Atmos. Chem. Phys. Discuss., 4, S2584–S2589, 2004
www.atmos-chem-phys.org/acpd/4/S2584/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Climatological features of stratospheric streamers in the FUB-CMAM with increased horizontal resolution" *by* K. Krüger et al.

Anonymous Referee #2

Received and published: 18 November 2004

The paper "Climatological features of stratospheric streamers in the FUB-CMAM with increased horizontal resolution" by K. Krueger, U. Langematz, L. Grenfell, and K. Labitzke investigates the occurrence of streamers in the winter stratosphere using model data with high spatial and temporal resolution. The paper is highly relevant, since streamers play an important role in transport and mixing processes in the middle atmosphere. The paper contains interesting results for the ACP readership. In general, it is well written and organised. I recommend publication after some revisions addressing the comments and questions given below.

Comment 1: (e. g. p6790, line 19):

According to the authors, “tropical-subtropical streamers” exhibit about a four times higher occurrence frequency than “polar streamers”, indicating that the subtropical barrier is more permeable than the polar vortex barrier (edge).

This results appears to be rather dependent on the selection process and criterion (thresholds) for streamers (see also comment 3). In addition, the number of streamers is only a very qualitative measure of the influence of streamers on the temporal evolution of the background atmosphere (irreversible transport). For example, a blob of polar air separated from the vortex must be completely mixed into the background atmosphere in the stratospheric surf-zone, while large parts of tropical-subtropical streamers may be associated with a reversible distortions of tracer contour lines in the vicinity of the tropical transport barrier (where the occurrence frequency of streamers is very high according to the present analysis). This also indicates the limitations of a simple classification into “tropical-subtropical streamers” and “polar vortex streamers” as introduced by the authors.

As stated by the authors, transport associated with tropical-subtropical streamers is probably more important under many conditions (no strong wave breaking event), since the subtropical transport barrier is more permeable. This is certainly true. However, characterisation of this by difference the derived occurrence frequency is somewhat misleading (see also comment 3).

Comment 2: p6790, line 28 and summary

According to the authors: “The results of this paper demonstrate that streamers could play a significant role in the strength and variability of the observed total ozone decrease at mid-latitudes and should not be neglected in future climate change studies”

This is not a new result emerging from the analysis of this paper. However, the study indicates that FUB-CMAM is able to capture this important transport feature.

ACPD

4, S2584–S2589, 2004

The importance of streamers for transport in the stratosphere (and therefore for the ozone budget) was already highlighted by Randel et al. [Nature, 365, 533, 1993] and Waugh [Nature, 365, 535,1993; JGR, 101, 4007, 1996]. According to their analyses, significant part of transport across the subtropical transport barrier occurs in form of tongues of tropical air (here called streamers) drawn into mid-latitudes, which are linked to disturbances of the polar vortex (produced by planetary wave activity). The current model study underlines that streamers are a frequent feature (and therefore, of course, important for transport and the ozone budget). It provides an improved statistical basis for the former findings.

Comment 3: (e. g. p6796, line 24 and following text)

- see also comment 1

The application of the same anomaly criterion for their selection (20 au) for “tropical-subtropical streamers” and “polar vortex streamers” is somewhat questionable. In many situations polar streamers appear to be generated at the same time as subtropical streamers (implying a ratio closer to one), as a result of the generation of subtropical streamers by the interaction of an elongated vortex edge with subtropical air masses. For example, the Asian and Atlantic tropical-subtropical streamers described by Offermann and al. (1999) were accompanied by two polar-vortex streamers (see Plate 2a of Riese et al., 1999). During CRISTA-2, a very pronounced tropical-subtropical streamer was observed in the Southern Hemisphere winter stratosphere as a result of a strong displacement of the south polar vortex edge (associated with enhanced activity of planetary waves 1 and 2). At the same time a weak polar vortex streamer was generated as a result of a slight vortex erosion (see fig. 6 of Riese et al., JGR, 107, 8179, 2002). Since the detection of such weak streamers could depend on the selected streamer threshold, the derived ratio of 4 times more “tropical-subtropical streamers” than “polar vortex streamers” can therefore be somewhat misleading.

