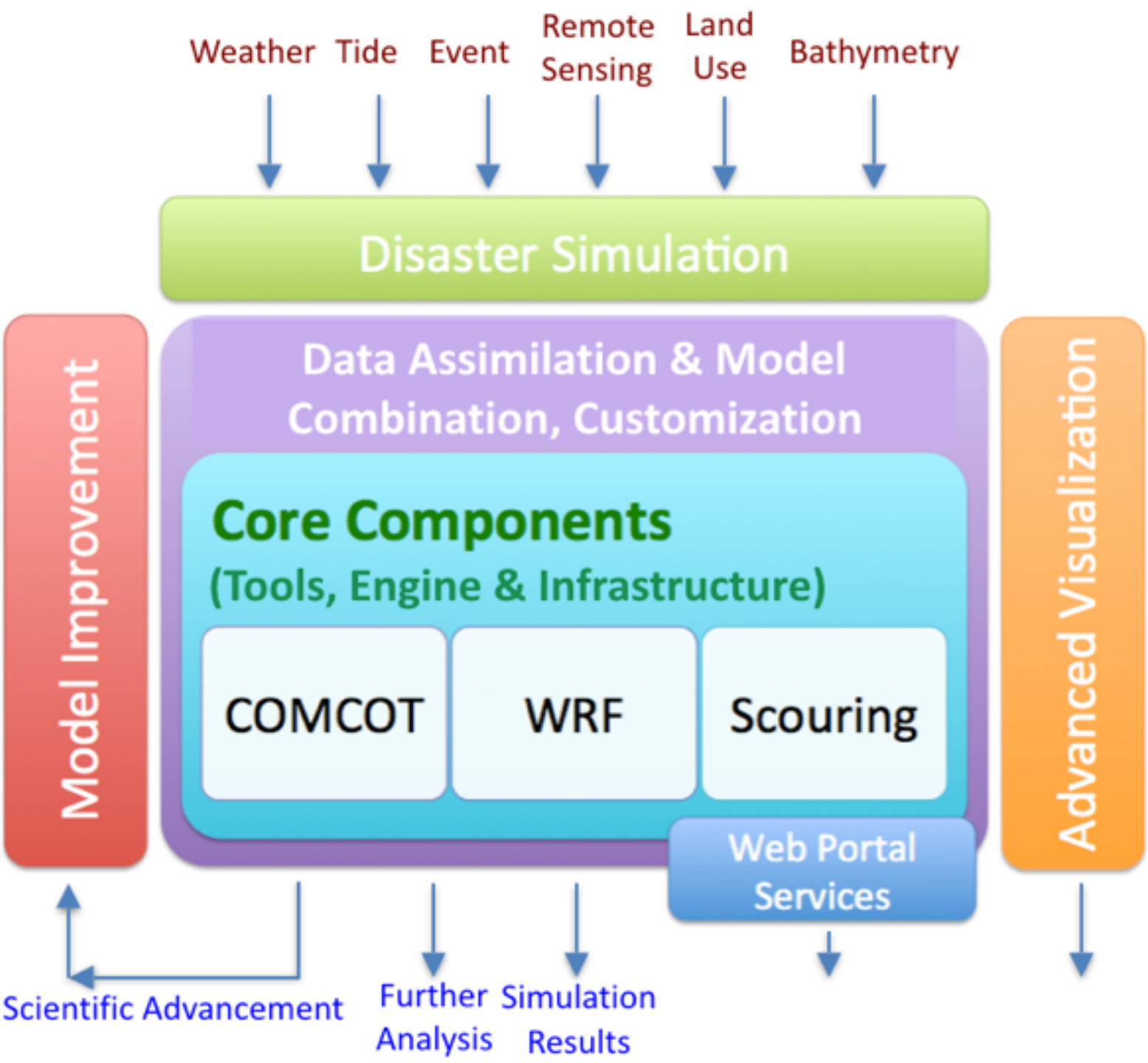
Case Study and Web Portals of Disaster Mitigation Competence Centre (DMCC)

Eric Yen
Academia Sinica Grid Computing Centre (ASGC)
Taiwan

EGI Conference 2016
April 6, 2016

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, KR, DE, UK (Nepal, VN)


Weather
Tide
Event
Remote Sensing
Land Use
Bathymetry
Disaster Simulation
Model Improvement
Data Assimilation & Model Combination, Customization
Core Components
(Tools, Engine & Infrastructure)
COMCOT
WRF
Scouring
Web Portal Services
Advanced Visualization
Scientific Advancement
Further Analysis
Simulation Results

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		First simulation by AS (global data) was done.	Demo @ APAN42	gWRF, Scouring
TH, TW	Flooding 2011		Simulation by NECTEC and AS (global data) were done. Aim to improve the accuracy and EWS.		gWRF, Scouring
ID, TW	Tsunami cave —> Forest Fire	air pollutants such as, CO, NOx (NO, NO2), SO2, O3, PM10, PM2.5 etc. with high temporal resolution	Data Collection and User Engagement	Demo @ APAN42	gWRF
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

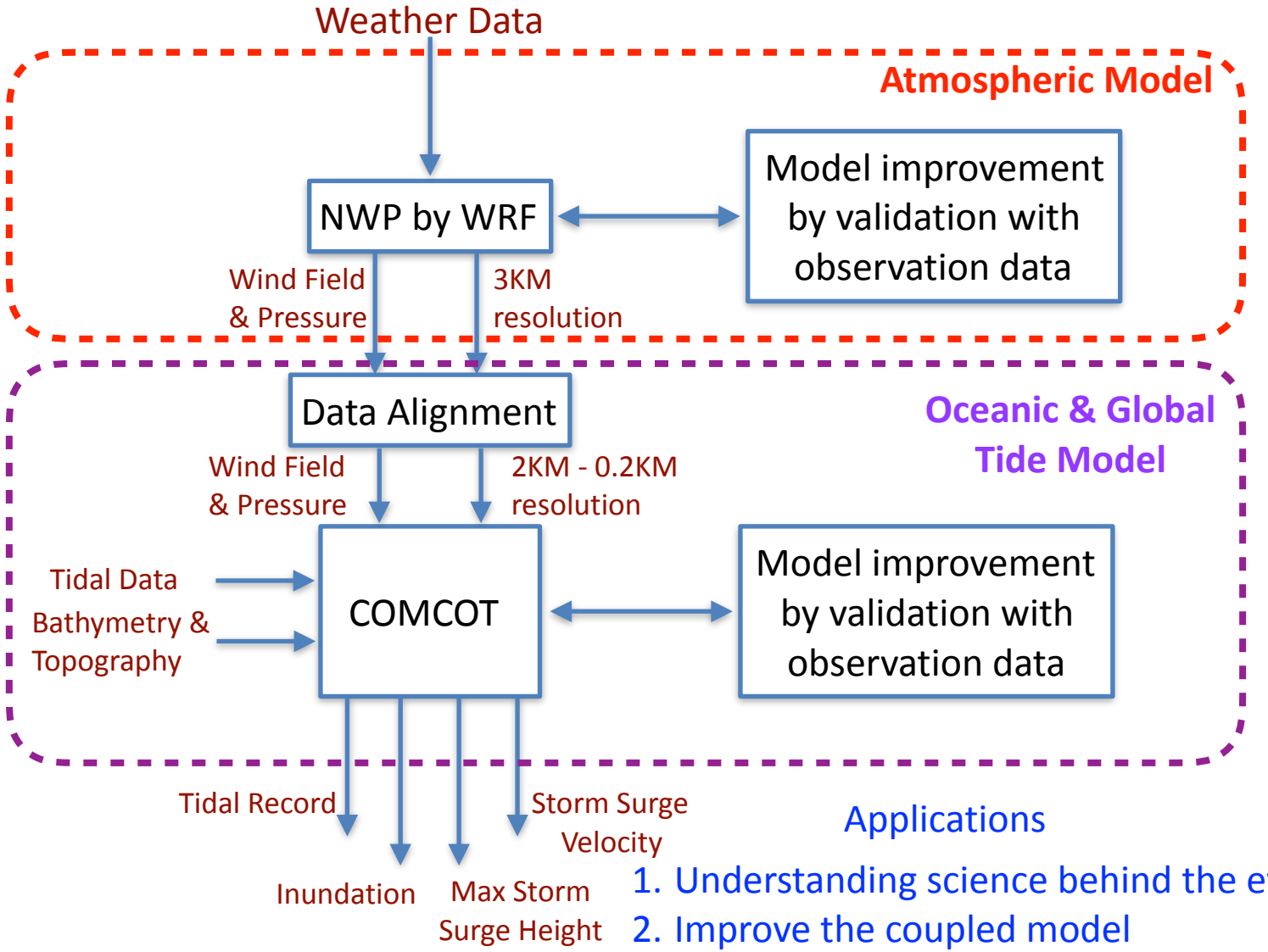
Workflow of Case Study

- Reconstruct the whole process of target events
  - Find better model of the case
  - collect observation data
  - validation and evaluation
- Integration 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

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

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



Applications

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

Goals for a Storm Surge Model

- Spherical coordinate system with a large computational domain was adopted to cover the complete life cycle of the typhoon
- Nonlinear, bottom shear stress and shoaling effects should be all considered in nearshore and multi-scale wave propagation
- Calculating inundation area with high-resolution topographic data
- Coupled with both atmospheric model (e.g. WRF and TWRF) and parametric typhoon model (e.g. Holland Model)
- Coupled with global tide model (e.g. TPXO and Nao99b)
- High-speed efficiency for the warning system
- Widely validated and open source

