Guidelines for the EPN Analysis Centres

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Changes

28-01-2010
- Complete revision of the guidelines (all sections)
- Moving separate EPN Processing Option Table as addendum into the guidelines

19-11-2013
- Final daily coordinate solutions became mandatory
- Recommendation for troposphere gradients submission
- Update of processing options (e.g. mapping functions)
- Minor changes to keep the Guidelines up-to-date

05-12-2016
- Minor changes to keep links up to date after switch to new EPN CB web site

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. **Analysis Centres (ACs)** 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 Combination Centre (ACC)** and the ACs as far as appropriate, ensuring that each station will be processed by at least 3 ACs, and considering further aspects that will be explained below. The ACs submit their sub-network coordinate solutions to the ACC, who processes the EPN combined solutions. EPN products are published at the EPN CB and **Regional Data Centres (RDCs).** Each component of the EPN analysis will be described separately in the following.

1.1 Analysis Centre Solutions

The ACs process the observations of the assigned sub-network (http://epncb.oma.be/_productsservices/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 ACs 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 AC compiles a "description form" (blank form from ftp://epncb.oma.be/pub/center/analysis/BLNKFORM.AC 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 ACs responsibility to keep the information in this form up to date.
In the following, the different solutions submitted by the ACs to EUREF are described.

Final Weekly Coordinate Solution (mandatory)
The ACs generate a weekly solution of the station coordinates based on daily coordinate estimates and using final products prepared by one of the IGS AC or the IGS itself. They submit the solutions in the SINEX format to the ACC. The deadline for upload of that product is 5 weeks after the end of observations of the analysed week.

Final Daily Coordinate Solution (mandatory)
The ACs generate and submit daily solutions of station coordinates based on final products prepared by one of the IGS AC or the IGS itself. Solutions in SINEX formatted files are passed to the ACC. The deadline for submission of that product is 5 weeks after end of observations of the analysed week. 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 ACs are asked to submit daily solutions of station coordinates based on rapid products prepared by one of the IGS AC or the IGS itself. Solutions in SINEX formatted files are passed to the ACC. The deadline for submission of that product is 22 hours after the end of observations of the analysed day.

Hourly Coordinate Solution (optional)
The ACs are asked to submit hourly solutions of station coordinates based on ultra-rapid products prepared by one of the IGS AC or the IGS itself. Solutions in SINEX formatted files are passed to the ACC. The interval of observations of this solution includes the past hour and possibly observations before the past hour to stabilise the solution, although this should not include more than additional 15 minutes. The total length of the observation interval is not yet fixed and may differ for individual ACs. The deadline for submission of that product is 50 minutes after end of observations of the analysed hour.

Final Daily Zenith Path Delays Parameters (mandatory) and gradients (recommended)
The ACs estimate mandatory (mostly hourly) tropospheric site zenith path delays and gradients for the EPN stations included in their sub-network. These zenith path delay estimates are submitted in daily troposphere files in the "Troposphere SINEX" format. It is also recommended to estimate and submit in addition tropospheric gradients. The deadline for submission of that product is 5 weeks after end of observations of the analysed week.

1.2 Coordinate Combination

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

Final Weekly Coordinate Solution
The ACC combines the weekly sub-network solutions of the ACs into the EPN weekly combined solution. The final weekly coordinate solution is mandatory for all ACs and thus the resulting combination includes all EPN stations. A full description on this solution is available at http://epncb.oma.be/_productsservices/combinedeurefsolution.php, while detailed comparisons and statistics from the combination procedure at www.epnacc.wat.edu.pl. The combined solution is generated in an iterative way: after a first combination, each individual solution is crosscheck against the combination and stations exhibiting a significant coordinate difference wrt the combined solution are eliminated. In a second step the solutions are combined again, but with the outliers removed.

Final Daily Coordinate Solution
The ACC combines the final daily sub-network solutions of the ACs on daily basis into the EPN daily combined solution. The final daily coordinate solution is mandatory for all ACs and thus the resulting combination includes all EPN stations. A full description on this solution is available at http://epncb.oma.be/_productsservices/analysiscentres/combinedeurefsolution.php while detailed comparisons and statistics from the combination procedure at www.epnacc.wat.edu.pl.
Rapid Daily Coordinate Solution
The ACC combines the rapid daily sub-network solutions of the ACs on a daily basis. This 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 necessarily include all EPN sites.

Hourly Coordinate Solution
The ACC combines the hourly sub-network solutions of the ACs on an hourly basis. This 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 necessarily include all EPN sites.

