FEATURES

Impact of a volcanic eruption in

Recent research by the University of Cambridge and the UK Met Office has shown that human-caused climate change has important consequences for how volcanic gases interact with the atmosphere. Large-magnitude eruptions will have greater effects as the climate continues to warm, whereas the cooling effects of small and medium-sized eruptions could shrink by as much as 75%. Since smaller eruptions are far more frequent, further research is needed to determine whether the net effect will be additional warming or cooling. In this article, Wyss Yim (Geology 1971-74) looks at the impact of the 1982 El Chichón volcanic eruption in Mexico.

Rainfall is an important indicator of climate change but has rarely been studied with the aid of reliable observation records. In support of anthropogenic global warming, temperature rise is assumed to increase the amount of water vapour entering the atmosphere to increase rainfall including the higher frequency and greater magnitude of floods. In this study, the eruption cloud from the 1982 El Chichón volcanic eruption in Mexico tracked by satellites for the first time is revisited to explain both the timing of rainfall and a record-breaking wet year in Hong Kong located over 14,000 kilometres away across the Pacific Ocean.

Volcanic eruptions release large amounts of water vapour, dust and ash into the atmosphere. They also produce large quantities of carbon dioxide and sulphur dioxide. If the eruption is large and tropical, any material in the stratosphere can circulate the globe and be transported pole-wards. The addition of aerosols, water vapour and particulates can also reflect solar radiation, causing a negative radiative forcing while their settlement through the atmospheric column contributes large amounts of condensation nuclei for generating rainfall.

The Total Ozone Mapping Spectrometer (TOMS) was a satellite instrument of the National Aeronautics and Space Administration (NASA), specifically a spectrometer, for measuring the ozone layer. The satellites carrying TOMS were first launched in 24th October, 1978 and operated continuously until 1st August, 1994 making it the first ever tool available for the tracking of volcanic eruption clouds.

In late March to early April, 1982 three successive eruptions of the El Chichón volcano in Mexico on 28th March, 3rd April and 4th April created a maximum cloud column height reaching 26 kilometres above sea level. The Volcanic Explosivity Index was ranked 5 while 7 million tonnes of sulphur dioxide aerosol and 20 million tonnes of particulates were estimated to be ejected into the stratosphere. Global maps of the volcanic cloud migration were made after the eruption, by combining information from the geostationary GOES East and GEOS West satellites and the polar-orbiting NOAA 7 satellite. The westerly drift of the volcanic cloud at an average rate of 20 metres/second was measured for the first time to completely circle the globe in 21 days.

The 1982 El Chichón eruption, Mexico

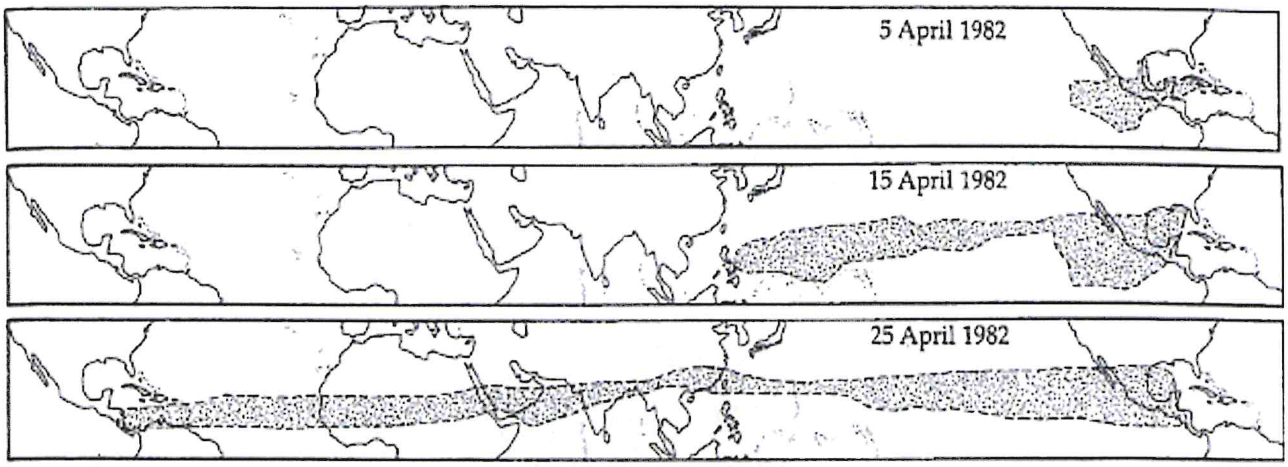
An analysis of the rainfall record of the Hong Kong Observatory's Headquarters Station near Nathan Road from 1884 to 2020 has revealed a mean annual rainfall of approximately 2,230 mm with a range of 2,441.9 mm. The driest year on record (901.1 mm) is 1963 and the wettest year on record (3343.0 mm) is 1997 one of the strongest El Niño year in the instrumental record. Previously 1982 (3247.5 mm) another strong El Niño year was the wettest year on record. This high rainfall variability found may be accounted for by Hong Kong's location on the coast of the large Asian continental land mass making it susceptible to wind shifts. Onshore winds are moisture laden and are largely responsible for rainfall in contrast to the dry offshore winds.

