HOWTO g11: A trick with the minimum and the maximum degree of the synthesis

You will learn a trick to work with a GGM, the size of which exceeds your RAM.

The main idea is to slice your GGM into several spectral bands (1st band: "0" ... "nmax1", 2nd band: "nmax1 + 1" ... "nmax2", 3rd band: "nmax2 + 1" ... "nmax3", etc.), each of which is small enough to be stored in RAM at once. Then, you can perform the synthesis for each sliced GGM and, finally, sum the syntheses (outside GrafLab) to the get final result. Certainly, this is substantially slower than using a single GGM, so this procedure should be avoided whenever possible. Nonetheless, with high-degree expansions, GGMs may require tens of GBs of RAM, so this may be the only option if you do not have a sufficient amount of RAM.

To employ this functionality, the input GGM file must be provided as the binary "mat" file and must contain three variables:

- a matrix of an arbitrary name (following the MATLAB's rules) with two columns specifying the spherical harmonic coefficients, [Cnm Snm]; the columns with harmonic degrees and harmonic orders are omitted; the rows of the table *must* follow the structure from "Table 1" from "HOWTO g02" and no other ordering scheme is supported (no check on this is performed by GrafLab!),
- an integer named as "nmin" specifying the minimum degree of the coefficients to be imported,
- an integer names as "nmax" specifying the maximum degree of the coefficients to be imported.

All the GrafLab input parameters are explained in ../docs/graflab.md.

```
clear; clc; init_checker();
```

Numerical example

A GGM file with an incomplete set of spherical harmonic coefficients can be obtained from the enclosed gravity field model "../data/input/EGM96.mat" using the following commands:

```
load('../data/input/EGM96.mat'); % Load EGM96, a gravity model up to degree
                                 % 360.  Importantly, the coefficients are
                                 % stored in agreement with "Table 1".  No
                                 % reordering of the coefficients is therefore
                                 % necessary.
EGM96(EGM96(:, 1) < 100, :) = []; % Delete coefficients below degree 100
EGM96(:, 1:2) = []; % Delete information on degrees and orders
nmin = 100; % Specify the minimum degree of the coefficients
nmax = 360; % Specify the maximum degree of the coefficients

% Finally, save the harmonic band "100" ... "360" of the EGM96 model and
% variables "nmin" and "nmax"
GGM_path = '../data/output/EGM96_nmin100_nmax360.mat';
save(GGM_path, 'EGM96', 'nmin', 'nmax', '-v7.3');
```

Now define the rest of the GrafLab input parameters.

```
GM                  = 3986004.415E+8;
```

```
R                 = 6378136.3;
ellipsoid         = 1;
crd               = 1;
point_type        = 0;
lat_grd_min       = -90.0;
lat_grd_step      =   1.0;
lat_grd_max       =  90.0;
lon_grd_min       =   0.0;
lon_grd_step      =   1.0;
lon_grd_max       = 360.0;
h_grd             =   0.0;
out_path          = '../data/output/howto-g11-sliced';
quantity_or_error = 0;
quantity          = 5;
fnALFs            = 1;
export_data_txt   = 0;
export_report     = 1;
export_data_mat   = 1;
display_data      = 0;
status_bar        = 1;
```

Do the synthesis.

```
out_sliced = GrafLab('OK', ...
    GM, ...
    R, ...
    nmin, ...
    nmax, ...
    ellipsoid, ...
    GGM_path, ...
    crd, ...
    point_type, ...
    lat_grd_min, ...
    lat_grd_step, ...
    lat_grd_max, ...
    lon_grd_min, ...
    lon_grd_step, ...
    lon_grd_max, ...
    h_grd, ...
    [], ...
    [], ...
    [], ...
    [], ...
    out_path, ...
    quantity_or_error, ...
    quantity, ...
    fnALFs, ...
    [], ...
    export_data_txt, ...
    export_report, ...
    export_data_mat, ...
    display_data, ...
    [], ...
    [], ...
    [], ...
    [], ...
    status_bar);
```

Now let's do the same synthesis but this time with the original full "../data/input/EGM96.mat" model and compare the results with the previous synthesis.

```
GGM_path          = '../data/input/EGM96.mat';
out_path          = '../data/output/howto-g11-full';
```

Do the synthesis.

```
out_full = GrafLab('OK', ...
    GM, ...
    R, ...
    nmin, ...
    nmax, ...
    ellipsoid, ...
    GGM_path, ...
    crd, ...
    point_type, ...
    lat_grd_min, ...
    lat_grd_step, ...
    lat_grd_max, ...
    lon_grd_min, ...
    lon_grd_step, ...
    lon_grd_max, ...
    h_grd, ...
    [], ...
    [], ...
    [], ...
    [], ...
    out_path, ...
    quantity_or_error, ...
    quantity, ...
    fnALFs, ...
    [], ...
    export_data_txt, ...
    export_report, ...
    export_data_mat, ...
    display_data, ...
    [], ...
    [], ...
    [], ...
    [], ...
    status_bar);
```

Now compute the RMS between the two syntheses (should be below "10^-14" or so).

```
fprintf("RMS of the differences is ""%0.16e"".\n", rms(out_sliced(:, end) - ...
                                                        out_full(:, end)))
```