

## Part 1: Panic

Pan American International High School (PAIHS) at Monroe & the New York Board of Regents



PAIHS Monroe is a specialized public school in the South Bronx for new and recently arrived high school age immigrants from Central and South America who do not speak English.

### PAIHS Monroe by the Numbers

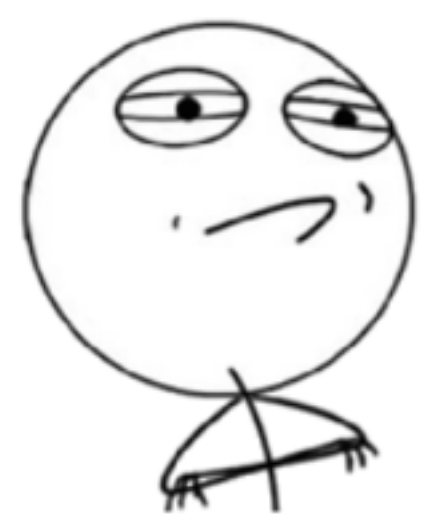
424 students	100% ELL	100% Free-and-Reduced Lunch
13 countries	33% SIFE	

In New York, earning a high school diploma means passing at least five high-stakes standardized tests; English Language Learners (ELLs) must do this while simultaneously learning a new language.

Unsurprisingly, the four-year graduation rate for ELLs in New York State hovers around 30% (NYSEd, 2014). PAIHS Monroe's solution? Performance-Based Assessment Tasks (PBATs), completed in lieu of standardized tests.

PBATs are long-term projects designed to teach depth of understanding rather than breadth of knowledge, and students are required to defend their projects in an oral presentation in front of a panel of evaluators.

### CHALLENGE ACCEPTED



# PBATs and Precipitable Water Measuring Water Vapor with an Infrared Thermometer

S.Adams, Pan American International @ Monroe; Mentor: M. Pippin, NASA LaRC

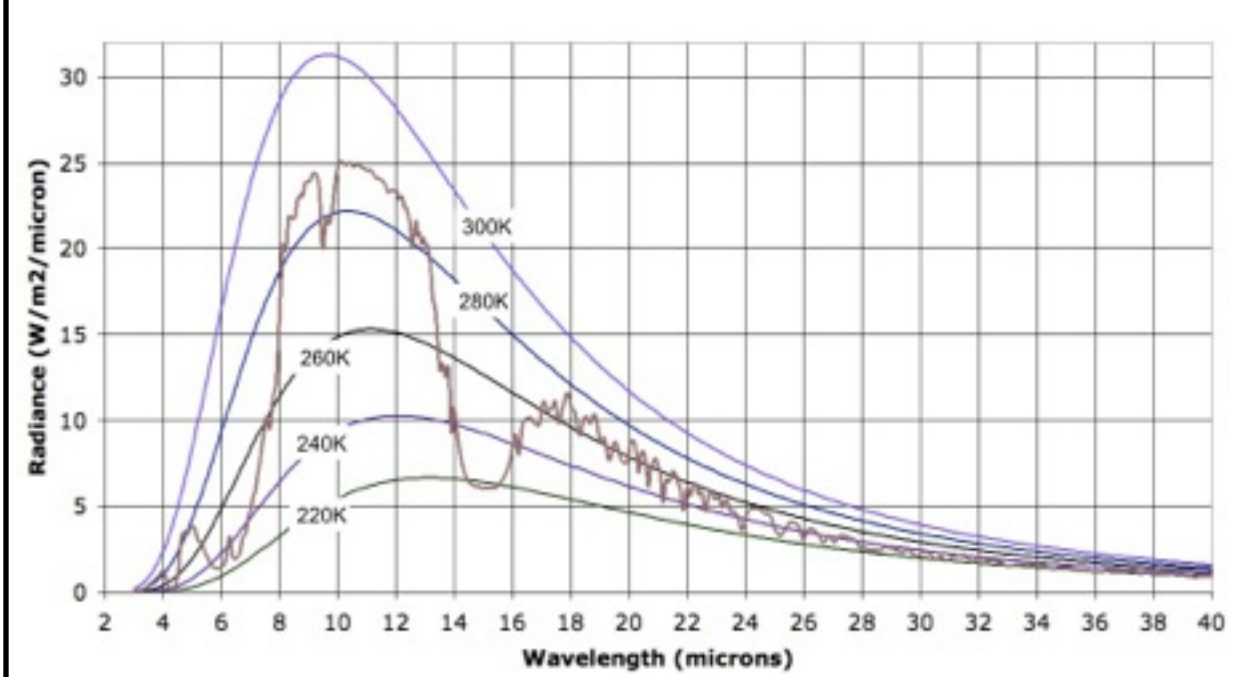


## Part 2: Prepare

**Measuring Total Column Water Vapor by Pointing an Infrared Thermometer at the Sky**  
This study, conducted partly at NASA LaRC and published in the *Bulletin of the American Meteorology Society* determined that it was possible to use an inexpensive, handheld infrared thermometer to measure water vapor within a vertical column; students in Classes R and S at PAIHS Monroe were given this paper to use as a procedural framework.

