GLOBE Surface Ozone Instrumentation: Evaluation, Improvements and Recommendations

17th GLOBE Annual Partner Meeting
Presentation to Science Advisory Committee
August 11, 2013

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NASA Langley GLOBE Atmosphere Training Center of Excellence

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Surface Ozone Scientist (since 2002)
Master Trainer

Lin Chambers
Contrails Protocol, PI (since 2002)
Master Trainer

Jessica Taylor
Master Trainer
Atmosphere Protocols
(since 2000)

NASA student interns
Tomer Cohen – LARSS 2004
Ashley Mertens – USRP 2006 & LARSS 2007
Cory Scott – LARSS 2007 & 2008
Alec Weisman – USRP 2012 & 2013
Charles (Stephen) Haggard – LARSS 2013

Surface Ozone Team testing of Zikua/Test Card System

Test cards

- colorimetric method; tin(II) diphenylcarbazide
- refined recipe for linearity of response
  and increased sensitivity at low ozone concentrations
- extensive laboratory and ambient air testing for T and RH dependence
- designed prototype inlet box for constant flow rates across test cards
- test card response with aging
- tested each batch of test cards before sending to schools through 2005

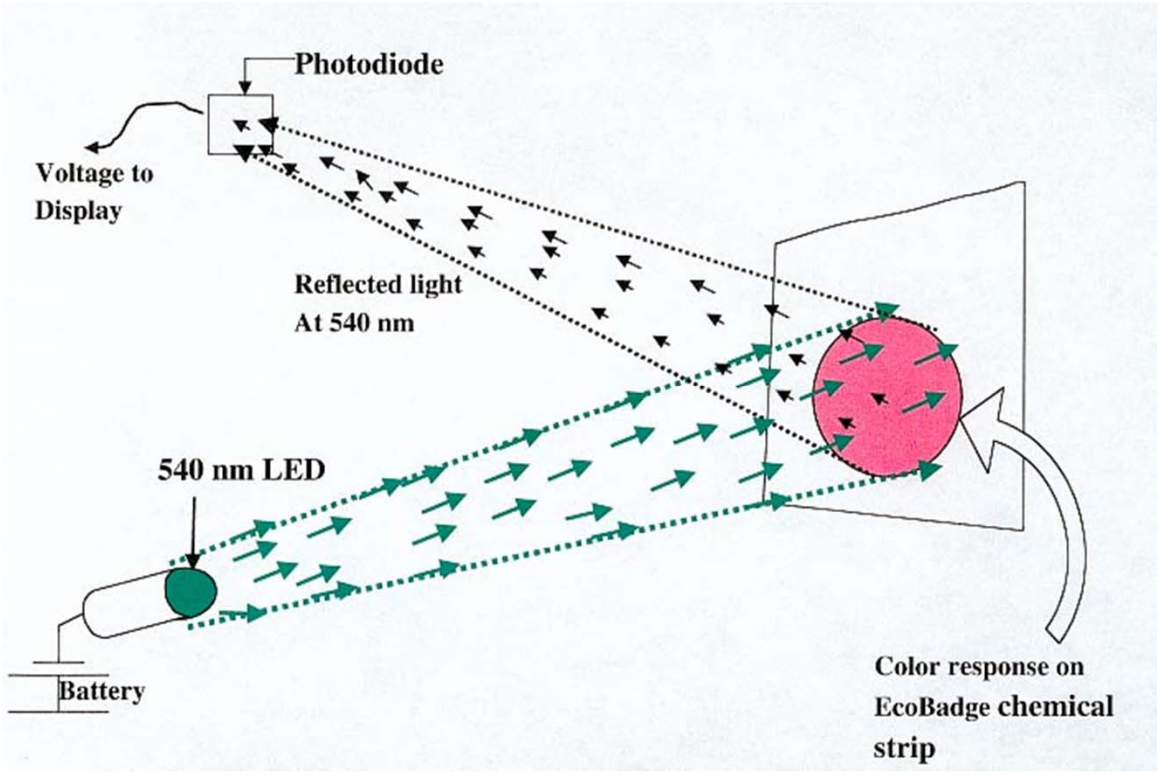
- observed manufacturing to correct procedure and for quality control issues

