Extreme regional precipitation events related to volcanic eruptions

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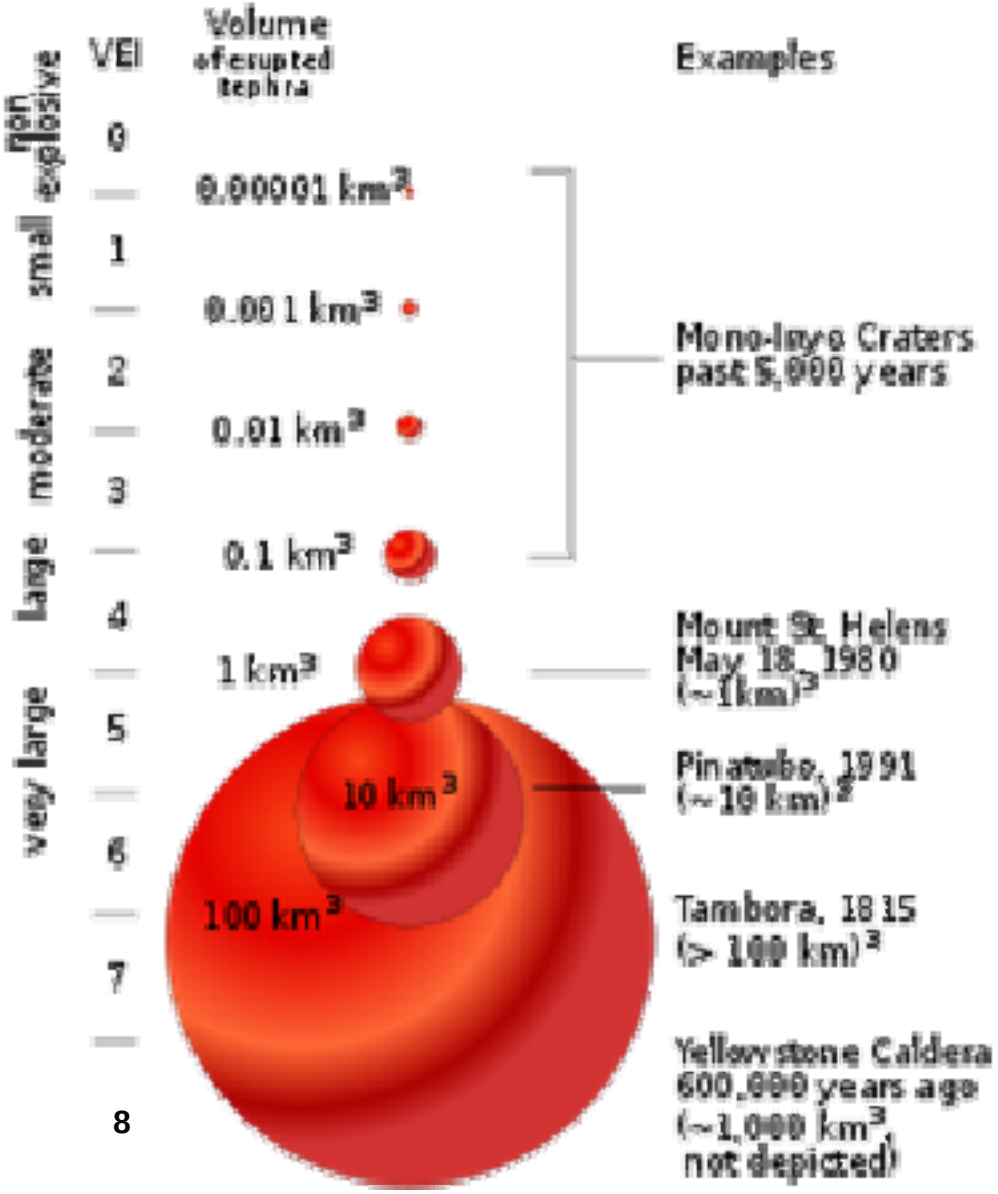
Volcanic Explosivity Index (VEI)

after Newhall & Self (1982)

Scale of volcanic eruptions



List of 13 ‘major’ volcanic eruptions since 1883 showing their location, main eruption date, volume of tephra and ranking. (Source: Global Volcanism Program)