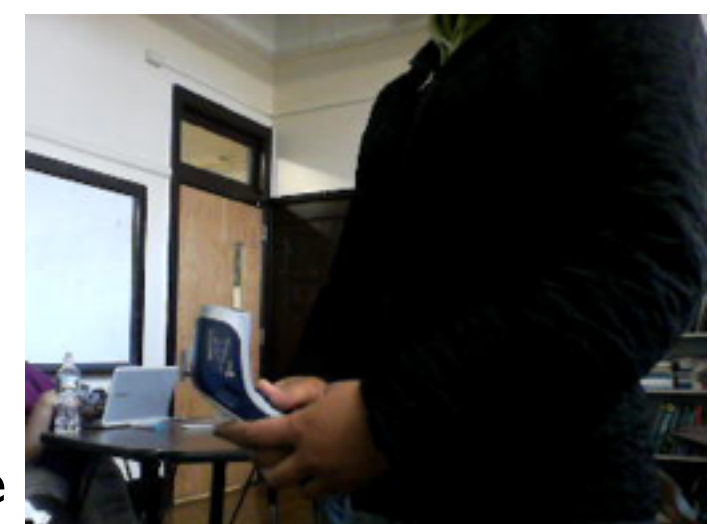


Read science



Before beginning the project, students studied the Earth's energy budget, the chemical makeup of the atmosphere, and how different gases behave in the presence of certain types of radiation.

The original study tested five different types of infrared thermometers; simultaneous measurements with a handheld sun photometer were used to derive a calibration equation with which to calculate precipitable water (as measured by the IR thermometers). Due to cost and availability constraints, only the Kintrex IRT0421 infrared thermometer was used in the experiment conducted at PAIHS Monroe. The GLOBE/GIFTS handheld water vapor instrument was supposed to be used to derive the calibration equation for the infrared thermometers.



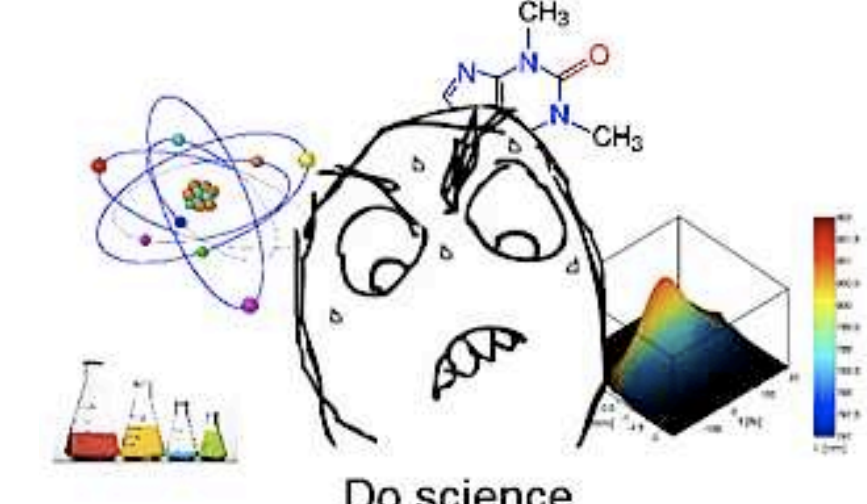
## Part 3: Proceed

### Data Collection

Students collected two different data sets. Measurements of the zenith sky temperature at the PAIHS Monroe observation site were made by three Kintrex IRT0421 thermometers. Simultaneously, readings were taken with three GLOBE water vapor instruments (handheld sun photometers measuring intensity of sunlight at specific wavelengths). The two classes of students conducting this experiment (approximately 20 students each) were subdivided into six smaller groups. Groups switched making measurements between the thermometers and GLOBE instruments on alternate observation days. Measurements were made every 15 seconds for 15 to 20 minutes.

### Problem #1: This is complicated. Miss!

Students found the GLOBE instruments difficult to use. The instrument must be properly aimed at the Sun (sunlight shining through mounted brackets is used as a guide), and four different observations must be made: voltage at two different near-infrared wavelengths with and without sunlight. The different wavelengths are measured by manually switching between channels using the knob on the front of the instrument. The relative complexity of the instrument lead to wildly inconsistent measurements and completely missing data (Part 4, below).



Joyce Guevara, Ivanna Polanco & Perla Vasquez make a water vapor measurement.



Bryan Ortega & Yenifer Iven double-check a temperature reading.



Patrick Abreu plays telephone with the GLOBE instrument. Luis, Maria and Anthony are unimpressed.

