Simulation Experiments for Geostationary Observations of Regional Air Quality

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Atmospheric Composition with Geostationary Measurements
Peter Zoogman, Daniel J. Jacob, Kelly Chance, Lin Zhang,
Philippe Le Sager, Arlene Fiore, Xiong Liu

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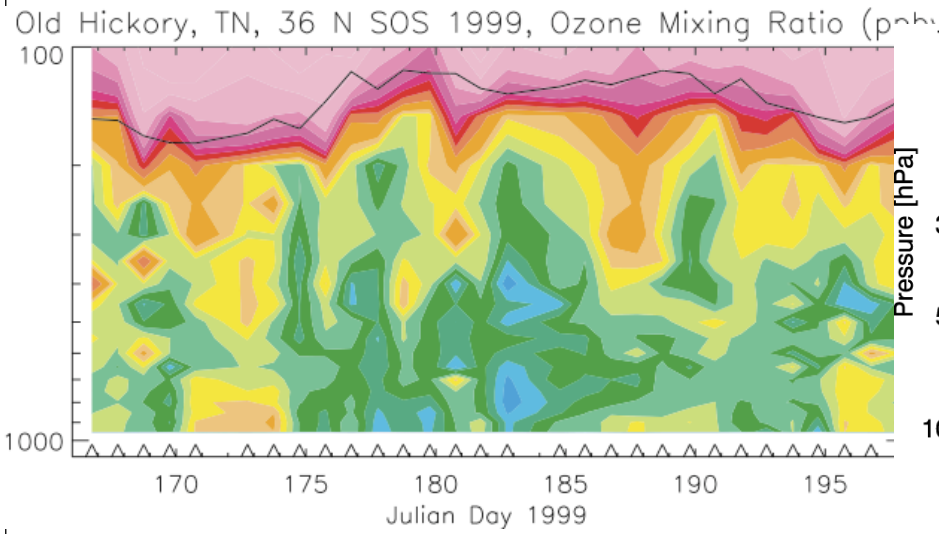
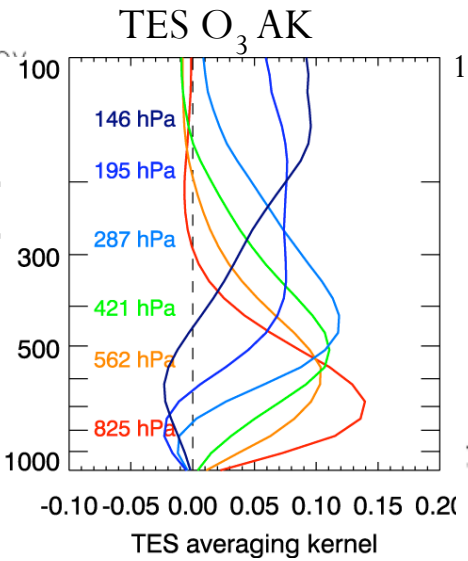
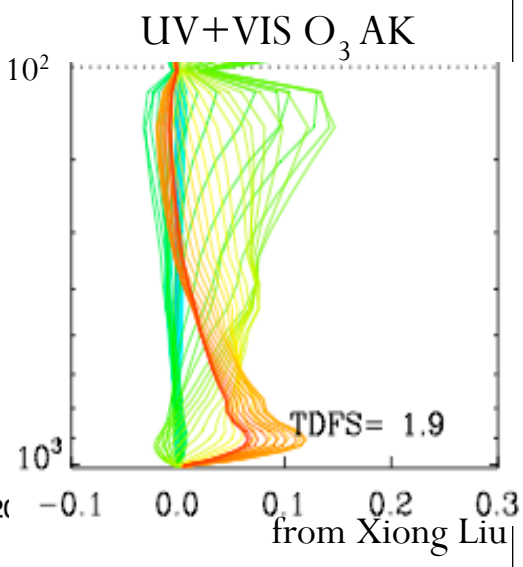
The Difficulty of Ozone Air Quality from Space

