ASCENT Project 022
Evaluation of FAA Climate Tools

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Objective:

- Further enhance the overall understanding of aviation impacts on climate and environment
- Studies exploring regional climate impacts from aircraft emissions.
- Evaluate capabilities, limitations, and uncertainties of climate metrics and simple models (e.g., APMT) to aid policy decisions.

Motivation

- Science-based evaluation of analytical tools used by the FAA;
- Development of ideas and concepts for the next generation treatment of aviation effects on the Earth system;
- Updated evaluation and analyses of the science of aviation effects on atmospheric composition and climate;
- Evaluation of potential environmental effects from assumed fleets of supersonic commercial and business jet aircraft
- Address policy questions and consideration of potential policymaking.

Project Benefits:

- Science-based evaluation of analytical tools used by the FAA;
- Development of ideas and concepts for the next generation treatment of aviation effects on the Earth system;
- Updated evaluation and analyses of the science of aviation effects on atmospheric composition;
- The evaluation of potential environmental effects from assumed fleets of supersonic commercial and business jet aircraft;
- To address policy questions and consideration of potential policymaking quantifying regional climate impacts.

Research Approach:

Analyses of atmospheric composition changes and climate effects from aviation emissions

- State-of-the art climate-chemistry modeling capabilities (we are using the greatly extended Whole Atmosphere Community Climate Model (WACCM) version of NCAR's Community Earth System Model) – ground to 140 km with comprehensive tropospheric and stratospheric chemistry.
- Conduct simulations with different emissions scenarios as well as sensitivity studies for different parameters (e.g., fuel burn, NOx) for supersonic and subsonic aircraft fleets.

Consideration of regional analyses concepts (potentially of value for APMT)

- Explore possible ways to derive temperature change for specific regions from subsonic emissions.

Major Accomplishments (to date):

- Two journal papers
- Biweekly telecons with FAA
- Quarterly reports to FAA
- Annual report summarizing progress
- Participate in writing reports for ICAO through ISG
- Presentations and participation in CCR and ASCENT meetings, ICAO, AGU and other conferences

Future Work / Schedule:

- Plan studies using inventories (from ASCENT Project 10) to estimate atmospheric impacts from projected supersonic fleets.
- Results from these studies inform the development of Aviation Portfolio Management Tool – Impacts Climate (APMT-IC) for supersonic impacts (ASCENT Project 58).

