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Interactive Comment

Interactive comment on "Intercomparison between Lagrangian and Eulerian simulations of the development of mid-latitude streamers as observed by CRISTA" *by* F. Khosrawi et al.

F. Khosrawi et al.

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We thank reviewer 1 for the constructive, helpful criticism. We have addressed to the points of reviewer 1 by presenting a test simulation with same dynamics and initial conditions and by considering the suggestions for strengthening the clarity and presentation of the material in the paper. A detailed response to the comments of reviewer 1 follows below.

Specific comments:
1. We agree with the reviewer that at least one test case should be shown where the usage of different meteorological data sets is explored. We followed the reviewers

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recommendation in so far that the paper now contains a test case (Figure 6 and discussion in chapter 4.5) for which the impact of using different meteorological analyses in CLaMS is explored. The use of different data sets do causes differences in the details of the structures of the simulated filaments. However, the use of different meteorological data sets in CLaMS does not alter the conclusions regarding the differences between CLaMS and KASIMA.

2. The transport in KASIMA is done on a grid. Mixing processes in the Eulerian transport scheme of KASIMA can not be examined by modifying the flux correction. The only possibility to influence mixing in this Eulerian model is by changing the resolution of the grid. The higher the resolution the lesser the numerical diffusion. To give a more detailed description of the two step flux corrected algorithm which is used in KASIMA, we included the following sentence: *A first order upwind scheme from Courant et al. (1952) is used which is followed by an antidiffusive step based on the difference between the scheme of Lax and Wendroff (1960) and the first order scheme multiplied by a limiter function given by Roe and Baines (1982).*

3. We agree with this statement in principle. However, running KASIMA in an isentropic model is not possible due to the model architecture of KASIMA. Nevertheless, a comparison with a mode using pressure as the vertical coordinate is meaningful since this is the coordinate used in many state of the art models including practically all climate models. We have included a brief discussion of this issue in the paper (introduction): *However, differences between KASIMA and CLaMS are also expected due to the fact that the vertical coordinate of the two models are different.*

4. The CLaMS model runs were all made in an adiabatic mode. Thus, no heating rates are calculated. The sentence in section 4.1, third paragraph, has been changed as follows: *The CLaMS simulations were made on an isentropic level of* $\Theta = 675\,\mathrm{K}$ *neglecting diabatic effects, using UKMO data to drive the model, an advection time step of*

$\Delta t = 24$ h *and a Lyapunov exponent of* $\lambda = 1.2$ *(in-situ optimised mixing, Konopka et al, 2003).*

5. The timestep of the Runge-Kutta scheme which calculates the air parcel trajectories is set to 30 minutes by default. This is basically used in all CLaMS simulations. The timestep at which the mixing is called is variable and set here to either 12 or 24 h. To clarify this point, we use now ''mixing timestep" instead of "advective timestep".

6. It is correct that the Southern Hemisphere streamer is somewhat difficult to see against the background of higher N_2O. However, a contour map of this data does not help to solve the problem. Such a figure can be found in Kouker et al. (JGR, 1999) and in this figure also the Northern Hemisphere streamers can be better identified than the Southern Hemisphere streamer. We included the following sentence in section 3: *The Southern Hemisphere streamer, however, is much weaker pronounced than those in the Northern Hemisphere as can be observed in the weak gradient of* N_2O.
The weak pronounced features of the Southern Hemisphere streamer even in the CRISTA data makes its interpretation with models a crucial job. This was already an issue in Kouker et al. (1999) and is taken into account in this paper in section 4.2: *A possible explanation of this failure may be found in the weak pronounced features of the streamer in the CRISTA data. Small errors in KASIMA e.g. in the reproduction of the residual circulation may lead to errors in the distribution in the polar vortex that in turn may affect the gradients in the streamers. This issue is known and has already been discussed in detail by Kouker et al. 1999. However, an overall correctness of the residual circulation in KASIMA has been shown in Ruhnke et al. 1999 and Reddmann et al. 2001.*

7. The asynoptic CRISTA profiles observed between 4-6 November 1994 were linearly interpolated in the vertical to 675 K and then transformed to the synoptic time on November 6, 12 UTC, by using isentropic forward trajectories calculated by the CLaMS trajectory module from UKMO winds. We included this explanation in the

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manuscript. The following sentence is included (section 3): *Here, asynoptic profiles observed between 4 November and 6 November were transformed to the synoptic time on 6 November, 12 UTC, by using isentropic forward trajectories.*
Further, we mistakenly stated that in Figure 1 the CRISTA observations are shown for 700±50 K level. In this figure the CRISTA data on the 675±25 K level is shown. This has been corrected in the text and in the figure caption.

