

Answers to referees' comments:

« Transboundary ozone pollution across East Asia: daily evolution and photochemical production analysed by IASI+GOME2 multispectral satellite observations and models”
by Juan Cuesta et al.

Dear referees,

We would like to thank you very much for your remarks that have improved the clarity of the paper. In the Revised Manuscript, called RM hereafter, we have addressed in detail each of your comments by adding new explanations in the manuscript and some minor modifications in the figures. All the recommendations of the reviewers have been followed and all clarifications were provided. Please, find below the detailed answers and how they are introduced in the manuscript.

Anonymous Referee #2

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This paper elaborates a comprehensive study of transboundary ozone pollution across East Asia via employing [1] the multiple-spectral IASI/GOME2 ozone profile product that provides the quantitative estimates of ozone concentration in the LMT; and [2] the combined modeling tools consisting of CHASER (global scale) and WRF-CHEM (regional scale) models. This study provides multi-species, multi-scale picture of pollutions across East Asia, helping in distinguishing between local and non-local drivers of pollution in LMT. The subject of the paper is appropriate to ACP. Below are a few comments concerning clarifications/extensions for consideration in the final publication.

This work uses the IASI carbon monoxide (CO) profile data to estimate the CO concentration in lower troposphere (LT), then use IASI LT CO and joint IASI+GOME2 LMT O3 as daily pictures for facilitate the study of daily evolution of pollution across East Asia.

1) The authors should describe how well the IASI LT CO data could represent the CO variability in the LMT.

Clarified.

The approach developed by ULB/LATMOS retrieves lower tropospheric CO (below 6 km of altitude) from IASI with 0.83 degrees of freedom and a height of maximum sensitivity around 4.7 km of altitude asl, in average over the region and period studied in the paper. This CO product is sensitive at the LMT (up to 3 km of altitude asl) with 0.51 degrees of freedom in average. In our paper, we use LT CO retrievals as they are already validated against MOZAIC in situ measurements (De Wachter et al., 2012). A dedicated validation of other CO partial columns against independent measurements is beyond the scope of the present paper, as it is mainly focused on ozone pollution.

In the RM, this is written as (lines 2-5 page 11): “LT partial columns are retrieved with 0.83 degrees of freedom (DOF, i.e. number of independent pieces of information in the retrieved profile) in average over the region and period studied in the paper. This product provides significant information on CO variability below 3 km asl, as DOF at the LMT are 0.51 on average.”

2) Drs. Miyazaki and Sekiya have developed a high-resolution CHASER simulation tool (version 4.0) with a finest spatial resolution of 0.56 degrees (Sekiya et al., 2017) – significantly higher than that of CHASER and WRF-Chem models used in this study. The performance of CHASER v4 has been validated using reference data sets from satellite missions and aircraft flight campaigns. The authors should include this reference in this paper and provide some discussions.

Sekiya T., Miyazaki K., Ogochi K., Sudo K., and Takigawa M., Global high-resolution simulations of tropospheric nitrogen dioxide using CHASER V4.0, Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2017-203>, in review, 2017.

Done.

Indeed, Sekiya et al. (2018) developed a high-resolution version of the CHASER model at 0.56° resolution and demonstrated the improved model performance over areas with strong local sources by increasing the horizontal model resolution from 2.8° to 0.56°. Nevertheless, the 2.8° resolution model is capable to simulate synoptic ozone patterns.

The RM provides this information as follows (lines 2-6 page 14): *“Sekiya et al. (2018) have recently developed a high-resolution version of CHASER with 0.56° horizontal resolution and demonstrated improved performances over areas with strong local sources with respect to the 2.8° resolution version. Nevertheless, the CHASER model with 2.8° resolution is capable of properly simulating synoptic ozone patterns.”*

3) Page 4, Line 5-6: There is a multiple spectral retrieval algorithm developed for CO profile retrievals (Fu et al. 2016). They demonstrated the feasibility of combining the measurements from Sentinel-5 precursor (S5P) TROPOMI (near infrared) and Suomi-NPP (SNPP) CrIS (thermal Infrared) sensors to extend Terra MOPITT both TIR alone and multiple spectral CO profile products capable of quantifying the first 2-3 km CO amounts, as well as improving spatial coverage and resolution in comparison to Terra-MOPITT. The authors could add some discussions nearby the end of first/beginning of second paragraphs of page 4, e.g., “The Sentinel-5 precursor (S5P) and Suomi NPP (SNPP) has successfully formed a new satellite constellation, leading to a unique opportunity to quantify the amounts of carbon monoxide in the LMT over global scale via combining the satellite measurements from SNPP CrIS (TIR) and S5P TROPOMI (NIR) instruments. Fu et al. (2016) presented the methodology and characteristics of joint CrIS/TROPOMI CO profile retrievals, demonstrating the feasibility of extending the decadal record of Terra-MOPITT CO products (Worden et al., 2010 and 2013).”

Fu D., Bowman K.W., Worden H., Natraj V., Yu S., Worden J.R., Veefkind P., Aben I., Landgraf J., Strow L., Han Y., High resolution tropospheric carbon monoxide profiles retrieved from CrIS and TROPOMI, Atmos. Meas. Tech., 9, 2567-579, 2016.

Worden H.M., Deeter M.N., Edwards D.P., Gille J.C., Drummond J. R., and Nédélec, P. P., Observations of near-surface carbon monoxide from space using MOPITT multi-spectral retrievals, J. Geophys. Res., 115, D18314, doi:10.1029/2010JD014242, 2010.

Worden H.M., Deeter M.N., Frankenberg C., George M., Nichitiu F., Worden J., Aben I., Bowman K. W., Clerbaux C., Co-heur P.F., de Laat A.T.J., Detweiler R., Drummond J. R., Edwards D.P., Gille J. C., Hurtmans D., Luo M., Martínez-Alonso S., Massie S., Pfister G., and Warner J.X., Decadal record of satellite carbon monoxide observations, *Atmos. Chem. Phys.*, 13, 837–850, doi:10.5194/acp-13-837-2013, 2013.

Done.

The 3 references have been added as well as the following paragraph in the RM (lines 9-20 page 4): *“Multispectral synergisms are also implemented to retrieve other atmospheric species with enhanced near-surface sensitivity, as carbon monoxide (CO). This is done with measurements in the thermal and near infrared from the Measurements Of Pollution In The Troposphere (MOPITT) instrument onboard the Earth Observing System (EOS) Terra satellite (Worden et al., 2010). Recently, Sentinel-5 precursor (S5P) and Suomi National Polar orbiting Partnership (SNPP) have successfully formed a satellite constellation, leading to a new opportunity to quantify the amounts of CO at the LMT over global scale by combining the satellite measurements in the thermal and near IR respectively from the instruments SNPP Cross-track Infrared Sounder (CrIS) and S5P TROPospheric Monitoring Instrument (TROPOMI). Fu et al. (2016) presented the methodology and characteristics of joint CrIS/TROPOMI CO profile retrievals, demonstrating the feasibility for extending the decadal record of MOPITT CO products (Worden et al., 2013).”*

4) Page 38, Line 2, Figure 2 caption: IASI+GOME -> IASI+GOME2

Corrected.