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The Hawaiʻi Volcanic Smog Network: Tracking air quality and community engagement near a major emissions hotspot

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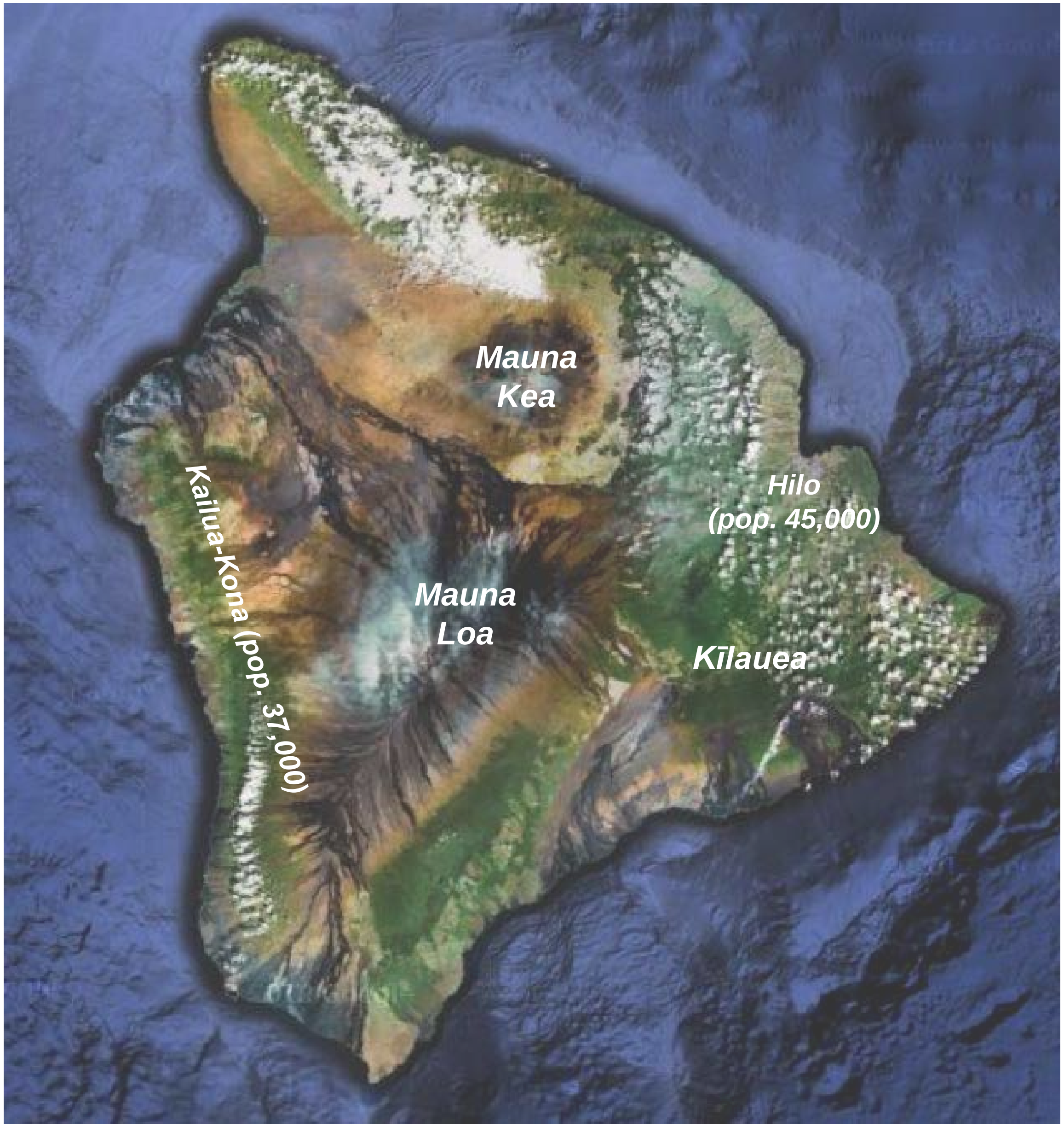
THE KOHALA CENTER
education. environment. empowerment.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Outline

1) Background/motivation
2) Technical approach
3) Community partnership
4) Education
5) Preliminary results, next steps

Island of Hawaiʻi



pop. 198,000

30.2% White (Non-Hispanic)
21.6% Asian
0.8% Black or African American
0.6% Native American
12.6% Hispanic or Latino
13.0% Native Hawaiian
30.1% Two or more races

18.3% Persons in poverty

US Census estimates, 2015

Air pollution

EPA's "Criteria Air Pollutants"

https://www.epa.gov/criteria-air-pollutants

CO carbon monoxide

O_3 ground-level ozone

NO_2 nitrogen dioxide

SO_2 sulfur dioxide

PM particulate matter

Pb lead

Wikipedia

Air pollution in Hawai‘i (“vog”)

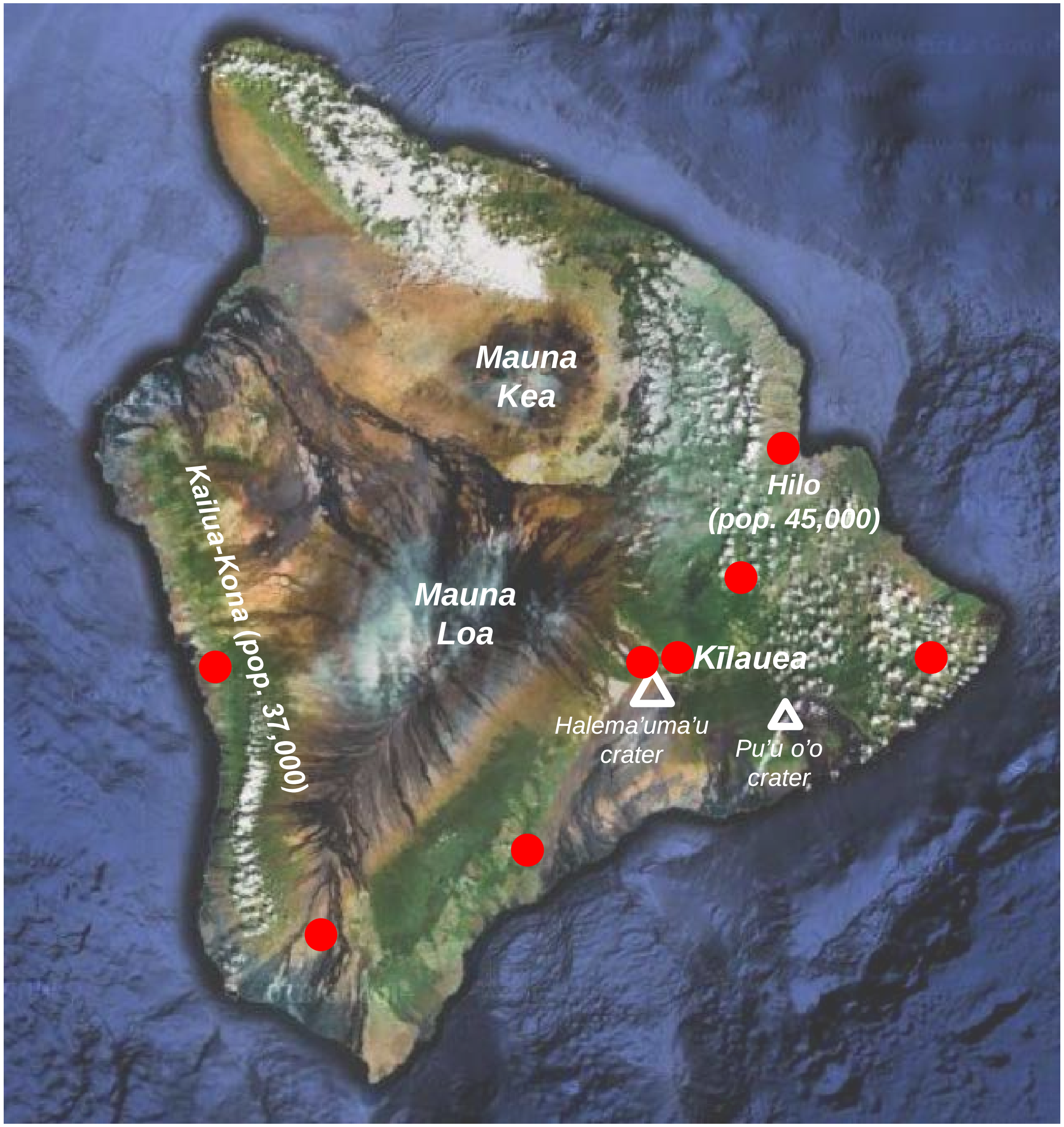
Sulfur dioxide (SO_2): Associated with respiratory problems, difficulty breathing

Oxidizes to form sulfuric acid (H_2SO_4), particulate matter (PM)