- Ozone concentrations very heterogeneous both spatially and temporally



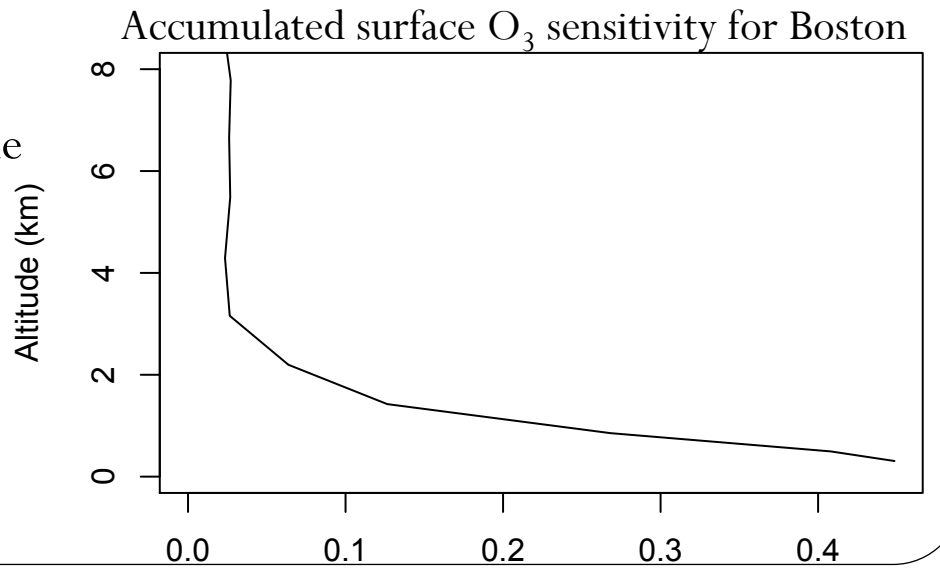
Newchurch et al 2003





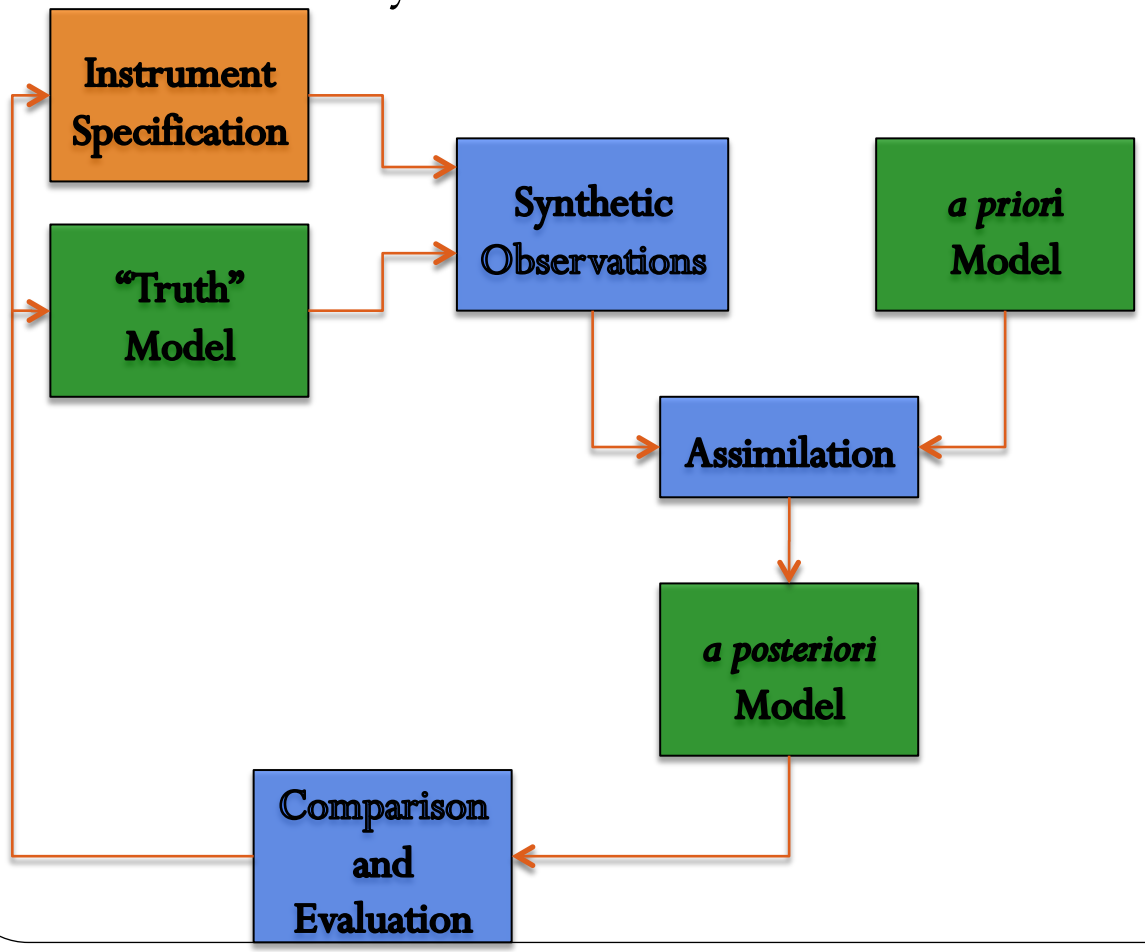
from Xiong Liu

- Adjoint model – Sensitivity of surface ozone to ozone produced at each vertical layer
- Surface ozone primarily sensitive to production below 2 km



Observing System Simulation Experiment

- To what degree can geostationary measurements resolve ozone near the surface?
