進擊的全球暖化與減碳趨勢

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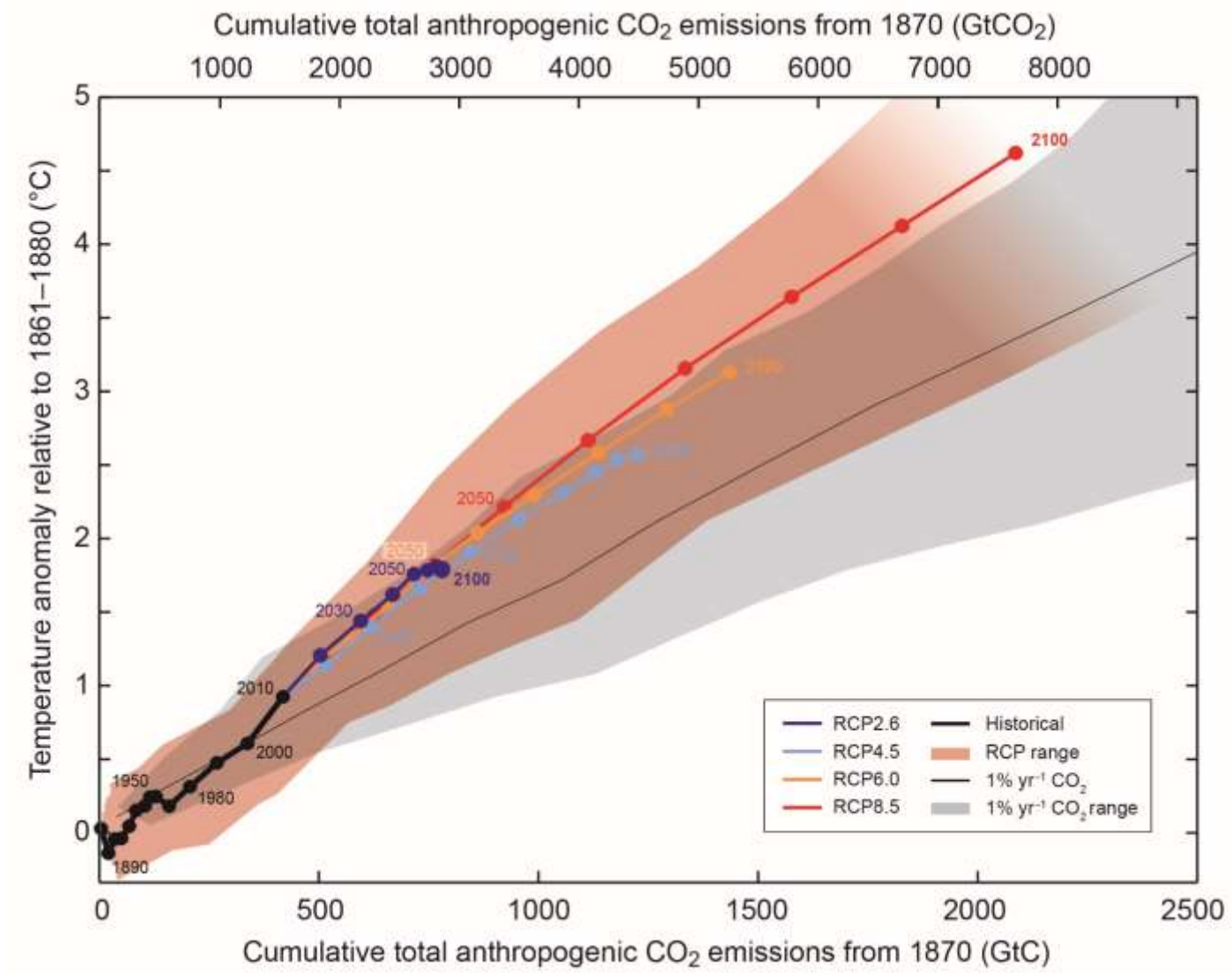
氣候變遷實驗室
中央研究院環境變遷研究中心

「1.5℃下的系統轉型」研習營
2019.9.4

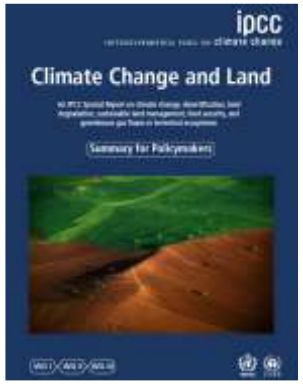
進撃、失速的全球暖化

IPCC AR5：排放越多、越久，溫室氣體累積越多，溫度上升越多！

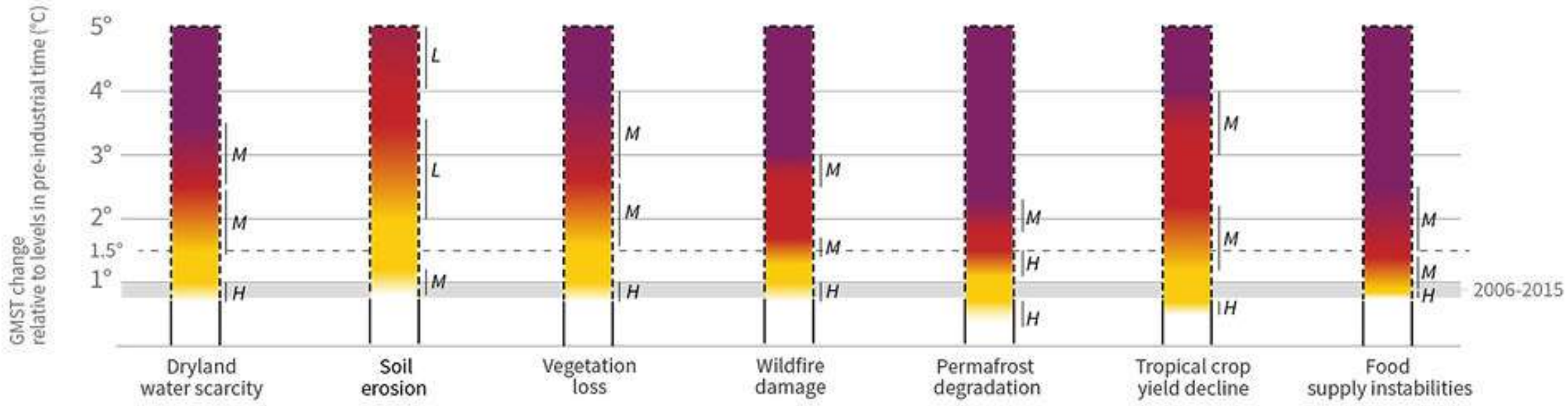


IPCC AR5

水資源短缺
水資源短缺
水資源短缺



IPCC 1.5°C特別報告系列(陸地、海洋、冰圈...):溫升幅度越高，全球衝擊越劇烈。



旱地水資源短缺

土壤侵蝕

植被減損

野火危害

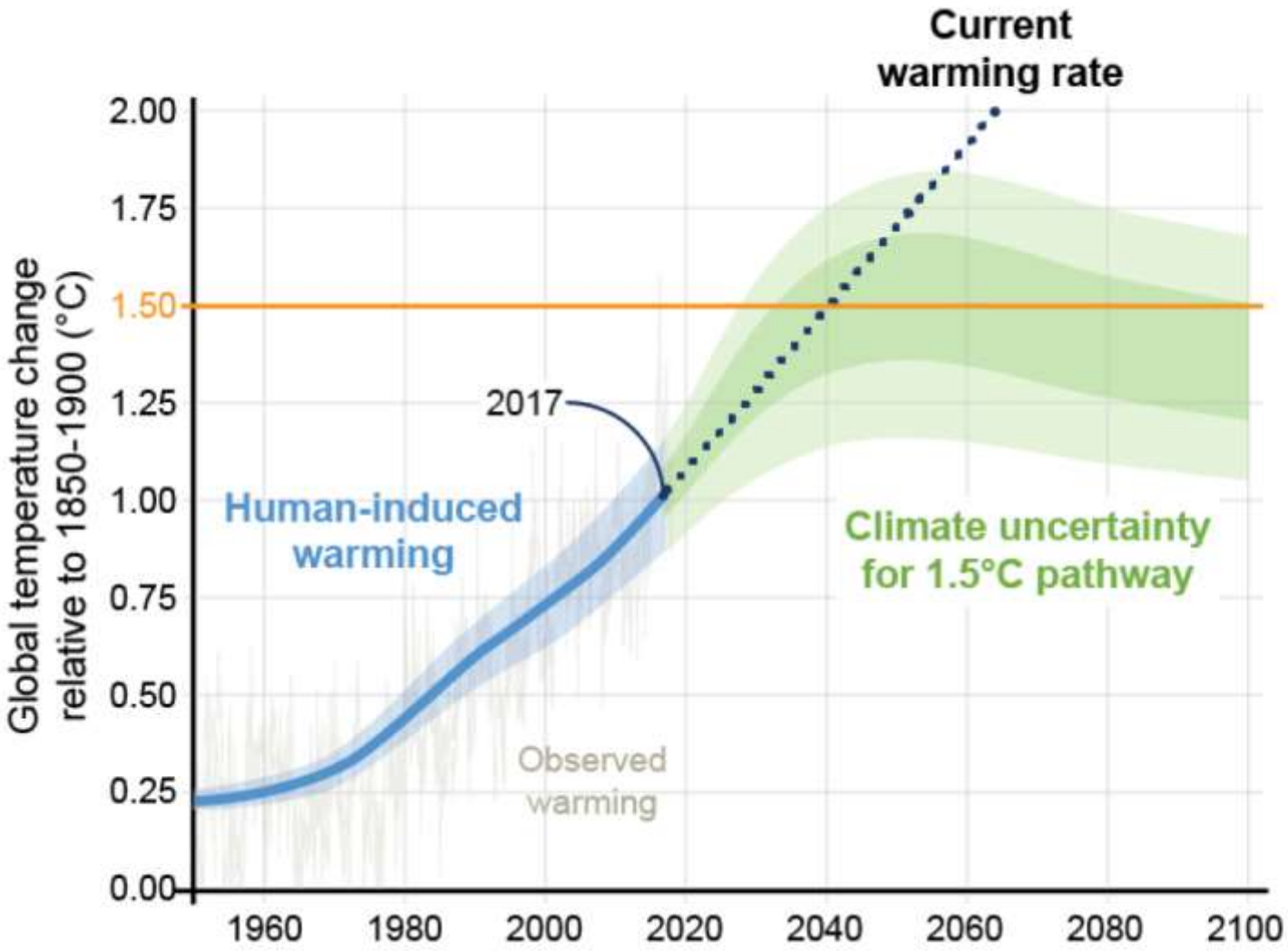
永凍土退化

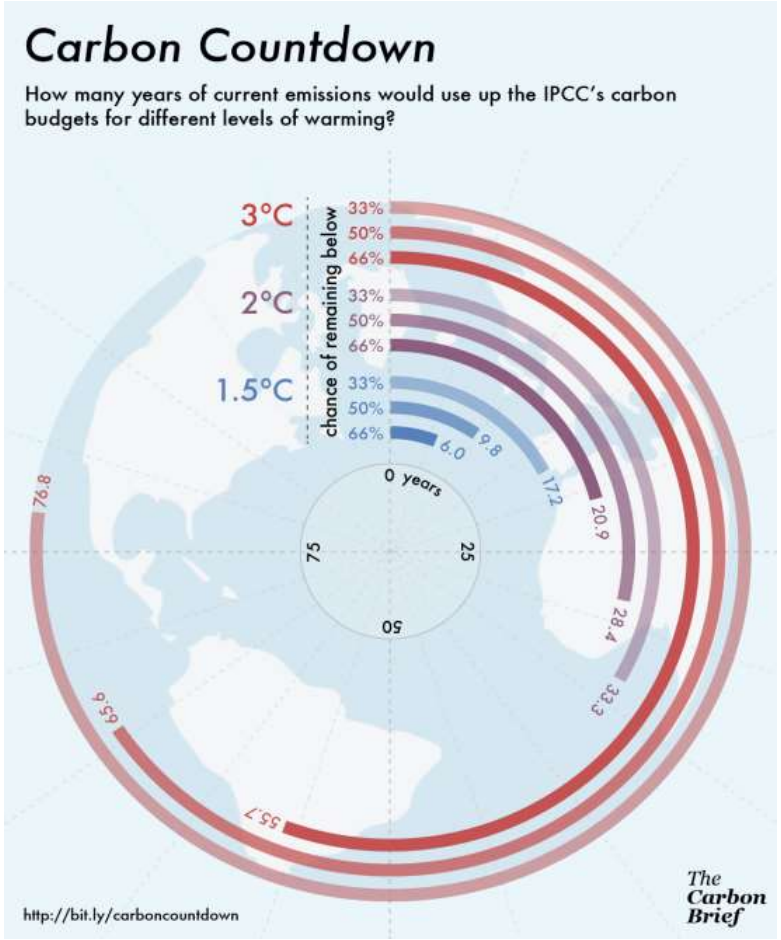
熱帶作物減產

食品供應不穩定

以目前的趨勢，2040年前後就會升溫至1.5°C

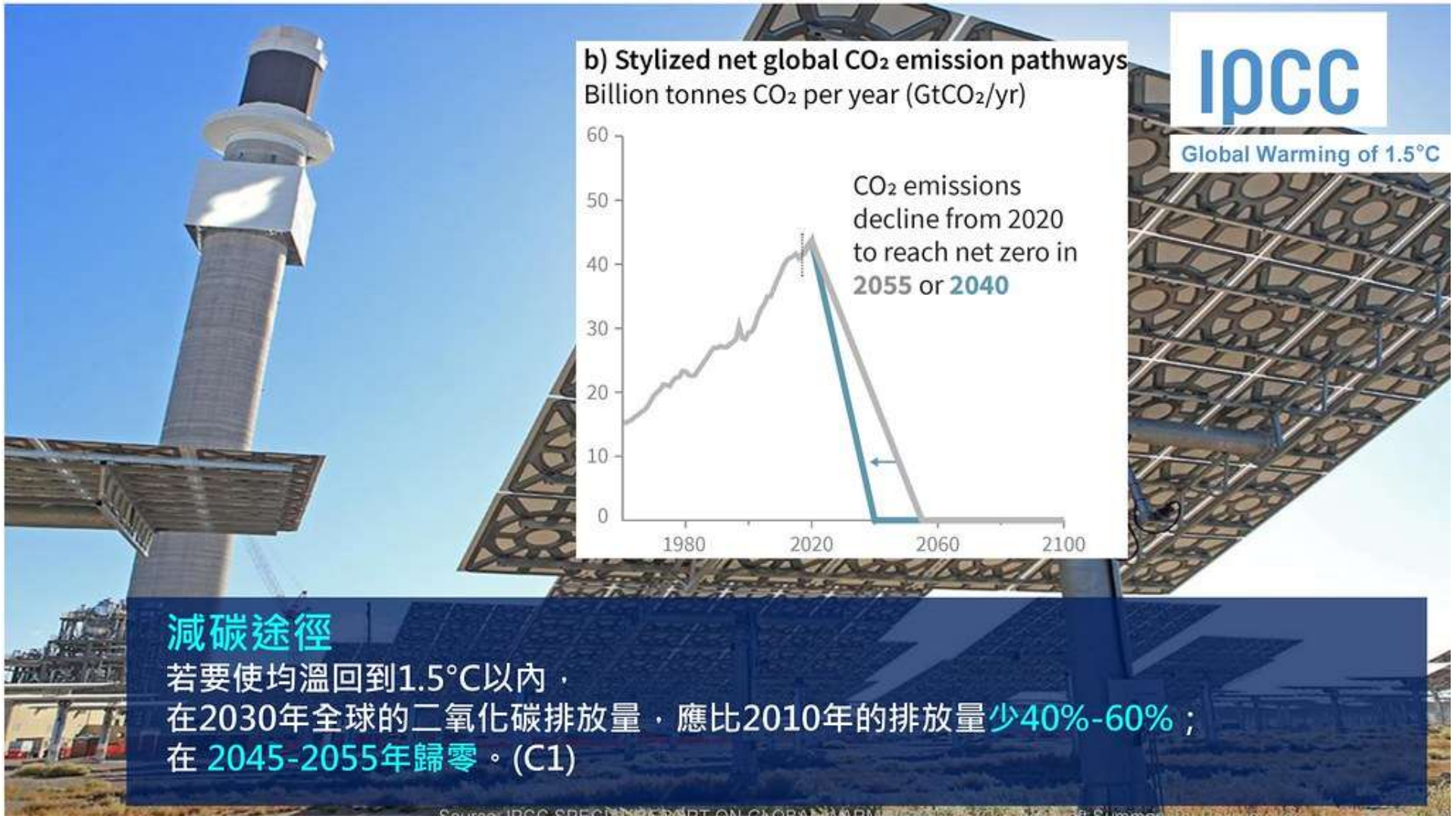
全球暖化的威脅是現在式，不是未來式





IPCC SR15

1.5°C目標的嚴峻挑戰: 立即、大幅度減。可能嗎?



