The Climate Impact of Hypersonic Transport

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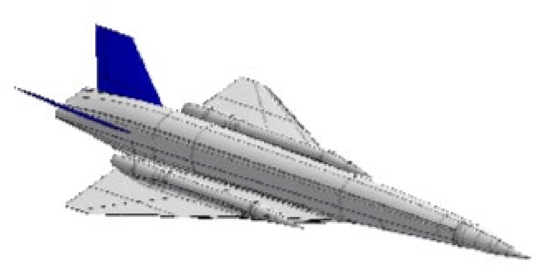
Three aircraft and the emissions of a respective fleet

Subsonic aircraft A350

H_2O 5.02 Tg/year
NO_x 0.07 Tg/year
H_2 0.00 Tg/year

Low flying hypersonic aircraft ZEHST



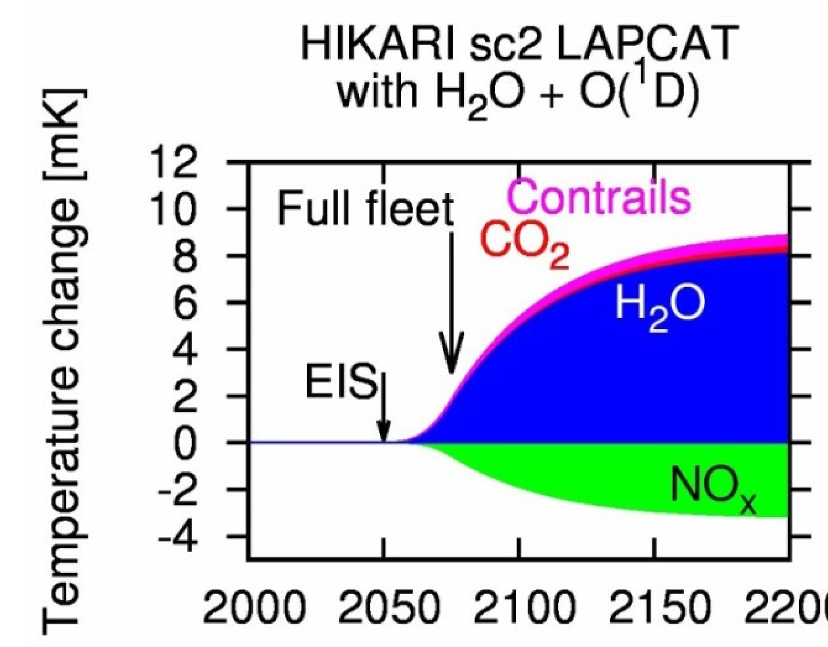
H_2O 22.58 Tg/year
NO_x 0.11 Tg/year
H_2 0.16 Tg/year

High flying hypersonic aircraft LAPCAT

H_2O 31.37 Tg/year
NO_x 0.11 Tg/year
H_2 0.31 Tg/year

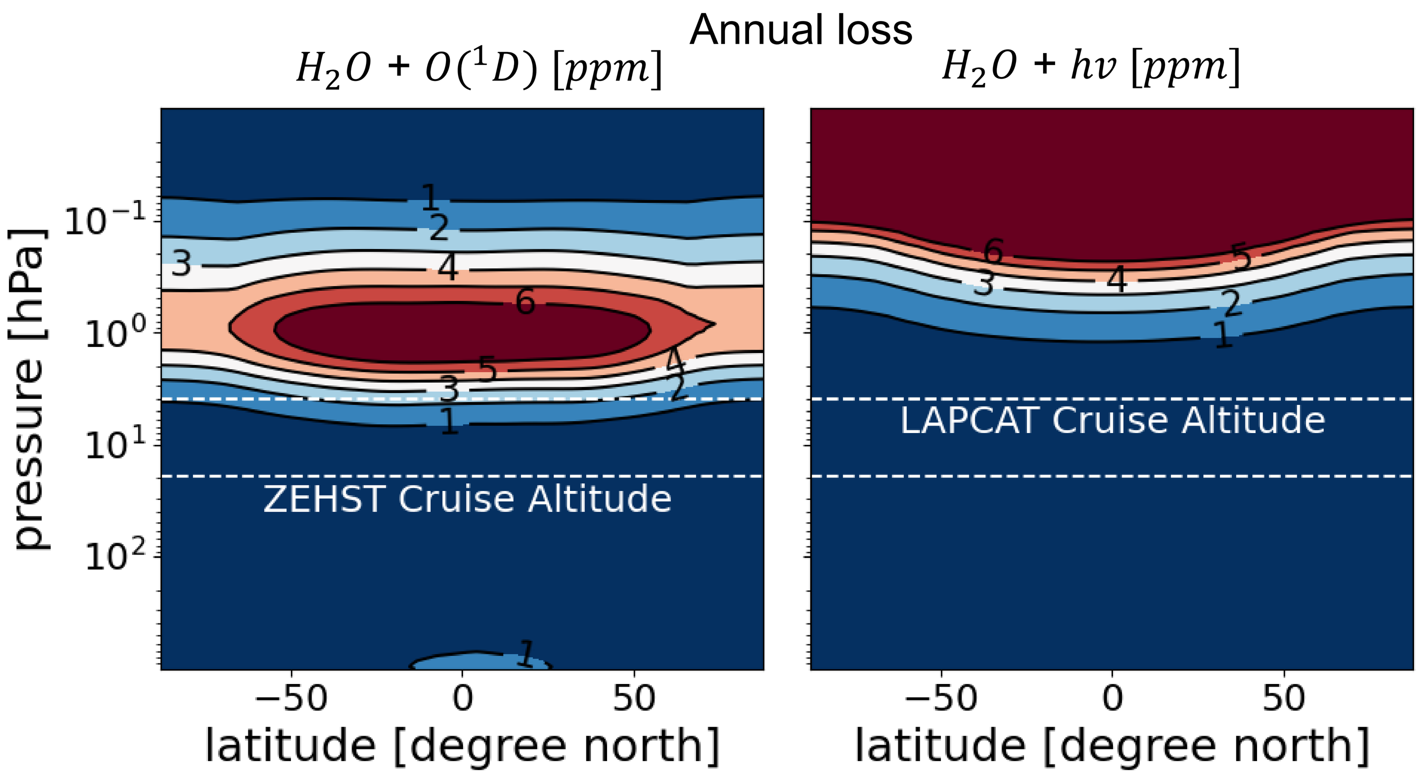
Hypersonic aircraft could replace subsonic aircraft at long-distance flights