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

Nonlinear Shallow Water Equations on the Spherical Coordinate

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

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

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

Validation of Pressure Gradient

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

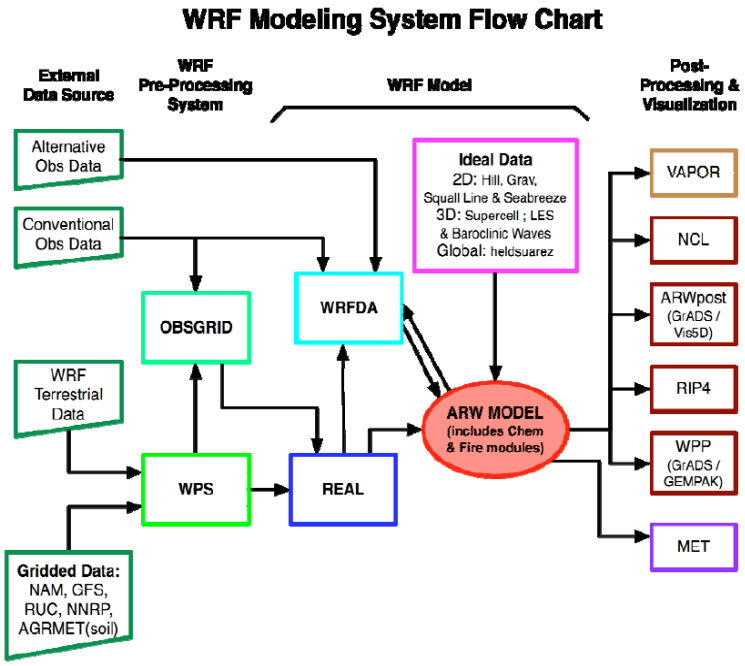
$$\longrightarrow \quad \frac{\partial P}{\partial t}+\frac{gH}{R\cos\varphi}\frac{\partial \eta}{\partial \psi}=-\frac{H}{\rho_w R\cos\varphi}\frac{\partial P_a}{\partial \psi}$$

Validation of Wind Shear Stress

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

$$\longrightarrow \quad \frac{\partial P}{\partial t}+\frac{gH}{R\cos\varphi}\frac{\partial \eta}{\partial \psi}=\frac{F_\psi^s}{\rho_w}$$

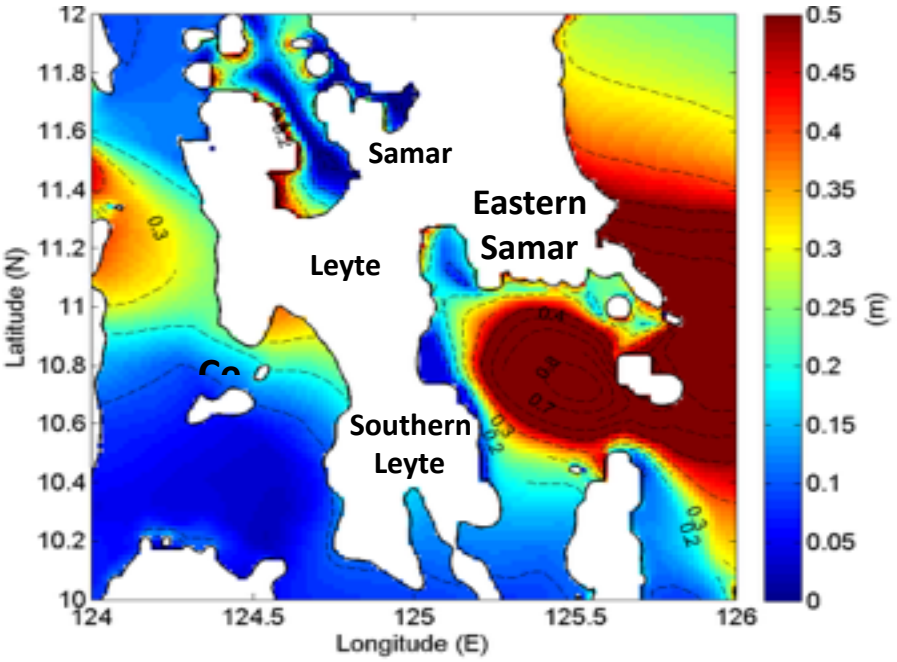
WRF model Configures

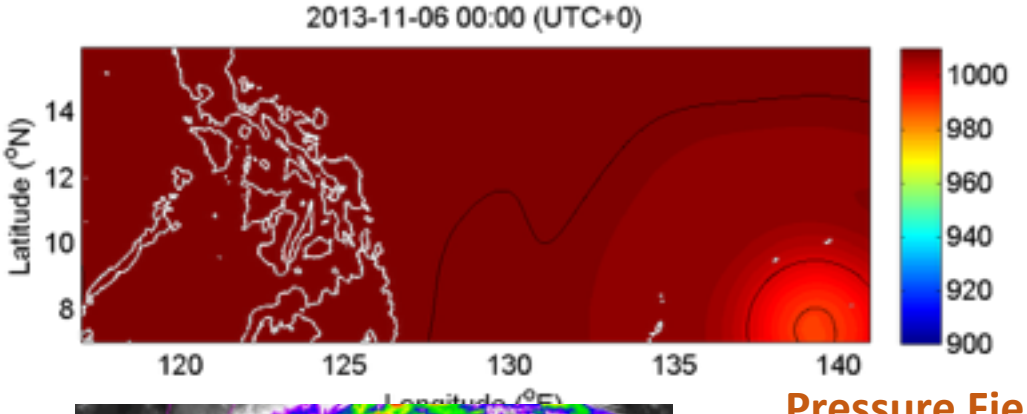


- dx,dy=3km
- number of horizontal grids=951x401
- number of vertical levels=45
- time_step=10sec
- Microphysics=WSM 5-class scheme
- longwave radiation= rrtm scheme
- shortwave radiation=Goddard shortwave scheme
- surface layer option=Revised MM5 Monin-Obukhov scheme
- land-surface option=unified Noah land-surface model
- boundary layer option=YSU scheme
- cumulus parameterization option=New GFS SAS from YSU
- grid analysis nudging on
- IC ,BC: NCEP reanalysis data set

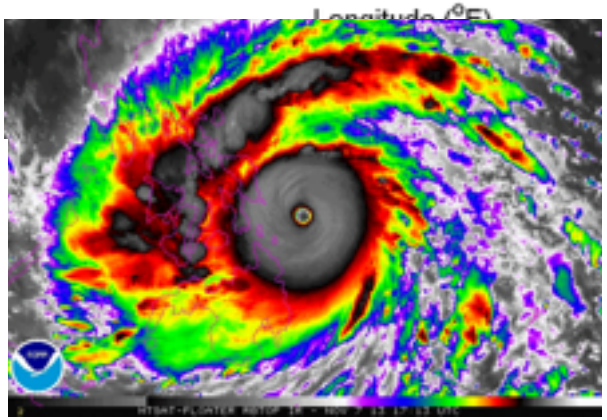
Storm Surge Modeling on 2013 Typhoon Haiyan by Coupling Ocean and Atmospheric WRF Model

