Why The Deeper Understanding Is Important to Disaster Mitigation?

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Disaster Mitigation, APAN43

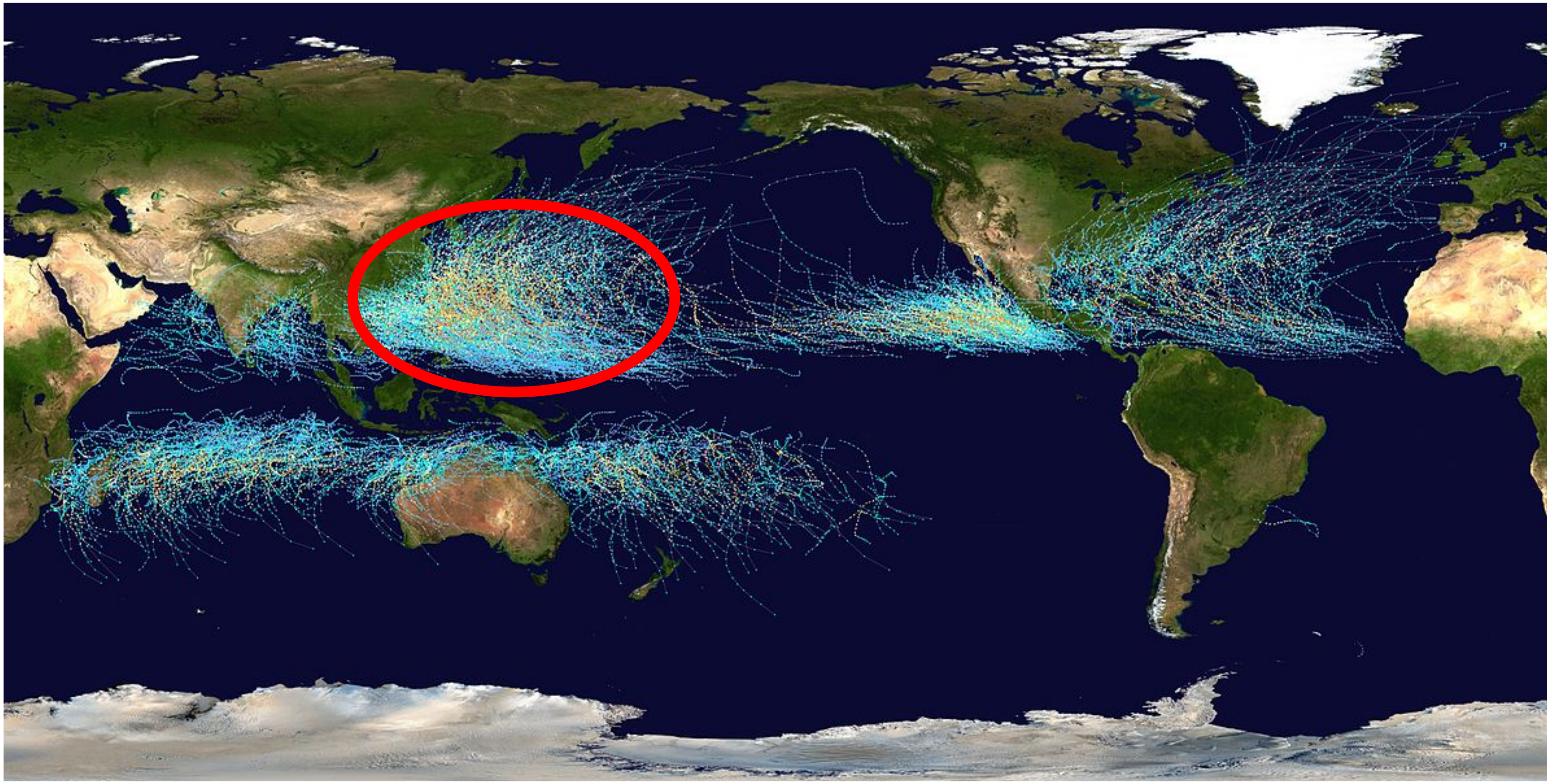
Rationale

- Disaster Mitigation often focuses on the worst case scenarios of natural disasters in order to protect the general public in case the worst might happen!
- Obviously, this is NOT the most optimized way to mobilize the mitigation resources and protect the loss of lives and property
- Had we predicted the disasters much more accurately, then the society as a whole could be better protected!
- However, the non-linearlity and inter-couplings of different forms of natural disasters deter us from improving accuracy easily!
- Therefore, some sort of deeper qualitative understandings such as possible weather and disaster patterns are crucial!

Examples if Time Allows

- **Flooding case in Taiwan (Soudelor 2015)**
- **Flooding case in Sri Lanka (2016**)
- **Storm surge in Philippines (Haiyan, 2013)**
- **Flooding in Malaysia (2014-2015)**
- **Environmental Research Topics**

The Great Global Trend of Typhoon



Tracks of all tropical cyclones which formed worldwide between 1985 and 2005.

(from [Joint Typhoon Warning Center])

Average Counts Increase

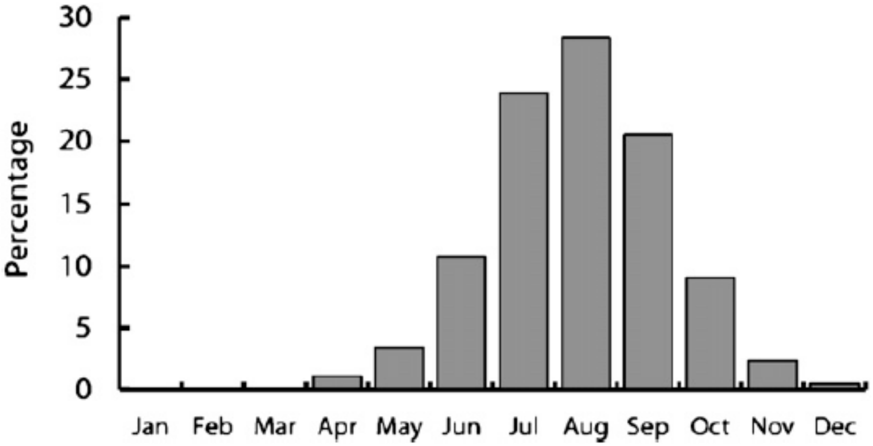
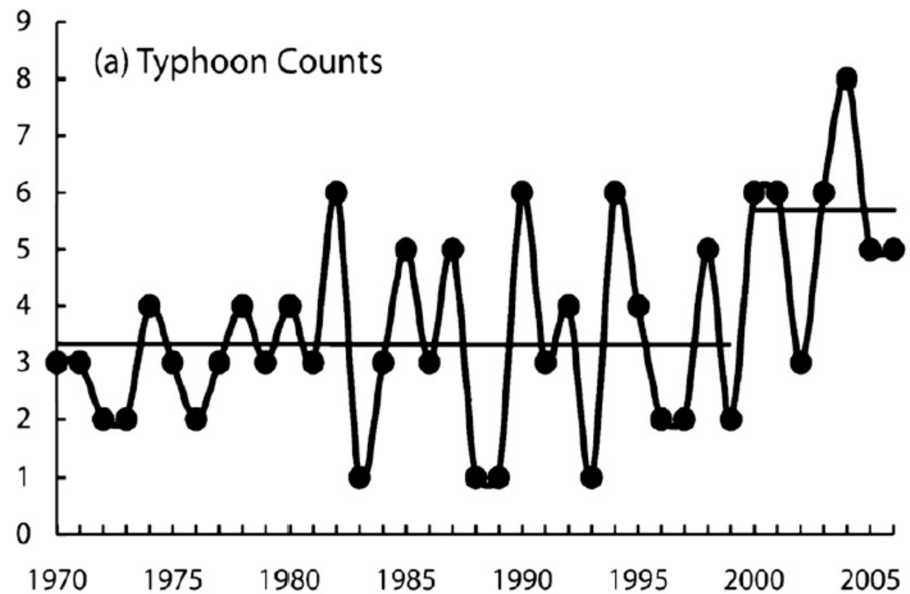


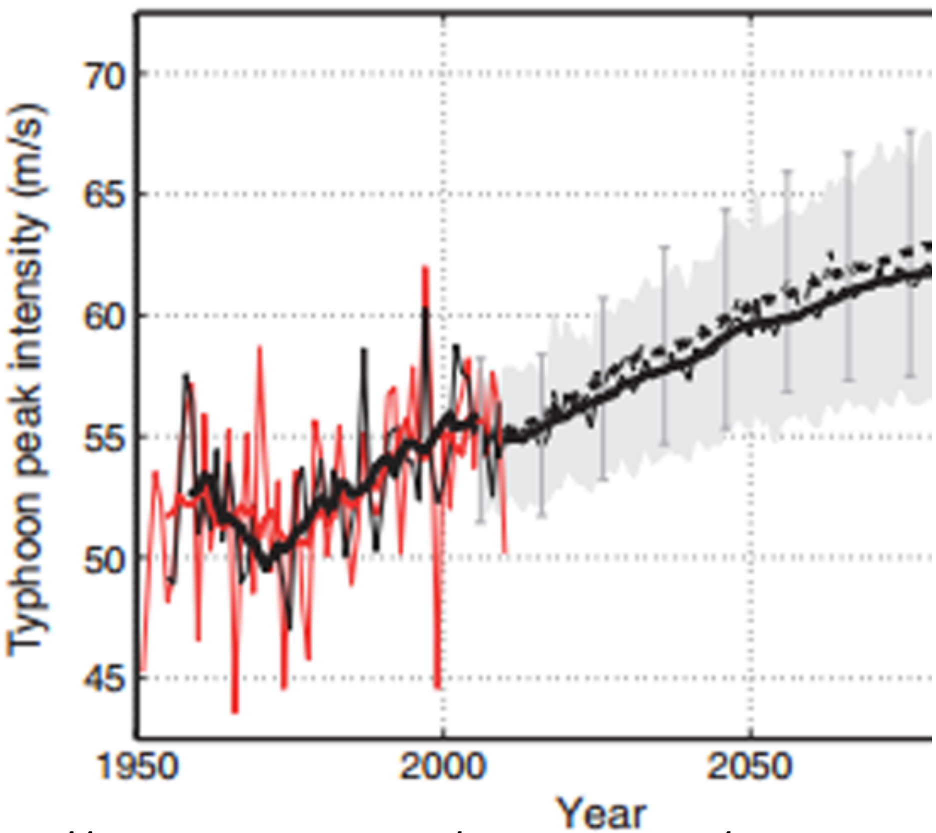
FIG. 2. Monthly percentage of typhoons impacting Taiwan averaged over the period of 1970–2006.

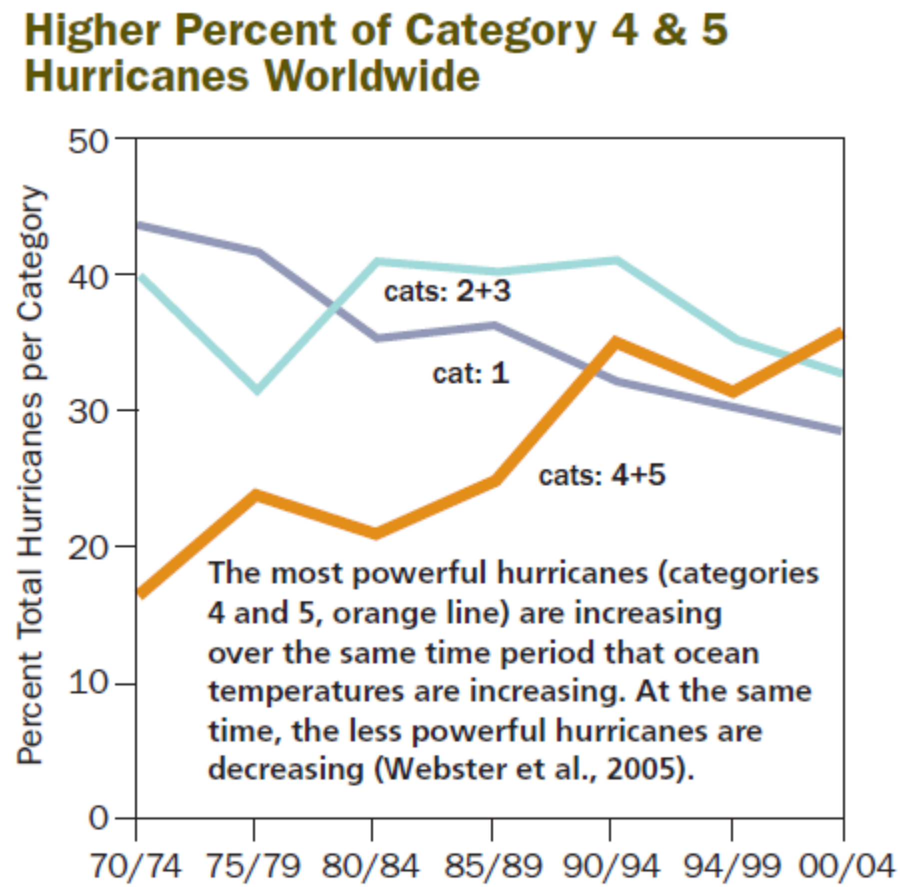


Time series of seasonal (JJASO) **typhoon numbers passing the vicinity of Taiwan from 1970 to 2006** as complied by the Central Weather Bureau. The vicinity was defined as21–26N, 119–125E.

(Tu et al. 2009)

Future Warming and Typhoon

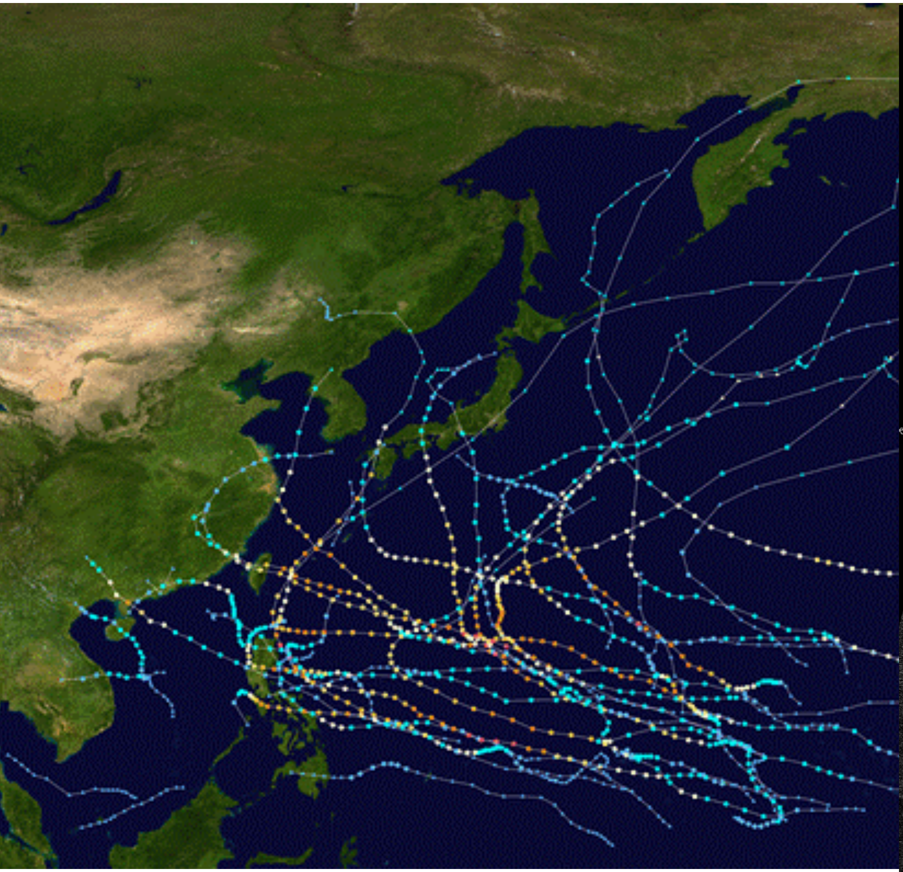




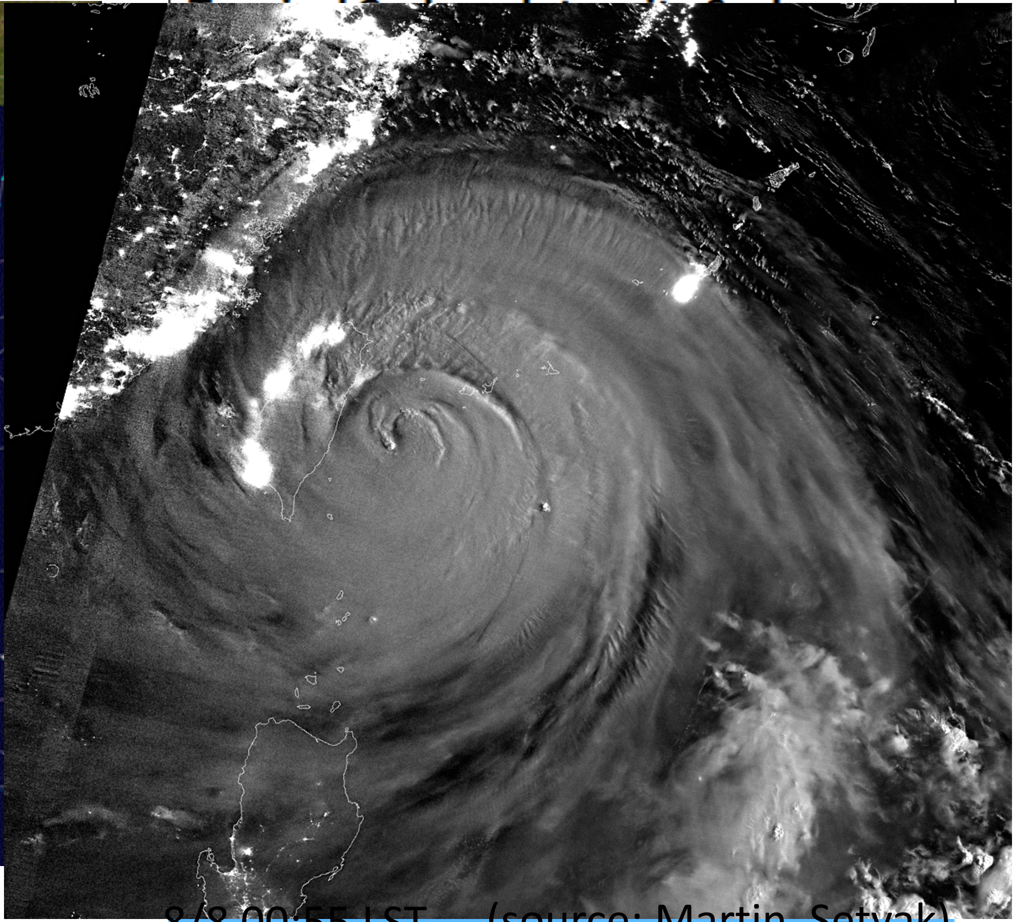
http://www.smh.com.au/environment/climate-change/super-typhoons-to-increase-in-strength-with-climate-change-researchers-find-20150529-ghcbfs.html

Flooding in Taiwan (Soudelor, 2015)

Storm tracks in 2015



Typhoon Soudelor



8/8 00:55 LST (source: Martin Setvak)

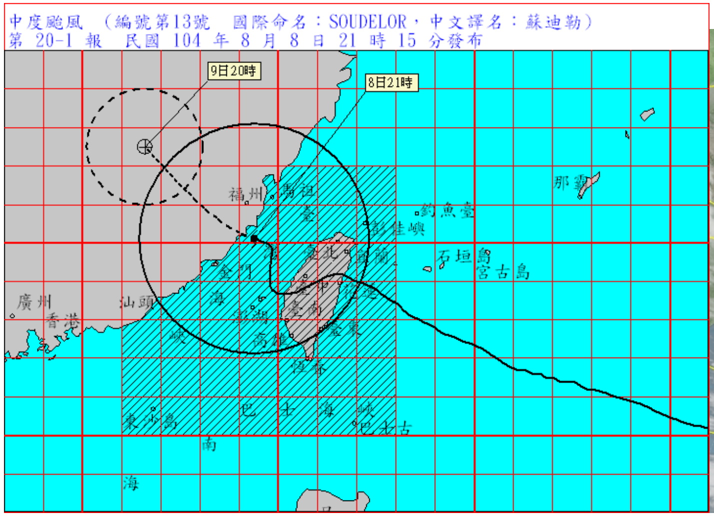
with peak winds at 180 mph (290 kph), according to the Joint Typhoon Warning Center.

