IONS-06 - INTEX (Intercontinental Chemical Transport Experiment) Ozonesonde Network Study – 2006

UT/LS Ozone Variability & Implications for Aura Ozone Retrievals and Assimilation Products

Anne Thompson, PI

Penn State Univ., amt16@psu.edu

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

IONS-06 (INTEX Ozonesonde Network Study): UT/LS Ozone Variability & Implications for Aura Ozone Retrievals and Assimilation Products

- **Anne M Thompson,** Penn State Univ, Dept of Meteorology, Univ Park, PA 16802-5013; 814-865-0479; anne@met.psu.edu

- with B F Taubman, J B Stone, S K Miller, A L Loucks, R B Long, S M Michaels, all at Penn State; J C Witte, T L Kucsera (SSAI at NASA/GSFC); G A Morris (Valparaiso Univ,) and S Hersey (Rice Univ)

ABSTRACT

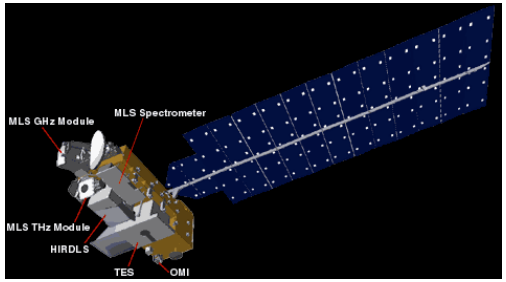
- As part of INTEX-B (Intercontinental Chemical Transport Experiment)/Milagro and Aura Validation, ozonesondes were launched in the greater Mexico City area (Tecamec site: 19.4N, 98.6W) and Houston (29.7N, 95.4W) in March 2006, during Phase 1 of IONS-06 (INTEX Ozonesonde Network Study; <http://croc.gsfc.nasa.gov/intexb/ions06.html>). The focus was on pollution in the late dry-season in Mexico and central America, when a secondary maximum occurs in the annual cycle of surface ozone. In Phase 2 of INTEX-B/Milagro/IONS-06, April-May 2006, soundings were taken in Richland, Washington, when transport of Asian outflow is greatest. Pollution episodes were identified at all sites and estimates of advected tropospheric ozone are presented. Furthermore, at all three sites, wave activity was manifest in the UT/LS in stable ozone and potential temperature laminae. For example, a 20% and 50% frequency of Rossby and Gravity waves, respectively, appeared in the Mexico City soundings. We examine the ways in which the differentiation of stratospheric and tropospheric ozone in the UT/LS is affected by these waves and implications for comparing sonde data with tropospheric and total ozone products based on OMI.

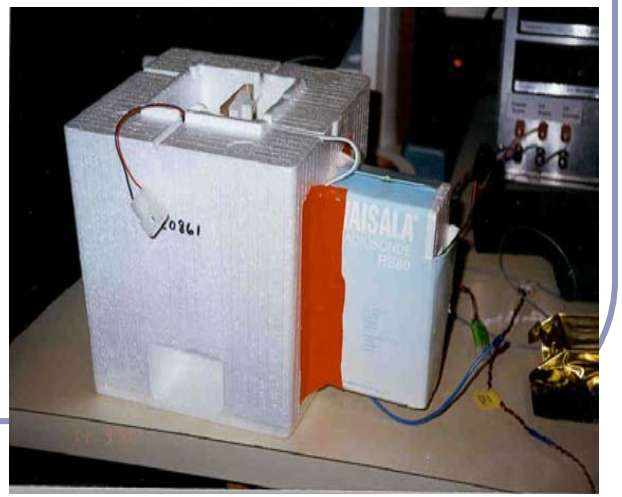
Poster Facts

- What is IONS-06?
  - Three-phase ozonesonde network for scientific studies and Aura validation
- Phase 1 in INTEX-B/Milagro (March 06)
  - Mexico City (Tecamec), Houston Ozonesondes
  - 4-component Tropospheric Ozone Budget
  - UT/LS Ozone wave structure
- Phase 2 in INTEX-B with NATIVE in Richland, WA

IONS-06: What - Three Science Phases & Aura Satellite Validation

- **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?





IONS-06: Who

Launches occuring around 1-2 pm local time with special launches for TES overpasses