Offshore Storm Surge Inundation Induced by Typhoon Haiyan



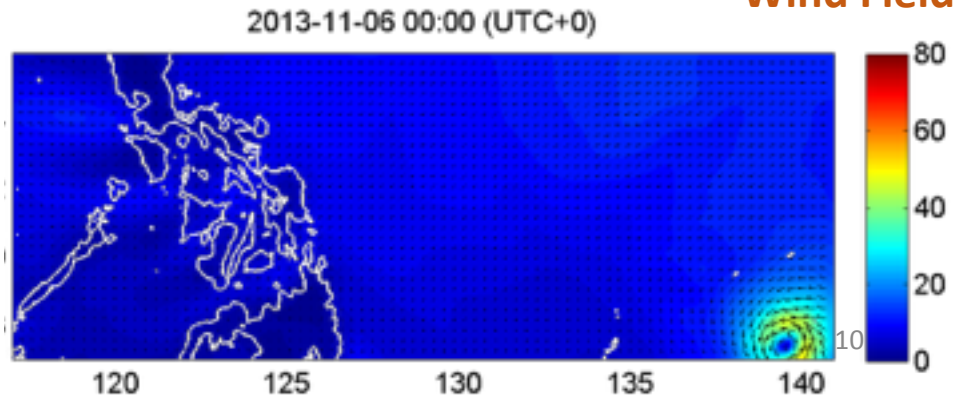


Pressure Field



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

Wind Field



Typhoon Morako in 2010 and 2100

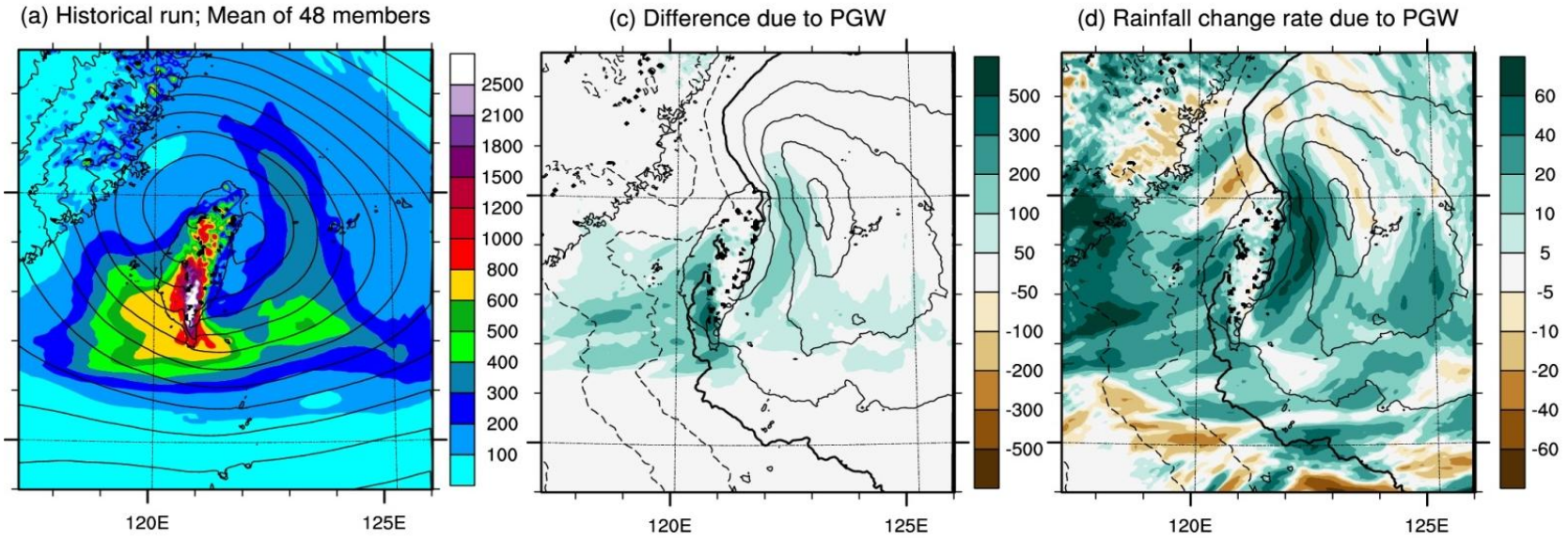
Pseudo Global Warming Experiment for Historical Typhoons

