

Author's Response to Referee 1 Commentary

The authors acknowledge the lack of references in the introduction as well as in the methods section and agree to add in numerous citations throughout the manuscript to address these shortcomings. We ensure that all our quantitative statements, or observations which carry significant importance which are not our own have been cited throughout our analysis. We add discussion (with citations) to address all specific comments which point out information gaps. We address all specific comments which have scientific questions that are intended to facilitate discussion and add citations as appropriate. The authors agree to fix all formatting issues with existing citations, and to add equation numbers throughout the manuscript. We break down statements throughout the manuscript in cases where a statement is a run on sentence, is unclear, or requires additional explanation. We also address all other grammatical and technical issues which have been pointed out. The authors would like to thank Referee 1 for giving feedback that is extremely clear and easy to follow. Referee 1's comments about our gaps in literature highlight an important weakness in our manuscript and we believe our motivation will be much stronger by addressing them. We especially thank Referee 1 for asking us questions regarding uncertainties and the assumptions used in our approach as we believe this will address a crucial gap in our data analysis.

General Changes Throughout Manuscript

1. Equation numbers have been added to all existing equations, and matrices are defined using new equations on separate lines for ease of reference and discussion.
2. Many new citations are being added throughout the introduction, as well as in the methods section.
3. Acronyms for Northern Hemisphere, Southern Hemisphere, and different species are defined at their first occurrence and then referred only by their acronym from then on.
4. Citation formatting errors are being double checked against AMT standard and corrected accordingly.
5. Grammatical and technical fixes are being implemented throughout in accordance with reviewer recommendations. Some sentences have been split or broken into

simpler statements where the authors were requested, to aid with the flow and clarity of language.

6. A new Section 2.4.5 in methods is being added to very briefly mention advanced methods of EOF analysis including cyclostationary EOFs so that our usage of them in results has better continuity and is not jarring.

Changes Addressing “Specific Comments” with References to Line/Page Numbers

The following changes are implemented to address the “specific comments” from Referee 1 with line/page references. Please note that the line numbers refer to the **original version** of the manuscript

Lines 1-3 Pg 1

We define MOPITT and more clearly describe the objectives of the study.

Line 27 Pg 2

Citations added to describe how the concentration level of NO_x affects ozone production.

Line 59 Pg 2-3

Citations added to emphasize retrieval inaccuracies and the lack of monitoring stations across Africa.

Line 63 Pg 3

Citations added to bolster arguments that changes in local trends are difficult to separate from background trends.

Line 83 Pg 3

Citations added to emphasize that the separation of secondary CO from surface emission aids source attribution and inverse modeling studies.

Lines 124-127 Pg 4-5

Citations added for other satellite instruments (TES, AIRS, IASI, TROPOMI, and CrIS)

Line 133 Pg 5

Citations added regarding potential discontinuities of IASI-A retrievals, the smaller number of measurements for TES, and the cloud clearing algorithm used by AIRS.

Line 152 Pg 6

Citations added to emphasize high contribution of anthropogenic emissions from China due to coal reliance and biofuel burning.

Line 171 Pg 7

Discussion added with citations to emphasize the relative contribution to CO due to oxidation from CH₄ as compared to the oxidation from NMHCs. Citations added regarding the temperature dependence of isoprene and terpenes. Discussion added with citations to clarify how the large annual contribution and high reactivity of isoprene makes it the most dominant hydrocarbon emission. The term “measurable in breath” has been removed and clarified (with citations) by describing the biological processes in animals where we can measure VOC emission.

Line 207 Pg 8

Acronyms for all 4 climate indices are expanded, with references included for each.

Line 213 Pg 8

We clarify the term “EOF” and add a brief description.

Line 228 Pg 9

We redefine the scaled matrix F' to be the matrix J to avoid confusion with the original F matrix.

Line 253 Pg 10

We clarify the term “SVD” and add a brief description

Line 267 Pg 10

We clarify the term “PCA” and add a brief description

Line 268 Pg 10

We discuss, with supporting citations, how our motivation for using asymptotic approximation is due to simplicity, unlike similar methods that rely on statistical analysis and resampling the dataset.

Line 272 Pg 10-11

We discuss, with supporting citations, the strengths and weaknesses of using an asymptotic expansion as compared with other methods.

Line 277 Pg 11

Significant discussion has been added, together with supporting citations, to explain why our estimation for the effective sample size is only valid for the case of red noise Gaussian processes where the true sample size N is very large.

Line 280-282 Pg 11

Discussion is added, with references, regarding tests that can be used to determine if eigenvalues are degenerate or potentially represent white noise.

Line 285 Pg 11

Discussion is added, with references, to better describe specifically how the list of drawbacks for EOF analysis affect results, and how best to mitigate them.

Line 409 Pg 16

Citations added to emphasize that one potential benefit of varimax rotation is to make spatial patterns simpler and easier to interpret.

Line 462 Pg 19

Discussion is added, with references, to bolster our argument for why we do not see a connection between Residual mode 1 and oceanic variability from oceanic cycles. We mention potential issues including dependence of modes, thermal gradients near the surface, and variability from other small scale oceanic processes.

Changes to Figures**Fig 1 (Referee #1)**

We change the y axis magnitude to “molecules/cm²”.

Fig 2 (Referee #1)

Please label our colorbar with the proper units molecules/cm²).

Fig 3 (Referee #1)

We add subplot names to our figures, and grid bin our data using a consistent colorbar. We label our colorbar with proper units.

Fig 4 (Referee #1)

We add subplot names to our figures.

Fig 5 (Referee #1)

We alter our color scheme so that the lines do not blend in as much.

Fig 6 (Referee #1)

We add subplot names to our figures, and grid-bin them using a consistent colorbar.
We label our colorbar with proper units.

Fig 7 (Referee #1)

We add subplot names to our figures.

Fig 8 (Referee #1)

We add subplot names to our figures.

Fig 9 (Referee #1)

We grid-bin the data and we label our colorbar with proper units.

Fig 10 (Referee #1)

We add subplot names to our figures.