Network RTK in Areas with High Geodynamic Activity

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Introduction

- multiple permanent GNSS reference stations
- **RTK-networks state-of-the-art** application providing
  - RTK services
  - DGNSS services
- **demand** of RTK service users for
  - consistency of framework
  - integrated access to user datum
- **pre-requisite** of RTK service provider
  - up-to-date coordinates of reference stations
  - optimum performance of RTK network
- **need** of RTK-network to provide transformation

GNTRANS

- development of Geo++ GNTRANS
  - GNTRANS transformation **model** can account for
    - varieties of local datum
    - distortions of current networks
    - high geodynamic activity
  - GNTRANS transformation **modules**
    - Germany-wide DB_REF* module
    - local or regional patches in Germany
    - Japan-wide module

* DB_REF geodetic system and network of German railway company DB AG

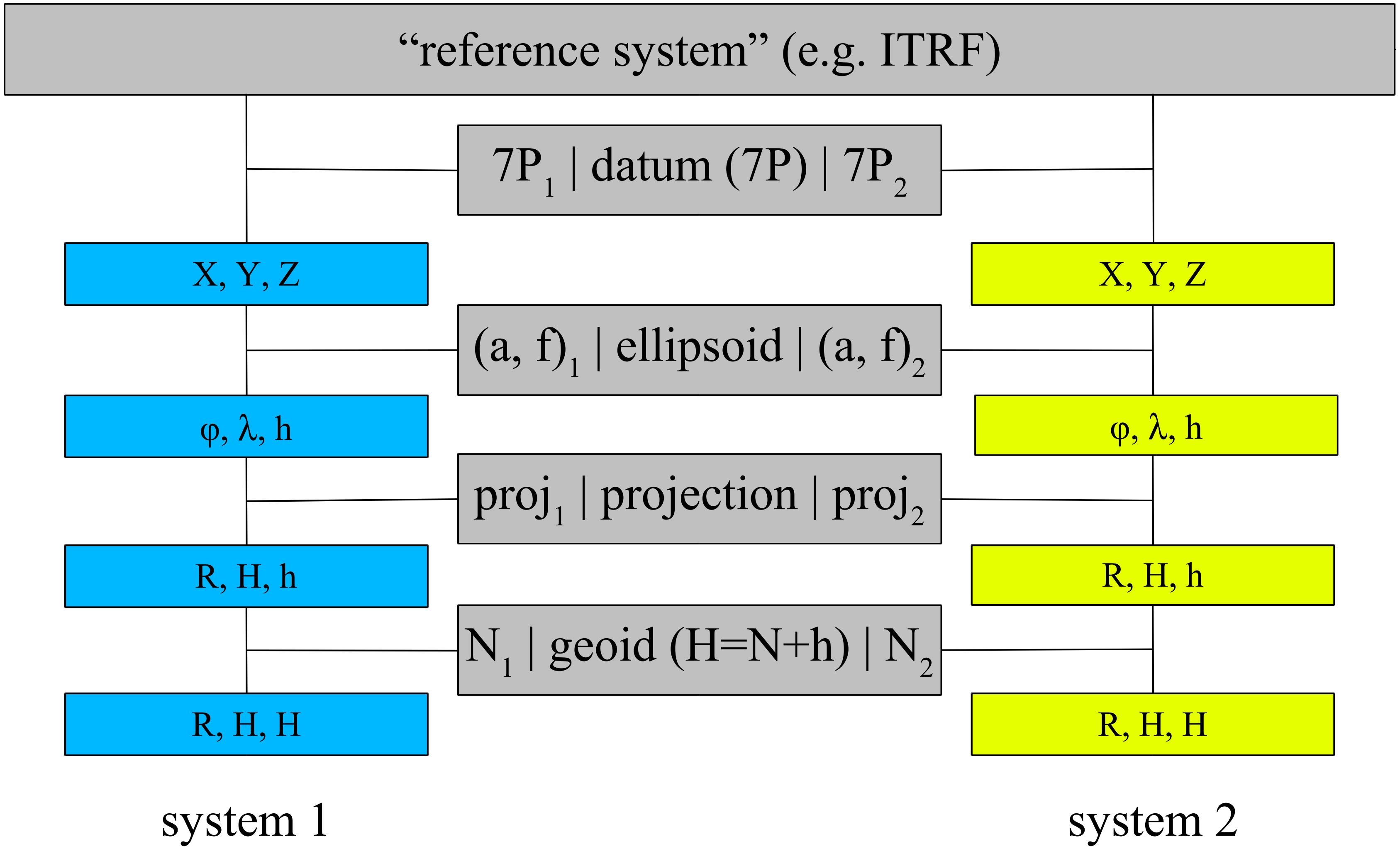
GNTRANS – Model

- multistage transformation
- applicable stages
  - 7P- transformation
  - continuous functional transformation
    - mathematical functional approach to describe remaining residuals after 7P- transformation or directly residuals
  - stochastic part
    - stochastic prediction of remaining discrepancies considering topological neighborhood (decorrelation along topology of discontinuity)

