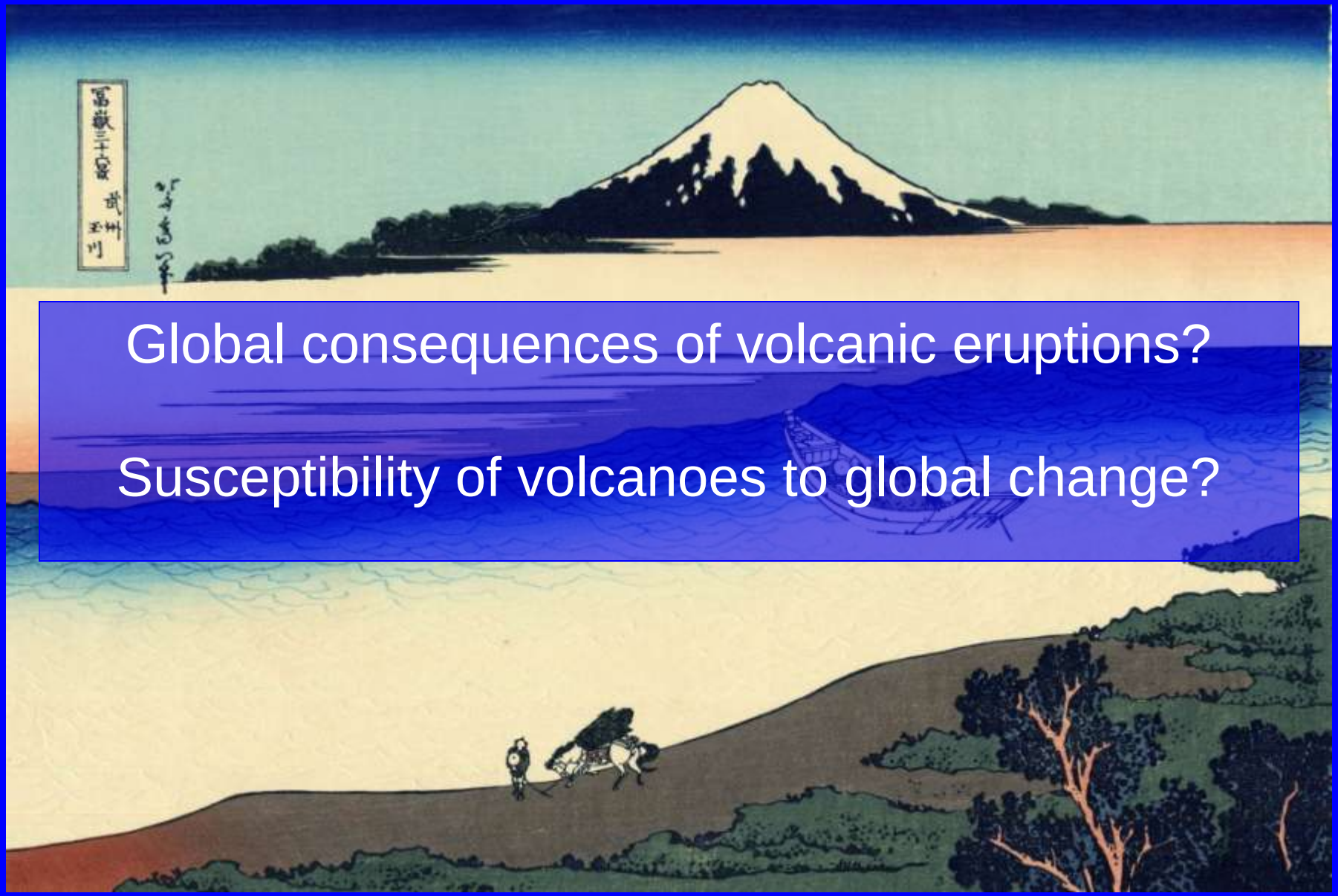
Volcanism, climate and society: feedbacks and sensitivities

David Pyle

david.pyle@earth.ox.ac.uk @davidmpyle

Volcanoes of southern Chile: Puntiagudo (left) and Osorno (right).



Global consequences of volcanic eruptions?

Susceptibility of volcanoes to global change?

Katsushika Hokusai, 1830. Fuji, overlooking Tama River in Musashi Province, Japan. Wikimedia commons

Glacial advance relative to volcanic activity since 1500 AD

THERE may be a connection between the periodicity of glacial advance and the occurrence of volcanic eruptions.

Bray, Nature, 1974

Kelly and Lamb, Nature, 1976

Prediction of volcanic activity and climate

Volcanic triggering of glaciation

Bray, Nature, 1976

Rampino et al., Science, 1979

Can Rapid Climatic Change Cause Volcanic Eruptions?

LETTERS TO NATURE

Volcanic winter and accelerated glaciation following the Toba super-eruption

Michael R. Rampino*† & Stephen Self‡

Rampino and Self, Nature, 1982

Ambrose, J Human Evolution, 1998

Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans

What are realistic consequences of global environmental change?

theguardian

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Environment › Climate change

Climate change will shake the Earth

A changing climate isn't just about floods, droughts and heatwaves. It brings erupting volcanoes and catastrophic earthquakes too

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Climate Change Will Trigger Earthquakes and Volcanic Eruptions

by NATHAN on MAY 10, 2012

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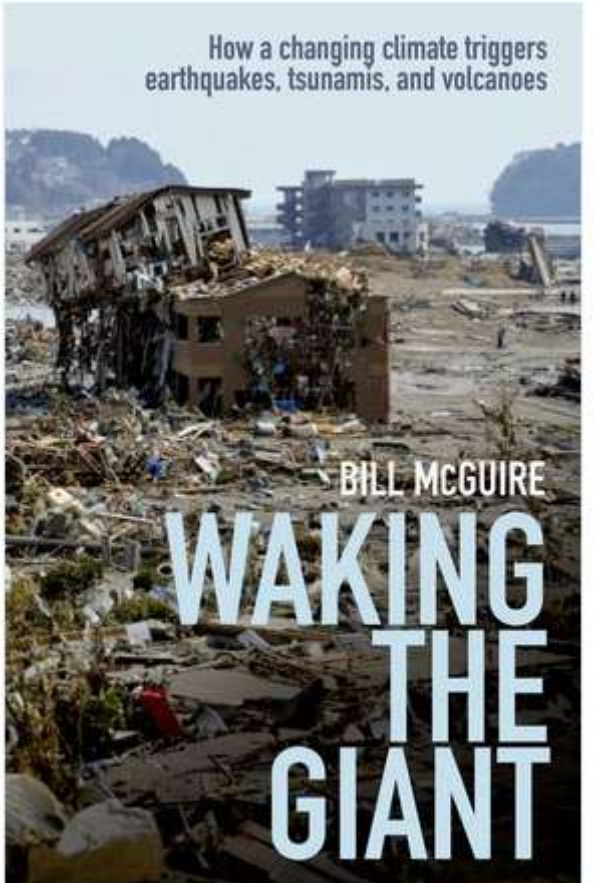

Plenty of models – little evidence..

