Application of satellite observations to ozone attainment planning in Texas

Daniel Cohan
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Project Team

DANIEL COHAN (PI)
DR. XUE XIAO
WEI TANG

ARASTOO POUR-BIAZAR

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Project Objectives

- GOES cloud data to improve photolysis rates
- OMI NO_2 columns and other data to create top-down NO_x inventory via inverse modeling
- CAMx-HDDM to assess how satellite-derived inputs influence ozone-precursor response in Texas SIP modeling episodes
  - *Seek stakeholder input on how to target these analyses to inform decision-making*

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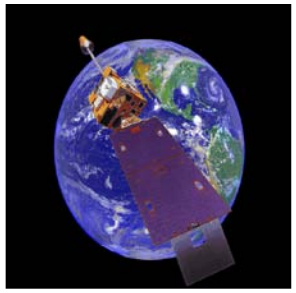
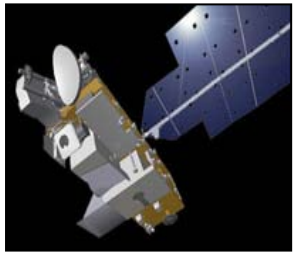
Approach





1. Photolysis Rates assimilated using GOES data

2. NO_x Emissions inverted from OMI and TexAQS-II data

3. Model how revised inputs affect ozone responsiveness metrics

4. Provide results to TCEQ and stakeholders for upcoming attainment planning

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Motivation: Misplacement of clouds by meteorology models