solution should be clear before applying to test cards

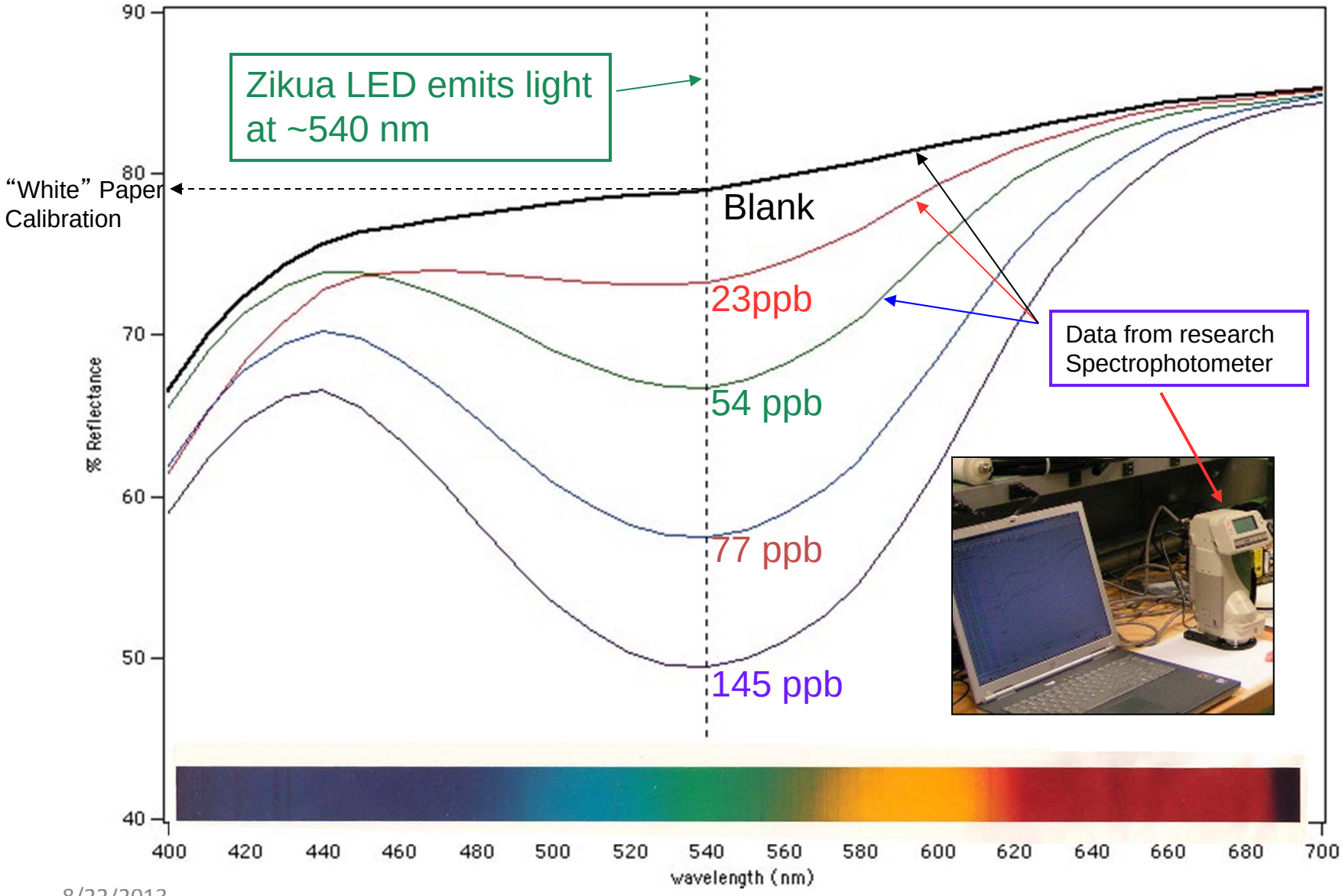
'Pink' solution was the cause of 'bulls-eye' effect on test cards

Operation of Zikua™ Optical Scanner

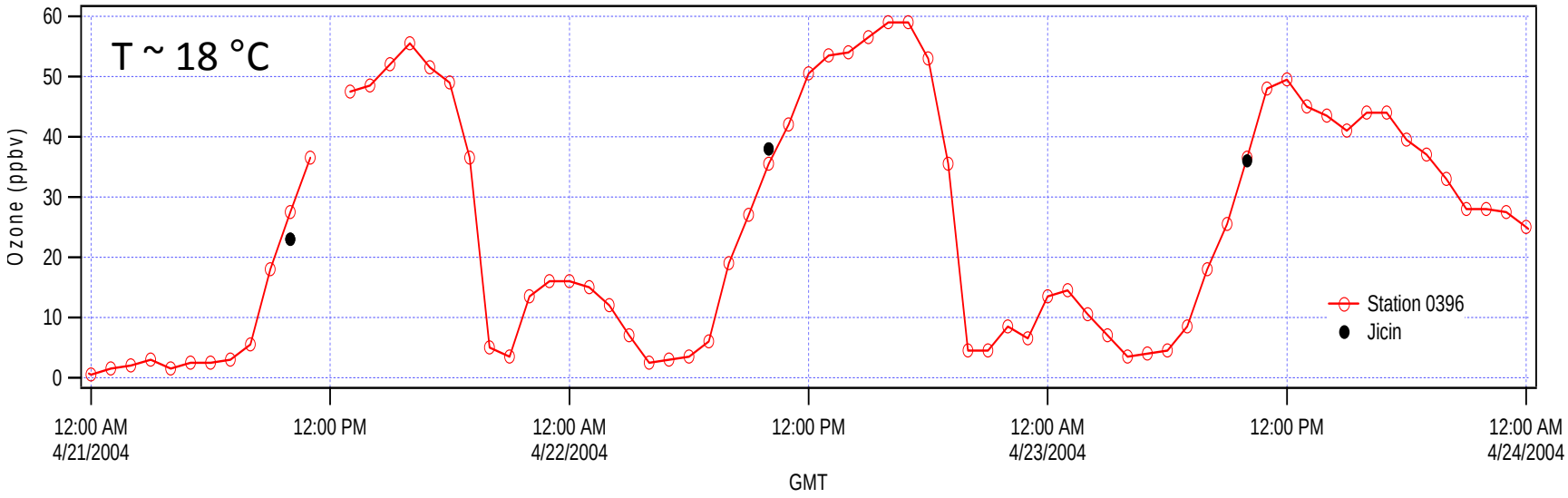
Exposed test card placed in slot of scanner

