

***Interactive comment on* “Linking horizontal and vertical transports of biomass fire emissions to the Tropical Atlantic Ozone Paradox during the Northern Hemisphere winter season: climatology” by G. S. Jenkins and J.-H. Ryu**

G. S. Jenkins and J.-H. Ryu

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Response to Anonymous Referee #2.

We are pleased at the positive comments that the reviewer #2 has made about this manuscript. We address the other comments now.

1. SYNTHESIS OF NEW RESULTS THIS IS A LONG TERM OBSERVATIONAL STUDY USING ALL AVAILABLE DATA TO EXAMINE ALL OF THE ASPECTS (HORIZONTAL, VERTICAL TRANSPORTS, SOURCE REGIONS) AS IT RELATES TO THE OZONE PARADOX FOR THE LONGEST POSSIBLE PERIODS. ONLY THE MODELING STUDY OF MARTIN ET AL. EXAMINED THESE VARIOUS FACTORS BUT DID

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NOT LOOK AT VERTICAL TRANSPORT (USING OLR/PRECIPITATION) NOR DID THEY EVALUATE LIGHTNING BASED ON OBSERVATIONS.

WE ARE NOT CLEAR ABOUT WHY YOU BELIEVE THAT THIS IS ONLY A DESCRIPTION OF EXISTING DATA AND PREVIOUS WORK. WE HAVE PUT THE PREVIOUS WORK IN THE CONTEXT OF THIS STUDY. THERE ARE NO STUDIES TO MY KNOWLEDGE THAT HAVE EXAMINED ALL OF THESE FEATURES DURING NH WINTER SEASON. IN PART 2 OF OUR PAPER, WE HAVE RE-EXAMINE THE LARGE-SCALE FIELDS ASSOCIATED WITH THE AEROSOLS99 SHIP CAMPAIGN. THIS PAPER WILL BE PUBLISHED ANY DAY NOW. We have now added in several paragraphs to reflect that this study is related to a companion paper that is in press and we have referenced this paper.

Page 5065 attached to the last sentence of objectives paragraph it now reads:

This paper focuses on a climatological time-scale (1979-1992) during the Northern Hemisphere winter season (DJF), while a companion paper examines objectives 1-4 on daily time-scales during the Aerosols99 ship campaign (Jenkins et al. 2003). In addition in the Conclusion section, we have not included some of the results of the (Jenkins et al. 2003 paper)

The results presented here are also consistent with the results of Jenkins et al. (2003) for the Aerosols99 campaign time period. We have shown in this paper, however, that on daily-time scales eastward propagating anti-cyclones in the middle/upper troposphere can influence the horizontal transport (trajectories) and convection in the Gulf of Guinea may lead the vertical transport of ozone/ozone precursors associated with biomass burning in West Africa. We have also shown that for this time period that lightning in Gulf of Guinea, Central Africa and South America influenced the measured ozone in the middle/upper troposphere. Because of westerly wind at high altitudes, lightning over South America can influence ozone mixing ratios at pressure levels less than 300 hPa, while lightning over Central Africa influences ozone mixing ratios in the

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middle troposphere (500/300 hPa).

Jenkins, G. S., Ryu, J-H, Thompson A. M., Witte, J. C.: Linking horizontal and vertical transports of biomass fire emissions to the Tropical Atlantic Ozone Paradox during the Northern Hemisphere winter season: 1998-1999, JGR, in press, 2003.

ALSO, SINCE THIS IS PART OF A COMPANION PAPER, WE DON'T WANT TO CHANGE THE TITLE ALTHOUGH LIGHTNING IS INCLUDED IN BOTH PAPERS.

SUMMARY OF NEW RESULTS IN THIS STUDY (SEE COMENTS FOR REVIEWER #1)

2. WE HAVE ACKNOWLEDGED THROUGH REFERENCES IN THE TEXT THAT THERE ARE DIFFERENT OZONE COLUMNS BY THE METHODS FOR ESTIMATING TROPOSPHERIC COLUMN OZONE IN THE INTRODUCTION. THIS DOES NOT MEAN THAT THE DATA IS USELESS. MANY OF THE DATA SETS SHOW RELATIVELY LOW TROPOSPHERIC COLUMN OZONE OVER THIS REGION DURING DJF. THIS CAN BE RESOLVED ONLY BY DIRECT MEASUREMENTS DOWNSTREAM OF WEST AFRICA DURING DJF BY THE LAUNCH OF OZONESONDES AND SATELLITE OBSERVATIONS.

