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Geodetic Reference Frame of Asia and the Pacific Assimilating VLBI Observation *

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1. Introduction

The United Nations General Assembly adopted the UN resolution on Global Geodetic Reference Frame (GGRF) for Sustainable Development at February 24th 2015 and UN Working Group on GGRF is working to develop a roadmap for promoting maintenance and improvement of GGRF. In the Asia-Pacific region, a regional geodetic reference frame has already been developed mainly through GNSS observations. In order to contribute to the global effort on GGRF, which incorporates not only GNSS but also other geodetic observation technologies including VLBI to develop an accurate reference frame, this regional frame should also be properly improved with other geodetic observations, and maintained under cooperation between nations and academic communities.

Japan has also been contributing to the regional geodetic reference frame and also to activities of capacity building on GGRF through international cooperation, technical assistance and training courses.

2. Participation to Regional Geodetic Reference Frame for Asia and the Pacific region

In Asia and the Pacific, a regional geodetic reference frame, Asia-Pacific Reference Frame (APREF), has already been developed through an activity of geodetic working group of Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP). APREF is realized through GNSS continuous observation and thus consistent with global geodetic reference frame. The activity is addressed under the leadership of Geoscience Australia. Geospatial Information Authority of Japan (GSI) started participating in the activity at the beginning by providing GNSS observation data of 10 CORS stations in Japan. GSI has also participated in another project of the working group, Asia Pacific Regional Geodetic Project (APRGP), which conducts GNSS campaign observation once a year in the region in order to densify the observation stations for the regional frame. GSI provides GNSS observation data of 10 CORS stations for APGRP every year.

3. Capacity building through JICA training course

In addition to participation in development of the regional geodetic reference frame,

GSI contributes to capacity building on the development of national geodetic infrastructure and geodetic reference frame. For example, UN-GGIM-AP has held technical seminars in conjunction with FIG, IAG and ICG in order to deepen recognition for importance of GGRF and enhance capacity building and technical assistance for implementation of GGRF. GSI participated in seminars, which were co-organized by UN-GGIM-AP, FIG, IAG and ICG to advocate the importance of GGRF and strengthen the capacity for the implementation of GGRF, as one of the speakers, and shared its experiences and technologies regarding development of national geodetic infrastructure and reference frame.

GSI has also been hosting training courses for developing countries on surveying and mapping that are supported by the Japan International Cooperation Agency (JICA). One of the training courses is on “Management and Utilization of National Control Points for Efficiency of Survey” which is designed based on the experiences of over 20 years in operating the CORS system of Japan, GNSS Earth Observation Network System (GEONET). The course provides the participants with opportunities to get themselves familiar with relevant technologies on CORS system and GNSS observation, to strengthen their capacity for taking a leadership role in the development of national geodetic infrastructure and reference frame. The course started in 2015 and accepted 8 participants from 7 countries.

4. Enhancing consistency between APREF and GGRF

APREF is widely recognized as the regional geodetic reference frame. It has been greatly contributing to the densification of regional geodetic reference frame and is an essential infrastructure for the region. The current frame is developed from collaborative GNSS observations and thus consistent with GGRF. However, the most commonly used global reference frame, International Terrestrial Reference Frame (ITRF), is realized by combining several space geodetic techniques such as GNSS, VLBI, SLR and DORIS. This means there is a possibility that APREF still has some systematic biases against ITRF because APREF is realized only from GNSS. Therefore, in order to develop a regional reference frame more consistent with ITRF, it is necessary to combine APREF with the other space geodetic techniques, more specifically VLBI.

VLBI international collaborative observation has been routinely conducted by International VLBI Service for Geodesy and Astrometry (IVS) since 1999 and the solutions of IVS has been integrated into ITRF. Japan has been participating in IVS observations since the beginning and contributed to the development of ITRF. Recently, the number of VLBI stations in Asia and the Pacific has been gradually increasing. In

order to enhance contribution to ITRF from Asia and the Pacific by leveraging VLBI observation in the region, Asia Oceania VLBI Group for Geodesy and Astronomy (AOV) was established in 2014. AOV is a regional collaborative initiative among Australia, China, Japan, Korea and New Zealand and stated as one of subgroups of IVS. Japan has been serving as the Secretariat of AOV. AOV is already conducting VLBI observations in the region and plans to enhance the observation in the future in order to contribute to the regional geodetic reference frame. Through the activity of AOV, coordinates of VLBI stations and Earth Orientation Parameters can be determined more accurately, and by combining these products with APREF, GGRF in the region also can be more accurately developed and maintained.

