



# SEA LEVEL RISE AND LAND SUBSIDENCE MONITORING IN INDONESIA

**Bayu Triyogo Widyantoro**

([bayu.triyogo@big.go.id](mailto:bayu.triyogo@big.go.id))

Act. Director of Geospatial Reference System  
Geospatial Information Agency of Indonesia

**UN-GGCE International Workshop on the Integration of Terrestrial,  
Maritime, Built and Cadastral Domains**

Bogor, 2 December 2024





BADAN INFORMASI  
GEOSPASIAL

# OUTLINE

UN-GGCE International Workshop

**JOINING LAND AND SEA**

The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

1. Background
2. Land Subsidence Monitoring Infrastructure
3. Land Subsidence Monitoring Results
4. Sea Level Rise Monitoring Infrastructure
5. Sea Level Rise Monitoring Results
6. Challenges
7. Solution
8. Conclusions



[www.big.go.id](http://www.big.go.id)



Badan Informasi Geospasial



@infogeospasial

## 1. High population density in coastal area



Abidin, H. Z., Andreas, H., Gumilar, I., Yuwono, B. D., Murdohardono, D., & Supriyadi, S. (2016). On integration of geodetic observation results for assessment of land subsidence hazard risk in urban areas of Indonesia. In *IAG 150 Years: Proceedings of the IAG Scientific Assembly in Postdam, Germany, 2013* (pp. 435-442). Springer International Publishing.

Most of Big City in Indonesia are located in coastal area

## 2. Economic impacts



Abidin, H. Z., Andreas, H., Gumilar, I., Fukuda, Y., Pohan, Y. E., & Deguchi, T. (2011). Land subsidence of Jakarta (Indonesia) and its relation with urban development. *Natural hazards*, 59, 1753-1771.

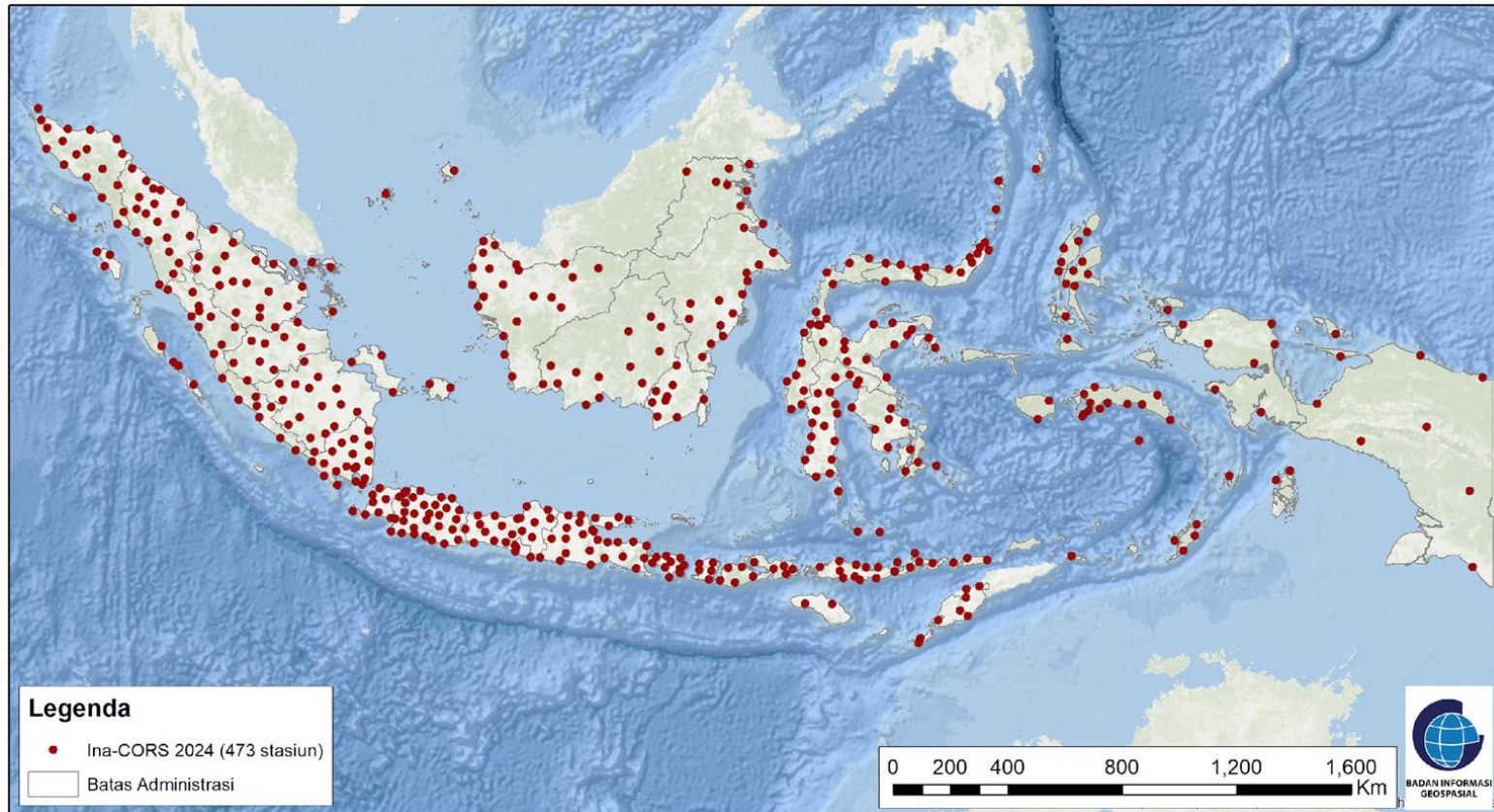
Subsidence may also enlarge the (tidal) flooding inundation areas, and in general will deteriorate their environmental quality so that impacts economic activities



