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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Summertime tropospheric ozone variability over the Mediterranean basin observed with IASI" *by* C. Doche et al.

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The authors thanks the referees for their interesting comments, which were very helpful to improve the discussion quality of the manuscript

Referee: a) The authors state that "the western ridge results from the spreading of the Azores anticyclone" (page 13023 at line 15). The western Mediterranean ridge may associated with the Azores high. However in Figure 1 the high pressure ridge over the western Mediterranean (referred in page 13023 at line 13) in fact extends over Central and Central-eastern Europe (or Balkans) which according to the current un-

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derstanding is detached from the Azores anticyclone. Many researchers underline the differences between the anticyclonic center over Central and Central-eastern Europe (or Balkans) and the Azores high pointing to the importance of anticyclonic vorticity advection from Northwestern Africa (Prezerakos, Arch. Meteorol. Geophys. Bioclimatol. 1984; Tyrlis and Lelieveld, J. Atmos. Sciences, 2013; Anagnostopoulou et al., Clim. Dynam., 2014). Furthermore when looking Figures 6 and 10 of Geopotential Height at 850 hPa you may notice that the Azores anticyclone is detached from the anticyclone which extends from Northwestern Africa towards western Mediterranean and central to central-eastern Europe.

Authors: The authors agree that there are two different high pressure systems, one above Europe driven by the Azores Anticyclone, one above the Mediterranean driven by the Northern African Anticyclone (as shown in Figures 6 and 10 of the current version of the paper). In order to clarify this point in the manuscript, red lines indicating the position of the two different ridges will be added in Figure 1 and details with the recommended references will be given in the text as follow (P13023-L12): "These summertime meteorological conditions are characterised by two high pressure ridges, one over the Central Europe and one over the Western Mediterranean basin, and a deep trough extending from the Persian Gulf to the Eastern Mediterranean basin (Fig.$\sim$1a). The Central Europe ridge results from the spreading of the Azores anticyclone and the Western ridge results from the spreading of the North African anticyclone, which leads to low winds, persistent clear sky conditions, and high solar irradiation \citep{prezerakos84,tyrlis13,anagnostopoulou14}".

Referee: b) Concerning the discussion for the role of transport on the spatial ozone variability over Mediterranean (Section 3) it should be noted that the subsidence (in Figure 2c) actually takes place at the western flank of the high PV-streamer (Figure 2b) as would be theoretically expected from a dynamical point of view with anomalous subsidence upstream a positive PV anomaly (Hoskins et al., Q. J. Roy. Meteor. Soc., 111, 877–946, 1985).

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Authors: This comment has been addressed in the revised manuscript as follow (P13031-L5): "[. . .] explain the enhancement of ozone over the eastern Mediterranean basin in the lower troposphere. It should be noted that the downward vertical transport actually takes place at the western flank of the high PV-streamer (Fig.2b) as would be theoretically expected from a dynamical point of view \cite{hoskins85}"

Referee: c) Apart from the important role of subsidence it should also considered the high probability of tropopause folds over the area which feeds stratospheric air in the upper and middle troposphere. There is a recent article by Tyrlis et al., (JGR, 2014) indicating a global "hot spot" of summertime tropopause fold activity over a sector between the eastern Mediterranean and Afghanistan, in the vicinity of the subtropical jet. Mind also that according to a study of Sprenger et al. (J. Atmos. Sci., 2007), a maximum in stratosphere-to-troposphere transport (STT) is identified at the western flank of the stratospheric PV streamers which implies a co-location with the area of the strongest subsidence.

Authors: This discussion has been addressed in the revised manuscript as follow (P13031-L5): "Apart from the important role of subsidence it should also considered the high probability of tropopause folds over the area which feeds stratospheric air in the upper and middle troposphere. \cite{tyrlis14} indicates a global "hot spot" of summertime tropopause fold activity over a sector between the eastern Mediterranean and Afghanistan, in the vicinity of the subtropical jet. According to a study of \cite{sprenger07}, a maximum in stratosphere-to-troposphere transport (STT) is identified at the western flank of the stratospheric PV streamers which implies a co-location with the area of the strongest subsidence."

Referee: d) The trough of high PV extending over SE Europe (Figure 3b) (thus inducing a deviation from a zonal distribution of PV) is not clearly represented in IASI 10 km ozone data. It could be possibly the selected colored scale that masks this feature in Figure 3a. It would interesting to show the similarity in the patterns of the ERA-interim PV and IASI O3 (e.g. by adding contour lines or modifying the colored scale). Mind

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that PV and O3 at the tropopause level should show similar field structures.

