Investigation on the effects of weather patterns on strategic climate impact mitigation measures: a data-based approach

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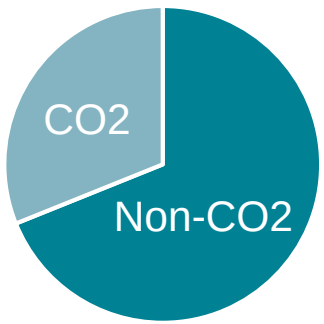
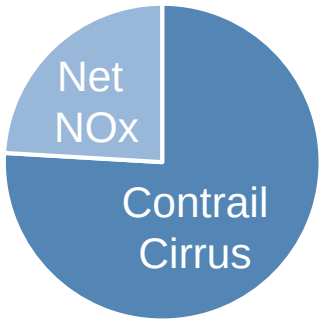
DLR

Motivation

Climate impact of Aviation

- Aviation contributes significantly to anthropogenic climate change
- Non-CO_2 effects account for about two-thirds of net radiative forcing





Mitigation measures

Technological	Operational	Regulatory
Eco-switch	Climate-optimized trajectories	Climate charged areas (CRAs)
New engine technology	Intermediate-stop-operations	Flight time restrictions
Improved Aircraft design	Altitude/speed changes	Flight restrictions

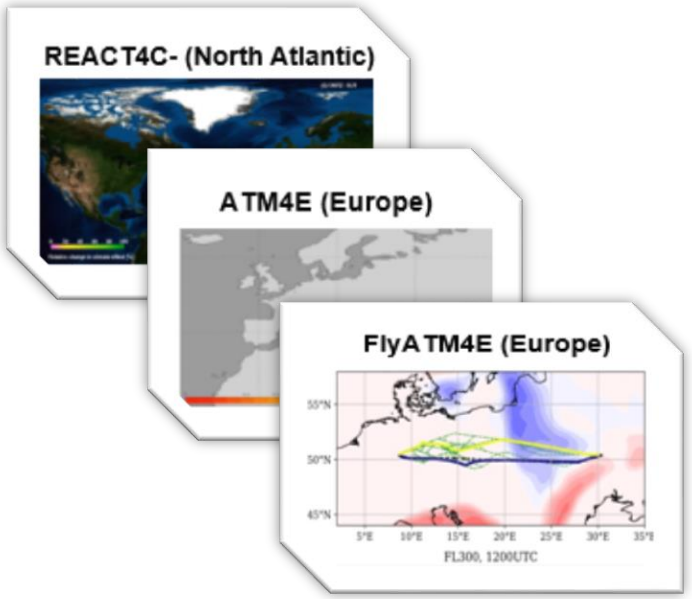
https://ourworldindata.org/co2-emissions-from-aviation, last accessed June 12th 2023.

Lee et al. 2021: The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. https://doi.org/10.1016/j.atmosenv.2020.117834.

