Evaluation of FAA Climate Tools

Project 22

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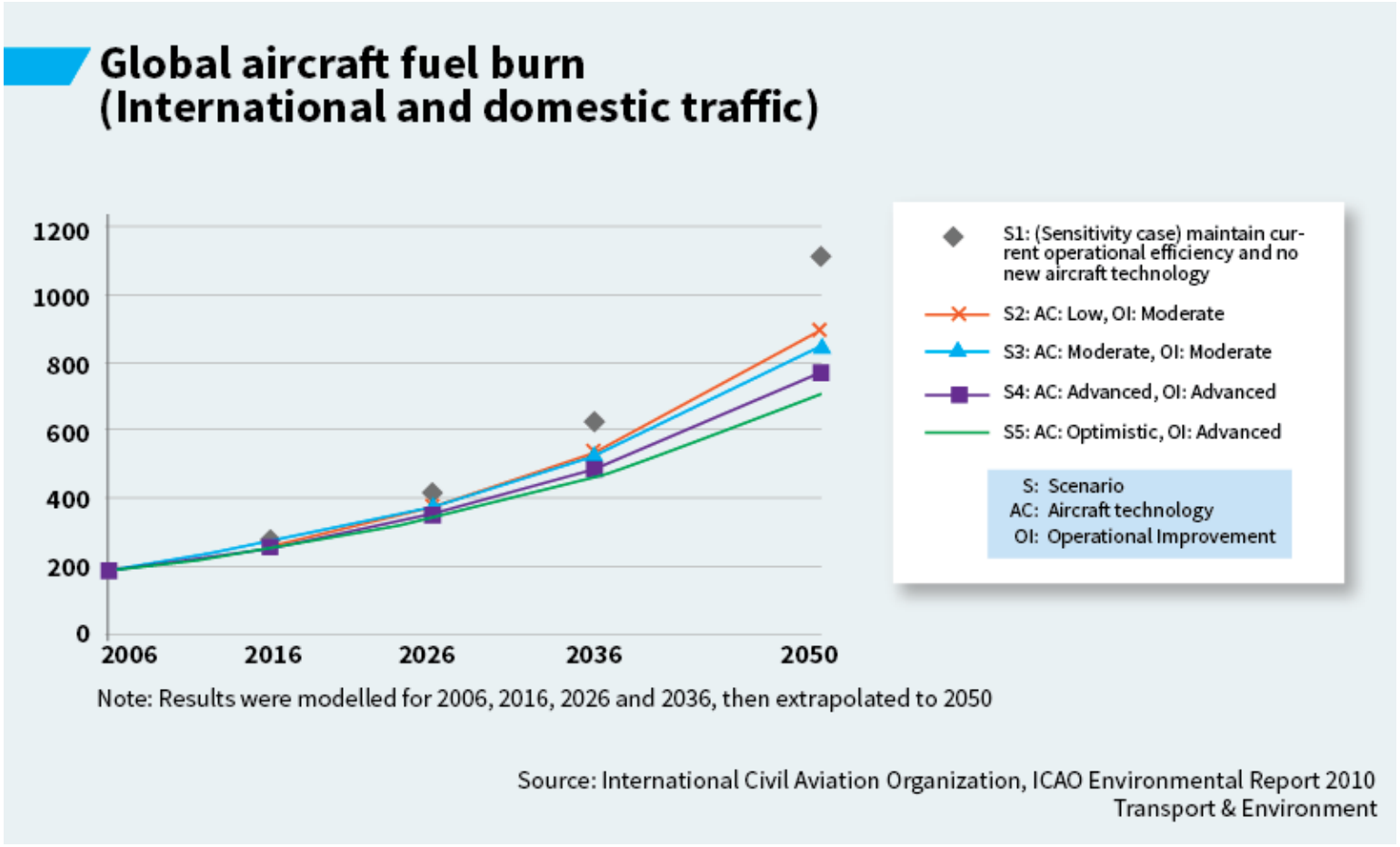
ASCENT
AVIATION SUSTAINABILITY CENTER