THE REAL PROBLEM IS ESTIMATING HOW MUCH THE RETRIEVAL ALGORITHMS ARE OVERESTIMATING OR UNDERESTIMATING THE TROPOSPHERIC COLUMN OZONE. SOME VALIDATION TO ACTUAL MEASUREMENTS ARE NECESSARY. PLEASE PROVIDE REFERENCES TO THAT WE CAN REFER THE READER TO THESE ADDITIONAL PROBLEMS. IT IS NOT THE GOAL OF THIS PAPER TO FOCUS ON RETRIEVAL PROBLEMS WITH SATELLITES. THE LOW TROPOSPHERIC COLUMN OZONE DATA IS SUPPORTED BY THE FIELD CAMPAIGNS THAT HAVE TAKEN PLACE DOWNSTREAM OF BIOMASS BURNING IN WEST AFRICA (THOMPSON ET AL. 2000, WELLER ET AL 1999., JONQUIERES ET AL 1998). THE RESULTS FOR JANUARY 1979-1992 ARE QUANTITATIVELY SIMILAR (SLIGHTLY LOWER) THAN THE SATELLITE ESTIMATES FOR JANUARY

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1999 (THOMPSON ET AL. 2000) AND JANUARY 2001 (EDWARDS ET AL. 2003). THOMPSON ET AL. 2000 SHOWS THAT THE OZONESONDE LAUNCHES WERE WITHIN +/- 4DU OF THE SATELLITE VALUES IN LATITUDES OF 14N-23S IN THE AEROSOLS99 CAMPAIGN.

3. ACTUALLY, THE LIGHTNING IS NOT THE CENTRAL PART OF THE PAPER. IT IS PART OF IDENTIFYING SOURCES OF POTENTIAL OZONE IN THE SH (ONLY) ALONG WITH BIOMASS BURNING AND ITS POSSIBLE TRANSPORT. WHILE THERE ARE MANY PAPERS THAT HAVE EXAMINED LIGHTNING, THERE ARE VERY FEW THAT HAVE EXAMINED THE RESULTS WITH RESPECT TO SOUTH AMERICA AND AFRICA DURING DJF USING TRMM DATA. THE STUDY BY EDWARDS WAS FOR A SHORT PERIOD (JANUARY 2001 ONLY) AND WE HAVE REFERENCED THIS PAPER. IN A SUBSEQUENT PAPER, WE DEVOTE OUR ATTENTION TO LIGHTNING ON A SEASONAL BASIS (DJF, MAM, JJA, SON) Ú JENKINS AND RYU (2003A).

Jenkins, G. S., J-H. Ryu, Spaceborne Observations link the Tropical Atlantic Ozone Maximum and Paradox to Lightning, Atmospheric Chemistry and Physics Discussion, 3, 5725-5754, 2003A

WE HAVE NOW ALSO INCLUDED THE STUDY OF MARTIN ET AL. (2000), WHICH FOUND THAT LIGHTNING EXPLAINS ABOUT 20% OF THE VARIANCE IN TROPOSPHERIC COLUMN OZONE. THIS STUDY HOWEVER, USED NOX EMISSION, WHICH WERE BASED ON PARAMETERIZATIONS OF LIGHTNING THROUGH OLR. IT SHOULD ALSO BE NOTED THAT THE SEASONALLY AVERAGED LIGHTNING NOX EMISSIONS IN MARTIN ET AL. (2000) ARE SMALLER OVER AFRICA THAN SOUTH AMERICA DURING DJF,SON WHICH IS OPPOSITE TO OUR RESULTS (more lightning over Africa) AND ALSO TO THE RESULTS OF CHRISTAIN ET AL. (2003). THERE IS MORE LIGHTNING OVER AFRICA (15S-15N) RELATIVE TO SOUTH AMERICA DURING EVERY SEASON BASED ON LIS DATA (JENKINS AND RYU, 2003A).

OUR STUDY, WHICH IS BASED ON OBSERVATIONS OF LIGHTNING FROM LIS IDENTIFIES LIGHTNING AS A POTENTIAL SOURCE OF OZONE. WE ARE SUGGESTING THAT LIGHTNING DOES INFLUENCE OZONE IN THE MIDDLE/UPPER TROPOSPHERE BASED ON THIS DATA FOR DJF (FIGURES 13, 15). THE FOLLOWING TEXT IS INSERTED P 5071, LINE 25.

§Moreover, the study of Martin et al (2000) using global lightning NO_x emission estimates available from Price et al. (1997) have found that lightning explains about 20% of the variance using EOF analysis in tropospheric column ozone value TOCs.ŧ

IT IS NOT THE GOAL OF THIS STUDY TO ADDRESS THE QUESTIONS OF HOW MUCH NO_x AND OZONE IS PRODUCED! WHY? THERE ARE OPEN QUESTIONS THAT HAVE NOT BEEN RESOLVED AT PRESENT: A. HOW MUCH NO IS PRODUCED PER FLASH?

B. IT IS POSSIBLE THAT NOT ALL OF THE NO THAT IS PRODUCED MAY GO INTO A SINGLE RESERVOIR TO FOR PRODUCING O₃, BUT THAT SOME OF IT MAY GO INTO OTHER RESERVOIRS INCLUDING NITRIC ACID. THAT IS NOT THE GOAL OF THIS STUDY.

