

FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Development of NAS wide and Global Rapid Aviation Air Quality Tools

Project 20

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- Aviation emissions lead to the formation of PM_{2.5} and ozone (O₃)
- Health impacts exist on local, regional, and global scale
- Traditional chemical transport models are computationally expensive
- Policy applications require a rapid assessment tool

Long-term:

- Provide a validated tool for both the US and the global domain, that enables the **rapid air quality assessment** (PM_{2.5} and O₃) of aviation emissions scenarios.

Near-term:

- Update the ozone capability of the tool
- Investigate second-order sensitivities with respect to background emissions
- Quantify the uncertainty of the tool
- Develop the Canadian, European and South-Eastern Asian high resolution domains
- Investigate the impact of changes in meteorology

Sensitivity matrices:

- Provide information about where the health impacts from aviation emissions come from (in terms of species, location, and time)

Uncertainty quantification:

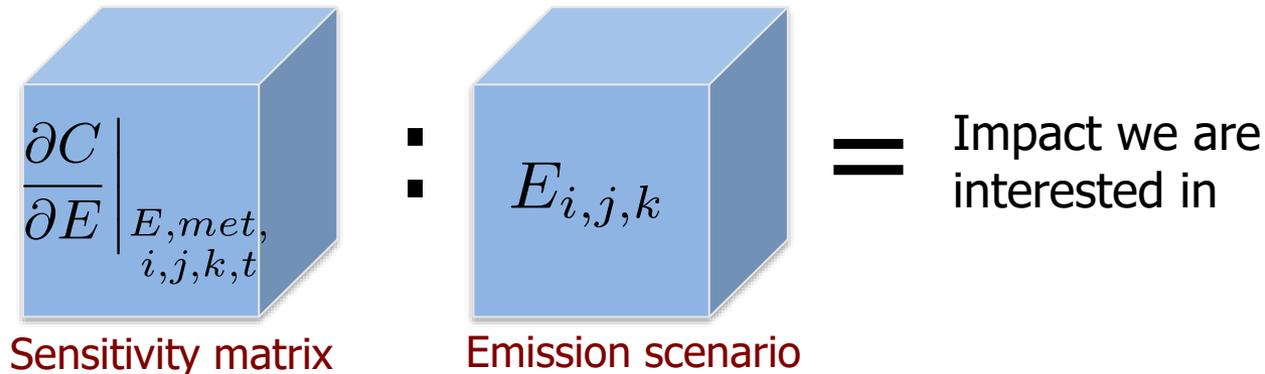
- Validation of the model against monitor observations

Non-US nested domains:

- Fine resolution analysis of the sources of health impacts from aviation emissions in Canada, EU, SEA

Practical applications

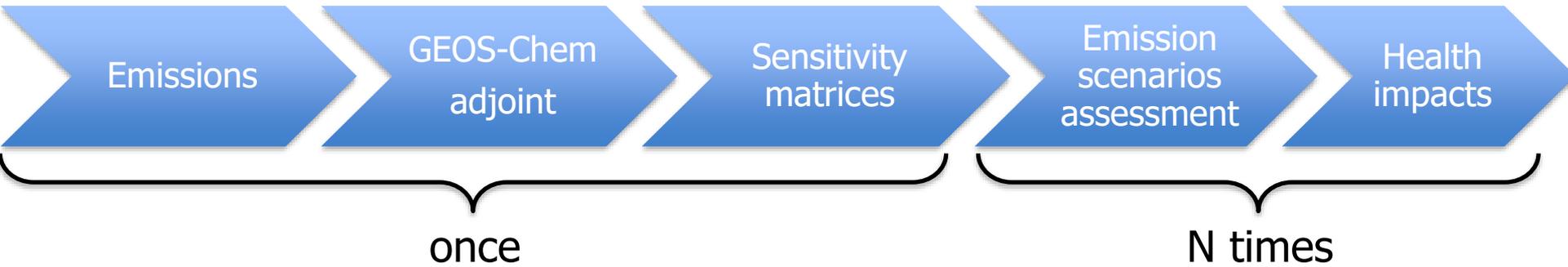
Rapid policy assessment tool:



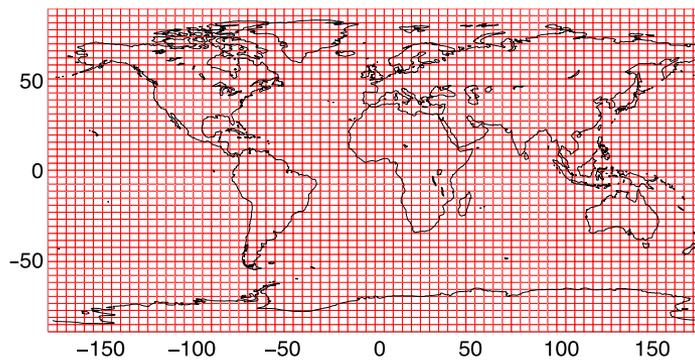
The sensitivity matrices provide information about the sources of health impacts from aviation emissions:

- Species
- Time
- Location

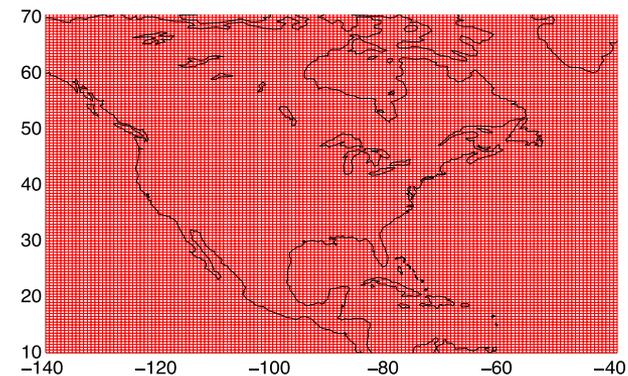
Approach



- Sensitivity matrices give us the gradient of the objective function (e.g. human exposure) with respect to multiple inputs
- Two different resolutions:



Global domain ($4^\circ \times 5^\circ$)



Nested NA domain ($0.5^\circ \times 0.666^\circ$)

Schedule and Status

| Time Period | Deliverables |
|---------------|--|
| February 2017 | Second-order sensitivities calculated and analyzed |
| March 2017 | Model evaluation and validation |
| May 2017 | Canadian nested-domain capability |
| June 2017 | Second order sensitivity study for changes in meteorology |
| August 2017 | Extend the tool to the EU and SEA nested GEOS-Chem domains |

- Current status: working on second-order sensitivity calculations and sensitivities of O₃-related health impacts

