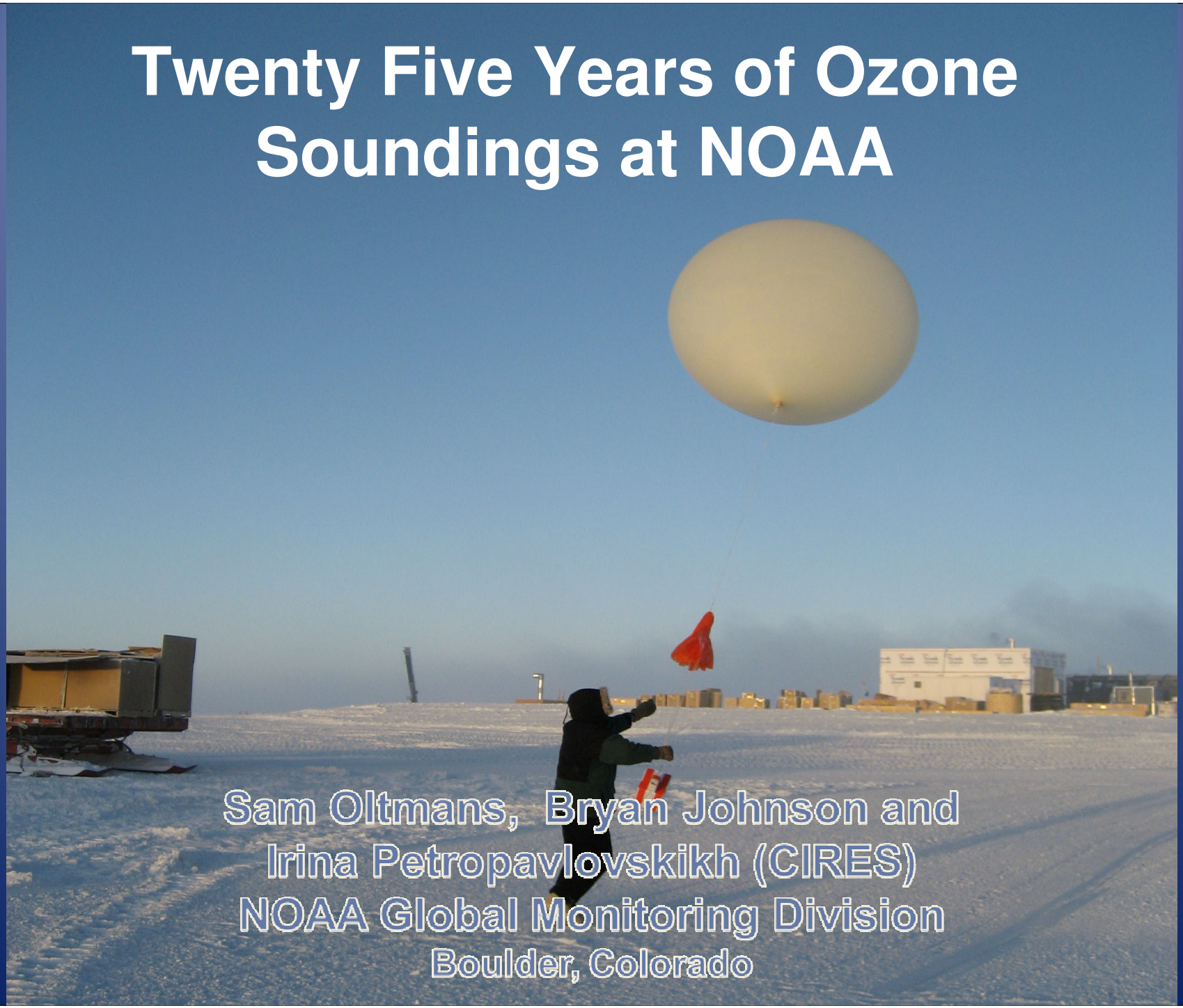
# Twenty Five Years of Ozone Soundings at NOAA



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# NOAA record includes longer term time series (~25 years) and mid length series (10-15 years)

- All of the soundings have been done with electrochemical concentration cell (ECC) ozonesondes.
- Over the course of the record there have been a number of changes in methodology.
  - Analog chart data recording vs. digital sondes, VIZ vs. Vaisala radiosondes, box vs. pump temperature (applies to time series > 20 years in length).
  - Shorter time series (<20 years) used digital sondes, Vaisala radiosondes, measured pump temperature.
- Ozonesondes from different manufacturers and with different sensing solution recipes were used.
- The background current was inconsistently measured and different pump efficiency corrections were applied.

# How can these potential inhomogenities be accounted for?

- Use results of the JOSIE chamber experiments (Herman's talk).
- Make use of laboratory experiments to measure the impact of sensor solution recipes and measure pump efficiency corrections.
- Use the results of dual soundings to develop corrections.
- Examine the methodology and conditions under which background currents were measured at various locations and during different observational periods (e.g., humid vs. dry conditions, analog vs. digital eras).

# How can we use the results from JOSIE to improve the NOAA ozonesonde record?

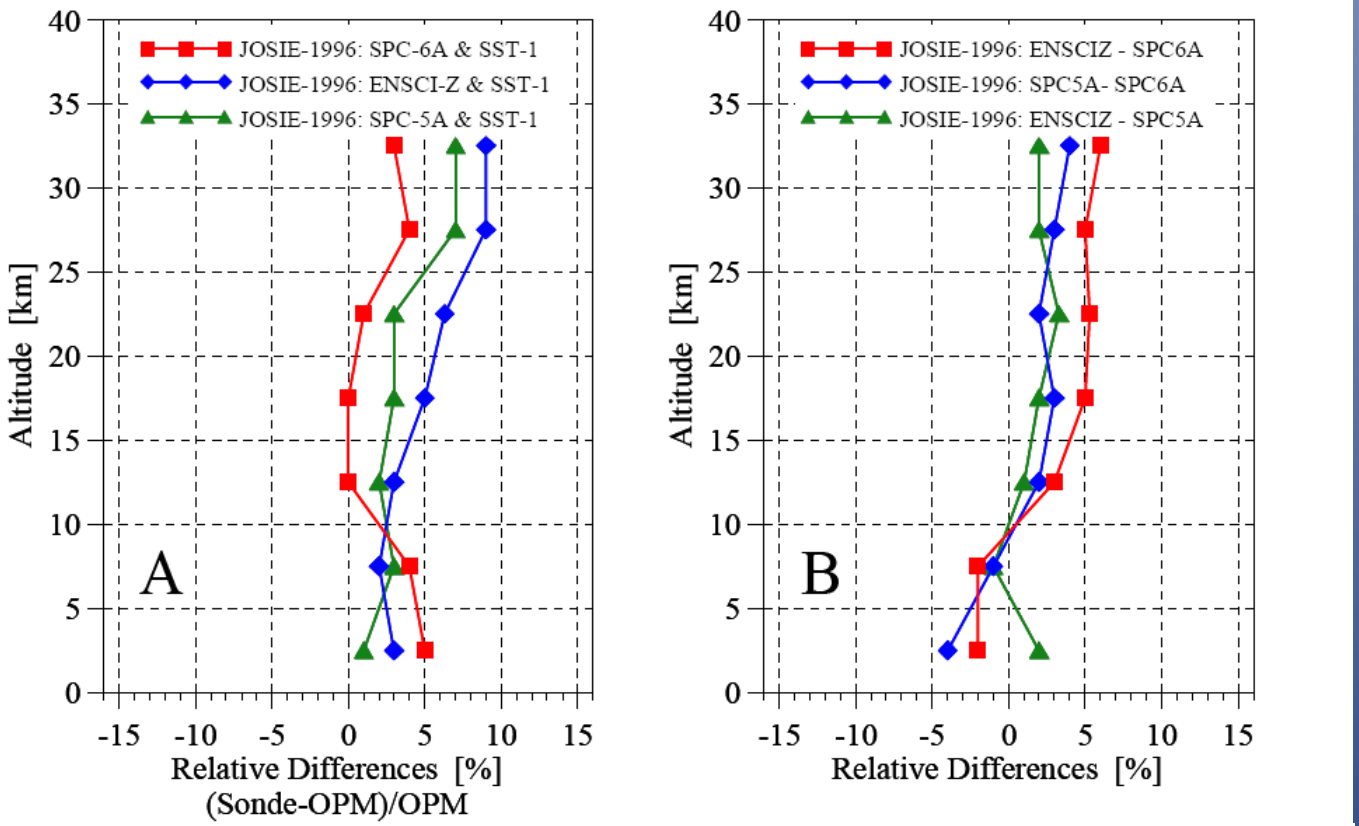
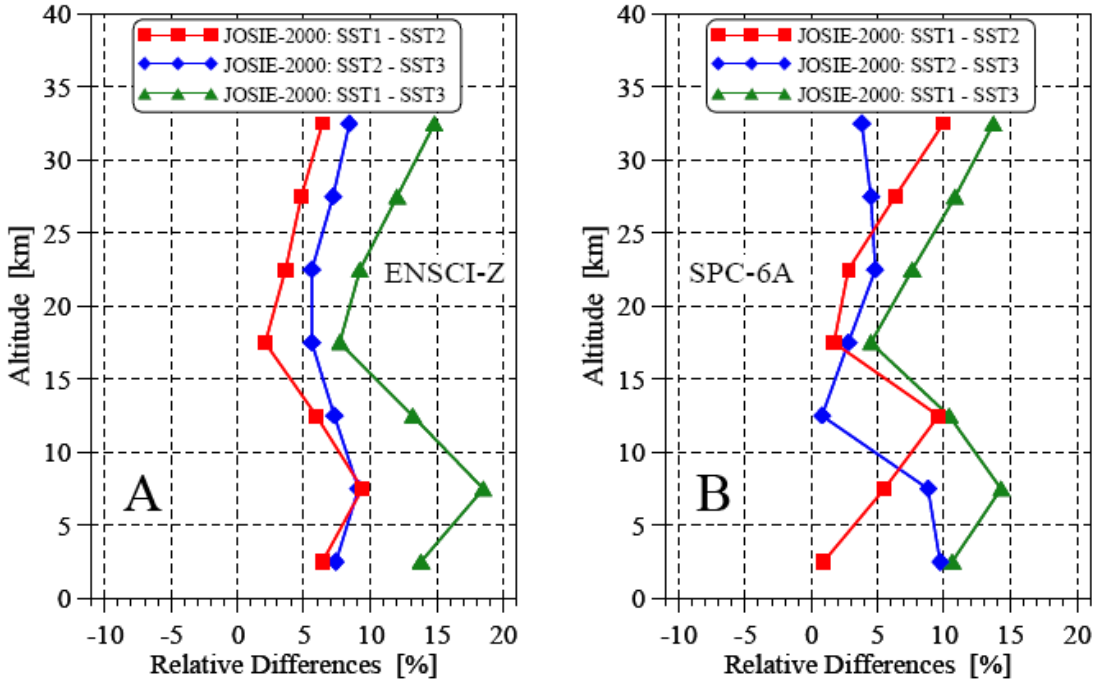



**Figure 5.** JOSIE 1996: Relative bias of each SPC-5A, SPC-6A and ENSCI-Z sonde type compared to UV-Photometer (OPM) (left) and relative differences between the three ECC-sonde types (right). All data processed according *Komhyr* [1986] (Table 3). The displayed data are averaged over altitude bins of 5 km.