《地球暖化1.5°C》IPCC特別報告——決策者摘要
台達電子文教基金會翻譯整理

https://e-info.org.tw/node/214503

2°C與1.5°C目標是嚴峻的挑戰，必須搭配負排放措施

Several carbon dioxide removal options have been proposed:

Afforestation and Reforetation
Tree growth takes up CO_2 from the atmosphere.

Bioenergy with carbon capture and storage
Plants turn CO_2 into biomass that fuel power plants. CO_2 captured and stored underground.

Ocean fertilization
Iron or other nutrients are applied to the ocean increasing CO_2 absorption.

Biochar
Partly burnt biomass is added to soils absorbing additional CO_2.

Enhanced weathering
Crushed minerals are applied to soil for chemical CO_2 absorbtion.

Direct Air Capture
CO_2 is removed from ambient air through chemical processes and stored underground.

連年輕人都失去了耐心

"You say you love your children above all else, and yet you are stealing their future in front of their very eyes."

「你說你愛你的孩子高於任何一切，但是你卻在孩子面前把他們的未來偷走了」

"The year 2078, I will celebrate my 75th birthday.

If I have children maybe they will spend that day with me.

Maybe they will ask me about you.

Maybe they will ask why you didn't do anything while there still was time to act.

…

We have run out of excuses and we are running out of time."

- Greta Thunberg 格蕾塔·桑伯格

各國政府風起雲湧的2050零碳排承諾

Theresa May commits to net zero UK carbon emissions by 2050
- The Guardian, 11 June 2019

Majority of EU states, including Germany, now support 2050 net zero climate goal
- Climate Home News, 17 June 2019

328 Mayors have now joined the call for net-zero emissions by 2050
- Build UP, 26 June 2019

Urban 20 Group of Cities meet in Tokyo and urge G20 to act urgently on Climate Change, Social Inclusion and Sustainable Economic Growth (22 May 2019)

Climate Action (2/5): Commit to decarbonizing the energy grid, with 100% renewable electricity by 2030, and 100% renewable energy by 2050.

Elizabeth Warren (US Sen., for president candidate) on Climate Change (**Green New Deal**)

1. **Green Marshall Plan ($100 billion)**
2. **Green Apollo Plan ($400 billions/10 years)**
3. **Green Industrial Mobilization (a $1.6 trillion Federal commitment/10 years)**

German defence minister **Ursula von der Leyen**, the next president of the European Commission

Von der Leyen is also set to announce a '**Green Deal for Europe**' in her first 100 days in office, which would include **a law to make Europe carbon neutral** by 2050. "**I want Europe to become the first climate-neutral continent in the world**," she said.

UN Secretary-General **António Guterres**

"I want to hear about how we are going to **stop the increase in emissions by 2020**, and dramatically reduce emissions to reach **net-zero emissions by mid-century**."

越來越多企業承諾零排放

9 Massive US Companies Pledge To Go 100% Renewable (2015)

http://thinkprogress.org/climate/2015/09/23/3704565/more-big-businesses-pledge-100-percent-renewable/

RE 100

a global corporate leadership initiative bringing together influential businesses committed to 100% renewable electricity

189 RE100 companies have made a commitment to go '100% renewable'.

IKEA · Swiss Re · 3M Science. Applied to Life.™ · Adobe · AEON · Allianz · BANK OF AMERICA · BURBERRY LONDON ENGLAND · Coca-Cola EUROPEAN PARTNERS · facebook · FUJITSU · Walmart

http://there100.org/re100

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CDP分析報告示警 低碳綠能勢在必行

企業揭露氣候變遷風險 五年內獲利恐受影響

全球前幾大企業預估，氣候變遷對於公司獲利的影響，恐將高達一兆美元，且許多損失將在近五年陸續兌現。

譯者 連育德

布拉德・普魯默（Brad Plumer）
《紐約時報》記者，專職報導氣候變遷、能源政策與其他環境議題。

根據新出爐的氣候披露分析報告，許多全球領導企業如矽谷科技公司與歐洲大銀行，獲利可能在五年內深受氣候變遷的影響。

根據新出爐的多全球領導企業如矽谷科技公司與歐洲大銀行，獲利可能在五年內深受氣候變遷的影響。

在股東與主導披露地球暖化對環境氣候可能衝擊轉趨嚴厲，可能投資價值，初期高達兩兆美元。

「目前的數

冰山一角。」CDP北美總監薩達（Bruno Sarda）說，CDP是撰寫這份報告的國際非營利組織，與全氣候變遷為營運帶一八年，逾七千家

許多企業面臨直接衝擊，日立指出，東南亞的降雨與水災增加，有可能重挫供

各國大企業預估，受到全球暖化的影響，沖銷或提早不用的資產，至少高達兩陳洪水區的建築嚴，而必須關閉

Inc.（Google母公，數據中心的冷

注大眾對氣候能源業者道達爾積極限制全球暖致部分石油天然國化學業者巴斯公司「碳足跡龐氣候變遷，否則的股東。

部分代慣，因為目前只有少數企業公布氣候風險，許多大企業去年並未提交披露報告給CDP，其中包括石油業者埃克森美孚（Exxon Mobil）與雪佛龍（Chevron），但即使披露了，化對財務的衝擊

舉例來說，量，企業要估算果是全球暖化或要估算對哪個地可就難多了。

其實，披露報

另一方面，約有二二五家大企業從氣候變遷看到潛在商機，金額總計約二・一兆美元，多數商機預計五年後實現。

美國藥廠總出，氣溫攀升會可以有優勢，可可也說，如果水等地廠房，氣候

歐盟企業願詳反觀美、中等

綠能趨勢抬頭亦帶來商機，荷蘭金融服務業者ING集團預估，如果低碳經濟範起，全球必須進一步投資乾淨能源，提高能源效率，金額可能總計三十兆美元，

另一方面，約有二二五家大企業從氣候變遷看到潛在商機，金額總計約二・一兆美元，多數商機預計五年後實現。

（BASF）表示，有鑑於公司「碳足跡龐大」，除非採取行動因應氣候變遷，否則可能會嚇跑具有環保意識的股東。

前將「氣候金融投資組合」規模加倍。

融體系的穩定。

「氣候變遷有可能成為歐洲區的系統性風險」，歐洲央行說：「如果市場錯誤反映這些

世界前幾大企業紛紛預估，氣候變遷將墊高成本，如谷歌便預估，其資料中心將因氣溫上升，而花費更多成本進行降溫。

CDP報告功臣現，總公司部在關懷

的企業更願意詳細列出全球暖化的財務影響，原因之一在於當地法規的要求。反觀美國、中國、巴西與墨西哥等企業，公布重大財務風險的機率低很多。

CDP北美總監薩達指出，在各界逐漸施壓之下，企業的披露報告預計「更透明」、「更精細」，但他也說：「工程勢必浩大。」

會要求上會提供相先鋒集團基金，已經驗，這股

超多小型設施設備數據的原因。

碳經濟

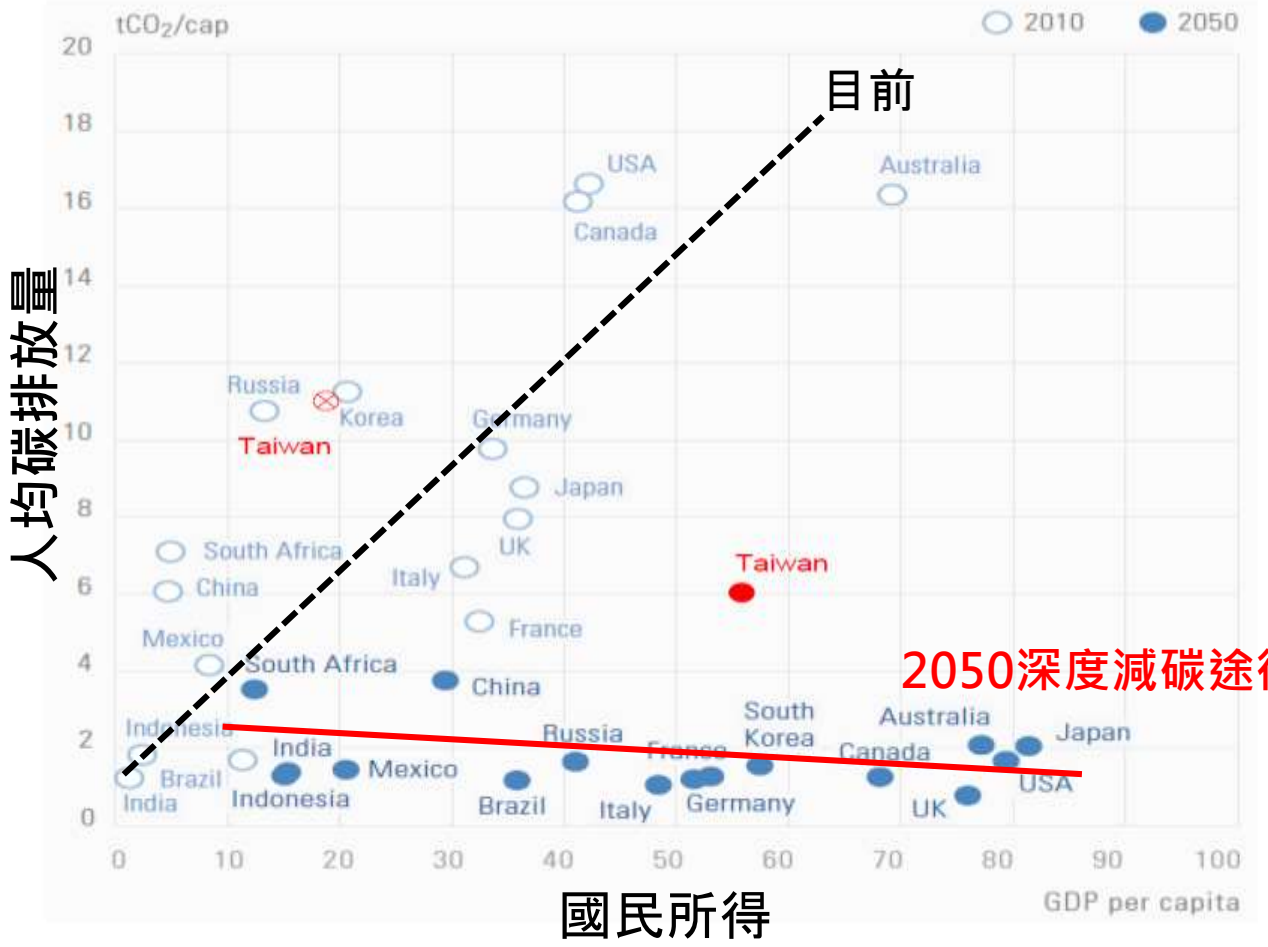
→低碳經濟:碳排放與經濟脫鉤

台灣人均GDP、人均CO_2排放量變化趨勢預估與DDPP會員國比較

DDPP:

溫管法的目標遠低於各國DDP目標(2°C)

DDP特色:
碳排與經濟脫鉤



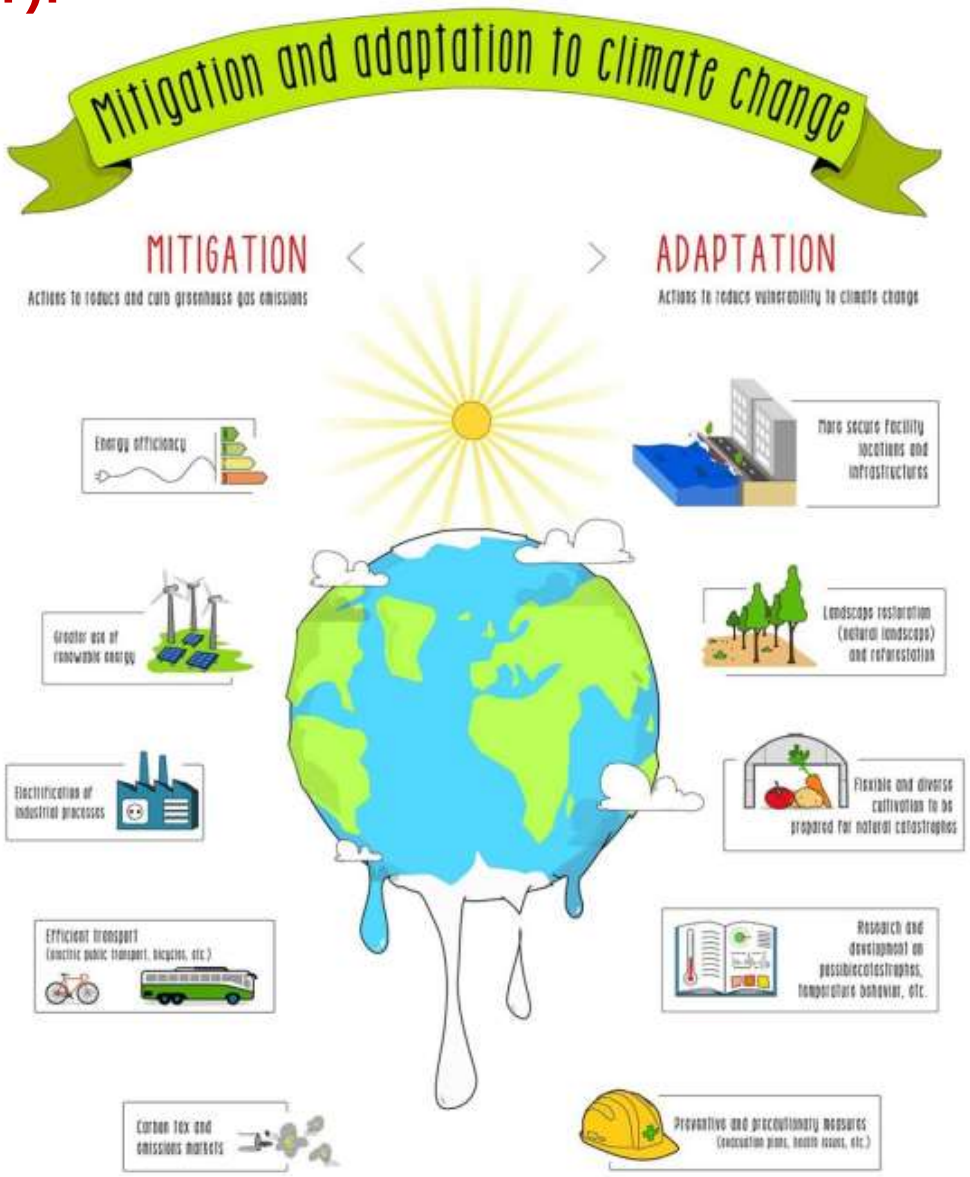
- 達不到1.5°C、2°C目標的風險很高。
- 需要調適措施的配合(2.5–3°C?):
  強化耐災能力!

