Advanced Data Processing

- Extract data subsets
  - gmtselect : geographical filtering
- Resampling of gridded files
  - grdedit: Modify header and content
  - grdsample : resample onto new grid
  - grdtrack : sample at arbitrary points
  - grd2xyz : Convert grids to tables
- Arbitrary grid operations
  - grdmath : Manipulate grids mathematically

grdedit

- Replaces header information in grdfiles
  - -Dxname/yname/zname/scale/offset/title/remark
  - = means leaves as is
- Changes the content of grdfiles
  - -N option
- Change grid registrations
  - -T option
- Convert from geodetic to geographic coordinates
  - -R and -S options

Exercise: Modify header info

- Run **`grdinfo`** to query the header information in the agegrid file
- Change the header record to the following:
  - xname and yname to stay the same
  - zname to "age of oceanic lithosphere"
  - scale and offset to stay the same
  - title to "Muller et. al. 2008 Present Day Agegrid"
  - remarks to "Downloaded from EarthByte website by $name on 10 April 2010"

Exercise: Modify header info

```
grdedit $infile -D=/=/"age of oceanic
lithosphere"/=/=/"Muller et. al. 2008 Present
Day Agegrid"/"Download from EarthByte Website
by Maria Seton 9 April 2010"
```

- Now change from a geodetic to geographic coordinates

  `grdedit -S -Rd`

Resampling grids: grdsample

- Resample to new grid spacing, region
  - -R and -I options
- Convert from gridline to pixel registration
  - -T and -F options
- Control over the interpolation method
  - -Q option

Exercise: Resample your grid

- What is the current grid spacing of your age grid file in minutes?
  - Note: The default value is degree
- Work out how to change your age grid to have a grid spacing of 10 m

```
grdsample age.3.6.grd -Gage_10m.grd
-I10m -V
```

Sample grid along profile

- grdtrack allows you to sample a 2D grid along a 1D profile
- Interpolates values at each of your profile locations
- Input: grid file and an ASCII file with x and y positions
- Control interpolation method
  - -Q option
- Suppress NaN values
  - -S option

Exercise 31: Sample along ship track

- Compare ship-track derived magnetic anomaly data with two satellite-derived magnetic models along the same profile.
  - ship-track file: eel32_mag.xymd contains long, lat, magnetic anomaly, distance
  - satellite-derived file 1: EMAG2 (Earth Magnetic Anomaly Grid)
  - satellite-derived file 2: WDMAM (World Digital Magnetic Anomaly Map)

Exercise 31: Sample along ship track

- Take the following steps:
  - Plot the ship-track data on a map to work out where in the world you are (hint: use minmax to get region)
  - Extract satellite derived magnetic anomalies from the EMAG2 file along the same ship track profile using grdtrack (hint: input 1D dataset is eel32_mag.xymd and input grdfile is EMAG2.grd)
  - Do the same for WDMAM file
  - Reformat the output from grdtrack to be a file with distance, magnetic anomaly (hint: use awk)

Exercise 31: Sample along ship track

- grdtrack eel32_mag.xymd -GWDMAM_NGDC_V1.1.grd -V > tmp1
- grdtrack eel32_mag.xymd -GEMAG2.grd -V > tmp2

- awk '{print $4, $3}' eel32_mag.xymd | psxy -R0/2777/-505/400 -JX10 -W1/red -Ba1000f500/a100f50 -K > psfile.ps
- awk '{print $4, $5}' tmp1 | psxy -R -J -W1/blue -K -O >> psfile.ps
- awk '{print $4, $5}' tmp2 | psxy -R -J -W1/green -O >> psfile.ps

Exercise 31: Sample along ship track

- Take the following steps:
  - Use psxy to create a linear plot of distance vs magnetic anomaly for all three profiles
  - Label and annotate axes and also label the three plots sing pstext with the colour of text corresponding to the colour of the line used
  - What is the difference between the three magnetic anomaly profiles?
  - The ship-track data should have been preprocessed (low and high pass filter). This can be done using filter1d but we will not be going into it in this course

pstext example

- pstext $textfile -R -JM -Sred > $psfile

- Example of $textfile
- 2000 -300 10 0 1 1 Shiptrack eel34

- Note: Because we want different colours for each textstring we need to create 3 separate $textfiles and run pstext 3 times

Create subset of data

- Use grdcut to create a subset of gridded data based on a regular rectangle or square

  `grdcut $ingrd -R$newregion -V -G$outgrd`

  - Exercise: Try making an even smaller subset of your us.grd and plot

- Use grdpaste to join two gridded data sets together along common lines
- Use grdblend to blend two grids along common lines

Reverse Polish Notation

- Invented by the Polish mathematician Jan Lukasiewicz (1878-1956)
- Eliminates brackets () from mathematical expressions by placing operators after and not in-between operands
- Implemented in HP's traditional scientific calculators
- Used by Adobe's PostScript page description language

Examples of RPN

Like in a German sentence, the verbs come at the end!

