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Geoscientific Model Development Discussions

Interactive comment on "Evaluation of near surface ozone over Europe from the MACC reanalysis" *by* E. Katragkou et al.

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We thank the reviewer for his/her comments. We responded to all of the points raised and changed the revised manuscript accordingly.

General comments

R3.1 "All along the manuscript, the authors should be more precise, both in their qualification of the results and the terms they use in general. For instance, in the abstract, what is 'the annual overall error' accounting for? What is the value of the 'average correlation' (p 1086, L1) etc : : : There are many points like these, I willl go back to these in the specific comments"

We improved the language in the revised manuscript, when communicating findings on

scores and model skill.

R3.2 "The use of the CTRL simulation was very promising but is finally disappointing because too short. In particular an explanation of the drop of the correlation from CTRL to MRE in Mediterranean marine stations and in Scandinavia would be expected in the discussion part. Finally, either the CTRL simulation should not be used at all, or compared to MRE all along the manuscript, with, if necessary, an adaptation of the time period to be analysed."

This paper was thought to be an extended evaluation of the reanalysis product with respect to near surface ozone. For anyone wishing to have this paper as a reference for the evaluation of the reanalysis product, we believe it would be better to include the whole period of the reanalysis (2003-1012). In the current manuscript we provide the basics of the comparison between the ctrl and the reanalysis (Fig 3 and Table 2). An extended report focusing on the impact of assimilation on surface ozone for the 2003-2010 is available as a VAL technical report, Deliverable D84.2 "Validation report on the Comparison of surface ozone in the global (2003- 2010) and regional reanalysis (2011) over Europe". The basic findings of our analysis are robust and do not depend on the length of the period examined.

The lower temporal coefficients (R) in the MRE are discussed in the revised manuscript. We attribute the deterioration of R the data assimilation procedure, related to the MLS bias correction, described in detail in the paper of Inness et al., 2013. The bias correction of MLS data, has caused drifts in the tropospheric ozone concentrations between August 2004 and December 2007, an issue which have been tracked down and alleviated after year 2008 of the MRE. After 2008 R appears to be improving. Comments are inserted in the revised manuscript. Figure 1 shows that temporal correlation of the MRE increases after bias correction (2008-2012).

R3.3 "Even if the paper describing precisely the MRE is referred to I would like the assimilation process to be described more precisely. In particular, the time-steps of the

assimilation, its vertical extent, and the chemical species that are assimilated. Only one sentence (p1087, L17-18) mentions that point: this is not enough. Moreover, even if it is implicit, the authors should explicitly mention that observations they use for this evaluation are independent from the assimilated ones."

More details are provided in the assimilation procedure and Table 1 is added in the revised manuscript. The observations used for this evaluation are independent from the assimilated ones. A comment is inserted in section 2.2

R3.4 "Figures and captions are generally too small (however they are in general very informative)."

Done. Figures are improved in the revised manuscript.

R3.5 "I would appreciate a conclusion that would give more perspectives to this work."

We have re-written conclusions with more concrete directions to future work.

Specific comments

p1078 L9-10 : define the “annual overall error” and “on average” (spatial, temporal, both?)

The annual overall error is the fractional gross error calculated on an annual basis and it is corrected in the revised manuscript. It is “on average”.. “over Europe” i.e. a spatial average.

p1082, L20-25 : can you give an estimation of the impact of taking real-altitude of the station instead of surface ?

In Figure 2 it is shown the modified normalized mean bias (mnmb) of the Austrian station Sonnblick (altitude = 3,106 m), evaluated i) with surface model data (Lev60, dots) ii) with data from level 46 (squares). Following the objective methodology described in section 2.2, it is shown that the bias is reduced, when adjusting o3 concentrations using atmospheric pressure as the correction criterion.

p1083, L28 : the precision of the ozonesondes is no more referred to hereafter. In 4.1, you should recall it to the reader and comment the results correspondingly.

