

IONS-06 for INTEX-B/ Milagro/

Aura & TEXAQS-2006/GOMACCS Strategy

Strategic Design for Three-Phase Network – Daily Sondes in 4-6-week Campaigns

March 2006 – Milagro

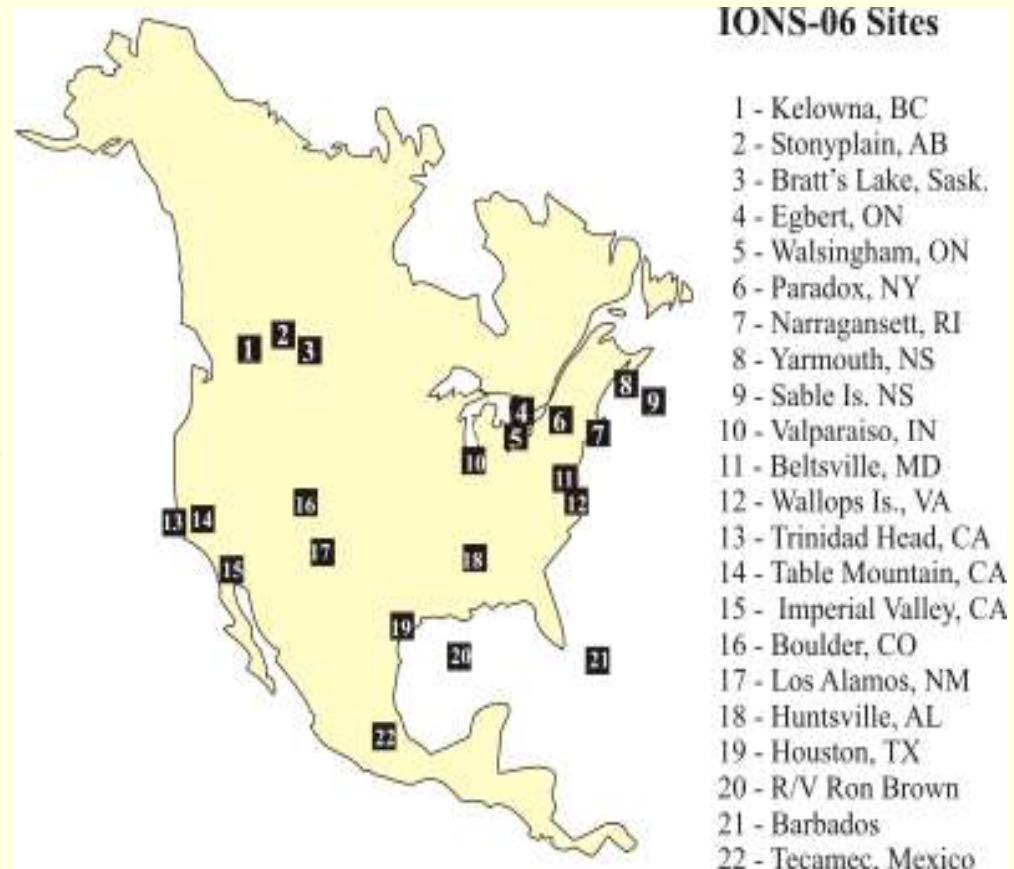
Is there a Mexico-to-Houston
Ozone connection?

