Global CO_2 and Temperature Monitoring with PGGM and FORMOSAT-3/COSMIC

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The 2nd International Workshop on Atmospheric Watch in Asia

21-22 Oct 2010, Jeju, Korea

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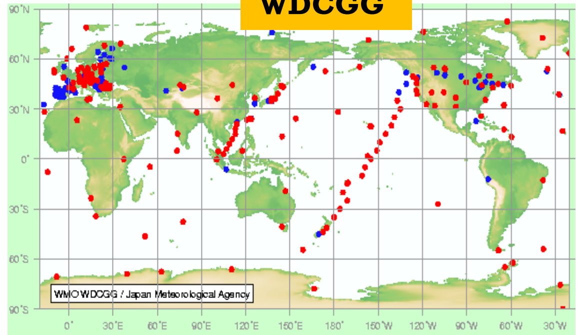
Outline

- 1. Introduction: Our innovative efforts in global climate monitoring
- 2. Global CO2 monitoring with PGGM
  - Ship-Based measurements
  - Air-Based measurements
- 3. Global temperature monitoring with FORMOSAT-3/COSMIC
- 4. Summary

現今全球二氧化碳濃度觀測平台
Global Greenhouse Gases Measurements Platforms

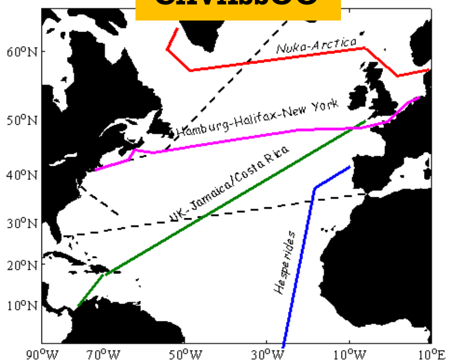
- 地面觀測站 Ground-Based stations:
  - 1990年世界氣象組織全球溫室氣體數據中心 (WMO World Data Centre for Greenhouse Gases, WMO WDCGG)
- 航空器觀測 Air-Based measurements:
  - 1994年歐盟MOZAIC計畫[Marenco et al., 1998]
  - 2005年起日本CONTRAIL計畫
  - 2009年美國HIPPO(五次任務飛行)
  - 2010年歐盟IAGOS計畫(預計)
- 衛星監測 Satellite Measurements:
  - 歐洲Envisat衛星SCIAMACHY [Burrows et al.,1999
  - 美國AQUA衛星AIRS載具[Chahine et al., 2005]
  - 日本GOSAT衛星, Jan 200
- 國際貨輪觀測 Ship-Based measurements:
  - 2001~2003年歐盟 CAVASSOO

WDCGG



MOZAIC

CAVASSOO



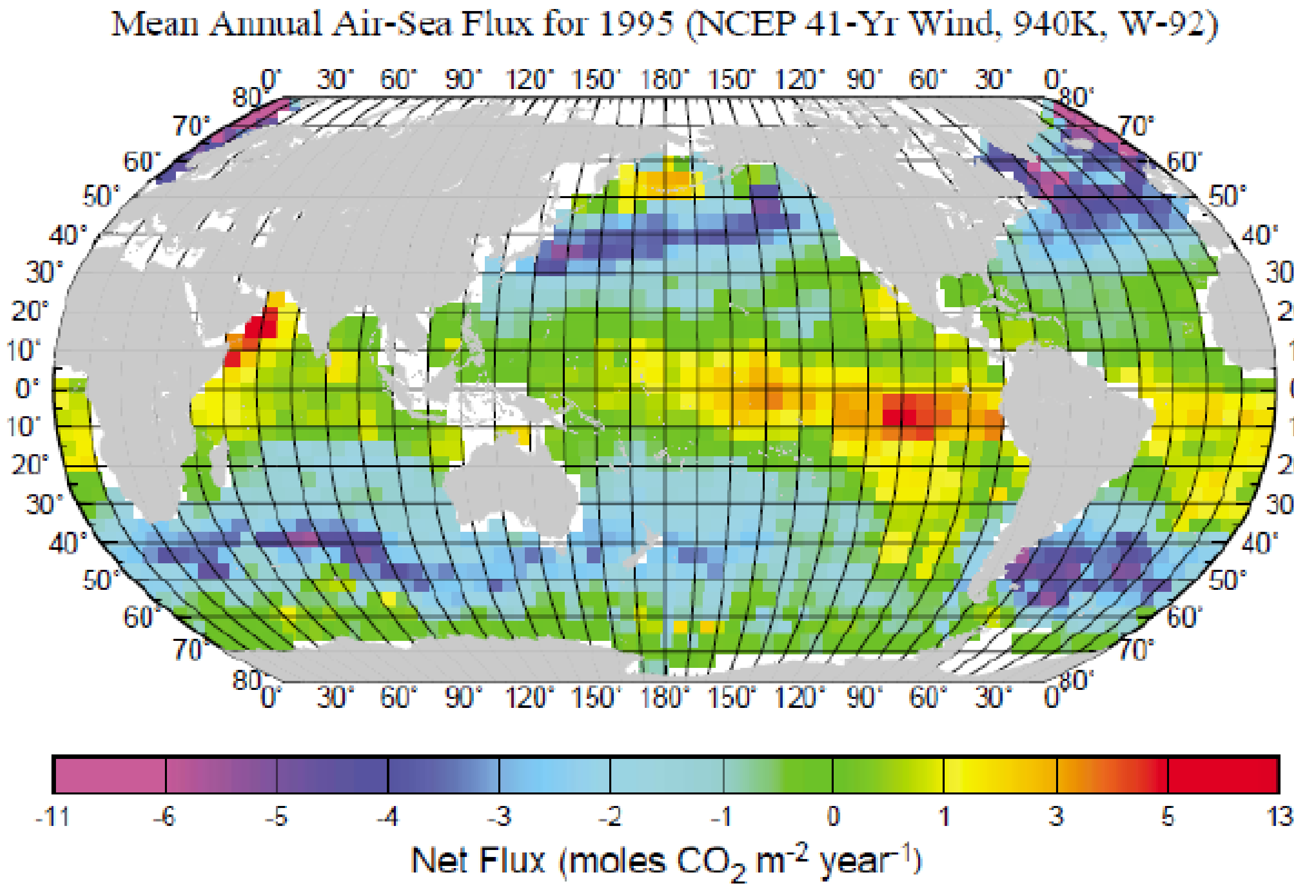


圖 2.1995 年年平均海氣二氧化碳通量。正值表示海洋對大氣二氧化碳為正貢獻，負值表示海洋對大氣為負貢獻。

PGGM

Pacific Greenhouse Gases Measurement

太平洋溫室效應氣體觀測計畫

行政院環境保護署
Environmental Protection Administration
Executive Yuan, R.O.C.(TAIWAN)

FORMOSAT-3

IAGOS

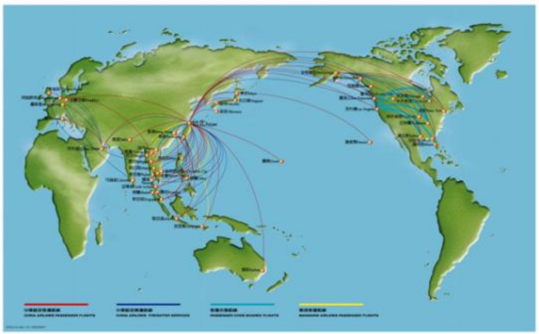
UNIVERSITY OF CAMBRIDGE

National Science Council

中華航空
CHINA AIRLINES

ECOTECH

中華航空國際航線圖
CHINA AIRLINES INTERNATIONAL ROUTES



CHINA AIRLINES

長榮海運
EVERGREEN

台灣中油股份有限公司

國立中央大學

Pacific Greenhouse Gases Measurement Project

Phase I: 2008-2010; Phase II: 2011-2013

OCO
Orbiting Carbon Observatory

FORMOSAT-3

GOSAT

GMES
Global Monitoring for Environment and Security

esa

USGS

©2007 Google

PGGM

PGGM Ship-Based Global Greenhouse Gases Measurements with EVERGREEN Since Jun 2009: A Special Thanks to Evergreen Marine Corp. (EMC)

行政院環境保護署
Environmental Protection Administration
Executive Yuan, R.O.C.(TAIWAN)

National Science Council

國立中央大學

UNIVERSITY OF CAMBRIDGE

United Kingdom

EVER STRONG, 8 Sep 2010, Taipei Harbour

Evergreen Full Container Service Routes

Pacific Greenhouse Gases Measurement Project

PGGM Package01:EVER ULTRA

PGGM Package04:EVER DECENT

PGGM Package07:EVER DEVOTE

PGGM Package02:EVER DAINTY

PGGM Package05:EVER DIAMOND

PGGM Package08:EVER DIADEM

PGGM Package03:EVER DELUXE

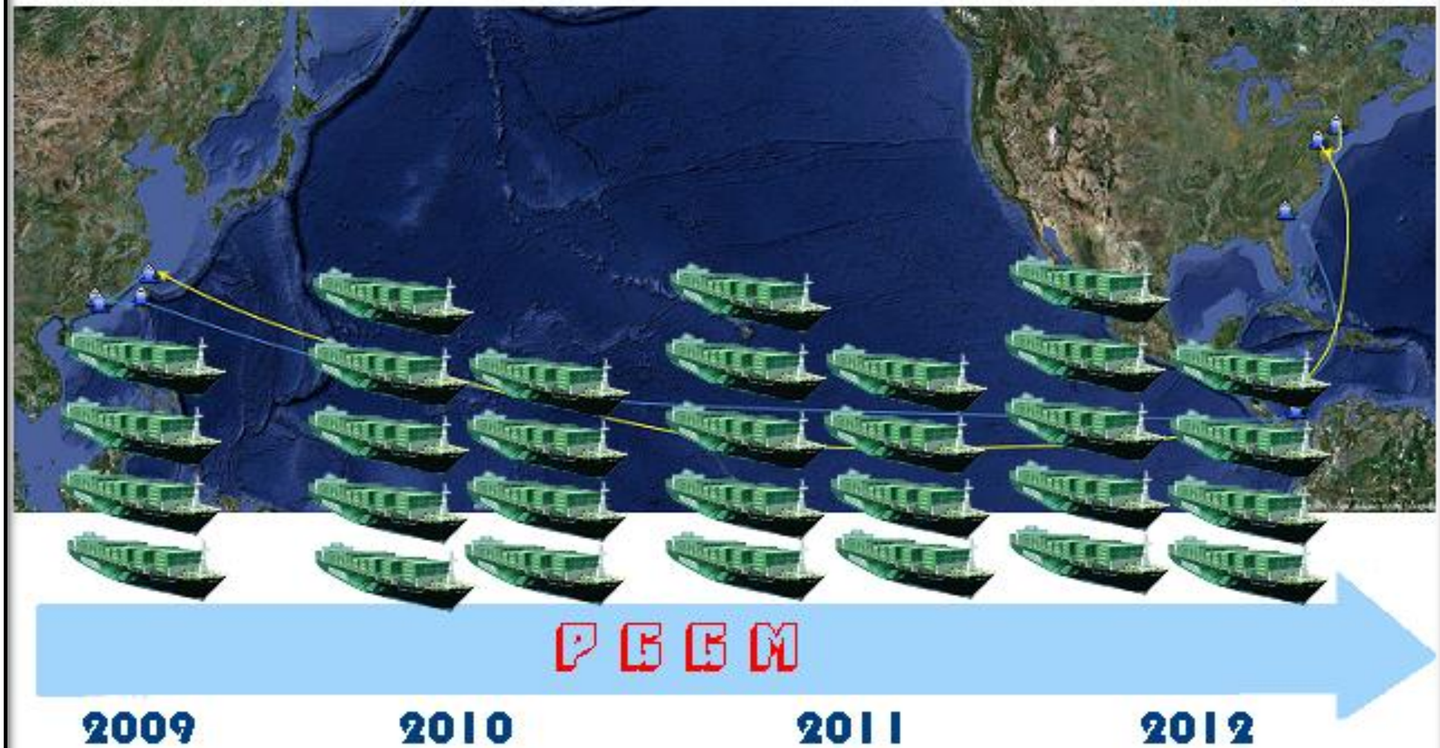
PGGM Package06:EVER DEVELOP

PGGM Package09:EVER DIVINE

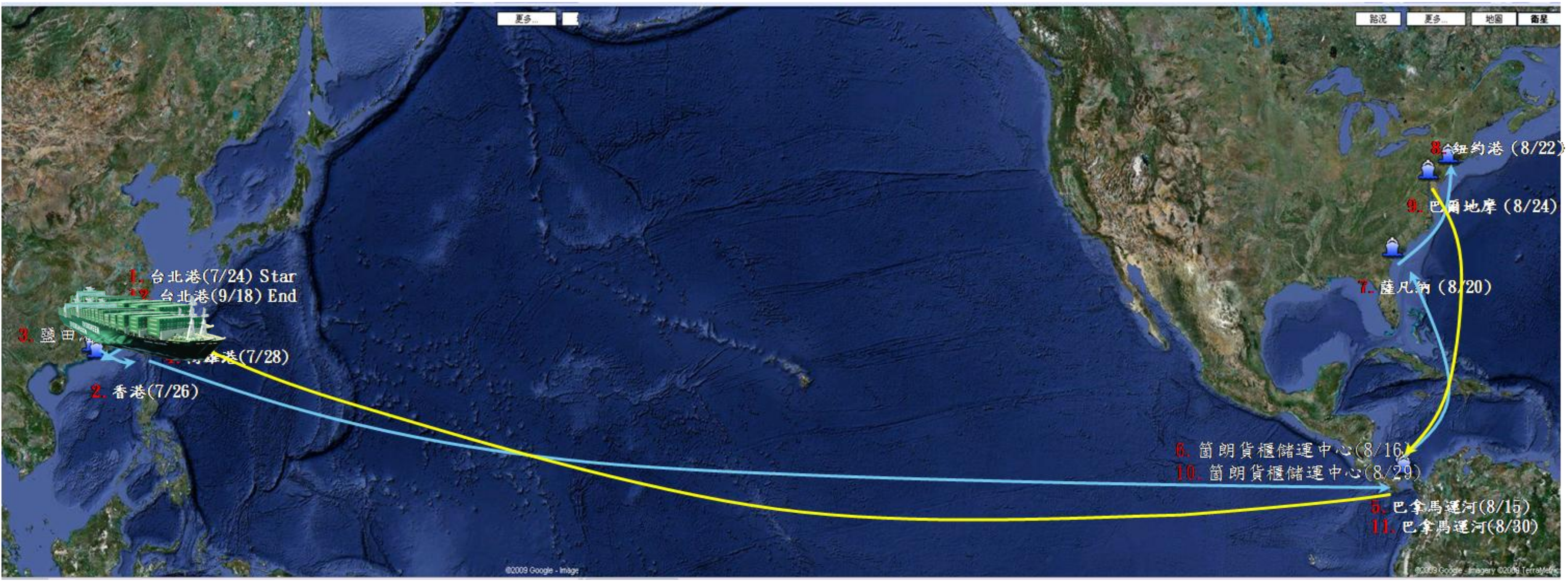
太平洋溫室效應氣體船測儀器觀測計畫

Pacific Greenhouse Gases Measurement Project

PGGM Ship-Based Measurement

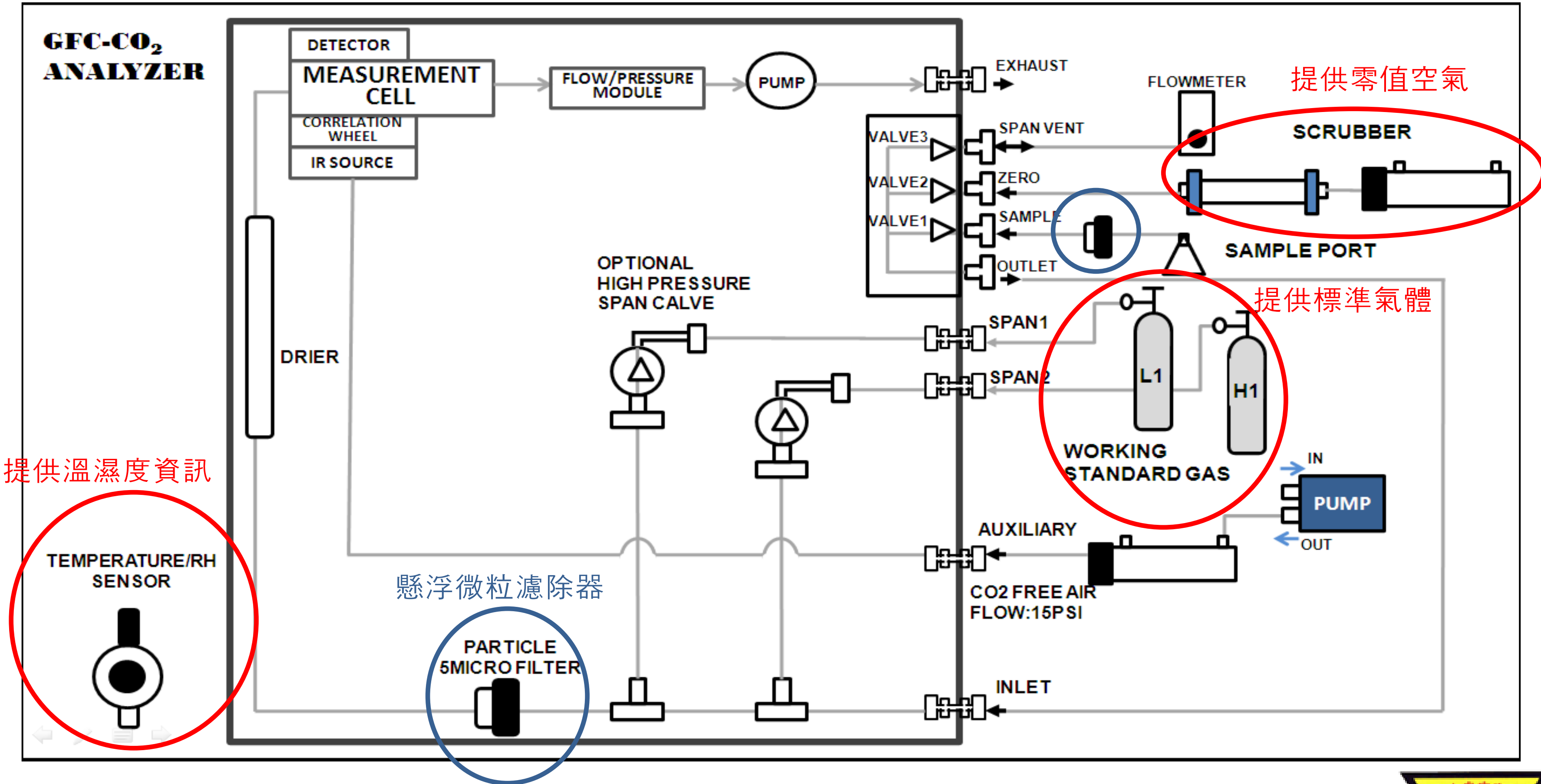


8艘D-type PGGM ship travel through Pacific-Atlantic region



• 觀測平台安裝

商用貨輪觀測平台觀測系統簡易架構圖



CO2 Standard Gases and Analyzers

- Primary standard: NOAA WMO CO2 Standards
- Working standard: Calibrated by Primary standard
- Ship-based CO2 analyzers
  - ECOTECH: EC9820, GFC analyzer
    - calibration cycle: Every 6 hours
      - zero CO2 air,
      - span gas (High and Low concentrations),
      - measurements

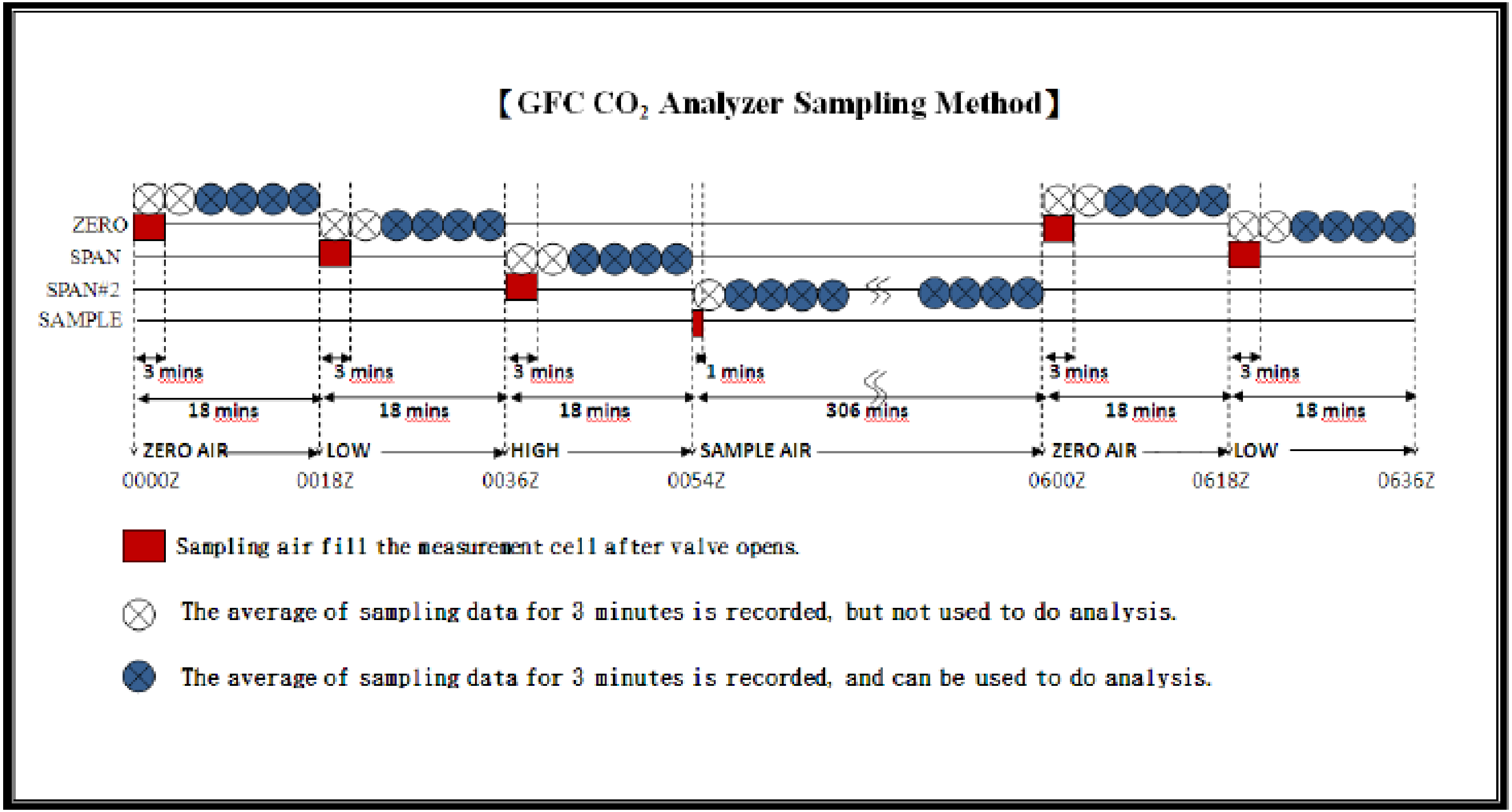
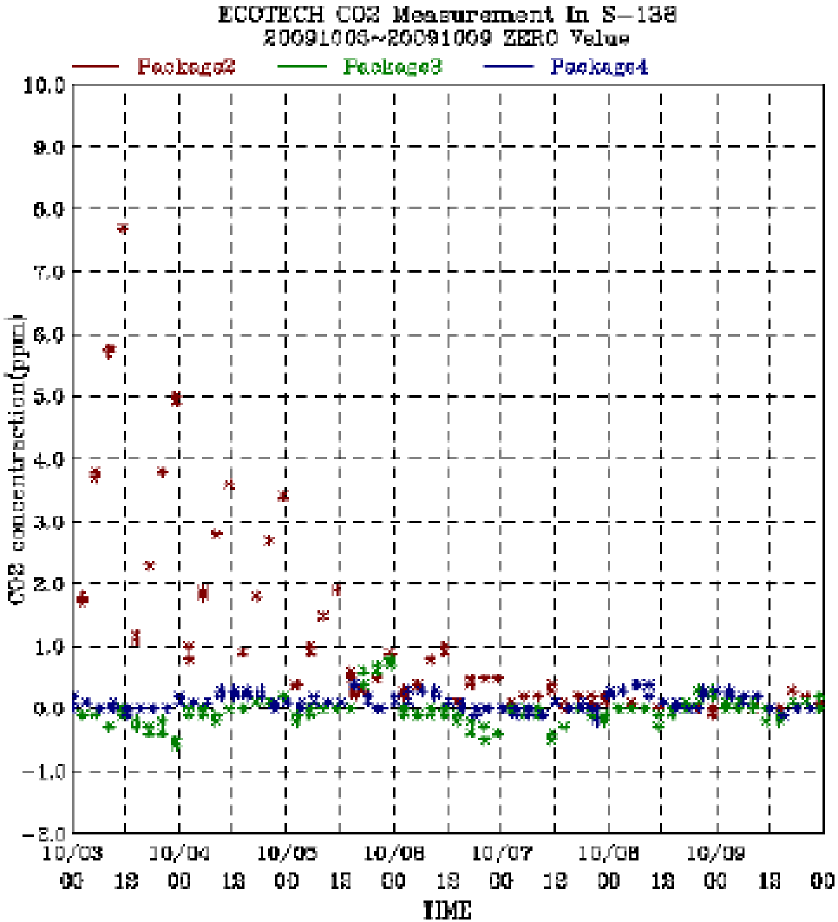
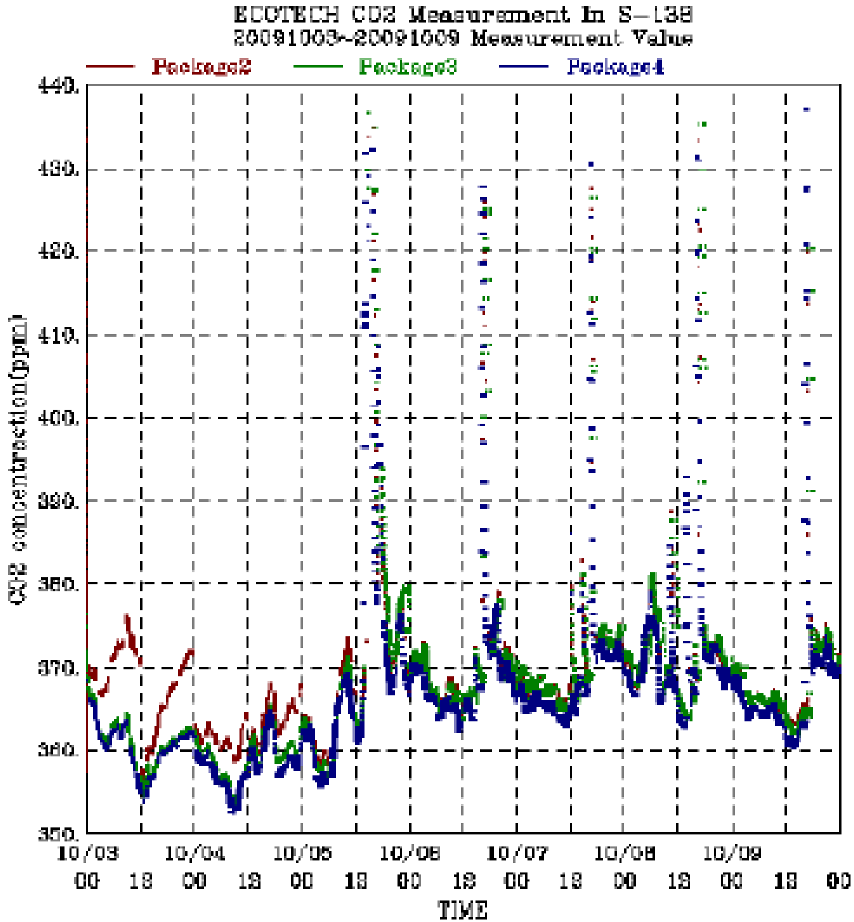


圖 12.GFC 二氧化碳分析儀採樣方式示意圖

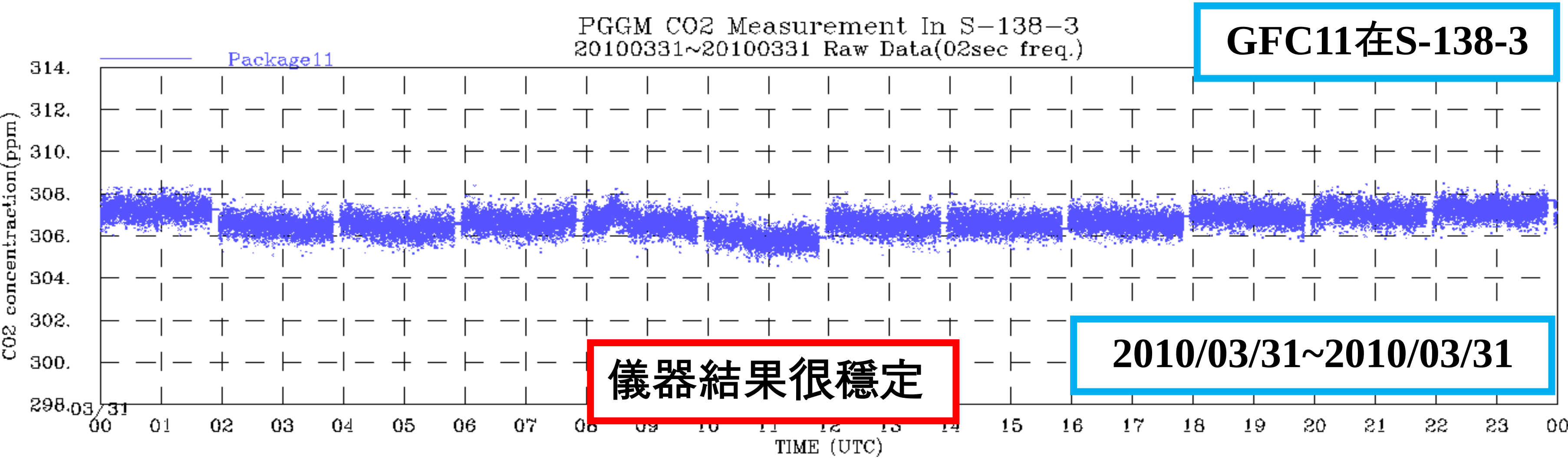
ECOTECH CO2 data-2009/10/03(六)~2009/10/09(五)

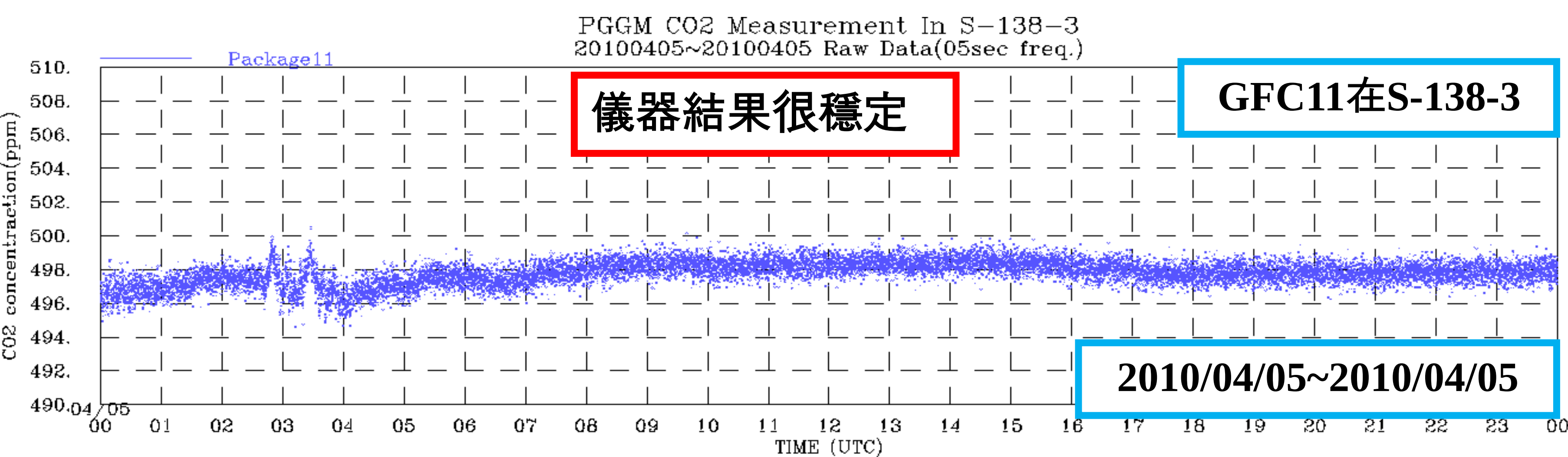
＊右邊量測sample的時序圖每天會有一次的高值現象
->因爲進實驗室載資料，呼吸放出二氧化碳。





●二氧化碳分析儀連續固定濃度二氧化碳觀測





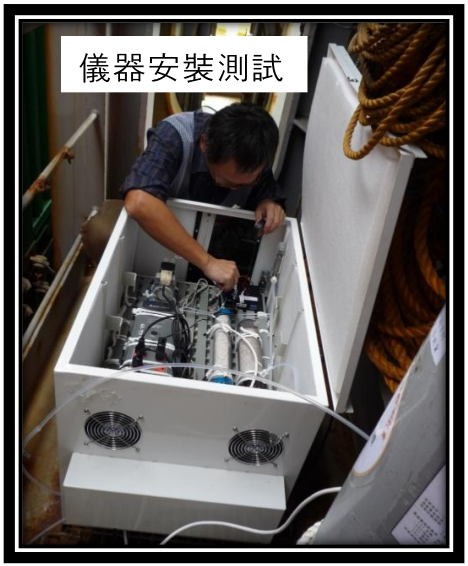
PGGM船測儀器在碼頭準備吊上船

使用吊車將PGGM船測儀器吊上船之情形

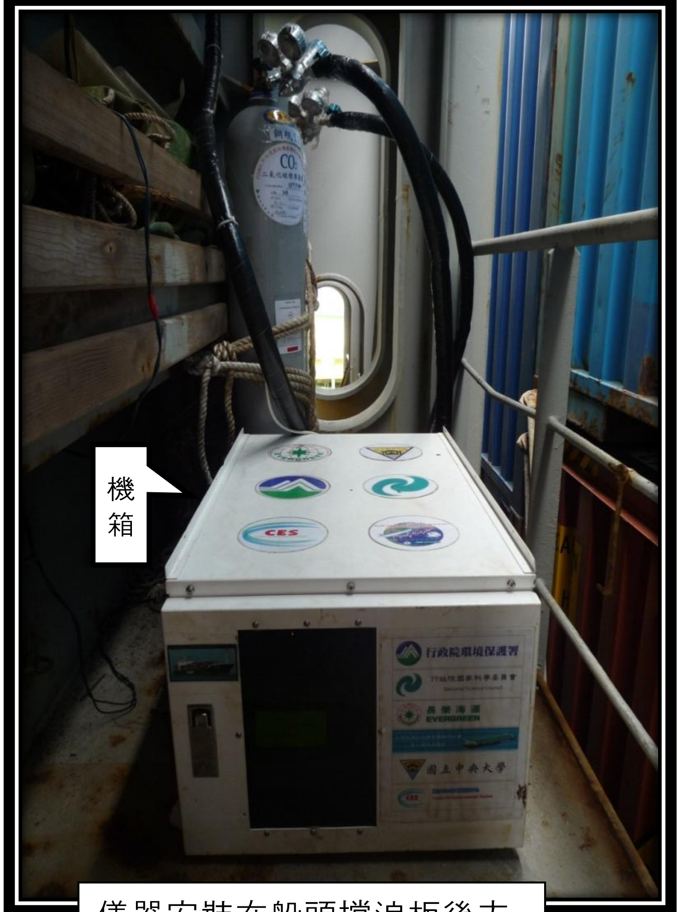
將儀器搬運至安裝位置

固定GPS及採樣口

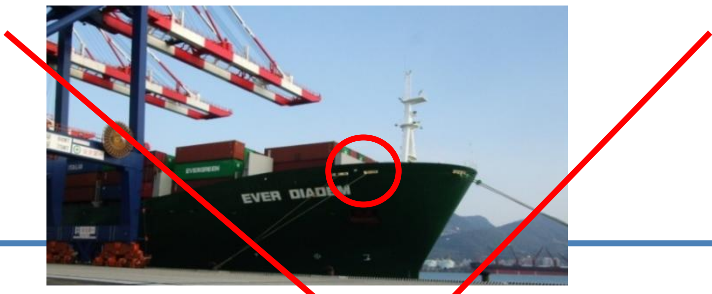
鋼瓶固定



儀器安裝測試



儀器安裝在船頭擋浪板後方

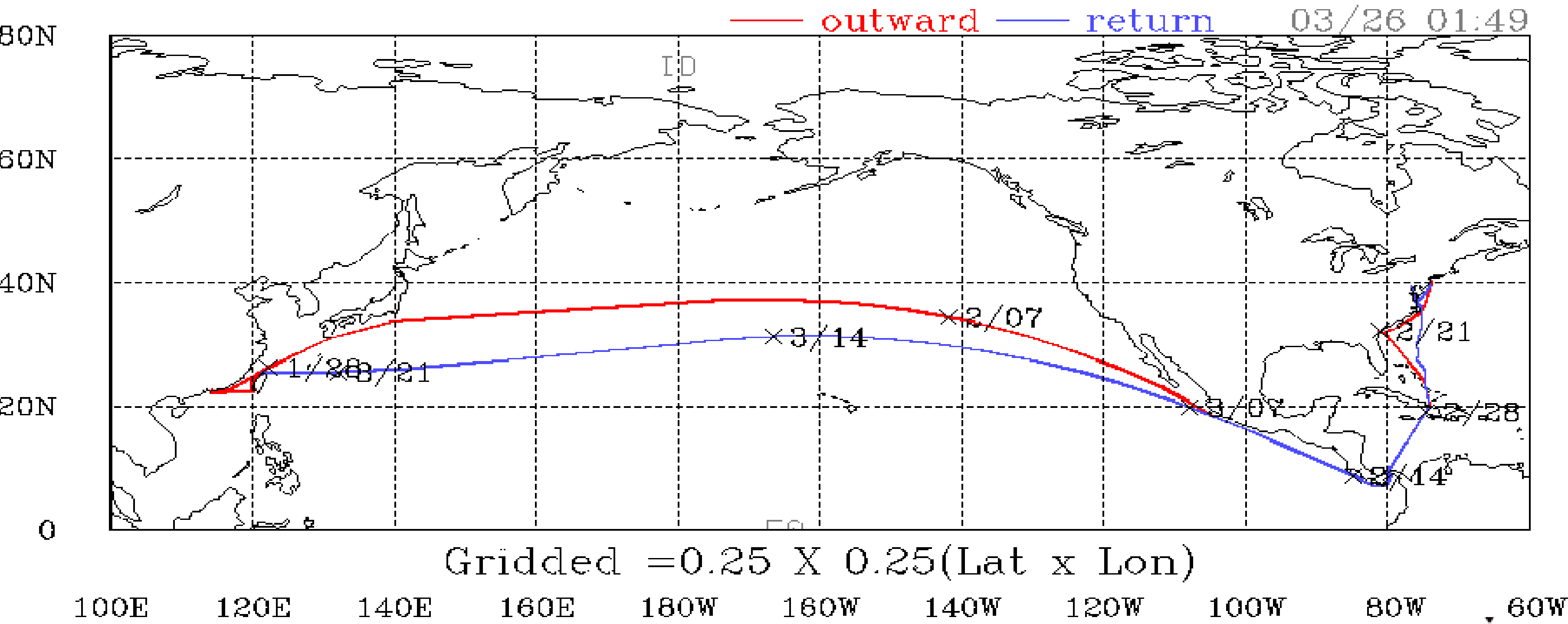


PGGM Ship-Based Package4 on-board EVER DECENT

- EVER DECENT 2010/01/22~2010/03/26
  - 太平洋-大西洋海域(AUE-63天)

●Path(實際,UTC):
●1.01/22台北港→2.01/23香港港→3.01/24鹽田港→4.01/26高雄港→5.02/15巴拿馬運河→
●6.02/15箇朗貨櫃儲運中心 →7.02/20薩凡納港→8.02/22紐約港→9.02/24巴爾地摩港→
●10.03/01箇朗貨櫃儲運中心 →11.03/02巴拿馬運河→12.03/26台北港

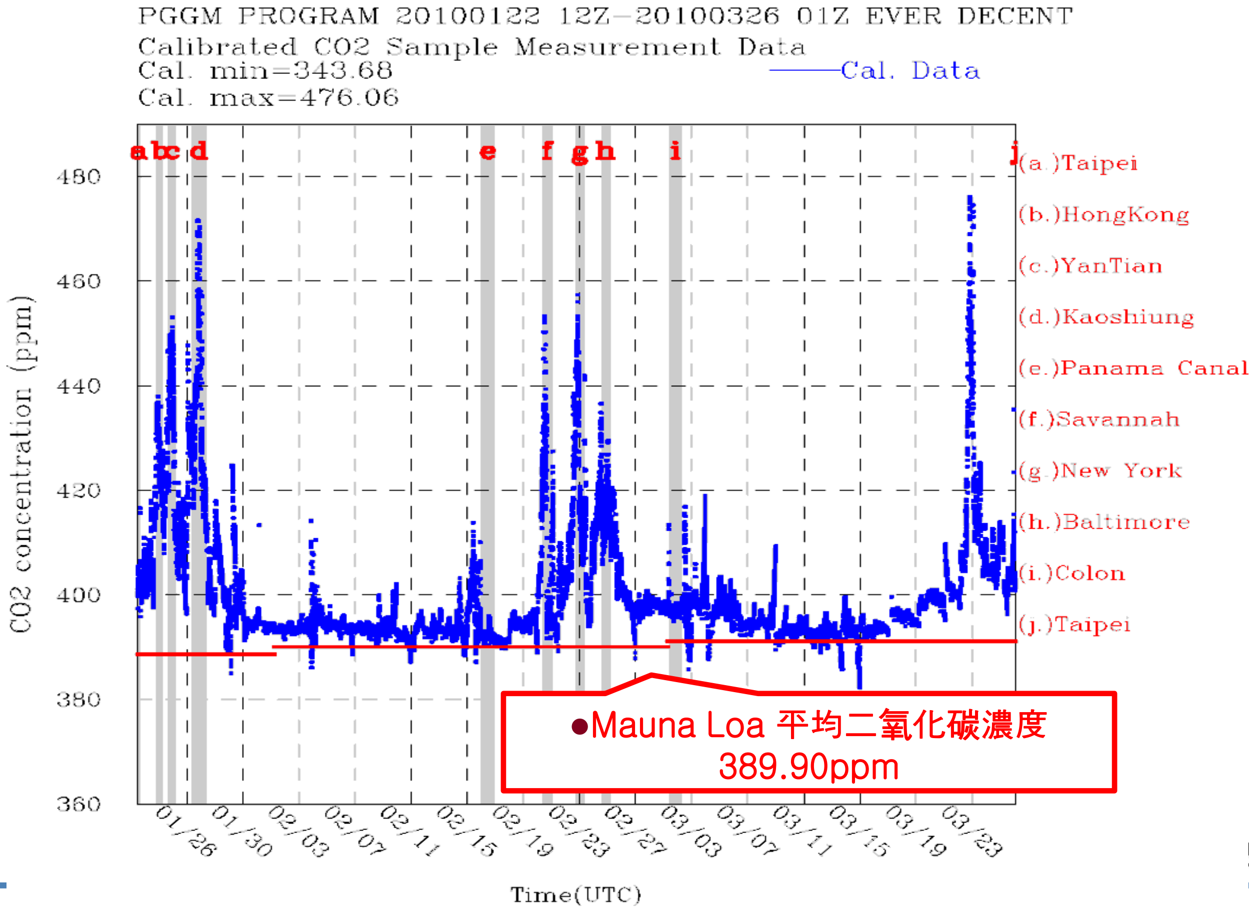
PGGM Package04 -- EVER DECENT CO2 Measurements
20100122~20100326 route(GPS)



Gridded =0.25 X 0.25(Lat x Lon)

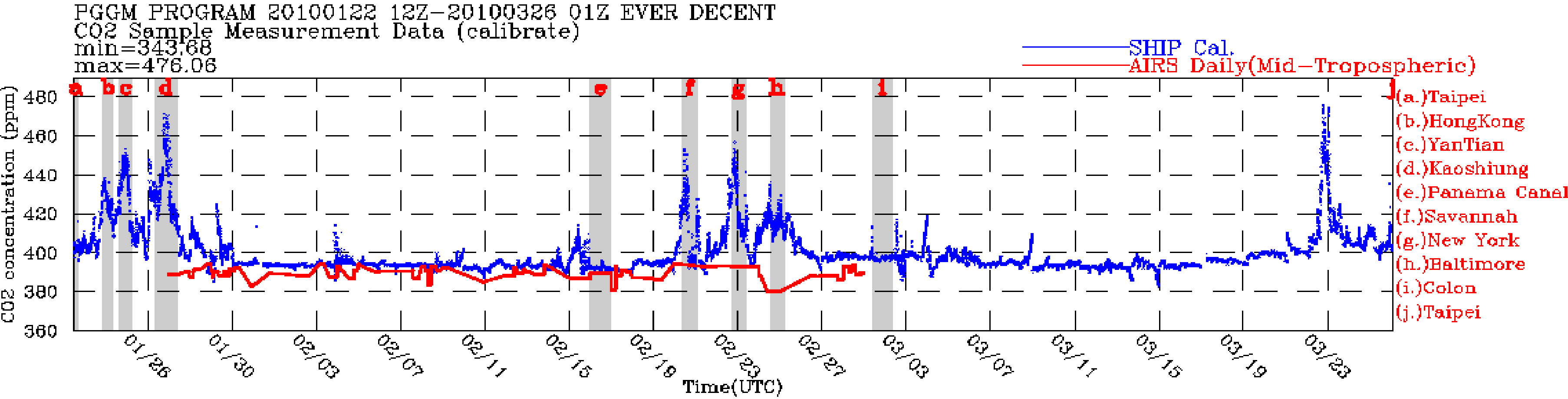
- 港區:二氧化碳的濃度迅速的升高至400~480ppm
- 北太平洋海域:二氧化碳濃度約在393~396ppm左右

年份	月份	AIRS月平均CO_2濃度(ppm)	平均
2010	1	388.57	389.90
2010	2	390.04	
2010	3	391.11	



大學

- 紅線:AQUA-AIRS衛星資料
- 藍線:船測二氧化碳資料

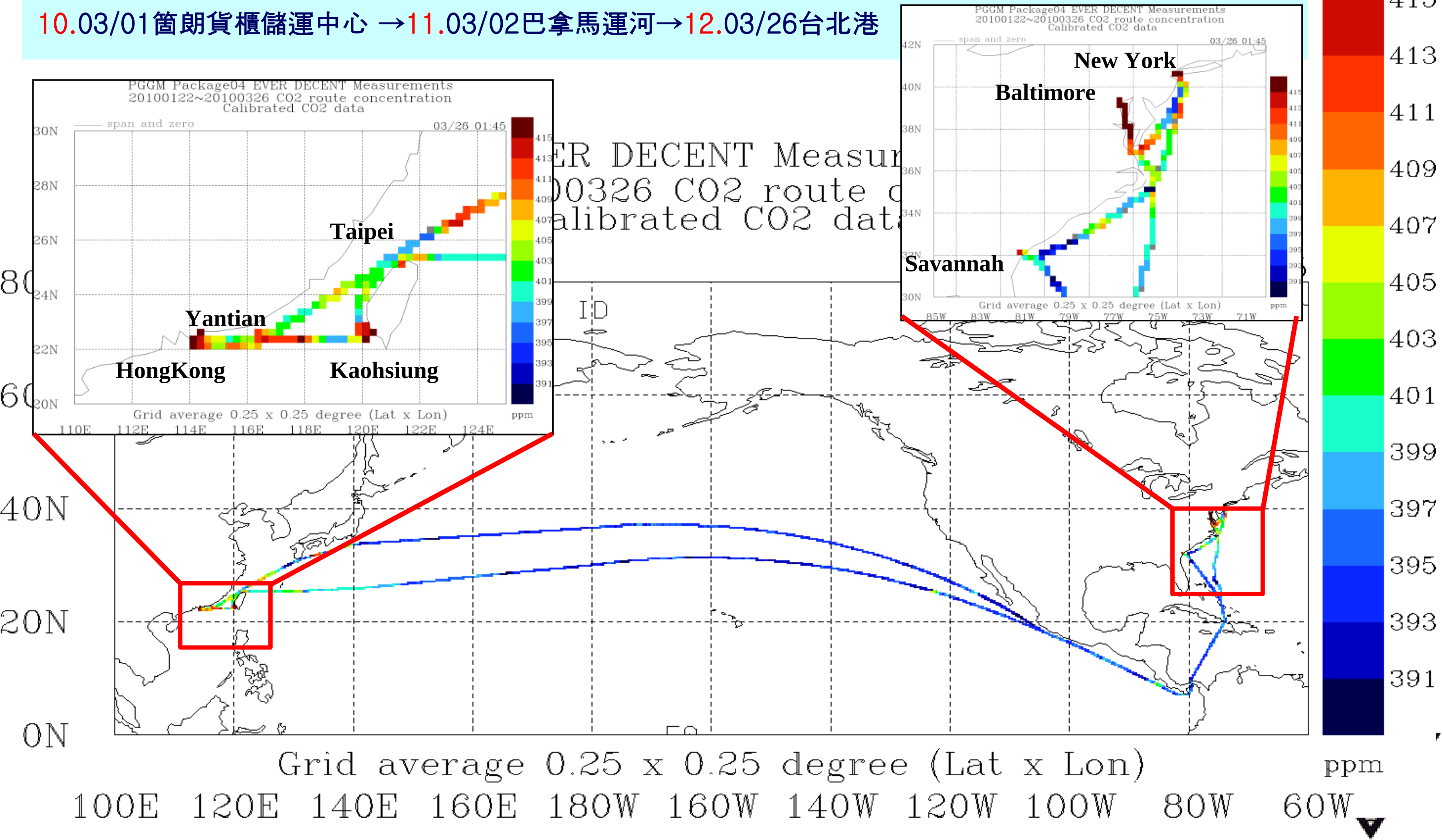


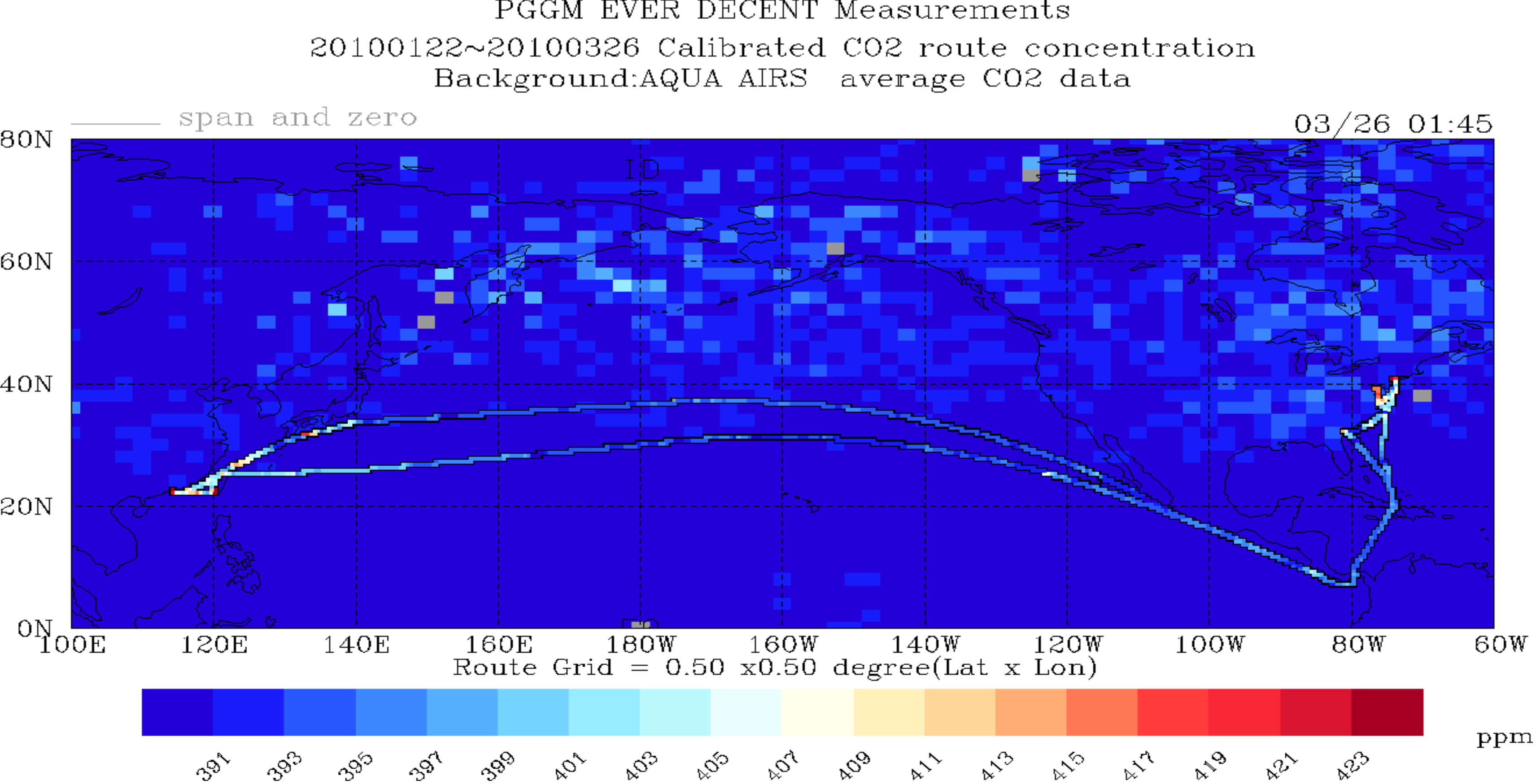
●Path(實際,UTC):