Volcano	Latitude & longitude	Main eruption date	VEI	Volume of tephra	Rank.
Krakatau, Indonesia	6°6’6”S 105°25’22”E	August 17, 1883	6	$2.0 \pm 0.2 \times 10^{10} m^3$	=2
Okataina, New Zealand	38°7’0”S 176°30’0”E	June 10, 1886	5	$2.0 \times 10^9 m^3$	10
Santa Maria, Guatemala	14°45’21”N 91°31”6”W	October 24, 1902	6?	$2.0 \times 10^{10} m^3$	=2
Ksudach, Russia	51°48’0”N 157°9’24”W	March 28, 1907	5	$2.4 \times 10^9 m^3$	8
Novarupta, USA	58°16’0”N 155°9’24”W	June 6, 1912	6	$2.8 \times 10^{10} m^3$	1
Cerro Azul, Chile	35°19’12”S 70°45’39”W	April 10, 1932	>5	$9.5 \times 10^9 m^3$	5
Kharimkotan, Russia	40°7’0”N 154°30’30”E	January 8, 1933	5	$1.0 \times 10^9 m^3$	13
Bexymianny, Russia	55°58’22”N 160°35’12”E	March 30, 1956	5	$2.8 \times 10^9 m^3$	7
Agung, Indonesia	8°20’30”S 115°30’30”E	March 17, 1963	5	$>1.0 \times 10^9 m^3$	12
St. Helens, USA	46°12’0”N 122°11’0”W	May 18, 1980	5	$1.2 \times 10^9 m^3$	11
El Chichón, Mexico	17°21’36”N 93°13’40”W	April 4, 1982	5	$2.3 \times 10^9 m^3$	9
Pinatubo, Philippines	15°8’0”N 120°21’0”E	June 15, 1991	6	$1.1 \pm 0.5 \times 10^{10} m^3$	4
Cerro Hudson, Chile	45°54’0”S 72°58’0”W	August 12, 1991	5	$4.3 \times 10^9 m^3$	6

Main impacts of ‘major’ volcanic eruptions

(1) Initial rise in temperature of the stratosphere followed by cooling of the troposphere.

(2) Volcanic clouds obstruct the incoming solar radiation causing the Earth’s surface temperature to decrease.

(3) The thermal plumes will interfere with the Earth’s ‘normal’ air circulation.

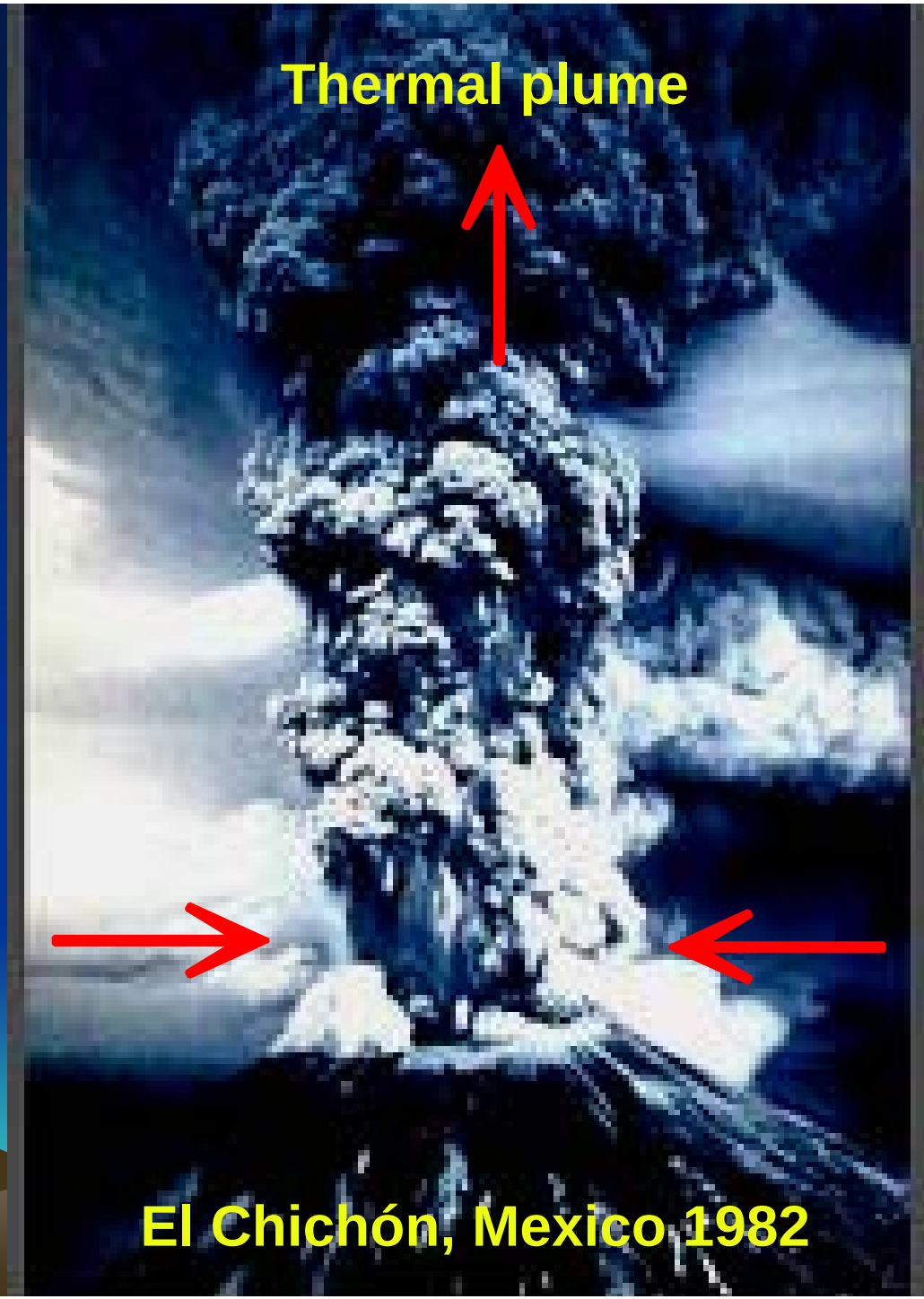
(4) Transfer of water vapour from the troposphere into the stratosphere.

