Possibilities and benefit of the online GNSS PPP free services for GNSS applications- the accuracy and reliability

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Outline

- Positioning techniques: PPP vs DGNSS
- PPP fundamentals
- PPP on line services
  - APPS,
  - CSRS,
  - GAPS,
  - magicGNSS
- Analyse of BIHPOS data results
- Conclusions

PPP vs DGNSS

Single Point Positioning

- Since 1970s, theory
- December 1983, civil use of GPS
- Accuracy
  - **code 100-150 m with SA**
- After May 2, 2000 **accuracy of rang** mesurement:
  - **C/A code: 3 m, but today 1.2 m**
  - **P code 0.3 m**
  - **Phase: reading resolution is 2 mm**

ERRORS of measurement remain in single point positiong!

Differencial Positioning

3 decades dominant for precise positioning and navigation

Accuracy (errors reduced)

code:

- single-frequency:
  - –few m to sub-metre

carrier phase:

- dual frequancy:
  - – sub-cm for postprocesing
  - –few cm for RTK

ERRORS budget

- Signal arrival C/A: ±(1-3m)
- Signal arrival P(Y): ± 0.3 m
- Ionosphere (good models) 5m
- Satellite clocks 2 m
- Orbit (today) Broadcast 1m
- Troposphere model dm
- Multipath 1 m

Single point positioning

Accuracy today:

C/A code: 6, 7 m

P code: 6 m

Phase carrier: L1 L2

Ionosphere, eliminate

Multipath, reduce (up 5 cm)

Antenna PVC–reduce (up to cm)

If ambiguity fixed, accuracy is of **cm level**

PPP vs DGNSS
Not competition!

PPP

PPP-an alternative to DGNSS

- Research since 1990s
- Static and kinematic modes
- Postprocessing mode
- Recently-cm level accuracy
  - for dual frequencies data

2 April 2013 IGS RTS lanched !!

DGNSS

Most country developed CORS, but

- it is expensive:
  - for good distribution,
  - quality of monumentation,
  - multi-GNSS reciveirs,
  - integrity and robustness,
  - sinals quality monitoring...

PPP matematical backgound

Ionosphere-free combination-code

$$l_P = \rho + c(b_{Rx} - b_{Sat}) + T_r + \varepsilon_P$$

Ionosphere-free combination-Carrier-phase

$$l_\Phi = \rho + c(b_{Rx} - b_{Sat}) + T_r + N\lambda + \varepsilon_\Phi$$

Geometrical rang between satellite and receveir

$$\rho = \sqrt{(x_{Sat} - x_{Rx})^2 + (y_{Sat} - y_{Rx})^2 + (z_{Sat} - z_{Rx})^2}$$

Meaning of the symbols in the formulas

l_P is ionosphere-free combination of L1 and L2 pseudorange;

l_Φ is ionosphere-free combination of L1 and L2 carrier phase;

b_{Rx} is receiver clock offset from reference (GPS) time;

b_{Sat} is satellite clock offset from reference (GPS) time;

T_r is signal path delay due to influence of the troposphere;

λ is the carrier combination wavelength;

N is the ambiguity of the carrier-phase ionosphere-free combination (not integer here)

ε_P is the code measurement noise, included multipath effects;

ε_Φ is the carrier-phase noise, included multipath effects;

c is speed of light (in vacuum).

PPP

Advantage

- costs efficant:
  - one receveir
  - no fee for softver/processing
  - less labor
  - less personal (costs)
  - no fee for CORS
  - no need for data of reference s.
  - no biases from CORS
  - ……

Disadvantage

- slow convergence time
- dual frequency receiver for good acc.
- no user equpment on the market for RT algorithm
- unserten coordinate datum
- no data standards jet
- user must be skiled with coord. trans.
- low (sub-m) accuracy for kinematic
- for cm acc. ! corrections to be applied
- …

Biases and errors to be applied

Correction type	PPP	DGNSS
Satellite specific errors		
Precise satellite clock correction	yes	no
Satellite ant. ph. c. offset and variation	yes	yes
Precise satellite orbit	yes	yes
satellite antenna wind-up	yes	no
Group delay differential	yes(L1)	no
Relativity term	yes	no
Receiver specific errors		
Receiver ant. ph. c. offset and variation	yes	yes
Receiver antenna phase wind-up	yes	no
Geophysical Models		
Solid Earth tide displacement	yes	no/yes
Ocean tide loading	yes	no/yes
Polar tides	yes	no/yes
Plate tectonics motion	yes	no/yes
Atmospheric Modeling		
Tropospheric delay	yes	yes
Ionospheric delay	yes/(L1)	no

Note:
Corrections models and geophisical models developed by DGNSS

PPP on line services

APPS (Automatic Precise Positioning Service)

- by Jet Propulsion Laboratory (JPL)
- Note: This service replaces Auto-GIPSY.

  http://apps.gdgps.net/

CSRS

- by Natural Resources Canada (NRCan)
- Note: Access to this service is FREE but you need to register.
  http://www.geod.nrcan.gc.ca/online_data_e.php

GAPS (GPS Analysis and Positioning Software)

- by University of New Brunswick (UNB)
- http://gaps.gge.unb.ca/

magicGNSS (Espania)

- by GMV http://magicgnss.gmv.com/ppp

Note: magicGNSS offers an "Aeronautical" processing option on their web.

APPS

Jet Propulsion Laboratory
California Institute of Technology

+ View the NASA Portal

JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

- Home
  - Unique Features
- About GDGPS
- How to use APPS
- Under The Hood
- Instant Positioning
- Registered Users
- Register

Welcome to APPS!
The Automatic Precise Positioning Service
of the Global Differential GPS (GDGPS) System.

APPS is now using GIPSY 6.2

APPS accepts GPS measurement files, and applies the most advanced GPS positioning technology from NASA's Jet Propulsion Laboratory to estimate the position of your GPS receivers, whether they are static, in motion, on the ground, or in the air. APPS employs:

- Real-time GPS orbit and clock products from JPL's GDGPS System
- JPL's daily and weekly precise GPS orbit and clock products
- JPL's GIPSY-OASIS software for processing the GPS measurements

APPS continues to provide JPL's venerable AutoGIPSY (AG) service - for *free*, for static post-processing (e.g. measurement latency of a week or more), but also offers new and unique services:

- APPS will generate a time series of positions if your receiver was in motion
- APPS has access to real-time GPS orbit and clock products so you never have to wait
- APPS is fast. Positioning is available in seconds

CSRS-PPP


Natural Resources Canada
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The CSRS Online Database allows users direct access to
federal horizontal and vertical control networks station information;
CACS RINEX and Precise Ephemeris files;
online CSRS-PPP (Precise Point Positioning) GPS processing service;
downloadable PC software (GPS·H, NTv2 and PPP Direct);
the Canadian Gravity Standardization Net (CGSN),
Date Modified: 2011-06-14
Top of page
Important notices

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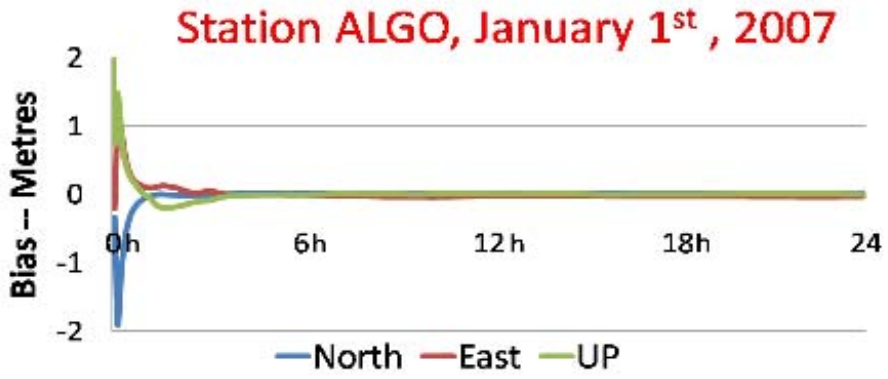
GAPS

GAPS provides users with precise and accurate positioning using a single GNSS receiver both in static and kinematic mode. Through the use of precise orbit and clock products produced by the International GNSS Service (IGS) it is possible to achieve centimeter positioning in static mode and decimeter positioning in kinematic mode given a sufficient convergence period. An example is shown of the convergence period of the computed coordinates for station ALGO, located in Algonquin Park, Canada, January 1st 2007. Processed in static mode.



The solution is with respect to the IGS non-cumulative weekly solution. An example of the results produced by GAPS can be seen here . Have some questions? Then check out the FAQ page here or contact us here .

Submit Observation File

GAPS Analysis Strategy

magic GNSS

Precise Point Positioning by email

Welcome to the email version of ***magicGNSS***/PPP (Precise Point Positioning), now processing **static** and **kinematic** GPS and GLONASS **real-time** data in RINEX format. Only **dual-frequency** PPP is supported at the moment.

Real-time GPS and GLONASS orbits and clocks needed by PPP are generated internally. Satellite clock rate is 5 min. *Rapid* and *final* GPS orbits and clocks from IGS are also used, if available. *Final* IGS clock rate is 30 sec.

Please follow these instructions:

- Send an email to magicppp@gmv.com with the Subject **Static** or **Kinematic** and one RINEX observation file attached (or a maximum of two files for static PPP).
- The attached files must be in standard or Hatanaka RINEX 2.10 or 2.11 format, compressed or not.
- The files can be compressed in the following formats: .Z, .gz, .zip.
- The filenames must follow the RINEX filename convention: daily, hourly, 15-min; if your file is compressed, you must keep the RINEX filename extension **and** the compression extension (for example **vill3120.09o.gz** is a valid name, but **vill3120.zip** is an **invalid** name; beware of Windows compression!)
- The RINEX data rate must be one of the following, in seconds: 30, 15, 10, 5, 1.
- The RINEX file must contain all of the following observables: P1 (or C1), P2, L1, L2.
- The "APPROX POSITION XYZ" record on the RINEX file header is mandatory, but the values can be zero (if in doubt, set all values to zero).
- GPS data earlier than **2000/05/03** cannot be processed, and GLONASS data earlier than **2010/01/01** cannot be processed.
- In **static** PPP, if you attach **two RINEX files** and they belong to the same station, you will also get the comparison of the two PPP results (difference of coordinates).
- **Kinematic** PPP can be used in two modes: **Terrestrial** and **Aeronautical** (default). This is configured within the email **body**, for example:

  To: magicppp@gmv.com
  Subject: Kinematic
  Aeronautical
- **Virtual PPP** (static) is also supported for IGS stations (no need to attach RINEX files!), just send an email to magicppp@gmv.com with the Subject **Virtual** and a **maximum of two** virtual RINEX files in the body of the message, with the following syntax:

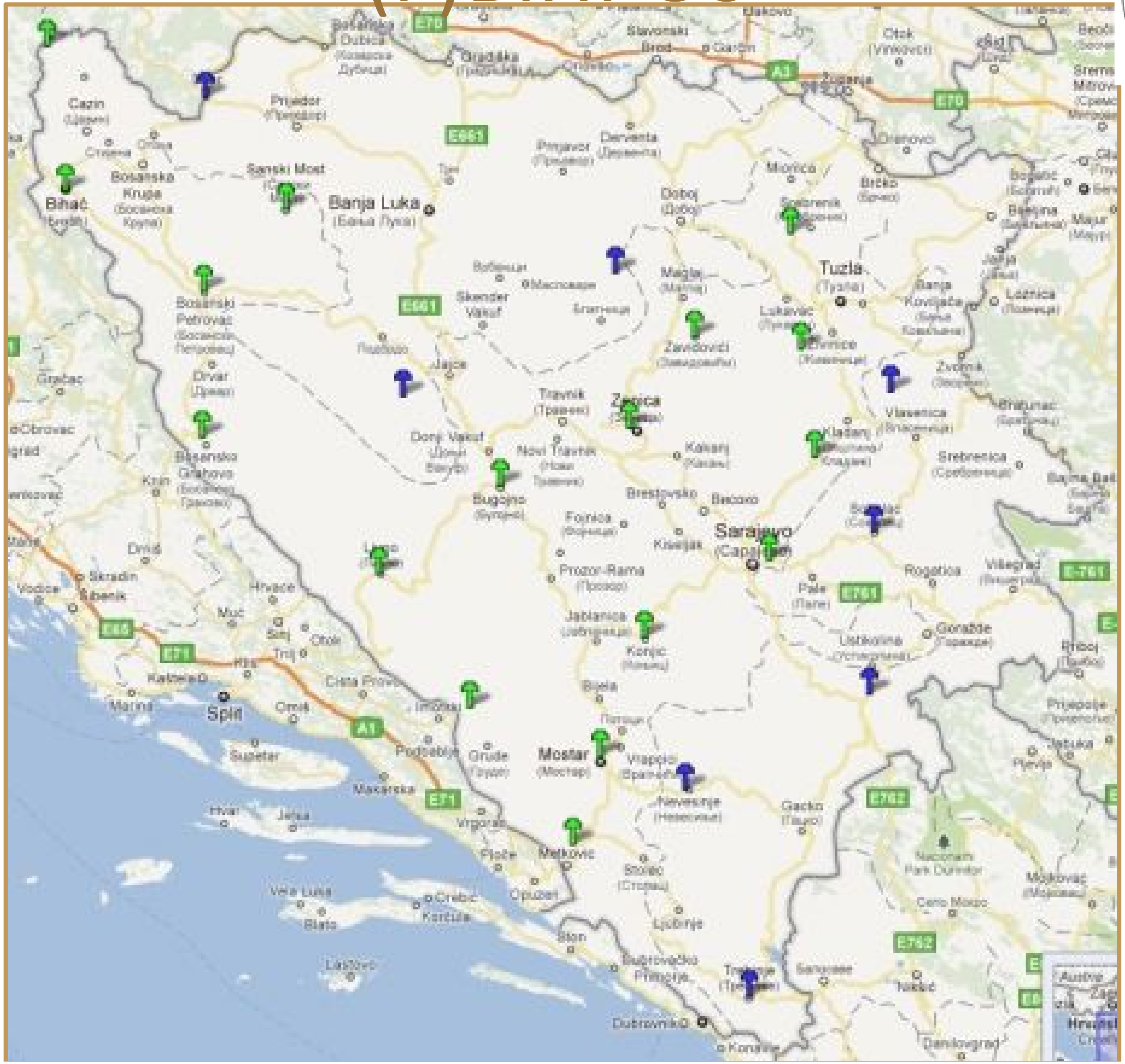
  rinex: ssssyyddd

  where **ssss** is the station name, **yy** is the two-digit year, and **ddd** the day of year. For example:

PPP services` Parametar

	APPS	CSRS	GAPS	magicGNSS
Reference frame	ITRF08	ITRF08 (IGB08)/NAD83	IGB08	ITRF08/ETRS89
Coordinate format	LLH/XYZ	LLH/XYZ/UTM	LLH/XYZ	LLH/XYZ
Quality information	covariance matrix, stand. deviations	covariance matrix, standard deviations	standard deviations	-
Antenna correction	IGS	IGS	IGS	IGS
Satellite orbits and clocks	JPL rapid/final	IGS	IGS	IGS or GMV
Elevation mask	minimal 7.5°	minimal 10°	minimal 10°	minimal 10°
GNSS system	GPS	GPS+GLONASS	GPS	GPS+GLONASS
Software	GIPSY	CSRS-PPP	GAPS v5.2.0	magic GNSS 5.3
File number for upload allowed	1 – max size 10 MB	maximal 1 file	maximal 1 file	max 2 files of 10 MB
Observation data	dual frequency, static and kinematic	dual frequency, static and kinematic	dual frequency, static and kinematic	dual frequency, static and kinematic
Data transfer	e-mail, web interface	e-mail	e-mail	e-mail, web interface
Data format	RINEX 2.0 or 2.11 or Hatanaka	RINEX 2.0 or 2.11 or Hatanaka	RINEX 2.0 or 2.11 or Hatanaka	RINEX 2.0 or 2.11 or Hatanaka
Troposphere modelling	GMF	Hydrostatic delay: Davis (GPT) Wet delay: Hopf (GPT) init Mapping functions: GMF	UNB-VMF1 (NCEP), UNB-VMF1 (CMC), VMF1(ECMWF),UNB3m Mapping Function: VMF1-gridded	-

(F)BiHPOS



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Jajce
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Zenica
Zvornik
Vlasenica
Kladanj
Donji Vakuf
Novi Travnik
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Kakanj
Bosansko Grahovo
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Fojnica
Srebrenica
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Pale
Rogatica
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Jablanica
Konjic
Goražde
Ustikolina
Foča
Split
Omiš
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Grude
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Korčula
Hvar
Šibenik
Sinj
Plevlja
Prijepolje
Priboj
Loznica
Danilovgrad

PPP post procesing BIHPOS static data

24 h of BIHPOS data from 25 station data organised as:

- RINEX Data of 062 DOY2013
- (March 3, 2013)
- Daily RINEX files splited to:
  - **3 h**
  - **6 h**
  - **12 h**
  - **24 h**
- Files uploaded to:
  - **APPS,**
  - **CSRS,**
  - **GAPS,**
  - **magicGNSS**

NOTE:

- Special attention to edit RINEX observation file header!

Results in: ITRF08 , ep. of the observ.
Transformed to ETRF2000, ep. 2011.3

BIHPOS

- Control centers in Sarajevo and Banja Luka
- Leica spider softwere
- Own on line processing service-DGNSS

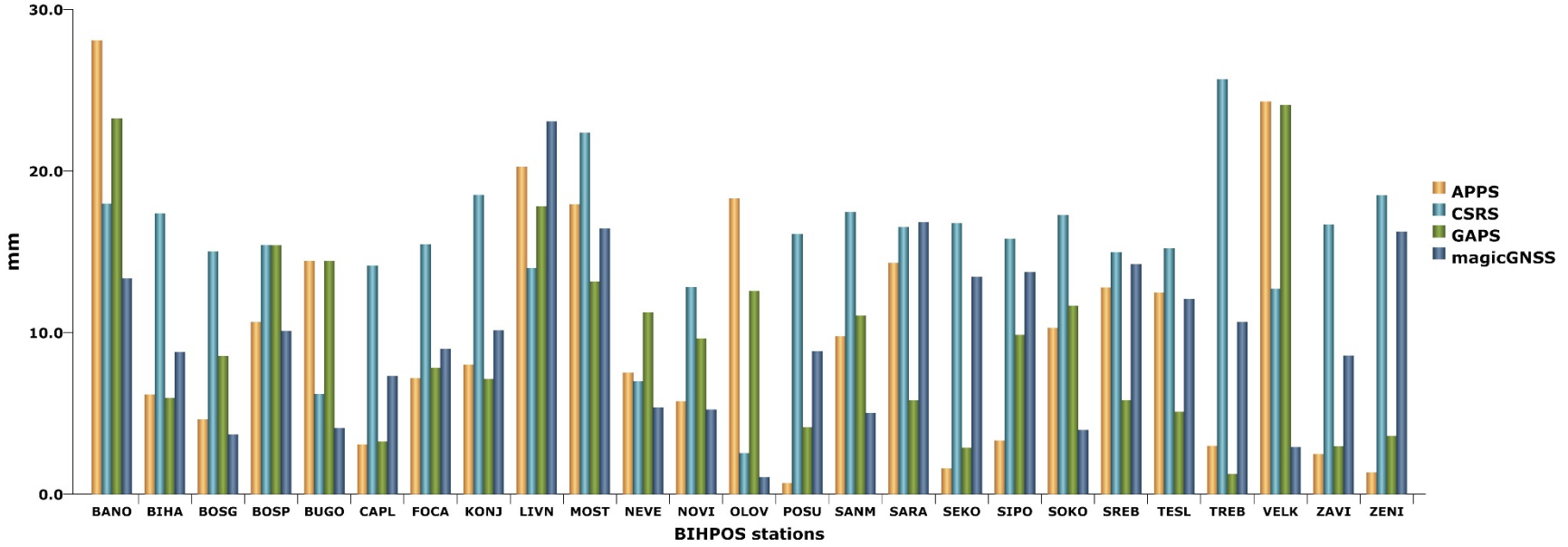
Official BIHPOS coorinates:

- 15 days of the observation
- Reference frame ETRF2000
- Reference epoch 2011.307
- Bernese software

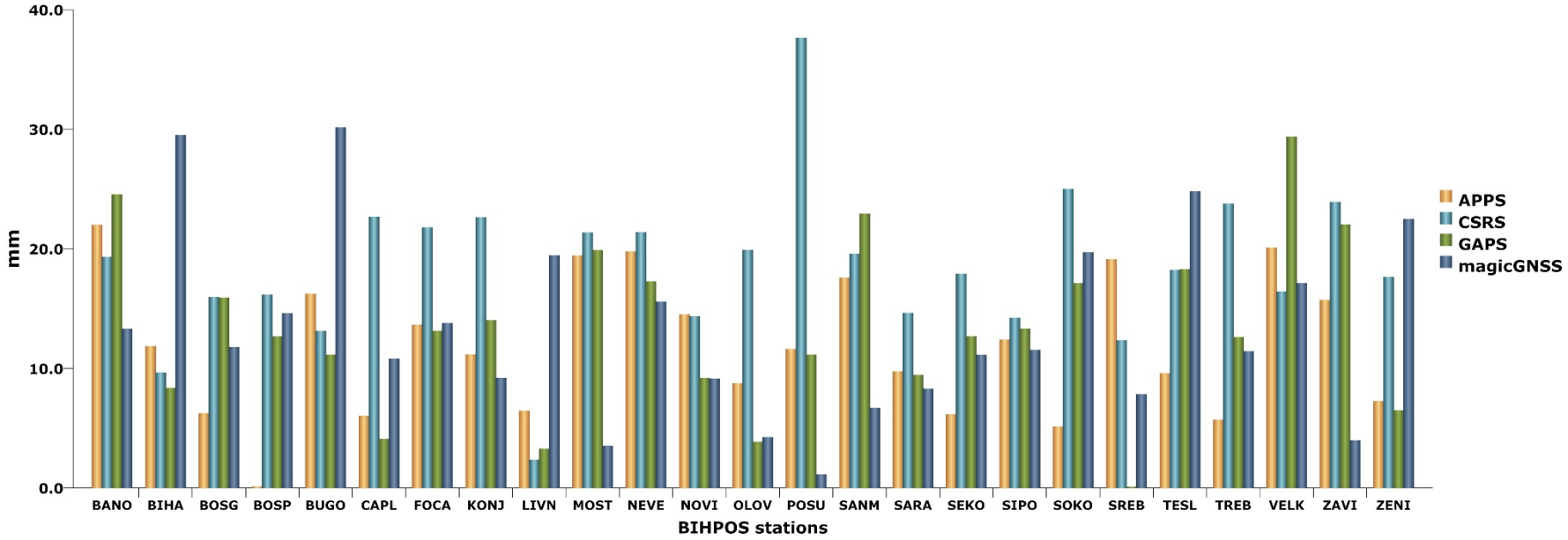
BIHPOS PPP solutions for observations of: 3, 6, 12, 24 h intervals and with final and rapid orbits.

