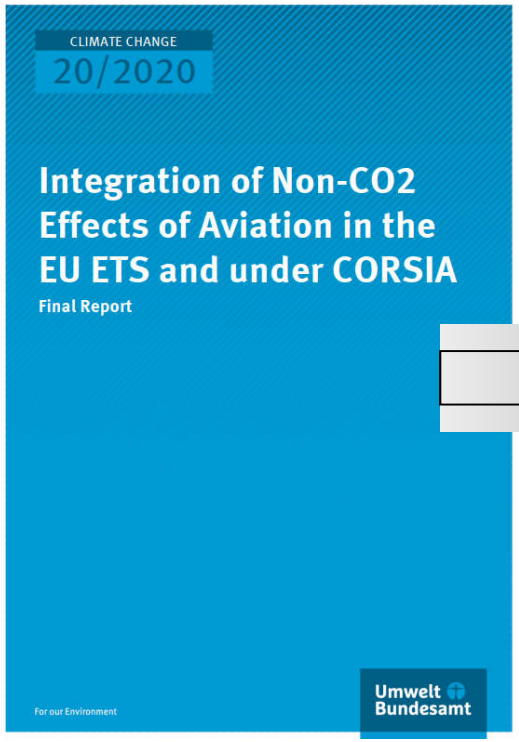
Testing of a Monitoring Reporting & Verification (MRV) Scheme for non-CO_2 aviation effects

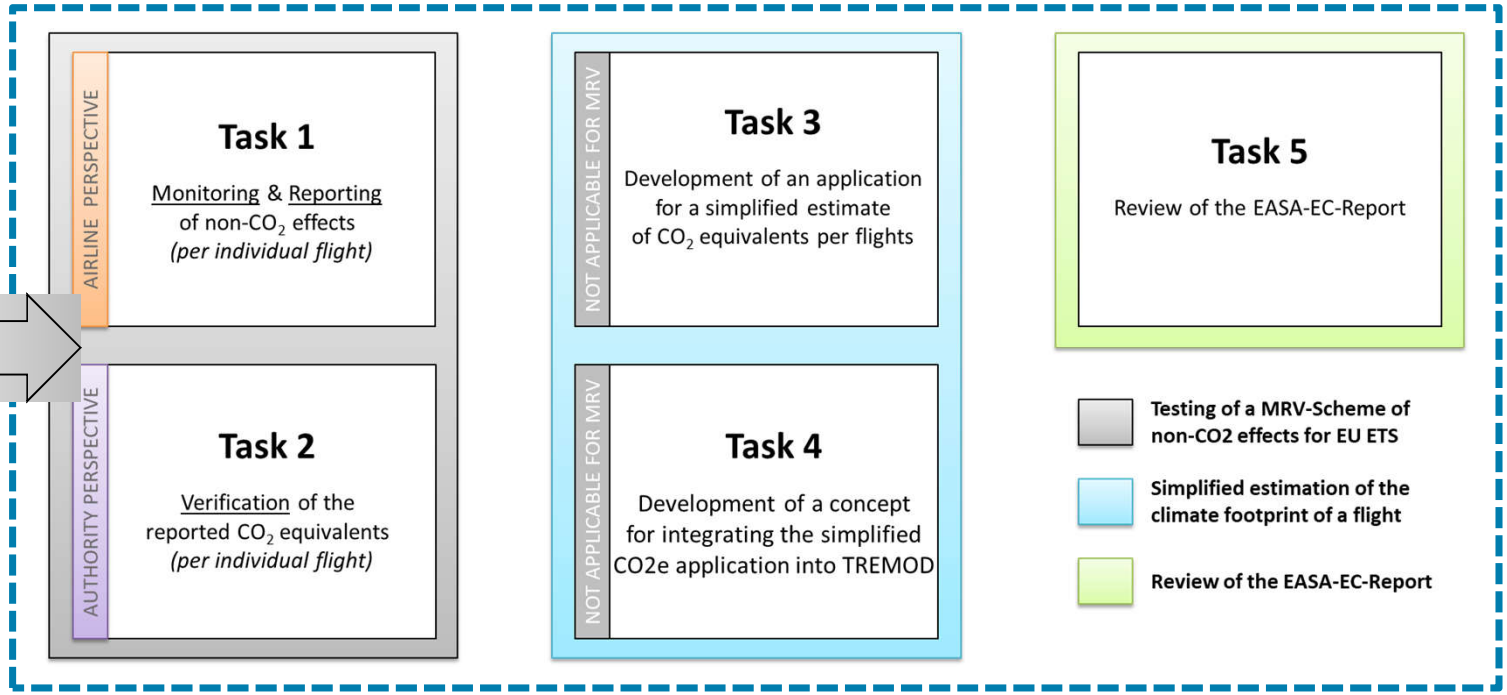
On behalf of the German Environment Agency
FKZ 3720 42 502 0
2020 - 2023

K. Dahlmann, M. Niklaß, V. Grewe
F. Linke, S. Maertens, S. Matthes, M. Plohr,
J. Scheelhaase, F. Wozny

DLR

Overview of current project activities

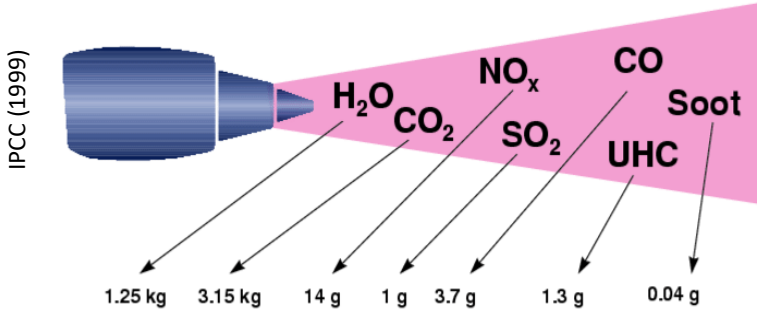




Niklaß et al., 2020

We focus our presentation on charts 6-8, 11, 13, 17-20.

