SHADOZ (Southern Hemisphere Additional Ozonesondes): Status & Comparison with OMI and Suomi/NPP OMPS Ozone Satellites

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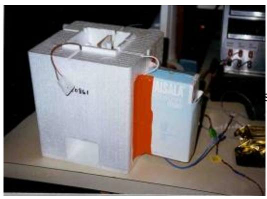
Archiver: J Witte, SSAI@GSFC; http://croc.gsfc.nasa.gov/shadoz

Integrated Earth Observing for Ozone



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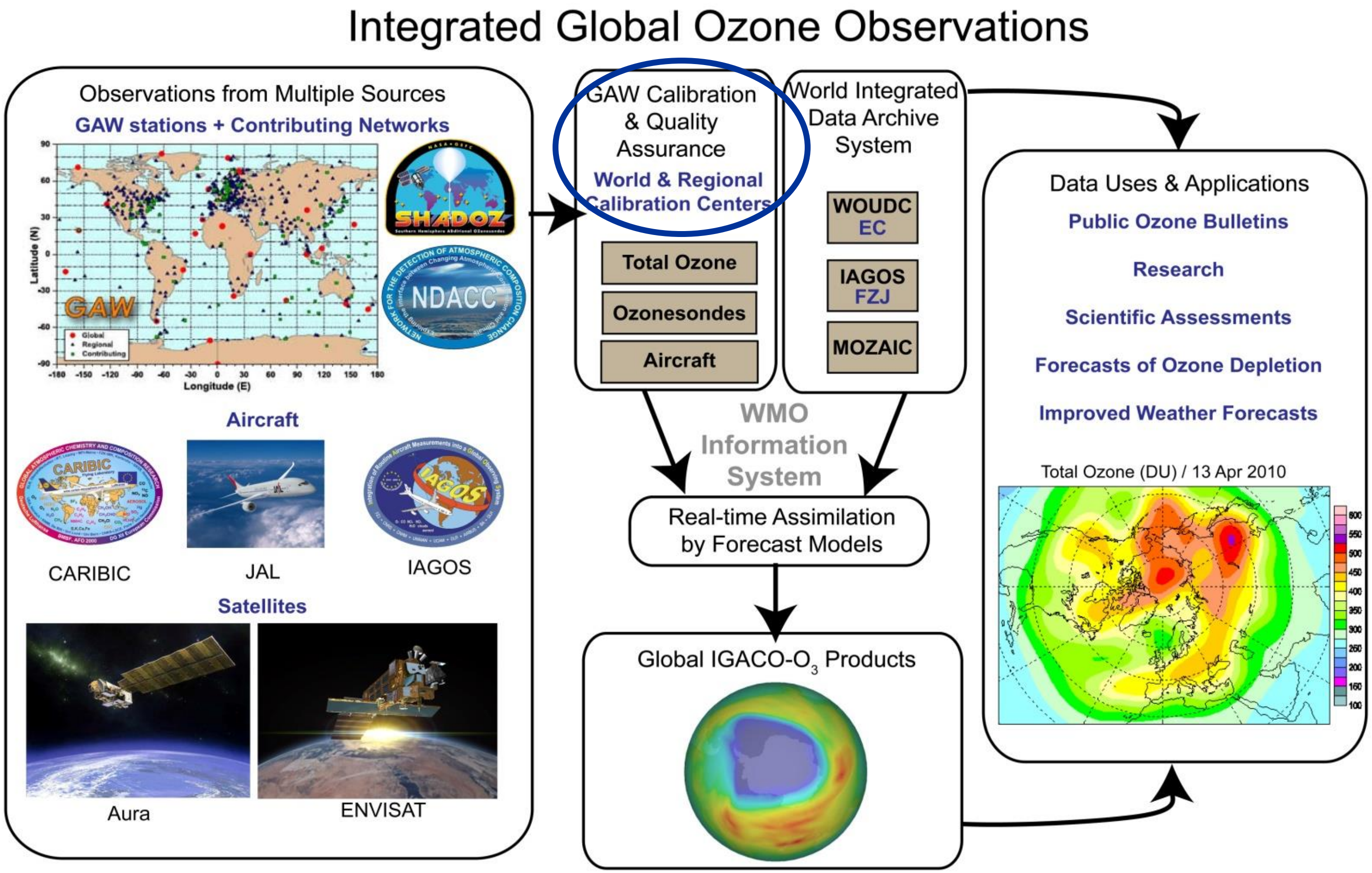
columns
50-100 n

Measure
Model
Predict



- Use satellites & ground-based (eg Dobson) for total ozone column
- Profile validation - partial columns (lidar, aircraft); only sondes measure surface to 5-10 hPa (35 km) with 50-100 m vertical resolution

Outline of Presentation

- **What, Why, Where, Who of SHADOZ (1998-> present)**
- **Recent SHADOZ Activities**
  - Network affiliations: NDACC & GCOS (2009), GRUAN (2014)
  - Reactivation of 4 Stations in 2013-2014. Six Station Visits by PI Thompson, B Johnson (NOAA), H Selkirk (USRA)
  - SHADOZ Newsletters: **http://croc.gsfc.nasa.gov/shadoz**
  - Data Re-processing by WMO/NDACC Sonde Guidelines
  - New Radiosonde (RS80-> RS92->Imet) "Pressure Offsets" - paper in *AMT* (Stauffer et al, 2014)
  - Trends papers cover tropical LS (Aschmann et al., Gebhardt et al., *ACP*, 2014) and sub-tropical FT (free troposphere; Thompson et al., *ACP*, 2014). ***NDACC talk***
  - Comparisons of SHADOZ sondes with total (OMI, Suomi/NPP/OMPS) and UT/LS (OMPS) ozone ***This talk***

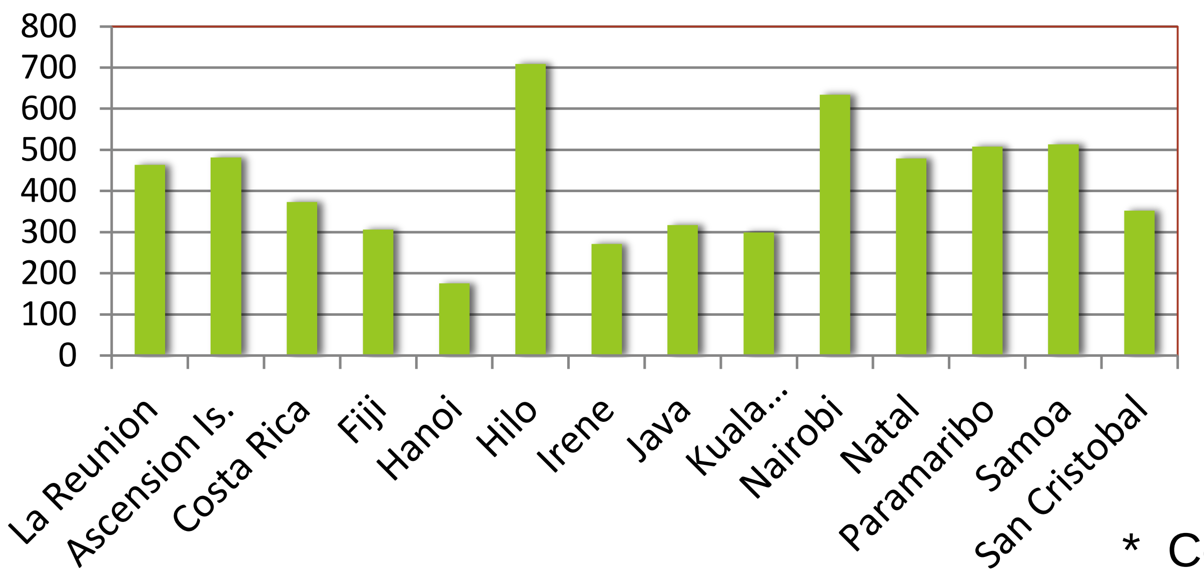
Why & How: SHADOZ Initiative: 1-2 Generations of Ozone Satellites Validation

