ASIA PACIFIC GEOSPATIAL FORUM

Geodetic Reference Frame, Infrastructure and Their Applications in Indonesia

Gatot Haryo Pramono

Head of Center for Geodetic Control Network and Geodynamics

Deputy of Basic Geospatial Information

Geospatial Information Agency of Indonesia

WG1 Meeting

12th UN-GGIM-AP Plenary

Bali, November 9th, 2023

UN-GGIM-AP
REGIONAL COMMITTEE OF UNITED NATIONS GLOBAL GEOSPATIAL INFORMATION MANAGEMENT FOR ASIA & THE PACIFIC

BADAN INFORMASI GEOSPASIAL

Pointer

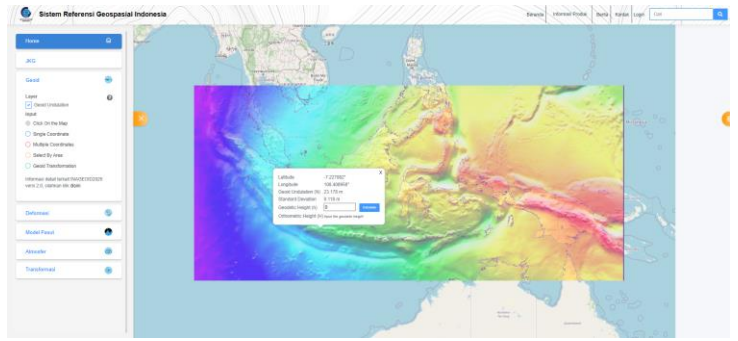
1. Indonesia Geospatial Reference System 2013 (SRGI2013)
2. Current Status of National Geodetic Infrastructure
3. Applications of National Geodetic Infrastructure
4. Summary

Indonesia Geospatial Reference System

- First launched in 17 October 2013.
- IGRS is a geospatial reference system which is used nationally and consistent for all Indonesian area and it is compatible with the global geospatial reference system (ITRS).
- It consists of:
  a. Horizontal Geospatial Reference System
  b. Vertical Geospatial Reference System


BADAN INFORMASI GEOSPASIAL

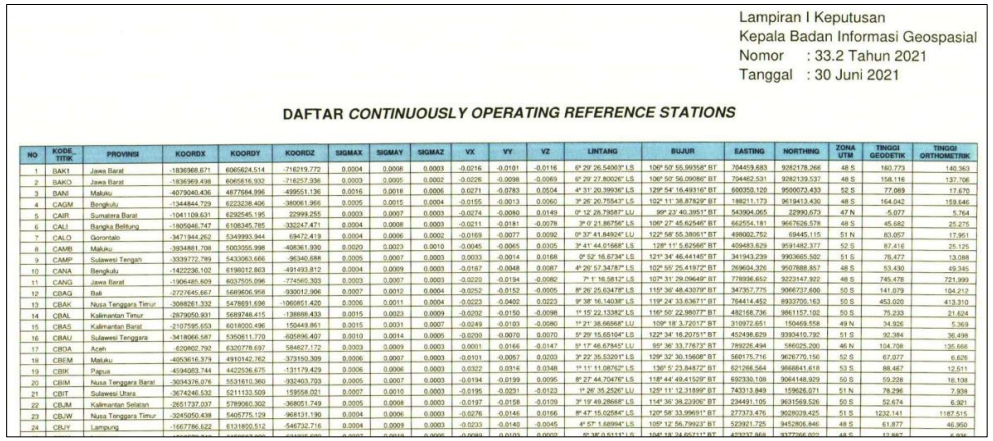
PERATURAN BADAN INFORMASI GEOSPASIAL
REPUBLIK INDONESIA
NOMOR 13 TAHUN 2021
TENTANG
SISTEM REFERENSI GEOSPASIAL INDONESIA



Indonesian Geospatial Reference System

ASIA PACIFIC GEOSPATIAL FORUM

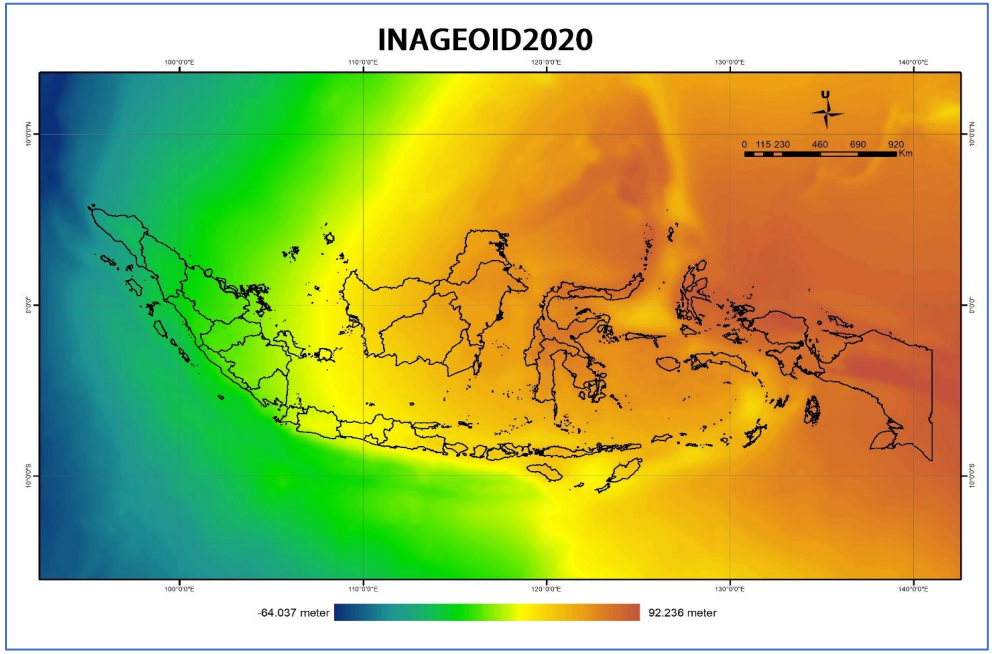
1. **Horizontal Geospatial Reference System - SRGI2013 (2021.0)**
   a. **Coordinate Reference System** → *International Reference Terrestrial System (ITRS);*
   b. **Coordinate Reference Frame** → Geodetic Control Network with set of coordinate at certain epoch (1 January 2021) and connected to global terrestrial reference frame (ITRF2014) or its update
   c. **Geodetic Datum** → WGS84;
   d. **The change of coordinate over time** (velocity rate) → Vx, Vy, Vz.
2. **Vertical Geospatial Reference System**:
   a. Geoid → InaGEOID 2020; and
   b. **Tidal Datum** → HAT, MHWS, MSL, MLWS, LAT.



