

氣候之秘： 太陽極小期

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Plan 內容

- (1) **Introduction** 簡介
- (2) **Temperature record of Hong Kong** 香港溫度記錄
- (3) **Rainfall record of Hong Kong** 香港降雨記錄
- (4) **Implications** 啟示
- (5) **Conclusions** 總結

Definition of climate change 氣候變化的定義

UN Framework Convention on Climate Change

聯合國氣候變化框架公約 (UNFCCC)

A change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

在同時期的比較，除了自然因素之外，人類活動直接或間接改變了地球大氣的成份而引致的氣候變化。

Intergovernmental Panel on Climate Change

政府間氣候變化專門委員會 (IPCC)

A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of the properties, and that persists for an extended period, typically decades or longer.

通過氣候特性的均值和/或變異性來識別（例如使用統計測試）氣候狀態的變化，並且這種變化會持續很長時間，通常為幾十年或更長。

Components of Earth' s systems

地球系統的組成元素

- **Atmosphere** 大氣圈 (air 空氣)
- **Hydrosphere** 水文圈 (groundwater, lakes, rivers & oceans 地下水, 湖泊, 河流及海洋)
- **Cryosphere** 冰凍圈 (ice 冰)
- **Biosphere** 生物圈 (living things 生物)
- **Pedosphere** 土壤圈 (soil 泥土)
- **Lithosphere** 岩石圈 (Earth crust including volcanoes 地殼包括火山)

Climate change is a product of astronomical forcing including solar variability and the interactions of the components

氣候變化是天文力量所形成，其中包括太陽活動變化，及各地球系統組成元素的相互作用

What controls Earth's climate 什麼控制了地球氣候?

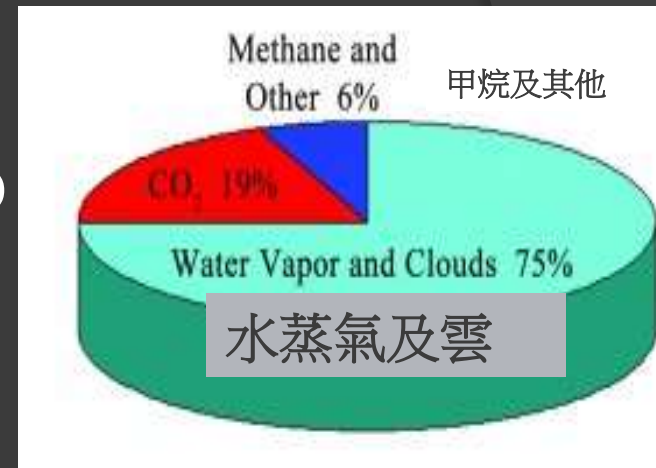
Air circulation/pressure changes 氣流/氣壓變動 (heat distribution 熱力分佈)

Greenhouse gases mainly 溫室氣體，主要為：-

-Carbon dioxide 二氧化碳 CO_2

-Methane 甲烷 CH_4

-Water vapour (most important) 最重要水蒸氣 H_2O



Water/cloud/ice distribution 水/雲/冰的分佈

Vegetation distribution 植被分佈

Ocean circulation changes 海洋環流變化

Astronomical factors e.g. sun & orbital changes 天文因素如太陽和軌道變化

Volcanic eruptions (both terrestrial & submarine) 火山爆發(陸地與海底)

Heat generation through human activities 人類活動所產生的熱力

WHAT IS THE ORDER OF IMPORTANCE 重要順序?

1st order 第一階

Astronomical forcing and the Sun e.g. glacial/interglacial cycles, solar cycles, monsoons and seasons

天文力量，如冰期/間冰期循環，太陽週期，季風和季節

2nd order 第二階

Geothermal heat/plate climatology 地熱/板塊氣候

www.plateclimatology.com

How geological forces affect the hydrosphere and atmosphere including terrestrial and submarine volcanic eruptions, their associated circulation changes and the release of CO₂ and methane

地質力量如何影響水文圈和大氣圈，包括陸地和海底火山噴發，其相關的環流變化以及二氧化碳和甲烷的釋放

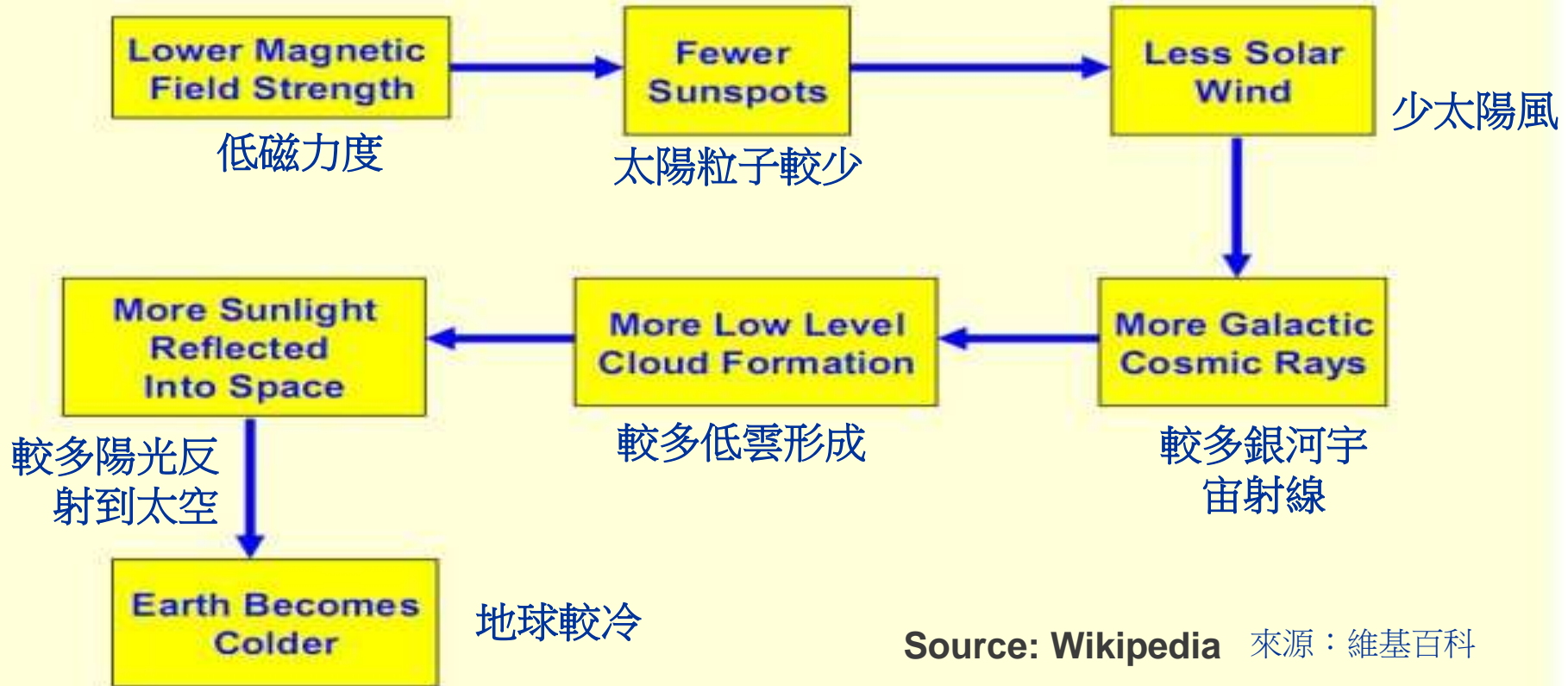
3rd order 第三階

Human-induced changes including urbanization, water cycle changes and emissions of greenhouse gases

人為因素引起的變化，包括城市化、水循環變化和溫室氣體排放

The Solar – Climate Relationship

太陽與氣候的關係



Relationship between solar magnetic field and the Earth's climate 太陽磁場與地球氣候的關係

Lower magnetic field strength means few sunspots 較低磁力度 >> 較少太陽粒子

Fewer sunspots means fewer solar winds 較少太陽粒子 >> 較少太陽風

Less solar winds mean more galactic cosmic rays 較少太陽風 >> 較多銀河宇宙射線

More galactic rays mean more low level cloud formation 較多銀河宇宙射線 >> 較多低雲形成

More low level cloud formation means more reflected sunlight 較多低雲形成 >> 較多陽光反射

Known regional climatic variability additional to monsoons 除了季風外已知的氣候變率

Physical Map of the World, June 2003

Arctic Oscillation 北極振盪 AO

Arctic Ocean pressure changes

High pressure + phase

Low pressure - phase

North Atlantic Oscillation 北大西洋振盪 NAO

Iceland/Azores pressure difference

Iceland high pressure + phase

Iceland low pressure - phase

Atlantic Multidecadal Oscillation 太平洋多年代振盪 AMO

AMO

Sea-surface temperature variability

Madden-Julian Oscillation

馬登·朱利安振盪 MJO

Intraseasonal variability of tropical atmosphere 30-90 days

Pacific Decadal Oscillation

太平洋十年振盪 PDO

surface water temperature difference

West Pacific cools + phase

West Pacific warms - phase

Quasi-Biennial Oscillation

準每兩年振盪 QBO

Change in equatorial zonal wind between easterlies and westerlies 28-29 months

Indian Ocean Dipole Oscillation

印度洋偶極振盪 IDO

East and west Indian Ocean surface water temperature difference

West Indian Ocean warms + phase

West Indian Ocean cools - phase

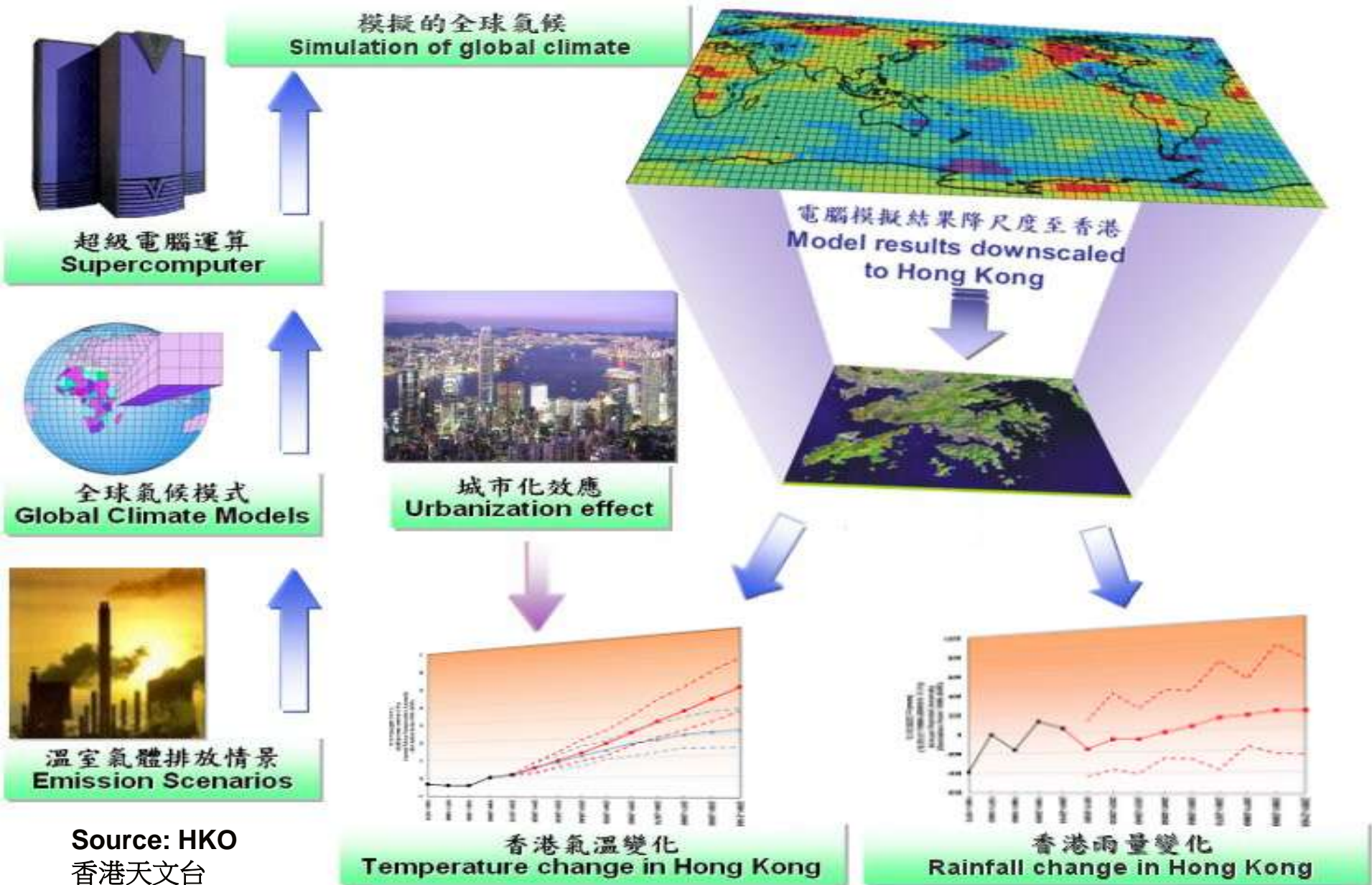
Southern Annular Mode 南半球環狀模 SAM

Mid /high latitudes, Antarctic pressure changes caused by ozone hole

Antarctic low pressure + phase

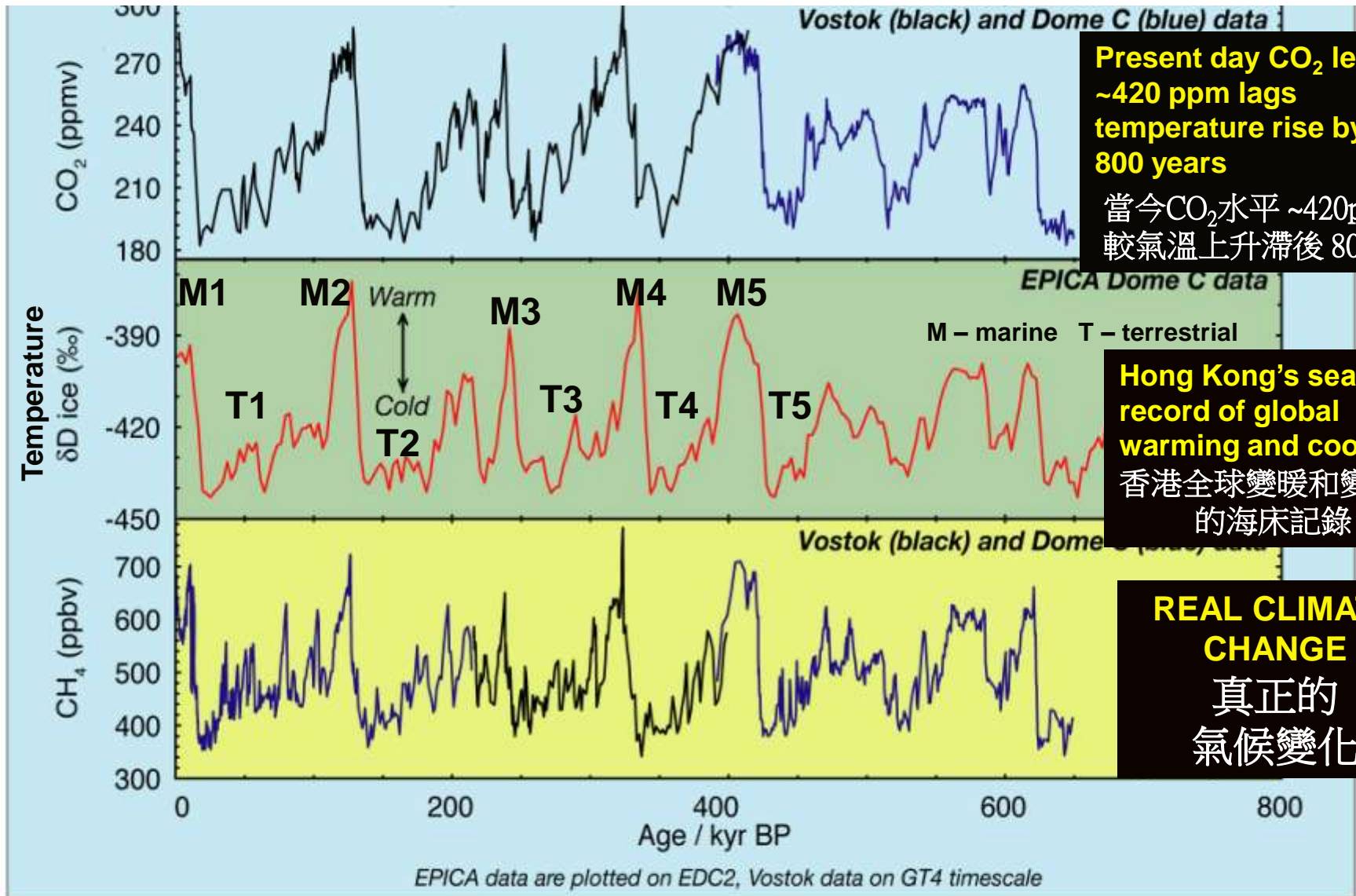
Antarctic high pressure - phase

Main assumption used in climate models – Man-made CO₂ increased global temperature by ~1°C since 1870s 氣候模式的主要假設 – 自1870年開始, 人為二氧化碳引致全球氣溫上升~1°C



Source: HKO
香港天文台

Antarctic ice core records 南極洲冰芯記錄： Vostok 和 EPICA 探測站 CO₂, CH₄ & δD



**Present day CO₂ level
~420 ppm lags
temperature rise by
800 years**

當今CO₂水平 ~420ppm,
較氣溫上升滯後 800年

**Hong Kong's seafloor
record of global
warming and cooling**
香港全球變暖和變冷
的海床記錄

**REAL CLIMATE
CHANGE**
真正的
氣候變化

Petit et al., 1999 (Vostok), Siegenthaler et al., 2005 (Dome C - CO₂),
Spahni et al., 2005 (Dome C - CH₄), EPICA community members, 2004 (δD)

Keeling curve for CO_2 的基林曲線

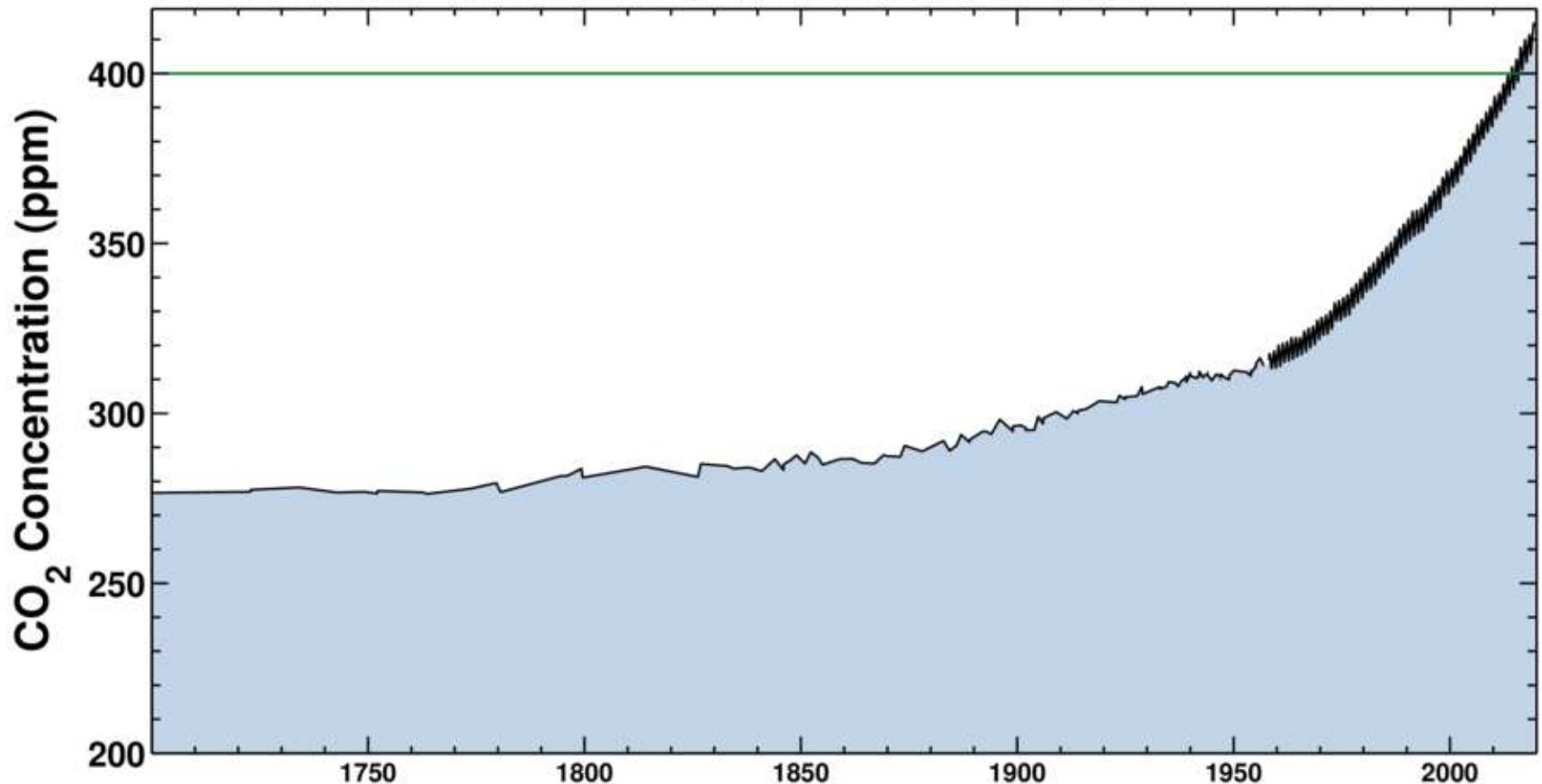
Annual increase 2-3 parts per million 每年增加百萬分之2-3