(5) Particulates and aerosols in the atmosphere form condensation nuclei.

(6) The sulphur oxides released lead to acid precipitation which damage vegetation.

The Model

Warm air stores more moisture



Eruption changes normal air circulation

Cool air stores less moisture

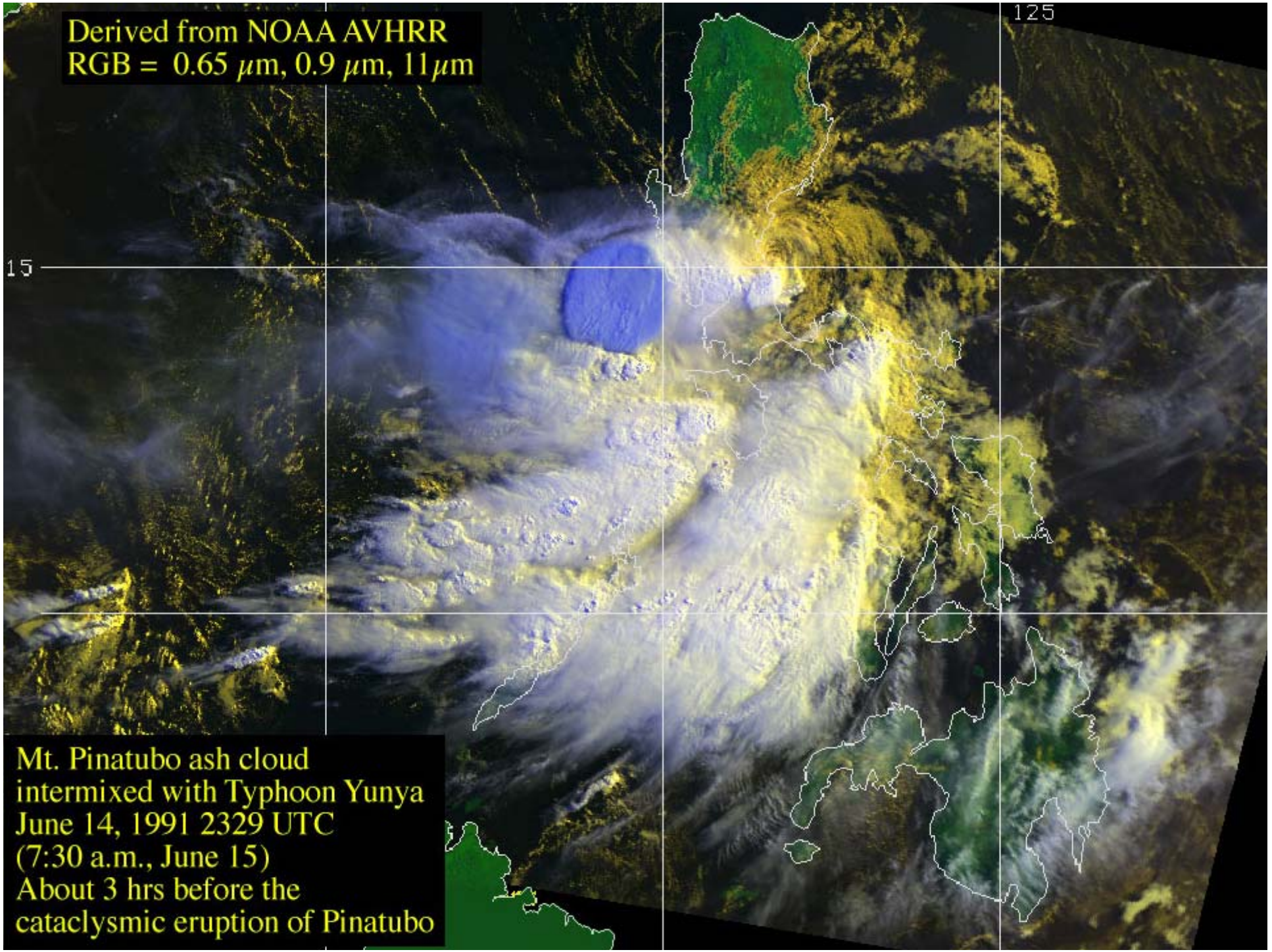
Cool air

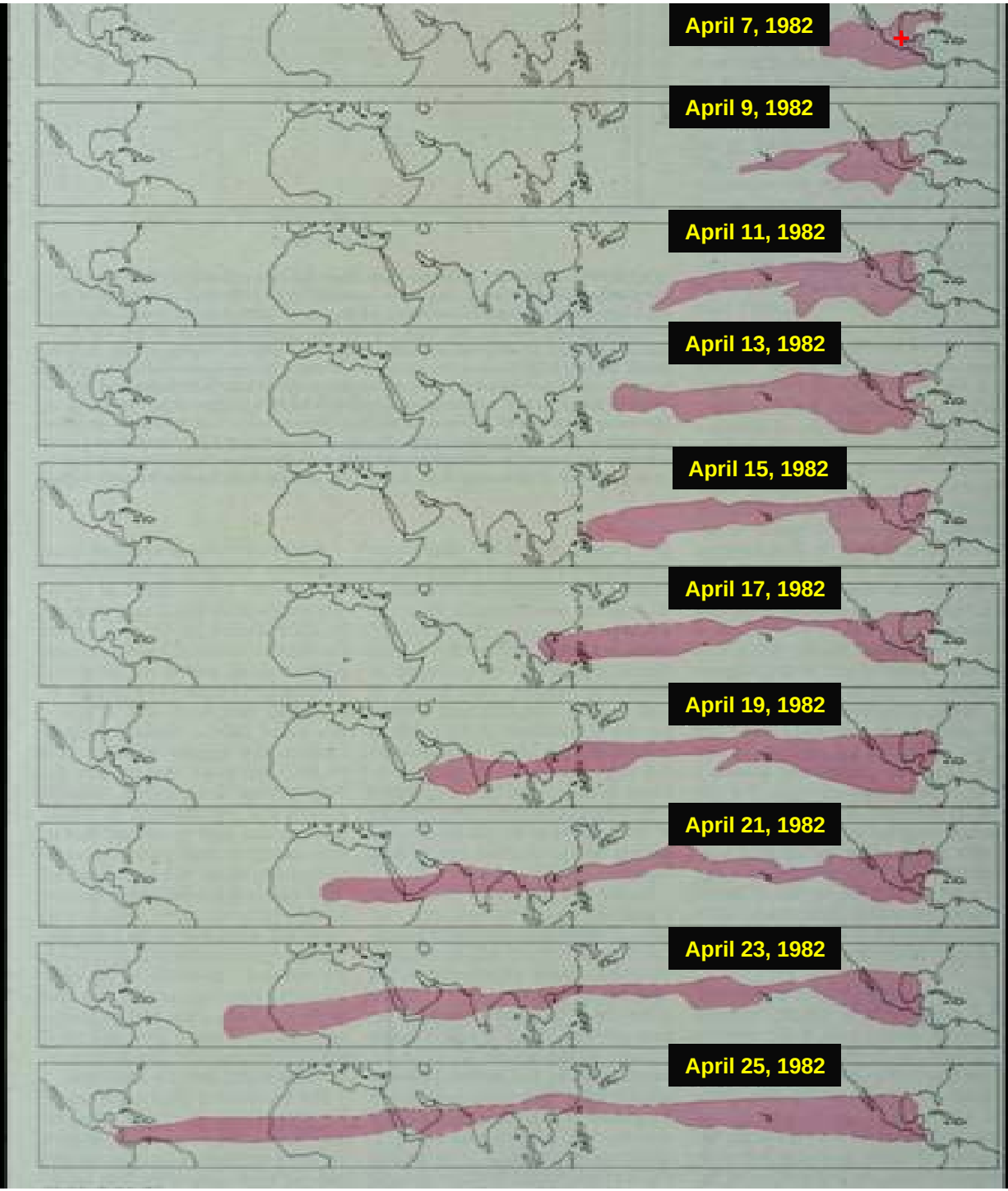
Latitude, first eruption date, volume of materials erupted and annual precipitation at the Hong Kong Station during the 1963 Agung, 1982 El Chichón and 1991 Pinatubo eruptions

Volcano	Latitude	Main eruption date	Cloud height (km)	Volume of materials erupted	Precipitation^ (mm)	Comment
Agung, Indonesia	8°S	March 17, 1963	22	~1 km^3 (Rampino & Self, 1982)	901.1	Driest year
El Chichón, Mexico	17°N	April 4, 1982	26	~0.6 km^3 (Rampino & Self, 1984)	3247.5	2nd wettest year
Pinatubo, Philippines	15°N	June 15, 1991	35	~5 km^3 (Self et al., 1999)	1639.1	10th driest year

^ Mean ~2225 mm.

Reason for drought years during the 1963 Agung and 1991 Pinatubo eruptions


Derived from NOAA AVHRR
RGB = 0.65 μm, 0.9 μm, 11μm
125
15
Mt. Pinatubo ash cloud
intermixed with Typhoon Yunya
June 14, 1991 2329 UTC
(7:30 a.m., June 15)
About 3 hrs before the
cataclysmic eruption of Pinatubo



Westerly drift of El Chichón eruption cloud after Rampino and Self (1984) based originally on Robock and Matson (1983)

