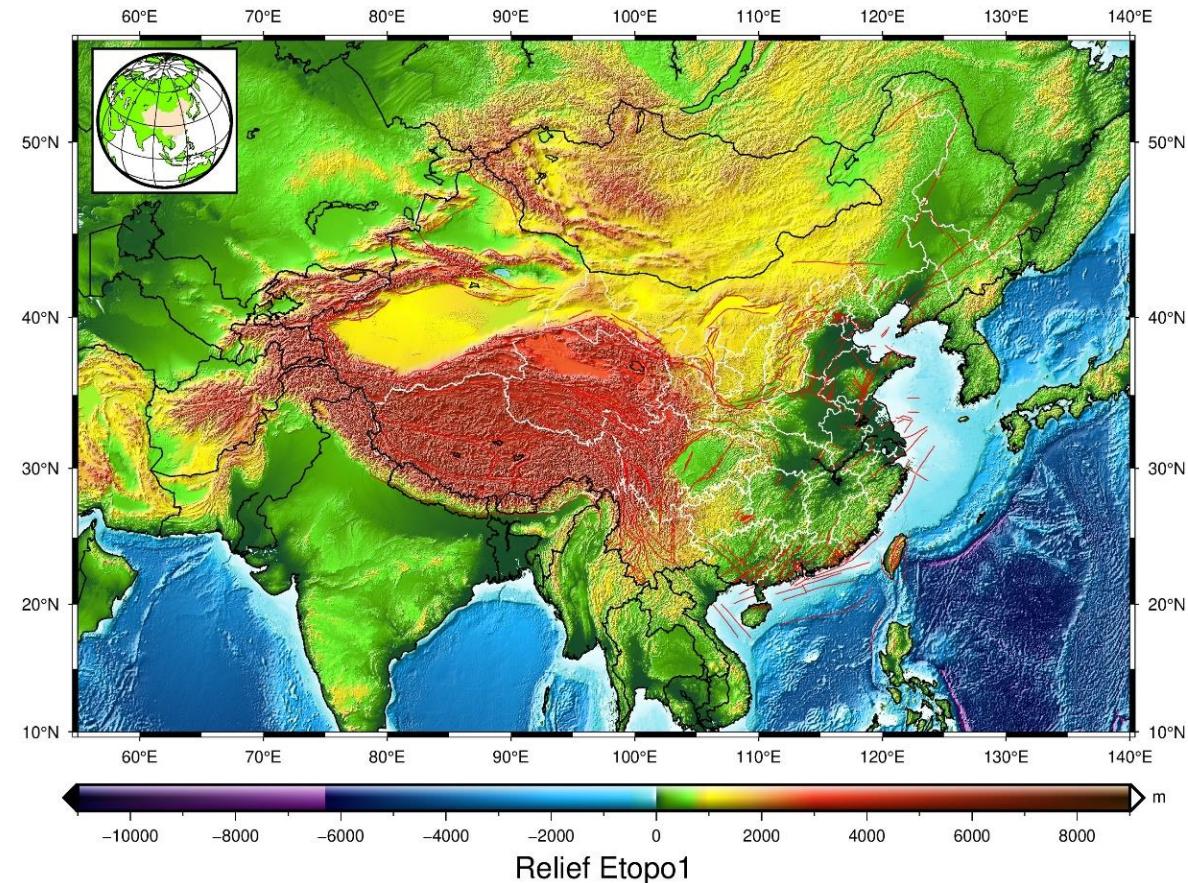
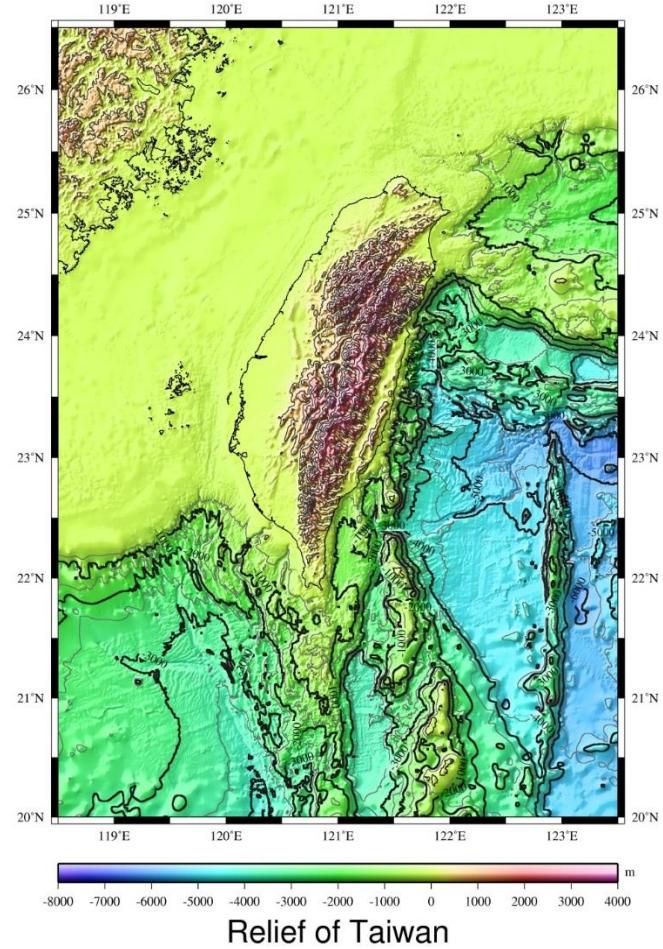


Lecto3: Bathymetry & Topography (II)



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GMT commands

`makecpt` - Make GMT color palette tables (製作GMT CPT 文件)

`grd2cpt` - Make linear or histogram-equalized color palette table from grid (根據網格檔的值生成CPT文件)

`grdcontour` - Make contour map using a grid (根據網格檔繪製等值線)

`inset` - Manage figure inset setup and completion (管理和設置插圖)

`plot` - Plot lines, polygons, and symbols on maps (在圖上繪製線段、多邊形和符號)

DOS/Shell commands

`type/cat` - 顯示檔案內容

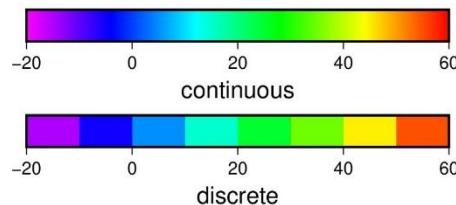
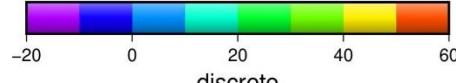
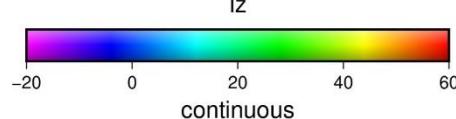
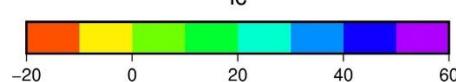
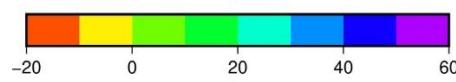
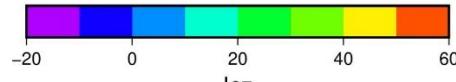
Data

1. `Taidp200m.nc`: 200m resolution of elevation around Taiwan
2. `GEBCO_2023 Grid`: Global terrain model for ocean and land, providing elevation data, in meters, on a 15 arc-second interval grid.
3. `@earth_relief_30s, 15s, 03s, 01s and 01m`: global relief data downloaded from GMT server (GMT會自動從伺服器上下載該資料檔案，並保存到GMT的快取預設目錄)

makecpt Make GMT color palette tables (cpt, 調色盤或色階檔)

```
gmt makecpt [ -Atransparency[+a] ] [ -Ccpt ] [ -D[i|o] ] [ -E[nlevels] ] [ -F[R|r|h|c][+c] ] [ -Gzlo/zhi  
] [ -H ] [ -I[c][z] ] [ -M ] [ -N ] [ -Q ] [ -Smode ] [ -T[min/max/inc[+n]|file|list] ] [ -V[level] ] [ -  
W[w] ] [ -Z ] [ -bibinary ] [ -dinodata ] [ -iflags ] [ --PAR=value ]
```

Open, run: tut_cpt01.bat or
tut_cpt01.sh



```
gmt makecpt -H -Crainbow -T-20/60/10 > disc.cpt  
gmt makecpt -H -Crainbow -T-20/60 -Z > cont.cpt  
gmt makecpt -H -Crainbow -T-20/60/10 -Iz > disc_lz.cpt  
gmt makecpt -H -Crainbow -T-20/60/10 -Ic > disc_lc.cpt  
gmt makecpt -H -Crainbow -T-20/60/10 -Icz > disc_lc_z.cpt
```

- **-Ccpt:** master color table CPT (內建主色階檔)
- **-I:** Reverse the sense of the color progression (翻轉顏色的順序). Append **z** to **reverse the sign of z-values** in the color table.
- **-H:** Modern mode only, write the CPT to standard output as well [Default saves the CPT as the **session current CPT**] (只在現代模式使用，將使用CPT輸出)
- **-Z:** Make a continuous rather than discrete table (製作連續的色階檔)

Lect03A1.bat

```
set prefix=Lect03A
set grd=c:\gridfiles\Taidp200m.nc
set range=119/123/21/26
gmt set FORMAT_GEO_MAP
ddd:mm:ssF
gmt grdinfo %grd% > Tw200m.nc.info
type Tw200m.nc.info
gmt begin %prefix% tif A+m0.5c
gmt makecpt -Cgeo -T-8000/4000
gmt grdimage %grd% -R%range% -
JM123/23/15c -Ba1f0.5 -I+d -V
gmt coast -Df -W1 -V
gmt colorbar -Dx5.7c/
1.2c+w12c/0.5c+h+jTC -By+Im -
Bxa2000f500g500+Elevation -I -V
gmt end
del *.conf *.info
```

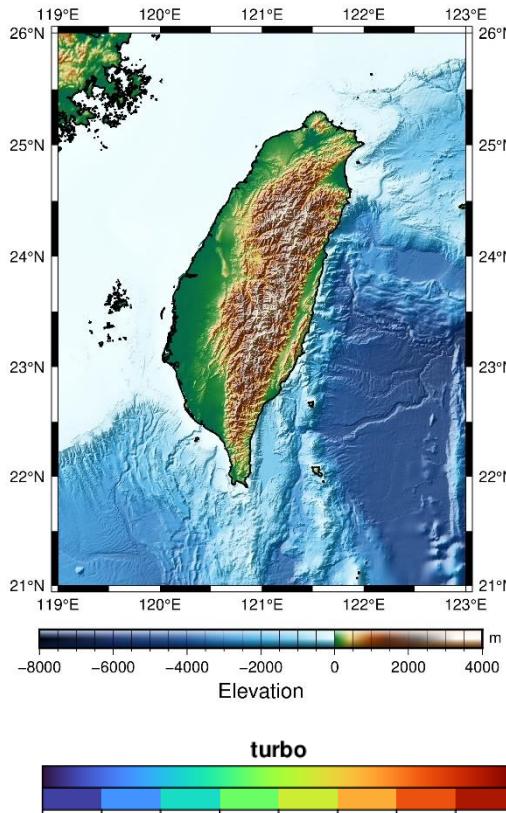
Lect03A1.sh

```
prefix=Lect03A
grd=/c/gridfiles/Taidp200m.nc
range=119/123/21/26
gmt set FORMAT_GEO_MAP
ddd:mm:ssF
gmt grdinfo $grd > Tw200m.nc.info
cat Tw200m.nc.info
gmt begin $prefix tif A+m0.5c
gmt makecpt -Cgeo -T-8000/4000
gmt grdimage ${grd} -R${range} -
JM123/23/15c -Ba1f0.5 -I+d -V
gmt coast -Df -Ba1f0.5 -W1 -V
gmt colorbar -Dx5.7c/
1.2c+w14c/0.5c+h+jTC -By+Im -
Bxa2000f500g500+Elevation -I -V
gmt end
del *.conf *.info
```

makecpt

Make GMT color palette tables (cpt, 調色盤或色階檔)

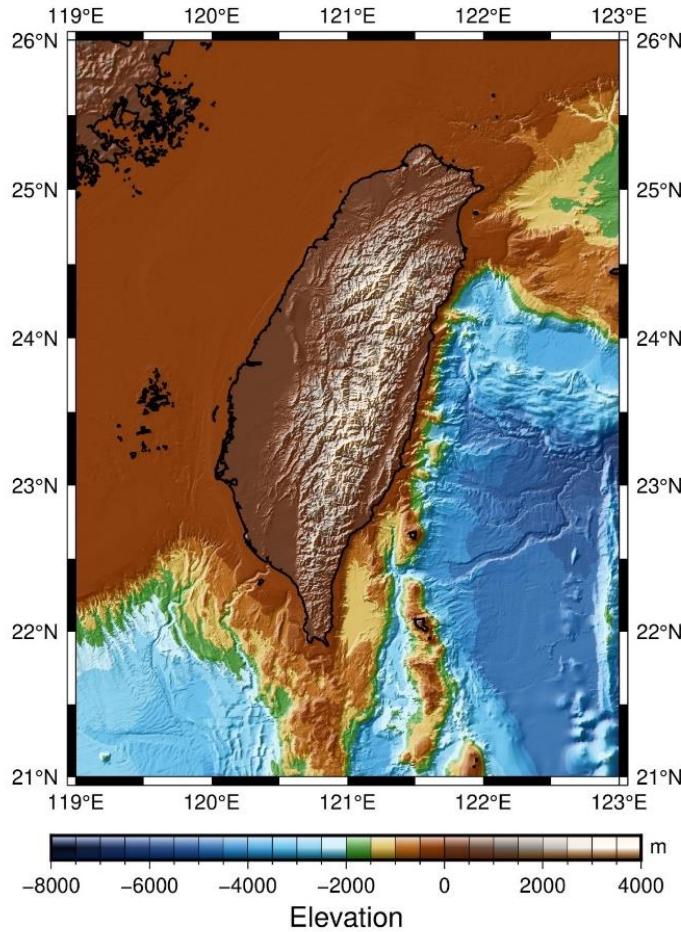
```
gmt makecpt [ -Atransparency[+a] ] [ -Ccpt ] [ -D[i|o] ] [ -E[nlevels] ] [ -F[R|r|h|c][+c] ] [ -Gzlo/zhi ] [ -H ] [ -I[c][z] ] [ -M ] [ -N ] [ -Q ] [ -Smode ] [ -T[min/max/inc[+n]]file|list ] [ -V[level] ] [ -W[w] ] [ -Z ] [ -bibinary ] [ -dinodata ] [ -iflags ] [ --PAR=value ]
```



gmt makecpt -Cgeo -T-8000/4000

- In **classic mode** we write the CPT to **standard output**, while under **modern mode** we simply save the CPT as the **current session CPT** (在經典模式中，將色階檔輸出到標準輸出或檔案，在現代模式中色階檔可暫存在目前的繪圖任務中，由後續指令使用)
- **-Ccpt:** Selects the **master color table CPT** to use in the interpolation. Choose among the **built-in tables** or give the name of an **existing CPT** [Default gives the **turbo CPT**] (指定要進行插值的**主色階檔**，預設值是**turbo**。可從內建的色階檔建立，亦或是使用者已經建立的色階檔)
- 內建色階檔名見C:/programs/gmt6/share/*.cpt，在**-C**後加上**內建色階檔**時，只用**檔名的首碼**，不加副檔名)

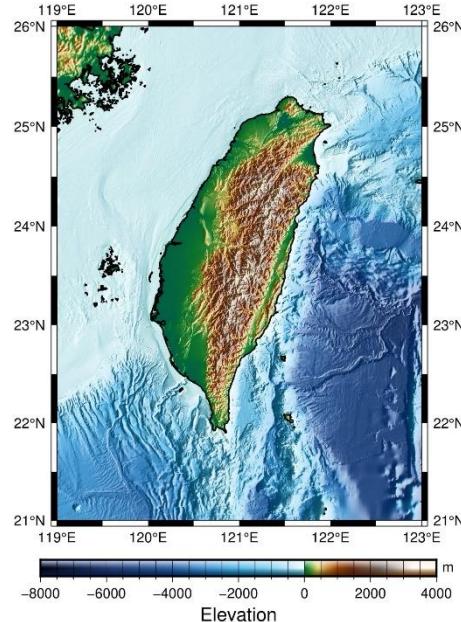
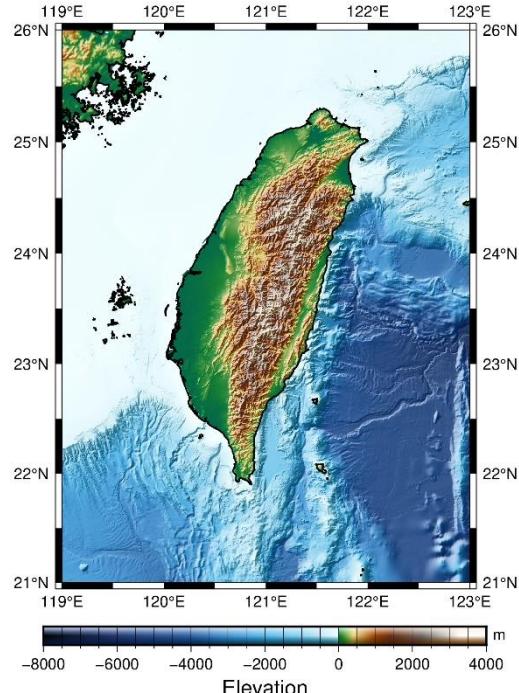
```
gmt makecpt -Cgeo -T-8000/4000
```



