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Japanese SLR Challenges

S. Nakamura (1), S. Kasho (1), K. Akiyama (1), H. Hashimoto (1), H. Kunimori (2), M. Sato (3), S. Watanabe (3), T. Otsubo (4)

(1) Japan Aerospace Exploration Agency
(2) National Institute of Information and Communications Technplogy
(3) Japan Coast Guard
(4) Hitotsubashi University
nakamura.shinichi@jaxa.jp

Abstract.
Since 1986 in which AJISAI was lounched, JAXA, NICT, Hitotshubashi Univ. JCG, and GSI made a local consortim whose purpose is share orbital data and analysical results. In 2010, when GSI pulled out of an agreement, AJISAI consortium has restructured as Japanese ILRS committee. Example of its activities is evaluation of prediction file of ETS-8 before starting ILRS campaign, evaluation of long term tred of AJISAI spin rate, and shareing operational know-how and how to fix mechanical failure. Additionary, this workshop has been organized as well.

Introduction

In Japan, there are 3 SLR stations in Japan, KOGC (NICT), SISL (JCG) and GMSL (JAXA), and well known analysis center, HIT-U. Moreover, there were collaborative work among them since AJISAI launched in 1986, but no paper and no presentation about Japan activities.
Taking LW18 opportunity, we summarize Japan activities.

Present status, Topics and Future Plan of each organization

First of all, we summarize Japanese 3 SLR stations in Table 1. Since KOGC-SISL-GMSL has good base line, about 1000km which is longer than meteological changing scale, each SLR station compensate each other. Moreover, for GEO/QZSS tracking, we have succeeded precise orbit determination by simultaneous tracking.

Table 1, Japanese SLR stations

Site Code	Organization	Location	Mission of Organization
KOGC	NICT	Tokyo	Research for optical communication
SISL	JCG	Wakayama Prefecture	Marine cartography and geodesy
GMSL	JAXA	Kagoshima Prefecture	Satellite Operation

(1) Koganei (KOGC, NICT)

- Past
  1996 KSP 4 station, ADEOS-RIS Experiment, Join ILRS
  2006 ADEOS-II
  2008 ALOS, OICETS Optical Communication
  2008 ETS-VIII, Technical development by domestic product

2010 QZS-1. T2L2, Selene-2, Hayabusa-21

- Future Plan
  Synergy by Telecommunication and SLR.
  System development with λ=1.5 m m
  Developing Automated Operation technology
  Contribution to ELT mission, depending on NICT condition.
  Technical development, such as mission support for Selene-2 and Hayabusa-2.
- Issues
  Market of SLR technology is so small that it is difficult to find all round treating company.

(2) Simosato (SISL, JCG)

- Replacement of SLR system in 2007-2009

In May 2007, the laser system broke down due to aging. We took this opportunity to replace the observation system in stages from 2007 to 2009 because other equipment was also aging. All equipment except the mount of the telescope was replaced.

- Achievement of 30,000 passes and 30th anniversary of SLR operation

On September, 2011, the cumulative number of passes reached 30,000. Main observed satellites were LAGEOS-1, LAGEOS-2, Ajisai, Becon-C, and Starlette. In March 2012, the SLR operation at Simosato commemorated its 30th anniversary.

- Coseismic displacement due to the 2011 Tohoku-oki Earthquake

On March 11, 2011, a huge earthquake (M9.0) occurred off northeastern Japan. Although Simosato is located about 800 km away from the epicenter, coseismic displacement of about 3 cm toward east-northeast was detected by SLR observation.

- Introduction of calibration target in telescope

We have used a calibration target on a steel tower, which is located about 1.5 km away from the observatory. To develop calibration accuracy, we are considering the introduction of a calibration target mounted in the telescope. This will enable us to make calibrations while we conduct ranging measurements.

(3) Tanegashima (GMSL, 7358, JAXA)

- Tanegashima SLR station repair

GMSL has operated for 11 years. Recently, once some trouble happened, it takes long time to fix because many parts are unavailable. JAXA is planning to repair SLR station. Conceptual design has finished. Now, due to lack of funding, repair plan is run in same place.

- QZS-2,3,… LRA

Thanks to ILRS QZS-1 campaign, we could evaluate bias on QZS-1. Contribution from SLR data improved accuracy of QZS-1's orbit. Following through on QZS-1, JAXA is supporting QZS's LRA.