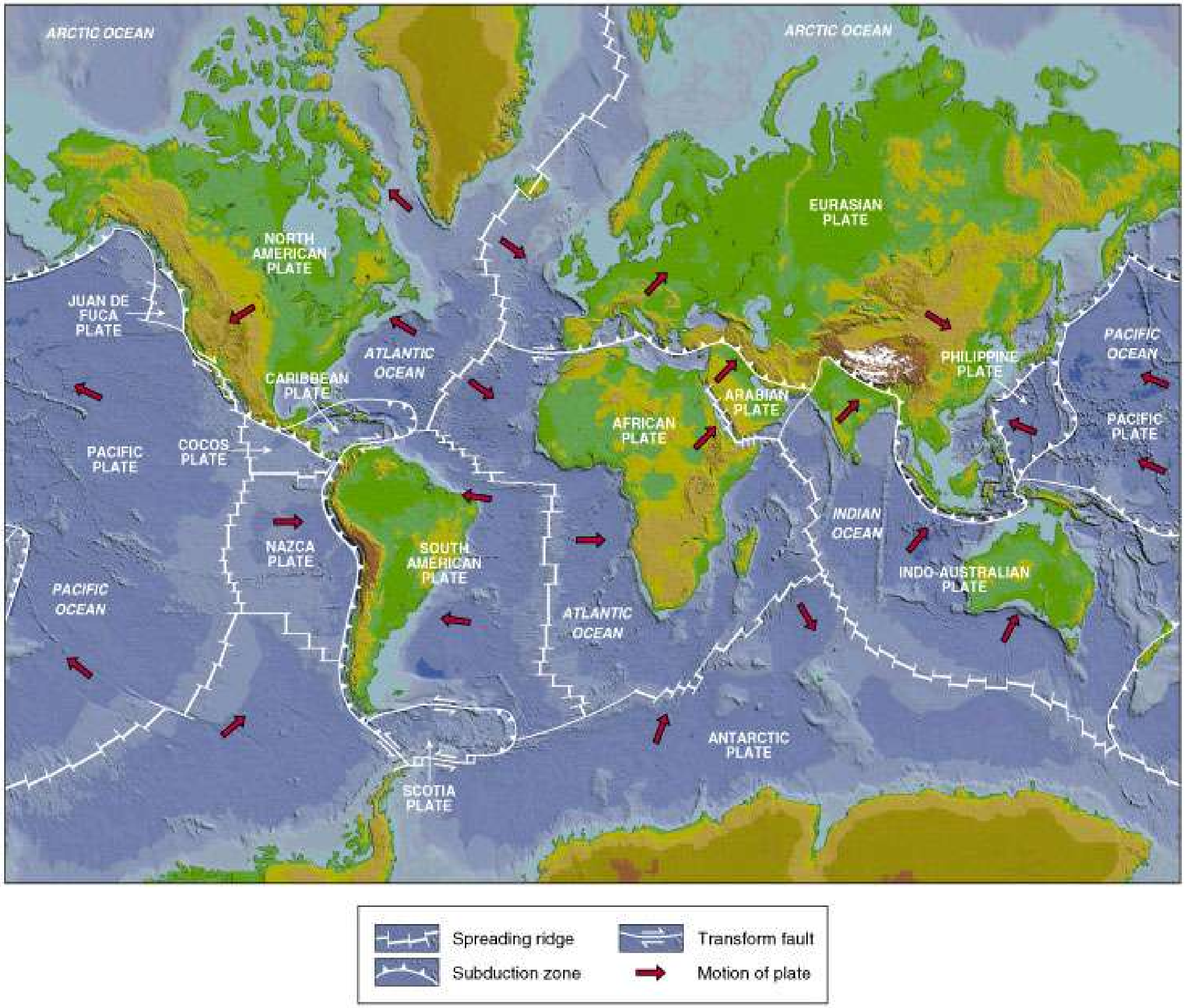
GNTRANS – Model Properties

- properties of transformation models
  - preservation of adjacent metric properties
  - uniqueness/standardized
  - homogeneity
  - continuity
  - consideration of discontinuities
  - biuniqueness (one-to-one mapping)

Principle of GNTRANS
Coordinate System Transformation



Major Geotectonic Plates



http://www.earth.northwestern.edu/people/seth/202/new_2004/davidson/plates_map.jpg

Modern Coordinate Systems

- three-dimensional coordinate system
  - geocentric, i.e. earth's center-of-mass origin (in practice within a few cm)
  - Z-axis aligned with the earth's axis of rotation (IERS reference pole)
  - X-axis IERS reference meridian
  - Y-axis completes right-handed coordinate system
- **why?**
  - satellite geodesy, ...
  - accuracy, consistency, internationally, globally, ...
- e.g. WGS 84, ITRS/ITRF xx, ETRS/ETRF xx, ...