減緩措施

Mitigation measures to avoid the increase of pollutant emissions

- **Practice Energy efficiency**
- **Greater use of renewable energy**
- **Electrification of industrial processes**
- **Efficient means of transport implementation: electric public transport, bicycle, shared cars ...**
- **Carbon tax and emissions markets**

https://www.activesustainability.com/climate-change/mitigation-adaptation-climate-change/?fbclid=IwAR2igG6cMeZvZxs4BWn7ixShQzdkGTdb2-Iu3WPs-OujjPAZmZSkuDzk2TM



調適措施

Adaptation measures help reducing vulnerability to the consequences of climate change

- **More secure facility locations and infrastructures**
- **Landscape restoration (natural landscape) and reforestation**
- **Flexible and diverse cultivation to be prepared for natural catastrophes**
- **Research and development on possible catastrophes, temperature behavior, etc.**
- **Preventive and precautionary measures (evacuation plans, health issues, etc.)**

台灣溫管法及國家自訂預期貢獻 (NDC)

《溫室氣體減量及管理法》

第4條：國家溫室氣體長期減量目標為2050年溫室氣體排放量降為2005年排放量50%。但可參酌聯合國氣候變化綱要公約與其協議，適時調整。

（2015年6月15日立法院會三讀通過）

我國 INDC 產出過程

- 考量能資源（熱汽電）整合、地熱發電、碳捕存等綠能低碳前瞻技術應用，並參與國際市場機制之境外減量，可擴大我國減量幅度與潛力；再抑低 2030 年我國溫室氣體排放量，比推估下限 220 百萬公噸，**再減 6 百萬公噸**。
- 準此，臺灣將向國際社會承諾，我國 INDC 減量目標為 **2030 年溫室氣體排放量為 BAU 減量 50%** 註 1
  - ✓ **低於 2000 年**排放量註 2
  - ✓ 相當於 **2005 年排放量**註 3 **再減 20%**，作為達成「溫室氣體減量及管理法」2050 年**降至 2005 年排放量 50% 以下的階段性目標**

註：1. 推估 2030 年 BAU 溫室氣體排放量約為 428 百萬公噸，減量 50% 約回到 214 百萬公噸
2. 我國 2000 年溫室氣體排放量為 227 百萬公噸
3. 我國 2005 年溫室氣體排放量為 269 百萬公噸

- 3 -

行政院環境保護署

- 以2050年溫室氣體長期減量目標來換算: 在2050年，整體排放量約較2010年排放水準減少49.4%。
- 符合氣候公約(達成2°C的水平)所提減量幅度40 %至70%之建議?

應該修正成更積極的減碳目標(1.5°C，接近零排放?)與調適策略!

中研院《臺灣深度減碳政策建議書》

2019.06.06

(1)**立即啟動「臺灣深度減碳途徑」規劃，呼應2030年永續發展目標以及《巴黎協定》長期減量策略。**經由參與國際DDPP平台，以取得更廣泛深遠的國際知識、資訊與資源交流，從宏觀而長遠角度規劃臺灣深度減碳的轉型途徑；**(途徑)**

(2)**以「多元利害相關人對話平台及公眾審議程序」開展深度減碳社會溝通。**深度減碳涉及經濟型態與生活方式的巨幅變動，因此在轉型過程中需積極爭取社會行動者的支持，建立涵蓋產業、政府、學界、公民團體四方面的對話平台，消弭彼此對深度減碳的歧見，透過成熟的社會機制，共同形塑轉型的共識與氛圍；**(共識)**

(3)**推動「氣候變遷法」，作為建構對深度減碳友善之法規體系與產業環境之上位法源**，使深度減碳轉型途徑能有穩健的法規依據，並能進行充分評估，以扶植具有前瞻潛力的新能源產業。**(法源)**

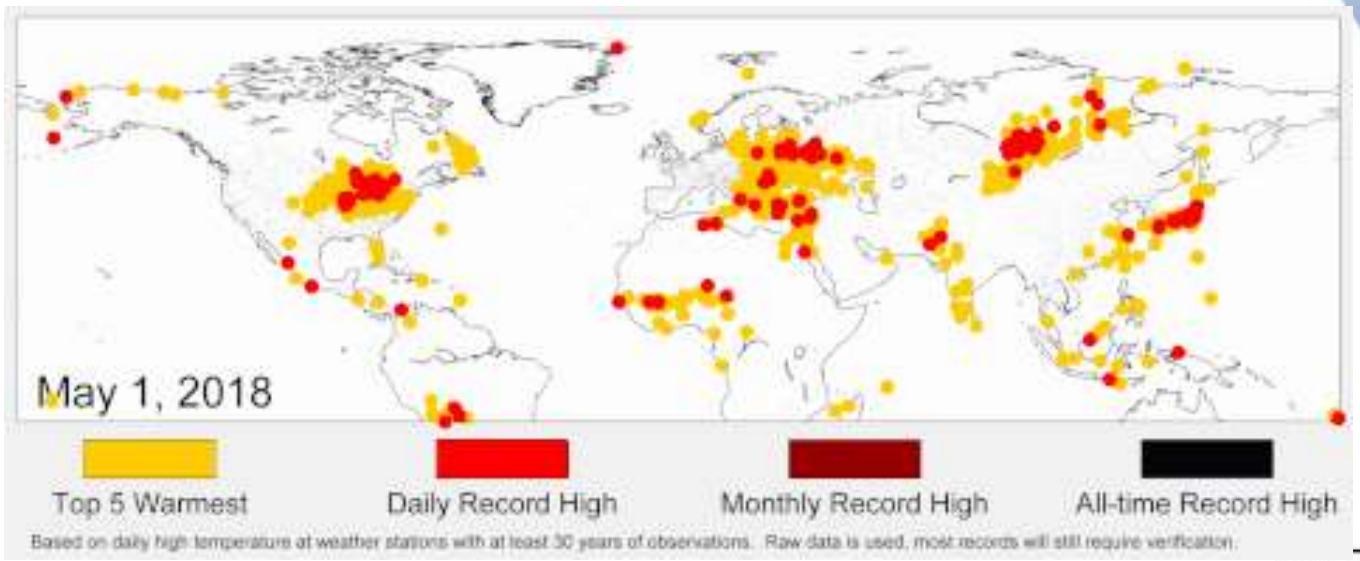
https://newsletter.sinica.edu.tw/%E6%9C%AC%E9%99%A2%E7%99%BC%E5%B8%83%E3%80%8A%E8%87%BA%E7%81%A3%E6%B7%B1%E5%BA%A6%E6%B8%9B%E7%A2%B3%E6%94%BF%E7%AD%96%E5%BB%BA%E8%AD%B0%E6%9B%B8%E3%80%8B/

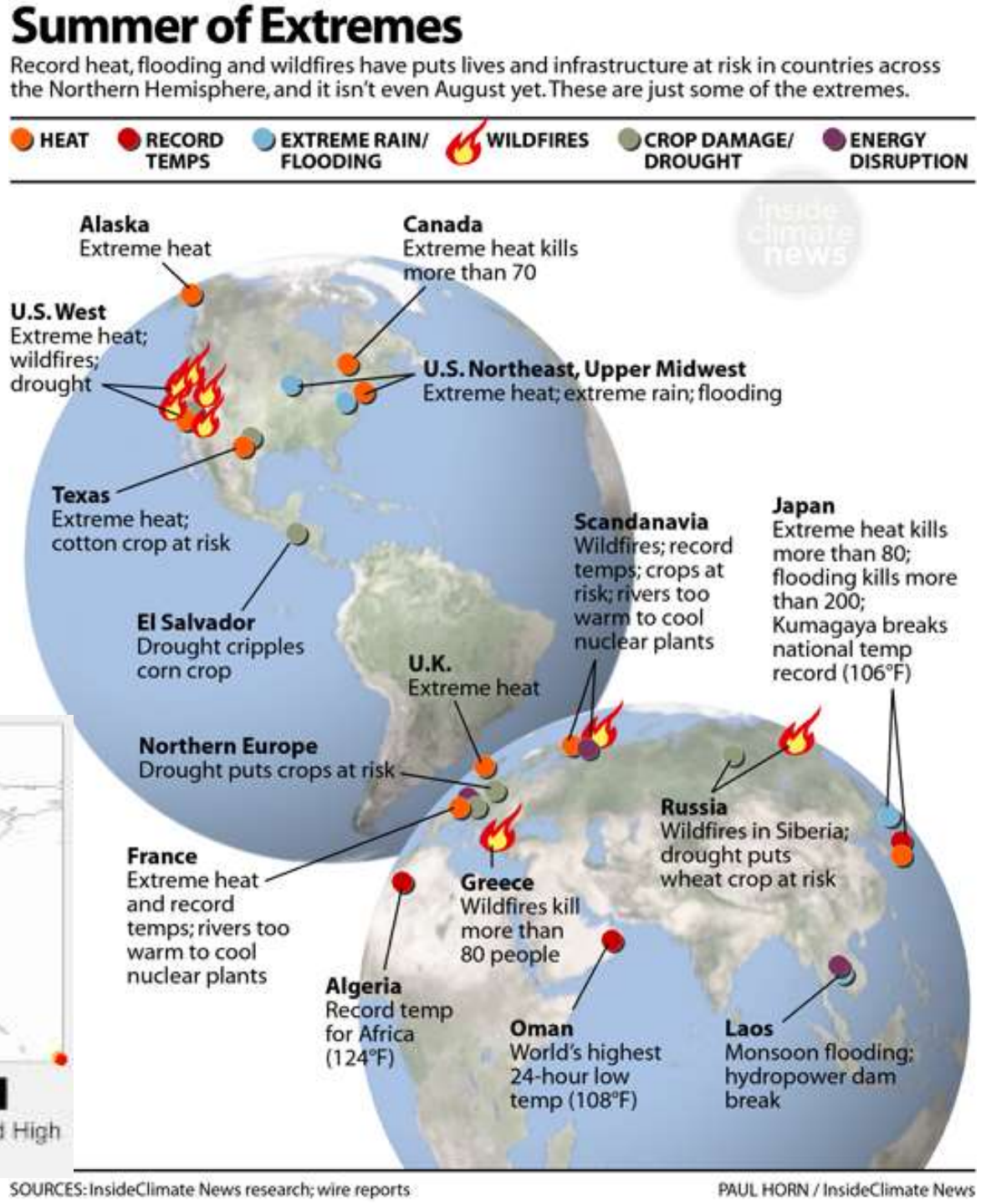
謝謝聆聽

2018夏季極端天氣

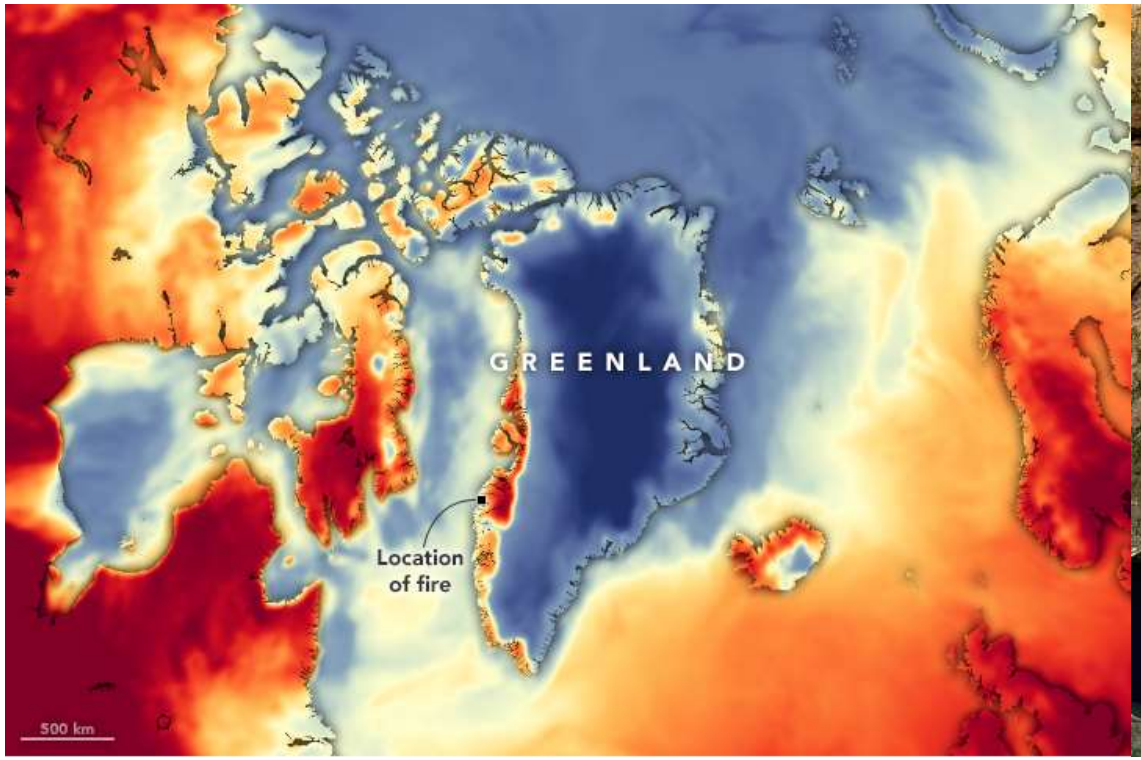
熱浪、森林大火
乾旱、豪雨

2018年5-7月高溫破紀錄的地區

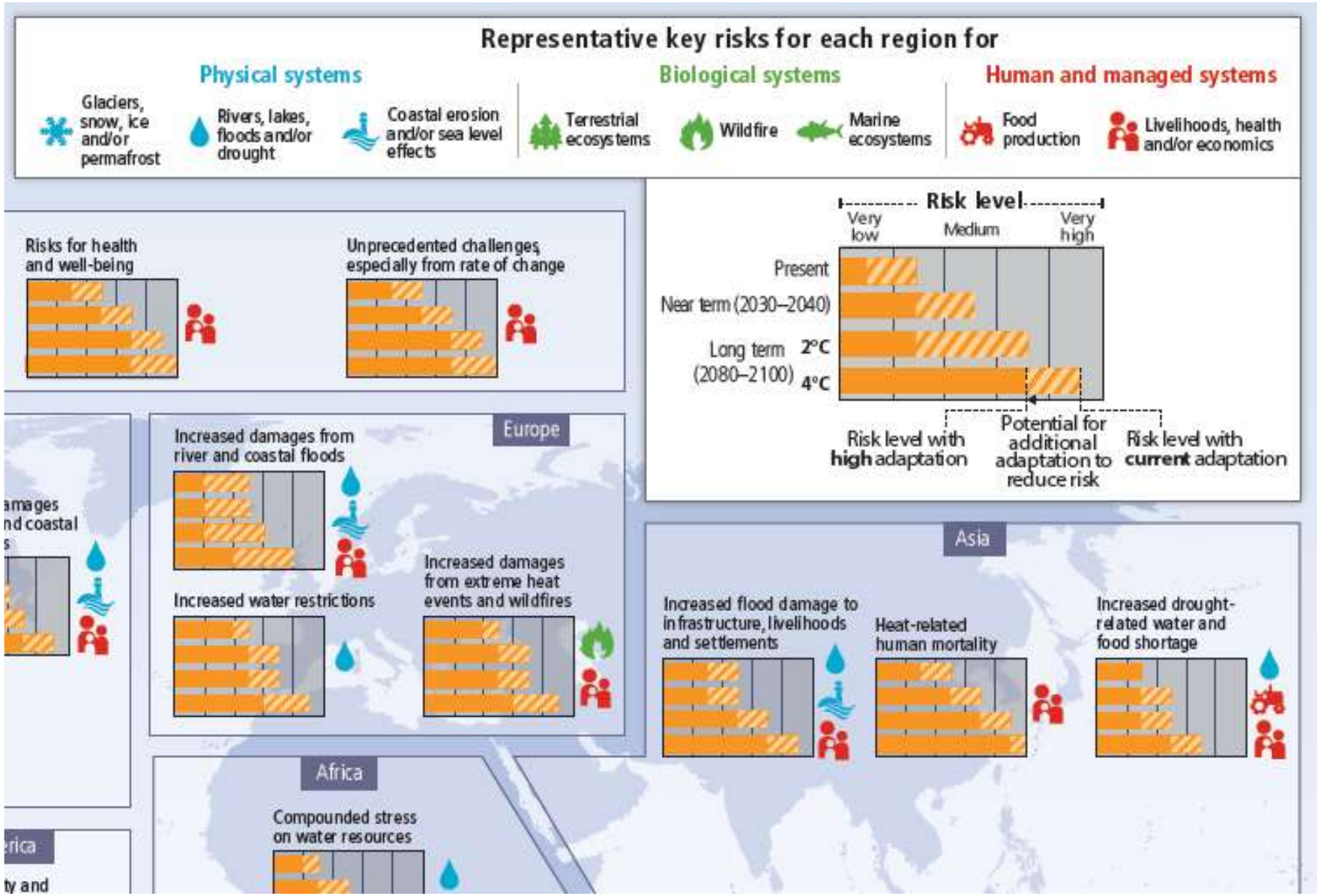




2019：連格陵蘭都失火了！

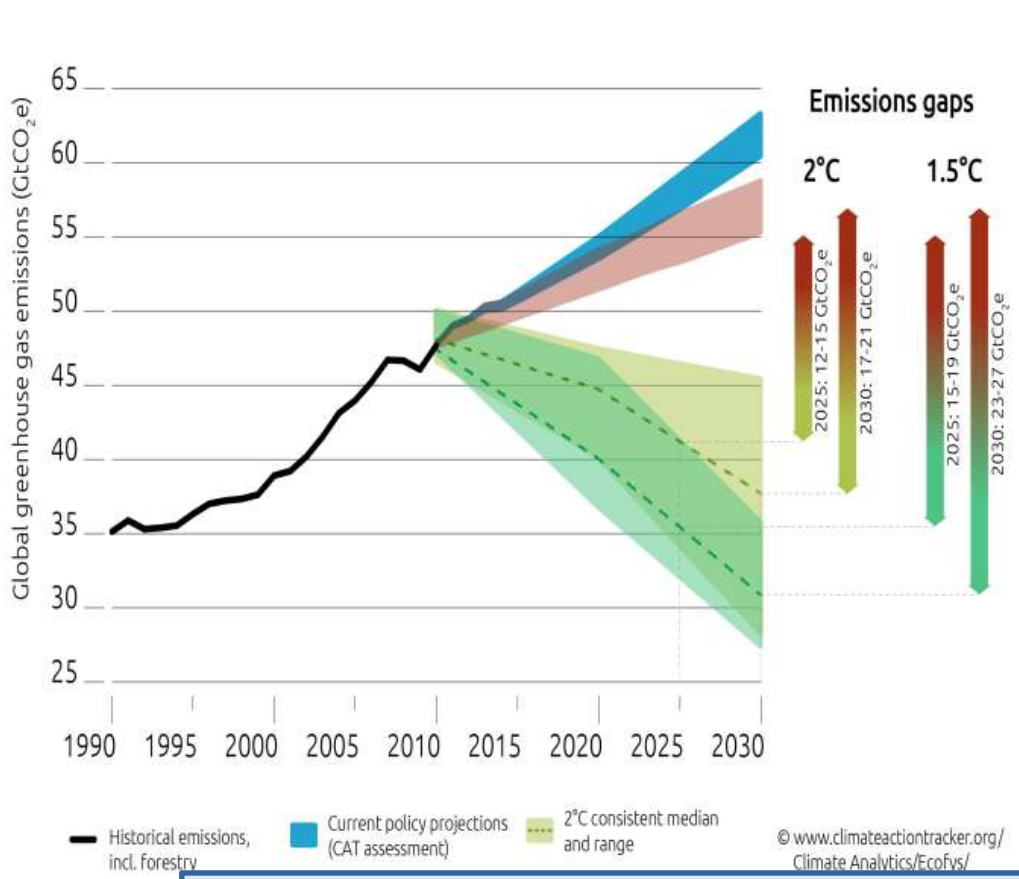


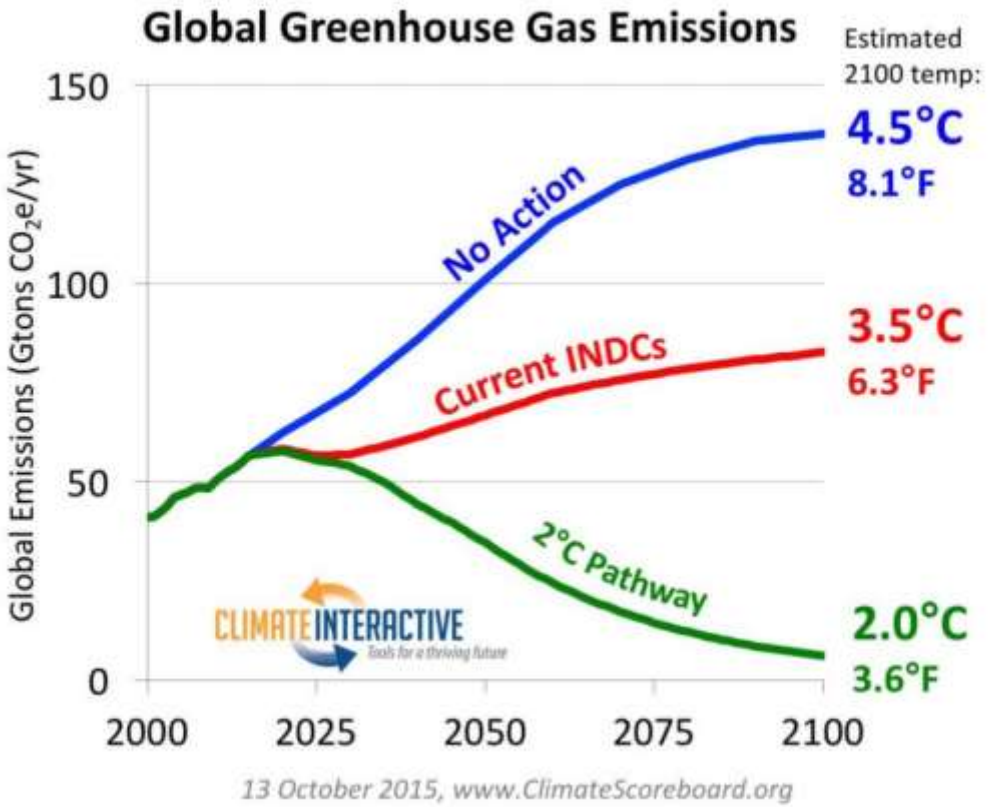
暖化程度低，威脅的風險也比較低



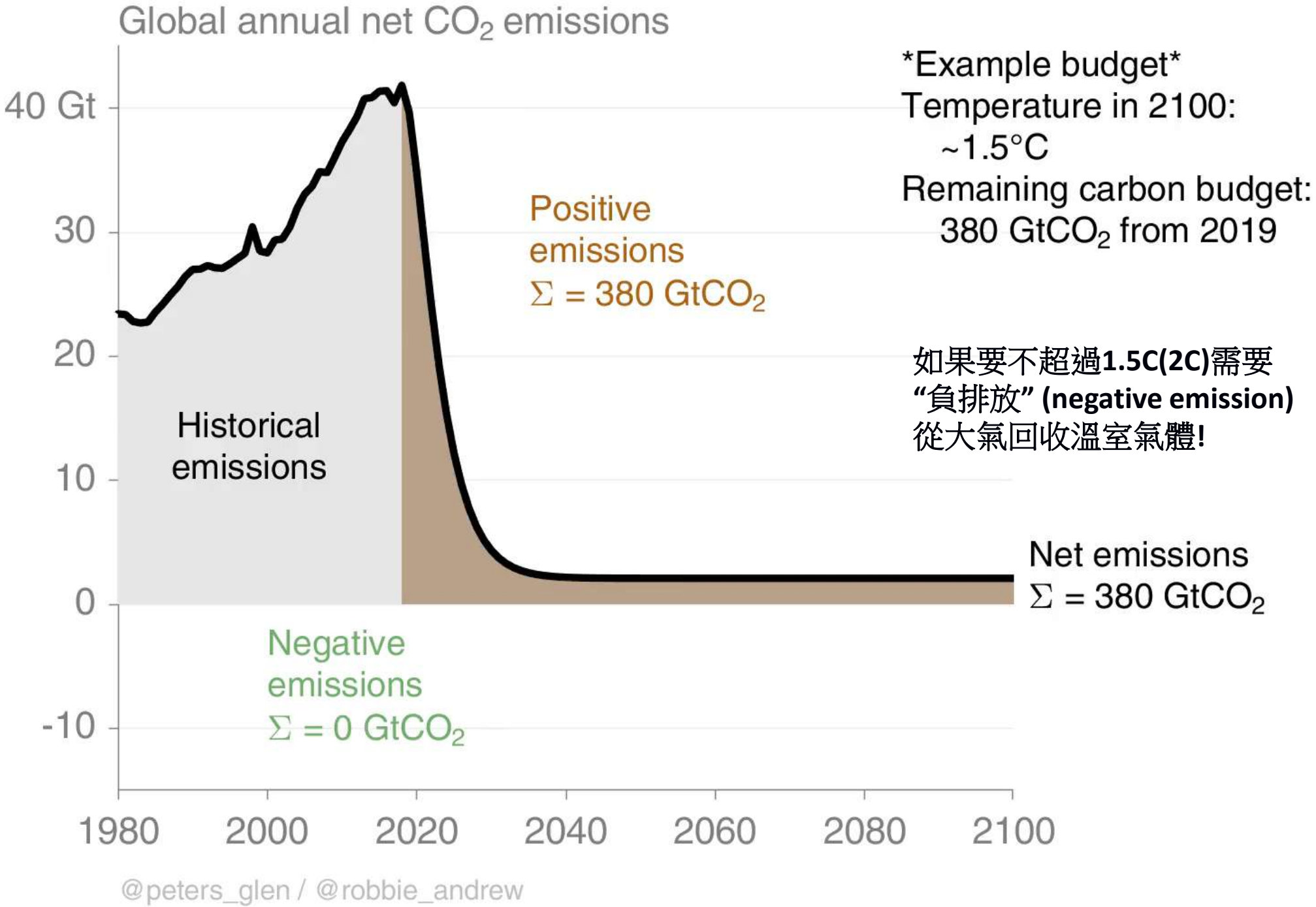
IPCC AR5

巴黎協議各國承諾的減排量與達成2°C(1.5)限溫目標有極大差距





**2°C的要求：2050年，人均排放～1.7噸。(台灣溫管法目標:約6噸)
以目前各國提的NDC標準，2°C根本不可能。研究單位估計升溫: 2.7 或 3.5°C。


Global annual net CO_2 emissions
40 Gt
30
20
10
0
-10
1980
2000
2020
2040
2060
2080
2100
Historical emissions
Positive emissions
Σ = 380 $GtCO_2$
Negative emissions
Σ = 0 $GtCO_2$
Net emissions
Σ = 380 $GtCO_2$
Example budget
Temperature in 2100:
~1.5°C
Remaining carbon budget:
380 $GtCO_2$ from 2019
如果要不超過1.5C(2C)需要
“負排放” (negative emission)
從大氣回收溫室氣體!
@peters_glen / @robbie_andrew

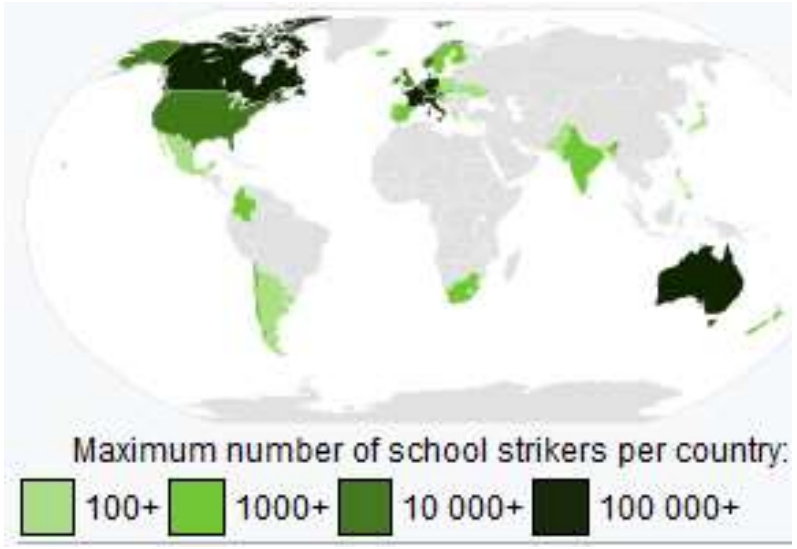
Greta Thunberg at UN Climate Change COP24 Conference （2018）

"You say you love your children above all else, and yet you are stealing their future in front of their very eyes."