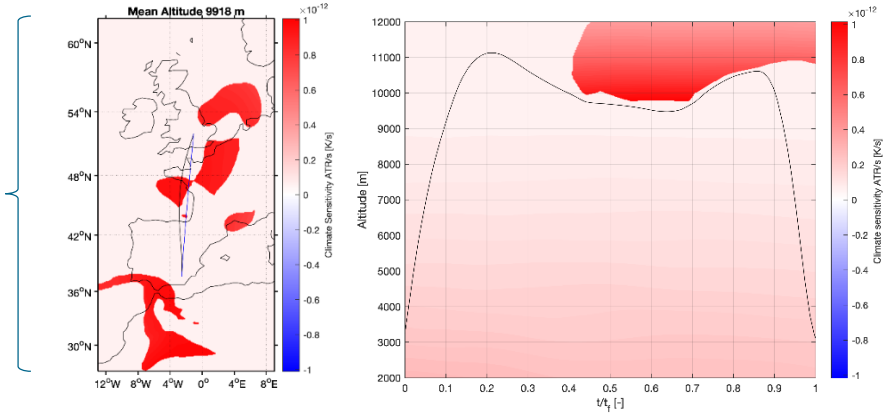
Background & Motivation

Climate-optimized flight planning

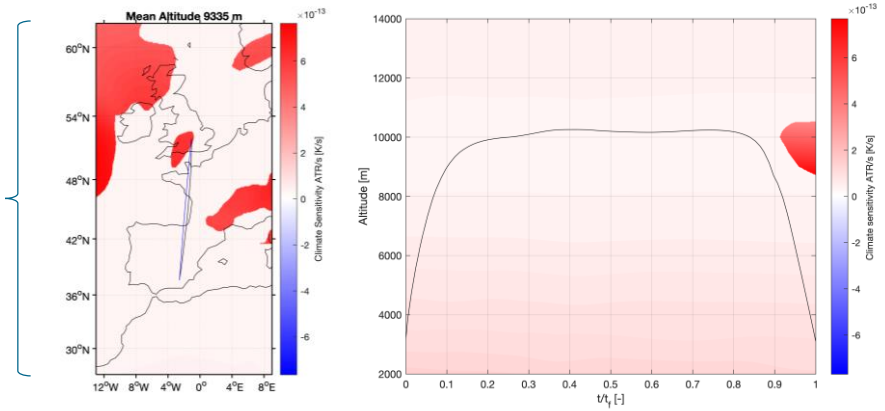
- Operational Measures have shown significant potential to reduce non-CO_2 effects of aviation