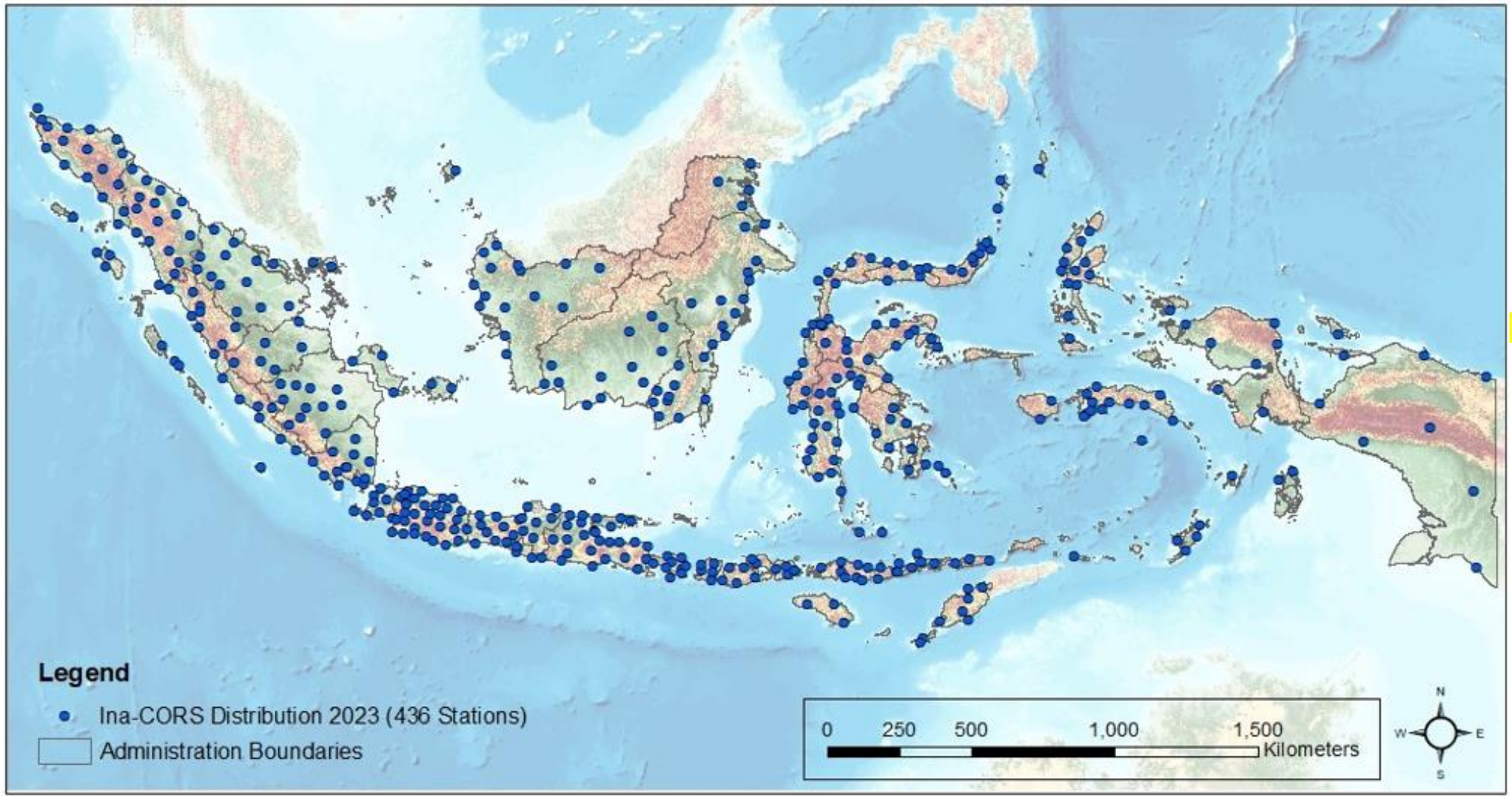
Lampiran I Keputusan
Kepala Badan Informasi Geospasial
Nomor : 33.2 Tahun 2021
Tanggal : 30 Juni 2021

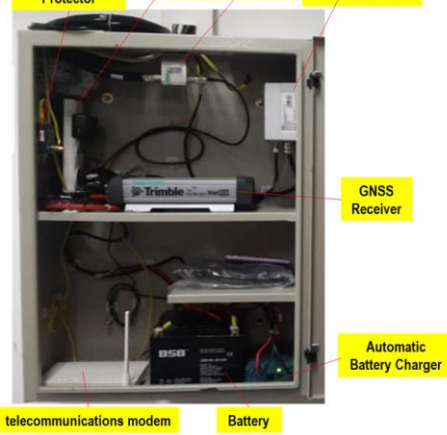
DAFTAR *CONTINUOUSLY OPERATING REFERENCE STATIONS*

NO	KODE TITIK	PROVINSI	KOORDX	KOORDY	KOORDZ	SIGMAX	SIGMAY	SIGMAZ	VX	VY	VZ	LINTANG	BUJUR	EASTING	NORTHING	ZONA UTM	TINGGI GEODETIK	TINGGI ORTHOMETRIK
1	BAK1	Jawa Barat	-1836368.671	6065624.514	-716219.772	0.0004	0.0008	0.0003	-0.0216	-0.0101	-0.0116	6° 29' 26.54063" LS	106° 50' 55.99358" BT	704459.683	9282178.266	48 S	160.773	140.963
2	BAK3	Jawa Barat	-1836369.436	6065616.932	-716257.336	0.0003	0.0005	0.0002	-0.0226	-0.0098	-0.0069	6° 29' 27.80526" LS	106° 50' 56.09658" BT	704462.531	9282139.537	48 S	158.116	137.706
3	BANI	Maluku	-4079040.406	4677584.996	-499551.136	0.0016	0.0006	0.0021	-0.0271	-0.0783	0.0504	4° 31' 20.39936" LS	129° 54' 16.49316" BT	600350.120	9500072.433	52 S	77.069	17.670
4	CAGM	Bengkulu	-1344844.729	6223238.406	-380661.956	0.0005	0.0015	0.0004	-0.0155	-0.0013	0.0060	3° 26' 20.75543" LS	102° 11' 38.87829" BT	198211.173	9618413.430	48 S	164.042	159.646
5	CAIR	Sumatera Barat	-1041109.631	6292545.195	22999.255	0.0003	0.0007	0.0003	-0.0274	-0.0080	0.0149	0° 12' 28.73587" LU	99° 23' 40.3951" BT	543904.065	22990.673	47 N	-5.077	5.764
6	CALI	Bangka Belitung	-1805046.747	6108345.785	-332247.471	0.0004	0.0006	0.0003	-0.0211	-0.0181	-0.0078	3° 0' 21.86756" LS	106° 27' 45.62546" BT	662554.181	9667626.578	48 S	45.682	25.275
7	CALO	Gorontalo	-3471944.262	5349993.944	-69472.419	0.0004	0.0006	0.0003	-0.0169	-0.0077	0.0092	0° 37' 41.84924" LU	122° 56' 55.38951" BT	499002.752	69445.115	51 N	83.657	17.951
8	CAMB	Maluku	-3934881.709	5003355.998	-408361.930	0.0020	0.0023	0.0010	-0.0045	-0.0065	0.0305	3° 41' 44.01668" LS	128° 11' 5.62566" BT	409483.629	9591482.377	52 S	87.416	25.125
9	CAMP	Sulawesi Tengah	-3339772.799	5433063.466	-96340.688	0.0005	0.0007	0.0003	0.0033	-0.0014	0.0168	0° 52' 16.6734" LS	121° 34' 46.64145" BT	341943.239	9903665.592	51 S	76.477	13.088
10	CANA	Bengkulu	-1422236.102	6198012.863	-491493.812	0.0004	0.0009	0.0003	-0.0187	-0.0048	0.0087	4° 26' 57.34787" LS	102° 55' 25.41972" BT	269604.326	9507888.857	48 S	53.430	49.345
11	CANG	Jawa Barat	-1906485.609	6037505.096	-774560.303	0.0003	0.0007	0.0003	-0.0220	-0.0134	-0.0082	7° 1' 16.5812" LS	107° 31' 29.09449" BT	779936.652	9223147.922	48 S	745.478	721.999
12	CBAG	Bali	-2727645.667	5491606.958	-939012.906	0.0007	0.0012	0.0004	-0.0252	-0.0152	-0.0005	8° 26' 25.63478" LS	115° 36' 48.43079" BT	347357.775	9066737.606	50 S	141.079	164.212
13	CBAK	Nusa Tenggara Timur	-3088261.332	5478691.696	-1060851.426	0.0006	0.0011	0.0004	-0.0223	-0.0402	0.0223	9° 38' 16.1403" LS	119° 24' 33.63671" BT	764414.452	8933705.163	50 S	453.020	413.310
14	CBAL	Kalimantan Timur	-2879050.931	5689748.415	-138898.433	0.0015	0.0023	0.0009	-0.0202	-0.0150	-0.0098	1° 15' 22.1338Z" LS	116° 50' 22.98077" BT	482168.736	9861157.102	50 S	75.233	21.624
15	CBAS	Kalimantan Barat	-2107595.653	6018000.496	150449.861	0.0015	0.0031	0.0007	-0.0249	-0.0103	-0.0080	1° 21' 38.66568" LU	109° 18' 3.72017" BT	310972.651	150469.558	49 N	34.926	5.369
16	CBAU	Sulawesi Tenggara	-3418066.587	5350611.770	-605896.402	0.0010	0.0014	0.0005	-0.0230	-0.0070	0.0070	5° 29' 15.65104" LS	122° 34' 16.20751" BT	452436.629	9393410.792	51 S	92.384	36.499
17	CBDA	Aceh	-602902.792	6320778.697	584627.172	0.0003	0.0005	0.0003	0.0001	0.0166	-0.0147	5° 17' 46.67445" LU	95° 36' 33.77673" BT	789226.494	585025.200	46 N	104.798	135.666
18	CBIM	Maluku	-4053616.373	4910142.762	-373150.309	0.0006	0.0007	0.0003	-0.0101	-0.0057	0.0203	3° 22' 35.53201" LS	129° 32' 30.15608" BT	560175.716	9626770.156	52 S	67.077	6.626
19	CBIK	Papua	-4594063.744	4422536.675	-131179.429	0.0006	0.0006	0.0003	0.0322	0.0316	0.0348	1° 11' 11.0876Z" LS	138° 5' 23.84872" BT	621266.564	9868841.618	53 S	88.467	12.511
20	CBIM	Nusa Tenggara Barat	-3034376.076	5531610.360	-932403.703	0.0005	0.0007	0.0003	-0.0194	-0.0199	0.0095	8° 27' 44.70476" LS	118° 44' 49.41529" BT	632330.108	9064148.929	50 S	59.228	18.139
21	CBIT	Sulawesi Utara	-3674246.532	5211132.509	159558.021	0.0007	0.0010	0.0003	-0.0195	-0.0231	-0.0123	1° 26' 35.2526" LU	125° 11' 12.31899" BT	743313.849	159526.071	51 N	78.296	7.939
22	CBJM	Kalimantan Selatan	-2651737.037	5789360.302	-368051.749	0.0005	0.0008	0.0003	-0.0197	-0.0158	-0.0109	3° 19' 49.28668" LS	114° 36' 38.23306" BT	234491.105	9631569.526	50 S	52.674	6.381
23	CBJW	Nusa Tenggara Timur	-3245950.438	5405775.129	-968131.196	0.0004	0.0006	0.0003	-0.0276	-0.0146	0.0166	8° 47' 15.02584" LS	120° 58' 33.99691" BT	277373.476	9028039.425	51 S	1232.141	1187.515
24	CBJY	Lampung	-1667786.622	6131800.512	-546732.716	0.0004	0.0009	0.0003	-0.0233	-0.0140	-0.0045	4° 57' 1.68994" LS	105° 12' 56.79923" BT	523921.725	9452806.846	48 S	61.877	46.950