AOV member organizations are 12 institutions from 5 countries (Table 1). Seventeen VLBI stations from 5 countries are currently participating in the AOV observation network (Fig.1 and Table 2). GSI, National Geographic Information Institute, University of Tasmania and Shanghai Astronomical Observatory are working as schedulers of observation sessions and correlators of observation data processing. The first AOV observation was already conducted on March 21 2015. AOV plans to conduct VLBI observation campaign six times in 2015 (Table 3). The first scientific meeting of AOV is also planned on November 19-20 in Hobart, Australia in order to share information of current situations and future visions of AOV members.

Table 1: AOV member organizations

Member Organization	Country
Auckland University of Technology (UTAS)	New Zealand
Commonwealth Scientific and Industrial Research Organization (CSIRO)	Australia
Geoscience Australia (GA)	Australia
Geospatial Information Authority of Japan (GSI) [Secretariat]	Japan
Korea Astronomy and Space Science Institute (KASI)	South Korea
National Astronomical Observatory of Japan (NAOJ)	Japan
National Geographic Information Institute (NGII)	South Korea
National Institute of Information and Communications Technology (NICT)	Japan
National Institute of Polar Research (NIPR)	Japan
Shanghai Astronomical Observatory (SHAO)	China
University of Tasmania (UTAS) [Chair]	Australia
Xinjiang Astronomical Observatory (XAO)	China

Figure 1: AOV Observing Network

Table 2: AOV Observing Stations

Code	Station Name	Country	Code	Station Name	Country
Ai	Aira 10m	Japan	Kv	Sejong 22m	Korea
Hb	Hobart 12m	Australia	Pa	Parks 64m	Australia
Ho	Hobart 26m	Australia	Sh	Seshan 25m	China
Is	Ishioka	Japan	Sy	Syowa 11m	Japan
K1	Kashima 11m	Japan	T6	Tianma 65m	China
Kb	Kashima 34m	Japan	Ur	Urumqi 25m	China
Ke	Katherine 12m	Australia	Vm	Mizusawa 20m	Japan

Kg	Koganei 11m	Japan	Ww	Warkworth 12m	New Zealand
Km	Kunming 40m	China	Yg	Yarragadee 12m	Australia

- Aira 10m is not operational and no longer available.

Table 3: AOV Observing Schedule in 2015

Session	Date	Observing Stations	Scheduler	Correlator
AOV001	Mar. 21	Ai Hb Is K1 Ke Kg Km Sh Ts Ur Ww Yg	UTAS	SHAO
AOV002	Apr. 30	Hb Is Ke Kv Sy Ts Vm Ww Yg	GSI	GSI
AOV003	May 17	Hb Ho Is K1 Ke Kg Km Pa T6 Ts Ww Yg	UTAS	GSI
AOV004	Aug. 26	Hb Is Kb Ke Kv Sh Ts Ww Yg	SHAO	NGII
AOV005	Sep. 26	Is K1 Kb Ke Kg Ts Ur Vm Ww Yg	GSI	NGII
AOV006	Dec. 16	Hb Is Kb Ke Km Kv Sh Ts Ur Ww Yg	SHAO	SHAO

5. Conclusion

APREF is a globally consistent regional reference frame for Asia and the Pacific which is developed through collaborative GNSS observations. It has already become an essential infrastructure for the region and facilitated the densification of the regional geodetic observation network. In order to improve APREF to be more consistent with the global geodetic reference frame, ITRF, integration of VLBI solution into APREF is the most effective way. Japan serves as a secretariat of the regional collaborative VLBI activity, AOV, and is committed to contributing to the development and maintenance of more consistent regional frame with ITRF through the activity of AOV.