Contrail-driven

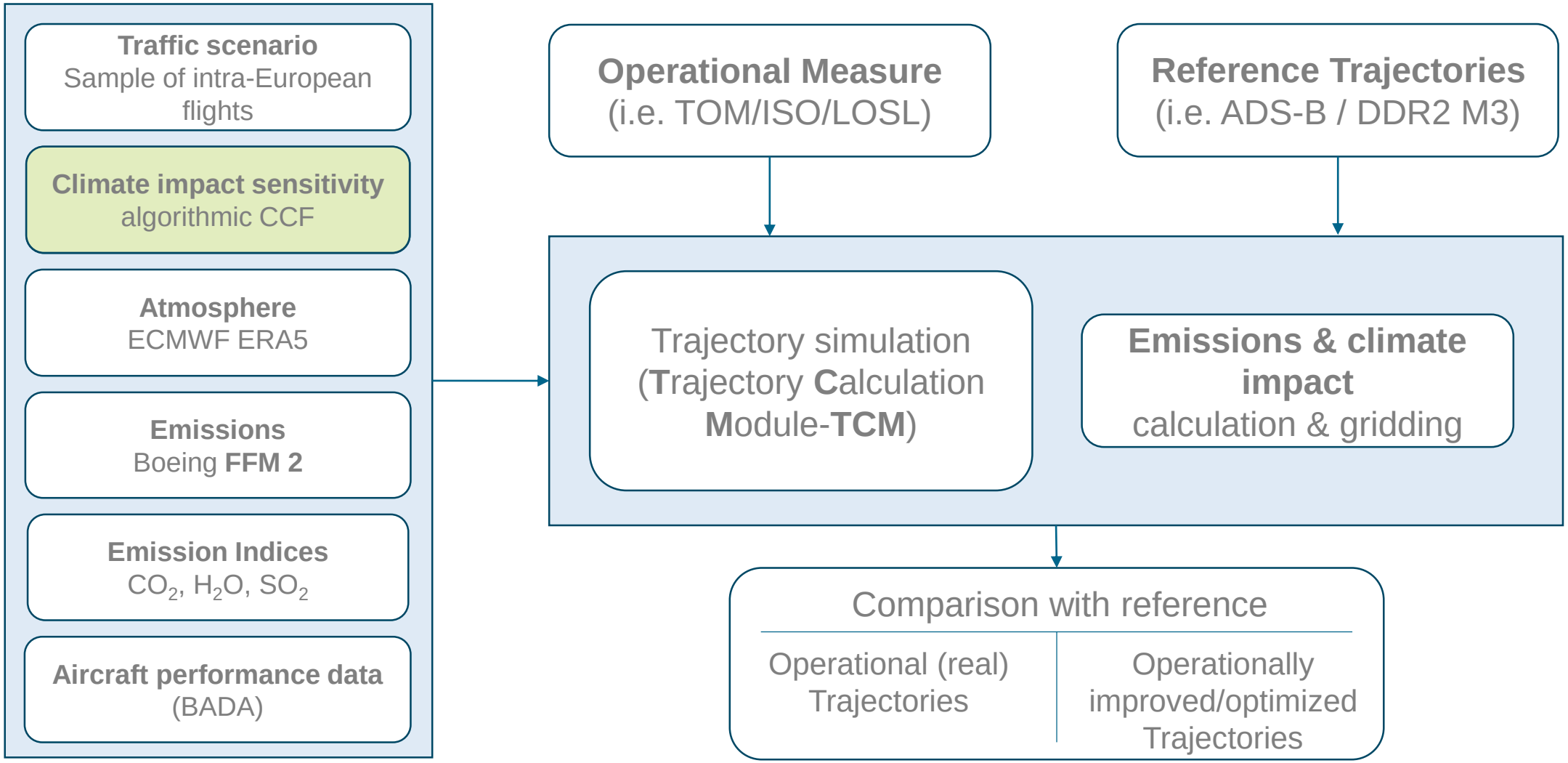


NO_x-driven



Meuser et al. 2022

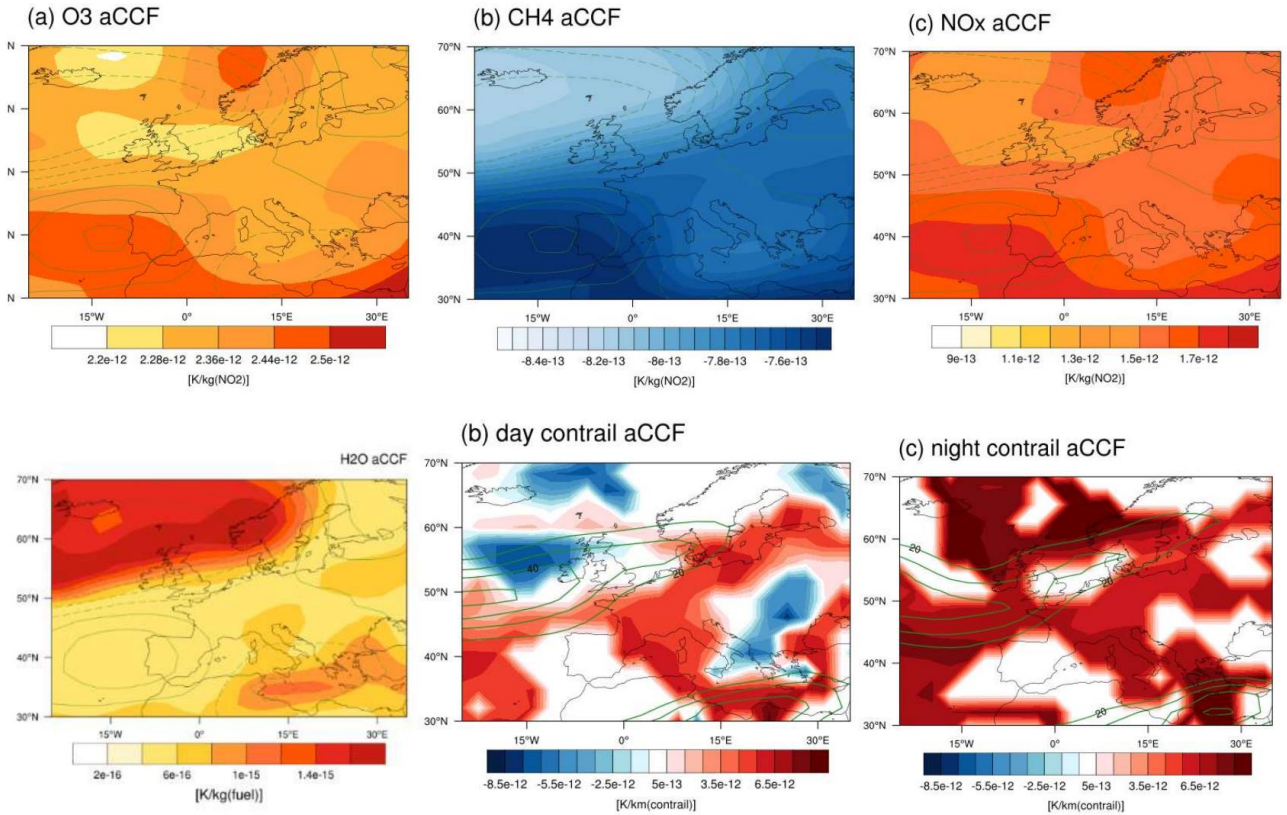
Climate Impact assessment
Methodology



Climate Impact & Atmosphere

aCCF: algorithmic Climate Change Function

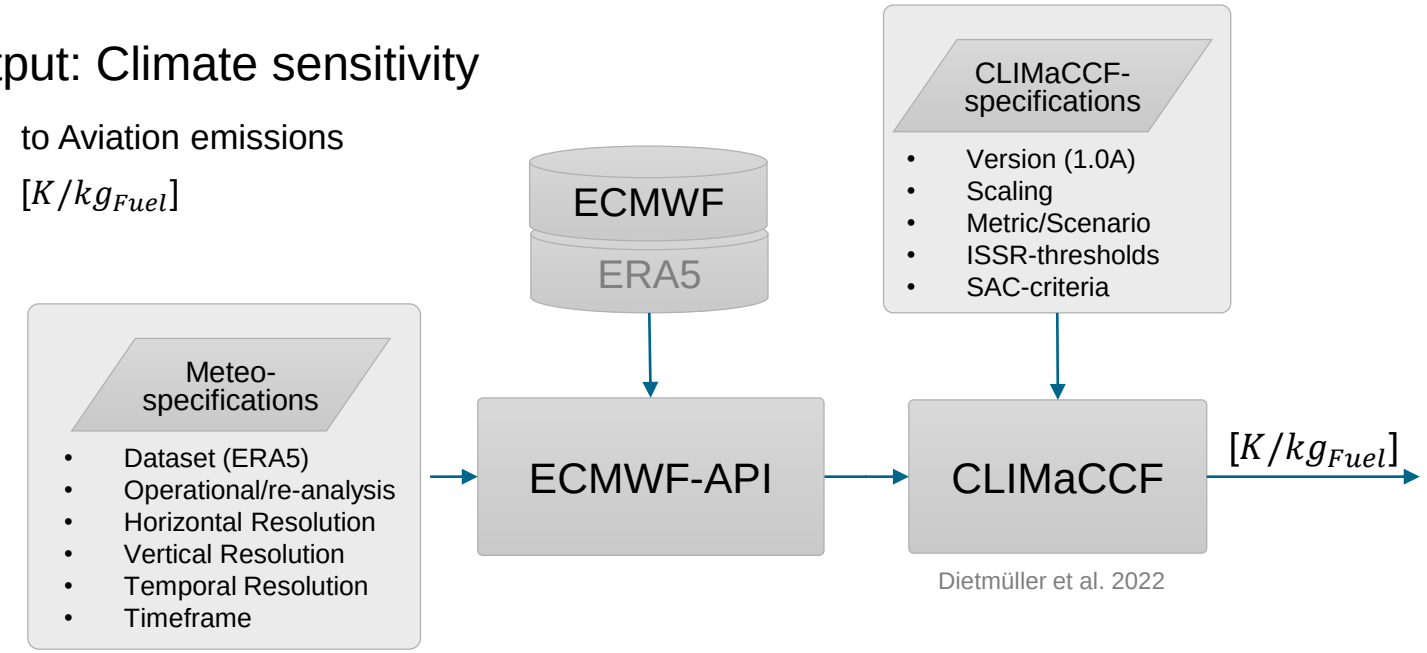
- Statistical method for estimation of CO_2 and non-CO_2 climate impact
- Fast computation
- Based on spatially and temporally resolved atmospheric information
- Estimate aviation's climate impact in terms of future near-surface temperature change