International Earth Rotation Service
World Geodetic System
International Terrestrial Reference System/Frame
European Terrestrial Reference System/Frame

ITRF Coordinates

- ITRF positions characteristics are generally
  - accuracy of a few centimeters or better
  - accurate even over continental or global distances
  - ongoing tectonic plate motion (continental drift) as well as other forms of crustal motion must be accounted for at this level of accuracy
  - ITRF positional coordinates valid for a specified epoch date, and appropriate velocities must be applied to estimate positional coordinates for any other date
  - relative to ITRF, even points located on a stable plate move continuously (e.g. North American plate at a rate of about 2.5 cm/yr)

extracted from http://www.ngs.noaa.gov/CORS/metadata1/

PAS Network in Japan

- Positioning Augmentation Services (PAS)
  - Mitsubishi Electric Corporation (MELCO)
  - GPS RTK network
  - using approx. 350 stations of GEONET network
  - commercially operated since September 2003
- GPS Earth Observation Network (GEONET)
  - Geographical Survey Institute (GSI)
  - established since 1994 to monitor crustal deformation
  - 1200 stations throughout Japan
  - typical separation 25 km
  - sub-set of stations transfer real time data
  - 1 Hz data provided to commercial users

Japanese Geodetic Datum 2000

- Geographical Survey Institute (GSI)
  - constructed new framework
  - referring to ITRF94 at epoch of 1997.0
- Japanese Geodetic Datum 2000 (JGD2000)
  - using domestic VLBI stations
  - 950 stations of GEONET
  - first- to third-order triangulation points (resurvey and re-computation)
  - GRS80 ellipsoid
  - since April 1, 2002

Magnitude of Geodynamics in Japan

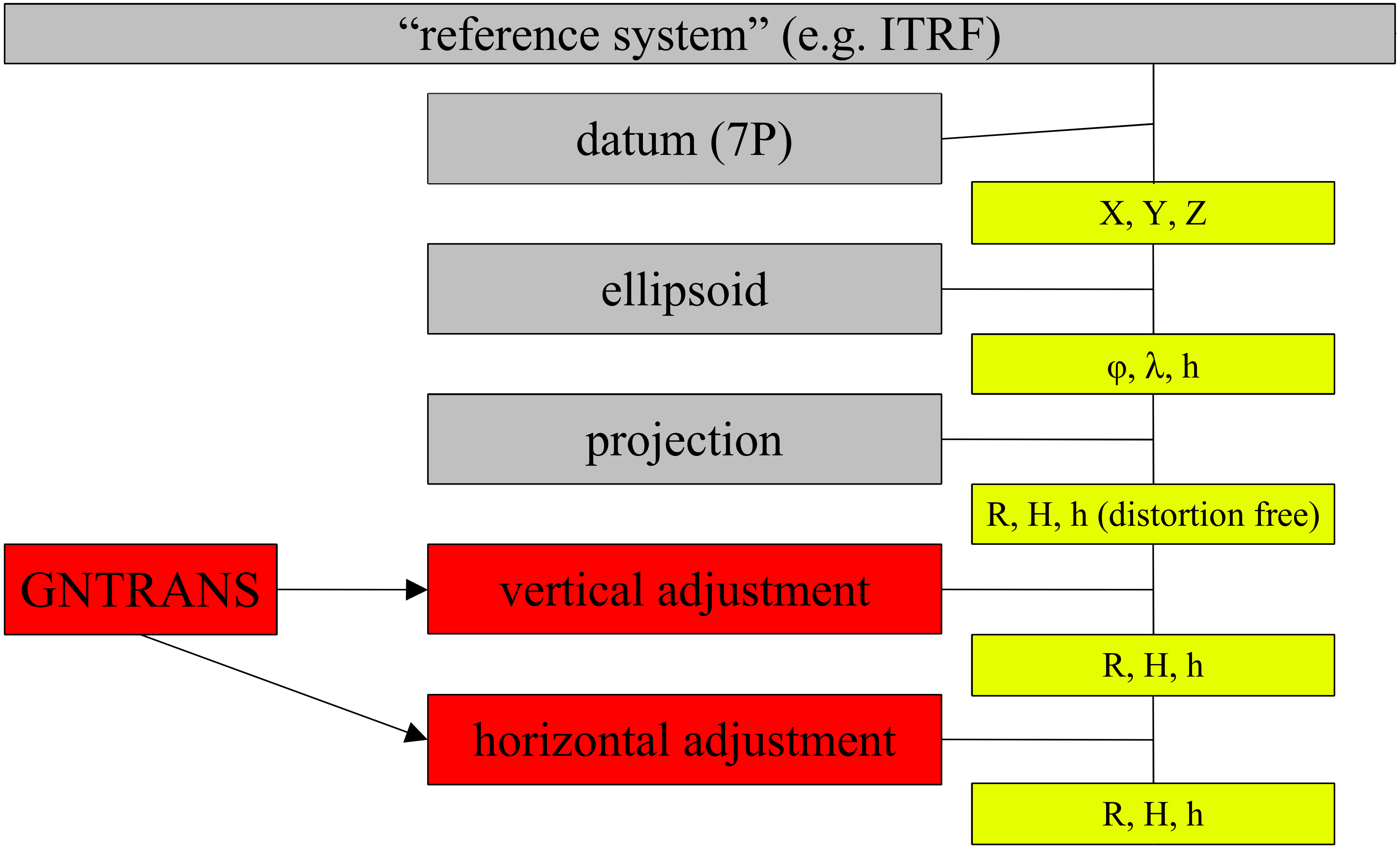
- station velocities (two VLBI anchor stations of JGD2000)