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Volcanic origin for Little Ice Age

By Richard Black
Environment correspondent, BBC News

The Little Ice Age was caused by the cooling effect of massive volcanic eruptions, and sustained by changes in Arctic ice cover, scientists conclude.

An international research team studied ancient plants from Iceland and Canada, and sediments carried by glaciers.

They say a series of eruptions just before 1300 lowered Arctic temperatures enough for ice sheets to expand.

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LITTLE ICE AGE STARTED WITH VOLCANOES

Analysis by Sarah Simpson
Fri Feb 3, 2012 04:19 AM ET
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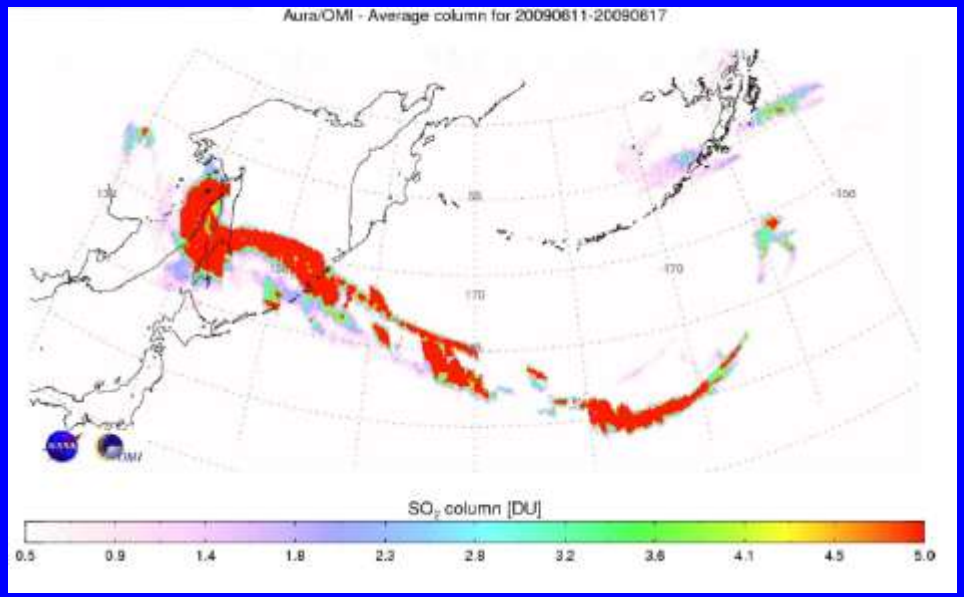
Was the Little Ice Age Triggered by Massive Volcanic Eruptions?

ScienceDaily (Jan. 30, 2012) — A new international study may answer contentious questions about the onset and persistence of Earth's Little Ice Age, a

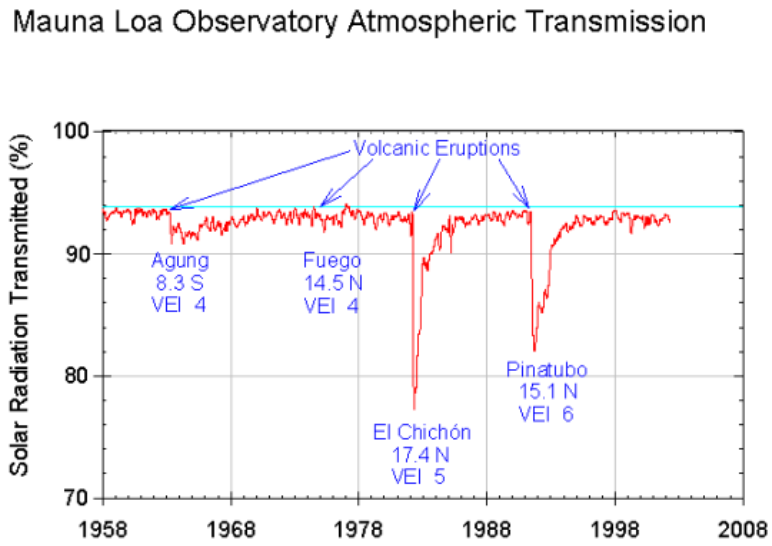
Climate impact of volcanism

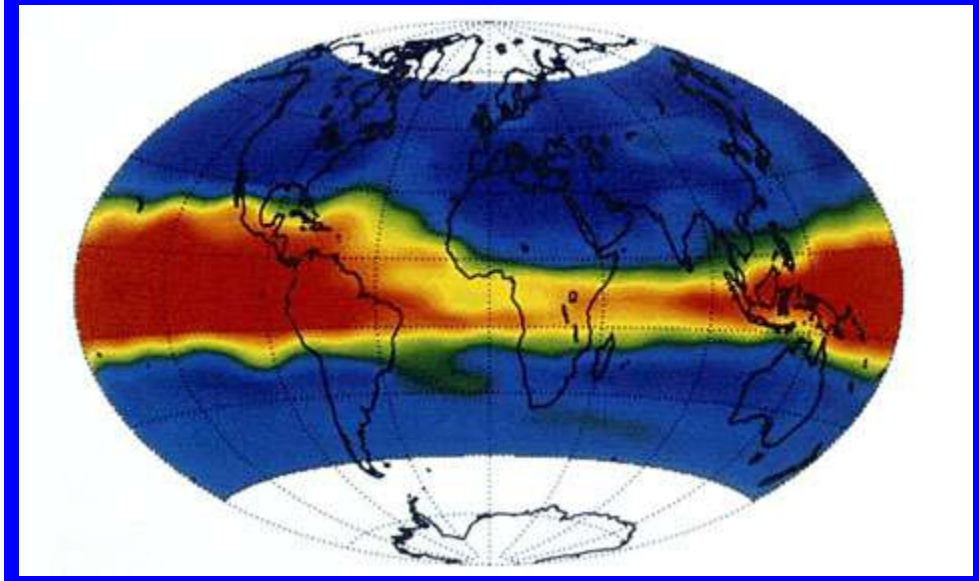


Volcanic injection of ash, sulphur dioxide into the atmosphere has short (days) to medium-term (< 1 -3 years) impacts on regional to global climate

