The Hawai‘i Island Vog Network: Building a community-based sensor network to track vog emissions

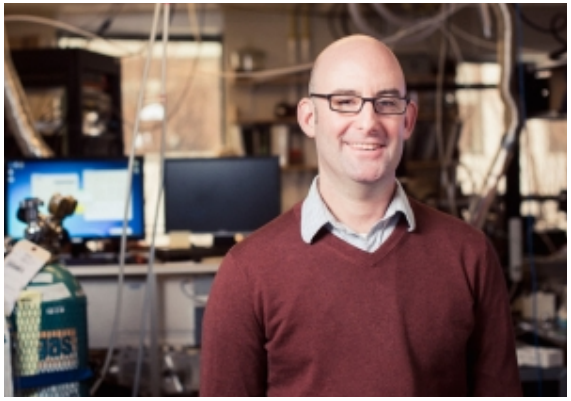
Civil and Environmental Engineering

MIT CEHS

THE KOHALA CENTER
education. environment. empowerment.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Introductions: MIT Team



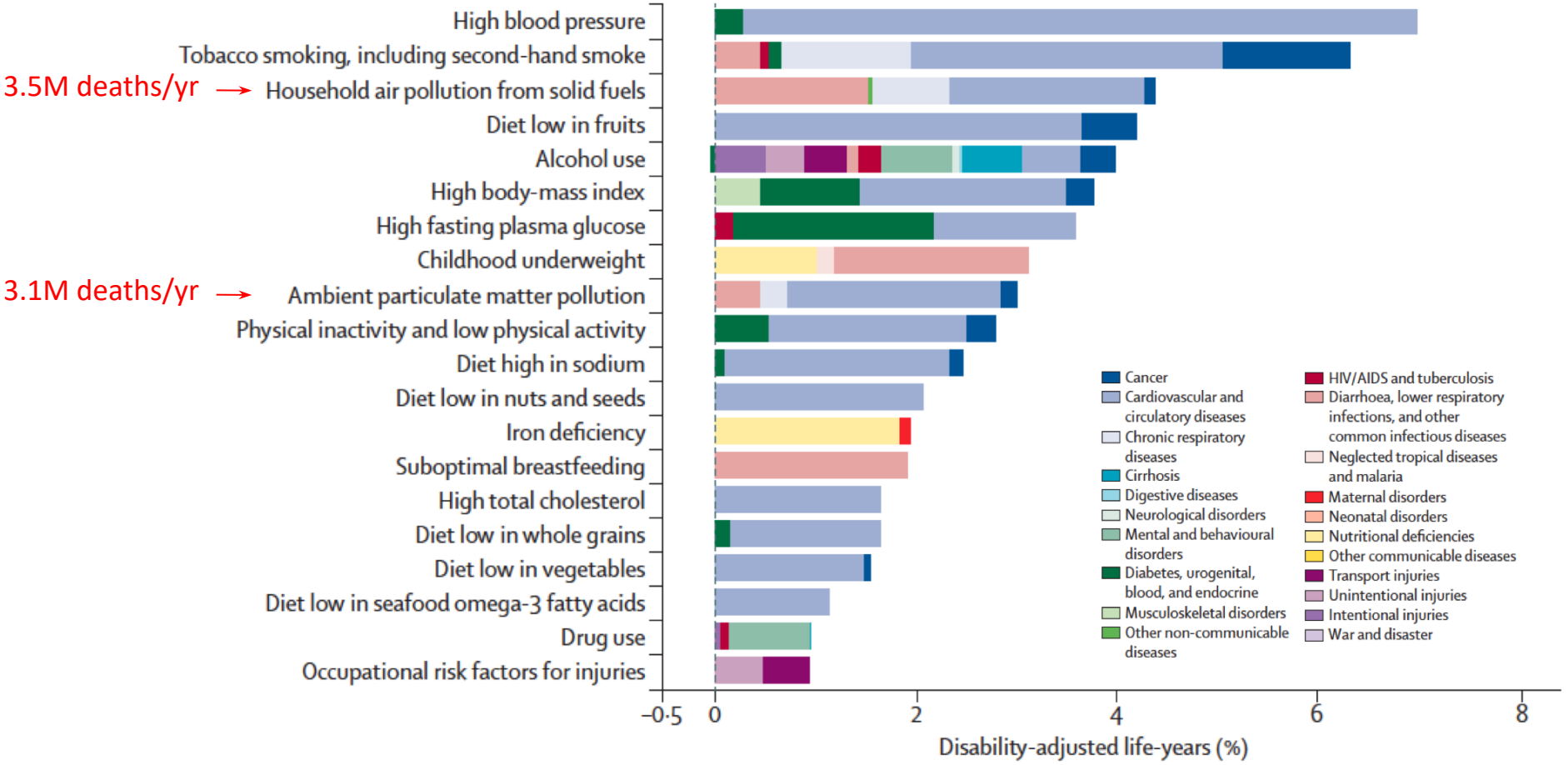
Jesse Kroll
(Principal Investigator)