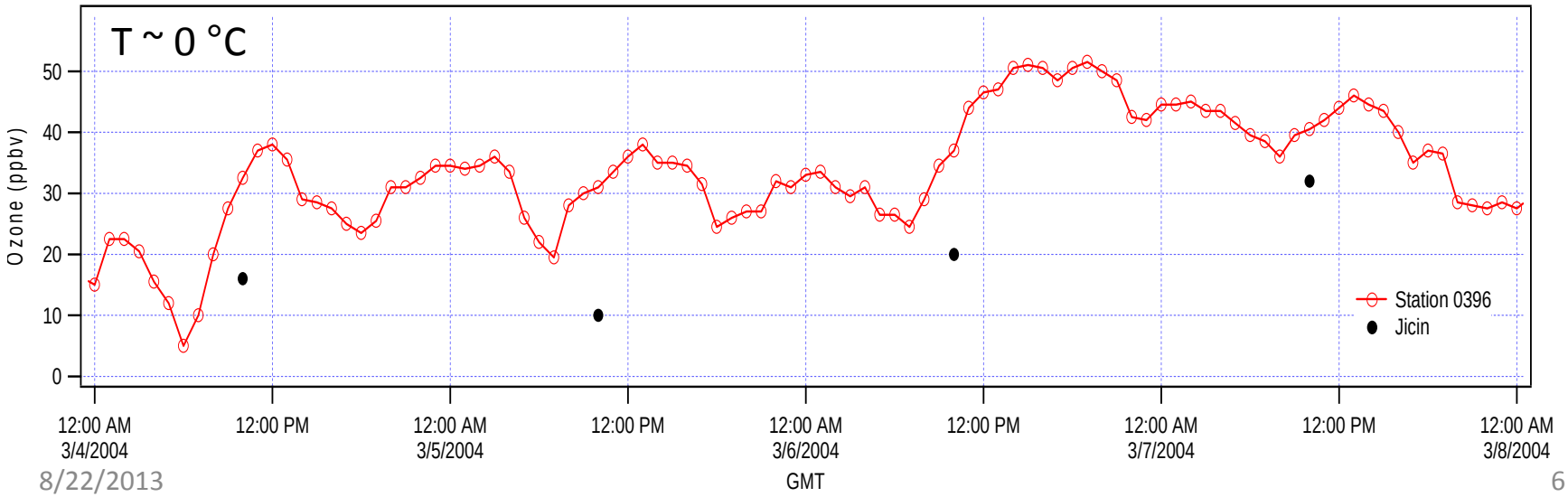


Spectral Reflectance as a Function of Ozone Concentration



GLOBE Ozone Data at Jicín, CZ
Shows Evidence of Temperature Dependence



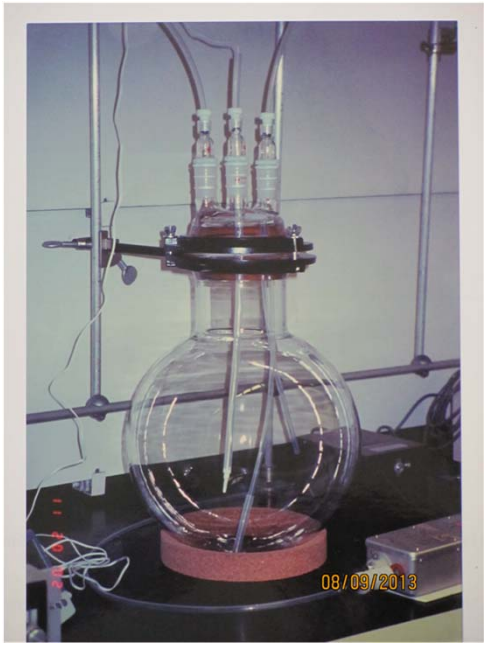


Calibration Tests Conducted at University of North Carolina Outdoor Smog Chamber Facility in July 2002

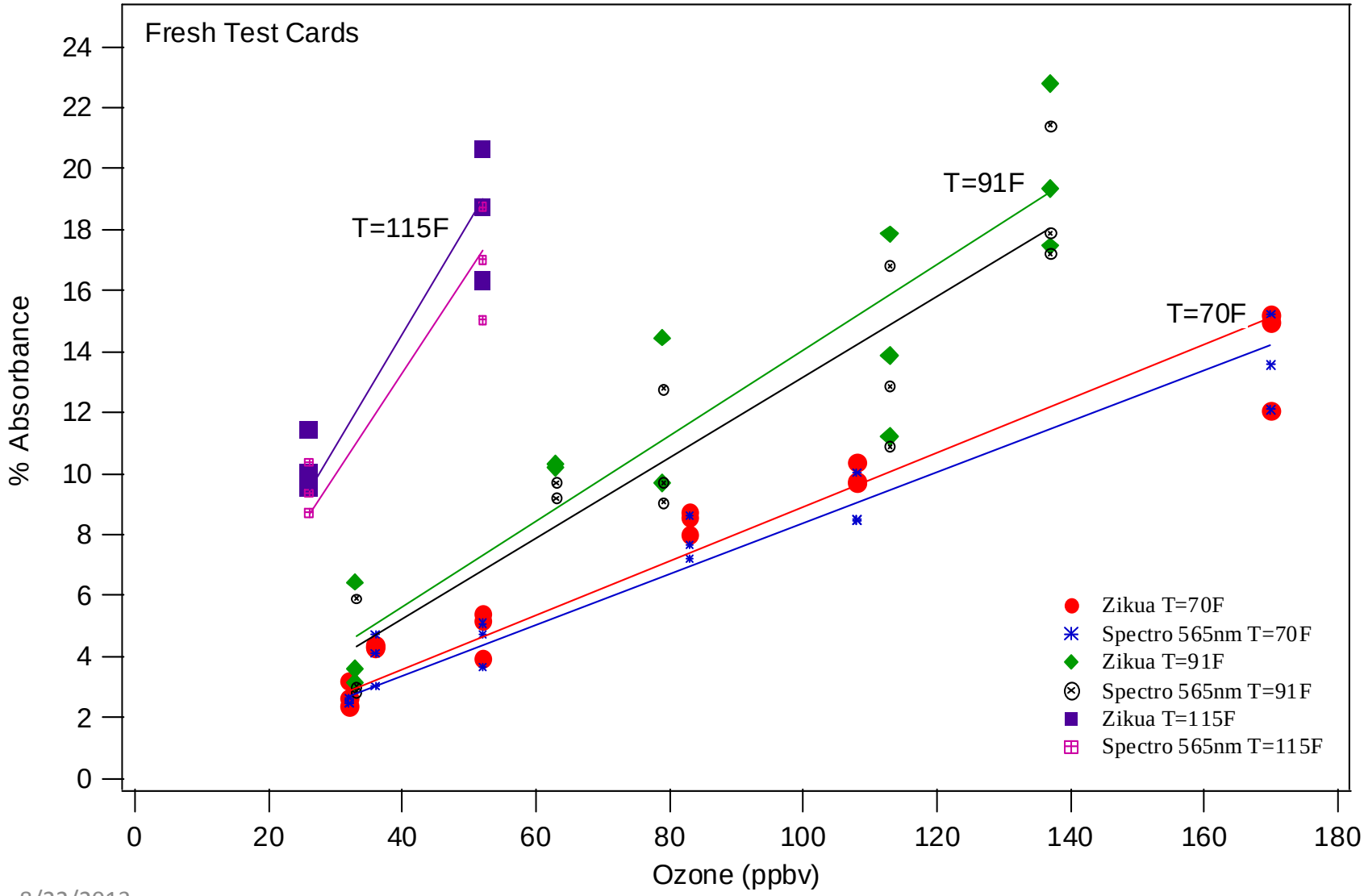
Facility originally built in 1973 by Harvey Jeffries and reconstructed in 1994 by Ken Sexton is 300 m^3.