- 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 Workshop 2016

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

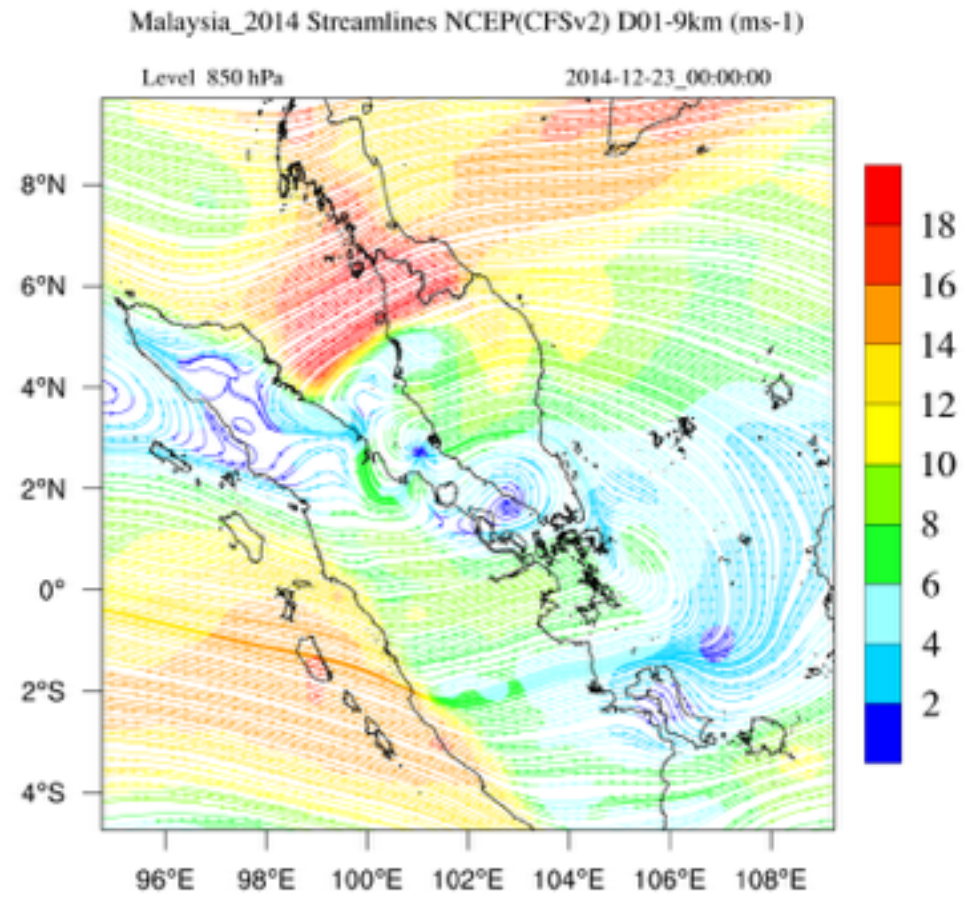
Overview of the Simulation Setup

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

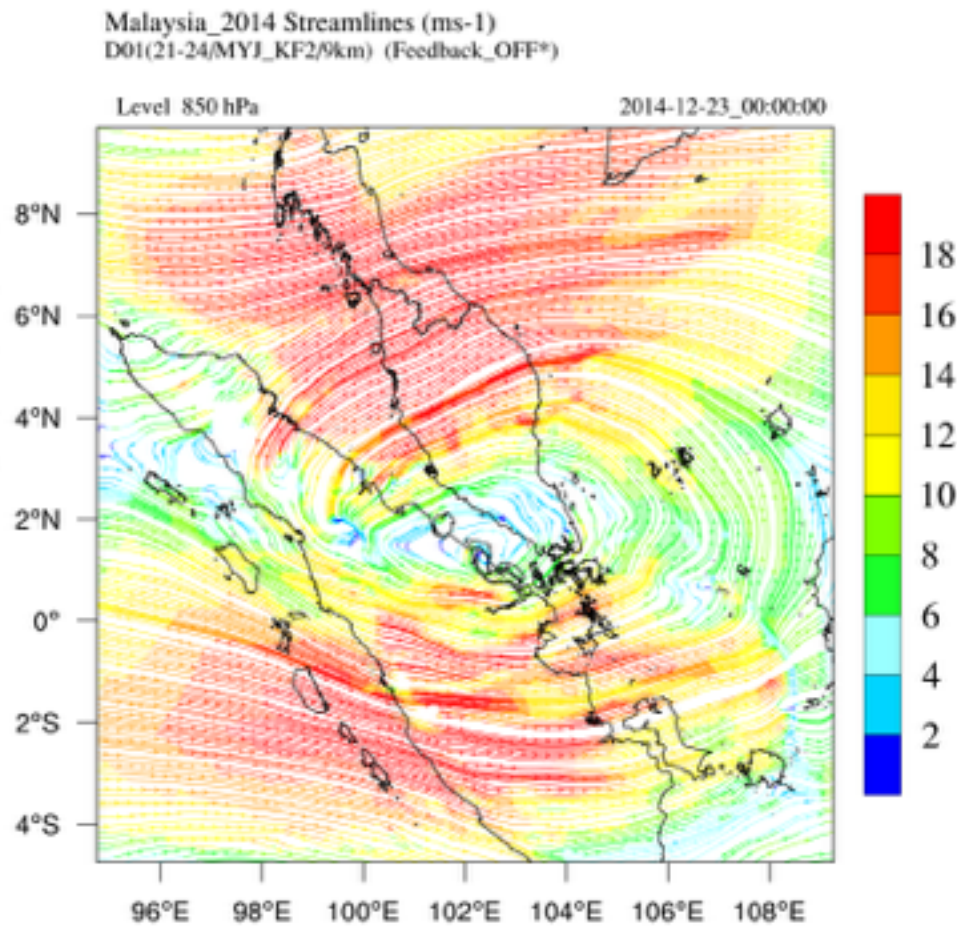
Streamlines

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

NCEP Data



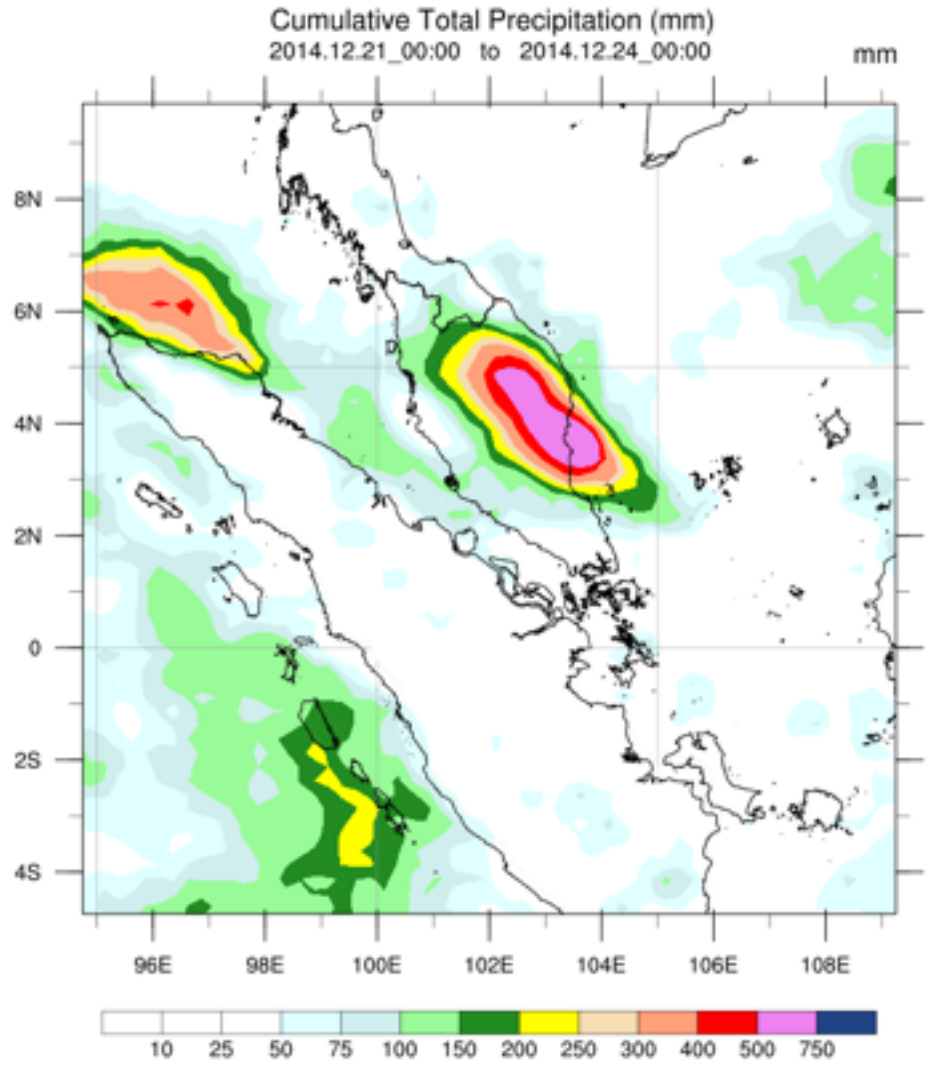
Simulation Results



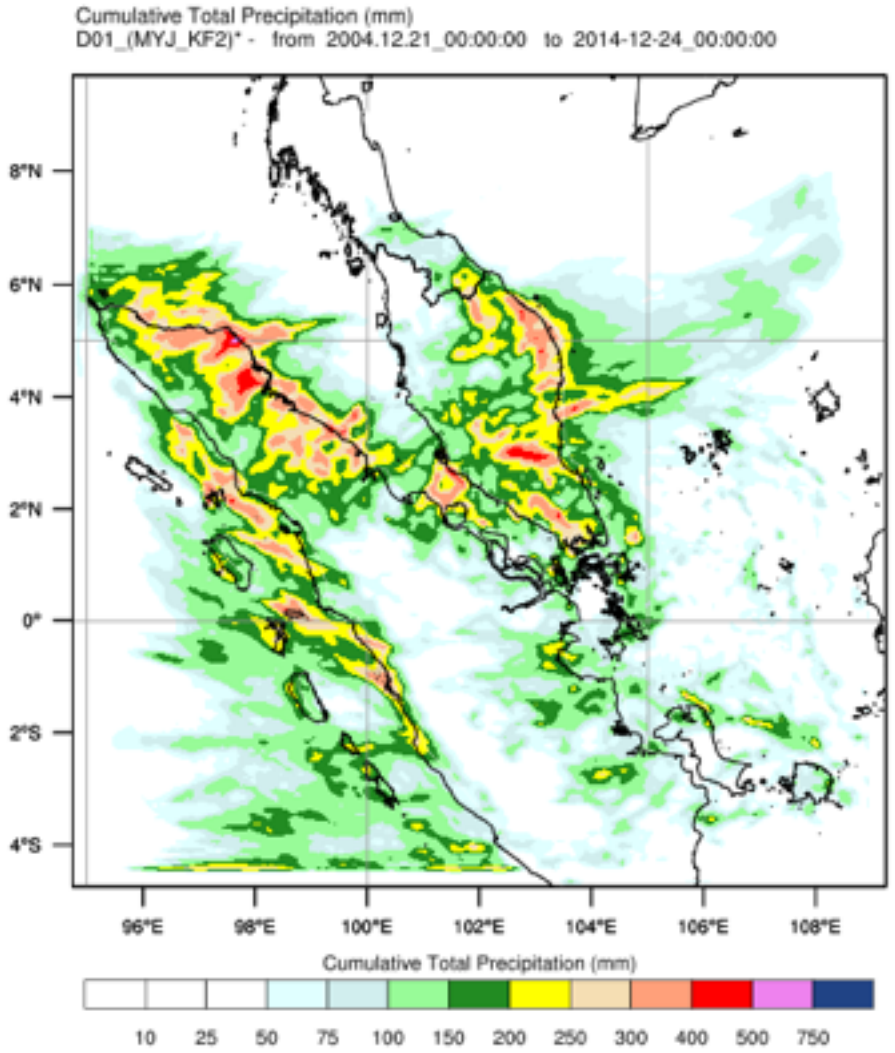
Cumulative Rainfall

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

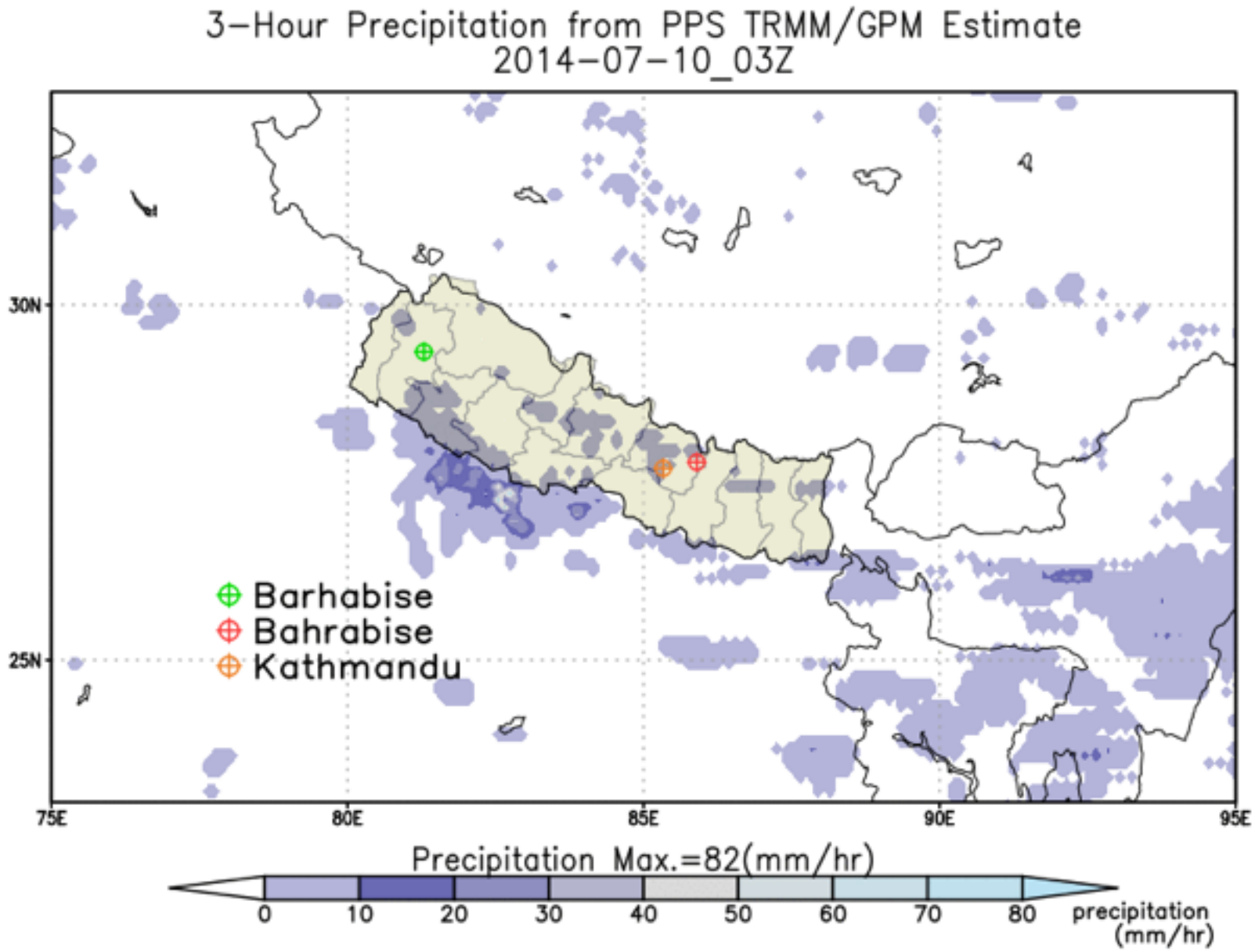
TRMM Data



Simulation Results

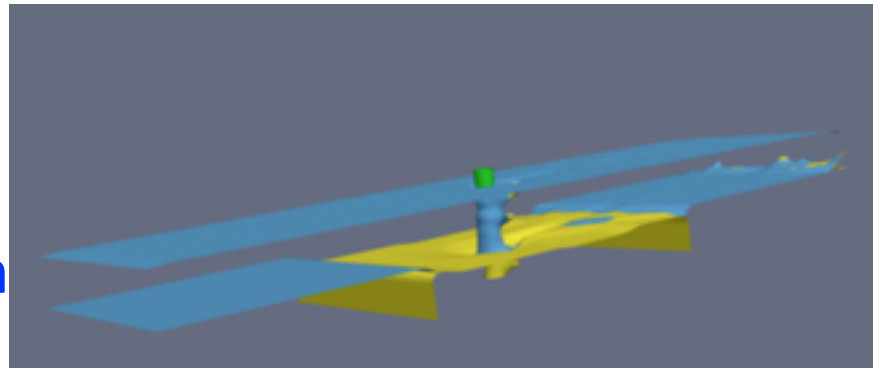


Flooding in Nepal



Advanced Visualization

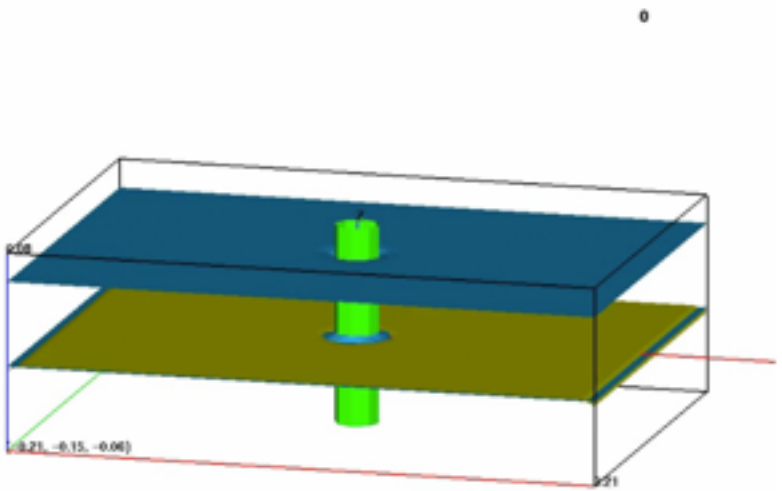
- Local Scouring case study is the first example by collaboration between NCU, ASGC and LRZ
- 3D Typhoon Morakot Visualization is the next case study



