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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Seasonal characteristics of chemical and dynamical transports into the extratropical upper troposphere/lower stratosphere" *by* Yoichi Inai et al.

Anonymous Referee #2

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The paper by Inai et al. investigates the air mass composition of the extratropical upper troposphere and lower stratosphere (exUTLS), and relates to CONTRAIL in-situ observations of several trace gas species (e.g., CH4, N2O, SF6, CO, CO2). The focus of the study lies on seasonal variations in air mass fractions and mixing ratios. In particular, it is found that seasonality in CH4, N2O and SF6 mixing ratios is controlled by transport from the deep stratosphere, due to the locations of the main chemical sink regions, whereas CO and CO2 are mainly controlled by transport from the tropical troposphere.

The air mass and tracer composition of the exUTLS is of particular relevance for global

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climate due to the radiative characteristics of this region. Hence, the present study fits well into the scope of ACP. The paper is well written and presented, and the current literature is appropriately discussed. I recommend publication after taking into account the several comments below, which I regard somewhere between major and minor.

Detailed comments:

1. Initialization: The trajectory initialization is somewhat unclear to me. In the respective text part it is said, that back trajectories are initialized between 0-140 deg E, but the corresponding Fig. 1 shows initialization locations for 0-360 deg E (P2/L27). How is the initialization done exactly?

2. Model-measurement comparison: The CONTRAIL measurements are mainly from Siberia. How is the model-measurement comparison done, exactly at the measurement locations/times, or just averaged over specific regions? I would suggest to explain this clearly directly after the description of the trajectory initialization (P2).

3. Reconstruction method: It would be good to mention (around P4/L10) that Eq. (2) holds only for species which are chemically inert along the trajectories. Can you give some quantitative information how well this assumption holds for the species and regions considered here? Perhaps some of the difference between reconstruction and measurements (e.g., Figs. 7-10) is related to neglecting chemistry effects?

4. Origin mixing ratios (P4/L28): Why not using higher altitude in-situ measurements (e.g., from balloons, Geophysica/Halo/ER2/... aircrafts) or global satellite observations for the reference mixing ratios? At least the "inversion method" outlined below could be validated with such data.

5. Minima in tracer distributions around 370K in spring/summer (P7/L21ff): I do not think these minima are just artifacts of the reconstruction. The fact that spring/summer transport of young tropical air strengthens first around 380-400K, leading to a "sandwich" structure with older air masses below is consistent with recent findings by Krause

et al. (2018) (see e.g. their Fig. 14) and Ploeger and Birner (2016) (e.g., their Fig. 7). In agreement with these papers, Fig. 9/10 show evidence for strongest polward transport above about 380K, causing the mixing ratio minima below. I would suggest to discuss these distributions more appropriately.

6. Trajectory method: Kinematic trajectories show stronger dispersion compared to diabatic trajectories (e.g., Schoeberl et al., 2003). Are the results presented here robust also for diabatic transport? At least include appropriate discussion in Sect. 4.3 ("Limitations of the current study").

Specific and technical comments:

P1/L29: maybe better "at/along the subtropical jet"?

P3/L23: "...where IT satisfies..."?

P3/L28: What is the "actual value" what is referred to here? Observations? Which?

P7/L29: ware –> were

P9/L10ff: The sentence "In addition ..." sounds unclear to me - I suggest rewording.

P9/L19: shown –> show

P10/L28ff: I don't understand the description of Fig. 15f. What PDF is integrated here (transit time pdf?). What is the unit of the y-axis? Please clarify and improve the description.

P12/L7: The Ploeger and Birner reference cited here is not in the reference list.

P12/L20: non-linear

References:

Krause et al. (2018), Atmos. Chem. Phys., 18, 6057-6073.

Schoeberl et al. (2003), J. Geophys. Res, 118, D3.

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