Bundesamt für
Kartographie und Geodäsie

I. Introduction

Using real-time GNSS satellite and receiver clock corrections, as processed within the IGS Real-Time Pilot Project, coordinate estimation via Precise Point Positioning (PPP) in real-time is becoming a more and more used tool. On the other hand, with a known (and fixed) receiver position the tropospheric zenith path delay (ZPD) can be estimated in real-time for use in numerical weather prediction or now-casting.

By using the latest version of the BKG Ntrip Client (BNC) the poster shows

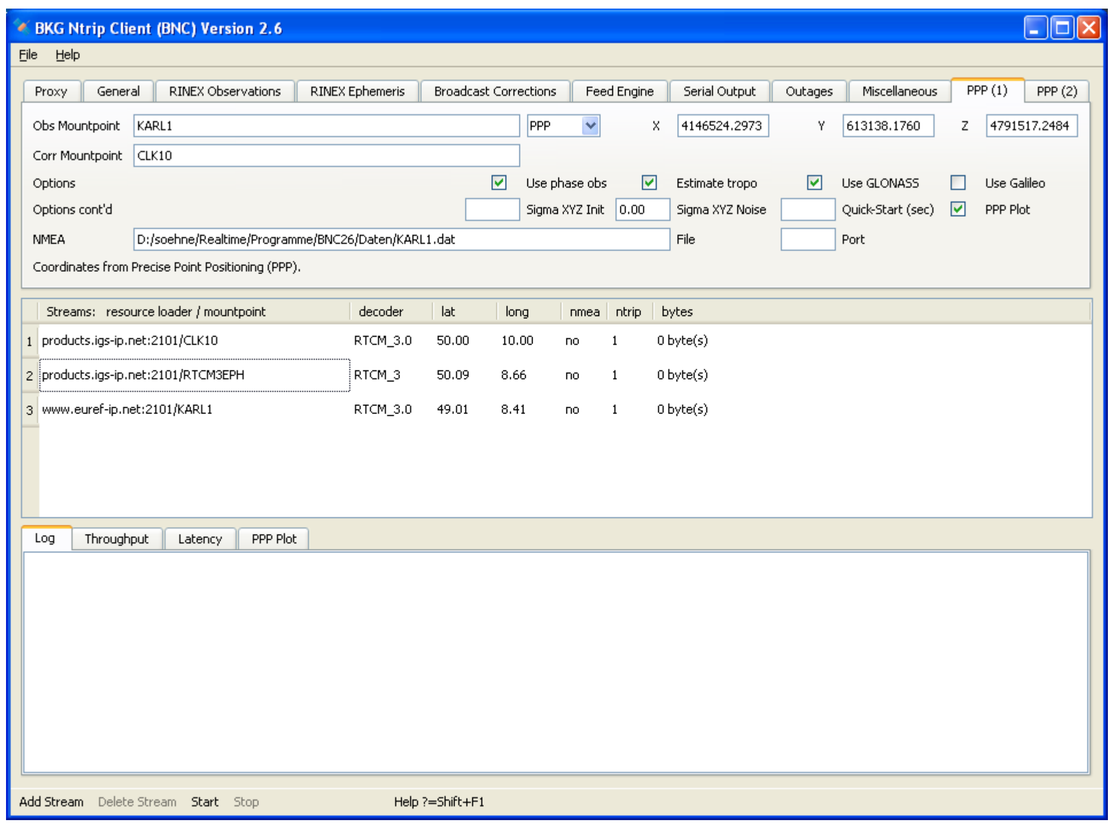
- Results of real-time PPP techniques in static mode
- Quality of tropospheric zenith path delays derived from real-time PPP compared to post-processed results (near real-time)
- Application of a ‘Quick-Start’ mode to shorten the convergence time of real-time PPP in kinematic application.

