The use of non-CO_2 multipliers for the climate impact of aviation: *The scientific basis*

by

Dr. David W. Fahey
Earth System Research Laboratory
National Oceanic and Atmospheric Administration
Boulder, Colorado USA

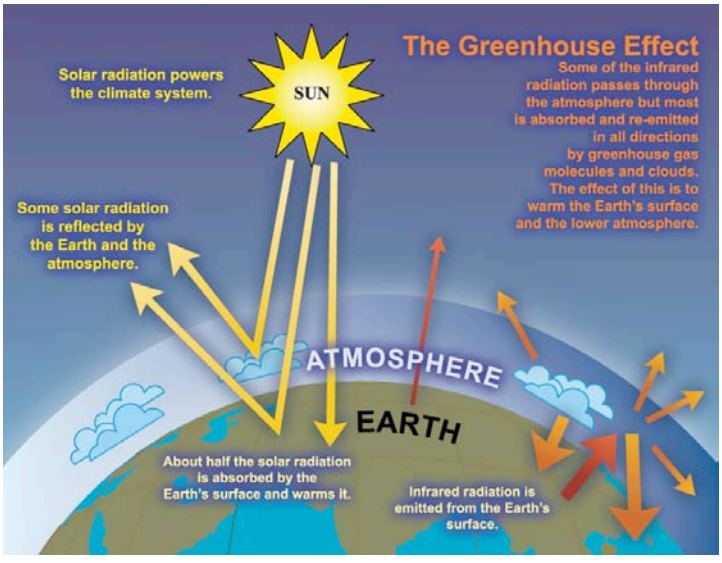
Outline

- Introduction
- Aviation and climate change radiative forcings
- The multiplier concept and limitations
- Conclusions & recommendations

Introduction

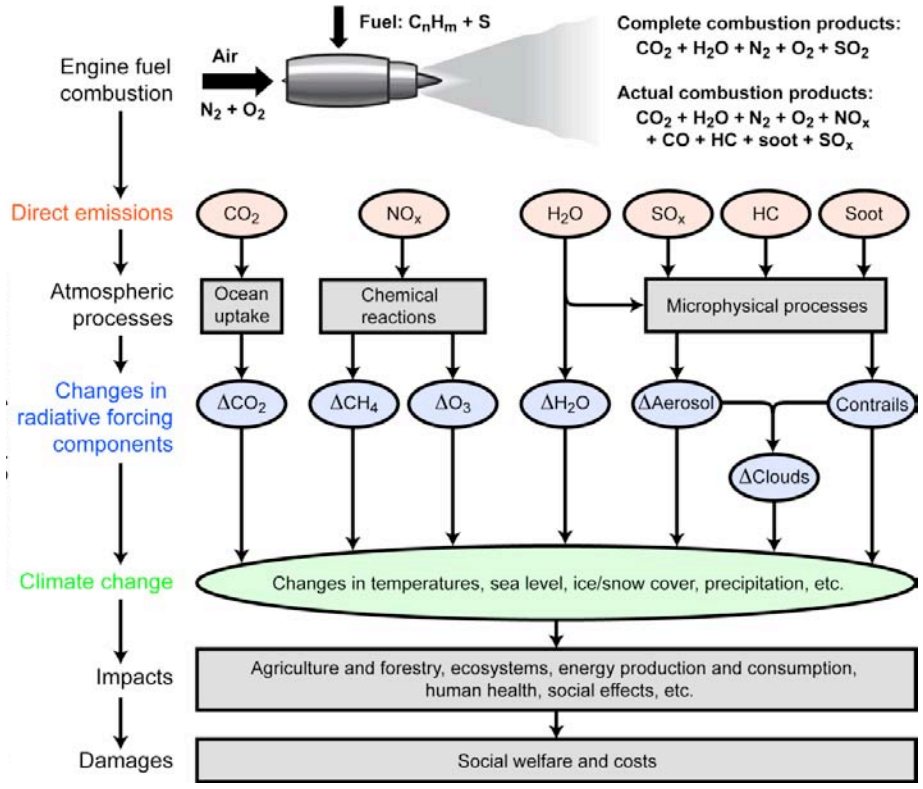
Aviation contributes to climate change by increasing atmospheric radiative forcing through the emission of gases and aerosols and changing cloud abundance.