連年輕人都失去了耐心

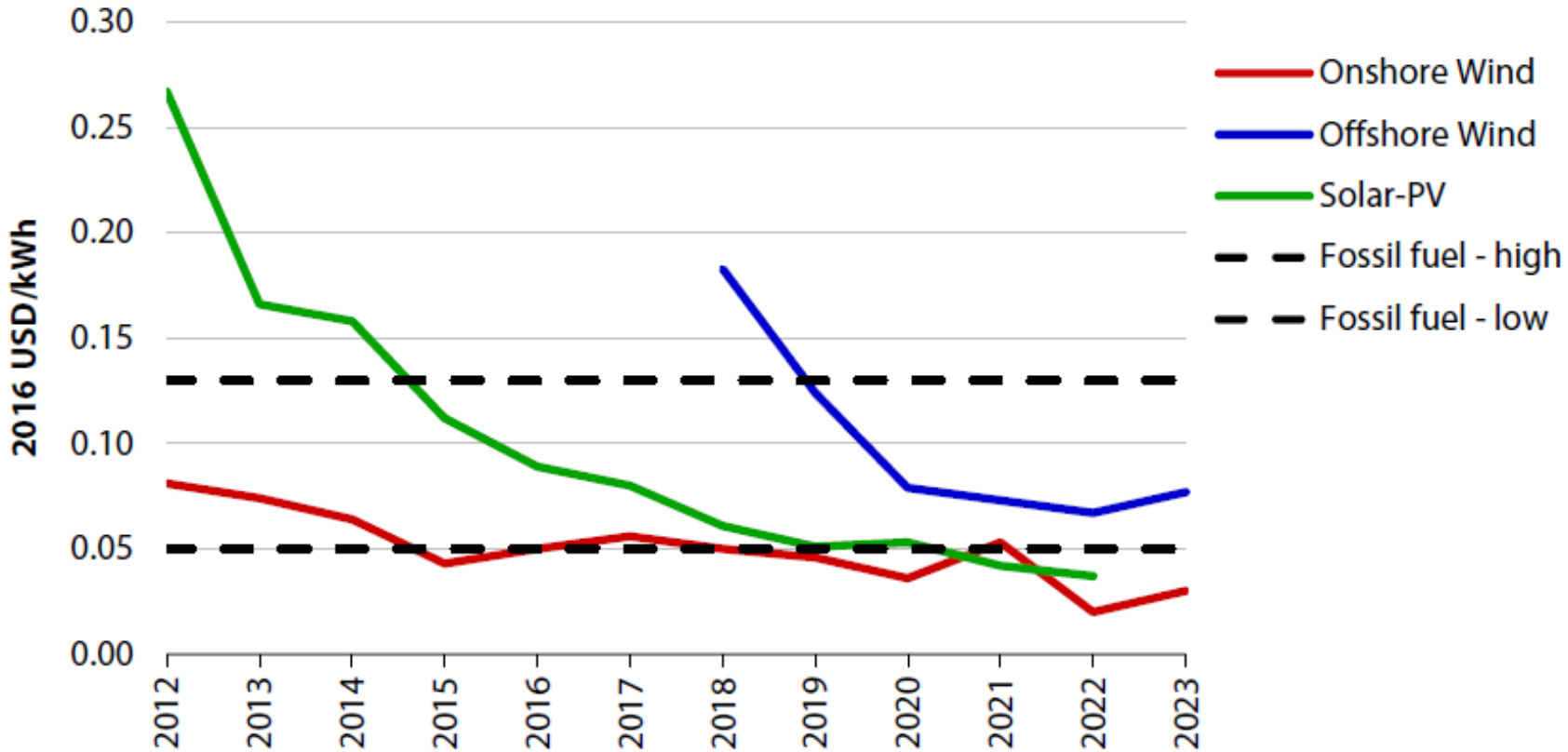
https://www.youtube.com/watch?v=VFkQSGyeCWg

School Strike for Climate
FridaysForFuture



Countries where a **climate emergency** has been declared, either for the entire country or only some subdivisions. **氣候緊急事件**

反抗滅絕

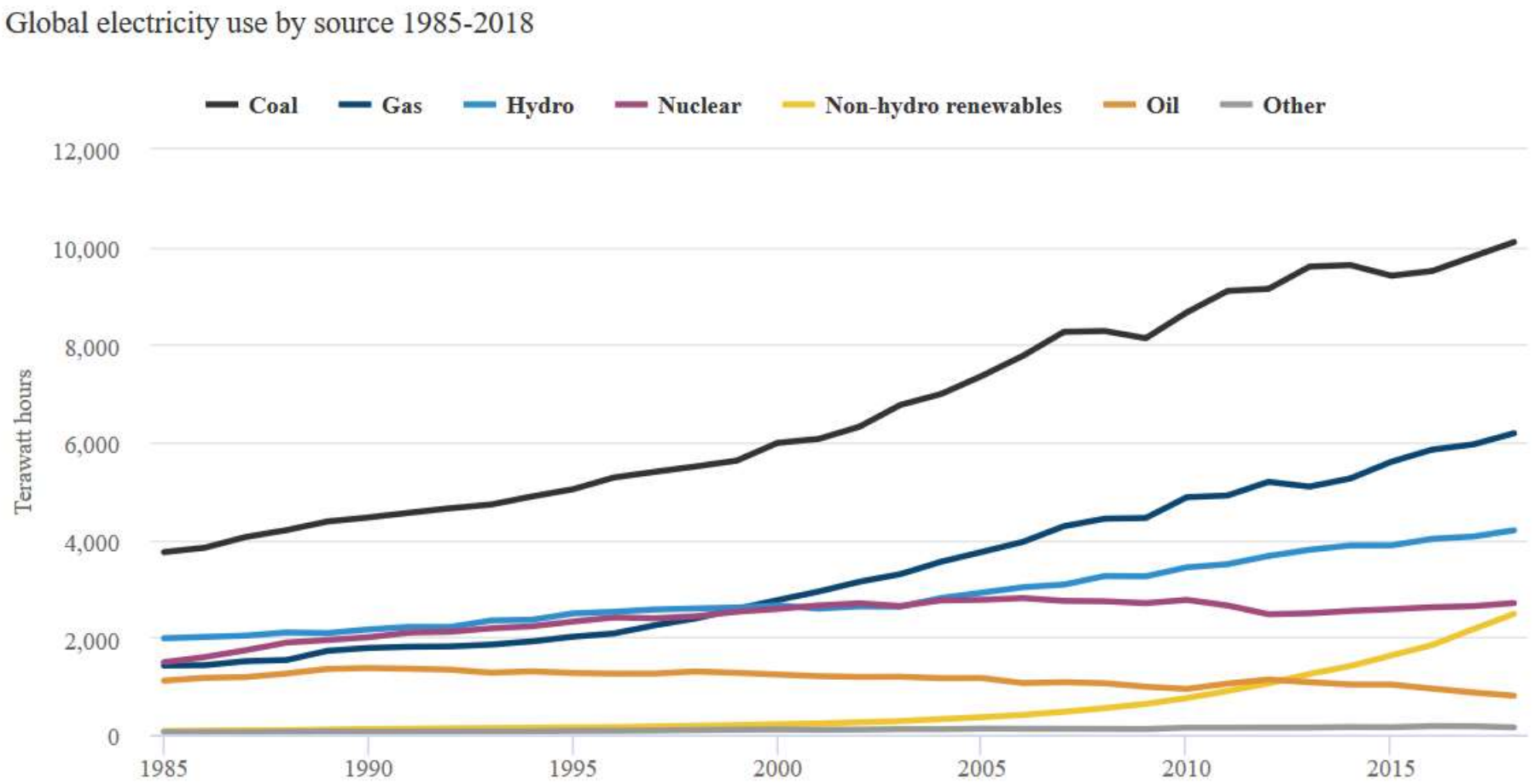


Source: IRENA (2018) *Renewable Power Generation Costs 2017*; IEA (2019) *Renewable Energy 2018*.

節能 - 綠色建築

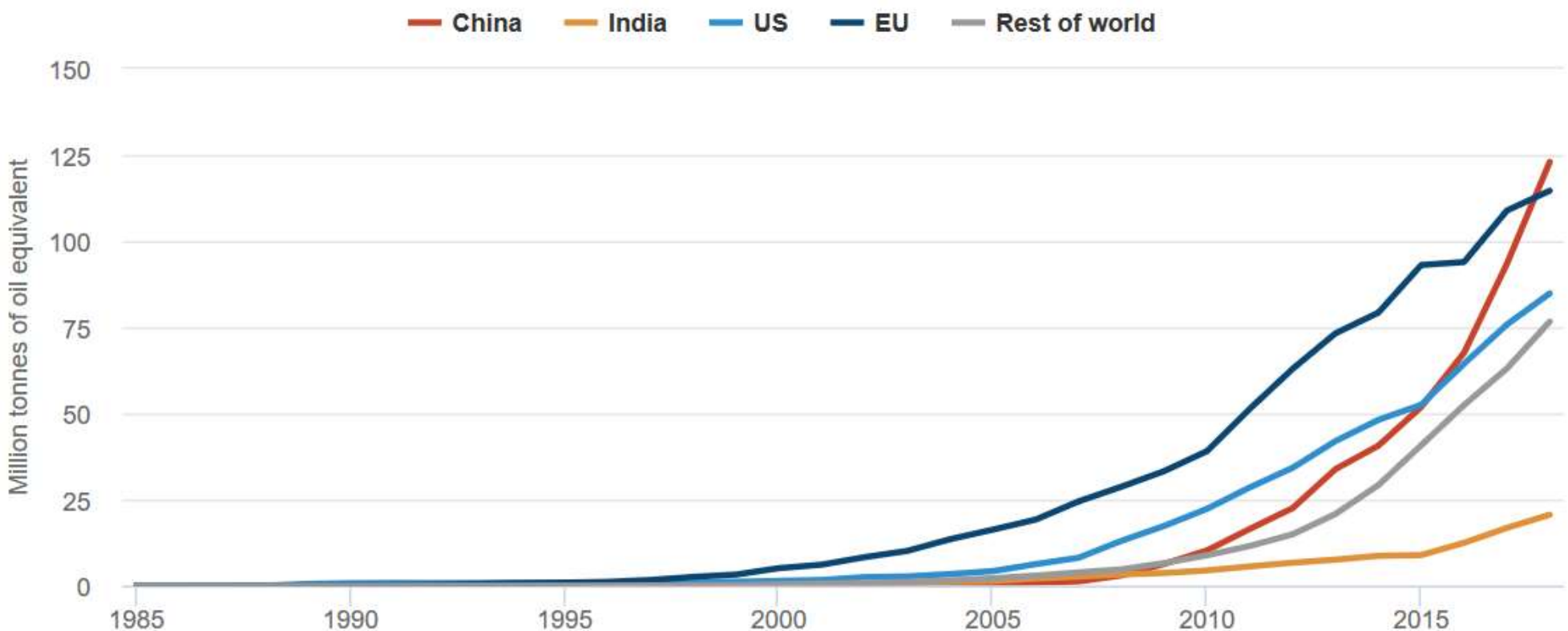
30 St Mary Axe, "The Gherkin",
The Swiss Re(-insurer) Tower

Global Electricity use by source 1985-2018



In-depth: BP data reveals record CO2 emissions in 2018 driven by surging use of gas
Zeke Hausfather, Global Emission, 12 June 2019

Wind and solar use by country 1965-2018



Renewable Energy Costs Are Falling

Analysts at Lazard compared the changing costs over time for generating a megawatt-hour of electricity from different energy sources, including coal, solar, wind, nuclear and natural gas.

HISTORICAL AVERAGE LEVELIZED COST OF ELECTRICITY

2009-2017

Notes: Reflects average of unsubsidized high and low levelized cost of energy range. Primarily related to North American alternative energy landscape, but reflects broader global cost declines.

SOURCE: Lazard estimates

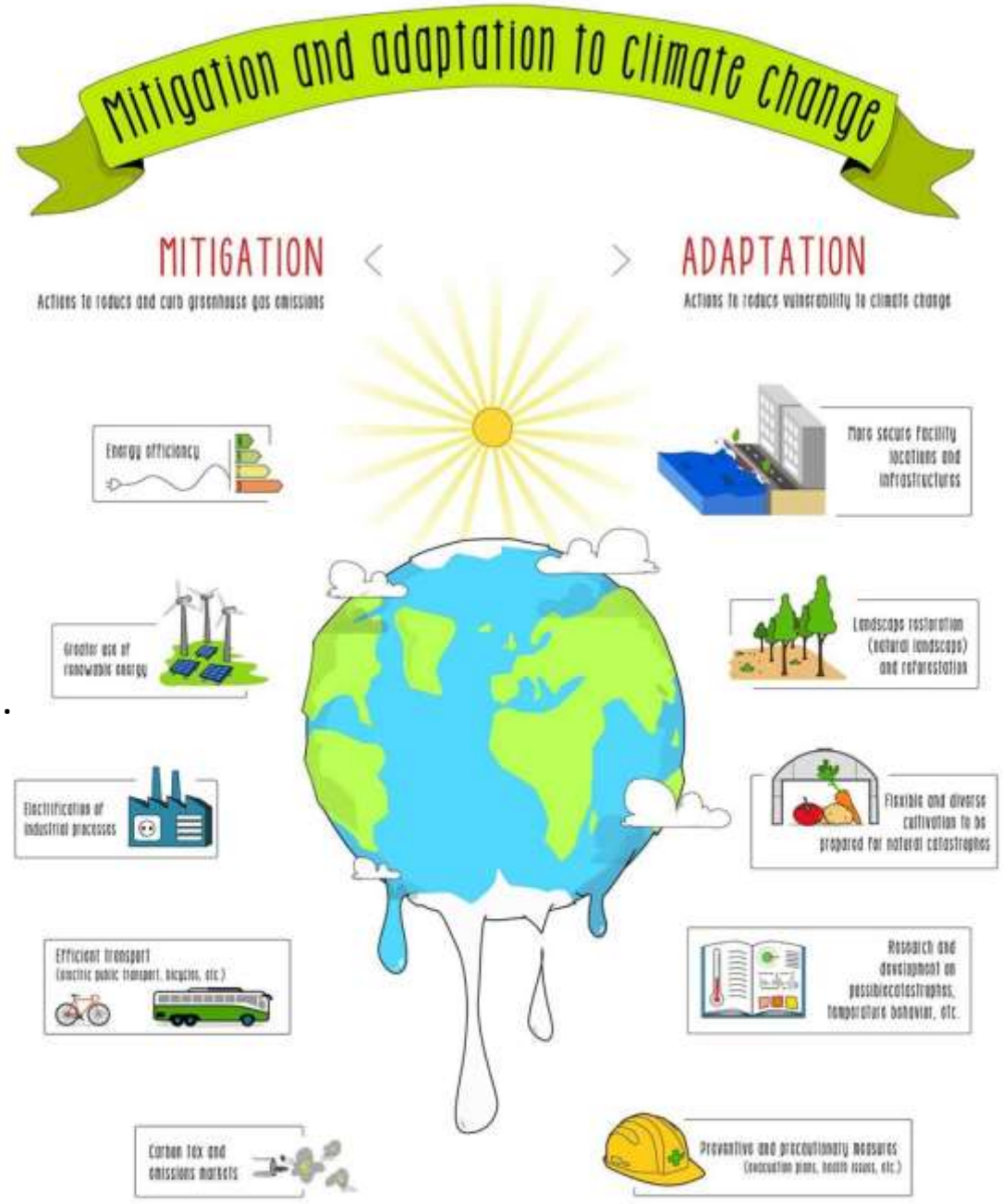
PAUL HORN / InsideClimate News

A zero-emission city is now a choice, not a fantasy
https://www.facebook.com/MetroUK/

mitigation measures to avoid the increase of pollutant emissions

- Practice Energy efficiency
- Greater use of renewable energy
- Electrification of industrial processes
- Efficient means of transport implementation: electric public transport, bicycle, shared cars ...
- Carbon tax and emissions markets

https://www.activesustainability.com/climate-change/mitigation-adaptation-climate-change/?fbclid=IwAR2igG6cMeZvZxs4BWn7ixShQzdkGTdb2-Iu3WPs-OujjPAZmZSkuDzk2TM



adaptation measures help reducing vulnerability to the consequences of climate change

- More secure facility locations and infrastructures
- Landscape restoration (natural landscape) and reforestation
- Flexible and diverse cultivation to be prepared for natural catastrophes
- Research and development on possible catastrophes, temperature behavior, etc.
- Preventive and precautionary measures (evacuation plans, health issues, etc.)