Authors: In the current version of the manuscript, Fig. 3a and 3b were not given exactly on the same geographical domain. Figure 3b was more extended eastward. This explains most of the differences noticed by the referee. In the revised version of the manuscript the Figures will be provided on the same domain. Moreover ozone and PV isolines will be added to help with the readability of the map. General features are similar for both the ozone and PV distributions. The ozone distribution at 10 km remains noisier compared to the PV distribution due to significant errors in the IASI observations (about 25% at this level – see Dufour et al., 2012 for more details).

Referee: e) The authors refer to a correlation of 0.99 between ozone and PV (page 13023, line 17) . Is this correlation calculated from a number of 18 data points (6 years x 3 months) shown in Figures 4 and 5? Please clarify in the text.

Authors: Indeed, the correlation is calculated from a number of 18 data points (6 years * 3 months). This will be specified in the revised version of the manuscript.

Referee: f) The discussion of the case of June 2008 refers to a deeper low-pressure system over Eastern Mediterranean but it misses any discussion of the link with the Asian monsoon which controls this low pressure system. This discussion maybe even more relevant in comparison to the other case of June-July 2009.

Authors: The anomalies in the summertime convective activity of the Indian Monsoon can be describeb by the Indian Monsoon Index (IMI). We use the seasonal and daily IMI provided byhttp://apdrc.soest.hawaii.edu/projects/monsoon/seasonal-monidx.html to complete our analysis. The 2009 daily IMI shows that the monsoon activity was significantly smaller in June and July compared to the climatology. This is in agreement with the negative ozone anomaly observed with IASI in June and July 2009. For 2008, the monsson activity is rather comparable to the climatology. However, some periods of June exhibit slightly more intense activity.

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We propose to add the followed sentences in the revised version of the manuscript (P13034-L15): “This is confirmed by the analysis of the daily Indian Monsoon Index (IMI, http://apdrc.soest.hawaii.edu/projects/monsoon/seasonal-monidx.html) which indicates positive anomalies events of the diabatical convective activity over the Indian Ocean during the month of June 2008.” P13035-L11: “Indeed, the IMI daily variation shows strong negative anomalies, indicating a lower diabatical convective activity than the climatological mean during June and July 2009.”

Referee: g) The analysis of the case of June 2008 uses an averaging over the whole Mediterranean Sea for IASI ozone and ERA-interim PV thus loosing the distinction of the circulation patterns between western and eastern Mediterranean. Maybe a differentiation between west and east could emphasize even more the controlling role of downward transport over the eastern part.

Authors: Ozone and PV time series have been studied separately for the Western and Eastern part of the Mediterranean basin. In summer 2008, the ozone concentrations and the PV values reach larger quantiles levels on the Eastern basin (up to 75% and sometimes up to 93%) than on the Western Mediterranean basin (under the median and sometimes under the first quartile).

The followed sentence will be added in the revised version of the manuscript (P13034-L10): “Studying separately the Eastern and the Western basin show as expected that the Eastern basin is the most affected. Ozone concentrations exceed 80 ppb during these periods and even exceeds the 93% quartile for some days, whereas the ozone concentrations remain smaller than 70 ppb on average on the Western basin (not shown).”

Referee: h) Mind please an analogous study which is under discussion in Atmospheric Chemistry and Physics (Atmos. Chem. Phys. Discuss., 14, 12377–12408, 2014).

Authors: The reference has been inserted in the conclusion. The last sentence has been change into: “Recently, \cite{safieddine14} investigated this point using IASI

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ozone observations and regional WRF-CHEM simulations."

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 13021, 2014.