station velocity (ITRF2000)	latitude m/yr	longitude m/yr	height m/yr	3D m/yr
KASHIMA	-0.0116	-0.0038	-0.0041	0.0129
SHINTOTSUKAWA	0.0215	-0.0156	0.0230	0.0351

- station movements (GEONET network)

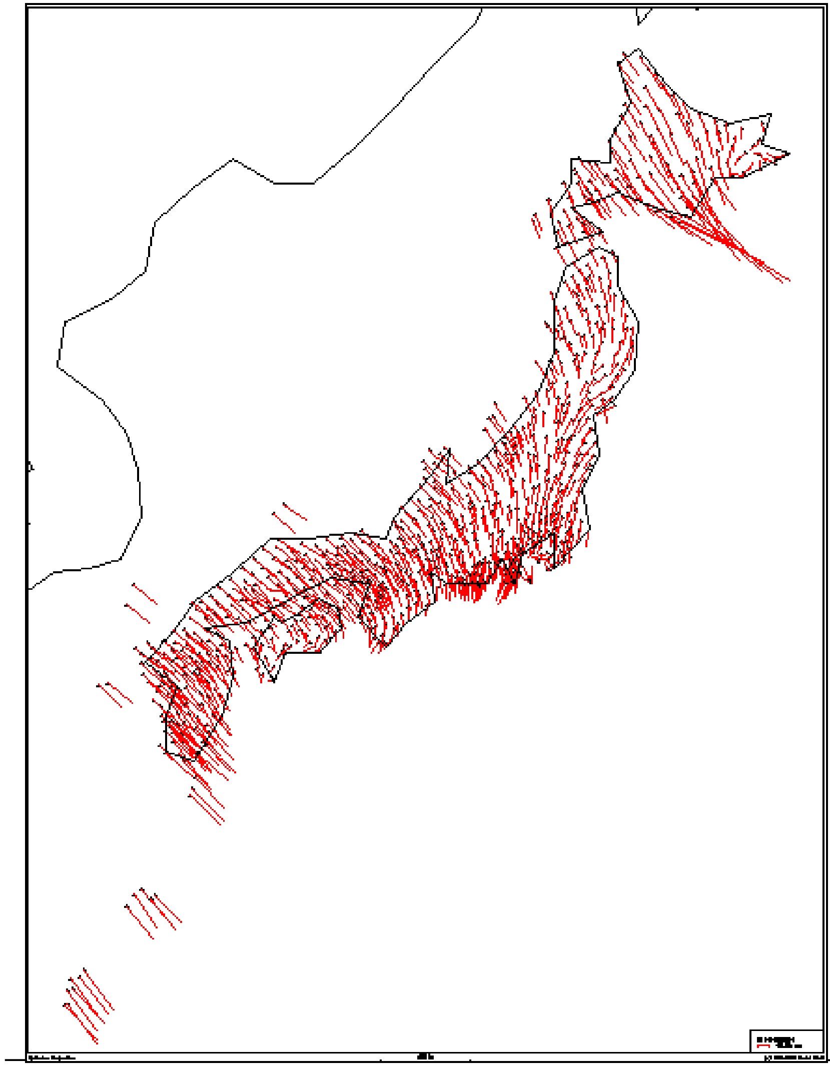
coordinate differences (930) after 7yrs	latitude m	longitude m	height m
min	-0.618	-0.132	-0.390
max	0.105	0.838	0.043
mean	-0.132	0.067	-0.107

