

The climate impact of aviation: Current status and mitigation options

Volker Grewe

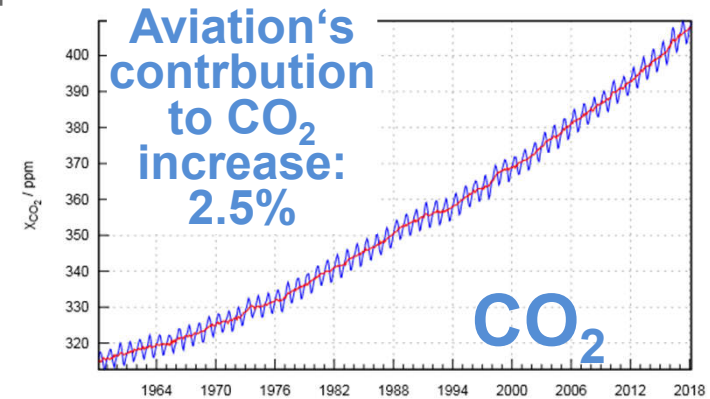
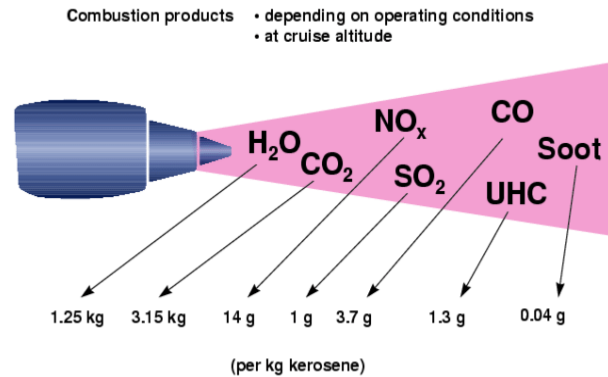
DLR-Institute for Atmospheric Physics