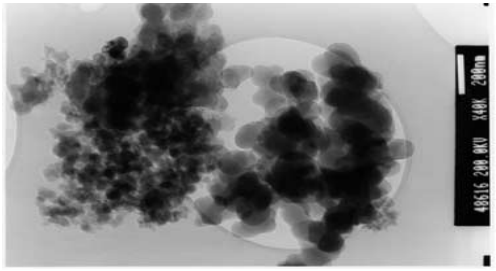
Climate Effects of Aviation Emissions



Direct greenhouse gases

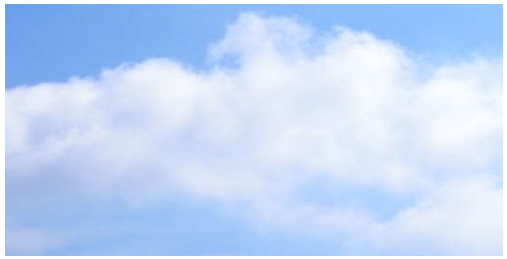
Indirect greenhouse gas chemistry

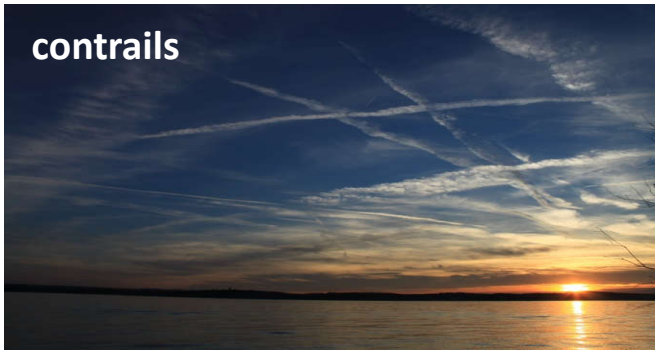
Direct aerosol effect



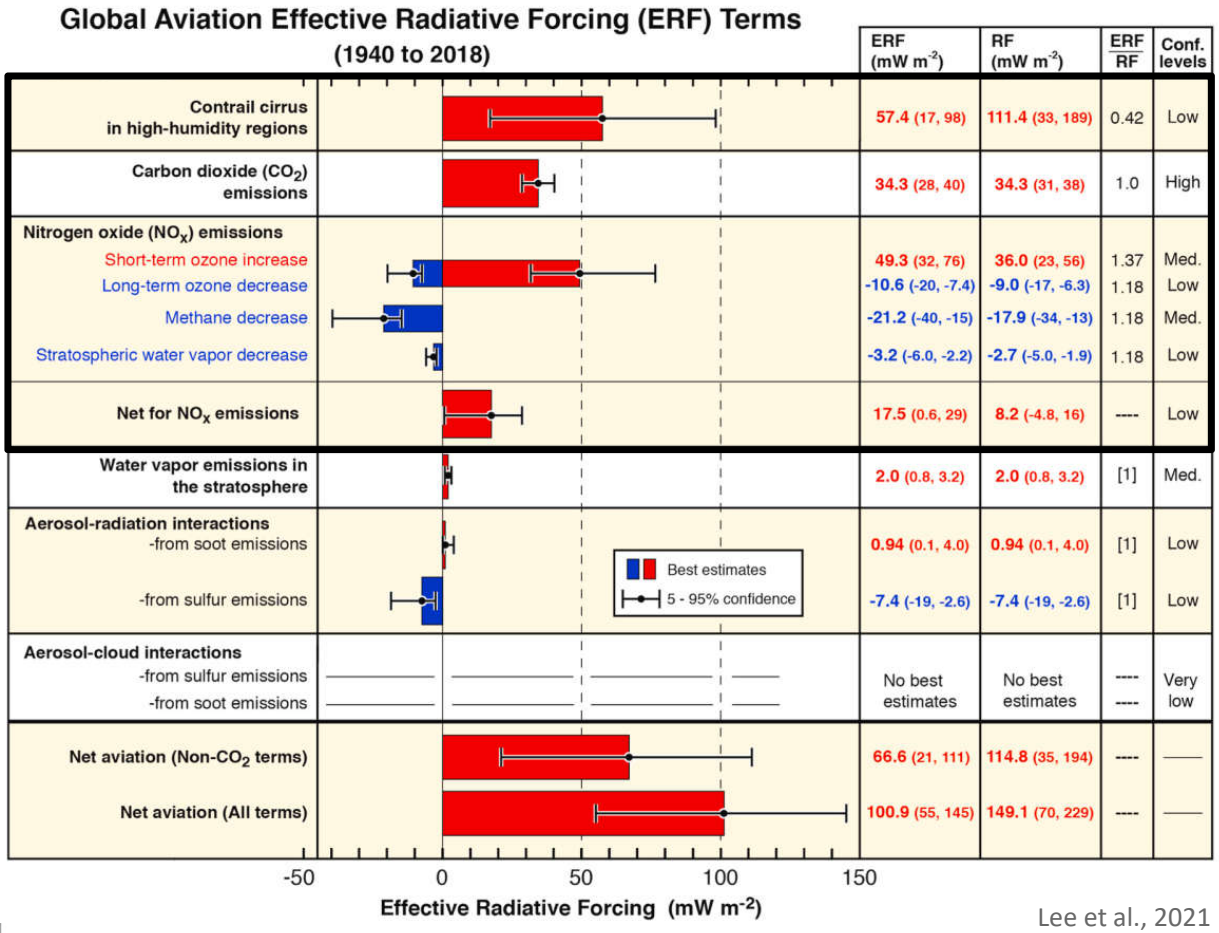
Popovicheva et al. (2004)

Aerosol effects on clouds





Effective Radiative Forcing in 2018 caused by historical air traffic emissions



Lee et al., 2021

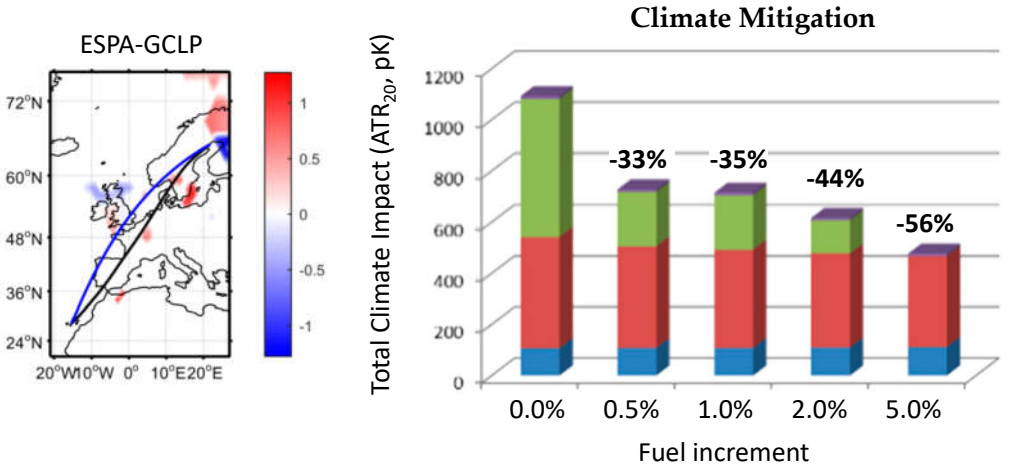
CO_2, NO_x and contrails cirrus are major contributors to aviation ERF

Individual contributions to total climate impact of alternative routings

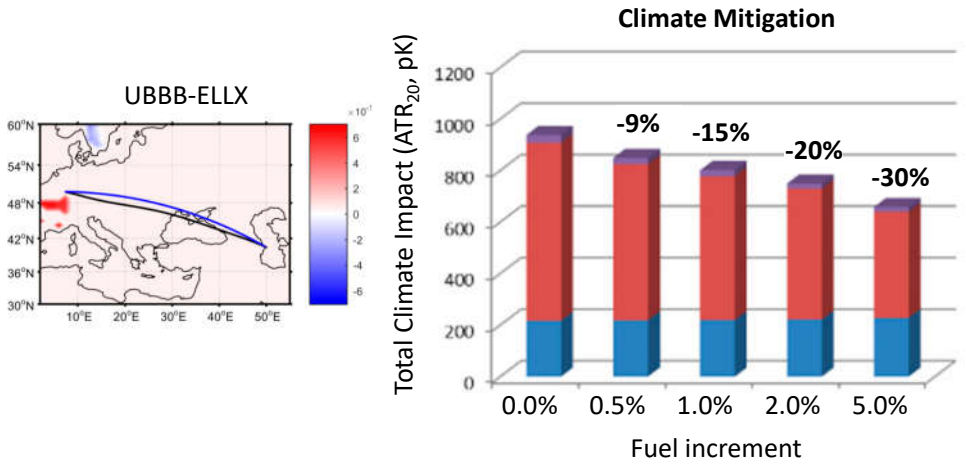
One Day Case Study of European Air Traffic on 18 December 2015

