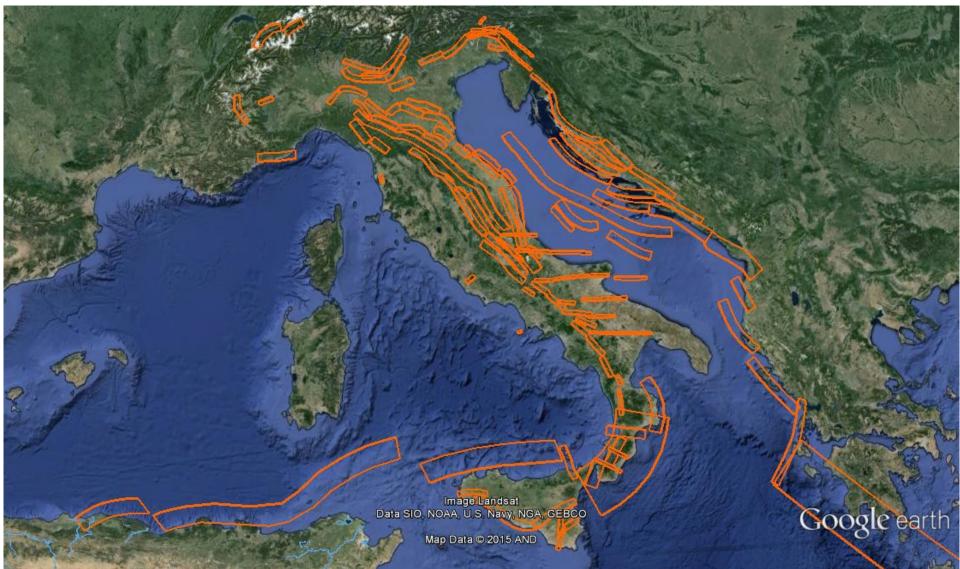
#### Data base of Italian velocities and strain rates at permanent GNSS sites

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## Outlook

- Italian permanent network: 450 sites, unique Domes and 4 char id, IGS/EPN logsheet; weekly sinex's for densification
- Cumulative solution from wk1632 present
- STA file links to Time Series web page; solution numbers
- Velocity to strain rate Matlab program generates Geostructures, KML/SHP files
- Overlay to DISS of INGV (surface deformation vs. structural faults/seismogenic areas)

Goal: monitor ground deformation 3D, particularly in the seismogenic areas (orange polygons): need velocity gradients!

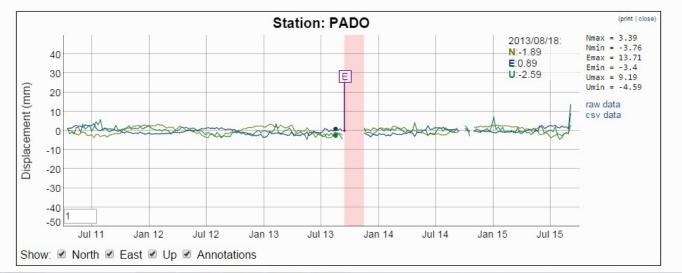


### Method: use data from >400 permanent sites, EPN\_A for georef

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#### Weekly/ multiyear processing according to EPN guidelinesTime series maintenance, dynamic link to STA file

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### From velocities to strain rate

- Igb08 velocities from MC cumulative solution (weekly update, publish on web site <u>http://retegnssveneto.cisas.unipd.it</u>)
- ETRF2000 velocities using 14 params memo v8 xform
- Convert horizontal velocities to 2D strain rate eigenvectors using weighted least squares collocation (== optimal autoregressive algorithm)

### Least Squares Collocation in 3 steps

1) Map scattered velocities to a point P using a covariance function; map variances as well.

2) transform scattered velocities to velocity gradient at a point P using the gradient of the covariance function; map variances of velocities to variances of 3) Get maximum strainrates onal strain rate from matrix diagonalization

$$\begin{bmatrix} V_n \\ v_e \end{bmatrix}_p = \sum_{s} C(d_{P,s}) \sum_{s'} [C(d_{s,s'}) + W_{ss'}]^{-1} \cdot \begin{bmatrix} v_n \\ v_e \end{bmatrix}_{s'} \quad s, s' = station \quad indeces$$

$$\begin{bmatrix} \sigma^2_n \\ \sigma^2_e \end{bmatrix}_p = \left\{ I - \sum_{s} C(d_{P,s}) \sum_{s'} [C(d_{s,s'}) + W_{ss'}]^{-1} C^T(d_{P,s'}) \right\} \cdot \begin{bmatrix} \sigma^2_n \\ \sigma^2_e \end{bmatrix}_{s'}$$