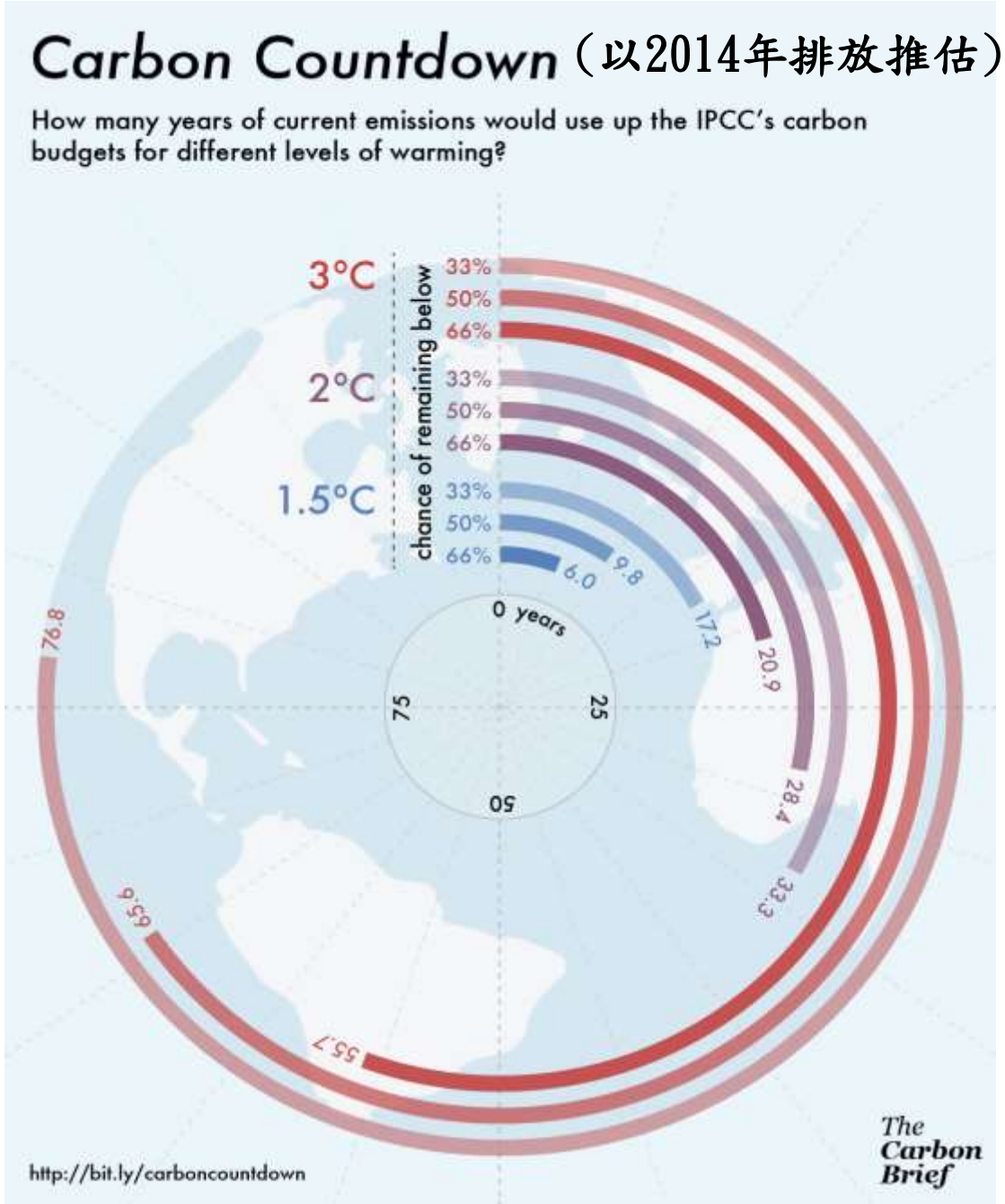
新竹市推校園太陽能　年效益12.3座大安森林公園

2019/06/10 18:14

news.tvbs.com.tw/life/1147155?from=Copy_content

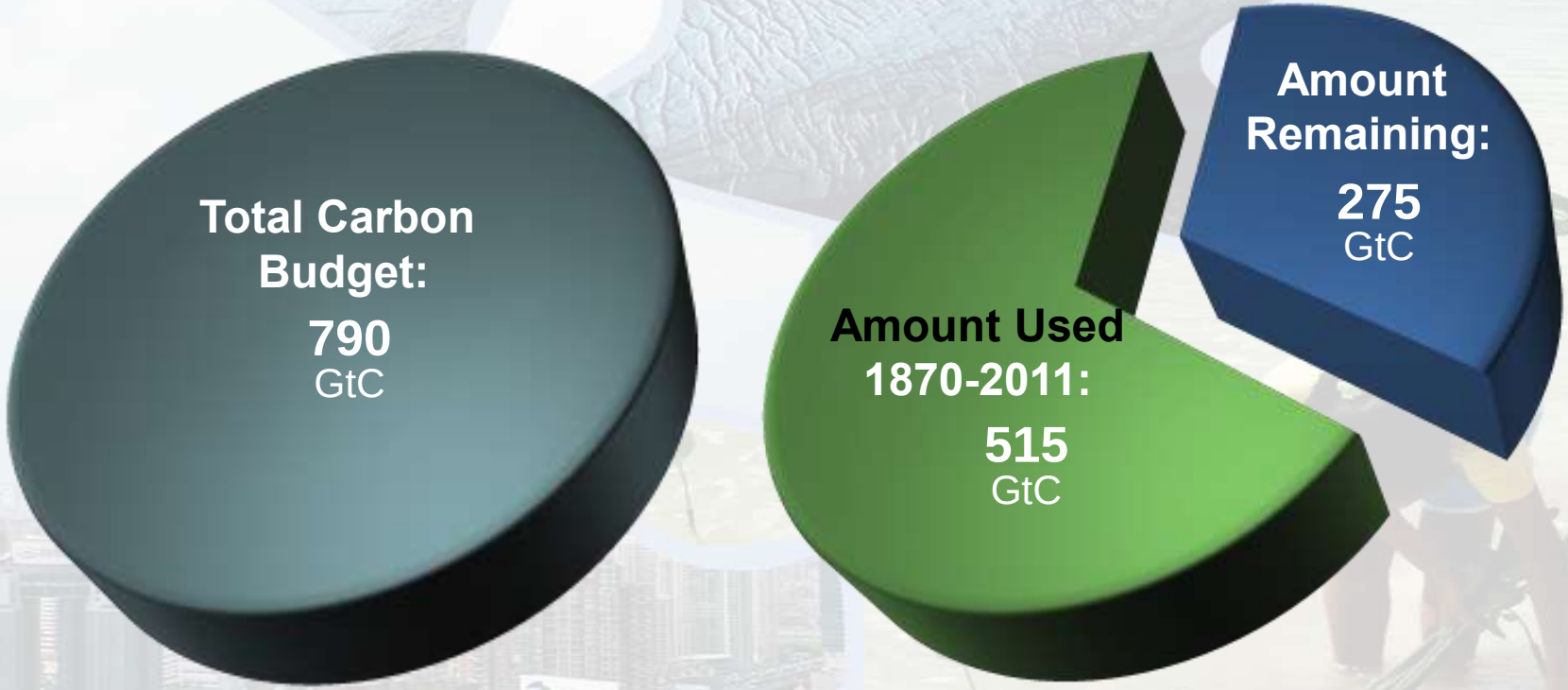
倒數計時 ...

5


Carbon Countdown（以2014年排放推估）
How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?
3°C
2°C
1.5°C
chance of remaining below
33%
50%
66%
33%
50%
66%
33%
50%
66%
0 years
75
25
50
76.8
65.6
55.7
33.3
28.4
20.9
17.2
9.8
6.0
http://bit.ly/carboncountdown
The Carbon Brief

The window for action is rapidly closing

65% of our carbon budget compatible with a 2˚ C goal already used

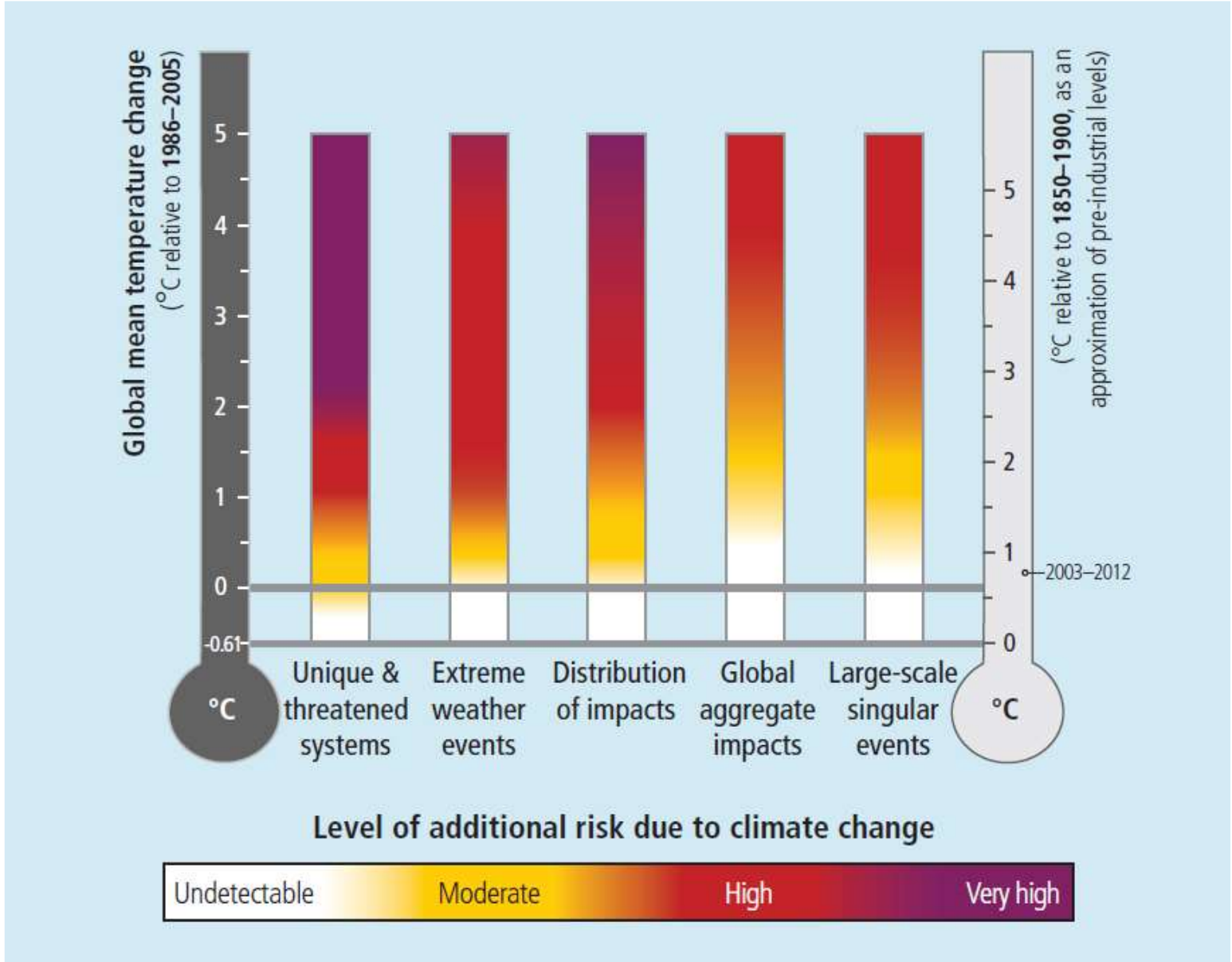


AR5 WGI SPM

若以2度C為目標，我們已經排放65%的碳，只剩35%"額度"。
要達成目標，需急速與深度減碳。

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP


Global mean temperature change
(°C relative to 1986–2005)
5
4
3
2
1
0
-0.61
°C
Unique & threatened systems
Extreme weather events
Distribution of impacts
Global aggregate impacts
Large-scale singular events
(°C relative to 1850–1900, as an approximation of pre-industrial levels)
5
4
3
2
1
0
2003–2012
°C
Level of additional risk due to climate change
Undetectable
Moderate
High
Very high

Box 2.4 | Reasons For Concern Regarding Climate Change

Five Reasons For Concern (RFCs) have provided a framework for summarizing key risks since the IPCC Third Assessment Report. They illustrate the implications of warming and of adaptation limits for people, economies and ecosystems across sectors and regions. They provide one starting point for evaluating dangerous anthropogenic interference with the climate system. All warming levels in the text of Box 2.4 are relative to the 1986–2005 period. Adding ~0.6°C to these warming levels roughly gives warming relative to the 1850–1900 period, used here as a proxy for pre-industrial times (right-hand scale in Box 2.4, Figure 1). *{WGII Assessment Box SPM.1}*

The five RFCs are associated with:

1. **Unique and threatened systems:** Some ecosystems and cultures are already at risk from climate change (*high confidence*). With additional warming of around 1°C, the number of unique and threatened systems at risk of severe consequences increases. Many systems with limited adaptive capacity, particularly those associated with Arctic sea ice and coral reefs, are subject to very high risks with additional warming of 2°C. In addition to risks resulting from the *magnitude* of warming, terrestrial species are also sensitive to the *rate* of warming, marine species to the rate and degree of ocean acidification and coastal systems to sea level rise (Figure 2.5).

2. **Extreme weather events:** Climate change related risks from extreme events, such as heat waves, heavy precipitation and coastal flooding, are already moderate (*high confidence*). With 1°C additional warming, risks are high (*medium confidence*). Risks associated with some types of extreme events (e.g., extreme heat) increase progressively with further warming (*high confidence*).

3. **Distribution of impacts:** Risks are unevenly distributed between groups of people and between regions; risks are generally greater for disadvantaged people and communities everywhere. Risks are already moderate because of regional differences in observed climate change impacts, particularly for crop production (*medium* to *high confidence*). Based on projected decreases in regional crop yields and water availability, risks of unevenly distributed impacts are high under additional warming of above 2°C (*medium confidence*).

