

An aerial photograph of a tropical island, likely in the Pacific, showing a large lagoon with a sandy beach and palm trees. The sky is blue with some light clouds. The text is overlaid on the image.

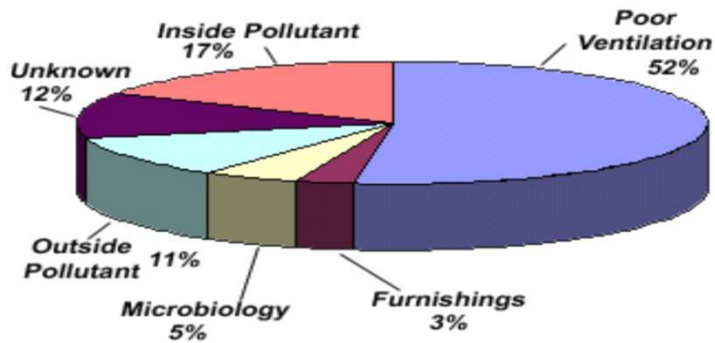
ATMO 102 Pacific Climates and Cultures

**Lecture: Pacific Island Air
Pollution**

Global Impacts of Indoor Air Pollutants

- According to the **World Health Organization**
 - ~4 million people a year die from the exposure to household air pollution.
 - Around 3 billion people cook and heat their homes using solid fuels (i.e. wood, charcoal, coal, dung, crop wastes) on open fires or traditional stoves.
 - Such inefficient cooking and heating practices produce high levels of household (indoor) air pollution which includes a range of health damaging pollutants such as fine particles and carbon monoxide.
 - In poorly ventilated dwellings, smoke in and around the home can exceed acceptable levels for fine particles 100-fold.
 - Exposure is particularly high among women and young children, who spend the most time near the domestic hearth.

Indoor Air Quality Identified Issues



Indoor Air Pollution Scale

Level 1

Adverse Health Impacts

Nose & Throat Irritation, Runny Nose, Congestion, Sneezing, Coughing & Wheezing, Asthmatic Flares

Allergens & Particulates

Dust & Pollen
Mold & Fungi
Mildew
Tobacco Smoke
Wood Smoke

Vehicle Exhaust
Dust Mite Feces
Pet Dander
Insect Debris

Level 2

Adverse Health Impacts

Sinusitis, Upper Respiratory Infection, Throat & Ear Infection, Bronchitis, Pneumonia

Infectious Agents

Streptococcus
Pneumococcus
Legionella
Tuberculosis

Influenza & RSV
Pneumonia
Cold Viruses
SARS
H1N1

Level 3

Adverse Health Impacts

Memory Lapse, Mild Depression, Lung Dysfunction, Blurred Vision, Headaches, Nausea, Vomiting, Lethargy

Toxic Compounds

Formaldehyde
Carbon Monoxide
Methyl Chloride
Nitrogen Dioxide
Pesticides

Toluene
Benzene
Tobacco Smoke
Mold Mycotoxins

Indoor Air Pollution - Global Maps from WHO

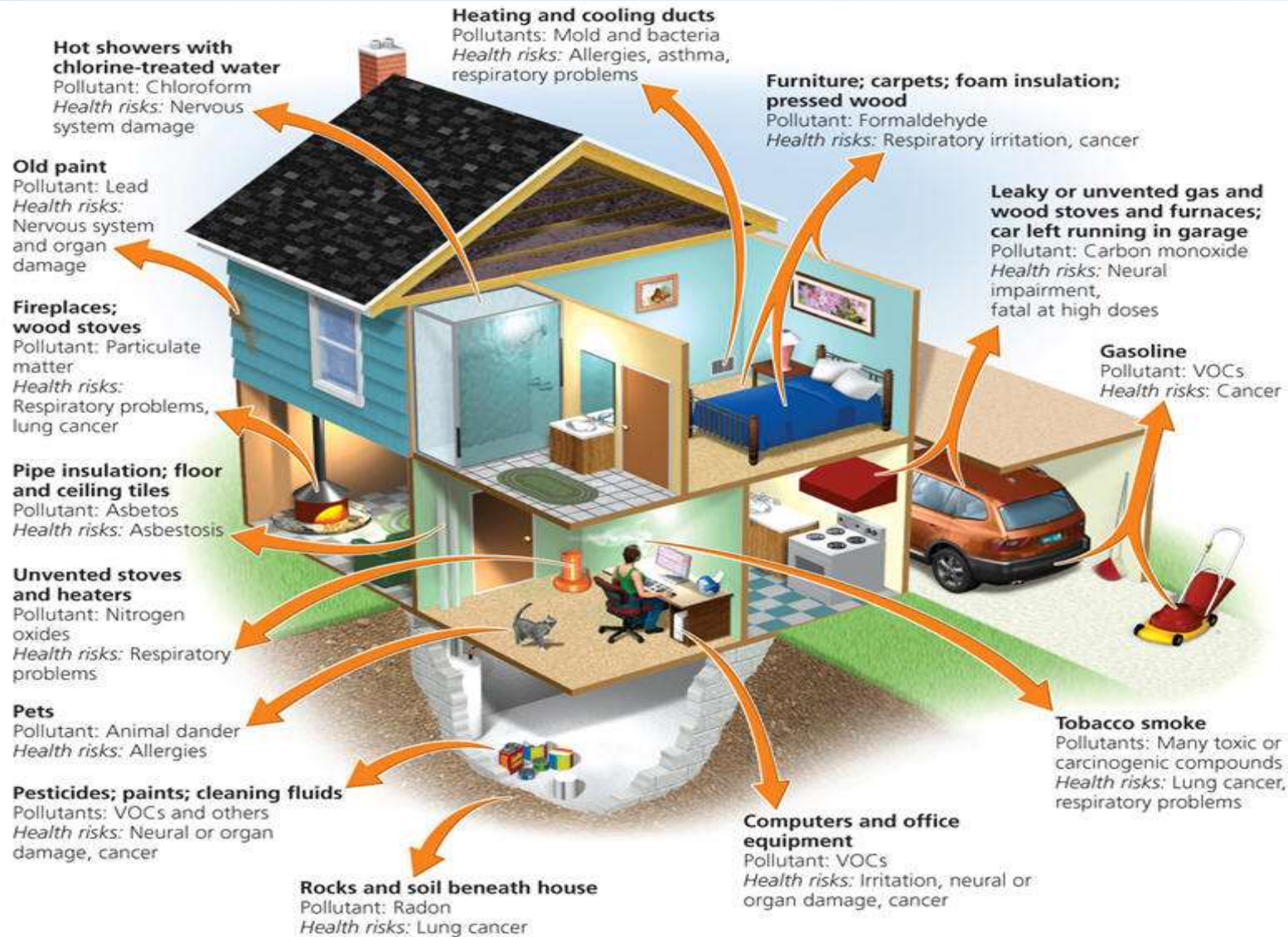
Deaths from indoor smoke from solid fuels