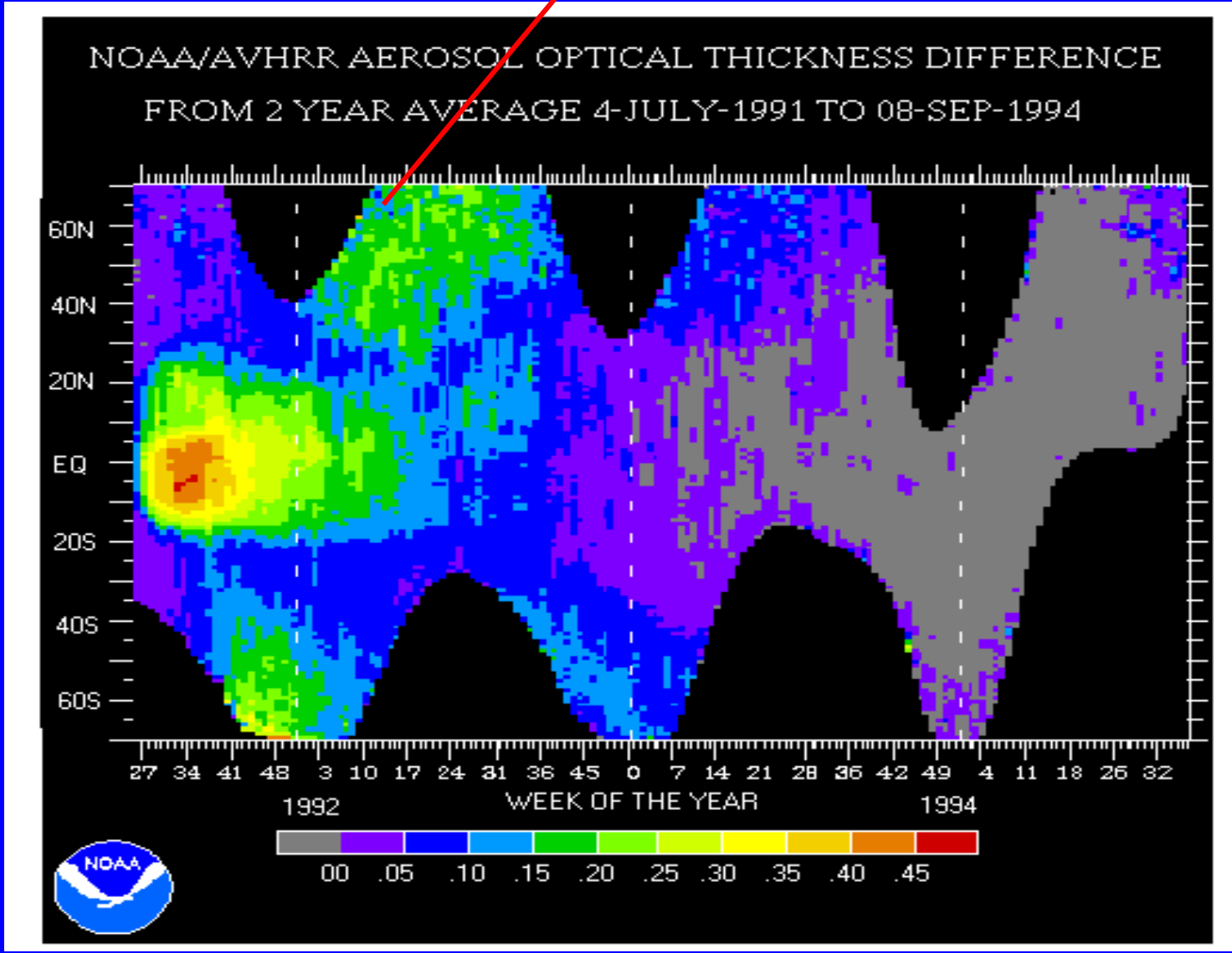
Sarychev Peak eruption, Matua island, Kuriles. 12 June 2009.
Photo: international space station/NASA

Climate forcing: aerosol and solar radiation





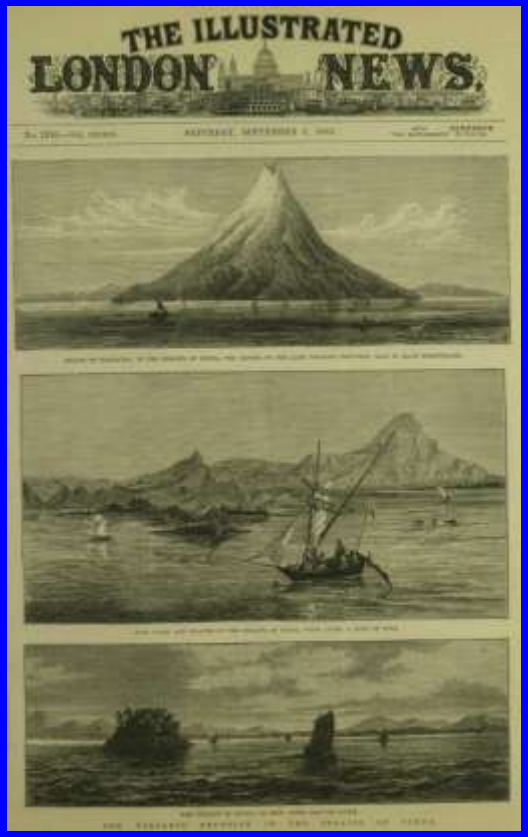
Peak Arctic ozone depletion– Spring 1992



Decay of Pinatubo aerosol, 1991 - 1994

NOAA AVHRR

The great eruption of Krakatoa, August 1883

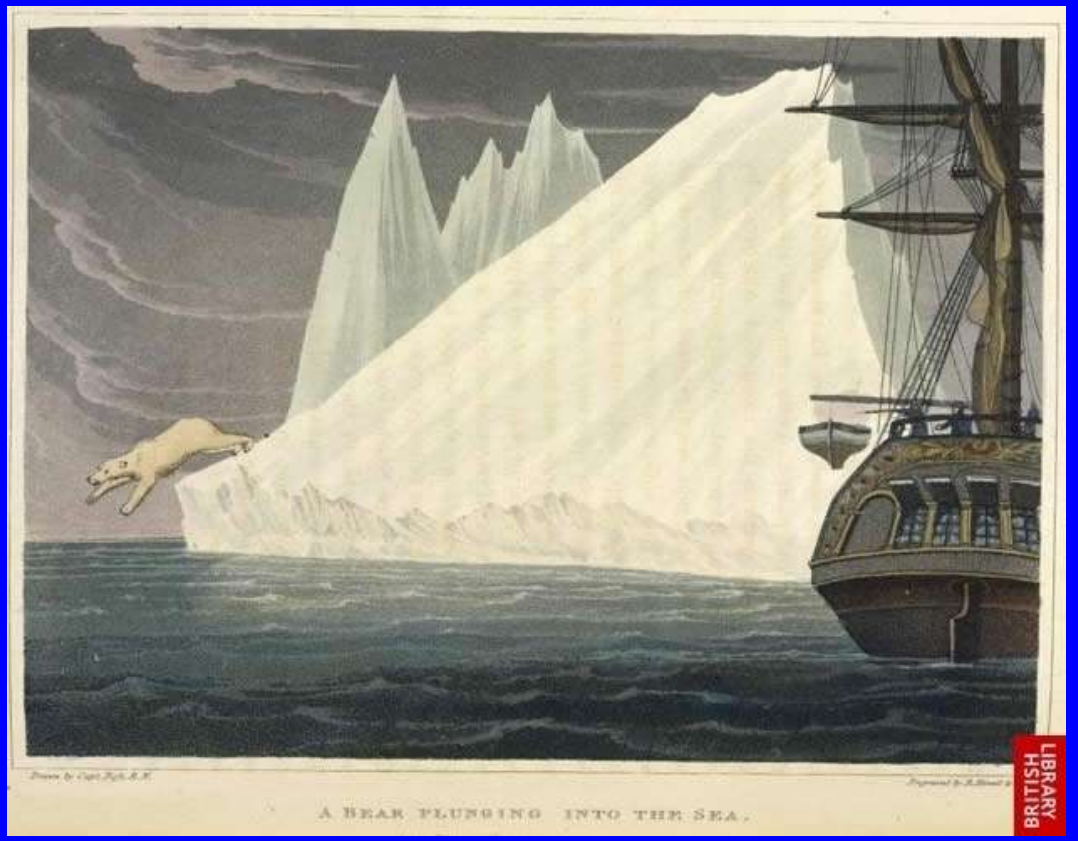


Gases (in particular sulphur dioxide) that were emitted during the eruption spread around the globe, high in the atmosphere. Tiny droplets of sulphuric acid caused scattering of sunlight, and led to some spectacular sunsets around the world.