Matthes et al., 2020

Example 1: Lulea – Gran Canaria (ESPA-GCLP)
Contrails-dominated climate impact



Example 2: Baku – Luxembourg (UBBB-ELLX)
NO_x-dominated climate impact (no contrails)



- **Climate-optimised routings can mitigate the total climate impact significantly**
- **The total climate impact of a flight can decrease despite increasing emissions** (e.g. -35% ATR_{20} for +1% fuel increase)
- **Climate-optimised routings might not be cost-optimal** (need for market-based / policy measures)

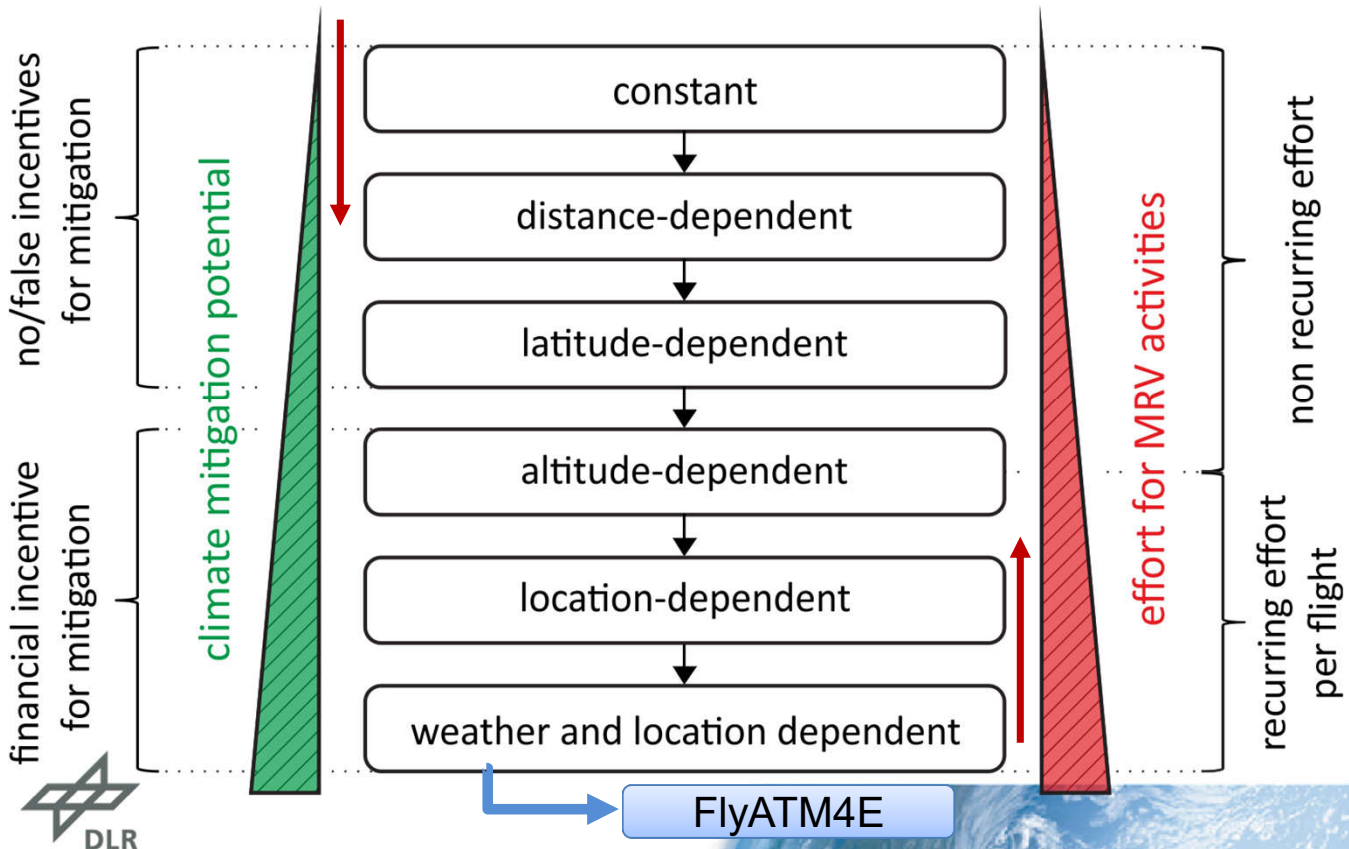
H_2O
AIC
NO_x
CO_2

Results from ATM4E

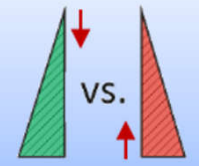
Need for market-based / policy measures

Various options for integrating non-CO_2 effects of aviation into EU ETS and under CORSIA

Integration based on CO_2 equivalents (CO2e)



Choosing a CO2e method is a trade-off between high climate mitigation incentives and low efforts for MRV activities.



Key criteria for selecting a CO2e method

- CO2e factors must provide an incentive for mitigating non-CO_2 effects
- CO2e factors should be easy to calculate, predictable and transparent

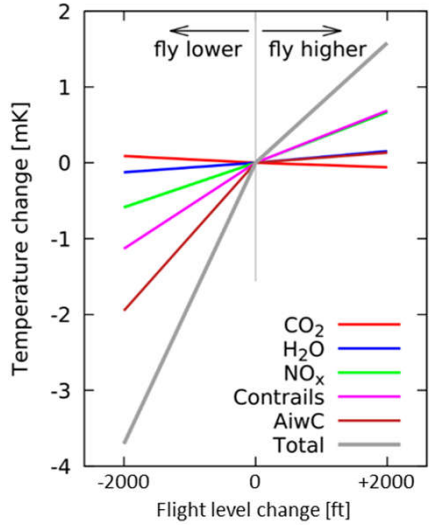
MRV: Monitoring, Reporting & Verification

Niklaß et al., 2020

Recommendation for CO_2 equivalent calculations, representing the non-CO_2 aviation effects

Not recommended

- **Simple CO2e factors** (constant, distance- or latitude-dependent)
  … further increase the focus on CO_2 reduction
  … might create false incentives *(incentive to fly higher rather than lower)*
  … "penalize" climate-optimised routings *(due to the increased fuel burn)*
  Potential applications: Estimation of the ecological footprint

