The statistical inference of eigenspace components of a three-dimensional, symmetric rank-two random tensor: Case study: strain rate tensor in central Mediterranean and Western Europe

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In reality, crustal motions and deformation are of three-dimensional nature and most deformation tensors derived from geodetic, geological and seismological observations are three-dimensional, such as the seismic moment tensors. The *eigenspace components* of these random deformation tensors (principal components, principal directions) are of focal interest in geodesy, geology, and geophysics. They play an important role in interpreting the geodetic-geological-geophysical phenomena like earthquakes (seismic deformations), plate motions and plate deformations among others. On the assumption that a strain tensor or stress tensor has been directly measured or derived from other observations, such a three-dimensional, symmetric random tensor of second order is a random tensor which we assume to be a realization of the tensor-valued Gauss normal distribution with independently, identically distributed (i.i.d.) tensor-valued observations, but with identical off-diagonal elements. Since the *eigenspace synthesis* of a symmetric random tensor is nonlinear in terms of the tensor-valued observations, the respective parameters have to be estimated within a special nonlinear multivariate *Gauss-Markov* model. *First*, based on the review and choice of orthogonal similarity transformation matrices the *eigenspace analysis and synthesis* of a three-dimensional symmetric random matrix are established uniquely. *Second*, the nonlinear function that relates the tensor elements to the eigenspace components is linearized with respect to a *special nonlinear multivariate Gauss-Markov model*, which enables the *BLUUE of the eigenspace elements* and *BIQUUE* of its variance-covariance matrix, developed by Cai (2001), to be successfully applied in the three-dimensional case. With these estimates and the proposed hypothesis tests for the random tensor sample means as well as its one variance component we successively perform the statistical inference in the case study of the three-dimensional random strain rate tensor in central Mediterranean and Western Europe. The related *linear hypothesis test* has documented large confidence regions for the eigenspace components, namely *eigenvalues and eigendirections*, based upon real measurement configurations. They lead to the statement *to be cautious* with data of type extension and contraction as well as the orientation of principal stretches.