

## Assignment 1 – Estimating sea-level trend using least-squares

### *Instructor*

Dr.ir. Wouter van der Wal

w.vanderwal@tudelft.nl

office: 9.02

phone: 015-2782086

**Group Size: 1 or 2 Students**

**Due: 17:30h, Tuesday 18 September, 2018**

**Estimated time: 10 hours per person**

Please read the section 'Rules for assignments' on Brightspace.

### 1. Parameter fitting (points: 100)

Global sea level is measured by altimetry satellites such as ERS, Envisat, Jason and Topex/Poseidon. The raw data is processed by many institutes, among others TU Delft (<http://rads.tudelft.nl/rads/rads.shtml>).

From the large number of sea level measurements taken at different locations and at different times a global mean sea level is estimated. On the following website you can download the data for this assignment:

<https://sealevel.nasa.gov/understanding-sea-level/key-indicators/global-mean-sea-level>



After downloading, only keep the part of the file that you need. You can then simply read the data in Matlab using the command `load('filename')`.

Refer to section 8.3.2 and 8.5 of the lecture notes for the theory.

- Estimate the sea-level trend and bias using least-squares and plot the data and your estimated trend. Write your own code for the least-squares estimation. **(10)**
- Do the same as for a) but simultaneously estimate a signal with a period of 1 year. Hint: use a combination of a sine and a cosine function. Explain in the report why it makes

sense to estimate a yearly signal in sea level data, and explain if and why the estimated trend differs from a). **(15)**

- c) Find out if the residuals are normally distributed. Explain your test and the conclusions in the report. **(10)**
- d) Do the same as b) and c) but now include an acceleration term. Explain if and why the estimated trend and the residuals differ from your answers to b) and c). **(10)**

Continue with your estimate of d) for the following questions.

- e) Explain conceptually what the differences are between residuals and true errors **(10)**.
- f) Estimate the standard deviation of the trend estimate. You can now assume that standard deviation of the measurements (measurement error) can be computed from the residuals as follows:

$$\sigma_l = \frac{\bar{\epsilon}\bar{\epsilon}^T}{m - n}$$

For the symbols see section 8.5 of the lecture notes. In the report, give the equation and describe what each symbol represents and comment on the value of the standard deviation. **(15)**

- g) Explain what the off-diagonal terms of the parameter covariance matrix represent **(10)**
- h) Explain if you expect that the sea level data you downloaded contain other physical signals except a bias, trend, acceleration and a yearly signal. Describe how you can test this with the data you have. **(10)**
- i) Mention four different error sources that affect the global mean sea level estimate derived from a satellite altimeter, assuming that we are interested in the climate-related sea level rise. **(10)**
- j) Please write in the beginning of your report how many hours you approximately spent on the assignment per person.