

Satellite, Typhoon, Ocean, and Global Warming – My Adventure

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(Many thanks to team members and collaborators...)



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BSc, Dept. of Atm. Sciences, NTU

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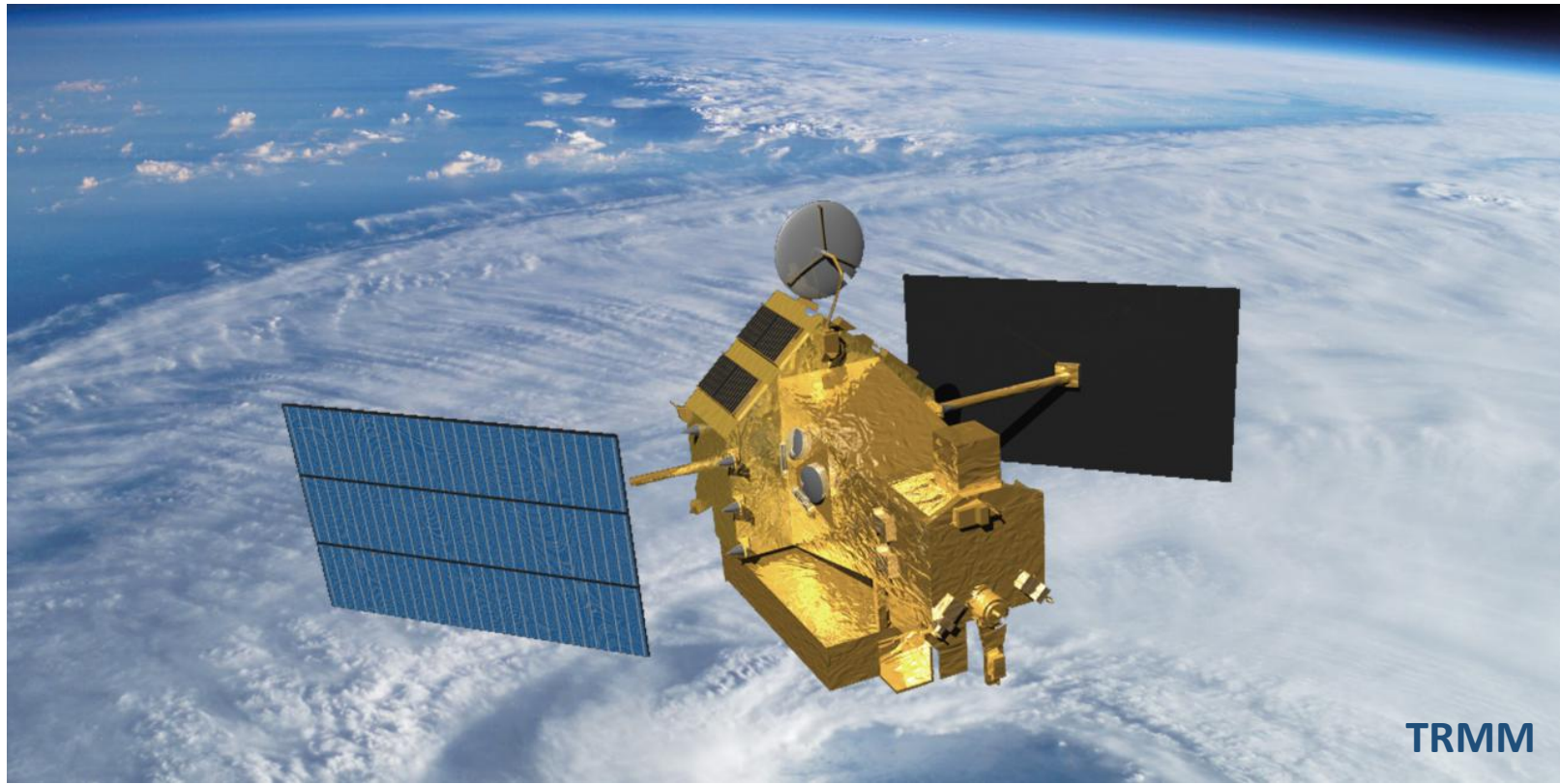
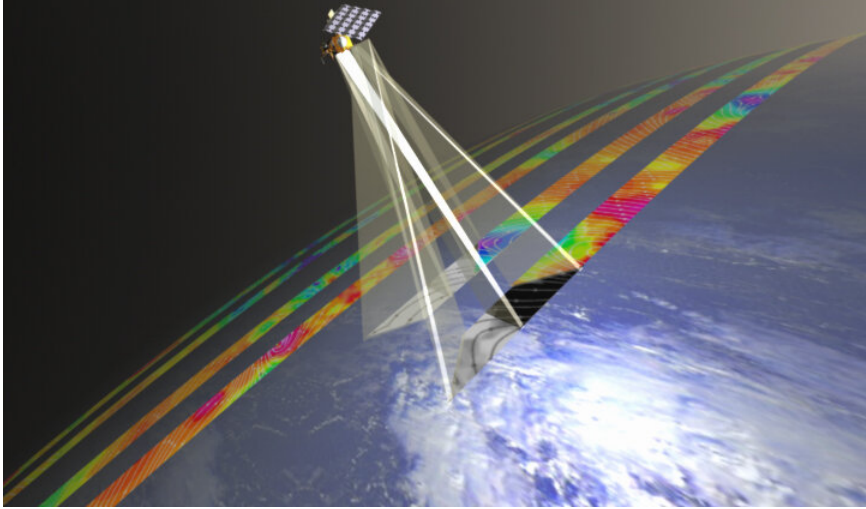
National Center for Ocean Research, MOST

Dept. of Atmospheric Sciences, NTU

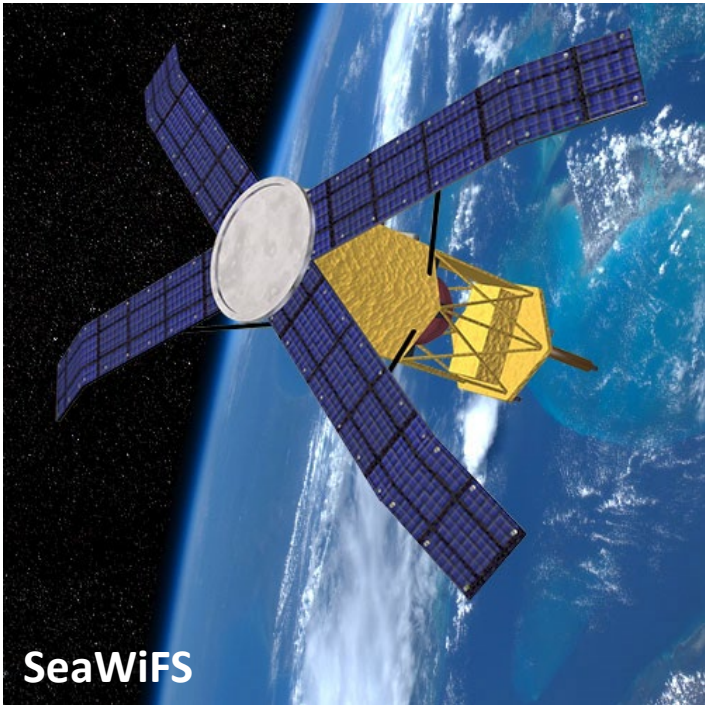
專長領域：跨領域衛星遙測、大氣科學、與海洋科學

研究主題：熱帶氣旋(颱風)-海洋交互作用、氣候、碳循環、全球暖化

ASCAT



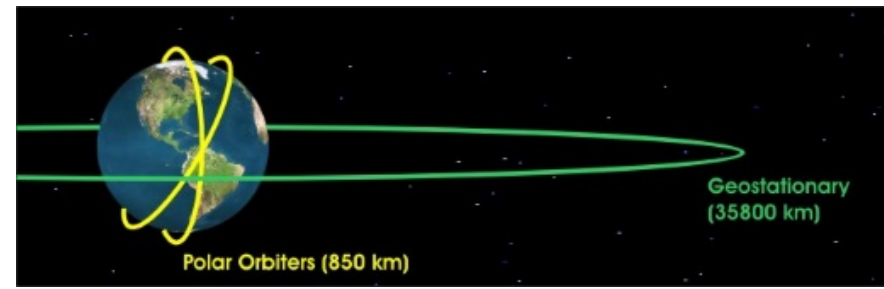
TRMM



SeaWiFS



Himawari



- 1. Grand and Global Perspective
- 2. Multi-satellites for Physical/Bio-Geochemical Interactions

A Whole New World (電影“阿拉丁”主題曲)

Lyrics:Tim Rice Music:Tim Rice Vocal:Peabo Bryson/Regina Belle

I can show you the world, Shining, Shimmering, splendid
Tell me, princess, now when did, You last let your heart decide
I can open your eyes, Take you wonder by wonder
Over, sideways and under, On a magic carpet ride
A whole new world, A new fantastic point of view
No one to tell us no or where to go, Or say we're only dreaming
A whole new world, A Dazzling place I never knew
But when I'm way up here, It's crystal clear
That now I'm in a whole new world with you
(now I'm in a whole new world with you)



On a magic carpet ride

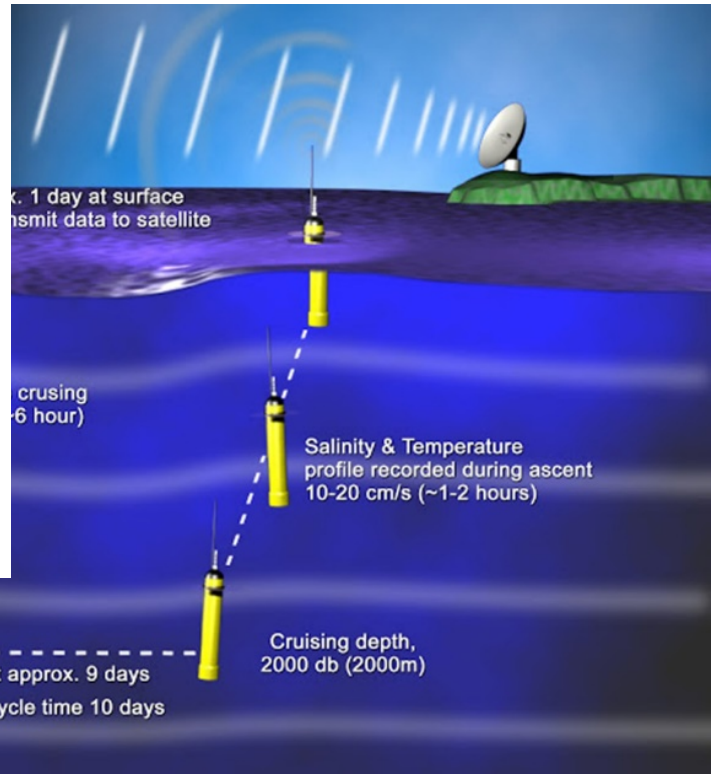
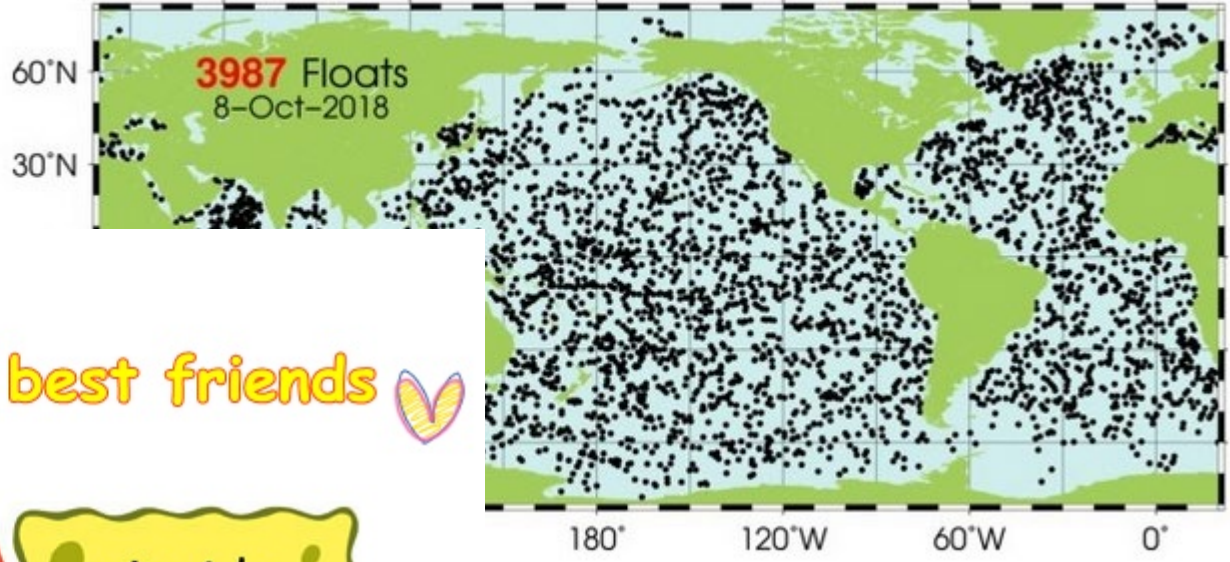
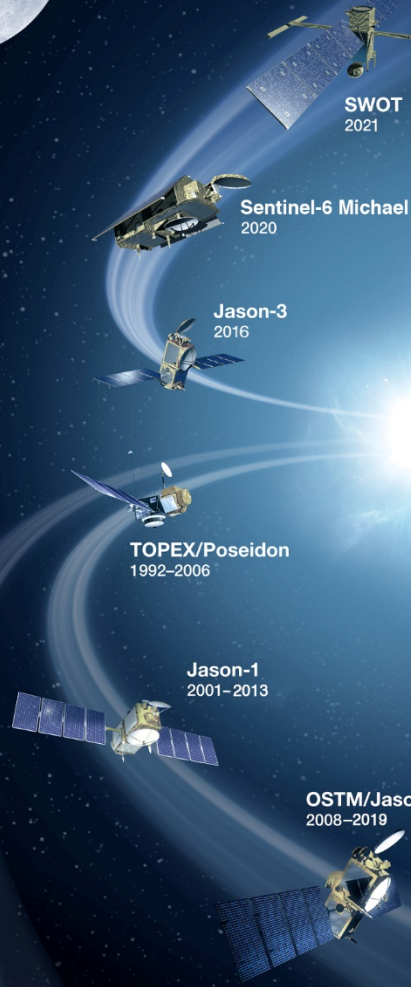
Play (k)