1.01/22台北港→2.01/23香港港→3.01/24鹽田港→4.01/26高雄港→5.02/15巴拿馬運河→

6.02/15箇朗貨櫃儲運中心 →7.02/20薩凡納港→8.02/22紐約港→9.02/24巴爾地摩港→

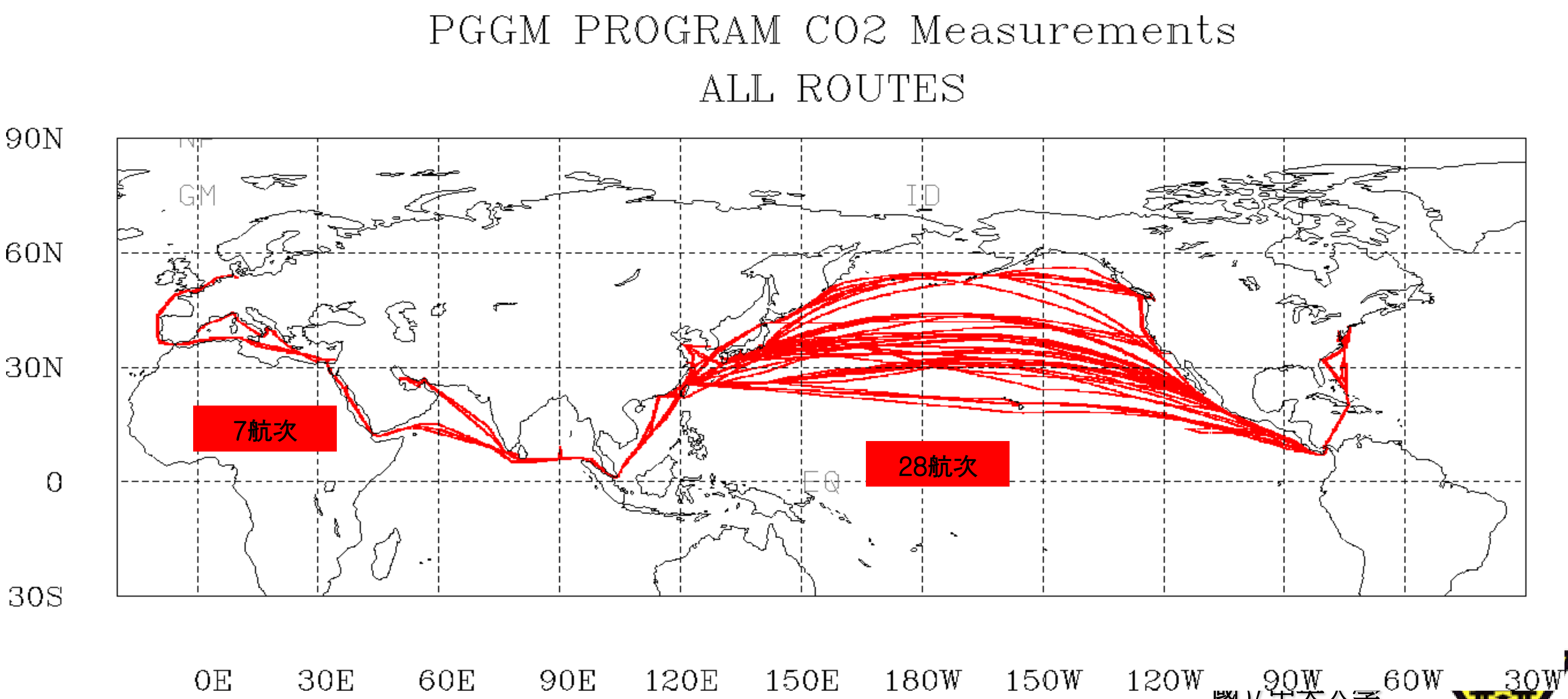
10.03/01箇朗貨櫃儲運中心 →11.03/02巴拿馬運河→12.03/26台北港





- 洋面區域:貨輪所觀測到的二氧化碳濃度資料和AIRS二氧化碳反演資料濃度值很相近
- 接近港區或是陸地附近的海域就有很明顯的差異

- 二氧化碳船測資料分析
  - 2009/06~2010/06/30共完成35個航次之觀測
    - 北太平洋10ºN~60ºN之間的海域
    - 印度洋
    - 西北大西洋



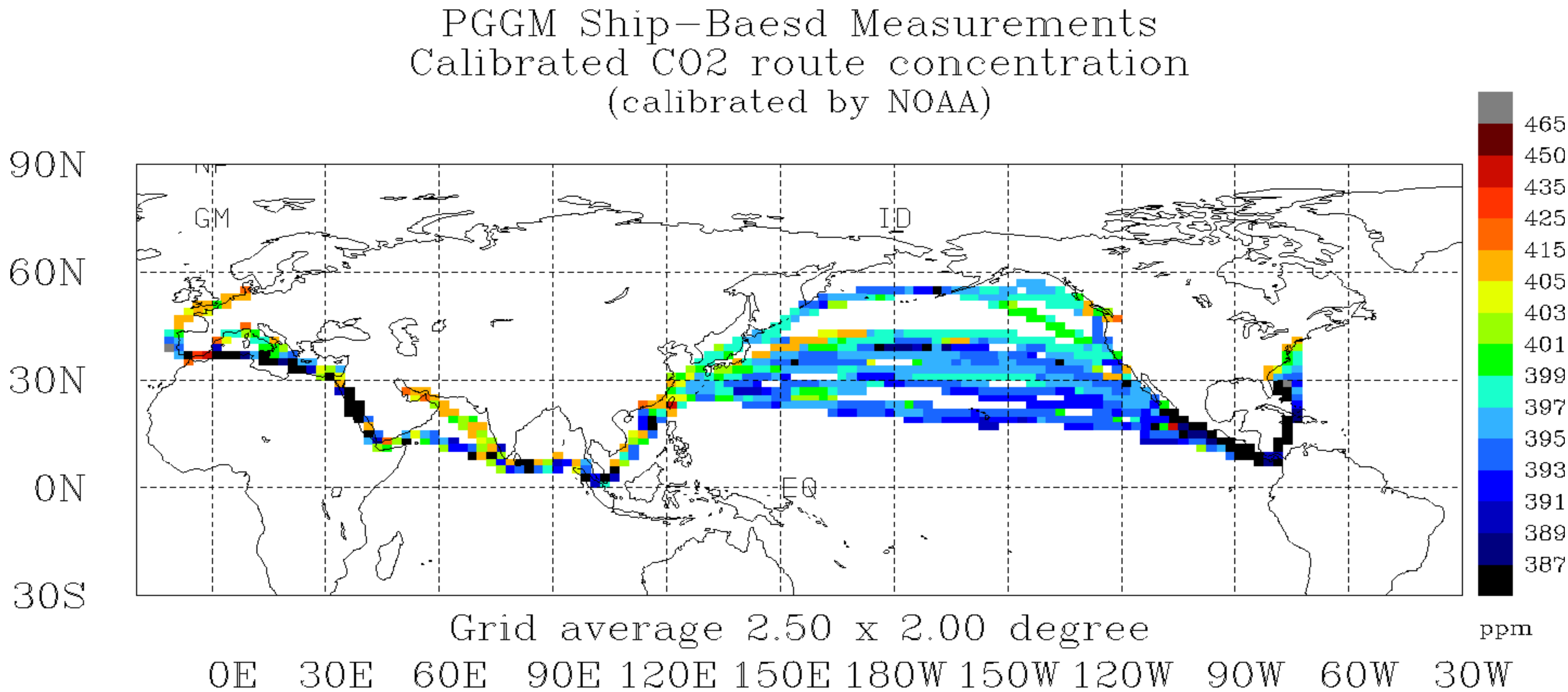

PGGM Ship-Baesd Measurements
Calibrated CO2 route concentration
(calibrated by NOAA)
90N
60N
30N
0N
30S
GM
ID
EQ
465
450
435
425
415
405
403
401
399
397
395
393
391
389
387
ppm
Grid average 2.50 x 2.00 degree
0E 30E 60E 90E 120E 150E 180W 150W 120W 90W 60W 30W

表 4.2 各港口名稱及經緯度位置

COUNTRY	PORT	LAT	LON
USA	Baltimore	39.23	-76.55
USA	New York	40.68	-74.02
USA	Savannah	32.11	-81.12
USA	Los Angeles	33.73	-118.26
USA	Oakland	37.79	-122.302
Taiwan	Kaohsiung	22.56	120.31
Taiwan	Taipei	25.15	121.37
China	Yantian	22.57	114.26
China	Shanghai	31.22	121.48
China	Ningbo	29.86	121.55
HK	HongKong	22.32	114.15

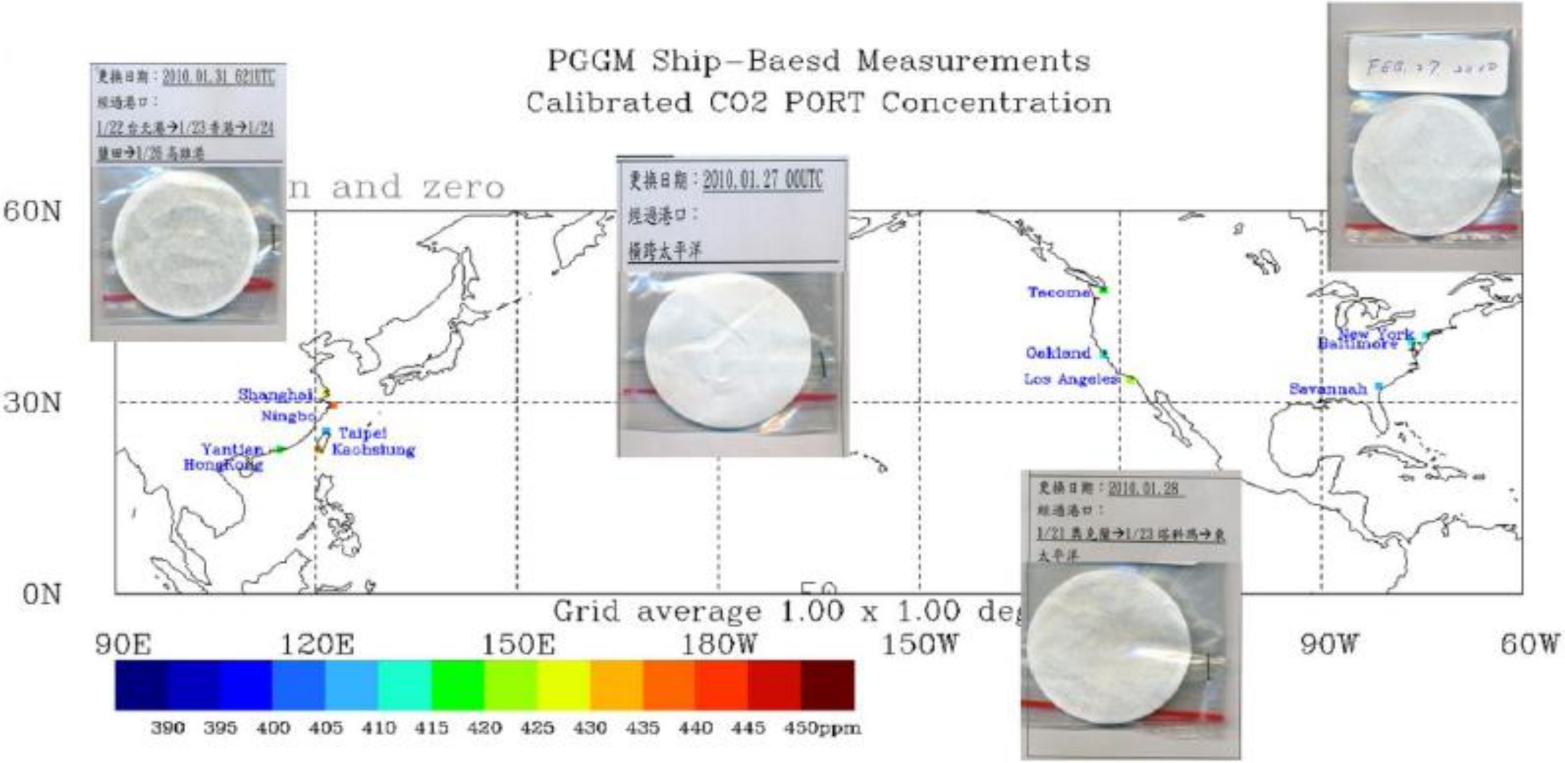


圖 4.16 2009 年 11 月至 2010 年 3 月觀測期間更換之濾紙

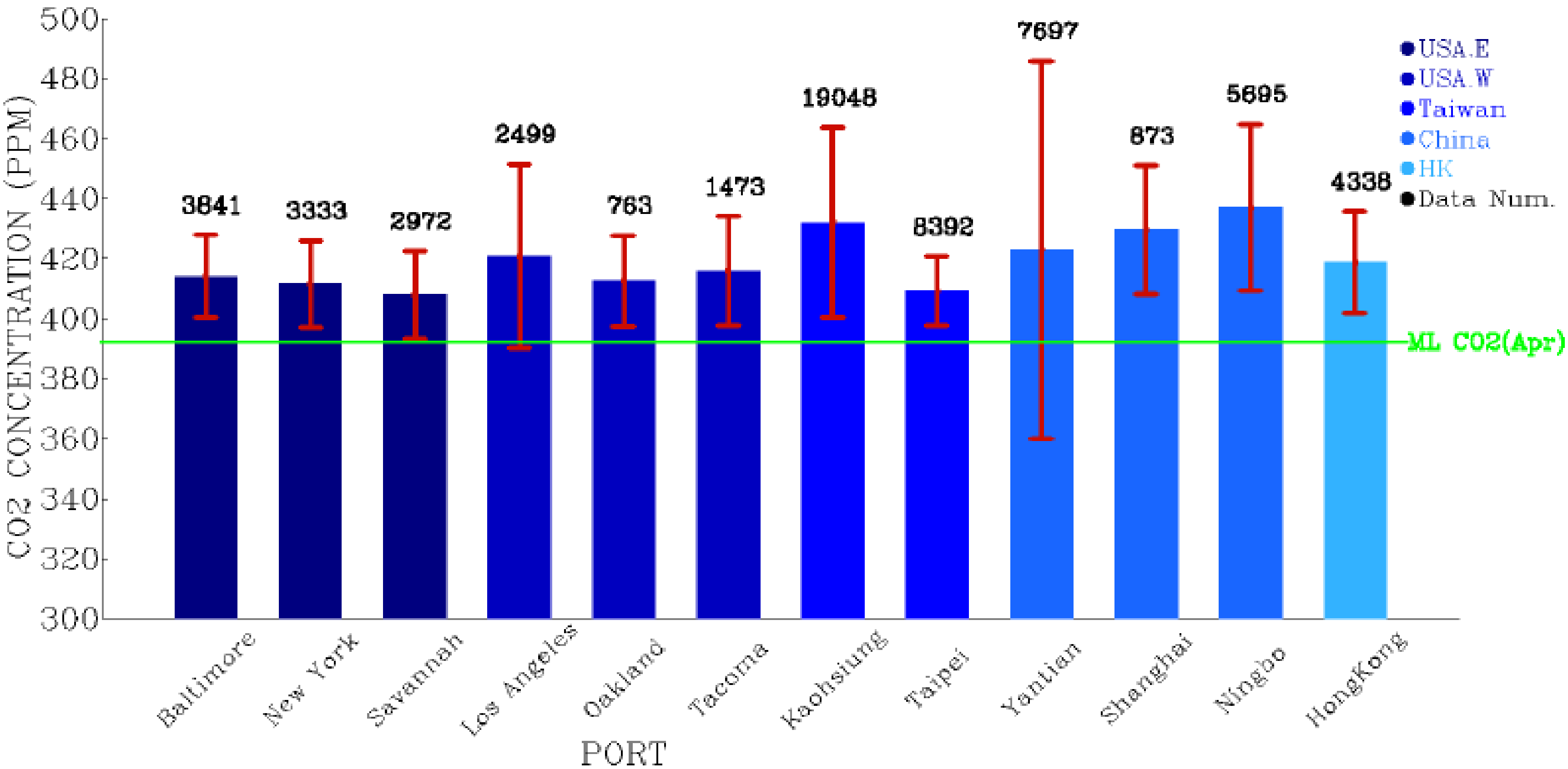


圖 4.17 各港口之二氧化碳濃度與標準差。紅色為正負一個標準差，綠色為夏威夷 Mauna Loa 測站 4 月平均二氧化碳濃度值，黑色為所選用之二氧化碳資料筆數

表 4.3 各港口之世界排名、平均港口二氧化碳濃度等資訊

COUNTRY	PORT	Ranking(2008)	CO2	AVG	STDEV
USA.E	Baltimore	125↑	414.05	410.98	13.799
USA.E	New York	20	411.55		14.423
USA.E	Savannah	40	407.84		14.753
USA.W	Los Angeles	16	420.74	416.40	30.717
USA.W	Oakland	47	412.63		15.094
USA.W	Tacoma	62	415.84		18.168
Taiwan	Kaohsiung	12	432.13	420.62	31.642
Taiwan	Taipei		409.11		11.506
China	Yantian		422.93	429.81	62.937
China	Shanghai	2	429.57		21.353
China	Ningbo	7	436.95		27.865
HongKong	HongKong	3	418.81	418.81	16.972

In-service Aircraft for a Global Observing System

Andreas Volz-Thomas and the IAGOS-Team

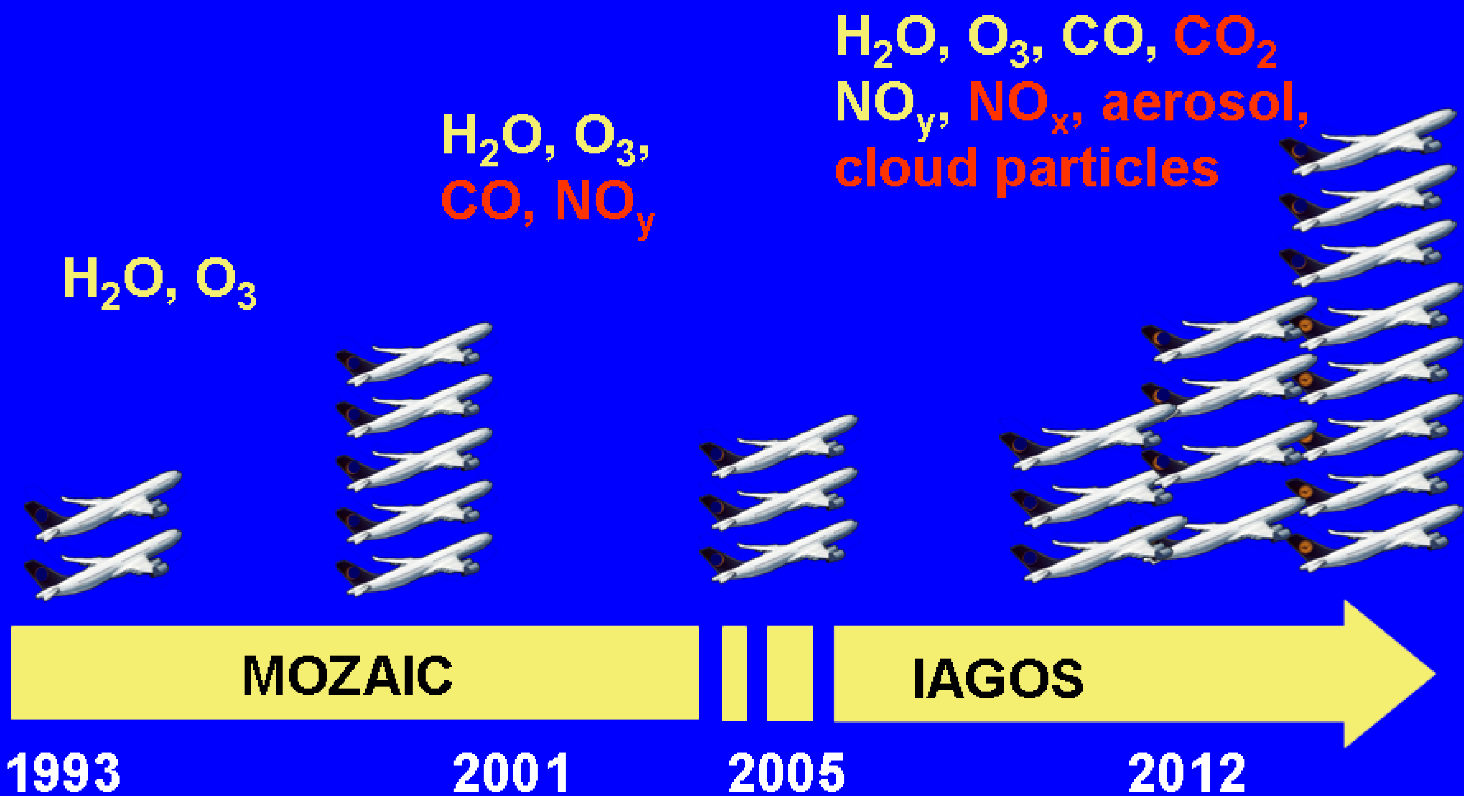
→ FIRST IAGOS ATLANTIC AIRCRAFT BY LTH IN 2010/2011

Lufthansa Airbus A340-300

Foto: Gerd Rebenich / Lufthansa DR 120-13-C 291
Nur für redaktionelle Zwecke / For editorial purposes only

From a research project to sustainable Earth observations

In-Service Aircraft for a Global Observing System

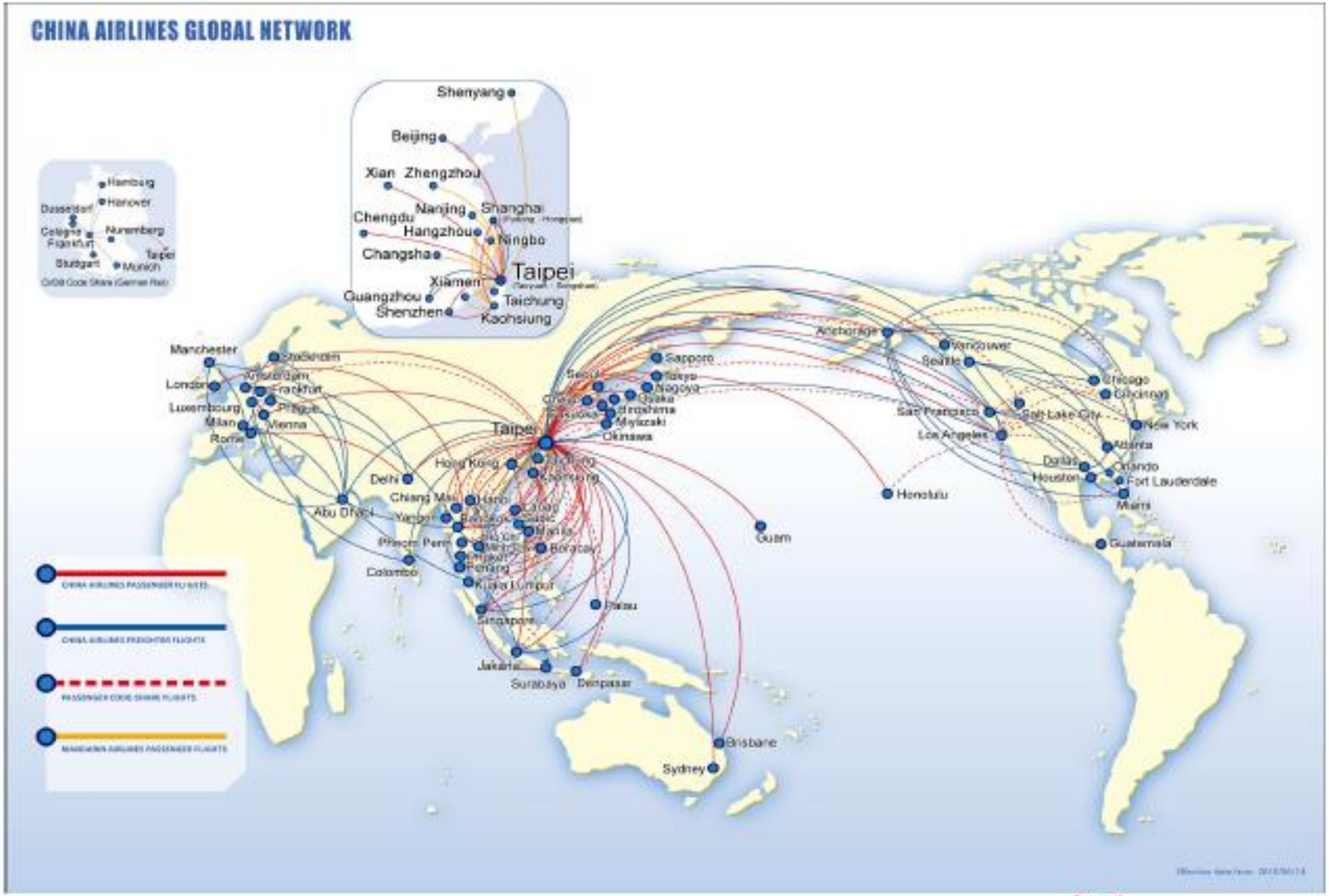


Feb 2008, Brussels

PGGM Air-Based Global Greenhouse Gases Measurements with China Airlines: A Special Thanks to China Airlines

China Airlines- first in the world to fly IAGOS for global environmental monitoring over the Pacific in 2011.

China Airlines Flies to 93 Destinations in 28 Nations



Summary

- PGGM Air-Based measurements will be launched from late 2011, pending on the successful progress of STCs for IAGOS packages 1 and 2 in 2010/2011.

- PGGM Ship-Based measurements has been successfully launched on 22 Jun 2009. We now have 9 vessels conducting routine CO2 measurements over Pacific, Indian, and Atlantic regions.