Latest 最新 CO_2 reading 讀數

01.07.2019

413.76 ppm

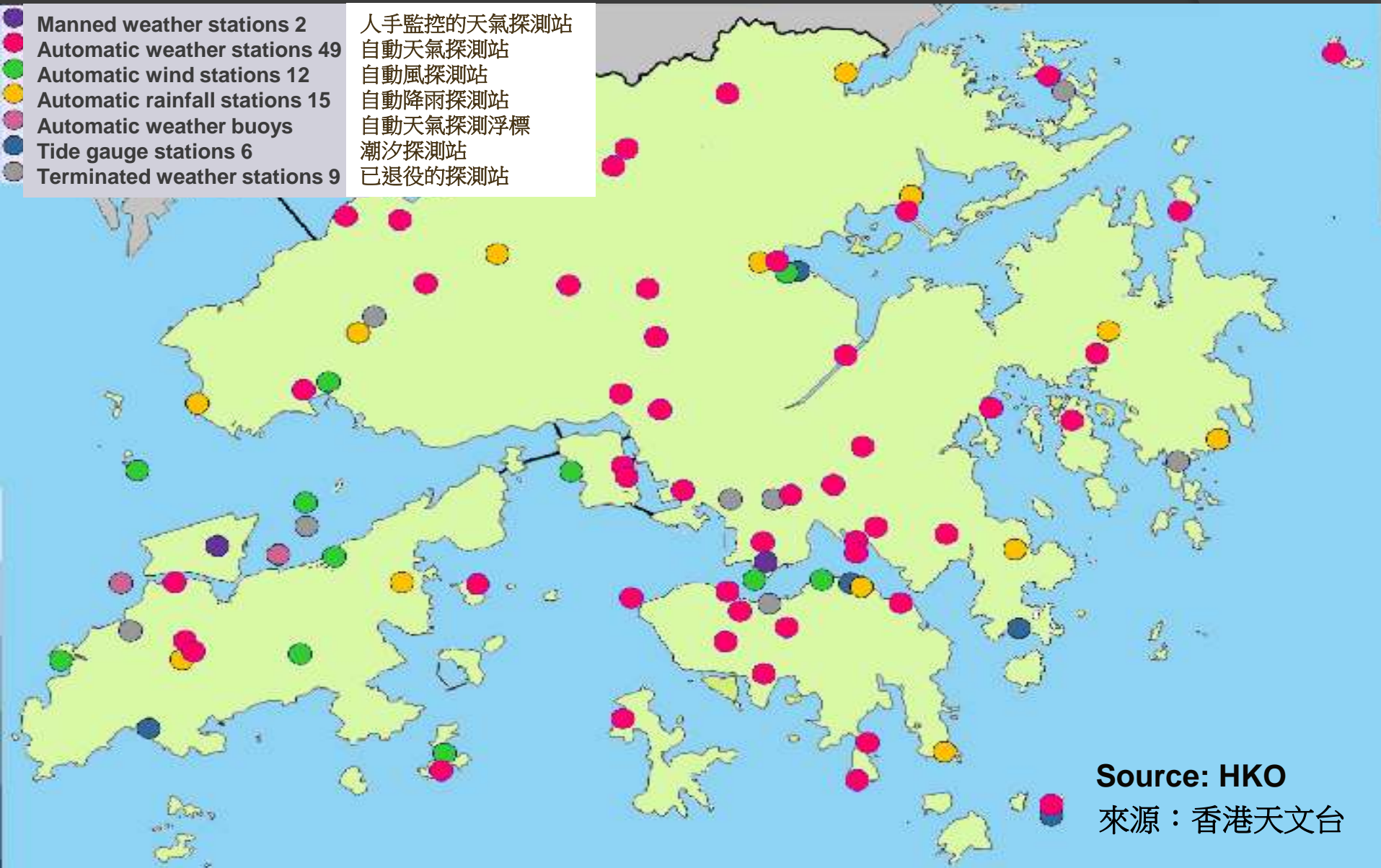
Ice-core data before 1958. Mauna Loa data after 1958.



Past and present weather stations in Hong Kong

香港過去和現在的天氣探測站

● Manned weather stations 2	人手監控的天氣探測站
● Automatic weather stations 49	自動天氣探測站
● Automatic wind stations 12	自動風探測站
● Automatic rainfall stations 15	自動降雨探測站
● Automatic weather buoys	自動天氣探測浮標
● Tide gauge stations 6	潮汐探測站
● Terminated weather stations 9	已退役的探測站

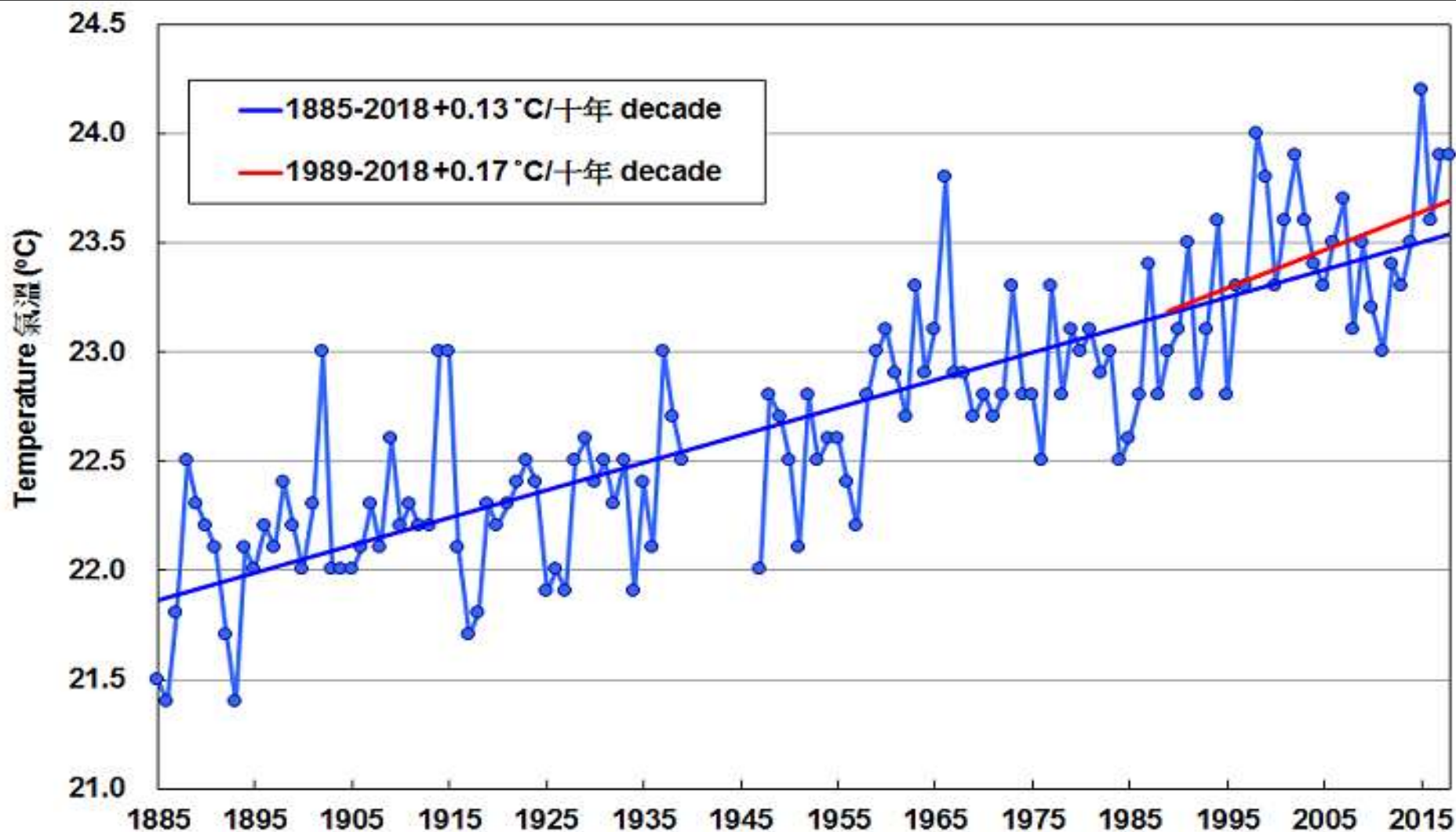


Hong Kong' s temperature statistics

香港溫度統計 1884-2018

Number of manned stations 人手監控的探測站	2
Number of automatic weather stations 自動天氣探測站	49
Station with the longest record 探測站 最長記錄	HKO Headquarters 香港天文台總部
Length of record 記錄長度	1884-1940 / 1947-present 至今
Mean annual temperature 年平均溫度	~22.6°C
Coldest year on record 紀錄以來最凍的年份	21.3°C (1884)
Hottest year on record 紀錄以來最熱的年份	24.2°C (2015)

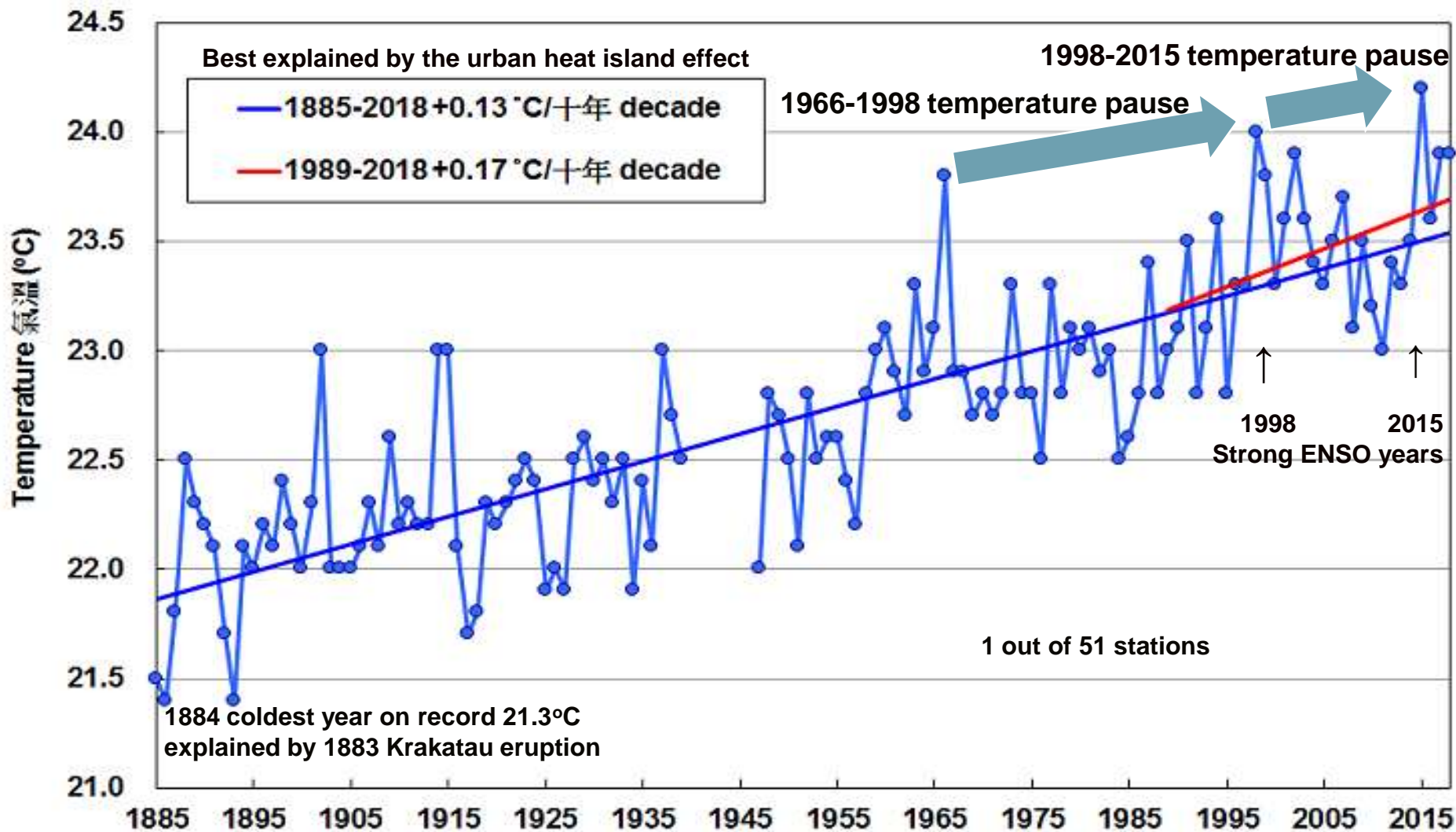
Annual mean temperature record of the HKO Station 香港天文台站年平均溫度記錄 1885-2018



Source: HKO

來源：香港天文台

Temperature record of Hong Kong Observatory's Headquarters Station 香港天文台總部站溫度記錄 1884-2018

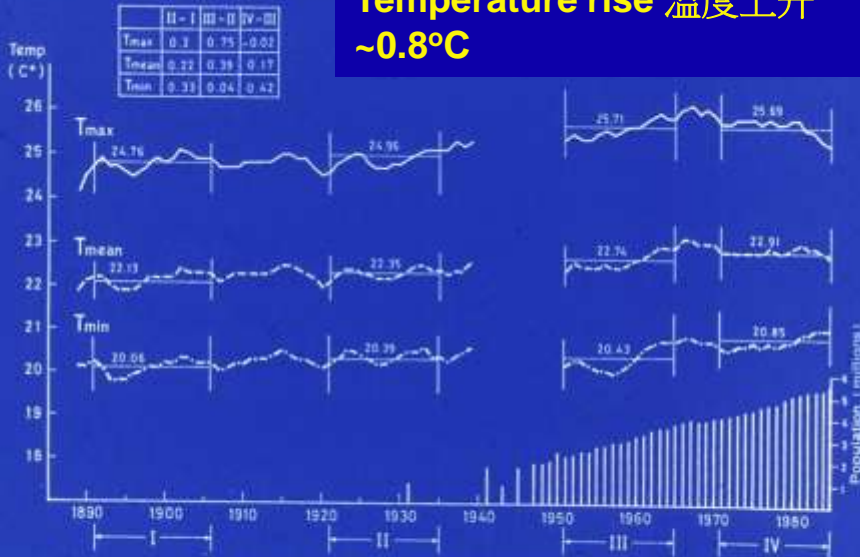


Source: HKO

來源：香港天文台

Comparison between annual temperature records and population growth at HKO Station and Macau Station 香港天文台站和澳門站年平均溫度記錄及人口增長的比較 1884-1985 (after Koo 1988)

**Temperature rise 溫度上升
~0.8°C**

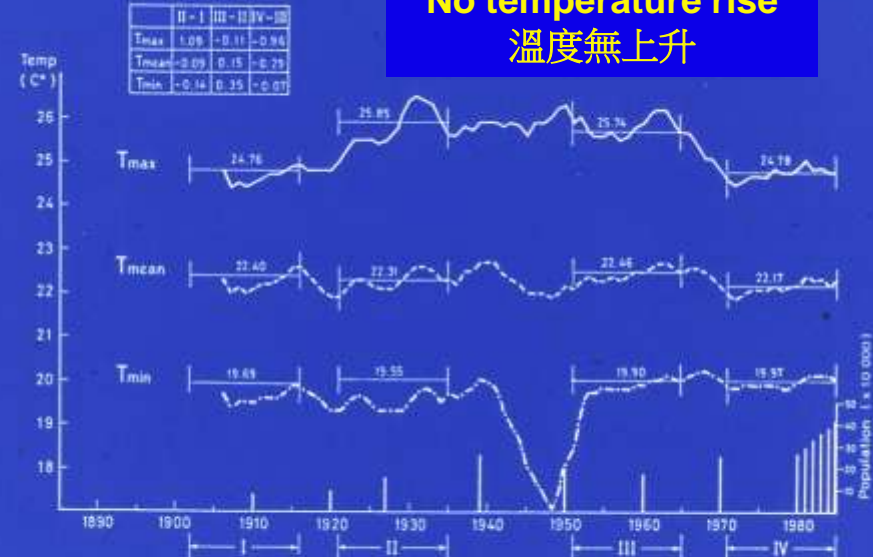


Hong Kong 香港

5-year running mean temperatures at Hong Kong Station (affected by the urban heat island because of Victoria Harbour basin)

香港站錄得的5年運行平均溫度
(因維多利亞港盆地受熱島效應影響)

No temperature rise 溫度無上升



Macau 澳門

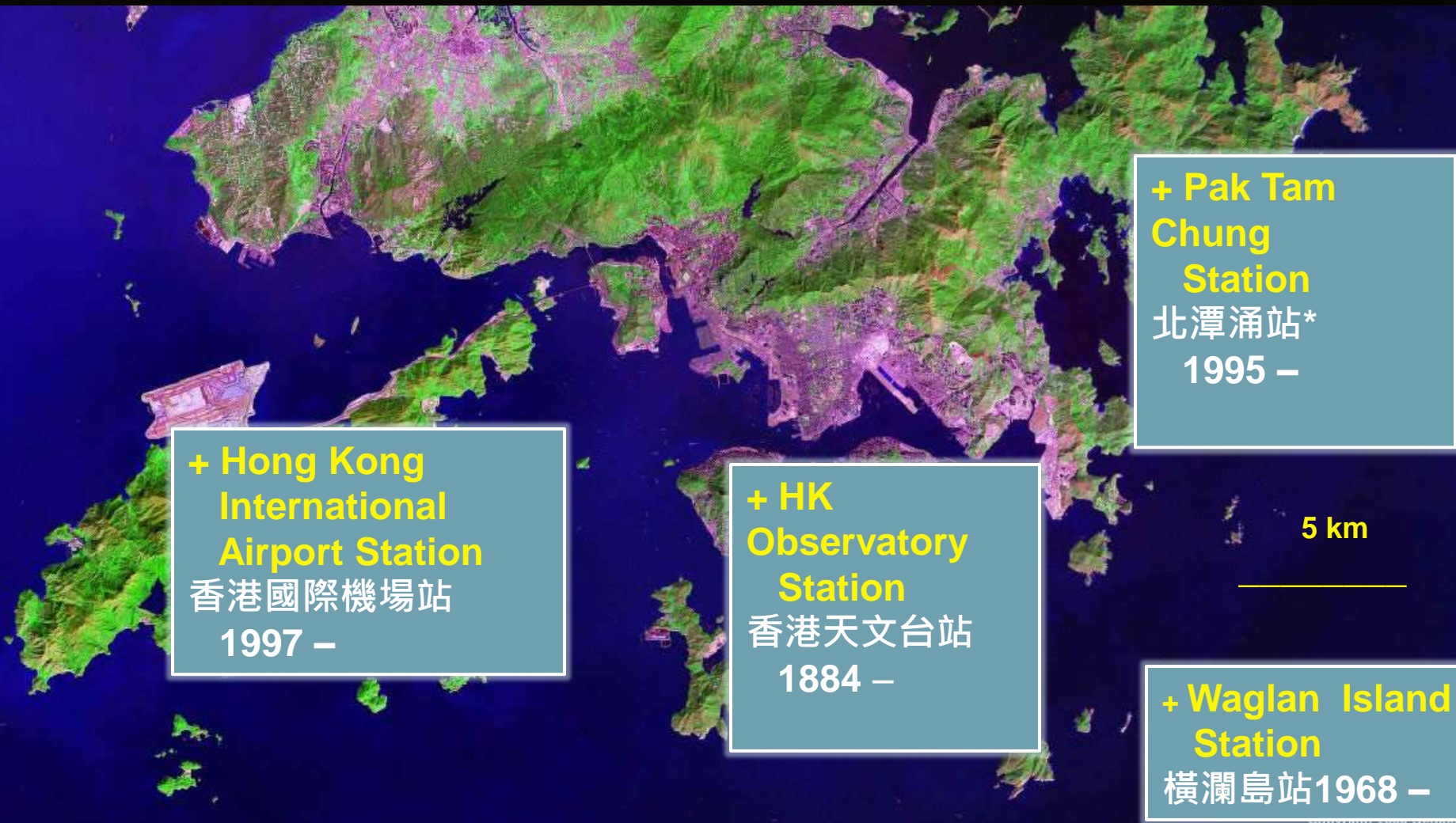
5-year running mean temperatures at Macau station (hill top location no obvious rise in temperature)

