Disaster Mitigation Workshop

- Disaster Mitigation Working Group
  - Chairman: Eric Yen (ASGC, TW)
  - Co-Chair: Peter Banzon (ASTI, PH)
- 1st Disaster Mitigation Workshop was held at APAN38 in Taiwan
  - And then APAN40, 41, 42 and 43

Disaster Mitigation Workshop @ APAN43

- Objectives
  - Disaster Mitigation Working Group aims to establish collaboration network of disaster mitigation for sustainable development of Asia. Developing numerical simulation facilities based on deeper understandings of sciences behind the natural hazards are the primary goal. Based on case studies and data analytics, more accurate and efficient simulation models would be produced and used for future events. Capacity building is also the focus by sharing the knowledge and resources from partners, campaigns of masterclasses and dissemination activities.
- In collaborations with EGI (Disaster Mitigation Competence Centre, DMCC), as well as Asia partners

Disaster Mitigation by Numerical Simulation & e-Science

Eric Yen

Academia Sinica Grid Computing Centre (ASGC)

Taiwan

Disaster Mitigation Workshop

APAN43

New Delhi, India

Feb. 15-16, 2017

Asia Pacific Natural Disasters in 2015 (UN ESCAP)
Risk Sensitive Development and Stronger Regional Collaboration are Essential

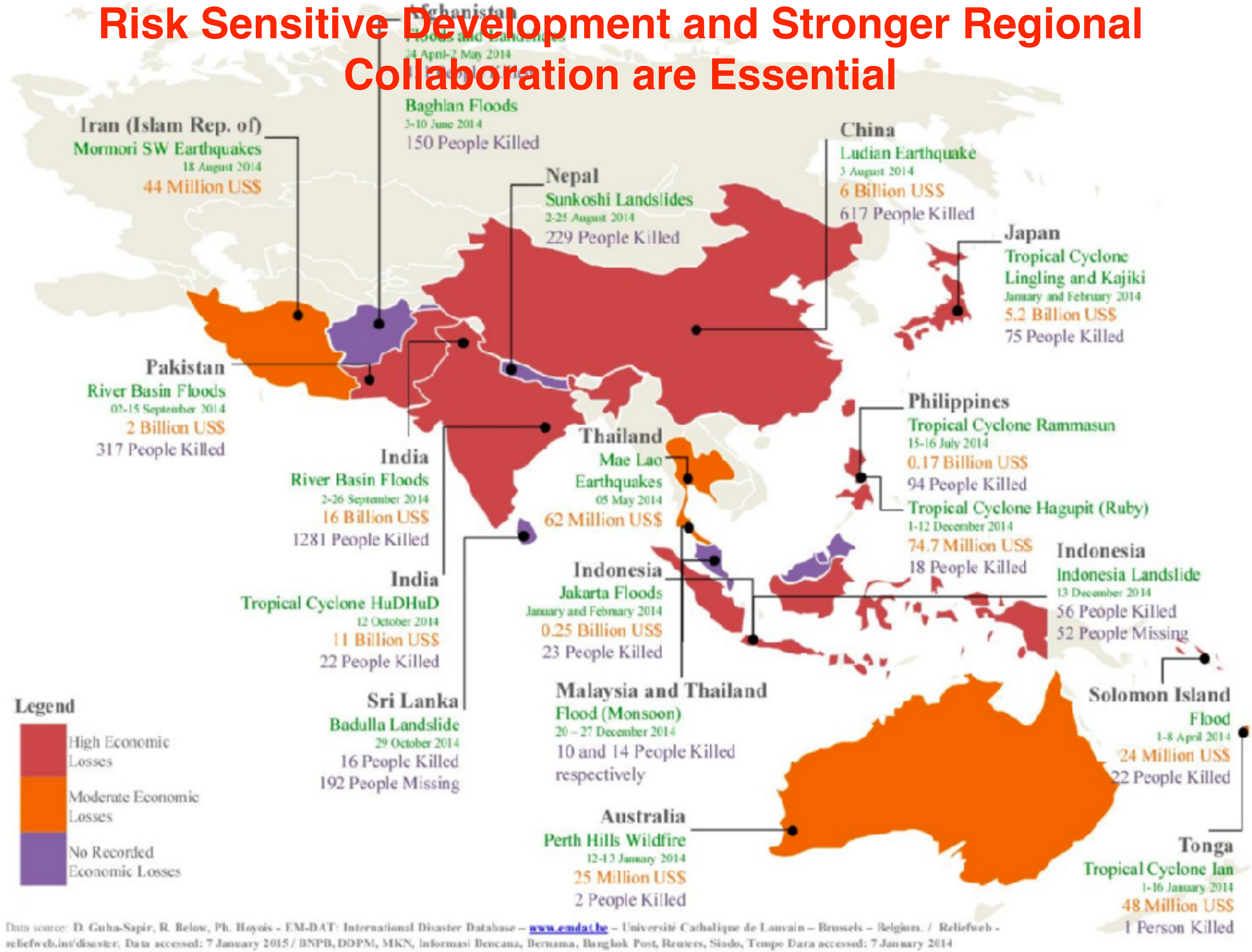


Table 1. 2015 Asia-Pacific losses by disaster type

Disaster Type	Occurrence	Deaths	Affected	Economic Damage (US$)
Flood	63	1,863	21,661,443	11.5 billion
Storm	43	446	9,135,551	11.8 billion
Earthquake	17	9,327	6,484,533	5.2 billion
Landslide	15	626	45,234	-
Extreme temperature	4	3,536	1,045,000	-
Others*	18	248	20,883,788	16.7 billion
Total	160	16,046	59,255,549	45.1 billion

*Data on slow-onset disasters are not yet available

Source: EM-DAT (Accessed February 2016).

Table 2. Country rankings: Economic damage and fatalities from disasters in Asia-Pacific in 2015

Top 5 Economic Damage Ranking		
Disaster type	Country	Economic Damage (US$)
Wildfire	Indonesia	16.1 billion
Earthquake	Nepal	5.2 billion (7.1 billion)*
Storm	China	4.2 billion
Flood	India	3 billion (7 billion)*
Flood	China	2 billion

Top 5 Fatalities Ranking		
Disaster type	Country	Fatalities
Earthquake	Nepal	8,790
Extreme Temperature	India	2,248
Extreme Temperature	Pakistan	1,229
Flood	India	325
Flood	India	293

*Numbers in parenthesis include losses

Source: EM-DAT (Accessed February 2016).

TABLE 1: 2014 ASIA-PACIFIC LOSSES BY DISASTER TYPE

Disaster type	Occurrences	Deaths	Total Affected	Economic Losses (US$)
Flood	52	3559	28.6 million	26.8 billion
Storm	37	730	16.3 million	25.8 billion
Earthquake	7	733	1.9 million	6.7 billion
Volcanic activity	5	101	0.17 million	186 million
Drought	5	180	31.5 million	18 million
Landslide	9	657	0.18 million	Not recorded
Extreme Temperature	3	88	1 million	Not recorded
Wildfire	1	2	168	25 million
Total	119	6050	79.6 million	59.6 billion

TABLE 2: TOP 5 ECONOMIC LOSSES AND FATALITIES IN ASIA AND THE PACIFIC

5 Top Economic Losses Natural Hazards in 2014		
Name	**Country**	**Economic Losses**
Riverine Floods	India	16 billion US$
Tropical Cyclone HudHud	India	11 billion US$
Ludian Earthquake	China	6 billion US$
Tropical Cyclone Lingling and Kajiki	Japan	5.2 billion US$
Riverine Floods	Pakistan	2 billion US$

5 Top Fatalities Natural Hazards in 2014		
Name	**Country**	**Number of Fatalities**
Riverine Floods	India	1281
Ludian Earthquake	China	617
Floods and Landslides	Afghanistan	431
Riverine Floods	Pakistan	317
Sunkoshi Landslides	Nepal	229

Data source: D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.
Data accessed: 7 January 2015

Disaster Mitigation

DMCC Aims to Achieve Early Warning Systems

- For selected disasters: Earthquake, Tsunami, Extreme Weather, Flood, Dust Transportation and Urban Heat Island
- Deeper understanding of disasters is an important goal by the e-Science approach
- Generating Hazard Maps: Based on better scientific models (combining atmosphere and oceanic models) and faster simulation facilities
- Validated by historical events, and the observation data
- Implemented by web portals together with workflows of target cases, and local user communities
- Gap analysis of participating countries will be conducted: e-Infrastructure, user engagement, technology and user support, outreach, etc.
- Partnership: TW, PH, TH, MY, ID, DE, UK (Nepal, VN)

Disaster Mitigation

Case Study & Collaboration Model

Partner	Selected Case	Required Data Sets	Status	Check Point	Simulation Framework
PH, TW	Typhoon Haiyan	Doppler Radar, Tidal gauge, air pressure, wind speed, typhoon path; hourly resolution	Finish 1st numerical study by combining atmospheric and ocean model	Demo @ APAN41	gWRF, iCOMCOT
MY, TW	Flooding 2014-15		Simulations by AS (global data) and MY have been achieved. Need more observation data to refine and confirm the model.	Demo @ APAN43	gWRF, Scouring
TH, TW	Flooding 2011 (Comparative Study)		Simulation by NECTEC and AS (global data) were done. Aim to improve the accuracy and EWS.		gWRF, Scouring
ID, TW	Forest Fire	air pollutants such as, CO, NOx (NO, NO2), SO2, O3, PM10, PM2.5 etc. with high temporal resolution	Simulations have been done. Need more observation data to refine and confirm the model.	Demo @ APAN43	WRF-Chem
Nepal, TW	Flooding 2014	High altitude and geographical features need to consider	Waiting for more necessary observation data		gWRF, Scouring
TW, PH	Tsunami Impact Analysis in South China Sea	Bathymetry, fault geometry, historical events,	In progress. Depends on high resolution bathymetry data from partners		iCOMCOT

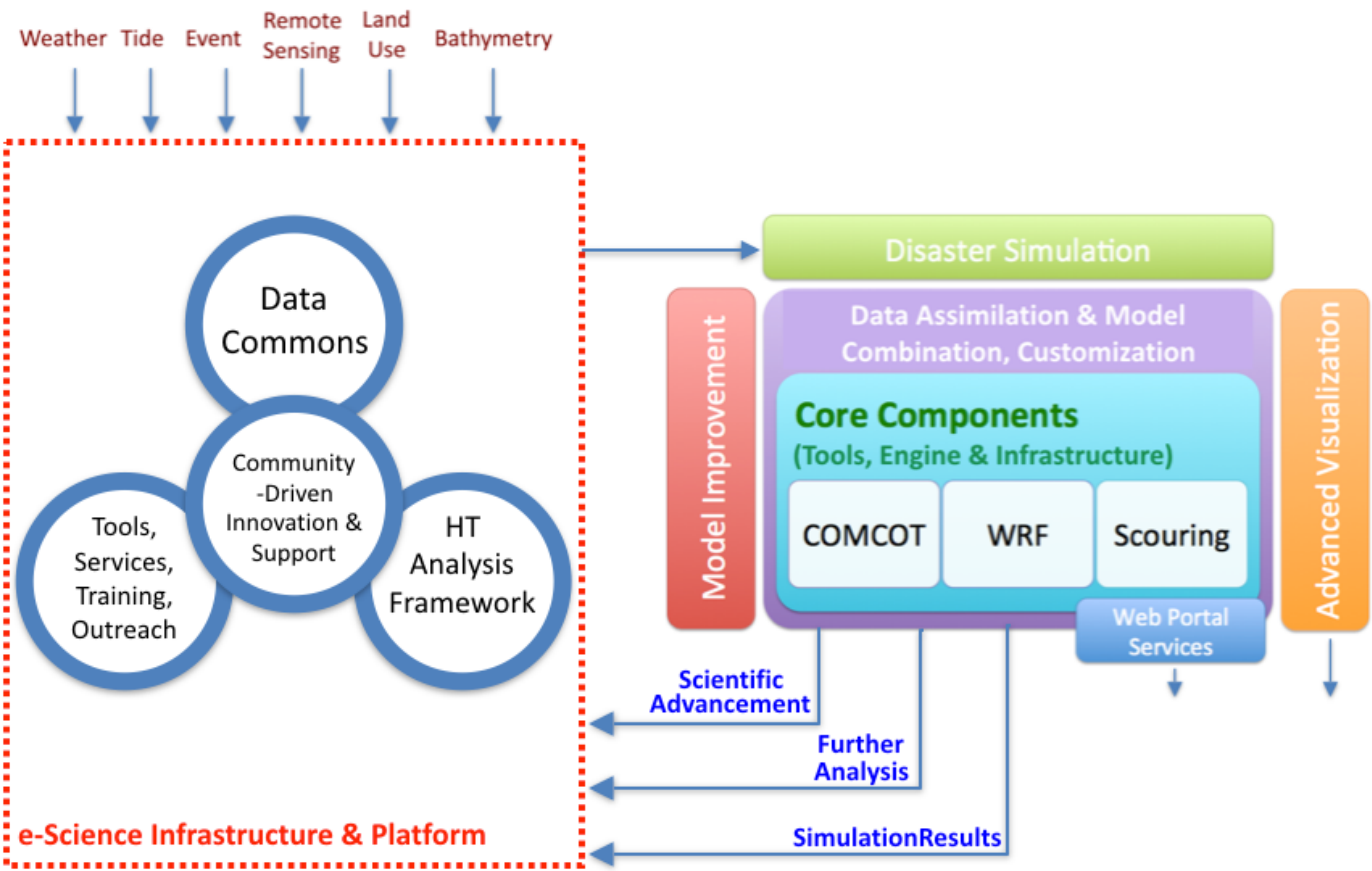
DE will provide advanced visualization support whenever it is possible

Typical Workflow of Case Study

- Reconstruct the whole process of target events
  - Find better model of the case
  - Collect observation data
  - Validation and evaluation
- Integrate with Advanced Visualization (LRZ)
- Towards early warning for future hazardous events
- Engage local user communities
- Answering ‘what-if’ questions
  - E.g., if typhoon Morakot happened again by end 2100, the total rainfall will be 1m more (from 3m to 4m) in 72 hours

Disaster Mitigation

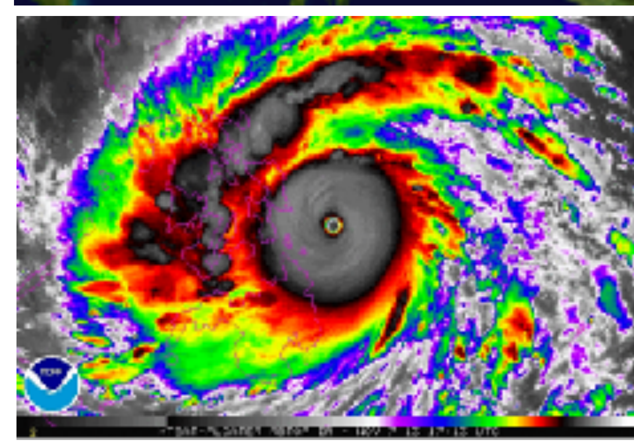
DMCC: Supporting Science Advancement and Improving e-Science Platform by Deeper Understanding of the Disasters

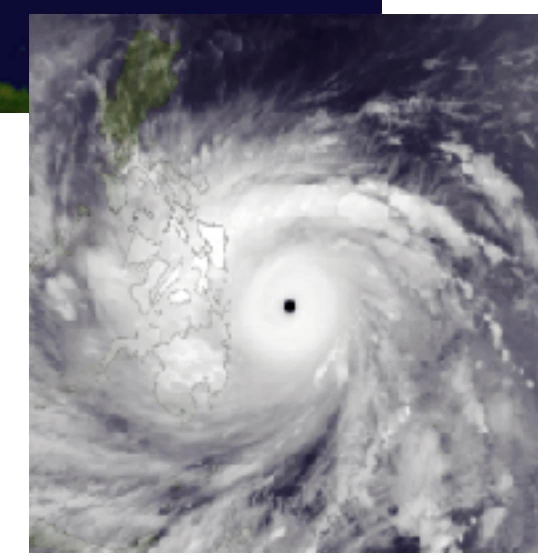


2013 Super Typhoon Haiyan in the Philippines

Typhoon Life Cycle: November 3rd –November 11th

*Typhoon Haiyan: '**It was like the end of the world**'.*





Typhoon Haiyan was the strongest typhoon than tropical cyclones ever recorded, and devastated portions of Southeast Asia, particularly the Philippines, in early-November 2013.

Peak: 230 km/h (145 mph) (10min)

Intensity: 895 hpa

Fatalities: 6,340 confirmed, 1,061 missing

Damage: $2.86 billion (2013 USD)

The Introduction of Storm Surge Model

(COrnell Multi-grid COupled of Tsunami Model – Storm Surge)

Nonlinear Shallow Water Equations on the Spherical

$$\frac{\partial\eta}{\partial t} + \frac{1}{R\cos\varphi}\left\{\frac{\partial P}{\partial\psi} + \frac{\partial}{\partial\varphi}(\cos\varphi\cdot Q)\right\} = 0$$

$$\frac{\partial P}{\partial t} + \frac{1}{R\cos\varphi}\frac{\partial}{\partial\psi}\left(\frac{P^2}{H}\right) + \frac{1}{R}\frac{\partial}{\partial\varphi}\left(\frac{PQ}{H}\right) + \frac{gH}{R\cos\varphi}\frac{\partial\eta}{\partial\psi} - fQ + F_\psi^b = -\frac{H}{\rho_w R\cos\varphi}\frac{\partial P_a}{\partial\psi} + \frac{F_\psi^s}{\rho_w}$$

$$\frac{\partial Q}{\partial t} + \frac{1}{R\cos\varphi}\frac{\partial}{\partial\psi}\left(\frac{PQ}{H}\right) + \frac{1}{R}\frac{\partial}{\partial\varphi}\left(\frac{Q^2}{H}\right) + \frac{gH}{R}\frac{\partial\eta}{\partial\varphi} + fP + F_\varphi^b = -\frac{H}{\rho_w R}\frac{\partial P_a}{\partial\psi} + \frac{F_\varphi^s}{\rho_w}$$

- Solve shallow water equations on **both spherical and Cartesian coordinates**
- **Explicit leapfrog Finite Difference Method** for stable and high speed calculation
- **Multi/Nested-grid system** for multiple shallow water wave scales
- **Moving Boundary Scheme** for inundation
- **High-speed efficiency**

• Moving Boundary Scheme

Moving boundary scheme was also introduced in COMCOT to model the run-up and run-down. The instant "shoreline" is defined as the interface between a dry grid and wet grid and volume flux normal to the interface is assigned to zero.

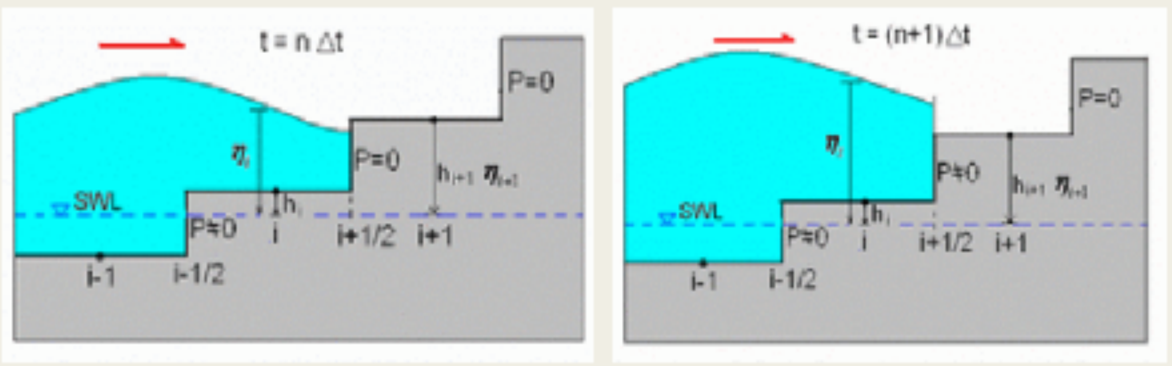
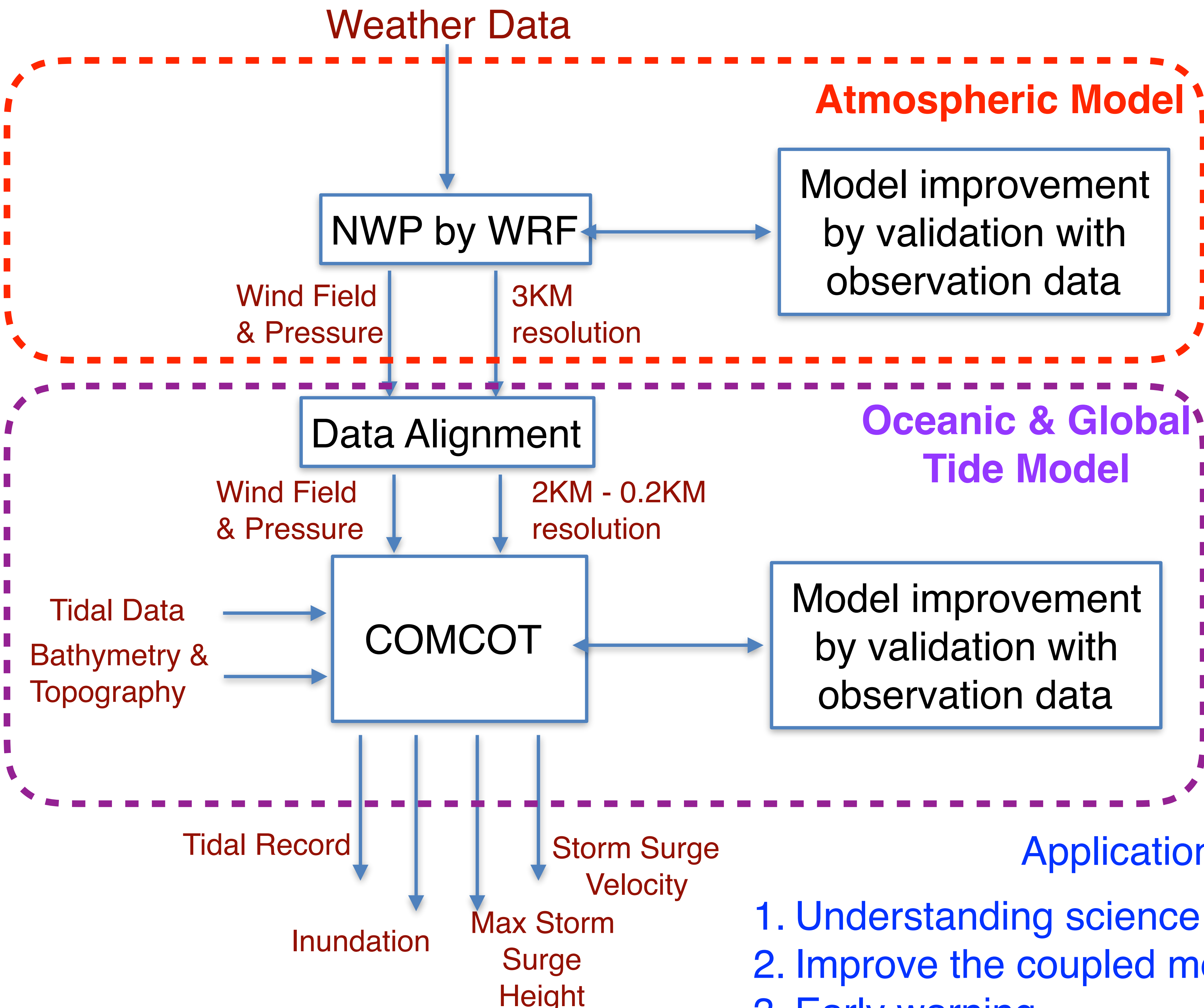


Fig.02 Moving Boundary Scheme

Typhoon Haiyan Case Study

- What have been done by Jan. 2016
  - Established the computational grid system of the open-ocean scale in the Philippines
  - Coupled WRF model and in-house COMCOT storm surge model
  - Simulated complete storm surge propagation induced by Typhoon Haiyan in open ocean
  - Analyzed maximum storm surges of Typhoon Haiyan in Philippines
- What we have before Aug. 2016
  - Considering tidal effect with the global tidal TPXO model
  - Simulating full hydrodynamic storm surge propagation of open-ocean, offshore and nearshore scales
  - Analyzing surge inundation induced by Typhoon Haiyan with high-resolution topographic and bathymetric data
  - Validating model results with observation data (gauge data and estimated run-up height data)
- Future Applications
  - Web Portal Services will be developed
  - Requirements: 1) observed water elevation; 2) meteorological records (air pressure and wind velocity); 3) inundated range and run-up height; 4) typhoon best track; 5) Doppler Radar Data

A New Storm Surge Model for Typhoon Haiyan by Coupling Atmospheric and Ocenic Models



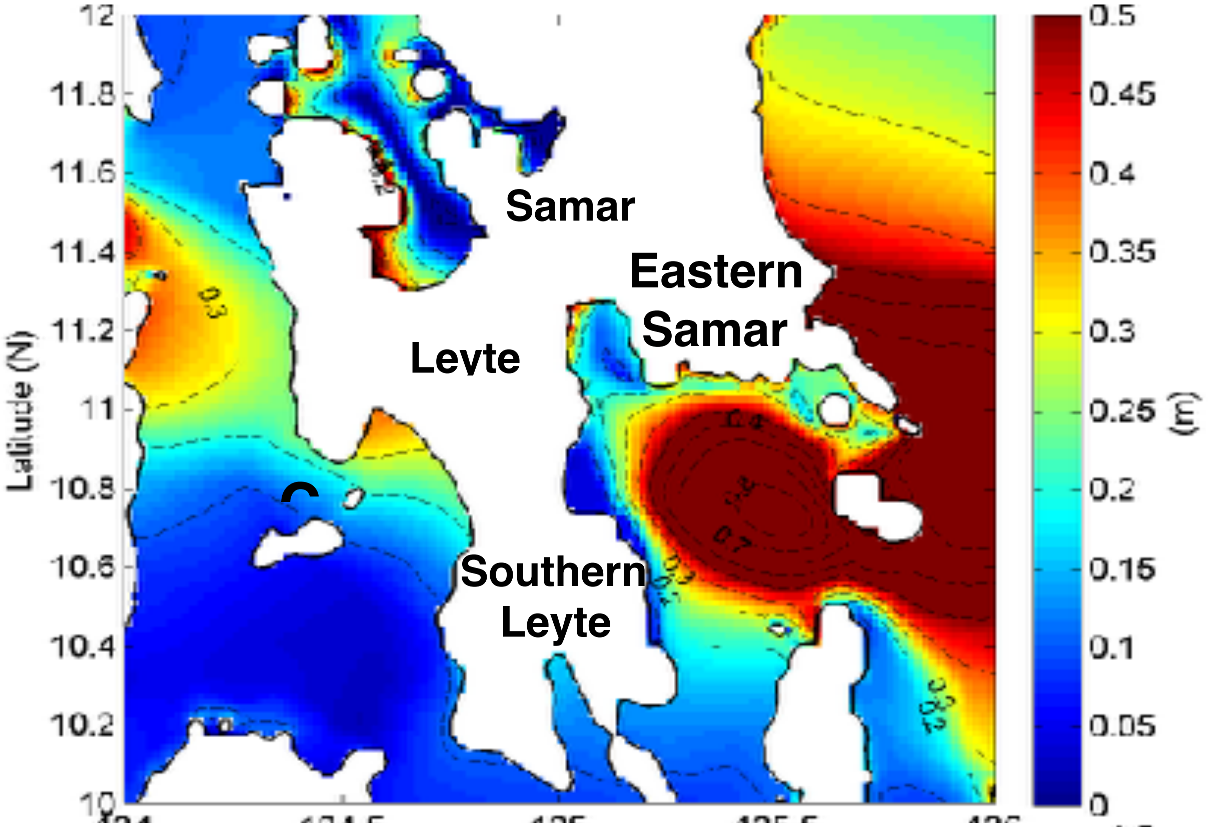
- ✓ Adopt the **large computational domain** to cover the complete typhoon life cycle and full storm surge propagation.
- ✓ Couple with the **dynamic atmospheric WRF model**.
- ✓ Couple with the **global TPXO tidal model**.
- ✓ Calculate **high-resolution storm surge inundation**.
- ✓ High-speed calculation for the **operational system**.

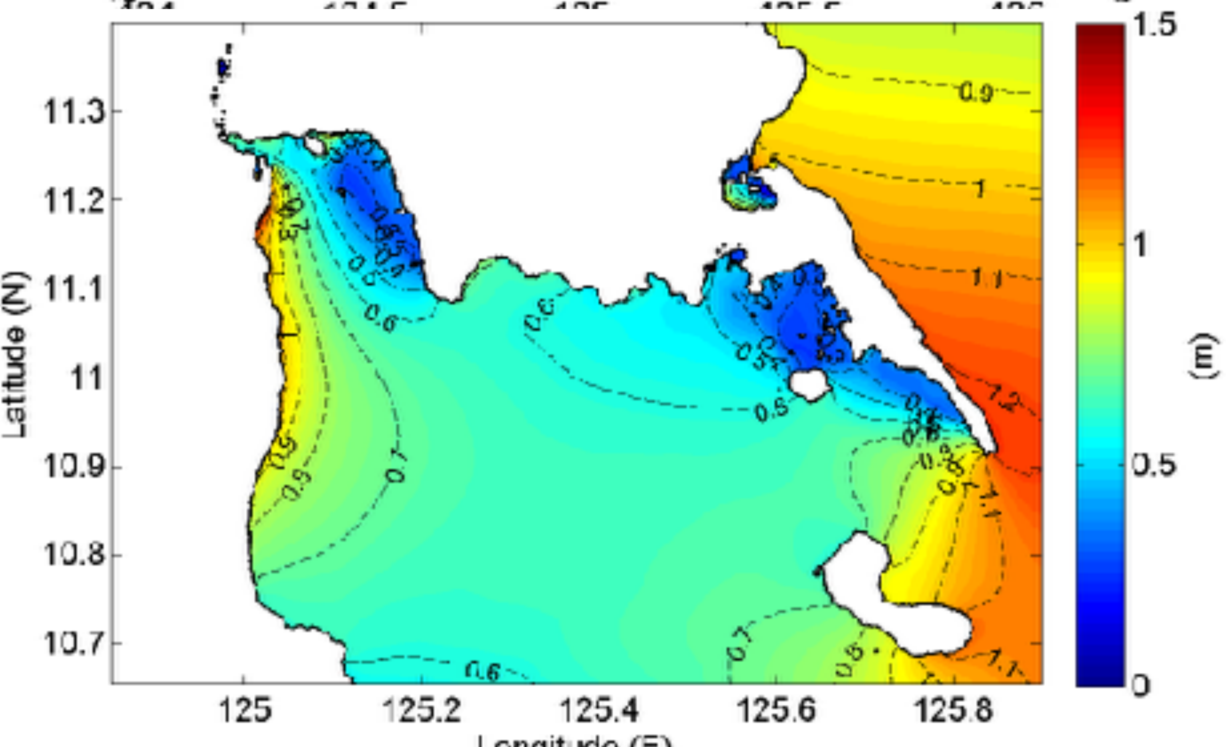
Applications

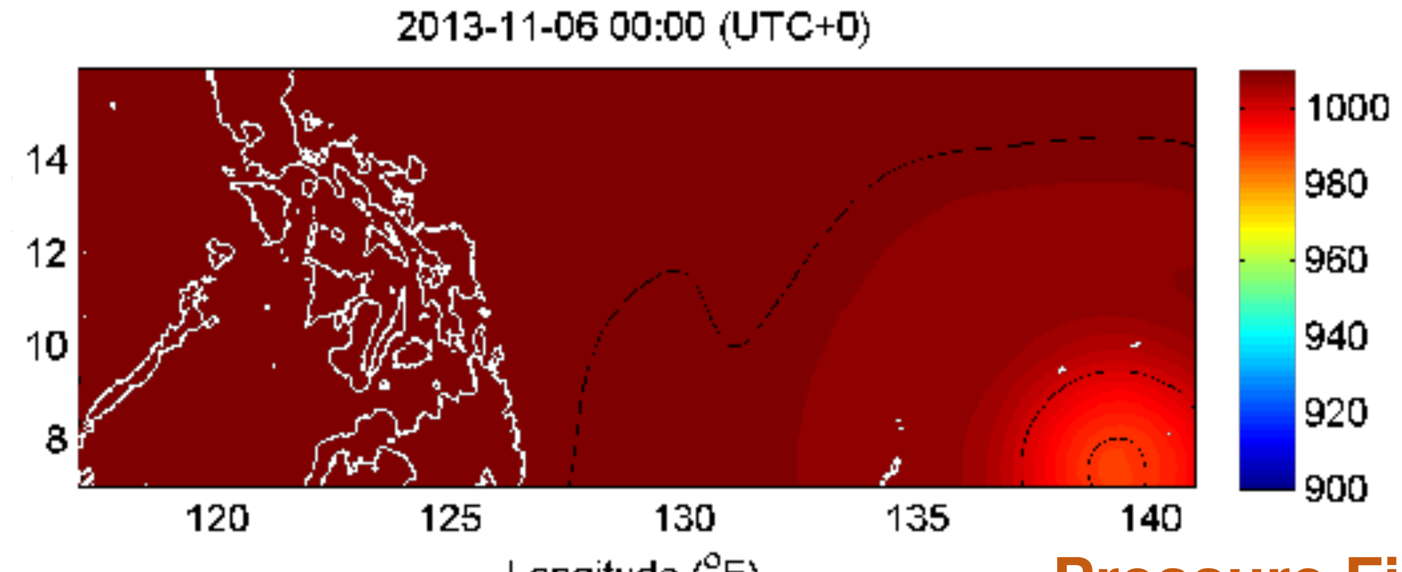
1. Understanding science behind the event
2. Improve the coupled model
3. Early warning
4. Providing hazard maps and risk potential analysis

Storm Surge Modeling on 2013 Typhoon Haiyan by Coupling Ocean and Atmospheric WRF Model

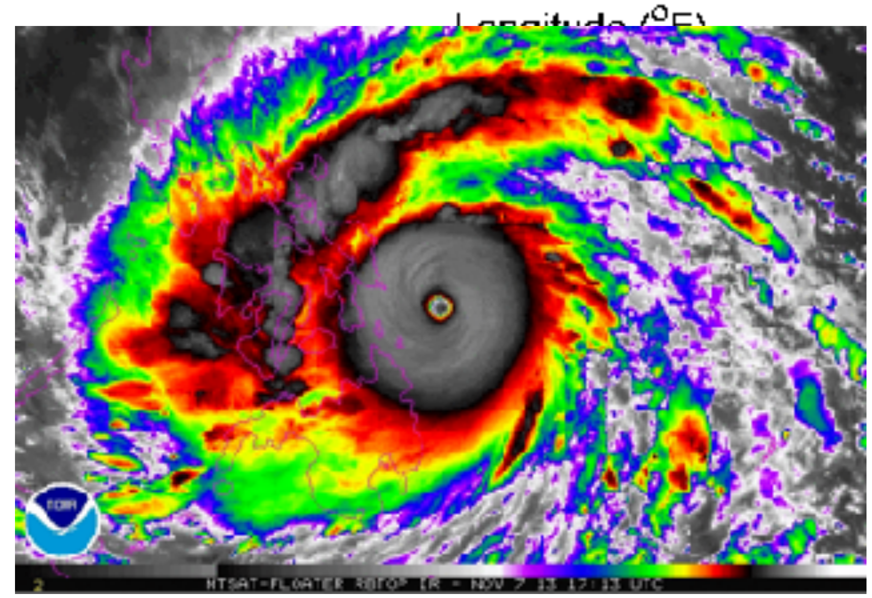
Offshore Storm Surge Inundation Induced by Typhoon Haiyan





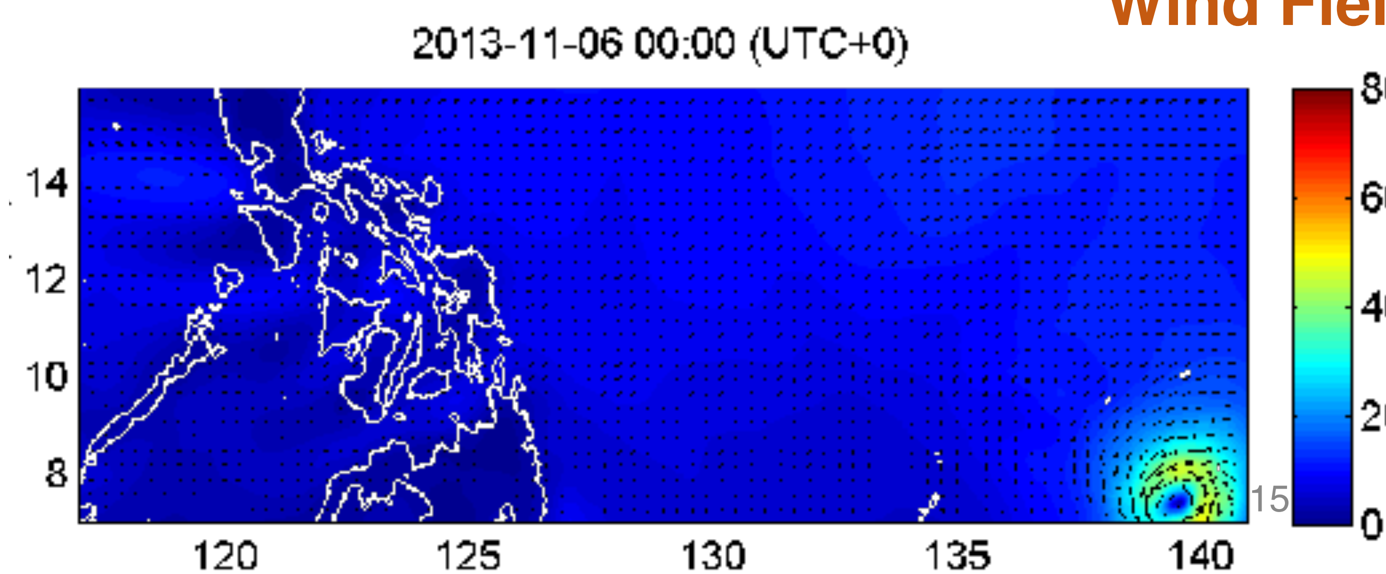


Pressure Field



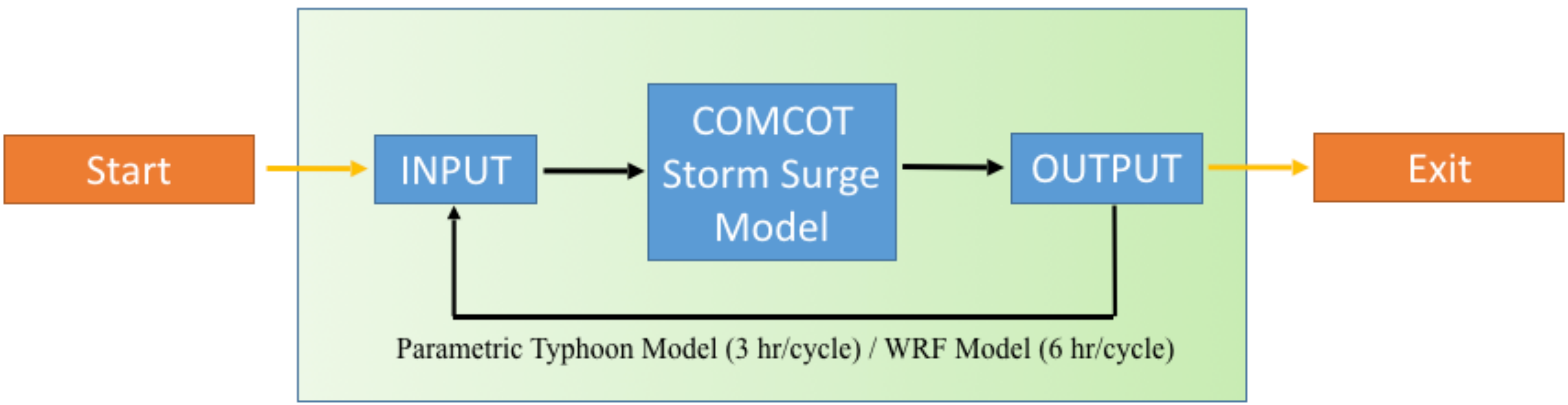
- *Asymmetric effect*
- *Topographic effect*
- *Hydrodynamic Pressure*

Wind Field



Taiwan Storm Surge Operational System

Our COMCOT storm surge model has been the official operational system at the Central Weather Bureau this year.