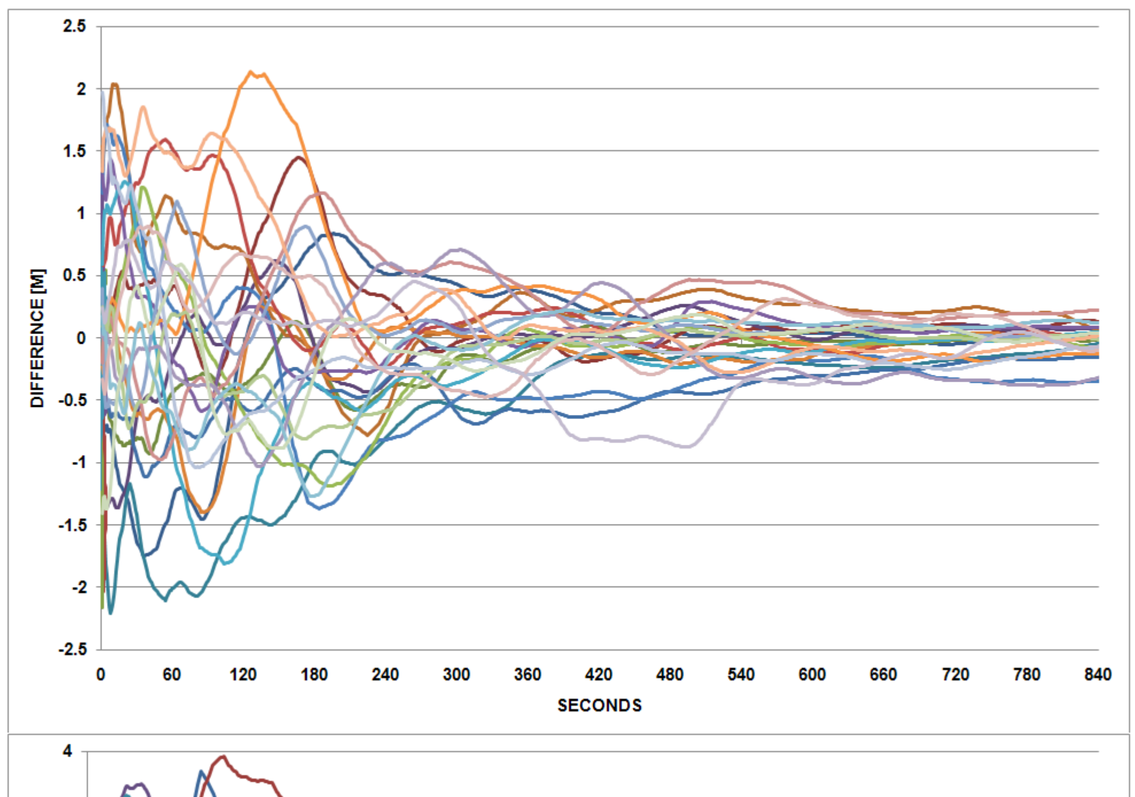
BKG Ntrip Client

The BKG Ntrip Client (BNC) has been developed by BKG and TUP since 2006 for real-time data & product streaming, using the Ntrip technology. Starting with version 2.0 one year ago, a precise point positioning (PPP) modul has been integrated. Through various options to be selected within the menu different modes can be run, e.g., static and kinematic, e.g., starting with or without known coordinates.

II. RT PPP in static mode

RT PPP in static mode is used at BKG for monitoring purposes (http://igs.bkg.bund.de/ntrip/ppp). Several scenarios have been set up to continuously evaluate the various orbit and clock correction streams of the IGS-RT PP. Figure 1 shows the PPP menu while measuring in static mode without starting with known coordinates.