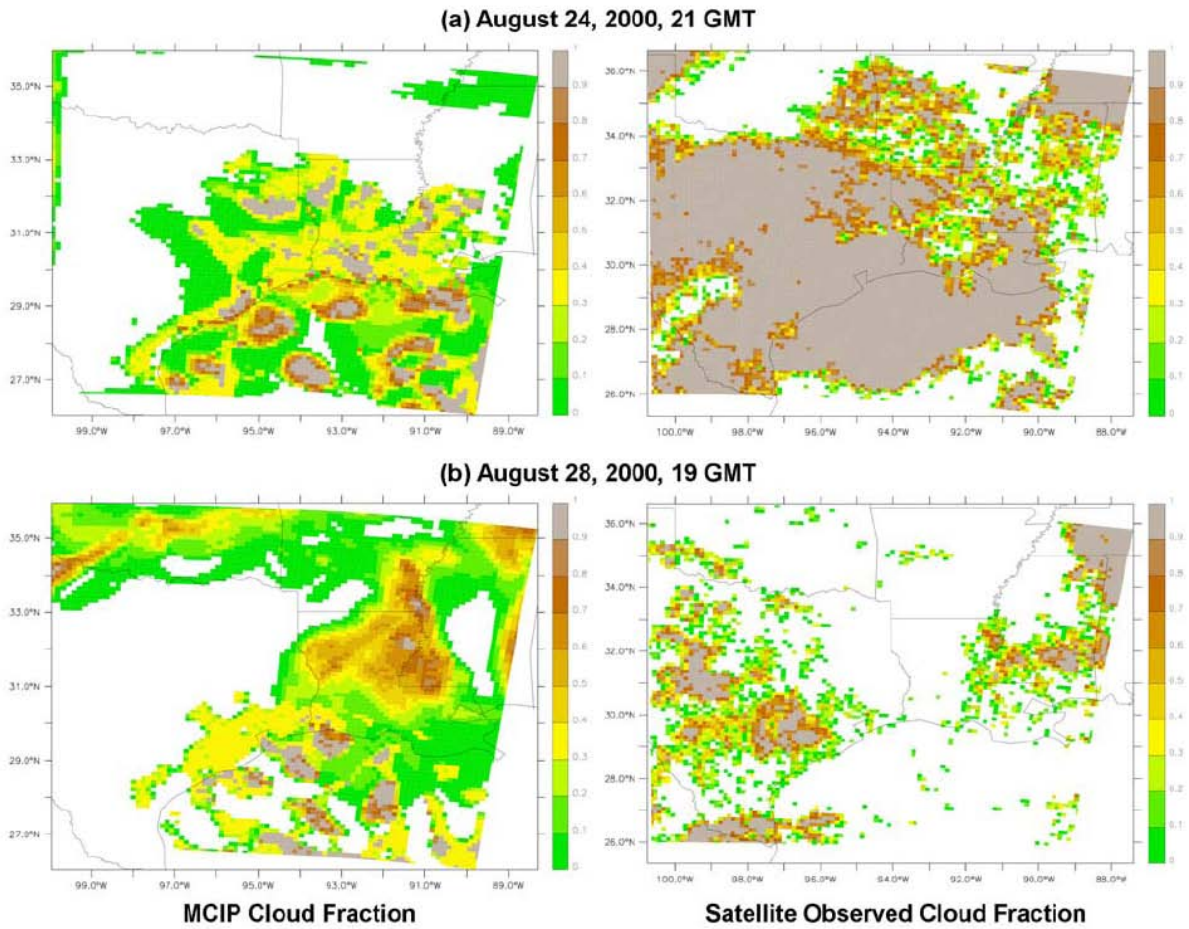


Figure 1. MM5 predicted and satellite observed cloud fields for (a) 24 August 2000, 2100 UT, and (b) 28 August, 1900 UT.