Kīlauea: ~3000 tonnes SO_2/day, ~1 megatonne SO_2/year

Anthropogenic emissions in U.S.: 5.7 megatonnes SO_2/year

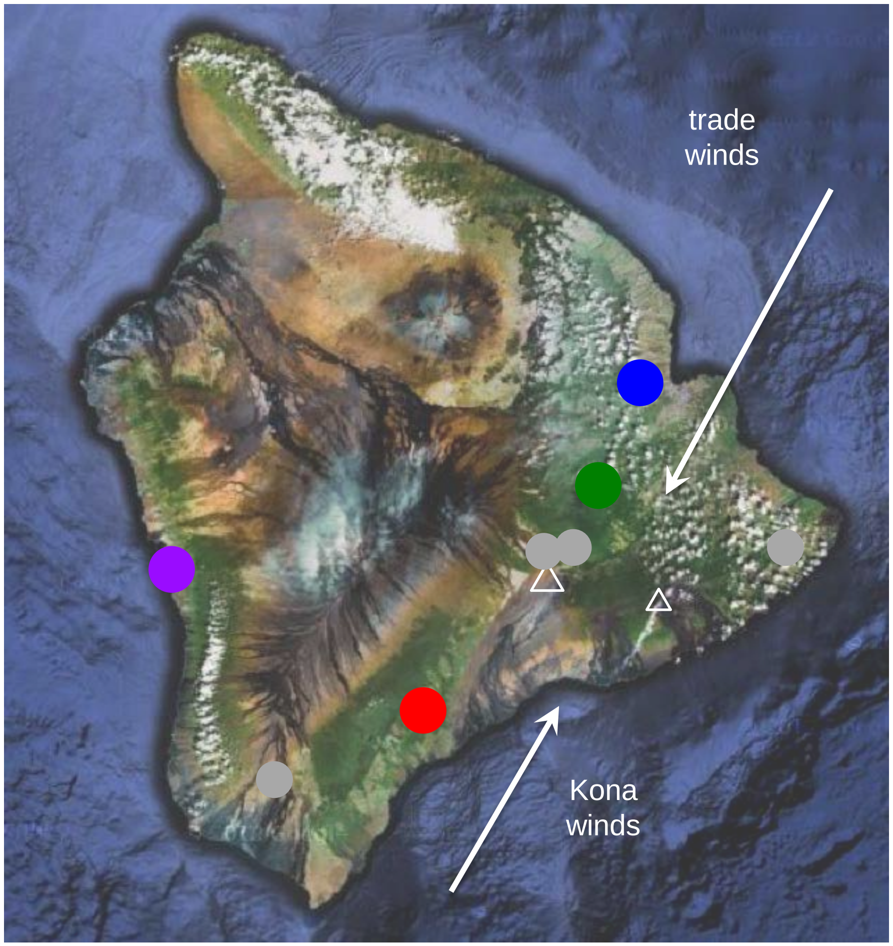
Current air quality monitoring

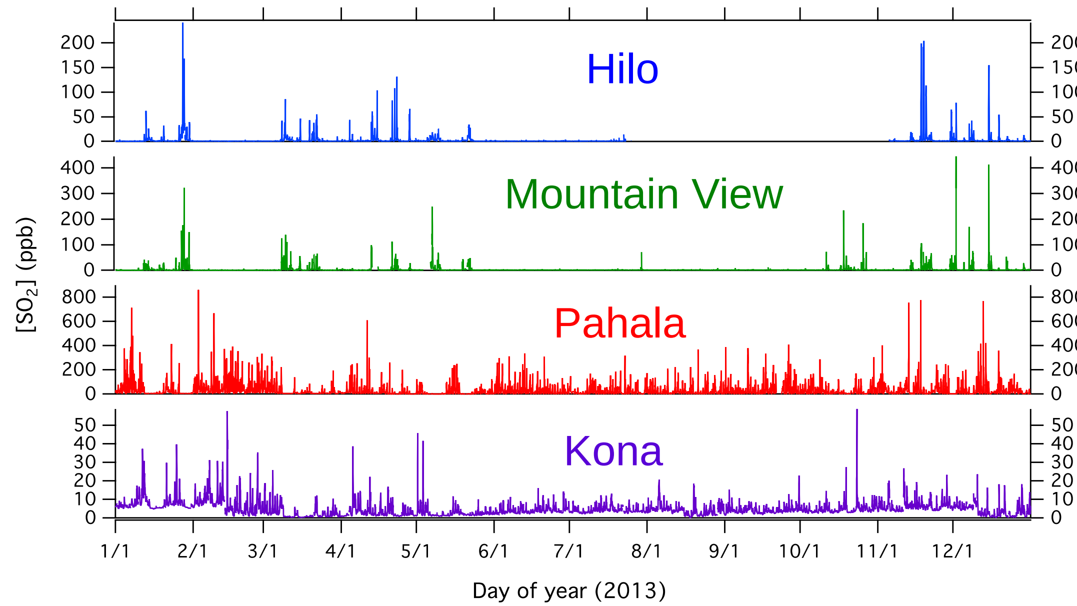


8 SO_2/PM monitoring sites

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

Spatial, temporal variability





data from Hawaii Dept. of Health Air Quality stations

Current project: Hawai‘i Island Vog Network

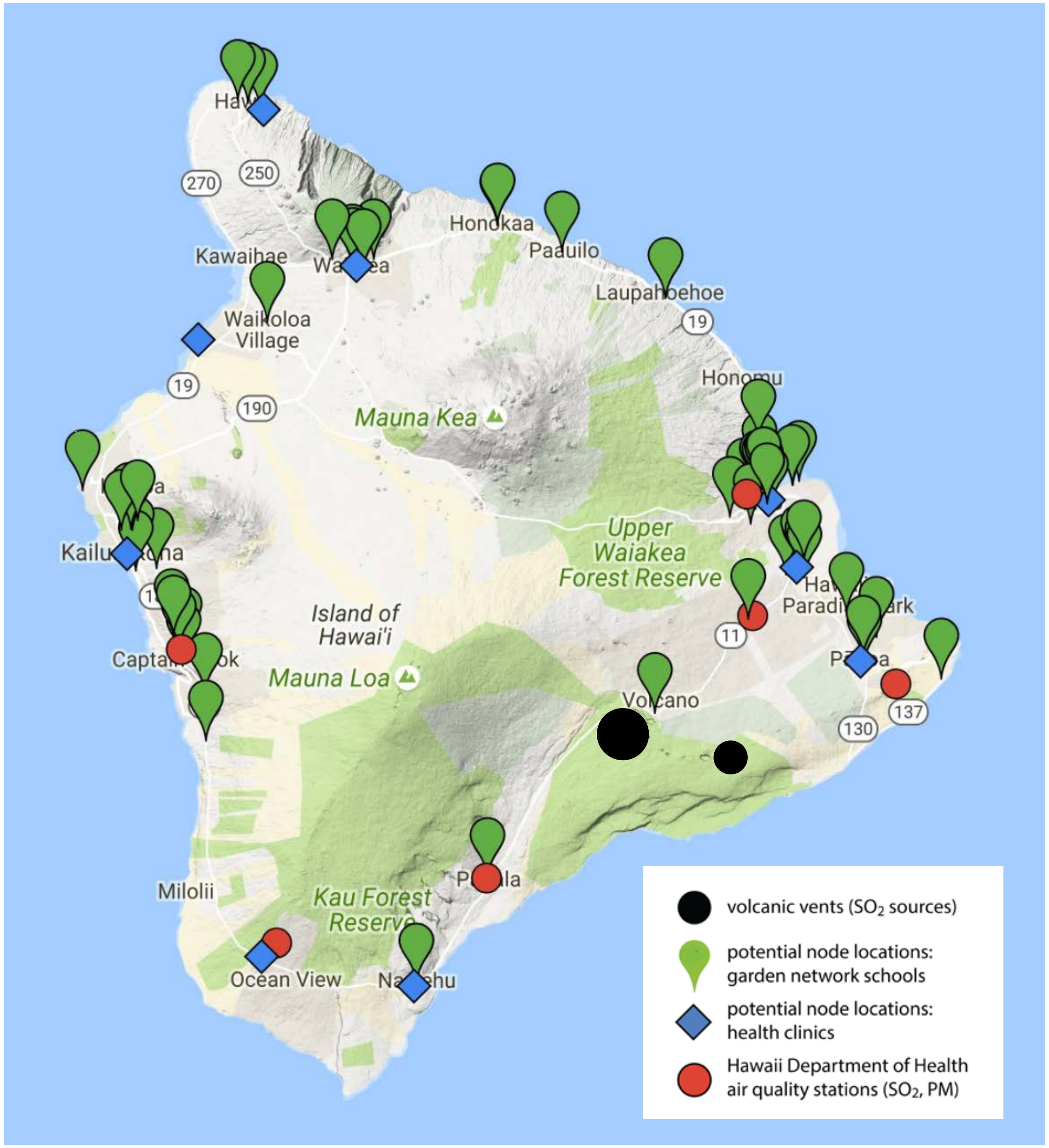
Develop, deploy sensor network for measuring volcanic SO_2, PM levels with high spatial, temporal resolution

Real-time, web-based availability of data: for use by community members, educators, health professionals, researchers

Use of measurements for education: Hawai‘i Island School Garden Network

Specific questions to address:
- how, when do people use air quality data?
- best-practices for sensor design, calibration, analysis?
- use of low-cost sensor networks be used as scientific, educational tools?