Second-order sensitivities

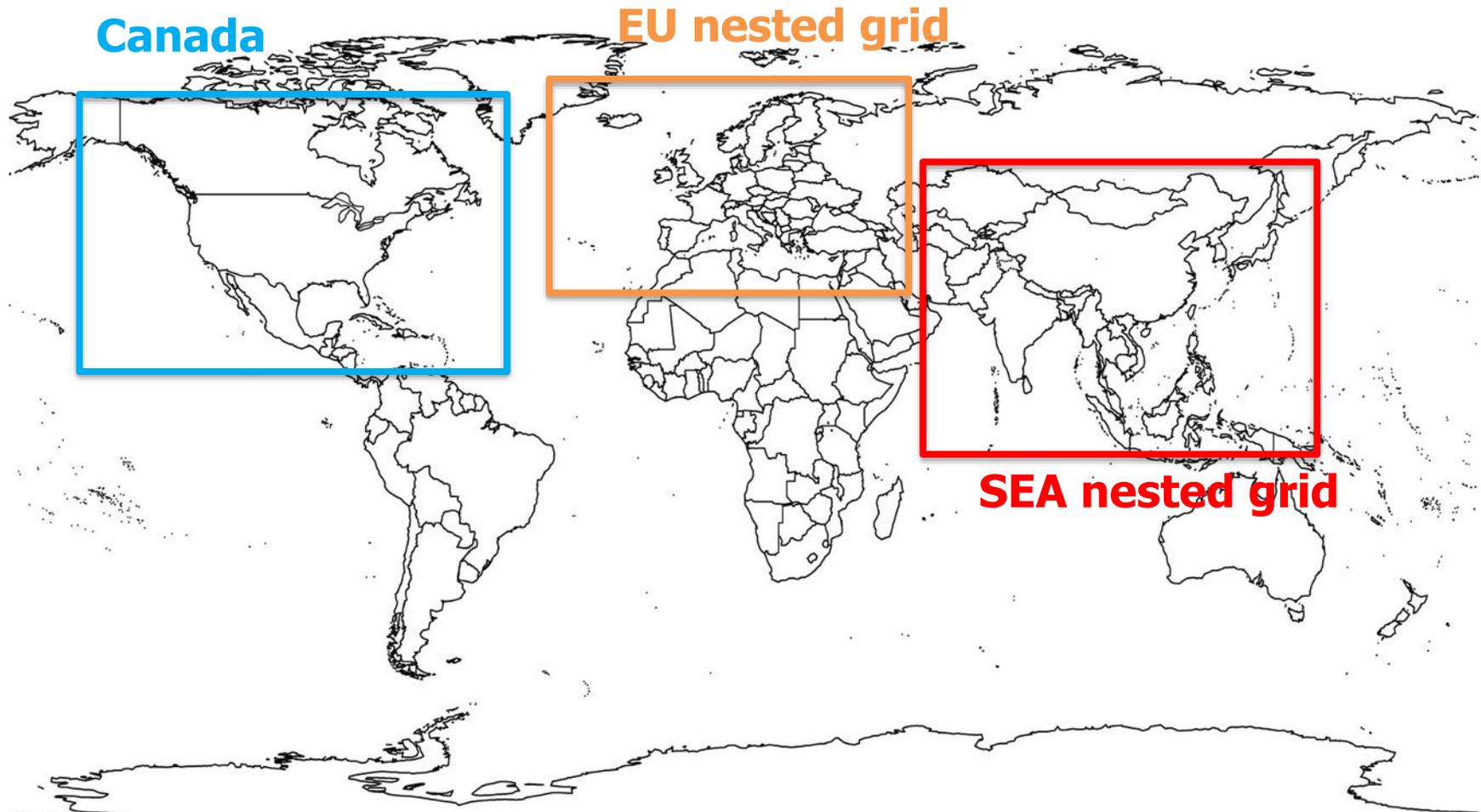
- Understand the impact of changes in:
 - Background emissions
 - Meteorology

Model evaluation

- Validation of the model against monitor observations
- Comparison on the model outputs with GEOS-Chem finite difference sensitivities

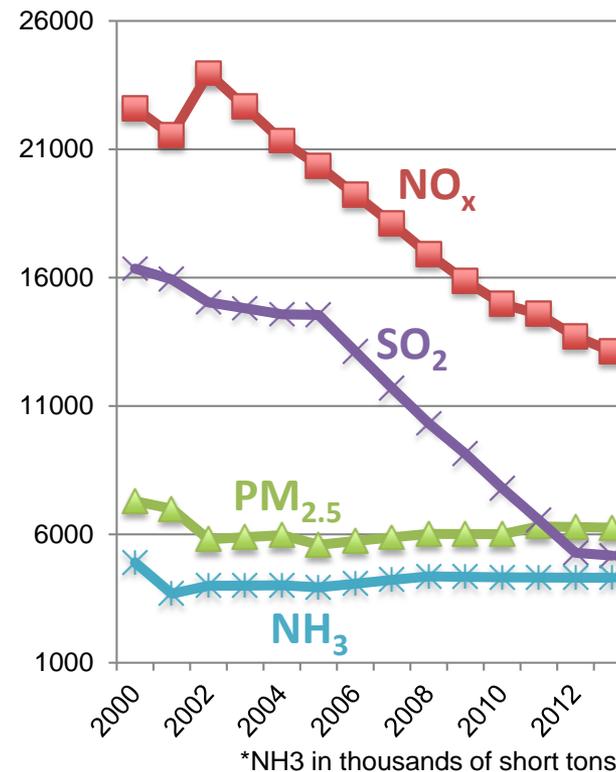
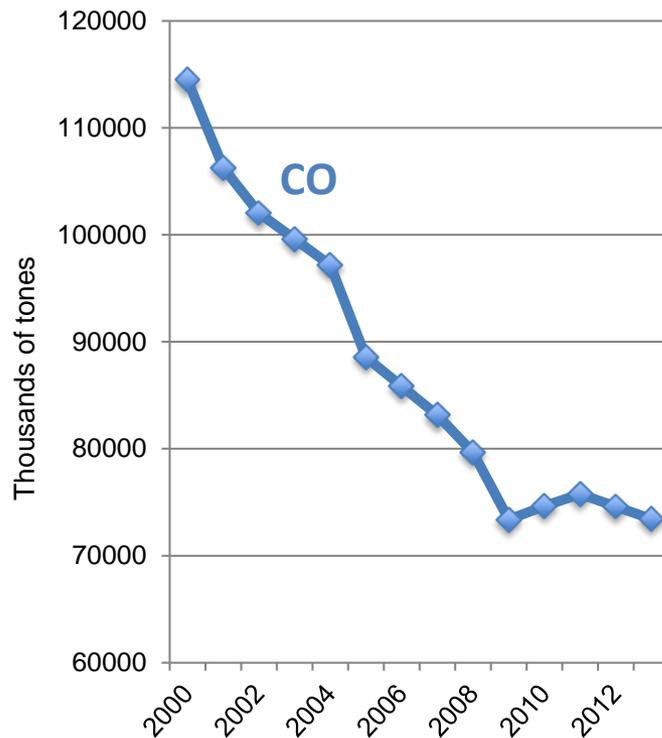
Scheduled outcomes