C. THE USE OF A MODEL IS NECESSARY TO COMPUTE HOW MUCH O₃ WOULD ULTIMATELY BE PRODUCED FROM NO_x VIA O₃. THAT IS NOT THE GOAL OF THIS STUDY. HOPEFULLY SOMEONE ELSE WILL TAKE UP THESE CALCULATIONS IN THE FUTURE BASED ON LIS DATA.

4. PAGE 5077, WE ARE SUMMARIZING OUR RESULTS FROM THIS STUDY WITH RESPECT TO LIGHTNING WHICH IS BASED SOLELY ON LIS OBSERVATIONS. THE RESULTS OF MARTIN ET AL. WERE BASED ON THE 3-D GEOCHEM MODEL GEO-CHEM AND THE RESULTS OF EDWARDS ET AL. (2003) WERE BASED ON 1 MONTH OF DATA. WE HAVE THEREFORE MADE THE FOLLOWING CHANGES TO THE TEXT (LINES 19-22):

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On the other hand, lightning over South America and Central Africa, as determined by LIS, enhances Southern Hemisphere ozone values in the middle/upper troposphere during DJF. The DJF 1998-2001 LIS results are agreement with the modeling study of Martin et al. (2002) and the satellite results for January 2001 by Edwards et al. (2003).

WE ARE UNDER THE IMPRESSION THAT REVIEWER BELIEVES THAT WE USED THE EDWARDS ET AL (2003) AND MARTIN ET AL (2002) AS THE BASIS OF THIS STUDY. IN FACT THIS WORK WAS DONE INDEPENDENTLY IN 2001 AND EARLY 2002 AND SUBMITTED . BECAUSE THESE STUDIES WERE PUBLISHED DOES NOT IMPLY THAT WE CANNOT OR SHOULD NOT PUBLISH OUR WORK ESPECIALLY WHEN WE ARE LOOKING OVER LONGER PERIODS OF TIME (CLIMATOLOGY). WE BELIEVE THE WORK COMPLEMENTS THE RESULTS OF EDWARD ET AL (2003), MARTIN ET EL (2002) AND THE VARIOUS SHIP CAMPAIGNS WHILE AT THE SAME TIME LOOKS AT DIFFERENT ASPECTS (SOURCES AND TRANSPORT OF OZONE) OF THE PROBLEM RELATED TO 'TROPICAL OZONE PARADOX'.

5. WE HAVE STATED ABOVE, THERE ARE NO STUDIES FOR THE CLIMATOLOGICAL PERIOD OF DJF RELATED TO BIOMASS BURNING AND TRANSPORT PROCESSES IN WEST AFRICA TO COMPARE TO THIS STUDY. THE ONLY STUDY THAT USES 1979-1992 TOMS DATA IS THE MARTIN ET AL (2002) STUDY. WE HAVE MADE COMPARSIONS WHERE IT IS APPROPRIATE.

6. MY FINAL REQUEST IS THAT THE REVIEWER SHOULD POINT OUT WHERE THE DATA IS FLAWED OR MIS-INTERPERTED. WE CANNOT ADDRESS GENERAL POINTS OF THE REVIEWER IN AN EASY MANNER. THE REVIEW IS ŞQUALITATIVEŞ RATHER THAN ŞQUANITATIVEŞ. THE REVIEWER MUST BE SPECIFIC IN HIS/HER POINTS. THIS HAS NOT BEEN THE CASE IN THIS REVIEW. FOR EXAMPLE THE REVIEWER COULD POINT OUT THAT:

THE RESULTS OF JENKINS AND RYU (2003) DO NOT AGREE WITH RESULTS FROM (REFERENCE).

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SHOW WHERE THERE ARE INCONSISTENTS OR MISINTERPERTATION IN FIGURES.

IS THERE SOME OTHER DATA THAT IS MISSING WHICH IS MAKING THE REVIEWER BELIEVE THAT HIS WORK IS ONLY QUALATATIVE. - COMMENTS RELATED TO THE SUMMARY PARAGRAPH

THE REVIEWER STATES THAT THIS STUDY DOES NOT CONTAIN ANY NEW RESULTS. IF THIS WORK HAS BEEN DONE ALREADY IT SHOULD BE APPARENT IN THE REVIEW AND POINTED OUT. WHERE ARE THE RESULTS THE SAME AS OTHER STUDIES?

REDUCE THE DESCRIPTION OF WELL KNOWN DATA SETS? I AM NOT SURE WHAT YOU ARE GETTING AT. DO YOU MEAN THAT WE SHOULD REDUCE THE DATA DESCRIPITON SECTION?

TRY TO MAKE THE ARGUMENTS LESS QUALITATIVE? WHICH ARGUMENT? WHICH SECTION OF THE PAPER? THIS COMMENT IS TOO GENERAL TO ADDRESS. PLEASE POINT TO THE SECTIONS OF THE PAPER THAT YOU ARE DISCUSSING.

Interactive comment on Atmos. Chem. Phys. Discuss., 3, 5061, 2003.

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