Terrestrial reference systems from theory to implementation

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With the advent of space geodesy since the early eighties, a significant effort was undertaken by several authors to clarify the concept and the practical realization of terrestrial reference systems. Recent developments on reference frame representation, and in particular under the form of time series of station positions underline the necessity to unambiguously clarify the meaningful of the metrological quantities observed or estimated by space geodesy. Admitting the basic terminology, distinguishing between the system (the theory) and the frame (the numerical implementation) seems to facilitate the educational part of understanding the meaningful of the geodetic estimated quantities. Based on this perspective, two classes of reference frames are of an extreme importance for the geophysical interpretation of the geodetically estimated quantities: a secular and an instantaneous reference frames. Relating both frames to each other requires rigorous geodetic and statistical models that have the ability to optimally preserve the frame definition and its physical properties. Within the framework of the ITRF combination activities, the paper focus will be devoted to the discussion on how to optimally use the instantaneous frames, through time series analysis, for the secular frame determination, while faithfully preserving the physical quantities, e.g. frame origin and scale, linear and non linear parts of station motions.