Volcanology: multidisciplinary science for a versatile campus

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Michigan Technological University

Spring 2017 Michigan Tech Research Forum Distinguished Lecture

Volcanology at Michigan Tech (1970 – present)

Bill Rose

Volcanology, remote sensing

Gregg Bluth

John Gierke

Ash/gas interaction

Jimmy Diehl

Palaeomag.

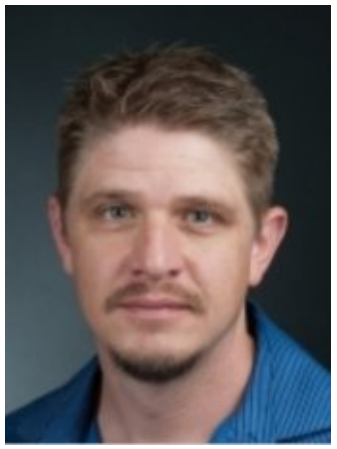
Matt Watson

Jeremy Shannon

Remote sensing

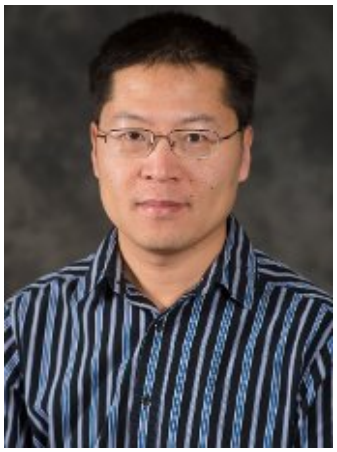
Greg Waite

Seismology



Chad Deering

Petrology



Shiliang Wu

Atmos. chemistry

Thomas Oommen

Slope stability

Alex Kostinski & Raymond Shaw

Cloud physics

Volcanism and Keweenaw copper

Greenstone lava flow
~1 Billion years old

Native copper

J. Jaszczak

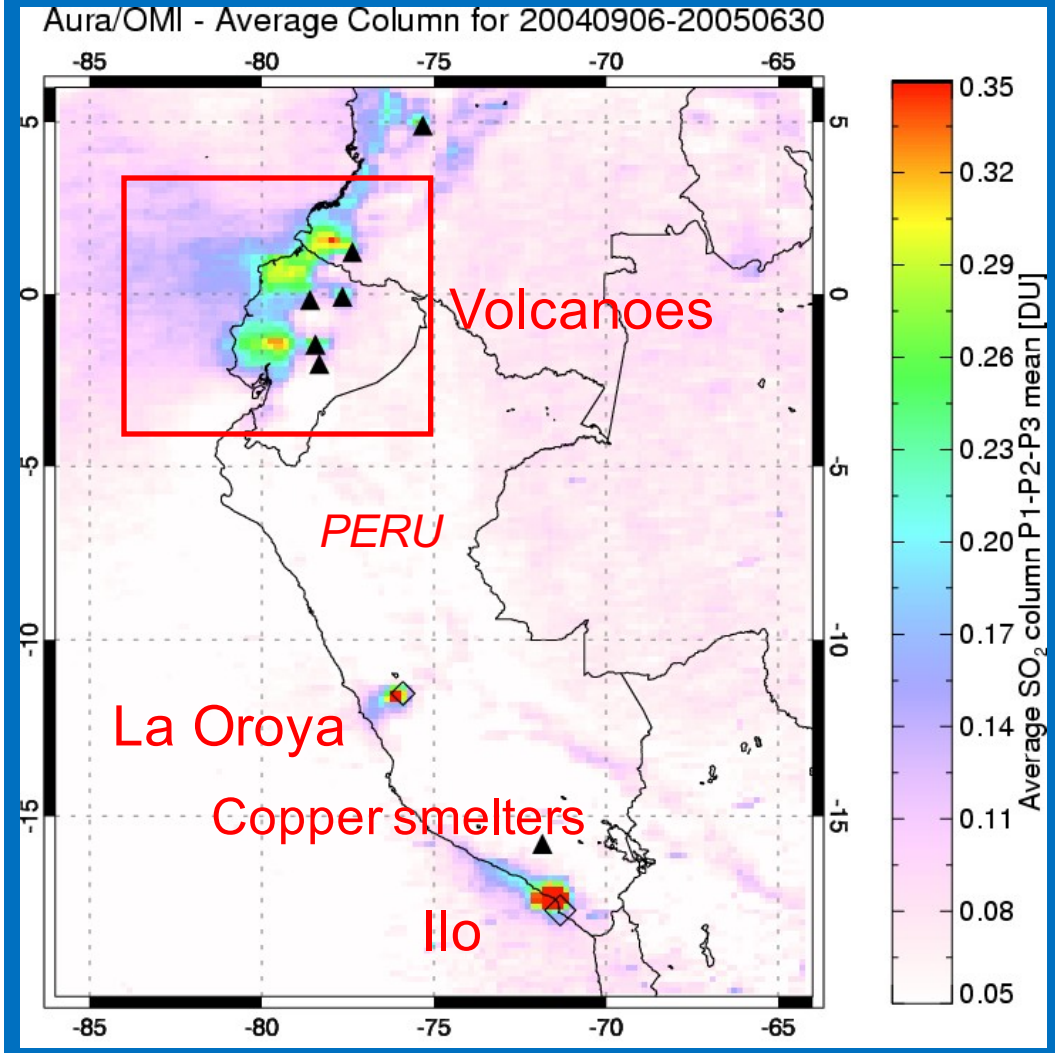
Chalcocite (Cu_2S)

Wikipedia

Jim Belote

Where did the sulfur go?

