Evaluation of lower/middle tropospheric ozone from air quality models using TES and ozonesondes

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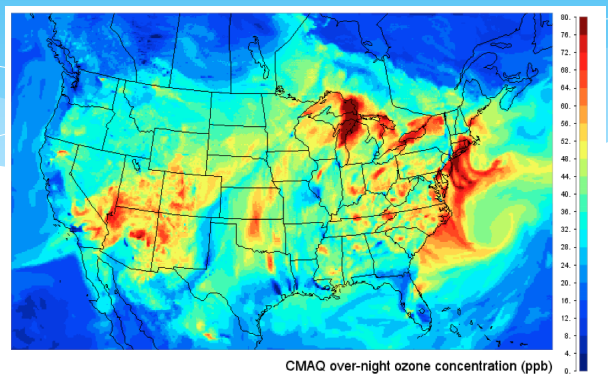
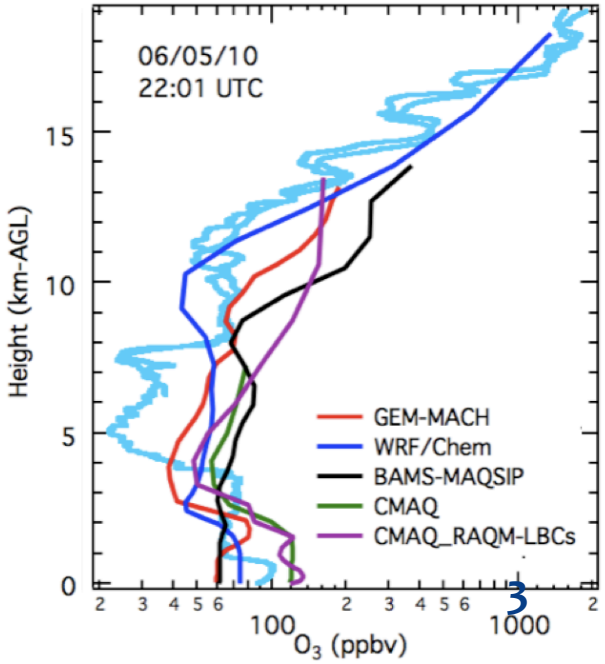
Outline

* Objectives
* Background on TES
* Comparing TES, CMAQ, and ozonesondes
* A case study of elevated nocturnal ozone

Project Objectives

* Evaluation of ozone, carbon monoxide and other key fields from the EPA CMAQ and NOAA National Air Quality Forecast Capability (NAQFC) in the middle/lower troposphere using satellite data
* Characterize nighttime ozone aloft using satellite data and ozonesondes
* Evaluate the ability of the air quality models to capture nighttime ozone aloft and possible relationship to air quality events
* Case Studies: Analyze a set of air quality events and determine if there is a relationship to nighttime ozone aloft

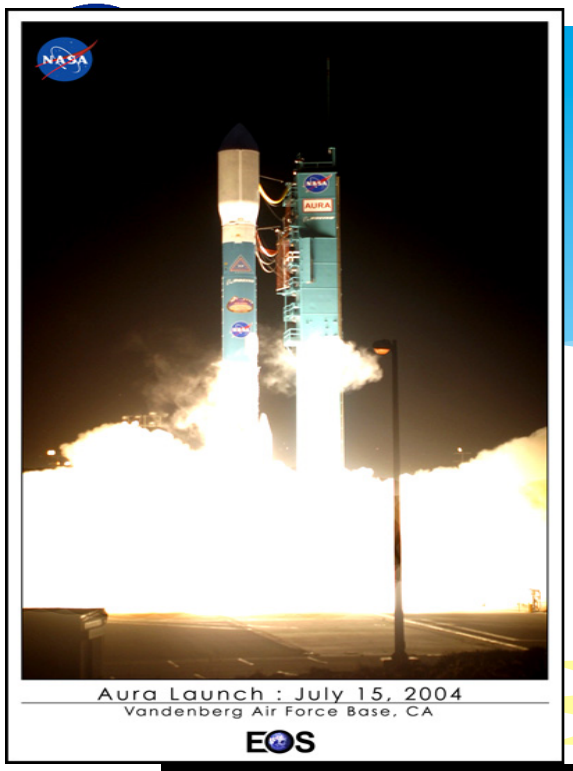

CMAQ over-night ozone concentration (ppb)

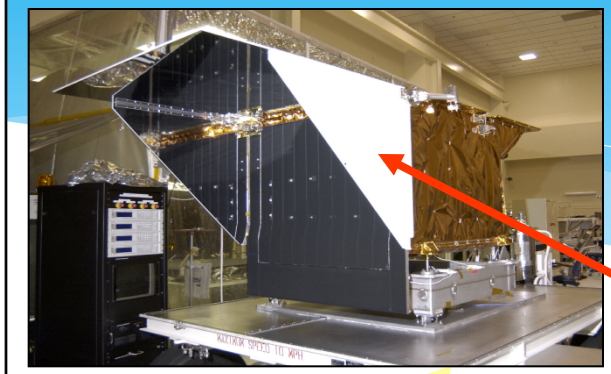


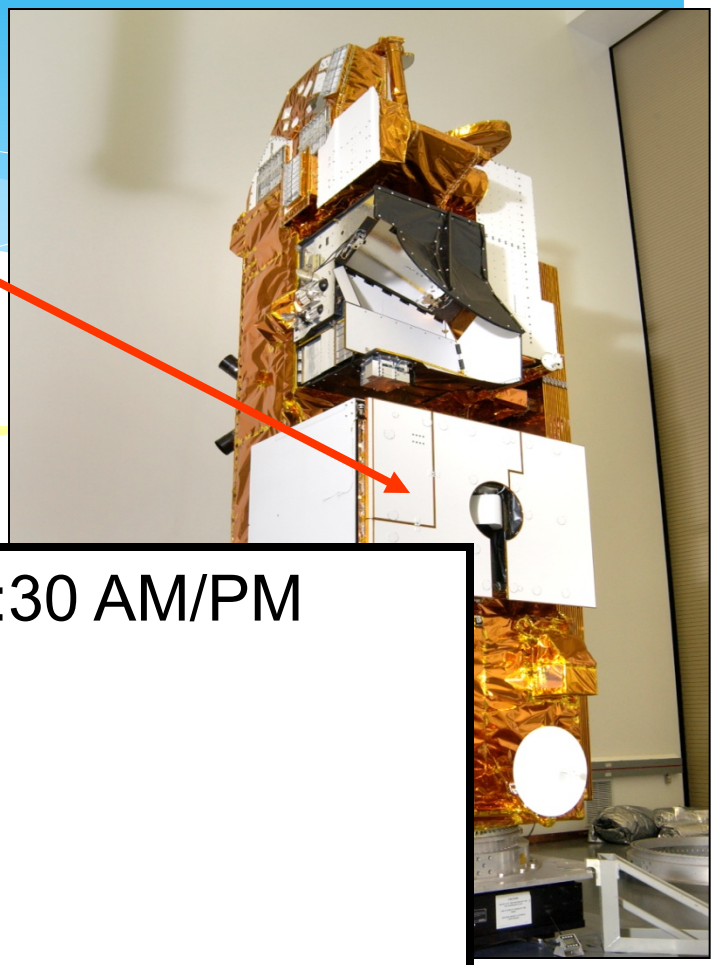
Data and Models

* Models:
  * NAQFC Forecast
  * EPA CMAQ 4.7.1
  * Time Periods – July/August 2006, 2008, 2009
* Evaluation Data Sets:
  * Satellite data from TES (O3, CO, TATM, H2O), and OMI (O3, NO2)
  * Ozonesondes
  * Surface monitors