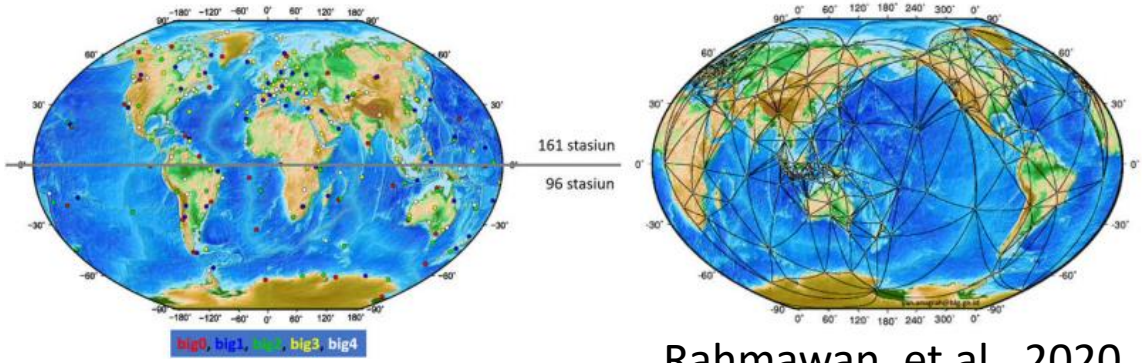


Geodetic Control Network
(Indonesian CORS Station Distribution)





Processing Strategy



Rahmawan, et.al., 2020

Absolute IGS phase center and offset models for receiver antenna and satellite transmitting antenna receiver antenna phase center : Igs14.atx

Troposphere appriori model : Input data meteorology
Mapping function : VMF1
Zenit delay estimation : 1 hour interval
Plate motion : free network
Solid earth tide : IERS 2010 convention
Pole tide : IERS 2010 convention
Ocean loading : FES2004
Non tidal displacement : Atmospheric loading

