We want to thank the referee for the helpful comments and suggestions. We have revised the manuscript according to the comments and addressed the points raised by the reviewers and updated the manuscript accordingly. Please see below for specific responses to each of the points raised.

Anonymous Referee #2

Received and published: 23 June 2014

This paper reports on the summer ozone maximum in the Mediterranean region using the thermal infrared space-borne instrument IASI and the model WRF-Chem results with additionally ground based EMEP stations. Authors investigate the 0-10km range within the 2008-2013 summer periods with a focus in 2010. They conclude on an ozone maximum, which is greater in the eastern basin (30E) than westward (15E). From WRF-Chem, they point out, the anthropogenic emissions strongly contribute to the maximum within the 0-1km altitude, whereas above 4km the transport from outside the domain is predominant. They investigate hypothesis on stratosphere to troposphere exchanges to explain the ozone enhancement in the east compared to the central basin around 15E.

The paper is well in the scope of ACP on a very interesting topic. It should be accepted if the paper is revised and improved. Material and methodology are well appropriated. Nevertheless, text should be more accurate and justifications are sometime insufficient. Results supported by fig 10, 11 and discussions on STE in particular are not enough convincing. Revised the conclusions and do not forget to provide recommendations.

- In the paper, could you explain the reason why you investigated 2010 as an example? Is it anomalous? Is it better documented: : : In figure 1 you qualify "it is representative": : : the June-July 2010 difference at 30_E is atypical and you mention Russian forest fires in 2010. Justify more clearly and rigorously, please, that would help.

When the model was run, we chose summer 2010 as a typical summer simply because it is the year of the anthropogenic emission inventory in the model. It turned out to be atypical because it is also the summer of the Russian heat wave, which was also interesting to discuss in the paper. We agree that stating that summer is "typical" or "representative" is not very appropriate, so we removed those 2 words in the manuscript, and discuss summer 2010 in section 2.1 when we introduce the model as follows:

[…]We focus our analysis on summer 2010, which corresponds to the year of the anthropogenic emission inventory used in the model. During July-August 2010, the Russian heat wave occurred that caused severe fires with high O_3 and O_3 precursors' emissions that were probably transported to the Mediterranean region, and will be further investigated in this study."

- Could you also modify the text in order to provide the exact years used for IASI. It is specified too late in the text, only in your figure 4, 5 and conclusions.

Text was changed. We added the exact years for IASI earlier: in the abstract, the introduction and section 3.

- Description of your model should be given in the section 2.2 and not lately. The regional context of the study is unclear to me and should be improved. For example, the Figure 2 should provide : the exact model domain with the Mediterranean region you are studying (model and IASI) and you refer to in the text. Take care your text agree with the description and keep it constant. the EMEP stations you include in the study (what you did). highlight the two regions you point out is the abstract : the eastern part of the basin and the middle of the basin. Note "middle of the basin" is not specified or mentioned elsewhere in the text. The two transects provided in figure 4 are too difficult to see.

All the information about the model is now included in section 2. We thank you for the suggestion of improving figure 2. Below is an update of figure 2 with: the whole WRF-Chem domain, the region used in this study, the EMEP stations as well as the 15 and 30E transects as follows:

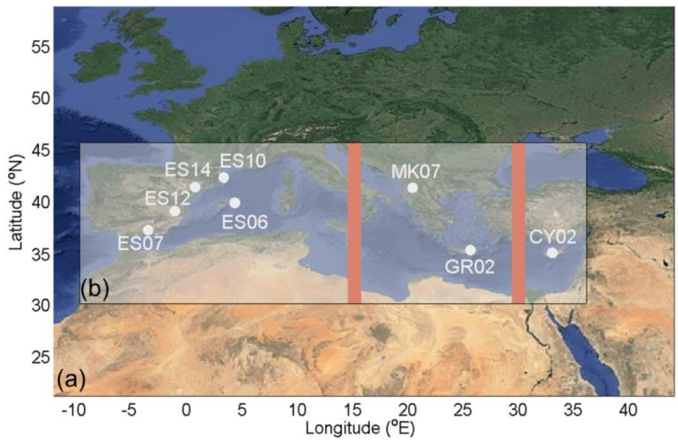


Fig 2. (a) The enlarged WRF-Chem model run domain. (b) IASI and WRF-Chem domain used in this study. White dots correspond to the location of the EMEP ground stations and the orange strips correspond to longitudinal transects at 15°E and 30°E used in Figures 5 and 10.

We add the following phrase to make clear that the transects we are choosing represent mid and east of the basin:
"we analyze longitudinal transects of 1° width along 15°E (representing the middle of the basin) and 30°E (representing the east of the basin), and marked in orange in Fig. 2."

- P12379, L2 : add "Thermal" before "infrared".

This suggestion was added to the manuscript.

- P12379, L6 : Specify exact period, "Six years (2008-2013)"…

This suggestion was added to the manuscript.

- P12380, L2 : Cairo, Istanbul and Athens you cited are located in the eastern part of the Mediterranean basin. Thus “surrounded” is not appropriated.

True. Instead of the word “basin” we now have “the eastern part of the basin”

- P12380, L7 : Would it be better to replace “region” by “circulation”???