澳門站錄得的5年運行平均溫度
(因位處山頂, 無明顯的溫度上升)

Location map of HKO Station, Pak Tam Chung Station, Hong Kong International Airport Station and Waglan Island Station

香港天文台站、北潭涌站、香港國際機場站及橫瀾島站位置圖

* **Best urban station and best rural station** 最佳市區及最佳郊野站
(Siu and Hart 2013)



Number of cold days $\leq 12^{\circ}\text{C}$ each winter at the HKO, HKIA, PTC and Waglan Island stations 香港天文台站、香港國際機場站、北潭涌站和橫瀾島站每年冬季氣溫 $\leq 12^{\circ}\text{C}$ 的日數 1995-2018

Year	HKO	HKIA	PTC	WI	Year	HKO	HKIA	PTC	WI
年份	香港天文台站	香港國際機場站	北潭涌站	橫瀾島站	年份	香港天文台站	香港國際機場站	北潭涌站	橫瀾島站
1995	17	nd	81	9	2007	32	36	75	0
1996	7	nd	70	2	2008	14	20	62	15
1997	11	25	51	5	2009	23	26	52	3
1998	4	10	45	8	2010	26	37	73	8
1999	23	26	72	0	2011	23	29	65	10
2000	5	23	59	15	2012	8	14	45	8
2001	9	16	53	1	2013	25	31	53	2
2002	11	26	49	2	2014	11	12	68	12
2003	19	25	66	2	2015	22	25	47	21
2004	24	30	59	13	2016	7	8	40	7
2005	20	26	48	16	2017	22	24	56	24
2006	9	13	48	5	2018	3	7	46	4

Source: HKO
來源：香港天文台

Statistics of cold days $\leq 12^{\circ}\text{C}$ each winter at HKO, HKIA, PTC and Waglan Island stations

香港天文台站、香港國際機場站、北潭涌站和橫瀾島站每年冬季氣溫 $\leq 12^{\circ}\text{C}$ 的日數統計數據 1995-2018

	HKO 香港天文台站	HKIA 香港國際機場站	PTC 北潭涌站	WI 橫瀾島站
Type 類型	Urban 市區	Airport 機場	Rural 郊區	Maritime 海上
Annual range 年度範圍	3 – 32	8 – 37	40 – 81	0 – 24
Annual mean 年平均	15.2	22.2	57.6	8.2

Source: HKO
來源：香港天文台

Number of very hot days $\geq 33^{\circ}\text{C}$ annually at the HKO, HKIA, PTC and Waglan Island stations

香港天文台站、香港國際機場站、北潭涌站和橫瀾島站每年
氣溫 $\geq 33^{\circ}\text{C}$ 的酷熱日數 1995-2018

Year 年份	HKO 香港天文台站	HKIA 香港國際機場站	PTC 北潭涌站	WI 橫瀾島站	Year 年份	HKO 香港天文台站	HKIA 香港國際機場站	PTC 北潭涌站	WI 橫瀾島站
1995	7	nd	nd	9	2007	32	68	41	38
1996	9	nd	19	16	2008	14	69	26	28
1997	5	12	5	9	2009	23	66	40	30
1998	10	55	36	30	2010	26	64	33	20
1999	6	56	44	26	2011	23	77	46	33
2000	10	66	54	26	2012	8	62	33	21
2001	9	53	46	21	2013	25	51	18	17
2002	10	52	36	26	2014	11	100	62	39
2003	14	61	55	36	2015	22	87	58	44
2004	6	60	62	28	2016	7	66	49	32
2005	12	54	54	7	2017	22	87	31	55
2006	3	42	41	19	2018	3	74	58	39

Statistics of very hot days $\geq 33^{\circ}\text{C}$ annually at HKO, HKIA, PTC and Waglan Island stations

香港天文台站、香港國際機場站、北潭涌站和橫瀾島站每年氣溫 $\geq 33^{\circ}\text{C}$ 的酷熱日數統計數據 1995-2018

	HKO 香港天文台站	HKIA 香港國際機場站	PTC 北潭涌站	WI 橫瀾島站
Characteristics 特徵	Urban 市區	Airport 機場	Rural 郊區	Maritime 海上
Overall range 總範圍	3 – 32	12 – 100	5 – 62	7 – 55
Annual mean 年平均	13.2	62.8	41.2	27.0

Source: HKO
來源：香港天文台

10 years showing the greatest annual mean temperature difference between the HKO Station and the Waglan Island Station

香港天文台站及橫瀾站10年最大年平均溫差顯示 1998-2018

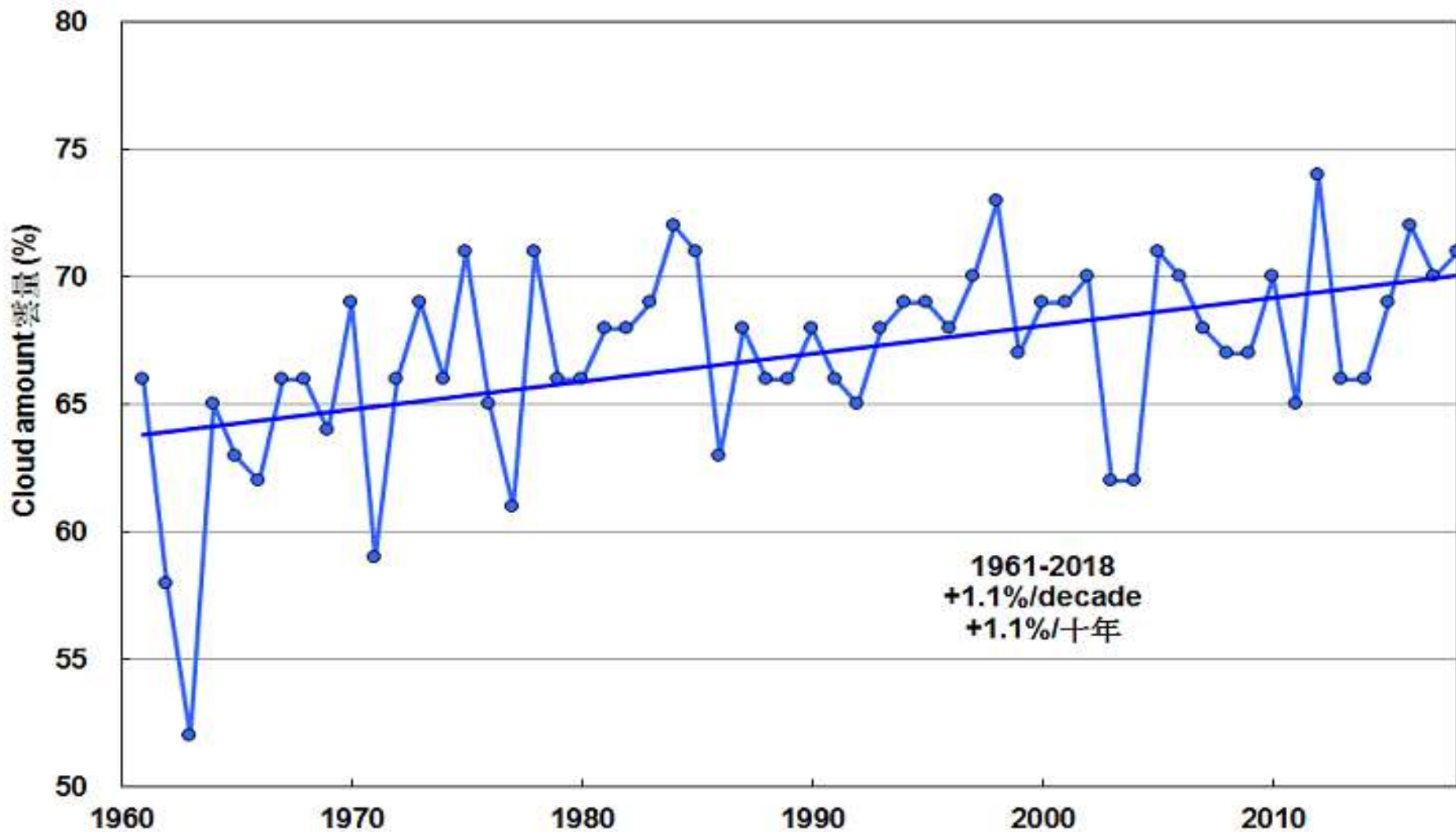
Year 年份	Difference (°C) 溫差	Explanation 說明
1997	1.5	Handover year infrastructure development 回歸年的基礎設施建設
1995	1.5	Pre-handover Infrastructure development 回歸前的基礎設施建設
1994	1.5	Pre-handover Infrastructure development 回歸前的基礎設施建設
1990	1.4	Early handover infrastructure development 回歸早期的基礎設施建設
1998	1.3	Post-handover year infrastructure development 回歸後的基礎設施建設
1996	1.3	Pre-handover infrastructure development 回歸前的基礎設施建設
2005	1.1	
1999	1.0	Post-handover infrastructure development 回歸後的基礎設施建設
2000	0.9	Post-handover infrastructure development 回歸後的基礎設施建設
1991	0.9	Early handover infrastructure development 回歸早期的基礎設施建設

Source: HKO

來源：香港天文台

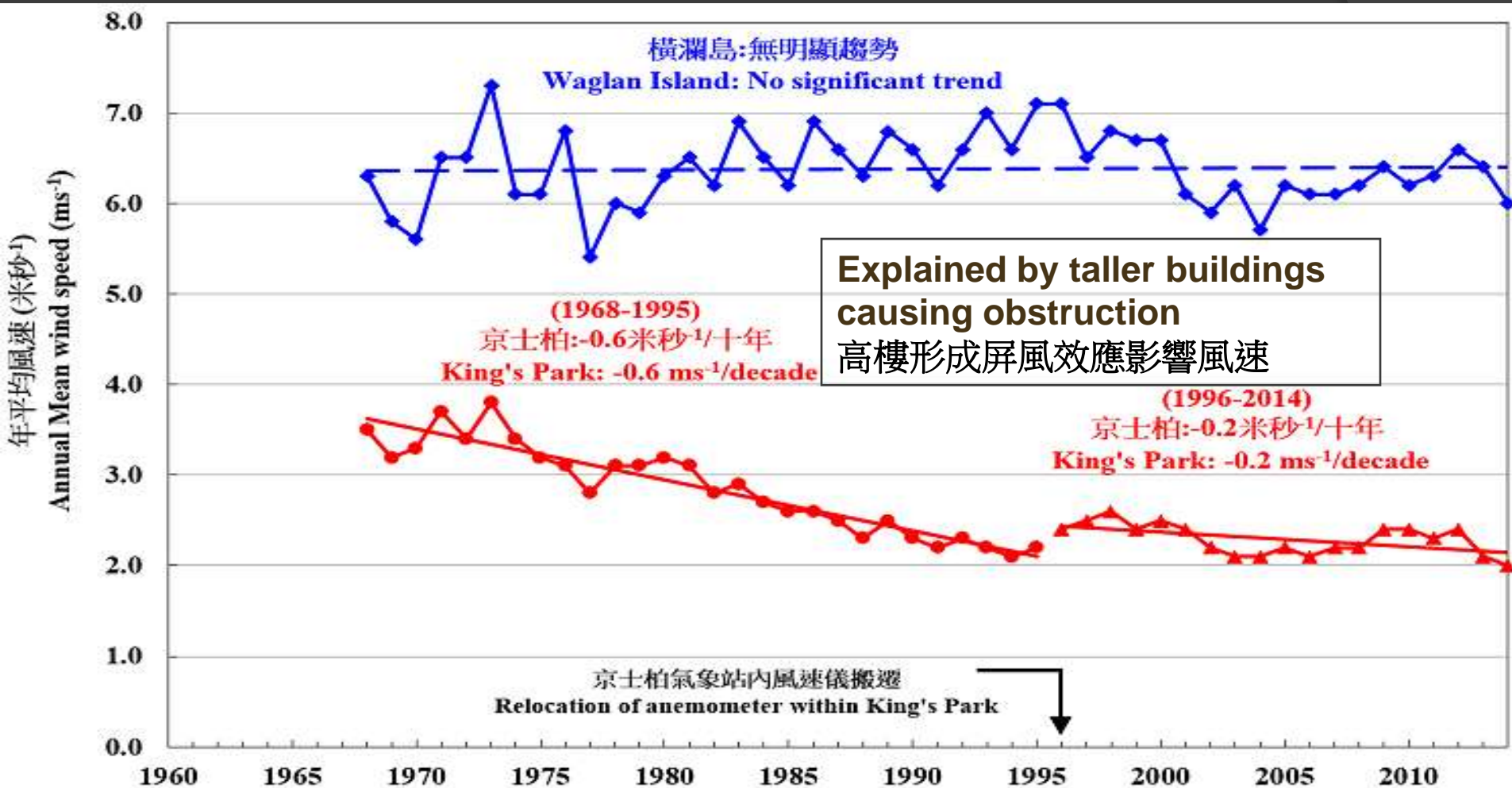
Annual mean cloud amount recorded at the Hong Kong Station

香港站記錄的年平均雲量 1961-2018



Source: HKO
來源：香港天文台

Wind speed changes at Waglan Island and King's Park 橫瀾島和京士柏的風速變化 1968-2014



Conclusions on temperature record 溫度記錄的總結

- **Unlike Macau Station, Hong Kong Station is severely affected by urban heat island** 有別於澳門站，香港站嚴重受城市熱島效應影響
- **Low annual mean temperatures in the early record of the HKO Station was caused by the 1883 Krakatau volcanic eruption** 香港站早期錄得的較低年平均溫度是由印尼喀拉喀托火山爆發所引致
- **Rural Pak Tam Chung Station shows a much higher number of cold winter days than HKO Station (better indicator of natural variability)** 北潭涌站顯示的冷天日數多於香港站(更好的自然變化指標)
- **Heat generation through infrastructure development in the 1990s was responsible for differences in annual mean temperatures between HKO Station and Waglan Island Station** 90年代香港站和橫瀾島站的年平均溫差主要因基建發展而產生的熱量
- **Hong Kong International Airport Station has overtaken the HKO Station as the hottest location because of airport heat** 機場運作產生的熱力令港國際機場站取代了香港天文台站成為最熱的探測站
- **Climatic models based on CO₂ warming failed to predict the 1998-2015 pause and 1966-1998 pause in temperature rise** 以二氧化碳為基礎的氣候模型未能解釋為何1998-2015和1966-1998年間的溫度停止上升
- **1998 and 2015 were strong El Niño years causing record high temperatures** 1998年和2015年的創紀錄的高溫，是因旺盛的厄爾尼諾現象年份

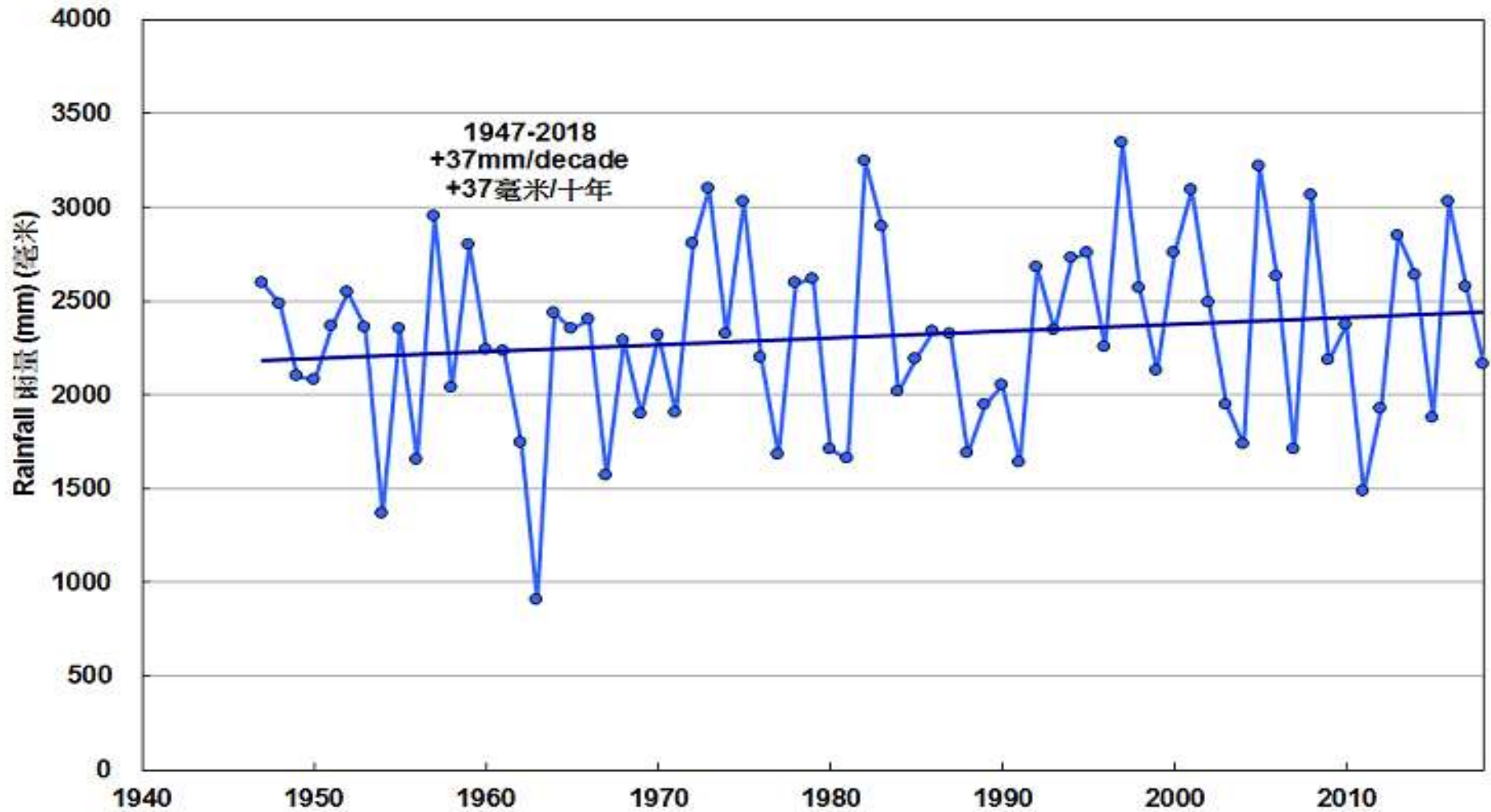
Hong Kong' s rainfall statistics

香港降雨記錄 1884-2018

Number of manned stations 人手監控探測站	2
Number of automatic weather stations 自動天氣探測站	49
Number of automatic rainfall stations 自動降雨探測站	15
Mean annual rainfall 年平均降雨	~2225 mm*
Driest year on record 紀錄以來最乾旱的年份	901.1 mm (1963)*
Wettest year on record 紀錄以來最潮濕的年份	3343 mm (1997)*