Colette Heald
(co-Principal Investigator)

Ben Crawford
(Postdoc, Local Project Lead)

Kathy Vandiver
(Education Coordinator)

Aerosol Pollution is a Significant Public Health Concern



[Lim et al., 2012]

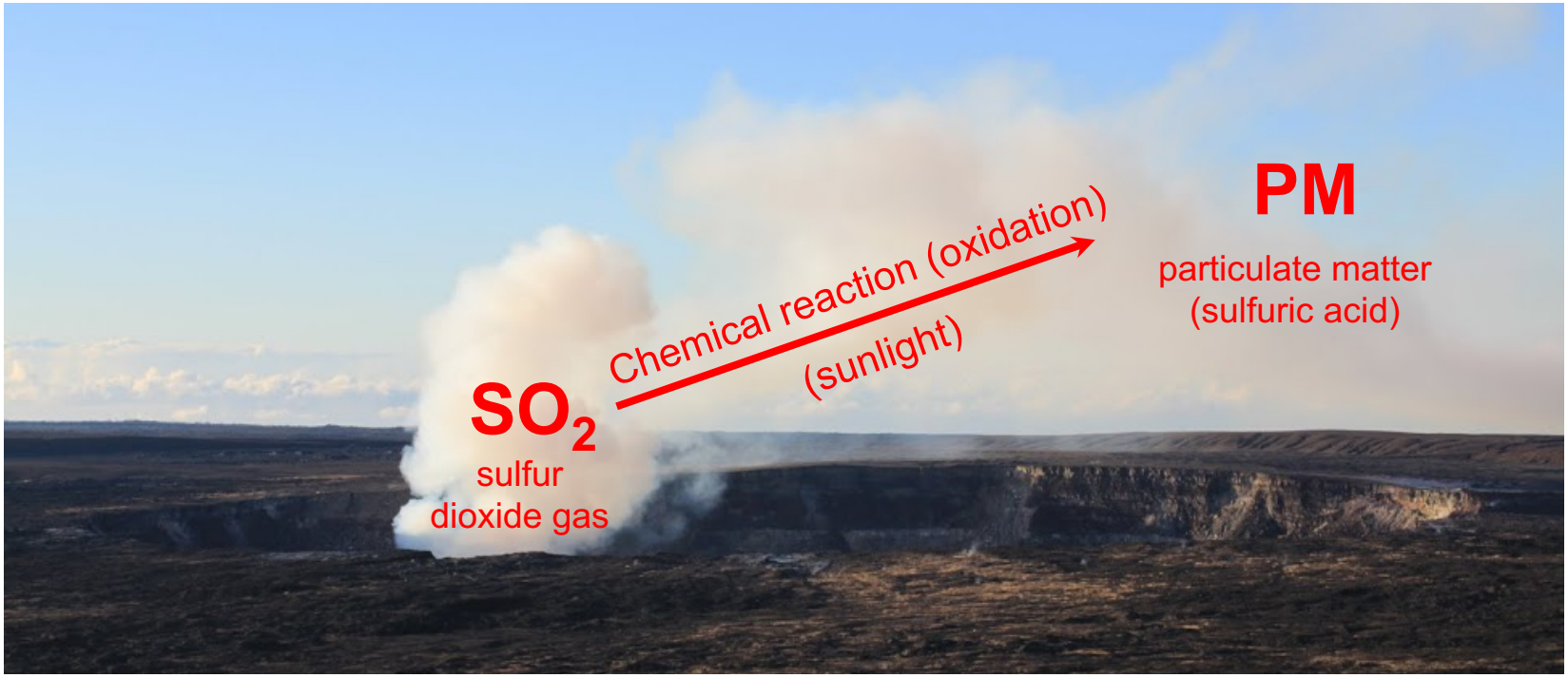
Project Origins: MIT class
“Traveling Research Environmental Experiences” (TREX)

January-term undergraduate class in MIT’s
Department of Civil and Environmental Engineering



research in Hawai‘i since 2001
studies of vog since 2012 (77 students)

Volcanic emissions ("vog")



~4000 tons SO_2/day

(largest single source in the US)

toxic to humans, plants

unhealthy to breathe

highly acidic

Health impacts of vog

Vog exposure is correlated with:

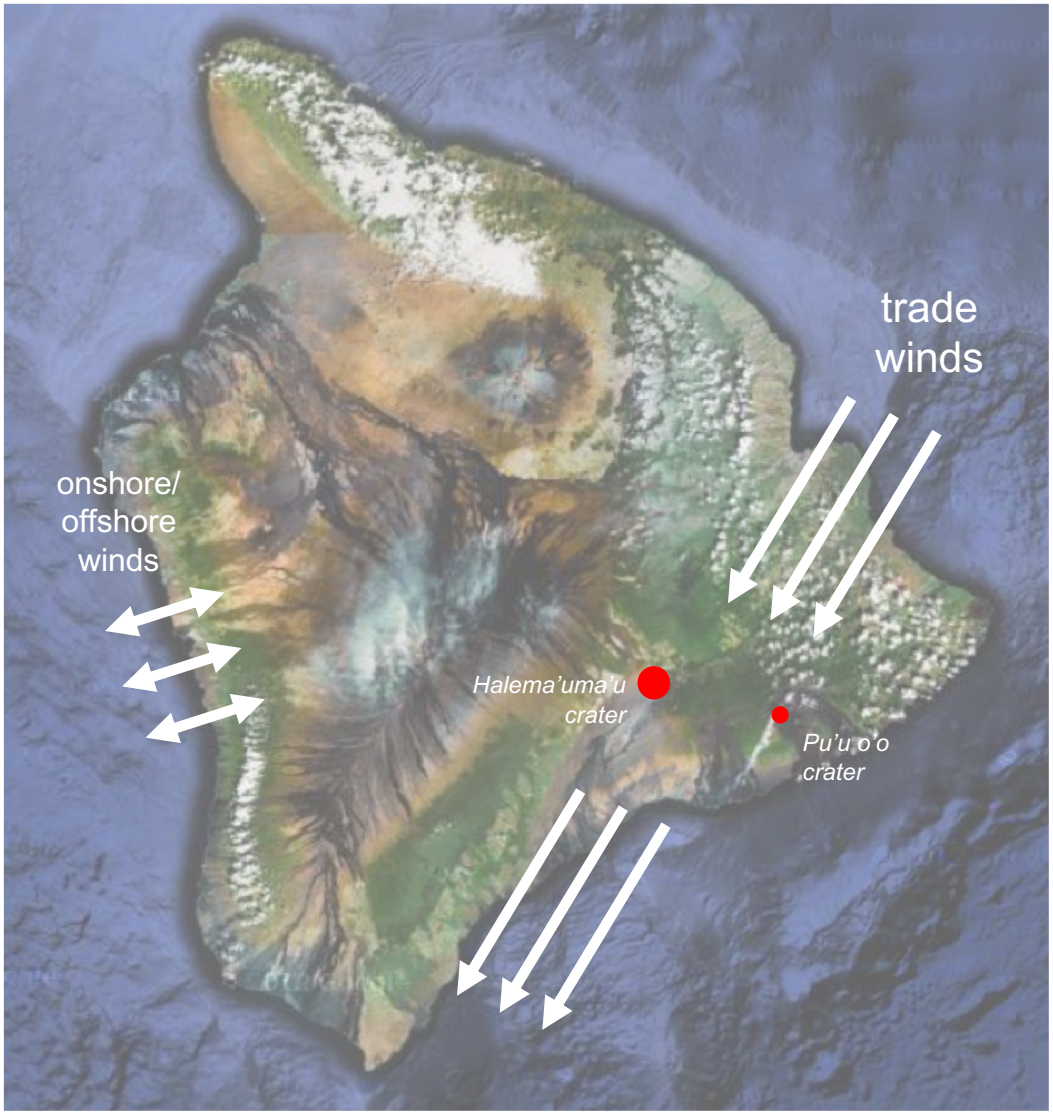
- increased blood pressure
- diagnosed hypertension
- increases in outpatient clinic visits for cough, headache, pharyngitis, and acute airway problems
- self-reported cough, phlegm, rhinorrhea, sore/dry throat, shortness of breath, sinus congestion, continual wheezing, eye irritation, skin irritation…

Among children, exposure to acidic PM is correlated with:

- cough, decreased FEV1/FVC (decreased pulmonary function)
- but not asthma or bronchitis

Longo 2008, Longo et al. 2010, Longo 2013, Tam et al. 2016

Air quality in Hawai‘i



Major pollutant of concern depends on location:

Hilo side - “fresh” vog - **SO_2**

Kona side - “aged” vog - **PM**

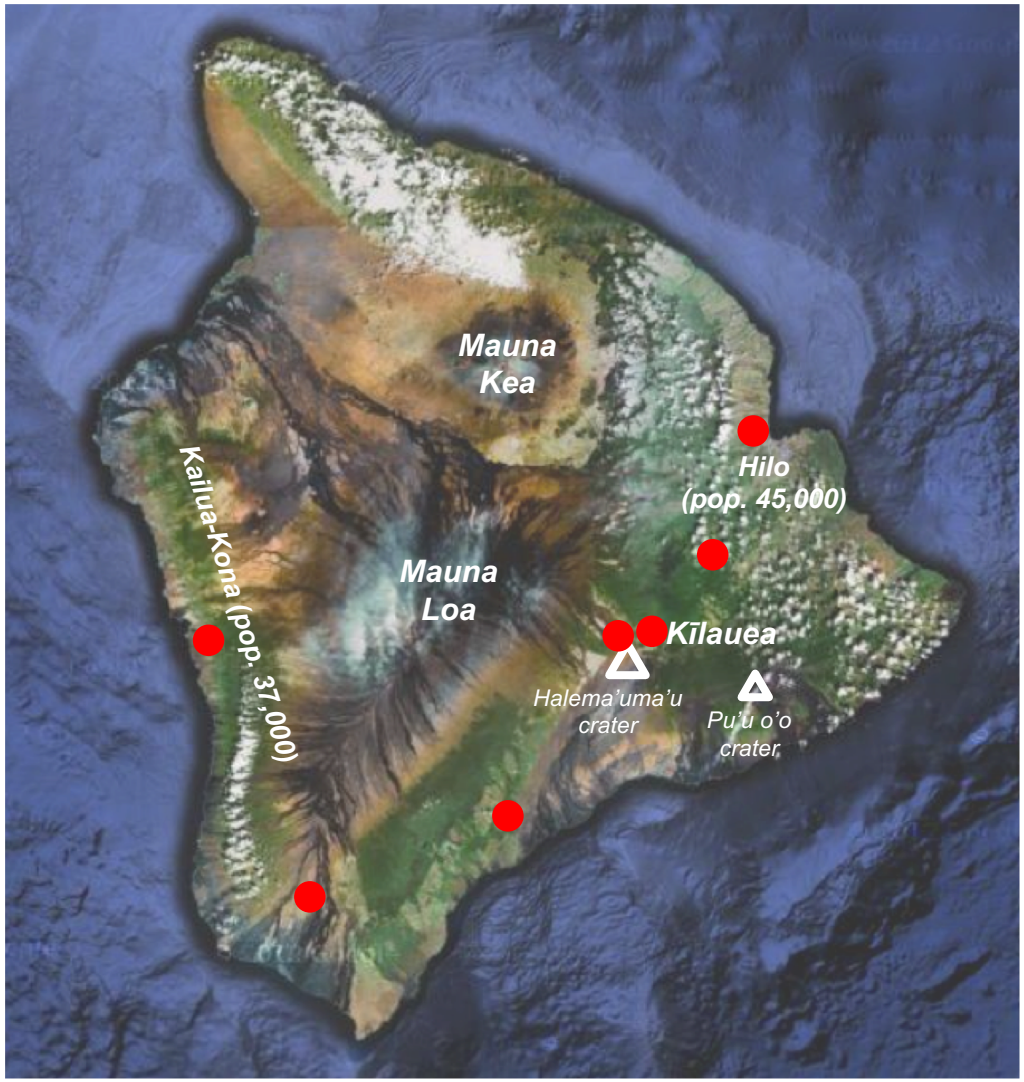
How to measure air quality?

- Research/regulatory grade instrumentation
- **Advantage:** precision and accuracy

- **Challenge:** expense (~$10K per sensor)
  - Limited spatial coverage -> where to place instruments?
    - Representative of a large area
    - Different purposes (e.g. research vs public health)

Met One Instruments, Beta Attenuation Monitor (BAM)

