GEONET
-CORS Network of japan-

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Geospatial and GNSS CORS Infrastructure Forum
Kuala Lumpur - Malaysia

Outline

国土地理院

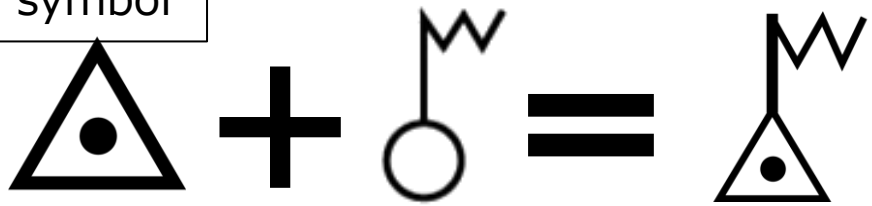
- Overview
- Analysis
  - Connection to ITRF
- Stations
  - Structure
  - Maintenance
- Applications

What is GEONET ?

GEONET is nationwide CORS network of Japan.

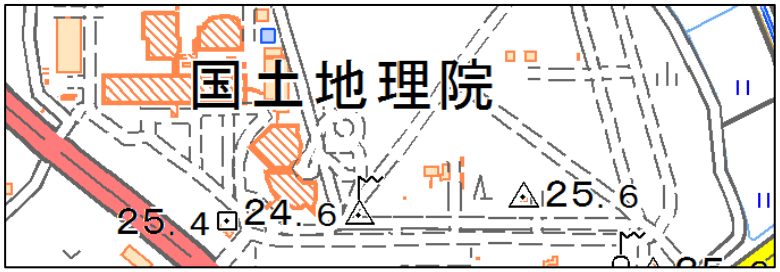
- 1,308 CORS stations
- Central analysis center

map symbol



Triangulation Control point + Tower (radio wave tower) = GEONET station

GEONET station



Central analysis center

Overview of GEONET

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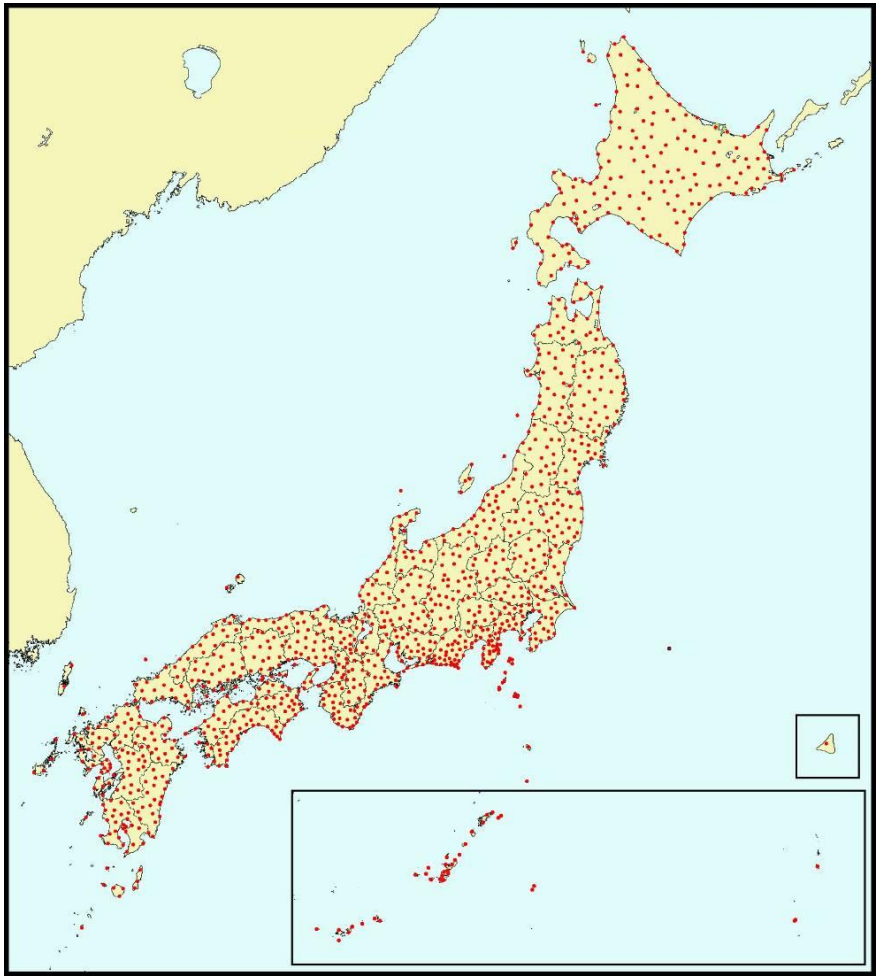
- Nationwide 1,308 CORS stations
  - About 20 km spacing in average
- Missions
  - Reference for Geodetic Surveying
  - Monitoring Crustal Deformation
- 1Hz data sampling
  - Real-time Data connection
  - Multi-GNSS capability - GPS, GLONASS, QZSS, Galileo

  *Galileo data are observed at about half of stations



Map of GEONET stations

History of GEONET

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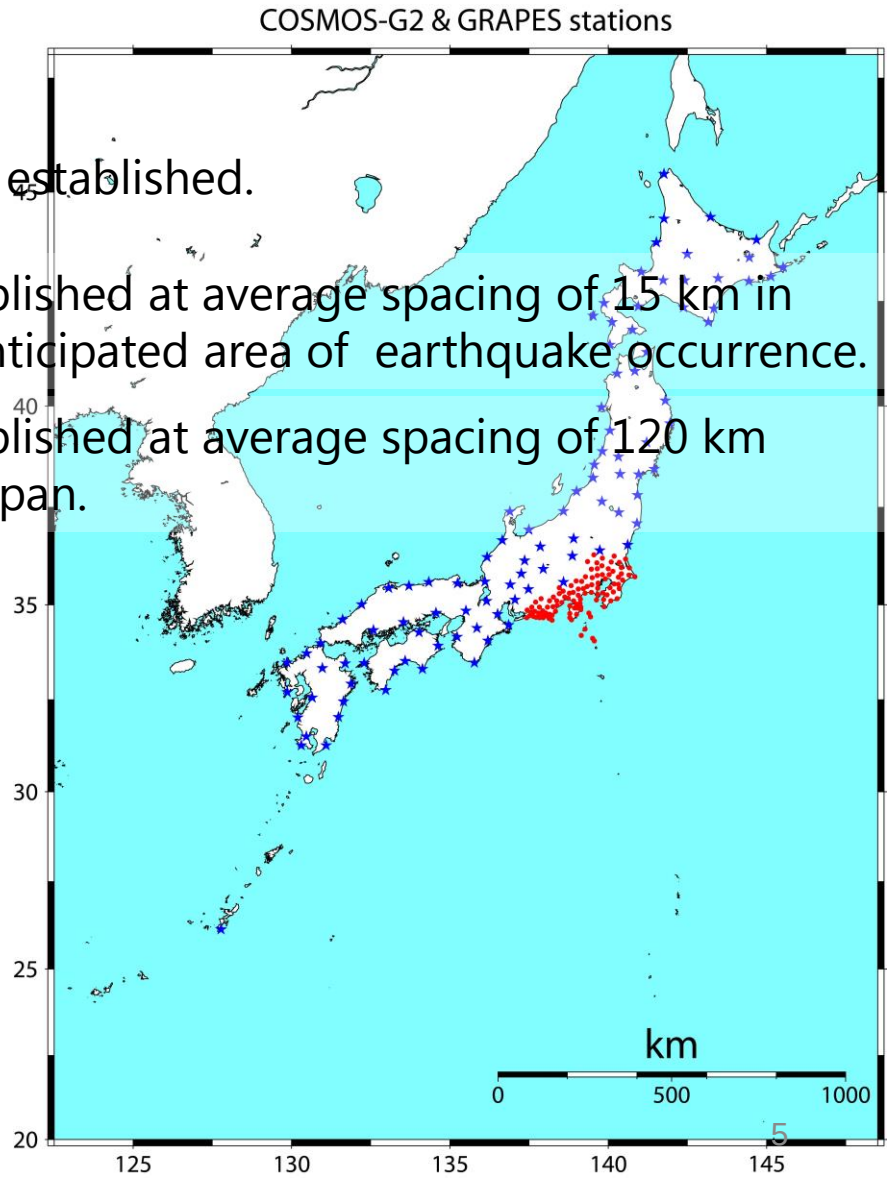
6	1992	The first stations were established.
110	1994	110 stations were established at average spacing of 15 km in metropolitan area & anticipated area of earthquake occurrence.
210	1994	100 stations were established at average spacing of 120 km covering all over the Japan.



