# Volcanic Gas Analytical Monitor (VGAM): Compact and Low Power Mass Spectrometer-based Instrumentation for Volcanic Gas Monitoring

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**University of Hawaii**

**and**

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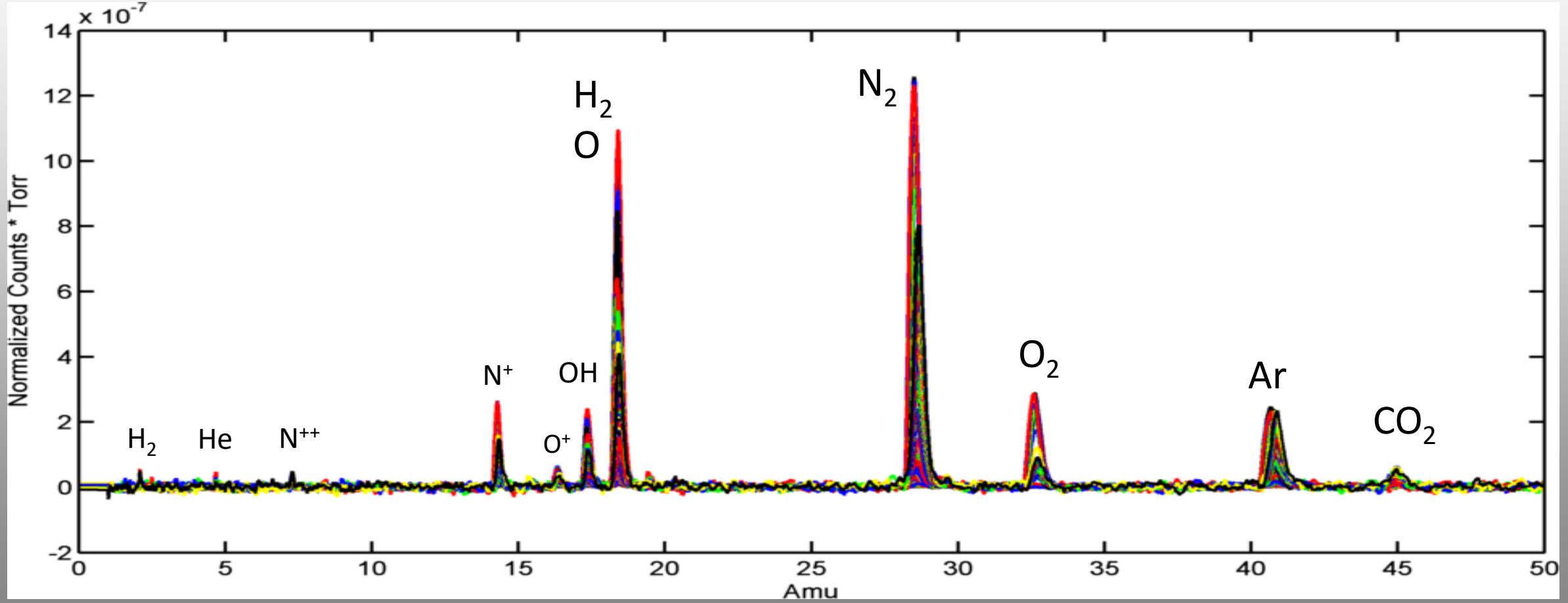
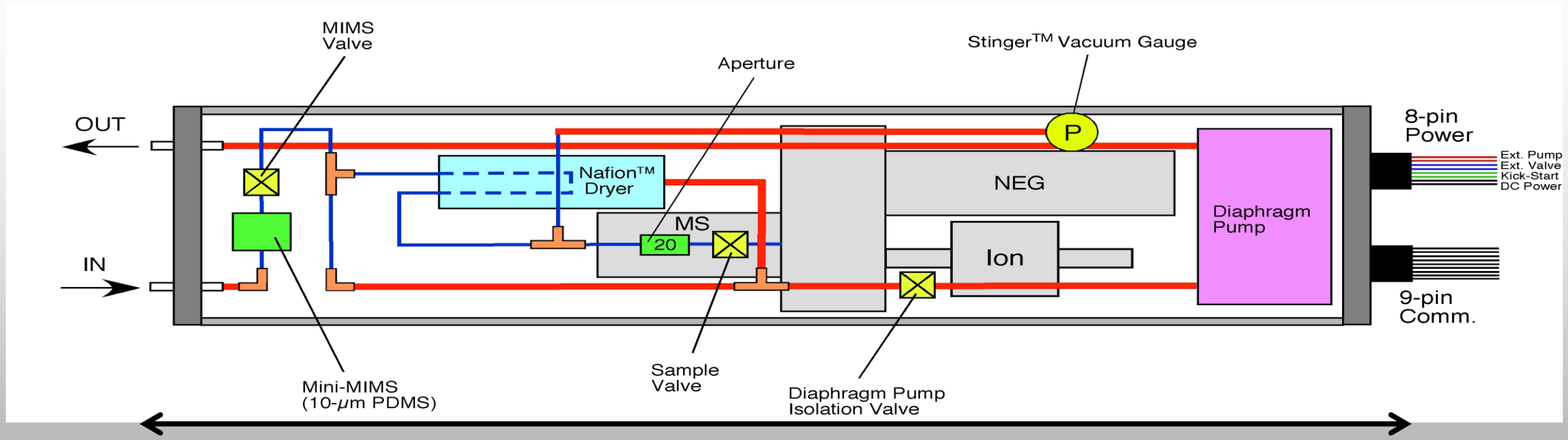
**University of New Mexico**

# Stacked Mass Spectra from Field Auto-Run Program




Analyzable Gases: $H_2$, He, $H_2O$, $N_2$, $O_2$, Ar, NO, $N_2O$, CO, $CO_2$, $H_2S$, SO, $SO_2$ and $CH_4$

# Mass Spectrometer and Peripherals

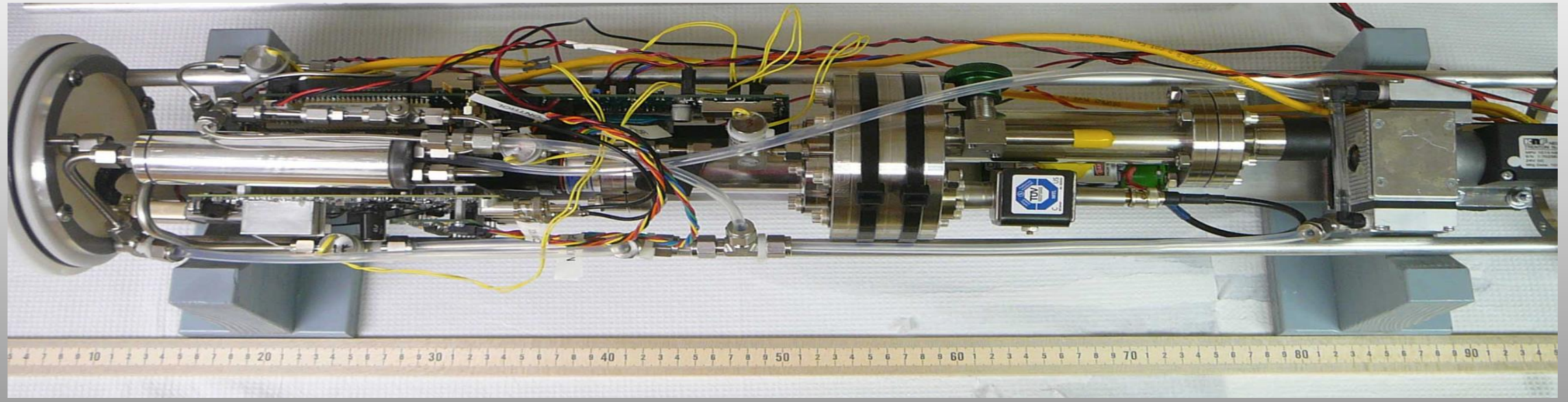



80 cm long, approx. 18 kg

Vacuum plumbing: Mini-MIMS and Nafion Dryer reduce liquid/vapor water to MS. Diaphragm pump provides rough vacuum (3 Torr).
Stinger™ convection gauge monitors rough vacuum. NEG-Ion Pump provides high vacuum for MS, and Ion Pump provides high-vacuum monitor. A 10-micron aperture cuts pressure from 3 Torr to ~ $10^{-6}$ Torr.

Mass Spec: Granville-Phillips 835 Auto Resonant Ion Trap (ART MS), 1-145 amu mass range.
Power: @ 24V DC, **25 Watt** when measuring, **1 Watt** in sleep mode.

# Scientific/Technical Description



**NEG-Ion VGAM (early V-CAFÉ version)**
**Bench Test**

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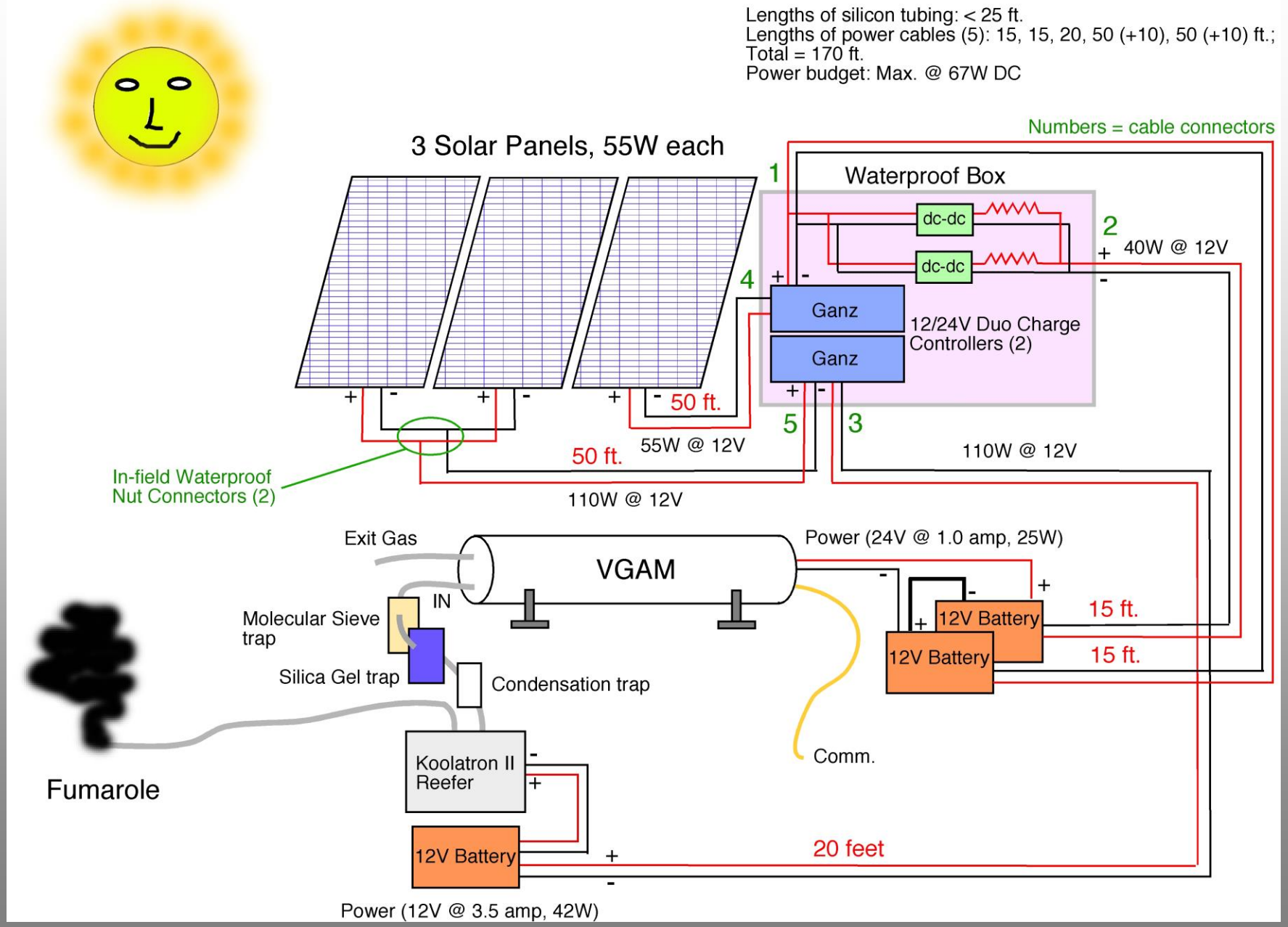
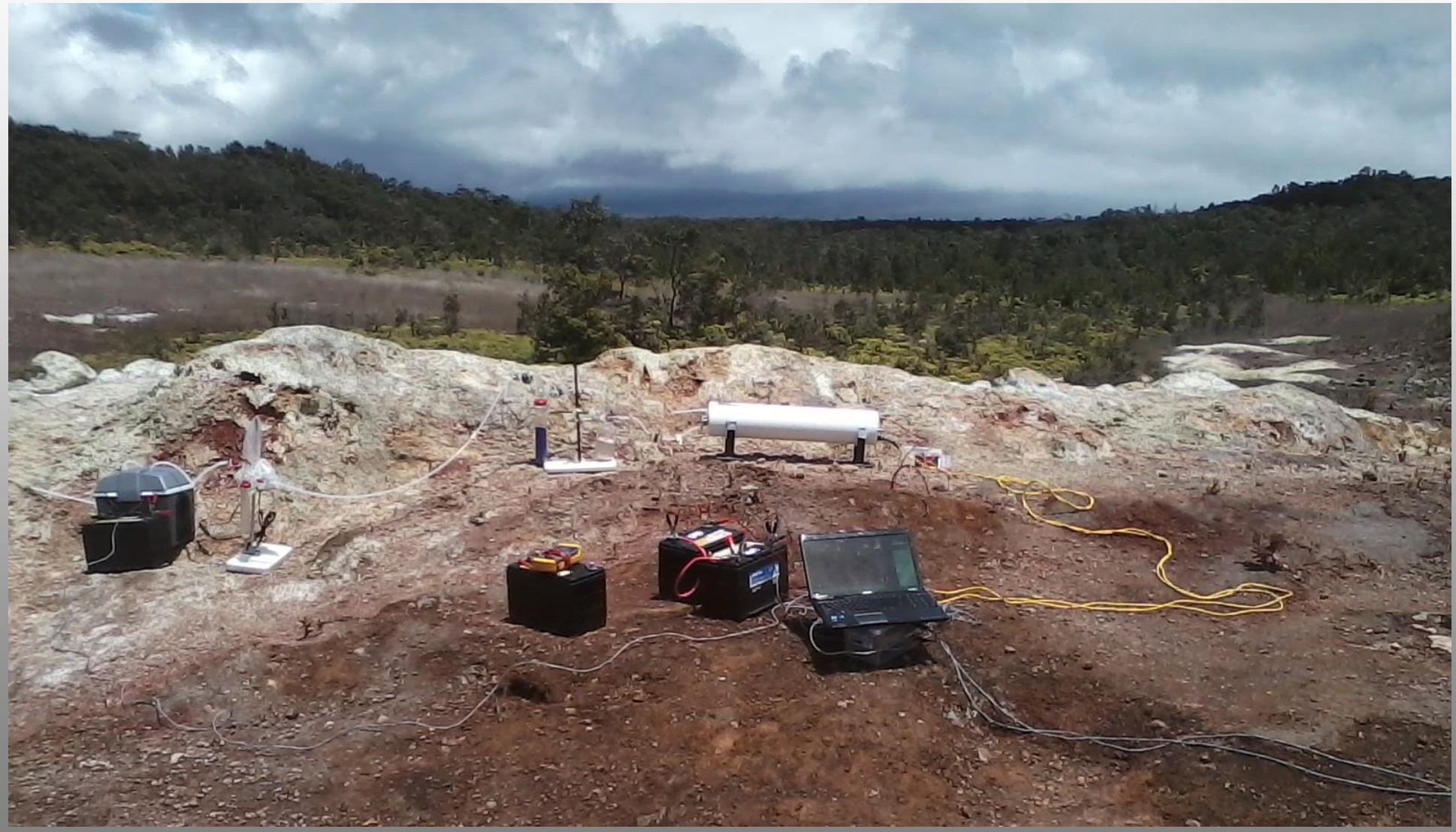
# Sulphur Bank Layout - July, 2014