- Many countries in Africa, Asia and the South Pacific rely on solid fuels for cooking food and heating their homes.
- For the Pacific Islands there are about 10-400 deaths per million due to indoor smoke.
- Not all islands are the same and are based on cultural cooking practices and modernizations on various islands.

Indoor Air Pollutants

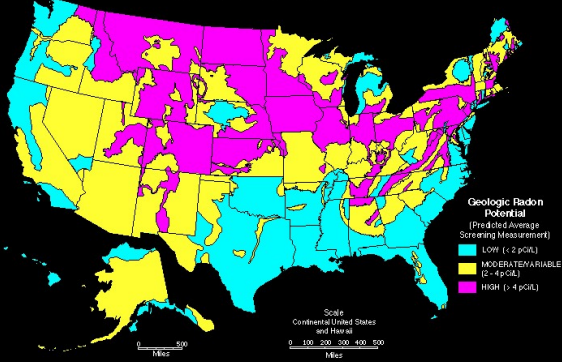
- You can use this figure to assess the safety of your home and workplace.
- Most important look out for:
 - Cleaning supplies or chemicals
 - Malfunctioning appliances or HVAC systems
- Refer to the previous lecture about the specific pollutants.



What should you worry about?

- The **relative importance** of any single source depends on **how much of a given pollutant it emits** and **how hazardous** those emissions are.
 - For example, an **improperly adjusted** gas stove can emit significantly more carbon monoxide than one that is properly adjusted.
 - Currently, **indoor air pollution** is ranked by the EPA as one of the top five **environmental risks** to public health. Some common **indoor air pollutants** that threaten **indoor air quality** include: lead, dust mites, mold, radon, pests, carbon monoxide, pet dander, mold, and second hand smoke.
- The two indoor air pollutants of greatest concern from a health perspective that haven't been mentioned before:
 - **Radon** is a naturally occurring gas that is odorless, colorless, and radioactive.
 - **Environmental tobacco smoke** (ETS) is the smoke emitted from the burning of a cigarette, pipe, or cigar, and smoke inhaled by a smoker.

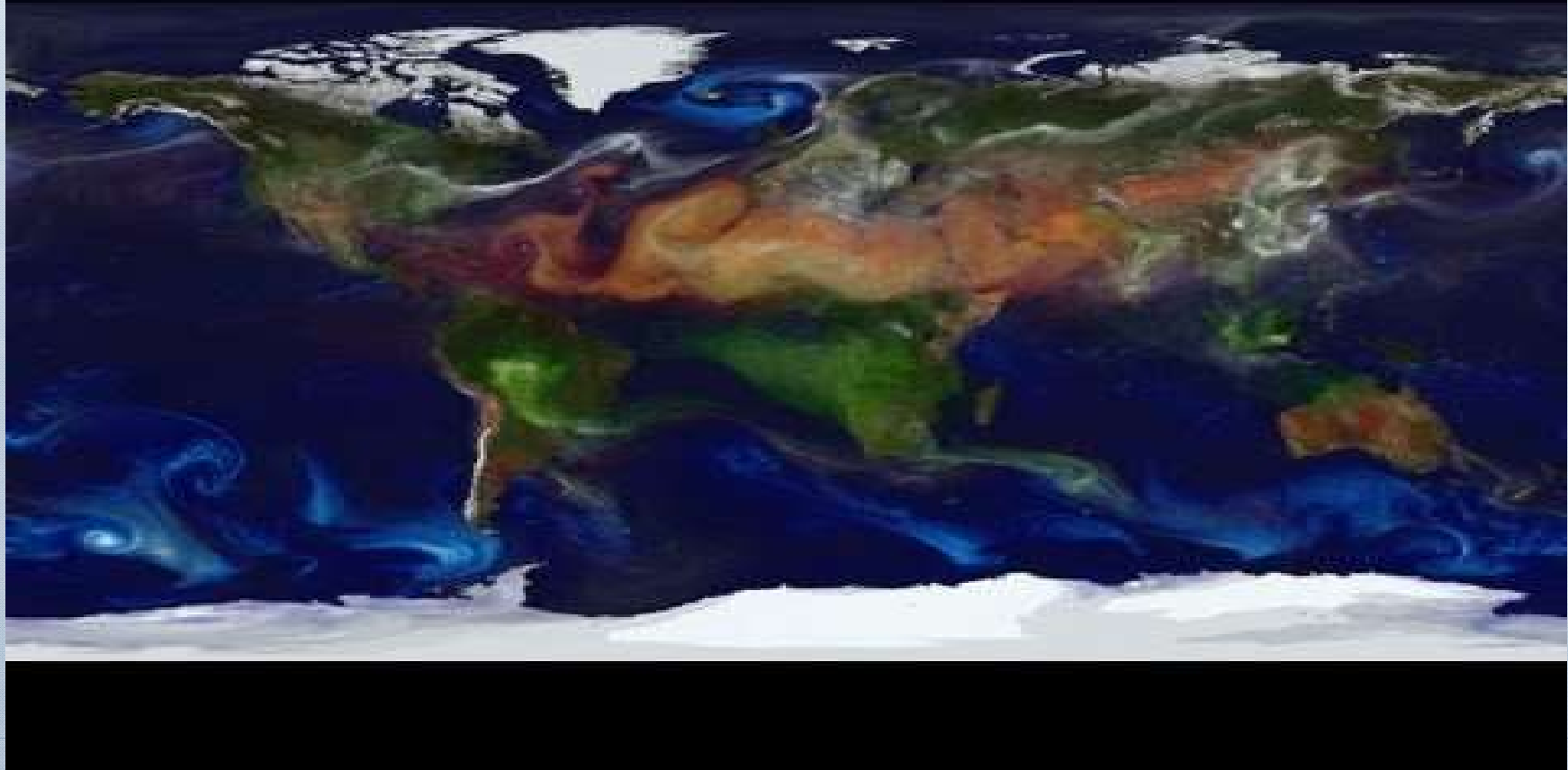
GENERALIZED GEOLOGIC RADON POTENTIAL OF THE UNITED STATES
by the U.S. Geological Survey