Climate impact of aircraft emissions



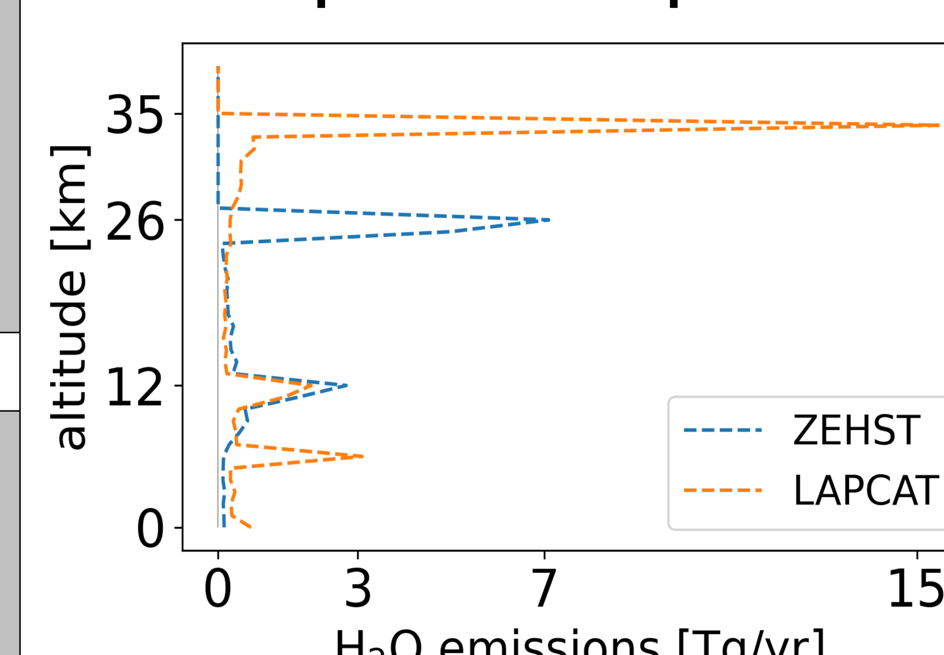
→ Water vapour dominates temperature change by emissions.

Stratospheric loss of H_2O driven by reaction with $O(^1D)$ and photolysis



- Loss rates are highly altitude dependent.
- $H_2O + O(^1D)$ dominant at middle altitudes.
- **Chemical removal of water vapour emissions more effective for high flying aircraft.**

