Development of Wide-Band Bandwidth Synthesis Software for Geodetic VLBI

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1. Introduction

Wide-band bandwidth synthesis (WBWS) is a technique to combine multi-band VLBI data of which bandwidth exceeds 10 GHz or more (band width is about 10 times wider than that of conventional bandwidth synthesis technique) not only to improve a delay resolution but also to increase a sensitivity of fringe detection. We have been developing WBWS software and have successfully applied it to actual wide-band VLBI data observed on a short distance (about 50km) baseline. The effect of ionospheric delay is neglected on the short baseline, however it cannot be neglected on a long baseline such as an inter-continental baseline. As for the conventional geodetic VLBI system receiving S and X bands, group delay at each band is observed, then later, ionospheric delay is compensated at a data analysis. It is planned in the WBWS that Ionospheric correction will be carried out with a bandwidth synthesis processing. Concretely, the difference of the total electron content (TEC) of the ionosphere along propagation paths is estimated from a cross spectrum of full band width. Software to proof this method has been developed and a test processing using simulated data shows an expected result.

2. Wide-band bandwidth synthesis (WBWS) software

Three corrections are considered in the development of WBWS software to connect each band data in the frequency domain. They are 1) inner-band phase correction, 2) inter-band delay correction, and 3) ionospheric delay correction. As for corrections 1) and 2), a realistic method has been developed which corrects the phase and delay based on those obtained by a reference scan (which is usually defined as a scan for a strong radio source) (Fig.1(a)). As for an ionospheric correction, it is not implemented yet in the software, but the difference of total electron content (TEC) will be estimated by using the phase characteristics of cross spectrum against the frequency (Fig.1(b)).

3. Results of WBWS

WBWS software is applied to true wide-band VLBI observation data obtained by an experiment conducted on Kashima-Ishioka baseline (about 50km) length (Fig.2) in Jan. 16, 2015. Fig.3 shows receiving frequency bands and Fig. 4 shows an example of results. Fig.5 demonstrates the estimation of ΔTEC.