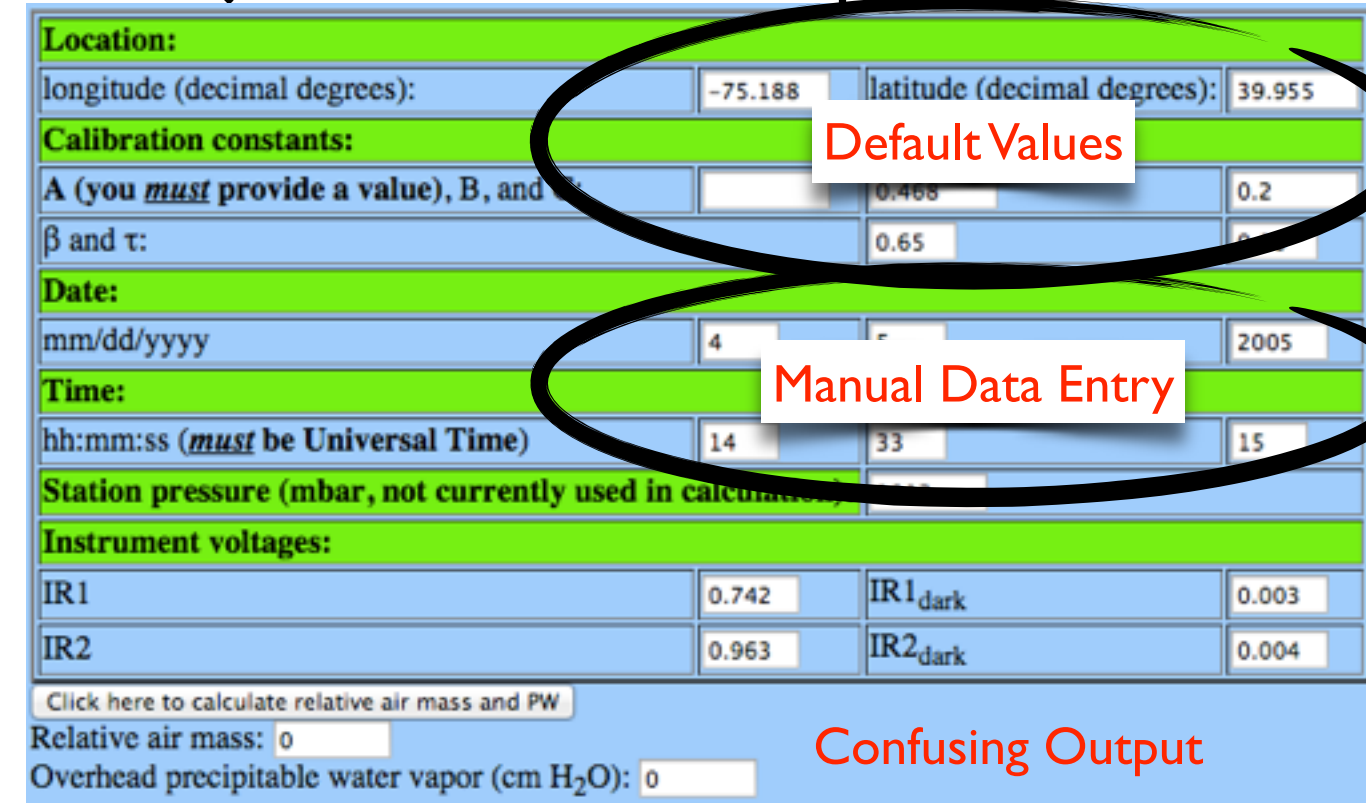
### Error 2: Which number goes where?

Some students were more interested in taking measurements than writing them down; between carelessness and confusion, data were missing for nearly every observation day. After data collection, students transferred their data into a shared spreadsheet; errors here include transposition or entering data incorrectly. Finally, Instesre's 'Calculations for Total Precipitable Water Vapor' website (screen shot, right) that was used to determine precipitable water from the GLOBE instrument's raw data was confusing for students; recorded results were often miscalculated.



With Samuel Mora's help, Patrick finally gets it right.

### A Major Source of Computational Error



## Part 4: Ponder

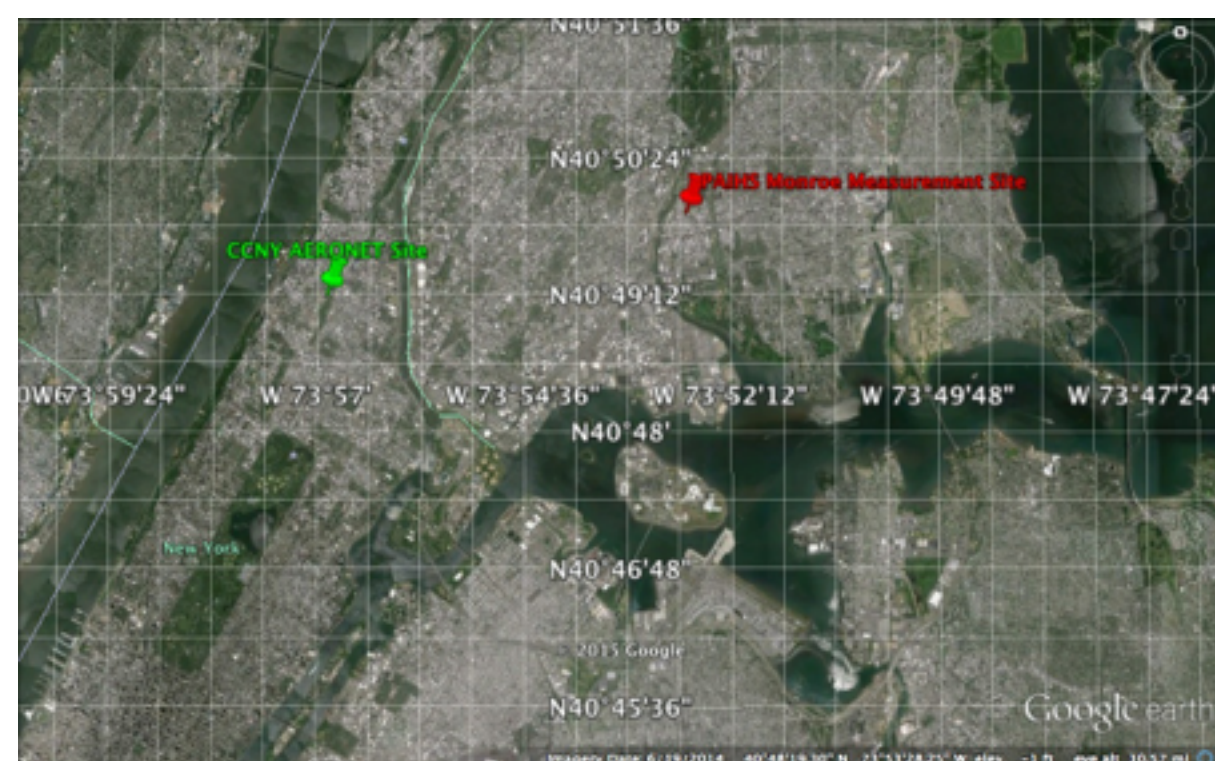
### Data Analysis

GLOBE and AERONET precipitable water are plotted in the top time series; zenith sky temperatures are plotted in the bottom time series. The three different colors represent precipitable water measurements calculated from the same raw data by three different groups of people; students in Class R, students in Class S and S.Adams. Note both low precision (miscalculated precipitable water) and low accuracy (measurement errors) on early observation days (12/4/2014). Later measurements are more precise; low accuracy remains. IR thermometer measurements show consistently higher precision.

