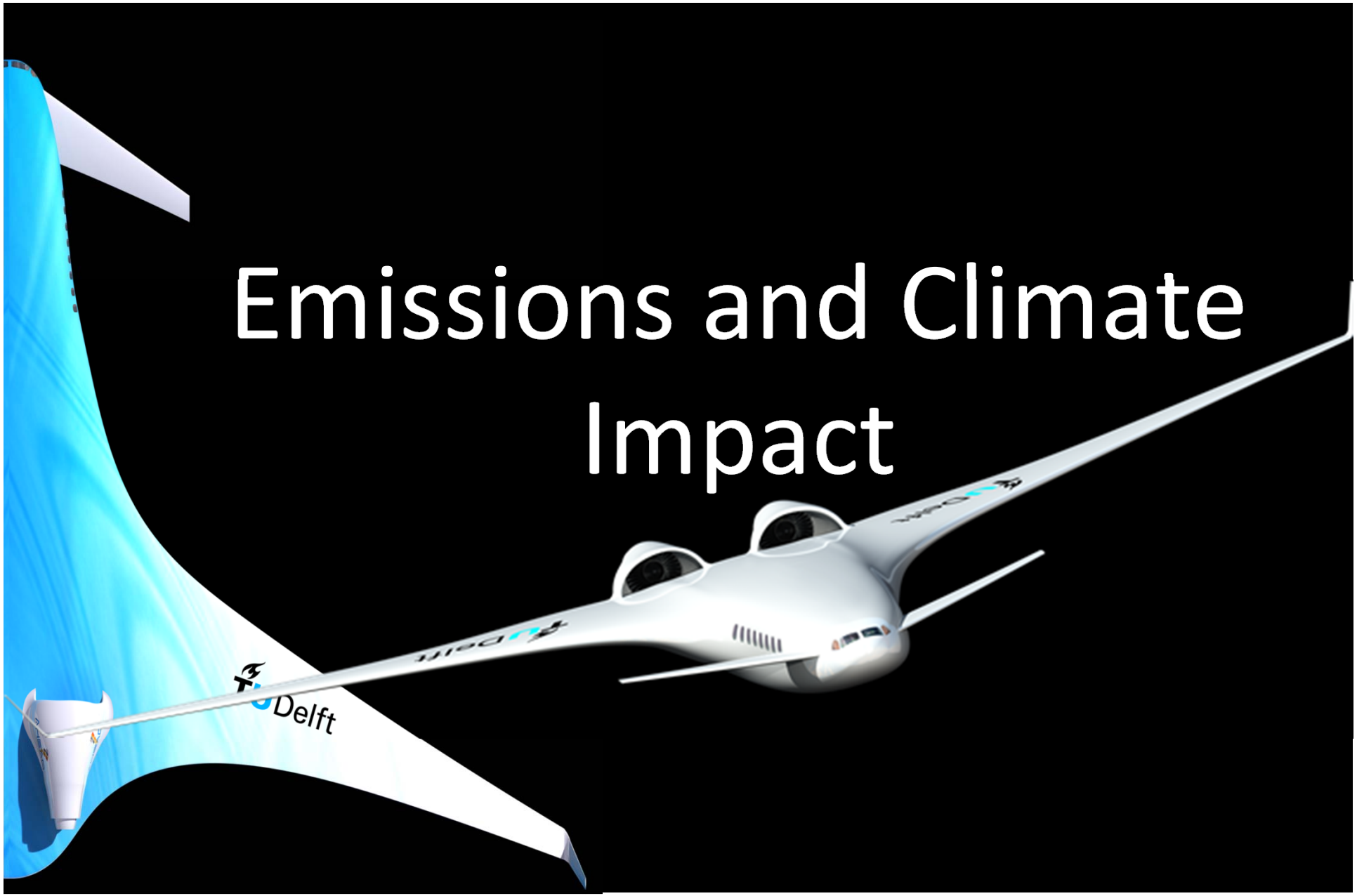
