Climate footprint of aviation propulsion technology: the climate propulsion modelling approach

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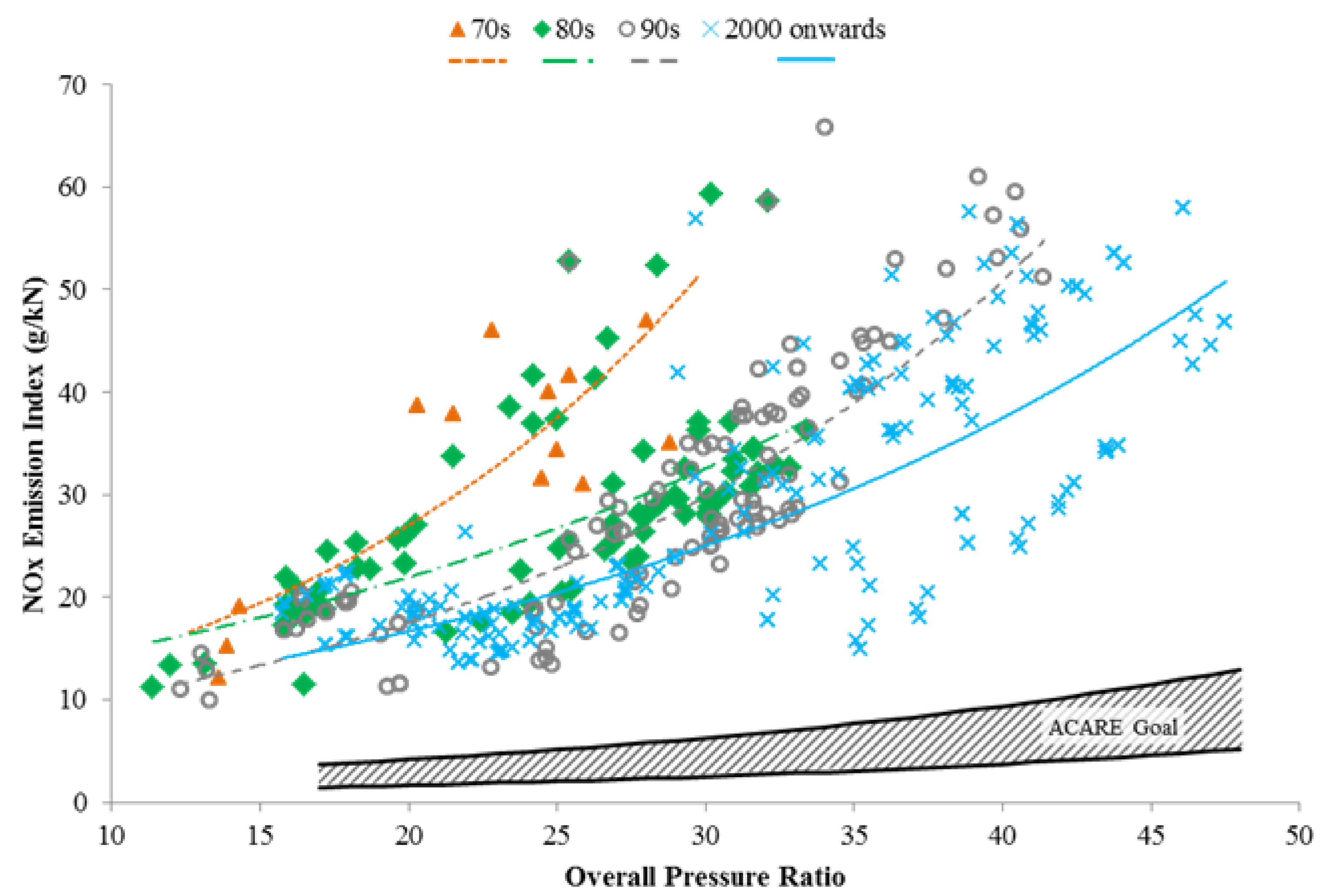
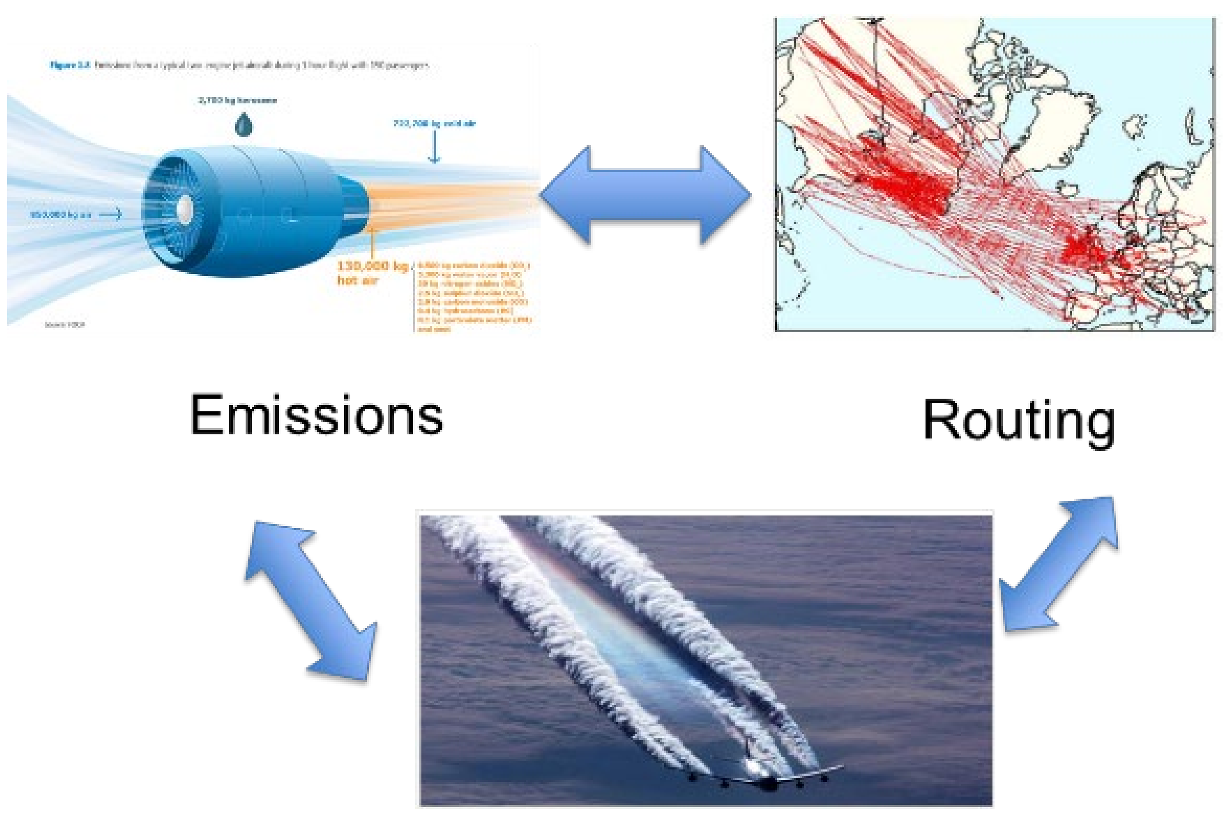
Motivation

