

Interactive comment on “Effects of mixing on resolved and unresolved scales on stratospheric age of air” by Simone Dietmüller et al.

Anonymous Referee #2

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Effects of mixing on resolved and unresolved scales on stratospheric age of air

General:

1. The paper is one of the first to quantitatively separate aging due to “unresolved” vs. “resolved” mixing throughout the stratosphere. A conclusion is made regarding how diffusion actually makes air slightly older (at least in these models), which contradicts some previous thoughts. This could be a significant text for others to use in the future, as we continue to look into why models differ in transport and trends, and how we can relate these results to observations.

2. Overall the paper is succinct and easy to read. My concerns are only medium/minor:

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expanding on ideas (so reproduction by others will be better possible), making figures clearer, and fixing syntax/grammar issues.

Issues throughout the paper:

1. The residual circulation advection terms (\bar{v} -star and \bar{w} -star) should have the bar only over the v/w , not over the star.
2. Could you make all the figures have the same y-scale lengths, tickmarks, and tick-mark labels? Could you increase the font on the figures (including the colorbar values)? Also, how would Fig. 4 look if it went down to 200hPa like the other figures?
3. Could you say “vertical advection by the residual circulation” instead of “tropical upwelling”? I think some people confuse “tropical upwelling” with “total upward transport” which is the sum of advection and vertical diffusion. Or just make a note that “tropical upwelling” only refers to vertical advection term and nothing else.

Individual issues:

1. p 5, line 17: How would the results change if you varied this zonal band seasonally? Don't need to re-run experiments, just acknowledge.
2. p 6, line 4-5: Is any info lost by using monthly means (instead of daily)?
3. p 6, line 11-12: Explain why this is 30S-30N and not 10S-10N? How wide do you think the zonal band is for the EMAC calculation (that uses the thermal tropopause)? Is it similar?
4. p 6, line 19: Do you interpolate the data on every lat,lon gridpoint? Or do you interpolate zonal mean data?
5. p 6, line 22: remove comma: “. . .are not considered[,] if they. . .”
6. p. 7, line 18: Could you give a mean value of H in the areas you are looking? Does it equal 7km in every model?

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7. p 7, line 23 (equation 3): Make sure prime (zonal deviation) is under the overbar (for $\overline{v'T}$). Also I think it should be a plus (instead of minus) inside the parenthesis. I imagine this is correct in your code, but double check.
8. p 8, line 4-5: Great job here.
9. p 10, line 3-4: You assume that numerical diffusion dominates in EMAC. Is this a good assumption? Can you cite anything?
10. p 10, line 6: Should this sentence "...by diffusion effect at 60thus arises..." instead say "...by [the] diffusion effect at 60S thus arises..."?
11. p 10, line 14: (talking about Fig. 3) I was wondering, do the (lapse rate) tropopause (not the entry levels used for the backward trajectories) differ between any of the models? This would be helpful to know, because it could affect the difference plots (shifting the signals in height by a bit).
12. p 11, line 29: insert comma "...velocities, from the momentum balance[,] and from..."
13. p 11, line 20: remove comma "The fact[,] that direct..."
14. p 11, line 31: add letter "estimate[s] are different..."
15. p 11, line 33-34: really emphasize that the EMAC-RC1SD line = 1 everywhere. For example, add: "...relative to the direct estimate of EMAC-RC1SD [such that the SD (black solid line) equals one throughout the profile]." or something like that.
16. p 12, line 2-3: reword this sentence to be "It is interesting that the two residual estimates are also different for EMAC-RC1SD."
17. p 12, line 13: reword "...northern lower stratosphere, consistent with lower AoA there."
18. p 12, line 15: Should this say "right column"?

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19. p. 12, line 18: reword, do you mean “higher” for CLAMS? Is this regarding the blue part (around 60S, 10-100hPa) of Fig. 3c (right column)?
20. p 12, line 28: reword, do you mean: is higher [than] in CLAMS?
21. p 13, line 9-10: Great work here.
22. p 13, line 14-15: How do you identify the gridpoints influenced by small-scale mixing? Is this quantity given by the model? Or is this just mathematically derived from the aging by diffusion value? How would another scientist find this?
23. p 14, line 4-5: I understand what you are saying, but could you briefly talk about how nudging might (or might not) counteract the underlying dynamics?
24. p 15, line 10: What latitude band? And what mean pressure level coincides with 550K?
25. p 15, line 25: reword “..might be related to a weaker vortex.”
26. p 16, line 9: insert “...and [unresolved] aging by diffusion.”
27. p 16, line 17: Can you stress how this finding differs from past work? Citations.
28. p 16, line 28: Which two models? Be specific here.
29. p. 16, line 33: insert comma: “...nudging on the residual circulation[,] sensitivity studies...”
30. p 17, line 1: insert s: “...varying nudging height[s] could...”
31. p 17, line 1-2: remove comma: “...on the AoA trend, we conclude[,] that unresolved...”
32. p 17, line 2: insert commas and reword “...has a minor[,] mostly non-significant[,] impact on AoA...”
33. p 17, line 3-5: very confusing to me, reword: “The AoA trend discrepancy between

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observations and both EMAC simulations still exists but cannot be explained by the trend in aging by diffusion.” . . .or something like that.

34. p 17, line 6-7: What does this mean? Elaborate on “difference could not be traced back to process level.” What is the process level?

35. p 17, line 8: remove comma: “Note here[,] that. . .”

36. p 17, line 9: insert comma: “. . .short data record[,] and technical. . .”

37: p 17, line 11: insert comma: “. . .AoA estimates[,] and AoA trends. . .”

Figure 8: Add text about the “black contours show climatological values”.

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