This paragraph was elaborated, upon the suggestion of referee 1, to investigate in more detail the dynamical process from the Asian monsoon, it now reads:

[…] “The dynamical processes of the summer circulation over the Mediterranean were previously attributed to the Hadley cell considered as the driver of the major subtropical dry zones. Rodwell and Hoskins (1996) argued that during the June-August period, the zonal mean Hadley circulation has very little motion and cannot explain the dry season of North Africa and the Mediterranean. Rodwell and Hoskins (1996; 2001) suggested, through numerical simulations, that the Asian monsoon heating induces an equatorially trapped Rossby wave to its west that interacts with the mid-latitude westerlies, producing a region of adiabatic descent and triggering subsidence. Long term analysis of dP/dt (units: $Pa.s^{-1}$, used to represent subsidence) shows indeed a positive enhancement over the Mediterranean region (Ziv et al., 2004) making the South Asian monsoon a fundamental driver of the summer circulation over the Eastern Mediterranean (Tyrlis et al., 2013).”

- P12380, L10 : The heat wave induces conditions in favour of severe fires: : : and the fires causes high O3 precursor emissions. The link between the Rossby wave and the climate extreme events with the Russian 2010 heat wave example remains in the context of your paper unclear to me…Please clarify.

This paragraph was updated; see the answer of your previous comment.

The reason why we included the Russian 2010 heat wave is just to be able to introduce it, as it is an important event that occurred in the year that we chose to model. It has an effect on the tropospheric WRF-Chem and IASI O_3 data. We separate this “link” between the Rossby wave and the Russian fires. We discuss the dynamics separately and then and we include, at a later stage, at the end of section 3, when discussing that July 2010 has the highest recorded IASI O_3 column, a note about the Russian fires.

- P12380, L12 : Could be better to replace “in Europe” by “for the European Union”.

This suggestion was added to the manuscript.

- P12381, L12 : Expression “Mediterranean atmosphere” should be more accurate, from X to X altitude or hPa, because your title is on tropospheric O3 and definition of troposphere is not given…

In this study we use the [0-8] km O_3 IASI column to assess the 2008-2013 seasonal variation. We show the averaging kernels from the surface up to 16 km. We use the [4-8] km O_3 IASI column to compare with the model, we use the WRF-Chem model at the surface, 2, 4, 6, and 8 km. and finally we show the latitude altitude plots [0-10] km for both IASI and WRF-Chem to assess stratospheric intrusions. Since we are using different

combinations of columns and profiles, we choose not to be specific in the introduction, and thus we use "Mediterranean troposphere" (instead of Mediterranean atmosphere), and discuss the details in the corresponding sections.

- P12381, L24-26, the text "most of Europe" is inaccurate… Please modify the whole sentence. I expect the model domain is over Europe and the study focus on …

The sentence was changed and it now reads:
"The model domain shown in Fig. 2a is over Europe and the Mediterranean basin, the latter being the focus of this study (Fig. 2b). The horizontal resolution is of 50 km x 50 km and the vertical resolution is of 28 levels between the surface and 10 hPa."

- It would be also interesting to specify the number of model levels relevant to the [0-10km] layer you studied.

This was included in the WRF-Chem/IASI comparison section: "the averaging kernels associated with each IASI measurement and its apriori profile are applied to the interpolated modeled profile (of around 7 layers between 4 and 10 km)"

The [0-10] km corresponds to around 19 levels (not added to the manuscript), because when we compare WRF-Chem and IASI we are using the [4-10] km column and not the [0-10] km.

- P12382, L22 : cite "Stratospheric impact on tropospheric ozone variability and trends: 1990–2009" by Hess and Zbinden, acp 2013. From this reference, you could see that the transport from lateral boundary conditions is an important term and that should be evaluated individually. As far as I understood your O3inflow include this term, Linox and STE. Please revised the text and indicate in your conclusions that to refine with more accuracy your hypothesis on STE, this evaluation would be an interesting point to investigate and solve.

The reference was added in the discussion and conclusion section (which is listed as the answer for a later comment). Indeed the $O_{3\text{-INFLOW}}$ includes transport from lateral boundaries, LiNox and STE.

- P12382, L25, "inflow" is here too imprecise, check with reference.

"inflow" was replaced with "transport".

- P12383, L12 : "Given that their contribution to the total budget in comparison with INFLOW and ANTHRO (please keep constant your labelling and modify here!) tracers is very small, they are not analysed in this study."Could you justify or at least evaluate the range of this "very small" contribution before you conclude on the O3 from fires discard from your study. Is seems to contradict to what you said P12380, line 10 on Russian fires in 2010… Note that they take place in late July and your figure 5 shows a great June-July enhancement on that specific year for the 30_E transect.

The labeling was modified to be uniform in the whole manuscript. The wording was changed since we discuss later on the residual ozone (from fires and biogenic sources) and we relate that to the Russian fires (as you also suggest in a later comment). The sentence now reads:

"Given that their contribution to the total budget in comparison with $O_{3\text{-INFLOW}}$ and $O_{3\text{-ANTHRO}}$ tracers is small (<10%), they are analyzed together in this study as "residuals" to the total budget and their contribution is defined as 100%-($O_{3\text{-ANTHRO}}$%+$O_{3\text{-INFLOW}}$%)."