April-May 2006 – INTEX-B

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

**August 2006 – TEXAQS-
GOMACCS**

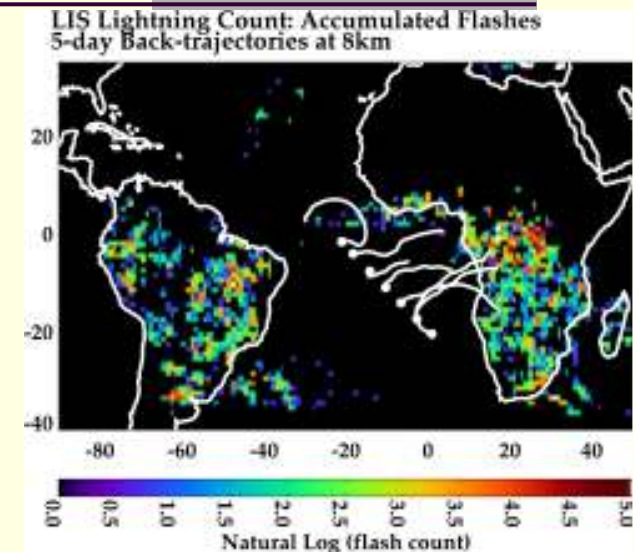
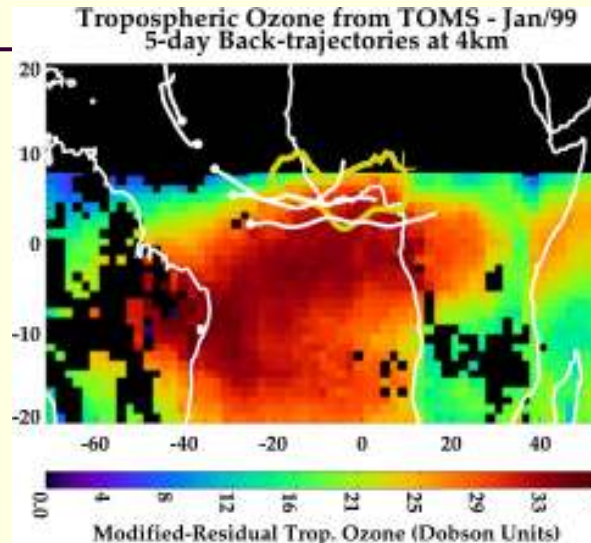
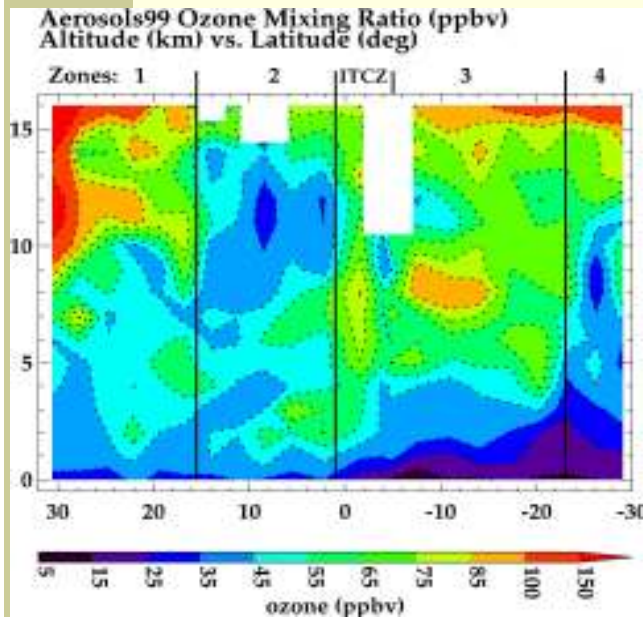
What is upwind-downwind
of Houston Ozone?



Highlights - SHADOZ Ozone Discoveries

- “Ozone Paradox”
- “Wave-one” in Tropospheric ozone
- Teleconnections among regions
- Trends & Climate Connections
- Tropospheric processes & budgets with “lamina-labeling”