Hawai‘i Island volcanic smog sensor network



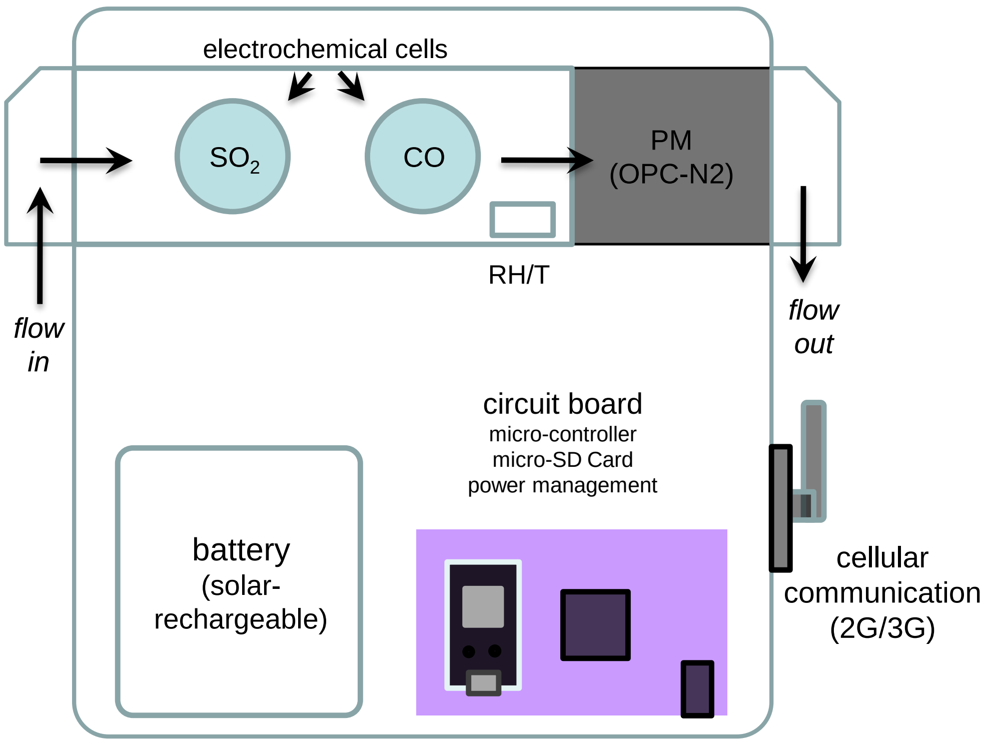
40 sensor nodes for measuring vog components and meteorological parameters

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 access via a public web portal

Node design



Electrochemical cells for SO_2 and CO (anthropogenic tracer)

Optical particle counter (OPC) for size-resolved PM concentration (down to 380 nm)

Data sent via cellular network (2G/3G) every 5 minutes

Solar panels, rechargeable battery: battery life >1 day absent any recharge

Total cost (parts) ~$1000

Calibration by co-location at Hawaii Dept. of Health Air Quality Stations

Community partner: The Kohala Center

Independent, community-based center for research, conservation, and education (founded in 2000)

Main focus areas: food self-reliance, energy self-reliance, and ecosystem health

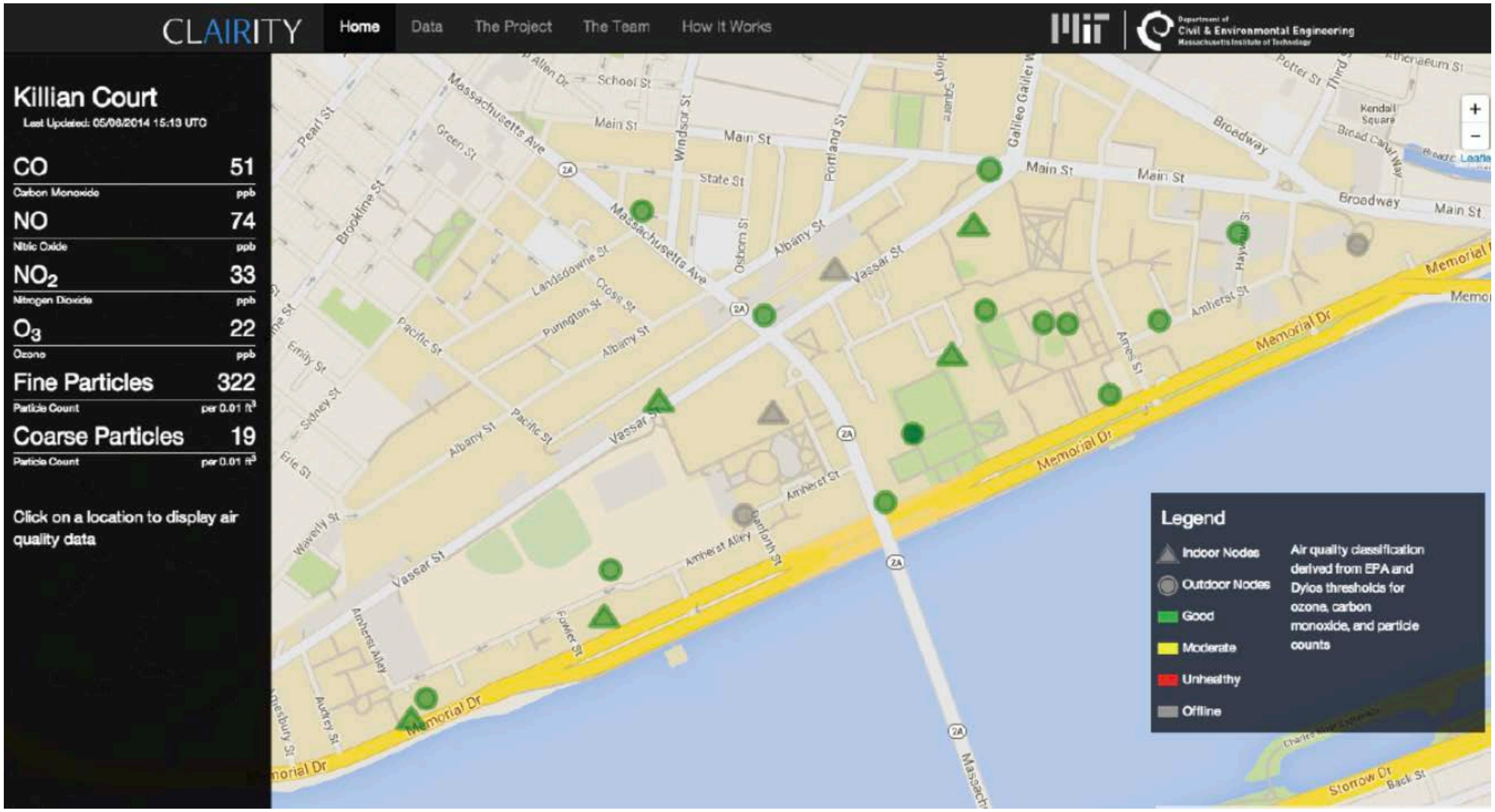
Efforts include: basic and applied research, policy research, conservation and restoration initiatives, public outreach and education; local, regional, national, and international partnerships.

Broad objective: development of a knowledge-based economy (research, ancestral knowledge), so that communities in Hawaiʻi and around the world can thrive ecologically, economically, culturally, and socially

photos courtesy TKC

Informing community members

Goal is to deliver quality information to the public so they can make decisions about the future of the island and its communities



example web portal: CLAIRITY network, Cambridge MA, 2014

TKC’s Hawaiʻi Island School Garden Network

School garden program: participation of >60 schools (public, private, charter):
70 acres of gardens, ~15 tons food/yr