- **"Strategic" ozonesonde network:** Coordinate launches for specific goals
- **SHADOZ Goals:**
  - Validate ozone profilers & new tropospheric products from TOMS/UARS/SBUV. Anticipate SCIAMACHY, Aura, NPP
  - Wave-one in total ozone – in stratosphere or troposphere? => *Requires zonal coverage of stations*
  - What is role of dynamics (convection, QBO, ENSO, etc) in ozone variability? => *Requires 2-5 launches/month*
- **PRACTICAL CONSTRAINTS**
  - Operational – host supplies ground stations, launch gas, personnel. Began with 9 stations, currently 13 in northern & southern tropics
  - NASA/NOAA supply *some* sondes – ALL data <u>open</u> @ GSFC
  - Leveraging of resources is key to sustainable network

What & Where: SHADOZ Archive Status

> 6000 sets of P-T-U & ozone profiles at:
http://croc.gsfc.nasa.gov/shadoz
also archived at WOUDC, NDACC linked

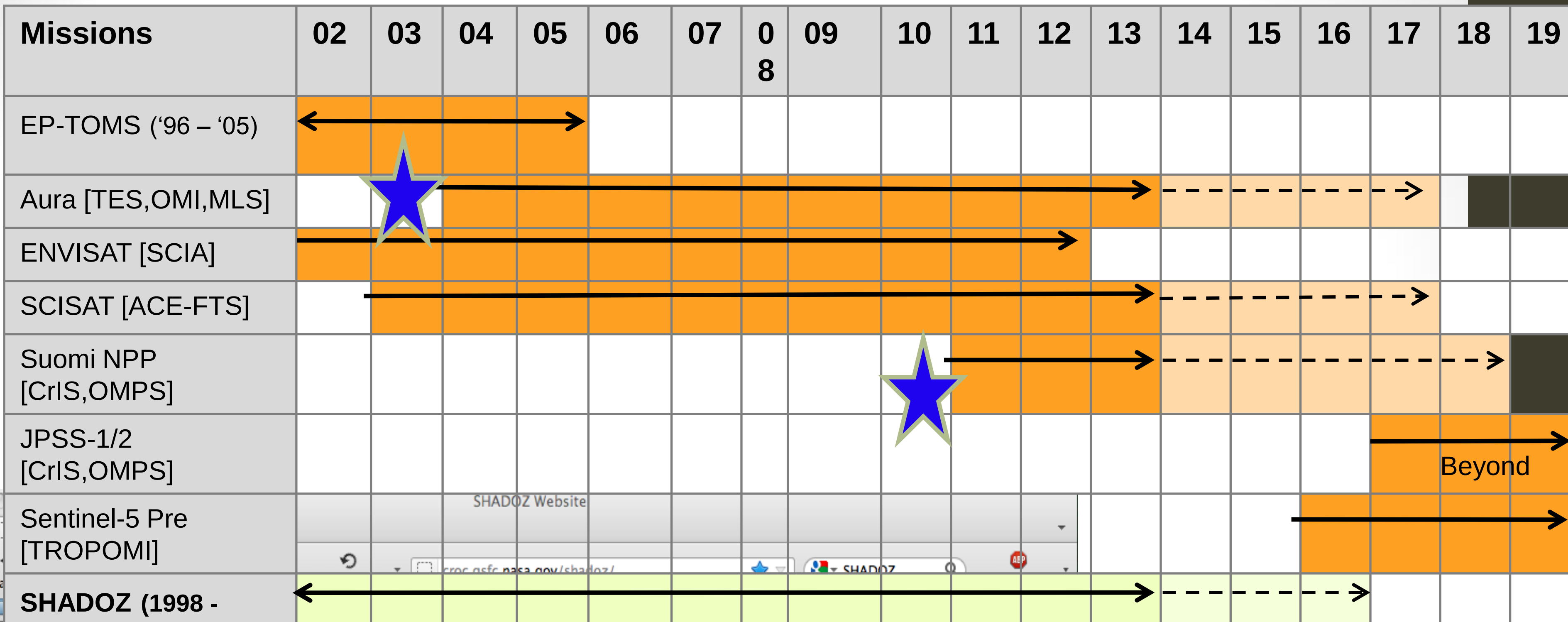
Thompson et al, *JGR*, 2012

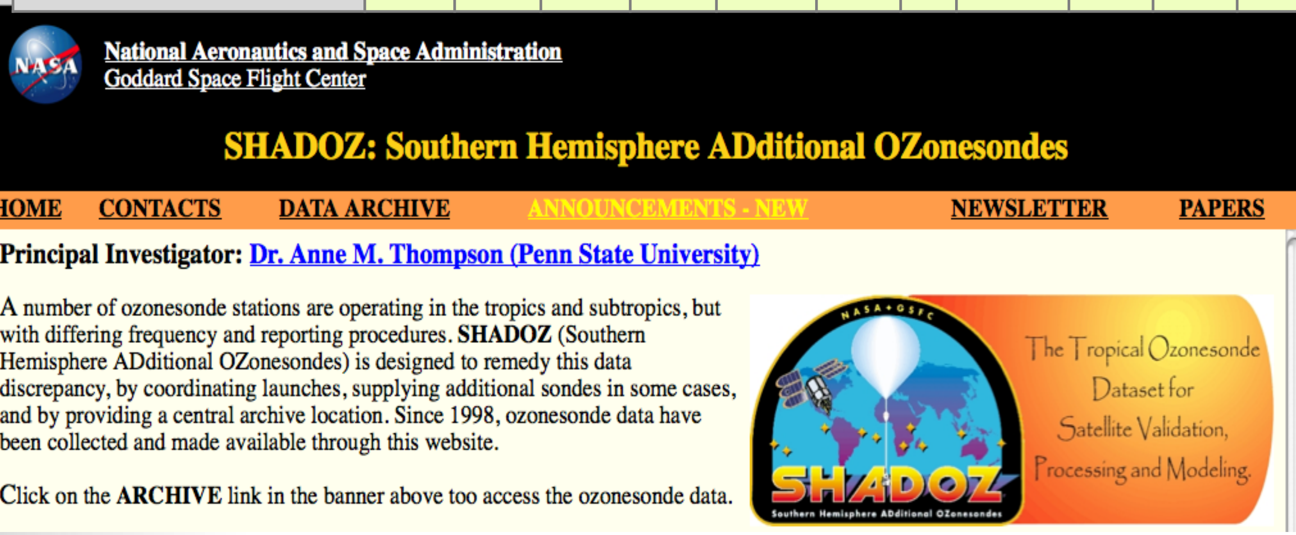


1999-2006:
~ 400 profiles/yr
2011-2013:
~ 300 profiles/yr

* Costa Rica, Hanoi after 2005

SHADOZ & Satellites: On-going Requirements





Participation in WMO chamber tests raises sonde precision & accuracy to ~5% in 2012 vs 15% in 2002. Data in major re-Processing.

