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Atmospheric Measurement Techniques Discussions

Interactive comment on "Intercomparison of Pandora Stratospheric NO_2 Slant Column Product with the NIWA M07 NDACC Standard" *by* Travis N. Knepp et al.

Anonymous Referee #1

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General Comments This paper presents an investigation of the Pandora instrument as a means to validate SAGE-III measurements of stratospheric column NO2. The Pandora instrument is a ground-based sun-viewing spectrometer and has proven success in measuring lower tropospheric NO2; Pandoras have been shown to provide reliable measurements of NO2 column amount in areas where the NO2 column is dominated by a polluted troposphere, but their capabilities in areas where the column is dominated by the stratosphere instead have not been previously investigated. Thus, the authors seek to determine the ability of Pandora to observe the stratospheric NO2 column through comparison with a collocated M07 spectrometer (an NDACC-standard instrument) at Lauder, New Zealand, a location considered to be atmospherically clean. The

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core motivation for this work is clear and necessary: SAGE-III intends to deliver stratospheric NO2 column observations as part of its final, end-user data sets, though this quantity is quite difficult to validate. A Pandora would provide a near-ideal ground-based instrument against which to validate SAGE-III measurements, given its potential to retrieve stratospheric NO2 columns and the fact that it is small and mobile, allowing it to be set up at many different locations at different times of year for a robust validation effort. This work found good agreement between the M07 instrument and the Pandora, demonstrating the potential usefulness of Pandora to validate SAGE-III observations for solar zenith angles between about 85°-90°. However, paper lackin context necessary for reader to understand full motivation and some other flaws listed here. Therefore, I recommend publication after several major revisions.

Specific Comments – Section 1: More details on the SAGE missions necessary. For instance, please add some more detail about how the SAGE-III/Meteor instrumentation works (including a short description of its viewing geometry, overpass times, etc.), the key SAGE species measurements (besides NO2), and any other data for which SAGE is used. This reviewer is not familiar with this missions, suspects that not all readers will be familiar. Added detail will greatly help to provide context on why validation against Pandora is both necessary and desirable.

What is the citation(s) for the NIWA M07 instrument being considered a standard for stratospheric NO2 measurements? This is unclear.

The NIWA M07 instrument is specifically mentioned only within the last sentence of the introduction; is this the particular instrument that is considered a standard for NO2? Or was it chosen for this intercomparison for another reason, and if so, why? This instrument needs to be introduced along with NIWA rather than at the end of the introduction, to prevent confusion over why the M07 instrument was used.

– Section 2.1: “Briefly, the Pandora model used in the current study consisted of. . .” is unclear; is this different from the “normal” working setup of the instrument, or the

same? A note on this would be helpful. The statement at the end of the section (“. . .the Pandora only operated in the zenith-observation mode. . .” also contributes to the lack of clarity.

– Section 3: “. . .both instruments were operated in their normal states, not in a customized operation mode. . .” – this gets back to the comment about Section 2.1 about whether Pandora was used the same it has been in previous studies (or not). This statement should be a reiteration of the mode of operation for Pandora (and M07) from Section 2, to make sure it is clear how these instruments were used (and how this does or does not differ from previous studies).

– Section 3: the statistics thing (troposphere beings so different)

– Section 3: Last sentence (“Since Lauder provides a clean, background-level,. . .”) provides a clear statement of the motivation for this work that is not dependent on the specific SAGE mission. This should be perhaps mentioned earlier in the paper (maybe even the introduction after introducing Pandora and Lauder, NZ).

– Section 4: What are the major retrieval uncertainties for Pandora and M07? These should be briefly described, in Section 2 where the two instruments are initially described. Also should make note of any other known limitations/issues related to the instruments or their retrievals.

What does it mean that some datasets were smoothed? Were both Pandora and M07 datasets smoothed, or portions of one or the other instrument’s datasets? This statement is unclear. Also, why was five minutes chosen for the averaging time–why not 1 minute, for example?

– Section 4.1: Need to explicitly state that the R2 values are given in Table 3, to make it easier for the reader to find the numbers that support the result that the correlation increased with decreasing SZA. Might even be good to list a few R2 values for some of the SZA bins, since to this reviewer, the correlation for the 87.5-90° SZA bin looks

strongest when looking at the plots in Fig. 3 (though this was not the bin with largest R2). A follow up question is whether the statistical significance of these correlations was tested, to determine if the correlations were statistically different from each other (at least for the bins containing SZAs less than 92.5°); a direct comparison of correlation coefficients can be misleading.

Are R2 values available for the sub-correlations for each panel of Fig. 3? An example for at least one panel might be good, showing how the correlation decreased with lower SZA within that SZA bin (and by extension for the other SZA bins).

Why can the dependence on SZA not be separated from day-to-day chemical variability? I'm not sure what "day to day chemical variability" refers to, so this statement is confusing. Does this refer to the annual variability of the NO2 column, or daily variability of the column? There needs to be a justification for this statement. It would seem that the correlation's dependence on SZA is due to daily photochemistry (available sunlight for photochemical reactions involving NOx), as well as limitations of either instrument at high SZA. So to start the analysis presented in Fig. 3 could be extended, to investigate how the time series of the NO2 columns from both instruments within each SZA bin and over all SZA's compare, comparing to O3 column data, etc.

– Section 4.2: Do the authors have a hypothesis for why the tailing behavior was limited to winter conditions? This would be good to state in the paper.

It's true that the R2 values remained high throughout most of the year, but it can be seen that R2 drops during the winter months for most SZA bins in Fig. 5, such as April-July 2015 bin for the 90-92.5° bin, and for the 80-85° bin. Is this just noise, or is this related to the trends observed in slope and SCD ratio for winter vs. summer? It needs some explanation, and this reviewer is not convinced that it can be said that there is no seasonal dependence seen in the correlation at this time.

– Section 5: The second conclusions paragraph is a little confusing to read. Not quite sure what the message is about, particularly about the twilight retrievals. Some re-

wording should be all that is needed to make the message clearer.

Technical Corrections: – When referencing parts of a figure, such as panel a in Fig. 3, use parentheses to encapsulate the letter to make it easier to distinguish for the reader (e.g.; Fig. 3 panel a → Fig. panel (a)). – Fig. 4 says “orrelation” in the plot titles rather than “Correlation”

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