- Determine satellite measurement requirements for surface ozone – motivated by the GEO-CAPE mission



a priori = GEOS-Chem model

"Truth" = MOZART model

a posteriori = GEOS-Chem + assimilation of synthetic observations

→ attempt to reproduce true atmosphere

Simulation Models

- MOZART and GEOS-Chem are completely different
  - Meteorology, Chemistry, Emissions

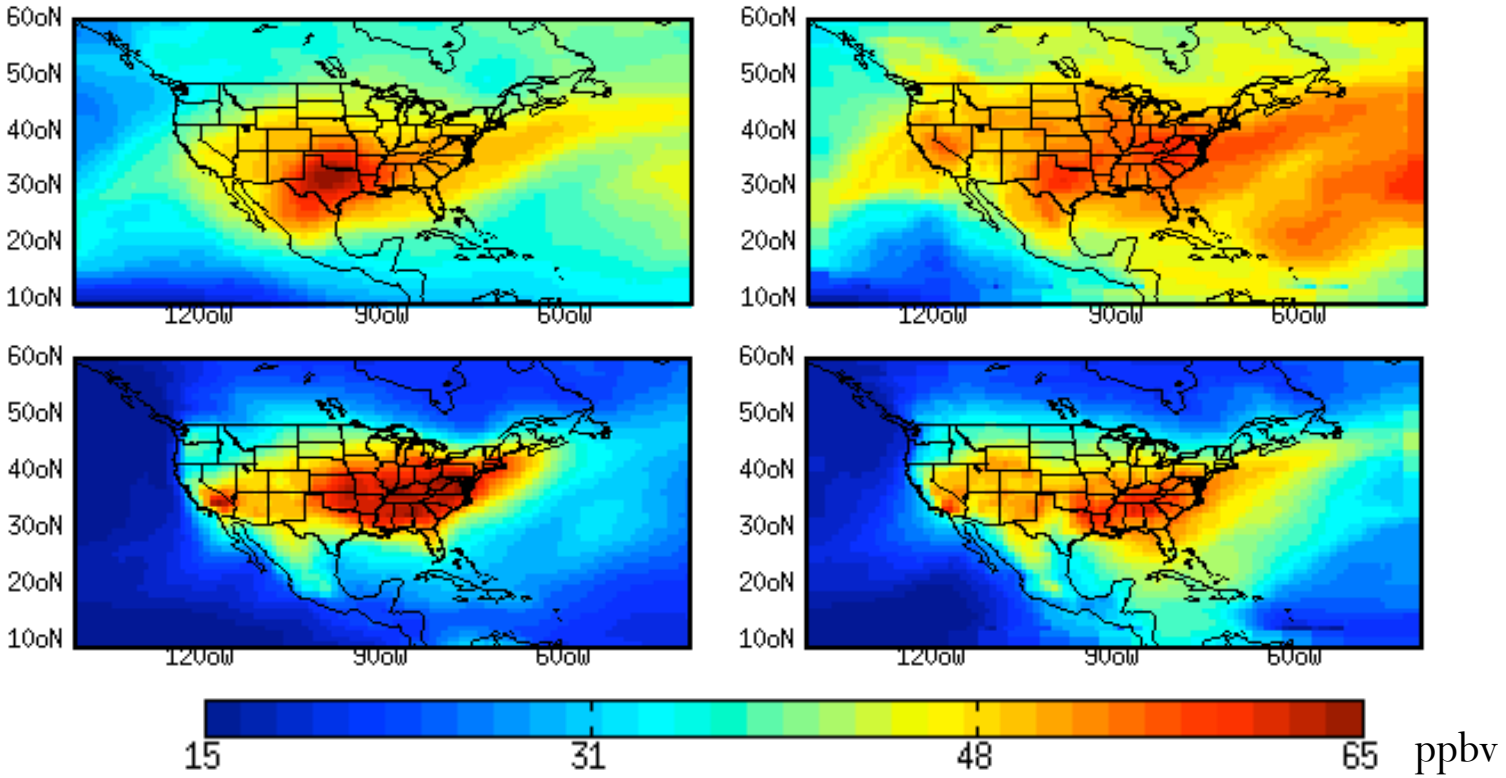
"Truth"