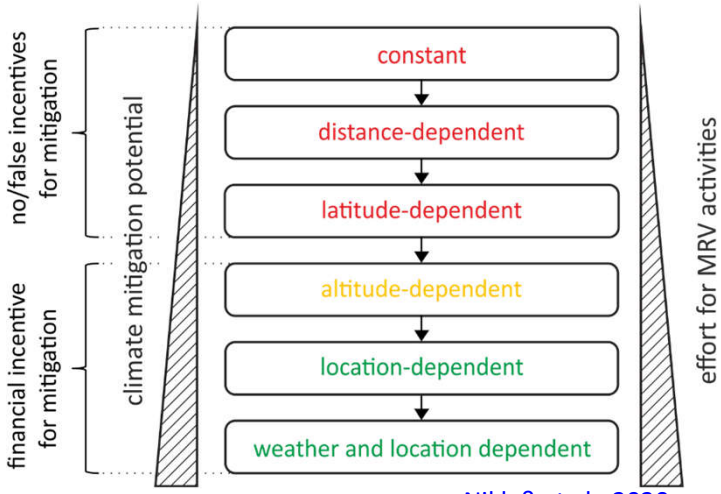


Matthes et al., 2021

Recommended

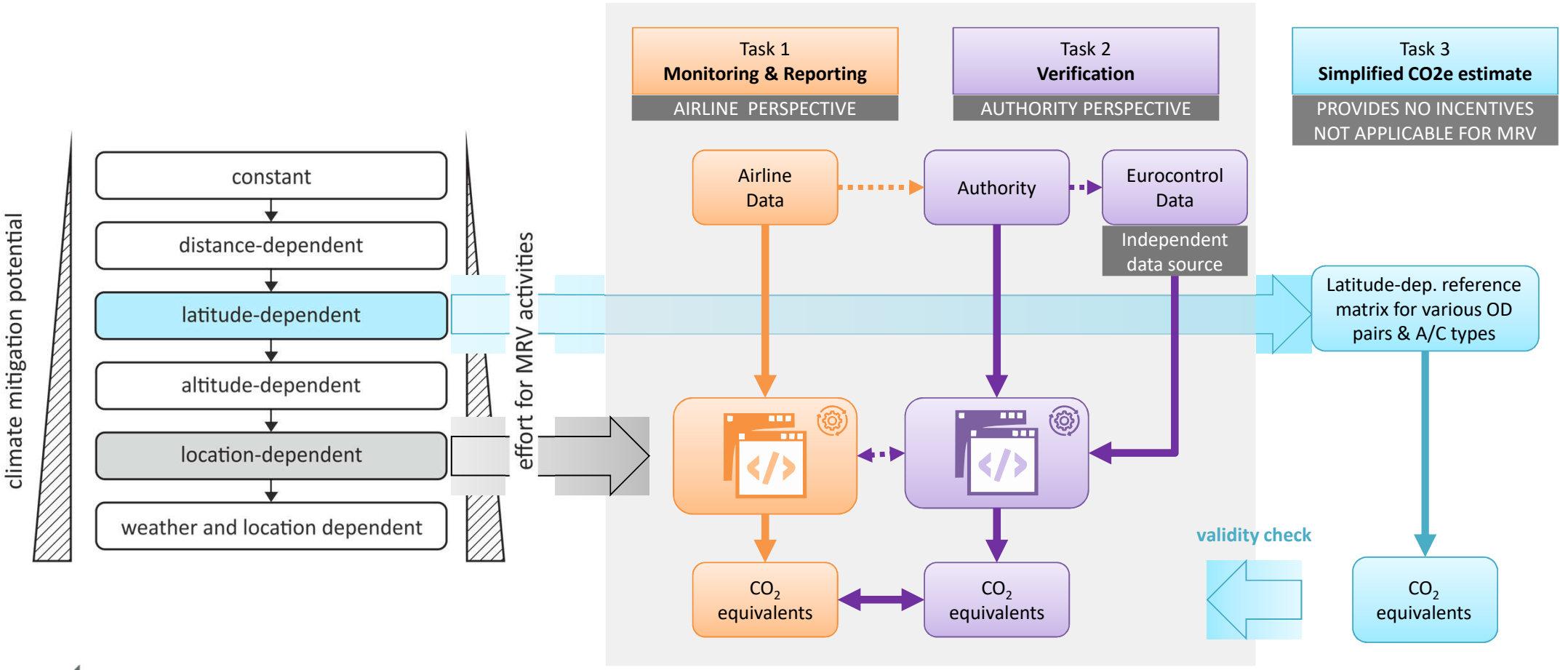
→ **More comprehensive CO2e factors** (altitude-, location- or weather-dependent) **needed to incentivize mitigation of non-CO_2 impacts**

- MRV effort could be reduced and transparency enhanced by using a public reference matrix with CO2e estimates for various
  … airport pairs and flight paths
  … aircraft and engine types
  … weather situations
- CO2e estimates must be assumed conservatively:
  Aircraft operators must not be better off with CO2e estimates

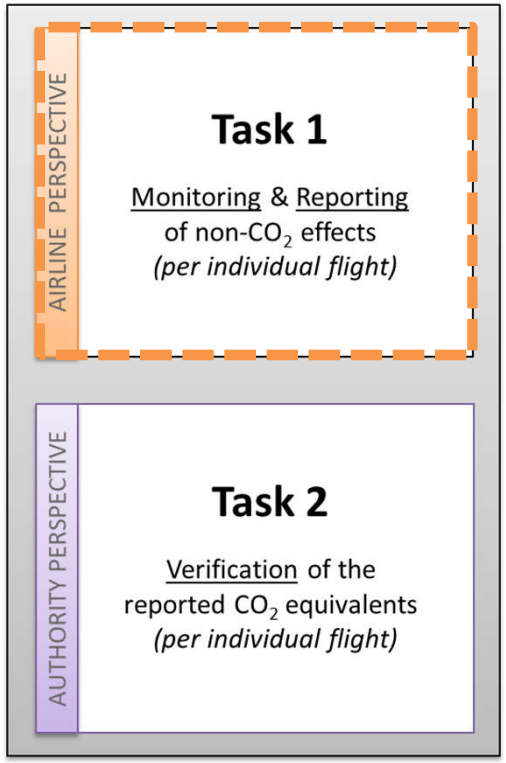


Niklaß et al., 2020

Project interfaces between Tasks 1, 2 & 3



Task 1: Monitoring and reporting of non-CO_2 effects



Objective of task 1:

Testing the steps to be performed by an aircraft operator to monitor and report CO_2 equivalents in the EU ETS **("airline perspective")**

Airline Data → What is the minimum data that must be reported to the authority?

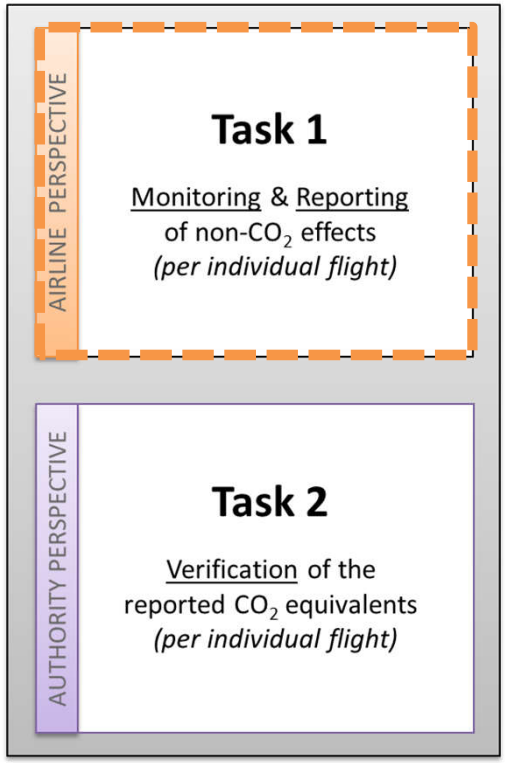
- Which data has to monitored during flight?
- Which data is available and recorded?
- How to deal with data gaps?