Coordinate weekly solution

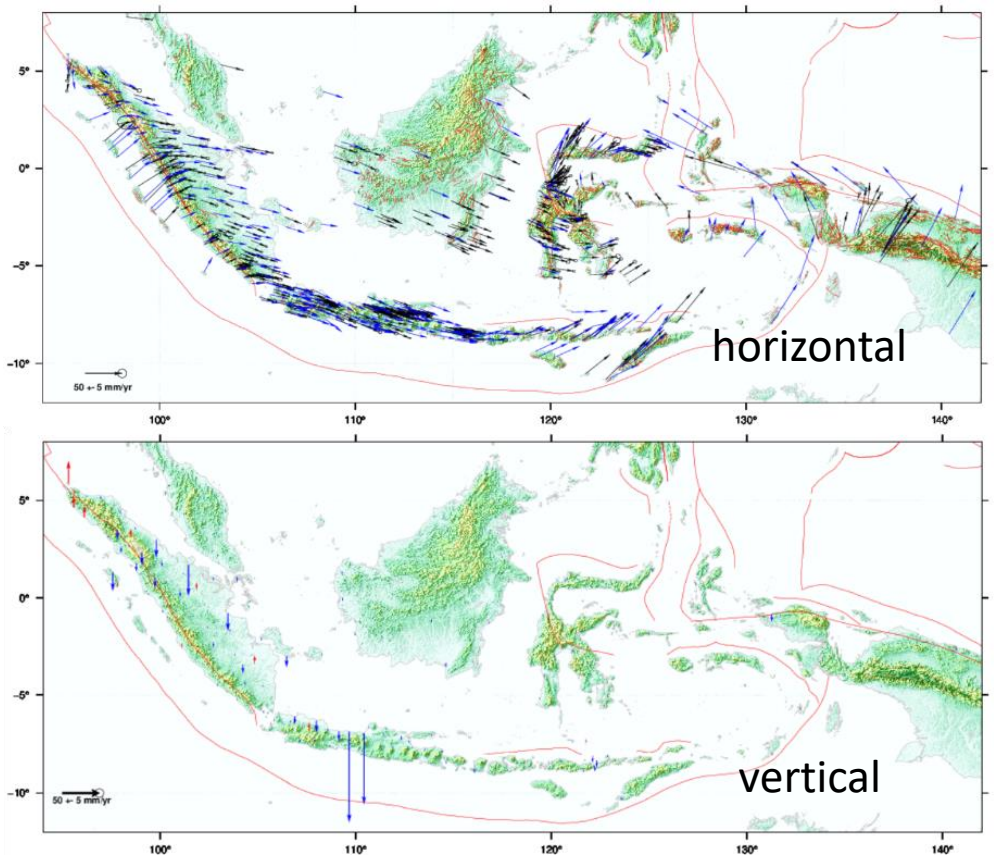
```
Starting Position stabilization iteration   4 weekly_181w.gdl
For   65 sites in origin, min/max height sigma       0.59      3.86 mm; Median       0.92 mm, Tol      15.00 mm weekly_181w.gdl

Position system stabilization results
-------------------------------------
X Rotation  (mas)     -0.11564 +-    0.00757 Iter  4 weekly_181w.gdl
Y Rotation  (mas)     -0.03727 +-    0.00738 Iter  4 weekly_181w.gdl
Z Rotation  (mas)     -1.04104 +-    0.00694 Iter  4 weekly_181w.gdl
X Translation (m)     -0.00062 +-    0.00022 Iter  4 weekly_181w.gdl
Y Translation (m)      0.00176 +-    0.00022 Iter  4 weekly_181w.gdl
Z Translation (m)     -0.00508 +-    0.00021 Iter  4 weekly_181w.gdl
Scale       (ppb)      0.10106 +-    0.07549 Iter  4 weekly_181w.gdl
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
STHL_GPS   0.89  MAS1_6PS   0.89  DAKR_3PS   0.89  CHPI_3BB   0.89  KELY_5PS   0.99  STJO_7PS   0.89
KOUR_8PS   0.92  KOUR_9PS   0.92  OHI3_6BB   0.89  CRO1_9PS   1.25  CRO1_JPS   1.37  CRO1_KPS   0.90
SANT_3BB   1.25  SANT_8IL   1.07  PARC_4BB   0.90  AREQ_8BB   1.07  AREQ_9BB   0.90  GODE_4PS   0.89
GLPS_4PS   0.89  ISPA_2BB   1.09  HOLM_2PS   1.02  DRAO_4PS   0.89  VNDP_6PS   1.41  VNDP_7PS   0.90
THTI_3PS   0.90  MKEA_2PS   1.37  MKEA_3PS   1.10  MKEA_4PS   1.01  MKEA_6PS   0.99  KOKB_4PS   0.89
CKIS_2PS   1.16  CKIS_3PS   0.91  NAUR_3TO   0.96  MCM4_4PS   0.89  NRMD_5PS   0.92  MCIL_4TO   0.98
MOBS_2PS   0.89  GUAM_3TO   0.96  GUAM_5TO   1.05  DARW_5PS   1.03  DARW_6PS   0.89  DAEJ_4TO   1.37
DAEJ_5TO   0.98  TNML_4TO   1.09  PERT_8PS   0.89  BADG_6TO   0.91  CUSV_3S2   1.41  CUSV_4S2   0.89
COCO_6S2   1.23  COCO_7S2   0.89  DAV1_5PS   0.89  IISC_4PS   0.89  POL2_4PS   0.89  KERG_5PS   0.89
ARTU_GPS   0.89  REUN_3PS   0.89  SEYG_GPS   0.90  BHR4_GPS   1.08  MAL2_3PS   0.89  HRAO_8PS   0.89
KIRU_5PS   0.91  SUTH_3PS   0.89  MATE_5PS   1.04  MATE_6PS   0.90  NKLG_2PS   0.89
 For  195 Position Iter  4 Pre RMS    0.0140 m; Post RMS    0.00127 m weekly_181w.gdl
 For   65 sites in origin, min/max NE sigma       0.31      1.85 mm; Median       0.42 mm, Tol      1.50 mm weekly_181w.gdl
POS STATISTICS: For   65 RefSites WRMS ENU   1.45   1.26   3.52  mm    NRMS ENU   4.42   3.98   4.21 weekly_181w.gdl
POS MEANS: For   65 RefSites: East  -0.08 +-   0.18 North   0.25 +-   0.16 Up   0.47 +-   0.44 mm weekly_181w.gdl
```

velocity solution

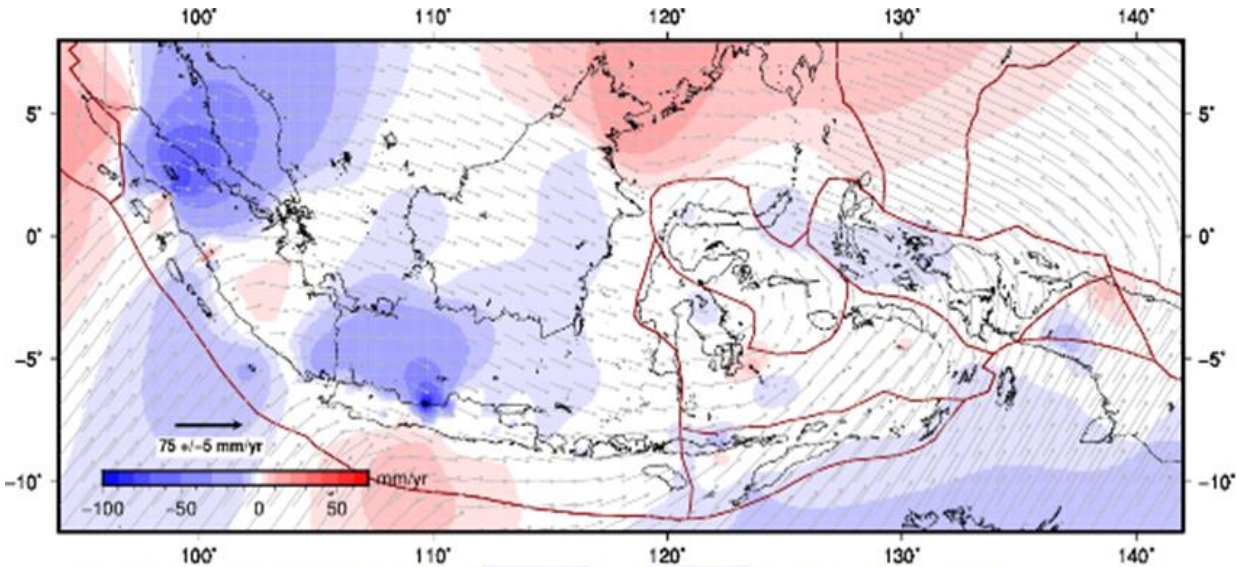
```
Starting Velocity stabilization iteration   4 weekly_181w.gdl

For   84 sites in origin, min/max dh/dt  sigma       0.21      1.00 mm/yr; Median       0.37 mm/yr, Tol      15.00 mm/yr weekly_181w.gdl

Velocity system stabilization results
-------------------------------------
X Rotate (mas/yr)      0.00538 +-    0.00176 Iter  4 weekly_181w.gdl
Y Rotate (mas/yr)     -0.00149 +-    0.00169 Iter  4 weekly_181w.gdl
Z Rotate (mas/yr)      0.09665 +-    0.00168 Iter  4 weekly_181w.gdl
X Trans    (m/yr)      0.00046 +-    0.00005 Iter  4 weekly_181w.gdl
Y Trans    (m/yr)     -0.00016 +-    0.00005 Iter  4 weekly_181w.gdl
Z Trans    (m/yr)      0.00046 +-    0.00005 Iter  4 weekly_181w.gdl
Scale    (ppb/yr)     -0.01009 +-    0.01769 Iter  4 weekly_181w.gdl
 Condition Sigmas used     0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
Sites and relative sigmas used in stabilization
VESL_3PS   0.99  STHL_GPS   0.91  MAS1_5PS   1.07  MAS1_6PS   0.91  DAKR_GPS   1.08  DAKR_3PS   0.95
CHPI_2BB   1.05  CHPI_3BB   0.93  KELY_5PS   0.92  STJO_6PS   1.03  STJO_7PS   0.92  KOUR_7PS   1.13
KOUR_8PS   0.93  OHI3_3BB   1.24  OHI3_6BB   0.93  CRO1_9PS   0.95  CRO1_JPS   1.24  CRO1_KPS   1.16
SANT_3BB   0.95  PARC_4BB   0.91  AREQ_7BB   0.98  AREQ_8BB   0.99  AREQ_9BB   1.19  GODE_GPS   1.10
GODE_4PS   0.92  GLPS_4PS   0.92  ISPA_GBB   1.15  ISPA_2BB   0.96  HOLM_2PS   0.92  DRAO_2PS   1.06
DRAO_4PS   0.92  VNDP_5PS   1.20  VNDP_6PS   1.01  VNDP_7PS   0.96  FAIR_4PS   0.90  THTI_3PS   0.90
MKEA_2PS   0.96  MKEA_3PS   1.05  KOKB_4PS   0.90  CKIS_2PS   0.98  CKIS_3PS   1.26  CHAT_2PS   1.16
NAUR_3TO   0.95  MCM4_4PS   0.90  NRMD_5PS   0.91  MAC1_4PS   1.11  MAC1_5PS   0.97  MAC1_7PS   1.00
MCIL_3TO   1.20  MCIL_4TO   0.96  MOBS_2PS   0.90  GUAM_3TO   0.92  DARW_5PS   0.92  DARW_6PS   1.03
DAEJ_4TO   0.98  DAEJ_5TO   0.96  TNML_4TO   0.95  PERT_7PS   1.15  PERT_8PS   0.92  BADG_6TO   0.91
CUSV_3S2   1.02  CUSV_4S2   0.95  COCO_5PS   1.11  COCO_6S2   0.98  COCO_7S2   0.97  DAV1_5PS   0.91
IISC_3PS   1.12  IISC_4PS   0.91  POL2_4PS   0.90  KERG_5PS   0.91  ARTU_GPS   0.90  REUN_3PS   0.90
SEYG_GPS   0.92  BHR4_GPS   1.20  MAL2_2PS   1.03  MAL2_3PS   0.92  HRAO_7PS   1.04  HRAO_8PS   0.92
KIRU_4PS   1.02  KIRU_5PS   0.92  SUTH_3PS   0.90  MATE_5PS   0.92  MATE_6PS   1.04  NKLG_2PS   0.91
 For  252 Velocity Iter  4 Pre RMS    0.0013 m/yr; Post RMS    0.00033 m/yr weekly_181w.gdl

 For   84 sites in origin, min/max dNE/dt sigma       0.13      0.48 mm/yr; Median       0.22 mm/yr, Tol      0.30 mm/yr weekly_181w.gdl
VEL STATISTICS: For   84 RefSites WRMS ENU   0.37   0.34   0.53  mm/yr NRMS ENU   2.61   2.52   1.65 weekly_181w.gdl
VEL MEANS: For   84 RefSites: East   0.02 +-   0.04 North  -0.03 +-   0.04 Up   0.06 +-   0.06 mm/yr weekly_181w.gdl
```