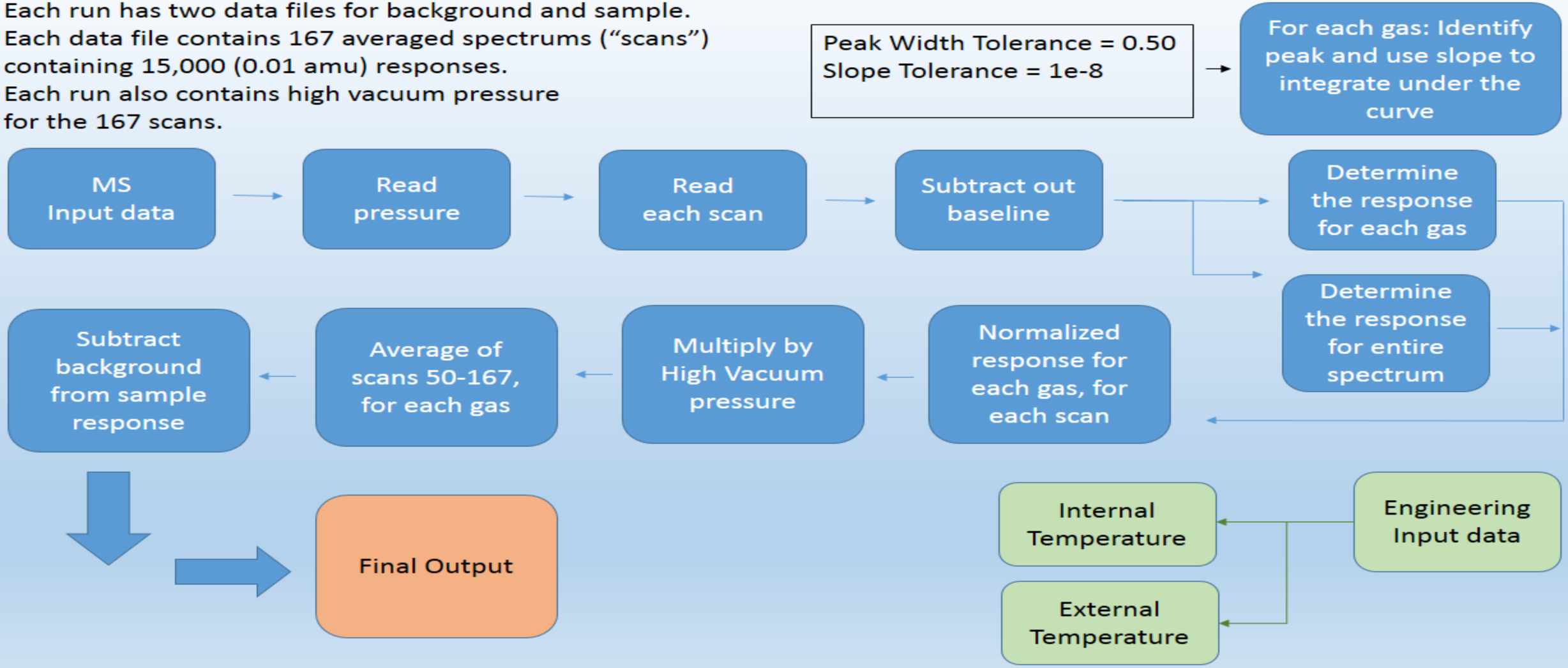
# Field Layout



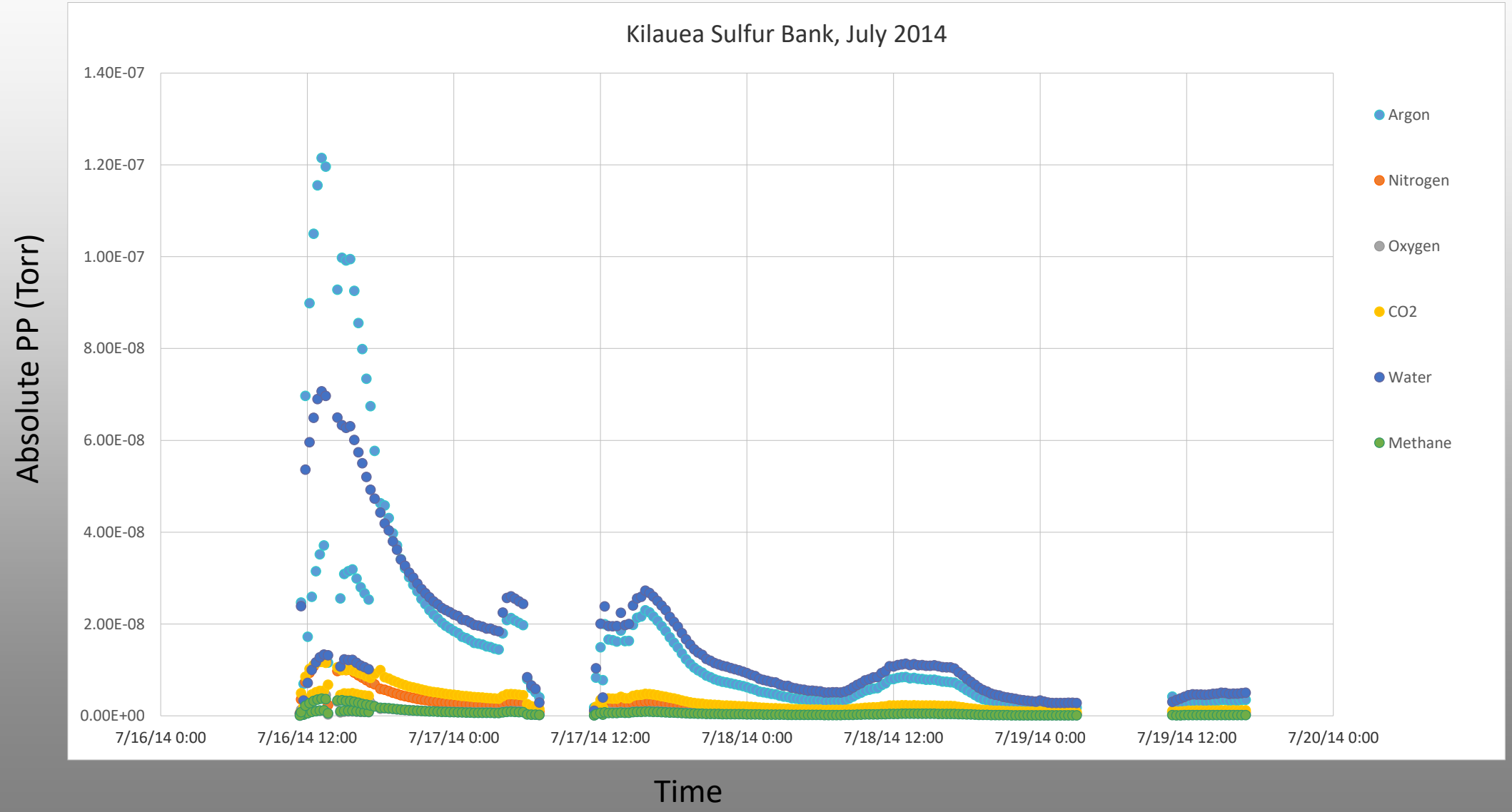
# Solar panels, Sample bottles

# Data Post-Processing

Each run has two data files for background and sample.
Each data file contains 167 averaged spectrums ("scans") containing 15,000 (0.01 amu) responses.
Each run also contains high vacuum pressure for the 167 scans.



# Kilauea Sulfur Bank Deployment



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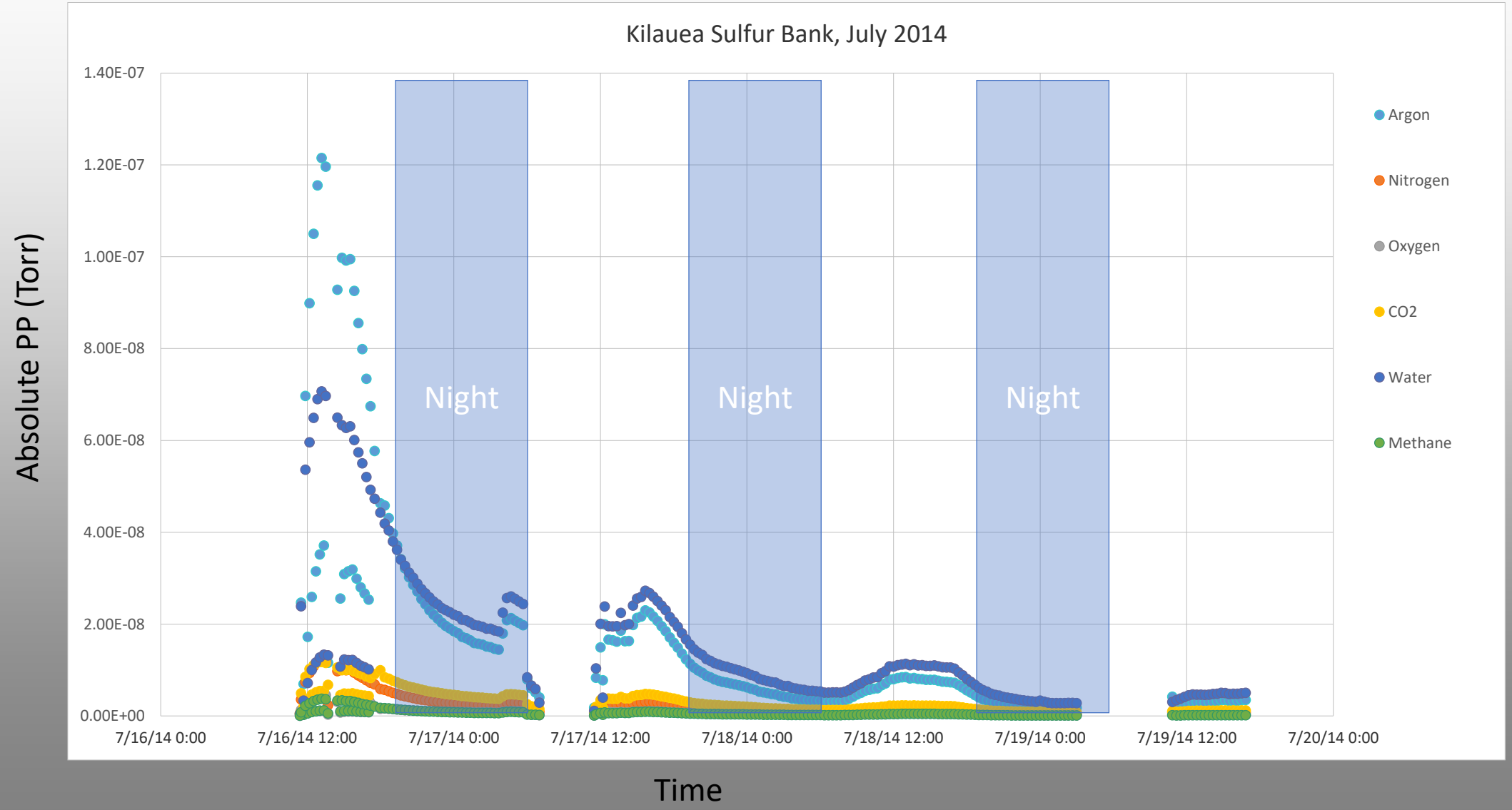