TES on EOS-Aura





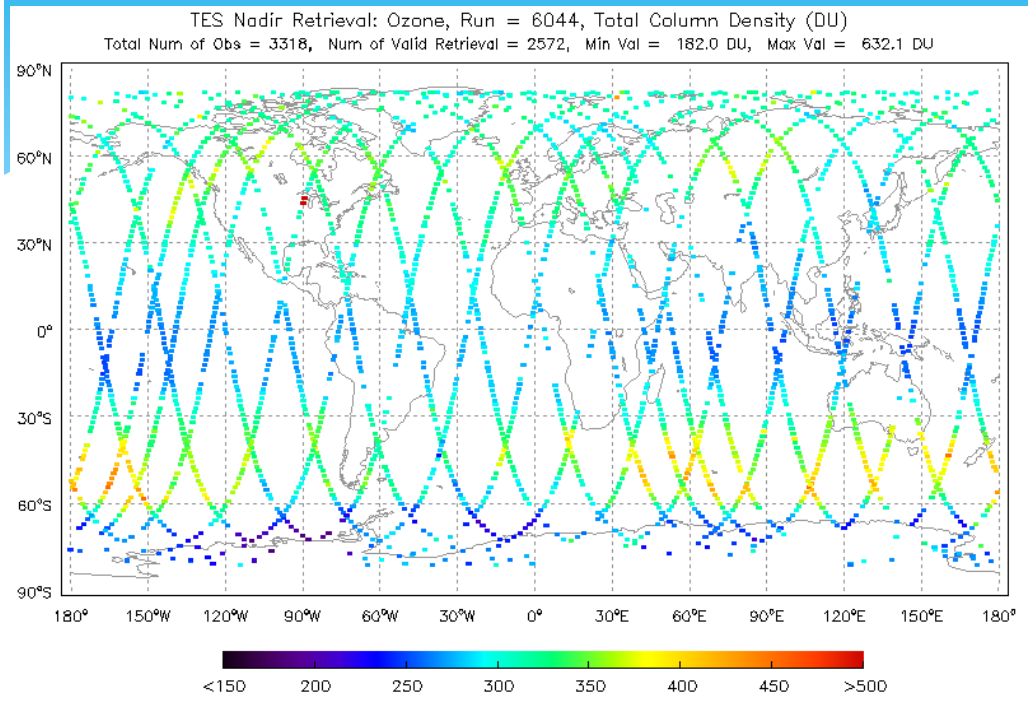


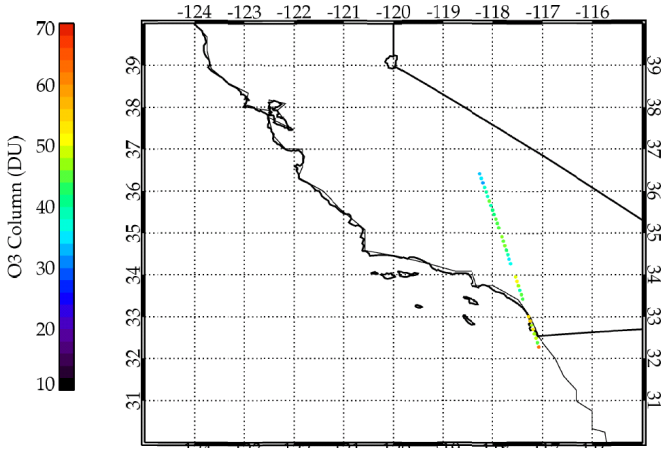
Launched 2004.07.15

TES Measures in Nadir Mode (~01:30 AM/PM Local Time):

- Ozone
- Carbon Monoxide
- Water Vapor and HDO
- Ammonia
- Methane and Carbon Dioxide
- Surface Temperature (Sea Surface Temperature)