-T[*min/max/inc[+b|l|h]|file|list]*

- Defines the range of the new CPT by giving the lowest and highest **z-value** (and optionally an interval) (定義要生成的色階之Z值範圍及Z值間隔)
- If **-T** is not given, the existing range in the master CPT will be used intact (若不使用**-T**選項，則預設使用主色階檔中的Z值範圍)
- **-Z**: Creates a **continuous CPT** [Default is **discontinuous**, i.e., **constant colors** for each interval] (生成連續色階檔。預設為生成不連續色階檔，即每個Z值間格內為同一顏色)

Try: 1. **-T-8000/4000/500**; 2. **-T-8000/4000 -Z**



```
gmt grdimage %grd% -Jm123/23/3c -Ba1f0.5 -  
R%range% -I+d -V
```

-I[intensfile|intensity|modifiers]

- **+d**: select the **default arguments (+a-45+nt1)**(直接使用**-I+d**以使用預放的光照效果，此預設會調用gmt grdgradient模組，依據網格Z值，依**+a-45+nt1**，即在方位角-45度打光，用正正規化光照梯度和振幅強度，計算光照效果)
- Append **+aazimuth** and **+nargs** to specify azimuth and intensity arguments for grdgradient module with **-A** and **-N** options (使用**+aazimuth+nargs**以調整gmt grdgradient指令的**-A**和**-N**選項，得到不同的光照效果)

Try: **-I+a110+ne0.8**

Lecto3A2.bat

```
set prefix=Lect03A2
set grd=tw_relief_15s.nc
set range=119/123/21/26

-----
gmt set GMT_DATA_SERVER_LIMIT
0
gmt grdcut @earth_relief_15s -
R%range% -G%grd%
...
type tw_relief_15s.nc.info
gmt begin %prefix% jpg A+m0.5c
gmt grdimage %grd% -Jm123/23/3c -
Ba1f0.5 -R%range% -I+d -V
gmt coast -Df -W1 -V
gmt colorbar -Dx5.5c/
1.2c+w12c/0.5c+h+jTC -By+Im -
Bxa2000f500g500+l"Relief
(SRTM15+)" -I -V
gmt end
del *.conf *.info
```

Lecto3A2.sh

```
prefix=Lect03A2
grd=grd=tw_relief_15s.nc
range=119/123/21/26
-----
gmt set GMT_DATA_SERVER_LIMIT
0
gmt grdcut @earth_relief_15s -
R%range% -G%grd%
...
cat tw_relief_15s.nc.info
gmt begin ${prefix} jpg A+m0.5c
gmt grdimage ${grd} -Jm123/23/3c
-Ba1f0.5 -R${range} -I+d -V
gmt coast -Df -Ba1f0.5 -W1 -V
gmt colorbar -Dx5.5c/
1.2c+w12c/0.5c+h+jTC -By+Im -
Bxa2000f500g500 +l"Relief
(SRTM15+)" -I -V
gmt end
rm *.conf *.info
```

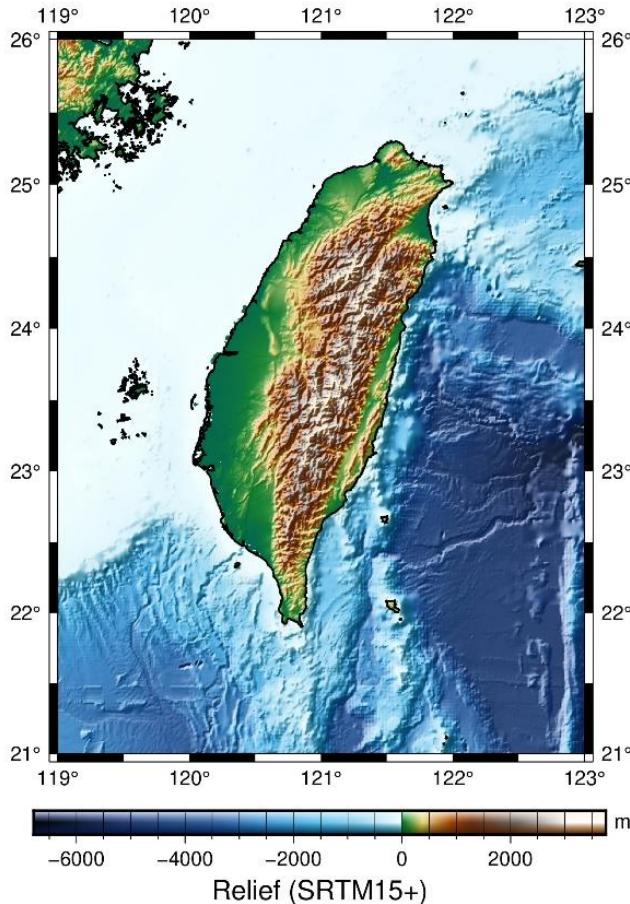
Using Global Relief Data

Code	Dimensions	Size	Description
01d	361 x 181	106 KB	60 arc minute global relief (SRTM15+v2 @ 111 km)
30m	721 x 362	376 KB	30 arc minute global relief (SRTM15+v2 @ 55 km)
20m	721 x 362	782 KB	20 arc minute global relief SRTM15+v2 @ 37 km)
15m	721 x 362	1.3 MB	15 arc minute global relief (SRTM15+v2 @ 28 km)
10m	721 x 362	2.8 MB	30 arc minute global relief (SRTM15+v2 @ 18 km)
06m	721 x 362	7.4 MB	6 arc minute global relief (SRTM15+v2 @ 10 km)
05m	721 x 362	11 MB	5 arc minute global relief (SRTM15+v2 @ 9 km)
04m	721 x 362	16 MB	4 arc minute global relief (SRTM15+v2 @ 7.5 km)
03m	721 x 362	27 MB	3 arc minute global relief (SRTM15+v2 @ 5.6 km)
02m	721 x 362	58 MB	2 arc minute global relief (SRTM15+v2 @ 3.7 km)
01m	721 x 362	214 MB	1 arc minute global relief (SRTM15+v2 @ 1.9 km)
30s	43200 x 21600	778 MB	30 arc second global relief (SRTM15+v2 @ 0.9 km)
15s	86400 x 43200	2.6 GB	15 arc second global relief (SRTM15+V2)
03s	432000 x 216000	6.8 GB	3 arc second global relief (SRTM3S)
01s	1296000 x 432000	41 GB	1 arc second global relief (SRTM1S)

https://docs.generic-mapping-tools.org/6.0/datasets/earth_relief.html

SRTM: Shuttle Radar Topography Mission

Using Global Relief Data



```
gmt set GMT_DATA_SERVER_LIMIT 0  
gmt grdcut @earth_relief_15s -R%range% -G%grd%  
....  
gmt begin %prefix% jpg A+m0.5c  
gmt grdimage %grd% -Jm123/23/3c -Ba1f0.5 -  
R%range% -I+d -V
```

- Earth relief grids: Specify a grid input named `@earth_relief_res` on a command line then such a grid will automatically be downloaded from the [GMT Data Server](#) and placed in the server directory under `$GMT_USERDIR` [`~/.gmt/cache`].
- Resolution *res*: allows a choice among **15 common grid spacings** 60m, 30m, 20m, 15m, 10m, 06m, 05m, 04m, 03m, 02m, 01m, 30s, and 15s as well as the SRTM tile resolutions 03s and 01s

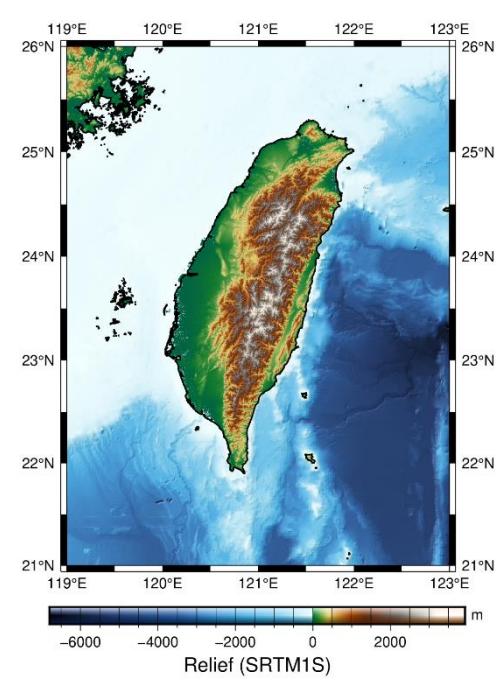
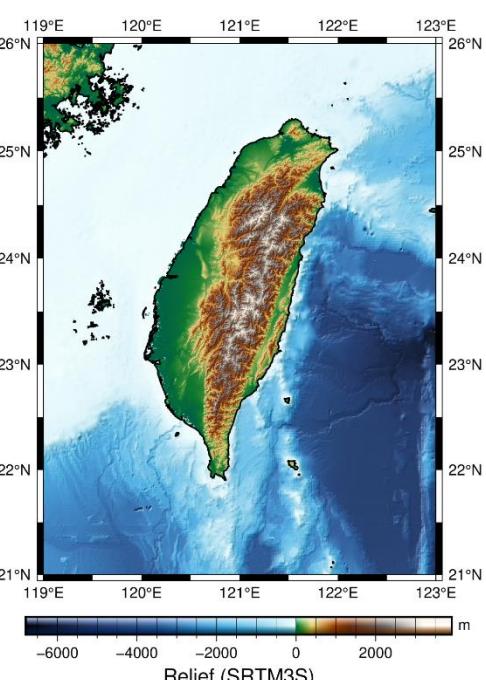
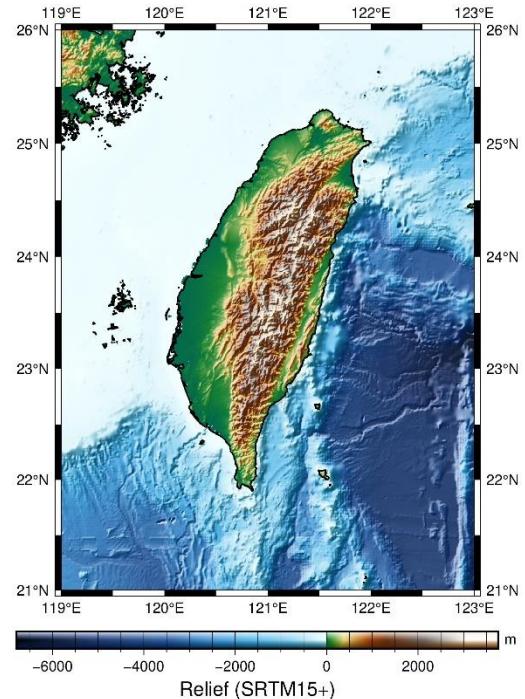
```
gmt grdimage %grd% -JM123/23/12c -Ba1f0.5 -R%range% -I+d -V
```

-C[cpt | master[+izinc] | color1,color2[,color3,...]]]

- cpt: Name of the CPT (for `grd_z` only). Alternatively, supply the name of a **GMT color master dynamic CPT** [`turbo`, but `geo` for `@earth_relief` and `srtm` for `@srtm_relief` data] to automatically determine a continuous CPT from the grid's z-range (and optionally an interval)
- 在使用GMT提供的全球數值高程時，會使用動態色階檔，預設為turbo，但是如果數值高程資料是`@earth_relief`或`@srtm_relief`，則預設色階檔為geo)

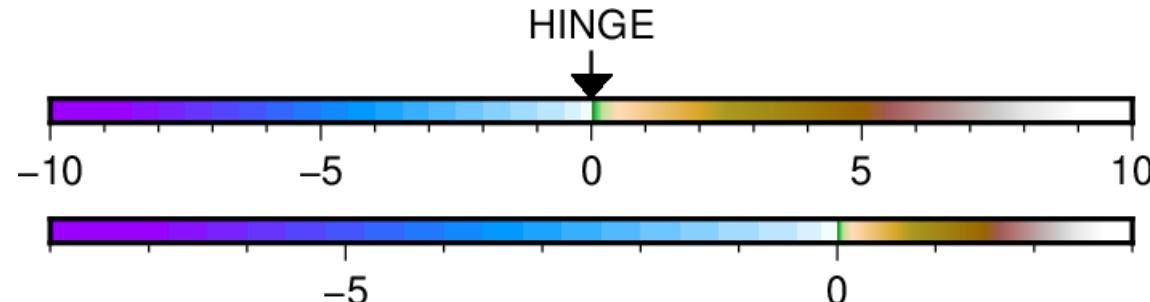
Try:

`@earth_relief_03S`



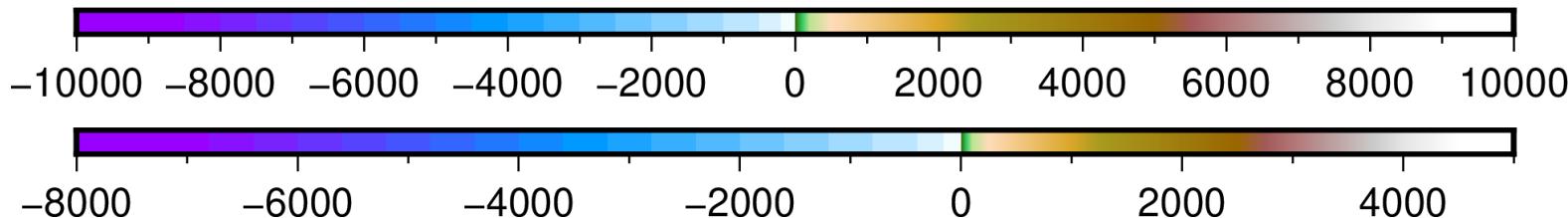
Built-in master color tables

- Master (dynamic) CPTs: The CPTs distributed with GMT are **dynamic**. (GMT內建的色標檔都是動態的)
- Normalized dynamic CPTs: If a CPT was designed to behave differently across a **hinge value** (e.g., a CPT designed specifically for **topographic relief** may include a discontinuity in color across the **coastline** at $z = 0$), then the CPT's z-values will range from -1, via 0 at the hinge, to +1 at the other end. (如果為存在分界的區域填色，如地形顏色在高程為0 的海岸線處發生非連續的分界，那麼色標檔的Z值在一側為-1到0；另一側為0到1；分界線上為0)
- Hinge value is specified via the special comment # HINGE = <hinge-value> (色標檔用# HINGE = <hinge-value>注釋分界線的值)
- CPTs with hinge value: earth, etopo1, geo, globe, polar, red2green, relief, sealand, split, terra, topo, world.



Built-in master color tables

- CPTs without a hinge are instead normalized with z-values from 0 to 1. Dynamic CPTs will need to be stretched to the user's preferred range (如果不存在顏色的分界，則色標檔的Z值會正規化至0到1之間。動態色標檔會依指用者偏好，將色標檔的Z值拉伸到指定的範圍)
- Default range specified in the master table via the special comment # RANGE = <zmin/zmax> (色標檔中依# RANGE = <zmin/zmax>注釋Z值的範圍)
- CPTs without a natural range are instead stretched to fit the range of the data in question (e.g., a grid's range) (色標檔中若未給定範圍，則Z值擴展到資料的極限值)

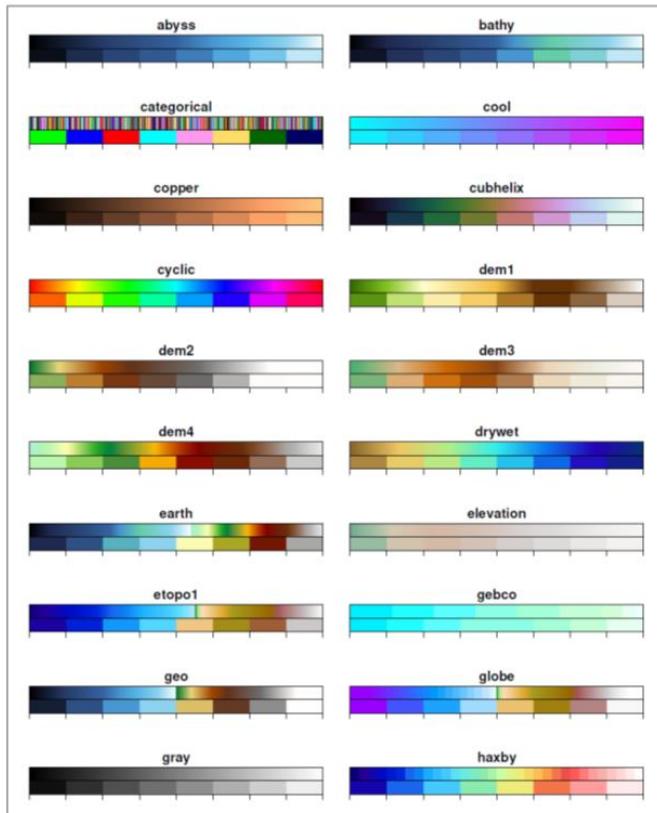


```
gmt begin cpt_range png  
gmt makecpt -Cglobe -T-8000/5000  
gmt colorbar -C -Ba2000f1000 -Dx0/0+w6i/0.1i+h  
gmt colorbar -Cglobe -Ba2000f1000 -Dx0/0+w6i/0.1i+h -Y0.5i  
gmt end
```

Open and run `inset01.bat` or
`inset01.sh`

Built-in master color tables

- Modules **makecpt** & **grd2cpt**: used to access these master CPT tables and translate/scale them to fit the user's range of z-values.
- Top half : Original color scale (discrete or continuous)
- Bottom half: Using makecpt **-T-1/1/0.25** (splitting the color scale into 8 discrete colors).
- Master (dynamic) CPTs:



abyss: Black/dark blue to lightblue for bathymetry [**RANGE = -8000/0**]

bathy: Like abyss but via aquamarine at mid-depths [**RANGE=-8000/0**]

categorical: Color table particularly suitable for categorical data [0/256]

cool: Linear change from blue to magenta [0/1]

