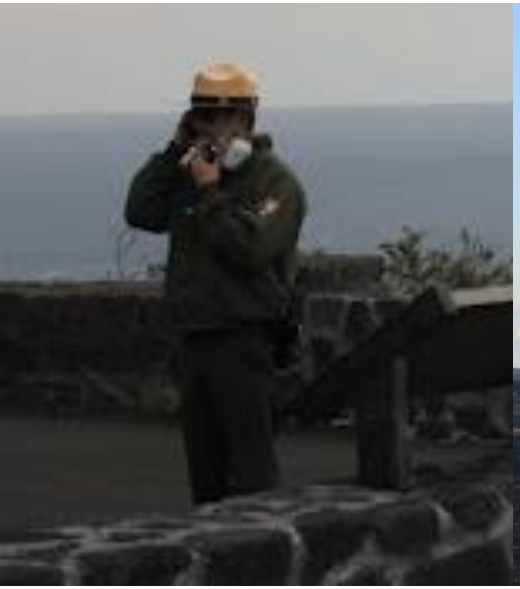
Air quality sensor networks near pollution hotspots: Measuring volcanic SO_2 levels on the Island of Hawai‘i

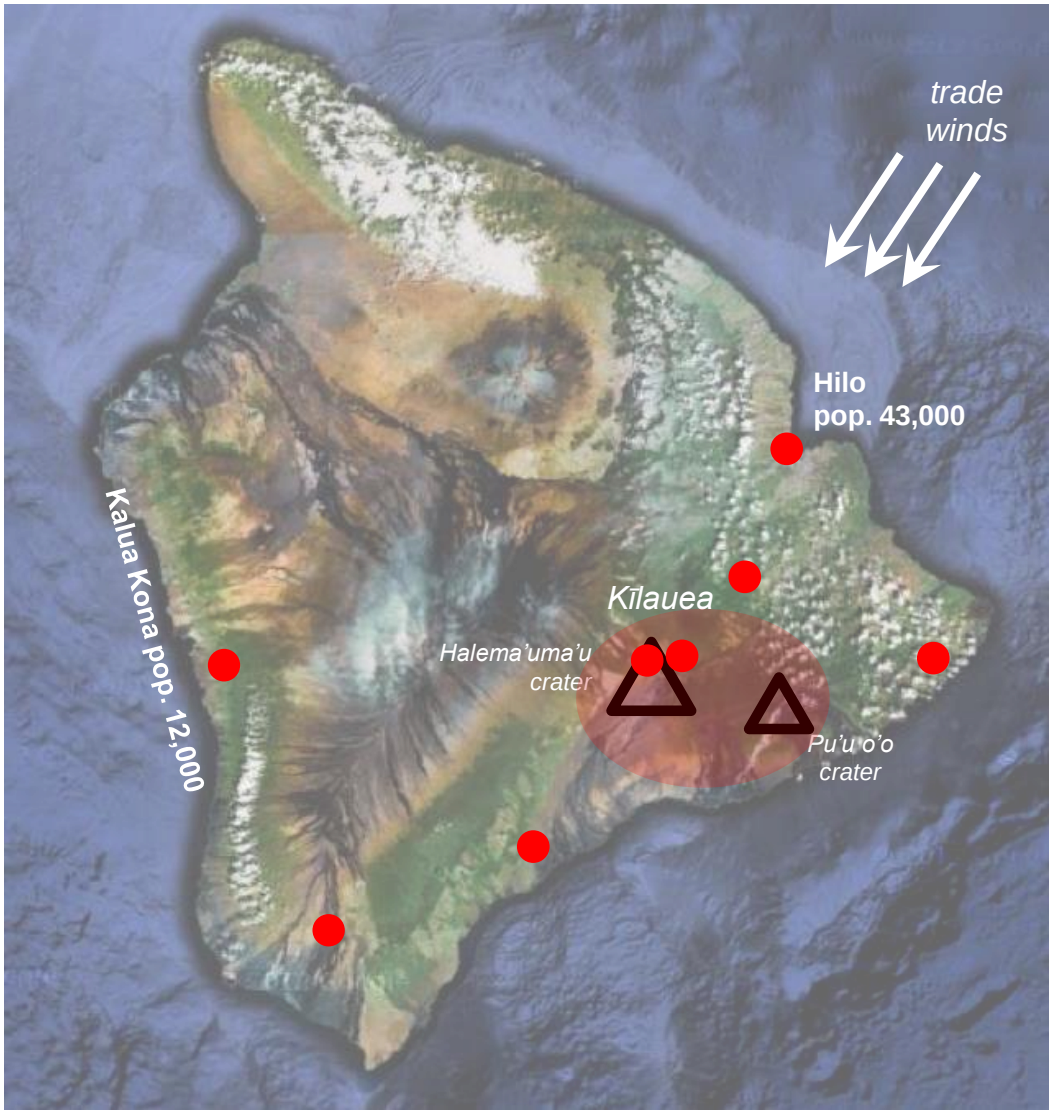


Civil and Environmental Engineering

Jesse Kroll
27 September 2017

MIT ATMOSPHERIC CHEMISTRY

Introduction: Air quality in Hawai‘i



area 10,400 km^2
pop. 187,000

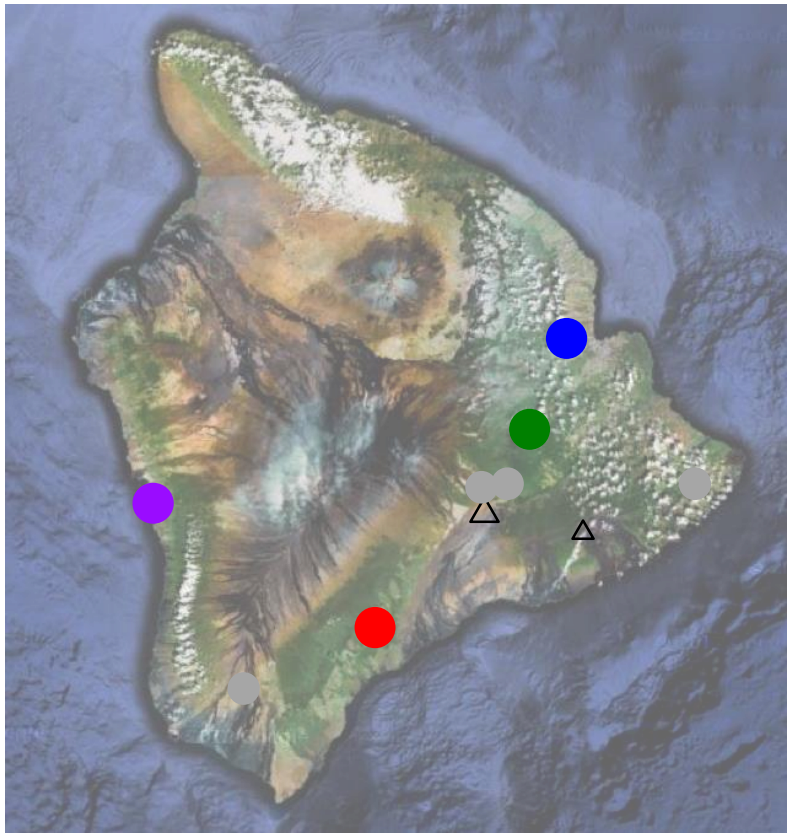
Kīlauea Volcano:

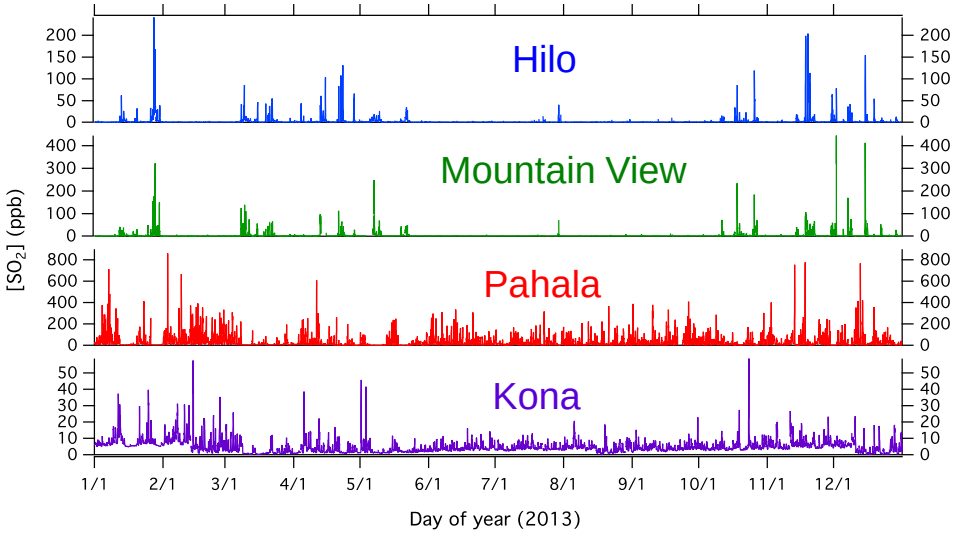
Largest point source of SO_2 in the U.S. (~1 Tg/yr)

SO_2, $PM_{2.5}$ (volcanic smog, or “vog”) represent a local nuisance and health concern

AQ monitoring stations run by DOH, NPS, USGS

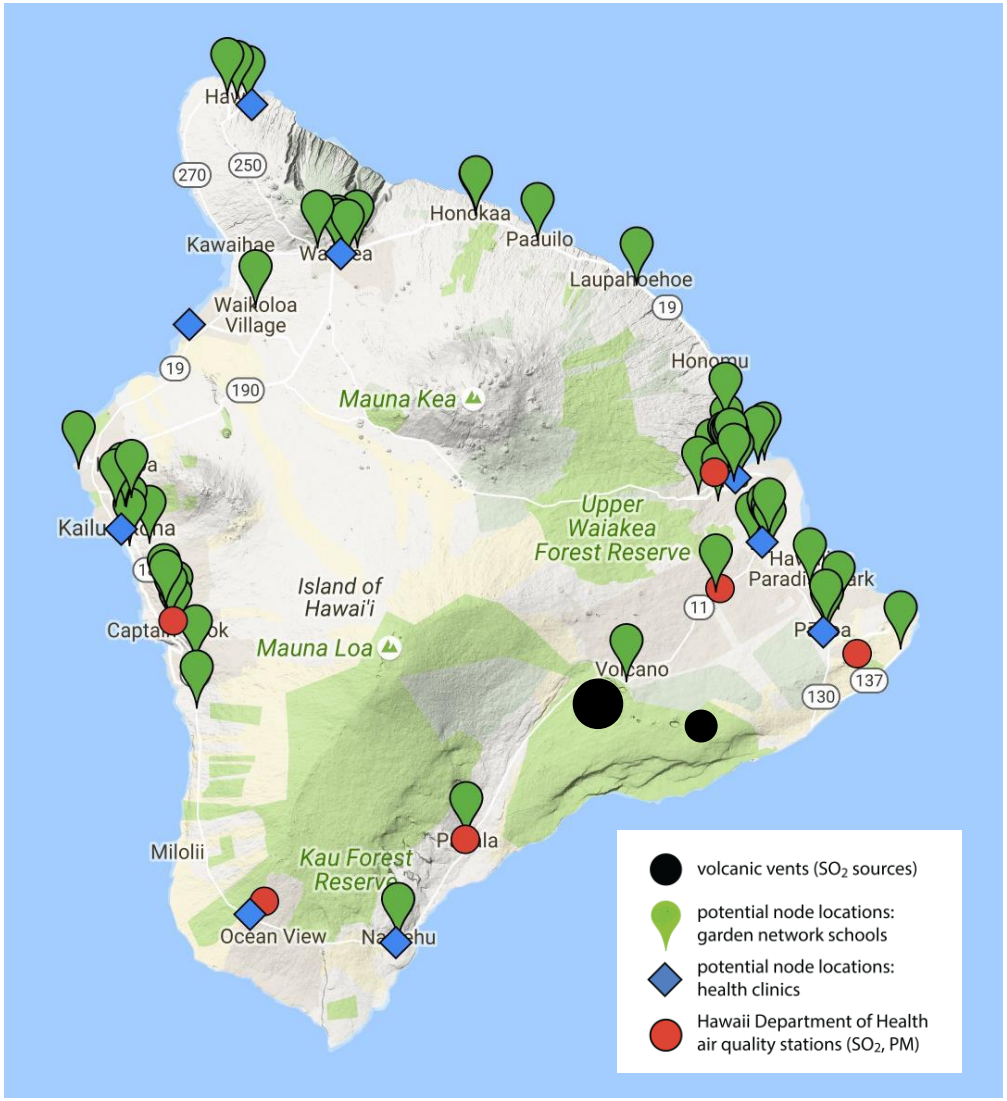
Spatial, temporal variability





data from Hawaii Dept. of Health Air Quality stations

Planned network (fall 2018)



Primary objectives:

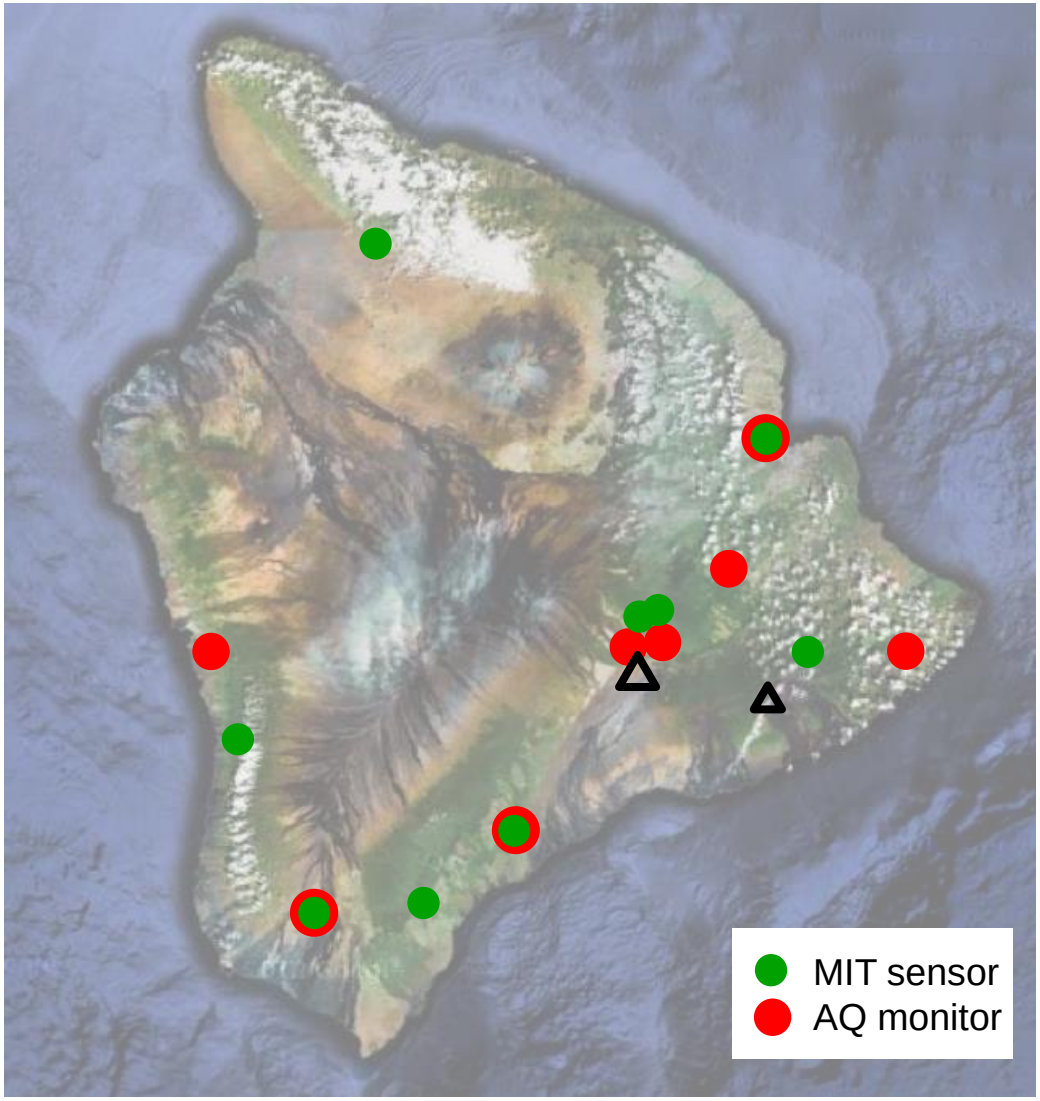
(1) characterize AQ sensors in these idealized conditions

(2) providing the population with highly localized AQ data

~40 sensor nodes for measuring SO_2, $PM_{2.5}$, and meteorological parameters

primarily located at schools (green pins), local health clinics (blue diamonds)

Proof-of-concept network



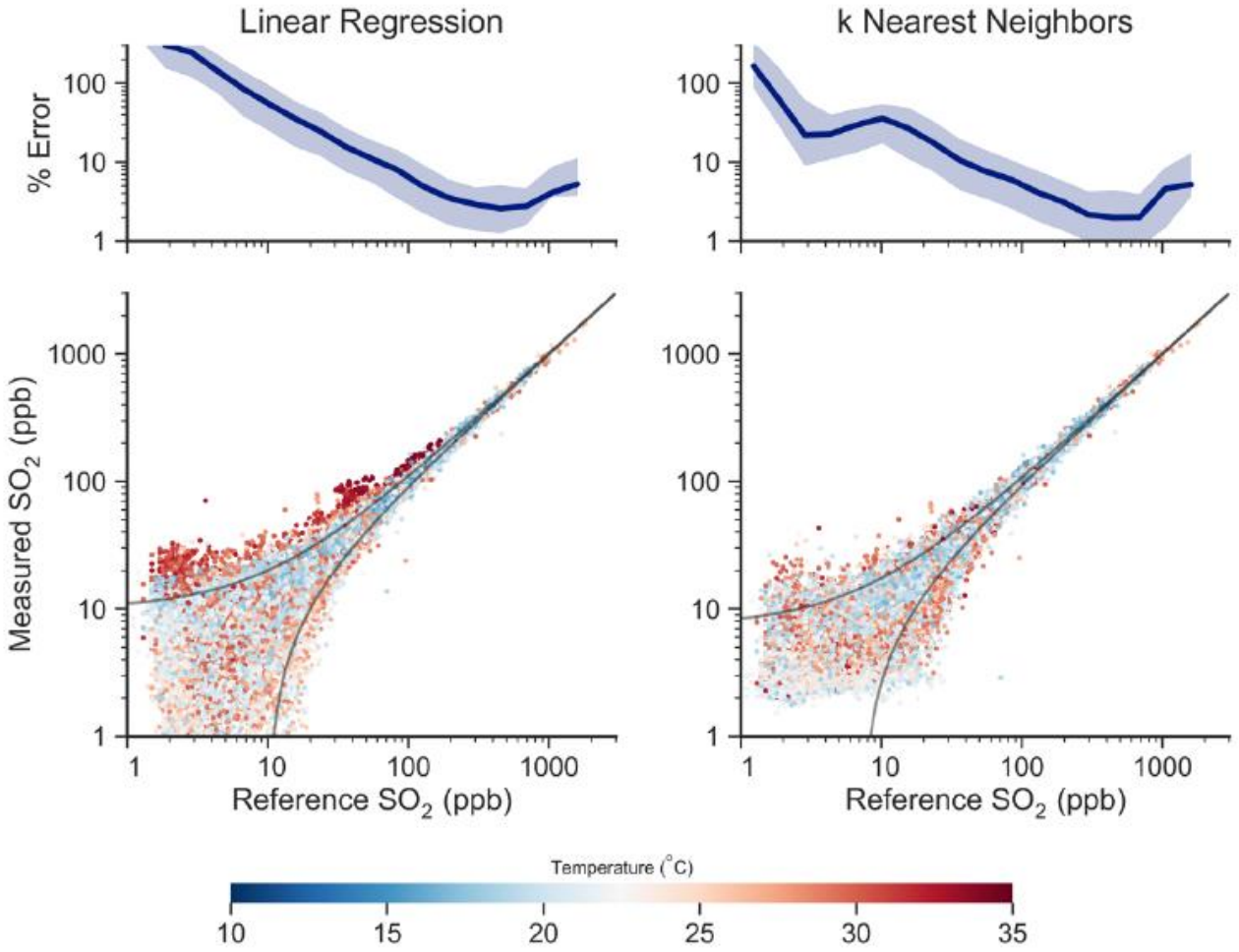
Deployed Jan 2017

SO_2 (Alphasense B4), RH/T

Solar-powered, 3G enabled (total components: ~$400)

