On the combination of VLBI and ring laser data for accurate Earth rotation determination

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EGU2011-11400

Introduction

The rotation of the Earth is normally measured using space geodetic techniques such as GNSS (Global Navigation Satellite Systems) and VLBI (Very Long Baseline Interferometry). In recent years a new technique sensitive to the rotation of the Earth has emerged: ringlaser gyroscopes. One problem with this technique is that the ringlaser measurements typically contain unknown offsets and drifts. However, the ringlaser data may be useful in a combination with other techniques in order to derive accurate time-series of the Earth Rotation Parameters (ERP), i.e. polar motion and Universal time (DUT1). Especially, ringlasers could improve the high resolution (sub-daily) ERP. In this work we combine the measurements from the "G" ringlaser in Wettzell with VLBI observations.

Ringlaser observations

The ringlaser observes the Sagnac frequency:

$$f_{sag} = A\vec{\Omega} \cdot \vec{n} + \Delta f_{instr}$$

where A is a constant, $\vec{\Omega}$ is the rotation vector of the Earth, $\vec{n}$ the normal of the ringlaser, and Δf_{instr} the instrumental error.

We have used data from the Wettzell ringlaser from the period 1 May–14 October, 2010.

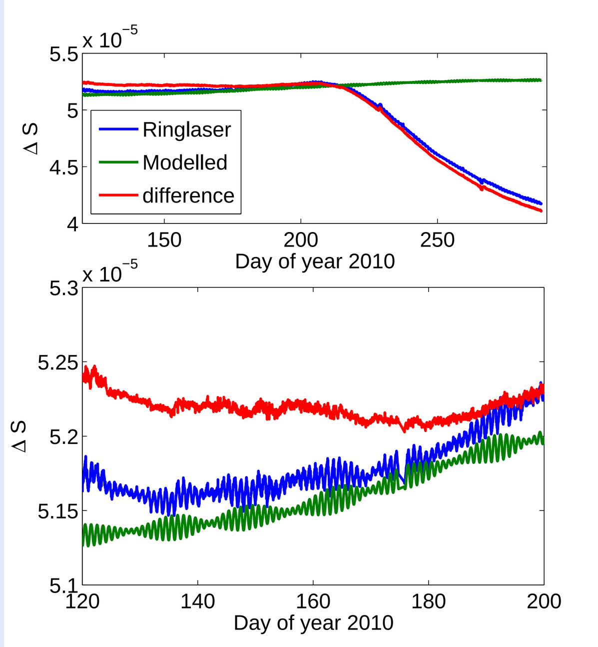

Fig. 1: Data observed by the Wettzell ringlaser and the expected variations due to the ERP.

Combination

The normal equations for the VLBI observations were set up using the Vienna VLBI Software (VieVS). Similarly, the normal equations for the ringlaser observations were set up and then stacked with the VLBI normal equations. The ERP were modelled as piece-wise linear functions in 1-hour intervals. For the ringlaser data, additionally one offset and one rate parameter were estimated for each 24 h VLBI session.

Results from individual sessions

Below the results of the combination are shown. From all estimated ERP the IERS 05 C04 values as well as the IERS model for high frequency ERP variations have been removed.

