Advanced Gravity Field Modelling
Regionale Schwerefeldmodellierung

Exercise Sheet 1

Elaboration of:

Family name, first name	Student number
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If necessary 1. resubmission to	
If necessary 2. resubmission to	

Feedback for teachers:

Time required for processing	
Motivation; 1 (low) … 10 (high)	
Level of difficulty of the exercise; 1 (low) … 10 (high)	

Feedback for students:

Estimated time required for processing	1
Estimated level of difficulty of the exercise; 1 (low) … 10 (high)	2
Evaluation of "clean work"; 1 (scribble) … 10 (very clean)	
Technical correctness; 1 (low) … 10 (high)	
Scientific work; 1 (underdeveloped) … 10 (very pronounced)	5
Comment:	

Form of the elaboration

You have to submit a pdf-document, which is created based on this template and therefore contains the title page and feedback, the written elaboration of the exercise sheet and the exercise.

The name (pdf file) must be clearly defined, e.g.

LVLV_BlattNr_ii__nnnvvv.pdf.
LVLV: Name of the course
ii: consecutive number, is incremented within the semester
nnnvvv: first 3 letters of surname, followed by the first 3 letters of surname
Letters of the first name.

This elaboration should contain the description of the solution including necessary formulas and graphics. Finally, the results are to be discussed and analysed.

If calculation routines were created during processing, e.g. using MATLAB or Excel, these must also be uploaded to ILIAS.

Resubmission

A maximum of two resubmissions is possible per exercise sheet. Workouts cannot be accepted due to errors in content or for formal reasons. Formal reasons for resubmissions are:

- Late submission of the exercise sheet. If, for important reasons, it is not possible to process an exercise sheet within the scheduled time, this must be communicated to the trainer in good time.
- Incomplete processing of the exercise sheet. All subtasks and questions must be answered.
- Insufficient form of elaboration.

Feedback

Regular feedback is essential to improve teaching. Therefore, please complete the Feedback for Teachers section on the cover page of each exercise sheet.

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Karlsruher Institute of Technology (KIT)

Dr.-Ing. Kurt Seitz

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Exercise 1: Synthesis of the time variable geopotential model EIGEN-6S4

In this exercise, the time variable geopotential model EIGEN-6S4 is considered. This GPM contains an offset, trend, and periodical contributions to the coefficients up to degree and order n=80. Elaborate the following tasks:

1. Download the model EIGEN-6S4 from the ICGEM web-page https://icgem.gfz-potsdam.de/tom_longtime EIGEN-6S4 has a maximum degree of N=300. Coefficients up to degree and order n=80 are time dependent. Each of the time dependent coefficient is represented as:

$$f(t) = c_0 + c_1(t-t_0) + a_1 \sin\left(2\pi\frac{t-t_0}{P_1}\right) + b_1 \cos\left(2\pi\frac{t-t_0}{P_1}\right) + a_2 \sin\left(2\pi\frac{t-t_0}{P_2}\right) + b_2 \cos\left(2\pi\frac{t-t_0}{P_2}\right)$$

Ans. Please refer file:
D:\MSRSGI\Summer_Semester24\AdvancedGravityModelling\Exercises\Exercise1\DownloadedEIGEN_6S4\EIGEN-6S4.gfc

2. Create with the given m-files the coefficient set for the epoch:

a. t1 = 2012-Jan 1
Ans. Please refer file:
D:\MSRSGI\Summer_Semester24\AdvancedGravityModelling\Exercises\Exercise1\EIGEN6s4\EIGENt1.gfc

b. t2 = 2012-Feb 1
Ans. Please refer file:
D:\MSRSGI\Summer_Semester24\AdvancedGravityModelling\Exercises\Exercise1\EIGEN6s4\EIGENt2.gfc

c. t3 = 2024-Jan 1
Ans. Please refer file:
D:\MSRSGI\Summer_Semester24\AdvancedGravityModelling\Exercises\Exercise1\EIGEN6s4\EIGENt3.gfc

d. t4 = 2024-Feb 1
Ans. Please refer file:
D:\MSRSGI\Summer_Semester24\AdvancedGravityModelling\Exercises\Exercise1\EIGEN6s4\EIGENt4.gfc

3. Plot the degree variances of the difference set t2-t1 and t4-t3. m-file is provided

Ans.