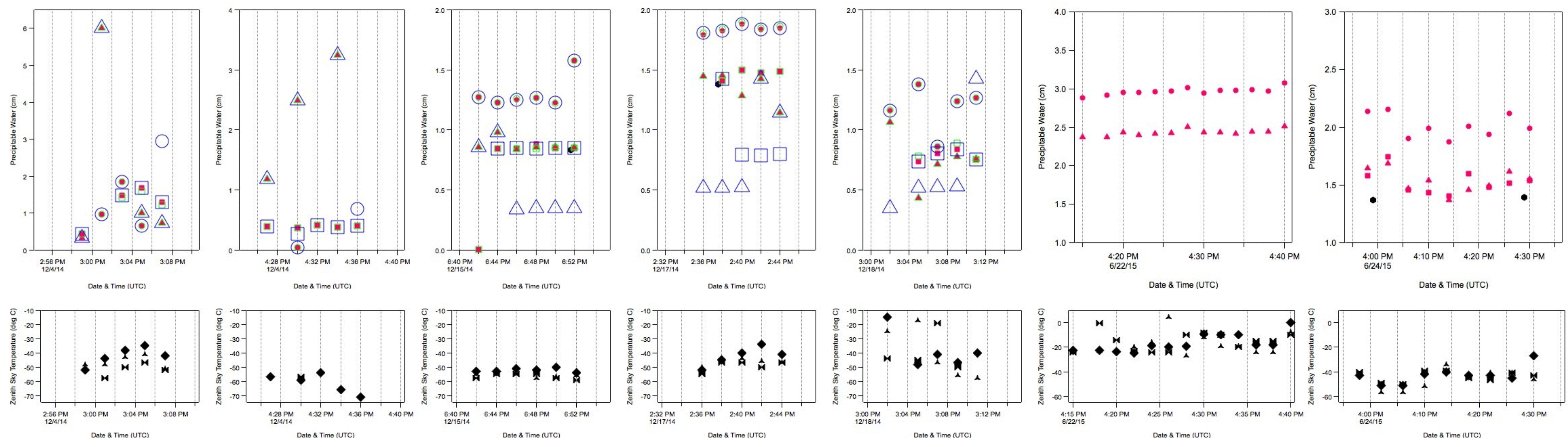
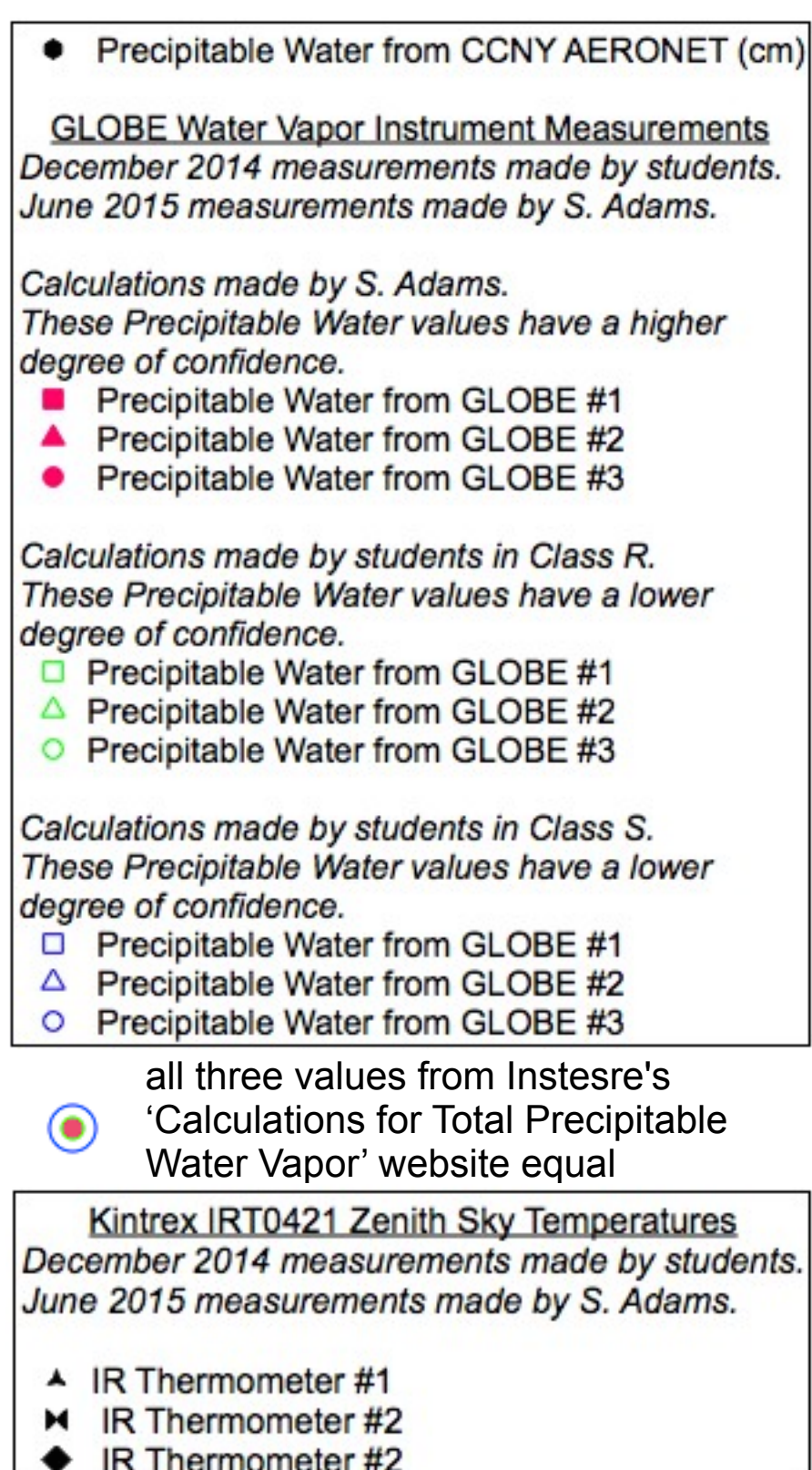


Hmm not quite going as expected...

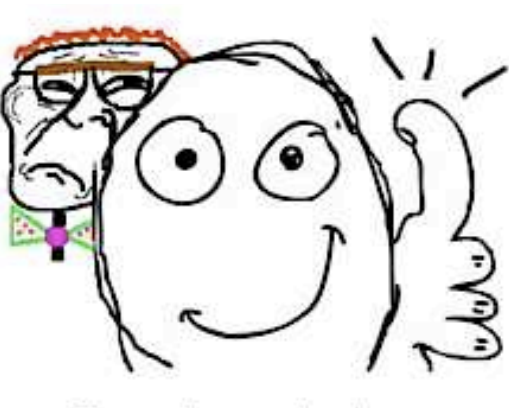
The protocol for calibrating infrared thermometers from Mims, et. al. calls for using NOAA GPS Integrated Precipitable Water data for correlation; however, the closest NOAA GPS site was nearly 100 kilometers from PAIHS Monroe. The handheld GLOBE instruments, used simultaneously with the IR thermometers, should have been able to be used for correlation, but the uncertainty of the data led to the use of the City College of New York's AERONET data. The CCNY AERONET site is 6 kilometers from PAIHS Monroe, with an 84m elevation difference. In Mims, et. al., correlation equations were generated using NOAA GPS data from sites up to 31km away with 105m difference in elevation.



Precipitable water measurement sites: PAIHS Monroe and City College of New York (CCNY).



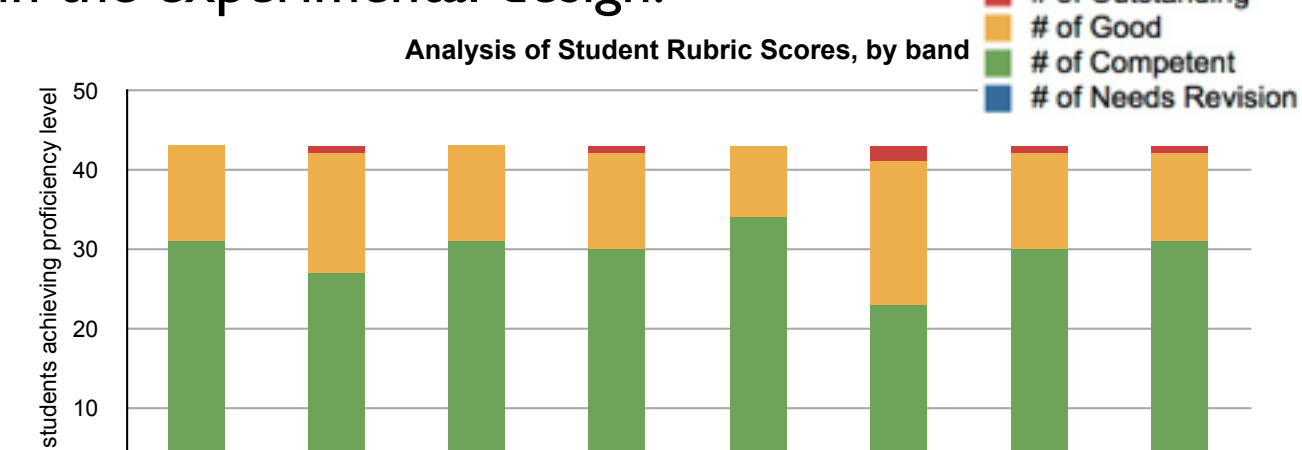
## Part 5: Present



Sweet, maybe I can publish this!

### PBATs Work

There were 43 students in the two classes that participated in this particular science PBAT project. All 43 students passed, achieving at least a Competent on both the written paper and oral evaluation.



Of the 43 students, 31 received an overall evaluation of Competent; 11 received a Good evaluation, and 1 achieved an Outstanding. In 2015, PAIHS Monroe had a four-year graduation rate of 80%, five percentage points higher than the 2014 rate, and nearly 70 points higher than the New York State graduation rate for English Language Learners in 2014.