Accurate VLBI session: R1446

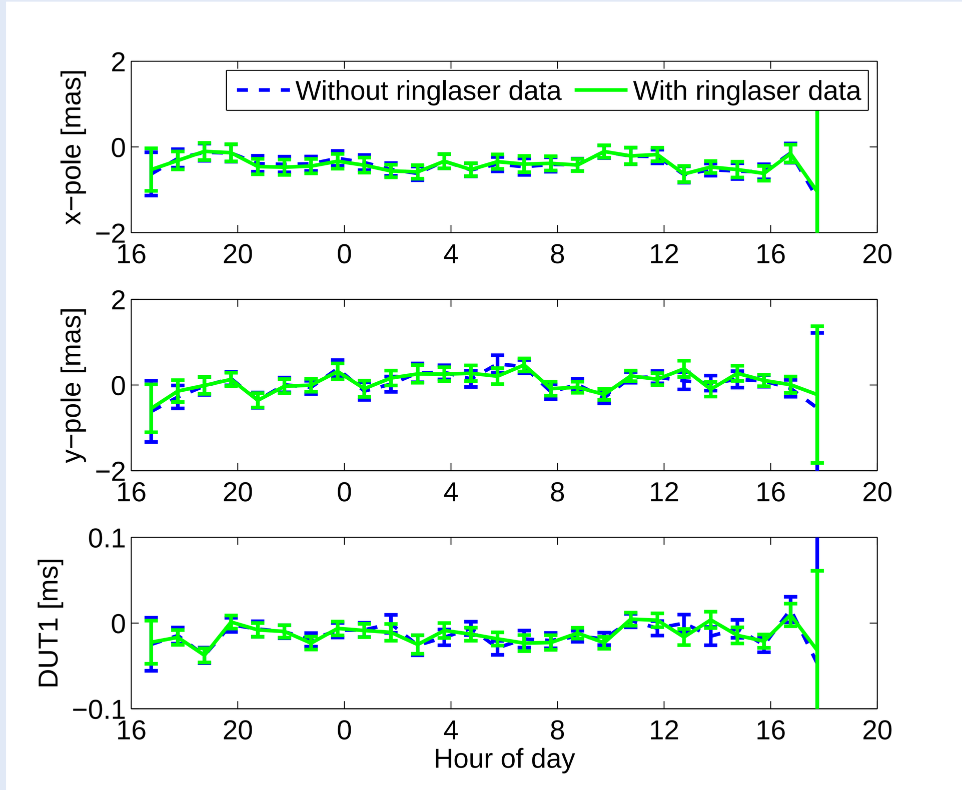

Fig. 2: ERP estimated from VLBI and the VLBI-ringlaser combination for the session R1446 (30–31 August, 2010). This VLBI session has a high sensitivity to ERP. Errorbars indicate the 1-σ formal errors.

Inaccurate VLBI session: T2070

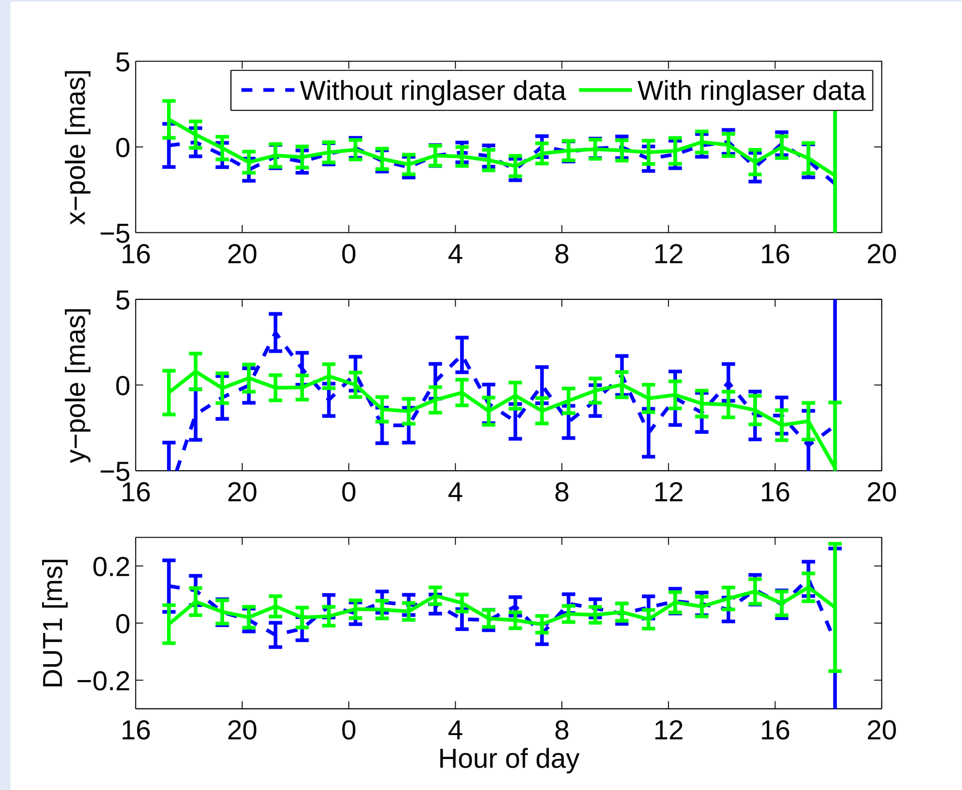

Fig. 3: ERP estimated from VLBI and the VLBI-ringlaser combination for the session T2070 (20–21 July, 2010). This VLBI session has a lower sensitivity to ERP than R1446.

Results from all sessions

Statistics for all VLBI sessions 1 May–14 October, 2010.