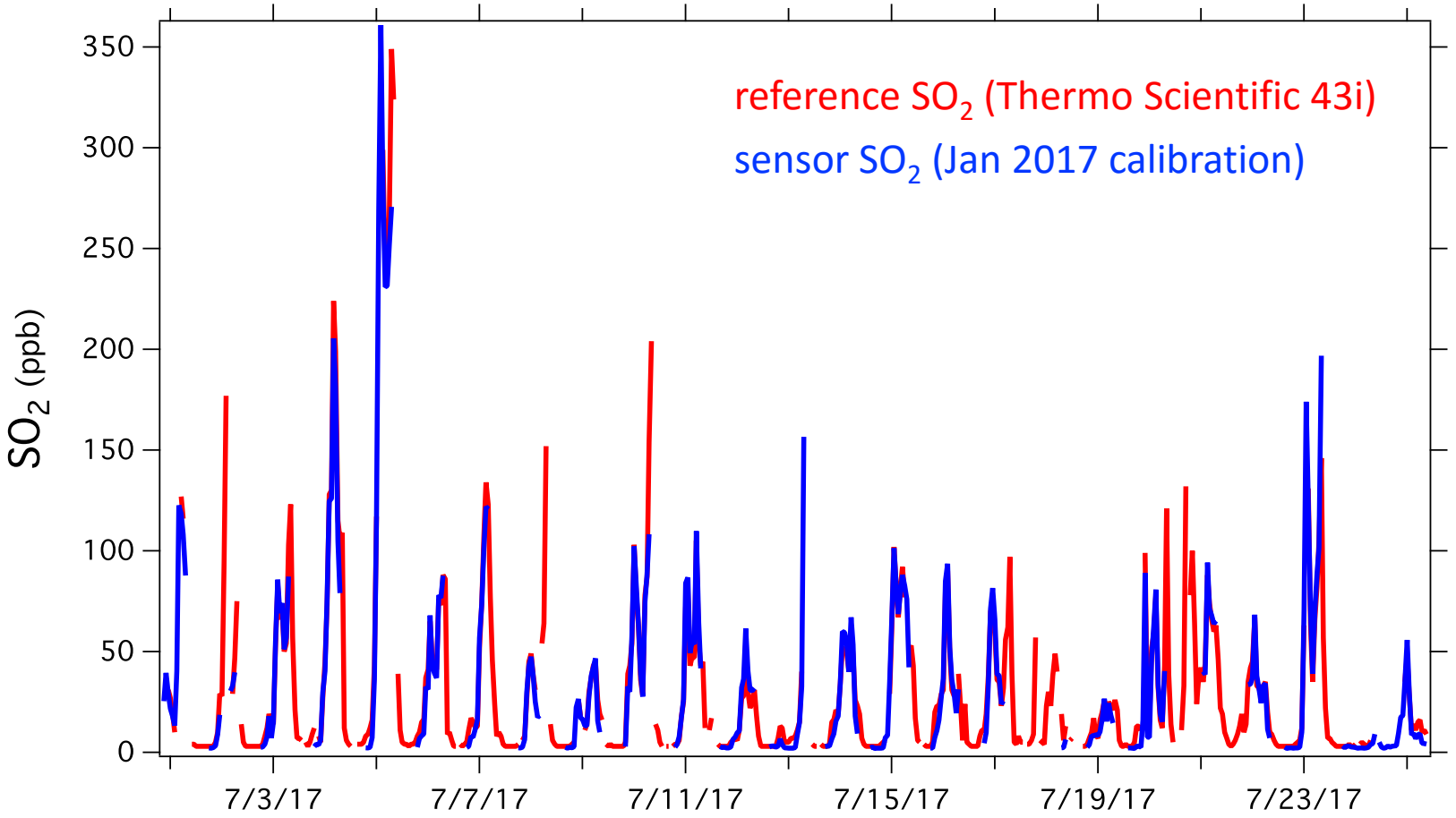
Calibration: co-location with DOH monitors [Hagan et al, *AMTD* 2017]

Calibration



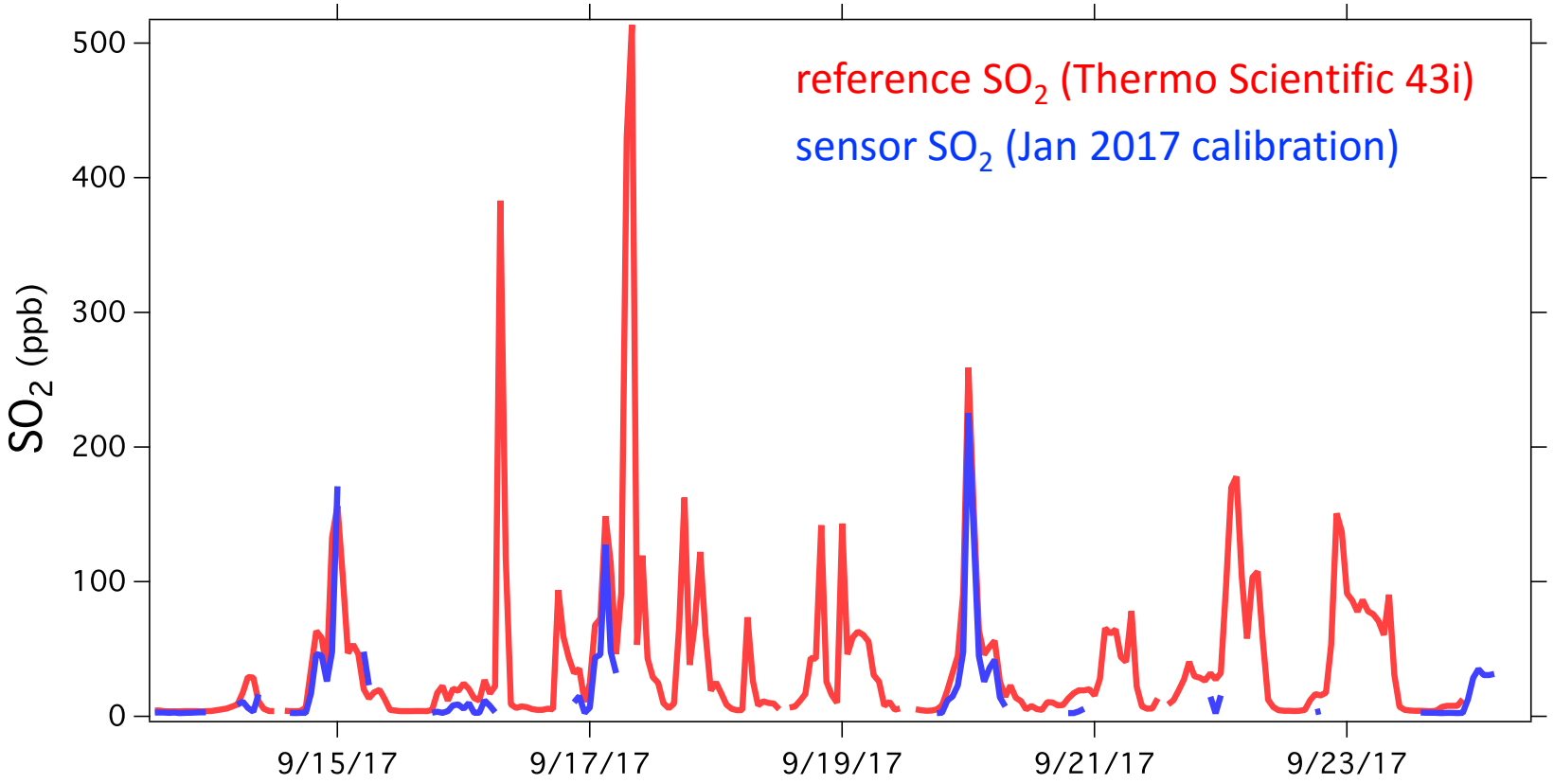
[Hagan et al., *AMTD* 2017]