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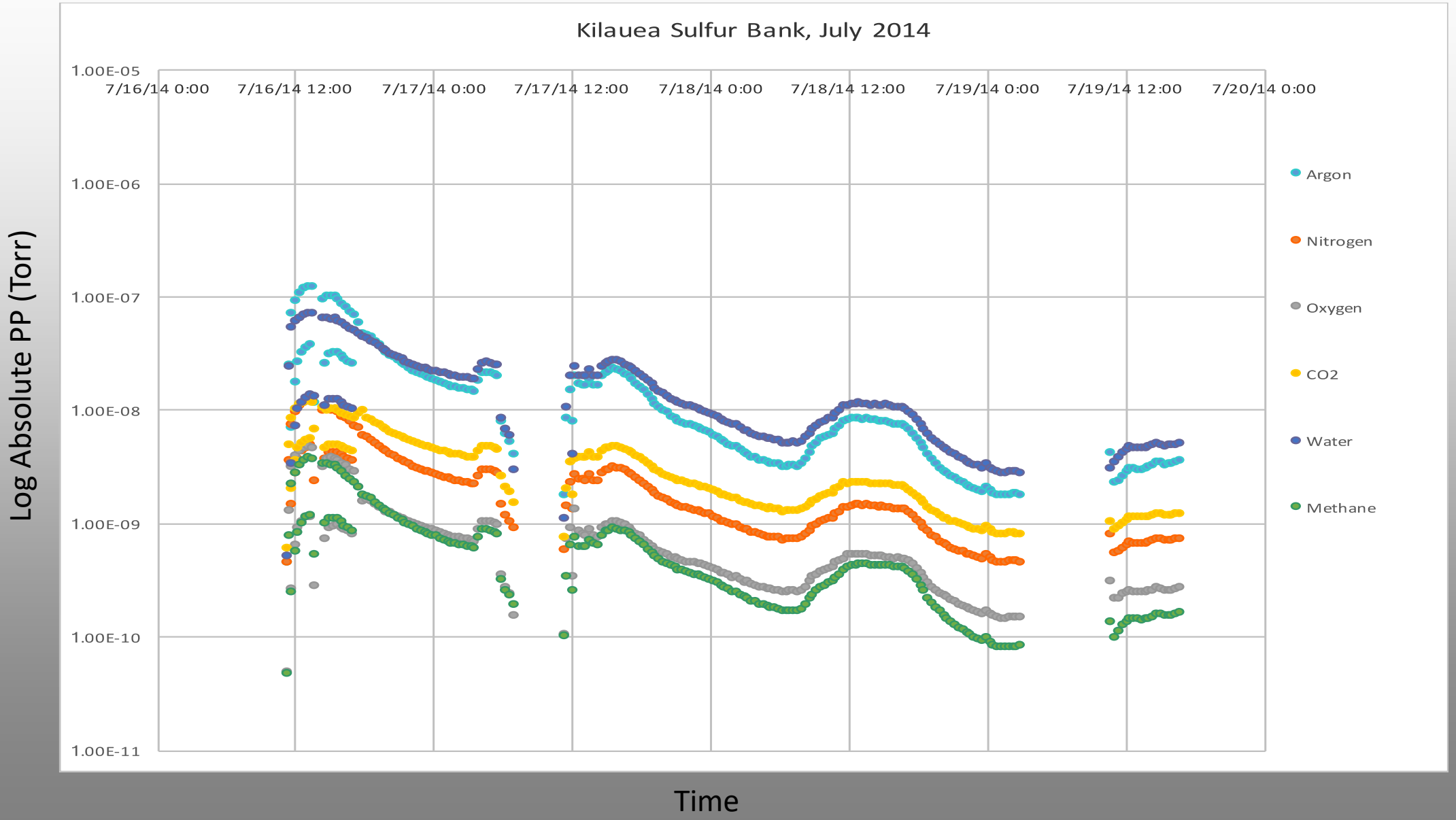

