Concept of Climate-Charged Airspace Areas

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Abstract

- Policy instrument for internalizing non-CO_2 effects of aviation
- To create an incentive for airlines for climate mitigation, a temporary climate charge is imposed for airlines that operate in highly climate sensitive regions
- This concept resolves the trade-off between economic viability and environmental compatibility: Climate impact mitigation of non-CO_2 effects can coincide with cutting costs.
- For climate mitigation, this concept does not require emission monitoring (CO_2, NO_x, etc.) nor the integration of complex non-CO_2 effects into flight planning procedures
- Its implementation is feasible and effective.

Motivation

- Non-CO_2 effects can be effectively mitigated by re-routing flights around highly climate-sensitive areas.
- Climate-optimized re-routing results in slightly increased values of flight time, fuel burn and operating costs, it is more climate-friendly with a reduction of ATR_{20} of up to -60% (Fig. 1) [1-3].

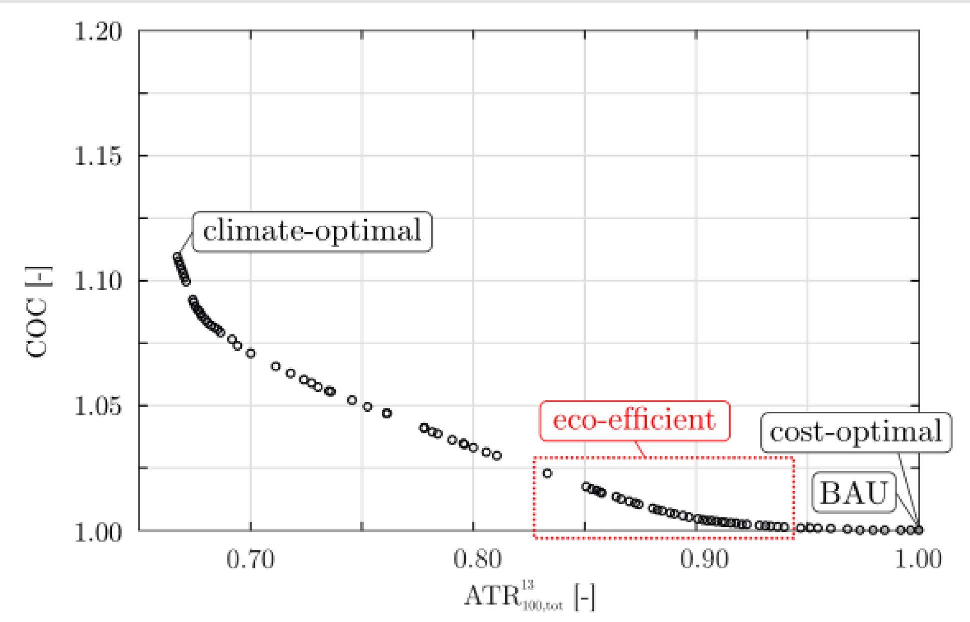

Fig. 1: Mitigation potential (in ATR_{100}) and operating costs (COC) of cost- and climate-optimized flying on the route LIS-MIA.

- However, if mitigation efforts are associated with an increase in costs, questions immediately arise whether passengers are willing to pay for environmental protection and whether airlines are willing to act in a more climate-friendly manner.

Concept

- To create an incentive for climate-optimized flying, a climate charge is imposed on airlines when operating in these areas [4,5].
- An airspace area **x** is levied at a time *t* with an environmental unit charge, U_{cj}, per kilometer flown, d_j, if its climate sensitivity with respect to aircraft emissions (CCF_{tot}) exceeds a specific threshold value (c_{thr}):

$$\mathrm{CCA}_j(\mathbf{x},t) = \begin{cases} U_{cj}, & \text{if } \mathrm{CCF_{tot}}(\mathbf{x},t) \geq c_{\mathrm{thr}} \\ 0, & \text{if } \mathrm{CCF_{tot}}(\mathbf{x},t) < c_{\mathrm{thr}} \end{cases}$$