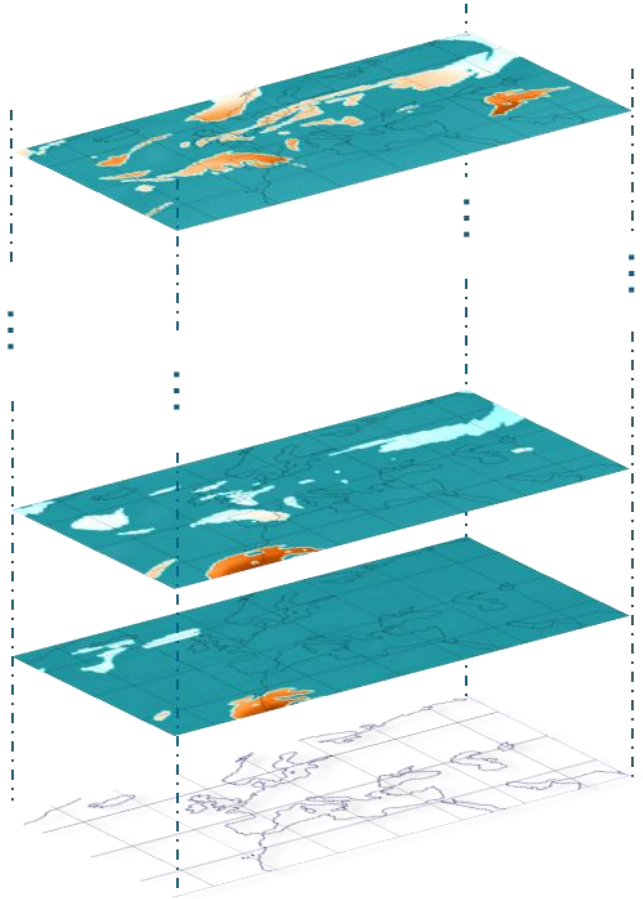
Climate Impact & Atmospheric conditions

CLIMaCCF

- Open Source python library
- Input: Atmospheric data (T,Rhi,PV,OLR…)
  - ECAC Airspace
  - Time scope: 5 years (2018-2022)
  - Every other day, 3h-resolution
  - 0,25° horizontal resolution, 37 Pressure levels
- Output: Climate sensitivity
  - to Aviation emissions
  - $[K/kg_{Fuel}]$