The westerly drift of the El Chichón volcanic eruption cloud from Mexico had significant impact on rainfall in Hong Kong in spite of the city's location over 14,000 kilometres away across the Pacific Ocean. The arrival date of the stratospheric cloud above Hong Kong on 16th April, 1982 coincided with the record low relative humidity measured at ground level (fifth lowest on record) and is consistent with the stratospheric influence of aerosols, ice crystals and particulates settling through the troposphere providing condensation nuclei for

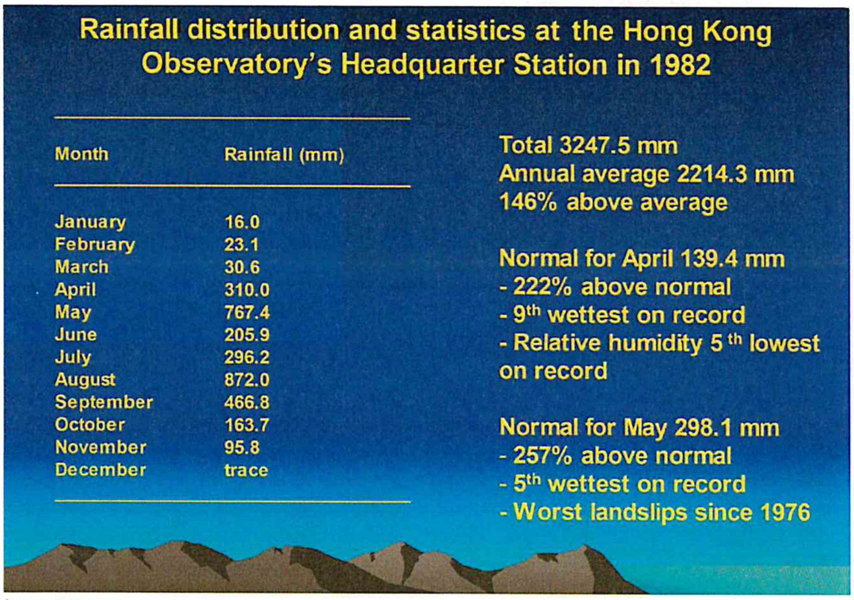
Location	Latitude 17.33°N Longitude 93.2°W
First eruption	11.32 pm on 28th March, 1982
Second eruption	7.35 am on 3rd April, 1982
Third eruption	5.22 am on 4th April, 1982
Volcanic Explosivity Index	5
Cloud column height	Maximum elevation 26 km
Average migration speed	20 m/second
Volume of tephra	< 1 km^3 of trachyandesite
Aerosol	7 million tonnes of sulphur dioxide
Particulates	20 million tonnes
Major climatic impact	Intense El Ninó of 1982-3 through changes in atmospheric circulation

Statistics of the 1982 El Chichón eruption in Mexico. Source: Wikipedia and Global Volcanism Programme.

Mexico on Hong Kong rainfall



Remote sensing satellites tracked the westerly drift of the El Chichón eruption cloud continuously and precisely. The eruption cloud was over Hong Kong after 11 days.
Source: Rampino, M.R. and Self, S. (1984) Scientific American 250/1: 34-43.



Date	Rainfall mm*	Wind direction*	Inference
19/4/1982	Trace	080	Rain fell several days after the arrival of eruption cloud above Hong Kong; the influence of stratospheric aerosols is in agreement with the low relative humidity recorded at ground level and prevailing wind direction; total April rainfall of 310 mm was the ninth wettest on record.
20/4/1982	0.1	050	
22/4/1982	70.9	150	
23/4/1982	59.9	040	
24/4/1982	31.0	050	
25/4/1982	11.6	060	
26/4/1982	7.3	030	

* Source: Hong Kong Observatory.

Daily rainfall at the Hong Kong Observatory's Headquarter Station and wind direction at the Waglan Island apparently attributable to the first arrival of the El Chichón eruption cloud over Hong Kong on 16th April, 1982.

rain. On 19th April the first trace of rainfall was detected becoming heavier on 22nd April with 70.9 mm.

During 1982 rainfall distribution in Hong Kong shows a bimodal distribution pattern with the first peak in May followed by a stronger second peak in August. The first peak can be explained by the first and second time drift around the globe of the El Chichón eruption cloud while the second peak shows subsequent drifts at least several more times contributing anomalously large amount of rain until November 1982.

In conclusion, volcanic eruptions are a natural cause of climate change responsible for the second wettest year in Hong Kong's instrumental record since records began in 1883. The year 1982 was notable for extreme weather events including disastrous floods and landslips. Based on the study of the observation record of the El Chichón eruption volcanic cloud, anthropogenic global warming may be ruled out as a cause. Further studies on the impact of other volcanic eruptions on rainfall are however needed to support this underestimated natural cause.

Professor Wyss Yim DSc PhD DIC FGS was at Imperial College in the Department of Geology from 1971-1974. After that he spent 35 years until retirement at the University of Hong Kong where he taught civil engineering, geosciences and environmental management students, and helped found the Department of Earth Sciences. He was awarded the DSc by the University of London in 1997. Wyss served as the deputy Chairman of the Climate Change Science Implementation Team of UNESCO's International Year of Planet Earth 2007-2009.