No.American Tropospheric Ozone Profiles from IONS (INTEX Ozonesonde Network Study, 2004, 2006):

Aura Applications & Statistics for Pollution Studies

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<http://croc.gsfc.nasa.gov/intexb/ions06.html>
<http://croc.gsfc.nasa.gov/intex/ions.html>

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- Jacquie Witte (SSAI, NASA/GSFC), Archiver & Webmaster
- S K Miller, J E Yorks, K M Dougherty (PSU), Analysis
- Co-Is: S J Oltmans (NOAA/ESRL/GMD), O R Cooper (CU-CIRES & NOAA/ESRL/CSD), E Joseph (Howard Univ), J T Merrill (URI), G A Morris (Valparaiso Univ), M J Newchurch (UAH), M Dubey (DOE/LANL), F J Schmidlin (NASA/WFF), D W Tarasick (EC-MSC, Downsview), G Forbes (EC-MSC-Sable Island), B Rappenglueck & B Lefer (Univ Houston), D Baumgardner (UNAM), R B Chatfield (NASA/Ames), T Leblanc (TMF/JPL)
- Comparison Data: R B Pierce (NOAA/CIMSS), M R Schoeberl (NASA/GSFC), J A Logan (Harvard)

North American Tropospheric Ozone Profiles from IONS (INTEX Ozonesonde Network Study, 2004, 2006): Aura Applications and Statistics for Pollution Comparisons

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- The recent deployment of strategically designed and launch-coordinated ozonesonde networks during Aura has transformed our capabilities for: [a] validation and intercomparison of satellite ozone products; [b] evaluation of models and assimilation mapping of global ozone; [c] sampling the UT/LS (upper troposphere-lower stratosphere) with consistent temporal and vertical resolution; [d] determination of dynamical and chemical processes affecting ozone throughout the troposphere. One example is the SHADOZ (Southern Hemisphere Additional Ozonesondes) tropical network <http://croc.gsfc.nasa.gov/shadoz>, operating since 1998 [Thompson et al., 2003]. The campaign-based IONS (INTEX [Intercontinental Transport Experiment] Ozonesonde Network Study) networks over North America in July-August 2004 and March-August 2006, <http://croc.gsfc.nasa.gov/intexb/ions06.html>, targeted Aura validation. An overview of IONS-06 tropospheric ozone as applied to satellite, assimilation and models will be given. Selected discoveries from the 2004 and 2006 IONS soundings are described. IONS-04 provided ~300 O3 profiles from eleven North American sites and the *R/V R H Brown* in the Gulf of Maine. With July-August 2004 dominated by low-pressure conditions over northeastern North America (NENA), UT ozone consisted of approximately 25% stratospheric O3 [Thompson et al., 2007a,b] interleaved with O3 from aged or relatively fresh pollution and lightning [Cooper et al., 2006; Morris et al., 2006]. IONS-06 covered boreal spring and summer, with a greater range (the eleven 2004 sites plus a dozen in California, New Mexico, Mexico City, Barbados and southwestern Canada). Tropospheric pollution statistics and contrasts in UT/LS O3 between 2004 and 2006 guide retrievals for various Aura retrievals. Both IONS periods displayed a persistent UT ozone maximum [Cooper et al., 2007] over the summertime south-central US. March 2006 IONS sondes over Mexico manifested persistent UT/LS gravity wave influence and more sporadic pollution.

Presentation Road Map

Strategic Ozonesonde Networks in Integrated Observations

IONS-2004 – High variability; both pollution & natural O_3 sources in troposphere. INTEX *JGR* Special Issues Vol **111 & 112**

IONS-2006

> Three-phase campaign, > 600 North American soundings
> Pollution, natural O_3 sources dominant again
> Aura Validation Papers (*JGR* Special Issue, in press)

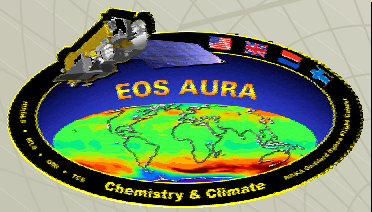
On-going Analyses with IONS Profiles

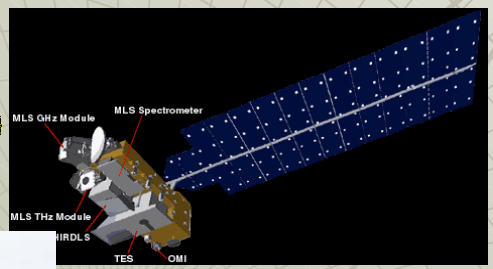
- Hui Poster – IONS-NATIVE-OMI comparisons
- Yorks Poster – IONS/Beltsville (MD) pollution statistics

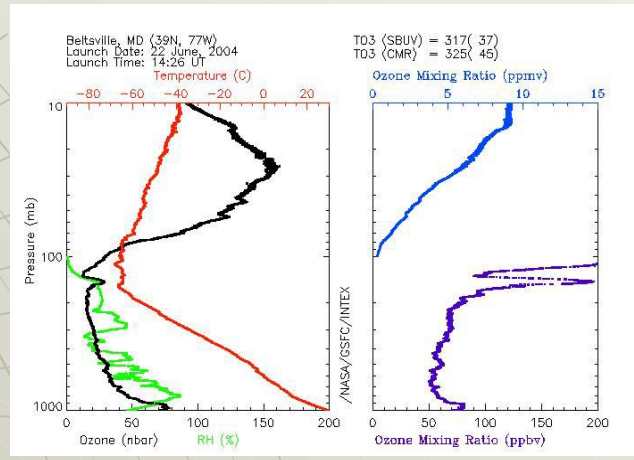
Future? Modify, optimize retrievals to account for variability