TU Delft, Chair for Climate Effects of Aviation

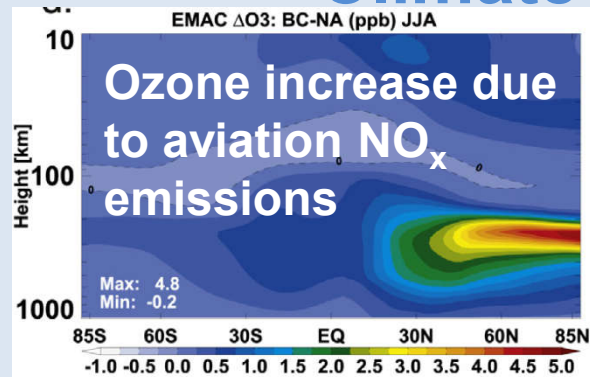
ECATS WG-Lead



Aviation emission and climate impact



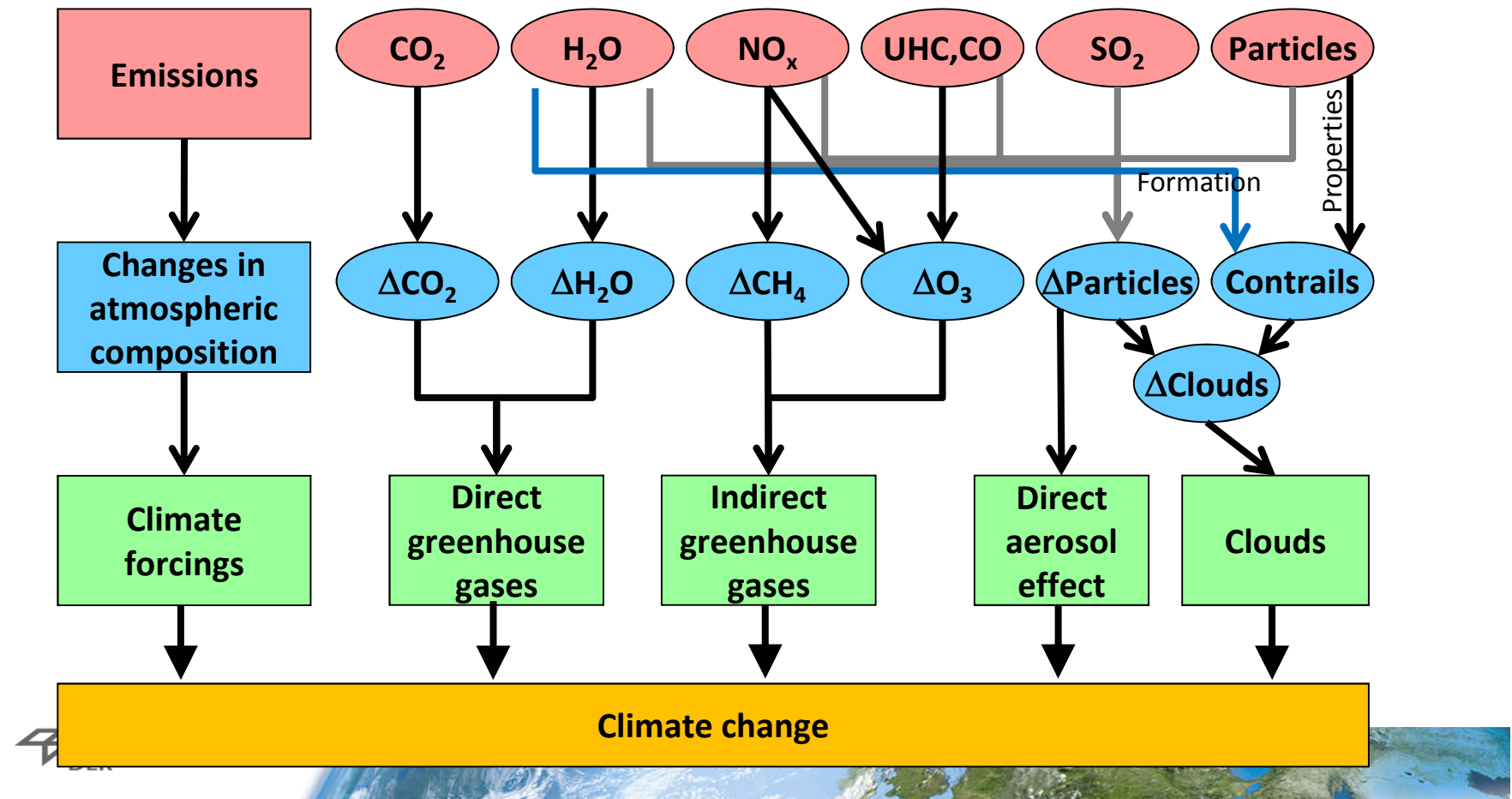
Climate impact of non-CO₂-Effects



Søvde et al. (2014)

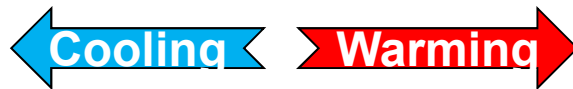
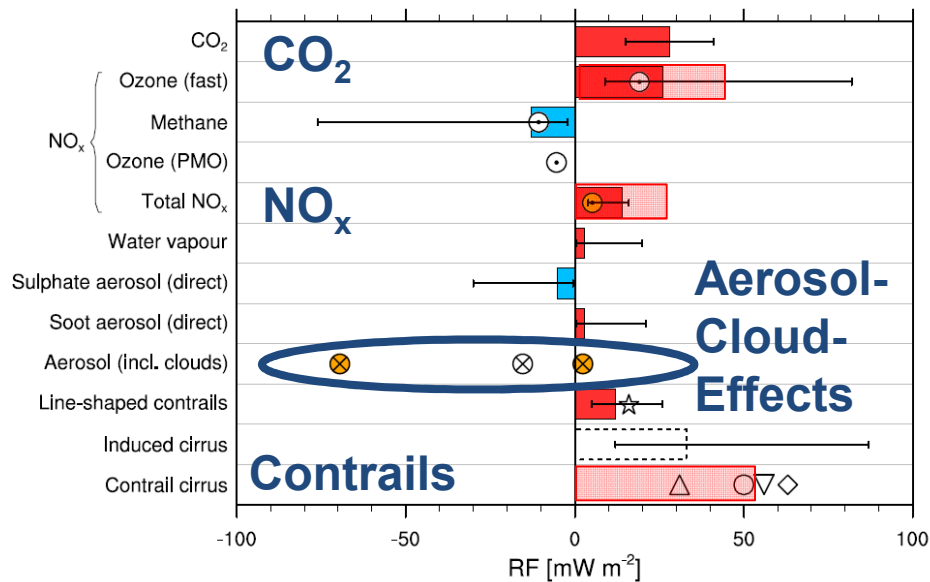


