The influence of engine design parameters on climate

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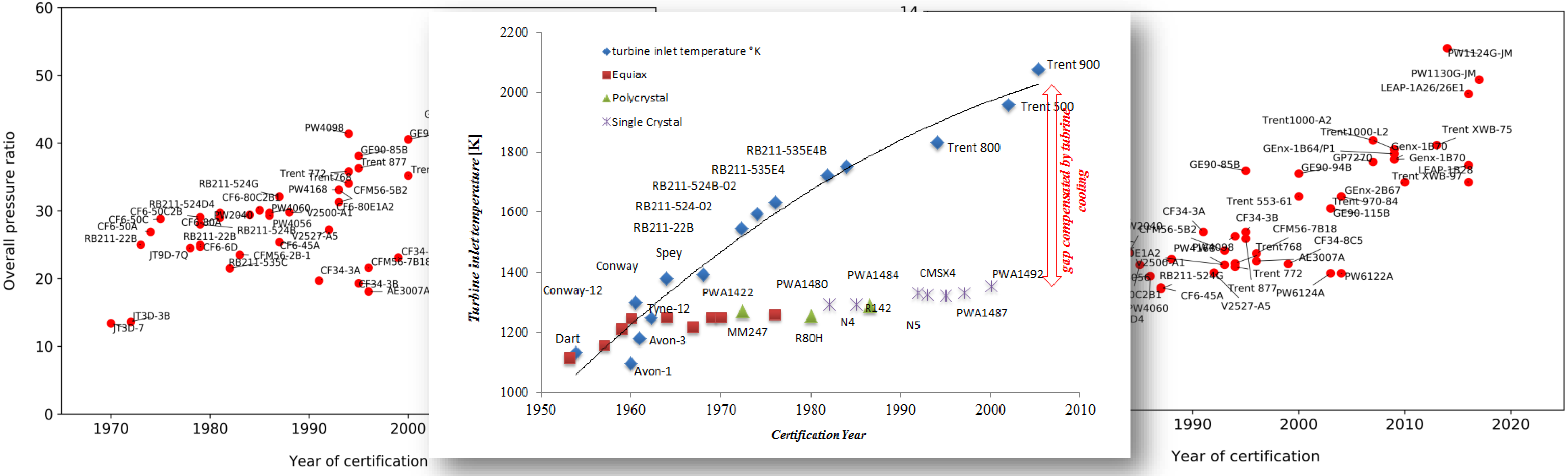
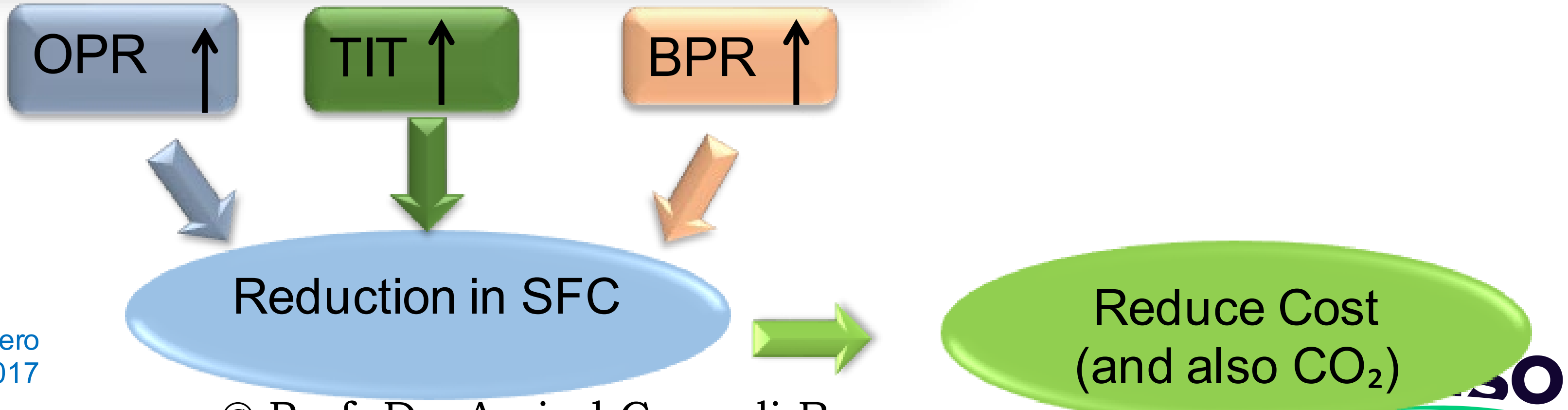
Improvement in aircraft engines