Satellites detect smelter SO_2 emissions in Peru

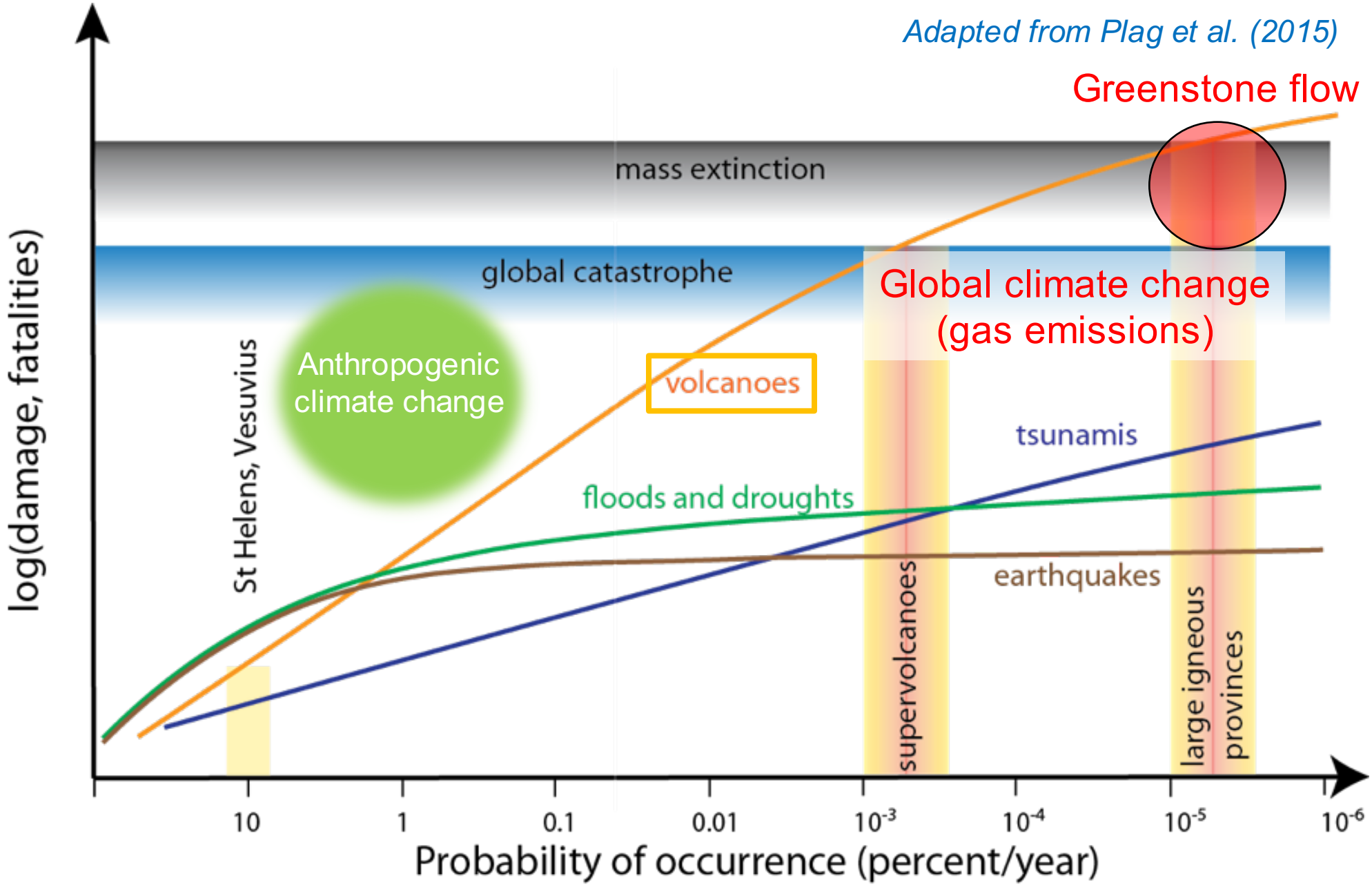


Average OMI SO_2 vertical column
Sep 2004 - June 2005

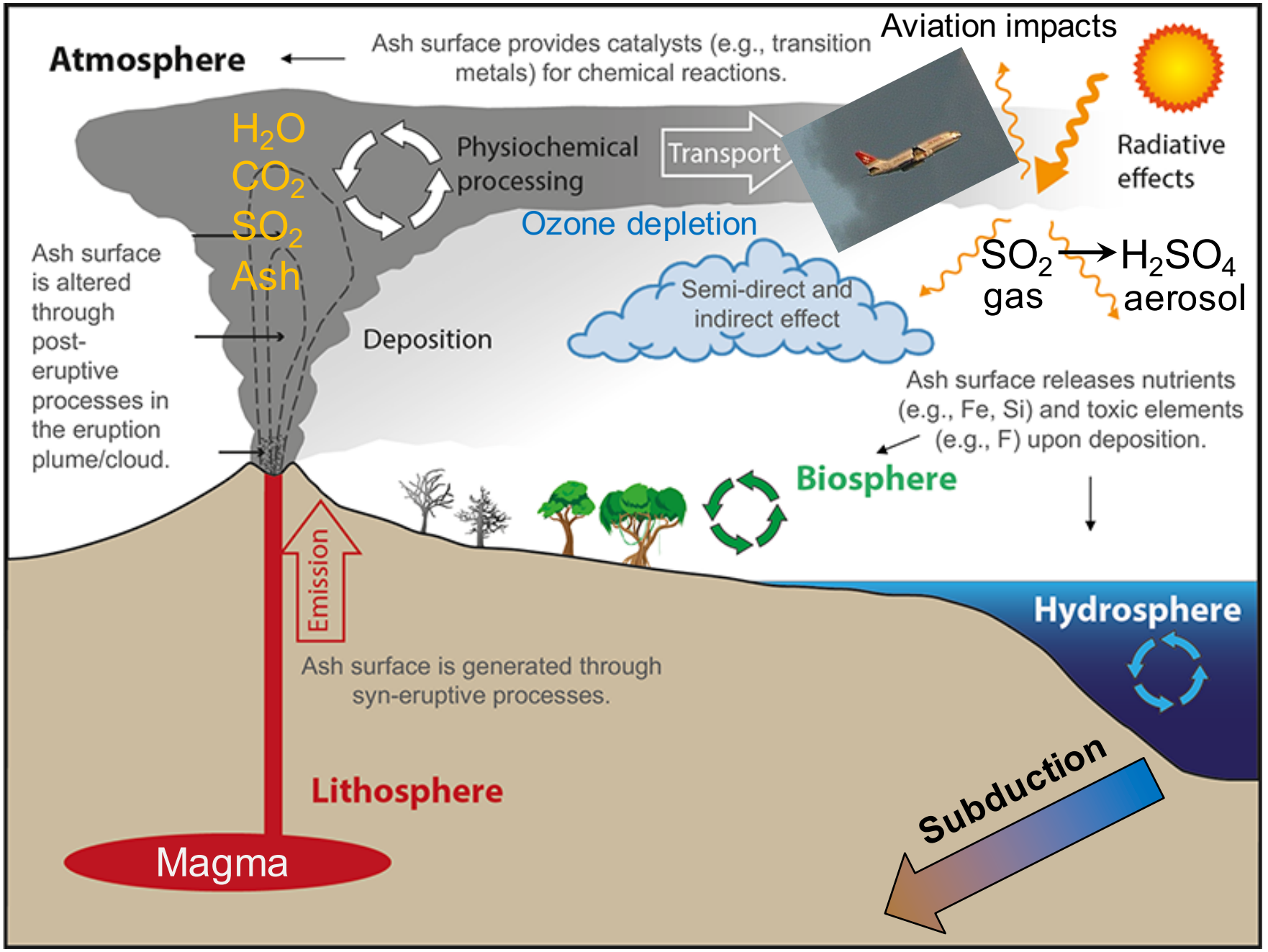
[Carn *et al.*, GRL 2007]

- Peruvian smelters were among the world's largest industrial sources of SO_2 in 2005-2010
- Signature of 'Anthropocene'

Consequences of natural hazards



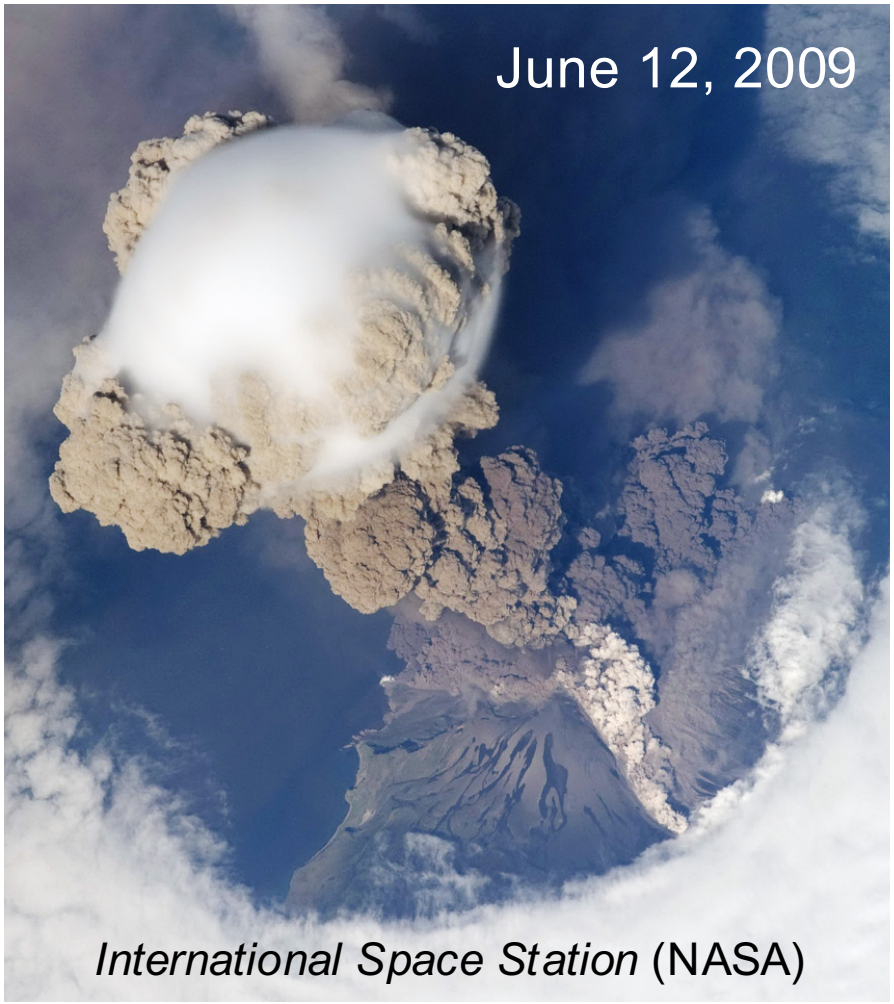
Volcanoes: Earth's recyclers



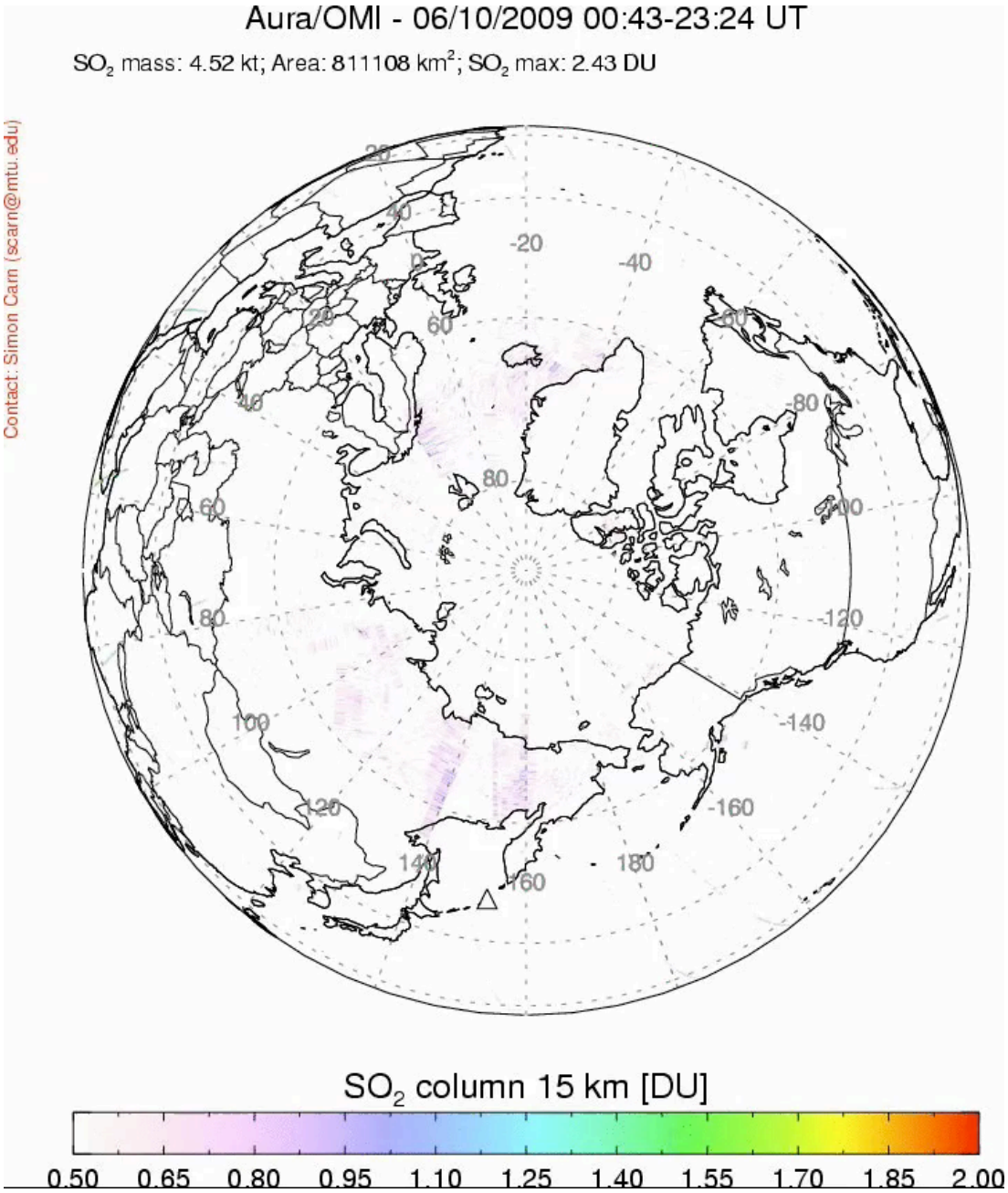
Adapted from: Hoshyaripour, EOS, (2017)

