The Current Status of Chinese Satellites Observation in the ILRS Mission List and Future Development

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Abstract

In the current ILRS mission there are eleven Chinese satellites, including nine compass satellites for BeiDou navigation and one oceanic environmental monitoring satellite and one nano-satellite for atmospheric density detection. The providers of orbit prediction and the user of laser data from those satellites are different because of belonging to different departments. This presentation will give the status of satellites observation, the utilization of laser data, tracking requirements and future development.

1. Introduction

SLR is the acknowledged high precise space geodesy observation technology and played a significant important role in the satellite orbit determination, astrodynamic research and the origin and scale of Global Terrestrial Reference Frame, Models of Earth's Gravity Field and so on. With the development of Chinese space industry, there are more and more Chinese satellites in space. The requirement of satellite orbit should be more precise. More satellites are equipped with laser retro-reflectors and SLR technology will become the important way through joining in the ILRS tracking mission. Now there are eleven Chinese satellites in the ILRS mission and the information of the 11 satellites are shown in Tab.1.

Tab.1 Information of 11 Chinese satellites in ILRS mission

Satellite	Satellite ID	NORAD Number	Altitude (Km)	Launch Date	First Tracked Date
COMPASS-G1	1000101	36287	35,786	2010-Jan-17	2012-Apr-28
COMPASS-I3	1101301	37384	35,786	2011-Apr-10	2012-Apr-27
COMPASS-I5	1107301	37948	35,786	2011-Dec-01	2012-Jul-06
COMPASS-I6B	1602101	41434	35,786	2016-Mar-29	2016-Mar-29
COMPASS-IS1	1501901	40549	35,786	2015-Mar-30	2015-Sep-08
COMPASS-IS2	1505301	40938	35,786	2015-Sep-29	2015-Sep-29
COMPASS-M3	1201801	38250	21,528	2012-Apr-29	2012-Jul-11
COMPASS-MS1	1503702	40749	21,528	2015-Jul-25	2015-Jul-25
COMPASS-MS2	1503701	40748	21,528	2015-Jul-25	2015-Jul-25
HY-2A	1104301	37781	971	2011-Aug-16	2011-Oct-02
PN-1A	1504905	40903	450-120	2015-Sep-19	2015-Nov-11

2. Compass constellation satellites

BeiDou system (COMPASS) is the new generation of satellite navigation system which is being developed in China, consisting of GEO, IGSO and MEO satellites with orbit altitudes from 21,500 km (MEO) to 36,000 km (IGSO/GEO). Beidou satellites are divided into the major two stage, the

regional and the global ones. Up to now the total of 22 Beidou satellites have been launched into space. Among of them, there are 5 regional and 4 global satellites in the ILRS mission.