# LAND SUBSIDENCE MONITORING INFRASTRUCTURE

UN-GGCE International Workshop  
**JOINING LAND AND SEA**  
The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

## 1. Indonesia Continuously Operating Reference Station (Ina-CORS)



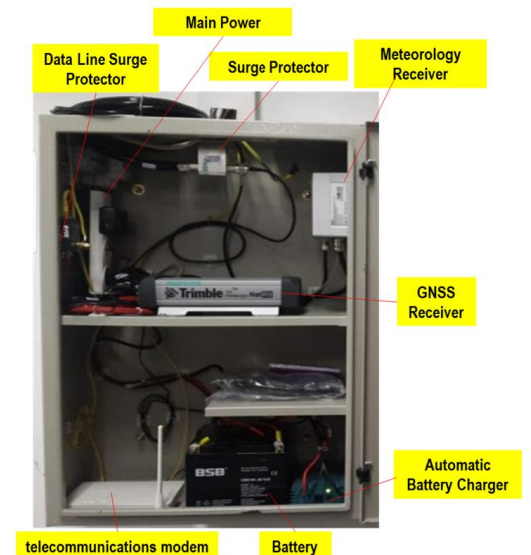
Concrete Monument



Solar Cell



meteorology Sensor

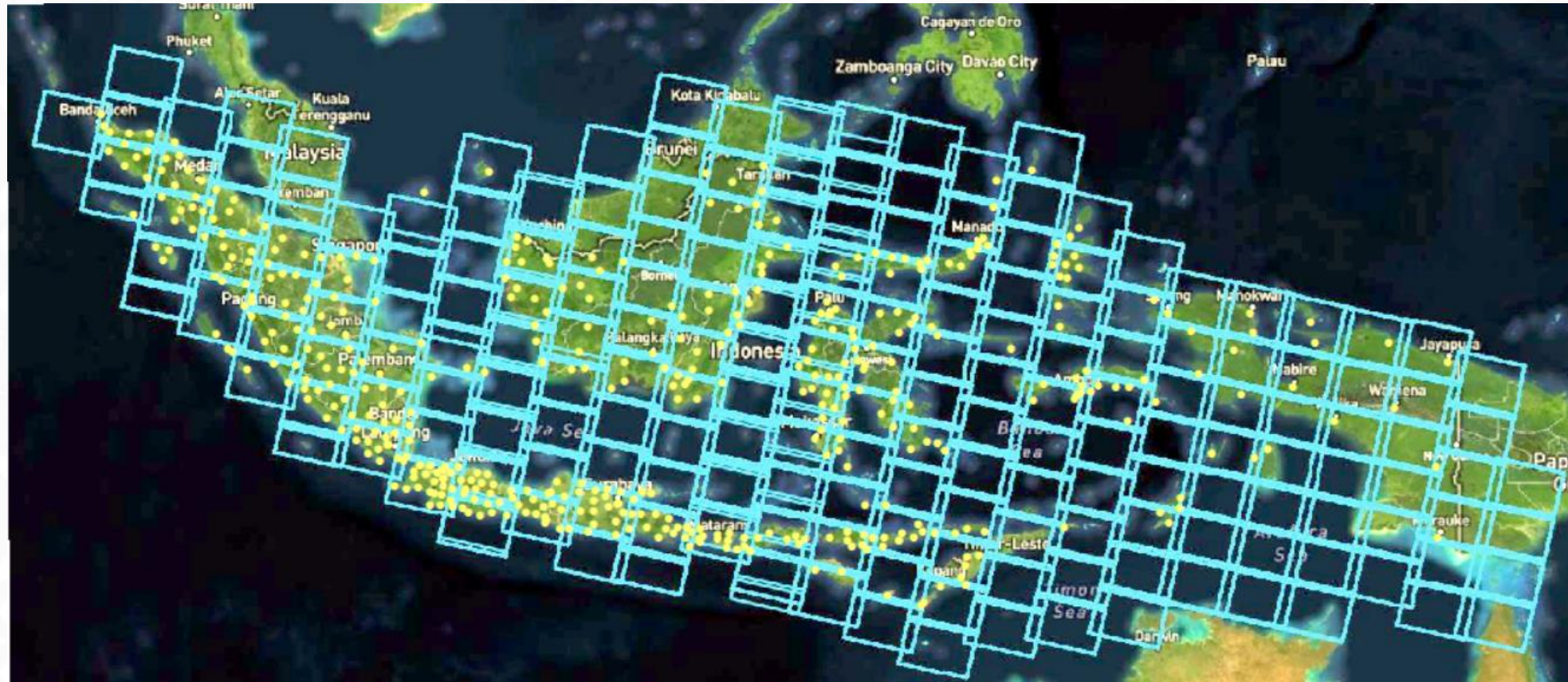




# LAND SUBSIDENCE MONITORING INFRASTRUCTURE

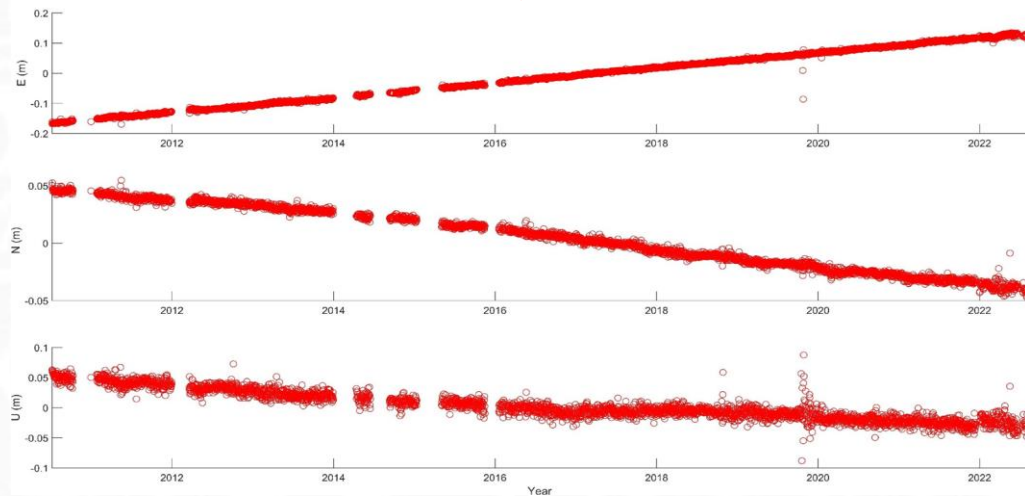
UN-GGCE International Workshop  
**JOINING LAND AND SEA**  
The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