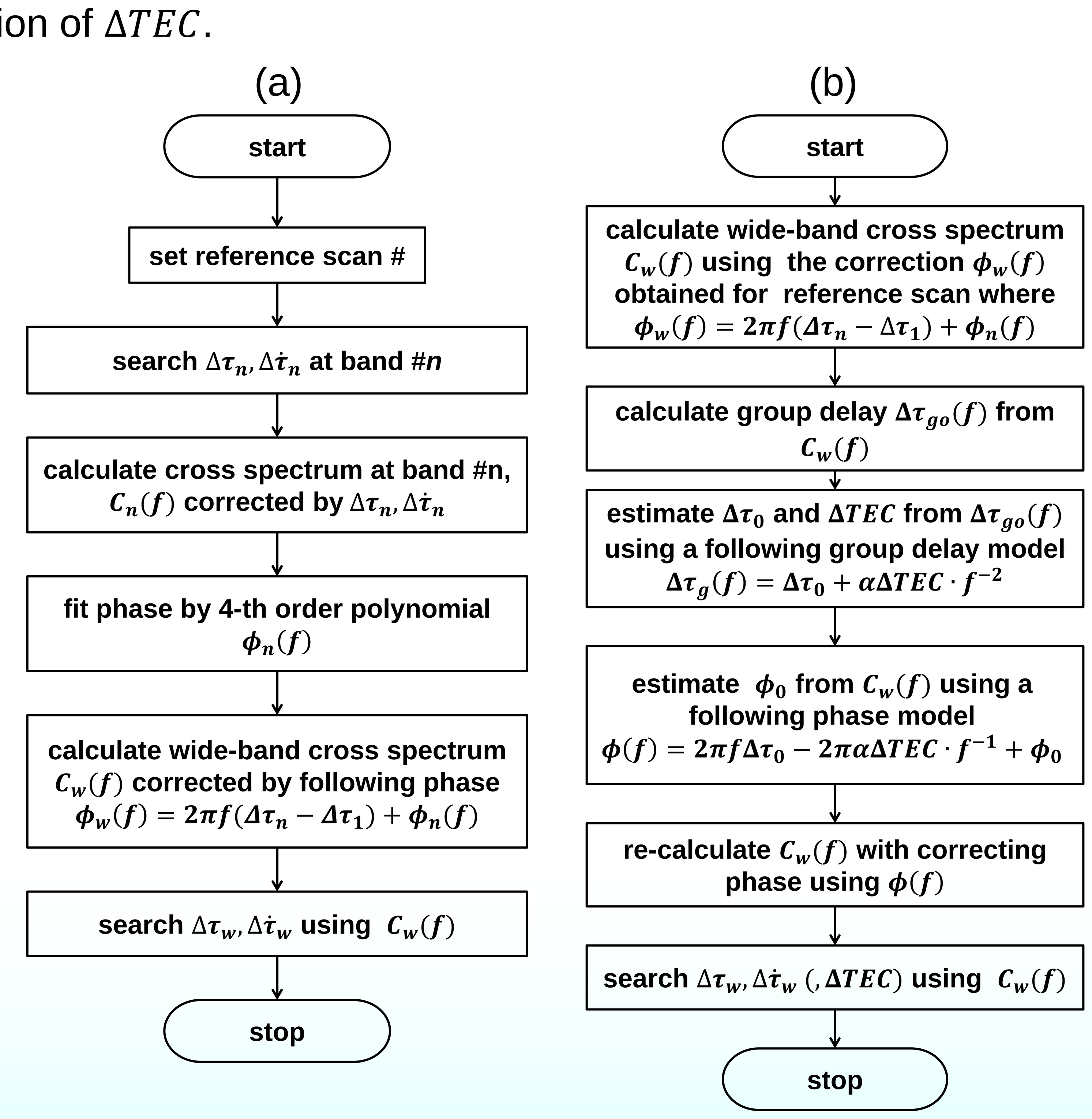

Fig. 1 Flowcharts of WBWS for (a) a reference scan and for (b) other scans.