Chamber Studies to Determine Dependence of T and RH

Margaret Pippin and Linda Bush Set Up Chamber Testing Capability at NASA Langley in May 2004



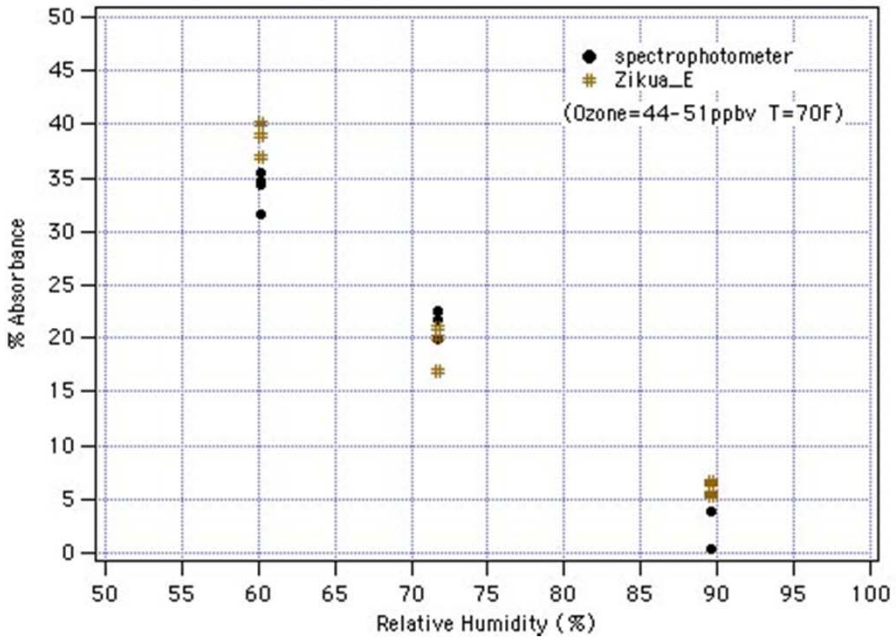
Temperature Dependence of Calibration Curves



Studies Suggest Dependence on Humidity

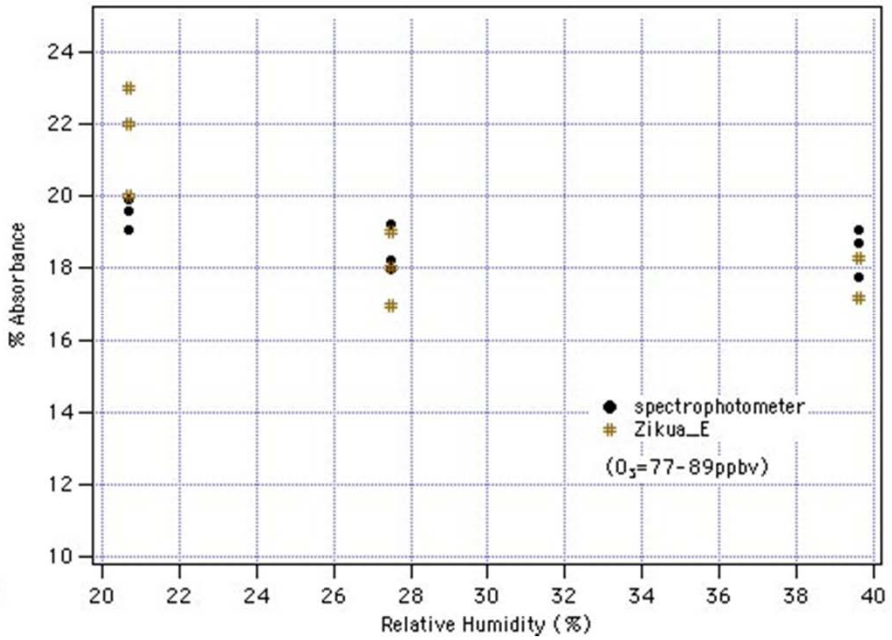
Measurements in Outdoor Chamber

(44-51 ppb)