Sample data: ~6 months in



no sign of sensor/sensitivity decay, or baseline drift

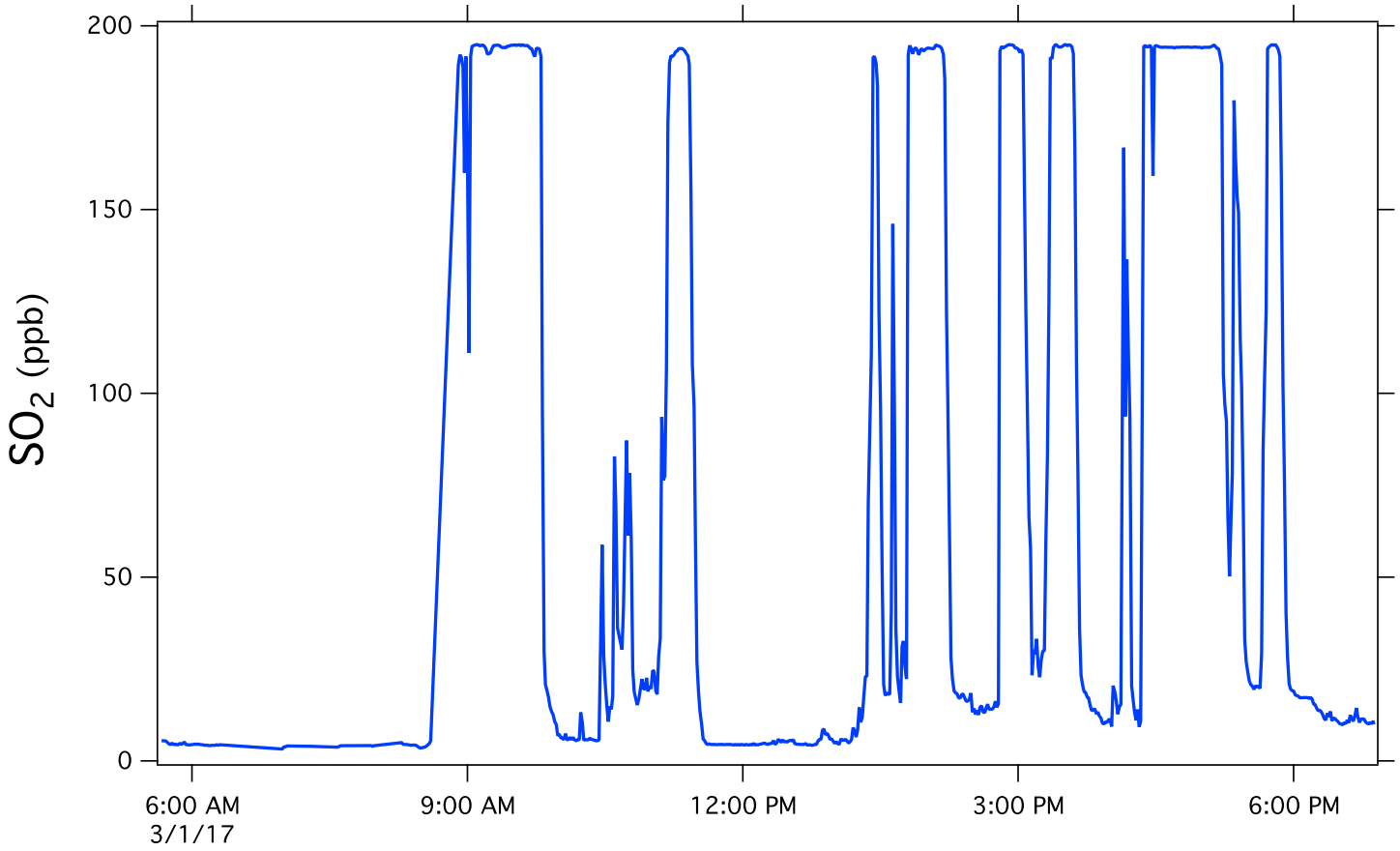
Sample data: ~8 months in



missing data (+ poorer accuracy): failing RH/T sensor

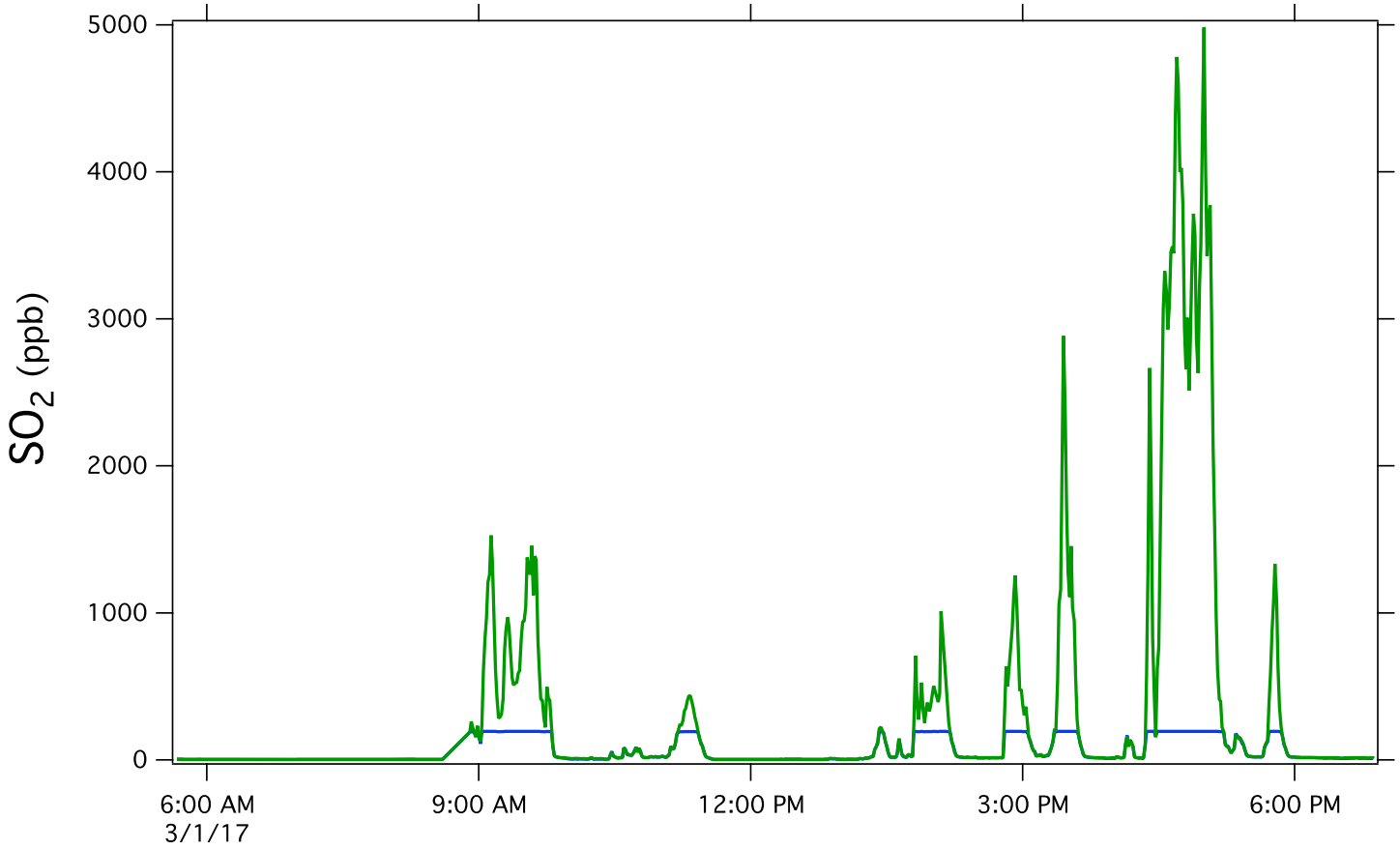
SO_2 measurements (~2 km from crater)