Smit et al., 2007, 2011; Thompson et al., 2007

Typical Aura OMI-SHADOZ Total Ozone: 2005-2009 Comparisons (Thompson et al, *JGR*, 2012)

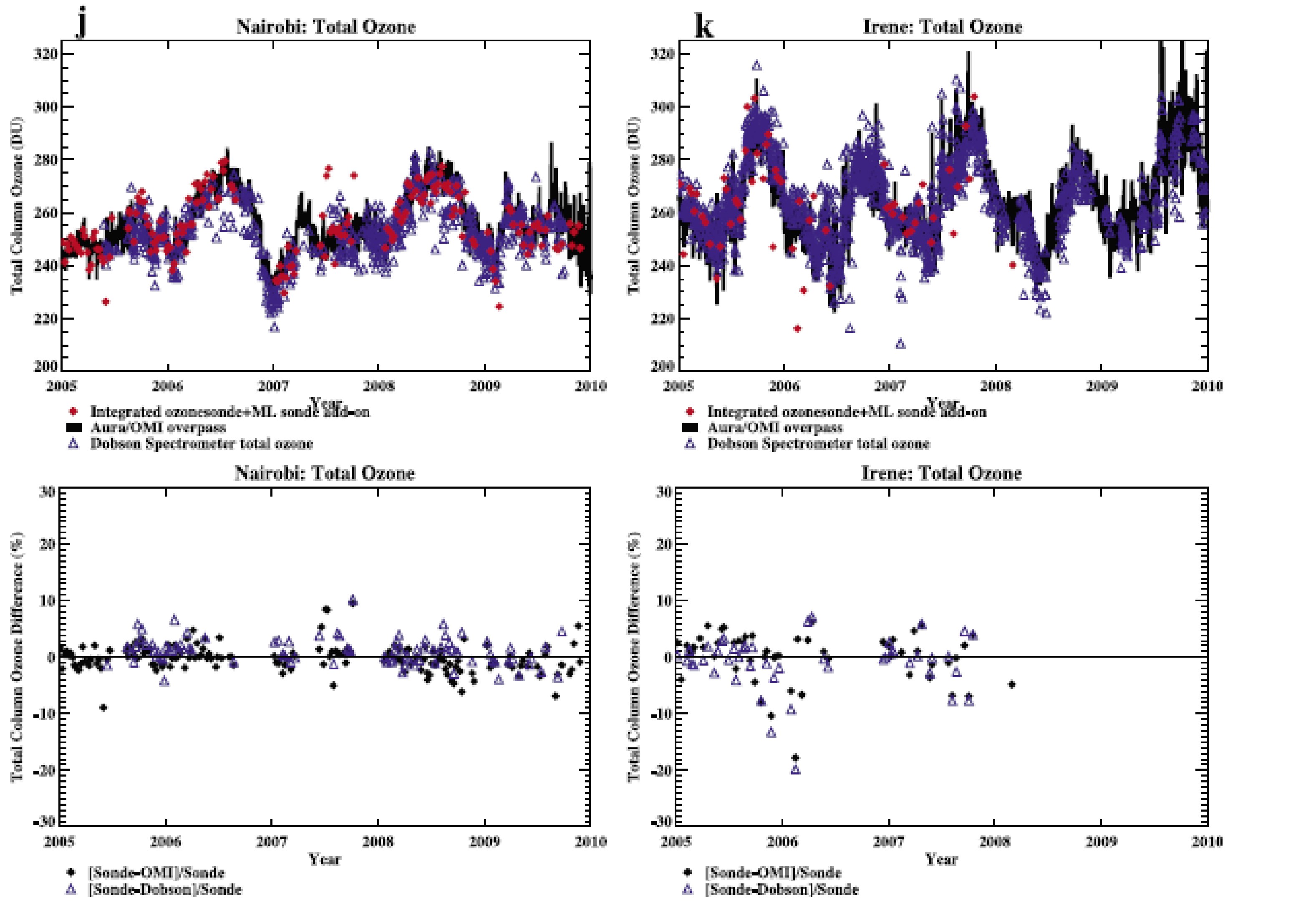
Black = OMI

Red = SHADOZ Sondes

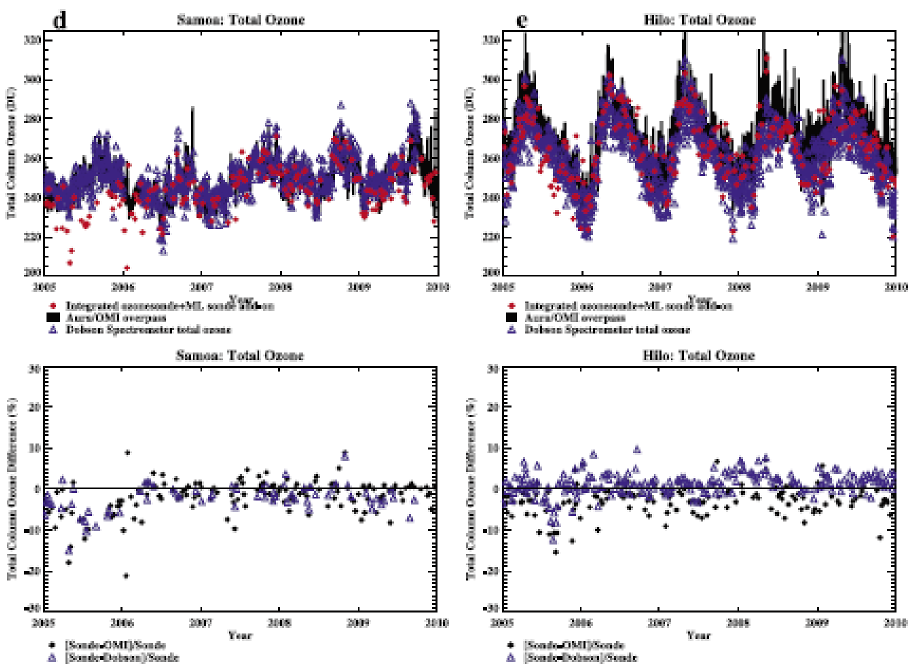
Blue = Dobson/ Brewer

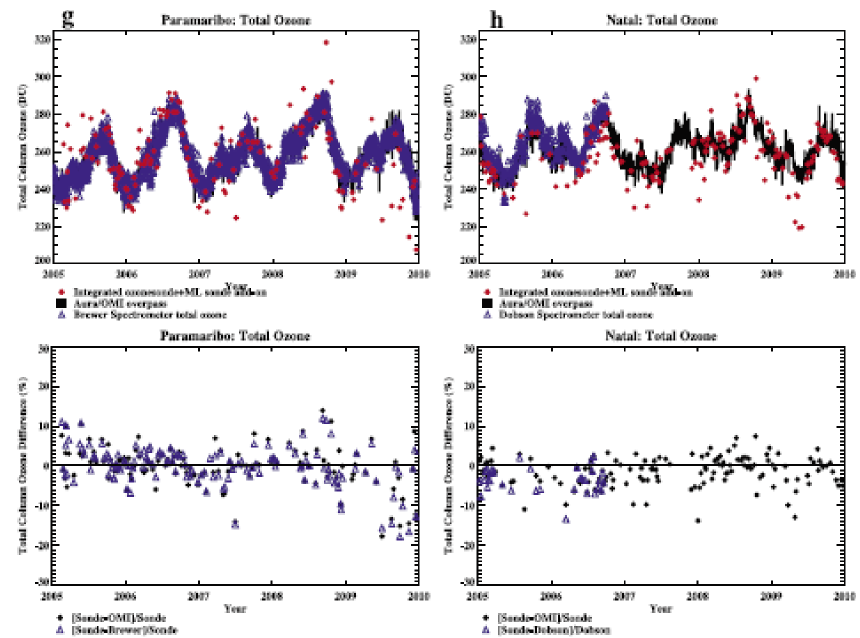
Upper = Total O_3

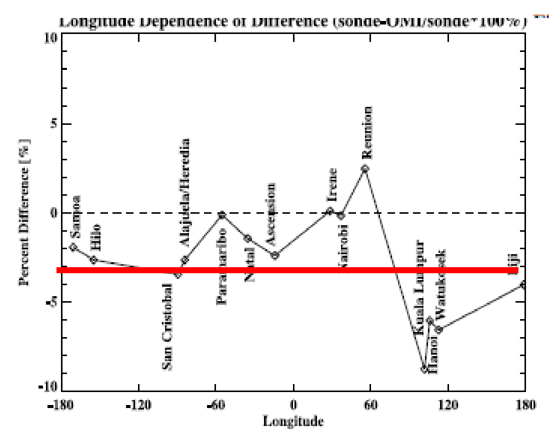
Lower = % Diff