Measurements in Laboratory Jar

(77-89 ppb)



Ambient Air Testing for T and RH Dependence - 2006

Goals:

1) Determine calibration equation for GLOBE surface ozone instrument
2) Provide a correction factor for school ozone data on GLOBE website

Method:

Use ambient O_3, T, RH, and %ABS to derive statistical relationship

$$\%ABS = f(O_3, T, RH)$$

Summer 2006

>700 measurements collected

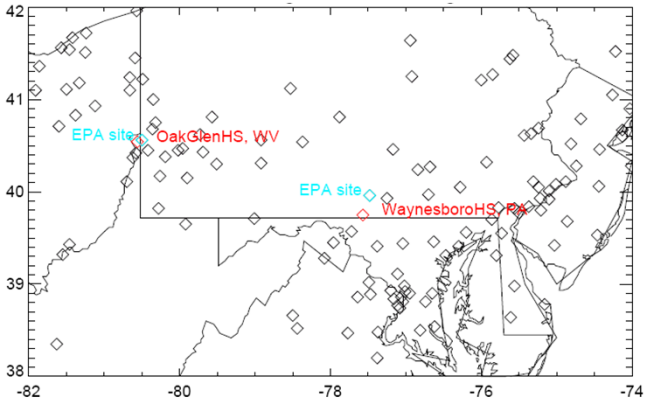
Results: Correcting GLOBE school ozone data

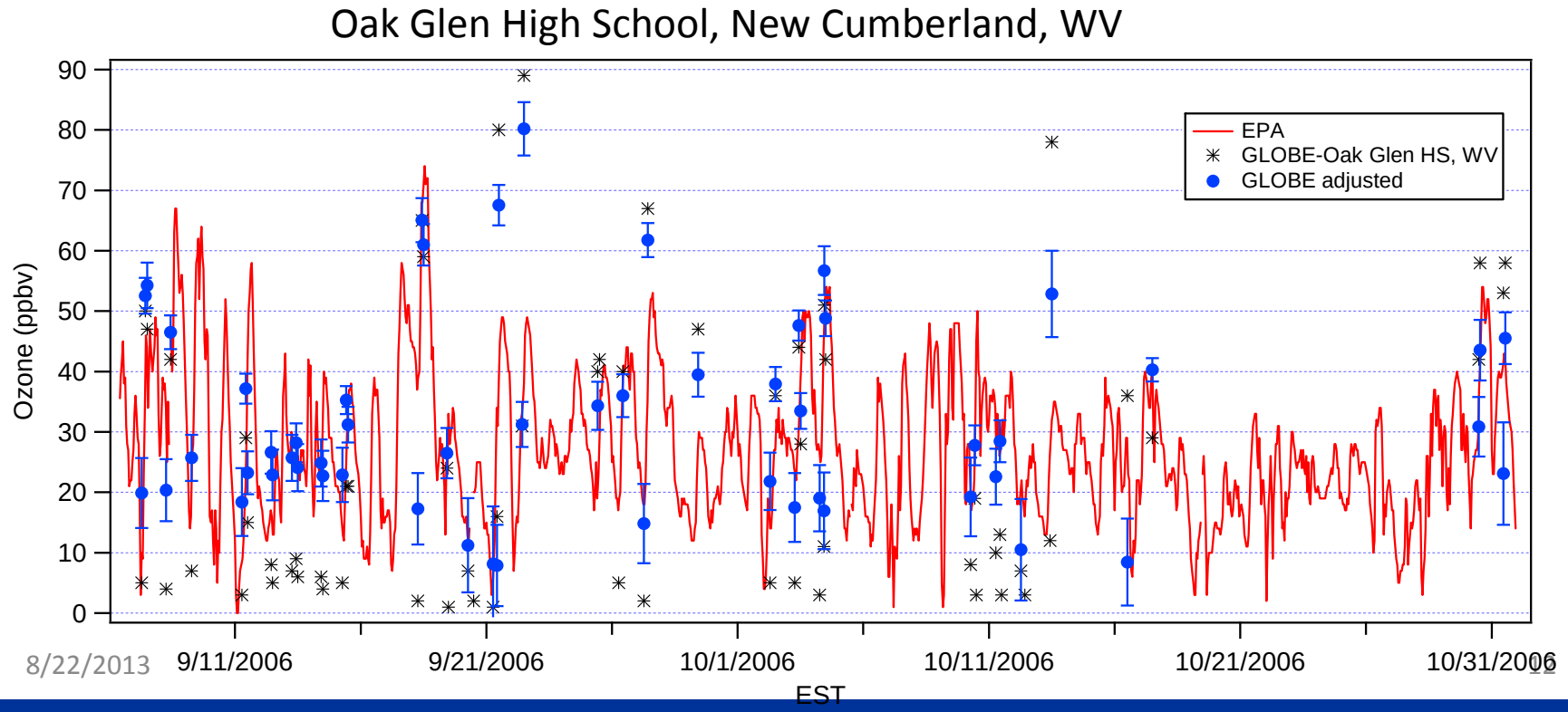
Regression equation

$$ABS = \beta_0 + \beta_1(Oz-\mu_{Oz}) + \beta_2(T-\mu_T) + \beta_3(Rh-\mu_{Rh}) + \beta_{13}(Oz-\mu_{Oz})(Rh-\mu_{Rh})$$

