Please note the following format:
• Reviewer's comments are in *italics*, followed by a ">" denoting the authors' reply.
• Paragraph numbers, Para(n), in the responses refer to the revised manuscript.

General Comments:

The manuscript describes incremental improvements in an instrument for the measurement of ambient O3 from aircraft via UV absorption. It builds on the decades-long heritage of a well-respected instrument deployed by NOAA. Novel improvements include the use of polarized light to fold the optical path thereby improving instrument precision for a given physical cell length. The authors were able to achieve slight reductions in instrument size and weight, while maintaining, or slightly improving, instrument performance. It appears to be a very nice instrument, though it is clearly an incremental improvement using good ideas, as opposed to totally novel approach. The overall quality of the manuscript is very high. The instrument and its performance are thoroughly described. I recommend publication essentially as is, though I suggest that several minor modifications be considered.

Specific Comments:
(1) Pressure measurement: Are there 2 sensors, 1 for each cell, or is there only one? Section 2.8 is all written in the singular, as if there is only 1 sensor. If there is only 1, where is it, and how accurately does it reflect the pressures in the 2 cells? I'm concerned the pressure in a cell could differ depending on which of the 2 flows is directed through it, the scrubbed flow or the sample flow. Or, are the 2 flows so similar that there is no pressure difference? If there is one sensor on each cell, then please state this.

> There is only one sensor because the difference between pressures in the two absorption cells is small under flight conditions (< 0.1 hPa). Two sentences are added for clarification: "The difference between pressures in the two absorption cells is small under flight conditions (< 0.1 hPa). Therefore only one pressure sensor is needed for cell pressure measurements."

(2) Noise from turbulence in sample cell: How significant is this? And how does it really affect the precision? It is certainly plausible that this is a significant effect, but I am a bit surprised. The authors attribute the worsening of precision, when in flight, to this effect, but I am not convinced that this is correct. Could there not be other effects in flight? Vibration? Electrical noise? Pressure fluctuations? How well understood is the effect of turbulence on precision, and how certain are the authors that this is the dominant effect, vs. other possibilities?

> It is significant and is demonstrated in Fig. 6. Please also see relies to the 2nd Reviewer's comments. The reason we exclude the other effects in flight is because we can change the flow rate and inlet to reduce the noise.

(3) Given the focus on the instrument itself, and a relative lack of focus on inlets, I don't think "and sampling inlet" belongs in the title. In any event, 2 inlets are mentioned, so if it

is kept, it should be made plural. I appreciate that inlets are hugely important and may compromise instrument performance, but there really is very little focus on inlets in the manuscript.

> The phrase "*and sampling inlet*" has been removed from the title.

(4) p. 3485, lines 5-7: It is stated that the artifact is small, and then it is stated that there is a negative bias of <10 ppb. 10 ppb strikes me as large, if this is 10 ppbv of O3. Please clarify.

> The 10 ppb bias is caused by the extreme humidity change. We have rewritten this part of text to better clarify: "For the catalyst and optical components used in both NOAA O_3 instruments, this artifact is small under normal flight conditions (~ 30 min from wet lower troposphere to dry upper troposphere). As one extreme example, O_3-scrubbed ambient air (~1% water) is replaced with dry synthetic air (< 10 ppm water) within a couple seconds. Both instruments show a negative bias of < 10 ppb at 820 hPa that drops to ~2 ppb after 6 min and continuously decreases to ~0.2 ppb over 30 min."

(5) Sample flow control and "dwell time" of the measurements: How continuous is the sample coverage? Is an interval of data tossed out after the valves switch? Please include this detail. Another way to say this is this: what are the start and stop times for a given 0.5-s value, and is there actually a time gap between consecutive reported values? I think there will be a gap.

> Yes, the Reviewer is correct. We do discard data points during flow switches. A sentence is added: "One data point immediately after the valves V1 and V2 switch is discarded (Proffitt and McLaughlin, 1983)." at the end of Section 2.4, and another sentence is added to the end of the second paragraph of Section 3.1: "Two and four data points are discarded immediately after V1 and V2 switches for 15 LPM and 10 LPM, respectively."

(6) P.3479, lines1-3: I would not go so far as saying that the reported values will not be valid if O3 changes significantly during the flushing period. No instrument perfectly samples all ambient variability. The measurement would still be an average, would it not? And so still valid, just not with the best time resolution.