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	1995	The Hyogo-Ken-Nanbu Earthquake(Mw 6.8) occurred.

History of GEONET

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400 1996 All stations are integrated , called GEONET.
(GPS Earth Observation NETwork)

1200 2003

1240 2011 The 2011 Great East Japan Earthquake occurred.

1273 2013 GLONASS and QZSS data was started to offer.

1308 2016 Galileo data was started to offer from 786 stations.

Roles of GEONET

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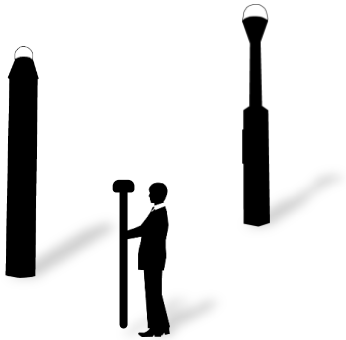
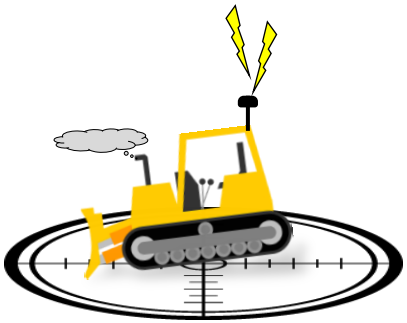
Reference for positions

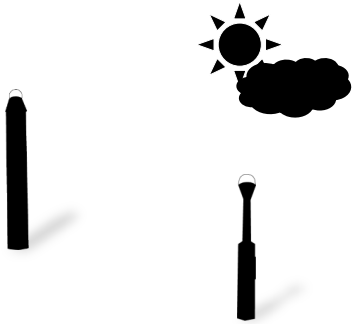


Surveying



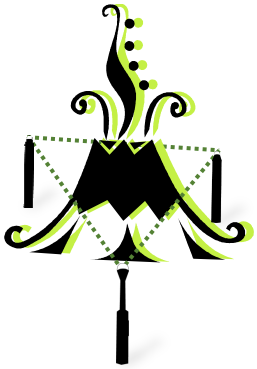
Navigation
(Intelligent construction etc.)

Others

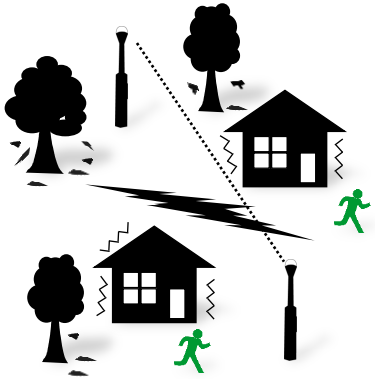


Atmospheric/ ionospheric monitoring

Monitoring crustal deformation



Volcano Monitoring

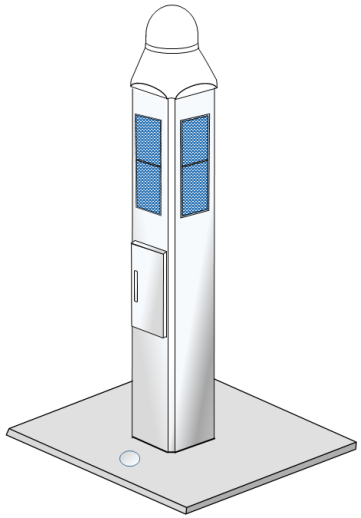


Earthquake Monitoring

Tsunami warning

Tsunami Estimation

Connection to ITRF

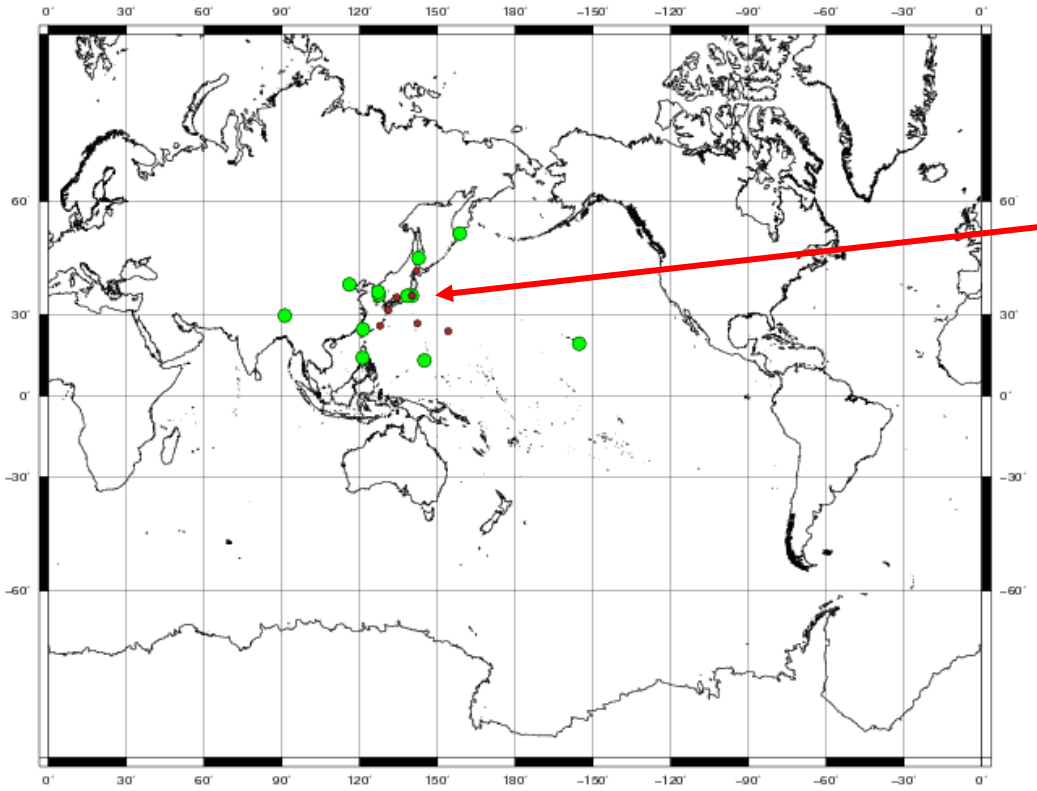


GEONET analysis

Consistency with global geodetic reference frame is extremely important for CORS network.

In order to achieve the consistency, GEONET analysis is divided to two steps.