Typical Aura OMI-SHADOZ Total Ozone: 2005-2009 Comparisons (Thompson et al, *JGR*, 2012)







Left = Pacific
Right=Atlantic (upper) &
2005-2009 Summary (lower)

Most stations within 2%, OMI usually higher

Aura/OMI-NPP/OMPS SHADOZ Total Ozone: Preliminary 2012-2013 Comparisons - 1

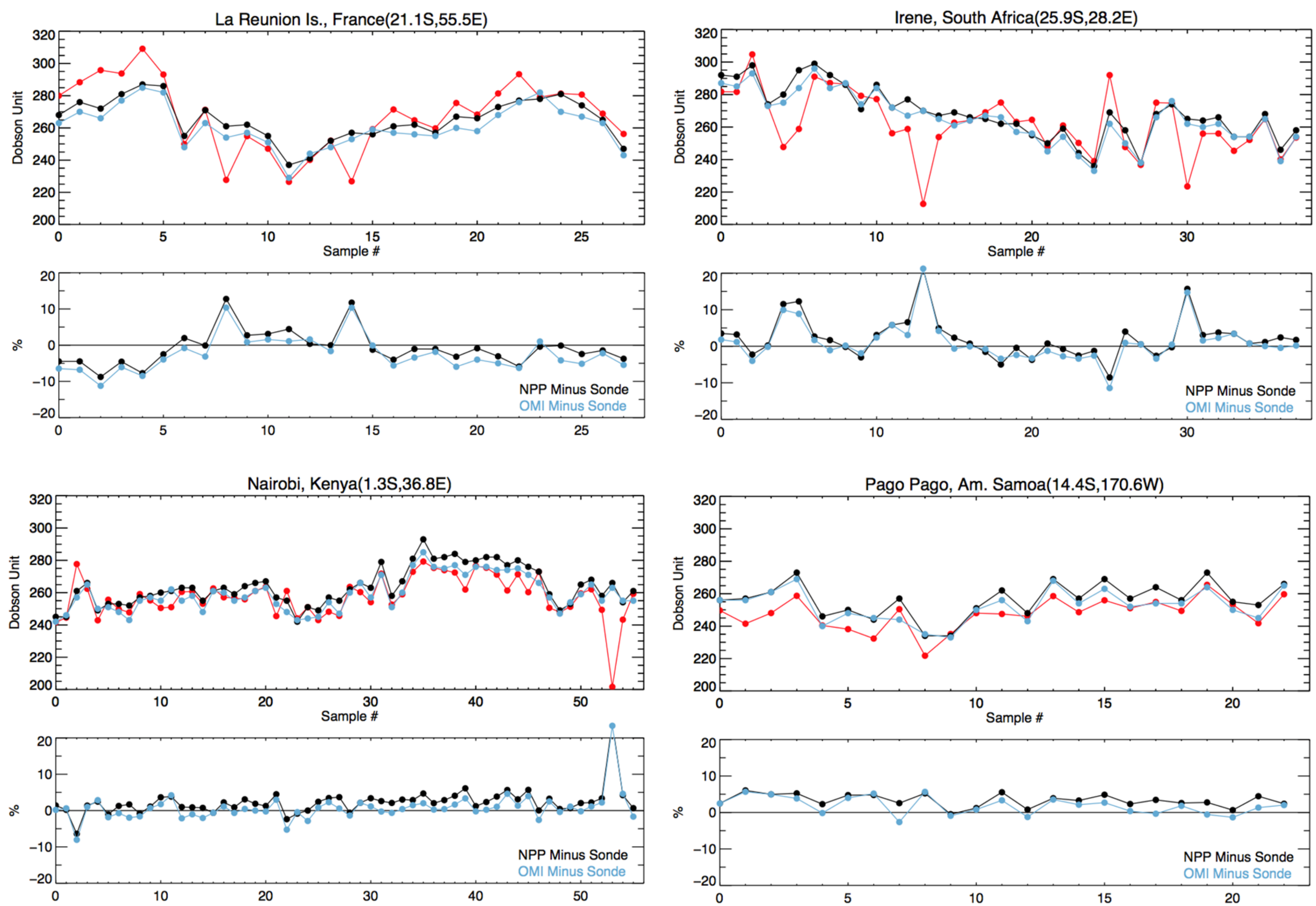
Black = NPP/Suomi

Red = SHADOZ Sondes

Blue = OMI

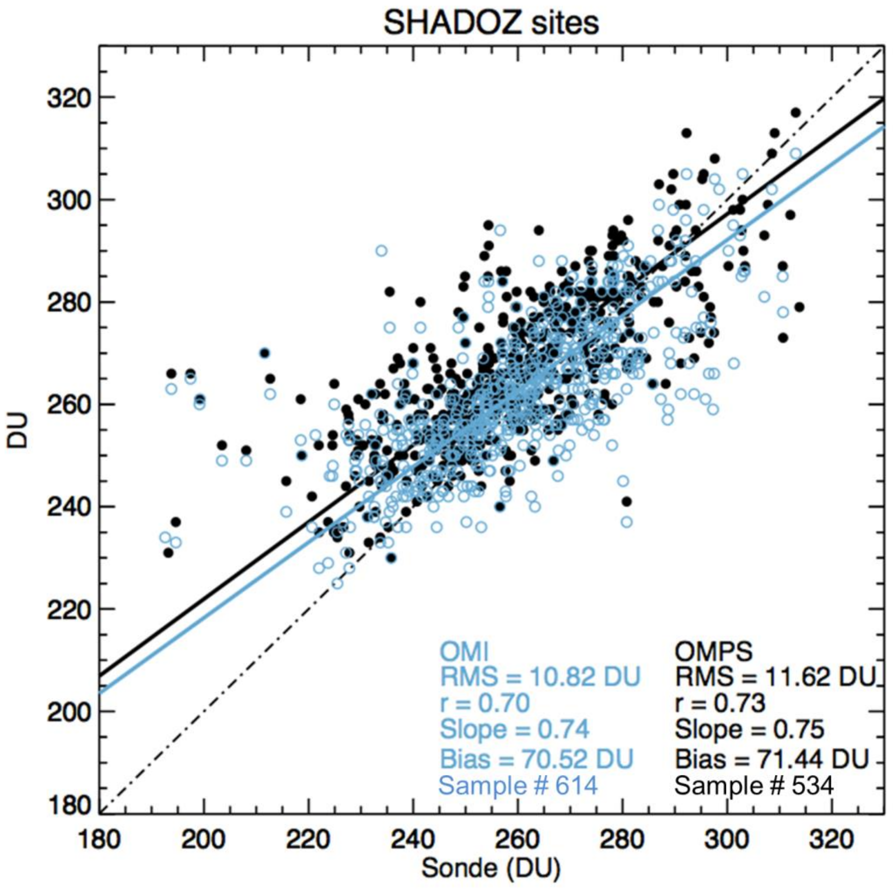
Upper = Total O_3 (DU)