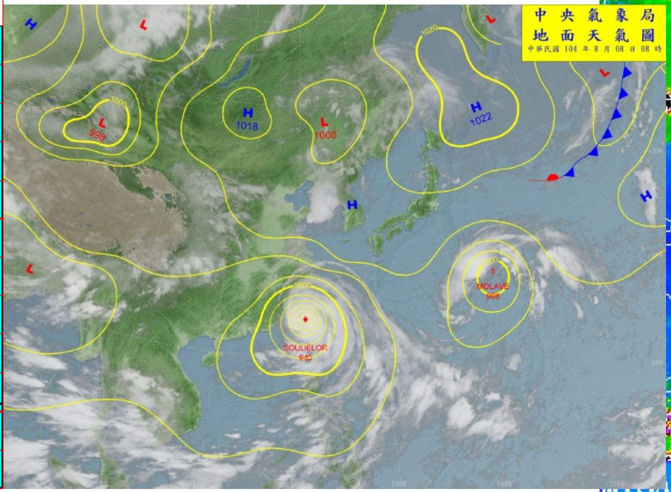

XINHUA/XINHUA VIA ZUMA WIRE/ZUMAPRESS.COM

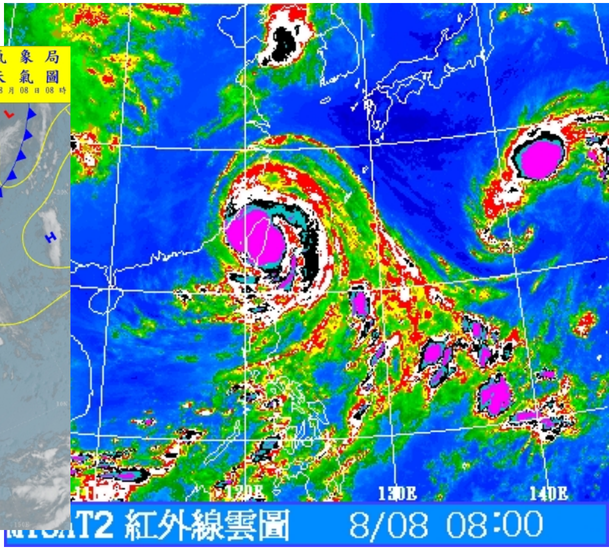

NEW TAIPEI FIRE DEPARTMENT/AP

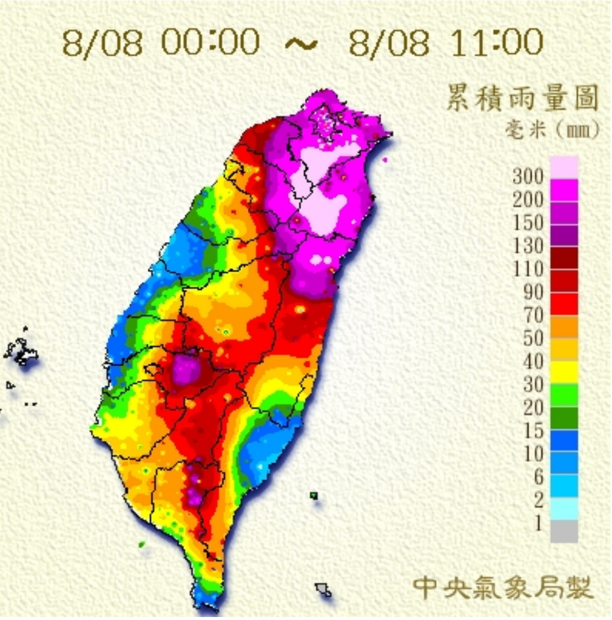

SAM YEHSAM YEH/AFP/GETTY IMAGES


中時電子報
chinatimes.com


中度颱風 （編號第13號 國際命名：SOUDELOR，中文譯名：蘇迪勒）
第 20-1 報 民國 104 年 8 月 8 日 21 時 15 分發布
9日20時
8日21時
福州
廣州
香港
汕頭
那霸
釣魚臺
石垣島
宮古島
東沙島


中 央 氣 象 局
地 面 天 氣 圖
SOUDELOR
MOLAVE


紅外線雲圖 8/08 08:00
120E
130E
140E


8/08 00:00 ～ 8/08 11:00
累積雨量圖
毫米（mm）
300
200
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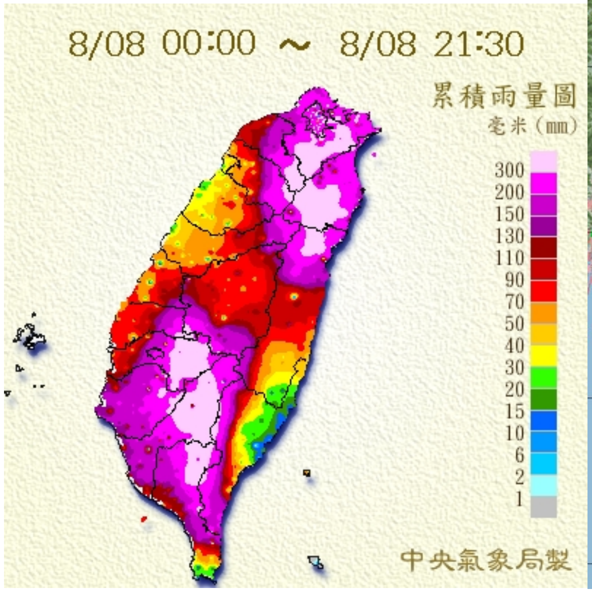
中央氣象局製


8/08 00:00 ～ 8/08 21:30
累積雨量圖
毫米（mm）
300
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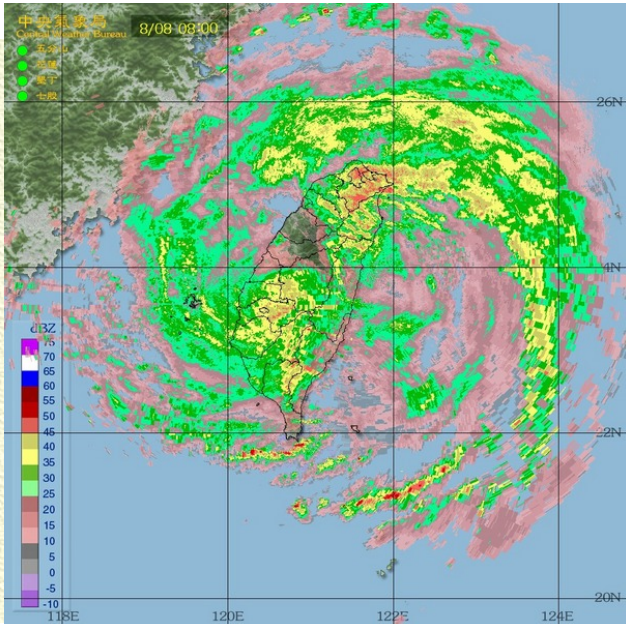
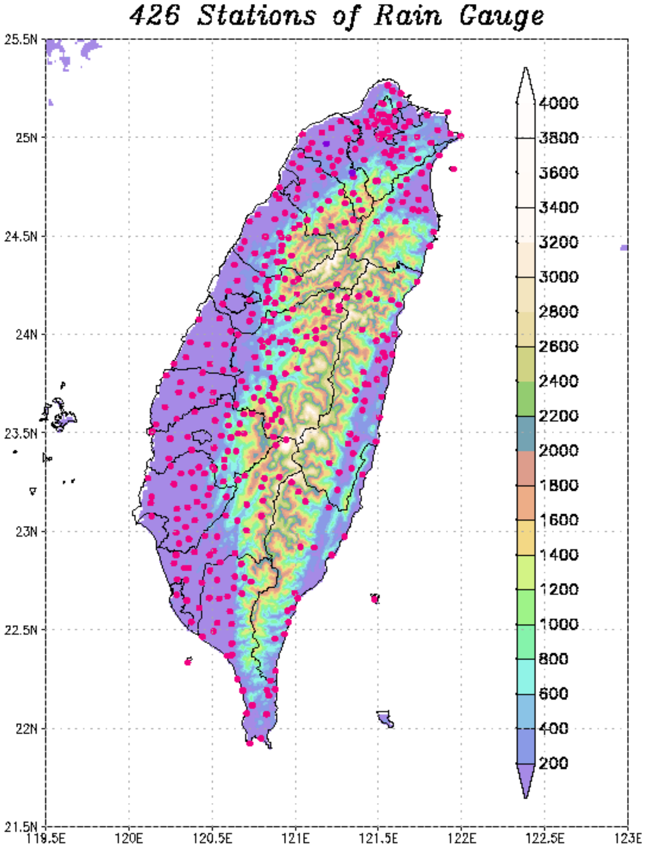
中央氣象局製

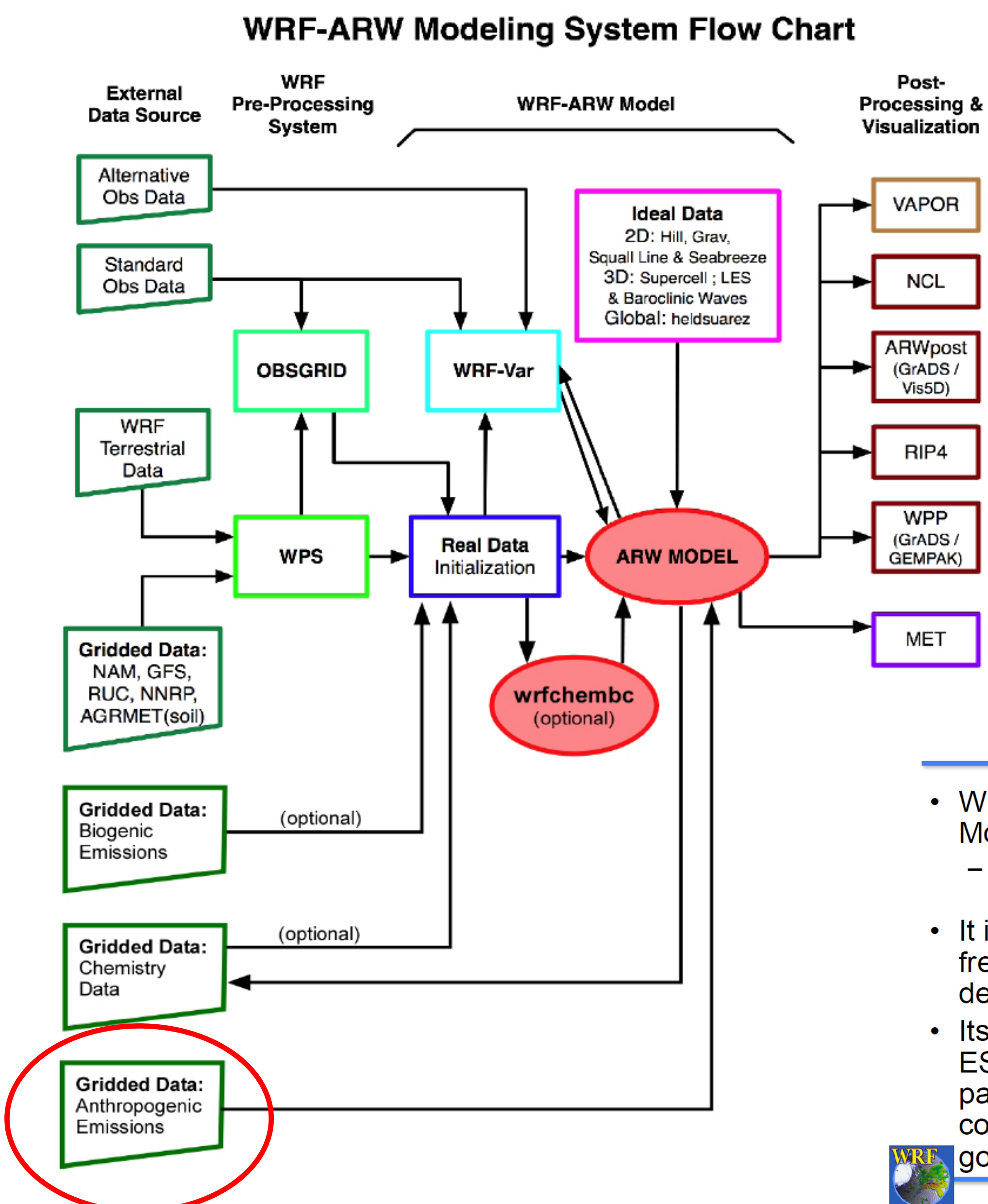

中央氣象局
Central Weather Bureau
8/08 08:00
dBZ
26N
22N
20N
118E
120E
122E
124E

How good can we simulate (predict) typhoon ?

- I.C., B.C. and resolution :the forecasting of track, intensity
- dynamic of Typhoon circulation and their interaction with the Taiwan terrain
- mesoscale wind and precipitation distribution



Model:WRF/WRF-Chem

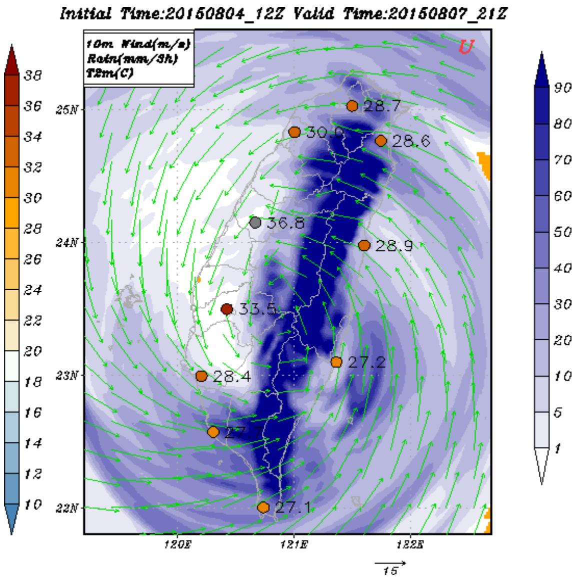


What is WRF?

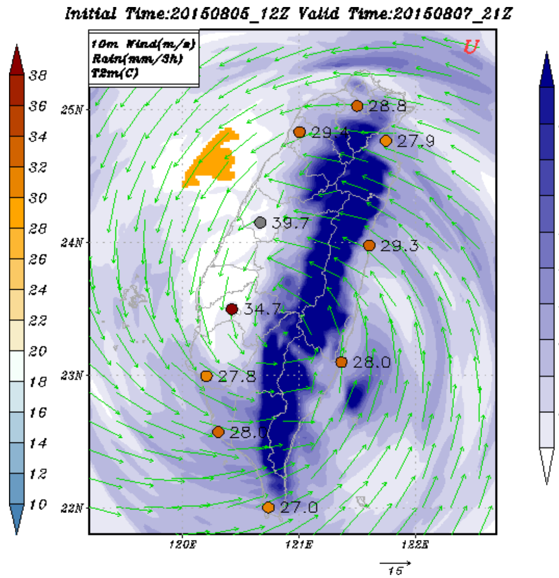
- WRF: Weather Research and Forecasting Model
  - Used for both research and operational forecasting
- It is a supported "community model", i.e. a free and shared resource with distributed development and centralized support
- Its development is led by NCAR, NOAA/ESRL and NOAA/NCEP/EMC with partnerships at AFWA, FAA, DOE/PNNL and collaborations with universities and other government agencies in the US and overseas

Initial condition impacts on landfall simulation

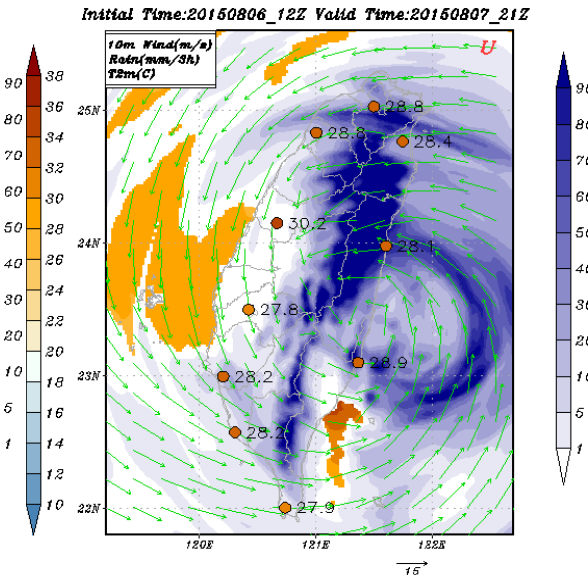
08/04-12Z



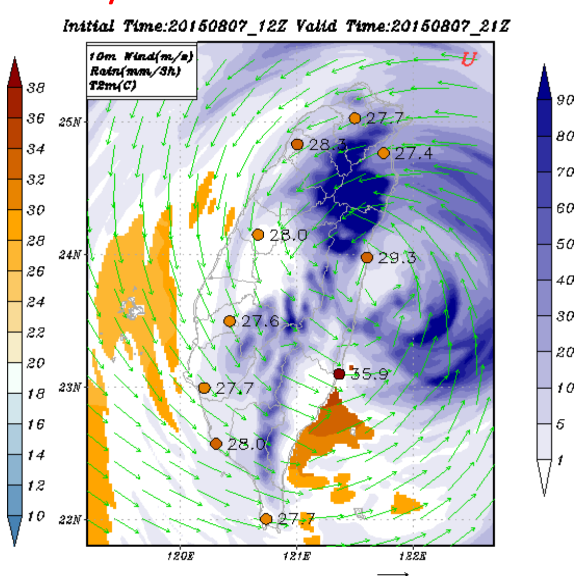
08/05-12Z

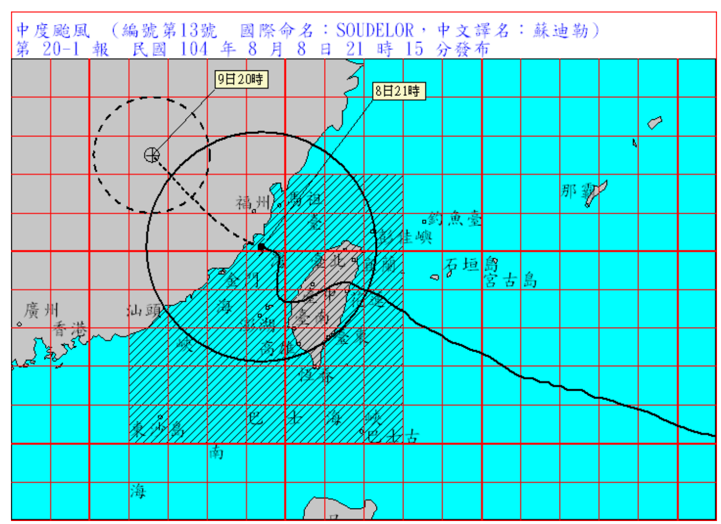


08/06-12Z

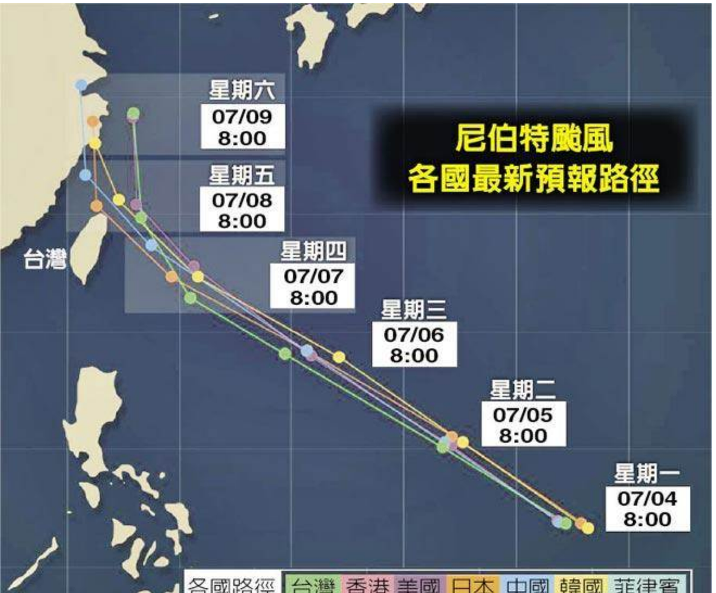


08/07-12Z

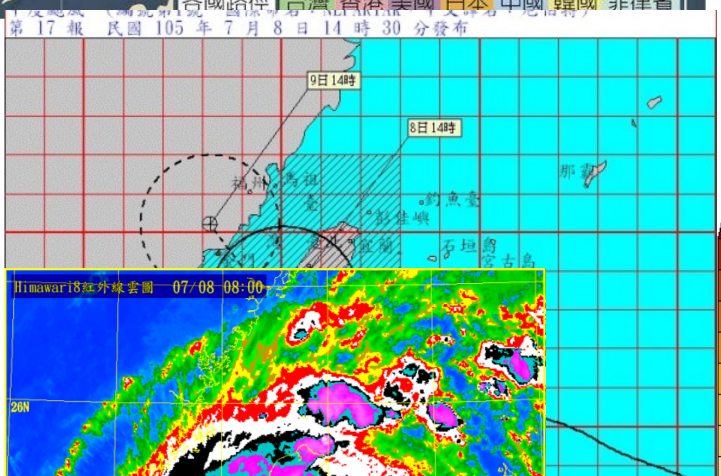


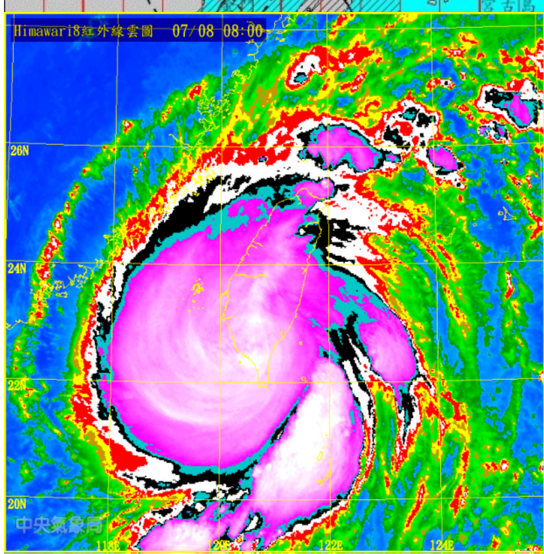


2016 Typhoon

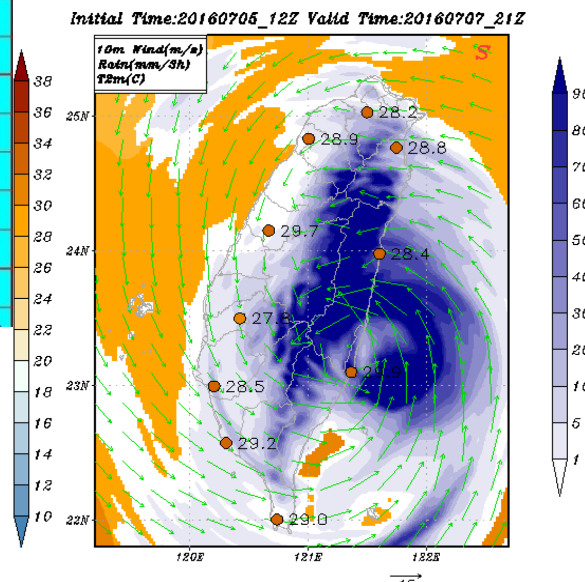


2016 07/08 Typhoon NEPARTAK

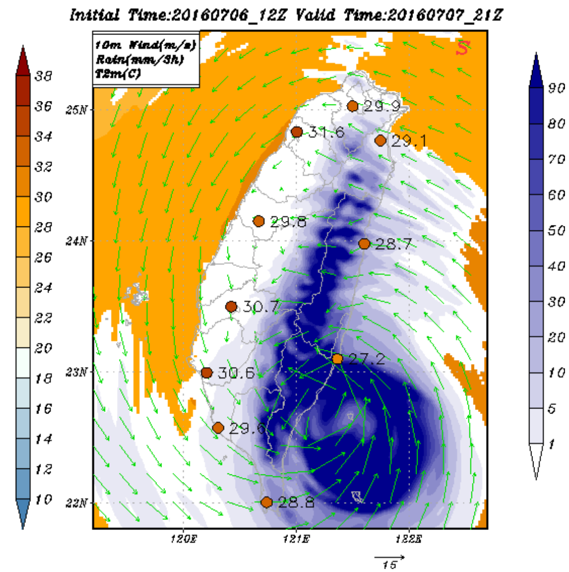




07/05 20LST → 07/08 05LST



07/06 20LST → 07/08 05LST



Flooding in Sri Lanka (2016)

Suranjith Bandara Koralegedara[1, 2, 3], Chuan-Yao Lin[1, 2*] and Yang-Fan Sheng[2]

[1] Taiwan International Graduate Programme,

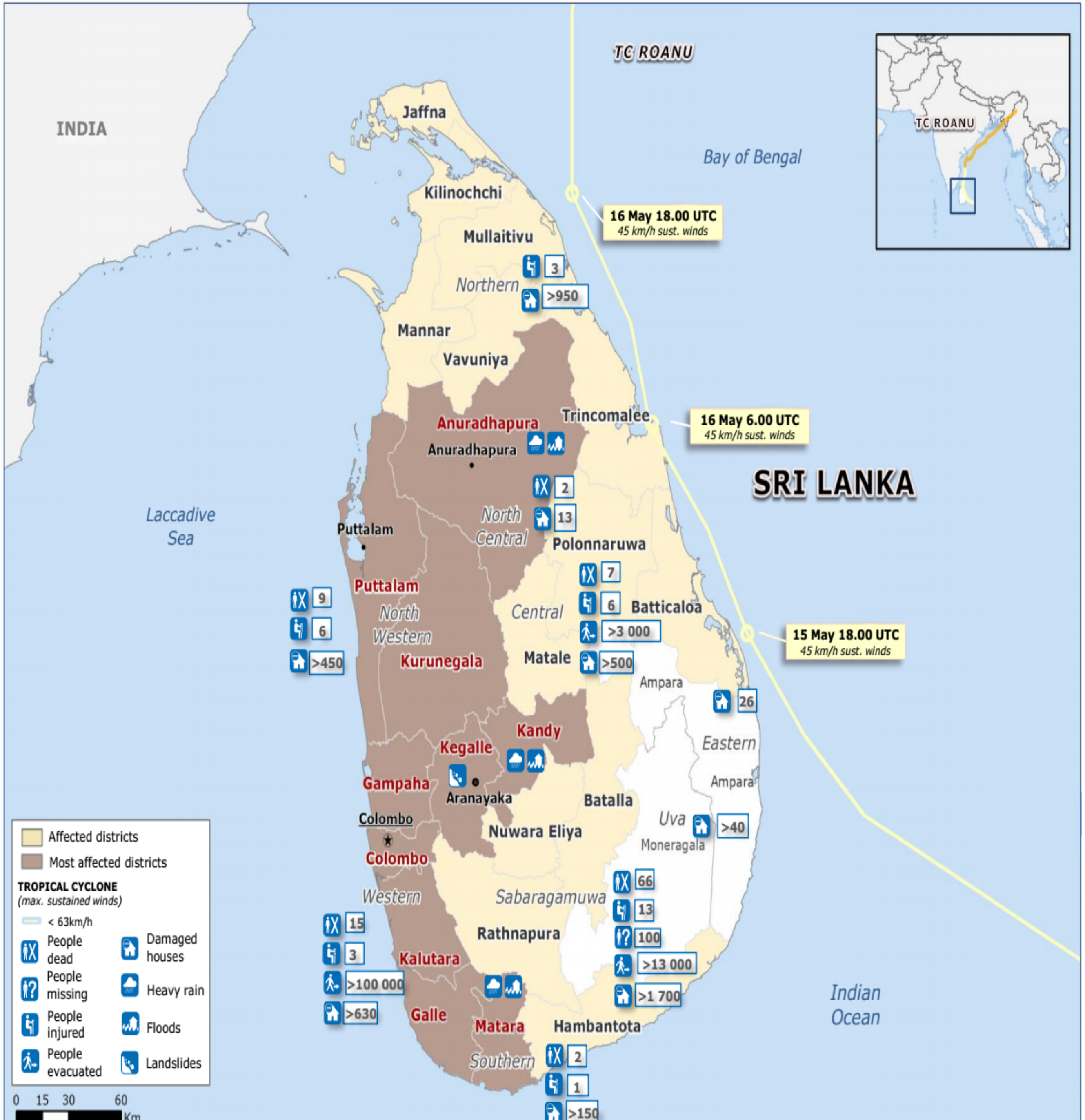
[2] Research Center for Environmental Changes, Academia Sinica, Nangang, Taipei, Taiwan.

