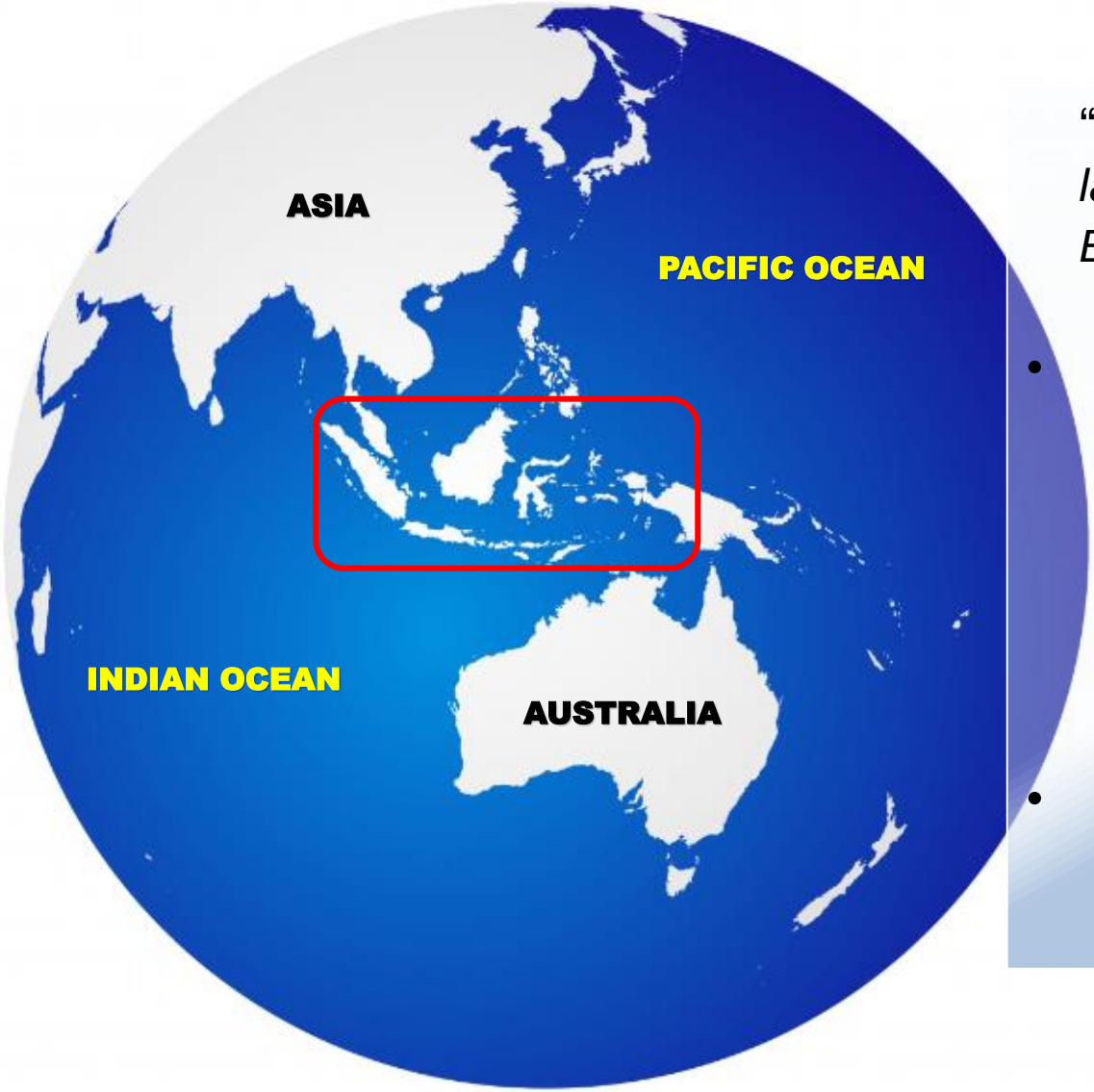
BMKG

END TO END OF COASTAL INUNDATION FORECASTING SYSTEM IN INDONESIA

2ND International Workshop on Wave, Storm Surge and Coastal Hazards
Melbourne 13th November 2019

*Nelly Florida Riama(1) , **Bayu Edo Pratama**(2) , Andri Ramdhani(2)*
(1) Director of Research and Development Center
(2) Marine Meteorology Centre
AGENCY FOR METEOROLOGY, CLIMATOLOGY AND GEOPHYSICS OF THE REPUBLIC OF INDONESIA (BMKG)

GEOGRAPHY OF INDONESIA



"*Indonesia is a miniature of our land – sea coexisting planet Earth*" Yamanaka, 2016.

- **an Archipelago with total waters / seas 70% of the total area** (the lands and seas over the actual Earth have been keeping similar area ratio).
- Having 3rd longest coastline in the world (99.093 Km) & more than **17.000 islands.**

BACKGROUND

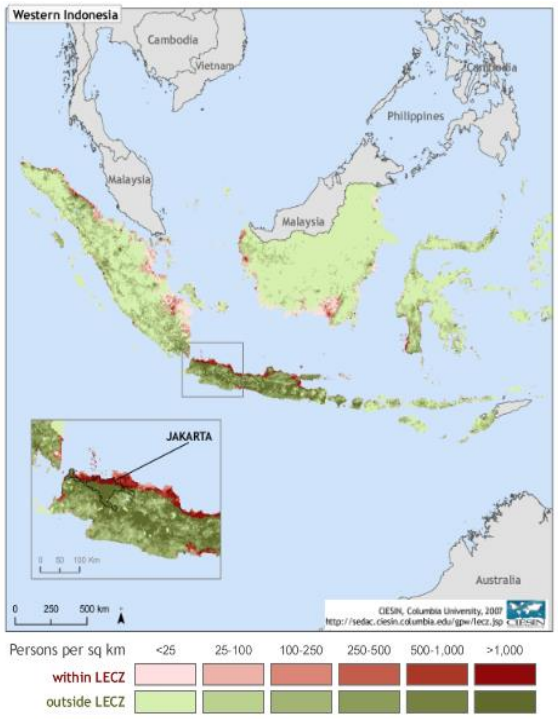
An accurate early warning needed for disaster mitigation plan

BACKGROUND

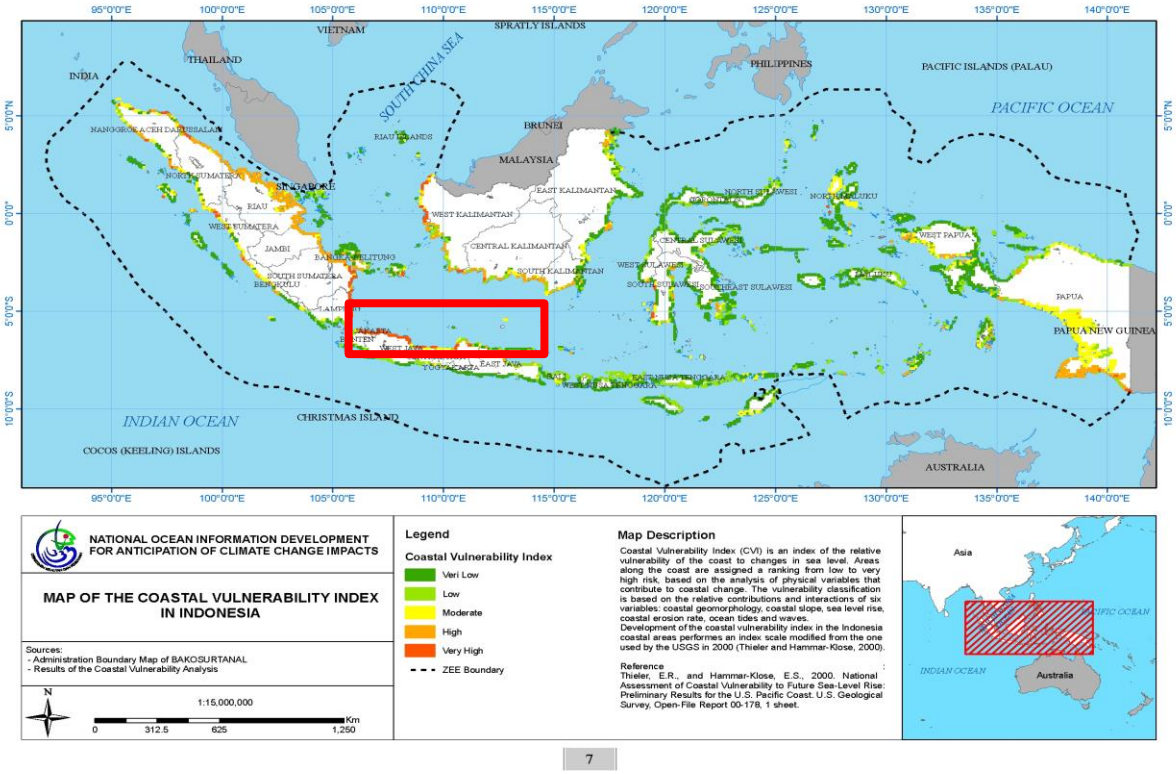
- Indonesia as archipelagic countries is very prone to coastal hazard
- coastal flooding by **extreme wave events, tropical cyclones,** and **high tides**
- Increased risk of coastal inundation due to **sea level rise + land subsidence.** As a Sample in Jakarta and Semarang City

BACKGROUND

Based on The United Nations Office for Disaster Risk Reduction (UNISDR), Indonesia **Coastal Flood** Hazard is classified as **medium.**