Lower = Diff in %



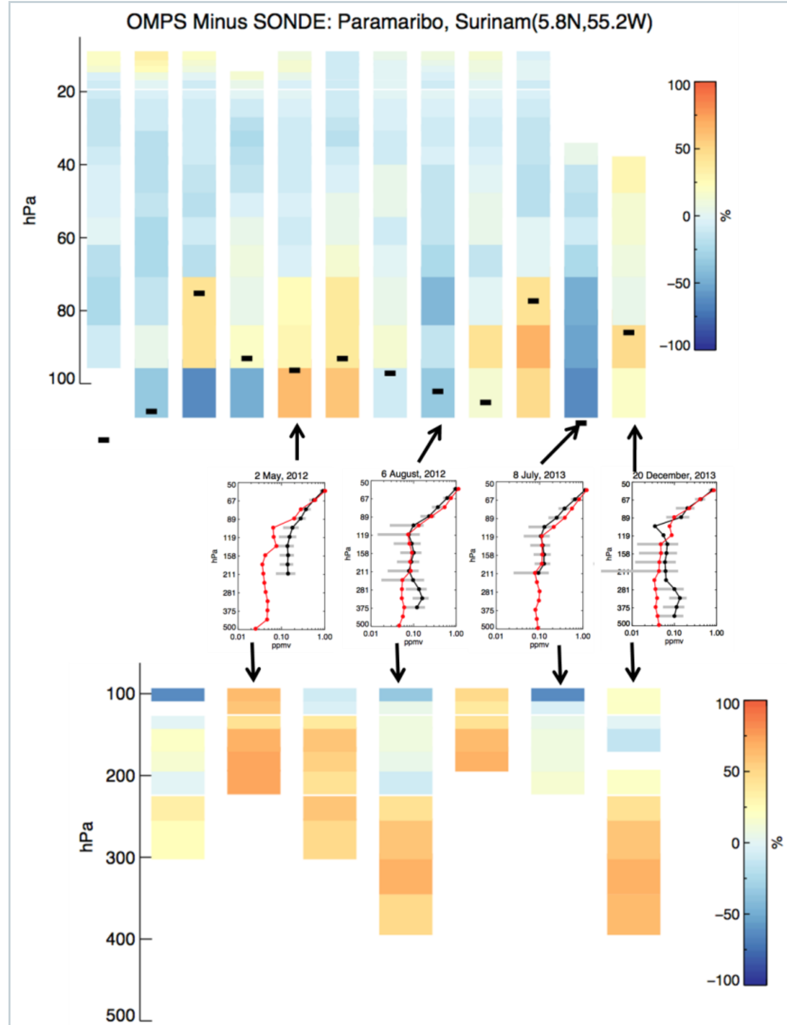
Aura/OMI-NPP/OMPS SHADOZ Total Ozone: Preliminary 2012-2013 Comparisons - 2

- OMI/OMPS –sonde agreement are similar to earlier SHADOZ comparisons (offsets, r coeff).
- Overall agreement (right) is good but will improve with further sonde Quality Assurance (QA) checks

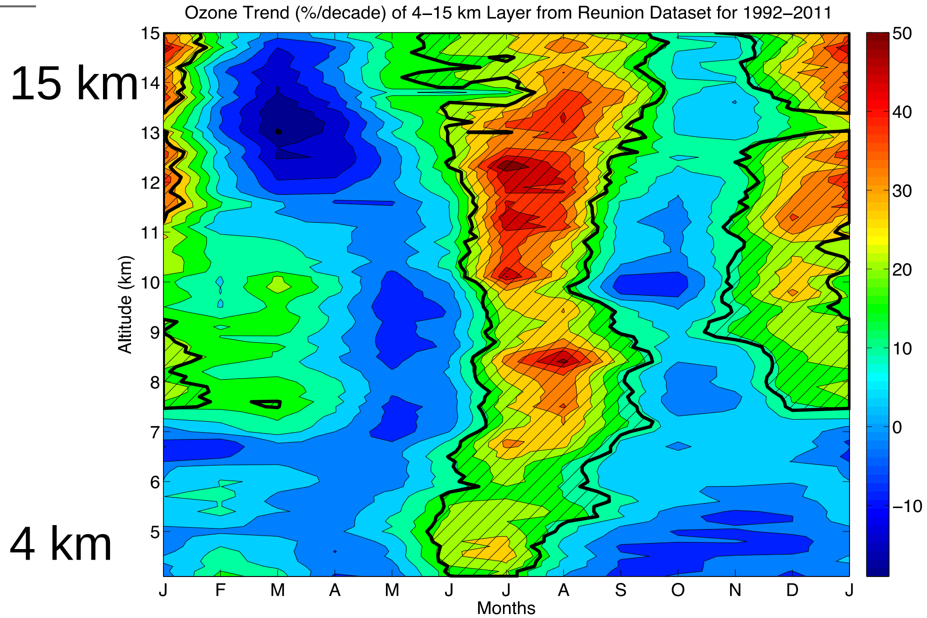


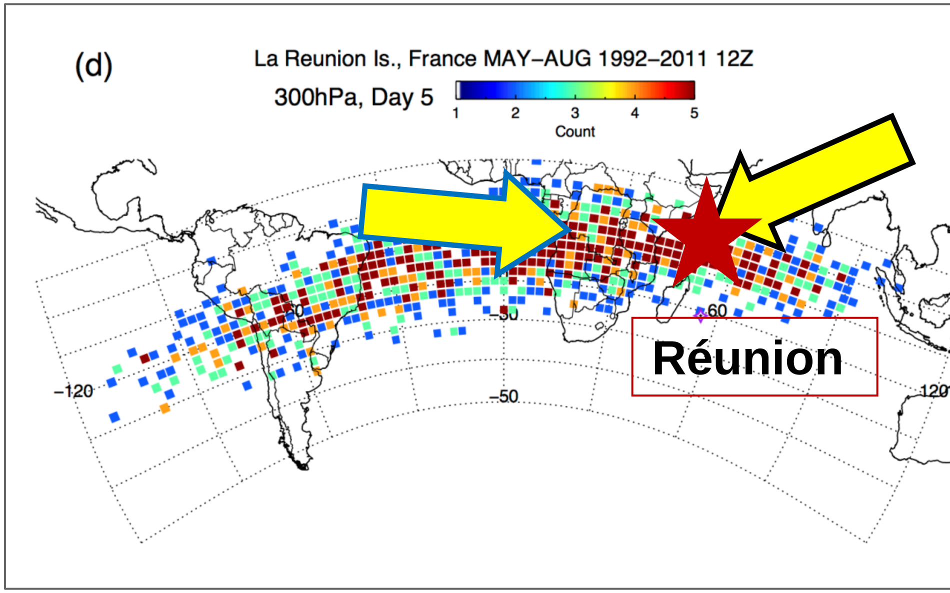
NPP/OMPS SHADOZ UT/LS Ozone: Preliminary 2012-2013 Comparison - Paramaribo

- OMPS (Ozone Mapping Profile System) limb profiler (LP) based on SBUV heritage. Layers indicated (upper)
- Sonde (**red**) comparison in UT/LS (center, lower)
- ~100 hPa tropopause. UT offsets range to + or – (50%)
- This station typical of all SHADOZ comparisons made to data
- MLS-OMPS differences are similar
- ? Why? ? OMPS TBD



Réunion Trend (1992-2011): Large Winter Trend. No Biomass Fire Season Trend. Asian Sources?