MOZART (1.9° x1.9° , NCEP)

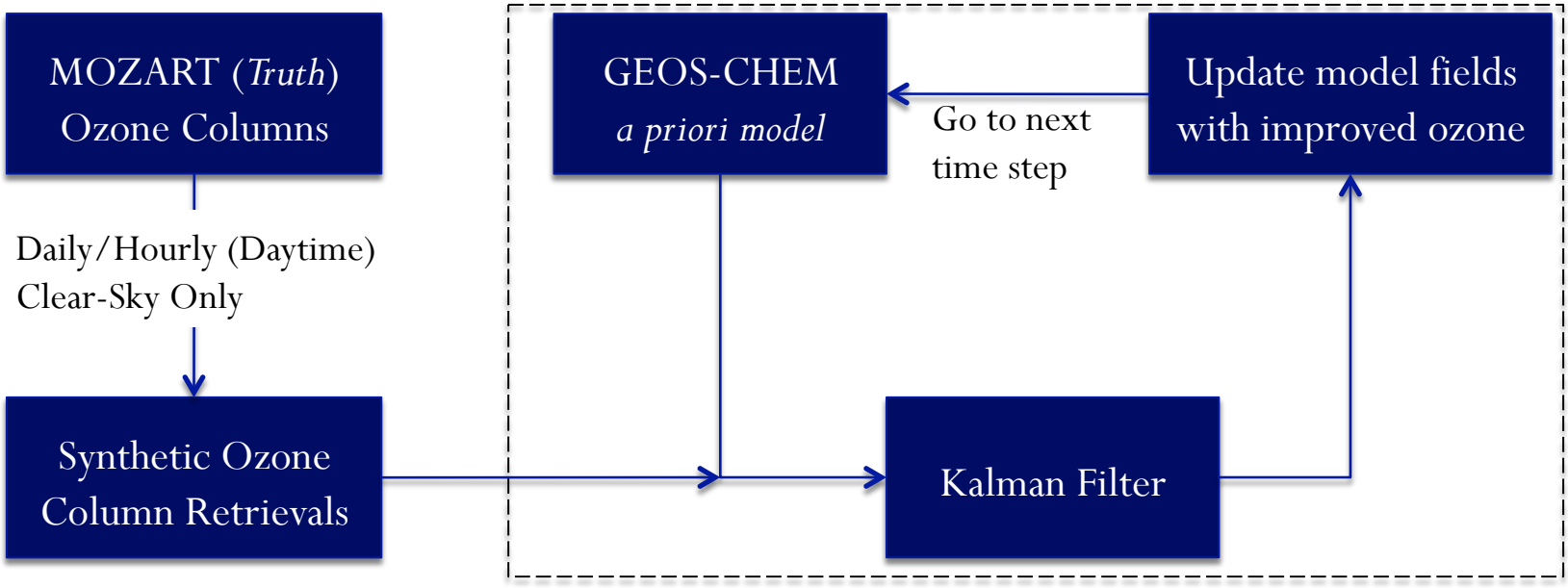
a priori

GEOS-Chem (1° x1° , GEOS-3)