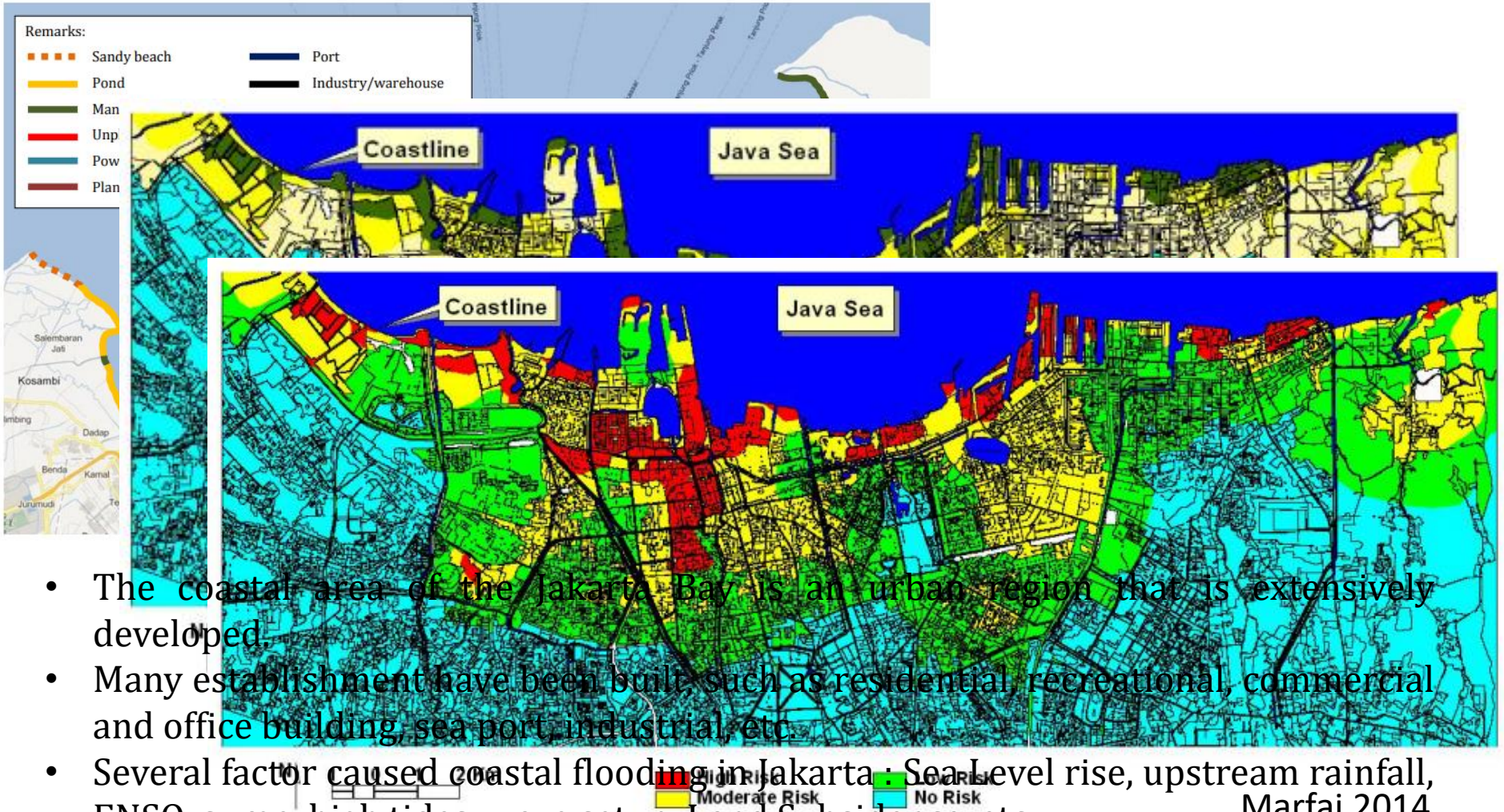


Population density
By Columbia University, 2007



Northern Coast of Java has low lying area, especially Jakarta and Semarang

BACKGROUND



- The coastal area of the Jakarta Bay is an urban region that is extensively developed.
- Many establishment have been built, such as residential, recreational, commercial and office building, sea port, industrial, etc.
- Several factor caused coastal flooding in Jakarta : Sea Level rise, upstream rainfall, ENSO, surge, high tides, wave setup, Land Subsidence, etc

Marfai,2014

Increasing of water level due to atmospheric forcing (wind, air pressure, and storms: Hagibis and Mitag Cyclones)

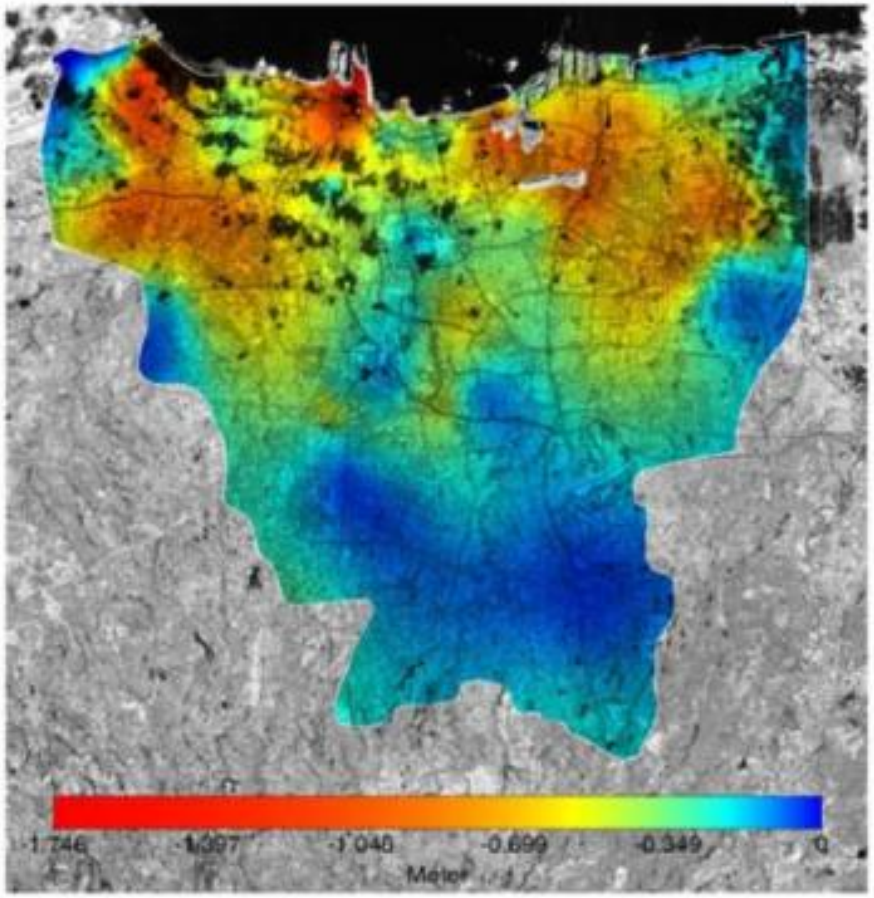
Losari, located at Central Java, experienced the highest surge among the others locations, namely 17.4 cm at 5:45 UTC on 5 December 2007

Name of the locations:

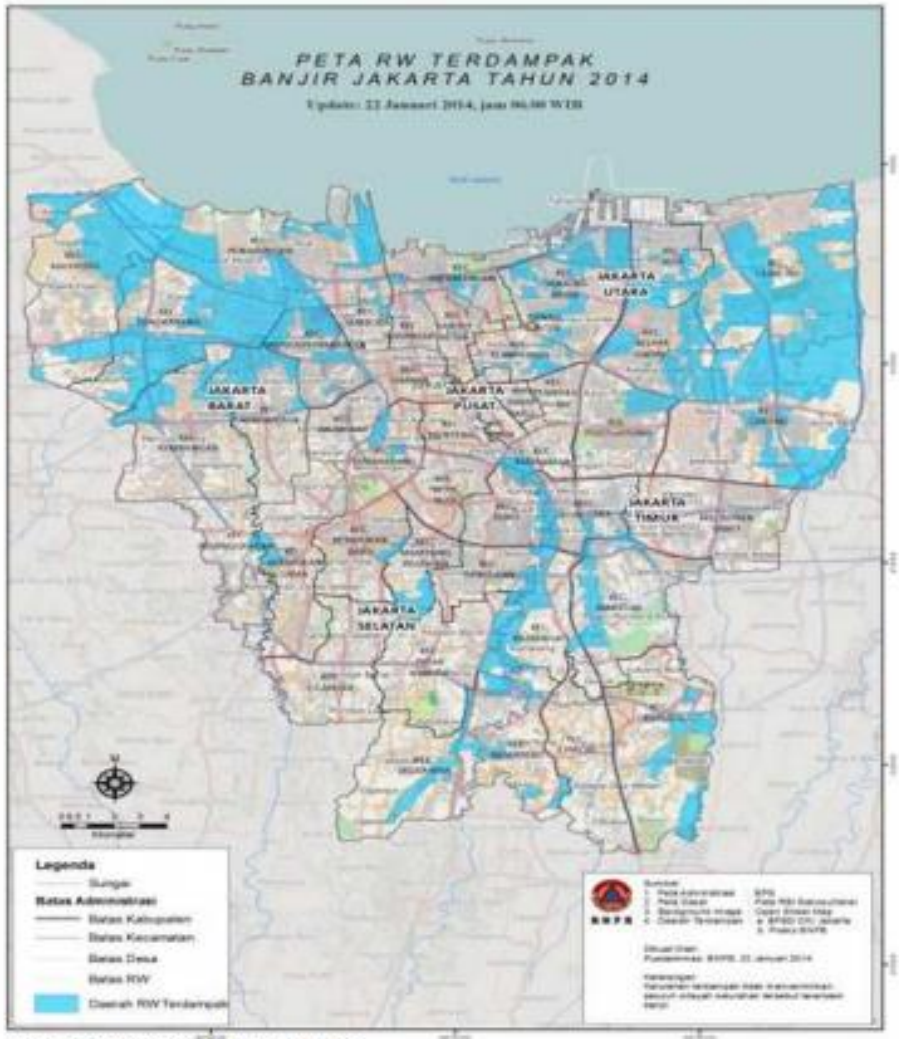
(1). Merak
(2). Banten Bay
(3). Tirtayasa
(4). Mauk
(5). Penjaringan
(6). Cilincing
(7). Karawang Cape
(8). Tambaksumur
(9). Sungaibuntu
(10). Cilamaya
(11). Pamanukan
(12). Indramayu
(13). Balongan
(14). Cirebon
(15). Losari
(16). Tegal
(17). Pekalongan
(18). Gringsing
(19). Semarang
(20). Jepara
(21). Bumimulyo
(22). Rembang
(23). Tambakboyo
(24). Labuhan
(25). Pangkah Cape
(26). Surabaya
(27). Sidoarjo
(28). Bangil
(29). Probolinggo
(30). Gending
(31). Gerinting Cape
(32). Panarukan
(33). Pamekasan
(34). Sampang
(35). Modung Cape
(36). Sapulu

Ningsih, et.al 2010

Spatial Correlation between GPS-derived Land Subsidence (2000-2011) and Flooding area in Jakarta (2014)



GPS-derived subsidence (2000-2011)



source: geospasial.bnpb.go.id


SRIBOGA

INDONESIA COASTAL INUNDATION FORECAST

- Trough World Meteorological Organization (WMO) → CIFDP **(transform to INA-CIFS)** , a coastal flood forecasting and warning systems for Jakarta and Semarang has been developed.
- BMKG collaborate with other institution, to create the National Coordination Team (NCT).

