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Medium-term predictions of F10.7 and F30 cm solar radio flux with the adaptive Kalman filter

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The solar radio flux at F10.7 and F30 cm is required by most models characterizing the state of the Earth's upper atmosphere, such as the thermosphere and ionosphere, to specify satellite orbits, re-entry services, collision avoidance maneuvers, and modeling of the space debris evolution. We develop a method called RESONANCE (Radio Emissions from the Sun: ONline ANalytical Computer-aided Estimator) for the prediction of monthly smoothed F10.7 and F30 indices 1–24 months ahead. The prediction algorithm has three steps. First, we apply a 13-month optimized running mean technique to effectively reduce the noise in the radio flux data. Second, we provide initial predictions of the F10.7 and F30 indices using the McNish–Lincoln method. Finally, we improve these initial predictions by developing an adaptive Kalman filter with error statistics identification. The rms error of predictions with lead times from 1 to 24 months is 5–27 sfu for the F10.7 index and 3–16 sfu for F30, which statistically outperforms current algorithms in use. The proposed approach based on the Kalman filter is universal and can be applied to improve the initial predictions of a process under study provided by any other forecasting method. Furthermore, we present a systematic evaluation of re-entry forecast as an application to test the performance of F10.7 predictions on past ESA re-entry campaigns for payloads, rocket bodies, and space debris that re-entered from 2006 to 2019 June. The test results demonstrate that the predictions obtained by RESONANCE in general also lead to improvements in the forecasts of re-entry epochs.

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