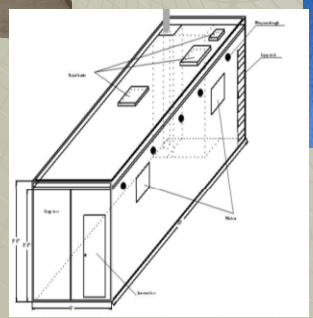
Synergistic Observations: Ozonesondes Integrate In-Situ Data, Satellites, Models

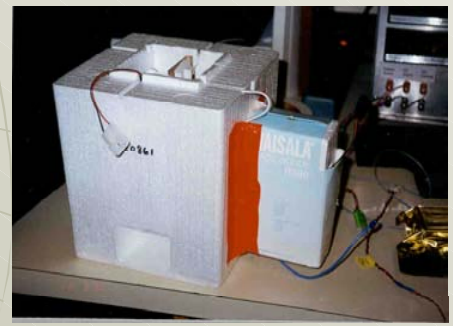
- High vertical resolution (~100 m), consistent sonde location guide other sampling, data-assimilation, satellite sampling & algorithms
- IONS supports aircraft missions, Aura's 4 O_3 sensors







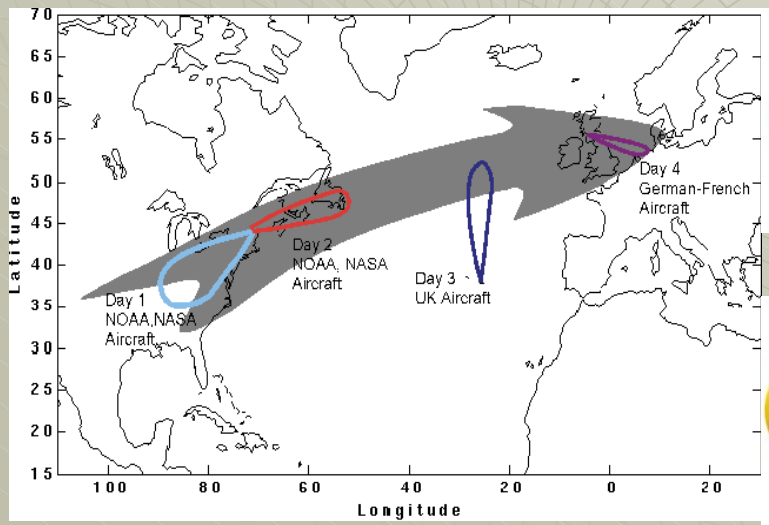


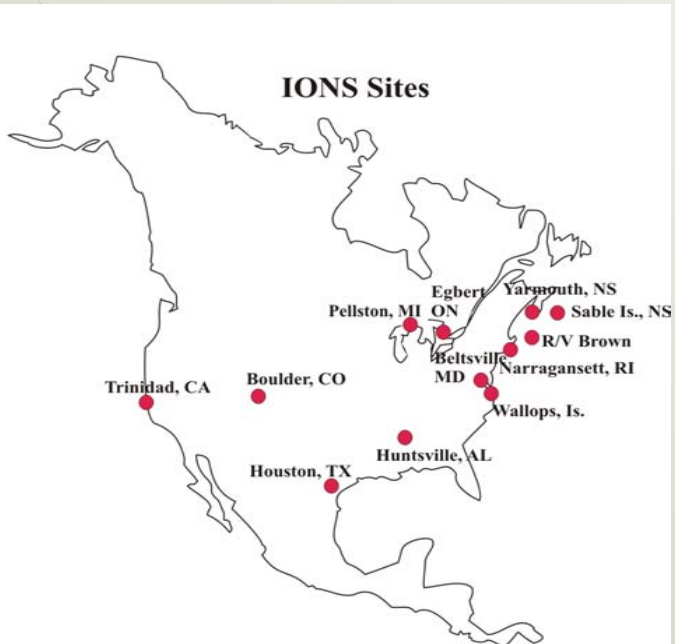


Define IONS-04 Network Requirements

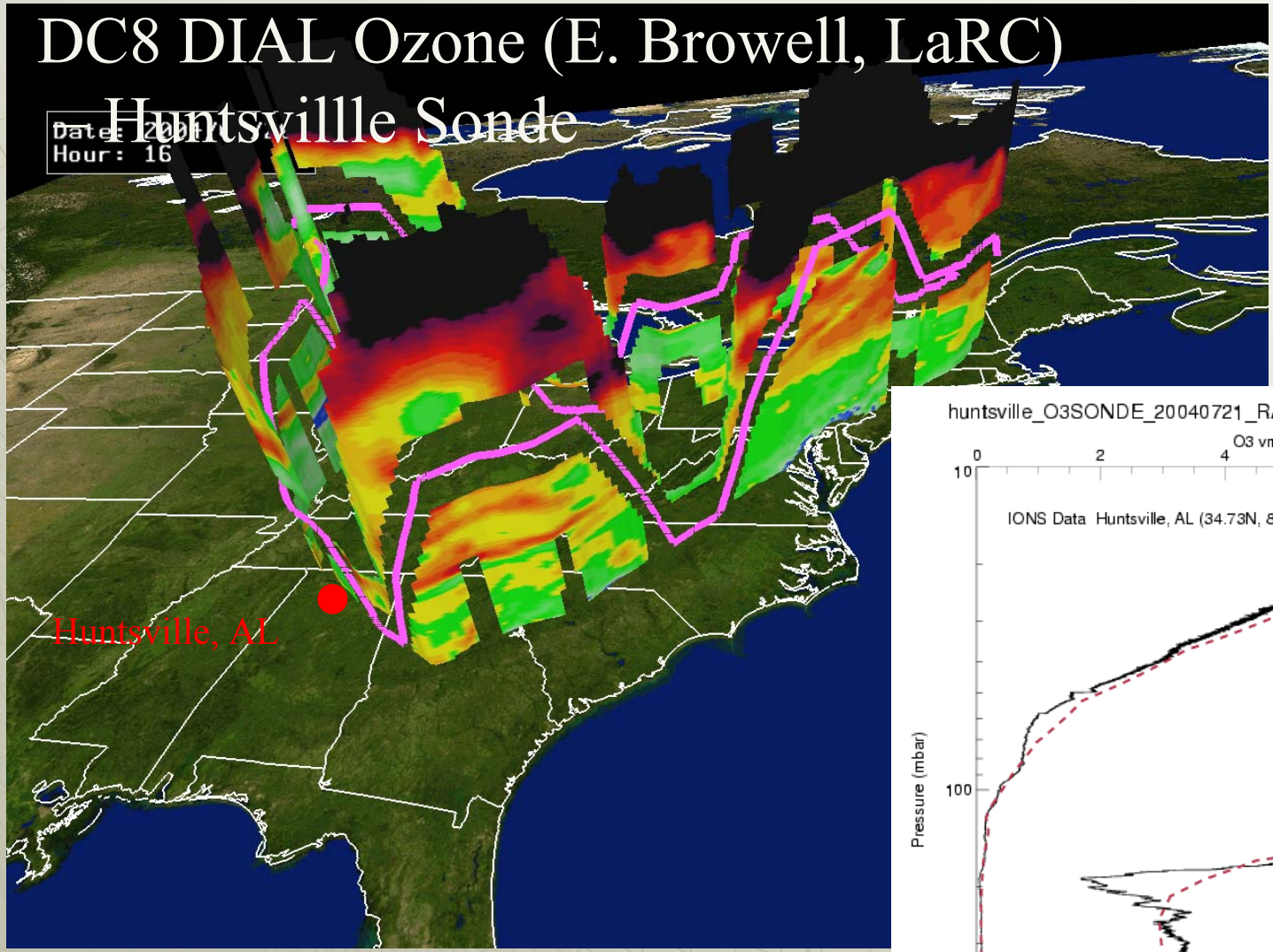
Design No. American O_3 sonde network for ICARTT/INTEX – NA (Intercontinental Transport Expt) to answer:

1. Can O_3 pollution be followed during ICARTT?
2. What are O_3 transport patterns across NA & to Europe?
3. How much Asian O_3 reaches NA? How much O_3 is from STE, advected pollution, lightning?
4. Can O_3 pollution be measured from satellite, predicted?