TES Nadir Coverage



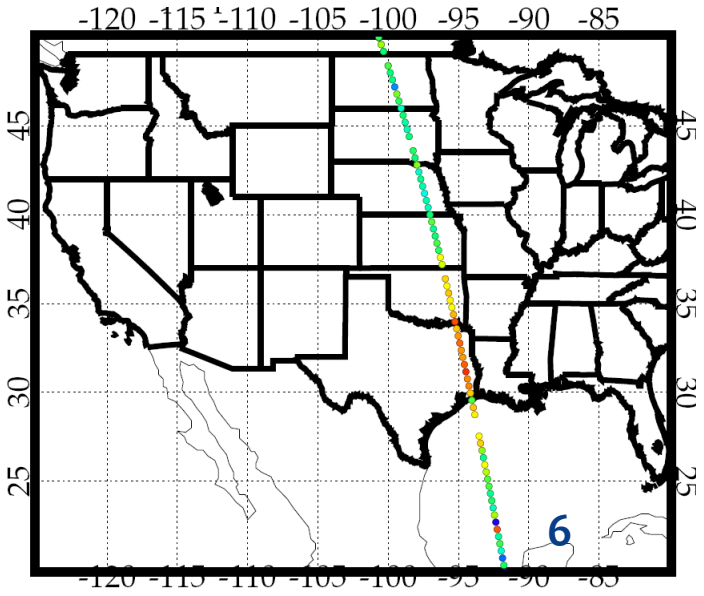


TES Footprint 5 x 8 km

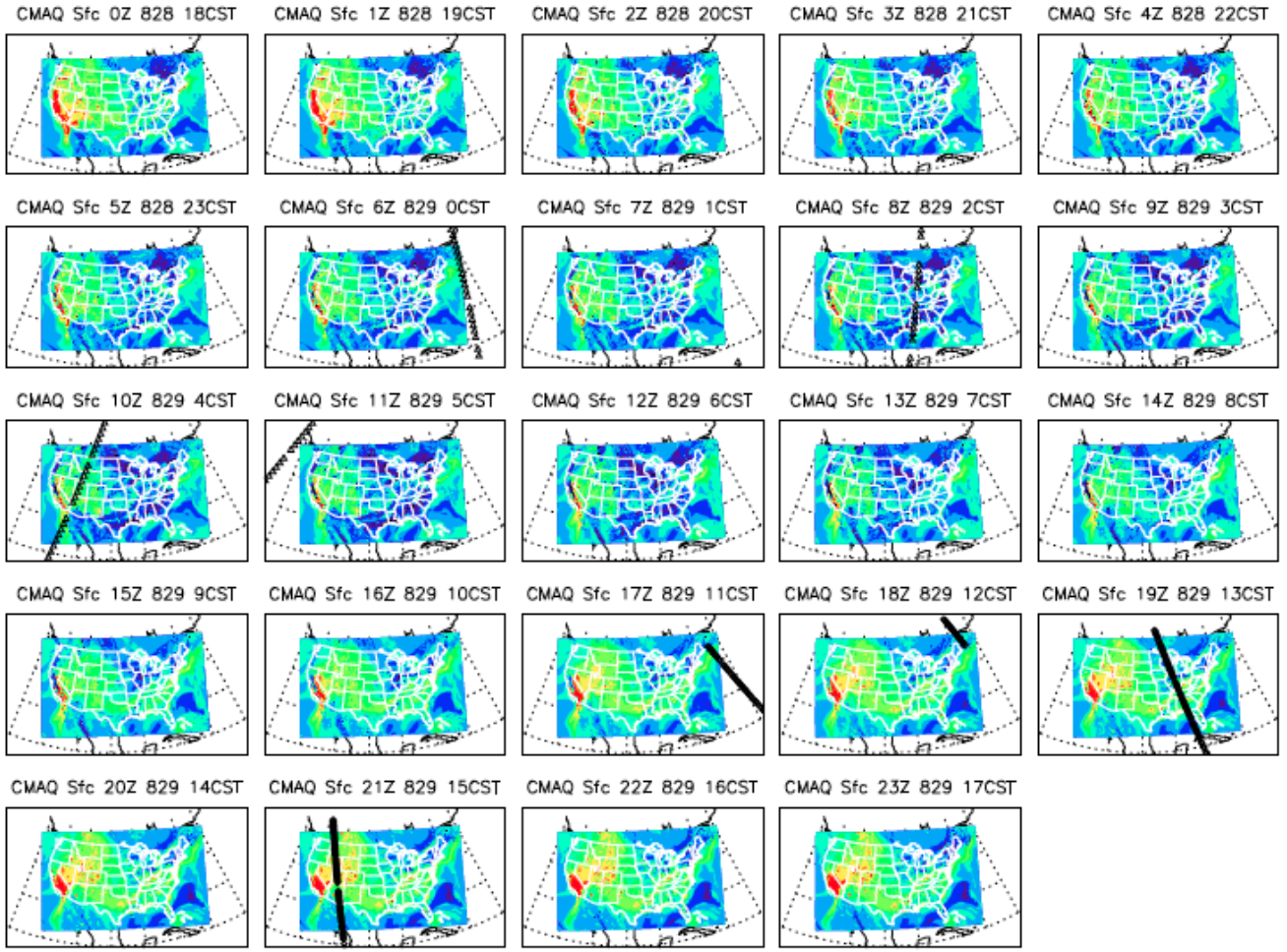
Global Survey footprints
180 km apart

Step & Stare footprints
45 km apart
Special observation

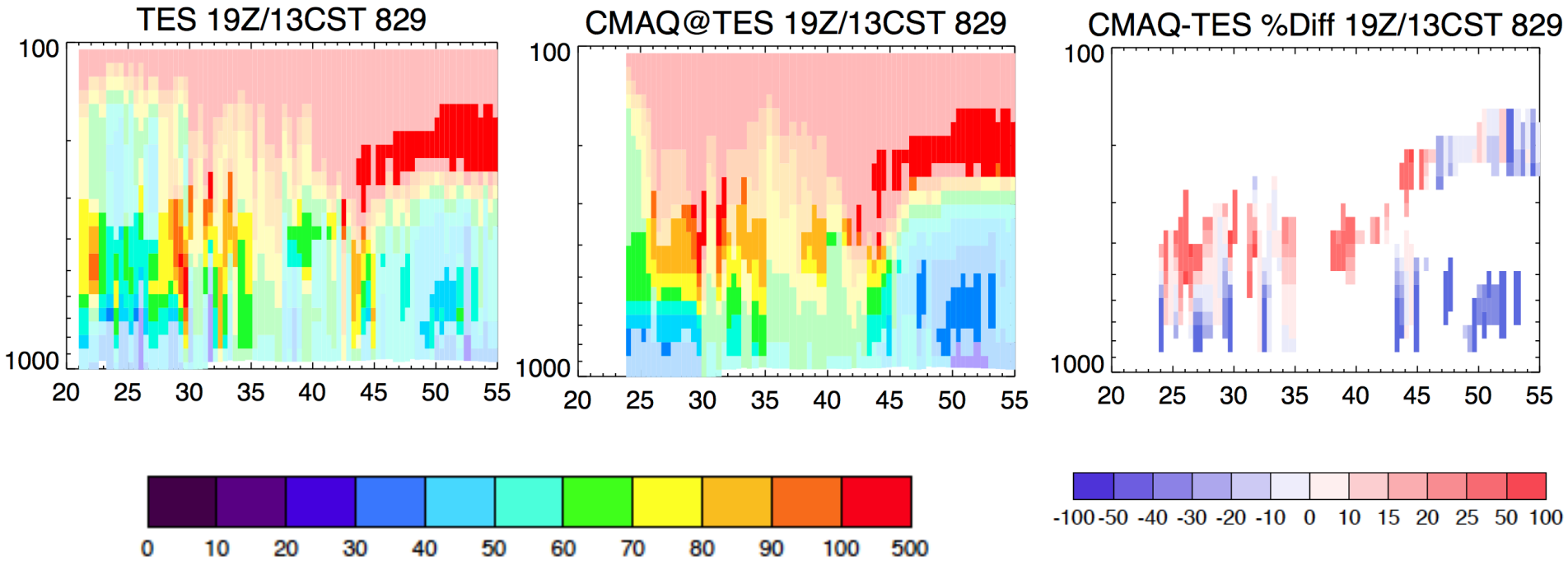
Transect footprints
12 km apart
Special observation