The view from space

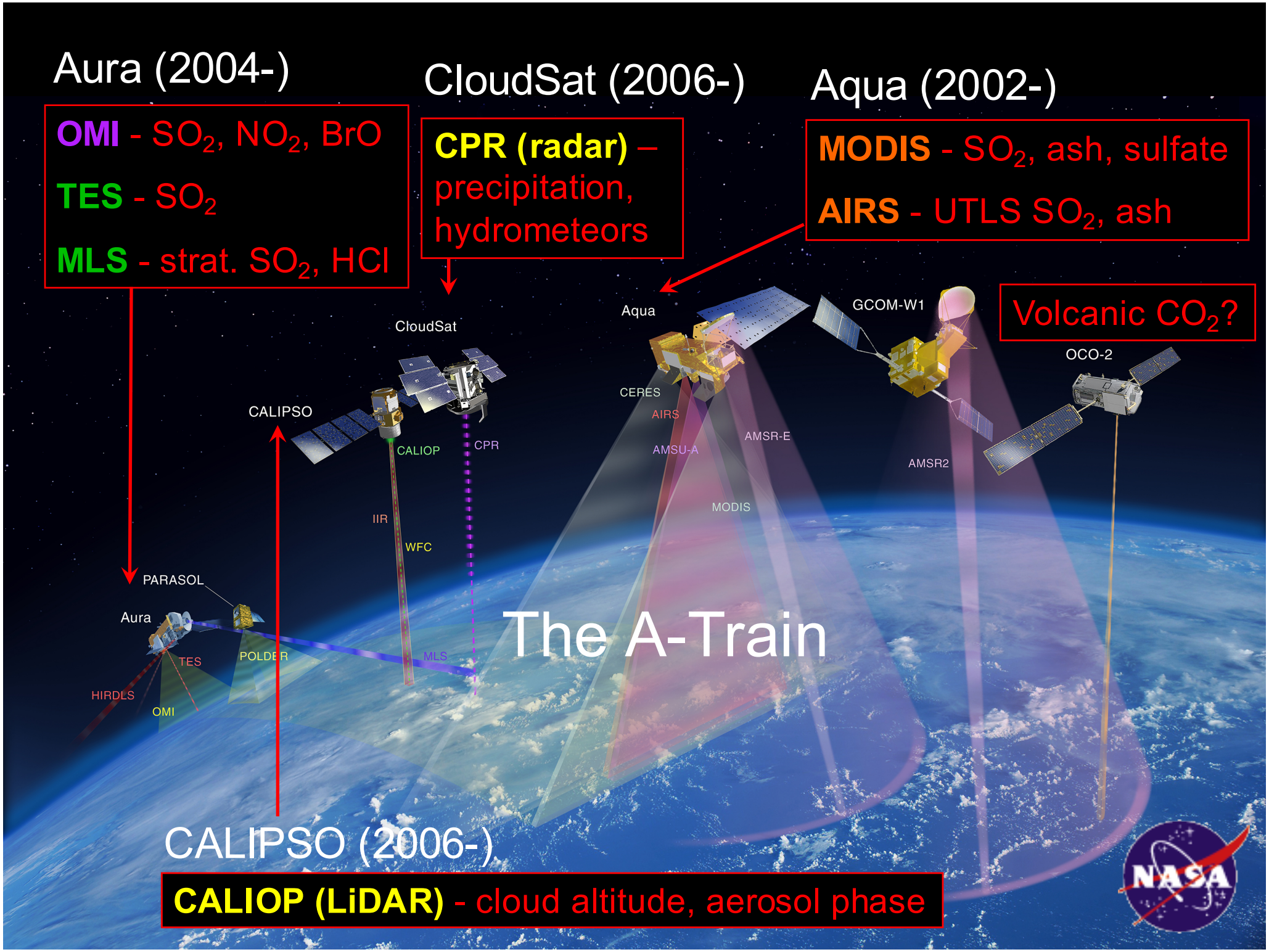
Sarychev Peak (Kurile Is, Russia)



International Space Station (NASA)



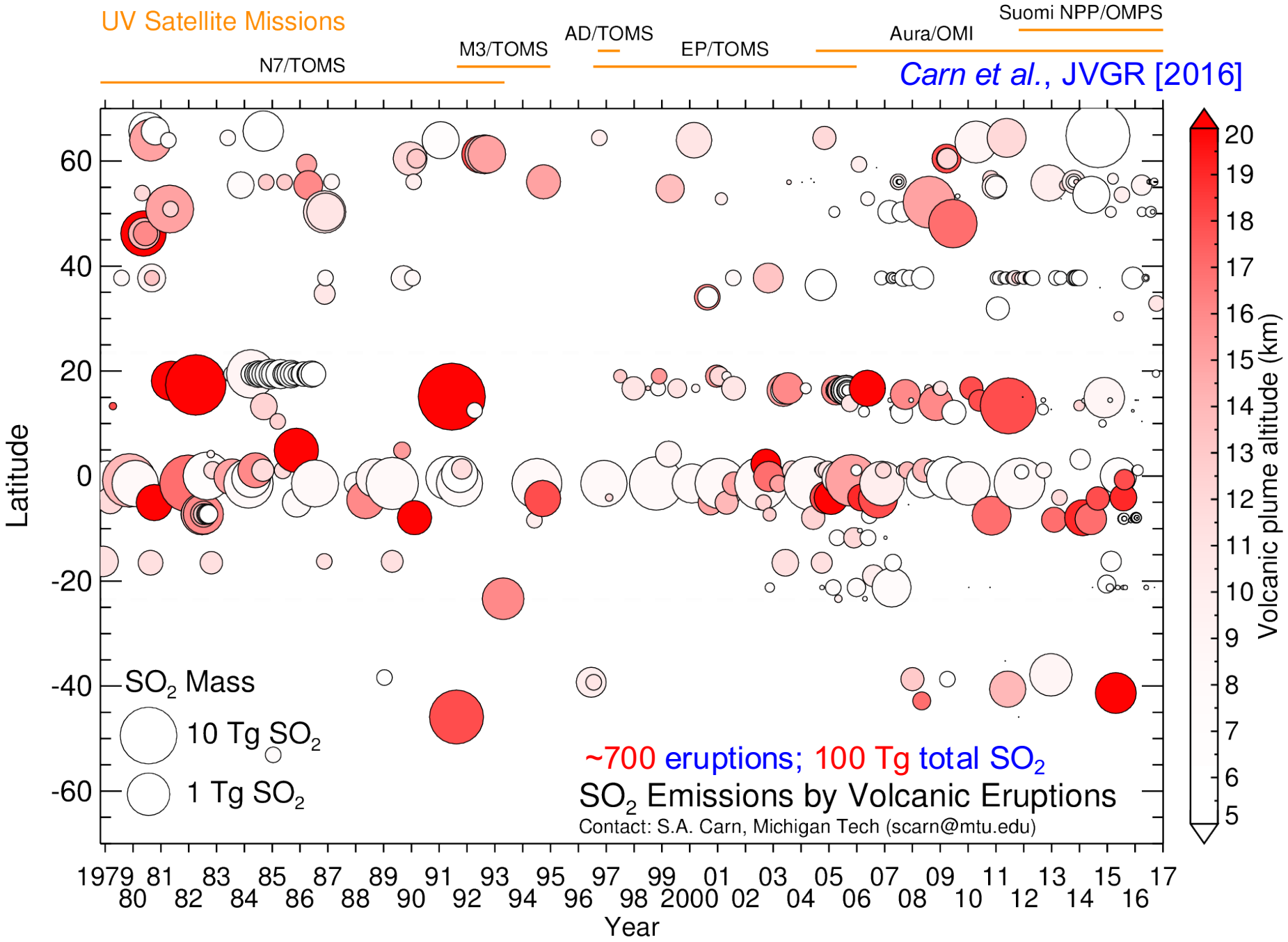
Satellites detect volcanic heat, gas & ash emissions, and ground deformation.


Aura (2004-)
OMI - SO_2, NO_2, BrO
TES - SO_2
MLS - strat. SO_2, HCl
CloudSat (2006-)
CPR (radar) – precipitation, hydrometeors
Aqua (2002-)
MODIS - SO_2, ash, sulfate
AIRS - UTLS SO_2, ash
Volcanic CO_2?
CloudSat
CALIPSO
CALIOP
CPR
IIR
WFC
Aqua
CERES
AIRS
AMSU-A
AMSR-E
MODIS
GCOM-W1
AMSR2
OCO-2
PARASOL
Aura
TES
POLDER
HIRDLS
OMI
MLS
The A-Train
CALIPSO (2006-)
CALIOP (LiDAR) - cloud altitude, aerosol phase
NASA

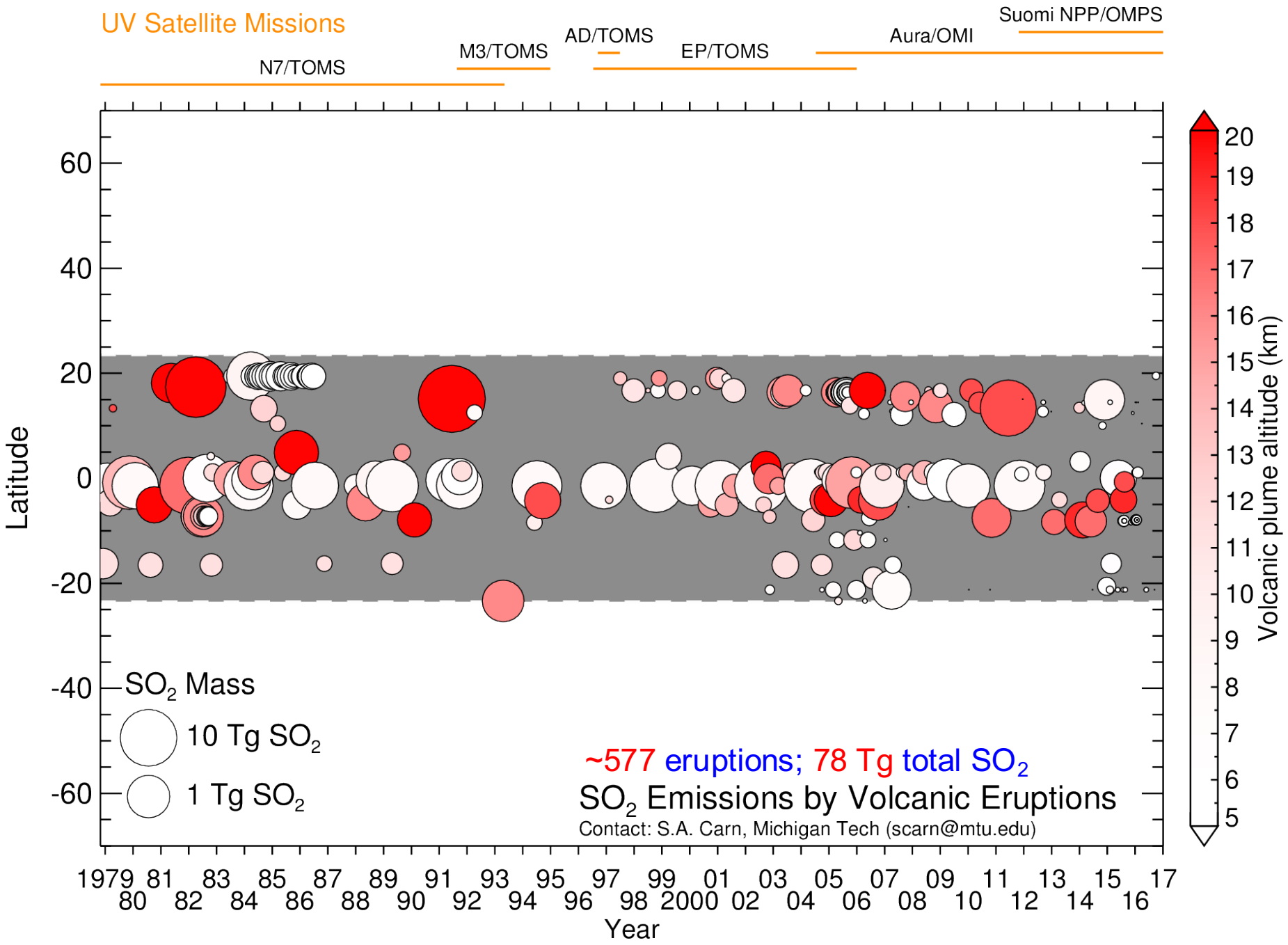
Some misconceptions about volcanic activity

- Every explosive volcanic eruption leads to cooling of climate
  - Not enough SO_2, most of the time
  - But volcanic cooling can be significant
- Volcanic emissions of SO_2 (a greenhouse gas) are causing climate change
  - Issues: lifetime of SO_2, magnitude of emissions
- Volcanic emissions of CO_2 are causing global warming
  - Issues: what is the magnitude of volcanic CO_2 emissions relative to anthropogenic emissions?
- Solutions
  - Education, publications, public outreach (e.g. Smithsonian Institution; http://volcano.si.edu/E3/)
  - Social media (Twitter etc.)

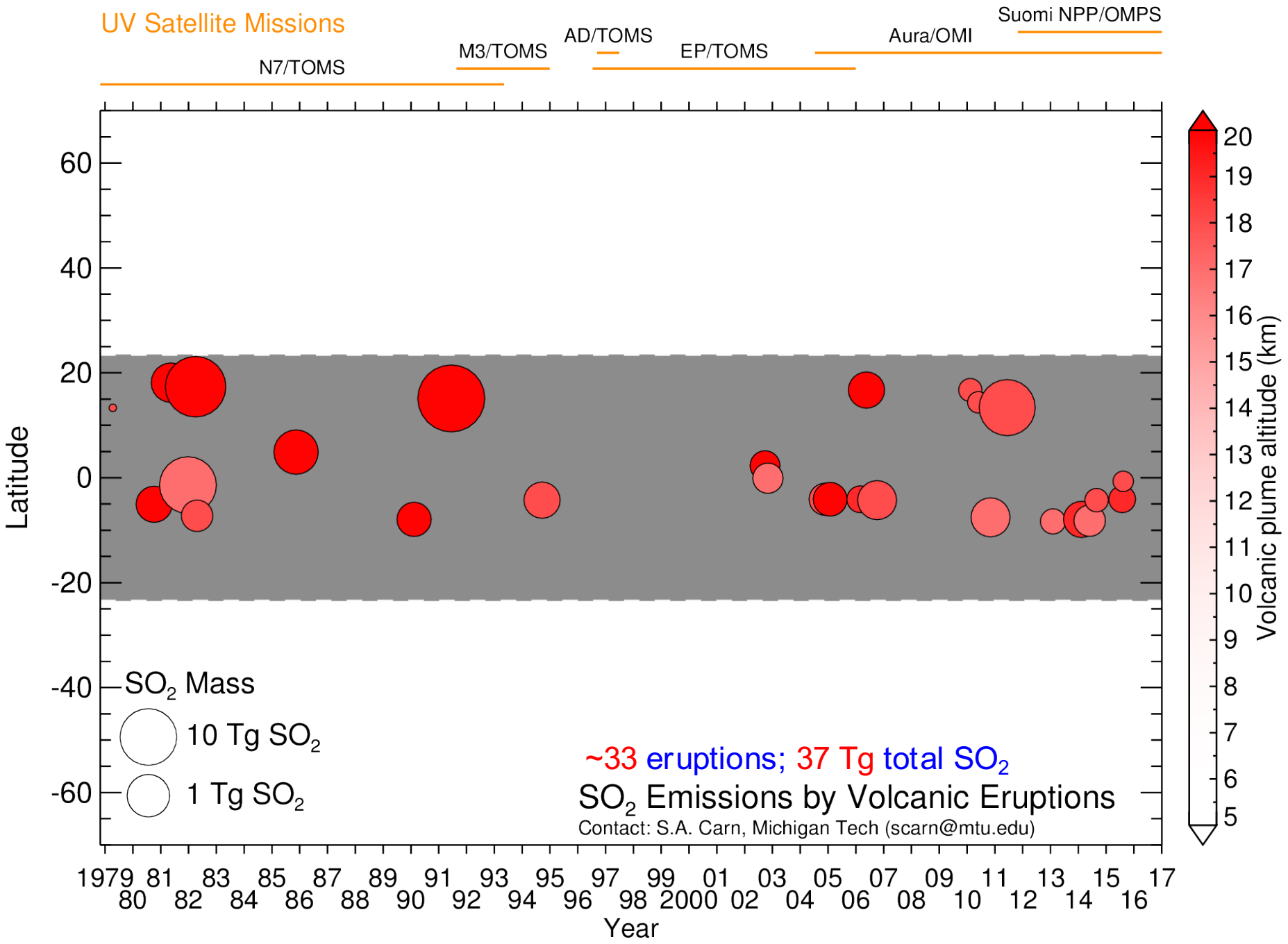
Volcanic SO_2 emissions (since 1978) – all eruptions



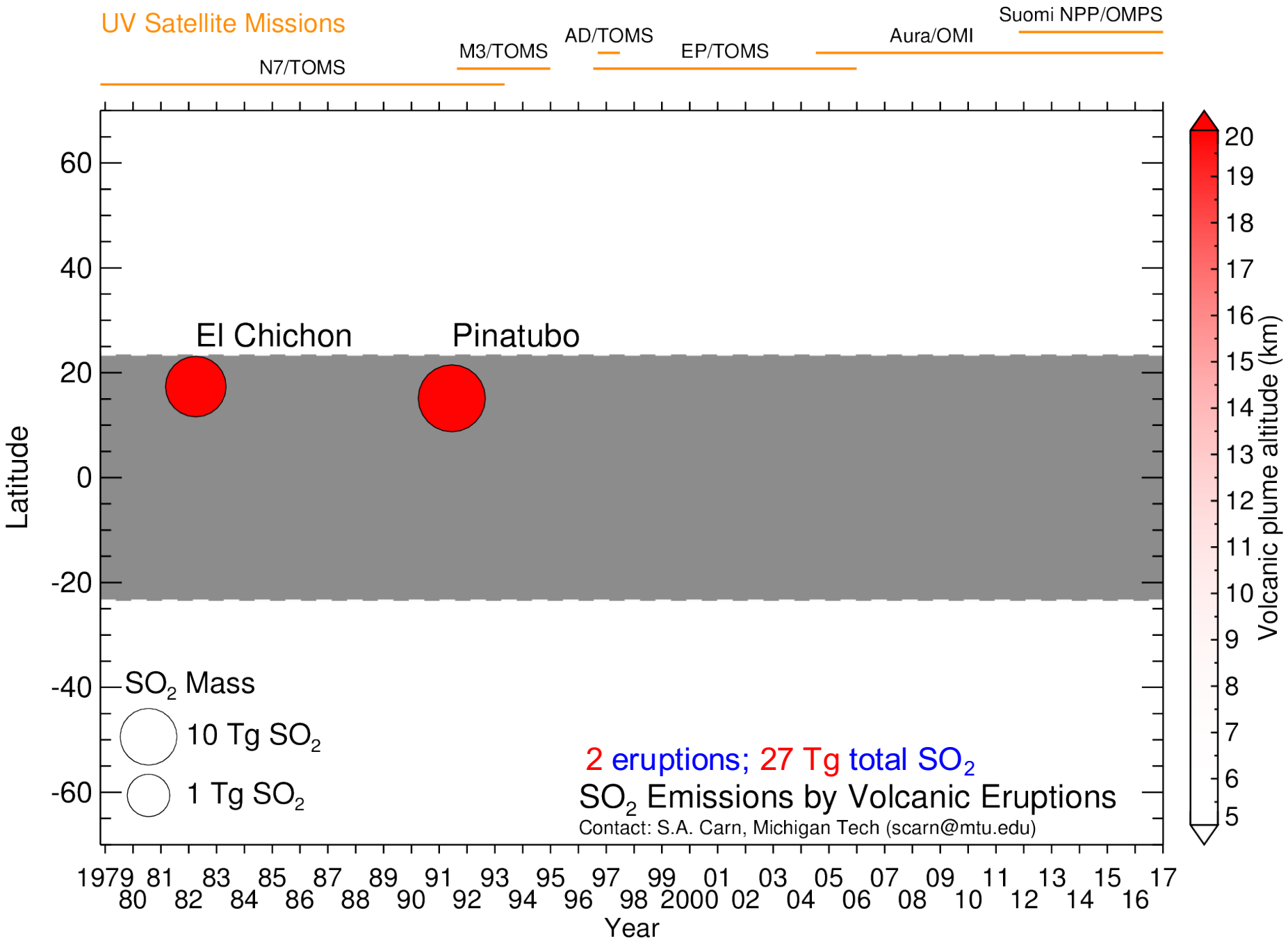
Volcanic SO_2 emissions (since 1978) – tropics



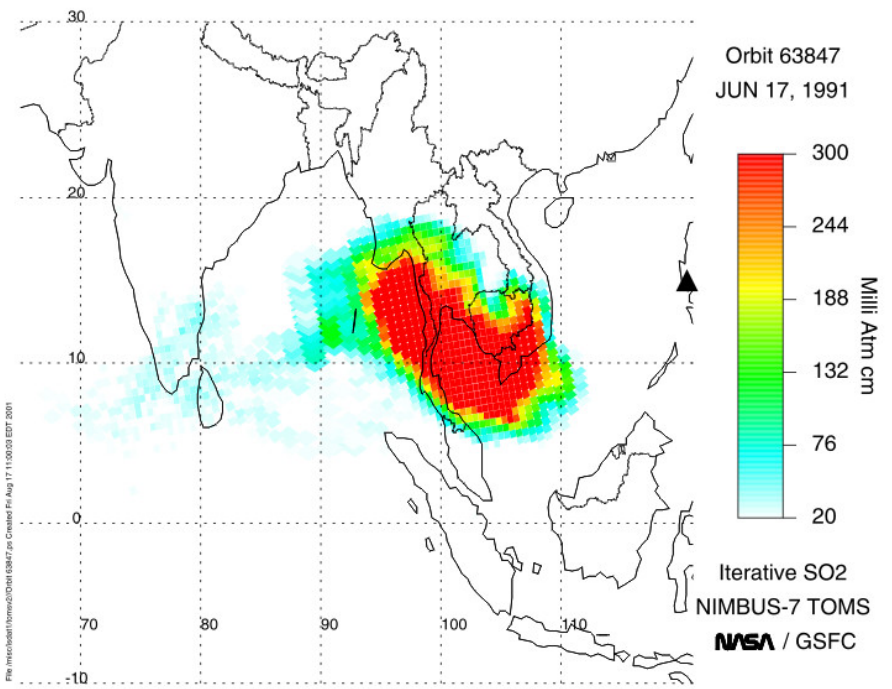
Volcanic SO_2 emissions (since 1978) – stratosphere

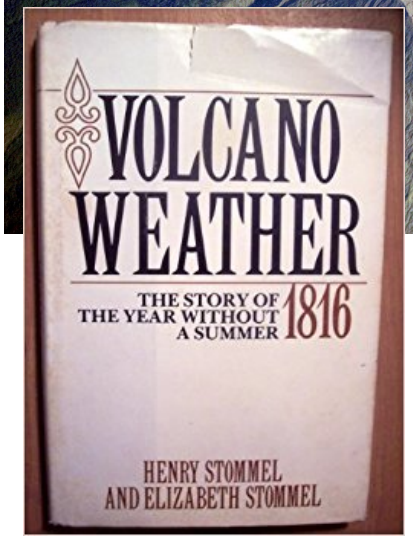


Volcanic SO_2 emissions (since 1978) – stratosphere



1816 – the 'Year Without a Summer'





- Tambora (1815): ~60 Tg SO_2
- Pinatubo (1991): ~17 Tg SO_2

[*Bluth et al.*, 1992; *Guo et al.*, 2004; *Self et al.*, 2004]

