



Lessons from Hawai'i: vog hazards and impacts

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NZ/USA Joint Commission Meeting on Science and Technology
Cooperation



Chronology of Kilauea eruption (1983-present)

- 1983-1986: Episodic lava fountaining from Pu'u O'o vent
- 1986 on: continuous lava effusion and sustained gas emissions
- 2008: Halema'uma'u vent opens at summit, increased gas emissions



Pu'u O'o vent, circa 1983. USGS Open Source



Chow, D.C. et al (2010) Is volcanic air pollution associated with decreased heart-rate variability? Heart Asia. 2010 Feb 23; 2(1): 36–41

Under trade wind conditions, plume trapped beneath inversion

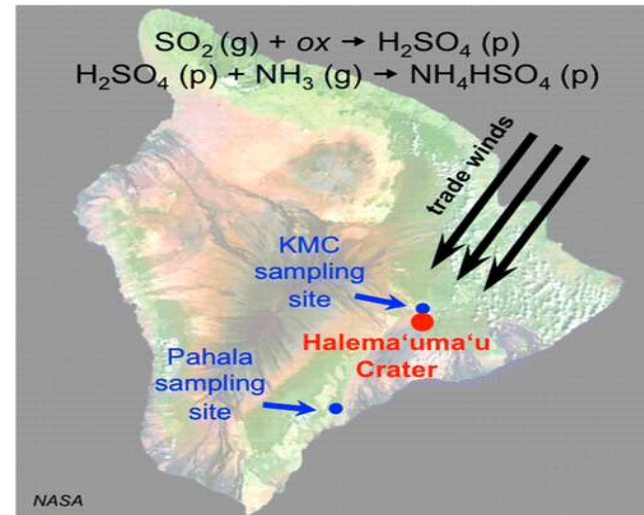


Current emission rates:
Halema'uma'u: ~4200 T/day
Pu'u O'o: ~280 T/day



$\text{SO}_2 \rightarrow \text{vog}$ (volcanic smog) and acid rain

- SO_2 (gas) \rightarrow sulphate aerosol (particle)
- Far-reaching hazard
- Continuous, long term hazard (worse since 2008) on Hawai'i
- Substantial health hazard
- Causes accelerated corrosion



Halema'uma'u vent (opened in 2008)

- Aim: to mitigate vog impacts by providing accurate forecasting
- HYSPLIT model used
- 48 hr forecast, hourly outputs
- Outputs for both SO₂ and sulphate aerosol (as PM_{2.5})

TABLE 1. SO₂ (PPM) and particulate matter ($\mu\text{g m}^{-3}$) concentrations used to define the VMAP color codes. The SO₂ designations are consistent with those used by the Hawaii State Department of Health for their short-term SO₂ index. The EPA uses PM_{2.5} concentration thresholds for their 24-h AQI designations. Measurements are generally made 2 m above the surface.

	1 Good	2 Moderate	3 Unhealthy for sensitive groups	4 Unhealthy	5 Very unhealthy	6 Hazardous
SO ₂ (PPM)	0–0.1	0.11–0.2	0.21–1.0	1.01–3.0	3.01–5.0	>5.01
PM _{2.5} (mg m ⁻³)	1×10^{-8} –15	15.01–35	35.01–65	65.01–150	150.01–250	>250.01