Monthly rainfall at the Hong Kong Station in 1982

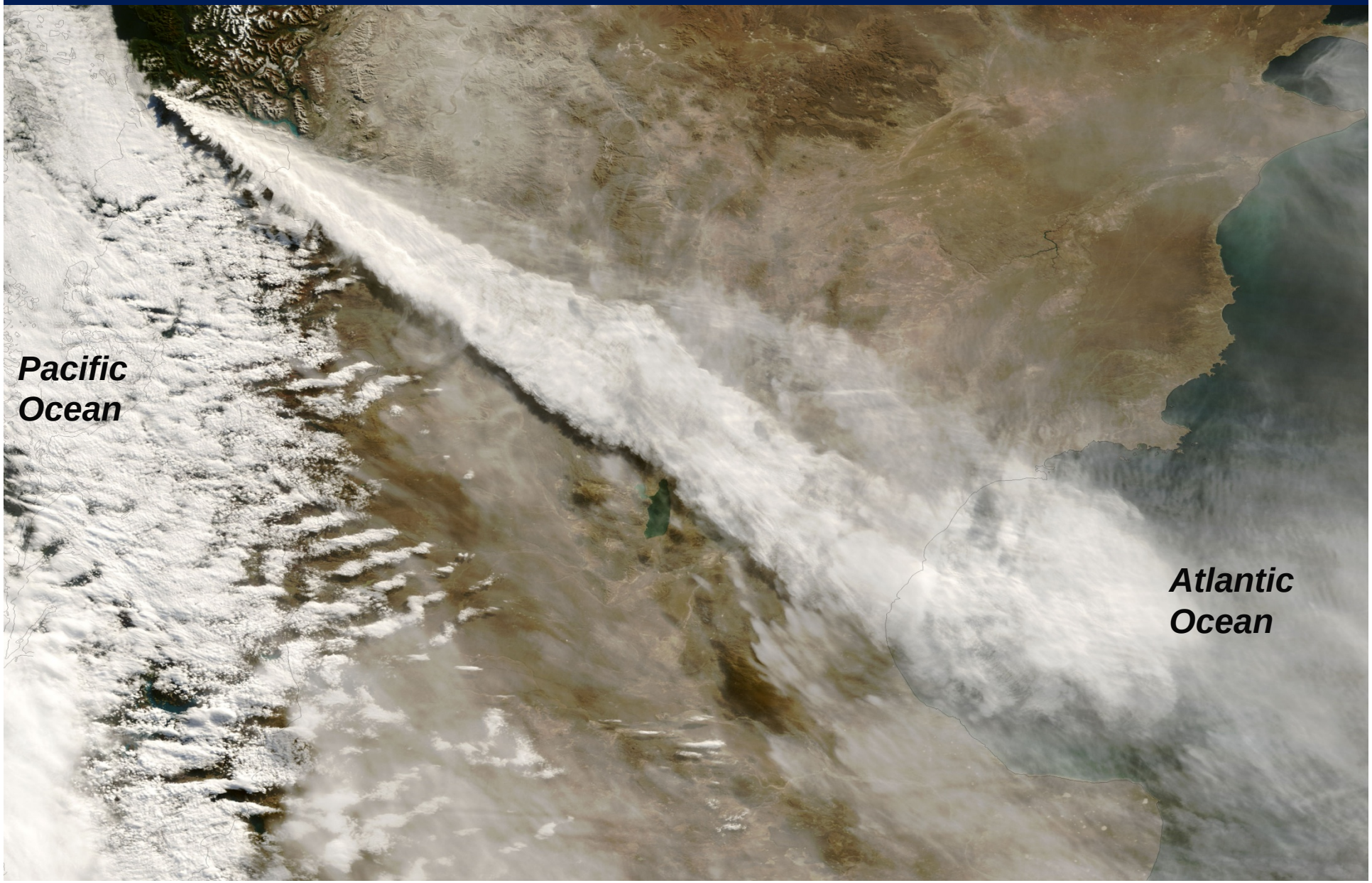
Month	Rainfall (mm)
January	16.0
February	23.1
March	30.6
April	310.0
May	767.4
June	205.9
July	296.2
August	872.0
September	466.8
October	163.7
November	95.8
December	trace

Total 3247.5 mm
Annual average 2225 mm
146% above average

Normal for April 139.4 mm
- 222% above normal
- 7th wettest on record
- relative humidity 5th lowest on record

Normal for May 298.1 mm
- 257% above normal
- 4th wettest on record
- worst landslips since 1976