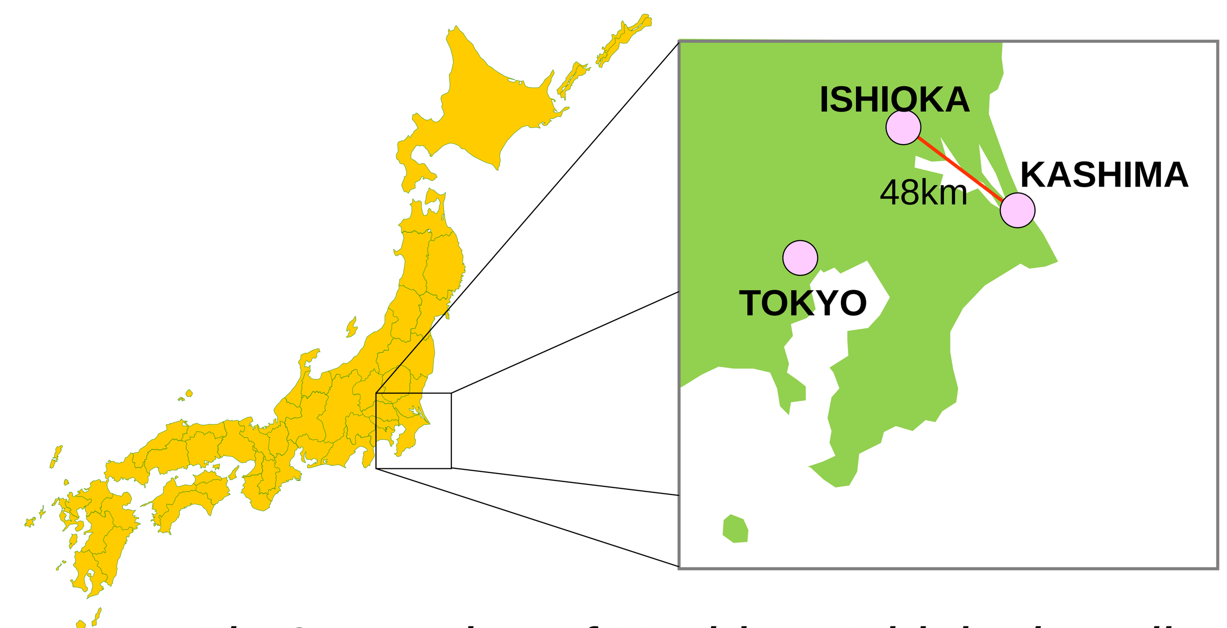

Fig.2 Location of Kashima-Ishioka baseline.

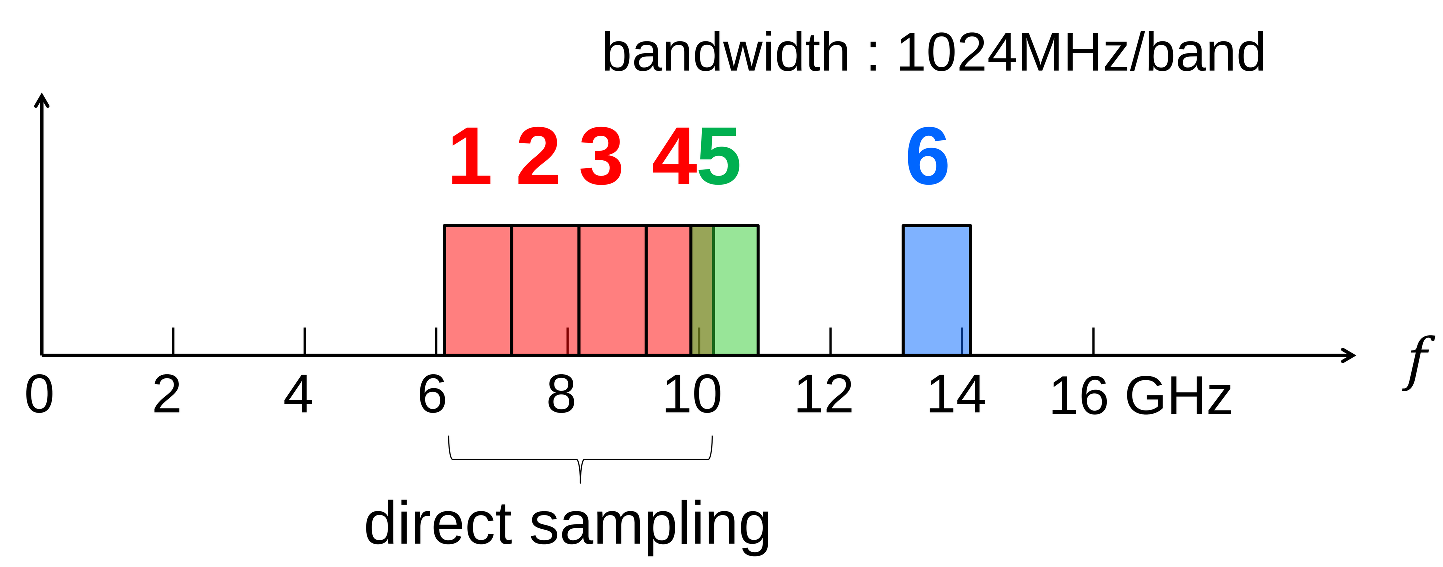

Fig.3 Receiving frequency bands. Bands 1, 2, 3, and 4 are sampled by one sampler (direct sampling). Bands 5 and 6 are sampled by different samplers. Each band width is 1024 MHz.