SO₂ forecast

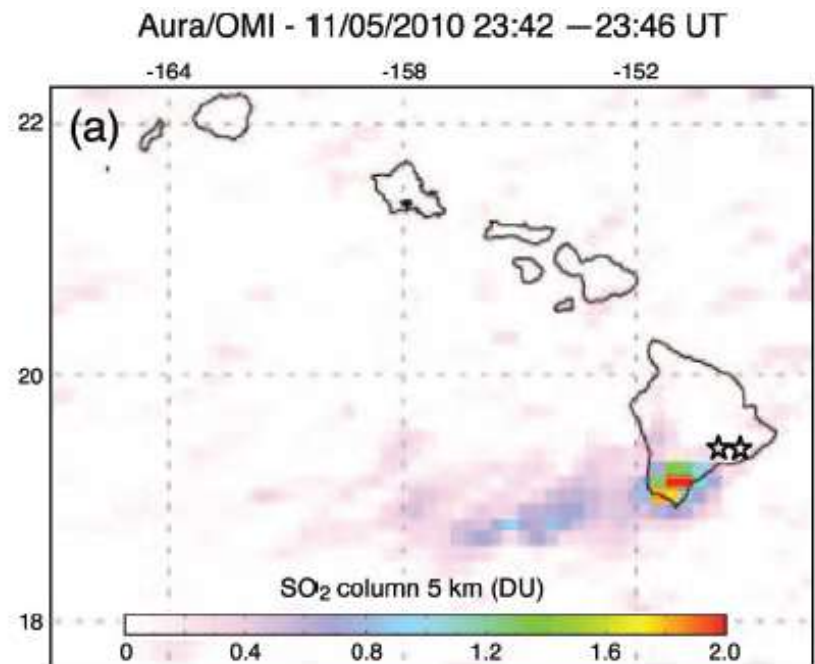
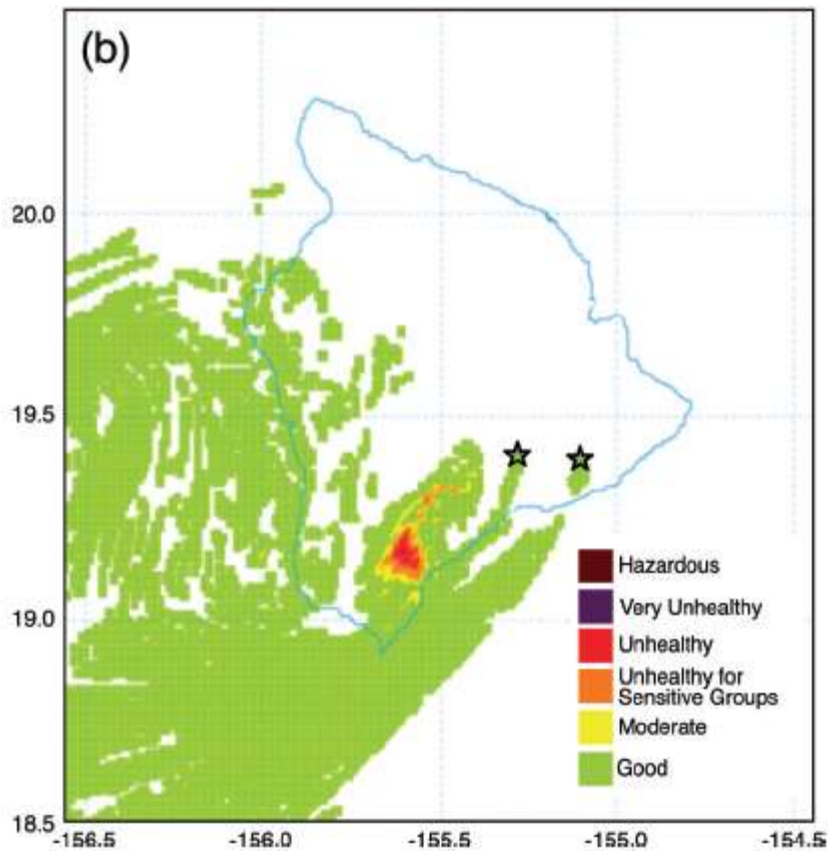


FIG. 9. (a) Aura-OMI satellite SO₂ column (DU) and (b) modeled ground-level sulfate concentration, valid at 2300–0000 UTC [1300–1400 Hawaii–Aleutian standard time (HST)] 5 Nov 2010 under prevailing northeasterly wind conditions.

