Enhancement of the EUREF Permanent Network Services and Products

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Introduction

The IAG sub-commission for Europe, EUREF, is responsible for defining, providing access and maintaining the European Terrestrial Reference System (ETRS89), which is recommended by the European Commission for use in all EU member states. In 1996, EUREF created the EUREF Permanent Network (EPN) based on a partnership with site operators of continuously operating GNSS sites who are willing to share their data with the public. The network comprises currently more than 220 stations and its GNSS observations are extensively used by the public, national mapping agencies, and researchers.

The EUREF Permanent Network in a Nutshell

The EUREF Permanent Network (EPN) • Continuously operating GPS and GPS+GLONASS (48%) stations • Maintained on a voluntary basis by EUREF members • Daily, hourly, RINEX. 15 min high-rate RINEX and real-time data in raw or RTK formats, see Fig. 2 • 2 Regional Data Centres, containing a copy of all hourly and daily data • 1 Regional Broadcaster (www.euref-ip.net), streaming all real-time data using NTRIP • EPN Central Bureau (CB), responsible for the day-to-day management of the EPN, http://epncb.oma.be is the gateway to all information about EPN • 16 Local Analysis Centers (LAC), providing daily and weekly SINEX (some also hourly) and hourly zenith path delays • Products: Weekly combined EPN SINEX solutions, station coordinates and velocities (ITRF/ETRS89), time series analysis, site zenith path delays

Relation to the International GNSS Service (IGS)

EUREF members are participating to the IGS Real-Time Pilot Project, the IGS GNSS Working Group, the IGS Antenna Calibration Working Group and the IGS Infrastructure Committee. In addition, IGS standards are used for the routine EPN operations. However, still some differences occur: • All antenna/radiometer combinations introduced within EPN stations after Dec. 5, 2006 must have true absolute calibrations (taking radome into account) • Reduce number of antenna/radiometer combinations without known absolute robot calibrations • Towards long-term improvement of network • EPN antenna calibration models: based on IGS ATX files, but EPN also accepts individual calibrations. The EPN Central Bureau makes available two calibration files: – epncb_05.atx with absolute individual antenna calibrations for EPN stations (if available) – epncb_05.atx with absolute antenna phase centre coordinates for all the EPN stations: it merges the absolute individual antenna calibrations (epncb_05.atx) and the absolute calibrations available from the IGS (igsc05.atx).

IGS Global Combination of Regional Networks

“MT T2 RNAAC” solution = weekly combination (8-week delay) of regional networks (EPN, SIRGAS and GSI) and IGS solutions. Figure 3 shows how the EPN, SIRGAS and GSI solutions densify the regions in Europe, South America and Japan.

Role of EUREF Epoch Campaigns

• Densification of ITRF/ETRS89 in Europe – Realization of ETRS89 for each country • Started in 1989 (before IGS) as continuation of European triangulation network → initial precision improved by factor 10 • Fiducials (ITRF97): semi-permanent GPS stations near SLR/VLBI sites → IGS sites → EPN sites • Campagnes → pseudo-campaigns from permanent stations • Differences between national ETRS89 realizations < 5 cm

EPN Densification of the ITRF

Need for regularly updated ETRS88/ITRS coordinates of EPN stations • Past: ETRSS9 updates following the ITRF97 updates: ITRF99, ITRF2000, and ITRF2005 • Now: new EUREF densification of the ITRF2005 – Initial step: Dec. 2008: EUREF densification of the ITRF2005 using EPN data up to Dec. 2005 – Since May 2009: EUREF densification of ITRF2005 is updated each 15 weeks, using the most recent EPN data • Station classification – Class A: station positions have a 1 cm accuracy at epochs of the time span of the used observations → to be used for national densifications of the ETRS89 – Class B: station positions have a 1 cm accuracy at the epoch of minimal variance of each station

EPN Tropospheric Product

• Combination of daily Zenith Path Delay (ZPD) parameters, based on the contributions of the LACs • Introduction of absolute antenna calibrations in Nov. 2006 shows significant improvement • Internal precision on the 2.3 m ZPD level after Nov. 2000 (GPS week 1400) • Thanks to Memorandum of Understanding between EUREF and IEFNET, access to radionode and synoptic observations for GNSS data processing, analysis and validation

EPN Reprocessing Project

• Pilot Phase (2009-2010): – Selection of suitable sets of reprocessed products as input for the first analysis of the 2006 data (pilot phase) – Each participating LAC shall setup the facilities for the reprocessing of the 2006 data. – Development of a common strategy to be used by all participating LACs. (e.g. current EPN strategy)

EPN Real-time Analysis Project

End 2007, “EUREF-IP” pilot project for real-time data streaming successfully transferred to routine operation • EPN guidelines for real-time data (2006), developed within the frame of the EUREF-IP Pilot Project: RTCM 3.3, metadata, latency • Number of EPN real-time stations: 16 (Jan. 2006) → 103 (May 2009) • Number of registered users at EUREF-IP broadcast: 500 (Jan. 2006) → 1250 (May 2009) • Launch of new Special Project “EPN Real-Time Analysis” with the primary goal – Re-distribution of GNSS real-time data/products in Europe via NTRIP broadcasters – Validation of satellite orbit and clock corrections to broadcast ephemeris – Establishment of back-ups for all critical real-time service components

Dissemination concept:

Today: EPN stations stream real-time data to EUREF-IP broadcaster maintained by BKG. Future: Series of top-level casters distributes real-time data and shares workload. A number of relay casters supports this activity by delivering real-time data to the public, national mapping agencies, and researchers. In the final stage it is envisaged that almost every reference station is streaming real-time data to at least two different broadcasters to overcome the “single point of failure” issue.

Conclusion

In response to evolving user needs, EUREF and its permanent GNSS network is continuously improving its products and services. Today, the EPN offers a non-profit, and voluntary basis a high quality service which provides surveyors as well as National Mapping Agencies in real-time mm-level access to the ETRSS9. In addition, the EPN is recommended to be used for national densifications of the ETRSS9. Upcoming EPN innovations comprise the real-time analysis and data reprocessing.