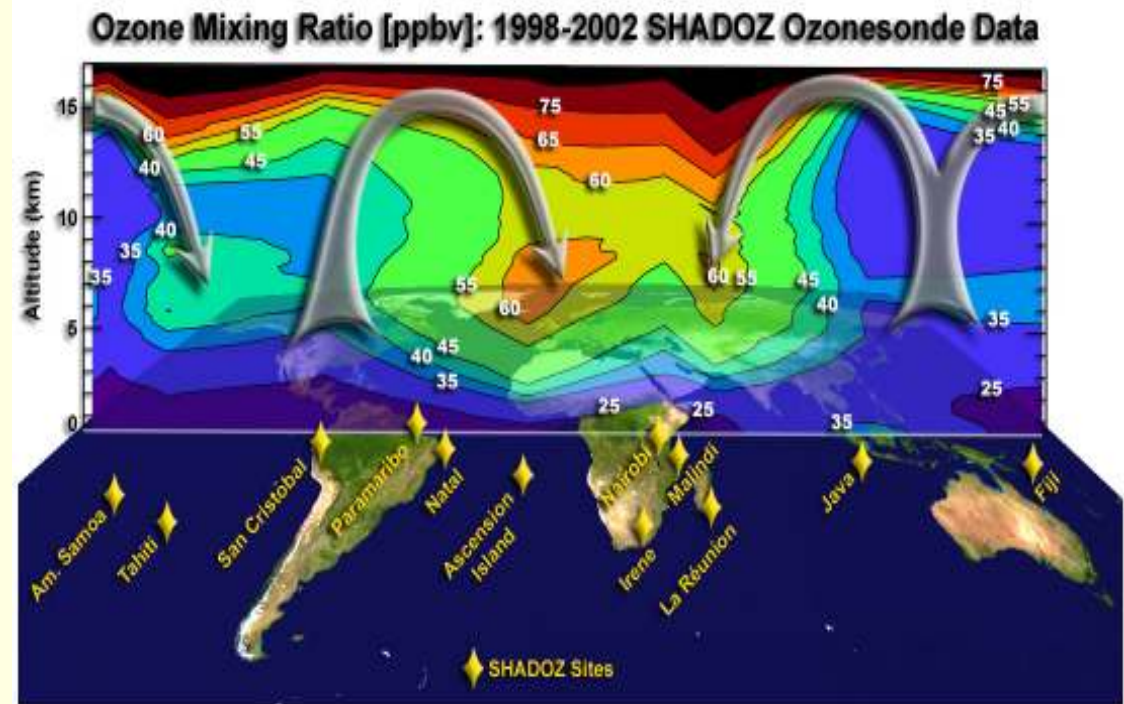
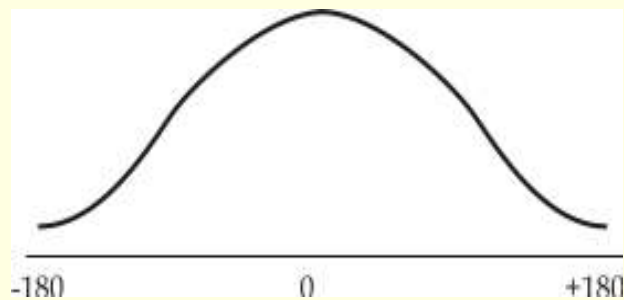
“Atlantic Ozone Paradox” Found on SHADOZ-linked Cruise



- “Paradox” (left, cross-section view; middle, satellite view) – more DJF ozone over southern hemisphere when north tropics (west Africa) burning! From Aerosols99 cruise, US to So Africa [Thompson et al., *GRL*, 2000]
- Mechanisms: Interhemispheric transport, ozone subsidence over So. Atlantic, lightning (right)

