Ge167 Homework 2
Due Tuesday, April 12 - Warning - do not wait until the last minute!

This homework is designed to familiarize you with the calculation and interpretation of geodetically derived strain measurements, with a particular emphasis on California GPS data. Please use CMM4 for this homework. Everything will be done in 2D Cartesian coordinates (we will ignore vertical velocities and strain).

- We can write the velocity $\mathbf{v_1}$ at an arbitrary position $\mathbf{x_1}$, in terms of the velocity gradient, $\mathbf{L}$ and velocity, $\mathbf{v_0}$, at another site, $\mathbf{x_0}$, as $\mathbf{v_1} = \mathbf{v_0} + \mathbf{L}\boldsymbol{\Delta}_{\mathbf{10}}$, where $\boldsymbol{\Delta}_{\mathbf{10}}$ is the vector baseline between $\mathbf{x_1}$ and $\mathbf{x_0}$. Here we have assumed homogeneous strain between the two sites. Rearrange this into a standard linear problem ($\mathbf{Gm} = \mathbf{d}$) for our 6 unknowns including all 4 components of $\mathbf{L}$ and 2 components of $\mathbf{v_0}$. Rewrite this explicitly in terms of the 2 velocities, 3 components of strain, and the rotation term.

- Convert your station locations to UTM Cartesian coordinates (use our matlab code `utm2ll.m`). Check your locations are correct by comparing the distribution of sites in UTM and geographic coordinates.
  - Estimate a single strain rate tensor and a single rotation rate tensor using all the data under the assumption of homogeneous strain.
  - Show two residual velocity maps, one after removal of the prediction based on the homogeneous strain assumption and a second where you just remove the rotation rate.
  - Calculate the dilatation, which is equivalent to I_1, the first invariant of the strain tensor and $\sqrt{I_2'}$, the square root of the second invariant of the deviatoric strain rate tensor, which serves as a measure of rate of shear.
  - What is the direction of maximum rate of compression, Ψ and is it consistent with your understanding of motion on the San Andreas Fault and at Northridge (for this, you will need to look at the eigenvectors of the deviatoric strain tensor)?

- We will not rely on a triangle formulation to calculate strain maps. Instead, calculate I_1, I_2', rotation rate w and Ψ, on a regular grid (5 km?) that spans the data extents, using the formulation you derived above. You may choose to only consider points in or near the network. To get spatial variation in the desired quantitities, introduce a weighting of each line of $\mathbf{Gm} = \mathbf{d}$ based on distance, δ, between the grid point and each observation point. I suggest using a weight of the form $W(\delta) = \exp\frac{-\delta^2}{2\alpha^2}$. Calculate your values for a few different scales, α. Show all your results in GMT plots as color on top of a shaded relief basemap. Show Ψ as appropriately oriented line segments (use `psvelo` with `-Sx`). If you are very brave (not required!), you can include error maps with your estimates. For these maps, it is useful to also show the major faults in the region (see Datalib for a fault file).

- What are the important warnings, limitations, caveats, or other issues you would want people to consider before interpreting your maps?

- Are there clear associations of I_1, I_2', and Ψ with known faults and topography? Where are the maxima of these quantities located?