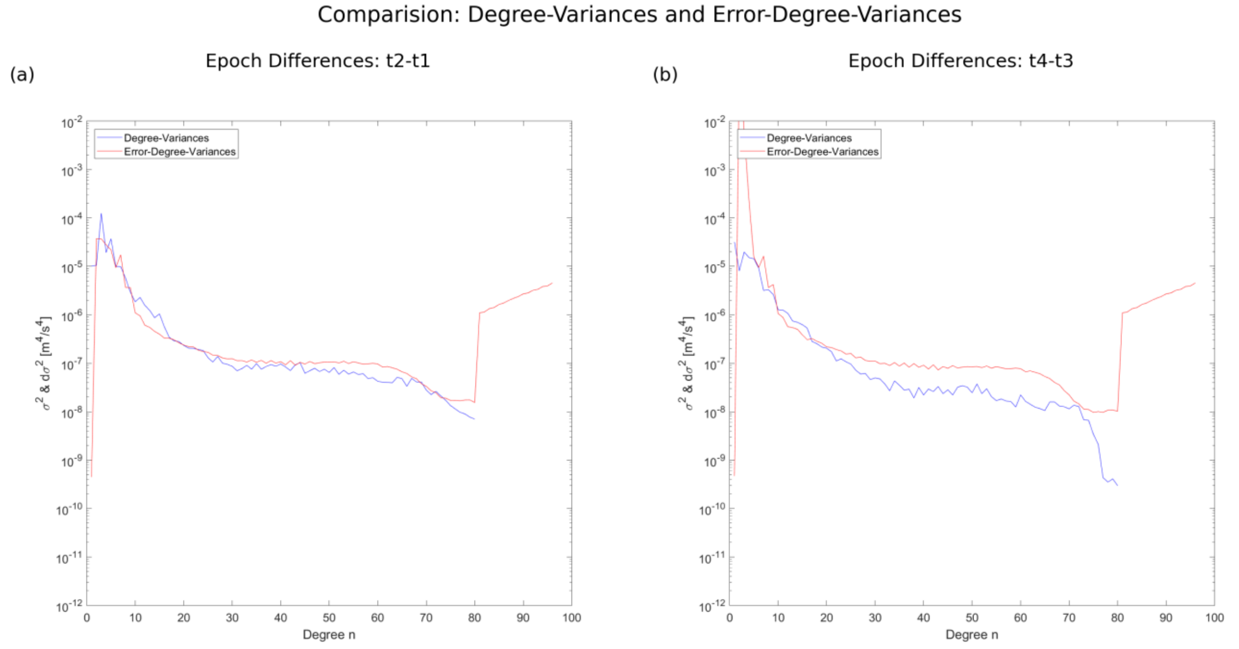

Figure 1: *Comparision of degree varaiances and error degree varaiance for the epoch differences of: t1 and t2 (a) and t2 and t3 (b). The blue line shows the degree-variances and red line shows the Error-Degree-Variances in both figures upto the degree 100. Units are* m^4 $s^{-4.}$

The degree variance change between the two-time epochs decreases up to degree n = 80, while the error-degree variance changes start to increase sharply after about around n = 80 for both the analyzed time windows: 2012 and 2024. Furthermore, the error degree variances for the second time window (January 2024) is more than that for the first time window (January 2012) at around degree of 10, but with the increase in the degree n, the behavior of both curves: degree variance and error degree variance shows somewhat the same behavior. This peaking of the error degree variance at the starting degree for the time frame 2024 may because we are computing the potential (or undulation) with respect to the epoch of 2050; but in case of plotting the potential in the first time frame (2012) we computed with respect to the epoch of 2013. So, the large time gap from the actual computed point and the reference epoch time must be responsible for such unusual behavior at the beginning of the degree at around 10 in the second time window.

4. Plot the potential change (globally) for January 2012 based on t2 and t1 and for January 2024 based on t4 and t3. m-file is provided.

Ans.