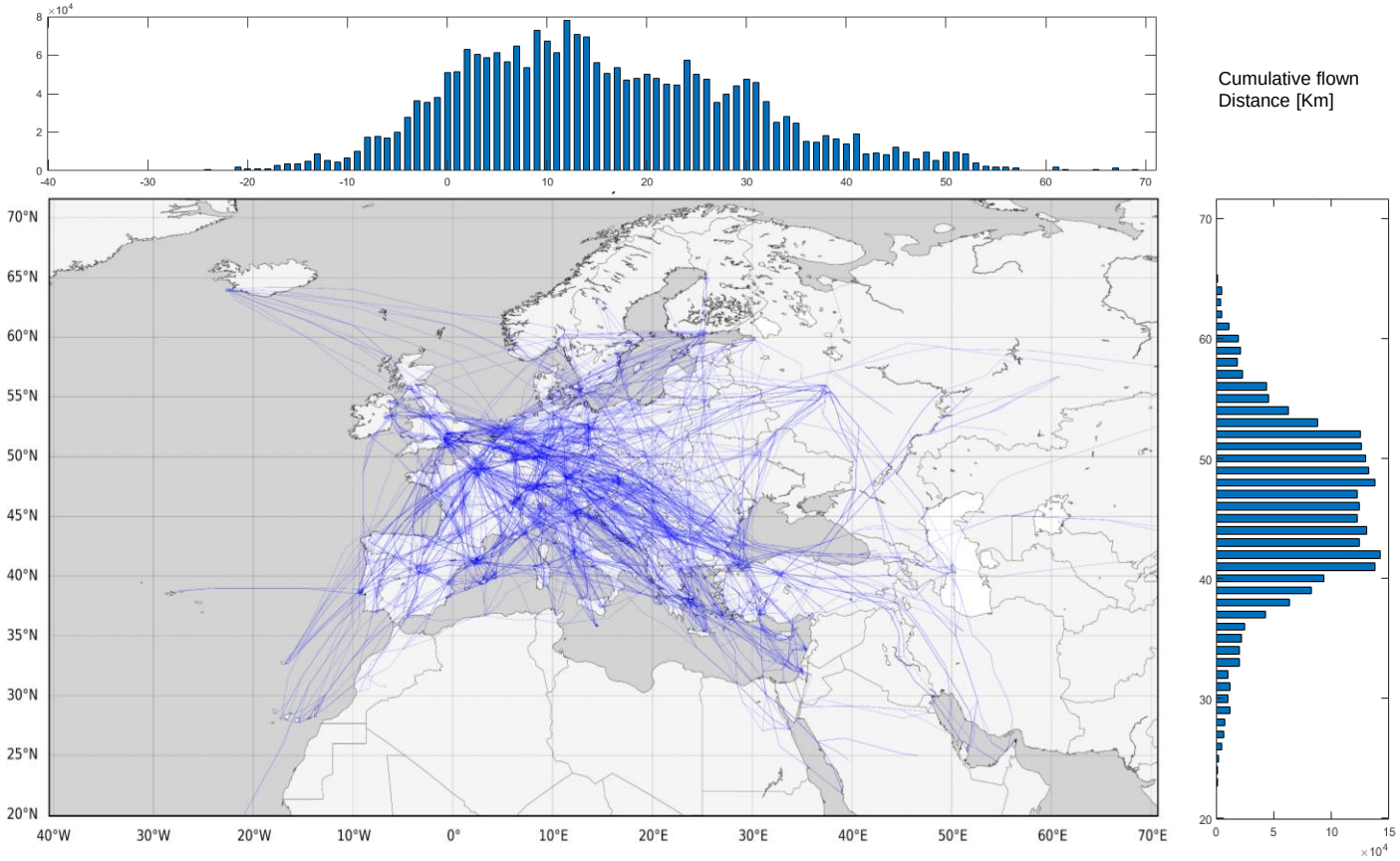
Dietmüller et al. 2022



European Air Traffic

Traffic parameters

- Historical traffic data from 2018 (i.e. post-operational data, EC DDR2, OpenSky ADS-B)
- Spectrum of:
  - mission lengths
  - cruise altitudes
  - AC & Engine-types
  - departure times
- Strong seasonal cycle
  - daily and weekly variation

