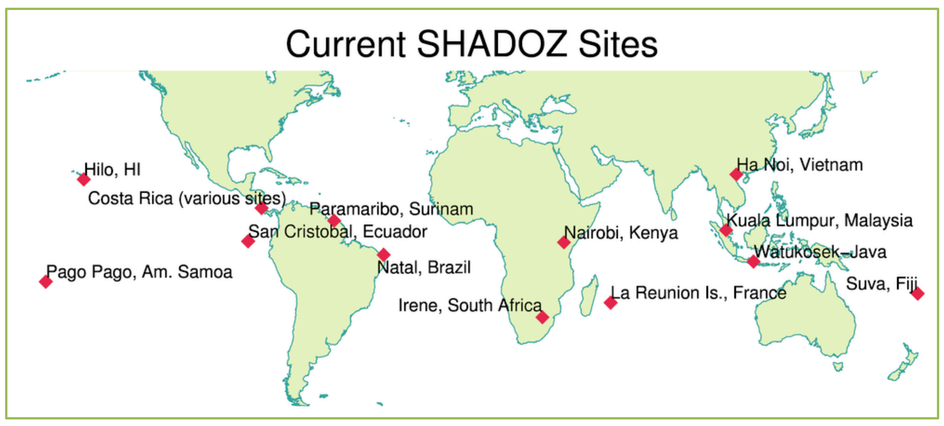
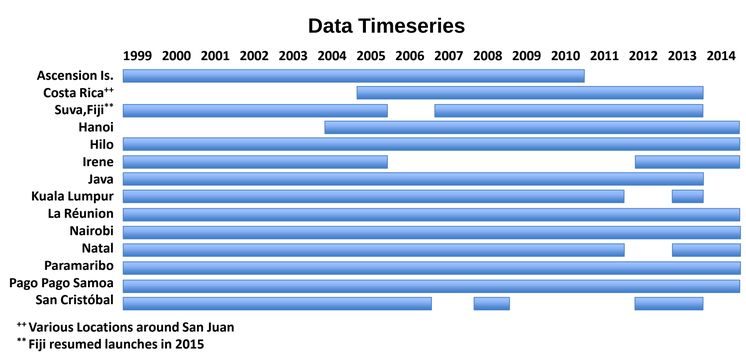
Southern Hemisphere ADditional OZonesondes (SHADOZ) Updates

Anne M. Thompson (NASA/GSFC); Anne.m.thompson@nasa.gov
Jacquie Witte (NASA/GSFC/SSAI), Bryan J. Johnson (NOAA/GMD),
Patrick Cullis (NOAA/GMD/CIRES), Chance Sterling (NOAA/GMD/CIRES),
Samuel. J. Oltmans (NOAA/GMD/CIRES),
Nikolay V. Balashov (Penn State Univ., Meteorology Dept.)

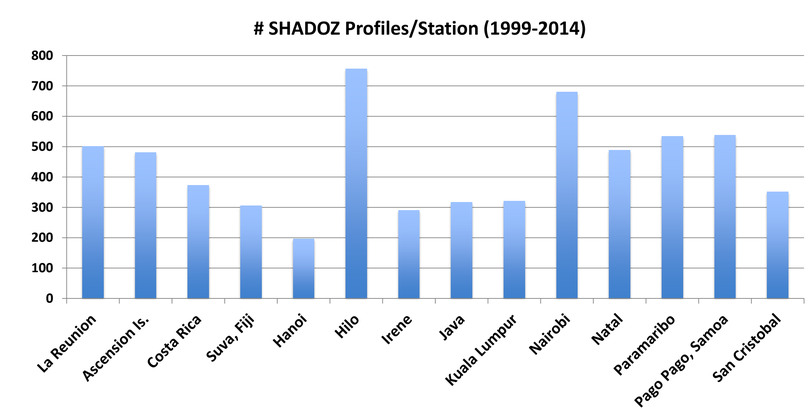
WEBSITE: http://croc.gsfc.nasa.gov/shadoz

