JUMPING JIVE
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Geodesy at K-band with the European VLBI Network

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Abstract

A non-standard VLBI geodetic experiment was carried out at K-band (22 GHz) in June 2018 using 14 radio telescopes from the European VLBI Network (EVN).

The purpose of this experiment is to determine accurate geodetic positions for those EVN telescopes that do not possess S/X receivers and hence do not participate in regular experiments organized by the International VLBI Service for geodesy and astrometry (IVS).

Even though the EVN is not a geodetic array, there are many reasons why such accurate radio telescope positions are desirable, including frequent observations using the phase-referencing technique to detect weak radio sources and to conduct relative astrometry. The experiment was fully correlated with the EVN software correlator at JIVE (SFXC) and exported into Mk4 format so that it can be further processed with standard geodesy software packages. Several changes were made at the EVN software correlator and detailed testing was carried out so that the correlator can successfully correlate geodetic experiments.

The poster presents the current status of the work, and how we foresee moving towards our objective of delivering accurate geodetic coordinates for the non-geodetic EVN telescopes.

This work is carried out as part of the JUMPING JIVE project funded by the Horizon 2020 Framework Program of the EU.

Introduction

The activities mentioned here are conducted as part of the Work Package (WP) 6 of the JUMPING JIVE project funded by the European's Union Horizon 2020 programme. JUMPING JIVE is dedicated to enhance the position of JIVE and the European VLBI Network (EVN) within the radio astronomy community.

The purpose of WP6 is to enable the geodetic use of the EVN Software correlator at JIVE (SFXC), among which is the possibility to correlate geodetic-type experiments and export them in a standard fashion so that they can be further processed by the usual geodetic software.

Unlike most astronomical VLBI observations conducted by the EVN in which all telescopes observe one source in a synchronized fashion (a scan), geodesy involves schedules with sub-netting. This means that one or more sub-arrays may be formed from the overall set of participating telescopes to observe one or more sources at a given time and this configuration is subject to changes throughout the course of a session. SFXC thus had to be adapted to correlate this type of experiments.

The final objective of the project is to measure the positions of some of the non-geodetic EVN telescopes. To this end, a dedicated experiment was conducted in June 2018. The observations were carried out at K-band since the EVN telescopes do not all have the capability to observe at the standard S/X band frequencies used in geodesy. Although this frequency is more sensitive to the troposphere, it is less sensitive to the ionosphere. Another advantage is that thanks to ICRF3, a number of radio sources have now known position at K-band, which facilitates the data analysis. Additionally, this experiment will allow us to corroborate the measured positions with previously-determined positions for some of the telescopes and obtain estimates of the geodetic velocities of those telescopes.

In the following, we present the progress of these activities.

New geodetic capabilities for the EVN correlator

The EVN software correlator at JIVE has been mostly devoted to astrophysical observations. In order to be able to correlate geodetic experiments, new features have been implemented to properly handle complex geodetic-like schedules with sub-netting, to incorporate total quantities and measured phase-cal values in the data provided to the users and to convert the correlator output to the standard geodetic Mk4 format.

To test these capabilities, the R1872 session of the International VLBI Service (IVS) was selected and fully correlated at JIVE. This is a 24-hour experiment conducted in December 2018 and involving eight IVS stations.

The results from correlation were compared to those obtained with the DiFX correlator in Bonn, where the session was originally processed, following the steps depicted in Figure 1.

After internal check of the whole pipeline, the output of the SFXC correlation was converted into Mk4 format, post-processed with HOPS (fourfit) and exported into vgosDB format following the usual geodetic practice. An example of a fringe plot derived with HOPS is shown in Figure 2.

The results indicate an overall agreement at the 5 ps level in the Total Multiband Delay (TOTMBD) derived from SFXC and DiFX, while the SNR ratios (JIVE SFXC wrt Bonn DiFX) are close to 1 with a mean value of 0.998 (Figure 3).