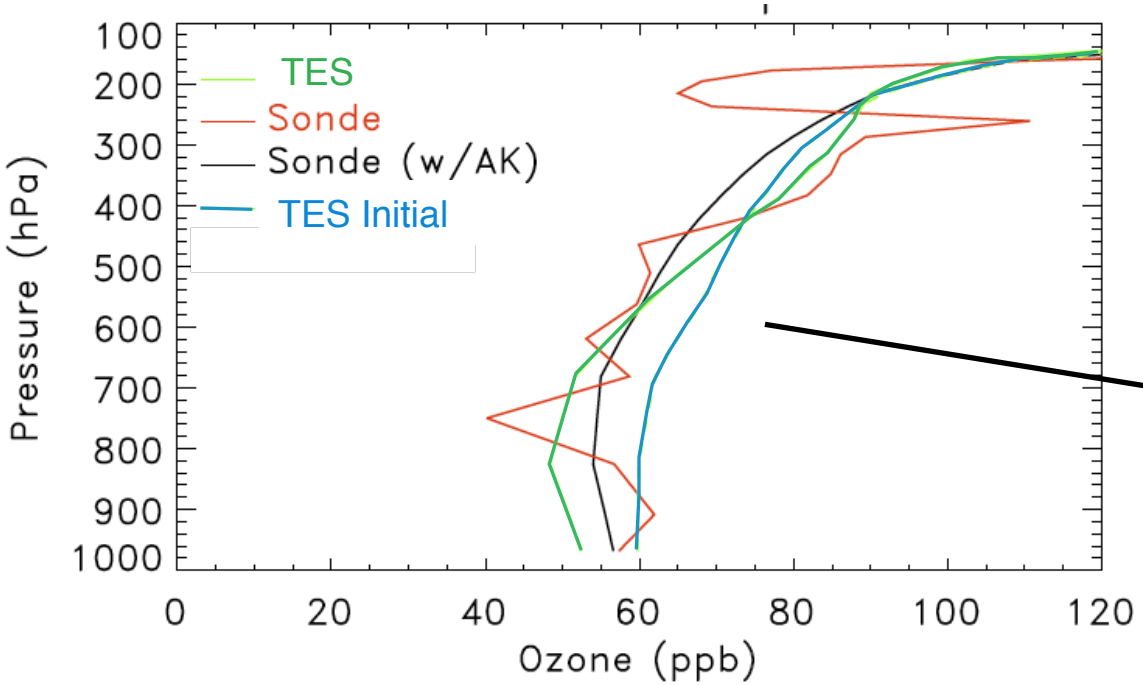
TES Observations – Aug 28-29, 2006

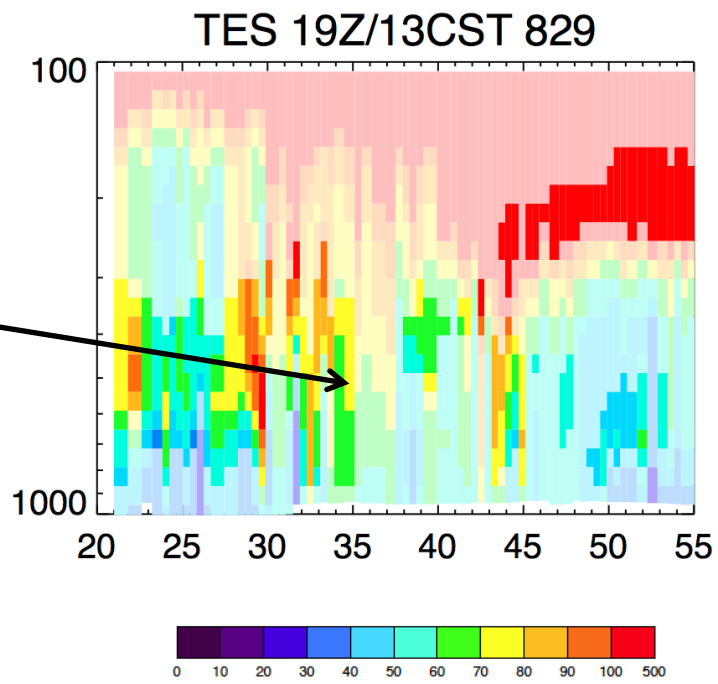


TES vs EPA CMAQ O3 – Aug 28-29, 2006



Profile Comparison: Daytime on Aug 29, 2006 Huntsville, AL

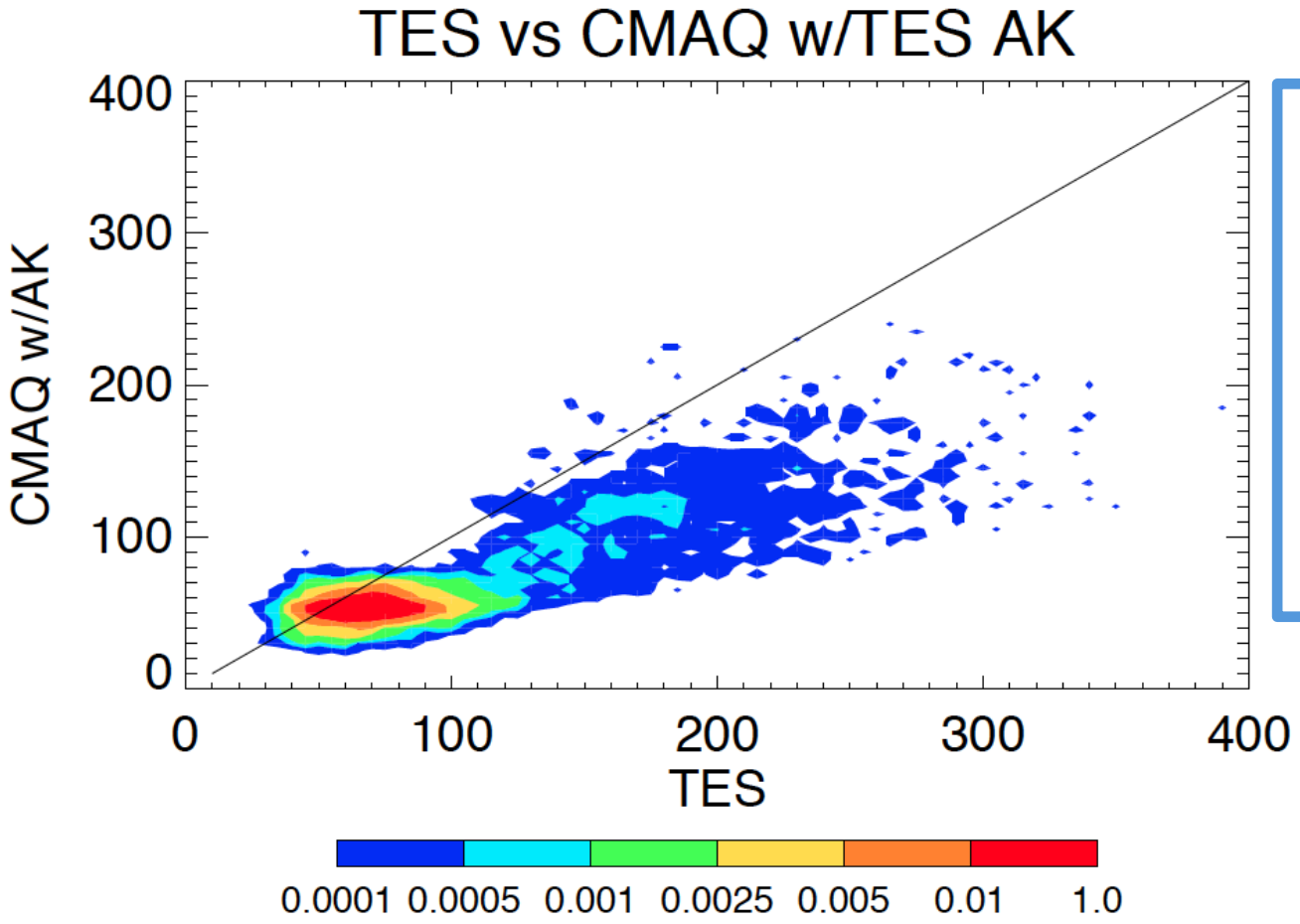




PDFs

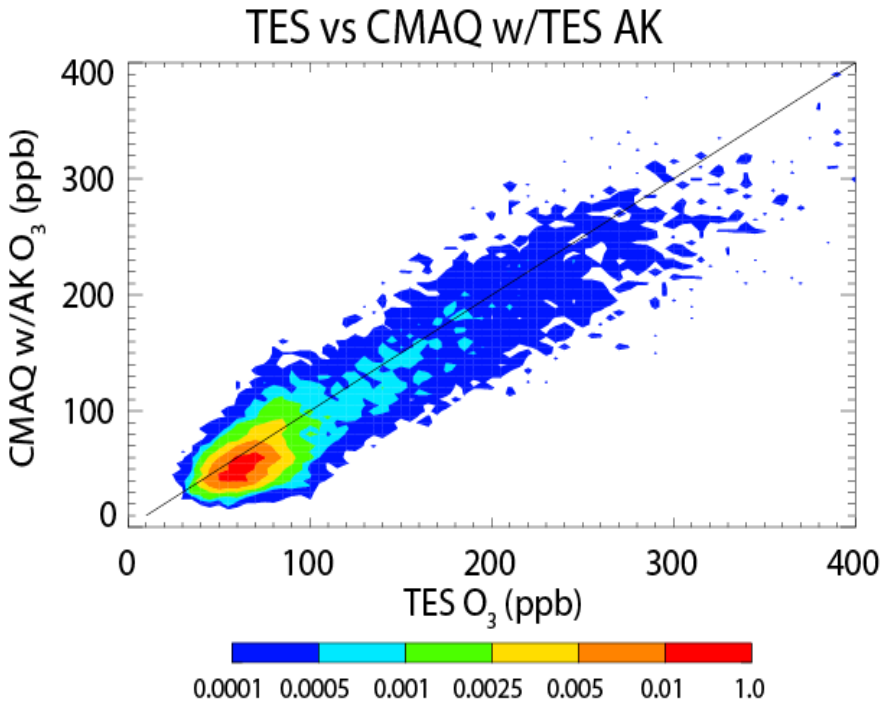
* TES, CMAQ matches are nearest in time, latitude and longitude
* Model interpolated to TES pressure grid and observation operator (averaging kernel) is applied
* Only TES data that passes the master quality flag is used
  * Pressure < 160 hPa
  * Diagonal of averaging kernel > 0.08