**Conclusion: The ENSCI-Z sondes produce a stronger response to ozone than the SPC-A sondes.**

# How can we use the results from JOSIE to improve the NOAA ozonesonde record?

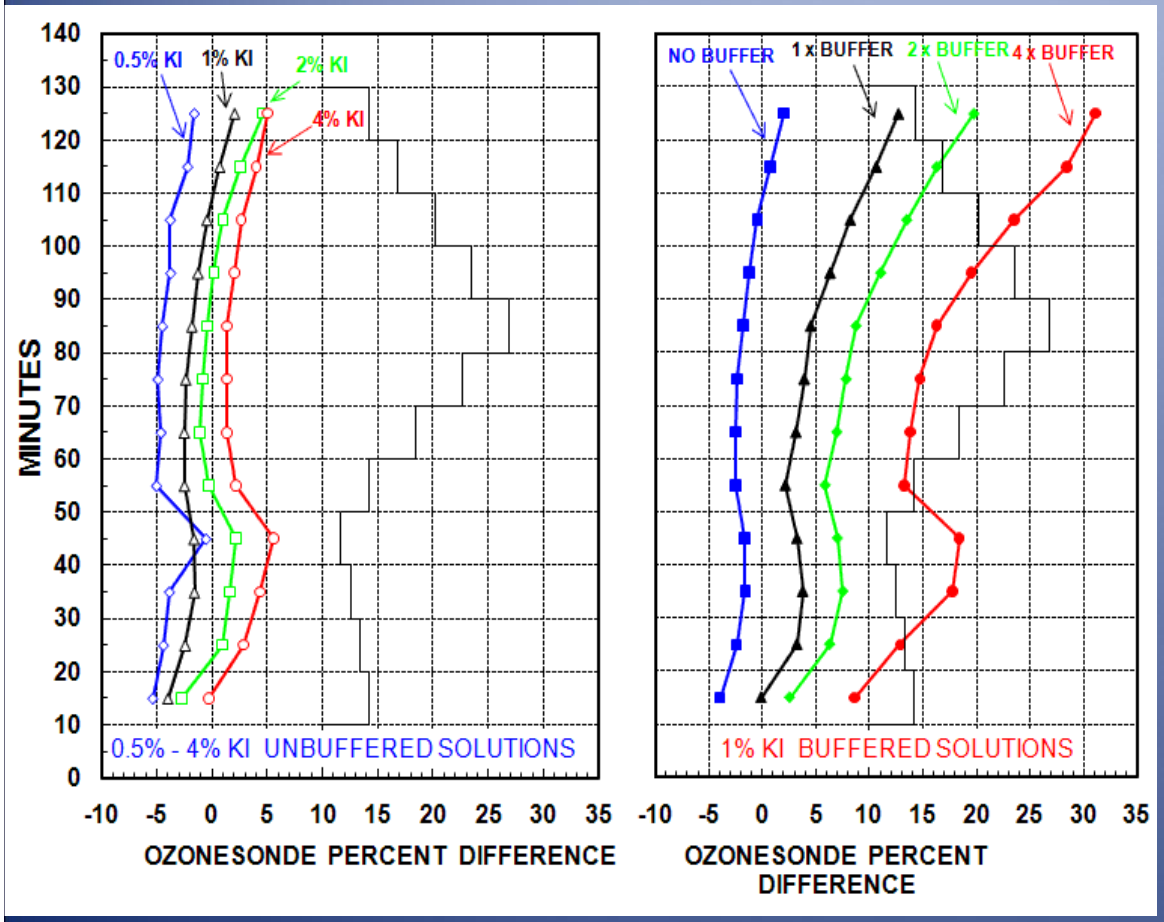


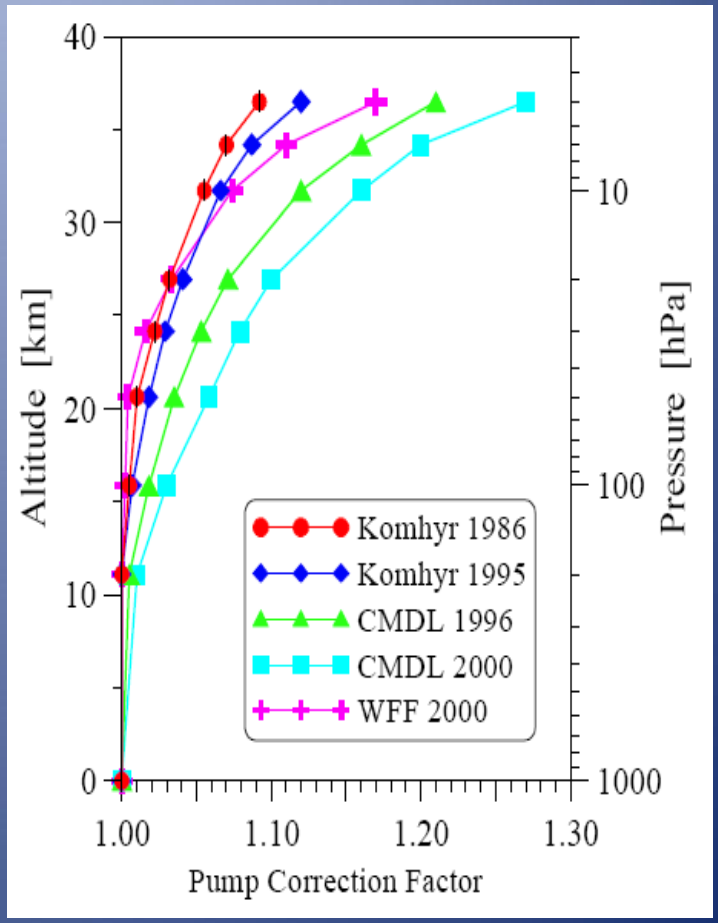

**SST-1: 1% KI, full buffer; SST-2: 0.5% KI, half buffer; SST-3: 2% KI, no buffer**

**Figure 9.** JOSIE 2000: Relative differences among the use of different SST for ENSCI-Z sonde type (left, A) and SPC-6A sonde type (right, B) as a function of altitude in bins of 5 km.

**Conclusion: The buffered solutions produce a stronger response to ozone that increases with altitude in the stratosphere.**

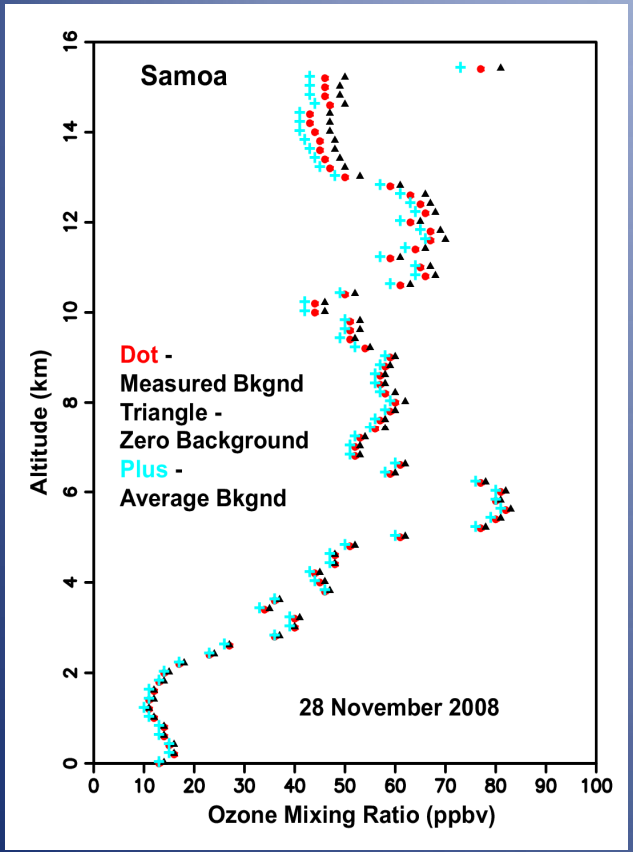
# How can we improve the NOAA ozonesonde record? Role of sensing solution recipe and pump correction

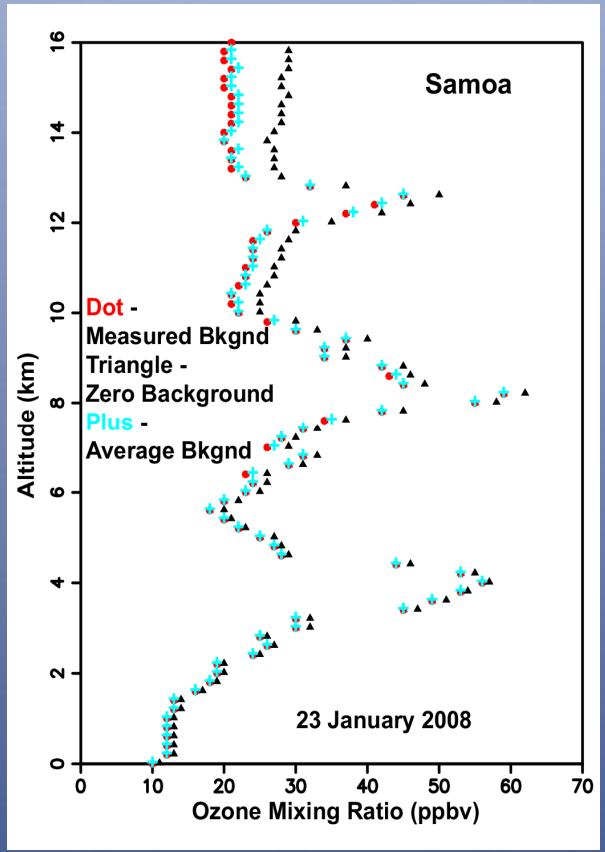


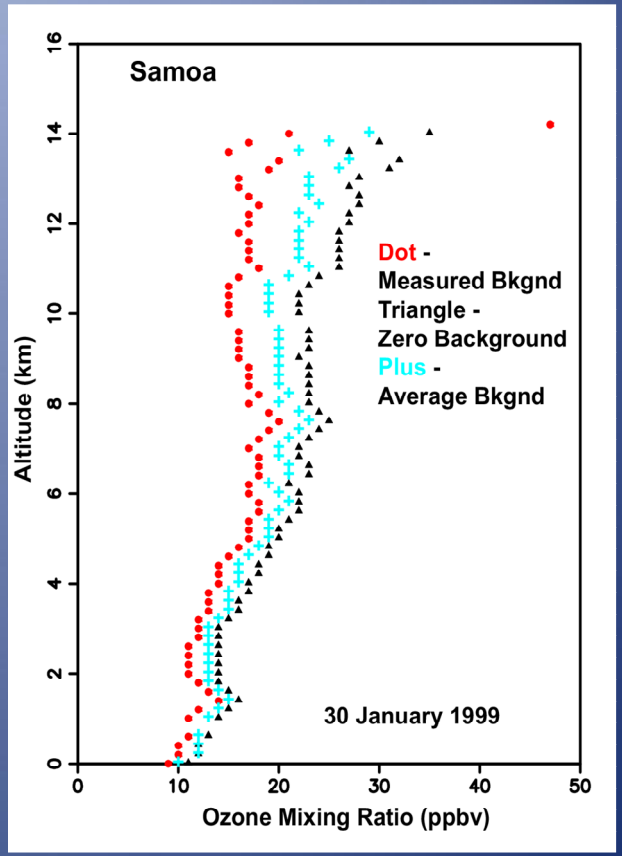




**Conclusion: (1) The response of the sensor is only weakly a function of the potassium iodide concentration but strongly influenced by the solution buffer. (2) Smaller pump efficiency correction compensates for the influence of the buffer in the upper portion of the profile.**

