Application of Kalman filtering for the analysis of Intensive sessions

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Data analysis

In this work we analyzed the Intensive sessions with the newly developed Kalman filter (KF) module in the VieVS@GFZ software (Nilsson et al., 2015). In the analysis, we estimated UT1-UTC, clocks, and zenith wet delays (ZWD). The gradients were fixed to the empirical APG model (Böhm et al., 2013). The results were evaluated by comparing the UT1-UTC estimates to those from simultaneous standard R1/R4 sessions. Furthermore, we inferred the Length of Day (LOD) from the UT1-UTC estimated from two subsequent Intensives and compared them to the values obtained from GNSS (IGS final product).

The Intensive sessions

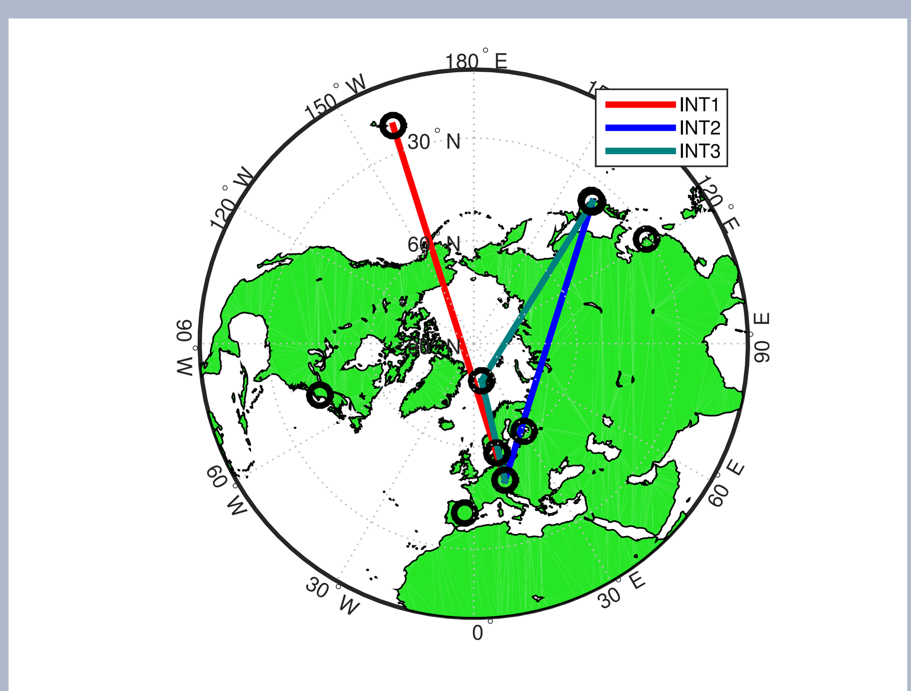

Figure 1: The stations participating in the Intensive sessions used in this work. In total we analyzed 4428 Intensives from the period 2002–2015.

