Research on Real-time Precise Point Positioning Algorithm Based on Broadcast Ephemeris and Global Reference Network

Fei Ye (1,2), Yunbin Yuan(1), Baocheng Zhang(1) and Wei Yan(3)

(1)State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Wuhan, China
(2)University of Chinese Academy of Sciences, Beijing, China
(3)Tianjin Institute of Surveying and Mapping, Tianjin, China

feiye@whigg.ac.cn

yybgps@whigg.ac.cn;
b.zhang@whigg.ac.cn;
yanweigps@hotmail.com

Real-time-11

Introduction

The traditional real-time precise point positioning (PPP) algorithm requires real-time orbit and clock products based on worldwide reference stations. Among them, real-time orbit products are usually predicted by precise orbit products, and the irregular motion of the satellite will reduce the accuracy and reliability of the predicted orbit products. In order to get rid of the dependence on the predicted orbit products and reduce the strong correlation between user location, satellite orbit and clock parameters. We use the joint solution on broadcast ephemeris, user station and global evenly distributed reference network, which can real-time estimate user location, satellite orbit and clock correction parameters. Moreover, satellite orbit and clock correction parameters can broadcast to other users to achieve PPP algorithm. In this poster, the following four parts will be presented.

Model and Method

For a satellite s observed by receiver r, the Ionosphere-Free Combination (IF) after linearization for code and carrier phase observation equations can be expressed:

$$P_{r,IF}^{s}=-\mu_r^s\cdot\Delta r+\mu_r^s\cdot\Delta s+cdt_r-cdt^s+M_r^s\cdot zpd_r+\varepsilon_{P_{IF}}$$

$$L_{r,IF}^{s}=-\mu_r^s\cdot\Delta r+\mu_r^s\cdot\Delta s+cdt_r-cdt^s+M_r^s\cdot zpd_r+A_r^s+\varepsilon_{L_{IF}}$$

Where,

$$cdt_r=cdt_{r,P_{IF}}$$

$$cdt^s=cdt_{P_{IF}}^s$$

$$A_r^s=A_{r,IF}^s+cdt_{r,L_{IF}}-cdt_{r,P_{IF}}-cdt_{L_{IF}}^s+cdt_{P_{IF}}^s$$

$P_{r,IF}^s$ and $L_{r,IF}^s$ are the observation residuals of the code and phase ionosphere-free combination, respectively; μ_r^s, Δr and Δs are the line-of-sight vectors, correction vectors of station coordinate and satellite orbit, respectively; $A_{r,IF}^s$ is the phase ionosphere-free combination ambiguity; $cdt_{r,P_{IF}}$ and $cdt_{P_{IF}}^s$ are the clock errors of receiver and satellite for code observation, respectively, which include signal delay; $cdt_{r,L_{IF}}$ and $cdt_{L_{IF}}^s$ are clock errors of receiver and satellite for phase observation, respectively, which include uncalibrated phase delays; $\varepsilon_{P_{IF}}$ and $\varepsilon_{L_{IF}}$ are refer to carrier observation and code observation errors, respectively.

Kalman filter model to a global reference network and user

Parameter nature	Value	Comments
Receiver clock at datum station	0	White noise
Receiver clock at other station	Covariance set to 4e14	
Satellite clock	Covariance set to 4e14	White noise
Zenith troposphere delay	$q=3\times10^{-8}m^2/\sec$	Random walk process
Coordinates at reference station	0	Fixed
Coordinates at static user station	Covariance set to 100	White noise
Coordinates at dynamic user station	Covariance set to 4e14	
Satellite orbit corrections	Covariance set to 100	White noise
Phase ambiguities	Constant (initial covariance set to 4e14)	Ambiguities are constant during a pass

Test and Analysis

To evaluate the effectiveness and reliability of the orbit and clock solutions obtained in the global network using kalman filter, a statistical analysis was performed on a large data set by PPP. Stations measurements and broadcast ephemeris were downloaded from the IGS. Fig.1 displayed their distribution, blue and red represented reference station and user receiver, respectively.