Radiative forcing is a change in the balance of solar and terrestrial radiation in Earth's atmosphere.



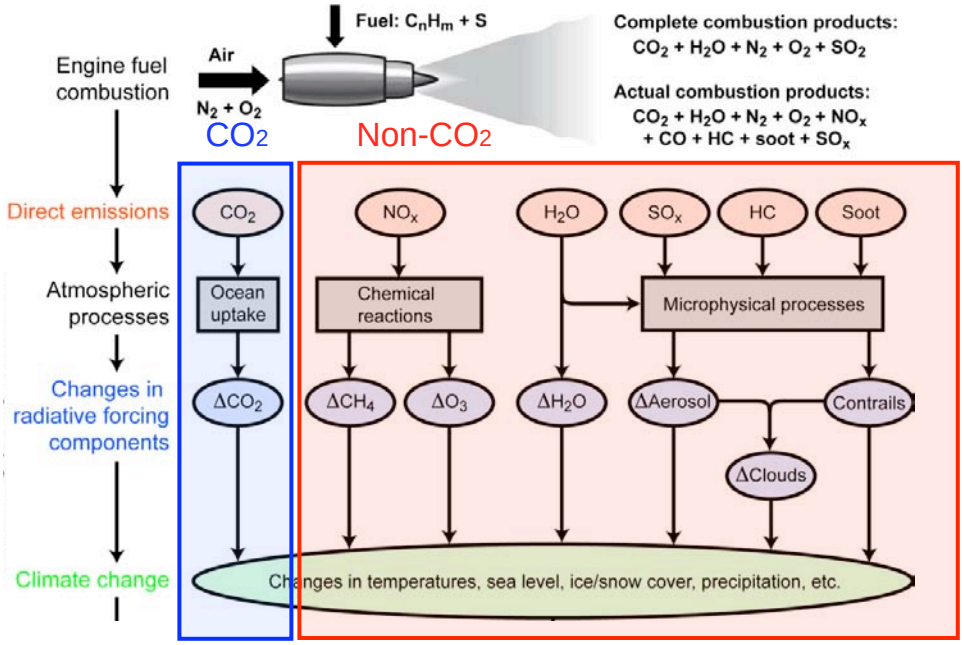
IPCC, AR4 (2007)