Motivation

- This ASCENT project is part of the Aviation Climate Change Research (CCR) Consortium Effort
- Aviation emission contributes to approximately **5%** of the current anthropogenic radiative forcing; and the impact is expected to increase



Objectives

❑ Long-term

Our project is aimed at enhancing the overall understanding of aviation impacts on climate and the evaluation of the capabilities, limitations, and uncertainties of climate metrics and simple models (e.g., APMT) to aid policy making decisions.

❑ Near term

We have several near term objectives:

1. Evaluation of the capabilities of APMT as new versions become available;
2. Provide new analyses of regional impacts from aviation, including an independent review of the work in this direction from CICERO;
3. Provide guidance to FAA relating to their modeling tools and datasets.

Outcomes and Practical Applications

- Outcomes
  - Biweekly telecons with FAA
  - Annual and other reports to the FAA as needed
  - Presentations and participation in CCR and ASCENT meetings, plus presentations at major science conferences

- Practical applications
  - Our research is aimed at enhancing the understanding of aviation effects on the global environment, including effects on climate, including the development and evaluation of metrics and simple tools for policy analyses.
  - Analyses are useful to the FAA, to ICAO, and to the aviation industry

Approach

- Regional analyses of climate effect for aviation emission
  - Use state-of-the-art modeling capabilities (e.g., CAM-chem)
  - Perform and evaluate modeling studies and sensitivity analyses towards understanding aviation emissions effects on atmospheric chemistry and climate

- Evaluation of APMT and its application
  - Synthesis of the current scientific literature and comprehensive model studies to help in the design and evaluation of APMT
  - Balance the tradeoffs between simplicity and properly addressing the underlying physics for policy analysis

Schedule and Status

- CCR / ASCENT Projects (Oct 2017 to Mar 2018):
  - ✓ Ongoing coordination with MIT and FAA on simple modeling tools (report sent to FAA on evaluation of latest version of APMT)
  - ✓ Evaluations of APMT v24 (FAA report completed)
  - ✓ Analyze NCAR CAM5-Chem coupled simulations for regional evaluation (ongoing)
  - ✓ Evaluation of the regional climate effects based on different latitudinal bands and regions (ongoing)
  - ✓ For regional studies, new modeling studies using CAM5-Chem to calculate the regional forcing effects of NOx and aerosols emissions (not yet started)
  - ✓ Evaluation of regional climate metrics and providing new insights on regional metrics that could capture regional heterogeneity of the aviation signal (not yet started)

Recent Accomplishments and Contributions

Part 1. Regional analysis

Aviation emissions scenarios in present day (PD) 2006 and in 2050

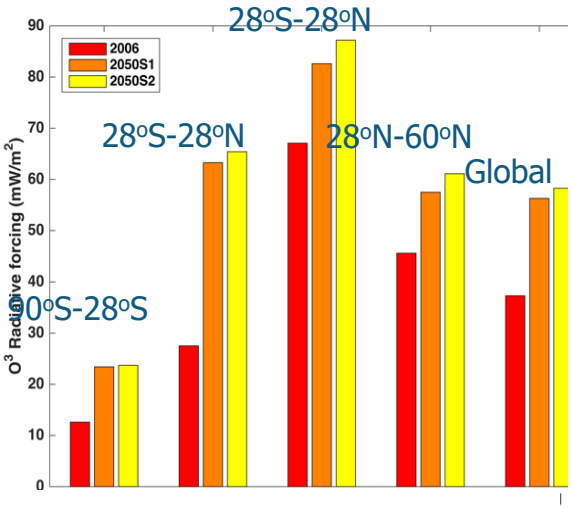
Future Scenario list	
Baseline	Baseline fuel burn (no technology improvement from PD)
Scenario 1 (SC1)	Reduced fuel burn (technology improvement included)
Scenario 2 (Alt)	Alternative fuel (reduced fuel burn, no sulfur, 50% BC)