- Non-US nested domains



Recent Accomplishments and Contributions

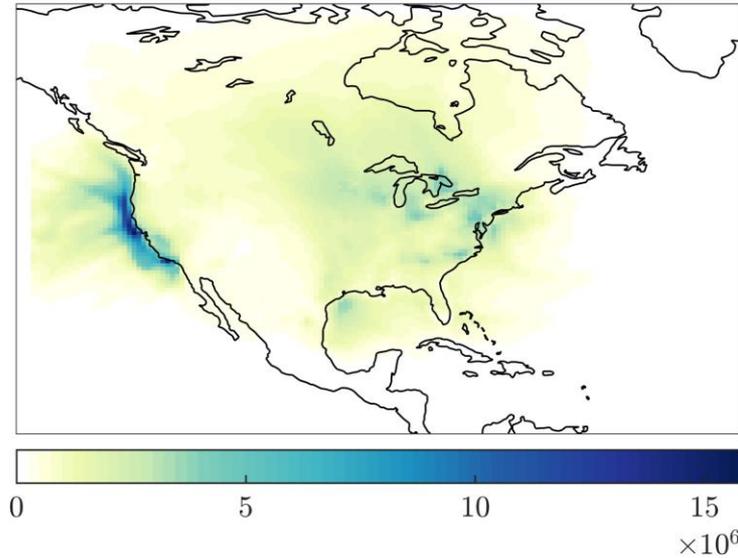
- O₃ capability update
- Inclusion of the 2010 AEDT inventory
- Second-order sensitivities w.r.t. background emissions