## 2. Interferometric Synthetic Aperture Radar (InSAR)

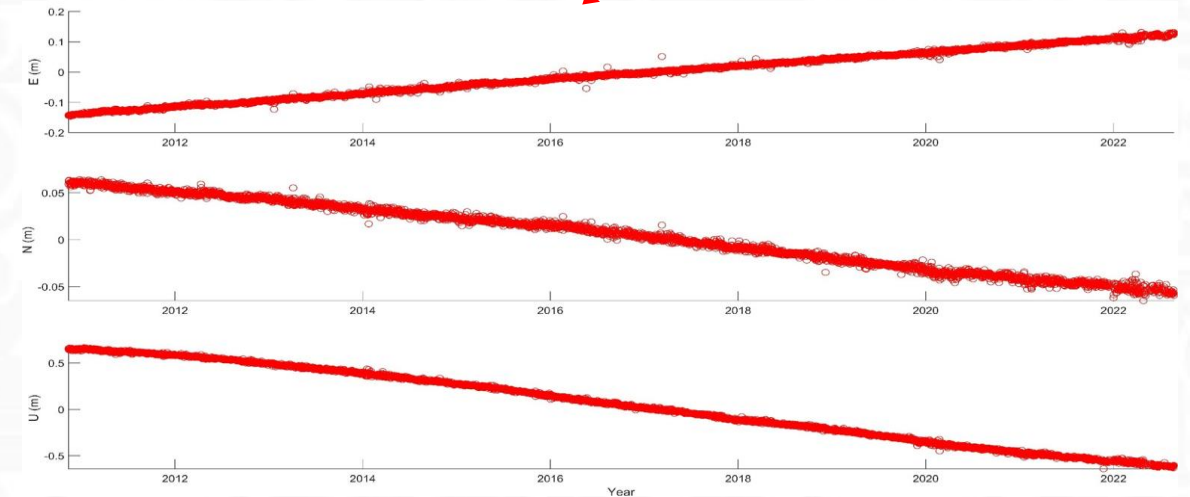


Sentinel-1 image coverage across Indonesia

## 1. Indonesia Continuously Operating Reference Station (Ina-CORS)

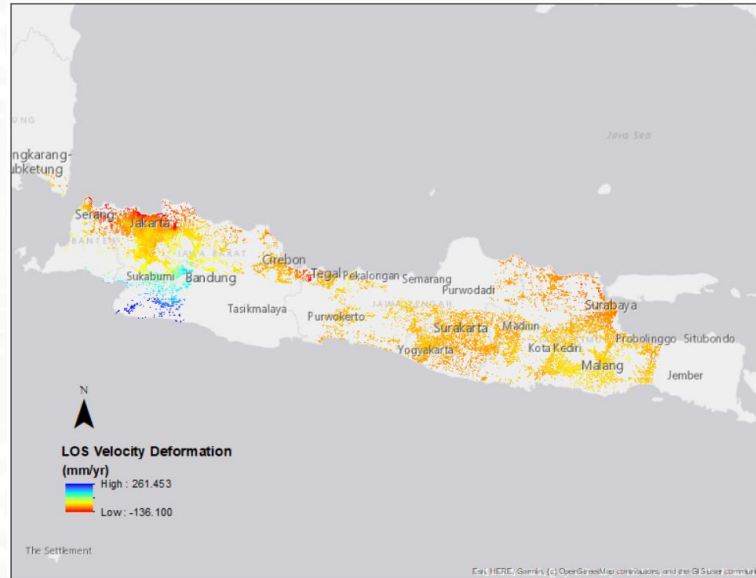


**Jakarta CORS (CJKT) experienced land subsidence 6.4 cm/yr**



**Pekalongan CORS (CPKL) experienced land