Ozonesonde data support satellite validation, model evaluation and studies of atmospheric pollution and dynamics. Strategic ozonesonde networks coordinate and schedule launches in a fixed region to answer specific questions (Thompson et al., *Atmos. Environ.,* 2011). The SHADOZ (<http://croc.gsfc.nasa.gov/shadoz>) network,has archived more than 6000 ozone and P-T-U profiles since 1998 from a dozen tropical and subtropical stations with 2-4 launches monthly. Updates since our last report to the GMD Annual Conference are presented. There have been visits by NOAA and NASA personnel to 5 stations (see Cullis et al. poster). We have begun the first major re-processing of SHADOZ data to account for inhomogeneities in ozonesonde and radiosonde type according to the guidelines of the WMO-sponsored Ozone Data Quality Assurance Activity (O3S-DQA). Large trends in free tropospheric ozone have been discovered using SHADOZ and pre-SHADOZ ozone profiles over Irene, South Africa (+25%/decade, 1990-2007), and Reunion Island (+ 40%/decade, 1992-2011; see Figure 2, updated from Thompson et al., *ACP*, 2014). Finally, comparisons of SHADOZ ozone in the upper troposphere and lower stratospheric with OMPS ozone amounts will be shown.





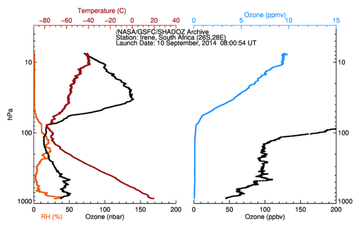
** Various Locations around San Juan
** Fiji resumed launches in 2015

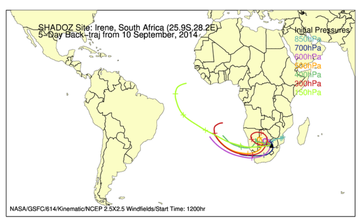


Site visit to Irene, South Africa

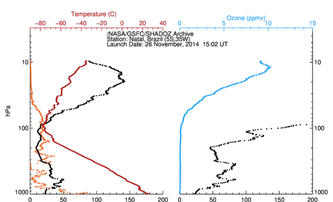
Above image of Irene, SA launch by Dr. Gert Coetzee of the South African Weather Service (SAWS). Right: Irene Dobson demonstration.

Ozonesonde profile plot and associated back-trajectories taken from Irene, SA. Irene is a reactivated site and has been launching with the latest Vaisala ground system. Images and data available on the SHADOZ archive.

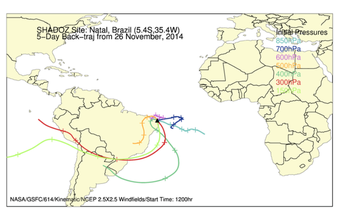




Site visit to Natal, Brazil



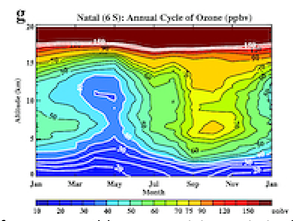
Site visit Sept. 2014 To Maxaranguape, Natal, Brazil sonde launch site.



Santa Maria in Rio Negro do Sul - atmospheric observatory operated jointly by INPE and the Federal University of Santa Maria (UFSM). Potential future SHADOZ site.

Meetings & Affiliations

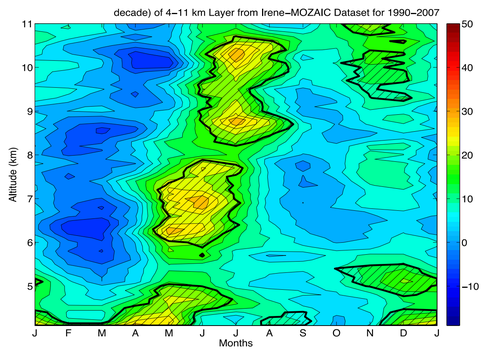
- SHADOZ continues NDACC affiliation and PI Thompson has joined the steering committee of GRUAN (GCOS Upper Air Reference Network).
- Four SHADOZ papers were presented at the Quadrennial CACGP/IGAC Symposium in Natal, Brazil, 9/14.