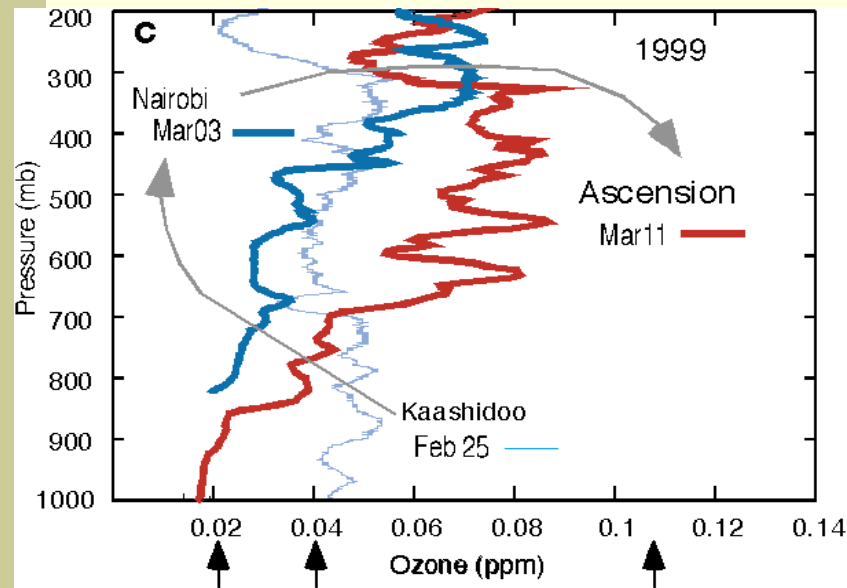
Wave-One in Tropospheric, Not Stratospheric Ozone – Interaction of General Circulation, Convection & O₃ from Fires, Lightning NO over So Atlantic

- “Wave” refers to more ozone over Atlantic than Pacific – in troposphere or stratosphere? (Thompson et al, *JGR*, 108, D2, 8241 2002JD002241, 2003).



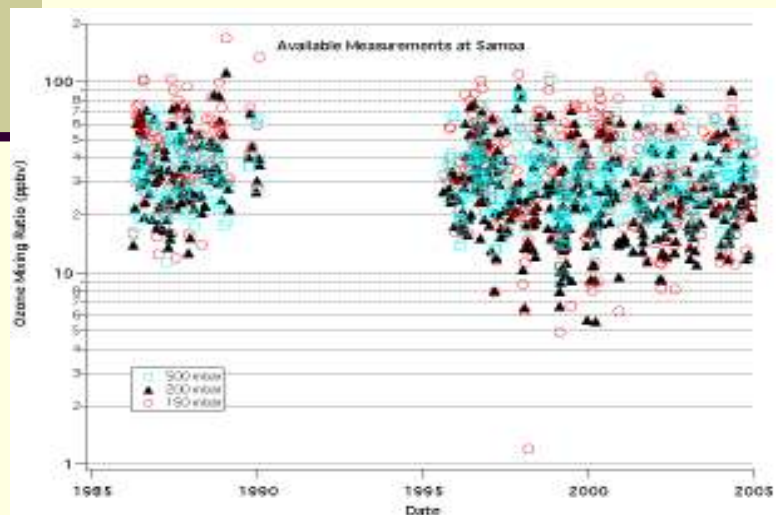
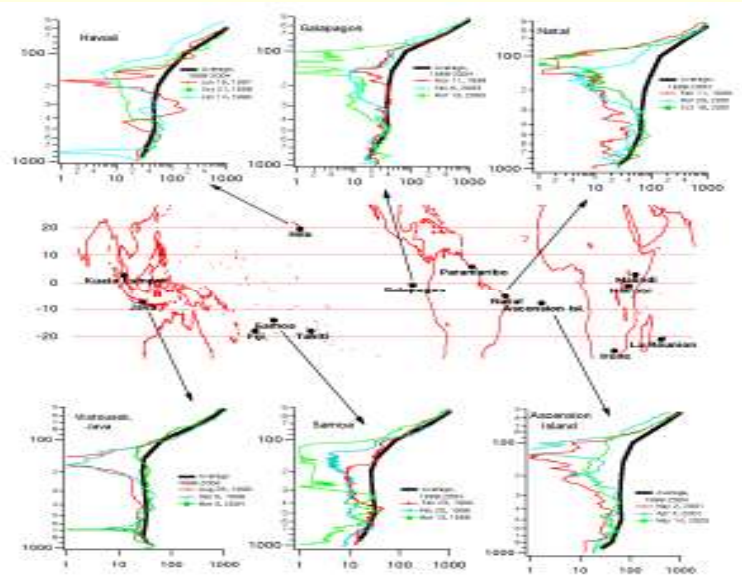
Wave in Troposphere - Thompson et al, *JGR*, 108, 8238, doi: 10.1029/ 2001JD000967, 2003