Air quality monitoring in Hawai‘i

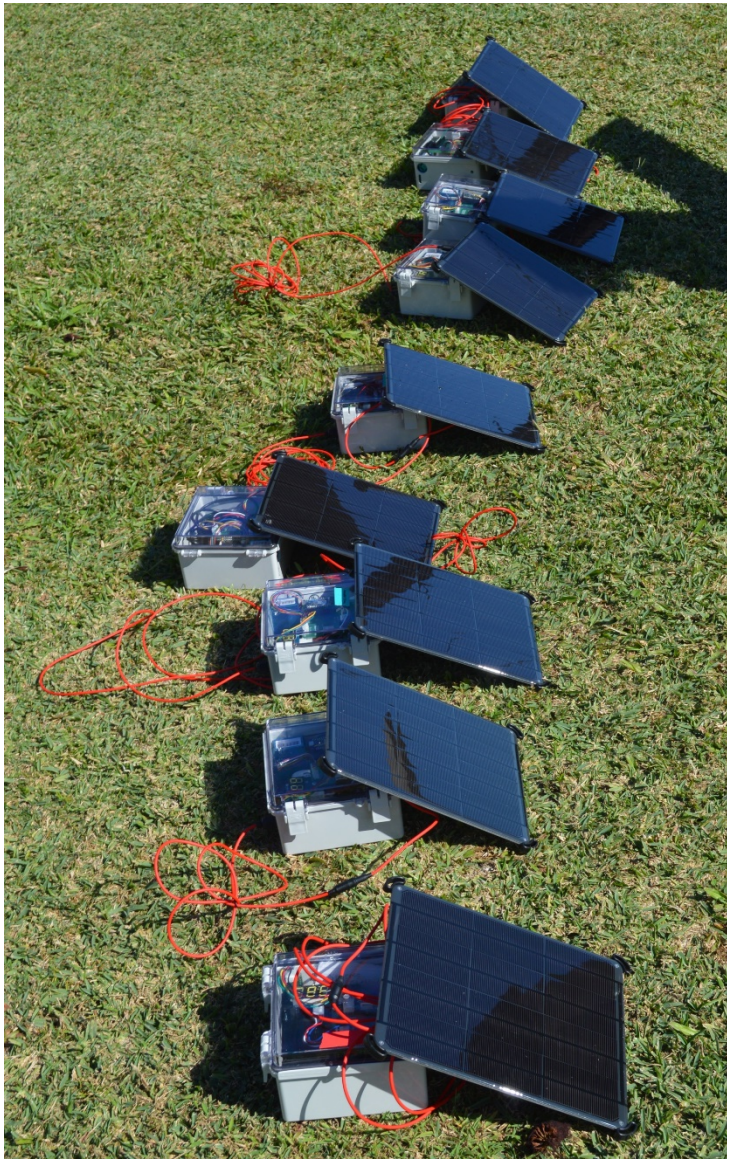


7 SO_2/PM monitoring sites

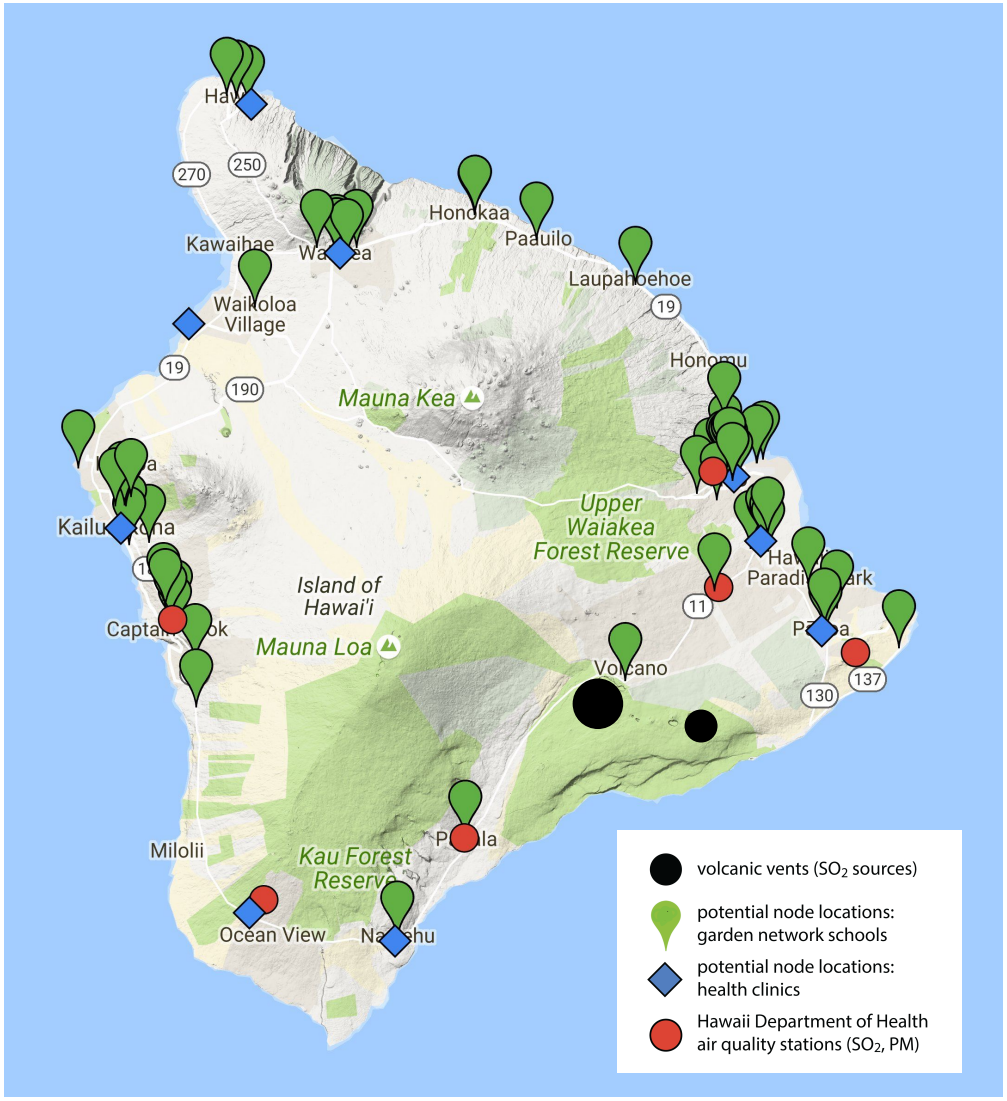
(5 Hawai'i Department of Health, 2 NPS/USGS)