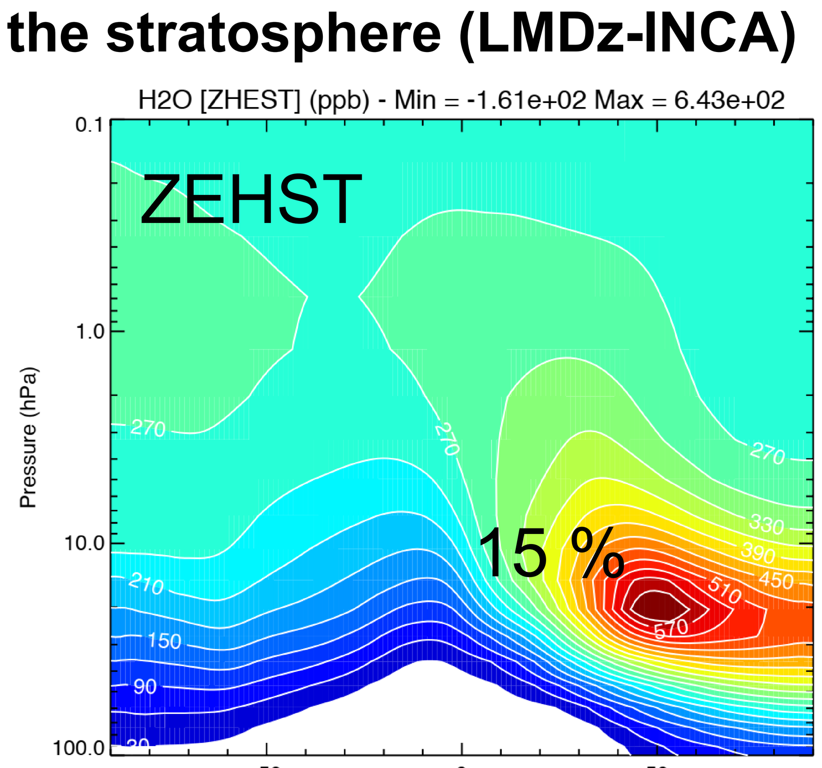
Model input: Water vapour emitted

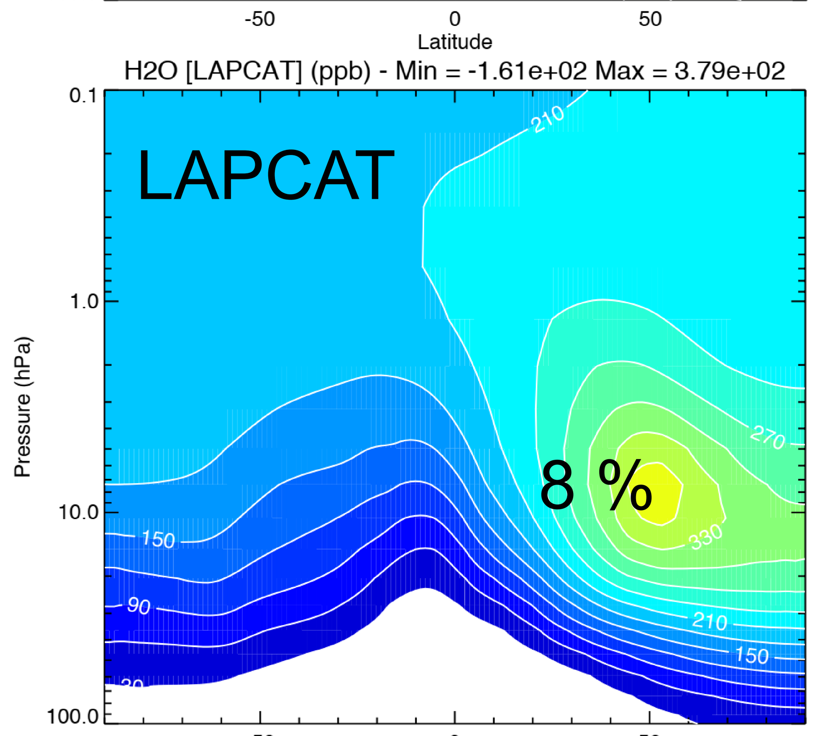


→ Around two-third of fleet emissions are emitted at high altitudes.