STATION	FILE ID	LAT (oN)	LON (oW)	ELEV. (m)	EnSci or SPC	Sol'n	Winds Y/N	TX AQ (August) Launch Frequency	PI	PI Email
CANADA										
Kelowna, BC	kelow	49.9	119.4	456	EnSci Z	1%	Y	Daily	David Tarasick	David.Tarasick@ec.gc.ca
Edmonton, AB	edmon	53.6	114.1	766	EnSci Z	1%	Y	weekly (Wed)	David Tarasick	
Bratt Lake, Sask.	bratt	50.2	104.7	580	EnSci Z	1%	Y	Daily	David Tarasick	
Egbert, ON	egber	44.2	79.8	251	EnSci Z	1%	Y	3/week (MWF)	David Tarasick	
Yarmouth, NS	yarmo	43.9	66.1	9	EnSci Z	1%	Y	Daily	David Tarasick	
Sable IS, NS	sable	43.9	60.0	4	EnSci Z	1%	Y	Daily	David Tarasick	
Walsingham, ON	walsi	42.64	80.6	200	EnSci Z	1%	Y	2-4/day, 10 days	Wayne Hocking	mardoc-inc@rogers.com
US										
Beltsville, MD	belts	39.0	76.5	24	EnSci 2Z	0.50%	N	4-5/wk	Everette Joseph	ejoseph@howard.edu
Boulder, CO	bould	40.3	105.2	1743	EnSci 2Z	2%	N	4/wk	Sam Oltmans	samuel.j.oltmans@noaa.gov
Houston, TX	houst	29.7	95.4	19	EnSci 2Z	0.5%	N	Daily	Gary Morris	gary.morris@valpo.edu
Huntsville, AL	hunts	34.7	86.6	196	EnSci 2Z	2%	N	Daily	Mike Newchurch	mike@nsstc.uah.edu
Imperial Valley, CA	imper									
Los Alamos, NM	losala							Daily	Mavendra Dubey	dubey@lanl.gov
Paradox, NY	parad	43.9	73.7	284	EnSci 2Z	1%	N	Weekly (Wed)	Shermane Austin	shermane.austin@gmail.com
Narragansett, RI	rhode	41.5	71.4	21	EnSci 2Z	1%	N	4/week (MWF?)	John Merrill	jmerrill@gso.uri.edu
RV Ron Brown	ronbr	TBD at launch ----		m.s.l.				Daily	Dan Wolfe	daniel.wolfe@noaa.gov
Table Mountain, CA	table	34.4	117.7	2285	EnSci 2Z	2%	N	3/week (MWF)	T. Leblanc, I. S. McDermid	leblanc@tmf.jpl.nasa.gov
Trinidad Head, CA	trini	40.8	124.2	20	EnSci 2Z	2%	N	Daily	Sam Oltmans	
Valparaiso, IN	valpo	41.5	87.0	240	EnSci 2Z	0.5%	N	3/week (MWF)	Gary Morris	
Wallops Is., VA	wallo	37.9	75.5	13	SPC 6A	1%	Y	3/week (MWF)	Frank Schmidlin	fjs@osb1.wff.nasa.gov
MEXICO										
Mexico City, Mex.	mexic	19.42	98.58	2272	EnSci 2Z	0.50%	N	Daily	Anne Thompson	

WHO I GET THE DATA FROM:

Data Contact	Station	Phone	Email
Jonathan Davies	All Canadian Stations-1	(416) 739 4210	Jonathan.Davies@ec.gc.ca
Gerry Forbes	Sable Is		gforbes@ca.inter.net
VIncent Davis	Beltsville	(757) 620 4823	augustus418@yahoo.com
Mavendra Dubey	Los Alamos		dubey@lanl.gov
Scott Hersey	Houston	(850) 549 5675	shersey@rice.edu
Michael Ives	Trinidad H.	(707) 826-3705	michael.ives@noaa.gov
Bryan Johnson	Boulder	(303) 497 6842	Bryan.johnson@noaa.gov
Thierry Leblanc	Table Mtn	(760) 249-1070	leblanc@tmf.jpl.nasa.gov
John Merrill	Narragansett	(401) 874 6715	jmerrill@gso.uri.edu
Gary Morris	Valparaiso	(202) 270 5339	gary.morris@valpo.edu
Rochelle Williams	Huntsville	(404) 630-0162	rochelle@nsstc.uah.edu
Brian Morrison	Wallops	(757) 824 1618	morrison@osb1.wff.nasa.gov
Robert Long	NATIVE & Mexico City	(703) 732 8055	rbl119@psu.edu
Shermane Austin	Paradox, NY	(718) 270 - 6038	shermane.austin@gmail.com
Dan Wolfe	Ron Brown		daniel.wolfe@noaa.gov