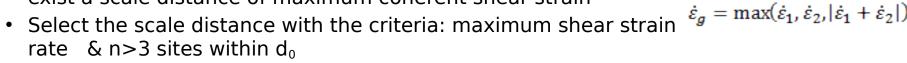
$$W_{ss'} = \frac{\frac{1}{\sigma^2_s}}{\sum_{s''} \frac{1}{\sigma^2_{s''}}} \delta_{ss'} \qquad C(d) = \frac{1}{1 + \left(\frac{d}{d_0}\right)^2}$$

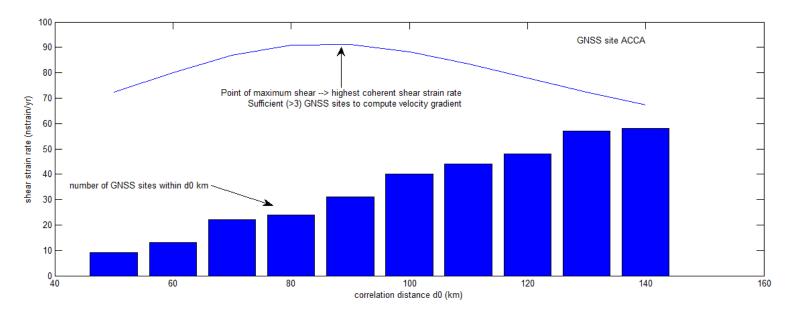
$$\begin{bmatrix} v_{n,n} & v_{n,e} \\ v_{e,n} & v_{e,e} \end{bmatrix}_p = \sum_{s} \begin{bmatrix} \frac{\partial C}{\partial n} & \frac{\partial C}{\partial e} \\ \frac{\partial C}{\partial n} & \frac{\partial C}{\partial e} \end{bmatrix}_{P,s} \sum_{s'} [C(d_{s,s'}) + W_{ss'}]^{-1} \cdot \begin{bmatrix} v_n \\ v_e \end{bmatrix} \quad s, s' = station \quad indeces$$

$$\hat{\varepsilon}_{1} = \frac{v_{n,n} + v_{e,e}}{2} + \sqrt{\left(\frac{v_{e,e} - v_{n,n}}{2}\right)^{2} + \left(\frac{v_{e,n} + v_{n,e}}{2}\right)^{2}} \\ \hat{\varepsilon}_{2} = \frac{v_{n,n} + v_{e,e}}{2} - \sqrt{\left(\frac{v_{e,e} - v_{n,n}}{2}\right)^{2} + \left(\frac{v_{e,n} + v_{n,e}}{2}\right)^{2}} \\ \sin 2\theta = \frac{v_{e,n} + v_{n,e}}{\varepsilon_{2} - \varepsilon_{1}}; \cos 2\theta = \frac{v_{e,e} - v_{n,n}}{\varepsilon_{1} - \varepsilon_{2}}$$

# How to select $d_0$ in the covariance function

- Covariance function depends on a scale distance which defines the C(d) = width of the Low Pass Filter
- If the scale distance is too small we are loosing coherent information from nearby sites; if too large, incoherent distant sites decrease the shear signal with random contributions [] there must exist a scale distance of maximum coherent shear strain





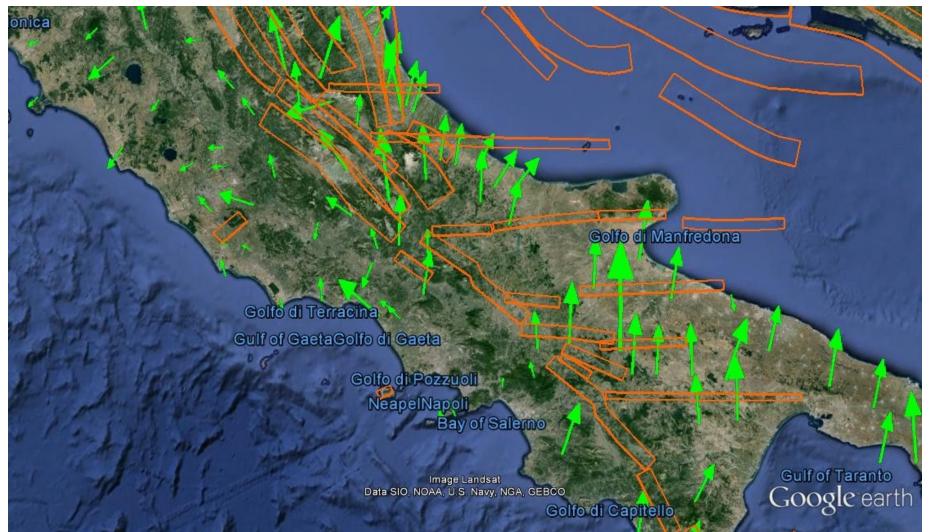
Computing the expected stratic stress drop at each site

