Assessment of Single Epoch Integer Precise Point Positioning

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Single Epoch IPPP using CNES-CLS IGS AC products

Due to recent improvements in ambiguity fixing at the zero difference level ([1]), the Precise Point Positioning (PPP) technique became an alternative to the classical differential approach. We call it Integer IPPP (IPPP). In particular, **Single Epoch IPPP** is a powerful method for geosciences applications, atmosphere monitoring, time transfer, and mobile tracking.

Single Epoch IPPP solutions are computed using a modified version of the GINS software. We implemented a Kalman based module dedicated to the computation of High frequency Single Epoch IPPP (e.g. 1Hz) solutions. WSB and GRG satellite products ([2]) are included into the input files, as presented in Figure 1.

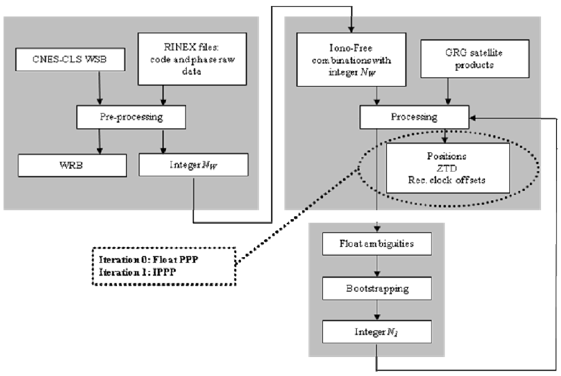

Figure 1. Procedure used to compute IPPP solutions using CNES-CLS WSBs and GRG satellite products.

Precision of Single Epoch IPPP Solutions

Data coming from a global network of ~150 IGS stations have been processed every 30s during 15 consecutive days. 24h batch solutions are independent. The processing follows standard parameterizations recommended by the 2010 IERS Conventions. Positions and receiver clocks are estimated every 30s and considered as white noise while ZWDs are estimated every 2h using a piecewise linear model. **About 95% of ambiguities over the whole network have been fixed to integer values.** Figure 2 presents RMS of Single Epoch IPPP solutions.

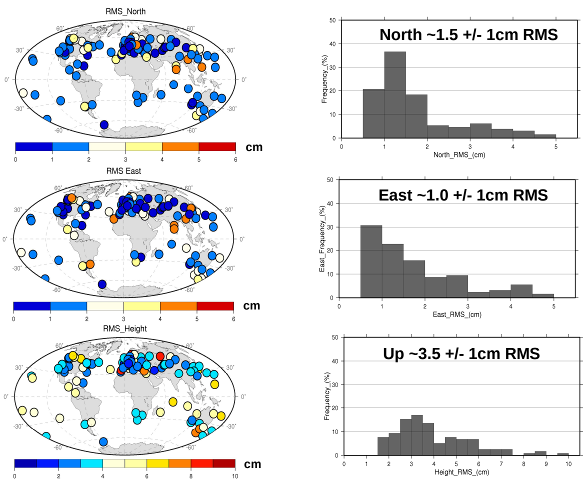

Figure 2. RMS on North (top), East (middle), and Height (bottom) of 30s Single Epoch IPPP solutions over 15 days. Solutions uses CNES-CLS WSBs and GRG satellite products (technique described in Figure 1).

Benefits of fixing ambiguity for Single Epoch IPPP Solutions

Figure 3 presents typical results over 24h (UNS3 IGS station). **Fixing ambiguity guarantees 1) continuity of time series at batch boundaries and 2) lower RMS than Float PPP.** However, **IPPP Height time series are still corrupted by remaining signals.**

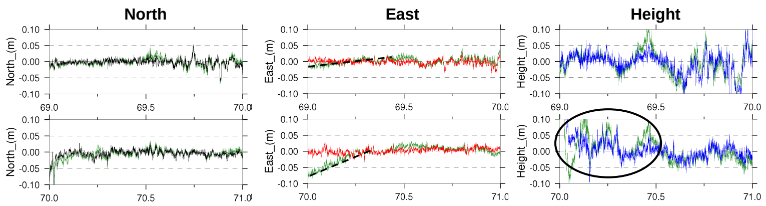

Figure 3. Typical Single Epoch Float PPP (green curves) and IPPP solution (black, red, and blue curves) over 24h.

References

[1] Laurichesse, D., Mercier, F., Berthias, J.P., Broca, P., Cerri, L., Integer Ambiguity Resolution on Undifferenced GPS Phase Measurements and Its Application to PPP and Satellite Precise Orbit Determination, Navigation, Journal of the Institute Of Navigation, 56(2), 135-149, 2009.

[2] Loyer, S., Perosanz, F., Mercier, F., Capdeville, H., Marty, J.C., GPS products from the CNES-CLS IGS Analysis Center, Zero difference GPS ambiguity resolution, J. Geod., doi:10.1007/s00190-012-0559-2, in press, 2012.

[3] Fund, F., Perosanz, F., Testut, L., Loyer, S., An Integer Precise Point Positioning Technique for Sea Surface Observations Using a GPS Buoy, submitted to Advances in Space Research, 2012.