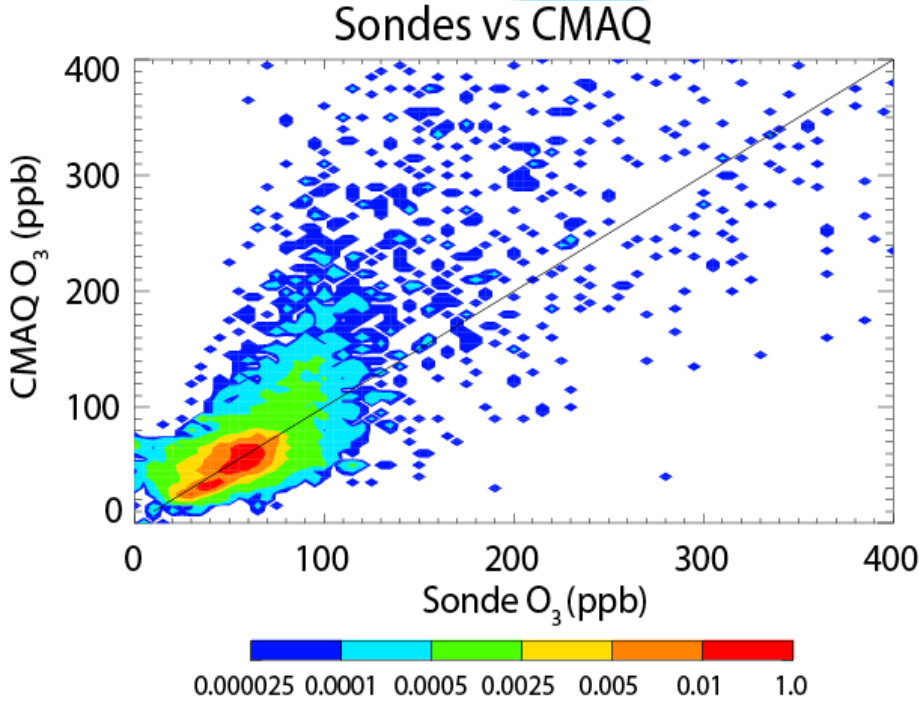
TES, NOAA/NWS AQ Forecast Comparisons



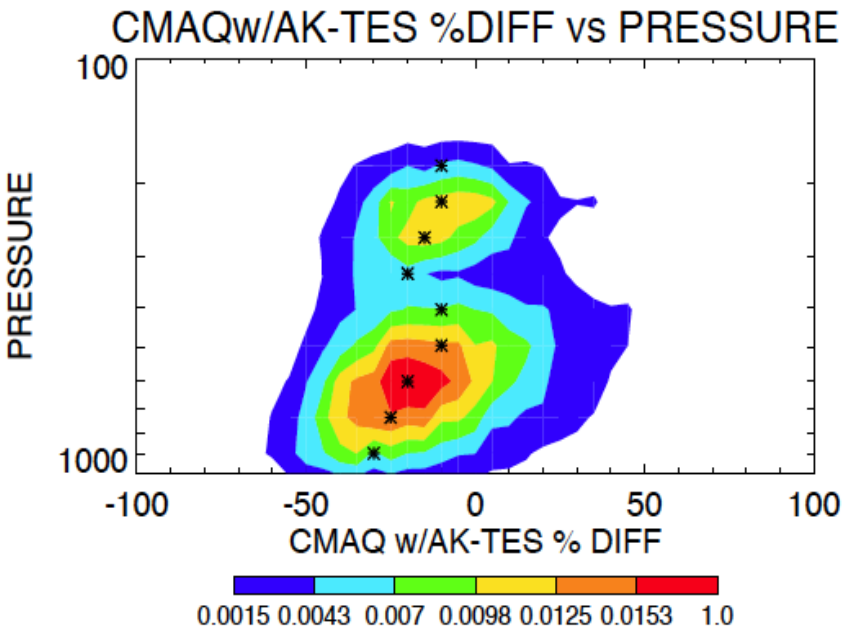
- Forecast model using forecast meteorology
- Older, static boundary conditions
- Will repeat using more recent dates

