KASI Combination Center 2013 Annual Report

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Abstract This report presents the activities of the Korea Astronomy and Space Science Institute (KASI) Combination Center during 2013 and outlines the planned tasks for 2014. In 2013, we focused on coordinate time series and a VLBI terrestrial reference frame using seven-year IVS products. During the combination using Bernese GNSS Software Version 5.0, we found restrictions on combining products. We report those and desirable features.

1 General Information

KASI is a government-funded research institute for Astronomy and Space Science. Thus, it has a wide range of research areas observing the Earth, the Sun, stars, and galaxies based on various instruments. For Earth observation, space geodesy is one of the important research fields of KASI. KASI operates GNSS, VLBI, and SLR stations and analyzes their observation data.

2 Component Description

KASI is in charge of operating an IVS Combination Center. KASI has rich experience in GNSS data processing and analysis using Bernese GNSS Software (hereafter Bernese). Bernese, especially the subprogram ADDNEQ2, supports stacking of normal equations and estimation of parameters [1]. We adopted Bernese to combine the sessionwise VLBI products of the IVS Analysis Centers (ACs) at the normal equation level. We modified the software, which was developed for GNSS data processing and analysis, to handle IVS products properly. The inputs to Bernese are the normal equation matrices and vectors from the daily SINEX files of the individual ACs (Table 1). The outputs are daily SINEX files including combined station coordinates and Earth orientation parameters (EOPs). The missions of the KASI Combination Center are creation of high quality combination products, mutual verification with the BKG/DGFI Combination Center, quality control of the ACs' results, provision of feedback to the Analysis Centers, and adherence to the IERS Conventions.

Table 1 IVS ACs which KASI combined.

AC	Time span	Software	Number of sessions
BKG	2003.0-2010.0	CALC/SOLVE	938
DGFI	2003.0-2010.0	OCCAM	891
GSFC	2003.0-2010.0	CALC/SOLVE	939
OPA	2003.0-2010.0	CALC/SOLVE	928
USNO	2003.0-2010.0	CALC/SOLVE	802

3 Staff

The staff members of the KASI Combination Center are listed below.

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Table 2 Personnel of the KASI Combination Center.

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4 Current Status and Activities

(1) Coordinate Time Series

The station position coordinates for each session were combined and estimated using the normal equations of each IVS AC summarized in Table 1 in order to verify the VLBI combination capability of Bernese. In total, 43 station coordinates were estimated. Figures 1, 2 and 3 show the examples of the time series for the latitude, longitude, and height of three of the 43 stations (Westford, Wettzell, and Kokee). In the figures, the red (darker) line represents the estimated values, and the green (lighter) line shows the a priori values based on ITRF2008. In each plot, a single tick mark of the vertical axis corresponds to about 1 m. It is obvious that the errors of the longitude components are relatively larger than those of the latitude and height components. For 43 stations, the root mean square (RMS) errors of the latitude and longitude components are 15.6 mm and 37.7 mm, respectively, and the error of the height component is 30.9 mm, with respect to ITRF2008 (a priori value).

Most VLBI results provide UT1-TAI values, while Bernese, which is the software for GNSS, can process only UT1-UTC values at the moment. For the normal equations of some ACs (BKG, GSFC, OPA, and USNO), which were entered in the software, the difference (leap seconds) between the UT1-TAI and UT1-UTC values was included. UT1 is a parameter that represents the rotation of the Earth, and it is correlated with longitude that has the same direction. Consequently, the UT1 errors of some ACs were included in the results of the longitude, and thus the longitude component showed a larger RMS error than the latitude and height components. In the future, the software needs to be improved regarding UT1 correction.

(2) VLBI TRF

We estimated TRF by combining the normal equations of five ACs (Table 1) during seven years (2003-2009) as one normal equation. Figure 4 shows the velocity vectors of the combined TRF (red arrows) by KASI and the ITRF2008 (blue arrows). ITRF2008 is the result that combined the data from the four space geodetic techniques (GNSS, VLBI, SLR, and DORIS) which had been accumulated for 25 years (1984-2008). Thus, the stations, which had performed observations up to 2003, exist only on ITRF2008. The YEBES sta-