subsidence 10.7 cm/yr**

## 2. Interferometric Synthetic Aperture Radar (InSAR)



Descending



Ascending

Results of preliminary processing using Sentinel-1 imagery on LiCSBAS in the Java Island area in 2014-2024 (without troposphere correction)



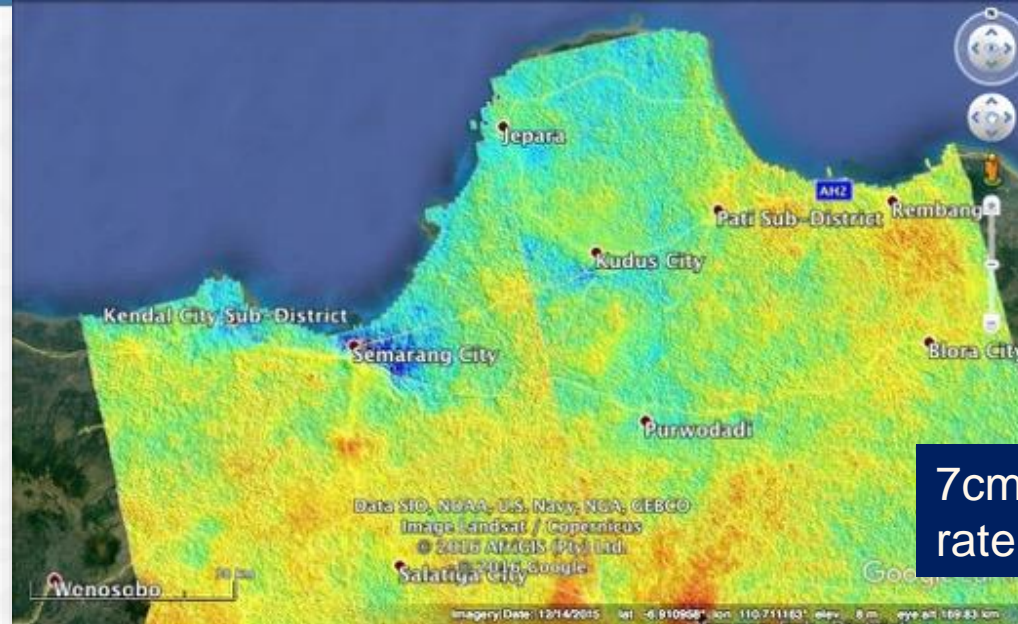
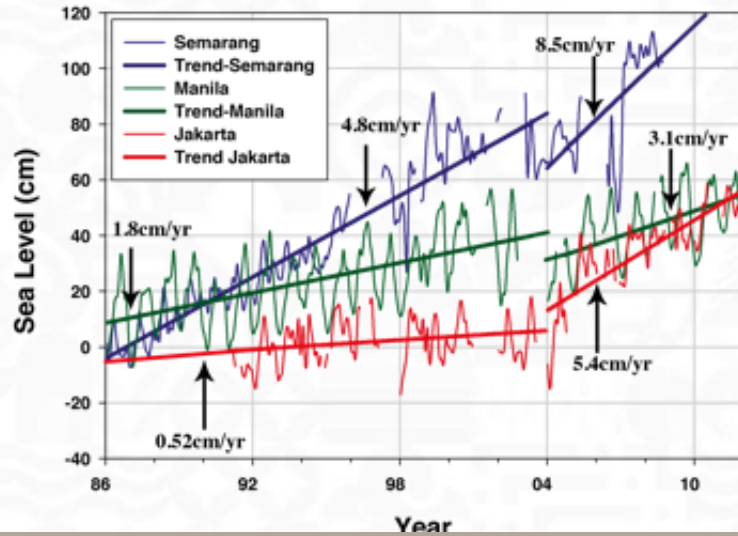
BADAN INFORMASI  
GEOSPASIAL