# How can we improve the NOAA ozonesonde record?
# Role of background current



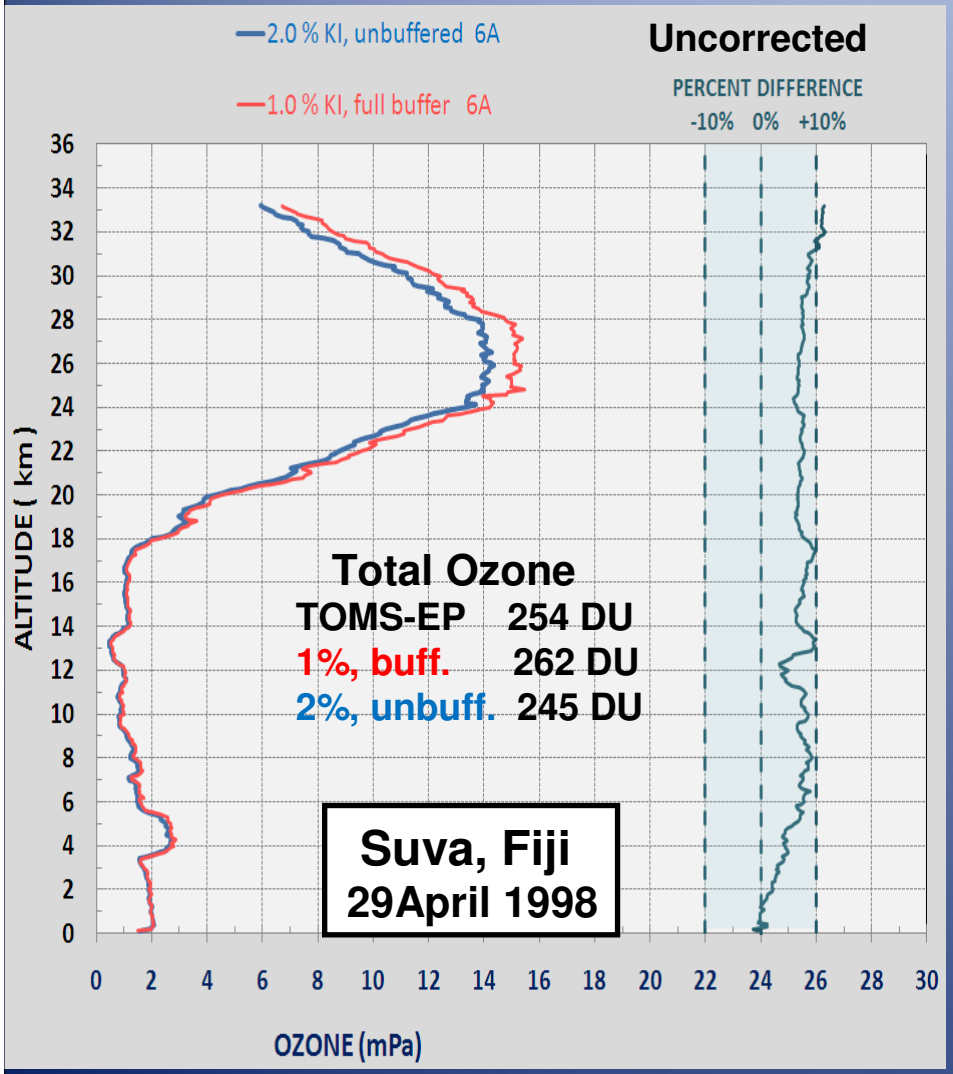



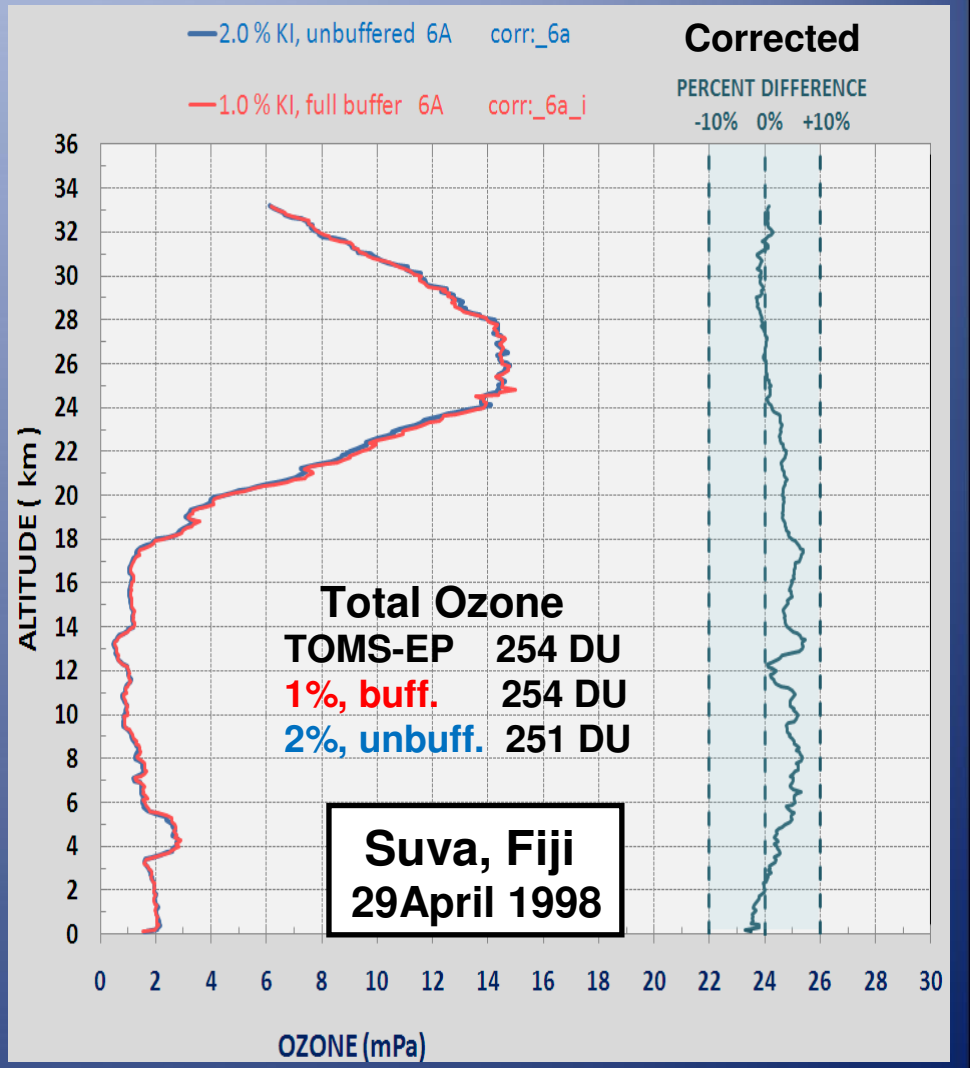




**Small Measured Background** **Avg. Measured Background** **Large Measured Background**

**Conclusion: When mixing ratios are low (tropics) upper tropospheric ozone can be impacted by using inappropriate background currents. In some cases, especially with older data, this is significant.**

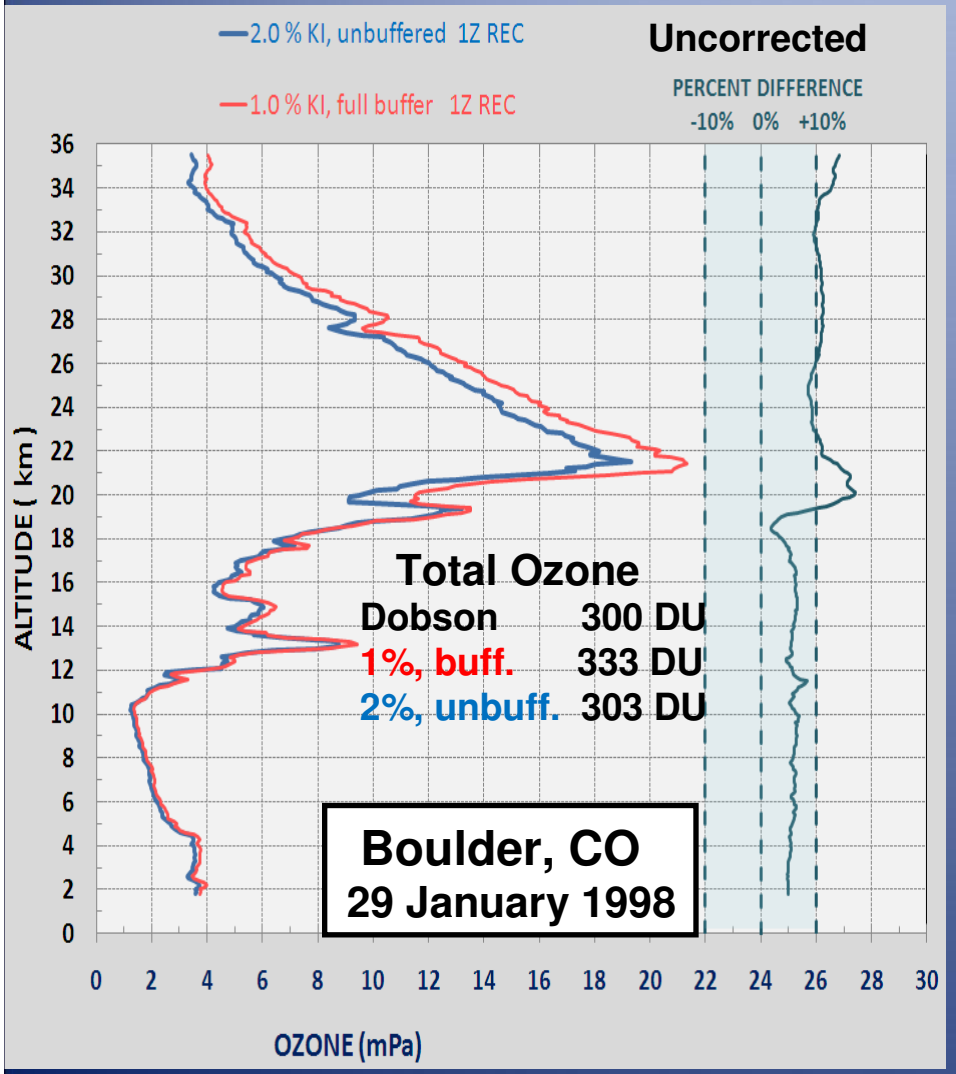
# How can we improve the NOAA ozonesonde record?
# Use of dual soundings

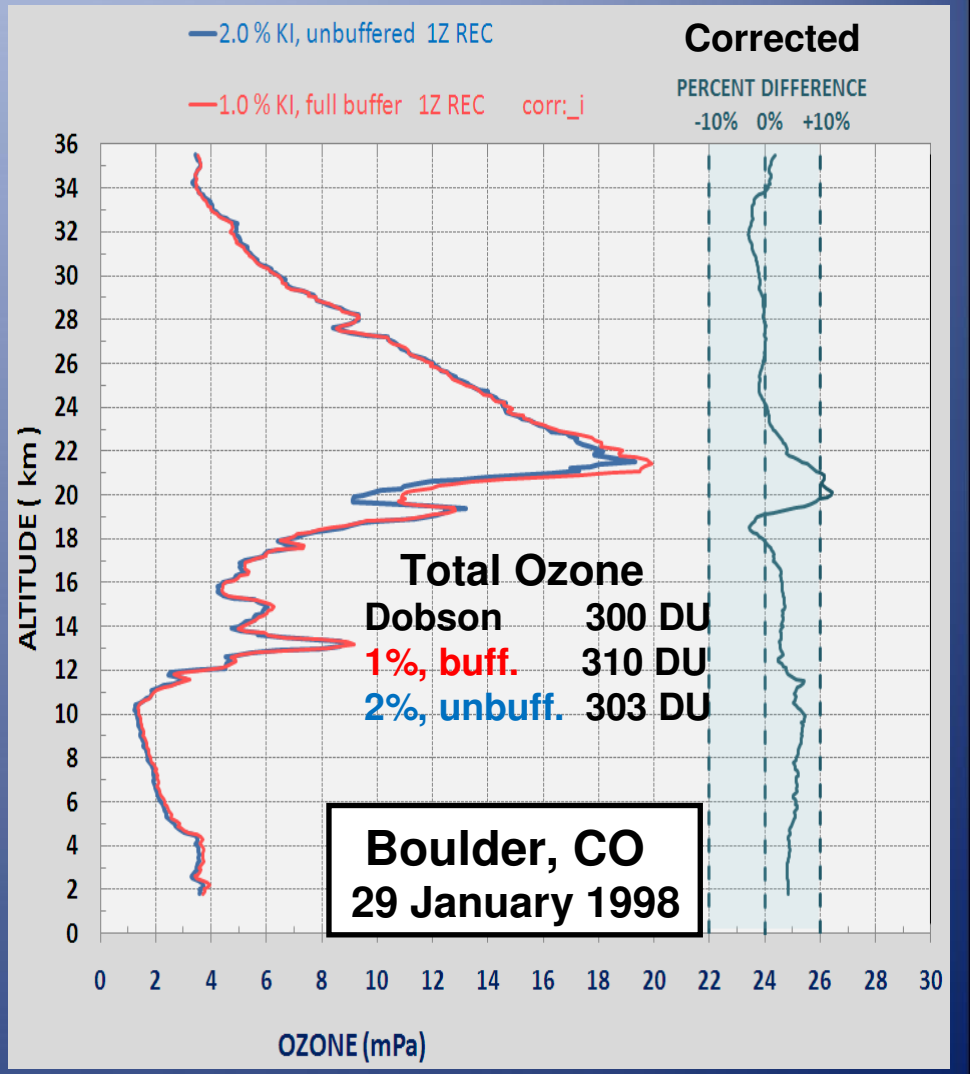



**Conclusion: Correcting for the buffer gives good agreement between the profiles. Also correcting for the sonde type (6A) improves the comparison for total ozone.**

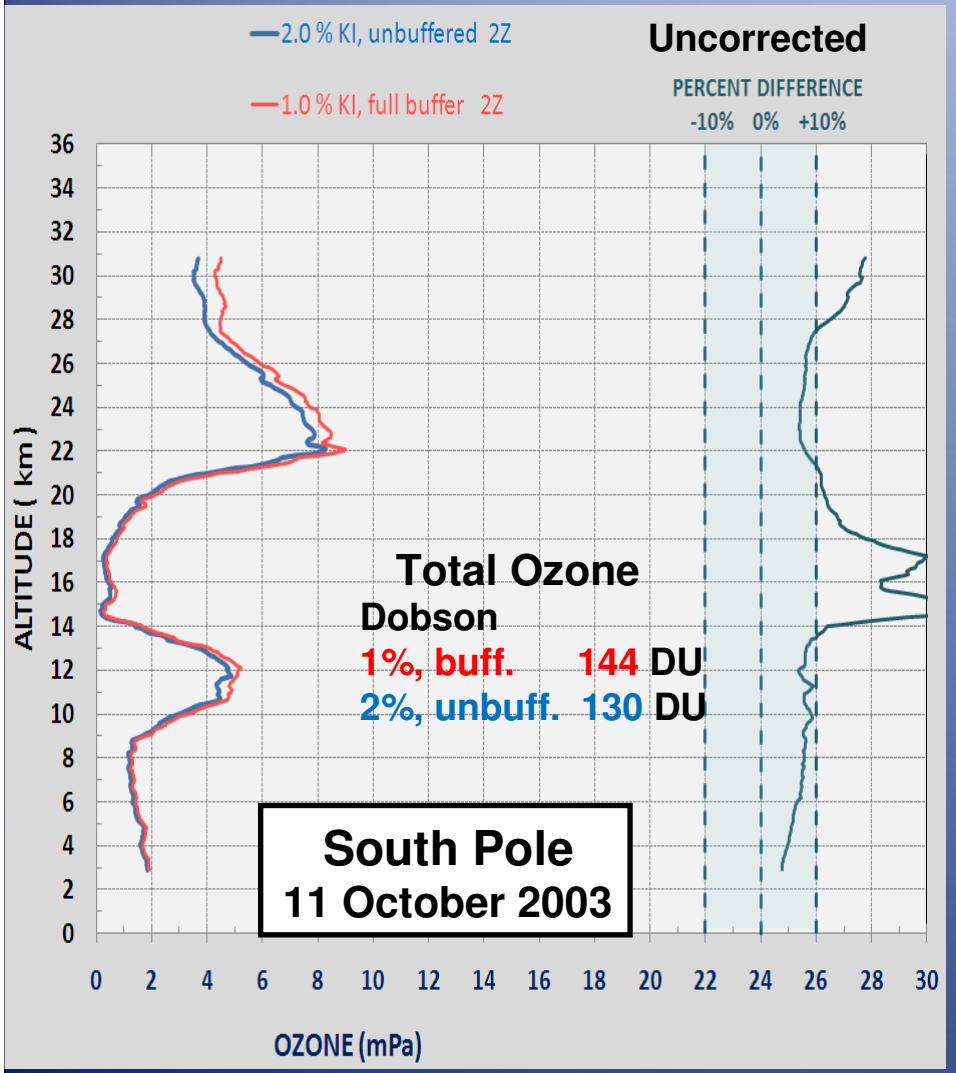
# How can we improve the NOAA ozonesonde record?
# Use of dual soundings