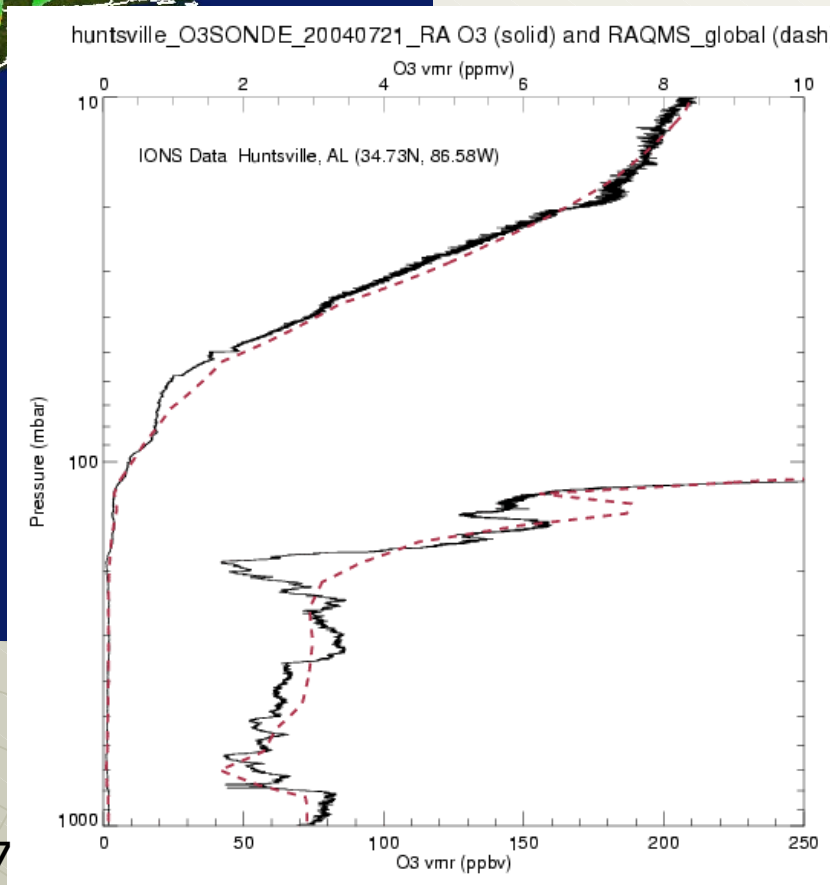


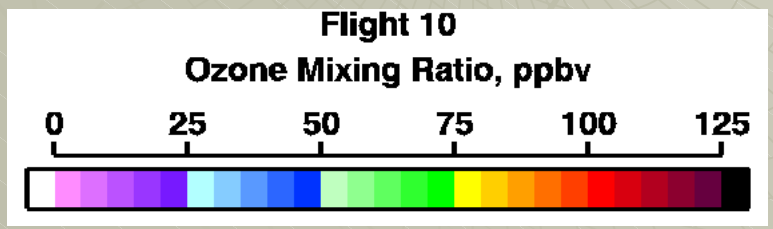


DC8 DIAL Ozone (E. Browell, LaRC)
Huntsvillle Sonde



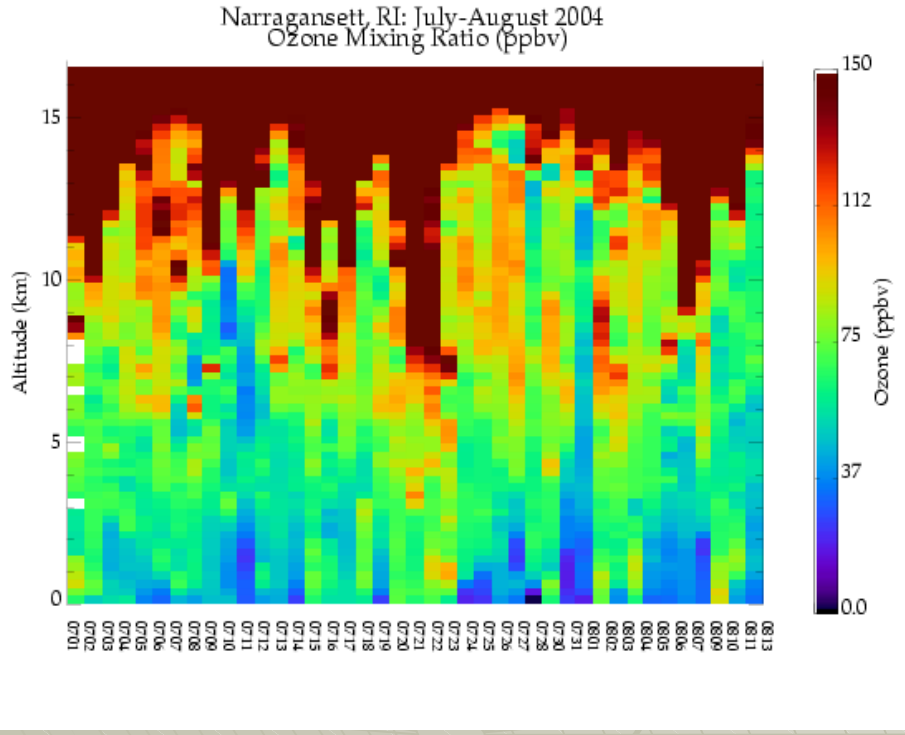
~300 profiles collected in 6 weeks.
Data at Ames & AVDC. Also WOUDC
←Image from M Avery

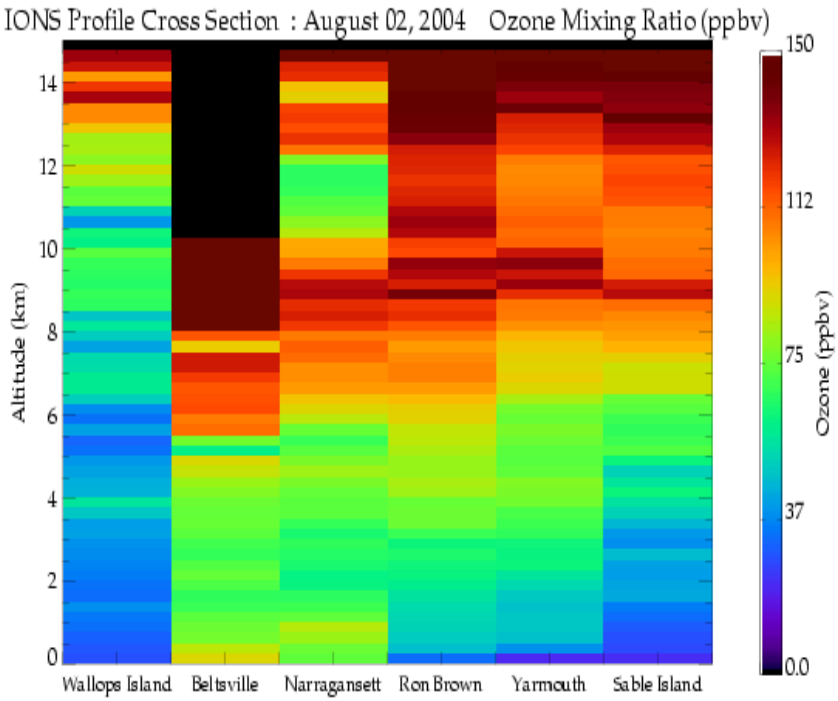




→ Pierce Et al, JGR, 2007

Ozone Variability in Curtains – IONS-04





- **<u>Single site variability</u> – Strong ST influence: Narragansett, other NE No American (NENA) sites below t'pause** (Thompson et al, 2007b)
- **<u>Single day variability (2 Aug)</u>, NENA Sites, ExTL layer, high ST O_3 mixed with pollution, lightning/convection**

IONS-04 Contributions – O_3 Budgets & Processes

- Northeastern No America ozone budgets from laminae analysis (Thompson et al, 2007a,b):
  - 25% from Stratosphere
  - 15% RCL – Regional convection, lightning
  - 10% - Boundary layer – local pollution
  - 50% - Advected fresh and aged pollution
- Pollution from Alaskan, Canadian fires (Pfister et al, 2005; Morris et al, 2006)
- UT ozone maximum – mostly lightning over south central US, FLEXPART analysis (Cooper et al, 2006)
- Comparisons of IONS to "smart balloon," (Mao et al, 2006) & models (Chai et al, 2007; Pierce et al, 2007; Tarasick et al, 2007)

IONS-06 for INTEX-B/ Milagro/Aura & TEXAQS-2006

March 2006 – Milagro

Is there a Mexico-to-Houston Ozone connection?