1. Evaluation of emission indices for relevant species (CO_2, H_2O, NO_x) along the flown flight profile
2. Calculation of CO_2 equivalents per flight

CO_2 equivalents

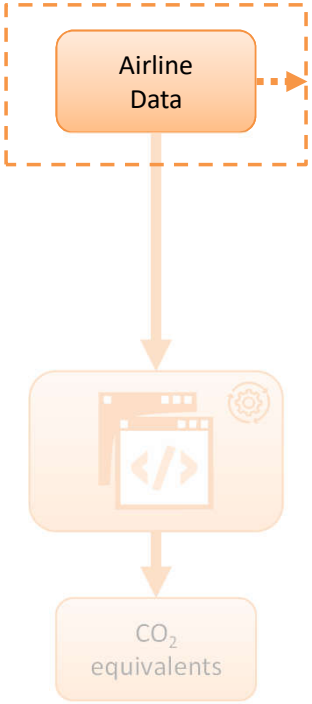
- How can these activities be structured and automated?
- What level of effort is required?
- Are there any legal issues?

Task 1: Monitoring and reporting of non-CO_2 effects



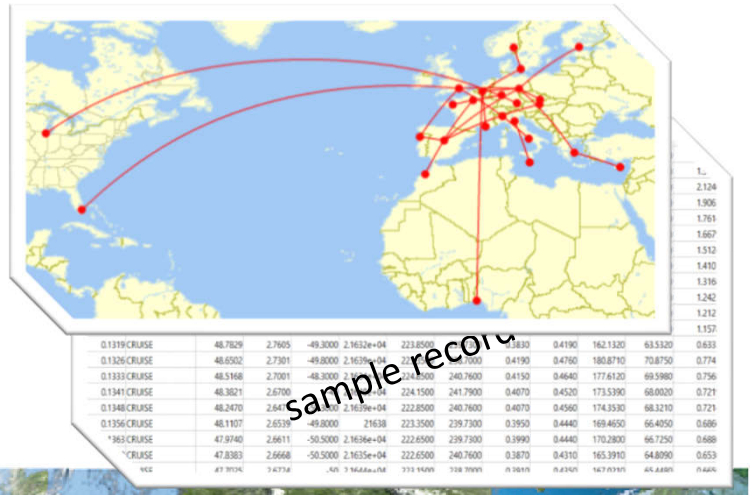
Objective of task 1:

Testing the steps to be performed by an aircraft operator to monitor and report CO_2 equivalents in the EU ETS **("airline perspective")**



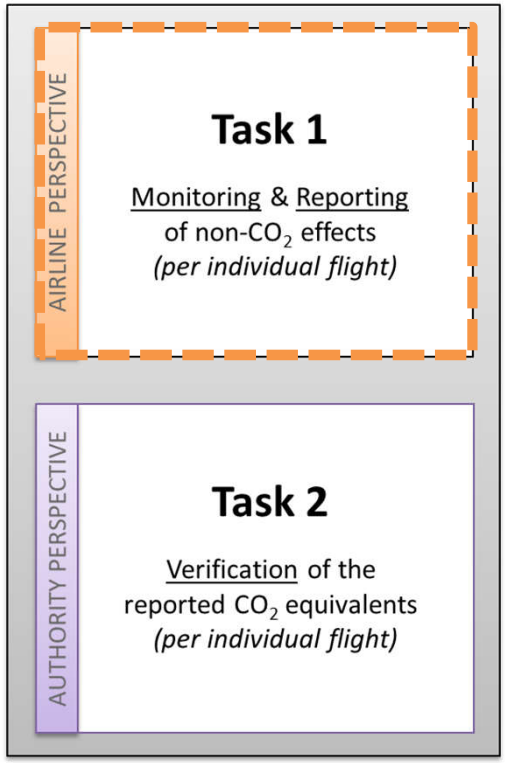
Evaluation of flight and fuel data of an European airline:

- European Air Transport Leipzig
  - German cargo airline owned by Deutsche Post
  - Main hub at Leipzig/Halle Airport
  - Providing flight and fuel data of approx. 30 short and medium/long haul flights
- Most frequent aircraft types:
  - Airbus A300-600RF
  - Boeing 757-200PCF
- Route network within the project:
  - Intra-European Routes: 19
  - North-Atlantic Routes: 2
- Reference route:
  - Madrid (MAD) – Leipzig (LEJ)
  - Frequency: approx. 10 flights



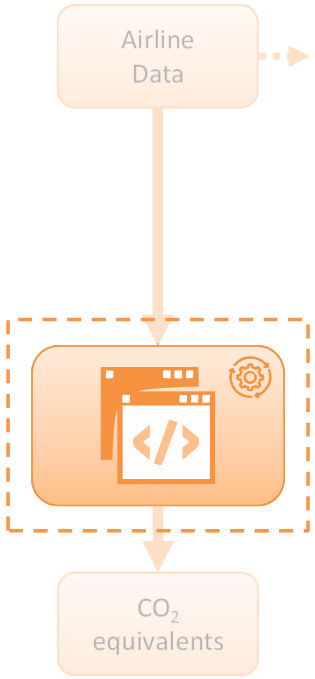
DLR

Task 1: Monitoring and reporting of non-CO_2 effects



Objective of task 1:

Testing the steps to be performed by an aircraft operator to monitor and report CO_2 equivalents in the EU ETS **("airline perspective")**