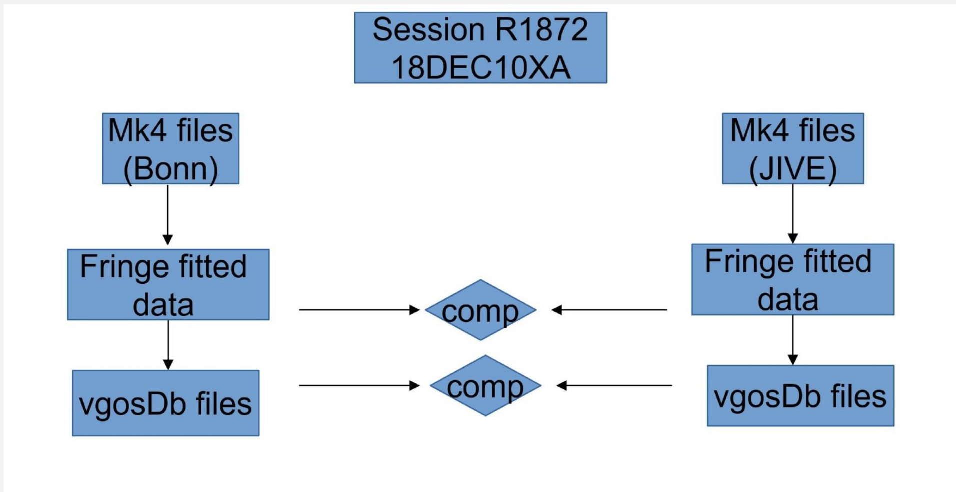

Figure 1: Methodology followed to compare the SFXC (JIVE) and DiFX (Bonn) correlator outputs.

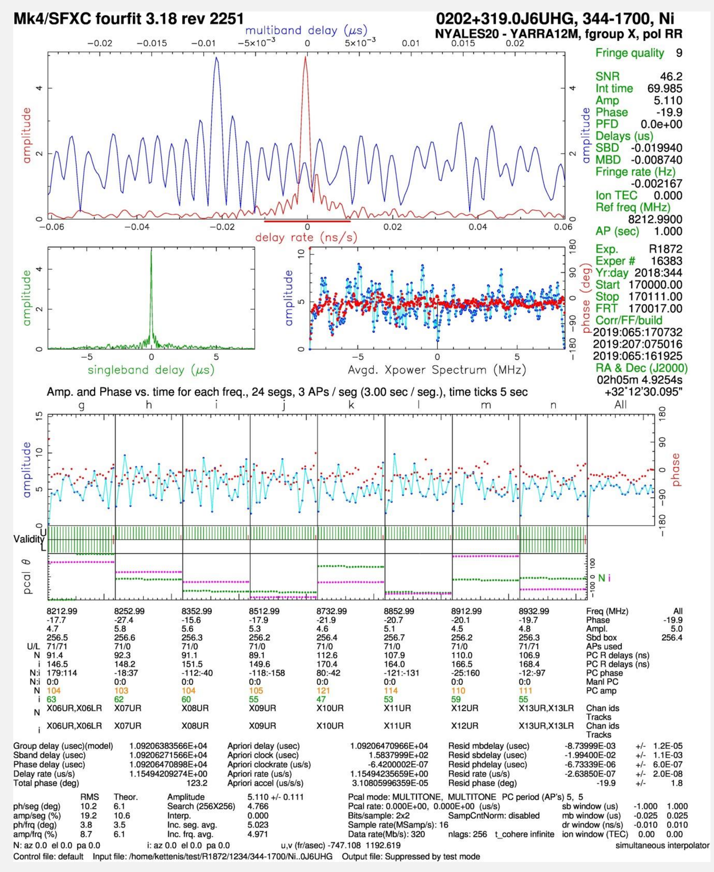

Figure 2: Fourfit fringe plot obtained from the data of the IVS-R1872 session correlated at JIVE.

