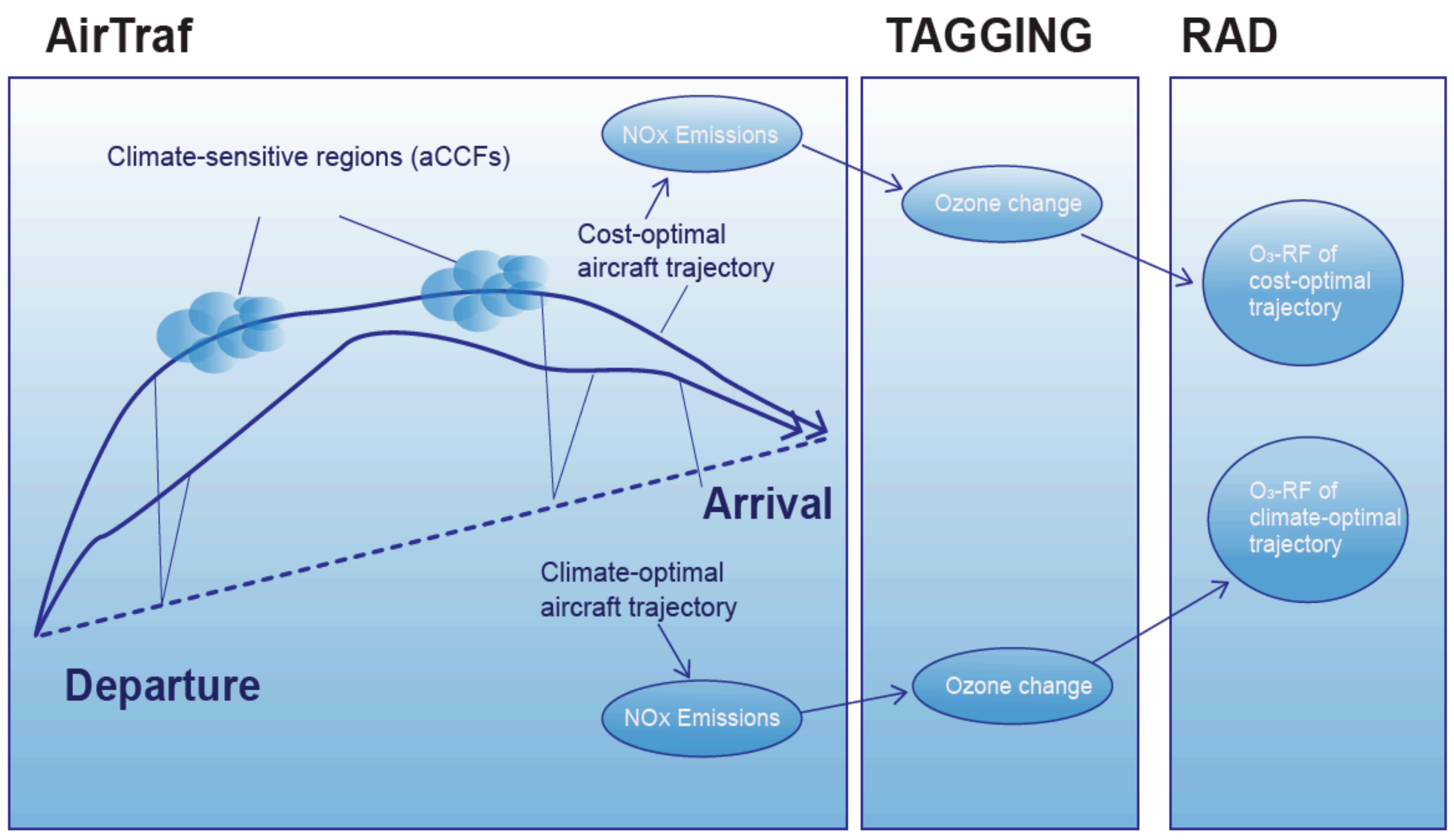
The analysis of NO_x-O_3 effects from optimised air traffic using algorithmic climate change functions (aCCFs)

Pratik Rao[1], Feijia Yin[1], Volker Grewe[1,2], Hiroshi Yamashita[2], Patrick Jöckel[2]

[1]Delft University of Technology, Aircraft Noise and Climate Effects (ANCE)
[2]German Aerospace Center (DLR), Institute of Atmospheric Physics

Motivation

- Aviation induced warming includes CO_2 (<35%) and non-CO_2 effects (>65%) from NO_x, H_2O, contrails and direct aerosols [1].
- The climate impact of non-CO_2 emissions are characterised by the meteorology, emission location and time [2].
- Algorithmic Climate Change Functions (aCCFs) [3] are response models that use meteorological data to estimate the climate impact of emissions at a given location and time.
- We need to **verify the effectiveness of aCCFs in generating green trajectories** that avoid climate sensitive regions.
- The focus here is specifically on **verifying O_3 aCCFs** which are expected to predict NO_x impact on Ozone.