Overview: Climate impact of aviation



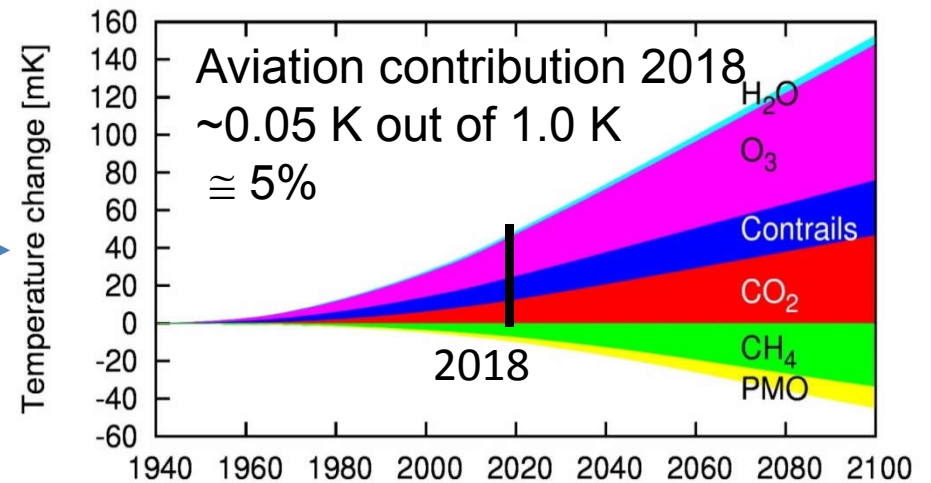
How important are the aviation non-CO₂-effects?

Radiation change



Grewe et al. (2017)

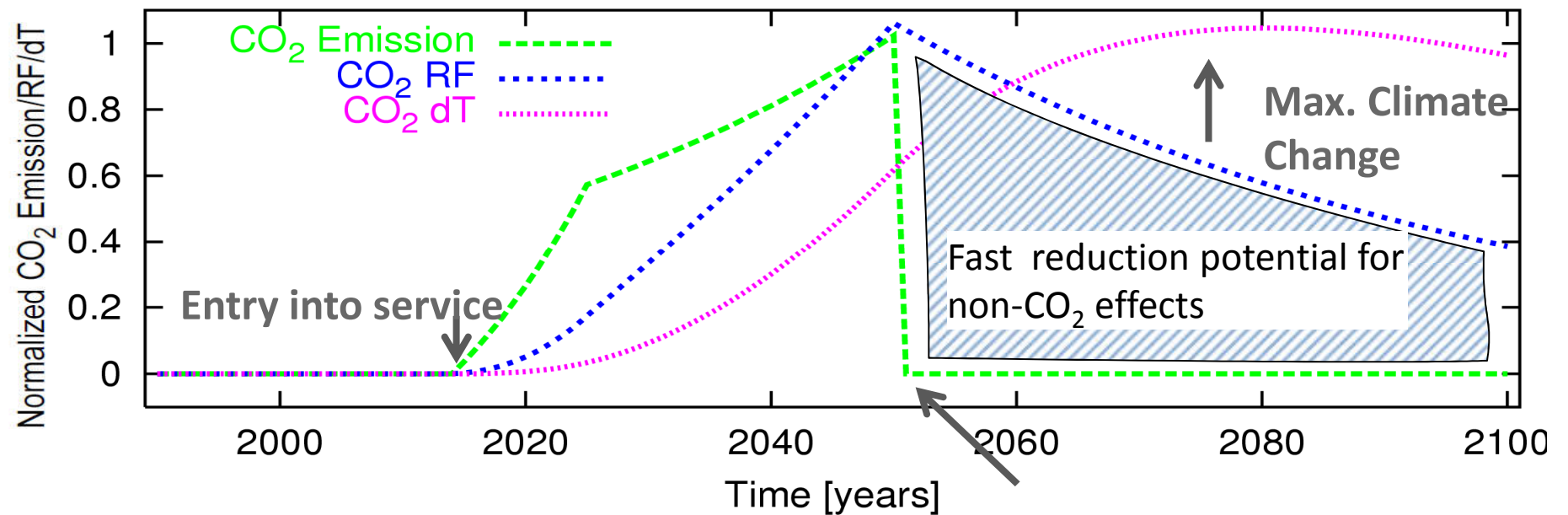
Temperature change



More than 50% of the aviation's climate impact results from non-CO₂ effects



Time scales: Emission – RF – dT (Thought experiment)