Sulphate aerosol forecast

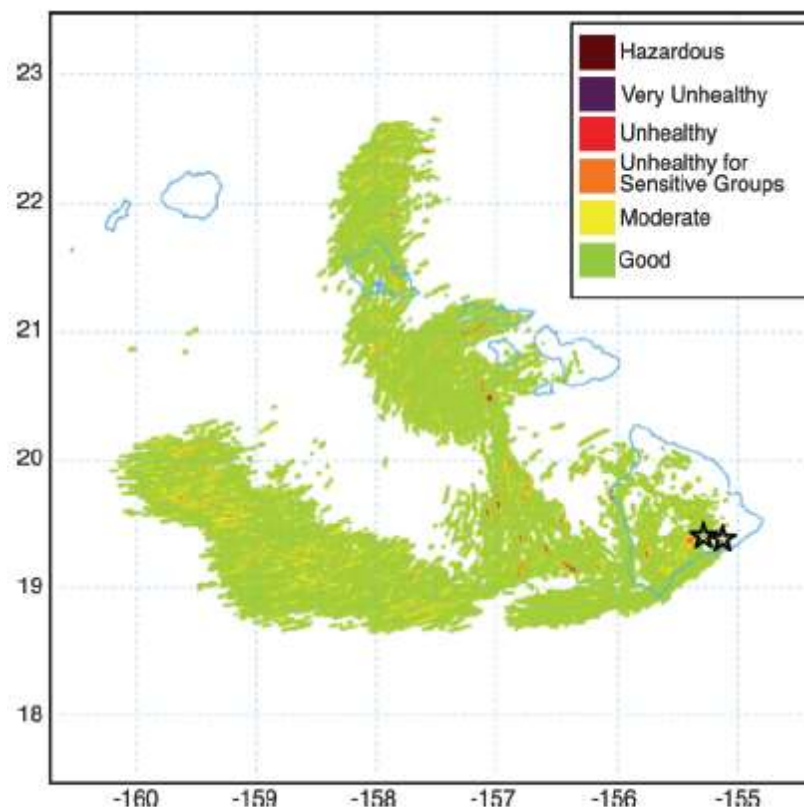


FIG. 7. Vog model 8-h forecast of sulfate aerosol concentration ($\mu\text{g m}^{-3}$) averaged between 0 and 100 m above ground level and integrated from 2200 to 2300 UTC 16 Apr 2013. Color scale shows EPA designations for six levels of health risk corresponding to the $\text{PM}_{2.5}$ AQI thresholds given in Table 1.

Vog health effects: short range

- SO_2 is irritating to eyes, throat and respiratory tract
- Asthmatic individuals are especially sensitive to SO_2
- 8 deaths* at volcanoes from SO_2 between 1989 and 1997



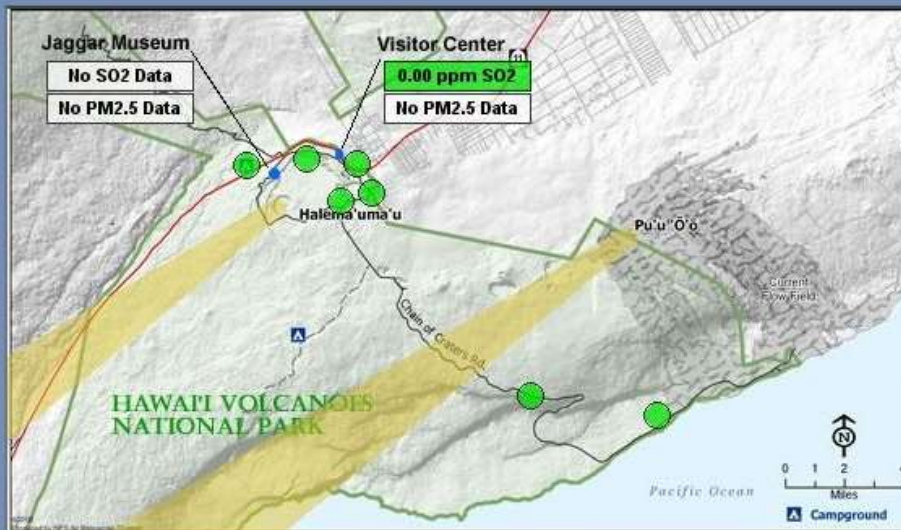
Entrance to Hawai'i Volcanoes National Park

*Documented by ivhnn.org



Hawai'i Volcanoes National Park

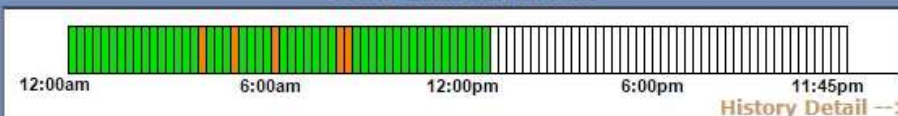
Current Sulfur Dioxide (SO₂) and Particulate (PM_{2.5}) Conditions



The map above indicates the approximate direction and extent of the volcanic gas plumes (yellow wedges) from Halema'uma'u and Pu'u O'o. Within the plumes are unhealthy concentrations of sulfur dioxide (SO₂) and small particles (PM_{2.5}). Color-coded health advisories (color circles or label boxes) are issued when the plumes affect surface areas.

 Sulfur dioxide gas plumes cross roads near Halema'uma'u and low on Chain of Craters Road. Sensitive individuals should limit exposure in these areas.

Today's Advisory History



Air Quality Conditions

Sulfur Dioxide Advisory Level

Good

Dec 8, 2015 • 1:00 PM HST



Particulate Advisory Level

Meaning of Advisory Colors-->

More Data -->

Weather

Wind Direction

Northeast

Wind Speed

6 mph (2.5 m/s)

Dec 8, 2015 • 1:00 PM HST

More Data -->

Additional Information

- [Summit Location](#)
- [Volcanic Gases](#)
- [Island of Hawai'i Air Quality](#)
- [Jaggar Museum Camera View](#)
- [Volcano House Camera View](#)
- [Kilauea Status](#)

*Data Disclaimer



This web page is jointly supported by the National Park Service and the U.S. Geological Survey.



Webmaster

Air quality health advisory levels

SO2 (ppm)	Air quality description	Action for sensitive individuals	Action for general population
<0.1	Good	None usually required	None required
0.1-0.2	Moderate	Use caution if outdoors	Health effects not expected
0.2-1.0	Unhealthy for sensitive groups	Avoid outdoor activities that cause heavy breathing	Health effects not expected for most
1.0-3.0	Unhealthy	Remain indoors	Avoid outdoor activities that cause heavy breathing
3.0-5.0	Very unhealthy	Remain indoors	
>5.0	Hazardous	Remain indoors, leave area if directed by Civil Defence, seek medical help if necessary	

For 15- minute exposure period

Vog health effects: long range

- Eye irritation
- Headaches
- Breathing difficulties
- Flu-like symptoms
- Dizziness
- Lack of energy
- Sore throat

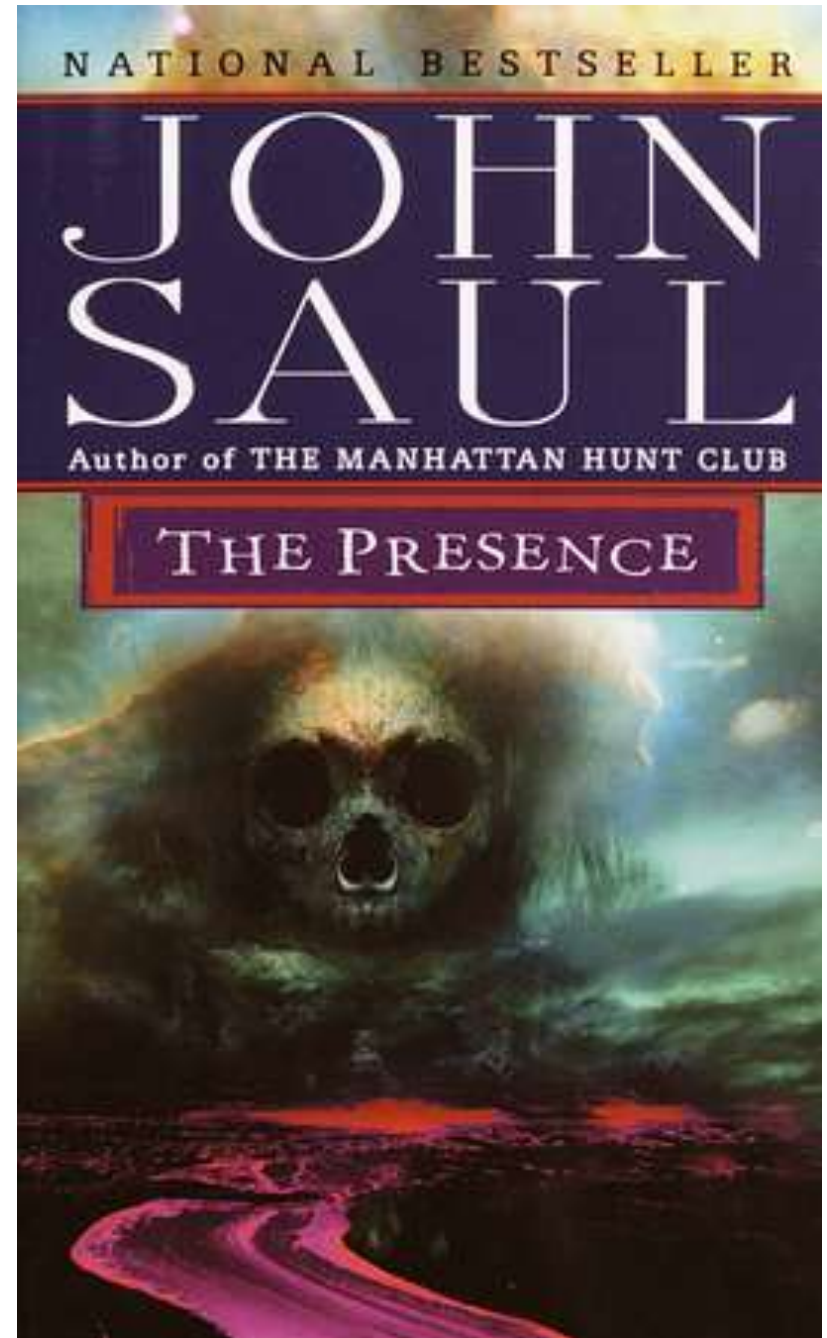
“East of 130, just south of Pahoa. Woke up and didn't even have to check AQ reports to know voggy. World sepia tinted, even dogs lethargic. Rats. If I decide to get active I'll wear my vog mask while working.”