1st step : coordinate calculation of one GEONET station from IGS stations around Japan using IGS final products



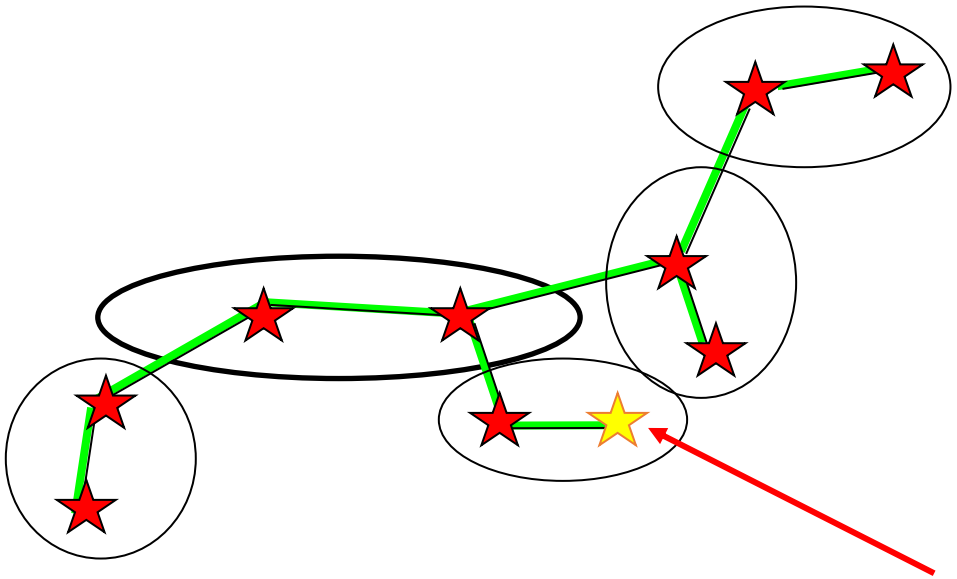
GEONET station:
Tsukuba1

IGS station

GEONET station

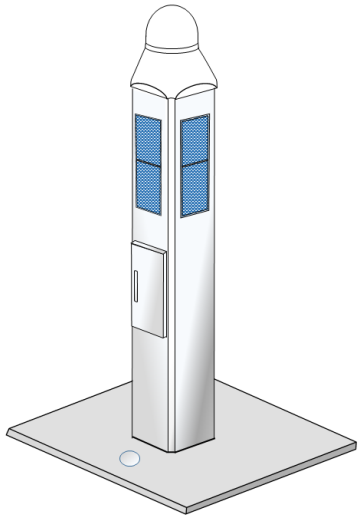
GEONET analysis

2nd step : coordinate calculation all GEONET stations with one station, Tsukuba1 fixed



FIX point:
GEONET station
Tsukuba1

Stations



GEONET station – Standard Structure

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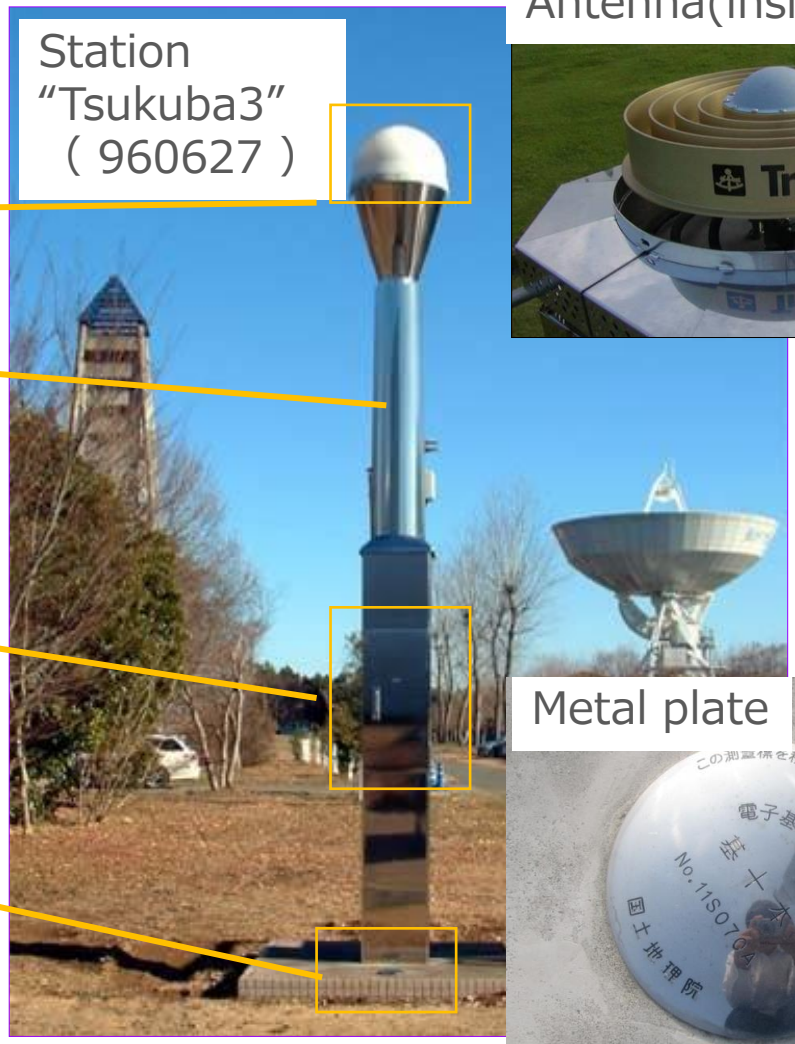
Radome : antenna protection

Pillar : stainless steel (about 5 m height)

Storage space : putting various equipment such as receiver, communication devices and batteries

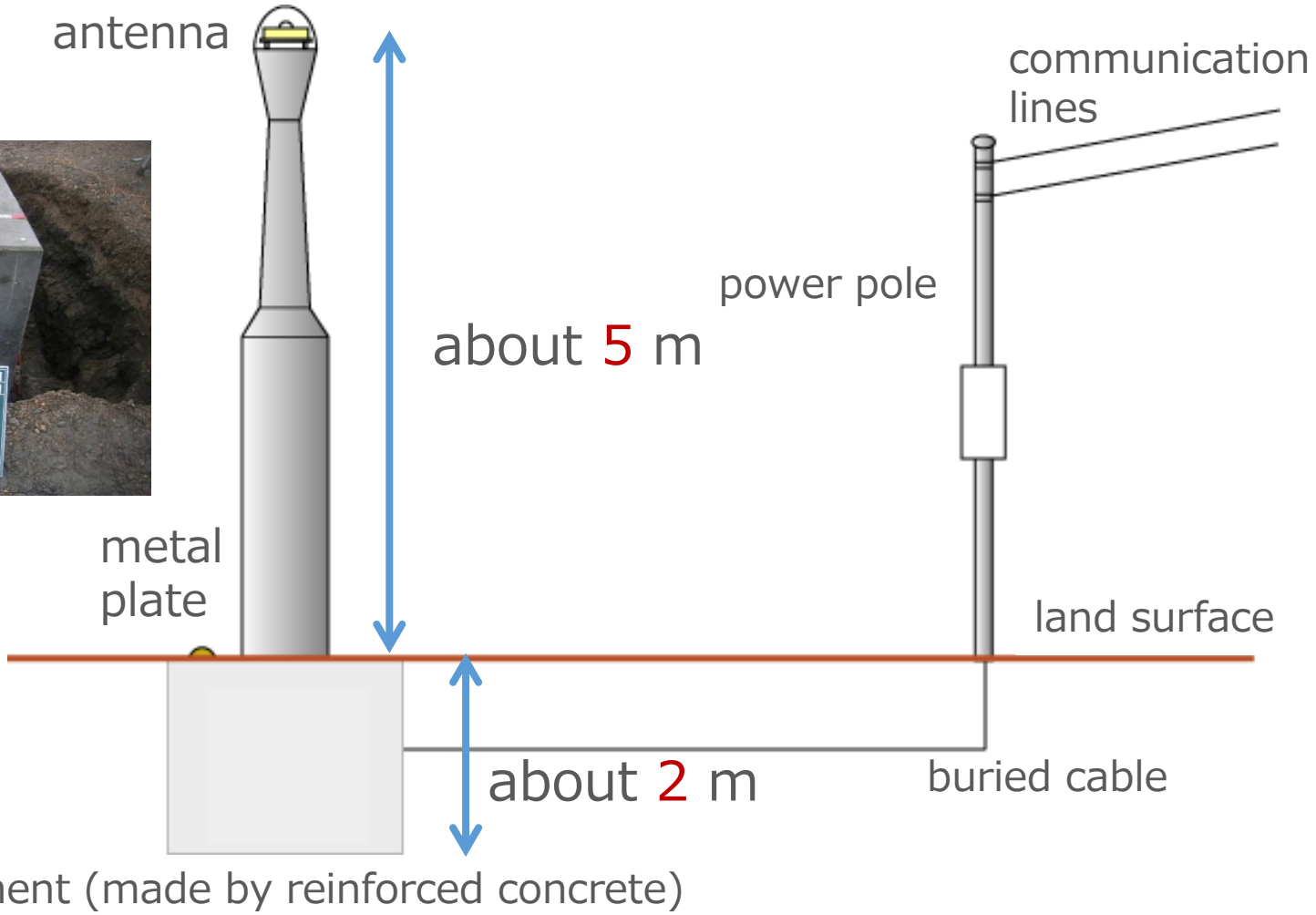
Metal plate : for the purpose of using Total Stations



Antenna(inside radome)

Metal plate

GEONET station – Standard Structure



※ The communication method depends on the station.

