Atmos. Chem. Phys. Discuss., 6, S6237–S6240, 2007
www.atmos-chem-phys-discuss.net/6/S6237/2007/

Atmospheric Chemistry and Physics Discussions

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

J. K. Nielsen et al.

Received and published: 15 January 2007

Final Author statement on "Solid particles in the tropical lowest stratosphere (Nielsen et al.)"

Answers to referee #1

1) Studies of convective effects.

It is true, as referee #1 writes, that studies of convective effects on the TTL are not properly represented in the introduction section. We shall improve on that in the final ACP version, and consider the references mentioned.

2) Wave Clouds

Referee #1 wonders if the particles could have nucleated as a result of gravity wave activity. The question is whether waves with periods of several hours could have initiated nucleation and caused the particles to grow to a size so large that they would

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

not have sublimated at the time of observation. We do not believe that is likely to be the case. Comparison between ascent temperature and descent temperature shows that there is actually fluctuations in the temperature around the TTL, but the difference between ascent and descent temperature is below 2 K at all levels, which is far from the (at leaast) 10 K needed just to get saturation. We do however admit that rejecting the "gravity-wave explanation" on basis of the characteristic wave-period of minutes may be dubious. Therefore we will reconsider and change the argumentation.

3) Particle size.

Referee #1 notes that the average color index does not represent the color index of the aerosol layers. We believe that this comment is due to a misunderstanding: The thick blue line illustrates the average taken over all (ten) flights of the campaign. These includes the single flight, in which the backscatter anomaly were observed only on descent (O1), and the 9 flights with no enhanced backscatter around 18 km.

The referee notes further that it is unclear how the particle size is estimated from figure 6. There seems to be another misunderstanding here: The smallest wavelength of the Wyoming sonde is 480 (not 532, which is the wavelength of the Microlidar), so in the geometric optics limit the color index approaches $(940/480)^4 = 14.7$

The color index cannot vary much for liquid aerosols in the stratosphere, since their size distribution does only respond weakly to changes in humidity. In fact experience from numerous backscatter soundings shows that background liquid aerosols always yield a color index around 6, and furthermore, the color index does not fluctuate as much for liquid aerosols as for solid particles, which can have all kinds of size-distributions. Solid particles typically shows a color index around 10 with much more variability (as is also seen in O1). This pattern is robust for both arctic and tropical aerosols, and it holds for in situ formed aerosols as well as volcanic aerosols. From this we conclude that the particles are not ordinary liquid aerosols, hence most likely solid. However, we cannot estimate their size from the backscatter information alone.

ACPD
6, S6237–S6240, 2007

EGU

Answers to referee #2

1) Particle composition.

Referee #2 expresses the concern that the particles might not be consist of ice, but rather NAT coated ice or aged smoke. The smoke hypothesis, is connected to the comment of M. Fromm, thus it is covered in our response to his comment. Here we want to add the following: We agree with referee #2 that ice particles of radius 1μ with only 40 ppbm ice water content, would sublimate very fast if they were subject to a small temperature increase, which leaves this interpretation somewhat weak. But we cannot exclude the possibility that the particles are the last dilute residual of ice left from a convective overshoot, possibly subject to sublimation during the observation. The statement of referee # 2, that thin layers observed at a time "precludes the interpretation that these are ice-clouds in equilibrium with water vapor" is hard to understand for us. As referee #2 also states, equilibrium is established in such a system on the timescale of tens of seconds, so if the ice-particles are there, they are most likely in equilibrium with the surrounding water. We do in fact mention in the papaer (p9015 l 28), that there are other possibilities for the particles composition, including NAT-coated ice as suggested by referee #2.

2) Availability of data from February 2001

This question is covered in the answer to M. Fromm. Additionally we can mention that the Micro-lidar was used for three balloon flights during HIBISCUS, and the reported (ground based) measurement were the only occasion where clouds were observed above the tropopause with this instrument.

There was one additional HIBISCUS observation, where considerable thicker clouds were observed above the tropopause with a Laser Backscatter Sonde. We have chosen to omit this observation, since it was recorded at ascent.

Answers to referee #3

ACPD

6, S6237–S6240, 2007

1) Ascent data.

Referee #3 is right that one should be careful with reporting ascent data from balloon measurements, and as mentioned in the answer to referee #2, we had already omitted an observation showing presence of particles recorded at ascent. We do however not see any problems in reporting *absence* of particles observed during ascent, since it appears unlikely that the balloon, which is actually in contact only with a thin air-layer should completely scavenge the air in front of the sonde for particles.

2) Data availability.

This question has been addressed in the answers to M. Fromm and referee #2. Additionally we can mention that the micro-lidar was flown three times during HIBISCUS without observing any particles above the tropopause.

3) Ice super-saturation.

Referee #3 is requesting a discussion of the reported findings in e.g. Jensen et. al. ACP, 2005, of extreme super-saturation with respect to ICE near the tropical tropopause. It is an interesting question, but at this point we can only guess about the causes and implications, and this is beoynd the scope of this article.

Answer to Fueglistaler

We acknowledge the comments of Fueglistaler, and have added a sentence with reference to Fueglistaler and Haynes.

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