Pour-Biazar et al., JGR, 2007

Impacts on transmissivity & photolysis rates

Base Model | Satellite-adjusted

Cloud Transmissivity

NO_2 Photolysis Rate

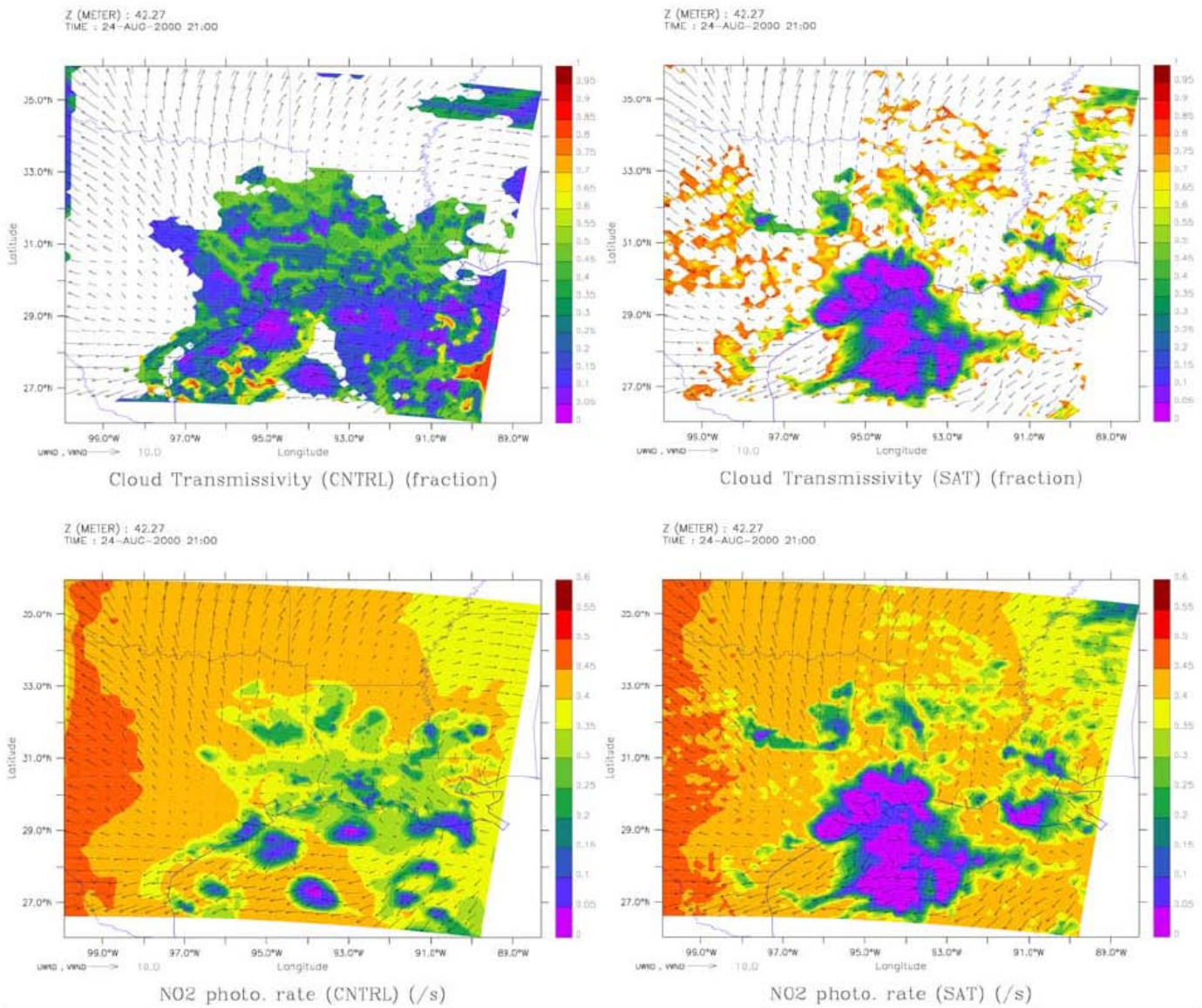
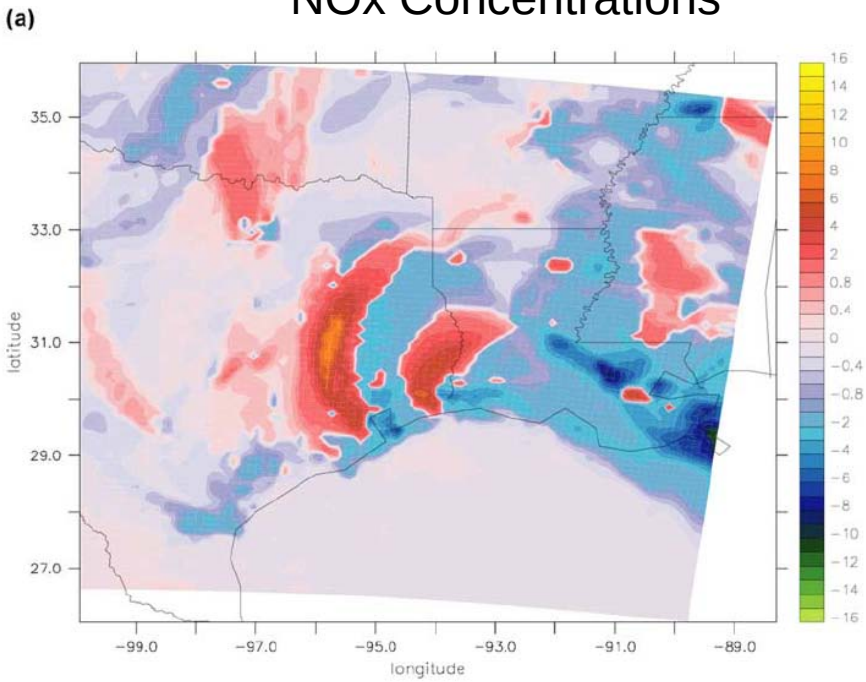


Figure 2. Cloud transmissivity and corresponding NO_2 photolysis rates for 24 August 2000 at 2100 UT from CMAQ_base and CMAQ_sat simulations at the surface (first model layer).