# LAND SUBSIDENCE MONITORING RESULTS

UN-GGCE International Workshop

## JOINING LAND AND SEA

The Integration of Terrestrial, Maritime, Built, and Cadastral Domains



7cm/yr of subsidence rate

Sea level rise rate is getting higher since 2004 detected by tide gauges

Subsidence caused by:

1. Building Load
2. Ground water extraction
3. Plate tectonics movement
4. Salt water intrusion

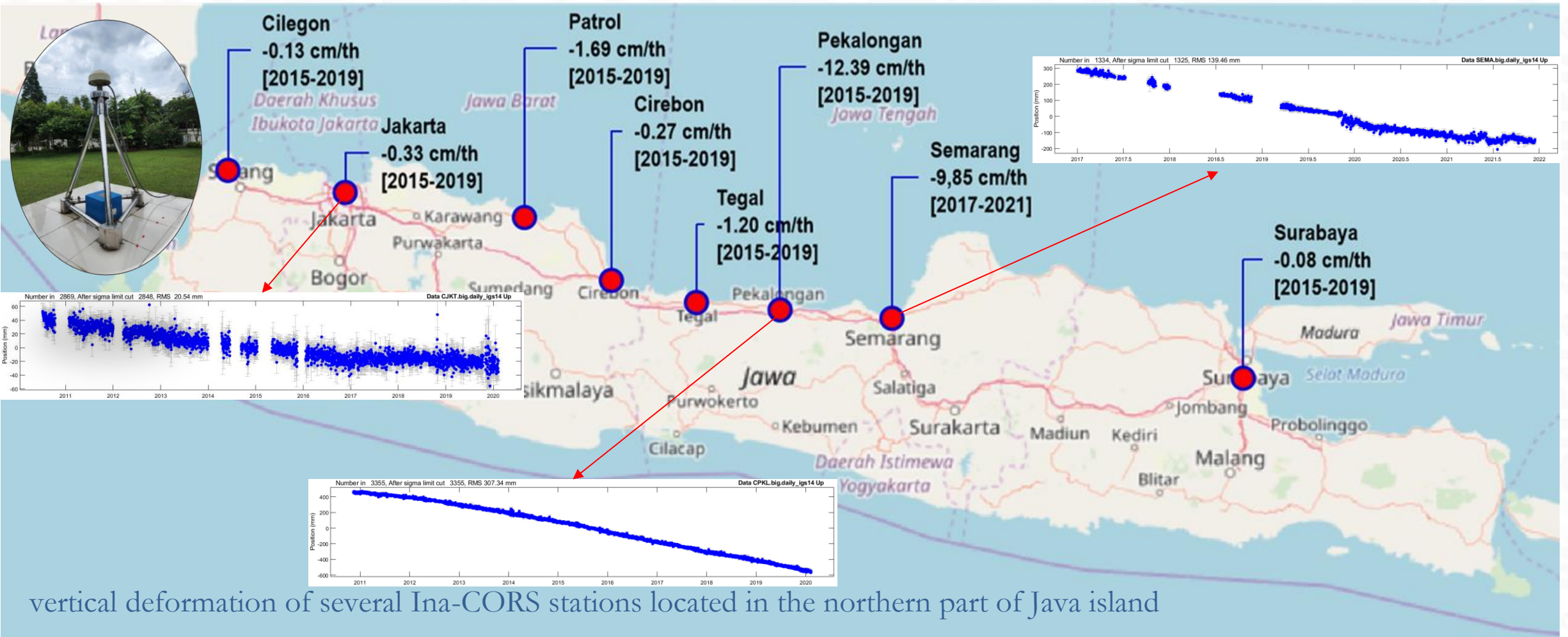
Sofian, 2022



Inundation at Semarang City



## BIG contribution of Landsubsidence Monitoring



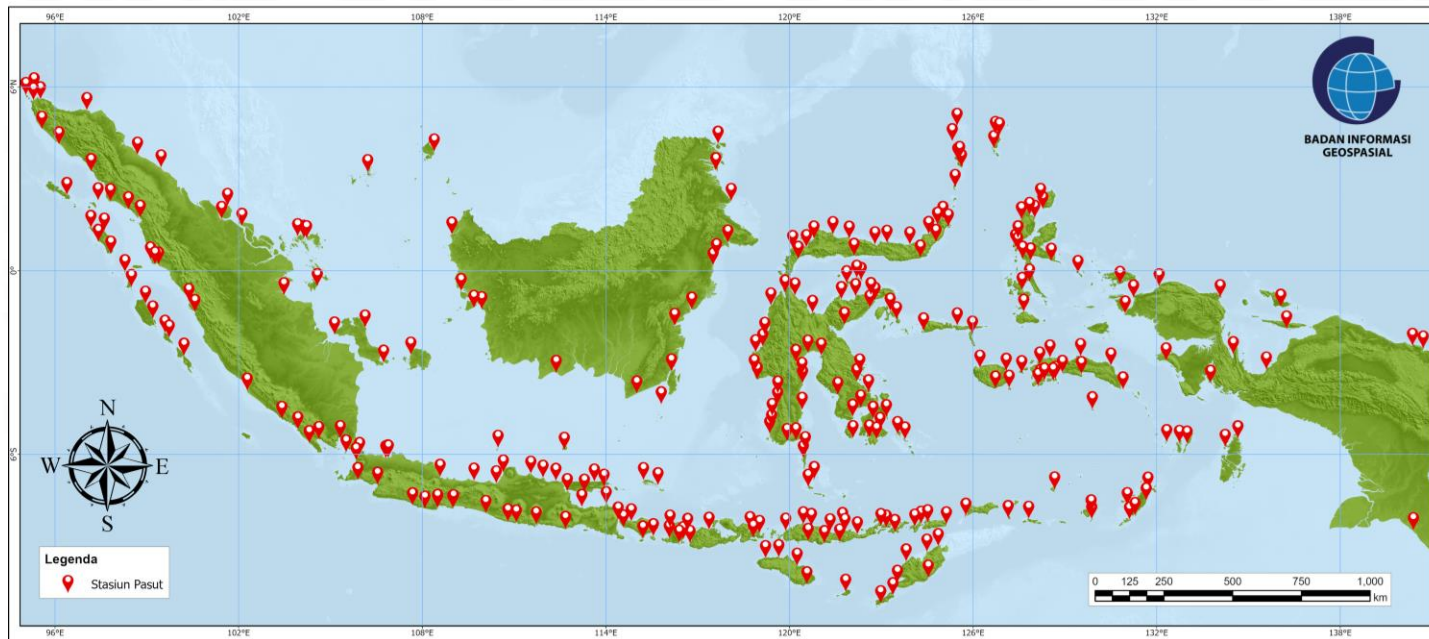
vertical deformation of several Ina-CORS stations located in the northern part of Java island



# SEA LEVEL RISE MONITORING INFRASTRUCTURE

UN-GGCE International Workshop  
**JOINING LAND AND SEA**  
The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

## Indonesia Tides (Ina-Pasut)



Modem

Data Logger

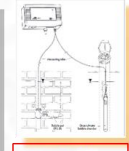
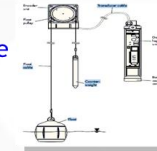
Float Gauge

Pressure Gauge

Radar Gauge

- BIG-Tide Gauge System:**
- Sensor 1 : Pressure Gauge
  - Sensor 2 : Float Gauge
  - Sensor 3 : Radar Gauge