Teleconnection: Indian Ocean Pollution Linked to “Atlantic Ozone Paradox”



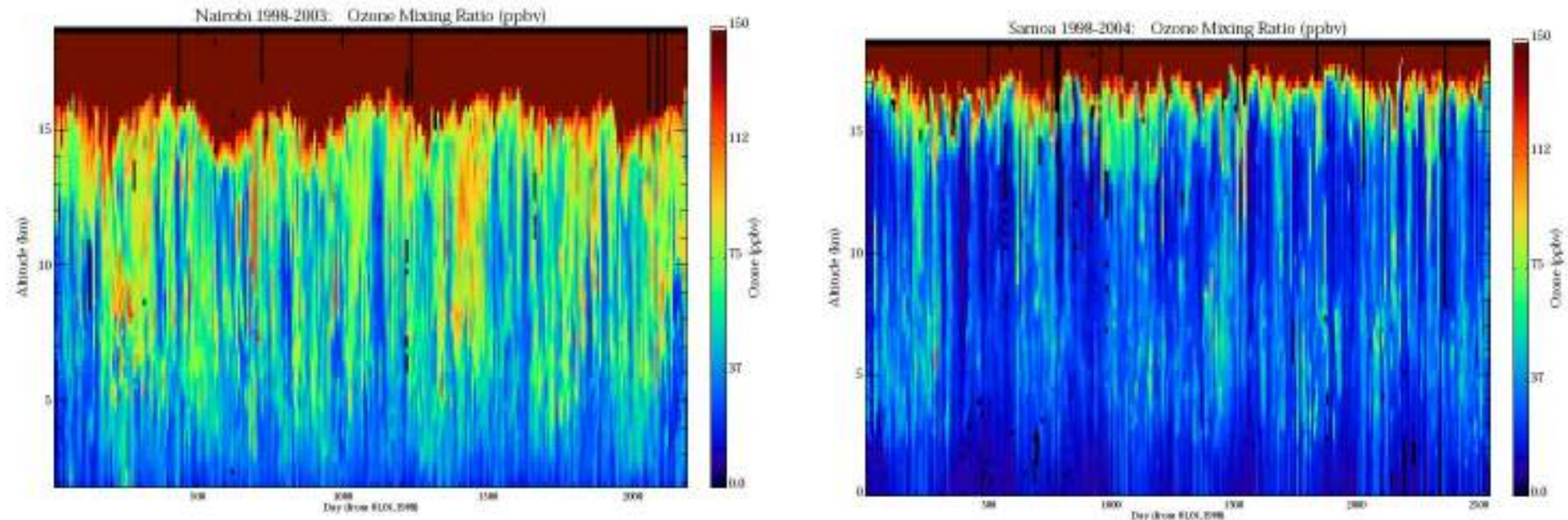
- Satellite, soundings show progression of O₃ pollution from Indian Ocean, lifted upward by convection, advected over Africa, subsiding over Atlantic, with lightning NO → O₃ enrichment during transit.
- Reference: Chatfield, Guan, Thompson, Witte, *GRL*, 31, L06103, doi: 10.1029/2003GL018866, 2004.

