Onsala Space Observatory – IVS Analysis Center Activities during 2014

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Abstract This report briefly summarizes the activities of the IVS Analysis Center at the Onsala Space Observatory during 2014 and gives examples of results of ongoing work.

1 General Information

We concentrate on research topics that are relevant for space geodesy and geosciences. These research topics are related to data observed with geodetic VLBI and complementing techniques.

2 Activities during the Past Year

We worked primarily on the following topics:

- Automated reference point determination
- A local tie vector based on classical survey and GPS measurements
- A purely GPS-based local tie vector
- Evaluation of DBBC vs. Mark IV
- VLBI with GLONASS signals
- Coastal sea level observations with GNSS
- Ocean Tide Loading
- Gravimetry observations

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3 Automated Reference Point Determination

The approach to determine the reference point of a radio telescope in an automated fashion during ongoing VLBI observations [1] was applied to the CONT14 campaign. Several retro-reflectors were mounted on the elevation cabin of the 20-m radio telescope and then observed from various survey pillars with total stations while the telescope was observing CONT14. A manuscript describing the experiment and its results is in preparation.

4 A Local Tie Vector Based on Classical Survey and GPS Measurements

In connection to the above described automated determination of the reference point of the 20-m radio telescope, a classical survey of the complete local site network was also performed, including the reference point of the IGS station ONSA. This allowed us to determine a new realization of the local tie vector between the VLBI and GNSS reference points at the obseratory in the local coordinate system. After the classical survey, a several week long GPS campaign was performed in the local network. The corresponding data analysis gave the coordinates of the markers of the local survey network in a global cartesian coordinate system. Thus, by combining the local survey results and the results from the GPS campaign, a new realization of the local tie vector expressed in a global cartesian coordinate system could be determined. The results were submitted to IERS to be used for the preparation of ITRF2014.

5 A Purely GPS-based Local Tie Vector

GPS data observed with the receivers connected to two gimbal-mounted GPS antennas on the 20-m radio telescope were analyzed for several observing sessions, both kinematic ones during real VLBI sessions, and dedicated semi-kinematic stop-and-go sessions. The data were analyzed together with the data from the IGS station ONSA and successively the reference point of the radio telescope, the axis offset, and the local tie vector between the VLBI and GNSS reference points were determined. The analysis shows that both types of sessions, i.e. kinematic and semi-kinematic, give consistent results, for both the local tie vector and the telescope axis offset. The repeatability of the local tie vector from the different sessions is on the order of 1.5 to 3 mm for the different components. The agreement with the ITRF2008 local tie vector is on the level of 1 to 5 mm in the different components. The study shows that this approach is suitable to continually monitor the local tie vector at co-location sites with accuracies on the order of a few millimeters [2].

6 Evaluation of DBBC vs. Mark IV

During 2013 and 2014, a large number of geodetic VLBI sessions performed at Onsala were observed both with the old Mark IV/Mark 5A data acquisition system and with the new DBBC/Mark 5B+ data acquisition system. Zero-baseline tests were performed using the DiFX software correlator at Onsala and at the Bonn correlator. The Bonn correlator also produced several VLBI databases that include two Onsala stations, one with the Mark IV/Mark 5A data acquisition system and one with the DBBC/Mark 5B+ data acquisition system. Several of these databases were analyzed and investigated for systematic differences in both the raw observations and also the geodetic parameters derived from the analysis [3]. No significant differences were found, and as a result of this study we decided to retire the old Mark IV rack in the summer of 2014 and to completely switch over to an operational use of the DBBC/Mark 5B+ data acquisition system.

7 VLBI with GLONASS Signals

We continued test experiments to perform VLBI observations with signals of GLONASS satellites. These tests were done on the Onsala-Wettzell baseline, involving the L-band system on the Onsala 25-m telescope and the L-band receiver on the Wettzell 20-m telescope. The data were successfully correlated with the DiFX software correlator installed at Onsala [4]. Different a priori delay models were tested. The correlation results were post-processed with both AIPS and Fourfit.

From the AIPS post-processing we could successfully determine group delays, integrated delay rates, and phase delays. The RMS-scatter of the phase delays was on the level of 10 ps for solution intervals of 2 s, while group delays reached an RMS-scatter below 1.5 ns for solution intervals not shorter than 30 s. Total delay values, i.e. a priori delay models plus fringe-fitted delay residuals from AIPS, agreed on a level of 0.8–0.9 ns for group delays and 0.2–0.4 ns for phase delays (approximated by integrated delay rates) [4].

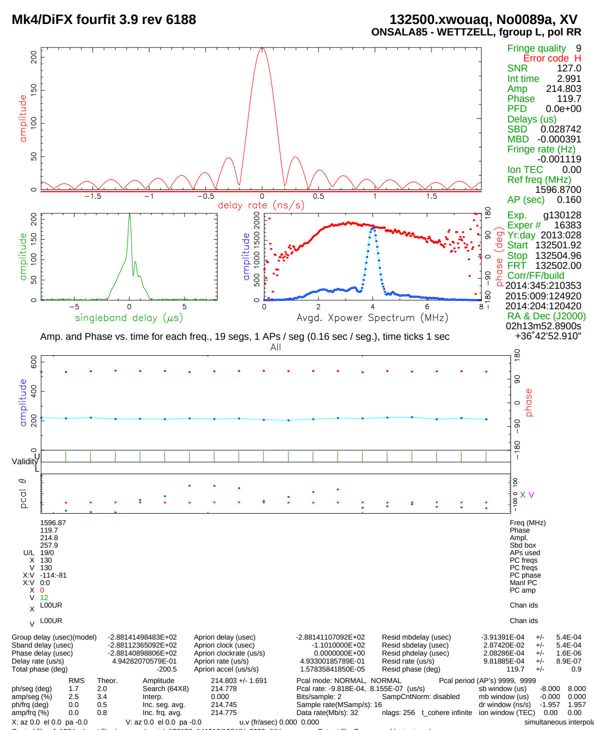

Fig. 1 Fringe plot for one scan of the GLONASS-VLBI experiment G130128, observed on the baseline Onsala–Wettzell.