- P12383, L16 : Please specify the EMEP instrumentation used.

The following sentence is added when introducing the EMEP data: "All ozone measurements within EMEP are done by UV monitors."

- P12383, L18 : In the legend the red line is not legible, adapt the colour to the red line used and your black symbol is also difficult to see. Please mention you EMEP stations are within 78m-1332m height and show up on each panel after the station name. That makes a great difference if you compare O3 at the surface with the O3 at _1000m height. It would it be interesting to show the six stations separately to improve the comparison (a table with the six stations would be convenient).

We assume that this comment is about Fig 6. We update the figure with the suggestion provided. The new figure is now as follows:

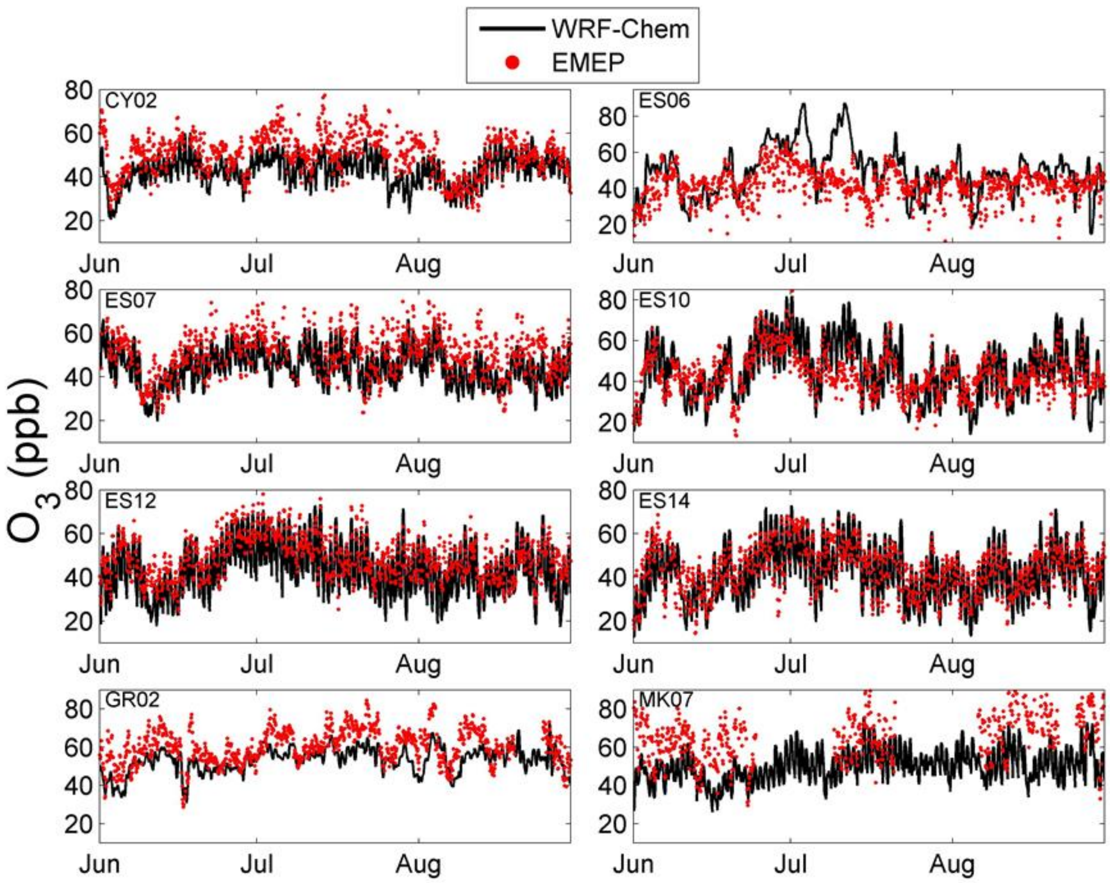


Fig. 6. O_3 time series of EMEP and WRF-Chem data at the surface for the stations localized in Fig. 2, for the period JJA 2010.

As suggested also by the first referee, we updated the manuscript with the following table. Fig 6B is therefore not necessary so we removed it. We also changed Fig 6A and the legend to make it more legible. The text was updated accordingly.

Table 2. Pearson correlation coefficient, bias and the corresponding mean normalized bias (MNB) of each EMEP and WRF-Chem ground station data localized in Fig. 2, for the period JJA 2010.

Station name	Corr. Coef. With WRF-Chem	Bias (ppbv)	MNB (%)
CY02	0.63	-7.78	(-14.2%)
ES06	0.41	+7.26	(+20.9%)
ES07	0.77	-7.24	(-13.4%)
ES10	0.72	+1.43	(+3.6%)
ES12	0.80	-5.96	(-12.7%)
ES14	0.78	-2.99	(-6.4%)
GR02	0.62	-7.38	(-11.3%)
MK07	0.57	-16.65	(-23.9%)

In fact when we compare the model to the station data, we are comparing them at the same altitude, because first EMEP stations are ground based stations and the altitude recorded in Table 1 is the one above the mean sea level. Second the model takes into consideration the orography at 50 km resolution. The only discrepancy comes from the fact that the resolution of the model is coarser than reality, so if the station is located on an elevation and the surrounding is not, then the altitude taken by the model will be the one averaged of the 50x50 km around the station. Also, from the table one can see that the altitude is not really correlated with the correlation coefficient. The location of the station is a more significant factor controlling the agreement between modeled and observed O_3 concentrations.