- 8-13 km (left) in *winter;* lesser trend in summer, Dec-Jan. Similar to South African (Irene) trends but larger.
- Back-trajectories (5-day, GSFC model) point to mixture of South American, African/Madagascar, and South Asian sources (right). Sources more northerly than SA sources.
- Note: Are increases observed from space? Seen in models?
- Thompson et al., *ACP,* SI2N Issue, 9/14

THANK YOU FOR YOUR ATTENTION!

Acknowledgments & References

- **Support from NASA, NOAA, with JOSIE and O3-DQA sponsored by WMO.**

- **J. Aschmann et al., On the hiatus in the acceleration of tropical upwelling since the beginning of the 21st century, *ACP Disc.,* 14, 9951–9973, 2014.**
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- **R. M. Stauffer et al., Propagation of radiosonde pressure sensor errors to ozonesonde measurements, *Atmos. Meas. Tech., 7,* 65-79. 2014. *doi:10.5194/amt-7-65-2014*.**
- **A. M. Thompson et al, Southern Hemisphere ADditional Ozonesondes (SHADOZ) 1998-2000 tropical ozone climatology. 1. Comparison with TOMS and ground-based measurements, *JGR,* 108, 8238, doi: 10.1029/ 2001JD000967, 2003.**
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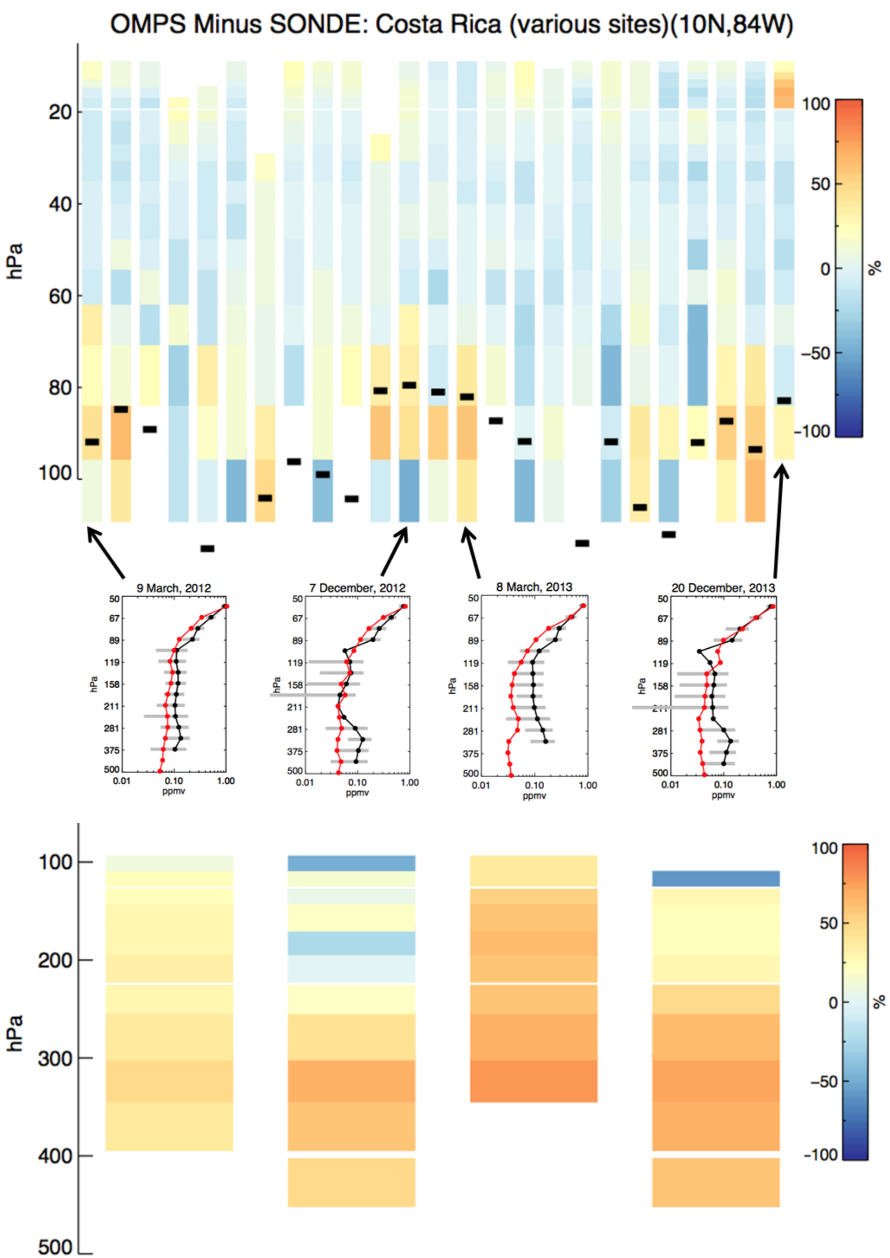
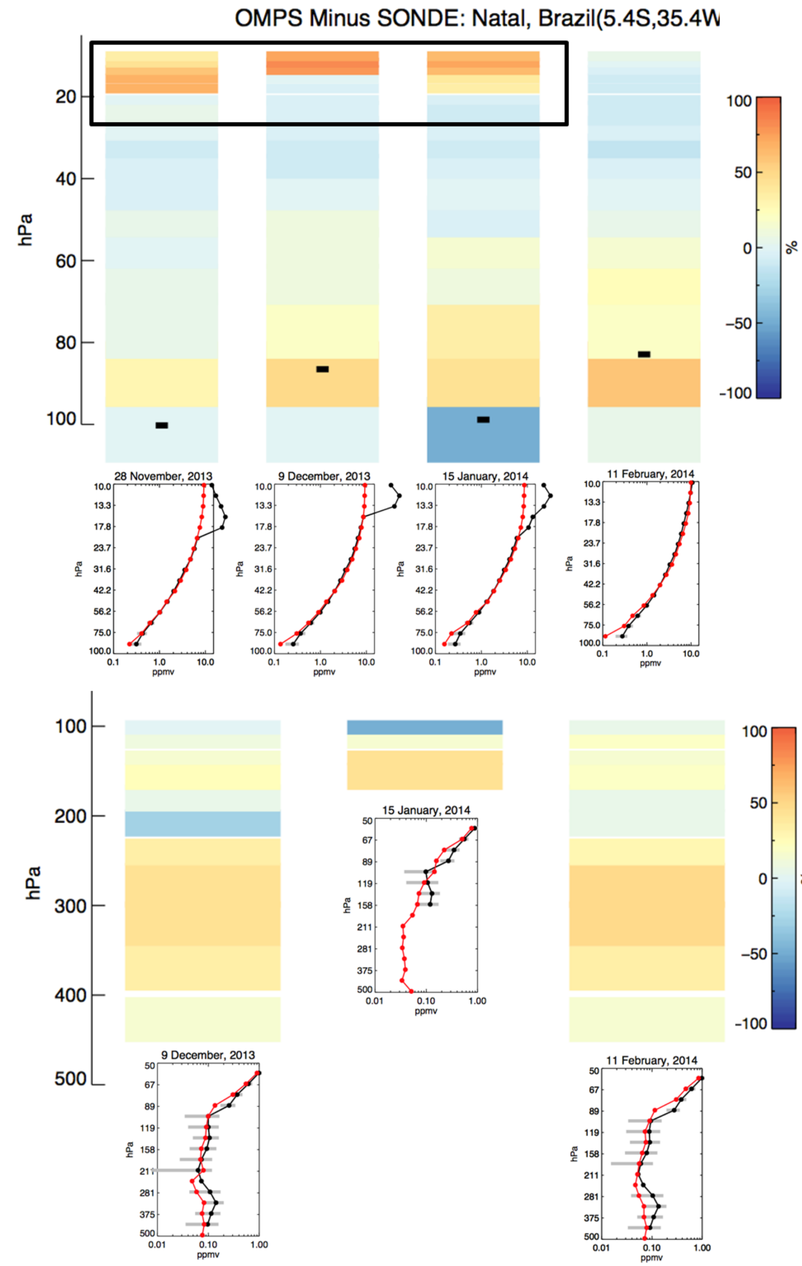
- **A. M. Thompson et al., Strategic ozone sounding networks: Review of design and accomplishments, *Atmos. Environ.* 45*,* 2145-2163, 2011.**
- **A. M. Thompson et al., SHADOZ (Southern Hemisphere Additional Ozonesondes) ozone climatology (2005-2009): Tropospheric and lower stratospheric profiles with comparisons to OMI-based ozone products, J*GR,* 117, D23301, doi: 10.1029/2011JD016911, 2012.**
- **A. M. Thompson et al., Tropospheric ozone increases over the southern African region: bellwether for rapid growth in Southern Hemisphere pollution? *ACP*, 14, 9855-9869, 2014.**