Pour-Biazar et al., JGR, 2007

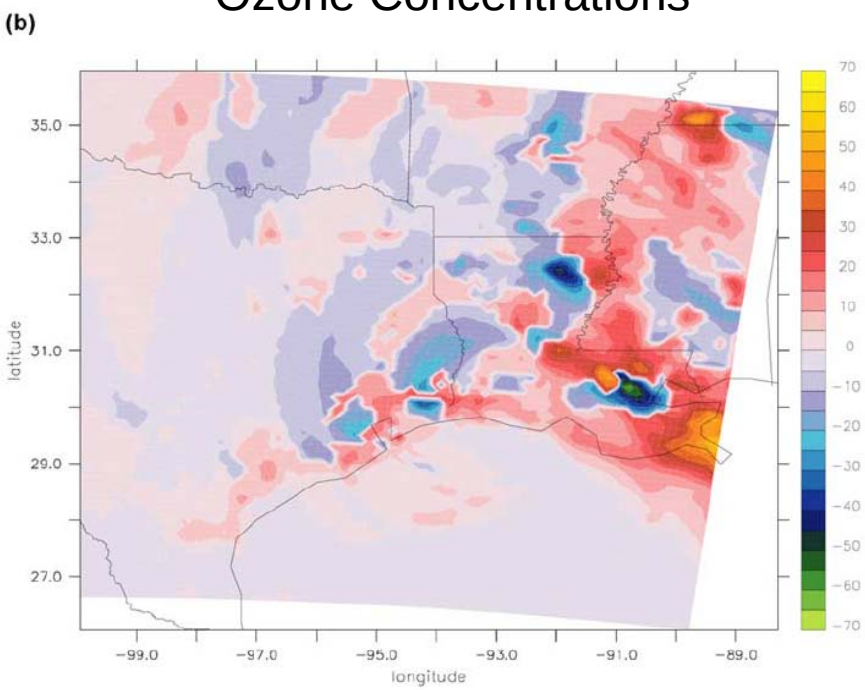
Motivation: Impact of satellite-based clouds on NOx & O3 concentrations

NOx Concentrations



Largest diff in NOx concentrations (ppb)

Ozone Concentrations



Largest diff in O3 concentrations (ppb)

Figure 7. Largest differences in (a) NO_x and (b) O_3 between assimilation and control simulations (assim-control) for the entire period of study covering from 0000 UT, 24 August 2000, to 0000 UT, 1 September 2000.

