School of Earth and Environment

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Sulfur pollution from Icelandic volcanic eruptions

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1783-1784 CE Laki eruption

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Lava = 14.7 km^3
Tephra = 0.4 km^3
SO_2 = 120 Mt

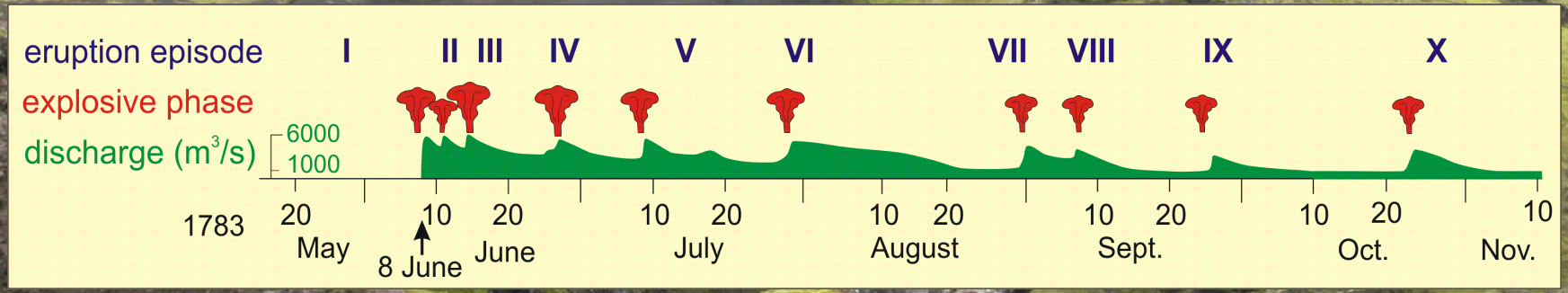

Photo courtesy of Alan Robock

Laki haze across Europe

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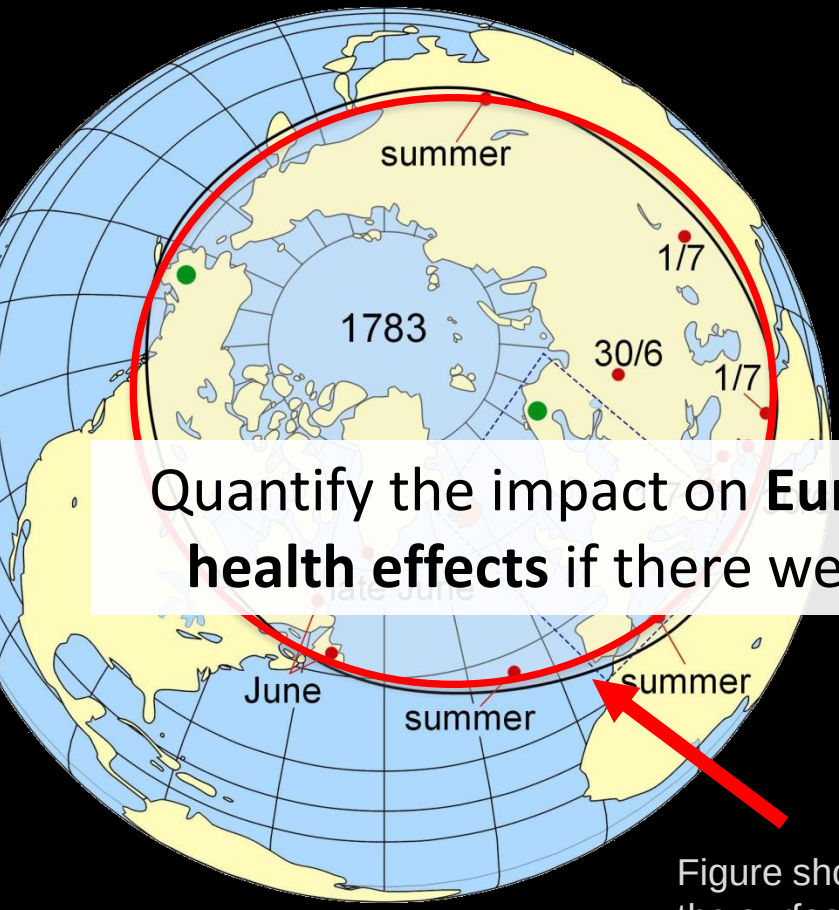
Laki was the biggest atmospheric pollution event in historic times.