Data reduction equation

$$Oz = \mu_{Oz} + (ABS-\beta_1-\beta_2(T-\mu_T)-\beta_3(Rh-\mu_{Rh}))/(\beta_1+\beta_{13}(Rh-\mu_{Rh})$$



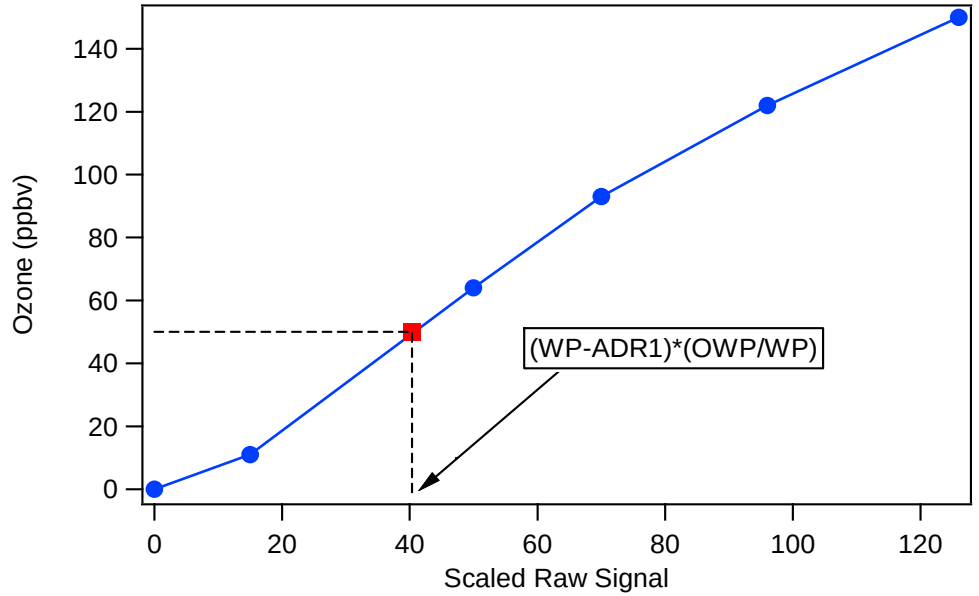


Surface Ozone Team testing of Zikua/test card system

Zikua

- calibration curve coded in chip has math errors
- corrected poor calibration coding and made recommendations to Vistanomics however recommendations were never implemented
- determined how to 'back-out' absorbances from zikua readings and then correct using derived statistical equation
- made changes to chip so they are programmable with our own calibration equation

Vistanomics Calibration Table for Zikua with default 135



Issues and Recommendations

Zikua/test card system

- when QC'ed, test cards can produce reliable long term trends
- however surface ozone team is no longer testing cards
- Vistanomics has changed test card manufacturer multiple times

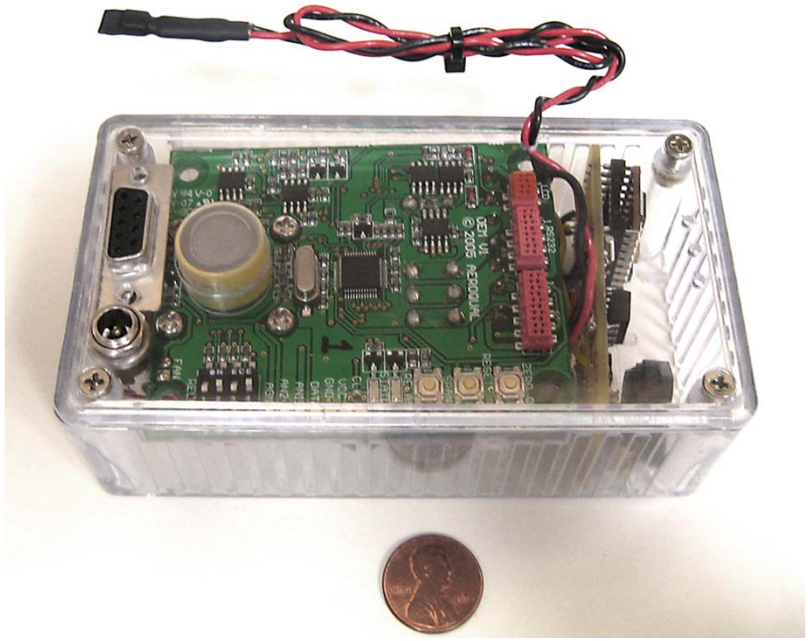
- test cards can be made in a high school chemistry class
- use correction factor for zikua readings

- Vistanomics has not been willing to make improvements
- recommend phasing in new instrument with updated technology

Evaluation of Protoype Ozone Sensor - 2008

Miniature Ozone Sensor (MOS)
Tungsten oxide semiconductor sensor
Operates continuously with a data logger
Instantaneous measurements at specified intervals, (1 min, 5 min, etc.)