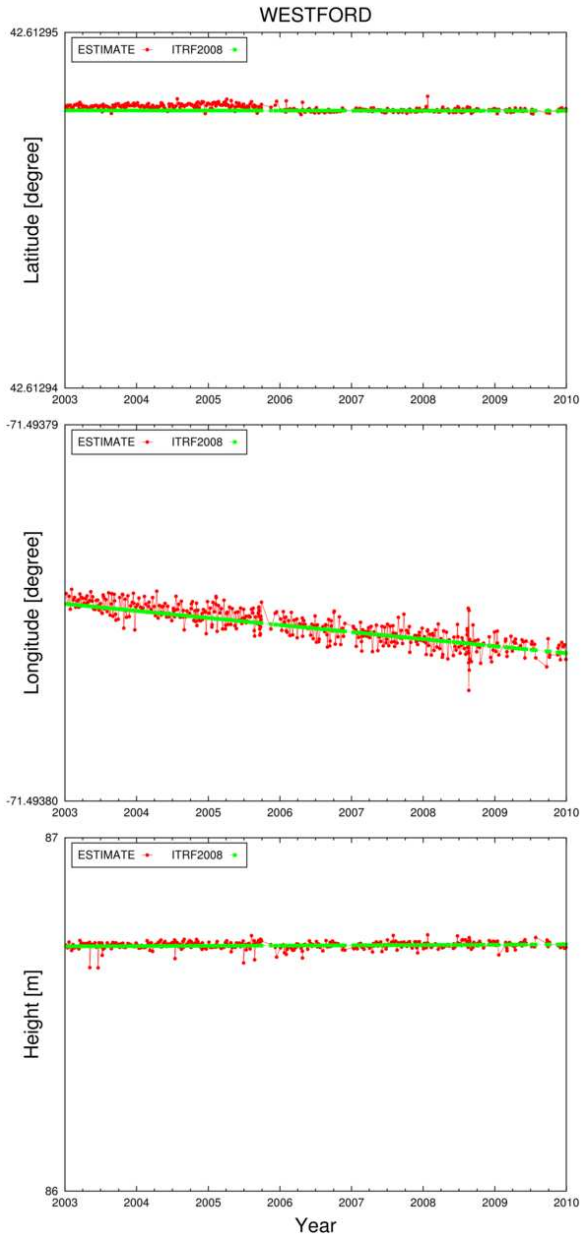

Fig. 1 Coordinate time series of Westford during 2003-2009.

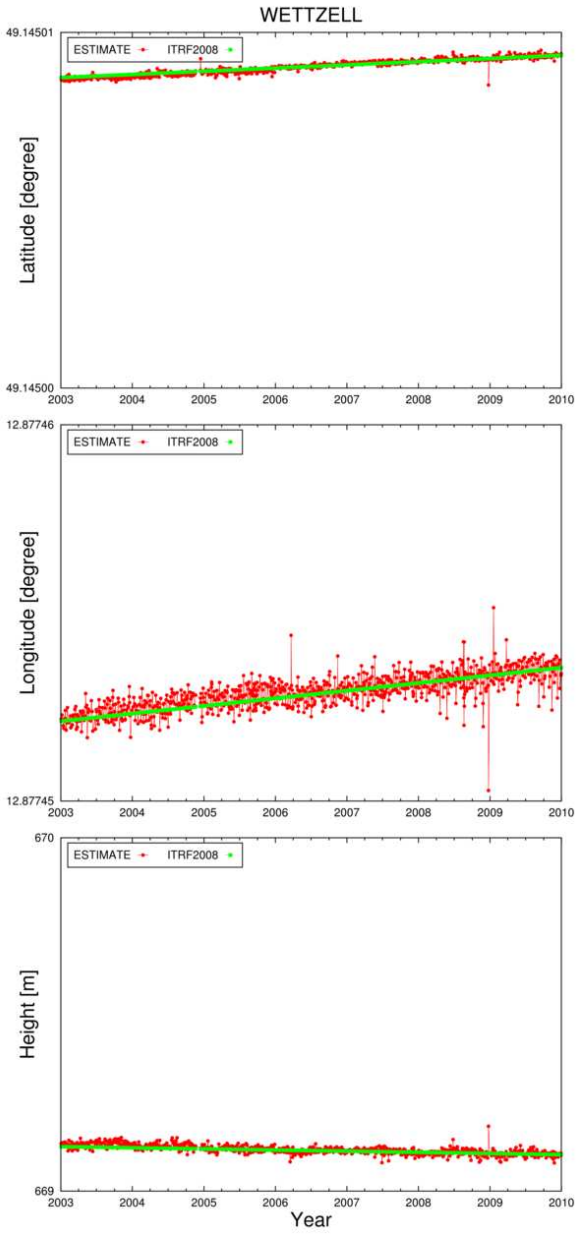

Fig. 2 Coordinate time series of Wettzell during 2003-2009.