INPUT

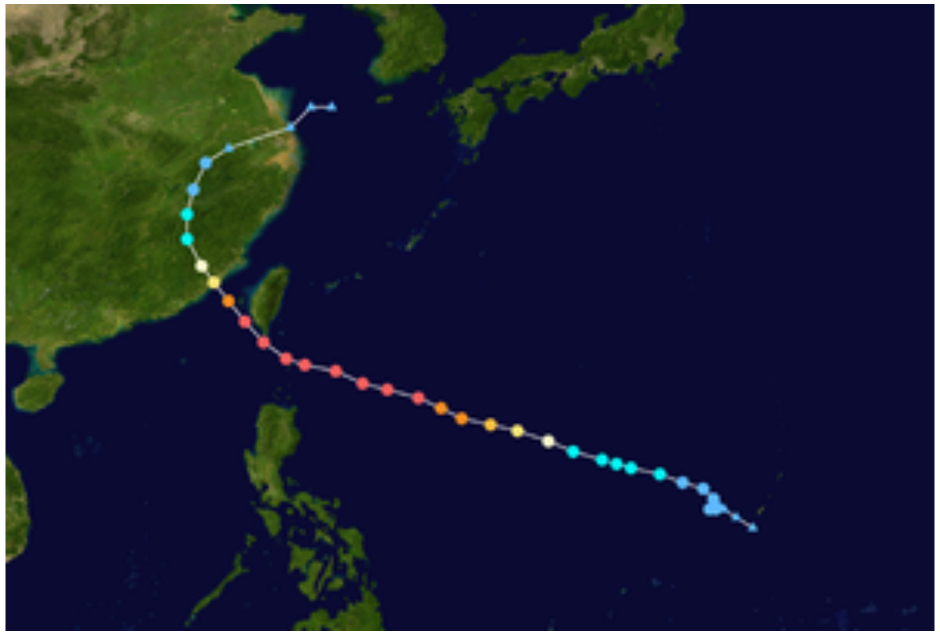
- ➢ Meteorological Force: Parametric Typhoon Model or WRF Model.
- ➢ Tidal Boundary Condition: TPXO 7.1 model.

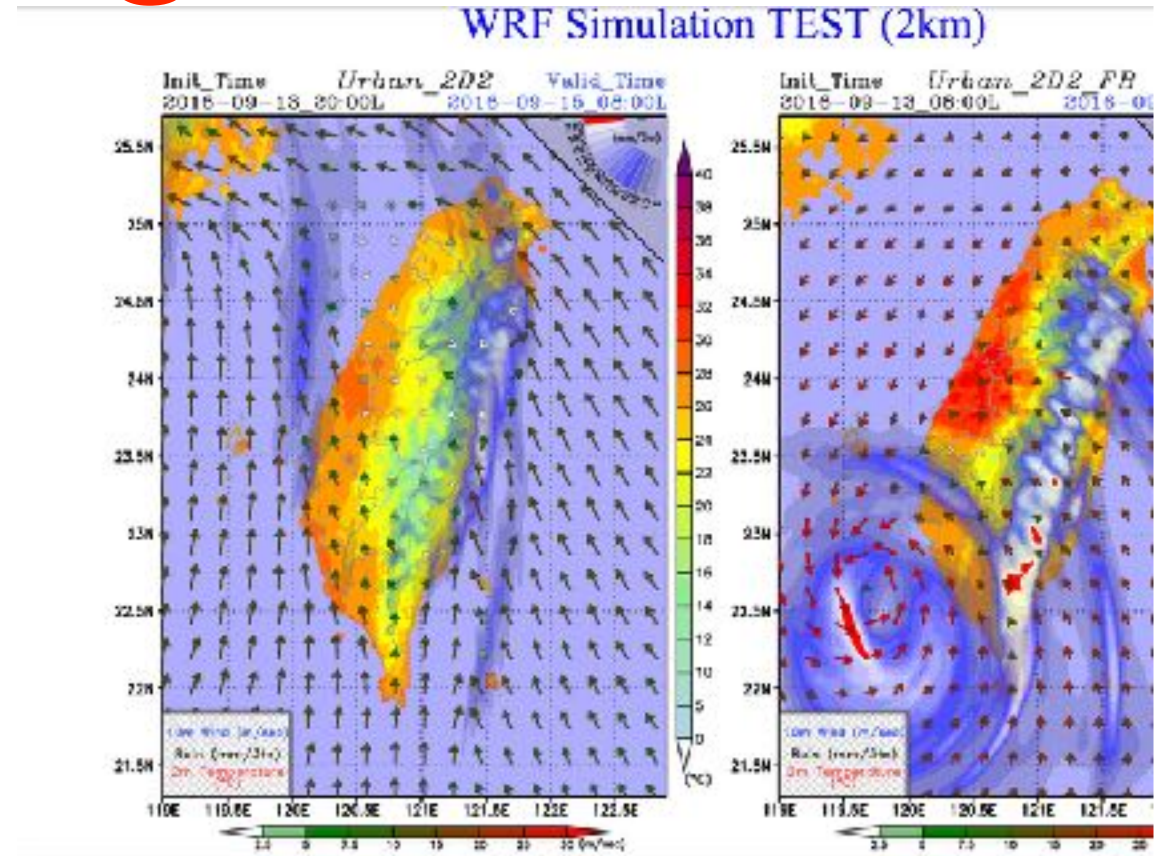
OUTPUT

- ➢ 48-HR Time Series for Storm Tide and Pure Tide at 34 specified locations.
- ➢ 2-dimensional model product.

Typhoon & Storm Surge Simulation

Typhoon Meranti (8-17 September 2016)





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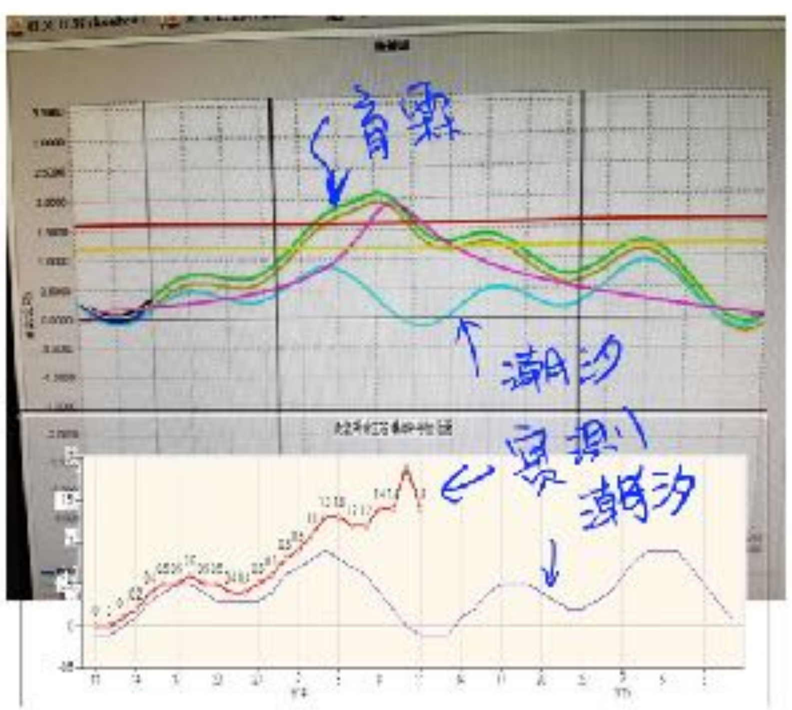
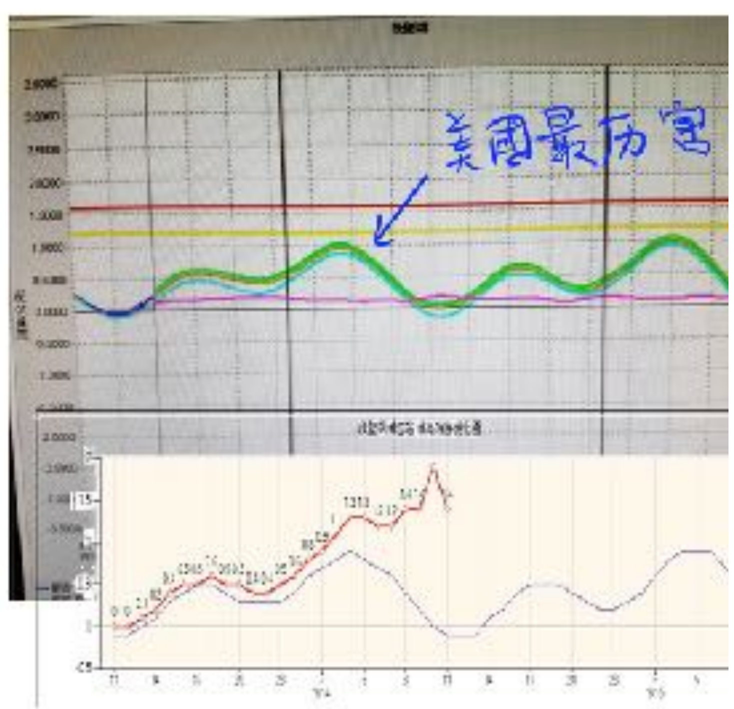
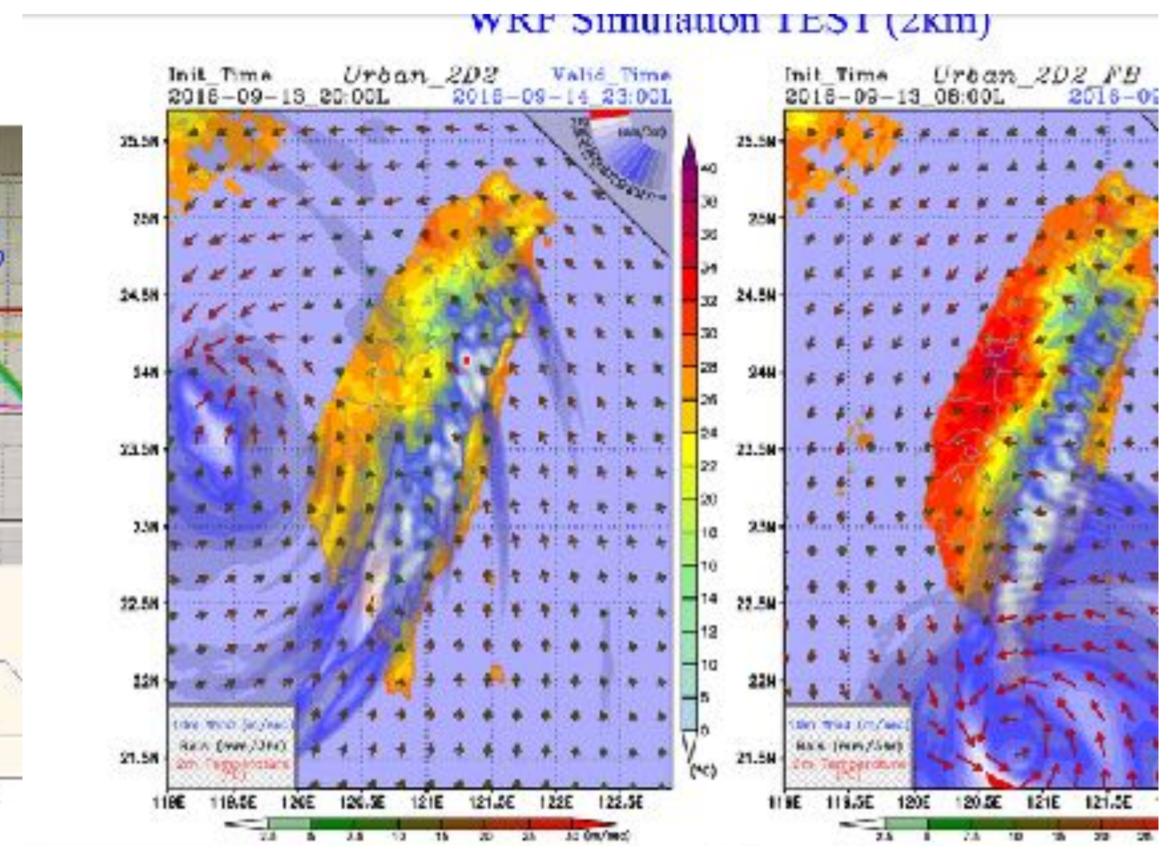
COMCOT模式