1.3 Troposphere Combination

The combination of the troposphere solutions of the ACs falls under responsibility of the **Troposphere Coordinator (TC)**. More details on this activity are available from http://epncb.oma.be/_productsservices/troposphere/.

1.4 Cumulative Position/Velocity 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 Reference Frame Coordinator (RFC).** During this analysis the RFC 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 provided 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/_productsservices/coordinates/.

1.5 EPN Projects

EPN Working Groups or 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 Working Group or Project, the TWG decides about adding the related activities to the routine EPN operations. An overview of the previous and actual EPN Working Groups or Projects is available from http://epncb.oma.be/_organisation/WG/.

2. Becoming an EPN Analysis Centre

Candidate ACs must be able to contribute to the EPN on a long-term basis. The sub-network solutions that are submitted to the ACC and the derived EPN combined solutions will be freely available for everyone. This data policy has to be approved by new ACs. The used analysis software must have the capacity to process the assigned sub-network and to fulfil the required EPN analysis standards. To avoid overlapping of the activities and solutions, some ACs can contribute through specific tasks related to their main interests (see section 2.1).

2.1 Keeping up-to-date

According to the new challenges which EPN has to face, current Analysis Centers are invited to contact EPN CB and ACC to discuss a possible re-orientation of their contribution to the EPN. The most urgent necessities are related, among others, to the real-time analysis, control analysis using different types of software and analysis made for the purpose of testing new strategies and models.

2.2 Initial Steps

1. Contact the EPN CB at epncb@oma.be and the ACC at epn_acc@wat.edu.pl to declare your desire to become an EPN AC. Give the name and address of the representative of your AC.
2. Add a proposal for a European region you intend to analyse or a specific task you want to perform. New EPN ACs are encouraged to perform specific tasks, which would fulfil current EPN requirements. In the case the AC wishes to contribute to the EPN through a standard data analysis, then take into account, that each station has to be processed by at least 3 ACs, but it is not allowed that a single station is processed by nearly all ACs (in general not more than 5 AC are accepted for one EPN station, some exceptions can be allowed for twin stations). The final list of processed stations has to be verified by the EPN CB and ACC.
3. Add a proposal for the 3-character identifier of your planned AC, 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 AC form can be completed (see ftp://epncb.oma.be/pub/center/analysis/BLNKFORM.AC). It is the AC’s responsibility to keep this form up to date.
5. Add a proposal for the first GPS week you plan to start the EPN analysis.

2.3 Acceptance procedure

1. The CB requests a **AC description form** that has to be filled out and to be submitted to the CB.

2. The EPN CB and ACC assigns a sub-network to the candidate AC taking into account the stations proposed by the AC and the need for additional AC for some EPN stations. Both EPN CB and ACC decide what are the most urgent EPN needs concerning the tasks performed by new AC (see section 2.1).
3. The EPN CB contacts the new AC 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://epncb.oma.be/_documentation/guidelines/guidelines_data_centres.pdf).

3.1 Preparation

1. Download the RINEX observation files 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 CB (see http://epncb.oma.be/_dataproducts/data_access/dailyandhourly/).
2. Download the orbit and Earth Rotation Parameter (ERP) files from the IGS or one of its AC. 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 actual IGS realisation of the ITRF (e.g. IGb08) , if not already done, from the IGS CB at ftp://igscb.jpl.nasa.gov/.
4. Prepare a table of ocean loading displacements for each involved EPN site either through using the online computation service at http://holt.oso.chalmers.se/loading/index.html or through downloading the table from the CB at ftp://epncb.oma.be/pub/station/general/.
5. Prepare the receiver and satellite antennae calibration table using individual calibrations (when available from the EPN CB) and IGS antenna calibrations, from a file in ANTEX format that is provided from CB (see http://epncb.oma.be/_documentation/equipment_calibration/).
6. Get and apply the list of excluded stations provided by EPN CB (e.g. inactive, excluded stations, see ftp://epncb.oma.be/pub/station/general/excluded/).
7. Make sure the correct meta-data (provided in ftp://epncb.oma.be/pub/station/general/euref.snx) is used during all steps of the data analysis, independent of the information in the RINEX header.

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" any reference coordinates).