Comment 5, section 4.1, section 4.2

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4, S2584–S2589, 2004

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The analysis based on the streamer climatology is rather qualitative. The authors present spatial and temporal distributions of relative frequencies of streamer events in a very descriptive manner. In section 3. the authors describe the development of streamers under a "cold wave-2" situation, which demonstrates the dependence of the streamer generation from the overall wave dynamics. The authors could use the results from the 10 year run, for example, to provide a deeper insight in this relationship.

Likewise, the analysis of the vertical extension of streamers in the stratosphere remains very descriptive. The increase of the relative frequencies presented in fig. 8 could also be related to wave 1 and 2 dynamics (i. e. amplitude growth with altitude, see for example Riese et al., 2002).

Comment 6, p6807, last paragraph of summary section.

"Streamers are likely to play a non-negligible role in determining large-scale air mixing processes in the stratosphere and therefore impact total ozone mid-latitude trends."

This is not a new finding that can be based on the results of the current analysis (see also comment 3). The results of the analysis underline the importance of streamer events for horizontal transport in the stratosphere. However, they do not provide enough information on the relationship of streamers and the overall dynamical situation (in particular wave dynamics) to judge about a possible trend in transport quantities (associated with streamers) for the real atmosphere (which could be related to the observed ozone trends).

Minor 1: p6790, line 7:

The authors state: "A new result of this paper is the classification of specific transport phenomena into tropical-subtropical streamer and polar vortex streamer"

From my point of view, this is a "new approach" and not a "new result".

Minor 2, p6792, line 28

"High temporal and spatial resolution of CRISTA shed light into the detection of both large-scale and smaller-scale transport phenomena (Offermann et al., 1999; Riese et al., 1999).

The referenced paper of Riese et al. gives a description of the CRISTA data processing and temperature and trace gas retrieval. An analysis of large-scale and smaller-scale transport phenomena and corresponding simulations with a CTM is given by Riese et. al, JGR, 16,419, 1999.

Minor 3: p6796, line 9

It is mentioned that no QBO has been taken into account in the experiment.

Since the large scale wind field plays an important role in the generation of streamer, QBO effects should play an important role in long-term assessments.

Minor 4: fig. 6.

The inter-annual frequency distribution for tropical-subtropical streamers shows a strong maximum in the area of the tropical-subtropical transport barrier. Could this also be connected to reversible distortions of tracer contour lines (with strong horizontal gradients) in the vicinity of the barrier ? The maximum at 70 to 75 deg N is probably more indicative for large irreversible transport in this region.

Minor 5, section 4.3, figs. 9 and 10

It is apparent in the October-November climatology (figs. 9a, 10a) that the Asian tropical-subtropical streamer is most pronounced in the 31-35 km altitude region, while the Atlantic streamer becomes important at lower altitudes (21 to 25 km). Interestingly, this finding is in good agreement with CRISTA observations, where the relative importance of the Atlantic streamer increases towards lower altitudes (below 30 km).

Minor 6, p6806, line 14

ACPD

4, S2584–S2589, 2004

The authors state the duration of streamers is 1-3 weeks in the model with a decaying time of 1-2 weeks. This decaying time appears to be in good agreement with CRISTA observations. During an observation period of one week, large part of the life cycle of streamers could be observed (e. g. Plate 3a of Riese et al., 1999)

Minor 7, p6806, line 18

“An overall result of the streamer climatology is that tropical-subtropical streamers have a higher frequency upt to 4 times”

See comments 1 and 3.

Minor 7 , P 6812, line 19

Replace “16,295-16,310” by “16,347-16,367”

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 6789, 2004.