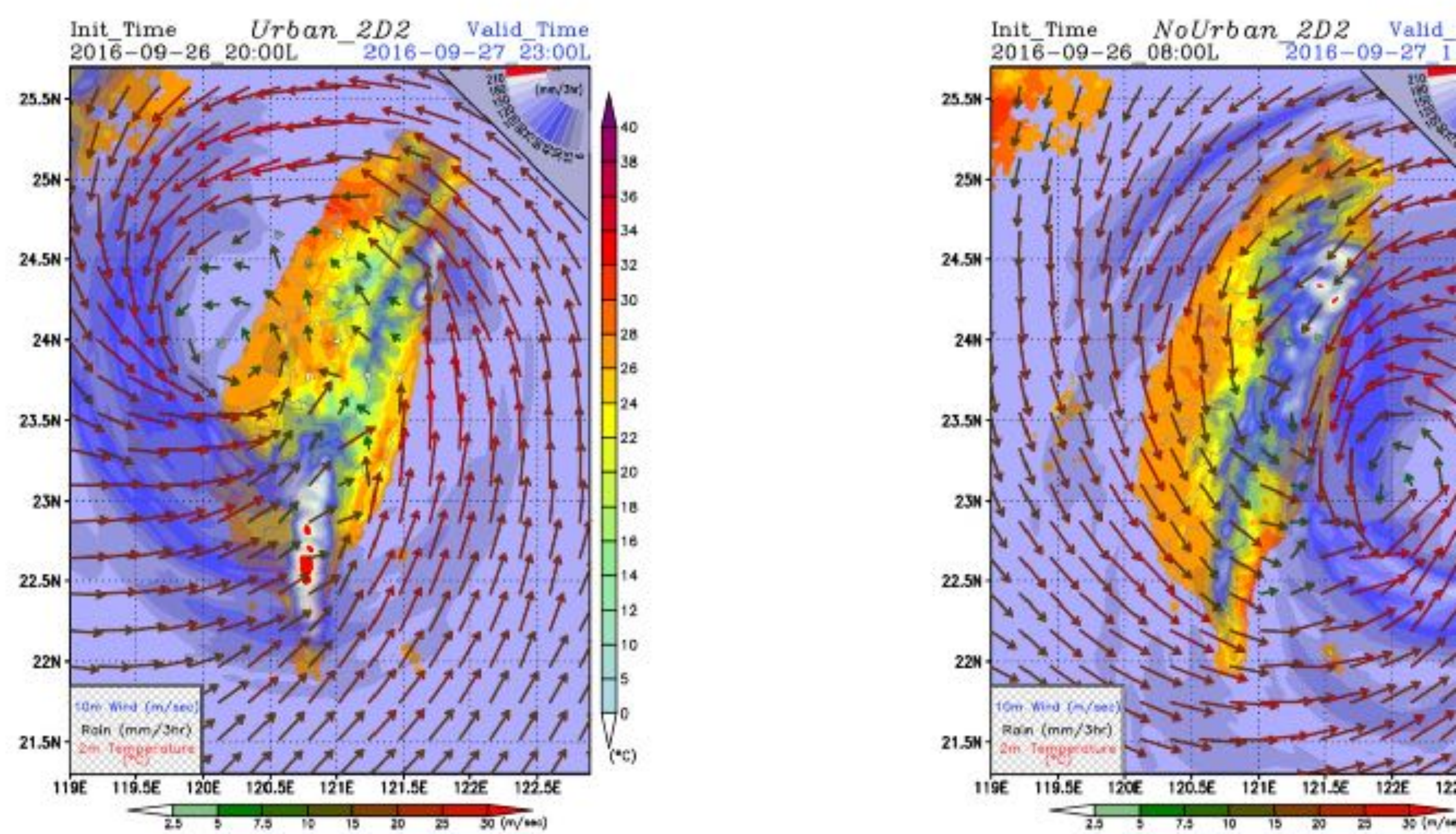
美國最強模式

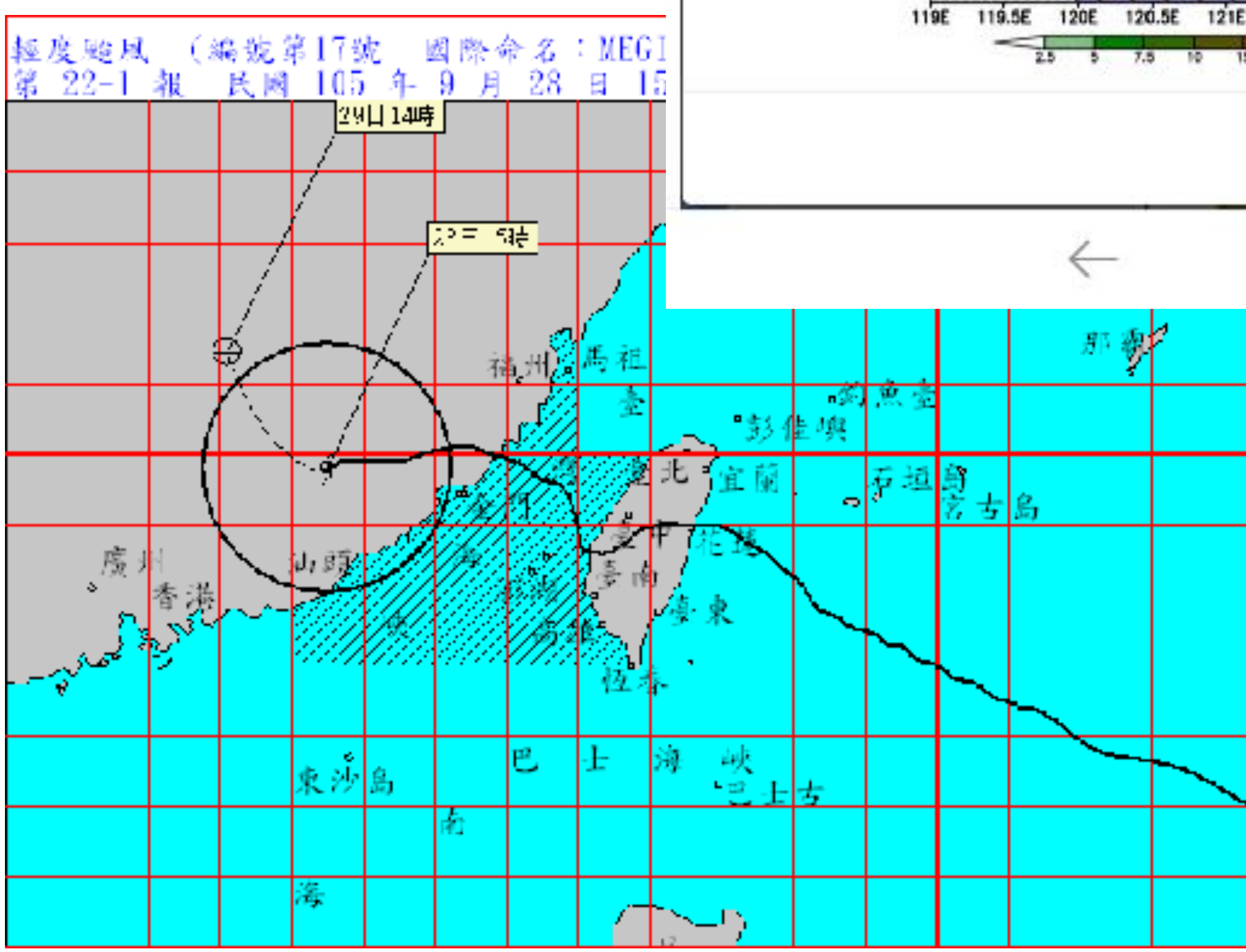


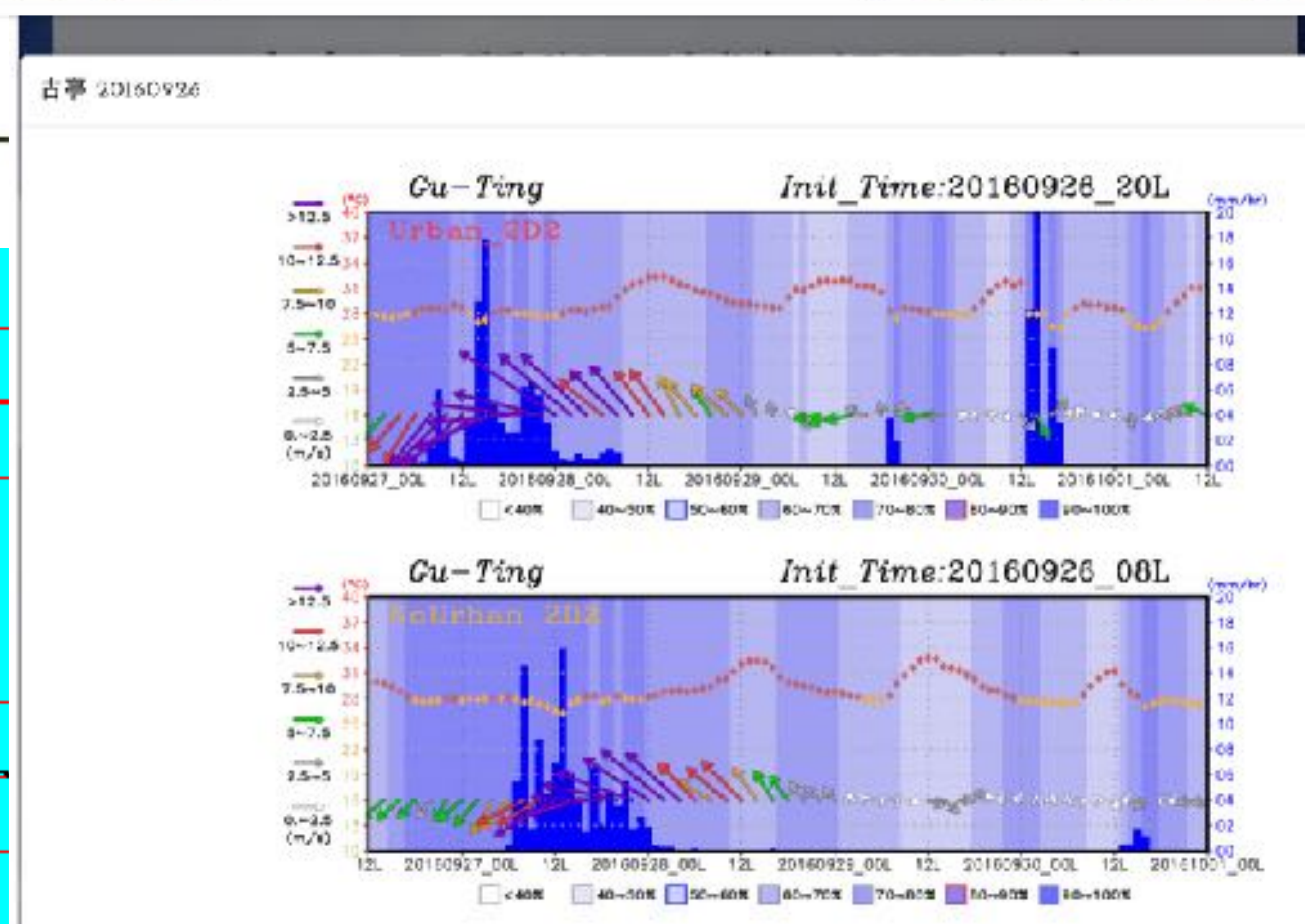


MODIS image captured by NASA's Aqua satellite - NASA Earth Observatory

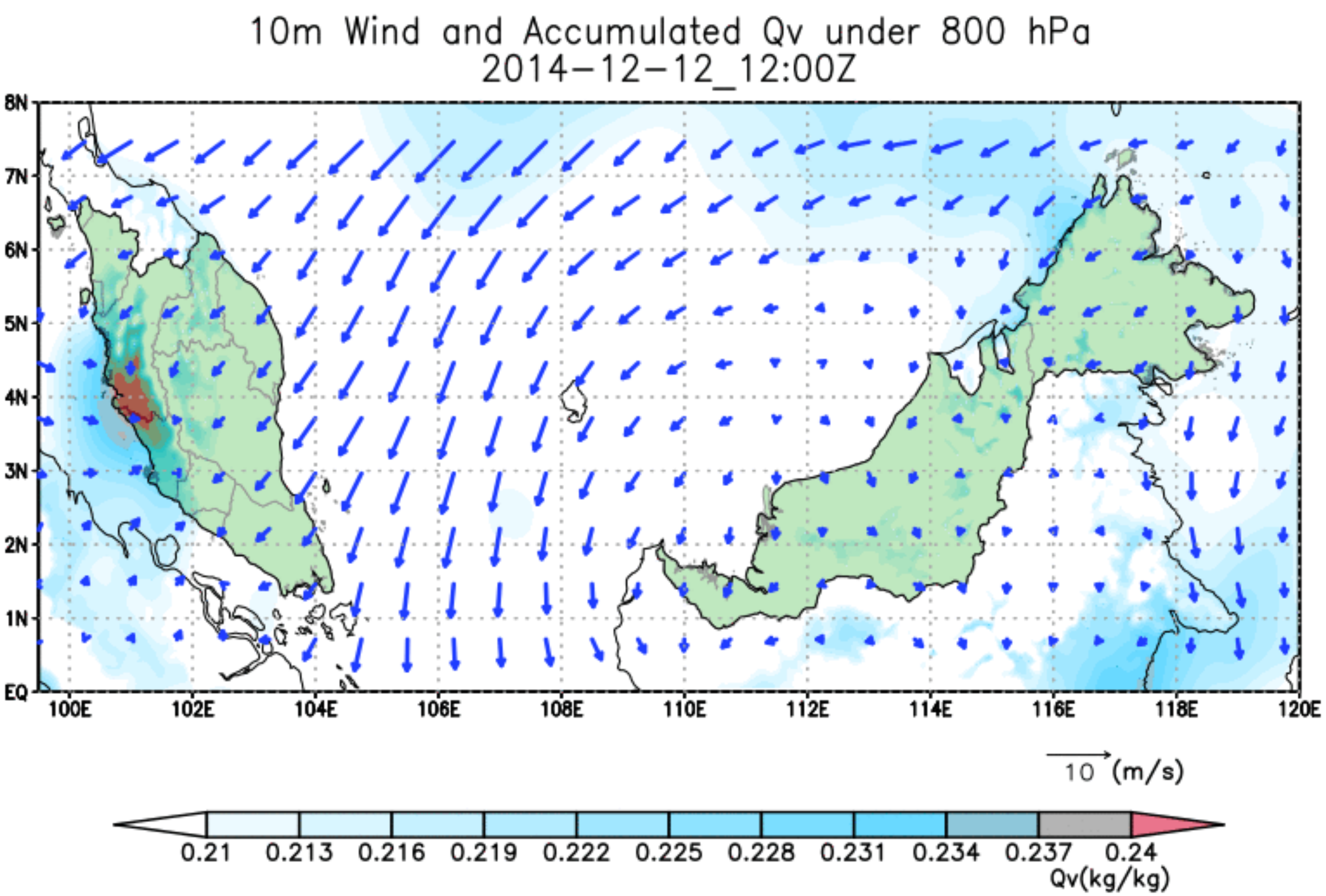
Simulation of Typhoon MEGI (hit Taiwan on Sep. 27 & 28, 2016)







Preliminary Results of the Simulation on 2014 Extreme Rainfall event over the Peninsular Malaysia



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
  - Northeasterly cold surges dominate the low-level circulation patterns
  - Quasi–stationary Borneo vortex
  - Madden-Julian Oscillations (MJO): on intra-seasonal time scales peak amplitude during boreal winter over the Maritime Continent

Overview of the Simulation Setup

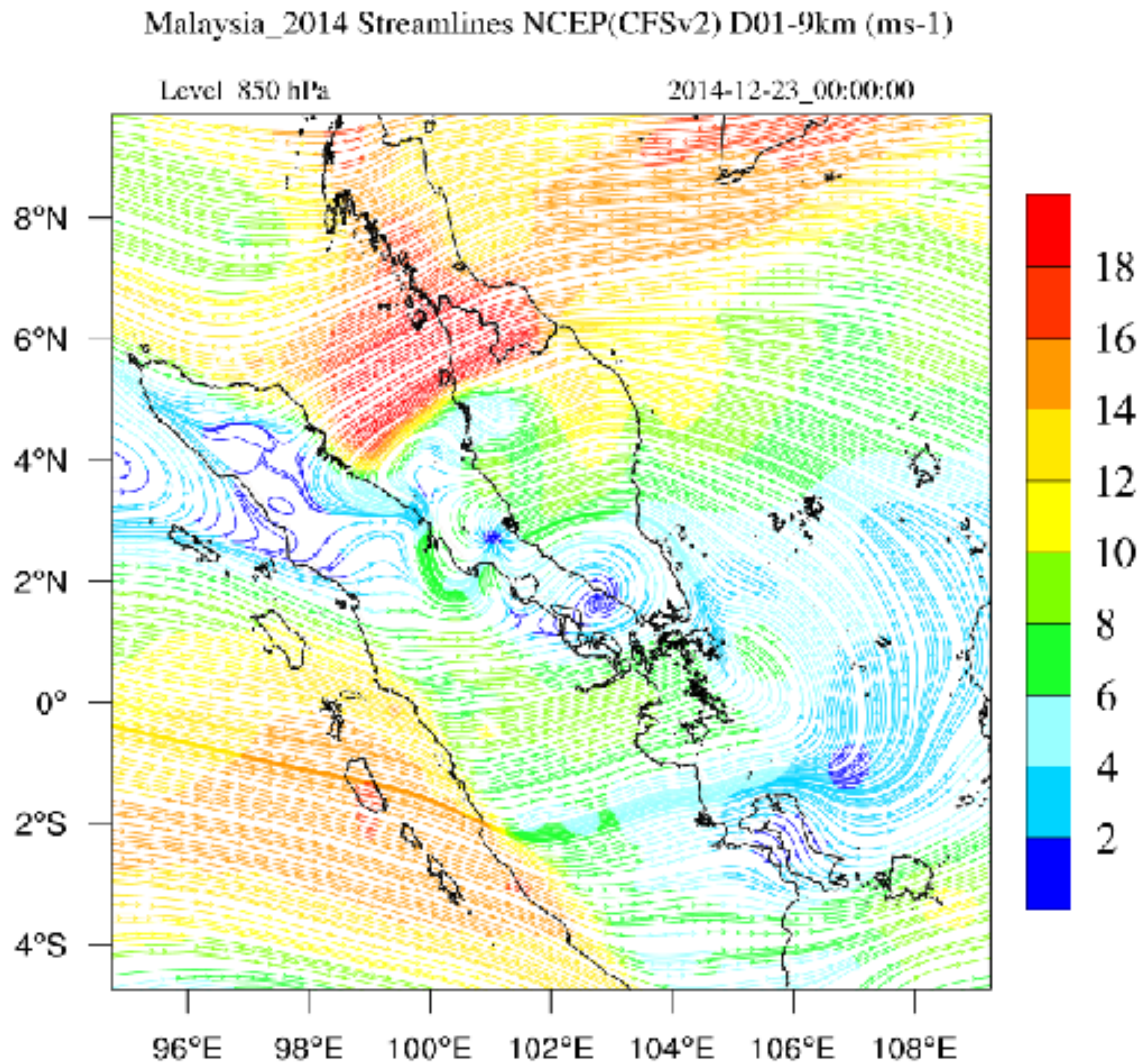
Model	WRF 3.6.1
Vertical levels	
Landuse Data	MODIS - 30 seconds (~900 m) spatial resolution
Domain Resolution	D01 – 9 km (181 X 181 grid points)
Initial and boundary conditions	NCEP global analyses (0.5^0 X 0.5^0) (~54 km) 6-hourly
SST update	ON
Feedback	OFF
Fdda	OFF

Model	WRF 3.6.1
Vertical levels	σ-coordinate system with 37 σ –levels (up to 100 hPa)
Landuse Data	MODIS - 30 seconds (~900 m) of spatial resolution
Domain Resolution	D01 – 9 km (181 X 181 grid points)
Initial and boundary conditions	NCEP global analyses (0.5^0 X 0.5^0) (~54 km) 6-hourly
SST update	ON
Feedback	OFF
Fdda	OFF

