Problem Set #2 - How Fast?

Use the time series you downloaded in Problem Set 1. The file name was “P090.NA12.txyz2”

Solve for rates of motion in the x,y,z and n,e,u components, and their uncertainties. Provide plots that show the model (straight line) that fits the time series best. Provide a table of the rates for this GPS site.

Assignment

Step 1. Read in data and get your MATLAB variables set up (see Problem Set 1). You will need the uncertainties in the positions for this one.

Step 2. Set up a matrix equation in MATLAB by building the ***G*** and ***d*** matrices.

$$\boldsymbol{G}\,\boldsymbol{m}=\boldsymbol{d}$$

where ***d*** contains the data (e.g. *x* coordinates) and ***G*** contains the coefficients to the model equation. The model vector ***m*** will contain the two model parameters you are solving for in each time series (in the case of fitting a line contains a rate *v* and an intercept *b*).

Solve this system for ***m*** using MATLAB to obtain the solution to the overdetermined least squares inversion :

$$\boldsymbol{G}^{-g}=(\boldsymbol{G}^{T}\boldsymbol{G})^{-1}\boldsymbol{G}^{T}$$

in MATLAB e.g.: `Gg = (G'*G)\G';`
or: `Gg = inv(G' * G)*G';`

$$\boldsymbol{m}_{est}=\boldsymbol{G}^{-g}\boldsymbol{d}$$

in MATLAB e.g.: `mest = (G'*G)\G'*d;`
or: `mest = Gg * d;`

You can get the predicted values for the data using the estimated model parameters

$$\boldsymbol{d}_{pred}=\boldsymbol{G}\,\boldsymbol{m}_{est}$$

and the residual are

$$\boldsymbol{r}=\boldsymbol{d}-\boldsymbol{d}_{pred}$$

Step 3. Compute the uncertainties in these model parameter estimates.

$$cov\,\boldsymbol{m}=\boldsymbol{G}^{-g}\,cov\,\boldsymbol{d}\,\boldsymbol{G}^{-gT}$$

in MATLAB e.g.:

```
covd = diag(sd.^2);
covm = Gg * covd *Gg';
```

where sd is the vector of uncertainties in d that you read in from the input file.

Do steps 2 & 3 for x,y,z and e,n,u time series. Makes sense to convert everything to mm with respect to the mean or first value. Rates should be in mm/yr.

Step 4. Make a table that clearly lists the estimated values and their uncertainties (you can use MATLAB "fprintf", do it by hand, Excel, OpenOffice, whatever). This table should include the covariances e.g.:

Coordinate	**b**	**sb**	**v**	**sv**	**cov(v,b)**	**corr(1,2)**
	(mm)	(mm)	(mm/yr)	(mm/yr)	(mm^2/yr)	(unitless)
x						
y						
z						
e						
n						
u						

where *b* and *v* are intercept and slope respectively. sb, sv are uncertainties in b, and v respectively.

Step 5. From your x,y,z rates, compute vn, ve, vu using vxyz2vneu.m (available on the class page). *Do you get the same thing as when you compute the rates directly from the n,e,u time series?*

Step 6. Make plots similar to those you made for problem set #1. Except now include a line (in a different color) that represents the model for this time series. Also plot the residual to each model, these time series are called "detrended".

Is the model a good model?

Step 7.

Try a weighted inversion using:

$$\boldsymbol{G}^{-g} = (\boldsymbol{G}^{T}\boldsymbol{W}\boldsymbol{G})^{-1}\boldsymbol{G}^{T}\boldsymbol{W}$$

where $\boldsymbol{W}$ is a square matrix that has weights for each observation on the diagonal. You want observations with small uncertainties to have more weight, so use $\frac{1}{\sigma_i^2}$ as your weights.
Does this approach make a difference in your velocity estimate?

Step 8.
Email your table, plot files, MATLAB code, and responses to questions to *whammond@unr.edu* in formats I can read (.m, .pdf, .ps, .doc, .docx, .xls, Open Office, etc.)