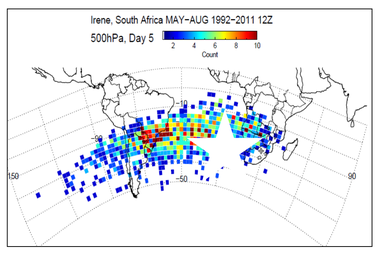


Contours of mean monthly ozone mixing ratio in the troposphere, based on monthly averages, 1998–2009. Figure from *A. M. Thompson et al., J. Geophys.Res., Volume 117, Issue D23, D23301, 1 DEC 2012 DOI: 10.1029/2011JD016911.*

Irene Trend (1990-2007): Large MJJA free tropospheric trend. No biomass burning seasonal trend.

- Includes MOZAIC JHBC profiles.
- Multi-variate regression model includes seasonal cycle, ENSO. Applied to monthly means at 100-m resolution.
- Hatched regions only significant.
- At 4-5 km, (upper) possible trend artifact due to variable launch times.
- In 6-11 km layer +(20-30%)/ decade O_3 JJA increase!
- No Sept-Oct fire season trend!
- Causes? * Emissions changes. * Long-range Transport: Back-trajectories initialized from Irene location reveal concentrated O3 origins from South America with ~20% mega-city emissions growth.
- Results based on Thompson et al., ACP, 9/2014; Balashov et al., JGR, 4/2014.

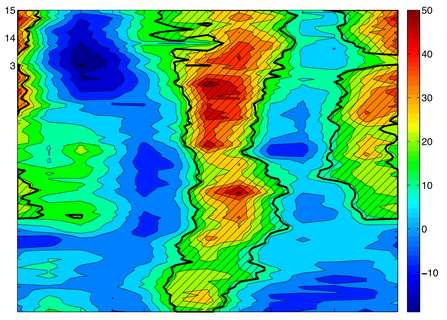


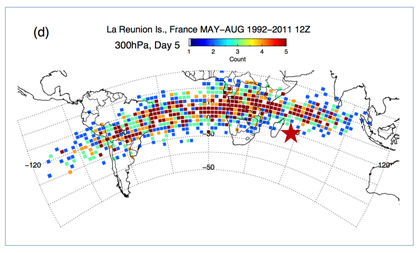


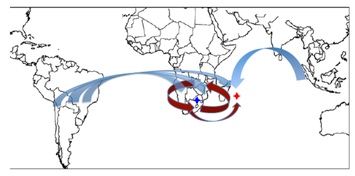
5-day back-trajectory endpoint locations binned

La Réunion Trend (1992-2011): Large JJA trend. No biomass burning seasonal trend.

- Hatched trends are significant. More than 35%/decade O_3 increase, 8-13 km in winter (JJA), lesser trend in summer (Dec-Jan).
- No biomass burning seasonal (Sept-Oct) trend.
- Back-trajectories below (5-day, GSFC model) initialized from the Reunion location point to mixture of South American, African/Madagascar, and South Asian sources. Sources more northerly than SA sources.