* Based on HKO Headquarter Station 跟據香港天文台站

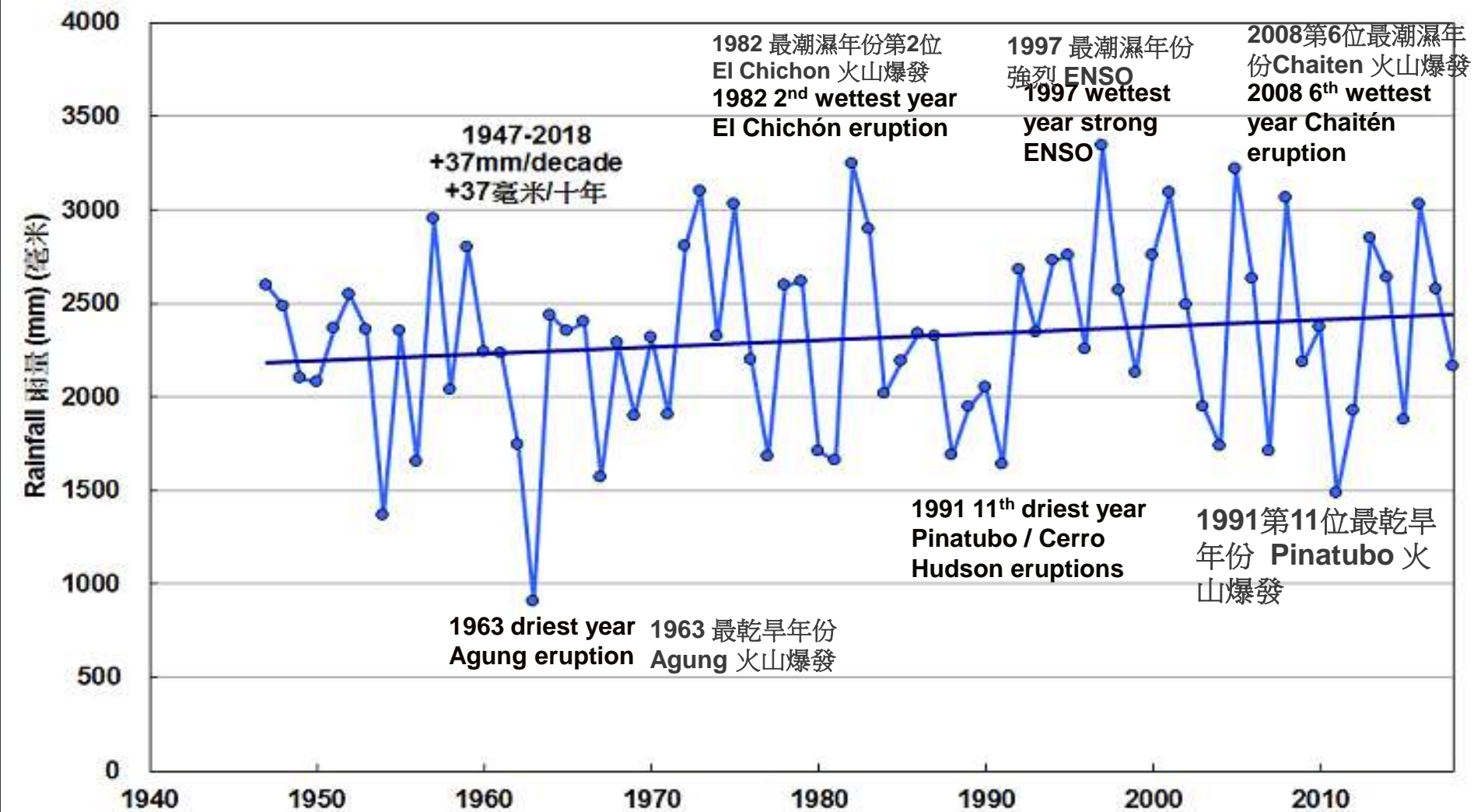
Annual mean rainfall at the Hong Kong Station 香港站年平均降雨 1947-2018



Source: HKO

來源：香港天文台

Identified cause of some abnormally wet and dry years in Hong Kong 1947-2018 引致香港異常乾燥和潮濕年份的因素



Source: HKO

來源：香港天文台

Derived from NOAA AVHRR
RGB = 0.65 μm , 0.9 μm , 11 μm

摘自美國國家海洋和大氣管理局進階極高解析度輻射儀

125

South
China Sea
南中國海

Luzon
呂宋

Pacific
Ocean
太平洋

15

皮納圖博火山的灰雲與
颱風 Yunya 混合 1991年
6月14日2329 UTC (6月
15日上午7:30) 皮納圖博
火山災難性爆發前約3小
時

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

1991 Pinatubo eruption VEI 6

A global drought year caused by the transfer of water vapour into the stratosphere 55 km above sea level

Global cooling 0.5°C

1991年皮納圖博火山噴發，VEI 6

由於水蒸氣被轉移至海平面55公里以上的平流層，引致是年全球乾旱，全球降溫0.5°C

May 2, 2008 Chaiten eruption, Chile
2/5/2008 智利 Chaiten 火山爆發 VEI = 4



**Pacific
Ocean**
太平洋

Argentina
亞根廷

**Atlantic
Ocean**
大西洋

美國國家航空航天局
中等分辨率航天成像光譜儀

Modis NASA

Impact on regional rainfall during 2008 following the eruption 智利 Chaiten 火山爆發後對2008年區域性降雨的影響

- **A wet May/June in South Africa** 南非潮濕的5、6月
- **A wet June in Australia including the continental interiors causing the flood of tourists to watch desert flowers blooming** 澳洲包括內陸地區潮濕的6月吸引了成千上萬的遊客前往沙漠賞花
- **Record winter rainfall in western Tasmania** 西塔斯曼尼亞錄得破紀錄的冬季降雨量
- **Wettest June in Hong Kong since record began in 1884 (1346.1 mm or 346.8% above average including an 1-1100 year rainstorm with record hourly rainfall of 145.5 mm triggering ~2400 landslides on Lantau Island)** 香港錄得自1884年有紀錄以來最潮濕的6月（較平均高1346.1毫米或346.8%，包括千年一遇的暴雨，降雨量達每小時145.5毫米，引致大嶼山發生~2400宗山泥傾瀉）

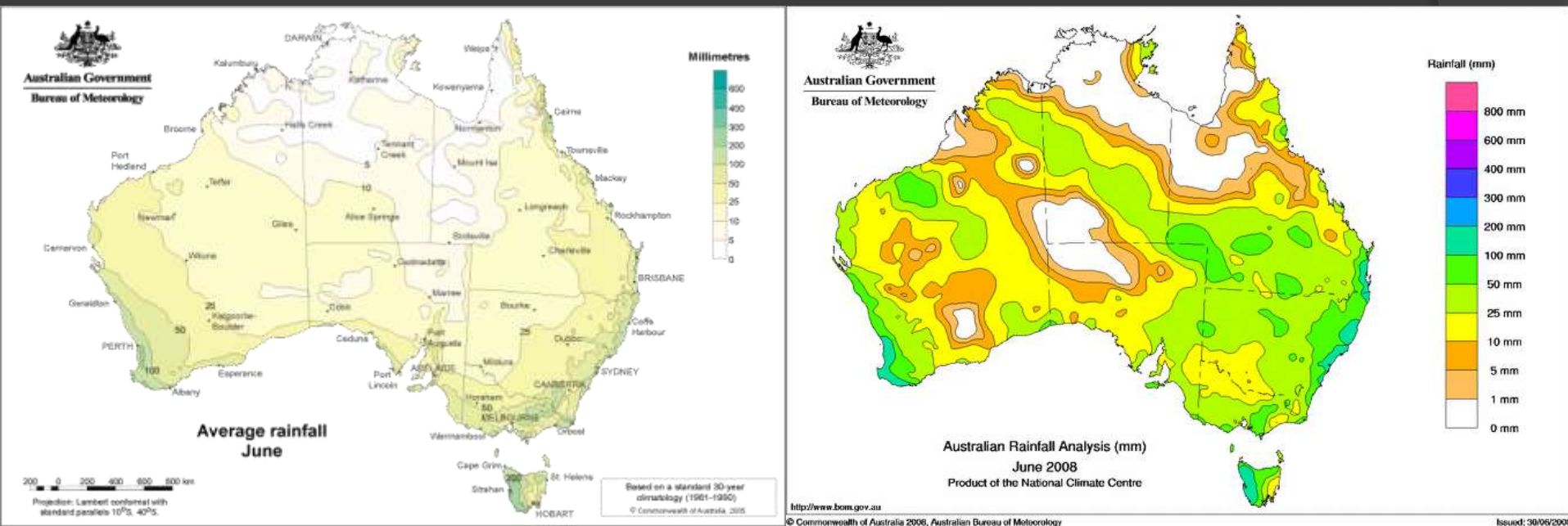


2008年6月6-8日最高4小時累計雨量分佈圖
Max. 4-hour rolling rainfall distribution in the rainstorm of 6-8 June 2008



Comparison between average June rainfall with June 2008 rainfall over Australia attributable to the May 2, 2008 Chaitén eruption in Chile

澳洲6月平均降雨量與因智利 Chaitén 火山於 2.5.2008 爆發引致當年6月降雨量的比較 (Zhang et al., 2016)



Flowers blooming in desert regions attracted tourists to the interior
沙漠開花吸引了成千上萬的遊客前往內陸地區賞花

Supporting evidence 支持論據

- **Eruption during the southern hemisphere autumn was favourable for aerosol transportation across the ITCZ second time around the globe**
爆發時間正值南半球秋季，天氣有利懸浮微粒穿越赤道低壓帶(或稱間熱帶輻合帶)第二次環繞地球
- **Eruption cloud height reached an altitude of over 21 km penetrating the stratosphere** 噴發雲高達21公里， 穿透平流層
- **CALIOP tracking of aerosols detectable over Southeastern Australia causing international flight cancellations** 雲 - 懸浮微粒偏震激光雷達在澳洲東南上空探測到懸浮微粒， 導致國際航班紛紛取消
- **Volcanic debris impacted Hong Kong under southwest monsoon condition**
火山碎片在西南季風帶動下影響香港
- **E-folding time of 35 days found for SO₂ conversion into sulphate from the study of the 1991 Pinatubo eruption was near perfect for the June 7, 2008 rainstorm** 從1991年皮納圖博火山噴發研究中發現的二氧化硫(SO₂)轉化為硫酸鹽的35天指數遞減時間近乎完美地解釋了香港2008年6月7日的暴雨

Conclusions on rainfall record 降雨記錄的總結

-Volcanic eruptions was the cause of both abnormally wet and dry years in Hong Kong because of circulation changes (predominantly offshore wind caused drought years and predominantly onshore wind caused record rainy years)

火山噴發導致循環變化是香港異常潮濕和乾燥年份的原因 (主要是離岸風和岸上風分別造成乾旱年和創紀錄的大兩年)

-The 1991 eruption cloud of Pinatubo with a maximum altitude of 55 km was responsible for a global drought year because of the large volume water vapour transferred into the stratosphere 1991年皮納圖博火山噴發高達55公里，把大量水蒸氣運送到平流層，導致全球全年乾旱

-The 2008 eruption cloud of Chaitén with an altitude of over 21 km was tracked by satellite to cause heavy rainfall in South Africa, Australia and after 35 days, the worse rainstorm in Hong Kong's history triggering ~2400 landslides on Lantau Island

衛星探測到2008年Chaitén火山噴發雲高達 21公里以上，引致南非和澳洲連場豪雨。並於35天後，觸發香港史上最厲害的暴雨，令大嶼山發生~2400宗的山泥傾瀉

-Heavy rainfall in Western Tasmania through the influence of Chaitén debris helped the Hydroelectric Commission of Tasmania to make record profits in 2008-2009

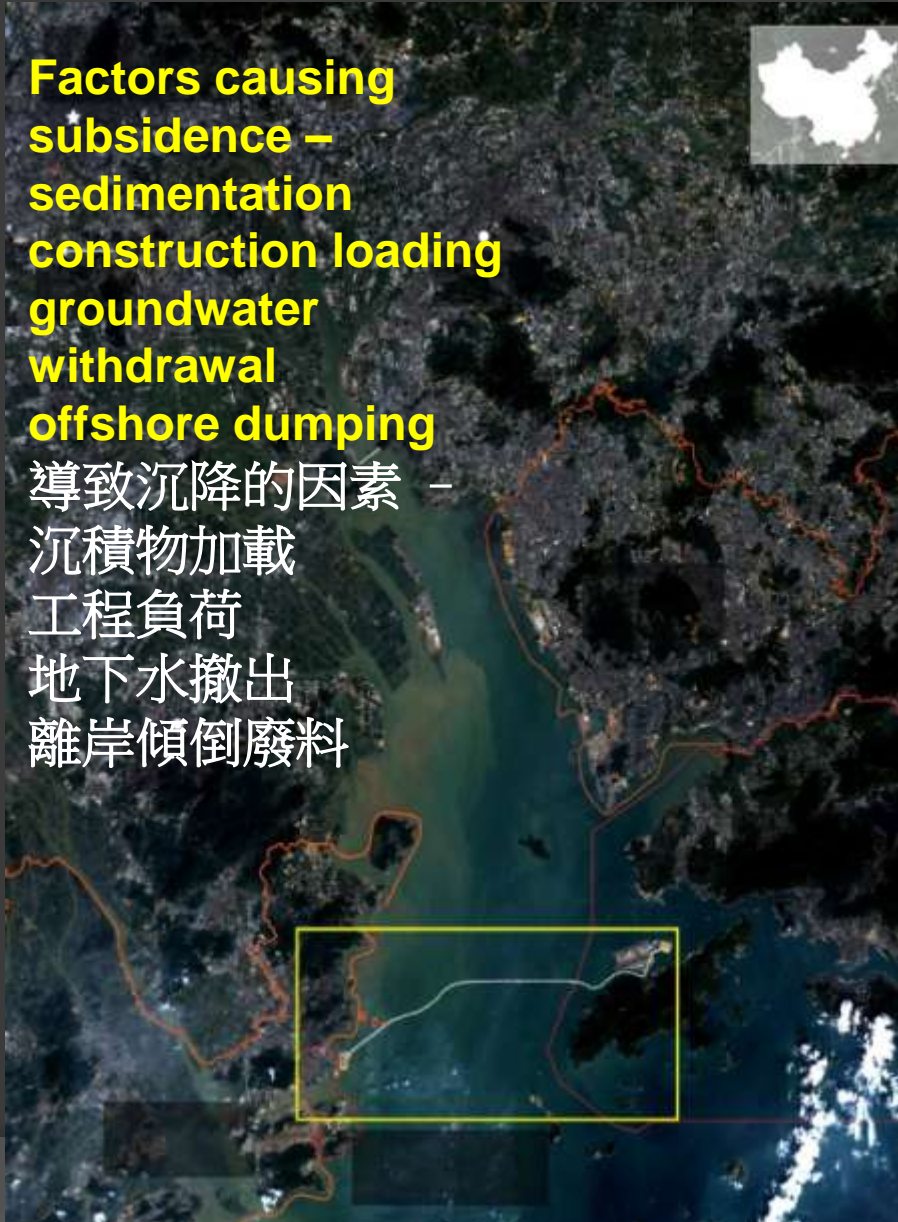
由於 Chaitén 火山碎片的影響，西塔斯曼尼亞迎來暴雨，令塔斯曼尼亞水電委員會在 2008-2009 錄得創紀錄的利潤

Satellite photo of Hong Kong and the Pearl River Estuary

香港及珠江口衛星圖

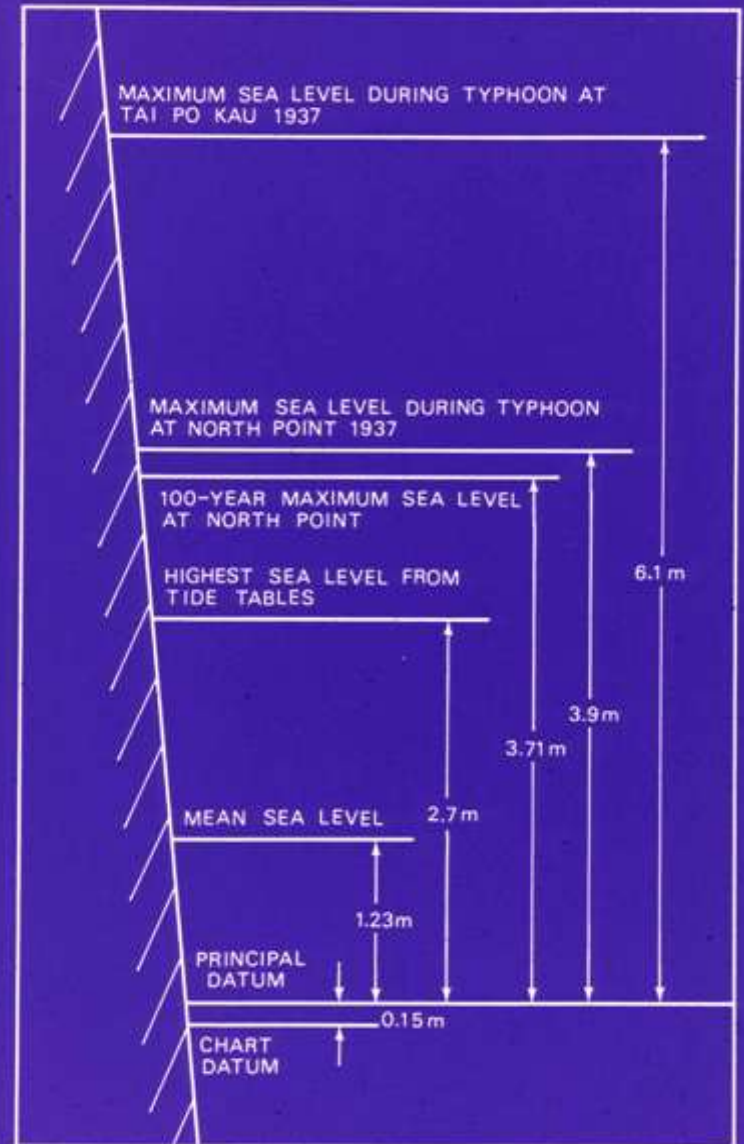
**Factors causing subsidence –
sedimentation
construction loading
groundwater withdrawal
offshore dumping**

導致沉降的因素 –
沉積物加載
工程負荷
地下水撤出
離岸傾倒廢料



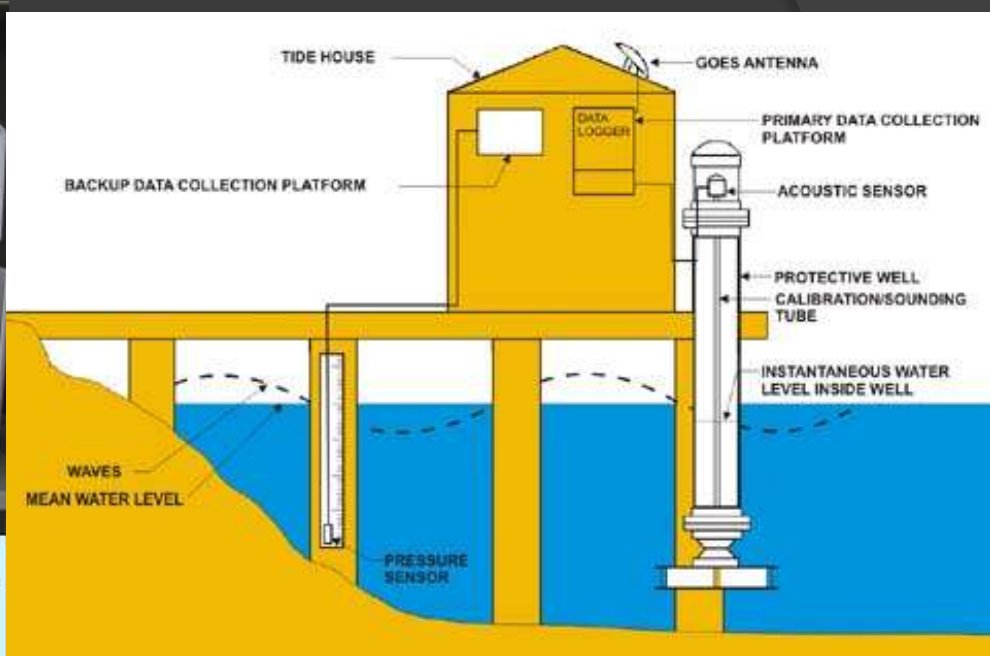
Sea-level datums in Hong Kong

海平面基準



Mechanical float tide gauge sea-level record in Victoria Harbour since 1954

自1954年以機械浮標潮汐測量儀探測的維多利亞港海平面記錄



NOAA

美國國家海洋暨大氣總署

Source: HKO

來源：香港天文台

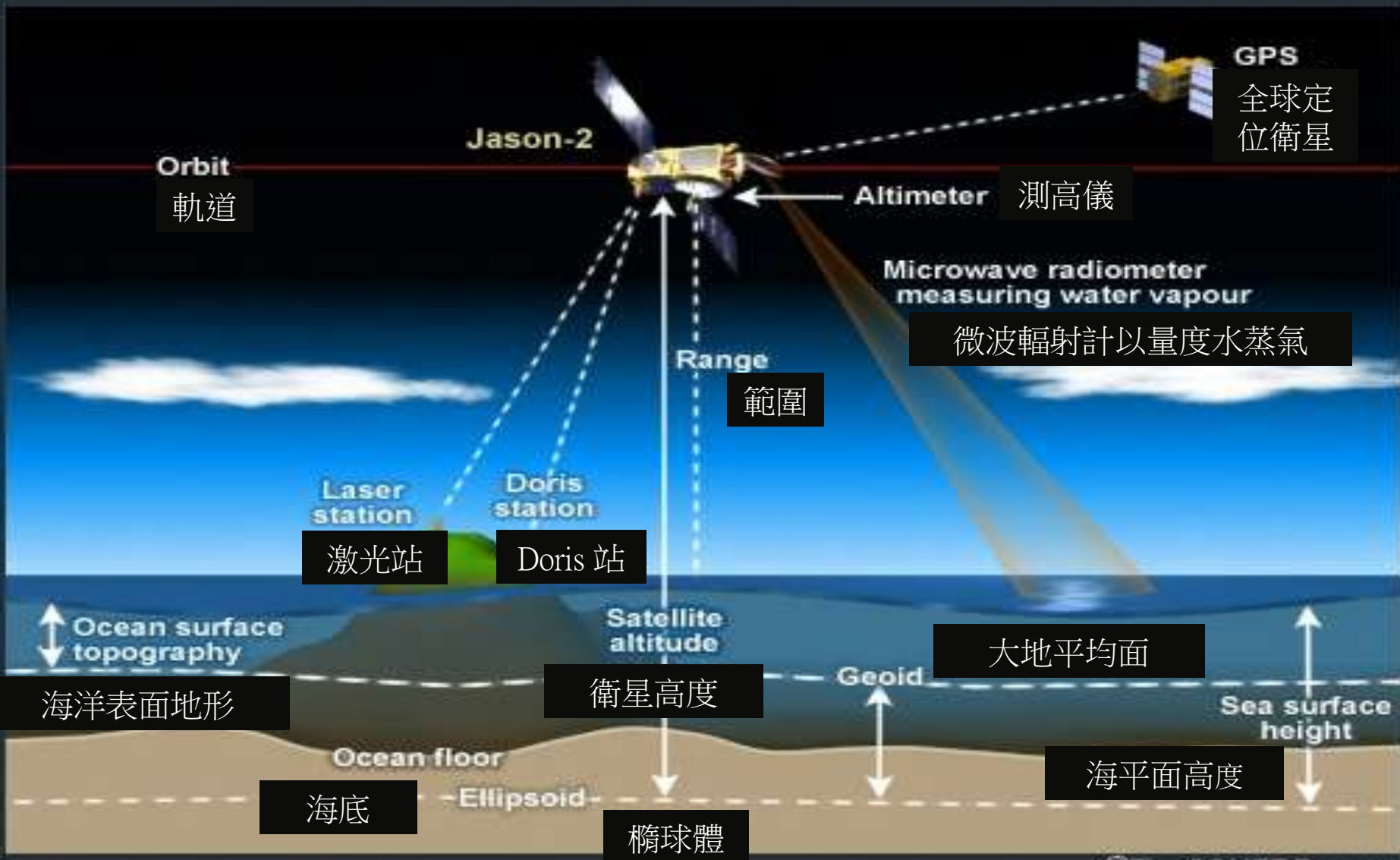
Tide gauges of the Hong Kong Observatory

香港天文台潮汐測量站



Satellite altimetry record of sea level since 1993

自1993年採用衛星高度測量海平面



Rates of sea-level change in Hong Kong and the South China Sea based on various studies

根據不同研究的香港和南中國海海平面變化速度

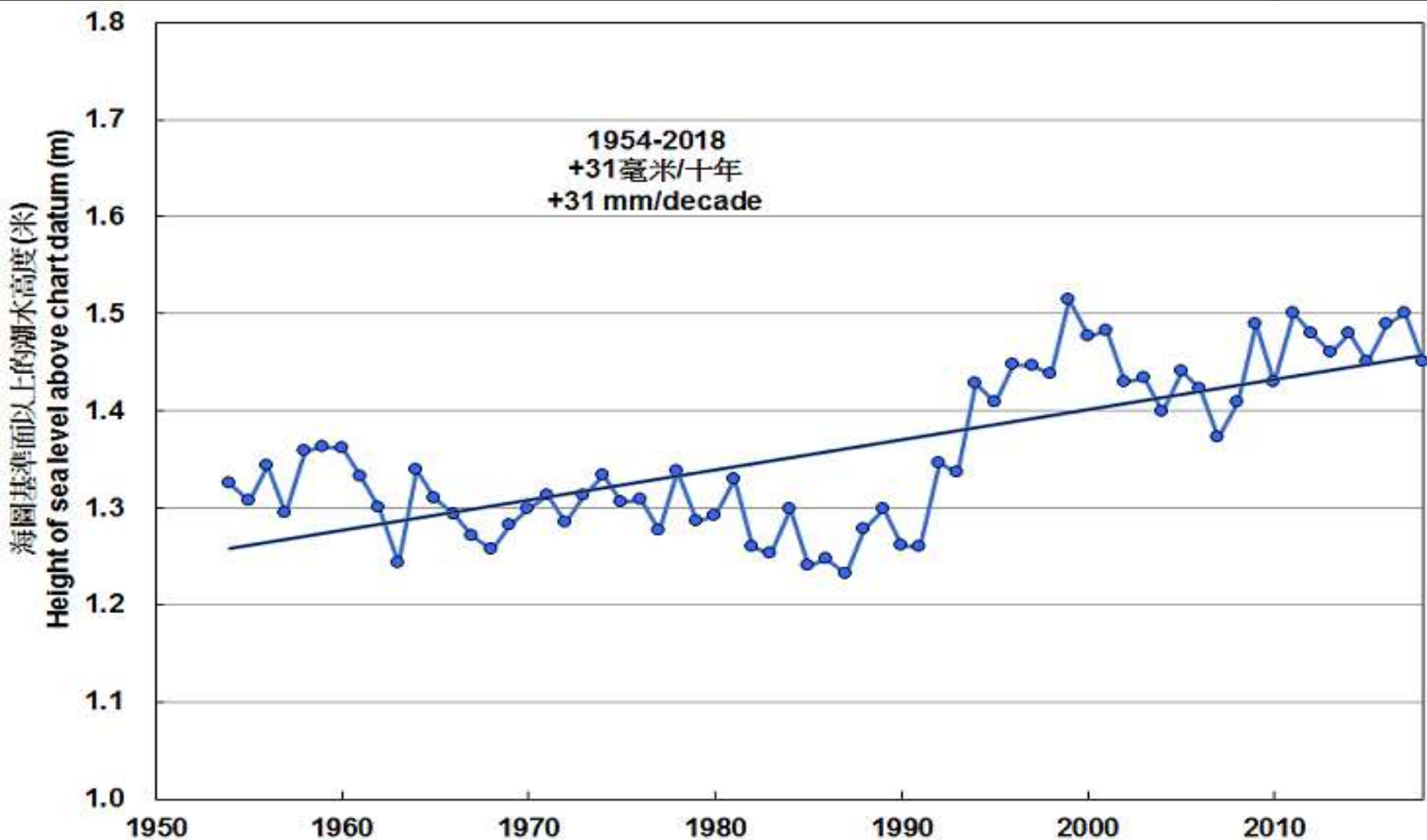
Source 來源	Area studied 研究範圍	Years examined 考據年份	Data analysed 數據分析	Rate of change 變速
Wong et al. (2003)	Victoria Harbour 維多利亞港	1954-1987	Tide gauge data 潮汐測量儀數據	Fall of 2 mm/yr 每年下降2毫米
Wong et al. (2003)	Victoria Harbour 維多利亞港	1987-1999	Tide gauge data 潮汐測量儀數據	Rise of 22.1 mm/yr 每年上升22.1毫米
Wong et al. (2003)	Victoria Harbour 維多利亞港	1999-2003	Tide gauge data 潮汐測量儀數據	Fall of 21 mm/yr 每年下降21毫米
Wong et al. (2003)	Victoria Harbour 維多利亞港	1954-2003	Tide gauge data 潮汐測量儀數據	Rise of 2.3 mm/yr+ 每年上升2.3毫米
Cheng and Qi (2007)	South China Sea 南中國海	1993-2000	Merged altimetry 綜合測高法	Rise of 11.3 mm/yr 每年上升11.3毫米
Cheng and Qi (2007)	South China Sea 南中國海	2001-2005	Merged altimetry 綜合測高法	Fall of 11.8 mm/yr 每年下降11.8毫米

+ The rate of change found is similar to Ding et al. (2002) studied 1954-1999 data

得出的變速與 Ding et al. (2002) 研究 1954-1999年數據相近

Annual mean sea level in Victoria Harbour

維多利亞港年平均海平面 1954-2018



Tide gauges in Victoria Harbour

- both sited on coastal land reclamations

位於維多利亞港的 潮汐測量儀數據 - 兩者皆位於沿岸的填海區



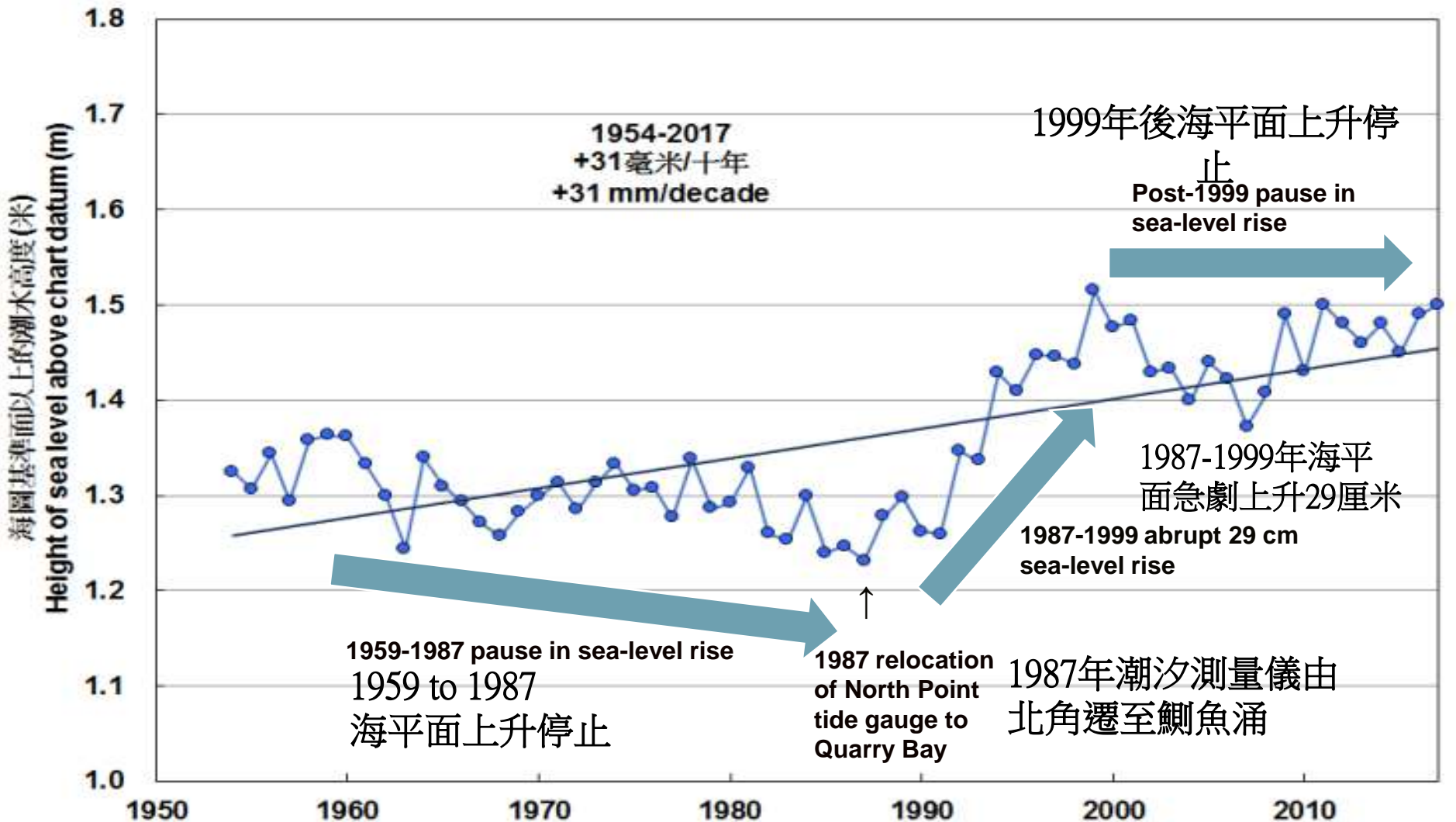
North Point 北角
1954 – 1986



Quarry Bay 鰂魚涌
1987 – present 至今

Victoria Harbour sea-level trend

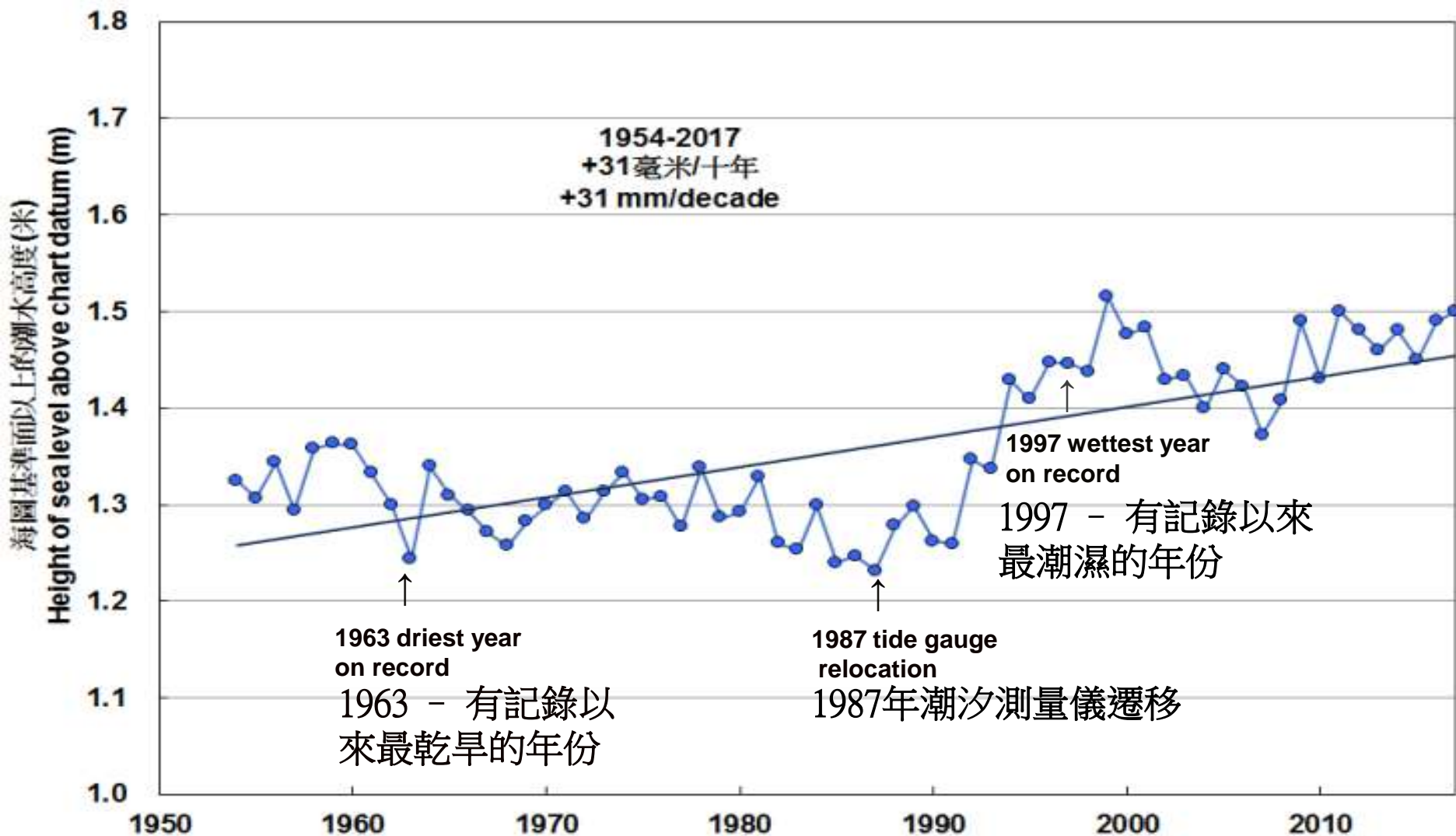
維多利亞港年平均海平面趨勢



Source: HKO

來源：香港天文台

Influence of the river discharge on sea levels during dry and wet years 河流排放對乾燥和潮濕年份的影響



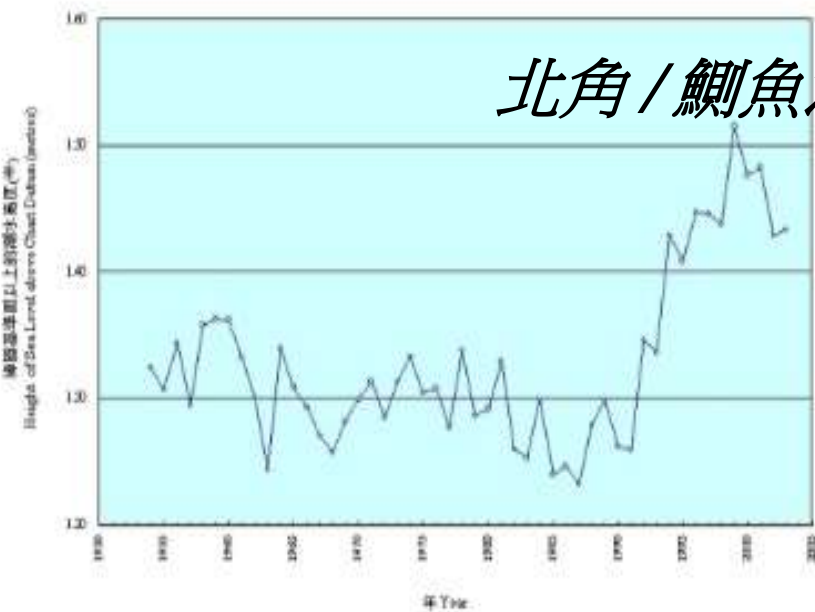
Source: HKO

來源：香港天文台

Comparison between records in Victoria Harbour and Tai Po Kau 1963-2003

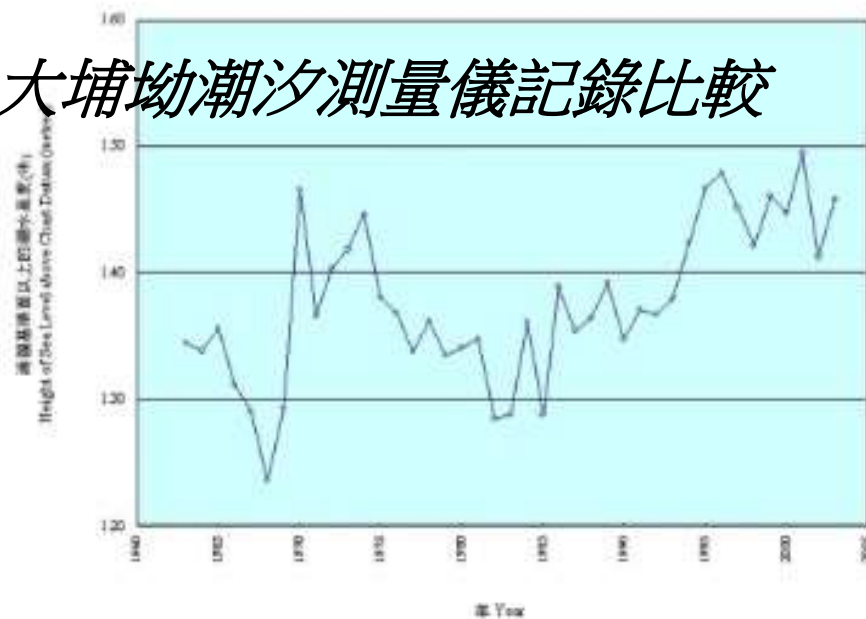
維多利亞港和大埔坳站記錄比較

北角/鯽魚涌年平均海平面 (1954-2003)
Annual Mean Sea Level at North Point/Quarry Bay (1954-2003)