Calibration from kNN, using a training set truncated at ≤200 ppb:



SO_2 measurements (~2 km from crater)

"Hybrid" calibration [Hagan et al., *AMTD* 2017]:
extrapolating to higher [SO_2] using linear regression:



Conclusions

The Island of Hawai‘i represents a unique testbed for low-cost AQ sensors (one gas-phase pollutant; extreme variability in levels)

Calibration by co-location with regulatory-grade monitors is promising, but introduces challenges when moving to new locations

AQ sensor nodes after 8 months of continuous operation:
- no major problems associated with power, communication
- no evidence of AQ sensor drift
- long-term viability limited by the RH/T sensor

Schools as “hosts” for sensor nodes

Acknowledgements/collaborators

MIT CEE: David Hagan, Jon Franklin, Gabriel Isaacman-VanWertz, Colette Heald

MIT CEHS: Kathy Vandiver

TKC: Betsy Cole, Donna Mitts, Nancy Redfeather

Hawaii Dept. of Health: Lisa Wallace

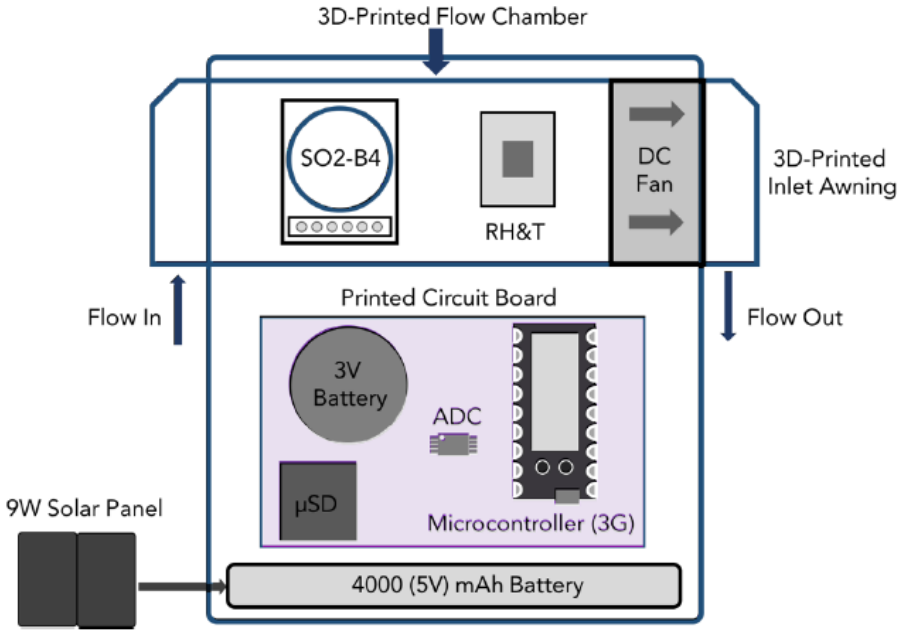
Teachers/Principals: Wendy Baker, Kalima Cayir, Ben Duke, Steve Hirakami, Darlene Javar, Chris King-Gates, Cindy Watarida

