HOWTO g10: Commission error

You will learn how to compute commission errors from a full covariance matrix of spherical harmonic coefficients and how to avoid a common conceptual mistake when computing commission errors.

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

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

Computations of the commission error

The input ASCII file with the error variance-covariance matrix must have the structure as shown in Table 3. A binary MAT-file can also be imported. However, in this case, the empty arrays in Table 3 must be filled with zeroes or corresponding covariances.

Table 3: Structure of the error variance-covariance matrix: spherical harmonic coefficients sorted primarily according to orders; the column CS determines whether the variance and covariances in the particular line are related to the coefficient "Cnm" (if "CS"=0) or to the coefficient "Snm" (if "CS"=1)

```
----------------------------------------------------------------------------------------------------
CS  n   m   variances and covariances of the spherical harmonic coefficients
----------------------------------------------------------------------------------------------------
0   2   0   -4.31E-25
0   3   0   -2.11E-26-2.48E-25
0   2   1   -3.79E-28-1.15E-27-3.84E-25
1   2   1   -3.44E-28-4.67E-28-1.17E-27-4.16E-25
0   3   1   -1.99E-27-7.61E-29-2.98E-26-3.18E-28-2.48E-25
1   3   1   -1.44E-28-8.80E-29-3.42E-28-2.54E-26-3.16E-27-2.70E-25
0   2   2   -8.17E-27-1.72E-27-2.94E-28-3.67E-28-9.06E-29-1.08E-27 4.02E-25
1   2   2   -1.14E-27-2.94E-28-5.61E-29-3.86E-28-1.23E-27-1.50E-27-8.37E-28-4.25E-25
0   3   2   -9.38E-27-6.35E-27-1.08E-27-1.81E-27-7.12E-28-3.53E-28-3.30E-26-9.75E-29-3.07E-25
1   3   2   -1.27E-28-3.45E-27-1.59E-27-7.97E-28-1.75E-28-1.15E-28-5.51E-28-2.30E-26-2.78E-27-3.09E-2
0   3   3   -7.74E-28-1.36E-28-9.93E-27-5.50E-28-9.55E-28-3.25E-27-1.06E-27-8.60E-28-2.85E-29-1.58E-2
1   3   3   -1.14E-27-2.19E-28-4.51E-28-1.26E-26-1.46E-28-4.90E-27-1.25E-28-1.76E-28-1.18E-28-5.22E-2
----------------------------------------------------------------------------------------------------
```

Define the GrafLab input parameters.

```
GM                  = 3986004.415E+8;
R                   = 6378136.3;
nmin                = 2;  % Important, must be "2" or higher
nmax                = 30;
ellipsoid           = 1;
GGM_path            = '../data/input/GRIM5C1_covmat.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            = '../data/output/howto-g10-full';
```

```
quantity_or_error = 1;  % Important
quantity          = 5;
fnALFs            = 1;
export_data_txt   = 1;
export_report     = 1;
export_data_mat   = 1;
display_data      = 2;
graphic_format    = 6;
colormap          = 1;
number_of_colors  = 60;
dpi               = 300;
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, ...
    graphic_format, ...
    colormap, ...
    number_of_colors, ...
    dpi, ...
    status_bar);
```

You may now want to inspect the output files. Importantly, this particular covariance matrix "GGM_path" is not calibrated (scaled). As a result, the values of the commission errors are off by several orders of magnitudes. Nevertheless, the relative spatial relations are correct.

```
fprintf("The output files are ""%s*"".\n", out_path);
```

Common mistake

It is a common mistake to attempt to compute commission errors from a diagonal covariance matrix instead of the full covariance matrix. This is usually done by taking the standard deviations of spherical harmonic coefficients from "gfc" files. The "gfc" file, however, never contains the covariances, which, as will be shown in this example, are crucial to get meaningful commission errors.

Let's take the covariance matrix "GGM_path", load it, set all non-diagonal elements to zero and finally save it to a new file.

```
cm = load(GGM_path);
cm = cm.covmat;
cm(:, 4:end) = eye(size(cm(:, 4:end))) .* cm(:, 4:end);
save('../data/output/GRIM5C1_covmat_diag.mat', 'cm', '-v7.3');
```

Now let's repeat the same computation but with the new covariance matrix, this time having only the diagonal elements. Update the GrafLab input parameters.

```
GGM_path = '../data/output/GRIM5C1_covmat_diag.mat';
out_path = '../data/output/howto-g10-diag';
```

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, ...
    graphic_format, ...
    colormap, ...
    number_of_colors, ...
    dpi, ...
    status_bar);
```

Now compare the commission errors obtained with the full covariance matrix and with the diagonal elements only. It can be seen that the two maps have almost nothing in common. Moreover, it is not difficult to show that the diagonal covariance matrix leads to commission errors that are perfectly symmetric with respect to the equator, *regardless of the matrix elements*. Obviously, this is not at all realistic.

```
fprintf("The output files are ""%s*"".\n", out_path);
```