- If climate-charged airspaces (CCAs) are (partly) bypassed, both climate impact and operating costs of a flight can be reduced: a more climate-friendly routing becomes economically attractive.
- In order to ensure easy planning and verification, resulting climate charges are calculated analogously to en-route and terminal charges:

$$C_{cj} = U_{cj} \cdot \left(\frac{m_{TOW}}{k_1}\right)^{k_2} \cdot I_{ac} \cdot d_j$$

- It is therefore neither necessary to monitor emissions (CO_2, NO_x, etc.) or to integrate complex non-CO_2 effects into flight planning procedures.
- By implementing the *precautionary* and *polluter-pays principles* of environmental economics, key requirements of a sustainable development are introduced into the field of aviation.

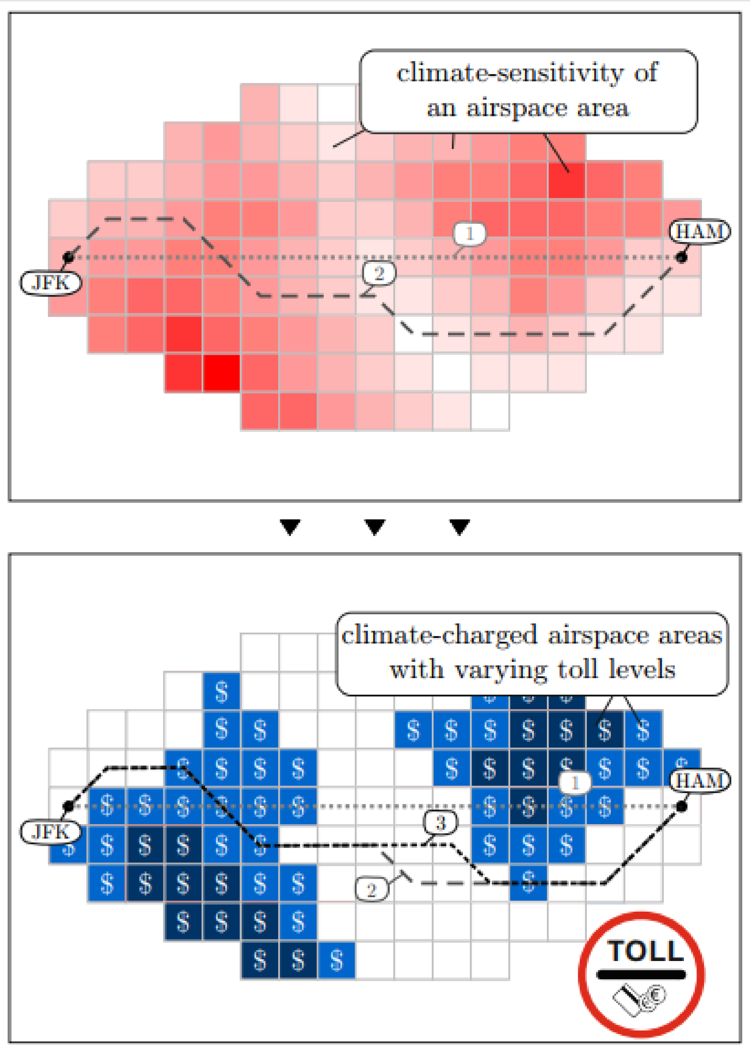

Fig. 2: time-optimized (1), climate-optimized (2), and cost-optimized trajectory within the CCA concept (3) are simplified by dashed lines

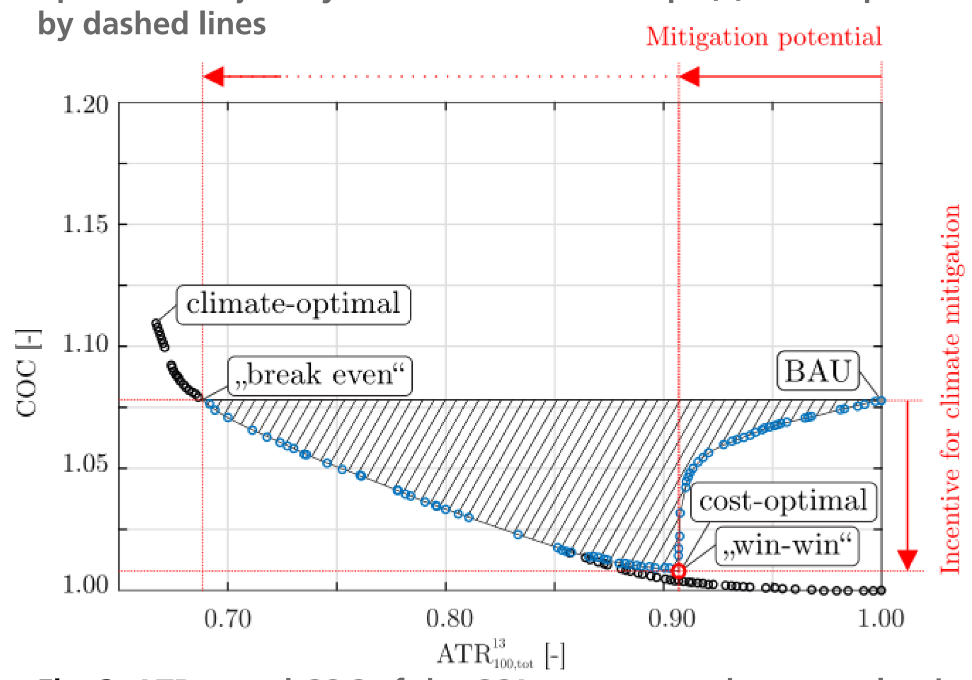

Fig. 3: ATR_{100} and COC of the CCA concept on the transatlantic route LIS-MIA for U_{cj} = 1\$/km and c_{thr} = 0.664

Mitigation effectiveness

- The feasibility and effectiveness of the concept is demonstrated with trajectory simulations on nine North Atlantic routes and benchmarked against the potential of eco-efficient trajectories.
- A financial incentive for climate mitigation has been identified for the concept that achieves on average more than 90% of the mitigation potential of climate-optimized trajectories (optimum)
- Sensitivity analyses are conducted to investigate the influence of the level of climate unit charges (U_{cj}) and the threshold value (c_{thr}):
  - The higher U_{cj}, the greater is the financial incentive for re-routing (Fig. 4a).
  - With decreasing threshold (c_{thr}), the size of climate-charged areas increases, which in turn raises the mitigation potential of the concept while keeping the incentive level for mitigation unchanged (Fig. 4b)
- The independent variables of the threshold and the climate unit charge are thus the key parameters of the concept
- An optimal set of these parameters can be found for the entire route network to create a monetary incentive on each route for a targeted mitigation potential, e.g. for a climate impact reduction of at least 5% on each North Atlantic flight (Fig. 5).

Practicability

- The practicability of a cost-driven re-routing approach can be demonstrated with the operating behavior of airlines on trans-European journeys:
- With the aim of cutting costs, a number of airlines took particularly large detours in 2015 relative to 2012-2014 – *a year when fuel costs were comparatively low* – and re-routed their flights over countries with lower air traffic control charges, such as Eastern and South-Eastern Europe (Fig. 6) [6,7].