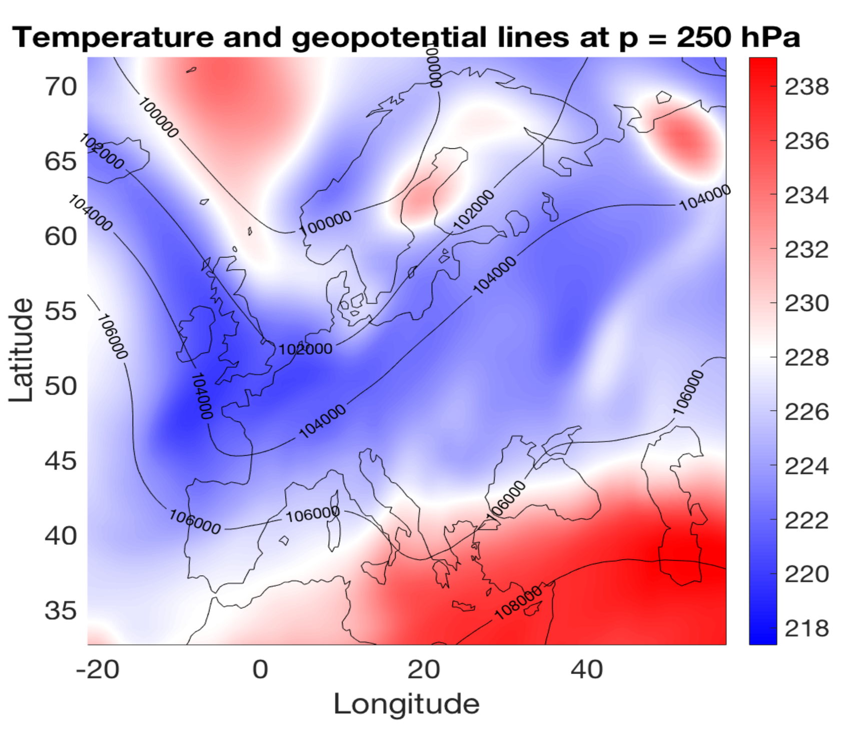
Simulation setup

Ozone aCCFs

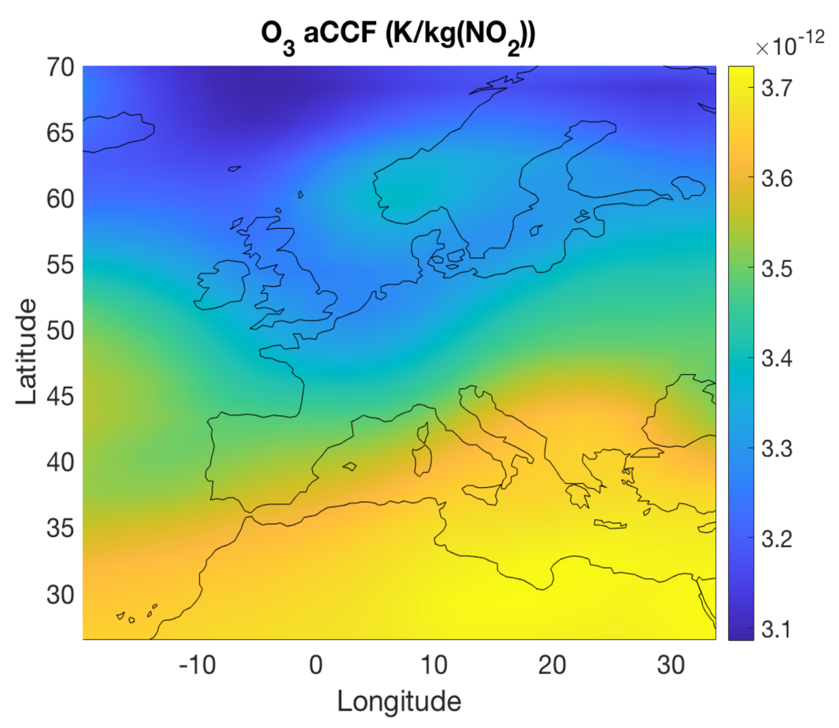
- O_3 aCCFs are dependent on temperature and geopotential:

$$\mathrm{aCCF}_{\mathbf{O_3}}(\mathrm{T}, \mathbf{\Phi}) = \beta_0 + \beta_1 \mathrm{T} + \beta_2 \mathbf{\Phi} + \beta_3 \mathrm{T}\mathbf{\Phi}$$

- The verification process will provide insight on the capability of O_3 aCCFs in predicting NO_x effects on Ozone from optimised air traffic.



Weather situation (T, Φ)



Climate impact of NOx on O_3

Verification Approach

- Optimise EU air traffic on days characterised by high variability of NO_x-O_3 aCCFs.
- Both horizontal and vertical re-routing is considered.
- The flight traffic emissions are tracked and used in a 4-month chemistry simulation.
- A direct climate impact comparison is made with cost-optimised air traffic.

Expected results

At the end of the project, the following is expected:

- The extent to which O_3 aCCFs are useful in predicting NO_x-O_3 impact from aviation re-routing procedures.
- Radiative forcing of Ozone from climate-optimised air traffic is lower than for cost-optimised traffic at the end of the simulation.

Air traffic optimised on:	Cost optimal	Climate optimal	Difference
Winter day	10.67	10.64	0.03
Summer day	8.85	8.73	0.12

Mean-adjusted O_3 RF (mW/m^2) from optimised air traffic

References

1. Lee et al., 2020. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018.
2. Grewe et al., 2014. Aircraft routing with minimal climate impact: the REACT4C climate cost function modelling approach (V1.0).
3. van Manen et al., 2019. Algorithmic climate change functions for the use in eco-efficient flight planning.

Acknowledgement: This project has received funding from European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement ID: 875503. Further gratitude is expressed to other collaborators from TU Delft (NL), DLR (DE), Deep Blue (IT), Royal NLR (NL), Amigo (IT), ITU (TR), IATA (ES) and SEA (IT).

TU Delft Delft University of Technology

CLIMOP

Challenge the future