Design and benefit of GFZ's GNSS-based Ground Tracking System (GTS)

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Link to paper (pdf-format) with more information about the GNSS-related components of GITEWS (Falck et al., 2010):

„Near real-time GPS applications for tsunami early warning systems"

Introduction

GNSS-stations move with their subjacent ground, respectively tectonic plates. Detected co- and post-seismic GNSS-station displacements allow conclusions about surface deformations resulting from and tectonic movements causing an actual earthquake. Early warning centers can use this information to get a more comprehensive situation overview. Onshore detected surface deformation data can be extrapolated to offshore earthquake epicenter areas, which can significantly improve the parameter assessment of possibly generated tsunamis. The displacement information is also very valuable to monitor tide gauge positions and to supplement seismological earthquake parameter determinations.
A fully automatic system for the near real-time determination and visualization of ground motions was developed by GFZ (German Research Centre for Geosciences) within the project GITEWS (German Indonesian Tsunami Early Warning System). The system is capable to continuously deliver displacement vectors for locations with appropriate GNSS-equipment within 1-2 minutes. This so called GTS (Ground Tracking System) is in operation at the national warning center in Jakarta (Indonesia) since November 2008. It was continuously improved since then. Training units for early warning center staff were developed in the project PROTECTS (Project for Training, Education and Consulting for Tsunami Early Warning Systems). The GTS software packet has a lot of features with a comfortable Web-GUI and is also recommended for many "regular", non-early warning monitoring tasks.

System Design

Automatic data acquisition and management
- GNSS data assimilation in real-time and/or by file-based data transfers
- orbit + clock data sync (IGU, COD, BRDC...)
- data format conversions (RTCM3, RINEX)
- quality checks (teqc etc.)
- data forwarding (Ntrip)
- data from GFZ's GEOFON service or a SeisComP3 system

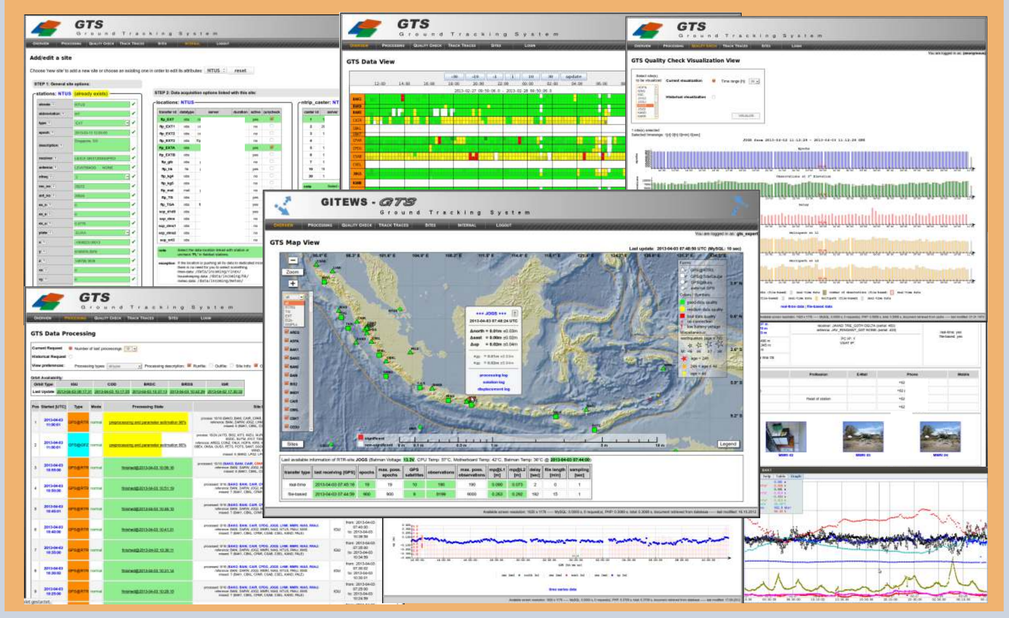
Automatic GNSS data processing
- using embedded, robust, BERNESE-based "processing engine"
- processing modes selected according to situation

"Normal Mode"
- used for regular monitoring
- processing of data from all stations
- repeat cycle, e.g., 5 minutes (depending on data volume and computer performance)