Pour-Biazar et al., JGR, 2007

Motivation: Influence of Photolysis Rates on Ozone-NOx Sensitivity

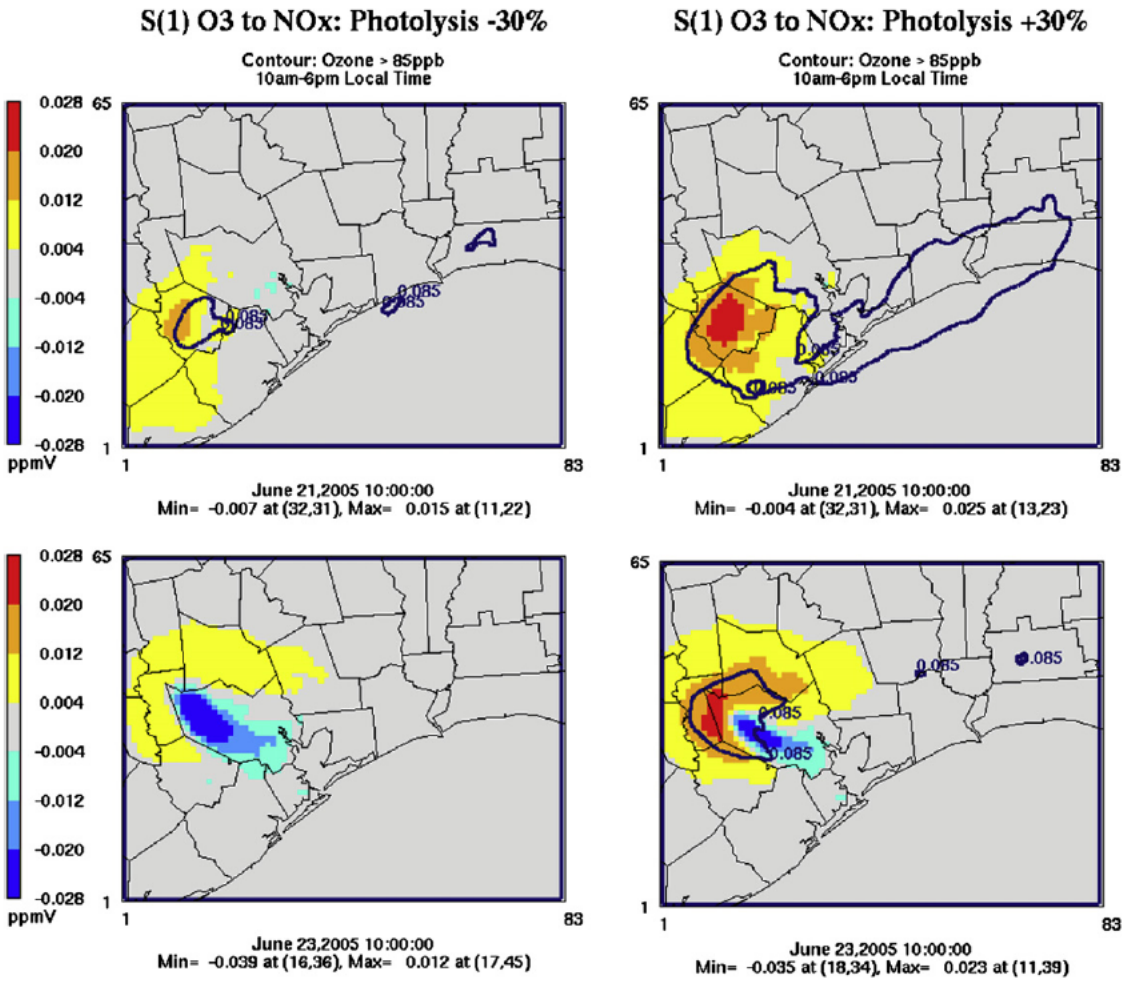
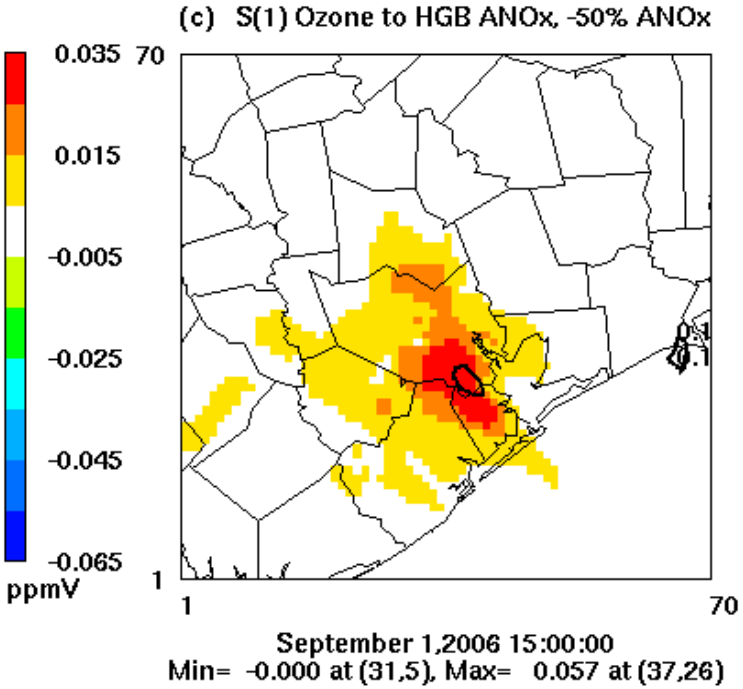


Fig. 5. Sensitivity of ozone to Houston anthropogenic NO_x emissions, if the rate of all photolysis reactions is 30% smaller (L) or larger (R) than in base case, for June 21 (top) and June 23 (bottom). Contours show $O_3 > 85$ ppb in each case.