[3] Institute of Atmospheric Physics,College of Earth Science, National Central University, Jhongli, Taoyuan, Taiwan

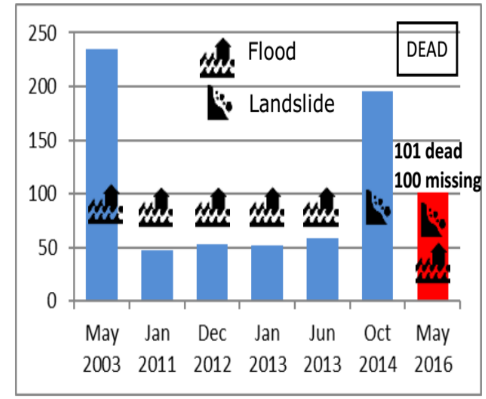

WWW.NEWS.CN

The flooding event

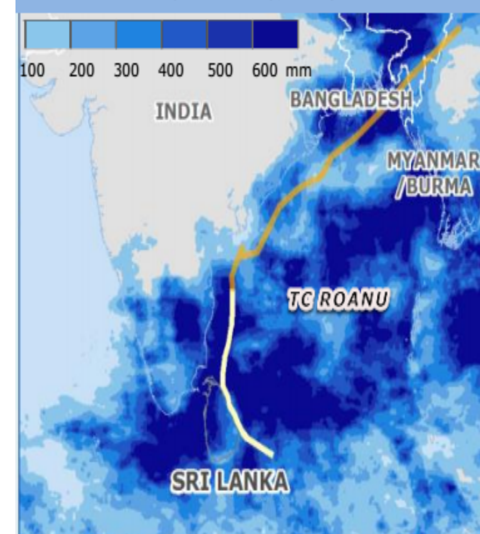
- A depression in the Bay of Bengal in the Indian Ocean to the South East of Sri Lanka caused heavy rainfall across Sri Lanka since 14 May 2016
- Causing wide spread heavy rains, flooding and land slide in as many as 22 districts,.
- **According to the Meteorology Department the last four days had seen one of the highest rainfalls in Sri Lanka**
- Total number of people affected 427,918, 101 deaths, 100 missing (landslide)
- Worst affected district - Colombo (Capital) – 185,835 affected
- Kelani Ganga is one of the main river basin in Sri Lanka which experienced **large scale flooding and sub sequent damage to property and livelihoods**.



The Floods and Landslides included in the Top 10 Natural Disasters in Sri Lanka (CRED/EM-DAT) for the period 2000-2016 sorted by number of dead are shown below (current event is in RED):



PRECIPITATION ACCUMULATION OVER THE LAST 14 DAYS
(as of 24 May, NASA)



Research Questions & Assumptions of the study

- What was the main cause for the heavy rainfall and flooding in western part of Sri Lanka?
  - Main cause for the heavy rainfall was the low pressure system.
- Why May 15 & 16 received the maximum rainfall over western part of Sri Lanka?
  - May 15 & 16 was the period low pressure system approaching and passing along Sri Lanka
- Why only western part of Sri Lanka received relatively maximum rainfall and why not the eastern part of Sri Lanka?
  - Location of the heavy rainfall was following the low pressure system
  - Westerlies and the low pressure system winds were interacting with mountain only over western part of Sri Lanka

WRF Model Configuration

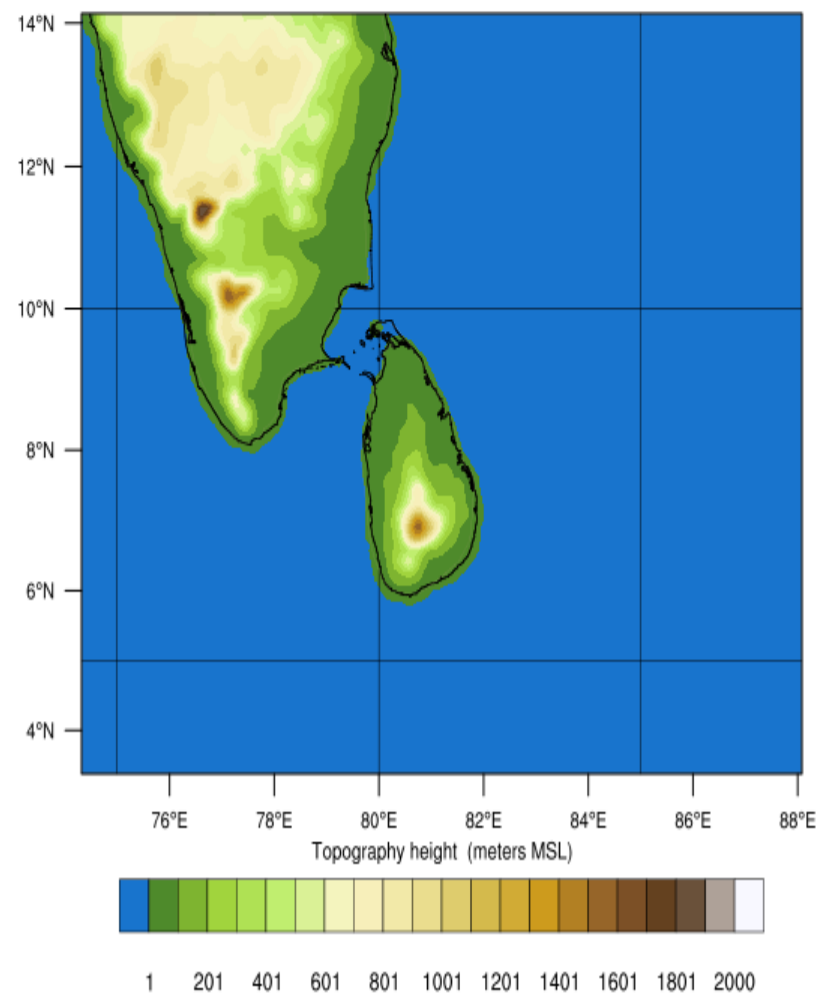
- **Model:**
  Weather Research and Forecasting (WRF) Advanced Research (ARW) Version 3.6.1

- **Time period:**
  May 14th 0000 – 21st May 0000, 2016

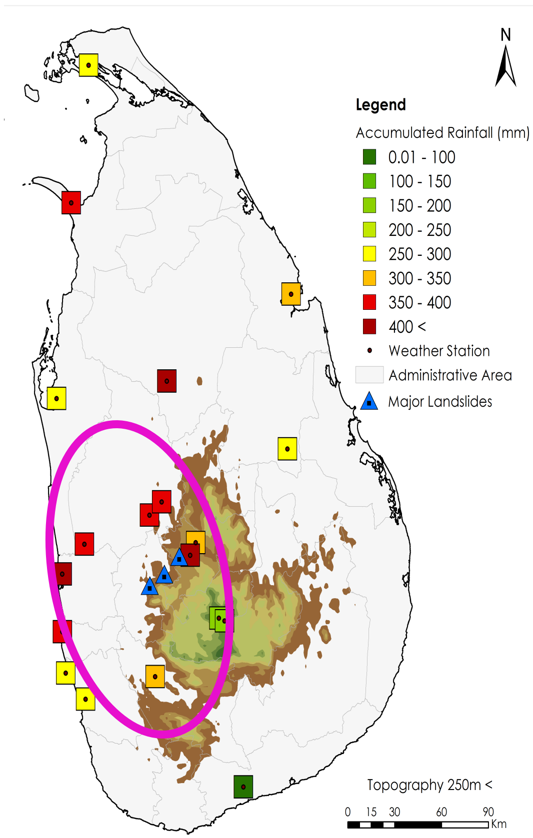
- Initial and Boundary Conditions: NCEP (CFSv2) 6-hourly

- Re-initialize WRF every 6 hours

Domain 01

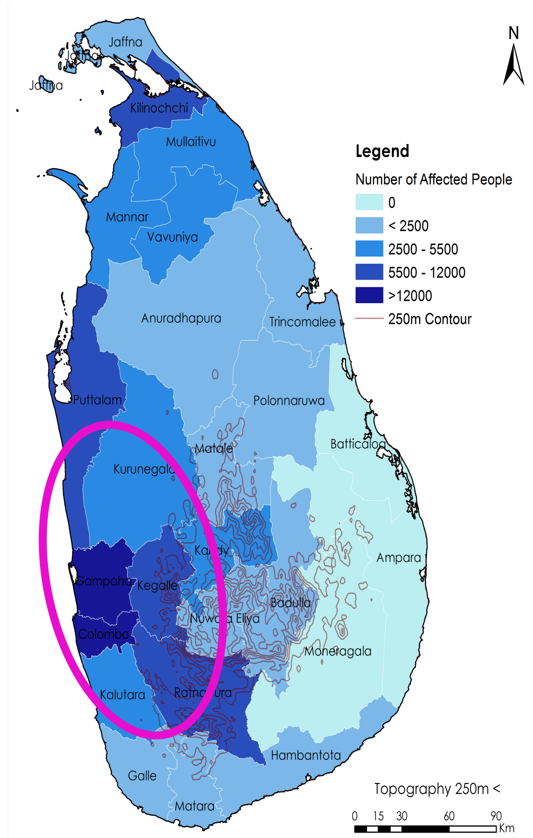


What was the main cause for the heavy rainfall and flooding in western part of Sri Lanka?



Source: Department of Meteorology

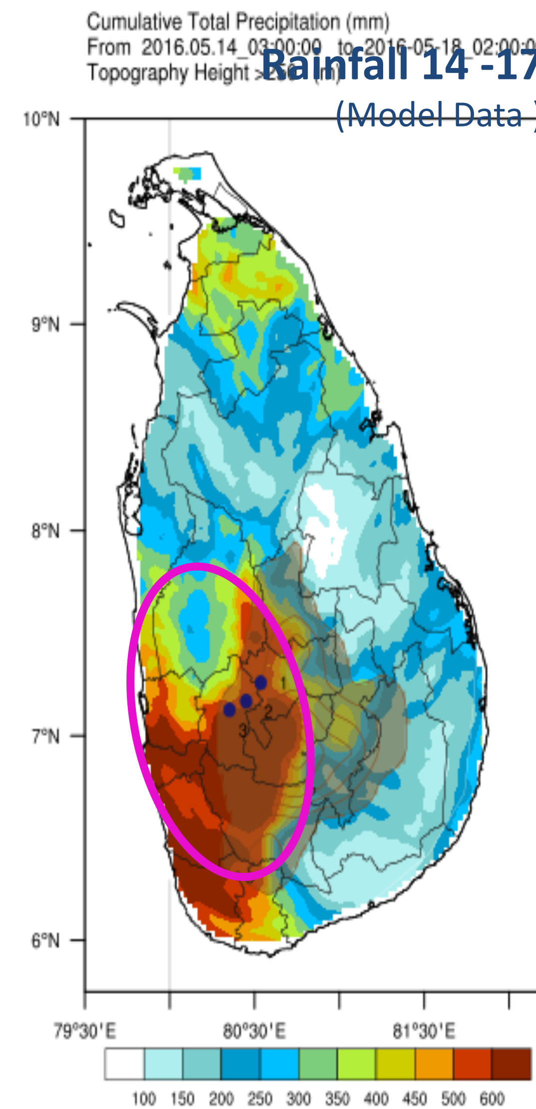
Rainfall 14 -17 (Weather Station Data)



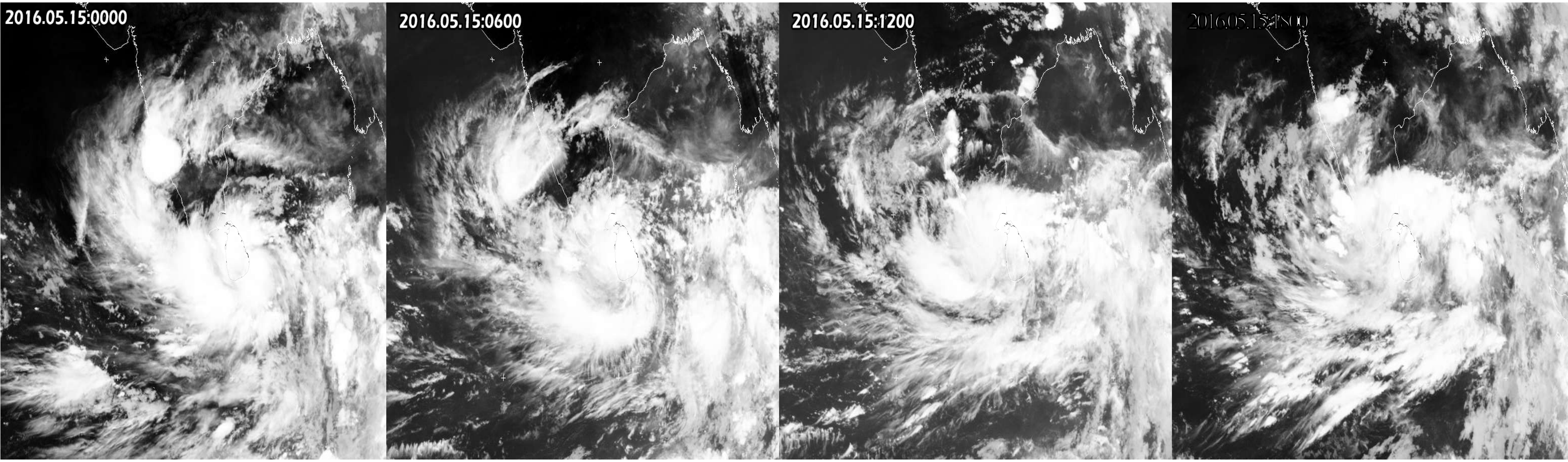
Source: Disaster Management Center (DMC)

No of Affected People as of 2016.05.22

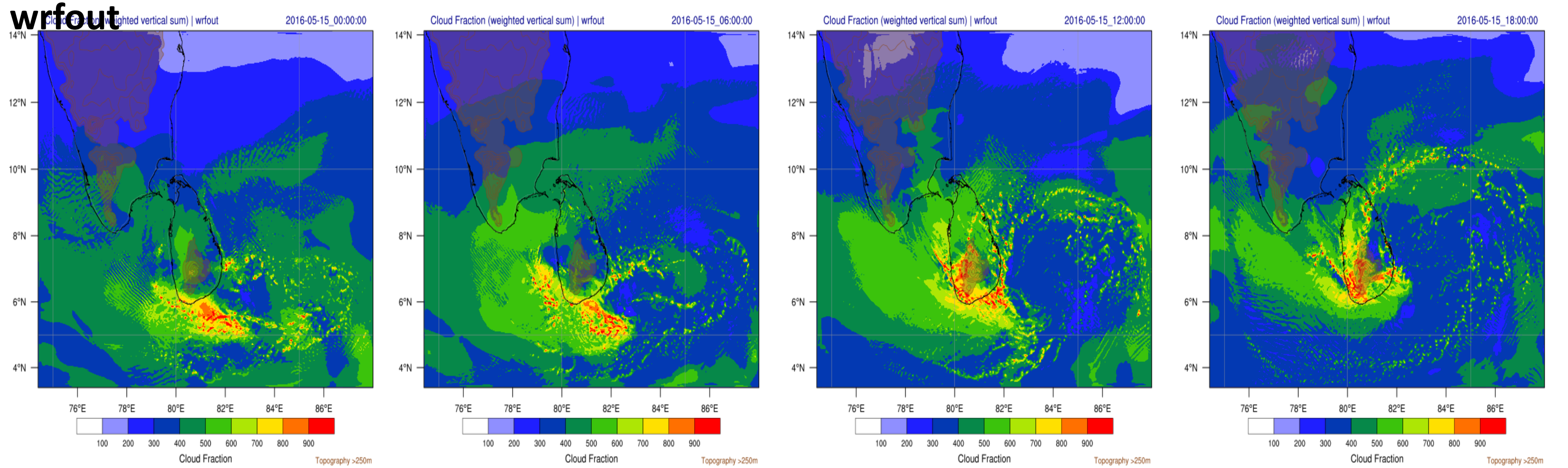
Rainfall 14 -17 (Model Data)



Cloud Image – TIR Satellite Images

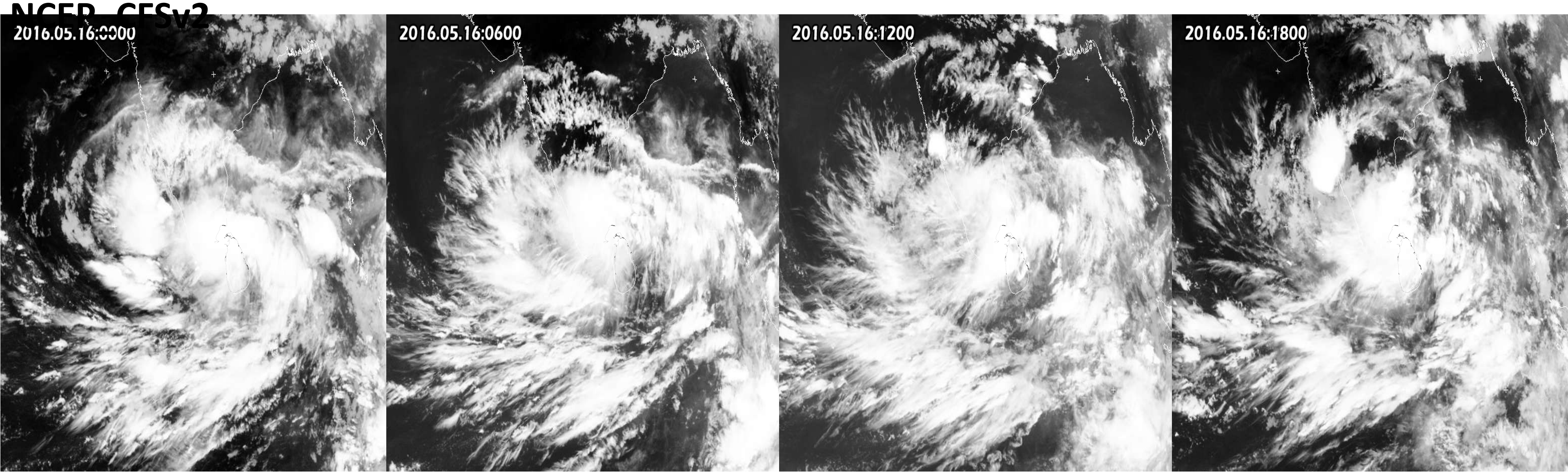


Model Results / wrfout

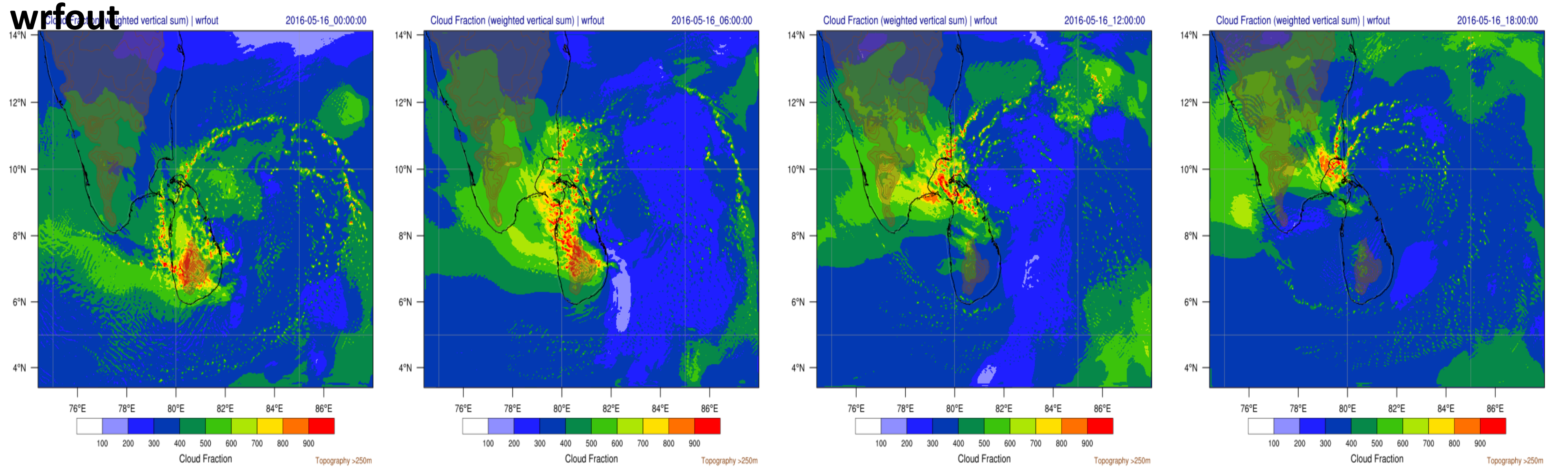


Cloud Image (Satellite) and Cloud Fractions (weighted vertical column sum) (WRF)–