'*The snow was 18 inches deep in Cabot, Vt., on June 8. On June 11, a temperature of 30.5 degrees was recorded in Williamstown, Mass. Frozen birds dropped dead in the streets of Montreal. Lambs died from exposure in Vermont.*'

http://www.newenglandhistoricalsociety.com/1816-year-without-summer/

Fake (volcano) news

Stunning footage shows a giant Russian volcano violently erupting for the first time in 250 YEARS

- **The 7,103ft tall (2.2km high) Kambalny volcano is in the Kamchatka peninsula in the far east of Russia**
- **The colossal volcano recently became active and spewed out a 60-mile long ash plume visible from space**
- **Snow-topped volcano last erupted and poured out lava during the reign of Catherine the Great in the 1700s**

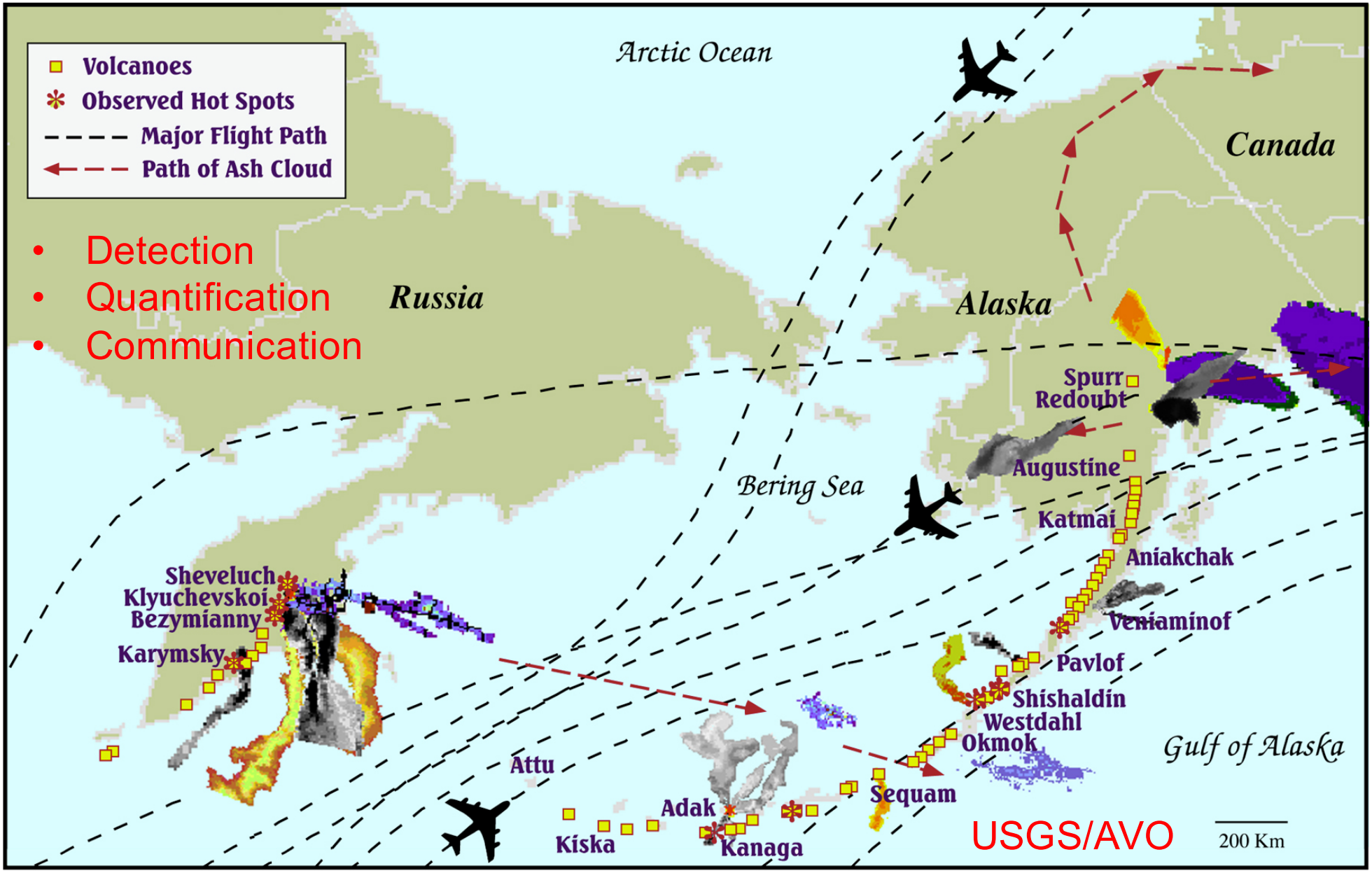
By WILL STEWART FOR MAILONLINE

PUBLISHED: 05:53 EDT, 29 March 2017 | **UPDATED:** 06:15 EDT, 29 March 2017

But Nasa scientists warned that the volcano may have spewed out large amounts of sulphur dioxide (SO2), which is harmful to human lungs.

'The higher SO2 amounts downwind could be due to multiple factors, including variable emissions at the volcano (such as an initial burst), increasing altitude of the plume downwind or decreasing ash content downwind,' Simon Carn, an atmospheric scientist at Michigan Technological University, told the Earth Observatory.

Aviation hazards from volcanic clouds



- Detection
- Quantification
- Communication

Flavors of volcanic emissions

‘Eruptive’

(Sporadic)

‘Passive’

(Continuous)

Global volcanic SO_2 emissions inventories

A time-averaged inventory of subaerial volcanic sulfur emissions

[*Andres & Kasgnoc*, JGR, 1998]

R.J. Andres and A.D. Kasgnoc

Institute of Northern Engineering, University of Alaska Fairbanks

SCIENTIFIC REPORTS

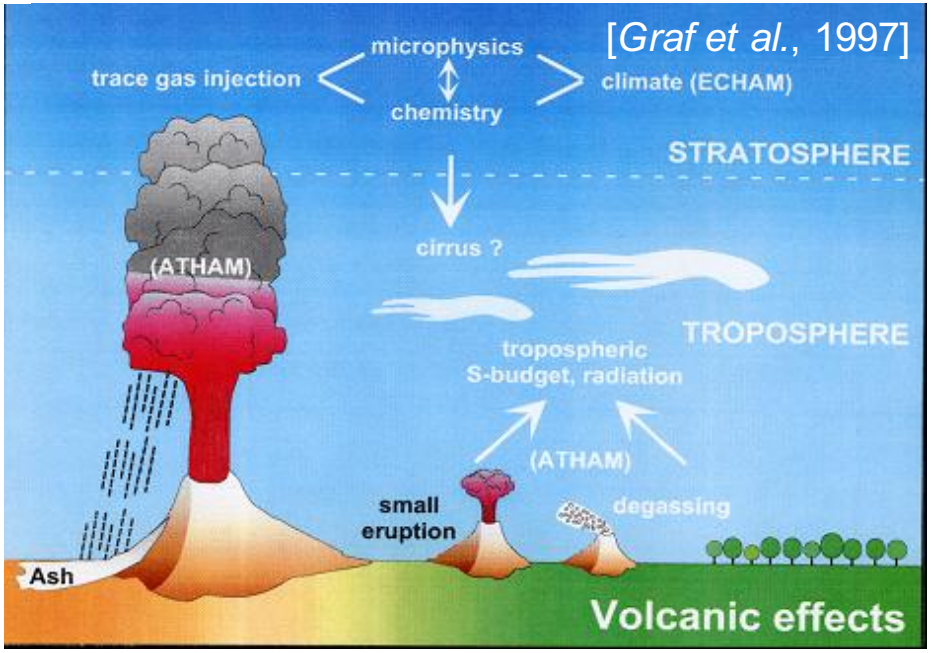
OPEN

A decade of global volcanic SO_2 emissions measured from space

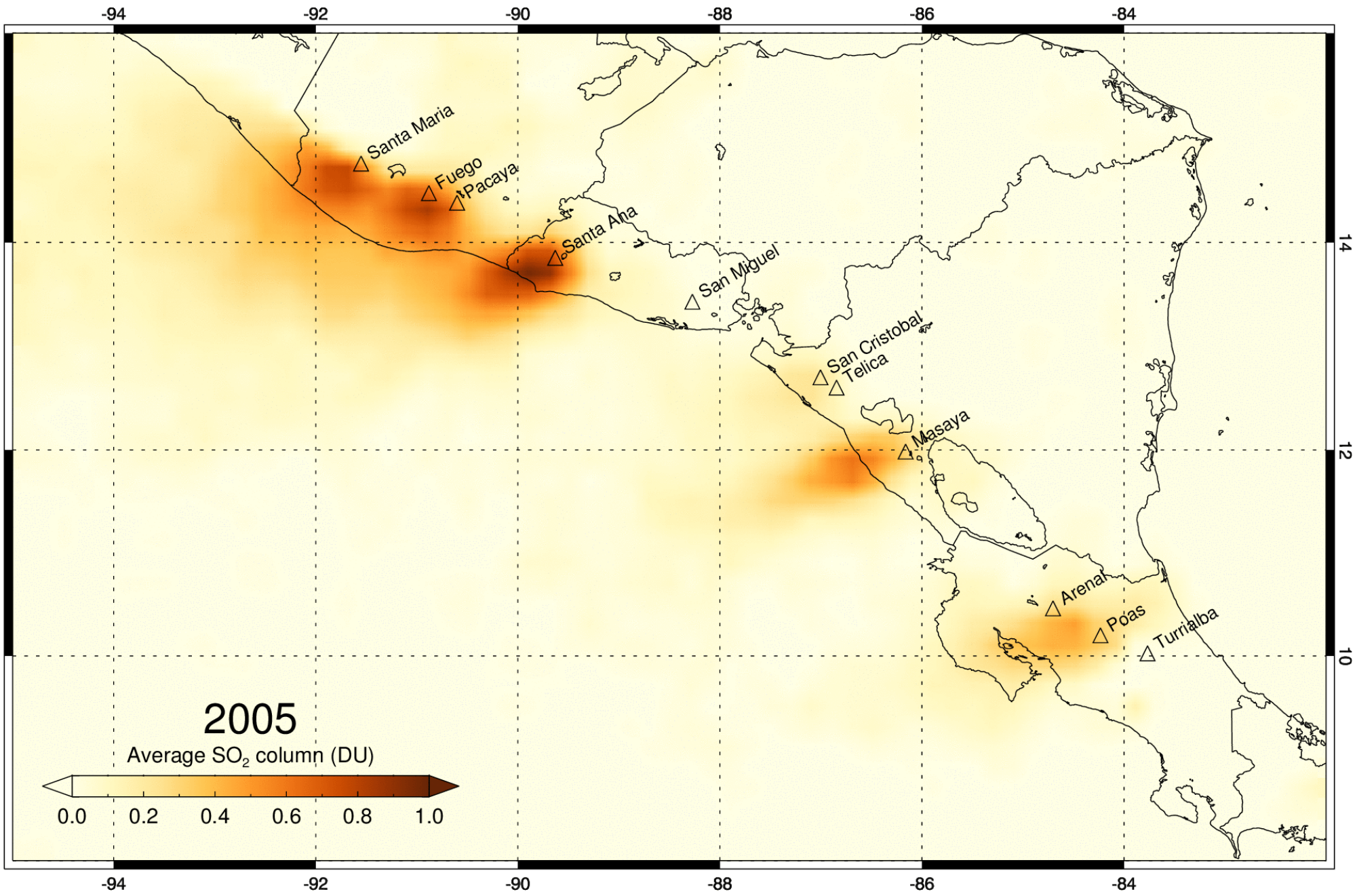
S. A. Carn[1], V. E. Fioletov[2], C. A. McLinden[2], C. Li[3,4] & N. A. Krotkov[4]