End of usage
= Max. Emission/Concentration/RF

Grewe and Stenke, 2008



Climate mitigation options for aviation

- Technology Measures

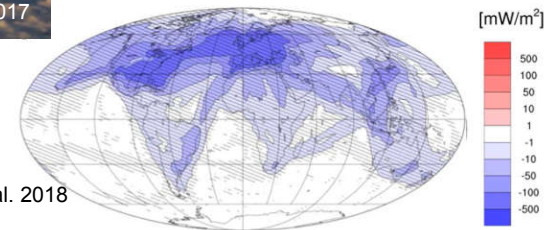
- New aircraft designs
- Cruise altitude changes
- Fuel efficiency
- Emission reduction
- Alternative fuels



- Operational Measures:

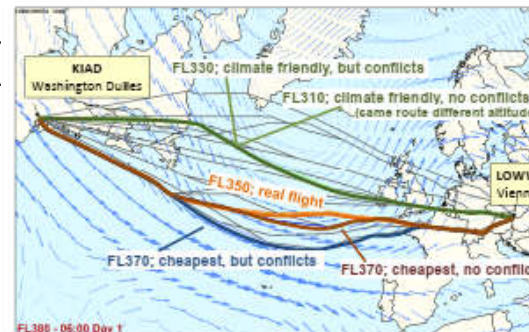
- Avoidance of climate sensitive regions
- Closure of airspace
- Intermediate Stop Operations (
- Formation flight

Burkhardt et al. 2018

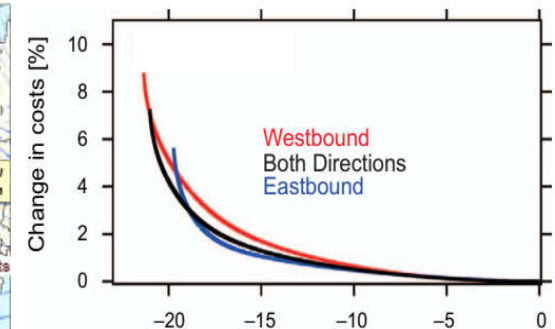


- Economical Measures

- Market-Based Measures
- Carbon off-setting



Grewe et al. 2014



Grewe et al. 2017



Climate mitigation options for aviation

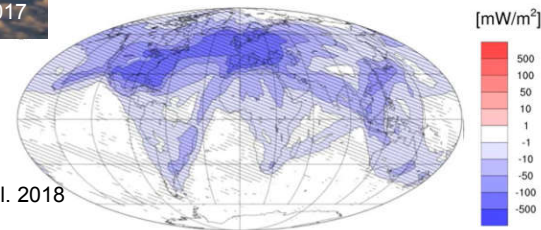
- Technology Measures

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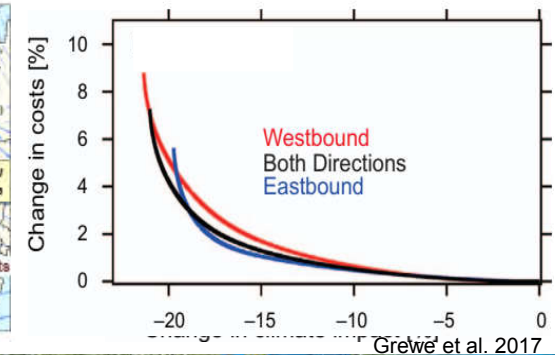
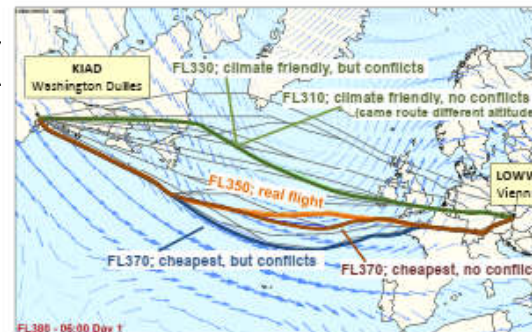
- Operational Measures:

- **Avoidance of climate sensitive regions**
- Closure of airspace
- Intermediate Stop Operations (
- Formation flight

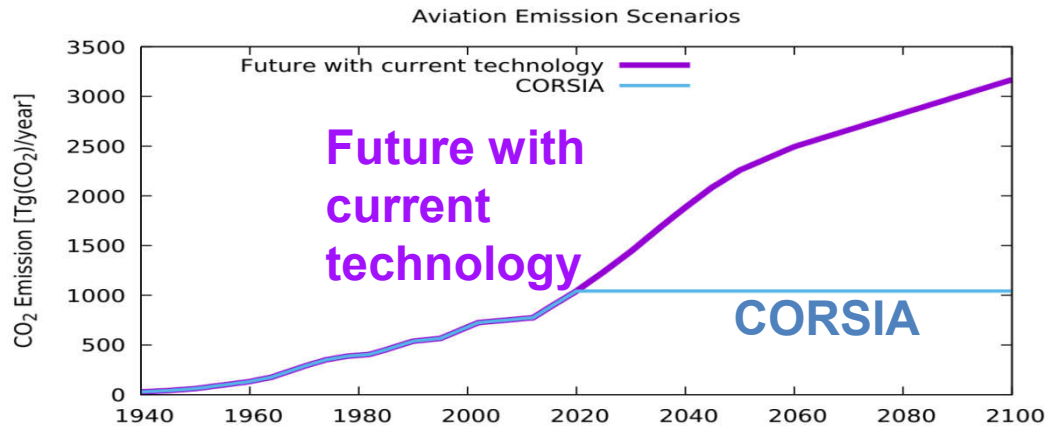


- Economical Measures

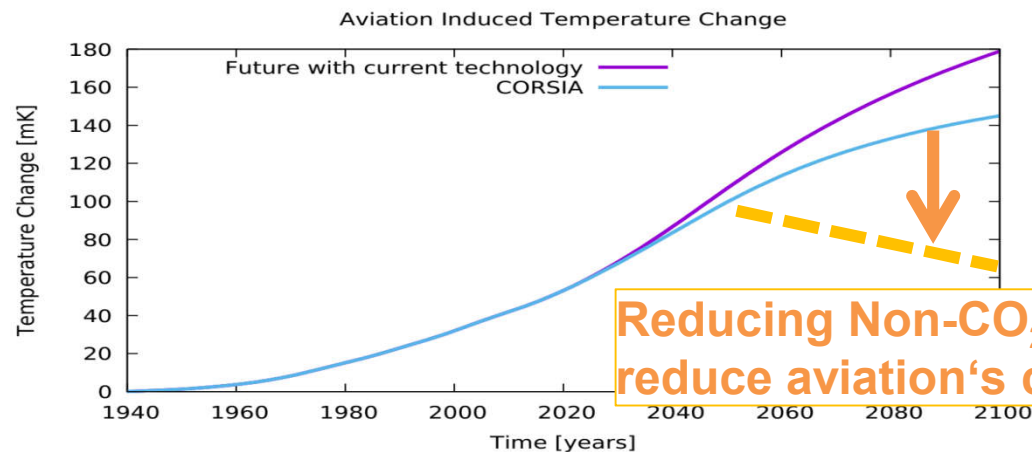
- Market-Based Measures
- **Carbon off-setting**



Why are non-CO₂-effects important to be considered in regulations?