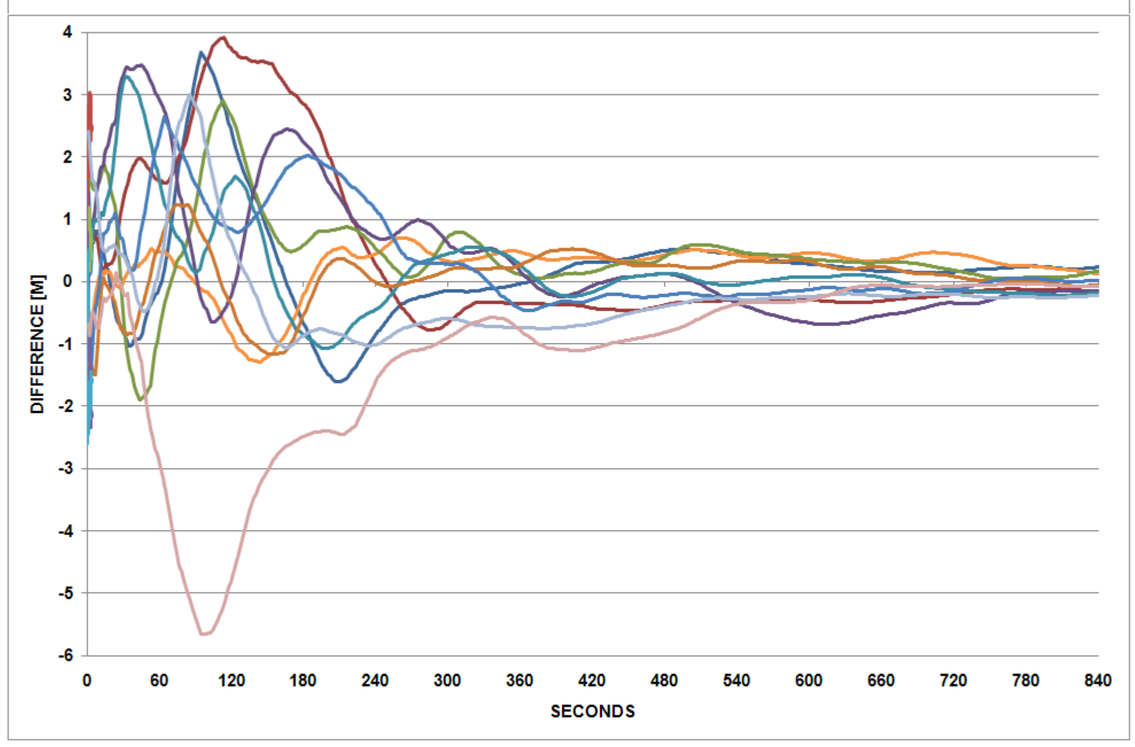


Figure 1 (up):
- Menu of BNC for PPP application
- static mode indicated by Sigma XYZ Noise = 0.00
- without known coordinates is indicated by Sigma XYZ Init = default (i.e, +/- 100 m)

Figure 2 (right):
- Time series of PPP solutions for 14 consecutive 15 minutes runs, in North and East (top) and Up
- Station KARL, differences to reference coordinates
- Convergence to less than one meter after less than five minutes

Quality of Positioning and Tropospheric Zenith Path Delays Derived by Real-Time PPP

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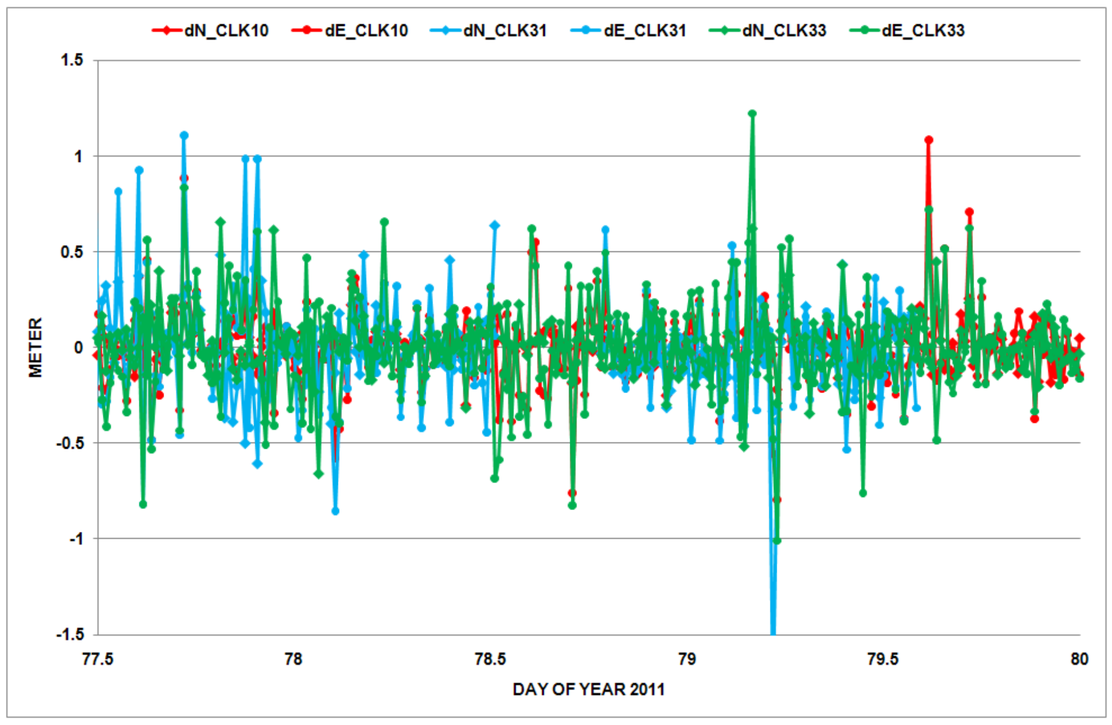