[*Carn et al.*, 2017]

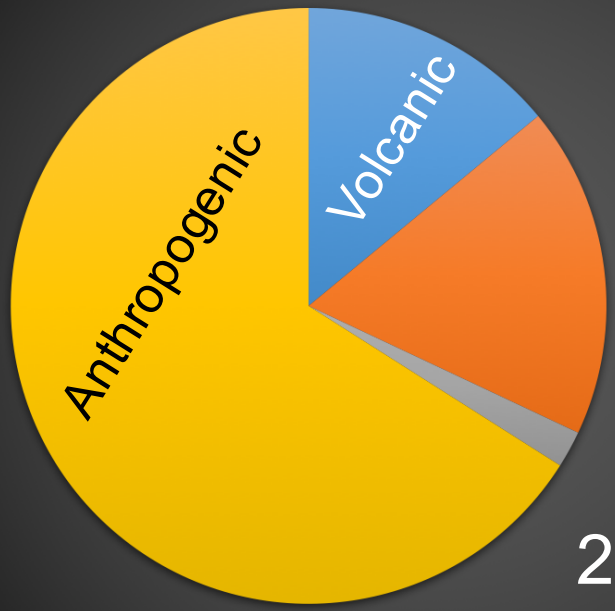
- Climate impact of tropospheric volcanic emissions (sulfate aerosol)
- Estimation of global fluxes of other volcanic gases (e.g., CO_2)
- Identifying field sites for volcanic gas studies



Volcanic SO_2 emissions in Central America



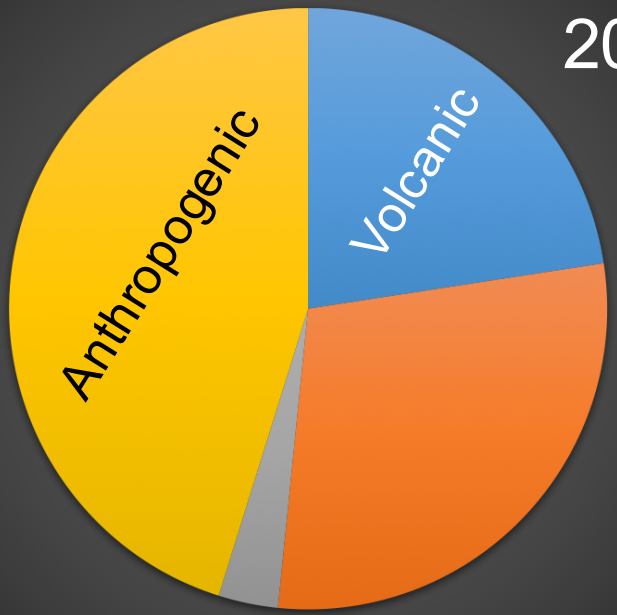
Volcanic emissions in a global context



SO_2

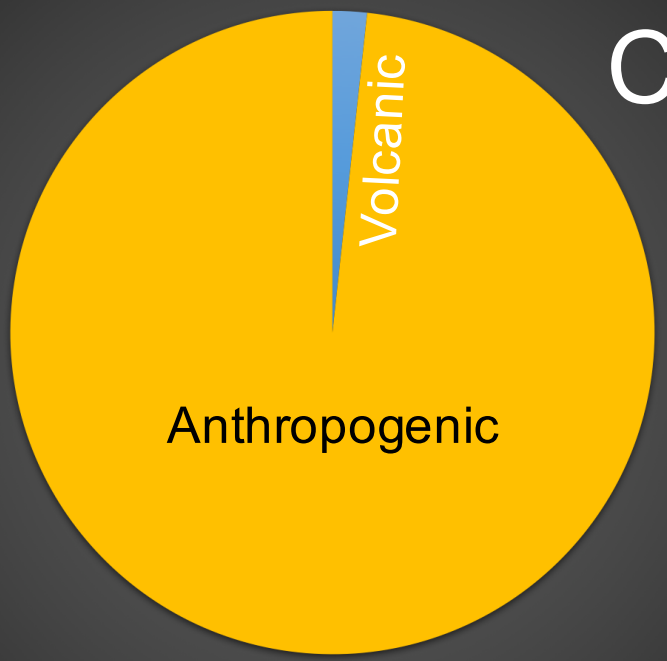
Volcanic
Marine
Biomass
Anthropogenic

2000



2015

Fioletov et al. (2016); *Carn et al.* (2017)



CO_2

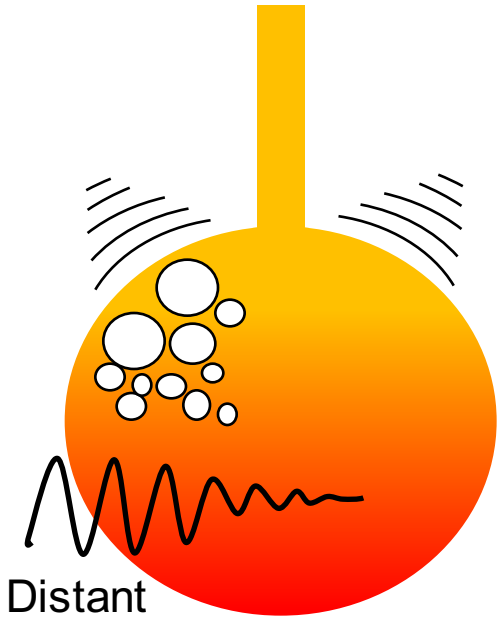
Volcanic Anthropogenic

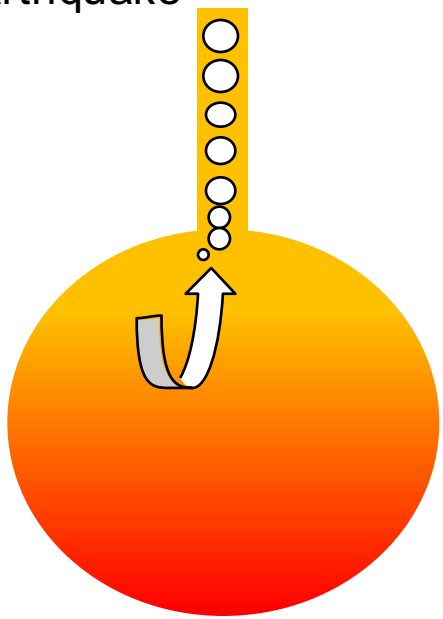
Mike Huckabee claimed that a single volcanic eruption "will contribute more than 100 years of human activity" toward global warming. Humans actually pump over 100 times as much CO_2 into the atmosphere every year than all the world's volcanoes combined.

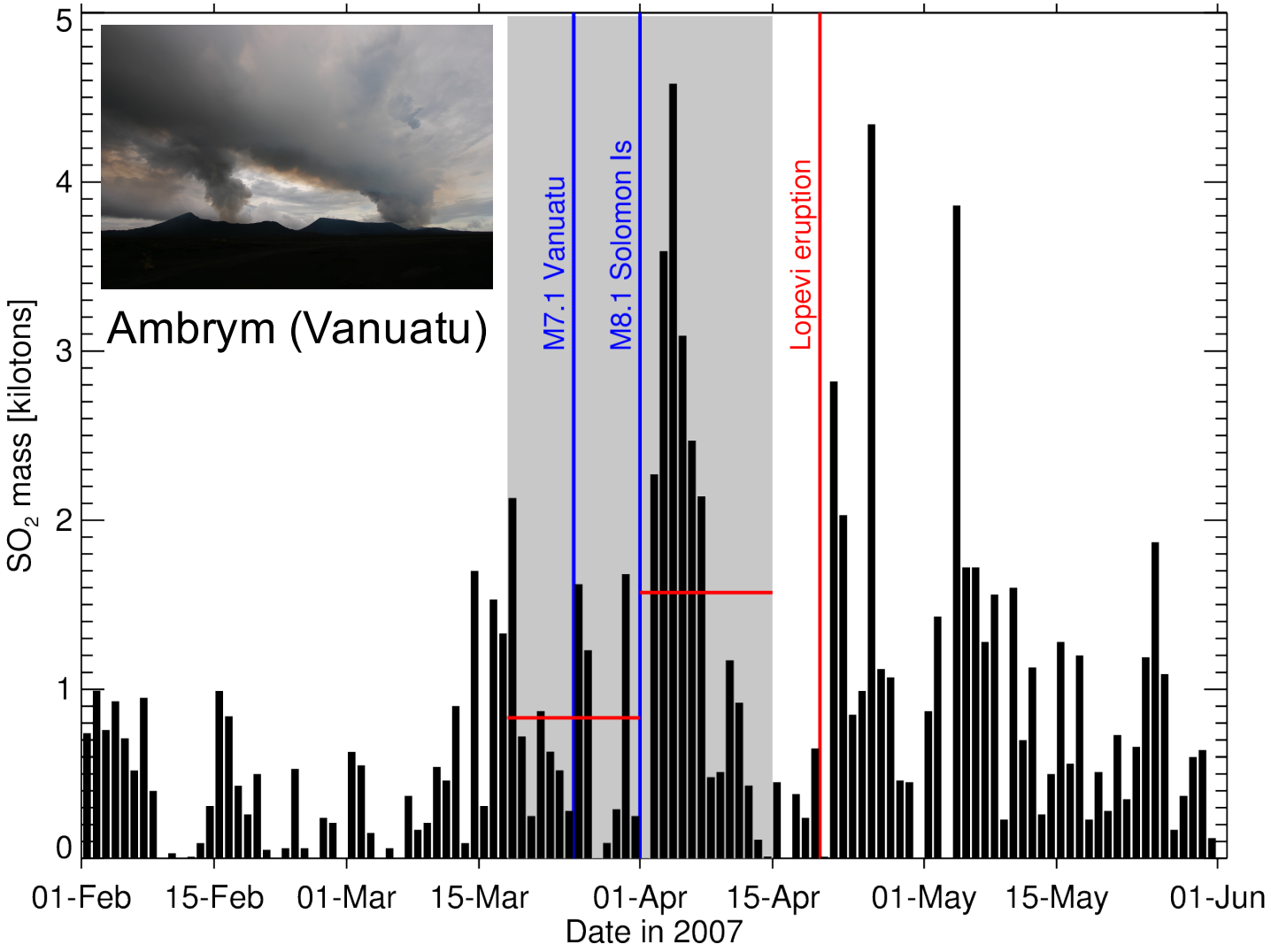
http://www.factcheck.org/2015/07/huckabees-hot-air-on-volcanoes/

