COMBINATION OF GLOBAL AND LOCAL GPS VELOCITY FIELDS USING LEAST SQUARES METHOD IN THE REGION OF IRAN

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If the horizontal velocities describe movement of a homogeneous, compact area on a spherical surface can be described as a rotation around the Euler pole with spherical coordinates φ_E and λ_E. The velocity components in north-south v_n and east-west v_e directions of the velocity vector $\boldsymbol{v}$ of the site with coordinates φ and λ are expressed as:

$$\begin{aligned} v_n &= \omega \sin(\lambda - \lambda_E)\cos\varphi_E \\ v_e &= \omega\left[\cos\varphi_E \sin\varphi \cos(\lambda - \lambda_E) - \sin\varphi_E \cos\varphi\right] \end{aligned} \qquad (1)$$

where ω is the angular velocity around Euler rotation axis (Figure 1). The same principle can be used for the determination of rotation between two velocity fields which are not evaluated in the same reference. In the first approach using different geophysical models, known Euler Poles between the Arabian and Eurasian plates and Central Iran block are used to combine the GPS velocity fields. In the second approach, if we denote velocity components in the reference (1) as $v_n^{(1)}$, $v_e^{(1)}$ and as $v_n^{(2)}$, $v_e^{(2)}$ the velocities in the reference (2) their differences are

$$\begin{aligned} \delta v_n &= v_n^{(2)} - v_n^{(1)} \\ \delta v_e &= v_e^{(2)} - v_e^{(1)} \end{aligned} \qquad (2)$$

Then these differences can be expressed as a rotation around the pole with coordinates φ_{ED} and λ_{ED}

$$\begin{aligned} \delta\ _n &= \delta\omega \sin(\lambda - \lambda_{ED})\cos\phi_{ED} \\ \delta\ _e &= \delta\omega\left[\cos\phi_{ED} \sin\phi \cos(\lambda - \lambda_{ED}) - \sin\phi_{ED} \cos\phi\right] \end{aligned} \qquad (3)$$

where $\delta\omega$ is the angular velocity describing the differential rotation of reference (2) relatively to reference (1). If the velocity differences δv_n and δv_e of at least two sites are available, then the position of pole of rotation φ_{ED} and λ_{ED} and the angular velocity $\delta\omega$ can be estimated using the method of least squares. Note that the parameters φ_{ED} and λ_{ED} are not in linear relationship with the observables δv_n and δv_e and the linearization of (3) is necessary. Then the approximate position of pole of rotation φ_{ED0} and λ_{ED0} has to be established. The unknown parameters $\delta\omega$, φ_{ED} and λ_{ED} will be estimated on the basis of a set of identical points for which velocities in two reference frames (1) and (2) are available. The covariance matrix of estimated parameters will be scaled by factor σ_0^2 obtained from residuals at identical points. The parameters $\delta\omega$, φ_{ED} and λ_{ED} will be subsequently used for transformation of velocities of non-identical points between frames (1) and (2).

In this paper we demonstrate two method of combination of global and local velocity fields into a homogeneous system. The transformation of velocities is based on evaluation of Euler pole and angular rotation, expressing the relations among reference and global or local velocities. The reference velocity frame is represented by *EPN* velocities which we consider as the most representative in the region of Iran.

We considered two Eurasia fixed and Arabia fixed velocity fields in the Zagros-Makran transition zone from Bayer et al., (2006) and Peyret et al., (2009), respectively. Geophysical models and least-squares method used for these fields combination to produce a combined Eurasia fixed velocity field. Figure 2 shows the Eurasia fixed velocity field in red from Bayer et al., (2006) and Arabia fixed velocity field in blue from Peyret et al. (2009). Two mentioned velocity fields are common in five station: JASK, MINA, MOSH, SARZ, FORC (Figure 2).

In order to do combination we first used known Arabia-Eurasia Euler pole estimated by Vernant et al. (2004). The result of combination has been shown in Figure 3 (in green). Combination results using this method shows that rotated velocity field is compatible with Eurasia field velocity field in common stations.

In continue, least squares method based on existing velocity vectors in common stations used for combination. Estimated Euler pole for two velocity field difference vectors in common stations located at the west of Arabian plate φ=28.53, λ=37.39, ω=0.82 $^{\circ}/Myr$. The difference velocity field vectors in common stations along with estimated Euler pole location (star) has been shown in Figure 4. Then the Arabia fixed velocity field rotated using the estimated Euler pole to produce a Eurasia fixed velocity field. The result of combination is satisfactory and there is no statistical difference between two velocity fields in common stations. The result of combination has been shown in Figure 5.

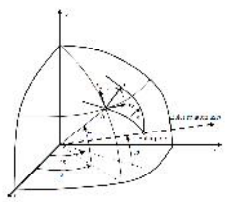

Figure 1. The horizontal velocities expressed as the rotation around Euler pole

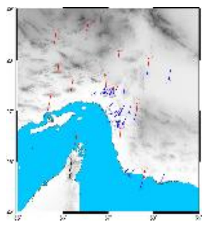

Figure 2. Eurasia-fixed (in red) and Arabia-fixed (in blue) GPS velocity fields considered for combination from Bayer et al. (2006) and Peyret et al. (2009), respectively

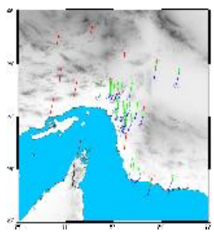

Figure 3. Combined velocity field (in green) using known Arabia-Eurasia Euler pole. Eurasia-fixed and Arabia-fixed velocity vectors are shown in red and in blue, respectively

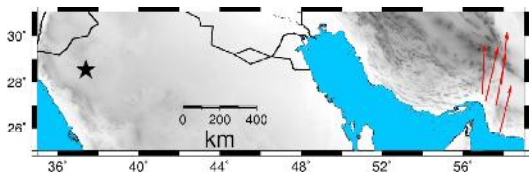

Figure 4. Difference vectors (in red) of two selected velocity fields in common stations with estimated Euler pole location for difference velocity field (star)

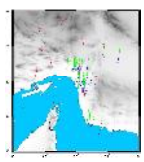

Figure 5. Combined velocity field (in green) with Euler pole estimated using least squares method

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