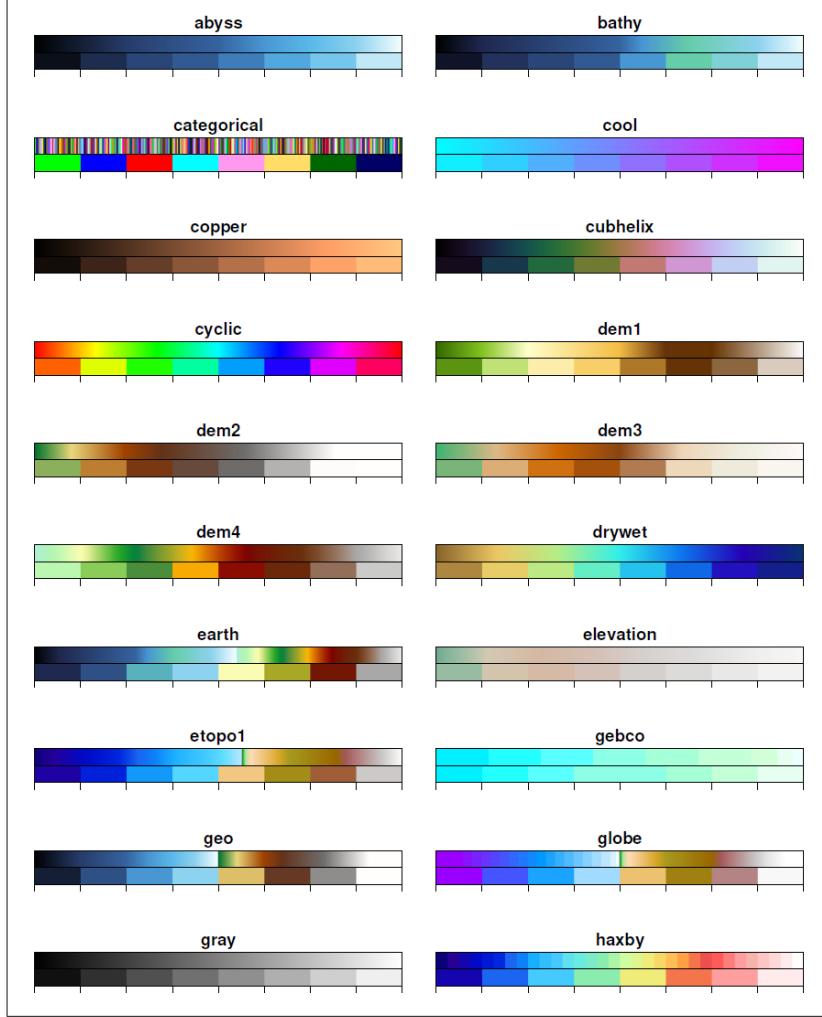
copper: Dark to light copper brown [0/1]

cubhelix: Intensity colormap via cube helix by Dave Green [0/255]

cyclic: Cyclic colormap, spans 360 degrees of hue (色相) [0/360]

dem1: Digital Elevation Model (DEM) scale by Thomas Dewez [RANGE=0/800]

Master (dynamic) CPTs (動態色階檔)



dem2: Digital Elevation Model (DEM) scale by Dewez/Wessel
[RANGE=0/5000]

dem3: Digital Elevation Model (DEM) scale by Paul Wessel
[RANGE=0/6000]

dem4: Digital Elevation Model (DEM) scale for Wikipedia figures
[RANGE=0/1500]

drywet: Goes from dry to wet colors [0/12]

earth: Colors for global bathymetry/topography relief [HINGE = 0,
RANGE= -11000/9000]

elevation: Washed-out colors for topography [RANGE = 0/7000]

etopo1: Colormap used in the ETOPO1 global relief map
[HINGE = -0.001, RANGE = -11000/8500]

gebco: Colors for GEBCO bathymetric charts [RANGE=-7000/0]

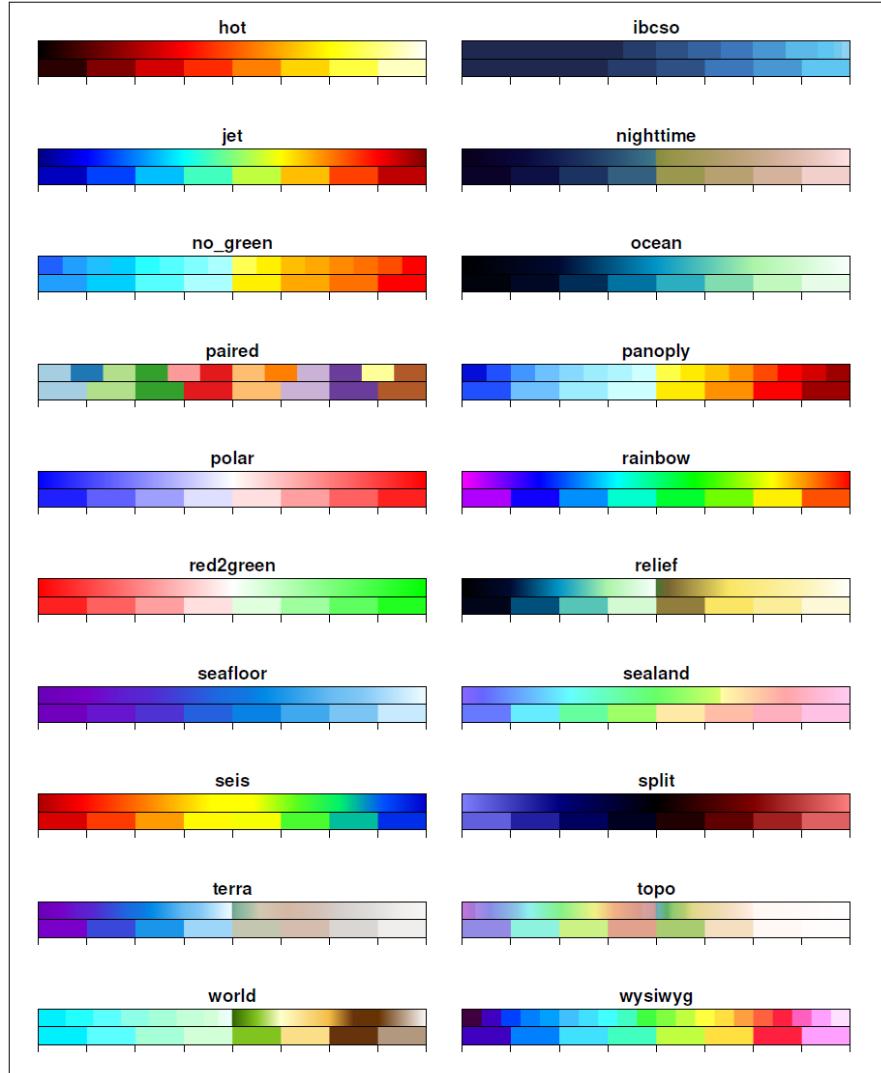
geo: Colors for global bathymetry/topography relief [HINGE = 0,
RANGE=-8000/8000]

globe: Colors for global bathy-topo relief [HINGE = 0, RANGE=-
10000/10000]

gray: Grayramp from black to white [0/1]

haxby: Bill Haxby's colortable for **geoid** & **gravity** [0/32]

Master (dynamic) CPTs (動態色階檔)



hot: Black through red and yellow to white [0/1]

ibcso: The IBCSO bathymetry colors [**RANGE** = -12000/0]

jet: Dark to light blue, white, yellow and red [0/1]

nighttime: Colors for DMSP-OLS Nighttime Lights Time Series [0/1]

no_green: For those who hate green [-32/+32]

ocean: white-green-blue bathymetry scale [**RANGE** = -8000/0]

paired: Qualitative color map with 6 pairs of colors [0/12]

panoply: Default colormap of Panoply [0/16]

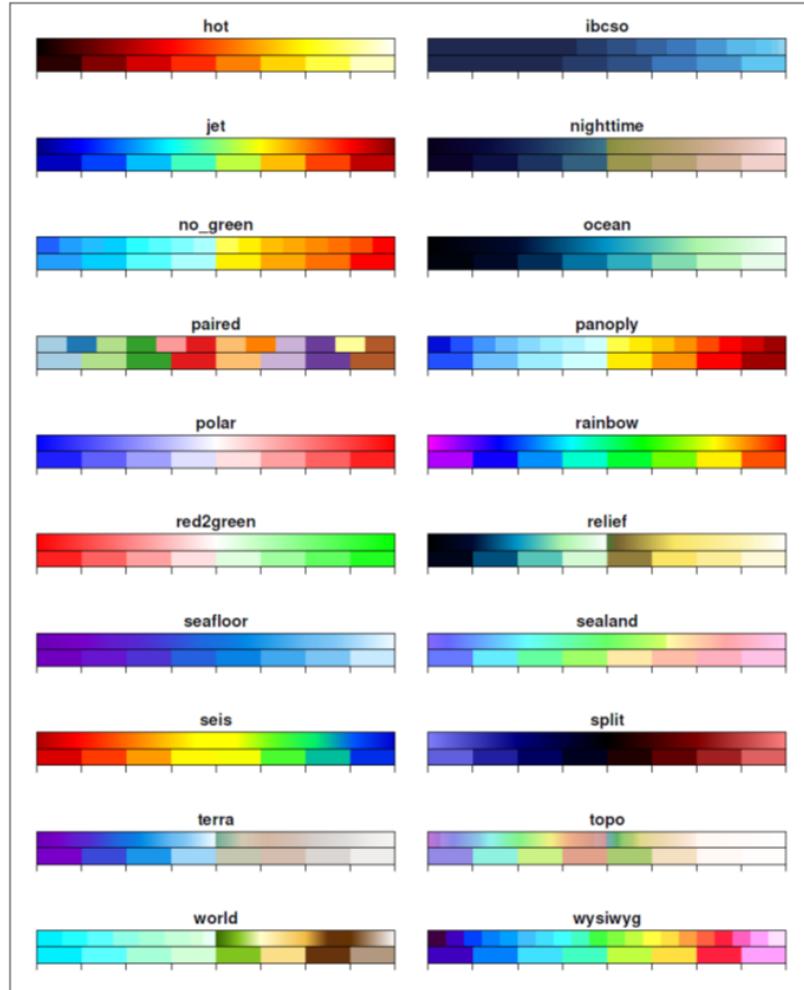
polar: Blue via white to red [-1/+1]

rainbow: Rainbow colors: magenta-blue-cyan-green-yellow-red [0/300]

red2green : Polar scale from red to green via white [-1/+1]

relief: Wessel/Martinez colortable for bathymetry/topography [**RANGE** = -8000/+8000, **HINGE**=0]

Master (dynamic) CPTs (動態CPT)



1. `C:\programs\gmt6\share\cpt`
2. Open DOS or Terminal, type `makecpt`

seafloor: Purple-blue-white bathymetry scale [RANGE = -6000/0]

sealand: Smith bathymetry/topography scale [HINGE = 0, RANGE=-6000/+3000]

seis: R-O-Y-G-B seismic tomography colors [-1/+1]

split: Polar scale like polar, but via black instead of white [-1/+1]

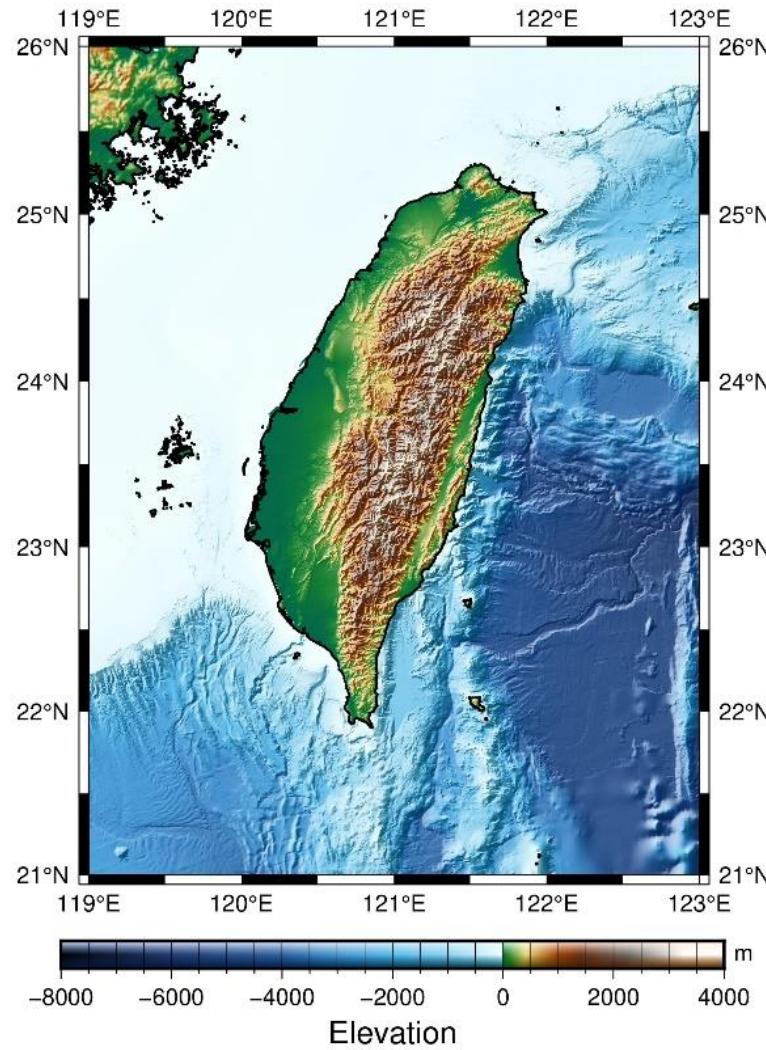
terra: Colors for global bathy./topo. relief [HINGE = 0, RANGE=-7000/7000]

topo: Sandwell-Anderson colors for topography [HINGE = 0, RANGE=-7000/+7000]

world: Colors for global bathy./topo. relief [HINGE = 0, RANGE=-7000/7000]

wysiwyg: 20 RGB colors for openwin -cubesize large and waxenvy printer [0/20]

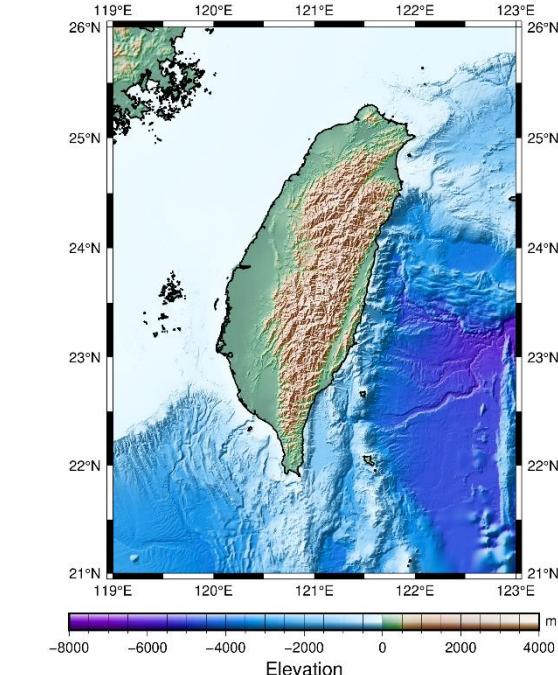
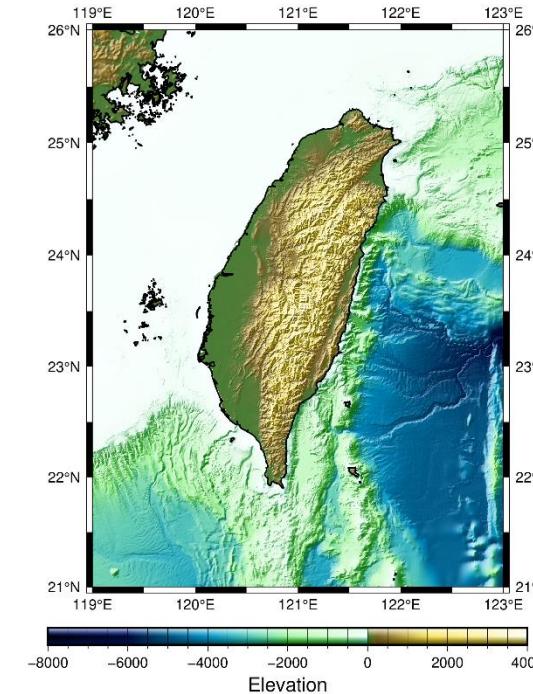
Lecto3A1



```
gmt makecpt -Cgeo -T-8000/4000 -V
```

-Ctable: Selects the master color table to use in the interpolation. Choose among the built-in tables ([type makecpt to see the list](#)) or give the name of an [existing cpt file](#)

