Geodetic Reference Frame of Japan Future Plan

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Growing demands for GNSS positioning services

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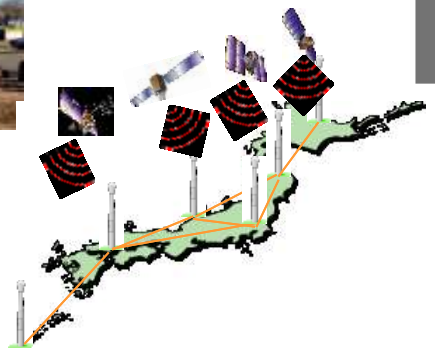
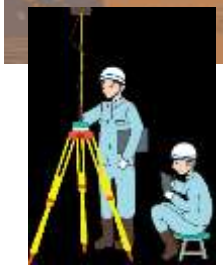
- Geospatial Information Authority of Japan (GSI) operates nationwide GNSS CORS network (GEONET). GEONET enables us to provide real-time precise GNSS positioning services.
- Users of precise GNSS positioning is growing in many emerging fields, such as smart construction, autonomous vehicle operation, smart agriculture, UAV operation and etc.
- We are planning to improve geodetic reference frame of Japan in order to establish basic infrastructure which enables us precise GNSS positioning including precise orthmetric height determination.





Issue 1 – crustal deformation -

- Japanese islands are continuously deforming because of crustal deformation caused by plate motions.

-> In order to keep consistency between GNSS positioning and geospatial information such as topographic maps, it is essential to correct crustal deformation.

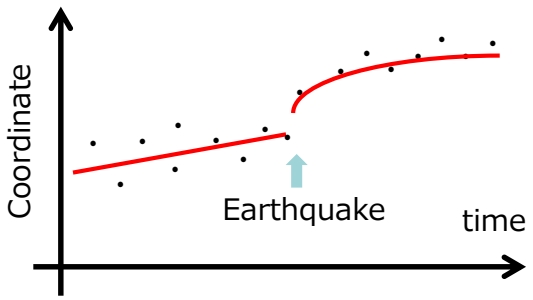
Challenge

- Development of precise crustal deformation model of Japan.
- Both secular crustal deformation model and coseismic displacement model are essential.

Martin et al. (2012)

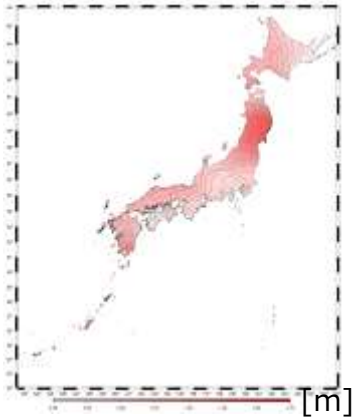
Model development of secular crustal deformation

- Development of secular crustal deformation using GNSS CORS network of Japan (GEONET)
- The first step is fitting coordinate time series of each GEONET station to functions such as linear or exponential etc., and determine most probable value of each day.
- The second step is to spatially interpolate the most probable values and generate deformation field of each day.