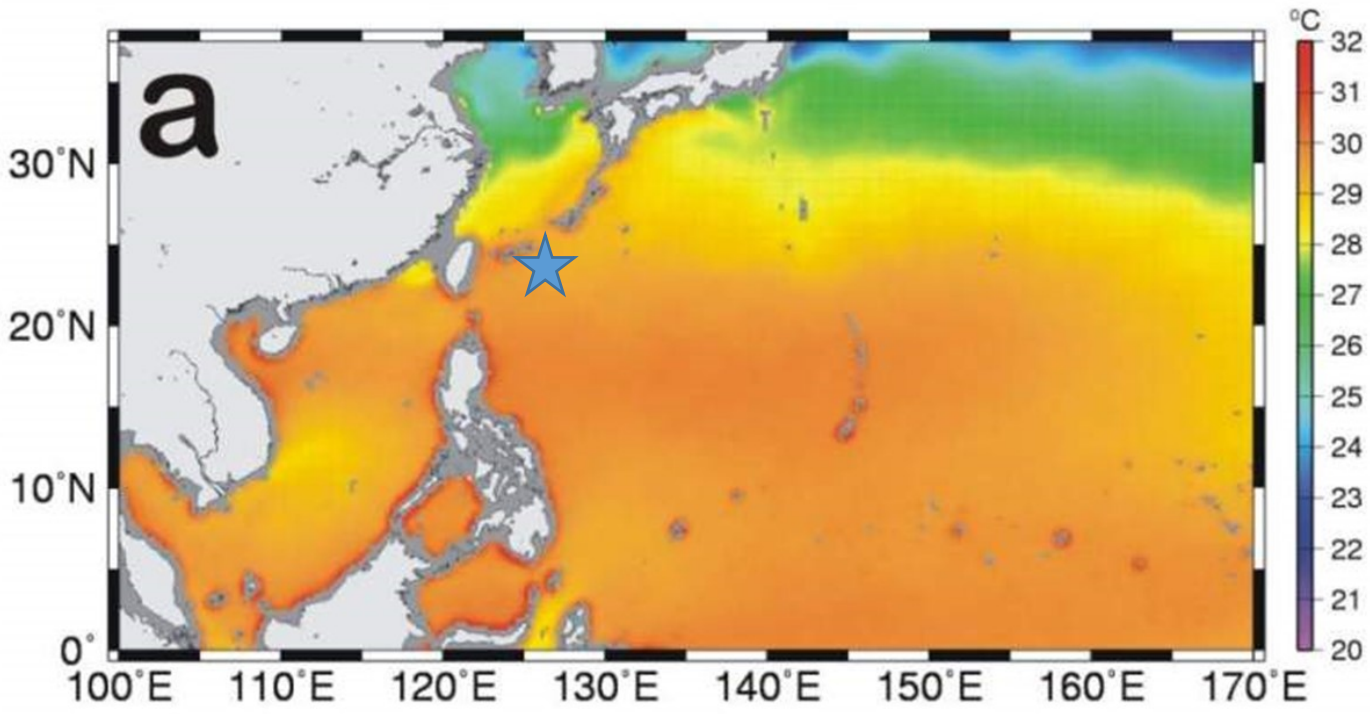
▶ ⏪ 🔊 1:05 / 2:52



A new fantastic point of view

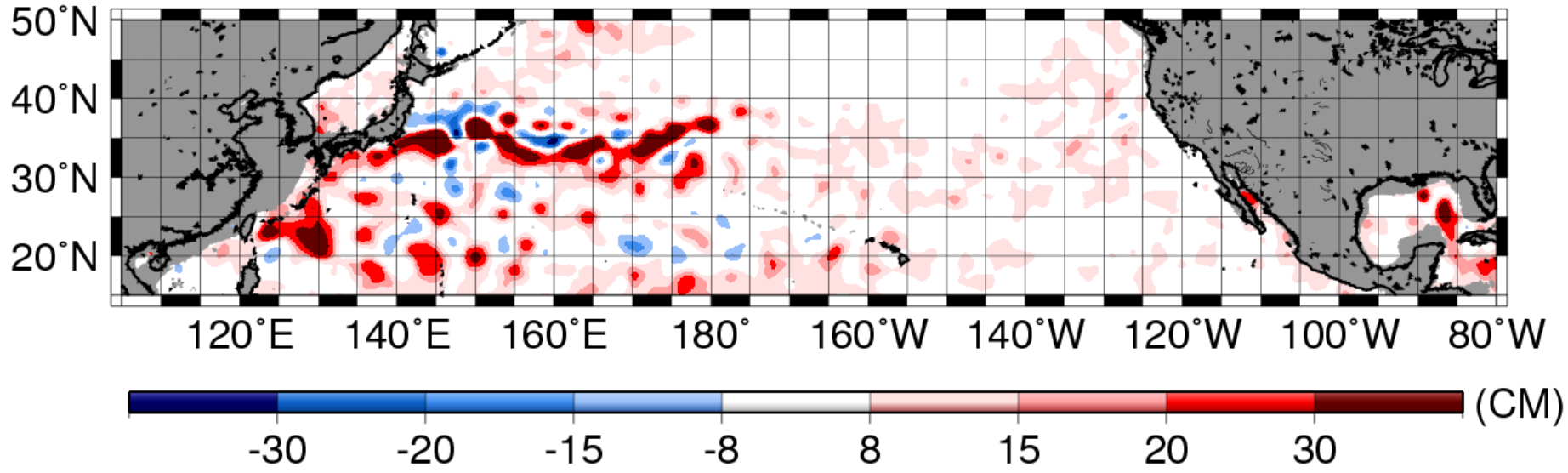




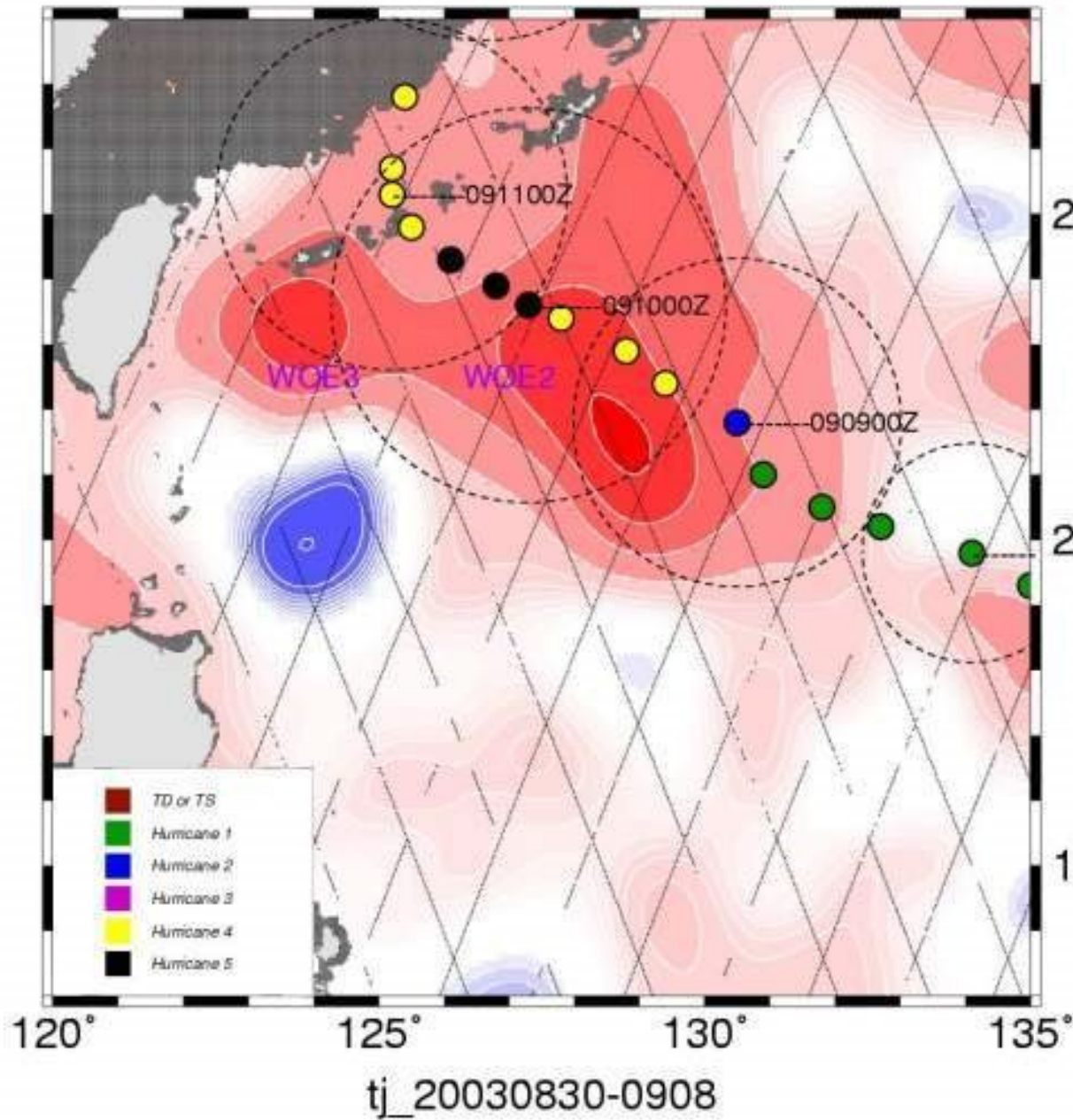


颱風突然增強—
預報挑戰，
why here?