北角/鯽魚涌 和 大埔坳潮汐測量儀記錄比較

大埔坳年平均海平面 (1963-2003)
Annual Mean Sea Level at Tai Po Kau (1963-2003)



Abrupt rise of 29 cm from 1987-1999
1987-1999 急速上升29厘米

Rise of 12 cm from 1987-1999
1987-1999 上升12厘米

~17cm difference may be attributed to ground settlement of the Quarry Bay tide gauge
~17厘米的差別可能因鯽魚涌潮汐測量站地面沉降所引致

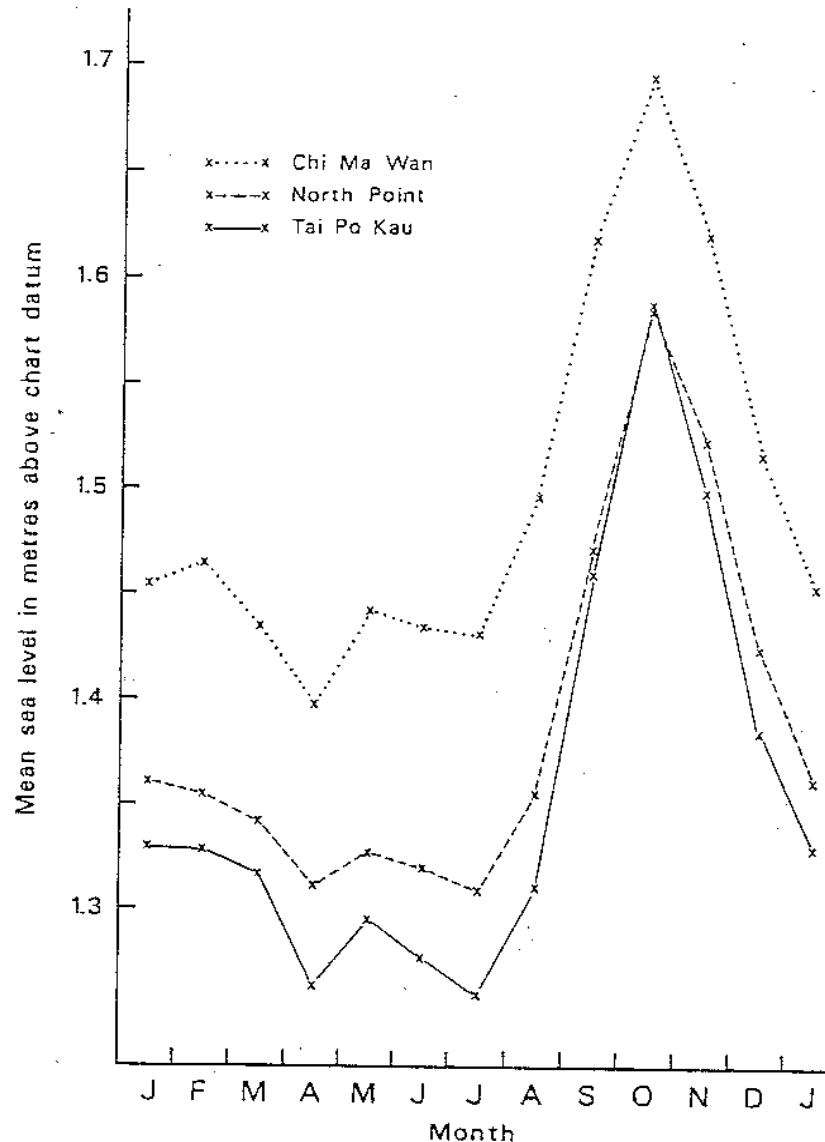
Comparison of 15-year monthly sea level during 1970-84 at the North Point, Tai Po Kau and Chi Ma Wan tide gauge stations 北角、大埔坳和芝麻灣潮汐測量站15年每月海平面比較 (Yim 1993)

Difference explained
by coastal
configuration
沿岸格局可以解釋差別

- Tai Po Kau highest
大埔坳最高

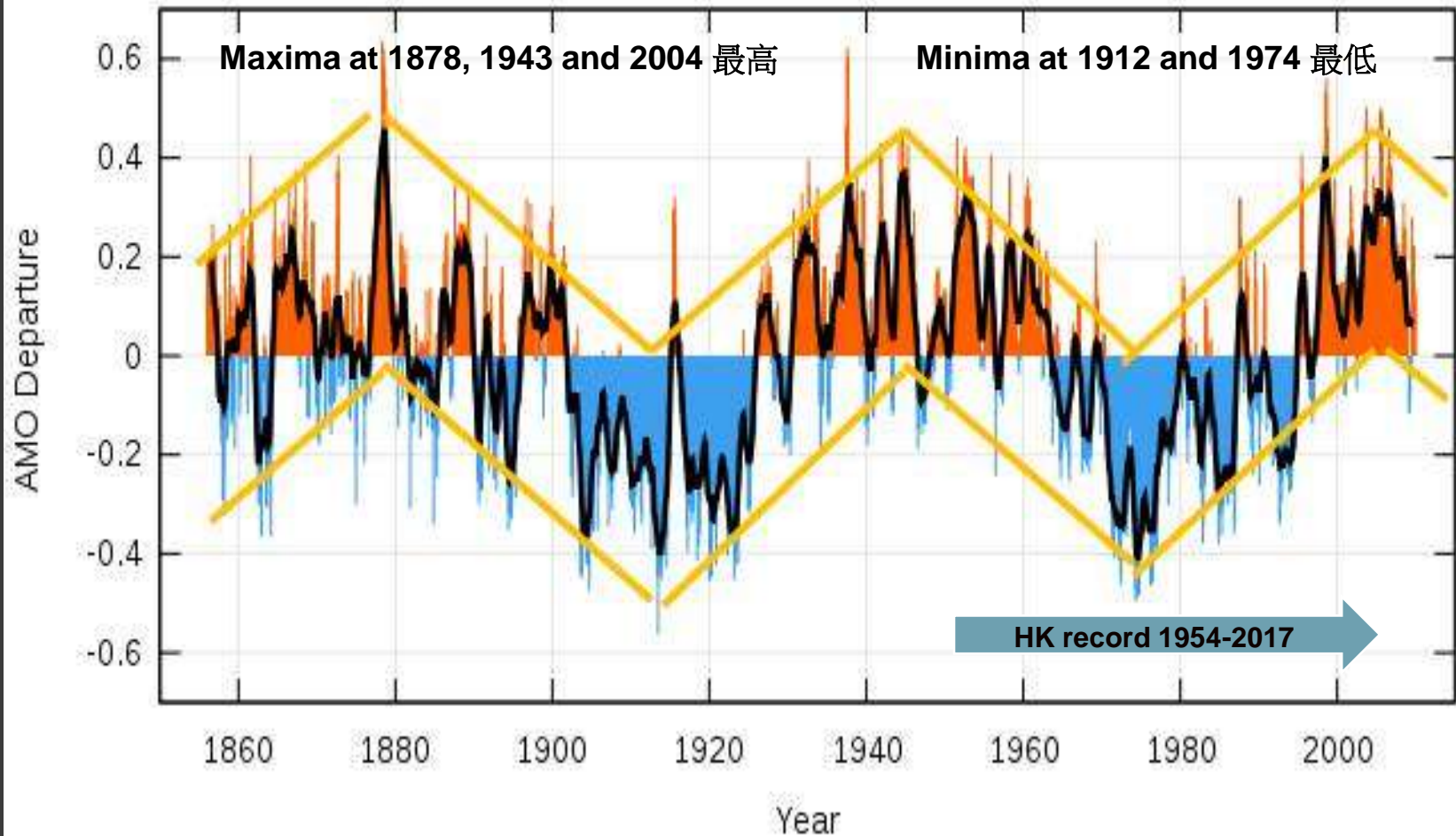
- Chi Ma Wan
intermediate
芝麻灣適中

- North Point lowest
北角最低



Atlantic Multidecadal Oscillation anomalies 1850-2009 with 62-year cycles

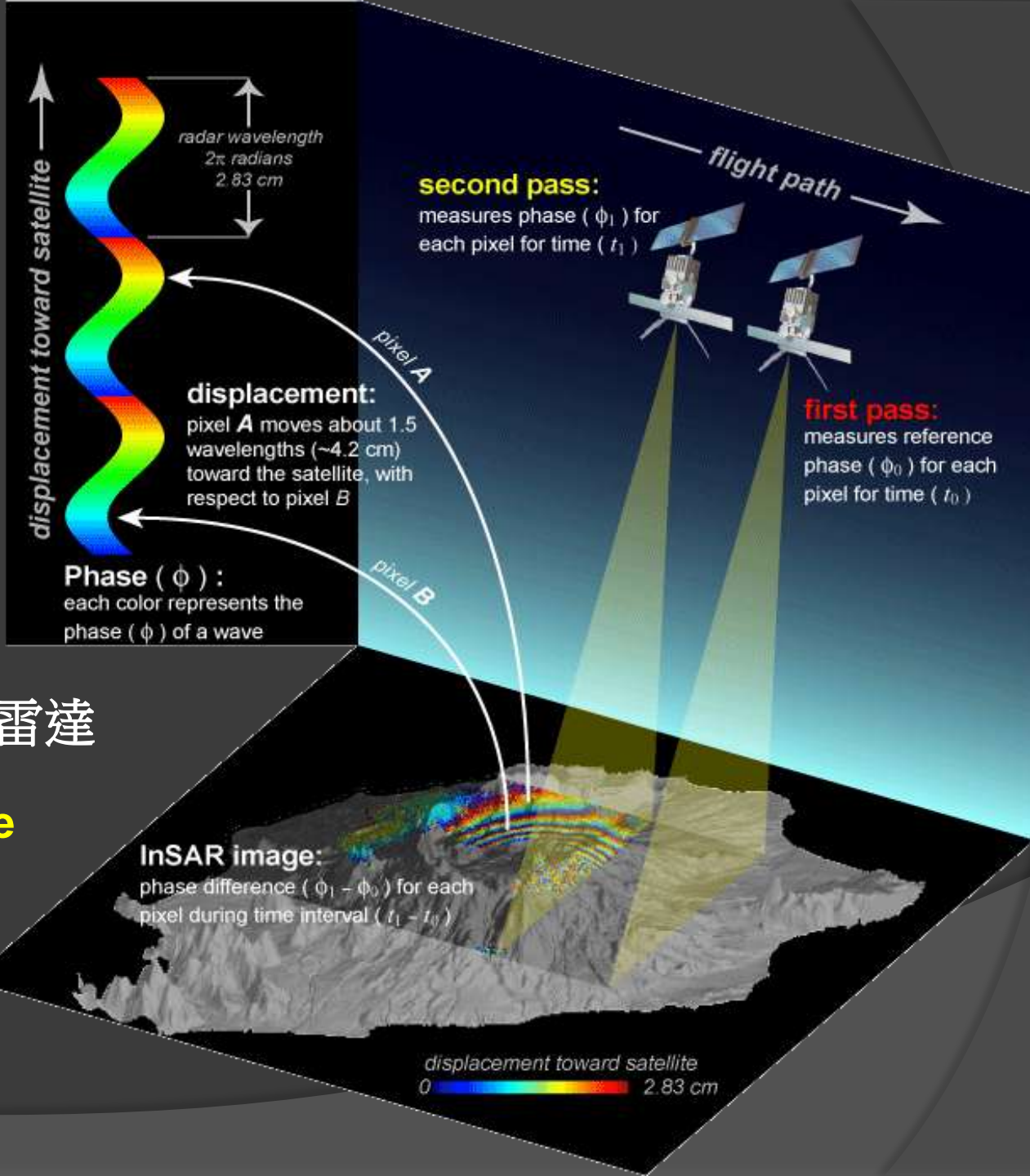
1850-2009 大西洋多年異常振盪，以62年為一周期
(Knudsen et al. 2011)



Detection of ground movement / crustal Stability

用於探測
地面活動 /
地殼穩定度

干涉儀合成光圈雷達 Interferometric Synthetic Aperture Radar - *INSAR*



Conclusions on sea-level record

海平面記錄總結

-Both tide gauge and satellite remote sensing records are too short at present to be conclusive

目前潮汐測量儀和衛星遙控的記錄太短，不足以下定論

- Tide gauges must be located on bedrock to eliminate noise caused by ground settlement

潮汐測量儀必須建於基岩上，以消除由於地面沉降而產生的假象

- The annual mean rate of sea-level rise of 31 mm/decade obtained by the HKO in Victoria Harbour is an anomaly in the Pacific region

香港天文台在維多利亞港獲得的海平面平均上升速度為每十年31毫米，這與太平洋地區現象不脛合

- **At least 60% of the 29 cm sea-level rise observed during 1987-1999 at the Quarry Bay tide gauge may be attributed to ground settlement**

鯪魚涌潮汐測量站在1987-1999年期間錄得的29厘米海平面上升，估計60%是因地面沉降引致

- **Short-term noise in sea-level change include river discharges and the Pacific Decadal Oscillation**

海平面變化的短期因素包括河流排放和太平洋十年振盪

- **Storm surge flooding generated by typhoons is our main problem**

颱風造成的泛濫才是我們最迫切面對的問題

HEAT WAVE

熱浪
2014-2016

A giant patch of warm water known as the blob shocks the Pacific, in what some fear is a preview of our future oceans.

一大片名為暖水團的溫水震撼了太平洋，令部分人擔心是我們未來海洋的先兆

National Geographic
September 2016

國家地理雜誌 2016年9月版

Dying eel and prawn mortality

垂死的鰻魚和死去的蝦



Mass mortality of red crabs

紅蟹大量死亡



Mass mortality of sea otters

海獺大量死亡

Nishinoshima submarine/terrestrial eruption 940 km south of Tokyo

西之島海底 / 陸地火山爆發 - 東京以南940公里
3.2013 – 8.2015



**Image on November 13, 2013:
Japan Coast Guard Submarine
eruption began in March**

13.11.2013 影像：日本海岸防衛
隊海底火山爆發始於 3.2013



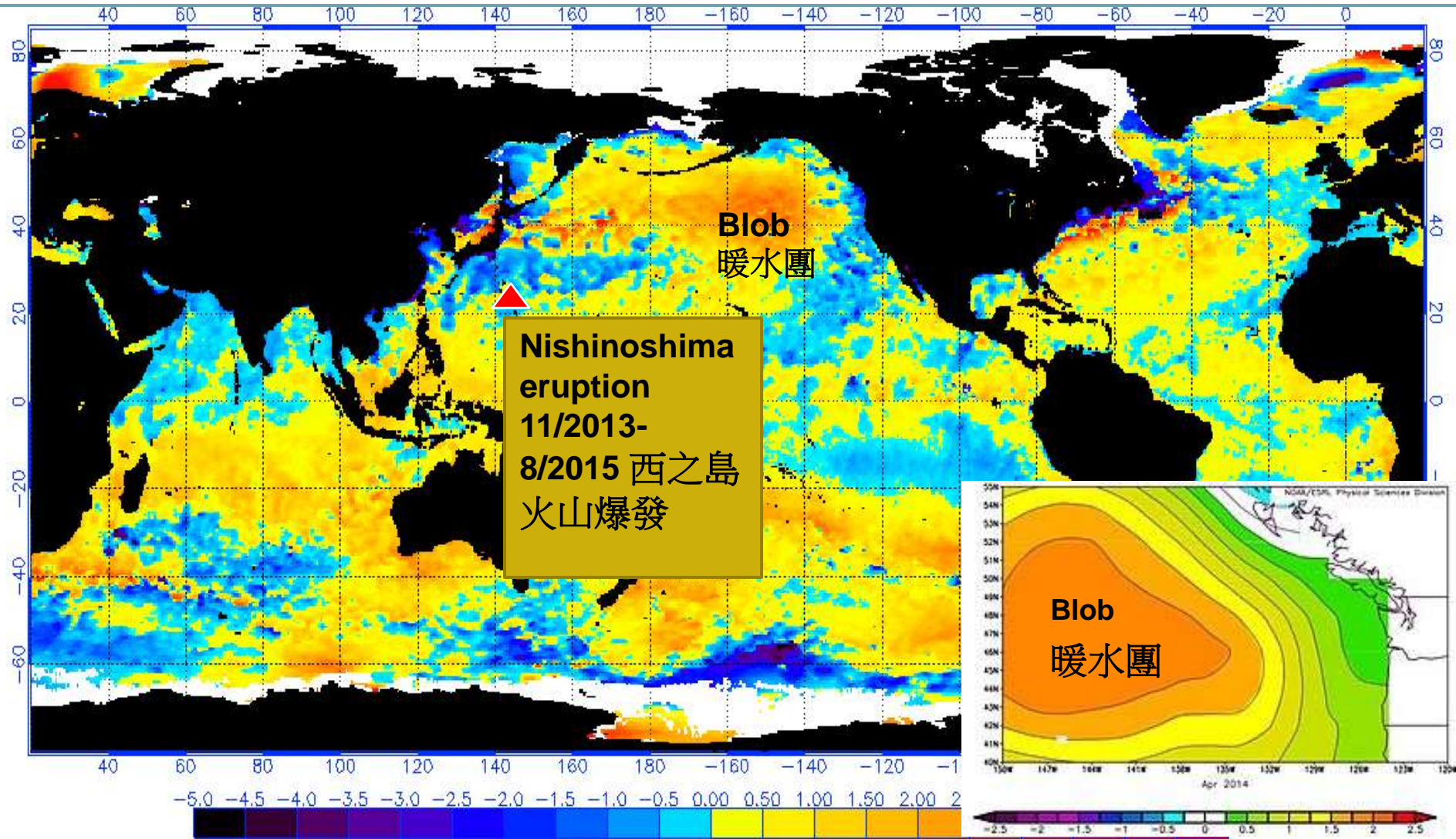
**Image on December
8, 2013: NASA**

8.12.2013 影像：美國太空總署

Sea-surface temperature anomalies caused by the North Pacific Blob

北太平洋暖水團引致海面溫度異常 2.1.2014

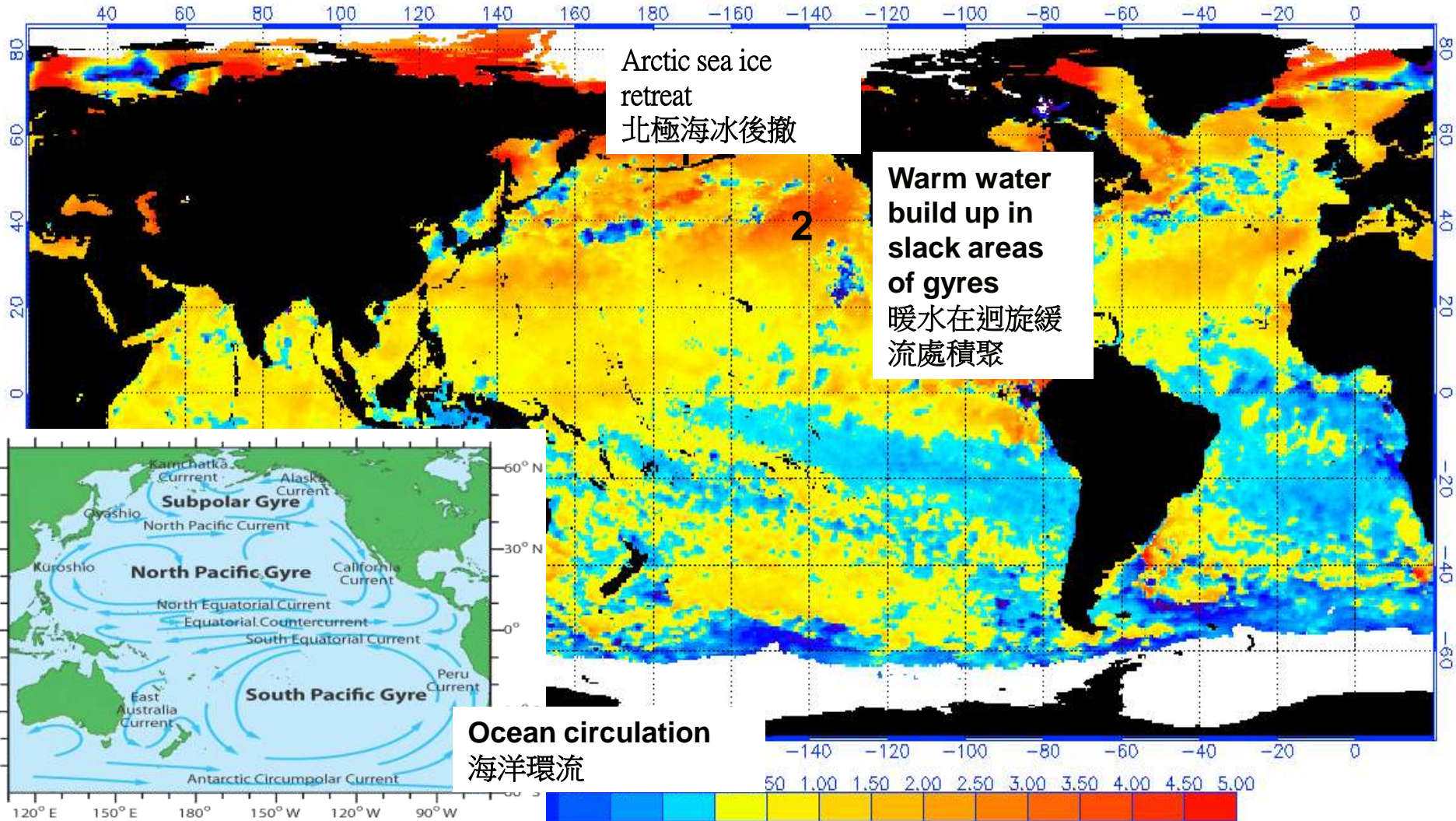
美國國家海洋和大氣管理局 / 國家環境衛星、數據和訊息服務 50公里全球分析：海面溫度異常 (°C)，2/1/2014 (白色部份為海冰)