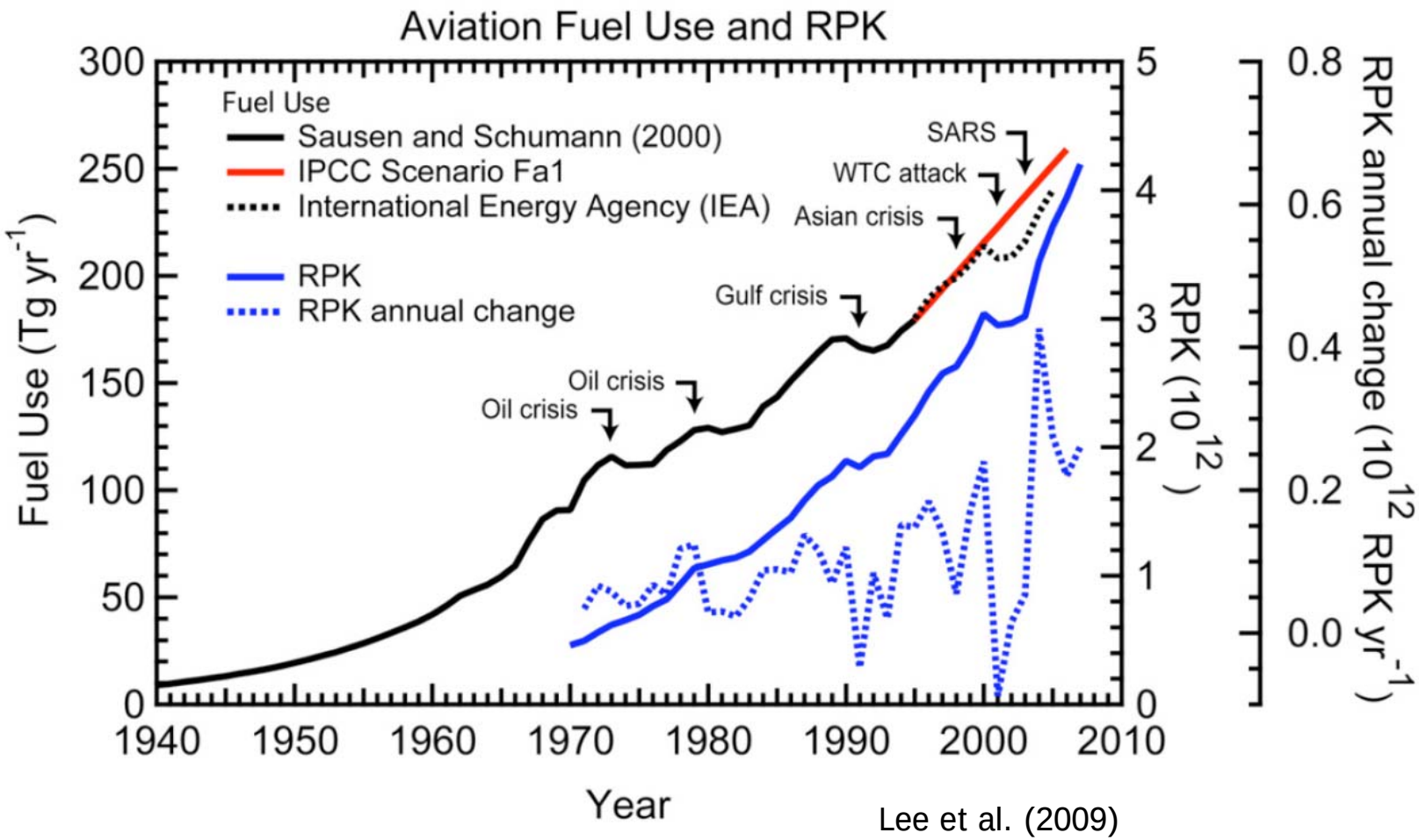
Emissions and Climate Impact