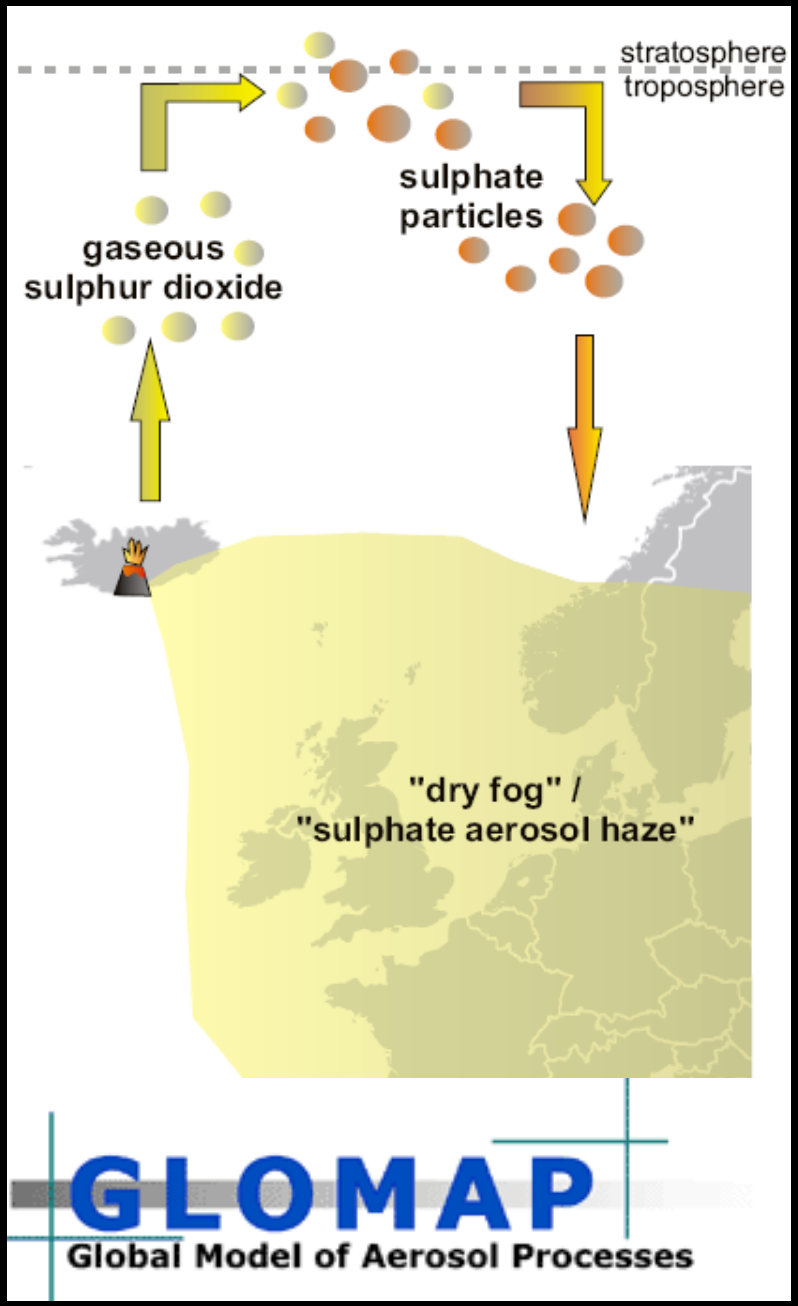


‘Many felt unusual pressure and pain in the head, **others difficulty breathing and shortness of breath** (….). **Others who have had asthma before, experienced new attacks from this disease**’

Quantify the impact on **European air quality** and the **potential health effects** if there were a **Laki-type eruption** tomorrow.

Figure showing extent and date of the first appearance of the Laki haze at the surface (from Thordarson & Self, 2003).