RESULTS ANALYSE

Position differences (N,E)
Official BIHPOS stations' coordinates minus PPP solutions
Rapid IGS products-3h observations



Differences in UP components
3h of observations
Rapid IGS products



Position differences (N,E)
Official BIHPOS stations' coordinates minus PPP solutions
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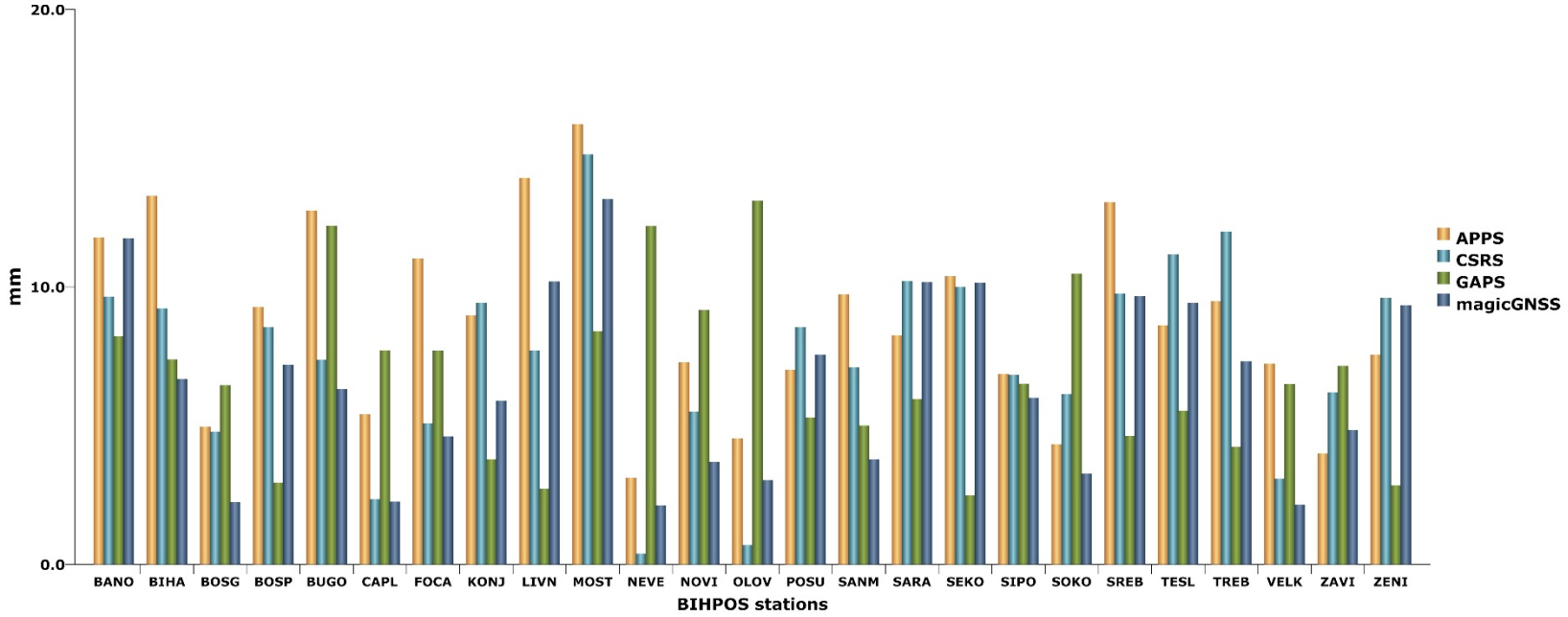

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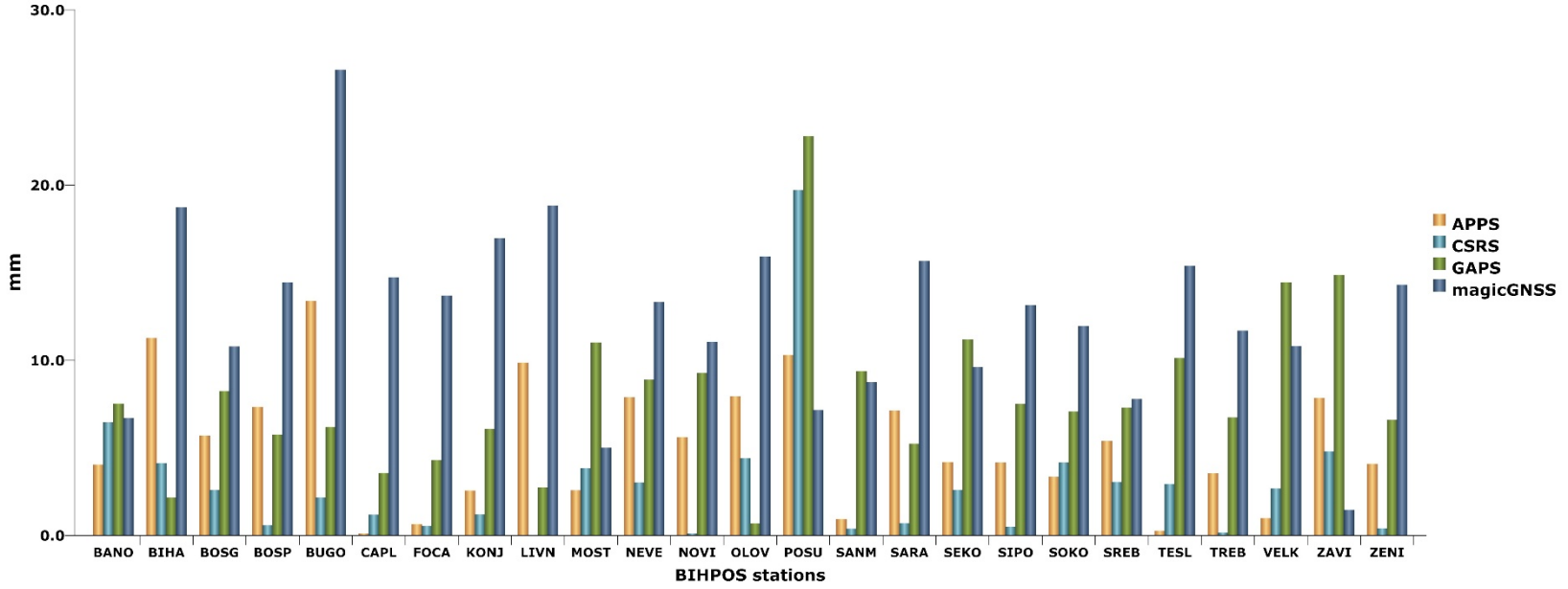

