Response to referee 2

Interactive comment on "Carbon monoxide climatology derived from the trajectory mapping of global MOZAIC-IAGOS data" by M. Osman et al.

Anonymous Referee #2

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General Comments

The paper of Osman et al. presents a global, height-resolved climatology of tropospheric carbon monoxide (CO) from MOZAIC-IAGOS data. A trajectory mapping approach was used to inter- and extrapolate the aircraft data to a regular spatial grid.

Several evaluation and validation efforts of the new climatology are presented. This includes detailed comparisons with MOPITT satellite measurements. Furthermore, horizontal and vertical distributions and trends of the CO distributions from the climatology as well as correlations with ozone distributions are discussed.

I found that the paper is well written and interesting to read. It fits in the scope of ACP. Most of the analyses presented here appear to be scientifically sound. The new data set will be of interest for atmospheric modellers looking for CO data sets to initialize and validate their simulations. It will be also helpful to retrieval scientists that could use it as a priori information and for regularization of the retrievals. My main concern is that the paper is very long. In the revision I would suggest to try to shorten and condense the information as much as possible. Specific comments and technical corrections for the author's consideration are given below.

We thank the referee for his thoughtful remarks. All the referees felt this way, so we have removed some sections and figures and tried to reduce the text as well.

Specific Comments

p29874, l8-p29875, l2: Such detailed background information on CO photochemistry might not be needed in this observational paper.

We've reduced the discussion of CO photochemistry.

p29876, l8-10: It seems your climatology is in fact four-dimensional, taking the time domain into account?

That's correct, if we consider time as a dimension.

p29878, l7: Does the 5% calibration error count as "accuracy" rather than "precision" error of the measurements?

It is described as a calibration uncertainty by Nédélec et al., (2003), so it can be regarded as a systematic uncertainty.

p29878, l23: Is there a general reference for MOPITT?

Drummond and Mand, 1996.

p29881, l11-12: How large are the typical vertical errors of your trajectory calculations?

That is discussed briefly on page 29881, and more thoroughly in our previous work. Also, Draxler et al. (1997) suggest that the total error accompanying a HYSPLIT generated trajectory to be anywhere from 15-30% of the travel distance. We have expanded slightly on this in the revised text.

p29881, l24-25: Is there a smooth transition of the correlation length between the troposphere and stratosphere?

Not likely --- based on ozone correlation lengths, (Figs. 5a & 5b of Liu et al., 2009) the transition is not smooth.

p29882, l16: Vectors (x, x_a,...) should appear in bold face, I think. You might add an additional term (+ G eps) in Eq. (2) to remind the reader that retrieval is also influenced by measurement errors (e.g., retrieval noise).

Done.

$$\mathbf{x}_{ret} = \mathbf{x}_a + \mathbf{A}(\mathbf{x} + \mathbf{x}_a) = \mathbf{A}\mathbf{x} + (\mathbf{I}+\mathbf{A})\mathbf{x}_a + \boldsymbol{\varepsilon} \text{ (or Ge)}$$

where $\boldsymbol{\varepsilon}$ is the retrieval error due to random errors in the measurement and systematic errors in the forward model (e.g., the error in the atmospheric temperature retrieval) and
where G is a gain matrix and where e is the measurement error vector.

p29883, l9-10: How large are the areas of the averaging kernels? Are they close to one? Another interesting quantity would be the FWHM of the averaging kernels, providing a measure of the vertical resolution of the retrievals.

The computed mean area of the averaging kernels is close to unity, but they vary considerably, as can be seen from Figure 2 (now Figure 3). The value of the number of degrees of freedom for the signal (DFS), which is calculated as the diagonal element sum of the averaging kernels, is typically 1.5 to 2. DFS provides an estimate of the number of independent pieces of information contained in the measurements. The full−width at half maximum (FWHM) in Fig. 2a (now Fig. 3a) of the 200-1000 hPa curves is approximately 5-6 km and the largest value of about 7.5 km is seen for the 500 hPa curve. In Fig. 2b (now Fig. 3b), the averaging kernels between 300 and 500 hPa are reasonably sharply peaked with their FWHM about 6 km.

p29891, l2-23: This text might better fit into the method/theory section (Sect. 2.4)?

We agree and have moved it as suggested.

p29892, ll-5: Vectors should be printed in bold face, I think.

$$c_{ret} = c_a + a(x + x_a)$$

$$c_a = t^T x_a$$

Done.

p29902, l14-15: I would also expect that the trajectory approach performs better than linear/quadratic interpolation, but this was not shown the paper.

Strictly speaking, that is true. We have removed this statement from the Conclusions. Instead, we note that the trajectory approach takes into account known atmospheric motions from the NCEP meteorological wind fields, and therefore can be expected to give a better estimate of the redistribution of CO than linear or quadratic interpolation, as it uses additional information about the atmosphere.

Using linear or quadratic interpolation is the default best estimate in the absence of such knowledge, so the worst case of trajectory mapping should be equivalent to linear/quadratic interpolation.

p29904, l4-9: Perhaps mention (once more) how the climatology data can be accessed?

Added on p29904,l9: The data set is publically available at

ftp://es-ee.tor.ec.gc.ca/pub/ftpdt/MOZAIC_output_CO/

Figures: Some figures (e.g., Fig. 2, 3, 15) have very small font sizes and low quality and resolution, making it difficult to read labels.

Done.

Technical Corrections

p29879, l12: "southward local equator" -> "southward equator" (?)

Done.

p29880, l7: remove brackets around url

Done.

p29886, l22: reveals _that_

Done.

p29886, l24: _an_ increasing number

Done.

p29888, l19-20: reword "a very few" (?)

Replaced by "a very small number"

p29890, l19: remove "also"

Done.

p29890, l19: except _for a_ few

Done.

p29892, l13: which _is_ not

Done.

p29892, l21: African -> Africa

Done.

We thank the referee for his/her careful review and very useful remarks.