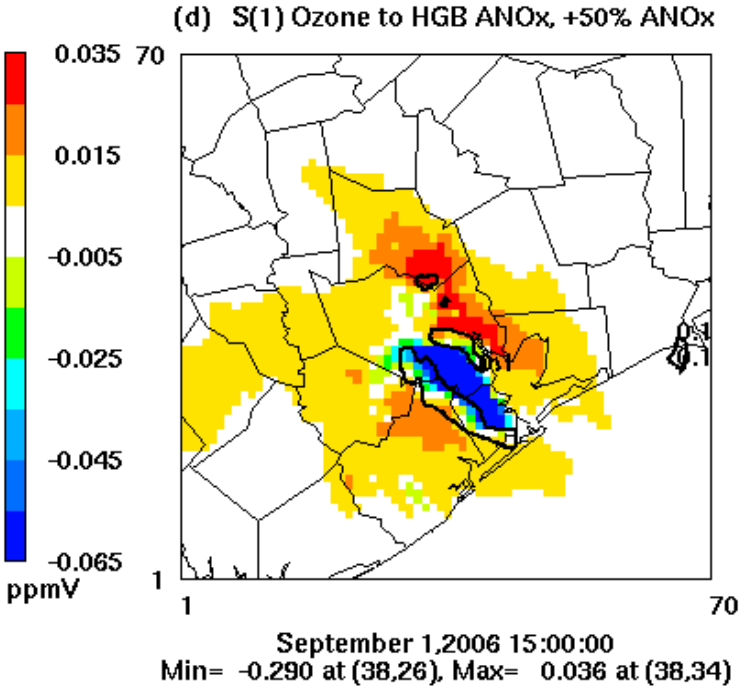
Cohan, Koo, and Yarwood, Atmospheric Environment (in press)

Motivation: Influence of NO_x inventory on O3 sensitivity to NOx

O3 sens to NOx under a 50% <u>smaller</u> NOx inventory



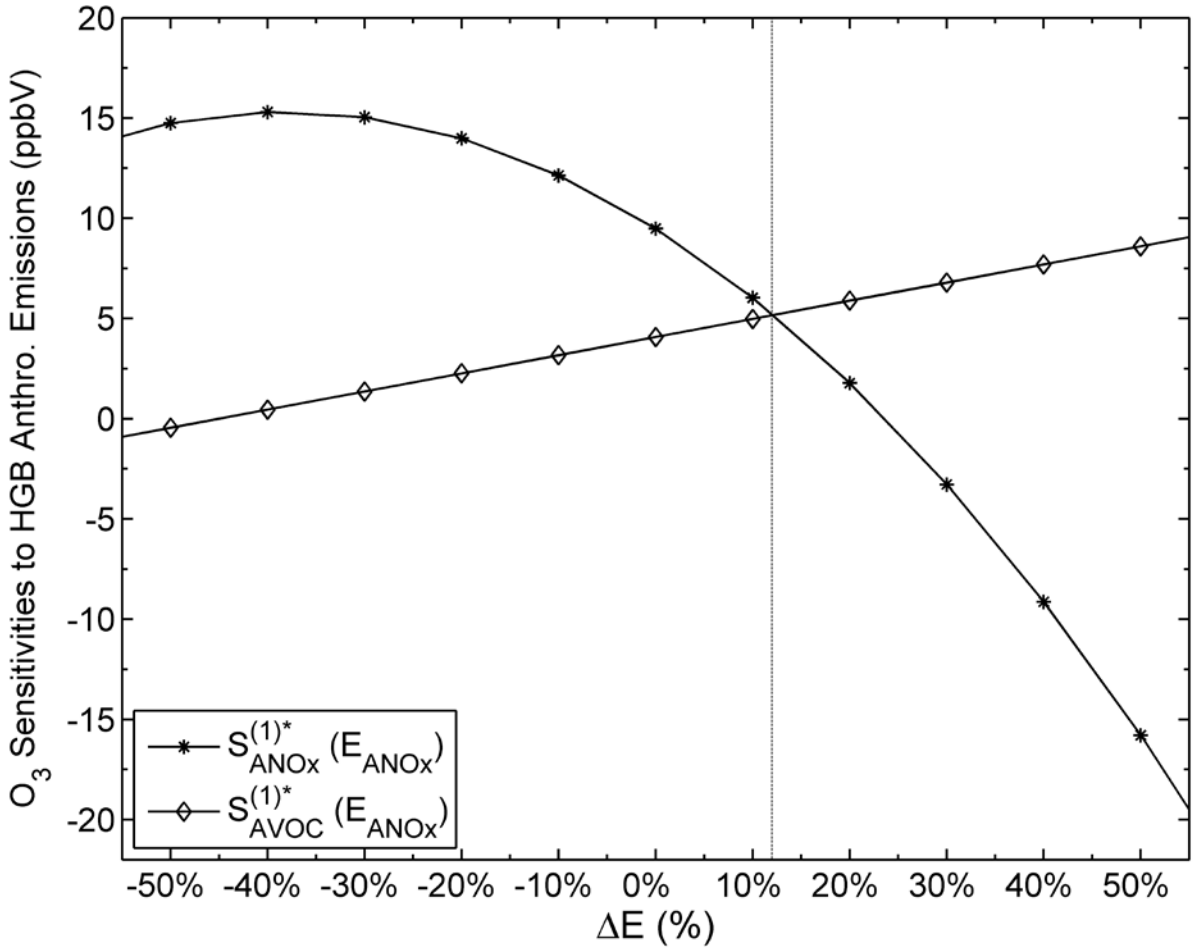
O3 sens to NOx under a 50% <u>larger</u> NOx inventory