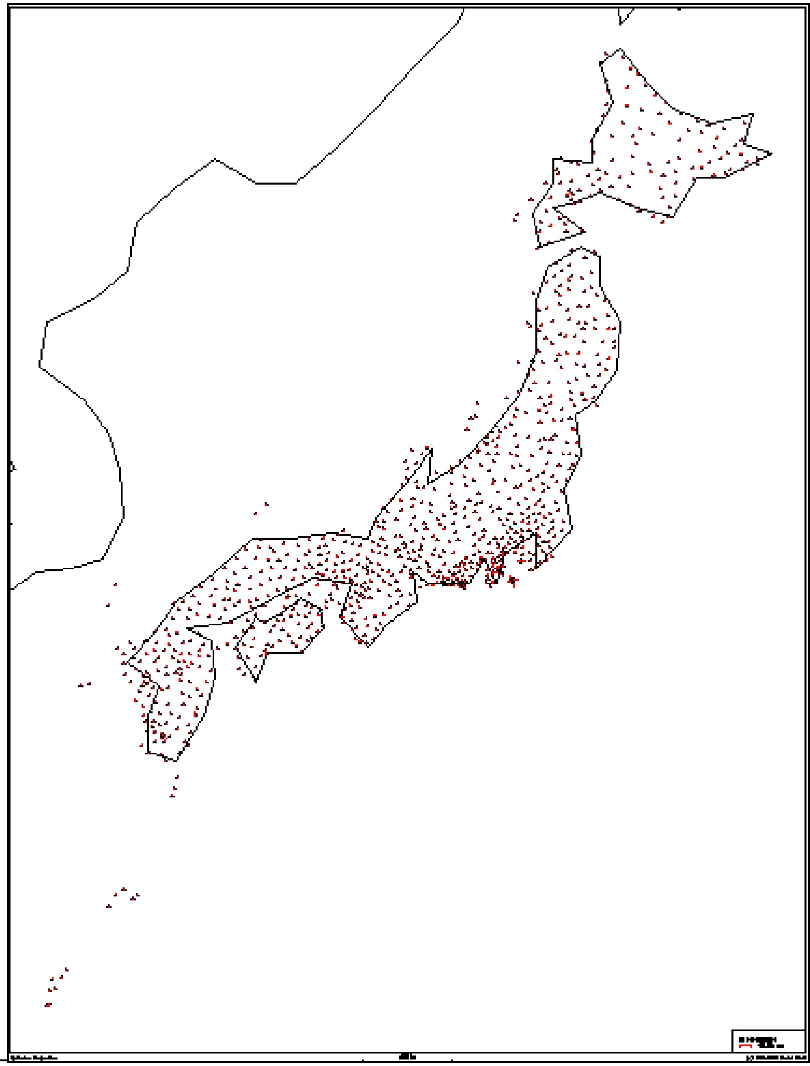
Principle of GNTRANS Transformation JGD2000/JGD2000 current Epoch



Differences JGD2000/JGD2000 2003.9

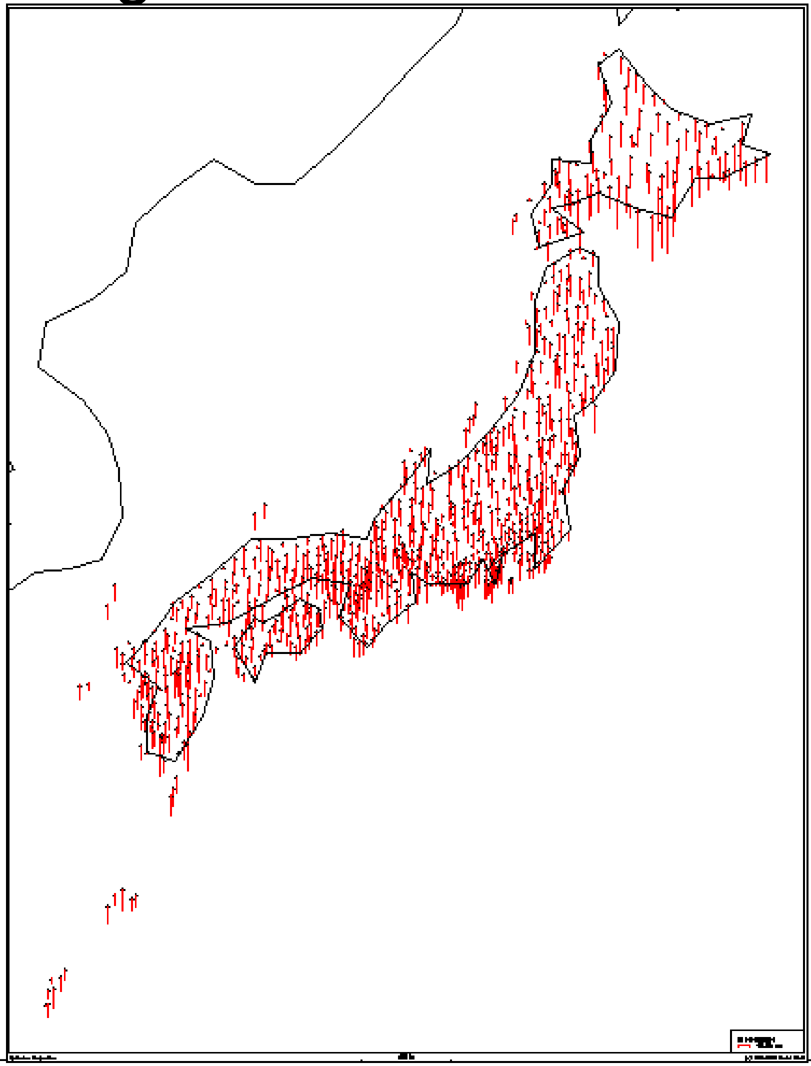
horizontal differences before and after transformation