Velocity Rate & Linier Deformation Model

Vector of Velocity Rate



Linier Deformation Model



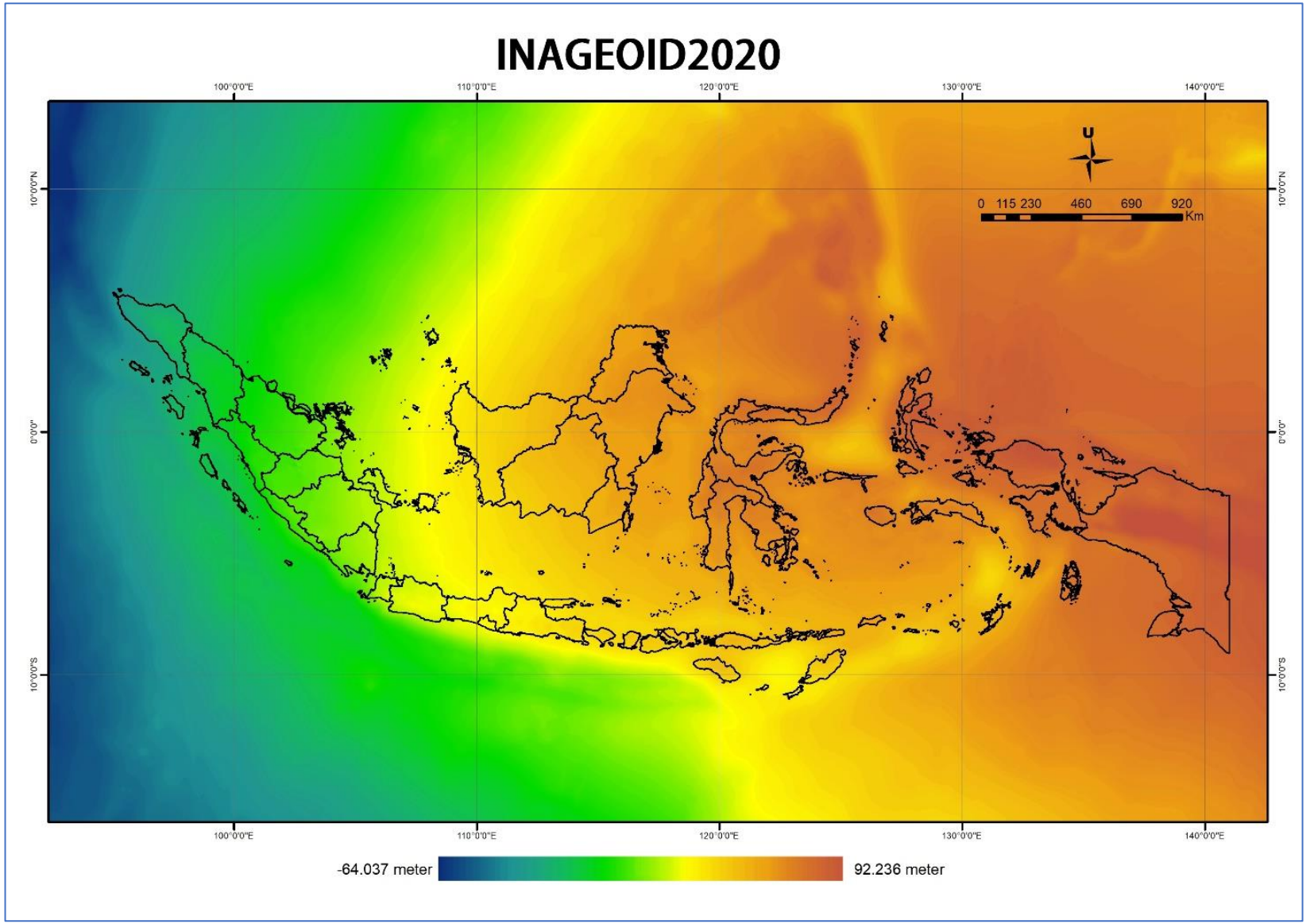
Gambar 4. Model deformasi linier wilayah Indonesia. Panah menunjukkan vektor horisontal, gradasi warna menunjukkan velocity rate vertikal.

INAGEOID2020 - Indonesian Geoid

- INAGEOID2020 as national vertical geospatial reference frame of Indonesia
- The use of INAGEOID2020 in Indonesia is mandatory.