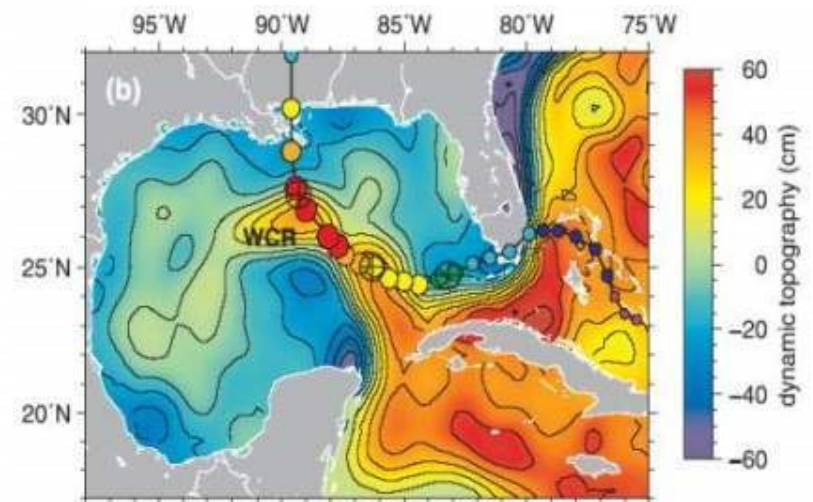
看似平靜，
其實……



TOPEX/Jason-1 Sea Surface Height Anomaly 20030823-0902

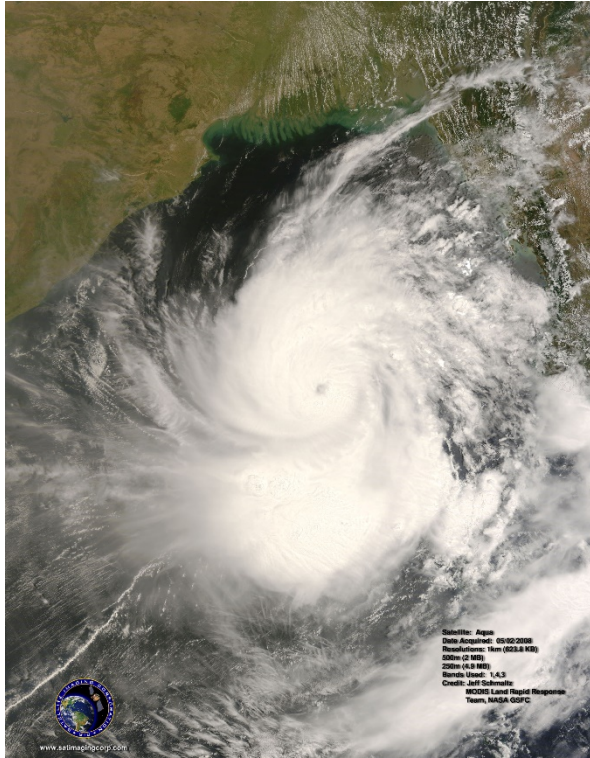


Maemi: most intense TC on earth in 2003,



Scharoo et al. EOS 2006

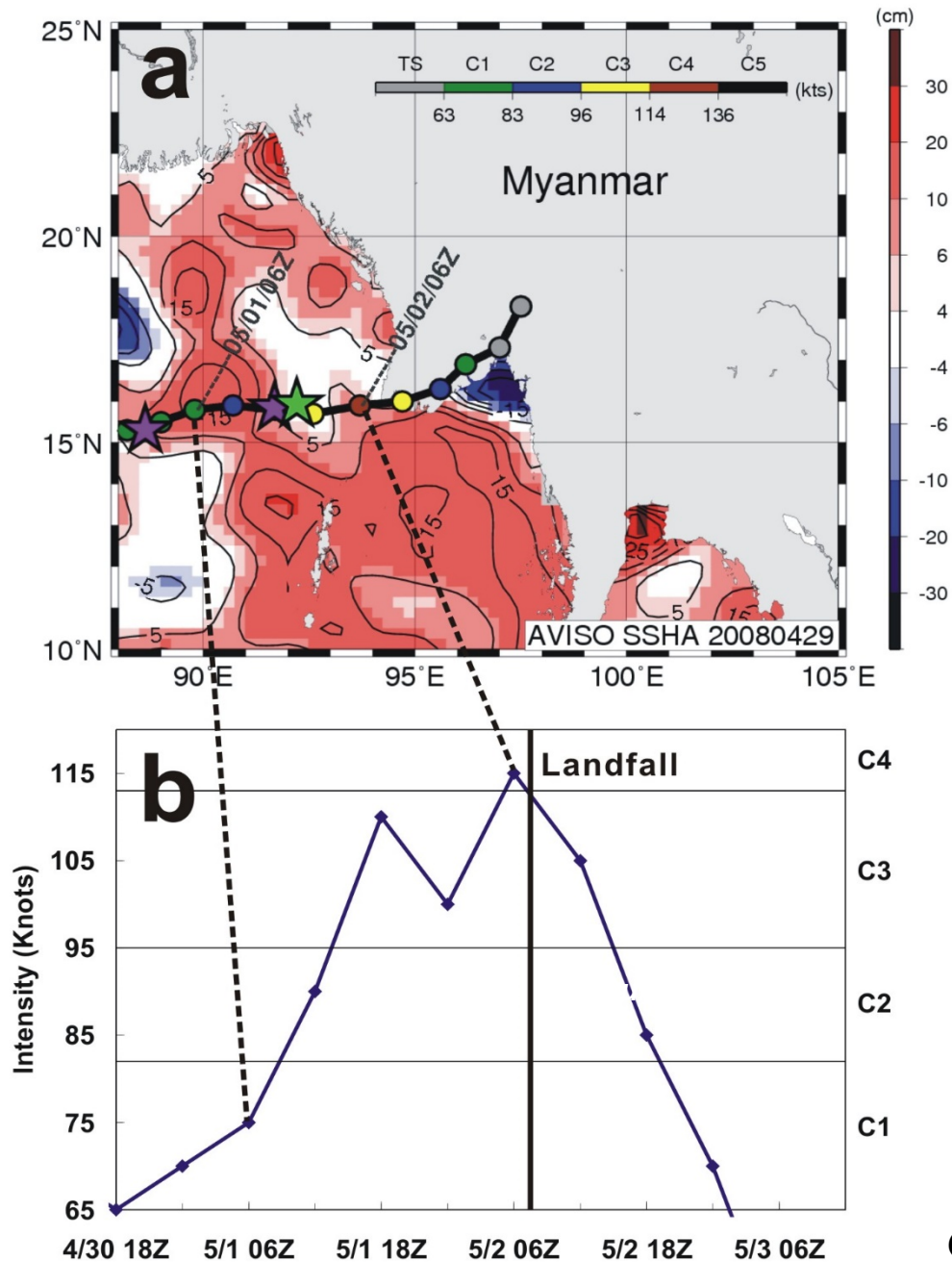
Killer Cyclone Nargis (2008)



**Death toll
> 130,000**

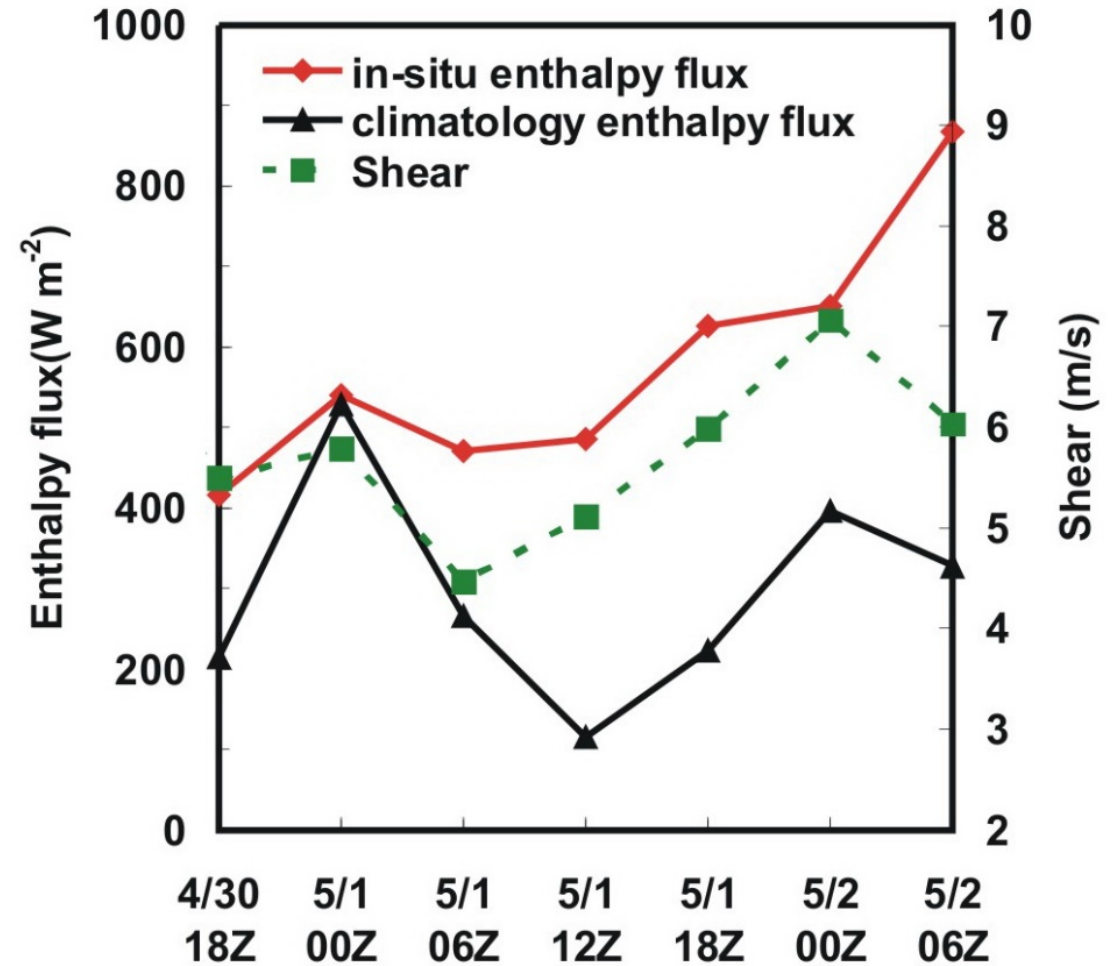


Killer cyclone Nargis (2008)



Sudden Intens. before landfall

在登陸前突然增強/海水倒灌



Lin et al.

GRL 2009

Catastrophic event:

RI just prior to landfall

GLOBAL CLIMATE CHANGE

NASA's Eyes on the Earth



- Home
- Key Indicators
- Evidence
- Causes
- Effects
- Uncertainties
- Solutions
- NASA's Role
- Missions
- Key Websites
- People

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- TWITTER

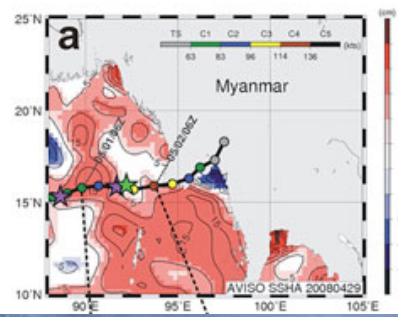
NEWS

text size + -

THE Cutting Edge Newly published JPL research

Seeds of disaster Mar. 2009

03.19.09



On May 2, 2008, Cyclone Nargis caused the worst natural disaster in the history of Myanmar, a country in Southeast Asia that is more commonly known as Burma. Over 130,000 people were killed and, according to United Nations estimates, 1.5 million people were severely affected. More than \$10 billion of damage was done.

One of the things that made Nargis so deadly was the way in which it intensified so quickly before making landfall -- from a category-1 to a category-4 tropical cyclone in just 24 hours. But how exactly did this happen? New research suggests that

Research from:

Jason-1

Jason-1 home page

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NASA Highlight (Feb. Mar. 2009)

USA Today, Science Week....

USA TODAY

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1d 10h ago ScienceDaily

NASA Study Finds 'Pre-Existing Condition' Fueled Killer Cyclone

ScienceDaily (Mar. 2, 2009) A "pre-existing condition" in the North Indian Ocean stoked the sudden intensification of last year's Tropical Cyclone Nargis just before its devastating landfall in Burma, according to a new NASA/university study. The

Related topics:
Nargis, NARR, Burma, Pasadena, California

ScienceWeek

The latest News Headlines from the Scientific, Research and

Study Finds 'Pre-Existing Condition' Fueled Killer Cyclone

26. 2 2009 (23:40)

(PhysOrg.com) -- A "pre-existing condition" in the North Indian Ocean stoked the sudden intensification of last year's Tropical Cyclone Nargis just before its devastating landfall in Burma, according to a new NASA/university study. The cyclone caused Burma's worst natural disaster ever and one of the deadliest in the world.