NASA “Paint by Particle” Aerosol Animation

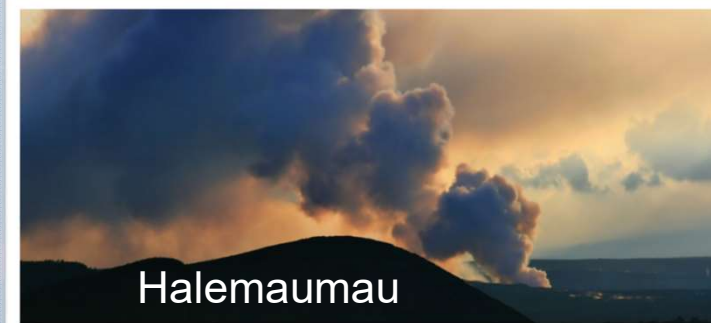
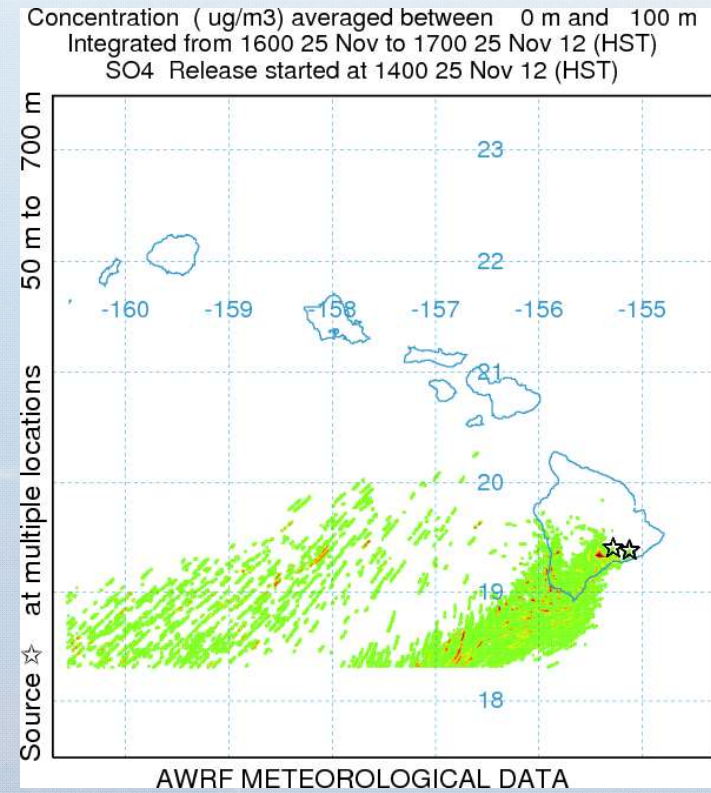
Animation of how particles travel in the atmosphere.

Brown = Dust, Green = Smoke from Forest Fires, White = industrial pollution, Blue = Ocean Emissions



Vog – Volcanic Smog

- Vent emissions are composed primarily of water vapor, SO₂, CO₂ and various trace gases and metals.
- SO₂ rapidly mixes with water vapor to form gaseous **sulfuric acid**.
- A majority of the liquid sulfate also quickly converts to various sulfate compounds forming aerosols via nucleation or condensation onto existing aerosol.
- **These sulfates form a layer of volcanic smog known as Vog.**
- Luckily Kilauea is on a break (since the 2018 eruption) so we don't have to worry about Vog.



