

Interactive comment on “Secondary maxima in ozone profiles” by R. Lemoine

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Various phenomena like the influence of dynamical activity in the troposphere and the stratosphere on ozone, ozone transport through the tropopause, lamination and exchange of air at the boundary of the polar vortex and so on have been studied in the past and have been the subject of many detailed articles. These articles contain several case studies and are summarised in the Introduction section. This Introduction is voluntarily long in order to convince the reader that, although no definite answer has been presented, the state of knowledge of these phenomena is relatively high.

Instead, the article discussed here tries to concentrate on work that has rarely or never been presented before, like the climatology and global distribution of ozone secondary maxima and their relation to ozone trend.

An early version of this article contained two case studies of ozone secondary maxima, with PV maps and description of the formation of the secondary maximum through

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advection of air masses from different origins. These case studies turned out at the end to be almost carbon copies of the case studies presented by O'Connor et al [1999] and Varotsos et al [1994]. Pushing the analysis further as suggested by referee#1 would require an article dedicated to that aspect only.

The only new information that came out of the case studies is the apparent systematic association between ozone secondary maxima and Rossby wave breaking events. This result is presented in the present article, with more cases (17 cases instead of 2). The tool used here is kept as simple as possible. The use of trajectories can sometimes be problematic but the consistency of the examples shown should convince the reader of the relevance of the analysis. Trajectories give only a part of the information needed. It is true that an air mass that was over the arctic 5 days ago can still be of tropical origin. However, if this air mass shows unusually high ozone concentration and no vertical displacement, the argument doesn't hold anymore.

About the Dobson hypothesis, intrusions of tropospheric air can lead to the formation of ozone-poor layers in the lower stratosphere, but this phenomena was not found to be the origin of ozone secondary maxima in the cases analysed. The opinion of the author is that tropospheric intrusions cannot create ozone poor layers as high as the 100hPa level where the low ozone layer is generally observed when associated with a secondary maximum (Fig. 4c).

About the regression section, an ozone profile contains more information than just ozone concentration levels at different altitudes. The shape of an ozone profile contains information about the air masses that were sampled by the sonde (or sensed by the satellite). The regression relating lower stratospheric/total ozone and aspects of secondary maxima should be understood this way: since secondary maxima are associated with atmospheric circulation and ozone transport, can we use the characteristics of secondary maxima as a proxy for the atmospheric circulation in the stratosphere instead of using classical quantities like the tropopause height or the QBO. The answer to that question is given by the results of the regression analysis. Evidence is pre-

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sented that secondary maxima are linked with the exchange of air between the polar vortex and mid latitude air. Section 8 gives evidence that the frequency and amplitude of secondary maxima can be used to describe a large part of the ozone variability and trend. Hence, it is deduced that the frequency and amplitude of secondary maxima are representative of the component of atmospheric circulation that has a direct influence on ozone.

It is true that secondary maxima could be related to modelled quantities like a Rossby wave activity index or the EP flux, but this is another approach and can be the subject of a more model-oriented study.

A detailed response to all the referee comments will be included in the final Author Comments.

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