BMKG PUSAIR BADAN INFORMASI GEOSPASIAL BNPB

MoU NCT signed March 29th ‘17

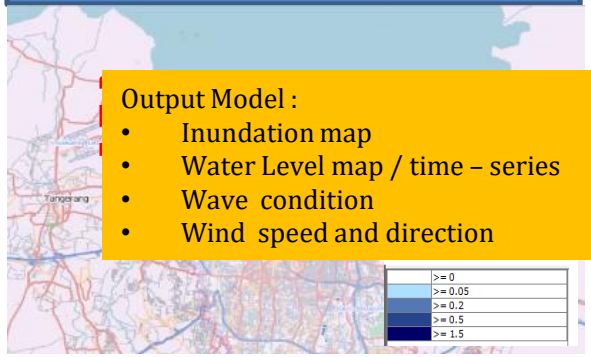
Ina-CIFS Launched on April 2019

CIFDP Final Meeting, Bali January 2019

END TO END COASTAL INUNDATION FORECATING SYSTEM

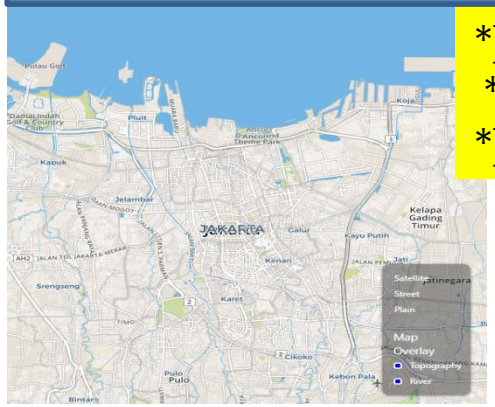
BMKG

OUTPUT MODEL



Output Model :
- Inundation map
- Water Level map / time – series
- Wave condition
- Wind speed and direction

Dashboard Early Warning System



*) Spaatial and Timeseries
*) Expertize by Forecaster
*) Impact base forecast

1. API Platform to bridge to another system

2. Image Output
3. Web Base interactive

Location : District warning

Emergency Response

- ✓ Vulnerability Assesstment
- ✓ Risk Assestment
- ✓ Impact Assestment

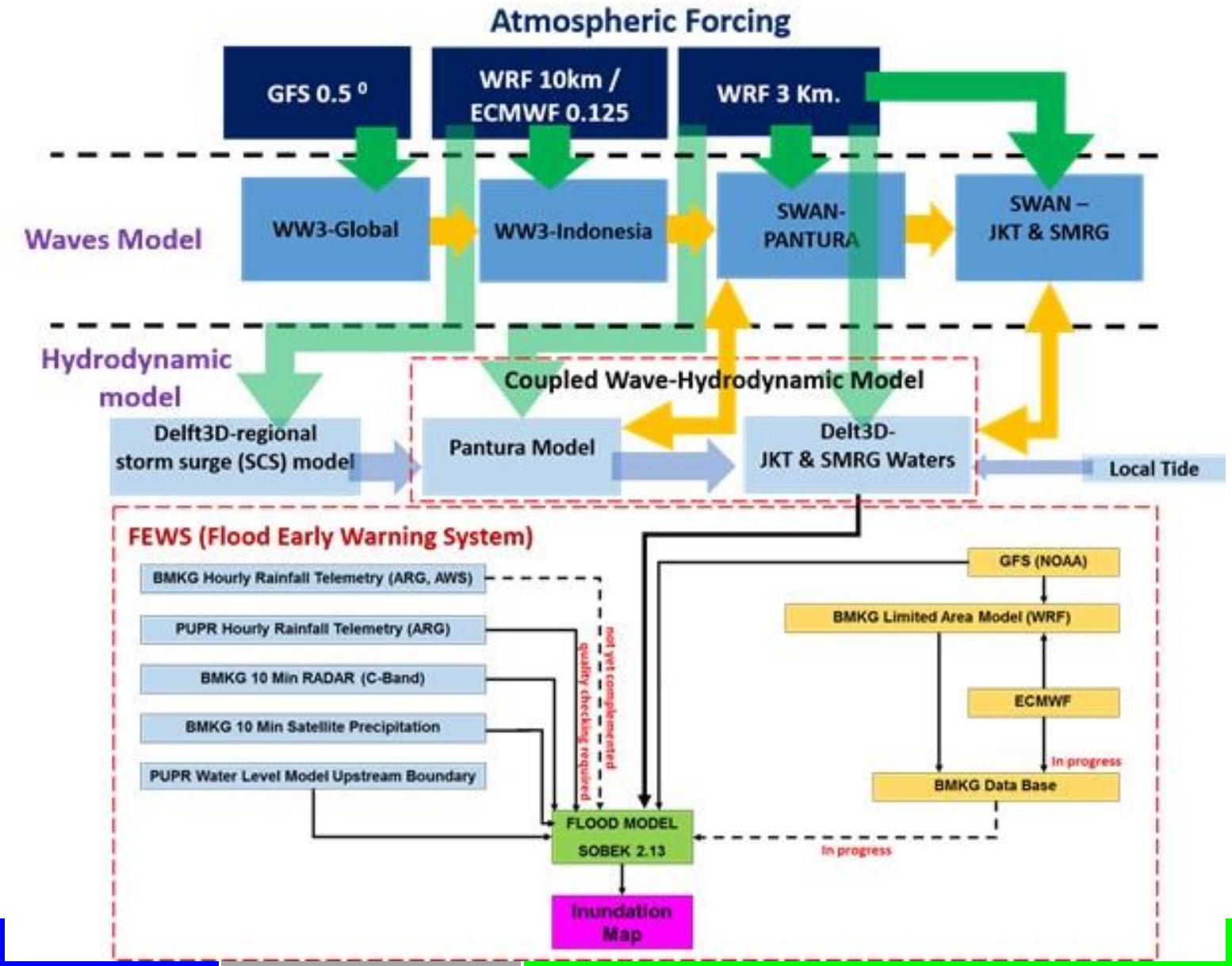
MODEL SCHEME

The model scheme for Ina-CIFS is included :

1. Wave model (Based on WW3)
2. Coupling wave-hydrodynamics model (Delft3D)
   - ✓ Nested WW3 – SWAN model
   - ✓ Coupled Delft3Flow - SWAN
3. Integrated with river flood model (Delft FEWS and Sobek Model)

The Ina-CIFS models and system were developed on BMKG High Performance Computing.

MODEL SCHEME (2)



MODEL SCHEME (3) – WAVE MODEL

RECENT WORK – Ocean Wave Model

Ina-Waves ~

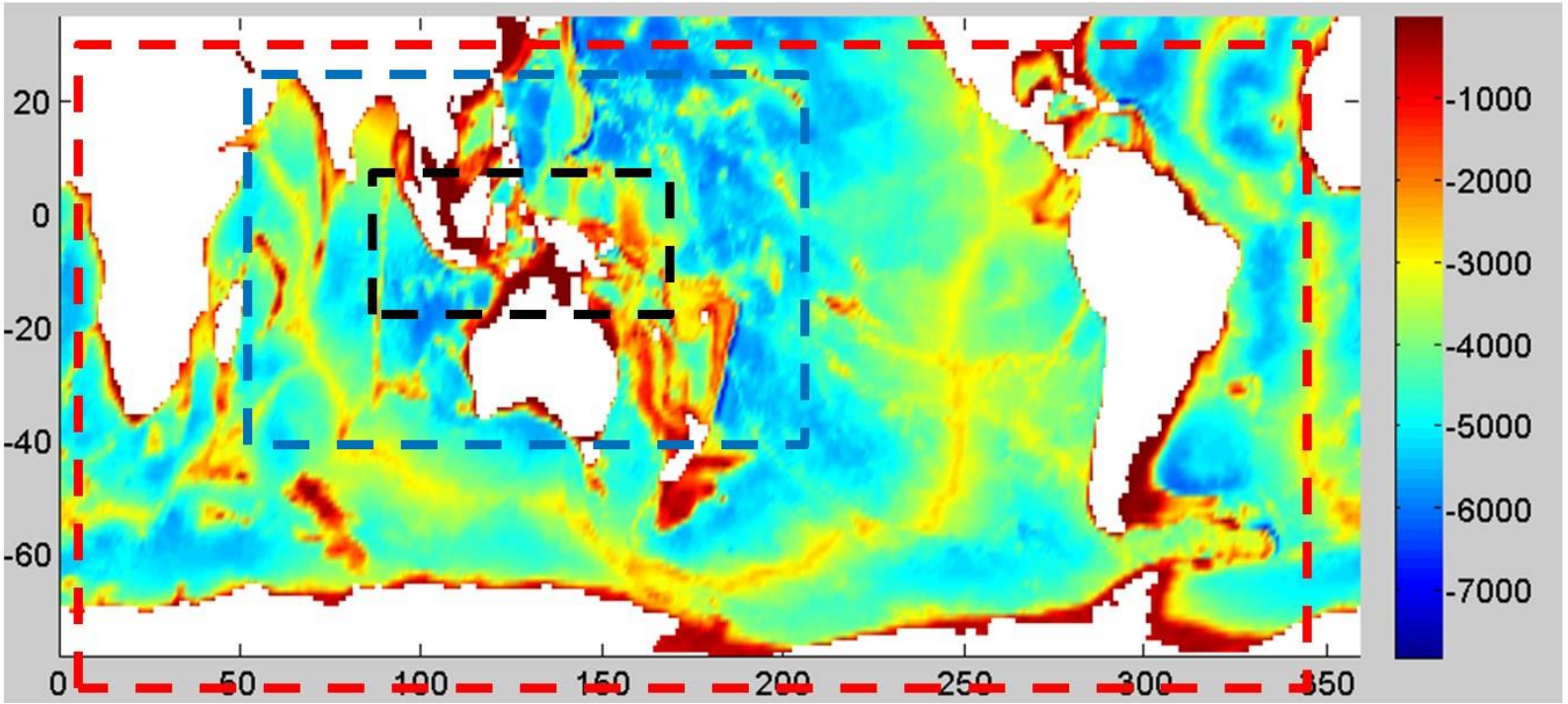
WW3- Model Domain & Grid Resolution.