April-May 2006 – INTEX-B

Is there an Asia-to-North America Ozone connection?

August 2006 – TEXAQS-GOMACCS

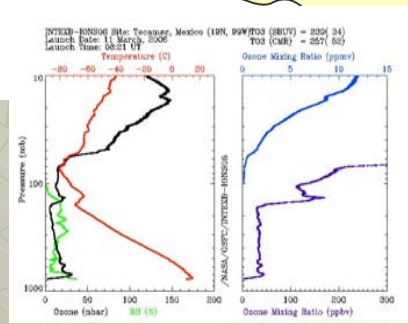
What is upwind-downwind of Houston Ozone?

700 profiles collected Mar-Sept 06

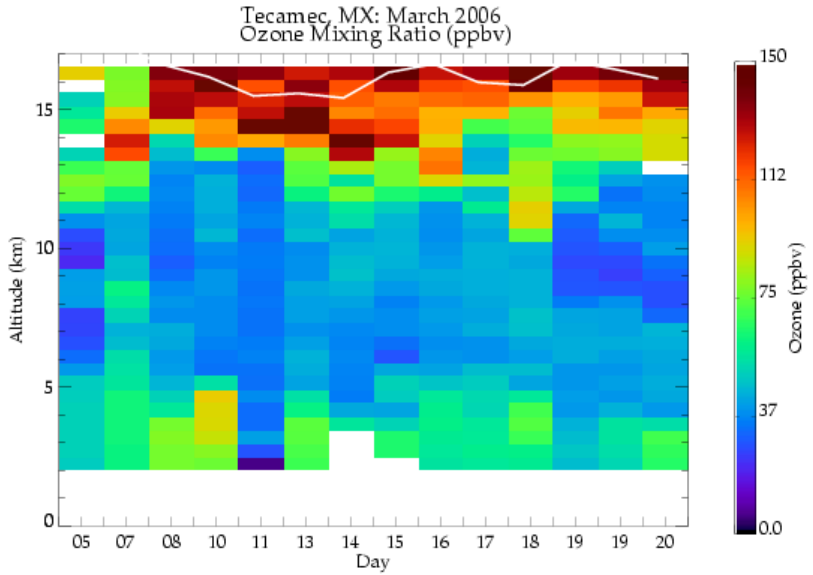
<http://croc.gsfc.nasa.gov/intexb>

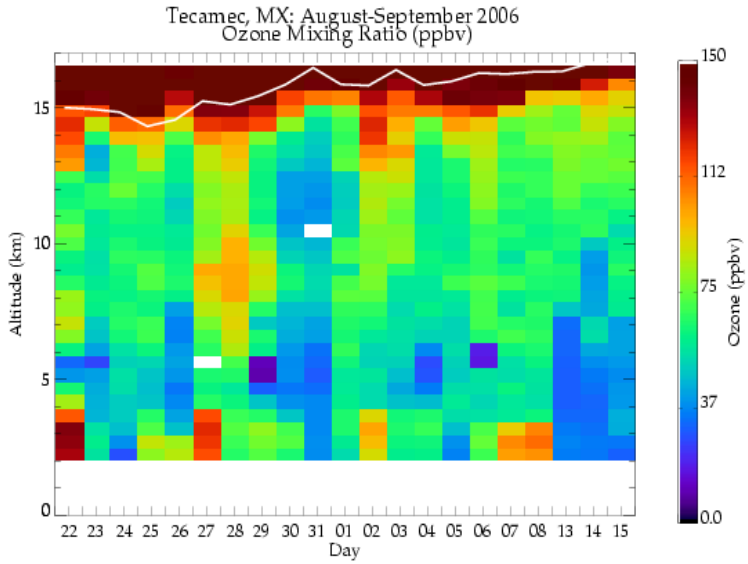
IONS-06 Sites

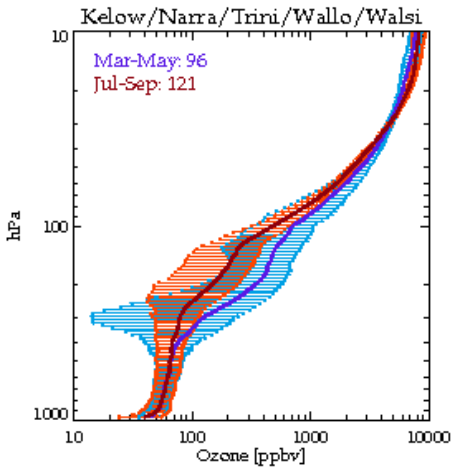
1 - Kelowna, BC
2 - Stonyplain, AB
3 - Bratt's Lake, Sask.
4 - Egbert, ON
5 - Walsingham, ON
6 - Paradox, NY
7 - Narragansett, RI
8 - Yarmouth, NS
9 - Sable Is. NS
10 - Valparaiso, IN
11 - Beltsville, MD
12 - Wallops Is., VA
13 - Trinidad Head, CA
14 - Table Mountain, CA
15 - Imperial Valley, CA
16 - Boulder, CO
17 - Los Alamos, NM
18 - Huntsville, AL
19 - Houston, TX
20 - R/V Ron Brown
21 - Barbados
22 - Tecamec, Mexico