Spatial resolution:	0,01 x 0,01 degree
Unit:	Meter
Reference system:	SRGI2013
Gravity reference frame:	IGSN71 or its update including IGRS
Coverage:	The whole area of Indonesia

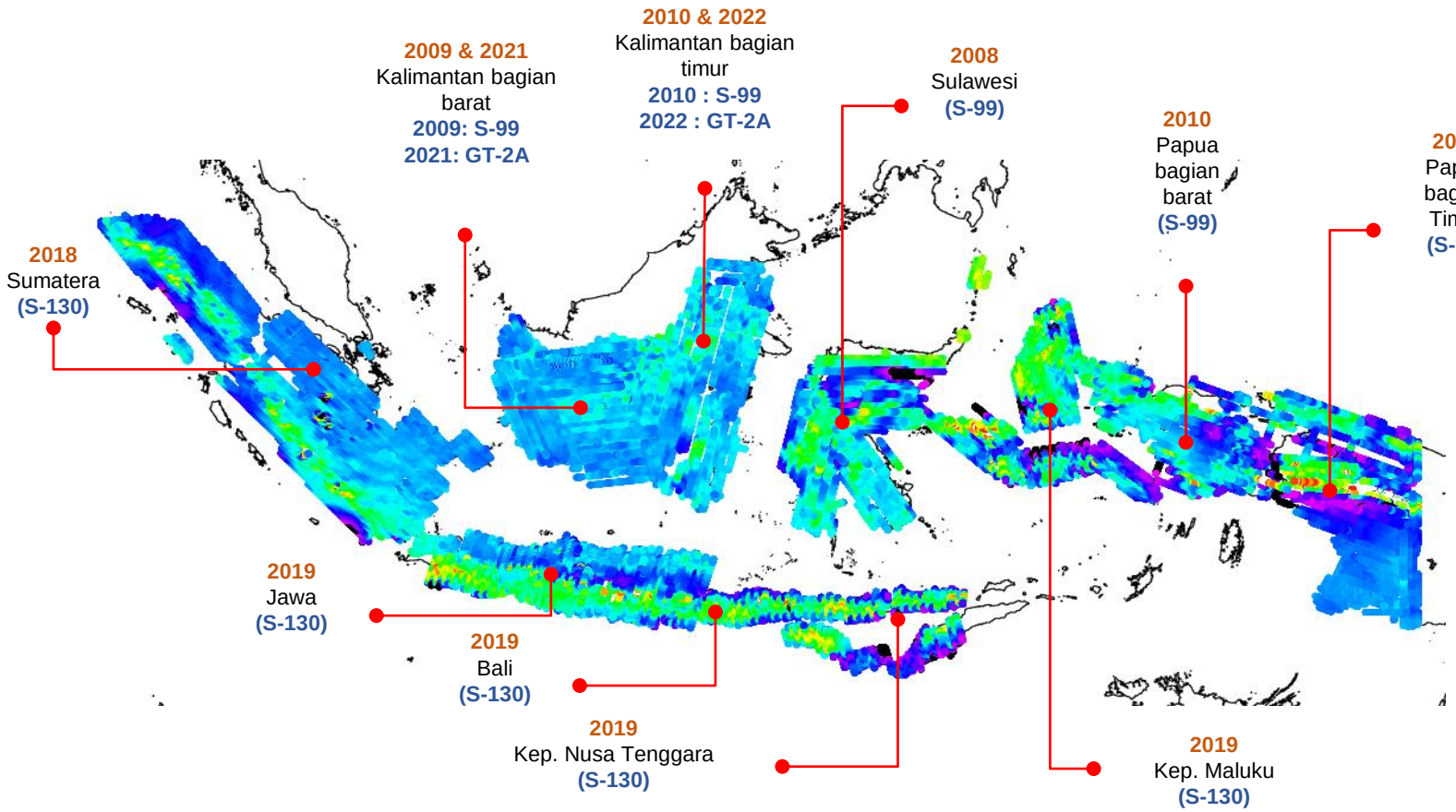
https://srgi.big.go.id



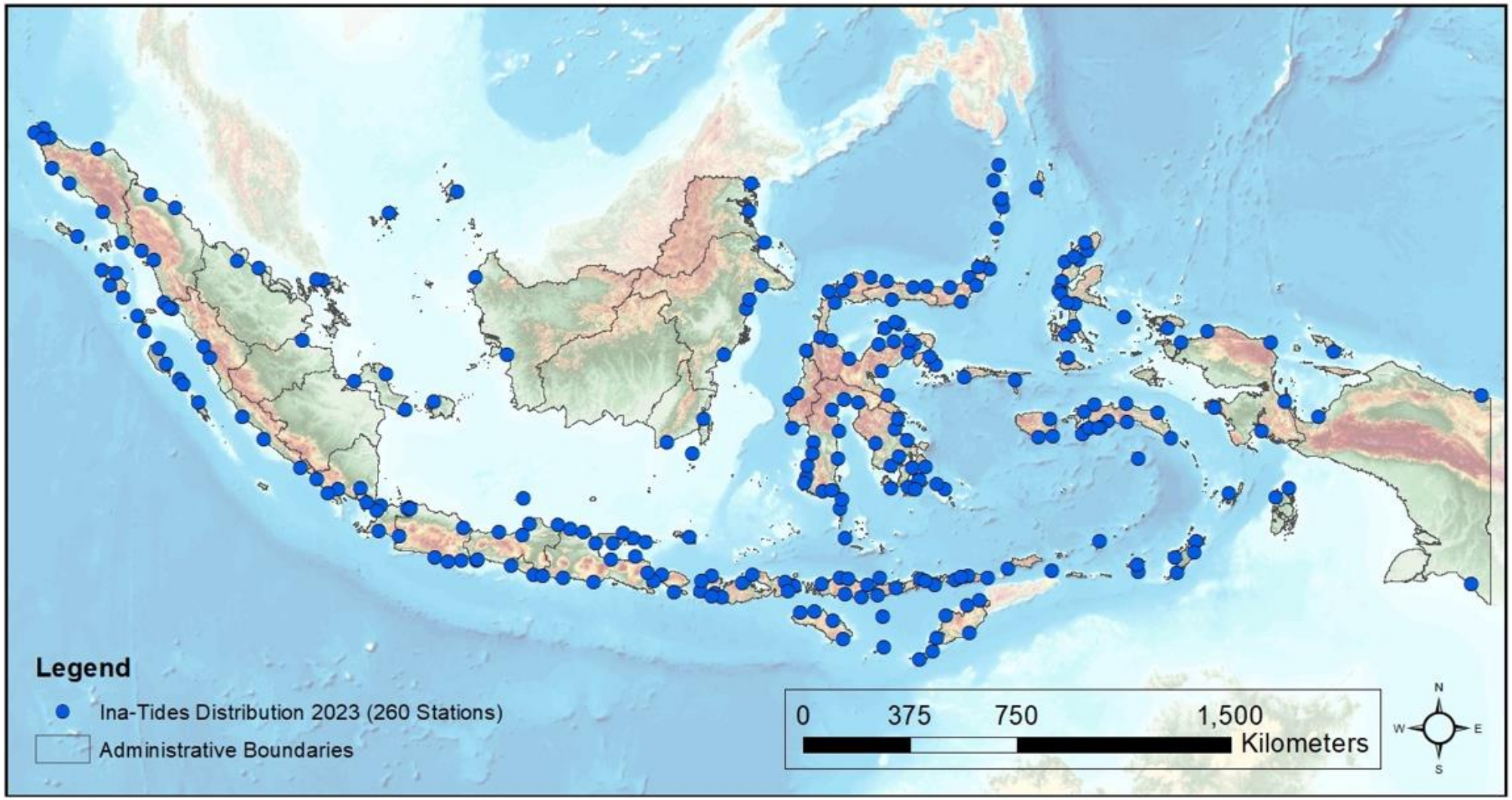
INAGEOID2020 - The Gravity Dataset & Infrastructures