Global Temperature Monitoring with FORMOSAT-3/COSMIC

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Jeju Workshop, 21-22 Oct 2010
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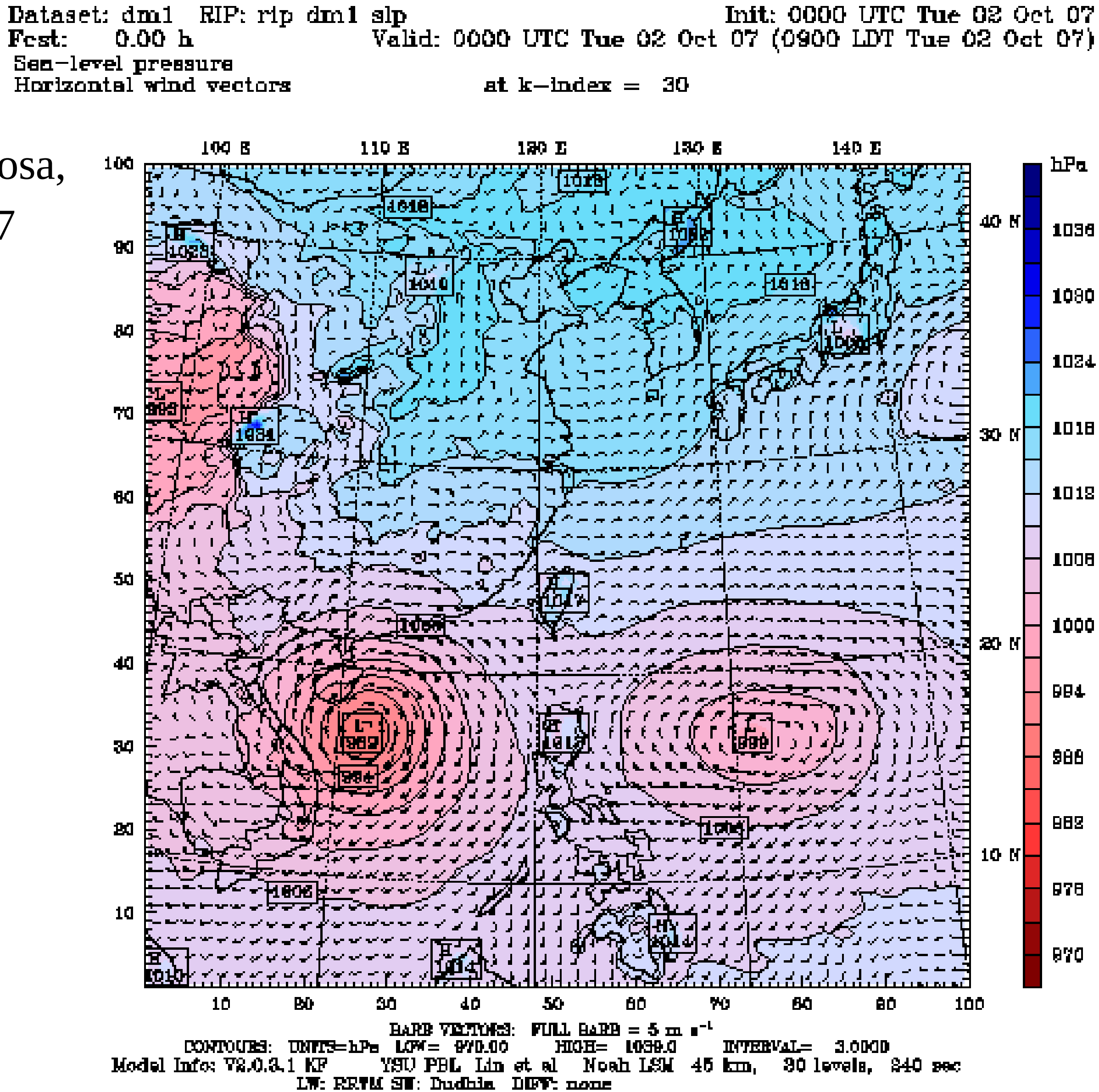
Acknowledgement

- NSPO (National Space Organization), Taiwan
- NSC (National Science Council), Taiwan
- Lou Chuan Lee, Chao-Han Liu, Yuea-An Liu, Ching-Youn Huang, Song-Chin Lin, Tiger Liu, Y.-H. Iq, Ben Chao (NCU), and CWB team.
- Neil Harris, Peter Braesicke, John Pyle,Cambridge University, UK: UKMO and ECMWF data
- UCAR and NCAR: COSMIC team, wrf/wrfchem
- NASA, NOAA: NCEP, MODIS, OMI, CALIPSO, etc, data

Outline

- 1. Introduction: A brief description of FORMOSAT-3/COSMIC (FS3/C) mission
- 2. Atmospheric studies with FS3/C
  - vertical temperature structures inside polar vortex
  - effect of volcano eruptions
  - effect of solar eclipses
  - impact Saharan dust outbreaks over the tropical North Atlantic
    → implication for hurricane forecast
  - data assimilation with FS3/C in the forecast models
- 3. Summary

Typhoon Krosa,
2-7 Oct 2007



(b)

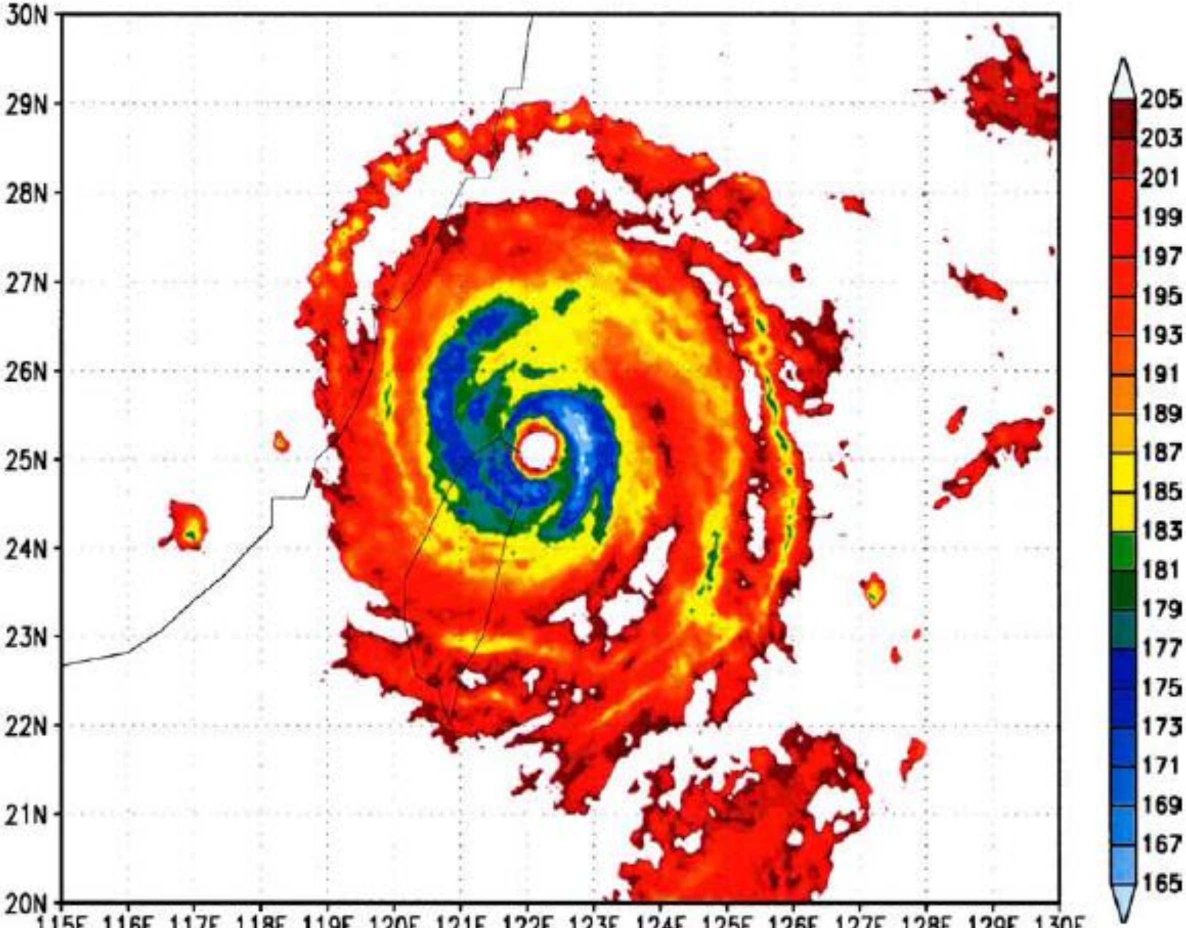


Figure 5. (a) Tracks of the movement of the center of Typhoon Nari. The colour bar indicates the dates in September (numbers above the bar) and the Julian day (numbers below the bar) since 1 January 2001, respectively. (b) A snapshot of the GMS satellite IR-3 brightness temperature (Kelvin) on 16 September 2001.

橫掃全台 | 重建問題 | 責任檢討 | 怪颱記錄 | 分析評論 | 回首頁 |

怪颱納莉狂飆全台

納莉災情統

納莉風災死亡

根據中央災
統計，納莉風
台至少八十四
六人失蹤，兩
傷，地下室淹
棟，十九個縣
業損失金額近

福衛3號升空的一刻　GPS全球氣象預測新紀元展開

COSMIC Launch - Picture Provided by B. Kuo - Click to view the COSMIC launch footage

世界頂尖氣象中心新聞

Leading Weather Center Newsletters

JCSDA Quarterly No. 18, March 2007

Joint Center for Satellite Data Assimilation • 5200 Auth Road • Camp Springs • MD • 20746 *Editor: George Ohring*

NOAA……………NASA…………US Navy…………US Air Force *Web-site: www.jcsda.noaa.gov*

News in This Quarter

Science Update

Cosmic Data to be Assimilated Operationally at NOAA

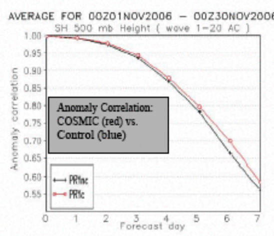
After successful testing at the JCSDA, Global Positioning System (GPS) radio occultation (RO) soundings from the COSMIC mission will go into operational use with the implementation of the Gridpoint Statistical Interpolation (GSI)/Global Forecast System (GFS) system at NOAA/NCEP on May 1st 2007.

In preparation for the assimilation of COSMIC data, the JCSDA developed, tested and incorporated the necessary components to assimilate GPS RO profiles. These components include forward operators and associated tangent linear and adjoint models, quality control algorithms, error characterization models, data handling, decoding procedures, and verification and impact evaluation techniques.

Impact tests indicate that the assimilation of GPS RO observations improves the fit to rawinsonde observations by reducing the mean and root-mean-square differences in the upper troposphere and stratosphere. The anomaly correlation (AC) scores for both the Northern and Southern Hemispheres also improved with the use of COSMIC data for the test period, November 2006. In general, the improvement in AC scores will be more or less significant depending on the meteorological situation and the model performance for the period under study. The accompanying figure shows the 500 hPa geopotential height AC as a function of the forecast range in the Southern Hemisphere for November 1st to 30th 2006. The assimilation of COSMIC data (PRYc, in red) improves the AC scores when compared to the control run (PRYnc, in black). Both PRYnc and PRYc experiments assimilate all the observations currently being used in operations. Therefore the difference between the runs is due to the impact of assimilating COSMIC data.

COSMIC, the Constellation Observing System for Meteorology, Ionosphere and Climate, a joint Taiwan-U.S. project, was launched in April 2006. The scientific foundation for COSMIC is the radio occultation (limb sounding) technique. The six-satellite constellation provides high vertical resolution information on atmospheric temperature/humidity at about a thousand locations each day.

(Lidia Cucurull, JCSDA/NCEP)



Anomaly correlation scores (Red: With COSMIC; Blue: without COSMIC) for the 500 mb height field in the Southern Hemisphere as a function of the forecast length.

Assimilation of MLS Ozone Observations Improves Antarctic Ozone Hole Depiction

NASA's EOS Aura satellite provides comprehensive atmospheric chemical composition measurements. For example, the Aura Microwave Limb Sounder (MLS) instrument captures ozone profiles with the vertical resolution of about 3 km in the stratosphere. These data can be used to constrain stratospheric ozone in atmospheric models, potentially improve assimilation of infrared radiances, and provide a better field for radiative computations. In combination with Aura's Ozone Monitoring Instrument (OMI) total column ozone measurements, the MLS ozone data can also be used to estimate tropospheric ozone, which is an important component of the air quality.

The Goddard Earth Observing System-5 (GEOS-5) Data Assimilation System at NASA Goddard's Global Modeling and Assimilation Office (GMAO) uses the Gridpoint Statistical Interpolation (GSI) as its analysis component. Recently, scientists at the GMAO modified the GSI code to add assimilation of ozone profiles, such as those produced by ozone retrievals from the Aura MLS.

The results from a recent one-month assimilation of MLS ozone data are very encouraging. The figure below compares zonal mean ozone partial pressure (mPa) at the end of the one-

FORMOSAT-3 Mission Highlighted by Nature

nature

news nature 17 May 2001

Array system promises global atmospheric monitoring

David Cyranoski, Tokyo

A Taiwan–US collaboration is hoping that its constellation of microsatellites equipped with Global Positioning System (GPS) receivers will provide a valuable new approach to meteorology, climatology and research into space weather.

Most weather forecasting currently relies on balloons that take readings such as temperature and humidity on their way up from some 900 locales worldwide. But these points are restricted to land, ruling out truly global weather models. Weather satellites give wider coverage, but they gather data by looking straight down to Earth, yielding little information about what is happening at various different altitudes.

But the Taiwan-led Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) could change that by using an array of microsatellites and a novel technique to improve the coverage and accuracy of data collection.

The six COSMIC microsatellites, scheduled to be launched in mid-2005, will pick up radio signals from 28 existing GPS satellites as they pass through the Earth's atmosphere. The microsatellites will observe the refraction (or bending) of the signals, and infer information about atmospheric density from it, at all altitudes. From the density data, researchers will be able to deduce the pattern of pressure and temperature.

"We can also calculate atmospheric moisture near the surface, construct pressure contours, and derive wind fields and other critical quantities," says Tom Yunck of NASA's Jet Propulsion Lab (JPL), which did much of the early work on the technique.

The most important advantage is coverage. "The microsatellite constellation will measure some 4,000 points spread uniformly around the globe, with high accuracy," says Chao-Han Liu, president of Taiwan's National Central University.

Researchers on space weather are also excited about the project, says Liu. In the ionosphere, at altitudes of about 80 km, electron density can be measured in a similar fashion to the atmospheric density. This will provide valuable information for predicting magnetic storms, which can affect the operations of satellites and power grids.

The COSMIC system has the potential to significantly improve climatological measurements, says Alan Thomas, director of the Global Climate Observing System secretariat. However, he warns that it will probably take time to develop a reliable system that produces measurements for climate-change applications, and another 20 years or so after that to obtain a meaningful long-term climate data set.

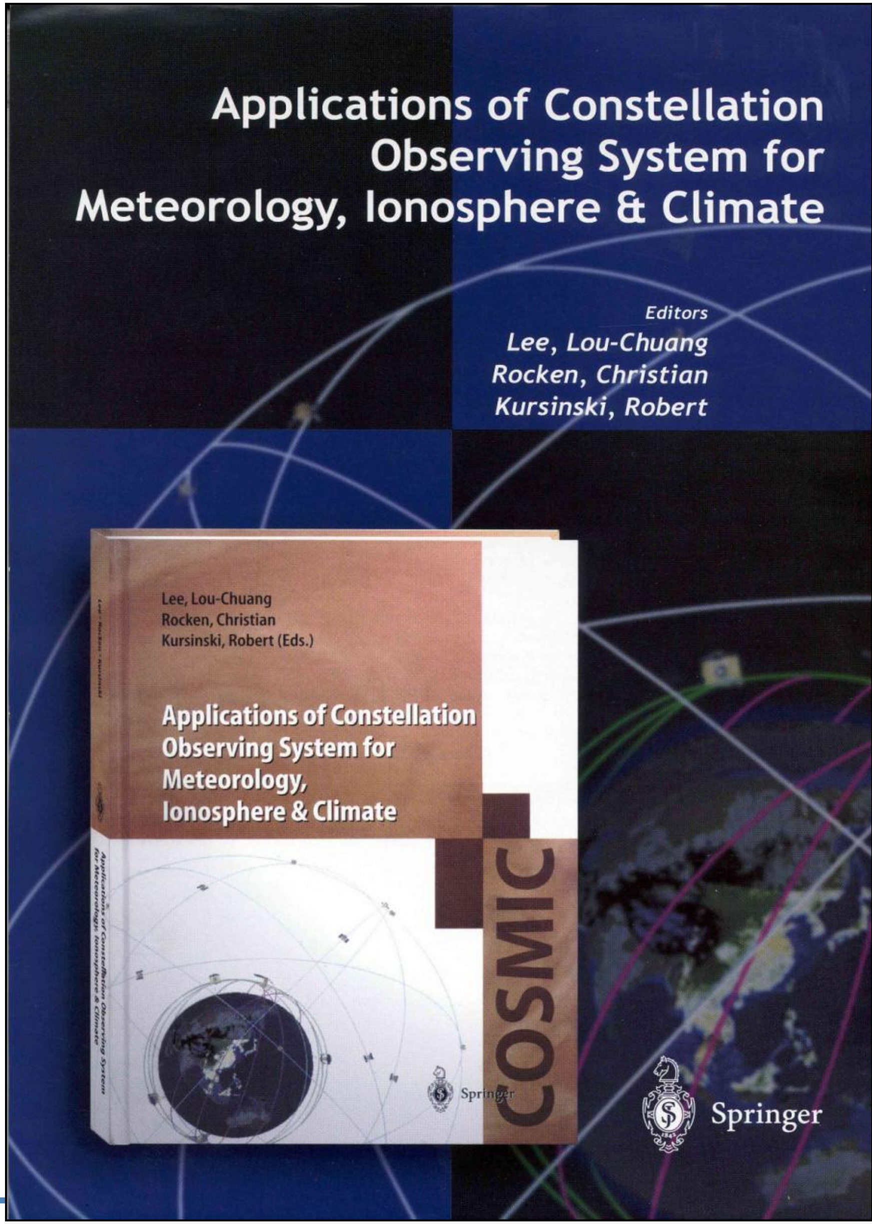
The agreement to build the system, signed on 3 May, involves Taiwan's National Space Program Office (NSPO), JPL, the US University Corporation for Atmospheric Research in Boulder, Colorado, and several US universities.

Taiwan will pay US$80 million of the estimated US$100 million total project cost and will build the satellites with the help of Orbital Sciences Corporation of Dulles, Virginia, which made a prototype version of the satellite in 1995 for a proof-of-concept experiment. Taiwan will also operate the mission.

"This is a chance to get people really interested in space science," enthuses Luo-Chang Lee, director of NSPO.

Saturation coverage: six microsatellites will improve the coverage and accuracy of climate data.

The COSMIC micro-satellites equipped with GPS receivers will provide a valuable new approach to meteorology, climatology and research into space weather. The new system has the potential to significantly improve climatological measurements.



A special monograph published
by NSPO and UCAR on the GPS radio sounding of earth atmosphere and ionosphere.

FORMOSAT-3/COSMIC

Launched 14 April 2006.

Total number of occultations - Please click on the numbers to update them.

Total Atm Occs: 456177 Total Ion Occs: 673355

Milestones:

- 14 Apr 2006: FORMOSAT-3 successfully launched into the orbit
- 12 Dec 2006: European Centre for Medium-Range Weather Forecast (ECMWF) started using FROMOSAT-3 data in operational weather prediction
- May 2007: First result on FORMOSAT-3 ionospheric study published in Geophysical Research Letters (Lin et al., 2007)
- May 2007: The US National Centers for Environmental Prediction (NCEP) and the United Kingdom Meteorological Office (UKMO) started using FROMOSAT-3 data in operational weather prediction
- Jun 2007: First result on FORMSAT-3 stratospheric study published in Geophysical Research Letters (Wang and Lin, 2007)
- Sep 2007: Meteo France started using FORMOSAT-3 data in operational weather predicton

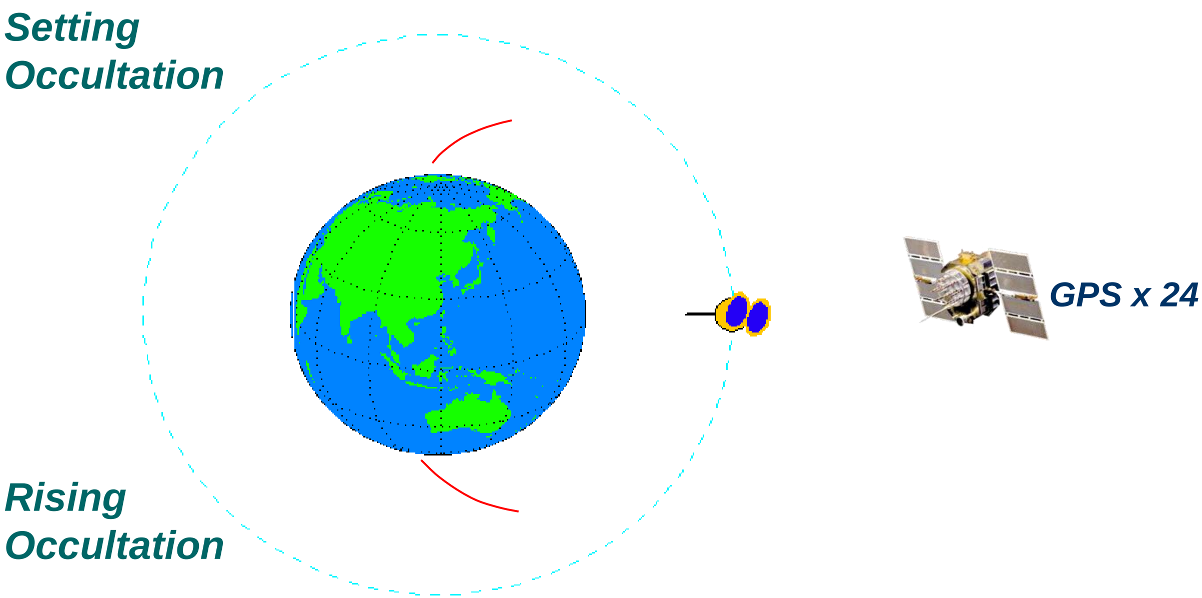
FORMOSAT-3 Users

Global Data Users *52 Countries*

U.S.A.	481	Chile	4
Taiwan	184	Portugal	4
India	135	Ukraine	4
China	95	The Netherlands	3
Japan	54	Poland	3
Korea	34	Thailand	2
Germany	34	United Arab Emirates	2
Canada	33	Israel	2
U.K.	33	Malaysia	2
Russia	29	Peru	2
Brazil	26	Puerto Rico	2
Italy	25	Finland	2
Indonesia	24	Bulgaria	2
Australia	24	Czech	2
France	21	Pakistan	1
Vietnam	17	Bangladesh	1
Austria	13	Singapore	1
Argentina	12	Bhutan	1
Philippine	11	Costa Rica	1
Spain	9	Sweden	1
Iran	6	Ireland	1
New Zealand	6	Norway	1
South Africa	6	Belgium	1
Nigeria	6	Egypt	1
Denmark	5	Senegal	1
Switzerland	5		
Turkey	4	Total	1,379

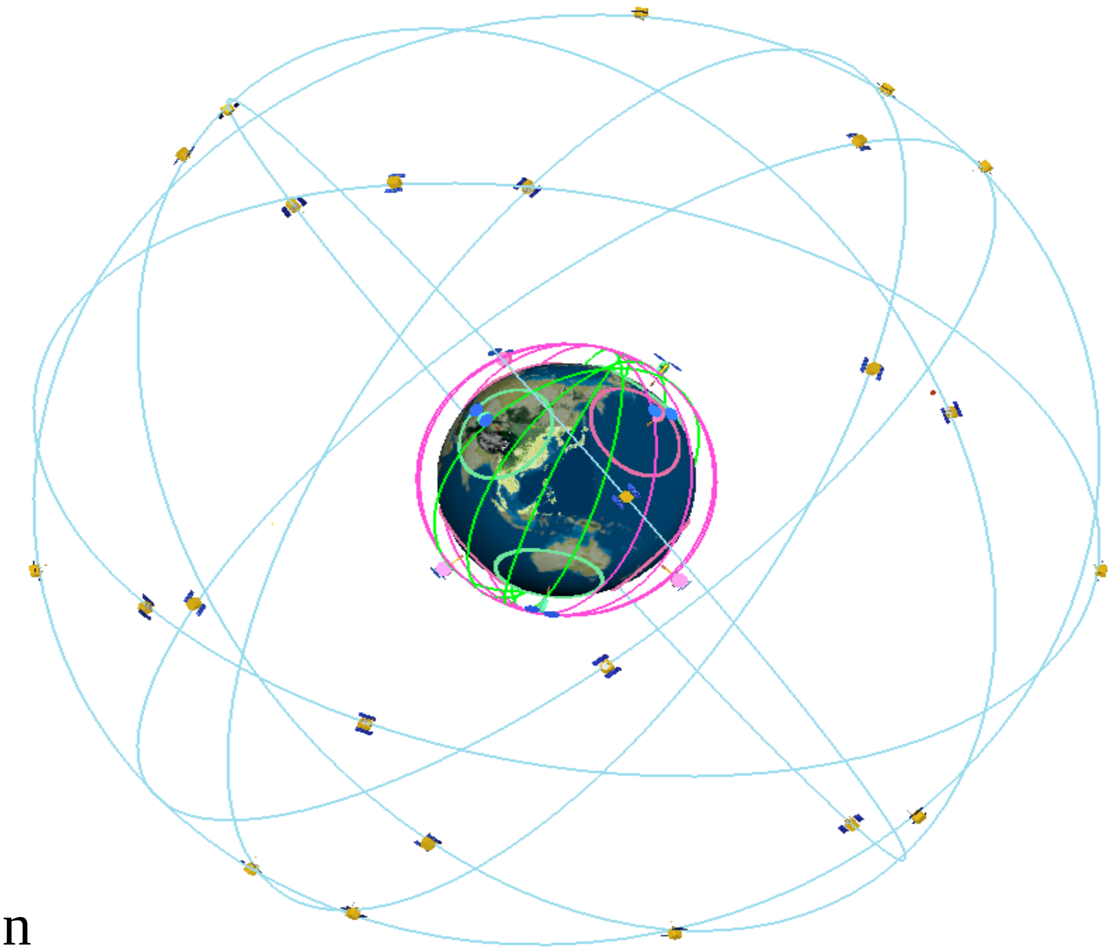
As of 8/31/2010

GPS Radio Occultation Technology

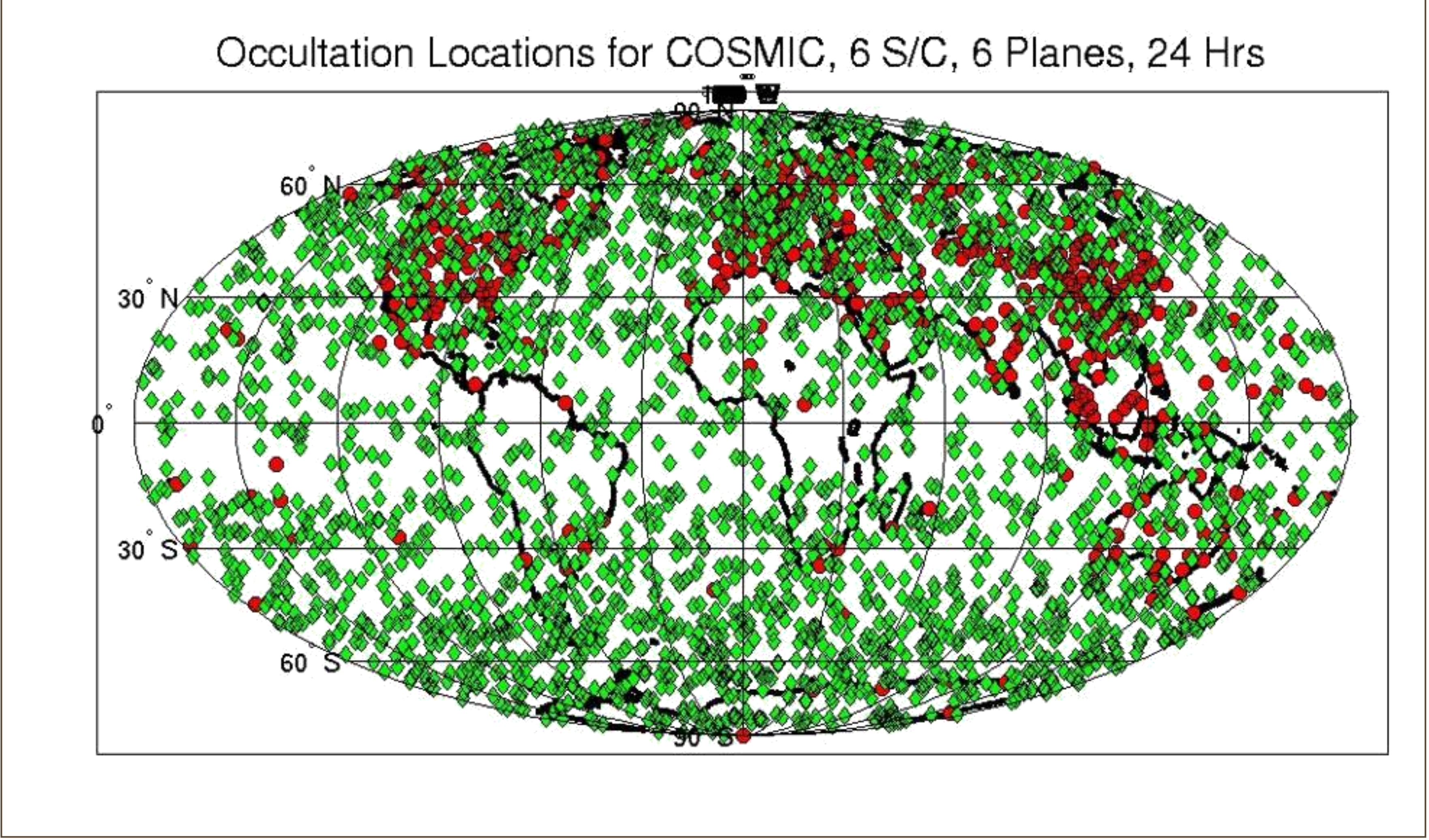


FORMOSAT-3 Mission

6 FORMOSAT-3 satellites receive signals from 24 GPS satellites to perform GPS occultation to retrieve atmospheric properties.