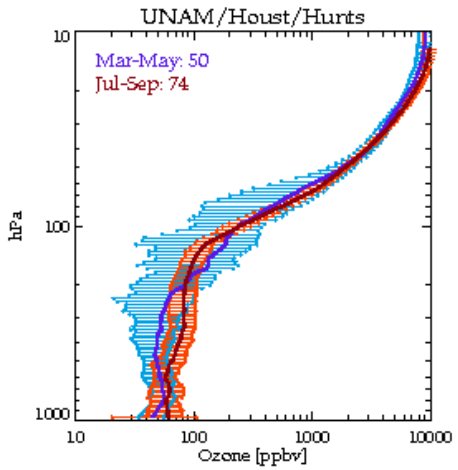


Spring-Summer IONS-06
Seasonal Contrasts, UT/LS Variability

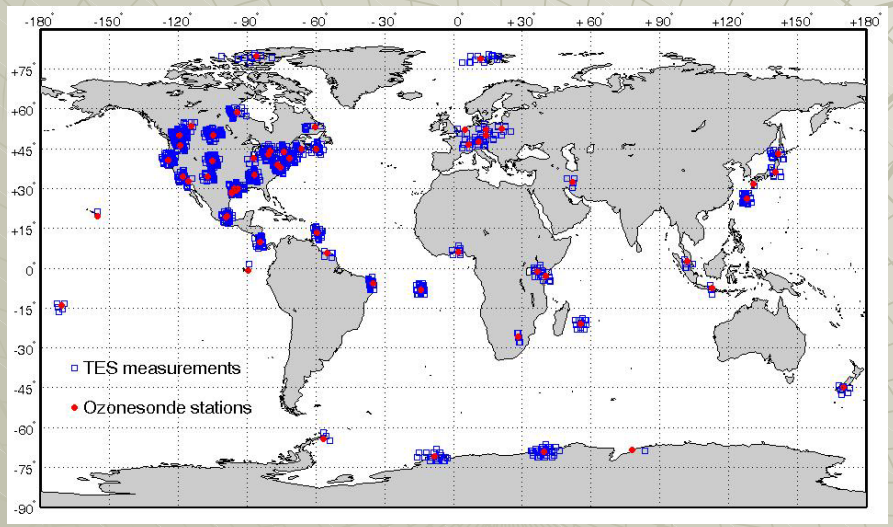








Satellite Comparisons, IONS-06 & TES Diverge in UT, BL (R Nassar, J Logan, *JGR*, in press)



Most No Am sites from IONS; Most SH Sites from SHADOZ

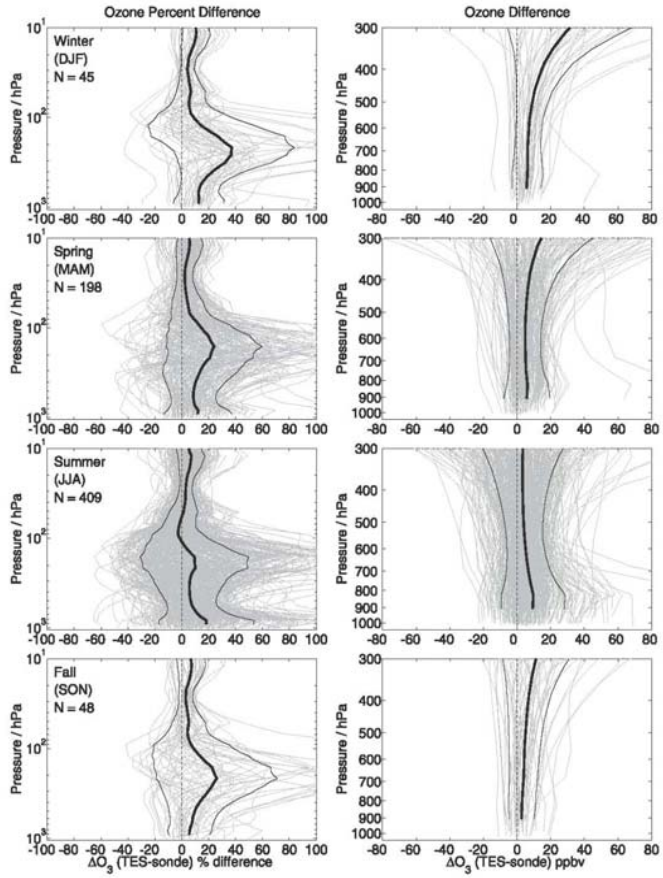


Figure 4. TES-sonde ozone percent differences and absolute differences for the four seasons (months abbreviated in parentheses) in the northern midlatitudes (35-56°N). Individual profiles are shown in grey and the mean and one standard deviation range are overlaid in black. *N* is the number of profiles plotted after removing cloudy scenes and flagged TES data.