Yin, Feijia, and A. Gangoli Rao. "Performance analysis of an aero engine with inter-stage turbine burner." *The Aeronautical Journal* 2017

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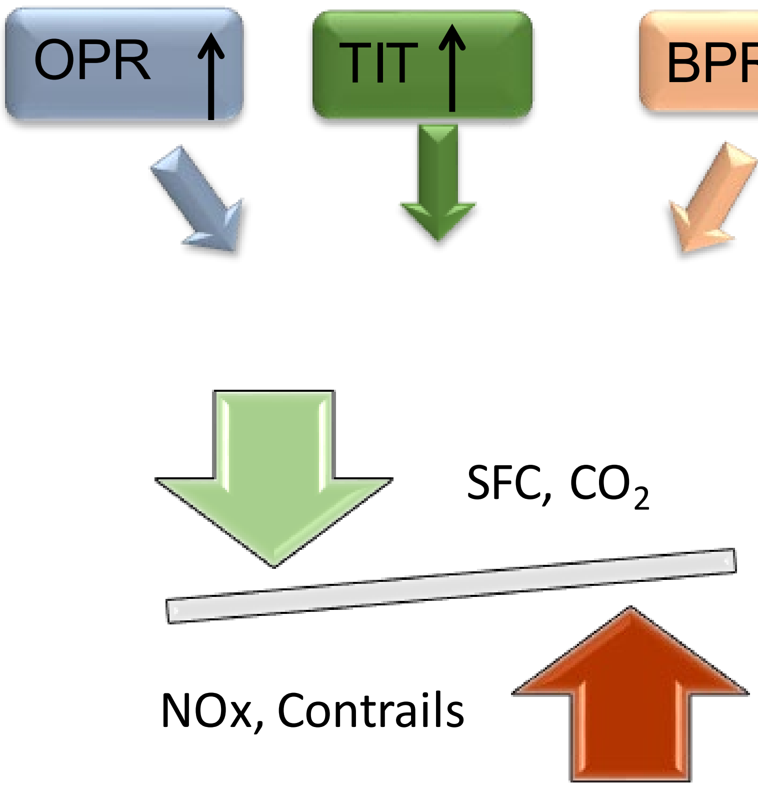
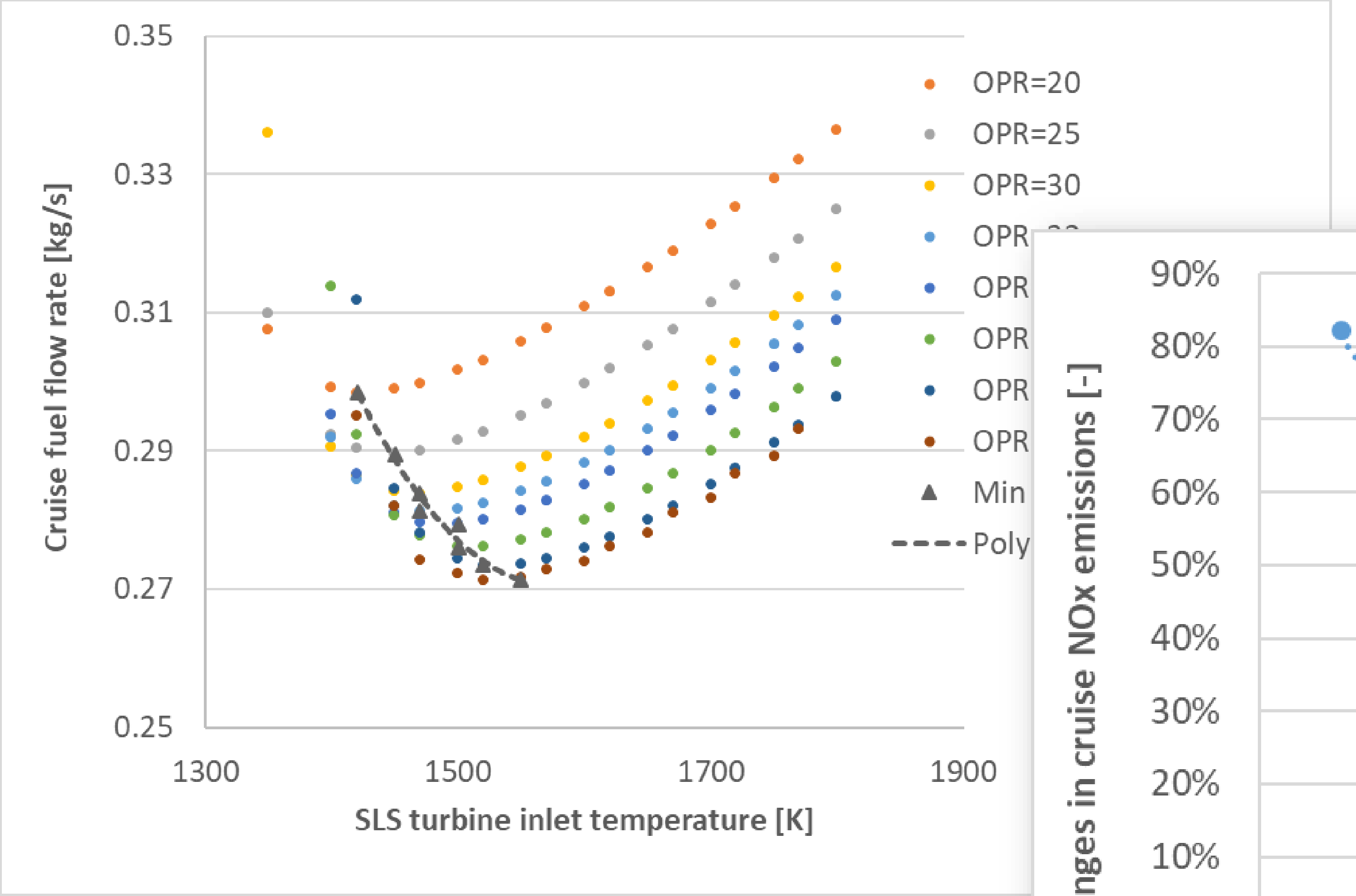
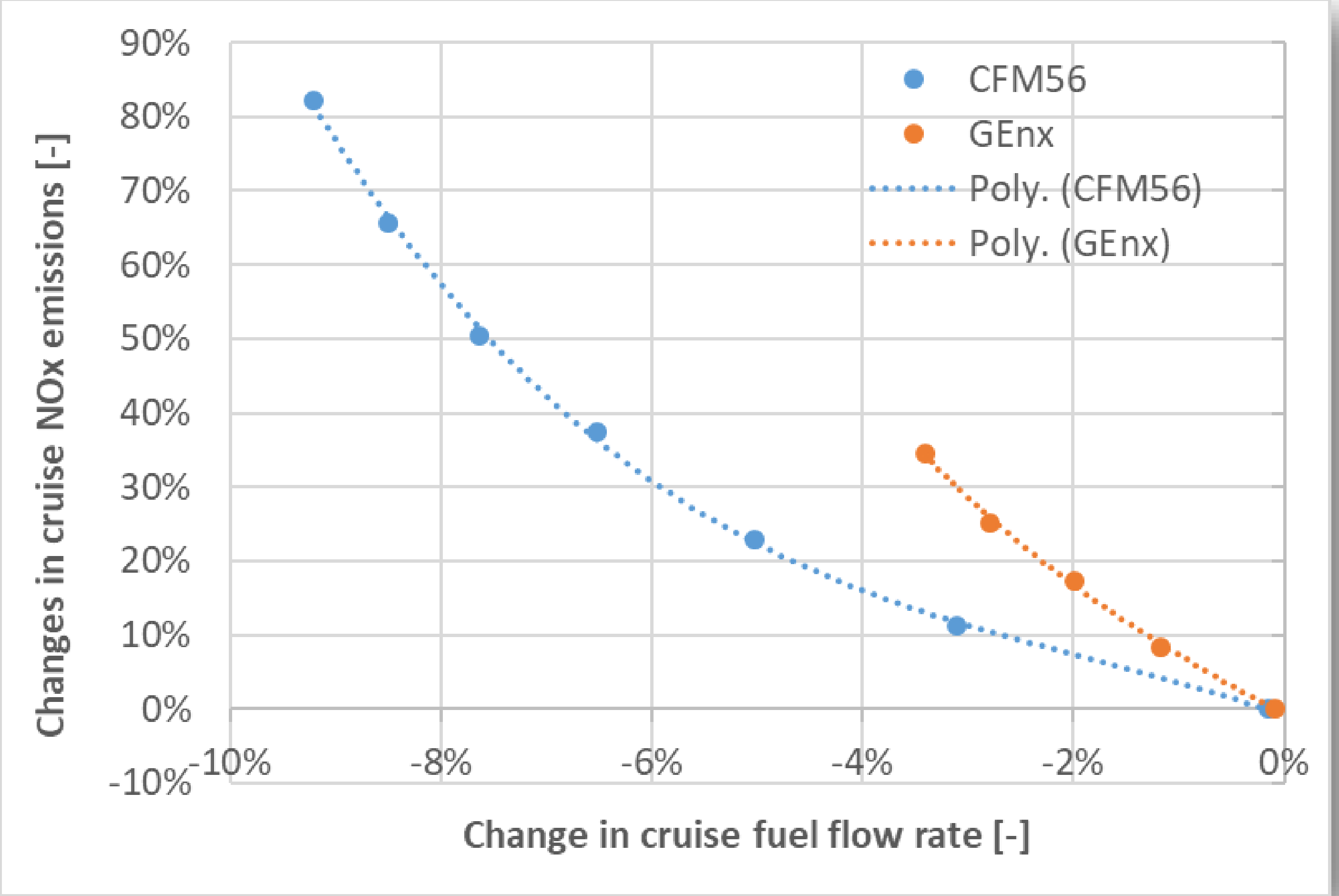
Environmental aspects

