Policy on National Geodetic Control Points of Japan - From Triangulation Control Points to GEONET -

Basara MIYAHARA, Kensuke KOKADO
and Tomoaki FURUYA

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Geospatial Information Authority of Japan

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Introduction

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- Geospatial Information Authority of Japan (GSI) has been maintaining Japanese geodetic reference frame from the beginning of Meiji era, 120 years ago.
- The reference frame was originally realized from triangulation surveys of triangulation control points.

- Total number of the points reached 100,000 until the end of 20th century.

- Considering performance of GNSS and needs for more accurate and efficient surveying utilizing GNSS, GSI decided to switch main geodetic control points from triangulation control points to CORS.
- The change in the policy was publicly announced in Japan at the end of June 2014.

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Geodetic Control Points in Japan

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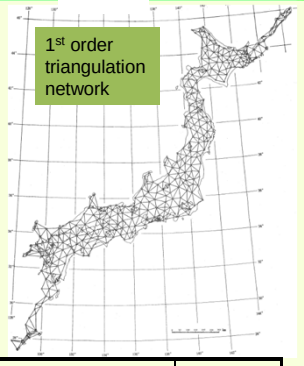
- Reference frame in Japan was realized from triangulation surveys of triangulation control points.
- The surveys had been conducted in a hieralchial way from first-order to forth-order and conitued over a hundred years.
- Total number exceeds 100,000 and maintenance cost has also been growing.



Category	Number	Sub-category		Ave. Int.
Triangulation control points 	109,766	First order triangulation stations	975	25 km
		Second order triangulation stations	5,045	8 km
		Third order triangulation stations	31,927	4 km
		Fourth order triangulation stations	71,819	1.5 km
Bench marks 	17,050	Fundamental bench marks	84	150km
		First order bench marks	13,825	2 km
		Second order bench marks	3,141	2 km
Total	126,816			

(As of April 1 2015)

Geodetic Control Points in Japan

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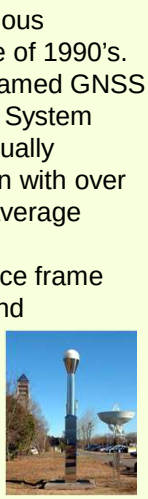
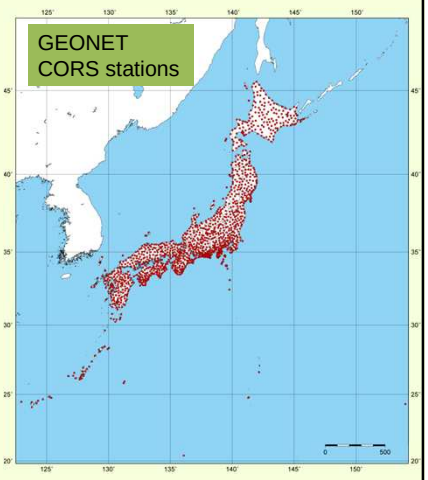
- GSI started GNSS continuous observation from the middle of 1990's.
- The observation system, named GNSS Earth Observation Network System (GEONET), has been gradually enhanced and covers Japan with over 1,300 stations with 20 km average spacing.
- Japanese geodetic reference frame has been mainly realized and maintained by GEONET.





Category	Number	Sub-category	Ave. Int.
GEONET CORS (GNSS-based control stations)	1,318		20 km

(As of April 1 2015)

Geodetic Control Points in Japan

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- Number of geodetic control points maintained by GSI

Category	# of stations	Sub-category		Average Interval
GEONET stations (GNSS-based control stations) 	1,318			20 km
Triangulation control points 	109,766	First order triangulation stations Second order triangulation stations Third order triangulation stations Fourth order triangulation stations	975 5,045 31,927 71,819	25 km 8 km 4 km 1.5 km
Bench marks 	17,050	Fundamental bench marks First order bench marks Second order bench marks	84 13,825 3,141	150km 2 km 2 km
Total	128,134			

(As of April 1 2015)

GSI decided to stop the maintenance of the most triangulation control points within 10 years

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Policy on maintenance of control points

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- Horizontal positions can be determined more accurately and efficiently by GNSS than by triangulation surveys.
- GSI is operating GEONET which covers Japan with 20km average spacing.
- GEONET can realize and maintain geodetic reference frame with a much smaller number of stations than triangulation control points.
- GSI decided to switch main geodetic control points from triangulation control points to GEONET stations and publicly announced a change at the end of June 2014.
- In the announcement, GSI stated;
  - GSI does not actively maintain triangulation control points and stop the maintenance of most of them within 10 years.
  - GSI makes the best of GEONET for realizing and maitaining geodetic reference frame in Japan.

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Crustal deformation detected by GEONET

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- The 2011 Off the Pacific coast of Tohoku Earthquake (the Great East Japan Earthquake) (March 11, 2011) caused unexpectedly huge crustal deformation and tsunami.
- Almost all of GEONET stations survived the disaster and continuously provided accurate positions through and after the event
- GEONET is one of key enablers for Japan to recover from the huge earthquake efficiently by providing the accurate positions for all restoration works.