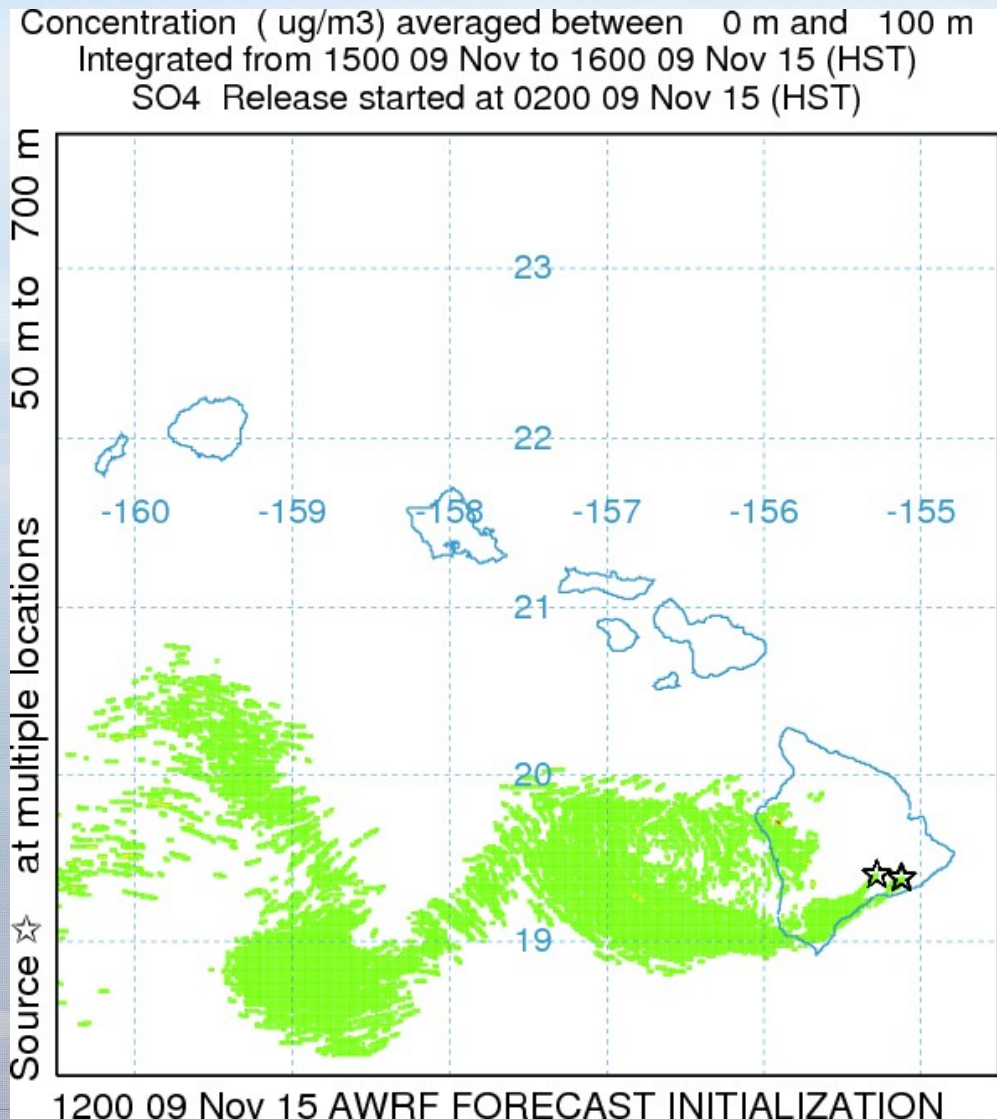
Vog – Information

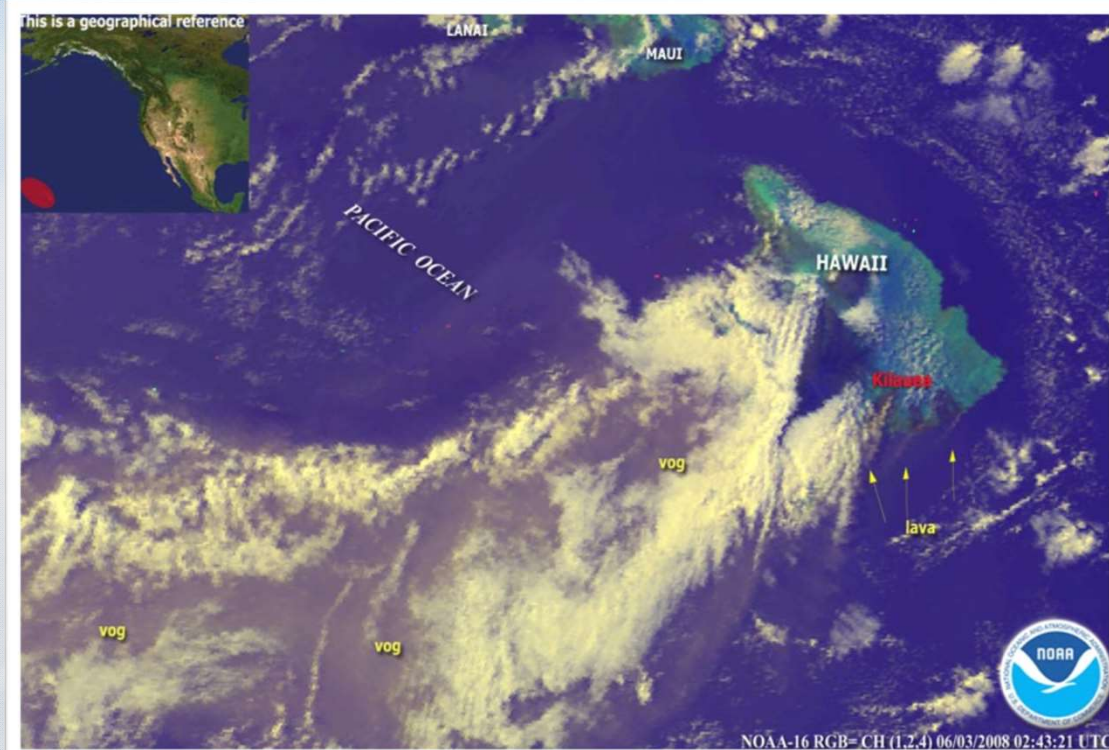


- Gas plumes of Kilauea used to rise up from three locations (and can restart at any time):
 - **Halema'uma'u Crater**
 - **Pu'u' Ō' ō vent**
 - along the coastline where lava flows from the **East Rift Zone** enter the ocean.
- The plumes created a blanket of vog that could envelop Big island.
- Vog mostly affected the **Kona coast** on the **west side of the Island of Hawai'i**, where the prevailing trade winds blew the vog to the southwest and southern winds then blew it north up the Kohala coast.

