

Interactive comment on “Is there a stratospheric fountain?” by J.-P. Pommereau and G. Held

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Thanks for appreciation and helpful comments and recommendations, which have been all taken carefully. The paper was written in a hurry for being part of the special issue, before knowing all the results of other groups involved in the campaign. Following the publication of these and further papers and according to the many comments of the several reviewers, it has been deeply modified. Hope the present writing will reply to your concerns. Here are answers to you specific comments.

(i) Role of tropopause penetrating convection compared to radiative heating at the global scale. We agree that observations at a limited location during a single season only do not allow concluding definitely at a global impact of the process. This is now discussed in the concluding remarks by making reference to further work suggesting that this is indeed the case. “The relative importance of the contribution of

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such continental convective updrafts compared to oceanic areas, with the exception of cyclones, is shown by the higher concentration of tropospheric chemical substances in the TTL above continents as demonstrated by the ODIN, MLS, HALOE and MOPIIT larger N₂O, CH₄ and CO concentrations (Ricaud et al., 2007, 2009). An indication of the importance of these, compared to the slow ascent by radiative heating at the global scale, is provided by the fast zonal tropical cleansing of the stratospheric aerosols up to 20 km by injection of clean tropospheric air during the most convective tropical season seen by the CALIPSO lidar (Vernier et al., 2009, 2011), suggesting a tape recorder head and thus a top TTL at 50-60 hPa rather than 90-100 hPa, as already suggested by Tuck et al. (2003)”

(ii) Irreversible mixing vs other processes. The answer given to this question to S. Sherwood, which applies also to that of referee is the following: We fully recognised that our gravity waves analysis applies to high vertical wave numbers only but didn't find a good idea for exploring the possible influence of wave packets. The argument for turbulent heat transport in contrast to adiabatic cooling applies to the fast afternoon cooling only shown to occur at 17-18 km that is 2-3 km above the LRT, and not at this level which is shown in contrast to warm slightly. A better description of these details is provided by the addition of an adequate PDF. The negative correlation between free tropospheric and upper tropospheric temperatures shown by Holloway and Neelin (2007), is around 100 hPa, which in the West Pacific is below the tropopause. If the cooling associated with convection at this level can be explained adiabatic lofting, it is not the case for a fast cooling well above the tropopause only. Other arguments developed in the revised paper supporting the mixing hypothesis, are the coincidence with ice crystals injections observed during the same Hibiscus campaign as well as over other land convective regions, and the non-hydrostatic model simulations (Jensen et al., 2007, Chaboureaud et al., 2007, Grosvenor et al., 2007) showing that they require fast uplift of tropospheric air at velocity of the order of 35-60 m/s, resulting in a strong cooling well above the tropopause (15K at 18 km in the case of Jensen).

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(iii) Diurnal temperature change compared to convective and non-convective periods. The contribution of the fast diurnal change compared to that observed on a longer timescale between convective and non-convective periods, highly depends on the altitude, as explained in the revised paper and shown by the PDFs in Fig. 3 and 5. The diurnal change contributes for one third only to the mid-troposphere warming on high convective days, and is in the opposite direction (warming instead of cooling) at the level of the LRT. It represents most of the cooling associated with convection observed at the altitude of the CPT around 17-18 km, and is the only change observed in the stratosphere above 20 km where no sign of convective influence at longer timescale is found. The discussion of the mechanisms responsible for the relative change between convective and non convective periods at each level is largely based on this difference: diabatic heating and advection of warm and moist air in the troposphere, adiabatic lofting at the LRT, absent in the diurnal change at this altitude, mixing with lifted cold heavy air at the CPT, and absence of convection influence but pure radiative diurnal cycle above 20 km.

(iv) Fountain and water vapour. Our understanding is, that the “maritime continent” is indeed the Indonesian Islands and Northern Australia region. Micronesia where the tropopause is the coldest and the highest, cirrus clouds are the most frequent and ORL the lowest is in the West Pacific. There is indeed some confusion in the Stratospheric Fountain of Newell and Gould-Stewart mixing the two areas, but where the coldest temperature at 100 hPa are reported over Micronesia. We have clarified this. Dryness of the stratosphere and relative importance of tropopause penetrating convection are different issues. As now explained in the discussion section, there is more and more evidence at the same time of i) hydration of the lower stratosphere by detrainment of total water across the tropopause by injection of ice crystals above thunderstorms and ii) large contribution of land overshooting turrets to troposphere-to-stratosphere transport at global scale. This is not necessarily in contradiction. Indeed, aircraft and balloon measurements never reported dehydration above thunderstorms as assumed by Danielsen and others. Another mechanism is thus required for explaining the dryness

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of the stratosphere. The hypothesis, which still requires demonstration, is the further condensation/sedimentation of water vapor along air mass circumnavigating trajectories in the coldest low stratosphere equatorial regions, such as the West Pacific during the NH hemisphere season. Note that this hypothesis would be also consistent with the larger water vapor concentration in the lower stratosphere during the warmer NH summer season. However these considerations exceed the scope of the paper where ice crystals observations are used only for illustrating the existence of fast updrafts at 35-60 m/s resulting in a strong cooling of the CPT layer. This is definitely not enough to conclude that tropopause penetrating overshooting convection is the major pathway into the stratosphere. This idea is just evoked at the end of the paper by quoting several recent publications suggesting that this might be the case.

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