Atmos. Chem. Phys. Discuss., 8, S3020–S3024, 2008
www.atmos-chem-phys-discuss.net/8/S3020/2008/

Atmospheric Chemistry and Physics Discussions

ACPD

8, S3020–S3024, 2008

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Interactive comment on "Radiative forcing from particle emissions by future supersonic aircraft" *by* G. Pitari et al.

G. Pitari et al.

Received and published: 26 May 2008

Detailed point-by-point reply to Anonymous Referee 3

We thank the reviewer for his helpful and constructive comments. Below we include responses to the points listed above.

(1) "Current subsonic" was a mistake in the text. We meant "projected subsonic". The text has been adjusted as follows (ACPD-5093 lines 4-7):

"In this paper the effects of the projected subsonic aviation fleet for year 2050 are compared to those of a mixed fleet (subsonic and supersonic aircraft), using (direct and indirect) radiative forcing calculations(RF) as a climate change index. As explained in Section 3 of the paper, this modeling study is based on the supersonic aircraft configurations developed by Airbus for years 2025 and 2050 during the EU-funded project

SCENIC (SCENIC 2005; Grewe et al., 2007). A summary of the 2050 emission scenarios is presented in Table 1, with S6 being the supersonic reference case (Mach 2.0) including also aerosol emissions: if not differently specified, in the remaining of the paper we refer to scenario S6. Fuel consumption and NOx emission indices for the future projected subsonic fleet in the SCENIC scenarios are 393 Tg/yr, 12.97 g/Kg for year 2025 and 677 Tg/yr, 10.85 g/Kg for year 2050 (i.e. scenario S4 in Table 1), to be compared with 2000 reference values of 169 Tg/yr, 12.78 g/Kg (Grewe and Stenke, 2008). This means that the SCENIC projected average increase of fuel use is about 3.4% up to 2025 and 2.8% up to 2050, both consistent with the 3% estimate in IPCC (1999), and taking into account the projected greater efficiency of aircraft in later future. We have added in the list of references the paper Grewe and Stenke, 2008: Grewe, V., and A. Stenke: AirClim: An efficient tool for climate evaluation of aircraft technology, Atmos. Chem. Phys., 8, accepted for publication, 2008".

(2) 250 is the number of passengers per plane. The sentence at page ACPD-5098 lines 19-20 has been changed as follows:

"which implies a constant number of 250 transported commercial passengers per plane".

(3) The anthropogenic sulphur flux changes every year in the 2036-2055 simulation. The value in 2050 is 97 Tg-S/yr. The following lines have been added at page APCD-5100 at line 22:

"After 2030, the anthropogenic sulphur flux is year-by-year linearly interpolated between the IPCC-A2 projected scenarios for 2030 and 2100, the latter being 60 Tg-S/yr (IPCC, 2001). This results in a 2050 anthropogenic sulphur flux of 97 Tg-S/yr".

(4) In the steady state stratospheric accumulation, all soot particles become heterogeneous nuclei for sulphuric acid particles. However, due to the low emission index of BC from supersonic aircraft, the stratospheric changes of sulphuric acid aerosol size, mass and surface area distributions are dominated by direct sulphate particle emissions at

about 5 nm radii (see Figure 1 right panel and Figure 2 mid and bottom panels). No heterogeneous reactions on black carbon soot are considered, because laboratory studies have shown that these are non-catalytic and may last for short time with significant reaction probabilities, due to poisoning of the BC surface. Before IPCC (1999), some studies in modelling atmospheric processes had suggested that heterogeneous chemistry on soot emitted from high altitude aircraft could affect stratospheric ozone depletion. However, these studies were limited because they did not adequately consider the decrease in reaction probability with time as the surface of the soot becomes "poisoned" by its interactions with various gases. Wei et al. (2001) have shown that, even if active sites on soot surfaces are regenerated, upper troposphere and lower stratosphere ozone losses on aircraft emitted soot occurring through heterogeneous reactions are insignificant once poisoning effects are considered. In the discussion of Figure 3, ultra-fine particles refer the peak at 5 nm from direct particle emissions. In order to clarify these points the text has been changed as follows (ACPD-5103 line 8):

"The effect of supersonic aircraft sulphur emission is to greatly increase the number of ultrafine particles at the 5 nm peak due to direct particle emission in aircraft plumes".