Global: 1^0 x 1^0 (lat/lon)

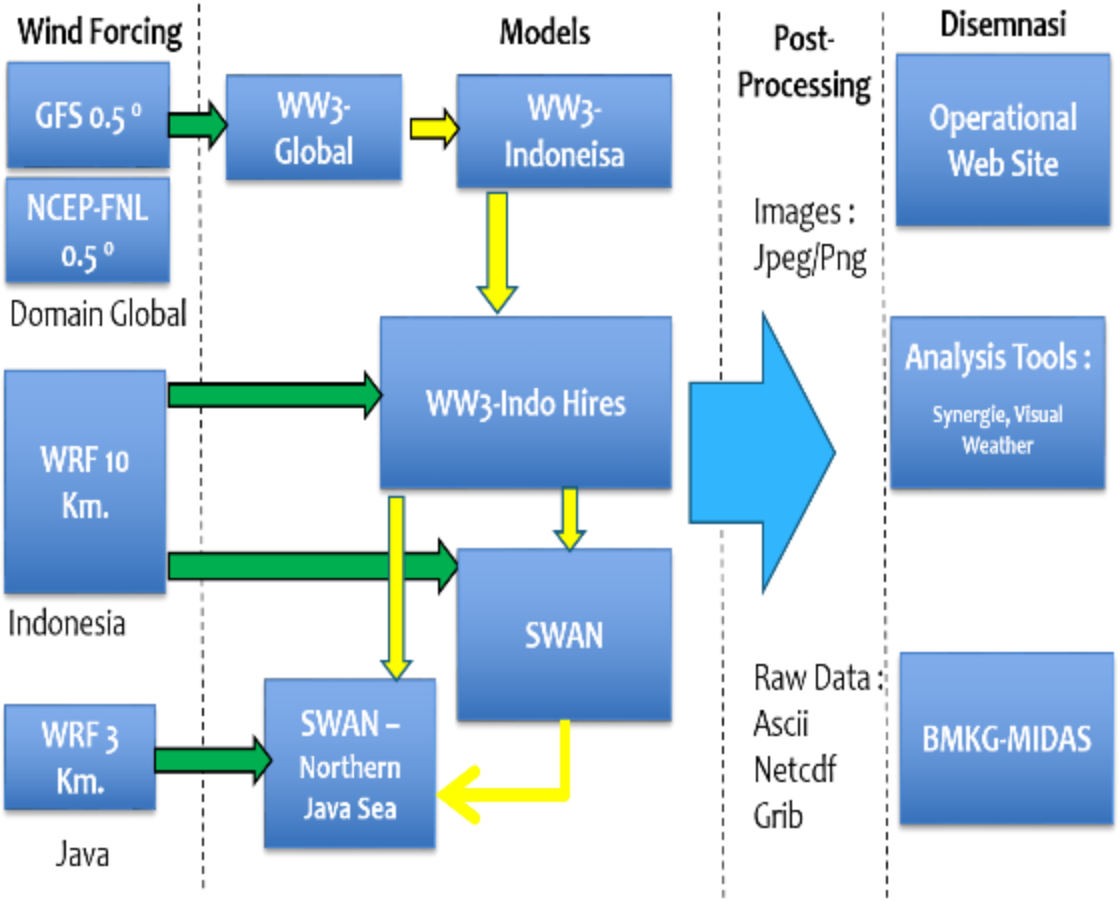
Asia – Austalia : 0.25^0 x 0.25^0 (lat/lon)

Indonesia Low Res : 0.125^0 x 0.125^0 (lat/lon)

Indonesia High Res : 0.0625^0 x 0.0625^0 (lat/lon)



BMKG OFS: WAVE MODEL FLOW CHART



Forecast

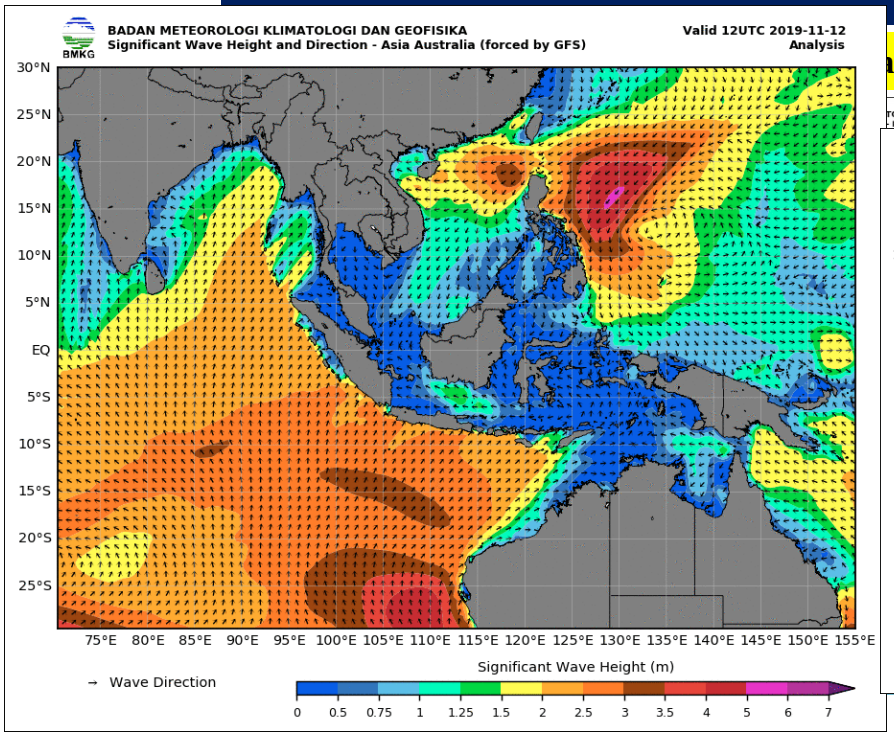
Up to 10 Days forecast:

- Waves: Height, direction, period
- Surface Wind: speed, direction
- Swell: Height, direction, period

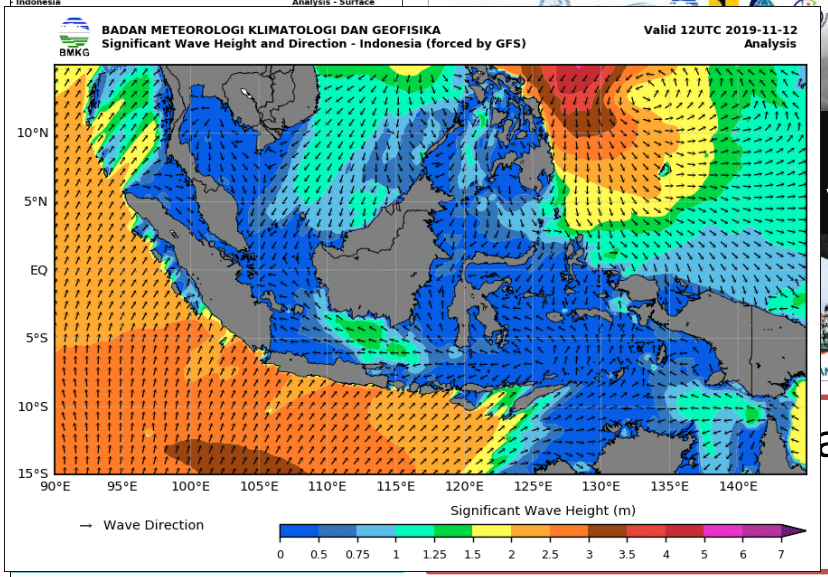
Hindcast / Reanalisis:

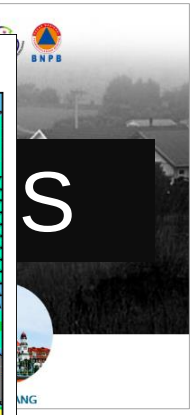
Wind & Wave Climatology

BMKG - OCEAN FORECAST SYSTEM (OFS)



aritim.bmkg.go.id/ofs-static





ation

Forecast up to 10 days

Twice a day

EXISTING

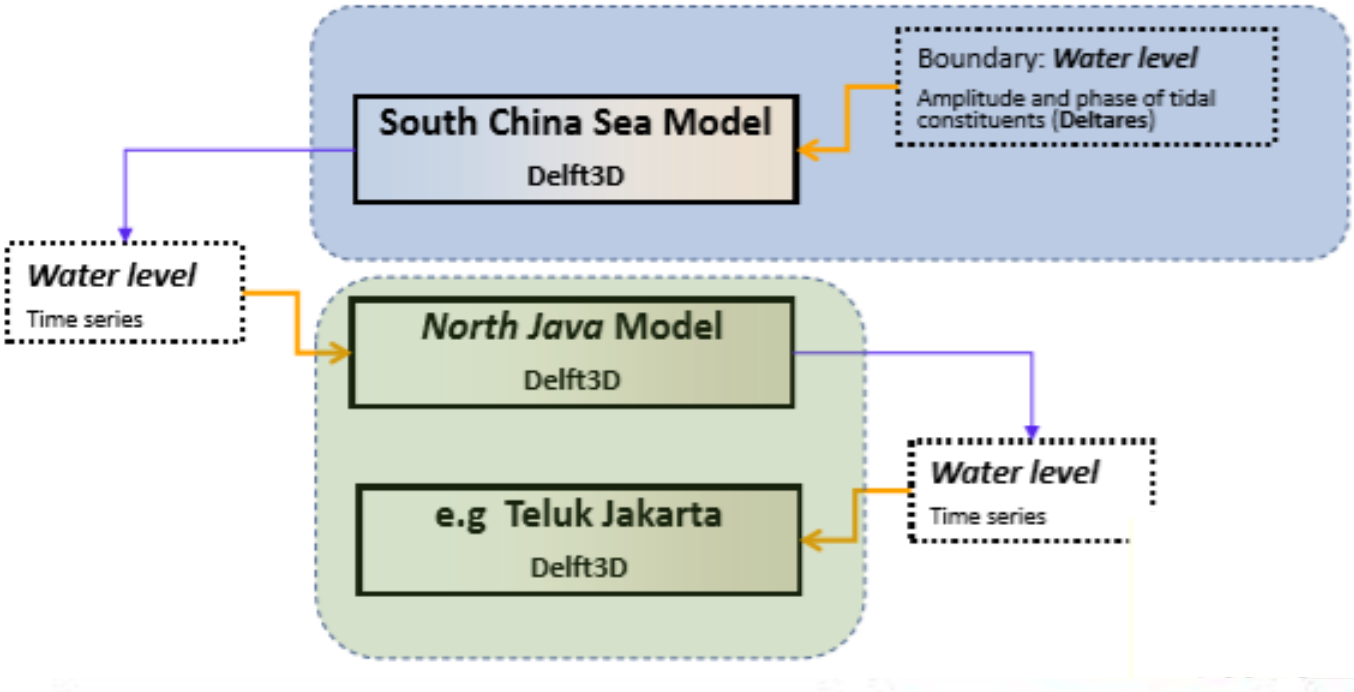
1. Res : 9 Km
2. Without Assimilation
3. 3 hours time step
4. Forcing : GFS

NEXT PROJECT

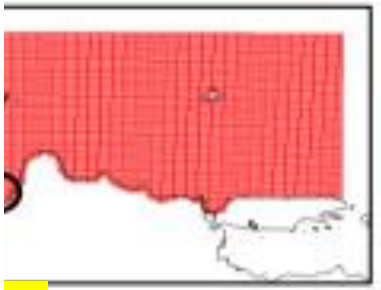
1. Res : 3 Km
2. With Assimilation
3. Ensemble Model
4. 1 hour time step
5. Forcing : GFS, ECMWF, WRF