Solar Charger Controller



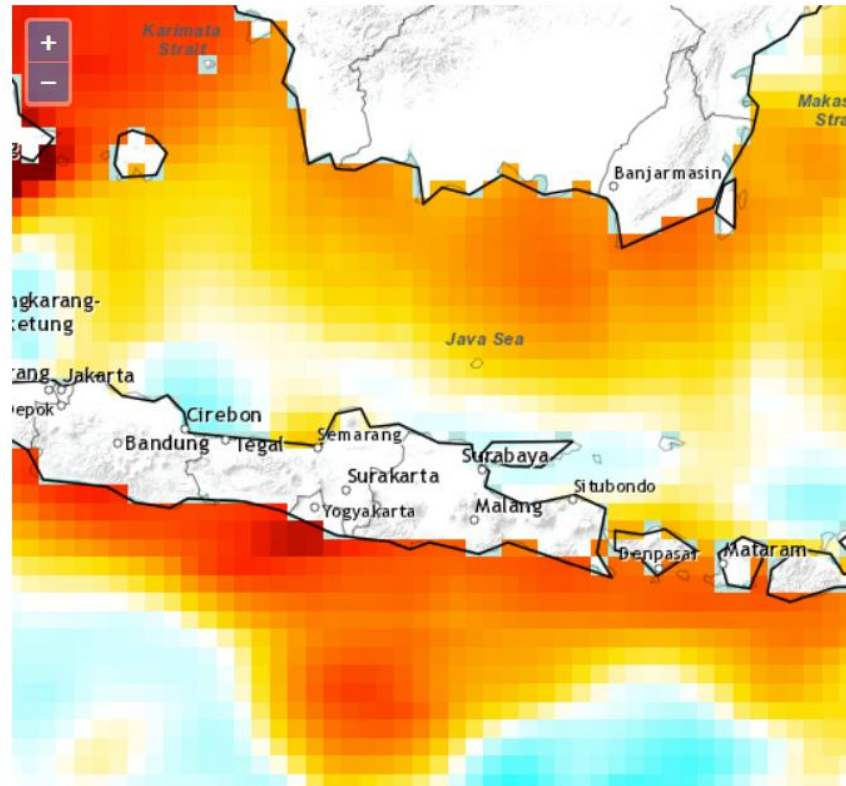
Bubble

Pressure



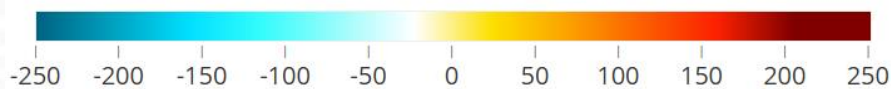
290 Tide Gauges as 2024

# SEA LEVEL RISE MONITORING

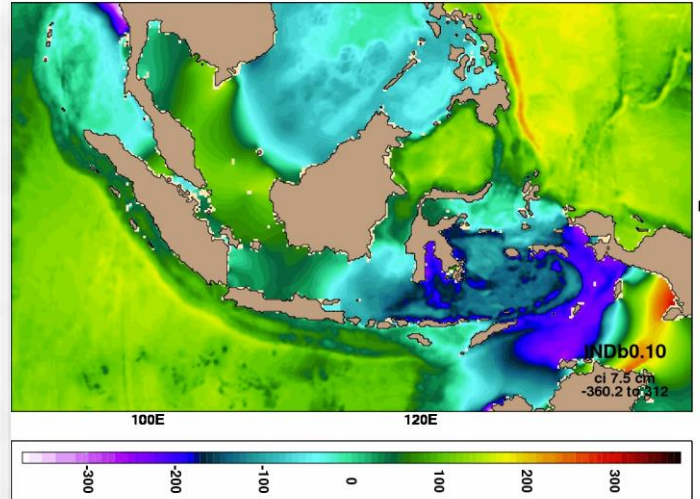


**MONTHLY SEA LEVEL VARIATIONS (MM)**

*Observed anomalies relative to mean of 1993-2012*



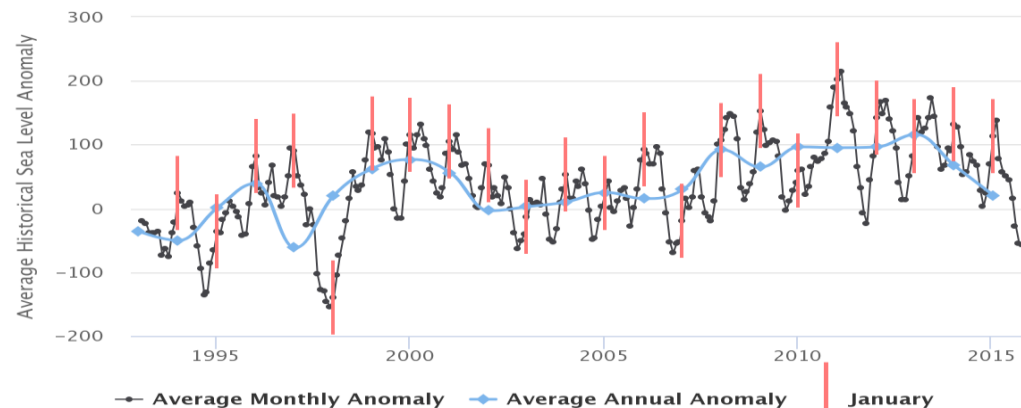
sea surf. height Dec 26, 1996 01Z [01.0H]