Summary

IONS-2004 – High variability regionally, temporally

-- Laminae – a consistent approach to tropospheric O_3 budgets

-- Northeast US/Maritimes show complex UT/LS: interleaved STE, lightning, pollution influences, ie "***extra-tropical tropopause layer***"

IONS-2006

> All sites display mixed ozone sources in UT/LS, with a south central summer "UT ozone maximum" similar to 2004

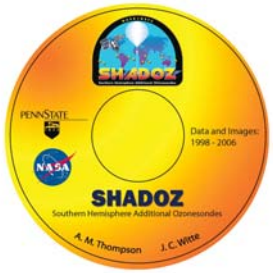
> In progress: 2004-2006 NENA comparisons; 2006 seasonal budgets - pollution, natural O_3 sources

> In press: IONS-06 & Validation of TES, OMI/MLS, MLS, HRDLS

Stay tuned for other IONS-06 Results

- Model & Assimilation comparisons
- Visit Hui, Yorks Posters

Acknowledgments, References



Aura Validation & SHADOZ (M. J. Kurylo); IONS/INTEX-A (B. G. Doddridge(IONS-04), IONS-06/INTEX-B (J. H. Crawford)

NEW SHADOZ CD! AGU & EGU 10th SHADOZ Anniversary Sessions!

Recent References on IONS Sondes & Sonde Precision

- H G J Smit et al, Assessment of the performance of ECC-ozonesondes under quasi-flight conditions in the environmental simulation chamber: Results from the Juelich Ozonesonde Intercomparion Experiment chamber (JOSIE), *J. Geophys. Res.*, 112, doi: 10.1029/2006JD007308, in press, 2007.
- A M Thompson et al., IONS (INTEX Ozonesonde Network Study, 2004). 1. Summertime UT/LS (Upper Troposphere/Lower Stratosphere) ozone over northeastern North America, *J. Geophys. Res.*, 112, D12S12, doi: 10.1029/2006JD007441, 2007a.
- A M Thompson et al., IONS (INTEX Ozonesonde Network Study, 2004): 2. Tropospheric ozone budgets and variability over Northeastern North America, *J. Geophys. Res.*, 112, D12S13, doi: 10.1029/2006JD007670, 2007b.
- A M Thompson, J C Witte, H G J Smit, S J Oltmans, B J Johnson, V W J H Kirchhoff, F J Schmidlin, Southern Hemisphere Additional Ozonesondes (SHADOZ) 1998-2004 tropical ozone climatology. 3. Instrumentation, Station Variability, Evaluation with Simulated Flight Profiles, *J. Geophys. Res.*, 112, D03304, doi: 10.1029/2005JD007042, 2007c.

ARC-IONS – 2008 Proposed for ARCTAS

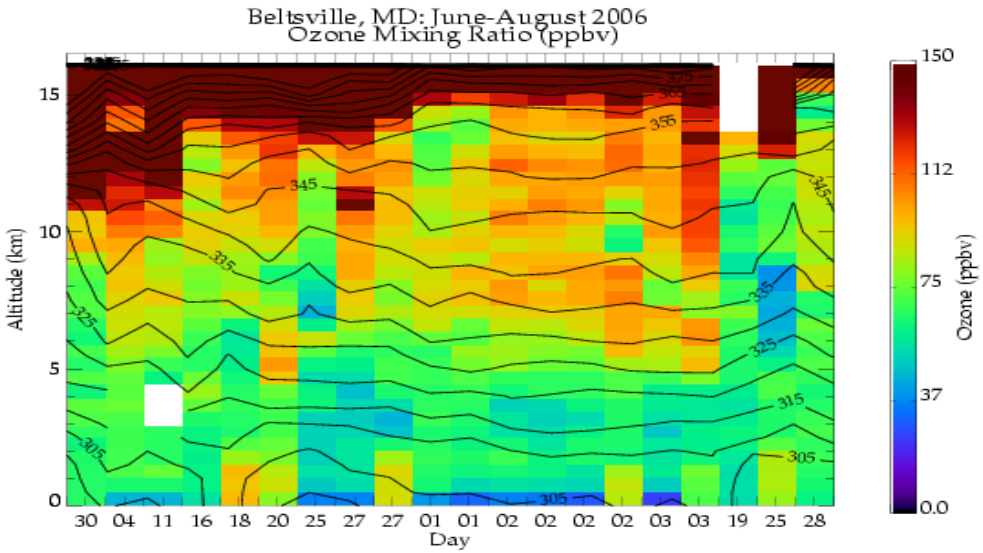
PENNSTATE

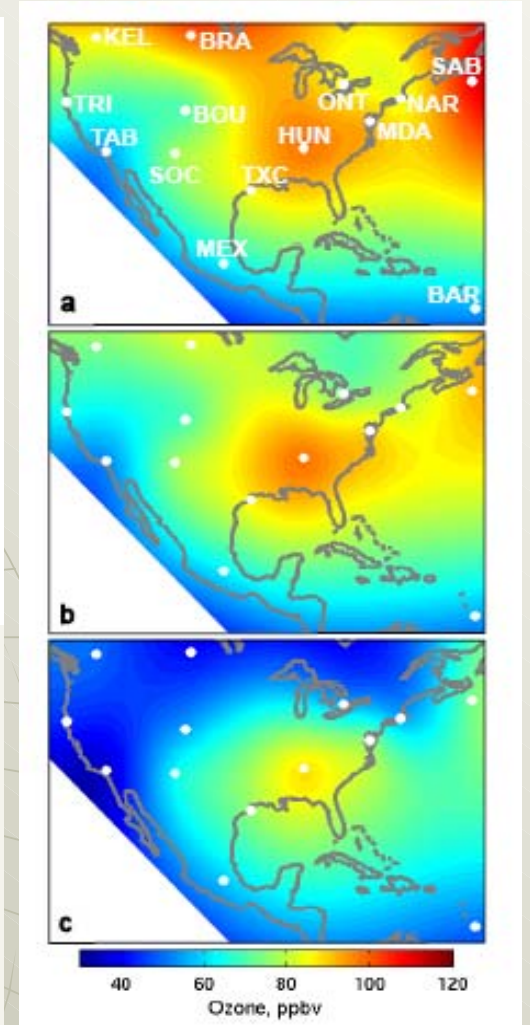
1855

NATIVE

Nittany Atmospheric Trailer & Integrated Validation Experiment

Major IONS Issue – Sources of UT Ozone. In Progress – IONS-WAVES (2007) at Beltsville. Compare to "FLEXPART Budget"





Above – ST influence above 8-9 km (300 hPa). Lightning too?