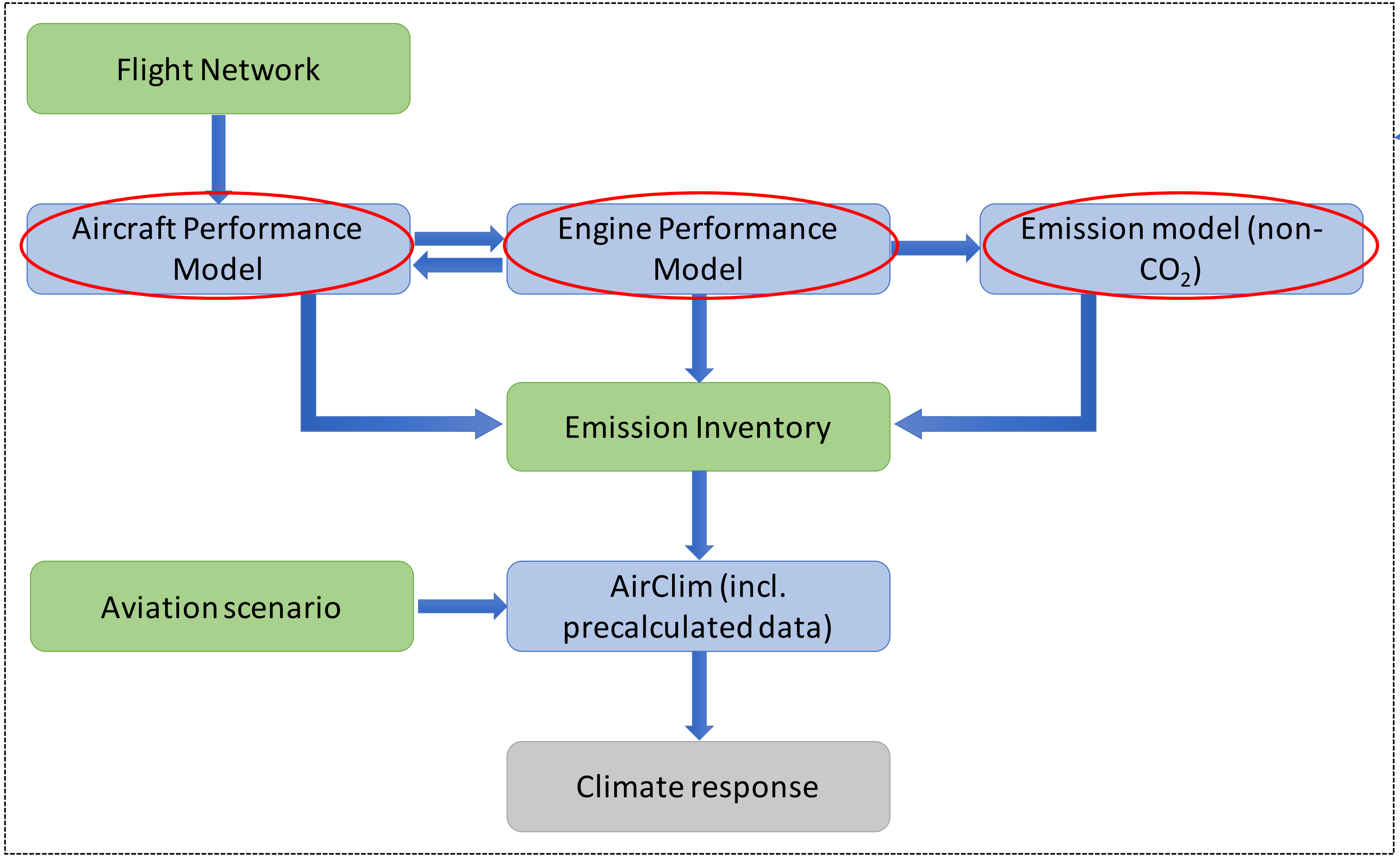


The NOx paradox: ParaNOx





Climate response modelling: methodology



Changes in design parameter(s)/fuel/combustor

For this assessment:

- Constant cruise altitude and Mach no. (FL330, M 0.78)
- Aircraft: A320
- Engine: CFM56-5B
  - OPR = 27.69
  - BPR = 5.9
  - Rated thrust = 120.11 kN

- Design point = Rated thrust at SLS conditions
- off-design = cruise

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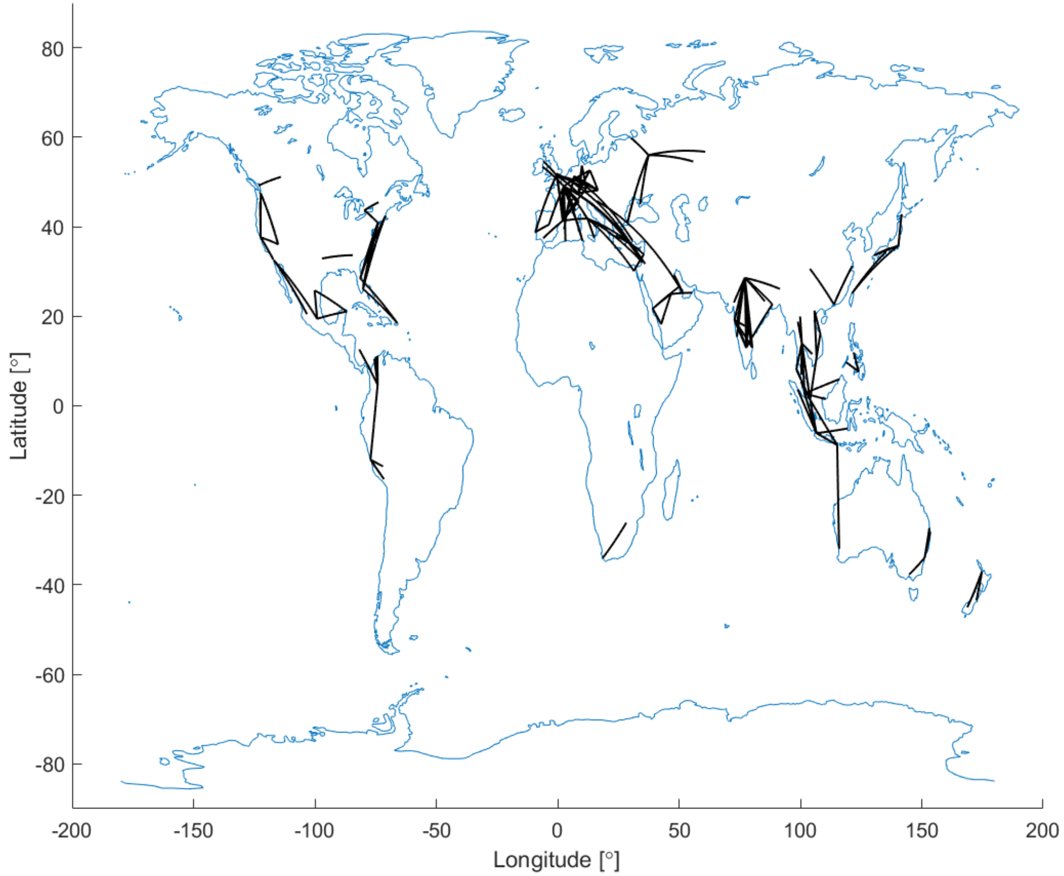
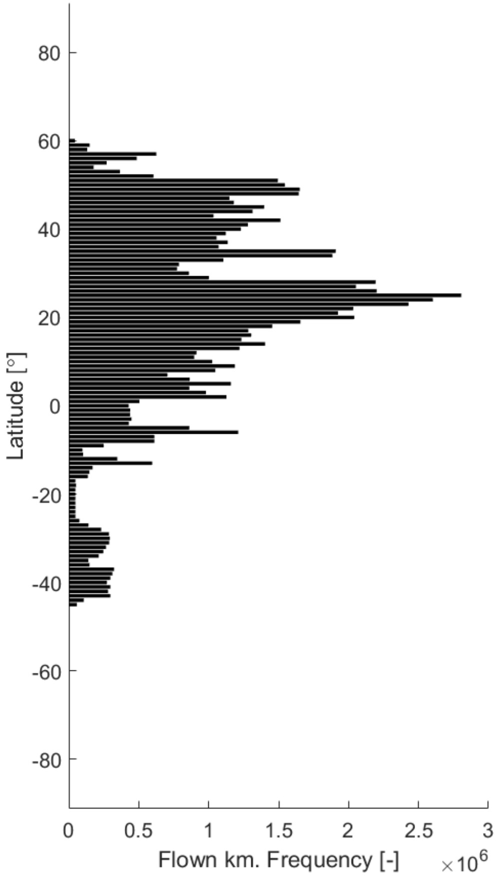
Climate assessment study