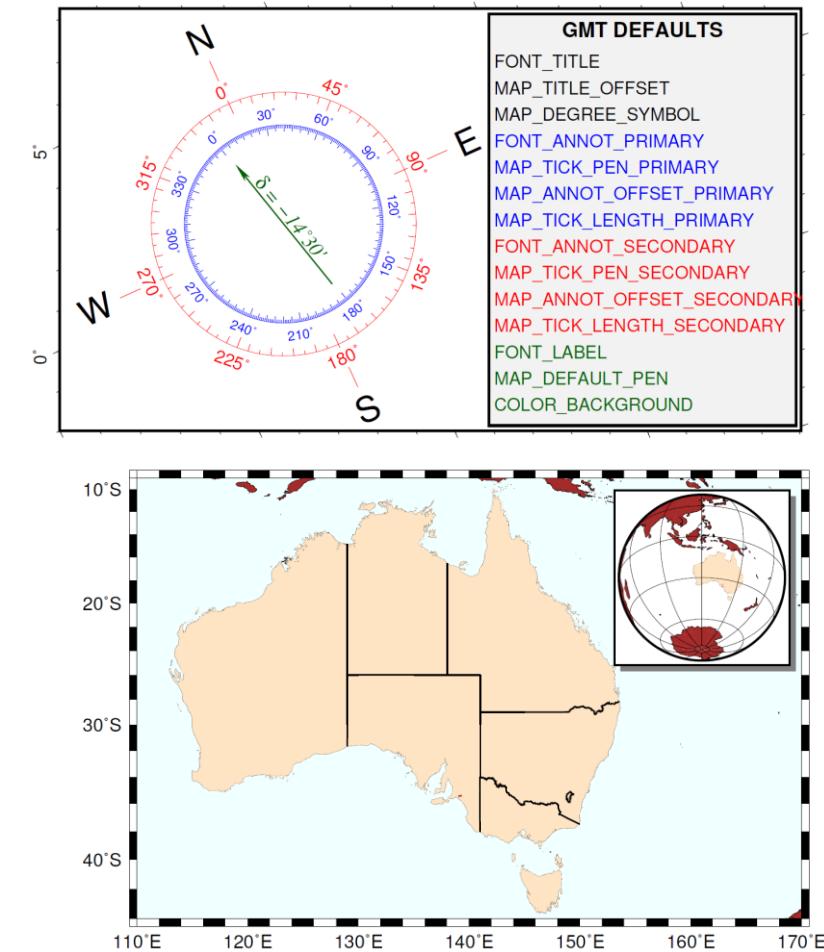
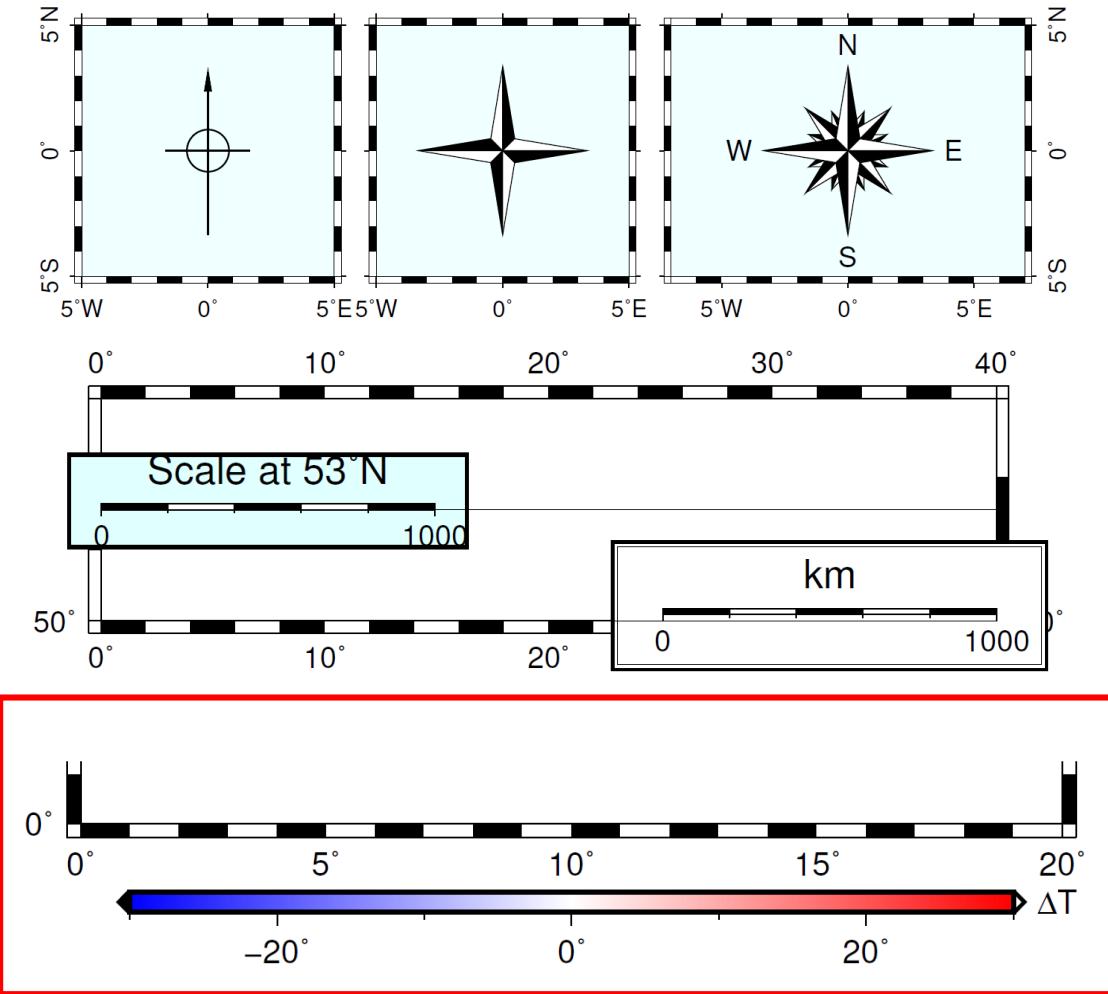
Try master cpt files: [relief](#), [terra](#),



Plot embellishments (繪製修飾物)

The 8 embellishments currently available:

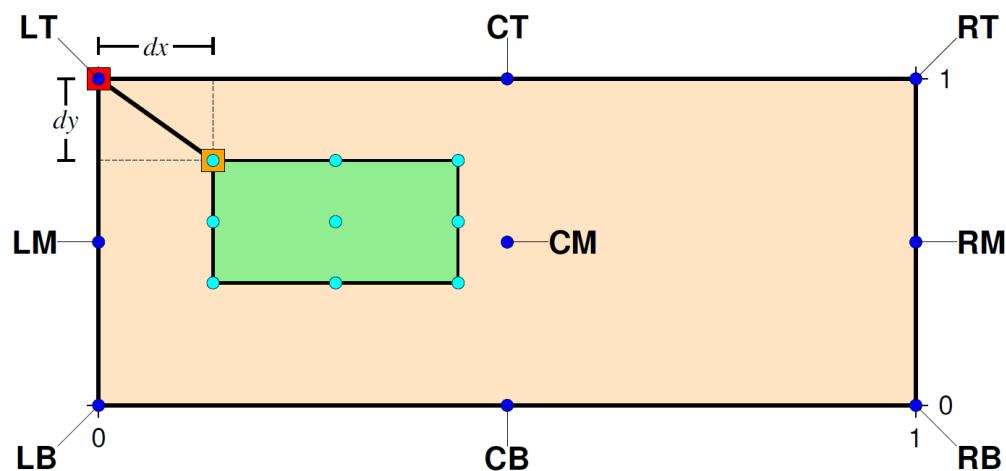
- Map scale (地圖比例尺), directional rose (方向玫瑰圖), magnetic rose (磁場玫瑰圖), color bar, map legend (圖例), image overlay of raster images or EPS figures (e.g., institutional logos, photos, etc.), GMT logo overlay and map insert.



Reference & anchor point specification

(參考點與錨點)

Reference point syntax is [g|j|J|n|x]refpoint



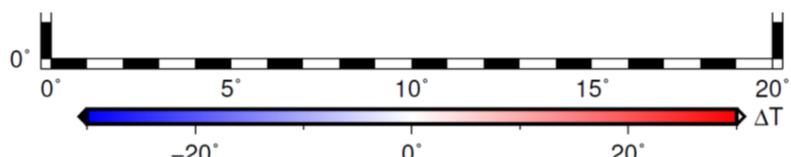
[g] Specify refpoint using data coordinates,
g135W/20N.

[x] Specify refpoint using plot coordinates, i.e., the
distances in inches, centimeters, or points from the
lower left plot origin, x2.75i/2c

[n] Specify refpoint using normalized coordinates,
n0.2/0.1

[j] Specify the location using one of the nine justification codes, equivalent to the justification
codes for placing text strings in text.

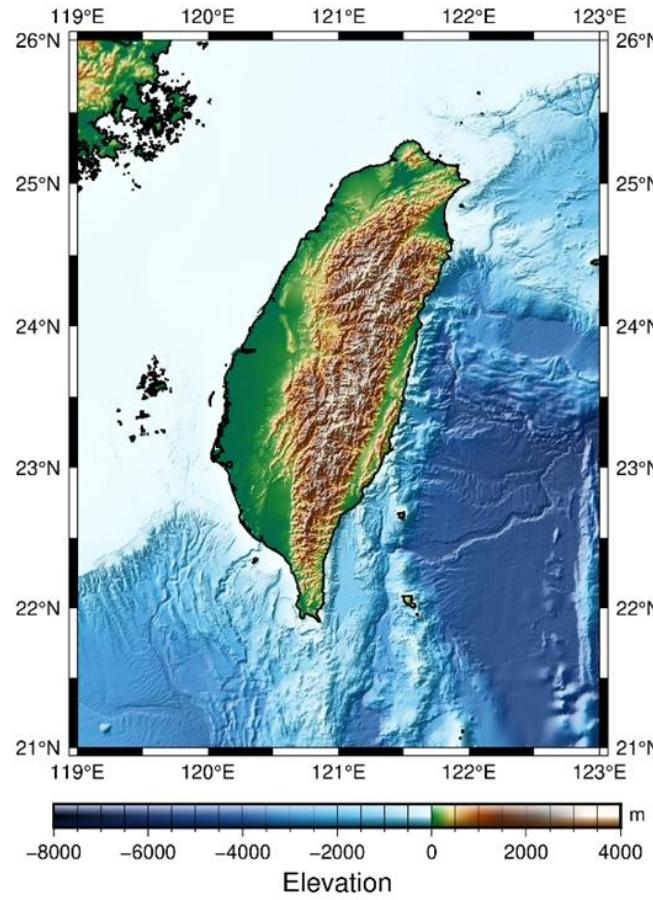
[J] This is the same as jexcept it implies that the default anchor point is the mirror opposite of the
justification code. So when using JTL, the anchor point on the map feature will default to BR. This
is practical for features that are drawn outside of the basemap (like color bars often are).



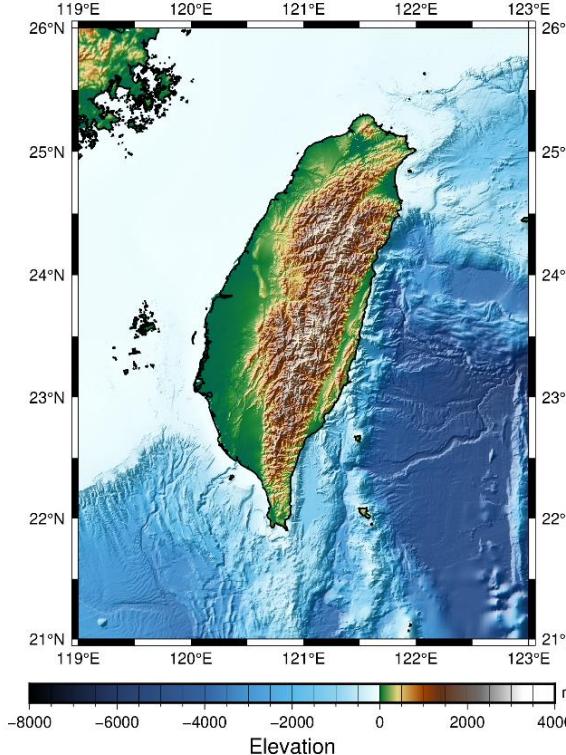
-DJBC+o0/0.35i+w4.5i/0.1i+h

```
gmt colorbar -Dx5.7c/-1.2c+w14c/0.5c+h+jTC -By+Im -Bxa2000f500g500+lElevation -I -V
```

- **+j:** Anchor point on the scale is assumed to be the bottom left corner (BL) by default; but this can be changed by appending **+j** followed by a **2-char justification code** justify.

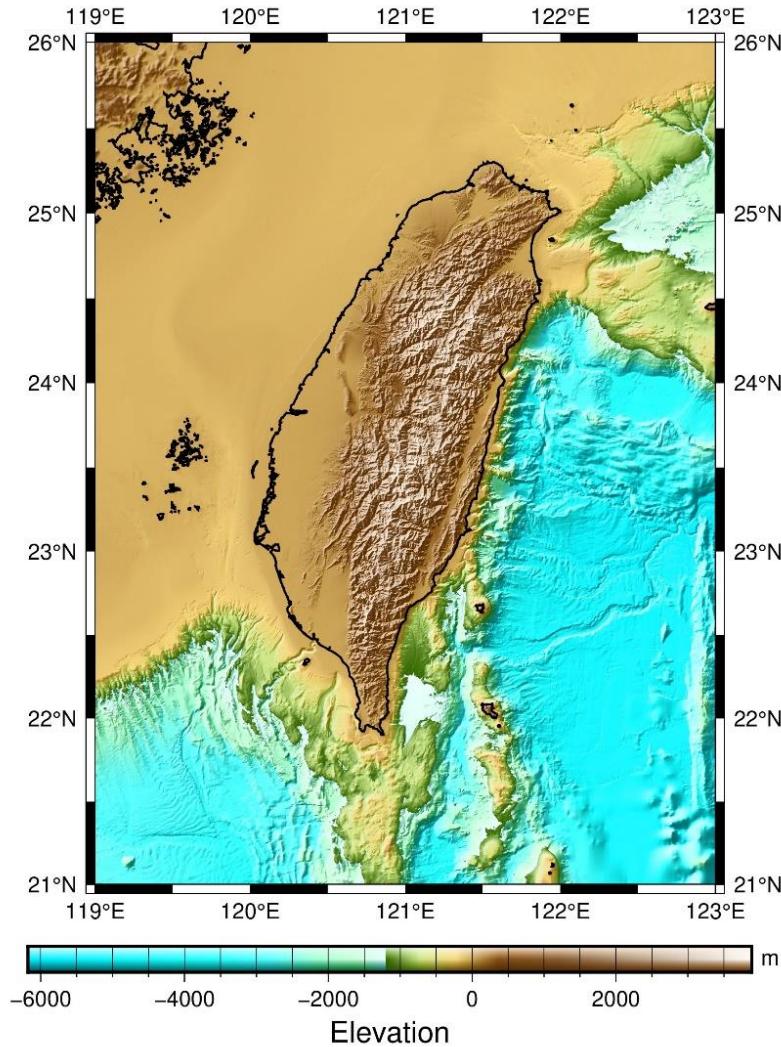


- **-I[max_intens|low_i/high_i]:** Add illumination effects. If not specified, 1 is used.



1. Try different 2-char justification code
2. Omit -I

Lecto3B



```
set prefix=Lect03B  
set grd=c:\gridfiles\Taidp200m.nc  
set range=119/123/21/26  
gmt set FORMAT_GEO_MAP ddd:mm:ssF  
gmt grdinfo %grd% > Tw200m.nc.info  
type Tw200m.nc.info  
gmt begin %prefix% tif A+m0.5c  
gmt grd2cpt %grd% -Cworld -Z  
gmt grdimage %grd% -R%range% -  
JM123/23/15c -Ba1f0.5 -l+d -V  
gmt coast -Df -W1 -V  
gmt colorbar -Dx5.7c/-1.2c+w12c/0.5c+h+jTC  
-By+l m -Bxa2000f500g500+lElevation -I -V  
gmt end  
del *.conf *.info
```

grd2cpt

Make linear or histogram-equalized color palette table from grid

```
gmt grd2cpt grid [ -Atransparency[+a] ] [ -Ccpt ] [ -D[i] ] [ -E[nlevels] ] [ -F[R|r|h|c][+c] ] [ -Gzlo/zhi ] [ -H ] [ -I[c][z] ] [ -Lminlimit/maxlimit ] [ -M ] [ -N ] [ -Q[i|o] ] [ -Rregion ] [ -Sh||m|u ] [ -Tstart/stop/inc ] [ -V[level] ] [ -W[w] ] [ -Z ] [ --PAR=value ]
```