Recent Accomplishments PM_{2.5} sensitivity changes – NO_x

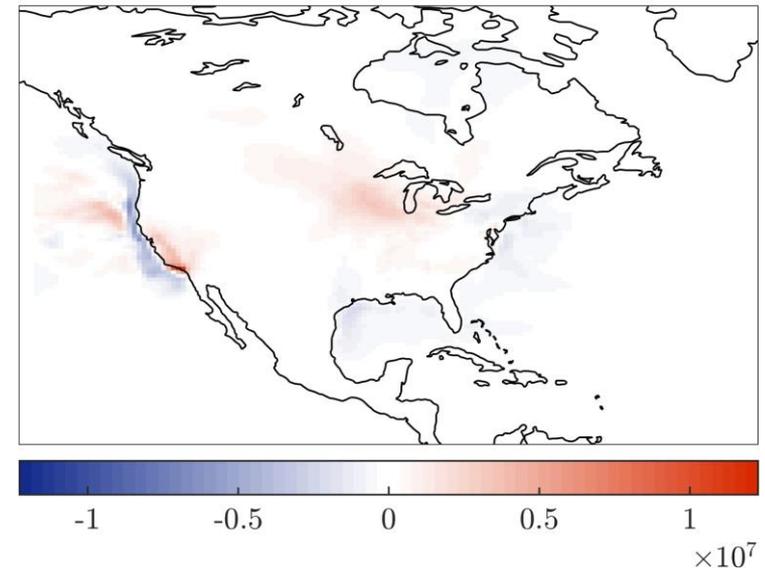
2006 sensitivity of US exposure to NO_x

2006



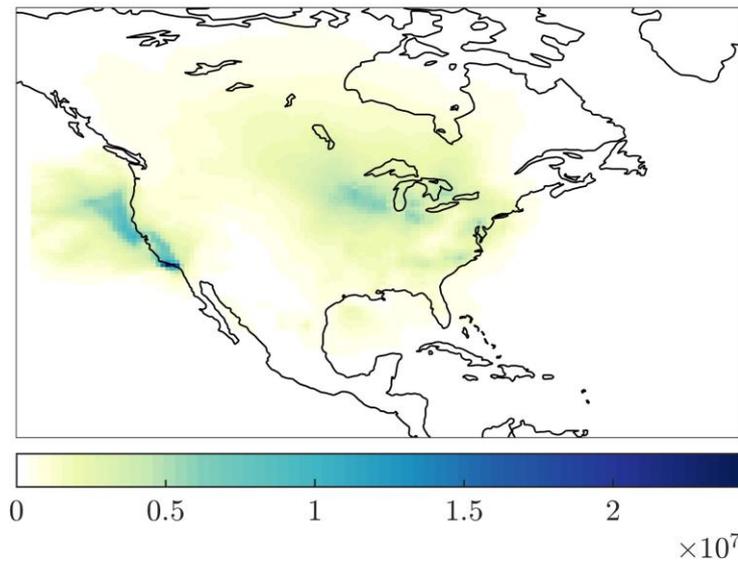
2011 – 2006

2011 - 2006 NO_x sensitivity difference



2011 sensitivity of US exposure to NO_x

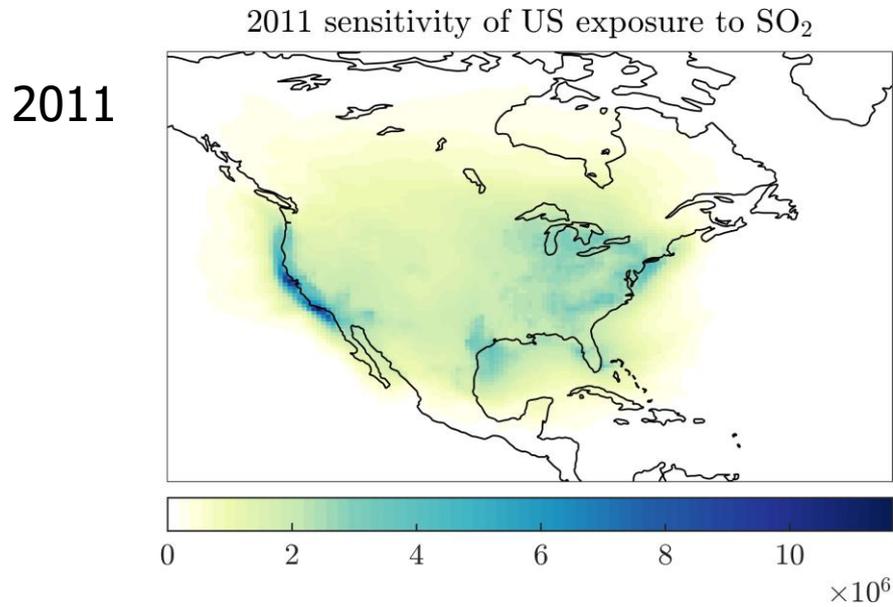
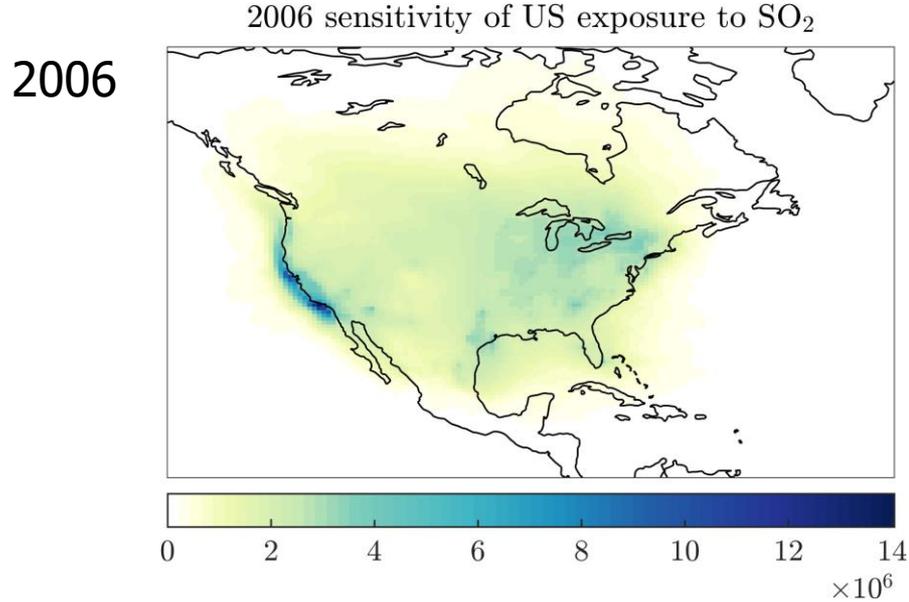
2011