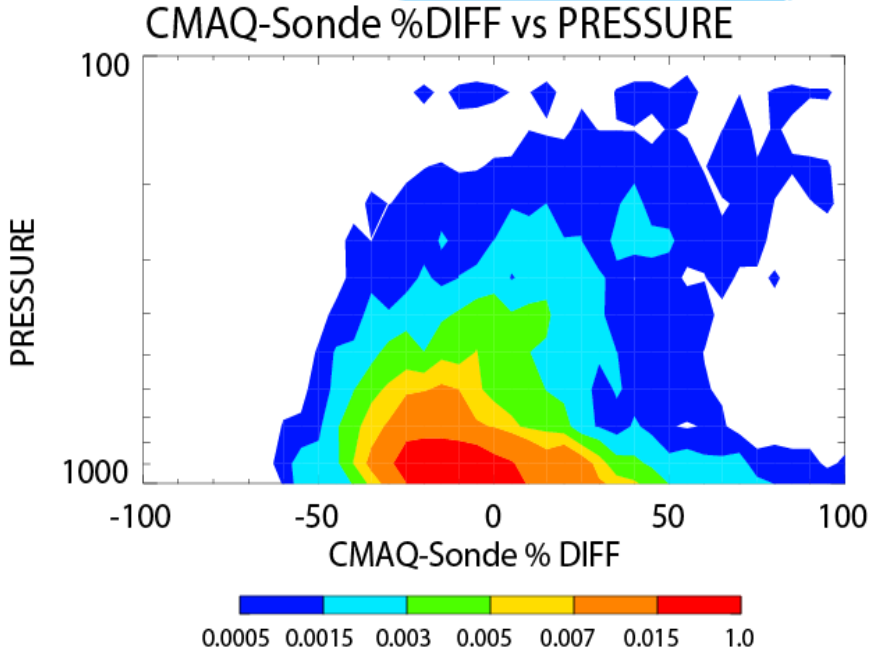
TES, EPA CMAQ Comparisons





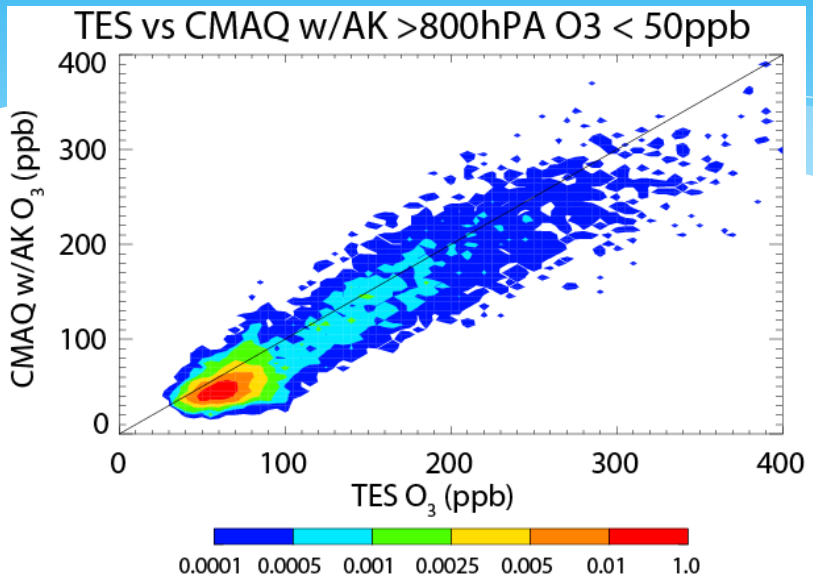
CMAQ-TES Difference – Aug 2006

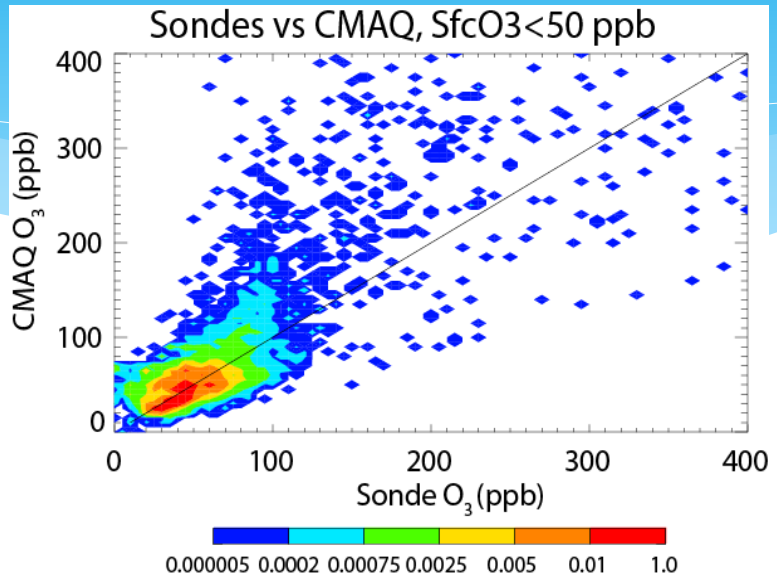


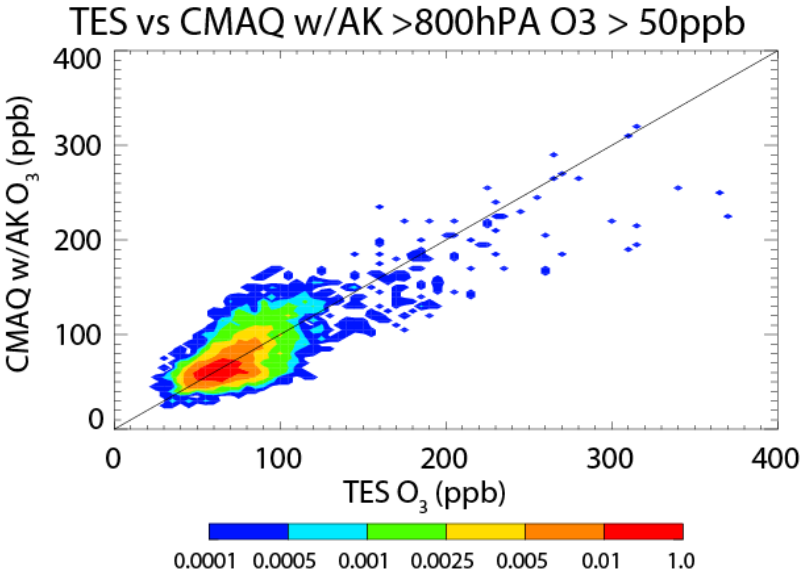


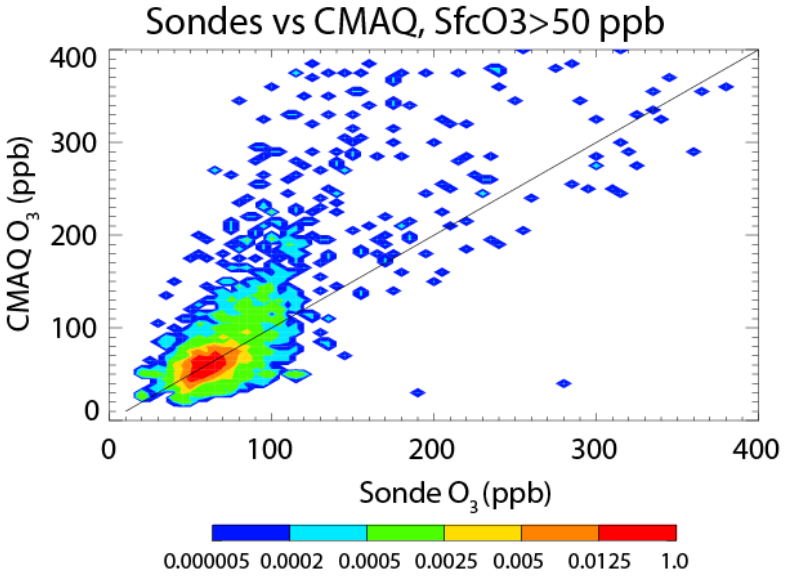
- Model is low compared to TES
- Most TES obs between 500-800 hPa

Clean vs Polluted Cases



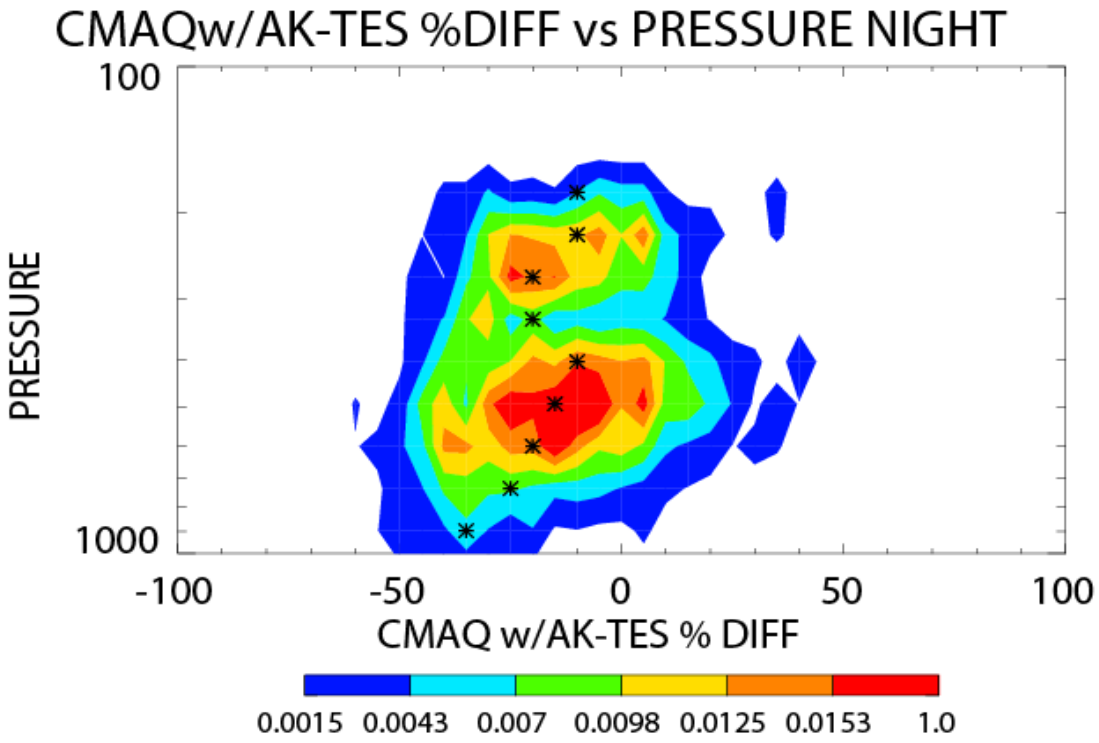






Nighttime Ozone

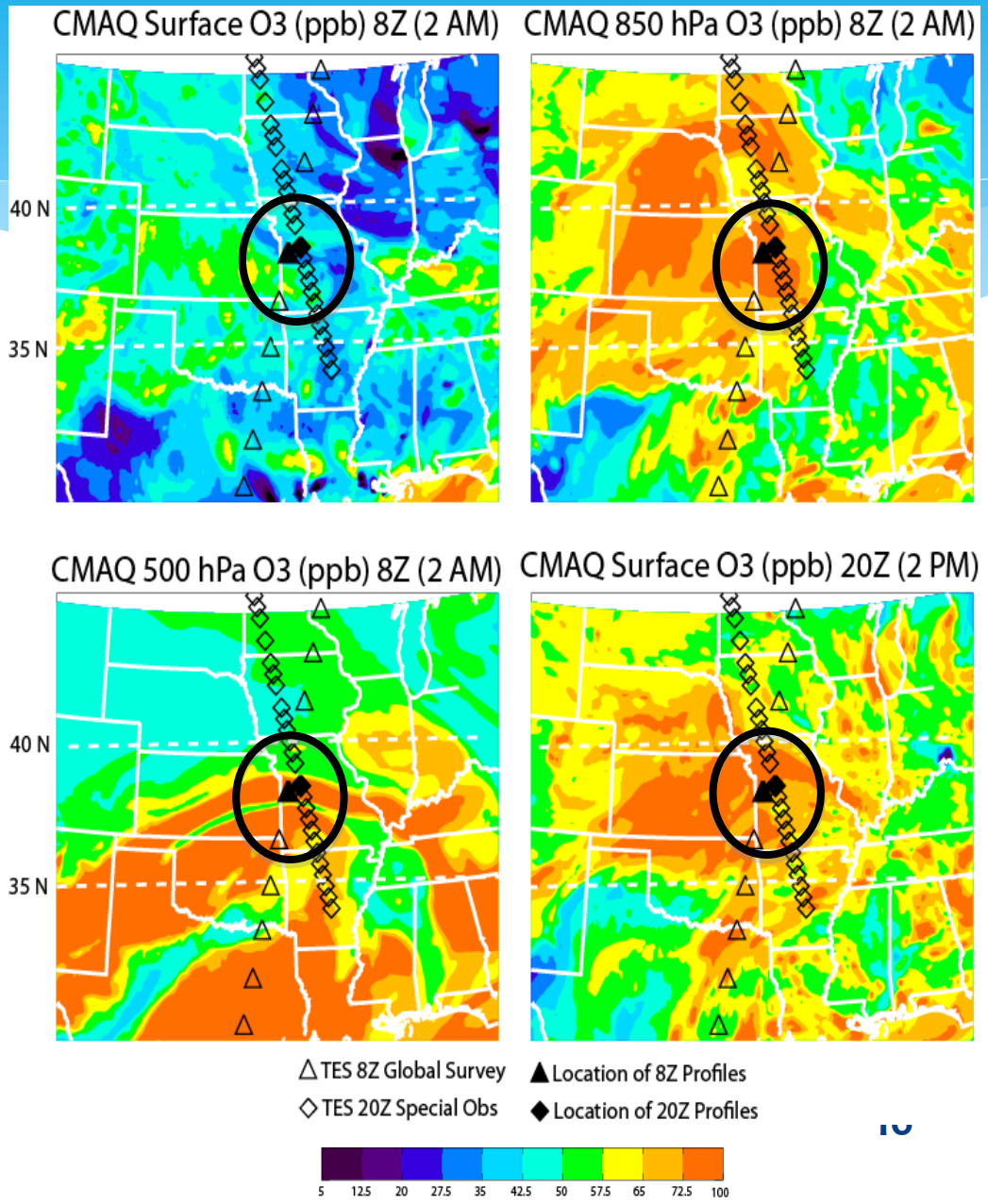
- Overall, the model agrees better with TES observations of the mid-troposphere at night than during the day
- Below ~700 hPa, however, it shows large negative biases.



