Regional Collaborations on Disaster Mitigation by Deeper Understanding Approach

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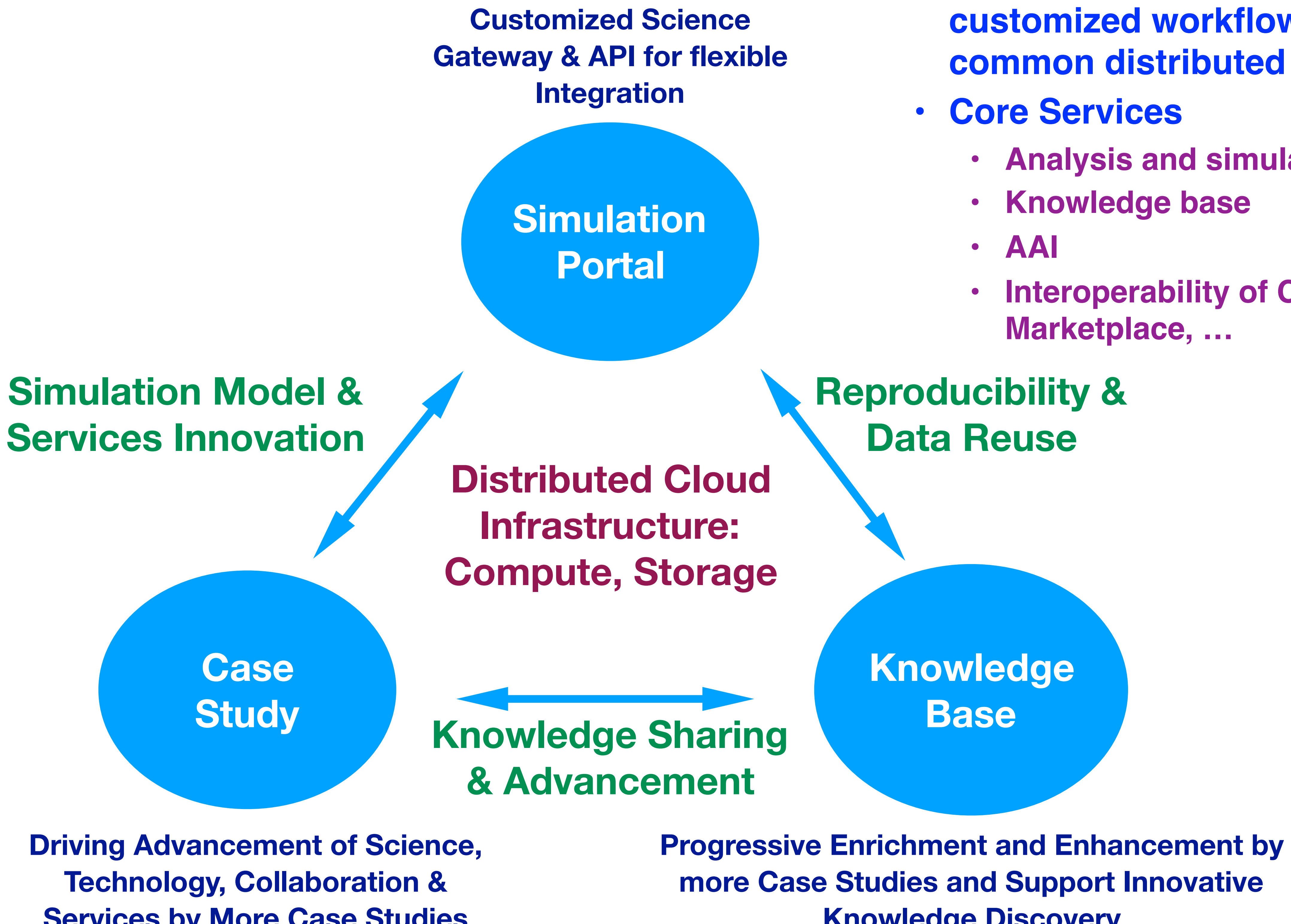
E-Science for the Masses: Deeper Understanding Approach for Disaster Mitigation

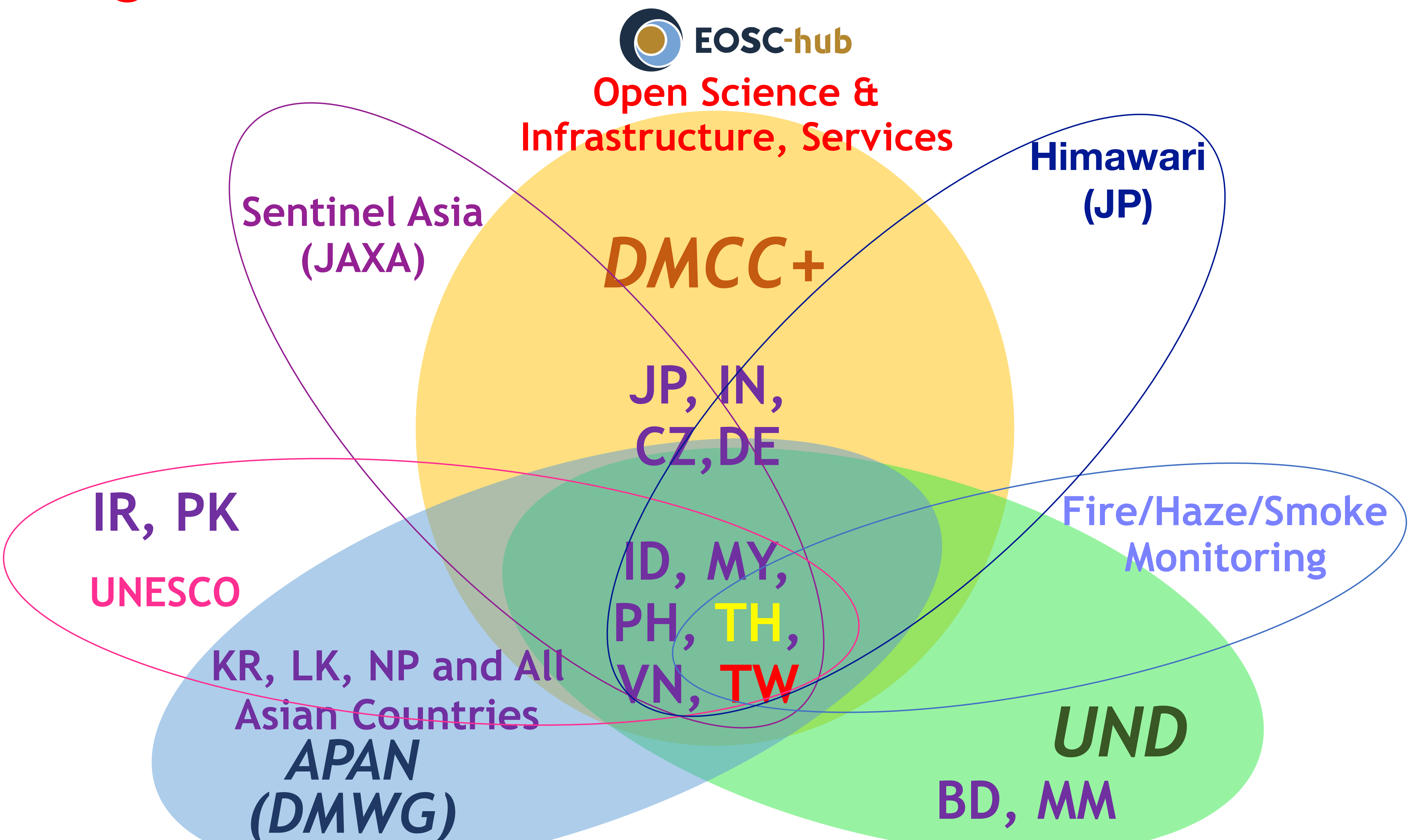
- **Background**
  - “Asia-Pacific is the most disaster-prone region in the world and accounted for almost half the affected people” in 2017 (UN Secretary General Antonio Guterre, 2018)
  - Limited knowledge is the greatest barrier to mitigate disaster impacts
    - Only limited knowledge on drivers and root causes of disaster events
    - Hardly to do experiments to understand the processes of a hazard on the similar scale
    - Limited event cases for study (with enough observation data)
    - Difficult to transform knowledge into simulation facility and share
  - Enhancing the understanding of natural disasters is the best approach to build up a more resilient community and to develop risk reduction approach effectively.
- **Deeper Understanding Approach: by case study, find out the physical mechanisms behind the disaster event, devise innovative simulation model and science gateway, and make the knowledge, data, tools, facility sharable**
  - An Open Collaboration Framework over distributed infrastructure is developed to support accurate event simulation (cover the whole lifespan), data/knowledge management and sharing and to grow progressively with more case studies

Open Collaboration Model for Disaster Mitigation Based on Deeper Understanding & Moving Towards Open Science

- We develop science gateway for each type of hazard based on case study & customized workflows over the common distributed infrastructure
- Core Services
  - Analysis and simulation platform
  - Knowledge base
  - AAI
  - Interoperability of Compute, Storage, Marketplace, …



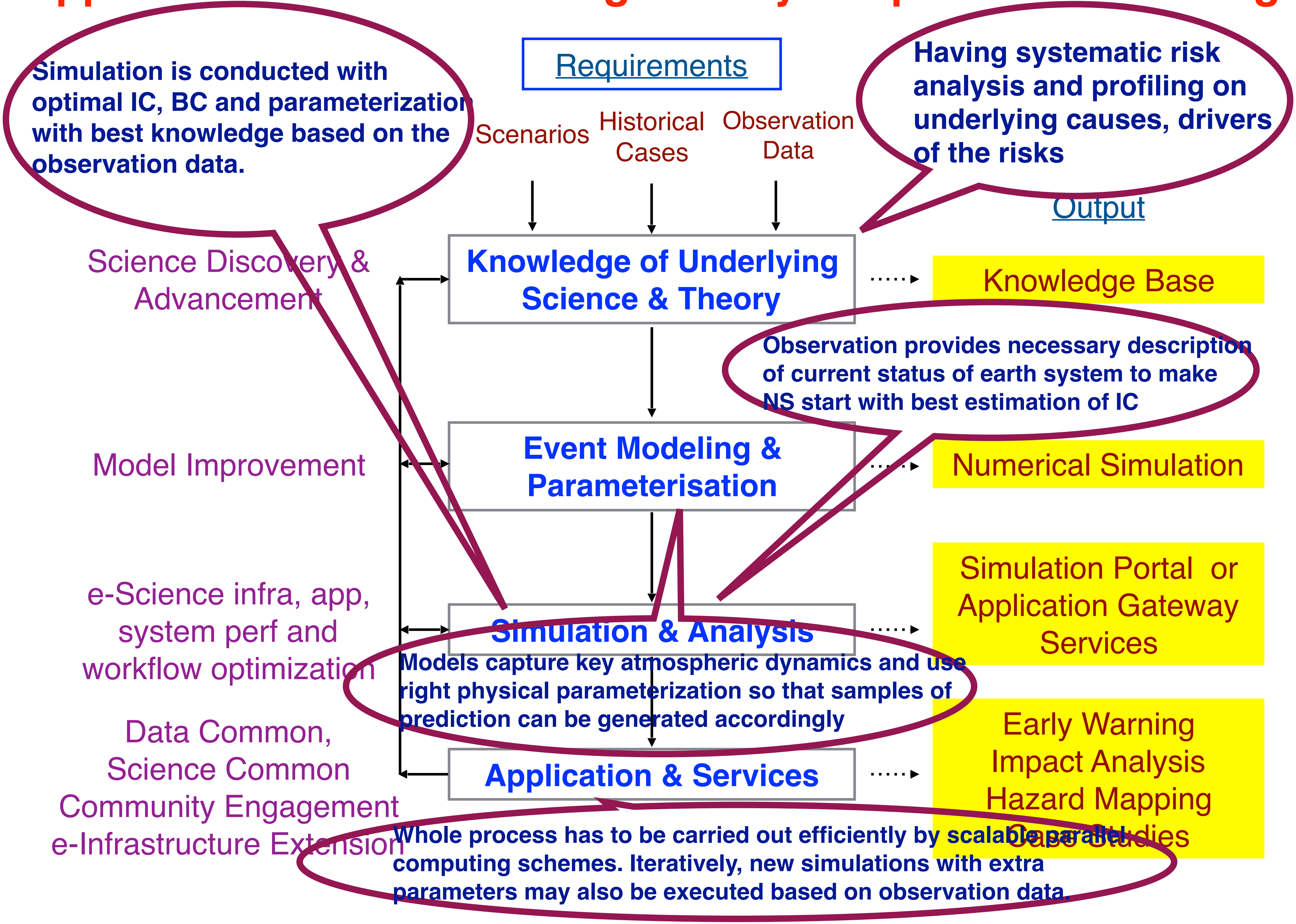
Regional Collaboration Framework: EGI+APAN



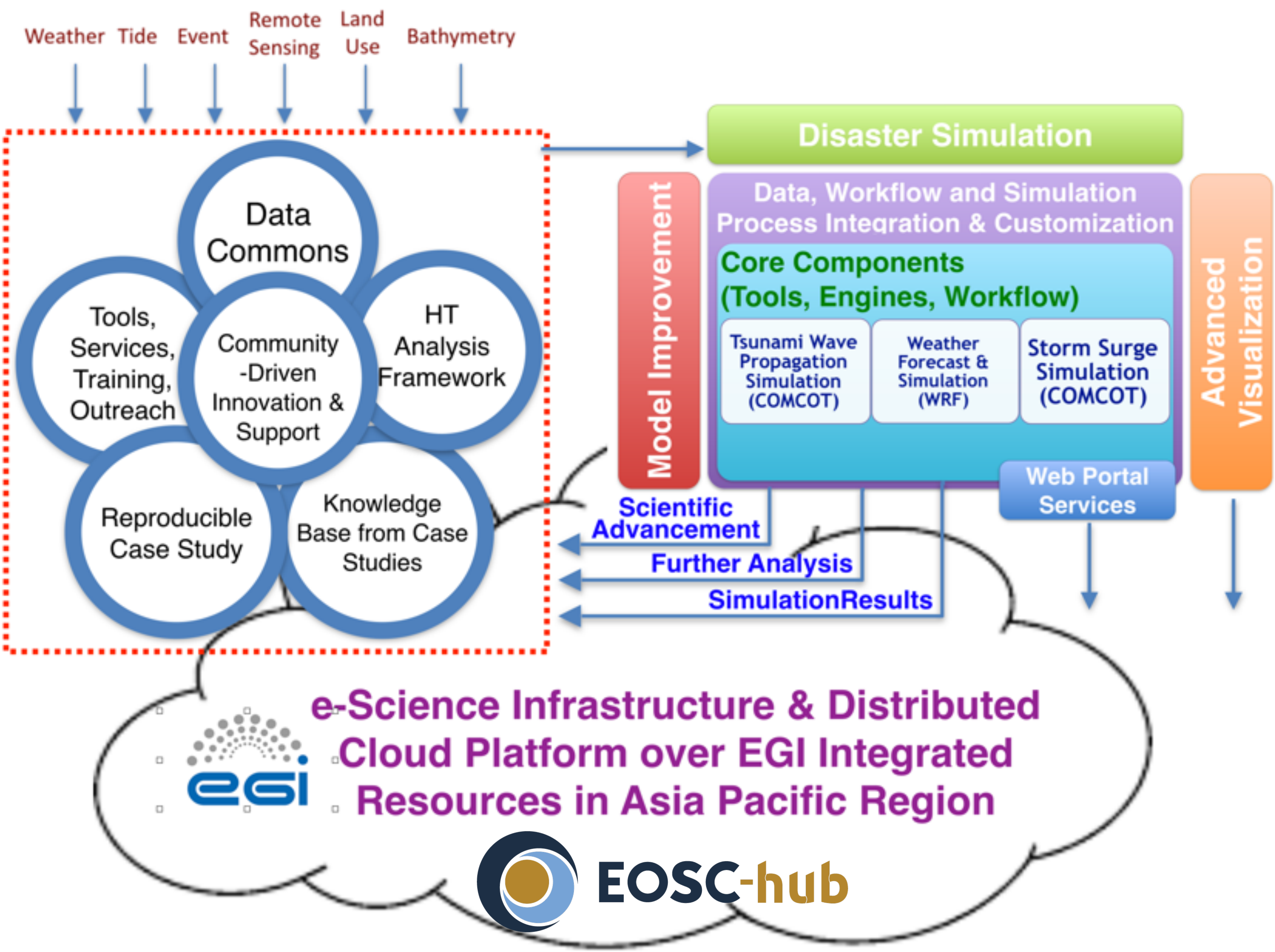
APAN: Enabling adv. R&E applications by networking & collaborations (NREN, Community, Application)