Sofian, 2022

**Historical Sea Level for coastal Indonesia (1993–2015)**

*observed anomalies relative to mean of 1993–2012*



<https://climateknowledgeportal.worldbank.org/country/indonesia/impacts-sea-level-rise>

<https://climateknowledgeportal.worldbank.org/country/indonesia/impacts-sea-level-rise>



BADAN INFORMASI  
GEOSPASIAL

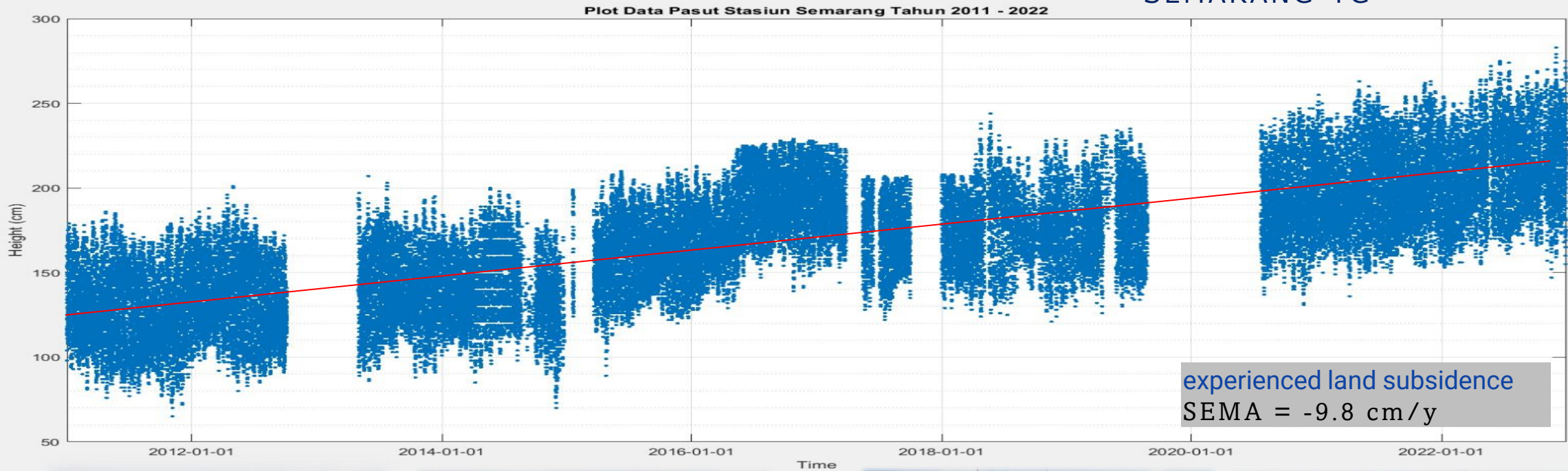
# Colocated GNSS and TG for SEA LEVEL MONITORING

UN-GGCE International Workshop

## JOINING LAND AND SEA

The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

### SEMARANG-TG



2011



2014



2019



2022



[www.big.go.id](http://www.big.go.id)



Badan Informasi Geospasial



@infogeospasial

BIG-GFZ



# CHALLENGES

UN-GGCE International Workshop

**JOINING LAND AND SEA**

The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

1. Ina-CORS is more precise than InSAR for monitoring land subsidence, but the results are not represents wide area
2. Coastal areas are often dynamic environments with complex interactions between natural and anthropogenic factors, complicating the isolation of subsidence and sea-level rise signals
3. InSAR precision is generally poorer in vegetative areas compared to open or urban areas



[www.big.go.id](http://www.big.go.id)



Badan Informasi Geospasial



@infogeospasial

1. Develop integrated land subsidence and sea-level rise monitoring infrastructure using Ina-CORS, Ina-Tides, and InSAR
2. Long-term monitoring. The longer the data, the more accurate the analysis



# CONCLUSION

UN-GGCE International Workshop

**JOINING LAND AND SEA**

The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

1. Combination between Ina-CORS and InSAR are capable to monitor land subsidence in wide area precisely
2. Ina-Tides is capable to monitor sea-level rise (locally)
3. Collocation between Ina-CORS and Ina-Tides can provide comprehensive information about land subsidence or sea-level rise



[www.big.go.id](http://www.big.go.id)



Badan Informasi Geospasial



@infogeospasial



UN-GGCE International Workshop  
**JOINING LAND AND SEA**  
The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

# THANK YOU



[www.big.go.id](http://www.big.go.id)



Badan Informasi Geospasial



@infogeospasial