- Static Stress drop is the maximum stress expected in an area of known m<sub>max</sub>, geodetic shear strain, statistical seismicity (Gutenberg Richter *a*,*b*)
- 'WC' stands for Wells and Coppersmith: rupture area + average displacement as a function of magnitude<sub>10</sub><sup>[awc+bwcmmax]</sup> - 10<sup>[awc+bwcmmin]</sup> b<sub>s</sub> + b<sub>wc</sub>
- $\begin{array}{l} \text{magnitude}_{10}[a_{wc}+b_{wc}m_{max}] 10^{[a_{wc}+b_{wc}m_{min}]} \\ \Delta \sigma \leq \Delta \sigma_{g} \equiv \frac{b_{s} + b_{w}}{40^{a_{s}}} \frac{b_{s} + b_{w}}{10^{[a_{wc}+(b_{s}+b_{wc})m_{min}]}} \\ \bullet m_{max} \end{array} \\ \begin{array}{l} \frac{b_{s} + b_{w}}{20^{a_{s}}} \frac{b_{s} + b_{w}}{20^$

# Results: all the information is stored in a structured variable/site

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## Horizontal velocities (numerical values in GE Balloons)



### Vertical velocities (numerical values in GE Balloons: red=uplift; blue= subsidence)

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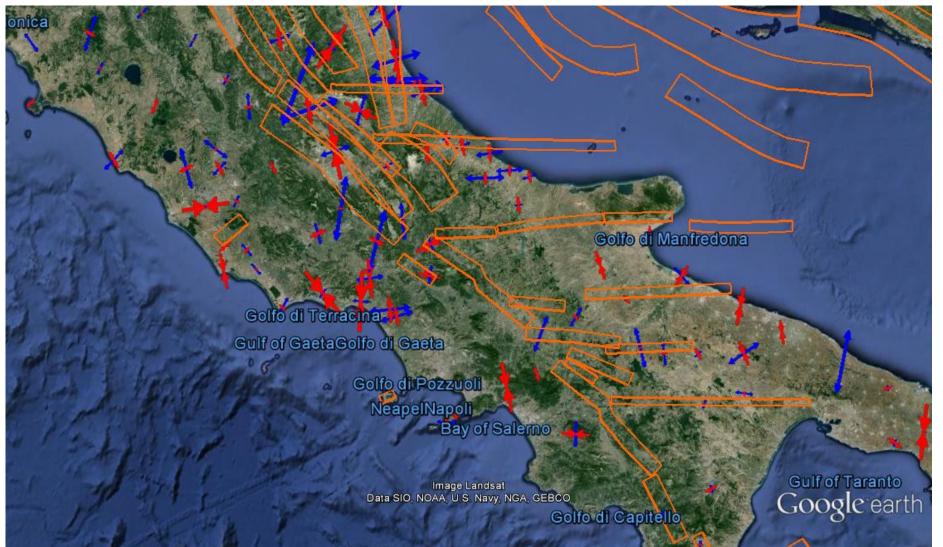
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Image Landsat Data SIO, NOAA, U.S. Navy, NGA, GEBCO Gulf of Taranto Google earth

Golfo di Manfredona

Golfo di Capitello

#### Strain rate (numerical values in GE Balloons: red=compression; blue=extension)



## Conclusions

- So far 415 permanent GNSS sites: IGS style logsheet, daily metadata checking in the Rinex files, unique 4 char id and DOMES from IGN
- Regularly updated database using Matlab script
- Geostruct with position, velocity, strain rate, stress drop and related information + hyperlinks
- Can be used to sample geodetic information along structural lines
- Particularly interesting as overlay to DISS 3.x

## **KML Products**

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- Italstrain: strain rate map
- Ital\_hor\_vel: horizontal velocity map (ETRF2000)
- Ital\_ver\_vel: vertical velocity map
- Italstrain\_balloon: balloon with
  - numerical/alphanumerical data
- Contour\_vertical: contour of vertical data (inland only)