Mean difference to C04

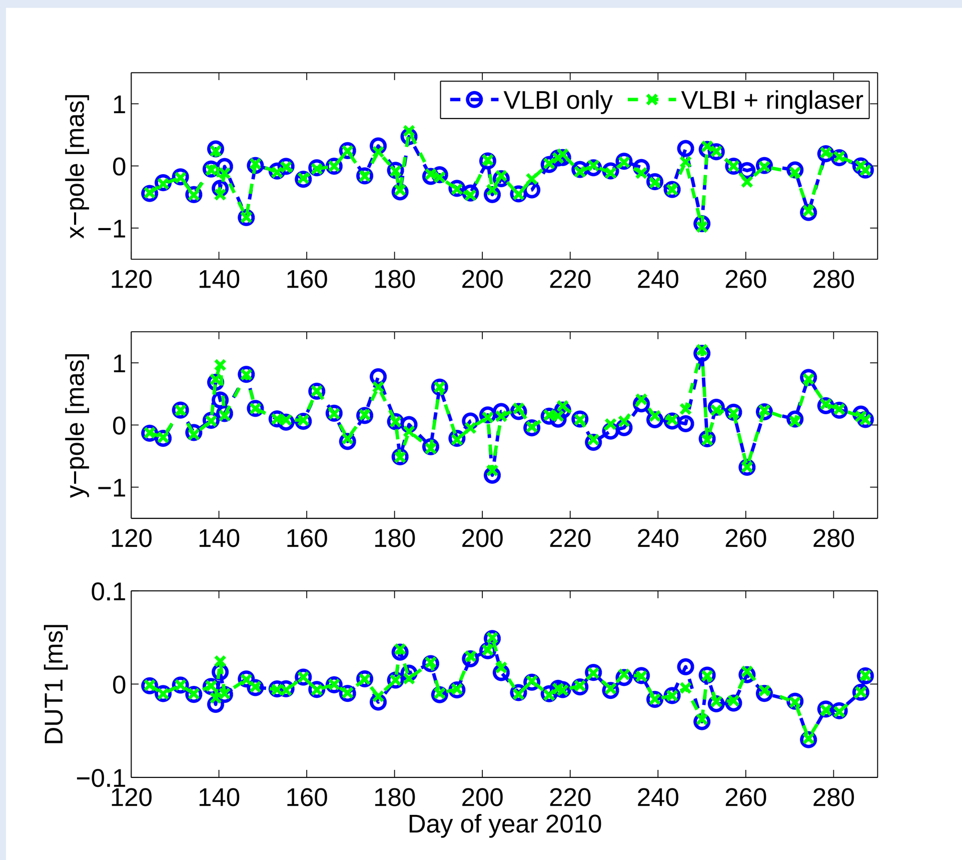

Fig. 4: Average differences between the ERP estimated from the VLBI sessions and the IERS 05 C04 values (plus the IERS high frequency ERP model). There is no significant impact of the ringlaser data on the mean values.

RMS differences to IERS hf model

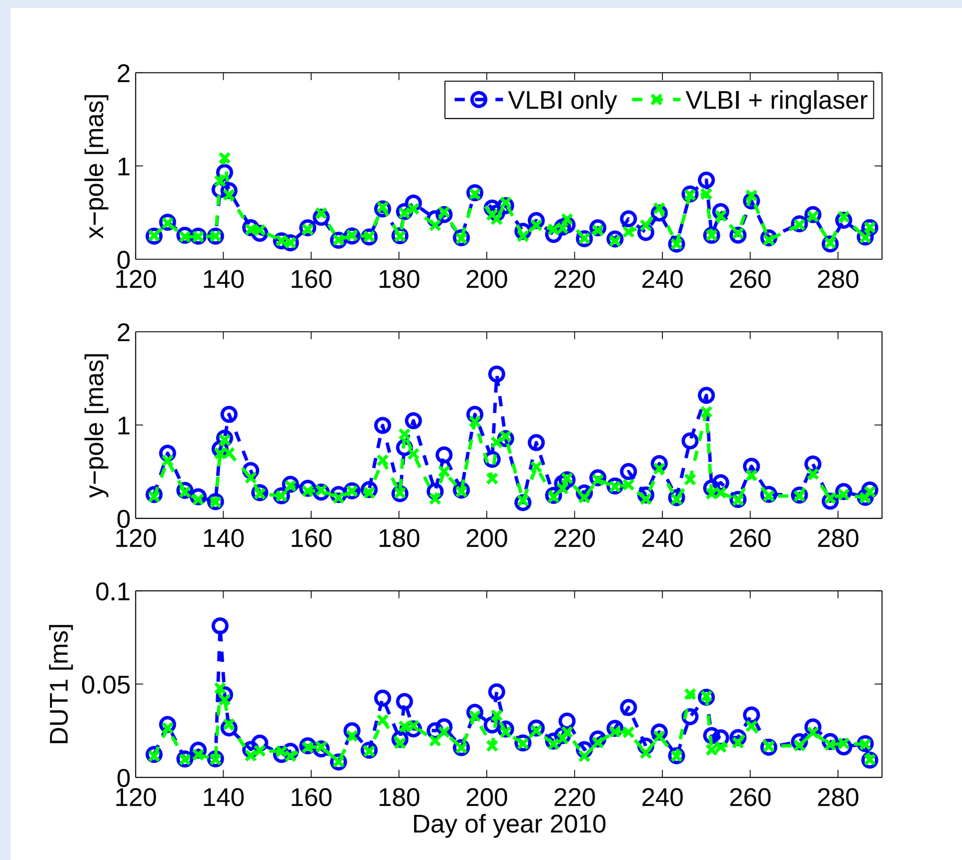

Fig. 5: RMS differences between the ERP estimated from the VLBI sessions and the IERS high frequency ERP model (plus IERS 05 C04). On average there is a reduction of the RMS in y-pole and DUT1 by 10%.