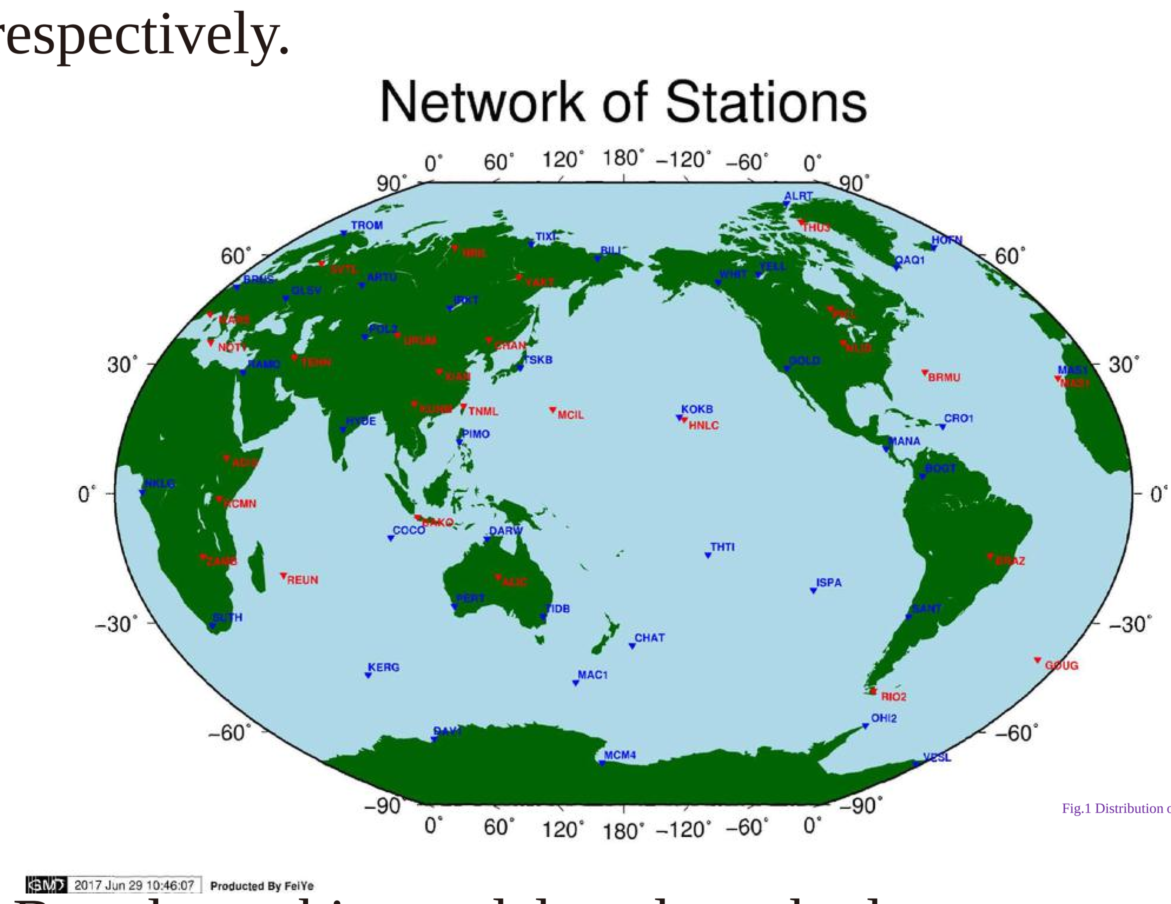

Fig.1 Distribution of reference stations and user stations

Based on this model and method, we processed the data set(2008-03-23) using real time simulation, and compared our positioning results with the coordinates provided by IGS. Fig.2, Fig.3 and Tab.1 showed the static positioning results, and Fig.4, Fig.5 and Tab.2 showed the dynamic positioning results.

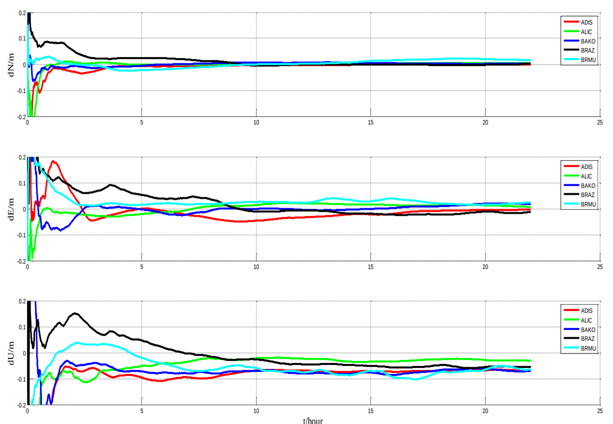
Fig.2 Static positioning results of five user stations

