

Interactive comment on “Impacts of anthropogenic and natural sources on free tropospheric ozone over the Middle East” by Z. Jiang et al.

Anonymous Referee #2

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This is a nice and original study making use of advanced modelling tools (e.g. the adjoint of GEOS-Chem) and previous assimilation results (Miyazaki et al. 2015) in order to better identify the causes for the observed seasonal cycle of tropospheric ozone over the Middle East. The study provides interesting conclusions regarding the importance of lightning as well as of transport patterns bringing South Asian air to the Middle East. In particular, it shows that the free tropospheric ozone summertime enhancement is less due to a transport of ozone from outside the area than an import of ozone precursors (most importantly NO_x).

The article is clear and well written, and the methods are generally sound. I recom-

C10957

mend the article for publication in ACP, if the authors address my only major comment (see below), related to the analysis of the role of transport using an idealized CO-like tracer:

In agreement with previous studies, Middle eastern O₃ is shown to be NO_x-limited. This questions the relevance of model results for a CO-like tracer with a lifetime of 30 days and only surface emissions, as opposed to NO_x which has a lifetime lower than one day and is partially emitted in the free troposphere. In fact, although lightning emissions are much lower than anthropogenic emissions over the Indian subcontinent (see Fig. 1), both emission categories contribute about equally to middle eastern summertime O₃ (Fig. 4a-b), which demonstrate very well the importance of the level at which NO_x is emitted. This asks for more discussion, given that lightning and anthropogenic emissions have a different seasonality. I wonder whether the authors could conduct additional tests using a shorter-lived tracer and/or with a source located in the free troposphere.

Minor comments:

p. 35524, l. 30: besides emissions and chemistry, transport processes are also poorly quantified.

p. 35524, l. 33-35 "we use updated reactive nitrogen (NO_x) emissions... to provide an improved estimate of O₃ precursor emissions": awkward. The purpose of the study is not to improve emission estimates. Please rephrase.

p. 35527, l. 5-7: were CO emissions not constrained as well? If not, a short justification might be needed.

p. 35527, l. 12-13: I suppose that the ozone observations also indirectly constrained NO_x emissions through photochemistry, a fact not really conveyed by this sentence.

p. 35528, l. 4-5: The model performs indeed very well in summer and fall (Northern hemisphere), but less so in winter and spring. Could you comment? Were the

C10958

CHASER-predicted O3 fields from Miyazaki et al. similar to those calculated by GEOS-Chem?

p. 35529, l. 9: insert "during the summer" after "O3 enhancement"

p. 35530, l. 7: Asian lightning emissions appear to contribute about as much as anthropogenic NOx emissions from Asia to middle tropospheric O3 (Fig. 4a).

p. 35530, l. 14-16: "... are not significant" is too strong (see Fig. 4). Maybe "less" or "much less" significant.

Technical comments:

p. 35526, l. 8: "will allow us" (drop the s)

p. 35526, l. 19: insert a space before FT2000

p. 35528, l. 4: "seasonality"

p. 35528, l. 22: "the maritime continent" is a bit obscure if simply "ocean" is meant.

p. 35528, l. 24-25: drop "the" before "highest"

p. 35529, l. 10: "troposphere"

p. 35529, l. 16: I suppose what is meant here is "the rest of Asia", not the entire continent.

p. 35529, l. 18: "they were not able" (instead of "are")

p. 35530, l. 27: "is produced" (instead of are)

p. 35531, l. 4: "very small" (instead of "much small")

p. 35533, l. 16: "observations"

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C10959