Right – Cooper et al (in press): [a] All median O_3, 10-11 km, Aug 06; [b] pv <1, stratospheric influence removed; [c] trop O_3 less ST O_3 from MPI model = lightning UT O_3 influence

TTOR Comparisons – Schoeberl et al, in press

ve show the comparisons at mid-latitudes by season. T
ical Southern Hemisphere so we restrict our analysis t
re.

SHADOZ data are used for our tropical comparisons.

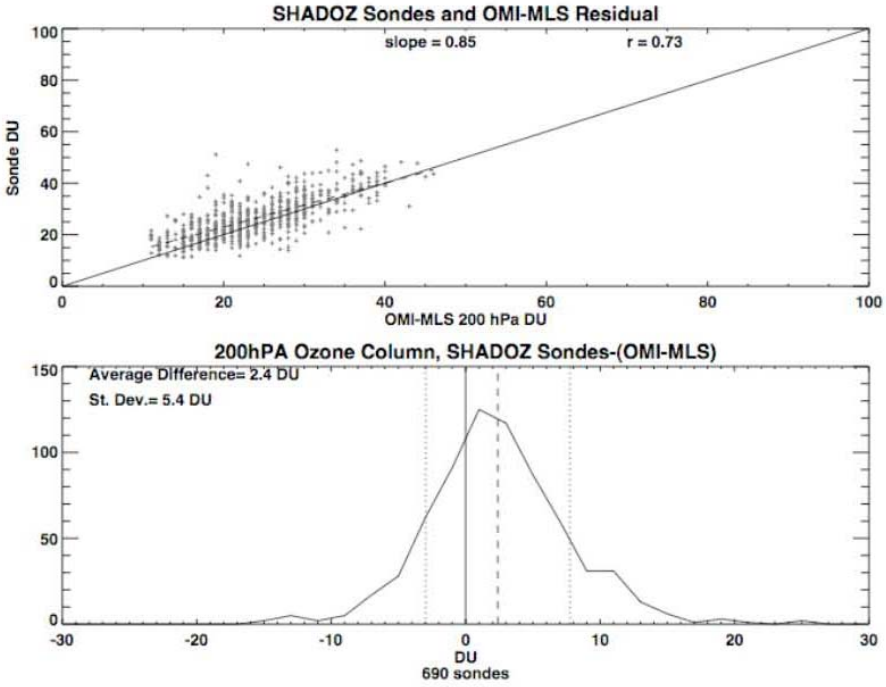
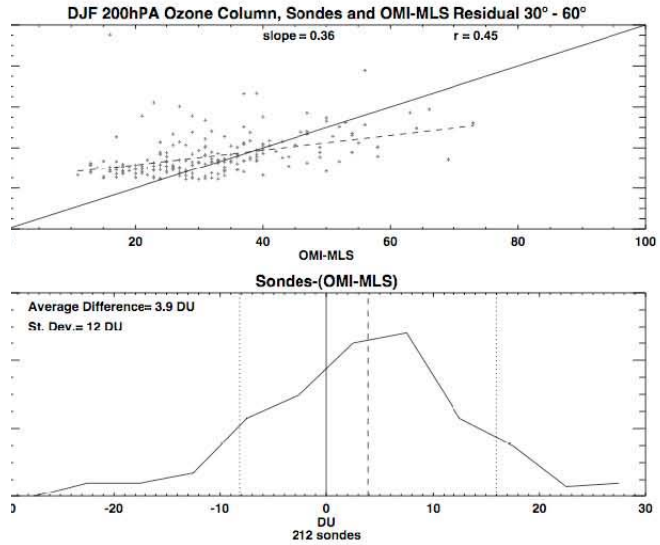
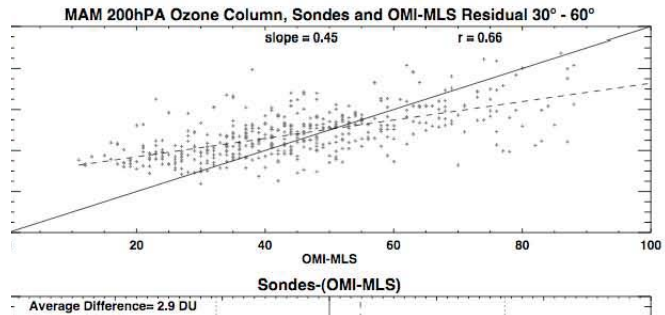



Figure 3. Comparison of ozonesondes 200TSC and the our 200TSC estimate. Upper figure shows the data points, the slope of the data (dashed line) and the correlation coefficient (r). The one-to-one line is the solid line. The lower figure shows a PDF of the difference between the sonde 200TSC with the mean and standard deviation (dashed and dotted, respectively).