Simulation models of geopolitical and migration interactions

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Megastore and global evolution

Cliodynamics

Cliodynamics – a new interdisciplinary area of research, which includes:

historical macrosociology,

theoretical history,

mathematical and computer modeling,

historical databases

the study of social evolution,

historical demography

etc.

Background

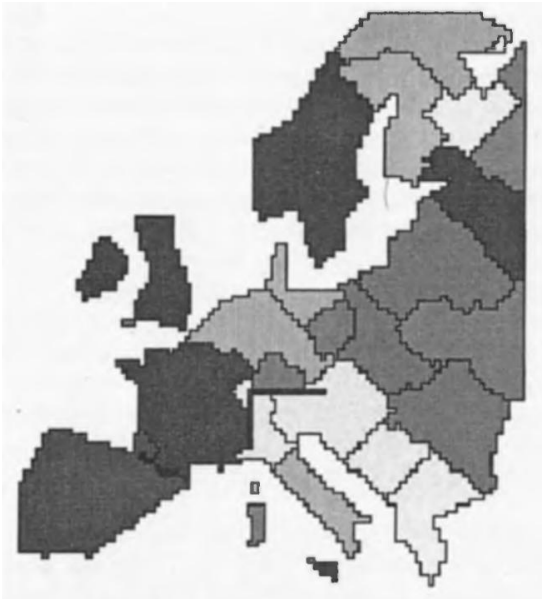
Spatial simulation models

- The model of territorial dynamics (Arzruni, Comes).
- Model for agrarian societies (A. S. Mal'kov, G. G. Malinetskii, D. S. Chernavsky);
- A model of the dynamics of trade flows of the Great silk road (The same);
- The model of inter-ethnic borderland (Peter Turchin);
- The model of the influence of interaction between the civilization center and the barbarian periphery (A. V. Korotayev, Leonid E. Grinin);
- The model of cultural and social evolution of the societies of the Old world (P. Turchin, S. Gavrilets)

Background: spatial Simulation models

The model of territorial dynamics

The map 500 year



Map predicted by the model for 1800

Territorial dynamics of the European system of States, Artsruni and Komlos (1996).
The bold lines indicate the location of the Pyrenees and the Alps

Background: spatial Simulation models

Model for agrarian societies

Qualitative results of the spatial modelling system for ethnic dynamics in Europe

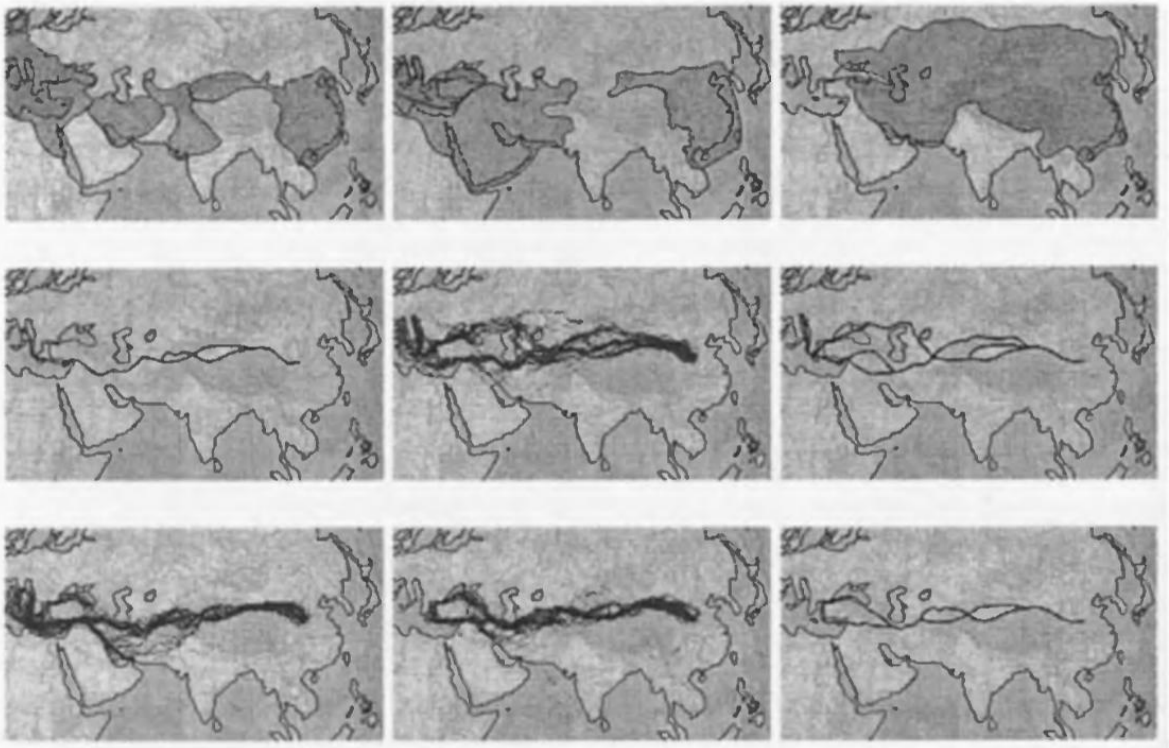
Background: spatial Simulation models

A model of the dynamics of trade flows of the Great silk road

a)

b)