> The sentence has been changed to: "Otherwise the time resolution of the instrument will be lower than purported value."

(7) Related to (5) above: The 2 cells could potentially have a systematic offset from one another for a given time period in flight (in derived O3 mixing ratio). Is this the case? It seems this would be a useful diagnostic of instrument performance. The authors must have looked at this. Are differences found? Is anything done, at the data reduction stage, to eliminate such differences?

> This is not the case. At any time period between valves V1 and V2 switches, only one

cell is filled with O3-containing ambient air. The other is filled with O3-scrubbed air. The derivation of O3 mixing ratio for a given point from raw digital counts is insensitive to optical changes on timescales longer than a few valve switching intervals. The details are well explained in Proffitt and McLaughlin (1983) and we now point to this paper in the text.

(8) Also related to (5) above: I am concerned about a potential negative bias from this technique that results from a lack of plug flow, and the potential for some scrubbed air to remain in the sample cell while the absorption measurement is being made. Can the authors relieve me of my concern? It seems to me that it might take a few times the plug-flow time to really purge the cell of all the scrubbed air, yet a shorter time is used (p3479, lines 9-12). How is the required flow for a true flush time determined? Are the PDs sampled at a high rate and leveling-off looked for? Is this done in flight to insure the quality of flight data?

> Incomplete flushing is always a concern. Fortunately, the general data reduction algorithm described in Proffitt and McLaughlin (1983) makes the problem obvious in the O3 mixing ratio results. An example is given here: The flow rate was at 15.5 LPM as shown in Figure 1. Count rates for both channels are shown in Figure 2. In either channel the counts are higher without O3 in the cell (scrubbed air), and lower with O3 in the cell. Channel-A data clearly shows counts in transition after valve switch (in this case there are two data points for each switch) before reaching a new stable reading. These data points in transition should be discarded because of incomplete cell flushing. Figure 3 shows the result of insufficient data exclusion (only one point instead of two). A clear reduction in calculated O3 values is visible after each valve switch. Sufficient data exclusion (two points) results correct O3 values (Figure 4).

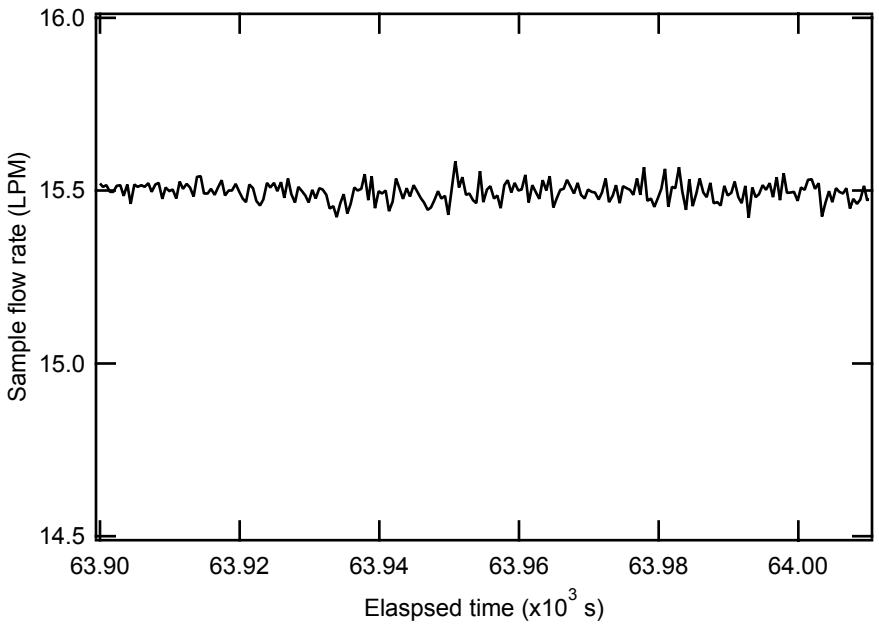

Figure 1. Sample flow rate for a laboratory run.