(5) There was an error in the caption of Figure 7: only the H2O RF was calculated with the DLR E39/C radiative code. We agree with the reviewer that this may generate confusion since all other RF calculations were made with the ULAQ model. For this reason, we have changed the caption of Figure 7 and the RF bar for H2O, adopting the ULAQ model RF results. The paper of Grewe et al. (2007) compares the H2O-RF values between the two models as follows:

"Previous studies showed that the uncertainty in the calculation of the radiative forcing is less than 10% except for water vapour (Forster et al., 2001). For water vapour, the ULAQ radiation scheme shows higher values than the DLR E39 model, employing the same water vapour perturbation and background field. These results are consistent with previous findings (IPCC, 1999), which showed an uncertainty of a factor of two in the calculation of the water vapour related RF, with lower values derived with the DLR

ACPD

8, S3020–S3024, 2008

Interactive Comment

E39 model, compared to a narrow band model (Forster and Shine, 1997)”.

This means that the ULAQ model H2O-RF calculations (after stratospheric temperature adjustment) are closer to the Forster and Shine (1997) results with respect to DLR E39C, that is another reason for including the ULAQ H2O-RF results in Figure 7, other that clarity and consistency with other RFs. The missing label Radiative forcing (mW/m^2) is now written on the vertical axis of Figure 7. The new caption is as follows:

”Fig. 7. Summary of (S6-S4) RF in year 2050 per component (mW/m^2), calculated with the ULAQ-GCM radiative code. The uncertainty bar on O3 and H2O forcings is obtained using the ULAQ-GCM radiative code with the O3 and H2O distributions from the four independent models (SLIMCAT, ULAQ-CTM, E39/C, OsloCTM2). The single RF values obtained with O3 and H2O changes from these models, in the order above, are: -4.3, -3.2, -2.0, -0.3 mW/m^2 (O3) and: 63.6, 28.0, 40.7, 31.4 mW/m^2 (H2O).

Technical Corrections

1) page 5093, para 2: Change "into" to "in" - "Most of the additional radiative forcing due to HSCTs results from accumulated water vapour in the stratosphere..."

2) page 5094, 3rd line, remove comma in "models, which are included..."

3) Section 2 title should be "Model Descriptions", not "Models description"

4) Section 2.4 - There should be a reference to the "Fast-J2 method"

Reference included : Brian and Prather (2002). Brian, H.S. and M.J. Prather, 2002: Fast-J2: Accurate simulation of stratospheric photolysis in global chemical models, J. Atmos. Chem., 41, 3, 281-296, doi:10.1023/A:1014980619462.

5) Section 3, 1st paragraph: Change "orientations" in "Some of these supersonic characteristics could be modified in response to pressures linked to air traffic demand, ..."

6) Section 3, 2nd paragraph: Change "on" to "for" in "P5 scenario... for which the range has been increased in response to traffic demand for longer distances"

ACPD

8, S3020–S3024, 2008

Interactive Comment

7) Section 3, 2nd paragraph: Change "consideration" to "considerations" in "P6 scenario ...for environmental considerations."

8) Section 3, 2nd paragraph: Add "the" to "i.e. the utilisation of a Mach 1.6 configuration ...so that the geographical emissions distribution is completely different."

9) Section 4, line 3: add "the" to "The SCENIC emission data were interpolated onto the ULAQ-CTM grid..."

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 5091, 2008.

ACPD

8, S3020–S3024, 2008

Interactive Comment