Vog – Information

- Prolonged periods of southerly **Kona winds**, however, used to cause vog to affect the eastern side of the Island on rare occasions, and affect islands across the entire state as well.
- By the time the vog reaches other islands, **the sulfur dioxide has largely dissipated, leaving behind ash, smoke, sulfates, and ammonia.**





Vog – Health Hazards & More

- **Volcanic sulfate aerosol is of a size (0.1-0.5 μm)** that can effectively reach down into the human lung, causing respiratory distress.
- **Sulfur dioxide** also promotes respiratory distress.
- **Reduction of visibility** in layers of high aerosol concentration near inversions represents a hazard to aviation.
- **Acid rain** negatively impacts ecosystems and reduces crop yields.

Indoor/Outdoor Air Pollutant – Smoke

Table 1. Mechanisms by which some key pollutants in smoke from domestic sources may increase the risk of respiratory and other health problems

Pollutant	Mechanism	Potential health effects
Particulates (small particles less than 10 microns, and particularly less than 2.5 microns aerodynamic diameter)	<ul style="list-style-type: none"> • Acute: bronchial irritation, inflammation and increased reactivity • Reduced mucociliary clearance • Reduced macrophage response and (?) reduced local immunity • (?) Fibrotic reaction 	<ul style="list-style-type: none"> • Wheezing, exacerbation of asthma • Respiratory infections • Chronic bronchitis and chronic obstructive pulmonary disease • Exacerbation of chronic obstructive pulmonary disease
Carbon monoxide	<ul style="list-style-type: none"> • Binding with haemoglobin to produce carboxy haemoglobin, which reduces oxygen delivery to key organs and the developing fetus. 	<ul style="list-style-type: none"> • Low birth weight (fetal carboxy-haemoglobin 2–10% or higher) • Increase in perinatal deaths
Polycyclic aromatic hydrocarbons, e.g. benzo[<i>a</i>]pyrene	<ul style="list-style-type: none"> • Carcinogenic 	<ul style="list-style-type: none"> • Lung cancer • Cancer of mouth, nasopharynx and larynx
Nitrogen dioxide	<ul style="list-style-type: none"> • Acute exposure increases bronchial reactivity • Longer term exposure increases susceptibility to bacterial and viral lung infections 	<ul style="list-style-type: none"> • Wheezing and exacerbation of asthma • Respiratory infections • Reduced lung function in children
Sulphur dioxide	<ul style="list-style-type: none"> • Acute exposure increases bronchial reactivity • Longer term: difficult to dissociate from effects of particles 	<ul style="list-style-type: none"> • Wheezing and exacerbation of asthma • Exacerbation of chronic obstructive pulmonary disease, cardiovascular disease
Biomass smoke condensates including polycyclic aromatics and metal ions	<ul style="list-style-type: none"> • Absorption of toxins into lens, leading to oxidative changes 	<ul style="list-style-type: none"> • Cataract



Sugar Cane Burning on Maui (Sept 2015)

Indoor/Outdoor Air Pollutant – Smoke

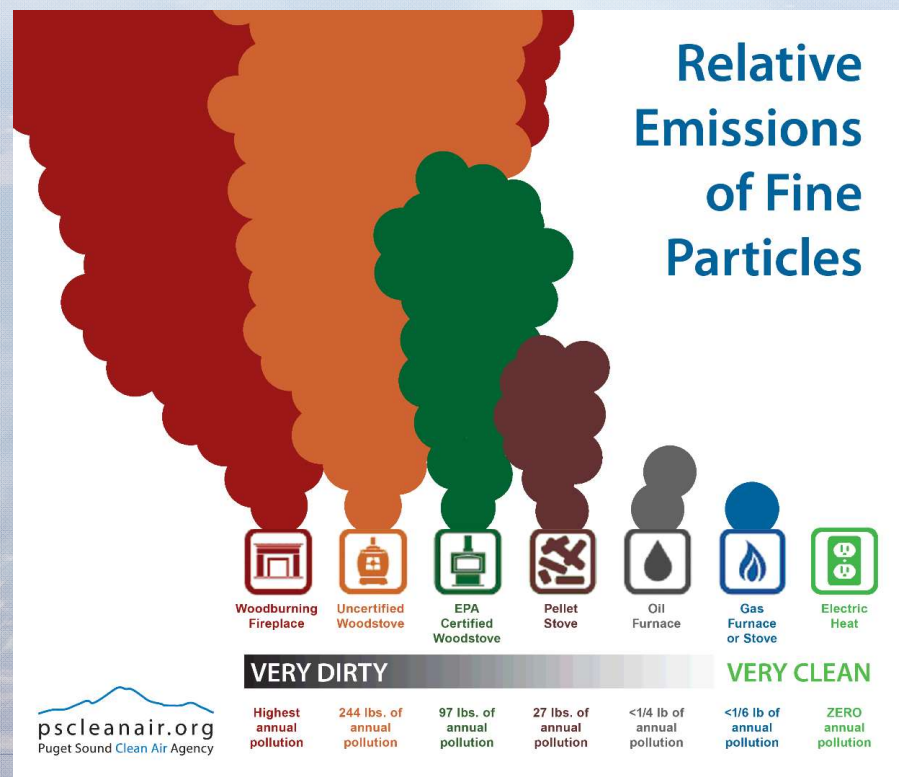
- The **Hawaii Department of Health** has completed the first phase of a study on the health effects of sugar cane burning on Maui.
 - **Preliminary results hint at people suffering ill effects downwind of cane burning**
- These preliminary results are not surprising since **Smoke produces Particulate Matter** which can be some of the most dangerous air pollutants.
- The development of the sugar industry really began to boom in the 1850 and recently has shrunk to only one company (Hawaiian Commercial and Sugar).
- **With the recent closing of another sugar mill the final burning of sugar cane in Maui occurred in 2016!!**