Low-cost approach

- **Advantage:** inexpensive (~$200 per sensor)
  - Dense spatial coverage
- **Challenge:** sensor performance needs to be studied
  - Calibration & maintenance for a large number of sensors

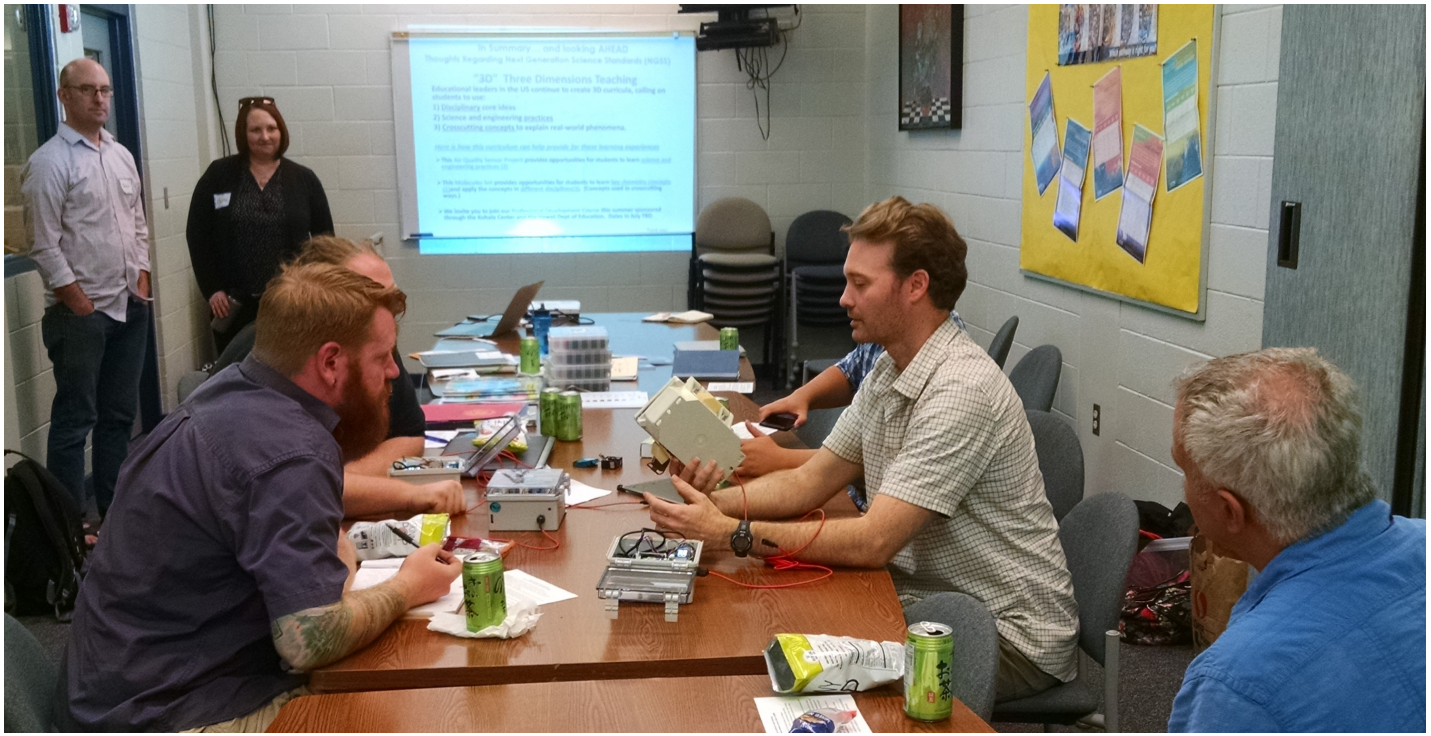


Planned low-cost network



- Several dozen sensor nodes for measuring Vog components and meteorological parameters
- Primarily located at schools (green pins), local health clinics (blue diamonds)
- Expected deployment: fall 2018
- Data sent in near-real-time to a server for online access via a public web portal
- **Intended as a public resource**

