Summer 2020 Kiel University
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Computer Science in Ocean and Climate Research

Exercise 2

Tutorial :
Develop a concept for a software framework that can compute an approximate solution of an initial value problem (IVP) for a system of ordinary differential equations (ODEs) on a given time interval,

$$\begin{aligned} \dot{y}(t) &= f(y(t),t), \quad t \in [t_0, T], \\ y(t_0) &= y_0, \end{aligned} \tag{1}$$

with $y_0, y(t) \in \mathbb{R}^d$, $f : \mathbb{R}^d \times \mathbb{R} \to \mathbb{R}^d$, $t_0, T \in \mathbb{R}, 0 \leq t_0 < T$.
The software framework shall realize the typical structure of a climate model

$$\left.\begin{array}{rcl} y_{k+1} & = & y_k + \Delta t \Phi(t_k, y_k, f, \Delta t), \\ t_{k+1} & = & t_k + \Delta t \end{array}\right\}, k = 0, \ldots, n-1, \quad \Delta t := \frac{T - t_0}{n}, \tag{2}$$

and have the following features:

1. Φ shall be an arbitrary function (the *time integrator*).
2. The *model function* f in (1) shall be arbitrary and passed as argument to Φ.
3. It shall offer the option to be dependent on additional parameters p that are passed as arguments (no global variables).
4. The whole time loop (2) shall be realized in one function that itself gets the time integrator Φ and f as arguments.
5. The dimension of $y(t)$ in (1) and thus the one of y_k in (2) shall be arbitrary.
6. All necessary parameters $t_0, T, y_0, p, \Delta t$ shall be passed as arguments to the functions. No parameters should be fixed inside the functions.

Home: (until April 28th)

1. Realize the above software framework in some programming language.
2. Use it to simulate the Energy Balance Model (see lecture)
3. ... and the predator-prey model see (see lecture).
4. ... with the two different time-integrators (see lecture).
5. Visualize the results.