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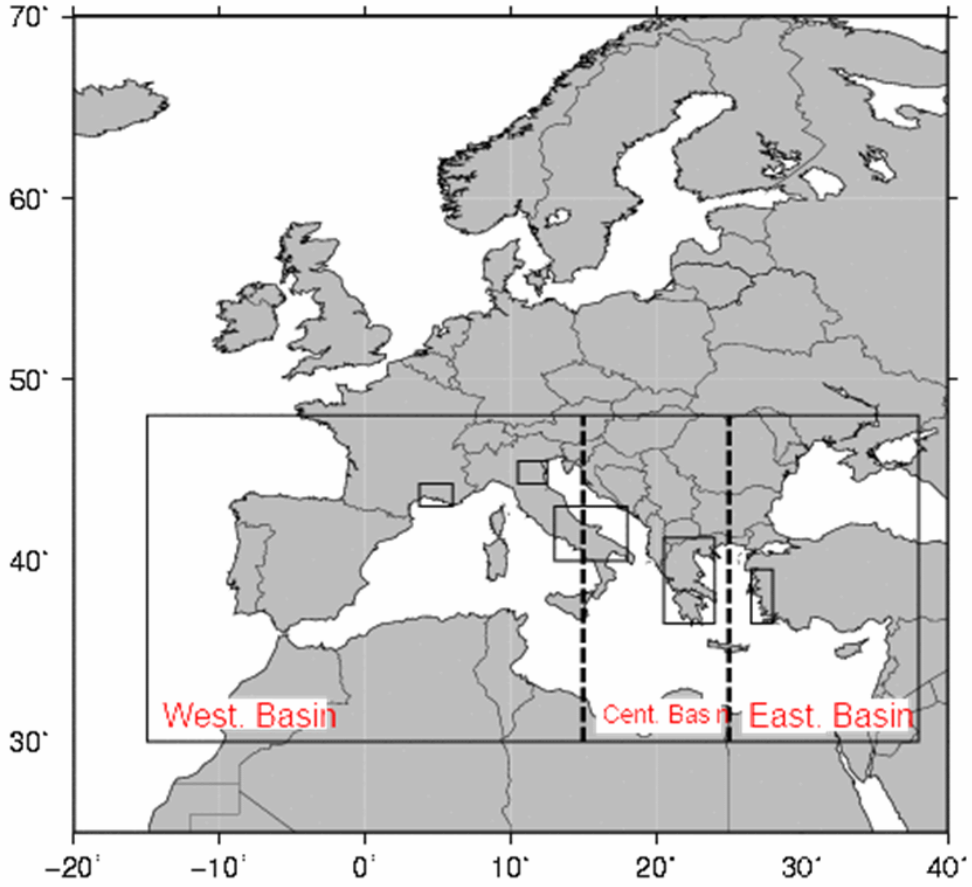

Fig. 1.

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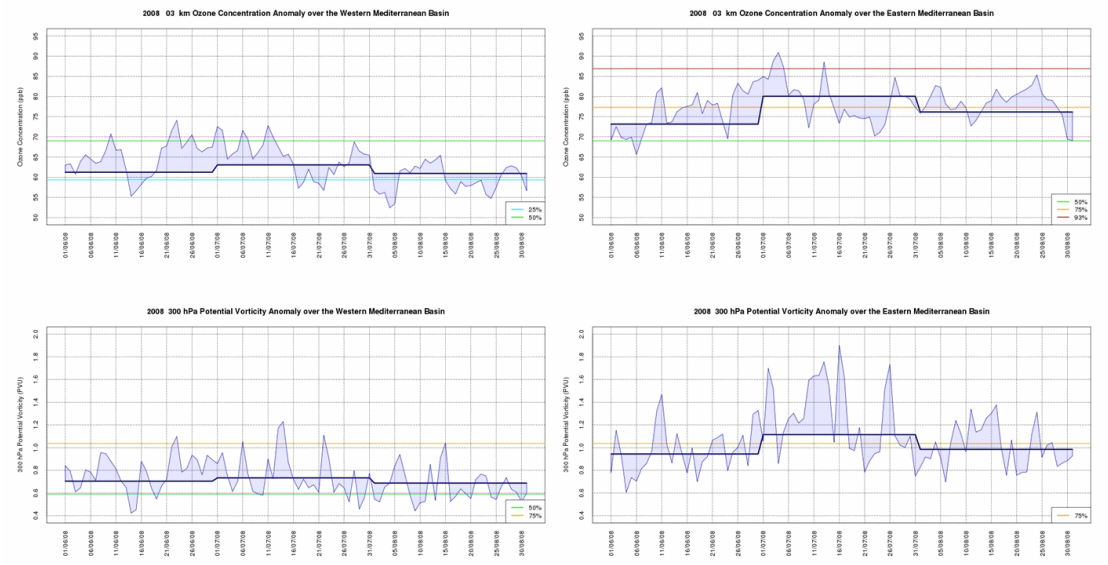

Fig. 2.

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