- New Science Mission

JAXA is planning new mission, which observe sea surface height like a Jason mission. In this mission, GNSS and SLR play very important role to determine the precise orbit.

(4) Hitotsubashi University

On-going development of analysis software "c5++", which written in C++ language, has Multi-technique combination at observation level, Various application & Flexibility, and IERS Conv. 2010 & other latest models.

Hitotsubashi Univ. plays an important role in Japan, such as vice chair of Japanese GGOS Working Group (Chair: Dr. Matsuzaka of GSI, Established in May 2013, seeking international contributions).

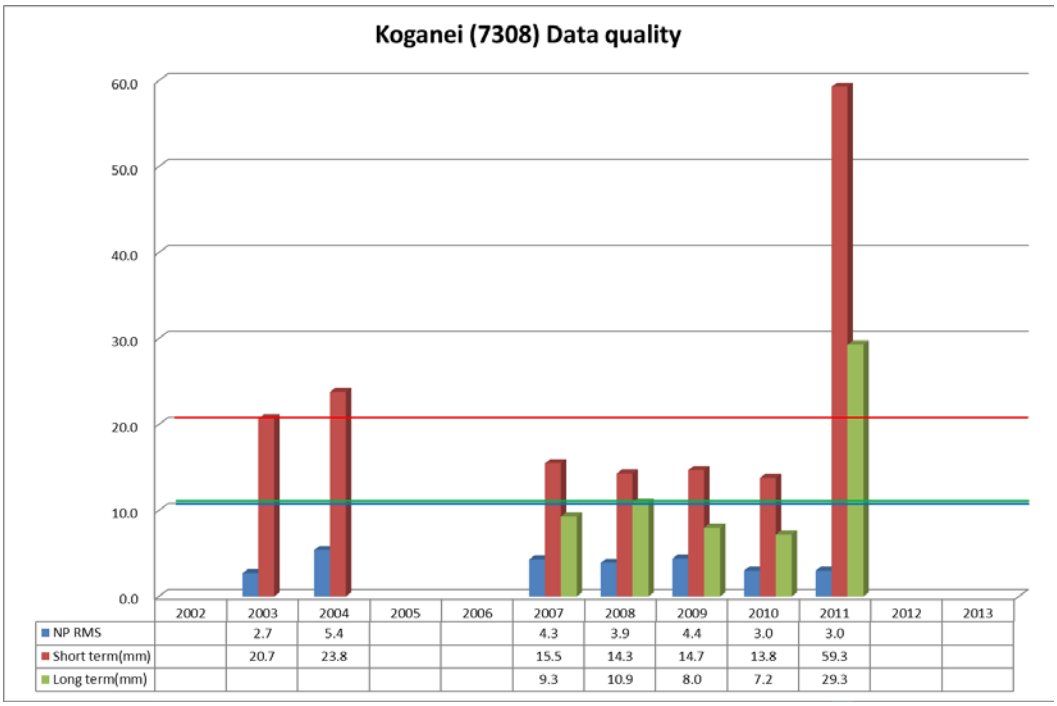
As an educational activities, young scientists welcome, D Kucharski from Graz: 2009-2010, and K Matsuo from Kyoto: 2013.

Historical Background in Japan Activities

In 1982, Simosato SLR station started operation.
In 1990, Koganei SLR station started operation.
In 1986, AJISAI has launched. AJISAI consortium has established among NASDA (JAXA), CRL (NICT), JCG, and GSI. They made consortium to track AJISAI, sharing data, and have a discussion board. Every year, AJISAI meeting has been held.
Since 1998, CRL started distributed bias data via internet. In 2007, this work succeeded to Hitotsubashi Univ.
In 2004, Tanegashima SLR station started operation, and JAXA started distributing TIRV (VPF) of AJISAI.
In 2007-2009, Simosato SLR station system upgraded.
In 2011, AJISAI consortium changed to Japan ILRS forum, which consist of JAXA, NICT, JCG, and Hitotsubashi Univ. Objective of discussion was widened to all topics related with SLR.
Only 2013, this Japan ILRS forum is working as "18th WS LOC".