Advance Visualisatio

LRZ: Siew Hoon Leong (12 May 2015)

lrz Chosen Case Study: Dey and Barbhuiya, 2005



Compute domain: 1.1m by 0.3m by 0.14m

Abutment model: Circular

Column radius: 0.015m

Uniform sediments

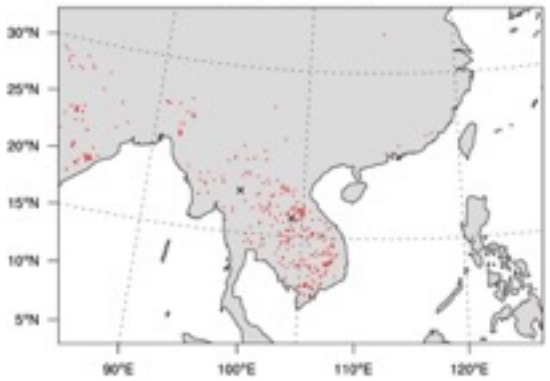
Mud: 6cm thick
Clean water: 6cm thick

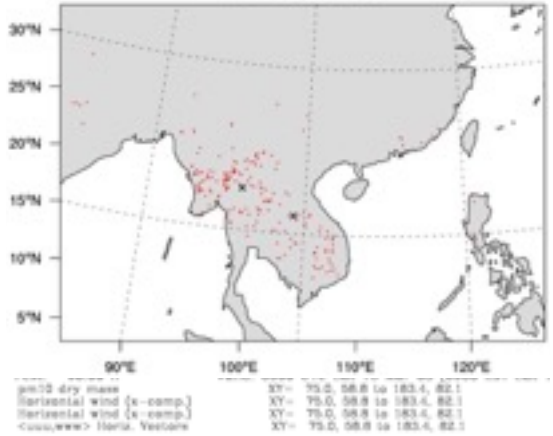
Provided by:
Chun-Wei Lin & Tso-Ren Wu (NCU)

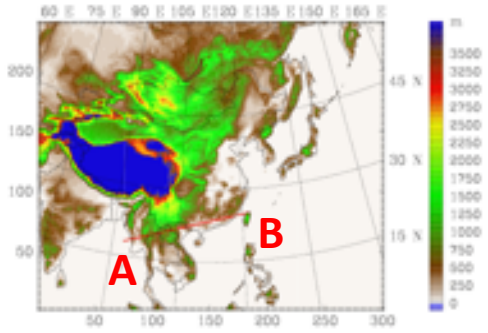
Tellus SERIES B CHEMICAL AND PHYSICAL METEOROLOGY

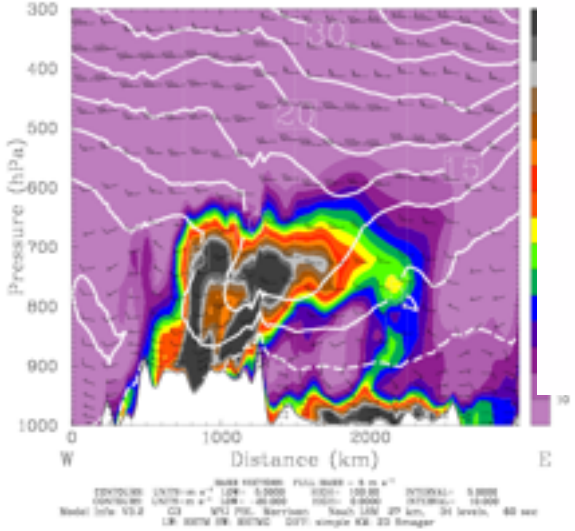
Modelling of long-range transport of Southeast Asia biomass-burning aerosols to Taiwan and their radiative forcings over East Asia

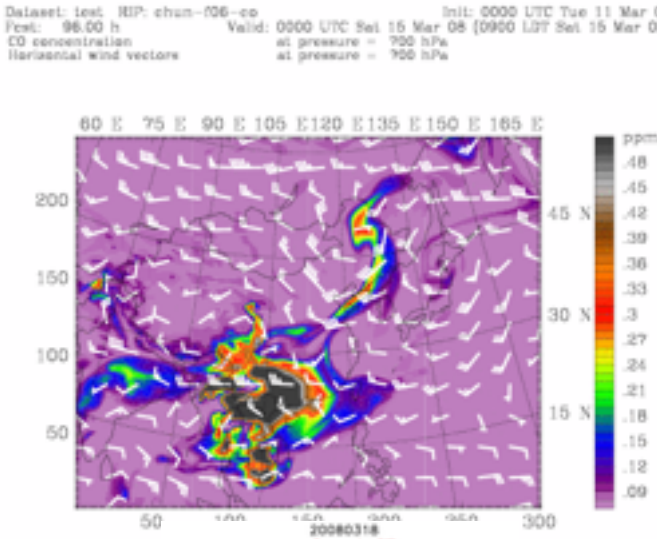
By CHUAN-YAO LIN[1]*, CHUN ZHAO[2], XIAOHONG LIU[2,3], N
WEI-NEI CHEN[1], [1]Research Center for Environmental Changes, Acaden