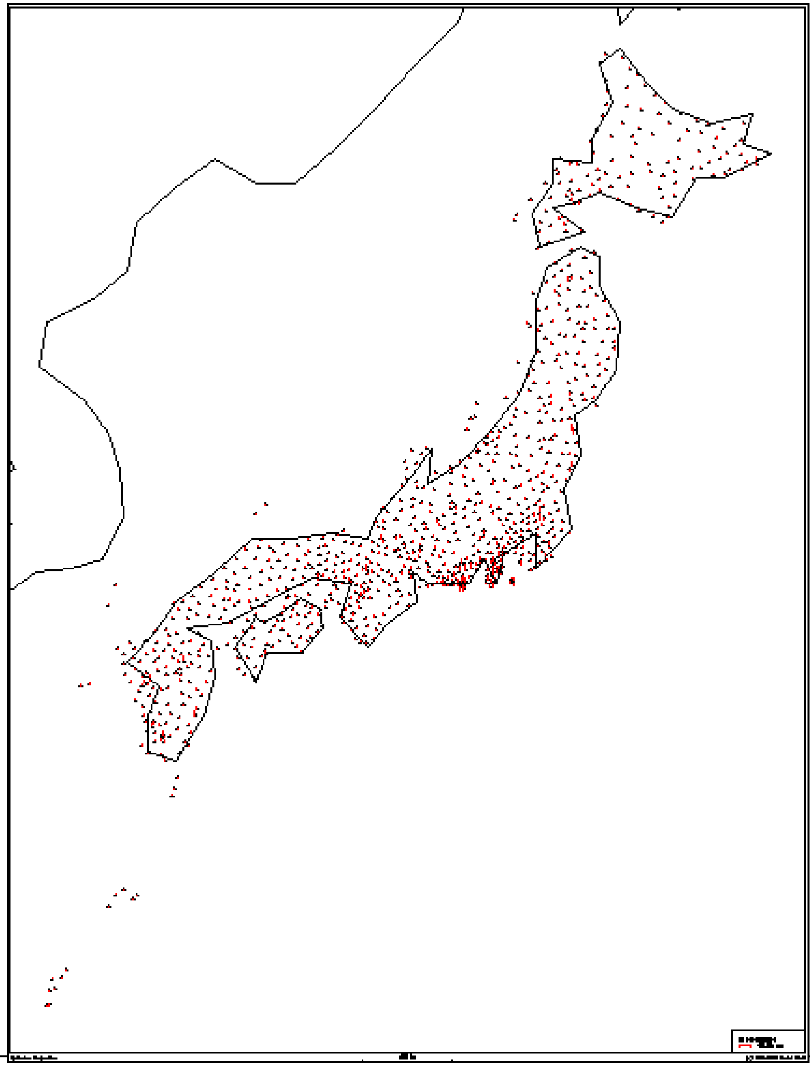




Differences JGD2000/JGD2000 2003.9

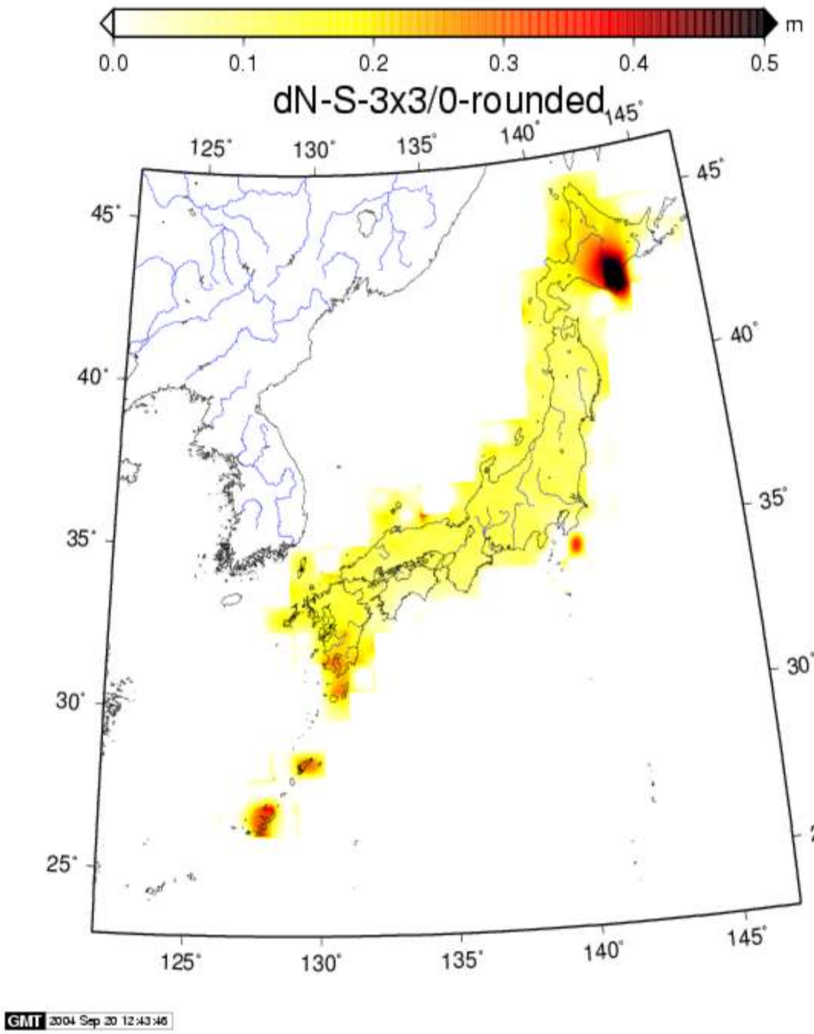
height differences before and after transformation