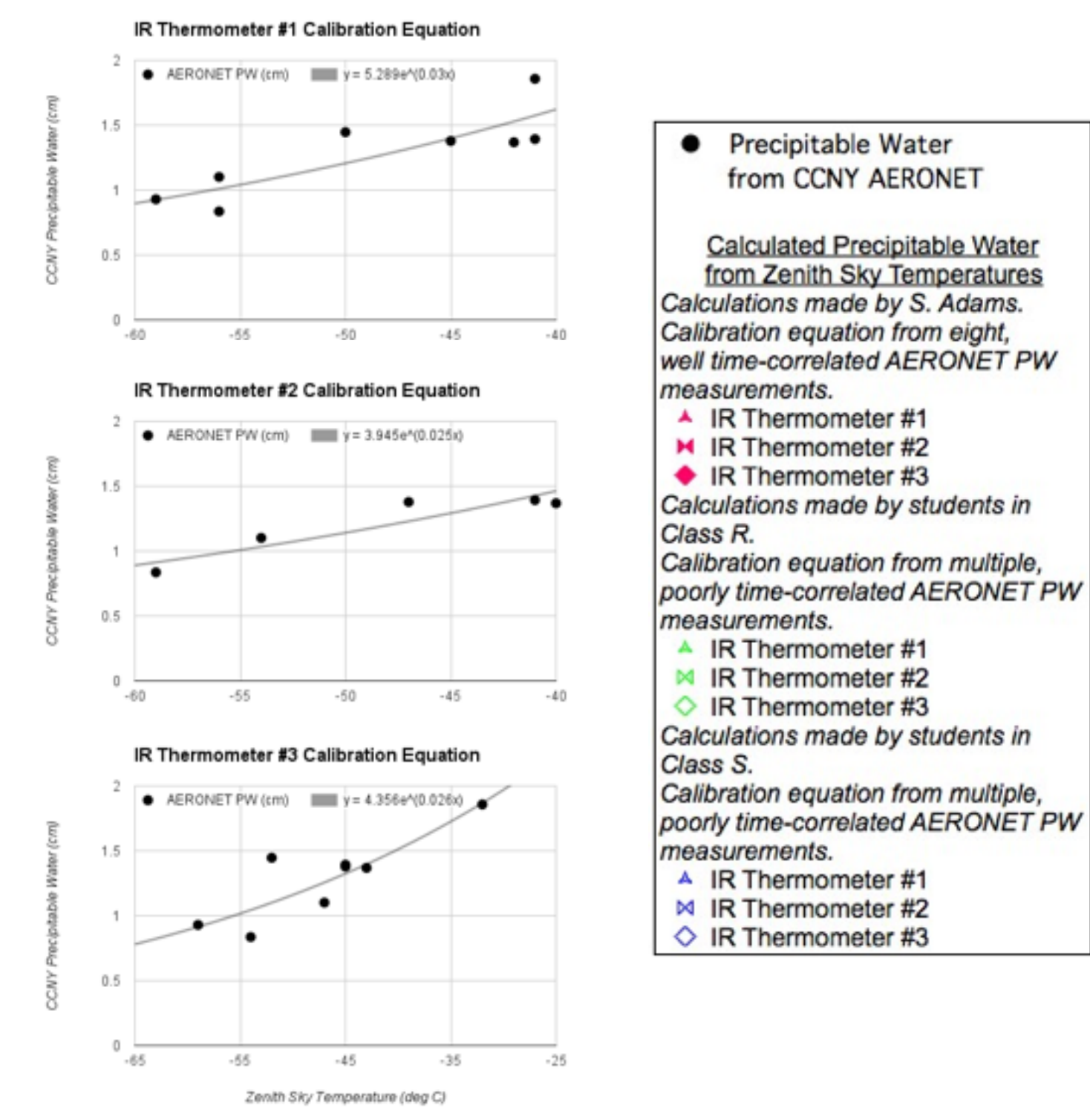


PAIHS Monroe Seniors preparing for graduation (June 26, 2015). Every graduating Senior completed 5 PBATs in one academic year.