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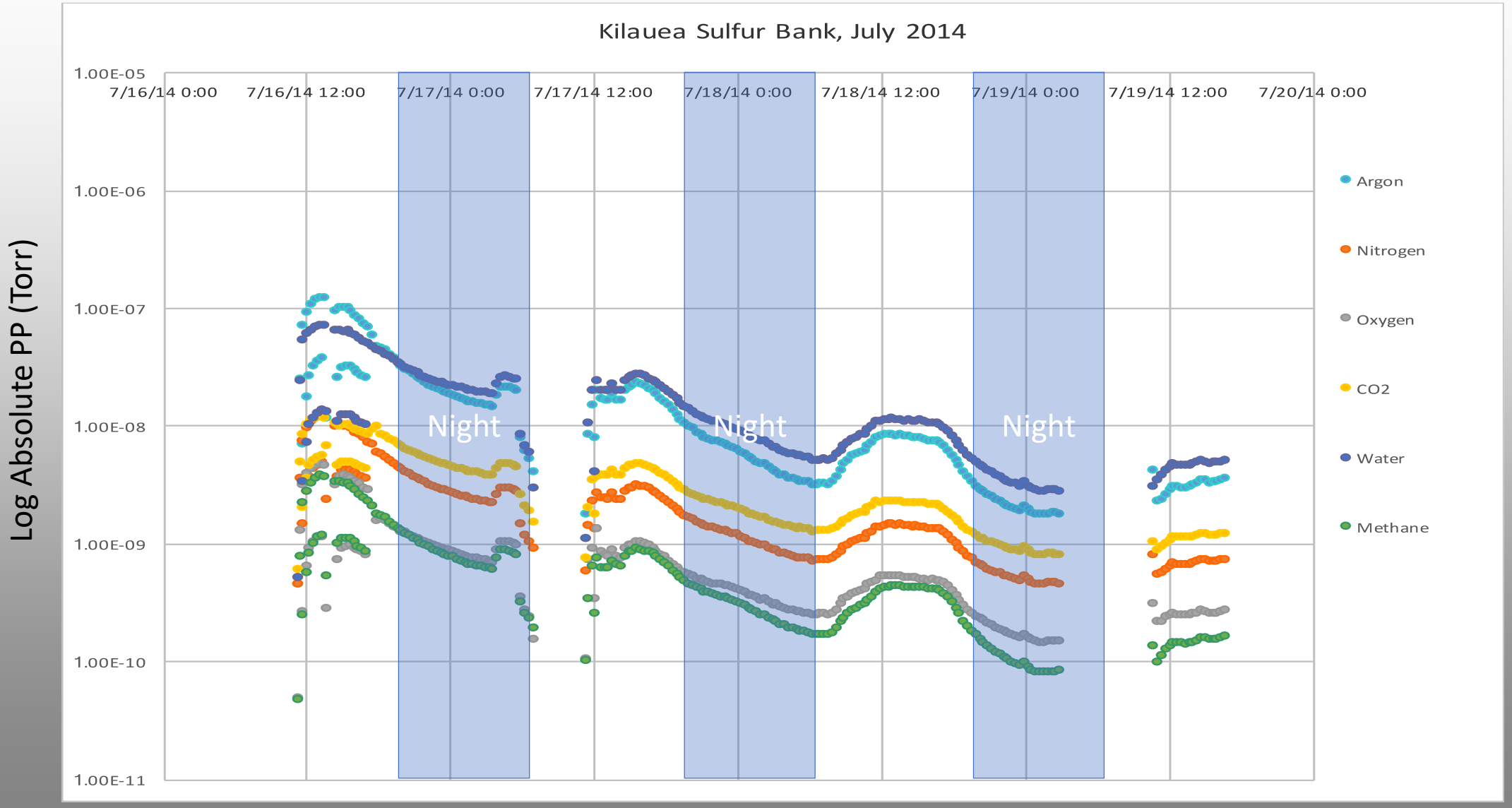
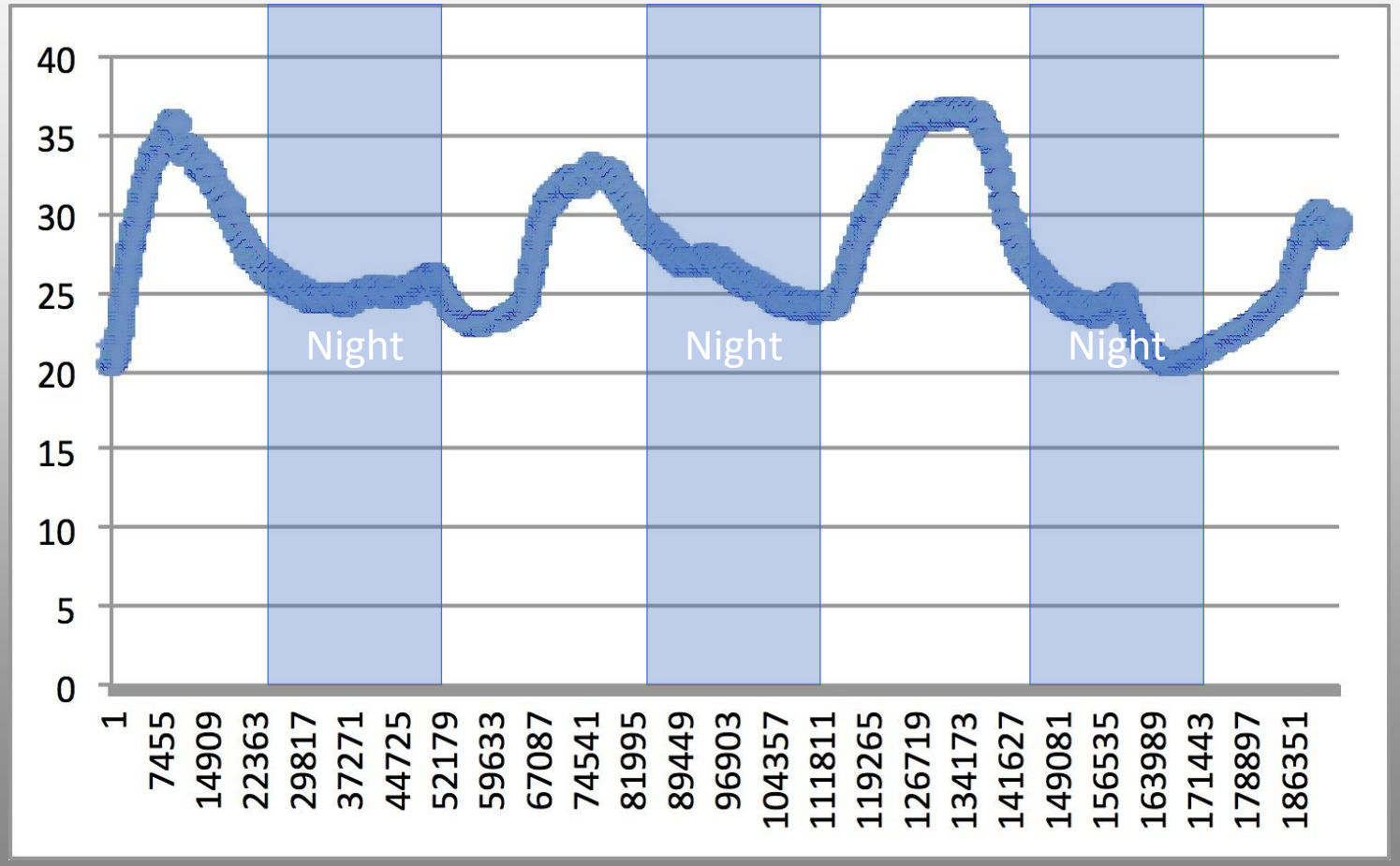
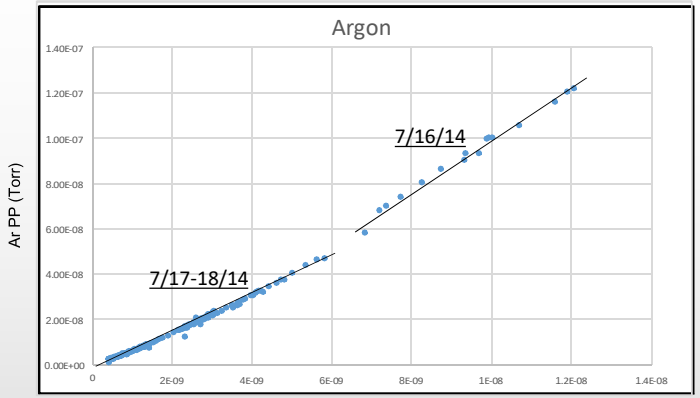
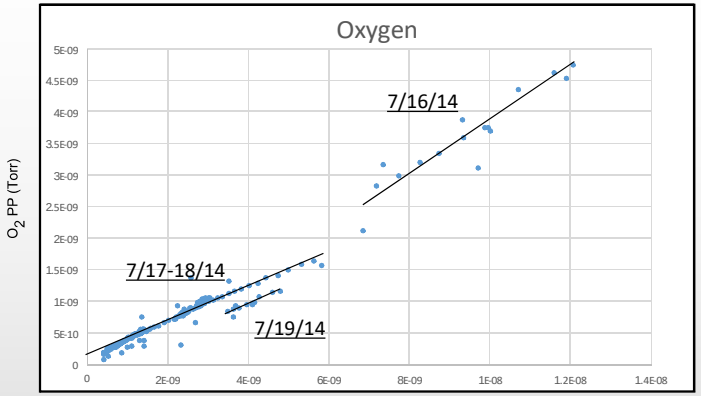


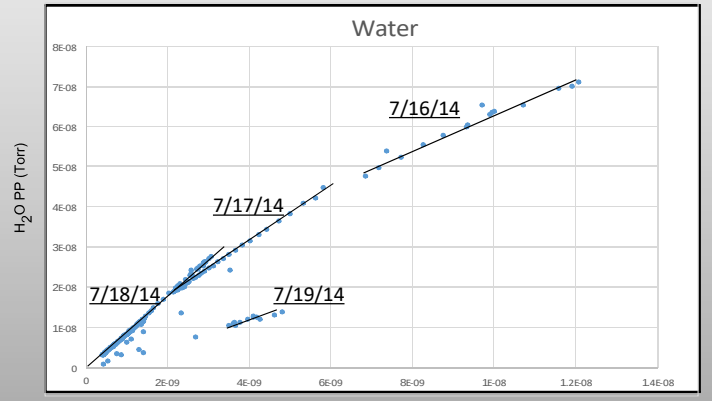
# Instrument Temperature (°C)