We specified in the text that the EMEP stations are ground based stations and that the altitude in table 1 is the one above mean sea level (caption to Fig 2 and in text).

- P12384, L16 : Why do you provide the averaging kernel for the specific June 2010, your are studying the 2008-2013 period with a focus on summer 2010. Explain why.

We mention in the legend that it is a "Typical O_3 averaging kernel over the Mediterranean". We chose this one (though it is a random observation during that day) in particular during summer 2010 because it is the year we use for the model run. The justification for the choice of summer 2010 was treated in a previous comment. We change the word "Typical" to "Random" to make it more appropriate.

- P12384, L26 add partial before "tropospheric O3 column".

This suggestion is now updated in the manuscript.

- P12384, L21 "on several pollutants": which one?

The following expression was added for clarification of the pollutants measured by the IASI instruments during a case study of China pollution event: "(e.g. carbon monoxide, ammonia, sulfur dioxide and ammonium sulfate aerosols)"

- P12385, L1-2: A bit too trivial here, revise and condense using the informations on season and month from lines 5-6.

The text was changed. Line 1-2 now reads:
"The data were averaged seasonally and daytime observations were used […]"

- P12385, L9: please refer also to the "A Lagrangian "1-year climatology of (deep) crosstropopause exchange in the extratropical Northern Hemisphere" study from H. Wernli and M. Bourqui, JGR 2002 who wrote : "Generally, the cross-tropopause mass fluxes are largest in winter and smallest in summer. The most pronounced seasonal variability occurs in the southern part of the midlatitudes (30_–45_N) where the STE winter values are 2–3 times larger than the summer ones… Clarify.

Figure 7 in the suggested paper shows indeed that there are considerable STE mass fluxes in winter, but also in spring for the Med region, and much less in summer.
We agree that this part and the references are outdated and (as also suggested by the first referee) we removed this controversial sentence.

- P12385, L15-17 : Is that your definition of the eastern and middle Mediterranean region? That should have been provided before…

This was answered in a previous comment, with the description of Fig 2.

- P12385, L18-22: Should be specified that this result is a 0-8km partial O3 column and may be valuable to clarify in the introduction (P12381, L12-18) the partial layers you will investigate?

These last 2 comments were taken into consideration in the following completing sentence in the introduction:
[…] we analyze six years (2008-2013) of IASI tropospheric *[0-8] km O_3 column seasonal* variation above the whole Mediterranean basin *as well as at 15°E and 30°E, representative of what we henceforth refer as "middle of the basin" and "east of the basin" respectively*.

and we added also in P12385, L18-22 the specification that it is the [0-8] km column.

- Figure 6 (a) : I could not find the CY2 station, should it be GR02?: : : Please check and modify.

Indeed it is called CY02 but reported previously (typo) as CY01, this was corrected.

- P12386, L11 : The model underestimates… Yes, from your fig 6b. But from 6a, I have the feeling the E06 (at 78m) and ES10 (at 23m) is in better agreement with an overestimate in July for these two stations, which stations are the closest to the surface. I noticed the Stations ES07 and MK 07 are above 1km. Furthermore, your Fig 8 highlight the difference between the modelled WRF-Chem O3 concentrations at the surface and 1km. Therefore may be interesting to provide the six individual results in a table instead of Fig 6b as said previously. A table was provided with the corresponding individual results instead of Fig 6b.

See previous comment. The stations are ground based stations and the altitude is the one above the mean sea level and same as the altitude reported in the model.

A table was also provided instead of Fig 6b.

- P12386, L14 : Suppress “which is around 0.5_ by 0.5_” as already given in the section 2.2 (and it is but in km) and just mention the ground resolution difference contribute to the discrepancy with the other possible reasons…

This expression was deleted and the phrase is updated as follows:
“The biases reported may be due to the resolution of the model resulting in a grid of around 50 km around the EMEP rural sites which may include other surface O_3 contributions.”

- P12386, L18-20 : It is unclear what your correlation refer to (range and mean value). Is that for individual rural EMEP sites vs WRF-Chem??? Clarify

Yes, it is the correlation between EMEP and WRF-Chem, these correlation are now clearer as they are reported in the new Table 2. We also make this clear by stating it explicitly:
“Table 2 shows the individual O_3 correlation between WRF-Chem and the EMEP for each of the stations used in this study during JJA 2010. The model simulates the surface O_3 with a correlation ranging from 0.41 (ES06) to 0.80 (ES12) and a mean value of 0.52.”

- P12387, L9-11 : As you provide on fig 7 the IASI and WRF-Chem results in DU for the 0-4 O3 partial column, why this summer mean bias is provided in ppbv? Is the difference less over land than over sea??? More comments are expected on that difference (line 7).