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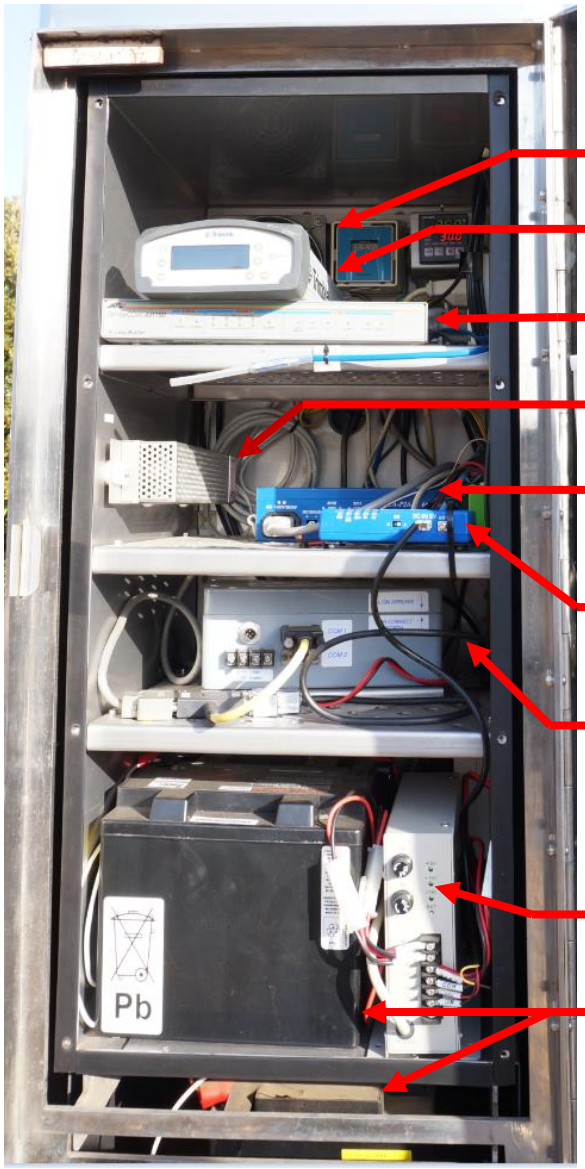
Equipment inside a pillar



Cooling Fan

GNSS Receiver

Communication device

Heater

Power monitoring device

Wireless network device

Tilt meter

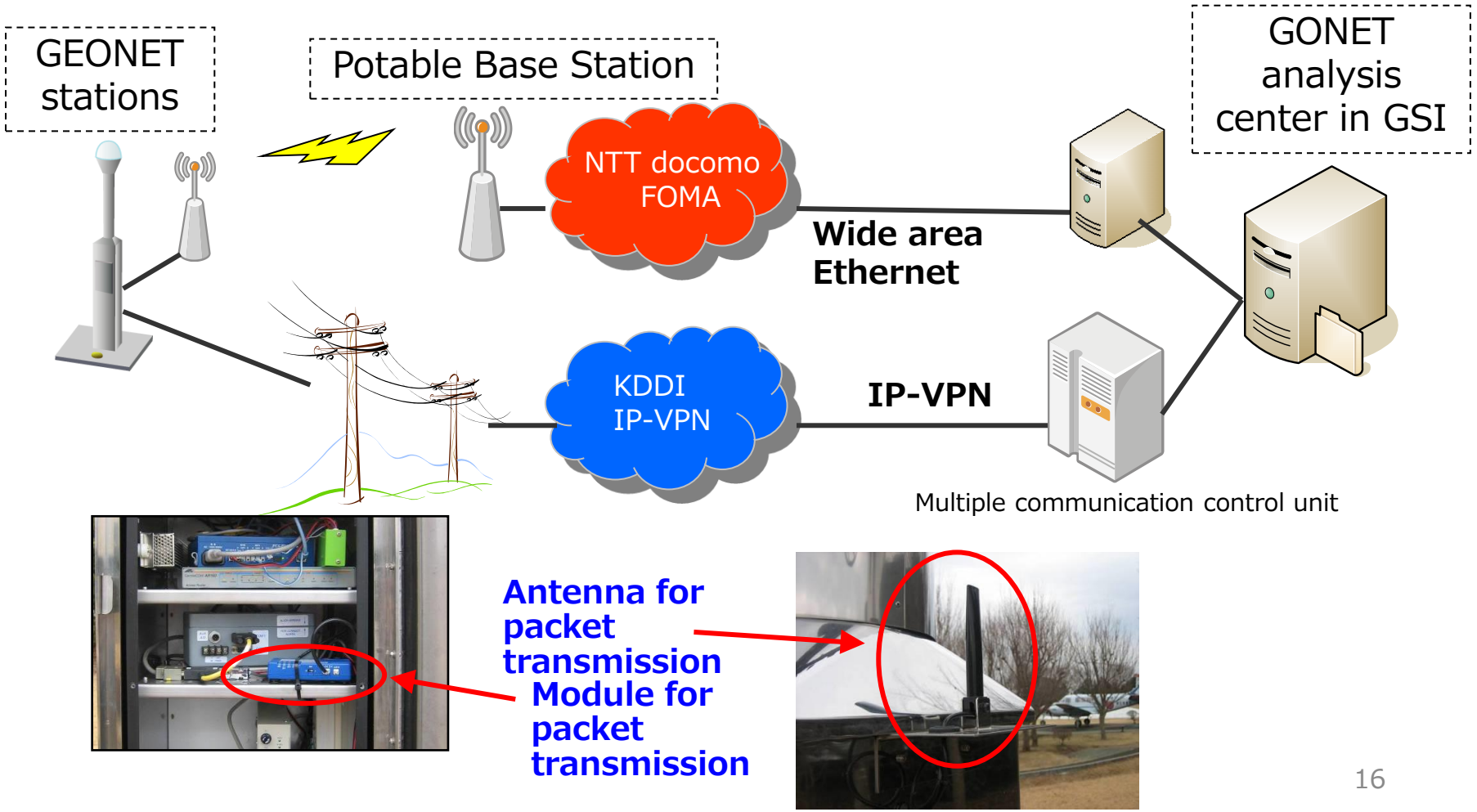
UPS

Battery (last about 72 hours)