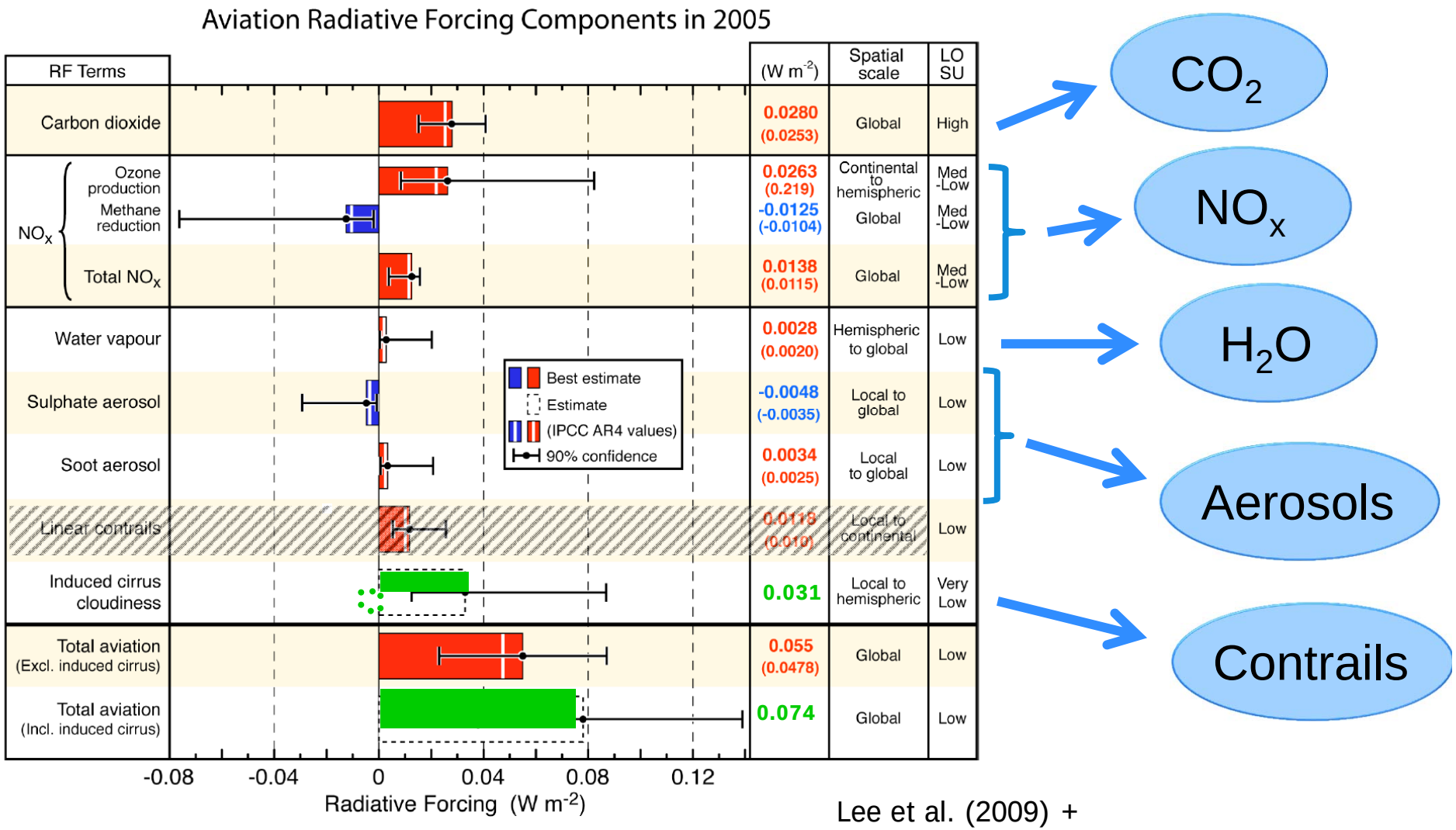


Increasing demand for mobility



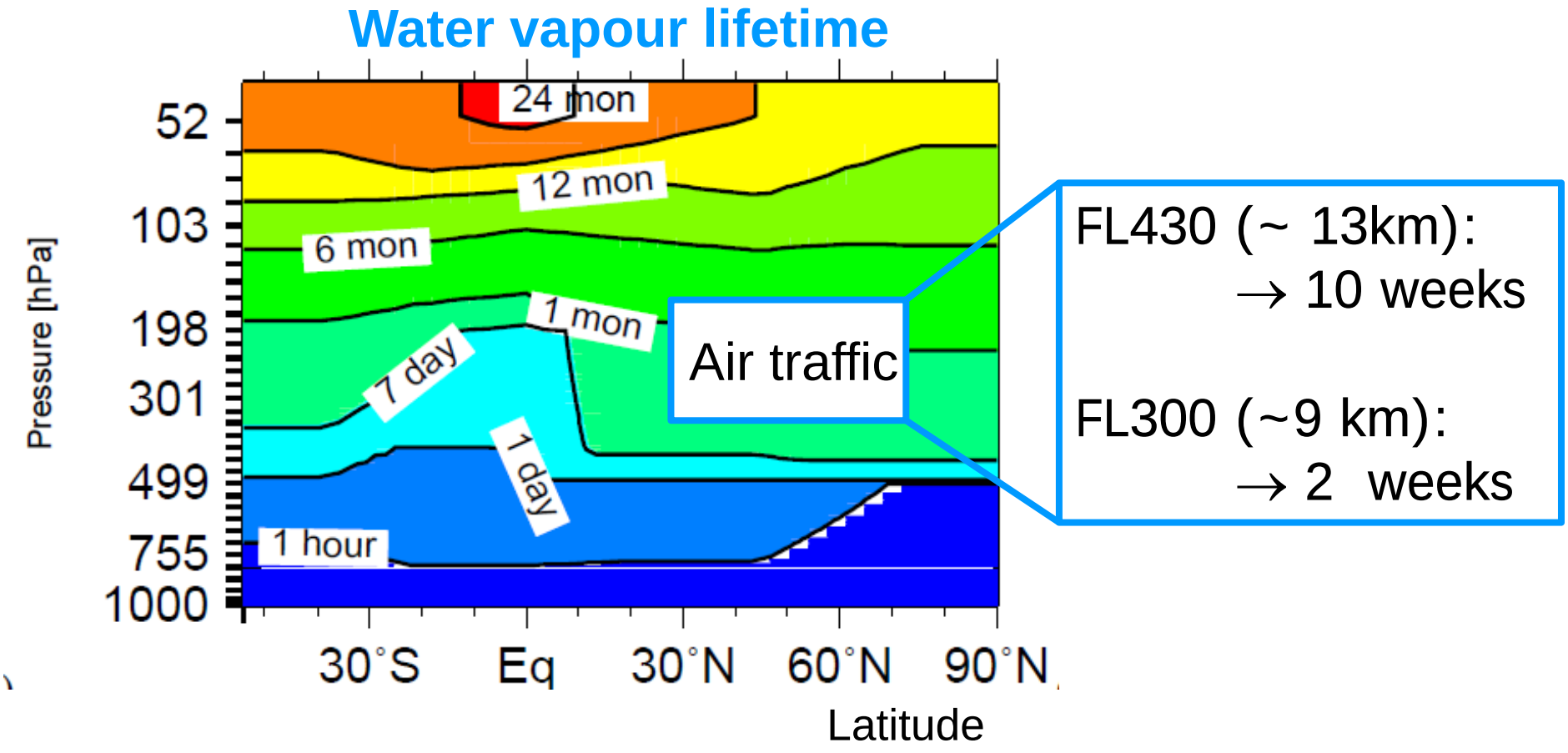
Lee et al. (2009)

Climate impact of air traffic is more than CO_2



Lee et al. (2009) + Burkhardt&Kärcher (2011)

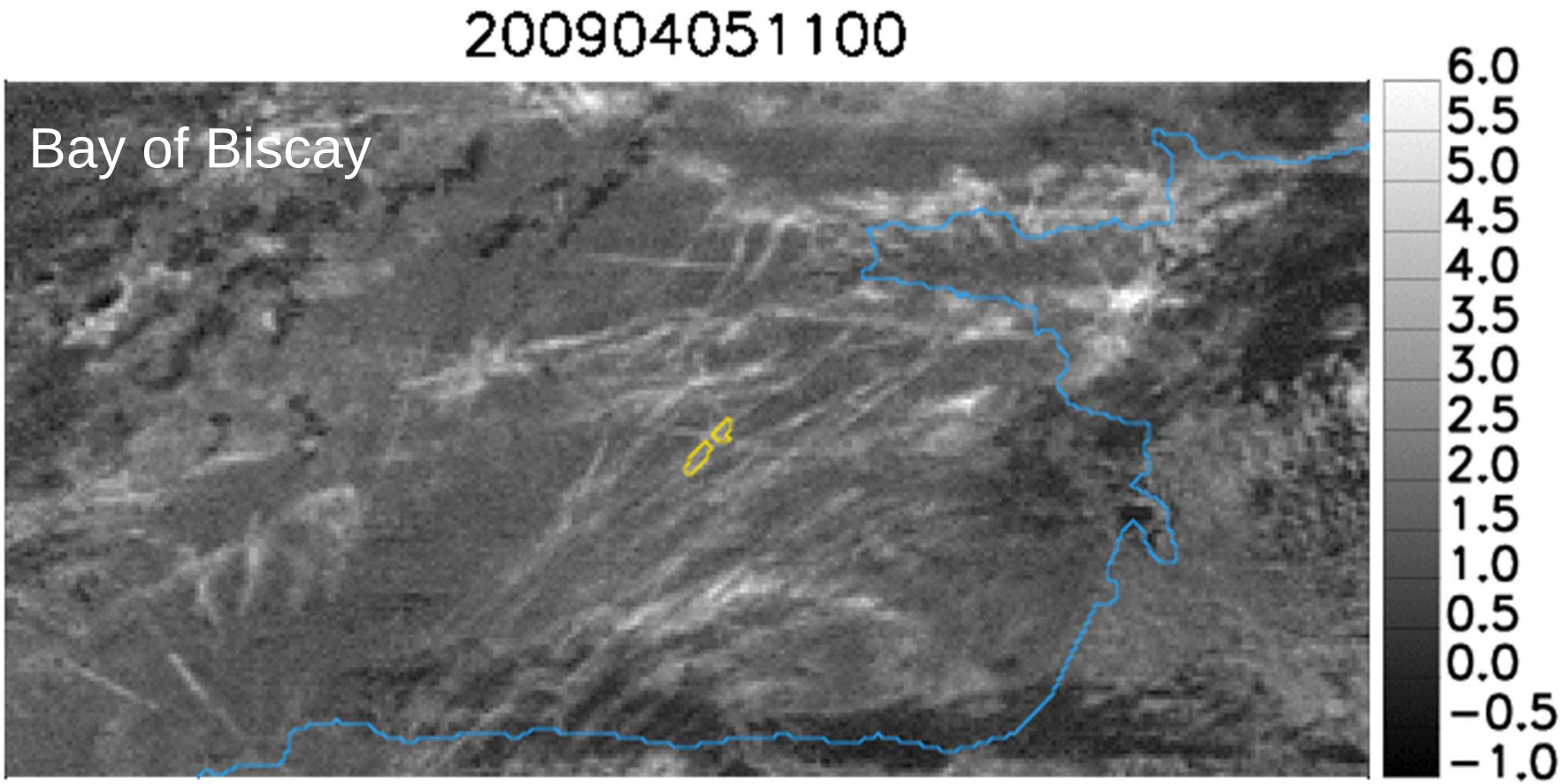
Location of non-CO_2 emission matters: H_2O