IONS-06 – Phase 3: Where

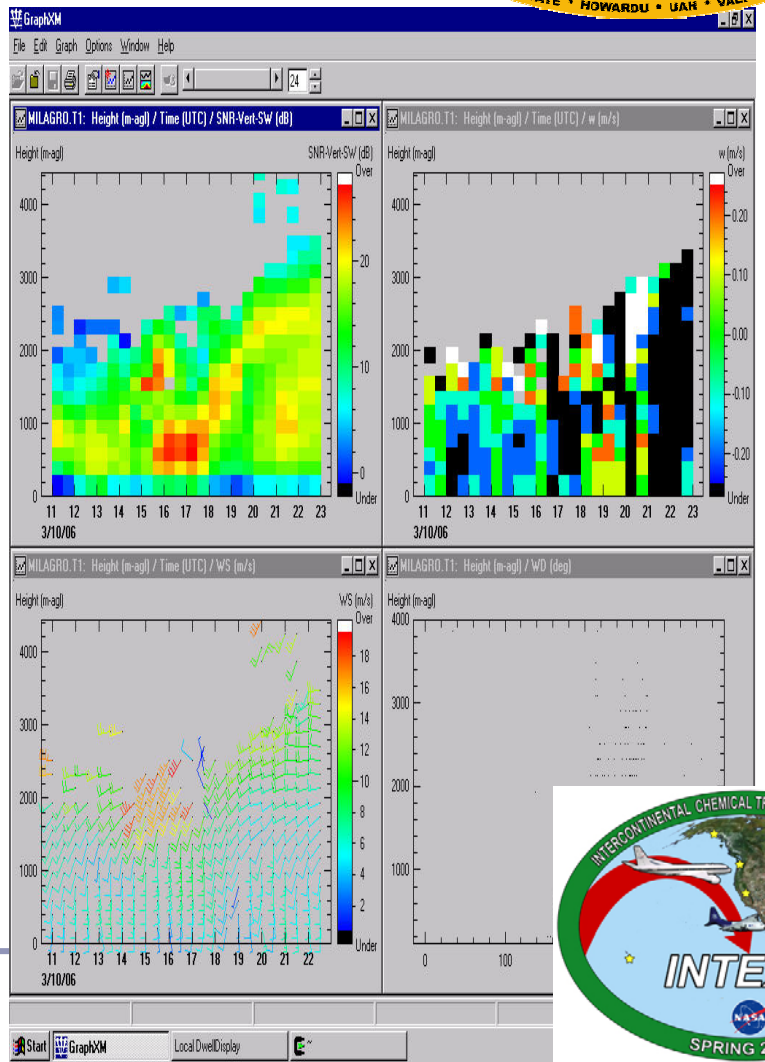
IONS-06 Sites

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

IONS-06 – Phase 1: INTEX-B/Milagro Highlights at Mexico City, Houston

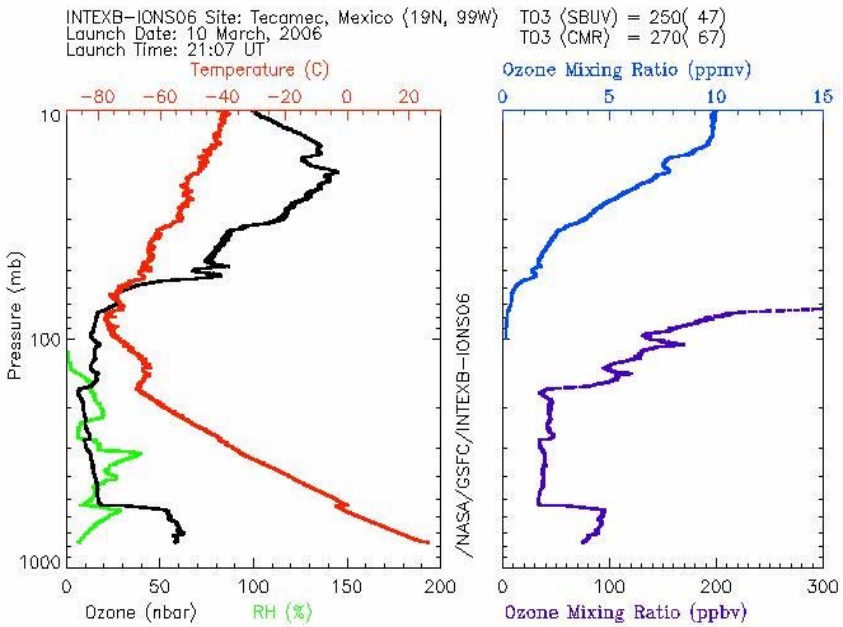
- **Examples of Polluted, Unpolluted Ozone** – Tecamec (Mexico City region) launches
- **Houston sounding shows Mexico City Link** – 8 March – Mexico; 10 March - Houston
- **Tropospheric Ozone budgets & Waves Identified with Lamina Labeling** – Tecamec, Houston similarities, contrasts

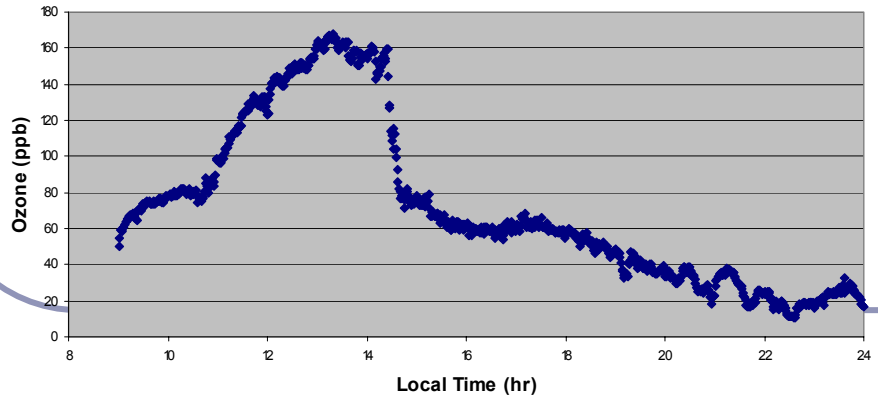
IONS/Milagro Tecamac Sondes, 7-20 March 2006



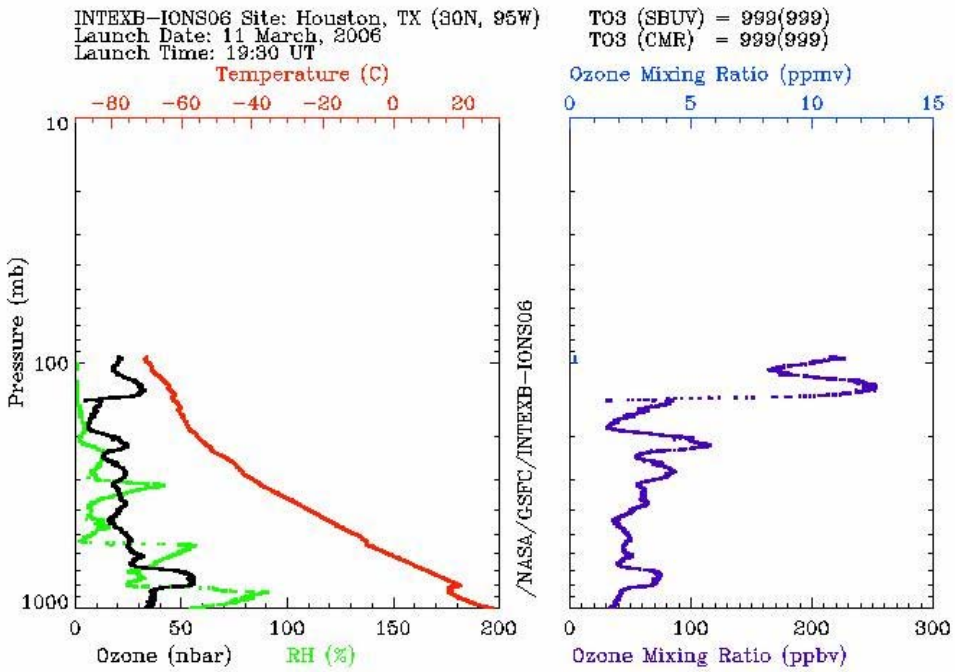
Mexico City Pollution, 10 March 06.