Enhancement for redundancy of data communication

Redundancy of data communications

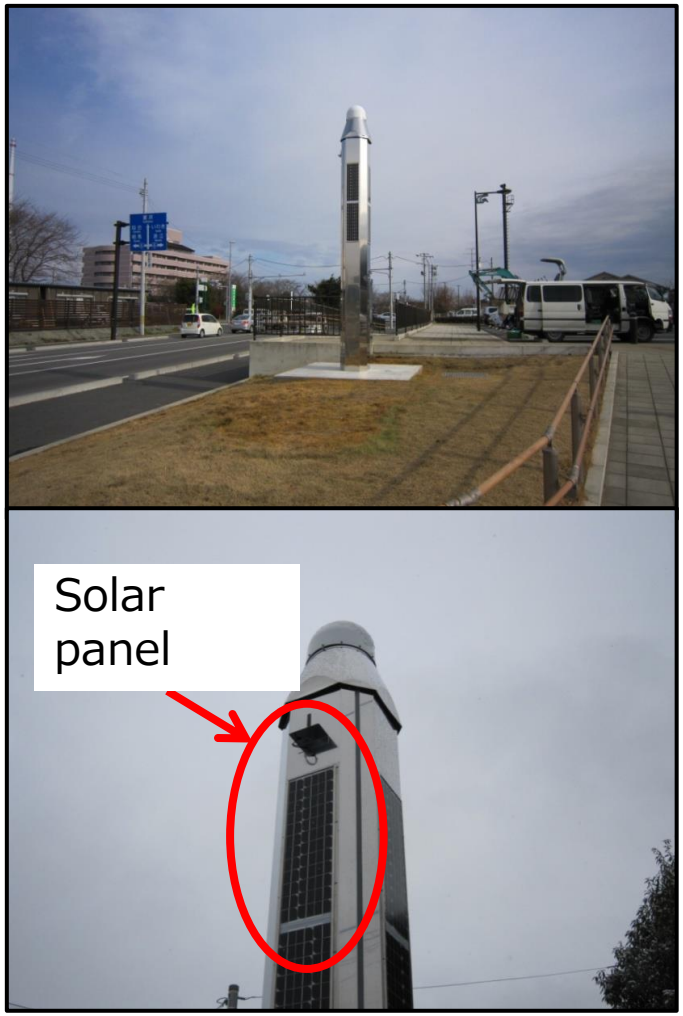
- Data communication of almost all GEONET stations is duplicated in order to get power supply even if the network cables are destroyed by a large disaster.



Latest improvement of GEONET stations

- More stable electrical power supply
  - 72 stations has solar panels to continue observation under long-term power outage.

Station S-Minamisouma-A in Fukushima pref.



Environment around stations

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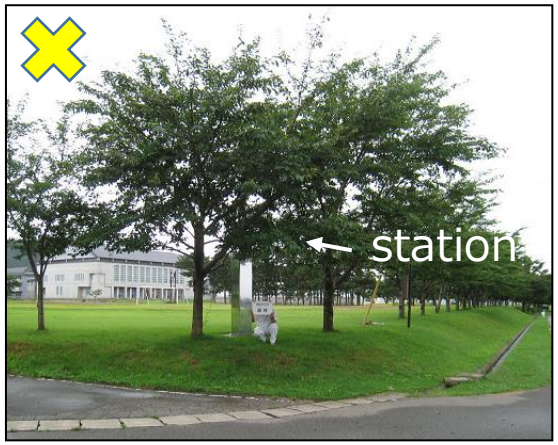
- Ideal setting for CORS station
  - firm ground (without slope , wetland)
  - no obstacle above / around stations (without “multipath”)
  - land owned by public sector (without a charge for use of the land)

to secure data quality and long-term observation



Tree trimming

In case trees block GNSS signals, this degrades the quality of GNSS observation. GSI trims the trees if the land owner allow GSI to do so.

(Trees are land owner's properties in Japan)

before

after

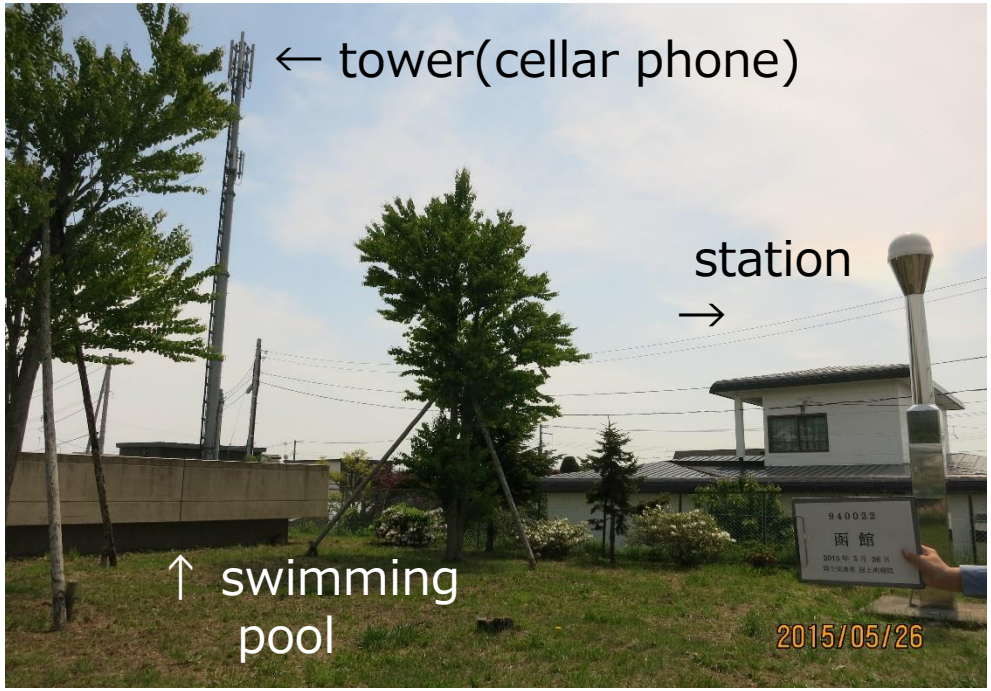
Environment

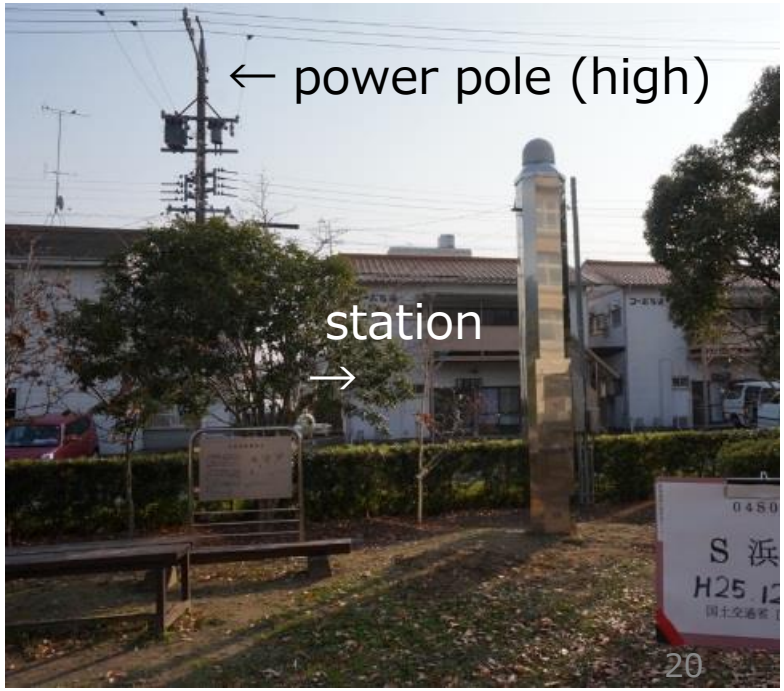
- Where is the station placed?

  The stations are mainly placed at school or park.

  (School: 650/1308, Park: 200/1308)

- Site environment largely affects the quality of observation.