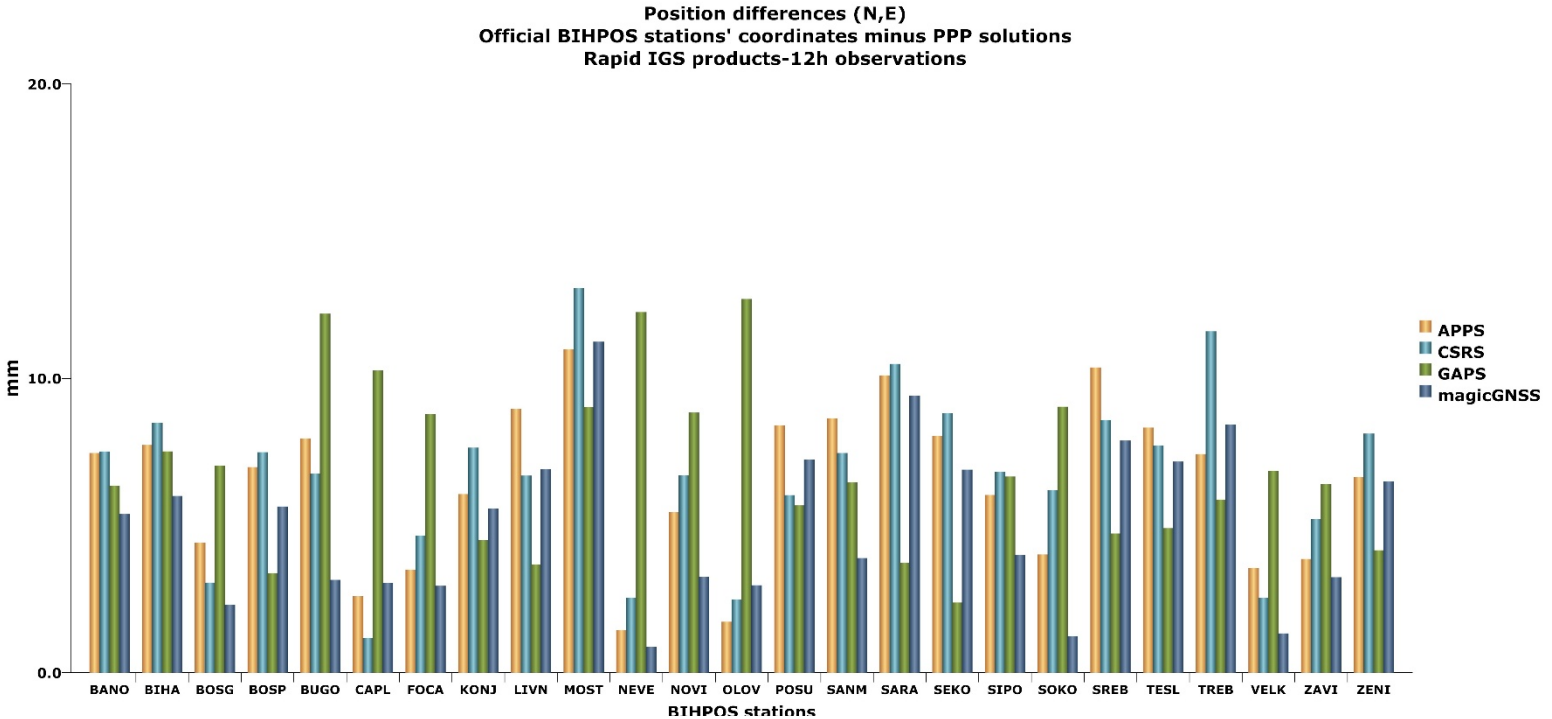
Position differences (N,E)
Official BIHPOS stations' coordinates minus PPP solutions
Rapid IGS products-12h observations
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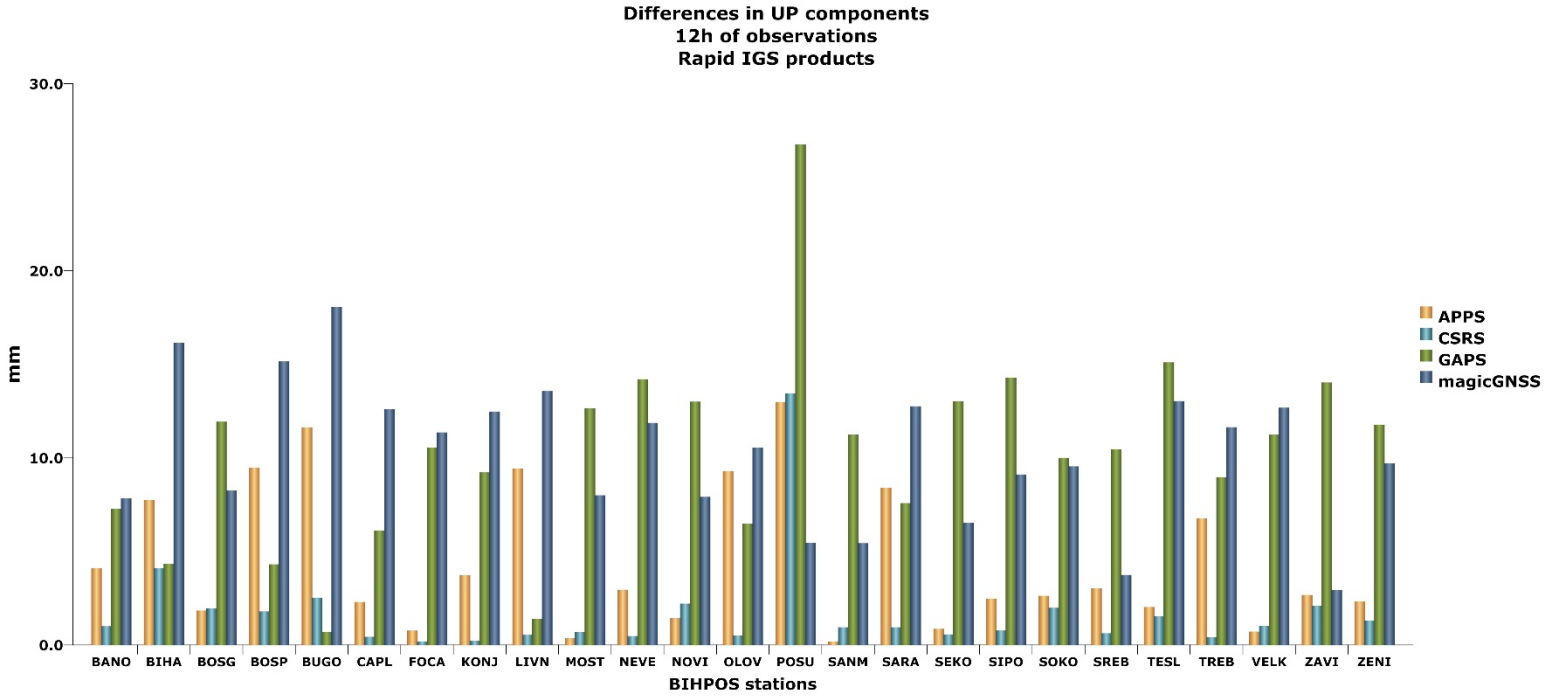
magicGNSS
BANO BIHA BOSG BOSP BUGO CAPL FOCA KONJ LIVN MOST NEVE NOVI OLOV POSU SANM SARA SEKO SIPO SOKO SREB TESL TREB VELK ZAVI ZENI
BIHPOS stations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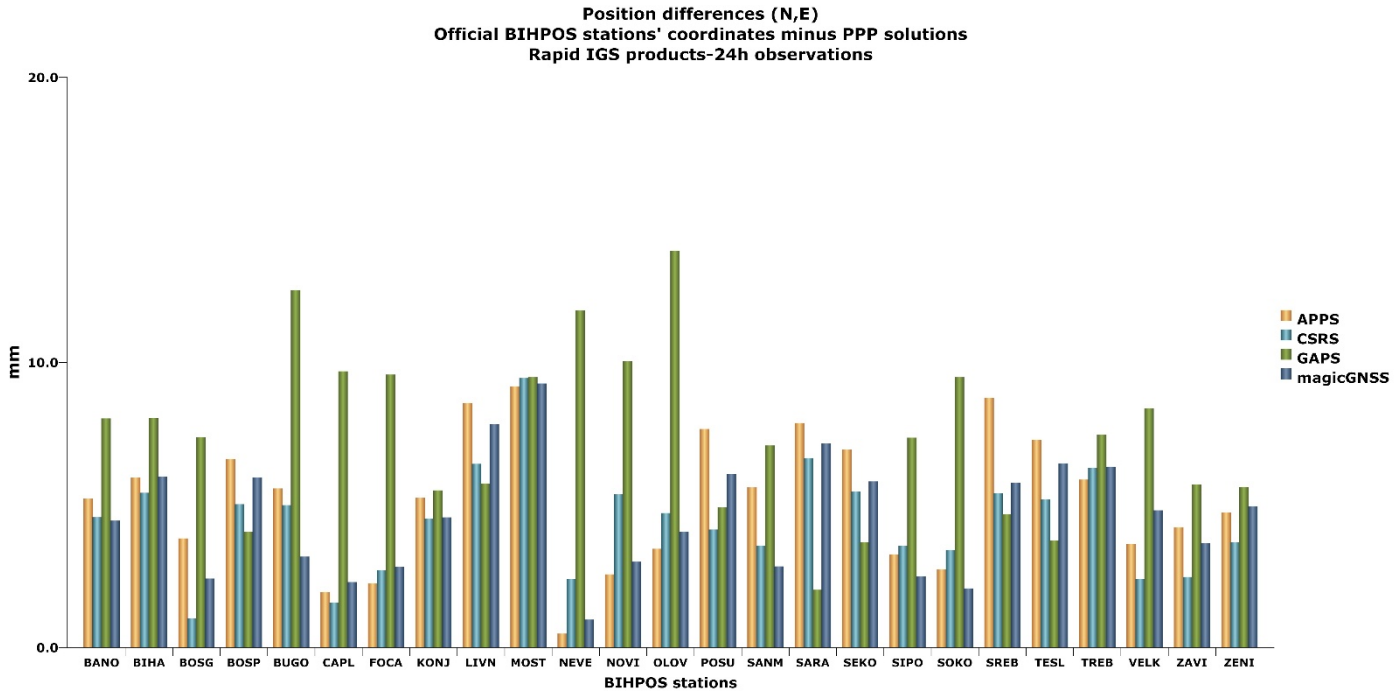
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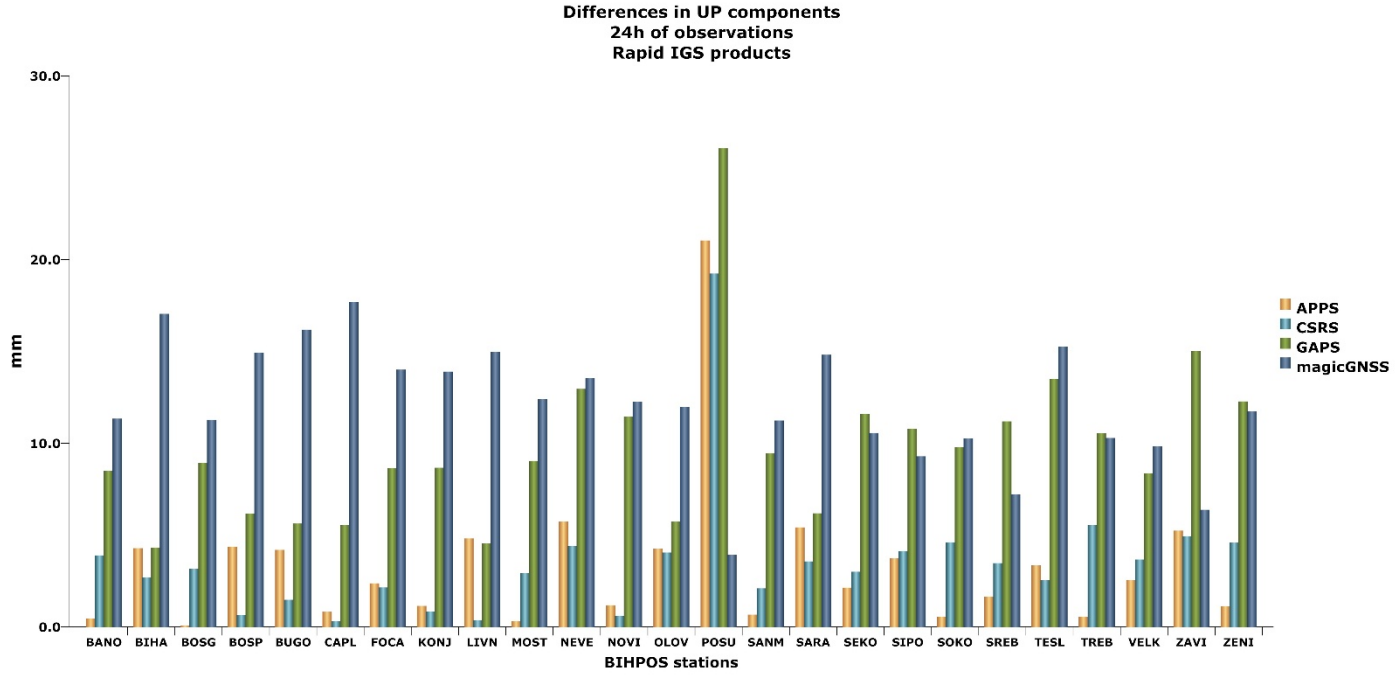
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Position differences (N,E)
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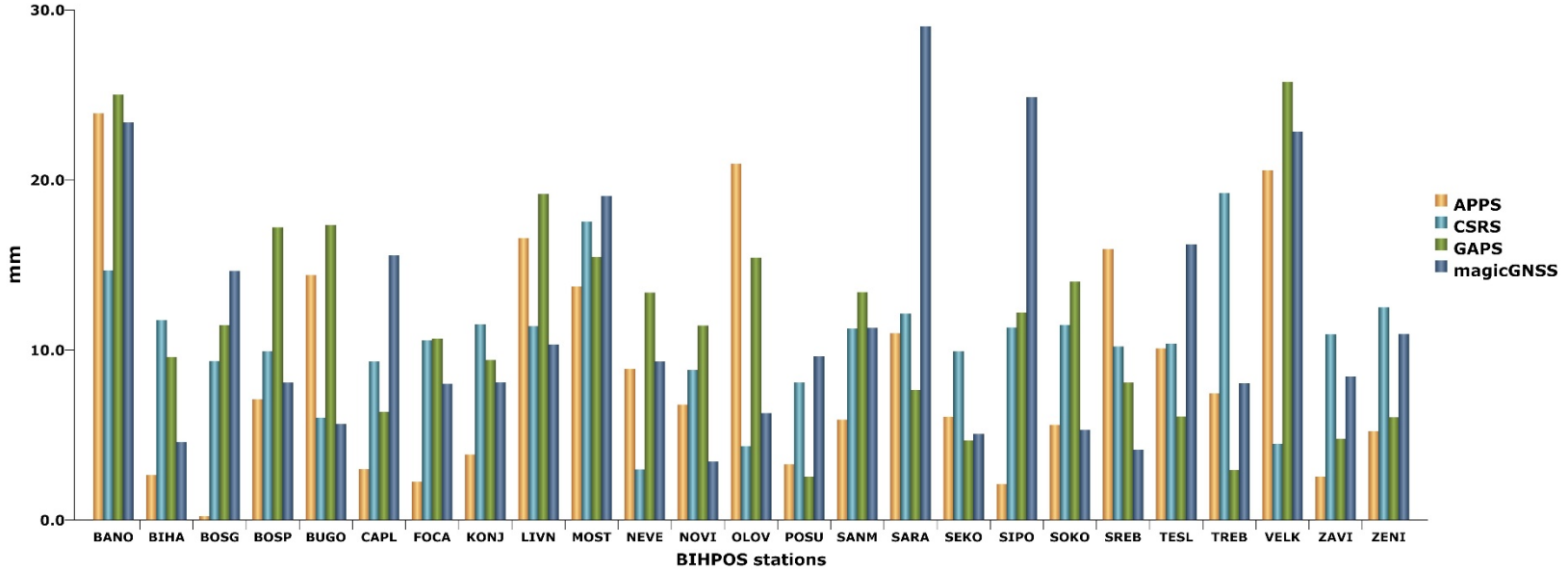
Final IGS products-3h observations



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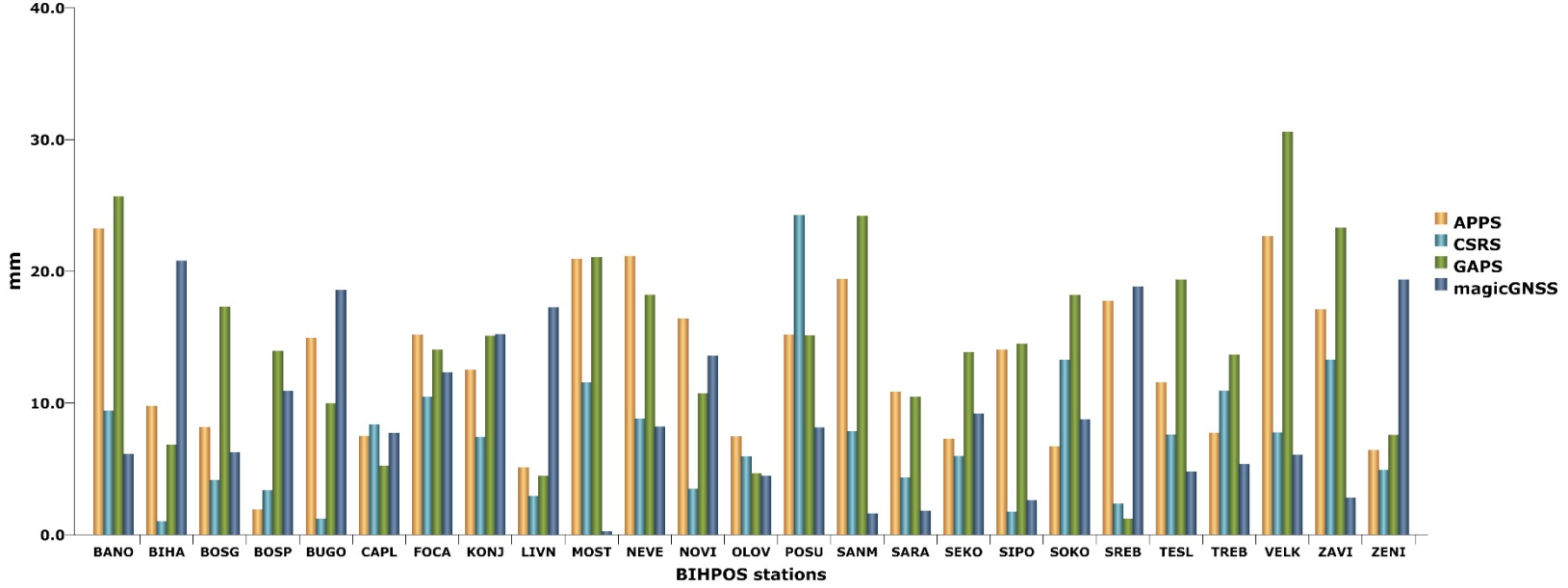