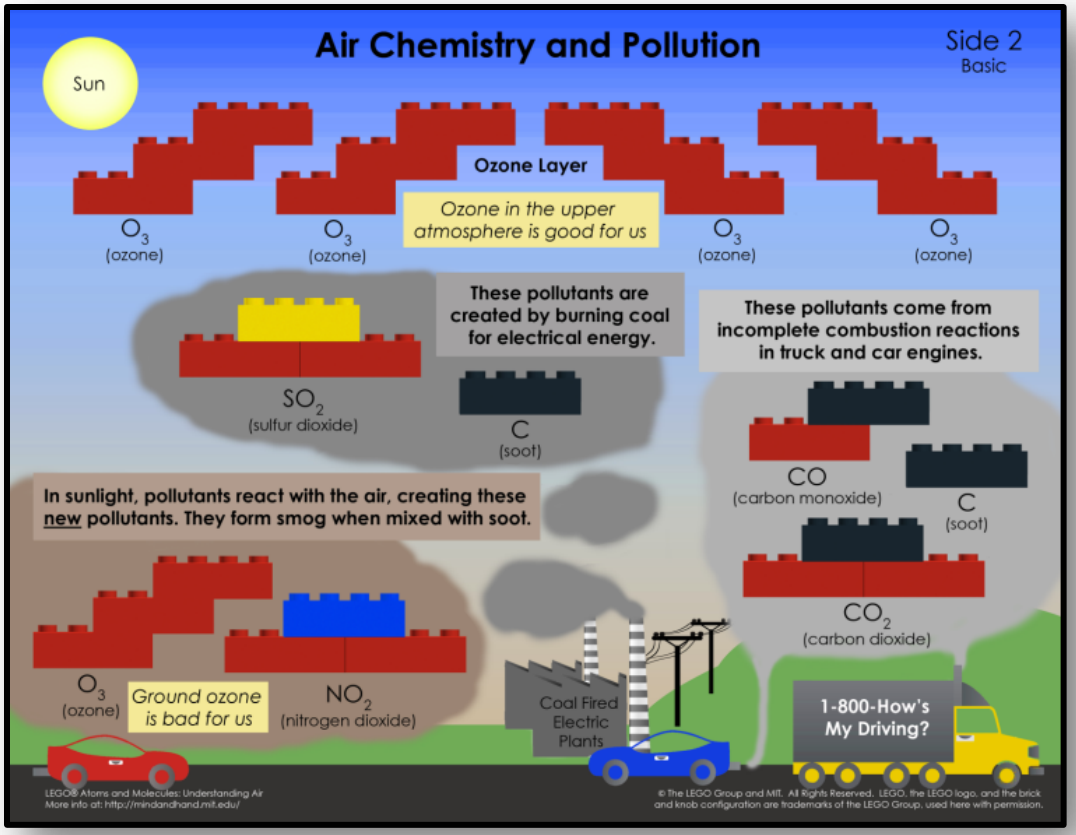
Education and Engagement



-January 2018: Project team (Kroll, Heald, Vandiver, Crawford) traveled to Hawai‘i to discuss the project with teachers, health professionals, and community members
- 3 teacher workshops (~50 educators total)
- 4 meetings at health clinics (~10 health professionals)
- public talk, several meetings with individuals

-Received offers to “host” sensor nodes, useful feedback on how the project can relate to educational curricula

Education and Engagement : **MIT Edgerton Center Molecule Set**



A hands-on STEM package for Teaching Key Concepts in Biology, Chemistry and Earth Science

Included in the PD Course planned for this summer
With the Air Quality Sensor Network!

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Funded by NIH-NIEHS Center Grant P30-ES002109

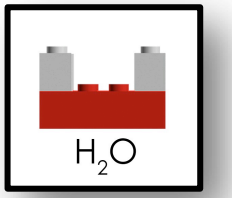
EDGERTON CENTER

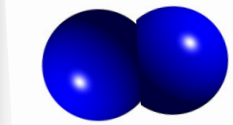
This curriculum is designed to introduce students to the Atomic Nature of Matter

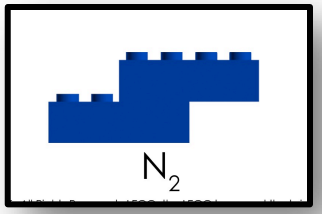
With examples from
- Chemistry
- Biology
- Earth Sciences

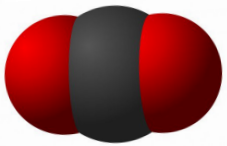
A LEGO® brick represents an atom. The key uses CPK chemistry colors.

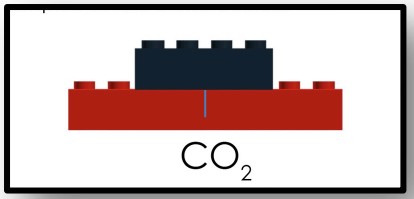
Hydrogen (H)	=	
Sodium (Na)	=	
Calcium (Ca) or Magnesium (Mg)	=	
Iron (Fe) or Copper (Cu)	=	
Carbon (C)	=	
Nitrogen (N)	=	
Sulfur (S)	=	
Oxygen (O)	=	
Chlorine (Cl)	=	











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Chemical reactions demonstrated in three subject areas:

Chemistry:
Chemical Reactions

Model the chemical reaction just experienced as a wet lab:
baking soda + calcium chloride produce sodium chloride, carbon dioxide, water and chalk.

