Surface and deep deformation of the Alps from geodetic and seismic anisotropy measurements

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ABSTRACT
We study crustal and mantle deformation of the great Alpine area as obtained by Global Positioning System (GPS) and seismic anisotropy measurements. We derive a new three-dimensional GPS velocity field, obtained from the analysis of thousands of continuous sites operating in the European plate. Using a multi-scale approach we estimate a continuous geodetic strain-rate field, which is compared with the tectonic deformation obtained from the analysis of earthquake focal mechanisms. Deformation of the mantle is obtained from the GPS spatiotemporal measurements collected during several experiments and available from different databases. The shear directions (or no-length-change directions) from the geodetic strain-rate field, are compared with the directions of a smoothed map of the GPS stations over the study area. In this study, contribution, dynamics and interconnections between crust and mantle are showed and the geodynamic implications are discussed.

SEISMOEOTONICS

We analyze data from continuous GPS stations using the spherical wavelet-based method of Tape et al., GJI, (2009), which allows the estimation of a spatially continuous velocity field on a sphere starting from a set of irregularly spaced geodetic stations. The velocity field at a given point of the Earth’s surface is obtained as a combination of waves separated into different spatial scales. The continuous ocean is assumed to consist of waves separated into anisotropically homogeneous frequency, which goes to the scales only where justified, based on the GPS site density. This is allowing for short-scale spherical wavelets in the extrabas in absence of GPS stations, and allowing only for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale. In case of tectonic deformation, reasonable maximum values of q ranges between 7 and 9, corresponding to scales of 55 and 14 km, the smallest resolved process according to the local spatial density of observations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale, the method allows for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations.

We derive the geodetic strain-rate field using the spherical wavelet-based method of Tape et al., GJI, (2009), which allows the estimation of a spatially continuous velocity and strain-rate field, on a sphere starting from a set of irregularly spaced geodetic stations. The velocity field at a given point of the Earth’s surface is obtained as a combination of waves separated into different spatial scales. The continuous ocean is assumed to consist of waves separated into anisotropically homogeneous frequency, which goes to the scales only where justified, based on the GPS site density. This is allowing for short-scale spherical wavelets in the extrabas in absence of GPS stations, and allowing only for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale. In case of tectonic deformation, reasonable maximum values of q ranges between 7 and 9, corresponding to scales of 55 and 14 km, the smallest resolved process according to the local spatial density of observations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale, the method allows for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations.

SEISMIC ANISOTROPY VS GEODETIC DEFORMATION

We compared the observed SKS fast axes with the SKS fast axes obtained using the spherical wavelet-based method of Tape et al., GJI, (2009), which allows the estimation of a spatially continuous velocity field on a sphere starting from a set of irregularly spaced geodetic stations. The velocity field at a given point of the Earth’s surface is obtained as a combination of waves separated into different spatial scales. The continuous ocean is assumed to consist of waves separated into anisotropically homogeneous frequency, which goes to the scales only where justified, based on the GPS site density. This is allowing for short-scale spherical wavelets in the extrabas in absence of GPS stations, and allowing only for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale. In case of tectonic deformation, reasonable maximum values of q ranges between 7 and 9, corresponding to scales of 55 and 14 km, the smallest resolved process according to the local spatial density of observations. Using Tape’s notation, q indicates wavelet order and a corresponding spatial scale, the method allows for long-scale spherical wavelets in the estimation where stations are sparse. The method locally matches the estimated strain process according to the focal spatial velocity of deformations.