- Large CO₂ emission reduction
- Large increase in Non-CO₂ effects

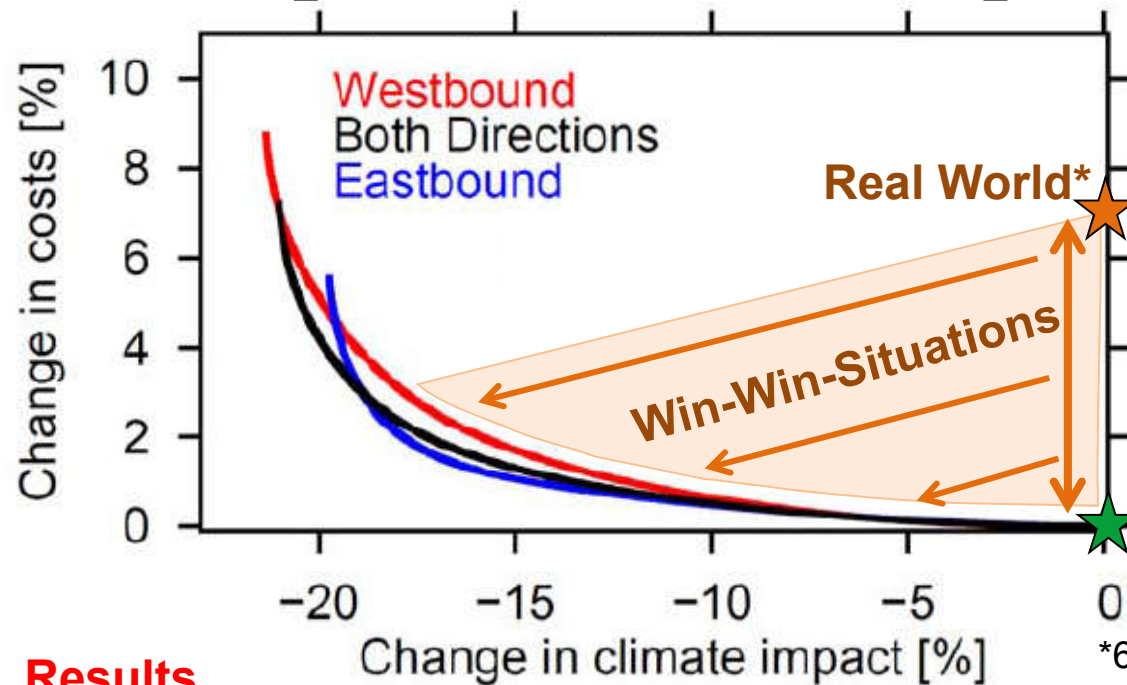
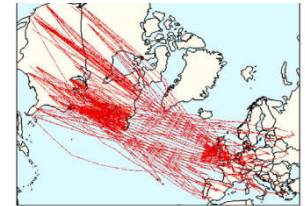


Small change in temperature because of

- CO₂ accumulation
- Large increase in Non-CO₂ effects



Avoiding Climate-Sensitive Regions



Approach

- Reducing the climate impact of 800 trans-Atlantic daily flights.
- Climate impact from CO₂, H₂O, contrail-cirrus, NO_x (O₃, CH₄, PMO) by utilising climate-change functions
- 8 climatological weather situations considered