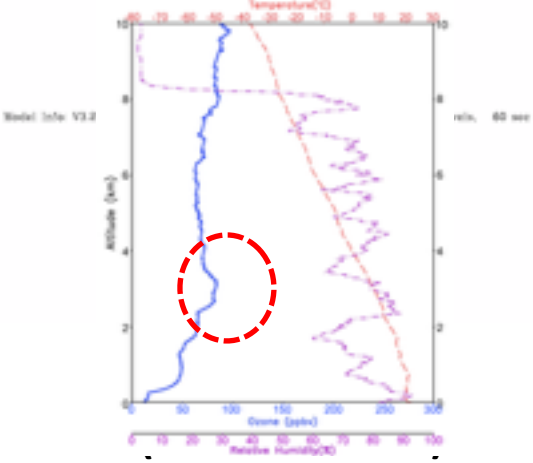




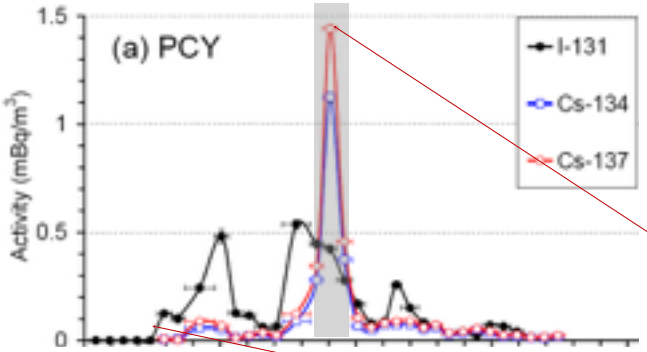


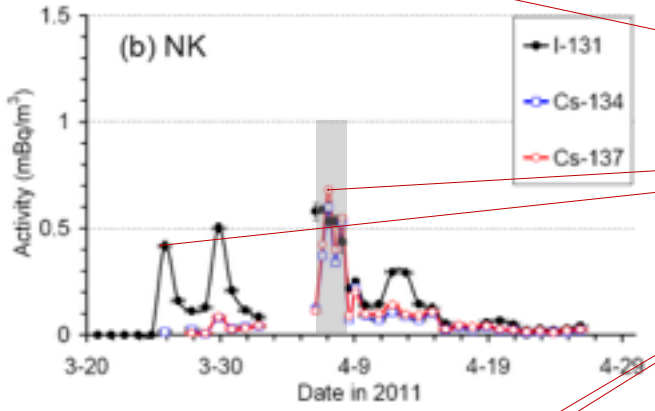


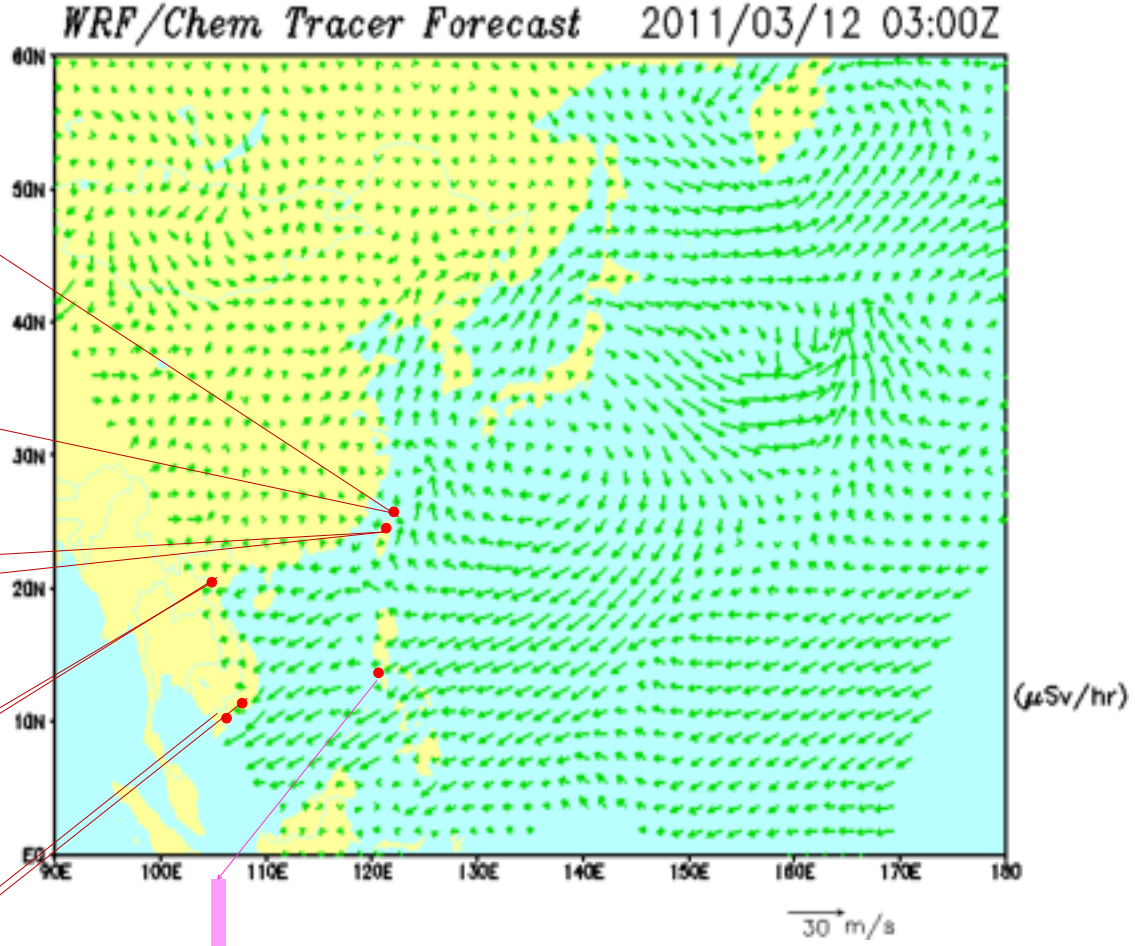


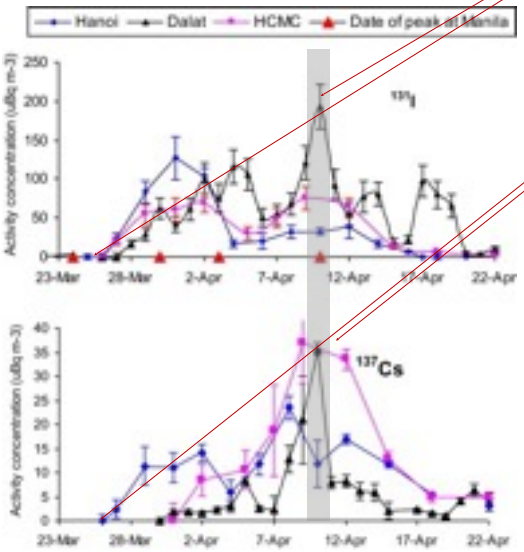


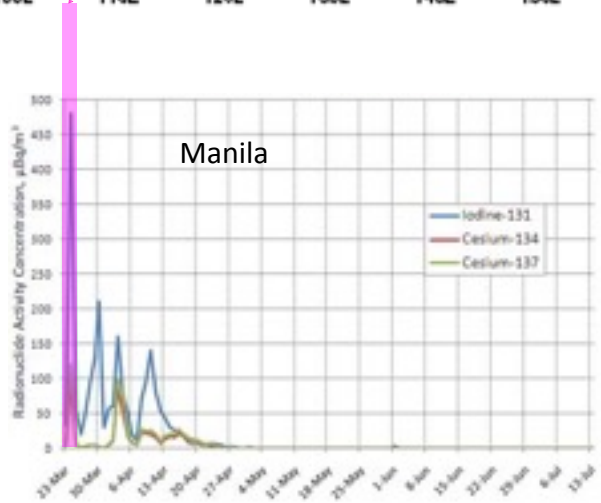
Model: WRF/Chem,
15 km resolution

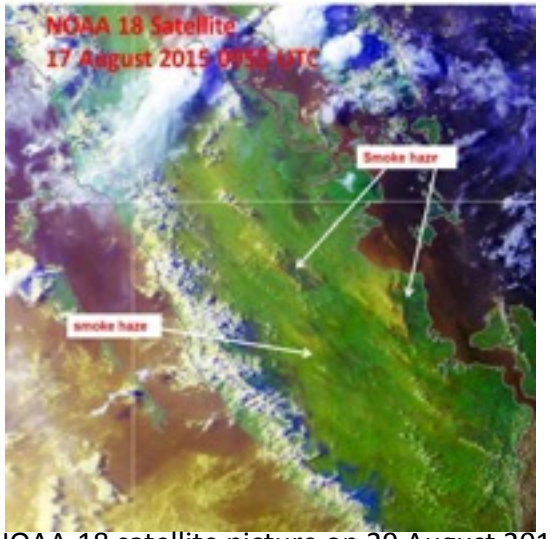

(a) PCY
I-131
Cs-134
Cs-137
Activity (mBq/m3)


(b) NK
I-131
Cs-134
Cs-137
Activity (mBq/m3)
3-20
3-30
4-9
4-19
Date in 2011

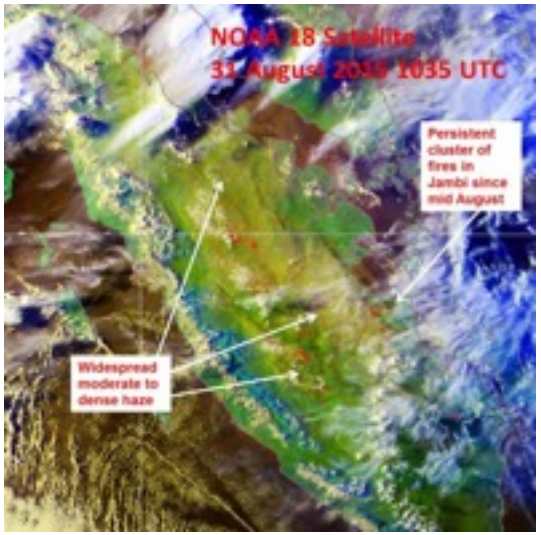

WRF/Chem Tracer Forecast 2011/03/12 03:00Z
60N
50N
40N
30N
20N
10N
EQ
90E
100E
110E
120E
130E
140E
150E
160E
170E
180
(μSv/hr)
30 m/s


Hanoi
Dalat
HCMC
Date of peak at Manila
131I
137Cs
Activity concentration (uBq m-3)
23-Mar
28-Mar
2-Apr
7-Apr
12-Apr
17-Apr
22-Apr

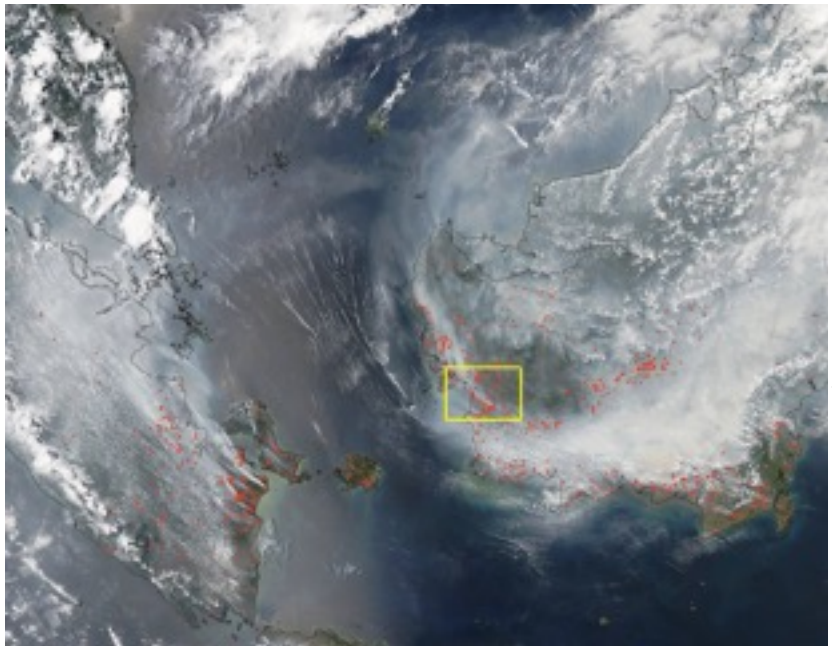

Manila
Iodine-131
Cesium-134
Cesium-137
Radionuclide Activity Concentration, pBq/m3



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.