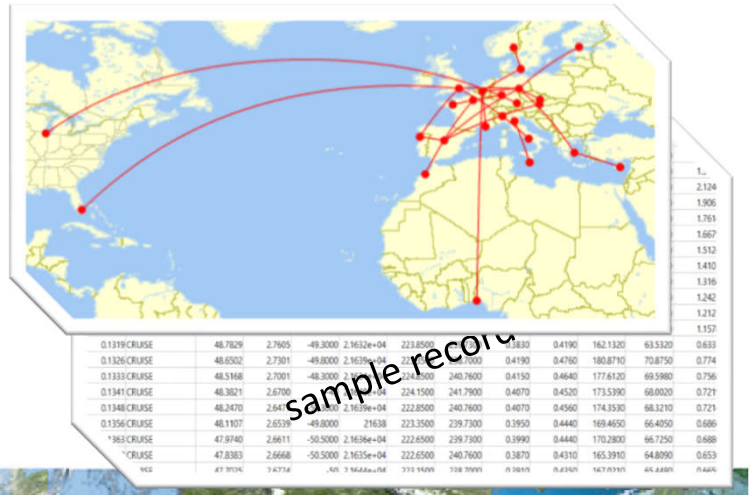


1. NO_x Emissions Calculation Procedure based on Boeing Fuel Flow Method 2:

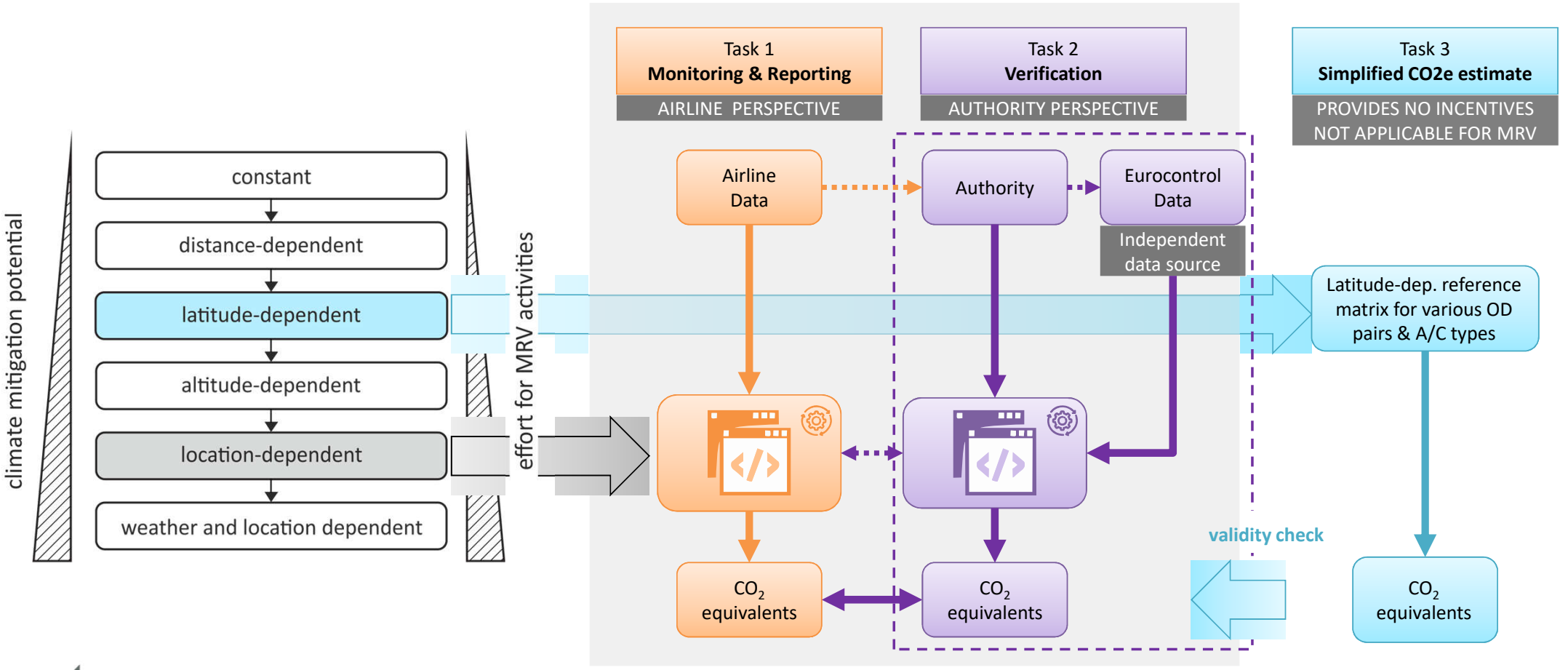
- 4 Step calculation procedure can be completely automated
- Data Source: ICAO Engine Exhaust Emissions Databank (EDB)
  Fuel flow and emission indices for 4 engine operating conditions:
  100%, 85%, 30%, 7% of max. rated thrust
- Required fuel flow data is directly recorded by aircraft/operator

2. Calculation of CO2e per flight :

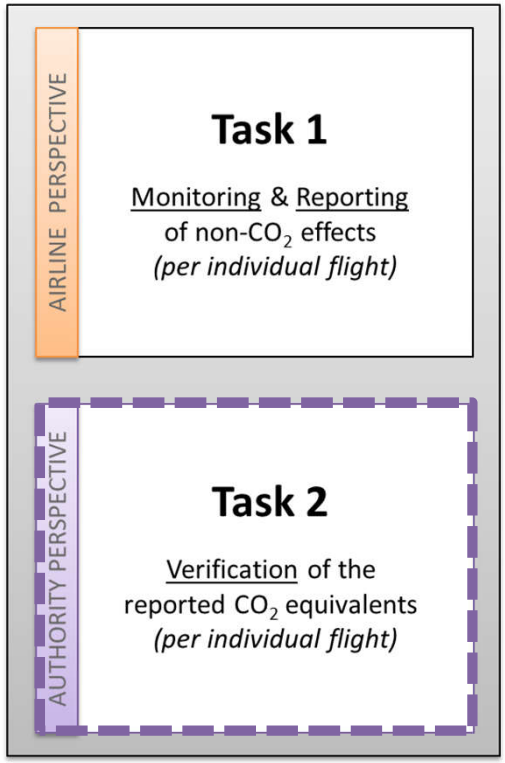
- Climate-response calculation based on *AirClim* (climatological mean data)
- Requires flight profile and emission inventory of CO_2, H_2O, NO_x
- Procedure can be automated but no public version available
- Open Source software of *AirClim* under development



Project interfaces between Tasks 1, 2 & 3

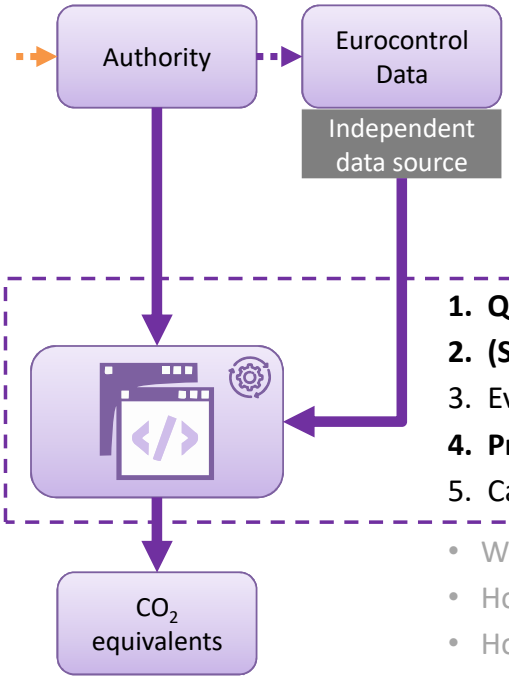


Task 2: Verification of non-CO_2 effects



Objective of task 2:

Testing the steps to be performed by a reviewing authority to verify reported CO2e in the EU ETS **("authority perspective")**

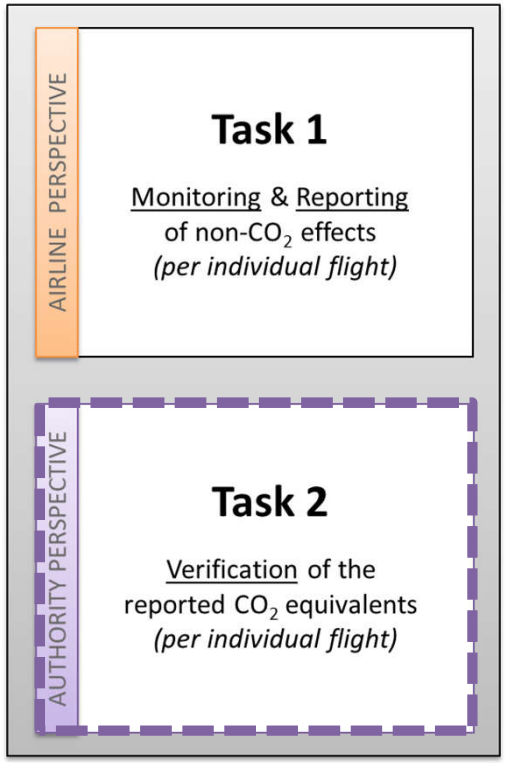


Which independent data sources can be used to verify reported CO2 equivalents?