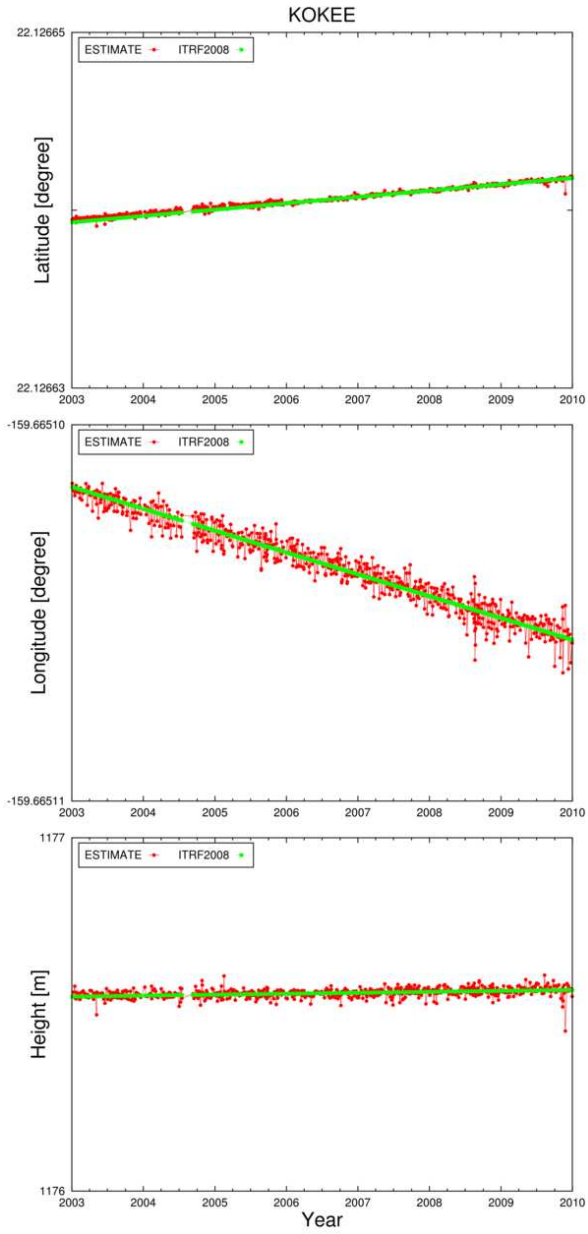

Fig. 3 Coordinate time series of Kokee during 2003-2009.

tion in Spain dismantled the 14-m antenna that had been used from 1995 to 2003. Accordingly, as for the data from the YEBES station used for the combined TRF, the observation period was very short (less than one year), and thus the estimation of a proper velocity vector was not available. Therefore, it had a completely different magnitude and direction, compared to the velocity vector from ITRF2008, and it was excluded from Figure 4. The velocity vector of the remaining 42 stations excluding the YEBES station showed a magnitude difference of 7.3 mm/yr (30.2%) and a direction difference of 13.8° (3.8%), with respect to ITRF2008. Those errors are thought to be due to the longitude component error mentioned above. As there is a large error in the longitude component, the Helmert transformation, which represents the relation between TRFs, is

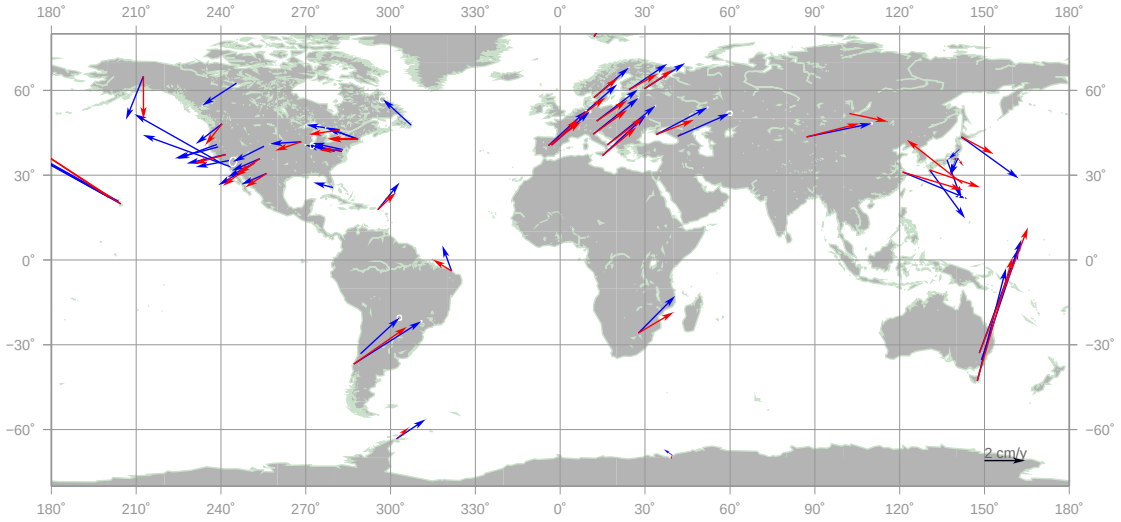

Fig. 4 Velocity map of ITRF2008 (blue/slightly darker) and combined TRF (red) by KASI.

not meaningful at the moment. Thus, it was not considered in this report.

5 Future Plans

In 2014 and beyond, we will focus on the following tasks:

- Proper UT1 correction in Bernese
- Combining whole period IVS products (1984-present)
- Outlier rejection
- Weighting the individual solutions
- Comparing with BKG/DGFI Combination Center [2], IERS 08C04 [3], and IGS solutions [4]
- Providing IVS EOP format solutions [2] (Rapid and Quarterly)
- Providing VLBI TRF

References

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