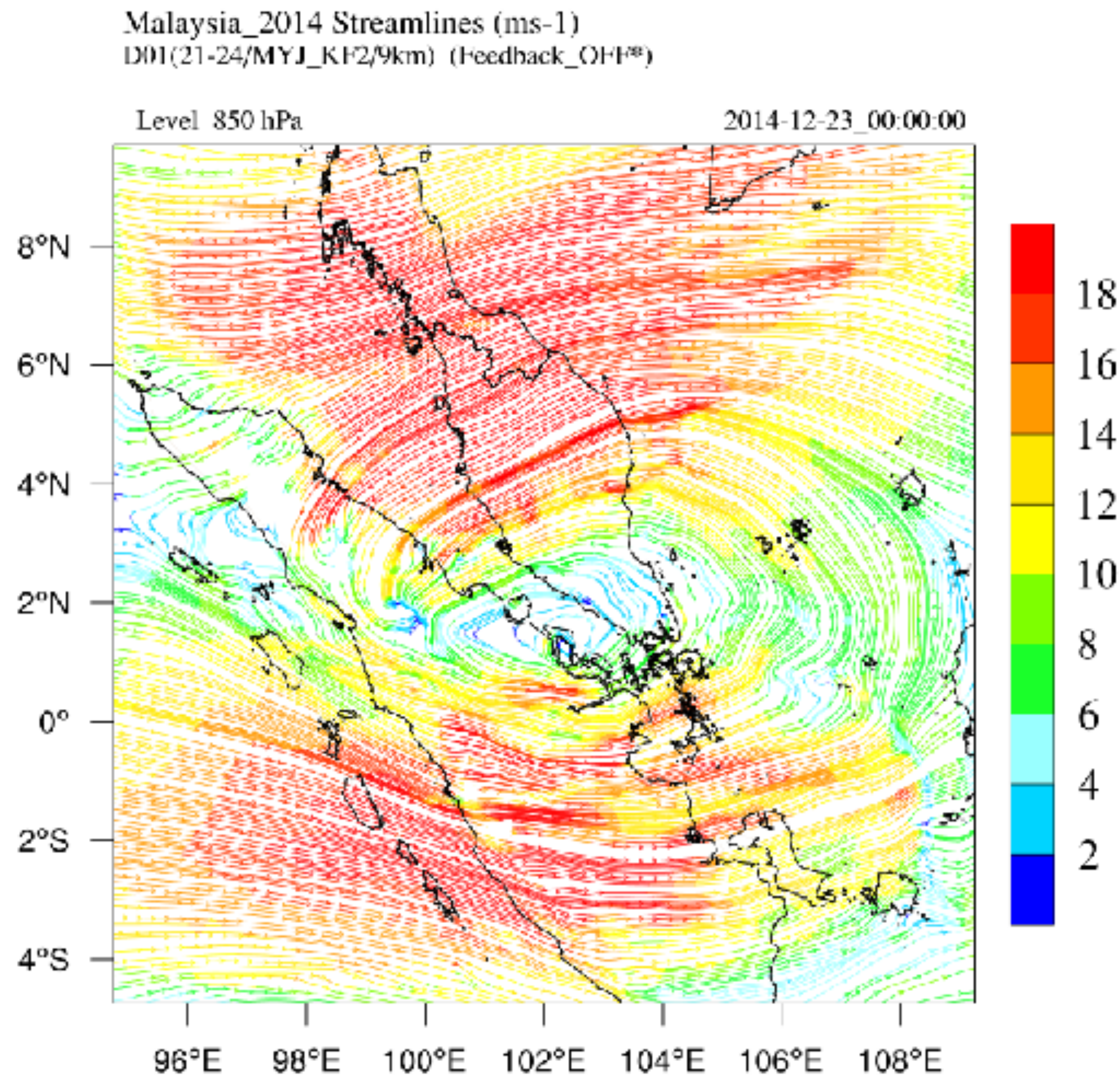
Streamlines

Simulation period > Dec 21-24 **|** 2014.12.23 – 00:00

NCEP Data



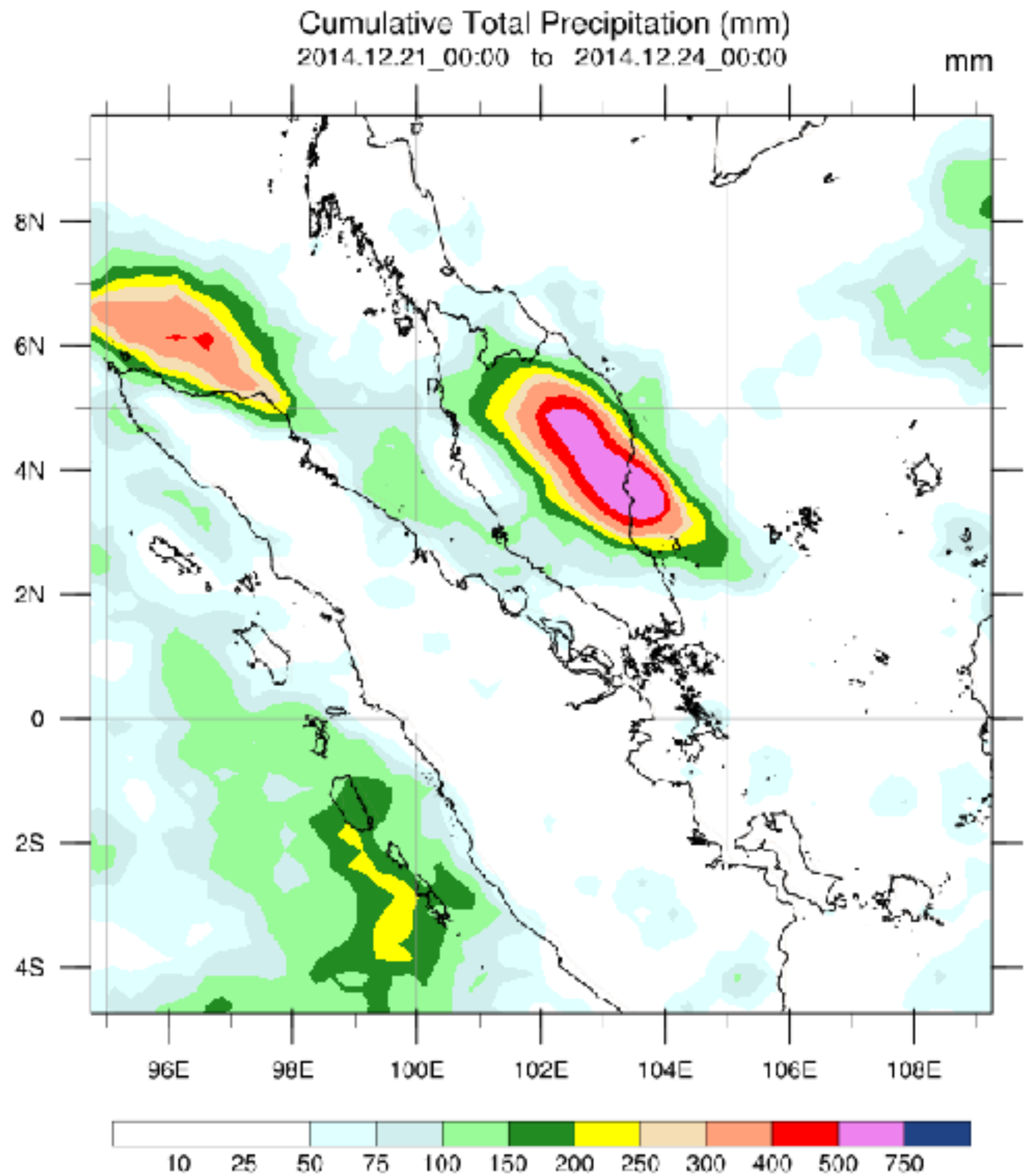
Simulation Results



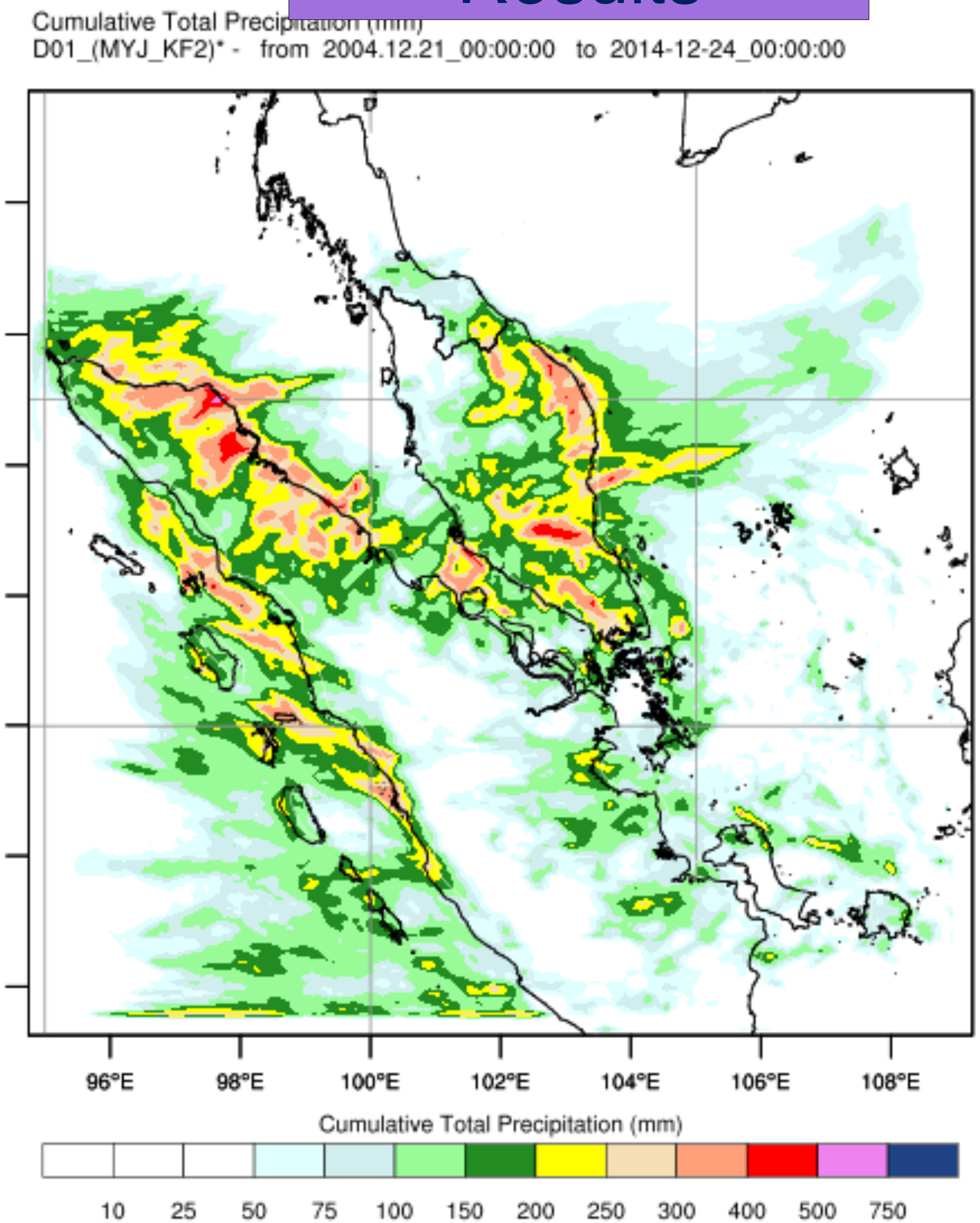
Cumulative Rainfall

Domain 02 - Simulation > Dec 21-24 I Cumulative Rainfall (Dec 21-24)

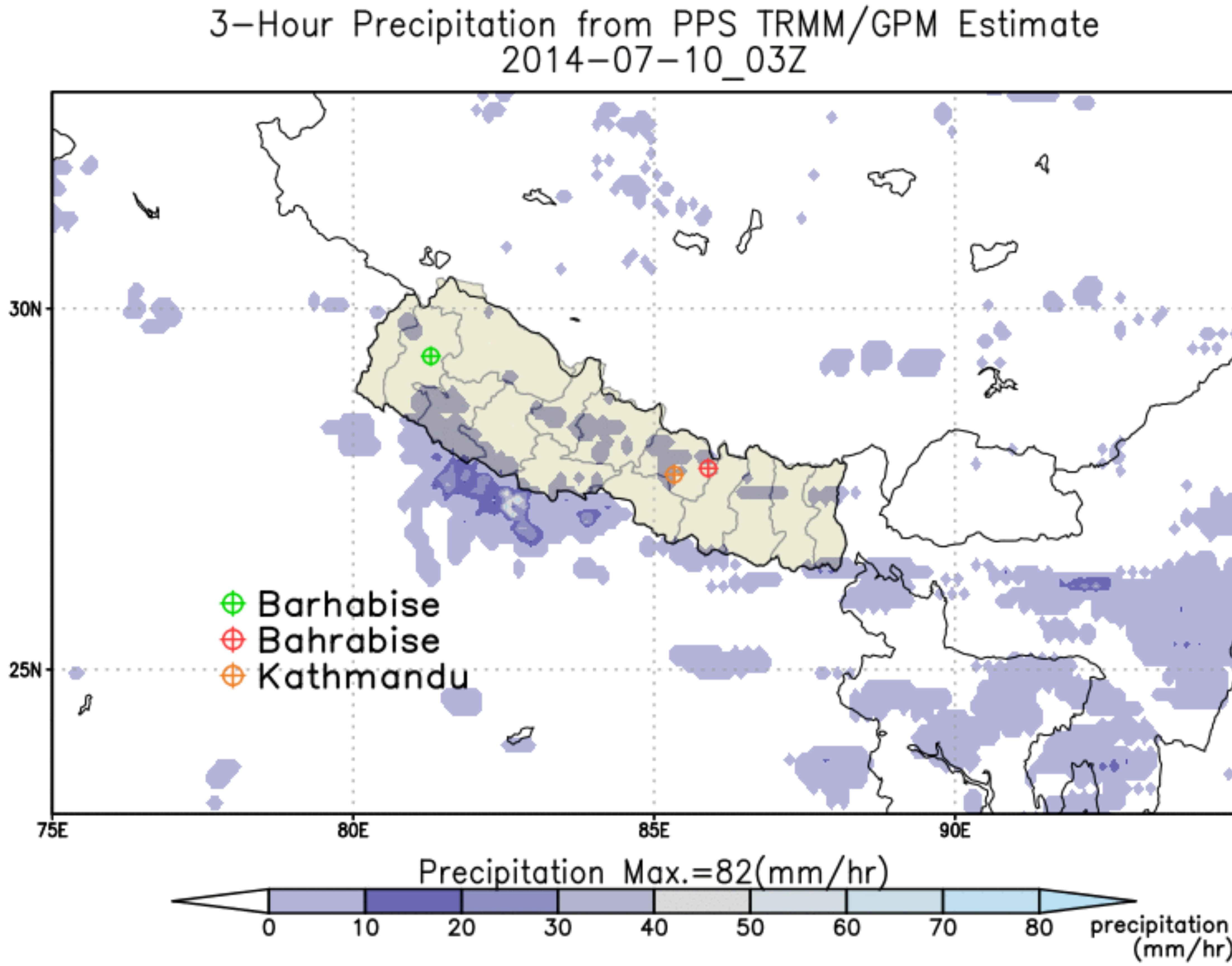
TRMM Data

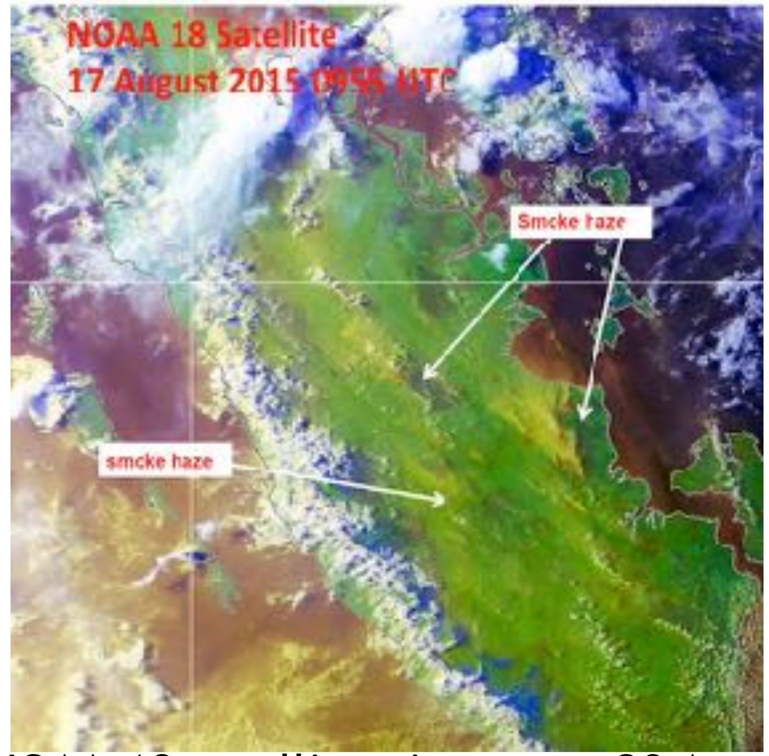


Simulation Results

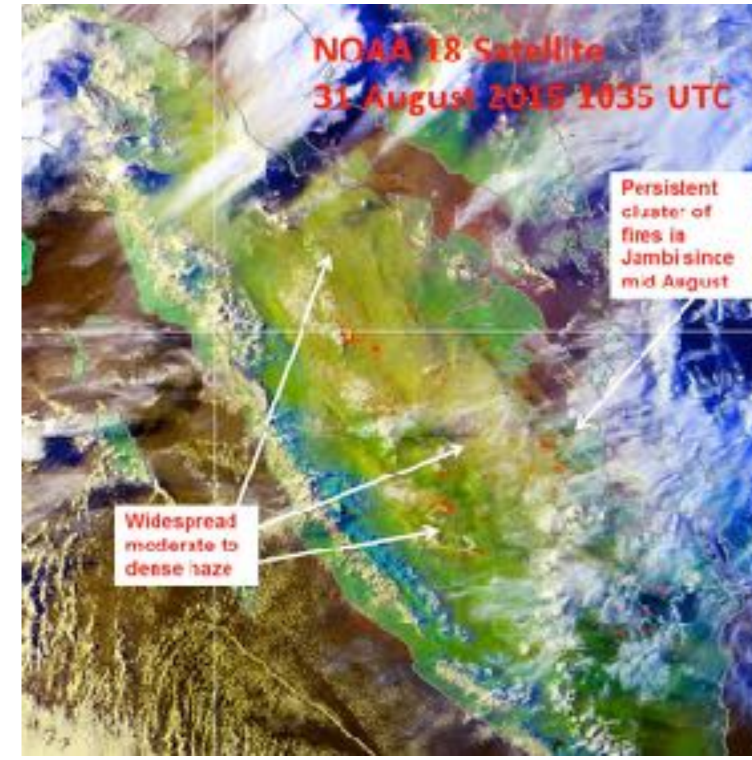


Flooding in Nepal

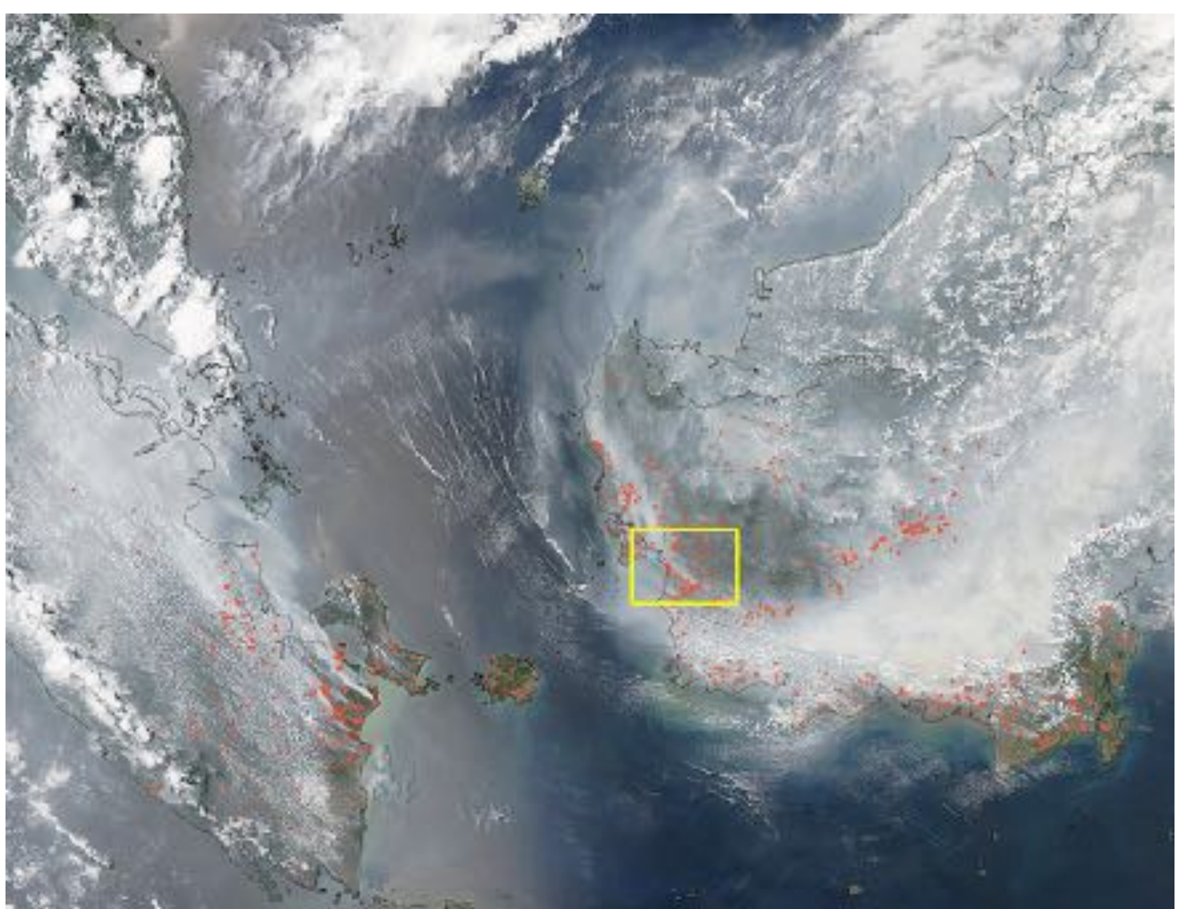




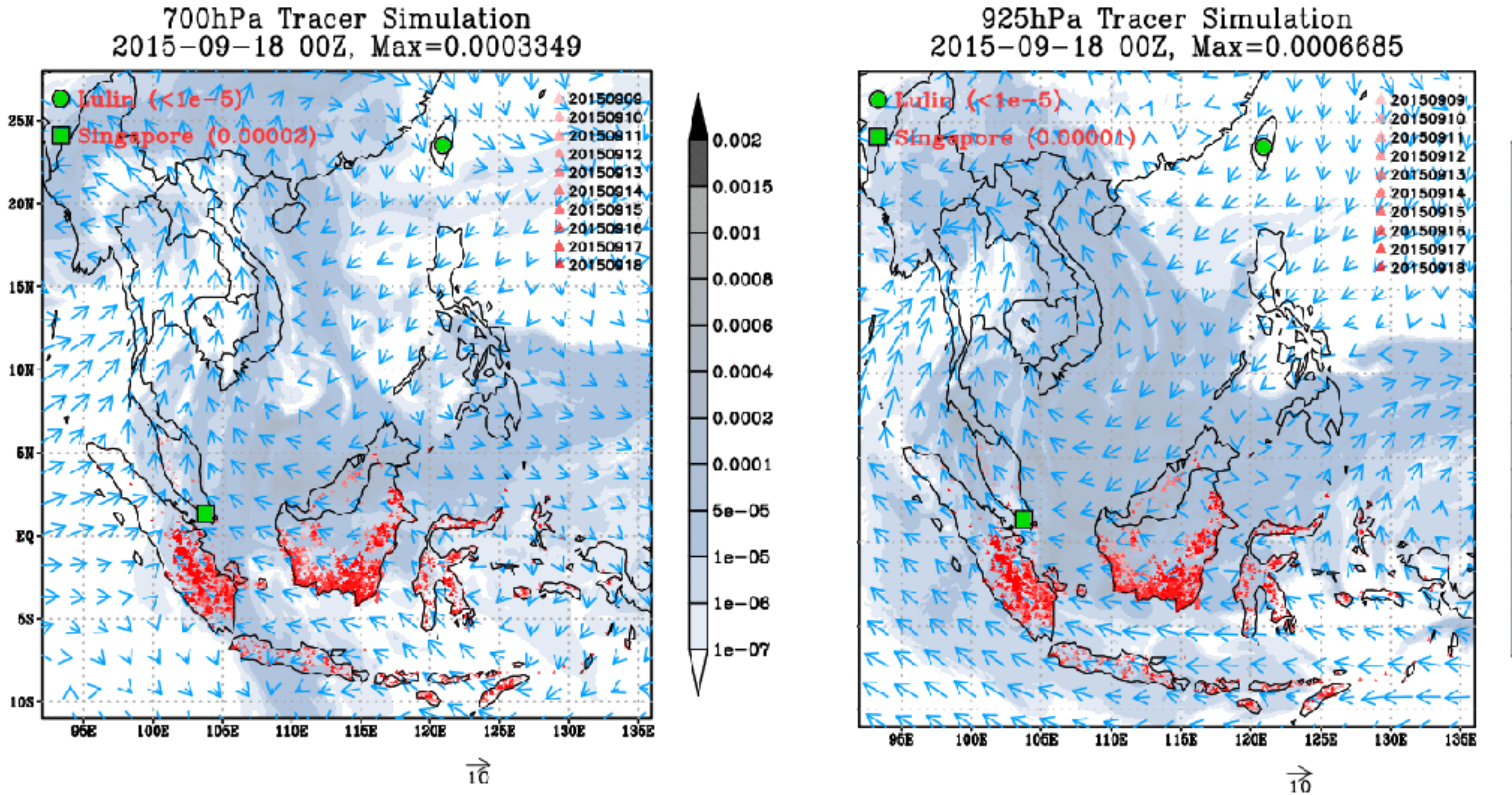
NOAA-18 satellite picture on 29 August 2015 shows deterioration of smoke haze situation in Kalimantan



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



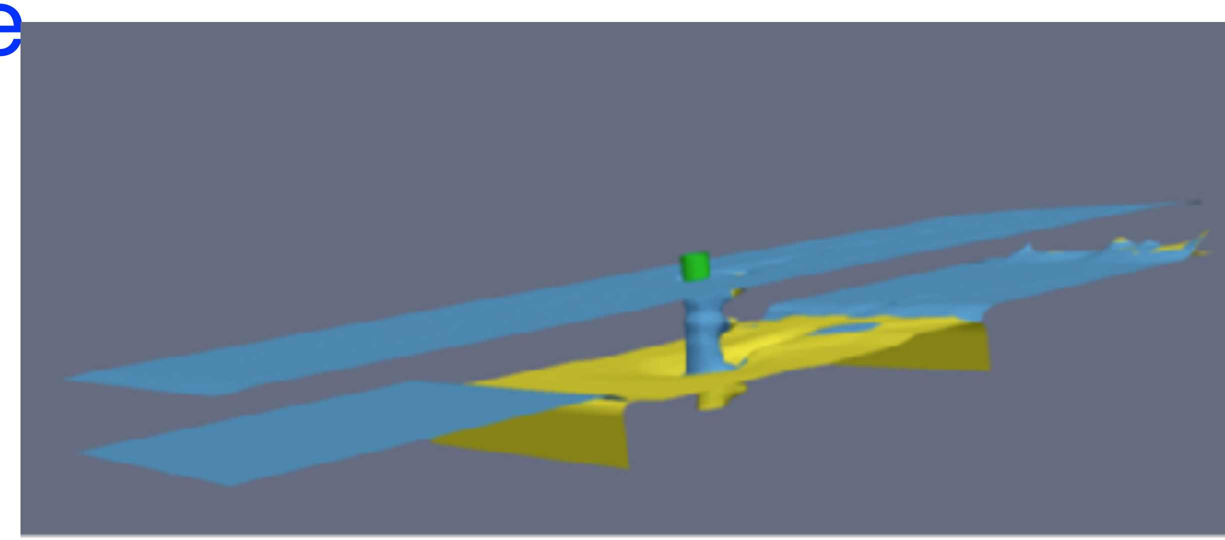
NASA's Aqua satellite collected this natural-color image with the Moderate Resolution Imaging Spectroradiometer, MODIS, instrument on September 22, 2015.