extras

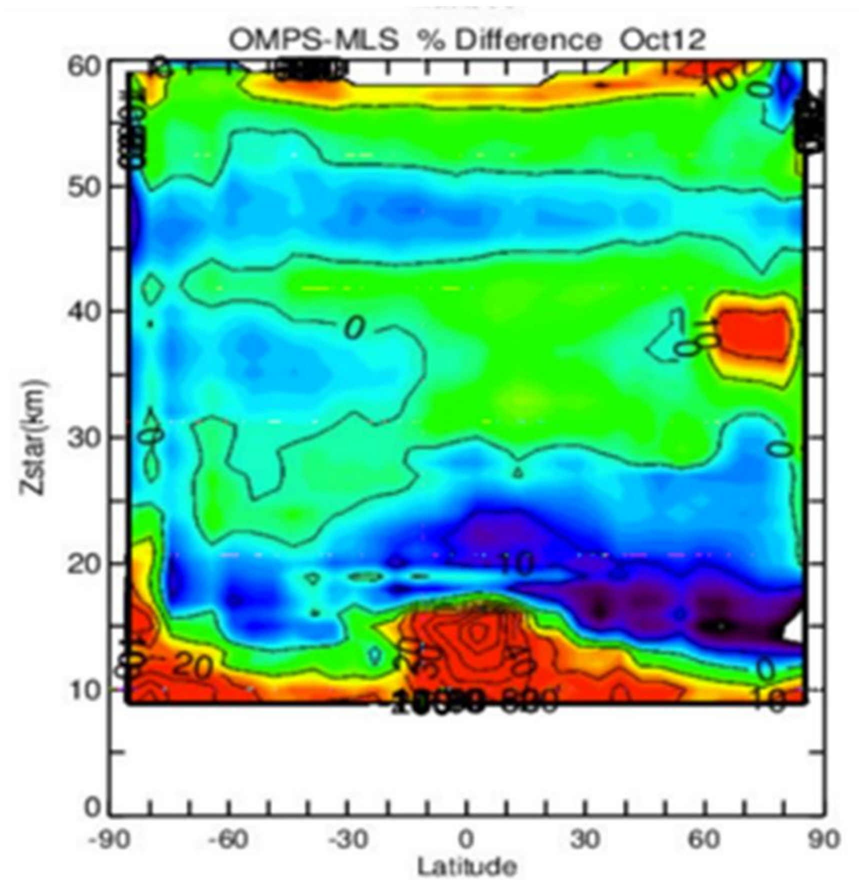


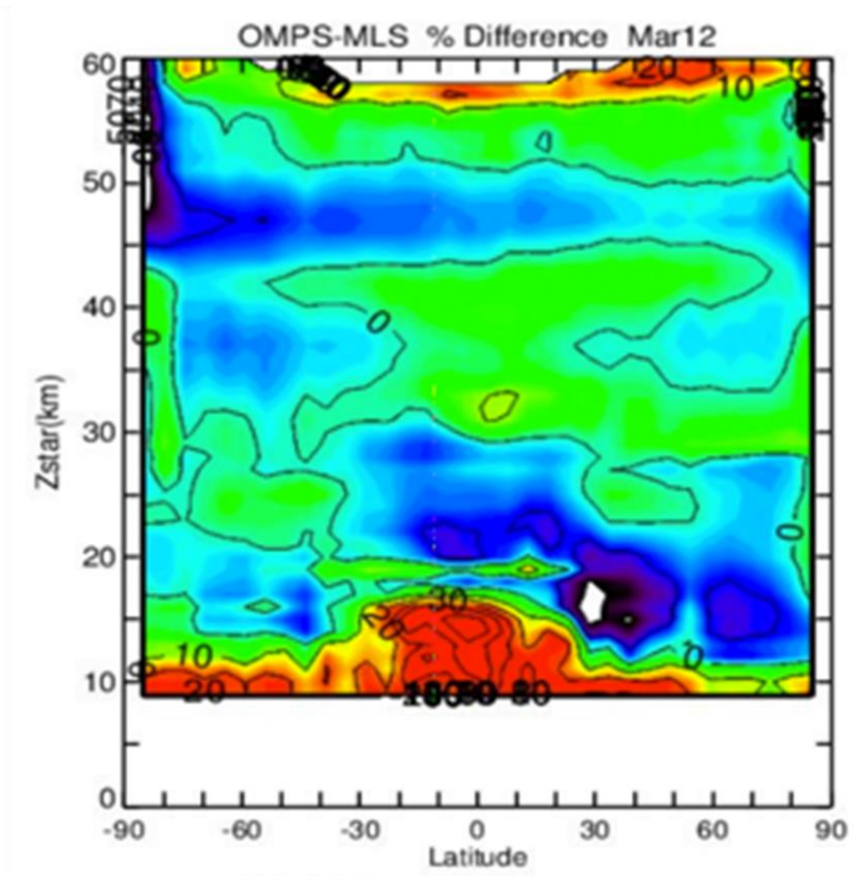
OMPS Minus SONDE: Costa Rica (various sites)(10N,84W)
hPa
%
9 March, 2012
7 December, 2012
8 March, 2013
20 December, 2013
ppmv



OMPS Minus SONDE: Natal, Brazil(5.4S,35.4W
hPa
%
28 November, 2013
9 December, 2013
15 January, 2014
11 February, 2014
15 January, 2014
9 December, 2013
11 February, 2014
ppmv

OMPS—MLS Ozone Discrepancies in Tropics > 30%





Info on 2012-2013 SHADOZ – OMI/NPP Comparisons from IGAC Poster (Witte et al, 2014)

- McPeters and Labow ozone climatology is added from sonde balloon burst to the top of the atmosphere *[McPeters, R. D., and G. J. Labow (2012), Climatology 2011: An MLS and sonde derived ozone climatology for satellite retrieval algorithms, J. Geophys. Res., 117, D10303, doi:10.1029/2011JD017006].*

- Ozone Mapping Profiler Suite contains a Total Column (TC) sensor that measures the daily global distribution of the total atmospheric O_3 column.