- Aviation causes approximately 5% of the total anthropogenic global warming, including CO_2 (<50%) and non-CO_2 effects (>50%) from NOx, water vapor, contrails and direct aerosols [1].
- Increasing engine efficiency, via increasing the operating pressure, temperature, and bypass ratio, ***reduces CO_2 emissions***, but ***increases NO_x emissions*** (as shown in the figure [2] on the right) and ***the chance of contrail formation*** (as suggested by the well-known Schmidt Appleman Criterion [3,4]).
- We need to ***consider the paradox of CO_2 and non-CO_2 effects when designing aircraft engines for climate.***



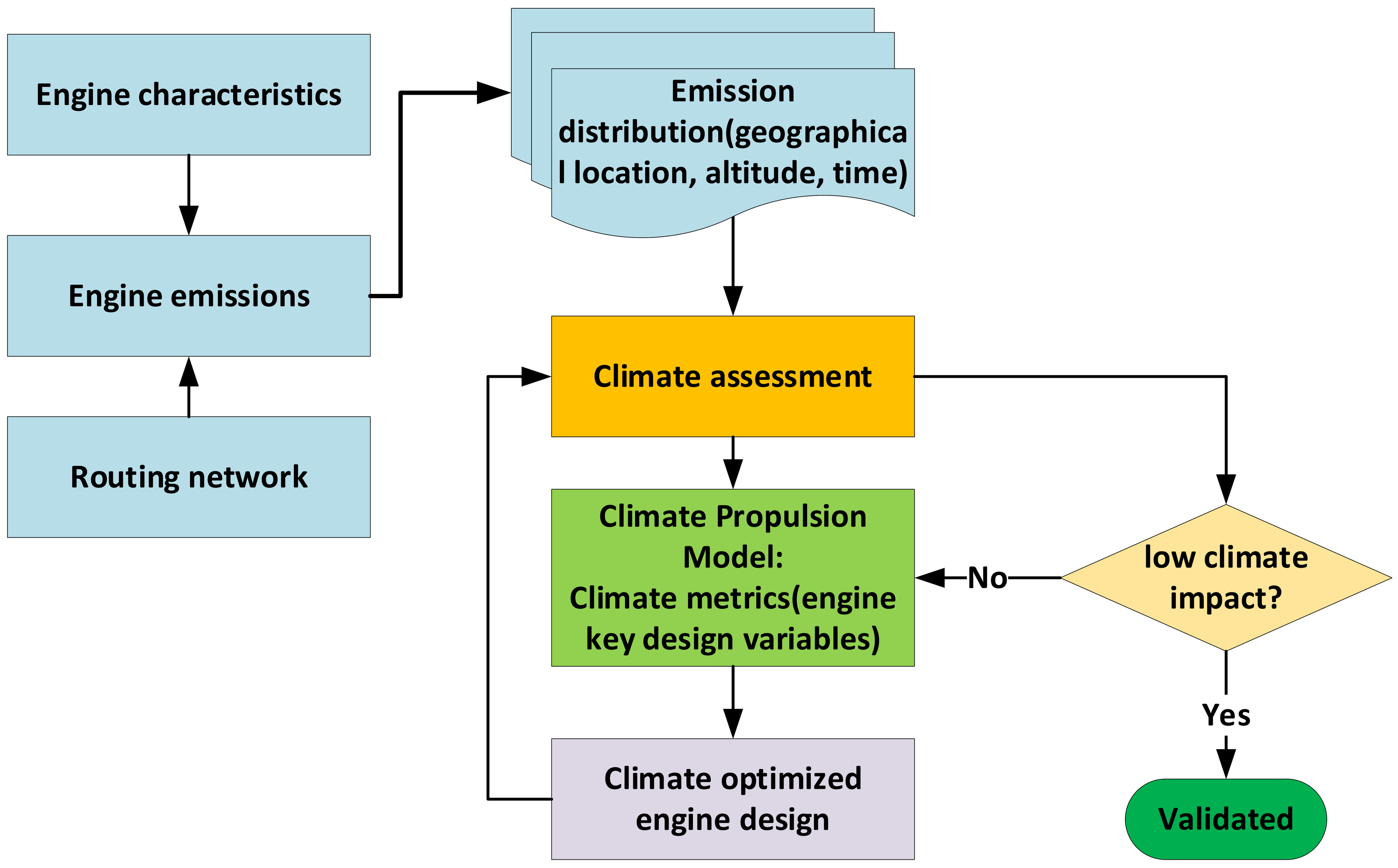
Climate assessment

- Aviation's climate impact (specifically non-CO_2 effects) depends on ***geographical location***, ***altitude*** and ***time*** of aircraft
- Non-CO_2 climate impact of aviation emissions varies with ***actual meteorological situation***, described by atmospheric chemistry and physics.
- An ***interactive approach*** between emissions, routing network and atmosphere will be used in this research.



CPM development approach

- An overview of the ***climate propulsion model (CPM)*** development approach is provided in the figure below.



Expected results

At the end of this project, the following two objectives are to be achieved:

- We will have ***a holistic view of the climate footprint*** of the engine technological development
- ***The first climate propulsion model*** envisaged as below:

  $climate\ metrics = \sum_n f_n(OPR, TIT, BPR, etc.)$, with n represents different species/effects
- The climate propulsion model will enable climate optimized engine design in future.

Reference:

1. Lee, D.S., Fahey, D.W., Forster, P.M., Newton, P.J., Wit, R.C.N., Lim, L.L., Owen, B. and Sausen, R., 2009. Aviation and global climate change in the 21st century. Atmospheric Environment. 43(22–23), pp. 3520-3537
2. Perpignan, A.A.V., Rao, A.G. and Roekaerts, D.J.E.M., 2018. Flameless combustion and its potential towards gas turbines. Progress in Energy and Combustion Science, 69: pp. 28-62.
3. Appleman, H., The formation of exhaust condensation trails by jet aircraft. 1953.
4. Schmidt, E. Die Entstehung von Eisnebel aus den Auspuffgasen von Flugmotoren. in Schriften der Deutschen Akademie der Luftfahrtforschung. 1941.

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