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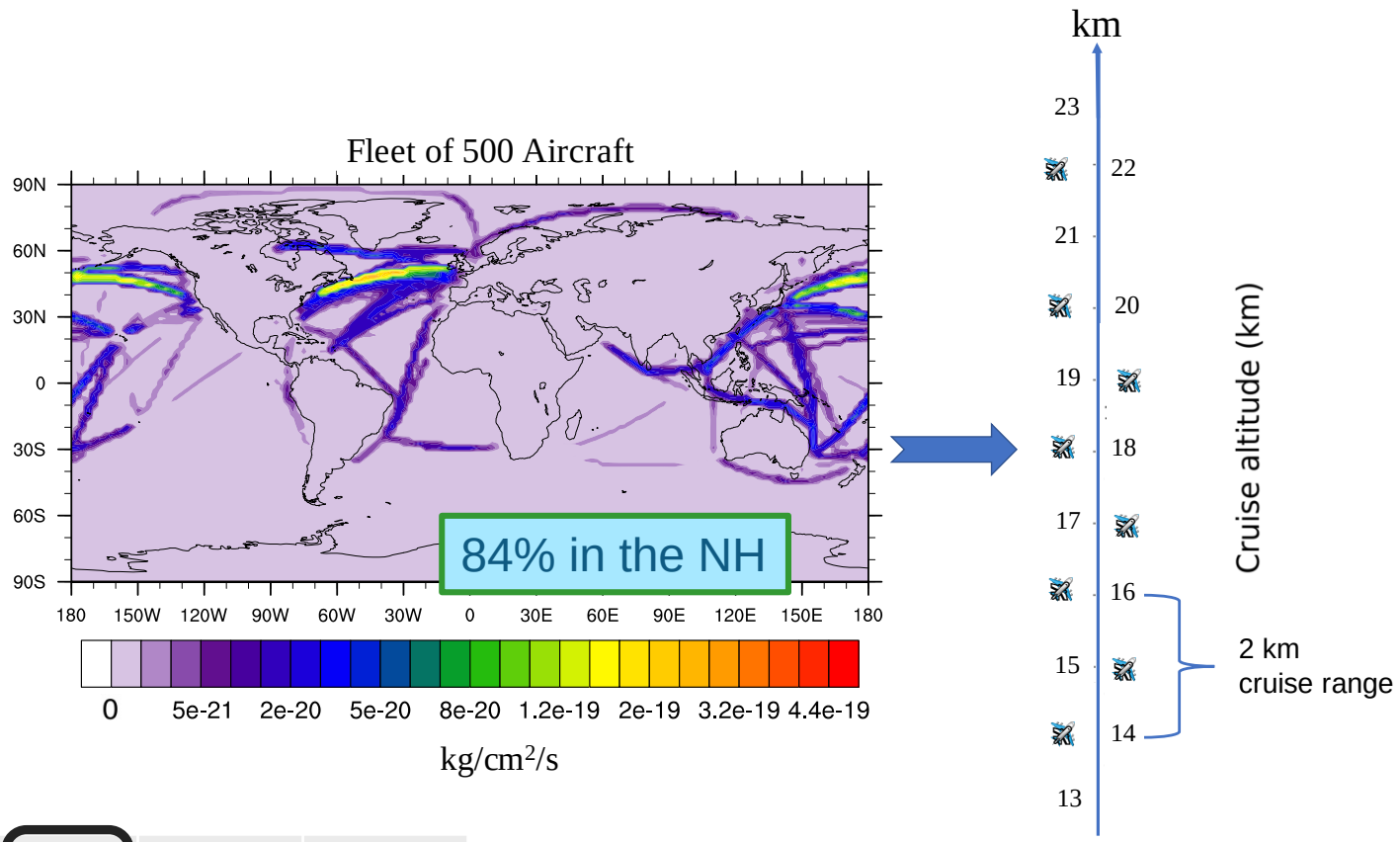
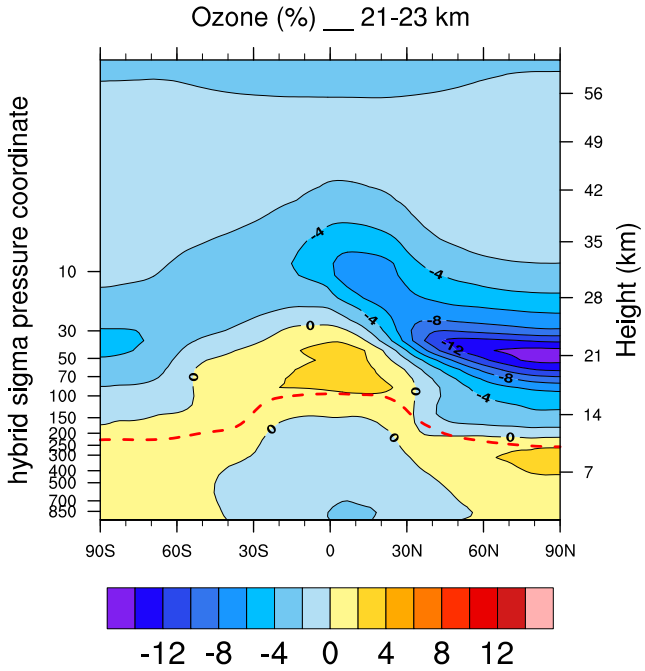


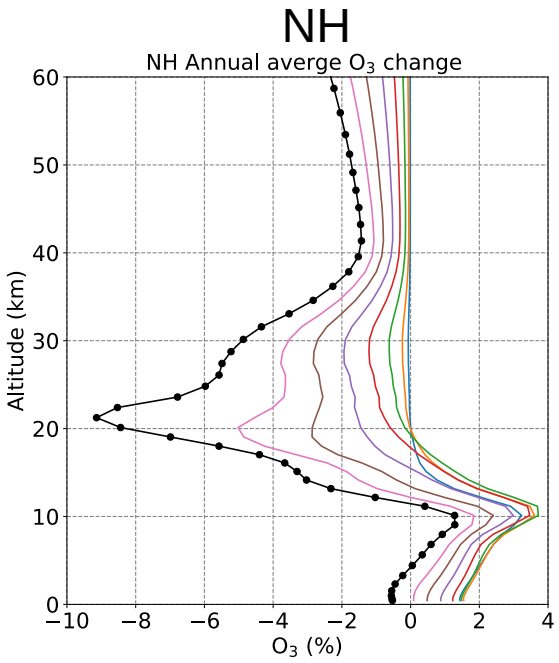
Fleet size	Fuel Burn (Tg/yr)	Cruise Altitude (km)	NOx Emission Index (g/kg)	H_2O Emission Index (g/kg)
500	47.18	13-15	20	1237
500	47.18	14-16	20	1237
500	47.18	15-17	20	1237
500	47.18	16-18	20	1237
500	47.18	17-19	20	1237
500	47.18	18-20	20	1237
500	47.18	19-21	20	1237
500	47.18	21-23	20	1237