Trends: SHADOZ Shows UT “Low O₃” Trend Compared to 1980’s-Early 90’s Record



- Low UT O₃ morphology implies convective redistribution from BL [Thompson et al, *BAMS*, 1997]
- Frequency of UT low O₃ episodes increased at Samoa, Ascension, Natal. Effect maximizes 300-150 hPa, absent at 500 hPa [Solomon et al, *GRL*, 2005]

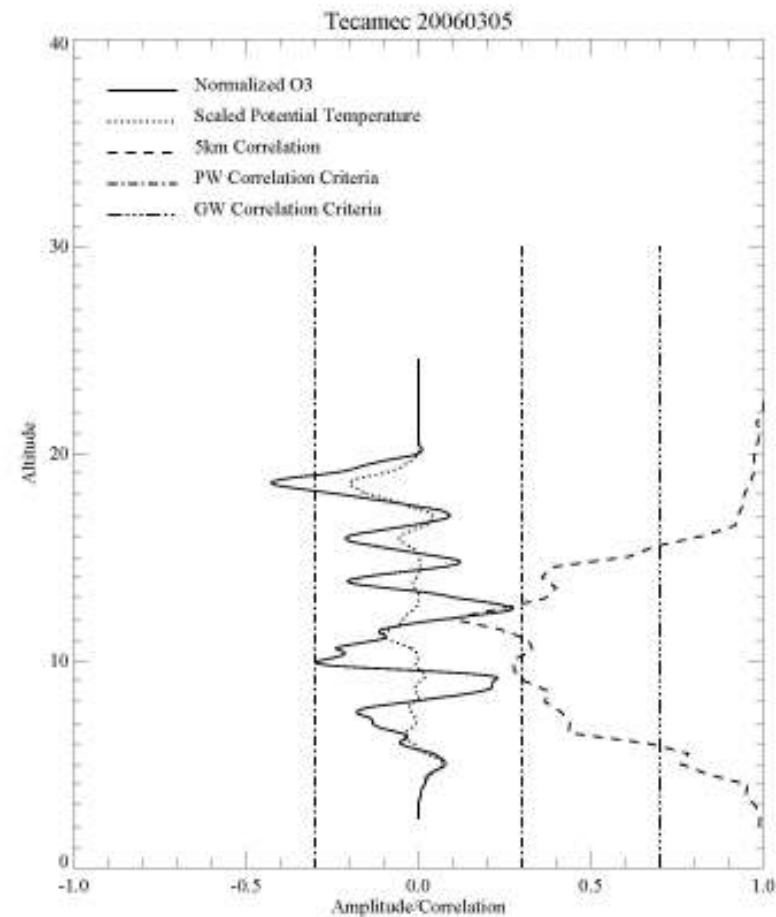
Ozone Variability – Regional, Temporal



- Single site tropospheric variability – week-by-week, 1998-2003/2004
- African (left), Pacific (right); Contrast Upper Troposphere/Lower Stratosphere (UT/LS) structure; lower/mid-tropospheric seasonality

UT/LS – Variability in SHADOZ

- Laminae identified by normalizing ozone and potential temperature to running means
- Percent of region with laminae is high, especially in UT/LS, shown as monthly mean in contours
- Positive pot temp – ozone laminae correlation – “Gravity Wave” or “GW”
- Anti-correlation of Pot Temp – ozone laminae – “Rossby Wave” or RW