20,200 km altitudes,
55 Degrees inclination



- The constellation of six FORMOSAT-3 /COSMIC satellites monitors
- as many as 2,000 profiles of the atmosphere each day.
- In comparison, ground sounding stations provide only 900 profiles of measurements.

國立中央大學

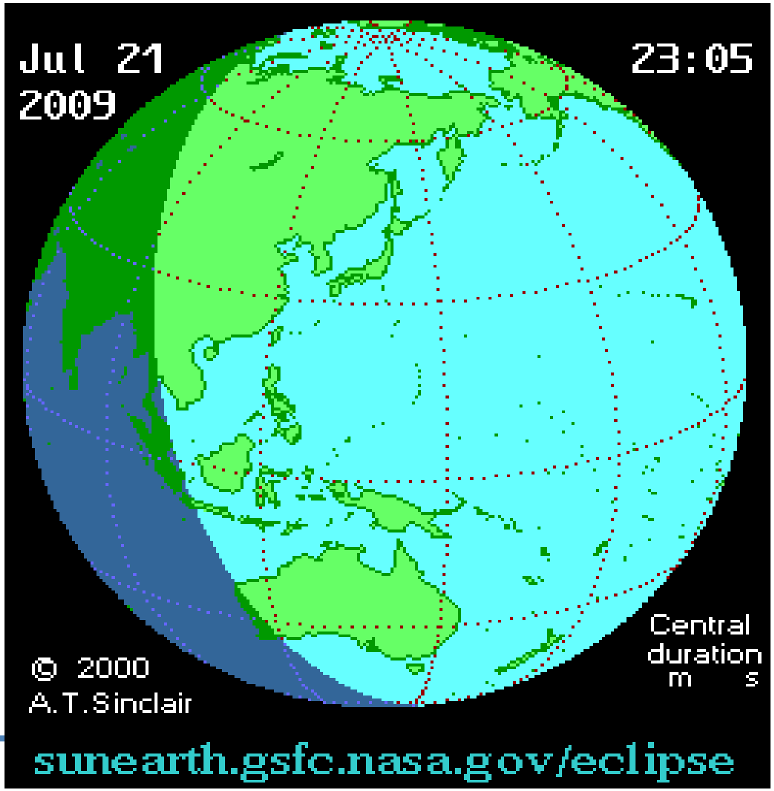
Here we show the use of FS3/C data
-In detecting the vertical temperature structures in the Antarctic polar vortex (Wang and Lin, GRL, 2007);
-in the volcanic plumes (Wang et al., GRL, 2009);
-in the Saharan dust plumes (Wang, Atmos. Res., 2010);
-during the total eclipse of 22 July 2009 (Wang and Liu, GRL, 2010).

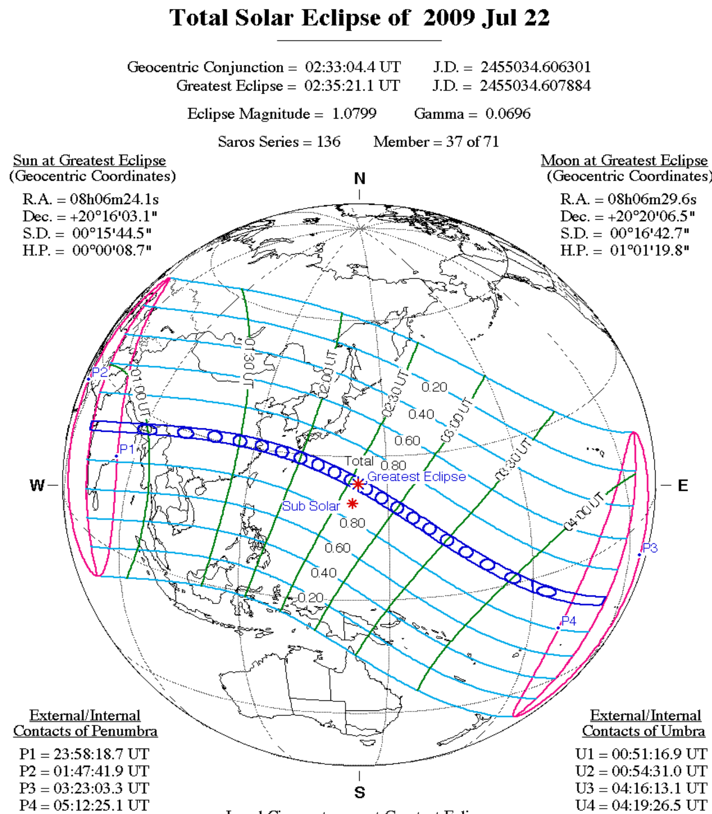
Some of the results are tested against measurements from AQUA AIRS.
These results highlight important processes that are lacked in the current weather prediction models such as ECMWF, UKMO, and NCEP.

GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L01804, doi:10.1029/2009GL040968, 2010

Profiles of temperature responses to the 22 July 2009 total solar eclipse from FORMOSAT-3/COSMIC constellation

Kuo-Ying Wang[1] and Chao-Han Liu[2]





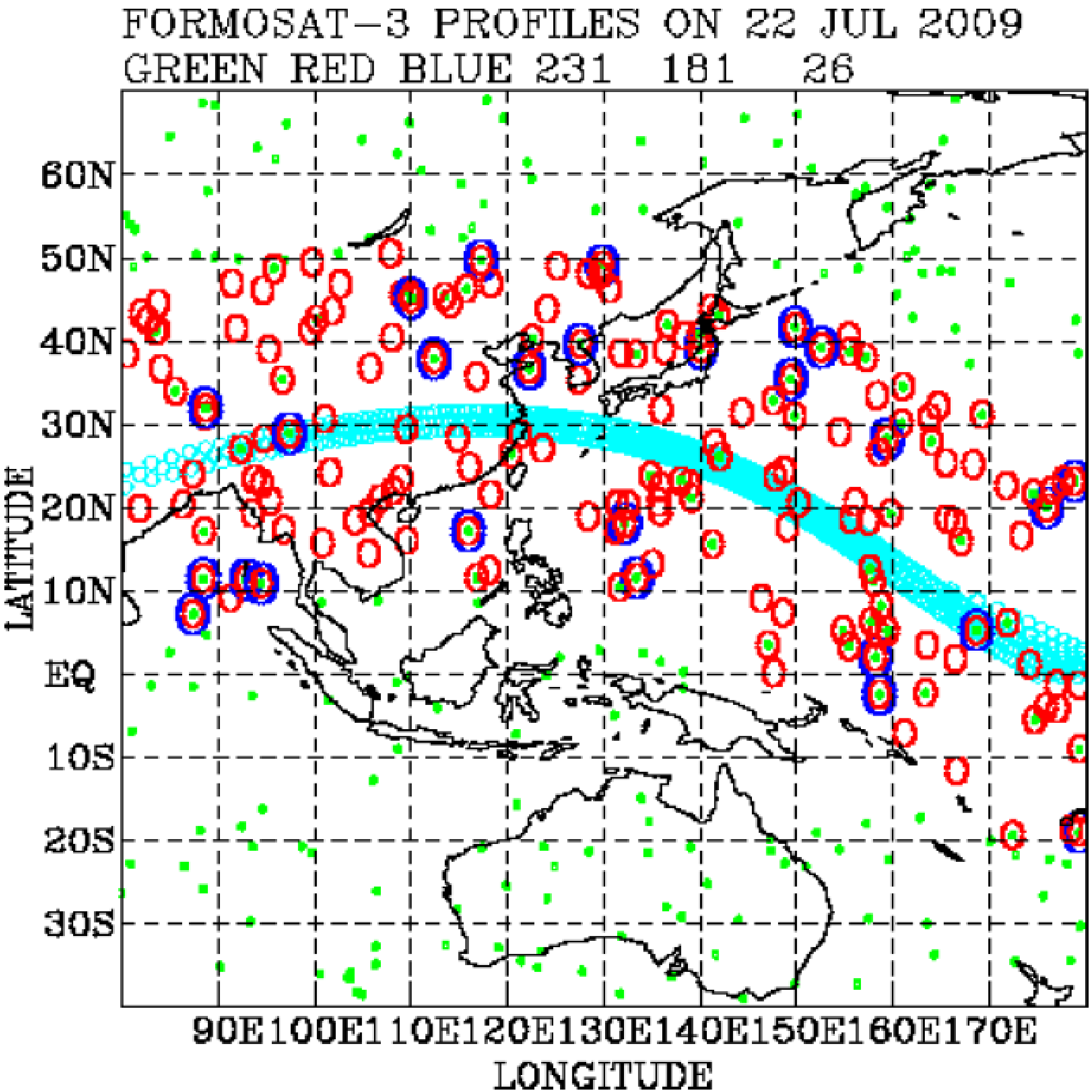


Figure 1. Spatial distribution of FS3/C GPS RO profiles (green dots, red, and blue circles) and path of the total eclipse (sky-blue circles) on 22 July 2009

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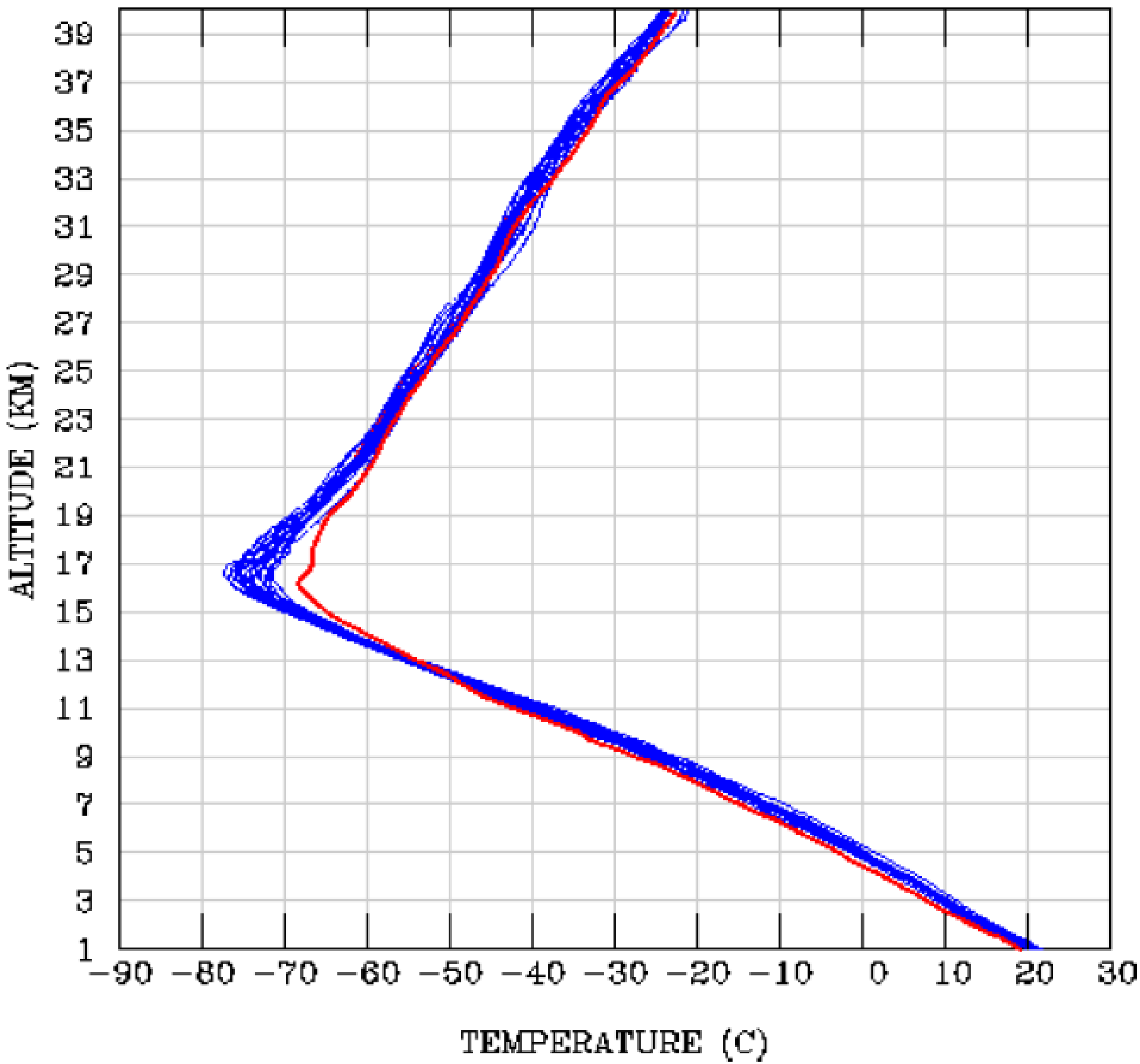

Figure 2. Profiles of temperatures from FS3/C on 22 July 2009 (red curve), and each days of 12 July-21 July, and 23 July-1 August 2009 (blue curves).

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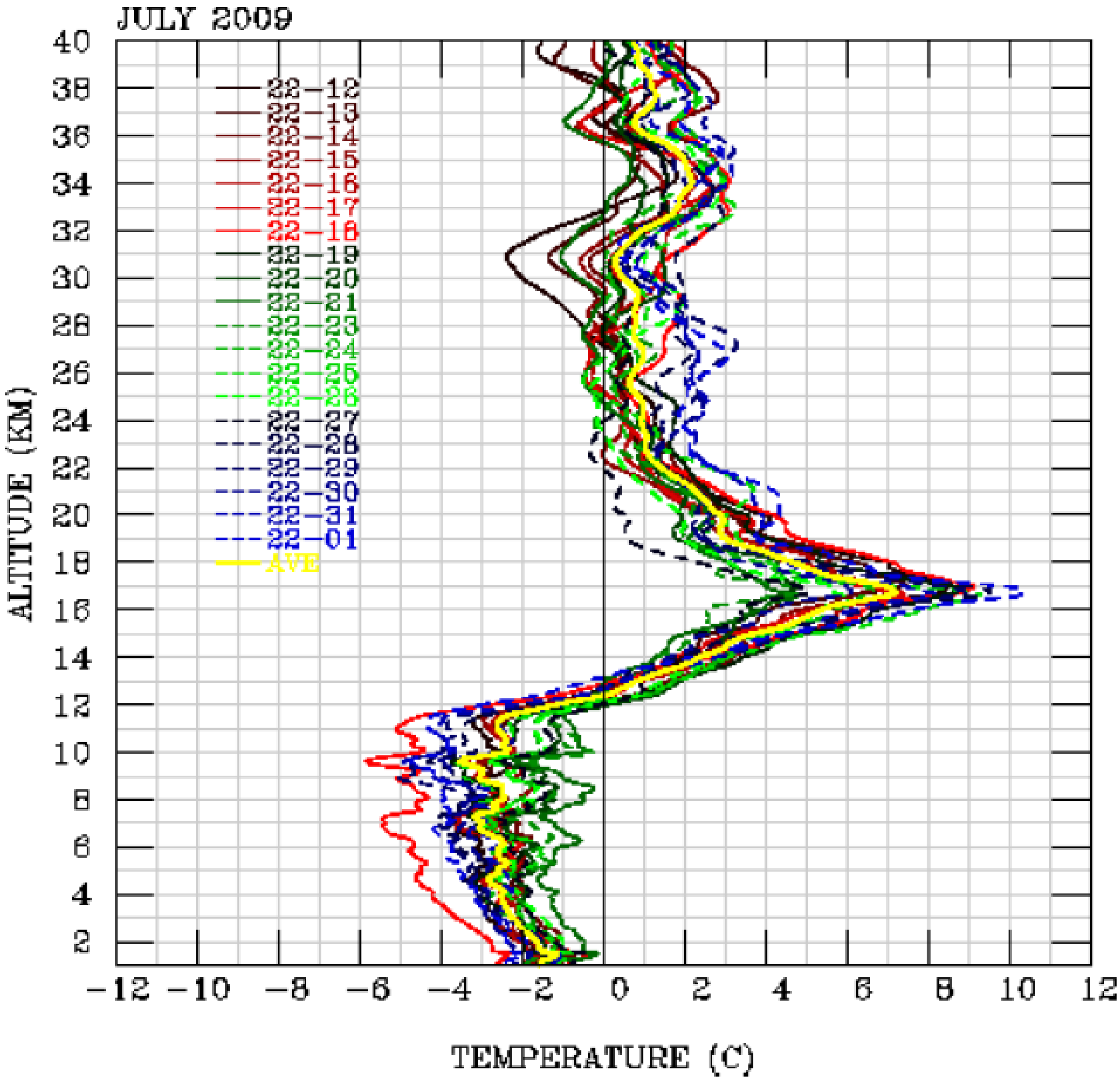

Figure 3(a) Profiles of temperature differences between 22 July 2009 (the eclipse day) and each day of 12 July-21 July, and 23 July-1 August 2009, respectively. Mean profile of temperature differences is shown in yellow curve.

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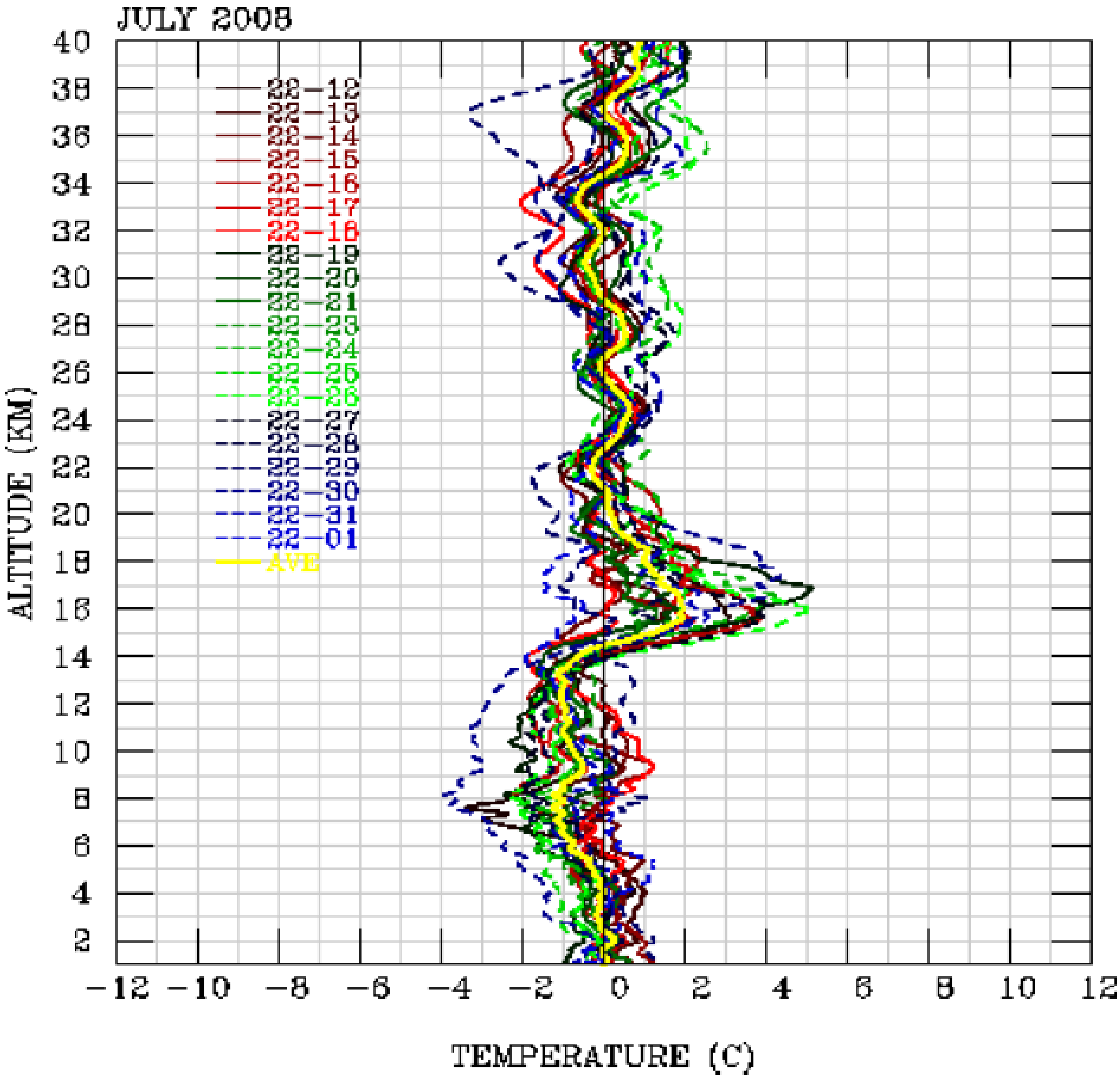

Figure 3(b) The same as in Figure 3(a) but for 2008.