Aviation and climate change



Adapted from Wuebbles *et al.*, 2007

Aviation and climate change

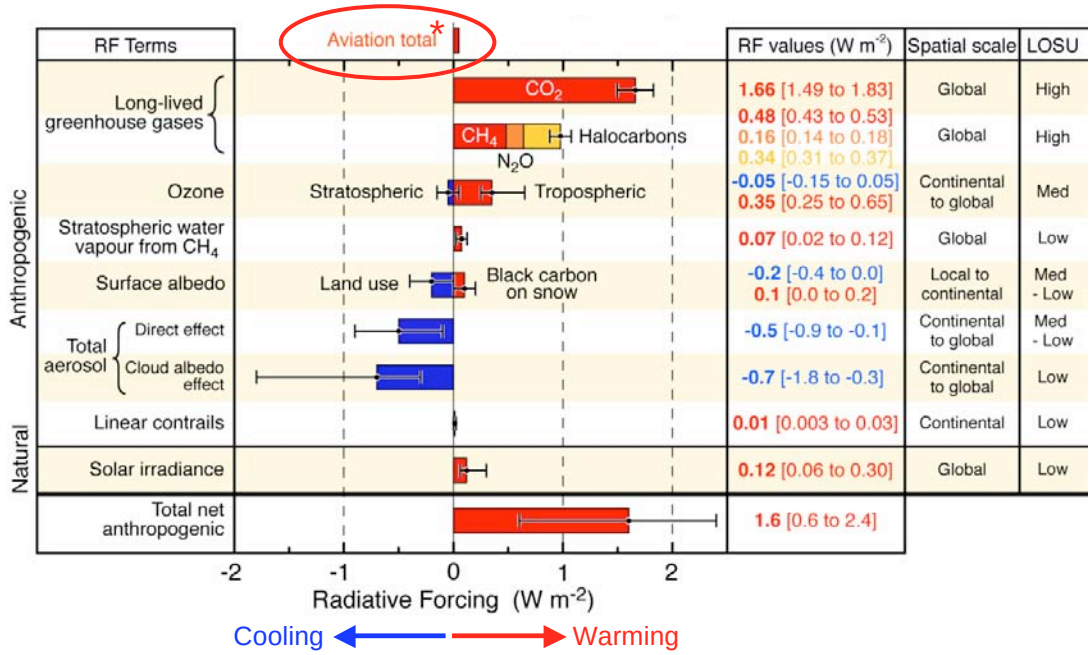


The non-CO_2 multiplier is an effort to simplify the accounting of aviation climate forcing from effects other than CO_2 accumulation.

Adapted from Wuebbles *et al.*, 2007

Global radiative forcing components

(1750 - 2005)



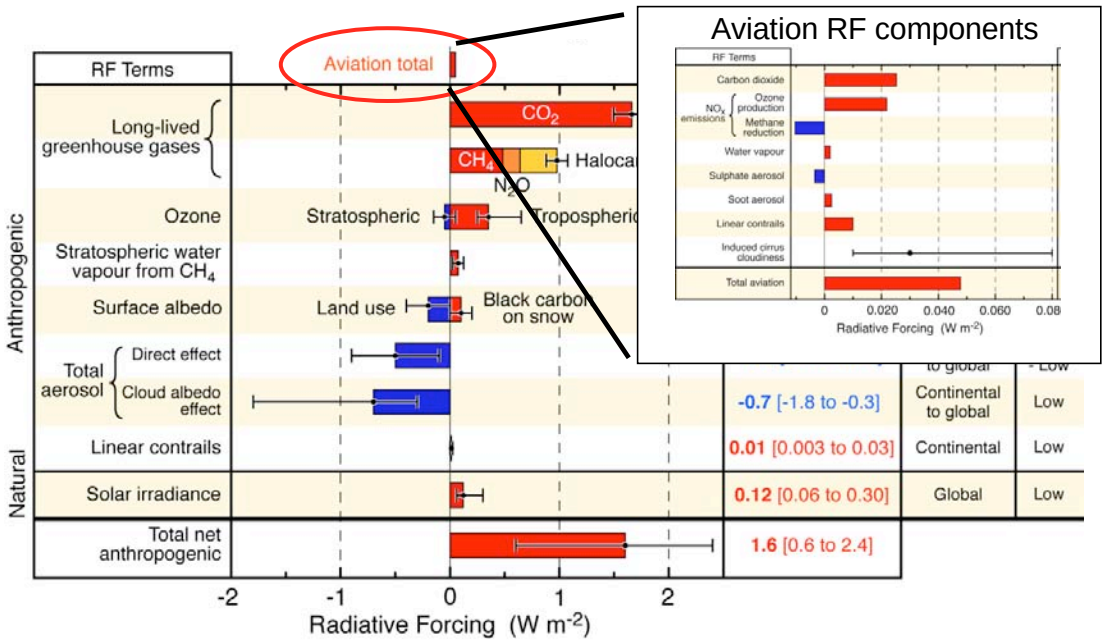
- Aviation represents 3% (range 2 - 8%) of anthropogenic radiative forcing in 2005

*(includes all components except induced cloudiness)

Adapted from IPCC, AR4 (2007)

Global radiative forcing components

(1750 - 2005)