Kalman filter vs LSM

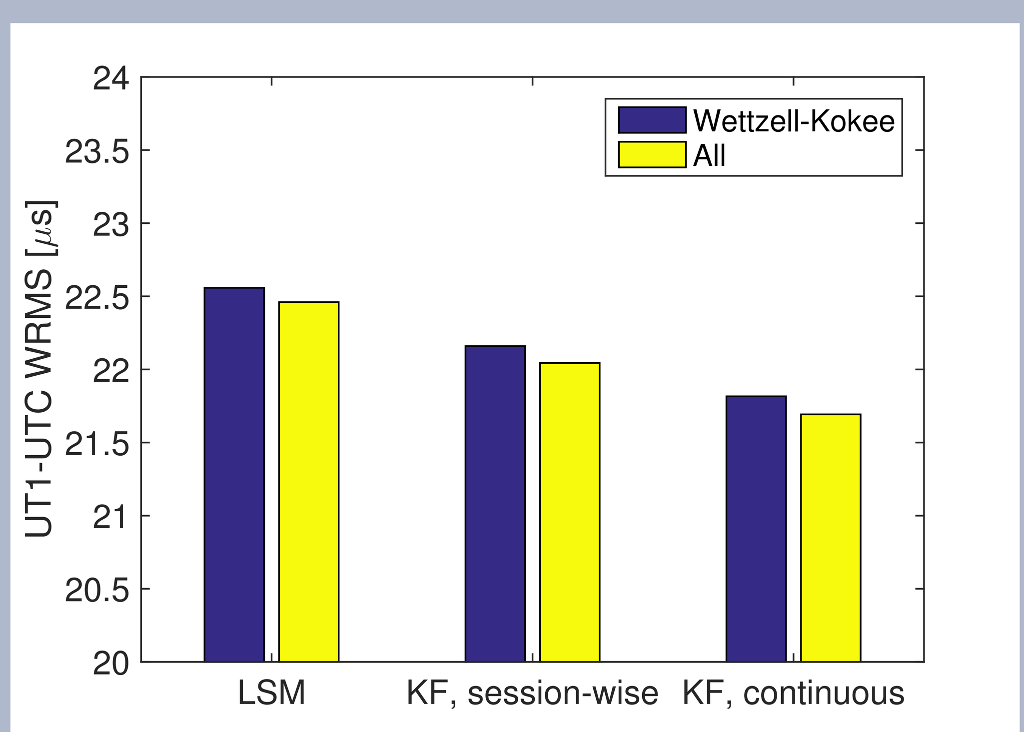

Figure 2: Weighted Root-Mean-Square (WRMS) differences between UT1-UTC estimated from the Intensives and from the R1/R4 sessions. Three different solutions were made: a classical Least Squares (LSM) solution, a KF solution where all sessions were analyzed independently (KF, session-wise), and a KF solution where the a priori UT1-UTC and ZWD were taken from the previous session (KF, continuous).

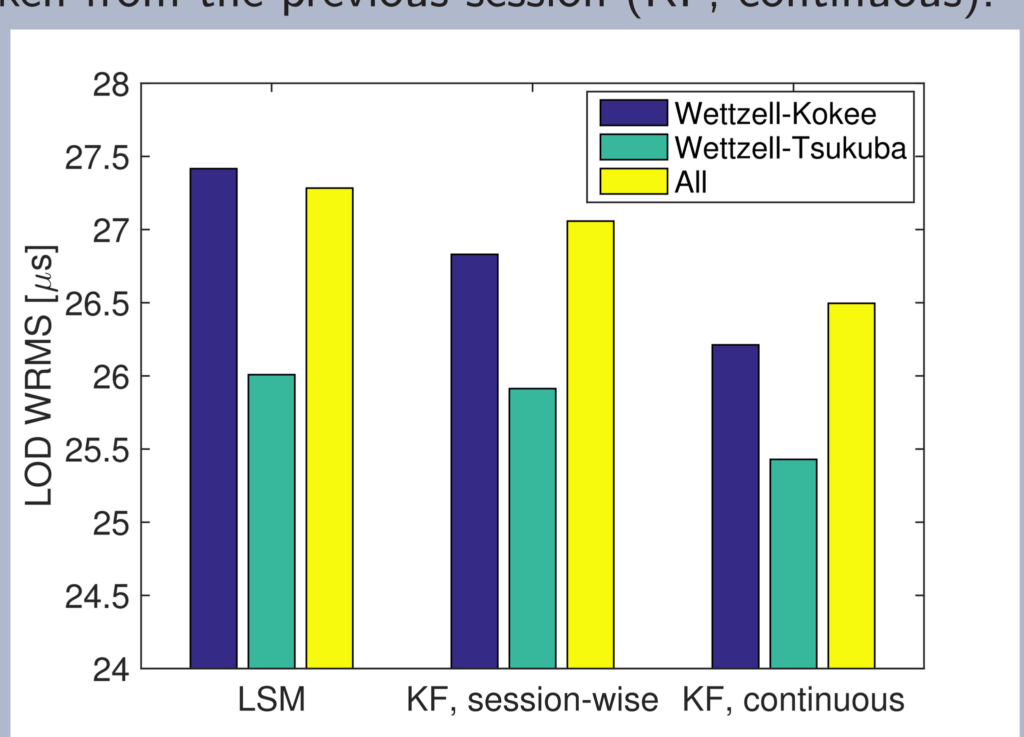

Figure 3: WRMS differences between LOD estimated from the Intensive solutions and from GNSS.

