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

3.5M deaths/yr

3.1M deaths/yr

High blood pressure

Tobacco smoking, including second-hand smoke

Household air pollution from solid fuels

Diet low in fruits

Alcohol use

High body-mass index

High fasting plasma glucose

Childhood underweight

Ambient particulate matter pollution

Physical inactivity and low physical activity

Diet high in sodium

Diet low in nuts and seeds

Iron deficiency

Suboptimal breastfeeding

High total cholesterol

Diet low in whole grains

Diet low in vegetables

Diet low in seafood omega-3 fatty acids

Drug use

Occupational risk factors for injuries

Disability-adjusted life-years (%)

[Cancer]

[Cardiovascular and circulatory diseases]

[Chronic respiratory diseases]

[Cirrhosis]

[Digestive diseases]

[Neurological disorders]

[Mental and behavioural disorders]

[Diabetes, urogenital, blood, and endocrine]

[Musculoskeletal disorders]

[Other non-communicable diseases]

[HIV/AIDS and tuberculosis]

[Diarhoea, lower respiratory infections, and other common infectious diseases]

[Neglected tropical diseases and malaria]

[Transport injuries]

[Unintentional injuries]

[Intentional injuries]

[War and disaster]
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")

- $SO_2$ (sulfur dioxide gas)
- Chemical reaction (oxidation) under sunlight
- Particulate matter (sulfuric acid)

- ~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

Air quality in Hawai‘i

Major pollutant of concern depends on location:

Hilo side - “fresh” vog - $\text{SO}_2$

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

This curriculum is designed to introduce students to the Atomic Nature of Matter with examples from:
- Chemistry
- Biology
- Earth Sciences
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.
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.

2) Rearrange the same 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!!