Maintenance of GEONET stations

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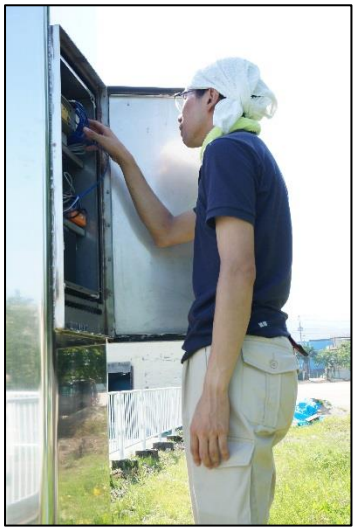
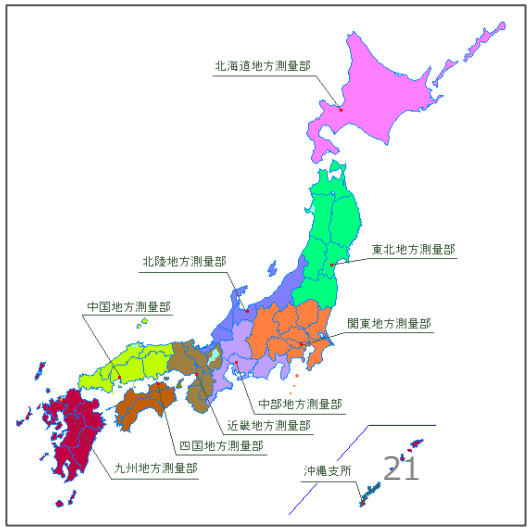
Check : regional offices of GSI

- ALL stations are checked by regional offices at least once every 4 years.

Repair and recovery : outsourcing

- In case that mechanical troubles are found, the devices are repaired within a week.

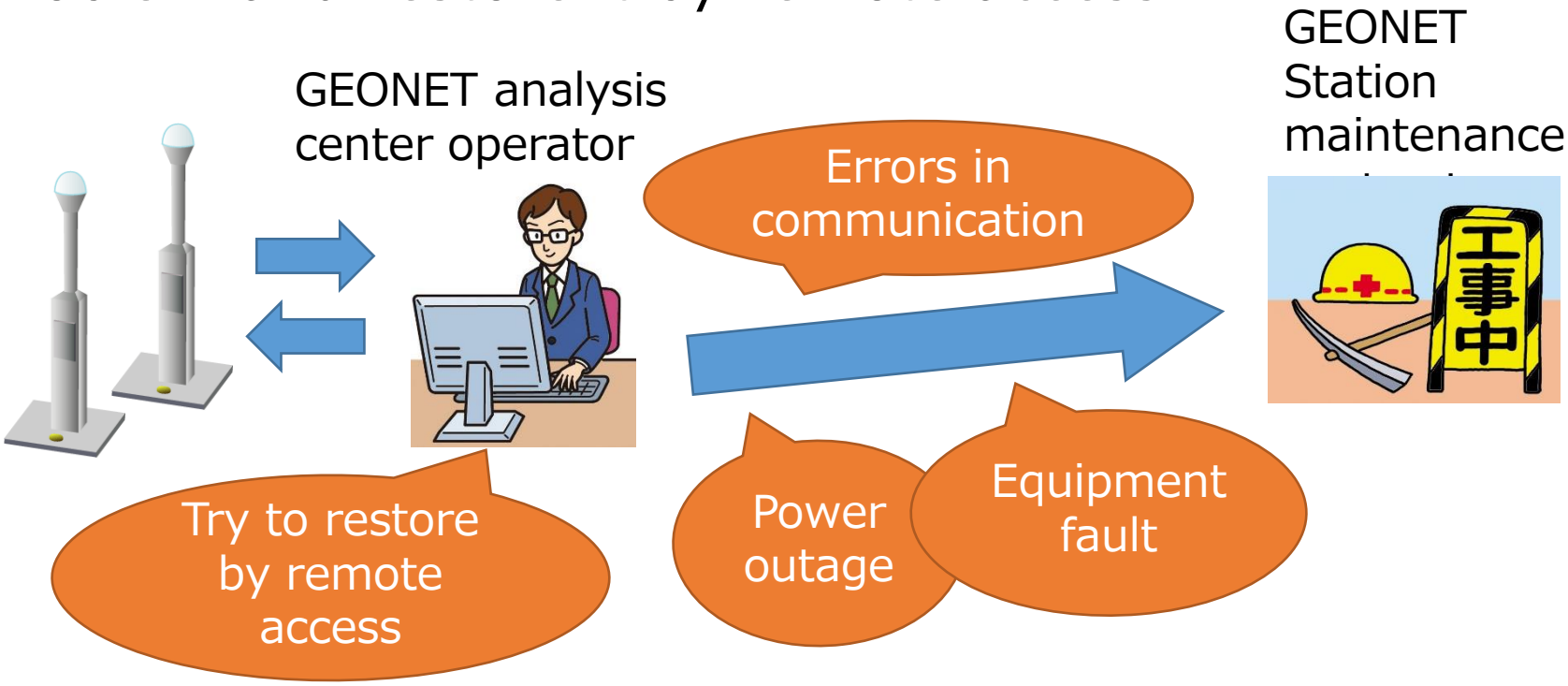




Maintenance of GEONET center

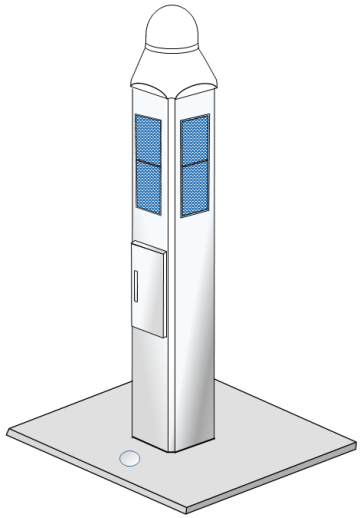
Operation of GEONET stations is outsourced.

In case of communication errors, the operator check the problem and restore it by remote access.



- If the observation stops, we would restart it within 7 days.