JULY 2001



Methods

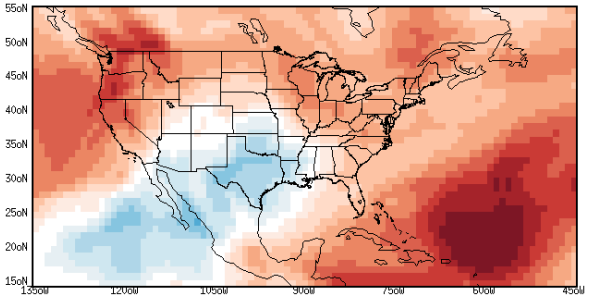


- Data Assimilation – Kalman Filter
  - Includes spatial covariance of 1 km in vertical, 100 km in horizontal
  - Error is evolved and transported as a passive tracer
- Model Error computed by comparison to ozonesonde ~25%
- Instrument noise error assumed to be diagonal, 5%

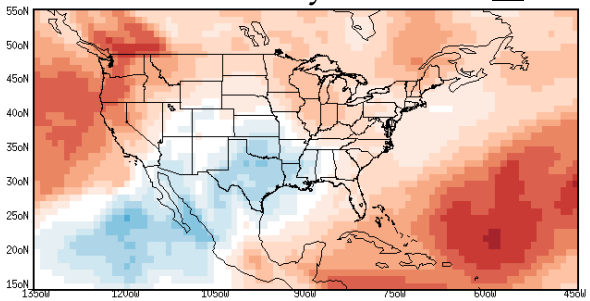
Assimilation Improvement at 700 hPa

GEOS-Chem mean absolute bias: 7.4 ± 4.1 ppbv

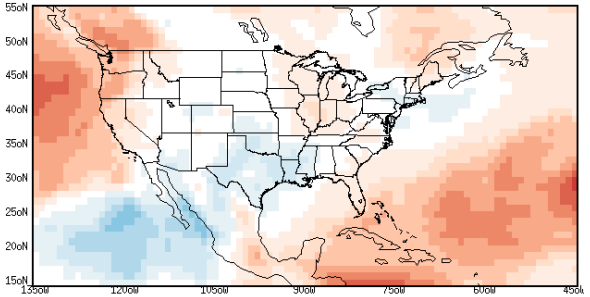
Mean July 2001 Ozone



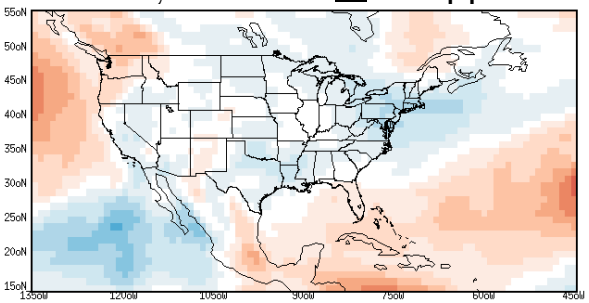
GEOS-Chem + Daily TIR: 5.6 ± 3.5 ppbv



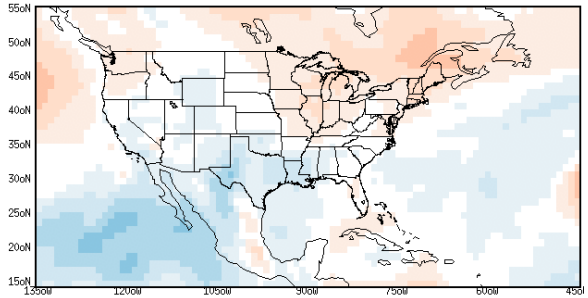
Daily UV+VIS: 3.5 ± 2.9 ppbv

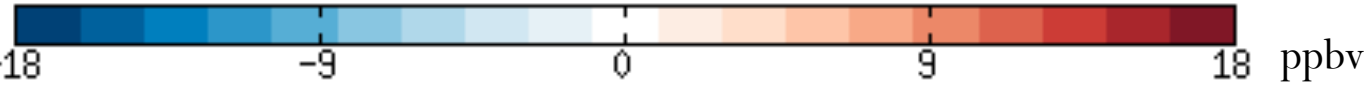


Hourly TIR: 2.7 ± 2.0 ppbv



Hourly UV+VIS: 1.8 ± 1.6 ppbv