Estimation of gradients

We tested the effect of estimating gradients in the data analysis (Nilsson et al., 2011).

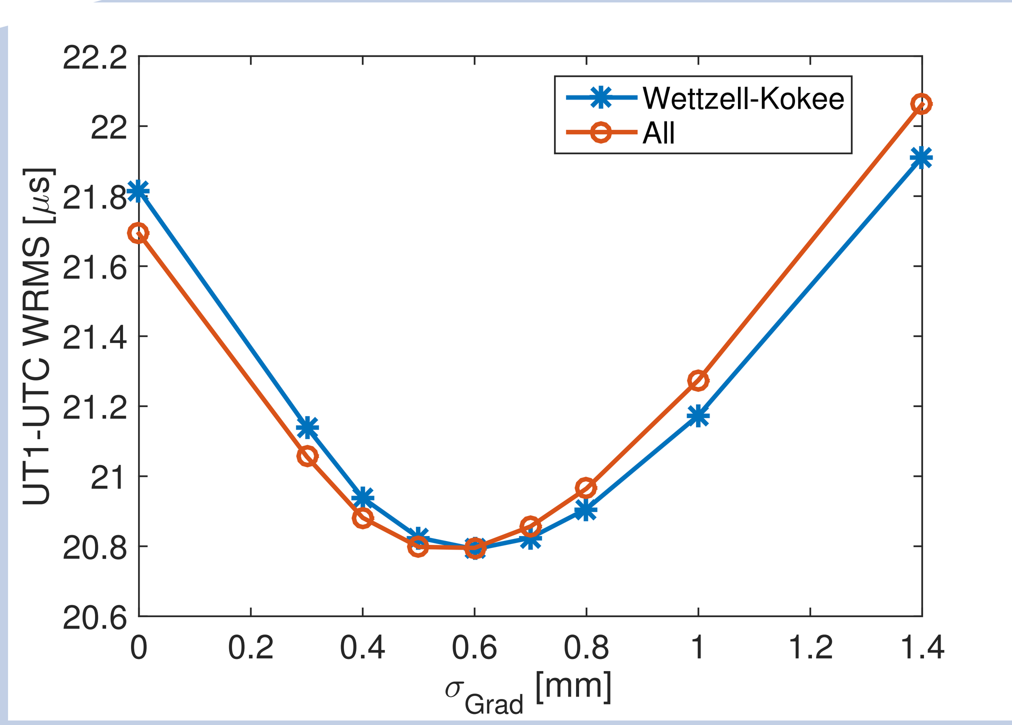

Figure 4: The WRMS UT1-UTC differences, as function of the assumed a priori gradient uncertainty σ_{Grad}.

