Air Transport Impact on the Local, Regional and Global Atmosphere

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Introduction

About 5 years have passed since the IPCC (1999) Special Report "Aviation and the Global Atmosphere" was published. In the meantime several further assessments of the atmospheric effect of aviation were produced. In 2003, the European Conference on Aviation, Atmosphere and Climate (AAC) in Friedrichshafen, Germany (Sausen et al., 2004) provided an update to our knowledge on this topic.

In the following we present an overview of the state of the art, mainly based on the assessments mentioned above. All figures of radiative forcing (RF) have been calculated/estimated for the air traffic of year 2000.

Subsonic Aircraft

a) Cruise

- CO_2 emission reduction is and will remain one of the most important reduction goals as the atmospheric life-time[1] of CO_2 is 60 to 100 years. The RF is about 30 mW/m2. (This is no significant change relative to IPCC, 1999.[2])

- NOx is an important ozone precursor. The aircraft-induced ozone enhancement results in a RF of about 25 mW/m2. The chemical life time of the ozone perturbations is in the order of weeks to a few months.

- NOx emissions from aircraft lead to a small reduction in methane concentration and a corresponding negative RF[3] of about –10 mW/m^2. The life time of methane perturbations is about 10 years.

- The difference in the positive ozone induced and the negative methane induced RFs is somewhat larger than estimated by IPCC (1999). Furthermore, the climate impact is not additive due to different regional and vertical structures of the methane and ozone perturbations.

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[1] Actually two time scales have to be taken into account when considering the impact of aviation on the atmosphere and climate: (1) the chemical/physical life time of the emitted species which differs from species to species and which is given here and in the following paragraphs; (2) the thermal inertia of the climate system, which is in the range of 20 to 40 years for the response of the coupled atmosphere/oceanic mixed layer system. The thermal inertia time is independent from the kind of emission. It delays the recovery of the climate system after stopping a sustained emission of any species.

[2] Note that IPCC (1999) provides the RF for 1992.

[3] A positive RF is associated with a warming, a negative RF with a cooling.

- The radiative forcing of linear contrails is significantly smaller (by a factor of five) than that estimated by IPCC (1999)[4], i.e., about 7 mW/m^2.

- A fraction of the linear contrails spreads to contrail cirrus (aircraft-induced cirrus clouds that look similar to natural cirrus clouds). The life time of contrail cirrus is in the range of hours to a few days at most. Changes in cruising altitudes and routing can efficiently reduce the formation of contrails and contrail cirrus. Additionally, aerosols from aircraft can result in a secondary cloud formation (and modification of cloud properties) much later after the emission. The aerosols from aircraft have life times in the range of weeks to a few months. Currently, only upper bounds of the radiative forcing from aircraft-induced cirrus exist, ranging from 25 to 100 mW/m^2.

- The direct effect of aircraft induced sulphate aerosols is small. However, sulphur emissions can modify the cloud properties.

- The direct RF of soot emissions is small (below 5 mW/m^2).

- The direct RF from water vapour from aircraft is small (below 5 mW/m^2).

- Hydrogen as fuel leads to zero CO_2 emissions. In comparison to kerosene powered aircraft, the contrail cover will increase and the ice particles in the contrails will be larger. Whether the total RF increases or decreases due to the introduction of hydrogen as fuel, depends on the changed optical properties of contrails, which are only poorly known, and on the level of the NOx emissions, which has to be evaluated by engine engineers.

b) LTO-Cycle

- NOx and UHC emissions are ozone precursors and need to be reduced for local and regional air quality regulation.

- Nano-particulates as from soot and some of the minor components e.g. formaldehyde, 1,3 butadiene and some PAH species are generally considered to be direct carcinogens.

Supersonic Aircraft[5]

- Some recent studies claim a stronger ozone destruction from NOx emission than expected in the IPCC (1999) but this result is controversial as other studies show an even lower effect.

- The largest RF is from water vapour emission as was reported by IPCC (1999).

References:

IPCC, 1999: *Aviation and the global atmosphere - A special report of IPCC working groups I and III*. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, NY, USA, 365 pp.

Sausen, R., C. Fichter, G. Amanatidis (eds.), 2004: European Conference on Aviation, Atmosphere and Climate (AAC) — Proceedings of an International Conference. Air pollution research report 83, European Commission, 369 S.

[4] The new value for 1992 is 3.5 mW/m^2.

[5] The on-going EU project SCENIC will provide an update of the atmospheric effects of supersonic aircraft in 2005.