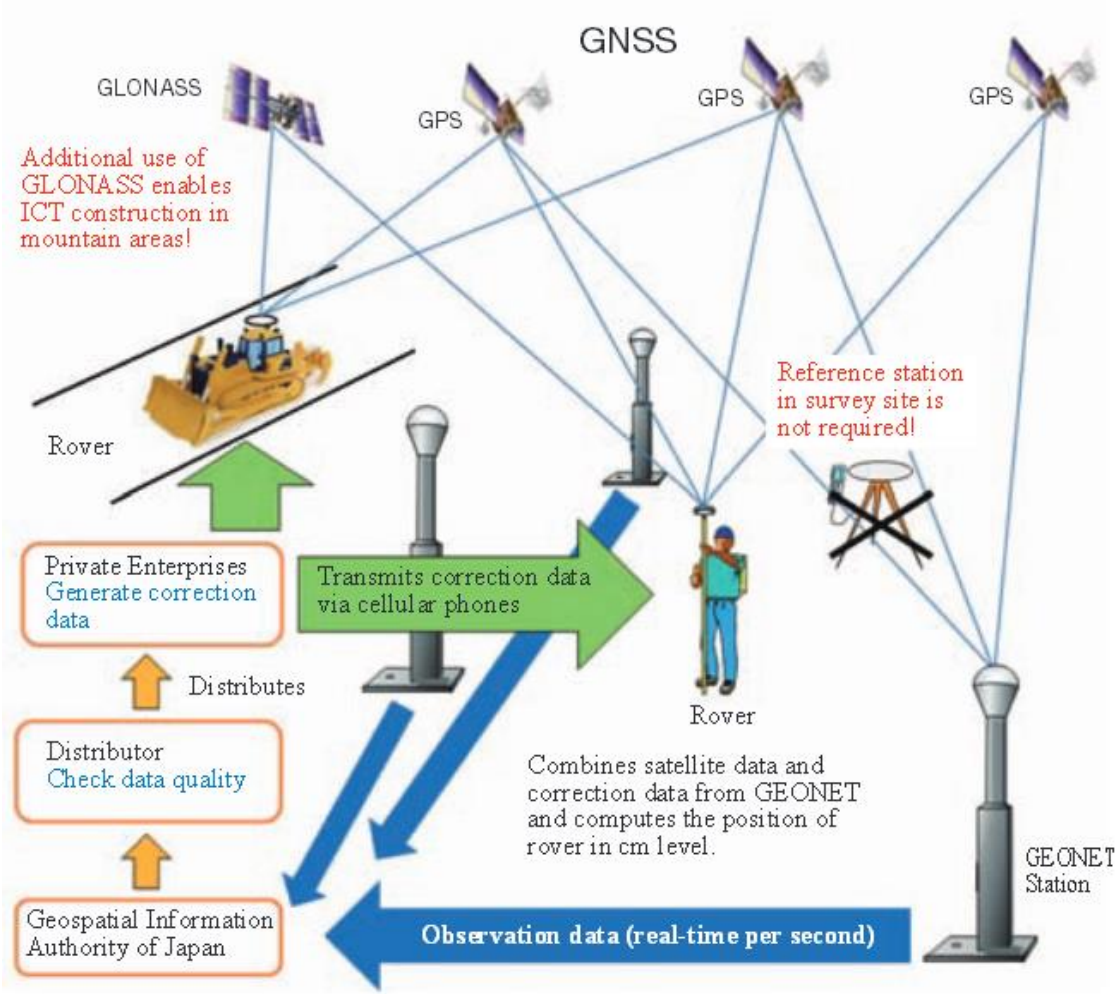
Applications



Real-time positioning service

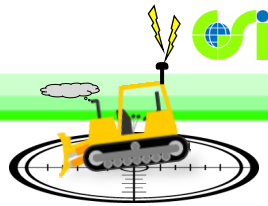
- 1 Hz data of GEONET is provided to the end users in real-time by private companies through NPO distributors

- Main purpose of the service is
  - Network RTK for surveying
  - RTK positioning for photogrammetry, ICT construction, etc.
  - Location-Based services
- GPS, GLONASS and QZSS real time data are available



Schematic view of network RTK positioning with GEONET real-time data

Navigation (Intelligent construction)



- Bulldozer with GNSS antenna is automatically controlled along preinstalled course.
- Position of the machine is precisely determined by RTK GNSS positioning.

Monitoring Crustal Deformation

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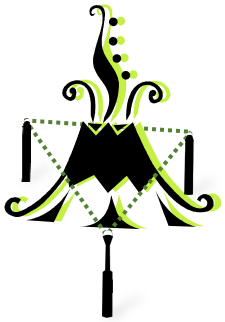
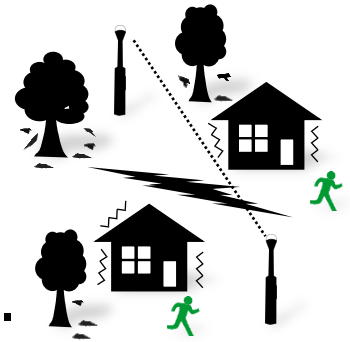
- Monitoring crustal deformation
  - Earthquakes and volcanic eruptions often occur in Japan.
  - Monitoring and understanding crustal deformation are crucial for mitigation of natural disasters.



- ***Distorted Japan***
  - Plates movement deforms the land of Japan, which affects the Japanese geodetic reference frame.
  - GSI maintains the reference frame using the displacement detected at each GEONET station.



Crustal Deformations

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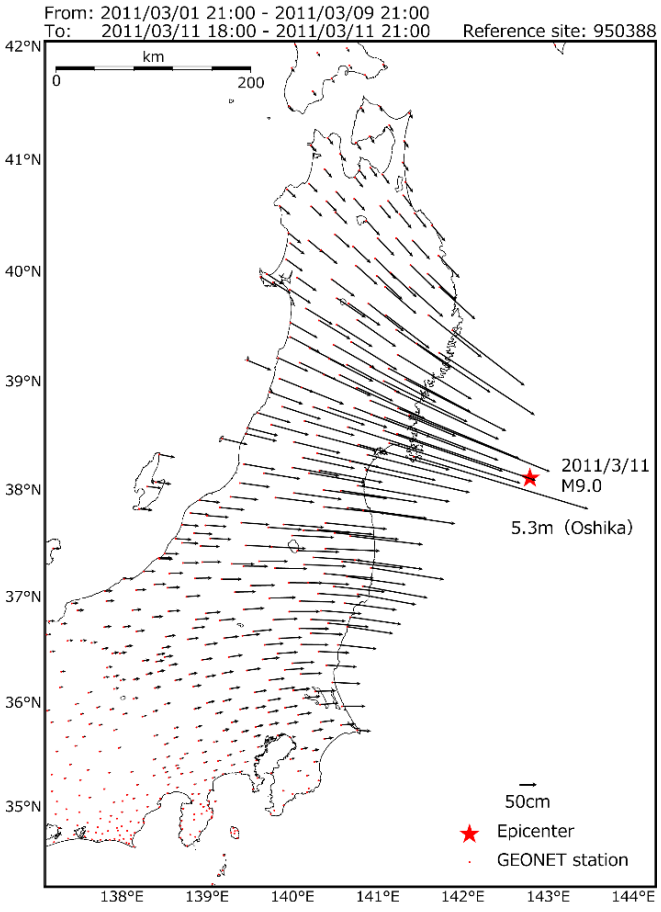
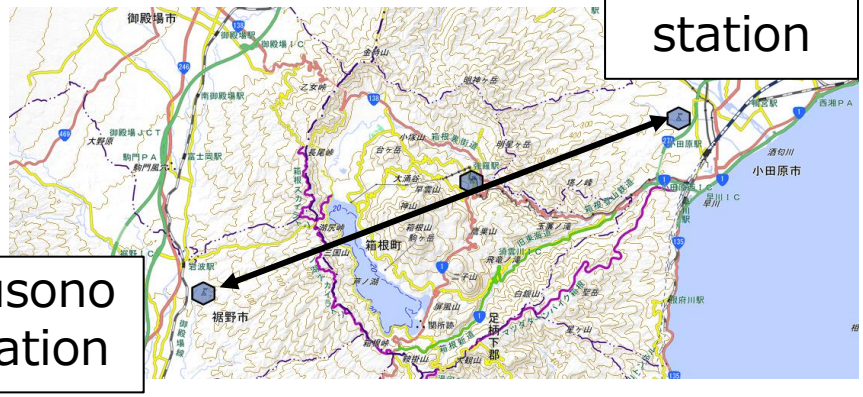
Coseismic displacements