Output from Japan activities

- Around 2004, Independent Verification & Validation for software development (JAXA-NICT, NICT-JGC). We set same condition → compare results and middle output → improved accuracy and confidence themselves.
- ALOS Campaign
  ALOS has some restriction. JAXA demanded "Go/NoGo key operation". In order to confirm operability, we performed rehearsal and dry run.
- Astro-G LRA baseline design
  Unfortunately, Astro-G project has aborted. Long ellipse orbit beyond GPS orbit, but high accuracy orbit determination was required. We designed plate plus pyramid style LRA.
- Before starting ETS-8 and QZS-1 campaign, accuracy of CPF was confirmed.
  Geostationary satellite ETS-8 and QZS-1 are farthest target without moon. Before starting ILRS campaign, we confirmed accuracy of CPF.
- Say Good Bye to Space Debris; ALOS
  Operation of ALOS terminated in 2011. In 2012, at that time, ALOS is so-called space debris. JCG and JAXA tried to track ALOS again. Through this collaboration, we confirmed how to track space debris.
- Selene-2/LLR
  We studied LLR for lunar mission. Details were presented on 14th lunar session.
- 2011.3.11 Earthquake and recovery
  We communicated system damage and how to recover. After settling into daily operation, we communicate range bias and displacement of SLR station. HIT-U report helped very much. Figure 1 shows the displacement at Koganei.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
NP RMS		2.7	5.4			4.3	3.9	4.4	3.0	3.0		
Short term(mm)		20.7	23.8			15.5	14.3	14.7	13.8	59.3		
Long term(mm)						9.3	10.9	8.0	7.2	29.3		

Figure 1, Data quality at KOGC. After earth quake, due to displacement of SLR station, data quality changed. This evaluation helped to maintain SLR station to keep data quality.

- AJISAI spin rate by Optical Observation
  Through AJISAI consortium activity, spin rate of AJISAI has evaluated from just after launch using telescope observation, Fig.2.

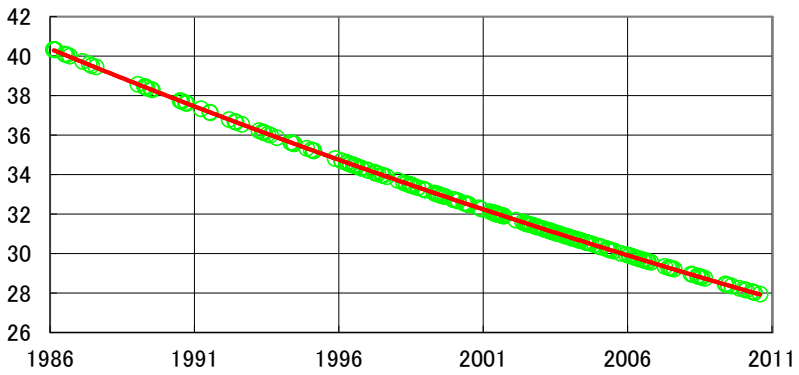


Figure 2, Long term trend of spin rate of AJISAI (left) and Observation facilities (right).
On left graph, horizontal and vartical axis mean year and RPM, respectively.Green circle means observed data, red line was written from regression formula, which assumed exponential damping.

Commonly recognized the worth of development & operation of AJISAI through 25 years, JAXA, JCG, GSI, NICT, and Hitotsubashi Univ. have received “Tuboi award” from Geodetic Society of Japan in May 2011

Japan ILRS committee

In 2010, when GSI pulled out of an agreement, AJISAI consortium has restructured as Japanese ILRS committee, which consists of JAXA, NICT, JGC, and Hitotsubashi Univ.

However, we had only annual meeting, for each organization has different reserch purpose. In 2013, joint work for LW18 changes us active committee.Moreover, new organization, national observatory japan (NAO), has joined japan ILRS committee.
In Japanese proverbial saying, ‘United you stand. Divides you fall’. JAXA, NICT, JGC, Hitotsubashi University and NAO are usually working independently. Since LW18 bound up 5 organization, we could take down fences among us. We gained confidence to work together. We firmly believed that Japan organizations will evolve with ILRS. We can execute responsibility in ILRS ongoingly.

Anyway, we are proud to have 18th workshop in Japan. This workshop re-established powerful relationship among us. We were successful in organizing this workshop. We owe this success to not only Japanese ILRS committee but also all attendee. We would like to our thanks for them. We also gratefully acknowledge helpful advice from ILRS CB and menber of techinical program committee.
See you next workshop!