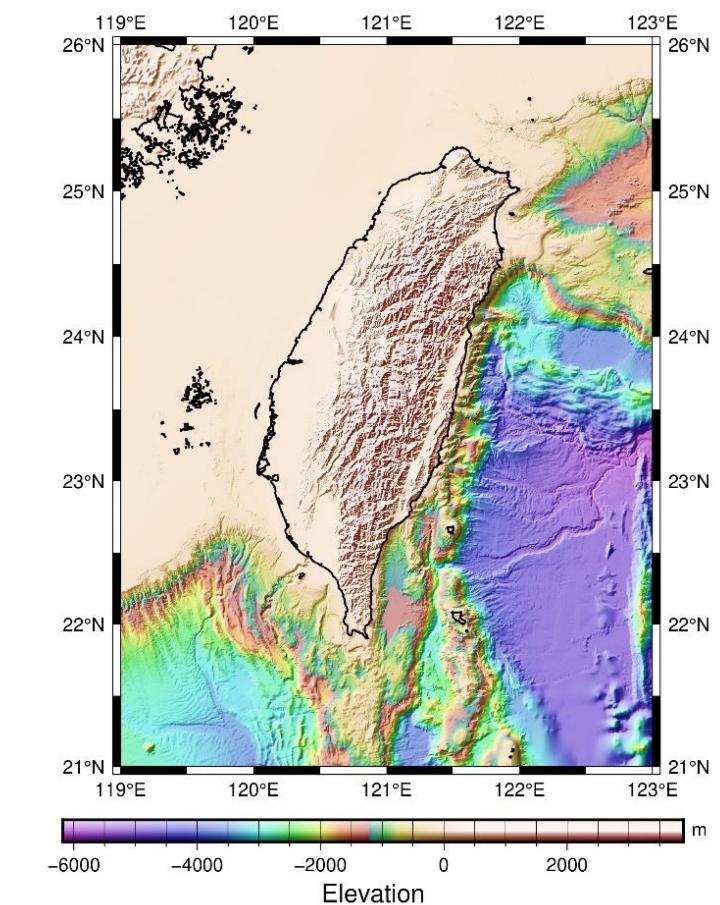
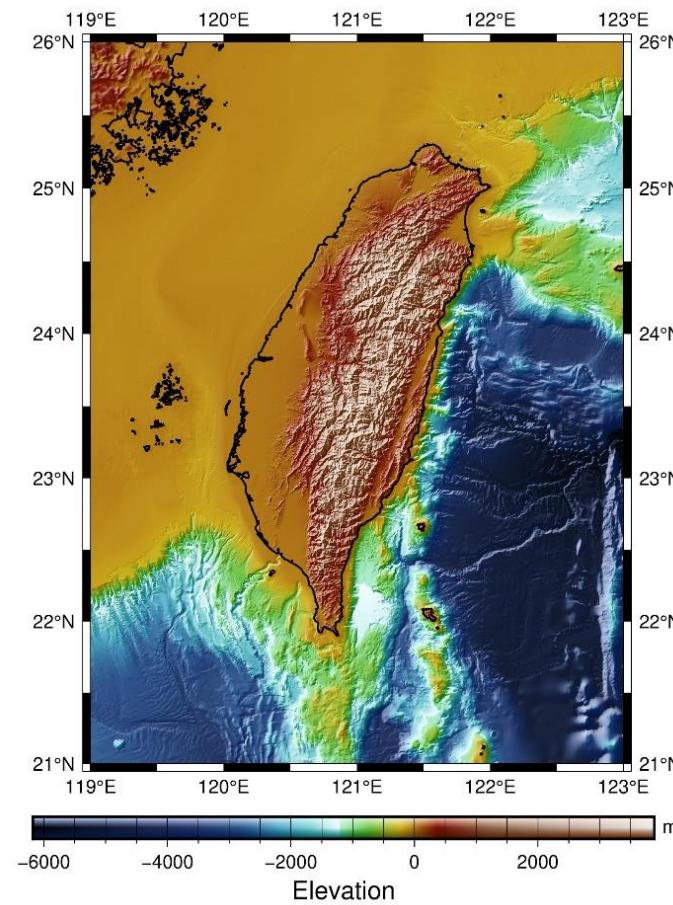
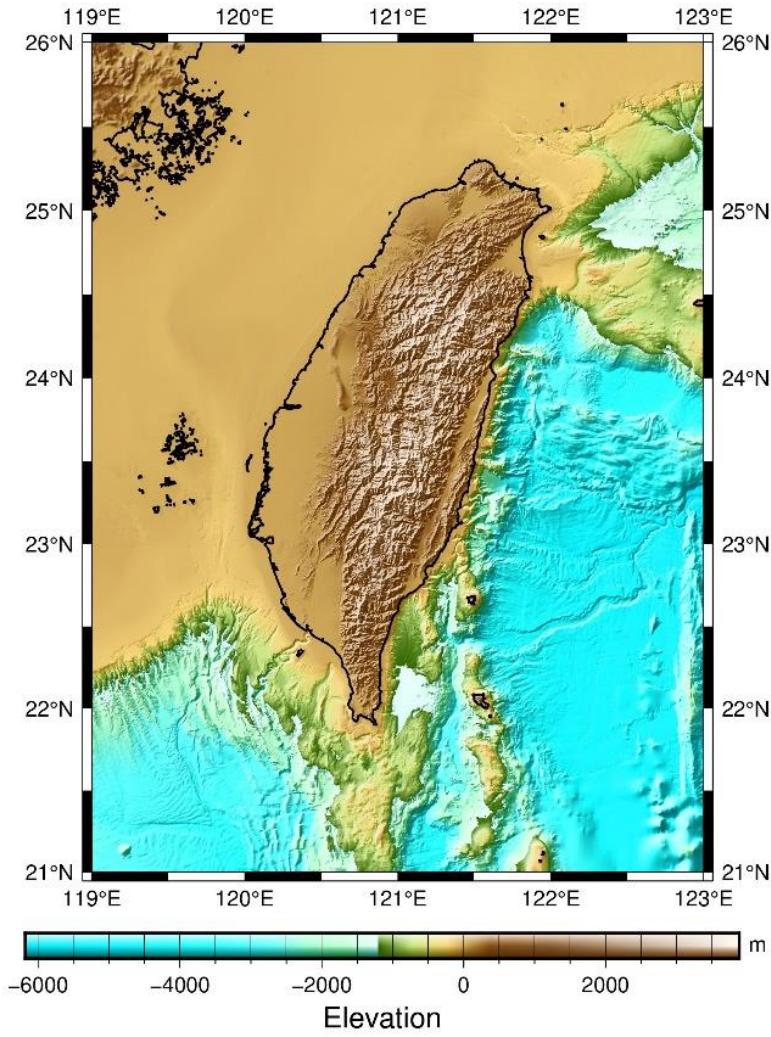
- **-A**: Sets a constant **level of transparency** (0-100) for all color slices. Append **+a** to also affect the fore-, back-, and nan-colors [**Default is no transparency**, i.e., **0 (opaque)**].
- **-C**: Selects the master color table to use in the interpolation
- **-L**: **Limit range of cpt file to minlimit/maxlimit**, and don't count data outside range when estimating CDF(Z).
- **-T**: **Set steps in CPT**. Calculate entries in CPT from start to stop in steps of (inc).
- **-Z**: Will create a **continuous color palette**.

To make a cpt file with entries from **0 to 200** in steps of **20**, and ignore data below zero in computing CDF(Z), and use the **built-in master cpt file relief**, run

```
grd2cpt mydata.nc -Crelief -L0/10000 -S0/200/20 –H > mydata.cpt
```

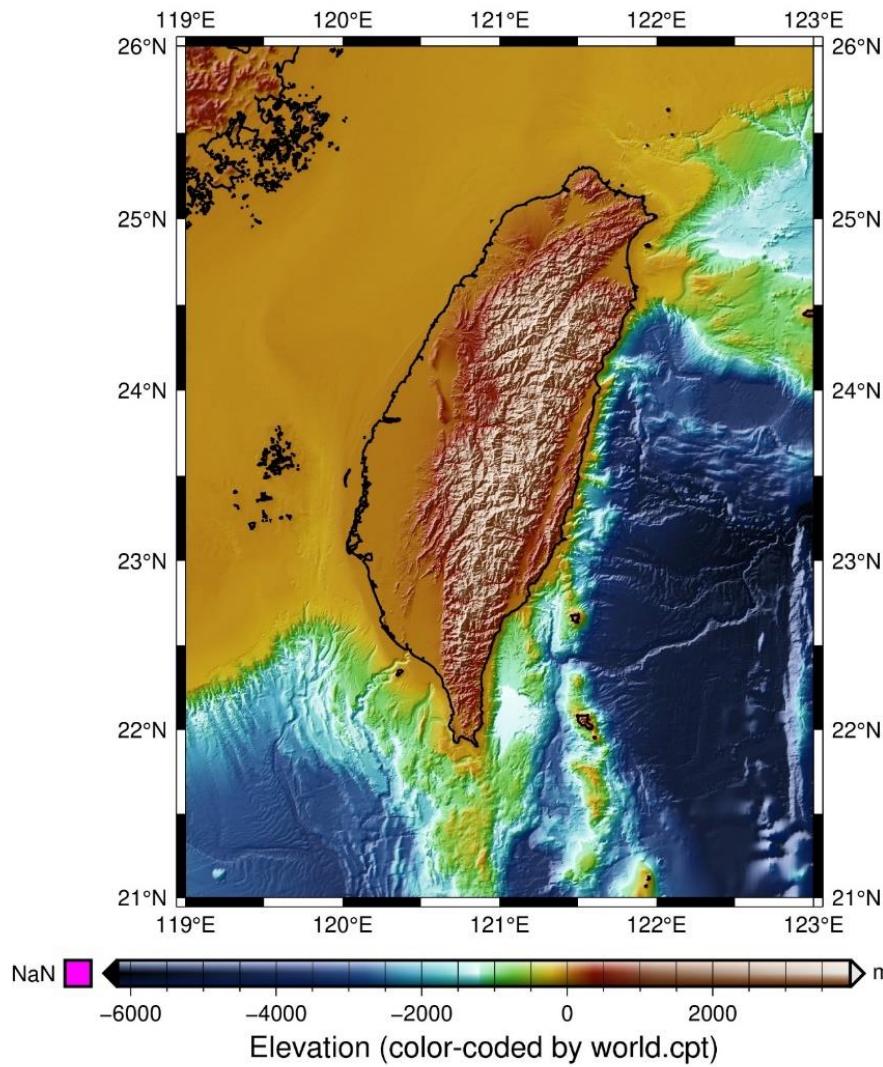
Lecto3B

```
gmt grd2cpt %grd% -Cgeo -Z -V
```



Again, try different master built-in cpt files,
earth and topo

Lecto3B



gmt colorbar

-Dx5.7c/-1.2c+w14c/0.5c+h+jTC+e+n

-By+l"m" -Bxa2000f500g500+l"Elevation (color-coded by world.cpt)" -l -V

-B[p|s]parameters: Set map Frame and Axes parameters

-B selects **p** (primary) [Default] or **s** (secondary) axes information

Parameters: **[p|s][x|y|z]intervals[+llabel][+pprefix][+uunit]**

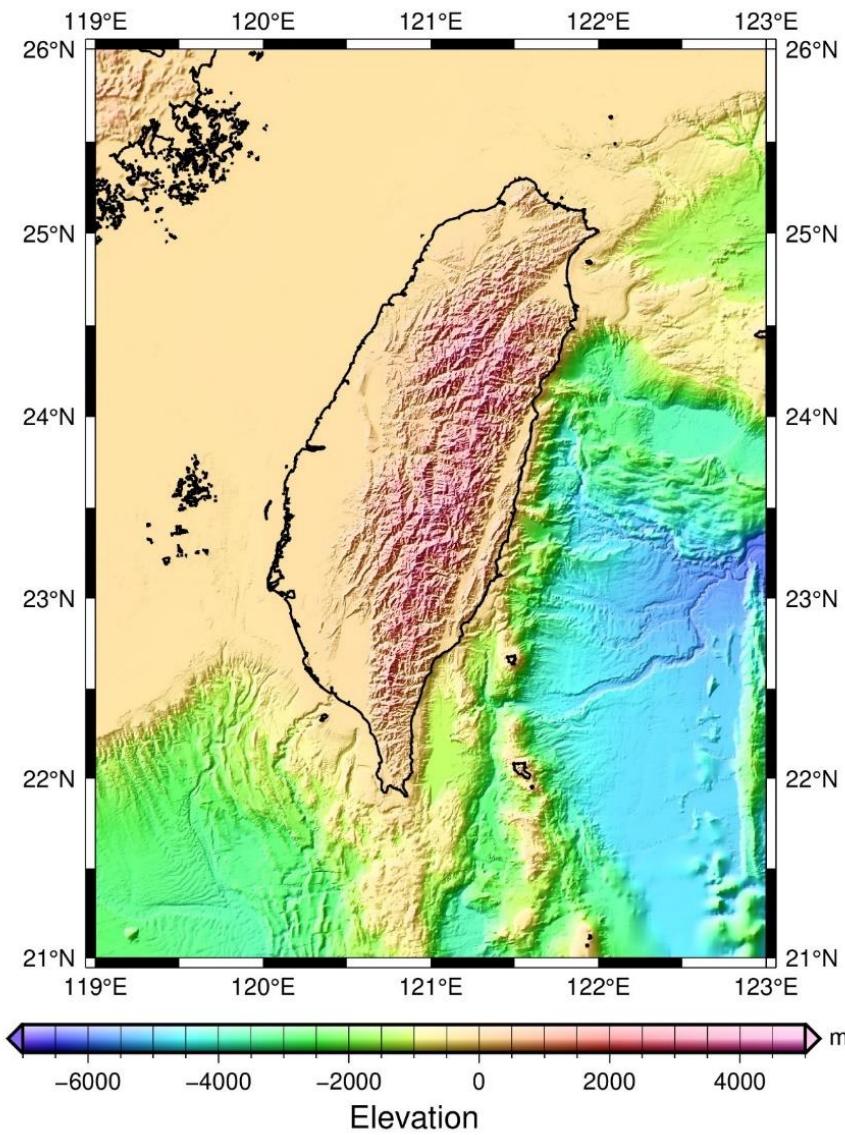
+e: Add sidebar triangles for back- and/or foreground colors.

+n: Show color of NaN

1. Try omitting " " (Quotation mark, 雙引號) of +l (label), what happens?

2. Add +e, +n or +e+n

Lect03c

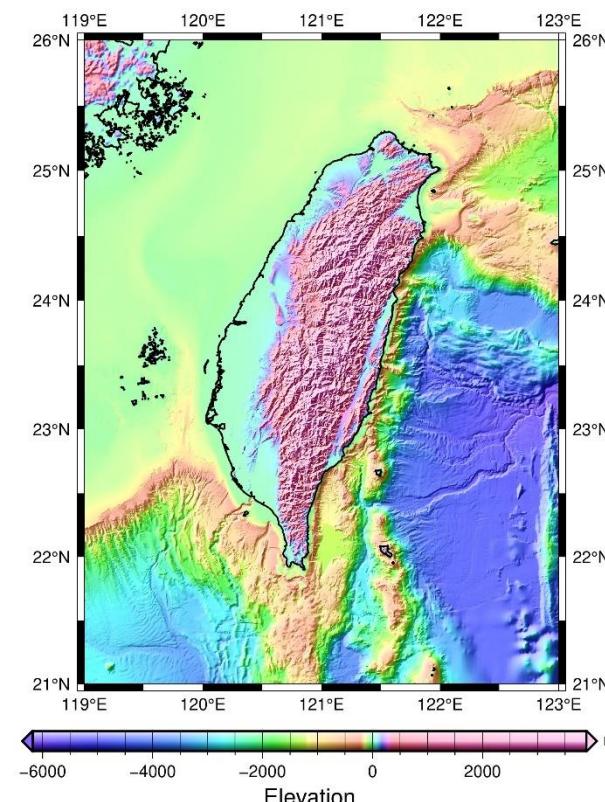
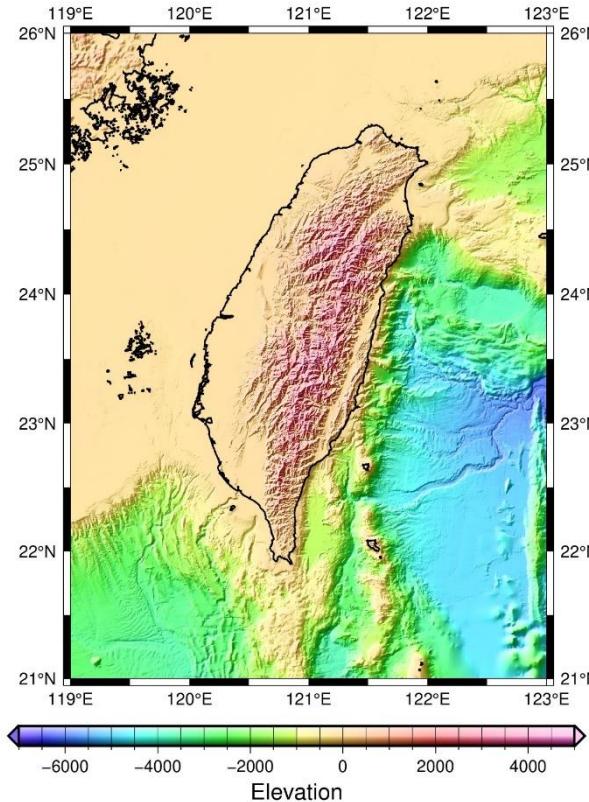


```
set prefix=Lect03C
set grd=c:\gridfiles\Taidp200m.nc
set range=119/123/21/26
gmt set FORMAT_GEO_MAP ddd:mm:ssF
gmt grdinfo %grd% > Tw200m.nc.info
type Tw200m.nc.info
gmt begin %prefix% tif A+m0.5c
gmt grd2cpt %grd% -Csealand -L-7000/5000 -T-
7000/5000/500 -Z
gmt grdimage %grd% -R%range% -JM123/23/15c
-Ba1f0.5 -I+d -V
gmt coast -Df -W1 -V
gmt colorbar -Dx5.7c/-1.2c+w12c/0.5c+h+jTC -
By+Im -Bxa2000f500g500+IElevation -I -V
gmt end
del *.conf *.info
```

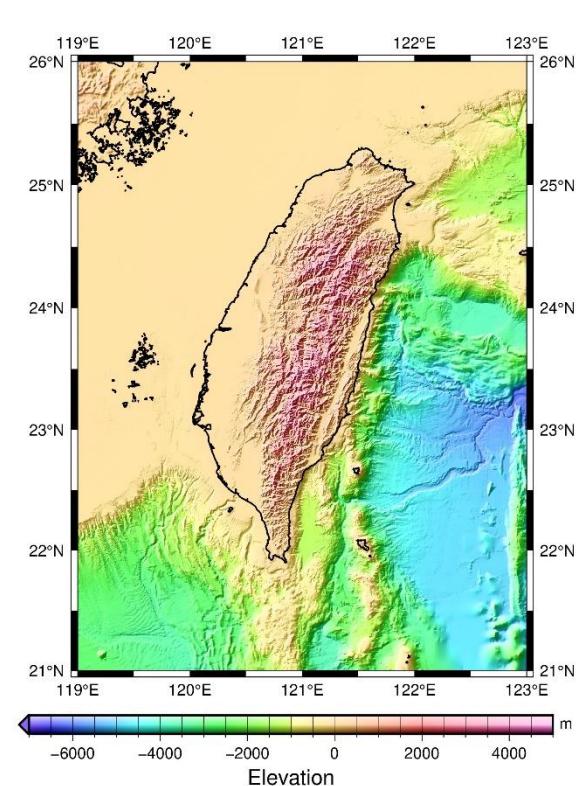
```
gmt grd2cpt %grd% -Csealand -L-7000/5000 -T-7000/5000/500 -Z -V
```

Try omitting **-L-7000/5000 -T-7000/5000/500**

+e: Add **f** or **b** for only one sidebar triangle



Try **+eb** or **+ef**



grdcontour

Make contour map using a grid

```
gmt grdcontour grid -Jparameters [ -A[-|contours][labelinfo] ] [ -B[p|s]parameters ] [ -Ccontours|cpt ] [ -Dtemplate ] [ -F[l|r] ] [ -G[d|f|n||L|x|X]params ] [ -Llow/high|n|N|P|p ] [ -N[cpt] ] [ -Q[cut[unit]][+z] ] [ -Rwest/east/south/north/[zmin/zmax][+r][+uunit] ] [ -Ssmoothfactor ] [ -T[h|l][+a][+dgap[/length]][+l[labels]] ] [ -U[stamp] ] [ -V[level] ] [ -W[type]pen ][+c[l|f]] [ -X[a|c|f|r][xshift[u]] ] [ -Y[a|c|f|r][yshift[u]] ] [ -Z[+sfactor][+oshift][+p] ] [ -bobinary ] [ -donodata ] [ -eregexp ] [ -fflags ] [ -ho[n] ] [ -pflags ] [ -ttransp ] [ --PAR=value ]
```

- **-C[+]**cont_int: Contours to be drawn
- **-L**: Limit range: Do not draw contours for data values below low or above high
- **-S**: Used to **resample** the contour lines at roughly every (**gridbox_size/smoothfactor**) interval,
- **-W[+]**[type]pen: type, if present, can be **a** for **annotated contours** or **c** for **regular contours** [Default].
- pen sets the attributes for the particular line. Default pen for annotated contours: **0.75p,black**. Regular contours use pen **0.25p,black**.

grdcontour

-A[-|][+]*annot_int*][*labelinfo*]

annot_int: annotation interval in data units; it is ignored if contour levels are given in a file.
[Default is no annotations].