Over 20 stations have tracked BeiDou satellites, and obtained 548, 464, 538 , 869, 116, 115, 118, 158 passes of laser data for COMPASS-G1,-I3,-I5,-M3,- I6B,-IS1,-IS2,-MS1 and -MS2 satellites in the latest one year. The global SLR data are used to determine satellite orbit and evaluate the precision of orbit. The orbit residuals by using global data is better than 1 cm for G1, I3, I5 satellites and about 2 cm for M3 satellite. Fig.1 shows the overlap errors of SLR orbits for -I5 and -M3 and Fig.2 shows the evaluation of broadcast ephemeris accuracy.
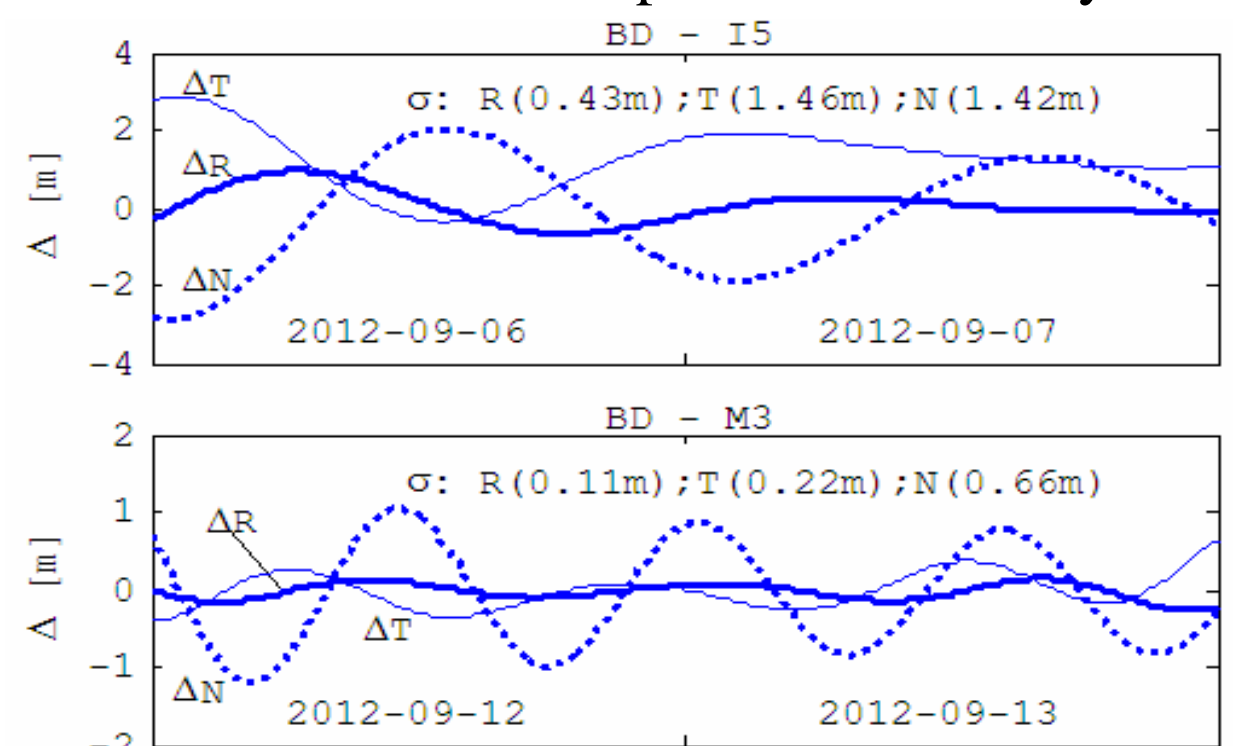

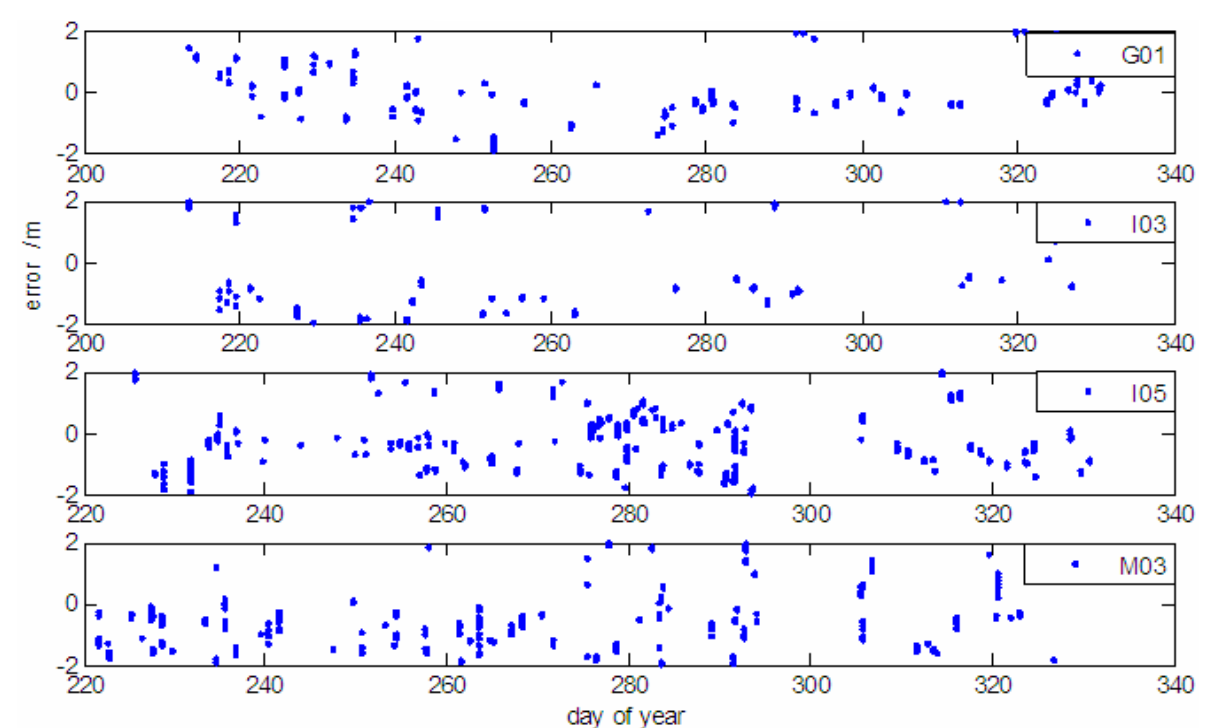Fig.1 Overlap errors of SLR orbits for COMPASS-I5 and -M3

Fig.2 The evaluation of error of broadcast ephemeris By using laser observation data

The laser data from the Beidou global satellites are also applied in the inter-Beidou satellites link check.