[Read the story at PhysOrg](#)

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Feb. 2009

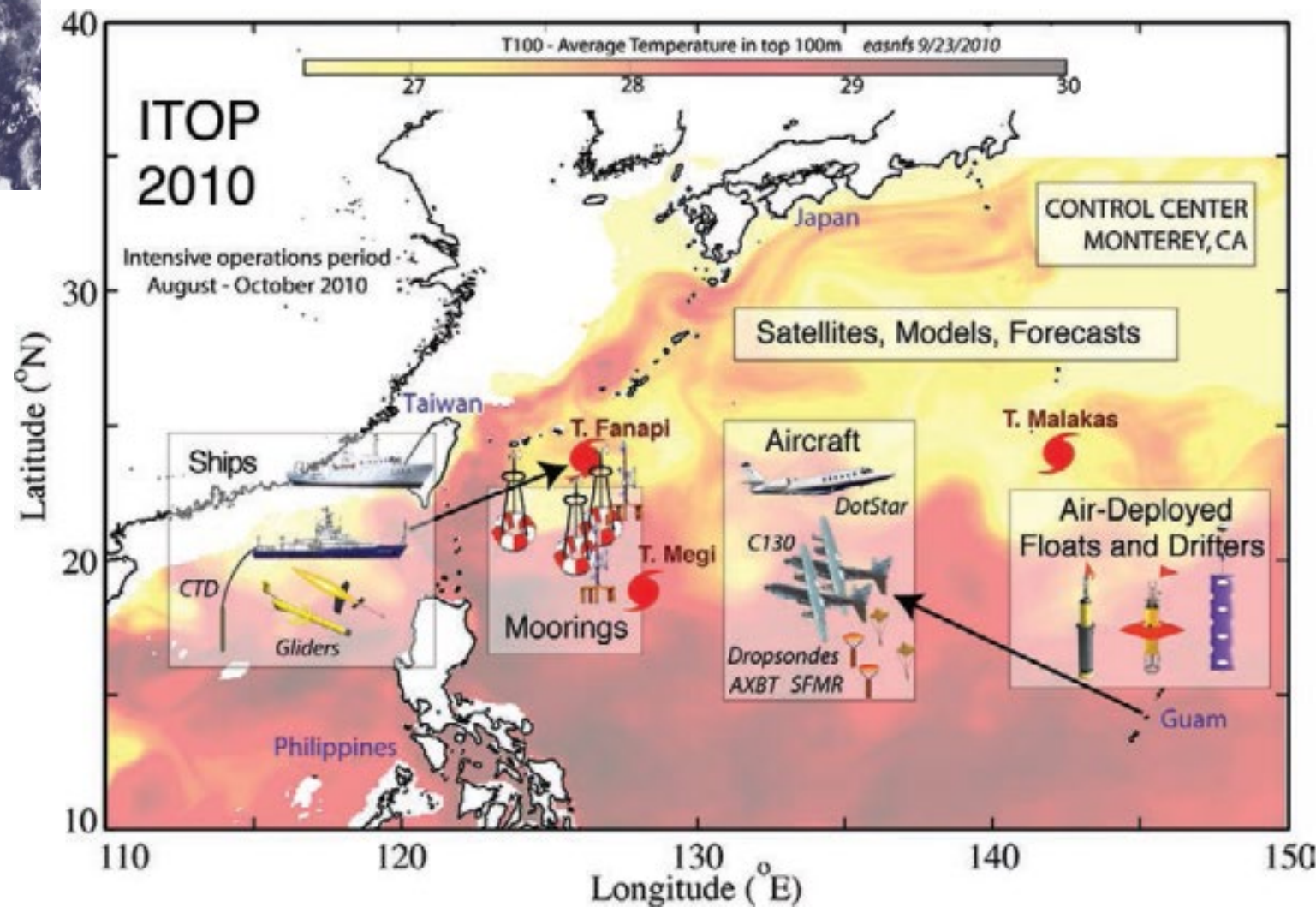
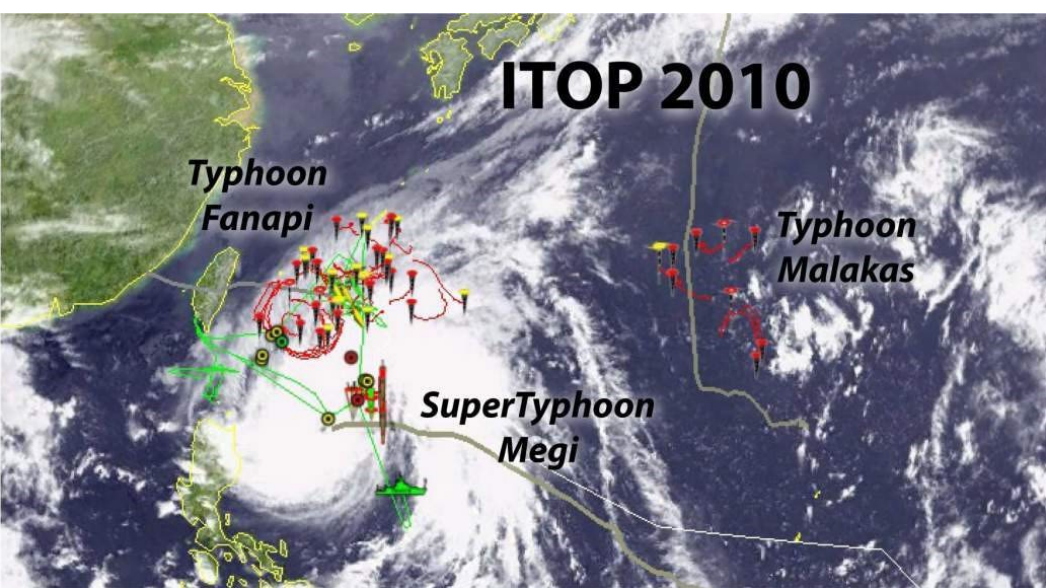
NASA Study Finds 'Pre-Existing Condition' Fueled Killer Cyclone



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D'Asaro et al. 2014

C130 Airdrop

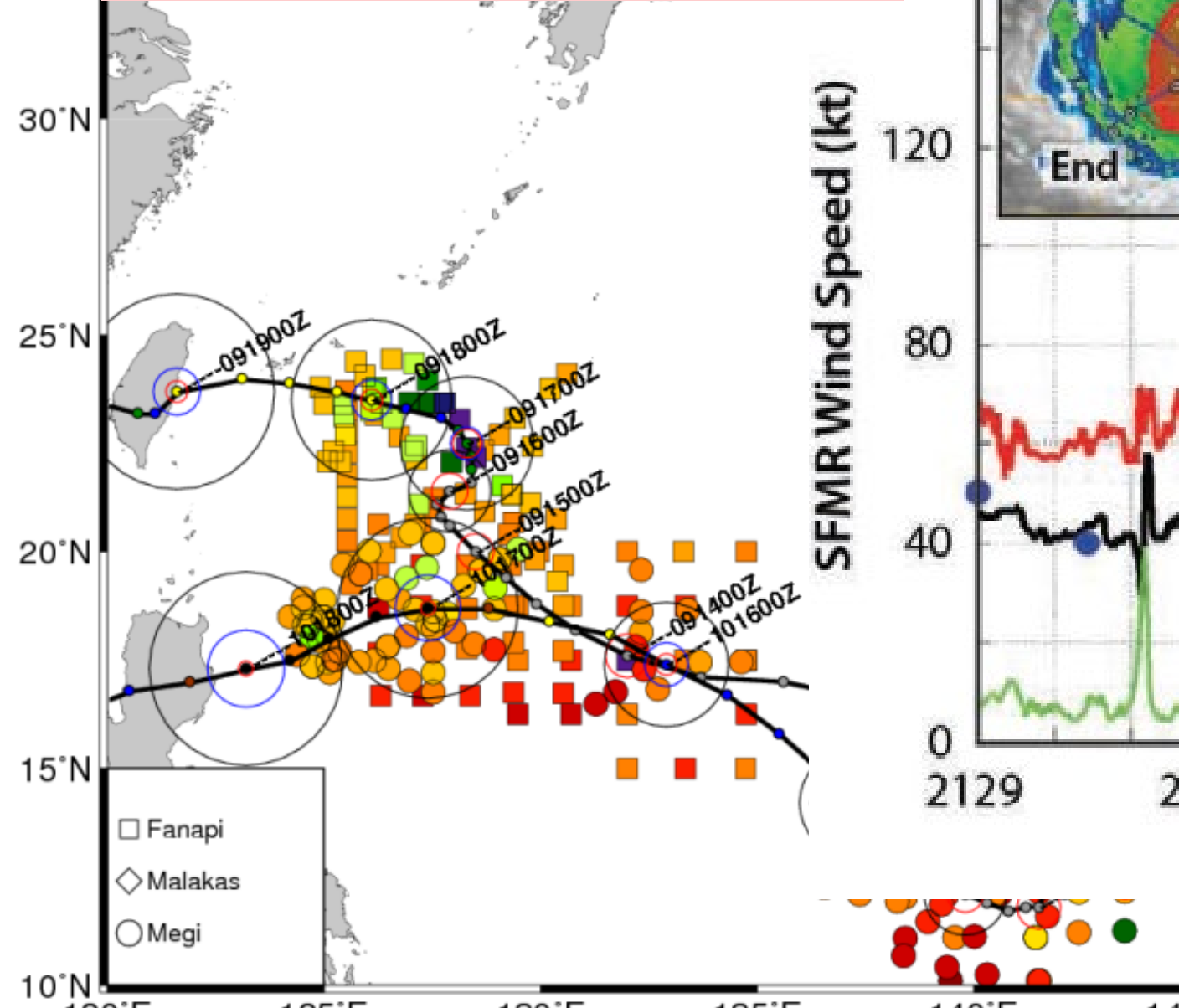


(From Dr. Eric D'Asaro, University of Washington)