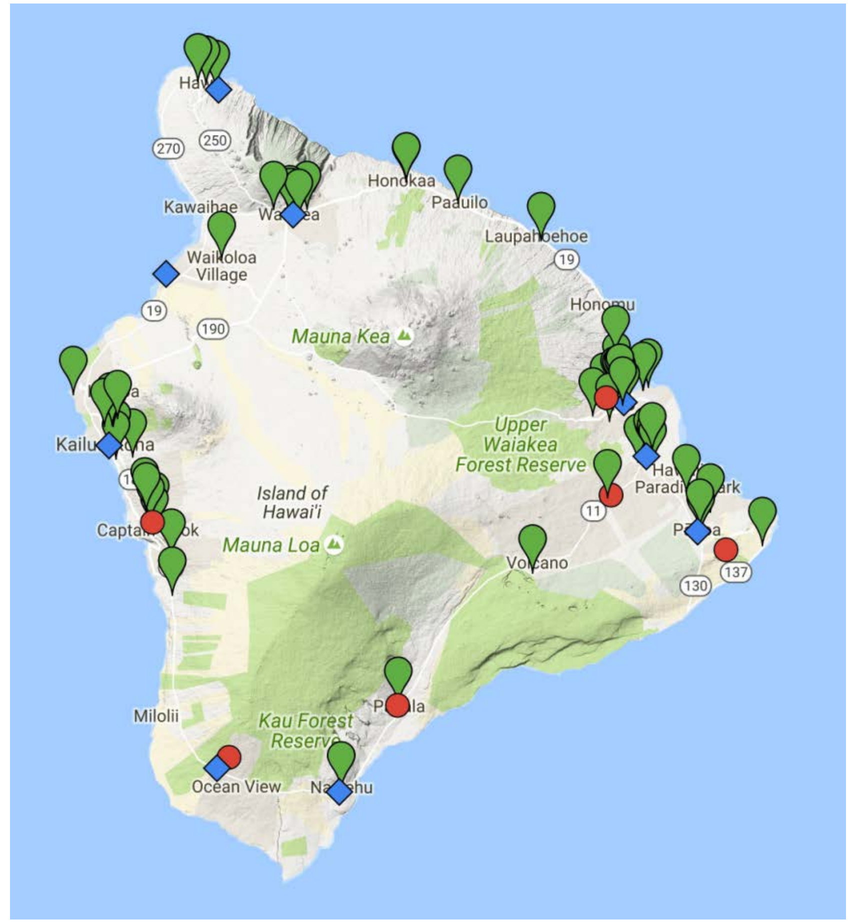
Students grow their own food, in turn helping them:
- develop a taste for healthy, fresh, locally grown fruits and vegetables
- learn about health and nutrition
- appreciate and practice environmental stewardship
- care for the island and its communities

photos courtesy TKC

TKC-MIT partnership

The Kohala Center works closely with researchers in building partnerships with local communities and developing effective teaching and research programs

Partnership via School Garden Network:
- sensor nodes located in school gardens
- direct connection with educators, students
- local SO_2 measurements for schools (air quality alerts)
- data for educational purposes (air quality, agriculture, climate)



Science curriculum

MIT CEHS
Center for Environmental Health Sciences

MIT's Center for Environmental Health Sciences has extensive experience in science outreach and education: *Community Outreach Education and Engagement Core (COE^{2}C), Kathy Vandiver, Director*

Activities include working alongside EPA's Region 1 Tribal Program (Michael Stover, program officer) with 5 federally recognized tribes in Maine

- tribal youth science programs
- professional development programs with teacher workshops
- talks, technical assistance for Tribal Environmental Conferences

photos courtesy CEHS

MIT's "Atoms and Molecules" curriculum

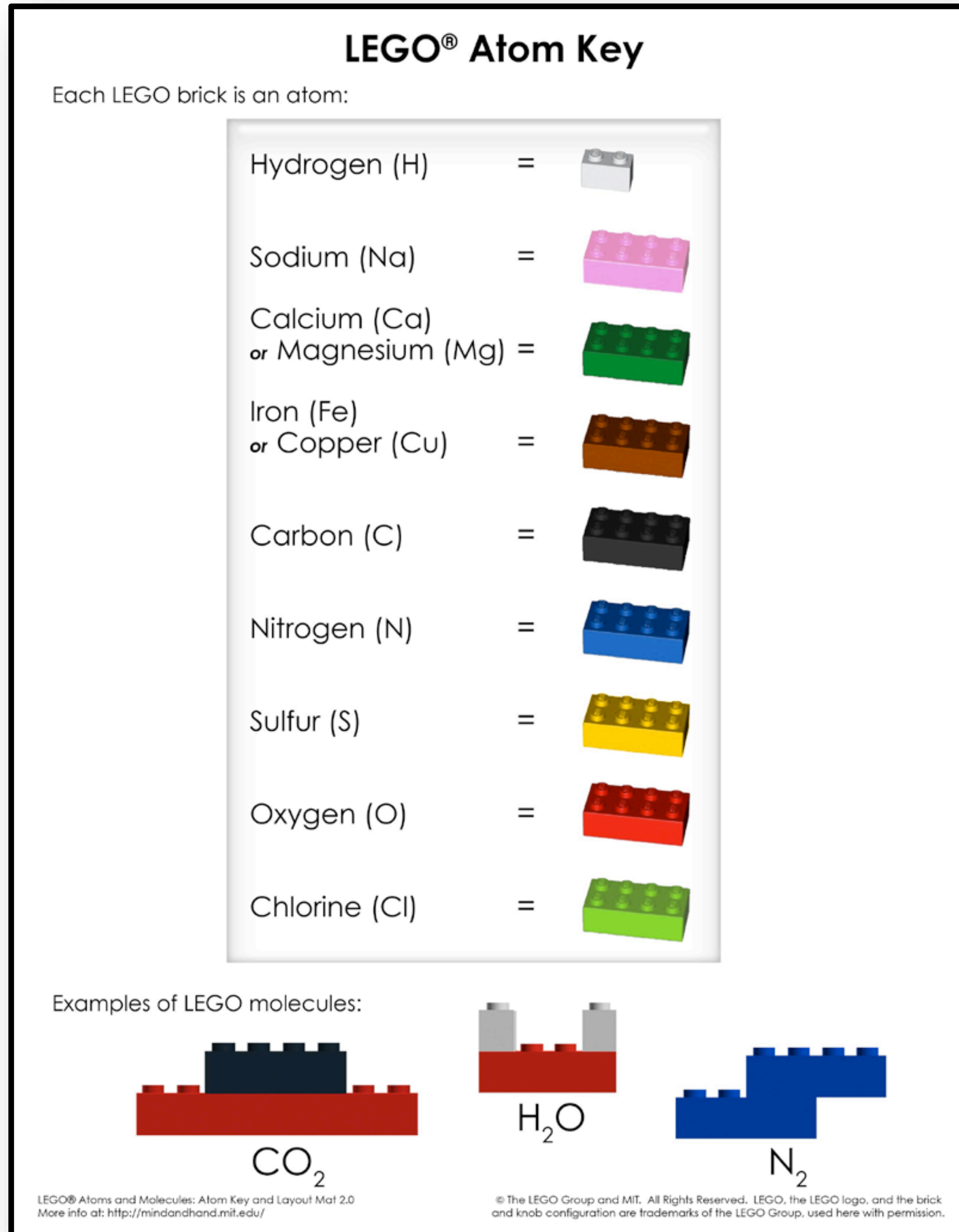
Chemistry curriculum aimed at middle schoolers

Key concepts include: atoms, molecules, mixtures, chemical reactions, *important real-world chemical systems*

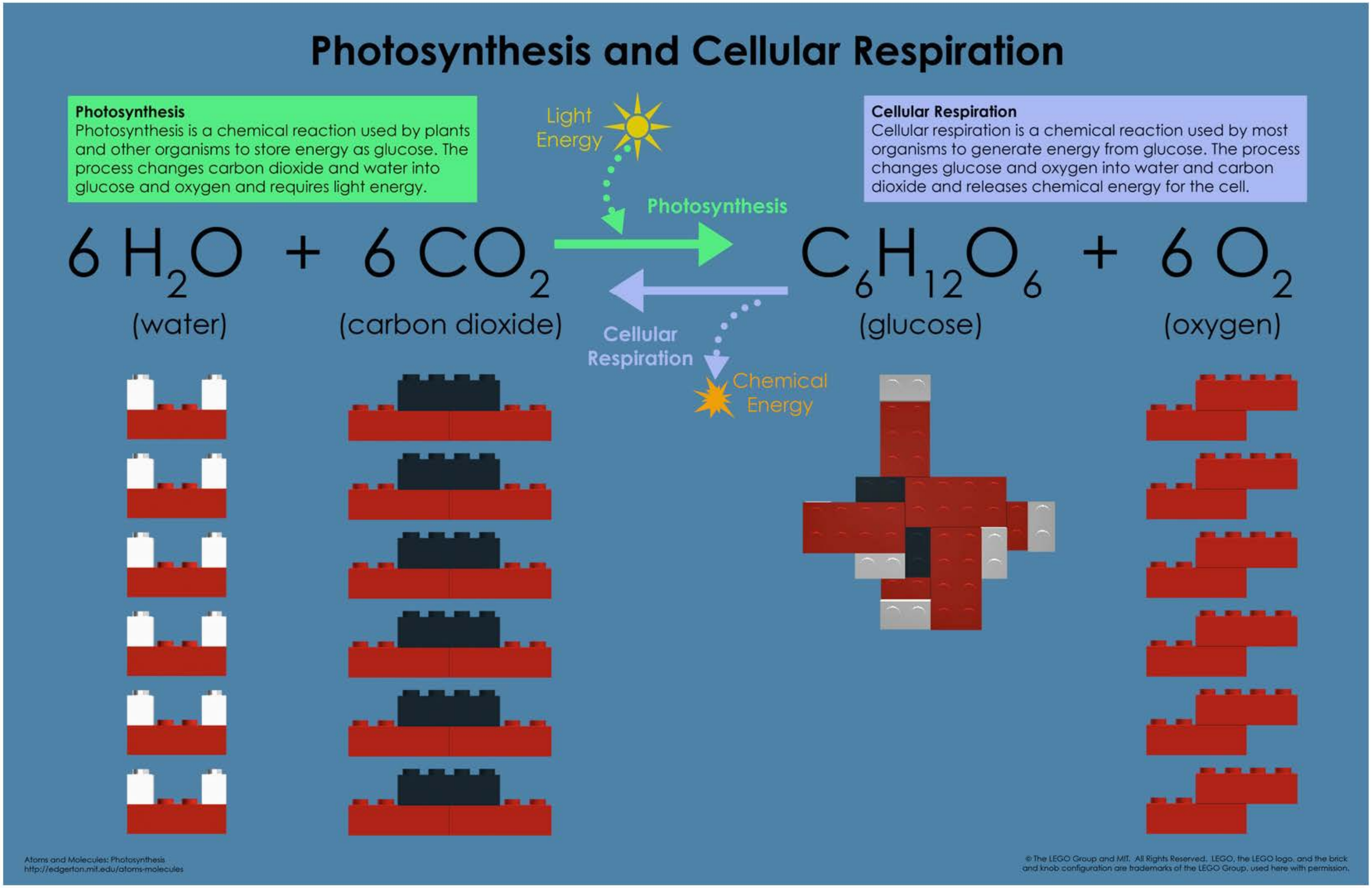
Aligns with Next Generation Science Standards