Xiao et al., JGR (in revision)

Motivation: Influence of NO_x inventory on O3-precursor response

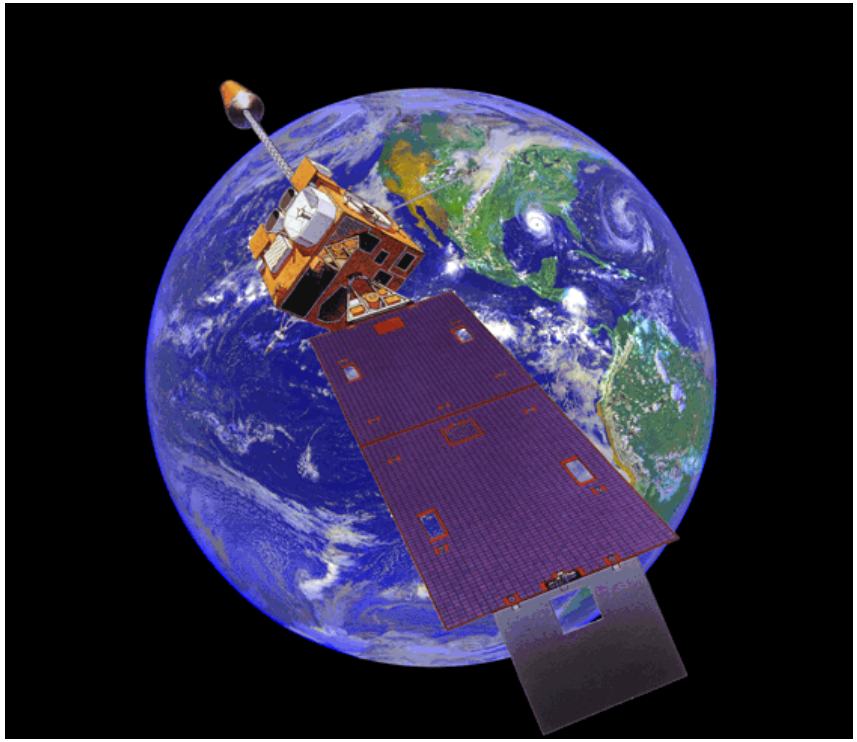
O3 Sens to NOx as Function of Baseline ENOx
(Harris County average, 9/1/2006, 3pm)



Xiao et al., JGR (in revision)

Approach: GOES-based photolysis rates

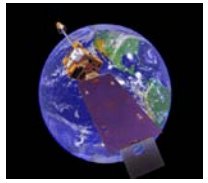
- Derive transmissivity fields based on GOES data (cloud albedo & cloud top pressure)
- Use original MM5-CAMx photolysis rates when satellite data unavailable
- Compute adjusted photolysis rates in CAMx-TUVRM