EPA's Science to Achieve Results (STAR) program

MIT's Tata Center for Technology and Design

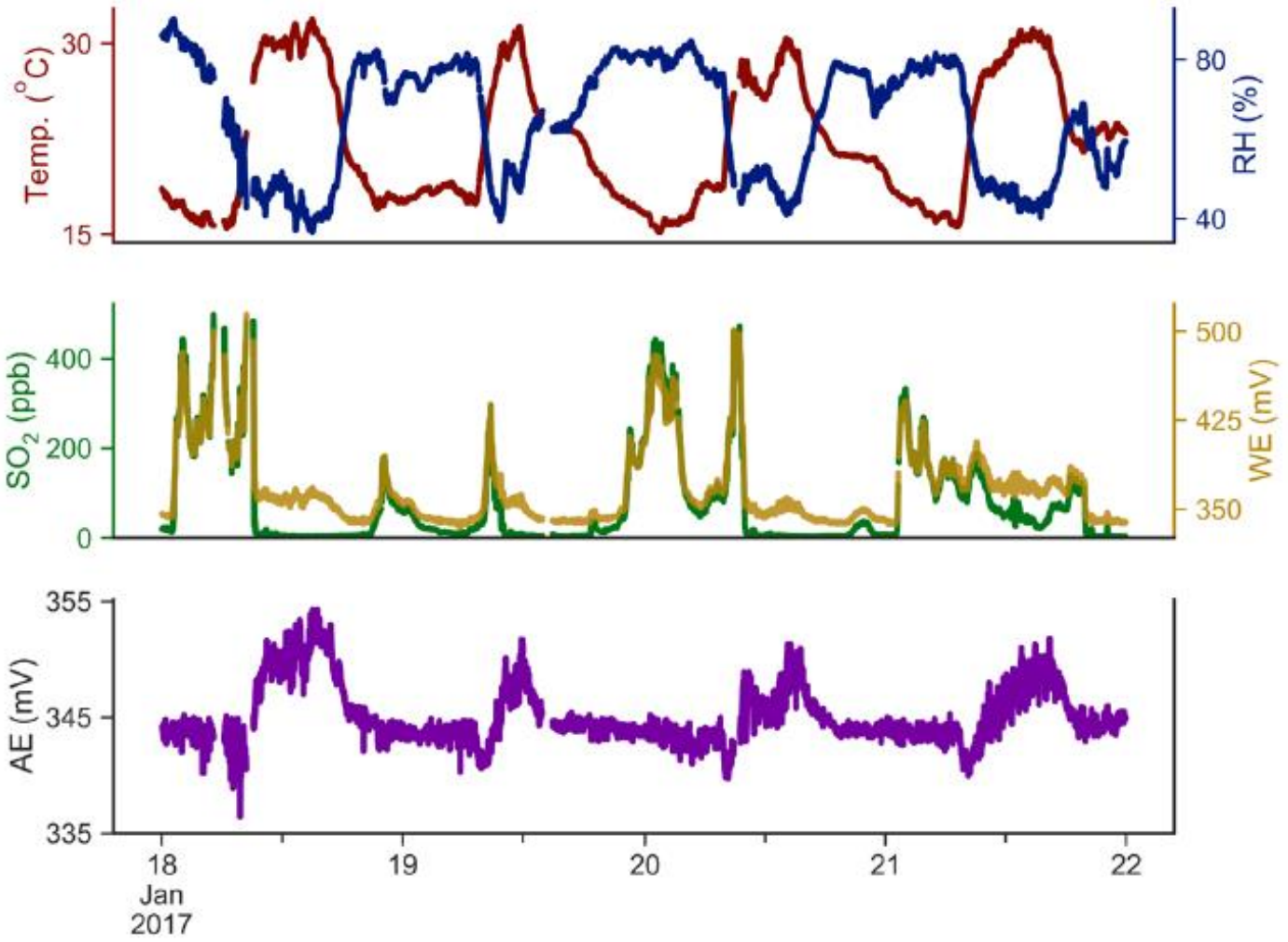
Extra slides

Sensor node



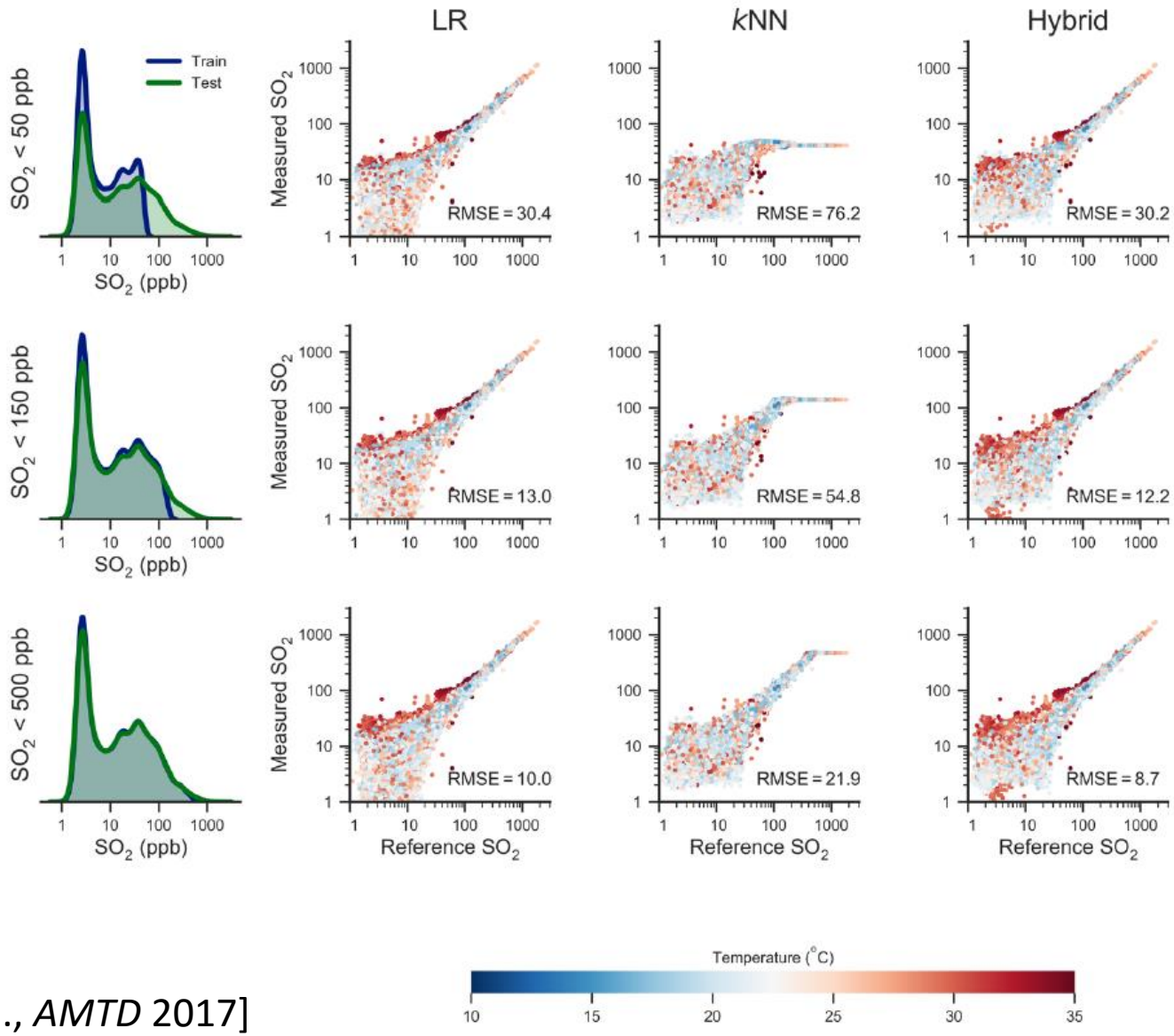
[Hagan et al., *AMTD* 2017]

Sample data



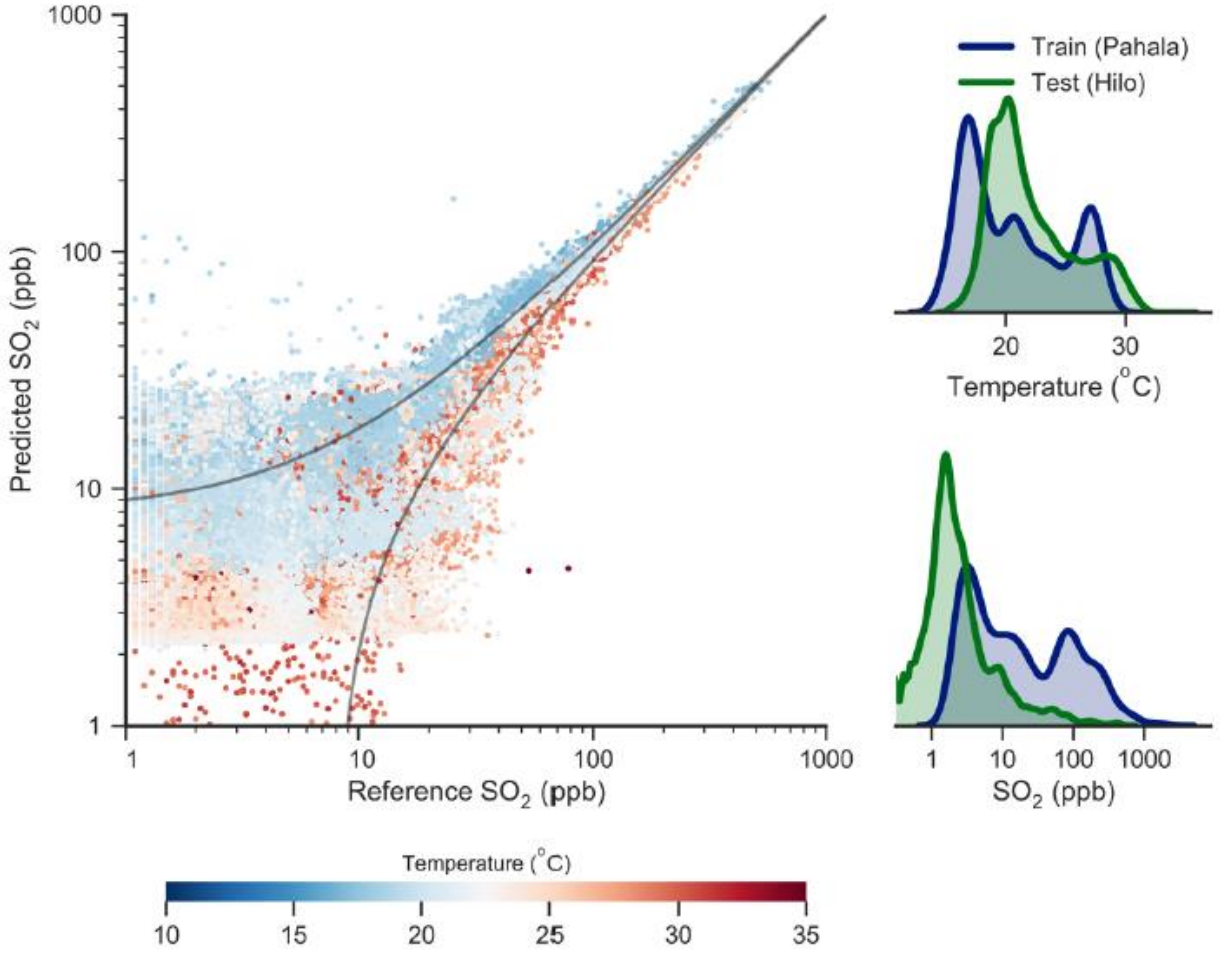
[Hagan et al., *AMTD* 2017]