Asi@Connect: Leverage e-Infrastructure for public services by TEIN network

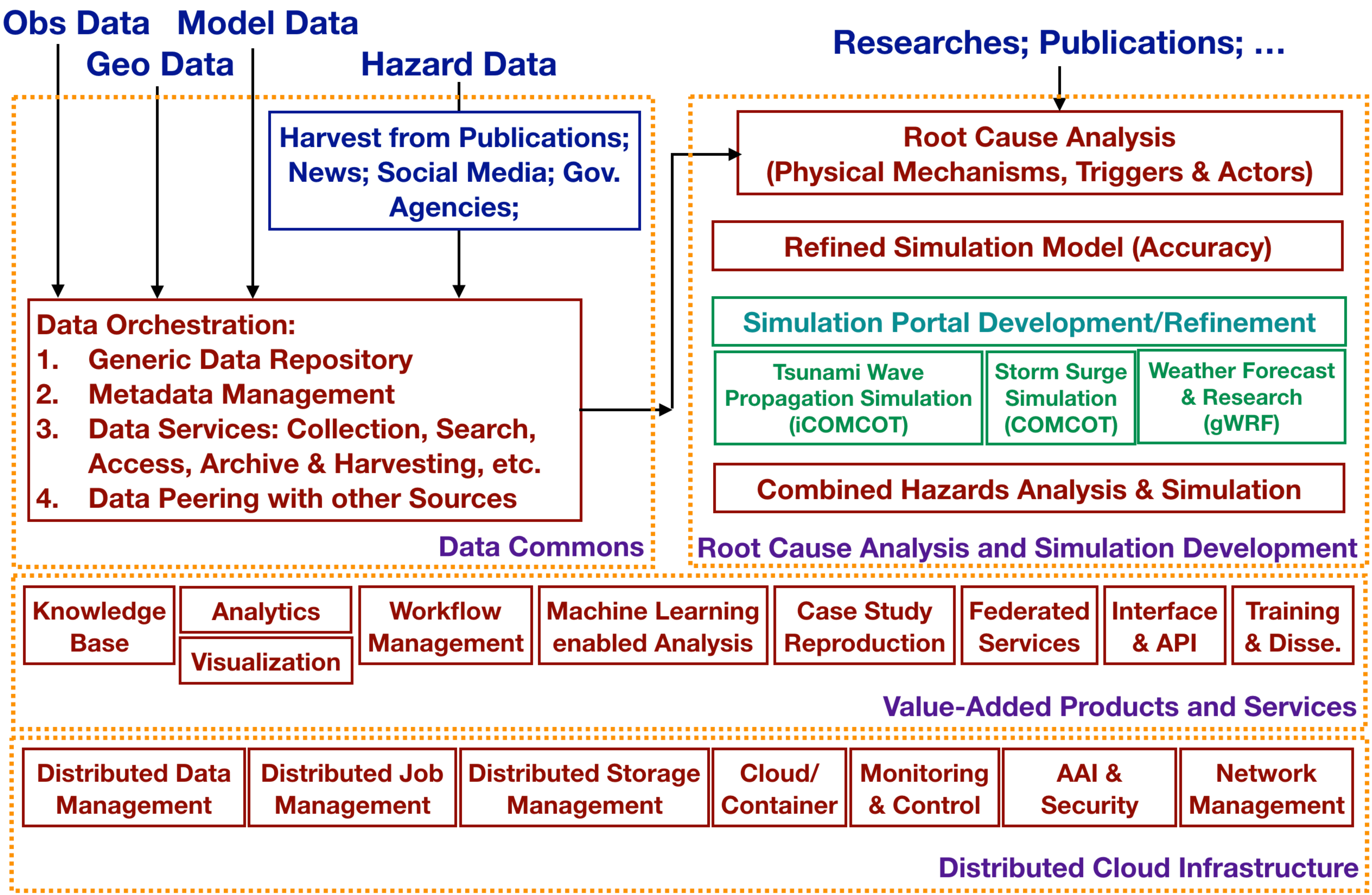
Approaches of Disaster Mitigation by Deeper Understanding



Open Science Platform of DMCC+ (Over Distributed Infrastructure)

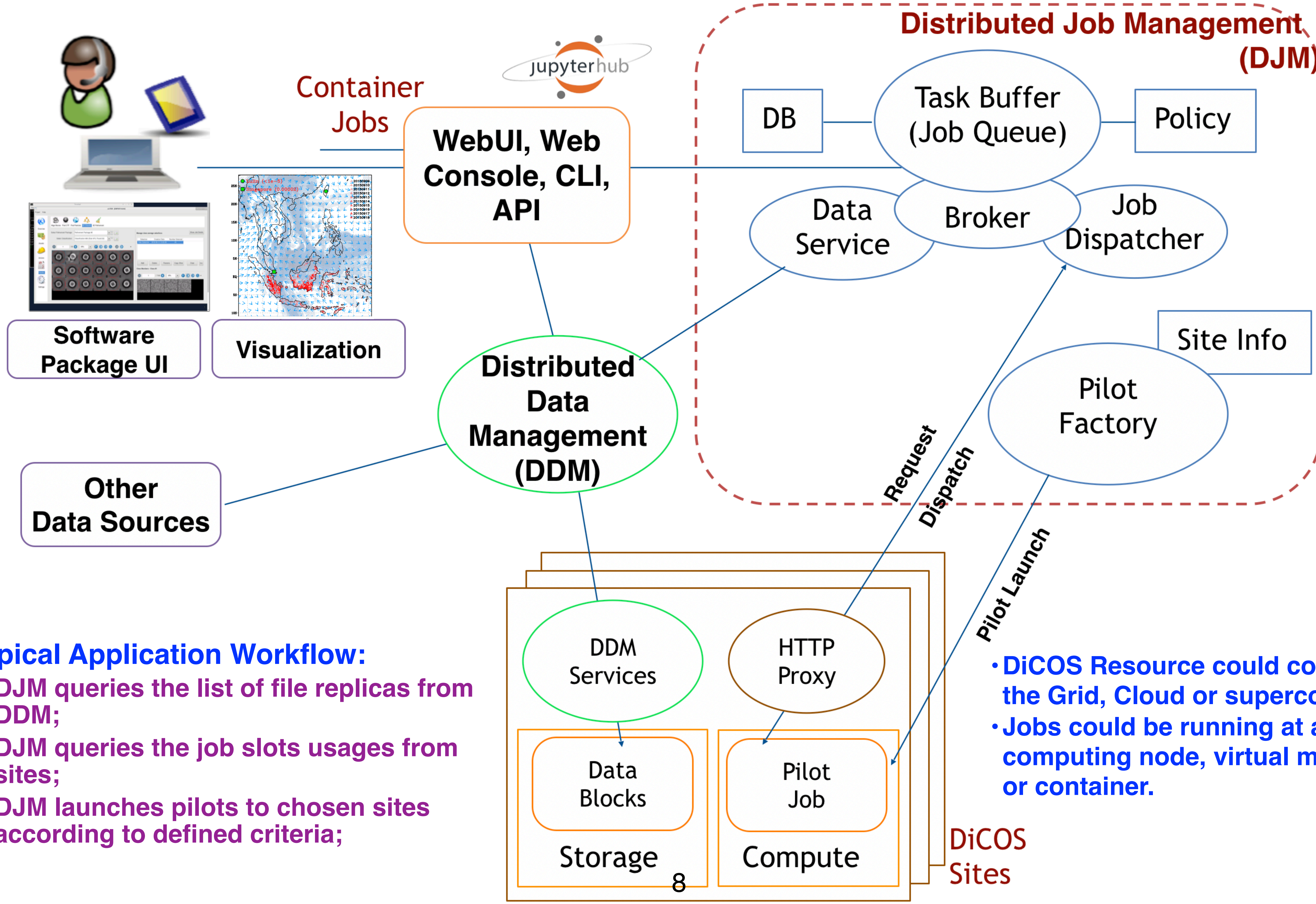


Application Framework Architecture for Deeper Understanding of Natural Disaster



Data Analysis Scenario and Some Core Components of DiCOS

Components are from open source or WLCG collaboration.
They evolve constantly and may be replaced to optimize system operation.
Job is run at the best available site and data is moved transparently



- **Typical Application Workflow:**
  - **DJM queries the list of file replicas from DDM;**
  - **DJM queries the job slots usages from sites;**
  - **DJM launches pilots to chosen sites according to defined criteria;**

- **DiCOS Resource could come from the Grid, Cloud or supercomputer.**
- **Jobs could be running at a computing node, virtual machine, or container.**

Planned Case Studies of DMCC+ & UND

Case Studies	Goal	Duration	Partners & Tasks	Outcome (Science Gateway)
Storm Surge	Accurate modeling and simulation of storm surge by combining atmospheric and oceanic models	Jan'18-Dec'18 Jul'18-Sep'19	PH, TH, TW BD, MM, VN	Storm Surge Simulation Portal
Flood	Accurate modeling and simulation on the weather event of the flood	Jan'18-Jun'19 Jul'18-Nov'19	TH, MY, VN, TW BD, MM	WRF Simulation on extreme weather event
Forest Fire/ Smoke/Haze Impact from Biomass Burning	Accurate modeling and simulation on the dust transportation	Jul'18-Feb'20 Jul'18-Jun'19	TH, ID, TW	WRF Chem Simulation on dust transportation
Tsunami	Tsunami Impact Analysis on Potential Tsunami Sources in South China Sea and Indian Ocean	Mar'18-Feb'20 Jul'18-Jun'19	JP, PH, VN, ID, IN, TH, TW, BD	iCOMCOT-based Simulation Facility
EOSC Service Integration	AAI, OPS, Jupyter, Cloud, Data Management, Storage, …	Mar'18-Jun'20	CZ, TW, …	EOSC-compatible DMCC infrastructure
Regional Infrastructure	Distributed Cloud with container support	Mar'18-Jun'20	All	

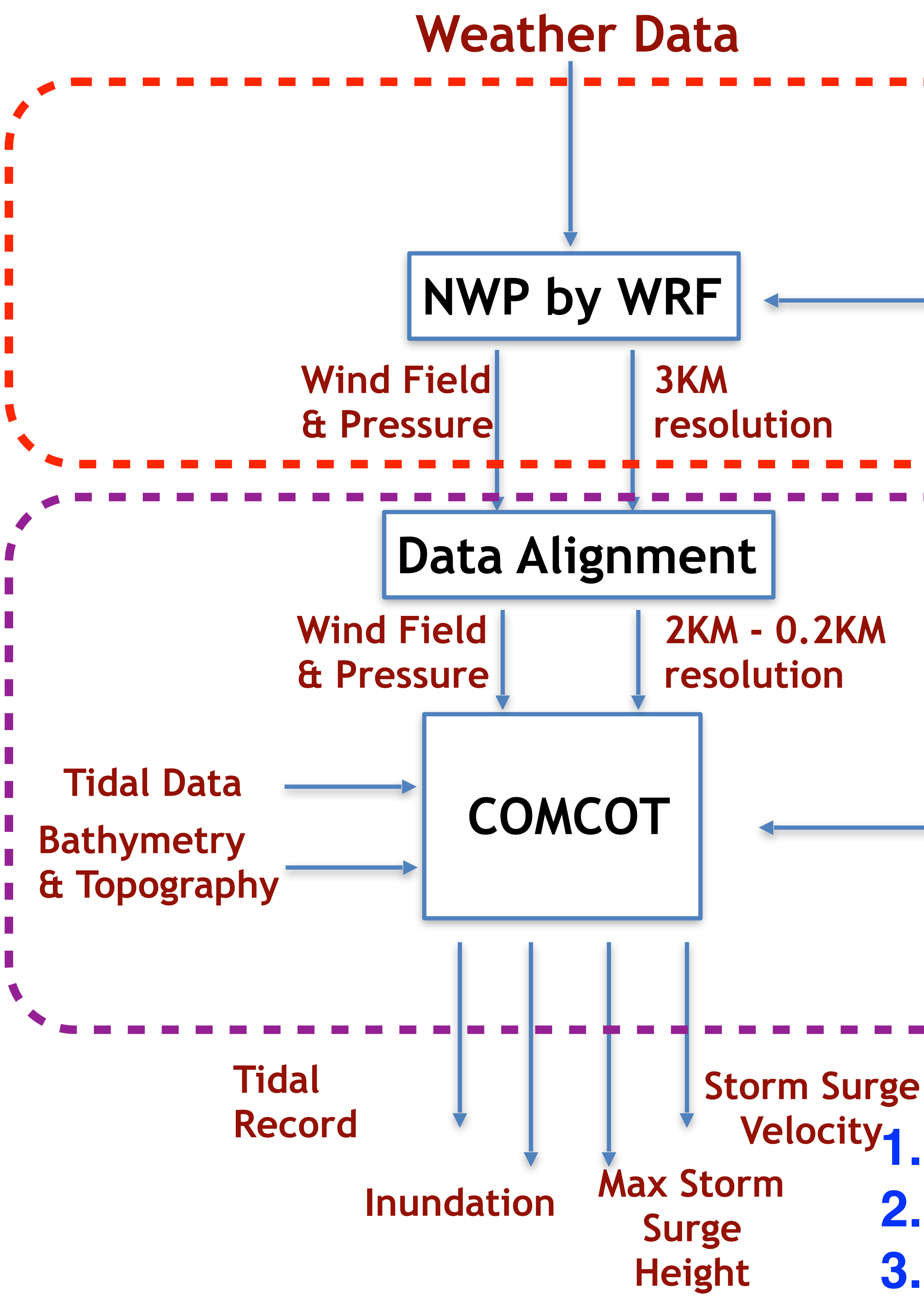
Contributions of Partners (DMCC+ & UND)

