Atmos. Chem. Phys. Discuss., 6, S4025–S4027, 2006
www.atmos-chem-phys-discuss.net/6/S4025/2006/

Atmospheric Chemistry and Physics Discussions

ACPD

6, S4025–S4027, 2006

Interactive Comment

Interactive comment on "Solid particles in the tropical lowest stratosphere" *by* J. K. Nielsen et al.

Anonymous Referee #1

Received and published: 24 October 2006

This paper presents lidar data on two occasions showing evidence of a particulate layer in the tropical lower stratosphere. They are best explained as outflow from an overshooting convective turret. A third case of high gas-phase water (˜ 10 ppmv, about 50% higher than normal) is also mentioned, giving indirect evidence of the same phenomenon at a later stage. These observations are the first in-situ evidence that I am aware of from the South American region, which features some of the most vigorous storms on Earth. This is important evidence that convective turrets not only reach altitudes near 20 km but actually mix with the environment and deposit water vapor at high levels.

The paper is well-written and carefully discusses all reasonable (and even a few unreasonable) hypotheses to explain the observations, before settling on convective overshoots. But I do have a few specific comments/criticisms:

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Interactive Discussion

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1) Introduction. There is thorough discussion of models based on purely quasi-horizontal, undisturbed ascent through the TTL (Jensen et al., Fueglistaler et al., Gettelman and Holton, Hartmann et al.), and several citations of papers describing gravity waves, but relatively limited discussion of previous work on convective effects in the TTL, which is strange given that the authors are presenting evidence for the latter. Several key previous observational findings indicating lofting of ice into the stratosphere such as Moyer et al 1996 (albeit not without other interpretation), Wu et al 2005's observations of large ice particles above the tropopause, or Knollenberg et al. (1993)'s observations of ice crytals from STEP, should be discussed, and perhaps more could be said about previous models of, or arguments for/against, convective hydration/dehydration. Also, the section discussing previous estimates of cloud-top height should probably mention the new results of Dessler et al. 2006 (JGR) using lidar data to quantify penetrations through the TTL–he obatins a number much higher than the Liu and Zipser figure based on 20 dBz radar echo.

2. Wave clouds. Although I accept the author's arguments that convective injection of air is a likely explanation for the observations, I'm not fully convinced by their rejection of gravity-wave induced cloud formation as another possibility. A 10-K localized cooling in such a wave is not impossible, and the stated period of six minutes is not a limit on gravity wave periods. Such waves are excited at all periods from a few minutes to hours or longer. Would a longer-period wave be able to do the trick? Also, the condensed water concentration implied by the measurements is well below that of ambient vapor, which should be mentioned as it leaves the door open a little wider for this explanation.

3. Particle size. The thick blue curve in Fig. 1, the average color index hovering near 6, seems unrepresentative of the layers that have most of the aerosol where the color index is as high as 12. You should weight the average by the amount of scatterer, which will yield something closer to 10.

In discussing these results, theoretical calculations are shown later (Fig. 6) only for one channel and it is not clear to me how it was decided that the color index allows only

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values in the circled region of that figure. It would appear difficult to establish an upper bound on particle size, as in the geometric optics limit the color index approaches 9.7 ((940/532)ˆ4) which is awfully close to the weighted average noted above. Do I understand this right? A sentence explaining how the color index relates to size probably wouldn't go astray (also, in the satellite community there is a similar quantity called the Angstrom exponent).

The deduced initial particle size of 7-25 micron radius (which does not depend on the issue above) is somewhat lower than the typical satellite-observed effective radii of 20-35 micron in cumulonimbus and thick cirrus clouds, which is reasonable and what one would expect from the authors' hypothesis since the largest particles would sediment out and would not be observed.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 9003, 2006.