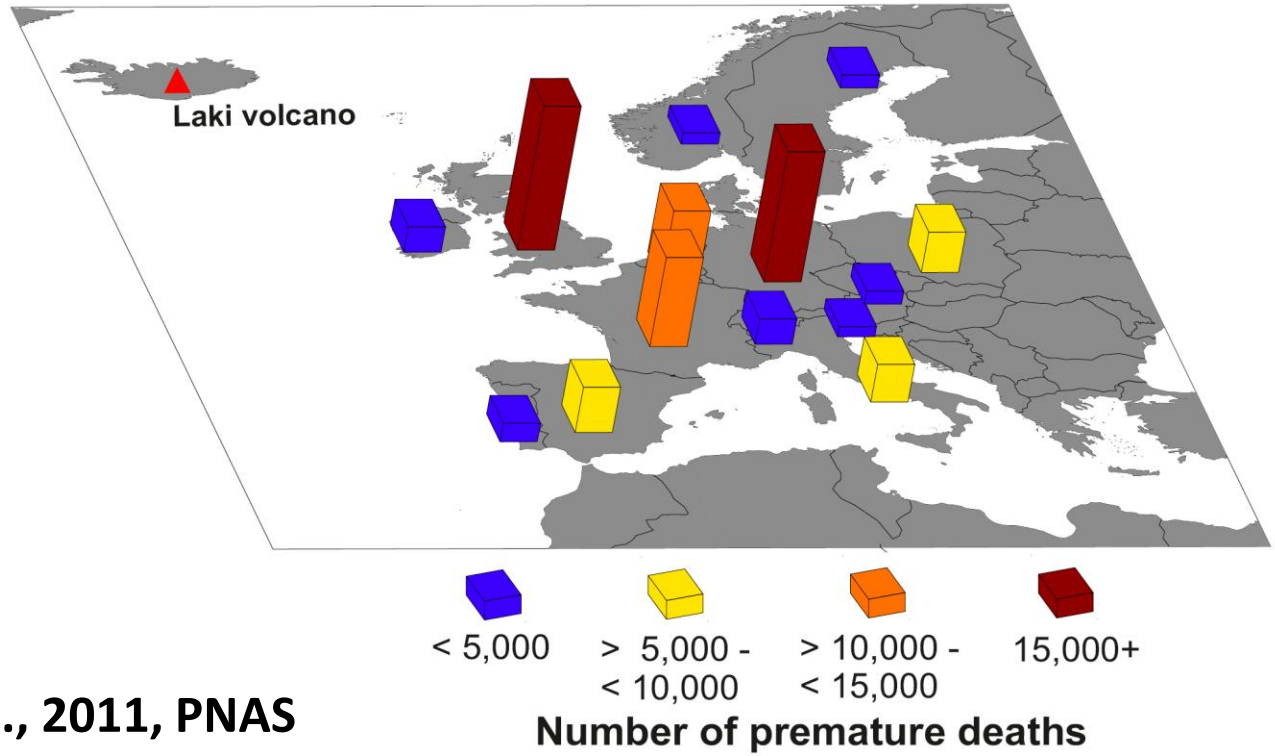
Volcanic air pollution + mortality rates



Simulate Laki-type eruption based on eruption source parameters as published for 1783-1784 Laki eruption.

Modelled impact on air quality
+
Population data
+
Baseline fatalities
+
Concentration-response functions

Cardiopulmonary deaths in year following a Laki-type eruption



Schmidt et al., 2011, PNAS

- **About 140,000 additional fatalities due to eruption.**
- Exceeds annual mortality rate due to seasonal influenza.
- Context: globally 800,000 deaths caused by “normal” air pollution.

(Cohen et al., 2004)

SO_2 + aerosol dispersion

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- Jan 2012: explosive & effusive eruptions added to UK National Risk Register for Civil Emergencies
- Research emphasis on tephra dispersion modeling + ground- and space-borne remote and in-situ measurements
- Degradation of air quality due to volcanic eruptions?
- Health impacts downwind the volcanic vent?
- What if VAACs had to forecast SO_2 operationally?

The Japan Times
14 Nov 2013

NATIONAL

Tokyo air pollutant traced to Kyushu volcano, China link discounted

KYODO

ARTICLE HISTORY | NOV 14, 2013

Volcanic gas carrying sulfur dioxide released from Mount Sakurajima in Kagoshima Prefecture is partly responsible for spikes in the level of the air pollutant PM2.5 in the Kanto and Tokai regions, according to the government's Meteorological Research Institute.

SO_2 dispersion

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What if VAACs had to forecast SO_2 operationally … Why?