- <http://www.mauinews.com/page/content.detail/id/565617/Early-study-results-hint-at-ill-effects-from-cane-burns.html?nav=10#sthash.kepB4JuY.dpuf>



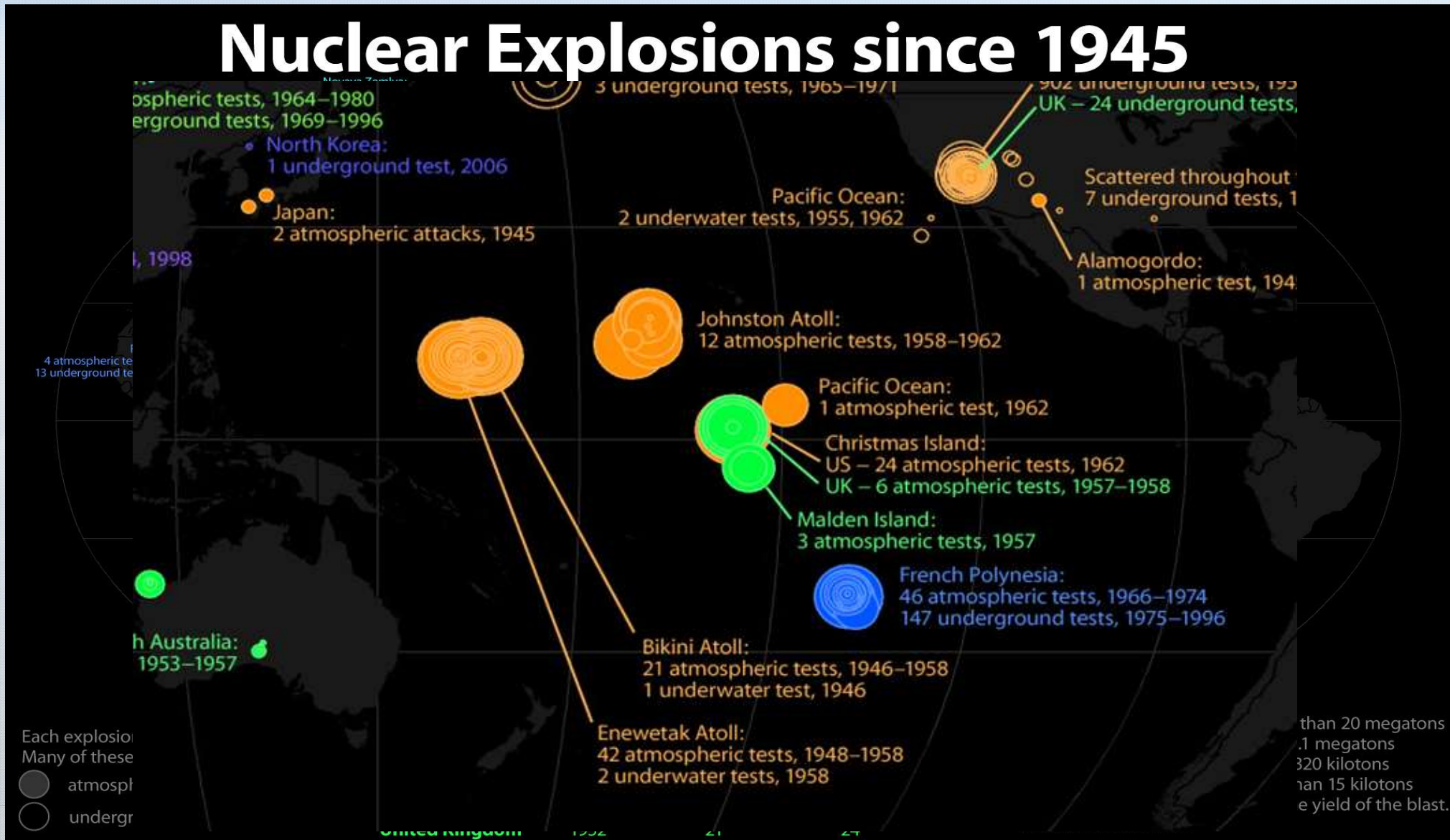
Cooking with Solid Fuel – Smoke

- Different heating and cooking sources produce different amounts of fine particles.



- Wood burning fireplaces are the worst while electric heat is the best.
- Some Pacific Islands are in the “Red” others are relatively clean.