Krakatoa images from: The Illustrated London News Historical Archive, 1842-2003. Gale Cengage Learning (gale.cengage.co.uk), and G.J. Symons, The Report of the Krakatoa Committee of the Royal Society, 1888.

The legacy of Tambora, April 1815.

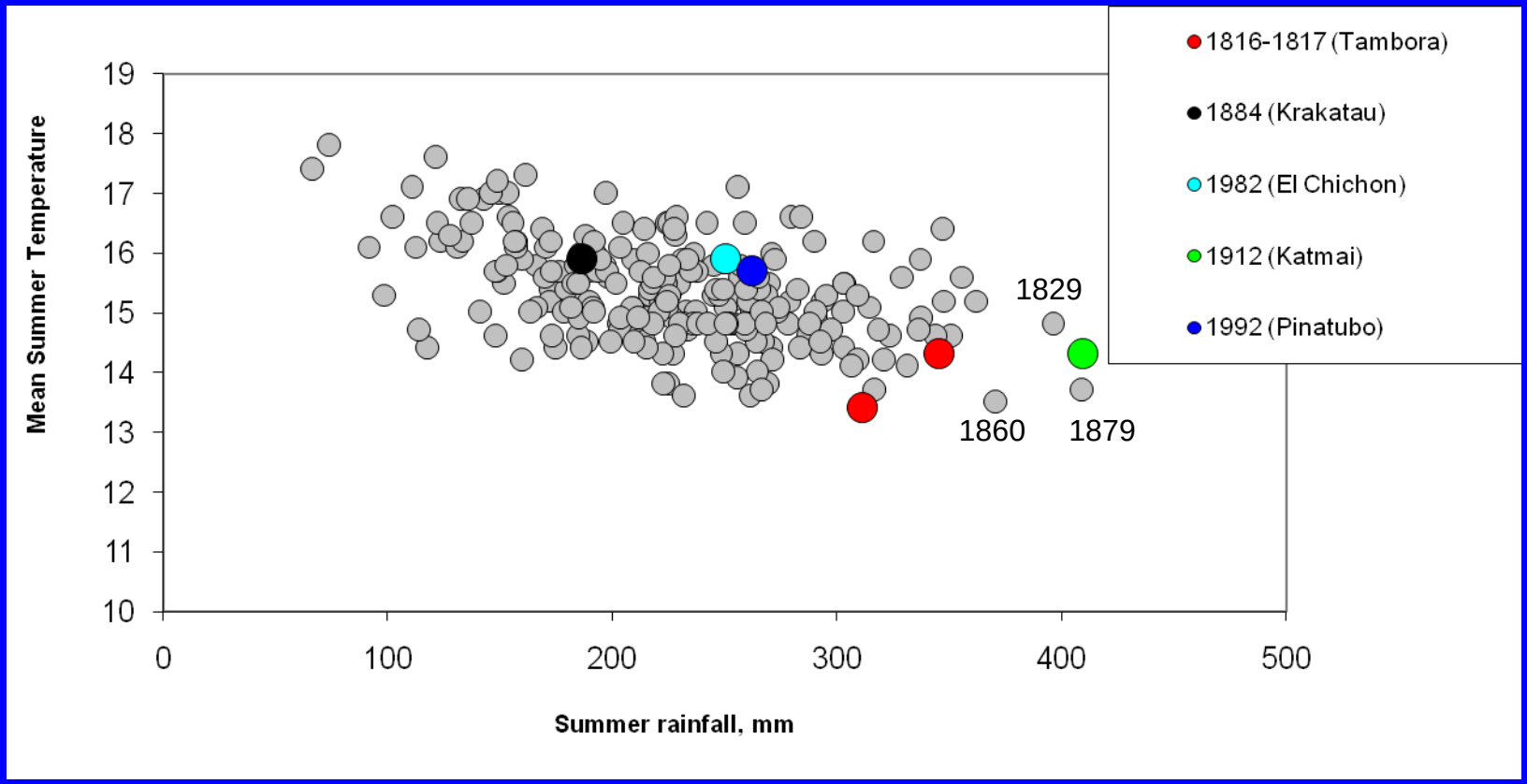
Mary Shelley's Frankenstein: written in 1816



Ross's exploration of the North-West Passage, 1818

Tate Gallery and British Library

Large explosive eruptions and 200 years of UK summer weather



Data from the Hadley Centre, Met Office: http://hadobs.metoffice.com/

Manley (Q.J.R.Met.Soc., 1974); Parker et al. (Int.J.Clim., 1992); Parker & Horton (Int.J.Clim., 2005)
Wigley & Jones (J.Climatol.,1987), Gregory et al. (Int.J.Clim.,1991); Jones & Conway (Int.J.Climatol.,1997), Alexander & Jones (ASL,2001)

Impact vs. likelihood?

Large magnitude events:

Effusive – e.g. Laki (1783)
Explosive – e.g. Pinatubo (1991_

Regional to global consequences for *climate* (1 – 3 yr perturbation of atmosphere, hydrosphere); potential for significant regional disruption to *agriculture* and *human health.*

Past events of this scale have a global recurrence rate of ~ 100 - 200 years.

Impact of changing climate on volcanoes.

Katsushika Hokusai, 1830. Fuji, overlooking Tama River in Musashi Province, Japan. Wikimedia commons

Global distribution of glaciers, ice caps and ice sheets.

Orizaba, Mexico

Kilimanjaro, Tanzania

Erebus, Antarctica

ESRI Digital Chart of the World (DCW), WGMS.

Photos: www.globetropper.com, Clive Oppenheimer, Road Trippin 24/7.