Labelinfo:

+a*angle*: For annotations at a fixed angle, **+an** for line-normal, or **+ap** for line-parallel [Default].

+cdx[/dy]: Sets the clearance between label and optional text box.

+f*font*: Sets the desired font [Default FONT_ANNOT_PRIMARY: 9p].

+g[i]color: Selects opaque text boxes [Default is transparent]

+s*size*: Sets the desired font size in points [Default is 9].

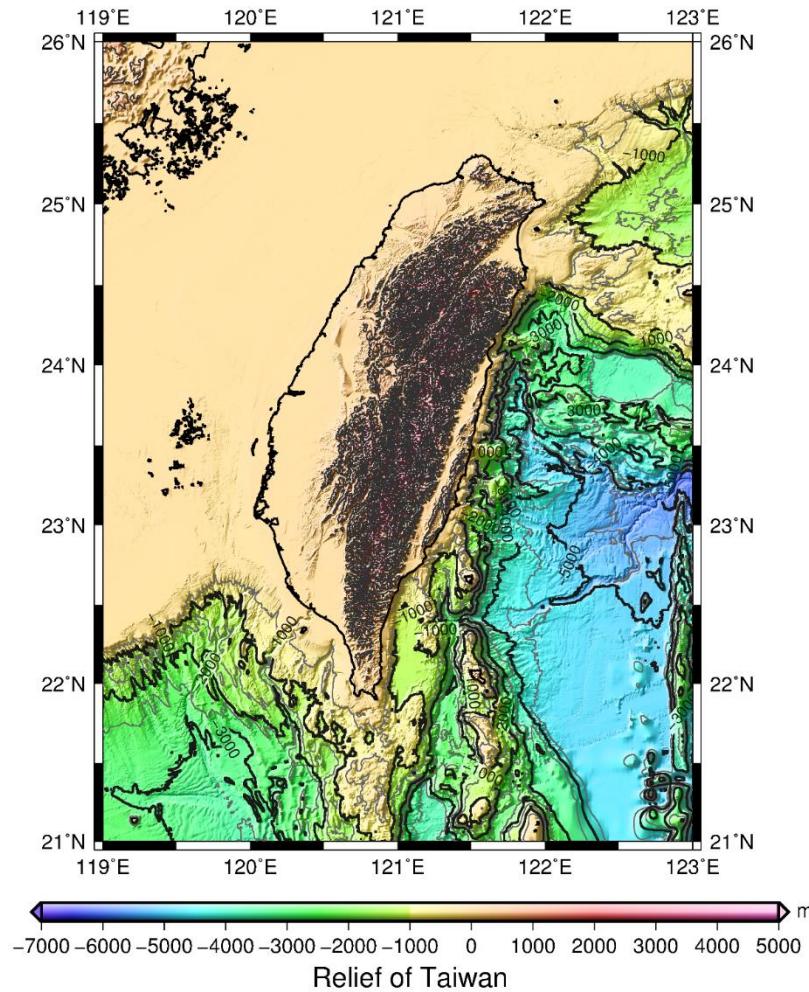
+u*unit*: Appends unit to all line labels

To contour the remote file AK_gulf_grav.nc every 25 mGal on a Mercator map at 0.5 inch/degree, annotate every 50 mGal (using font size = 10p), using 1 degree tick marks, and draw 30 minute gridlines:

```
gmt grdcontour @AK_gulf_grav.nc -JM16c -C25 -A50+f10p -B -pdf alaska_grav1
```

Nota bene: **quick modern mode** GMT Modern Mode One-line Commands syntax

Lecto3D



```
set prefix=Lect03D  
set grd=c:\gridfiles\Taidp200m.nc  
set range=119/123/21/26  
gmt set FORMAT_GEO_MAP ddd:mm:ssF  
....  
gmt begin %prefix% tif A+m0.5c  
gmt grd2cpt %grd% -Csealand -L-  
7000/5000 -T-7000/5000/500 -Z  
gmt grdimage %grd% -R%range% -  
JM123/23/15c -Ba1f0.5 -l+d -V  
gmt coast -Df -W1 -V  
gmt grdcontour %grd% -L-8000/-500 -C500  
-A1000 -Wa1p,25 -Wc0.5p,100 -S80 -V  
gmt grdcontour %grd% -L500/4000 -C1000  
-Wc0.4p,50 -S20 -V  
gmt colorbar -Dx5.7c/-  
1.2c+w12c/0.5c+h+jTC -By+Im -  
Bxa2000f500g500+l"Relief of Taiwan" -I -V
```

inset

Manage figure inset setup and completion

```
gmt inset begin -Dinset-box [ -Fbox ] [ -Mmargins ] [ -N ] [ -V[level] ] [ --PAR=value ]
```

- **inset module:** carve out a **sub-region** of the **current plot canvas** and **restrict further plotting** to that section of the canvas (在畫布紙張畫出一片區域，並限制接下來的繪製指令，均只在該小區域內操作)
- The **inset setup** is started with the **begin** directive that defines the placement and size of the inset (begin開啟插圖模式，定義插圖區域的位置和大小)
- The inset is completed via the **end** directive, which reverts operations to the full canvas and restores the plot region and map projection that was in effect prior to the setup of the inset. (end結束插圖模式，所有的操作都會回到原繪大圖中的設定)

-D: Define the **map inset rectangle** on the map (管理和設置插圖), Specify the rectangle in one of following ways:

1. **-Dxmin/xmax/ymin/ymax[+r][+uunit]:** Give west/east/south/north of geographic rectangle bounded by parallels and meridians, see **-R** option.
2. **-D[g|j|J|n|x]refpoint+wwidth[/height][+justify][+odx/dy]:** Give the reference point on the map for the inset using one of four coordinate systems (根據四種坐標系統指定插圖區域的參考點位置、尺寸和對齊方式)

Map inset rectangle

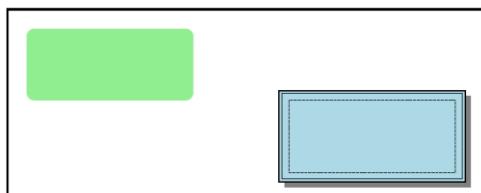
```
gmt inset begin -Dinset-box [ -Fbox ] [ -Mmargins ] [ -N ] [ -V[level] ] [ --PAR=value ]
```

-D[g|j|J|n|x]refpoint+wwidth[/height][+jjustify][+odx[/dy]]:

-D[g|j|J|n|x]: (1) Use -Dg for **map (user) coordinates**, (2) use -Dj or -DJ for setting **refpoint** via a 2-char **justification code** that refers to the (invisible) map domain rectangle, (3) use -Dn for **normalized (0-1) coordinates**, or (4) use -Dx for **plot coordinates** (inches, cm, etc.)

-F[+cclearances][+gfill][+i[[gap/]pen]][+p[pen]][+r[radius]][+s[[dx/dy/][shade]]]: Draws a rectangular border around the map inset using **MAP_FRAME_PEN** (繪製插圖的圖框，畫筆屬性由 **MAP_FRAME_PEN** 定義)

+cclearance: clearance is either **gap**, **xgap/ygap**, or **lgap/rgap/bgap/tgap** where these items are uniform, separate in x- & y-direction, or individual side spacings between logo and border (設置修飾物與圖框之間的空白距離。gap為四個方向增加相同的空白距離；xgap/ygap分別指定X向及Y向不同的空白距離；lgap/rgap/bgap/tgap指定四個方向不同的空白距離)



+gfill: fill the logo box [no fill] (圖框填色，預設不填色)

+i [[gap/]pen]: draw a secondary, inner border as well (繪製圖框內邊框，由gap設定兩框空白距離)

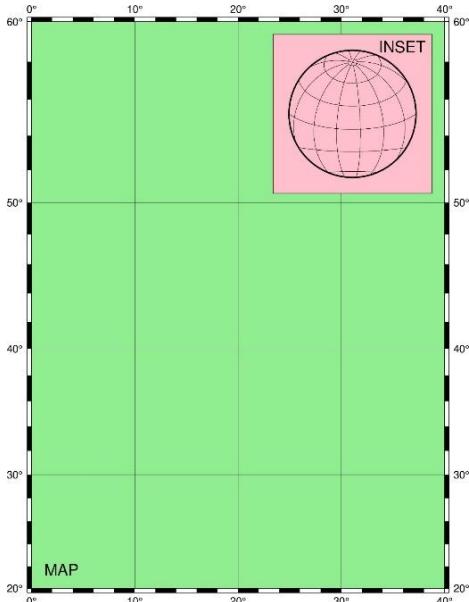
inset example 02

-F[+cclearances][+gfill][+i[[gap/]pen]][+p[pen]][+r[radius]][+s[[dx/dy/][shade]]]:

+p[pen]: specify a different pen (繪製插圖邊框。pen為邊框的畫筆屬性)

+r[radius]: draw rounded rectangular borders instead, with a 6p corner radius (繪製圓角邊框，radius為圓角的半徑，預設值6p)

+s[dx/dy/][shade]: Draw an offset background shaded region. dx/dy indicates the shift relative to the foreground frame [4p/-4p] and shade sets the fill style to use for shading [gray50] (繪製陰影區。dx/dy是陰影區相對於邊框的偏移量，shade是陰影區的顏色，預設值為4p/-4p/gray50)



Open and run `inset01.bat` or `inset01.sh`

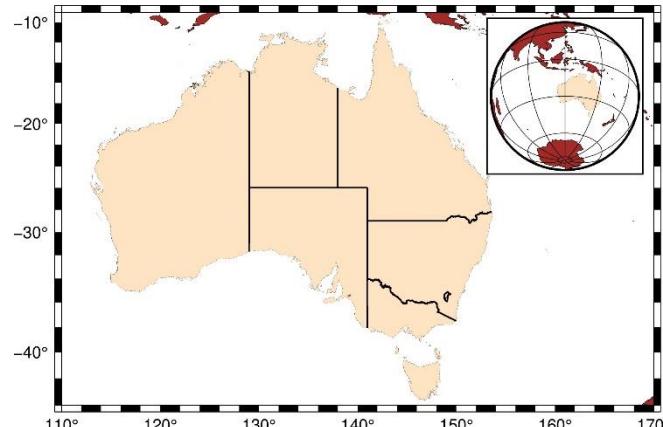
```
gmt begin inset1 jpg
gmt basemap -R0/40/20/60 -JM6.5i -Bafg -B+glightgreen
gmt inset begin -DjTR+w2.5i+o0.2i -F+gpink+p0.5p -M0.25i
gmt basemap -Rg -JA20/20/2i -Bafg
gmt text -F+f18p+cTR+tINSET -Dj-0.15i -N
gmt inset end
gmt text -F+f18p+cBL+tMAP -Dj0.2i
gmt end
```

inset example 02

```
gmt begin inset02 jpg
gmt coast -R110E/170E/44S/9S -JM6i -B -BWSne -Wfaint -N2/1p -
Gbrown -EAU+gbisque
gmt inset begin -DjTR+w1.5i+o0.15i/0.1i -F+gwhite+p1p+c0.1c
gmt coast -JG120/30S/? -Rg -Bg -Wfaint -Gbrown -EAU+gbisque -A5000
gmt inset end
gmt end
```

Orthographic projection (-Jg -JG): perspective projection from infinite distance (正交方位投影：從無窮遠距離處的透視投影，常用於繪製從外太空看地球)

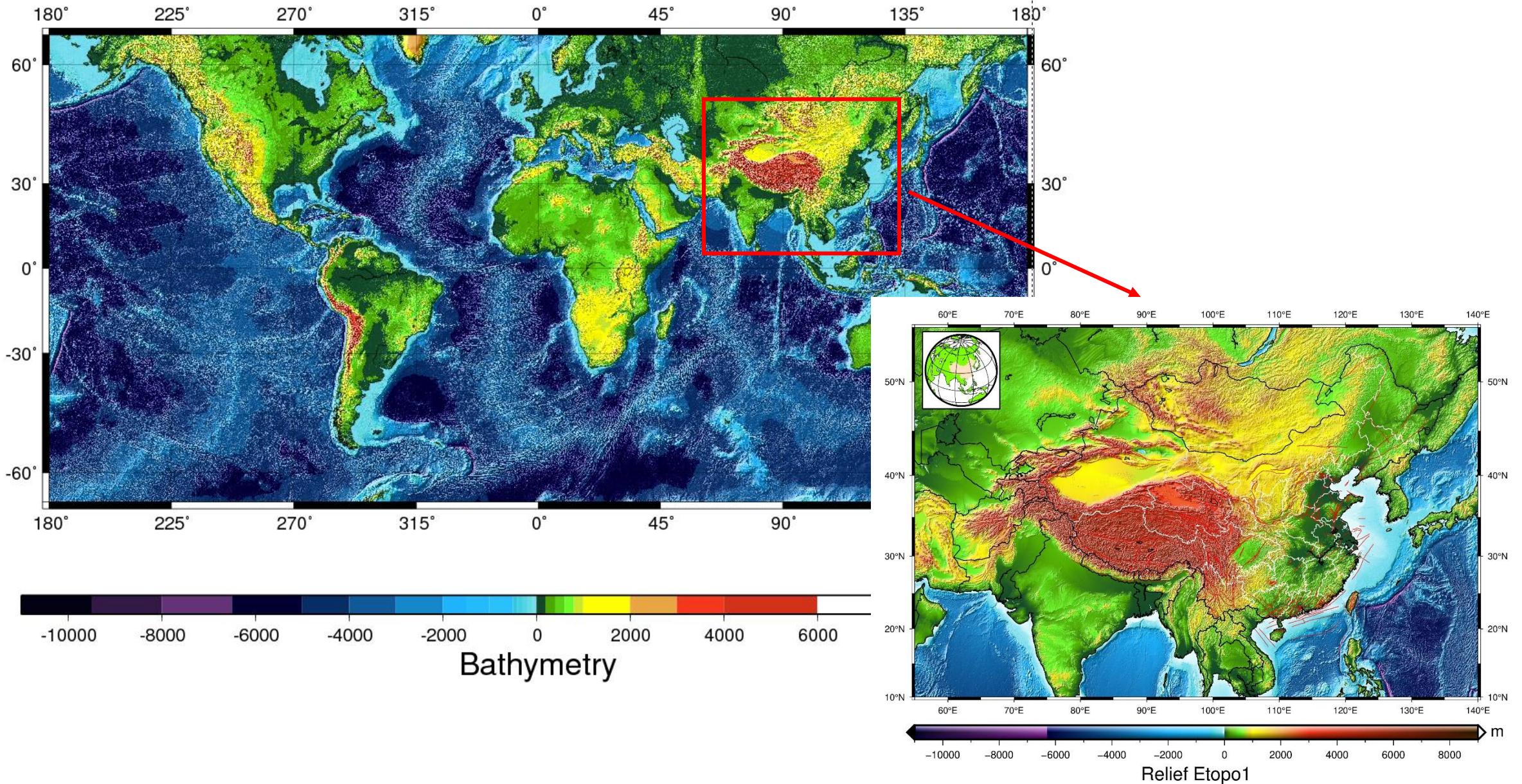
-JGlon/lat[/**distance**]/width: lon/lat represents longitude and latitude of the projection center (投影中心位置的經緯度)



distance: **Horizon**, i.e., the number of degrees from the center to the edge (<= 90, **default is 90**) (邊界離投影中心的度數，預設值為 90)