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Crustal deformation detected by GEONET

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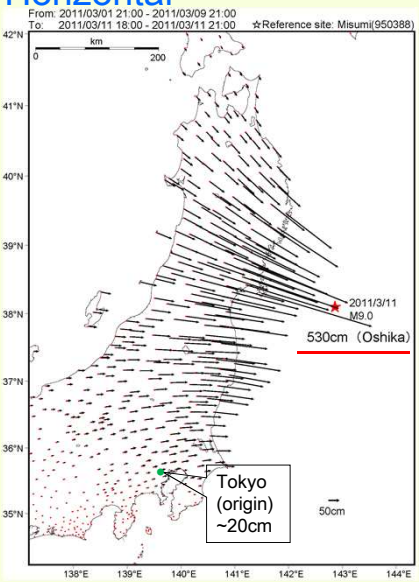
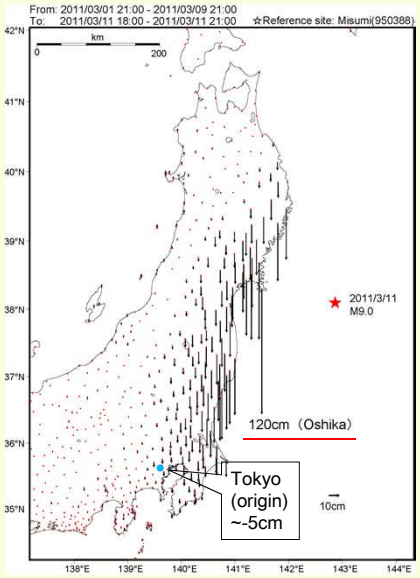
Co-seismic Movement by Great East Japan Earthquake

Horizontal



Vertical



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Revision of survey results by GEONET

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East Japan

Survey results were closed (Mar. 14)

GNSS & VLBI observations & analyses.

Revised new survey results were re-opened (May. 31)

West Japan & Hokkaido

Not revised

All new data set is called “Geodetic Coordinates 2011”

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Semi Dynamic Correction by GEONET

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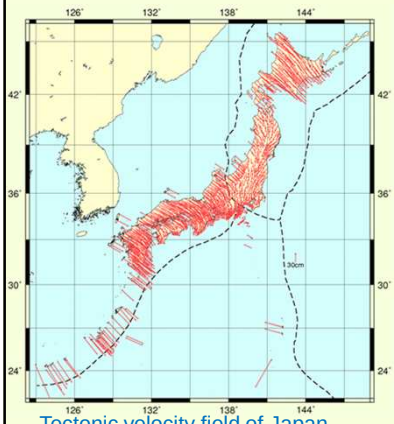
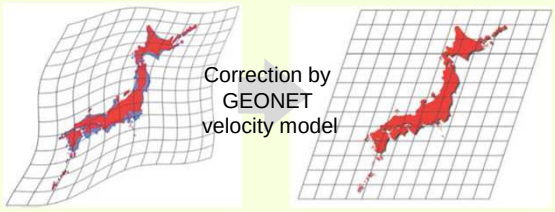


Tectonic velocity field of Japan
Detected by GEONET

- Japan is located on boundaries of active plates.
- Crustal deformation is continuously occurred through the islands.
- Cumulative deformation decreases accuracy of survey results. As time goes, differences between survey results and "real" positions are getting larger and larger.



Semi-Dynamic Correction is a method to remove crustal deformation from survey results and improve consistency. Crustal deformation of Japan is modeled from a velocity field detected by GEONET observation. Parameters for the correction are calculated from the model and applied for land surveys.

Hybrid geoid model of Japan, "GSIGEO2011"

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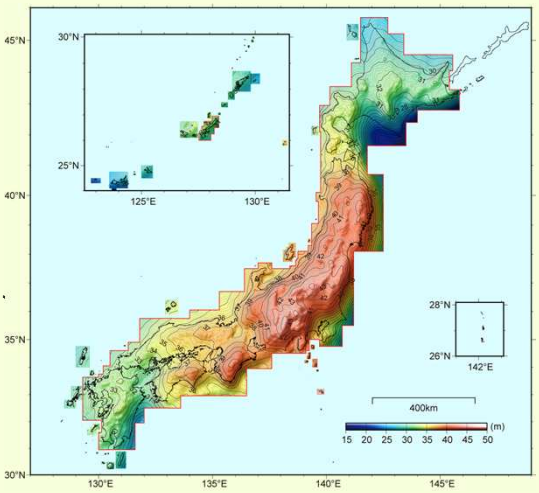
- GSI developed hybrid geoid model of Japan, "GSIGEO2011" by utilizing ellipsoidal heights of GEONET stations.
- GSIGEO2011 is developed to enable orthometric height determination by GNSS surveying.
- The model is established by fitting gravity geoid model of Japan, "JGEOID2008", to geoid heights determined from GNSS/Leveling at 850 GEONET stations, 29 tidal stations and 142 benchmarks.
- GSIGEO2011 has been open on April 1 2014 and available for public survey in Japan.