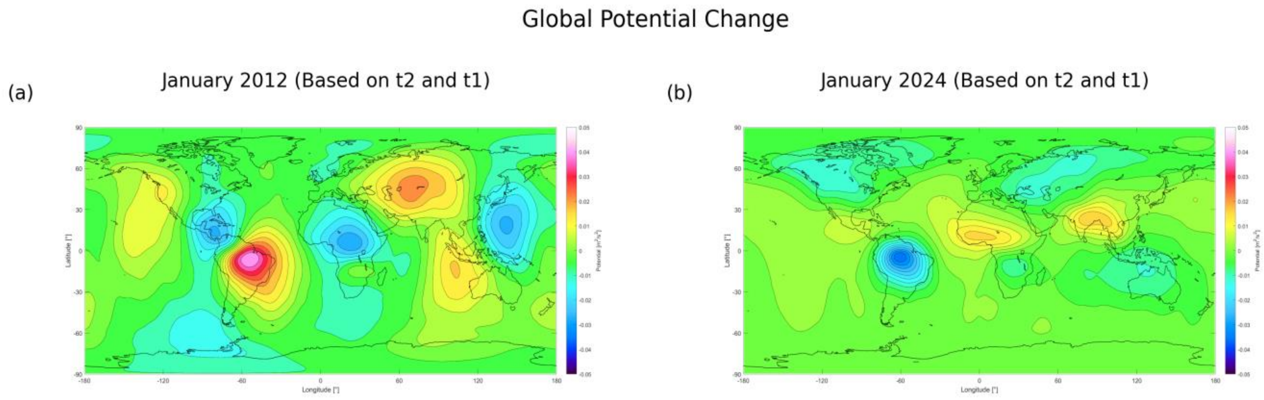

Figure 2: *Comparision of the Global Potential Change for the month of: January of 2012 based on t2 and t1 (a) and January of 2024 based on t4 and t3 (b). Units are* m^2/s^2.

5. Discuss your results.

Ans. The significant change in the geopotential values in South America around the equator in the Amazon Basin derived from the EIGEN-6S4(v2) model from approximately 0.01 to 0.005 m^2/s^2 for January 2012 (based on the epochs: 2012 Jan 1 and 2012 Feb. 1) to the negative geopotential (-0.005 to -0.001 m^2/s^2) values in January 2024 (based on the epochs: 2024 Jan 1 and 2024 Feb. 1) in just 12 years indicate the extreme drought in the Amazon Basin which is in agreement with (Gschwind et al., 2024). Furthermore, the evidence that the Amazon Basin had experienced extreme drought is also supported by the plot of the undulation, shown in Figure 3, derived from the same model considering the same time epochs.

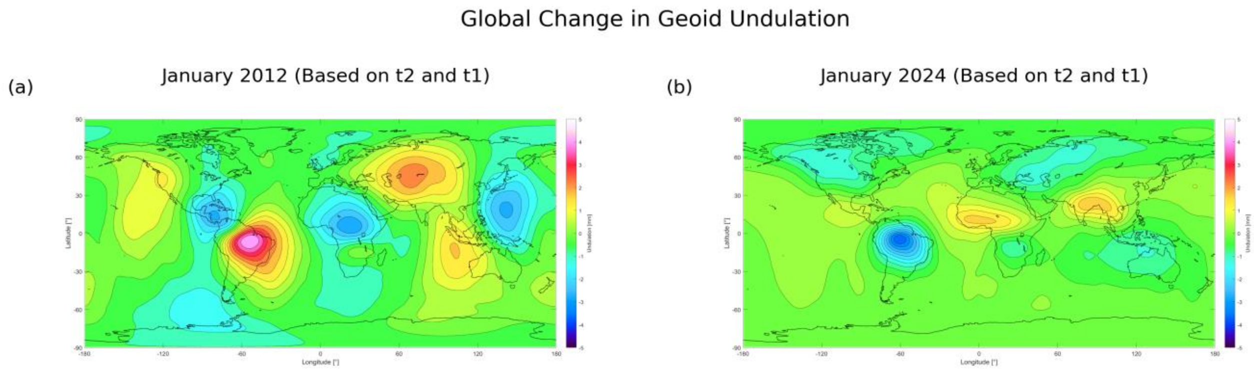

Figure 3: *Comparision of the Global Change in Geoid Undulation for the month of: January of 2012 based on t2 and t1 (a) and January of 2024 based on t4 and t3 (b). Units: mm*

It is clear from Figure 3, that the differences in geiod undulation for January 2024 are on average lower than for January 2012 for the Amazon Basin and vary symmetrically around zero. This decrease in geoid undulation values signifies the decrease in Total Water Storage (TWS) in the basin, which results from the effect of El Niño —the region has experienced in connection with the warming of the tropical Atlantic, progressive loss of forests in the Amazon intensifying the drought conditions, and many other anthropogenic factors.

References

Gschwind, C., Seitz, K., Dalheimer, L., Duckstein, A., & Kutterer, H. (2024). A comparative study on the parametrization of a time-variable geopotential model from GRACE monthly solutions. In *Acta Geodaetica et Geophysica* (Issue 0123456789). Springer International Publishing. https://doi.org/10.1007/s40328-024-00446-x