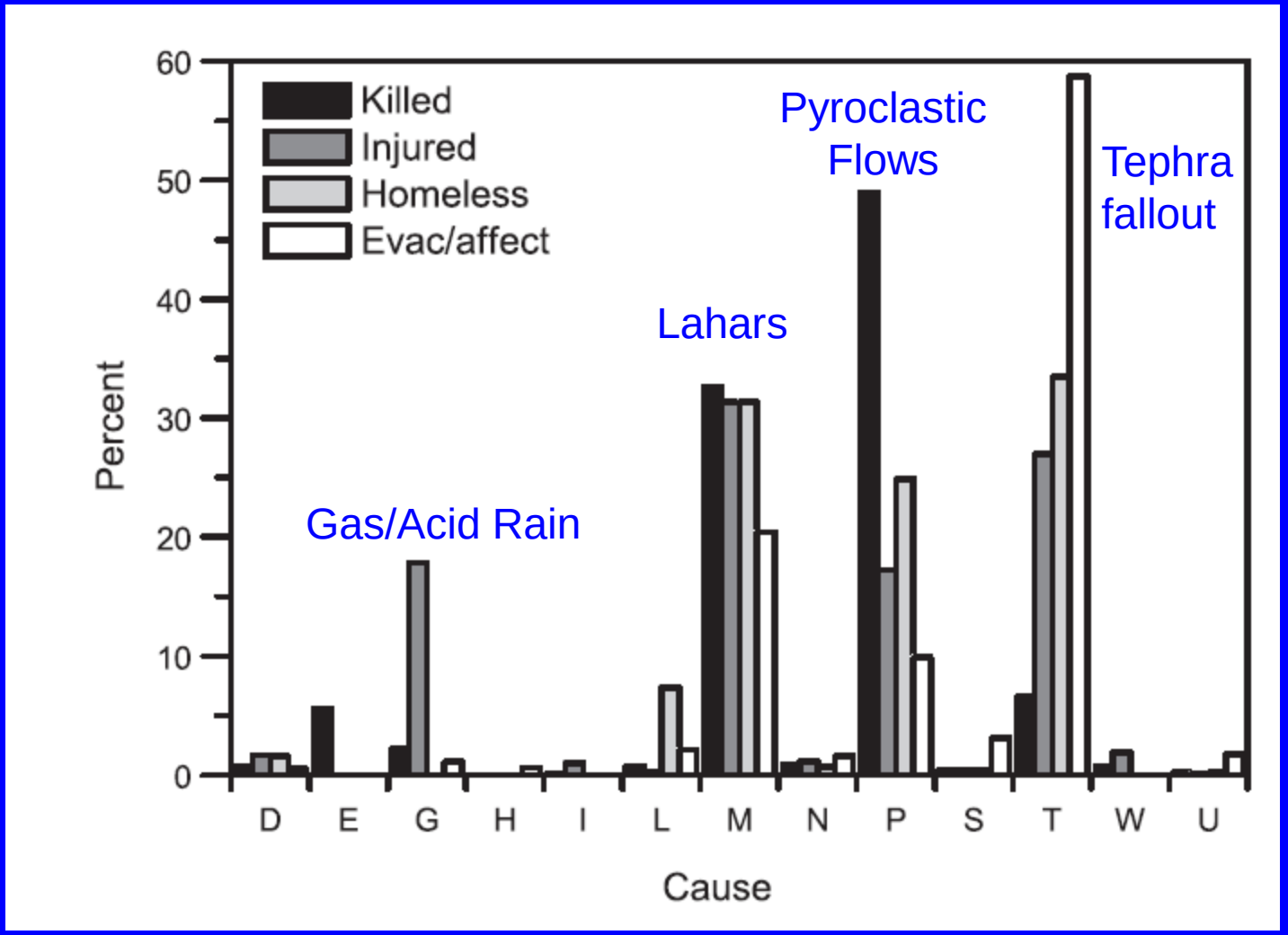
Nevado del Ruiz volcano, Colombia

International Space Station astronaut photograph ISS023-E-27737 April 23, 2010. NASA Earth Observatory

Armero, Colombia, 1985. 45 km from Nevado del Ruiz.

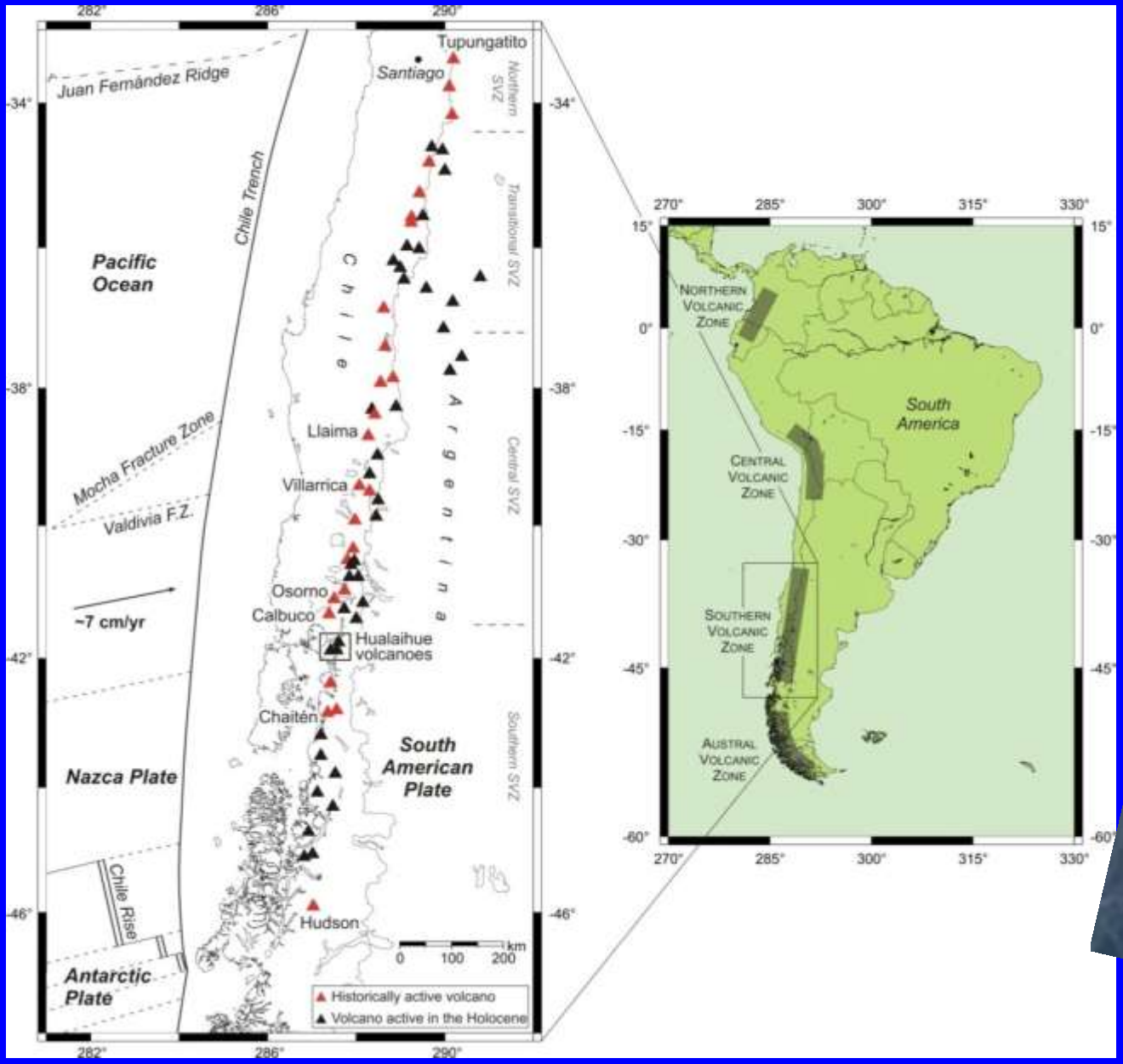
USGS photograph by R.J. Janda

Direct human impacts of 20th century eruptions



Witham, 2005: Volcanic disasters in the 20th Century.