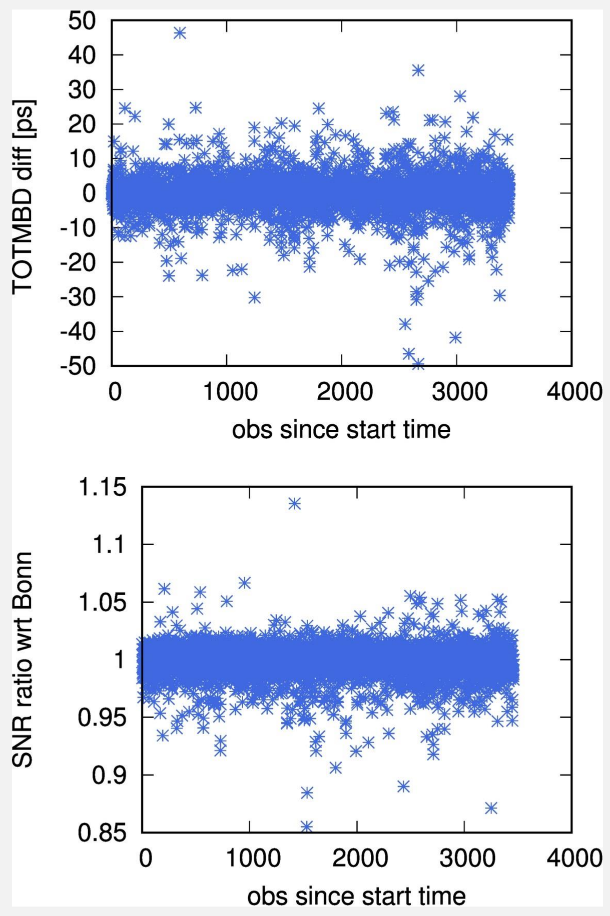

Figure 3: Differences in total multiband delays (upper panel) and SNR ratios (JIVE SFXC wrt Bonn DiFX, lower panel) obtained after comparing the vgosDB files produced by SFXC and the Bonn DiFX correlator for the IVS session R1872

The EC065 experiment

The experiment EC065 was conducted at K-band on 13-14 June 2018 for a total of 24 hours. It comprised 14 EVN telescopes, 66 sources with known ICRF3 positions at K-band and 478 scans. A map of the network is shown in Figure 4. The experiment was fully correlated with SFXC and post-processed basically in the same way as that employed for the IVS-R1782 session.

The Vienna VLBI and Satellite Software (VieVS), foreseen to analyze this session, was adapted to analyze observations in K-band. As we do not have two frequencies, a ionospheric map from CODE was used for a first trial with VieVS. The differences between the observed and estimated (O-C) time delays are plotted in Figure 5. Although some improvements in the post-processing and analysis still have to be made, the results already demonstrate that it is possible to process from the beginning to the end a K-band non-standard geodetic session correlated at JIVE.