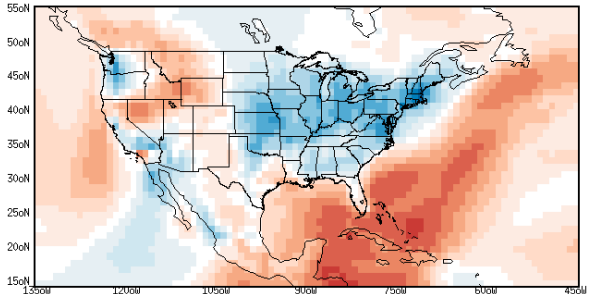


Hourly observations (daytime clear-sky only) provide successful correction, much better than daily observations

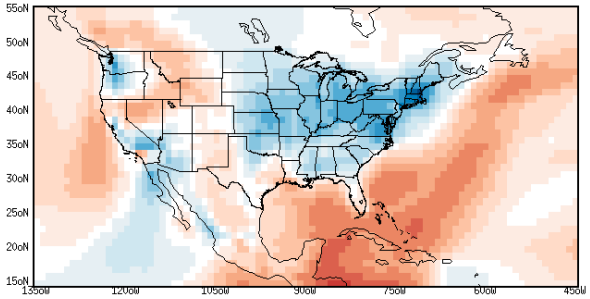
Assimilation Improvement below 1 km

GEOS-Chem mean absolute bias: 4.3 ± 3.3 ppbv

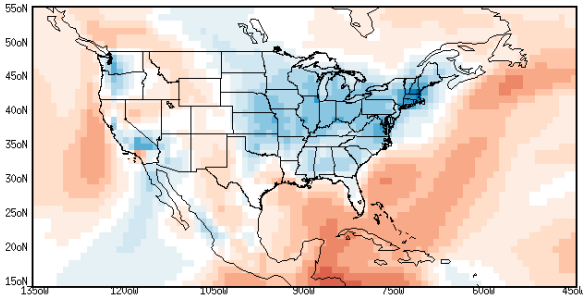
Mean July 2001 Ozone



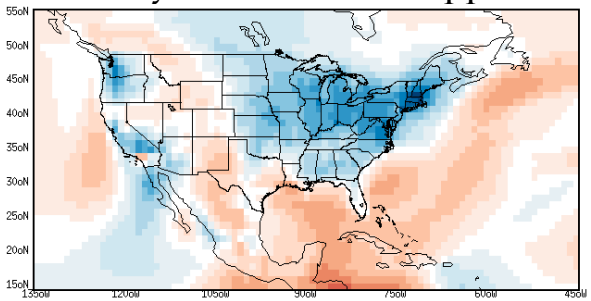
GEOS-Chem + Daily TIR: 4.1 ± 3.0 ppbv



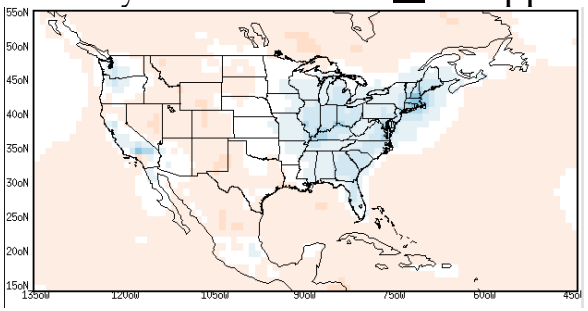
Daily UV+VIS: 3.6 ± 2.5 ppbv



Hourly TIR: 3.4 ± 2.7 ppbv



Hourly UV+VIS: 1.7 ± 0.9 ppbv



TES sensitivity to boundary layer is insufficient to correct model significantly at the surface – UV+VIS multispectral instrument provides significant correction

Do we need ozone over the oceans?