Partner	Scientist Group	IT Group	User Support	Regional e-Infrastructure	Case Study
TW	Lead	Lead	Lead	Lead	All
BD	Co-Lead (Flood)		X		Flood, Storm Surge
ID	Co-Lead (Forest Fire/smoke/haze Monitoring & Dust Transportation)	X	X		Earthquake, Forest Fire/smoke/haze, Dust Transportation, Tsunami, Storm Surge
MM	X		Co-Lead (Dissem. & Training)		Storm Surge, Flood, Typhoon
MY	X		X	Co-Lead (e-Infrastructure)	Flood
PH	Co-Lead (Tsunami, Storm Surge)	X	X		Tsunami, Storm Surge
TH	Lead (Forest Fire/ smoke/haze Monitoring & Dust Transportation)	X	Lead (Forest Fire Monitoring/smoke/ haze & Dust Transportation)		Forest Fire/smoke/ haze , Dust Transportation, Tsunami, Storm Surge, Flood
VN	X	X	Co-Lead (Dissem. & Training)		Tsunami, Storm Surge

Finished Case Studies

- Super Typhoon Haiyan (The Philippines, 2013)
  - Contributions: accurate super typhoon simulation and accurate storm surge simulation
  - Fundamental challenge on super typhoon Haiyan simulation is the insufficient wind intensity and lowest pressure.
    - Need to combine atmospheric model and oceanic model together
    - Initial and boundary conditions as well as dynamics of typhoon circulation and their interactions with terrain are keys to accurately estimate the future behaviors of typhoon.
- Tsunami 2004 in Banda Aceh and 2011 Tohoku Earthquake and Tsunami
  - COMCOT model for tsunami wave propagation simulation is verified

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



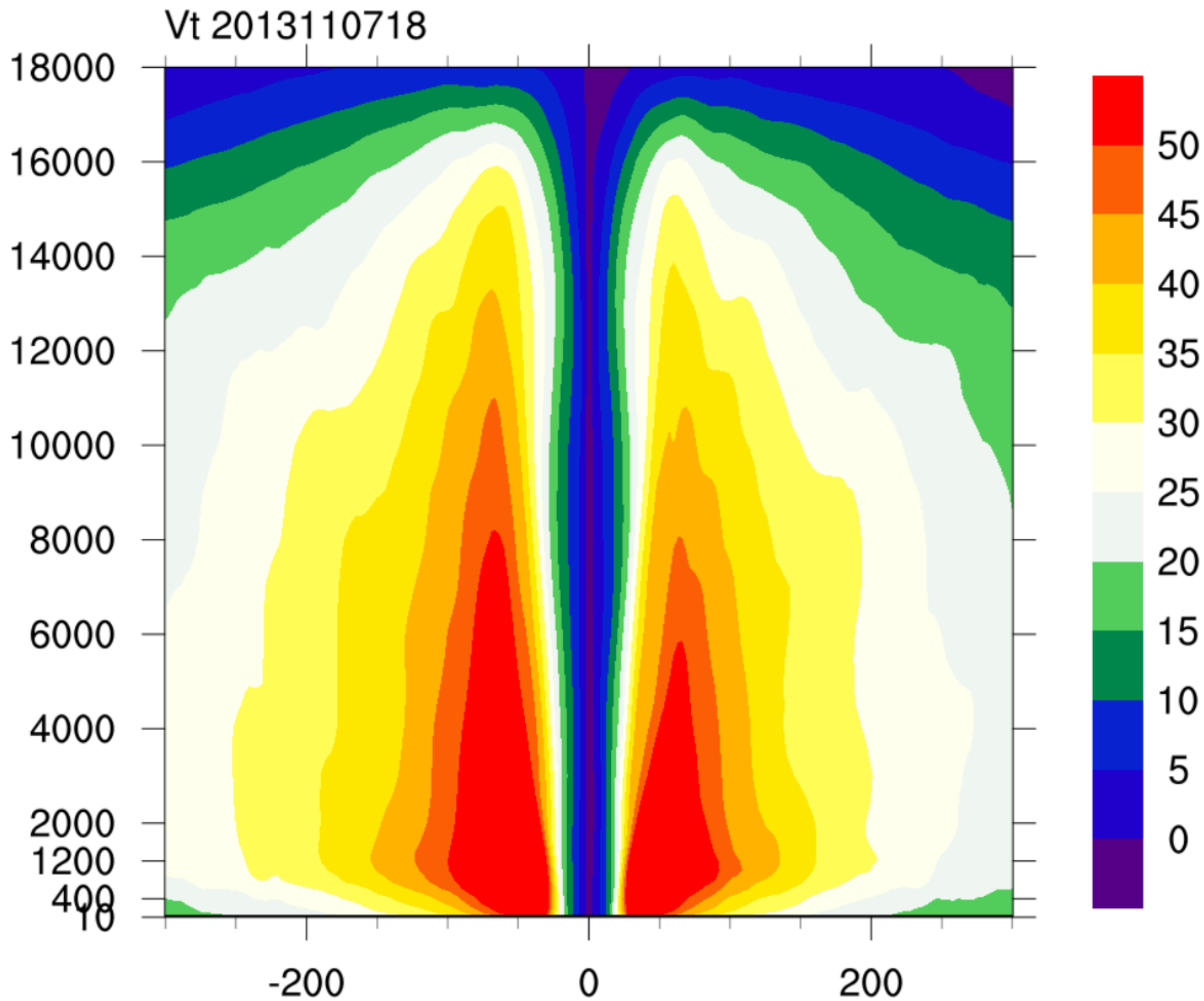
- Adopt the large computational domain to cover the complete typhoon life cycle and full storm surge propagation.
- Couple COMCOT with the dynamic atmospheric WRF model.
- Couple with the global TPXO tidal model.
- Calculate high-resolution storm surge inundation.
- High-speed calculation for the operational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

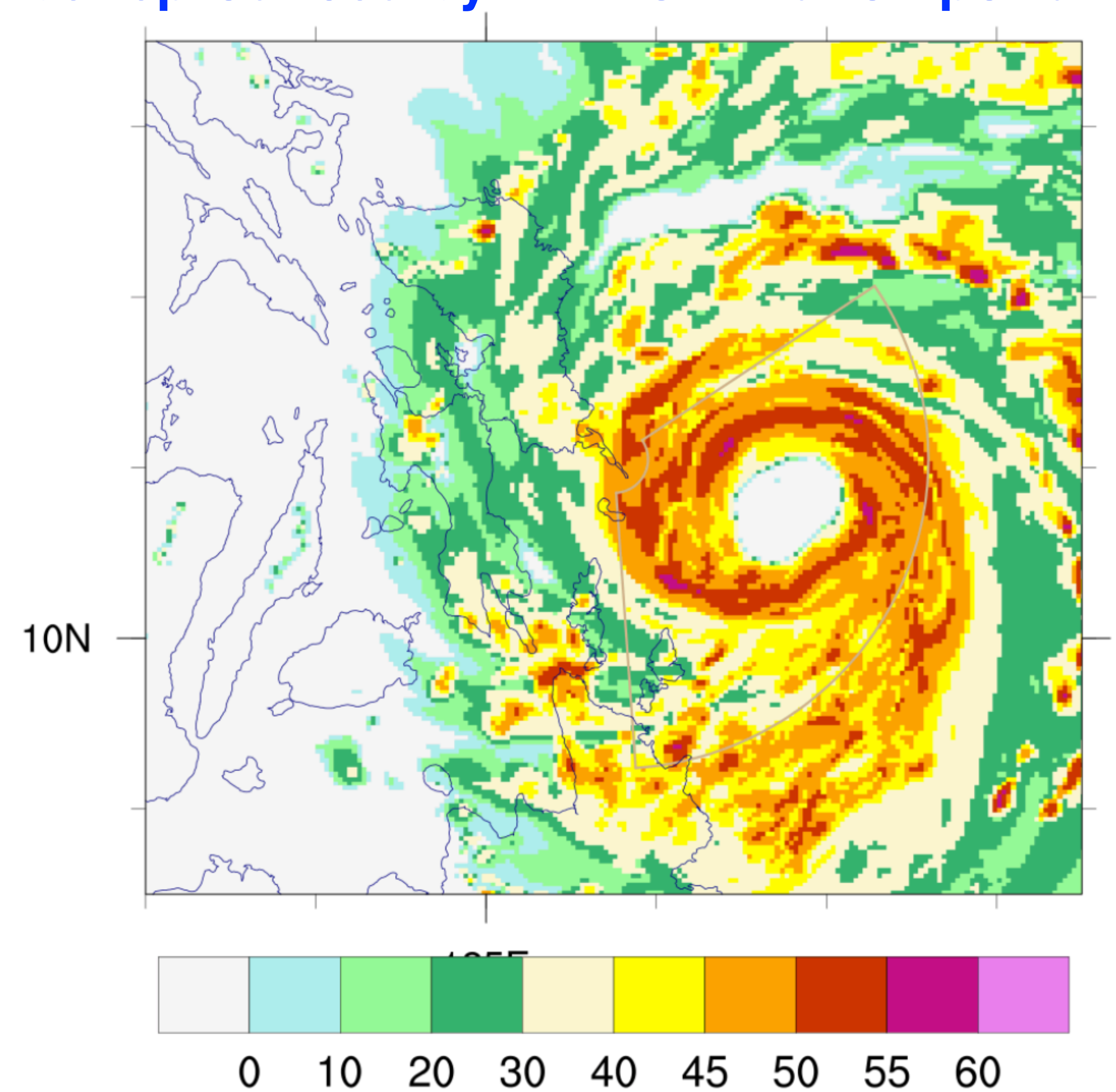
Applications

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

Improved Vertical Wind Field Structure and Eyewall Contraction for Typhoon Haiyan

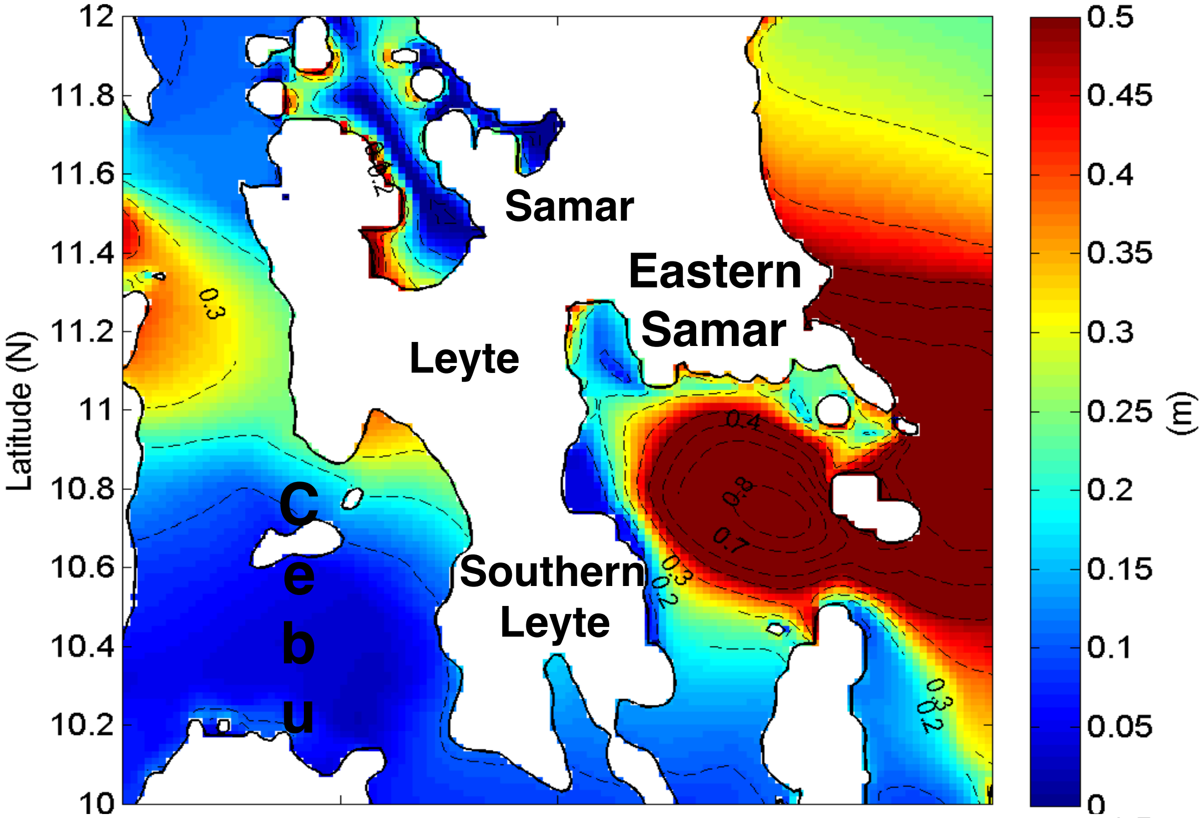
- By increasing horizontal resolution to 3KM, we could better capture thermal dynamics of typhoon, especially eyeball contraction.
- Simulation problems of insufficient strongest wind speed and lowest pressure of typhoon Haiyan are resolved: By means of realistic characterization of interactions between atmospheric and oceanic layers as well as land-sea interfaces, we achieved more accurate surface flux parameterization
- Entire lifetime of typhoon Haiyan is then able to be reproduced by WRF simulation portal