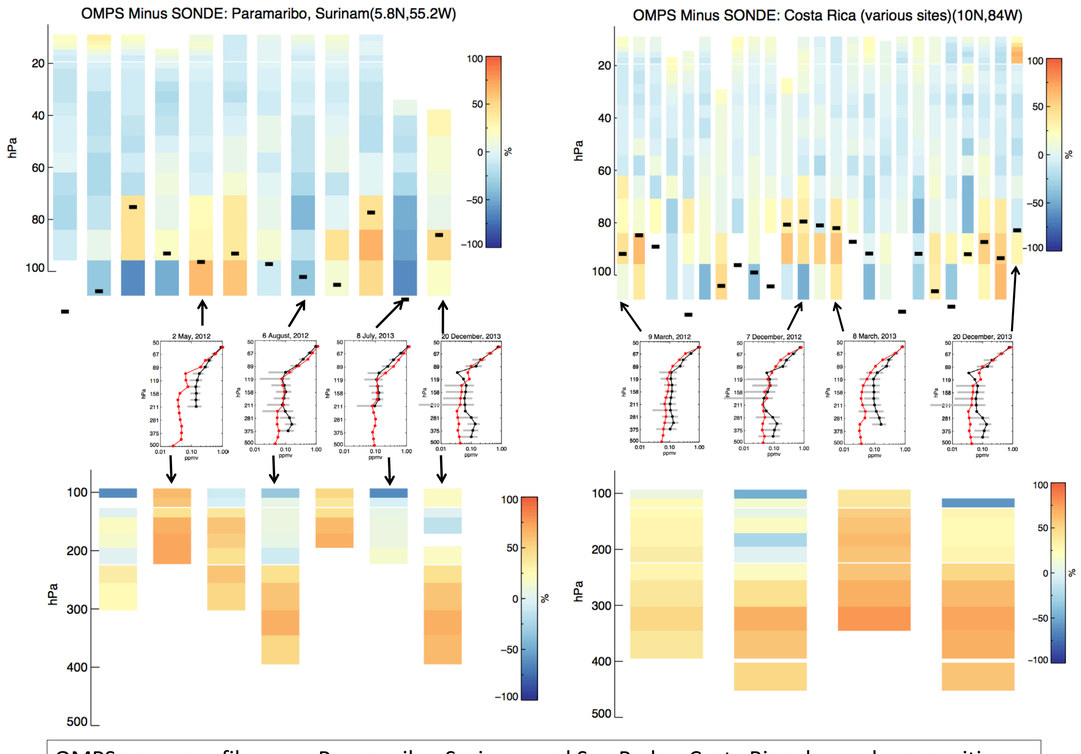




Schematic of typical recirculation patterns over southern Africa and an outflow route to the Indian Ocean (maroon arrows). Flows towards the southern African region and eastern Indian Ocean from South America and southern Asia are in blue arrows. *Taken from Thompson et al., ACP, 9/2014.*

NPP/OMPS Profile Comparisons

An individual bar is a profile color coated by percentage difference relative to OMPS at the OMPS resolution. Top plots show the stratosphere (100-10 hPa), bottom plots the troposphere (500-100hPa).



OMPS ozone profiles over Paramaribo, Surinam and San Pedro, Costa Rica show a large positive bias below the tropopause and negative bias above, relative to SHADOZ sondes. Comparisons with all other SHADOZ stations show similar biases.

- Recently released OMPS Level 2 data and documentation are available here: http://ozoneaq.gsfc.nasa.gov/omps
- The OMPS Limb Profiler (LP) algorithm is adopted from the heritage SBUV/2 operational algorithm. The sensor is designed to observe the Earth's limb radiance in the 290-1020 nm spectral range.
- Data are co-located to the sondes within ±2° Lat. x ±4 ° Long.
- There are large differences between co-located OMPS LP and SHADOZ sonde profiles, particularly below the tropopause (positive bias generally > 25%). Above the tropopause the bias in the lower stratosphere is negative (upper plots: biases generally within 25 %). A few stations are shown but this positive tropospheric /negative stratospheric bias is true at all SHADOZ stations.
- These positive tropospheric bias is consistent with OMPS - MLS comparisons (below provided by Jerry Ziemke, NASA/GSFC) where zonal monthly mean OMPS LP ozone mixing ratios are much higher than MLS in the tropical troposphere (% difference plots below) . This is true for all months of the OMPS record.
- Algorithm development in the tropospheric portion of the OMPS LP profiles continues. However, this preliminary study indicates the OMPS LP ozone record below the tropopause in the tropics remains unusable for scientific studies.