Correlations between parameters in IPPP solutions

We derived correlations coefficients using the first member of IPPP normal matrix. We used a real GPS orbit coverage. Despite of changes in satellite availability, we found that **correlation coefficient are constant over 24h at a 5% variability.** Figure 4 presents mean correlation coefficients between East, North, Height, ZWD, and receiver clock biases when processing GPS data at the zero-difference level in IPPP mode using a 10° cutoff elevation angle.

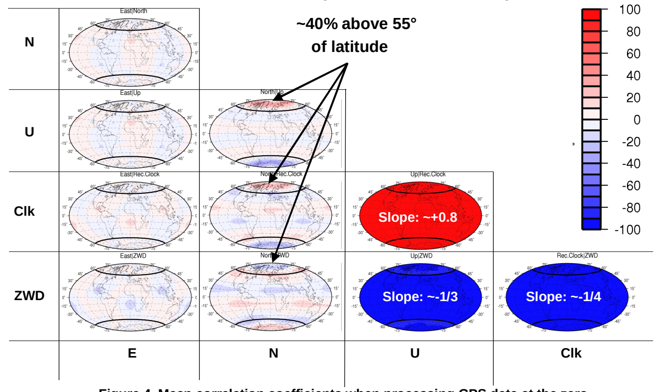

Figure 4. Mean correlation coefficients when processing GPS data at the zero-difference level in IPPP mode and a 10° cutoff angle.

<u>Impacts of correlations on a short baseline: USN0-USN3</u>

USN0 and USN3 stations are equipped with the same models of receiver/antenna and clocks (5MHz H-MASER). We calculated **Differential IPPP solutions (DIPPP)** over the USNO-USN3 short baseline to see if errors impacts similarly at both stations. We constrained the number of observations used at each epoch in both computations to be equal. We found similar results when using OHI2-OHI3 and TSKB-TSK2 short baselines. Figure 5 presents Differential IPPP results of North, East, and Up components over 2 days. Differential IPPP time series of ZWDs and receiver clocks estimates are also plotted.

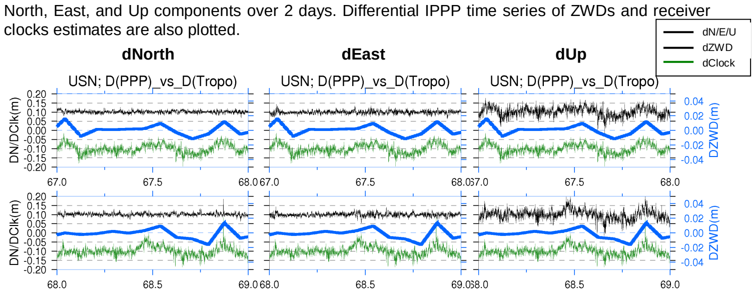

Figure 5. Differential IPPP results of North (left), East (middle), and Up (right) components of the USN0-USN3 baseline over 2 days (black curves). Differential IPPP results of ZWDs (blue curves) and receiver clocks (green curves) are also plotted.

DIPPP results of North and East components are similar to one would obtain using classical single or double differences techniques. Due to the correlations between ZWD, receiver clocks and Up components (Figure 4), **DIPPP results of the Up component are not equal at both sites.** Single or double differences techniques would give better time series because ZWD would not be estimated (an implicit constraint of equality would be used). Here, **tropospheric errors on IPPP time series introduces errors up to 5cm on the Up component!**

<u>Behavior of Differential IPPP series of the Up component over two weeks</u>

We investigated the behavior of DIPPP series of the Up component over 13 consecutive days. We applied a Vondrak filter to separate high and low frequencies in that series. Results are presented in Figure 6.

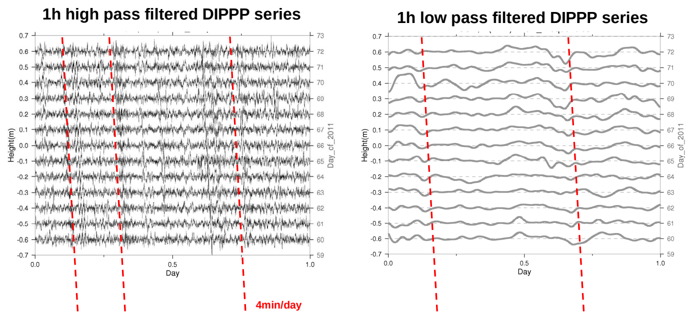

Figure 6. 1h high-pass (left) and 1h low-pass (right) filtered DIPPP series of the Up component of the USN0-USN3 baseline over 13 days.

Signatures on high pass filtered series looks like to multipath. Several spurious peaks appear every sidereal day. Low pass filtered series do not appear to be dependent to satellite geometry as those on high pass filtered series. These signature remain unclear but we assume that they can come from differences in receiver clock behaviors at both stations. **We think that any zero-difference processing require consistent constraints on positions and/or ZWD estimated with the expected signal.** We found the same problem with DIPPP Up series of a GPS buoy calculated with respect to a close GPS static station ([3]). The same equipment (receivers/antennas) was also used.