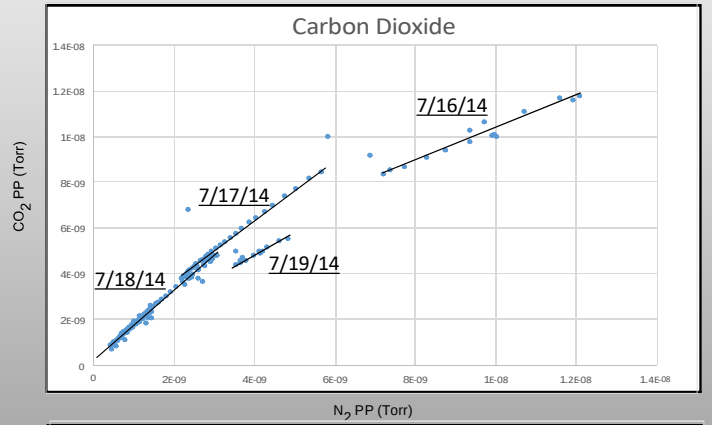


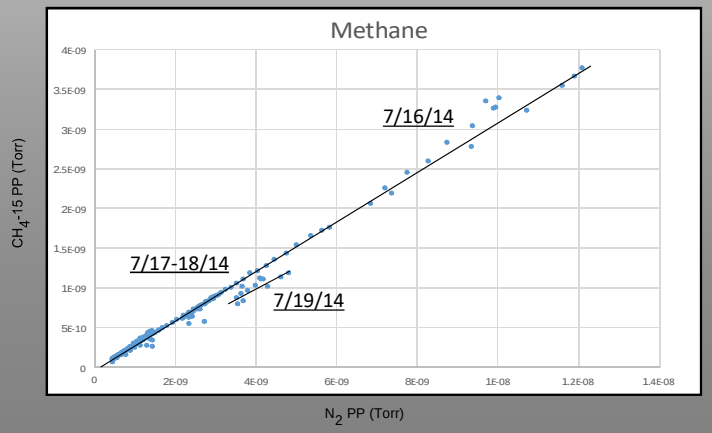
# Kilauea Sulfur Bank July, 2014

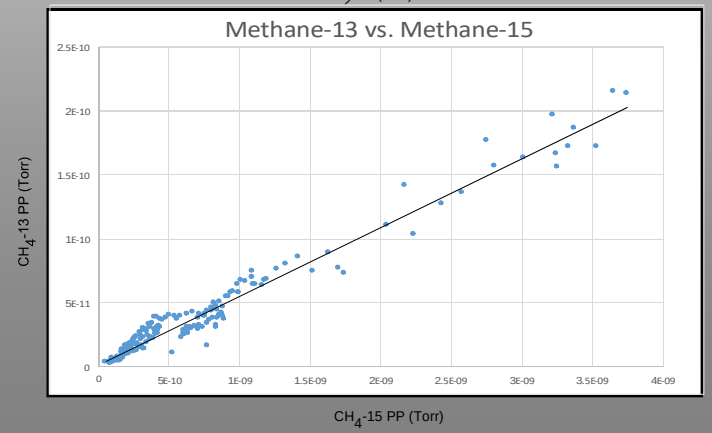


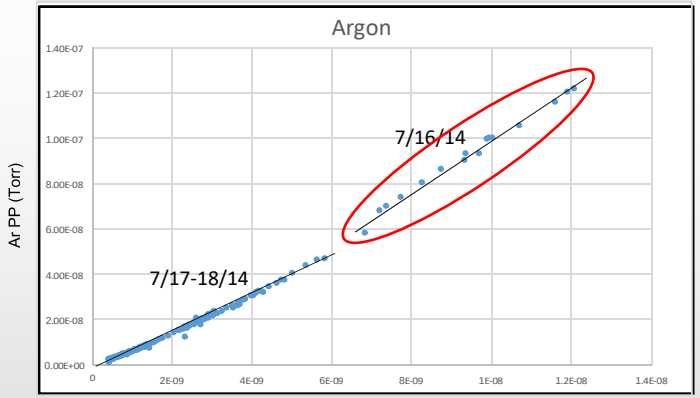



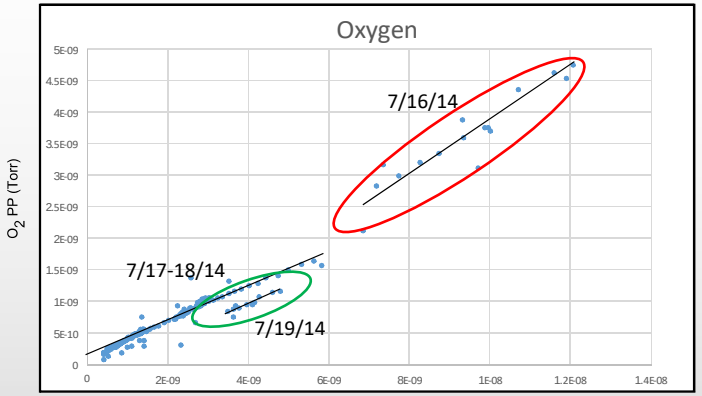



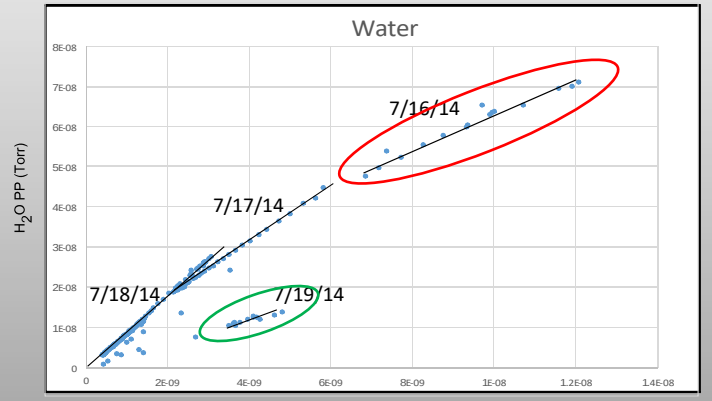
# Kilauea Sulfur Bank July, 2014

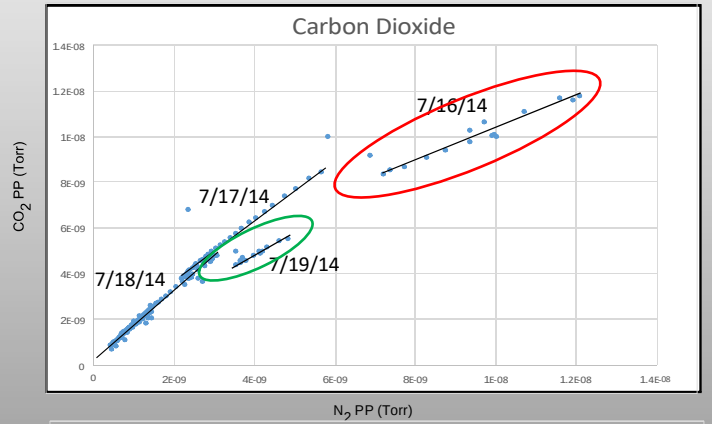
= July 16 PM

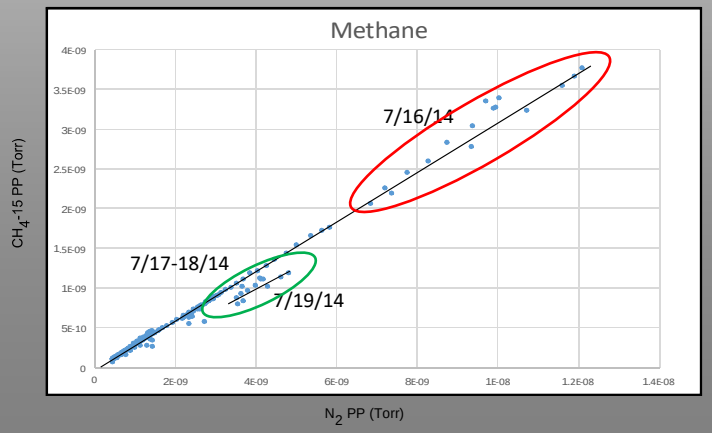
= July 19 PM