Conventional	RPN
3 × (7 + 8) =	3 7 8 + × =
(3 − 8) × (9 + 2) / 3 =	3 8 − 9 2 + × 3 / =
2 × (sin30 − 3e-3) =	2 30 sin 3 -3 e × − × =
exp(cos(sqrt(1 − p))) =	1 p − sqrt cos exp =
((((z − y) − 1) × 2) − 3) =	z y − 1 − 2 × 3 − =

Most conventional calculators can only handle two levels of brackets.

Reverse Polish Notation in GMT

- Implemented in gmtmath and grdmath
- Works on a stack of operands
- Operators may take one or more operands, e.g.
  - **ADD**, **SUB**, **MUL**, **DIV**, **JN** take 2
  - **SIN**, **COS**, **TAN**, **ERF**, **SQRT** take 1
- Since parentheses are not used, nest your expressions and work from the inside out

grdmath

- Performs mathematical operations on entire grids, one node at the time
- Can read existing grids or create one from scratch (given **–R –I**)
- Commands are given in **Reverse Polish Notation** (RPN, like old HP calculators and the PostScript language)
- Choose from over 100 functions

Working with 2 or more grids

- Grids must be exactly equal
  - i.e. each node must correspond to the exact same location in all grids
  - e.g. grid spacing, region, nx and ny, registration

Purpose of grdmath

- Create grids and evaluate mathematical or logical expressions using **RPN**
  - To create an empty grid requires **–R –I**
- Read grids and manipulate z content
  - Choose among ~100 operators
  - Special constants are available:
    - **X** : A grid with the x coordinate of each node
    - **Y** : A grid with the y coordinate of each node
    - **PI** : Grid with the constant 3.1415926…
    - **E** : Grid with the constant 2.7182818…
- Any combination of the above

Simple grdmath

- To add a constant value to all grid cells:

```
grdmath infile.grd 15 ADD = result.grd
```

- To subtract a constant value to all grid cells:

```
grdmath infile.grd 15 SUB = result.grd
```

- To multiply a constant value to all grid cells:

```
grdmath infile.grd 15 MUL = result.grd
```

- To divide a constant value to all grid cells:

```
grdmath infile.grd 15 DIV = result.grd
```

Simple grdmath

- To add a constant value of 1000 to all grid cells and then divide by 2:

```
grdmath infile.grd 1000 ADD 2 DIV =
result.grd
```

- To add a constant value of 1000 to all grid cells and then divide by 2 and then minus 1:

```
grdmath infile.grd 1000 ADD 2 DIV 1
SUB = result.grd
```

Simple grdmath

- To add two grids together:

```
grdmath infile1.grd infile2.grd ADD =
result.grd
```

Example of RPN

If your equation is

z.grd + 2*sqrt [0.5 (a.grd + b.grd)] + 15

then the grdmath **RPN** expression becomes

```
grdmath a.grd b.grd ADD 0.5 MUL SQRT
  2 MUL z.grd ADD 15 ADD = result.grd
```

Exercise 32: Create residual map

- Create a residual satellite-derived magnetic anomaly map based on the two magnetic models in the previous exercise (WDMAM and EMAG2)
  - Resample the grids so that they are equal using grdsample
  - Subtract one grid from the other using grdmath
  - Create a colour palette using makecpt or grd2cpt
  - Plot the grid using grdimage

- grdsample -I6m $infile1 -G$outfile1 -V
- grdsample -I6m $infile2 -G$outfile2 -V

- grdmath $outfile1 $outfile2 SUB = final.grd

More grdmath

- Another useful function of grdmath is being able to merge grid files without performing any mathematical operations (i.e. when you have NaN values in your grid/s)
- Use the AND operator
  - NaN if A and B == NaN, B if A == NaN, else A
- Use the OR operator:
  - NaN if A or B == NaN, else A

Exercise: merge 2 files

- Create an agegrid map with the continental areas masked out (i.e. so that the continents can be NaN)
  - Check to make sure that you do not need to resample grids grdsample or change from geodetic to geographic coordinates grdedit
  - Merge the two grids using grdmath
  - Create a colour palette using makecpt or grd2cpt
  - Plot the grid using grdimage