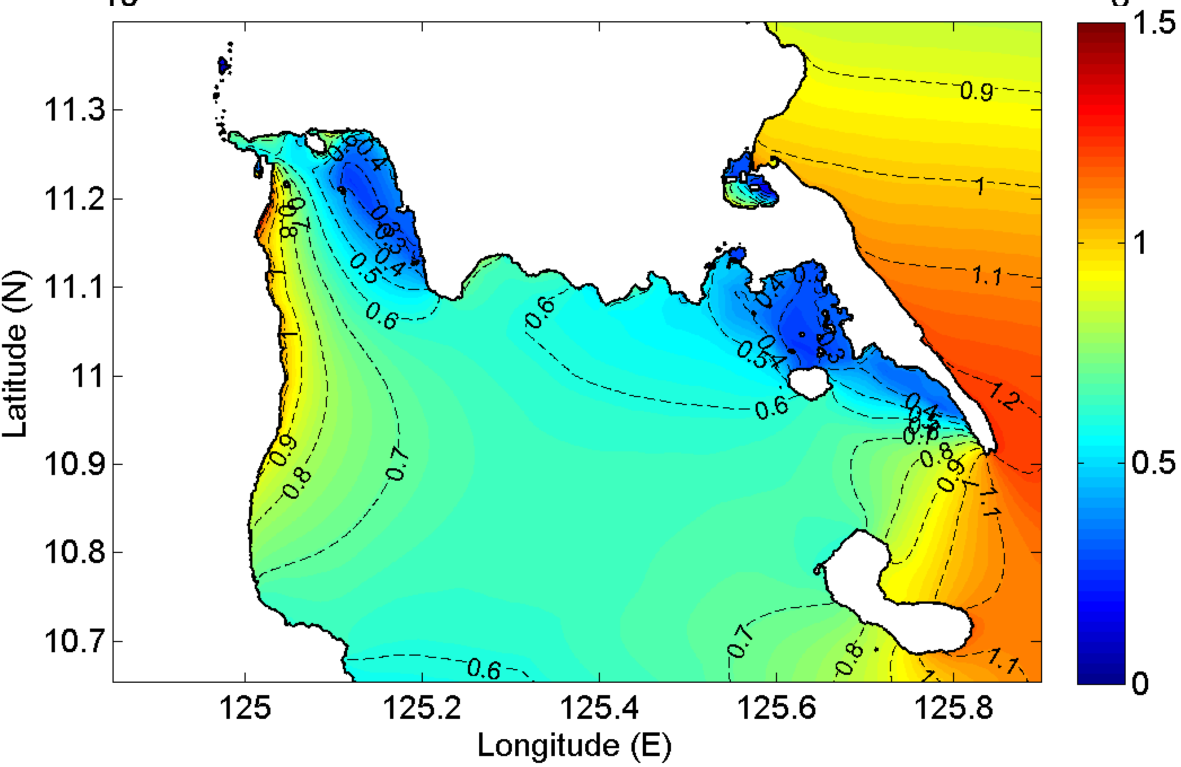


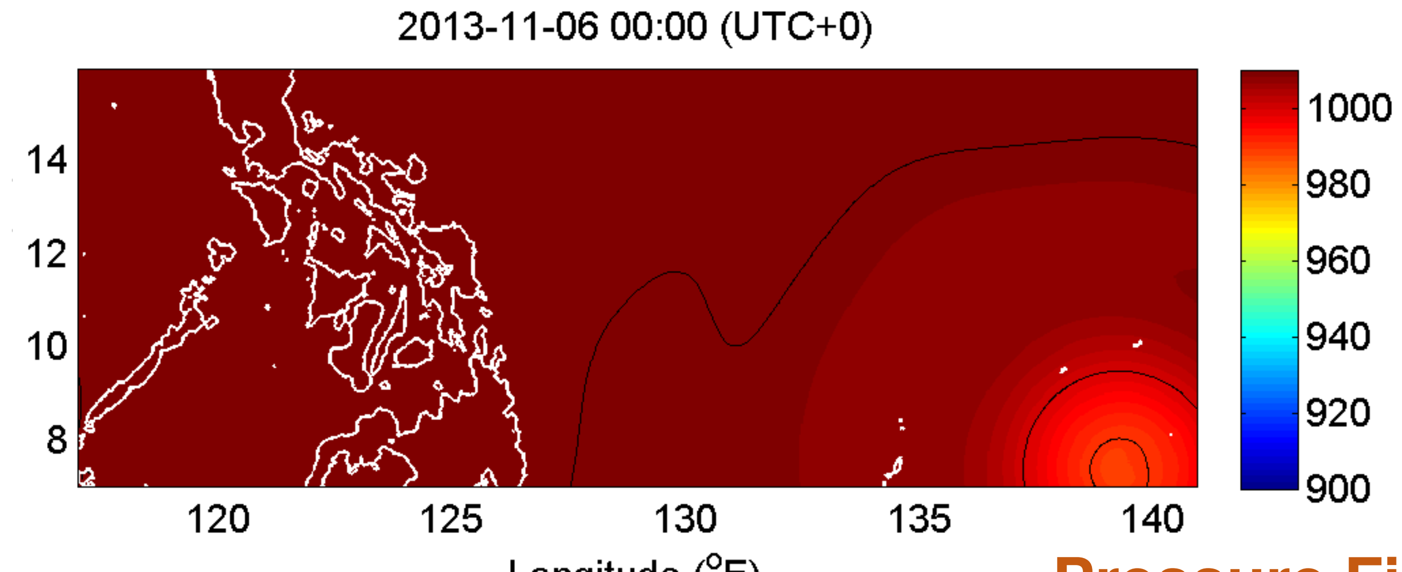


Storm Surge Modeling on 2013 Typhoon Haiyan by Coupling Ocean and Atmospheric WRF Model

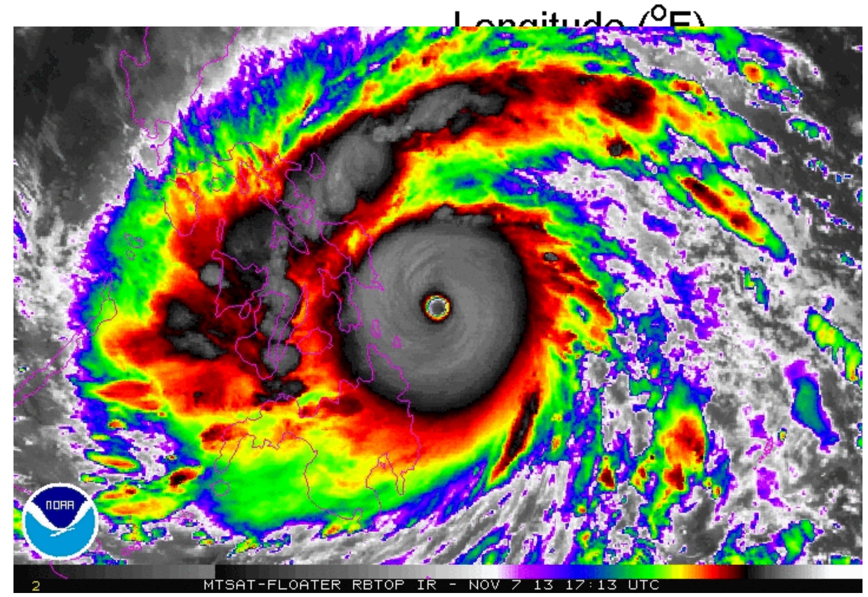
Offshore Storm Surge Inundation Induced by Typhoon Haiyan





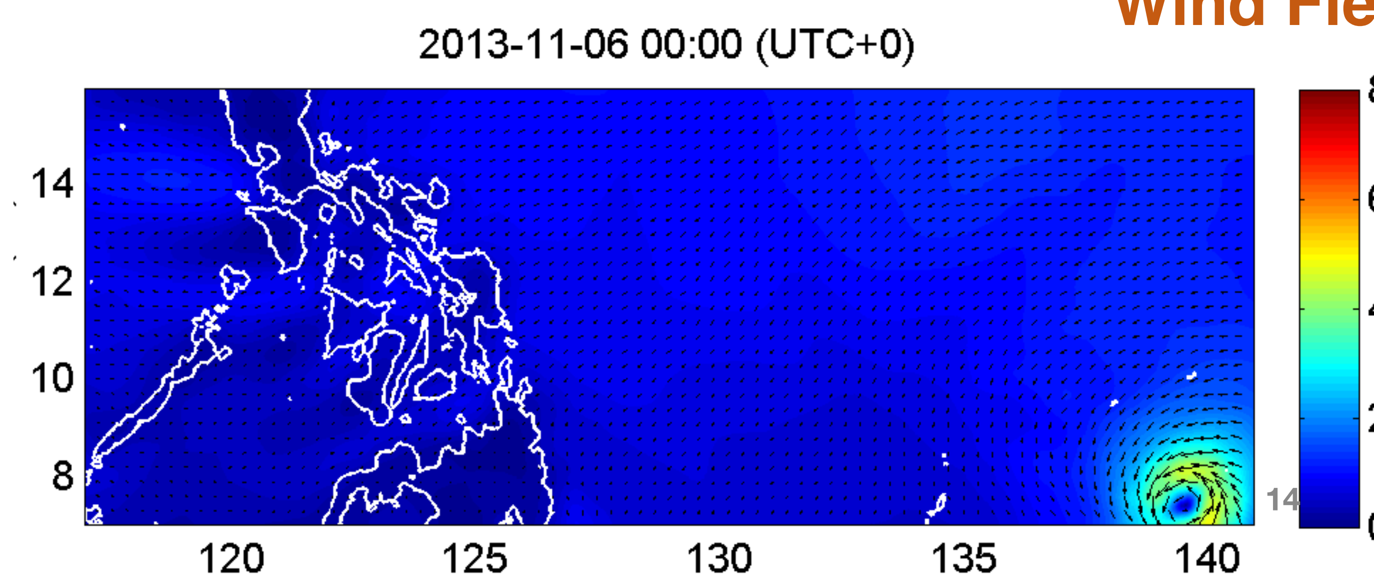


Pressure Field



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

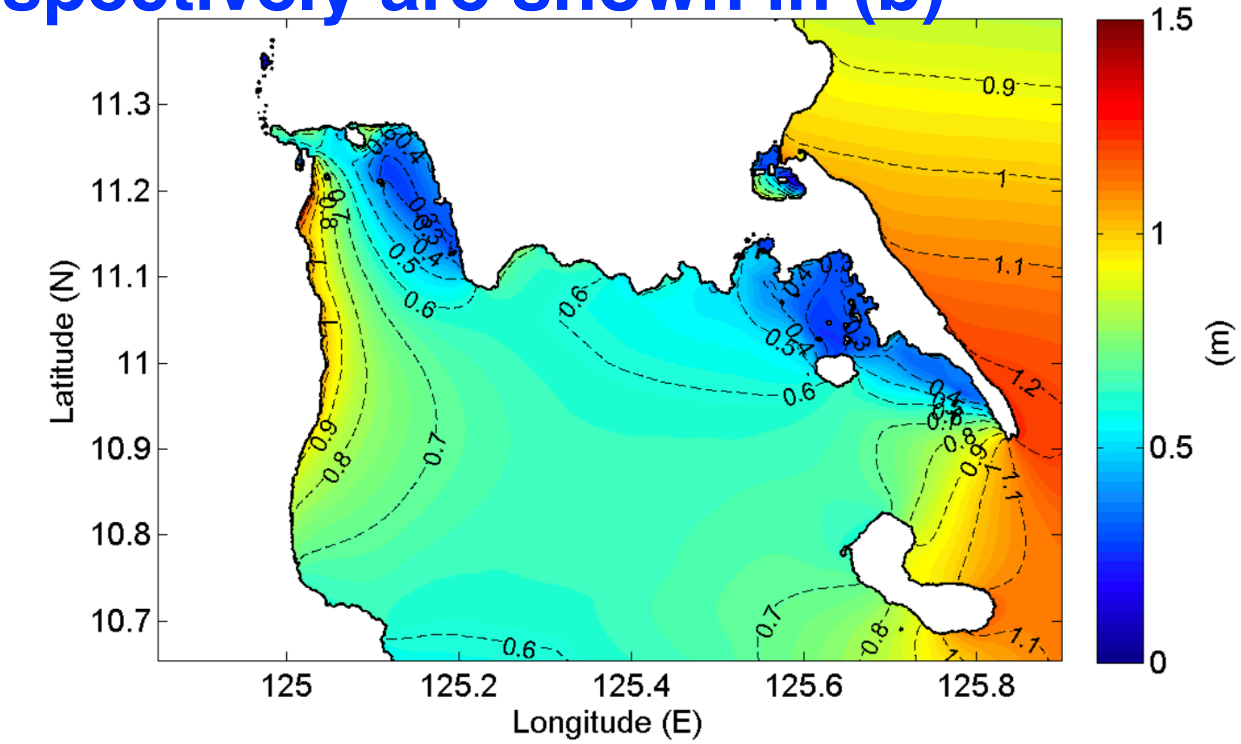
Wind Field



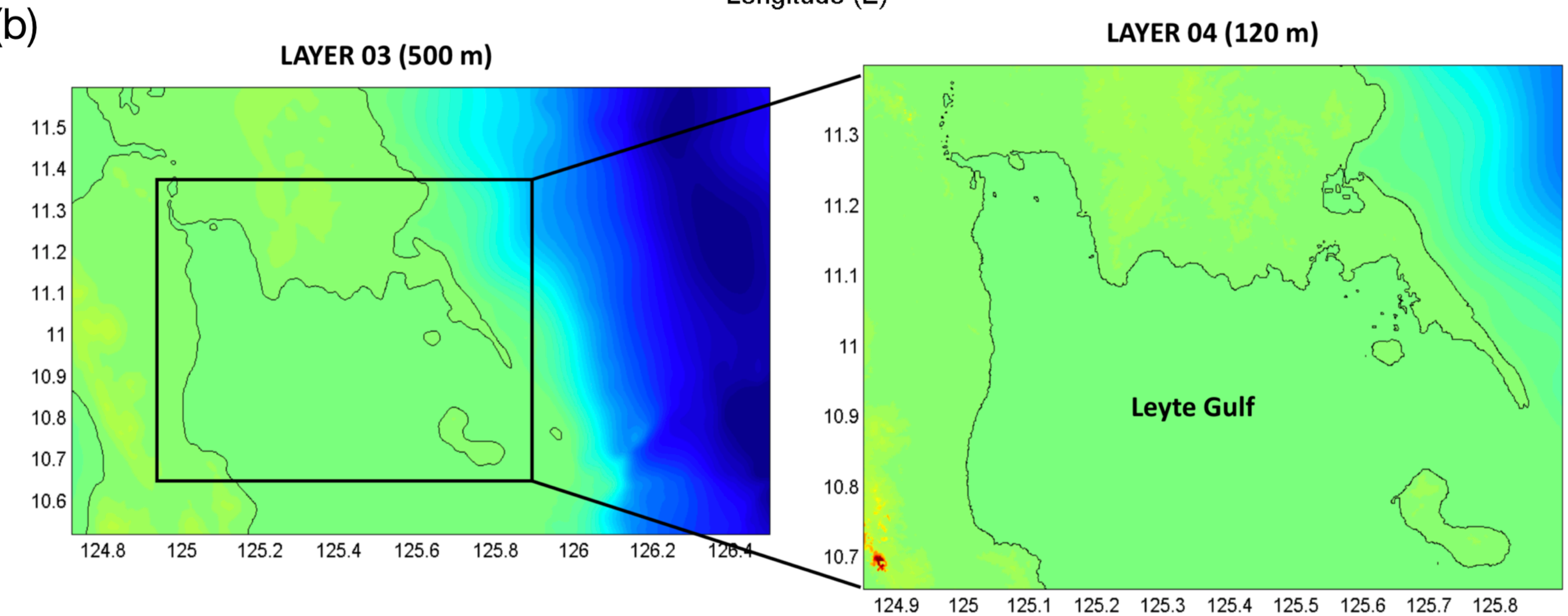
Simulated Impacts of Storm Surge Induced by Typhoon Haiyan

- **Results of the simulated maximum storm tides at Leyte Gulf by the COMCOT-Surge in the collaboration framework is showed in (a)**
- **Two highest resolution layers of computational domain which cover the storm surge propagations in offshore and nearshore regions in 500m and 120m resolution respectively are shown in (b)**

(a)



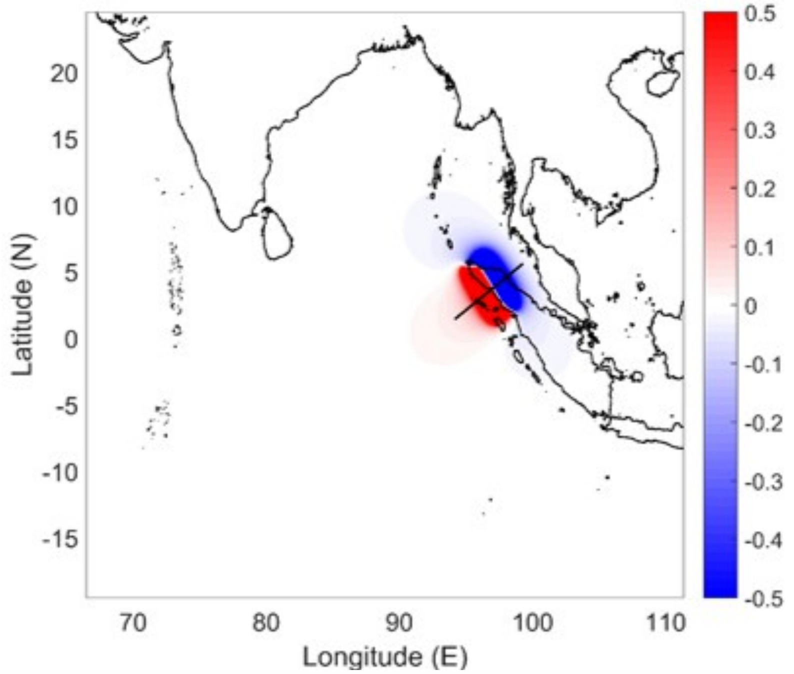
(b)