ASIA PACIFIC GEOSPATIAL FORUM

The Distribution of Gravity Anomaly Generated from Airborne Gravity Surveys in Indonesia
(2008-2022)



Ina-Tides: Indonesian Tides Station



Ina-Tides: System

Modem

Data Logger

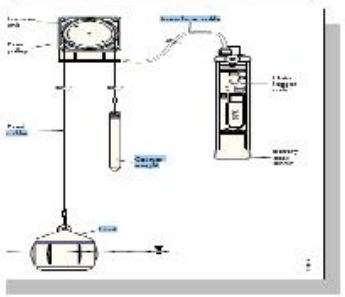
Float Gauge

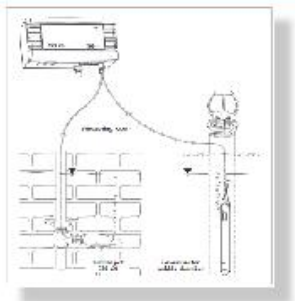
Bubble Gauge

Radar Gauge

BIG-Tide Gauge System:

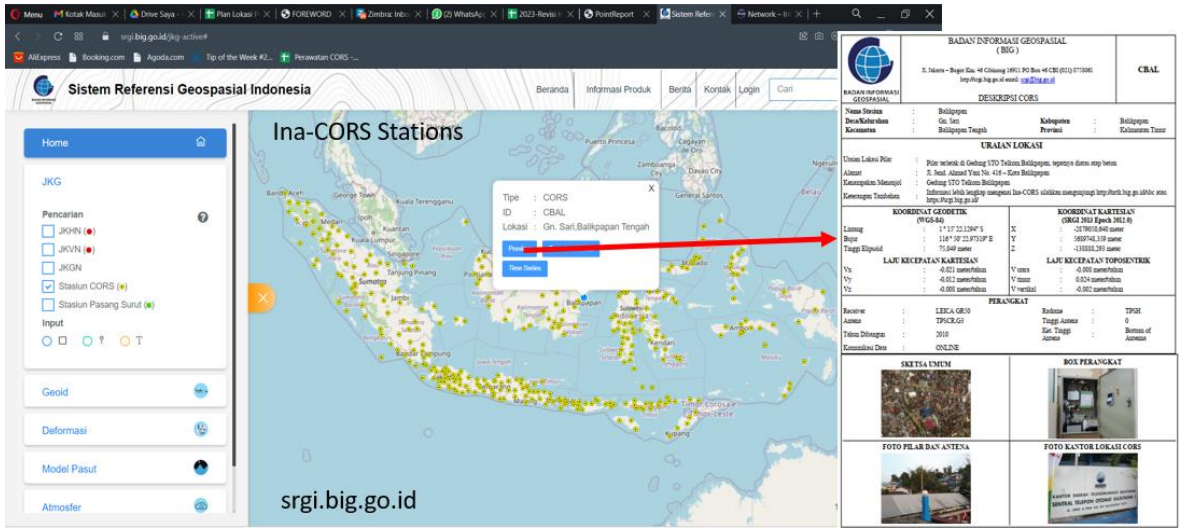
- Sensor 1 : Bubble Gauge
- Sensor 2 : Float Gauge
- Sensor 3 : Radar Gauge

