Towards an aviation weather forecast for green operations

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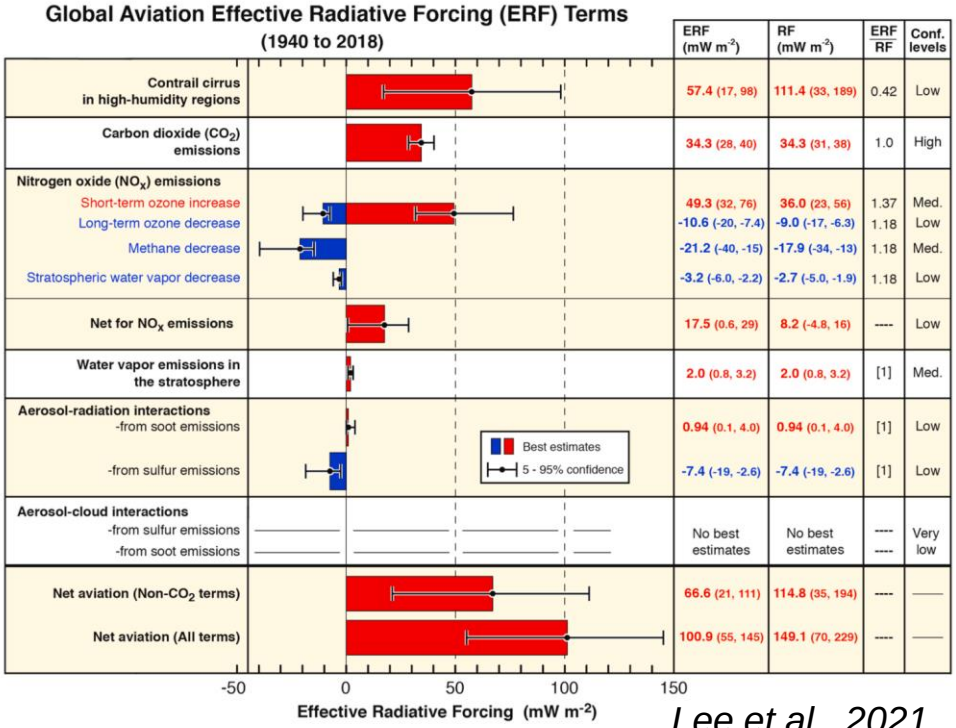
Climate impact of aviation: CO_2 and non-CO_2 effects



Lee et al., 2021

- The non-CO_2 effects contribute at least 2/3 to the total aviation ERF.
- Non-CO_2 effects also occur if alternative fuels are used, in particular H_2.
- The magnitude of the non-CO_2 effects depends on location and time of the emissions.

$\Delta T = \lambda$ ERF (Effective Radiative Forcing)

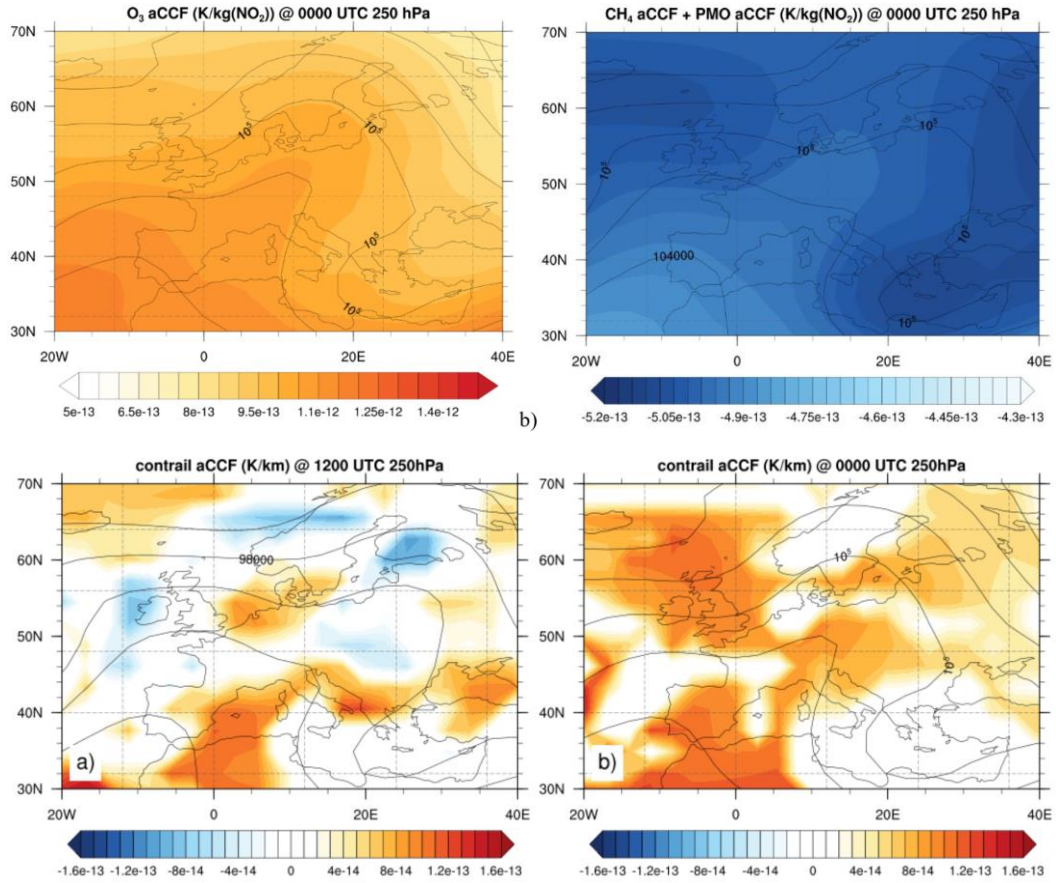
Forecast of individual climate effects (NO_x and its chemical effects, contrails): algorithmic climate change functions (aCCFs)

aCCFs describe the climate effect of an individual unit emission in a certain choosable metric. They depend on the meteorological conditions at the time and place of emission.

Currently there exisit aCCFs calculated for Europe and the Northern Atlantic for NO_x, water vapour and contrails.

While the chemical effects have smooth aCCFs, contrail aCCFs are patchy and highly structured.

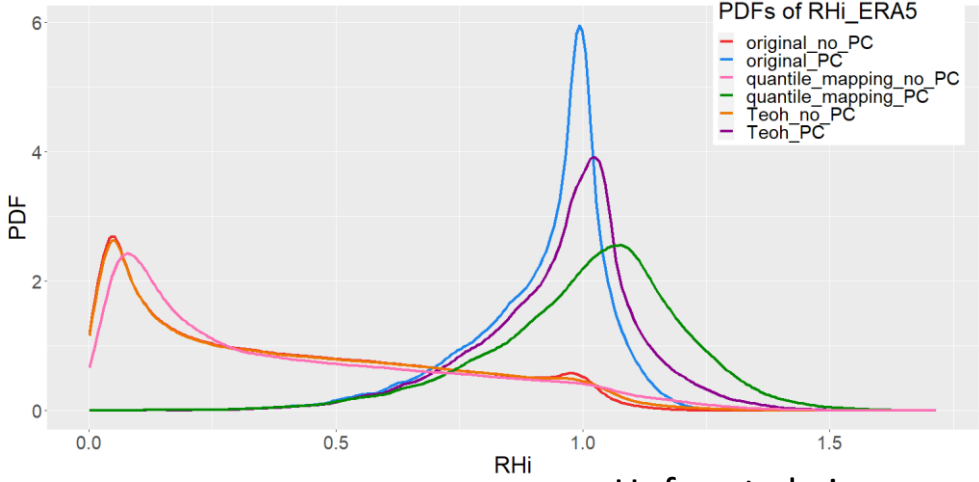
- Figures from Yun et al., GMD, 2023.



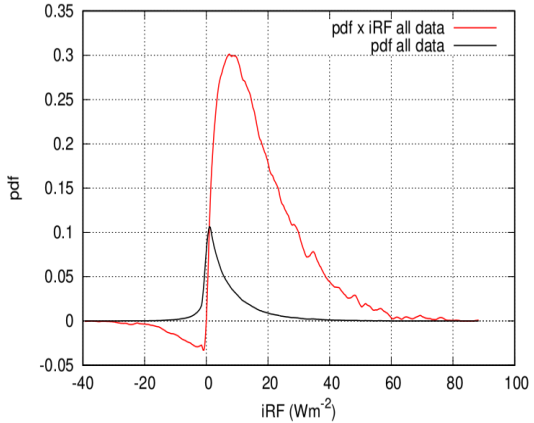
Forecast of persistent contrails and their individual climate effect

Necessary steps for avoiding contrails:

1. Predict the formation of contrails with a reasonable skill
   - ⇨ Schmidt-Appleman criterion
2. Predict the formation of **persistent** contrails with a skill that is sufficient for deviating air traffic
   - ⇨ Predict the occurrence of ice super-saturated regions (ISSRs)
3. Predict the RF (ERF, ATR, ...) associated with individual contrails with a skill that is sufficient for deviating air traffic



