VLBI Intra-technique Combination for Kalman Filter and Least-Squares Solutions

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ABSTRACT

The VLBI software packages for the data analysis which are used by different IVS (International VLBI Service for Geodesy and Astrometry) Analysis Centers (BKG (Federal Agency for Cartography and Geodesy), NASA GSFC (Goddard Space Flight Center), DGFI (Deutsches Geodaetisches Forschungsinstitut), SHA (Shanghai Astronomical Observatory), USNO (U.S. Naval Observatory), MAO (Main Astronomical Observatory), AUS (Geoscience Australia)) use various statistical methods. These statistical methods are the Least-Squares (LSQ) method, the Kalman filter (KF) method, the Square-Root Information Filter (SRIF) and the Least-Squares Collocation (LSQC) method and consider the behaviour of stochastic parameters in different way. For the intra-technique combination of different VLBI Analysis Center solutions, the effect of using different stochastic models on the estimates of geodetic parameters should be taken into account. In this study, we start to consider the combination of Kalman filter and LSQ solutions in our VLBI intra-technique combination algorithm. With the Kalman filter method, the use of polynomials to model the effect of the clocks and atmospheric delays are replaced with stochastic models. The implementation of the Kalman filter estimator to account for stochastic behavior on those parameters which vary during a VLBI experiment will be discussed.
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Abstract

The VLBI software packages for data analysis which are used by different IIVS (International VLBI Service for Geodesy and Astrometry) Analysis Centers (RRK, NASA GSFC (Goddard Space Flight Center), DDFI (Deutsches Geodätisches Forschungsinstitut), SAG (Shanghai Astronomical Observatory), NMO (Main Astronomical Observatory), AUS (Geodetic Survey of Australia)) use various statistical methods. These statistical methods are the Least-Squares (LSQ) method, the Kalman filter (KF) method, the Square-Root Information Filter (SRIF) and the Least-Squares Collocation (LSQC) method and consider the behaviour of stochastic parameters in different ways. For the intra-technique combination of different VLBI Analysis Center solutions, the effect of using different stochastic models on the estimates of geodetic parameters should be taken into account. In this study, we consider the combination of Kalman filter and LSQ solutions in our VLBI intra-technique combination algorithm. With the Kalman filter method, the use of polynomials to model the effect of the clocks and atmospheric delays are replaced by stochastic models. The implementation of the Kalman filter estimator to account for stochastic behavior on those parameters which vary during a VLBI experiment will be discussed.

Introduction

In Tanir et al. (2007), simulated CONTOS sessions were analyzed by the OCCAM software with KS and LSQ adjustment methods. Baseline lengths are used as an accuracy measure for making comparison between results taken from KS and LSQ. The formal errors of the baseline lengths estimated by Kalman filter were always smaller than those estimated by Least-Squares method (see Fig.1), e.g., the uncertainties for the estimated baseline lengths WETZELL-HARTRAO are around 0.4 cm by LSQ and around 0.3 cm by KS. In order to understand the reason of such differences, it is necessary to go into detail in the implemented algorithm for the KS solution.

Method

We have studied on a simple example with simulated VLBI observables for one station which cover clock parameters, slant delay and white noise in 24-h (Pany et al., 2007). KS and LSQ estimation results of these simulated observables are compared w.r.t. two important issues:

- the time intervals for the piecewise linear functions in LSQ and for estimation in KS
- the constraints for the rates in LSQ and the system noise in KS
- the application of forward and backward KS

Time intervals

The stochastic parameters like clock and wet zenith delay might have LSQ and KS estimation for different time intervals in 24-h. In this study, firstly we compare KS results in the estimation time interval of 30min with LSQ results in the time intervals for the piecewise linear functions as every 10min for wet zenith delay and every 1-h for clock (Pany et al. 2007). It means that we don’t have the same number of estimations for the same parameters from LSQ and KS.

The parameter estimation results and associated covariance matrices from KS analysis solutions for certain estimation intervals (beginning and ending of the intervals have to coincide with the LSQ estimation epochs) are combined by using superposition of normal equations to get representative estimation parameters and corresponding variance covariance matrices (KS COM) for certain time intervals in which we have LSQ estimation results.

Conclusions

We might reach equal results from KS and LSQ by using

- the same estimation time intervals in LSQ and KS (see Fig.1),
- constraints for rates in piecewise function in LSQ as equal system noise in KS (see Fig. 2),
- not only forward but also backward solutions (see Fig.3)

Starting from KS formulation one could write the equivalent normal equation matrix and normal equation vector but you need to start very early, when the solution is not yet calculated. We plan to use other smoother formulations (see Albertella et Al 2005) to verify if we can improve the final Kalman solution and the agreement with LSQ solution.

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References:

