Zero-difference ambiguity fixing for PPP

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Abstract

Now, new algorithms and processing techniques are available to isolate the zero-difference GNSS ambiguities as integer values, which have improved the accuracy and consistency of the GNSS positioning.

Since 2009, the CNES/CLS IGS analysis center begins to provide corresponding new GPS satellite clocks data ('GRG' phase clock solution and widelane satellite biases).

With these new clock products, the positions of the IGS ground stations are determined by applying zero-difference ambiguity fixing method. The accuracy are analyzed and compared with the traditional PPP methods. In addition, the influential factors to the ambiguity fixing success rate are discussed in detail.

Introduction

The Fixing of the integer phase ambiguities is the key to improve high-precision for the GNSS positioning, which has been widely applied in the traditional double-difference positioning mode.

Compared with the double-difference processing method, the PPP (Precise Point Positioning) technique, which processes the undifferenced observations, has great advantages, especially for long-distance positioning. And the integer ambiguity fixing for zero-difference observations, is the key to improve the accuracy and shorten the convergence time of the PPP technique.

During the past several years, the reason that why the floating ambiguity can't be fixed to integers has been revealed and several different algorithms, which are equivalent in theory, are put forward to fix the zero-difference ambiguities. And from 2009, the CNES/CLS IGS analysis center begin to provide the widelane biases and integer phase clock products, which can be used to fix the widelane and narrowlane ambiguities for the zero-difference positioning.

In this paper, we will use the products from the CNES to fix the ambiguities in the PPP and some experiment results are outlined.

Equation

The pesudorange and phase observations are modeled as the following:

$$P_1 = \rho + T + \quad I + c(dt^r - dt^s) + b^r_{P_1} - b^s_{P_1} + \epsilon_{P_1}$$
$$P_2 = \rho + T + \gamma I + c(dt^r - dt^s) + b^r_{P_2} - b^s_{P_2} + \epsilon_{P_2}$$
$$\lambda_1(\Phi_1 + N_1) = \rho + T - \quad I + c(dt^r - dt^s) + b^r_{L_1} - b^s_{L_1} + \epsilon_{L_1}$$
$$\lambda_2(\Phi_2 + N_2) = \rho + T - \gamma I + c(dt^r - dt^s) + b^r_{L_2} - b^s_{L_2} + \epsilon_{L_2}$$

where: $\gamma = \left(\frac{f_1}{f_2}\right)^2 \quad \lambda_1 = \frac{c}{f_1} \quad \lambda_2 = \frac{c}{f_2}$

c is light speed , f_1, f_2 are the frequency of L_1, L_2 band of GPS.
T, I is tropospheric and ionospheric delays
dt_r, dt_s is the clock for the receiver and satellite respectively
b^r_*, b^s_* is the biases for the receiver and satellite on the * frequency
N_1, N_2 is the integer ambiguity for the two phase observable.

Actually, the raw observation can't be solved directly because the parameters are correlated in them. In order to solve the zero-difference ambiguity, two types of difference combination are applied together, which are the Melboune-Wubbena combination and ionosphere-free combinations.

Melboune-Wubbena combination：

$$MW = -\lambda_w N_w + \mu_i - \mu^j$$

Once the widelane are fixed, then the ionosphere-free combination can be expressed as:

$$P_c = \rho + T + c(dt^r_{P_c} - dt^s_{P_c})$$
$$Q_c = L_c + \lambda'_w N_w = \rho + T + c\left(dt^r_{L_c} - dt^s_{L_c}\right) - \lambda_c N_1$$

Experiments

Estimation

- ◆ receiver position (x, y, z) , and receiver clock (dt)
- ◆ tropospheric delay
- ◆ integer ambiguities

Ambiguity Fixing

- ◆ One satellite's ambiguity is forced to any integer, commonly zero, according to the elevation.
- ◆ Ambiguity rounding method from (Dong and Bock, 1988),
- ◆ LAMBDA method.

Data Sets

- ◆ Widelane biases and integer phase clock products are from CNES website: http://www.ppp-wizard.net/links.html
- ◆ The GPS data are from the IGS tracking stations BRUS and POTS on 03.02, 2011

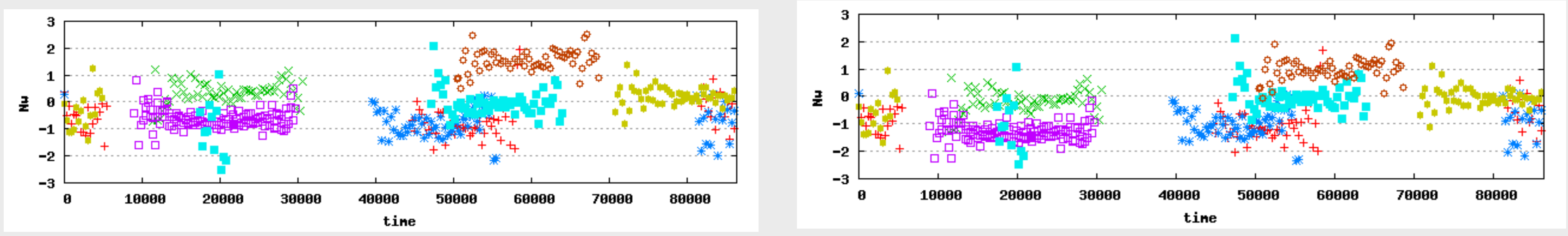

Fig.1 Comparison of raw Nw (left) and the Nw corrected by widelane biases(right)