Large-scale response to ice removal: southern Chile

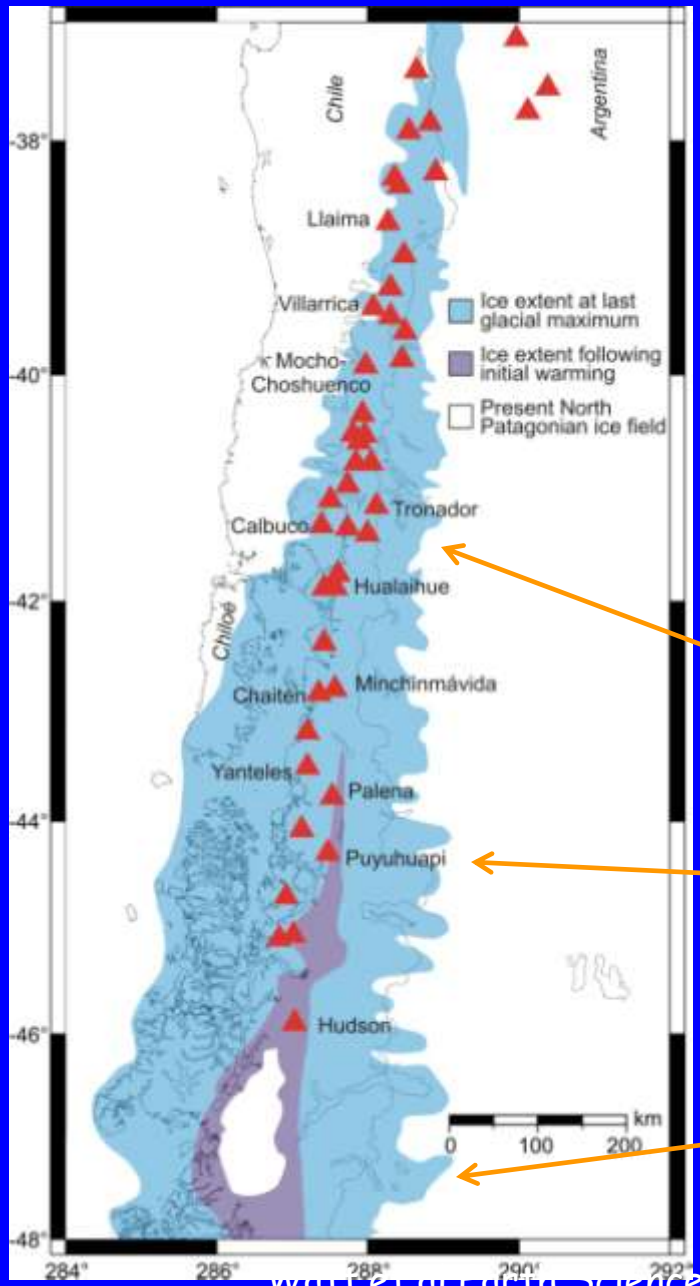


Glaciated volcanoes in Southern Chile

Early post-glacial calderas; young, rapidly formed andesitic cones

~ 70 potentially active volcanoes in the Southern and Austral Volcanic Zones

Timing of ice retreat



End glaciation ~ 17,300 yrs

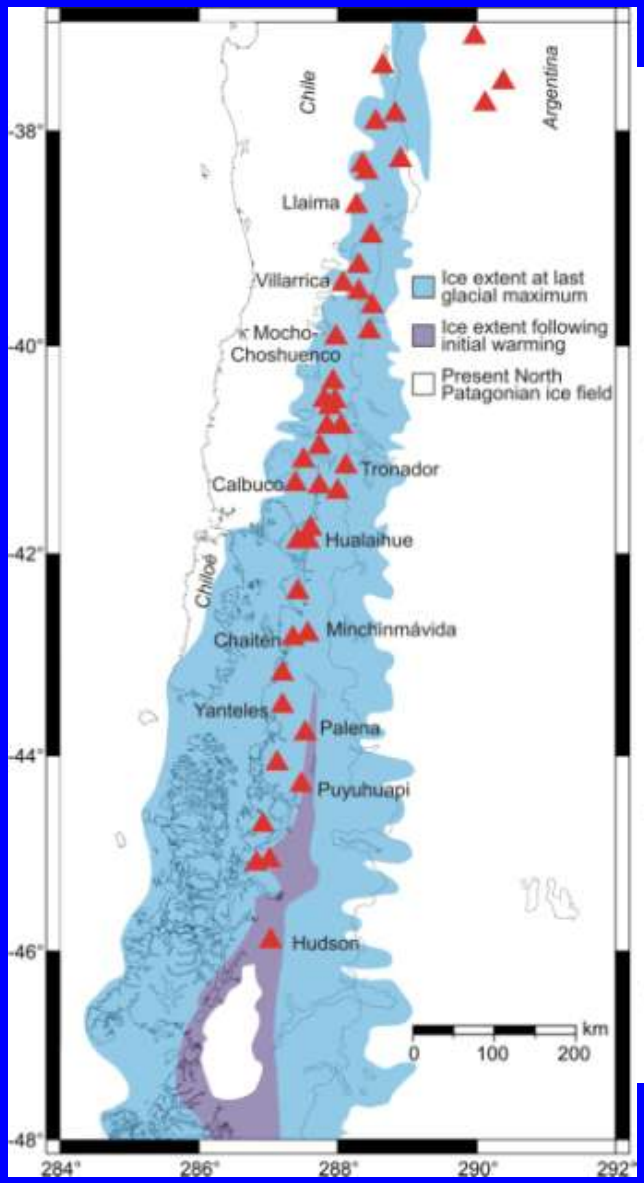