An example for post-correlation analysis with Fourfit is presented in Figure 1, which depicts the fringe plot for one scan of the experiment G130128. A high quality fringe with SNR 127 and stable phase is achieved from an integration time of just 3 s.

8 Coastal Sea Level Observations with GNSS

We used the GNSS-R tide gauge at Onsala to study reflected signals from multiple GNSS, i.e. from GPS and GLONASS. The recorded data were analyzed with two different strategies, using only data from the upward-looking antenna and applying the SNR analysis, and using data from both antennas and applying geodetic phase delay analysis. The analysis shows that multi-GNSS signals give consistent results for sea level derived from reflectometry [5]. The agreement with respect to sea level observed by a co-located traditional tide gauge is better for the phase-delay analysis than for the SNR analysis. Figure 2 depicts results from the analysis of multi-GNSS observations collected during 20 days in 2012. The root-mean-square (RMS) differences were on the level of 32 to 35 millimeters for GPS and GLONASS phase-delay solutions, while the SNR solutions gave RMS differences on the order of 40 to 90 millimeters. The worst RMS agreement was achieved with SNR analysis on the L2 frequency.

The SNR approach was applied also to other coastal stations worldwide that are only equipped with one upward-looking GNSS antenna [6]. The chosen stations were located in different regions around the world, in both hemispheres and exposed to different multi-path environments, as well as different tidal ranges. All stations had co-located traditional tide gauges that could be used for comparison to the derived sea level results. The analysis shows that the relative accuracy of the SNR technique, defined as the ratio of RMS and tidal range, is between 2.4% and 10.0% for all stations.

A new reflectometry instrument that focuses specifically on GLONASS signals was compared to the Onsala GNSS-R tide gauge. The new system is based on rather inexpensive commercially off-the-shelf equipment. It could be shown that the precision and accuracy of the GLONASS-R system is comparable to the existing GNSS-R [7].

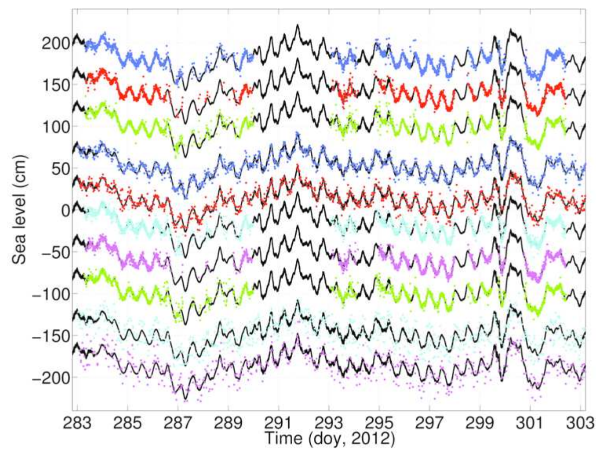

Fig. 2 Sea level derived from the GNSS tide gauge at the Onsala site during 20 days in 2012 (October 9 to 29). From top to bottom the sea level times series are derived from: GPS phase (L1), GLONASS phase (L1), GPS and GLONASS phase (L1), GPS SNR (L1), GLONASS SNR (L1), GPS phase (L2), GLONASS phase (L2), GPS and GLONASS phase (L2), GPS SNR (L2), and GLONASS SNR (L2). Each time series is paired with the independent sea level observations from the co-located tide gauge (black line). A mean is removed from each time series, and the pairs are displayed with an offset of 40 cm to improve visibility.

9 Ocean Tide Loading

The Automatic Ocean Tide Loading service was operated throughout the year. It is heavily used by the international scientific community.

10 Gravimetry Observations

The superconducting gravimeter in the gravity laboratory was operated throughout the year. The data loss in 2014 was 0.52% in the one-second record, confined to one event at the end of February, a failing Flash Card memory in the data buffer of the ADCconverter. Since September 2014, tide solutions have been prepared on a weekly basis and results made available on the SCG homepage (http://holt.oso.chalmers.se/hgs/SCG/toe/toe.html).
The analysis includes the sea-level sensors at the Onsala Space Observatory as ancillary data in the regression. The RMS of the residual is typically below 8 nm/s^2.

11 Future Plans

The IVS Analysis Center at the Onsala Space Observatory will continue its efforts to work on specific topics relevant to space geodesy and geosciences. For the future we plan to intensify our activities, in particular concerning tropospheric parameters, e.g. horizontal gradients in the atmosphere using VLBI, GNSS and radiometers. A special focus for the coming years will be work related to the Onsala Twin Telescope project. Furthermore, we will work on an automated near real-time analysis of the IVS INT-sessions. We will also continue our efforts concerning VLBI observations of GNSS signals.

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