8. We used CRISTA Version 3 data. For this data version the systematic and statistical errors of are 26% and 3%, respectively, at 25 km and 23% and 3.5%, respectively, at 30 km. We included this in the text (section 3): *Here, we focus on the CRISTA measurements of N_2O. The systematic and statistical errors are 26% and 3%, respectively, at 25 km and 23% and 3.5%, respectively, at 30 km (Version 3 data). A description of the CRISTA error analysis can be found in Riese et al. (1999).*

9. see reply to point 1

10. We agree with the reviewer that it is worth noting that both models show an anticylconic circulations in the northern and southern hemisphere, respectively, which were involved in the formation of the east Asian and southern hemisphere streamer, respectively. We included the following sentence in the text (section 4.2, last paragraph): *Both model simulations show high values in the region centered around $140°$ W and $50°$ N. This appears to be in an anticylconic circulation, which is likely part of the planetary wave event that caused the east Asian streamer. Further, both models show a swirling pattern centered near $120°$ E and $70°$S which appears to be associated to the anticyclone that was involved in the Southern Hemisphere streamer.*

11. We agree with the reviewer 1 that the inability of the KASIMA 9-year run to get the correct gradients could be related to errors in the residual circulation. However, seasonal studies with KASIMA (Ruhnke et al., 1999, JGR, 104, 3755-3772) or

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multiannual studies on the age of air (Reddmann et al., 2001, JGR, 106, 14525-14537) suggest a proper simulation of the residual circulations in KASIMA.

12. For the model simulations described in section 4.6 the same nudging technique as for the 9-year simulations were used. The following sentence has been included in the text: *As in the previous KASIMA simulations the nudging technique is used. The model is nudged to the ECMWF re-analyses (ERA-40, see chapter 2.1*.
Further, we included the following sentences to describe the initialisation in more detail (chapter 4.6). *The tracer has a source region in the equatorial lower stratosphere (equatorwards of 15 latitude and at altitudes below 100 hPa) and a prescribed photolysis coefficient depending on altitude and zenith angle only (Eyring et al, 2003). From many experiments it has been shown, that this combination of meteorological and chemical initialisation reveals a 3-distribution of* N_2O *after several days typically observed in the lower stratosphere.*

13. The resolution of the T106 run is 1.125° × 1.125° according to the ECMWF data. For the T106 run the same flux correction as for the T42 run was used. We included the resolution of T42 and T106 in the text (section 4.6). *To assess the impact of the spatial resolution of the KASIMA model on the model results, the simulations were repeated using a resolution of T42 and T106 (*$2.8^\circ \times 2.8^\circ$ *and* $1.125^\circ \times 1.125^\circ$ *(250 × 250 km and 110 × 110 km), roughly corresponding to 8000 and 50.000 air parcels (250 km and 100 km), respectively).*

14. We agree with the reviewer 1 that it would be interesting to examine the time evolution of the tracer PDFs in both models from initialisation on 6 November 1994. However, as reviewer 1 already correctly pointed out this is beyond the scope of this paper.

15. As suggested, a reference to the paper of Hu and Pierehumbert (2001,2003) has been included (section 4.7). *The study of the PDFs (probability density functions)*

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of tracer differences between APs (air parcels) separated by a prescribed distance offers an effective way to analyse the variability of tracer distributions (e.g.,Sparling et al., 2000, Hu and Pierrehumbert 2001,2002).

16. We skipped our statement that the KASIMA (T42) simulations provide a reliable basis for establishing streamer climatologies since, as reviewer 2 correctly pointed out, such an statement is difficult if only one case study is considered. However, we inlcuded the following sentence: *Although from a case study as the one presented here no conclusions on the validity of a climatology can be drawn, the agreement between the principle features of the CLaMS and KASIMA simulations with the streamer structures observed by CRISTA gives confidence in the ability of KASIMA to simulate the large scale structure of streamers.* Further, we would not expect that the KASIMA simulation would underestimate the amount of streamers. We would rather expect that the strength of the gradients may be underestimated and maybe the exact location of the streamer may be different, as it can be seen in our case study.

Technical corrections: We have corrected the typing and spelling errors.

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