Burton et al. (2013)

Satellites provide consistent, long-term records





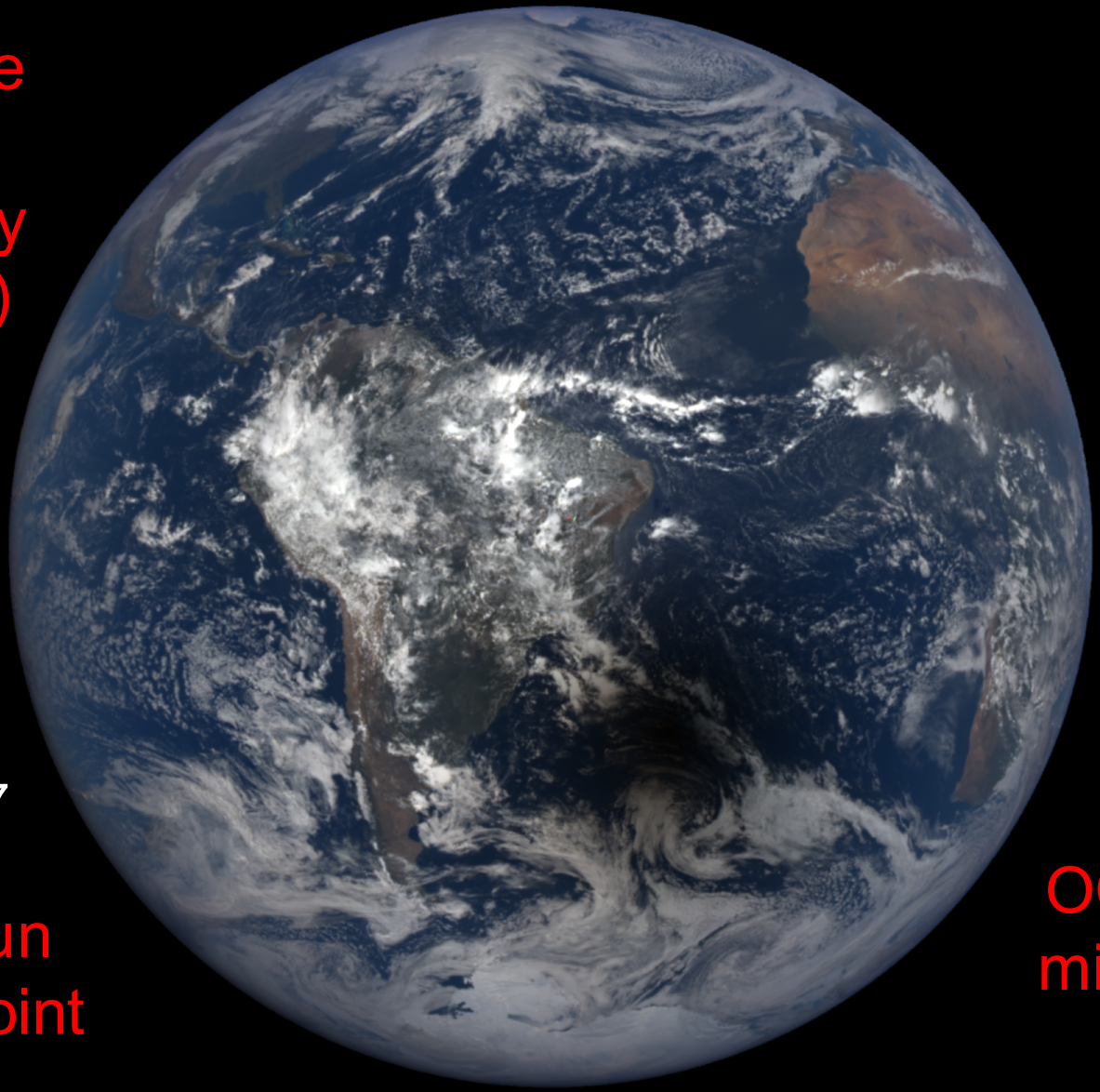


- Analysis of earthquake-triggered volcanic activity
- Only possible with global, long-term satellite data

Avouris et al. (2017)

NASA Climate missions under threat

Deep Space Climate Observatory (DSCOVR)



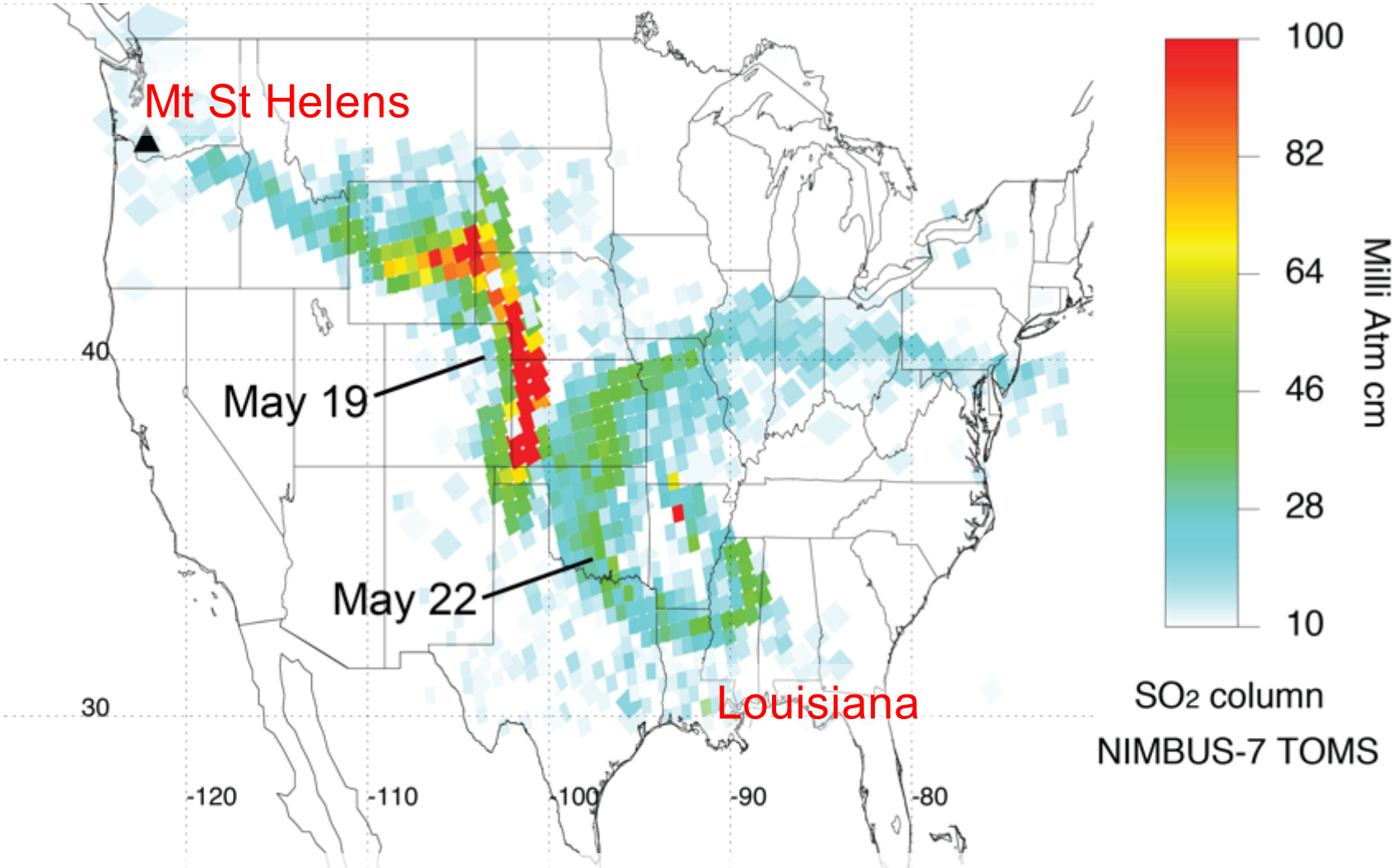
Feb 26, 2017

L_1 Earth-Sun Lagrange Point

OCO-3 (CO_2 mission) also targeted

Earth Polychromatic Imaging Camera (EPIC)
http://epic.gsfc.nasa.gov

Politics of volcano monitoring



'*Republican governor Bobby Jindal questioned why "something called 'volcano monitoring' " was included in the nearly $800 billion economic stimulus bill Obama signed earlier this month*.' (Feb 2009)

http://edition.cnn.com/2009/POLITICS/02/25/jindal.volcanoes/

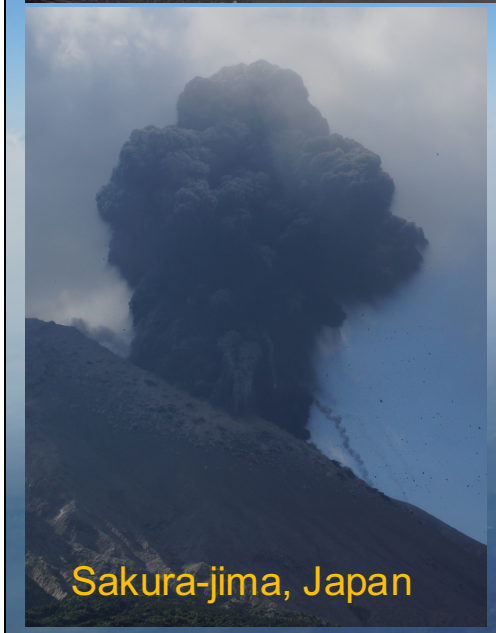
Submarine volcanoes: a new frontier

Images courtesy of Alaska Volcano Observatory (AVO)
https://avo.alaska.edu/

- Hazardous but difficult to observe
- Submarine ROV/AUV to map subsurface topography?