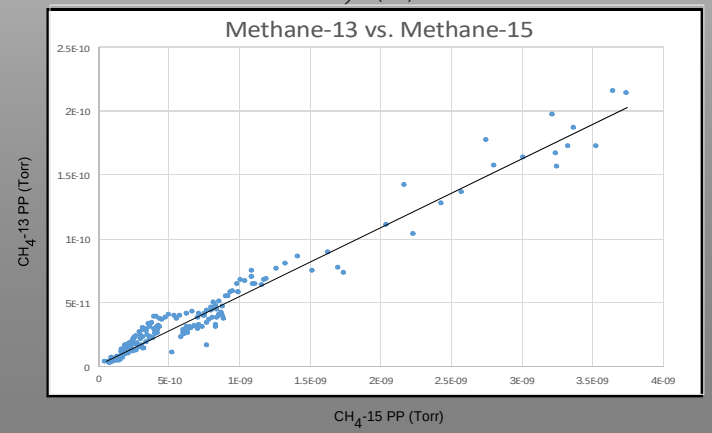


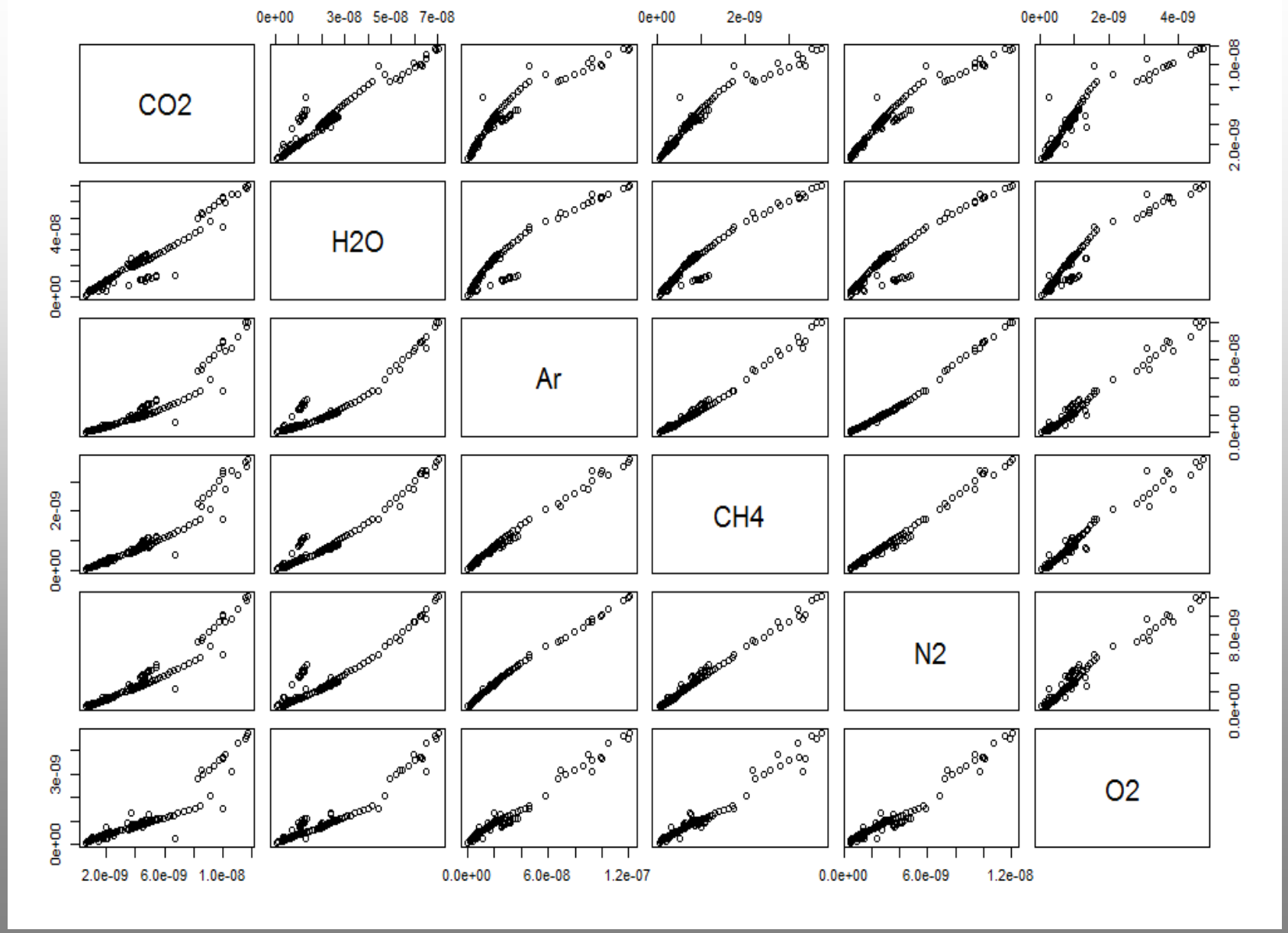



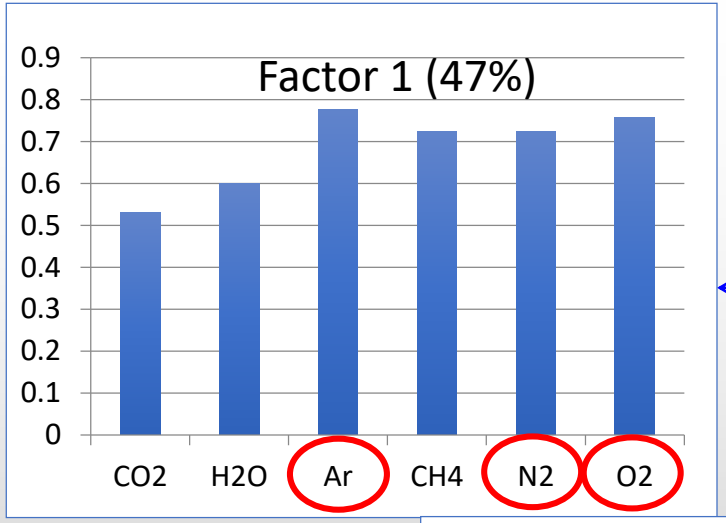



# Correlation Matrix for Gases

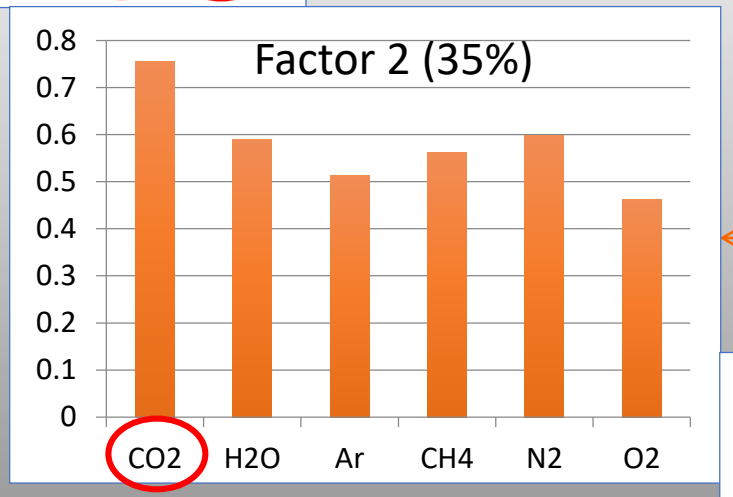


# Principal Component Analysis

## Normalized Factor Loadings

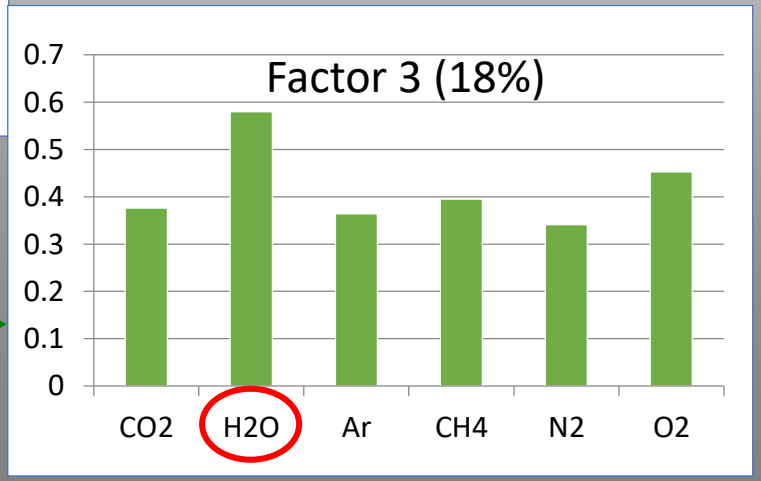



Atmospheric Factor
(Ar, $O_2$, $N_2$ dominated)

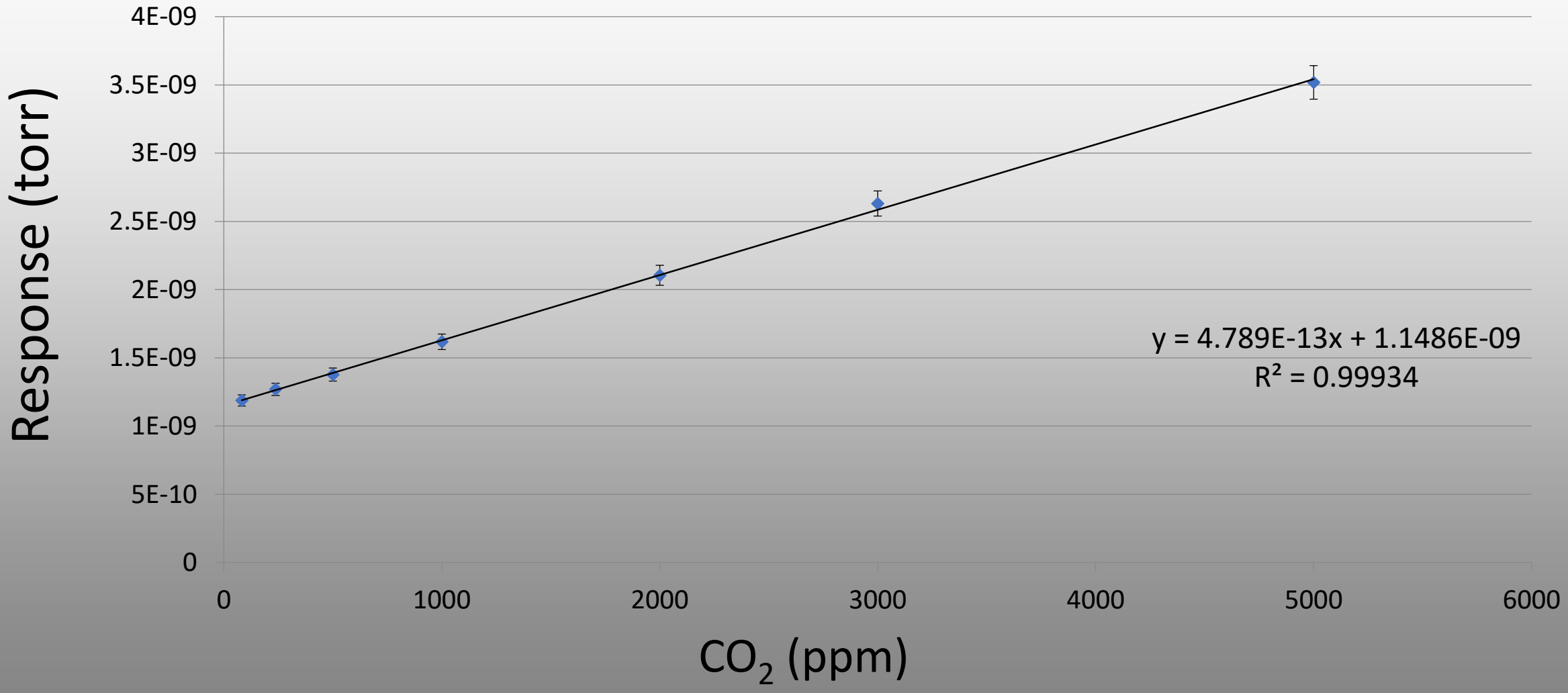



Volcanic Factor
($CO_2$ dominated)