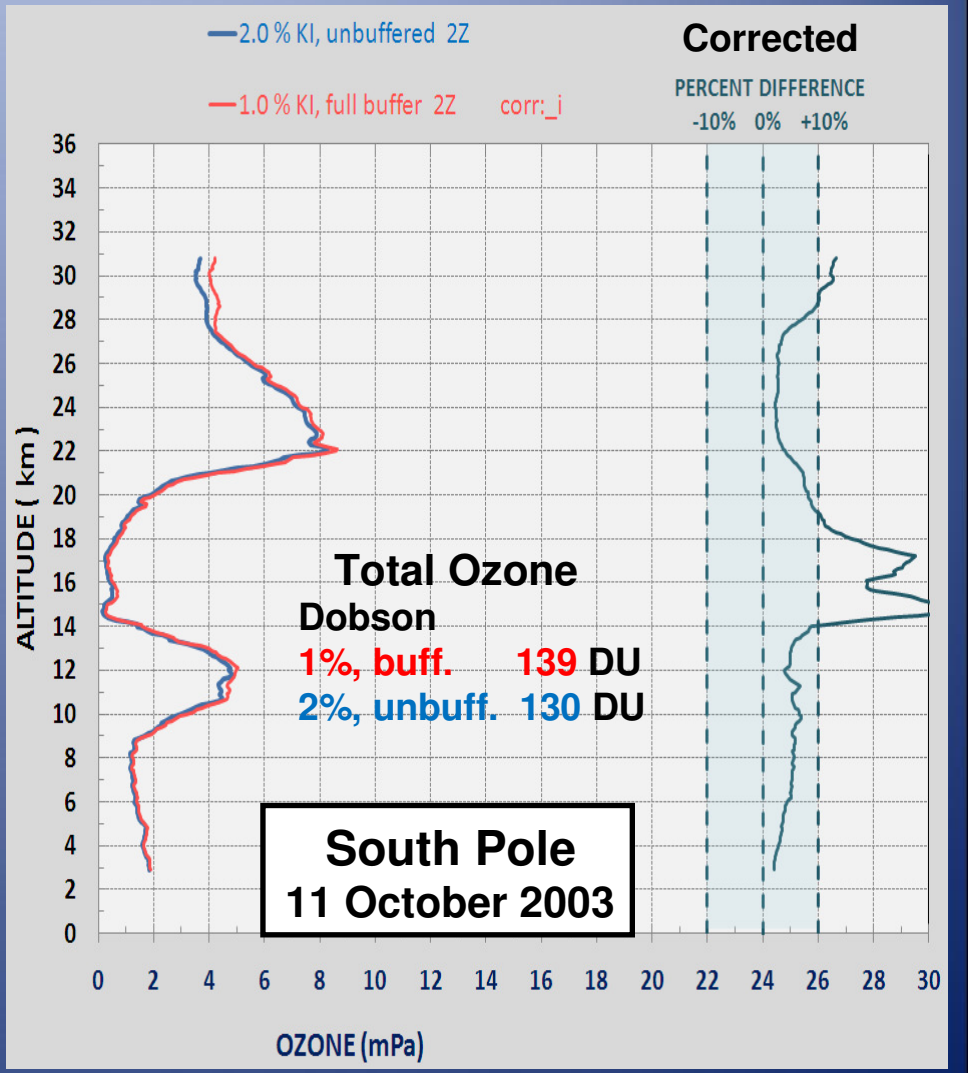



**Conclusion: Correcting for the buffer gives good agreement between the profiles.**

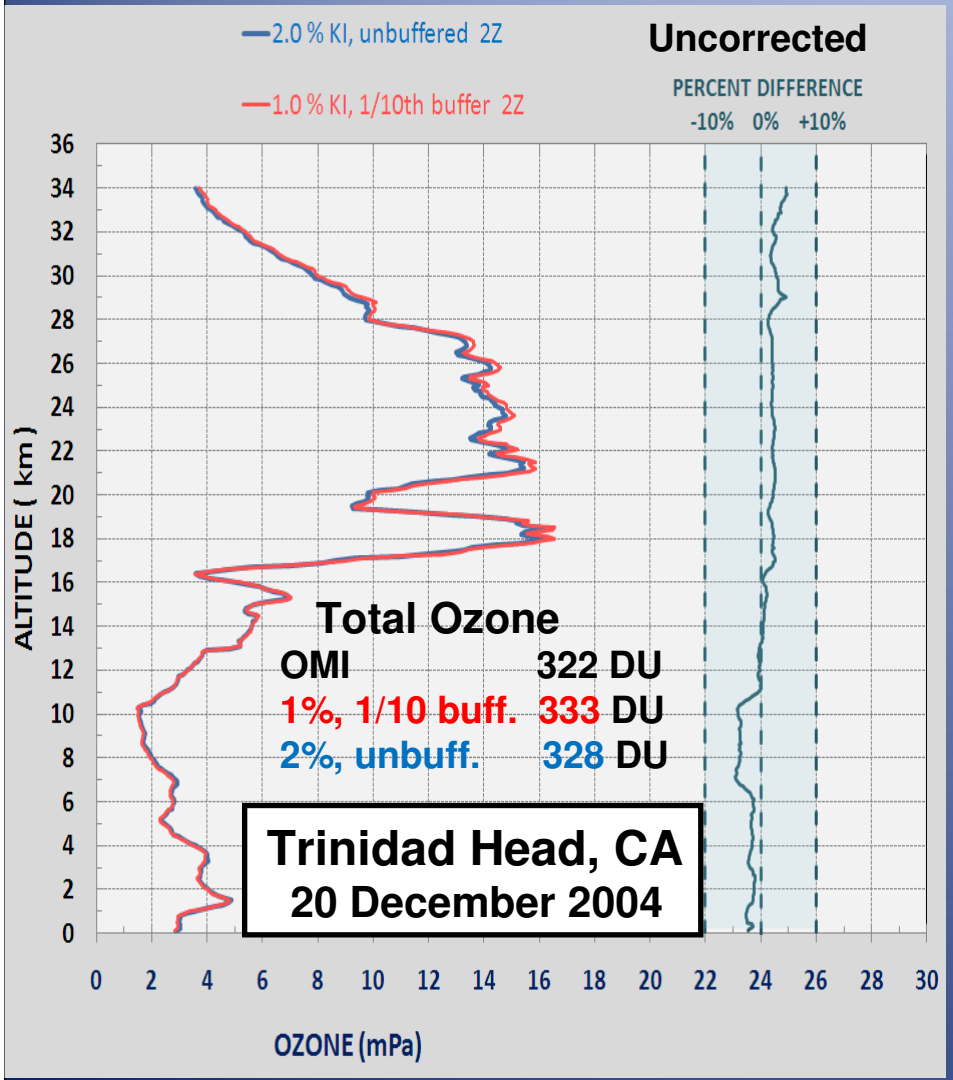
# How can we improve the NOAA ozonesonde record?
# Use of dual soundings