1. **Query of relevant flight plan data**
2. **(Simplified) fuel flow estimation along the trajectory**
3. Evaluation of emission indices for relevant species (CO_2, H_2O, NO_x)
4. **Projection of aircraft emission along the flown flight profile**
5. Calculation of CO_2 equivalents per flight

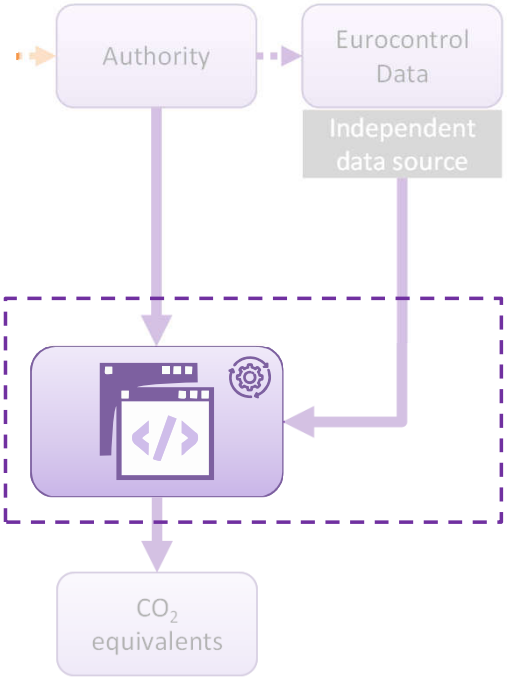
- What level of effort is required?
- How accurate is the verification process?
- How can these activities be structured and automated?
- Are there any legal issues?

Task 2: Verification of non-CO_2 effects



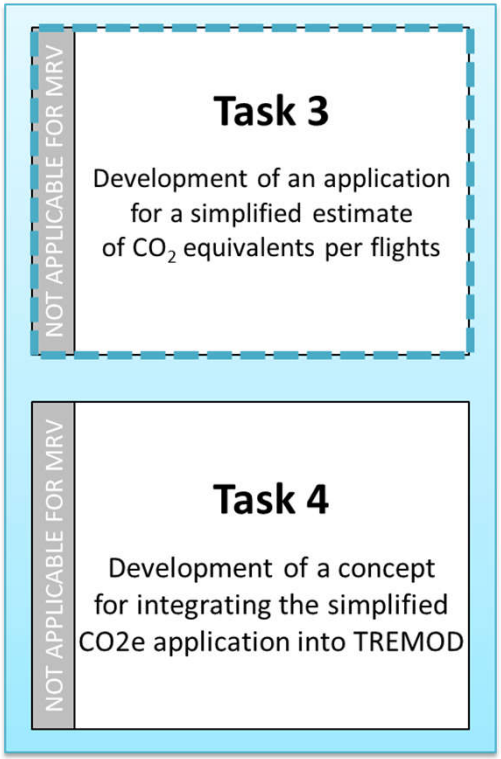
Objective of task 2:

Testing the steps to be performed by a reviewing authority to verify reported CO2e in the EU ETS **("authority perspective")**



1. **Query of relevant flight plan data** (here: Eurocontrol DDR2 m3 data, if available)
   - Processing of flight data according to the required granularity
   - Procedure can be completely automated
2. **(Simplified) fuel flow estimation along the trajectory:**
   - Calculation performed with varying simplifications (incl./excl. wind data, detailed A/C performance vs. regressions, etc.)
   - Automation depending on the procedure
3. **NO_x Emissions Calculation Procedure based on Boeing FF Method 2**
4. **Projection of aircraft emission along the flown flight profile**
   Procedure can be fully automated
5. **Calculation of CO_2 equivalents per flight**
   (Step 3 & 5 analogous to Task 1: Procedures can be completely automated)

Task 3: Application for a simplified estimate of CO_2 equivalents



Objective of task 3:

- Provide a simplified calculation methodology for estimating the total ecological footprint *(CO_2 & non-CO_2 effects)* of a flight
- Simplified CO2e estimate should be based only on data, which are already used by UBA for CO_2 calculation, like airport location and aircraft type

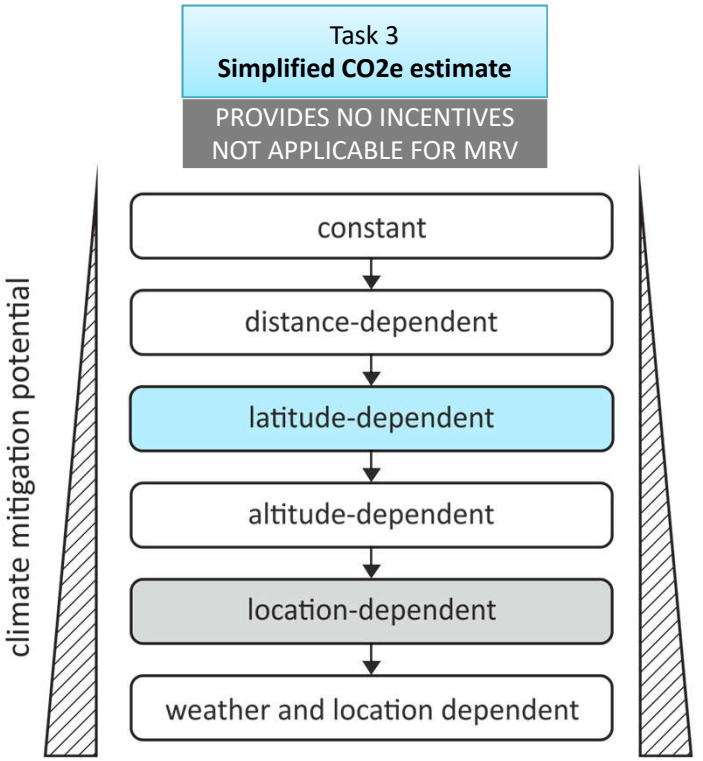
Note:

Simplified CO2e estimates should not be used for a MRV scheme as they …

… further increase the focus on CO_2 reduction

… might create false incentives
(incentive to fly higher rather than lower)

… "penalize" climate-cost-efficient routings
(due to the increased fuel burn)



Task 5: Review of the EASA-EC-Report

Task 5

Review of the EASA-EC-Report

1. Aviation Non-CO_2 Impacts – Current status of science and remaining uncertainties

- Comprehensive and thoughtful status of the current understanding of the atmospheric impacts of aviation emissions.
- A large part of the summary is based on the findings in Lee et al. (2021) and for net NOx-RF on Skowron et al. (2021) and rounds it off by addressing other recent literature, leading to the more general conclusion that **"the largest of these effects are the forcing from the current-day net NO_x effect and contrail cirrus."**
- Discussion on **uncertainties is in general largely supported**

2. Technological and Operational factors for limiting or reducing non-CO_2 impacts from aviation and related trade-off issues

- Summarises in more detail the knowledge on non-CO_2 emissions.
- Trade-offs are discussed for e.g. CO_2 and NO_x emissions

3. What research has been undertaken on potential policy action to reduce non-CO_2 climate impacts?

- EC-Report provides a comprehensive and broad analysis of possible measures for the limitation of aviation's non-CO_2 effects
- This selection comprises most types of potential policy measures suitable for the reduction of air transport's climate relevant species.