Flight network:





~150 city pairs.

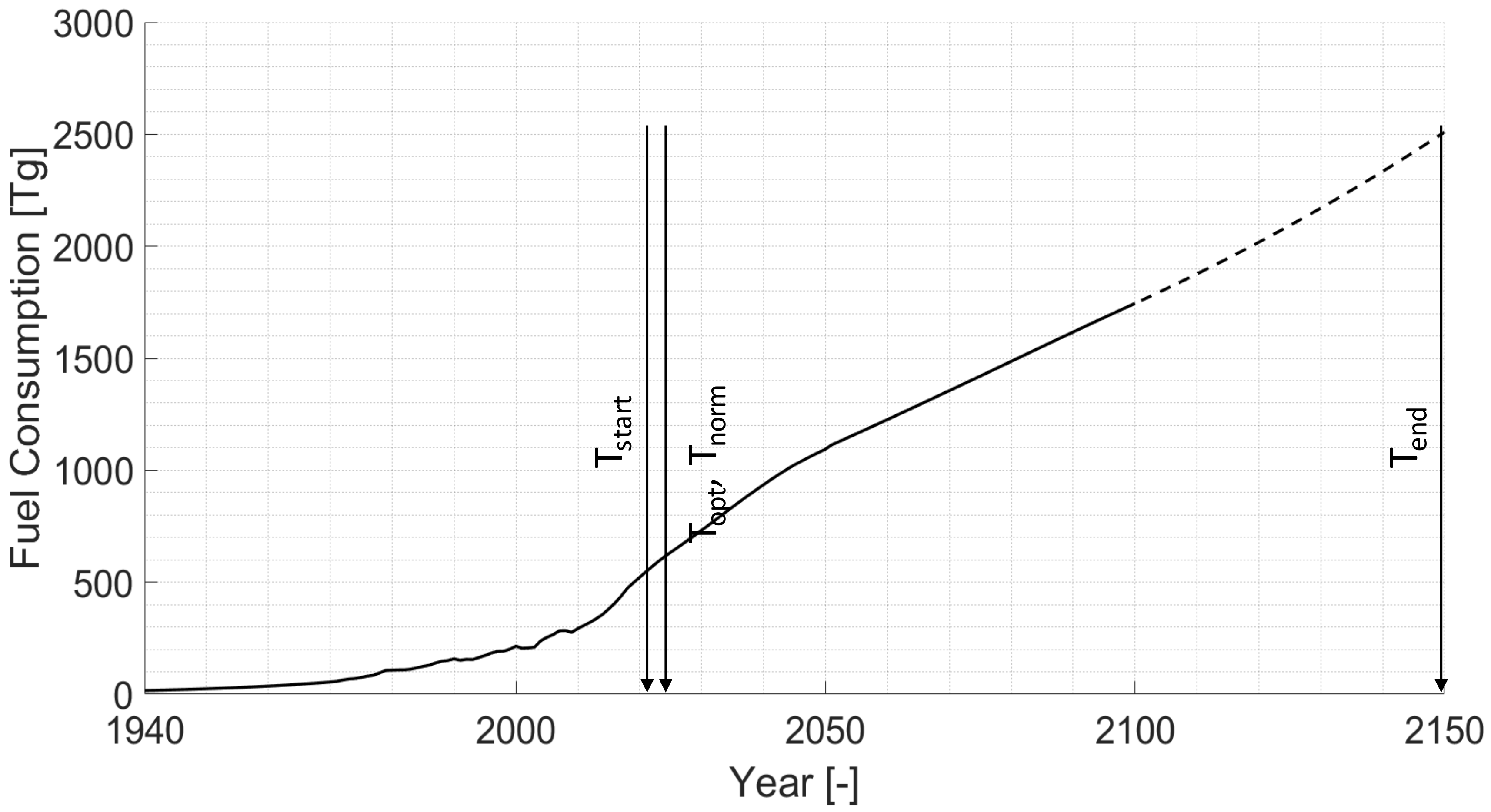
No flights below 500 km.