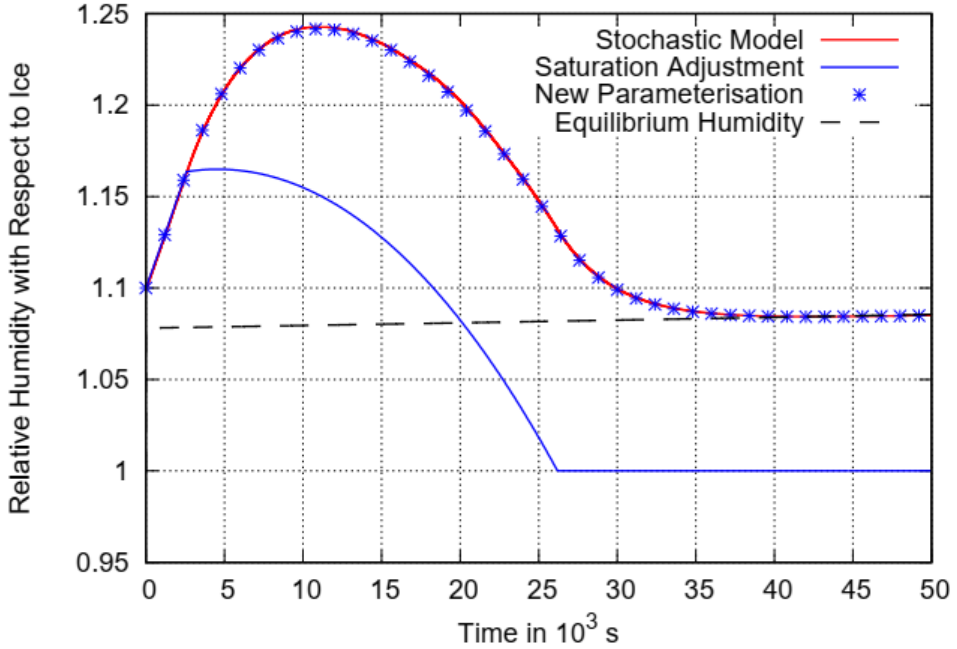
Hofer et al., in prep.

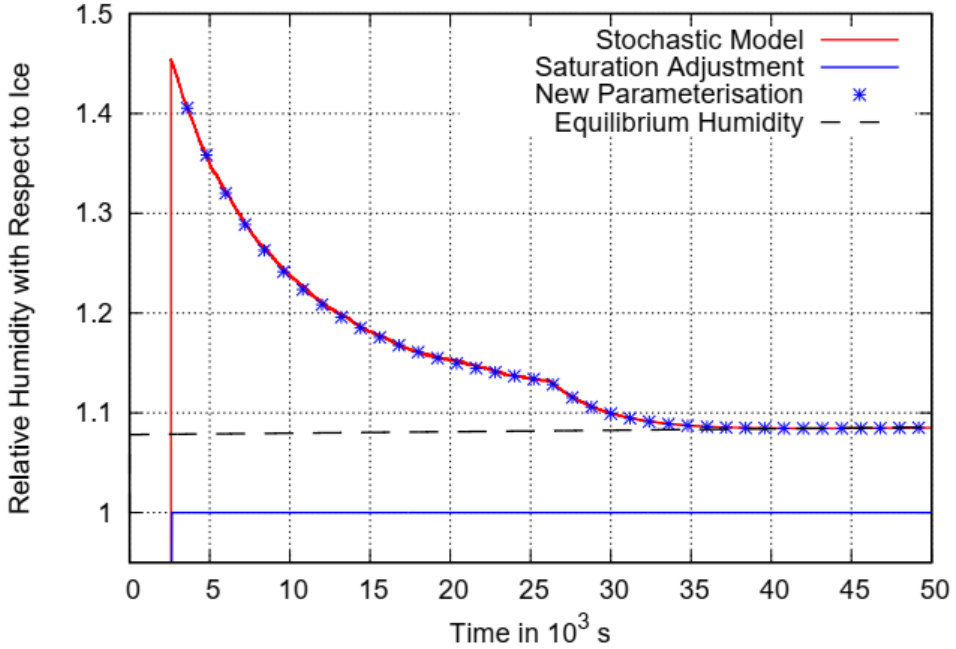


Wilhelm et al., 2021

Current developments in EU-projects ACACIA and BeCoM

- Forecast of ice supersaturated regions using dynamical proxies (regression and neural networks)
- New cirrus parameterisations for numerical weather prediction models
  - one-moment model (abandon saturation adjustment)
  - two-moment model (DWD)





Summary and further research

- Aviation contributes to climate change (warming) through CO_2 emission and non-CO_2 effects. The latter are short-lived and strongly situation-dependent. This implies that they can be lowered by a cimate-aware flight-planning.
- Chemical effects are currently treated using socalled algorithmic Climate Change Functions, which provide an *expected* individual climate effect of a unit mass of emissions.
- Strongly warming persistent contrails can be avoided if flights avoid ice supersaturated regions. The forecast of the latter is challenging.
- We need improved representations of ice-clouds and their supersaturated environment in NWP models.
- We need many more good humidity measurements at cruise level for data assimilation
- We need better detection of contrails in sat. data for validation.