	Fuel Burn (Tg)	NOx (Tg N)	BC (Gg)	H2O (Tg)	SO2 (Tg)	SO4 (Gg)
PD	188.1	0.73	5.0	232.0	0.221	6.77
SC1	514.4	1.38	13.7	559.8	0.53	16.74
Alt	514.4	1.38	6.9	559.8	0	0

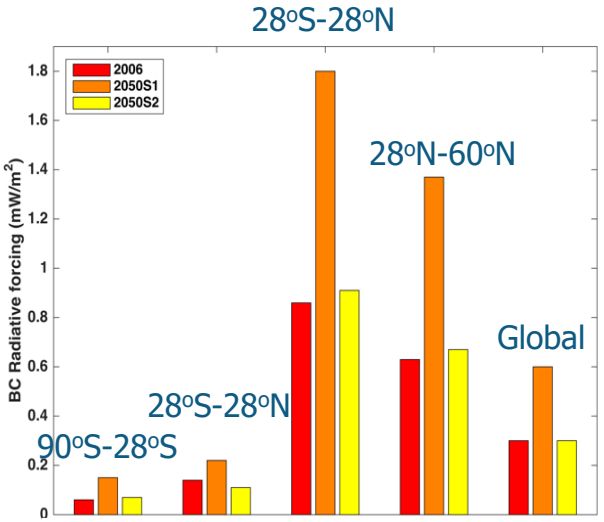
No sulfur emission from alternative fuel

Recent Accomplishments and Contributions

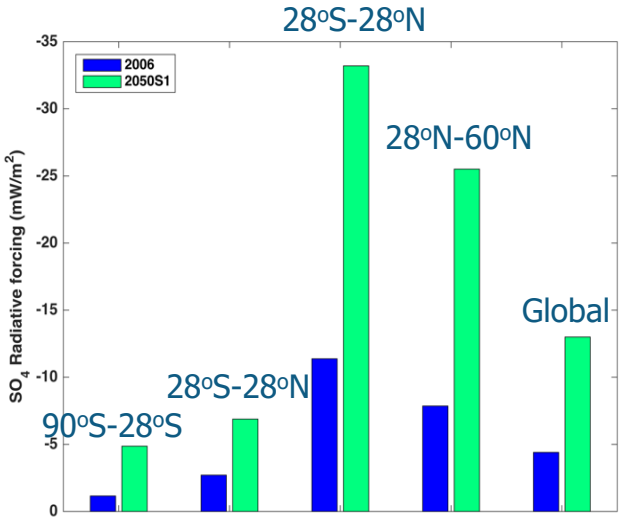
Comparison the radiative forcings over four latitude bands (90°S – 28°S, 28°S – 28°N, 28°N – 60°N, 60°N – 90°N) to global values in 2006 and future scenarios