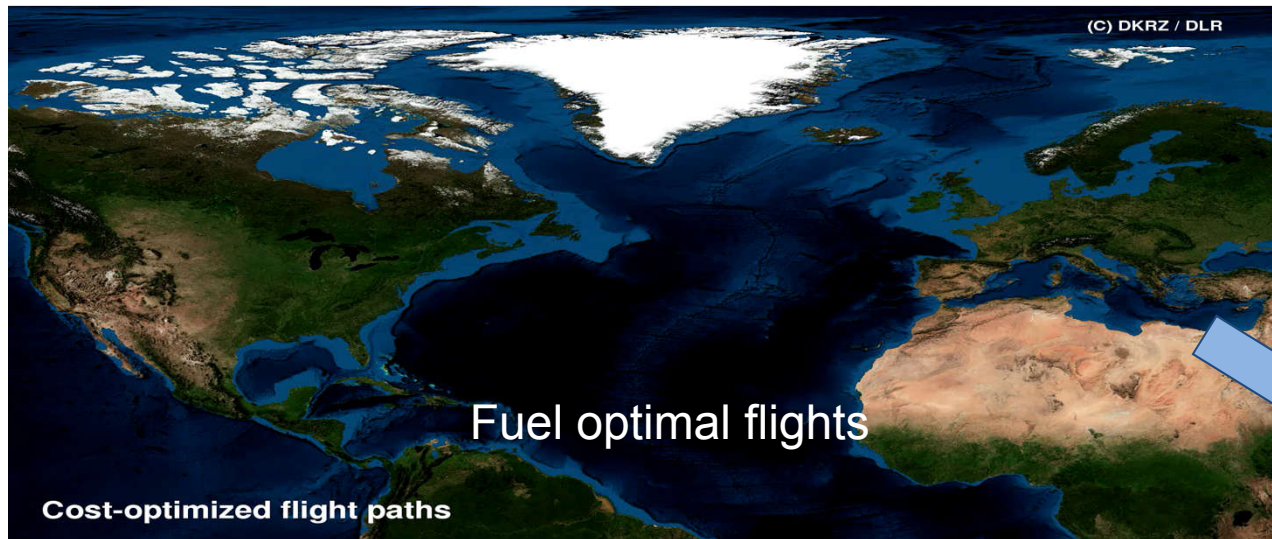
Theoretical Minimum

*6-8% ATM inefficiency (Boeing & CANSO 2012)

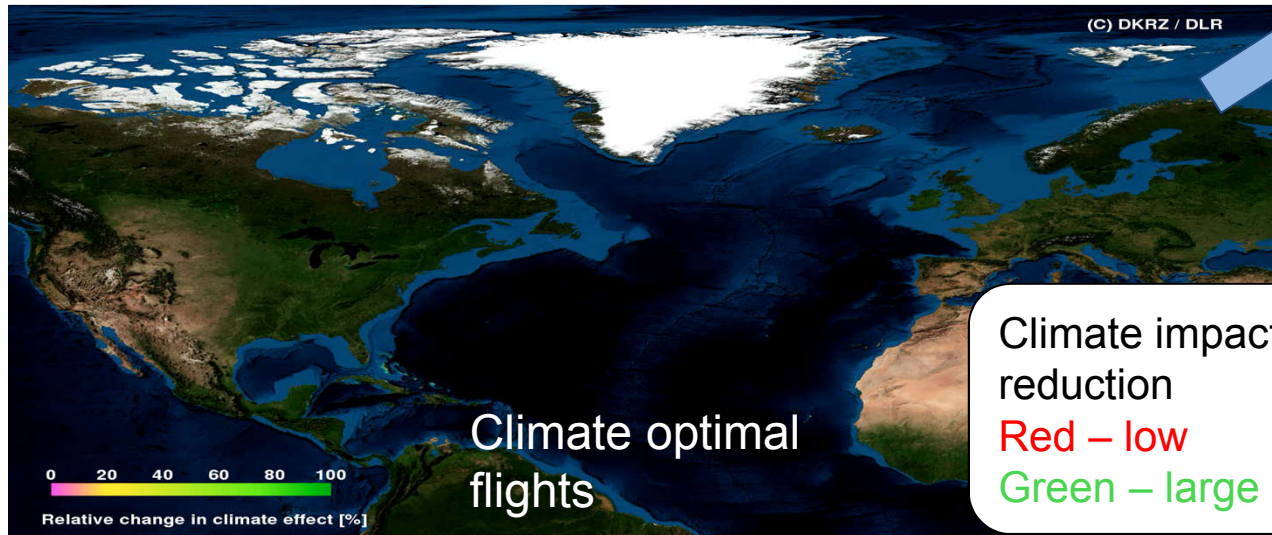
Results

- Very flat Pareto-Front \Rightarrow Large benefits at low costs
- Win-Win situations exist, where a reduction in both, climate impact and fuel use, can be achieved due to inefficiencies in ATM. Grewe et al. (2017), Matthes et al. (2017)





North-Atlantic Flight routed

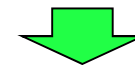


Climate impact
reduction

Red – low

Green – large

Only small
differences in
routing visible



Effective reduction of
the climate impact with
little routing changes
possible.

Summary

- Enhanced knowledge on the processes related to aviation emissions.
- More than 50% of the climate impact from aviation due to non-CO₂ effects.
 - Aerosol impacts on clouds are uncertain
- Uncertainties remain, but may be better understood and can be employed to obtain robust solutions
- More mitigation studies, which include non-CO₂ effects.
 - Climate-sensitive areas could substantially reduce the climate impact of aviation at low cost increase.
 - CO₂ versus non-CO₂ trade-offs have to be solved
- Non-CO₂ effects play an important role and are not part of CORSIA, but may be included via equivalent CO₂ emissions or other means
- Combination of several options necessary: Alt. fuels + Tech + Operations





Thank you for your
attention