Nuclear Explosions since 1945



Nuclear Tests and Fallout in the Pacific

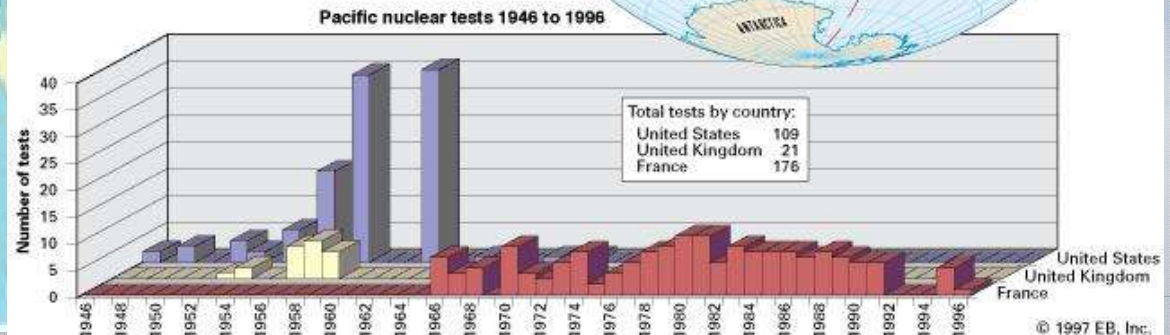
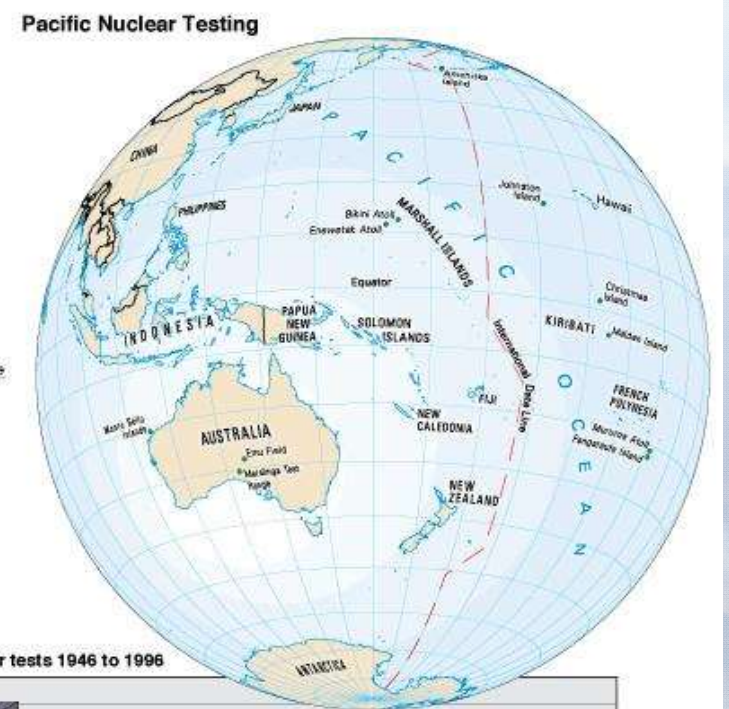


Pacific area test sites (testing party)

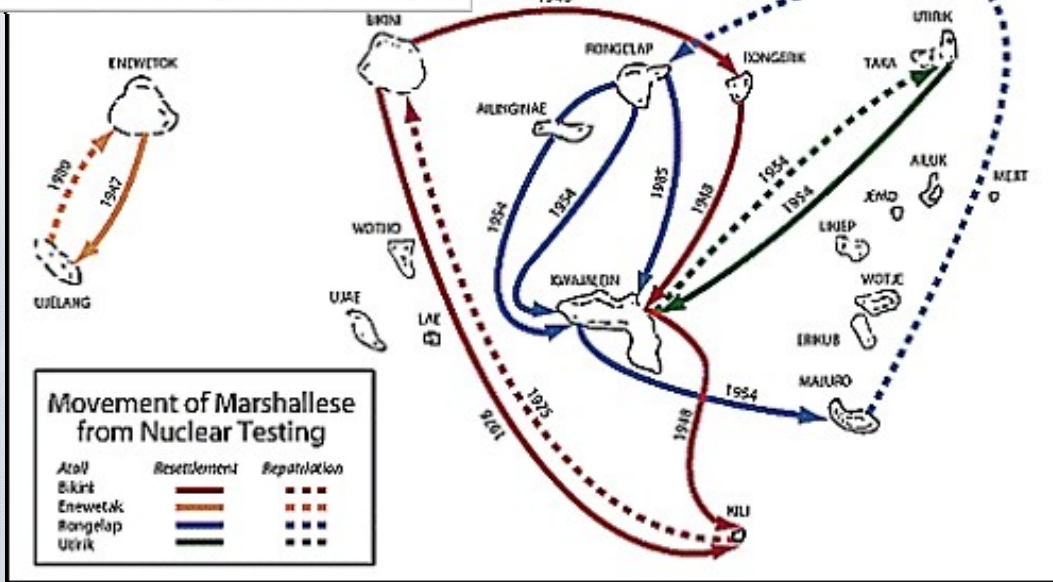
Bikini Atoll, Marshall Is. (U.S.)	23
Enewetak Atoll, Marshall Is. (U.S.)	43
Christmas Island, Kiribati (U.S. and U.K.)	30
Johnston Island (U.S.)	12
Amchitka Island, Alaska (U.S.)	3
Monte Bello Islands, Australia (U.K.)	3
Emu Field, Australia (U.K.)	2
Maralinga Test Range, Australia (U.K.)	7
Malden Island, Kiribati (U.K.)	3
Mururoa Atoll, French Polynesia (France)	114
Fangataufa Island, French Polynesia (France)	10
Other French Polynesia (France)	52
Other Pacific (U.S.)	4
TOTAL	306

Nuclear tests conducted at site

23
43
30
12
3
3
2
7
3
114
10
52
4
306



Nuclear Tests



- July 1947 - **The Marshall Islands and the rest of Micronesia became a United Nations strategic Trust Territory** administered by the United States.