- OMPS TC measures UV radiances in the range from 300 to 380 nm. The total column algorithm uses 22 wavelengths from this range. The retrieval algorithm is adapted from the heritage TOMS version 7 algorithm.

- OMI and OMPS are co-located to the sondes within ±2° Lat. × ±4 ° Long.

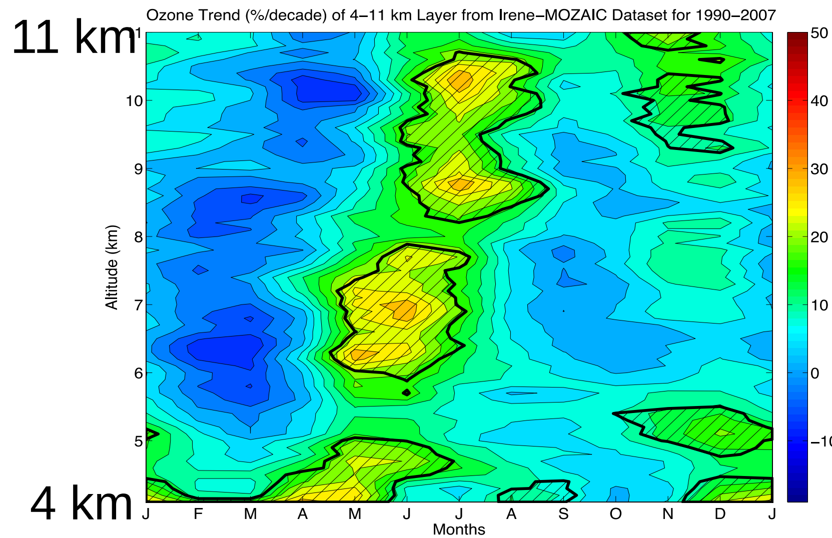
- OMI and OMPS TC comparisons are in very good agreement with SHADOZ sondes. OMPS shows a slightly better agreement overall (correlation = 0.73).

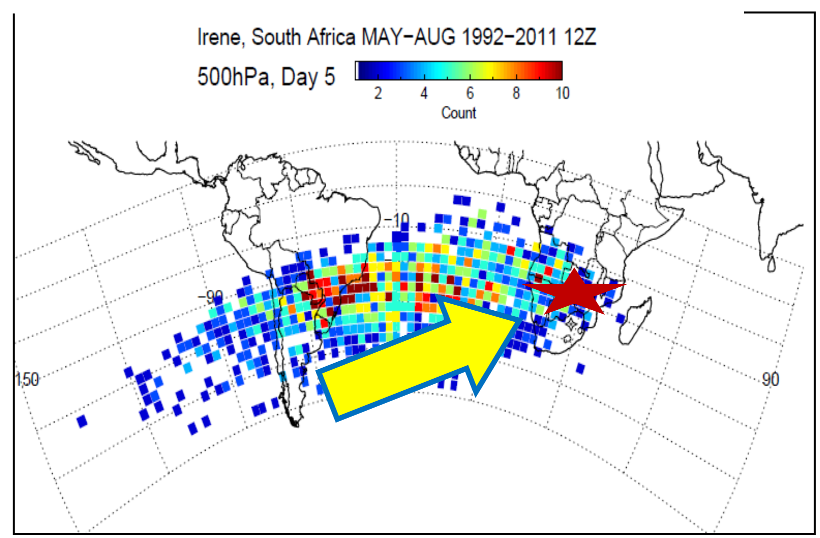
- Timeseries of selected stations show satellite measurement deviations from the sondes to be within 10%. This is generally true for all SHADOZ stations in the 2012-2013 record. Large deviations between OMI, OMPS and the sondes (seen in the timeseries plots) may be due to errors in the sonde measurements. The quality of these individual profiles will be assessed.

SA Trend (1990-2007): Free Tropospheric Ozone from Irene SHADOZ/MOZAIC JHB

- Hatched regions only statistically significant.
- At 4-5 km, (upper) possible trend artifact (changing launch time)
- **In 6-11 km layer +(20-30%)/ decade O_3 JJA increase! No Sept-Oct biomass fire season trend!**
- Causes? Emissions changes hard to track. Long-range Transport: back-trajectories* (lower) reveal concentrated ozone origins from South America where mega-cities growing in emissions ?%/decade

*May-Aug sonde launch dates





Topic of Study	Station*	Co-I/Sponsor**	SHADOZ start year	Site start year	Network affiliation **	Ancillary data/UACO variables	Expected sonde freq./year
Long-term Validation / Trends **(Data available prior to 1995)**	**Kuala Lumpur**	Maznorizan bt Mohamad, & YY Toh, Malaysian Met., S. Yonemura, Japan	1998	1992			26
	Watukosek	Ninong Komala, LAPAN & Masatomo Fujiwara, Hokkaido Univ.	1998	1998	SOWER	CFH-water vapor profiles	26
	Am. Samoa	Bryan Johnson & Samuel J. Oltmans, NOAA	1998	1986	NDACC / GAW	Dobson / surface CO2, CH4, CO, CFCs, O3	52
	Natal	Francis J. Schmidlin, NASA/Wallops & Neusa Paes Leme, INPE	1998	1979	NDACC	Brewer	52
	Hilo	B. Johnson , D. Hurst & S. J. Oltmans, NOAA	1998	1982	NDACC / GAW	MLO – Dobson, FTIR, O3 Lidar, CFH-water vapor / surface CO2, CH4, CO, CFCs, O3	52
	Irene	G.J.R. Coetzee, S. African Weather Serv.	1999	1990		Dobson	26
	La Reunion	Françoise Posny, Université de La Réunion	1998	1998	NDACC	SAOZ, O3 Lidar	26
Processes in the FT, TTL, and LS	**Fiji**	B. Johnson & S. J. Oltmans, NOAA	1998	1997			26
	San Jose* **	Rennie Selkirk, NASA/GSFC & Holger Vömel, GRUAN Lead Center	2006	2006	GRUAN	SO2 sondes, CFH-water vapor profiles	52
	San Cristobal	B. Johnson (NOAA) & H. Voemel	1999	1998	GRUAN / SOWER	CFH-water vapor profiles	52
	Paramaribo	Rinus Scheele, KNMI	1999	1999	NDACC	Brewer	52
	Ascension Is.	Francis J. Schmidlin, NASA/Wallops	1998	1990	TCCON / GAW	Carbon columns / surface CO2, CH4, CO, CFCs	26
	Nairobi	Bertrand Calpini, MeteoSwiss & John Nguyo, KMD	1999	1996		Dobson, surface O3	52
	Ha Noi	H. Gia Hiep, AMO, S. Ogino, JAMSTEC, M. Fujiwara, Hokkaido Univ., & M. Shiotani, RISH	2005	2004	SOWER	CFH-water vapor profiles	26

* Colors for stations indicate geographic region: blue-Western Pacific, red-Atlantic/Africa, white-Subtropics, & green-Equatorial Americas
** See Acronyms in Appendix
*** Station formerly referred to as Alajuela / Heredia