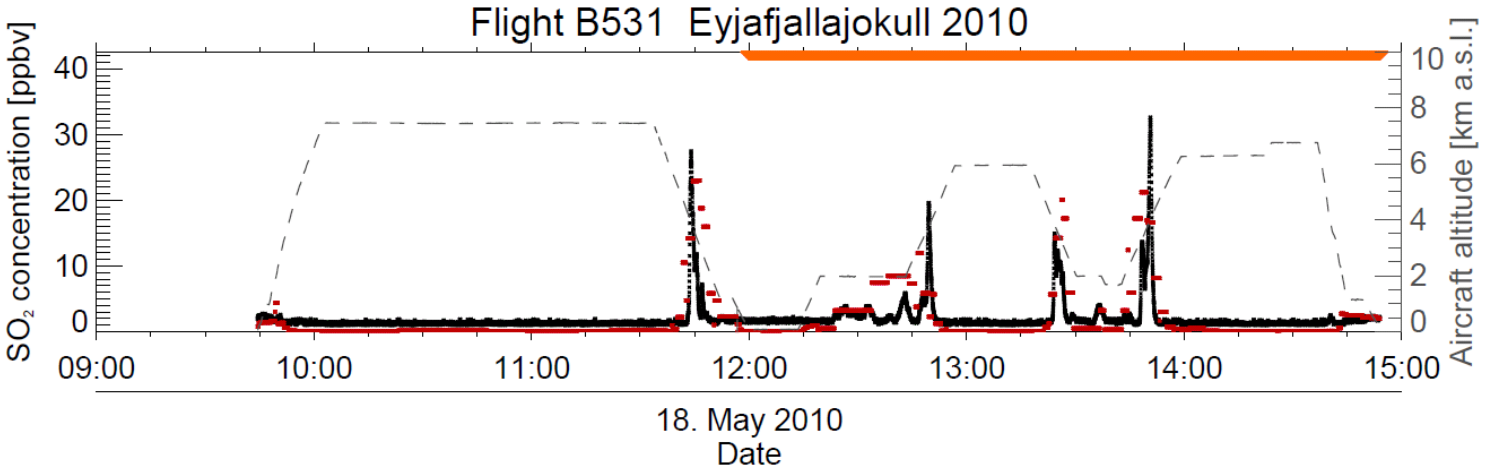
1) Proxy for ultrafine volcanic ash particles (assuming co-location of the two species)

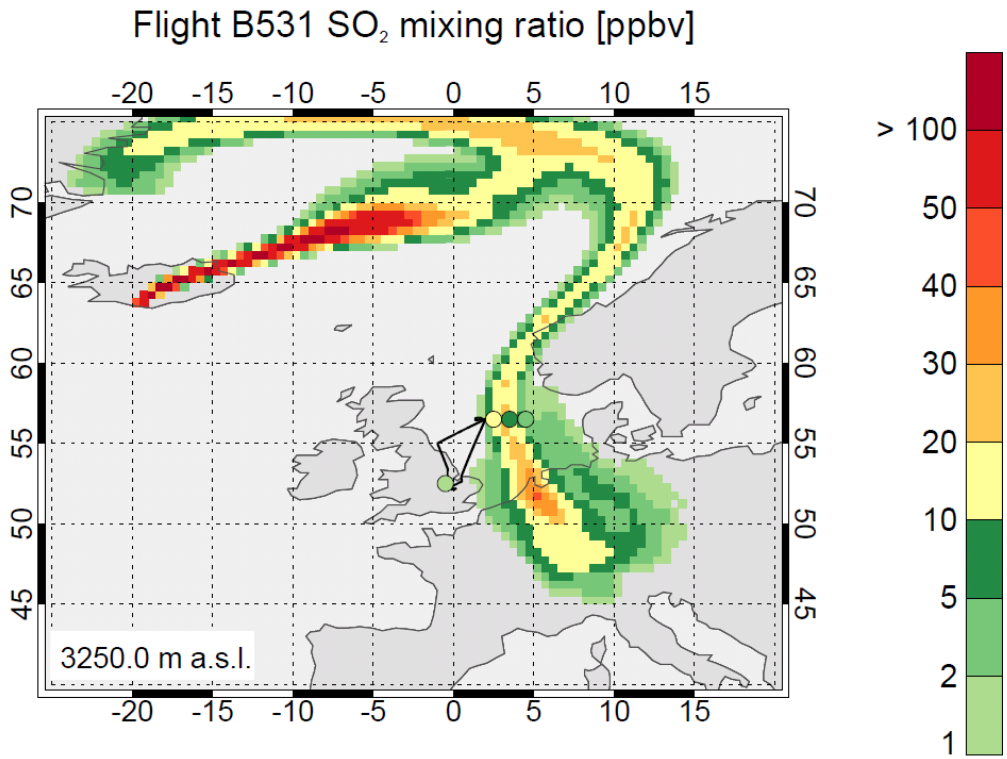
2) SO_2 is thought to be a hazard to aircraft after oxidation to sulfuric acid aerosol (highly corrosive; may cause damage to the aircraft fuselage; maintenance cost?)