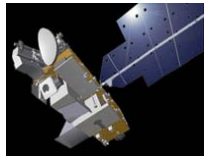


Limitations of satellite-based photolysis rates

- Missing data at some times/locations
- Inconsistency between photolysis rates and other cloud properties (wet deposition, cloud processing)

Approach: NOx inverse modeling





Baseline SIP modeling inputs from TCEQ

Photolysis rates assimilated using GOES data

Base Emission Inventory

CAMx-DDM model

Simulated NO & NO_2 concentrations <u>and</u> their sensitivities to emissions

Convert to NO_2 column densities

NO_2 column densities (OMI satellite retrievals)

NO_x observations (aircraft & surface monitors)

Kalman Filter Optimal Estimator

Updated Emission Inventory E_{n+1}

$|E_{n+1}-E_n| < \delta$?

No

Yes

Final Emission Inventory

Approach: NOx Inverse Modeling

- Similar to Napelenok et al (ACP, 2008) Kalman filter inversion, except:
  - Use data from newer, higher-resolution OMI instead of SCIAMACHY
  - Incorporate other observations (including TexAQS2 field campaign) into inversions

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Challenges in NOx Inversions

- Poor model performance for upper tropospheric NO_2
  - Correcting for this influences results, esp. in rural areas
- How to "weight" different data sources
- How to define source regions and categories
- Comparing 3D gridded model results with satellite column pixels

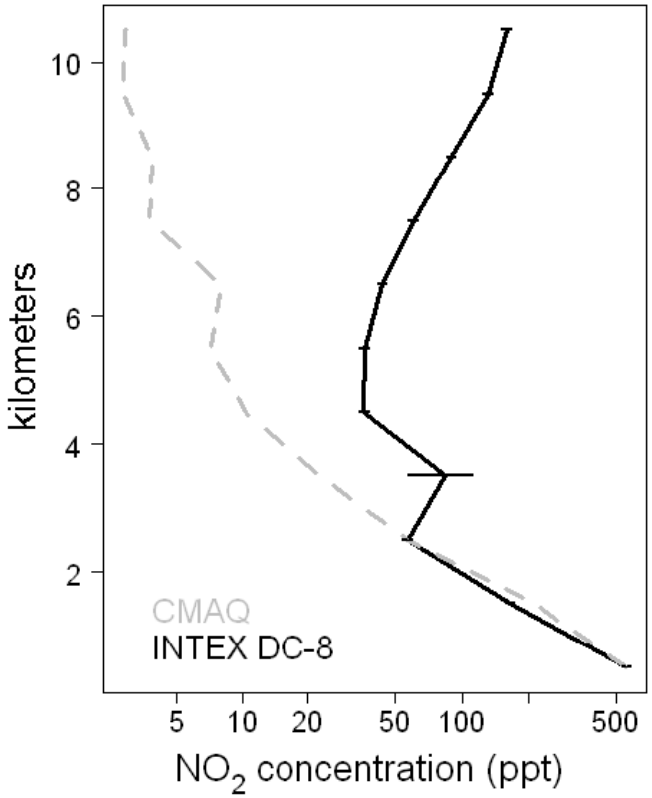

Fig. 7. Vertical distribution of NO_2 concentrations observed by NASA INTEX DC-8 flights over the eastern United States compared to model predictions matched in space and time. Error bars

Napelenok et al, 2008

Assessing the impact of satellite-based inputs

- Plan to model Aug-Sept 2006 (HGB/TexAQS2) and June 2006 (DFW) episodes from TCEQ
- Run CAMx-HDDM with original and satellite-based inputs to compare concentrations and their sensitivities to emissions
- Model future year (2018) to explore impacts on relative reduction factors

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Comments and Feedback

- How to define NO_x source regions and categories?
- Control scenarios for sensitivity modeling?
- Suggested modifications or extensions?

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Contact Information

Daniel Cohan, Ph.D.
Assistant Professor
Dept. of Civil & Environmental Engineering
Rice University
713-348-5129
cohan@rice.edu
http://cohan.rice.edu