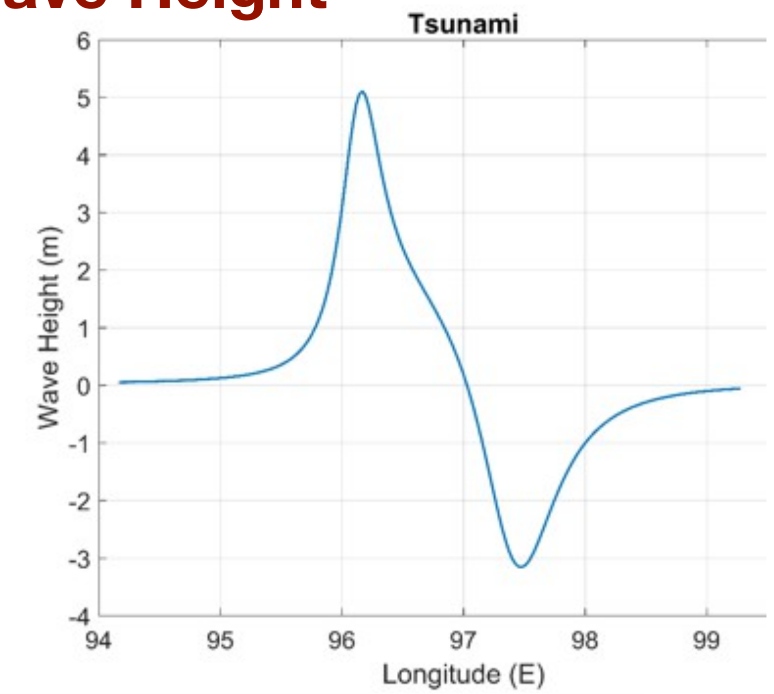


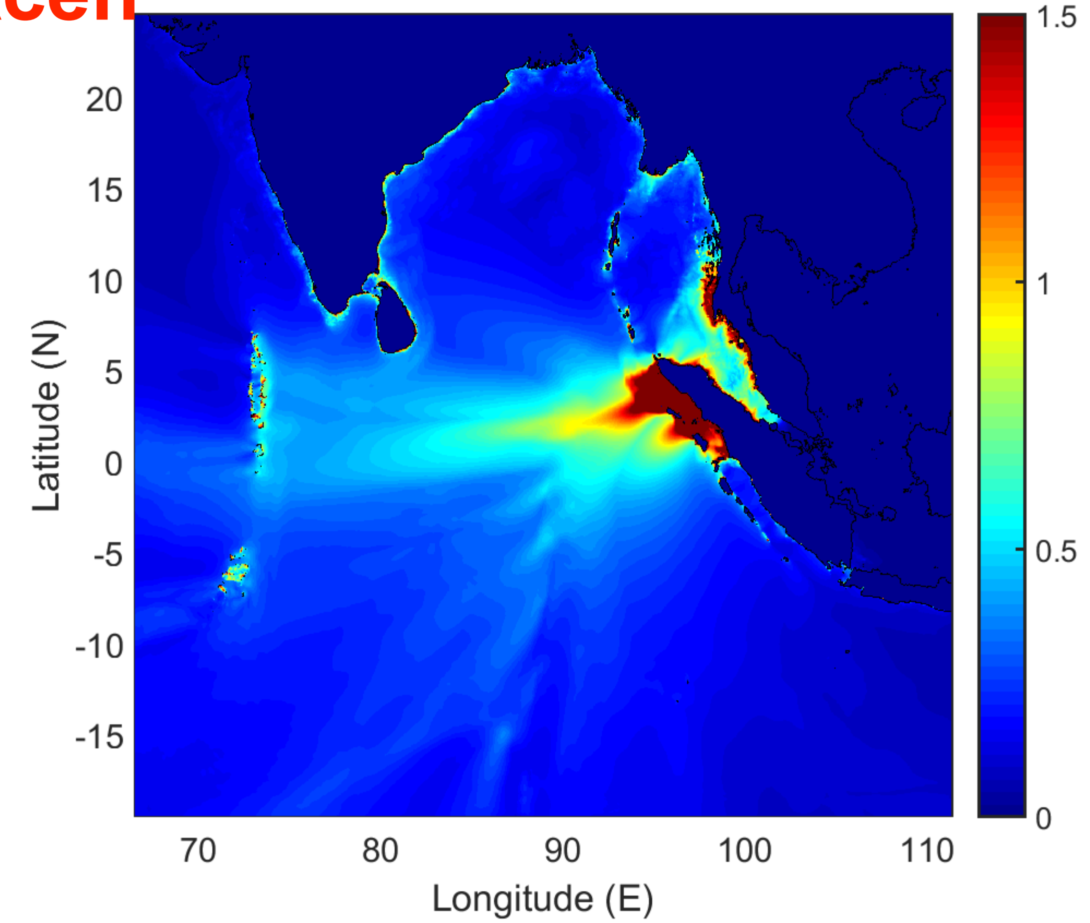
Tsunami 2004 in Banda Aceh

```
Depth= 28.6   Half duration=95.0
Centroid time minus hypocenter time: 139.0
Moment Tensor: Expo=29  1.040 -0.427 -0.610 2.980
Mw = 9.0    mb = 8.9    Ms = 8.9   Scalar Moment = 3.95e+29
Fault plane:  strike=329    dip=8   slip=110
Fault plane:  strike=129    dip=83   slip=87
```