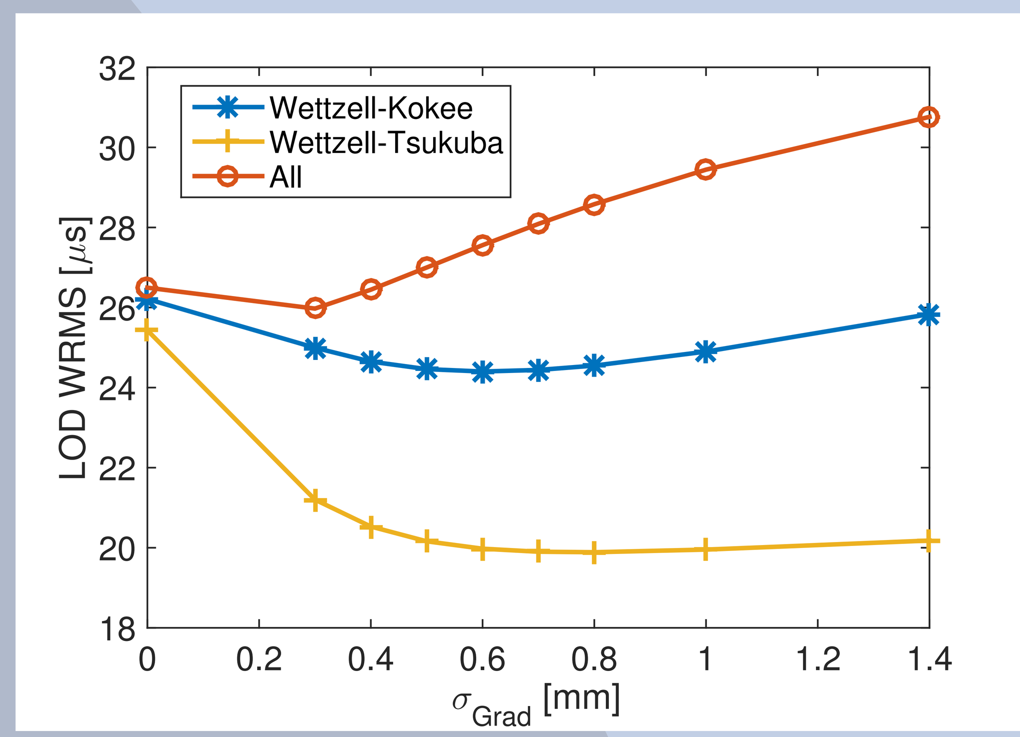

Figure 5: The WRMS LOD differences, as function of the assumed a priori gradient uncertainty σ_{Grad}.

Gradients from GPS

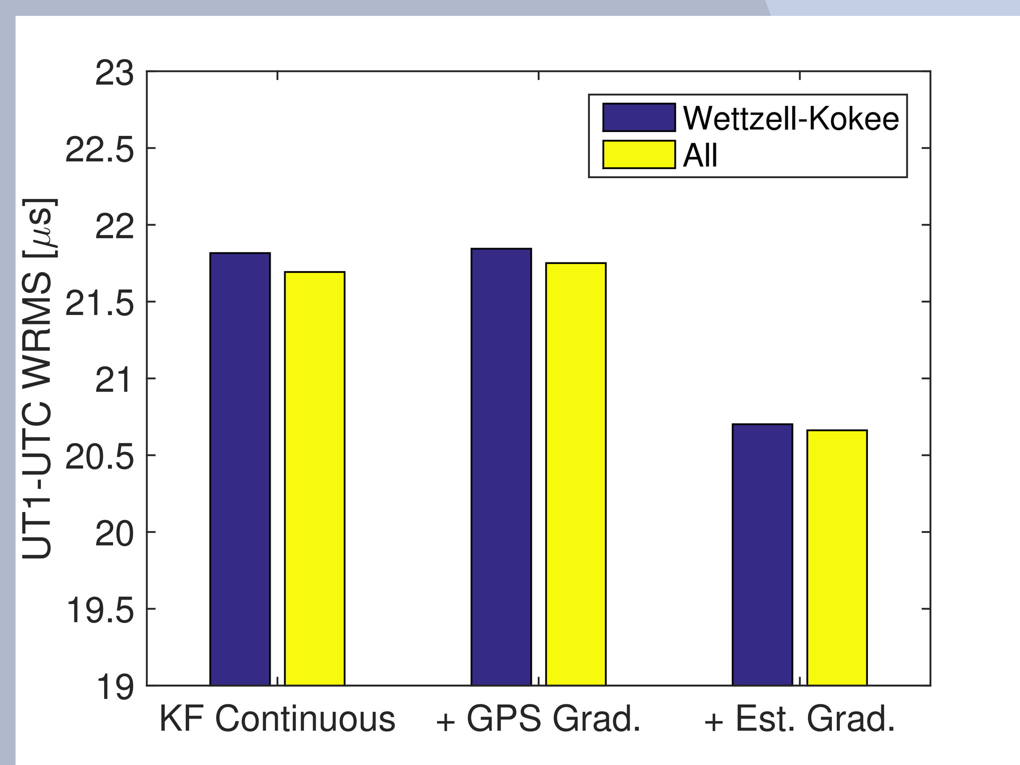

Figure 6: The WRMS UT1-UTC differences, when using a priori gradients from GPS. Two solutions were tested: fixing gradients to the ones from GPS (+GPS grad), or additionally estimating gradients using the formal errors of the GPS gradients as the a priori uncertainty (+ Est.). When no GPS gradients were available, APG was used.