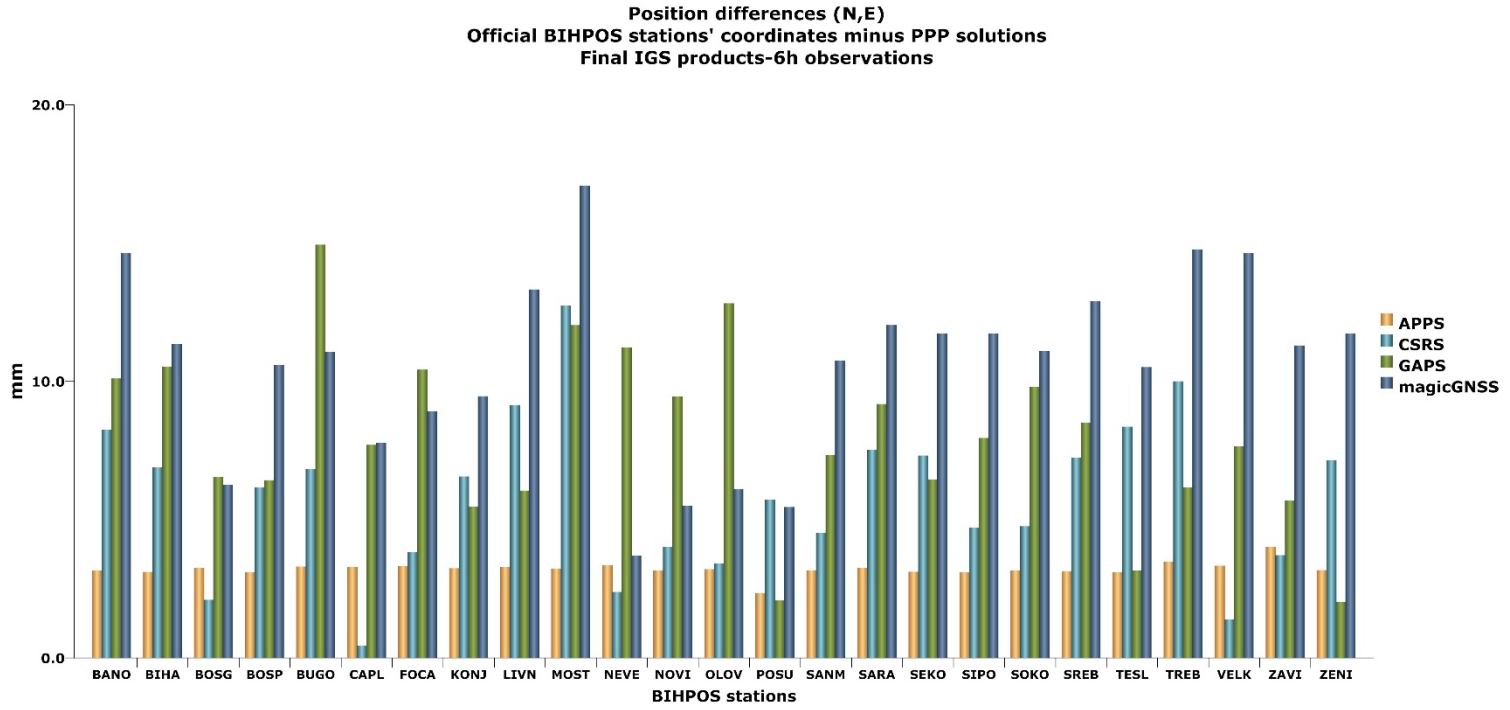
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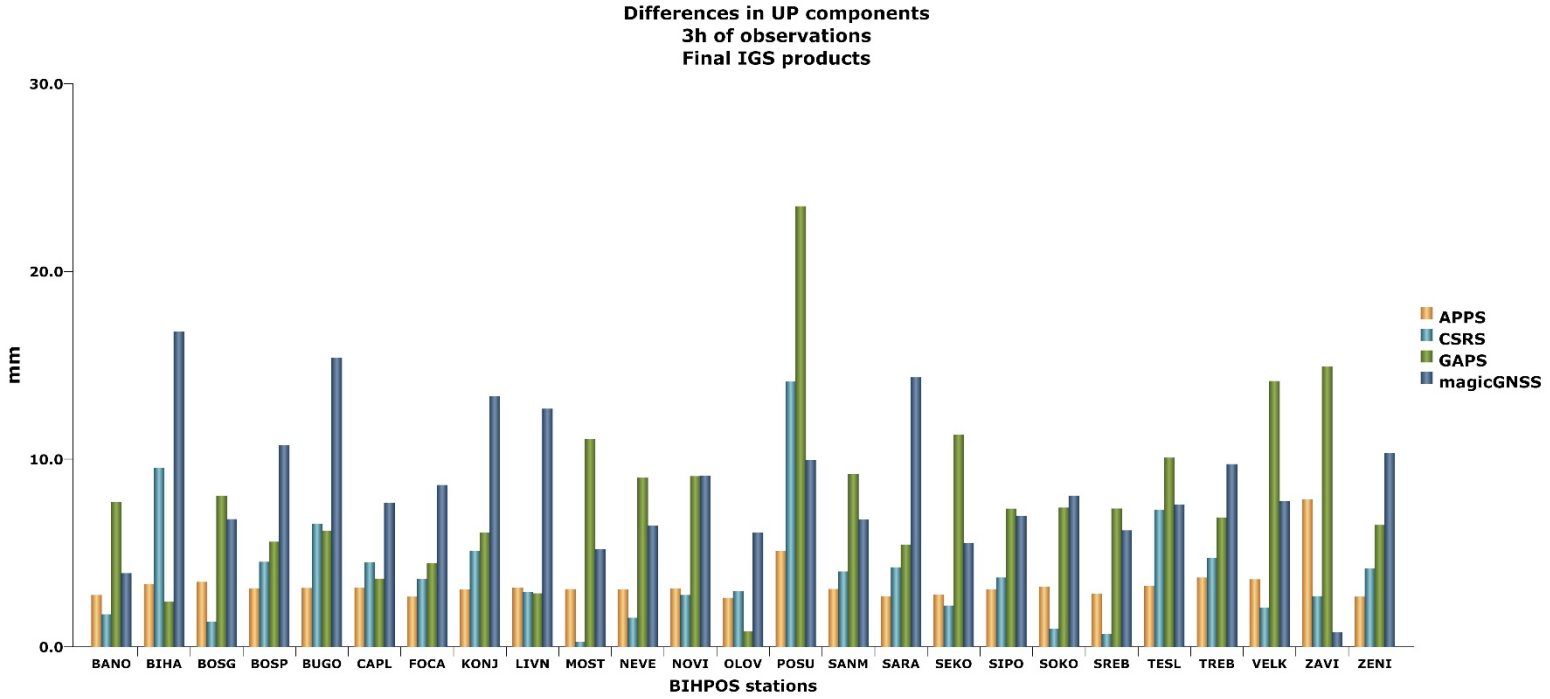
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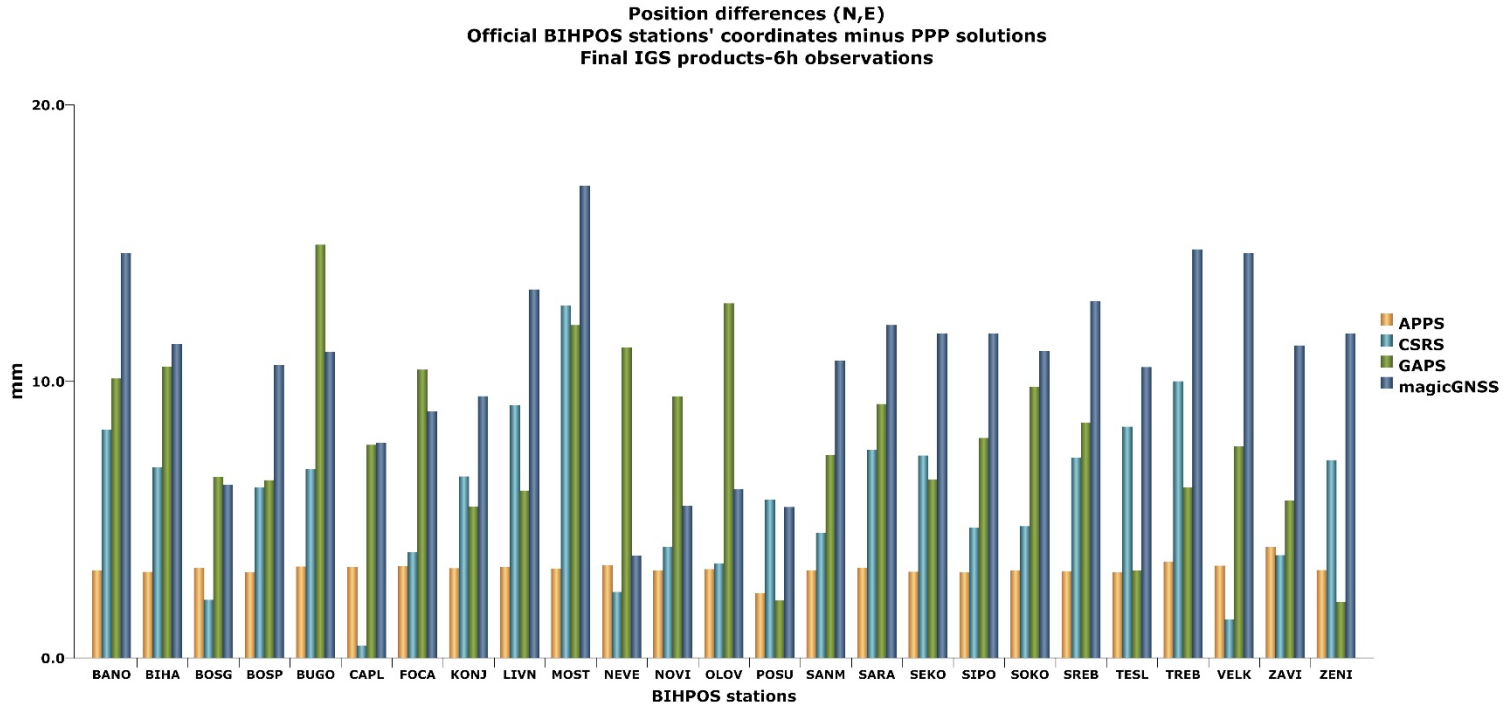
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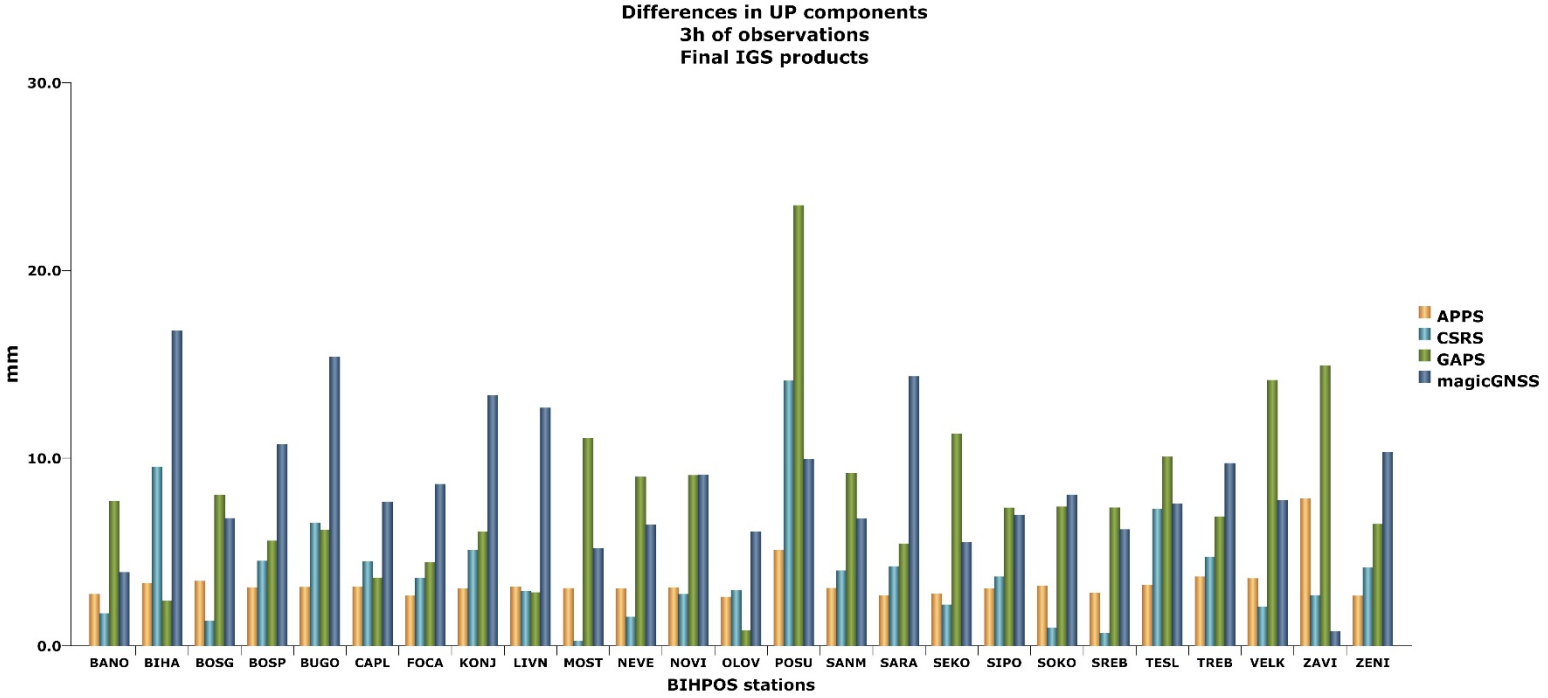
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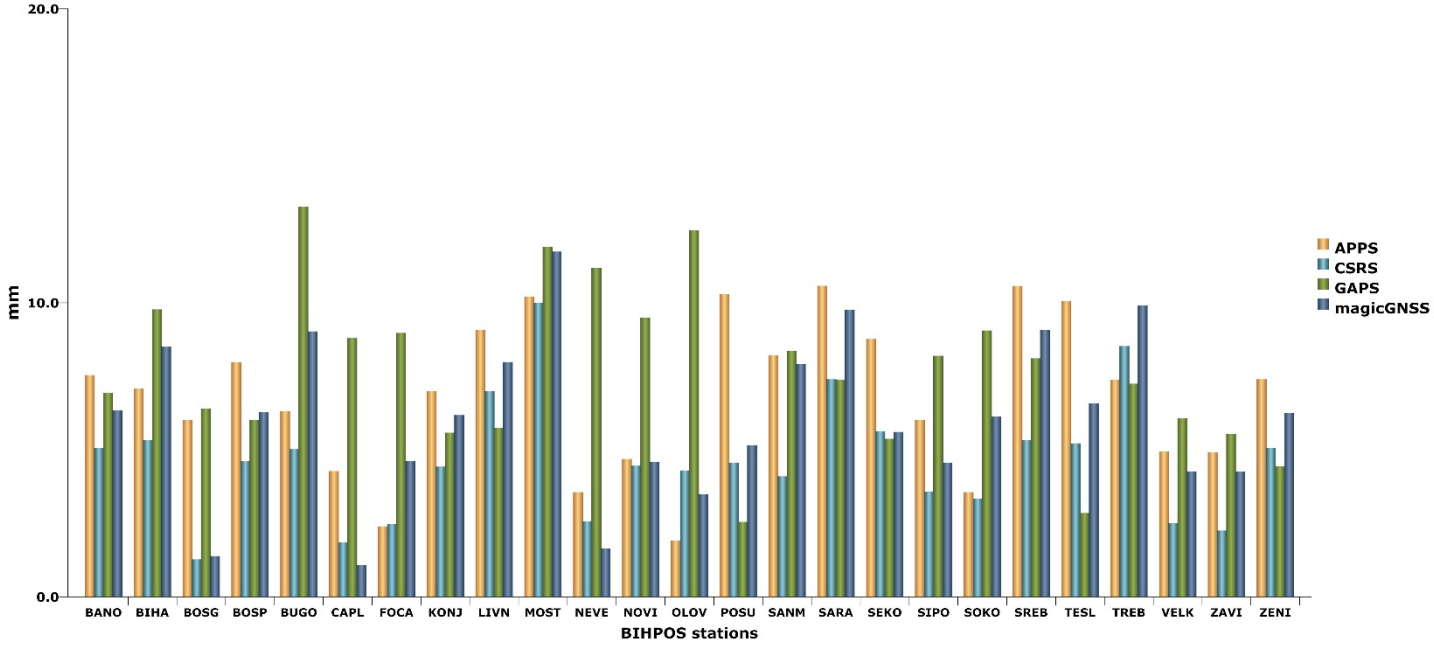