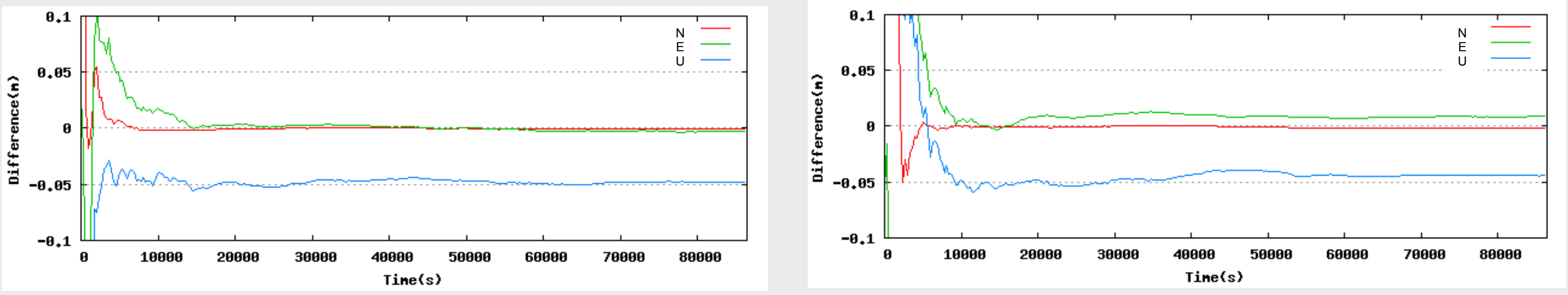

Fig.2 Static PPP for BRUS station with float (left) and fixed ambiguity (right)

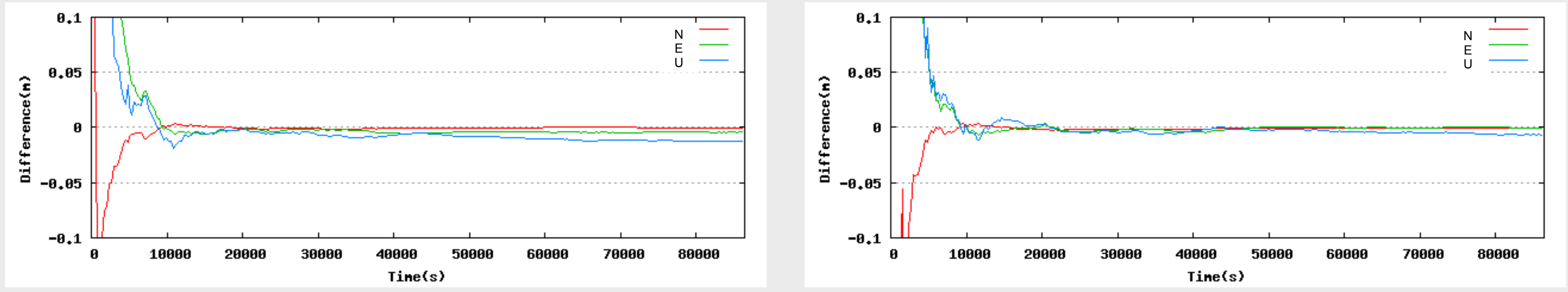

Fig.3 Static PPP for POTS station with float (left) and fixed ambiguity (right)

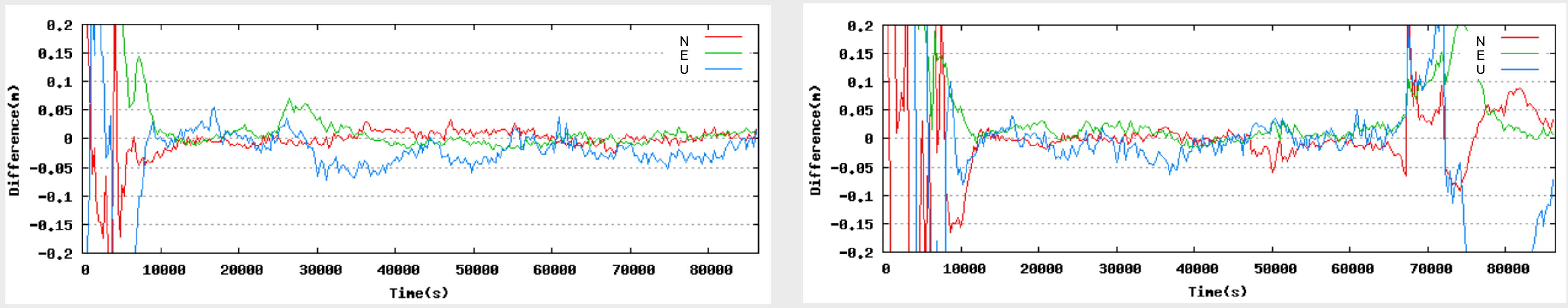

Fig.4 Kinematic PPP for POTS station with float (left) and fixed ambiguity (right)

Conclusions

- ✓ The raw Nw values computed from Melboune-Wubbena combination usually doesn't near an integer, after correcting the widelane biases, it is evident that the Nw can be fixed to integers
- ✓ For the static PPP, the solution with fixed ambiguities converge faster than the float ones, but there are no evident improvement.
- ✓ In theory, the solution with fixed ambiguity will be better than the float ones, but the results from the BRUS station are different, which may be caused by wrong ambiguity fixing.
- ✓ For the kinematic PPP, the convergence time is longer than the float ones, but once the ambiguities are fixed, the solution have evident improvement (see figure 4)

References

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