13.09% of the global A320-flown km (6.43 bn km) in 2019.

Climate assessment study

<u>Background scenario:</u>

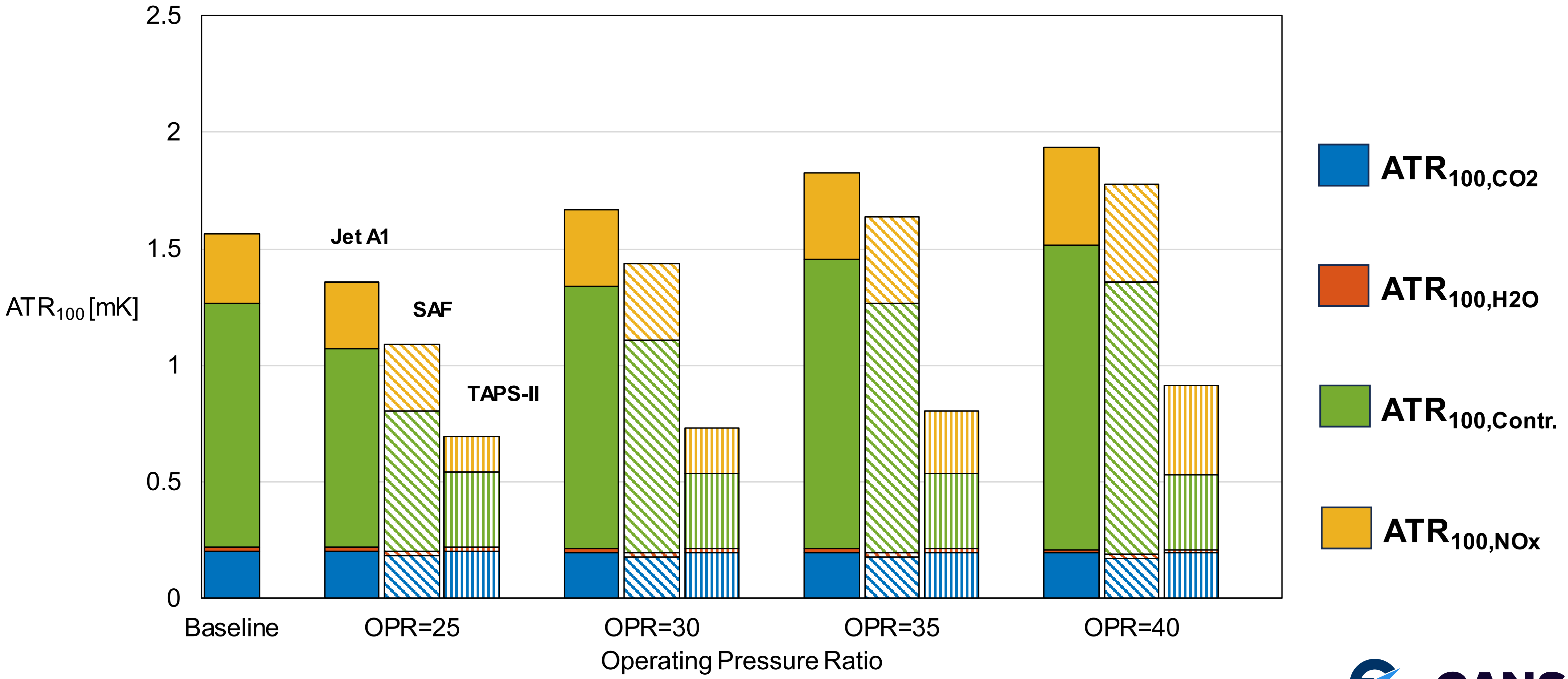
- *CurTec* fuel scenario. Based on expected aviation growth, with technology freeze.
- <u>Assumption:</u> Constant fuel growth trend beyond 2100.