The Blob separated into three parts

暖水團分為三部份 1.9.2014

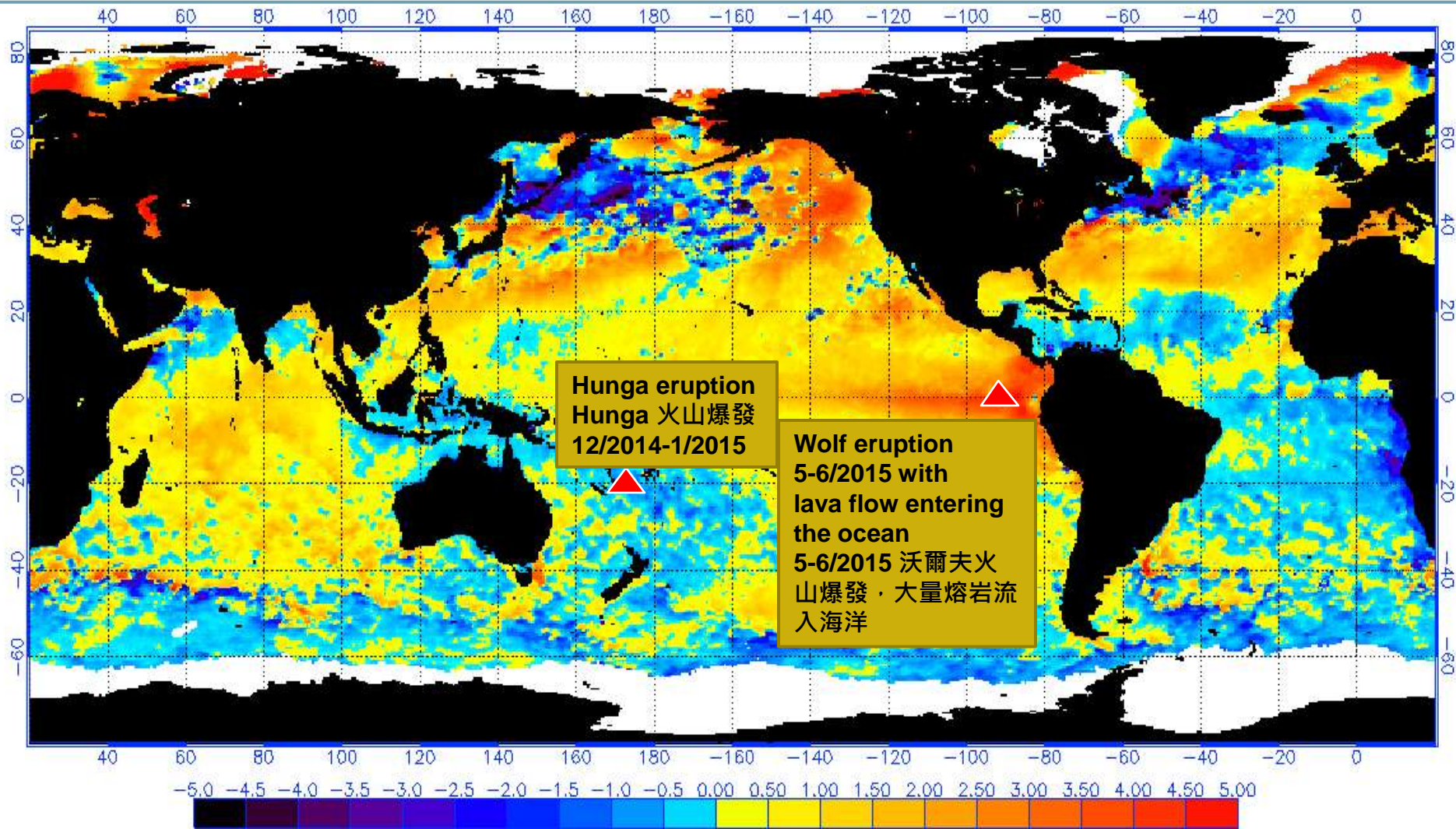
美國國家海洋和大氣管理局 / 國家環境衛星、數據和訊息服務 50公里全球分析：海面溫度異常 (°C)，1/9/2014 (白色部份為海冰)



Sea-surface temperature anomalies on after the Wolf eruption ended

沃爾夫火山爆發後海平面溫度異常 29.06.2015

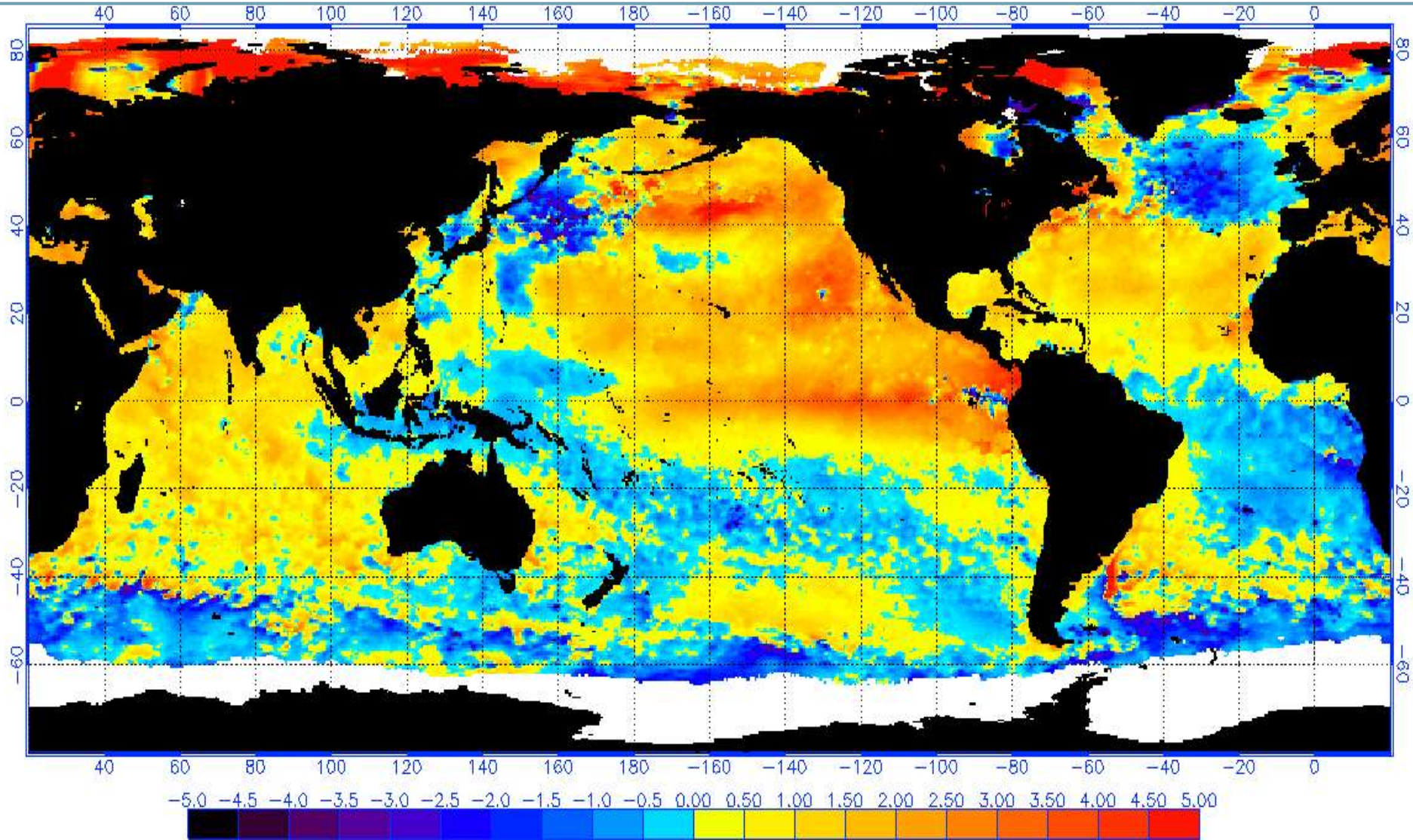
美國國家海洋和大氣管理局 / 國家環境衛星、數據和訊息服務 50公里全球分析：
海面溫度異常 (°C)，29/6/2015 (白色部份為海冰)



Establishment of the strong and long-lasting 2014-2016 El Niño

強勁而持久的 2014-2016 厄爾尼諾現象形成

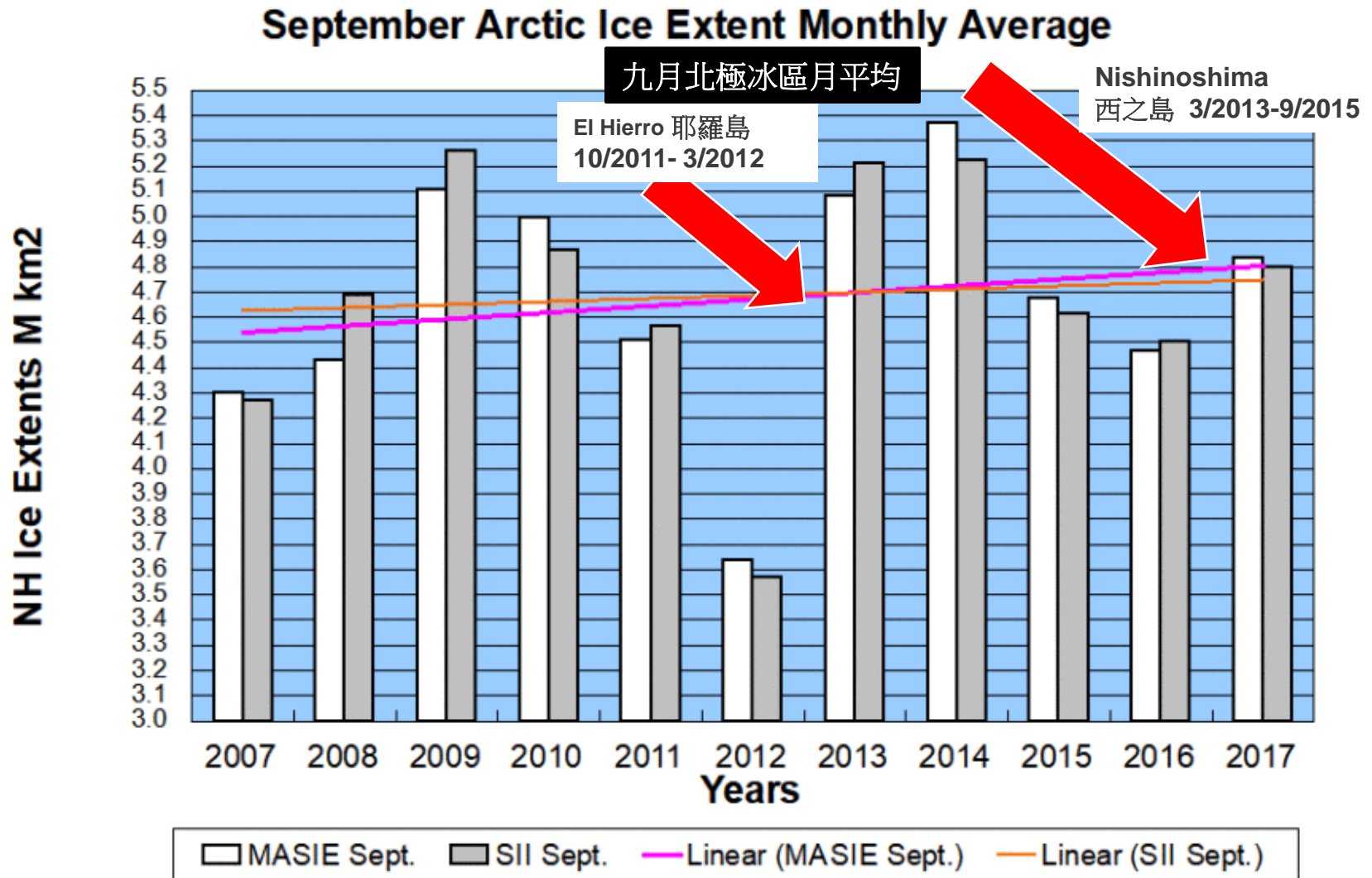
美國國家海洋和大氣管理局 / 國家環境衛星、數據和訊息服務 50公里全球分析：海面溫度異常 (°C)，31/8/2015 (白色部份為海冰)



Arctic sea ice changes 2007-2017 北極海冰改變

Explained by the release of geothermal heat through submarine volcanism

海底火山爆發釋放地熱解釋北極海冰減少的原因



Why CO₂ reduction is ineffective

為何減少二氧化碳(CO₂)是無效?

- **CO₂ is a life-giving gas in plant photosynthesis**
CO₂在光合作用是一種賜予生命的氣體
- **Heat generation through human activities is the problem**
因人類活動而產生的熱力才是問題癥結
- **CO₂ lags temperature rise by ~800 years in Antarctica ice cores**
南極冰芯記錄顯示 CO₂上升較溫度上升慢約800年
- **Clouds and water vapour distribution are more important than CO₂ in temperature changes**
雲和水蒸氣的分佈較 CO₂更影響溫度變化
-

- **Climate models cannot explain the two recent pauses in HK temperature rise and the poor correlation between CO₂ and past temperature records**

氣候模型不能解釋香港溫度上升過程中的兩次停頓，及 CO₂ 與過去溫度記錄之間的低相關性

- **Subaerial and submarine volcanic eruptions are underestimated natural causes of cooling and warming**

陸地和海底火山爆發這些自然因素對變暖和變冷的影響被低估

- **~55-70 year climatic cycles may be responsible**

~55-70 年的氣候周期可能是造成氣候變化的原因

- **ENSO years in existence long before the industrial revolution was responsible for warming during 2014-2016**

厄爾尼諾現象在工業革命前經已存在，並且是 2014-2016 年暖化的主因

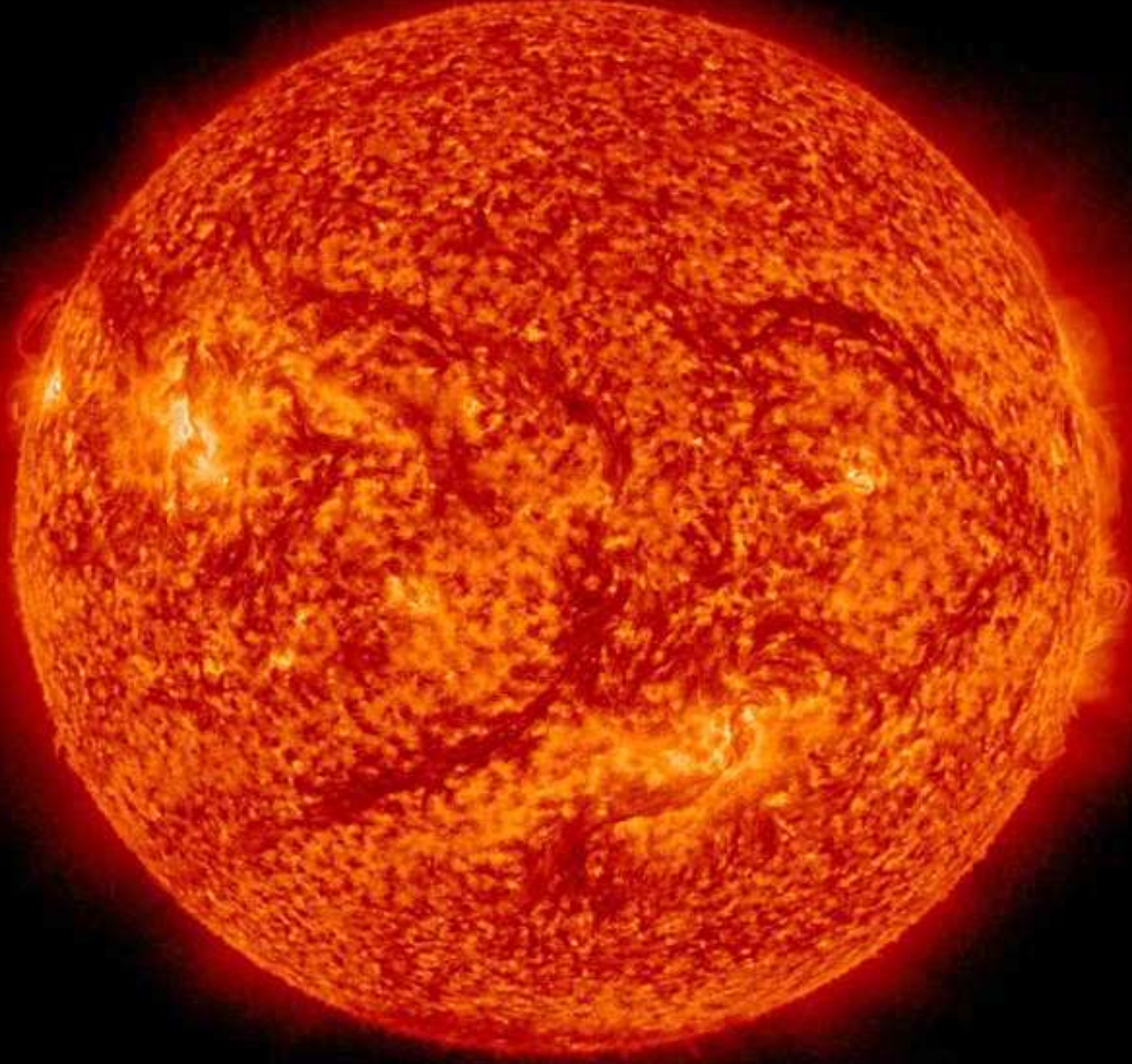
Main conclusions 主要結論

- **Heat generation through human activities is directly responsible for temperature rise. Important causes identified includes hydro-environment changes, urbanization, transportation heat and the construction of major infrastructures during the 1990s.**
人類活動所產生的熱力直接影響溫度上升，已識別的因素包括：水環境轉變，城市化，運輸產生的熱力和1990年代主要基礎設施的建設
- **The worst rainstorm in Hong Kong's history on June 7, 2008 was influenced by debris from a Chilean volcanic eruption 35 days earlier.**
在2008年6月7日香港有史以來最嚴峻的暴雨是受到 35天前智利火山噴發的碎片所影響
- **Sea level is not rising rapidly but another fifty year of measurement is needed to be certain.**
海平面並非快速上升，但肯定需要多50年的測量

- **There are good scientific reasons to challenge the decision made by the United Nations and governments for unnecessary spending on reducing CO₂ emissions.**
有充份科學理據質疑聯合國和各國政府為減低二氧化碳排放量作出不必要支出的決定
- **The role of volcanic eruptions in climate change (both cooling and warming) is underestimated ... our dynamic Earth.**
火山爆發在氣候變化中的作用（變冷和變暖）被大大低估...
我們的地球是充滿動力的