>500 sets distributed so far

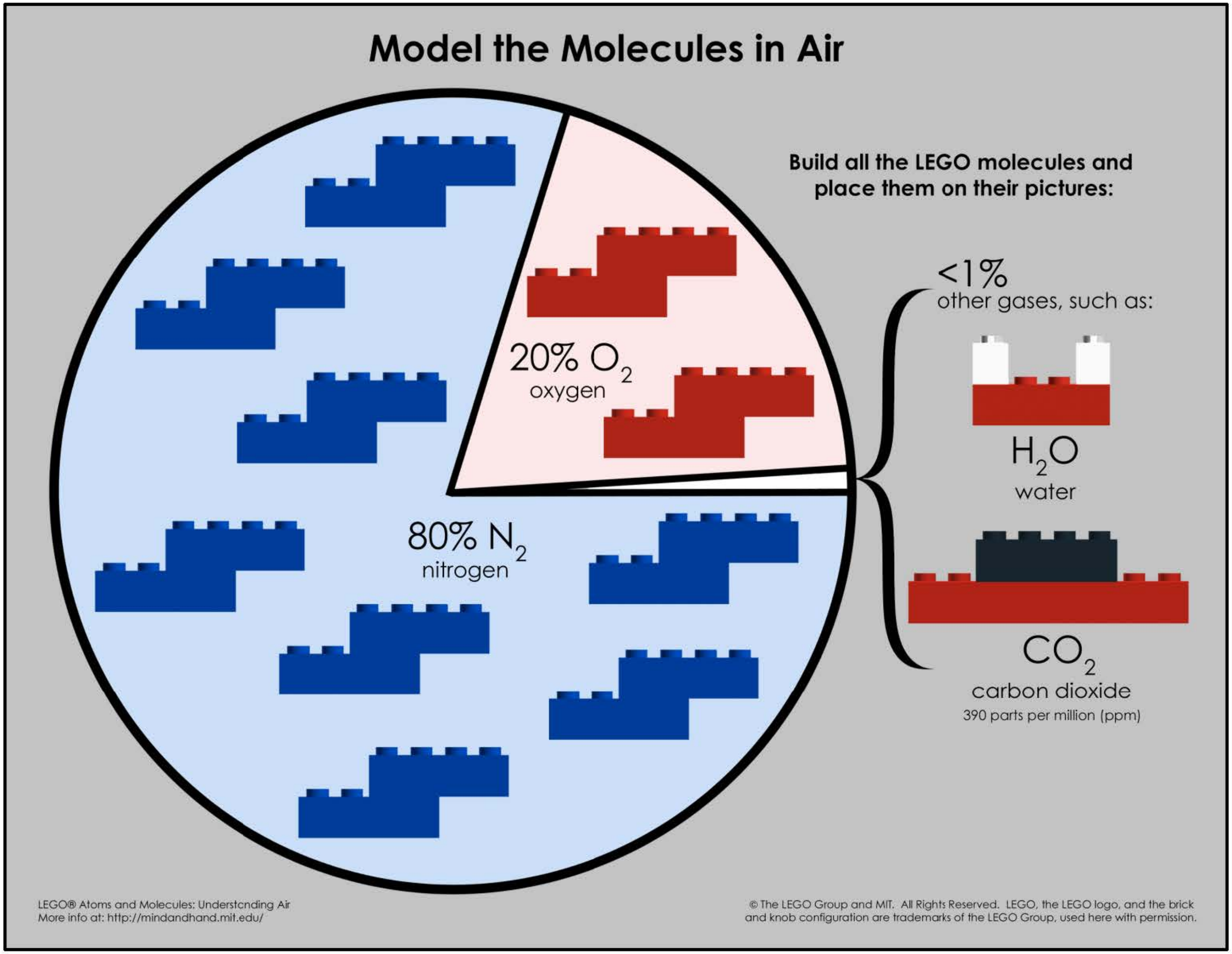
https://edgerton.mit.edu/molecule-set



Atoms and Molecules: Photosynthesis



Atoms and Molecules: Understanding Air



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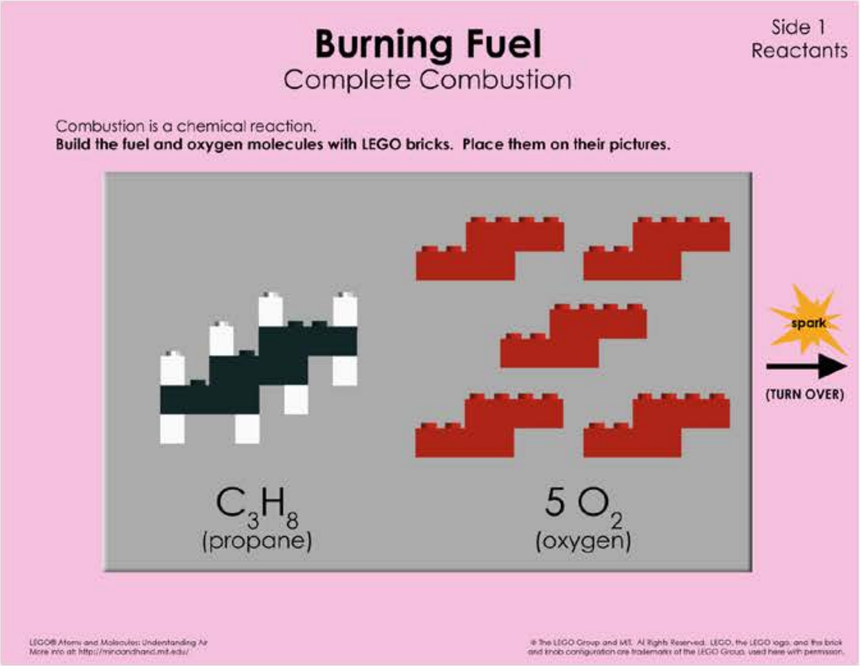

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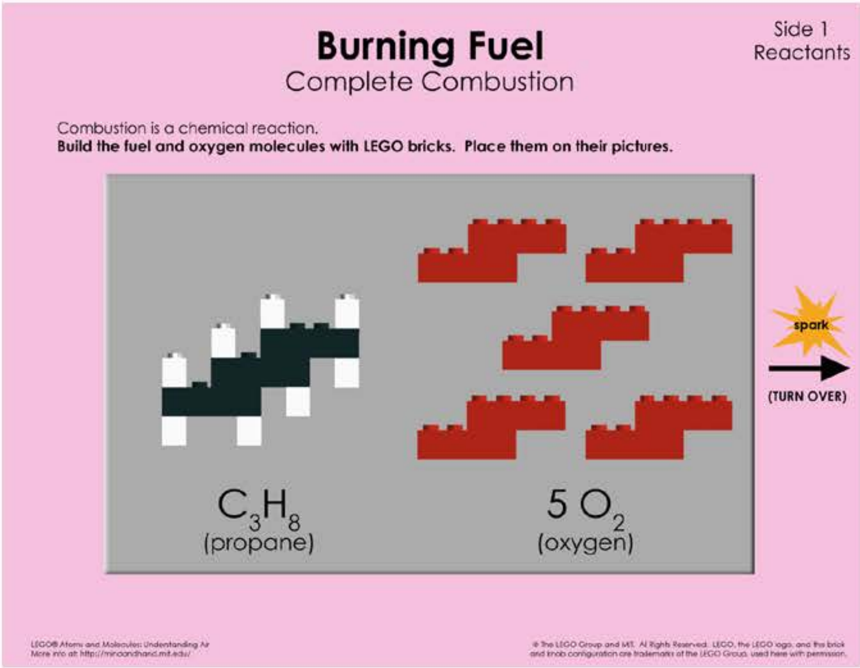