Fitting GEONET time series to functions

Spatial interpolation of most probable values of a day

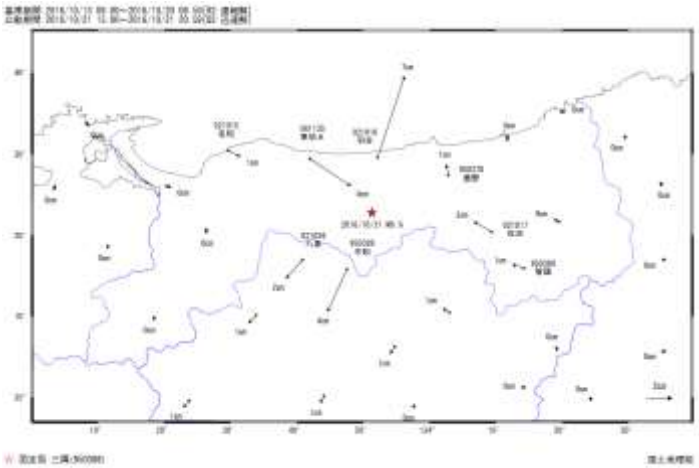


Accumulated horizontal deformation filed from reference epoch to 2017

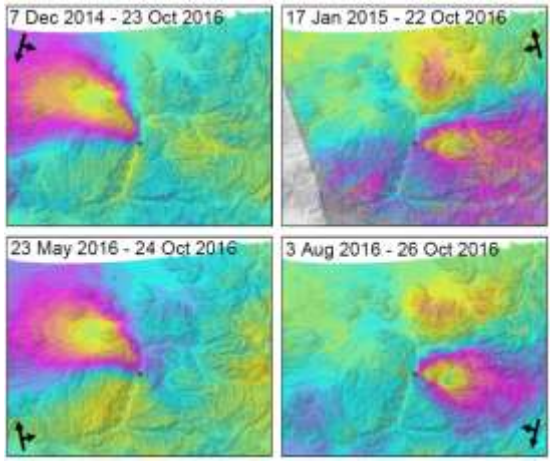
Model development of coseismic displacement

- Coseismic crustal deformation field can be created from coseismic displacement detected at GEONET stations and coseismic displacement distribution detected by 3D InSAR.