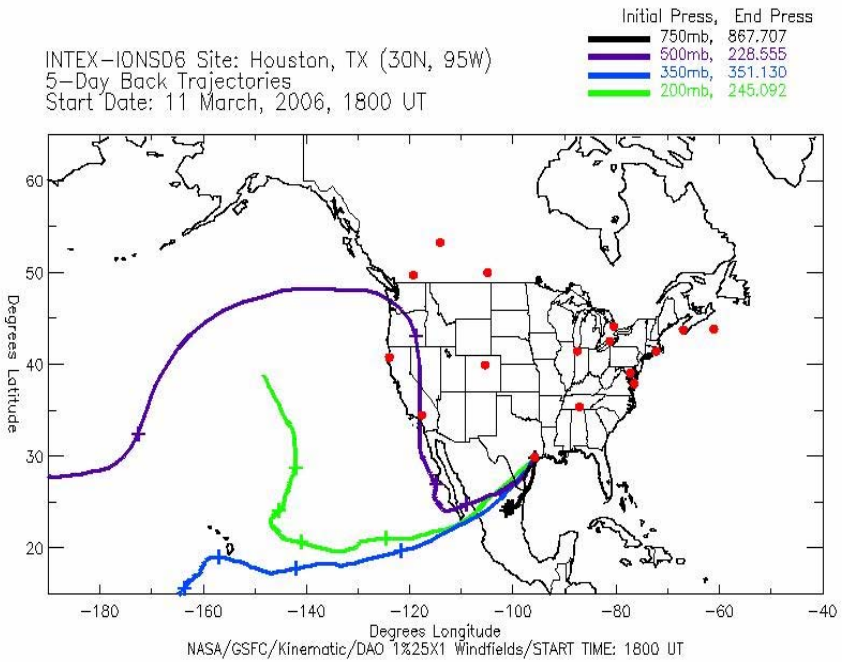
Launch before Daily Ozone Maximum



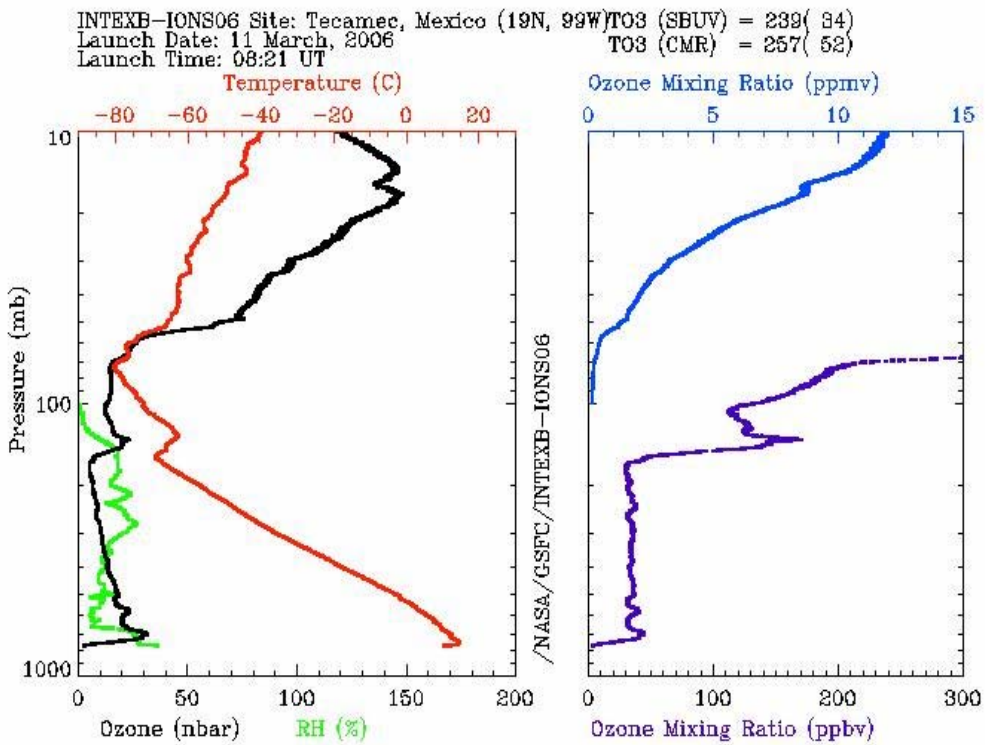


Mexico – Houston Pollution Link – 11 March 06. Back-trajectory Origin





Special TES Tecamec Launch – 11 Mar 06

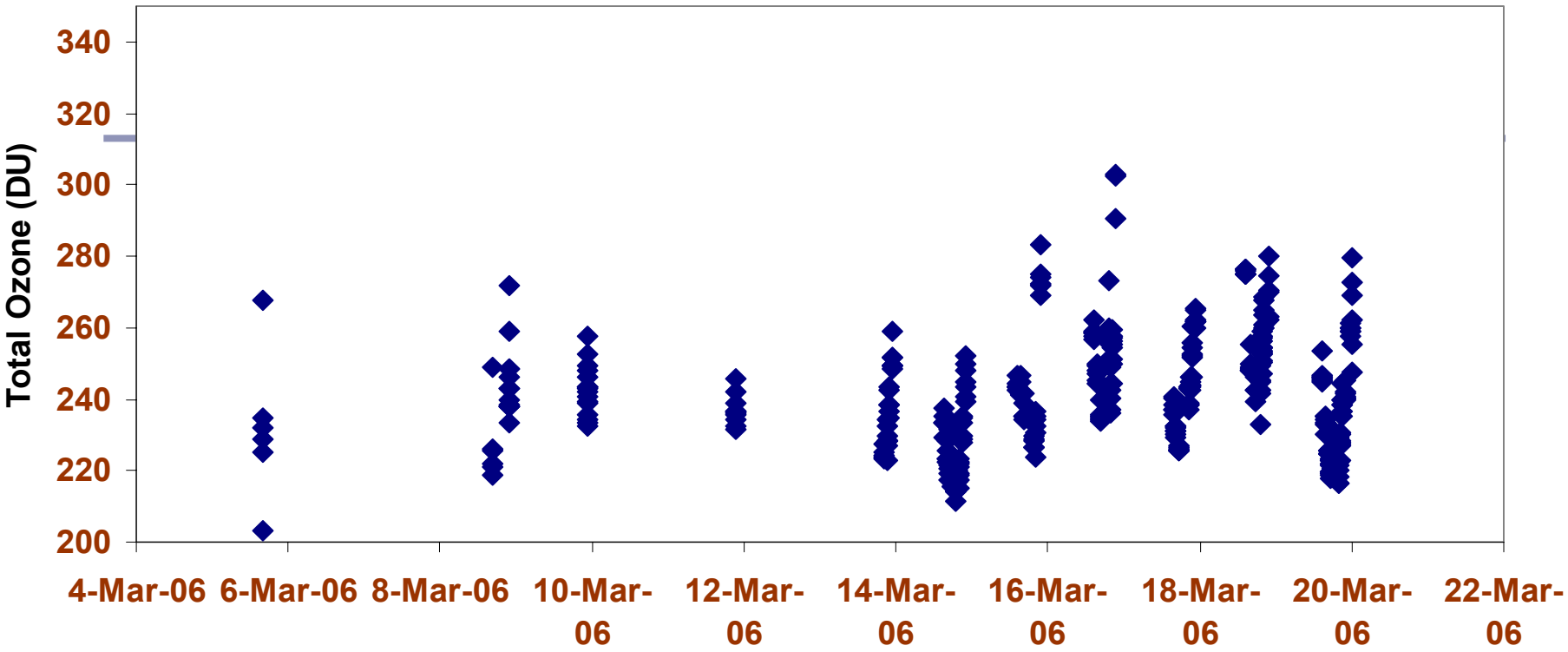


- Launch coincided with nighttime Aura TES sample
- Nighttime profile illustrates NO_x titration of O_3, “constant” mixing ratio in troposphere
- UT/LS STE O_3 prominent in many Mexico soundings – compare Rossby Wave index

IONS-06 & Aura Ozone Retrievals

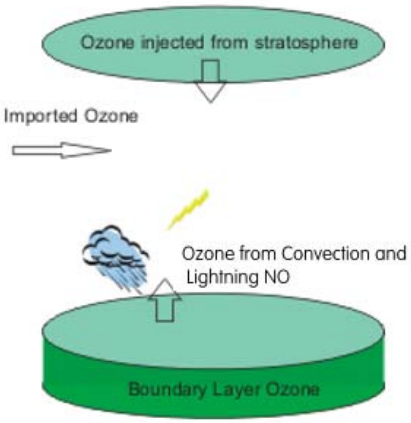
