HOWTO g03: Minimum and maximum harmonic degree of the synthesis

You will learn how to modify the minimum and the maximum harmonic degrees of the synthesis.

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

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

Synthesis from degree 0 up to degree 10

Define the GrafLab input parameters.

```
GM                = 3986004.415E+8;
R                 = 6378136.3;
nmin              = 0;  % The minimum degree of the synthesis
nmax              = 10; % The maximum degree of the synthesis
ellipsoid         = 1;
GGM_path          = '../data/input/EGM96.mat';
crd               = 0;
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          = sprintf('../data/output/howto-g03-nmin%d-nmax%d', ...
                            nmin, nmax);
quantity_or_error = 0;
quantity          = 5;
fnALFs            = 1;
export_data_txt   = 1;
export_report     = 1;
export_data_mat   = 1;
display_data      = 0;
status_bar        = 1;
```

Do the synthesis

```
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);
```

Synthesis up to the maximum degree of a GGM

The maximum harmonic degree in "GGM_path" is 360. To synthesize up to this degree, you can manually set "nmax" to 360 or, even better, to 'nmaxGGM'. In the latter case, GrafLab scans the file for its maximum harmonic degree and automatically uses the maximum value it founds. This is useful when dealing with multiple GGM files with varying maximum harmonic degree, e.g., monthly gravity field solutions.

Update the GrafLab input parameters.

```
nmax     = 'nmaxGGM';  % Uses automatically the maximum degree of GGM
out_path = sprintf('../data/output/howto-g03-nmin%d-nmaxGGM', nmin);
```

Do the synthesis

```
out_grd = 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);
```

Synthesis up to maximum degree smaller than 2

GrafLab refuses to do a synthesis up to maximum degree that is smaller than 2. This is due to some unwise decisions made in the early months of the GrafLab development. Hopefully, this will be fixed one day. Until then, if you need "nmax" smaller than 2, there is a workaround:

- prepare a GGM file with coefficients up to degree at least 2,
- set all coefficients beyond your "nmax" (which is either 0 or 1) to zero, and
- do the synthesis at least up to "nmax = 2".

If is **not** recommended to do this kind of a trick

- for any quantity that involves the normal gravity field (the coefficient "C20_ell" of the normal field would be incorrectly subtracted), and
- for the gravitational and distubring tensor in the local north-oriented reference frame.

Synthesis with "nmin" larger than zero

In addition to modifying "nmax", you may also change the "nmin" value. "nmin" represents the minimum degree of the harmonic synthesis. For some gravity field quantities, GrafLab does not, however, allow non-zero "nmin" value. The quantities includes: 9, 10, 15, 20, 23 (see the code numbers for "quantity" from ../docs/graflab.md). If you attempt to evaluate these quantities with "nmin > 0", you will get an error. If you set "nmin" to a value larger than "nmax", you will get an error, too.

We simply increase "nmin" and modify the name of the output files.

```
nmin     = 100;  % Increase the minimum degree of the synthesis
out_path = sprintf('../data/output/howto-g03-nmin%d-nmaxGGM', nmin);
```

Do the synthesis.

```
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);
```