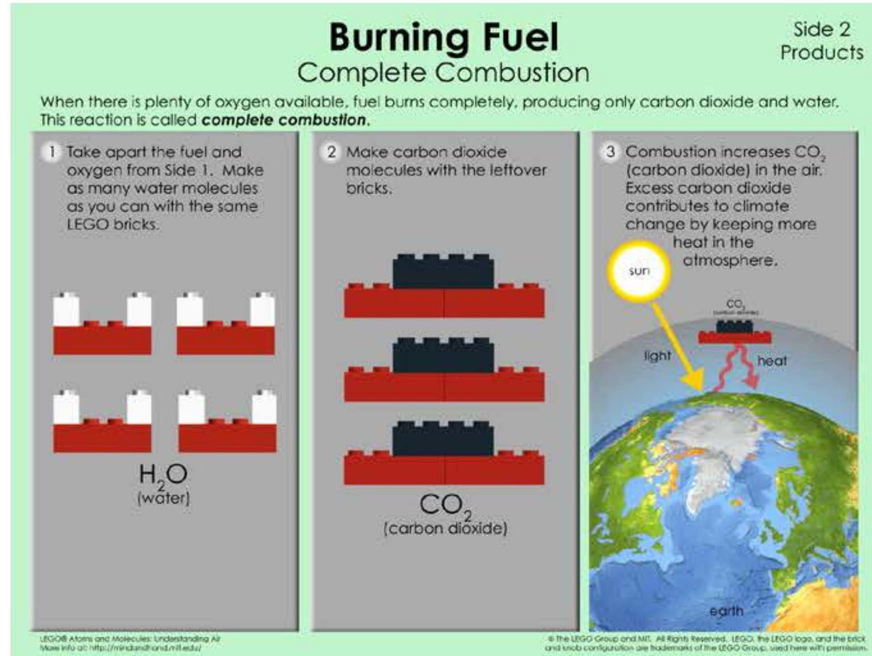

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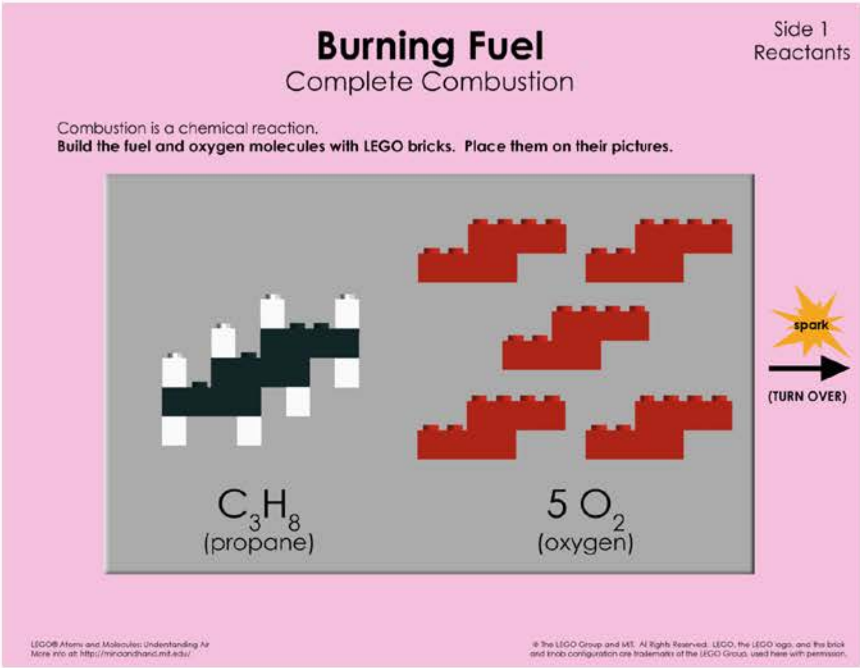