- Total Ozone from MicroTops, Tecamec
- Tropospheric Ozone – Optimize retrievals with 4-term budgets derived from IONS sondes
  - Lamina used to assign ozone sources – Method of Pierce & Grant [1998], adapted by Thompson et al. [2006]
  - Stratosphere (ST), Regional convection-lightning (RCL), boundary layer (BL), advected (imported, AD)
- Complex UT/LS structure at all sites, as expected in Spring

MicroTOPS Tecamec Series



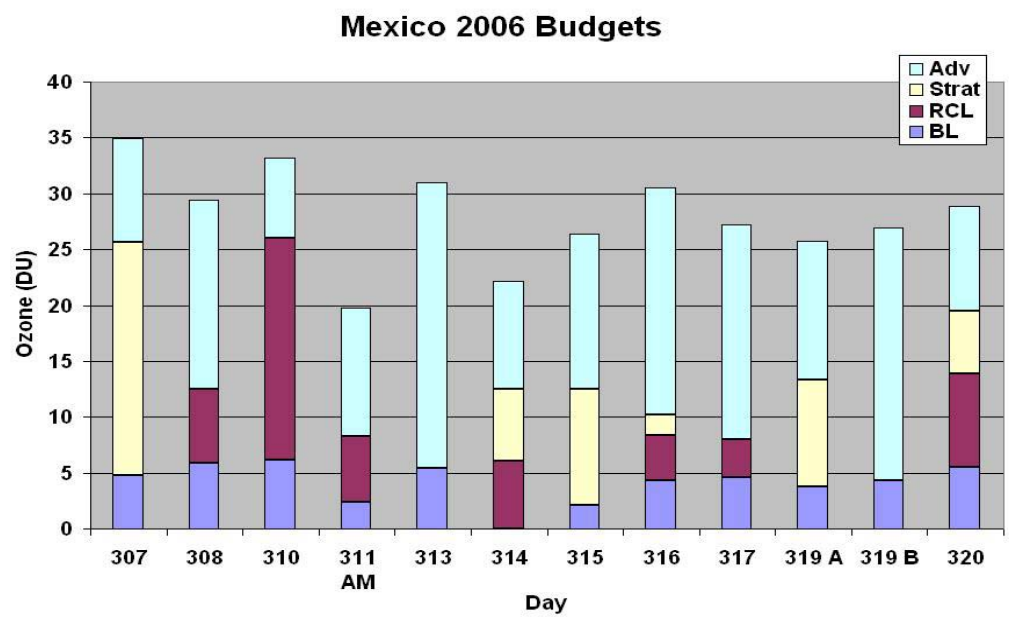
- 4-5 scans approx. every hour
- Total ozone (DU) and Aerosol Optical Depth
- MicroTOPS - Thanks: G. Labow, SSAI/NASA-GSFC

Tropospheric Ozone Profile. Budgets Computed From Each IONS Sounding

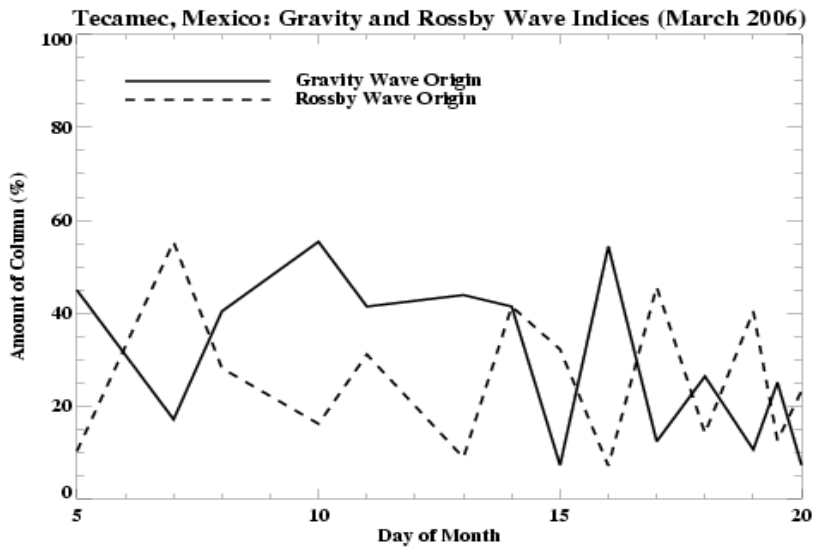


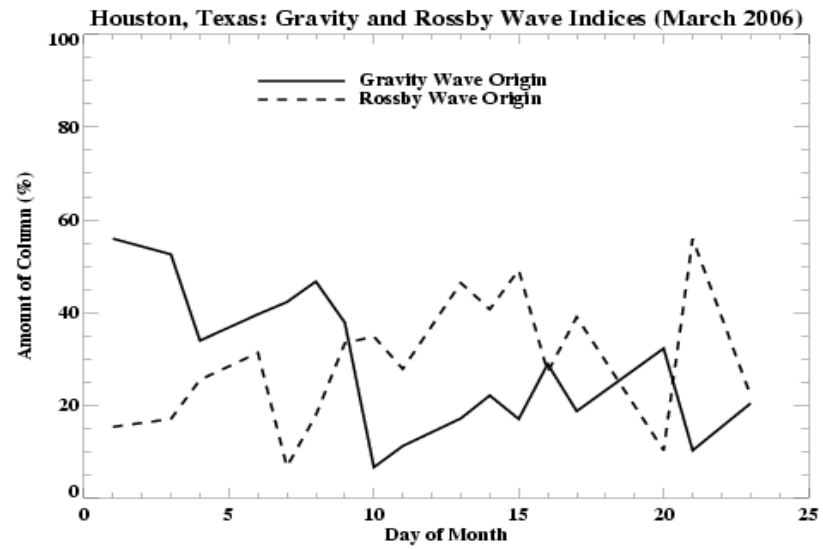
- Four Terms
  - ST O_3
  - BL (local) O_3
  - Regional Convection + Lightning (RCL) O_3
  - Advected O_3

- ST O_3 from Rossby Wave (RW); confirm with PV, H_2O
- RCL from Gravity Wave, Lightning Map
- 14 March – no BL data
- Method in Thompson et al., *JGR*, in revision, 2006a,b



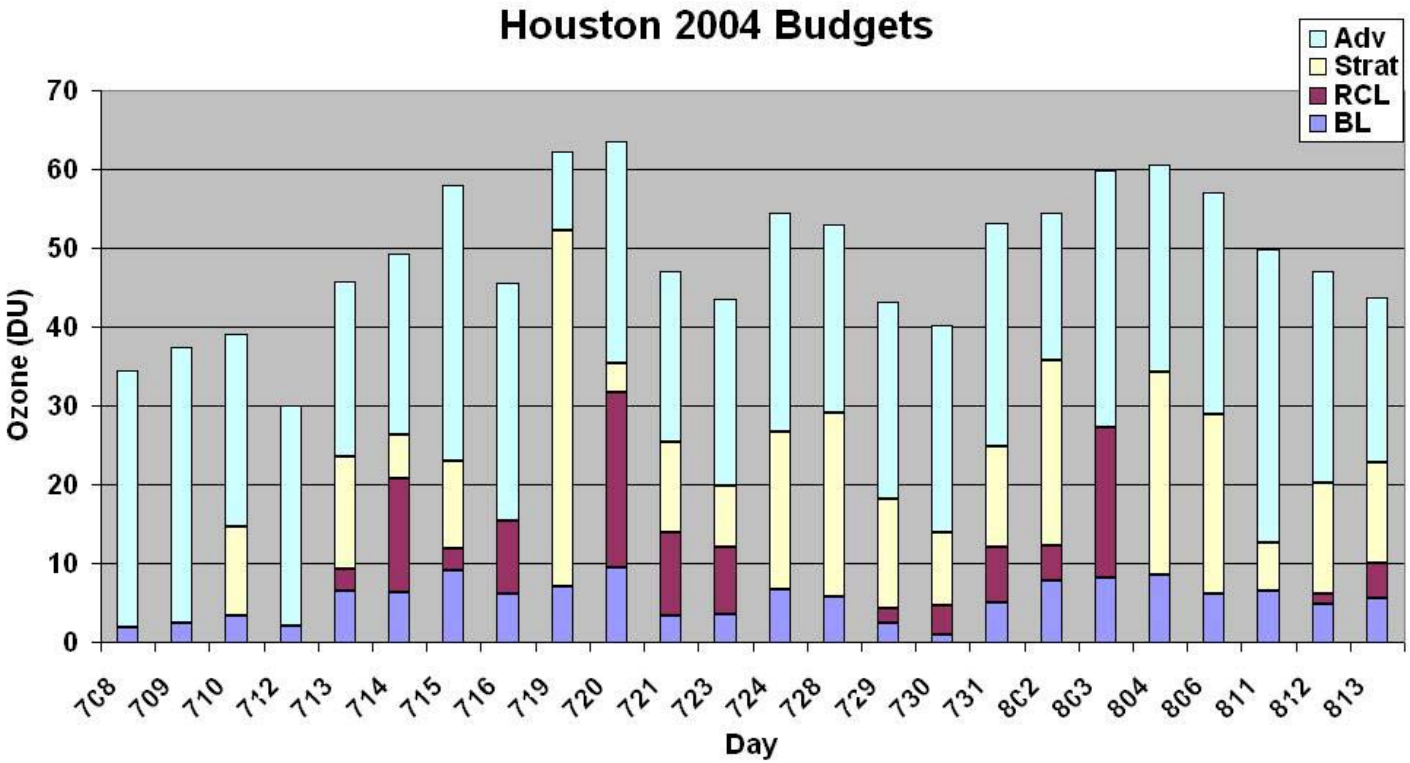
Wave Climatology in Tecamec, Houston Profiles





- Percent from fraction of O_3 profile to 25 km with laminae corresponding to RW or GW (Pierce & Grant, 1998)
- Wave activity most concentrated in UT/LS (15-20 km)
- More GW in Tecamec. Both sites - STE from RW

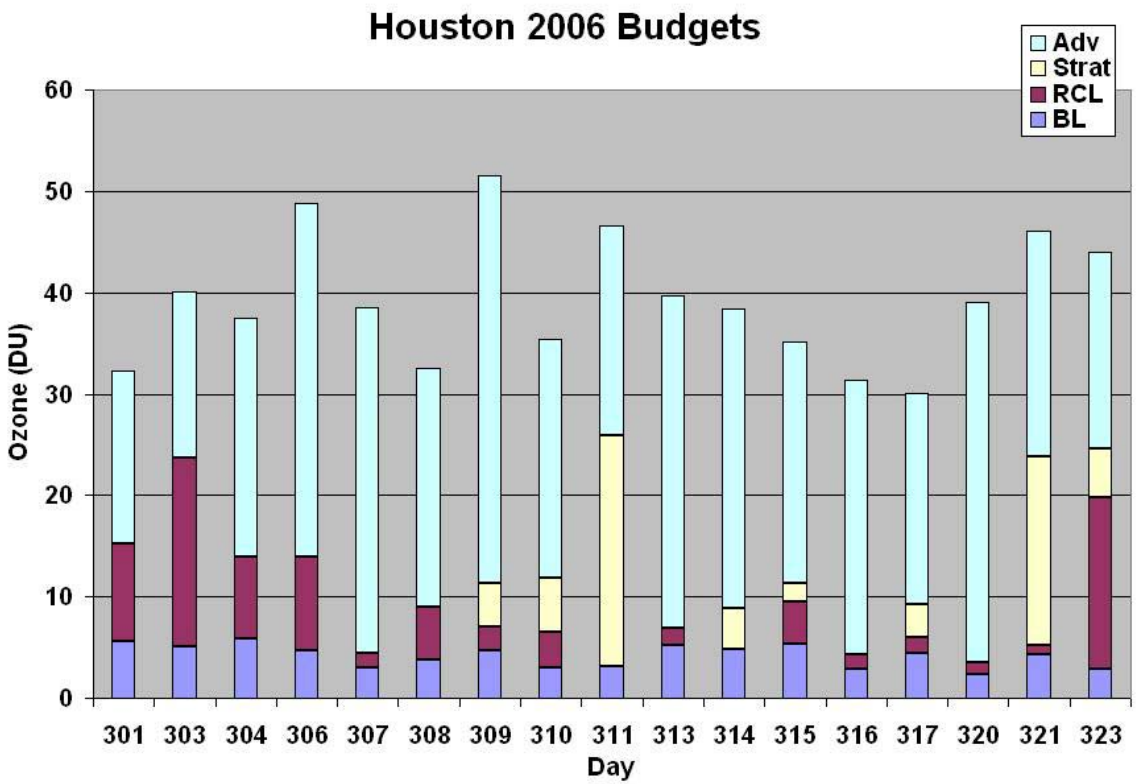
Houston IONS-04 Ozone Sources*



- Stratospheric influence in 2004 anomalously high for summer
- * **Thompson et al., *JGR*, 2006JD007670, in revision, 2006.**