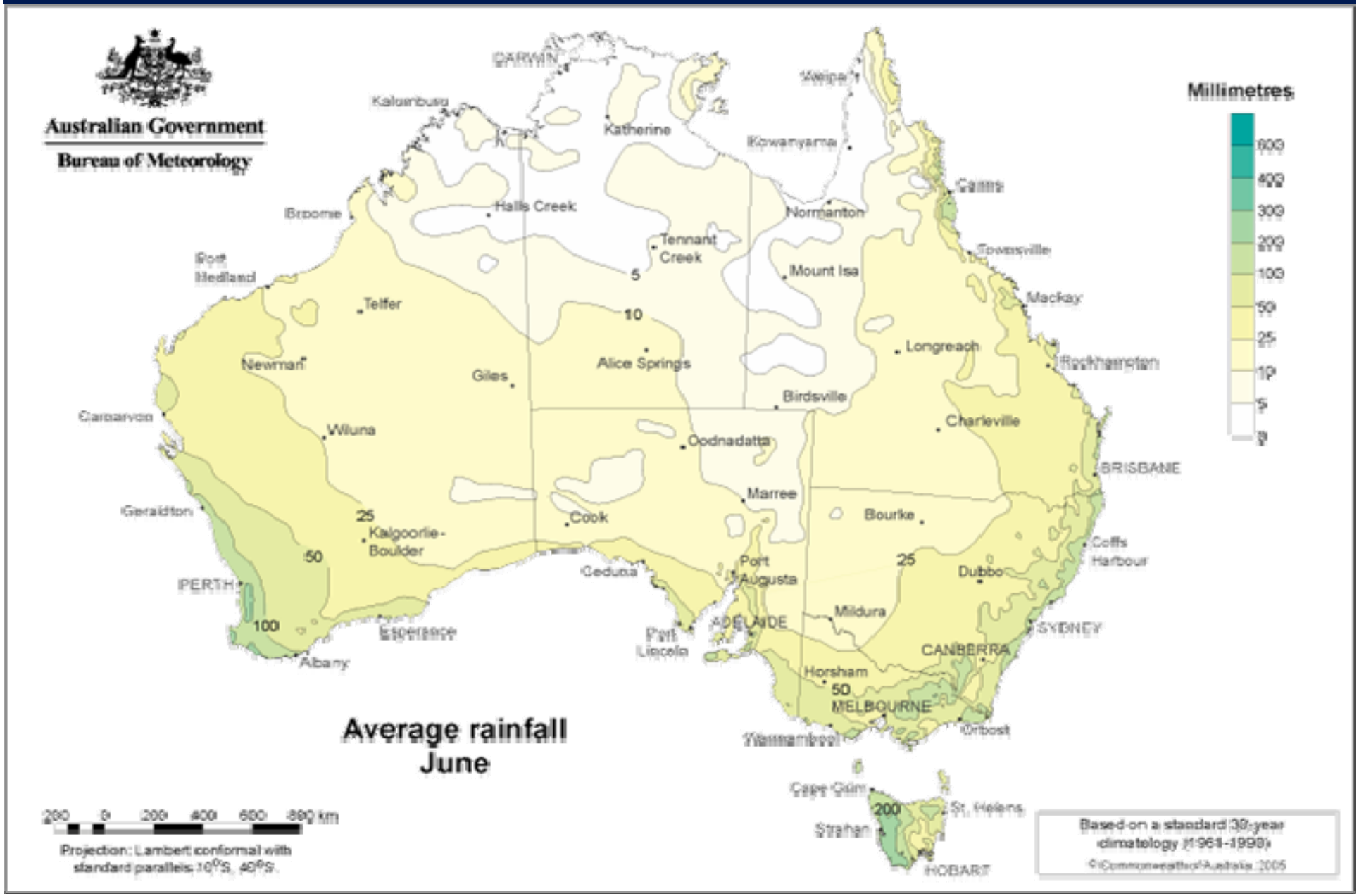
May 2, 2008 Chaiten eruption, Chile VEI = 4



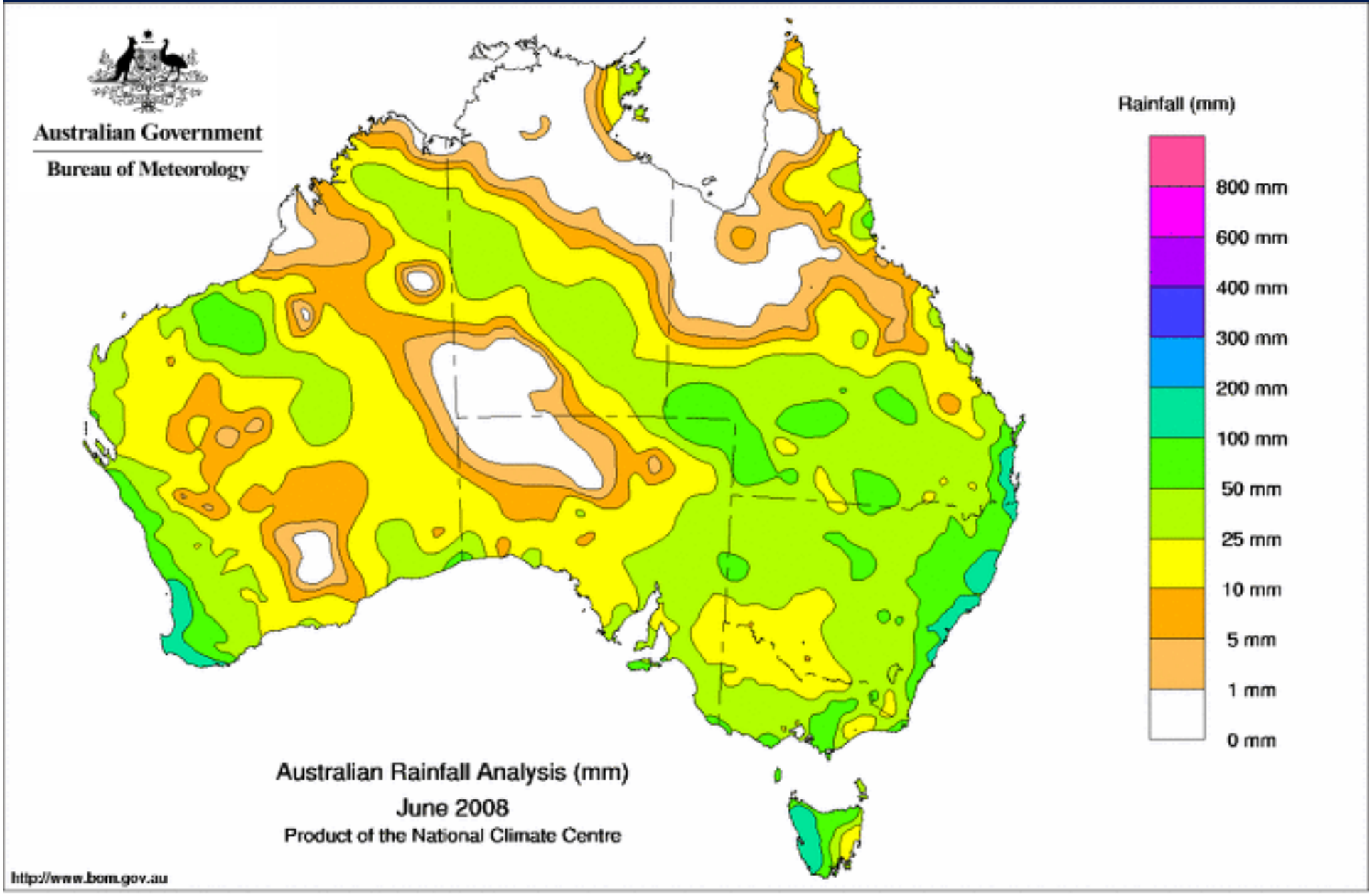
Selected impacts on regional rainfall pattern