On loan from PAX Analytics, Inc



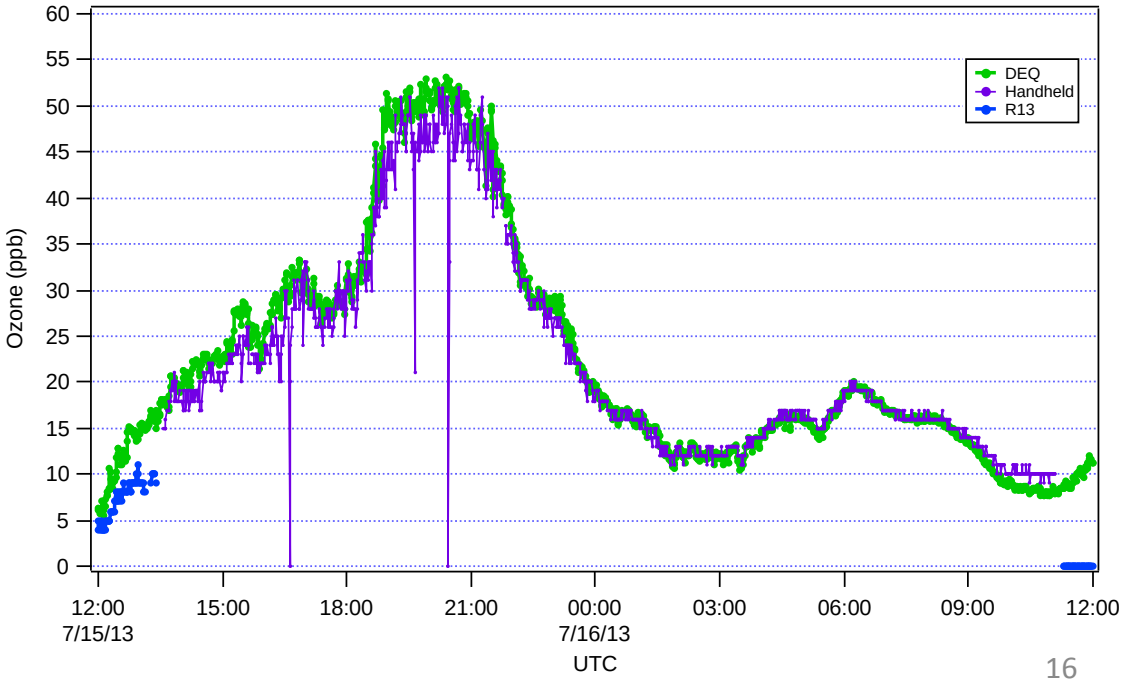
Developed at Smith College under an NSF grant
- Joyce Cheung (student)
- Paul Voss
- Thomas Hartley
- David Greenberg

Potential Ozone Sensor for GLOBE - Aeroqual ozone sensor

Aeroqual ozone sensor

- Tungsten oxide semiconductor sensor
- Operates continuously with a data logger
- Instantaneous measurements at specified intervals, (1 min, 5 min, etc.)
- cost ~$800 - $1200

Inter-comparison studies summer 2013



Aeroqual compares well with VA DEQ air monitoring data at CAPABLE site

http://www.ozonesolutions.com

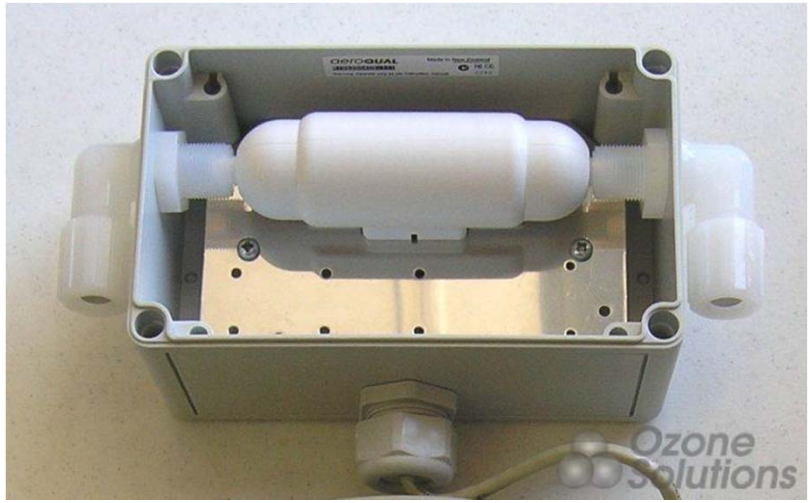
Instrument testing in progress

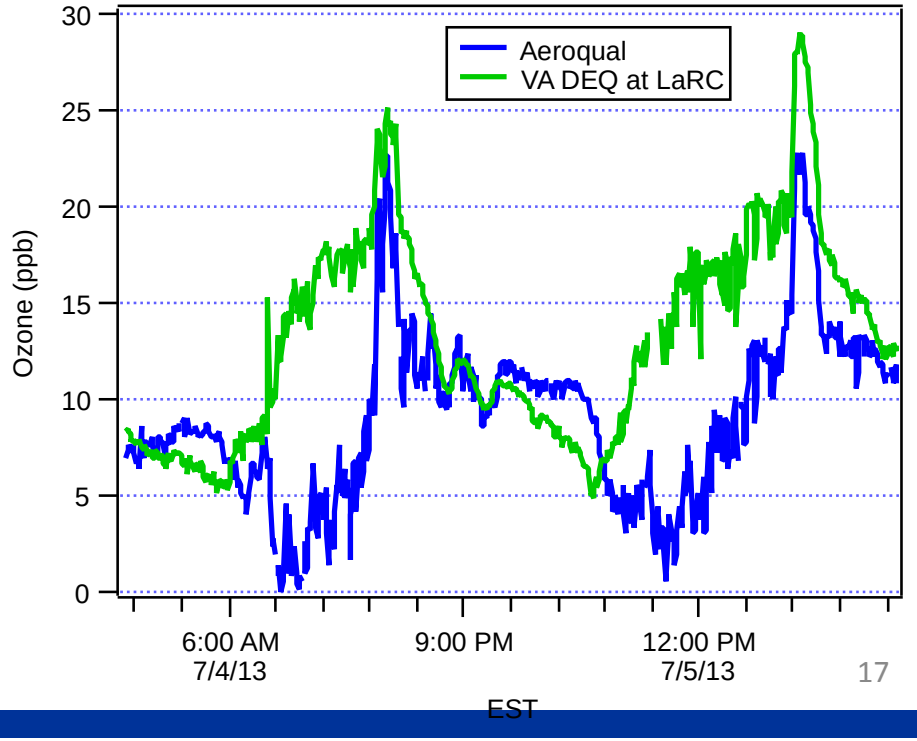
Aeroqual testing with and without inlet box