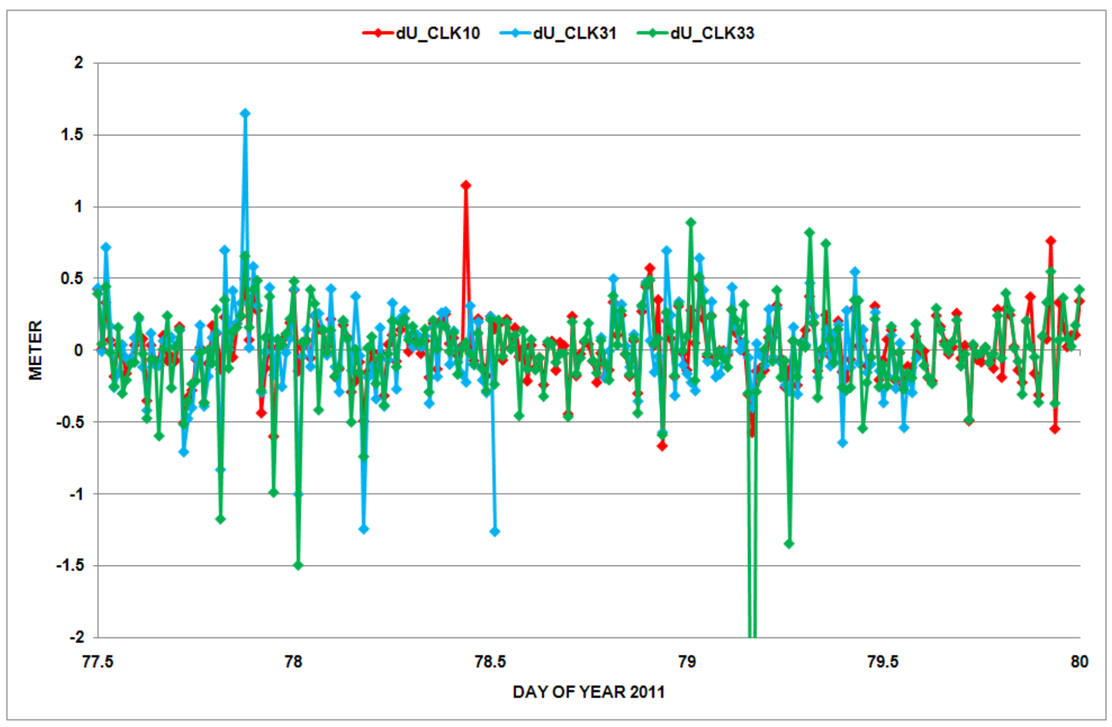

Figure 3:
• PPP with BNC26 for station KARL using three clock corrections:
– CLK10 (individual contribution from BKG),
– CLK31 (combined solution from IGS-RT PP) and
– CLK33 (combined solution with BNC)
• Differences to reference coordinates after 15 minutes are displayed for North and East (left) and Up

	X		Y		Z	
Parameter settings	Mean [m]	Stdev [m]	Mean [m]	Stdev [m]	Mean [m]	Stdev [m]
A: EstimateTropo=yes, pppSigTrpP=1e-5, pppSigTrpP=0.00, GPS	+0.06	0.19	+0.01	0.19	+0.08	0.13
B: EstimateTropo=yes, pppSigTrpP=1e-6, pppSigTrpP=0.00, GPS	+0.06	0.19	+0.01	0.19	+0.08	0.13
C: EstimateTropo=yes, pppSigTrpP=1e-5, pppSigTrpP=0.00, GPS+GLO	+0.01	0.15	+0.02	0.17	+0.03	0.12
D: EstimateTropo=yes, pppSigTrpP=1e-6, pppSigTrpP=0.00, GPS+GLO	+0.01	0.15	+0.02	0.17	+0.03	0.12
E: EstimateTropo=no, pppSigTrpP=0.00, GPS	+0.16	0.16	+0.02	0.17	+0.19	0.11
F: EstimateTropo=no, pppSigTrpP=0.00, GPS+GLO	+0.13	0.14	+0.02	0.16	+0.15	0.10