Extrapolation



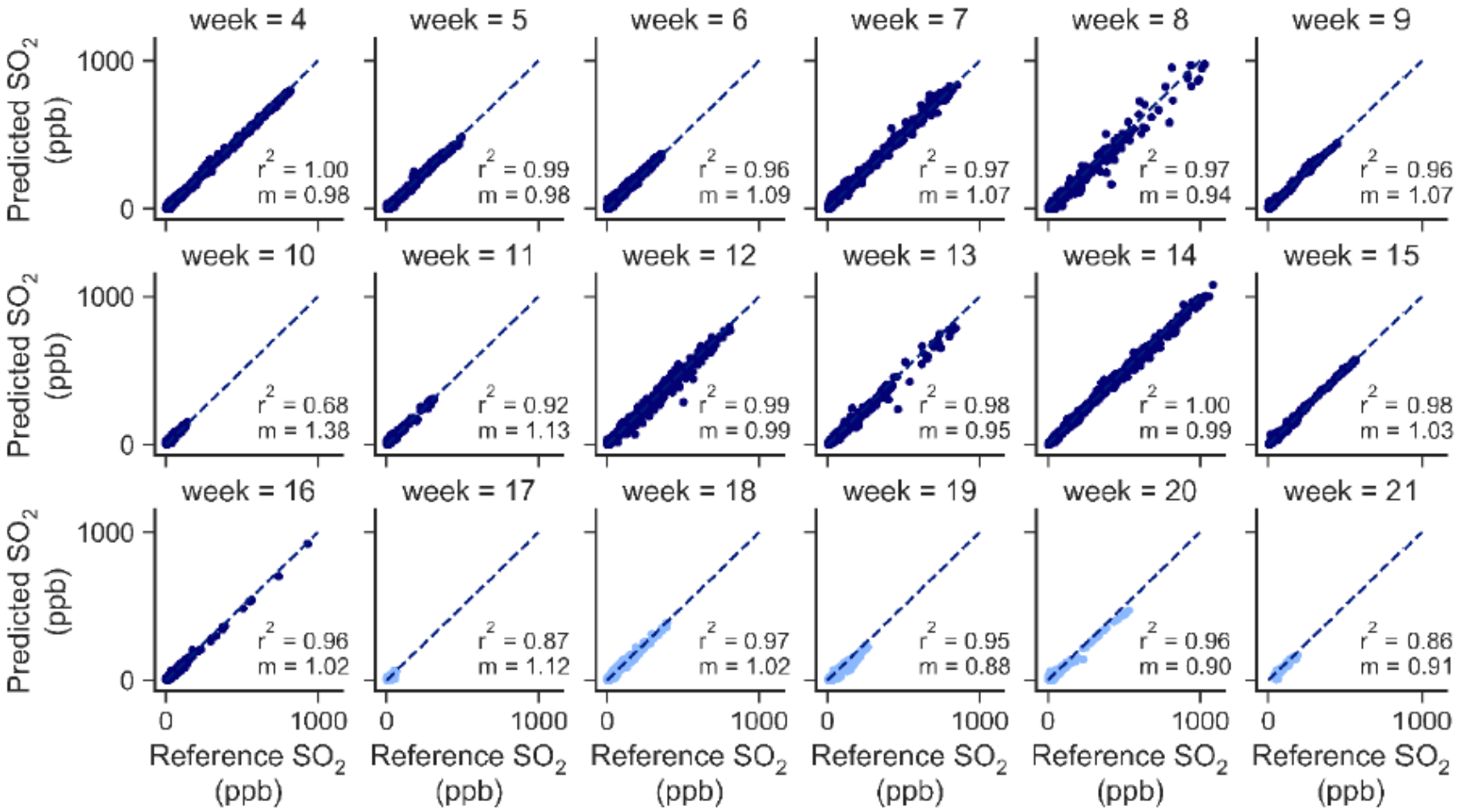
[Hagan et al., *AMTD* 2017]

Changing locations



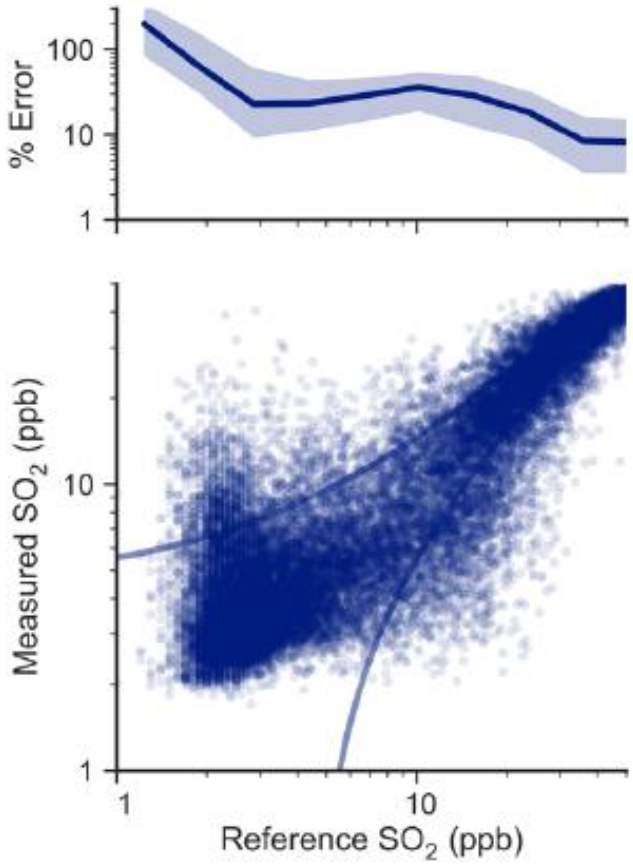
[Hagan et al., *AMTD* 2017]

Sensor drift



[Hagan et al., *AMTD* 2017]

Low concentrations



[Hagan et al., *AMTD* 2017]