Guidelines for EPN Analysis Centres

Prepared by the EPN Coordination Group and the EPN Central Bureau

Changes

12-02-2010

- Complete revision of the guidelines (all sections)
- Moving separate EPN Processing Option Table as addendum into the guidelines

This document comprises the guidelines for EPN Analysis Centres specifying the analysis procedure and submission of the results. The reader is introduced into the EPN analysis method and the connection between the sub-network analysis, the combination and the Projects. But this document gives no detailed explanation of the last two items. All steps for becoming an Analysis Centre are explicitly listed and the processing instructions include the processing scheme as well as the required options. The submission guidelines give the filename convention and address the upload of the analysis results. It is also explained, how the Analysis Centres could check their performance against the combination. The addendum holds detailed information about processing options and the history, which could be helpful to understand inconsistencies in coordinate time series.

1. EPN Analysis Components

The strategy to analyse EPN observations is in accordance with the so-called distributed processing approach. **Local Analysis Centres (LACs)** process the observations of a dedicated sub-network of EPN stations. The **EPN Central Bureau (CB)** assigns stations to the particular sub-networks following proposals from the **Analysis Coordinator (AC)** and the LACs as far as appropriate, ensuring that each station will be processed by at least 3 LACs, and considering further aspects that will be explained below. The LACs submit their sub-network coordinate solutions to the AC, who processes the EPN combined solutions. EPN products are published at the CB and **Regional Data Centres (RDCs).** Each component of the EPN analysis will be described separately in the following.

1.1 Local Analysis Centre Solutions

The LACs process the observations of the assigned sub-network (http://epncb.oma.be/_dataproducts/analysiscentres/dataprocessingdistribution.php shows the distribution of the sub-networks). There is no explicit requirement for the analysis software to be used. It is by default in the responsibility of the LACs to meet the scientific state-of-the-art analysis methods, and to select proper processing options. Some processing options, however, have been defined for the EPN analysis explicitly and will be noted in the following paragraphs. A detailed description and the history of these options are given in the addendum.
Each LAC compiles a "description form" (blank form from ftp://epncb.oma.be/pub/center/analysis/BLNKFORM.LAC) that holds information about models and parameters treated in the analyses and sends it to the CB (ftp://epncb.oma.be/pub/center/analysis/). It is the LACs responsibility to keep the information in this form up to date.
In the following, the different solutions submitted by the LACs to EUREF are described.

Final Weekly Coordinate Solution (mandatory)
The LACs generate a weekly solution of the station coordinates based on daily coordinate estimates and using IGS final products. They submit the solutions in the SINEX format to the AC. The deadline for transmission of that product is 5 weeks after end of observations.

Final Daily Coordinate Solution (recommended)
The LACs are asked to submit daily solutions of station coordinates based on IGS final products in SINEX formatted files to the AC. The deadline for submission of that product is 5 weeks after end of observations. This product is suitable for high frequency spectral analysis of coordinate time series, due to seven times higher sequence of available solutions w.r.t. the weekly solutions.

Rapid Daily Coordinate Solution (recommended)

The LACs are asked to submit daily solutions of station coordinates based on IGS rapid products in SINEX formatted files to the AC. The usage of IGS ultra-rapid products is accepted, if the analysis is performed in sub-daily intervals. The deadline for submission of that product is 22 hours after end of observations.

Hourly Coordinate Solution (optional)
The LACs are asked to submit hourly solutions of station coordinates based on IGS ultra-rapid products in SINEX formatted files to the AC. The interval of observations of this solution includes the past hour and possibly additional observations before the past hour to stabilise the solution. The total length of the observation interval is not yet fixed and may differ for individual LACs. The deadline for submission of that product is 50 minutes after end of observations.

Final Daily Tropospheric Zenith Path Delays (mandatory)
The LACs estimate mandatory (mostly hourly) tropospheric site zenith path delays for the EPN stations included in their sub-network. The zenith path delay estimates are submitted in daily troposphere files in the "Troposphere SINEX" format. The deadline for submission of that product is 5 weeks after end of observations.

1.2 Coordinate Combination

The AC combines the SINEX files of the sub-networks as provided by the LACs into the EPN combined solution. This combination is performed for each product type.

Final Weekly Coordinate Solution
The AC combines the weekly sub-network solutions of the LACs into the EPN combined solution. The final weekly coordinate solution is mandatory for all LACs and thus the resulting combination includes all EPN sites. More details on this solution are available from http://epncb.oma.be/_dataproducts/products/combinedeurefsolution.php. The combined EPN solution is used to check each individual solution against it and to eliminate extreme station values.