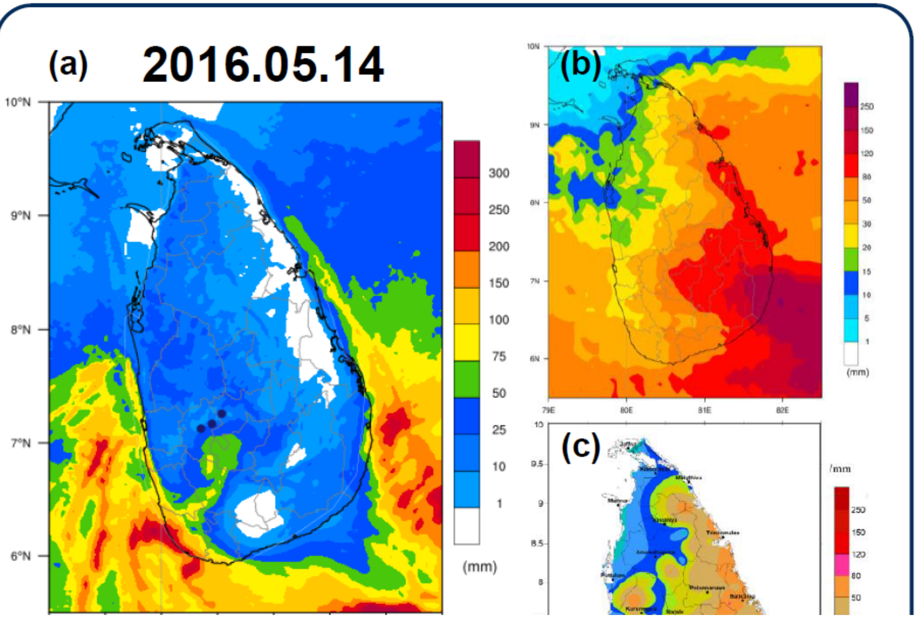
Met_em Data / NCEP_CFSv2

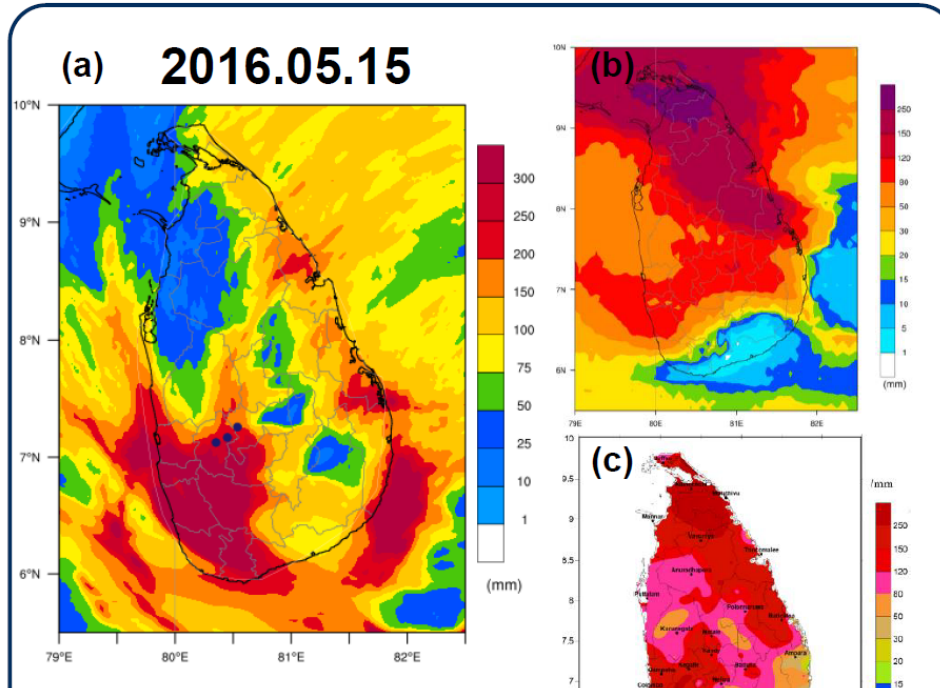


Model Results / wrfout

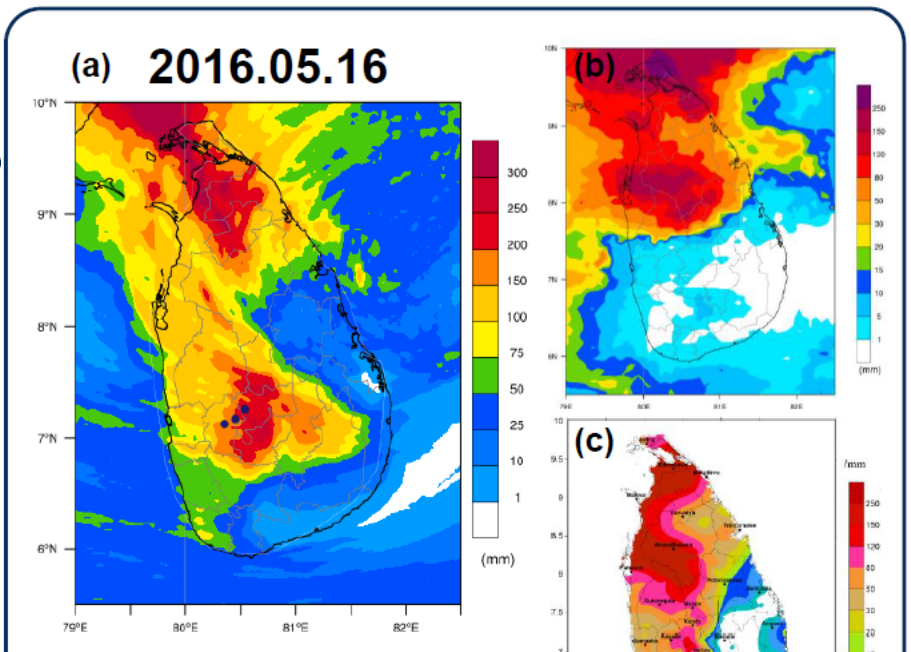


Cloud Image (Satellite) and Cloud Fractions (weighted vertical column sum) (WRF)–





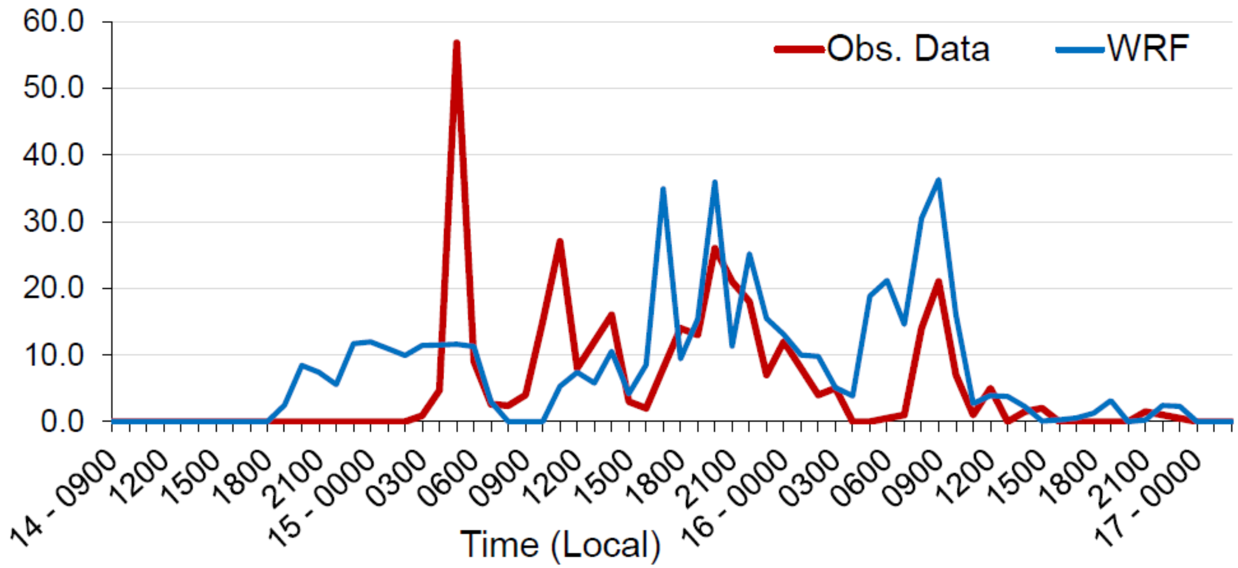
(a) WRF simulated rainfall
(b) CMORPH rainfall estimates
(c) Observation – rainfall from DOM

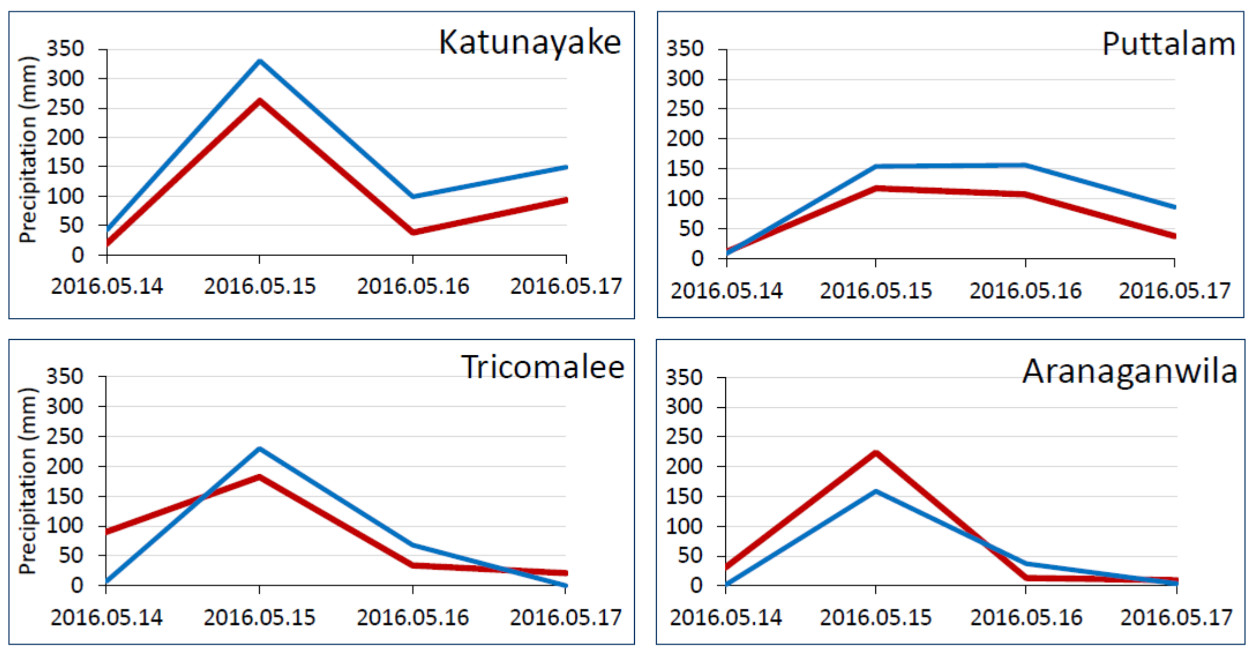


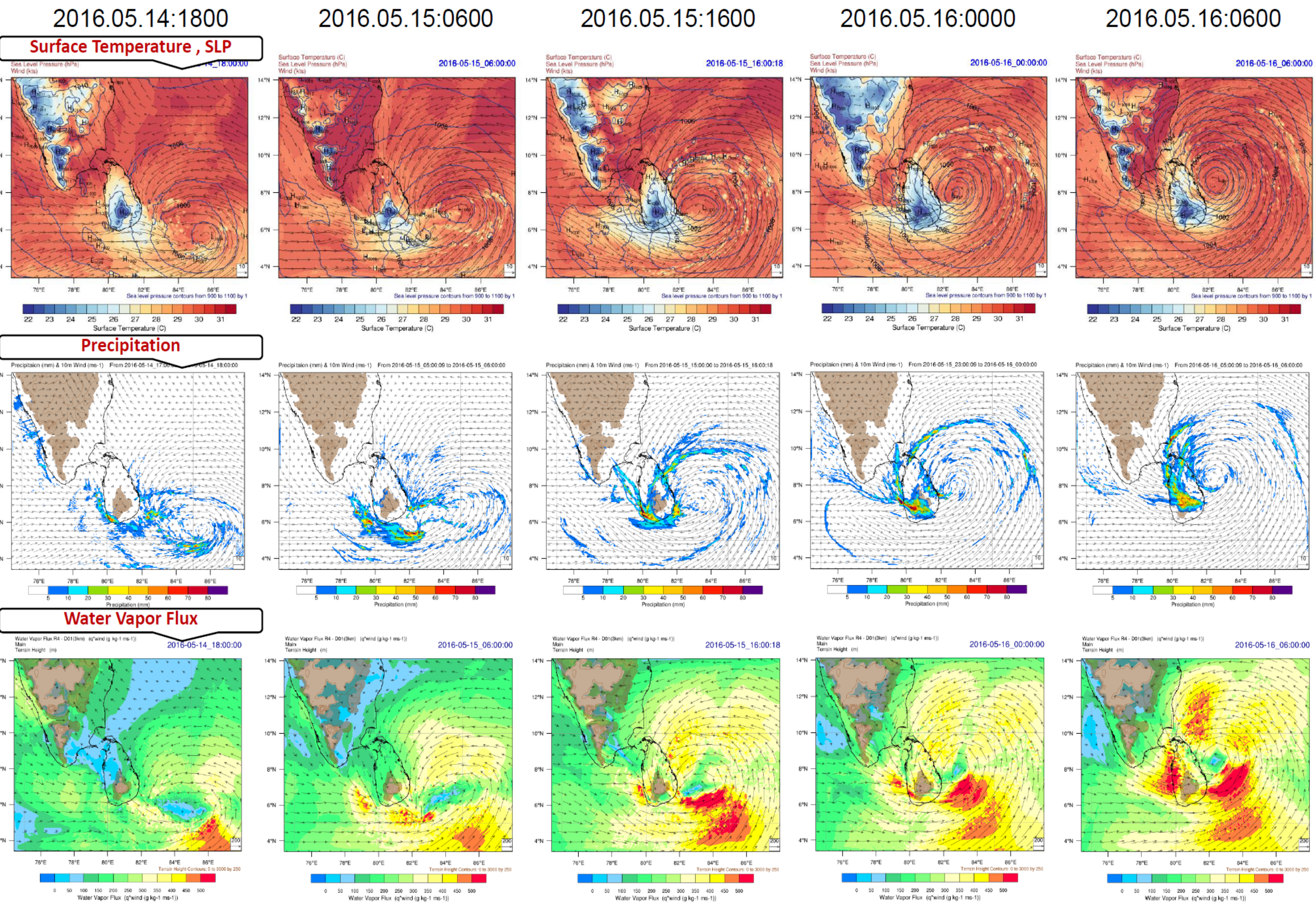
(a) WRF simulated rainfall
(b) CMORPH rainfall estimates
(c) Observation – rainfall from DOM

Model performance

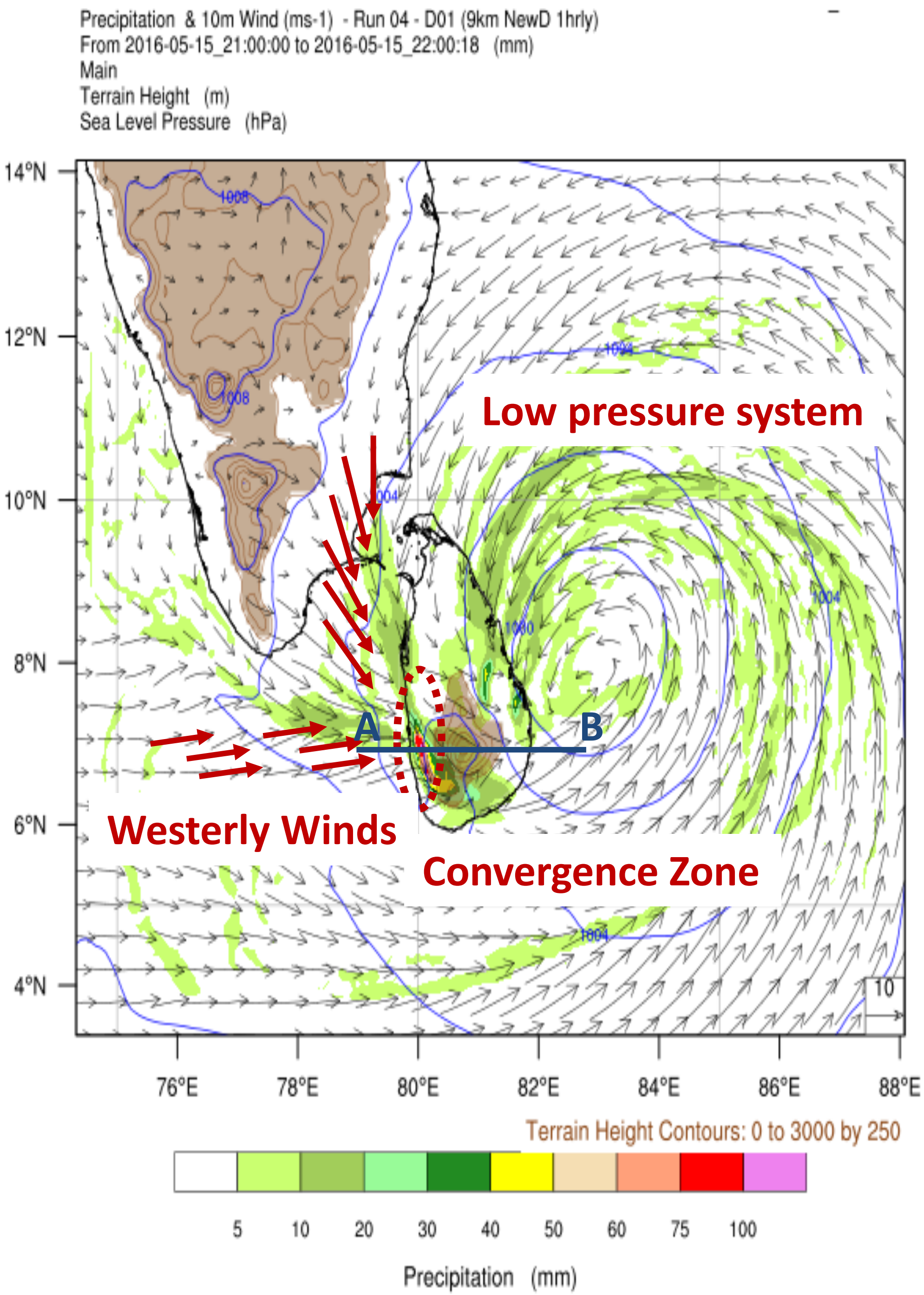
Rainfall Time Series (14^{th} -17^{th}, May) (hourly data / local time)
Colombo Weather Station (6.9^0N,79.867^0E)

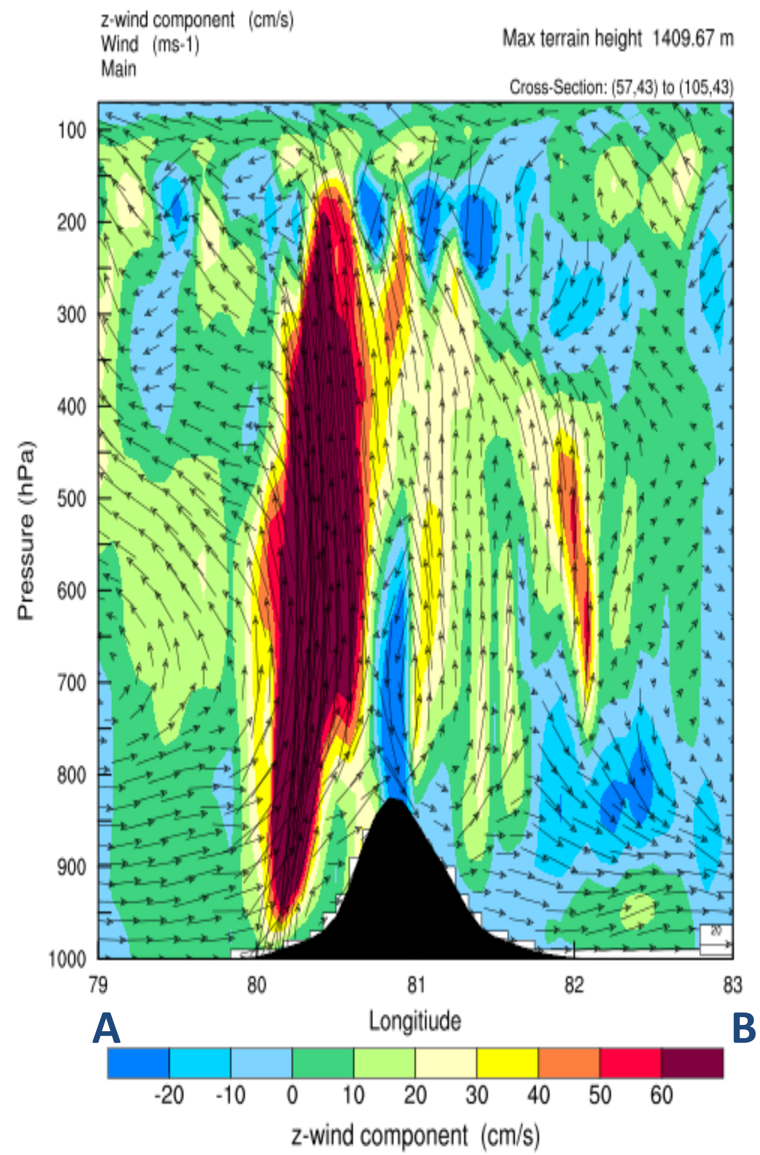





2016.05.14:1800
2016.05.15:0600
2016.05.15:1600
2016.05.16:0000
2016.05.16:0600
Surface Temperature , SLP
Surface Temperature (C)
Sea Level Pressure (hPa)
Wind (kts)
2016-05-15_06:00:00
2016-05-15_16:00:18
2016-05-16_00:00:00
2016-05-16_06:00:00
Sea level pressure contours from 900 to 1100 by 1
Precipitation
Precipitation (mm) & 10m Wind (ms-1)
From 2016-05-15_05:00:09 to 2016-05-15_06:00:00
From 2016-05-15_15:00:00 to 2016-05-15_16:00:18
From 2016-05-15_23:00:09 to 2016-05-16_00:00:00
From 2016-05-16_05:00:09 to 2016-05-16_06:00:00
Precipitation (mm)
Water Vapor Flux
Water Vapor Flux R4 - D01(3km) (q*wind (g kg-1 ms-1))
Main
Terrain Height (m)
2016-05-14_18:00:00
Terrain Height Contours: 0 to 3000 by 250
Water Vapor Flux (q*wind (g kg-1 ms-1))