The following sentence was added in the revised manuscript: “It should be also considered that the range of the % biases in the troposphere are comparable with the respective precision of electrochemical concentration cell ozonesonde measurements.”

P1085, L8-9 : “the confidence interval : : : subregion” : this sentence is unclear to me. “The confidence interval for each month was derived using the values of the diurnal range for the stations that reside in the same subregion.”

The grey areas in Figure 6 show the 95% confidence interval of the mean sub-regional diurnal range, derived when averaging diurnal ranges of all stations within the sub-region.

p1085-86, L20-1 : I do not agree for having British Isles and Scandinavia at the same level. Their correlations are really different. I would put together BI and MDm (0.51 and 0.54) and separate Sc (0.26). This is implicitly what you mention later. (L26-27), so this sentence could finally be removed.

Done

P1086,L10-11: I suppose the numbers you give (40:28% etc..) correspond to the mean value of the data. It should be specified, since the median could also be taken into account and give significantly different results.

The numbers refer to the FGE which is introduced I section 2.3 (Eq 2).

P1087, L9-10 : for a correlation that drops from 0.74 to 0.49, ‘a slightly reduction’ is not an appropriate description. Moreover, how do you explain that drop?

We delete the word “slight”. The temporal correlation over Scandinavia is low, because the MRE cannot capture the spring maximum. Moreover, MLS bias correction in the assimilation procedure has caused drifts in tropospheric ozone (a detailed explanation

of the technical problem can be found in Inness et al., 2013). This issue was tracked down and alleviated after year 2008 of the MRE.

We attribute the deterioration of R to this inherent problem of the data assimilation procedure. Comments are inserted in the revised manuscript. Figure 1 shows that temporal correlation increases after bias correction (2008-2012).

P1087,L23-25 : The terms “cycles have differences in the shape”, although it is true, are too imprecise. These differences should be numerically estimated through correlation, to make sure the analysis is objective.

The two tables (Figure 3) provide the correlation of the diurnal cycles (left) and the annual cycles (right). The diurnal cycle is well reproduced, while problems in the correlation of the annual cycles are discussed in the manuscript.

P1088, L8-12: you should mention that this point will be discussed later.

Done

P1089, L18-19: “the MRE captures quite well: : :” : once again, this should be more precise.

The Table with R_diurnal cycle (provided above) justifies the fact the MRE reproduces the diurnal cycle. The text has been modified “The MRE reproduces the diurnal cycle, but exhibits positive bias in summer (except for the Mediterranean marine region),. . .”

P1090, L12 : the word “ozone” is lacking between “near surface” and “between”.

Done

P1090, L13 : “It” is lacking before “is known”. P1091, 4.1 : this subsection would really benefit from a comparison to CTRL simulation.

Done

P1093,L1-4 : “The amplitude: : :, which indicates that we have more intense local

oxidation”. I find this interpretation too rapid. I agree that photochemical processes will play an important role. But a too active convection, or a bad representation of emissions could for instance lead to the same behaviour.

We agree with the reviewer that this is an important issue. We used a box model with the CBIV chemical mechanism to calculate ozone production efficiencies for typical summer conditions using initial conditions for NOx and other gaseous species from the MACC model at BI, IP and ME. We calculated that 3 to 4 molecuels of O3 produced for every molecule of NOx oxidised at BI and ME and up to 5 pbbv at IP. The above values agree well with ozone production efficiency estimates from previous studies for summer at rural semi-polluted sites with NOx more than a few ppbv in Europe and US (Chin et al., 1994; Derwent and Davis, 1994; Rickard et al., 2002).

Furthermore, the box model estimated ozone production efficiency values comparable to the MRE ratio ΔO3/ ΔNOx (ΔO3 increased over the day; ΔNOx decreased over the day) shown in Figure 10, which is roughly 3 for BI, 3.5 for ME and 10 for IP. Additionally, we have also estimated MRE ΔO3/ΔNOx ratio values at 925 hPa (above near surface but within the atmospheric boundary layer) being roughly 3.5 for BI, 3 for ME and 4 for IP, being in good agreement with the box model calculations.