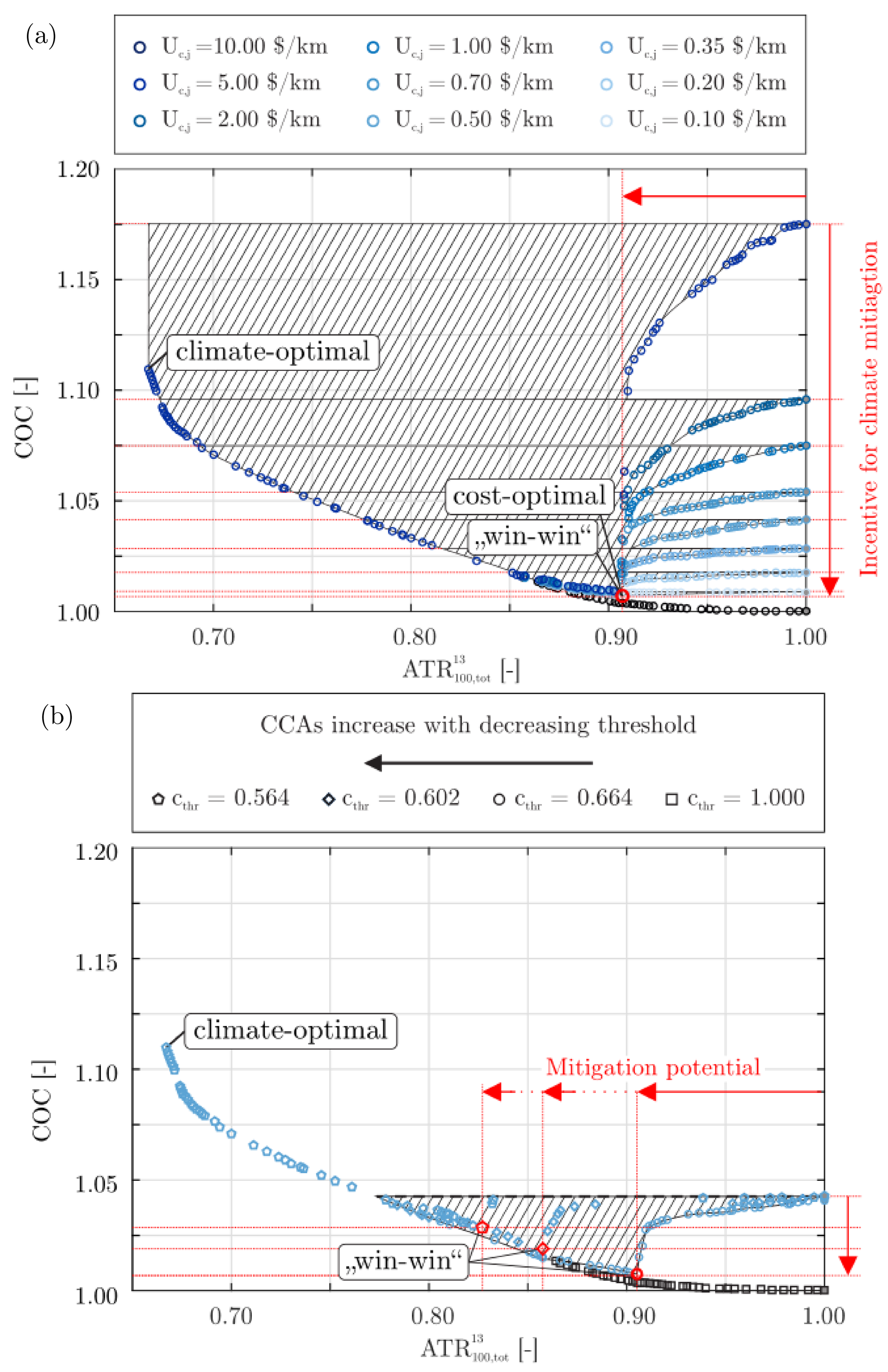

Fig. 4: Impact of climate unit charges (U_{cj}) and (b) threshold values (c_{thr}) on the cost-benefit potential of CCAs

