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An algorithm for the search of homogeneous strain-rate fields

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What's new

Starting from a Fortran code for the estimation of 3D strain-rate tensor under the hypothesis of homogeneous strain behavior, not requiring a priori discretization of the network in polygons or triangles *(Pietrantonio & Riguzzi, Journal of Geodynamics, 2004)*, we implemented a new algorithm for the automatic search of sites belonging to an initial user-defined homogeneous strain-rate field.

The new software, developed in Matlab, is able to find areas of homogeneous strain behavior, taking into account all the available 3D GPS velocities in the area and performing suitable statistical tests.

The statistical tests

Both the statistical tests are based on the standard hypothesis of normal observations and are carried out at the chosen confidence level.

Global test

The aim is to verify if the model (functional + stochastic) is globally correct (homogeneity of the strain-rate field + absence of outliers)

$$H_0 : \hat{\sigma}_0^2 = \sigma_0^2$$

where $\hat{\sigma}_0^2$= posterior variance factor.

The test statistics is a χ^2 with *r* degrees of freedom (r = redundancy)

$$\chi^2_{\exp} = r\frac{\hat{\sigma}_0^2}{\sigma_0^2}$$

If $\chi^2_{\exp} < \chi^2_r$ the model is correct.

Local tests

The aim is the outlier detection

$$H_0 : \hat{v}_k = 0$$

where $\hat{v}_k$= residual of the *k-th* observation.

The test statistics (normalized residual) for the *k-th* observation is a Thompson variate with *r* degrees of freedom

$$\tau_{k,\exp} = \frac{e_k^t P \hat{v}}{\hat{\sigma}_0 \sqrt{e_k^t P Q_{vv} P e_k}}$$

where P = weight matrix of input velocities, Q_{vv} = cofactor matrix of residuals, e_k = null vector except for the *k-th* element equal to 1.

If $|\tau_{k,\exp}| > \tau_r$ the *k-th* observation is a possible outlier.

The algorithm

1. User definition of the initial field

The strain-rate tensor is least-squares estimated starting from the hypothesis of homogeneous strain-rate field.

The choice of the initial 4 sites defining an homogeneous strain-rate field ("seed" sites) is iteratively performed by the user, on the basis of the result of the χ^2 test on the homogeneity of the field.

2. Adding sites...

Once an initial homogeneous strain-rate field is defined, the software automatically searches for sites belonging to this field, starting from the site nearest to the barycentre of the "seed" sites and proceeding until a user-defined maximum distance.

The definition of the area of homogeneous strain-rate is driven by the results of suitably implemented statistical tests: each time a site is added, the strain-rate tensor is re-estimated and both χ^2 global test and Thompson local tests are performed to verify the homogeneity of the newly obtained field and the eventual presence of outliers.

Sketch of the software

Input
GPS velocities with covariance matrix
Approximate site coordinates

User choices
4 sites defining homogeneous strain-rate field
Maximum distance
Confidence level for statistical tests

SR_HOMO

Output
3D strain-rate tensor for the homogeneous area
Horizontal principal axes

Test case: NE of Italy and around

Choices	
"Seed" sites	MPRA UDIN ACOM KOET
Maximum distance	150 km
Confidence level	99%

- Alpine compression, about N-S: **$(-20\pm3)\cdot10^{-9}$ yr^{-1}**

- Non significant extension: $(1\pm2)\cdot10^{-9}$ yr^{-1}

Global test	
$\chi^2_{(dof=48)}$	**77.4**
χ^2_{exp}	71.3

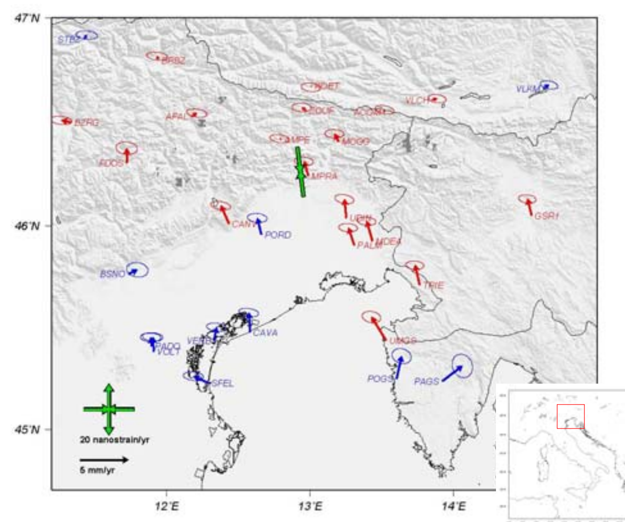
Local tests	
$\tau_{(dof=48)}$ = **2.529**	
Sites	τ_{exp} V_X V_Y V_Z
MPRA	-2.023 -0.342 -0.342
UDIN	-1.593 0.114 0.267
ACOM	-0.028 0.234 -1.313
KOET	1.838 0.140 0.188
MOGG	0.274 -0.232 0.301
ZOUF	2.148 -0.243 1.231
AMPE	1.128 0.174 -1.209
PALM	-0.195 -0.125 0.251
MDEA	-2.365 -0.353 -1.027
VLCH	1.148 0.817 -0.022
CANV	-1.143 -0.500 0.708
AFAL	0.101 0.830 0.350
TRIE	0.622 0.240 0.681
BRBZ	-1.565 -0.288 0.820
UMGS	1.741 -0.630 1.223
GSR1	-0.844 -0.236 -0.306
FDOS	-2.145 0.084 -0.100
BZRG	0.700 -0.974 -0.472

GPS velocities are expressed in an Eurasia-fixed reference frame.

An area of more than 100 km^2 of homogeneous strain-rate is detected, inside the whole considered area shown in the figure.

In red the accepted sites, in blue the rejected ones.

Site PORD is rejected, since both global and local tests fails, because of problems in the height component (sw works in 3D...)



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