Nevertheless, the diurnal meteorological patterns of wind speed and boundary layer height that lead to higher dilution of primary pollutants at daytime than at nighttime, may also contribute for the diurnal pattern of NOx in Figure 10 (see Figure 4 of this review, the diurnal cycle of wind speed and boundary layer height). This is supported from the fact that CO, which is a species with much longer chemical lifetime than NOx, has a similar diurnal pattern with NOx .

The text in Section 4.2 was modified accordingly and the relevant references were added (see below). Figure 4 of this review is added as Figure S1 in the revised manuscript.

References

Chin, M., Jacob, D. J., Munger, J. W., Parrish, D. D., and Doddridge, B. G., 1994: Relationships of ozone and carbon monoxide over North America, J. Geophys. Res. 99, 14,565–14,573.

Derwent, R. G. and Davis, T. J., 1994: Modelling the impact of NOx or hydrocarbon control on photochemical ozone in Europe, Atmos. Environ. 28, 2039–2052.

Rickard, A. R., Salisbury, G., Monks, P. S., Lewis, A. C., Baugitte, S., Bandy, B. J., Clemitshaw, K. C., and Penkett, S. A.: Comparison of measured ozone production efficiencies in the marine boundary layer at two European coastal sites under different pollution regimes, J. Atmos. Chem., 43, 107–134, 2002.

P1094,L12 : a word is missing at the end of the line.

The sentence was corrected.

Interactive comment on Geosci. Model Dev. Discuss., 8, 1077, 2015.

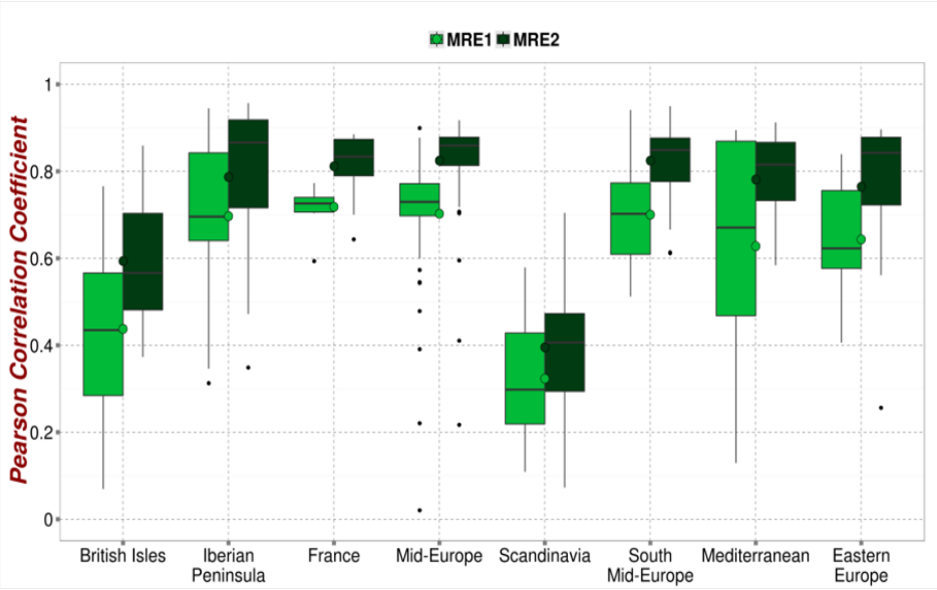

Fig. 1. Whisker plots for surface temporal correlation for MACC reanalysis averaged over 2003-2007 with bias correction (MRE1, light green) and over 2008-2012 without bias correction (MRE2, dark green)