Mechanisms of the rainfall event

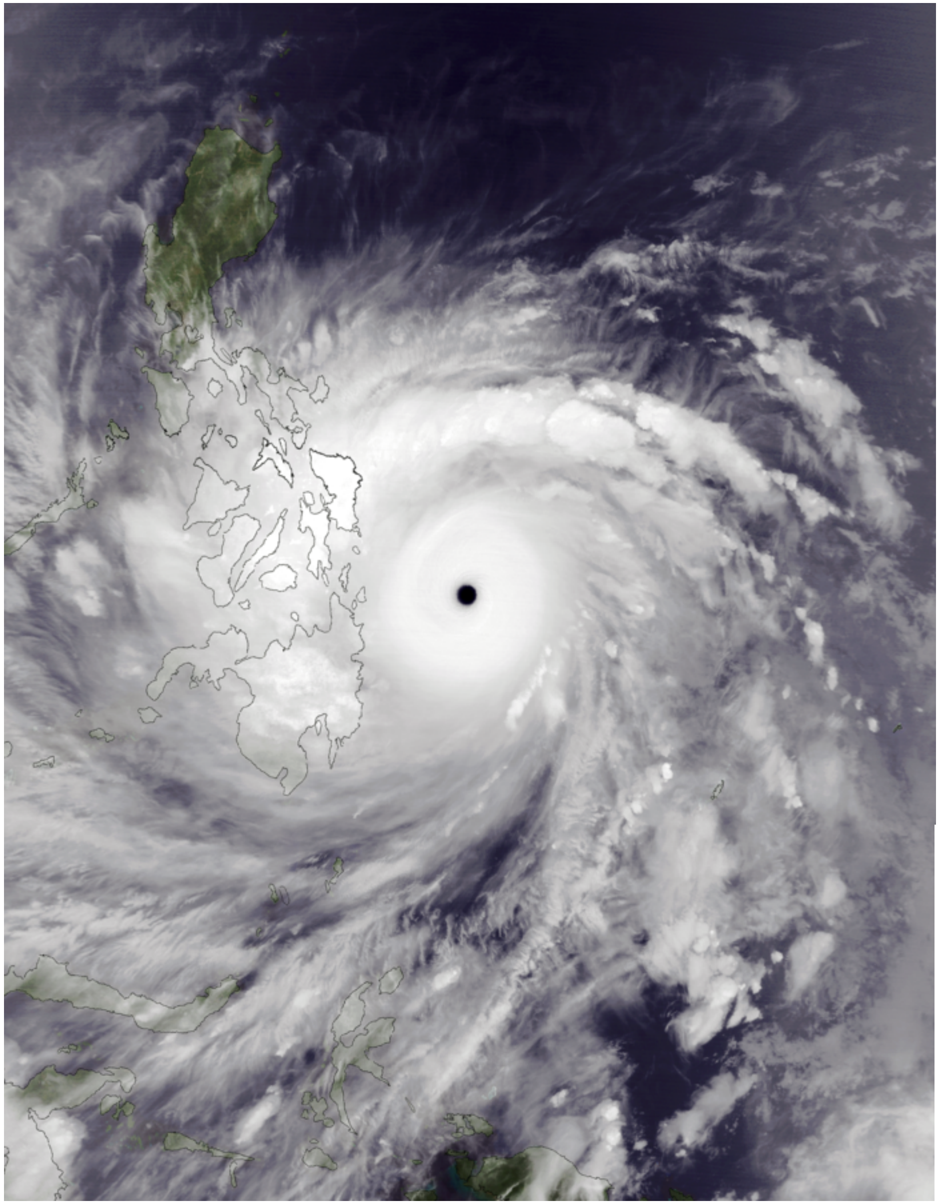




The possible mechanism of the rainfall event

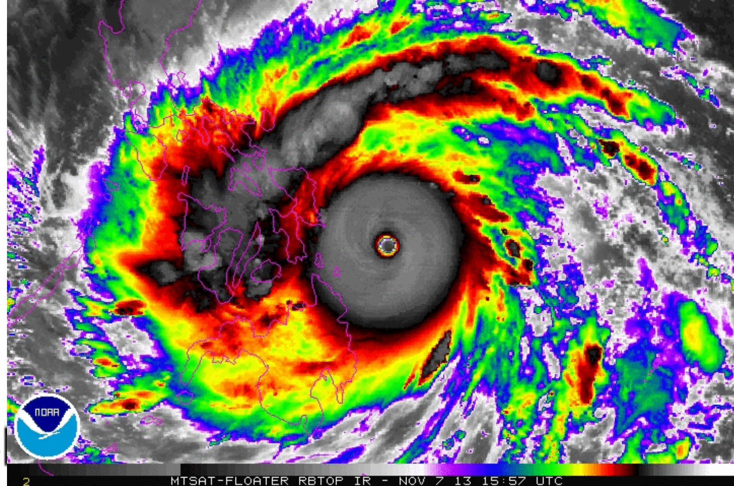
- The low pressure system was moving along the east coast.
- While the observed rainfall was highest particularly in the western part of the country.
- Westerlies influenced by the south west monsoon converged with the winds of the low pressure system over the western part of Sri Lanka.
- This convergence zone sustain over western part of Sri Lanka for relatively longer period with respect to the low pressure system movement.
- High vertical motion can enhance the convective activity and also bring more moisture.

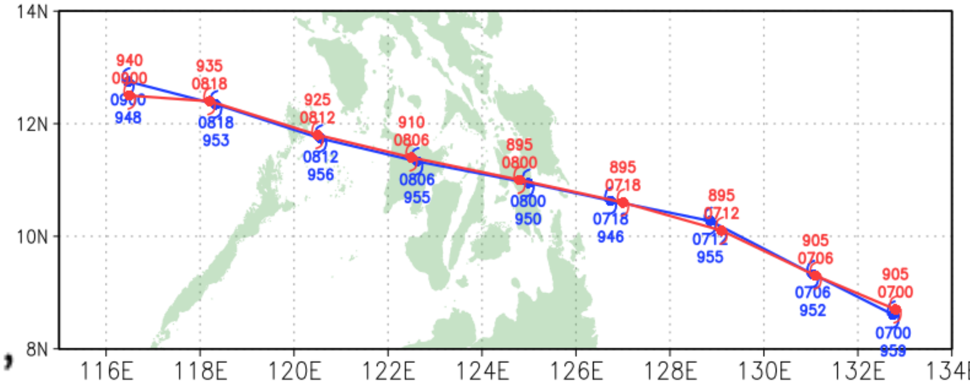
Storm Surge in Philippines (Haiyan, 2013)

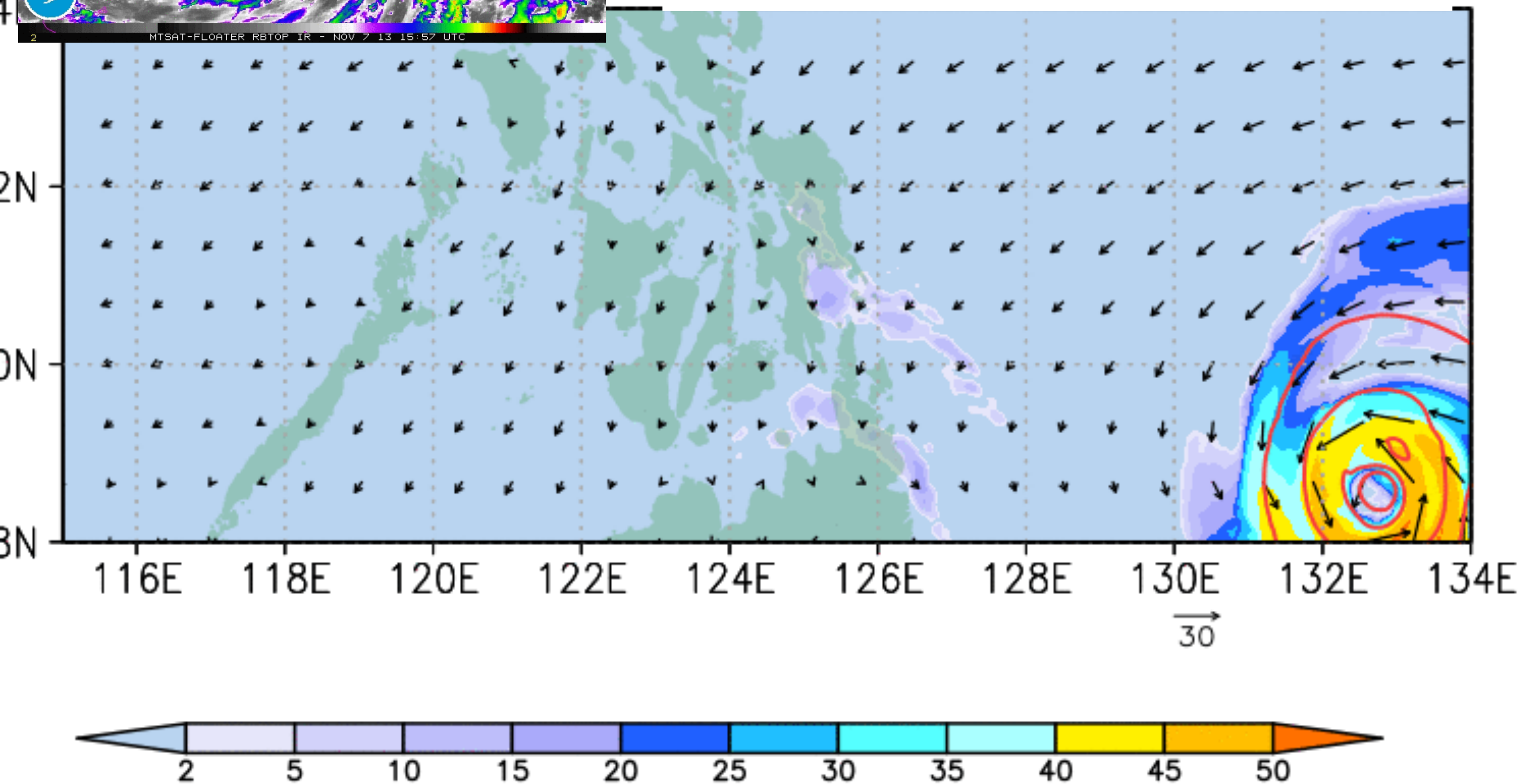


Duration : Nov.3-11
Peak: 230 km/h (145 mph) (10min)
Intensity: 895 hpa

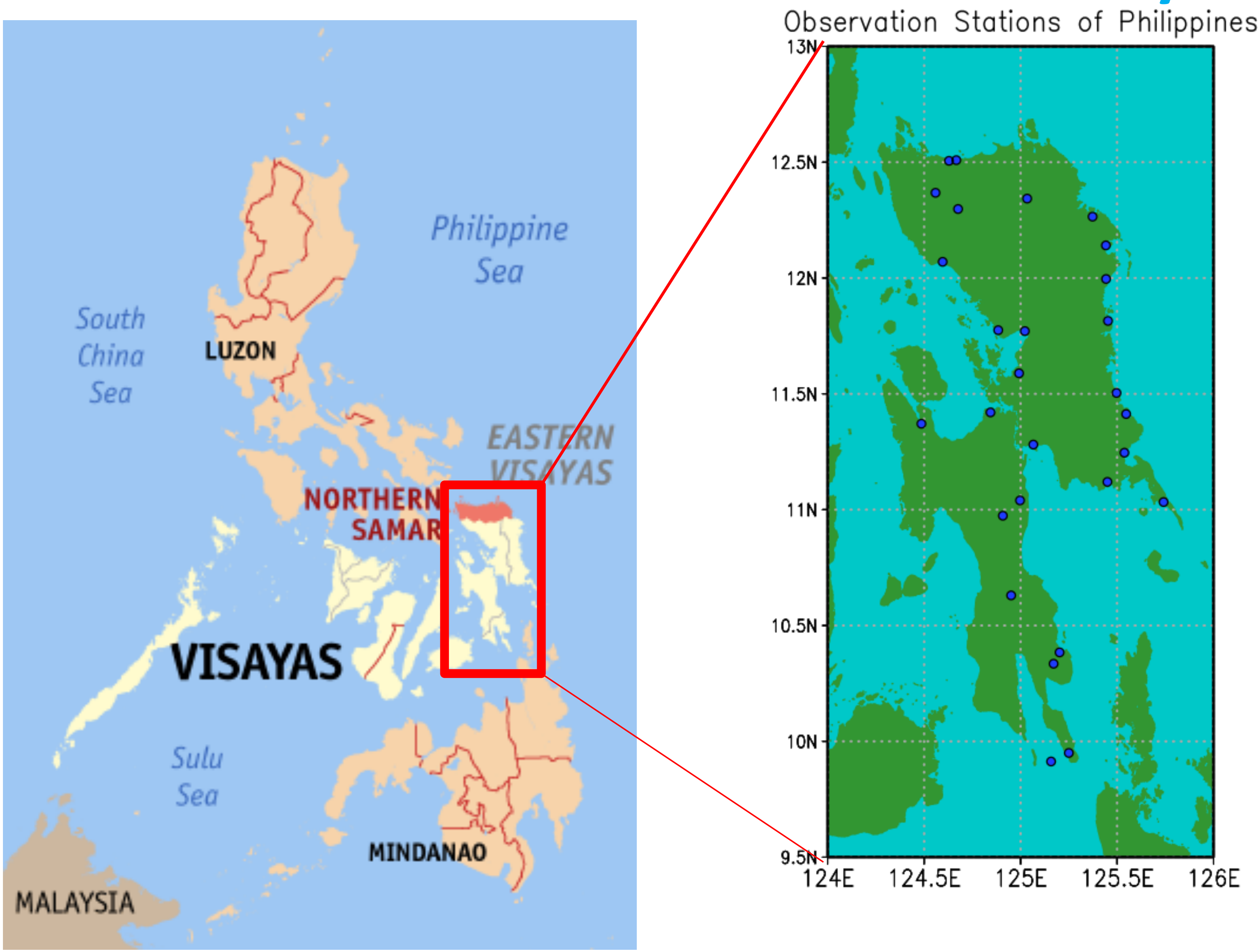
四級 4	最高持續風速	59–70 m/s	131–156 mph	114–135 kt	210–250 km/h
	風暴潮	13–18 ft		4.0–5.5 m	
	中心最低氣壓	27.17–27.88 inHg		920–944 mbar	
	潛在傷害	小建築的屋頂被徹底地完全摧毀。靠海附近地區大部分淹沒，內陸大範圍發洪水。			
	典型熱帶氣旋	颶風哈格比 –颶風尹布都 –熱帶氣旋翠西 – 颶風賀璞 – 颶風杜鵑 – 特強氣旋風暴納爾吉斯 – 颱風珍珠 - 強颱風韋森特 - 颱風馬鞍 - 颱風尤特			
五級 5	最高持續風速	≥70 m/s	≥157 mph	≥137 kt	≥252 km/h
	風暴潮	≥19 ft		≥5.5 m	
	中心最低氣壓	<27.17 inHg		<920 mbar	
	潛在傷害	大部分建築物和獨立房屋屋頂被完全摧毀，一些房子完全被吹走。洪水導致大範圍地區受災，海岸附近所有建築物進水，定居者可能需要撤離。			
	典型熱帶氣旋	颶風狄普 – 颶風卡崔娜 – 颶風約翰 – 颶風琳達 – 熱帶氣旋莫妮卡 – 颶風威爾瑪 – 強烈颱風電母 – 颱風寶發 – 颱風梅姬 – 超強颱風三巴 – 超強颱風烏莎吉 – 特強氣旋風暴費林 - 颱風范斯高 - 颱風利奇馬–超強颱風海燕			


NOAA
MTSAT-FLOATER RBTOP IR - NOV 7 13 15:57 UTC

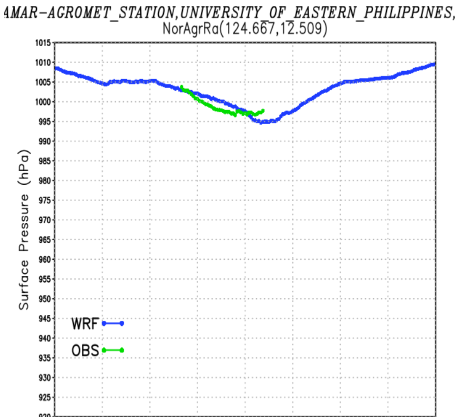

14N
12N
10N
8N
940
0900
948
935
0818
953
925
0812
956
910
0806
955
895
0800
950
895
0718
946
895
0712
955
905
0706
952
905
0700
116E
118E
120E
122E
124E
126E
128E
130E
132E
134E

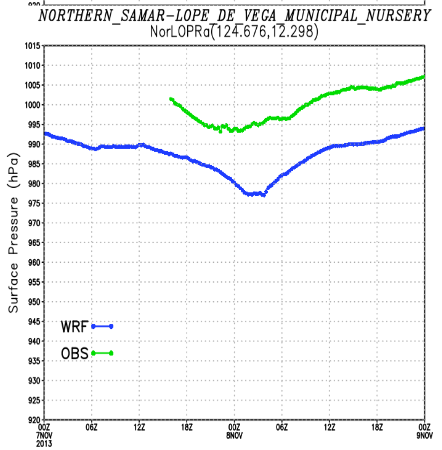

2N
0N
8N
116E
118E
120E
122E
124E
126E
128E
130E
132E
134E
30
2
5
10
15
20
25
30
35
40
45
50

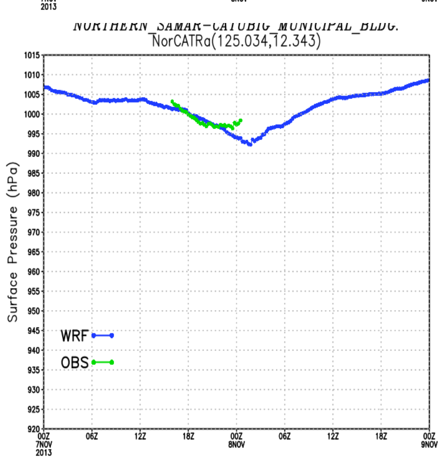
Samar & Leyte

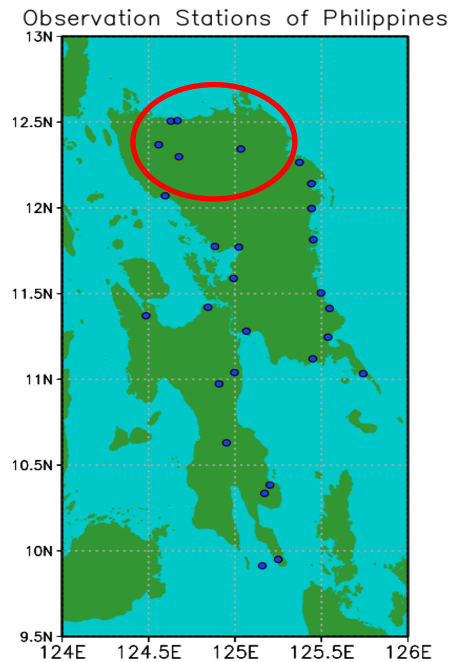

Philippine Sea
South China Sea
LUZON
EASTERN VISAYAS
NORTHERN SAMAR
VISAYAS
Sulu Sea
MINDANAO
MALAYSIA
Observation Stations of Philippines
13N
12.5N
12N
11.5N
11N
10.5N
10N
9.5N
124E
124.5E
125E
125.5E
126E

