration. In this study, we have tried our best to constrain the impacts of spectral shift. In Fig. 10, the noises are mainly caused by several factors: the noise of the observed spectra (especially for the absorption lines center), the error from the spectra simulation, and the error of the wavelength registration (especially for shoulders of the absorption lines). In this study, even the shifting of the observed spectra is well calibrated, the comparison difference also exists, and it is hard to be reduced by shifting the spectra. We tested this by manually shifting the observed spectra, and then found the comparison difference caused by the apparent shifting error could be many times larger than current ones.

Fig. 11: why is the deepest part of the O2 A-band missing in (a)? Why are there two dotted lines in (b)?

Answer: (a) The deepest part of the O2 A-band locates in the R branch (left part) of the spectrum, which has the lowest signal-to-noise ratio (SNR). Furthermore, some adjacent absorption lines in the R branch are combined and hard to define. Thus, the error of wavelength registration in the R branch is relative bigger. These will bring in extra noise to the comparison studies. Thus we mainly focus our analysis on the P branch.

(b) For the dotted lines, they indicate the variation of solar radiation observation versus air mass. Because the atmospheric conditions in the morning and in the afternoon are not totally same, we can see two dotted lines for some air mass ranges.

Fig. 12: diffuse spectra > diffuse zenith sky spectra

Answer: We have revised it as suggested.

Textual errors:
p. 1028:
- l. 9: 0.16 nm > 0.016 nm (this mistake occurs several times)
- l. 11: combing > combining
- l. 12: HTRAN > HITRAN (this mistake occurs several times)
- l. 16: (-0.06, 0.05): please clarify. What is the unit? Fraction? Percent / 100? These confusing numbers occur several times in the paper.

p. 1029:
- l. 3: the atmosphere > the atmospheric spectrum

p. 1030:
- l. 19: monochrometer > monochromator (this occurs several times)

p. 1031:
- l. 15/16: the absorption spectrum

p. 1032:
- l. 1: enhances
- l. 2: are > have

p. 1033:
- l. 1: spectrum shape > spectral shape (please check for more occurrences in the paper)
- l. 2: a filter function

p. 1037:
- l. 3: and etc. > etc.
- l. 4: DISORT model
- l. 5: remove the word super, this is meaningless (occurs more often)
- l. 5: spectra > spectral
- l. 27: the slit function

p. 1039:
- l. 27: 0.16 > 0.016

Answer: Thanks a lot for the very thorough comments. We have revised them as suggested.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 1027, 2014.