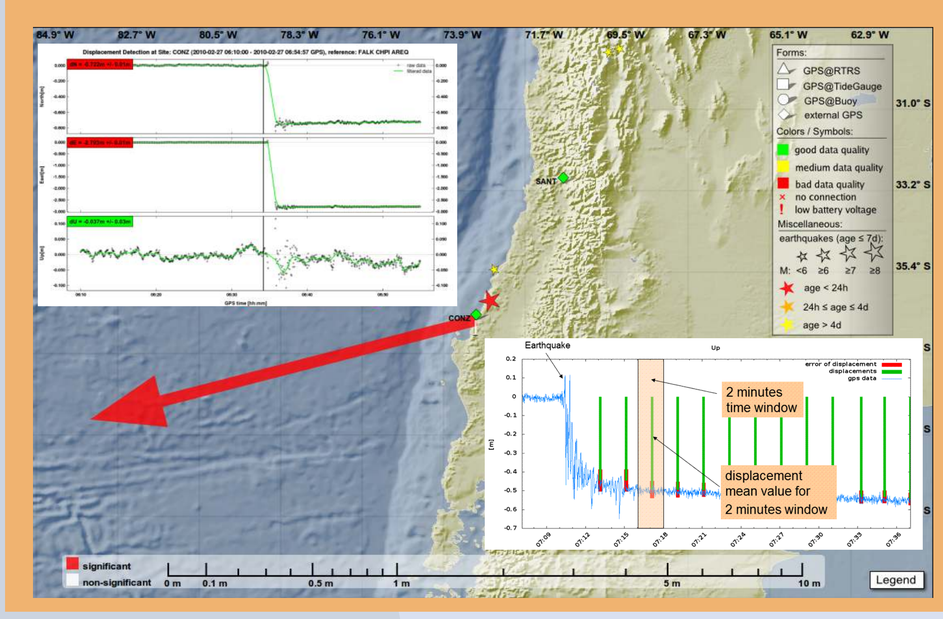
"Alert Mode"
- e.g., after strong earthquakes
- processing of most relevant data (stations nearest to the earthquake)
- repeat cycle 1-2 minutes

Automatic product dissemination
- "push mode" interface for subsequent (warning center) functions like:
- surface deformation analysis
- earthquake parameter estimation
- tide gauge station position monitoring
- tsunami generation assessment
- decision support system, wall displays etc.

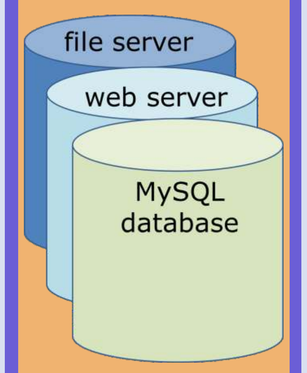
Web-based GUI (monitoring, data analysis, administration)
- allows simultaneous access for multiple users, even from remote



Automatic displacement detection
- inclusive signal / noise / significance assessment of displacements



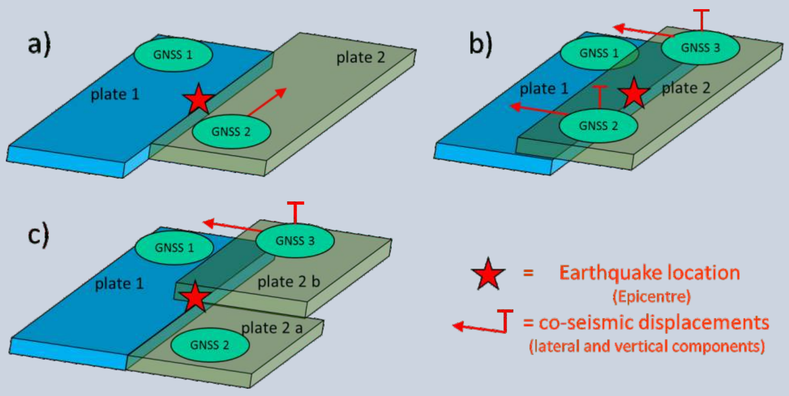
Data system
- connected with all GTS modules
- providing fast data access, e.g., for Web-based GUI



Basic system layout and screenshots from the Web-based Graphical User Interface (box in left-bottom corner). The screenshots show (from top left to bottom left) views for the system administration, the last 24 hour GNSS-network status, quality parameter graphs of a GNSS-station, site information, special analysis graphs, the processing system status and a network area mapview (middle of collage).

GTS to support tsunami generation assessments

Earthquakes are detected reliably by seismology, but without certainty about the co-seismic ground movements. GNSS-stations track local ground movements instantly. Detected displacements can be extrapolated to the rupture zone (if they are not too far away) to assess parameters of a possibly generated tsunami.



Simplified relation between earthquakes, tectonic plates, GNSS-based displacement determination and tsunami generation: In case a) a tsunami generation may be excluded (strike slip mechanism, no vertical displacement), while there is a high probability for a tsunami generation in cases b) and c) with vertical movements. In case c) only a part of plate 2 is moved (plate 2b) which corresponds to a smaller tsunami generation area as in case b).

More GTS functions for an Early Warning System

The GTS allows a co- and post-seismic tide gauge position monitoring, which is mandatory before using tide gauge data for early warning tasks. The GTS also supports an improved earthquake parameter estimation, which is useful especially in cases of very strong earthquakes. Interfaces are provided for other warning center components, e.g., wall displays and a decision support system. Additional input, e.g., earthquake parameter from a SeisComP3 system, can be displayed together with detected displacements, overlaying digital regional maps.

GTS operator desk at the Indonesian Tsunami Early Warning Center

GTS-related support and training since 2008

Since the installation of the GTS at the Early Warning Center in Jakarta, GFZ continuously provides technical support and training for the colleagues in Indonesia (Projects GITEWS and PROTECTS). The list of covered topics extends from "real-time reference GNSS-station design" to "GTS system administrator training". Training and software updates for the GNSS processing kernel is offered, independently from GFZ, by the BERNESE team in Switzerland, which supports the GTS's sustainability.

Pictures from training activities related to the Ground Tracking System, operated at the Indonesian Tsunami Early Warning Center in Jakarta since end of 2008