- A wet May/June in South Africa
- A wet June in Australia (LIDAR picks up ash as far as southeastern Australia)
- Wettest June in Hong Kong since record began in 1884 (1346.1 mm or 346.8% above average including an 1-1100 year rainstorm)

Average rainfall in June 1961-1990



June 2008 rainfall in Australia



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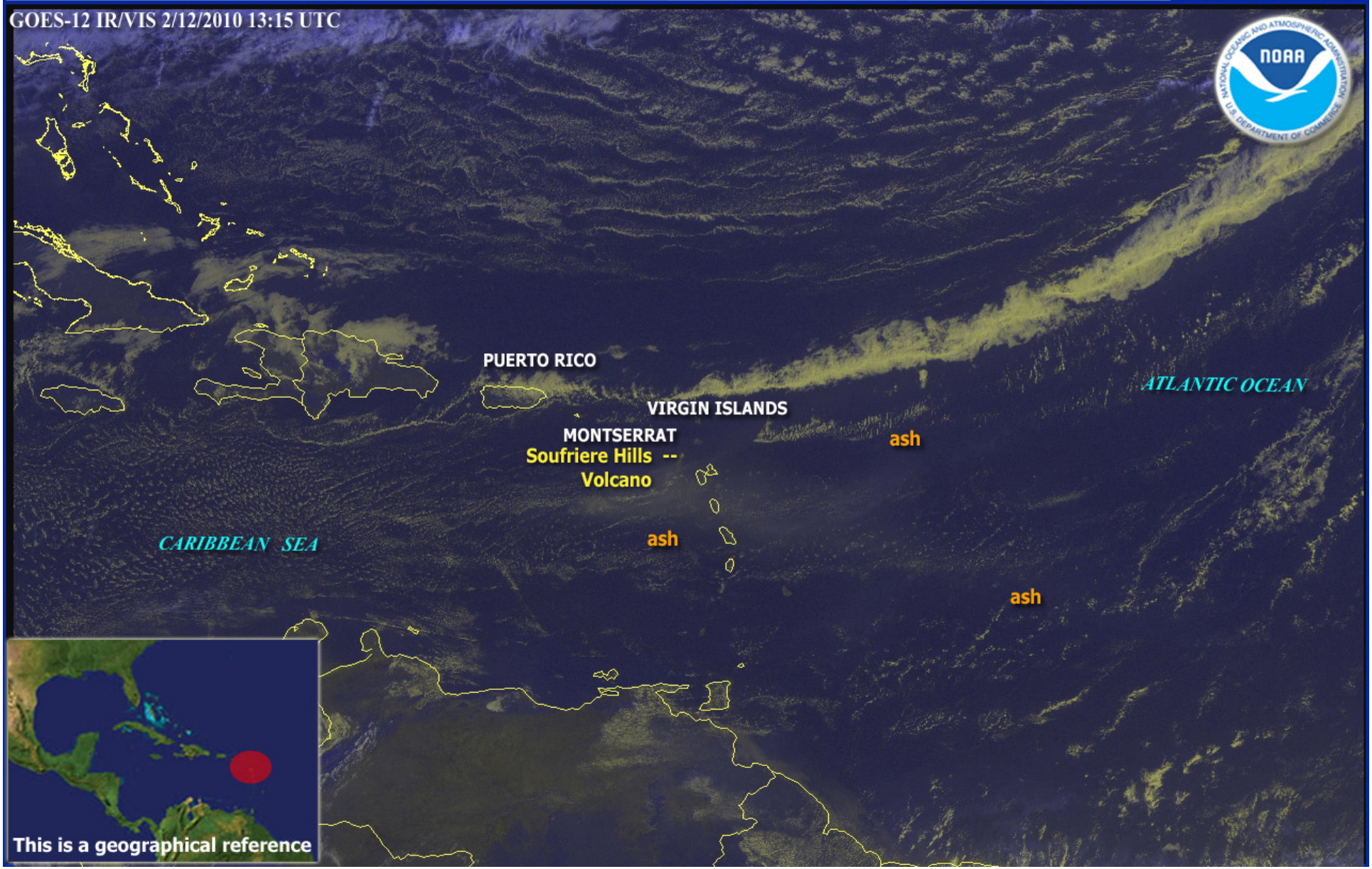
Some of the ~ 2400 landslides on Lantau Island caused by the 1-in-1100 year rainstorm in Hong Kong on June 7, 2008