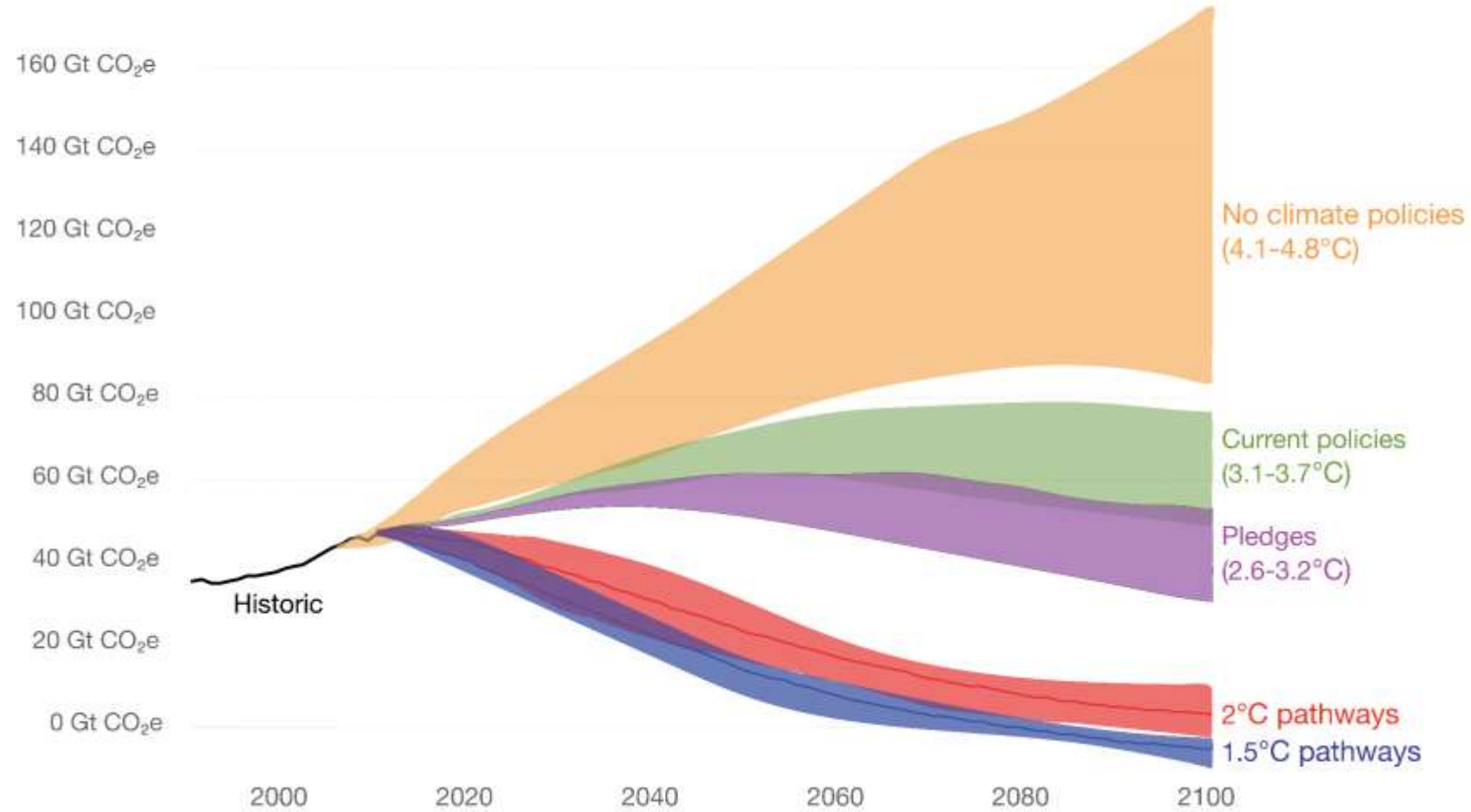
4. **Global aggregate impacts:** Risks of global aggregate impacts are moderate under additional warming of between 1°C and 2°C, reflecting impacts on both the Earth's biodiversity and the overall global economy (*medium confidence*). Extensive biodiversity loss, with associated loss of ecosystem goods and services, leads to high risks at around 3°C additional warming (*high confidence*). Aggregate economic damages accelerate with increasing temperature (*limited evidence, high agreement*), but few quantitative estimates are available for additional warming of above 3°C.

5. **Large-scale singular events:** With increasing warming, some physical and ecological systems are at risk of abrupt and/or irreversible changes (see Section 2.4). Risks associated with such tipping points are moderate between 0 and 1°C additional warming, since there are signs that both warm-water coral reefs and Arctic ecosystems are already experiencing irreversible regime shifts (*medium confidence*). Risks increase at a steepening rate under an additional warming of 1 to 2°C and become high above 3°C, due to the potential for large and irreversible sea level rise from ice sheet loss. For sustained warming above some threshold greater than ~0.5°C additional warming (*low confidence*) but less than ~3.5°C (*medium confidence*), near-complete loss of the Greenland ice sheet would occur over a millennium or more, eventually contributing up to 7 m to global mean sea level rise.

Global greenhouse gas emissions scenarios

Our World in Data

Potential future emissions pathways of global greenhouse gas emissions (measured in gigatonnes of carbon dioxide equivalents) in the case of no climate policies, current implemented policies, national pledges within the Paris Agreement, and 2°C and 1.5°C consistent pathways. High, median and low pathways represent ranges for a given scenario. Temperature figures represent the estimated average global temperature increase from pre-industrial, by 2100.



Based on data from the Climate Action Tracker (CAT).
The data visualization is available at OurWorldinData.org. There you find research and more visualizations on this topic.

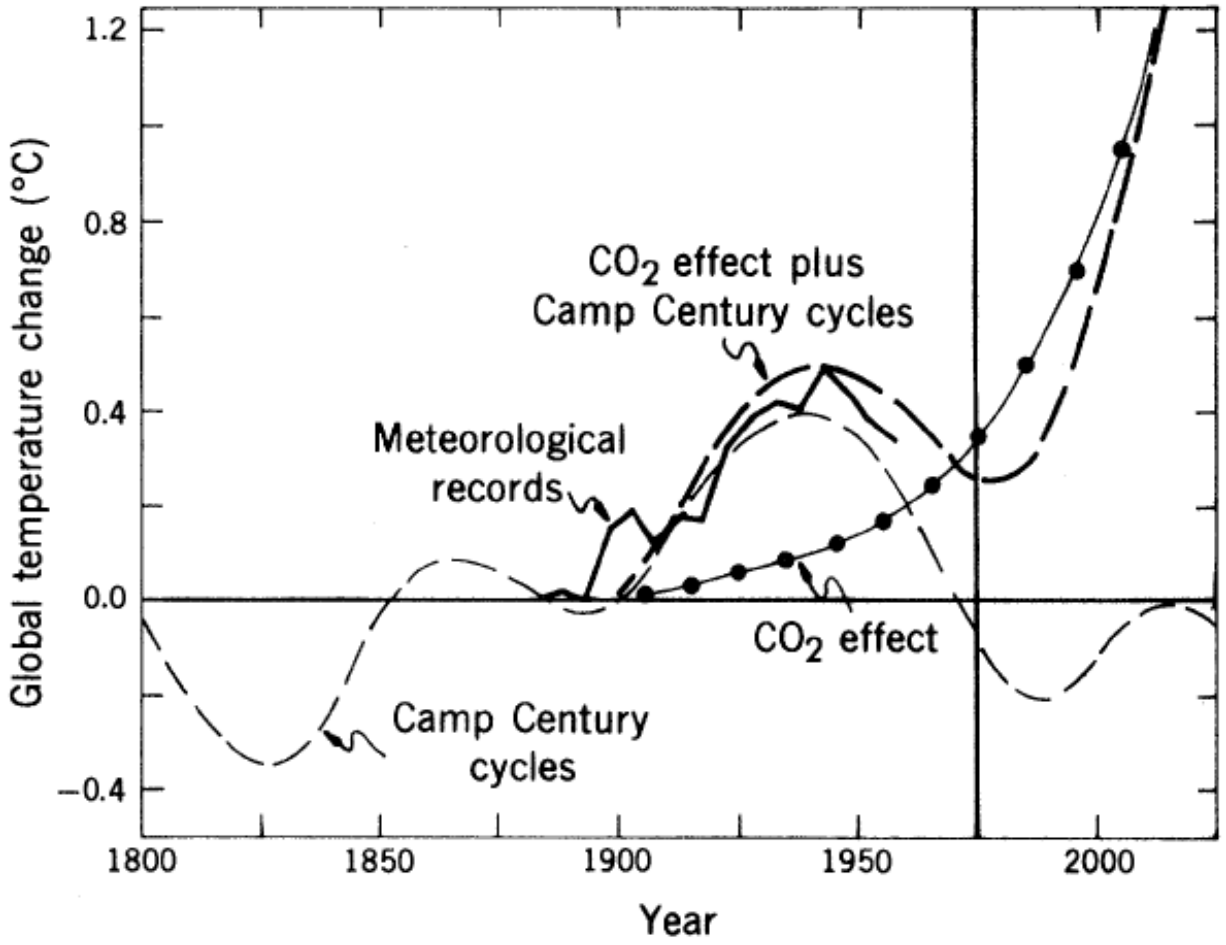
Licensed under CC-BY-SA by the authors Hannah Ritchie and Max Roser.

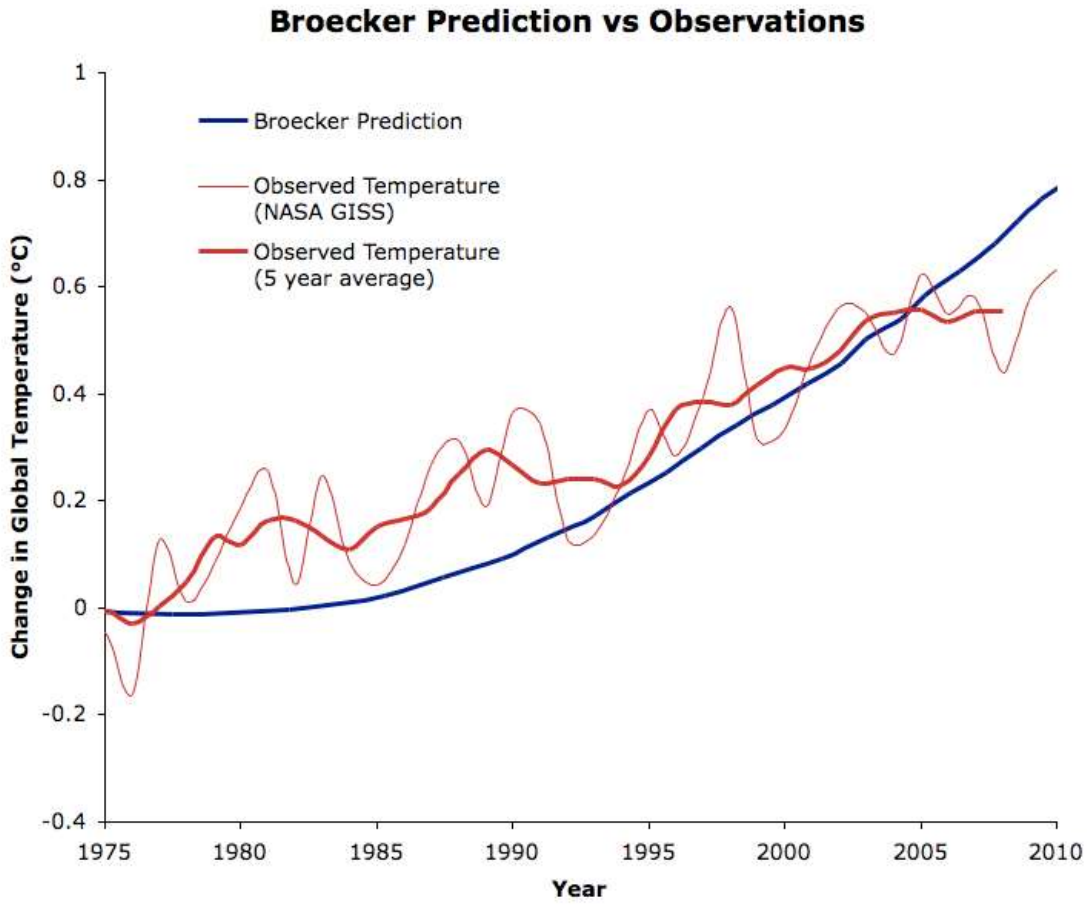
CO_2 and other Greenhouse Gas Emissions
https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions?fbclid=IwAR2HpI-3utY2t-6pEVsobZh-X0aDOfk2SM6t5BkNHs09QcqL3pYRZ9NO6vQ

Exxon predicted in 1982 exactly how high global carbon emissions would be today
https://thinkprogress.org/exxon-predicted-high-carbon-emissions-954e514b0aa9/?fbclid=IwAR1GoM1FWOntaw8U88O4Bc7dk_EcFqXfLgvJRfWu8HNn3QrZVM3FDF1JsFo

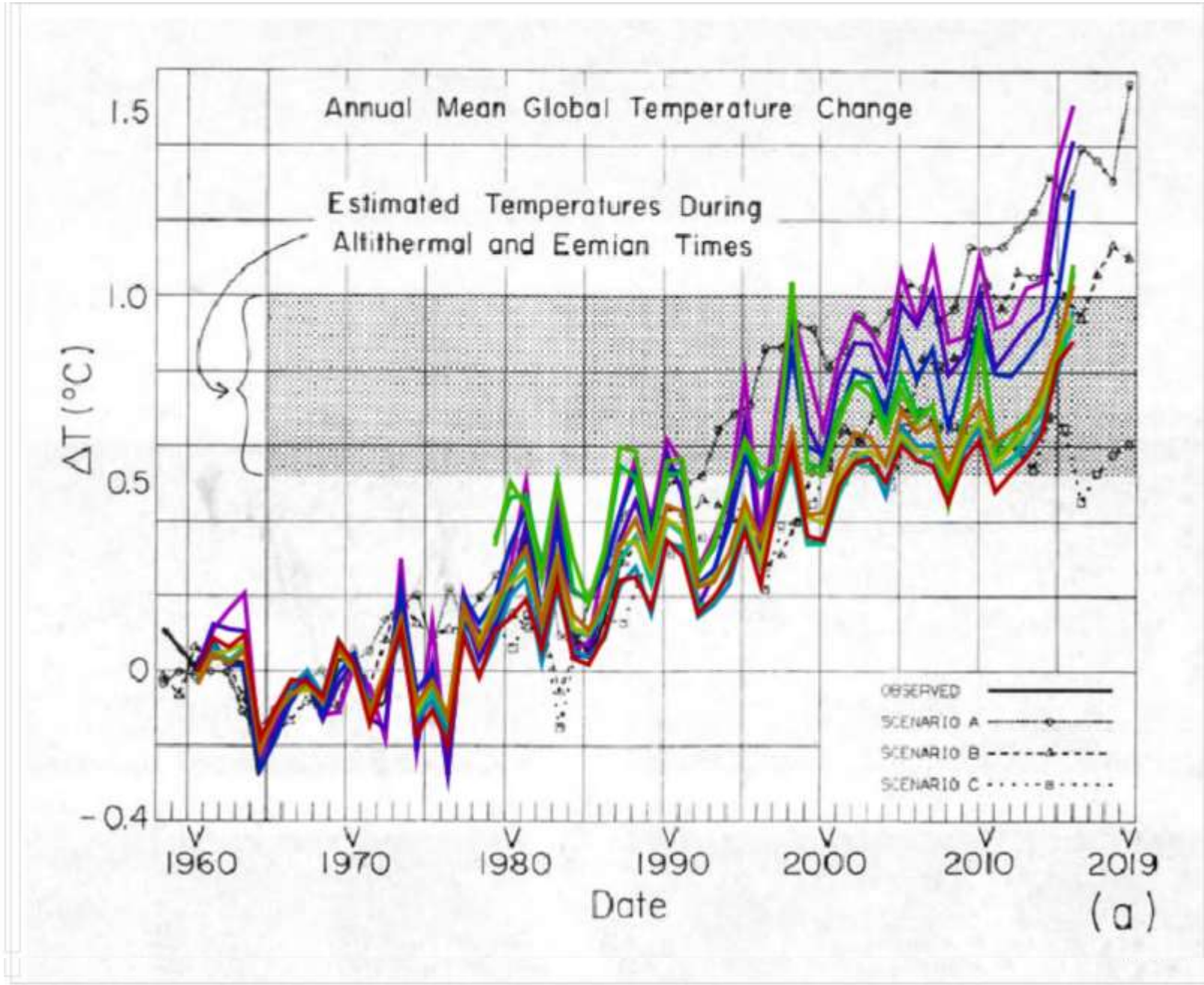
In-depth: BP data reveals record CO2 emissions in 2018 driven by surging use of gas
https://www.carbonbrief.org/in-depth-bp-data-reveals-record-co2-emissions-in-2018-driven-by-surging-use-of-gas?fbclid=IwAR09YLupJ0Q114mJ9TCiztehY_cocrg7uOl2OV6z6UQk3vCIWLBhgHV5soA