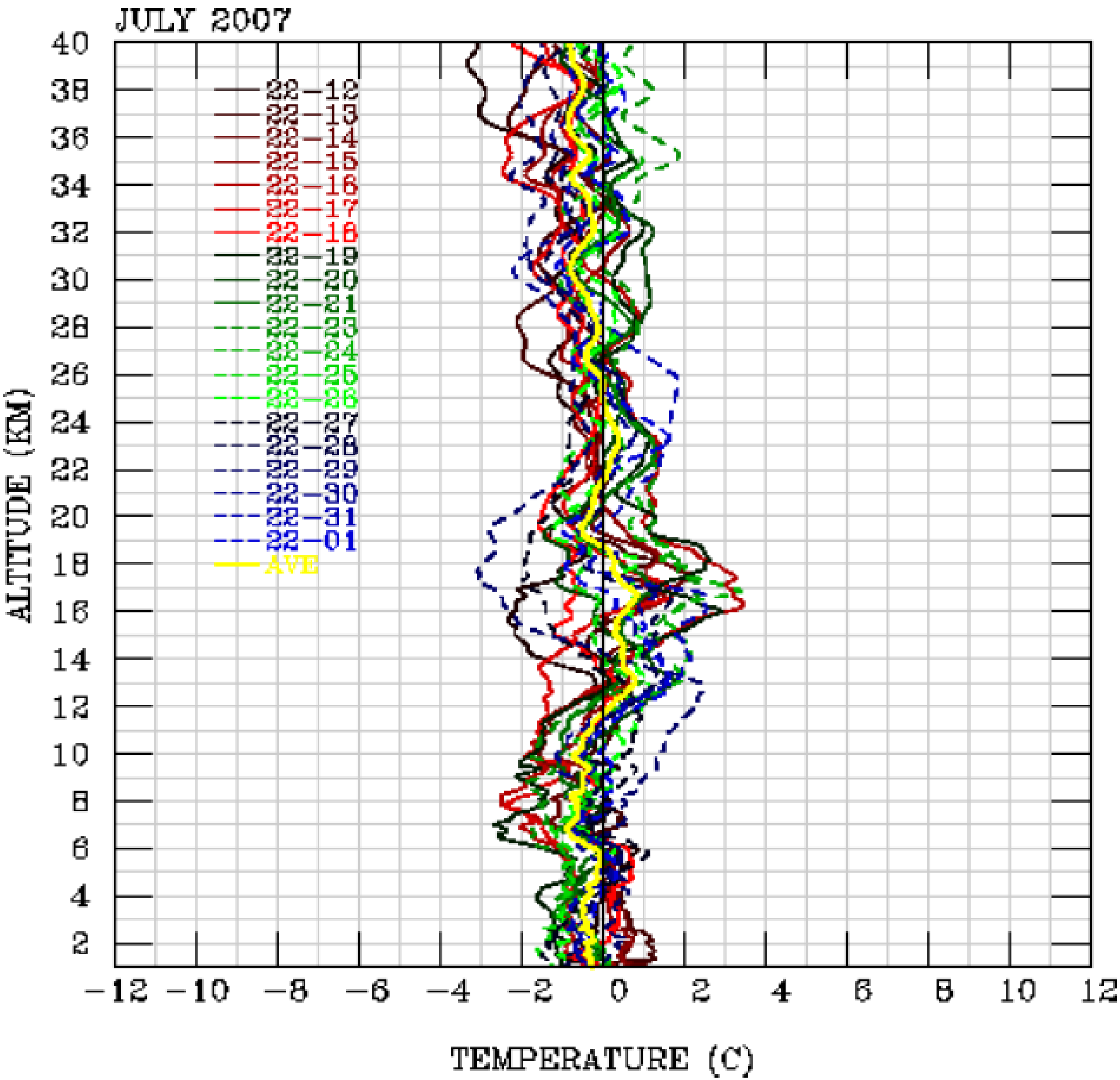

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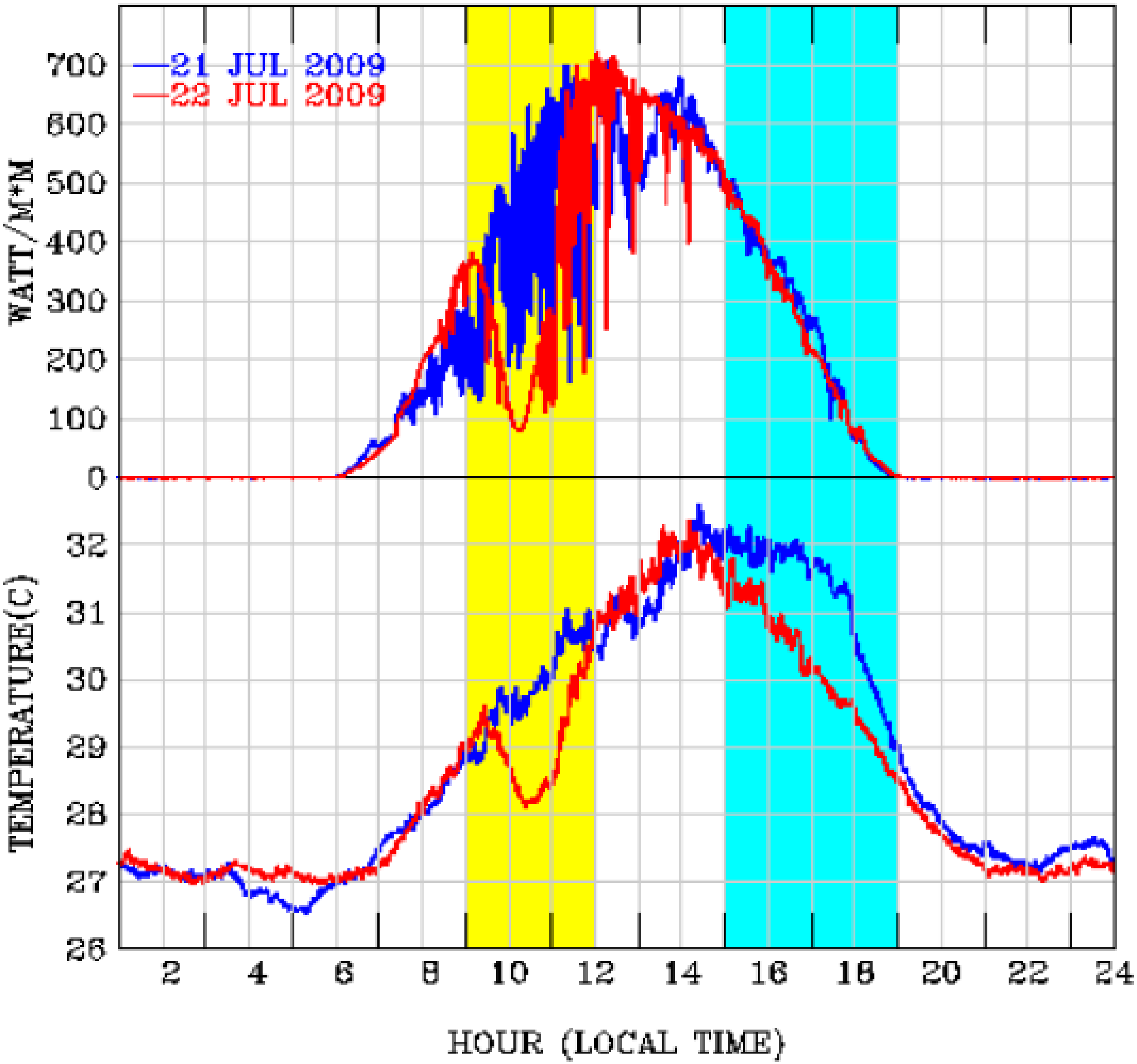
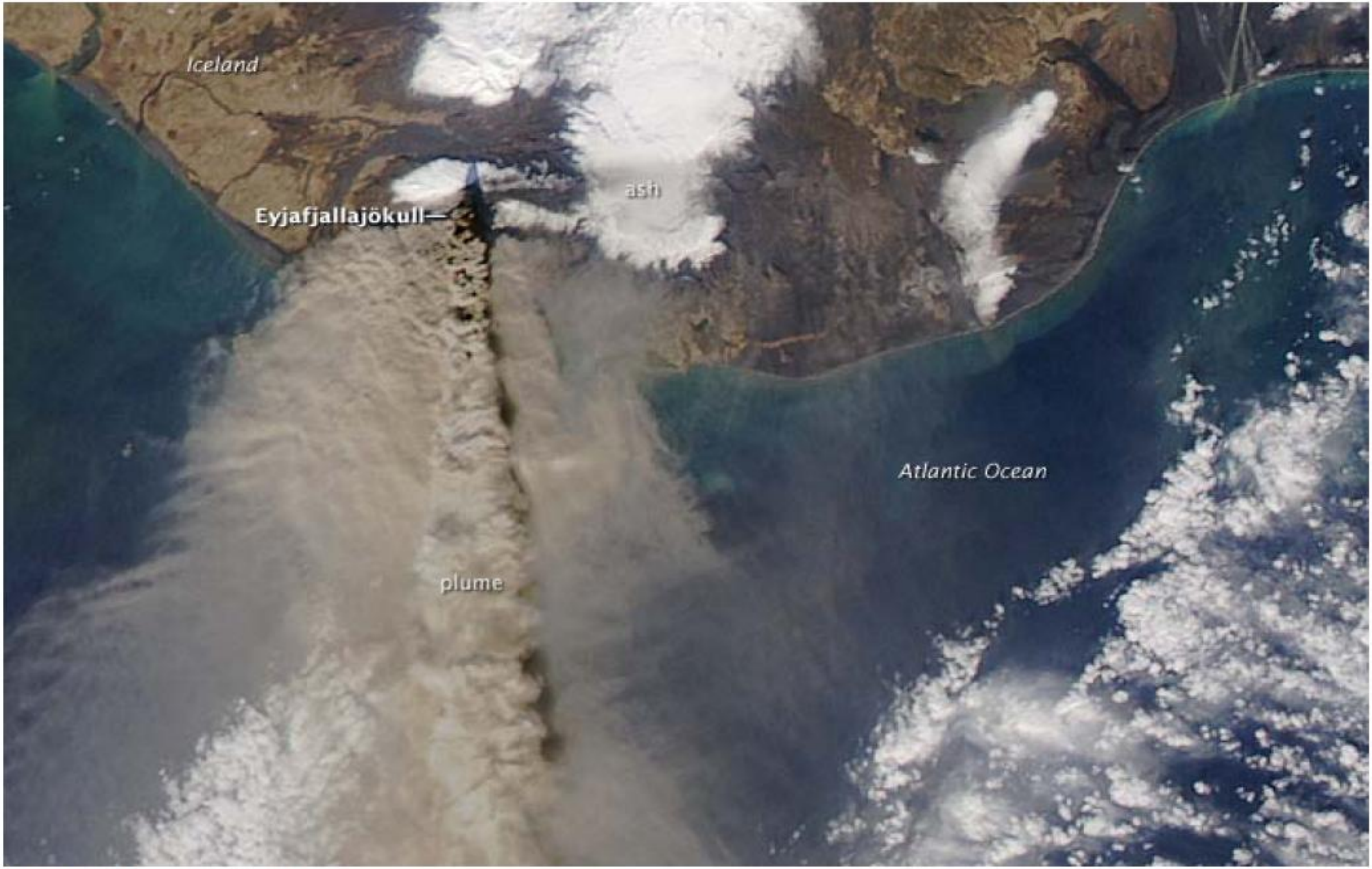
Figure 3(c). The same as in Figure 3(a) but for 2007.



21 JUL 2009
22 JUL 2009
WATT/M*M
700
600
500
400
300
200
100
0
TEMPERATURE(C)
32
31
30
29
28
27
26
2
4
6
8
10
12
14
16
18
20
22
24
HOUR (LOCAL TIME)

Eruption of Eyjafjallajökull Volcano, Iceland

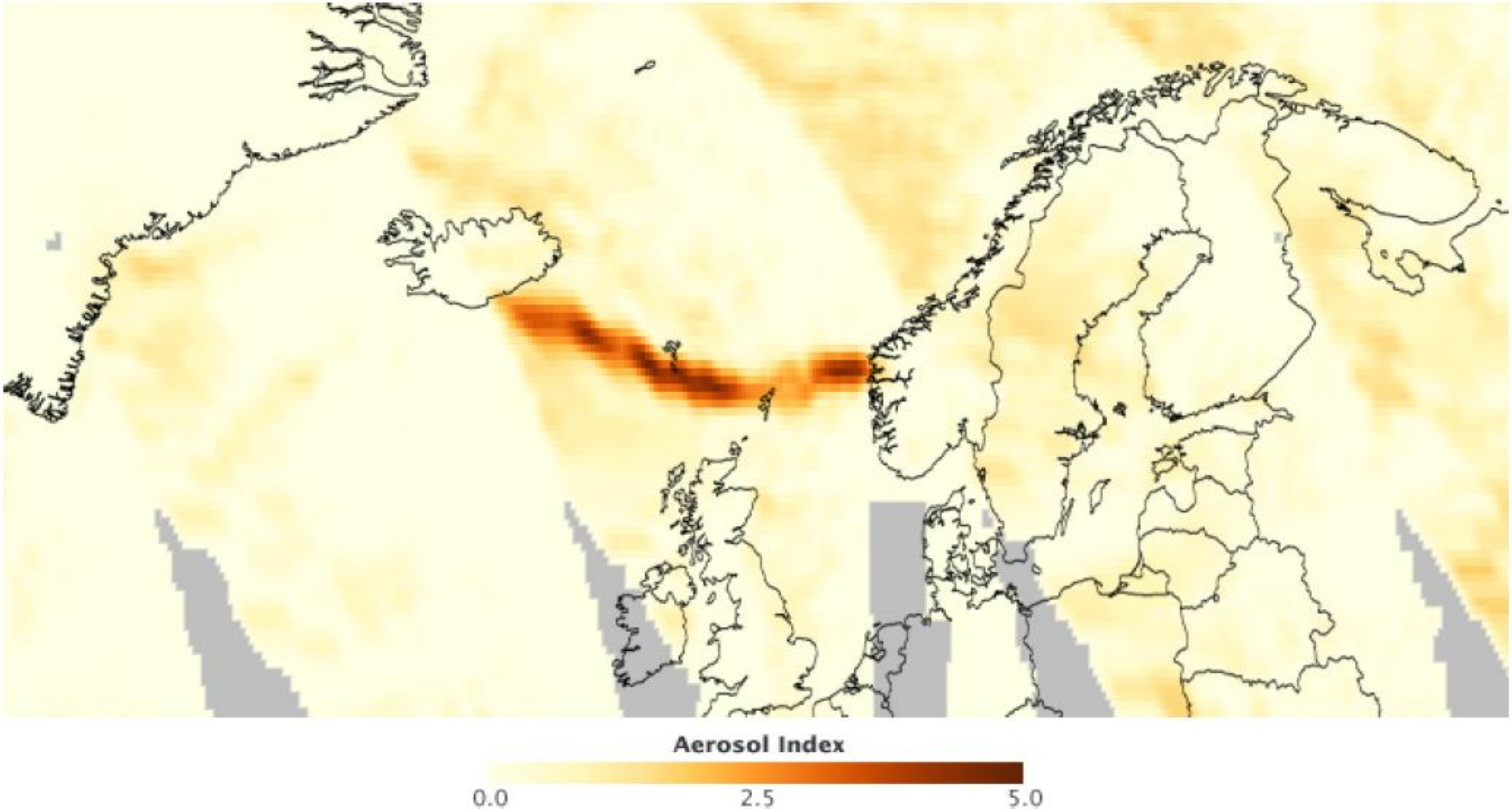


download large image (3 MB, JPEG)

acquired April 17, 2010

Source: EOS/NASA

Eruption of Eyjafjallajökull Volcano, Iceland



acquired April 15, 2010

Source: EOS/NASA

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L03808, doi:10.1029/2008GL036802, 2009

Immediate impact of the Mt Chaiten eruption on atmosphere from FORMOSAT-3/COSMIC constellation

Kuo-Ying Wang,[1] Song-Chin Lin,[1] and Lou-Chuang Lee[2]

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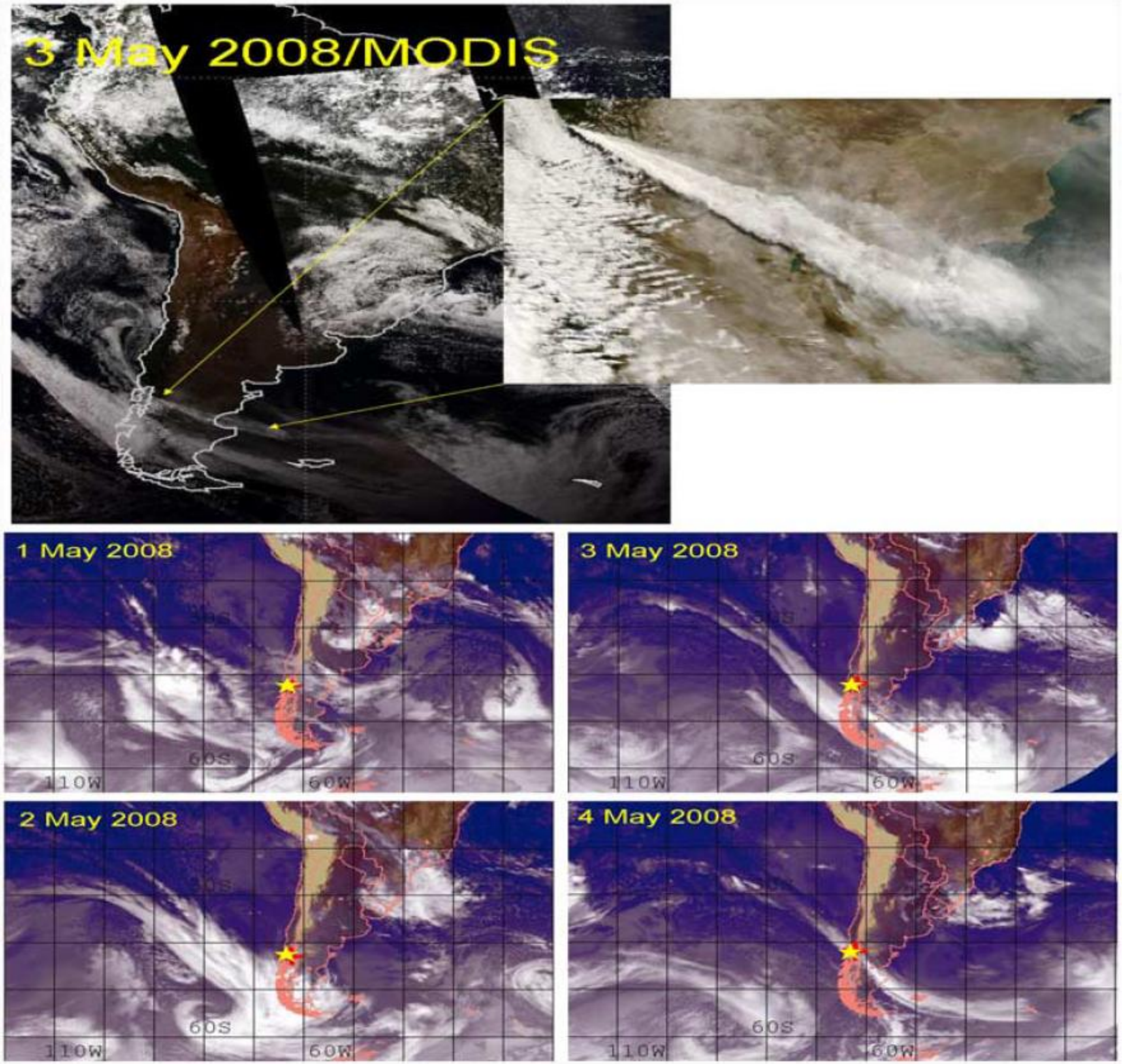
The (2 May) 2009 Mt Chaiten eruption



Wang, Lin, and Lou-Lee, 2009, GRL

3.5. FORMOSAT-3/COSMIC Monitoring

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L03808, doi:10.1029/2008GL036802, 2009

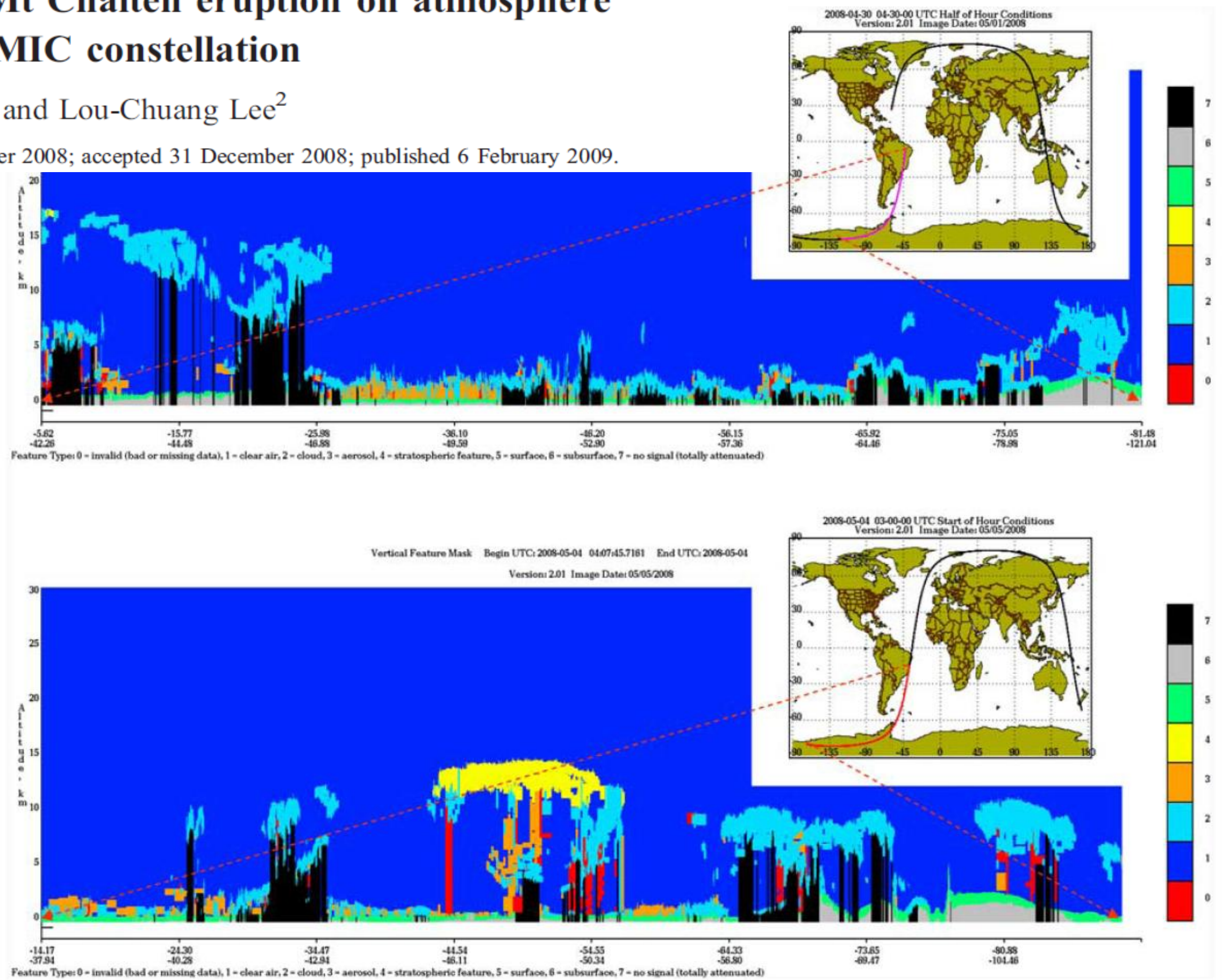
Click Here for Full Article

(a) The (2 May) 2009 Mt Chaiten eruption

Immediate impact of the Mt Chaiten eruption on atmosphere from FORMOSAT-3/COSMIC constellation

Kuo-Ying Wang,[1] Song-Chin Lin,[1] and Lou-Chuang Lee[2]

Received 26 November 2008; revised 9 December 2008; accepted 31 December 2008; published 6 February 2009.



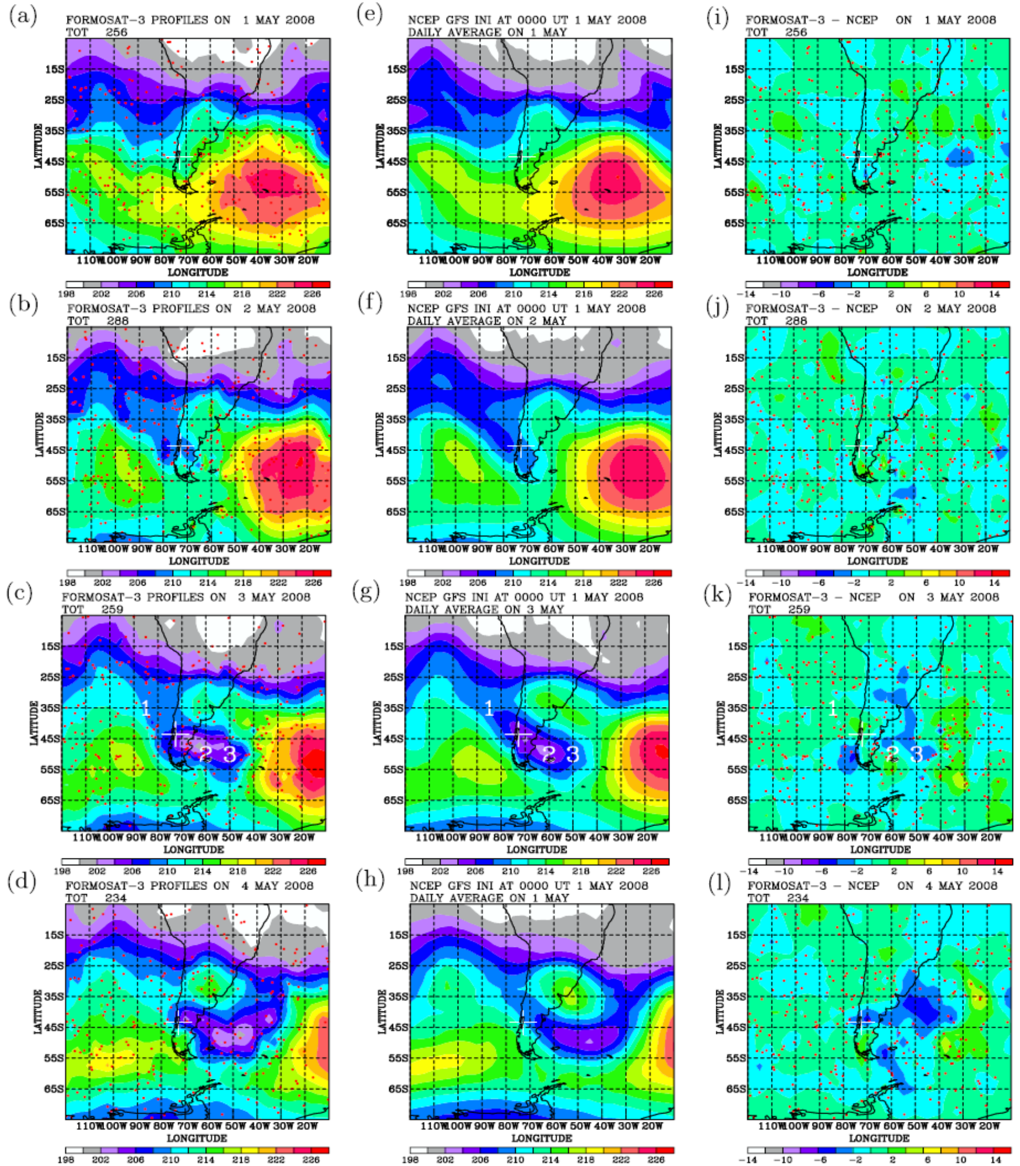


Figure 3. Daily average temperature analyses at 15 km altitude from the FS3/C profiles (red dots) for (a) 1, (b) 2, (c) 3, and (d) 4 May 2008. Daily average temperature distribution from the NCEP GFS model on (e) 1 May, and the subsequent predictions at 15 km altitude for (f) 2, (g) 3, and (h) 4 May. (i–l) Difference between the FS3/C analysis and the NCEP GFS model. The crosses on each plot indicates the location of Mt Chaiten.

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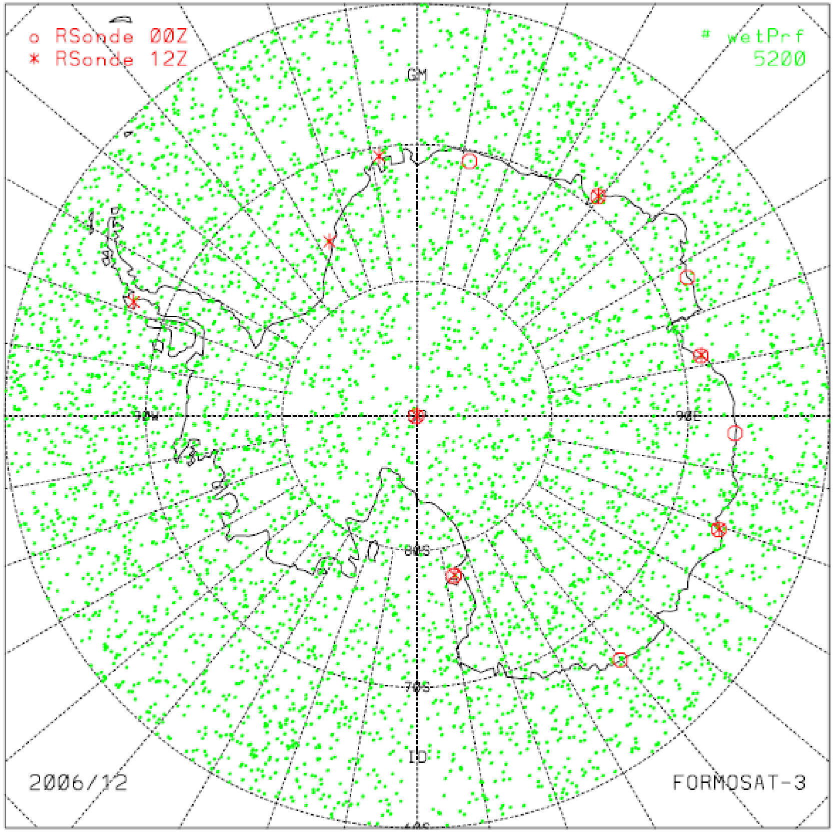
GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L12805, doi:10.1029/2007GL030159, 2007

First continuous GPS soundings of temperature structure over Antarctic winter from FORMOSAT-3/COSMIC constellation

Kuo-Ying Wang[1] and Song-Chin Lin[1]

- **GPS 掩星觀測位置(.)和南極大陸無線電探空**
- **Ground stations (。)分佈情形**



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South Pole, Antarctica, United States [SPO]

南極大陸無線電探空測站

- Source: NOAA CMDL

準備釋放無線電探空氣球

- Source: NOAA CMDL

南極上空的大氣溫度觀測　非常困難

- Source: NOAA CMDL

一個典型的南極測站觀測報告

SOUTH POLE STATION ANTARCTICA. AUGUST 2000 CLIMATE SUMMARY. 第 1 頁，

SOUTH POLE STATION ANTARCTICA. AUGUST 2000 CLIMATE SUMMARY.