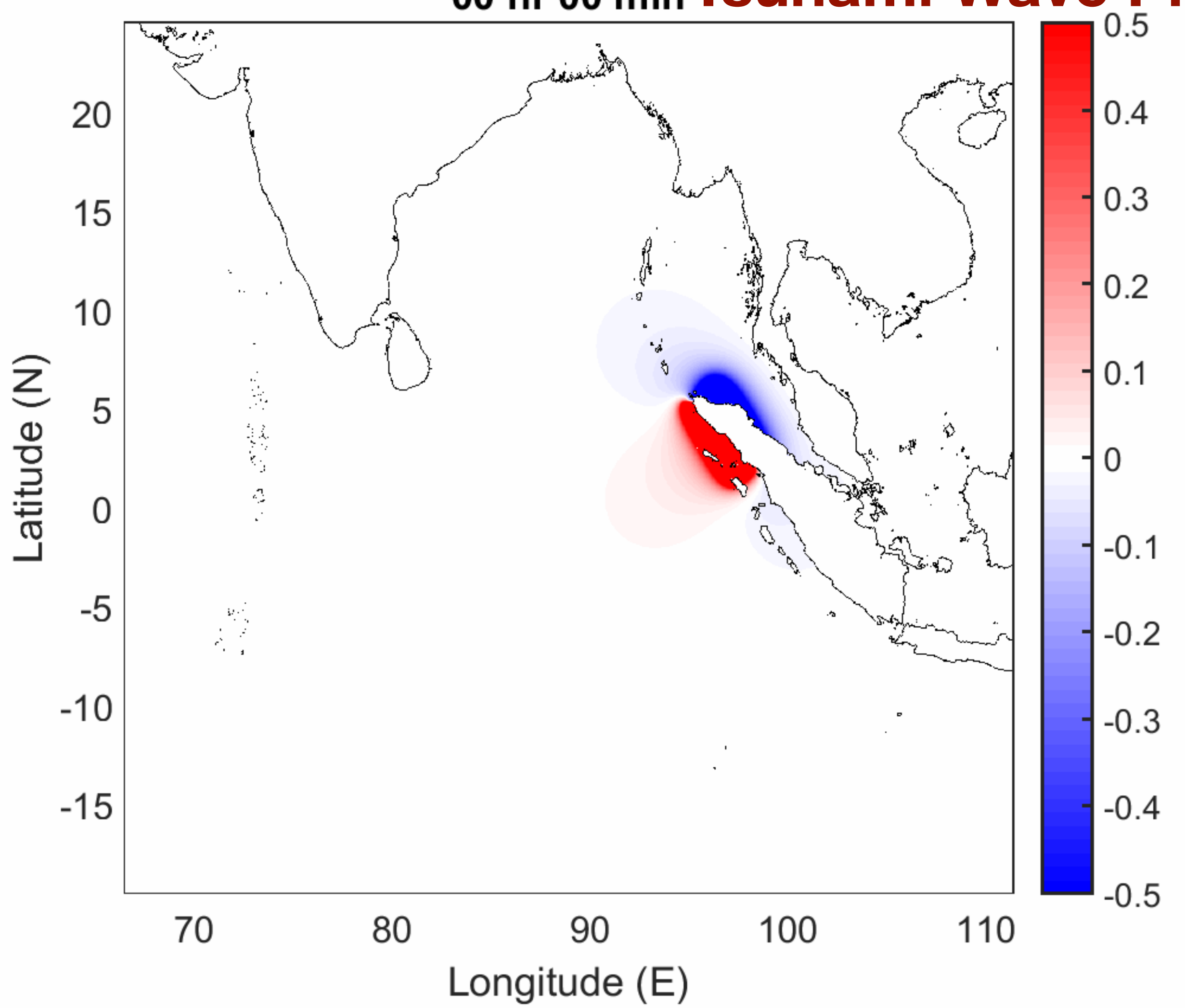
Initial Wave Height

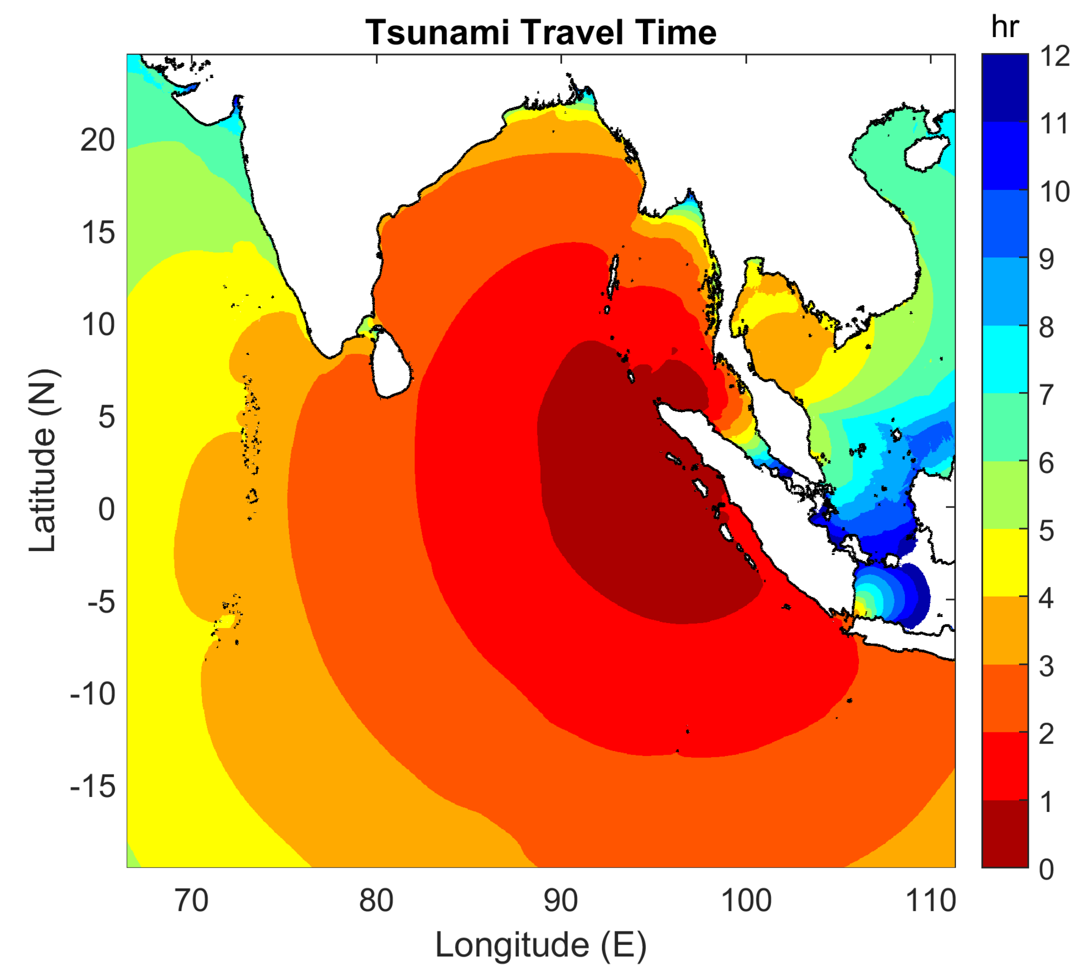






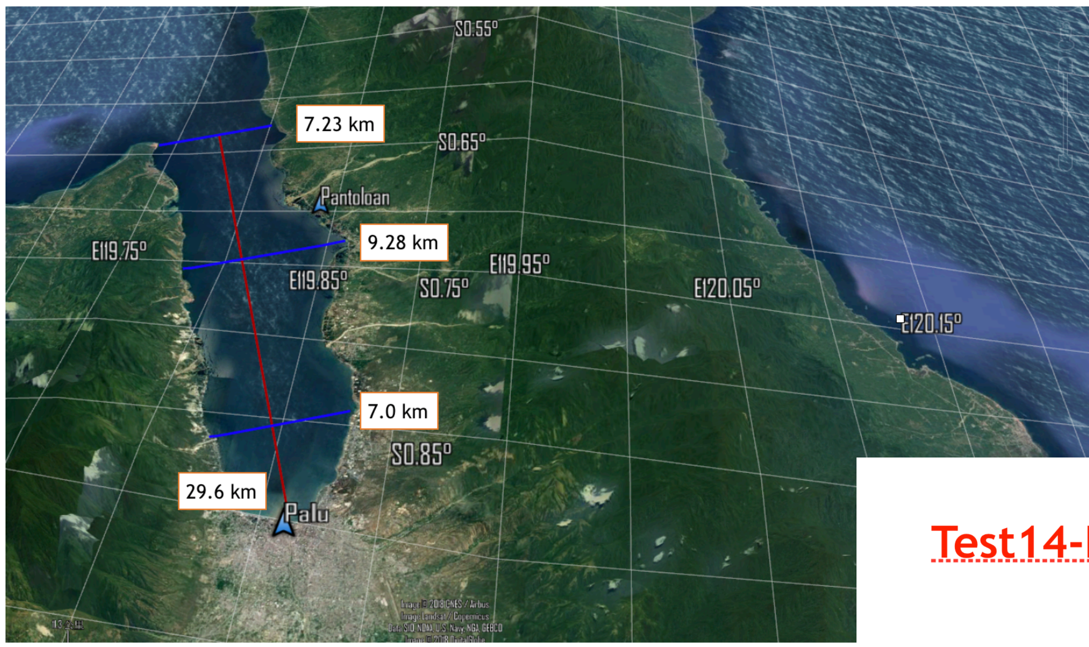
Tsunami Wave Propagation

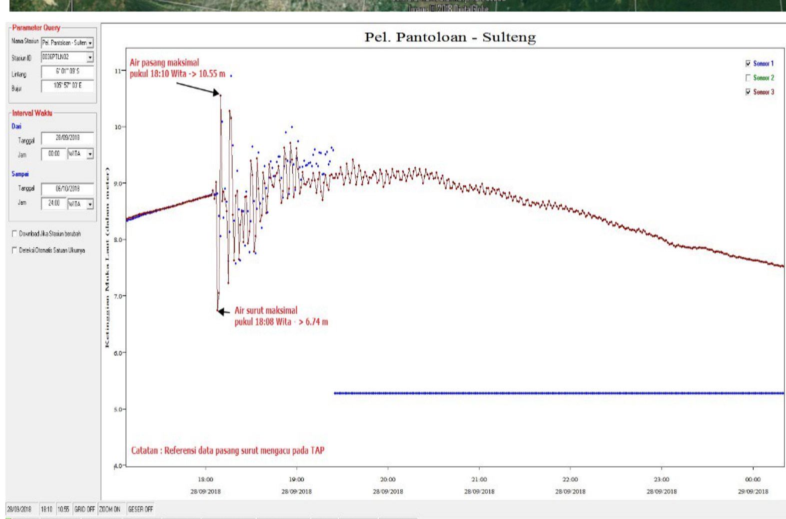




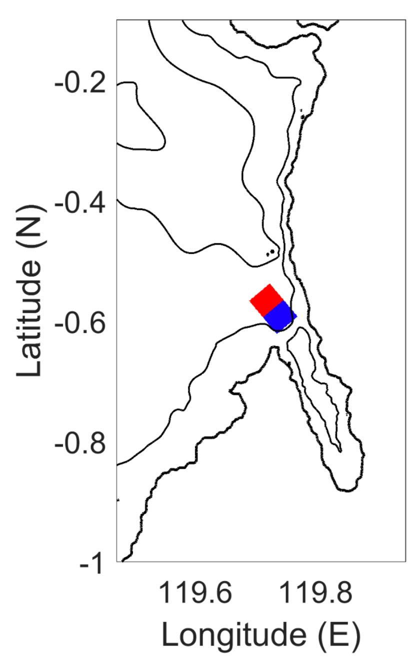
Case Study on Sulawesi Tsunami in 2018 (TW, TH, ID)

- **Find out the possible causes of the tsunami: earthquake and landslide by Impact Intensity Analysis and Tsunami Arrival Time Analysis**
  - **The tsunami source of 2018 Sulawesi tsunami event located at the mouth of the Palu Bay.**



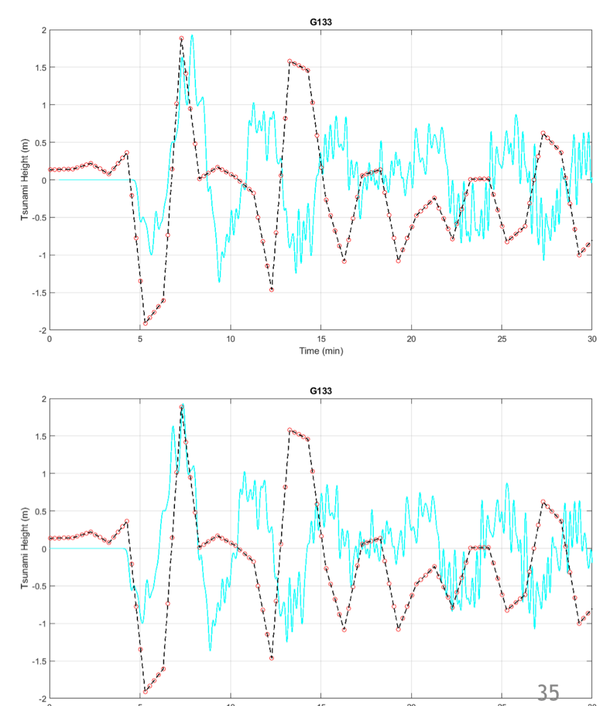


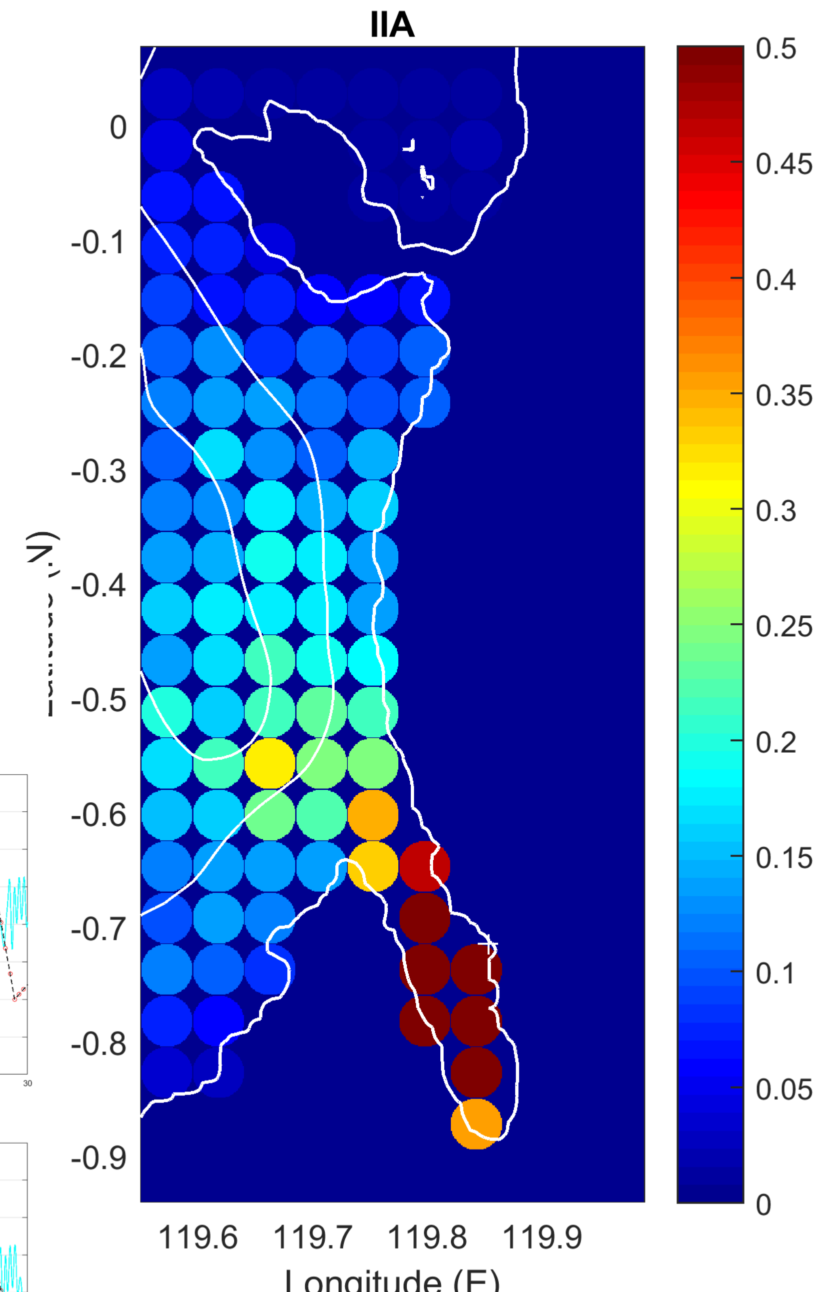
Test14-Pantoloan



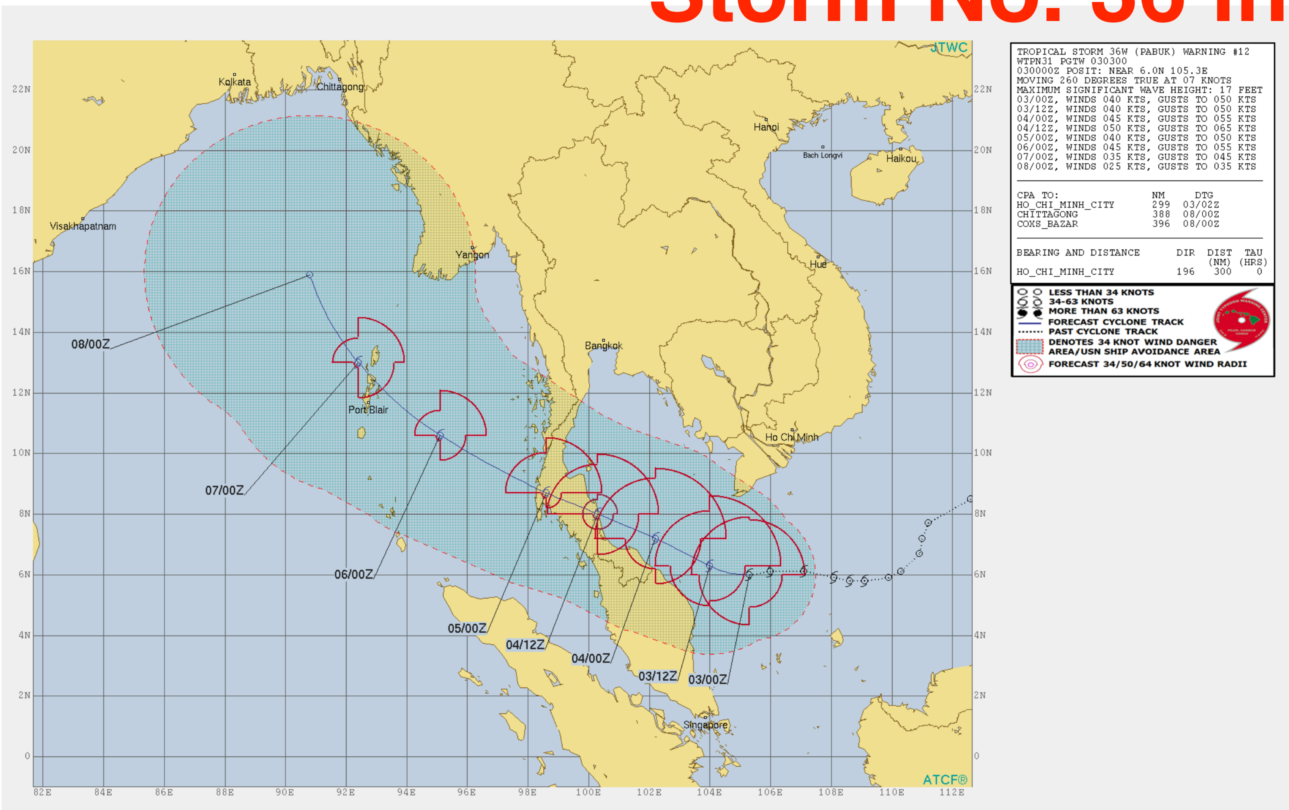
W = 5 %km
L = 4
nL = 4
Etaheight = 3;

nEtaheight = -4;
xx_long = 119.73
yy_lat = -0.58
strike = 230

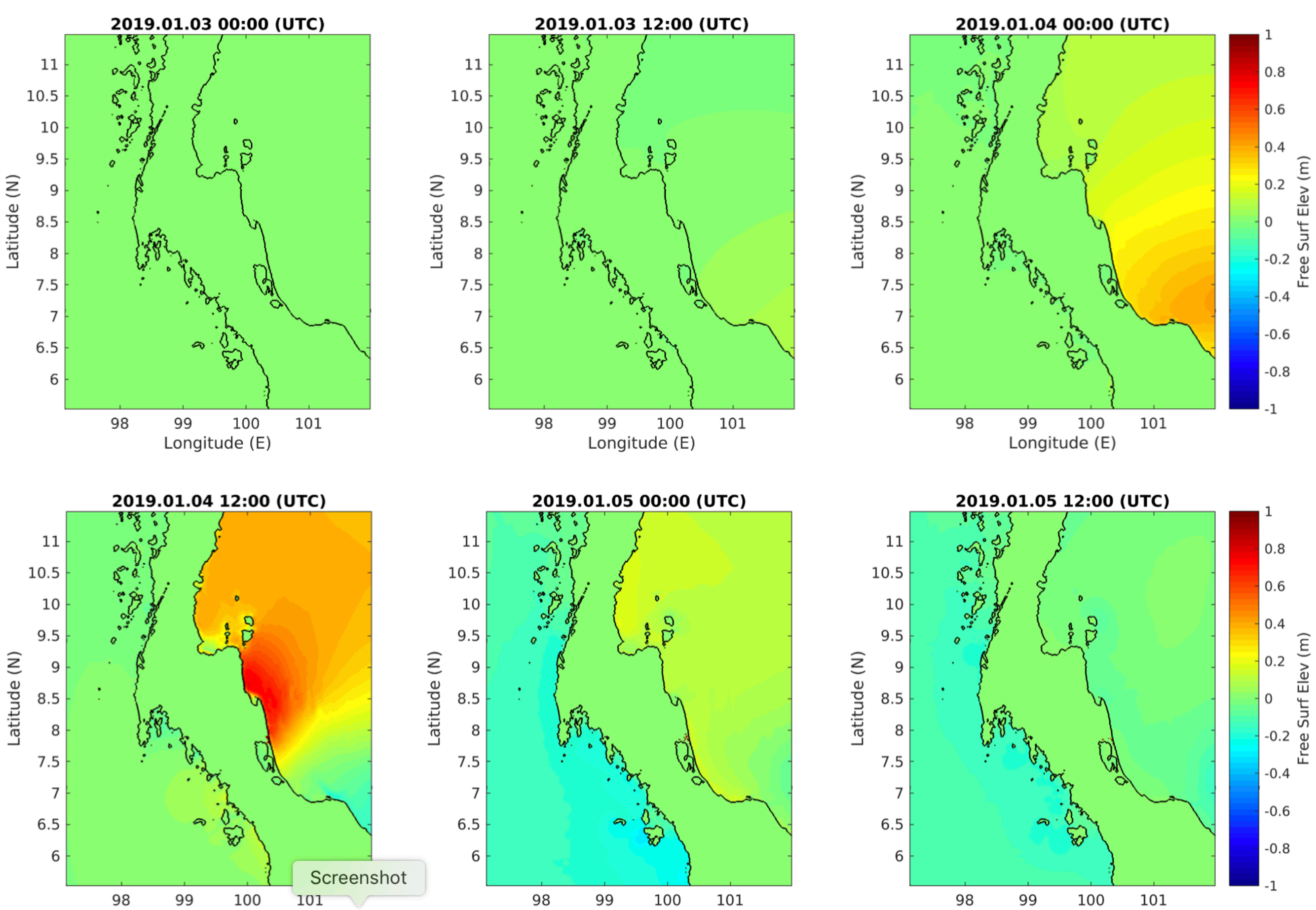




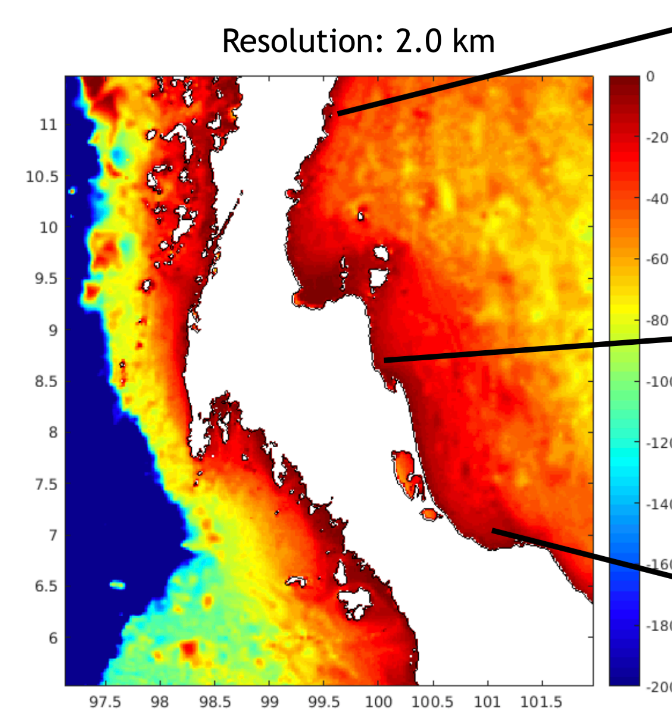
Case Study on Storm Surge Forecasting Induced by Tropical Storm No. 36 in Thailand in 2019