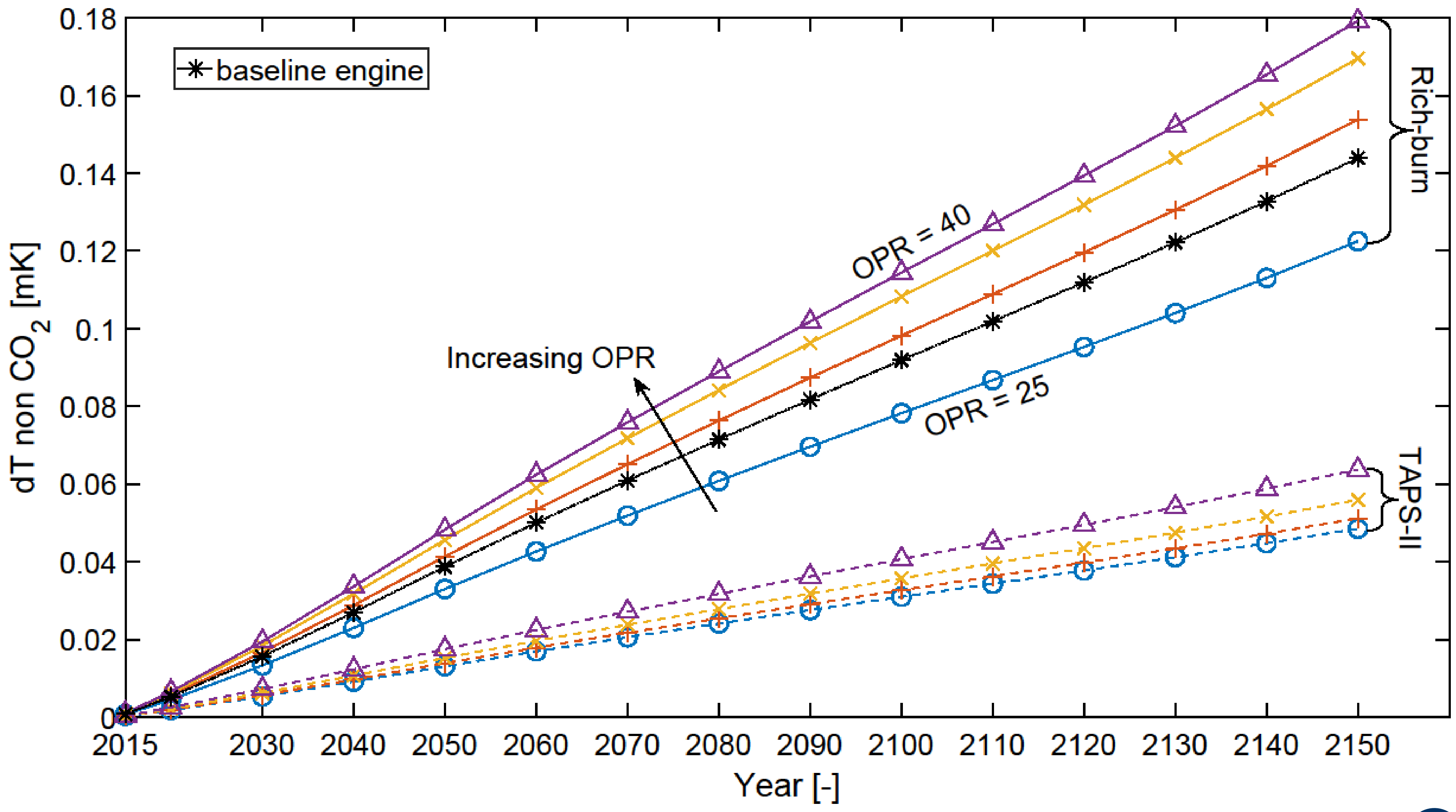
T_{start} = 2015
T_{end} = 2150
T_{opt} = 2019
T_{norm} = 2019

Climate assessment study: Results

Species response for changes in engine design parameters:



Lean vs RQL



baseline engine
dT non CO_2 [mK]
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2015
2030
2040
2050
2060
2070
2080
2090
2100
2110
2120
2130
2140
2150
Year [-]
OPR = 40
OPR = 25
Increasing OPR
Rich-burn
TAPS-II

Key learnings

- Increase in the OPR:
  - **CO_2 climate impact.**
  - **NO_x and contrails climate impact.**
  - **NO_x and contrails climate impact > CO_2 climate impact.**
- Increase in the OPR + SAF:
  - **CO_2 climate impact. (Synergy between fuel consumption and SAF CO_2 decrease).**
  - **Contrails climate impact (At higher OPRs, SAF nvPM reduction is not sufficient).**
- Increase in the OPR + TAPS-II:
  - **NO_x climate impact.**
  - **Contrails climate impact (consistent reduction, heavier volatile particles may contribute to contrail formation).**

- Large uncertainties in climate effects (e.g. lifetimes, radiative forcing, climate sensitivities etc.), which need to be considered for more reliable results.
- **Clean combustion technologies can reduce the non-CO_2 effects without compromising the CO_2 emissions.**

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The future belongs to those who anticipate it first

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