A Case Study

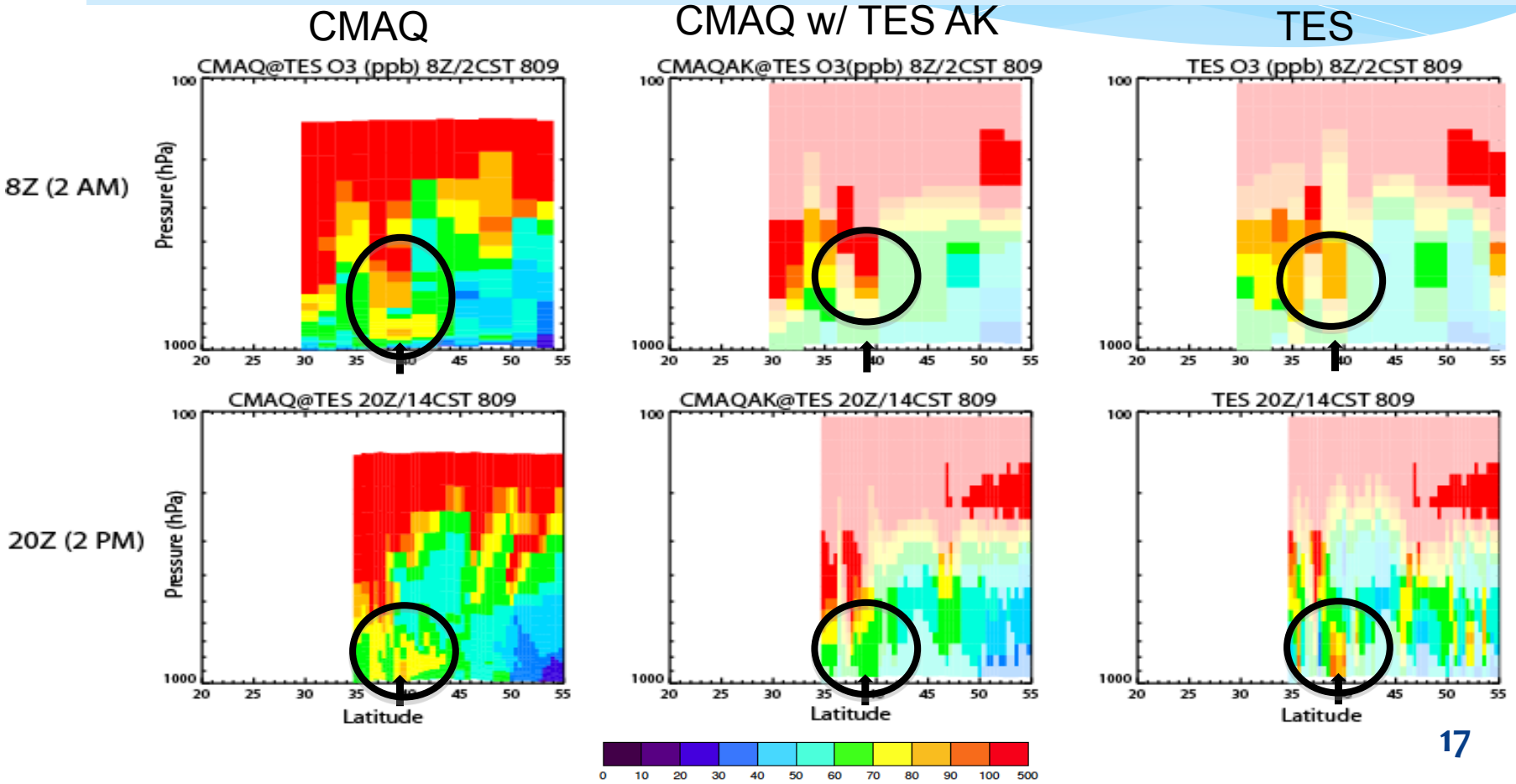
- TES passed over the region at 1:30 AM during a Global Survey and then again at 1:30 PM during a transect.
- TES curtain plot shows elevated mid-tropospheric O_3 at 1:30 AM at ~38N and elevated near-surface O_3 at the same location 12 hours later.
- CMAQ curtain plot and maps show a large region of elevated nocturnal O_3 at 500 hPa, in agreement with TES. They also show a second layer at 850 hPa, where TES is not sensitive.
- CMAQ 2 PM near-surface O_3 enhancements agree qualitatively with TES

CMAQ O_3 with TES Locations – Aug 9, 2006



Curtain plots of Nighttime Ozone

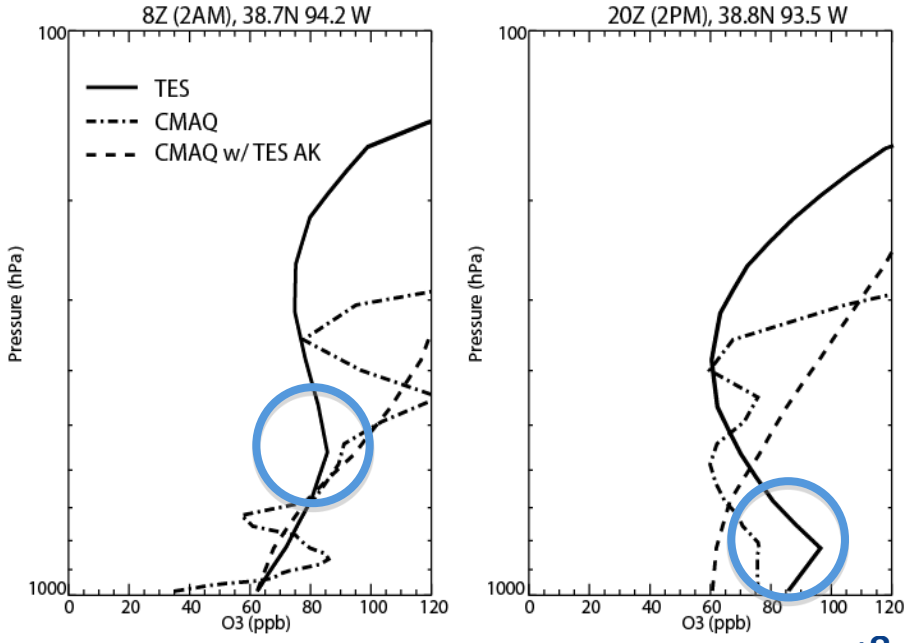
Curtain plots along TES tracks at 1:30 AM (top) and 1:30 PM (bottom)