Preliminary results – Comparing EMAC and LMDz-INCA

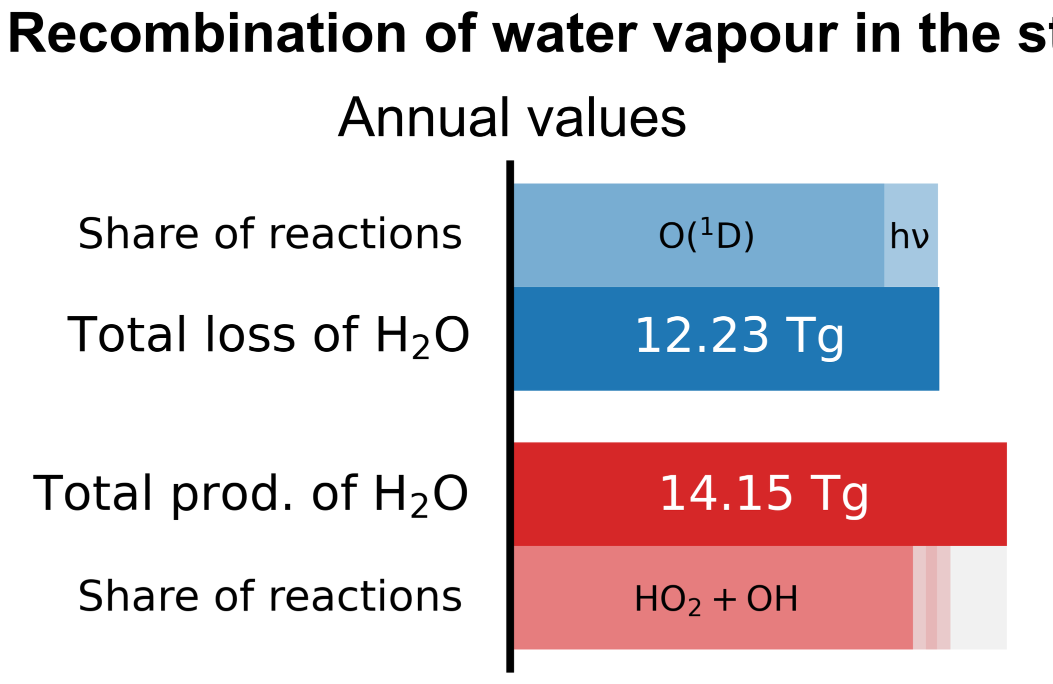
Accumulation of water vapour in the stratosphere (LMDz-INCA)



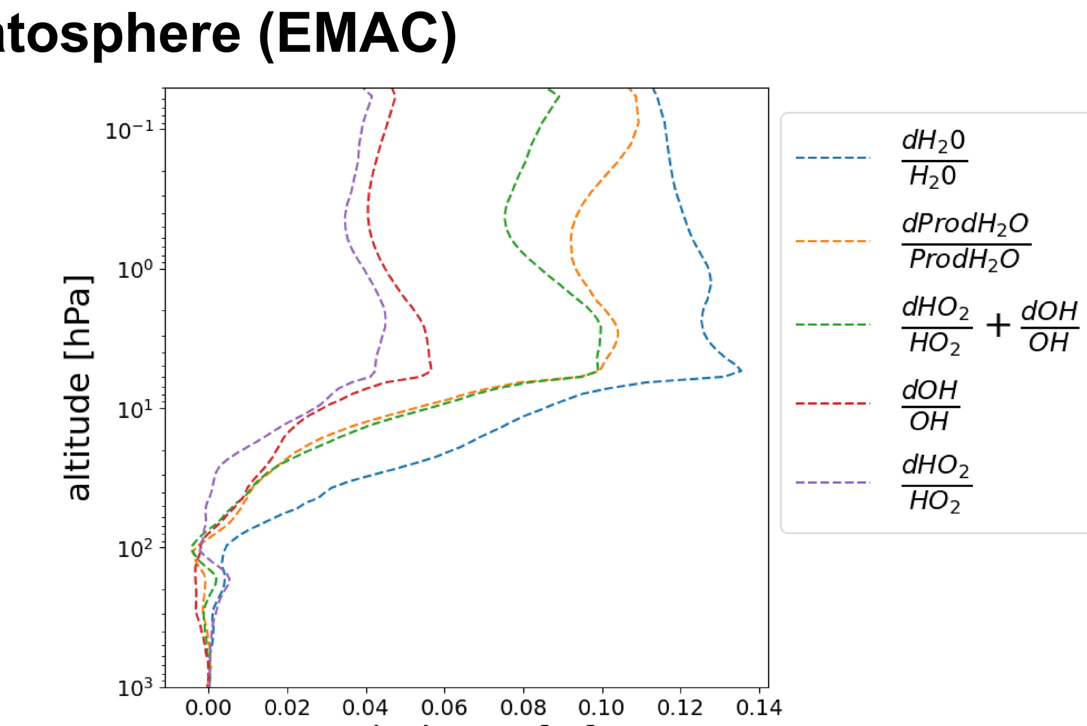


H_2O emissions introduce a peak 15 % and 8 % ppb on top of the CH_4 oxidation based H_2O background for ZEHST and LAPCAT respectively.

Recombination of water vapour in the stratosphere (EMAC)



5 H_2O-destroying- and 45 H_2O-producing-reactions at 0.1 - 100 hPa altitude.



Current status

- Chemical depletion of water vapour more efficient at higher altitudes.
- HOx-recombination reforming water vapour defining factor in model EMAC.
- Good model agreement for ZEHST aircraft, differences for LAPCAT aircraft (LMDz-INCA & EMAC).
- AirClim model agrees well with LMDz-INCA. Climate impact of ZEHST aircraft ~50 times and of a LAPCAT aircraft ~10 times larger than for a subsonic reference (not shown).

Conclusion

- H_2O increase leads to warming.
- NO_x increase causes ozone reduction and thus cooling.

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