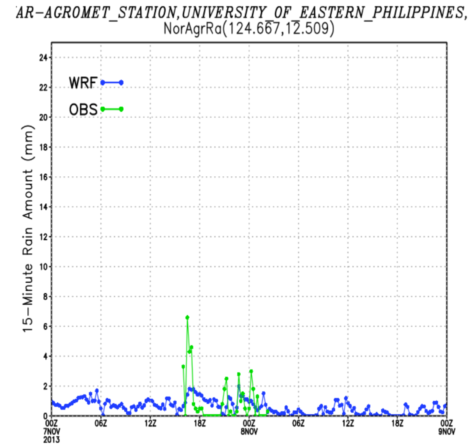
Northern Samar

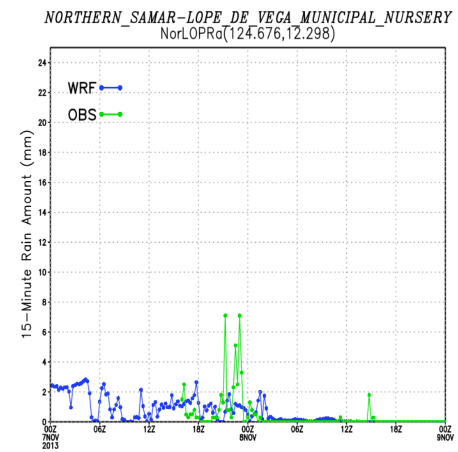


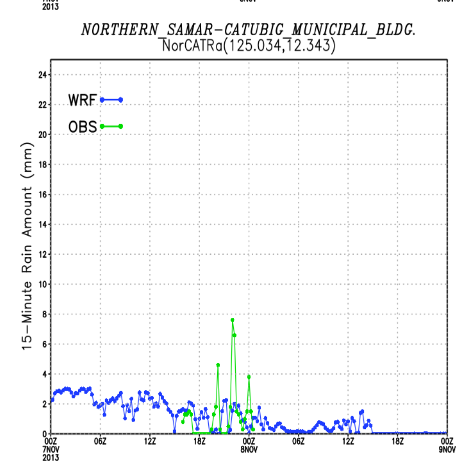


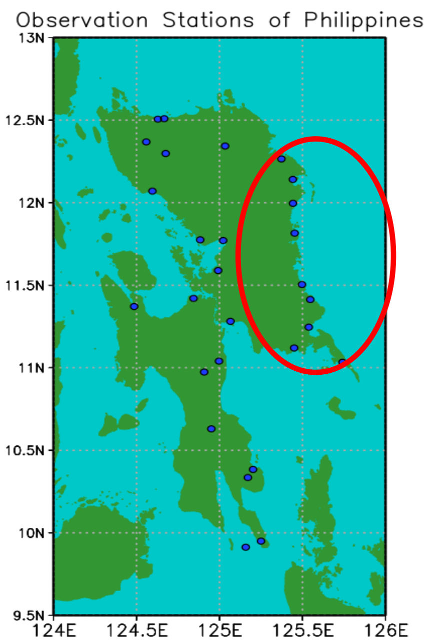


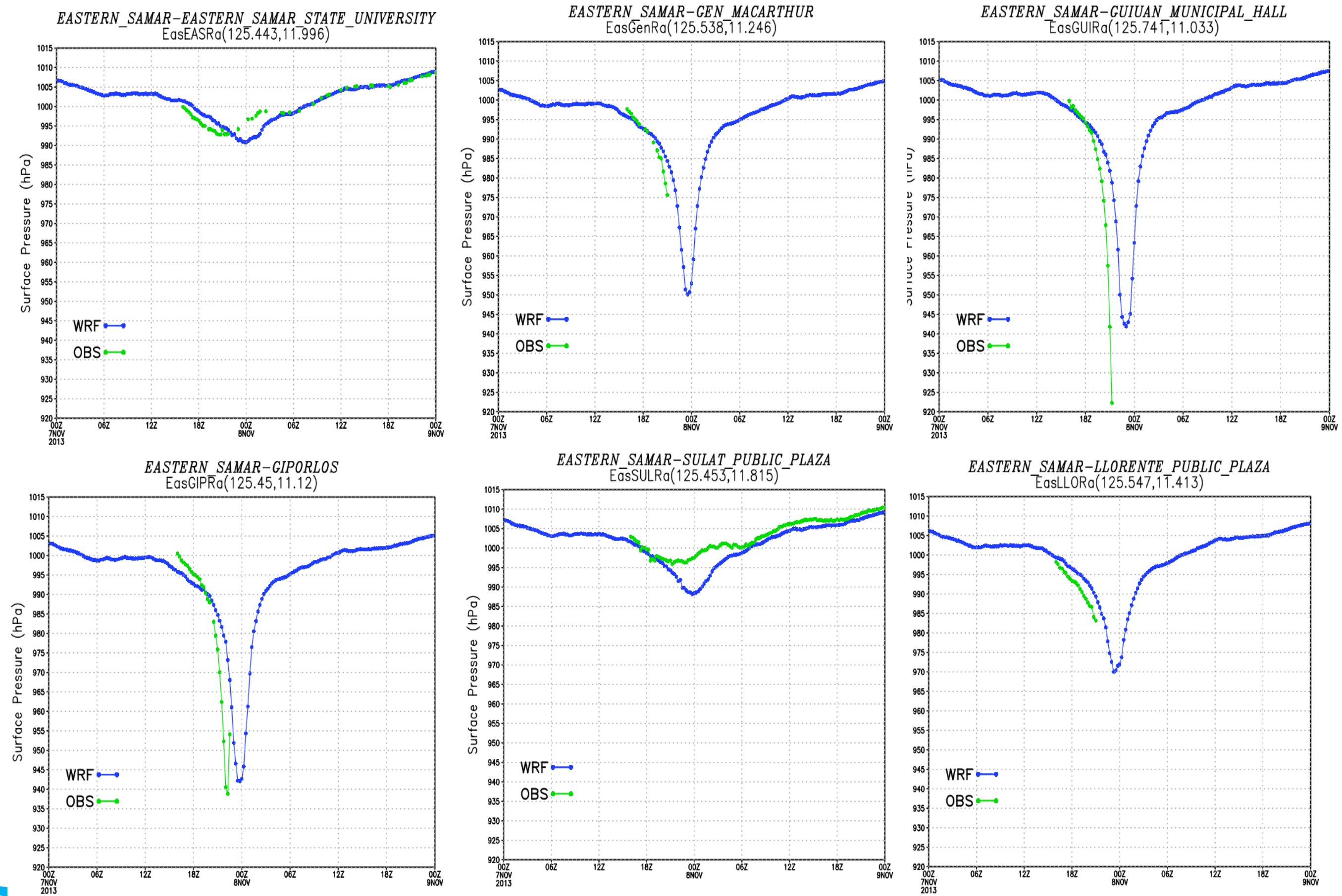






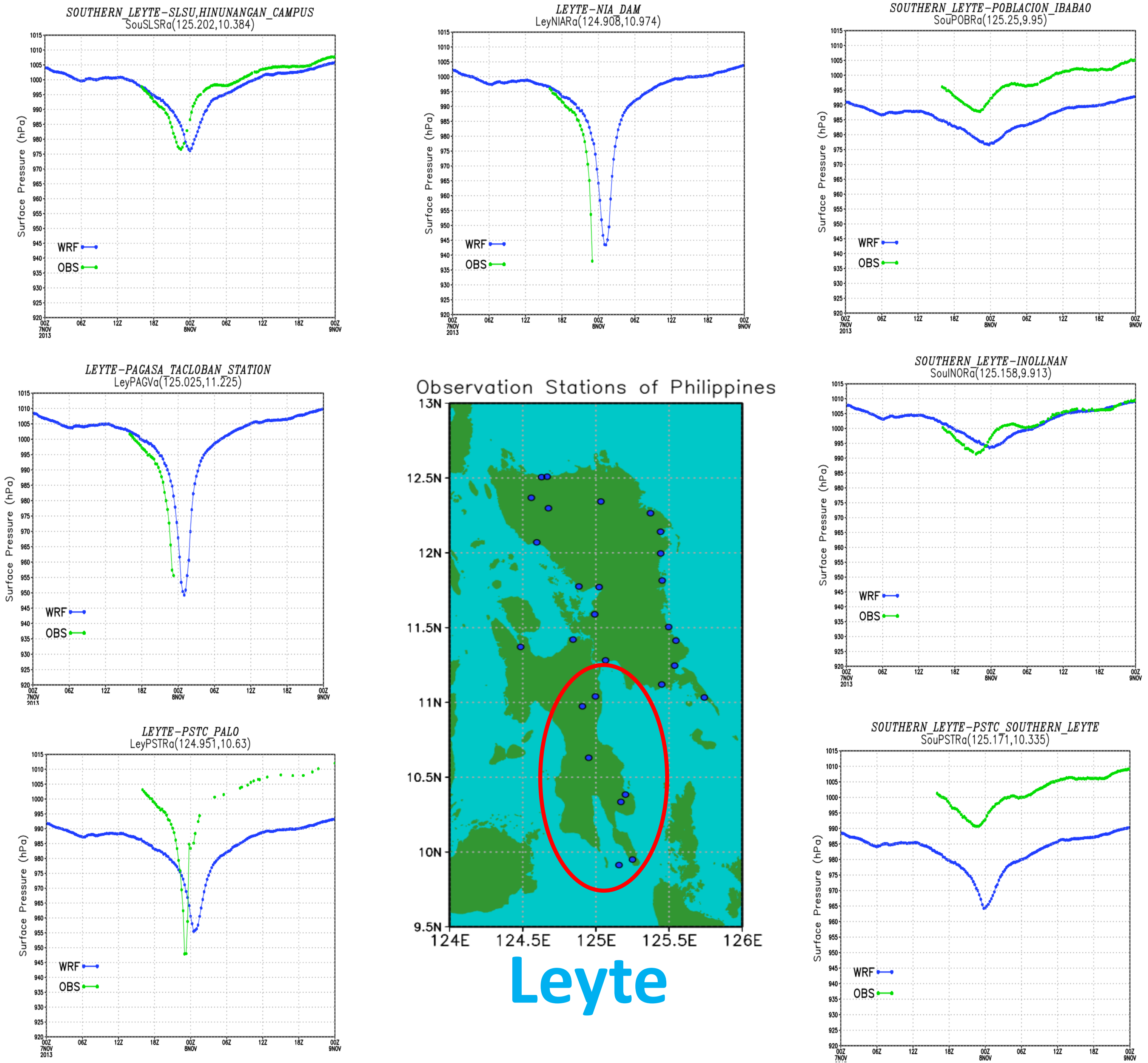






Eastern Sama

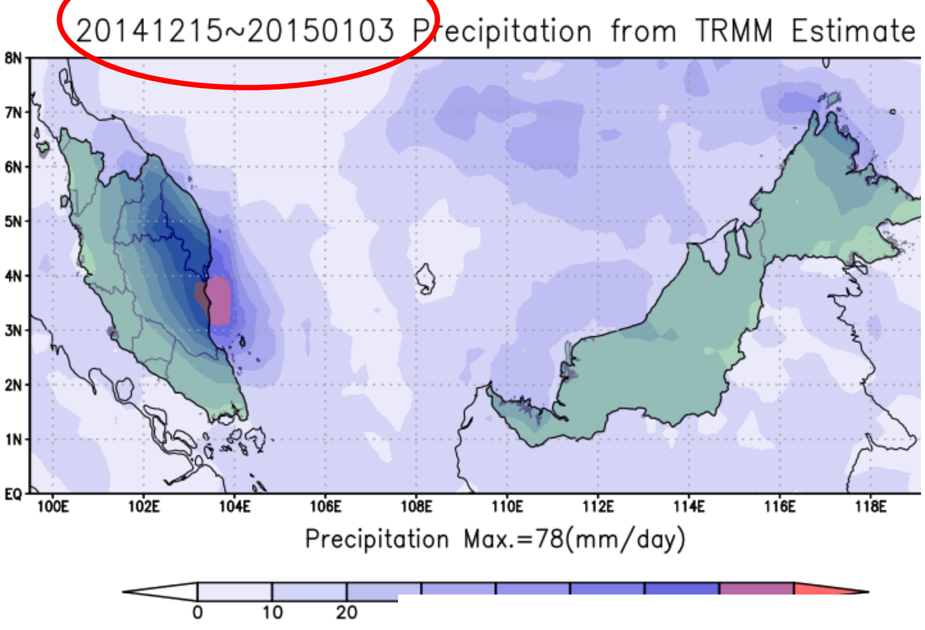
(pressure)

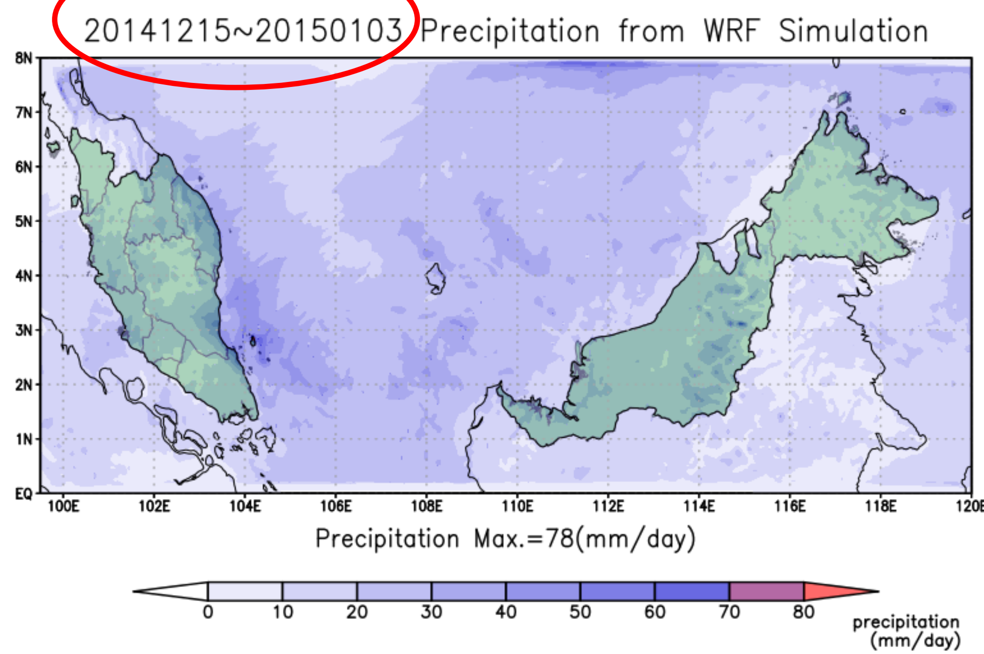


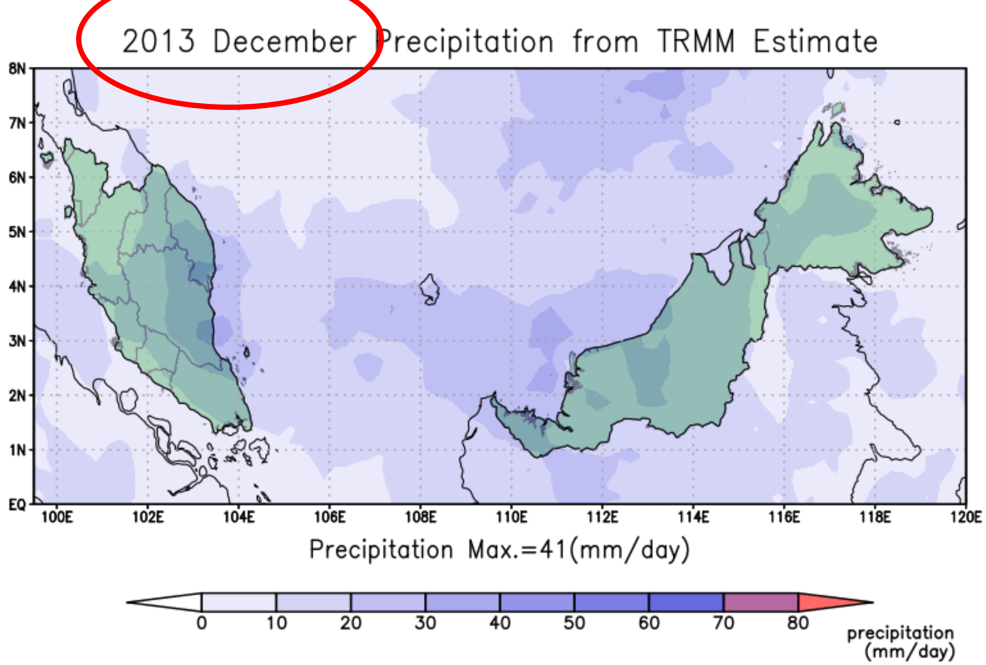
SOUTHERN_LEYTE-SLSU,HINUNANGAN_CAMPUS
SouSLSRa(125.202,10.384)
LEYTE-NIA_DAM
LeyNIARa(124.908,10.974)
SOUTHERN_LEYTE-POBLACION_IBABAO
SouPOBRa(125.25,9.95)
LEYTE-PAGASA_TACLOBAN_STATION
LeyPAGVa(125.025,11.225)
SOUTHERN_LEYTE-INOLLNAN
SouINORa(125.158,9.913)
LEYTE-PSTC_PALO
LeyPSTRa(124.951,10.63)
SOUTHERN_LEYTE-PSTC_SOUTHERN_LEYTE
SouPSTRa(125.171,10.335)
Surface Pressure (hPa)
WRF
OBS
00Z 7NOV 2013
06Z
12Z
18Z
00Z 8NOV
00Z 9NOV
Observation Stations of Philippines
13N
12.5N
12N
11.5N
11N
10.5N
10N
9.5N
124E
124.5E
125E
125.5E
126E
Leyte

Flooding in Malaysia (2014-2015)

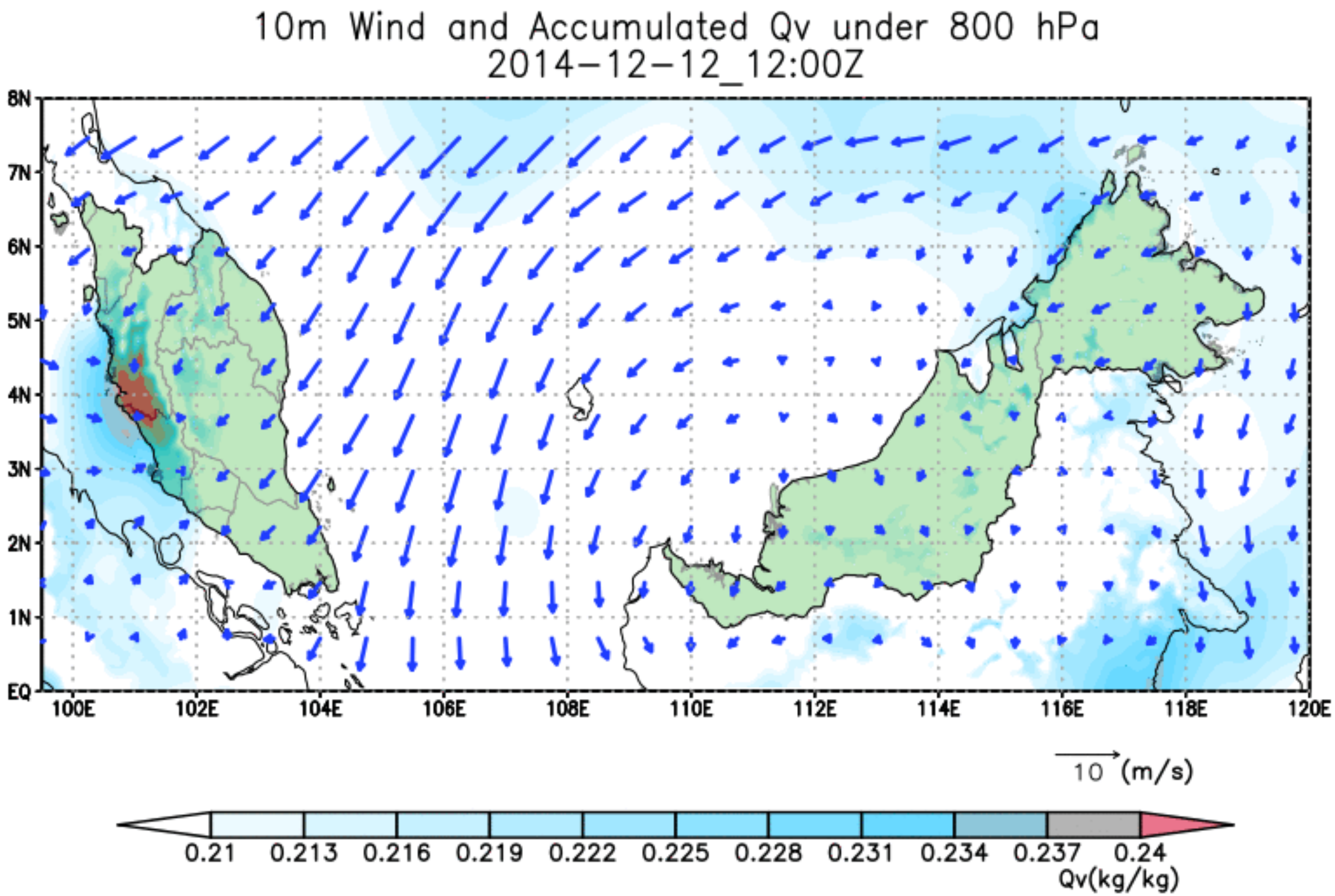
As part of the [northeast monsoon](),[4] heavy rains since 17 December forced 3,390 people in Kelantan and 4,209 people in Terengganu to flee their homes.[5] Several Keretapi Tanah Melayu(KTM) intercity train services along the East Coast route were disrupted on 18 December following the floods.[6] On 20 December, the area of Kajang, Selangor, was also hit by serious floods.[7]By 23 December, most rivers in Kelantan, Pahang, Perak and


20141215~20150103 Precipitation from TRMM Estimate
8N
7N
6N
5N
4N
3N
2N
1N
EQ
100E
102E
104E
106E
108E
110E
112E
114E
116E
118E
Precipitation Max.=78(mm/day)
0
10
20


20141215~20150103 Precipitation from WRF Simulation
8N
7N
6N
5N
4N
3N
2N
1N
EQ
100E
102E
104E
106E
108E
110E
112E
114E
116E
118E
Precipitation Max.=78(mm/day)
0
10
20
30
40
50
60
70
80
precipitation
(mm/day)


2013 December Precipitation from TRMM Estimate
8N
7N
6N
5N
4N
3N
2N
1N
EQ
100E
102E
104E
106E
108E
110E
112E
114E
116E
118E
120E
Precipitation Max.=41(mm/day)
0
10
20
30
40
50
60
70
80
precipitation
(mm/day)

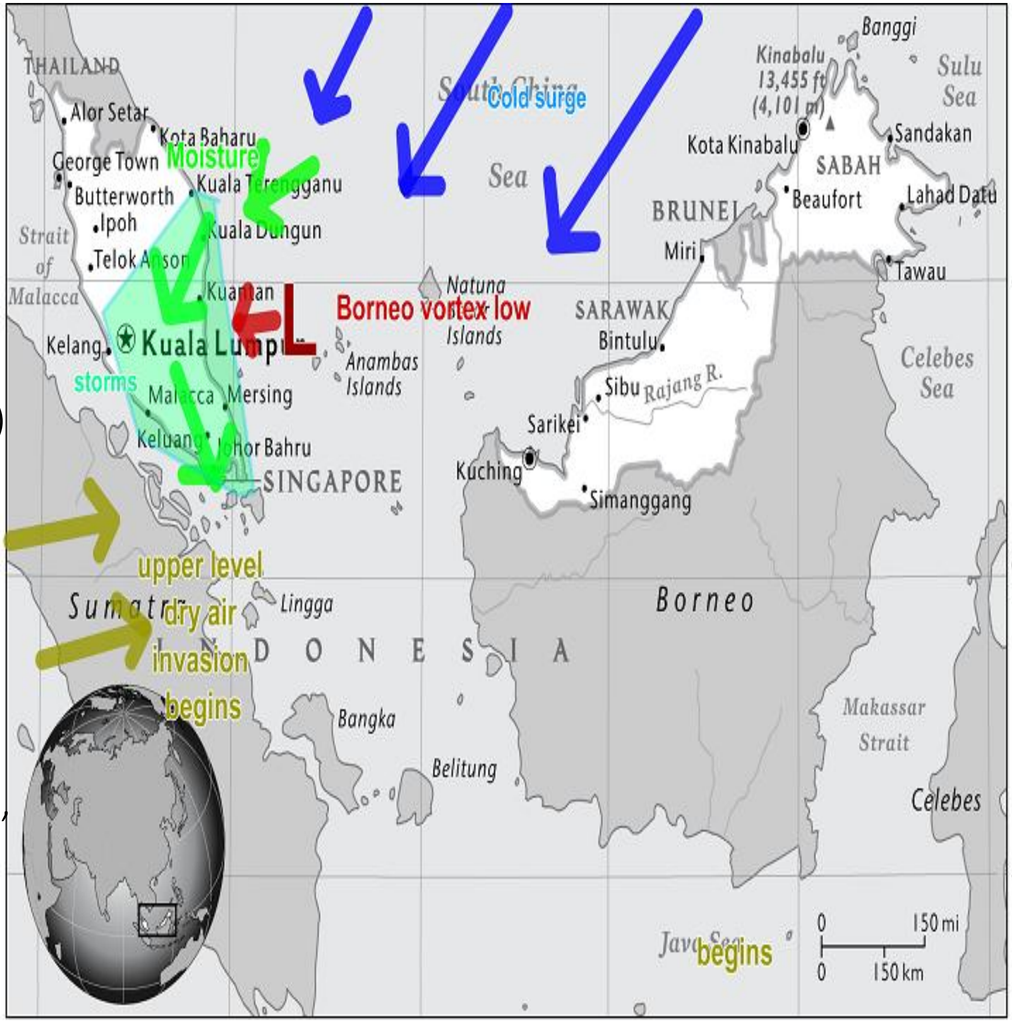
(20 days)



The **2014–15 Malaysia floods** hit Malaysia from 15 December 2014 – 3 January 2015. More than 200,000 people affected while 21 killed on the floods.[1] This flood have been described as the worst floods in decades

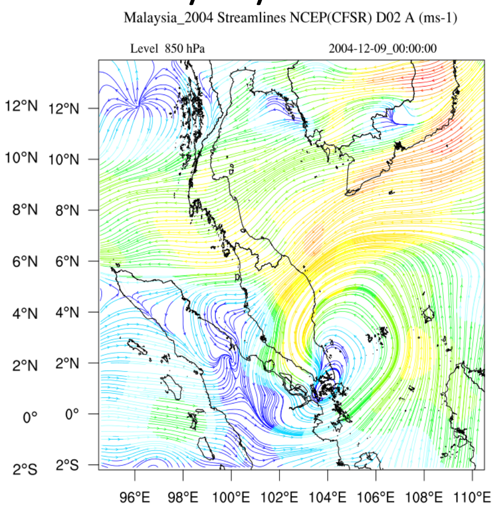
- This area is subjected to significant largescale and mesoscale interactions
  - **Topographic feature :** distribution of deep convection (Chang et al, 2005)
  - **northeasterly cold surges** dominate the low-level circulation patterns (Zhang et al. 1997)
  - Quasi–stationary **Borneo vortex** (Johnson and Houze, 1987; Chang et al. 2003, Chang et al. 2005, Juneng et al. 2007)
  - Madden-Julian Oscillations **(MJO):** (Madden and Julian, 1972)

  on intra-seasonal time scales peak amplitude during boreal winter over the Maritime Continent

