Application of Satellite and Ozonesonde Data to the Study of Nighttime Tropospheric Ozone Impacts and Relationship to Air Quality

Greg Osterman – Jet Propulsion Laboratory

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Investigators

- AURA 2010 Proposal
- Annmarie Eldering (PI, JPL), Jessica Neu (JPL)
- Jeff McQueen, Youhua Tang (NOAA/NWS)
- Rob Pinder (EPA)
Project Objectives

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

- **Models:**
  - NAQFC Forecast
  - EPA CMAQ 4.7.1

- **Evaluation Data Sets:**
  - Satellite data from TES (O3, CO, TATM, H2O), and OMI (O3, NO2)
  - Ozone sondes
  - Surface monitors
TES
Launched 2004.07.15

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)
Step & Stare footprints
45 km apart
Special observation

Global Survey footprints
180 km apart
Every 2 days… ~767 and counting

Transect footprints
12 km apart
Special observation

TES Footprint 5 x 8 km
Elevated CO and O3 over SE Texas observed from TES on Aug 23, 2006

- TES resolves peaks in middle and lower tropospheric O3 and CO over East Texas
- Used to identify high ozone in middle troposphere
- Assimilated (along with OMI and MLS data) into RAQMS
AIRS & TES CO – August 23, 2006

Local PM (ascending) AIRS CO at 500 mb on 20060823

TES Step & Stare Nadir Retrieval Result: CO
Cross Section Along Orbit Track: Run0=4911, Seq=1-1, Seqa=0-124, UTC Time=2006-8-23 19:34:49-19:48:51

CO Volume Mixing Ratio (ppb)
Measurement Sensitivity
New: TES + OMI

TES
- Surface to 825 hPa
- 825 to 400 hPa
- 400 to 100 hPa
- 100 to 10 hPa

Total DOFS: 3.80
Trop DOFS: 1.52
Surf–700 hPa: 0.27

TES and OMI
- Surface to 825 hPa
- 825 to 400 hPa
- 400 to 100 hPa
- 100 to 10 hPa

Total DOFS: 6.14
Trop DOFS: 2.05
Surf–700 hPa: 0.35
Measurement Sensitivity

Wallops Island, Virginia, USA
2005/10/28
Ozonesonde
TES
TES and OMI
A priori

Pressure (hPa)

Ozone Volume Mixing Ratio

Surface to 825 hPa
825 to 400 hPa
400 to 100 hPa
100 to 10 hPa

Total DOFS
TES and OMI: 6.14
TES only: 3.80

Surf–700 hPa DOFS
TES and OMI: 0.35
TES only: 0.27

dx_est/dx_true
Air Quality Model Evaluation using TES
Model Evaluation using TES Tropospheric O3

Looked at mean of TES profiles for July in three areas:

- Northern CA/NV and Southern Oregon
- Southern CA Desert
- Pacific off CA Coast
Must take into account vertical sensitivity of TES measurements when comparing profiles to the model.
TES Step & Stare observation July 18, 2006
TES data used with models can provide information on transport of data across the Pacific
Ocean

TES Step & Store Nadir Retrieval Result: Ozone
Cross Section Along Orbit Track; RunID=4957, Seg=1–1, Scan=0–124, UTCTime=21:37/22–21:51:13

Pressure (hPa)

Latitude (degree)

Ozone Volume Mixing Ratio (ppb)

<20 40 50 60 70 80 90 >100

TES, CMAQ Mean O3 Profiles – Ocean – July 2006

TES

CMAQ Model w/ TES Sensitivity
• TES shows lower tropospheric ozone than the model in the lower troposphere (5-15 ppb)
• Good comparison in the upper troposphere
Evaluation: Northern California

- TES shows reasonable comparison with model throughout the troposphere
- Surface monitor data higher than CMAQ for month at Lassen and Yreka
Evaluation: Southern California Desert

- TES shows higher tropospheric ozone than the model in the lower troposphere (15-20 ppb)
- Good comparison in the upper troposphere
- Surface monitor data higher than CMAQ for month at Death Valley, Palm Springs and Joshua Tree
Evaluation of CAMx Ozone in Free Troposphere

- **Preliminary Result** – CAMx model higher than TES in lower troposphere
TES Observations of Nighttime Ozone
TES Observations of Nighttime Ozone

- June 2009 – Transect Special Observations

TES Nadir Retrieval Result: Ozone, 2009-06-21
Cross Section Along Orbit Track: RunID=10022, Seq=1-1, Score=0-39, UTCTime=06:30:04-06:34:20

Pressure (hPa)

Latitude (degree)

Ozone Volume Mixing Ratio (ppb)
min = -0.00233300, max = 0.235861

Pressure (hPa)

Diagonal Value of the Averaging Kernel

< -0.04  0.00  0.04  0.08  0.12 >
TES Observations of Nighttime Ozone

NOAA HYSPLIT MODEL
Backward trajectories ending at 0800 UTC 21 Jun 09
NAM Meteorological Data

Source at 29.72N 95.34W
Ozone in the Houston area on the morning of June 7 was in the range of 30-40.
Wrap Up

• Just getting started …
  • Model outputs received – July and August 2006 from EPA and NOAA/NWS
  • Beginning day time comparisons with TES and ozonesondes
  • Systematic comparisons to models (daytime and nighttime)

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• Thank you!