The Analysis of Strategies for BDS2/BDS3 Combined Precise Orbit Determination

Yuanxin Wang[1,2],Baoqi Sun[1,2],Xuhai Yang[1,2],Hang Su[1,2]
1. National Time Service Center,Chinese Academy of Sciences
2. Key Laboratory of Precision Navigation and Timing Technology, Chinese Academy of Sciences

Introduction

The second generation of BeiDou, BDS2, has been providing public service through B1I/B2I/B3I signals for users. At present, BDS3 is being built rapidly. 12 full operational capability satellites has been launched until August, 2018. In addition to the new B1C, B2a signals, BDS3 satellites also broadcast the original B1I, B3I signals as same as BDS2 satellites. Based on observations from iGMAS and IGS MGEX stations, the effects of different processing strategies on the combined precise orbit determination of BDS2 and BDS3 satellites are analyzed from the aspects of signals combined selection, zero-differenced or double-differenced, etc.

Figure 1 shows 16 iGMAS stations (red pot)and 10 MGEX stations (blue pot) which can track BDS3 satellites.

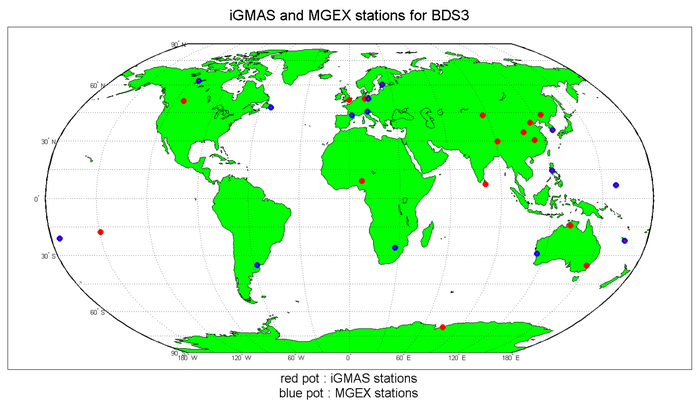

Figure 1. Distribution of selected stations for BDS3

NORAD	COSPAR	PRN	SRN	Launch Time
43001	2017-069A	19	MEO01	05-11-2017
40748	2015-037A	19	MEO01-S	25-07-2015
43002	2017-069B	20	MEO02	05-11-2017
43107	2018-003A	27	MEO07	11-01-2018
43108	2018-003B	28	MEO08	11-01-2018
40749	2015-037B	28	MEO01-S	25-07-2015
43207	2018-018A	21	MEO03	12-02-2018
43208	2018-018B	22	MEO04	12-02-2018
43245	2018-029A	29	MEO09	30-03-2018
43246	2018-029B	30	MEO10	30-03-2018
43581	2018-062A	23	MEO05	29-07-2018
43582	2018-062B	24	MEO06	29-07-2018
43602	2018-067A	25	MEO11	24-08-2018
43603	2018-067B	26	MEO12	24-08-2018

Table 1. BDS3 satellites information

POD model and processing strategy

To evaluate the performance of BDS3 and BDS2 POD, different observation preprocessing, signals and stochastic pulse strategies are evaluated with one-month data of DOY 213-244 in 2018 which is described in Tab.3. 16 iGMAS stations and 4 MGEX stations are used here. Including gamg, met3, tlsg, tong, yar3, nmrg, there are 10 MGEX stations could track BDS3, but the GPS POD result shows that it will be better without six stations metioned before. It also should be noted that there are only 14 iGMAS stations used in Test 6. And if station coordinates and tropospheric delay fixed, the processing is using two steps. First step is to estimate stations coordinates and tropospheric delay with GPS orbit and clock fixed by using IGS product. The second step is to estimate BDS orbit.

option	Test1	Test2	Test3	Test4	Test5	Test6
System	BDS2/BDS3	BDS2/BDS3	BDS2/BDS3	GPS	BDS2/BDS3	BDS2/BDS3
Observations	double-differenced	double-differenced	double-differenced	double-differenced	Zero-differenced	Double-differenced
Frequency	B1I/B3I	B1I/B3I	B1I/B3I	L1/L2	B1I/B3I	B1C/B2a
Station coordinate	Estimated with tight constraint	Estimated with tight constraint	Fixed	Fixed	Fixed	Estimated with tight constraint
Tropospheric	Estimated	Estimated	Fixed	Fixed	Fixed	Estimated
Stochastic pulse	2 per/day	No	2 per/day	2 per/day	4 per/day	2 per/day