Houston IONS-06 Spring Ozone – Compare to Summer

- Spring 2006 mean – 35-40 DU vs 45-50 DU in Summer 2004.
- BL Summer = 2-3 * BL Spring



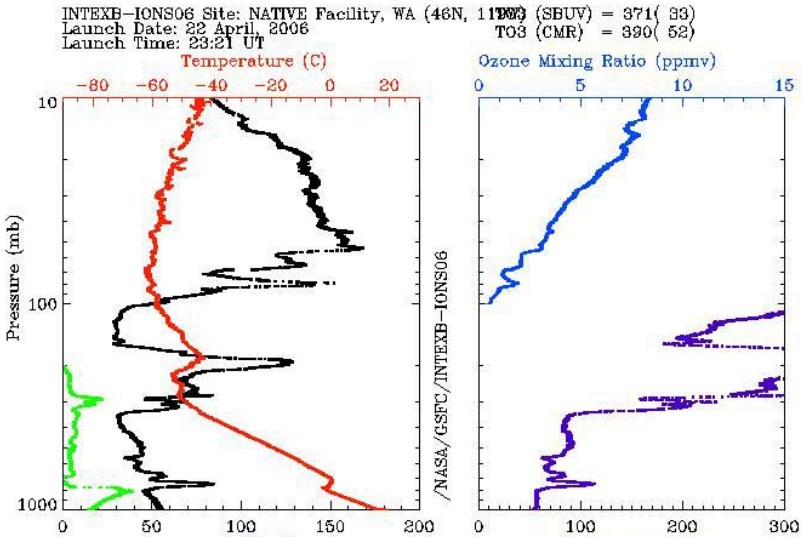
IONS-06 Phase 2: Sondes & NATIVE at Richland, WA, in INTEX-B

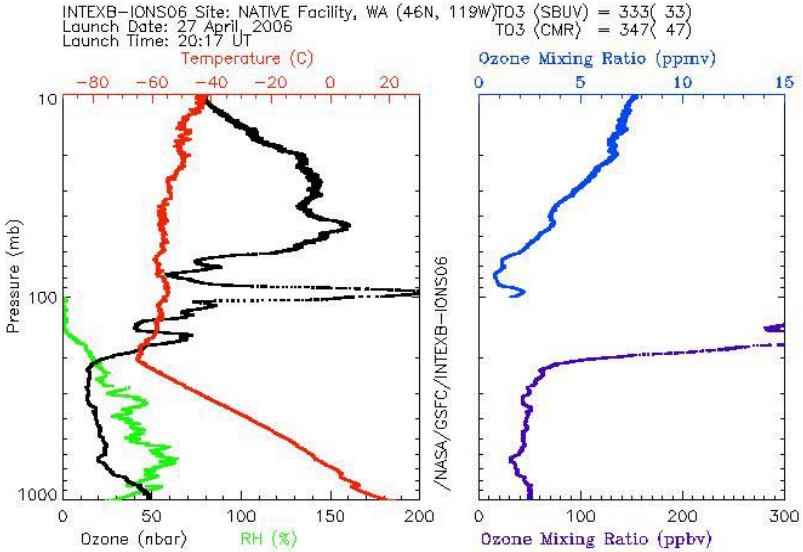
NATIVE

Nittany Atmospheric Trailer & Integrated Validation Experiment

- Deploy **PSU NATIVE** & launch **IONS** sondes mid-April-mid-May 2006 at Richland (46N,119W)
- Aura validation with **PSU NATIVE** and G Mount (WSU) MAX-DOAS for NO_2
- For **NATIVE** results: B Taubman, PSU

IONS-06 – Phase 2 at PNNL





- **22 April 2006**
  - Prominent strat O_3 peak; double tropopause
  - Elevated O_3 (low H_2O) above BL
  - Inversion near surface
- **27 April 2006**
  - Well-mixed trop. O_3; inversion absent
  - Relatively moist throughout troposphere

Summary – Perspective

- IONS – Three phases with > 350 ozone profiles integrating Aura and assimilated ozone
- INTEX-B/Milagro sondes
  - Expected pollution in Mexico, less in Houston
  - Stratospheric signatures prominent in Mexico, Houston, Richland soundings
- Aura Implications
  - UT/LS complexity may confound ozone retrievals when tropopause location is critical
  - Tropospheric ozone budgets offer consistent approach for algorithm and model evaluations

Acknowledgments, References

- Aura Validation; NASA Tropospheric Chemistry Program for INTEX-B
- NOAA GMD - Sam Oltmans & Bryan Johnson
- NOAA CSD/CIRES – Owen Cooper
- Environment Canada – David Tarasick
- NASA/WFF, Howard U, URI, LANL, JPL, PNNL, Milagro Logistics, UAH

- References

  - R B Pierce & W B Grant, *GRL,* 25, 1859-1862, 1998
  - A. M. Thompson, et al., IONS (INTEX Ozonesonde Network Study, 2004). 1. Perspective on Summertime UT/LS (Upper Troposphere/Lower Stratosphere) Ozone over Northeastern North America, J. Geophys. Res., 2006JD007441, submitted, 2006.
  - A. M. Thompson, et al., IONS-04 (INTEX Ozonesonde Network Study, 2004): 2. Tropospheric Ozone Budgets and Variability over Northeastern North America, J. Geophys. Res., doi: 10.129/2006JD007670, submitted, 2006.

PI: A.M. Thompson