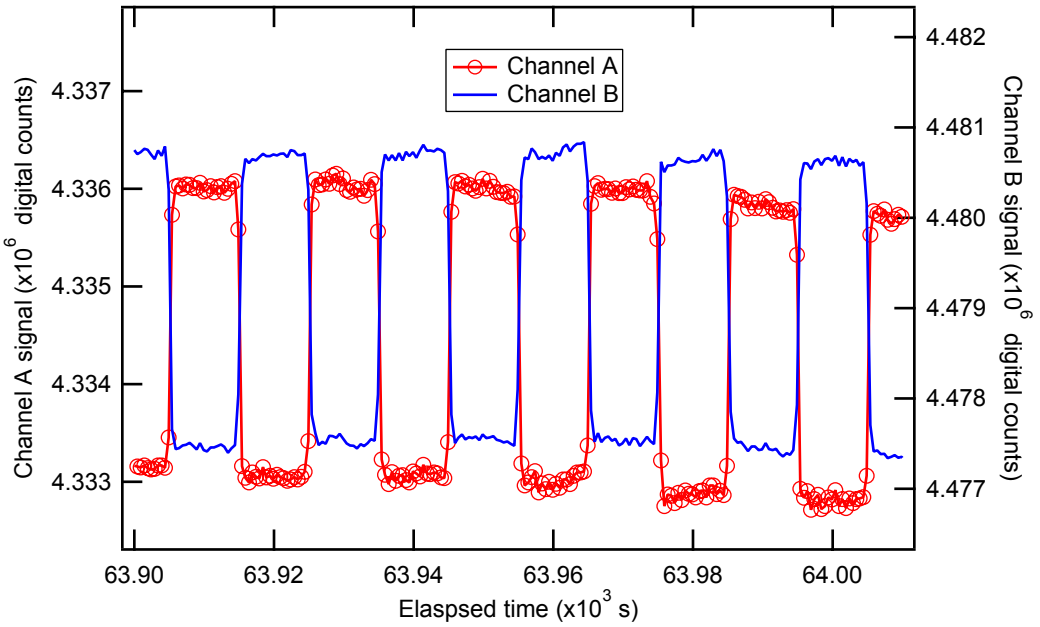

Figure 2. Count rates for Channels A (red) and B (blue).

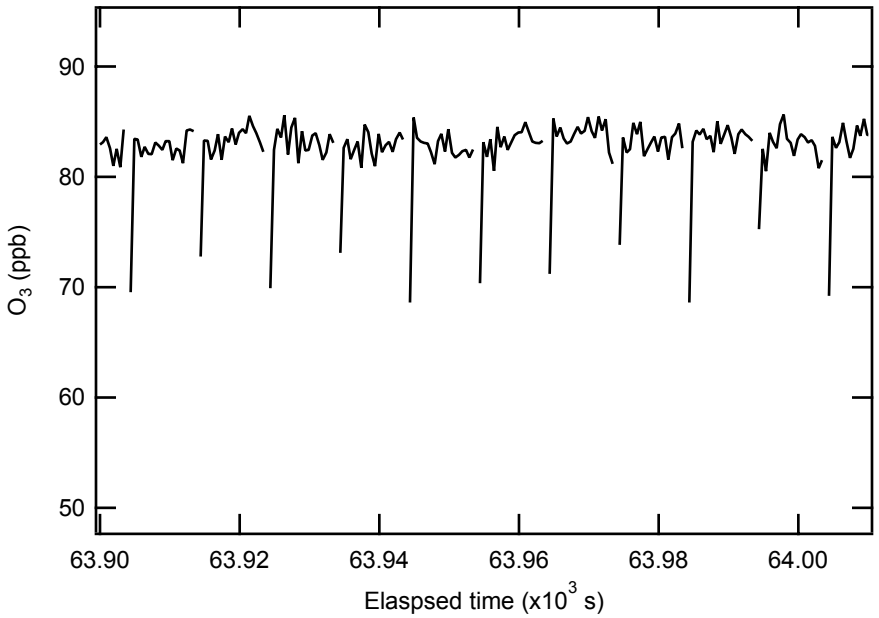

Figure 3. Reduced O3 data with only data point discarded per valve switch.