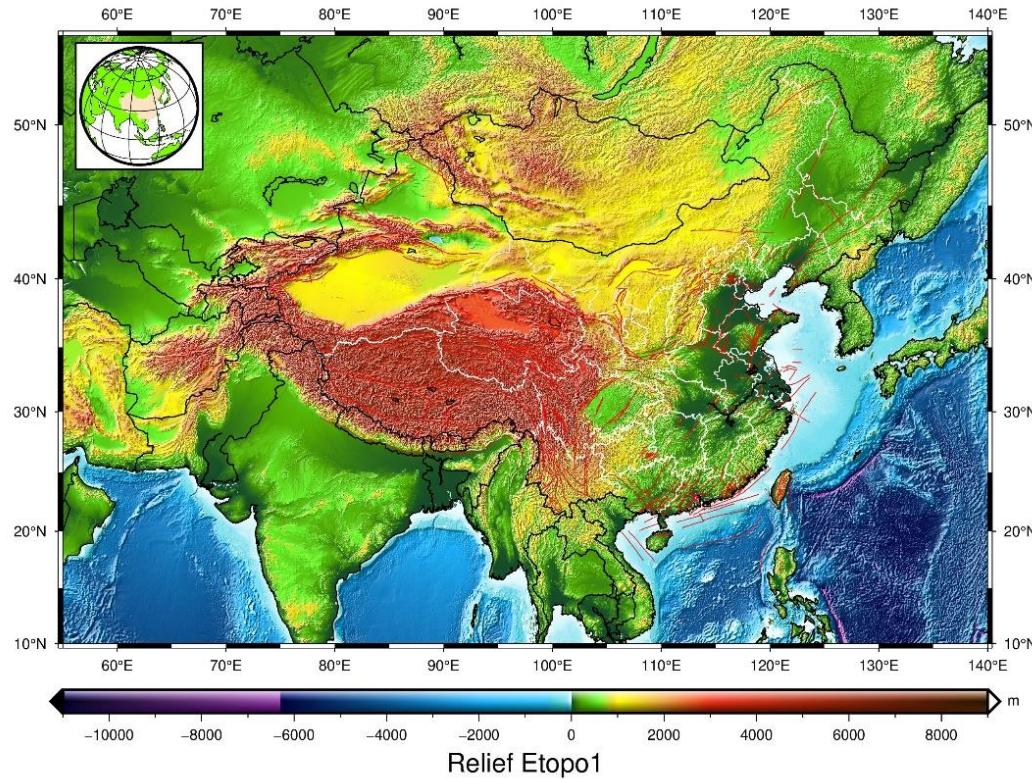
?: use ? as scale or width, adjusting the scale or width to fill the inset as best as possible, given the inset size and margins (if selected). (若投影方式中底圖寬度或比例用?表示，則會根據-D 選項設置的圖尺寸自動確定插圖的投影參數)

Cut a sub-region from a grd file



Lecto3E

```
set grd1=earth_relief_01m.grd  
set grd2=GEBCO_2023_sub_ice_topo.nc  
set grd3=china_earth_relif_01m.nc  
set grd4=china_GEBCO.nc  
set range=55/140/10/55  
gmt grdcut %grd1% -G%grd3% -R%range%
```



Try:

```
gmt grdcut %grd2% -G%grd4% -R%range%
```

GEBCO 2023 grid

```
gmt grdinfo gridone.nc > gridone.nc.info  
type gridone.nc.info
```

[china_GEBCO.nc](#): Title: The **GEBCO_2020 Grid** - a continuous terrain model for oceans and land at **15 arc-second intervals**

[china_GEBCO.nc](#): Command: gmt grdcut GEBCO_2023_sub_ice_topo.nc -Gchina_GEBCO.nc -R55/140/10/55

[china_GEBCO.nc](#): Remark:

[china_GEBCO.nc](#): Pixel node registration used [Geographic grid]

[china_GEBCO.nc](#): **Grid file format: nf = GMT netCDF format (32-bit float), CF-1.7**

[china_GEBCO.nc](#): x_min: 55 x_max: 140 x_inc: 0.00416666666667 (15 sec) name: longitude n_columns: 20400

[china_GEBCO.nc](#): y_min: 10 y_max: 55 y_inc: 0.00416666666667 (15 sec) name: latitude n_rows: 10800

[china_GEBCO.nc](#): v_min: -10021 v_max: 8627 name: Elevation relative to sea level [m]

[china_GEBCO.nc](#): scale_factor: 1 add_offset: 0

[china_GEBCO.nc](#): format: netCDF-4 chunk_size: 129,129 shuffle: on deflation_level: 3

[china_GEBCO.nc](#): Default CPT:

Detail, see <http://www.gebco.net> & **GEBCO_2023_Grid_documentation.pdf**

GEBCO (General Bathymetric Chart of the Oceans)

- GEBCO: Operates under the auspices of the International Hydrographic Organization (IHO) & the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

Data & Products ▾ Seabed 2030 Training News & Media About ▾ Contact

IHO International Hydrographic Organization
unesco Intergovernmental Oceanographic Commission

GENERAL BATHYMETRIC CHART OF THE OCEANS 120 1903–2023

General Bathymetric Chart of the Oceans

Since 1903 GEBCO aims to provide the most publicly available bathymetry data sets for the world's oceans.

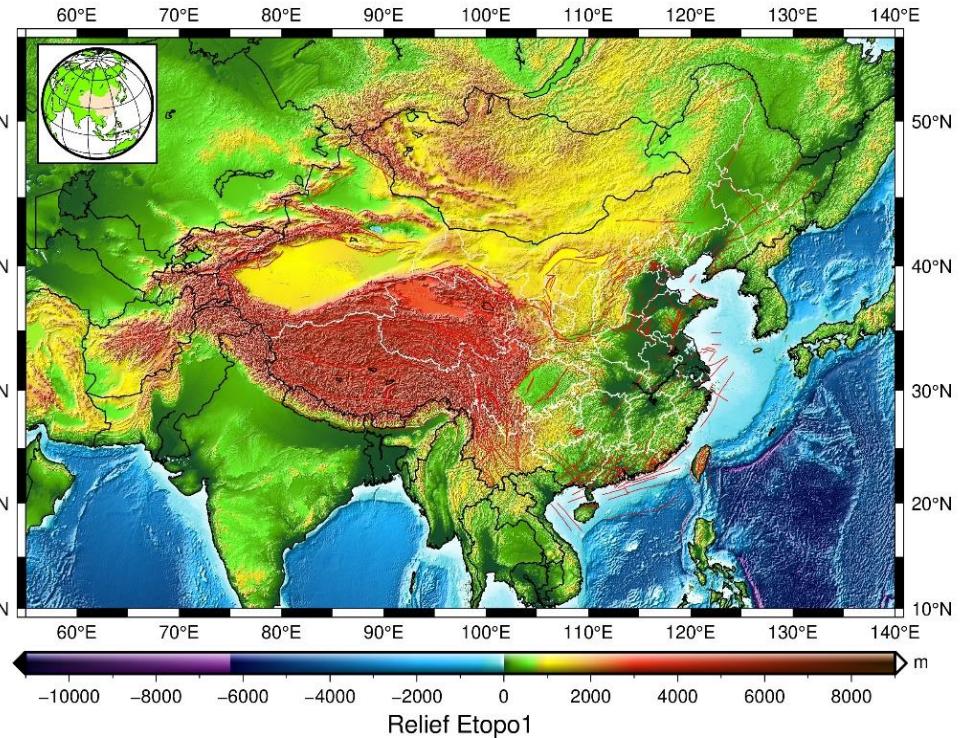
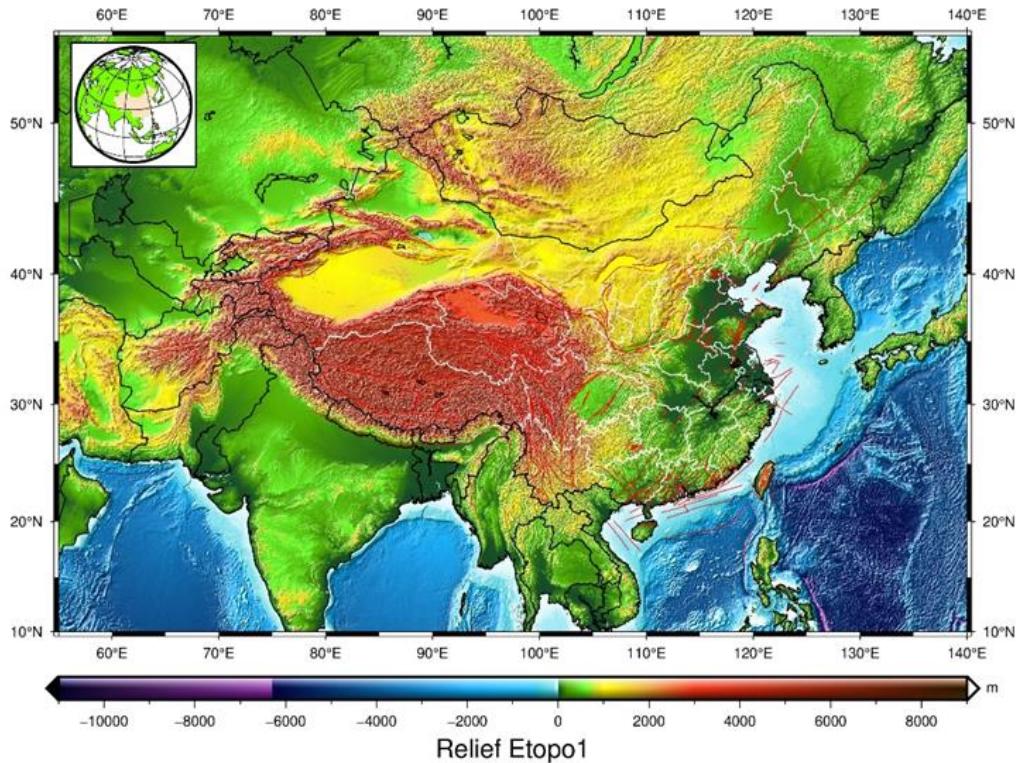
Download GEBCO's global grid Download polar grids Contribute data

GEBCO_2023 Grid (ice surface elevation)	netCDF (4 Gbytes, 7.5 Gbytes uncompressed)
GEBCO_2023 Grid (sub-ice topo/bathy)	netCDF (4 Gbytes, 7.5 Gbytes uncompressed)
GEBCO_2023 TID Grid	netCDF 90 Mbytes, 4 Gbytes uncompressed)

Lecto3E

```
set range = 60/135/10/55  
gmt gmtset ANNOT_FONT_PRIMARY 9p  
gmt gmtset FRAME_WIDTH 0.1c
```

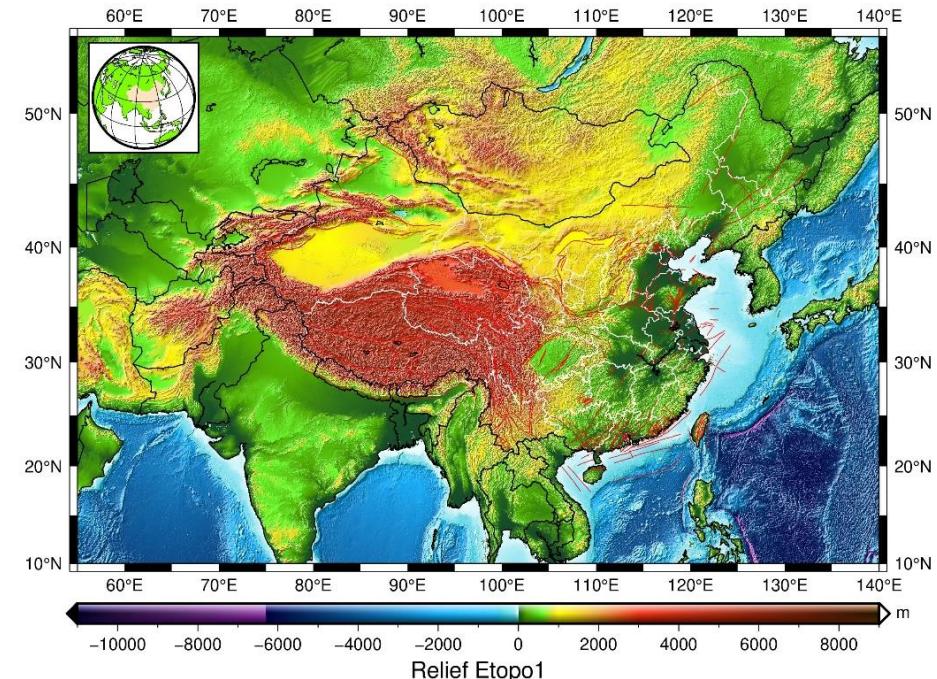
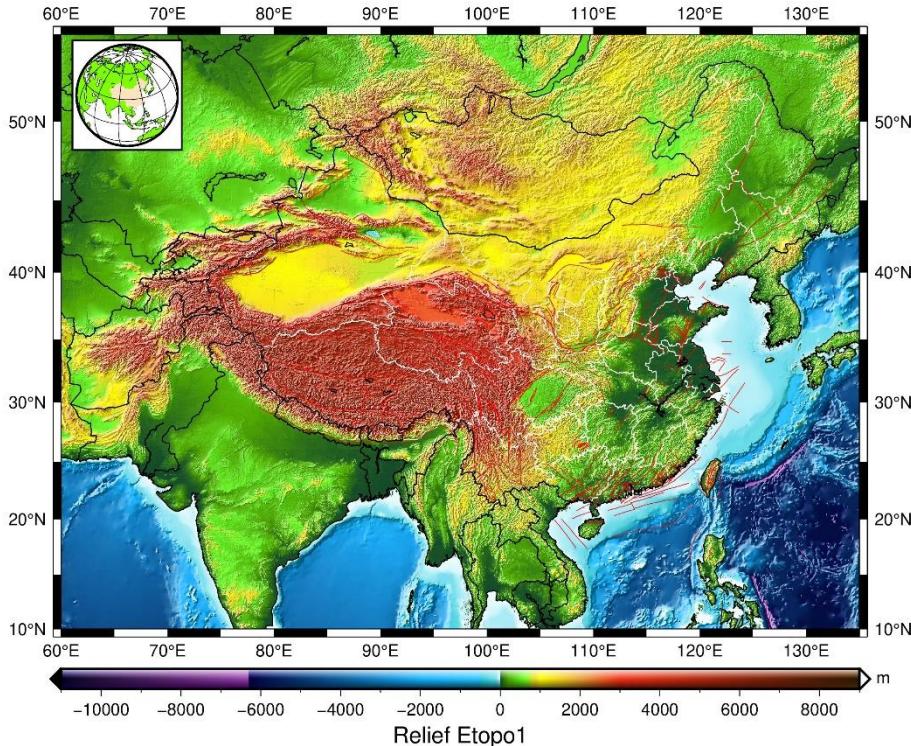
Try: **ANNOT_FONT_SIZE_PRIMARY 12p FRAME_WIDTH 0.2c**



Lecto3E

```
set grd1=earth_relief_01m.grd  
set grd2=GEBCO_2023_sub_ice_topo.nc  
set grd3=china_earth_relif_01m.nc  
set grd4=china_GEBCO.nc  
set range=60/135/10/55  
gmt grdcut %grd1% -G%grd3% -R%range%
```

Try: 1. **set range=55/140/10/55.** 2. **gmt grdcut @earth_relief_01m**



Plot

Plot lines, polygons, and symbols on maps

```
gmt plot [ table ] -Jparameters -Rwest/east/south/north/[zmin/zmax][+r][+uunit] [ -A[m|p|x|y] ] [ -B[p|s]parameters ] [ -Ccpt ] [ -Ddx/dy ] [ -E[x|y|X|Y][+a][+cl|f][+n][+wcap][+ppen] ] [ -F[c|n|r][a|f|s|r|refpoint] ] [ -Gfill ] [ -I[intens] ] [ -L[+b|d|D][+x|l|r|x0][+y|l|r|y0][+ppen] ] [ -N[c|r] ] [ -S[symbol][size[u]] ] [ -U[stamp] ] [ -V[level] ] [ -W[pen][attr] ] [ -X[a|c|f|r][xshift[u]] ] [ -Y[a|c|f|r][yshift[u]] ] [ -Z[l|f]value ] [ -aflags ] [ -bibinary ] [ -dinodata ] [ -eregexp ] [ -fflags ] [ -ggaps ] [ -hheaders ] [ -iflags ] [ -lflags ] [ -pflags ] [ -ttransp ] [ -:[i|o] ] [ --PAR=value ]
```

- plot reads **(x,y) pairs** from files [or standard input] and generates PostScript code that will plot **lines**, **polygons**, or **symbols** at those locations on a map.
- If a **symbol** is selected and no symbol size given, then psxy will interpret the **third column** of the input data as **symbol size**.
- To explicitly close polygons, use **-L**.
 - **-W[pen][attr]**: Set **pen attributes** for **lines** or the **outline of symbols** [Defaults: width = default, color = black, style = solid].

Input data for plot

[Open China_active_faults.gmt](#)

```
# @VGMT1.0 @GLINESTRING
# @R73.560404/132.525177/16.395/52.733
# @Je4130
# @Jp"+proj=longlat +ellps=WGS84 +towgs84=0,0,0,-0,-0,-0,0 +no_defs
```

```
.....
96.244644 39.896218
96.23763 39.894403
96.208 39.887
```

```
...
92.716278 39.241597
92.693986 39.23836
>
90.539931 38.573348
90.488037 38.562601
```

```
.....
87.390281 37.945596
87.366619 37.940525
>
83.754729 36.568174
83.731741 36.560699
```

-h: Input file(s) has header record(s).

Default number of header records is
IO_N_HEADER_RECS.