Counter interval is 20cm and numerals in meters

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Japanese hybrid geoid model, "GSIGEO2011"

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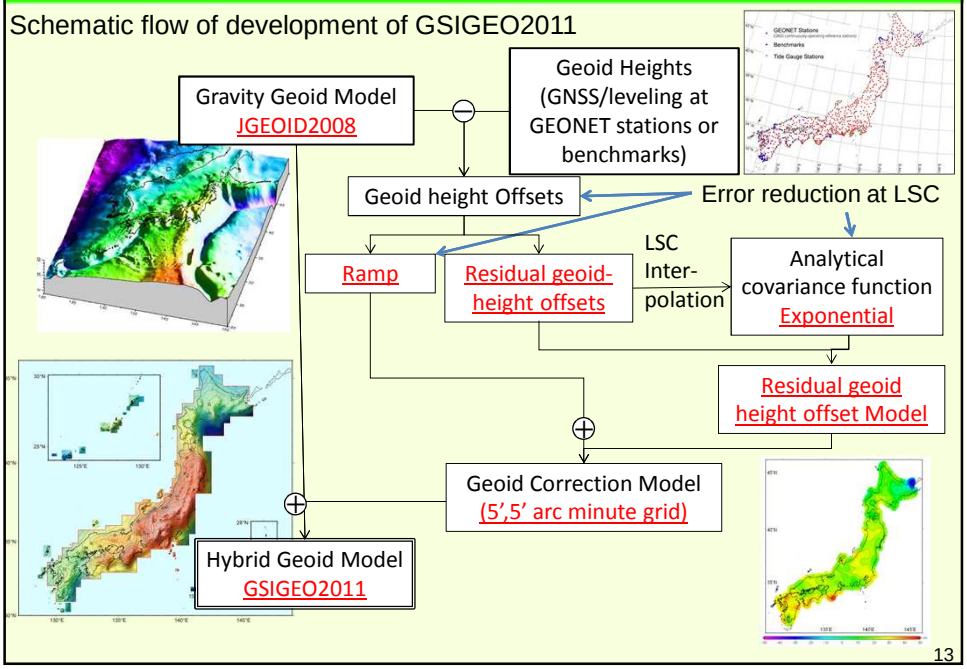
Schematic flow of development of GSIGEO2011



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Evaluation of GSIGEO2011

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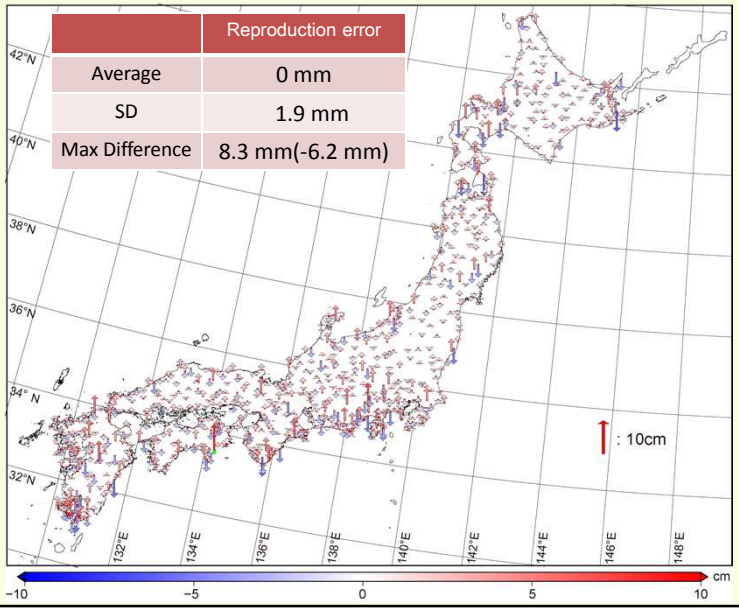
○ Reproduction errors (differences between GSIGEO2011 and GNSS/leveling).

	Reproduction error
Average	0 mm
SD	1.9 mm
Max Difference	8.3 mm(-6.2 mm)



Miyahara, B., T. Kodama and Y. Kuroishi (2014): Development of new hybrid model for Japan,"GSIGEO2011", Bulletin of the Geospatial Information Authority of Japan, Vol.62, 11-20.

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Summary

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1. GSI decided to switch main geodetic control points from triangulation control points to GEONET stations.
2. GEONET is essential infrastructure for realizing and maintaining geodetic reference frame in Japan, especially detecting and measuring crustal deformation.
3. GEONET is also utilized for orthometric height determination by GNSS surveying.

Thank you for your attention.

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