DKRZ- project 781
REACT4C – Reducing Emissions from Aviation by Changing Trajectories for the benefit of Climate

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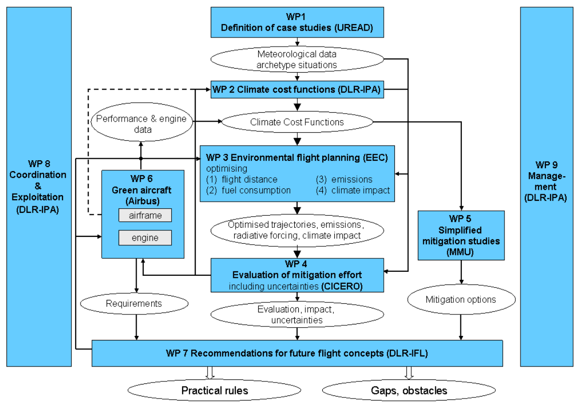
EU FP7 Project REACT4C

The main objectives of the collaborative project REACT4C (Reducing Emissions from Aviation by Changing Trajectories for the benefit of Climate) are:

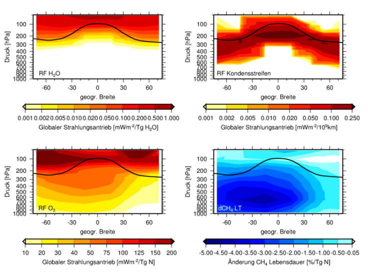
- to calculate 4-dimensional-climate-cost-functions for typical weather patterns
- to explore the feasibility of climate optimized flight altitudes and flight routes
- to expand current operational flight planning tools to account for environmental effects via cost functions
- to estimate the overall global effect of such ATM measures in terms of climate change
- to derive practical rules for an environmentally friendly flight planning
- to develop concepts of future (green) aircraft adapted and optimized for the new environmentally compatible flight routing
- to estimate the mitigation gain of such aircraft in terms of environmental and climatic impact
- to disseminate the results to stakeholders in the aviation sector, science community and general public

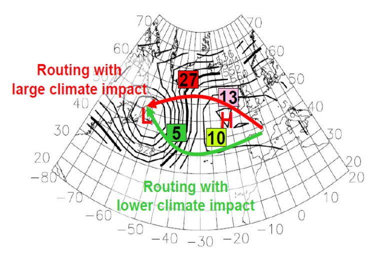
Overall project structure



Climate cost functions and climate optimized routing

- The aviation climate impact depends on latitude, altitude and the actual weather situation
- Climate cost functions are a measure for climate impact of individual aviation emissions in dependency of the emission location, emission altitude, emission time and weather during emission
- Climate cost functions represent the basis for climate-optimized routing
- Aviation impacts investigated: O_3, CH_4 + PMO, contrails, H_2O, CO_2
- Climate optimized routes should avoid regions which are sensitive to aviation emissions

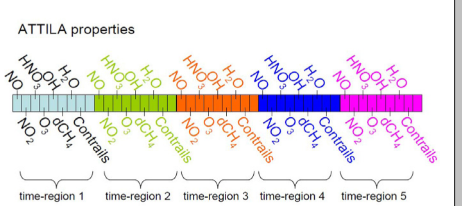




EMAC/AIRTRAC submodel for calculating climate cost

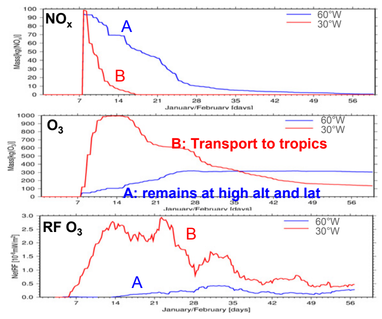
EMAC/ATTILA:
- Chemistry-climate model with state of the art atmospheric-chemistry and Lagrangian tracer transport