-hi if only input data should have header records
[Default will write out header records if the input data
have them]. **Blank lines and lines starting with # are
always skipped**

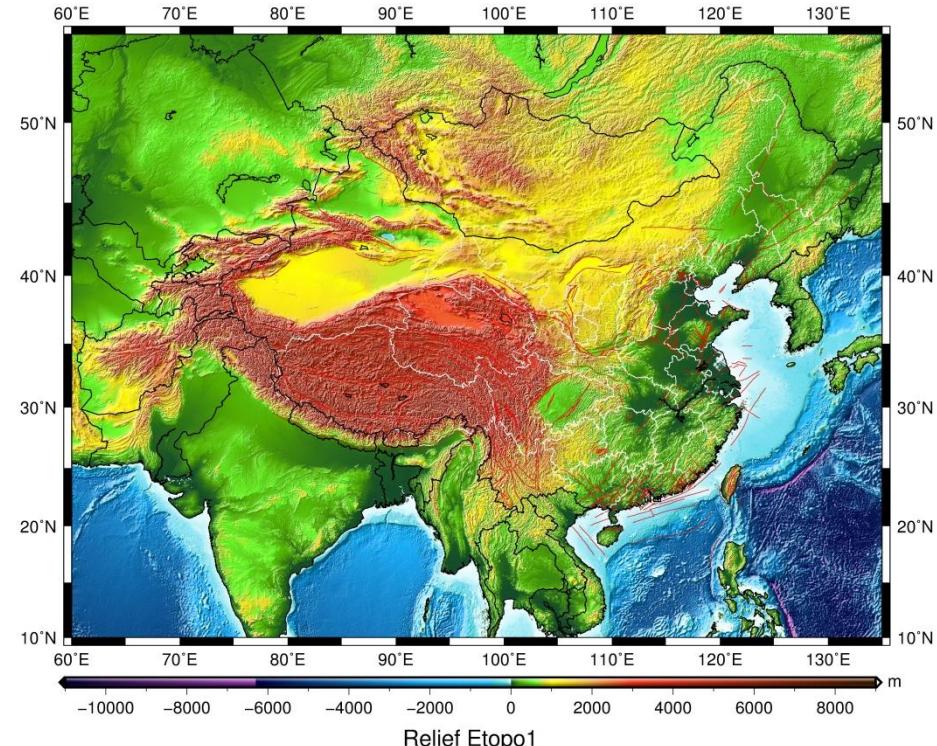
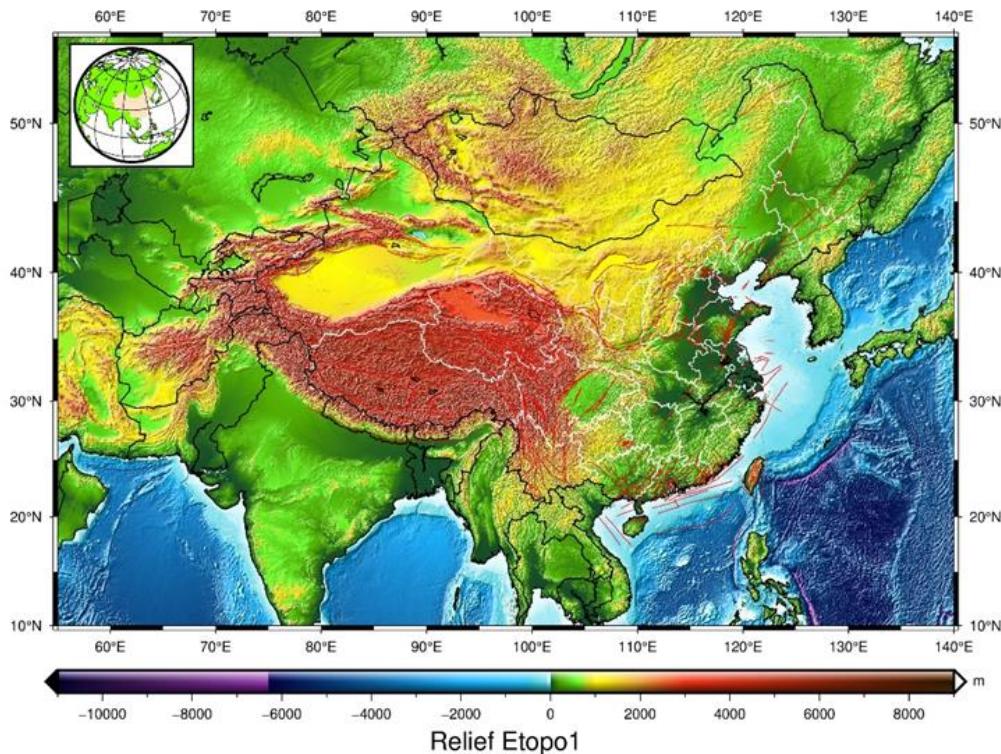
Nota bene: **Multiple segment file.** Segments are
separated by a record whose first character is ***flag* >**.

Lecto3E

```
gmt plot China_provinces.gmt -W0.4p,white -V  
gmt plot China_active_faults.gmt -W0.3p,red -h9 -V
```

Try: -W width with different predefined pen names

faint	0	thicker	1.5p
default	0.25p	thickest	2p
thinnest	0.25p	fat	3p
thinner	0.50p	fatter	6p
thin	0.75p	fattest	12p
thick	1.0p	obese	18p





SOCIOECONOMIC DATA AND APPLICATIONS CENTER (SEDAC)

A Data Center in NASA's Earth Observing System Data and Information System (EOSDIS) — Hosted by CIESIN at Columbia University

> guangdong_sheng

109.843399	21.492111
109.847102	21.485148
109.847914	21.479664
109.852238	21.47589
109.857785	21.474068
109.863514	21.472506
109.869309	21.471195
109.875428	21.47217

.....

> guangxizhuangzu_zizhiqus

108.871472	21.746466
108.867587	21.756672
108.872468	21.763047
108.871736	21.770109
108.86606	21.774337
108.857255	21.776547

gmt plot China_provinciates.gmt
-W0.4p,white -V

Open [China_provinces.gmt](#)

SEDAC

NASA Socioeconomic Data and Applications Center (SEDAC) – Hosted by CIESIN (Center for International Earth Science Information Network) at Columbia University

<http://sedac.ciesin.columbia.edu/>

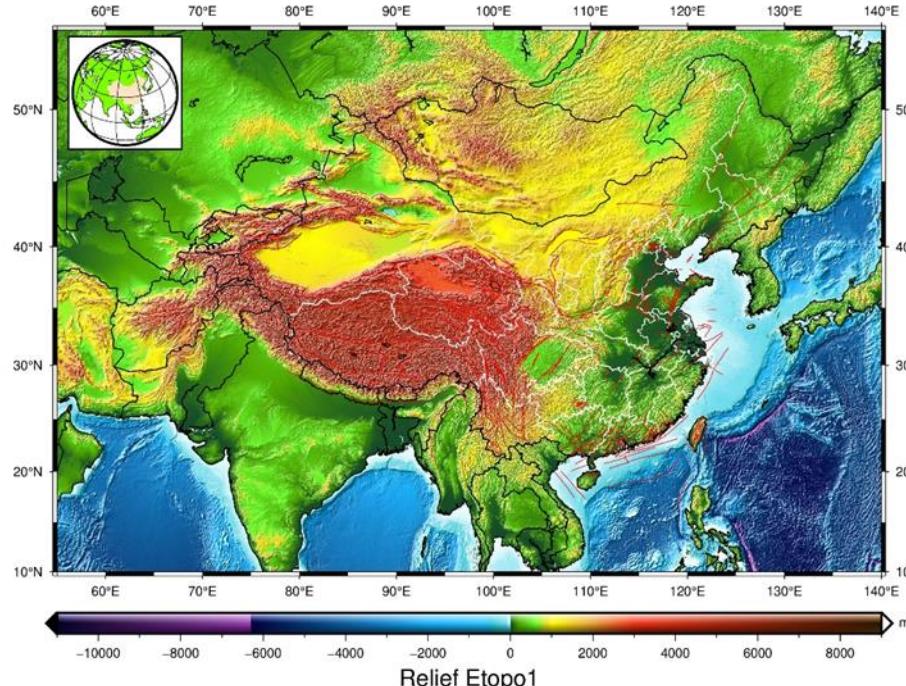
```
gmt plot China_active_faults.gmt -J -R -W0.3p,red -h9 -V
```

Open China_active_faults.gmt, how many lines of header?

```
# @VGMT1.0 @GLINESTRING  
# @R73.560404/132.525177/16.395/52.733  
# @Je4130  
# @Jp"+proj=longlat +ellps=WGS84 +towgs84=0,0,0,-0,-0,-0,0 +no_defs "  
-----
```

```
93.095 39.308  
92.988 39.299  
92.895 39.284  
92.824 39.269  
92.753 39.248  
92.716278 39.241597  
92.693986 39.23836  
>  
90.539931 38.573348  
90.488037 38.562601  
90.449485 38.558832  
90.40574 38.550541
```

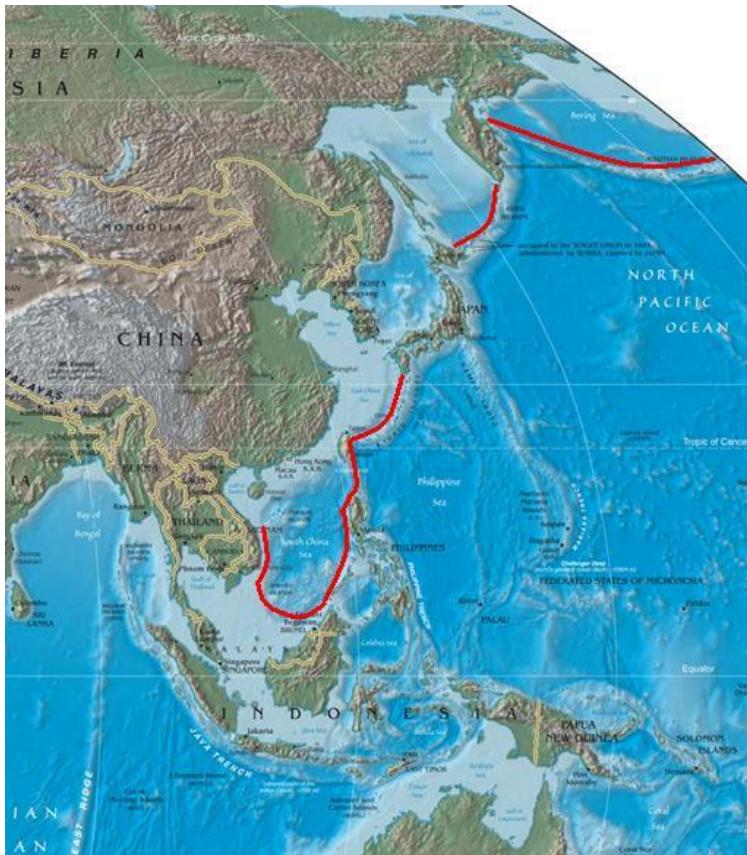
- Segments are separated by a record whose first character is *flag* '>'.



Exercise 03: Geopolitics (地緣政治學)

First island chain (第一島鏈) and Blue-water navy (藍水海軍)

- Major archipelagos: Principally composed of the Kuril Islands, Japanese Archipelago, Ryukyu Islands, Taiwan, the northern Philippines, and Borneo; from the Kamchatka Peninsula to the Malay Peninsula



Why Taiwan Matters? Is it good to Taiwan geopolitically
Why Douglas MacArthur referred to Taiwan as an
"unsinkable aircraft carrier"

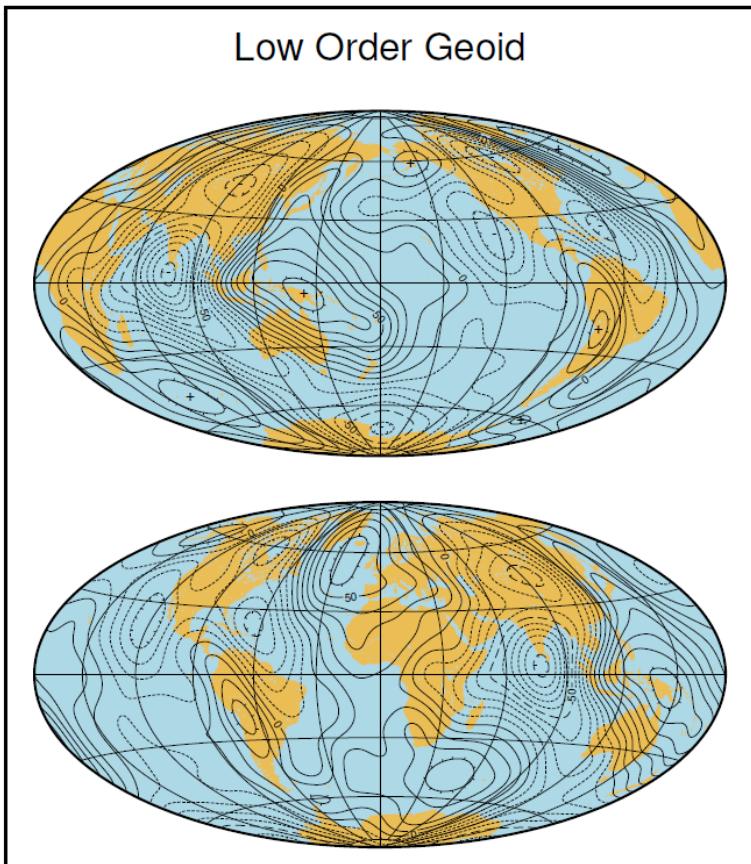
<http://thediplomat.com/2011/03/why-taiwan-matters/>

- Using `gridone.nc` (GEBCO) or `@earth_relief_01m` to draw the topography and bathymetry with **Mercator projection** (-JM or -Jm).
- Using `makecpt` or `grd2cpt` for color legends with `terra.cpt`.
- Add a title “First Island Chain” and political boundaries.

Homework 03: example 01 in cookbook

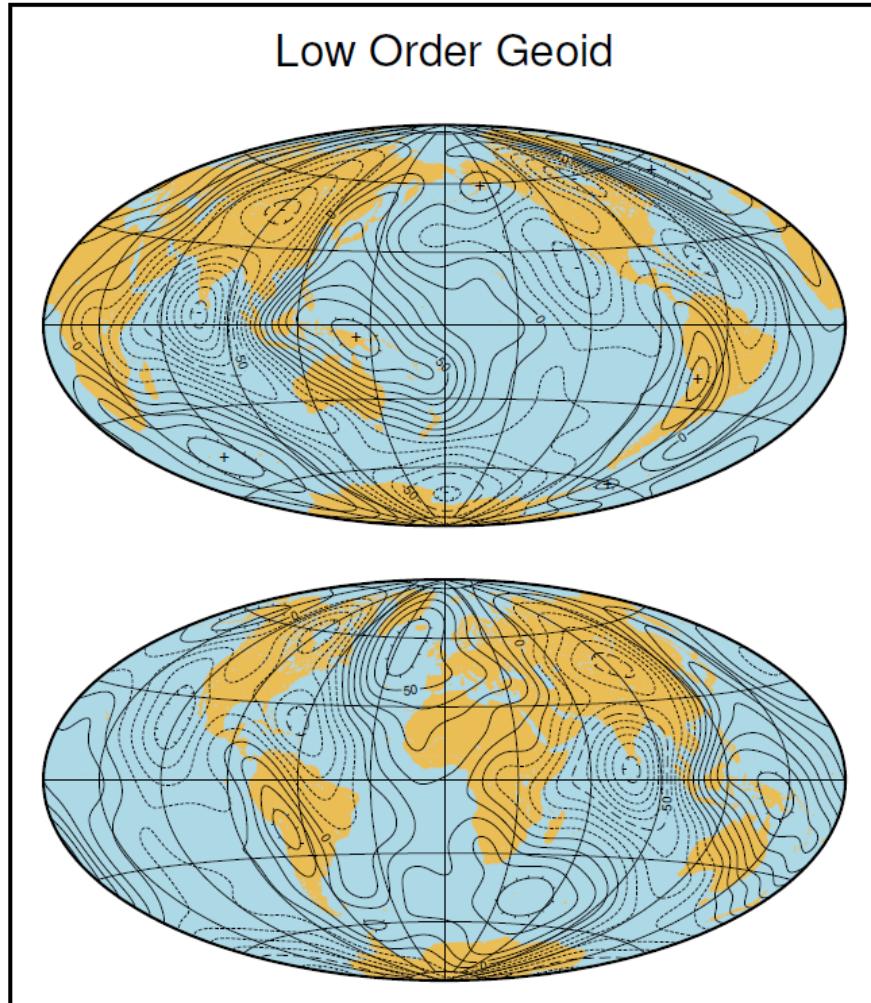
Path: c:\programs\gmt6\share\doc\examples\ex01

[ex_01.bat or ex01.sh](#)



```
gmt begin ex01 ps
gmt set MAP_GRID_CROSS_SIZE_PRIMARY 0
FONT_ANNOT_PRIMARY 10p
gmt subplot begin 2x1 -A -M0.25i -Blrtb -Bafg -T"Low Order Geoid"
-Fs6.5i/0 -Rg -JH6.5i
gmt coast -JH? -Glightbrown -Slightblue -c0,0
gmt grdcontour @osu91a1f_16.nc -C10 -A50+f7p -Gd4i -Ln -
Wcthinnest,- -Wathin,- -T+d0.1i/0.02i+l
gmt grdcontour @osu91a1f_16.nc -C10 -A50+f7p -Gd4i -LP -
T+d0.1i/0.02i+l
gmt coast -JH0/? -Glightbrown -Slightblue -c1,0
gmt grdcontour @osu91a1f_16.nc -C10 -A50+f7p -Gd4i -Ln -
Wcthinnest,- -Wathin,- -T+d0.1i/0.02i
gmt grdcontour @osu91a1f_16.nc -C10 -A50+f7p -Gd4i -LP -
T+d0.1i/0.02i
gmt subplot end
gmt end show
```

Homework 03: example 01 in cookbook



1. Change **arguments** in **optional flags** to make a new countour map of Geoid
2. A report (MS Word document, max. 3 pages) for how you change arguments in optional flags, especially for those are not taught in lectures 01 and 02 (e.g., **-JH?**, **JH0?** **-A50+f7p**, **-LP**, **Ln** and **-T0.1i/0.02i**)
3. Using grdinfo to extract information of osu91a1f_16.nc