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Kalman filtering for real-time GNSS-reflectometry

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Recent advances in GNSS-reflectometry based on inverse modelling have increased the number of parameters which can be retrieved, and increased the precission of the parameter retrievals. However, as the method is based on least squares adjustment it is necessary to have access to longer SNR time series before any inversion can be performed. Lomb-Scargle analysis could be used in close real-time, but such an approach would lead to inferior performance compared to inverse modelling. To move toward real-time high precision GNSS-R processing we propose a method based on Kalman filtering of the SNR data using the same inversion model as previously. The method is based on a recursive B-spline approximation for reflector height changes and is specially designed to meet the Kalman filter framework. However, because of the highly non-linear relationship between the SNR oscillations and the parameters of interest, an Unscented Kalman filter implementation has to be used. Based on tests with data from the GTGU installation at Onsala Space Observatory, Sweden it is demonstrated that the method performs almost as well as the post-processing inversion algorithm. Since the Kalman filter solution can be used in real-time and it outperforms the classical Lomb-Scargle analysis it is recommended to be used for short-latency GNSS-R retrieval applications. In conclusion, the Kalman based inversion algorithm makes real-time high precision GNSS-reflectometry feasible, and opens up the field for new applications.