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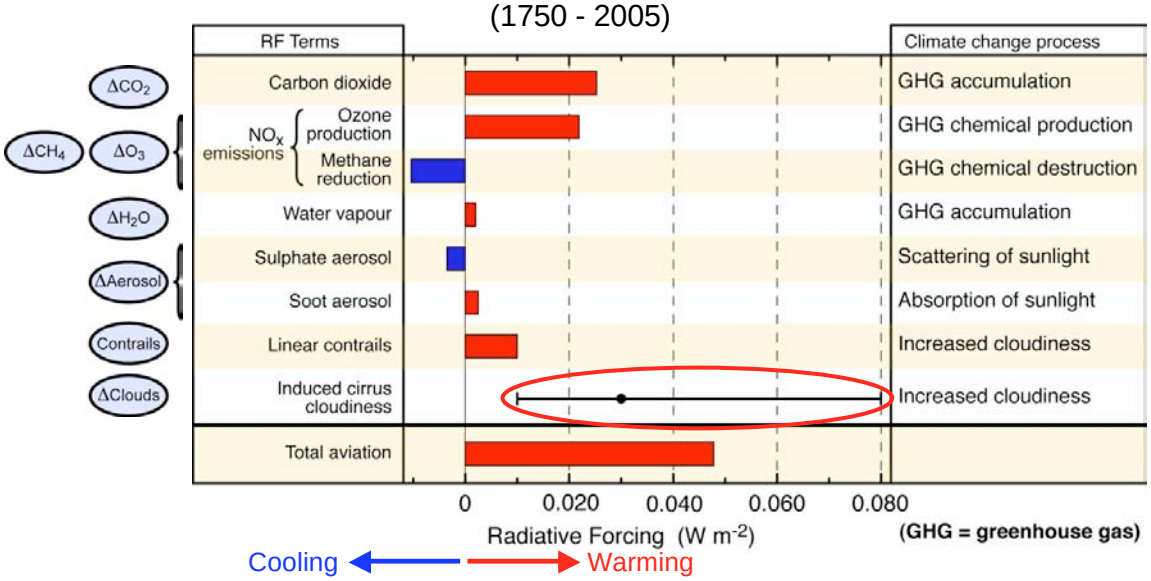
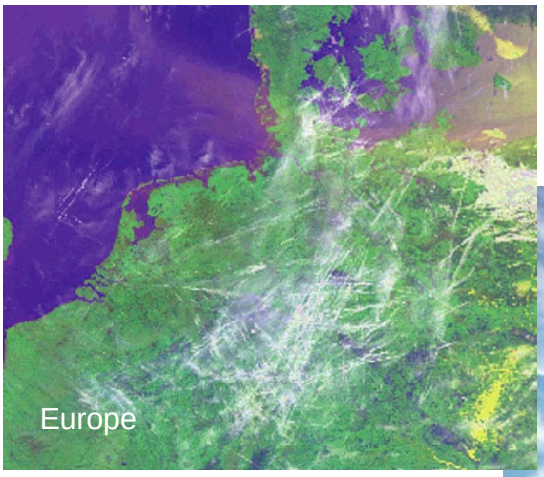


- Aviation radiative forcing components have been quantified with *best estimates* except for induced cirrus cloudiness which includes aerosol cloud effects.
- Radiative forcing is a backward-looking metric that integrates over previous aircraft operations (*i.e.*, 1750-2005) and hence is not a suitable metric for future aviation.

Adapted from IPCC, AR4 (2007)

