EGU General Assembly

The analysis of the climate mitigation potential in terms of O_3-Radiative Forcing from aviation NO_x using O_3 algorithmic climate change functions (aCCFs)

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- The latter contributes to nearly **2/3** of the climate impact! [2]
- The impact depends strongly on emission location, timescale, chemical background, etc. → **Weather** plays a large role
- Regions where variations are large → **climate sensitive regions**
- Avoid these regions → **climate optimised routing** → But how?

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- Sensitive regions can computed by aCCFs [3], which express a relation between weather variables and estimated climate impact from aviation
- aCCFs have been derived individually for O_3 and CH_4 (from NO_x), H_2O, contrails and CO_2

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Focus

Evaluate the effectiveness of reducing aviation NO_x induced climate impact via O_3 formation, using O_3 aCCFs in air traffic optimisation

- Lateral re-routing: flight altitude is fixed [$\approx$ 10.4 km]
- Vertical re-routing: flight altitude is variable [$\approx$ 8.8 to 12.5 km]

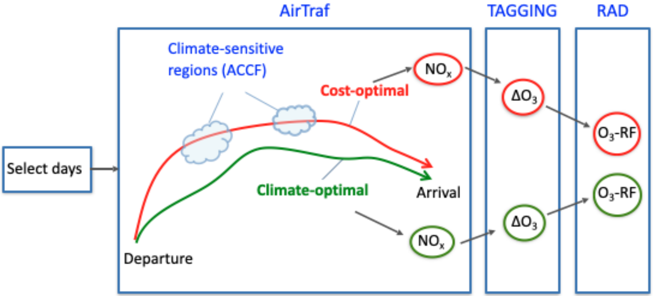
O_3 aCCFs

- O_3 production from NO_x depends on **weather**, solar radiation, background chemistry, etc.
- O_3 aCCFs are a function of temperature (T, [K]) and geopotential (ϕ, [m^2/s^2]):

$$\mathrm{aCCF}_{\mathrm{O}_3}(\mathrm{T}, \phi) = \beta_0 + \beta_1 \mathrm{T} + \beta_2 \phi + \beta_3 \mathrm{T} \phi$$

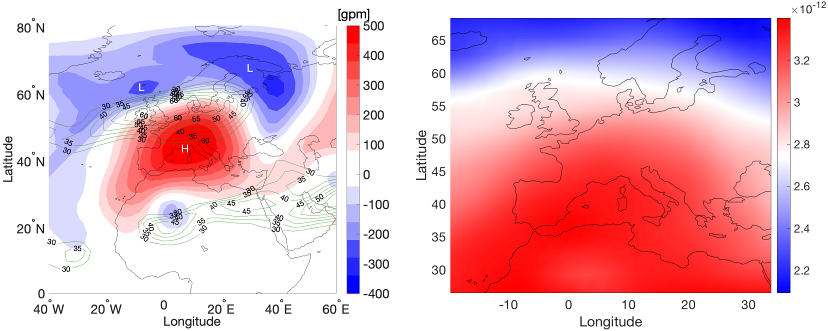
- Measures the climate impact in terms of $ATR20_{O_3}$ [K/kg(NO_2)]

Simulation setup



- Select winter and summer day characterised by high variability of O_3 aCCFs
- Air Traffic optimisation (Europe) + chemistry-climate simulation over 4 months + compare O_3-RF [4]

Results for winter day

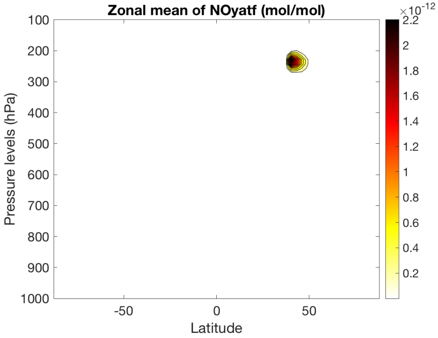


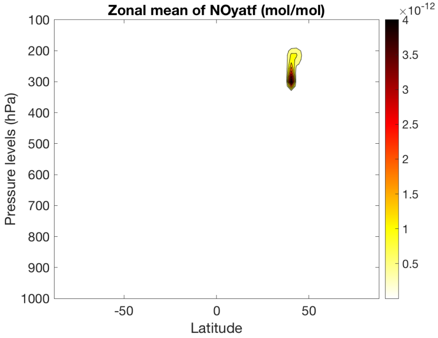
Winter day meteorology and O_3 aCCF value at 250 hPa

- Bulk of NO_x is transported towards the South and downwards

Results for winter day

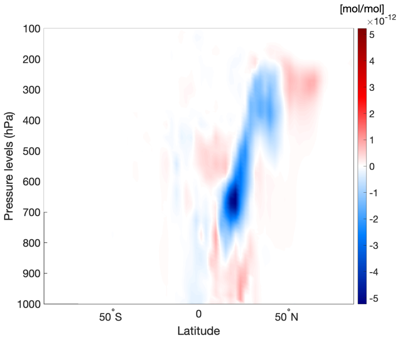
- Atmospheric transport of emissions (a) lateral re-routing, (b) vertical re-routing

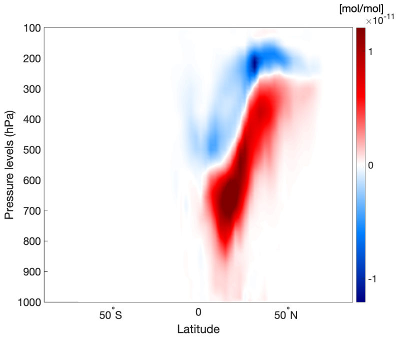




Results for winter day

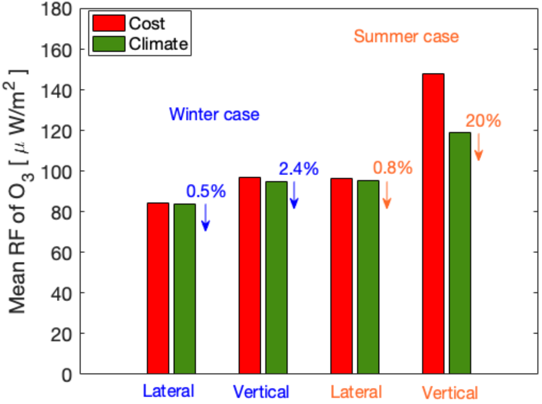
- **Difference** in Ozone production for (a) lateral re-routing, (b) vertical re-routing





Results for climate impact

- Mean O_3-RF for all scenarios



Summary

- The weather situation was shown to play a major role in the climate impact of non-CO_2 effects (aviation NO_x)
- Climate impact of NO_x in summer was found to be larger than in winter $\rightarrow$ matches literature
- Climate-optimised flights lead to lower O_3-RF compared to the cost-optimised flights
- Lateral re-routing for the chosen altitude leads to the least RF
- Vertical re-routing in summer shows largest mitigation potential
- O_3 aCCFs can reduce climate impact but can be improved even further

References and Acknowledgement

[1] Grewe et al., 2021. Evaluating the climate impact of aviation emission scenarios towards the Paris agreement including COVID-19 effects.

[2] Lee et al., 2020. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018.

[3] van Manen et al., 2019. Algorithmic climate change functions for the use in eco-efficient flight planning.

[4] Rao et al., 2022. Case Study for Testing the Validity of NO_x-Ozone aCCFs for Optimising Flight Trajectories

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Thank you for your kind attention!

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