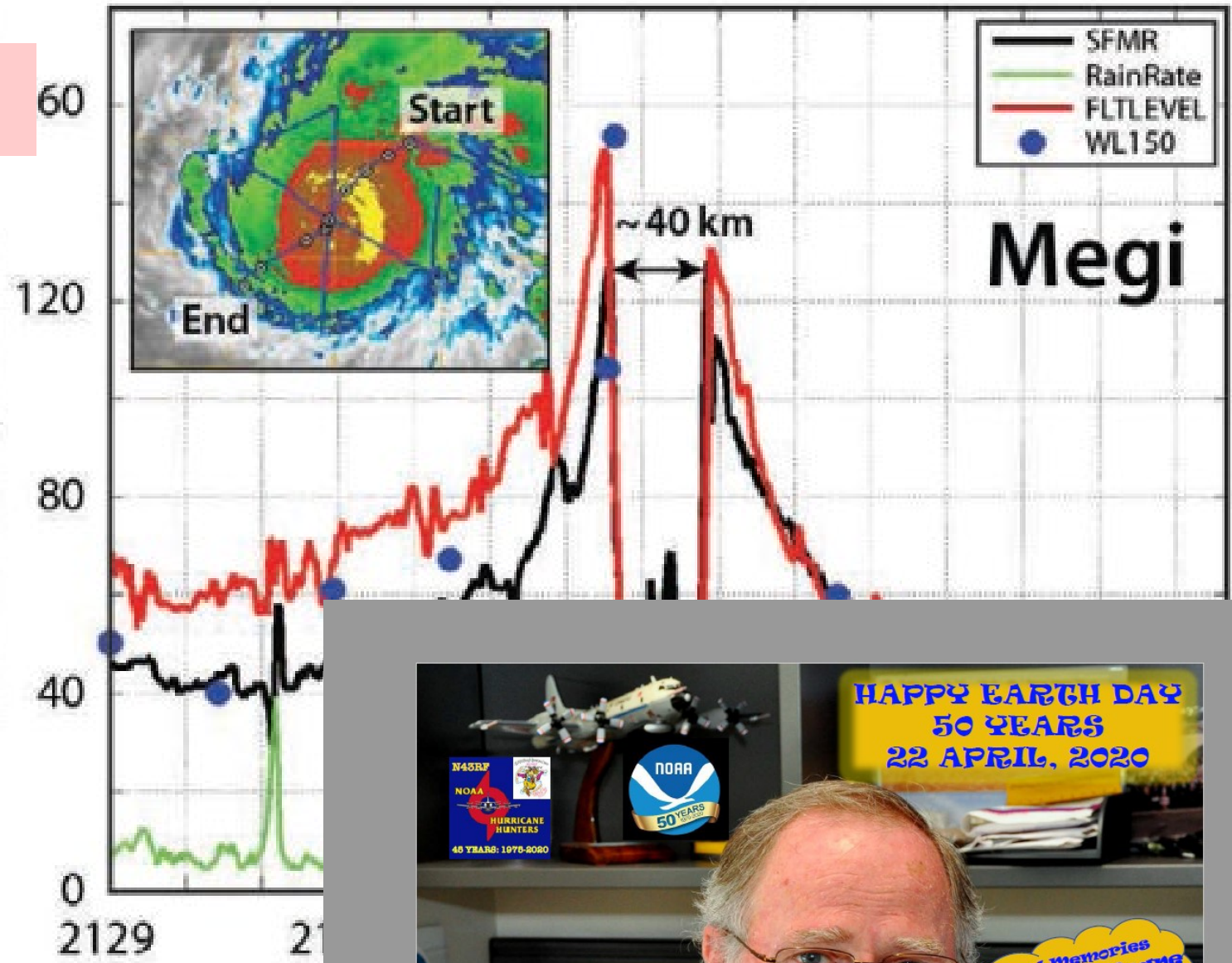
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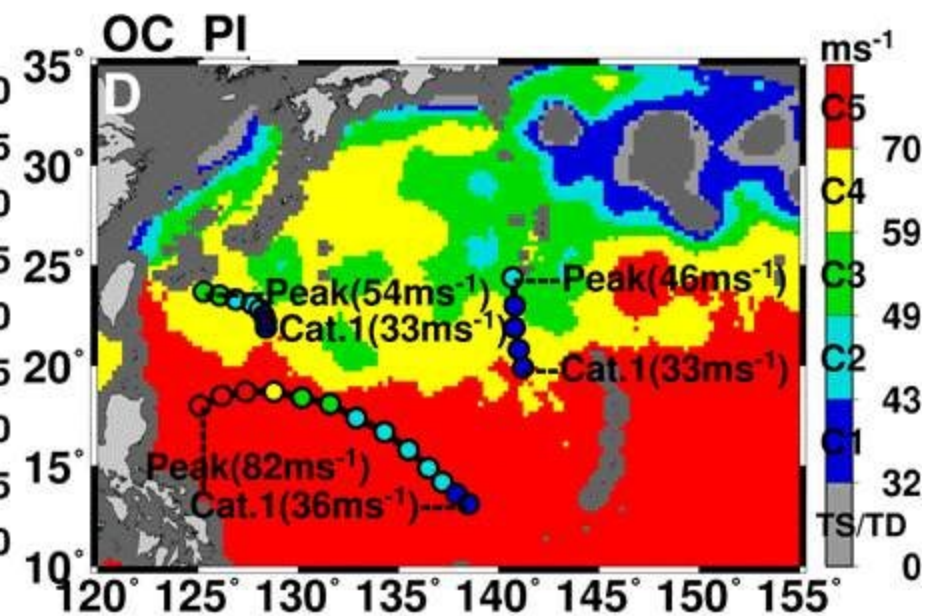
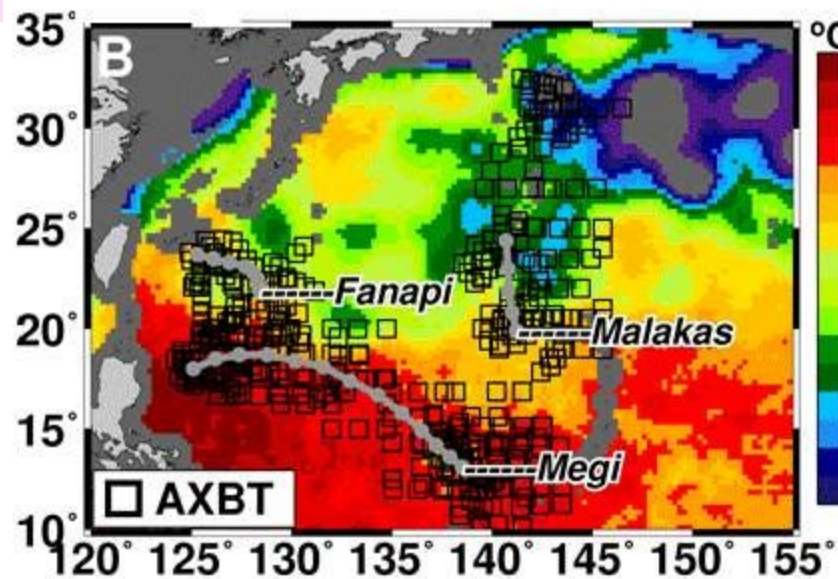
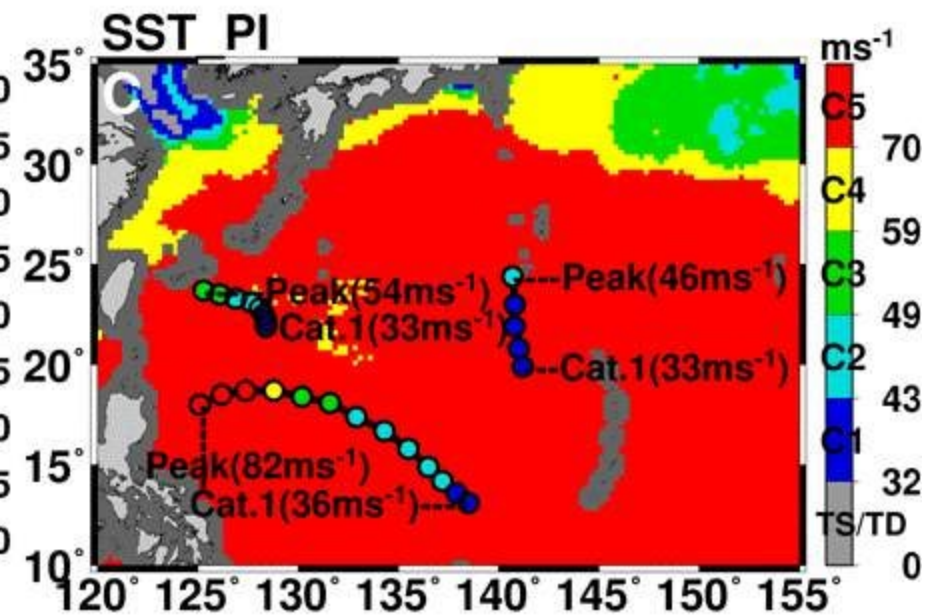
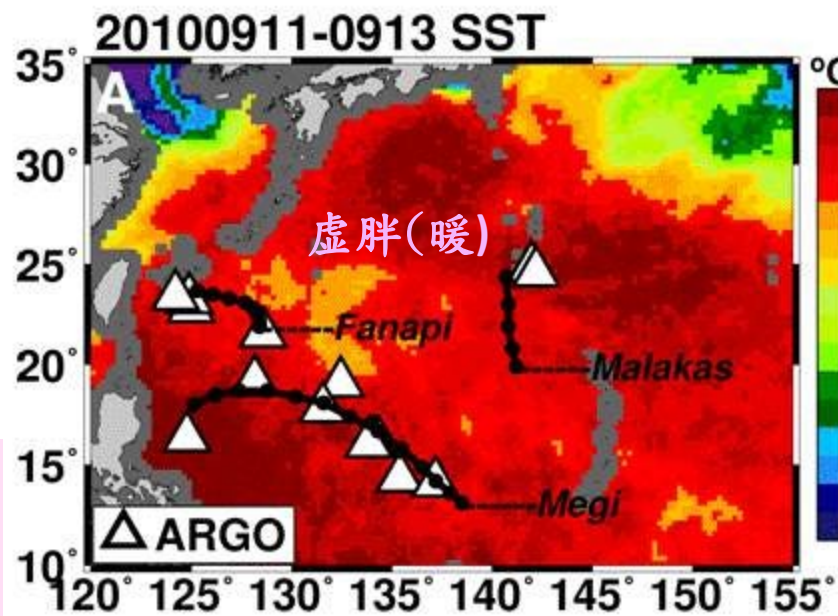
4 Million USD/1.2億 N T
Before, During, After



SFMR Wind Speed (kt)



虛暖區
. VS.
實暖區





1.98m

2.29m

Typhoon Haiyan

Print edition

Worse than hell

One of the strongest storms ever recorded has devastated parts of the Philippines, and relief is slow to arrive

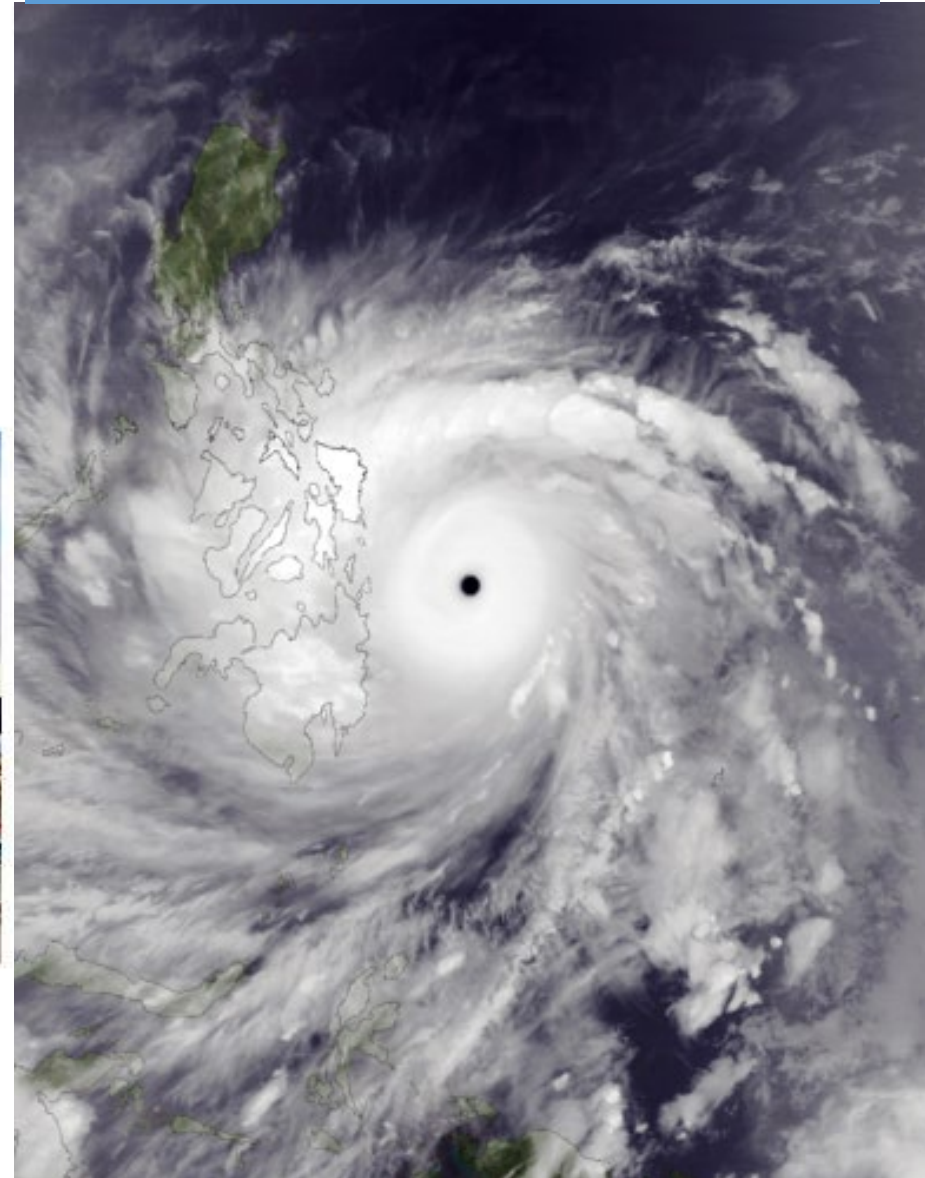
Nov 16th 2013 | CEBU, HANOI AND MANILA | From the print edition



37



Cat. '6', Haiyan (海燕颱風): 170kts!