Table 1:
• Mean differences and standard deviations over 134 BNC PPP runs of 15 minutes each. The different PPP parameter settings are explained in column 1
• The usage of GPS+GLO shows slightly better results than GPS only
• Without estimating troposphere parameters simultaneously (i.e., „Estimate tropo“ in Figure 1 not chosen) a significant bias in the height component is induced

	North		East		Up	
Mountpoint, clock correction	Mean [m]	Stdev [m]	Mean [m]	Stdev [m]	Mean [m]	Stdev [m]
KARL1,CLK10	+0.01	0.10	+0.00	0.23	+0.02	0.22
KARL1,CLK31	-0.00	0.18	-0.01	0.31	+0.02	0.33
KARL1,CLK33	+0.01	0.15	+0.00	0.28	+0.00	0.30
FFMJ1,CLK10	-0.00	0.11	+0.02	0.25	+0.02	0.24
FFMJ1,CLK31	-0.02	0.17	+0.00	0.28	-0.00	0.30
FFMJ1,CLK33	+0.00	0.15	+0.02	0.30	+0.00	0.30

Table 2:
• Mean differences and standard deviations over 125 BNC PPP runs of 15 minutes each. Used clock corrections explained in Figure 3
• Usage of individual solution shows better results than using combined solutions
• possible reason: combined solutions have (more) periods of outages or are too much delayed to be used in BNC

III. Kinematic PPP

For kinematic applications one usually has to wait some minutes of initialisation time before starting to move. This drawback can be overcome in BNC, when starting at a known station, using a so-called ‚Quickstart‘ option. Choosing a setting of, let‘s say, 120 seconds allows the PPP solution to rapidly converge after startup.

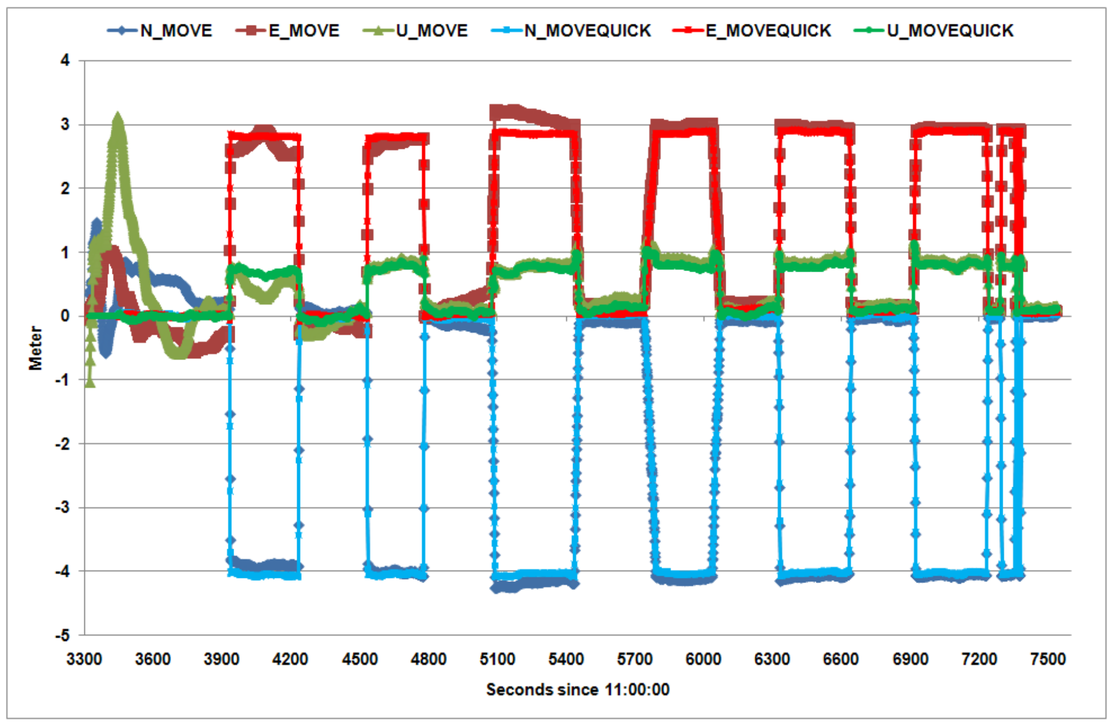

Figure 4:
• Moving antenna between two concrete markers (distance: 5 m) with and without ‚Quickstart‘ option
• Differences in NEU to reference coordinates of first station
• Different behaviour during initialisation phase with or without using fixed coordinates can be clearly seen
• Using ‚Quickstart‘ leads to lower repeatability at the consecutive markers as well
• Coordinate repeatability at remote station (over six sections), NEU in [m]:
• without ‚Quickstart‘: 0.11 / 0.16 / 0.14
• with ‚Quickstart‘: 0.07 / 0.06 / 0.06