Late advance ~ 13,300 yrs

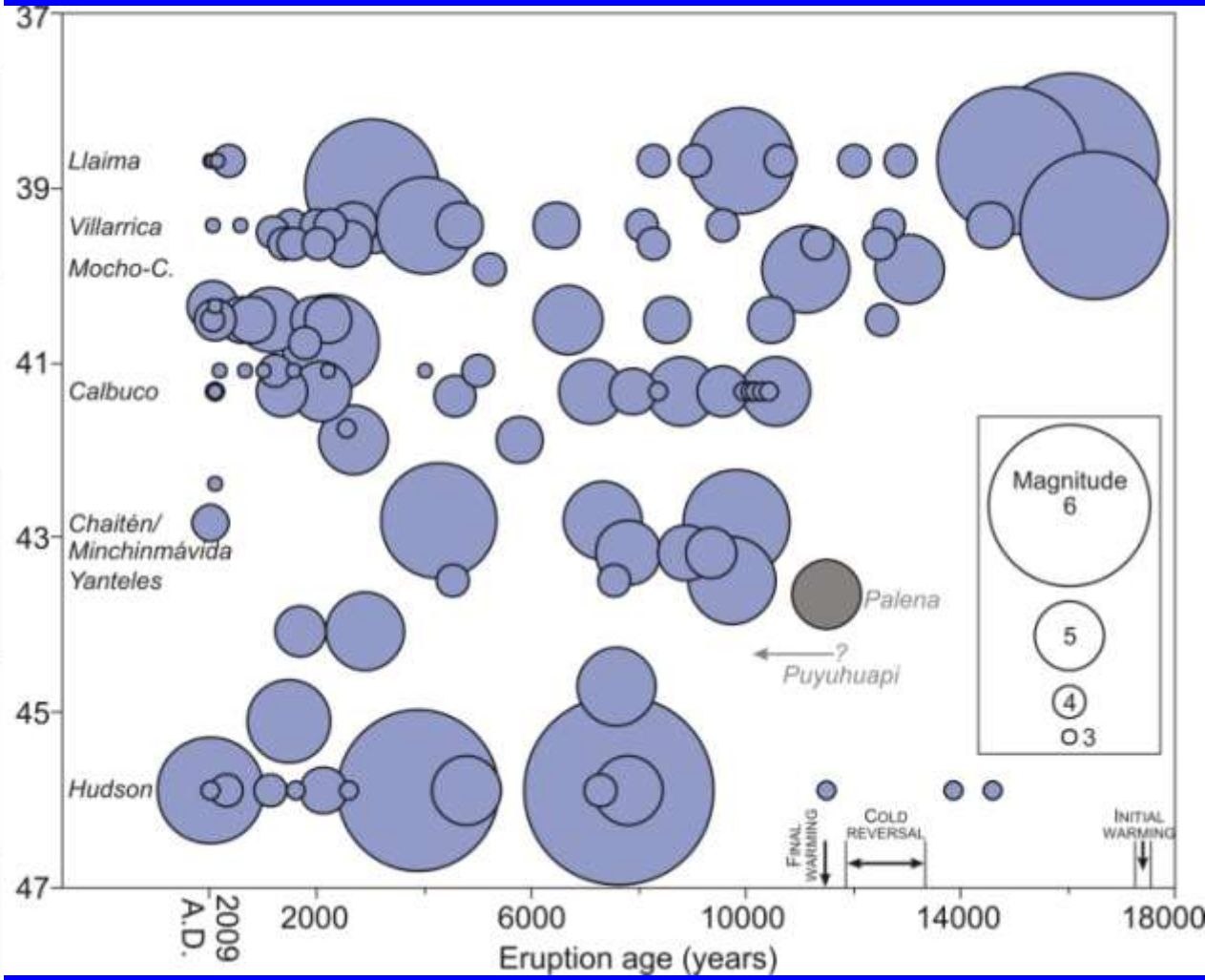
Final warming ~ 11,000 yrs

End glaciation > 16,000 yrs

Wall et al Earth Science Reviews (in review)

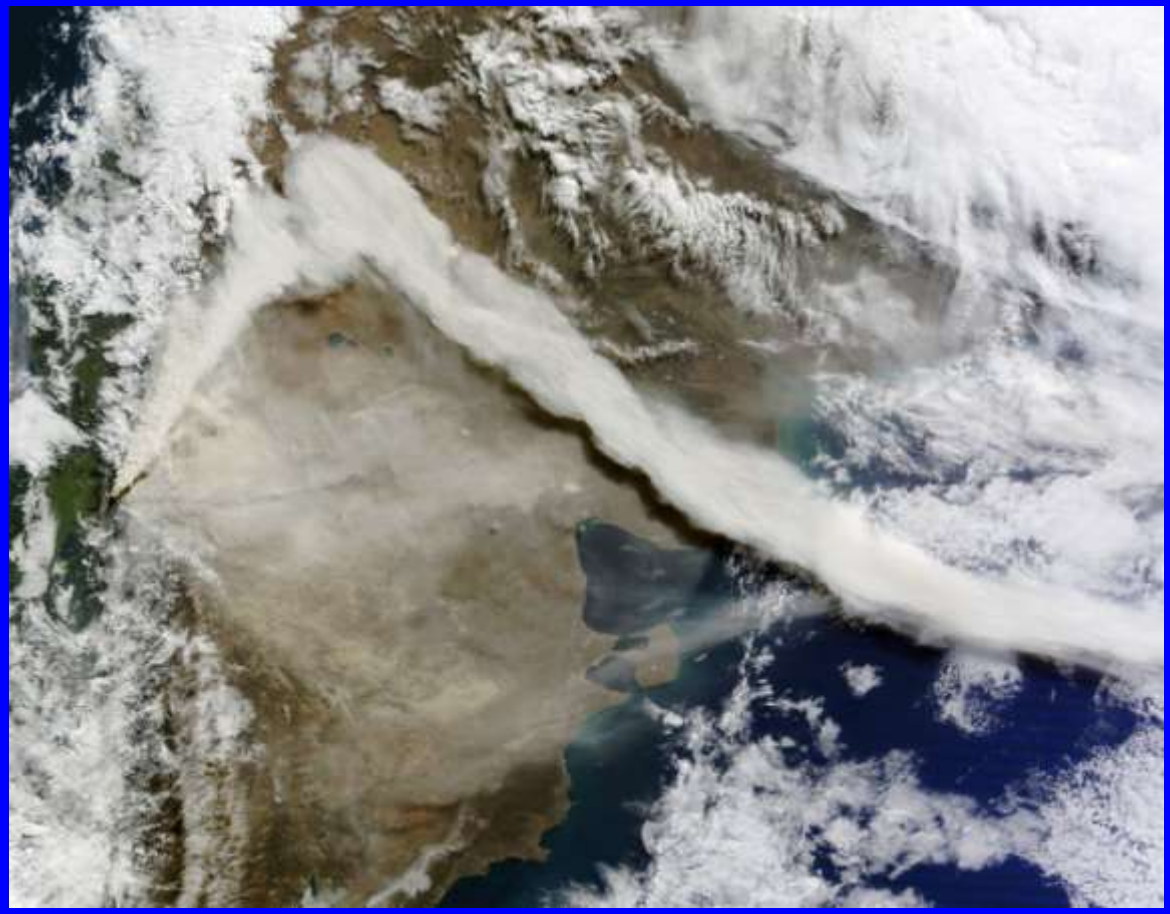
Ice retreat, eruption timing and size





Frequent small-moderate explosive eruptions deliver ash to the oceans

Puyehue – Cordon Caulle, June – October 2011.