Contrails and induced-cirrus cloudiness

The estimates of aviation cloudiness have large uncertainties



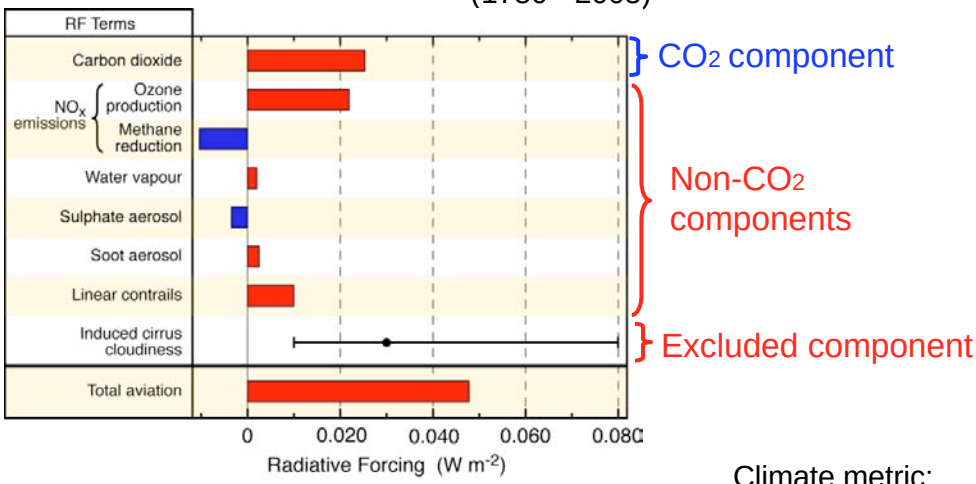
Persistent contrails spread to form additional cirrus or induced cirrus in high relative humidity regions

IPCC, 1999

US Environmental Protection Agency (EPA), Aircraft Contrails Factsheet

Aviation radiative forcing components

(1750 - 2005)



Aviation multiplier = $\left[\frac{(CO_2 + \text{non-}CO_2)}{(CO_2)}\right]$ climate metric

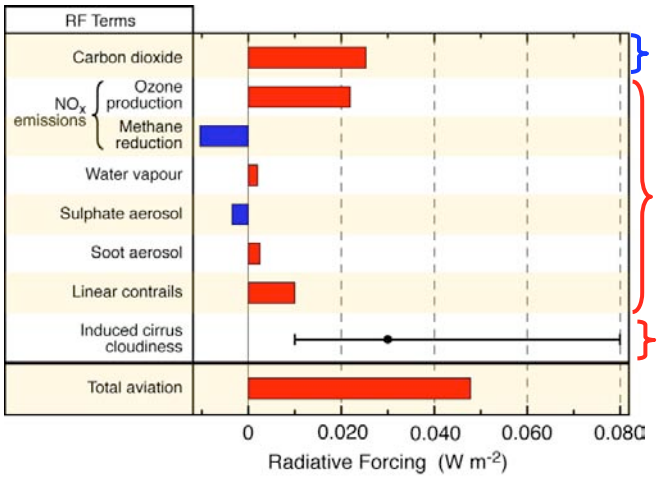
Climate metric:
= radiative forcing, temperature change, potential of climate change, etc.

Radiative forcing index = RFI = $\left[\frac{(CO_2 + \text{non-}CO_2)}{(CO_2)}\right]$ Radiative forcing = 1.7 (in 2005)

IPCC (1999)

Aviation radiative forcing components

(1750 - 2005)



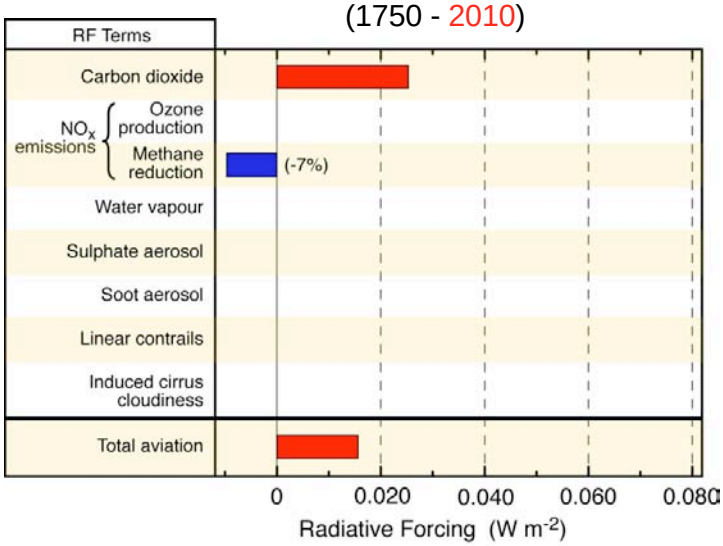
Long atmospheric lifetime (>100 yrs)

Short atmospheric lifetime (< 1 - ~10 yr)

➢ The short lifetime of most aviation climate forcings adds complexity to using a multiplier to weigh the climate impact of non-CO_2 forcings.