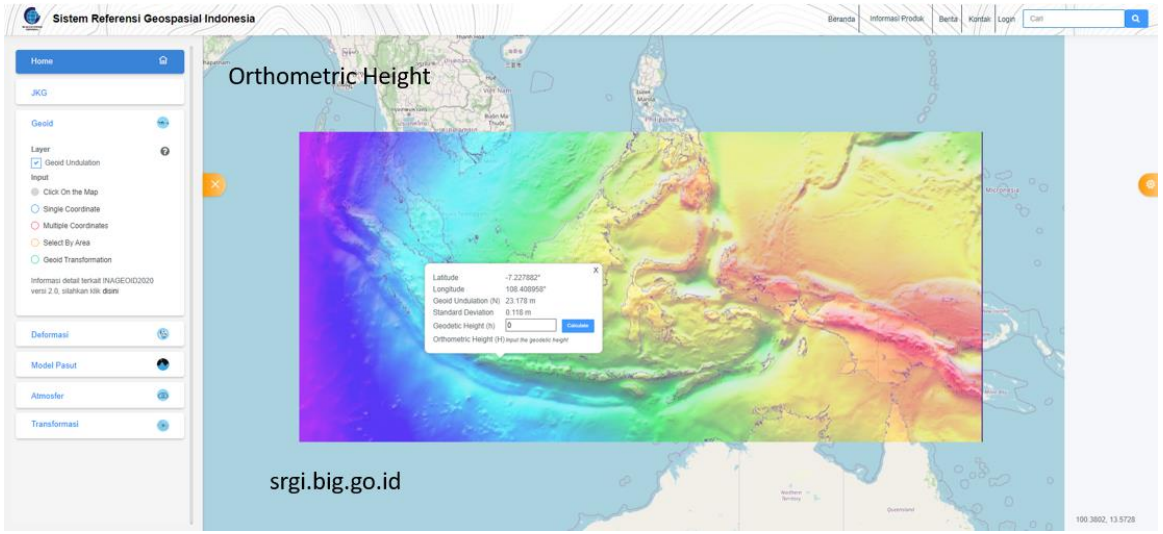


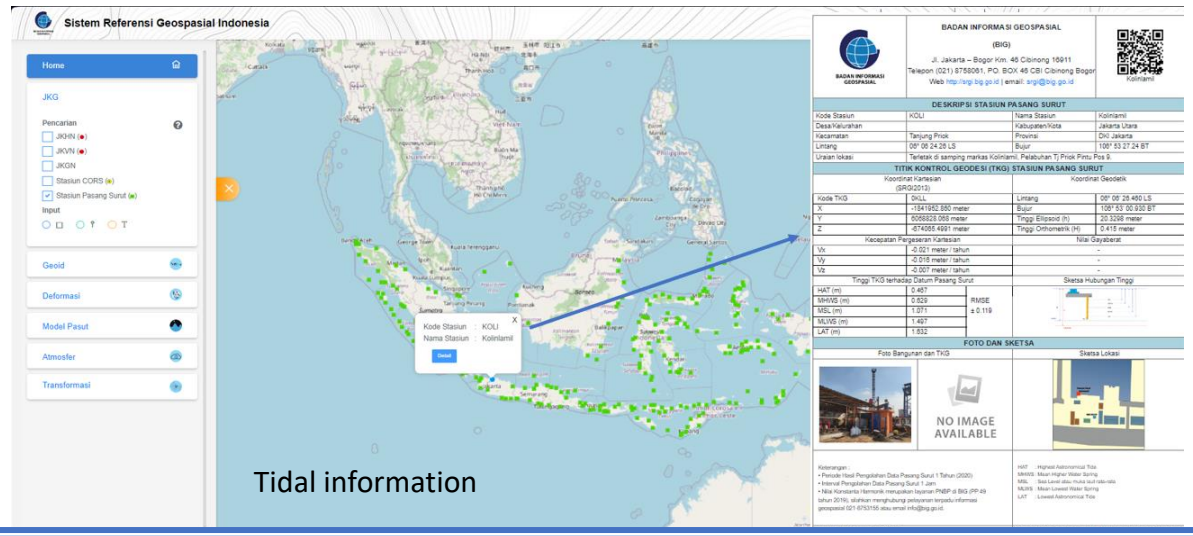


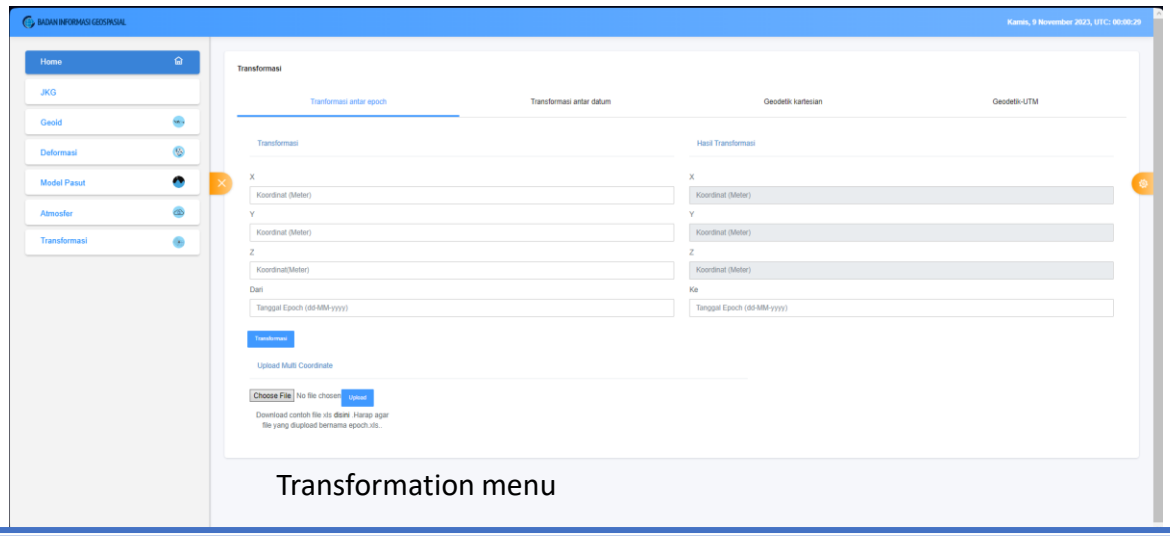
IGRS Service and Access System

https://srgi.big.go.id









Ina-TEWS: Indonesian Tsunami Early Warning System

- Presidential Decree No. 93/2019: Strengthening and developing earthquake information systems and tsunami early warning.
- Ina-Tides supports Ina-TEWS on detection of rapid sea level changes as a confirmation to tsunami occurrence
- Ina-CORS supports Ina-TEWS on detection of displacement waveforms when earthquake happens to provide additional data for earthquake parameters computation

SALINAN

PRESIDEN
REPUBLIK INDONESIA

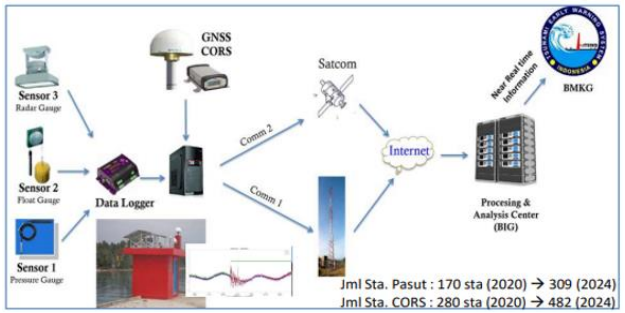
PERATURAN PRESIDEN REPUBLIK INDONESIA

NOMOR 93 TAHUN 2019

TENTANG

PENGUATAN DAN PENGEMBANGAN SISTEM INFORMASI GEMPA BUMI

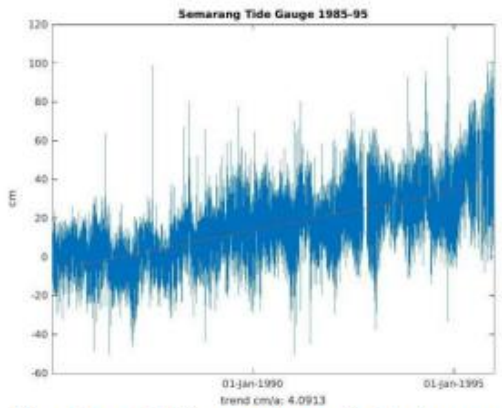
DAN PERINGATAN DINI TSUNAMI



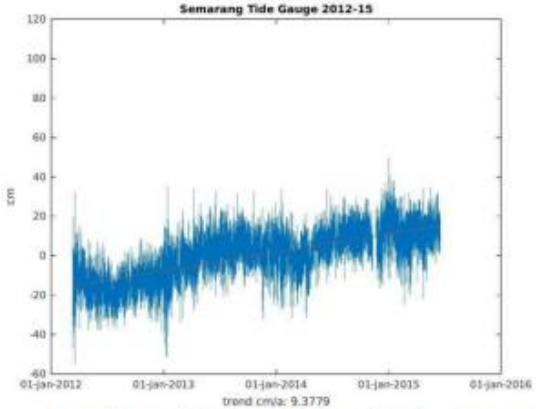
GNSS Controlled Tide Gauges For Sea Level Rise and Land Subsidence Monitoring

ASIA PACIFIC GEOSPATIAL FORUM

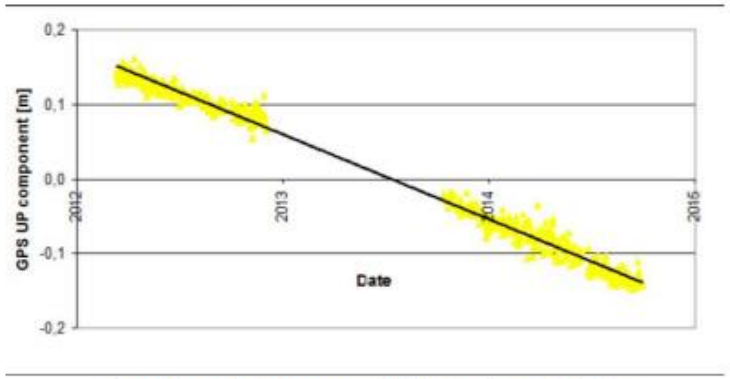
Case Study: **SEMARANG**



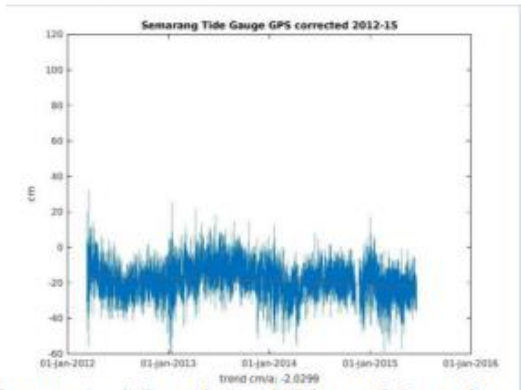
Sea Level Rise of 4 cm/yr between 1985-1995.



Sea Level Rise of 9 cm/yr between 2012-2015.



Land subsidence of 11 cm/yr (2015)



Corrected Sea Level Rise of 2 cm/yr

Challenges

1. Infrastructure challenges
   a. at remote sites: electricity, communication coverage,
   b. permission to use harbor or government building
2. Data sharing: strict policies at several institutions inhibit the data sharing among stakeholders
3. Improvement of technical capacity at national level for data processing and analysis

Concluding Remarks

1. The IGRS plays an important role in survey and mapping activities to implement One Map Policy in Indonesia
2. The development of geodetic infrastructure will continue to cover most of Indonesian area.
3. Geodetic infrastructure in Indonesia is utilized in a wide range of applications, such as:
    a. Surveying and Mapping
    b. Earth System Monitoring
    c. Indonesian Tsunami Early Warning System (Ina TEWS)
    d. Land Subsidence Monitoring
    e. Sea Level Rise Study


Thank you ....
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