Possible improvements

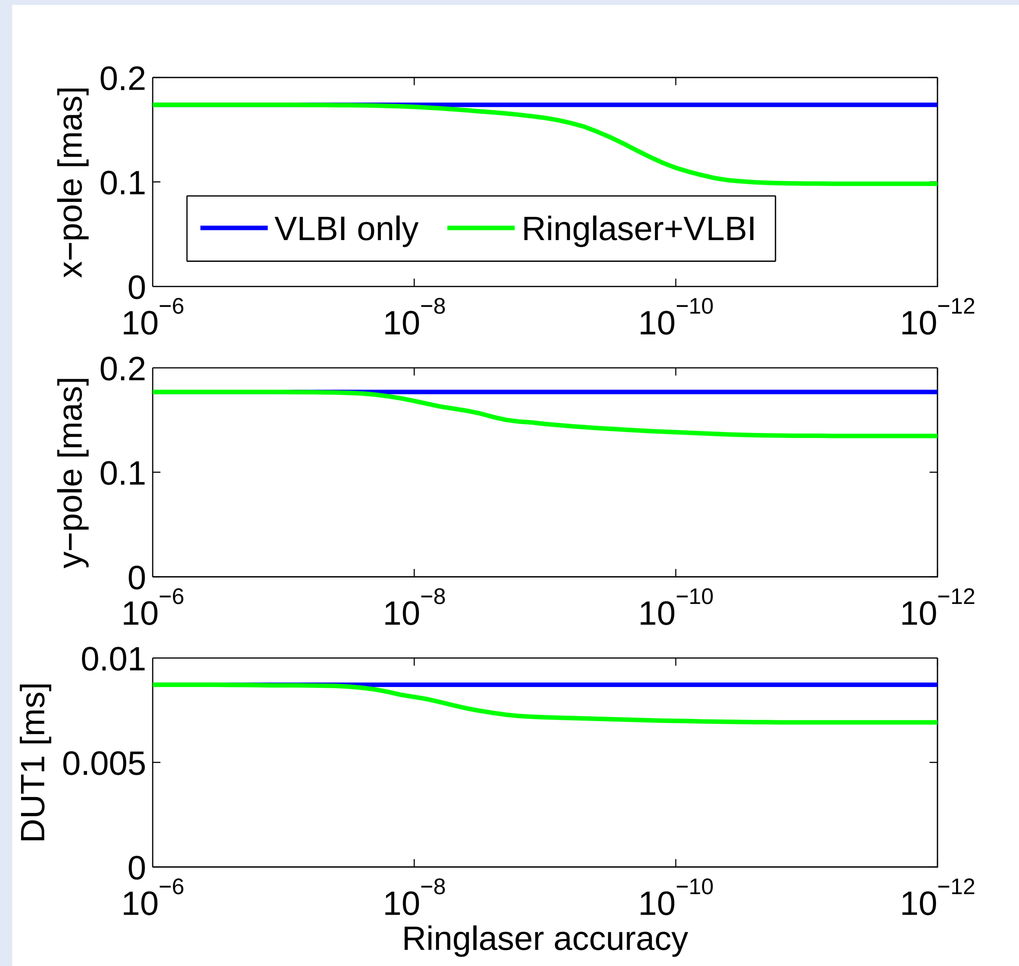

Fig. 6: Median formal errors of the ERP estimated from the VLBI-ringlaser combination (session R1446) for different assumed accuracies of the ringlaser measurements. The current value is about 10^{-8}.

Conclusions

The ringlaser observations and the VLBI data have been successfully combined. The impact of the ringlaser data on the solution is however in most cases minor. The reason is that the accuracy of the ringlaser is about one order of magnitude lower than the accuracy of VLBI. However, for sessions where VLBI has a low sensitivity to ERP (due to e.g. station distribution) the ringlaser sometimes improves the estimated ERP, especially y-pole and DUT1. If the accuracy of the ringlaser data would improve by one order of magnitude (or more), the ringlaser could significantly improve the ERP also from normal VLBI sessions.

Acknowledgements

We are grateful to the International VLBI Service for Geodesy and Astrometry for providing the VLBI data. This work was funded by the German Science Foundation (DFG, Deutsche Forschungsgemeinschaft) within the Research Unit FOR584 "Earth Rotation and Global Dynamic Processes" (project number: SCHUH 1103/3-2).