Balloon flight data:

- Number of soundings for the month... 40
- Average height of soundings......... 165.4 mbs or 12121 meters above msl

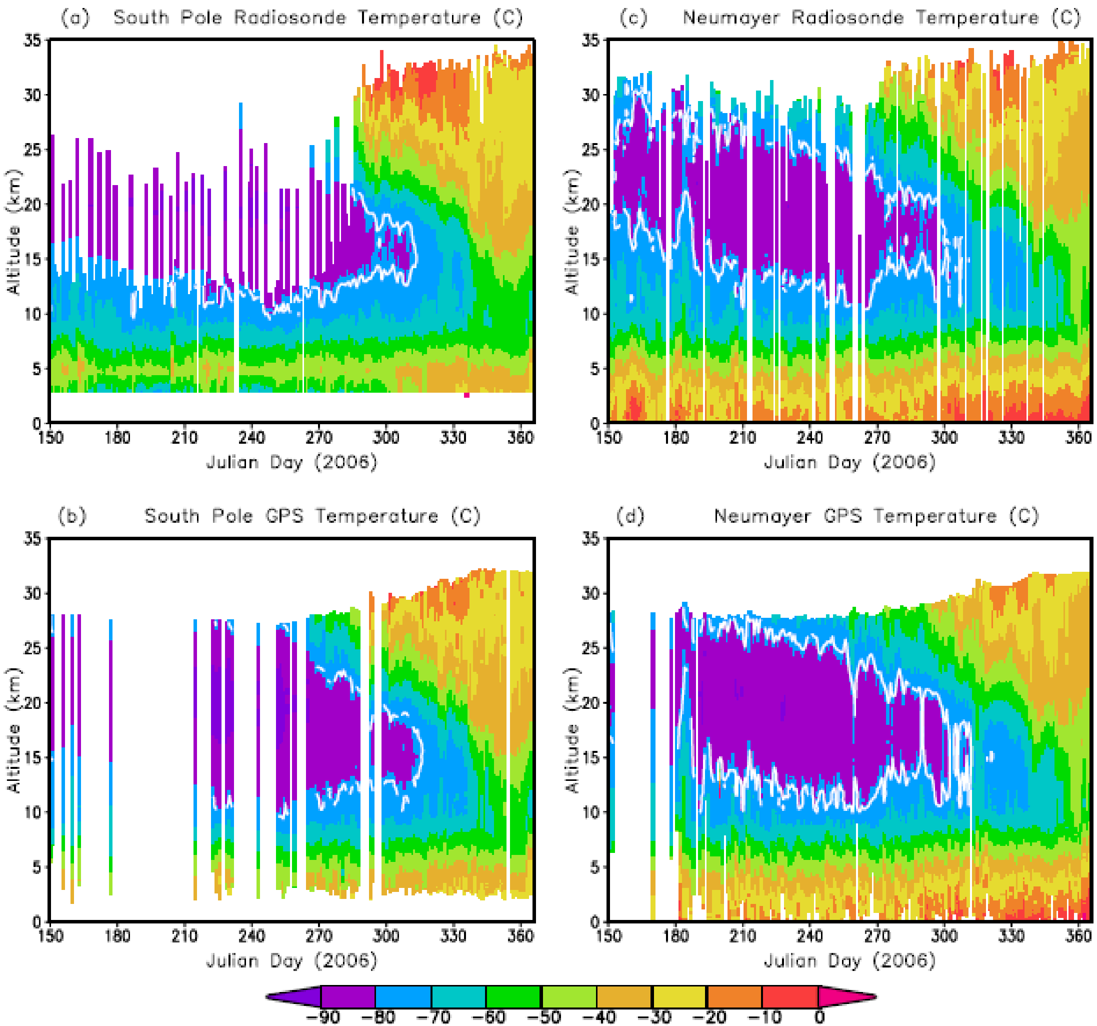
Remarks:

- 0 soundings were missed
- 1 sounding was terminated above the 50 mb level
- 1 sounding was terminated between the 50 and 100 mb level
- 38 soundings were terminated below the 100 mb level

http://astro.uchicago.edu/home/web/gd1/aug00climate.html

2006年南極大陸上空單點大氣溫度垂直結構的連續觀測

- Sonde 無線電探空
- FS3/C 福衛3號



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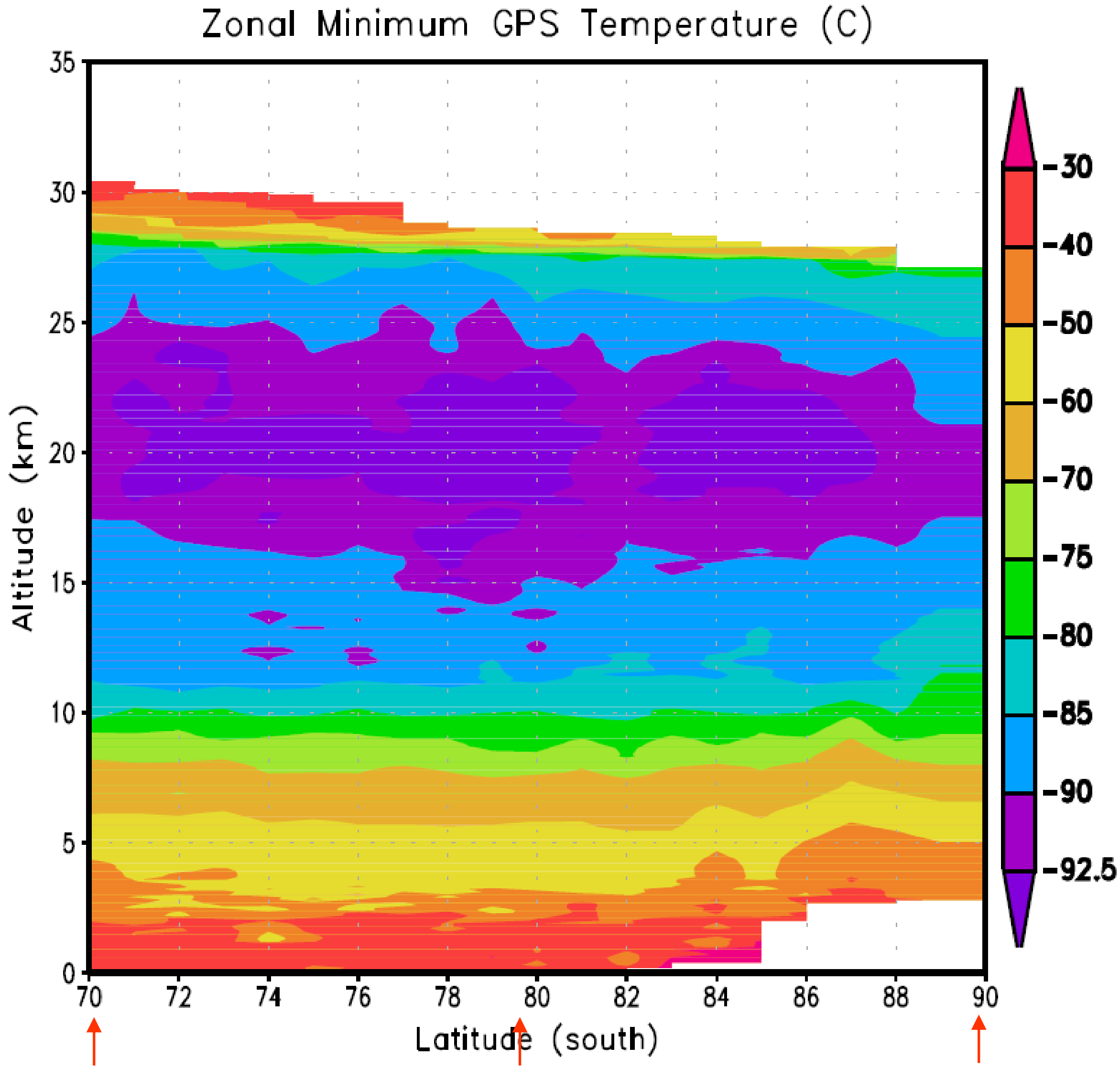

Figure 4. Latitude-height profiles of the zonal minimum temperature for the 2006 winter to spring seasons from the GPS soundings.

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South Pole

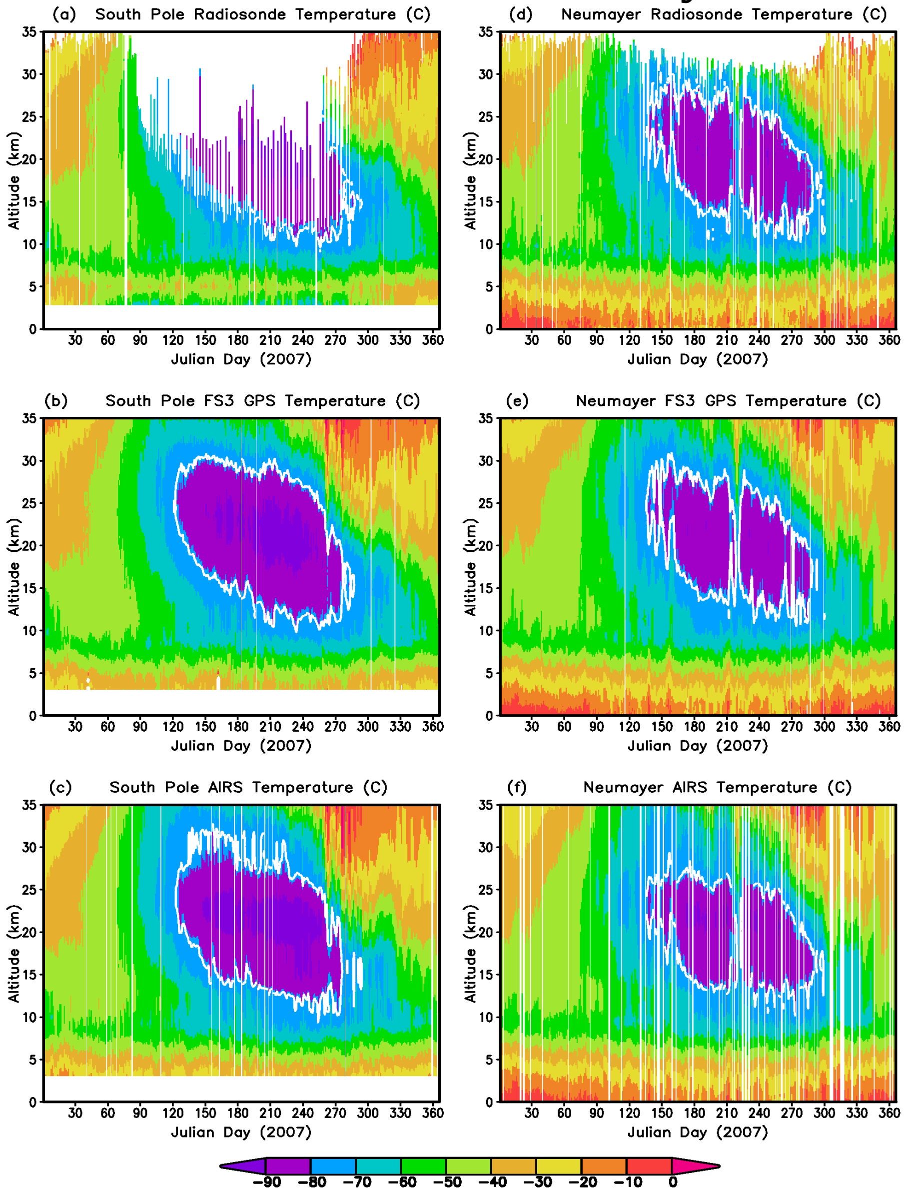
Neumayer 70S

2007

Sonde

FS3/C

Aqua/AIRS



國立中央大學

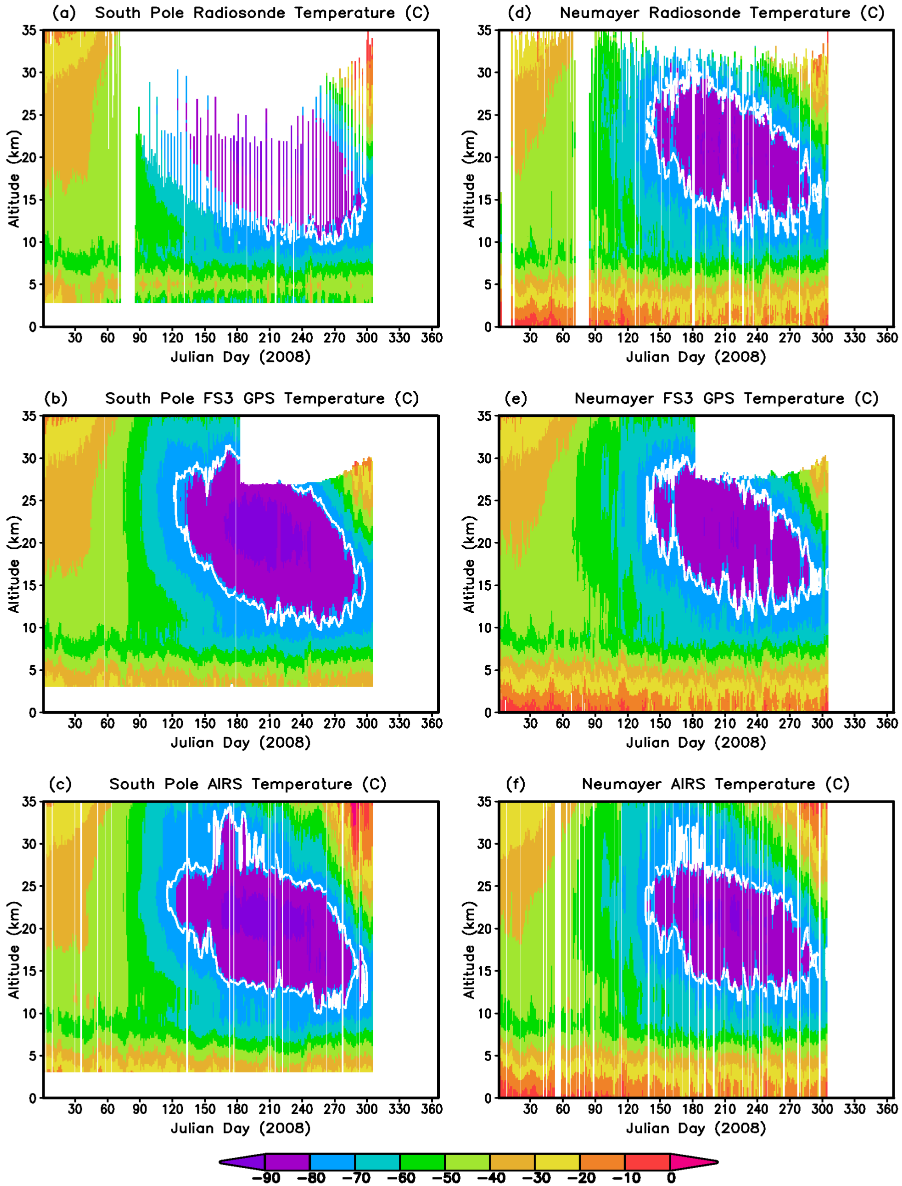
South Pole　Neumayer 70S

2008

Sonde

FS3/C

Aqua/AIRS



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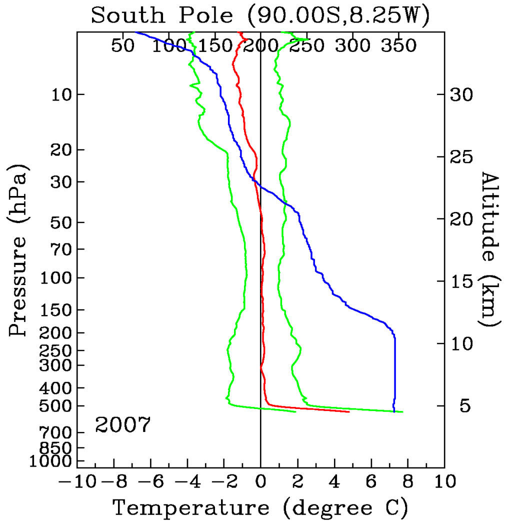
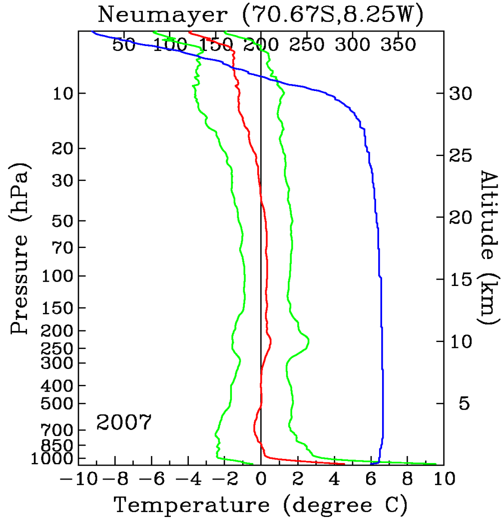
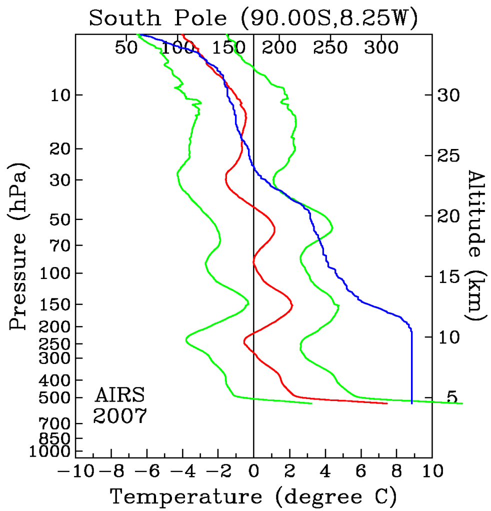
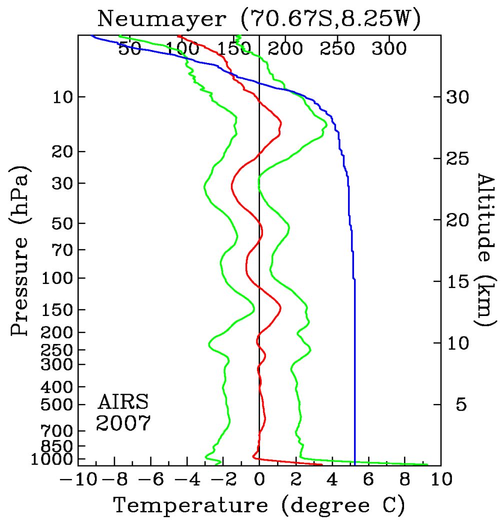
FS3/C – Sonde : 2007





AIRS - Sonde





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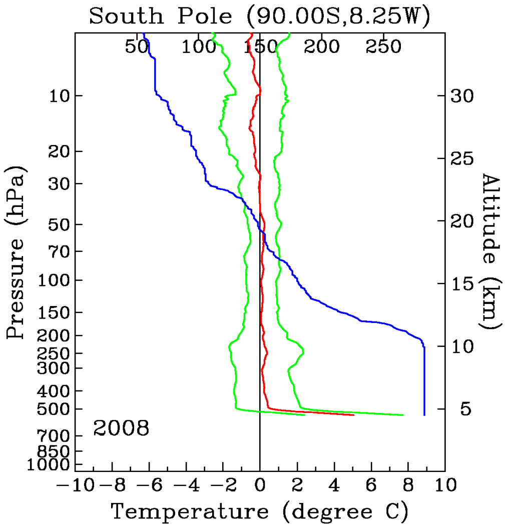
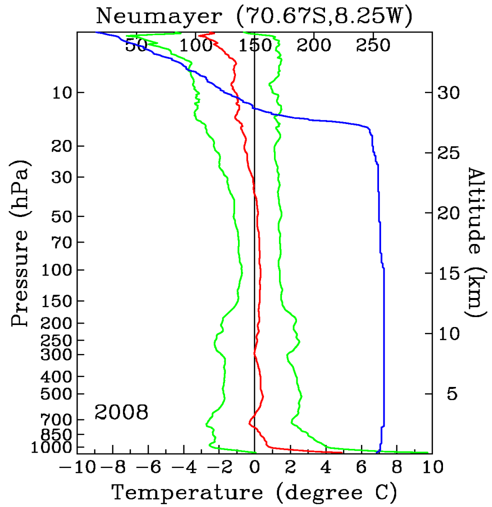
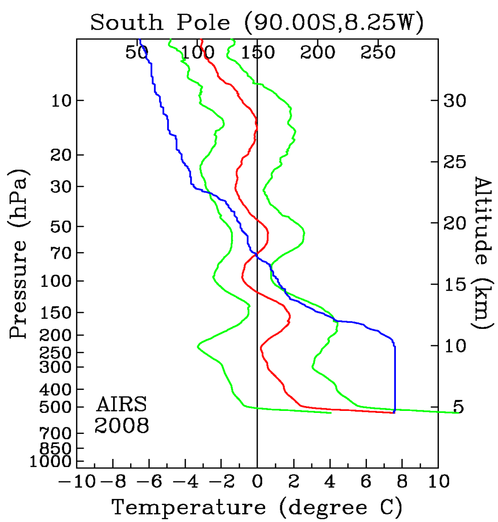
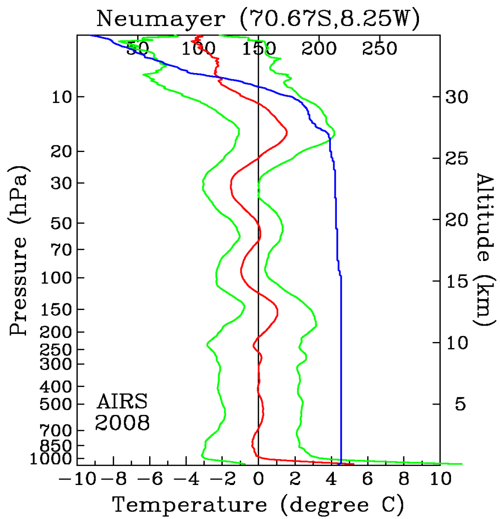
FS3/C – Sonde : 2008





AIRS - Sonde





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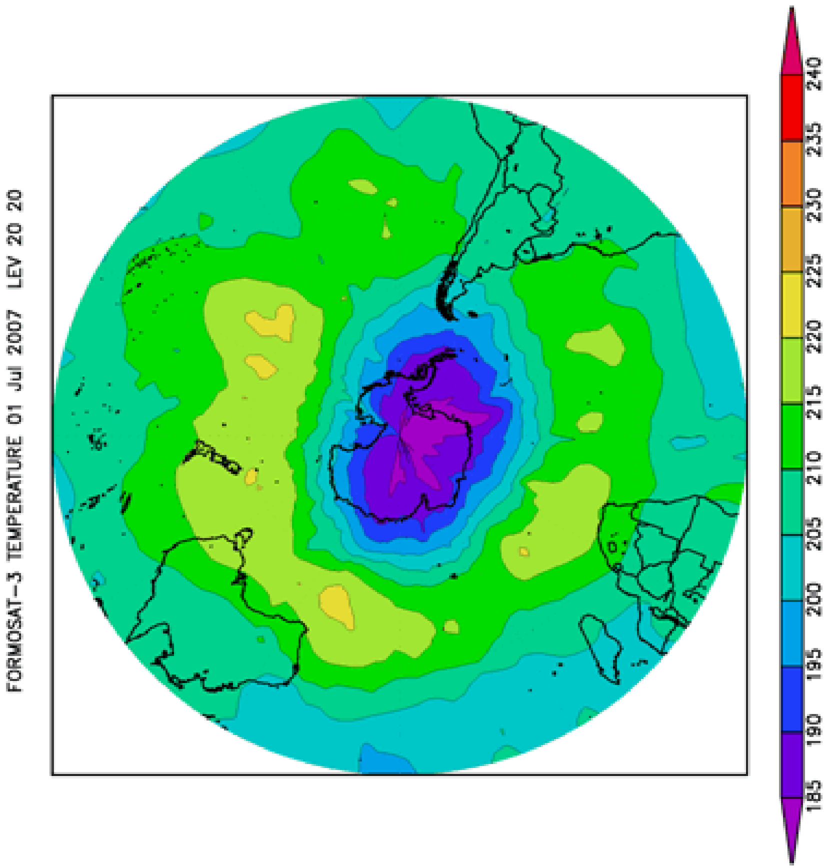
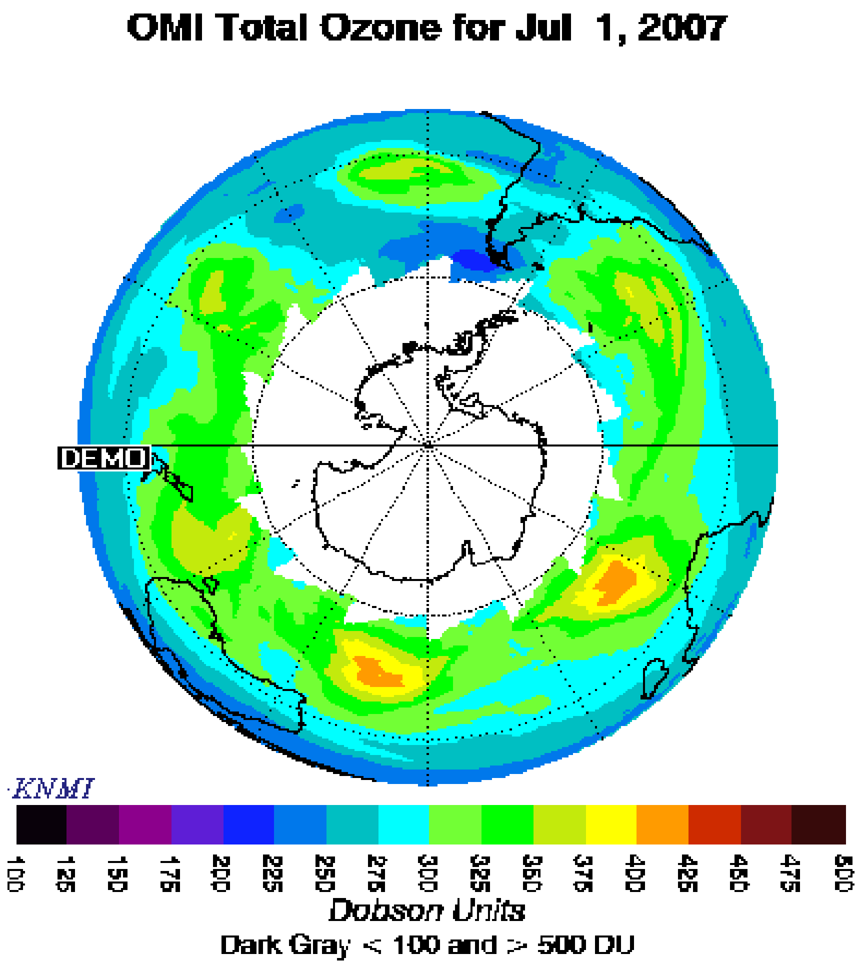
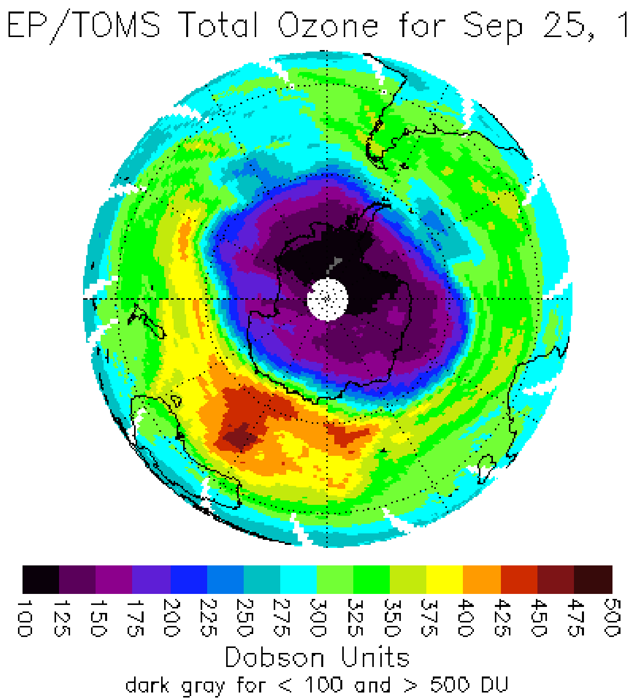
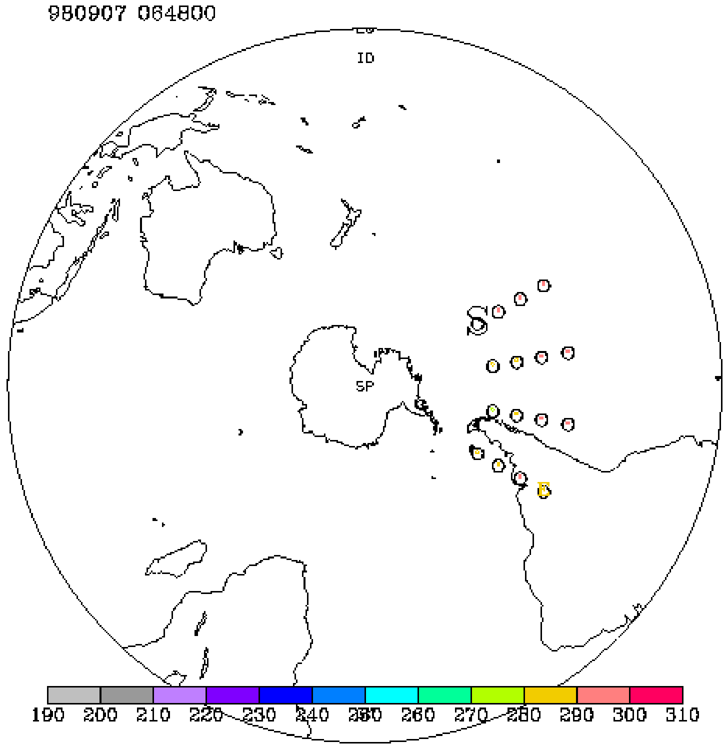

FORMOSAT-3 TEMPERATURE 01 Jul 2007 LEV 20 20
185
190
195
200
205
210
215
220
225
230
235
240


OMI Total Ozone for Jul 1, 2007
DEMO
KNMI
100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500
Dobson Units
Dark Gray < 100 and > 500 DU