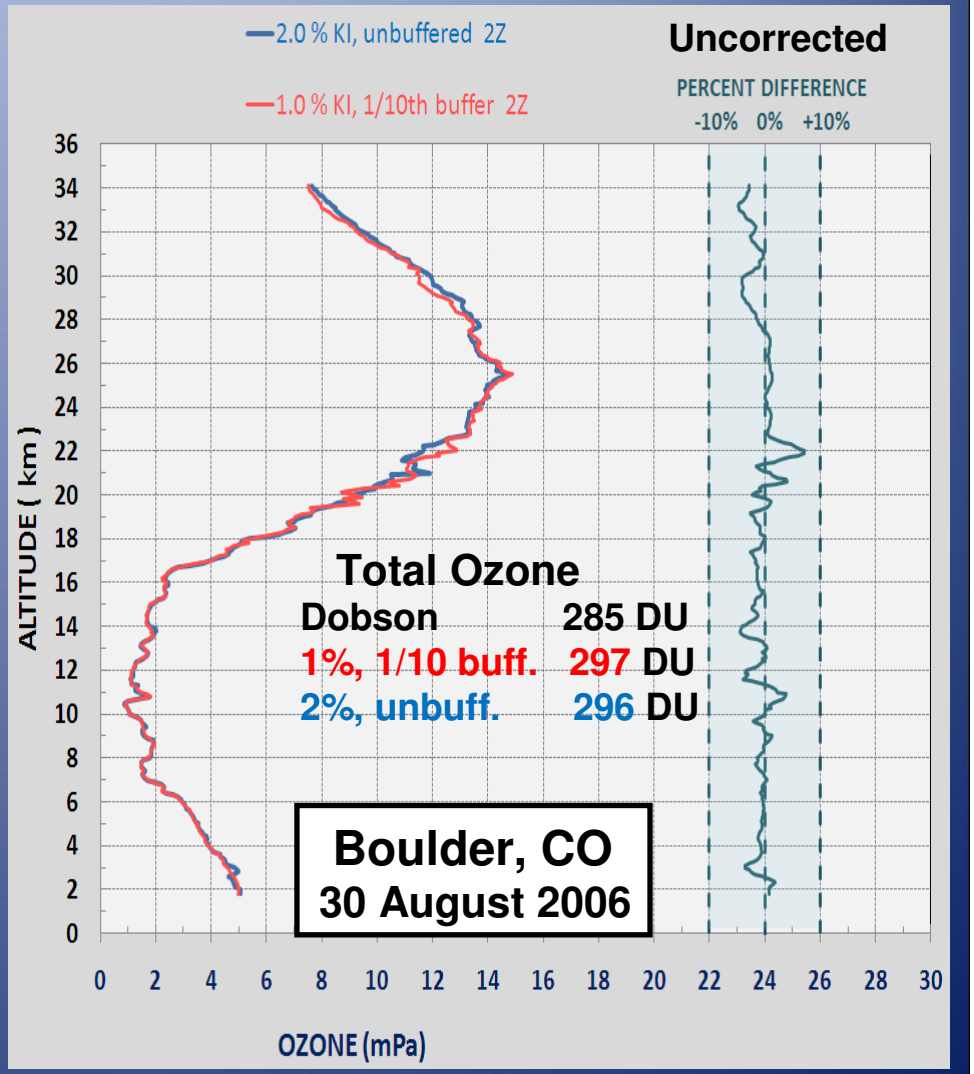



**Conclusion: Correcting for the buffer gives good agreement between the profiles.**

# How can we improve the NOAA ozonesonde record?
# Use of dual soundings



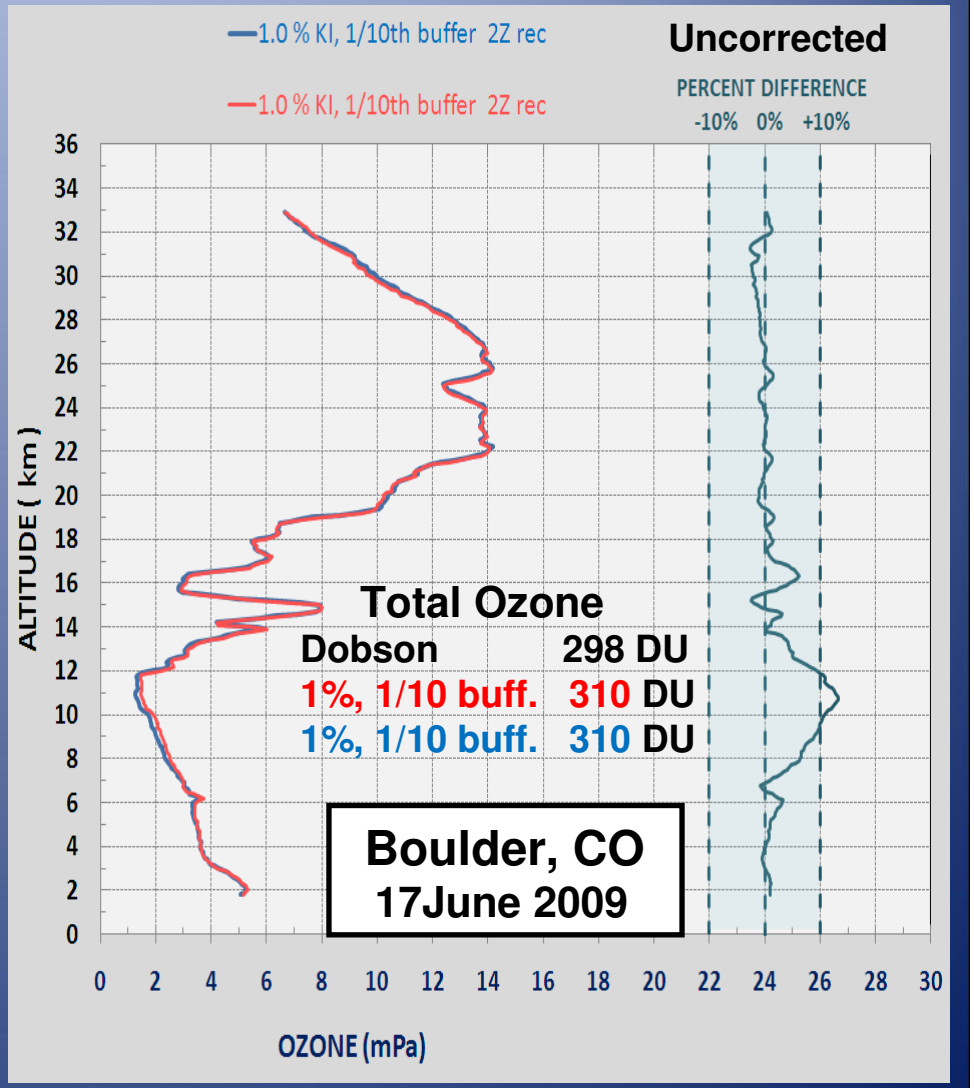




**Conclusion: The weakly buffered (1/10) 1% KI solution performs very similarly to the 2% KI, unbuffered solution.**

# How can we improve the NOAA ozonesonde record? Use of dual soundings

## Summary of Results from Dual Soundings

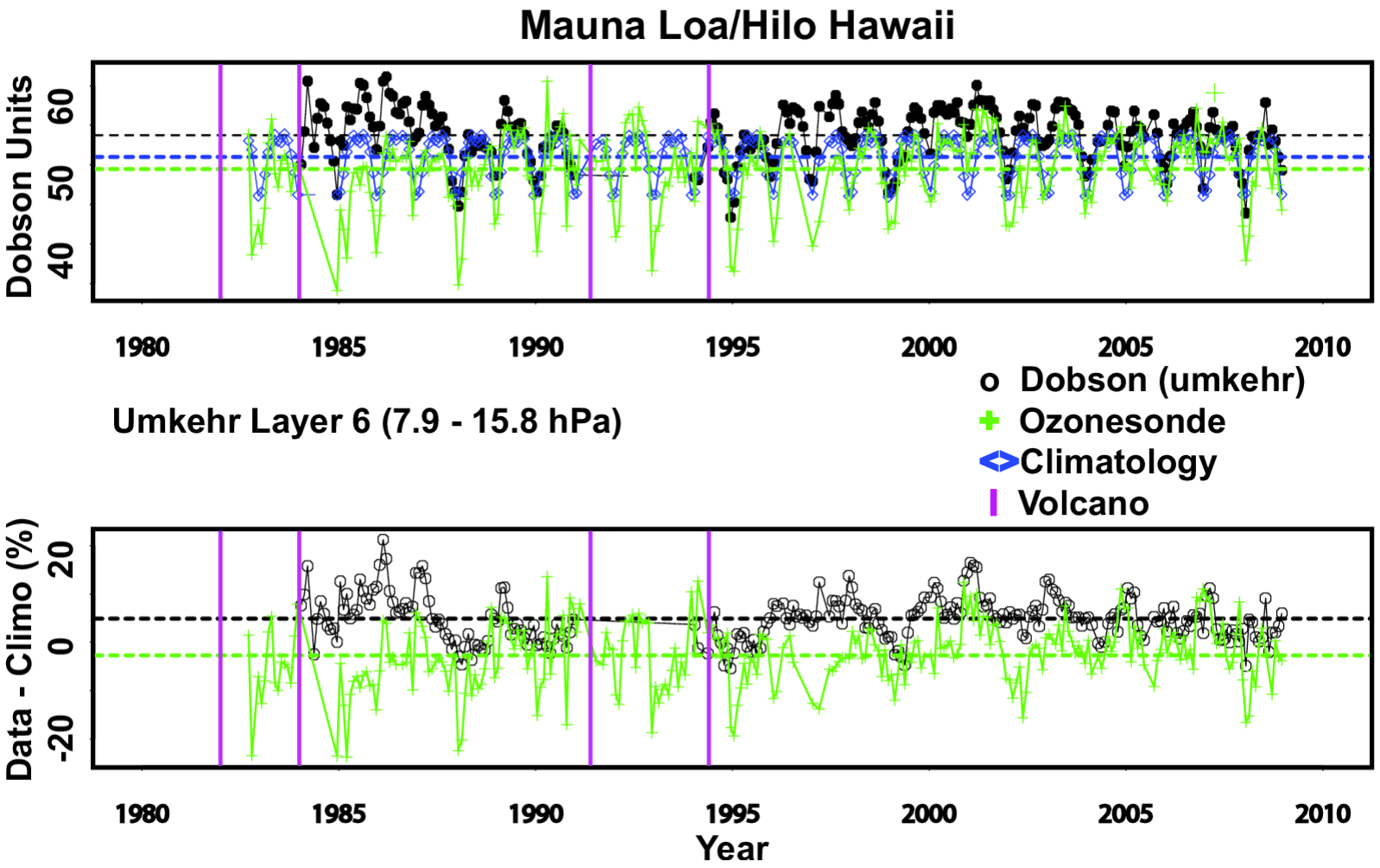
- Confirm results seen in the JOSIE chamber and laboratory experiments.
- Corrections can be developed to bring soundings using different measurement protocols into reasonable agreement.
- Weakly buffered solutions provide the benefit of the buffer without producing ozone exposures biases.
- Soundings using consistent procedures produce a high level of precision and reasonable accuracy.



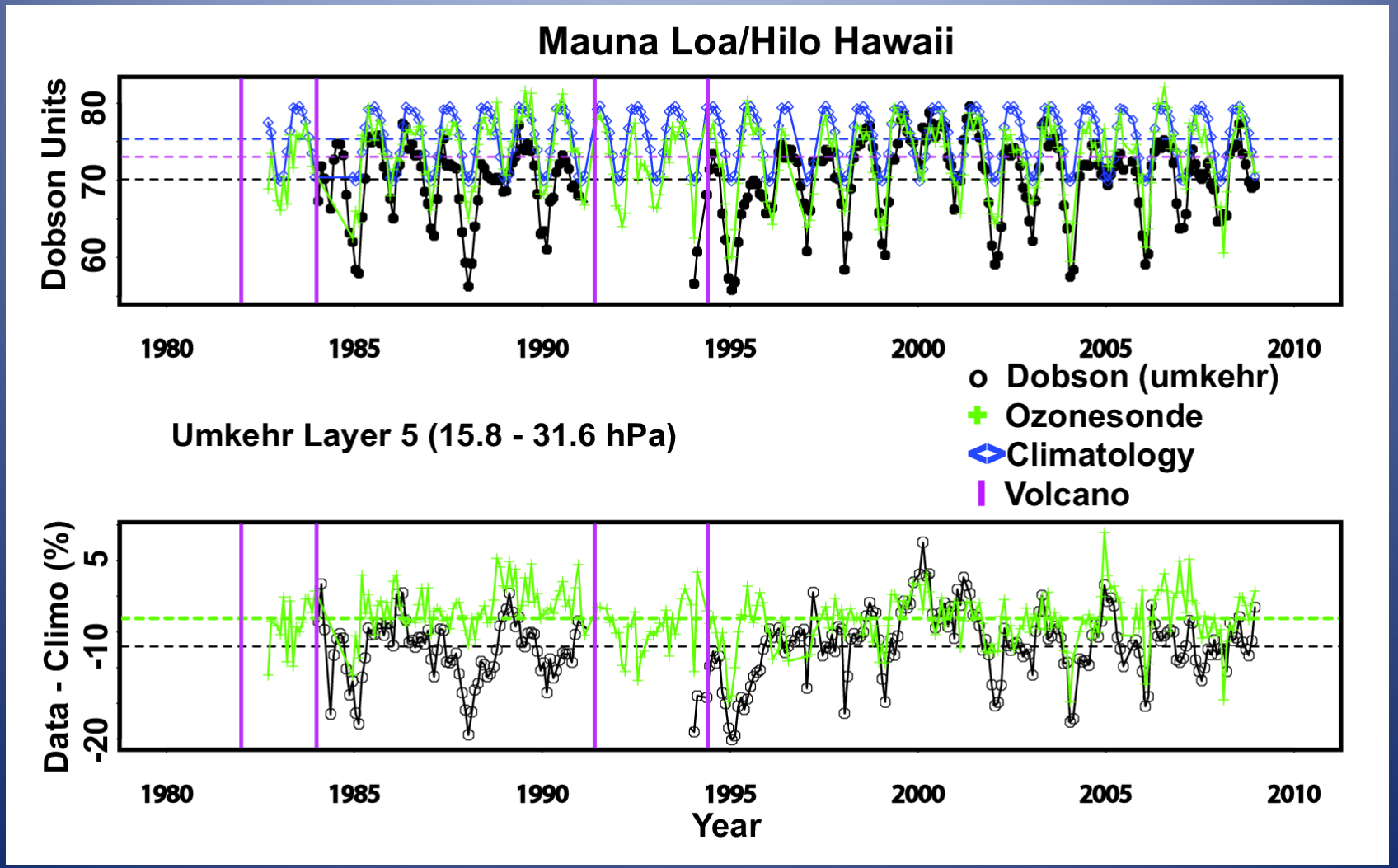
# What does this mean for producing a longer term time series?

- Unlike many measurement systems that are based on a single instrument measuring over a relatively long period, each ozonesonde profile is from a different instrument.
- Consistent procedures are very important in a system like the ozonesondes but it is possible (maybe even likely) to do things consistently incorrectly (e.g. treatment of the background current).
- An independent total column ozone measurement for comparison with the integrated ozonesonde profile is a useful way of checking the stability of the system.

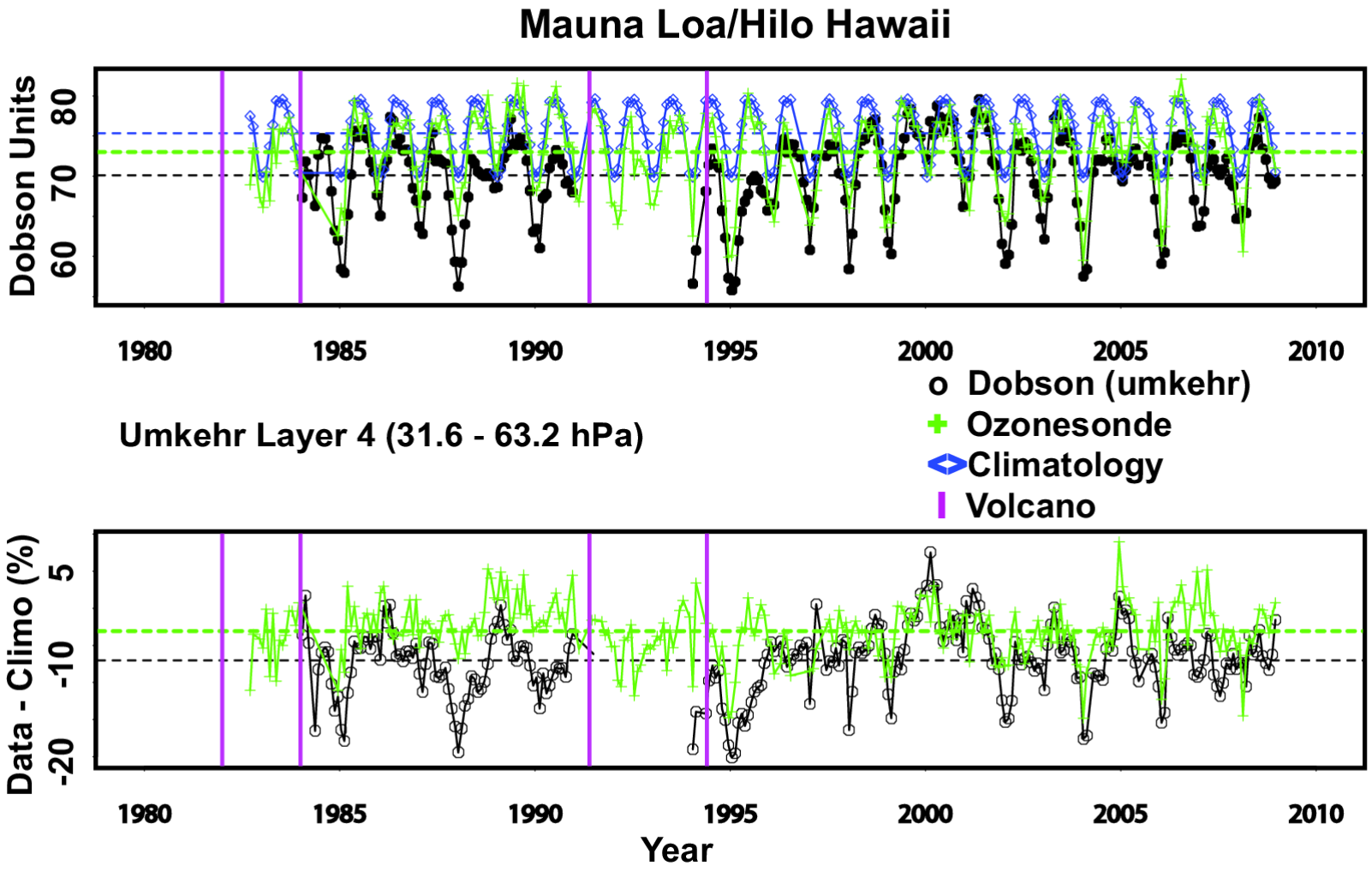
# Comparison of Hilo Corrected Ozonesonde and Mauna Loa Umkehr Time Series (8 – 16 hPa)



