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A Kalman filter approach for the determination of celestial reference frames

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The coordinate model of radio sources in International Celestial Reference Frames (ICRF), such as the ICRF2, has traditionally been a constant offset. While sufficient for a large part of radio sources considering current accuracy requirements, several sources exhibit significant temporal coordinate variations. In particular, the group of the so-called special handling sources is characterized by large fluctuations in the source positions. For these sources and for several from the "others" category of radio sources, a coordinate model that goes beyond a constant offset would be beneficial. However, due to the sheer amount of radio sources in catalogs like the ICRF2, and even more so with the upcoming ICRF3, it is difficult to find the most appropriate coordinate model for every single radio source. For this reason, we have developed a time series approach to the determination of celestial reference frames (CRF). We feed the radio source coordinates derived from single very long baseline interferometry (VLBI) sessions sequentially into a Kalman filter and smoother, retaining their full covariances. The estimation of the source coordinates is carried out with a temporal resolution identical to the input data, i.e. usually 1-4 days. The coordinates are assumed to behave like random walk processes, an assumption which has already successfully been made for the determination of terrestrial reference frames such as the JTRF2014. To be able to apply the most suitable process noise value for every single radio source, their statistical properties are analyzed by computing their Allan standard deviations (ADEV). Additional to the determination of process noise values, the ADEV allows drawing conclusions whether the variations in certain radio source positions significantly deviate from random walk processes. Our investigations also deal with other means of source characterization, such as the structure index, in order to derive a suitable process noise model. The Kalman filter CRFs resulting from the different approaches are compared among each other, to the original radio source position time series, as well as to a traditional CRF solution, in which the constant source positions are estimated in a global least squares adjustment.