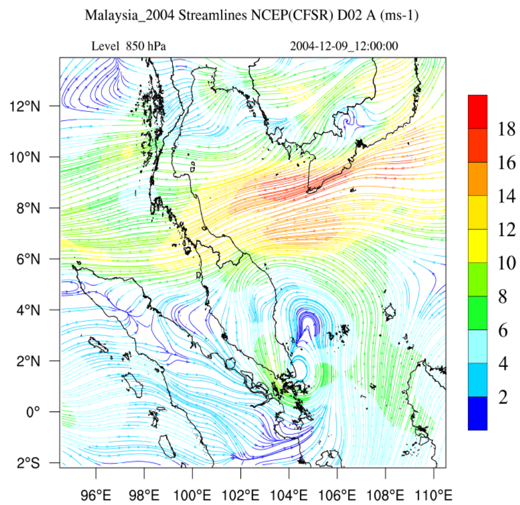


Preliminary Results in 2004 flooding Case

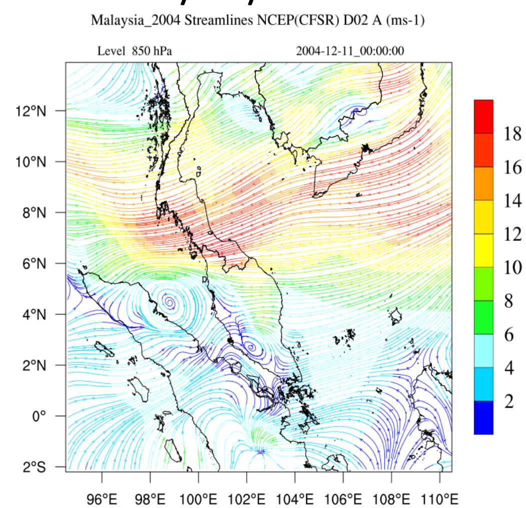
2004/12/09 00UTC



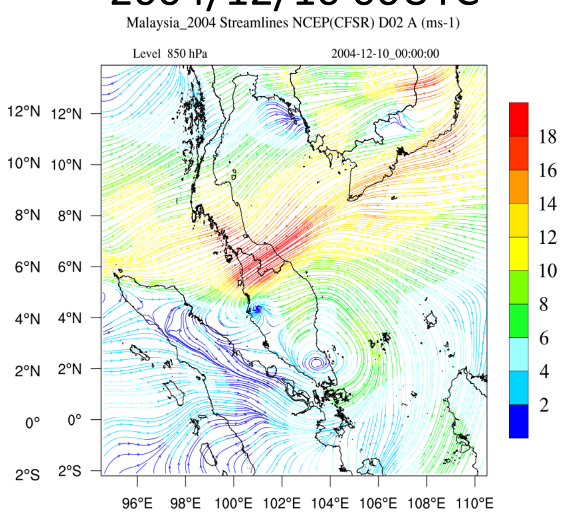
2004/12/09 12UTC



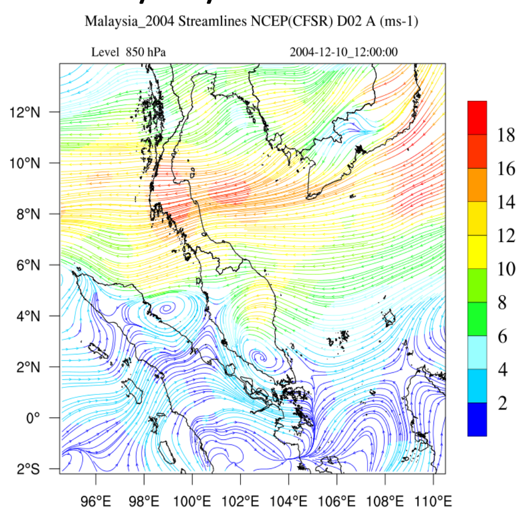
2004/12/11 00UTC



2004/12/10 00UTC

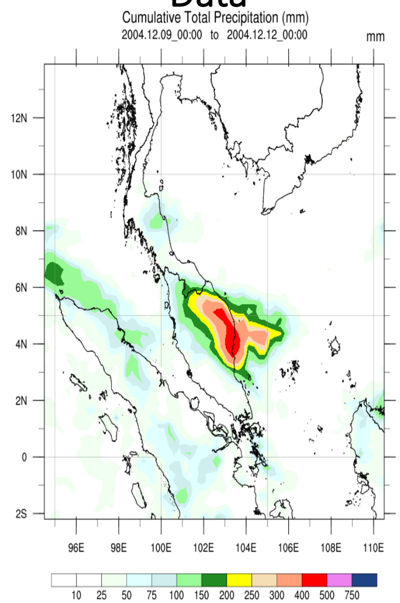


2004/12/10 12UTC



Domain 02 - Simulation > Dec 09-12 | Accumulaton Rainfall

TRMM Data



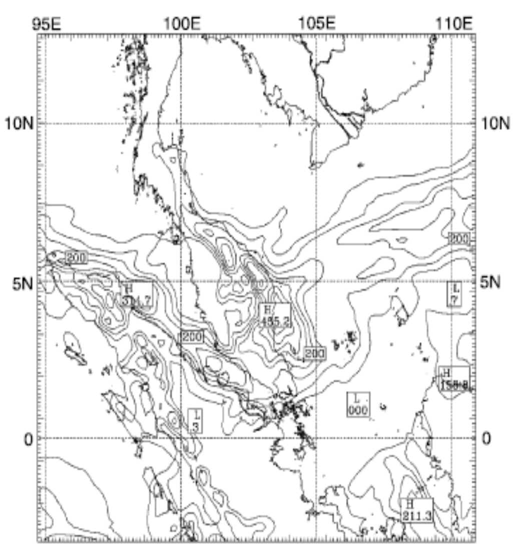
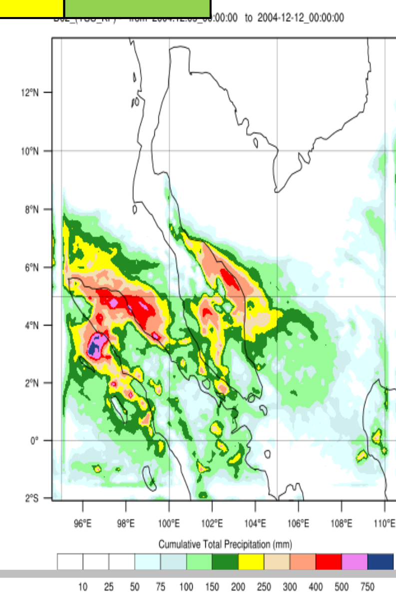


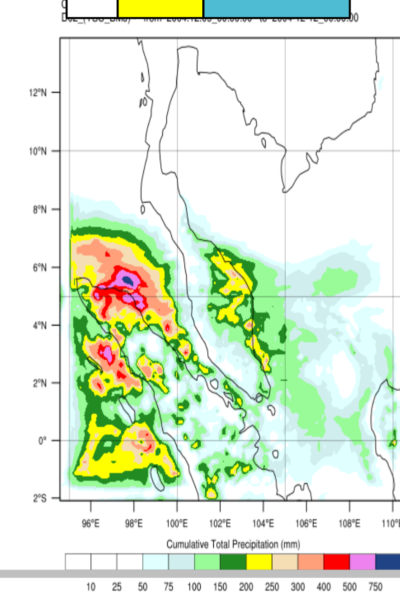
Fig. 7. 72 h accumulated rainfall simulated by the CTRL model run

(Juneng et al. 2007)

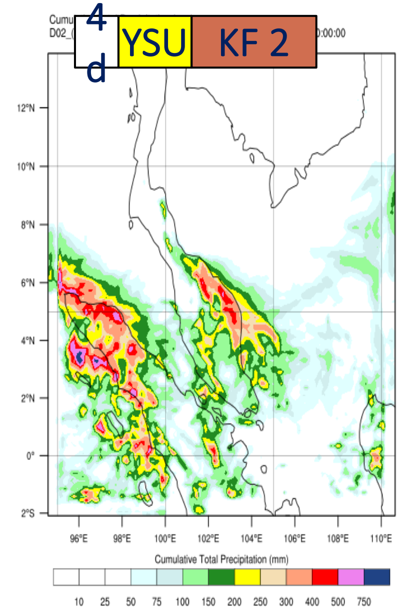
4a YSU KF



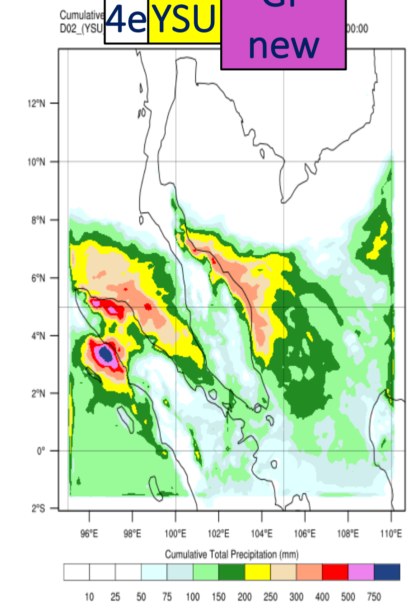
4b YSU BMJ



4d YSU KF 2



4e YSU GF new



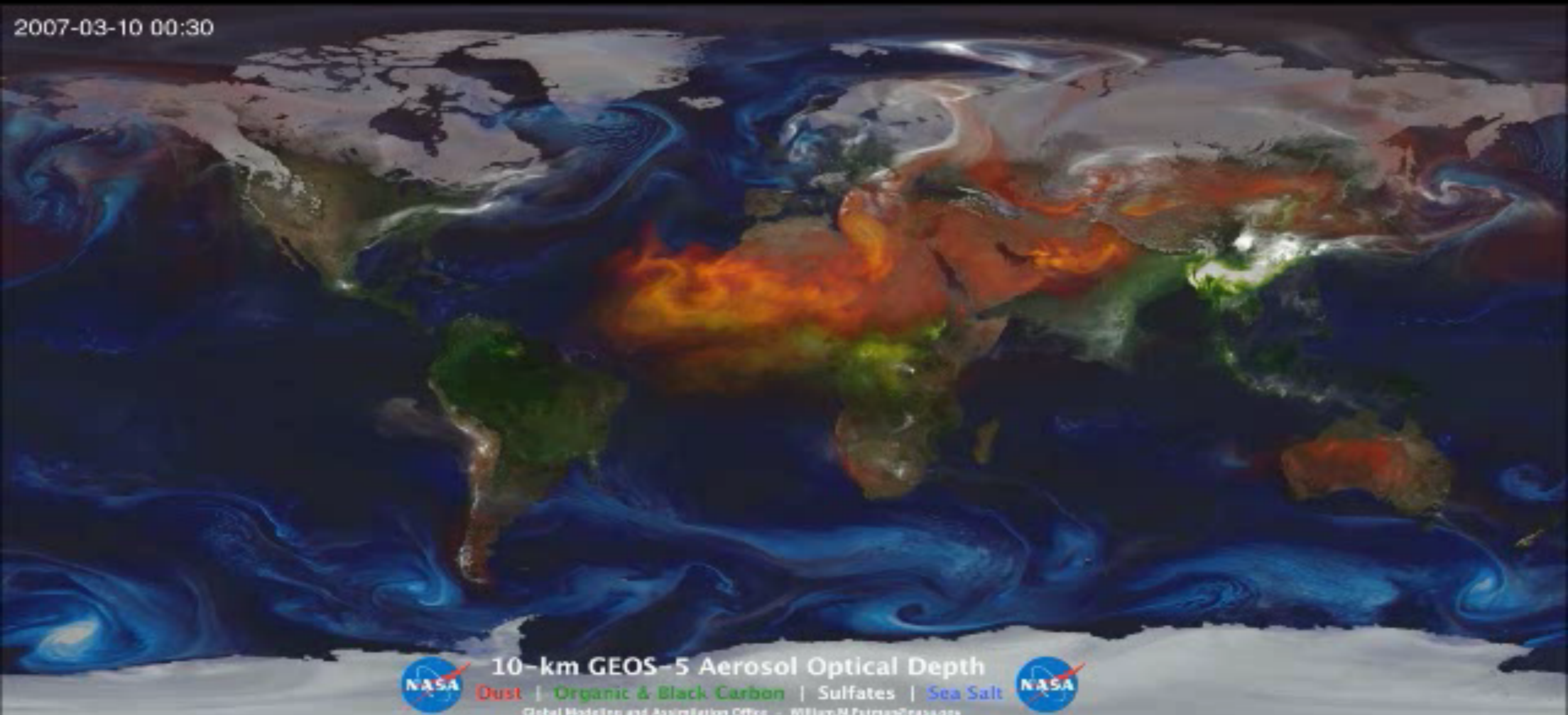
Environmental Research Topics

Environmental Research Topics

- **Long-range transport of air pollutants to Taiwan**

  Asian dust and air pollutants from China

  Impact of Biomass burning pollutants from Indochina

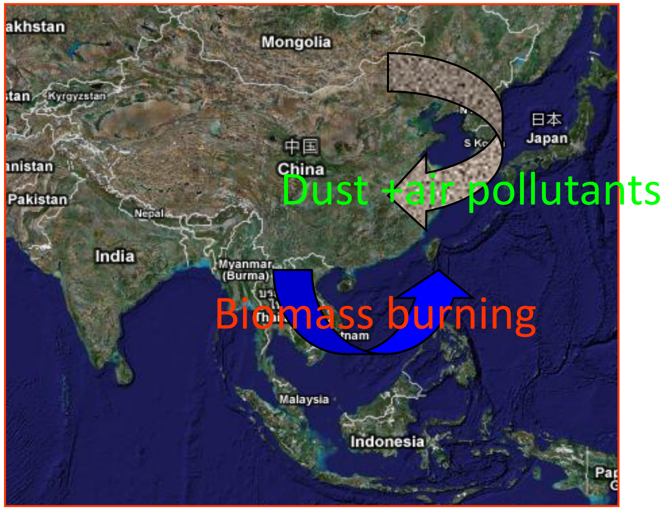

2007-03-10 00:30
10-km GEOS-5 Aerosol Optical Depth
Dust | Organic & Black Carbon | Sulfates | Sea Salt
Global Modeling and Assimilation Office

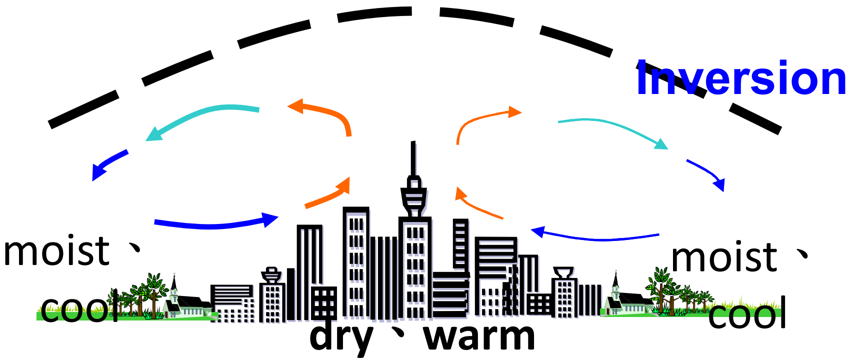
Research Topics

- **Long-range transport of air pollutants to Taiwan**

  Asian dust and air pollutants from China

  Impact of Biomass burning pollutants from Indochina





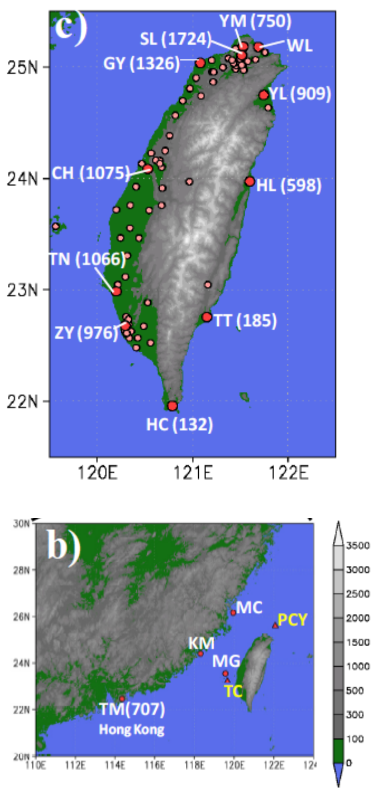
UHI effect

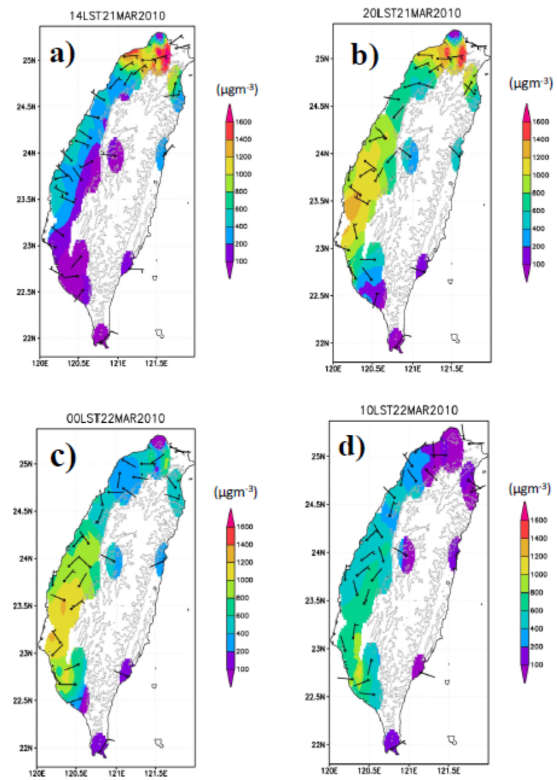
Atmos. Chem. Phys., 12, 271–285, 2012
www.atmos-chem-phys.net/12/271/2012/
doi:10.5194/acp-12-271-2012

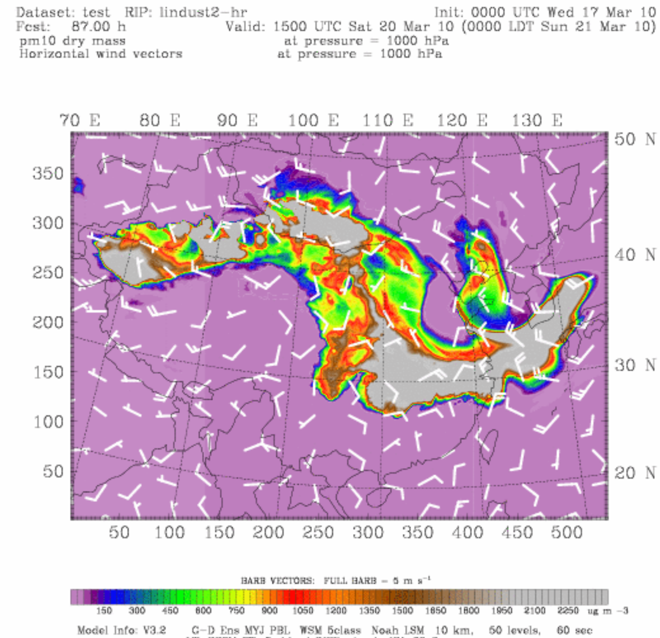
Atmospheric Chemistry

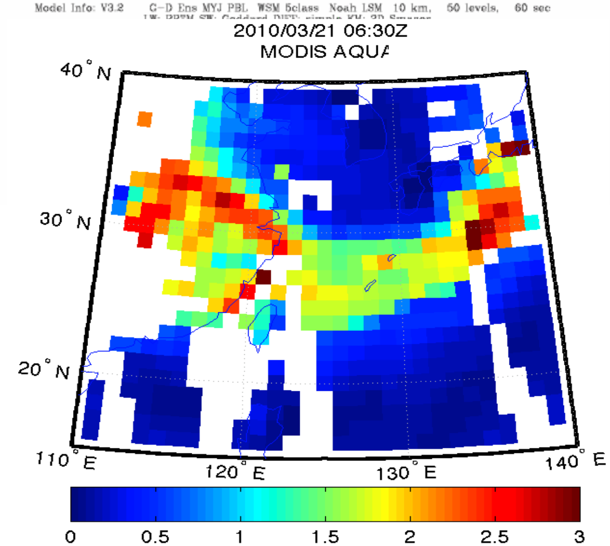
The impact of channel effect on Asian dust transpo a case in southeastern Asia

C.-Y. Lin[1], Y.-F. Sheng[1], W.-N. Chen[1], Z. Wang[2], C.-H. Kuo[3], W.-C. Chen[1], and T. Yan









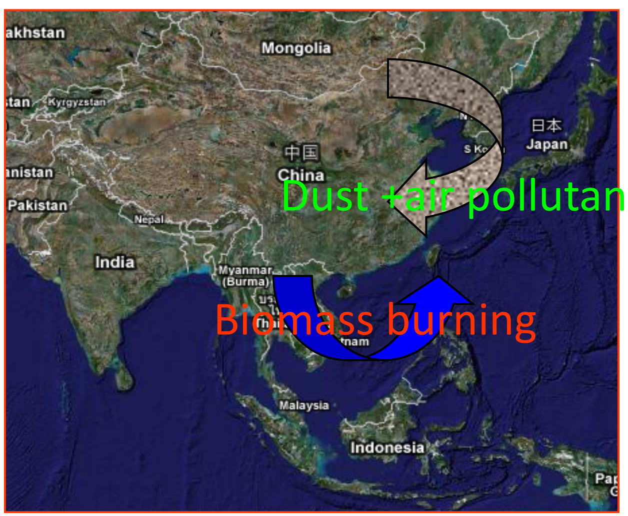
Model: WRF/Chem, 10 km resolution

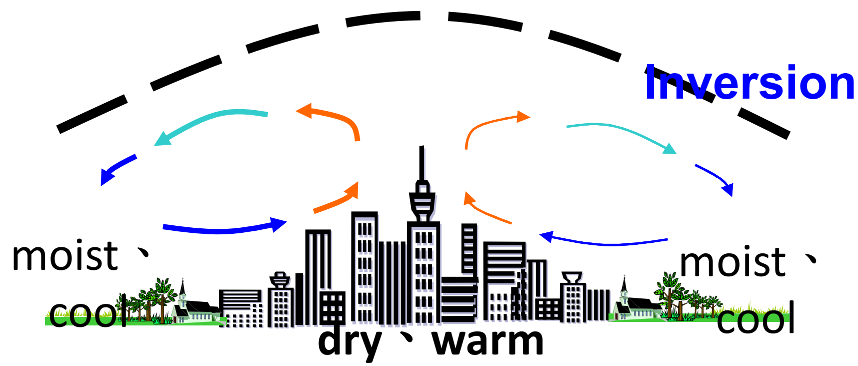
Research Topics

- **Long-range transport of air pollutants to Taiwan**

  Asian dust and air pollutants from China

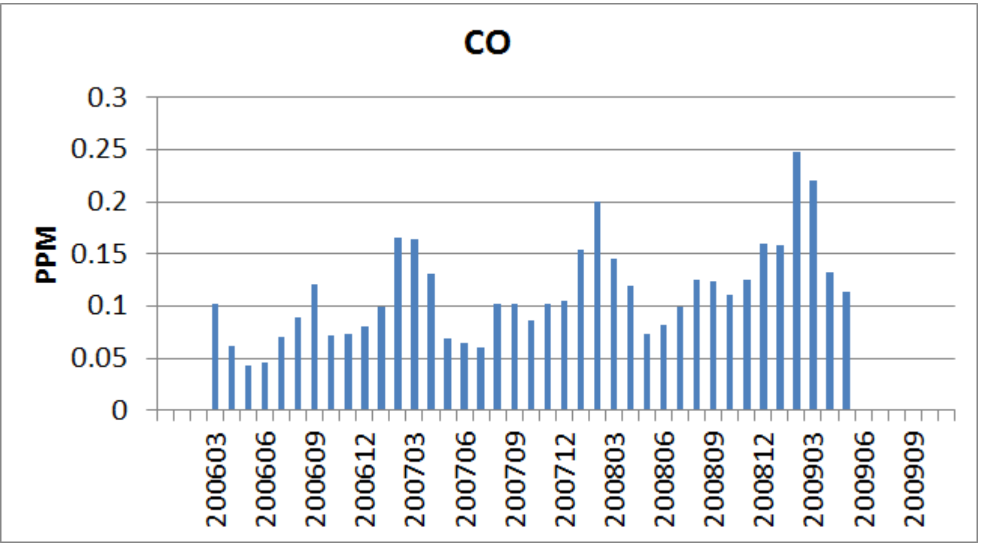
  Impact of Biomass burning pollutants from Indochina