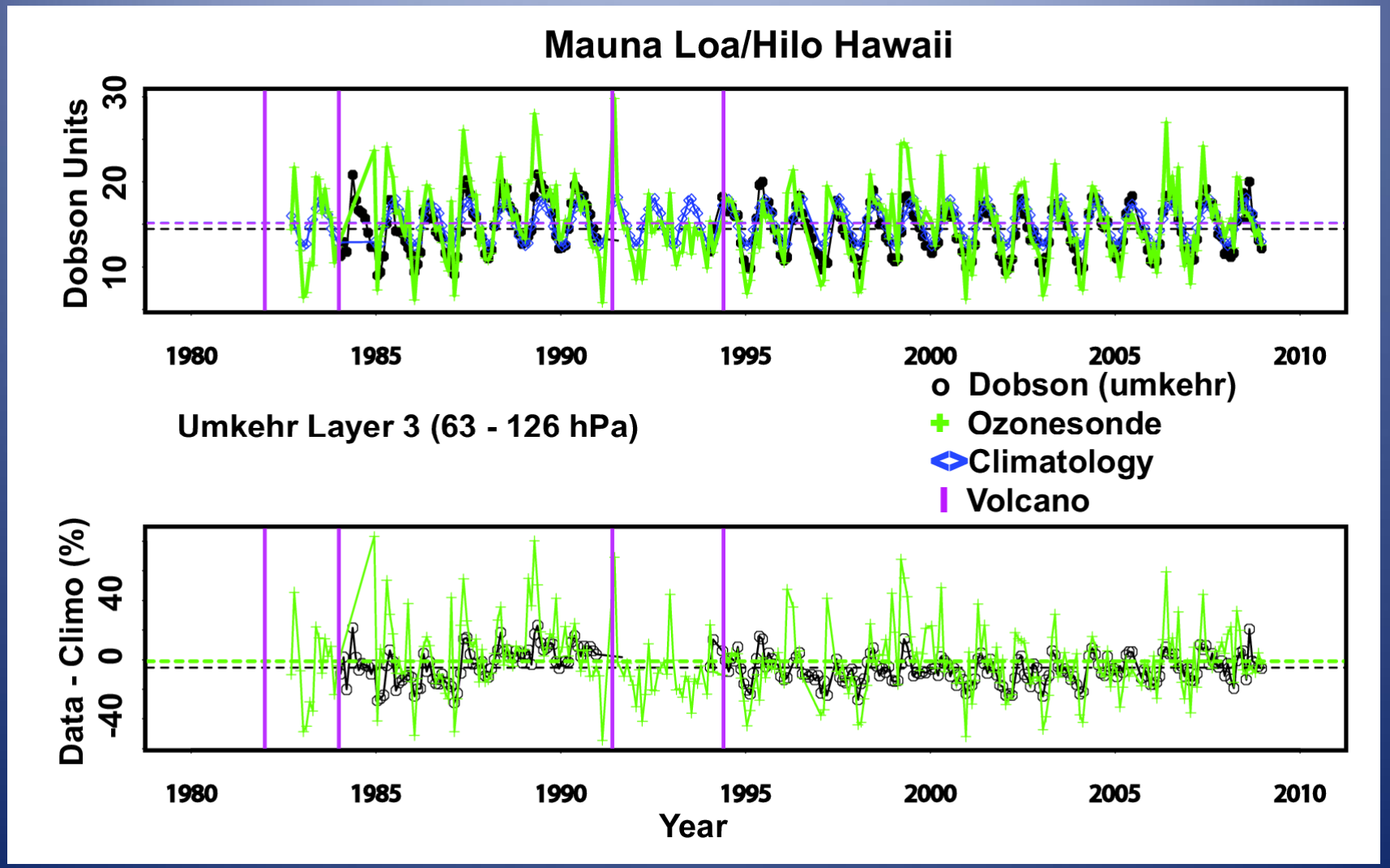
# Comparison of Corrected Ozonesonde and Umkehr Time Series (16 – 32 hPa)



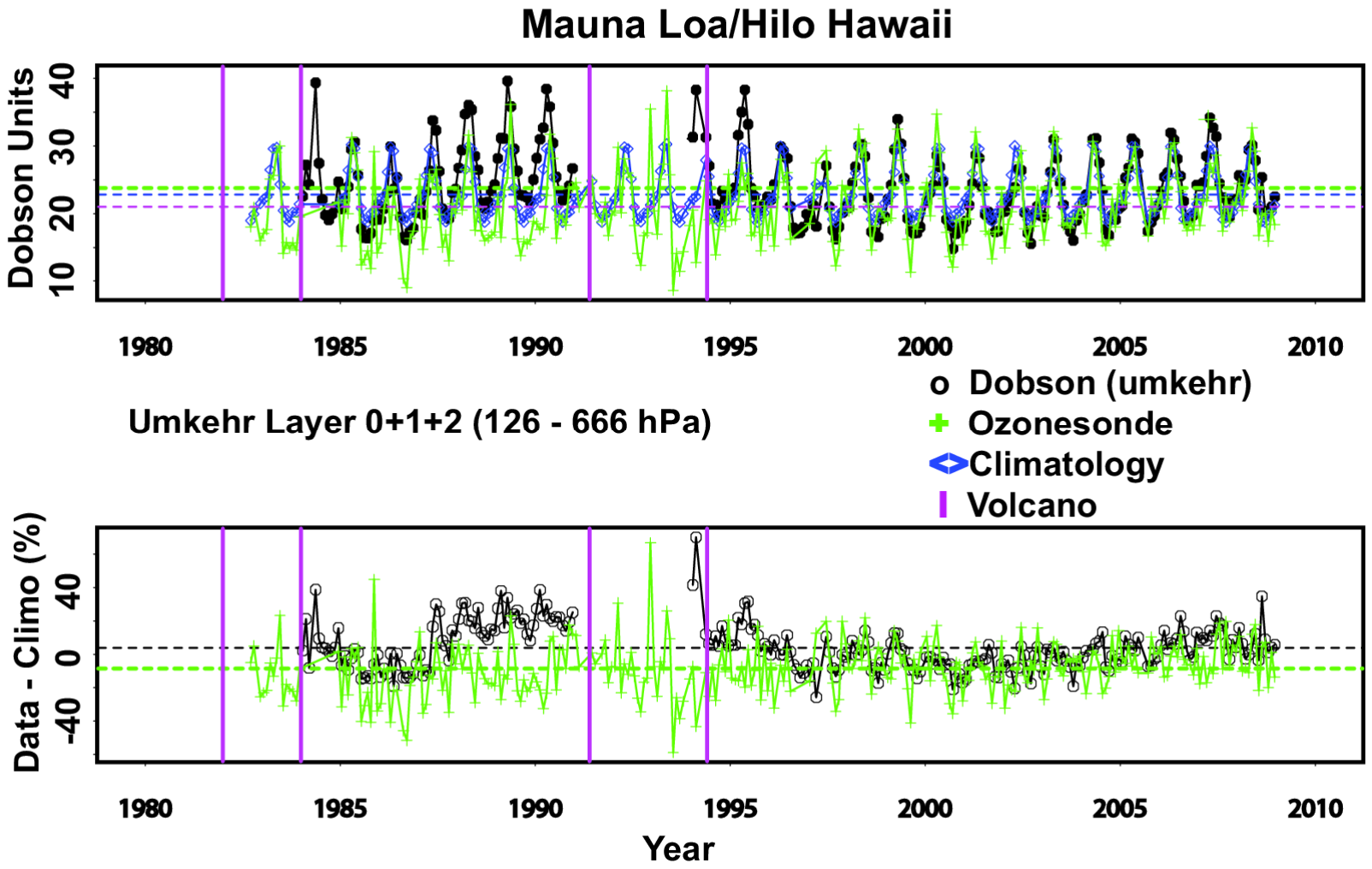
# Comparison of Corrected Ozonesonde and Umkehr Time Series (32 - 63 hPa)



# Comparison of Corrected Ozonesonde and Umkehr Time Series (63 - 125 hPa)



# Comparison of Corrected Ozonesonde and Umkehr Time Series (125 hPa - Surface)




**Conclusion:**

# Longer Term NOAA Sonde Records

**Records of more than 20 years:**

- **Boulder: 1967-1971, 1979 - present**
- **Hilo: 1982 – present**
- **South Pole: 1968-1971, 1986 – present**
- **Samoa: 1986-1990, 1995 – present**

**Records of more than 10 years**

- **Trinidad Head, California**
- **Huntsville, Alabama**
- **Fiji**
- **Galapagos**

# Conclusions

- Varying equipement (Z vs. A sondes), sensing solution recipes, and background treatment have introduced inhomogenities in the NOAA ozonesonde record.
- Use of the results of the JOSIE Chamber experiment, other laboratory tests, and dual soundings provide useful information for developing correction procedures.
- Application of this information seems to produce a more homogeneous time series, but does not remove all suspected discrepancies
- Comparison with other profile time series show broad consistency but more detailed comparison is warranted.

# SHADOZ Contributions to Vertical Trend Studies



## SHADOZ in its 14th Year!

- > 5000 profile sets at <http://croc.gsfc.nasa.gov/shadoz>
- GCOS Affiiliate (2007), NDACC "Cooperative Network" (2009)
- SHADOZ DVD ! Website Images & Data

## Recent Examples of Trends & UT/LS Ozone

## SHADOZ Activities to Enhance Value

- Added Hilo, Hanoi Sites since 2008
- Maintain coverage – current efforts to restore Irene, Ascension, San Cristobal
- V5 re-processing in 2011 to list background current, pump flow (see Vömel & Diaz, 2010)
- Continual participation in WMO/JOSIE type activities.

** Review: Thompson, Oltmans, Tarasick, Smit, von der Gathen, Witte: *Atmos. Environ.,* D-10-0009, in press.


Operational, 2008-2010

PENNSTATE 1855

NASA

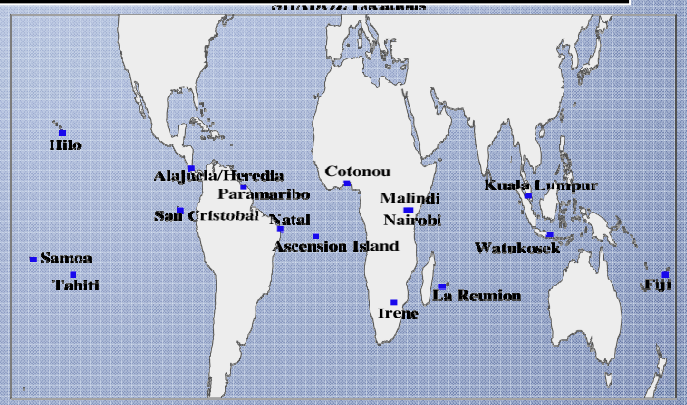
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

# WHO is SHADOZ: Co-I's in <http://croc.gsfc.nasa.gov/shadoz>

Thompson et al, *JGR*, 108, 8238, doi: 10.1029/2001JD000967, 2003

## Right: SHADOZ Sites, 1998-2010

| Participants | Affiliation | Country |
|---|---|---|
| **Anne M Thompson – PI ator** | NASA/GSFC, Penn State | USA |
| **Jacquie Witte - Archiver** | SSAI, NASA-GSFC | USA |
| Rene Stuebi, G Levrat | MeteoSwiss | Switz. |
| K K Chow (partners – H Tsuruta/S Yonemura, JP) | Malaysian Met. Service | Malaysia |
| Gert J R Coetzee, K Motolo | So. African Wea Service | S. Africa |
| Masatomo Fujiwara | Hokkaido University | Japan |
| Rinus Scheele | KNMI | Nether. |
| | Kenyan Meteor. Dept. | Kenya |
| N P Leme | Brazil Space Agency | Brazil |
| Gi Laneve (thru 2006) | Rome University | Italy |
| | Vietnam Met Service | Vietnam |
| S J Oltmans, B Johnson | NOAA/GMD | USA |
| Françoise Posny | La Réunion University | France |
| Frank J Schmidlin | NASA/WFF | USA |
| Masato Shiotani, T Ogina | Kyoto University | Japan |
| N Komala, S Sasripriya | Indonesian Space Agency (LAPAN) | Indo-nesia |
| Valérie Thouret (2006-2007) | CNRS | France |