For Beidou regional satellites, the satellites orbit prediction are stable, so the laser data is enough. But for the global ones, the procedures of satellite test are still underway until the end of this year and the orbit prediction is not good and the laser data should be increased through improving the precision of orbit prediction. The multi-arc observations for Beidou satellite should also be required in order to cover the longer arc pass.

The SLR data from Beidou satellites has produced the nicer effect and it can be applied to BeiDou satellites precise orbit determination, broadcast ephemeris evaluation and the performance check of inter-satellites link. The significant contributions in Beidou system have made as the high precise measuring technique. More Beidou satellites will be measured in future.

3. HY-2 constellation satellites

The HY-2 are the oceanographic remote sensing constellation satellites, including 4 satellites: HY-2A, HY-2B, HY-2C, HY-2D. The objective of HY-2 is to monitor the dynamic ocean environment with radar sensors to measure sea surface wind field, sea surface height and sea surface temperature. Now HY-2A is in the mission and other three satellites will launch in the next few years. In the latest one year, 27 stations have tracked HY-2A, and obtain 3918 passes of data and the irreplaceable contributions are made for ocean measurements. Fig.3 shows the results of orbit determination using and the 3D-RMS of orbit is about 10cm. The current status and working mode for HY-2A observation are normal for its application.
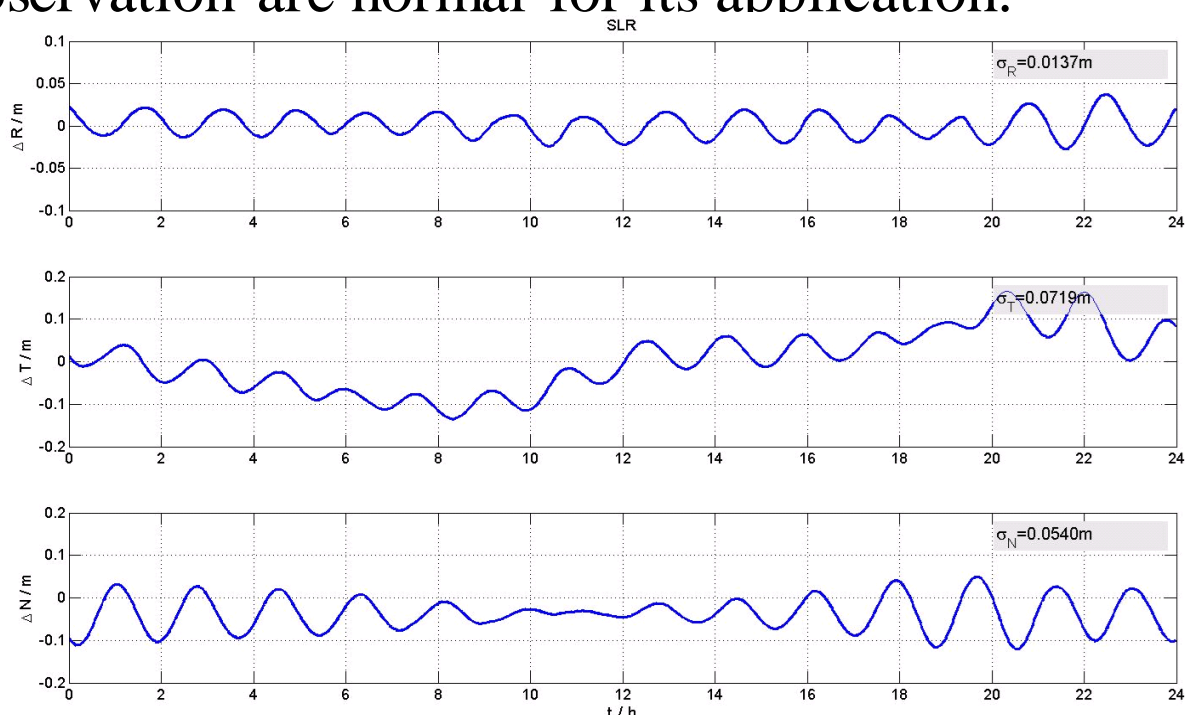
Fig.3 Orbit determination results of HY-2A using ILRS SLR data