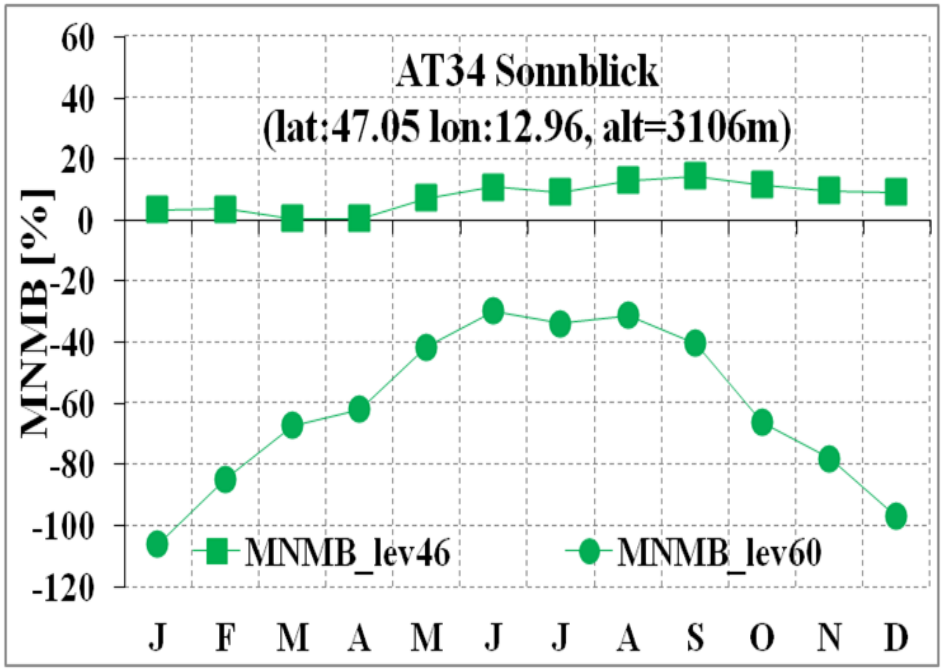

Fig. 2. Modified Normalized Mean Bias for the Sonnblick station evaluated with model data from the surface model level and upper vertical model levels

R_daily_cycle	
subregion	R
BI	0.93
IP	0.98
FR	0.99
ME	0.97
SC	0.95
SME	0.92
MDc	0.98
MDm	0.98
EA	0.96

R_annual_cycle	
subregion	R
BI	0.67
IP	0.96
FR	0.91
ME	0.89
SC	0.32
SME	0.89
MDc	0.96
MDm	0.99
EA	0.83

Fig. 3. Correlation of diurnal cycles (left) annual cycles (right)

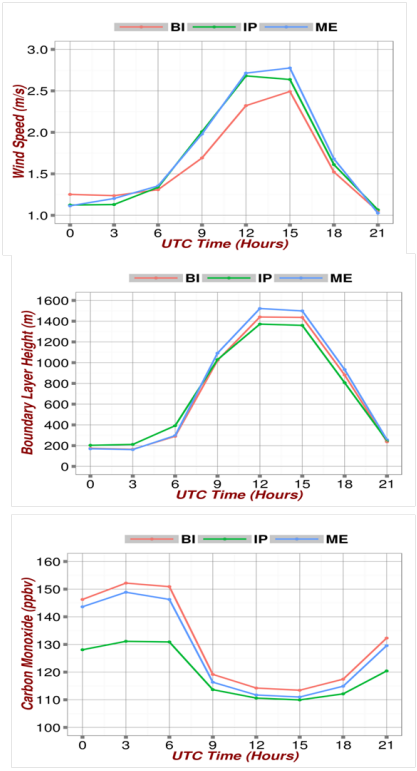

Fig. 4. Mean summer diurnal cycle of wind speed (m/s), boundary layer height (m) and near surface carbon monoxide (ppbv) for the sub-regions BI, IP and ME based on MRE.