Thanks for your careful reading as the ppbv is a typo. It should be “DU”. This was corrected in the manuscript.
We precise that the WRF-Chem model columns shown on the figure 7 are smoothed with the averaging kernel of IASI. Averaging kernels are variable, and particularly depend on surface properties. This means that when the model is smoothed with the AK then compared to IASI, the surface type (land/sea) should not matter. But this does not mean that the surface type has no influence on the O_3 comparison. There can be physical reasons, e.g. convection stronger over land surfaces, etc… However, in Fig. 7, we do not see a difference between land and sea and therefore we do not discuss this issue in the manuscript.

- P12387, L17-20 : Please clarify “We analyzed the IASI columnar total error relative to measurement for the [4–10]km integrated partial column”, I do not understand what you meant here… Revised and clarify the whole lines 17-20.

This sentence was changed to make it simpler:
"We analyzed the IASI total retrieval error for the [4–10] km partial column"

As a side note: the total retrieval error contributions come from the limited vertical sensitivity (smoothing error), from the measurement noise and from uncertainties on fitted and fixed parameters (Hurtmans et al., 2012).

- P12387, L25 : Please note that your summer maximum occurs at 1km and careful take it into account in your EMEP comparison at _1km with WRF-Chem surface.

The issue of stations altitude was treated in a previous comment.

- P12388, L3 : "the entire model study …10 hPa" : this should be removed from this section and included in section 2.2. What "the entire model study" means. Keep the labelling steady or explain the difference.

This sentence was condensed and now reads: "In order to investigate possible sources of high O_3, we run the model with 2 different tracers of pollution: $O_{3\text{-}ANTHRO}$ and $O_{3\text{-}INFLOW}$ as described in section 2.1. ***$O_{3\text{-}ANTHRO}$ (Fig. 8 d-f) assesses the possible anthropogenic contribution of O_3 at different altitudes, while $O_{3\text{-}INFLOW}$ (Fig. 8 g-i), provides an estimate of transport of O_3 including the stratosphere."***

The sentence : "the entire model study …10 hPa" was removed since it is already mentioned in section 2.1: "The model domain shown in Fig. 2a is over Europe and the Mediterranean basin, the latter being the focus of this study (Fig. 2b). The horizontal resolution is of 50 km x 50 km and the vertical resolution is of 28 levels between the surface and 10 hPa."

- P12388, L4 : To what I understood, these residuals plots should reveal the O3 from biogenic sources and O3 from fires… This seems in contradiction with what is said on P12383 L 12-14.

The residual plots represent the ozone from biogenic and fire sources. We make it clear by stating it twice in the text.

We change P12383 L 12-14, so it reads:
"Two more tracers are available to complete the O_3 budget: O_3 from biogenic sources and O_3 from fires. Given that their contribution to the total budget in comparison with $O_{3\text{-}INFLOW}$ and $O_{3\text{-}ANTHRO}$ tracers is small (<10%), they are analyzed together in this study as "residuals" to the total budget and their contribution is defined as 100%-($O_{3\text{-}ANTHRO}$%+$O_{3\text{-}INFLOW}$%)."

We change P12388 L4: "The residual plots plotted in panels (j-l) represent the completion of the O_3 budget, and represent the O_3 contribution from fires and biogenic sources. These plots show that the residual contribution is between 0 and 10% inferring that the $O_{3\text{-}ANTHRO}$ and $O_{3\text{-}INFLOW}$ are responsible of 90 to 100% of the total O_3 budget over the model domain, at the different altitudes of Fig. 8 and 9.

- P12388, L5 : Provide evaluation in the text instead of “most”, too imprecise.

The wording is changed, it now reads:

“These plots show that the residual contribution is between 0 and 10% inferring that the $O_{3\text{-ANTHRO}}$ and $O_{3\text{-INFLOW}}$ are responsible of 90 to 100% of the total O_3 budget over the model domain, at the different altitudes of Fig. 8 and 9.”

- P 12389, L 13-14 : the extended domain… includes the Russian fires ??? Still the same, your domain (here extended) is not rigorously defined. You must define this clearly and rigorously in section 2.

The exact model domain is now more rigorously presented in Figure 2 and also discussed in section 2.

- Figure 10 : Replace “along” which is confusing by “at” and add after “15_ E” “(left)” and “30_ E” “(right)”. Remove from the figure caption : “The Eastern part of the basin : : :events” Could you add in the text or figure the altitude of your seasonally-averaged coldpoint, quartiles tropopause or the dynamical tropopause at 2pvu with statistics on the quartiles to be more meaningful: : : I have the feeling your 100ppbv is more above 8km than between 6-8km (also on fig 9c).

The suggestions for the caption were implemented. We also added on the plot the dynamical tropopause height.