Resolution: 10 km

Advanced Visualization

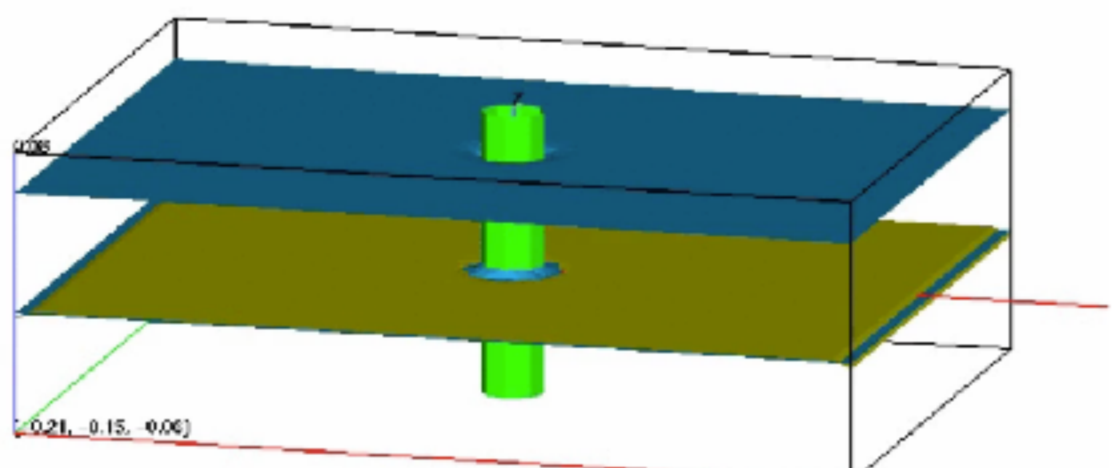
- Local Scouring case study is the first example by collaboration between NCU, ASGC and LRZ
- 3D Typhoon Morakot Visualization is the next case study



Chosen Case Study: Dey and Barbhuiya, 2005

Advance Visualisatio

LRZ: Siew Hoon Leong (12 May 2015)



Compute domain: 1.1m by 0.3m by 0.14m

Abutment model: Circular

Column radius: 0.015m

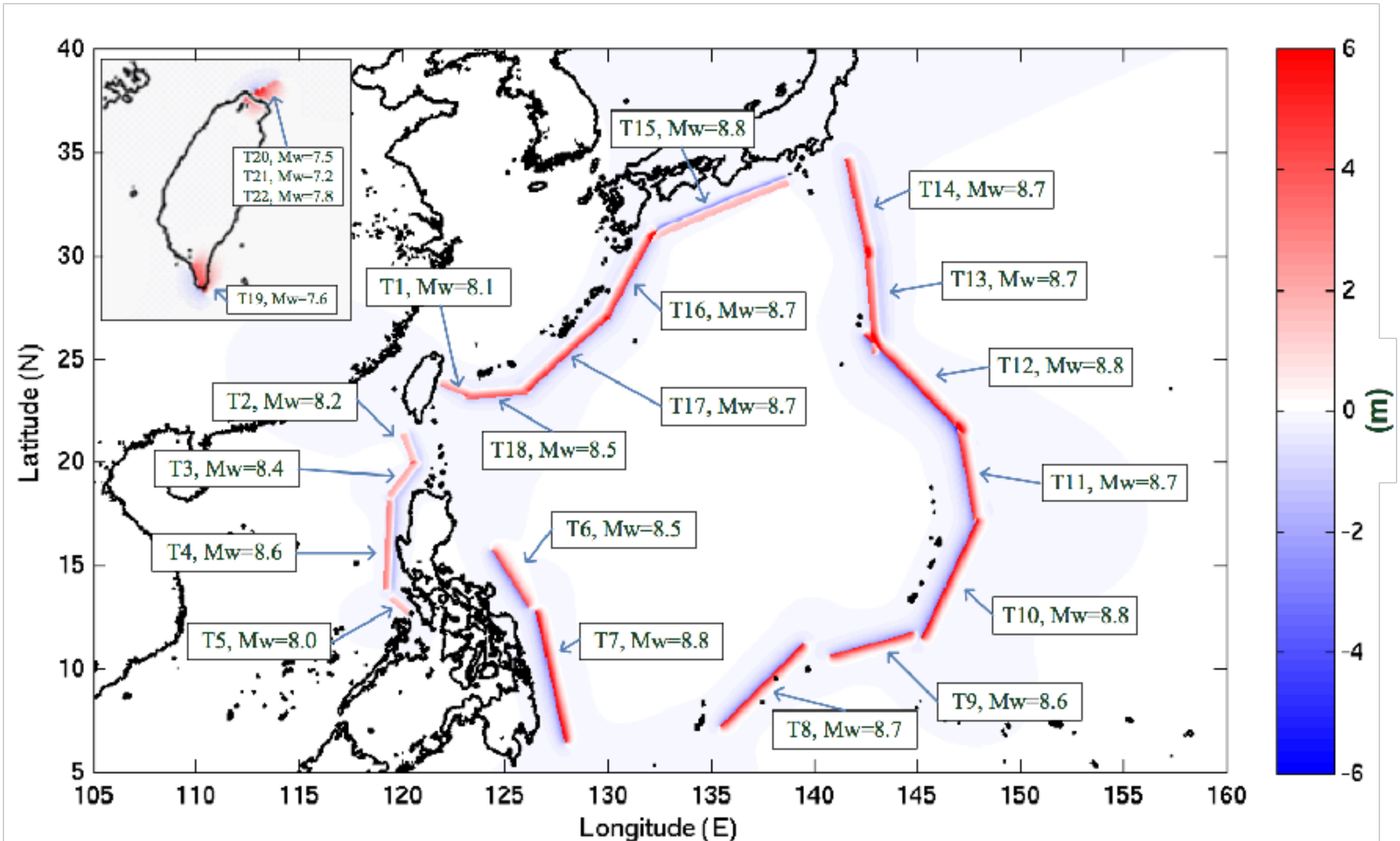
Uniform sediments

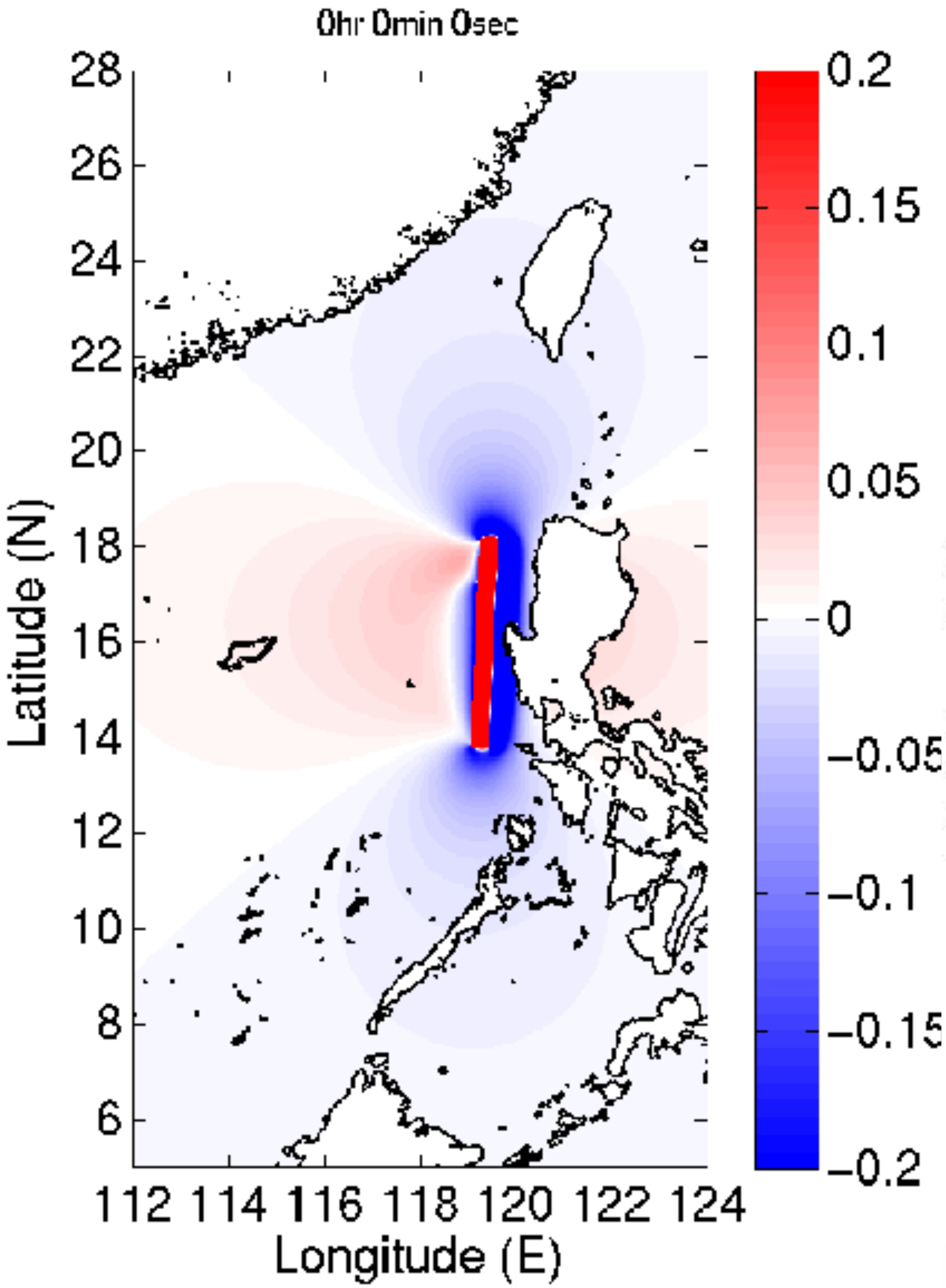
Mud: 6cm thick
Clean water: 6cm thick

Provided by:
Chun-Wei Lin & Tso-Ren Wu (NCU)

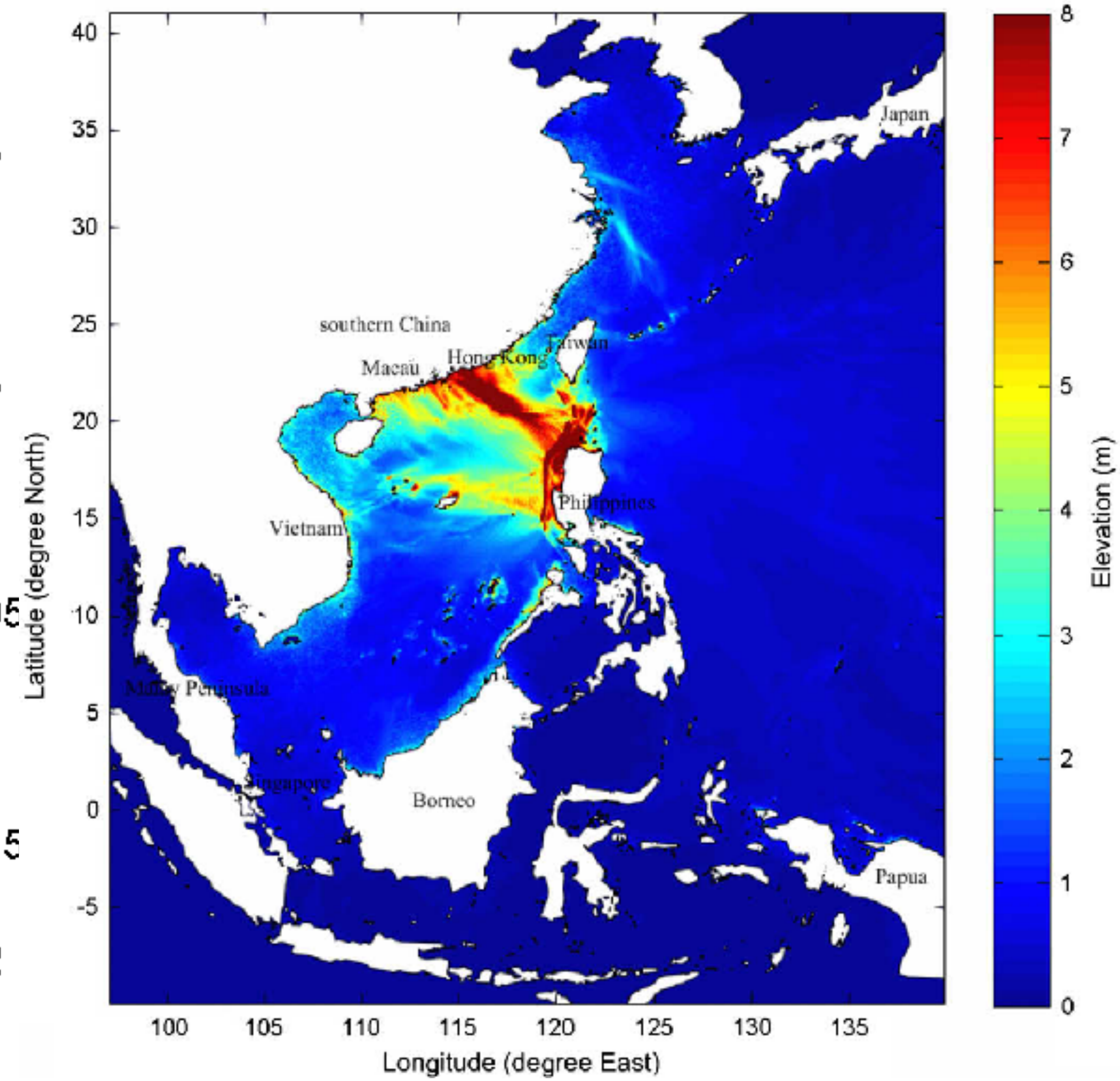
Tsunami Sources of 18 Trench and 4 Fault Segments

18 Trench-type tsunami sources（T1~T18） 4 Fault-type tsunami sources（T19~T22）



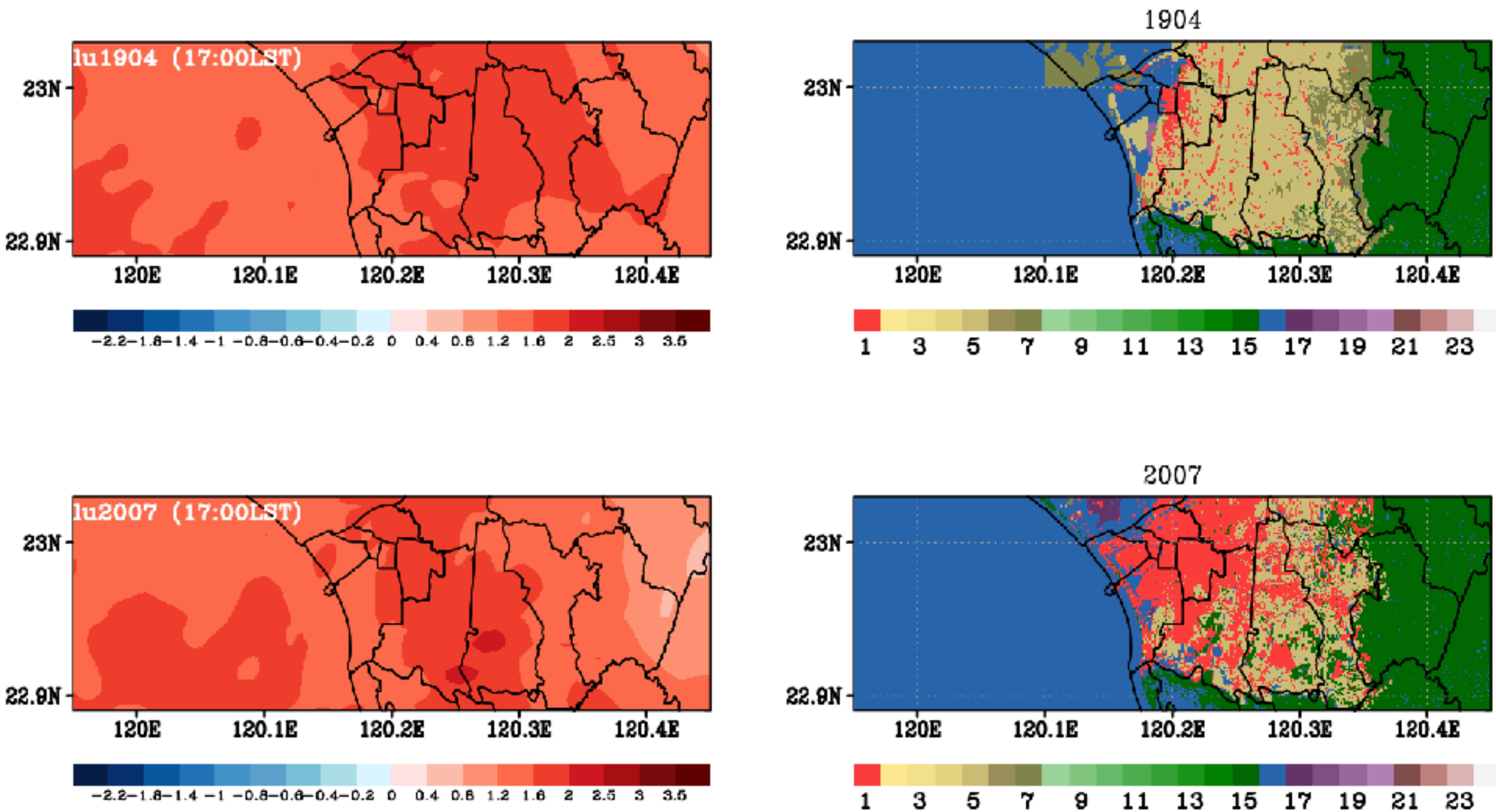


0hr 0min 0sec
Latitude (N)
Longitude (E)



southern China
Macau
Hong Kong
Taiwan
Japan
Philippines
Vietnam
Malay Peninsula
Singapore
Borneo
Papua
Latitude (degree North)
Longitude (degree East)
Elevation (m)