Final Daily Coordinate Solution
The AC combines the final daily sub-network solutions of the LACs on daily basis. This product type is a recommendation and doesn't implicitly include all EPN sites.

Rapid Daily Coordinate Solution
The AC combines the rapid daily sub-network solutions of the LACs on daily basis. The solution is suitable to monitor the EPN station performance with a time delay of less than 24 hours. This product type is a recommendation and doesn't implicitly include all EPN sites.

Hourly Coordinate Solution
The AC combines the hourly sub-network solutions of the LACs on hourly basis. The solution is suitable to monitor the EPN station performance with a time delay of less than 1 hour. This product type is a recommendation and doesn't implicitly include all EPN sites.

1.3 Troposphere Combination

The combination of the troposphere solutions of the LACs is under responsibility of the **Troposphere Coordinator (TC)**. More details on this activity are available from http://epncb.oma.be/_dataproducts/products/sitezenithpathdelays/.

1.4 Accumulated Coordinate Solution

The weekly combined EPN solutions are used to maintain the ETRS89 and monitor the EPN time series by means of the regular computation of EPN cumulative position/velocity solutions. This task is performed by the **EPN Time Series Coordinator (TSC).** During this analysis, the TSC is keeping track of the EPN station performance (assigning the stations to a Class A or B) and maintains a list of station discontinuities (jumps in the station coordinates) which is available in the IGS discontinuity SINEX format. The list is available from ftp://epncb.oma.be/pub/station/coord/EPN/EPN_discontinuities.snx. More details on this activity are available from http://epncb.oma.be/_trackingnetwork/coordinates/ and http://epncb.oma.be/_dataproducts/products/timeseriesanalysis/.

1.5 EPN Projects

EPN Projects are set up by the **EUREF Technical Working Group (TWG)** to introduce new applications into the EPN or to study special aspects for a limited time span. With the end of an EPN Project, the TWG decides about adding the related activities to the routine EPN operations. An overview of the previous and actual EPN Projects is available from http://www.epncb.oma.be/_organisation/projects/.

2. Becoming a Local Analysis Centre

Candidate LACs must be able to contribute to the EPN on a long-term basis. The sub-network solutions that are submitted to the AC and the derived EPN combined solutions will be freely available for everyone. This data policy has to be approved by new LACs. The used analysis software must have the capacity to process the assigned sub-network and to fulfill the required standards.

2.1 Initial Steps

1. Contact the EPN CB at epncb@oma.be and the AC with a statement of desire to become an EPN LAC. Give the name and address of the representative.
2. Add a proposal for a European region you intend to analyse. Take into account, that each station has to be processed by at least 3 LACs, but it is not allowed that a single station is processed by nearly all LACs (in general not more than 5 LAC are accepted for one EPN station). If possible, explain the station selection, e.g., there are some research activities of your institution in this region.
3. Add a proposal for the 3-character identifier of your planned LAC, e.g., "COE" for the Centre for Orbit determination in Europe at the Astronomical Institute University Berne.
4. Give a description of the analysis software you plan to use as well as the planned data analysis strategy. For this purpose a LAC form can be completed (see ftp://epncb.oma.be/pub/center/analysis/BLNKFORM.LAC).
5. Add a proposal for the first GPS week you plan to start the EPN analysis.

2.2 Acceptance procedure

1. The CB requests a **LAC description form** that has to be filled out and to be submitted to the CB.
2. The EPN CB assigns a sub-network to the candidate LAC taking into account the stations proposed by the LAC and the need for additional LAC for some EPN stations. The AC participates to the final selection of the station sub-network.
3. The EPN CB contacts the new LAC after acceptance of the proposal by the **TWG**, represented by the **EPN Coordination Group (CG)**.

3. Processing Instructions

Daily and hourly observation files in RINEX format of EPN stations are publicly available at the two **RDCs** (refer to http://www.epncb.oma.be/_organisation/guidelines/guidelines_data_centres.php).