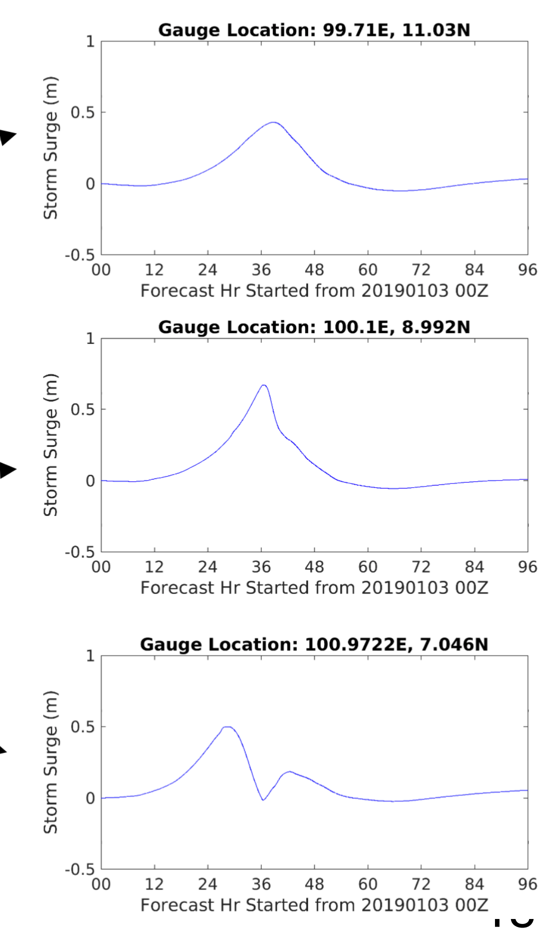


Storm Surge Simulation from 20190103 00Z



Tidal-gauge Prediction





Developing Tsunami Early Warning System for Indian Ocean

Develop a Tsunami Early Warning System for the Indian Ocean.

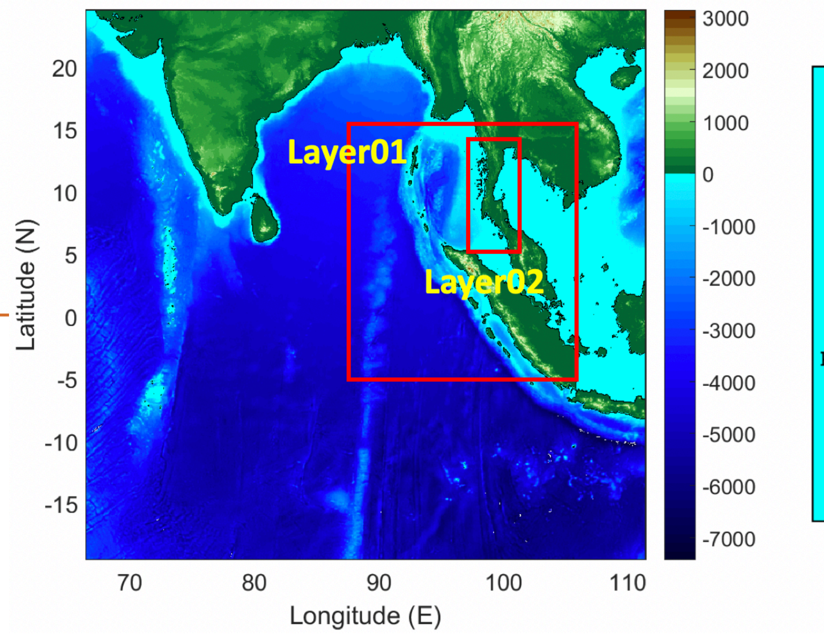
Lower resolution simulations are used for verification first

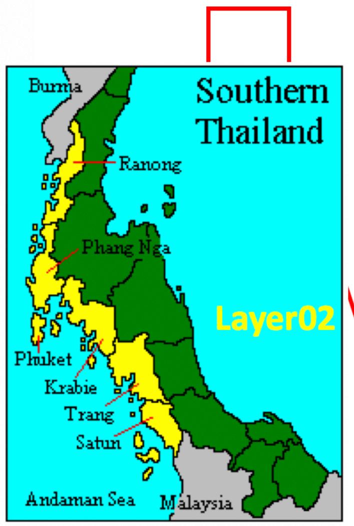
In order to prepare for the tsunami, we have prepared the following plans to implement.

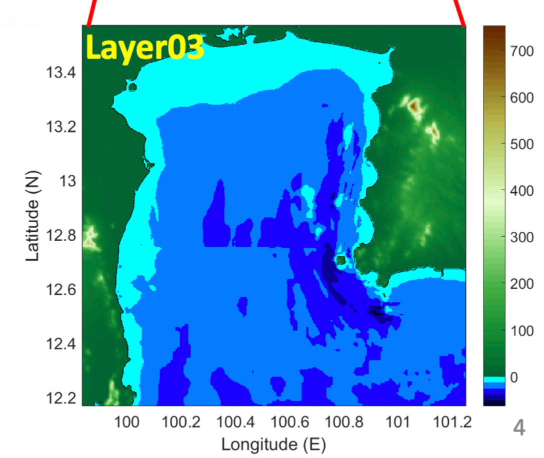
To improve accuracy of simulation results, use a nested grid to add to the second layer.

Target on major and populated cities.

Screenshot

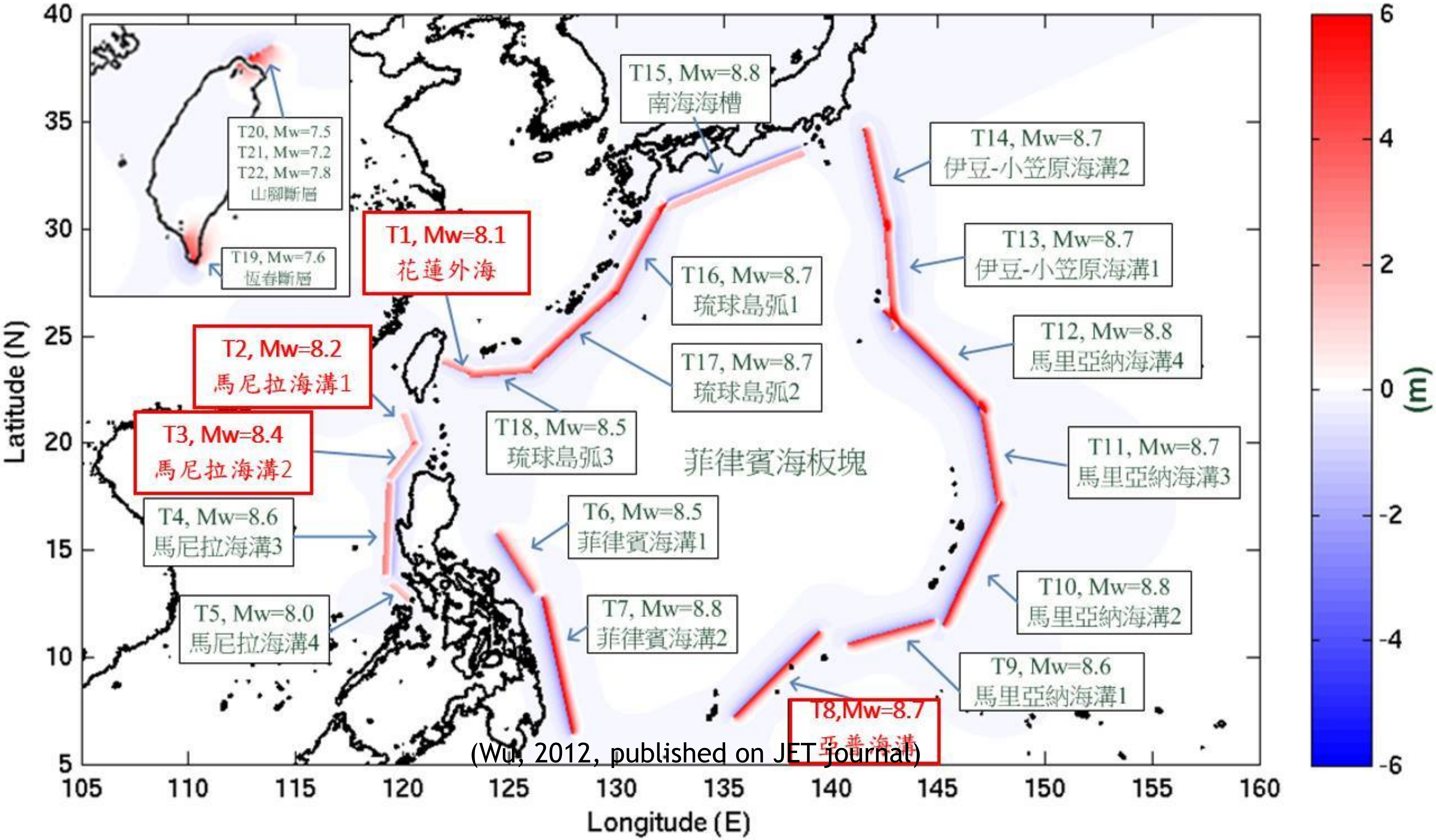






Layer01	4.0 arc min
Layer02	1.0 arc min
Layer03	0.2 arc min

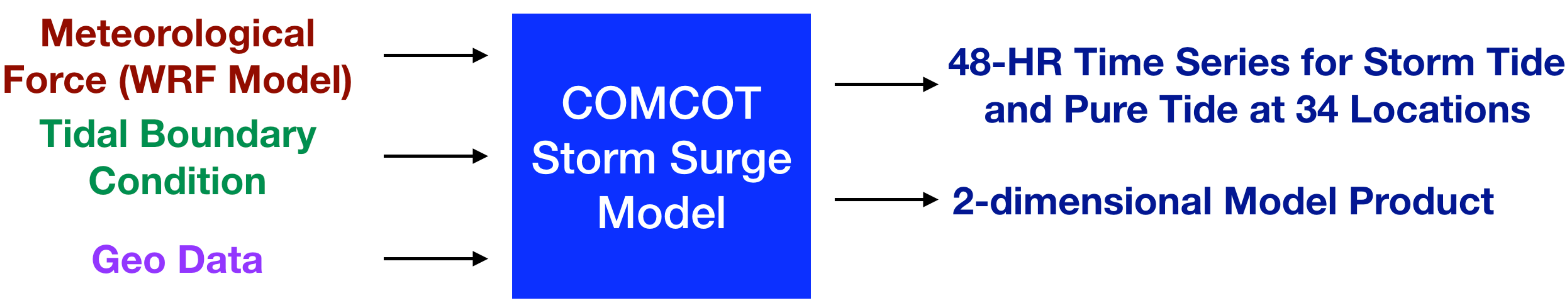
Potential Tsunami Sources for Taiwan Regions



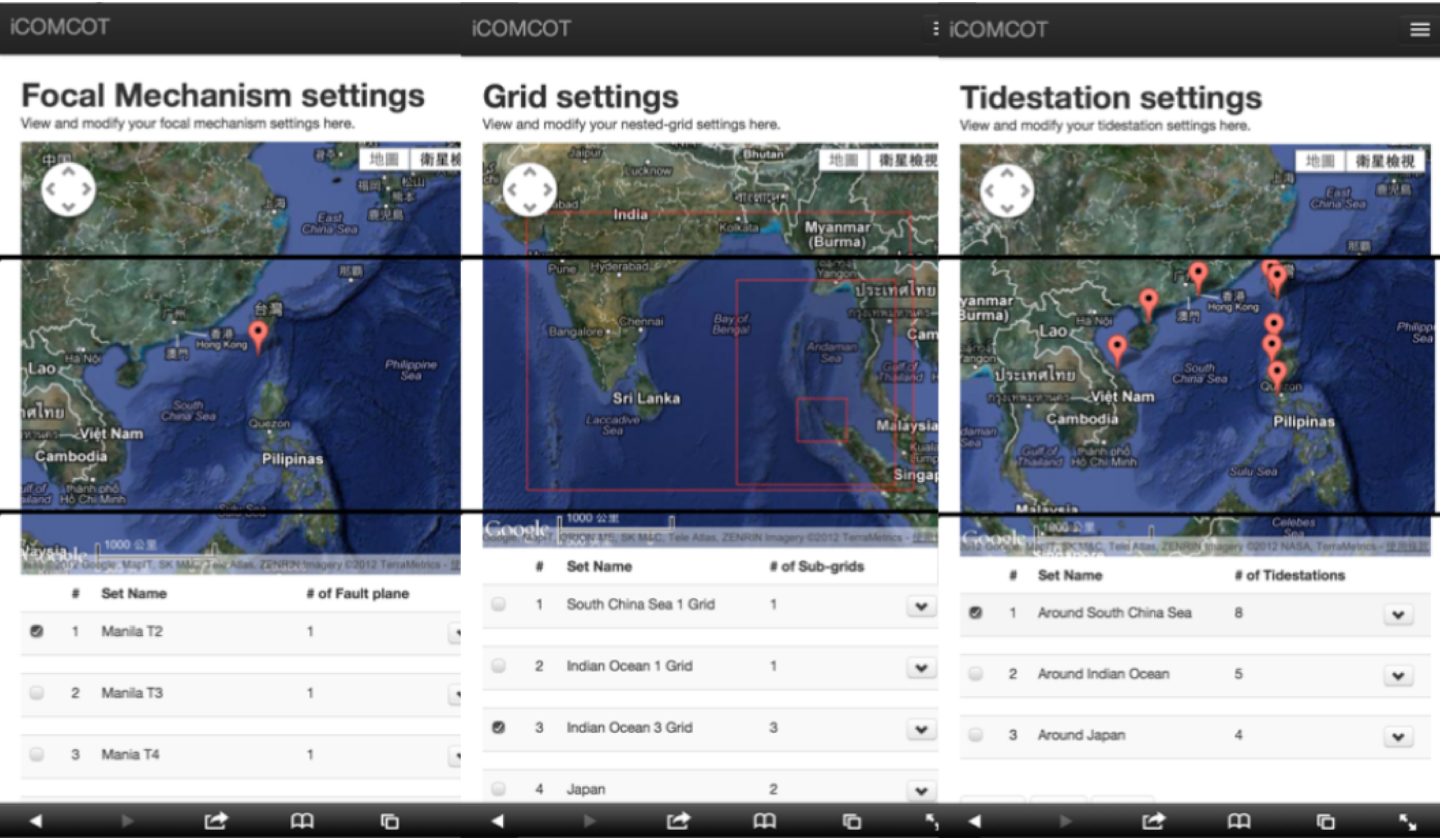
(Wu, 2012, published on JET journal)