Profiles in Detail

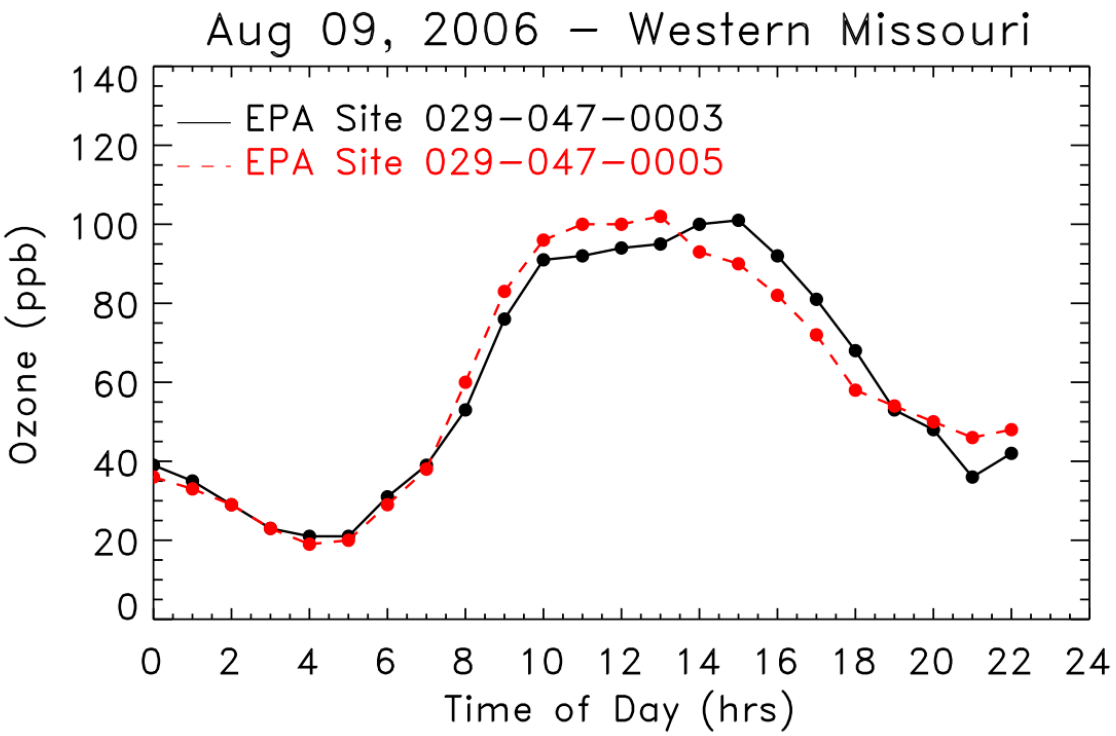
- TES profiles show broad enhanced layer of nocturnal O_3 in the mid-troposphere.
- CMAQ profiles show much narrower nocturnal layers.
- The low CMAQ tropopause causes the enhanced layers to disappear when the averaging kernel is applied.

Profiles at the location of the filled symbols



Ground Based Observations

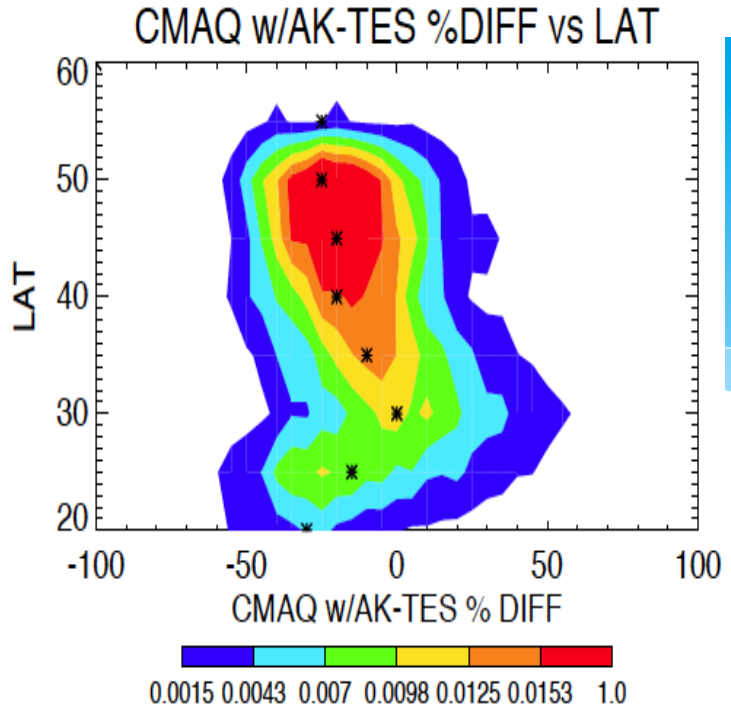
- TES observes near surface O_3 of ~90 ppb at 1:30 PM, in good agreement with nearby surface measurements.
- CMAQ surface O_3 is <80 ppb at 2 PM
- We will examine the mixing of nocturnal O_3 into the surface layer in detail for this case study.

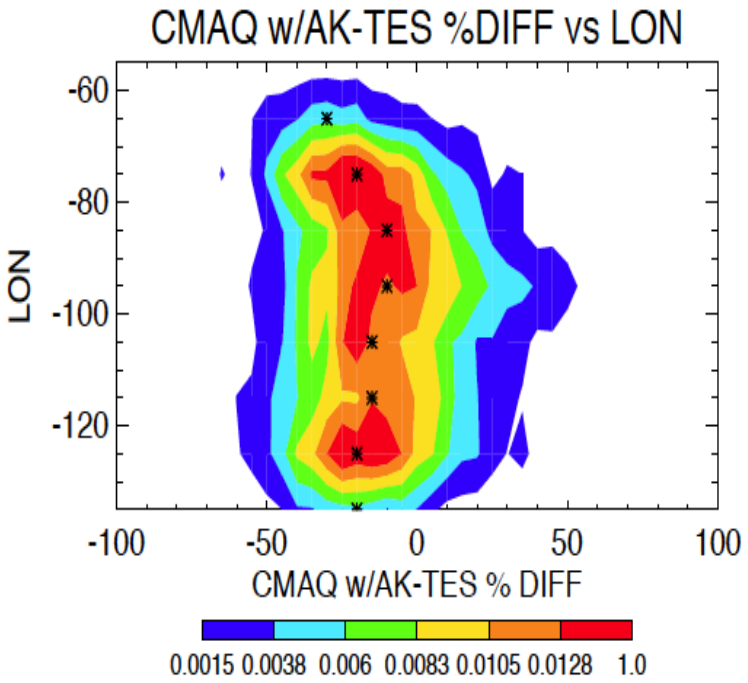


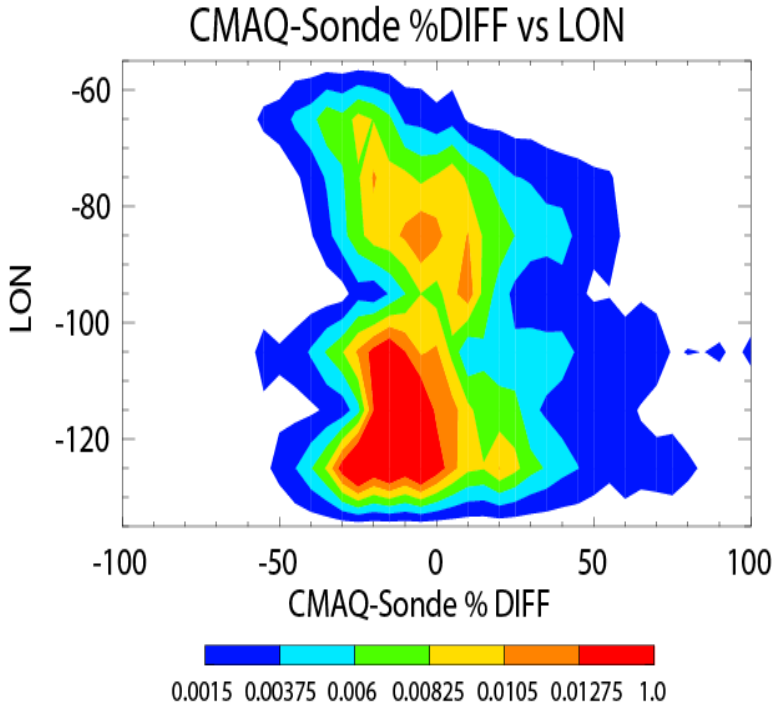
Status & Next Steps

* Status:
  * Initial set of CMAQ, TES and sonde comparisons have been completed
  * Developed method of visualizing the comparisons
  * Completed preliminary evaluation of aggregated model results using TES for August 2006
* Next Steps:
  * Continue comparison of August 2006 model results to ozonesondes
  * Incorporate surface monitor data into comparisons
  * Repeat analysis for other seasons, years
  * Focus on nighttime ozone comparisons and identify case study opportunities

CMAQ-TES Difference vs Latitude







Polluted vs Pressure