IV. ZPD estimation

Likewise estimating ZPD while fixing the coordinates for numerical weather prediction in NRT applications, BNC allows to fix the coordinates of the station by choosing small or zero settings for ‚Sigma XYZ' (see Figure 1).

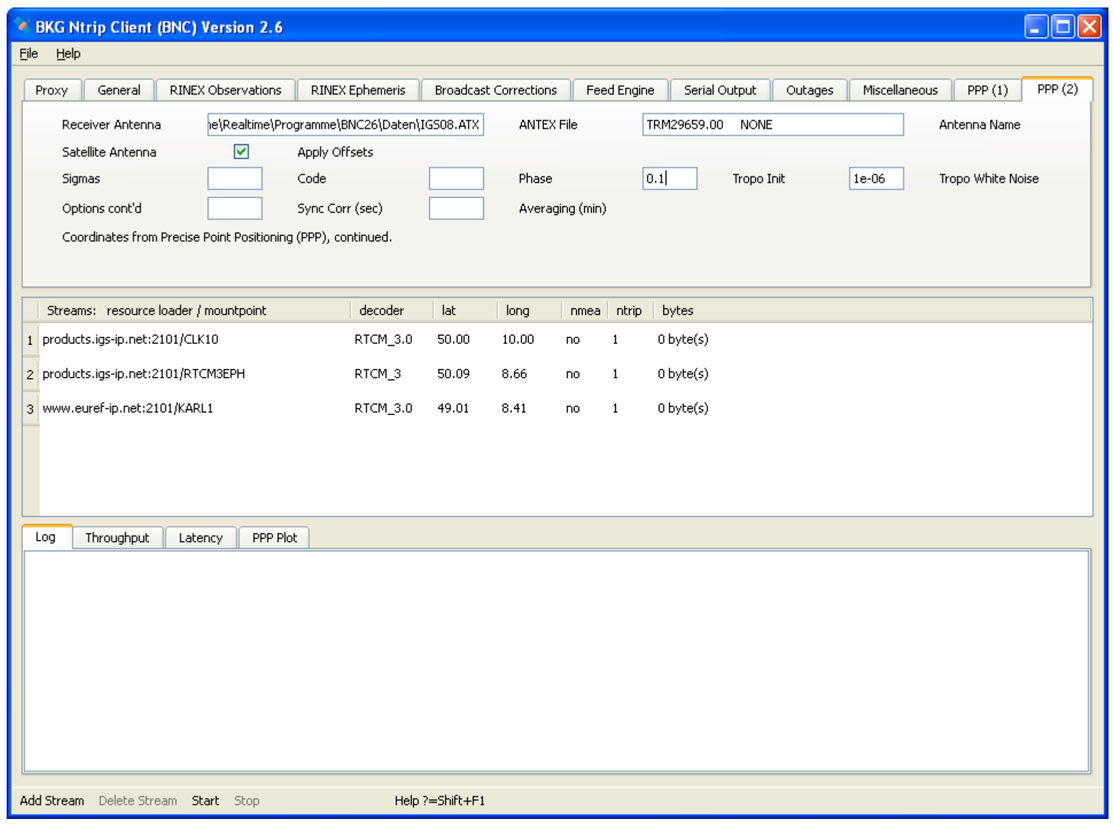

Figure 5: Menu of BNC for PPP application; choosing of appropiate values for Tropo initialisation and white noise combined with fixing coordinates (see Figure 1) allows individual estimation of zenith total delay parameters.