Death: 6300; Injured: 28689;

Damage : US \$ 2,051,710,653 (2 billion)

http://en.wikipedia.org/wiki/Typhoon_Haiyan



Record holder

Haiyan (170kts) , Megi (160kts), Lin et al. GRL 2014

天啊，
三次方

PDI:
Power
Dissipation
Index
(Destructive
Potential)

ACE:
Accumulated
Cyclone Energy

Category	Winds (knots)	V ² (fcn. of ACE, k. energy)	V ³ (fcn. of PDI, destructiveness)
1	64-82	4,096	262,144
2	83-95	6,889	571,787
3	96-113	9,216	884,736
4	114-135	12,996	1,481,544
5 (Katrina)	>135 - 159	18,225	2,460,375
'Cat 6'? (Haiyan)	>=160 (160-170- 185)	25,600- 28,900- 34,225	4,096,000-4,913,000- 6,331,625

19

13

18

22

25

x1.7

x1.3

x1.4

x1.4

x1.5-1.6-
1.9

x2.2

x1.5

x1.7

x1.7

x1.8-
2.0-2.6

Pun et al. 2013

Lin et al. 2014

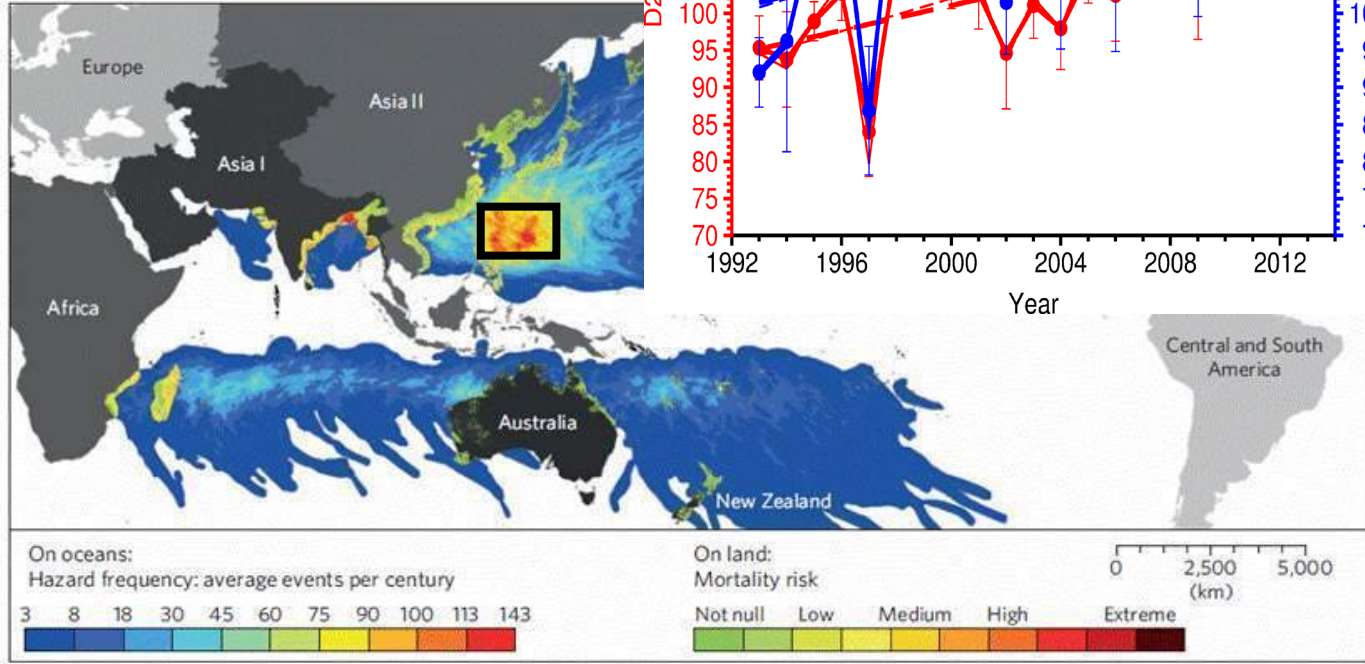
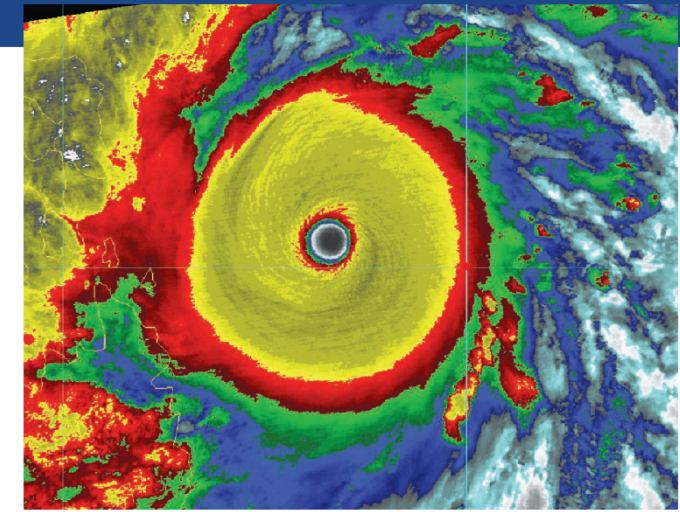
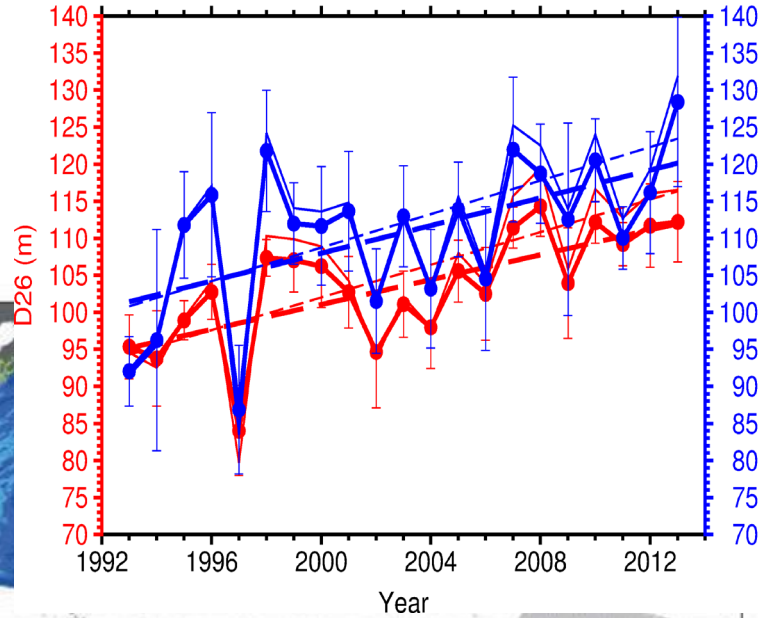


Figure 1 | Map showing distribution of hazard frequency and mortality risk from TCs for the year 2010. Estimates are applied to all pixels on a geographic grid. Mortality risk is categorized from low to extreme.



CLIMATOLOGY

Clues to Supertyphoon's Ferocity Found in the Western Pacific

Tropical storm watchers agree that Haiyan was probably the strongest typhoon to make landfall when it slammed into the Philippines on 8 November, packing winds of up to 314 kilometers per hour. What gave Haiyan, which killed thousands and displaced millions, its deadly wallop?

Researchers think they have at least a partial answer to that question: unusually warm subsurface Pacific waters off the Philippines. A related phenomenon—rising sea levels in the western Pacific—likely abetted Haiyan's devastating storm surge, which caused more deaths than the winds themselves.

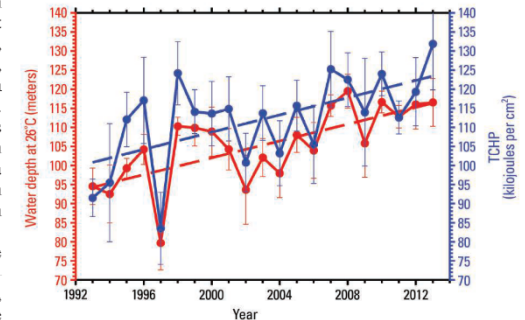
Typhoons draw heat from the ocean for the energy that generates their winds. Typically, as a storm's winds increase, they stir up deeper, cooler ocean waters that temper its strength. This cooling effect "is nature's brake to stop typhoons from intensifying," says I-I Lin, a specialist in typhoon-ocean interactions at National Taiwan University in Taipei.

Drawing on data from satellite observations and Argo floats—thousands of instrumented, subsurface probes that measure ocean temperature, salinity, and current speeds—Lin and others

have documented a steady 2-decade rise in subsurface temperatures in the western North Pacific and a bulging warm water layer. The warmer and thicker that subsurface layer, the more heat is available to feed a storm. Oceanographers use a measure called the Tropical Cyclone Heat Potential (TCHP) to quantify the heat reservoir. Lin and colleague Tom Esi Bon reported online on 3 September

康熙盛世-multi-decadal contri.

since the early 1990s (see graph). While surface waters along Haiyan's path were only slightly warmer than normal, waters



Heated situation. Over 2 decades, a thickening layer of warm water (red) increased the storm-driving heat potential (blue) at the latitudes Haiyan traversed.

Feeding the monster. Unusually warm Pacific waters supercharged Haiyan.

down to 100 meters were 3° warmer than the historical average. So as Haiyan churned up western Pacific waters, it drew more wind-intensifying heat, Lin says.

Other factors contributed to Haiyan's intensity. "The genesis location was very important," says Il-Ju Moon, a marine meteorologist at Jeju National University in South Korea who studies how ocean heat influences typhoons. Haiyan originated around 5° latitude north of the equator and was at about 10° when it hit land. "The ocean heat content is very high in that region," Moon says. And starting more than 3000 kilometers east of the Philippines gave Haiyan plenty of open water over which to strengthen.

Haiyan was a speed demon as well. "It was flying over the water" at 32 kilometers per hour, Lin says, nearly twice as fast as most typhoons travel. "Why it moved so fast is unknown," she adds. Researchers speculate that a fast-moving storm passes by before its churn pulls energy-sapping deeper, cooler water to the surface. In any case, "the warmer the subsurface layer, the faster the moving speed, the smaller the cooling effect," Lin says. "It's like a car without a brake, only an accelerator."

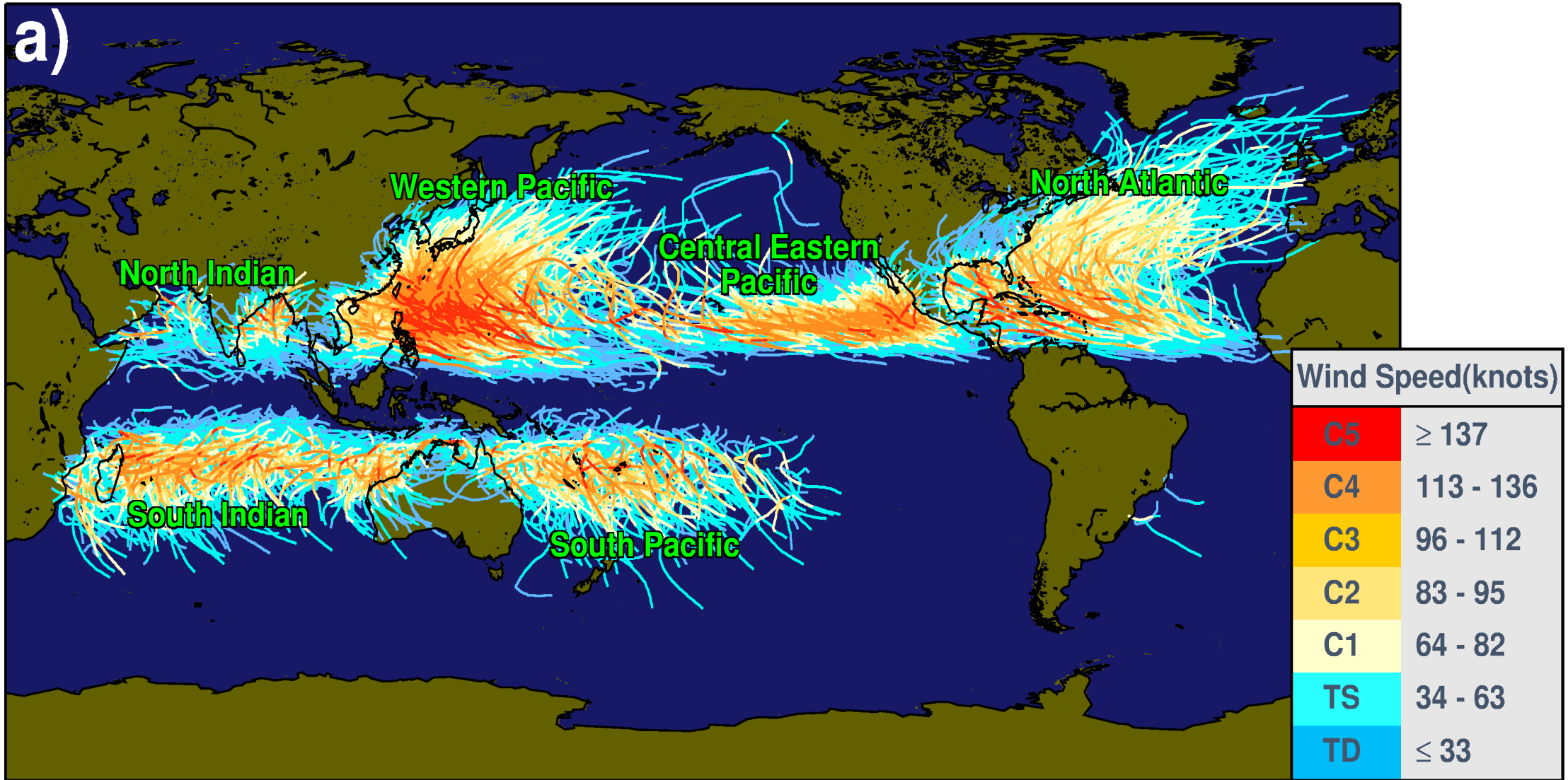
The warm bulge in the western North Pacific is the result of stronger easterly trade winds. This phenomenon also aggravated Haiyan's storm surge. In addition to blowing waves, the storm literally piled up water, where the sea level rose over the past 20 years exceeds 20 centimeters, says Bo Qiu, an oceanographer at the University of Hawaii, Manoa. "It is likely that the elevated sea level contributed to the flood and inundation problems" in the Philippines, he says.

