Summer 2020 Kiel University
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Computer Science in Ocean and Climate Research

Exercise 1

Homework: (until the exercise on April 14th)

Implement (in your favorite programming language) the following time simulation algorithm for a climate model

$$\left.\begin{array}{rcl} y_{k+1} & = & y_k + \Delta t f(y_k, t_k), \\ t_{k+1} & = & t_k + \Delta t \end{array}\right\}, k = 0, \ldots, n-1, \Delta t := \frac{T}{n}.$$

Here, f should be the *Energy Balance Model* (see lecture)

$$\dot{y}(t) = c_1 S(1-\alpha) - c_2 y(t)^4 =: f(y(t), t),$$

$t_0 = 0$ the initial and T the end time, y_0 an arbitrary, but positive initial value for the temperature, and $N \in \mathbb{N}$ the number of time steps used in the time interval $[0, T]$.

1. Use the parameters

   $$c_1 = \frac{1}{4C}, c_2 = \frac{\sigma\epsilon}{C}$$

   with

   - the thermal coupling constant $C = 9.96 \times 10^6$,
   - the emissivity $\epsilon = 0.62$ (corresponding to the fact that a part of the outgoing radiation is hold back in the atmosphere due to the greenhouse effect),
   - the Boltzmann constant $\sigma = 5.67 \times 10^{-8}$
   - the solar constant $S = 1367$,
   - and the albedo $\alpha = 0.3$.

   Here we omitted all physical units in the parameters. Use $t_0 = 0$ for some $T > 0$ and $n \in \mathbb{N}_{>0}$.

2. Visualize the resulting temperature over time.

3. Vary the initial value y_0 and the number n of the used time steps.

4. How can you modularize your code?