Task 5: Review of the EASA-EC-Report

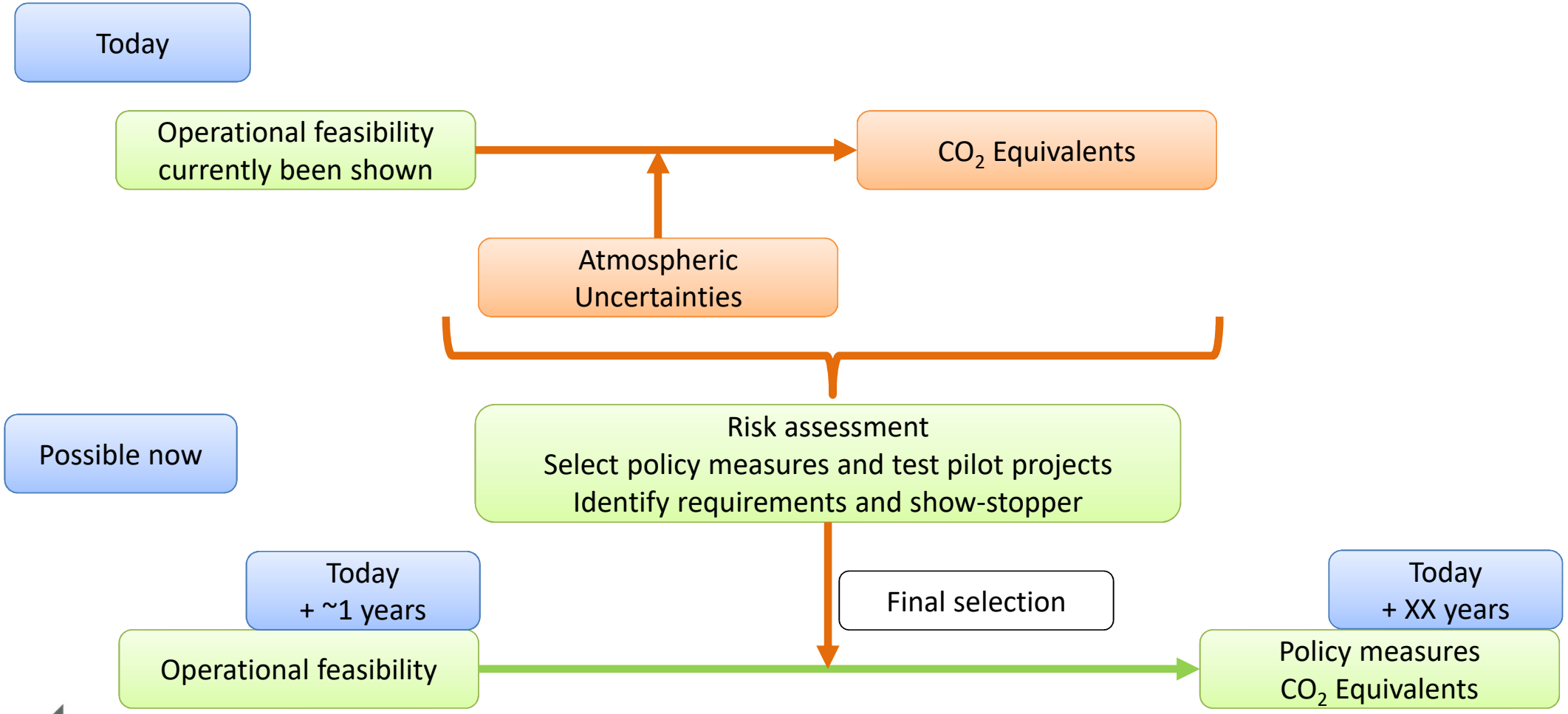
Task 5

Review of the EASA-EC-Report

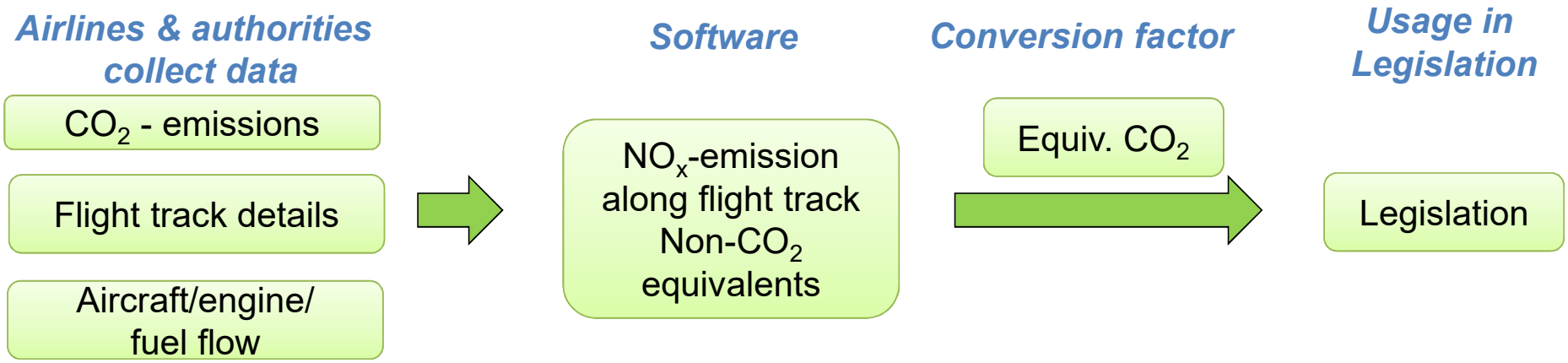
EASA Report	DLR Review
Uncertainties	Risk Assessment
Climate Metrics = User Choice	Discuss possible Climate Objectives and deduced climate metrics
Differences in Climate Metrics	Requirements for Climate Metrics
Static Trade-offs depending on references	Win-Win situations for combined options
Tentative discussion of measures and lack of economic assessment	1) Select promising measures 2) Analyse economic impact 3) Conduct pilot projects

DLR

Feasibility of the implementation of non-CO_2 aviation effects in policy measures



Roadmap: Some possible steps forward



1. **Uncertainties**: Make use of uncertainties in calculation of equivalent CO_2
2. **Transition**: Stepwise implementation of CO2e accounting (20%, 40%, 60%, … at different years)
3. **Inclusion of uncertainties**: CO2e accouting for confidence intervals for each species individually (e.g. only 20%, 40%, 60%, 80% depending on uncertainties)
4. **Planning reliability:** No surprises (e.g. based on weather forecast or hindcast)

Summary

Aviation climate effects

- CO_2 and non-CO_2 are important contributors to aviation's climate impact
- The understanding of non-CO_2 effects has been largely increased
- The nature of non-CO_2 effects, i.e. the dependency on meteorology largely limits reduction in uncertainties

Requirements for non-CO_2 calculation methods

- Should provide incentives for actually reducing non-CO_2 effects
  - not a constant factor, but depending on e.g. technology and operations
  - not simply adding costs, but providing the possibility to reduce climate impact and cost of operation

Policy measures and inclusion of non-CO_2 effects by CO_2e calculations

- Several calculation methods for non-CO_2 effects are in principle available, which differ in the degree of detail and are subject to uncertainties related to atmospheric science.
- Effort for operationalization is strongly dependent on the chosen CO_2e approach
- Risk assessment is required to better understand the impact of uncertainties on the calculation of non-CO_2 effects and thereby on the potential of setting wrong incentives
- Operational feasibility currently tested. Monitoring, reporting and verification of non-CO_2 emissions seems to be technically possible.
- Promising measures could be selected now, the economic impact analysed and pilot projects conducted