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Small-scale supersonic transport aircraft (S4TA): HISAC project

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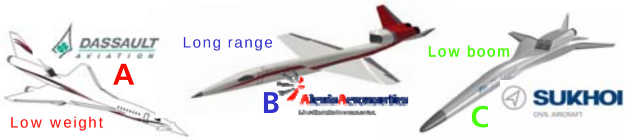
Motivation

- Supersonic transport would facilitate long-range one day trips
- Market for small-scale aircraft
- Light aircraft with low boom shape could enable high speed even over land.
- Here: What is the potential climate impact?

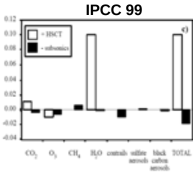
The 3 HISAC Families



Common Requirements	Entry into Service	Ref PAX	Max. PAX	Subsonic Cruise	Max. Speed	Max. Alt.	Max Range	Height Seating
	2015	8	19	0.95 MN	1.6 MN	FL410	4000 nm	1785 mm
Specific config.	**Length [m]**	**Wing span [m]**	**MTOW [tons]**	**Fuel /MTOW [%]**	**Max. Speed**	**L/D**	**Max Range**	**Number of engines**
A - weight	36.8	18.5	51.1	53	1.6	7.00	4000 nm	3
B - range	41.6	24.0	60.5	53	1.6	7.45	5000 nm	2
C - boom	40.9	19.1	53.3	51	1.8	7.74	4000 nm	2

Overview on previous studies on supersonic transport

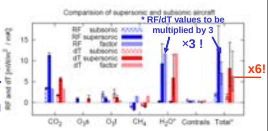
IPCC 99



Main contributors: H_2O and CO_2

Large-Scale Supersonic Aircraft have a 6 time larger climate impact than subsonics.

SCENIC/ECATS



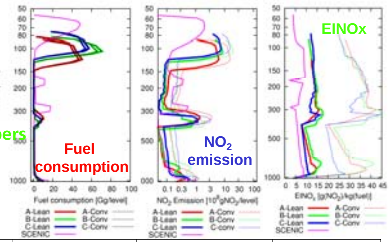
Grewe and Stenke, 2008

Project	Concept	Full fleet	Cruise Alt. [km]	Number Aircraft	PAX	Speed [Mach]	Fuel [10^9 kg/a]	RF [mW/m²]
HSRP 1999	Boeing	2015	18-21	500	~300	2.4	82	-
IPCC 1999	Boeing	2050	17-20	1000	309	2.4	137	100
NASA 2002	Boeing	2015	15,17,19	500	10	<<2.4	1-4	-
SCENIC 2007	Airbus	2050	16-19	500	250	2.0	62	40
HISAC 2009	Dassault Alenia Sukhoi	2050	15-16	250	8	1.6-1.8	0.4	0.1

HISAC Emissions

Methodology:

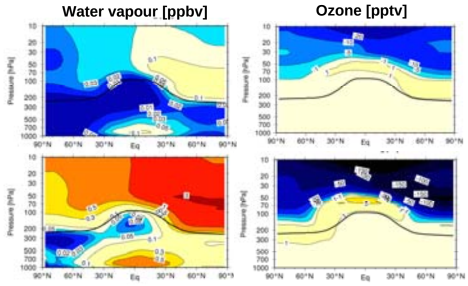
- 4 flight trajectories representing regions from Pole to Tropics
- Calculation of emissions along flight trajectories
  - 2 combustion chambers (conventional, LPP)
- Calculation of concentration changes
- and climate impact



Configuration	Mean flight altitude [kft]	Mean fuel Consumption [t]	Mean fleet fuel Consumption [Tg]	EINOx (LPP) [g(NO_2)/kg(fuel)]
A	50.6	1.584	0.396	11.8
B	52.6	1.589	0.397	11.9
C	54.0	1.776	0.44	10.6
SCENIC	54-64	-	62.0	4.6

Atmospheric composition changes

Water vapour [ppbv] — Ozone [pptv]



HISAC fleet

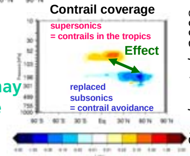
SCENIC scaled to HISAC fuel consumption

Changes relative to background:
Water vapour: 0.01 to 0.05 %
Ozone layer: ~ -0.0005%

Non-CO_2 effects are a factor of 5-10 smaller than for the SCENIC fleet

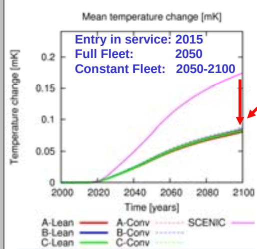
Contrails may form in the tropics!

Contrail coverage

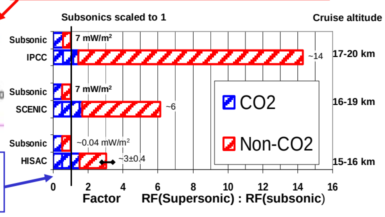


Stenke et al. 2008

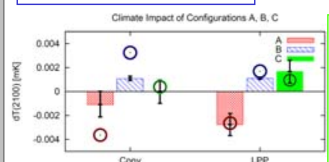
Climate impact



- Climate impact by 2100: ~0.08 mK
- 50% reduction of the climate impact by reducing non-CO_2 effects.
  = lower cruise altitude wrt SCENIC/IPCC



Climate impact factor:
Large Scale Aircraft: 6-14
Small Scale Aircraft 3±0.4



- Small differences between A, B and C
- Configuration A: Minimal climate impact
- Results based on Monte-Carlo simulation covering uncertainties in atmospheric processes.
- 2 combustion chambers:
  CONV = Convetional
  LPP = Lean-Premixed-Prevaporised

Summary

- Climate impact / ozone depletion of a fleet of S4TA are considerably smaller than for supersonic fleets considered previously for 3 reason:
  (1) Smaller fleet size (Factor 2-4)
  (2) Smaller aircraft = less fuel consumption (Factor ~40)
  (3) Lower flight altitude = smaller Non-CO_2 effects (Factor ~5)
- Climate impact and ozone depletion of a S4TA fleet are larger than for respective subsonic fleet (Factor 3±0.4).

Outlook

Current and future 3D-emission estimates for small-scale aircraft needed.

Direct intercomparison of climate impact of sub- and supersonic small-scale aircraft should be performed on the basis of those data.

References

Grewe, V. and A. Stenke, AirClim: an efficient climate impact assessment tool, ACP 8, 4621 - 4639, 2008.
Stenke, A., V. Grewe, and S. Pechtl, Do supersonic aircraft avoid contrails?, ACP ., 8, 955-967, 2008.
Grewe, et al., Climate impact of supersonic air traffic: ..., ACP 7, 5129-5145, 2007.
Grewe, Plohr, Cerino, Muzio, Deremaux, Galerneau, Chaika, de Saint Martin, Hasselrot, Tengzelius, Korovkin, Estimates of the Climate Impact of Future Supersonic Business Jet Configurations – Results from the HISAC Project, in prep., 2009.
Grewe, Stenke, Plohr, Korovkin, Climate functions for the use in multi-disciplinary optimization in the pre-design of supersonic business jet, submitted to The Aeronautical Journal, 2009.

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