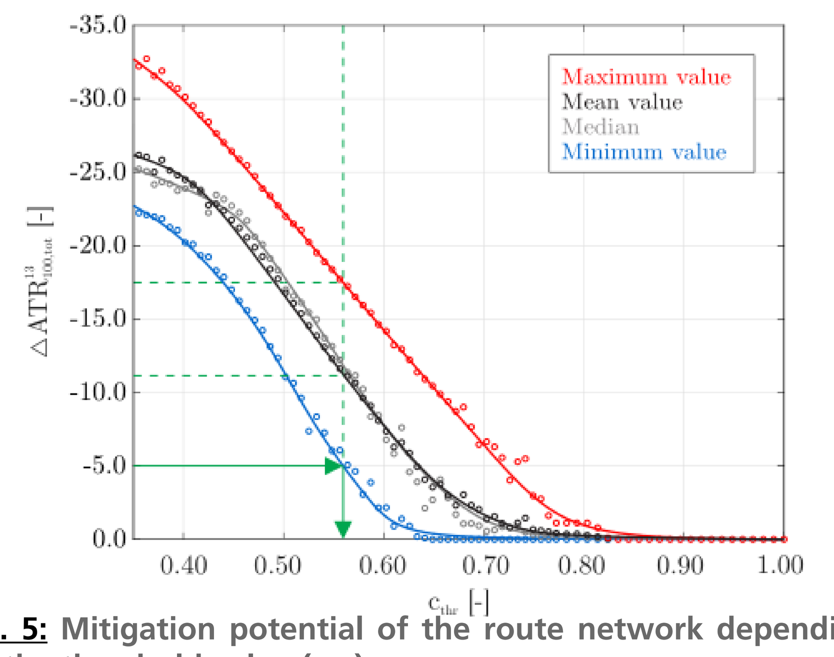

Fig. 5: Mitigation potential of the route network depending on the threshold value (c_{thr})

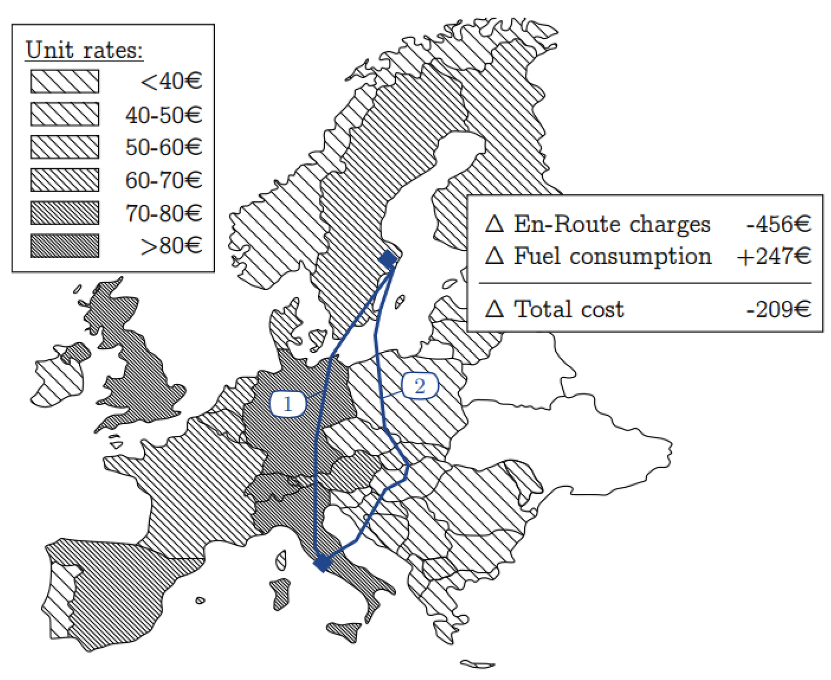

Fig. 6: Influence of current air traffic control (ATC) unit rates on operating costs and flight route for a full service carrier flight from Stockholm, Sweden to Rome, Italy [6]

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