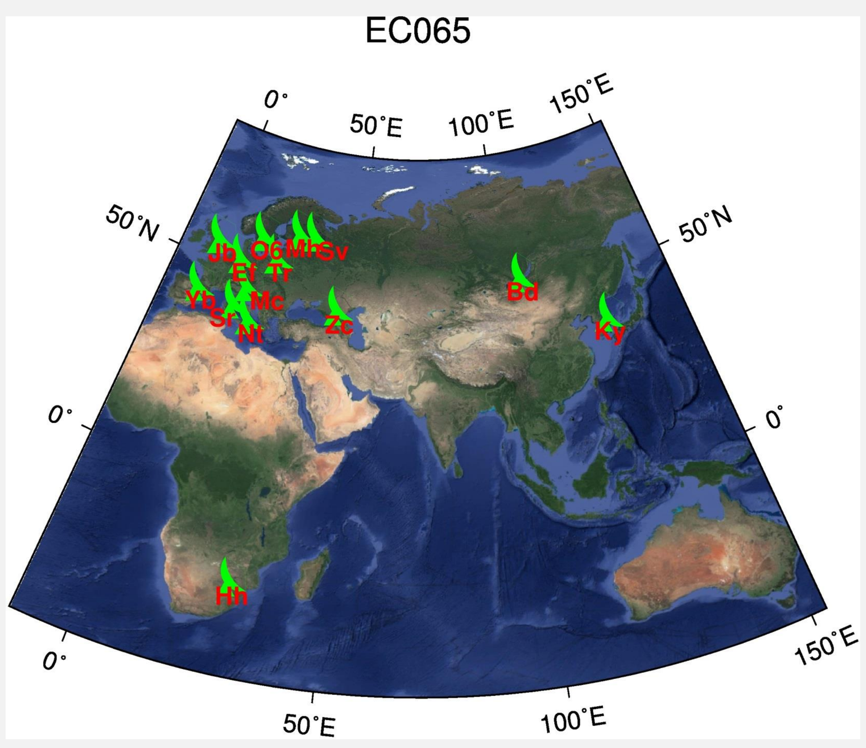

Figure 4: Map of the EC065 network

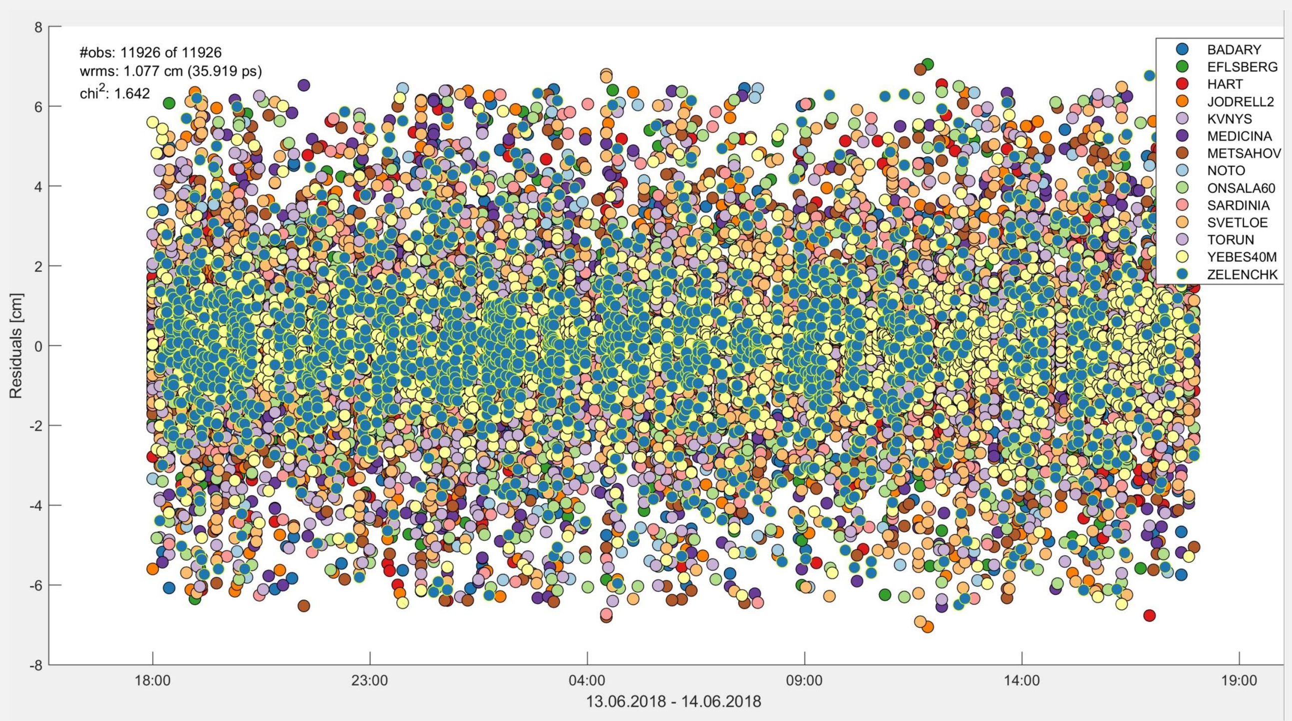

Figure 5: (O-C) delay residuals obtained after a first run with VieVS

Conclusion & Outlook

We have shown here that a typical 24-hour IVS session that took place in December 2018 has been fully processed with the EVN software correlator at JIVE (SFXC) and post-processed and analyzed with standard geodetic tools.

The comparison of those results with the results from the DiFX correlator at the Bonn correlation center, where the session was originally correlated, post-processed and exported, indicates an agreement at the 5 ps level, which is the level of consistency expected.

We have also demonstrated here that the pipeline from correlation to session analysis works also for a non-standard geodetic session like EC065, hence meaning good progress towards the establishment of a standard pipeline at JIVE for the processing of geodetic sessions in S/X or K-band.

Acknowledgements

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