40°S

NASA – MODIS real-time images from June, July 2011

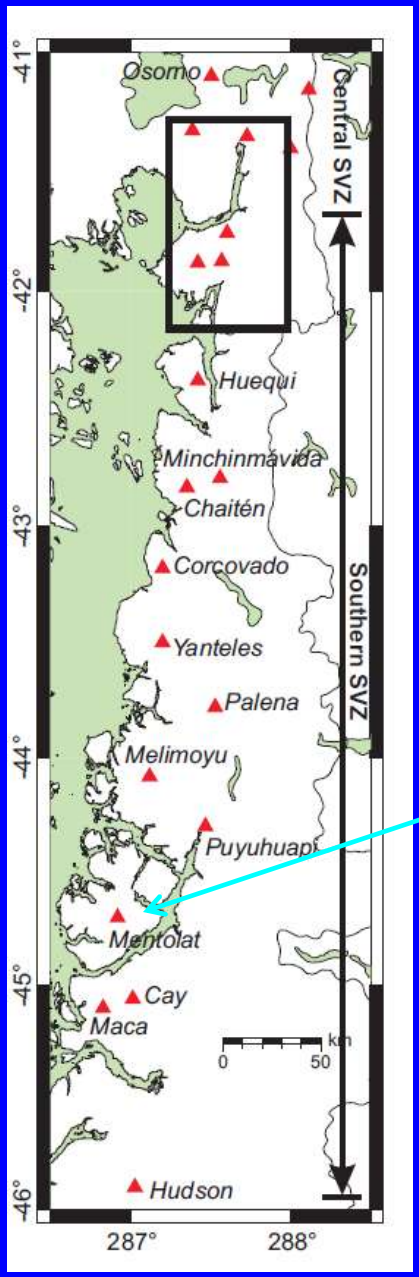
Chaiten, 2008 : first major ash plume for ~20 years

May 5, 2008. (MODIS).

Ash fallout in Futaleufu, Chile (May 2008)

Still cleaning up, Futaleufu (January 2009)

A very short historical record: eruption rates are poorly known



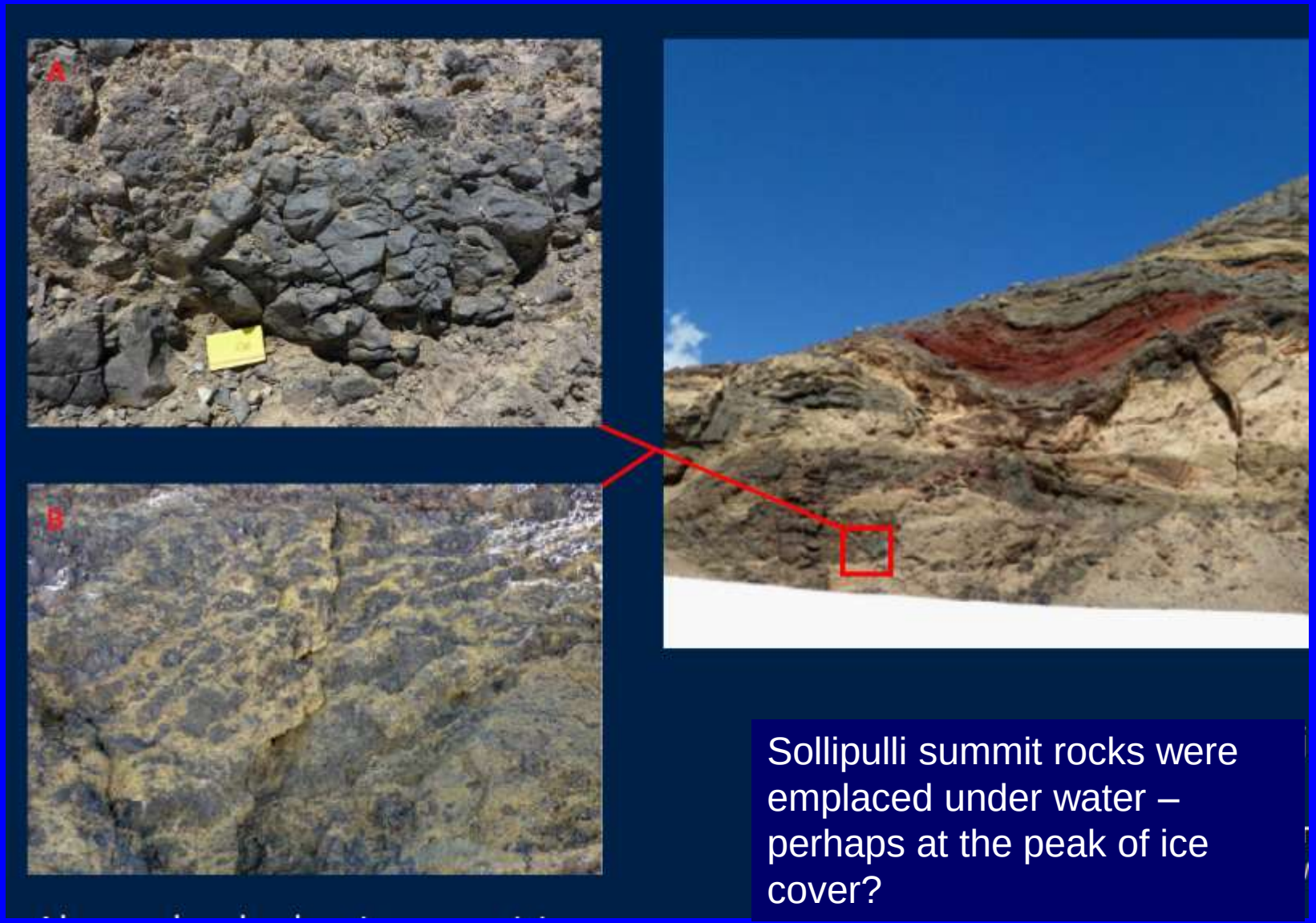
Mentolat, 1697-1721 AD

First field evidence for an early 18th century explosive eruption

Hazards of ice-capped volcanoes: volcan Yate

Lago Cabrera: a village drowns

Volcan Sollipulli: a 300-m deep ice-filled caldera



Sollipulli summit rocks were emplaced under water – perhaps at the peak of ice cover?

There's only one route out for meltwater

NASA (International Space Station) 2009

Risks of even small eruptions increasingly appreciated

National Risk Register of Civil Emergencies
2012 edition

Impact	Between 1 in 20,000 and 1 in 2,000	Between 1 in 2,000 and 1 in 200	Between 1 in 200 and 1 in 20	Between 1 in 20 and 1 in 2	Greater than 1 in 2
5				Pandemic influenza	
4			Coastal flooding Effusive eruption		
3	**Major industrial accidents**	**Major transport accidents**	Other infectious diseases Inland flooding	Severe space weather Low temperatures and heavy snow Heatwaves	
2			Zoonotic animal diseases[1] Drought	Explosive eruption **Public disorder**	
1			Non-zoonotic animal diseases[1]	**Disruptive industrial action**	

Likelihood

Avenues for future work?

Relative consequences (local, regional, global) to larger rarer events *vs*. smaller, frequent events?

How will changes in regional patterns of precipitation, and equilibrium-line altitude influence hazards at snow-covered volcanoes around the world?

Expect:
- continued ice-retreat leading to increased erosion, mass wasting, lahars, and significant downstream impacts

- loss of volcanic glaciers will impact communities reliant on these for their water supplies;

- potential for catastrophic ‘glacial outburst floods’ will continue to increase, particularly at volcanoes with ice-filled craters.