Location and Density of Precipitation Impacted by Urbanization of Tainan (1904-2007)



Typhoon Morako in 2010 and 2100

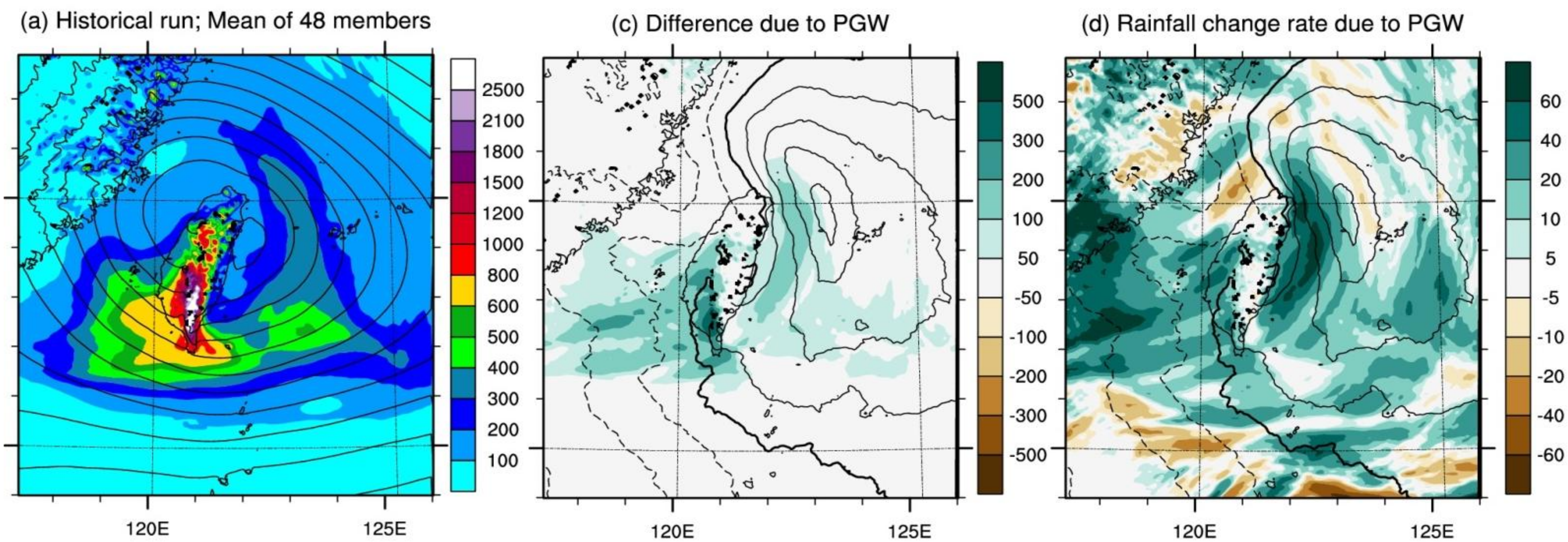
Pseudo Global Warming Experiment for Historical Typhoons

- Typhoon Morakot (2009) in the end of 21st Century

Superposition circulations of future change and historical events

$$C_{PGW} = C_{history} + (\overline{C}_{future} - \overline{C}_{present})$$

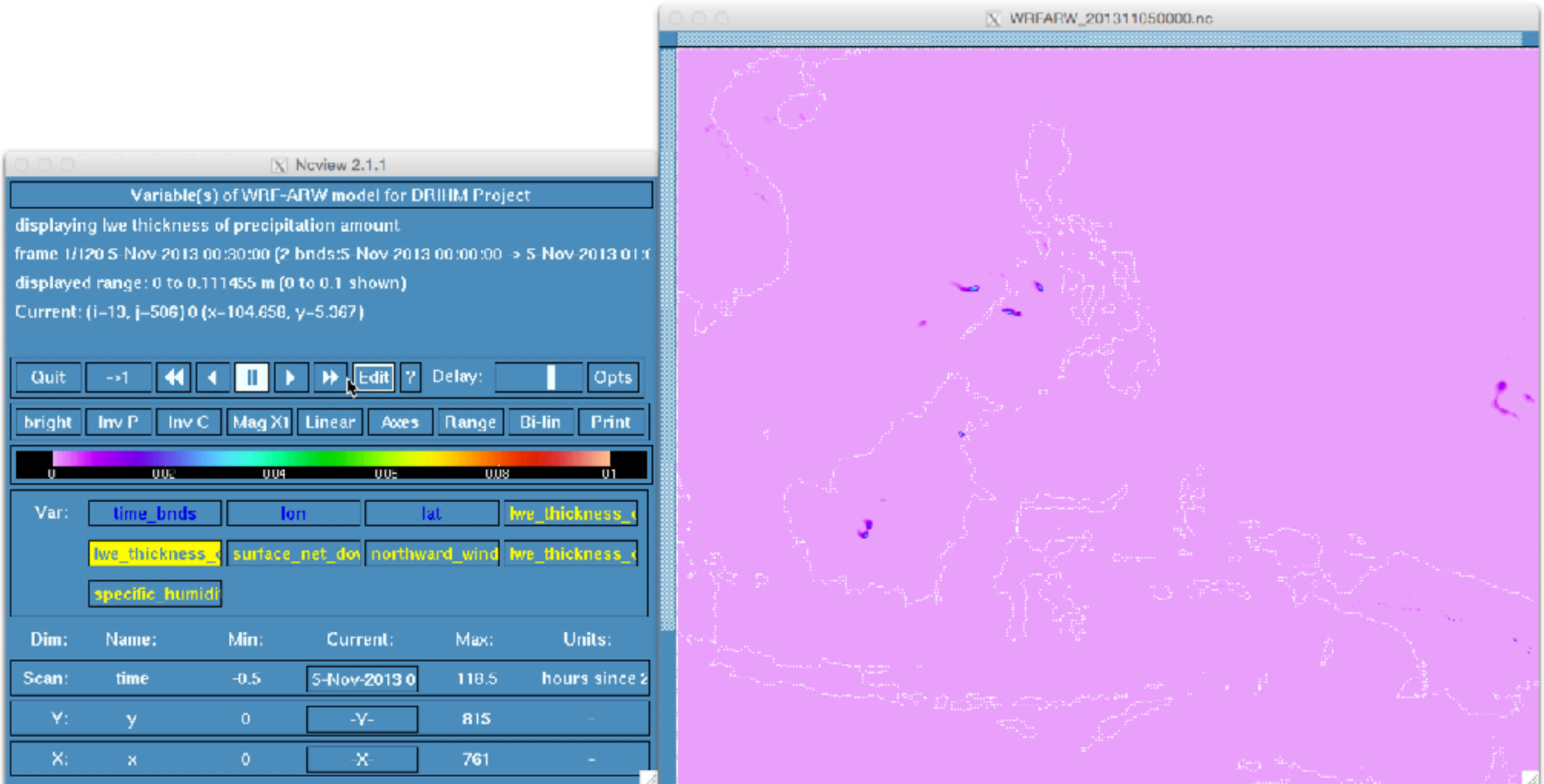
$\overline{C}$: Climatology of 30 day mean; $C = T \cdot RH \cdot U \cdot V \cdot \Phi \cdot SST$



- Consider circulation change of MRI-AGCM3.2S in 2075-2099 under A1B scenario and 2009 typhoon Morakot (top rainfall record : 3000 mm in 5 days)
- 48 ensemble runs.
- Precipitation increase rate over southern plain can reach 40% (from 3000 mm to 4200 mm)

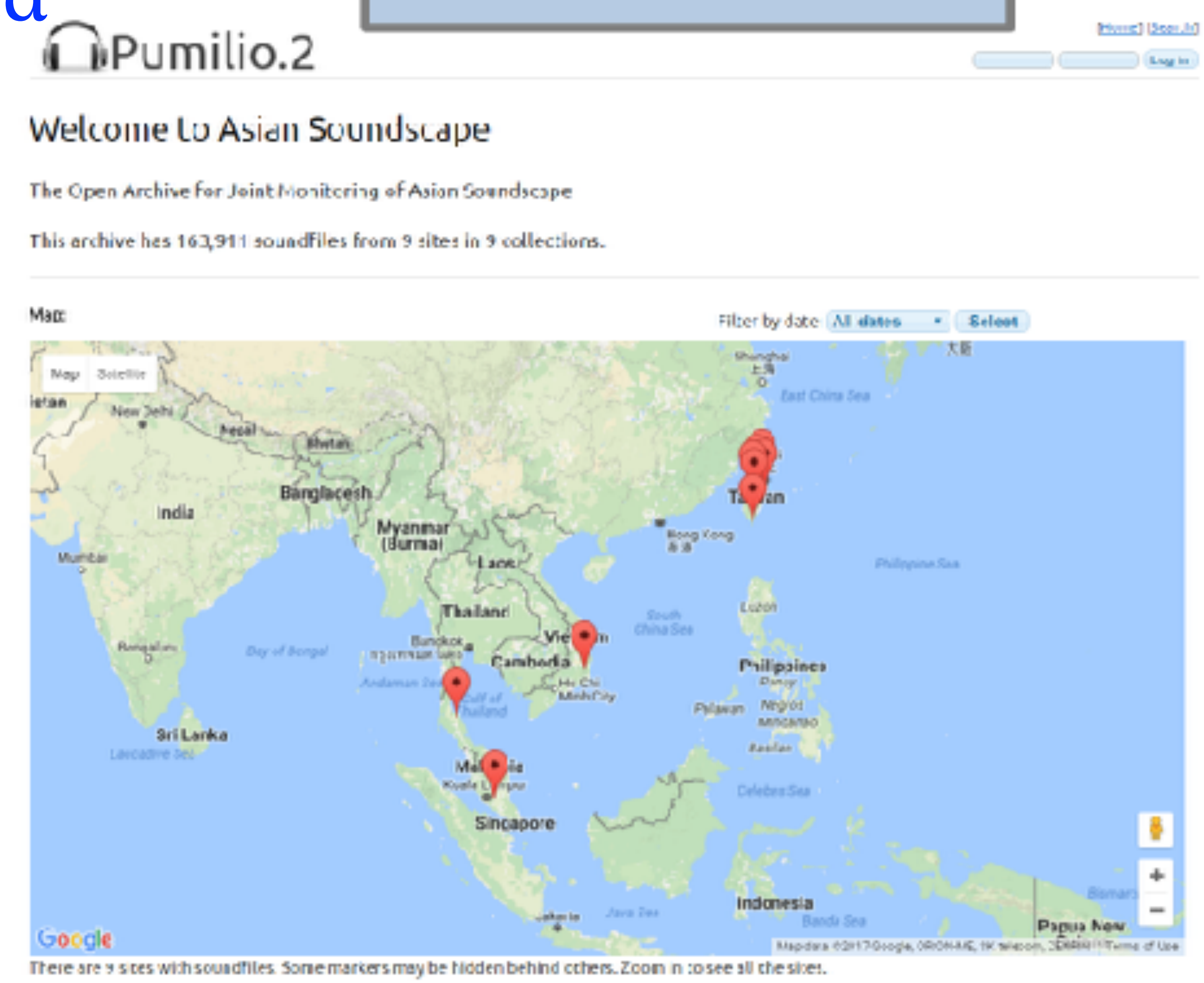
Source: Prof. Huang-Hsiang Hsu (RCEC, AS), EnvComp Works

Collaboration with DRIHM
(Distributed Research Infrastructure for Hydro-Meteorology)



Soundscape Monitoring Network

- To explore dynamics of soundscape
- To evaluate biodiversity change based on biological sounds
- To study the interactions between wildlife, habitat, and human activities based on soundscape data



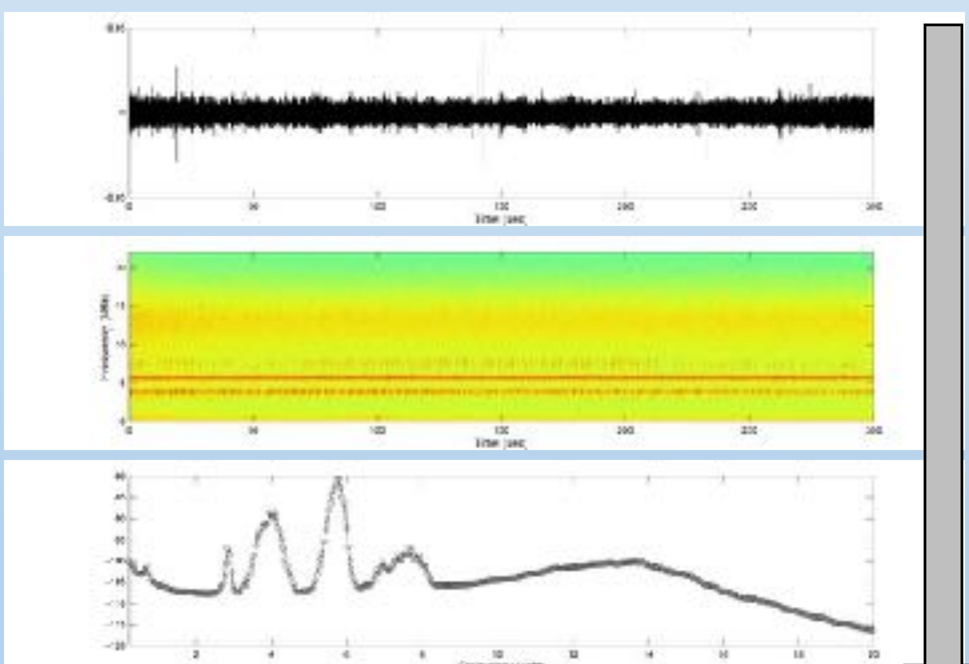
Long-Term Spectral Average

- Long-term spectral average (Welch 1967)
  - Averaged the power spectrum density of each 5-min recording clip
- Other Soundscape Index
  - ACI (Acoustic Complexity Index)(Pieretti, et al. 2011)
  - ADI (Acoustic Diversity Index) (Villanueva-Rivera et al. 2011)
  - BAI (Bioacoustic Index) (Boelman, et al. 2007)