‘Open-vent’ volcanoes


Semeru, Java (GVP)


Sakura-jima, Japan


Karymsky, Russia

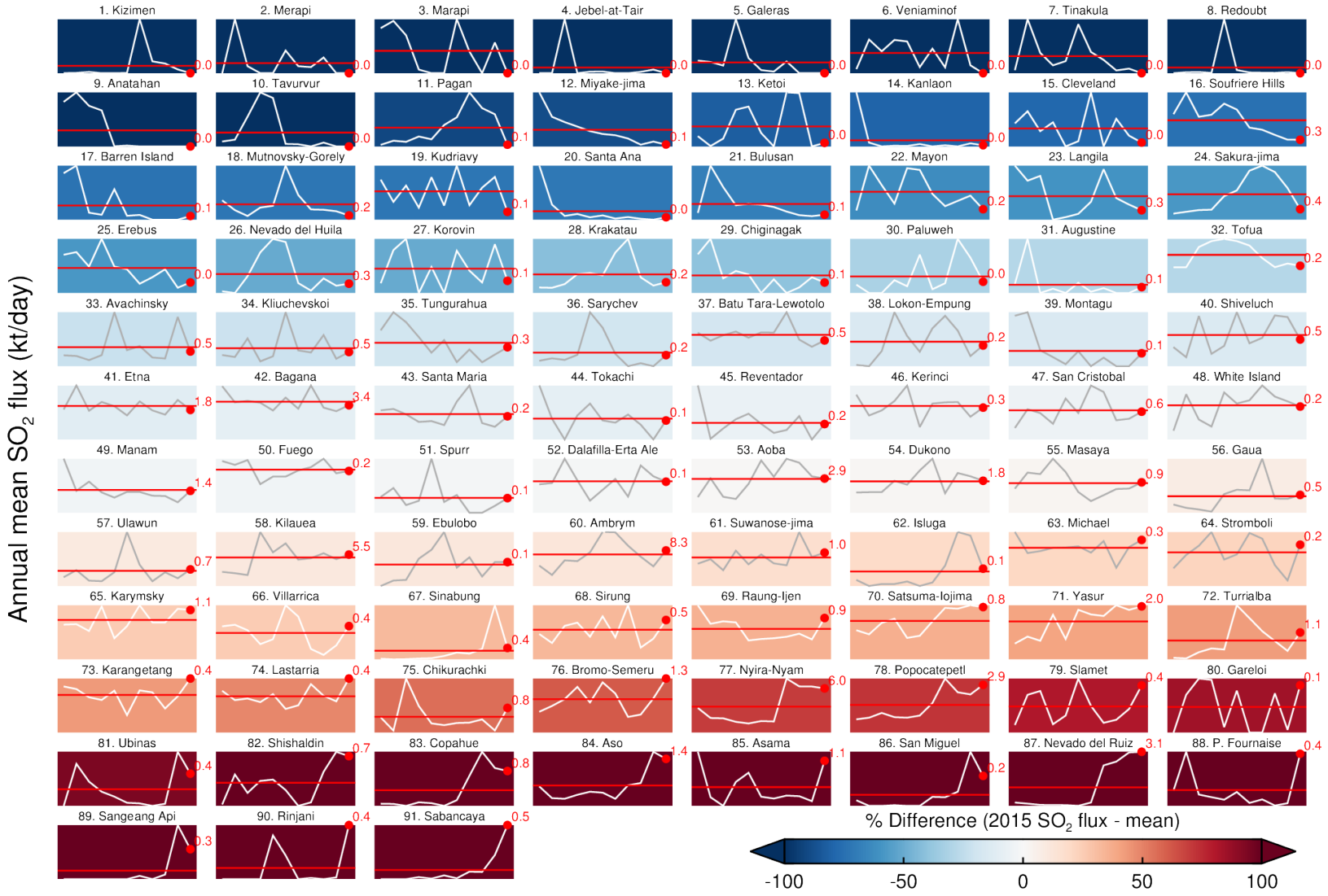
- Santiaguito (Guatemala): unique, aerial view of hot, exploding lava dome
- ‘Laboratory’ volcano for studying volcanic processes.

Remote sensing of volcanic gas emissions

MIDAC FTIR
Stirling-cooled MCT detector
~2-15 μm, 0.5 cm^{-1}

- Active volcanic vents are ‘extreme’ environments analogous to some other planets – can we design new sensors and materials for such extremes?

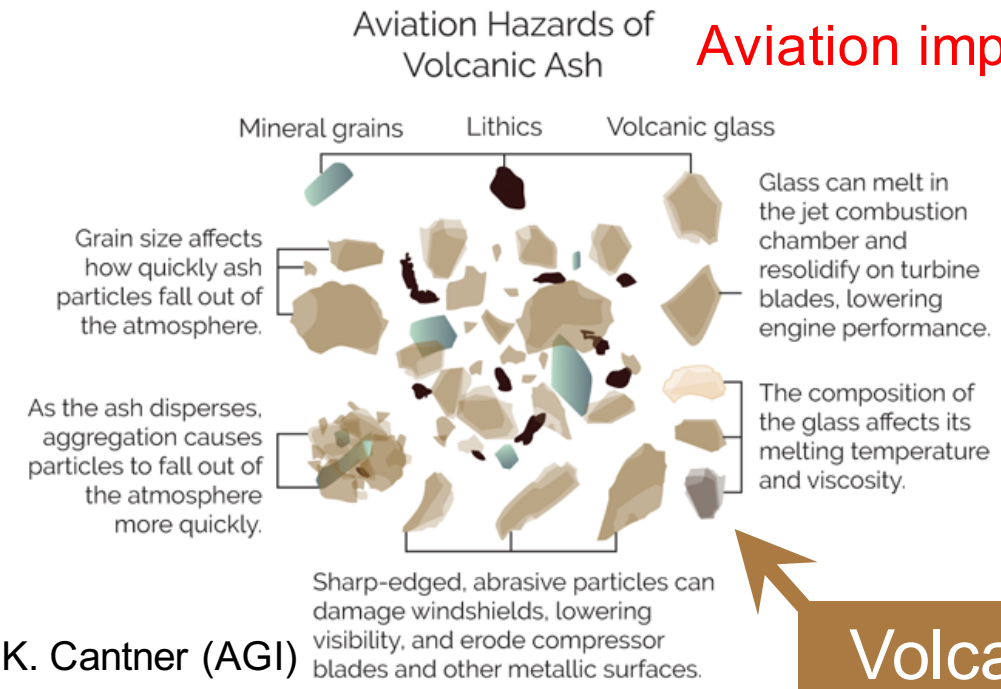
The challenge of data visualization



Carn et al., Sci. Rep. (2017)

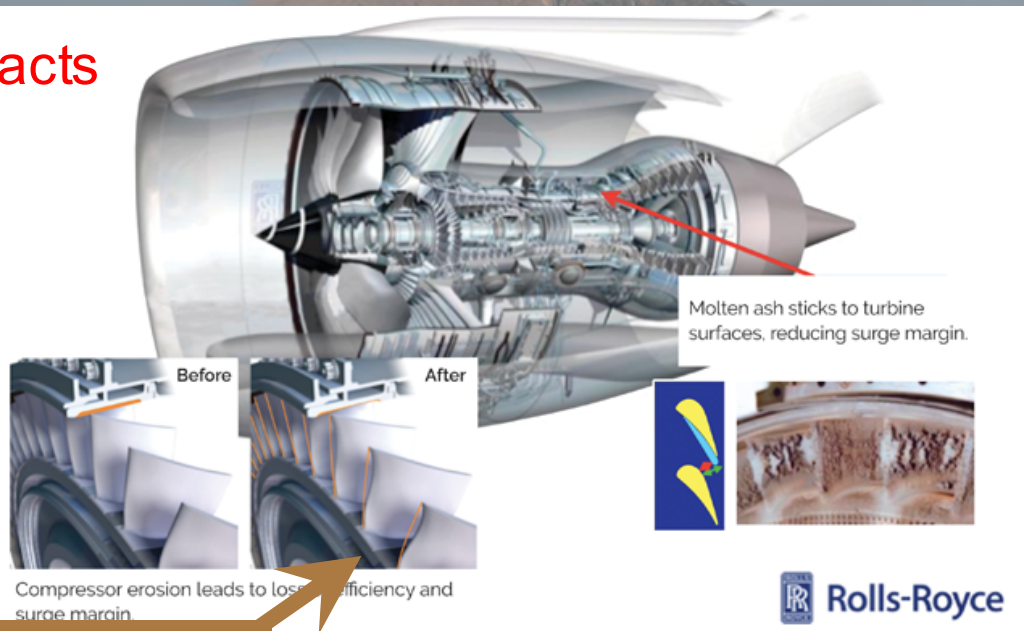
- Telling stories with data (e.g., NASA Earth Observatory)
- Computing, cognitive and learning sciences

Hazards and impacts of volcanic ash

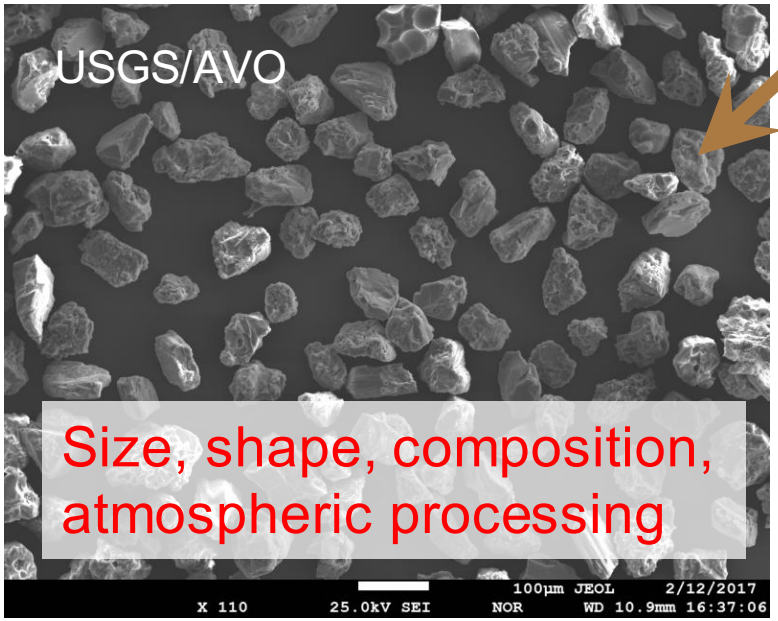


K. Cantner (AGI)

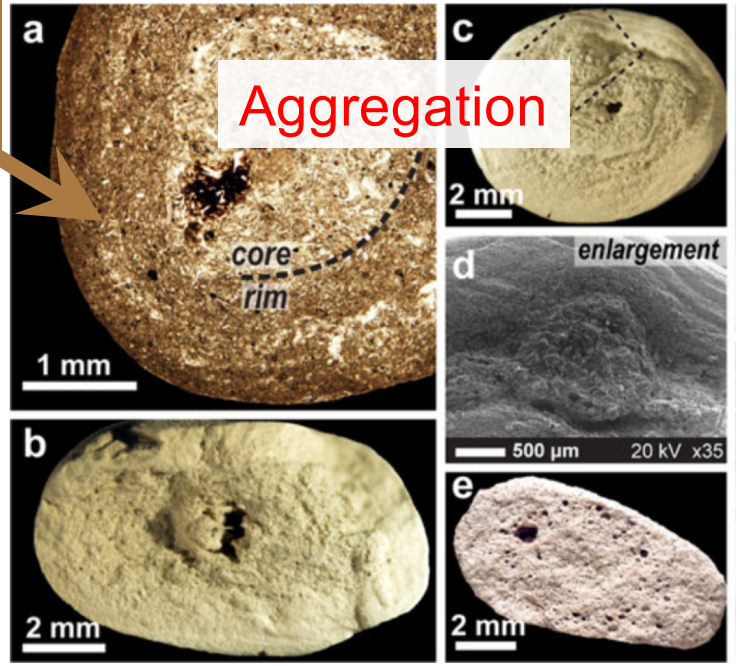
Aviation impacts



Volcanic ash samples



Aggregation



Van Eaton et al. (2012)

Summary

- Volcanic emissions are important, and their atmospheric impact is increasing.
- Long-term satellite monitoring of volcanic activity is crucial, but some current & future NASA assets and funding are under threat.
- The multidisciplinary nature of volcano science offers several new avenues for exploration.