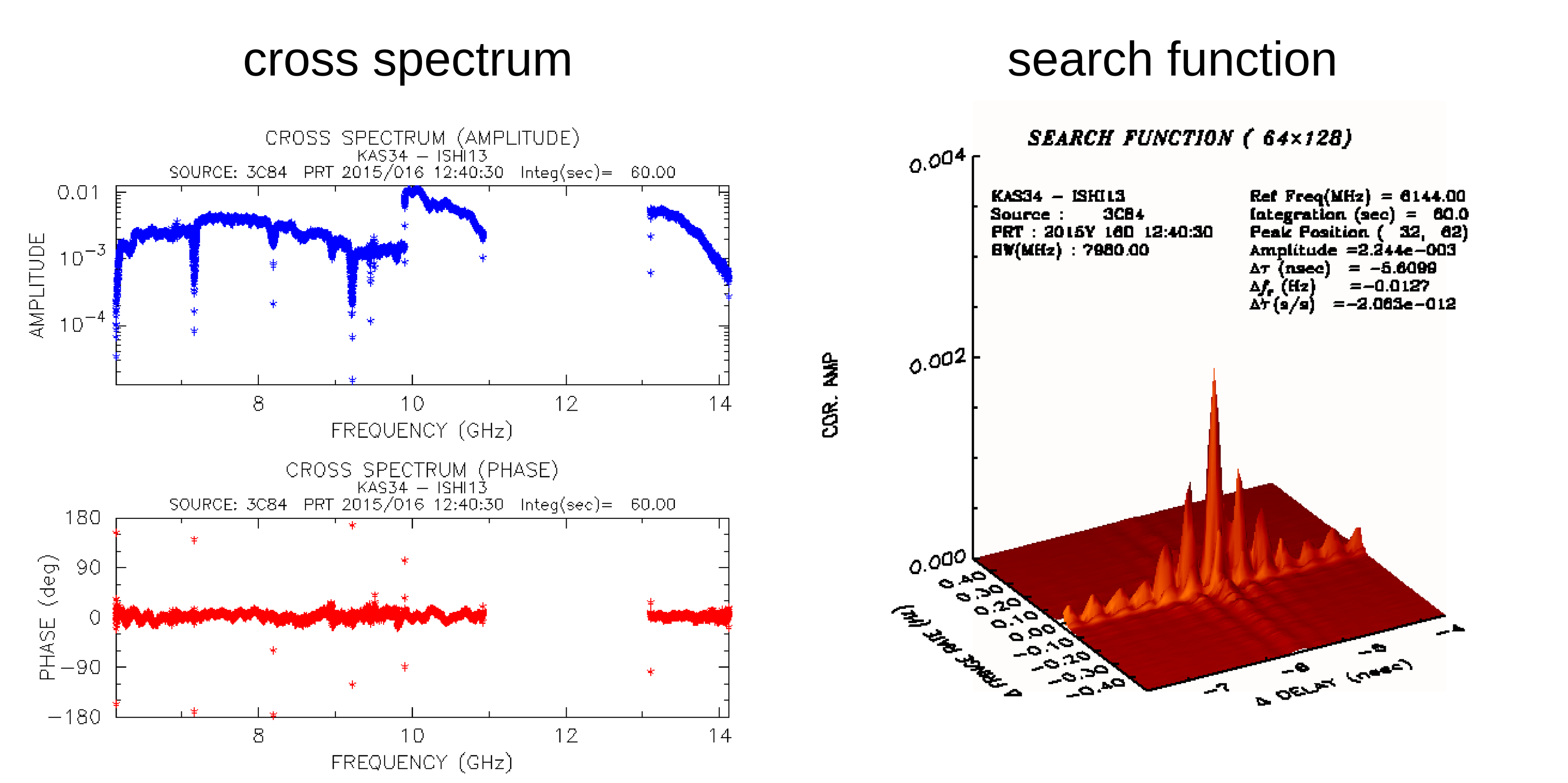

Fig.4 An example of WBWS results. Horizontally aligned phase spectrum means the success of WBWS. Observables $\Delta\tau_w$ and $\Delta\dot{\tau}_w$ are given as the position of the maximum peak on a search function.