MODEL SCHEME (4) – COUPLING

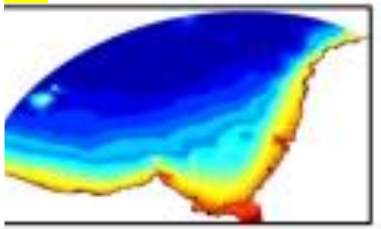
BMKG



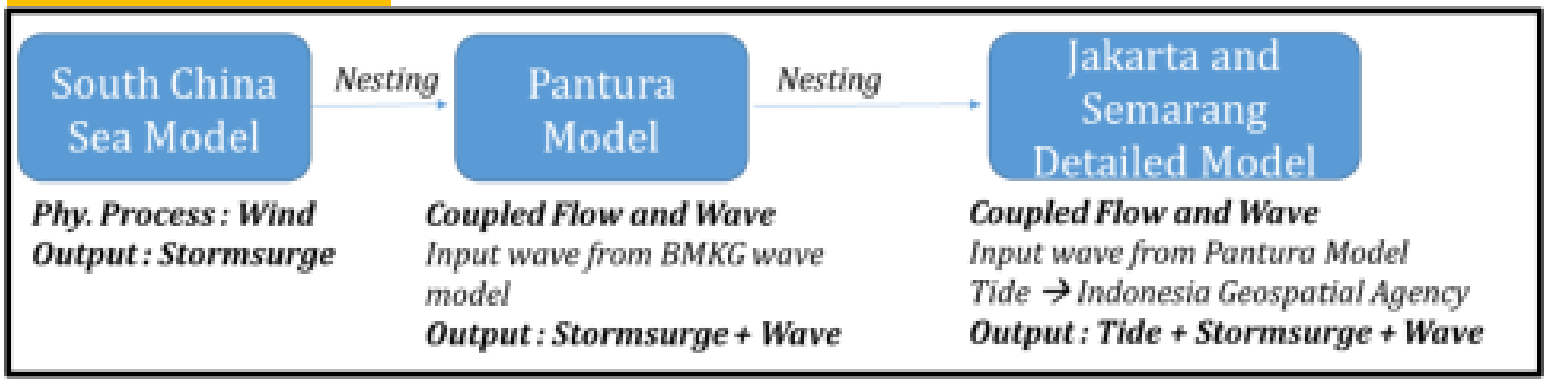
odel



el



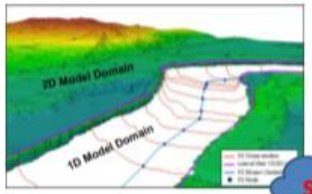
Model Process :



MODEL SCHEME (4) – RIVER MODEL

BMKG

River Flow Model



$$\frac{1}{A}\frac{\partial Q}{\partial t}+\frac{1}{A}\frac{\partial}{\partial x}\left(\frac{Q^2}{A}\right)+g\frac{\partial y}{\partial x}-g(S_o-S_f)=0$$

$$\frac{\partial V}{\partial t}+V\frac{\partial V}{\partial x}+g\frac{\partial y}{\partial x}-g(S_o-S_f)=0$$

Kinematic Wave
Diffusion Wave
Dynamic Wave

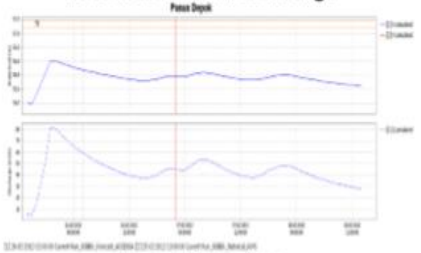
SOBEK

SOBEK is a powerful modelling suite for flood modelling, flood forecasting, optimization of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality

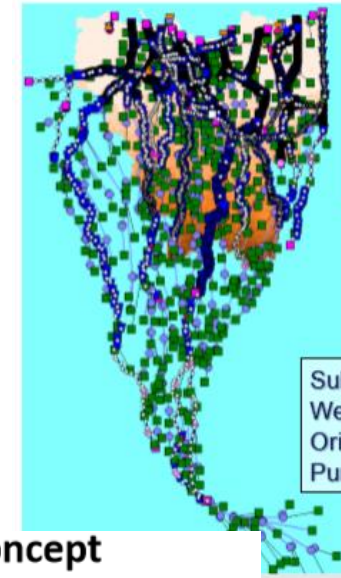
The programs represent phenomena and physical processes in an accurate way in one–dimensional (1D) network systems and on two–dimensional (2D) horizontal grids

SOBEK SOBEK is a powerful, integrated 1D/2D modelling program for water management, design, planning and

Water Level and Dischcarge



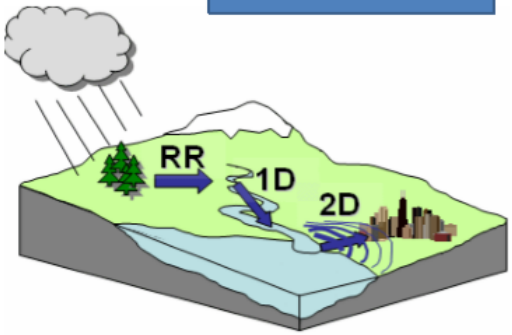
Inundation Area



The SOBEK model of Jakarta consists of
- *Sacramento Rainfall runoff module*
- *SOBEK 1D2D integrated flow and overland flow simulation model*

Sub Basin	:	449
Weir	:	22
Orifice	:	32
Pump Station	:	33

Jakarta Flow Modelling Concept



Calculation of runoff using Sacramento model (SOBEK-RR)

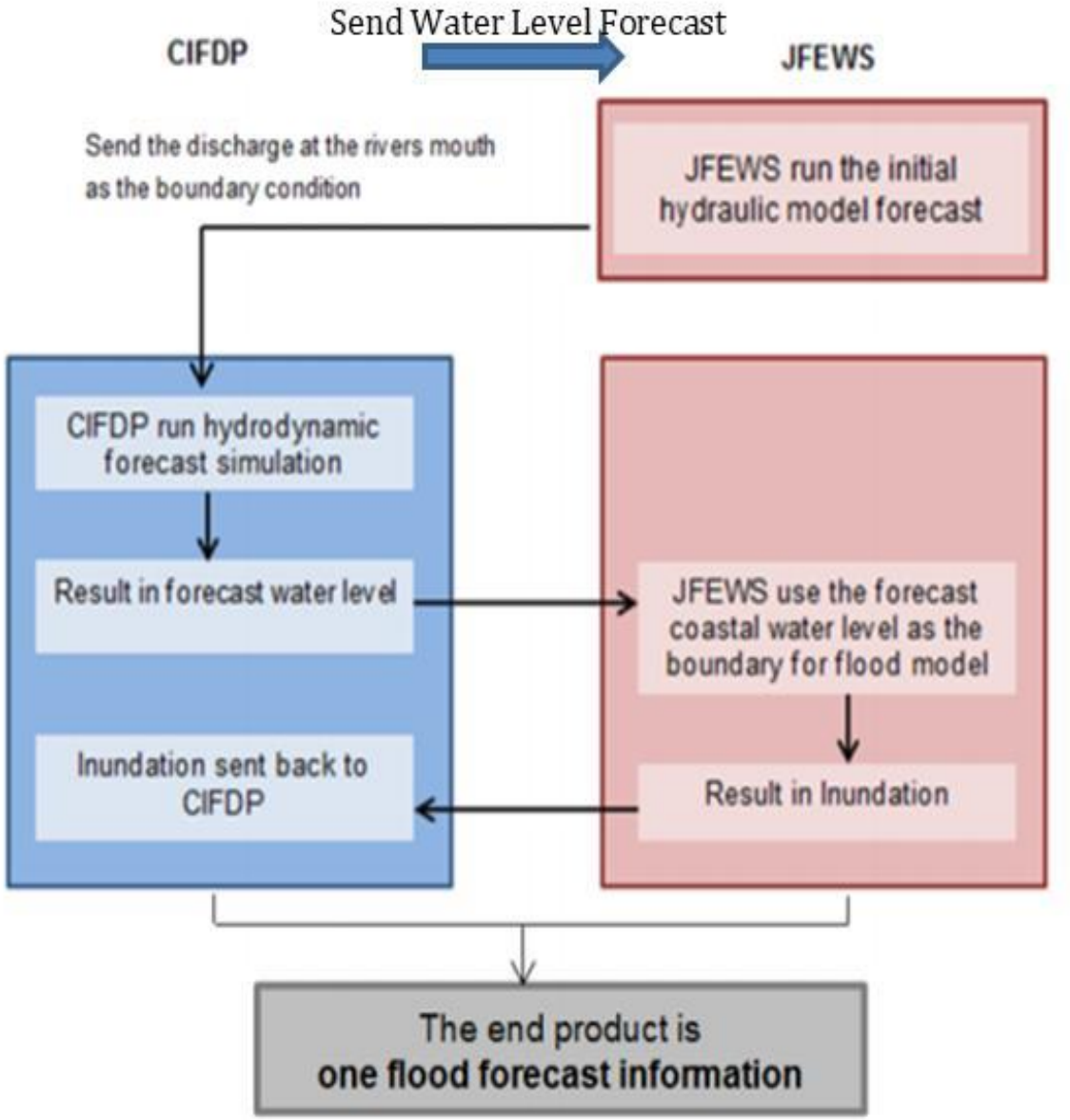
Hydrologic routing of runoff towards main river system using Muskingum method (SOBEK-RR)

Hydraulic routing through river system towards sea (SOBEK-1D)

Hydraulic routing through floodplain (SOBEK-2D)

