Department of Mathematics and Informatics
University of Cologne
Prof. Dr. Gregor Gassner

April 2, 2026

An Introduction to Climate Modeling

Milestone 1 - Geography and Visualization

1 Read-in and Plot Geography

In this milestone, the goal is to read-in the geography information of planet Earth and plot it as a two-dimensional world map. We consider an equirectangular grid of the Earth, i.e., an equidistant rectangular grid in spherical coordinates, where the grid point (i, j) has the spherical coordinates (θ_i, φ_j), where θ_i is the latitude between $-90°$ south and $90°$ north (including the poles) and φ_j the longitude between $-180°$ west and $180°$ east. The basis for this is the input file `The_World128x65.dat`, which describes the distribution of the different Earth surface types. This file contains a matrix $G \in \mathbb{N}^{65\times128}$ with entries $g_{ij} \in \{1, 2, 3, 5\}$, where the entry g_{ij} stores the Earth surface type at grid point (i, j). Here, 1 represents the Earth surface type *land*, 2 represents *sea ice*, 3 represents *snow*, and 5 represents *ocean*. The grid resolution in longitude and latitude direction is $2.8125°$. The basis for this distribution and grid is from Zhuang et al.[1] You can proceed as follows:

1. Write a function `read_geography`, which reads the file `The_World128x65.dat` from the folder `input` and outputs a matrix $T \in \mathbb{N}^{65\times128}$ with the classification of the earth surface types.
2. Write a function `robinson_projection`, which maps an equirectangular grid in spherical coordinates to the plane. For simplicity use the approximate formula by Beineke for the Robinson projection,

$$x(\theta, \varphi) = \frac{\varphi}{\pi}\left(0.0379\,\theta^6 - 0.15\,\theta^4 - 0.367\,\theta^2 + 2.666\right),$$
$$y(\theta, \varphi) = 0.96047\,\theta - 0.00857\,\mathrm{sign}(\theta)\,|\theta|^{6.41},$$

   where φ is the longitude and θ the latitude in radians. This function should return two matrices $X = x_{ij}$ and $Y = y_{ij}$, where $x_{ij} = x(\theta_i, \varphi_j), y_{ij} = y(\theta_i, \varphi_j)$.

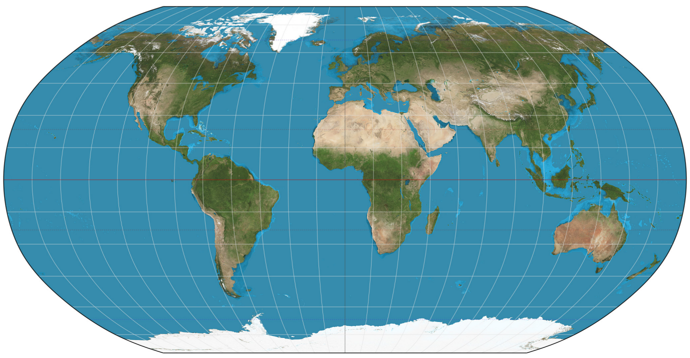

Figure 1: Robinson projection of the world [2]

3. Write a function `plot_geo` that creates a plot of the Earth surface type g_{ij} against the mapped coordinates (x_{ij}, y_{ij}).
4. Use these functions in a program and run it to check your results.

2 Control Solutions

[1] K. Zhuang, G.R. North, M.J. Stevens, *A NetCDF version of the two-dimensional energy balance model based on the full multigrid algorithm*, SoftwareX, Vol. 6, pp. 198-202, July 7, 2017.
[2] Daniel R. Strebe, `https://en.wikipedia.org/wiki/File:Robinson_projection_SW.jpg`

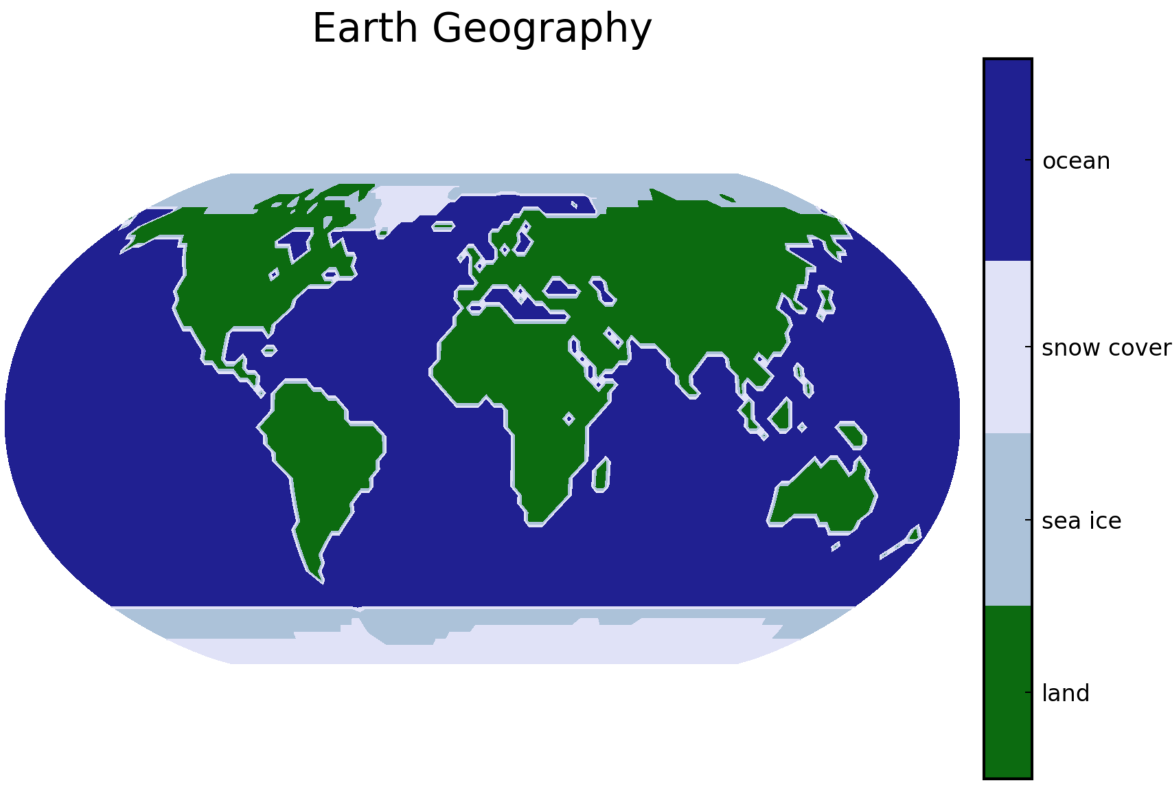

Figure 2: Robinson projection output