4. PN-1 constellation satellites

APOD (Atmospheric detection and Precise Orbit Determination) is consisting of 1 Nano-Cube Sat(A) and 3 Pico-Cube Sats(B/C/D), with a mass of ~ 25kg and 10 kg respectively. The objectives of APOD mission are Precise Orbit Determination, as well as in-situ atmospheric density detection. Due to the compact satellites and low attitude orbit the satellite control is not well, and the status of satellite are not stable. Now only PN-1A satellite is in the ILRS mission and the other 3 ones are still in the test procedure. In the latest one year, there are 15 stations have observed PN-1A, obtaining 381 passes.

Fig.4 shows the residuals of laser ranging of 5 stations, which conducted more and successive observations. The maximum value doesn't exceed 30 centimeters. If we averaged all stations, we can get the mean value and RMS of residuals is about
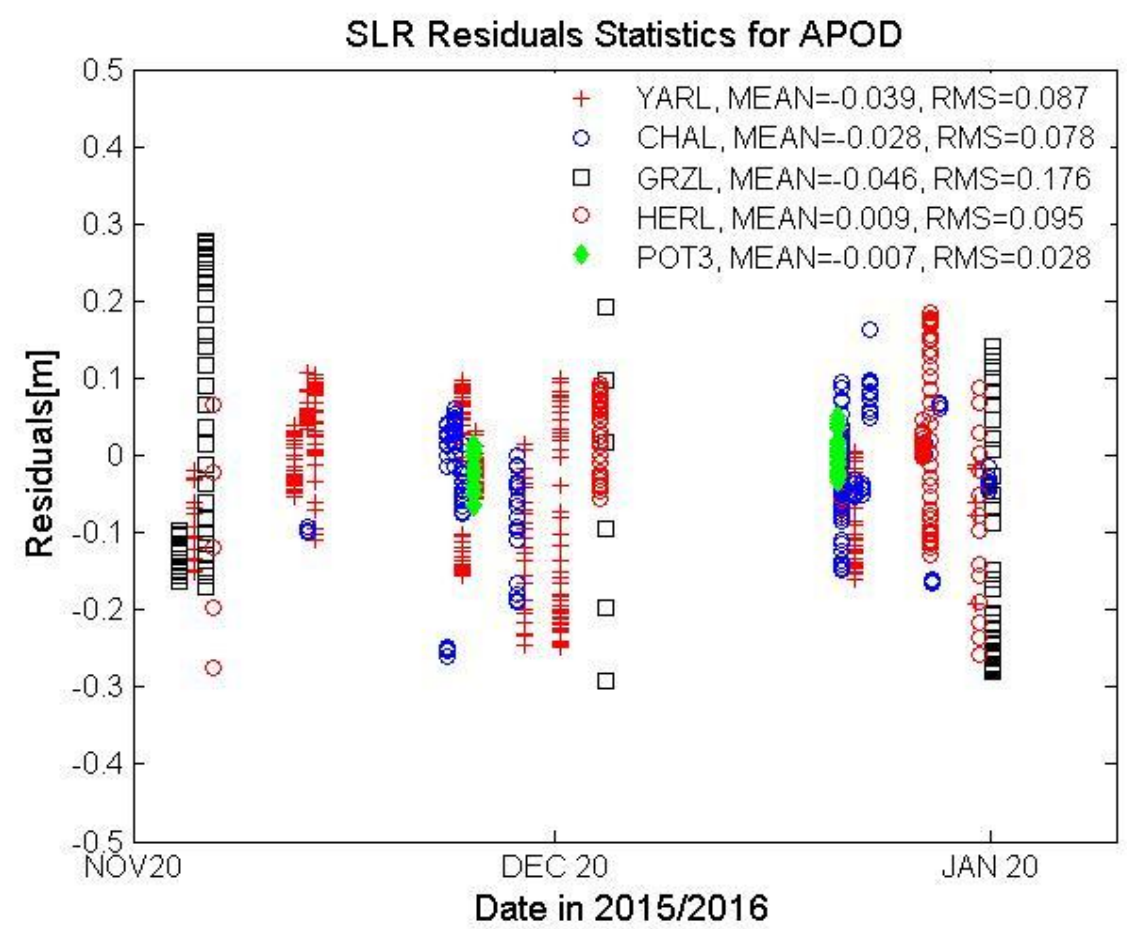
-3cm and 10cm respectively.