O_3



Direct BC

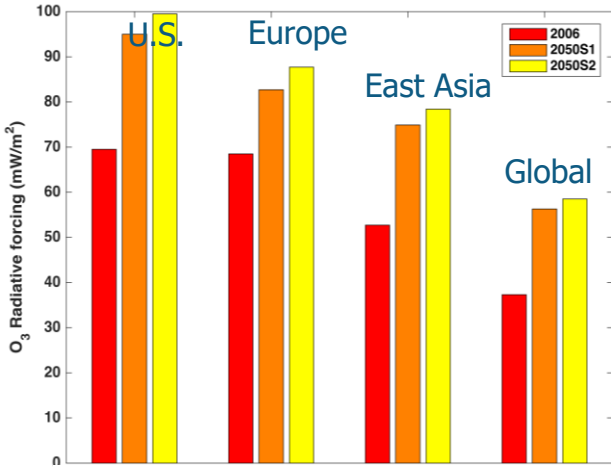


Direct Sulfates

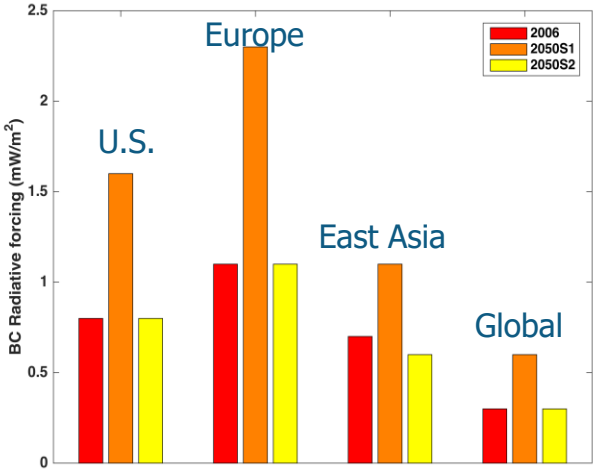
- RF are mainly distributed over the NH, particularly between the latitude band 28°N-60°N, where most of aviation emission occurs.
- Forcing of BC and SO_4 have larger hemispheric asymmetries than O_3-short.
- Total forcing over the NH is up to 10 times more than the forcing over SH.

Recent Accomplishments and Contributions

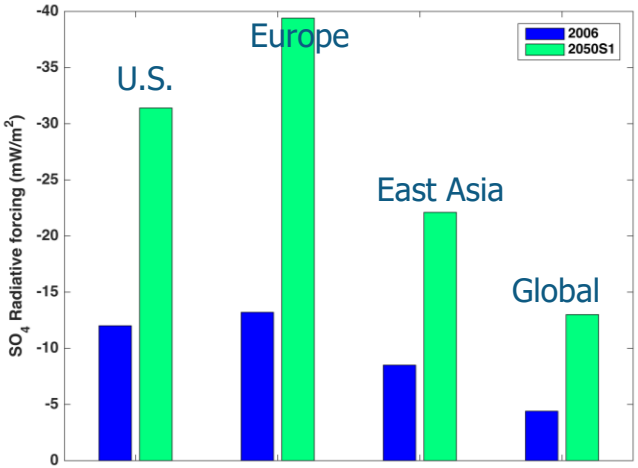
Comparison the radiative forcings over local regions (United States, Europe and East Asia) to global values in 2006 and future scenarios



O_3



Direct BC



Direct Sulfate

- Forcing for short-lived species over U.S., Europe and East Asia is **up to 4 times** of its corresponding **global values**.

- BC and Sulfate RFs have larger **regionality** than ozone forcing, which is likely related to the **lifetime differences**: O_3-short (a few months) and BC and Sulfates (a few days to few weeks).