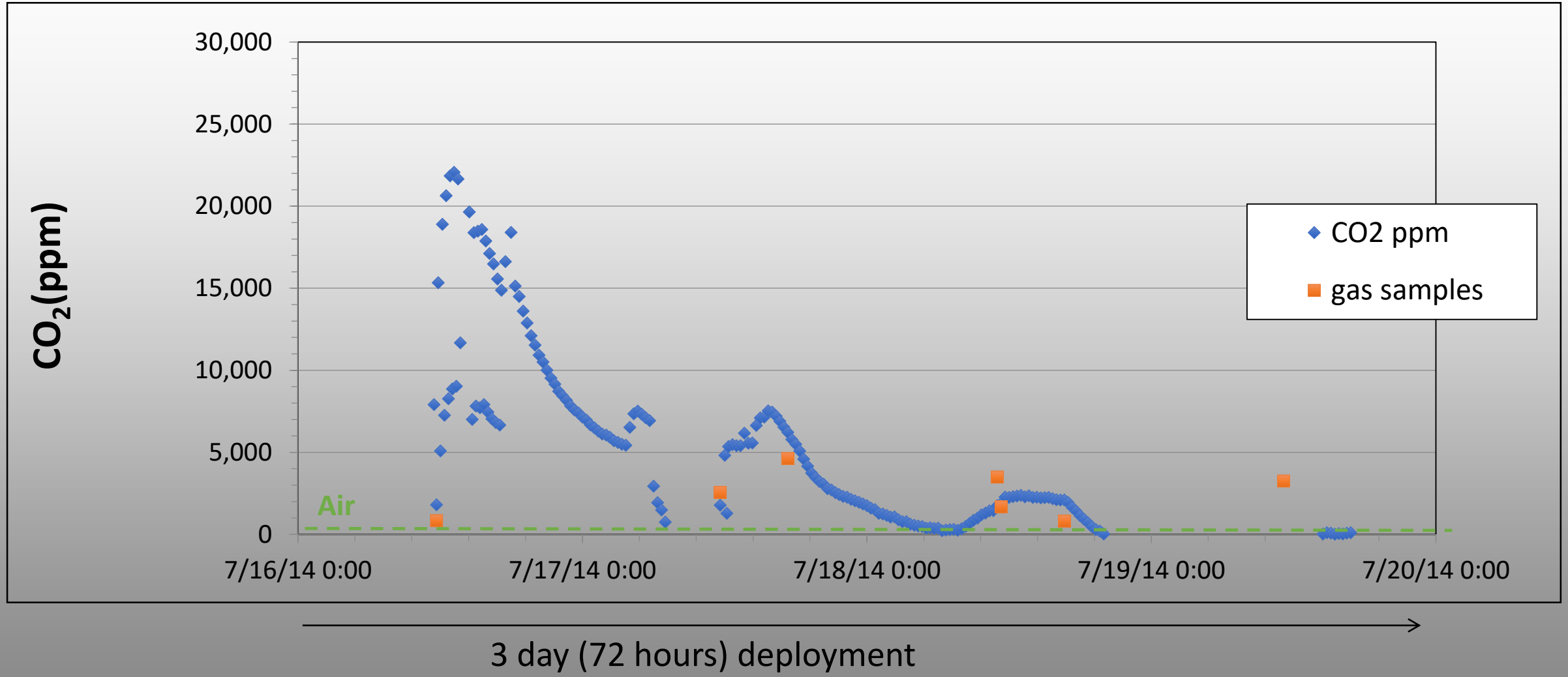
Water Factor
(Humidity)



# Lab Calibration for $CO_2$



# Kilauea Sulfur Bank Deployment – comparison to gas samples



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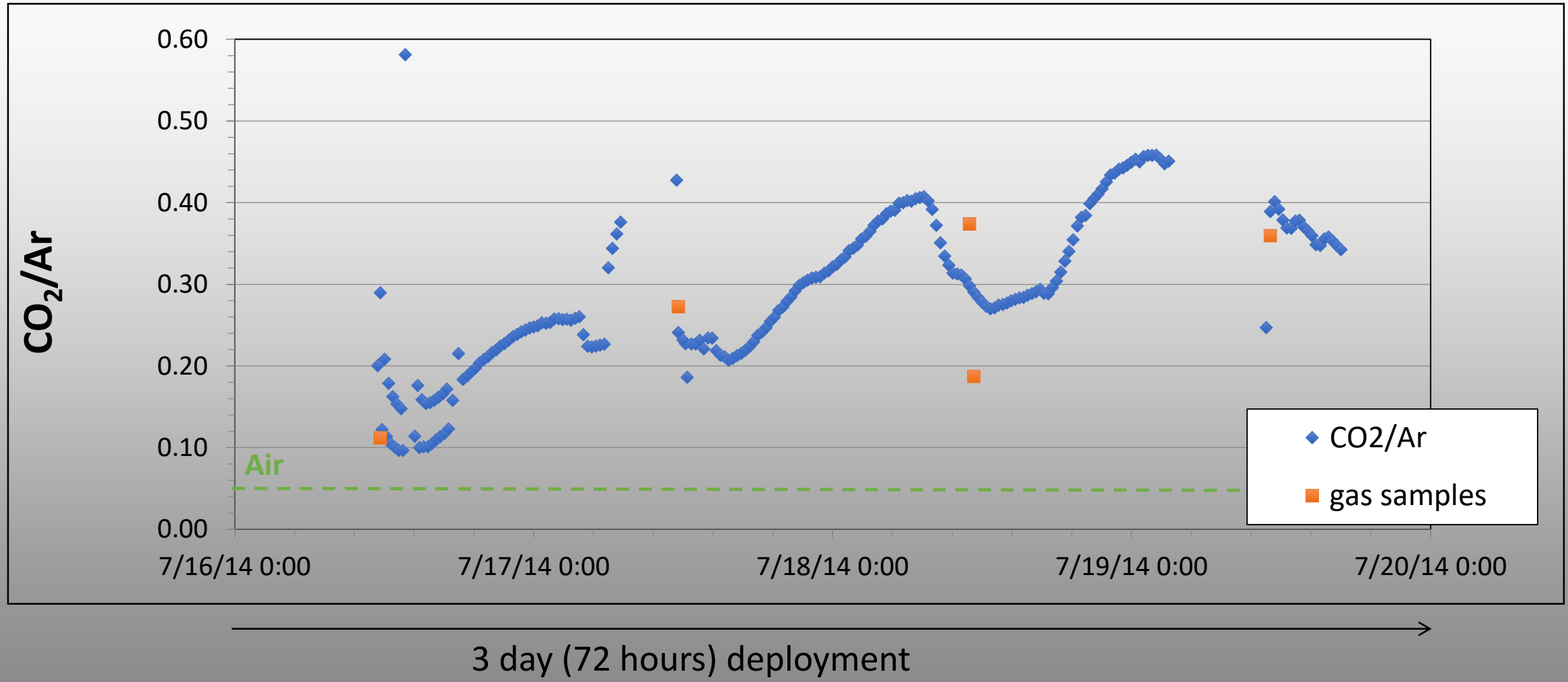

# Discussion & Conclusions

- Weather was a big factor in this short deployment, with increasing rainfall at the site over the deployment period. This apparently affected the signal strength from the fumarole, as seen in the decreasing partial pressures of all gases over time.

- A day-night pattern is clearly displayed that likely reflects the small ambient temperature variation. These partial pressure trends compare well with the internal temperature sensor data, but not with the fumarole temperatures taken manually.

- Although highly correlated, plots of Ar, $O_2$, $H_2O$, $CO_2$ and $CH_4$ versus $N_2$ show slope changes that reflect increasing volcanic signature with respect to nitrogen: higher $CO_2$ and $H_2O$ and lower atmospheric Ar and $O_2$ over time. Methane is abundant but shows no trend over time. It is likely sourced from local microbial activity.

- Lab-calibrated $CO_2$ and $CO_2$/Ar trends compare well with bottle sampling, showing a decrease in $CO_2$ concentration over time, but an increase in $CO_2$/Ar , consistent with an increasing volcanic signature of the rainfall-diluted fumarole gas flux over time.

Volcán Poas, Costa Rica
Hard on the equipment!
25/12/2009 09:53