- U.S. promised to "**protect the inhabitants against the loss of their lands and resources.**"

- Marshallese were relocated from island to island to "protect" them from the nuclear tests.

- **Many suffered, some starved living on less than ideal islands.**

- They were still **exposed to fallout** due to tests (including Hydrogen bombs) that were conducted under less than favorable weather conditions.

Nuclear Tests and Fallout in the Pacific



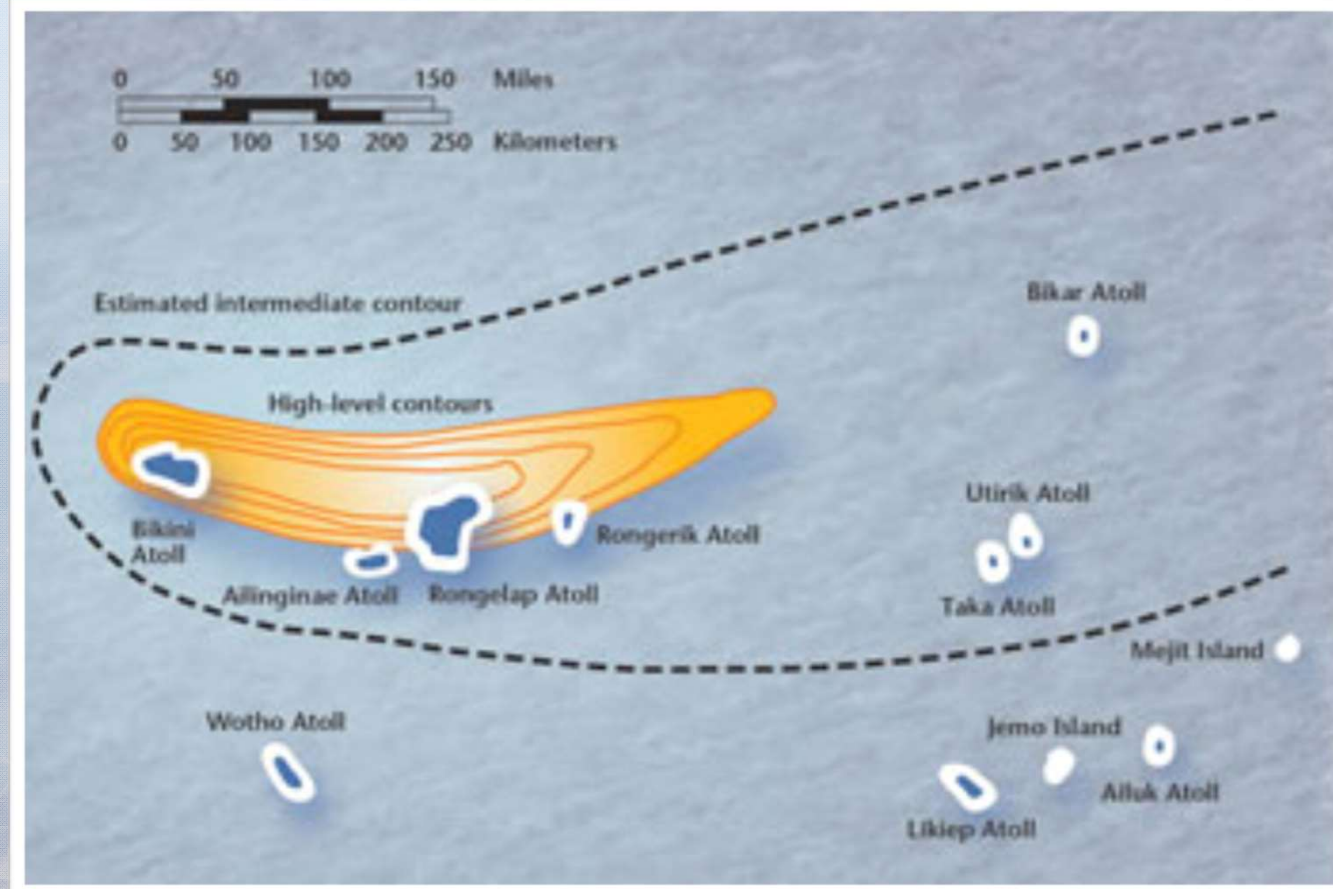
The U.S. Atomic Energy Commission issues a statement to the press calling Bravo a "routine atomic test", and stating that some Americans and Marshallese were "unexpectedly exposed to some radioactivity. There were no burns. All were reported well."

- Despite weather reports showing that winds are blowing in the direction of inhabited islands, the March 1 1954 Bravo hydrogen bomb test is detonated at Bikini.
- **At 15 megatons, it is 1,000 times the strength of the Hiroshima bomb.**
- **Within hours a gritty, white ash is enveloping islanders** on Rongelap and Ailinginae Atolls. A few hours later, American weathermen are exposed to the snowstorm of fallout on Rongerik, and still later the people of Utrik and other islands experience the fallout "mist".
- Those exposed experience **nausea, vomiting and itching skin and eyes**. March 3 Rongelap islanders are evacuated 48 hours later, and Utrik is evacuated 72 hours after Bravo.
- **Skin burns on the heavily exposed people begin to develop, and later their hair falls out.**

Nuclear Tests and Fallout in the Pacific



- Nuclear Fallout travels with the mean wind during the test.
- Affected other islands.



Map of the Republic of Marshall Islands showing the fallout pattern from the Bravo nuclear test conducted on March 1, 1954.