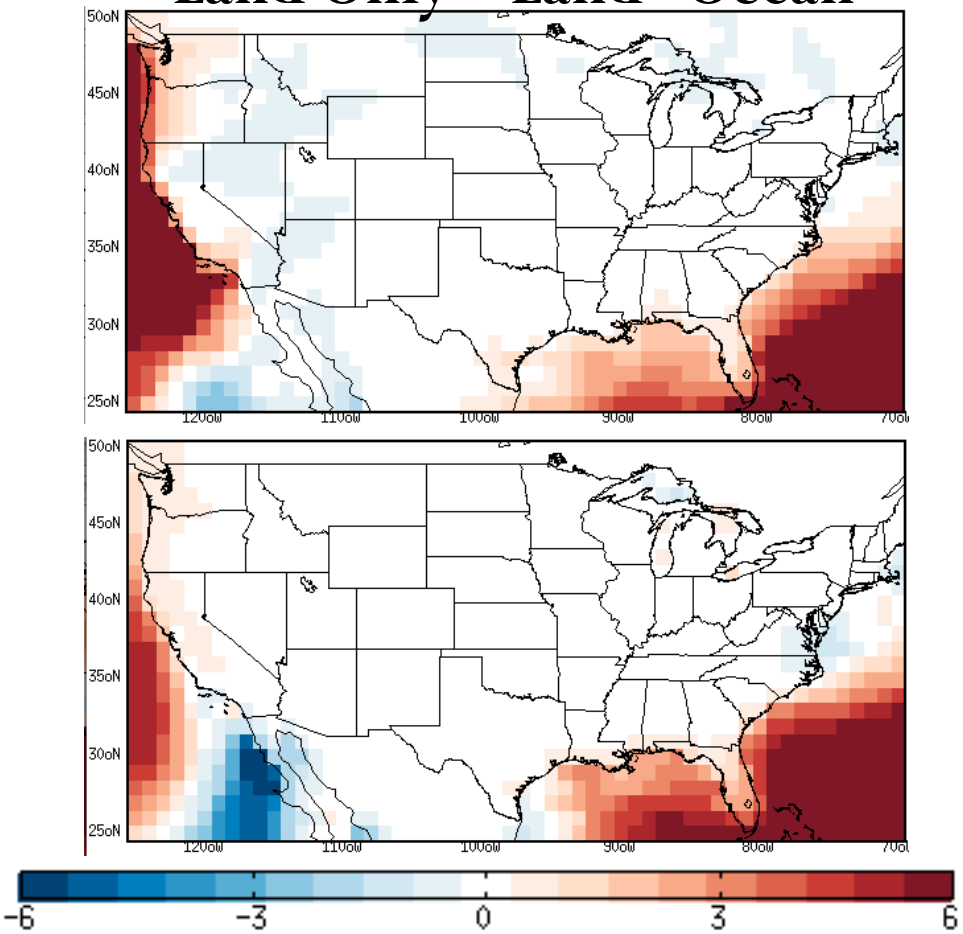
- Performed a simulation with hourly UV+VIS observations only over NA land (including coastline) and compared to simulation with observations over entire NA domain

Land Only – Land+Ocean

Mean July 2001 Ozone

At 700 hPa

Below 1 km



No significant difference for ozone concentrations over land from removing ocean observations

Conclusions

- TIR measurements not sufficient for boundary layer ozone
- Multispectral UV+VIS measurements are capable of significantly correcting BL ozone
- Hourly observations provide highly significant benefit compared to daily observations
- May be able to limit observing domain with minimal penalty for ozone air quality