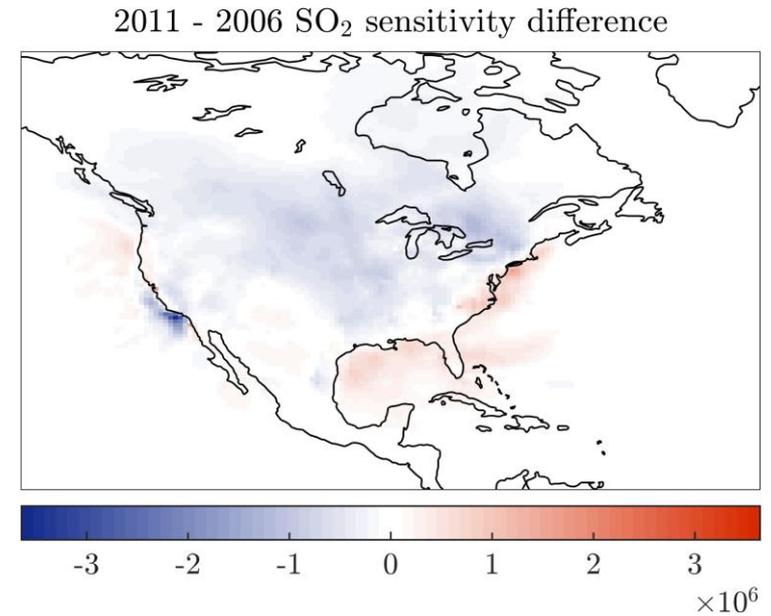
Increased OH availability for the formation of nitric acid, due to CO reductions, leads to increased NO_x sensitivities

Recent Accomplishments

PM_{2.5} sensitivity changes – SO₂



2011 – 2006



Lower free ammonia availability for neutralizing all available sulfate leads to the decrease of the SO₂ sensitivities

Summary: Development of a rapid tool to assess air quality health impacts resulting from aviation emissions, and evaluate policies directed toward the mitigation of negative impacts

Next steps:

- Validation of the tool
- Inclusion of other high resolution domains
- Analysis of the impact of changes in meteorology

Key challenges/barriers:

- Modeling differences between forward GEOS-Chem and adjoint might affect validation of the tool
- Numerical/subtraction errors when calculating second order sensitivities

Acknowledgements



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Participants

- Prof. Steven Barrett, Irene Dedoussi, Guillaume Chossière, Dr. Raymond Speth