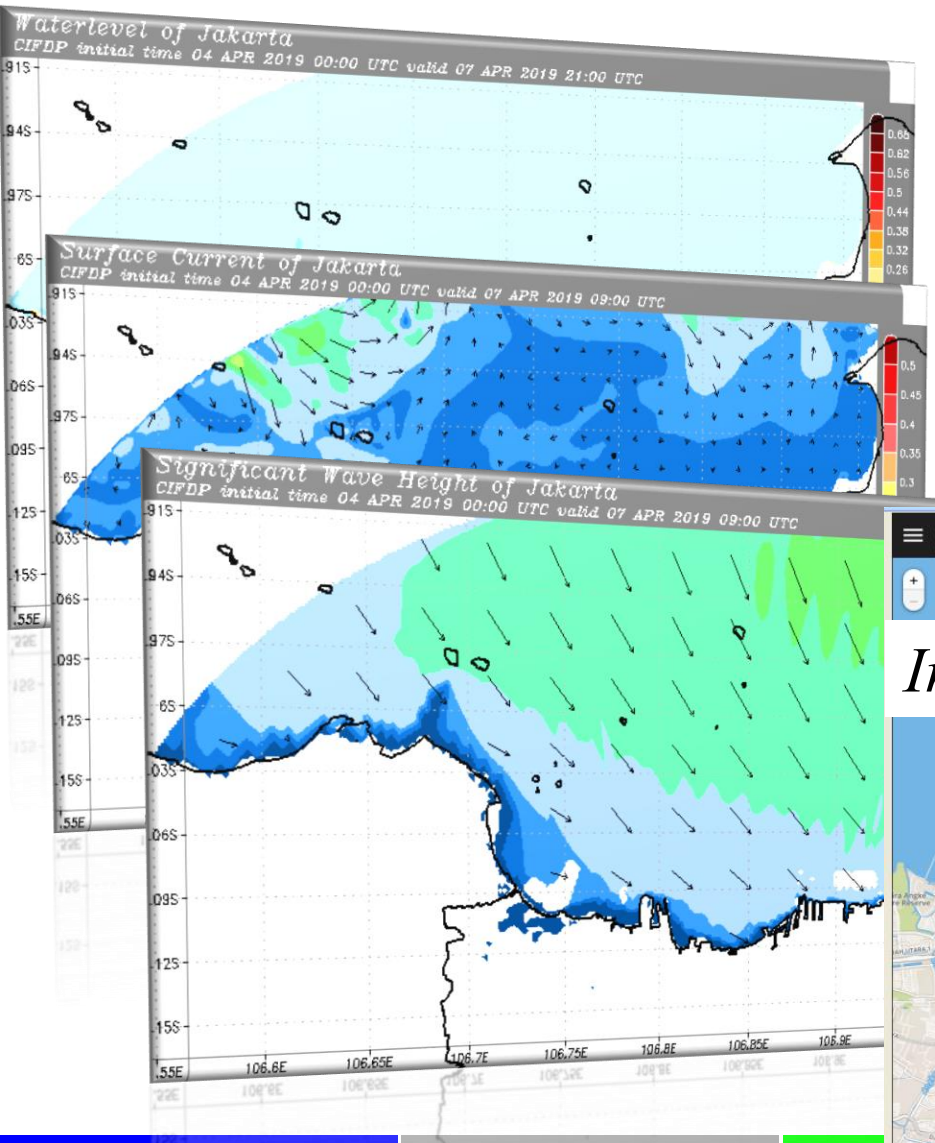
BMKG

INTEGRATION WITH RIVER FLOOD MODEL



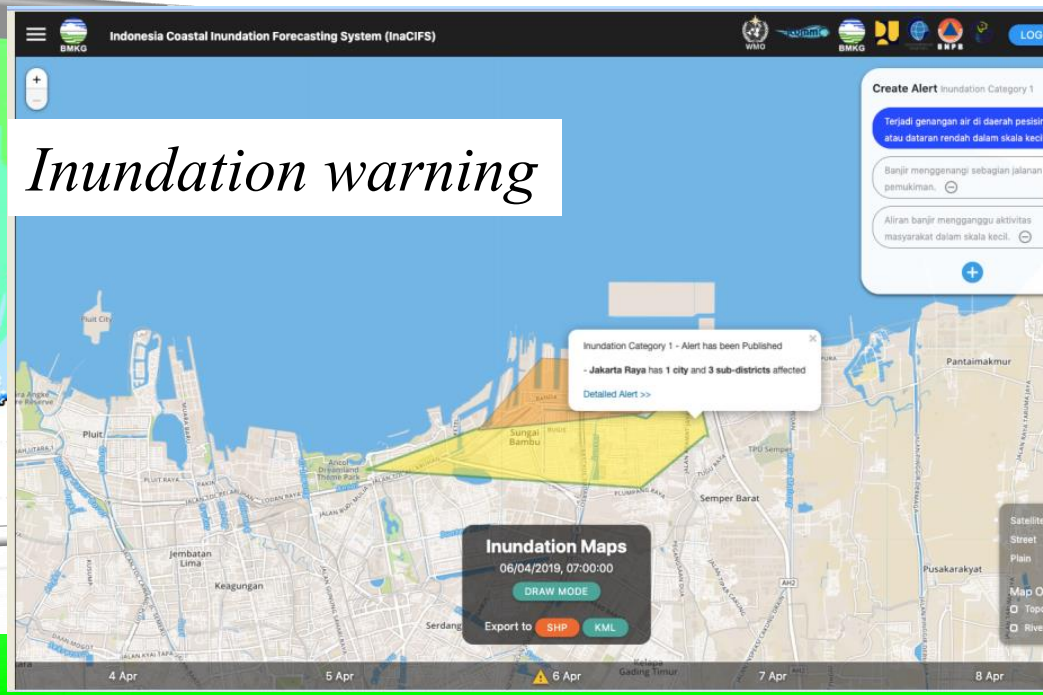
BMKG

OUTPUT OF INACIFS

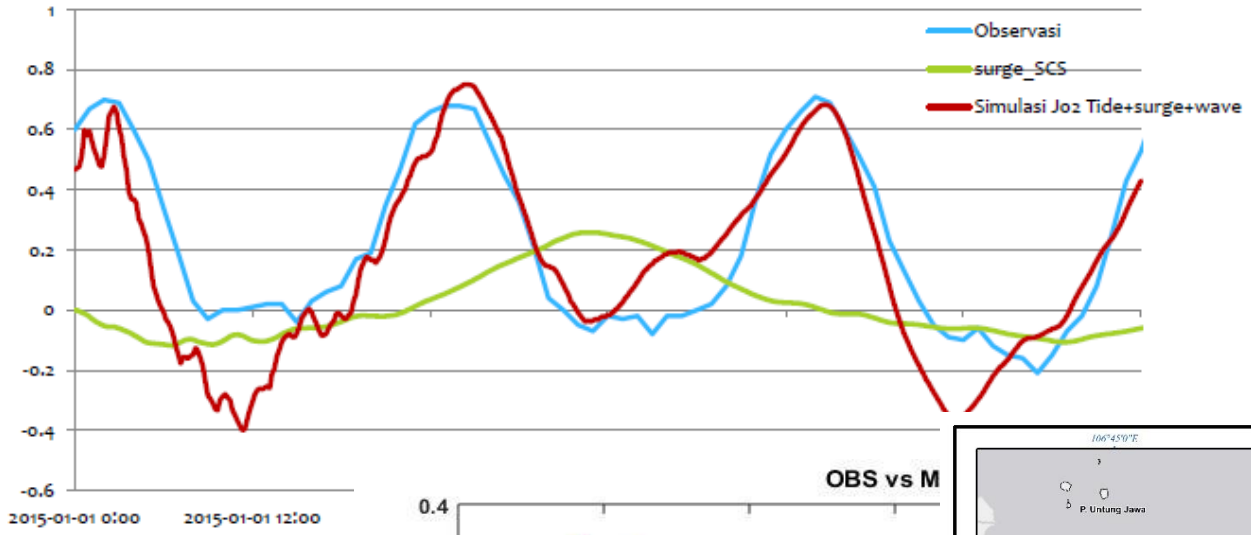


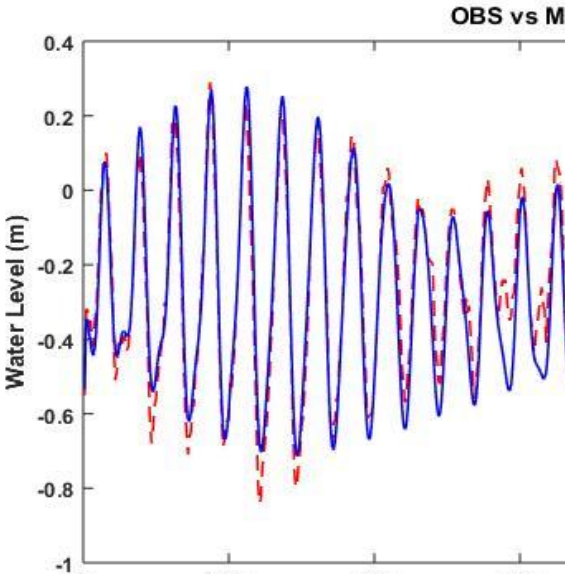
High Resolution and Coupled model for Water Level, Surface Current, Wave Height and Inundation.