Disaster Mitigation WG of APAN Approved in Jan. 2016

- Facilitate regional efforts on DM and Extending DM works to all APAN members (20 members from 17 countries)
- Take advantage of the new collaboration framework between APAN and EGI
- Cloud + (Security + AAI) + Networking + Applications
- Case Study: Starting from Agriculture and Disaster Mitigation WG
- Service Directory: Welcome all parties provide any service end point
- Data Directory:
  - weather, geospatial, observation, satellite images/data, earthquake, etc.
  - public open data sources
- Proof of Concept Experiment
- Review the Progress at least once every year at APAN meeting
- Next Workshop is in Aug. 4th, 2016 at APAN42 in Hong Kong

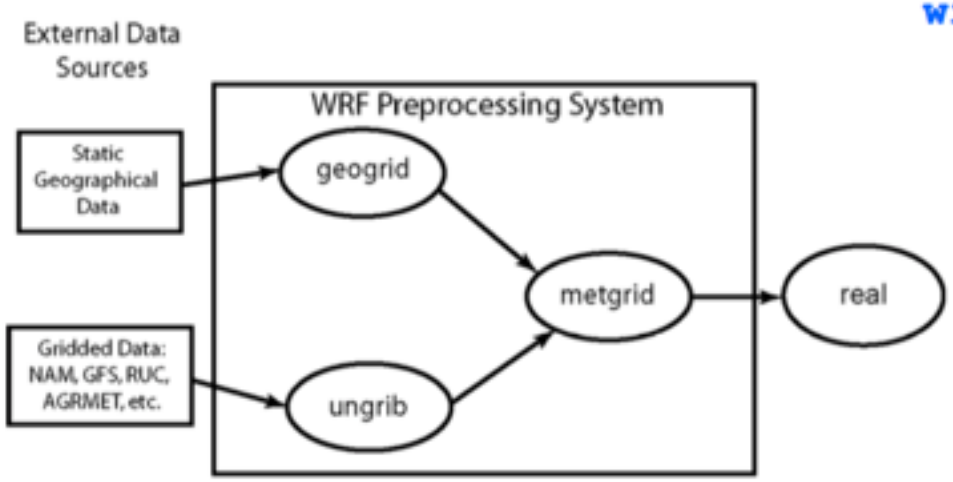
Collaborations & Outreach

Team up the user communities, service providers and technology providers

- 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

Running WRF

1. WPS - WRF Preprocessing System

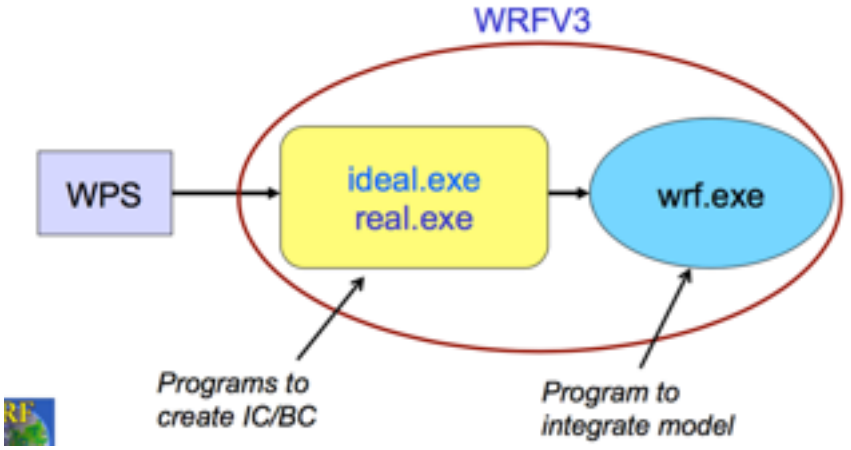


- geogrid: Define size/location of model domains and interpolate static terrestrial fields to simulation grids
- ungrib: Extract meteorological fields from GRIB files
- metgrid: Horizontally interpolate meteorological fields (from ungrib) to simulation grids (defined by geogrid)

2. Running WRF

`ideal.exe` - ideal case initialization program

`wrf.exe` - model executable



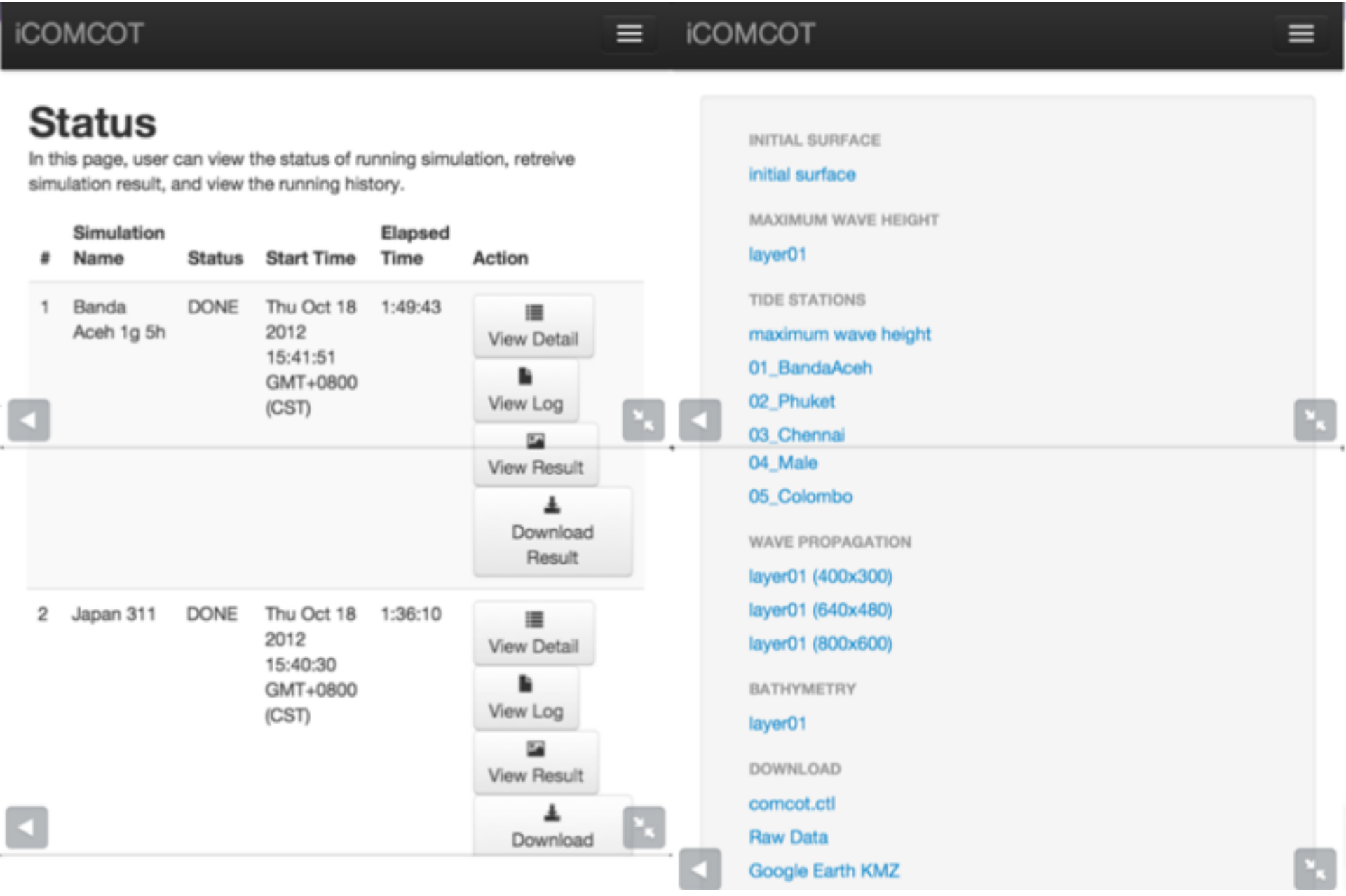
ARWpost

GrADS

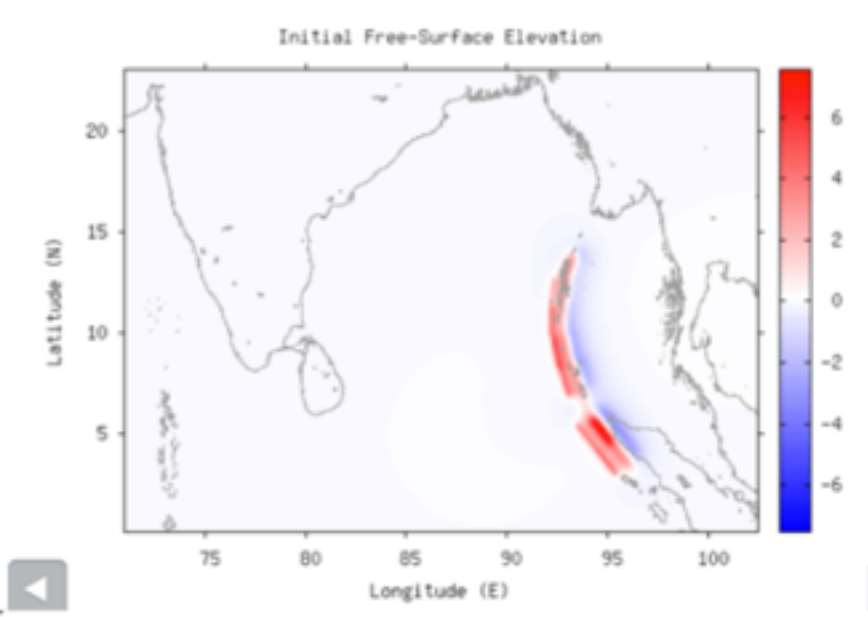
3. ARWpost is a Fortran program that reads WRF-ARW input and output files, then generates GrADS output files.