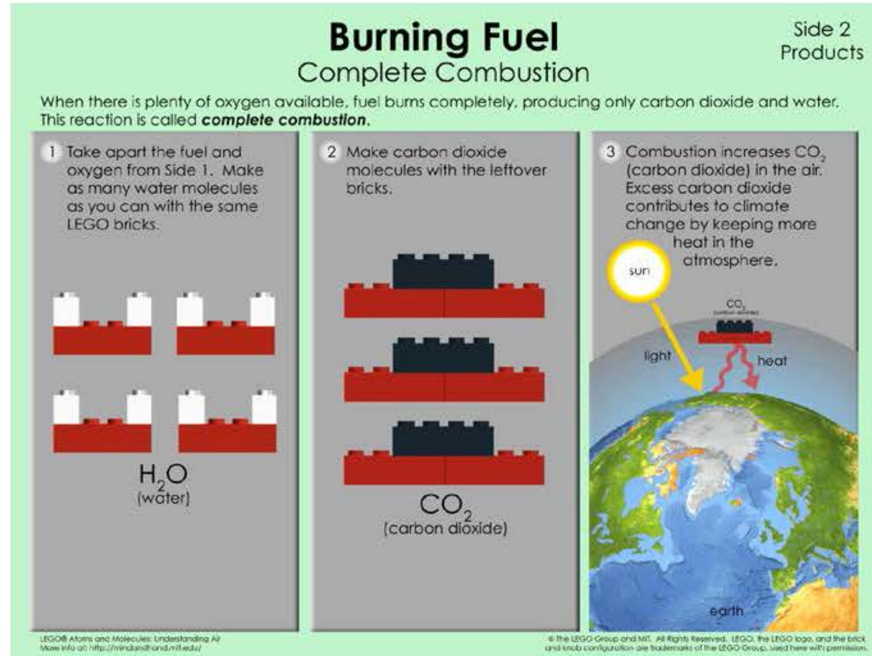
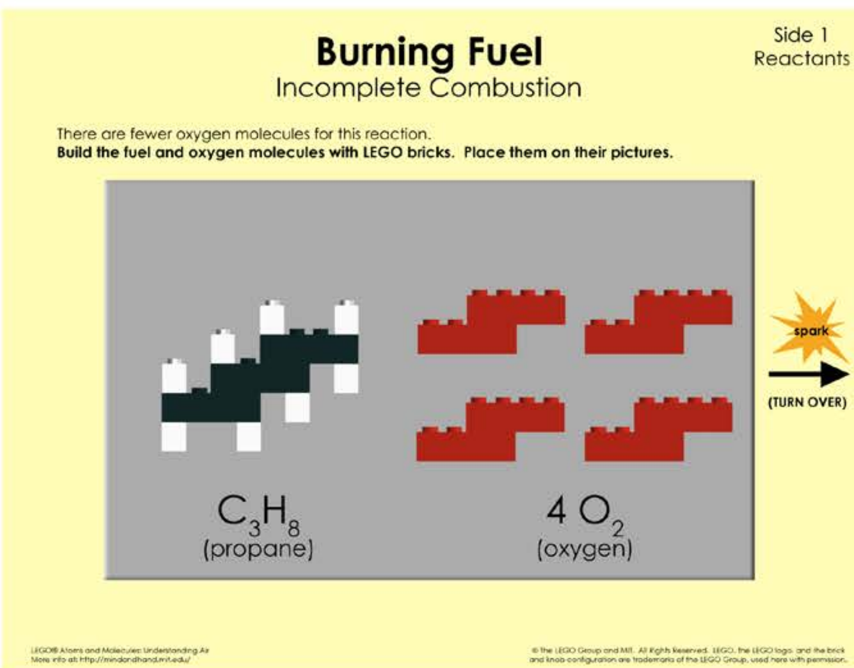
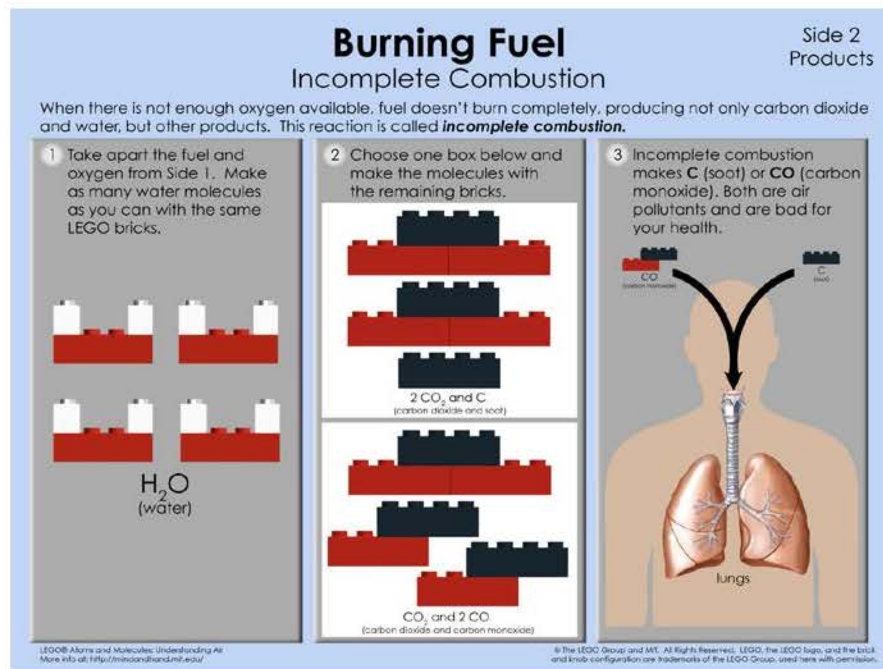
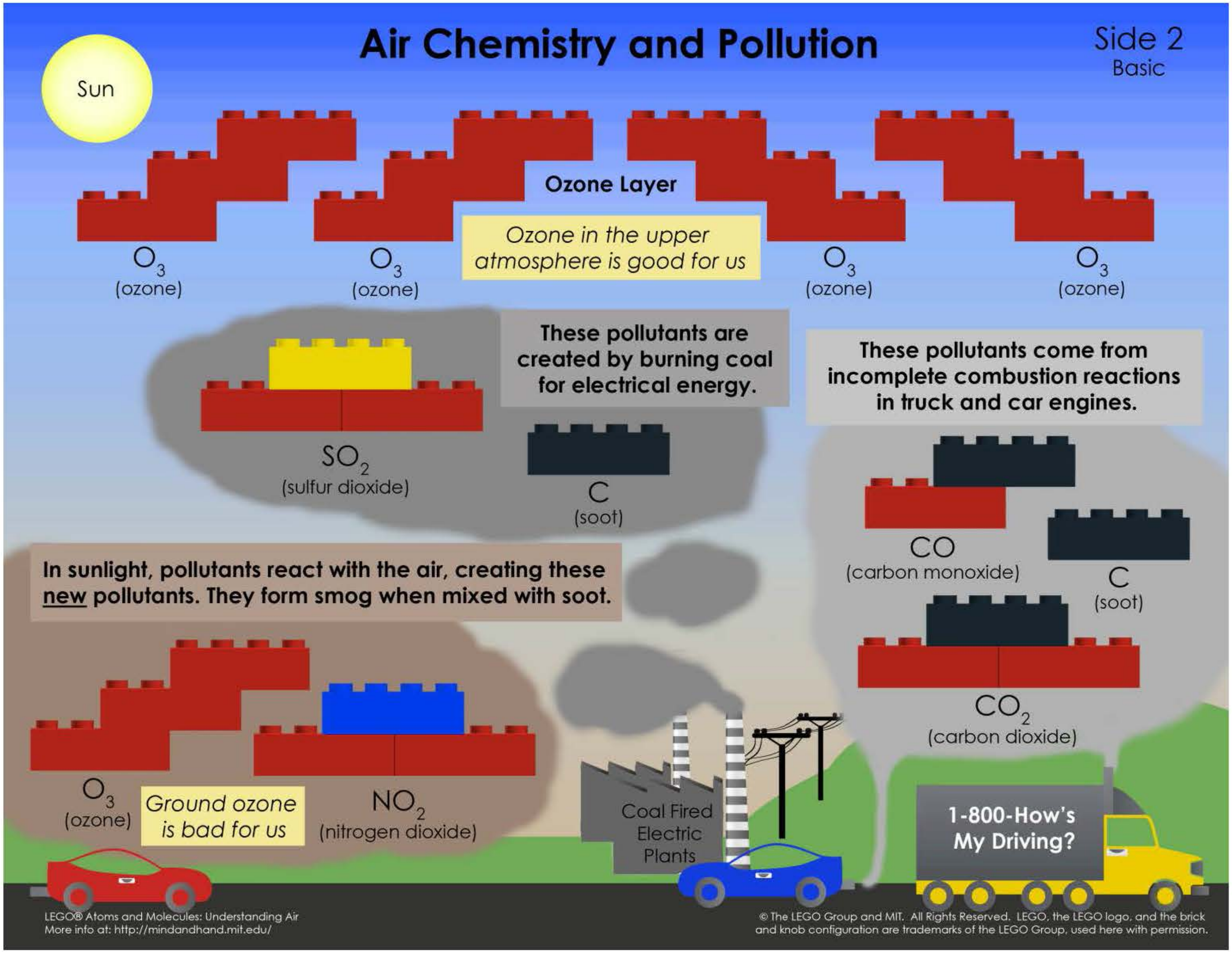