Fig.4 SLR residuals statistics for PN-1A

Fig.5 shows the results of ~30 day overlapping orbit comparisons in RTN by using laser data and 9.14cm in R direction, 14.1cm in T direction, and 3.62cm in N direction.
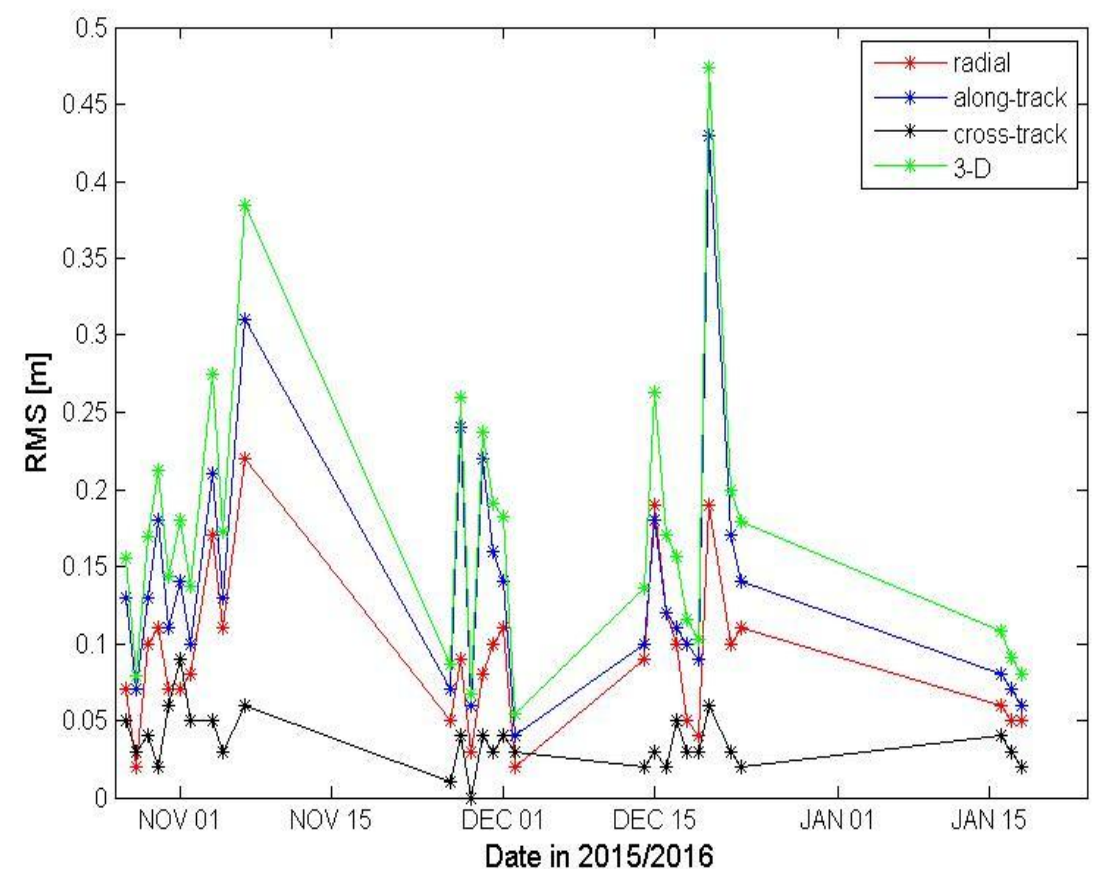
Fig.5 Statistic results of almost 30 day's overlapping comparisons in RTN directions

Because of its sun-synchronous orbit, the observing times are almost daylight, The number of the observed stations and the amount of laser data are less than that from HY-2A. So the ability of daylight ranging for station should be increased for satellite observation and the improvement of orbit prediction will be also implemented.

5. Summary and future development

Global SLR stations and laser data have played an important role in the development of Chinese satellites and thanks to ILRS stations for supporting Chinese satellites observation. For Beidou satellites, the tracked ones will be continuously replaced with the new ones and the requirements of multi-arcs tracking with ~30min time interval are needed to cover the longer pass. The tracking PN-1A will last ~1 year and other 3 ones is still indeterminate now. The HY-2A will last until its out of work and the follow-up ones will be added in future. More Chinese satellites with the demands and requirements of SLR observation will be increased. Hope to get more supports from ILRS.