While many observers blame Haiyan's destructive power on climate change, tropical storm experts say there is little hard evidence of a link. "It is possibly natural variability," Lin says. Nor is it certain that the western Pacific has become a supertyphoon breeding ground. Although warmer subsurface waters might raise the risk, Lin says, atmospheric conditions may not always cooperate.

-DENNIS NORMILE

Peduzzi et al. Nat. C.C. 2012

Best track data from NHC and JTWC, 1980~2018



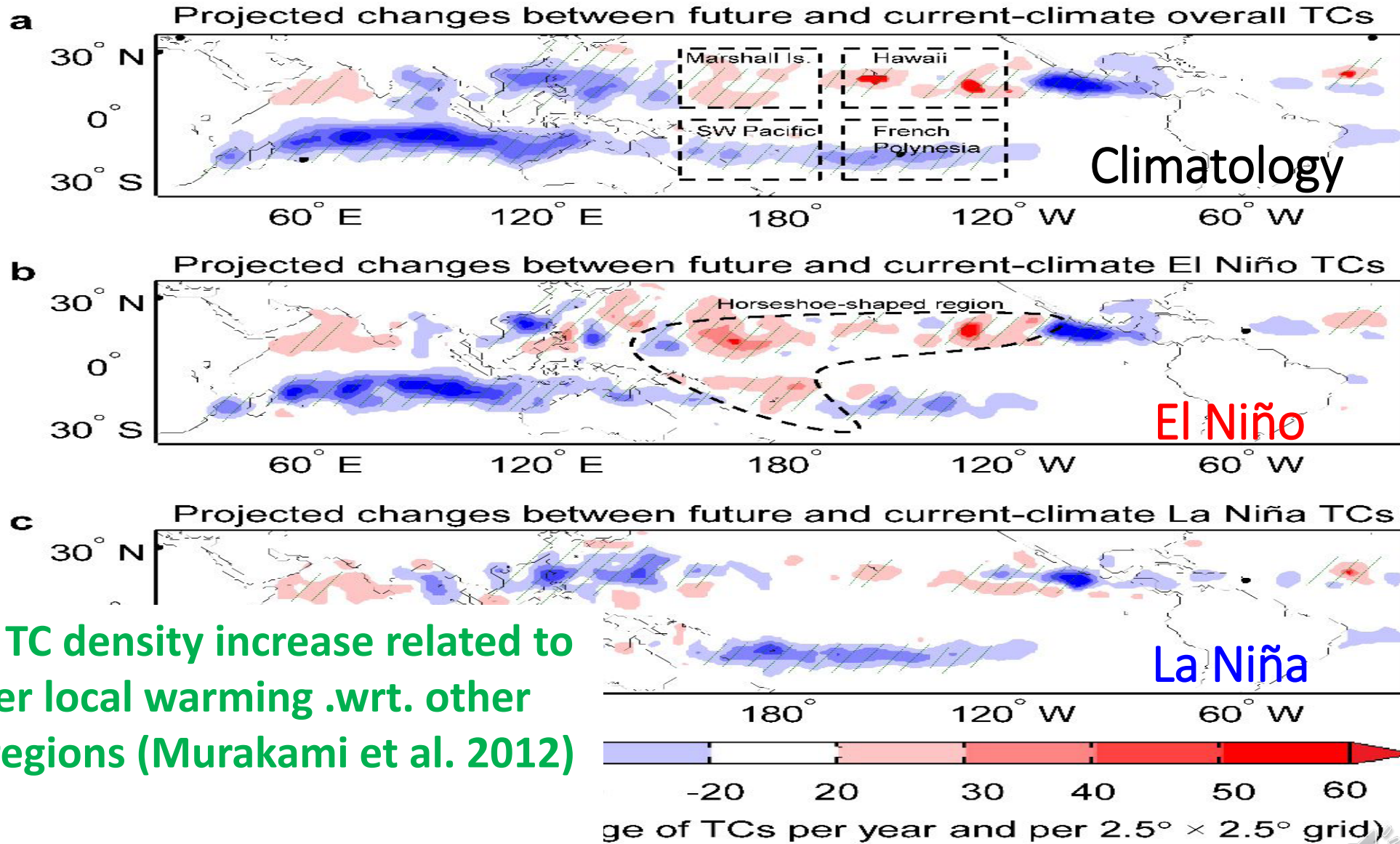
Tropical Cyclone Projections (2°C Global Warming)

結構性問題
複合性問題



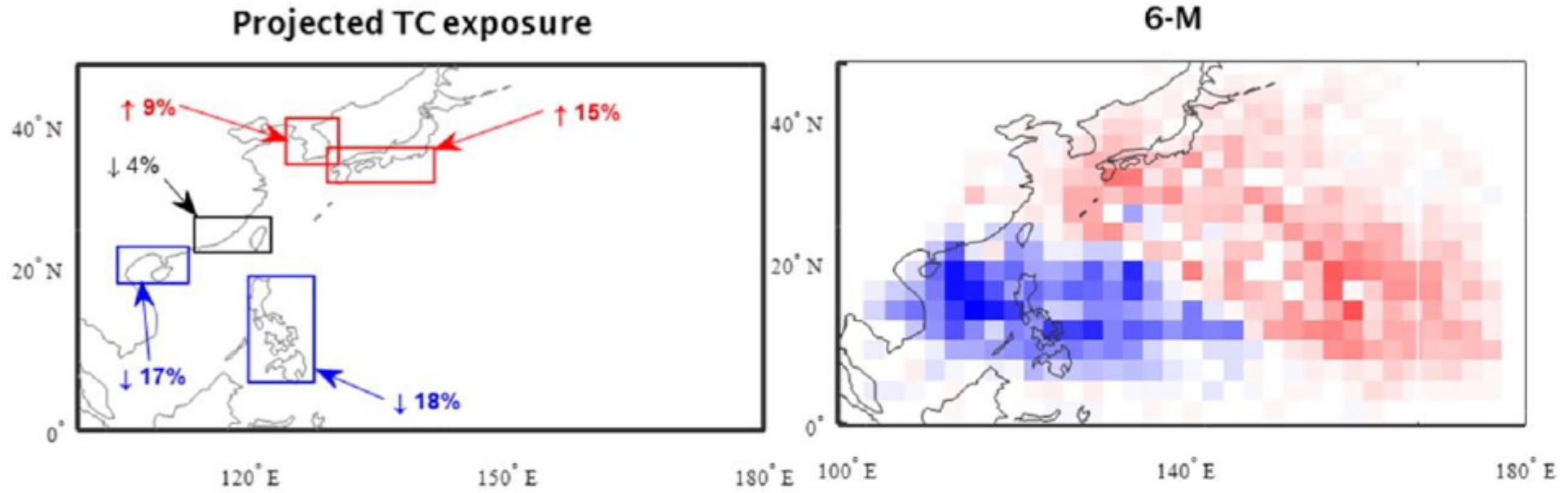
Infrastructure and Mitigation strategy
need to change, 30 years come fast!

Global Warming, TC, and ENSO 2020

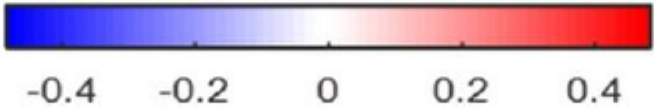


Regional TC density increase related to stronger local warming .wrt. other tropical regions (Murakami et al. 2012)





Not our own issue

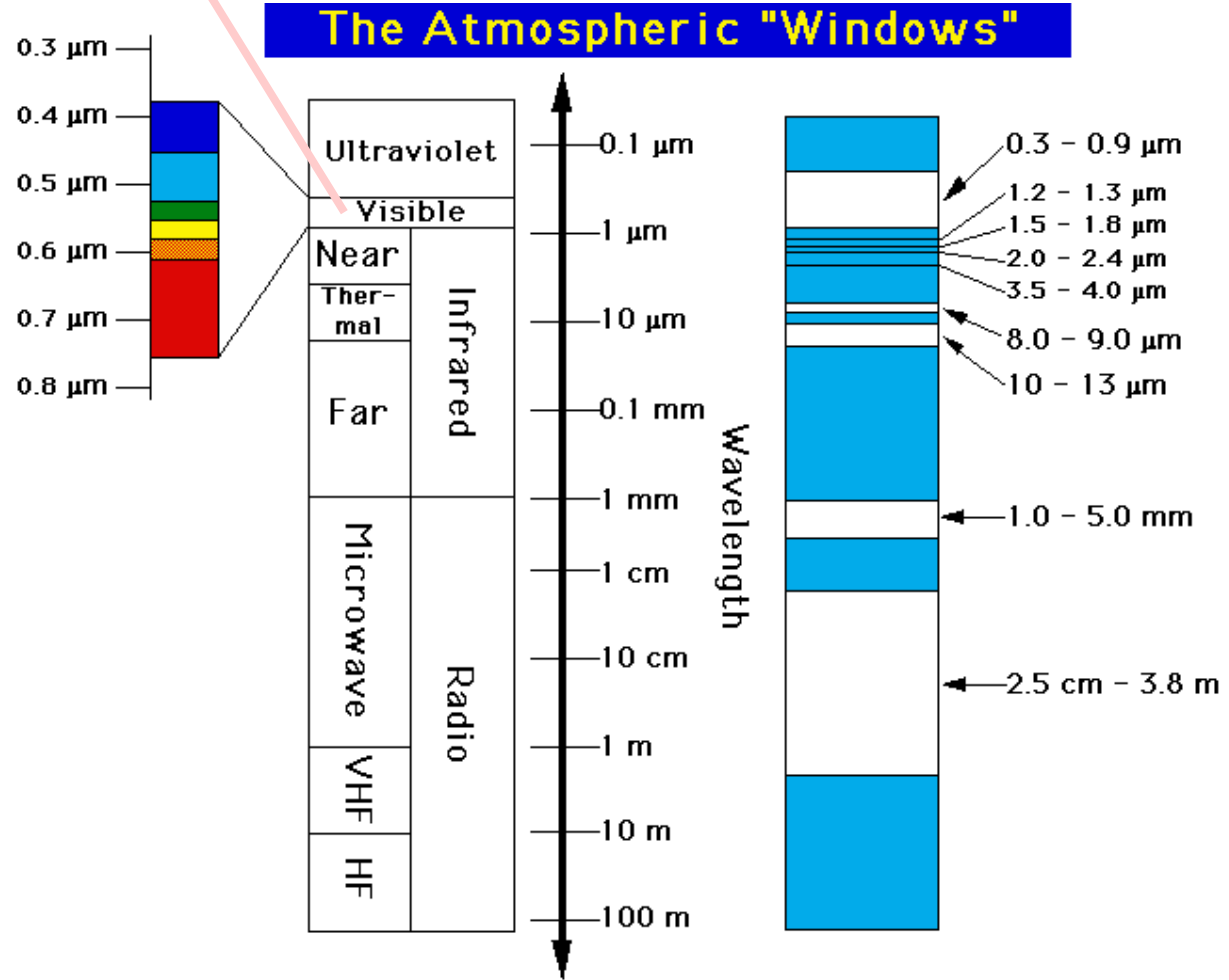


Tropical expansion

From NASA



narrow window, otherwise we can not see the earth from space!