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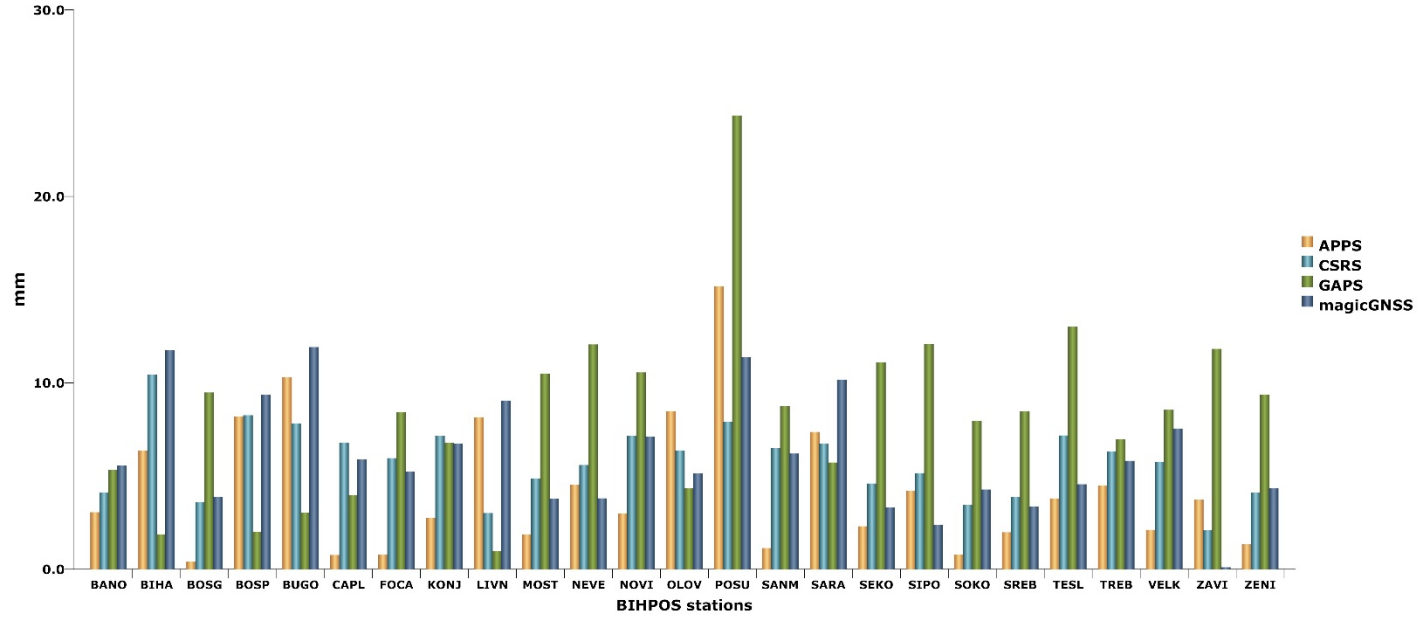