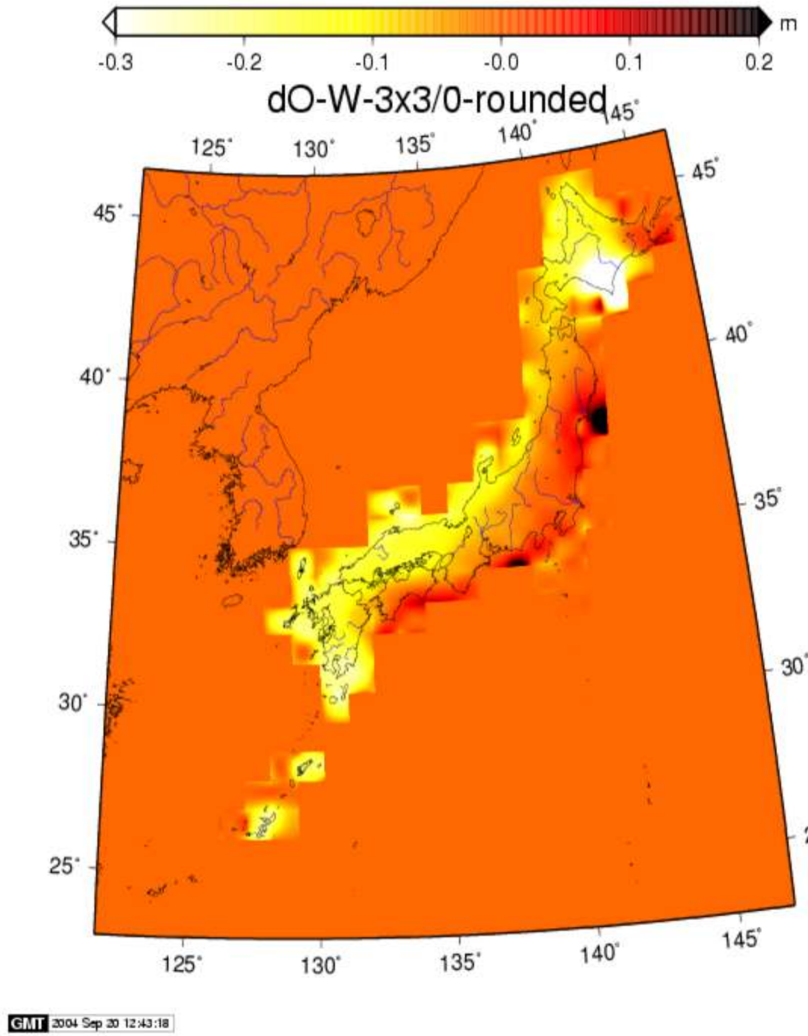


Magnitude of Position Changes

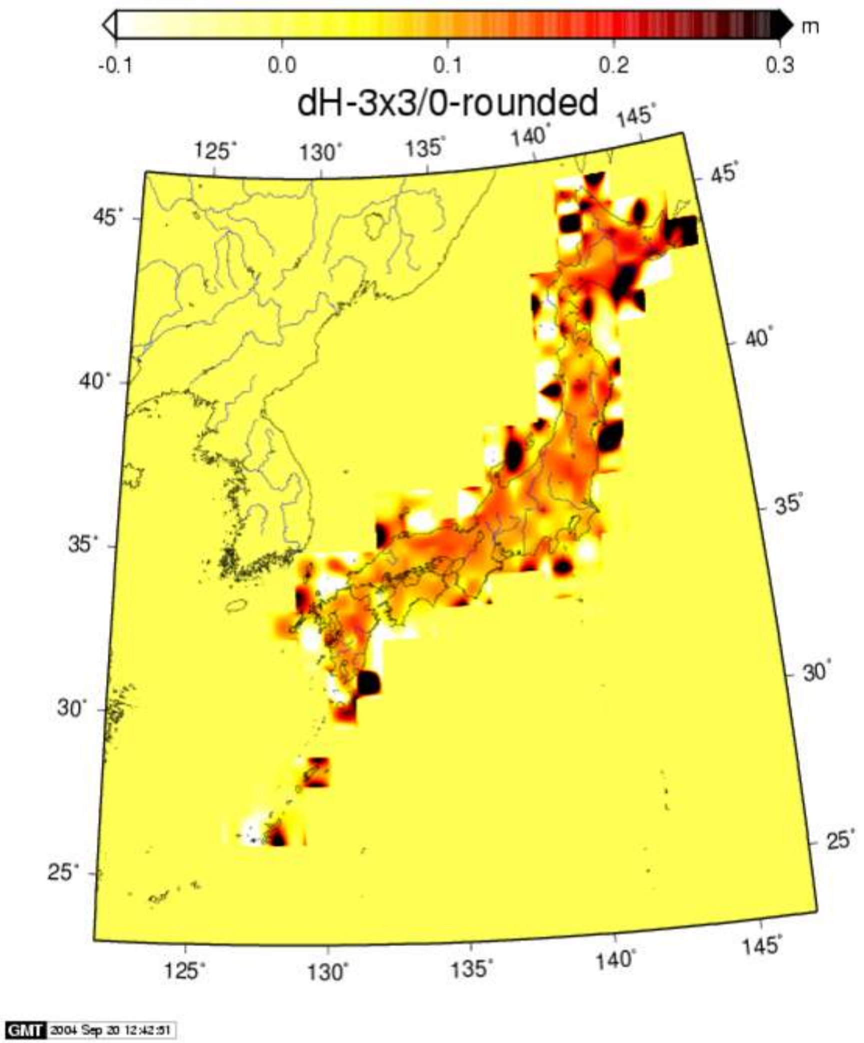
north-south component



east-west component



Magnitude of Height Changes



height component

Accuracy of GNTRANS Module Japan

- internal accuracy
  - standard deviation derived from given station coordinates before transformation

area	sN [m]	sE [m]	sh [m]
Japan	0.149	0.119	0.123

  - standard deviation derived from given station coordinates after transformation

area	sN [m]	sE [m]	sh [m]
Japan	0.003	0.003	0.009

Update of GNTRANS Module

- situation in Japan
  - continuously deformation of network due to tectonic movements (dynamic datum)
  - maintain temporal consistency of framework by removing crustal deformation
  - **frequent update of GNTRANS module** using GEONET coordinates (1200 stations)
  - important for public survey using RTK network
  - agreement with Japan Geodetic Datum 2000

Providing GNTRANS Transformation

- RTK network service provides
  - transmitting GNTRANS module parameter
  - position correction computed at user site
  - using same simplex communication link as GPS data
  - broadcast solution
- RTK network user
  - sends coordinate to provider
  - GNTRANS computation at RTK network center
  - modification of GPS correction data
  - duplex communication link required

Summary

- RTK networks in high geodynamic areas
  - coordinates constantly changing
  - frequently update of reference station coordinates required
  - consistency of framework required
- RTK network service users
  - demand for consistency and transformation
- GNTRANS model applied to compensate tectonic movements of coordinates
  - applicable within RTK network service
  - demonstrated with GNTRANS module Japan

for publications on the presented topic refer also to

www.geopp.com

or directly to

http://www.geopp.com/publications/english/lit_e.htm