GEOL 700(i): Geophysical Geodesy - Day 6

Preliminaries

- Questions on reading?

- Problem Set #3

- Reminder: Geoff Blewitt coming next week.

New Readings

Strain mapping and western US tectonics:

Kreemer, C., and W. C. Hammond (2007), Geodetic constraints on areal-changes in the Pacific-North America plate boundary zone: What controls Basin and Range extension, *Geology*, *v. 35, doi: 10.1130/G23868A.1*, p 943-947.

Calculating strain rate from geodetic measurements:

Savage, J. C., W. Gan, and J. L. Svarc (2001), Strain accumulation and rotation in the eastern California shear zone, *Journal of Geophysical Research*, *106*, B10, 21,995-22,007.

Inferring Strain Rate and Rotation

co-latitude

nanostrains

strength of different networks, separation of rotation and strain not always possible.

Models and Data

What is a model?

What is a *good* model?

1) fits data
2) meets some prior conditions.
3) is "reasonable" or simple.

1) What are the measures of data fit?

Small residuals (data minus the predictions of the model).

We can impose this condition mathematically on a problem by requiring that

$$\|\boldsymbol{r}\|=0$$

Misfit can be quantified

$$\chi^2=\sum_{i=1}^{N}\frac{(d_i-d_{i,pred})^2}{\sigma_i^2}$$

$$\chi_\nu^2=\frac{1}{\nu}\chi^2$$

also used to describe the amount of 'scatter' in the residuals:

RMS = $\sqrt{\frac{\sum r_i^2}{N}}$

or the WRMS = $\sqrt{\frac{\sum w_i r_i^2}{\sum w_i}}$

which is similar (though not exactly the same) as χ^2 if using the data uncertainties as your weights.

The "degrees of freedom" ν = number of data (N) minus number of model parameters. The statistic χ_ν^2 is always positive and follows χ^2 distributions.

2) Meets prior conditions

Many ways have been tried. One way is to look for a model that is close to some other particular model:

$$\|\boldsymbol{m}-\boldsymbol{m}_{apriori}\|=0 \quad .$$

3) Model is reasonable

What is reasonable? Well that depends. But commonly we prefer simple models to complex models. This is a choice of the modeler, owing to an acknowledgement that our data have more detail than we can model, or the belief in "Occam's razor" or "the Principal of Parsimony" applied to modeling. That is, the simplest model tends to be the correct one.

$$\|\boldsymbol{m}\|=0$$

This is ofter termed *damping* the solution. Finding the solution that is closest to zero.

A different choice might be to enforce model *flatness :*

$$\|\frac{\partial \boldsymbol{m}}{\partial \boldsymbol{x}}\|=0 \quad .$$

Another choice is to enforce model *smoothness.* This can be achieved by setting the norm of the Laplacian operator of **m** is as close to zero as possible.

$$\nabla^2 \boldsymbol{m}=0$$

These are a few of the most common techniques, and many others are possible.

Balancing criteria

In the end a model can find a balance between multiple criteria by finding a way to minimize some function of all three e.g. solve the system such that

$$\|\boldsymbol{r}\|+\|\boldsymbol{m}\|+\nabla^2 \boldsymbol{m}=0$$

the importance of the various terms can be controlled by using weights, i.e.

$$\alpha\|\boldsymbol{r}\|+\beta\|\boldsymbol{m}\|+\gamma\nabla^2 \boldsymbol{m}=0$$

where alpha, beta, gamma are imposed by the modeler, experimented with until a model with the desired properties is found.