Volcano deformation

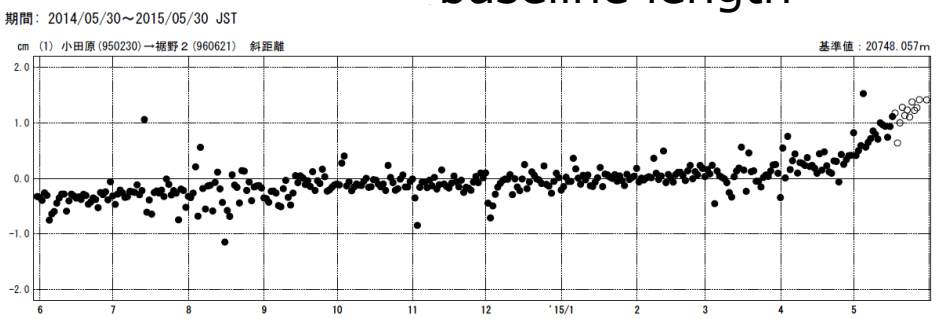
Hakone Volcano

Odawara station



Susono station

baseline length



Atmospheric Monitoring

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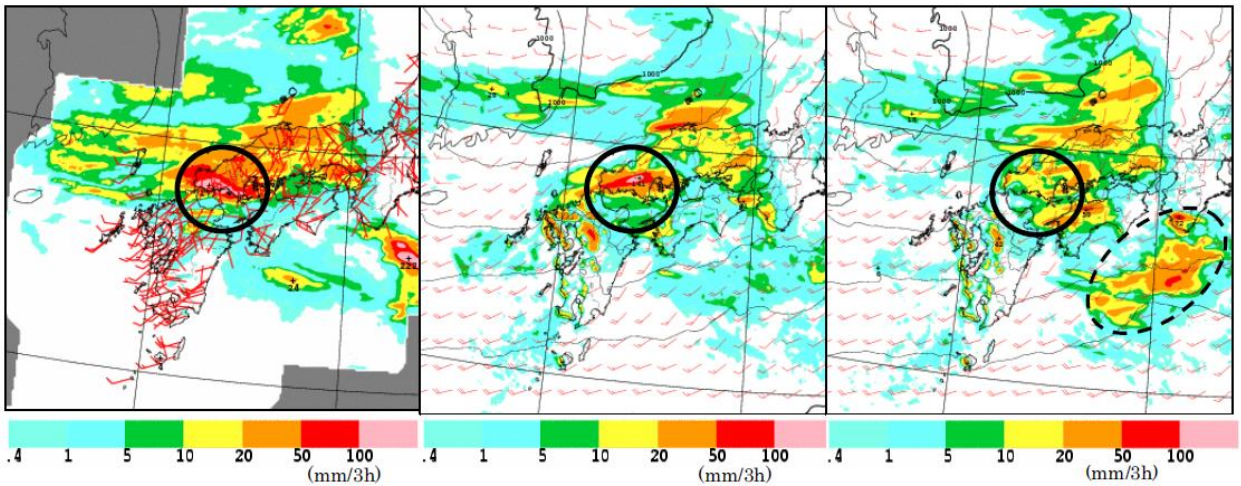
- Weather Forecast

Precipitable water can be estimated from GNSS observation data, and the estimated precipitable water is utilized for numerical weather model of Japan by Japan Meteorological Agency.

Distribution of precipitable water



Observation　　Model with GPS　　Model without GPS

Atmospheric Monitoring

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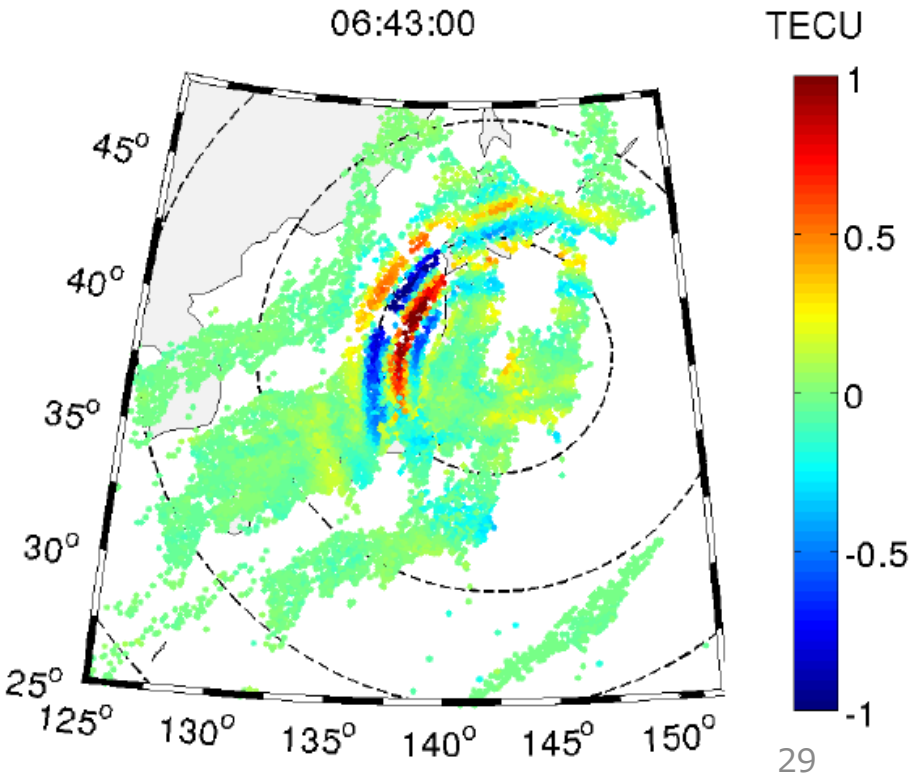
- Monitoring of Ionosphere

TEC (Total Electron Content) be estimated from GNSS observation data, and the estimated TEC is utilized for monitoring of ionosphere.



TEC map 1h after
the Great East Japan EQ
(Rolland et al. [2011])

Tsunami magnitude estimation

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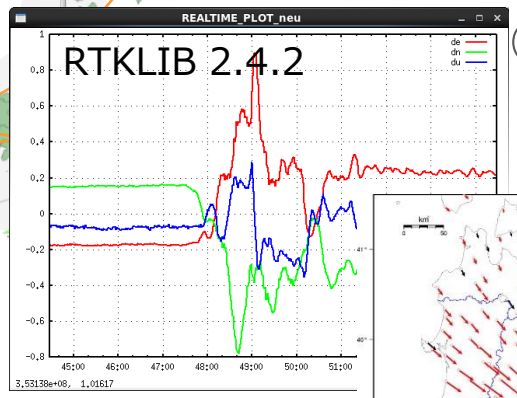
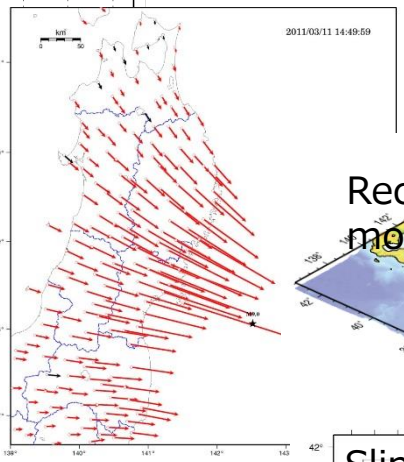
GEONET

① collect data

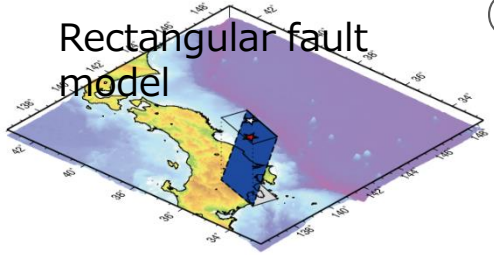


② real-time positioning

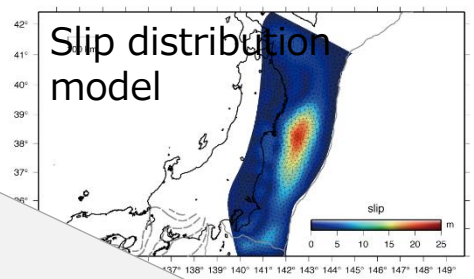


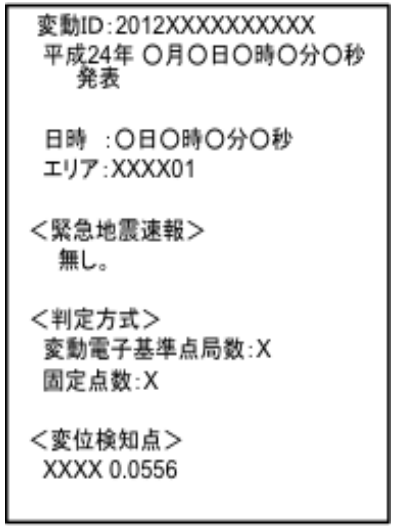
③ detect deformation

2 detection method
- Early earthquake warning (JMA)
- RAPiD (Ohta et al.,2012)



④ estimate fault models





⑤ send results

within 3 minutes

2 inversion methods
- Rectangular fault model (Nishimura et al., 2012)
- Slip distribution model (Kawamoto et al., 2015)

Summary

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- GEONET is nation wide CORS network of Japan operated over 20 years.
- Station coordinates of GEONET is connected to ITRF through IGS stations around Japan.
- GEONET stations have standard structure which enables stable communication and observation.
- Environments around stations are critical for quality of observation data.
- CORS network can be utilized for positioning, navigation, monitoring of crustal deformation, weather forecast etc.