Elegance in Nature and Its Complex Precision





Symphony No. 6

Edited by
Ilya Kaler

Ludwig van Beethoven
Op. 68

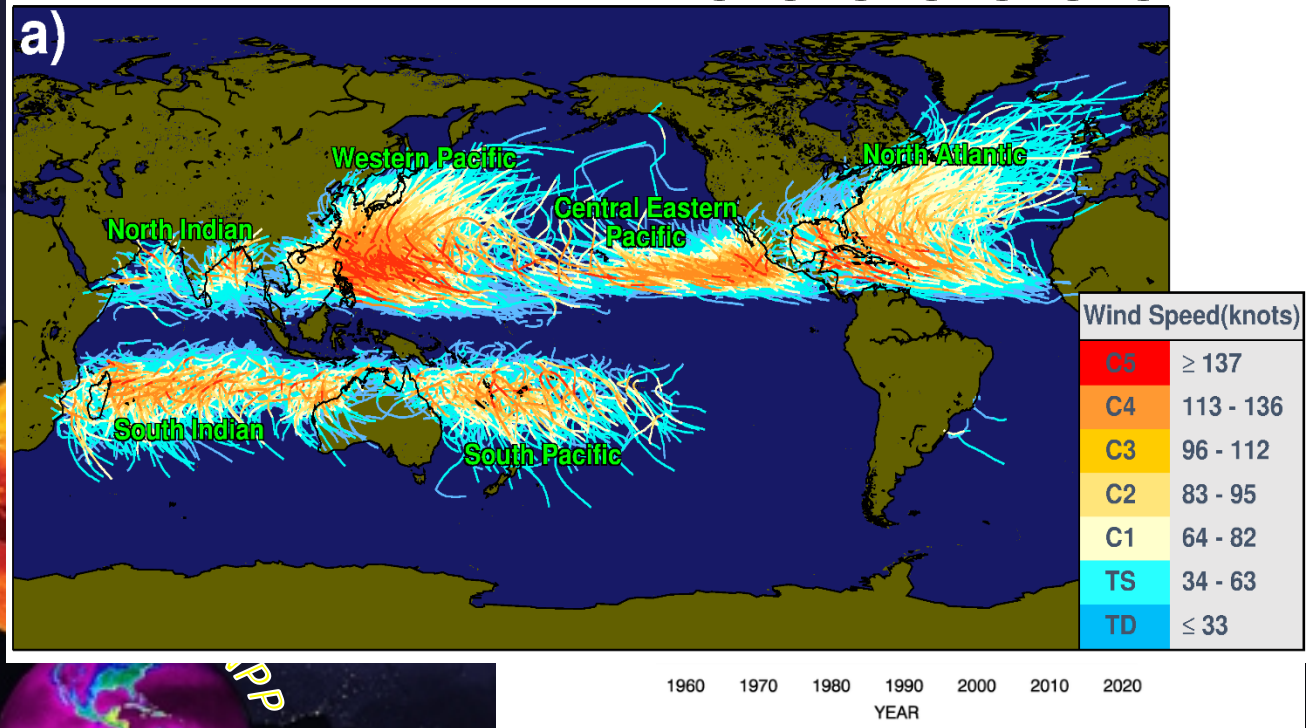
Violin I

Erwachen heiterer Empfindungen bei der Ankunft auf dem Lande

Allegro ma non troppo $\text{♩} = 66$



Best track data from NHC and JTWC, 1980~2018



Brightness Temp

PP

Precip Irradiance

Ozone

3-D Clouds



謙卑人必承受地土，以豐盛的平安為樂
詩篇 37(11)

Courtesy: NASA, SC Tsai



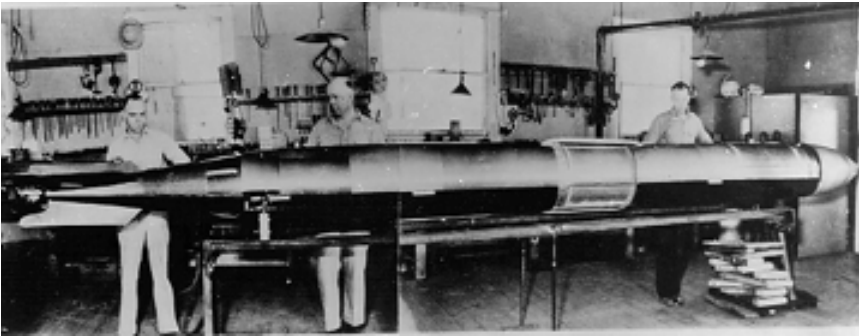
(1882-1945)

Goddard Space Flight Center



The father of modern rocket propulsion Dr. Robert Hutchings Goddard of America.

Along with Konstantin Eduardovich Tsiolkovsky of Russia and Hermann Oberth of Germany, Goddard **envisioned the exploration of space.**



But still try, for who knows what is possible.

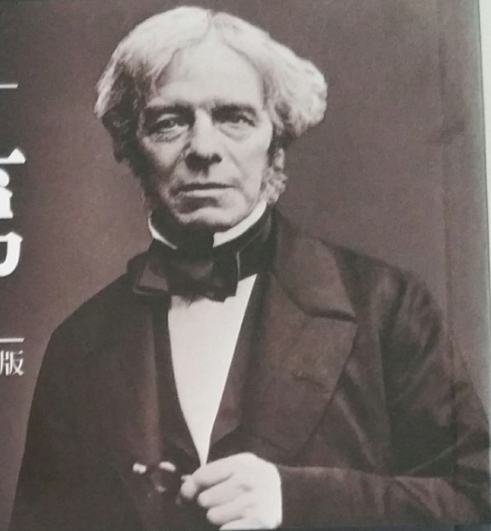
—— 電學之父 ——

法拉第

—— 的故事 ——

修訂版

The Story of
Michael Faraday



台大生工系教授 張文亮 著

一個僅受過小學教育的書本裝訂工，
走向改變人類歷史的偉大科學家的傳奇！

雖然他製造發電機，讓人們邁向電力世界，
就算他發明馬達，帶人們走進動力時代，
他依然保持謙讓態度、用滿滿的祝福走過跌宕的一生！

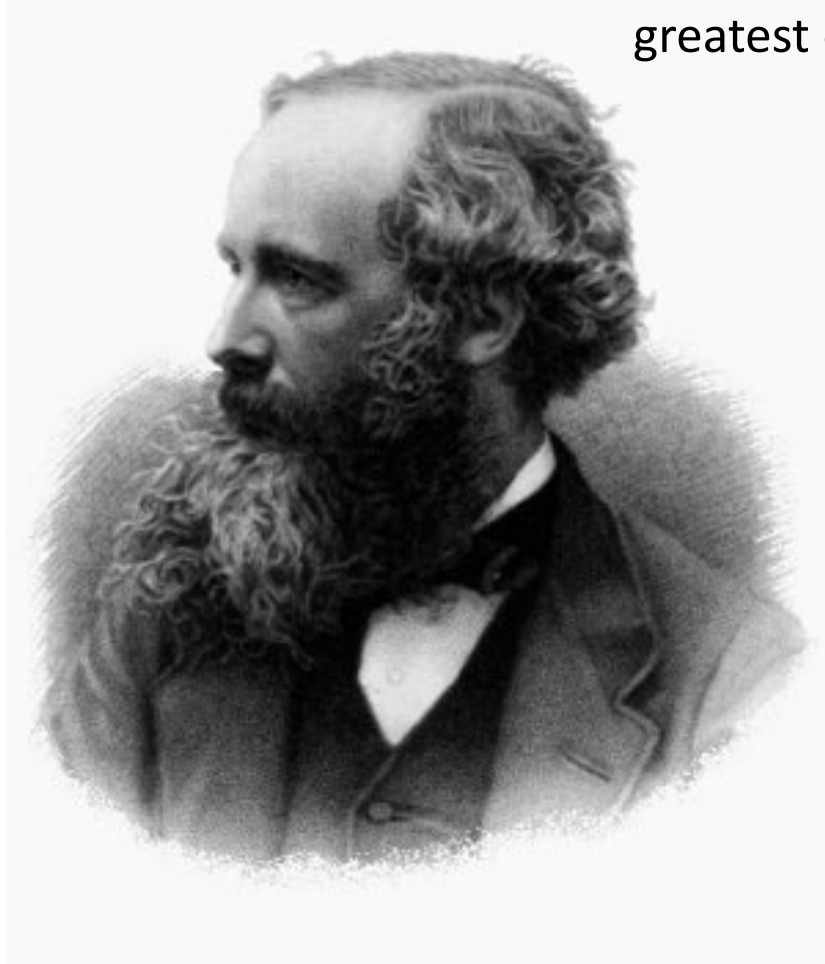
出版界雙獎最高殊榮

好書
大家讀

金鼎獎

Fundamental equations for electromagnetic radiation

Maxwell's equations are regarded to be the greatest equations ever (Crease, 2004)



James Clerk Maxwell (1831-1879)

Perhaps the most memorable tribute to Maxwell is the T-shirt slogan seen on university campuses in the 1990s:

And God said:

$$\partial \mathbf{E} / \partial t = c \nabla \times \mathbf{B} - 4 \pi \mathbf{j}$$

$$\partial \mathbf{B} / \partial t = -c \nabla \times \mathbf{E}$$

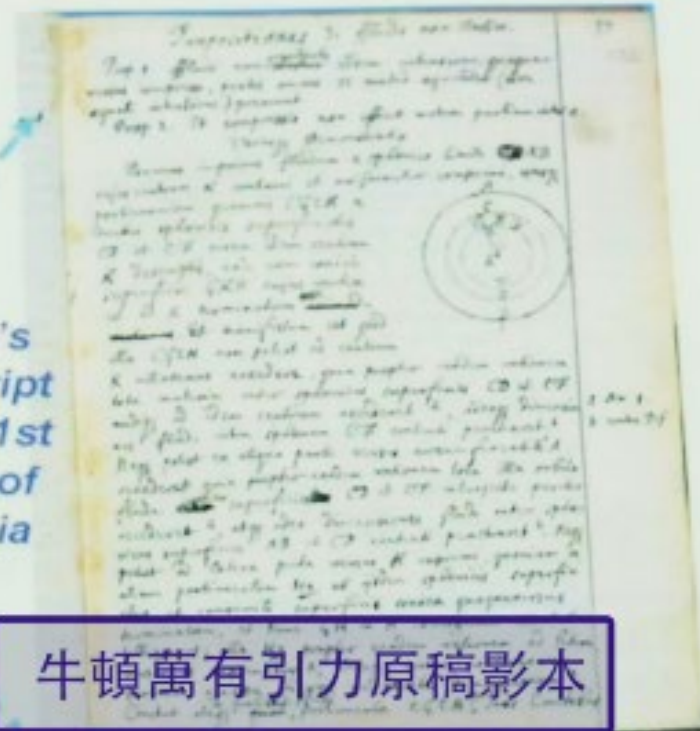
$$\nabla \cdot \mathbf{E} = 4 \pi \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

And there was light.



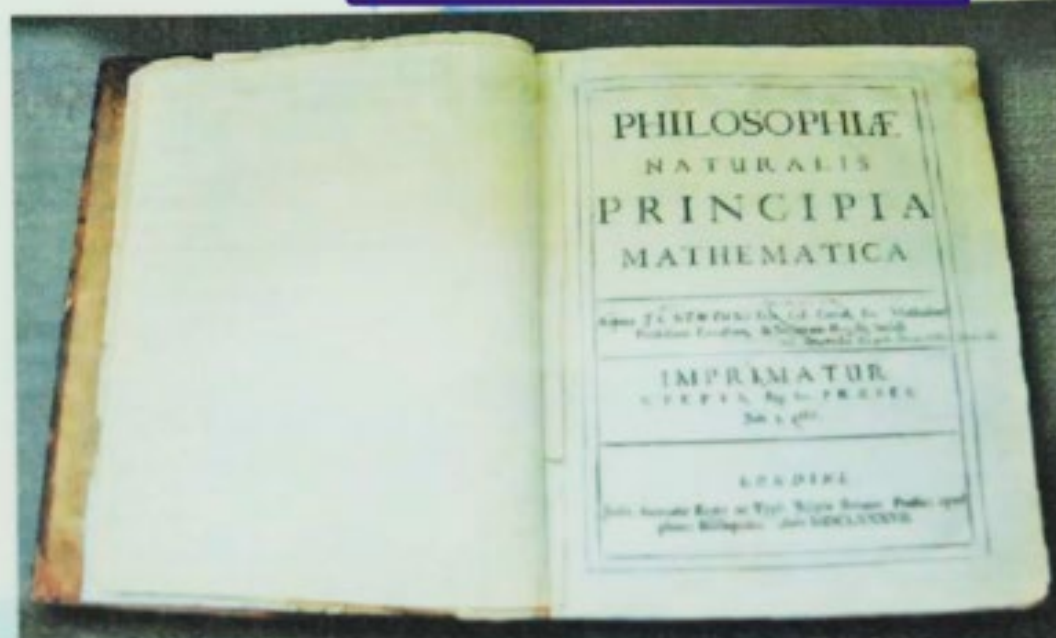
Newton's
manuscript
and the 1st
edition of
Principia



牛頓萬有引力原稿影本

英國劍橋大學牛頓蘋果樹的樹葉標本

Descendent of Newton's
apple tree in Cambridge



- 在高度競爭的國際社會,全球都在競爭STEM (Science, Technology, Engineering, and Mathematics) 人才。根據國家發展委員會在2021年的報告,台灣最缺乏的也是STEM人才。可是在2020年只有30%的畢業生是屬於此範疇,更不論在畢業後不同階段的人才流失。而女生的流失更為嚴峻。
- 當作訓練頭腦,在此階段不用顧慮太多,勇敢一點