AIRTRAC:
- emissions placed directly on trajectories
- different time-regions in North Atlantic flight corridor
- 50 trajectories started in each time-region + background trajectories
- every trajectory has information on all species and related prod and loss terms



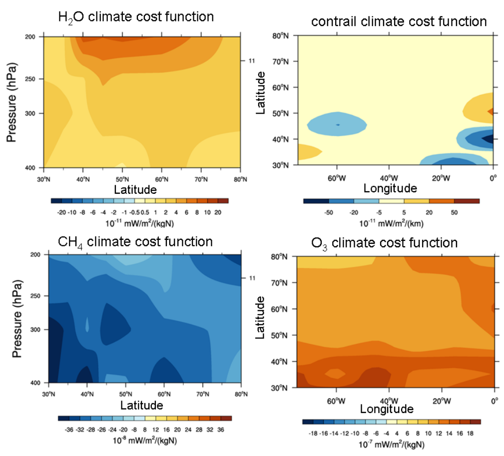
O_3 and O_3 RF for two different emission locations for weather pattern "strong zonal jet"

- Transport of NO_x to tropics and mid and lower troposphere → larger O_3 production efficiency
- RF not only depends on magnitude, but also on location and altitude
- Ozone perturbation in tropics and in tropopause height → larger specific radiative impact



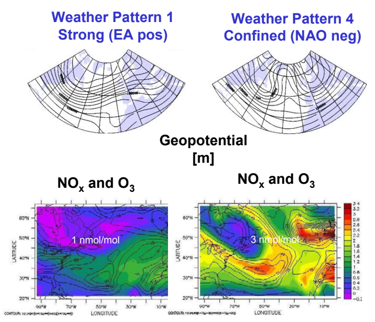
Examples of climate cost functions

- O_3 and H_2O RF increase with altitude
- CH_4 and PMO RF negative; largest neg. RF in tropical mid troposphere
- O_3 und CH_4 RF anti-correlated
- Contrail RF shows strong local variations; RF can be both positive and negative
- O_3 and H_2O RF increase towards tropics



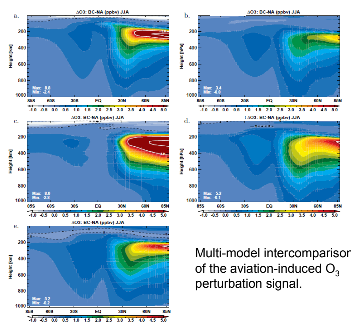
Weather pattern related aviation perturbation signal

- In the North Atlantic Flight Corridor prevailing synoptic patterns can be categorized into typical weather patterns using EA and NAO indices
- Such atmospheric patterns influence the way in which aviation emissions change the atmospheric concentration and hence their climate impact
- Within a QCTM simulation of EMAC2 an analysis of typical weather patterns and the corresponding aviation perturbation signal was performed
- Two typical weather patterns for winter are shown: the strong zonal jet (WP1) and the confined jet (WP4)
- The aviation perturbation signal in NO_x and O_3 varies by a factor of three between individual weather patterns
- The objective is to derive generalized recommendations for climate-optimal, weather-dependent aircraft routing



Multi-model comparison of aviation-induced ozone

- Within the REACT4C-Consortium a coordinated multi-model comparison of aviation-induced perturbation signals is performed
- The objective is to provide a multi-model estimate of aviation-induced climate impact for two simplified mitigation scenarios ("flying higher" and "flying lower")
- The coordinated modelling initiative allows to estimate associated uncertainties related to model representations of governing processes
- The estimates of the aviation signal are derived by means of the perturbation approach
- MOZART-3, EMAC-2 (QCTM), ULAQ, Oslo CTM-2&3 are used
- The overall climate impact is calculated with different modeling approaches in order to determine the related uncertainty
- The aviation short-term ozone radiative forcing ranges between 16-23 mW/m²



Multi-model intercomparison of the aviation-induced O_3 perturbation signal.

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