    Comment: It is recommended to use the actual IGS realisation of the ITRF (e.g., IGb08 instead of ITRF2008) to reach the best possible consistency with IGS products (IGS satellite orbits, clocks and EOP) for all processing steps. Users must aware that the published ITRFyyyy to ETRF2000 transformation parameters are also valid for the actual IGS realization.
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,

    although it is recommended to submit normal equation solutions if possible (subsection e).
3. ACs are requested to keep the ACC and CB posted about disturbances noticed in solutions (e.g. high outliers resulted in stations elimination)
4. Generation of tropospheric zenith path delays
    a. Heavily constrain the weekly coordinate solution to the recent IGS realisation of the ITRF 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 (zenith path delays and optionally gradients) into daily SINEX Troposphere format files (final troposphere result).
c. To accommodate for the gradients, the fields 'TGNTOT, TGETOT' are introduced the SINEX TRO format

3.3 Processing Options

Processing should be done in accordance with IERS Conventions 2010.

1. Use the suitable IGS products (combined or from one of the IGS AC) corresponding to the solution to be processed. Select from "final", "rapid" and "ultra-rapid". IGS provides satellite orbits, satellite clocks and Earth orientation parameters. Take in particular care on the usability of orbits for unhealthy satellites.
2. Introduce ocean-loading corrections for the stations. Be aware to use the same model for all stations. Optionally introduce atmospheric tidal loading corrections.
3. Use the 3° elevation cut-off angle. Apply elevation dependent weighting of observations.
4. Use the state-of-the-art tropospheric mapping function with a priori ZHD model and estimating ZWD only use the Vienna Mapping Function or Global Mapping Function to map the tropospheric delay in zenith direction.
5. Estimate hourly station specific troposphere parameters.
6. Fix the initial phase ambiguities to integer numbers for GPS data processing.
7. Recommendation: Use GPS as well as GLONASS observations.

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, markus.goltz@bkg.bund.de or erwin.wiesensarter@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 = AC abbreviation,
   wwww = GPS week,
   d = doy of week 0,…,6,
   hh=hour 00, ..., 23,
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. AC Performance Control

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

1. The weekly EUREF AC report as distributed to the ACs by E-Mail includes a list the 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 ACs. 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 combination report. It includes a direct comparison of the station coordinates from the individual solutions wrt the combined solution. 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 AC with respect to the combined solution.
3. The EPN ACC verifies metadata of the stations; stations with contradictions in metadata (with reference to the euref.snx file) will be removed from the combined solutions for the particular AC.

4. The EPN ACC webpage (http://epnacc.wat.edu.pl) presents graphs and statistics about combination with information about excluded sites and comparison between the individual and combined solutions.
5. A weekly EUREF troposphere combination report (EURwwww7.TSU) is distributed to the ACs by E-Mail and provides statistics for the differences of the individual AC estimates to the mean. The information contained in these mails is available in graphical form from the EPN Central Bureau at http://epncb.oma.be/_productsservices/troposphere/mean_zpd_biases.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 1765* to set the elevation cut-off angle to 3° (Ref. Discussion within LACs during 8th EPN LAC Workshop, Brussels, April, 2013).

> It was *recommended for weeks 1550-1764* 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).
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> 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 (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).

Satellite Orbits
It is *recommended since week 1765* to use orbits and clocks consistent with the analysis options and software used by LAC. Alternatively the combined IGS products may be used. (Ref.: Discussion within LACs during 8th EPN LAC Workshop, Brussels, April, 2013). It *is mandatory since week 1765* to exclude the defective satellites.

> It was *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 products (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).

Atmospheric Tidal loading corrections
It is *recommended since week 1765* to apply atmospheric tidal loading corrections (Ref. Discussion within LACs during 8th EPN LAC Workshop, Brussels, April, 2013).

A priori troposphere
It is mandatory to use a priori ZHD either from VMF1 model or, alternatively, from GPT or GPT2 global pressure models.

Troposphere Mapping Function
It is *mandatory since week 1765* to use the Global Mapping Function or the Vienna Mapping Function (Ref. Discussion within LACs during 8th EPN LAC Workshop, Brussels, April, 2013).

> It was *mandatory for weeks 1130-1764* to use the Niell Mapping Function (Ref.: Minutes of 3rd EUREF LAC Workshop, Warsaw, May 31- June1, 2001).

Number of Troposphere Parameters
It is *mandatory since week 1765* to estimate hourly troposphere parameters for each station (Ref. Discussion within LACs during 8th EPN LAC Workshop, Brussels, April, 2013).

> It was *recommended for weeks 1130 – 1764* to hourly troposphere parameters for each station. (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). It is *recommended since week 1765* to use Chen-Herring model or an adequate model for the estimation of gradient tropospheric parameters. It is *recommended since week 1765* to submit the estimated gradients in the "Troposphere SINEX" format.

Ionosphere Corrections
It is *mandatory since week 1765* to include 2nd order of ionospheric corrections and ionospheric ray bending corrections.