Table 3. The strategies for BDS2/BDS3 combined POD

Option	Settings
Software	Bernese GNSS software(5.2)
Sampling	300s
Elevations	Cutoff angle5°elevation dependent weighting with cos(z)**2
Tropospheric delay	Vienna mapping function(VMF)(Boehm,2006)
Satellite antenna PCO and PCV	GPS PCO and PCV：Corrected,Igs08.atx. BDS PCO:Corrected;
Attitude model	Yaw-steering mode
Geopotential	EGM2008 model up to 12×12
N-body gravity	Sun,Moon,and other planet(JPL DE405)
Solar radiation	ECOM 5-parameter
Tide displacement	Solid Earth tide,pole tide,ocean tide
Relativity effect	IERS2010
Station coordinates	Estimated with tight constraint
Ambiguity	Float

Table 2. Parameter settings

BDS2/BDS3 combined POD

The RMS values for 24-h overlap for BDS2/3 satellites from Test 1 to Test3 are shown in Figure 2. It can be seen that with stations coordinates and tropospheric delay fixed, the POD performance is worse than that with those estimated, which is not as expected. And the overlap RMS of C29 and C30 shows larger that other BDS3 satellites.

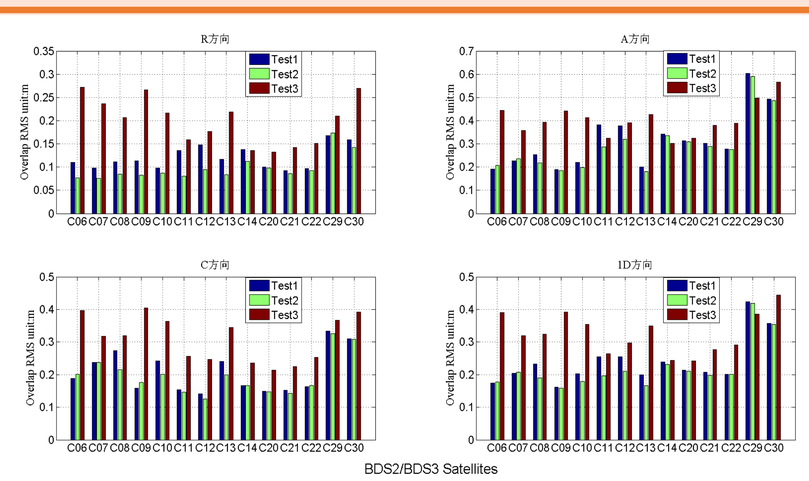

Figure2. 24-h Overlap RMS of BDS2/BDS3 in Test 1, 2, 3

All six strategies results are shown in Table 4. In Test 6,considering that there are only 16 iGMAS stations can receive the new B1C/B2a signals, the BDS3 POD performance is still need to be improved which the 24-h overlap RMS is about 1m now.

		Test 1	Test 2	Test 3	Test 5	Test 6	Test 4
BDS2	1D	0.19	0.22	0.33	0.75	——	GPS
BDS3	Radial	0.12	0.12	0.20	0.59	0.40	0.03
	Along-Track	0.42	0.41	0.46	1.15	1.09	0.12
	Cross-Track	0.21	0.22	0.31	1.14	1.07	0.07
	1D	0.28	0.29	0.35	1..03	0.94	0.08

Table 4. 24-h Overlap RMS of BDS2/BDS3 /GPS

Conclusion and outlook

In this contribution, with 2 stochastic pulse per day , station coordinates and tropospheric delay estimated, the BDS3 POD performance presents the smallest overlap of 0.12, 0.42, 0.21cm in radial, along-track, cross-track component, which is 25-40% better than that with fixed stations coordinates and tropospheric delay and 1-5% slightly better than that with no stochastic pulse.

Compared with the results of GPS POD in Test 4, the BDS2/BDS3 combined POD with fixed station coordinates and tropospheric delay may need to be improved. And the result based on zero-difference observations isn't quite well as expected. It may be attributed to that both the receive clocks and ambiguity are not fixed. Those all are the issues should be studied next.

E-mail:wangyuanxin@ntsc.ac.cn