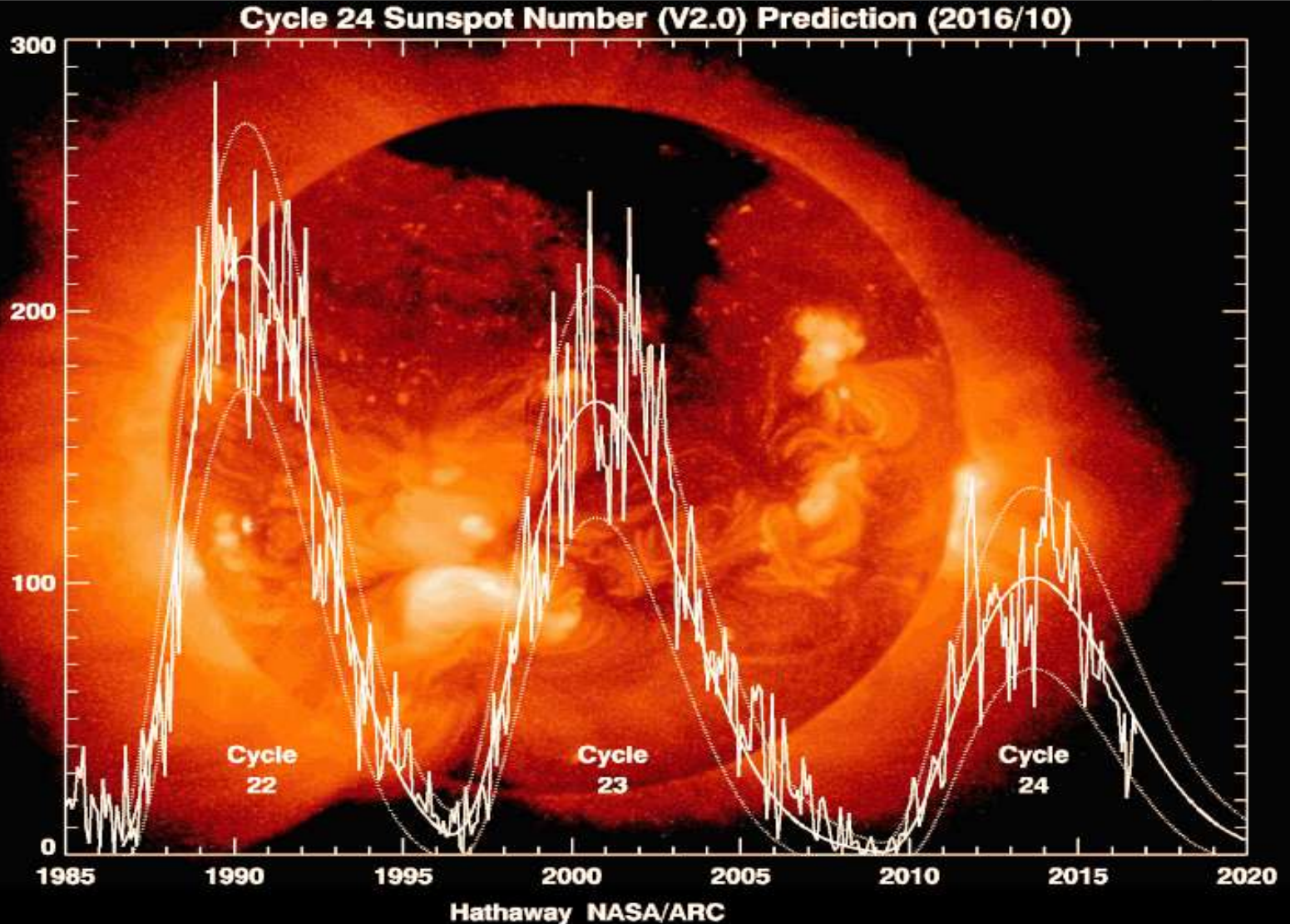
Image of the sun on July 14, 2015

14.7.2015 太陽影像

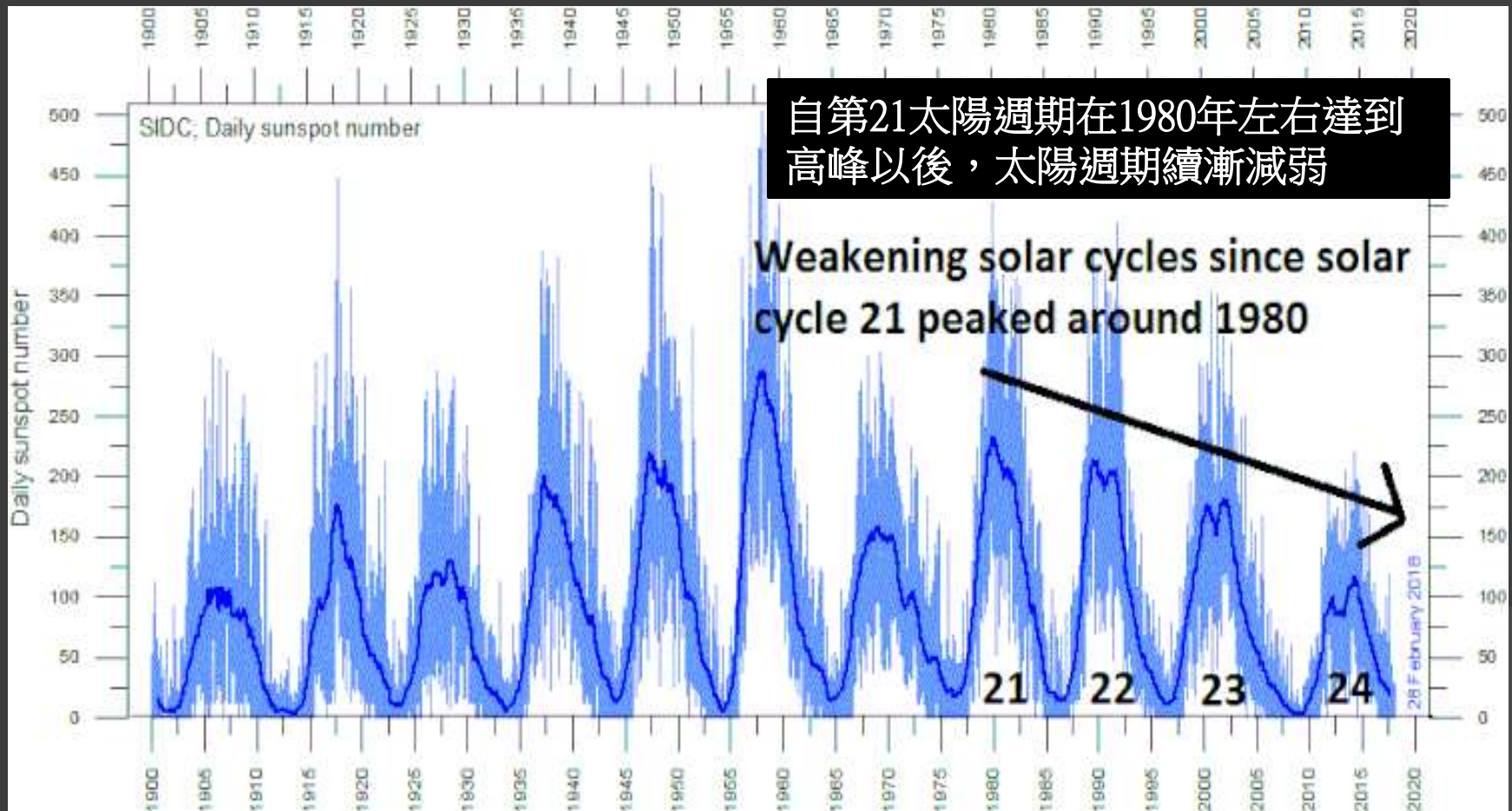


Sun spot cycle 24 第24太陽週期

第24週期太陽黑子估計數目 (V2.0) (2016/10)



Next Little Ice Age 下次小冰河時期

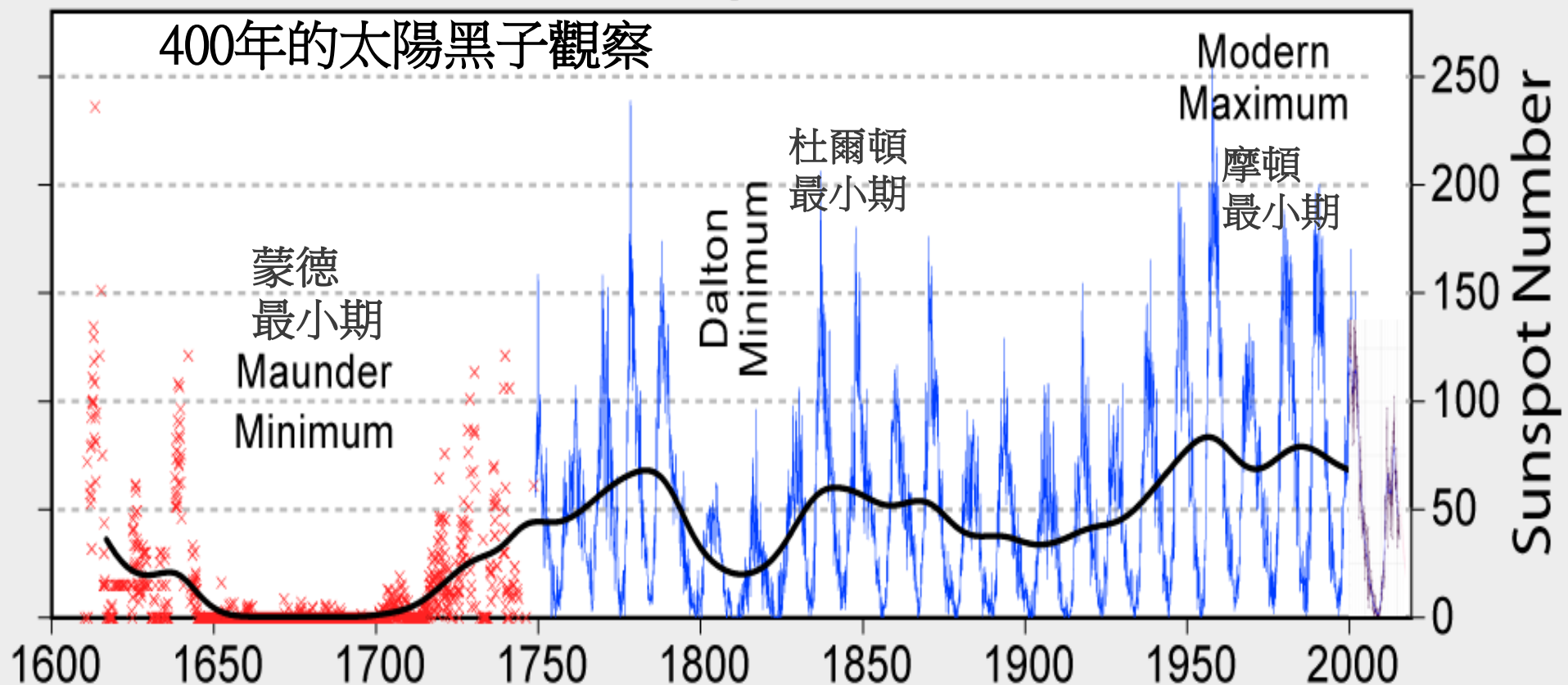


Source: SIDC – Solar Influences Data Analysis Centre

2030 the next Grand Solar Minimum

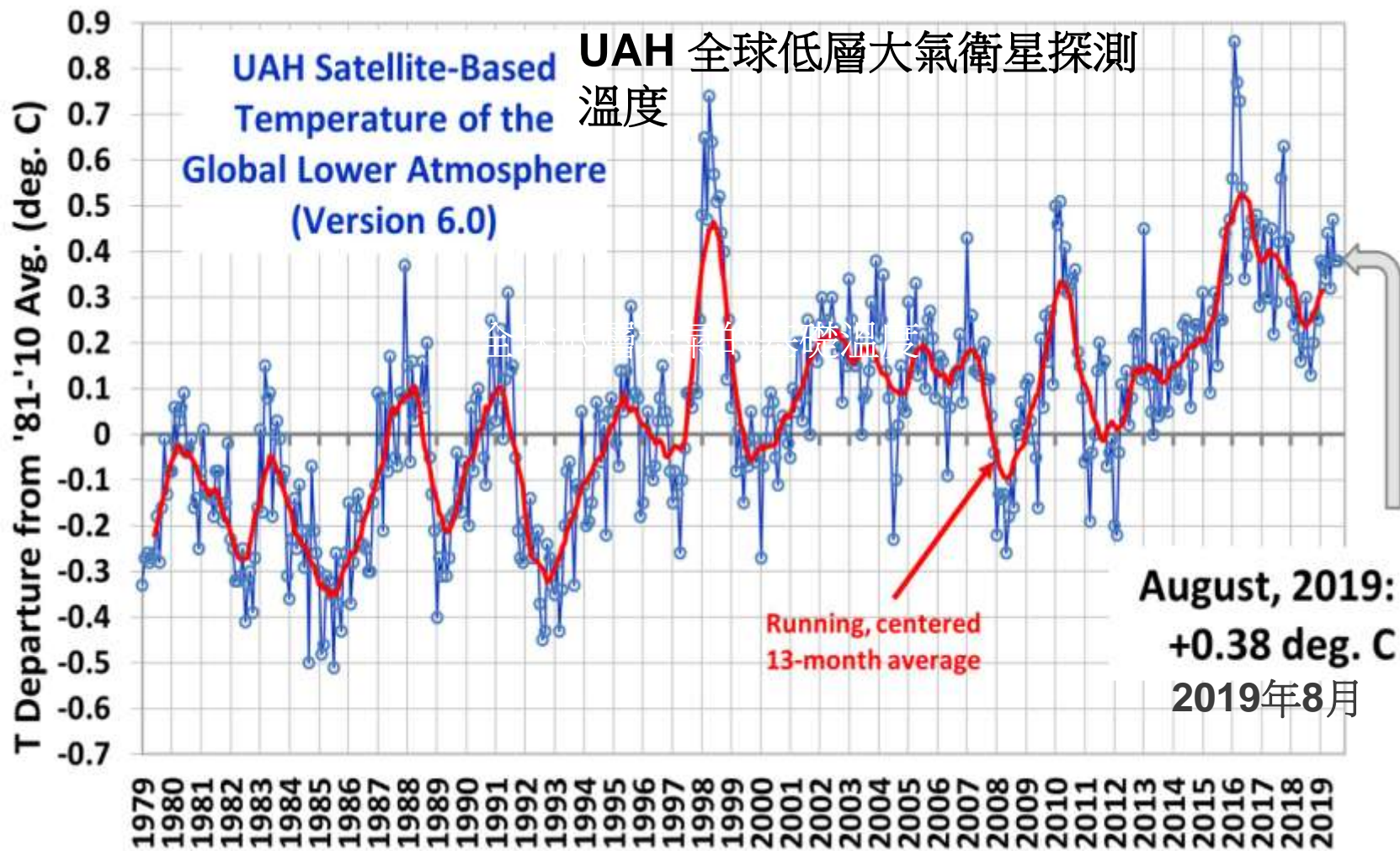
2030 是下次的太陽極小期

400 Years of Sunspot Observations



LATEST NASA GISS MONTHLY MEAN GLOBAL SURFACE TEMPERATURE

最近美國太空總署戈達德太空研究所月平均全球表面溫度

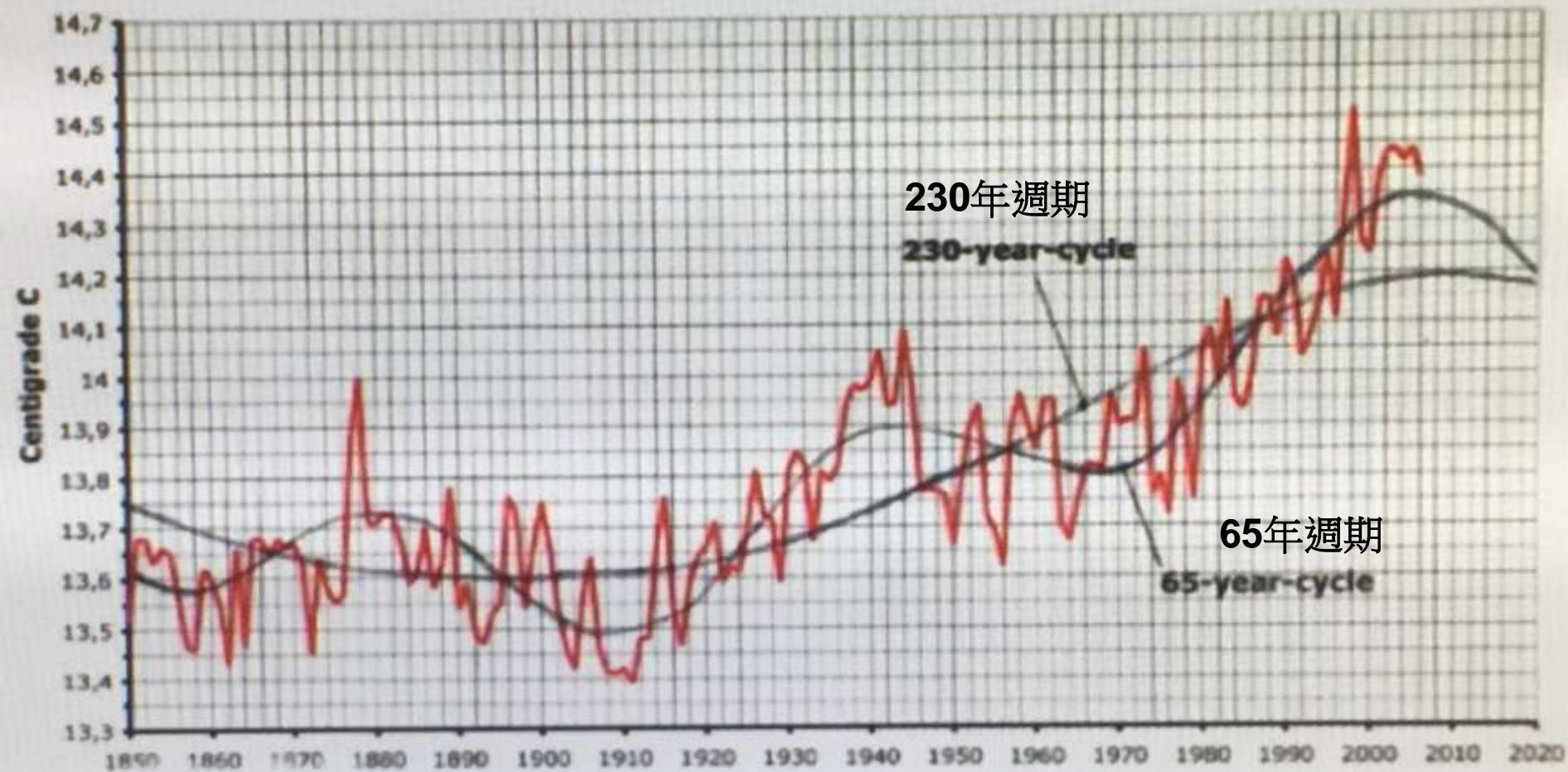


230-year De Vries cycle and 65-year AMO cycles matches global temperature record since 1850

230年的 De Vries 週期和65年的太平洋多年代波動週期符合1850年以來的全球溫度記錄

全球溫度歷史

Global Temperature History (CRU Data)



Conclusions 總結

(1) Climate has always changed.

氣候常變

(2) No correlation can be found between atmospheric carbon dioxide and climatic records (temperature/rainfall/sea level).

沒有發現大氣二氧化碳與氣候記錄（溫度/降雨/海平面）之間有相關性

(3) Climate change is cyclic and the sun is mainly responsible.

氣候變化是周期性的，太陽是主因

(4) Carbon dioxide cannot overtake the importance of the sun.

太陽的重要性超過二氧化碳

(5) Water vapour is a much more important greenhouse gas than carbon dioxide.

水蒸氣是較二氧化碳更重要的溫室氣體

(6) We need to adapt to the forthcoming Grand Solar Minimum – global cooling instead of global warming.

我們需要適應即將到來的太陽極小期 – 全球冷卻而不是全球暖化

(7) Carbon dioxide is not a pollutant and does not cause global warming.

二氧化碳不是污染物，不會導致全球暖化

Shiveluch eruption in eastern Russia on August 25, 2019 with eruption cloud reaching 21.3 km above sea level

25.8.2019 俄羅斯東部的 Shiveluch 火山噴發，噴發雲高達海拔 21.3 公里以上

預測 - 從現在至
2070 天氣變冷

**Prediction –
Period of cooling
from now to 2070**



Q & A

你問我答

thank you