Aviation radiative forcing: Hypothetical scenario

(1750 - 2010)



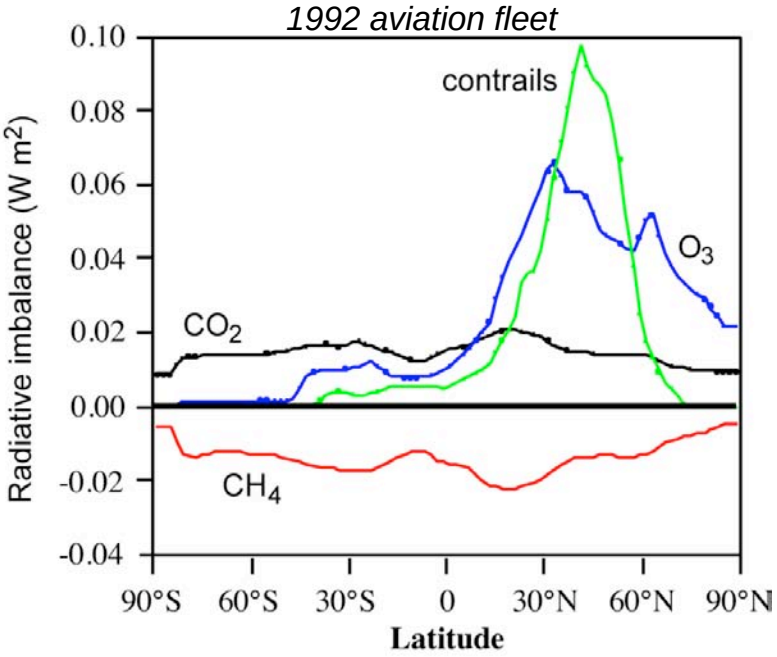
Hypothetical scenario:
No aviation operations starting in 2009

Result: In 2010, aviation radiative forcing components would be zero except for CO_2 and CH_4.

- Aviation multipliers can be chosen for emphasis on either short term or long term climate effects.
- The choice of an aviation multiplier metric requires a policy decision to prioritize climate protection goals.

Aviation radiative forcing: Regional distributions

1992 aviation fleet



- Additional uncertainty and difficulty in the use of multiplier arise from the different regional distributions of non-CO_2 forcings.

IPCC, 1999

Aviation multipliers …….

… can be defined for a variety of metrics: current or future radiative forcing, temperature change, etc.

$$\text{Aviation multiplier} = \left[\frac{(CO_2 + \text{non-}CO_2)}{(CO_2)} \right]_{\text{climate metric}}$$

… generally will be an underestimate if induced cirrus effects are not included.

… will be complex because of the short lifetimes of non-CO_2 effects in comparison to CO_2.

… will show regional differences because of differences in the regional distribution of aviation forcings

Summary Remarks

> Aviation contributes to global climate change through emissions and cloud effects

- Aviation currently contributes 3 - 8% of total anthropogenic radiative forcing

> Aviation induced cirrus is an additional component that currently has no best estimate and high uncertainty.

> The radiative forcing index (RFI) is unsuitable for a changing atmosphere and a changing aviation fleet.

> Aviation multipliers must be defined and implemented with care in order to remain consistent with scientific understanding.

> The choice of multiplier requires climate protection goals and priorities to be established by policymakers

> Metrics other than RF exist for aviation multipliers: global temperature potential (GTP) and global warming potential (GWP) (O. Boucher presentation).