VogTalk Facebook contributor, 25 Nov 2015



Honolulu, 9 October 2012

Slowly, horrifyingly, and without rational explanation, otherwise healthy children are falling victim to a sudden, life-grabbing illness that defies all medical knowledge. ...



Many health impacts documented

- B. Longo et al. (2010)
**Acute health effects
associated with
exposure to volcanic
air pollution (vog)
from increased
activity at Kilauea
Volcano in 2008.**

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Posted: May 08, 2015 2:13 PM

Updated: May 08, 2015 2:25 PM

By Chris Tanaka

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HONOLULU (HawaiiNewsNow) - The health impacts of vog are well



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Living with vog - advice

- DOH advice
 - Listen for vog alerts and forecasts
 - Stay indoors in voggy conditions
 - Keep up fluid intake
 - Avoid exertion in voggy conditions
- Keep vog out of houses and workplaces
 - Seal doors and windows tightly
 - Use air conditioning on recirculation mode
 - Use HEPA filters (remove particles)
 - SO₂ more difficult to remove (activated carbon filter)

‘Shelter indoors’ an important part of advice for mitigating vog impacts – but many Big Island houses not airtight



DIY vog remover (UH Hilo)



1. Pour baking soda into a pan.



2. Add water.



3. Mix with a spoon to create a paste or slurry.



4. Soak cheesecloth in the slurry.



5. Use clothespins to attach the soaked cheesecloth to the fan.



6. Spray fresh water onto the cheesecloth periodically to ensure that there is sufficient moisture to dissolve the vog compounds.

School vog protocols (in place since 2008)

- 'Shelter in place' provisions: Schools must have air-conditioned rooms with HEPA filters and gas scrubbers for asthmatic students/staff
- All classrooms have HEPA filters
- During crises, monitors wear SO₂ exposure badges and refer to colour-code system



Effects of vog on visibility, Kona coast (potential hazard for air and ocean traffic)



Acidic aerosol leads to corrosive environment



**Guardrails: 20-25 year lifetime
now reduced to 5 years**





Hawaii & Pacific Basin NEWSLETTER

April 2012



Your Farm Service Agency Online Monthly Newsletter Covering the Latest Topics

Second Sign Up Announced for Vog Damaged Fences

Hawaii County producers who have livestock fencing that has prematurely corroded due to vog or volcanic emissions may be eligible for cost-share assistance under the Emergency Conservation Program (ECP). This disaster program, administered by the U.S. Department of Agriculture, Farm Service Agency (FSA), provides cost-share assistance if the damage is so severe and costly that Federal assistance is required to return the damaged area to productive agricultural use.



Vog emissions from Halema'uma'u Crater, Hawaii

The following emergency conservation practice is available to ranchers and other producers on the island:

EC3 – Restoring or replacing fences needed to restore the land to productive agricultural use to include:

- ♦ Cross fences
- ♦ Boundary fences
- ♦ Cattle gates

INSURANCE JOURNAL

Agricultural damages reported in Hawai'i County include: damage to vegetable crops (especially leafy greens), some orchard crops, flower and foliage (including those under greenhouses). Ranchers have experienced adverse impacts on range grasses and premature corrosion of fencing, gates and other metal infrastructure.



Macadamia Photo: M. Nagao

Acid rain

- SO_2 acidifies rainfall to $\sim\text{pH } 4$
- Acid rain can leach lead from roof and plumbing components into domestic drinking-water supplies



National Park Service water treatment plant, Kilauea (add sodium carbonate)



Many residents have roof catchment tanks

Lessons for NZ in event of prolonged SO₂ emissions

- Would likely be a **regional scale** event
- Schools, public facilities would need to develop policies and procedures and gear up with filters
- Expect high level of public interest and concern; need excellent syndromic surveillance monitoring systems
- Need excellent air quality monitoring data linked to public health advice and readily accessible to public
- Public health advice needs to carefully consider people's homes and lifestyles

Thanks for your attention



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