3.1 Preparation

1. Download all observation files in the RINEX format of your sub-network for the period going to be processed. The data of all EPN stations are available at the EPN data centres that are listed at the EPN CB (see http://www.epncb.oma.be/_dataproducts/data_access/dailyandhourly/).
2. Download the IGS orbit and Earth Rotation Parameter (ERP) files from an IGS data centre. IGS final, rapid or ultra-rapid products have to be used depending on the solution to be generated. For information about access to IGS products see http://igs.org/.
3. Download the coordinates and velocities of the recent ITRF realisation, if not already done, from the IERS ITRS Centre at http://itrf.ensg.ign.fr/.
4. Prepare a table of ocean loading displacements for each involved EPN site either through using the online computation service at http://www.oso.chalmers.se/~loading/ or through downloading the table from the CB at ftp://epncb.oma.be/pub/station/general/ .
5. Prepare a calibration table for receiver and satellite antennae from a file in ANTEX format that is provided from the CB.

3.2 Processing

1. Process the observation files of the assigned sub-network

a. Write the estimated station coordinates into the resulting SINEX file.
b. Align the solution to the valid ITRF at the current epoch, e.g., through applying "minimum-constraint-conditions" to the reference sites (do not "fix" reference coordinates).

Comment: *It is recommended to use the IGS realisation of the ITRF, e.g., IGS05which is the IGS realisation synchronous to the ITRF2005, to reach the best possible consistency to other IGS products (IGS satellite orbits, clocks and EOP) for all processing steps. The alignment to such IGS reference frame is accepted for the resulting SINEX file. Users intending to transform to ETRF should first align their minimally constrained solution to ITRF by imposing appropriate constraints to class A stations (see http://www.epncb.oma.be/_trackingnetwork/coordinates/), and then transform from ITRF to ETRF following the Boucher & Altamimi 'memo'.*

2. The following SINEX data blocks are mandatory
   a. +SOLUTION/STATISTICS
   b. +SOLUTION/EPOCHS
   c. +SOLUTION/APRIORI
   d. +SOLUTION/ESTIMATE
   e. +SOLUTION/NORMAL_EQUATION_VECTOR and
      +SOLUTION/NORMAL_EQUATION_MATRIX L
      or
      +SOLUTION/MATRIX_ESTIMATE L COVA and
      +SOLUTION/MATRIX_APRIORI L COVA
3. Generation of tropospheric zenith path delays
   a. Heavily constrain the weekly coordinate solution to the ITRS and re-substitute the resulting coordinates in the daily solutions while solving for the hourly station specific troposphere parameters.
   b. Write these final estimates of the troposphere parameters into daily SINEX Troposphere format files (final troposphere result).

3.3 Processing Options

1. Use the IGS products corresponding to the solution to be processed. Select from "final", "rapid" and "ultra-rapid". IGS provides satellite orbits, satellite clocks and earth orientation parameters.
2. Introduce ocean-loading corrections for the stations. Be aware to use the same model for all stations.
3. Use the lowest elevation cut off angle that is reasonable for the applied troposphere mapping function and for which absolute phase centre variation numbers of the processed station antennae are available. Apply elevation dependent weighting of observations.
4. Use the Niell mapping function, Vienna mapping function or global mapping function to map the tropospheric delay in zenith direction.
5. Estimate hourly station specific troposphere parameters. Refer each hour to the minute '30'.
6. Fix the initial phase ambiguities to integer numbers
7. Recommendation: Use GPS as well as GLONASS observations. Ensure consistency of GPS and GLONASS satellites orbits, clocks and Earth rotation parameters.

Further details on processing options and their history are given in the addendum.

4. Submission Guidelines

1. Submit your solutions to the RDC at the Federal Agency for Cartography and Geodesy (BKG). Contact the BKG at heinz.habrich@bkg.bund.de or jens.kuscherka@bkg.bund.de to get the required login and account information. Filename conventions are described below. Apply z-compression before submission that will add the extension ".z" to each file.
2. Notation:
   ccc = LAC abbreviation,
   wwww = GPS week,
   d = doy of week 0,…,6,
   hh=hour 00,15,30,45,
3. Final weekly coordinate solution: cccwwww7.SNX
4. Final daily coordinate solution: cccwwwwd.SNX
5. Rapid daily coordinate solution: cccwwwwdR.SNX
6. Hourly coordinate solution: cccwwwwd_hh.SNX
7. Final daily troposphere zenith path delays: cccwwwwd.TRO

5. LAC Performance Control

Each LAC needs the information how well the single solution fits into the combined solution to check the analysis. There are various sources of such kind of information:

1. The weekly EUREF LAC report as distributed to the LACs by E-Mail includes a list of such stations, which have explicitly been excluded in the combination of station coordinates. It is marked, whether the station was excluded for a single or for all LACs. This report includes also the residuals between the individual and the combined solutions before the exclusions had been carried out.
2. The EUREF Mail exploder distributes a weekly EUREF report. It includes a comparison of the station coordinates between the individual solutions as given in the submitted SINEX files. Thus it reflects the alignment of the individual solutions, which is important for the reduction of the troposphere parameter biases. The EUREF report shows moreover un-weighted RMS values of each LAC with respect to the combined solution.
3. A weekly EUREF troposphere combination report (EURwwww7.TSU) is distributed to the LACs by E-Mail and provides statistics for the differences of the individual AC estimates to the mean. The information contained in these mails are available in graphical form from the EPN Central Bureau at http://www.epncb.oma.be/_dataproducts/analysiscentres/LACreports.php .

Addendum

EUREF Permanent Network Processing Options

Ambiguity Fixing
It *recommended since week 0860* to fix the ambiguities in the final solution (Ref. : a)Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997, b) Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Antenna Phase Centre Corrections
It is *mandatory since week 1400* to apply absolute antenna phase centre corrections as provided by the EPN Central Bureau (Ref.: Conclusions of the EPN LAC Workshop, March 15 - 16, 2006, Padua, Italy).

> It was *mandatory* for *weeks 0860 – 1399* to apply elevation dependent phase centre correction values adopted by IGS (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

GLONASS Observations
It is *recommended since week 1400* to add GLONASS observations to the GPS data analysis (Ref.: Conclusions of the EPN LAC Workshop, March 15 - 16, 2006, Padua, Italy).

Observation Cut-Off Angle
It is *recommended since week 1550* to use the lowest cut off angle that is reasonable w.r.t. the applied troposphere mapping function and for which absolute antenna phase centre variation corrections are available (Ref.: Discussion within EPN Coordination Group in November 2009).

> It was *mandatory* for *weeks 1130 – 1549* to set the elevation cut-off angle to 10°, provided an elevation-dependent weighting of observations is performed as well (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

> It was *recommended for weeks 0860 – 1129* to set the elevation cut-off angle to 15° (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

Observation Weighting
It is *mandatory since week 1130* to apply elevation dependent weighting to the observations. ACs which can't use the elevation dependent weighting scheme because of missing particular software options are advised to use a 15° elevation cut off angle (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Observation Sampling Rate
It is *recommended since week 0860* to use an observation sampling rate of 180 sec for the final parameter estimation (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

GPS Satellite Orbits
It is *mandatory since week 1130* to use IGS final orbits in EPN analysis (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

> It was *mandatory for weeks 0860 to 1129* to use IGS or CODE orbits in EPN analysis (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

Orbits and Earth Orientation Parameter Consistency
It is *mandatory since week 0860* to use consistent GPS satellite orbits and earth orientation parameters (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

Tidal Displacements
It is *mandatory since week 1130* to apply ocean loading corrections for the stations (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Tidal Displacements Model

It is *mandatory since week 1400* to use FES2004 model for tidal displacement (Ref.: Conclusions of the EPN LAC Workshop, March 15 - 16, 2006, Padua, Italy).

Troposphere Mapping Function
It is *mandatory since week 1130* to use the Niell Mapping Function (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Number of Troposphere Parameters
It is *recommended since week 1130* to estimate hourly troposphere parameters for each station. This option is *mandatory* for ACs contributing to the Troposphere Special Project (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

> It was *recommended for weeks 0860 – 1129* to estimate one troposphere parameter for every 2 hours for each station (Ref.: Minutes of EUREF Analysis Workshop, Brussels, April 10 - 11, 1997).

Troposphere Parameter Reference
It is *recommended since week 1130* to save the estimated troposphere parameters in the daily normal equation files. Generate a weekly coordinate solution. Re-generate the daily troposphere parameter solutions with fixing the weekly coordinates; so-called coordinate "re-substitution"(Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Global Troposphere Parameters
It is *recommended since week 1130* to not introduce global troposphere parameter estimates (Ref.: E-Mail discussion within the EPN Coordination Group in February 2002).

A-Priori Weight of Troposphere Parameters
It is *recommended since week 0860* to use 5 m a priori weight for the absolute and relative troposphere parameters (Ref.: Decision of EPN Coordination Group, 2000).

Tropospheric Gradient Parameters
It is *mandatory since week 1400* to estimate tropospheric gradient parameters (Ref.: Conclusions of the EPN LAC Workshop, March 15 - 16, 2006, Padua, Italy).