Atmos. Chem. Phys. Discuss., 8, S10370–S10372, 2009
www.atmos-chem-phys-discuss.net/8/S10370/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The governing processes and timescales of stratosphere-to-troposphere transport and its contribution to ozone in the Arctic troposphere" *by* Q. Liang et al.

Anonymous Referee #1

Received and published: 12 January 2009

General: This manuscript is a very comprehensive study of ozone budget in the Arctic troposphere, in particular with respect to stratosphere-troposphere exchange (STE). The strength of this study is a detailed analysis of all relevant dynamical and chemical processes supported by comparison with observations. In particular, the contributions of the stratosphere (transport + NOx-driven chemistry) and of the troposphere (mainly chemistry) to the observed seasonality of ozone in the UT/MT/LT is quantified. However, there are still some open questions which should be clarified before the paper can be published by ACP.

Major points:

- Definition of O3ST and O3TR, O3 chemistry due to NOx
  Even if these (artificial) species allow some deep insights into the undergoing processes (e.g. very important Fig. 7), they do not sufficiently explain the impact of stratospheric NOx on the tropospheric ozone chemistry. The question that still arises is what is the impact of the stratosphere (i.e. via direct transport versus via NOx) on the seasonality of ozone in the troposphere. In section 5.2, there is some discussion on this point but the mentioned separation is not quantified (in contrast to the contribution of transport from the stratosphere that was convincingly analyzed in the section 5.1)

- Definition of the DT-tracer family
  In Fig. 4 there are significant differences between the CFC-12S anomaly (that is black in the figure and gray in the legend) and the dynamical tracers (color lines). In particular, I would expect a better agreement in LS. A part of these differences probably results from the initialization of the dynamical tracers. Why you do not use CFC-12S above the tropopause to define the DT-family tracer ? (the use of an average of 100 ppbv and of peak-to-trough amplitude is not very convincing).

- NOx-driven ozone chemistry
  There is a gap in explaining the impact of NOx on the ozone cycles (Fig. 9 and section 5.2). I still do not understood how NOx coming from the stratosphere (where in summer the NOx-driven catalytic ozone destruction dominates, e.g. Crutzen et al, 1970, see high ozone destruction rate above 200 hPa in Fig. 9) changes its ”behavior” from strong destruction in LS to production (around 300 hPa in summer) and than destruction around 700 hPa. I know that there are different regimes of NOx with respect to P(O3) but the paper does not clarify this point. Even if the discussion up to the section 5.2 is a very comprehensive analysis, the discussion of NOx-related chemistry is significantly weaker (maybe an additional figure between fig. 9 and 10 explaining different regimes of NOx with respect to P(O3) would help).

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Interactive Comment

Minor points:

- p 19379/par 20
  ...whether they have stratospheric sources or not ...
  CO, CO2, N2O and CH4 you mentioned have mainly tropospheric sources and no stratospheric origin (please clarify)
- p 19380/par 15
  if slower downward transport, why short-lived species may have little dependence on STE ?
- p 19384/par 5
  what are typical lifetimes of O3 and HCl (please give numbers for your examples)
- p 19385/par 10
  Definition of CFC-12S. What is the lower boundary (=0 ?)
- p 19387/par 15
  why active springtime chemistry ? Is the “wintertime downwelling” not sufficient to explain CFC-12, HNO3 and O3 ?

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 19377, 2008.

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