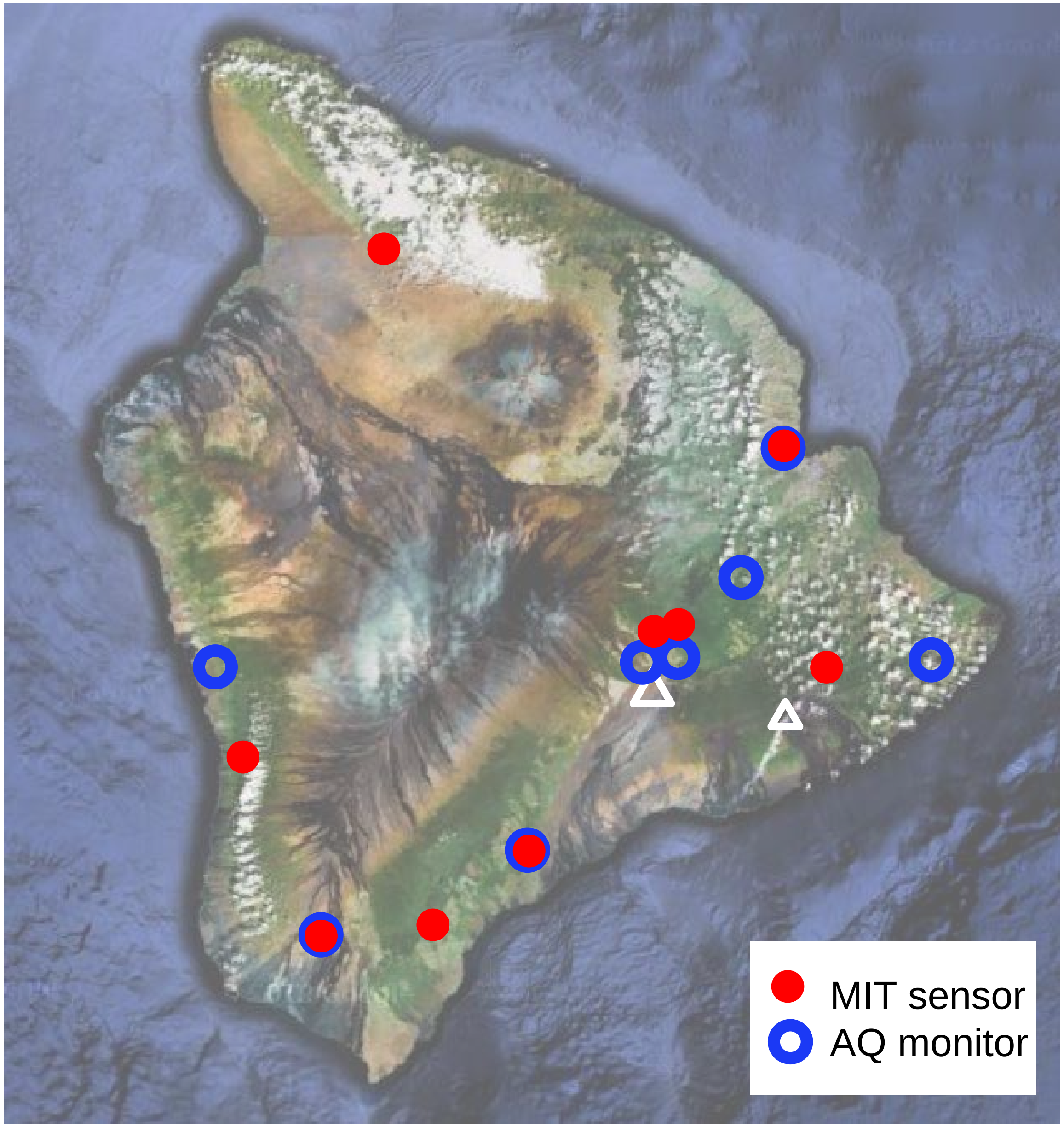




Atoms and Molecules: Understanding Air



Initial SO_2 measurements

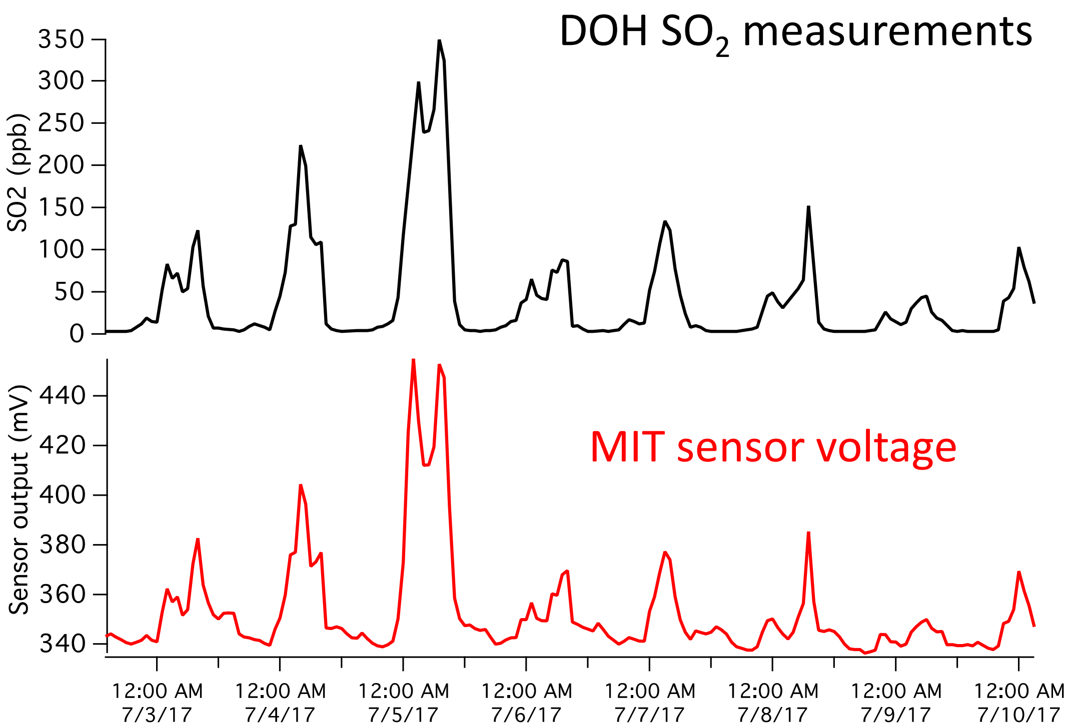


12 1st-generation nodes (SO_2 only) deployed starting Jan 2017

All were first co-located with DOH station; then distributed to various schools and DOH stations

Most are still running, providing info on sensor calibration and long-term performance

Sample SO_2 data



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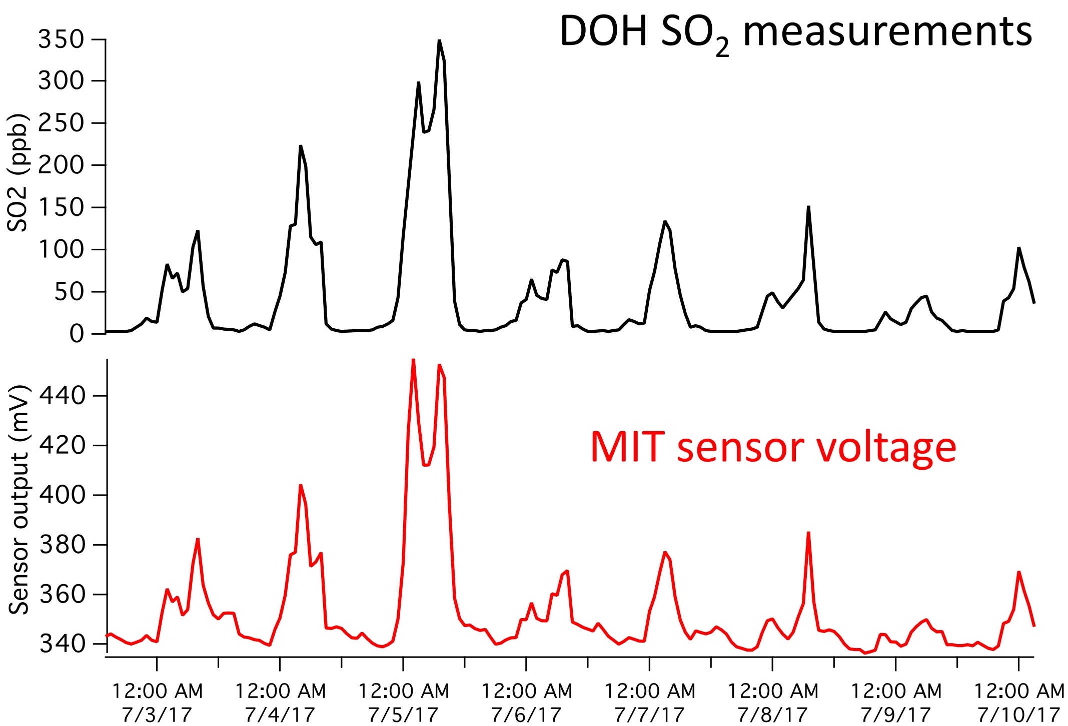
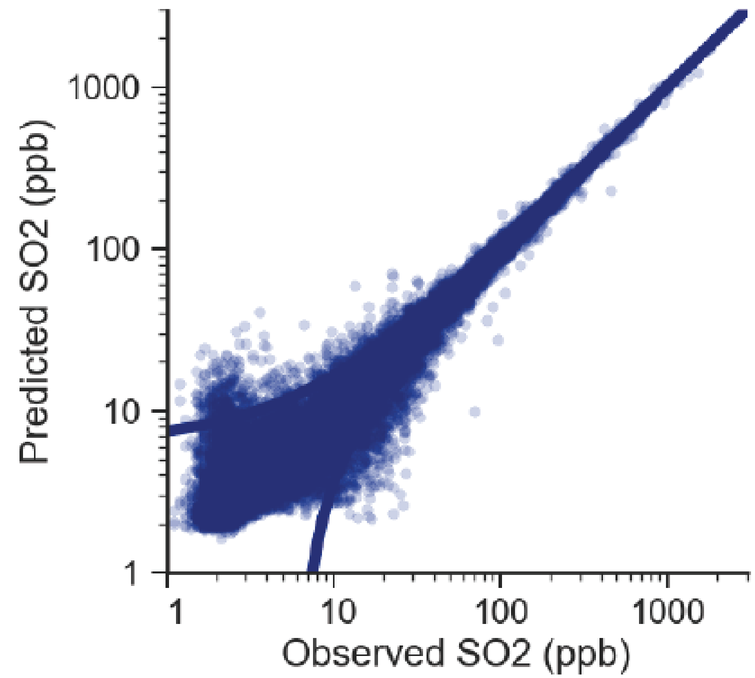




Excellent predictive power (to within 7 ppb SO_2)

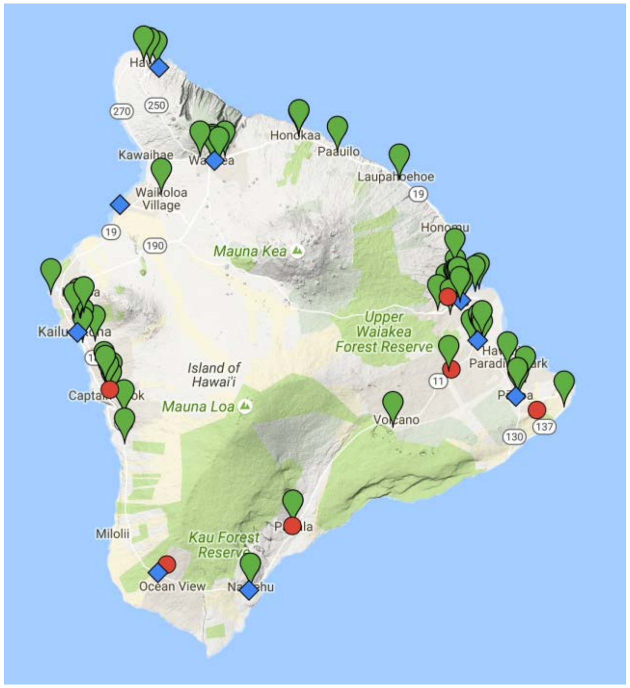
No evidence of degradation over ~6 months

Next steps

Fall 2017-spring 2018: Design next generation node (CO, PM, improved power management)

First formal teacher training in June 2018

Summer-Fall 2018: deployment of network, website launch



Summary/overview

- Volcanic smog (vog) is a major (natural) form of air pollution in the US
- High spatial, temporal variability; need for distributed sensing

- Planned sensor network will serve as a community resource, educational tool, testbed for air quality sensing
- Preliminary results: SO_2 measurements of high enough quality for such objectives

Acknowledgements/collaborators

MIT CEE: Colette Heald, David Hagan
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Hawaii Dept. of Health: Lisa Wallace

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

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