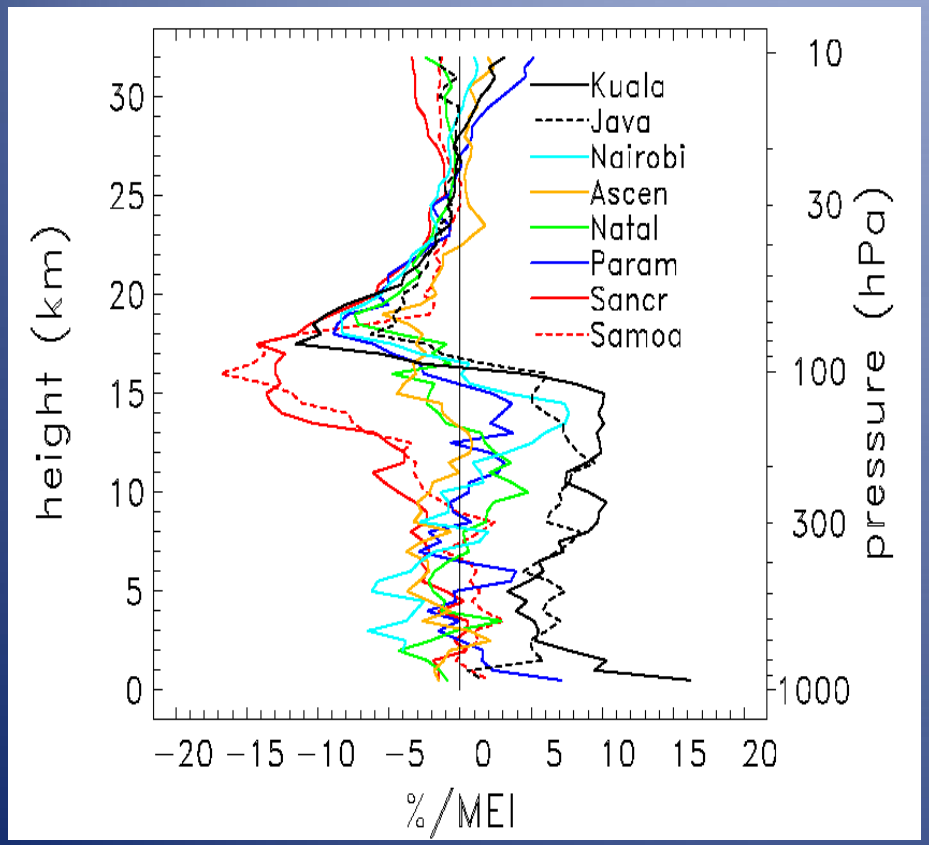


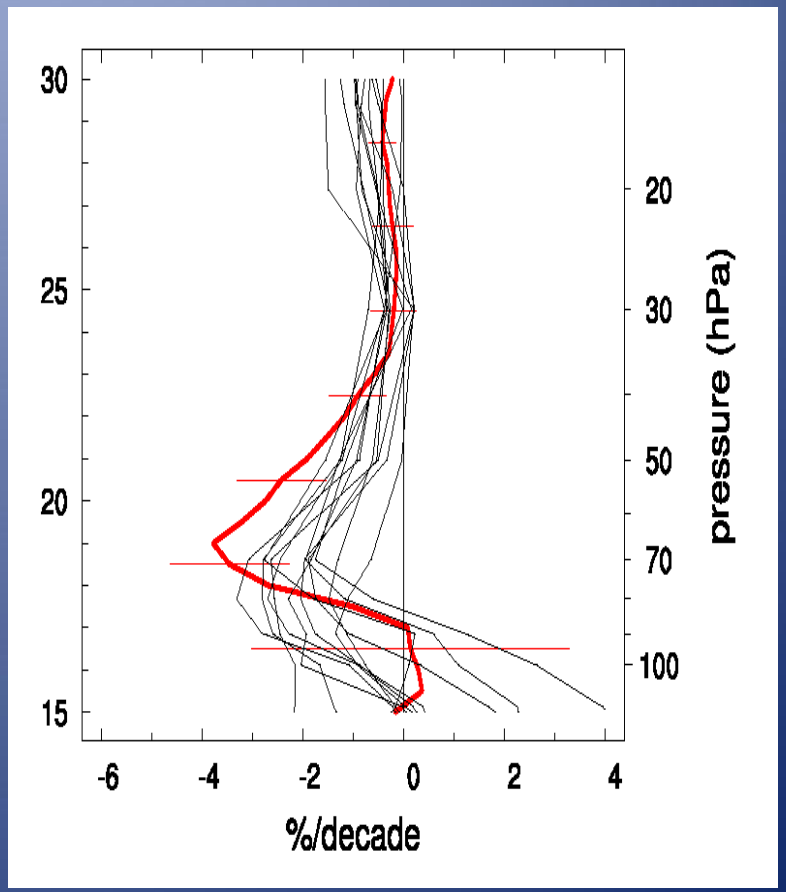

**2009-11 Milestones, Activities**

* Added Hilo Data Archive from NOAA/GMD
* Hanoi joined (M Shiotani, Kyoto U)
* WMO Data Managers Toronto meeting recommends more Level 0 data. SHADOZ to add Background Current info
* **Remedying data gaps:**

Fiji (NOAA-GMD, B Johnson)
Ascension (NASA, F Schmidlin)
Irene (So Afr Weather, G Coetzee)

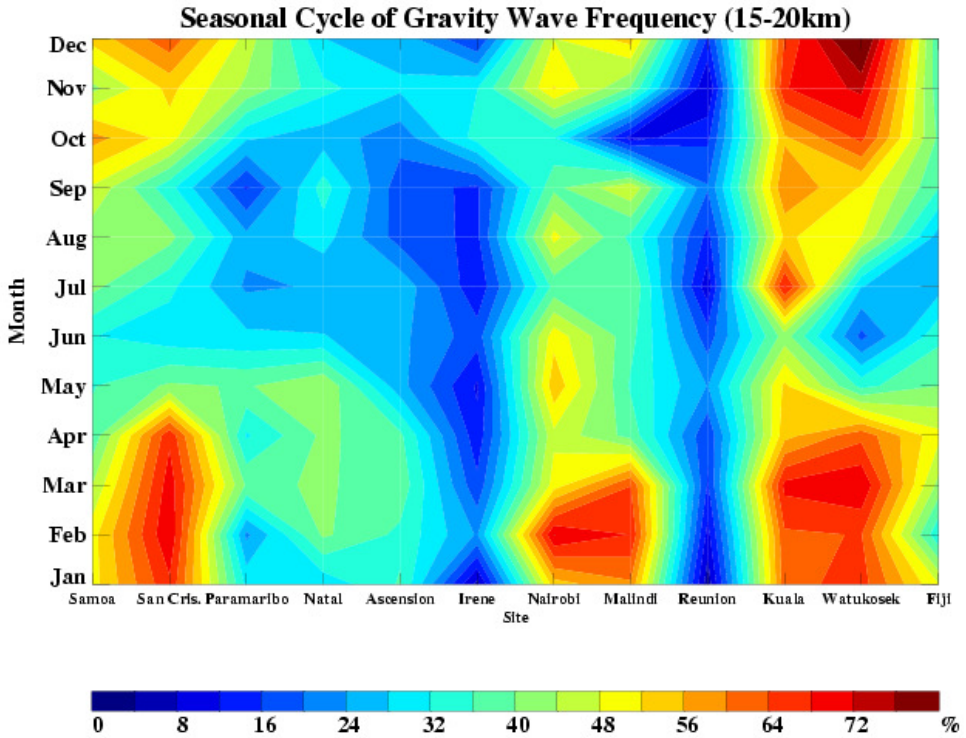
# Example of ENSO Effect on Ozone Variability at SHADOZ Sites (Left), Trends & Series of Models from CCMVAL2 Activity (Right)

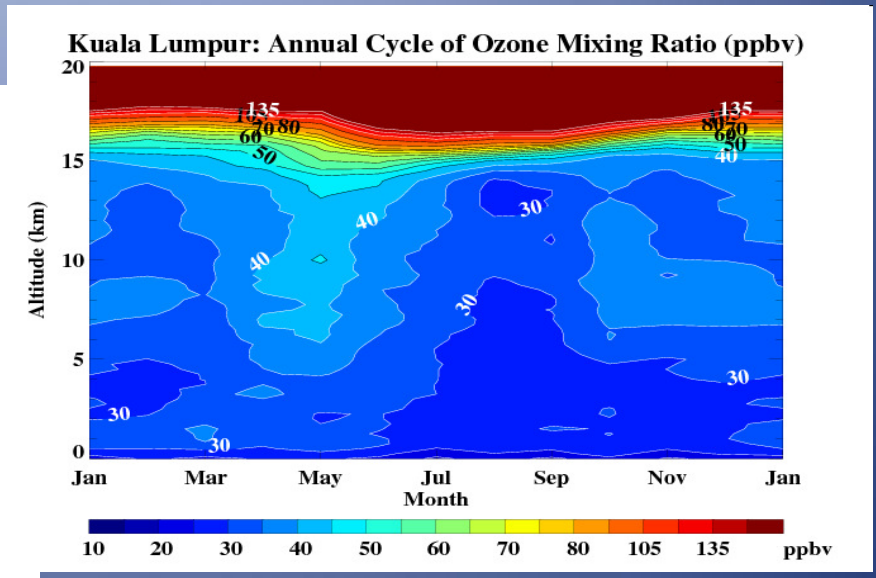


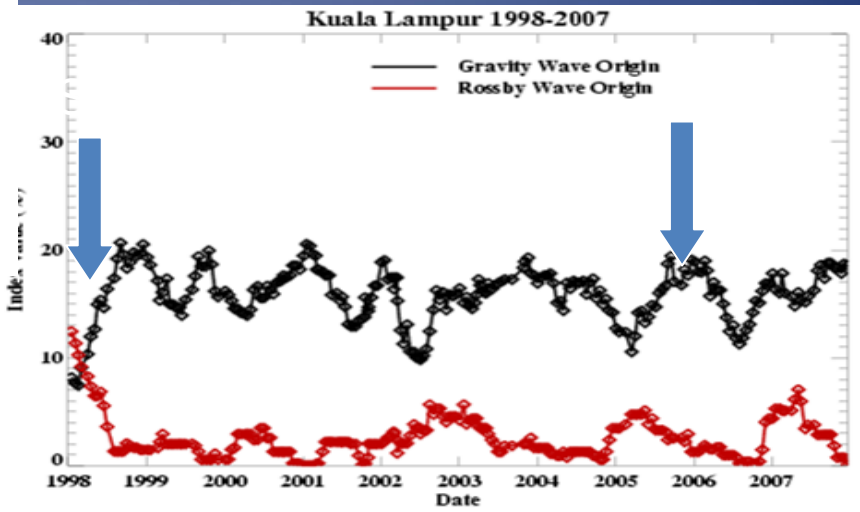




From Randel & Thompson, *JGR*, in press

# Gravity Wave (GW) frequency, mean %, 15-20 km (Left), from Laminar Method, maximum at convective season, site, eg Kuala Lumpur. GW Index shows ENSO Link (Right)