## Part 6: Post-Analysis

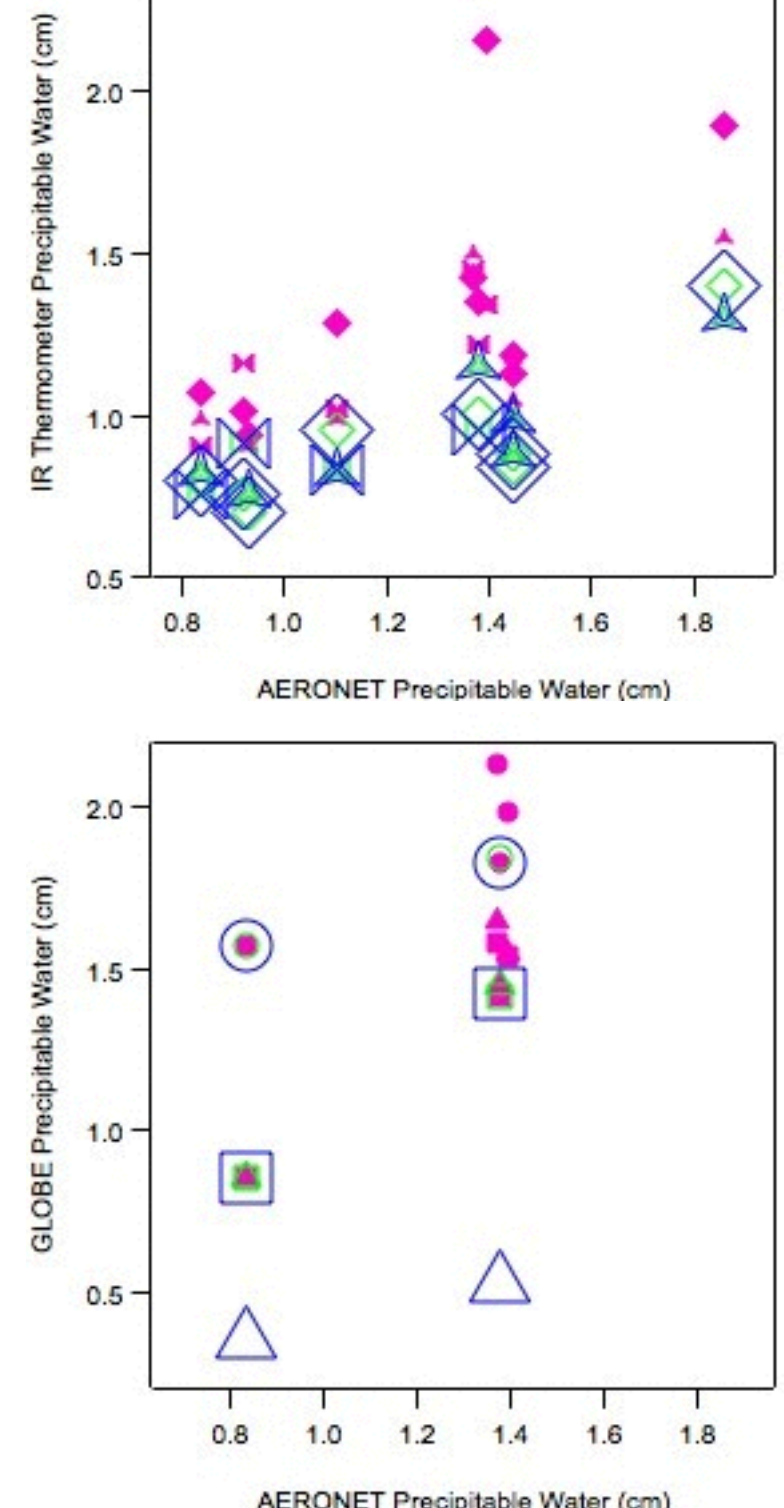
### Correlation Equations

Calculated from AERONET PW and IR Thermometer measurements made within two minutes of each other.

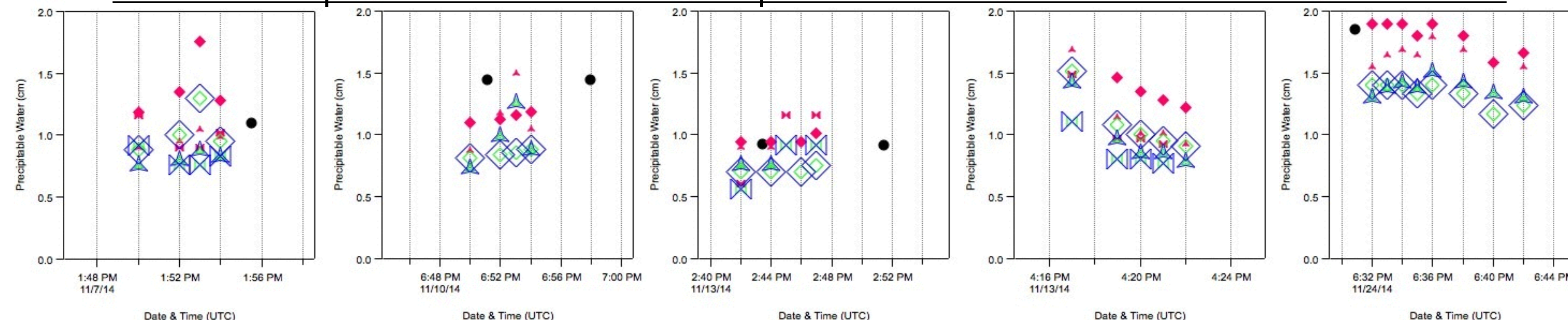


### Correlation Plots

Calculated from AERONET PW and IR Thermometer measurements made within two minutes of each other.



### Calculated Precipitable Water from Calibration Equations for three Kintrex IRT0421 Infrared Thermometers



## Acknowledgements

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- Thanks to students in Classes R and S, Pan American International High School at Monroe Class of 2015, for collecting data (with frequent hilarity) during one of the coldest, snowiest NYC winters on record: Class R - Patrick Abreu, Jazmin Almanzar, Leidy Bravo, Juan Bustos, Yeniffer Cabeja, Carlos Diaz, Daliza Diaz, Luis Encarnacion, Joyce Guevara, Maria Guzman, Jean Carlos Hinojosa, Ruddy Holguin, Yenifer Iven, Elvis Jimenez, Mario Linares, Albert Mosquera, Bryan Ortega, Luz Quiroz, Anthony Ramos, Evelyn Reyes, Sarai Sanchez, Marco Yupan, and Class S - Hector Campuzano, Gissell Cuevas, Kevin Deoleo, Jose Genao, Emeli Hernandez, Luis Hinojosa, Blady Jimenez, Michael Monogro, Samuel Mora, Randy Nova, Melany Nunez, Isidro Pena, Any Perdomo, Brayan Pimentel, Ivanna Polanco, Maria Rivera, Jorge Roa, Arali Sanchez, Stephanie Sanchez, Perla Vasquez.
- Thanks to Sam Ahmed, Alex Gilerson, Rick Wagener and their staffs for establishing and maintaining the CCNY AERONET site used in this investigation.

## Resources

- Mims, F.M., Chambers, L.H & Brooks, D.R. (2011). Measuring Total Column Water Vapor Thermometer at the Sky. *Bulletin of the American Meteorological Society*, 92, 1311 - 1320.
- NASA GSFC AERONET data & imagery. ([http://aeronet.gsfc.nasa.gov/new\\_web/data.html](http://aeronet.gsfc.nasa.gov/new_web/data.html))
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