... Location also matters for NO_x and contrails, though differently

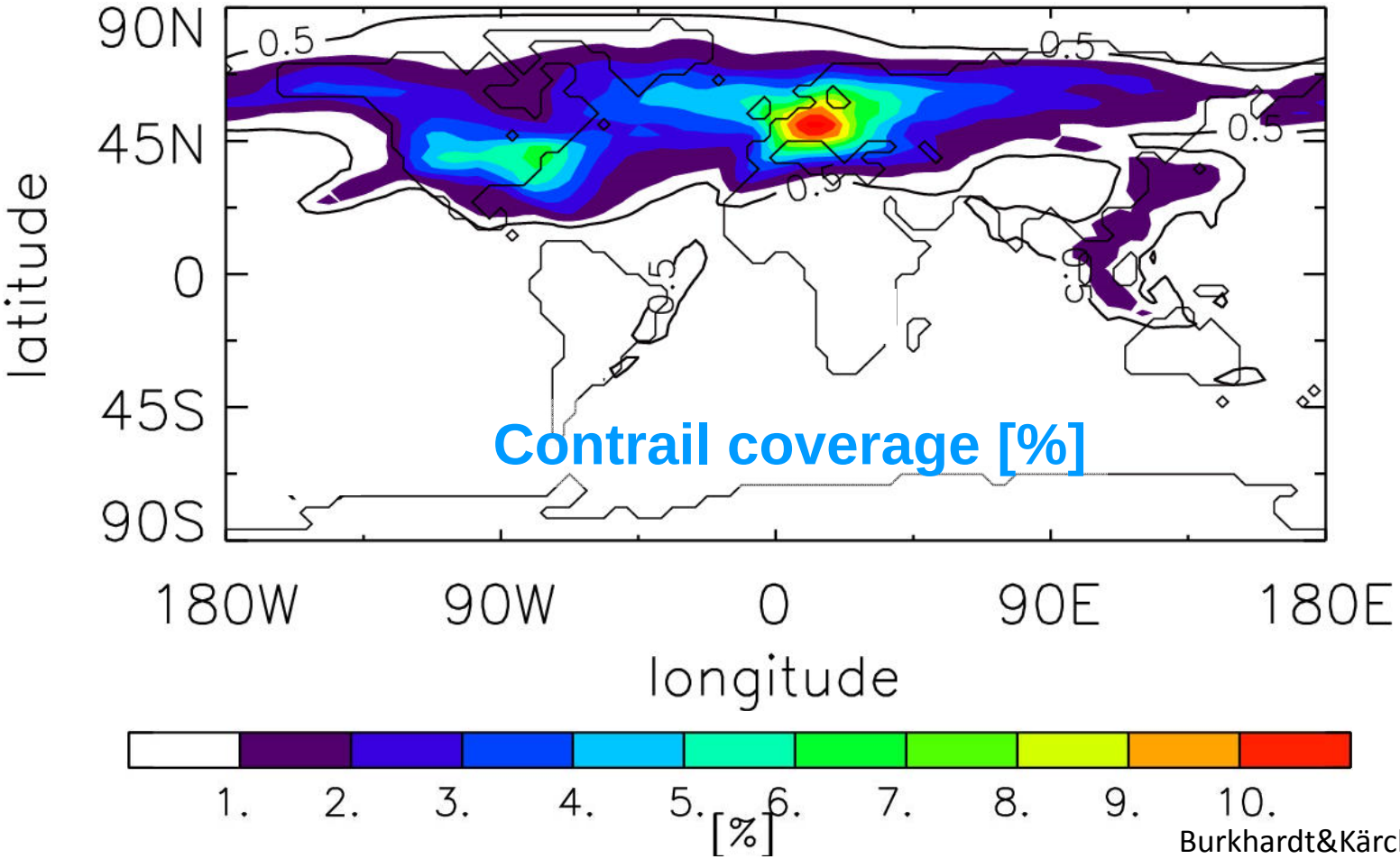
Grewe&Stenke (2008)