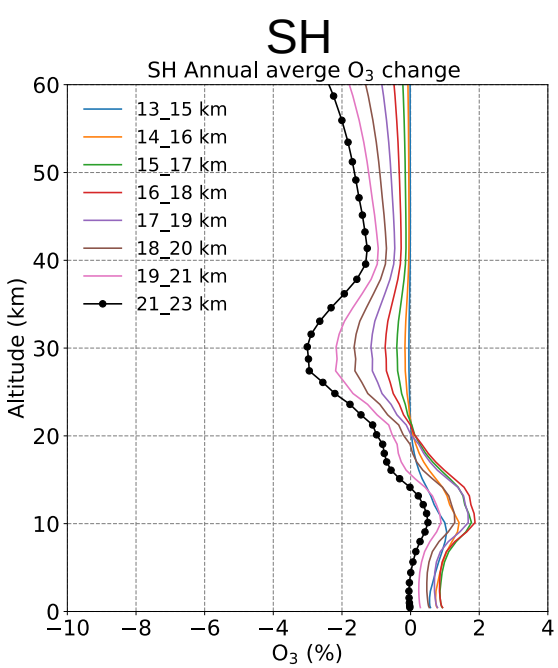
Projected distribution of fuel usage (kg/cm^2/s) vertically integrated at cruise altitudes for the assumed fleet of 500 supersonic aircraft applied to this parametric sensitivity study.