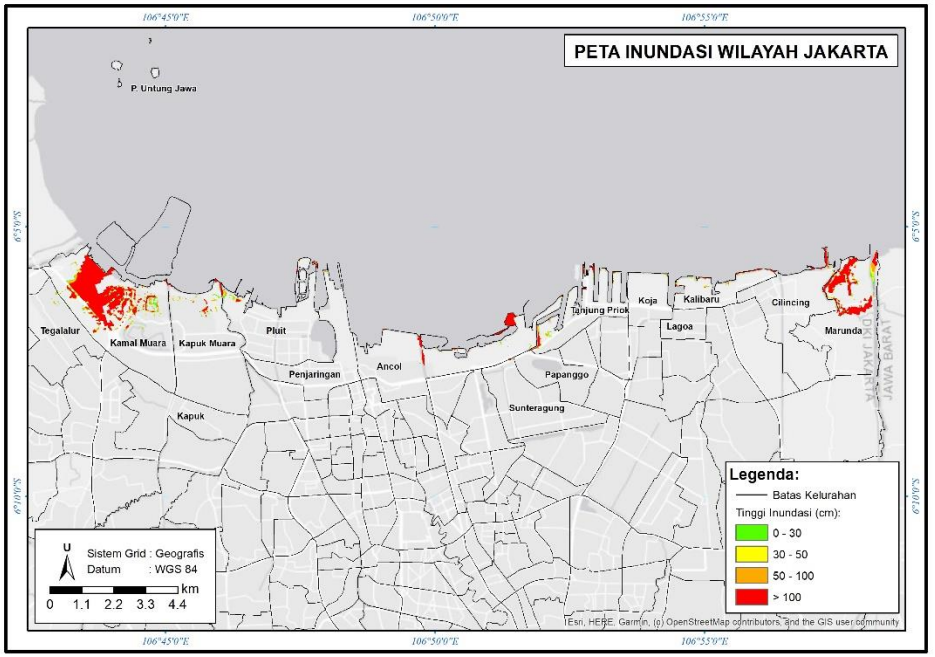
Forecast up to 5 days



OUTPUT OF INACIFS



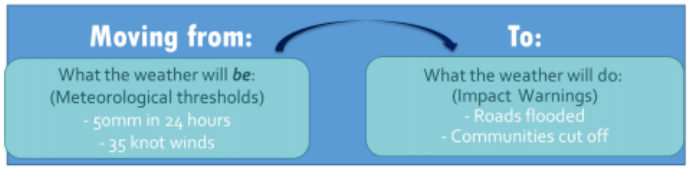


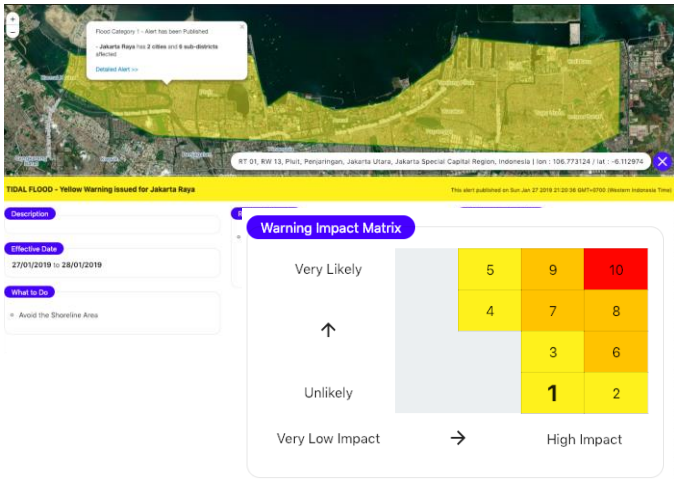


SHIFT PARADIGMS

BMKG

- ❑ Based on user needs
- ❑ High Impact forecast
- ❑ Risk based warning

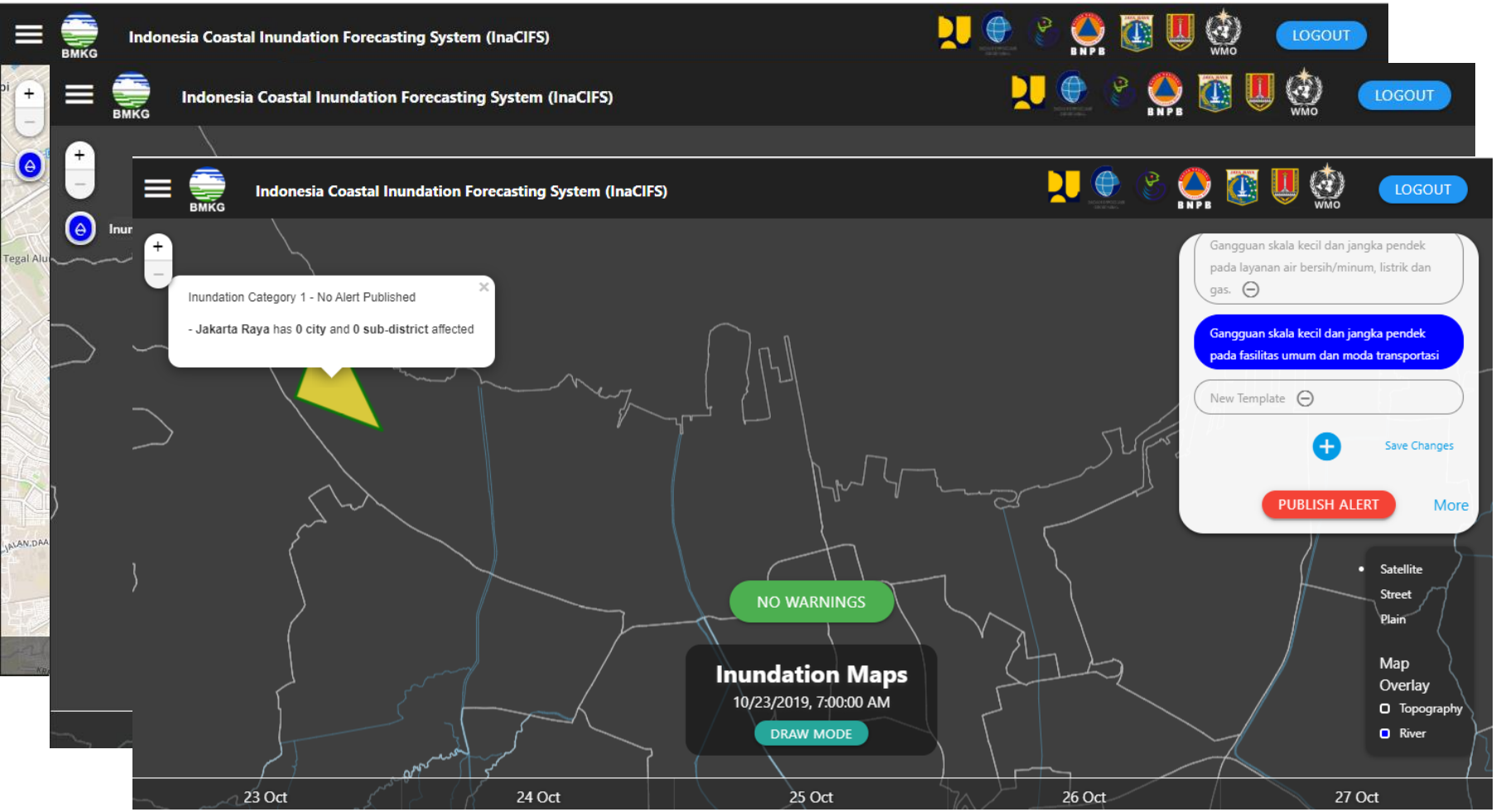




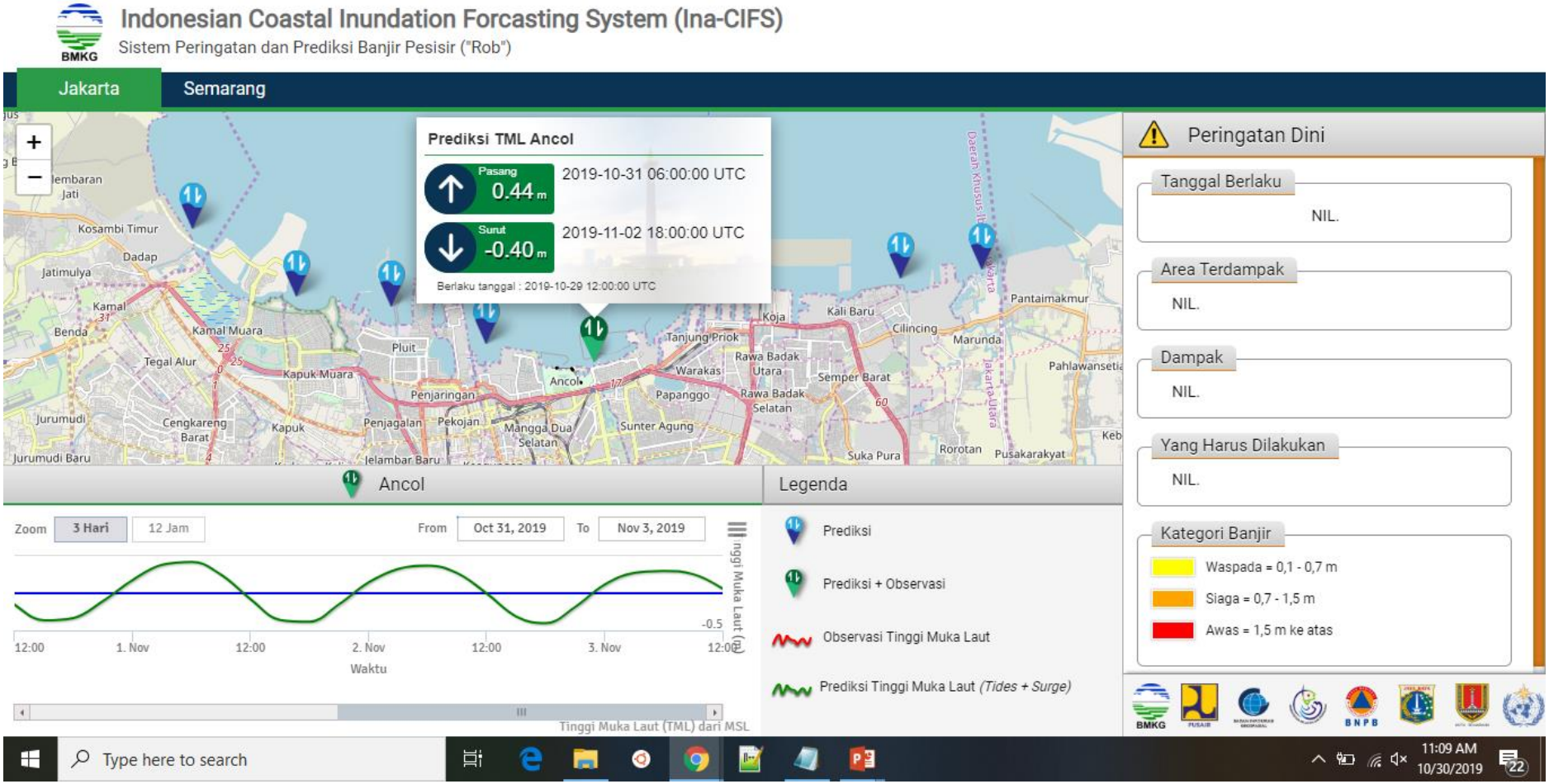
- BMKG and BNPB collaborate to develop: Hazard matrices;
- Response matrices, including agreements on specific SOPs for addressing coastal inundation;
- Common communications strategy, between the two partners.

- BMKG and BNPB have met the risk and response matrix according to the predicted phenomena.
- Response from BNPB from each warning level was compiled based on the agreed likelihood (BMKG) and impact (BNPB).
- In the future BMKG will provide forecasts and warnings with impact levels that can be responded directly by BNPB and BPBD.