Contrail-Cirrus information from space



Mannstein et al. 2012
Vasquez Navarro, 2011

Contrail-Cirrus information from space and modelled with a climate model



Burkhardt&Kärcher, 2011

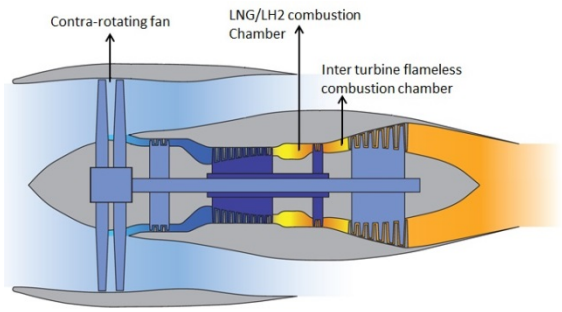
AHEAD: Climate impact: Methodology

Detailed physical modelling:

- Calculate contrail formation criterion for this specific fuel-aircraft configuration (Schmitt-Appleman)
- Simulate contrails of a fleet of aircraft with a climate model

Climate-Chemistry-Response modelling:

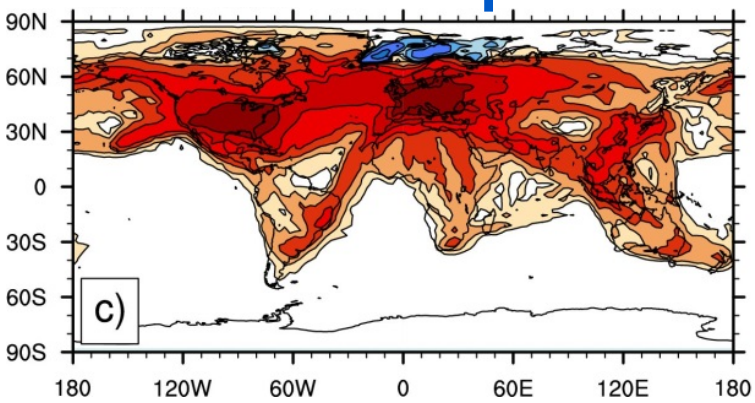
- Adapt response model AirClim to new detailed modelling
- Consider a fleet of aircraft with
  - Entry into service in 2050
  - Full fleet in 2075
- Reference aircraft B787 including some future enhancements (efficiency & bio fuels)
- Details of AHEAD engine/aircraft from TUD, TUB, Technion
- Calculation of the of near surface temperature change



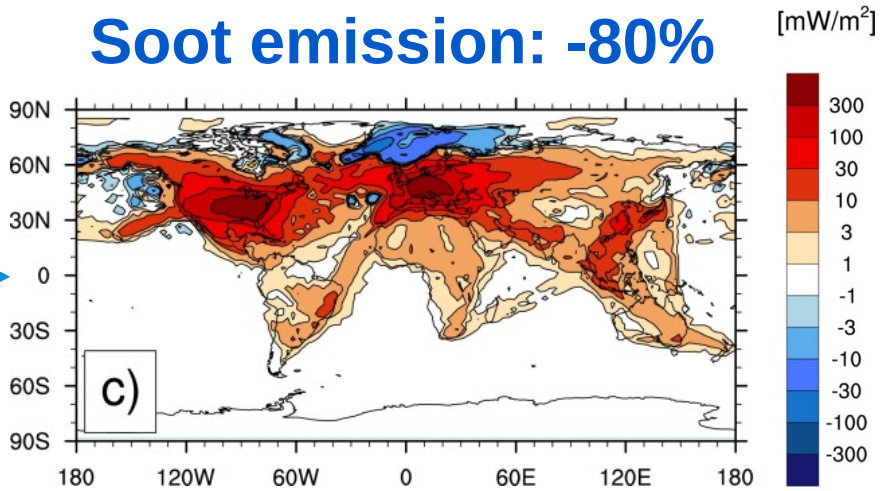
AHEAD-BWB: Reduction of soot:
Impact on contrail properties and climate:

Radiative Forcing [mW/m²]