Biology:
Photosynthesis

Model the reaction for photosynthesis: water and carbon dioxide produce sugar and oxygen. (The reaction for cellular respiration – the reverse can be modeled too!)

Earth Science:
Understanding Air

Model air as a mixture of gases.
→ *Model combustion using hydrocarbons + oxygen to produce carbon dioxide + water.*
Pollutants such as CO and C appear if less oxygen is available.

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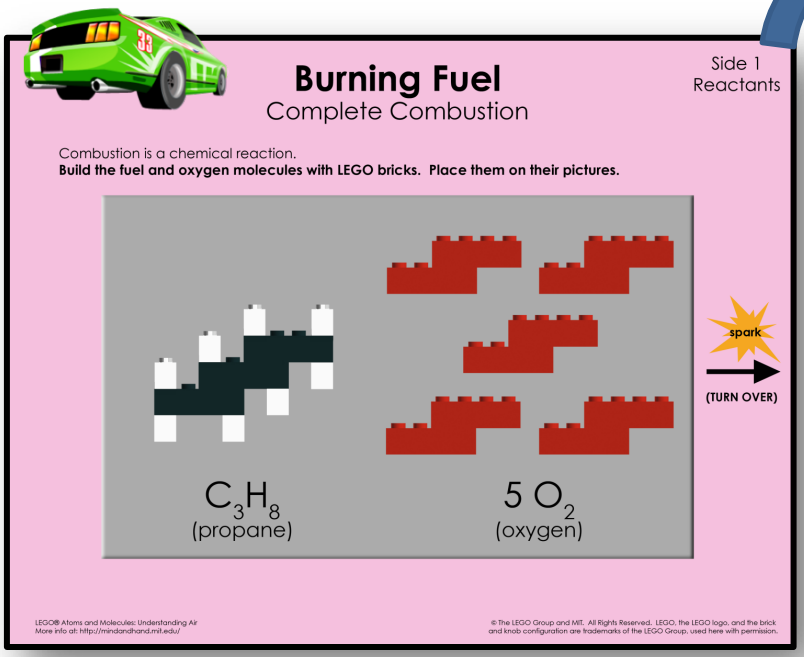
Lego chemical reaction example

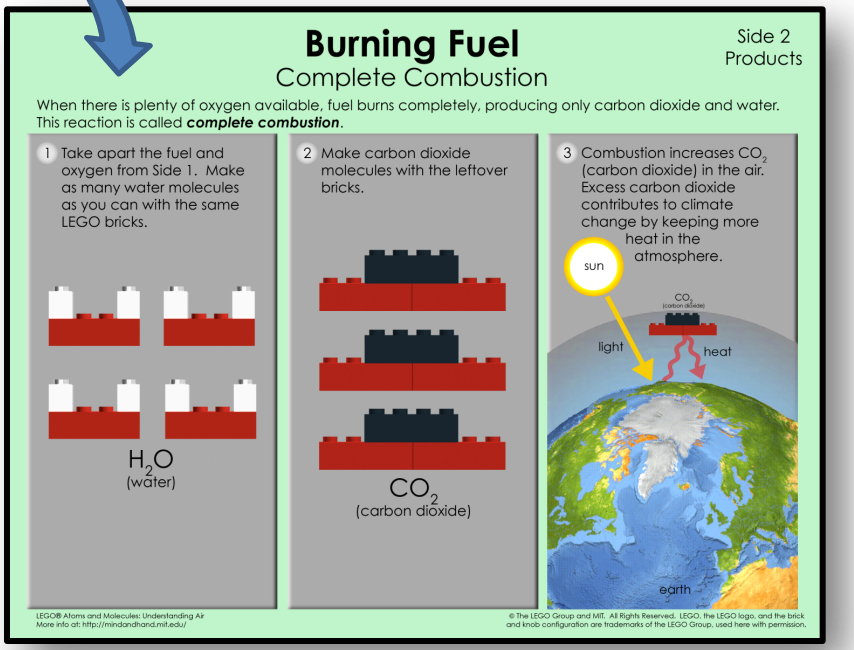
Years ago, CO_2 in the air measured 350 ppm (parts per million).
In January 2018, CO_2 in the air measured 406 ppm!
See how burning fuel continues to create more CO_2 below?

1) Build propane and oxygen.
Place the atoms on their pictures below.

Reaction Occurs!

2) Rearrange the <u>same</u> atoms into these products. Place them on their pictures below.





Next steps / feedback

September 2018: Educator PD course (Using the sensor node & data; Atoms and Molecules)

September 2018: Ben moves to Hawai‘i; Installation of sensor nodes

Please contact us if you are interested in “hosting” a sensor,
and/or if you have any ideas/thoughts/questions!

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Thanks!!