Architecture of COMCOT-Surge Storm Surge Simulation System

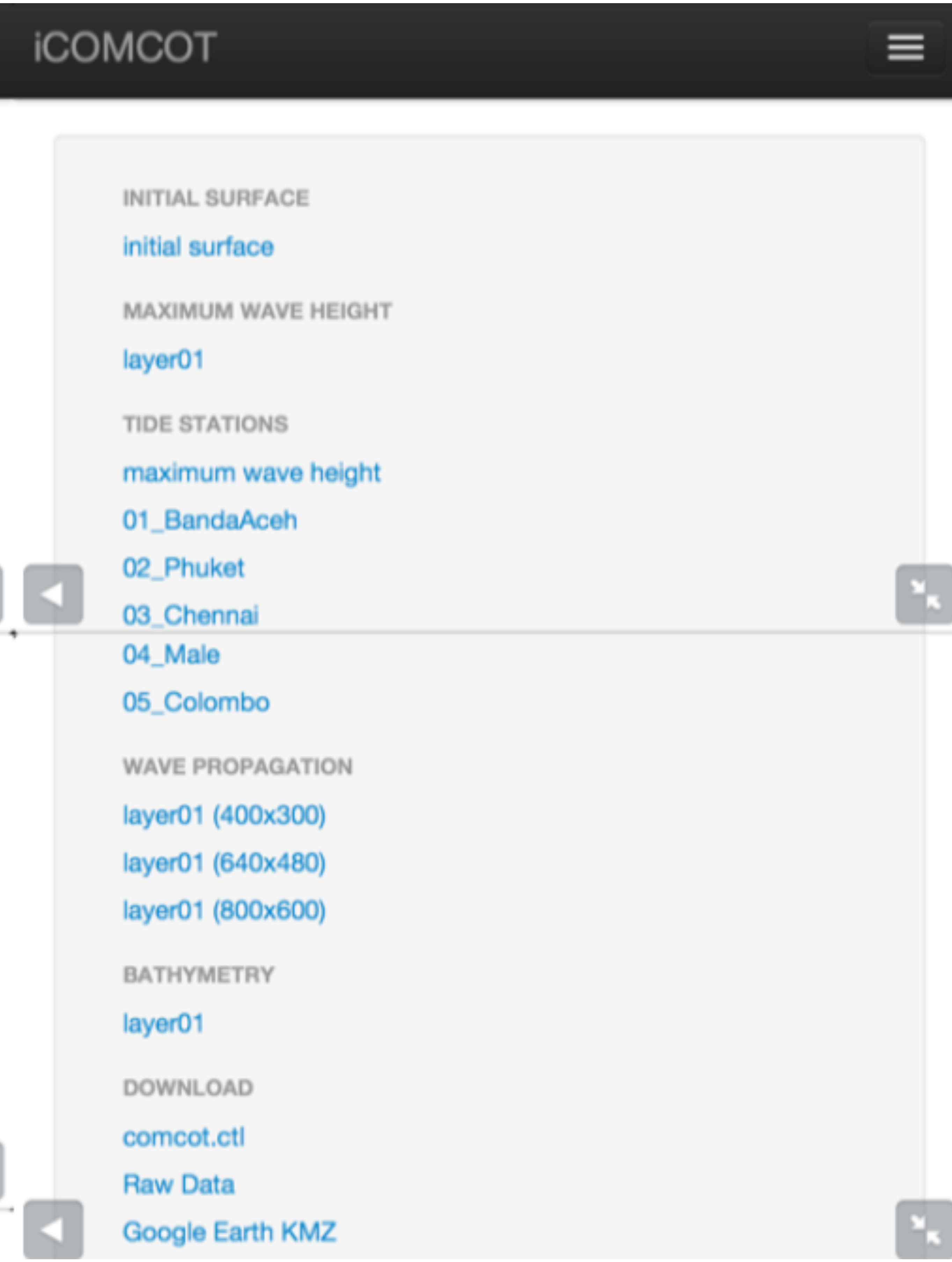
- COMCOT-Surge model can adopt large computational domain to cover complete typhoon life cycle and full storm surge propagation.
- High-resolution storm surge inundation can be achieved efficiently
  - Resolution in coastal regions is separately calculated in nested-grid scheme.
  - COMCOT-Surge model is combined with dynamic WRF model and combined with global TPXO tidal model in this case study.
  - Cloud-enabled parallized COMCOT simulation system has been integrated in the application framework to support high-performance simulations and applications.
- Storm surges simulation provides estimated inundation and wave height information for the next 48 hours with computation time less than 10 minutes



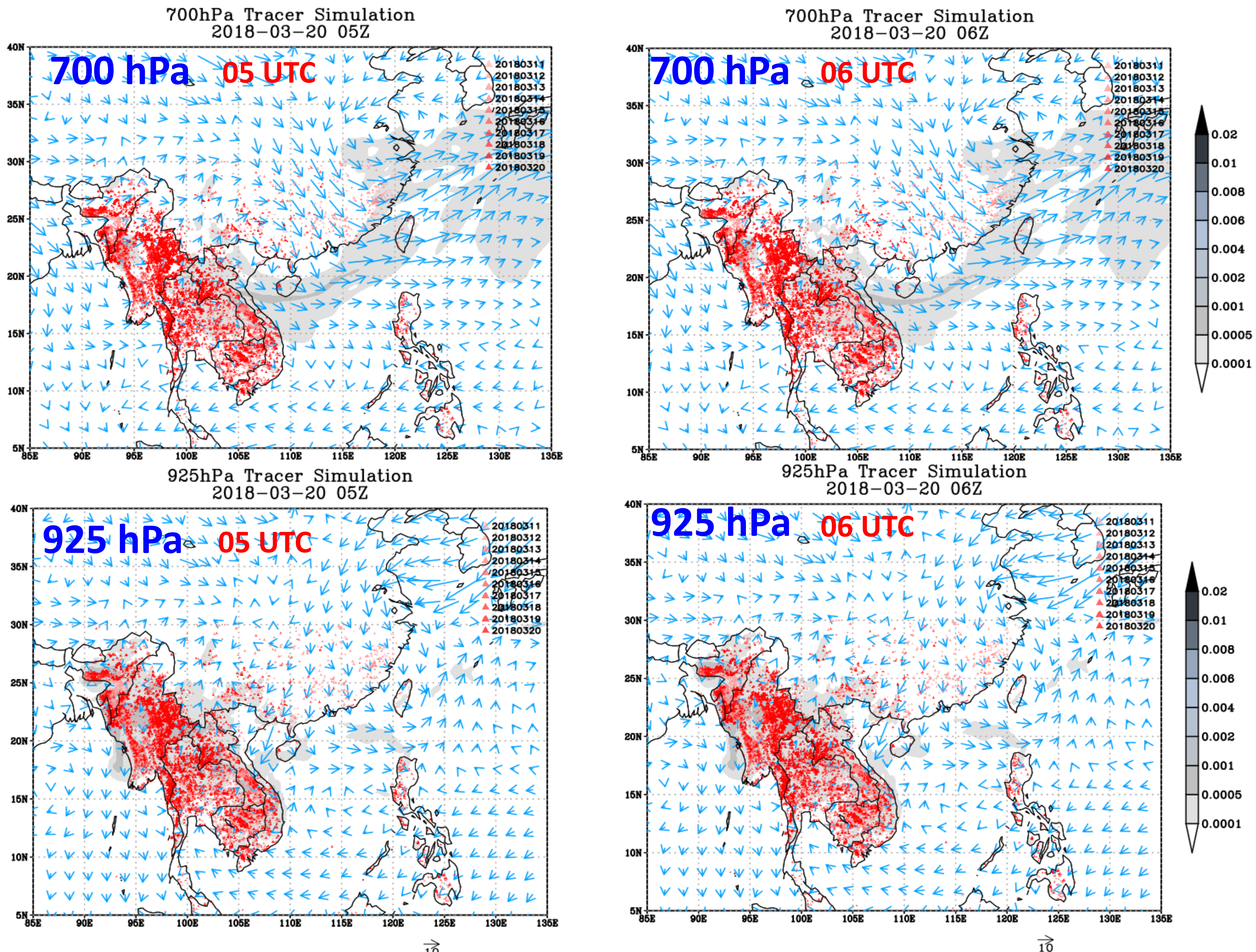
iCOMCOT User Interface (I)



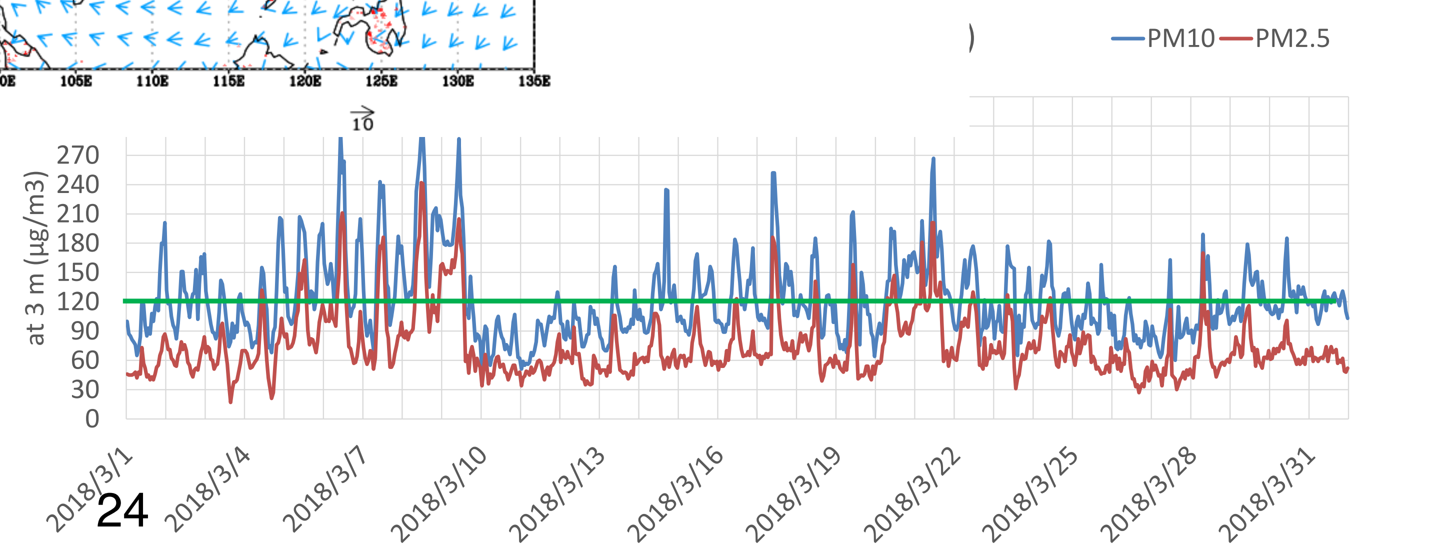
iCOMCOT User Interface (II)



Biomass Burning Simulation



(data from Veerachai)



Outcomes From Collaborations of Agriculture and Disaster Mitigation Communities at APAN47

- Action Plan
  - Start from one case study (historical event with 10-year data) of Thailand (province scale) - Evaluation of Meteorological Parameters Impact on Agriculture Production
    - With specific target users, requirements and necessary data
    - e.g., Weather parameters (solar radiation, soil temperature, changes of temperature and rainfall, etc. for years) and their impact to agriculture —> buildup the correlation between yields and weather indicators as the baseline
    - Simulate the risk/impact for another time frame
  - Pursue funds for collaboration projects, e.g., SATREPS, Asi@Connect
- Use APAN as the open platform of collaborations
  - Catalog of resources, projects, etc.
- Future events: review the progress, promote the collaboration, enhance communications and engage local communities
  - Joint workshop at APAN48
  - Hosting joint session(s) at APFITA/WCCA 2019, 29-31 Oct. 2019 in Taichung, Taiwan

Activities

- 3rd Master Class on Disaster Mitigation and 1st UND Project Workshop Co-hosted by UND, APAN Disaster Mitigation Working Group and DMCC (EOSC-Hub) @APAN46 in New Zealand (2018)
    - UND Project Meeting, 7 Aug. 2018: 16 attendees from 9 partners (BD, ID, JP, MM, MY, PH, TH, TW, VN)
    - Master Class & UND Workshop, 8-9 Aug. 2018: 42 attendees, 11 invited speakers (3xNZ, 1xAU, 1xJP, 2xTW and 4 remote speakers from JAXA, NASA, UNOOSA and PH)
- Monthly Meeting on Case Studies from Oct. 2018: Tsunami (ID), Storm Surge (TH), Typhoon (TH), Flood (MY), Fire/Haze/Smoke/Dust (TH)
- Environmental Computing Workshop in ISGC: Updates from partners and collaborations
- APAN Disaster Mitigation Working Group: twice a year from APAN38 (Taiwan, 2014)
- 4x Training Events in BD (2019), MM (July 2019), MY (2020) and VN/PH/TH (2020)
- UND Project Symposium in 2020 (ISGC 2020 in Taiwan, March 2020 is an option)

Future Works

- More case studies are happening in next few years
  - Case studies on storm surge, forest fire, smoke and haze as well as floods in different partner countries including Vietnam, Thailand, Indonesia, Myanmar, and Bangladesh will be conducted in the next two years coordinated by DMCC+ and UND projects
  - In addition, Scientist group and user communities of every partner country will be engaged to work together on those case studies from root cause analysis, simulation process improvements, workflow customization, knowledge base maintenance and services design, training and dissemination etc.
- Several case studies of different hazard types had been conducted by the simulation portals in the system
  - Indian Ocean earthquake and tsunami in 2004 at Banda Aceh, the potential tsunami risk analysis around Taiwan, several super typhoons hit Taiwan and the Philippines, as well as the long-distance dust transportation of biomass burning in Southeast Asia.
- Advanced analysis possibilities
  - With support of accurate hazard risk assessment by numerical simulation, correlation analysis between potential threats and types of interactions between hazards as well as patterns of combination of geophysical environment and triggers might be useful for new discoveries and better predictability with ML methodologies
- Capacity building for dealing with more complex multi-hazard scenarios
- Topographical structure might be changed after a disaster. Related data has to be updated accordingly in time. Such changes should be all recorded in the open application framework.
- Towards Open Science

Further Collaborations

- Local user communities engagement: scientists, users, agencies, service/infrastructure providers,
    - Scientists: Tsunami (ID), Forest fire/haze/smoke (TH),
    - Satellite images: (Himawari, Sentinel Asia, JAXA)
    - Infrastructure and platform: EGI, ASTI, MY, ID, TH, …
- Interoperability with EOSC
- New WRF portal in collaboration with CIMA foundation (Antonio) and other partners (and on GPU)
- Satellite images: NSPO, Sentinel Asia, Himawari, etc.
- Towards open data and open science