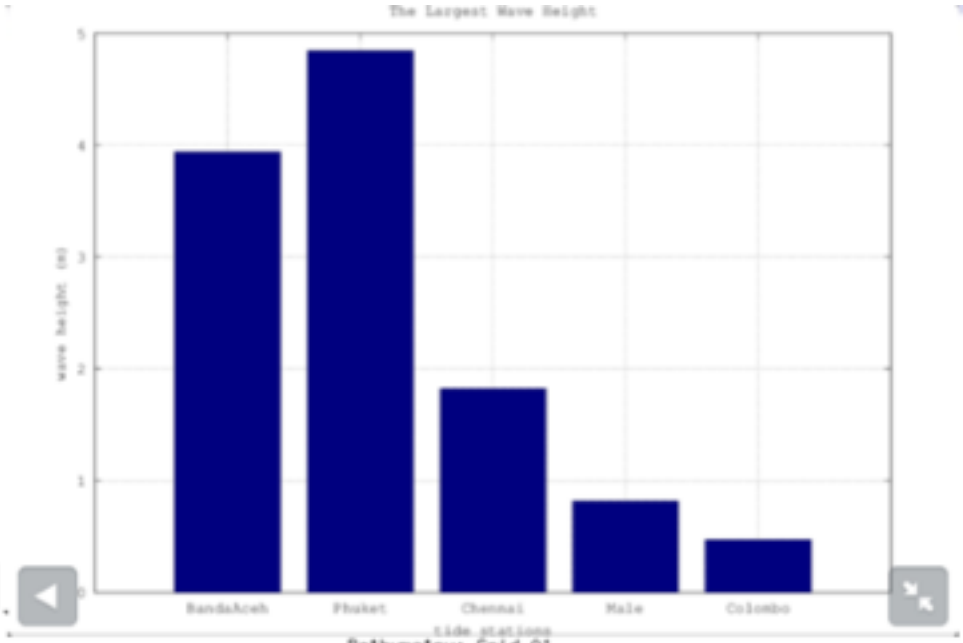
iCOMCOT User Interface (I)

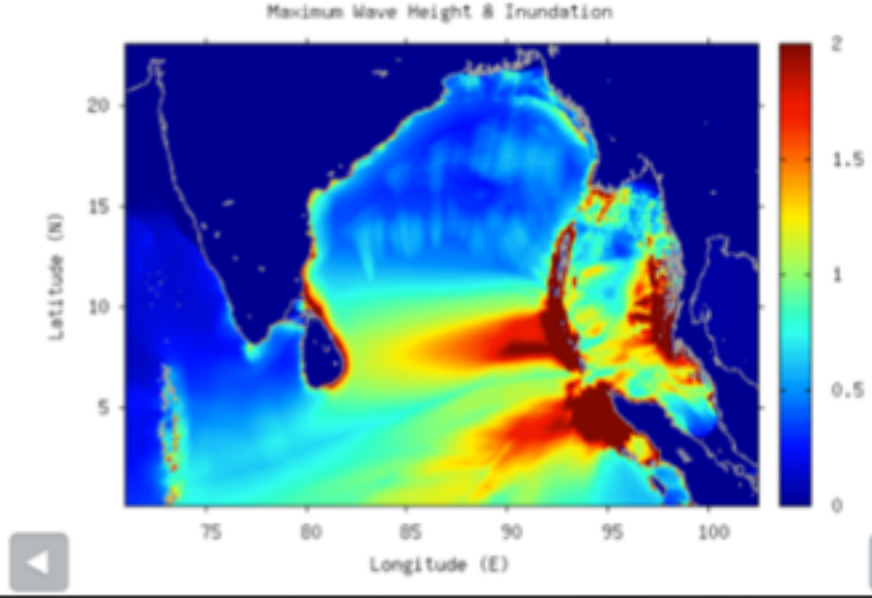
iCOMCOT User Interface (II)

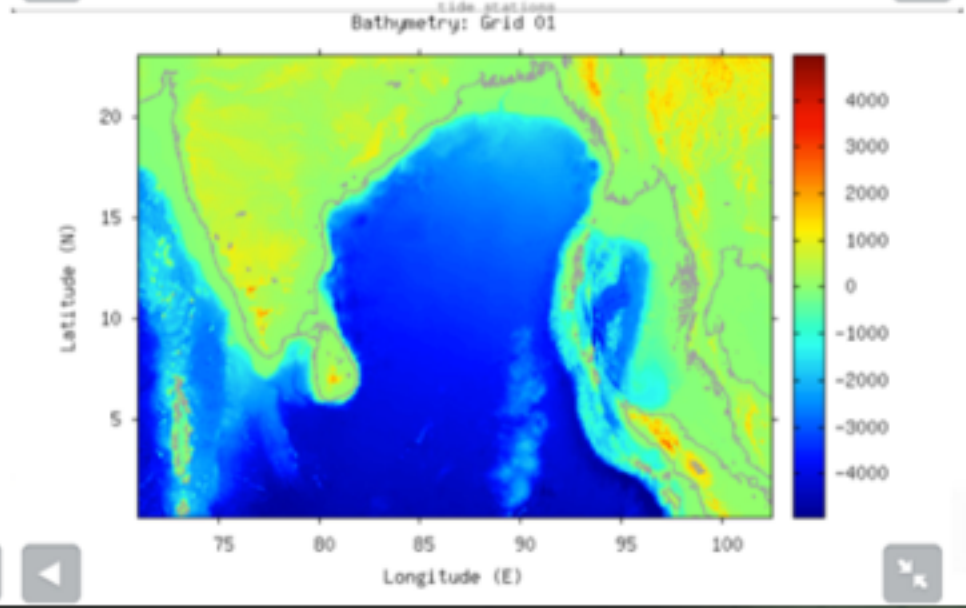


iCOMCOT Result Visualization



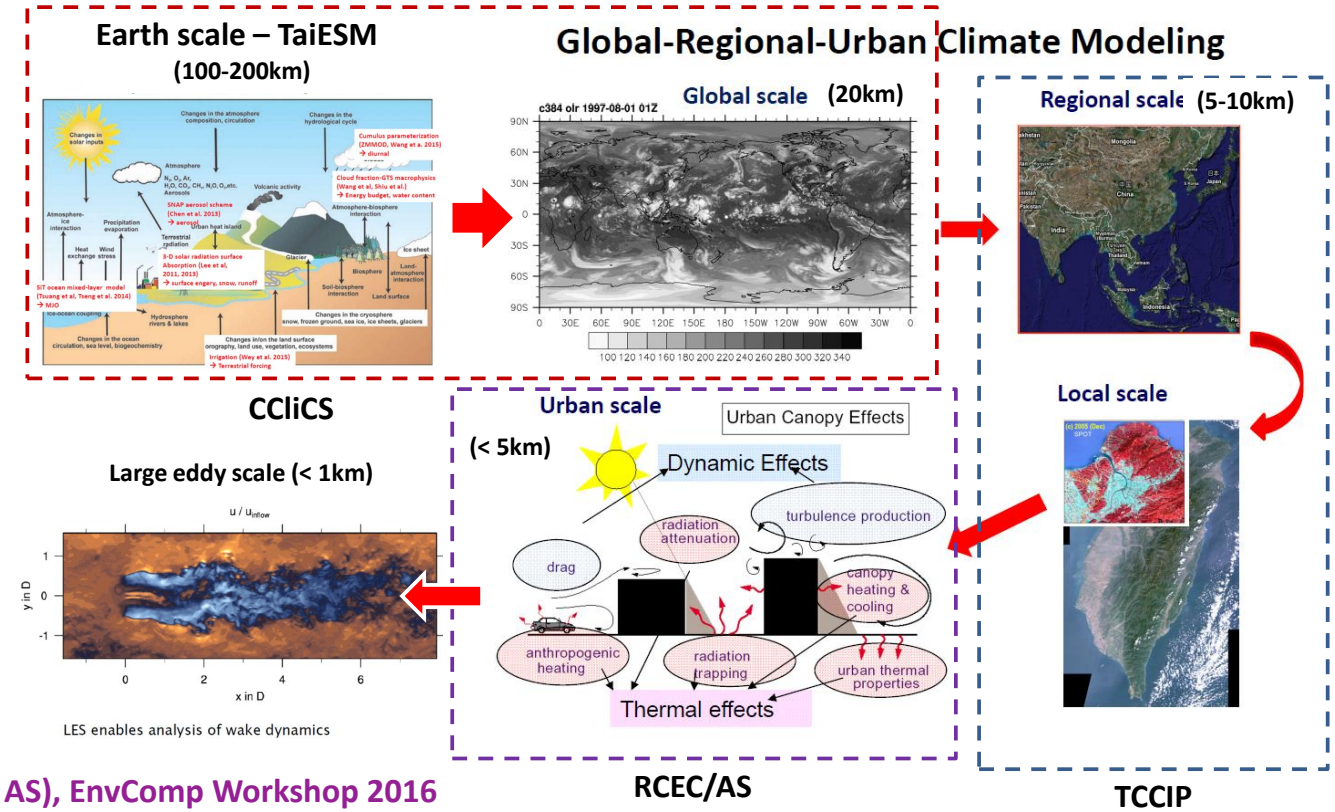






- **Support effective disaster mitigation based on deep understandings**
- **Facilitate scientific advancement on disaster modeling and simulation**
- **Provide e-Services for Scientists, Governments and wider user communities**

Cross-scale Climate Modeling System



Source: Prof. Huang-Hsiang Hsu (RCEC, AS), EnvComp Workshop 2016