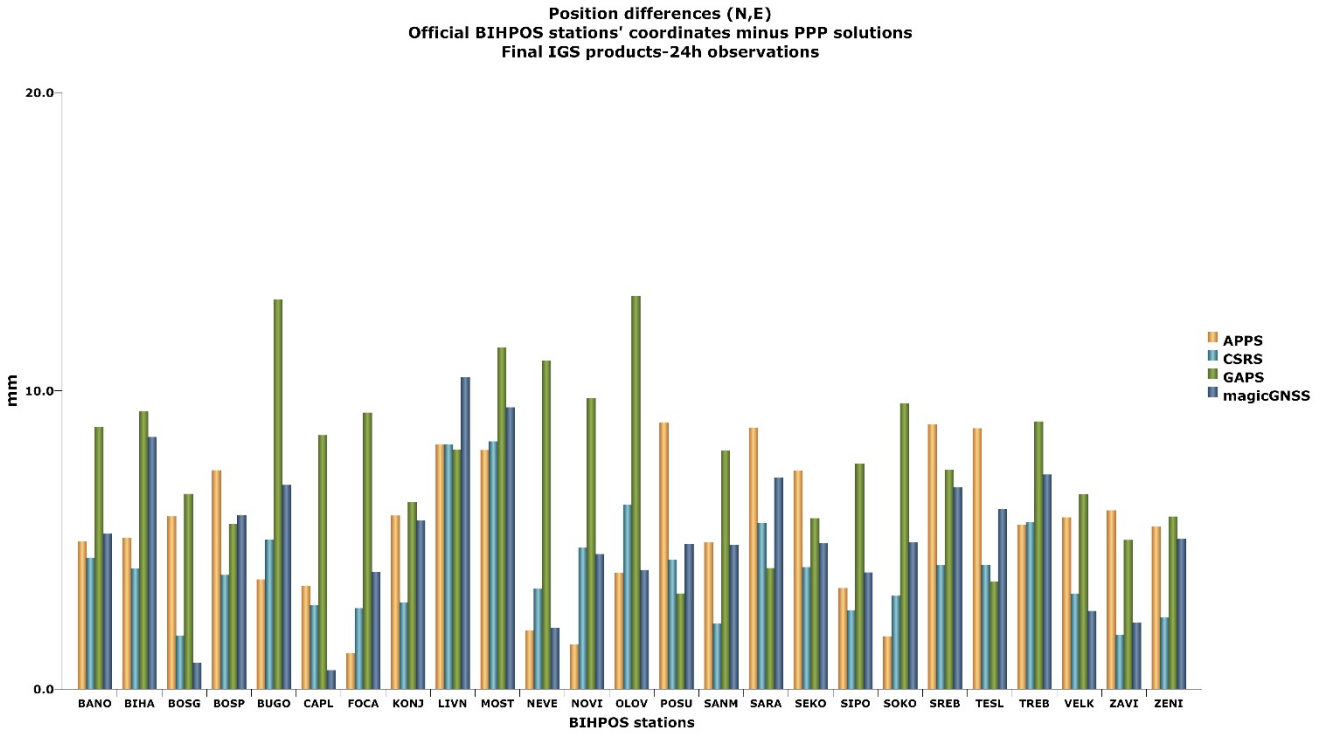
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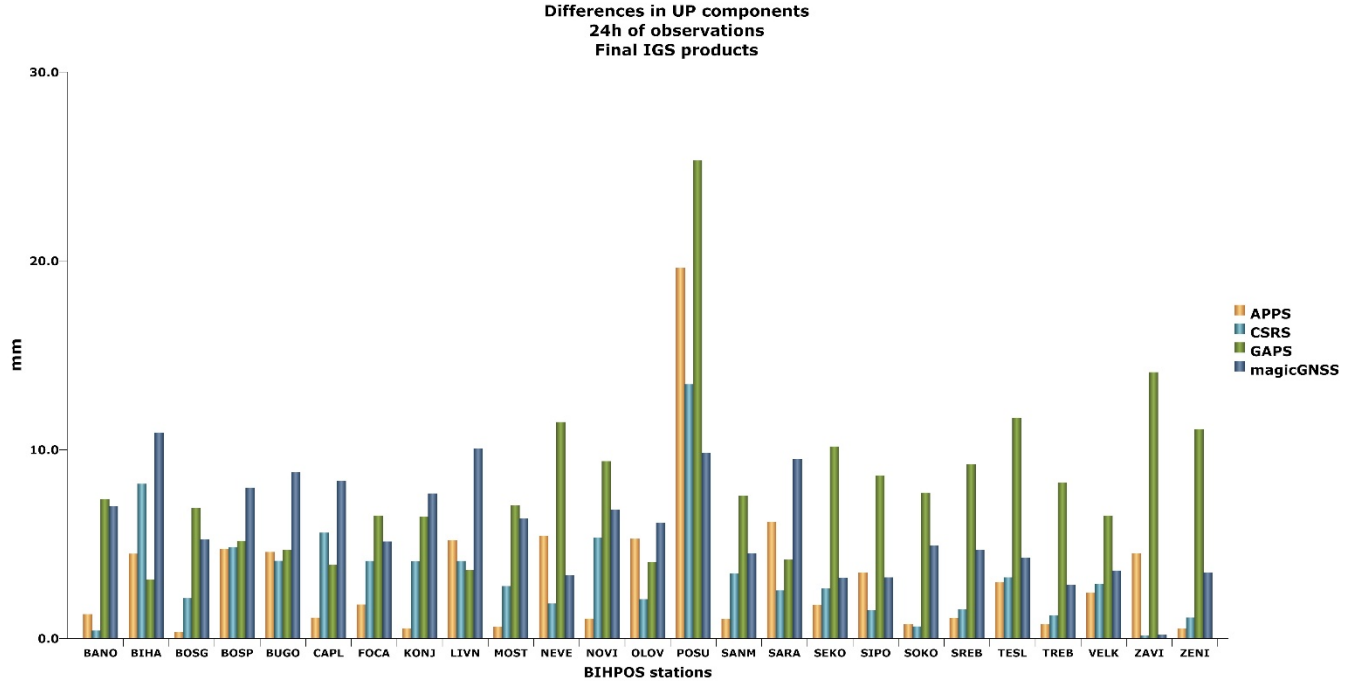
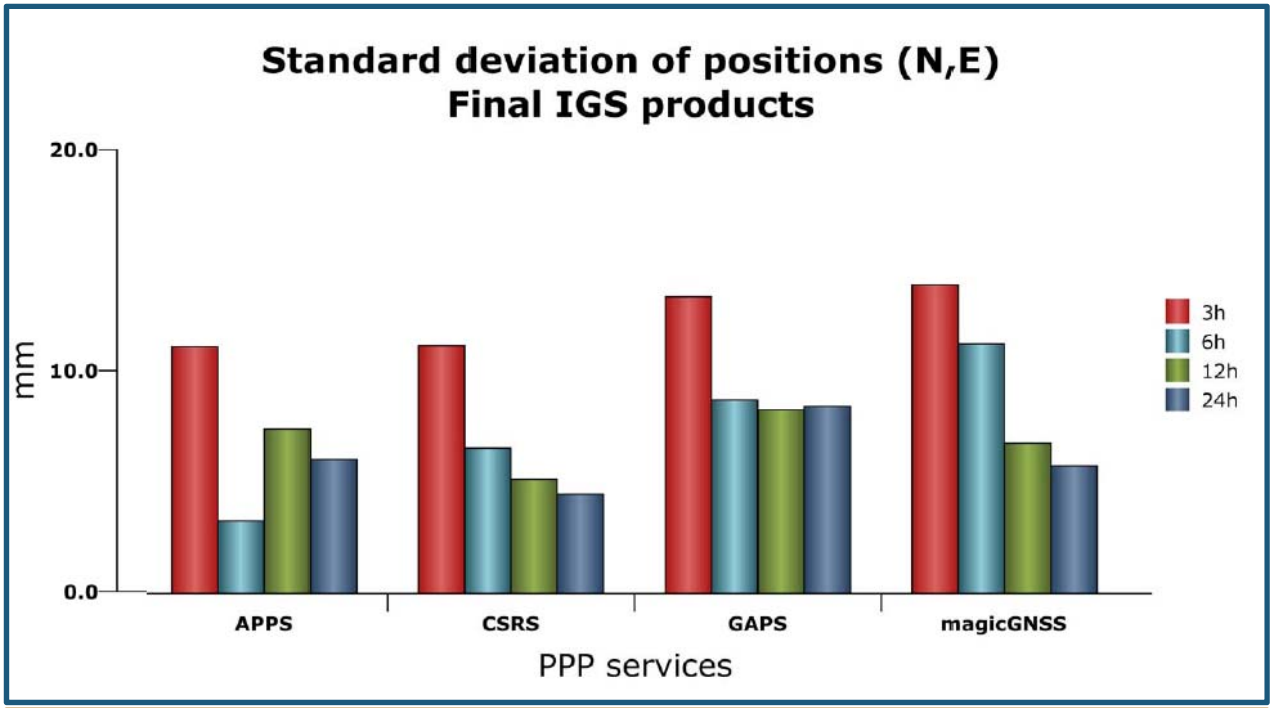
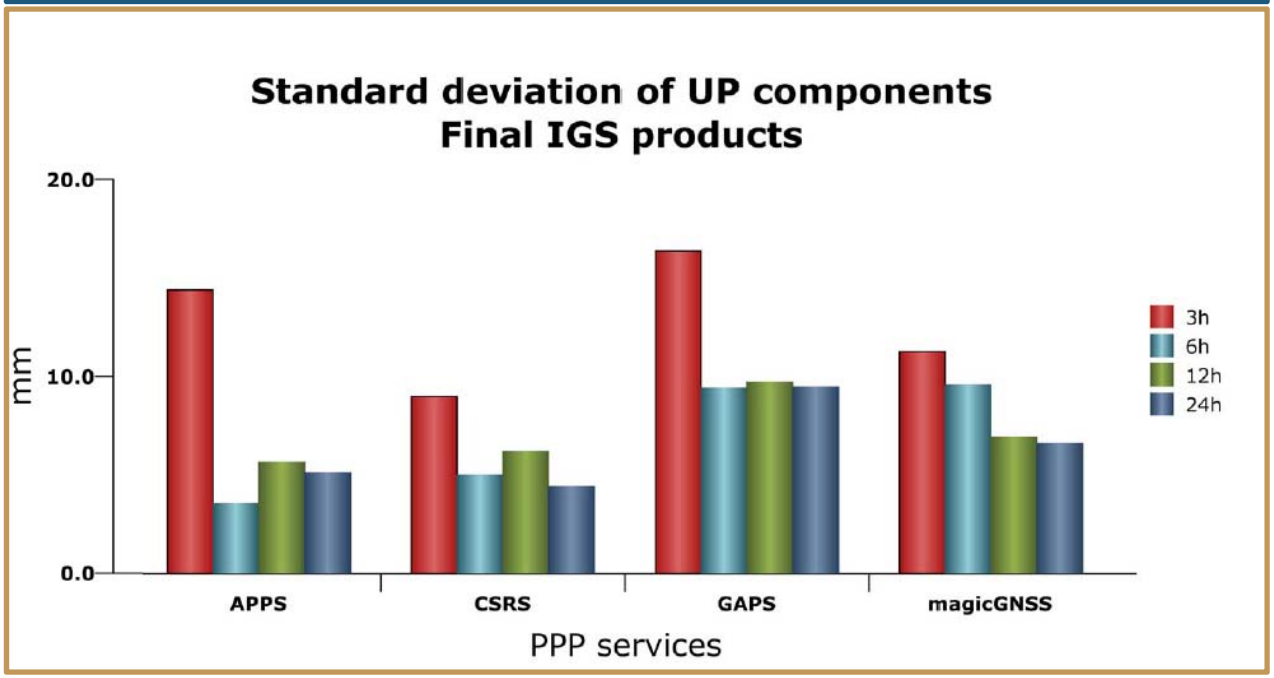
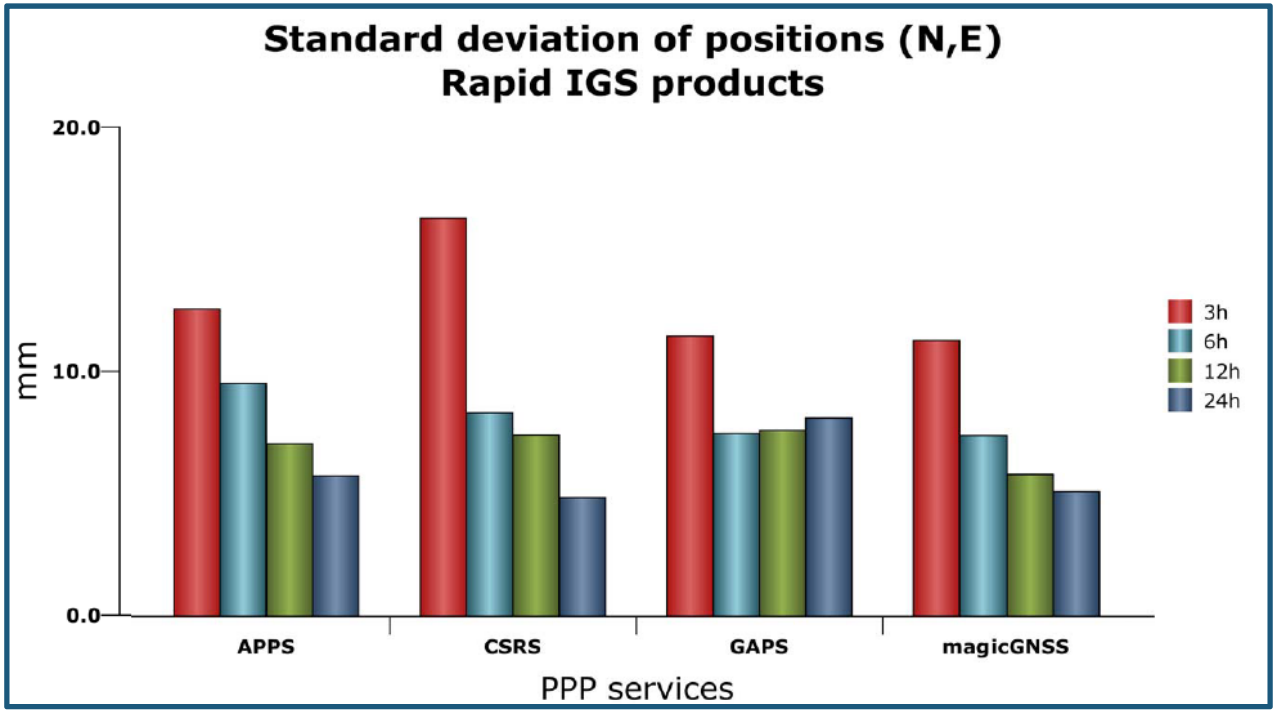
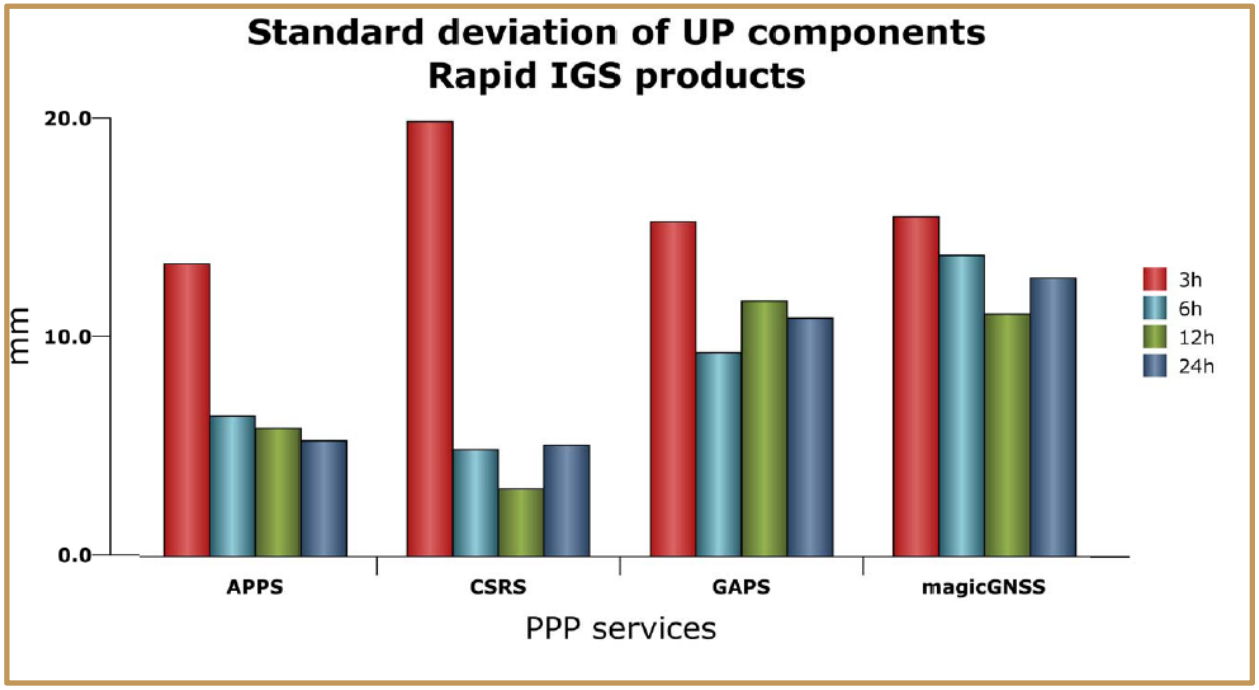
GAPS
magicGNSS
BANO BIHA BOSG BOSP BUGO CAPL FOCA KONJ LIVN MOST NEVE NOVI OLOV POSU SANM SARA SEKO SIPO SOKO SREB TESL TREB VELK ZAVI ZENI
BIHPOS stations


Differences in UP components
24h of observations
Final IGS products
30.0
20.0
10.0
0.0
mm
APPS
CSRS
GAPS
magicGNSS
BANO BIHA BOSG BOSP BUGO CAPL FOCA KONJ LIVN MOST NEVE NOVI OLOV POSU SANM SARA SEKO SIPO SOKO SREB TESL TREB VELK ZAVI ZENI
BIHPOS stations


Standard deviation of positions (N,E)
Final IGS products
20.0
10.0
0.0
mm
3h
6h
12h
24h
APPS
CSRS
GAPS
magicGNSS
PPP services


Standard deviation of UP components
Final IGS products
20.0
10.0
0.0
mm
3h
6h
12h
24h
APPS
CSRS
GAPS
magicGNSS
PPP services


Standard deviation of positions (N,E)
Rapid IGS products
20.0
10.0
0.0
mm
APPS
CSRS
GAPS
magicGNSS
PPP services
3h
6h
12h
24h


Standard deviation of UP components
Rapid IGS products
20.0
10.0
0.0
mm
APPS
CSRS
GAPS
magicGNSS
PPP services
3h
6h
12h
24h

Conclusions

- **Standard deviations** of the BIHPOS stations coordinates show that PPP services provide the similar accuracy **(cm level)** after one day of observation.
- **Similar results** was sown for the observation intervals of **12 and 6 hours**.
- Pretty good results also archived when rapid products used.
- Not allways necessary to wait for final products to be available.

- **The investigation need to be continued, but for multiple DOY and:**
  - Shorter intervals need to be processed: **0.5 h, 1 and 2 hours,**
- IGS RTS service,
- Kinematics mode.

- Free on line PPP services are good opportunity for sciencis and professional from developing counties:
  - **No investment in GNSS software procesing.**
  - **Only one receiver nedeed.**
  - **Not to have reference network.**

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Thank you for your attantion!

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