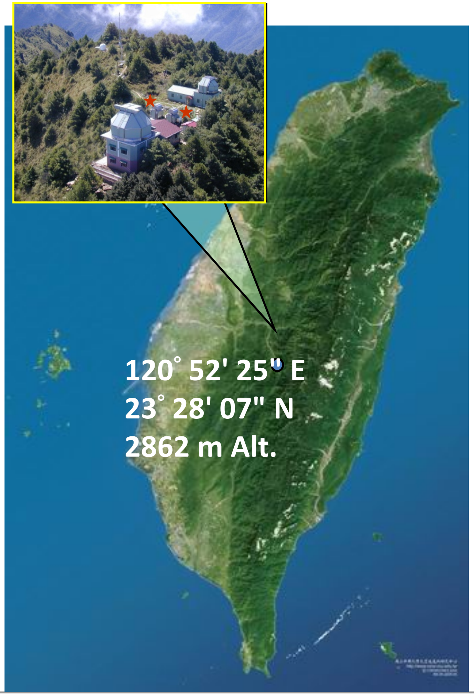


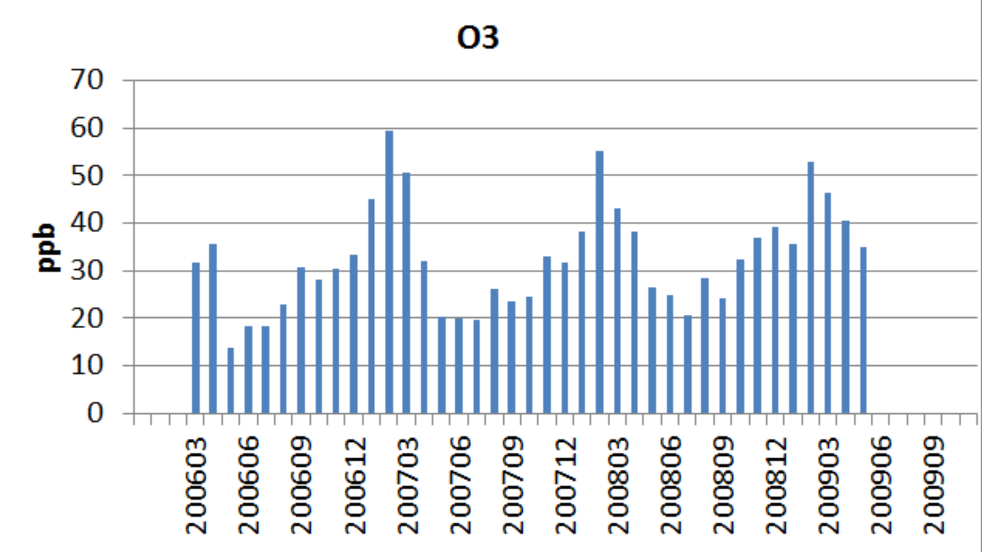


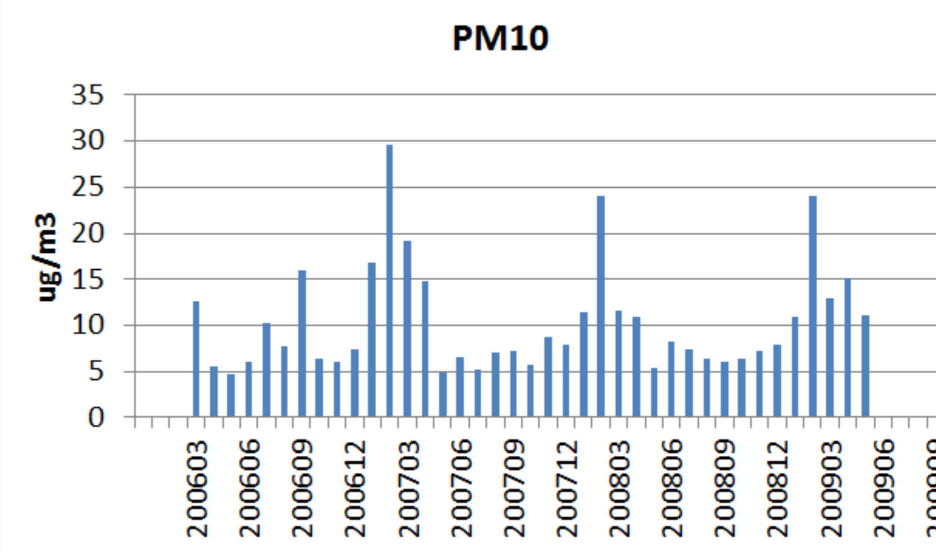
UHI effect

Seasonal variation of CO, O3 and PM10 at LuLin Mountain station (2006-2009)





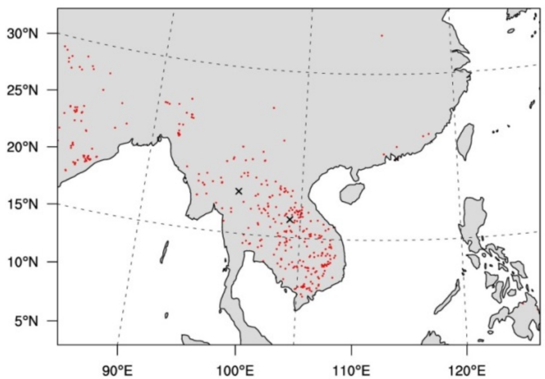


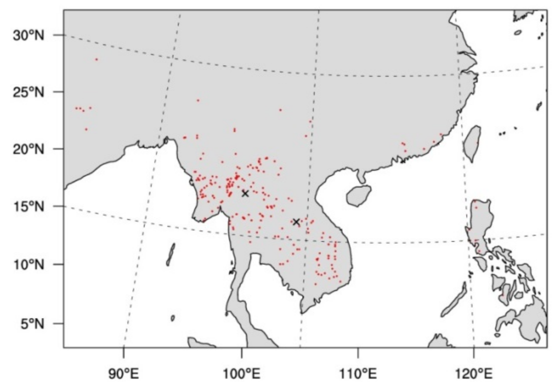


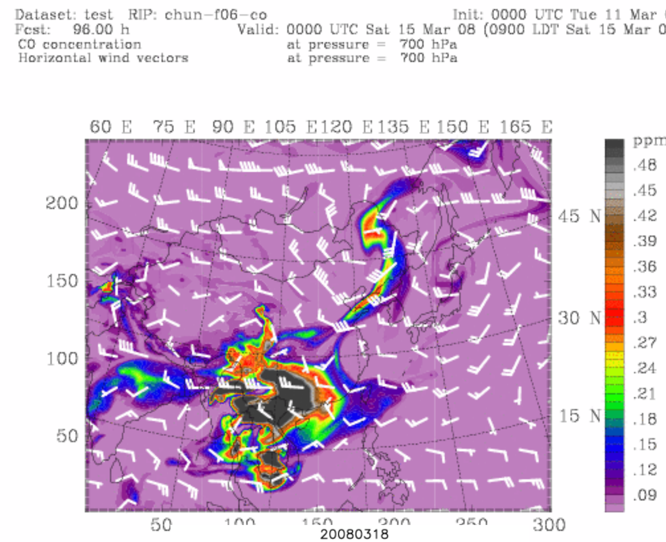
Tellus
SERIES B
CHEMICAL
AND PHYSICAL
METEOROLOGY

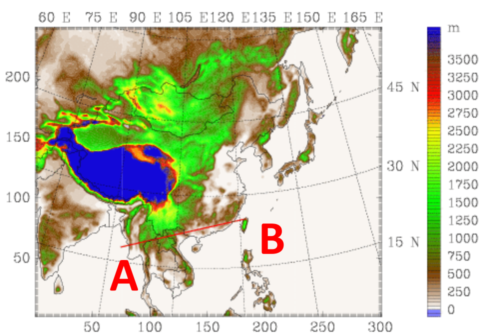
Modelling of long-range transport of Southeast Asia biomass-burning aerosols to Taiwan and their radiative forcings over East Asia

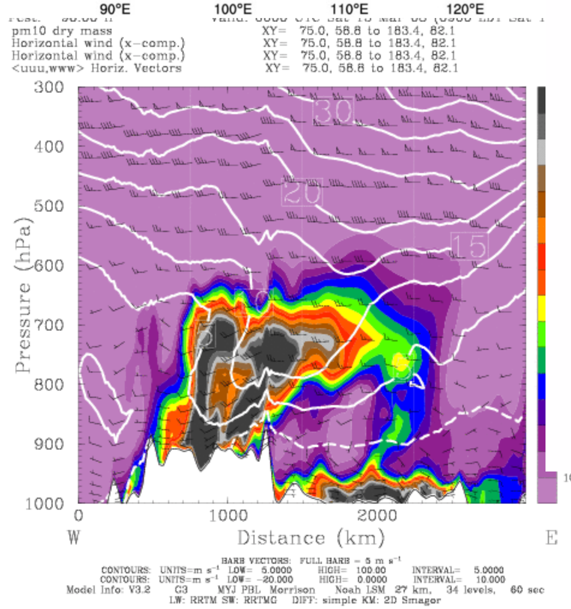
By CHUAN-YAO LIN[1]*, CHUN ZHAO[2], XIAOHONG LIU[2,3], N
WEI-NEI CHEN[1], [1]*Research Center for Environmental Changes, Acaden*

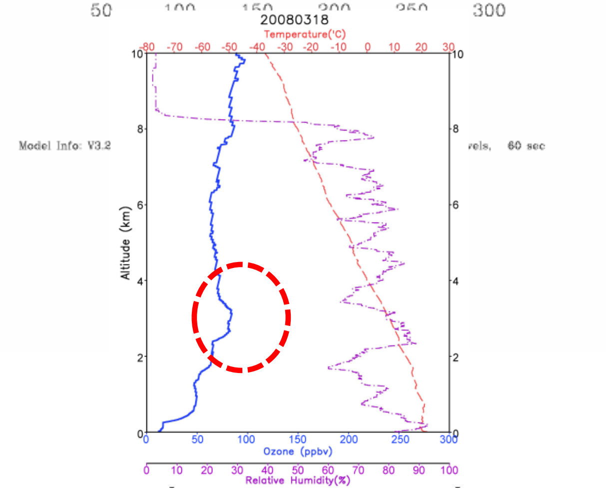






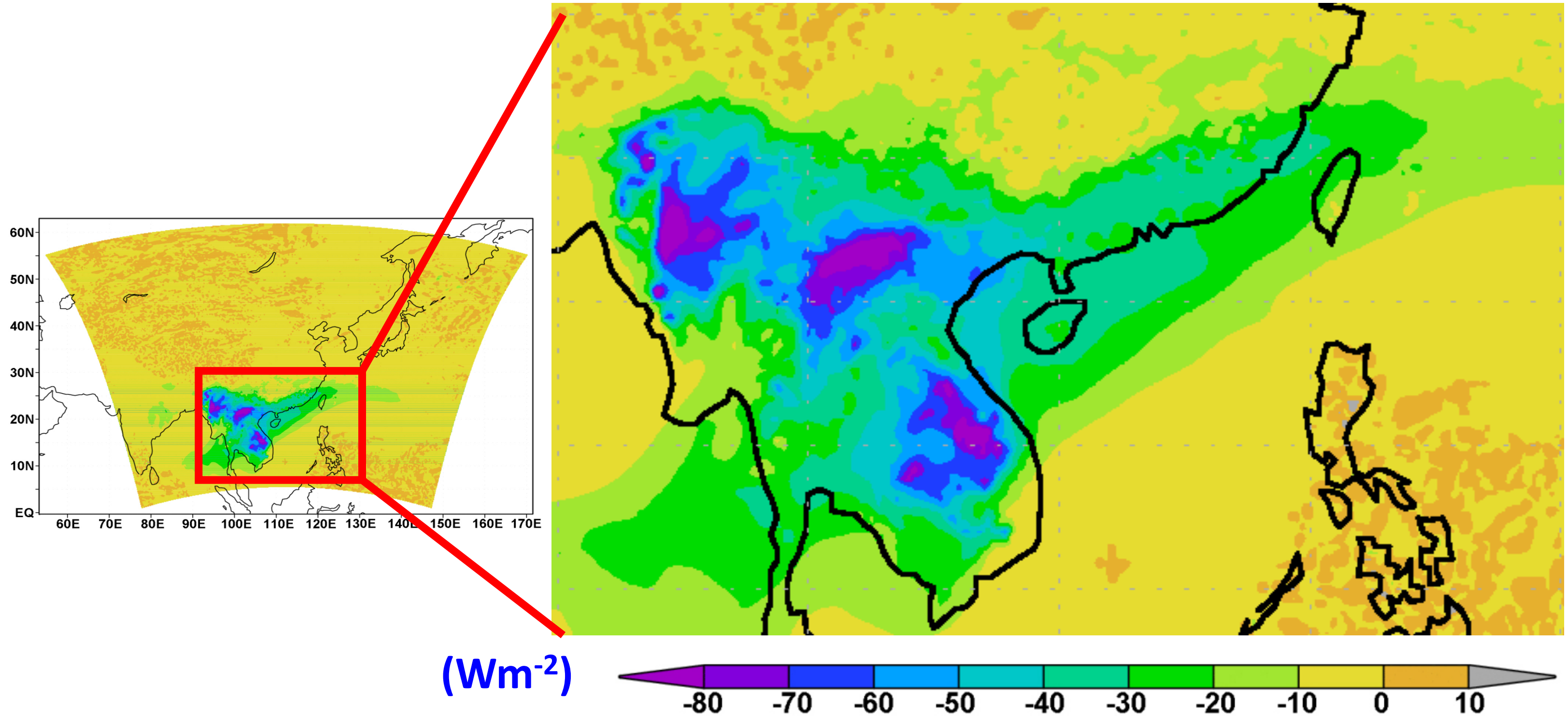






Model: WRF/Chem,
15 km resolution

Difference of downward shortwave flux at surface (biomass burning emission turn on and off)



Average reduction in shortwave radiation fluxes at ground surface simulated with and without biomass-burning emission during 15-18 March, 2008 (unit W m^{-2}).

(Lin et al. 2014)

South East Asia haze 2015

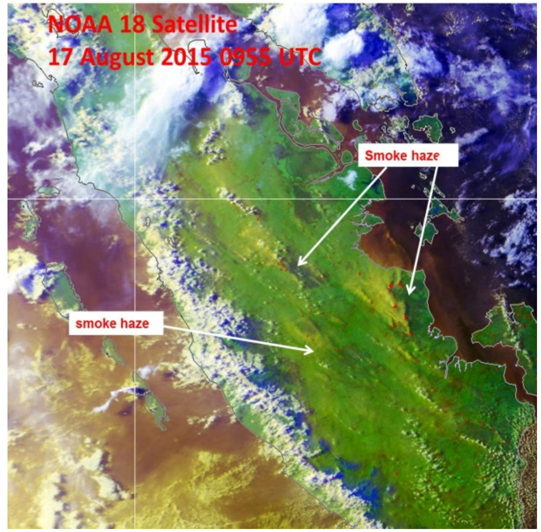
The haze affected Indonesian from at least late June, to the end of October, turning into an international problem for other countries in September.

Indonesian

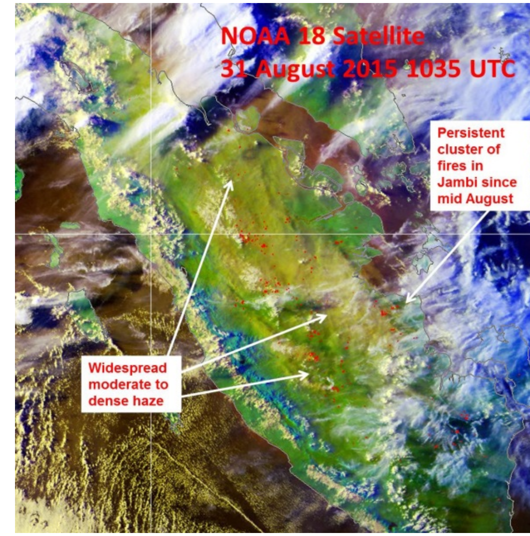
Indonesian

Singapore

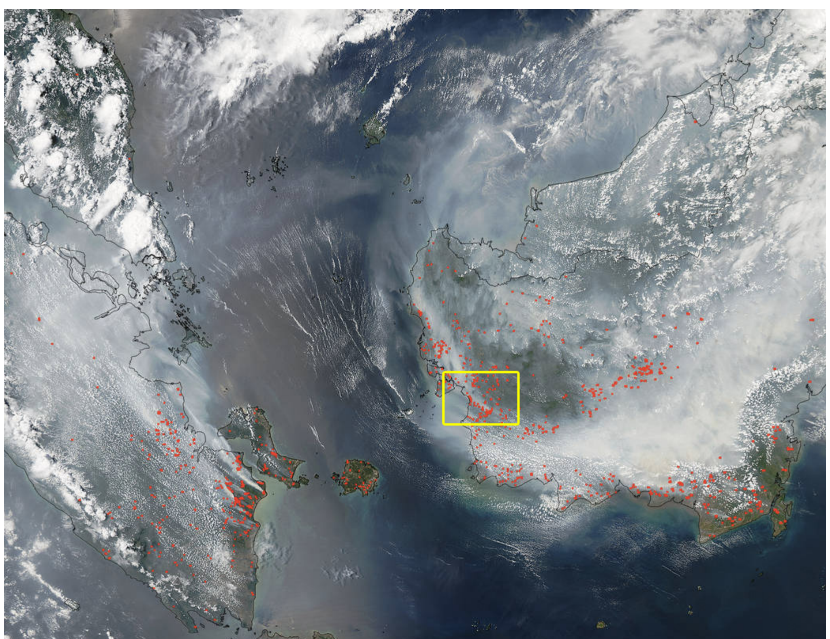
https://zh.wikipedia.org/wiki/



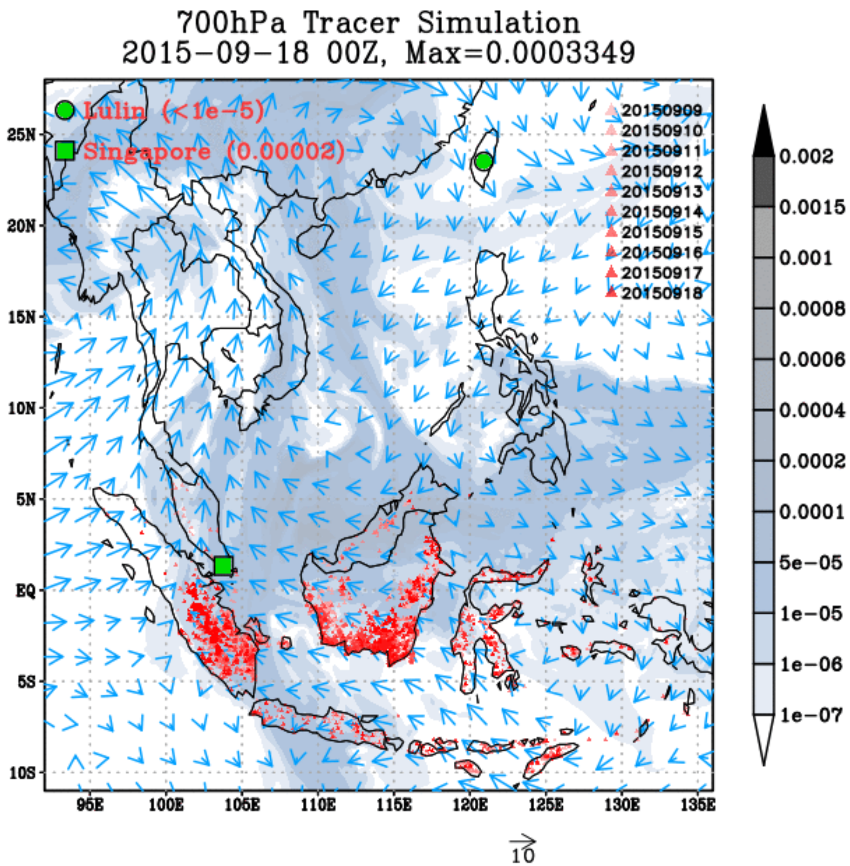
NOAA-18 satellite picture on 29 August 2015 shows deterioration of smoke haze situation in Kalimantan

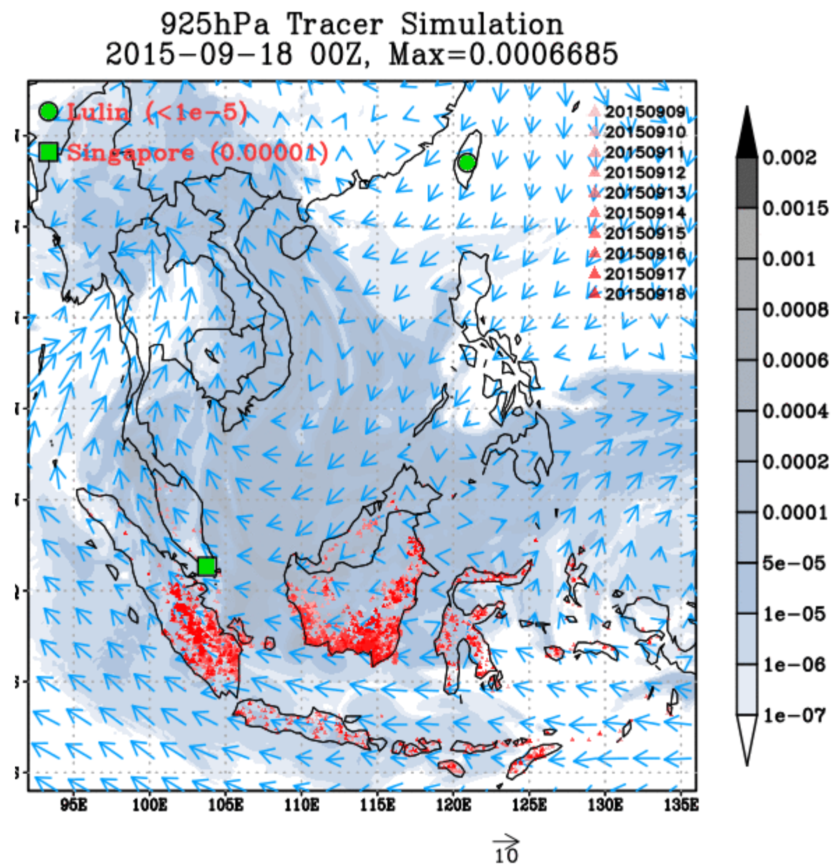


NOAA-18 satellite picture on 31 Augusts 2015 shows widespread smoke haze from Sumatra spreading into the Strait of Malacca.



NASA's Aqua satellite collected this natural-color image with the Moderate Resolution Imaging Spectroradiometer, MODIS, instrument on September 22, 2015.





Resolution: 10 km

Summary

- Three fundamental issues for deeper understanding: I.C., B.C. and Observation Data
- Resolution and Computing Power may be useful
- Interaction with Terrain structure often being ignored
- Interaction of different Air systems are not easily predicted, look for potential pattern
- Long-range Dust transport and Biomass burning are recently realized
- Data, Data, Data! Observation stations are often destroyed after the onset of major disaster events!

Thank you !!!