Waveform

Spectrogram

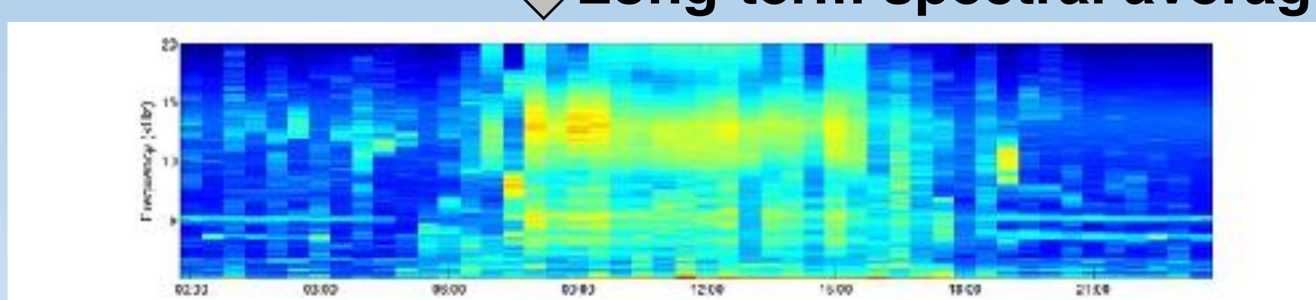
Mean PSD



FFT analysis
Hamming window
1024 samples, no overlap
Frequency resolution: 43 Hz

Average &
Log transform to dB

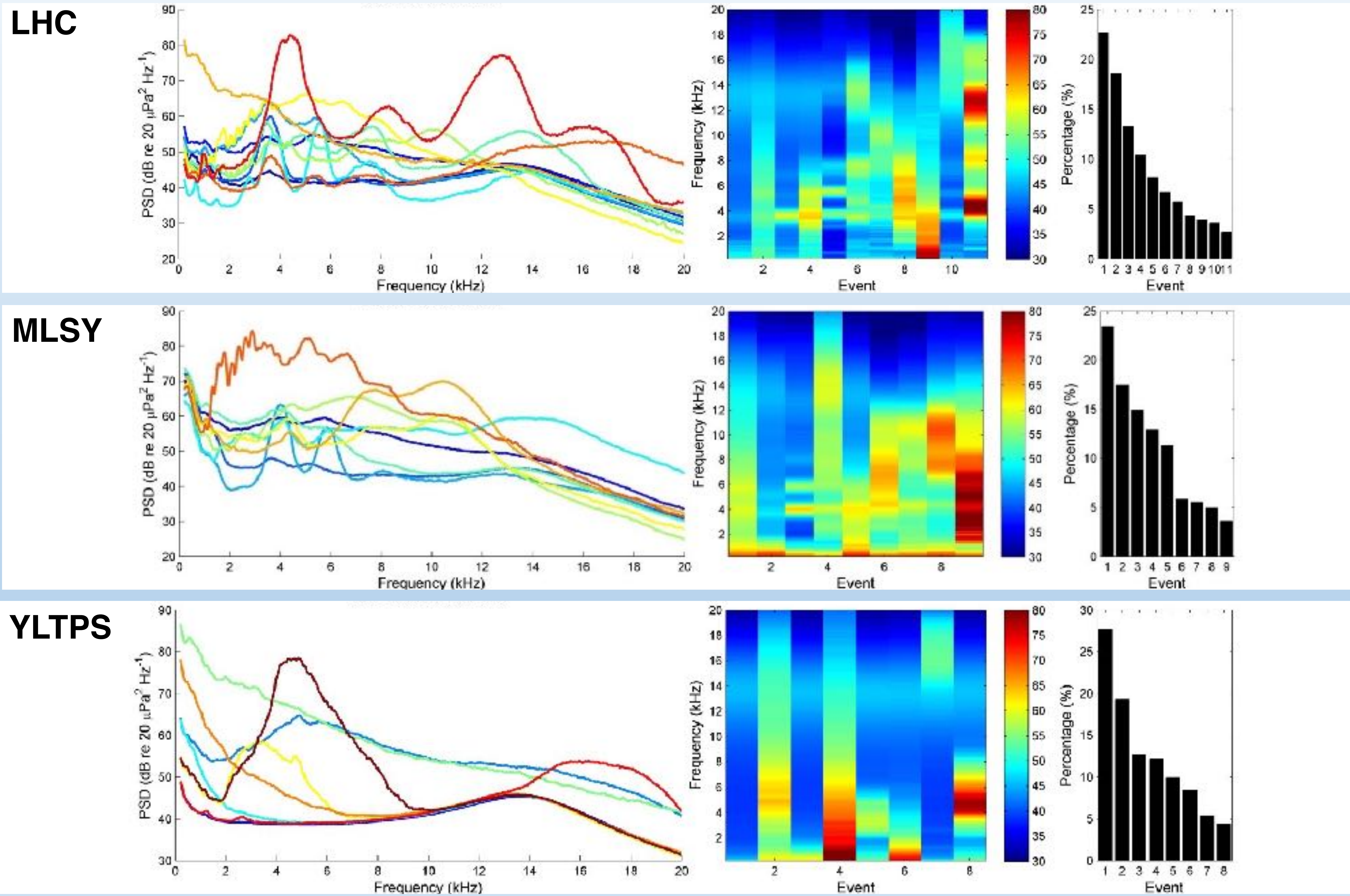
Long-term spectral average



Site Comparison by Soundscape

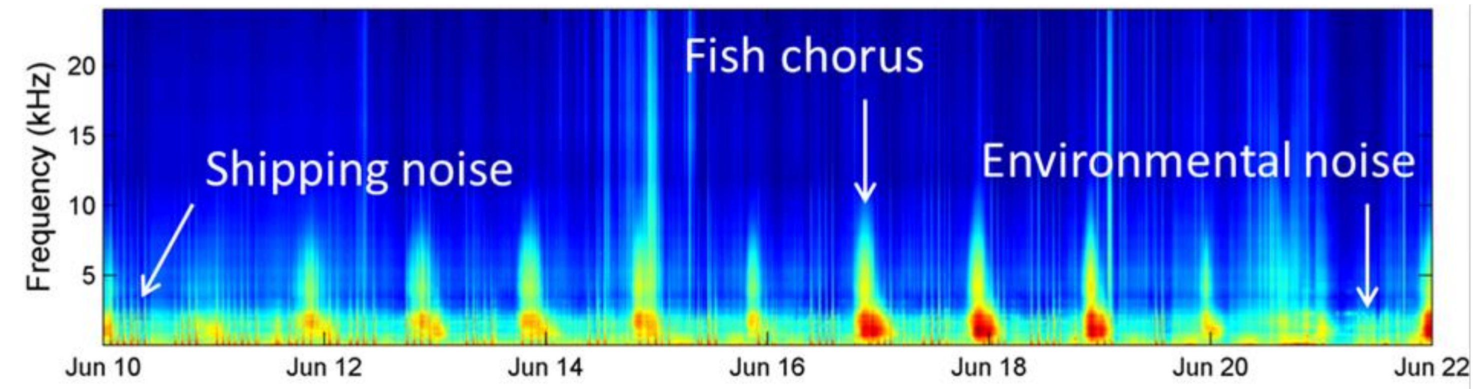
PSD of each event

Probability of each event

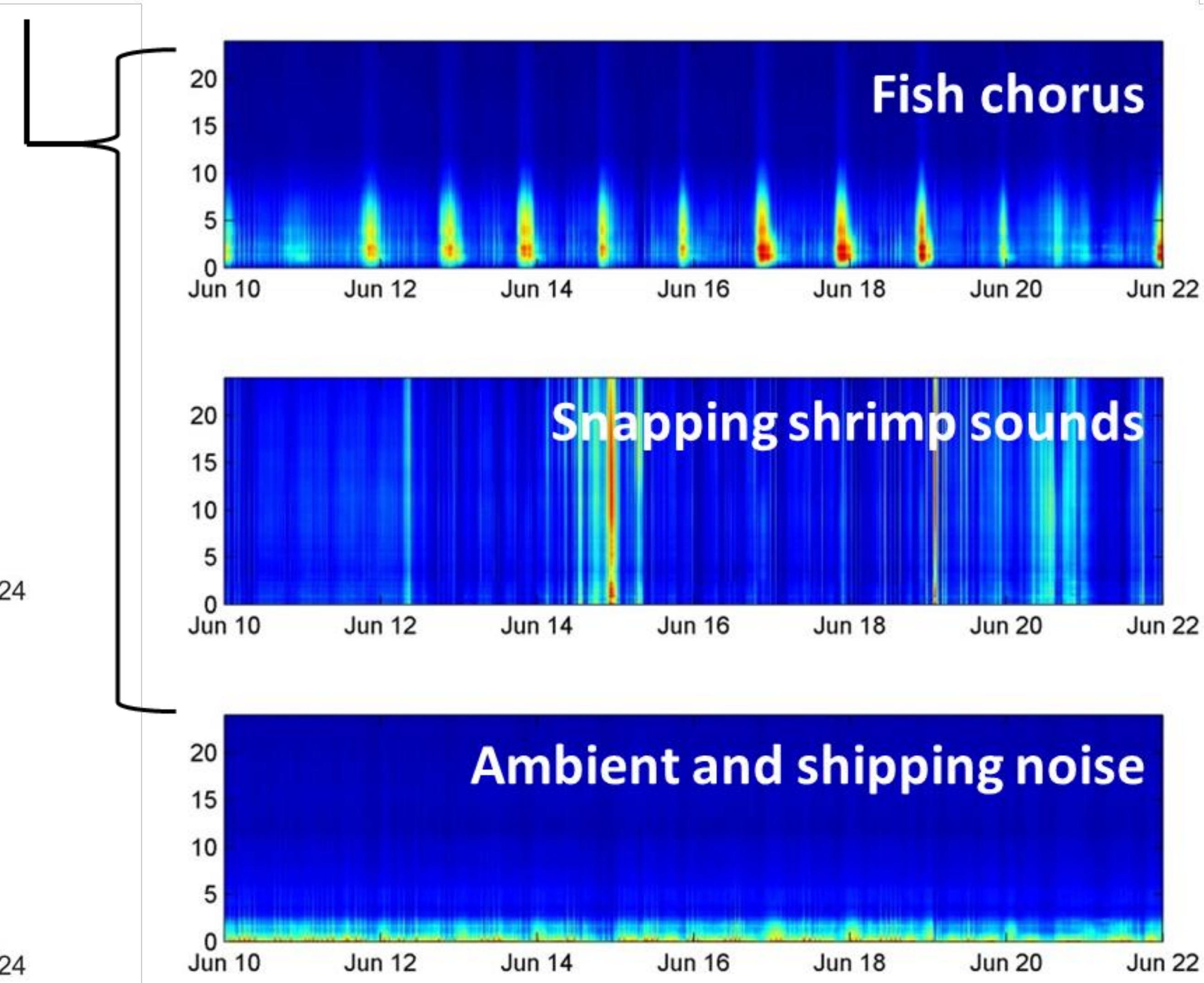


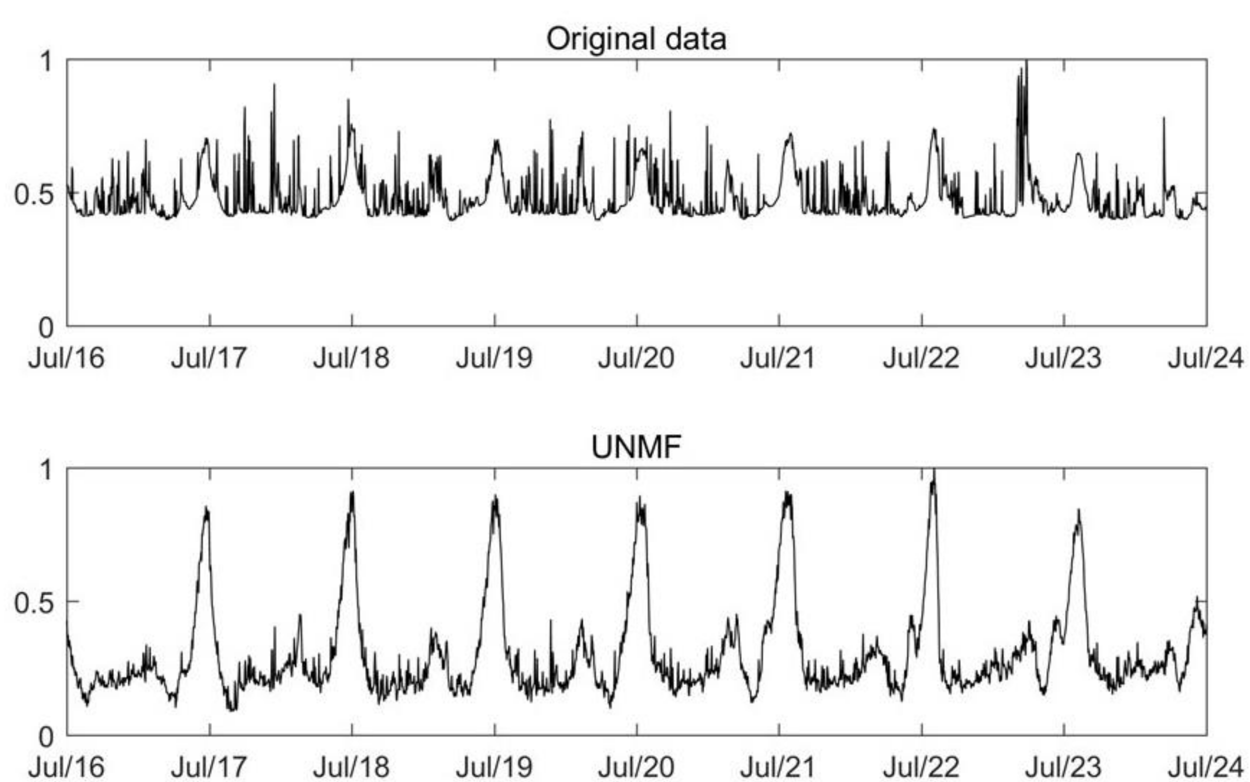
Separation of biological and non-biological sounds

- An general approach for evaluating the complexity of soundscape

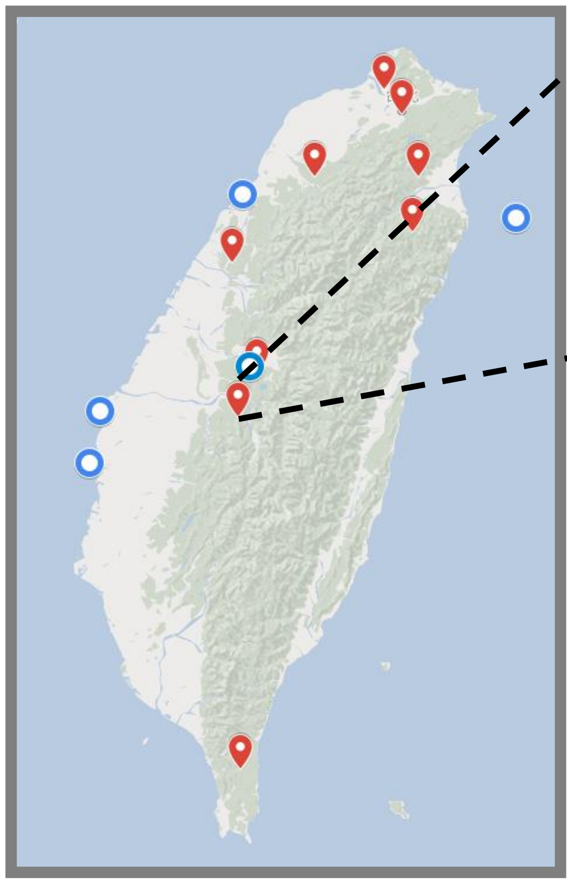


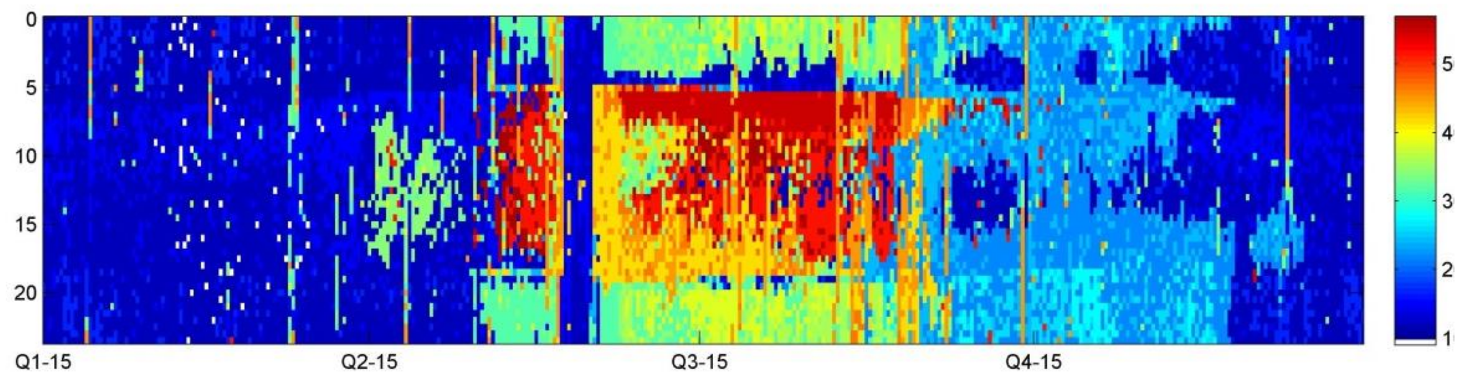
- Enhance signal quality



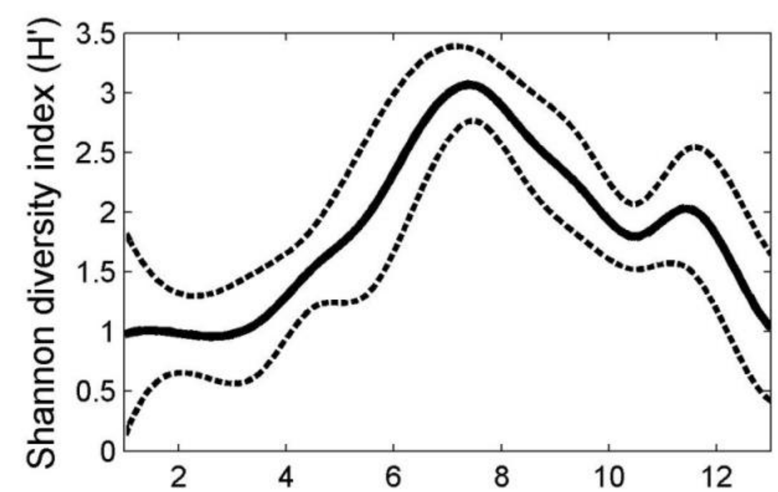


Temporal and spatial change of biodiversity



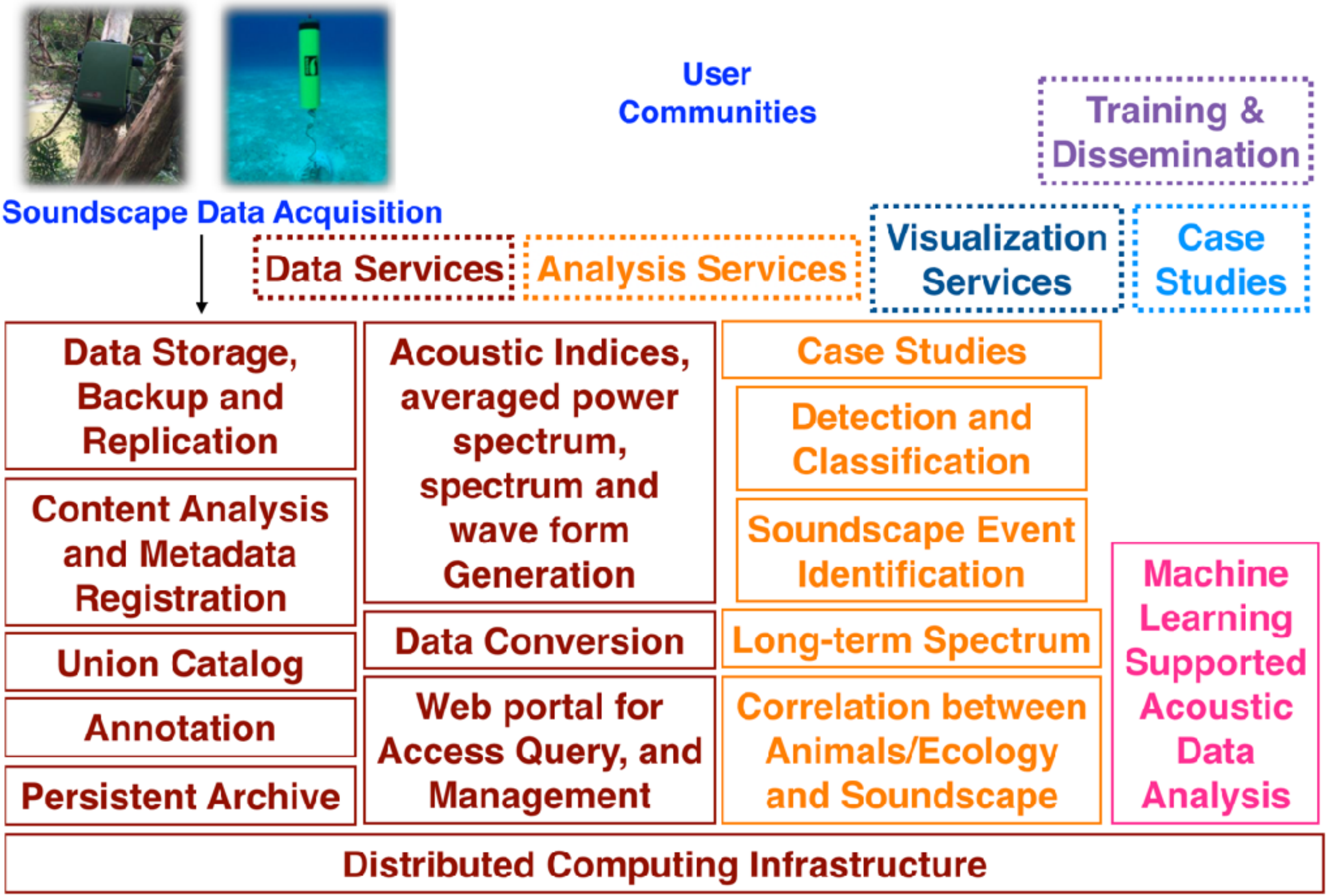


- Geophony
- Anthrophony
- **Biophony**



Estimate the biodiversity change according to the complexity of biophony

Open Science Platform for Soundscape Research Network



Regional Infrastructure

- Regional Cloud Federation based on Grid-based distributed infrastructure: EUAsia VO
  - Web portal will make use of available resources from TW (256+ CPU cores) for the moment. MY is working soon. PH and ID will join later.
  - Workflow of selected case studies are implemented by the Web portal
  - Generic Web portal will be open for EGI
    - iCOMCOT is ready
    - gWRF is validated by user communities
  - Supporting all cases by the same infrastructure
- Application Portals
  - Tsunami wave propagation simulation portal (iCOMCOT):
    - https://icomcot.twgrid.org
  - WRF portal: both Web portal and CLI will be provided
    - https://gwrf.twgrid.org
- Next Generation Cloud and EGI Integration
  - Integration with EGI: Ongoing
  - EGI Federated Cloud testbed and integration: Ongoing

Disaster Mitigation

Collaborations & Outreach

Team up the user communities, service providers and technology providers not just in Asia

- EGI and EC Projects
- Asia Pacific Advanced Network: 2 meetings a year
- International Symposium on Grid and Cloud (ISGC)
  - http://event.twgrid.org/isgc2016/
- Environmental Computing Workshop
  - Collocated at ISGC 2016, https://indico4.twgrid.org/indico/event/1/session/2/?slotId=8#20160313
  - Next one will be at ISGC 2017
- DRIHM
- Remote Sensing
- Biodiversity and Ecological Monitoring Communities

Disaster Mitigation

Collaboration with DRIHM

(Distributed Research Infrastructure for Hydro-Meteorology)

- Test Case on DRIHM Gateway: Typhoon Haiyan
- Opportunities
  - Leverage WRF Web Portal Services without duplicate efforts
  - Will make use of regional infrastructure
  - Collaborate on modeling and high performance simulation by e-Science for disaster mitigation
  - Extend collaborations, services and infrastructure to wider regions
- Virtual meeting will be held for further discussions on case study, WRF portal integration, etc.

Future Meetings and Events

- Environmental Computing Workshop in ISGC 2017 on March 6
- DMCC Project Meeting together with APGI meeting in ISGC 2017
- Future Routine Project Meeting (last Tuesday of each month)
  - 16:00 - 17:00, 28 March, 2017
  - 16:00 - 17:00, 25 April, 2017
- EGI Conference 2017 in Catania, Italy on May 9-12, in partnership with INDIGO Summit
- Disaster Mitigation WG Meeting and DMCC face-to-face Meeting at future APAN meetings
  - APAN44 (Dalian, China), Aug. 2017
  - APAN45, Jan/Feb 2018

Summary

- In Collaborations with Scientists + Case Studies + Simulation/Analytics Facilities + Regional Distributed Computing Infrastructure, we have been providing simulation services for early risk estimations of hazards based on deeper understandings of the sciences behind.
- Through APAN, training and knowledge sharing are conducted and the collaborations are further extended.
- Capacity Building for Sustainability Development of Asia Countries is also our Goals
- Driving the Development of Disaster Mitigation by e-Science in Asia Pacific Region and APAN Partner Countries
    - Multi-disciplinary & cross-institutional collaborations, Infrastructure, Simulation facilities, Data & knowledge sharing, etc.
- Building the Open Science Platform on Disaster Mitigation for Asia
- Vision
    - Building Safer Community against Natural Disasters by Deeper Understandings and Numerical Simulations (e-Science)
    - Making Things Impossible Possible