8 emissions scenarios are evaluated

Perturbed Ozone

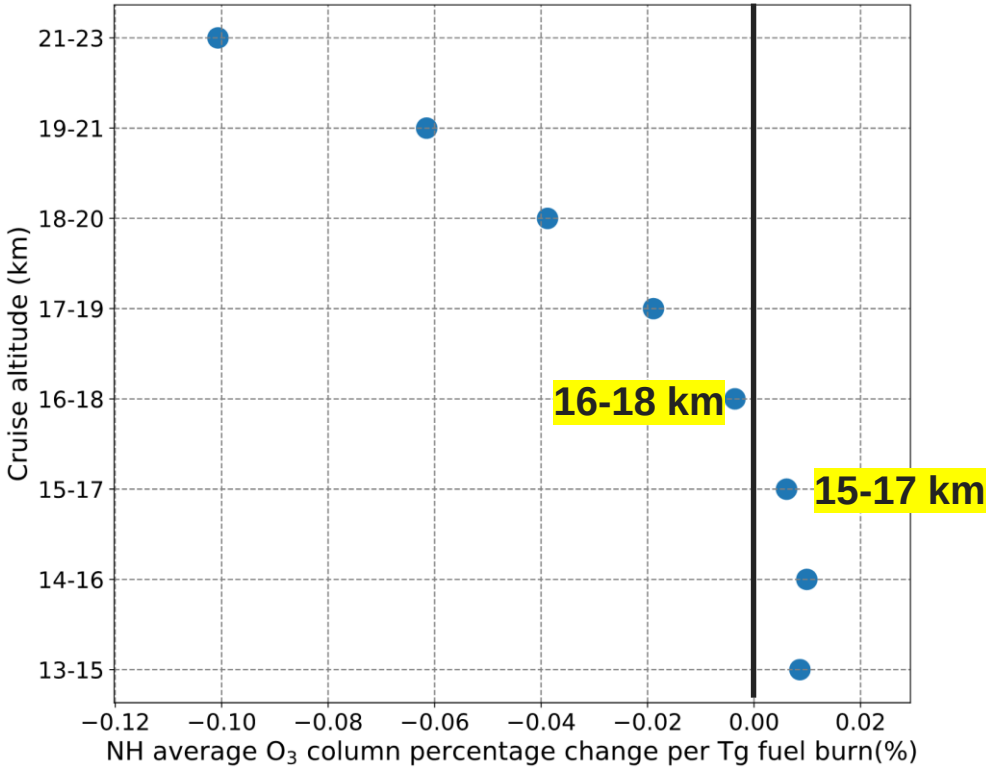






- Ozone production vs. Ozone reduction zone.
- The reduction extends southward to the tropics and SH, with a larger fraction of ozone depletion confined in the NH.
- Ozone depletion increases with cruise altitude;
- For higher emissions altitudes, more ozone depletion occurs in the SH.

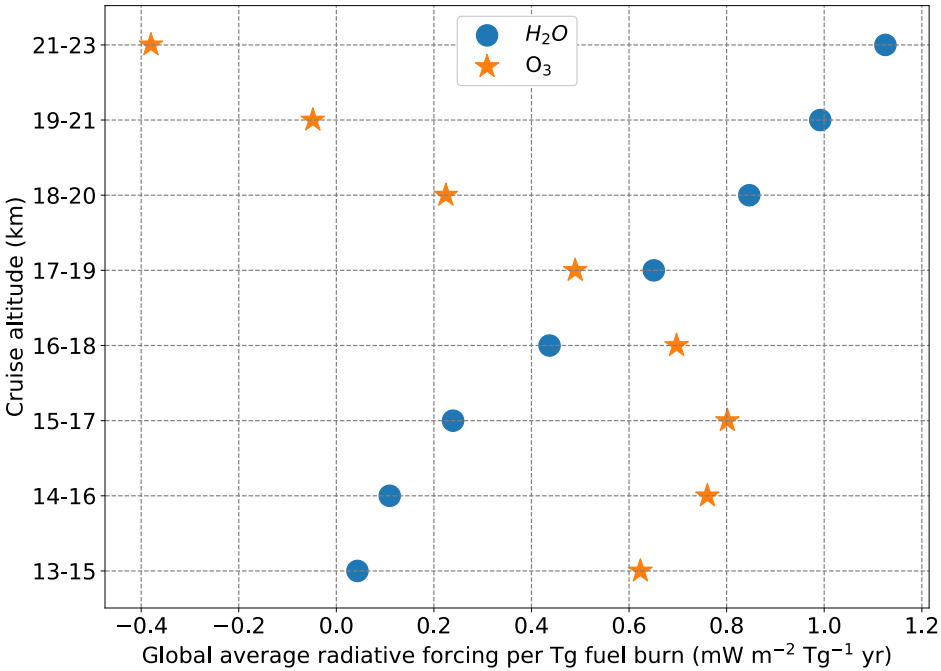
Total column ozone sensitivity to cruise altitude



- Below 17 km, the ozone impact for flying supersonic aircraft is calculated to be positive and overall very small.
- The ozone depletion increased sharply as the flight altitudes exceeded 17 km and effects get more and more negative for higher cruise altitudes.

NH total column ozone change (%) per Tg of fuel burn as a function of cruise altitudes.

Climate Forcing response of NOx and H_2O emission



Radiative forcing per Tg of fuel burn (mW m $^{-2}$ Tg $^{-1}$ yr) as a function of cruise altitudes for the changes in H_2O and O_3.

- Increase of H_2O induced positive forcing with increasing cruise altitude.
- O_3 forcing is the result of perturbations from H_2O and NOx emissions, which depends on cruise altitude.
- The O_3 production below 18 km induce warming; above 18 km, the O_3 depletion results in a cooling result.

Summary

Findings

- For cruise altitudes between 13 and 17 km, total column ozone indicates a slight increase.
- At higher cruise altitudes from 17 to 23 km, the ozone destruction increases with higher cruise altitude.
- Future supersonic aircraft designs are under consideration and actual fleets are highly uncertain. This sensitivity study provides insights on the potential impacts on O_3 relative to cruise altitudes.

Next steps

- Plan studies using inventories developed by ASCENT Project 10 to estimate atmospheric impacts from projected supersonic fleets.
- The results from these studies will inform the development of Aviation Portfolio Management Tool – Impacts Climate (APMT-IC) for supersonic impacts (ASCENT Project 58).

Key challenges/barriers

- Scenarios need to be better defined for studies of potential future SST fleets.

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