IMPACT BASE FORECAST DASHBOARD

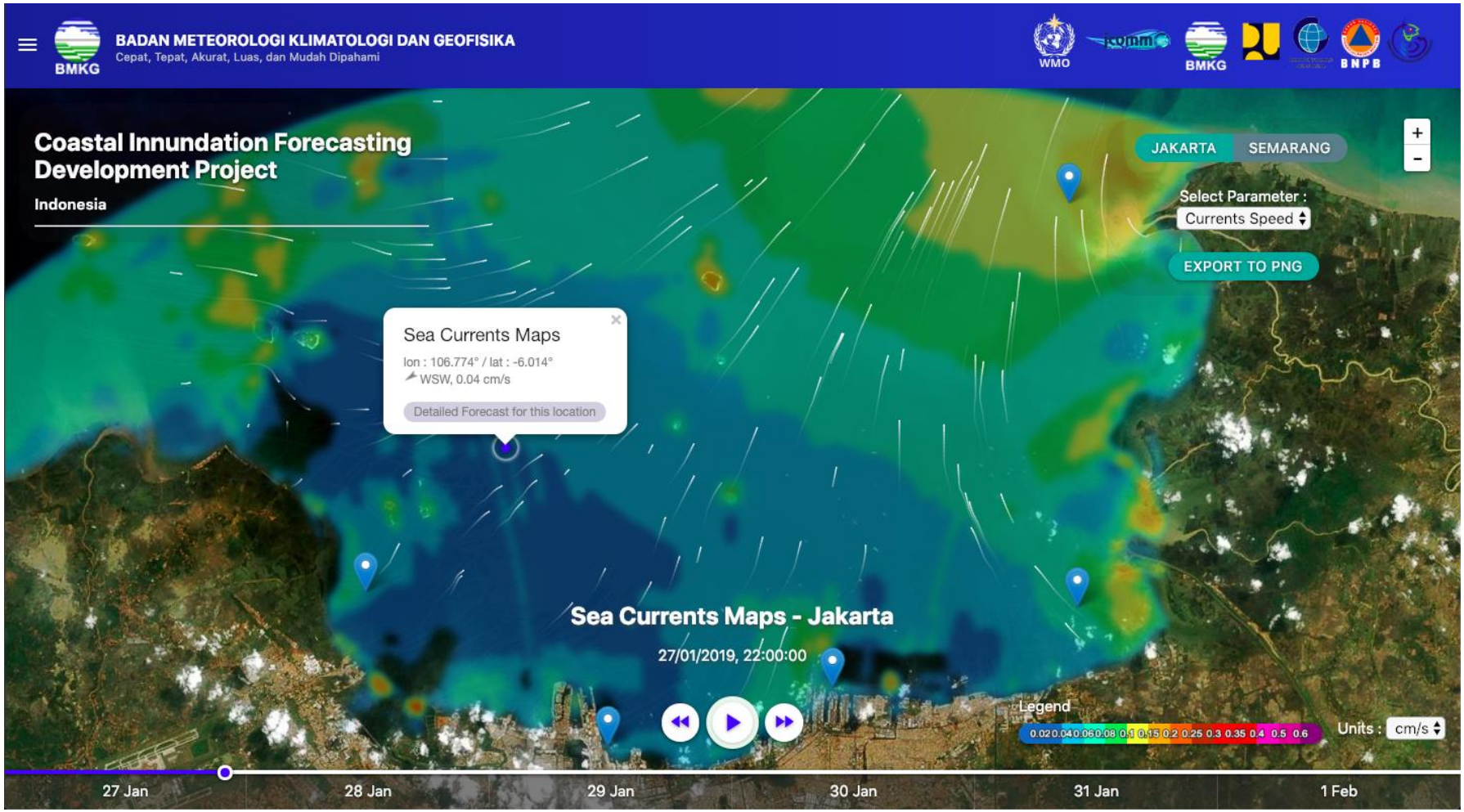


INACIFS DASHBOARD



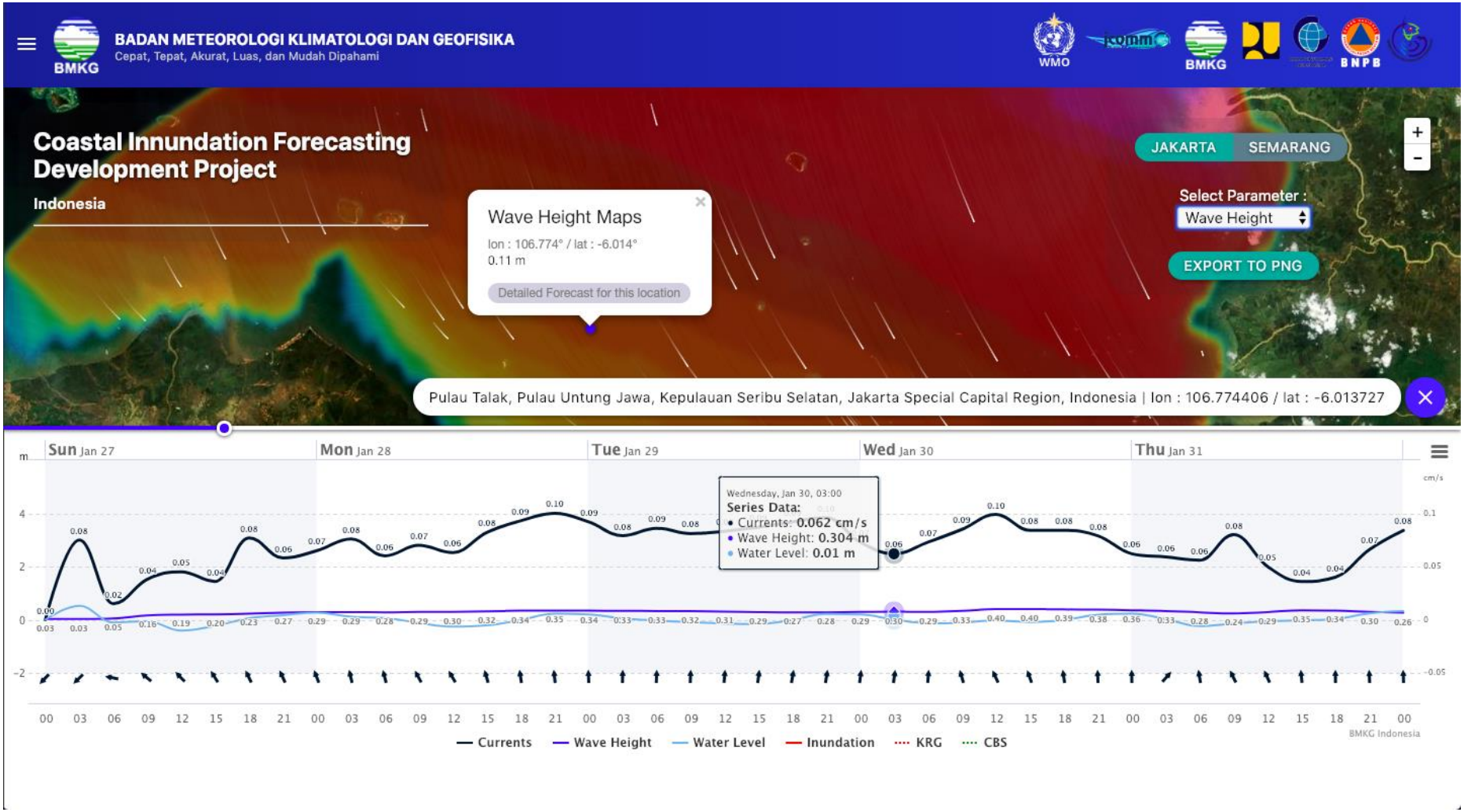
WEB DASHBOARD SYSTEM (1)

Spatial Output → Water Level, Sig Wave Height, Surface current, Inundation map



WEB DASHBOARD SYSTEM (2)

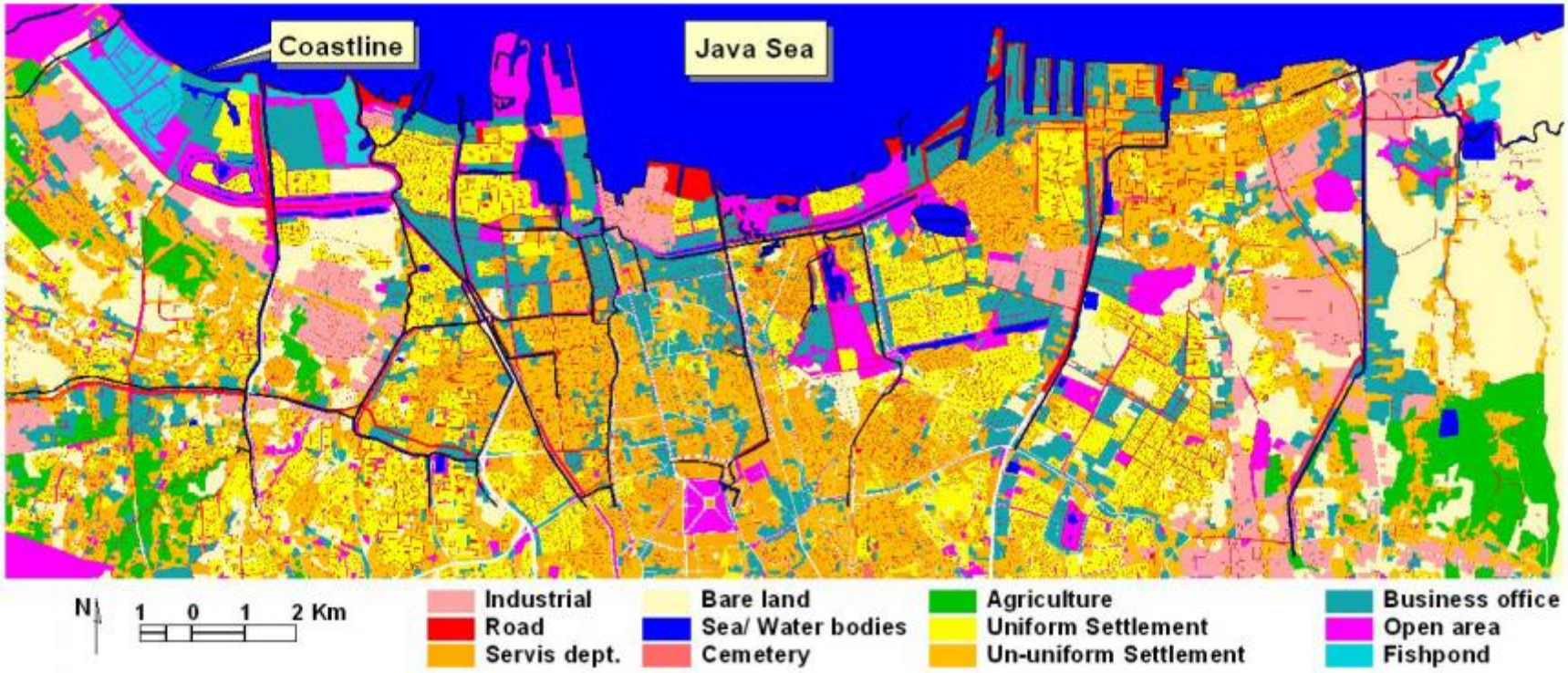
Time - Series Output



THANK YOU

BMKG

Element at Risk



BMKG

Weather Ready Nations in Indonesia

	Phase One:	Phase Two:	Phase Three:	Phase Four:	Phase Five:	Phase Six:
WRN (supported by NOAA & WRN)	Collect Data and Develop Hazard, Response and Risk Matrices	Expand Stakeholder Participation	Forecaster and Disaster Management Interface	Standard Operating Procedures (SOP)	Demonstration Test	Public Awareness and Outreach
	2018	**2019**	**2019**	**2020**	**2020**	**2020**
		Workshop one: Initial development of sector specific matrices (e.g. health, public works, transportation and other key partners) Workshop two: Finalize sector specific matrices (eg. health, public works, transportation and other key partners)	Workshop one: Develop web-based display system to share information between forecasters and disaster managers	Workshop one: Draft the Standard Operating Procedures (SOPs) Workshop two: Finalize the Standard Operating Procedures (SOPs)	Workshop one: Train the Trainer and Train Forecast and Civil Protection Staff Workshop two: Train the media and NGOs Workshop three: Simulation test in conjunction with Civil protection and NMHSs	Workshop one: Development of outreach material and public awareness to encourage people and organizations to volunteer to assist with communication and mitigation efforts.