Wallace Broecker (1975)
Climatic Change: Are We on the Brink of a Pronounced Global Warming?





https://skepticalscience.com/lessons-from-past-climate-predictions-broecker.html



James Hansen presenting early evidence of global warming to the US Congress

Wallace Broecker (1975)
Charney et al. (1979)

Jim Hansen 1988 國會作證:
人為暖化已經發生
且預測了暖化趨勢

結果呢?
趨勢有掌握到。

其實，埃克森美孚石油公司也早就知道了！

“Exxon predicted in 1982 exactly how high global carbon emissions would be today”
(Kyla Mandel, Think Progress, May 19, 2019)

CO_2 GREENHOUSE EFFECT

A TECHNICAL REVIEW

PREPARED BY THE

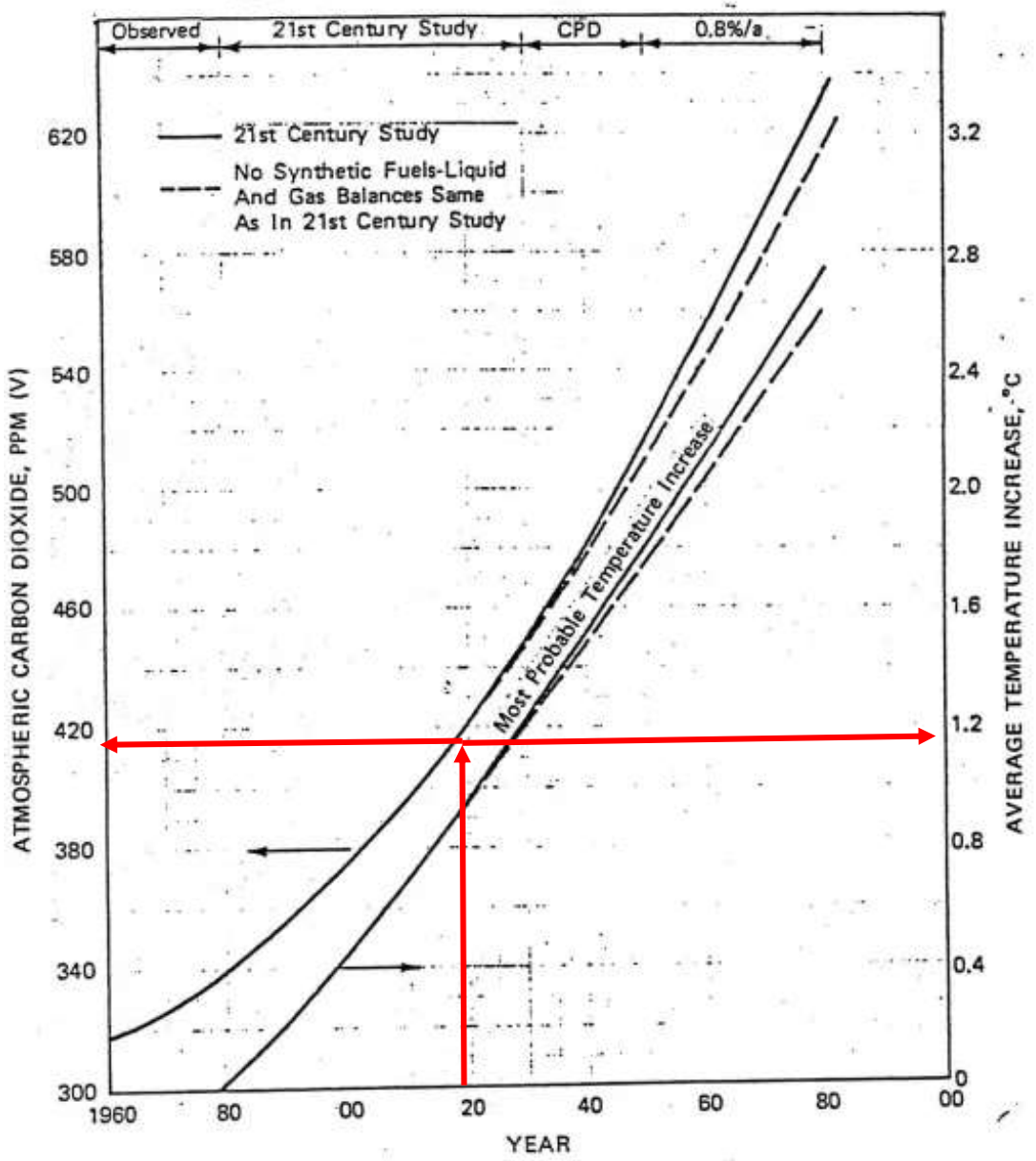
COORDINATION AND PLANNING DIVISION

EXXON RESEARCH AND ENGINEERING COMPANY

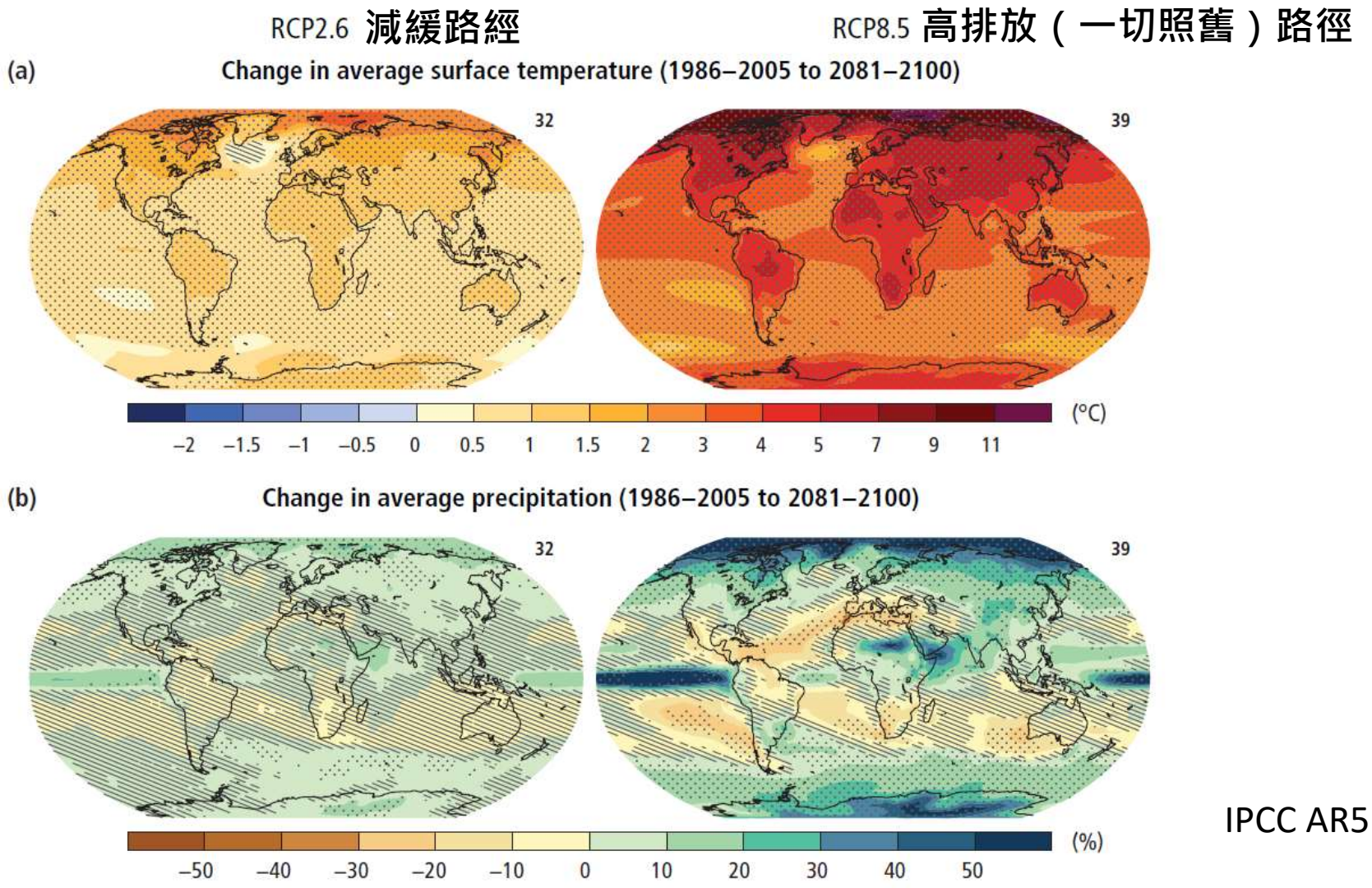
APRIL 1, 1982

Figure 3

GROWTH OF ATMOSPHERIC CO_2 AND AVERAGE GLOBAL TEMPERATURE INCREASE AS A FUNCTION OF TIME

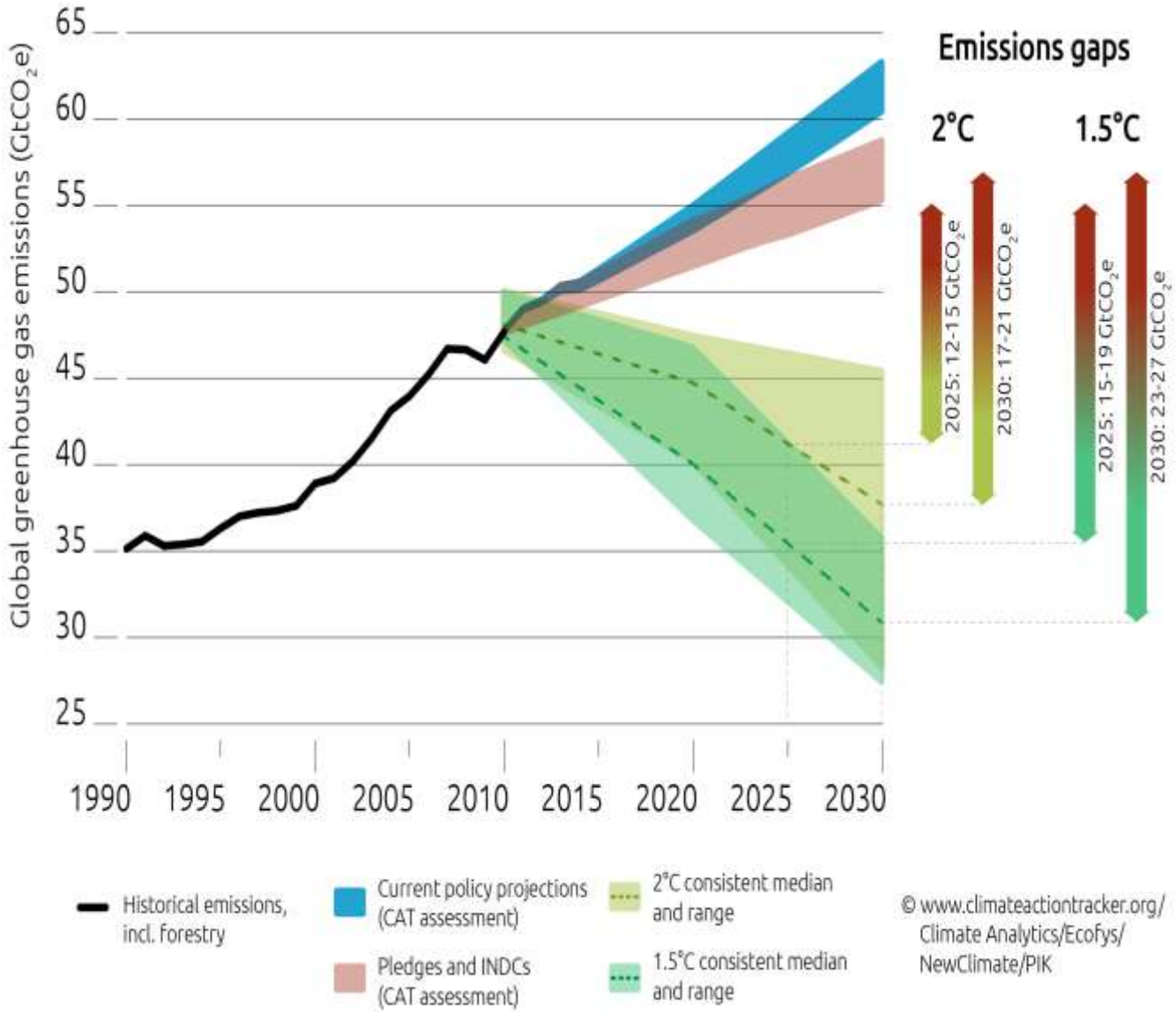


全球暖化已經無法避免，但有機會選擇暖化程度，降低衝擊



IPCC AR5

巴黎協議各國的減排承諾與2°C(1.5°C)所須的減排量有明顯差距



Limiting Temperature Increase to 2˚C

控制在2˚C

Measures exist to achieve the substantial emissions reductions required to limit likely warming to 2˚ C

現有方法可達2˚C所需的深度減碳

A combination of adaptation and substantial, sustained reductions in greenhouse gas emissions can limit climate change risks

結合調適與深度減碳可以限制氣候變遷風險

Implementing reductions in greenhouse gas emissions poses substantial technological, economic, social, and institutional challenges

深度減碳面對可觀的的技術、經濟、社會與制度挑戰

But delaying mitigation will substantially increase the challenges associated with limiting warming to 2˚ C

延遲落實減緩機制，難度大幅增加

AR5 WGI SPM, AR5 WGII SPM,AR5 WGIII SPM

UNFCCC - COP21
第21屆聯合國氣候變遷大會
巴黎，2015/11/30-12/11

簽訂巴黎協議
（4.11.2016生效）

- 減碳目標：2°C，努力達到1.5°C
- 規範法制化，5年查核點（2021）
- 節能、減排、再生能源
- 永續發展與調適
- 氣候金融(每年2000億美金，Green Climate Fund)
- 邁向低碳與韌性經濟→新綠色經濟
- 由下而上:社區、企業、地方政府、國際組織

面對超限的未來

需要超限的思維與作為

新思維、新的生活形態、新的商業行為→創意無限的未來

危機＝機會

錯過減排風潮，喪失翻轉良機

想想 –
全球暖化的未來，
台灣(妳/你)的機會在哪裡?
如何將危機，化為轉機?

- 發揮創意，拯救地球，改善環境，成就自己 -