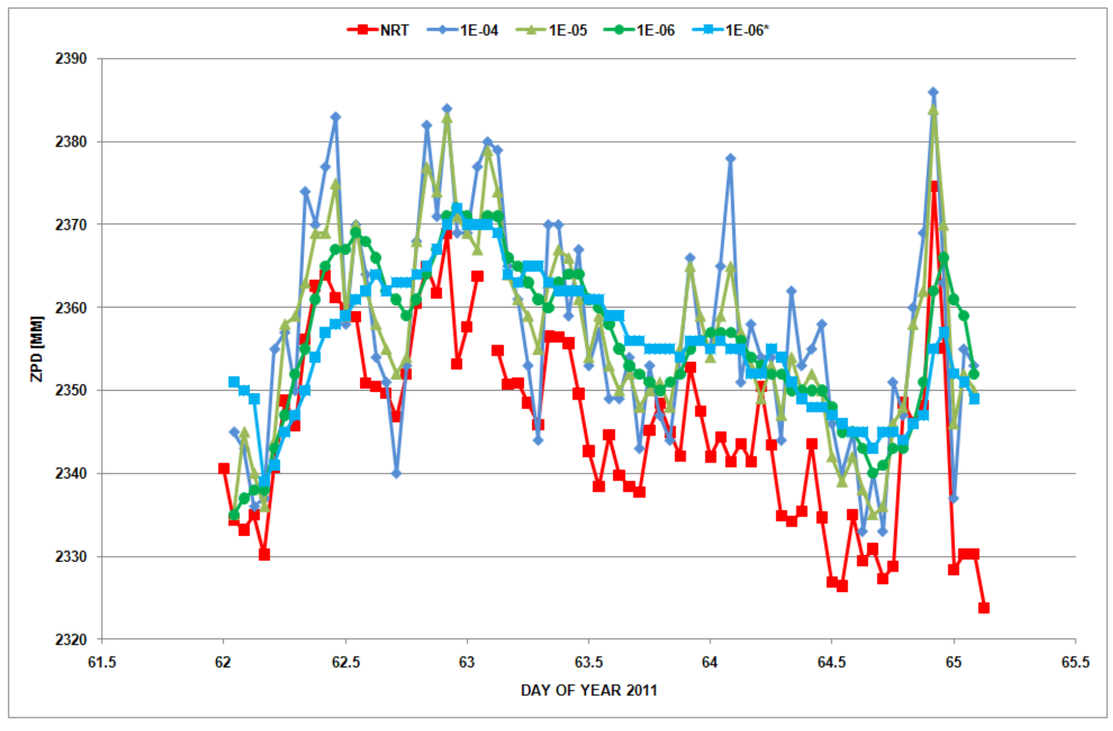

Figure 6: ZPD estimates from BNC26 for station KARL using clock corrections CLK11 (GPS+GLO) and different settings for tropo white noise, compared to NRT results
Smoothing effect when constraining with 1e-06 (or less)
* solution without fixing the coordinates