3) SO_2 = toxic = could be hazardous to aircraft occupants

1) SO_2 & oxidized products = impact on climate

NAME dispersion model: Eyjafjallajökull 2010





- Hekla 2000: SO_2 conc. up to 1000 ppbv in the 35-hour-old plume (Rose et al., 2003)
- Humans may perceive SO_2 at about 300 ppbv
- Current 1-h mean ambient air quality standard is 75 ppbv (EPA, 2010)

Ongoing work

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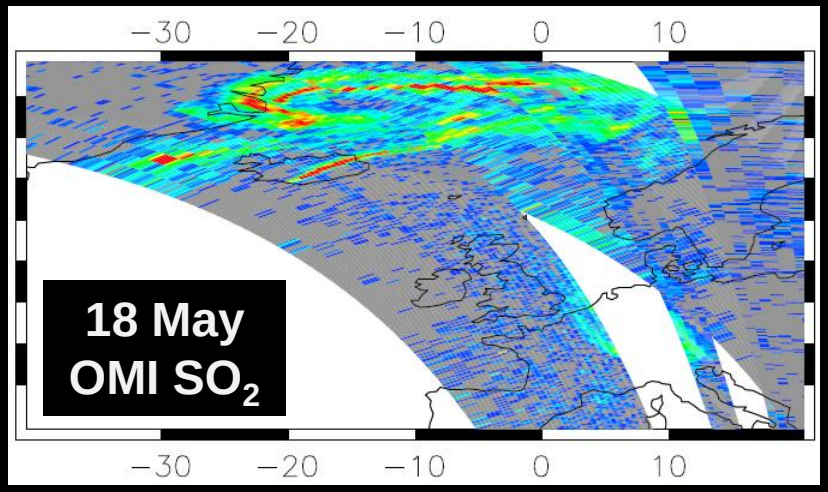
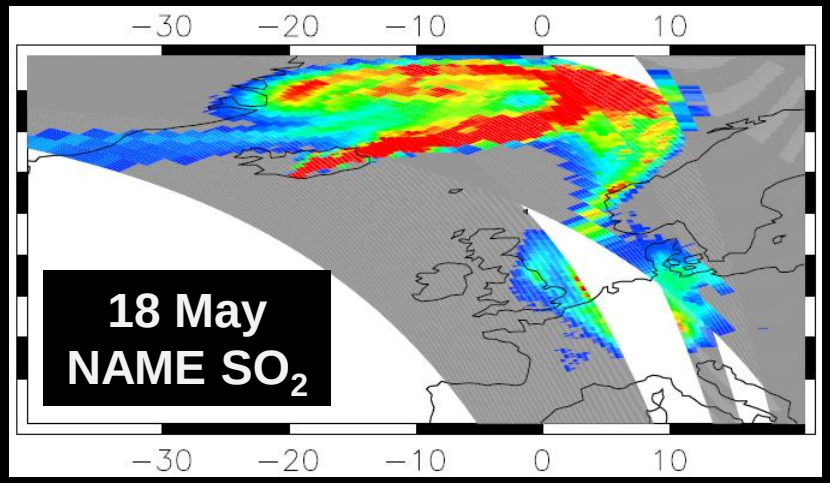
- Evaluating the model against OMI satellite retrievals
- Simulate SO_2 concentrations for a set of hypothetical eruptions with eruption source parameters (injection altitude, mass of SO_2 released) that are typical for Icelandic volcanism.
- SO_2 and sulfuric acid aerosol particles a hazard to commercial aviation? → exposure/dosage calculations





OMI retrievals courtesy of Nicolas Theys

Conclusions

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- NAME model captures both dispersal of volcanic gases and concentrations downwind of the vent
- Eyjafjallajökull 2010, SO_2 concentrations downwind of the vent remained well below current air quality standards.
- Particulate matter → air quality impacts at surface
- Flight level hazards ambiguous (lack of evidence)

Met Office

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CabinetOffice
Civil Contingencies

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Vnaheim

BGS 1835

Thank you!

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