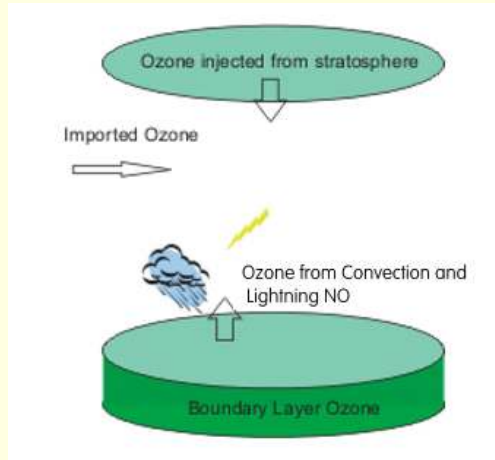


Ozone Budgets, Laminar Approach*

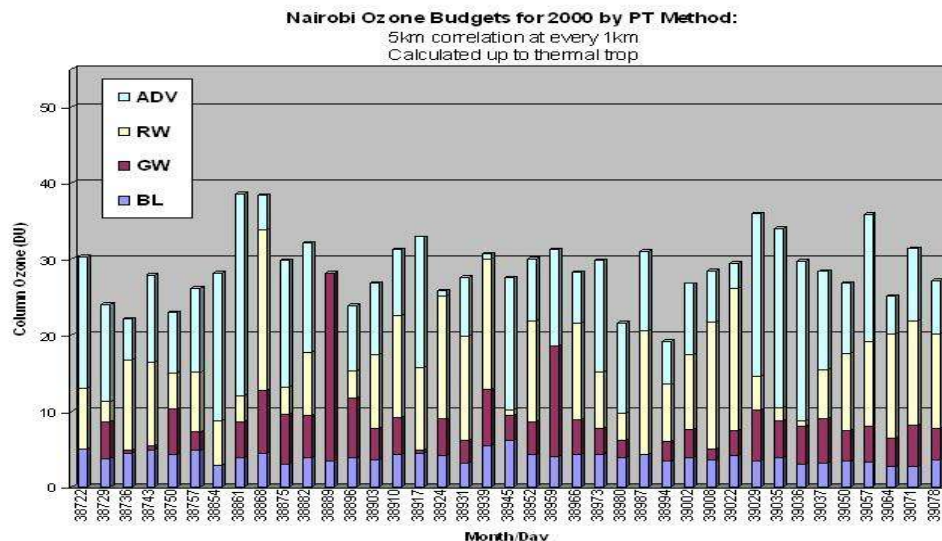
- Fundamental ozone origin questions underlie every field investigation
- Budget approach provides consistent framework for evaluating variability site-by-site, day-to-day
- Budget approach useful for longer time-series, trends analysis because processes are identified
- Complementary approaches are useful
 - Tracers, trajectories
 - Models

* Pierce & Grant, *GRL*, 1998; Thompson et al., *JGR*, doi 10.1029/2006JD007441, in press, 2007a; Thompson et al., *JGR*, doi 10.1029/2006JD007670, in press, 2007b.

Tropospheric O₃ Profile & Budget – Each Profile Analyzed with Laminar Method



- Fundamental origin questions underlie all field investigations
- Budget approach provides consistent evaluation of temporal, spatial variability
- **Four Terms****
 - ST O₃ from RW
 - BL (local) O₃
 - Regional Convection + Lightning (RCL) O₃
 - Advected O₃



** Pierce & Grant, *GRL*, 1998; Thompson et al., *JGR*, doi 10.1029/2006JD007441, in press, 2007a; Thompson et al., *JGR*, doi 10.1029/2006JD007670, in press, 2007b.

Summary

O₃ & Measurement Strategy Design

- Network (space, time) must match scientific questions. For ozone this means scale of dominant meteorological processes
- Network ideal complement to campaign activities
- Tropical issues define SHADOZ (~12 global sites, 1/wk)

Analyses – It's not all Pollution!

- Trends in UT ozone apparent in Pacific SHADOZ sites
- Tropical ozone – climate dynamical (wave) signatures prominent in UT/LS

Eos Era Sounding & Integrated Strategies

- IONS demonstrates satellite-sonde-aircraft-ground-based synergism in ozone measurements

References & Acknowledgments

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- Thompson, A. M., et al., IONS-04 (INTEX Ozonesonde Network Study, 2004): 2. Tropospheric Ozone Budgets and Variability over Northeastern North America, *J. Geophys. Res.*, doi: 10.1029/2006JD007670, in press, 2007b.
- **SHADOZ Archiver J. Witte (SSAI, NASA)**
- **Operators, Scientists in 20 nations – 2004 NASA Group Honor Award Graphics – J C Witte (SSAI/NASA); J Stone, S Miller, A Loucks (PSU)**