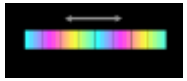
Coseismic displacement vector map

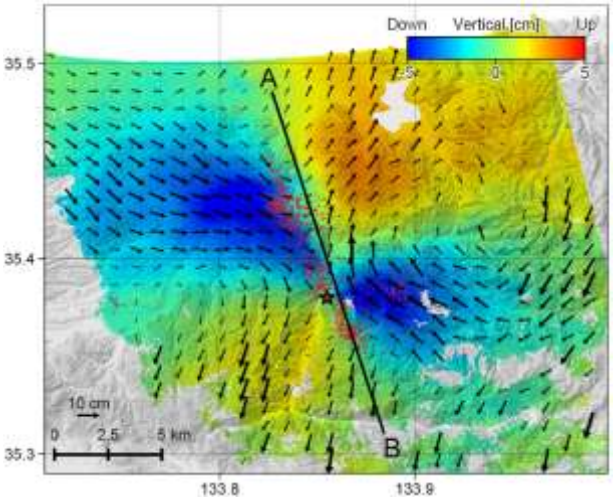


Interferograms



Analysis by GSI from ALOS-2 raw data of JAXA

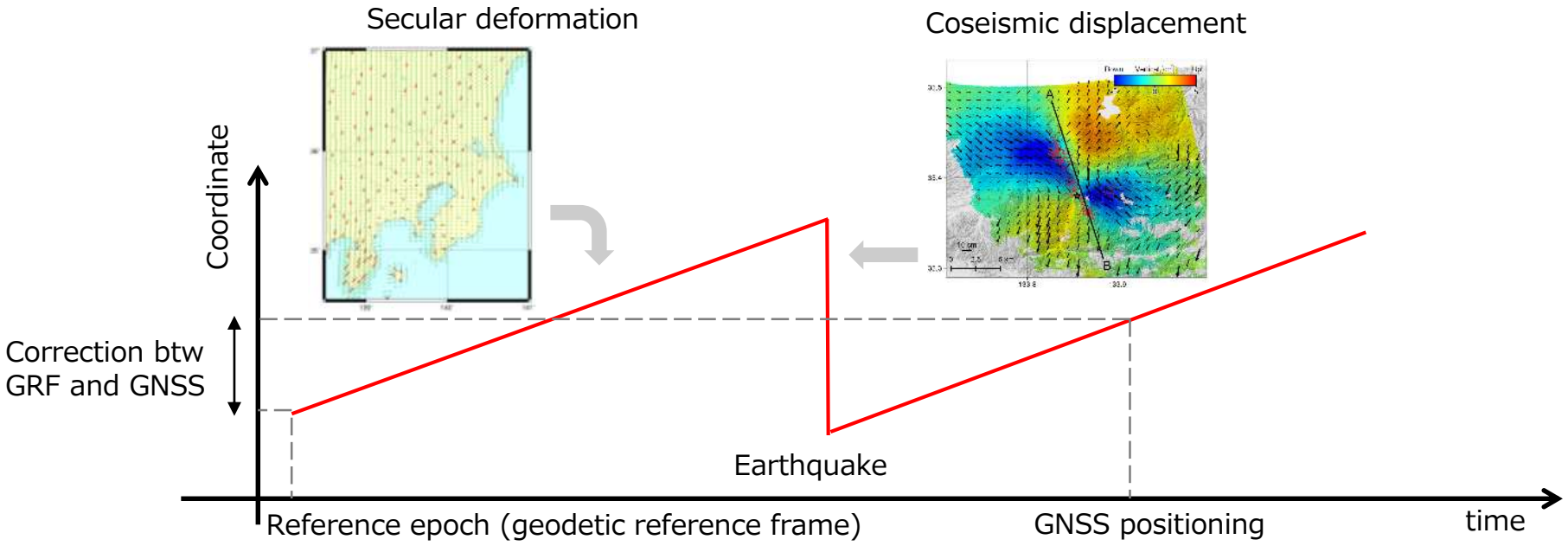




Coseismic displacement field

Time dependent (4D) crustal deformation model

- By combining models of secular crustal deformation and coseismic displacement, we can generate 4D crustal deformation model which provides positions of anywhere at any time.
- The 4D model can be base of next generation correction system which connects geodetic reference frame and GNSS positioning .



Issue 2 - vertical reference frame -

- Vertical datum of Japan has been realized and maintained with nationwide geodetic leveling.
- However, geodetic leveling covering the whole territory takes long time and huge cost.
- Prompt revision of datum is strongly required for prompt rehabilitation especially after large earthquakes, but revision through leveling takes at least several months.
- Orthmetric height determination with GNSS and geoid have a capability to enables us more prompt revision, but current gravity geoid model of Japan is not enough accurate to substitute for geodetic leveling.
- One solution is hybrid geoid model created from gravity geoid and GNSS/leveling, but the accuracy degrades time by time because of continuous crustal deformation.

Challenge

- Development of precise gravity geoid model of Japan
- Shift to geopotential vertical datum

Development of precise gravity geoid of Japan

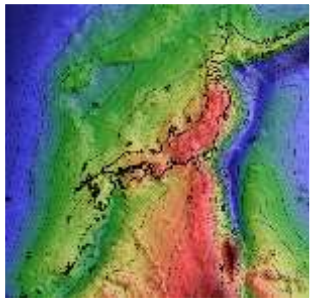
- Precise gravity geoid model is essential for realizing geopotential vertical datum.
- Dense and fresh gravity data covering the whole territory is essential for the development of precise gravity geoid model.

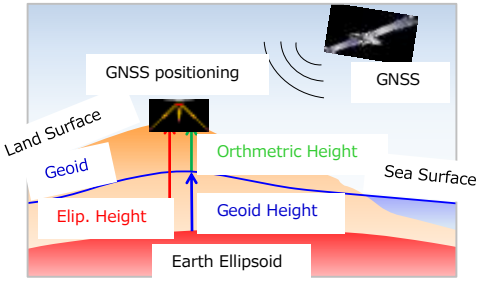
- We will purchase an airborne gravimeter in 2018.
- We are also seeking a possibility to conduct airborne gravity measurements covering the whole territory, develop precise gravity geoid model of Japan and shift to geopotential vertical datum.

2018: Purchase of reliable airborne gravimeter
2019-2022: Airborne gravity measurements & development of beta version of geoid models
2023: Development of national gravity geoid model
2024: Evaluation and Publication of the new geoid model
Shift to next generation geopotential vertical datum

Purchase airborne gravimeter

Airborne gravity measurement


Development of gravity geoid model



Geopotential Vertical datum

Barriers and necessary capacity development

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Barriers

- Lack of observatories and observation data
- Lack of human resource and funding

Necessary capacity development

- Crustal deformation modeling using GNSS and InSAR
- Airborne gravity measurement
- High precision gravity geoid model computation

Summary

- We are planning to improve geodetic reference frame of Japan in order to provide basic infrastructure for more accurate GNSS positioning.
- We are planning to develop correction system which connects geodetic reference frame (existing geospatial information) and GNSS positioning.
- First step of the development is modeling of secular and coseismic crustal deformation of Japan.
- The secular model is planed to be developed by utilizing coordinate time series of GNSS CORS network of Japan (GEONET).
- The coseismic model is planned to be developed by GEONET and 3D InSAR.
- We are also planning to develop precise gravity geoid model of Japan, and seeking a possibility to shift to geopotential vertical datum.
- We will purchase an airborne gravimeter in 2018.
- We also plan to conduct 4 years airborne gravity measurement.