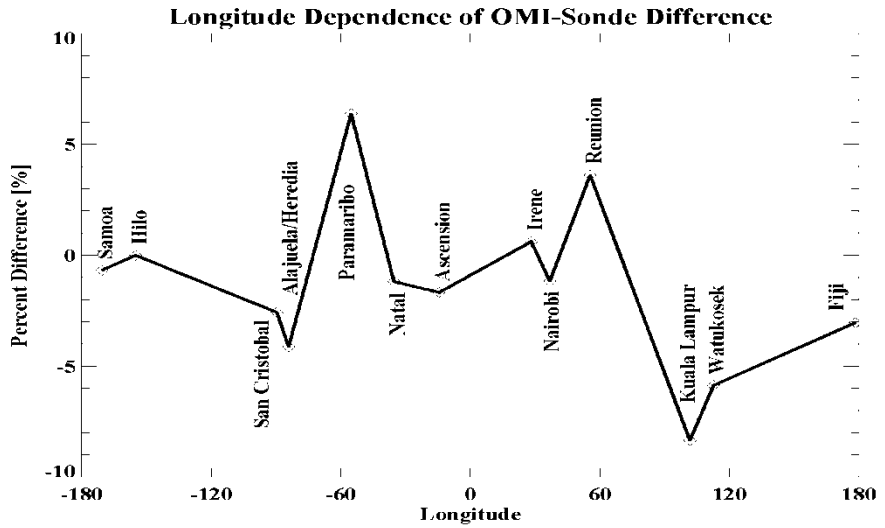



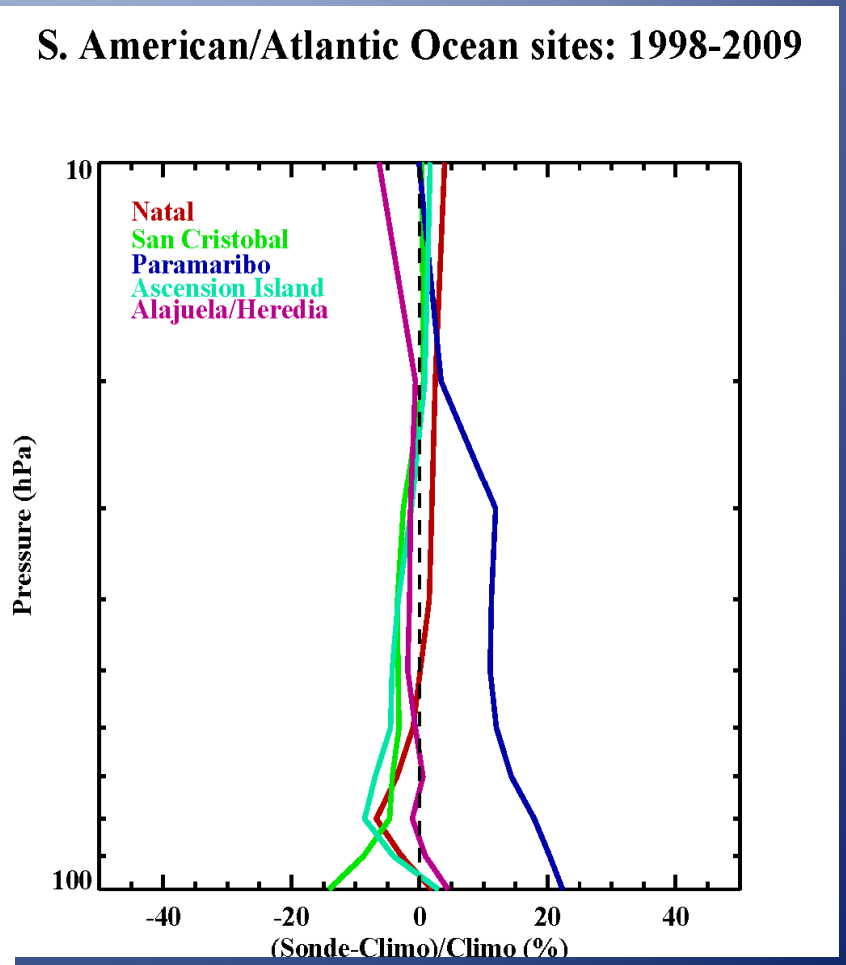




Thompson et al., JGR, in press

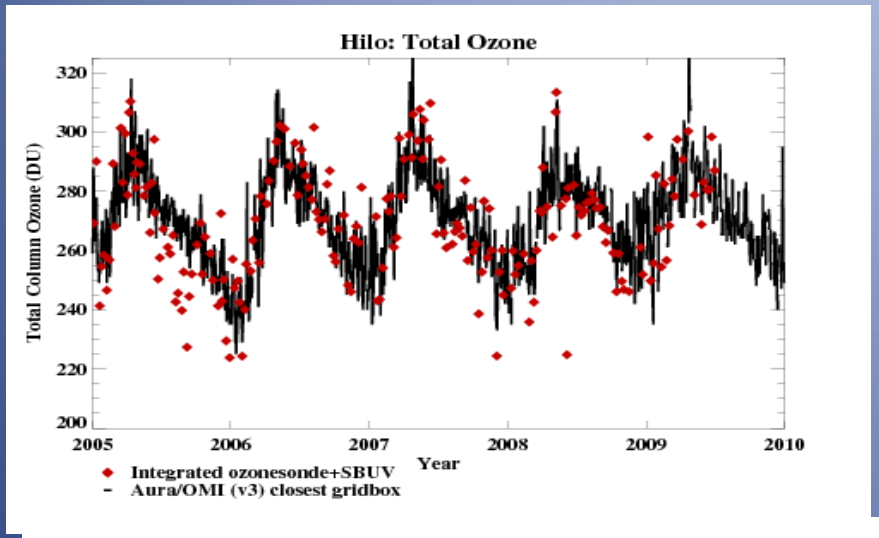
# Example of On-going Evaluations

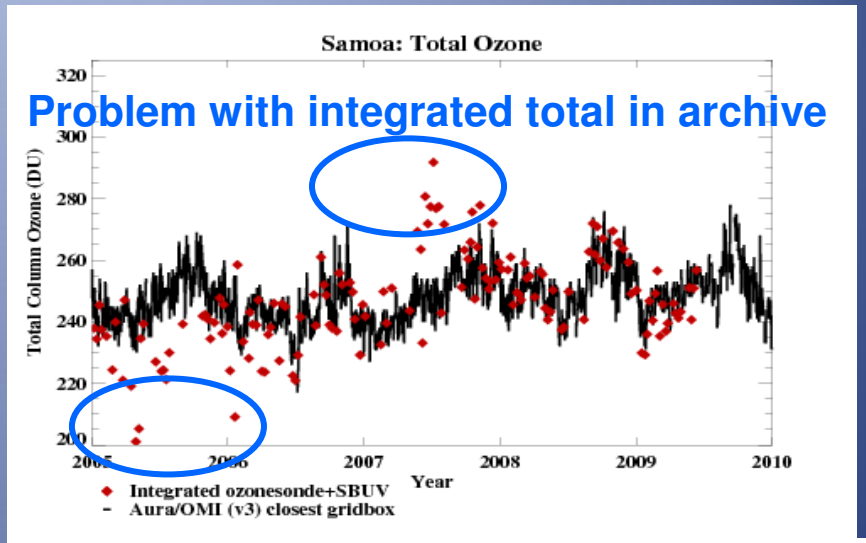
- SHADOZ-OMI (TOMS version, thru 2009) shows improved agreement relative to SHADOZ-TOMS (1998-2004) discrepancy in total ozone (Left)
- Offsets of mean profiles for individual SHADOZ stations suggest high bias over Paramaribo (Right)

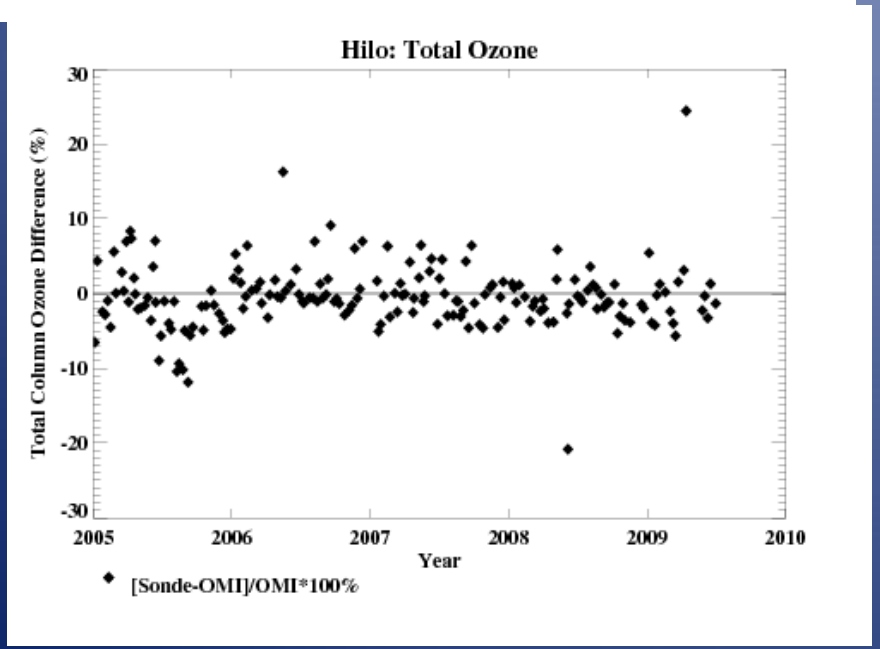


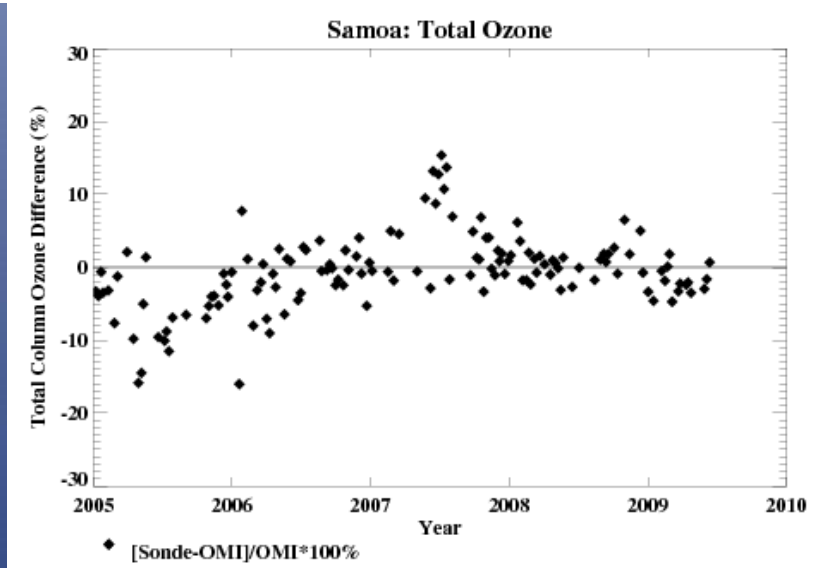



# New OMI (TOMS v8 Algorithm) – SHADOZ Total Ozone Comparisons, 2005-2009

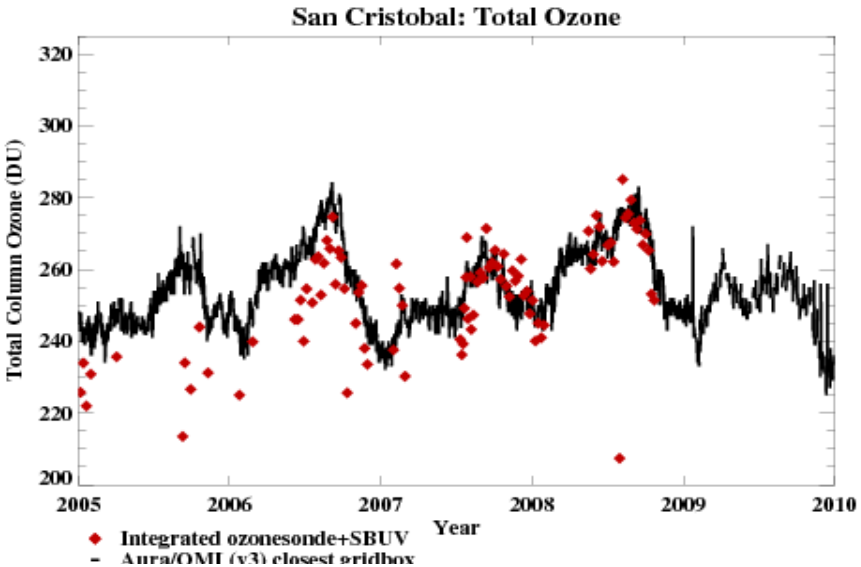


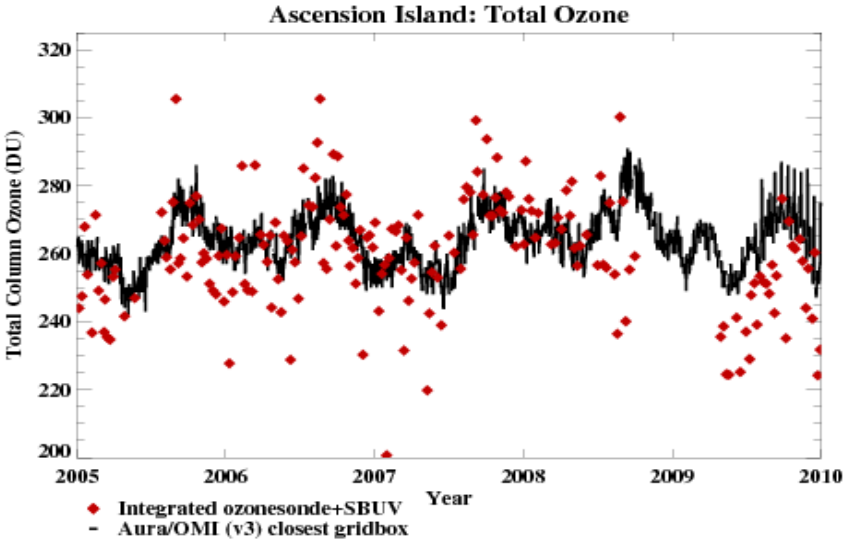



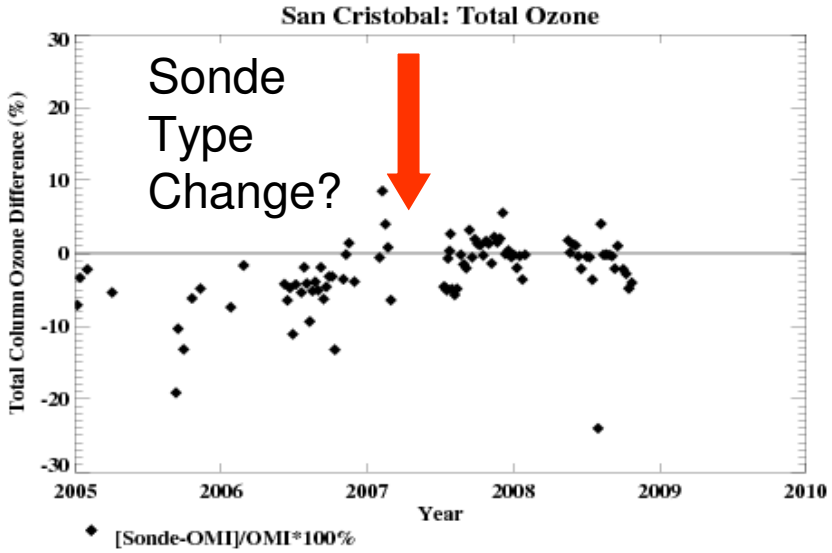



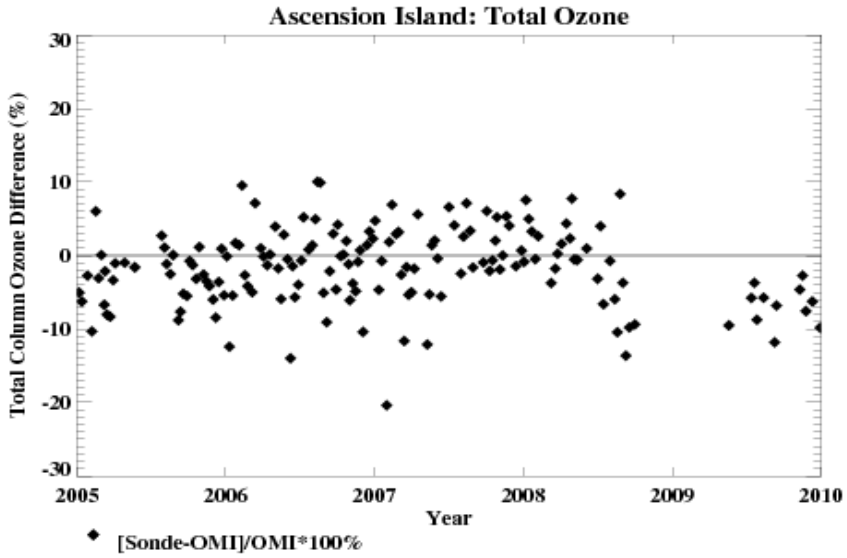



# OMI (TOMS v8 Algo.) – SHADOZ Comparisons, 2005-2009



# Acknowledgments, References



- Aura Validation & SHADOZ (M J Kurylo, K W Jucks, NASA); NDACC (M Kurylo, G Braathen); WMO (L Barrie, G Braathen) & JOSIE (H G J Smit)
- SHADOZ Co-Is & National Sponsors
- SHADOZ DVD – Oct 2010!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  - A M Thompson et al., Southern Hemisphere Additional Ozonesondes (SHADOZ) 1998-2009 tropical ozone climatology. 4., in prep, 2011