* Aeroqual ozone sensor head
must be calibrated in inlet box

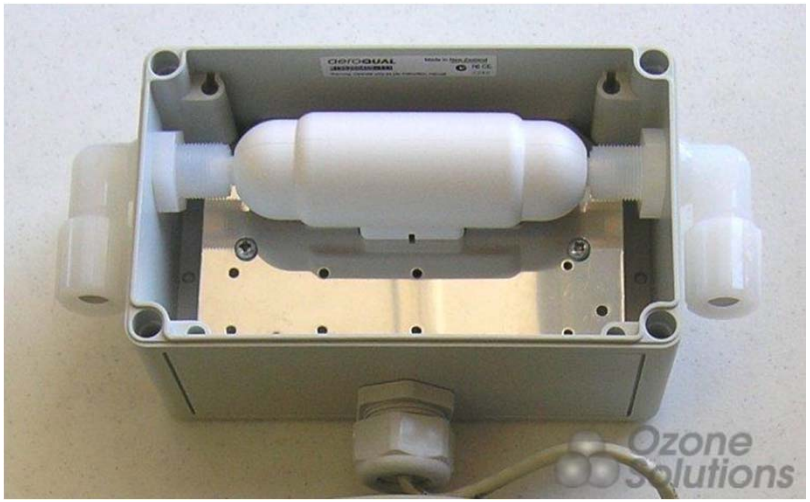
Coincident measurements show importance of calibration
Sensorhead received from vendor not calibrated in inlet box

Weather-tight inlet box





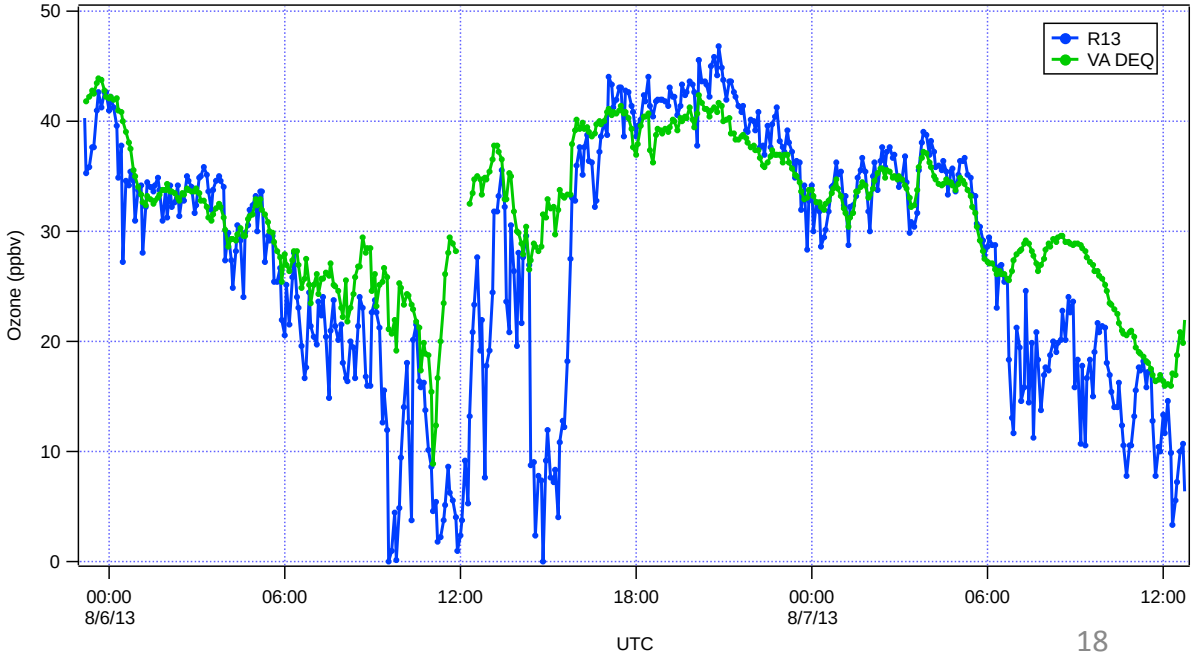
Instrument testing in progress



Modifications to inlet box

- removed screens at inlet tube entrance (well known that airflow over metal causes losses – research-grade ozone instruments use teflon fittings rather than stainless steel)

inlet wall-losses not as great with screens removed



Issues and Recommendations for Aeroqual instrument

- Need to test a sensor that has been calibrated for use in the inlet box
- issues with battery life - rechargeable but instrument must remain on to charge
- issues with warm-up time before measurements are valid
- odd data dropouts; possibly due to serial to USB connector for data download
  (experienced similar issues with prototype instrument;
  it is known that certain brands of connectors perform better than others)

Aeroqual ozone instrument is very promising as an alternate GLOBE instrument

- sensor technology is being further developed and NASA research scientists are using this instrument and similar instruments for TEMPO & DISCOVER-AQ missions
- EPA is also testing Aeroqual for use in citizen scientist projects
- NASA and EPA are collaborating and sharing results on Aeroqual tests and findings