Recent Accomplishments and Contributions

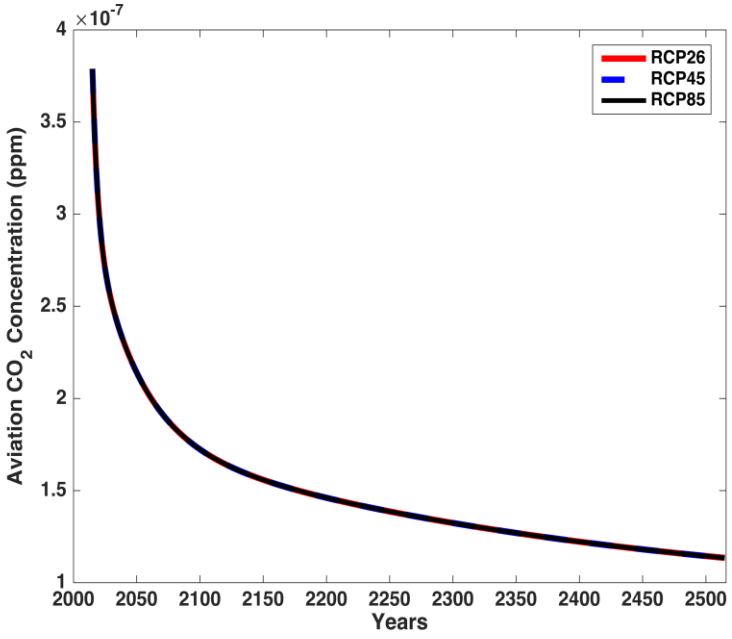
Part 2. APMT evaluation

- Previous report pointed out that APMT did not include the climate effect of nitrate aerosol.
  - Latest APMT v24 has included the cooling effect of nitrate aerosol as a short-lived forcing
- APMT v24 now includes the non-linear treatment of the impulse response function for CO_2 that we had previously recommended.
- Indirect water vapor forcing (in stratosphere) still needs to be included in APMT.

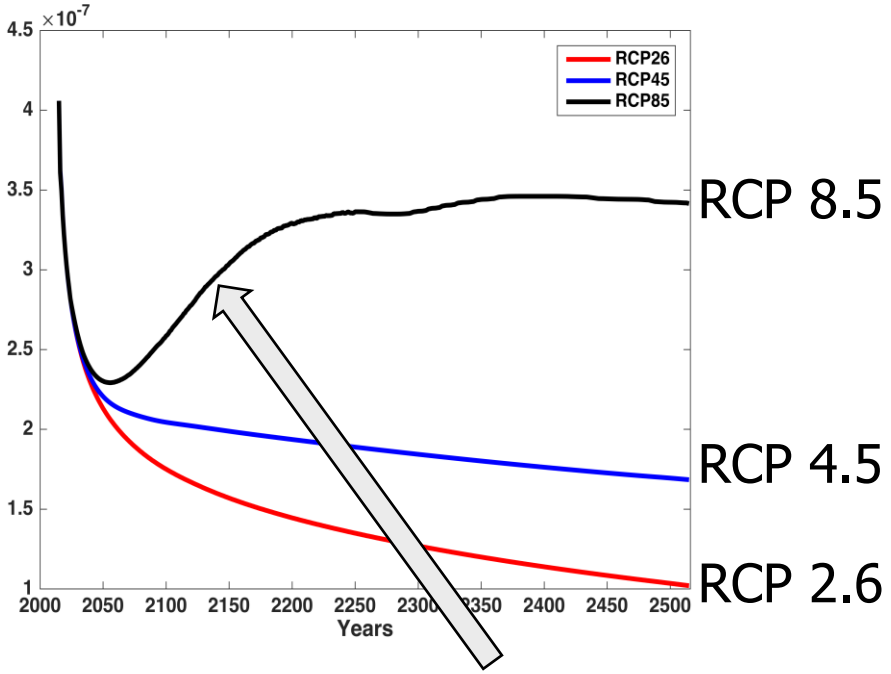
Recent Accomplishments and Contributions

CO_2 model in APMT (Pulse emission in 2015)

v23



v24



The increase trend under RCP8.5 likely related to ocean responses.

- APMT v24 can now capture the nonlinearity of the ocean and biosphere carbon uptake.

Summary

- Summary statement
  - Completed review the recent version 24 of APMT, report sent to FAA
  - Completed portions of the the regional analysis of climate effects from aviation -- for short-lived species (O_3-short, BC and sulfate)
  - Analyses of NCAR CAM5-Chem coupled runs partially completed

- Next steps
  - Development of modeling studies using CAM5-Chem to calculate the forcing effects of aviation NOx and aerosols emissions as needed
  - Evaluation of regional climate metrics – analysis of Absolute Regional Temperature change Potential (ARTP) from CICERO using our model results
  - Evaluation of regional climate sensitivity and examine how remote emissions and forcings affect local response
  - Complete and publish our analyses of regional effects from aviation based on latitude bands and global subregions

References

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