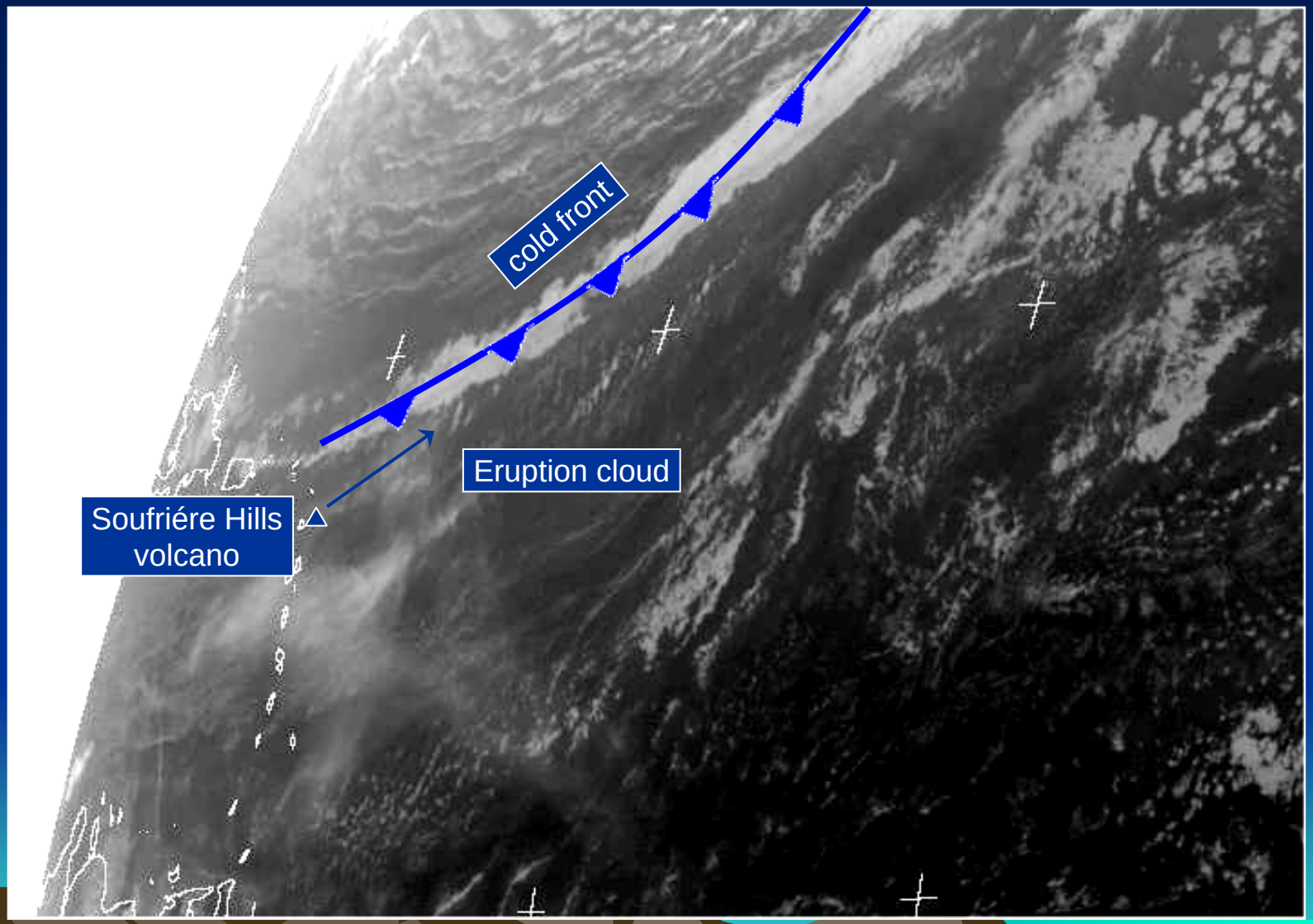
Residual ash from an explosive eruption yesterday at the Soufriere Hills Volcano located on the Caribbean Island of Montserrat. Currently the ash extends approximately 425 miles to the east of the summit.

February 11, 2010 1635 UTC eruption - ash plume reached 15.2 km altitude VEI = 4?

Credit: NOAA



Ash plume caught up within the warm sector of frontal system



Meteosat Seviri Channel 7 (www.sat.dundee.ac.uk)

Frontal activity storms with torrential rainfall

20/2/2010 Madeira death toll > 48 death toll

28/2/2010 Xynthia Western France > 62 death toll (> 240 km/hour wind, damage ~ 3 billion Euros)

Others countries affected – Spain, Belgium and Germany

Both storms were exacerbated by the volcanic eruption plume and aerosols

Cleveland 2009, Aleutian islands

Thank you