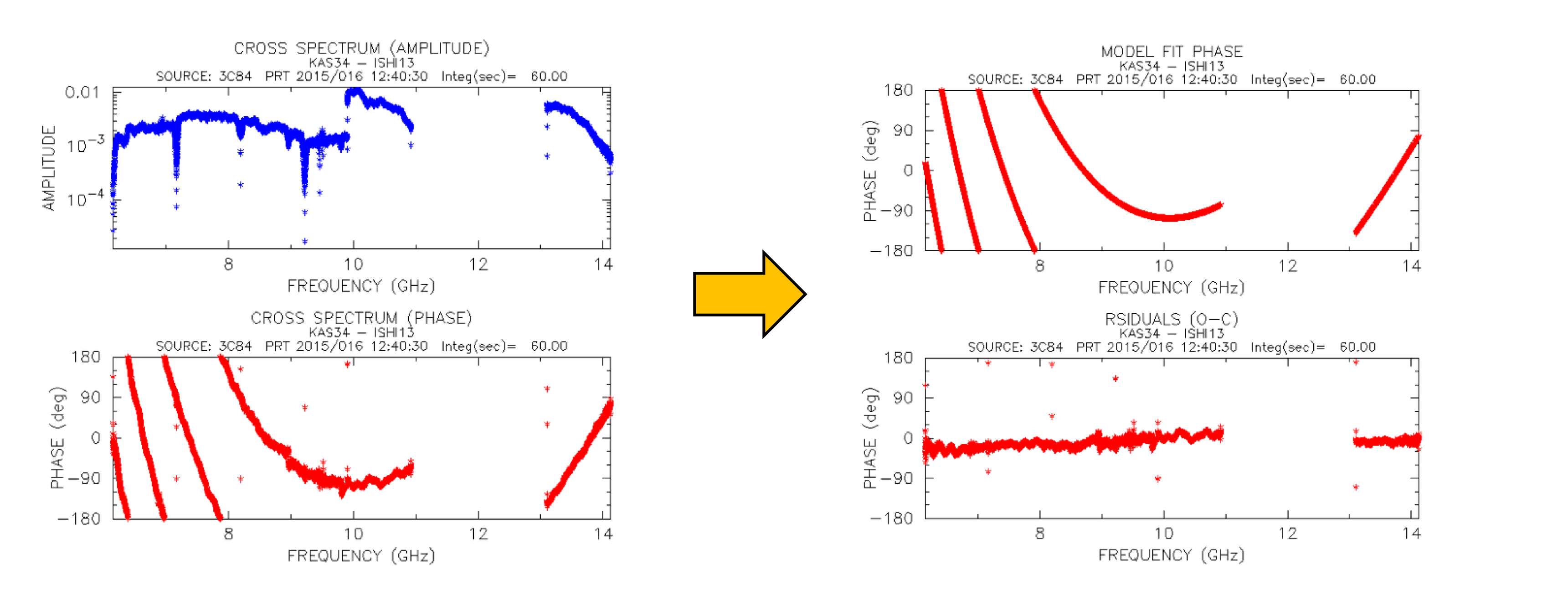

Fig.5 Demonstration of the estimation of ΔTEC. Left panel shows simulated cross spectrum in the case of $\Delta TEC = -100$ TECU. Right panel shows estimated $\phi(f)$ (upper panel) and residual phase, O-C (lower panel). Estimated ΔTEC is -100.2 TECU.

4. Conclusion

We have been developing the WBWS software and it has been almost completed. WBWS on the short baseline shows good results. The software has not a chance to check the correction of the ionospheric effect, however the test using simulated data demonstrates good results too. Actual evaluation should be carried out by using true long base line data such as an inter-continental baseline.