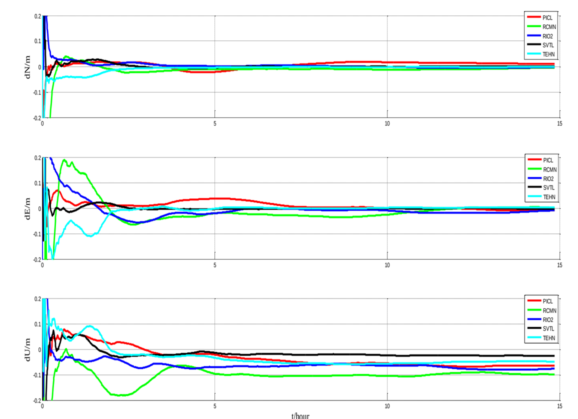
Fig.3 Static positioning results of the other five user stations

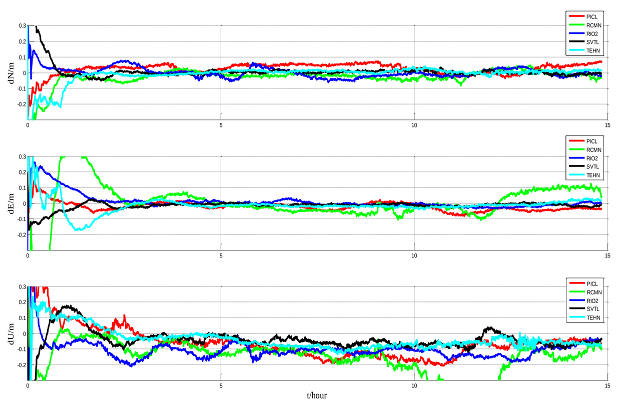

Fig.4 Dynamic positioning results of five user stations

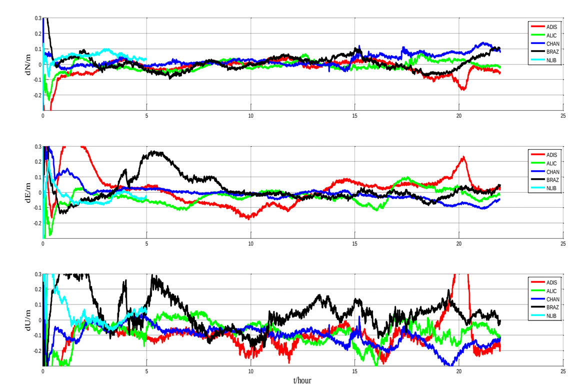

Fig.5 Dynamic positioning results of the other five user stations

	Station	Mean/m			RMS/m		
		dN	dE	dU	dN	dE	dU
Static positioning bias	ADIS	−0.005	−0.020	−0.077	0.007	0.016	0.012
	ALIC	0.003	0.006	−0.036	0.002	0.016	0.020
	BAKO	0.002	0.001	−0.071	0.006	0.012	0.010
	BRAZ	0.007	0.009	−0.018	0.012	0.034	0.050
	BRMU	−0.002	0.023	−0.055	0.003	0.007	0.036
	PICL	0.007	0.008	−0.044	0.004	0.014	0.025
	RCMN	−0.011	−0.022	−0.103	0.004	0.017	0.023
	RIO2	0.000	−0.016	−0.068	0.005	0.013	0.009
	SVTL	0.000	−0.002	−0.022	0.003	0.003	0.004
	TEHN	−0.003	0.000	−0.045	0.002	0.004	0.013
Mean		0.000	−0.001	−0.054	0.005	0.014	0.020

Table.1 Statistics of static positioning results

	Station	Mean/m			RMS/m		
		dN	dE	dU	dN	dE	dU
Dynamic positioning bias	ADIS	−0.015	0.008	−0.083	0.039	0.083	0.147
	ALIC	−0.007	−0.026	−0.070	0.027	0.043	0.065
	CHAN	0.029	−0.020	−0.103	0.037	0.032	0.067
	BRAZ	0.001	0.023	0.030	0.043	0.078	0.093
	NLIB	0.058	−0.042	0.003	0.020	0.028	0.039
	PICL	0.030	−0.024	−0.088	0.026	0.022	0.060
	RCMN	−0.016	0.000	−0.171	0.024	0.058	0.122
	RIO2	−0.002	−0.005	−0.118	0.029	0.014	0.036
	SVTL	0.001	−0.011	−0.051	0.011	0.008	0.027
	TEHN	0.004	−0.012	−0.058	0.012	0.017	0.030
Mean		0.008	−0.011	−0.071	0.027	0.038	0.069

Table.2 Statistics of dynamic positioning results

Results

(1)The static and dynamic real-time positioning bias RMS of the algorithm is about 1-2cm and 10cm, respectively.

(2)Our algorithm can get rid of the dependence on the ultra-ephemeris and reduce the strong correlation between user location, satellite orbit and clock parameters.