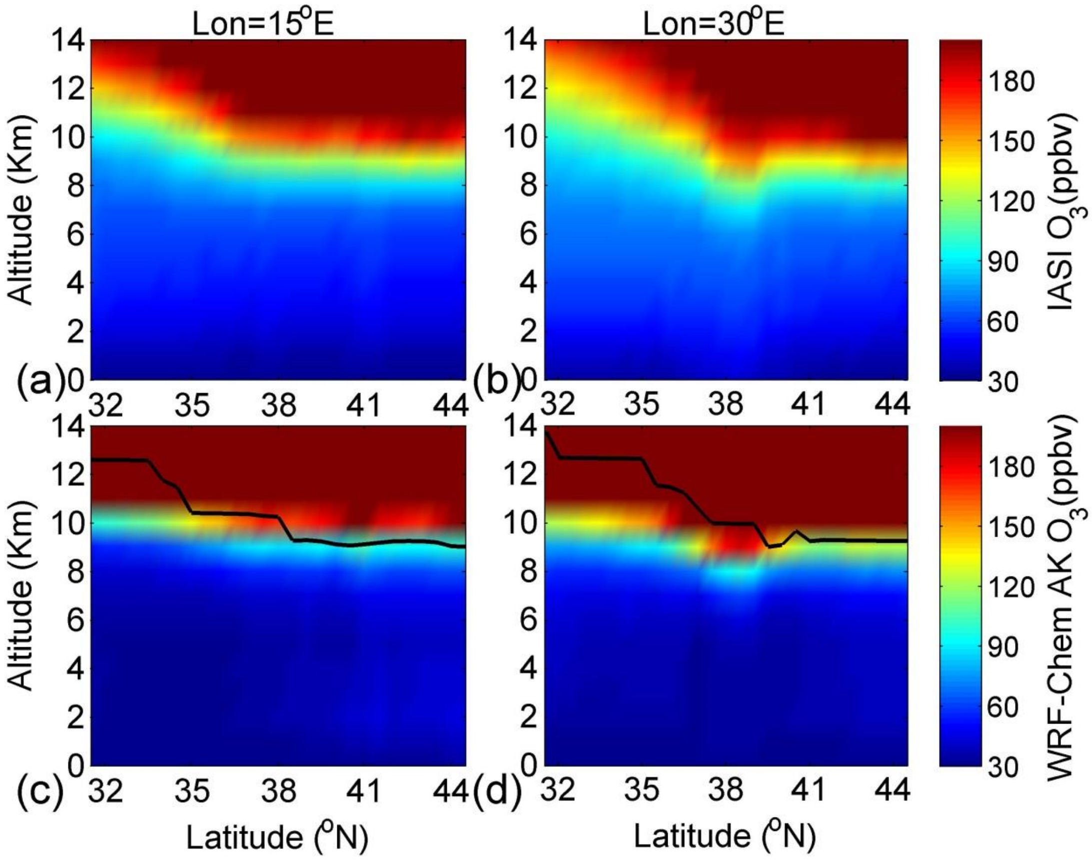
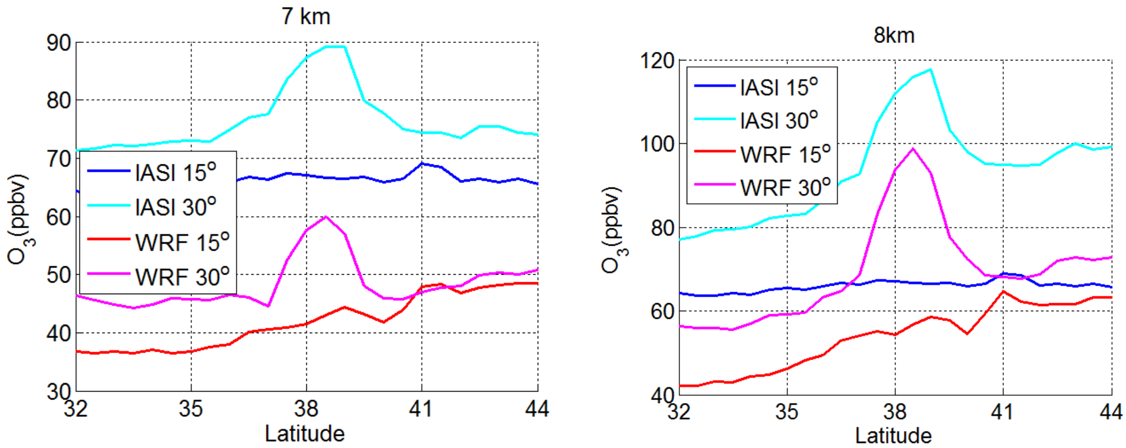


Fig.10. Mean latitude-altitude cross sections of IASI-O_3 (a-b) and modeled-O_3 (c-d) averaged over JJA 2010 at 15°E (left) and 30°E (right). Black line corresponds to the dynamical tropopause height.