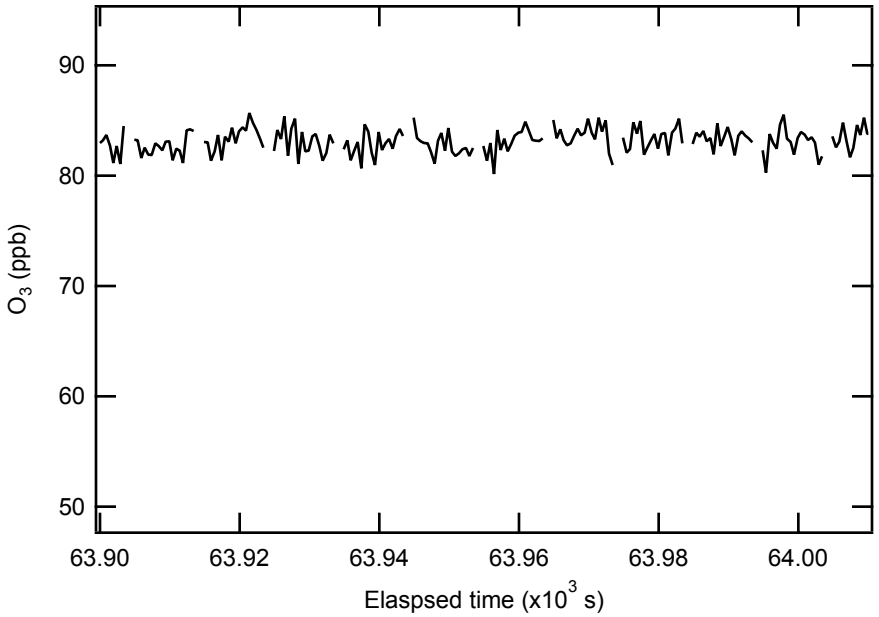

Figure 4. Reduced O3 data with two data points discarded per valve switch.

In the interests of length we have added a sentence that points the reader to the Proffitt et al. discussion of this aspect.

(9) Optical Configuration: Are there any problems due to lack of perfect polarization, or lack of perfect alignment of the optical components. Is alignment robustly maintained? Is the technique sensitive to misalignment?

> We did not notice any problems due to imperfect polarization or misalignment. This is not surprising since imperfect polarization or misalignment change the instrument signal strength, while the data reduction algorithm is only sensitive to the short-term change in signal due to valve switching, which is, of course, due to O3. A paragraph is added to the beginning of Section 3: "The instrument performs well in the laboratory and in flight. The optical system is very robust, unaffected by in-flight vibrations. No problems due to imperfect polarization or misalignment were experienced. This is not unexpected since imperfect polarization or misalignment only affect instrument baseline signal strength, while the data reduction algorithm is only sensitive to the short-term changes in signal due to valve switching, which are, of course, due to O_3 changes (Proffitt and McLaughlin, 1983)."

(10) Abstract, line 9: The sampling rate is quoted as 2 Hz, without a qualifier. However, later it appears that this only applies at high altitudes. I gather from p.3482, lines 12-18, that at lower altitudes the frequency degrades to 1 Hz and 0.5 Hz. If so, then the abstract should reflect this.

> Agreed. Abstract has been changed: "2 Hz at < 200 hPa, 1 Hz at 200 - 500 hPa, and 0.5 Hz at ≥ 500 hPa".

(11) Little to nothing is mentioned of data acquisition. Little is required, but perhaps a few sentences are in order.

> A short section (Section 2.9) has been added for the data system:

2.9 Data system

A National Instrument CompactRio controller (National Instrument, Austin, TX) was used for instrument control, data collection, and communication with the host aircraft. A detailed description of the data system can be found at http://sine.ni.com/cs/app/doc/p/id/cs-12343.

Technical:
p.3484: should be fig. 3, not 2

> Fixed.

p. 3491, fig. 2: the red letters are hard to discern, esp. on a printed copy, a little better on a computer screen. Have you tried a lighter color, even white?

> Due to a computer upgrade, the software for modifying Fig. 2 is no longer available.

p. 3485, line 6: suggest using ppmv, rather than ppm. Likewise for ppb if that is O3 mixing ratio.

> The use of "ppm" and "ppb" is more appropriate to describe the molar mixing ratios measured in this technique.

p. 3476, line 26: could say "precision generally improves" rather than "increases," as the precision's numerical value will decrease.

> Done.