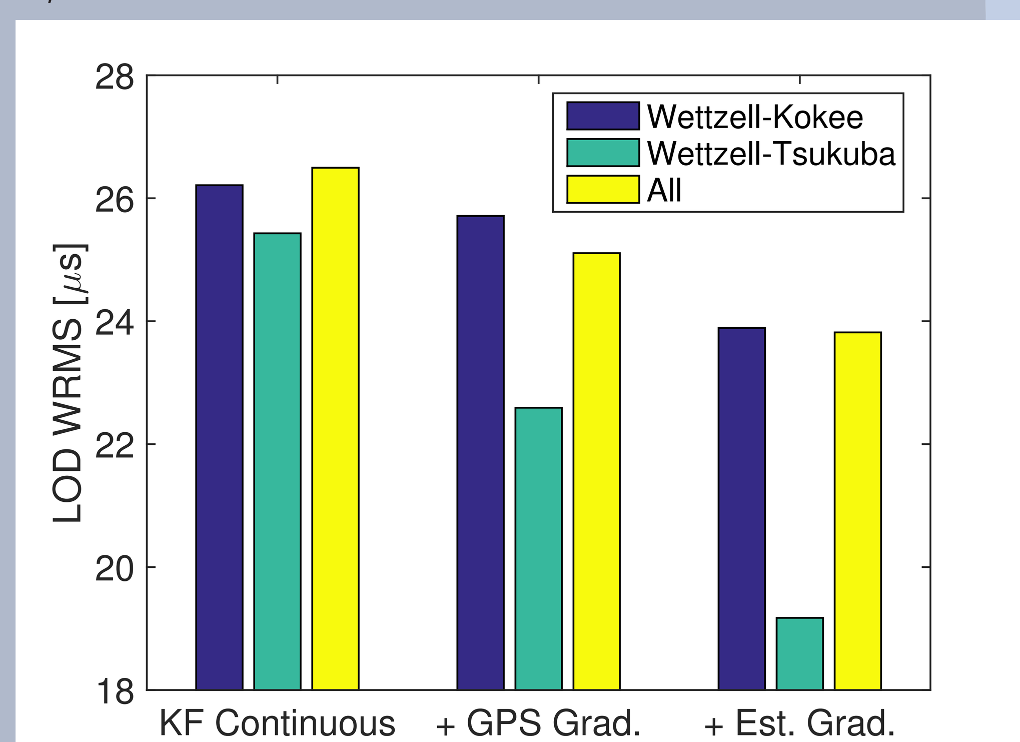

Figure 7: The WRMS LOD differences, when using a priori gradients from GPS.

Zenith wet delay comparisons

Another way to study the general quality of the Intensives is to look at the quality of the ZWD estimates.