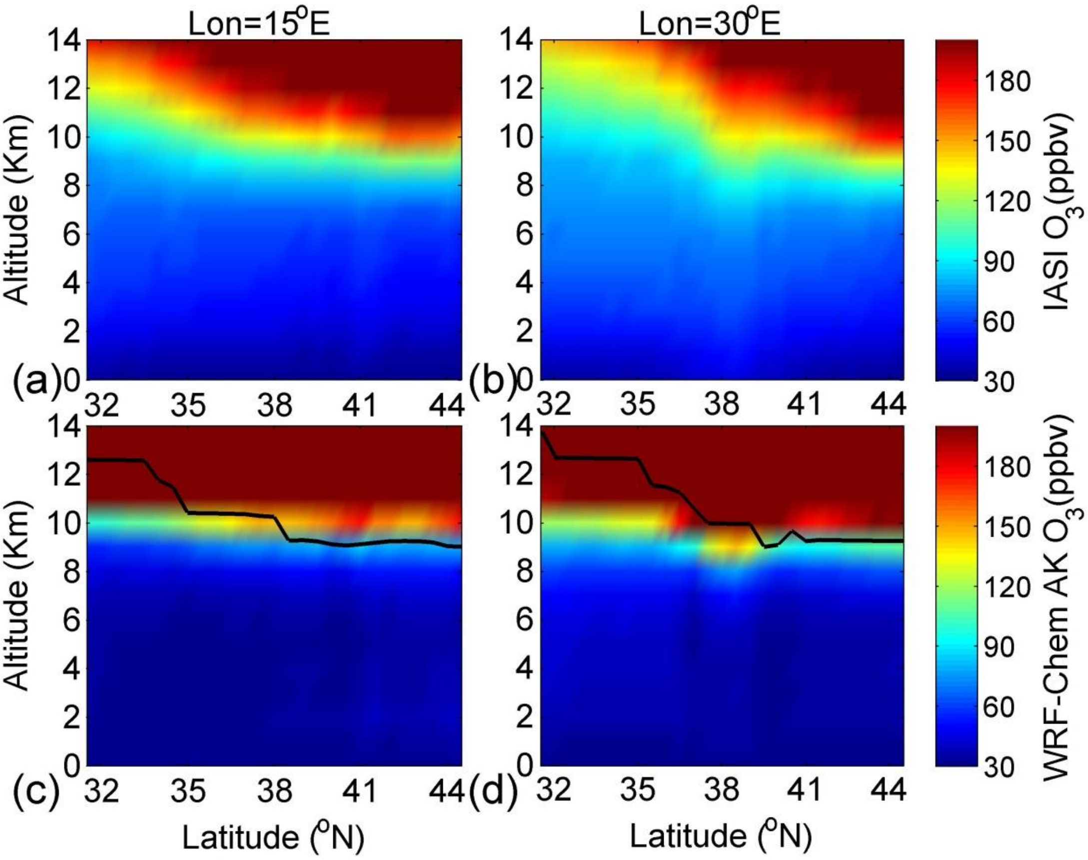
Fig_A: O_3 from IASI and WRF-Chem (smoothed with the IASI AK) at 7 and 8 km.

Fig_A shows that at 8 km values of 100 ppbv are reached for IASI and WRF-Chem at around 38.5 E.

- Undoubtedly you have more ozone at 30_E than at 15_E. Nevertheless, I am not convinced by your concluding remark because below 8km I can't see any typical STE features as described in the figure 5a and 5 from Zanis et al. 2014 showing O3 values much higher that 100ppbv in July-August within 1998-2009. Moreover your 2010 JJA-average include a June low O3 anomaly at 30_E. The highest PV values you cite 0.8 to 1.4 pvu in the east-basin and the lowest are 0.6-0.9 in the midbasin (15_E) appears as typical tropospheric PV values. STE events should provide higher values, is that the effect of the 3-month averaging?: : : To me the June 2010 doesn't seem to be so typical and probably lessen you result in 10 b and 10 c. Your O3inflow is not an exclusive tracer on O3 from STE and you mentioned from Pfister al al (2013) the transported plumes over large distance might not be well resolved from the model. To improve may be valuable to provide if possible where, when and how frequent the maximum PV-values are occurring in your model after the tropopause position has been clarified. STE events are not shown so clearly on fig 10 at least it could be transients or shallow events. I recommend concluding more carefully on the impact of STE and using "suggest" which seems to me more appropriated. Figure 11 and Page 12289 L 21 : Provide the longitudes in Fig 11a-b. After the figure 10, this figure doesn't help much to conclude on STE. The layer you investigate is _8-10km whilst the fig 10 is within 0-10km

This is how Fig. 10 looks like without the month June. One can note that there is little difference between this plot and the plot we had in our paper, inferring that the month of June does not change much the overall shape of Fig. 10

We also updated Fig 11 with the potential vorticity and water vapor mixing ratio at different altitudes, which makes it clearer to see that in particular at 8 and 10km we have higher PV values to the east. We discuss the results and compare it to other studies. The conclusion was changed and updated with a discussion with previous studies. We use the word "suggest" for STE.
The updated part of the conclusion now reads:
"[…] Focusing on summer 2010, we use IASI and the regional chemical transport model WRF-Chem to interpret these maxima. A tagging scheme is used to keep track of O_3 from anthropogenic sources in the domain ($O_{3\text{-ANTHRO}}$) and O_3 from inflow at the domain boundaries and stratosphere ($O_{3\text{-INFLOW}}$). Our results show that transport plays an essential role in the O_3 budget over the Mediterranean troposphere and that summer O_3 maxima over the region are recorded especially in the eastern part of the basin. Even though high local anthropogenic emissions are responsible to 60-100% of O_3 in the boundary layer (surface-2 km), as demonstrated by the anthropogenic O_3 tracer of the WRF-Chem model, above 2 km, O_3 is mainly transported. Kalabokas et al. (2007, 2013) showed that the highest ozone concentrations in the low troposphere are associated with large-scale subsidence of ozone-rich air masses from the upper troposphere. However, Zanis et al., (2013) using model simulations reported, that at the low troposphere, long distance transport and local photochemical processes dominate. In the free troposphere, WRF-Chem shows that vertical and lateral transport of O_3 take place represented by the $O_{3\text{-INFLOW}}$ tracer which is responsible for 70-100% of O_3 at 4, 6 and 8 km. In the Eastern Mediterranean, Roelofs et al. (2003) showed important contributions to elevated O_3 in the middle troposphere by transport from the stratosphere. More recently, Hess and Zbinden (2013) showed that stratospheric inter-annual O_3 variability drives significantly the O_3 variability in the middle troposphere, between 30^{o} and 90^{o}N but not the overall trend which is largely affected by transport processes. The increase in O_3 seen by the model and the IASI instrument in the eastern part of the Mediterranean basin suggests that stratosphere to troposphere exchange (STE) events contribute to elevated ozone in the upper free troposphere. This is further shown in the WRF-Chem simulations that predict elevated potential vorticity (PV) and water vapor mixing ratio (Q_{vap}) over the same region. This result is in agreement with many previous studies e.g. Butkovic et al. (1990); Varotsos and Cracknell (1993); Kalabokas and Bartzis (1998); Kalabokas et al. (2000, 2007); Kouvarakis et al.(2000); Lelieveld et al.(2002); Sprenger and Wernli (2003); Papayannis et al. (2005); Gerasopoulos et al. (2006a); Akritidis et al. (2010); Zanis et al. (2013); Doche et al. (2014) that have shown the occurrence of STE events in the eastern Mediterranean region in summer. Since O_3 maxima have the potential to strongly impact regional air quality and climate (e.g. Hauglustaine and Brasseur, 2001), the present study further demonstrate the importance of quantifying and analyzing O_3 and its sources at different altitudes in the atmosphere. Quantifying long term trends and a distinction between the different sources is crucial. This should be possible with observations and model runs over longer time scales with additional tracers to identify all O_3 sources."



Fig_B. Mean latitude-altitude cross sections of IASI-O_3 (a-b) and modeled-O_3 (c-d) averaged over July and August 2010 at 15°E (left) and 30°E (right). Black line corresponds to the dynamical tropopause height.

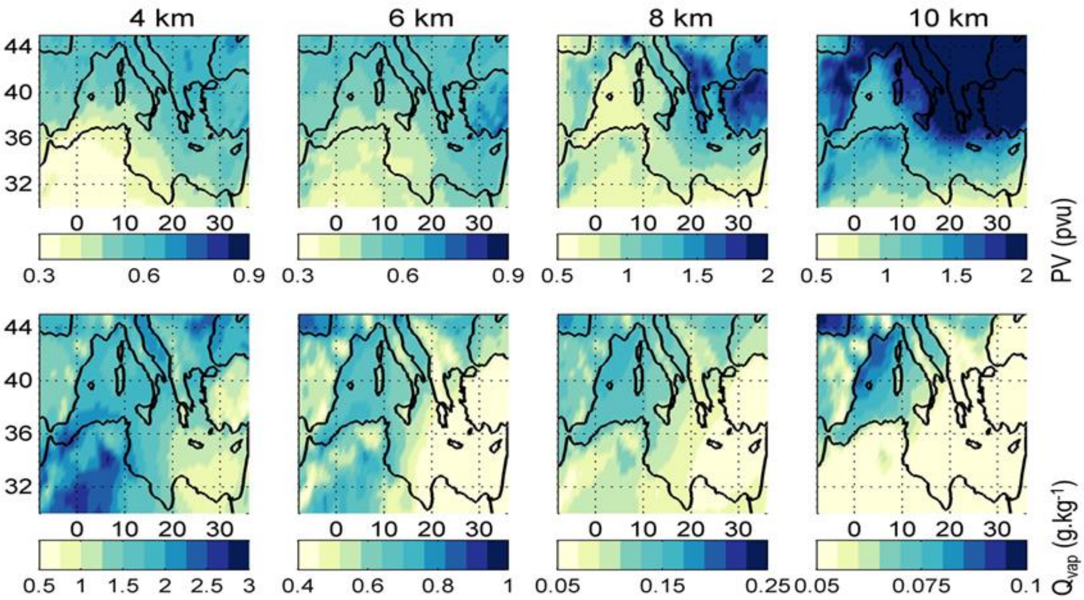


Fig. 11. WRF-Chem (a) potential vorticity at 4, 6 and 8 and 10 km over the Mediterranean region for JJA 2010 and (b) water vapor mixing ratio for the same vertical levels and time period.

References to add :

Liu et al., JGR 2011: "Influence of interannual variations in transport on summertime abundances of ozone over the Middle East".
A large number of useful references are provided by Zanis et al. 2014: : :

We added the following sentence with the reference in the introduction: " Liu et al., (2011) showed with long term model analysis that the dominant sources of O_3 in the Middle East (including the Mediterranean) are the transport from Asia and local production."
This reference and many others from Zanis et al., are now included in the manuscript, particularly in the discussion and conclusions section (see previous comment).

Take into account and refer to a study submitted recently to acpd by Doche et al, 2014 on "Summertime tropospheric ozone variability over the Mediterranean basin observed with IASI"

This reference was added in the discussion and conclusions:
"A complementary study by Doche et al. (2014) using IASI data at 3 km height, also showed 6 years recurrent O_3 summer maxima in July to the east of the basin."