World fleet contrail climate impact



Soot emission: -80%



Bock (2014)

An 80% reduction in particle number leads to significant decrease in radiative forcing (climate impact)
This is taken as an assumption for the AHEAD soot emission

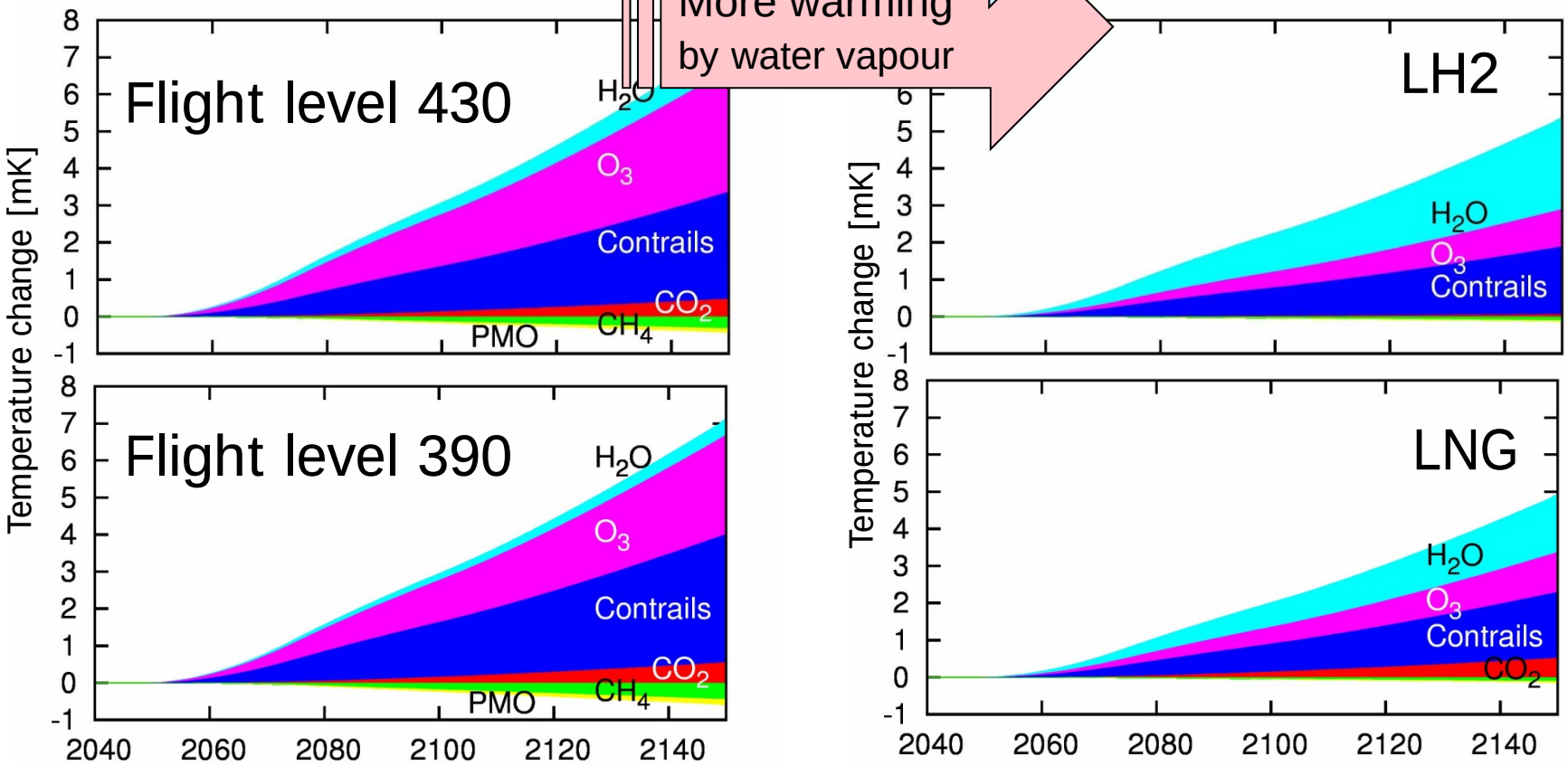
AHEAD: Climate impact: Temperature change

Reference aircraft: B787 flying at FL430 and FL390

Climate impact: Temperature change [mK]

Less warming by CO_2, NO_x, contrails

More warming by water vapour

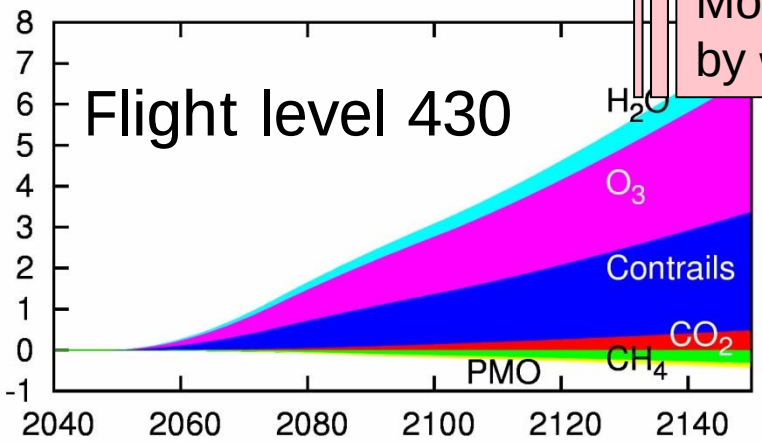


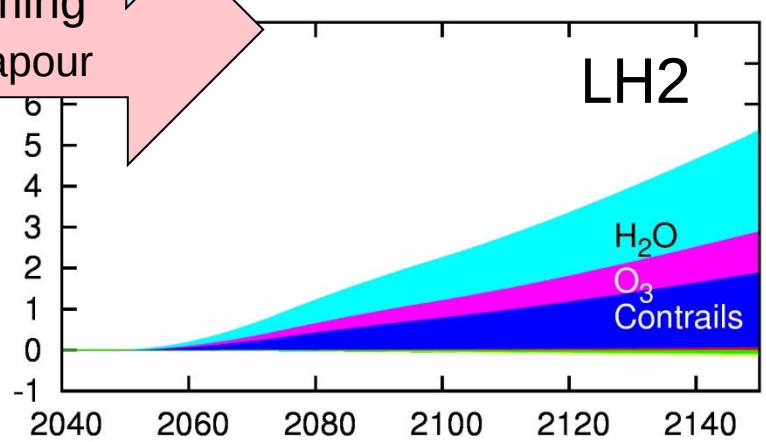
Grewe et al. (2014)

Climate impact: Temperature change [mK]

Less warming by CO_2, NO_x, contrails

More warming by water vapour



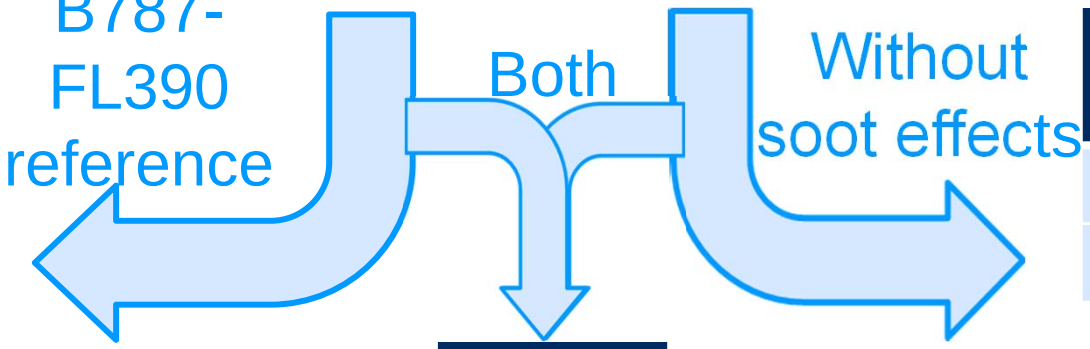


Climate change [%]	CO_2	NO_x	Con-trails	H_2O	Total
LH2	-6	-29	-15	+25	-25
LNG	-0.6	-28	-16	+12	-32

Grewe et al. (2014)

Climate impact: Some sensitivities

Climate change [%]	CO_2	NO_x	Con-trails	H_2O	Total
LH2	-6	-29	-15	+25	-25
LNG	-0.6	-28	-16	+12	-32



Total
-20
-27

Total
-1
-8

Con-trails	Total
2	-8
1	-15

Grewe et al. (2014)

Summary & Conclusion

The climate impact of the AHEAD aircraft shows in comparison to a B787 future reference:

- CO_2 and NO_x induced climate impact reduction.
- H_2O induced climate impact increase.
- Potentially a decrease in the contrail climate impact due to a decrease of particle emissions, which is offset by the increase in H_2O emissions (ongoing analysis).

Both aircraft (AHEAD & B787) have a **higher flight altitude** and a **larger H_2O climate impact** than other long-range a/c.

AHEAD technology implies a shift in the climate impact:
CO_2, NO_x and contrail $\Longrightarrow$ contrail and H_2O.
Might be easier to mitigate these by other measures.


Thank you for your
attention