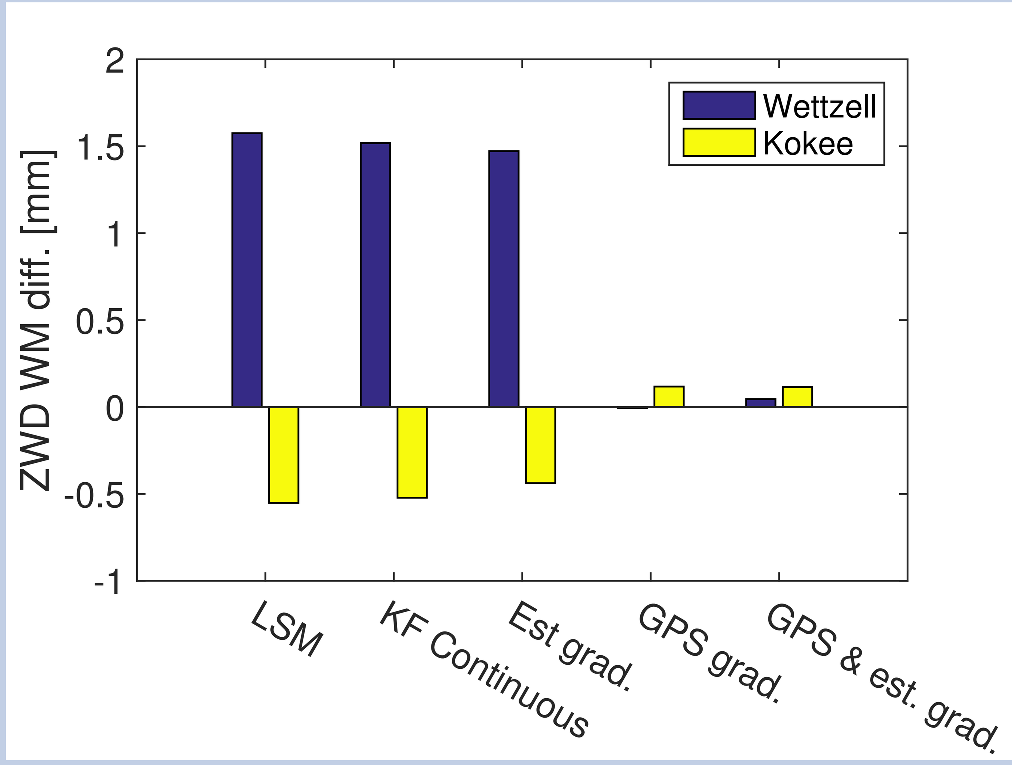

Figure 8: Weighted mean (WM) differences between ZWD estimated in the Intensives solutions and ZWD estimated from simultaneous R1/R4 sessions.

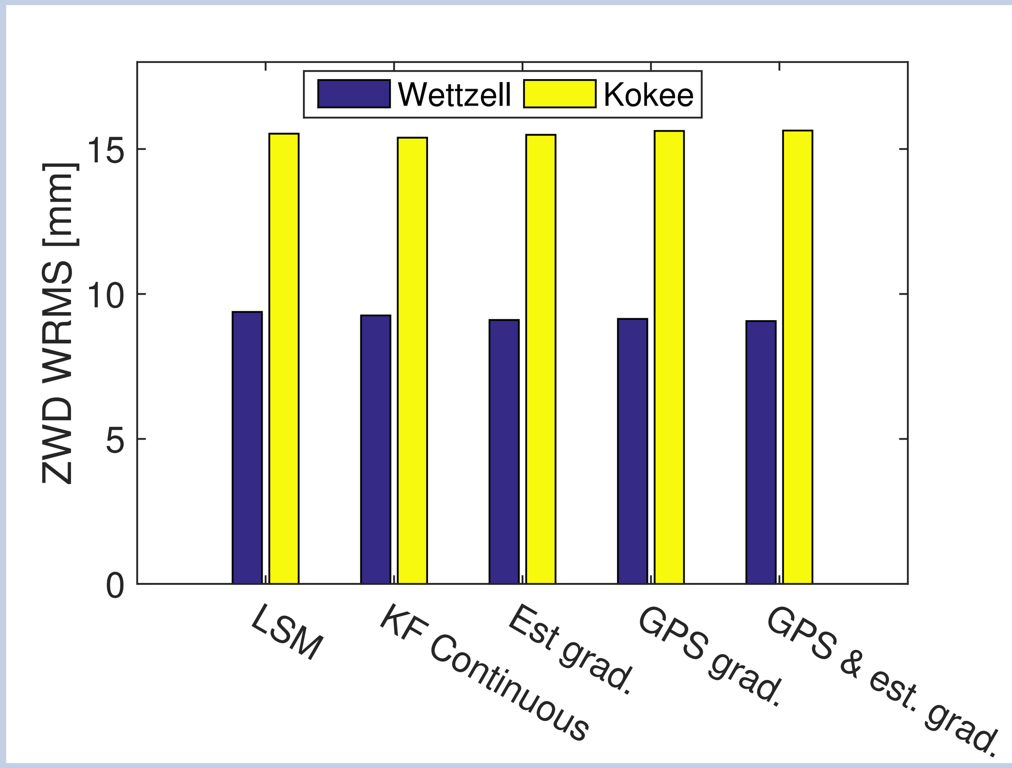

Figure 9: WRMS differences between ZWD estimated in the Intensives solutions and ZWD estimated from simultaneous R1/R4 sessions.

Conclusions

The results from the KF solution are slightly better than those from LSM, especially when the a priori UT1-UTC and ZWD are taken from the previous session. Further improvement is obtained when also gradients are estimated in data analysis (strongly constrained to the a priori values), and/or a priori gradients from GPS are applied.

References

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Acknowledgments

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