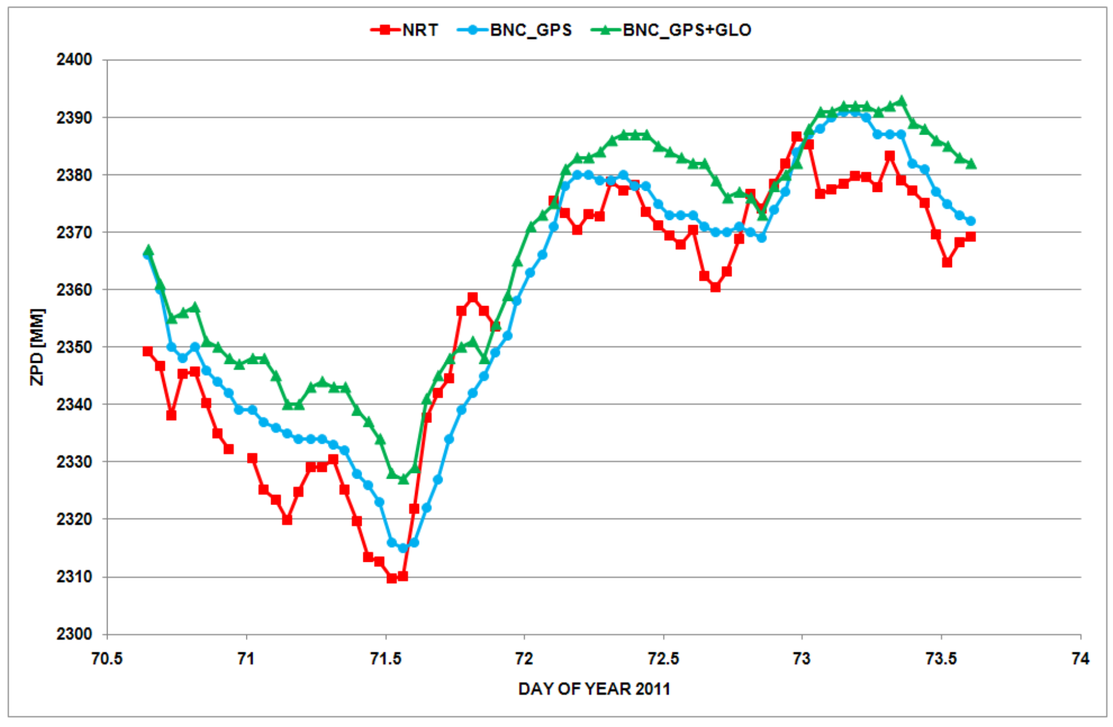

Figure 7: ZPD estimates from BNC26 for station KARL using clock corrections CLK10 (GPS) and CLK11 (GPS+GLO)
Both RT curves follow the NRT values with a small time delay and a bias of ~ 10-15 mm ZPD

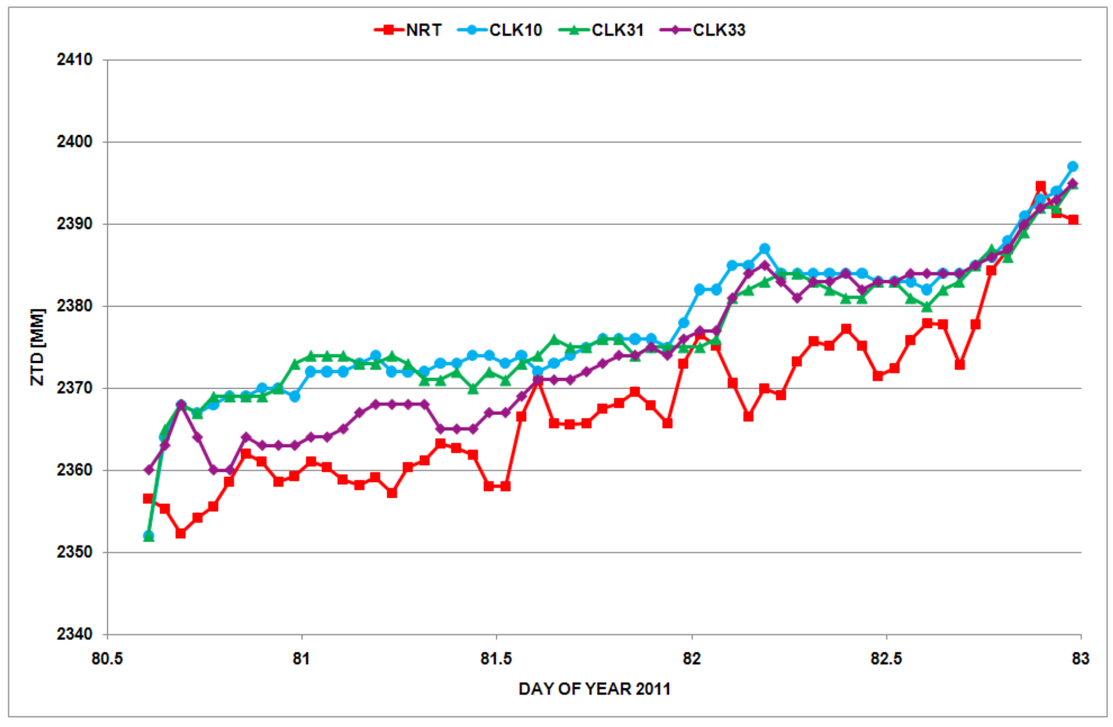

Figure 8: ZPD estimates from BNC26 for station KARL using clock corrections CLK10 (individual contribution from BKG), CLK31 (combined solution from IGS-RT PP) and CLK33 (combined solution with BNC)
All RT solutions agree on a < 10 mm ZPD level but combined solutions have more periods of outages (not shown here)

V. Conclusions

- Accuracy of RT PPP using BNC and IGS-RT PP orbit & clock corrections better than few dm after less than 15 minutes observation (convergence) time
- Quickstart option reduces initialisation and convergence time significantly
- Currently, usage of individual clock correction stream showing better results than with combined clock correction → needs increasing robustness of clock combination
- Usage of GNSS seems to improve performance and results compared to GPS only