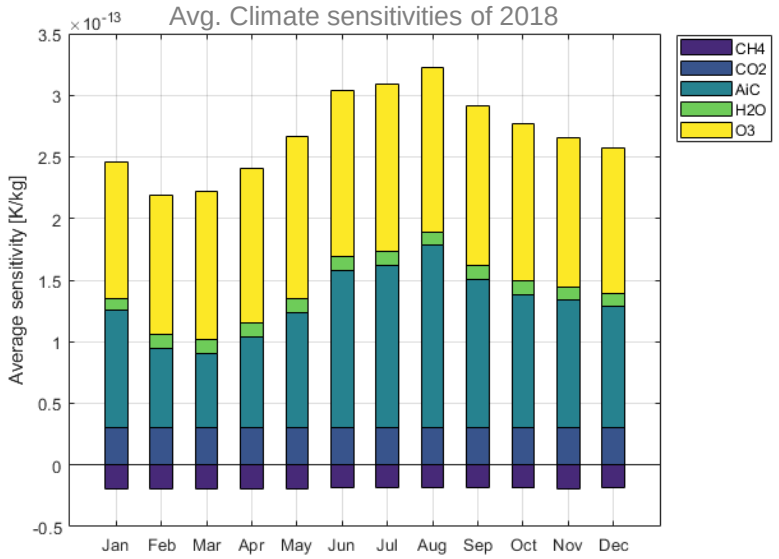


European Air Traffic & Climate Impact

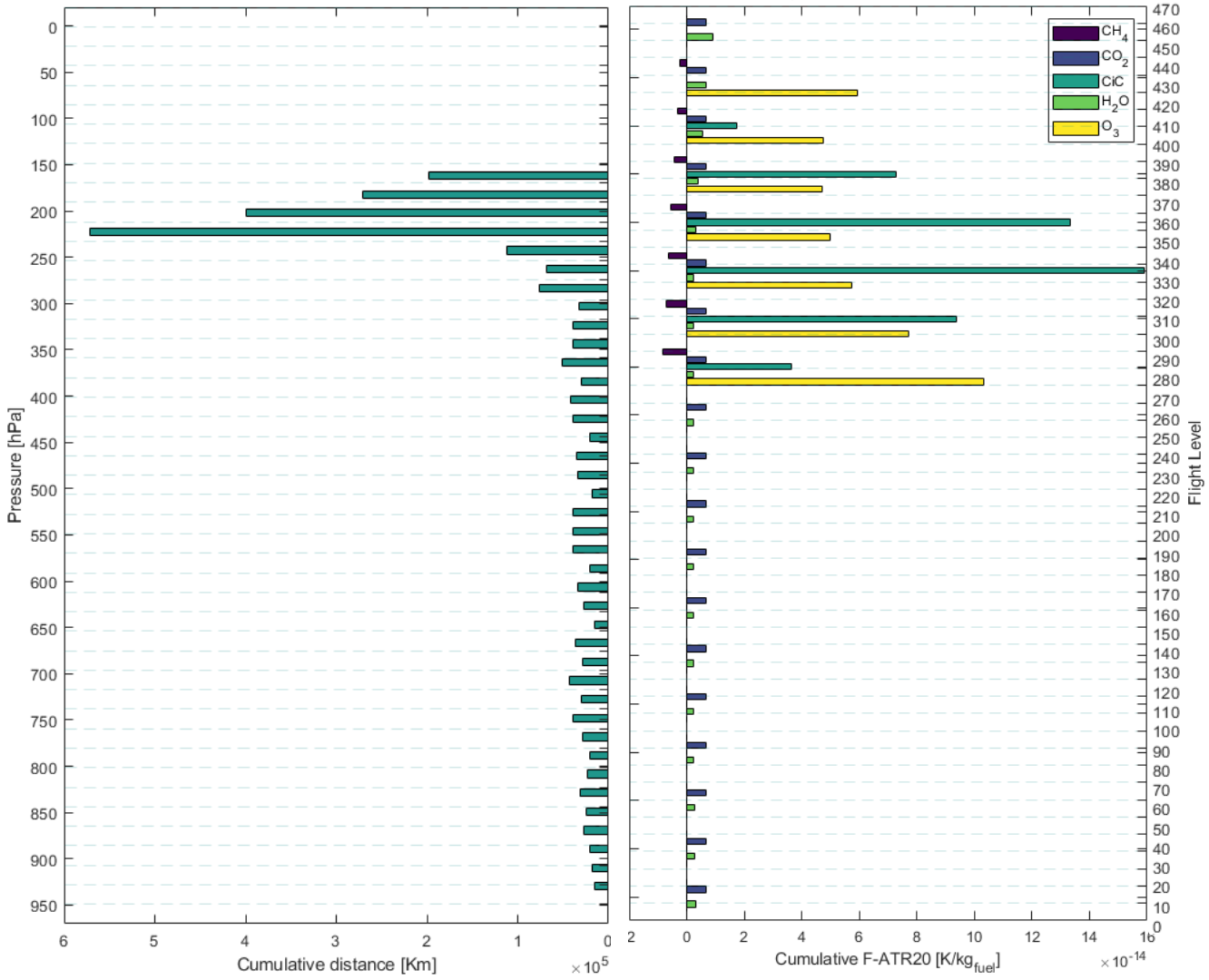
preliminary

Preliminary example: A320 fleet

- Based on real traffic data from OpenSky (ADS-B) 2018
- Vertical dimension (Flight Levels)
- Temporal dimension (seasonal cycle)



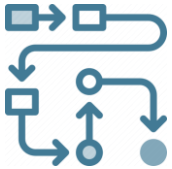
Yearly evaluation of average climate sensitivity per emission species for ECAC-airspace based on single-aisle aircraft emission characteristics



Summary and Outlook

- Dataset computed to evaluate climate impact sensitivity (as a function of location, time and atmospheric conditions) based on a large set of atmospheric data

- Proposed methodology to assess strategic mitigation measures on network-level evaluating mitigation potential in terms of ATR



- Next steps**:**
  - Further analysis of dataset to investigate dependency of mitigation potentials on spatial and temporal effects
  - Evaluation of areas highly sensitive to aviation emissions and correlation with current traffic flows
  - Derive strategic measures on network level based on previous evaluation
  - Verify results with existing studies

Thank you for your attention!

Making aviation environmentally sustainable

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ECATS International Association

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