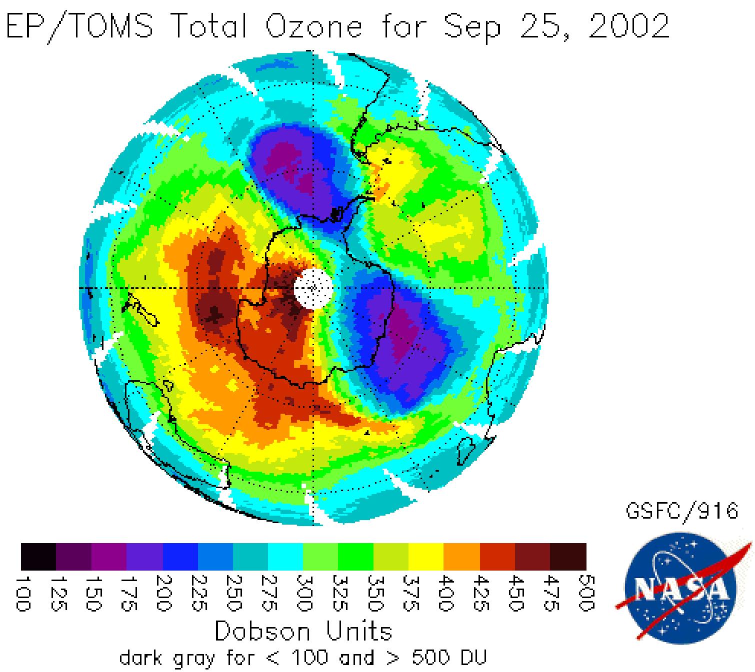
1998年南極臭氧洞 和極區渦漩

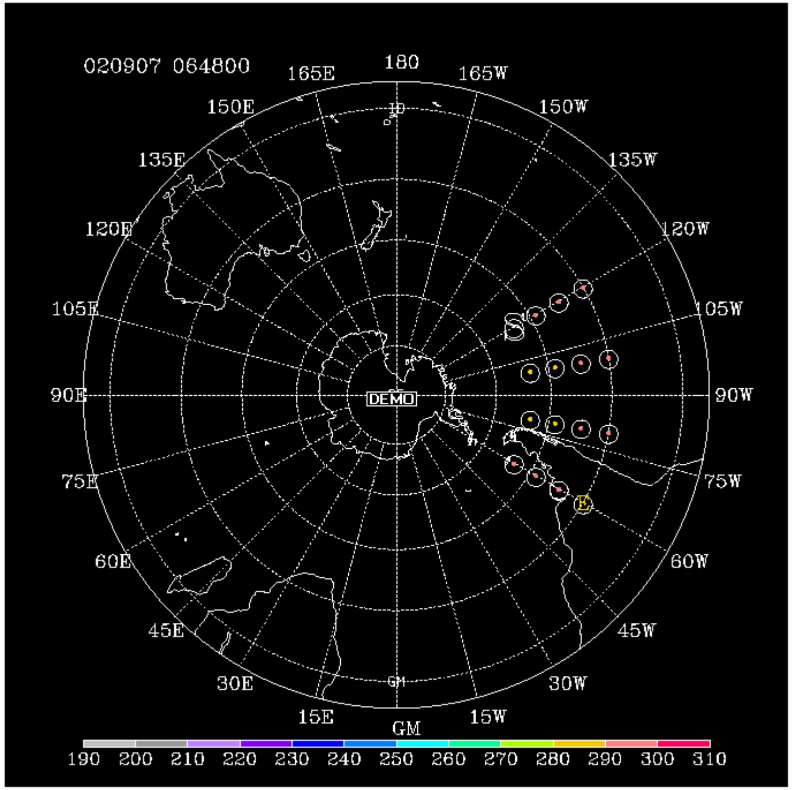




4

2002年南極臭氧洞 和極區渦漩





Atmospheric Research 96 (2010) 110–121

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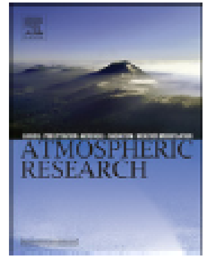
journal homepage: www.elsevier.com/locate/atmos



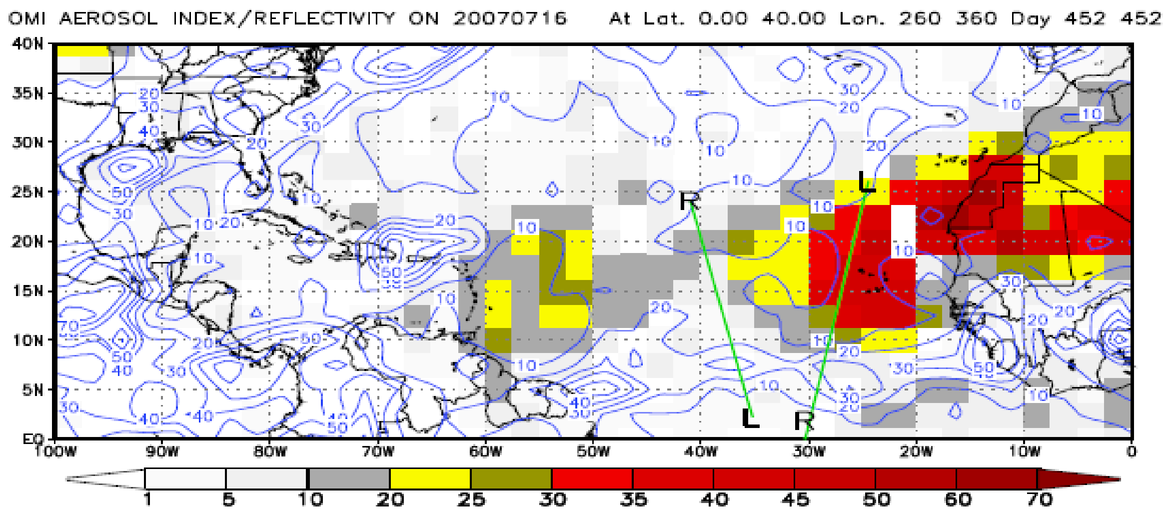
ELSEVIER

Profiles of the atmospheric temperature response to the Saharan dust outbreaks derived from FORMOSAT-3/COSMIC and OMI AI

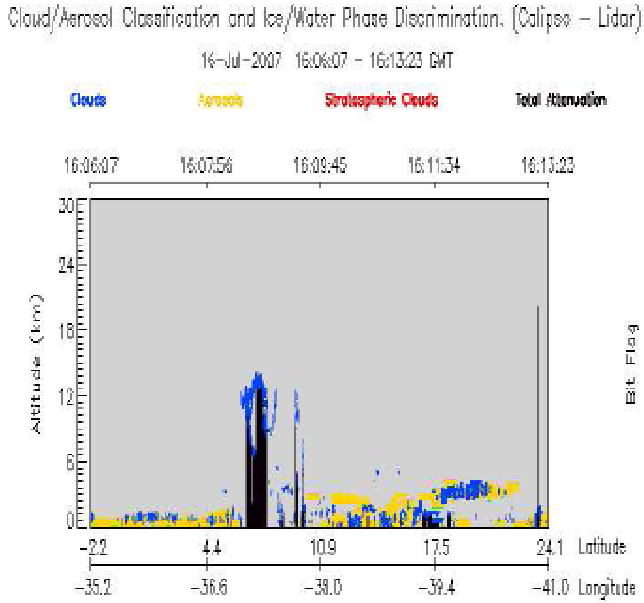
Kuo-Ying Wang

Department of Atmospheric Sciences, National Central University, Chung-Li, Taiwan

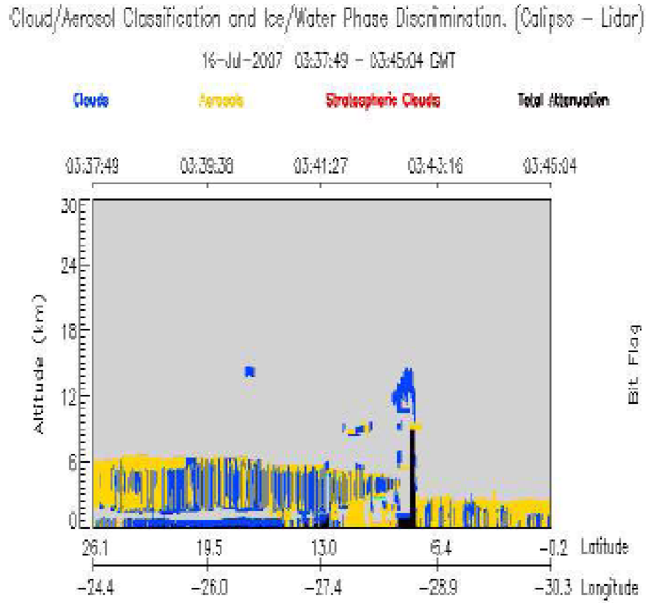
(a)

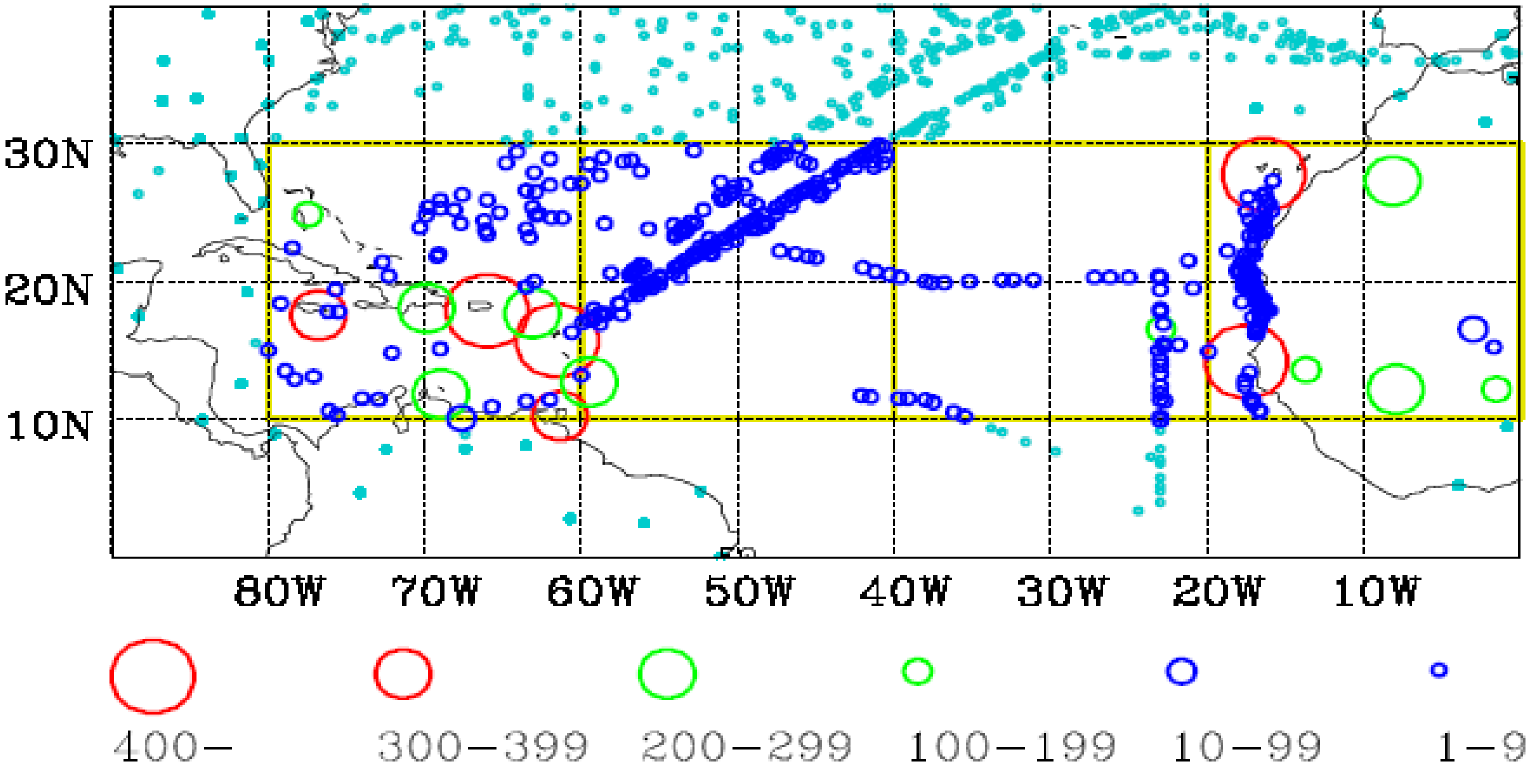

OMI AEROSOL INDEX/REFLECTIVITY ON 20070716 At Lat. 0.00 40.00 Lon. 260 360 Day 452 452
40N
35N
30N
25N
20N
15N
10N
5N
EQ
100W
90W
80W
70W
60W
50W
40W
30W
20W
10W
0
R
L
L
R
1
5
10
20
25
30
35
40
45
50
60
70

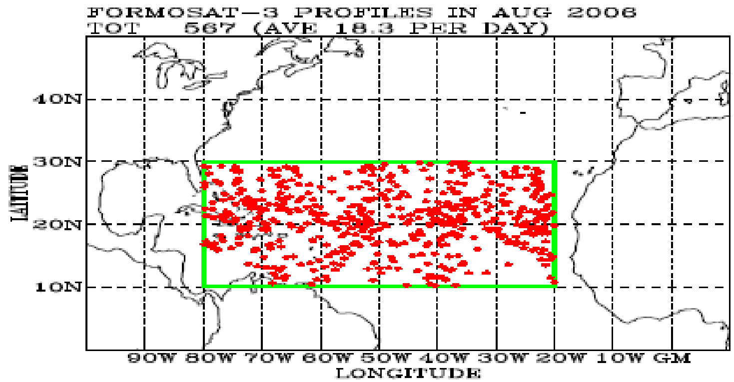
(b)


Cloud/Aerosol Classification and Ice/Water Phase Discrimination. (Calipso – Lidar)
16-Jul-2007 16:06:07 – 16:13:23 GMT
Clouds
Aerosols
Stratospheric Clouds
Total Attenuation
16:06:07
16:07:56
16:09:45
16:11:34
16:13:23
Altitude (km)
Bit Flag
Latitude
Longitude
-2.2
4.4
10.9
17.5
24.1
-35.2
-36.6
-38.0
-39.4
-41.0

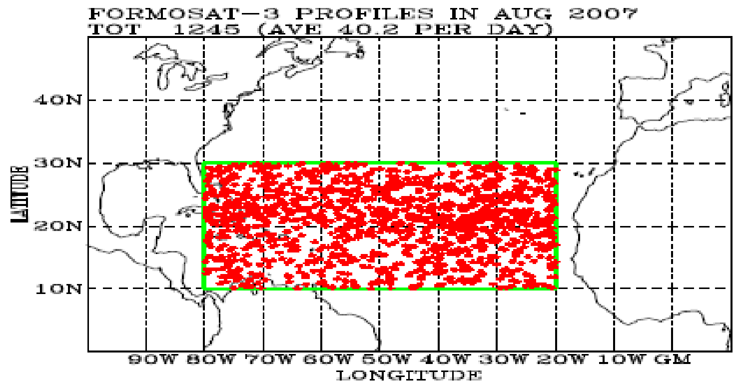
(c)


Cloud/Aerosol Classification and Ice/Water Phase Discrimination. (Calipso – Lidar)
16-Jul-2007 03:37:49 – 03:45:04 GMT
Clouds
Aerosols
Stratospheric Clouds
Total Attenuation
03:37:49
03:39:38
03:41:27
03:43:16
03:45:04
Altitude (km)
Bit Flag
Latitude
Longitude
26.1
19.5
13.0
6.4
-0.2
-24.4
-26.0
-27.4
-28.9
-30.3

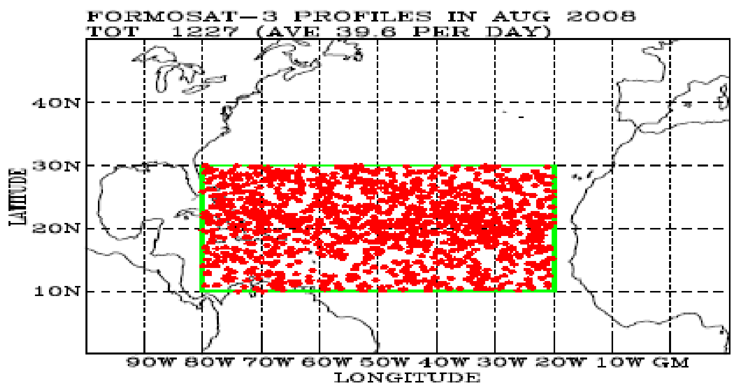

30N
20N
10N
80W
70W
60W
50W
40W
30W
20W
10W
400-
300-399
200-299
100-199
10-99
1-9


FORMOSAT−3 PROFILES IN AUG 2006
TOT 567 (AVE 18.3 PER DAY)
40N
30N
20N
10N
LATITUDE
90W 80W 70W 60W 50W 40W 30W 20W 10W GM
LONGITUDE

(a)

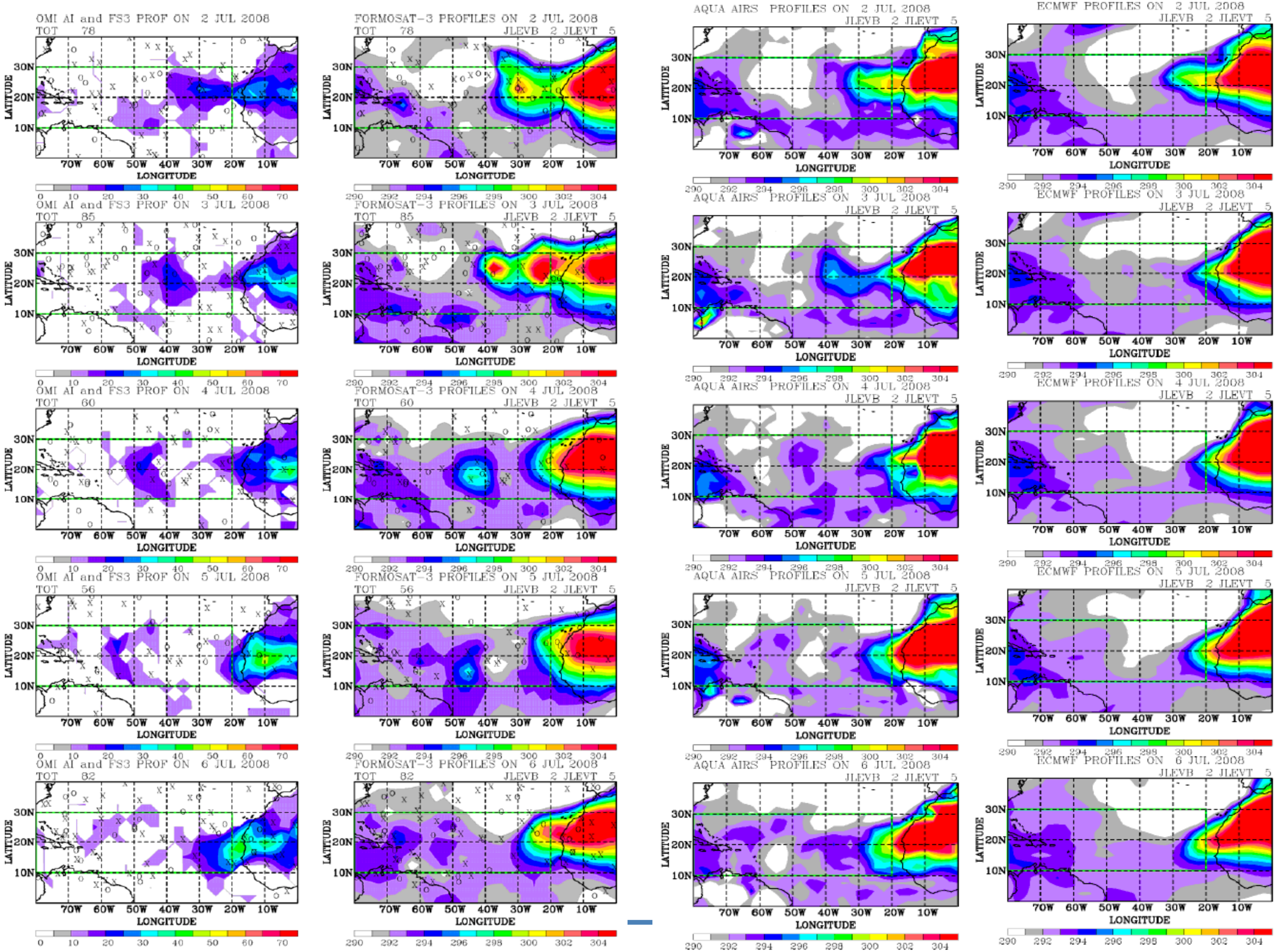

FORMOSAT−3 PROFILES IN AUG 2007
TOT 1245 (AVE 40.2 PER DAY)
40N
30N
20N
10N
LATITUDE
90W 80W 70W 60W 50W 40W 30W 20W 10W GM
LONGITUDE

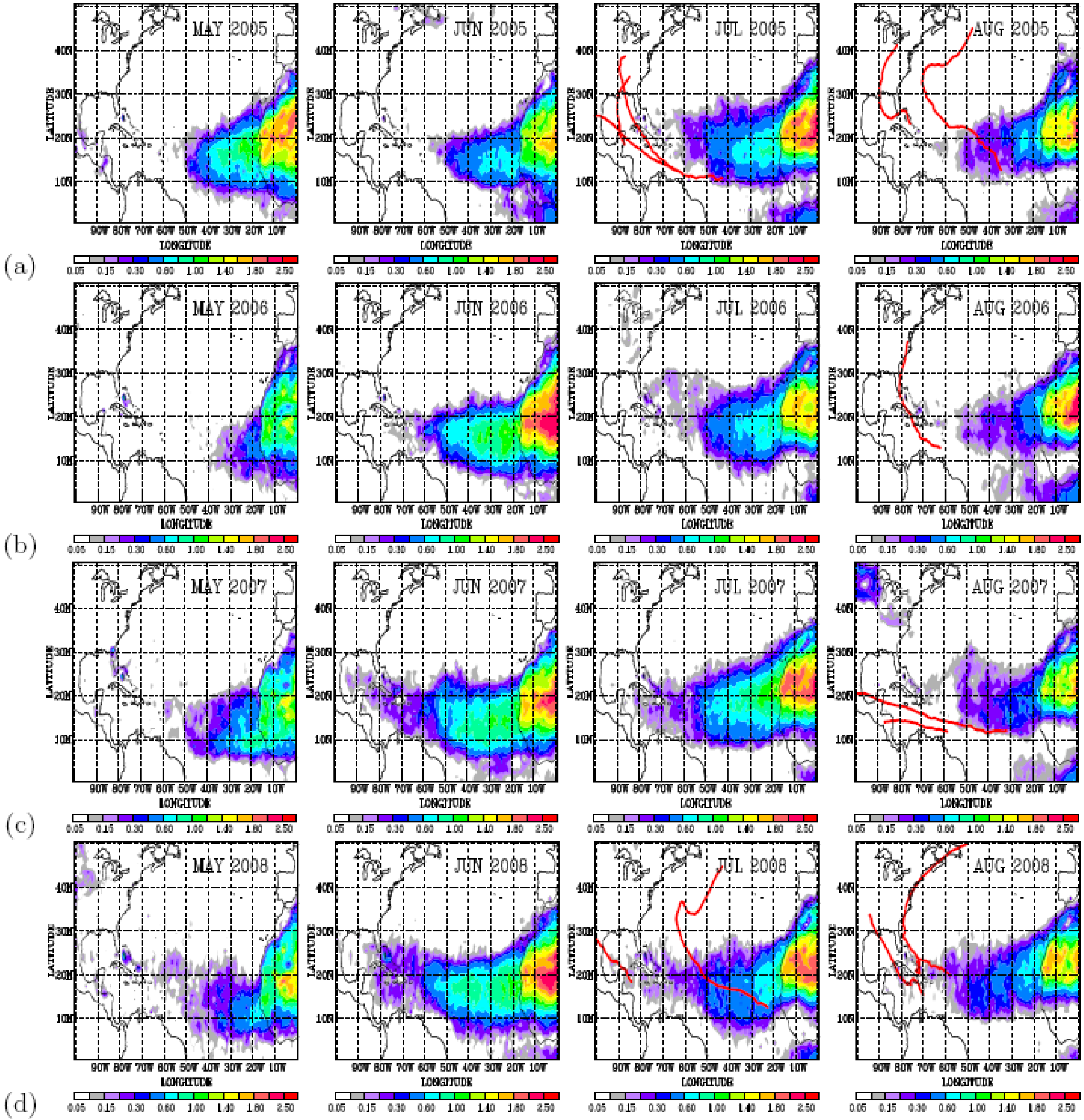
(b)


FORMOSAT−3 PROFILES IN AUG 2008
TOT 1227 (AVE 39.6 PER DAY)
40N
30N
20N
10N
LATITUDE
90W 80W 70W 60W 50W 40W 30W 20W 10W GM
LONGITUDE

(c)

OMI AI | FORMOSAT-3/C | AQUA AIRS | ECMWF




(a)
MAY 2005
JUN 2005
JUL 2005
AUG 2005
(b)
MAY 2006
JUN 2006
JUL 2006
AUG 2006
(c)
MAY 2007
JUN 2007
JUL 2007
AUG 2007
(d)
MAY 2008
JUN 2008
JUL 2008
AUG 2008
LATITUDE
LONGITUDE
10N 20N 30N 40N
90W 80W 70W 60W 50W 40W 30W 20W 10W
0.05 0.15 0.30 0.60 1.00 1.40 1.80 2.50

Summary

- Since the successful launch of FORMOSAT-3/COSMIC (FS3/C) on 14 April 2006, daily GPS RO profiles have been persistently produced for global analysis and modeling.

- These RO profiles provide an unprecedented opportunity in improving our understanding of atmospheric processes that were not able to achieve before due to the limit availability of high resolution atmospheric profiles in space and time.

- Here we show the use of FS3/C data
- In detecting the vertical temperature structures in the Antarctic polar vortex (Wang and Lin, GRL, 2007);
- in the volcanic plumes (Wang et al., GRL, 2009);
- in the Saharan dust plumes (Wang, Atmos. Res., 2010);
- during the total eclipse of 22 July 2009 (Wang and Liu, GRL, 2010).

- Some of the results are tested against measurements from AQUA AIRS.
- These results highlight important processes that are lacked in the current models such as ECMWF, UKMO, and NCEP.

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SR-5 Launch on May 5, 2010, In Taiwan. (Courtesy of Liberty Times, and NSPO)

Remark

- 有一流的數據，才有一流的科學.

  L.-C. Lee, Fellow of Academic Sinica

  4 Jul 2009, Yahoo News

PGGM 計畫觀測其他人所無法觀測的資料，這是一件令人興奮且值得驕傲的工作與成就.

敬請繼續支持， 讓我們一起為地球環淨保護貢獻一份心力.

Credit: NASA

Stepping out

An astronaut's boot print, photographed during the *Apollo 11* Moon landing.

The PGGM Team and International Collaborators

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- EPA: I.-L. Wu (Greenhouse Gases Reduction and Mitigation Office)
- China Airlines: Vice President Capt. Ding Hwai Young
- Evergreen Marine Corporation: Capt. S.-C. Tai
- Taiwan Leder Instrument Corp.

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– Germany: Andreas Volt-Thomas, FZJ, Julich
– Japan: Machida, NIES
– UK: John Pyle, Neil Harris, Andrew Robinson
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Thank you very much for your listening.