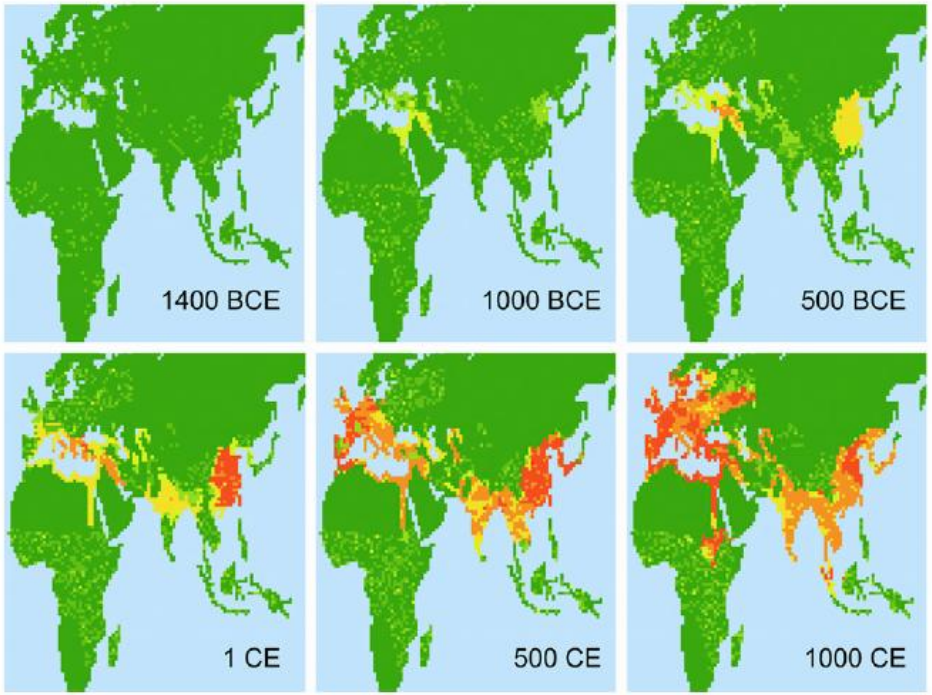
c)



The dynamics of the silk road in different epochs: a) a large Empire, b) historical actual data, b) simulation results

Background: spatial Simulation models

The model of cultural and social evolution of Old world societies



A single realization of model dynamics of density ultrasociality

The proposed spatial simulation models

Objectives and methodology

Goal # 1 – to build a spatial simulation model of geopolitical interaction, taking into account geographical features of the landscape

Goal # 2 – to build a spatial simulation model of migration and demographic dynamics taking into account geographical features of the landscape and fertility

The method is to build program code in MATLAB

The proposed spatial simulation models

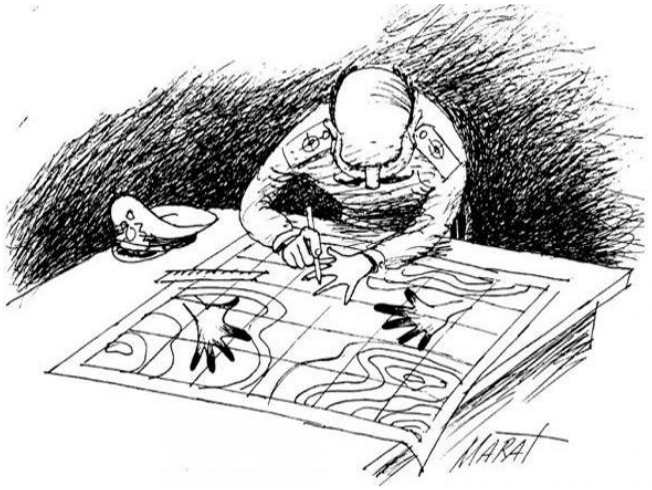
Methodology

Goal # 3 – to test the developed model on the empirical data of specific time periods

Method – data collection:

- on territorial dynamics (The Centennia Historical Atlas 3.1)
- on demographic dynamics (MeEvedy C., Jones R. Atlas of World Population History)

The proposed spatial simulation models



The model of geopolitical interactions

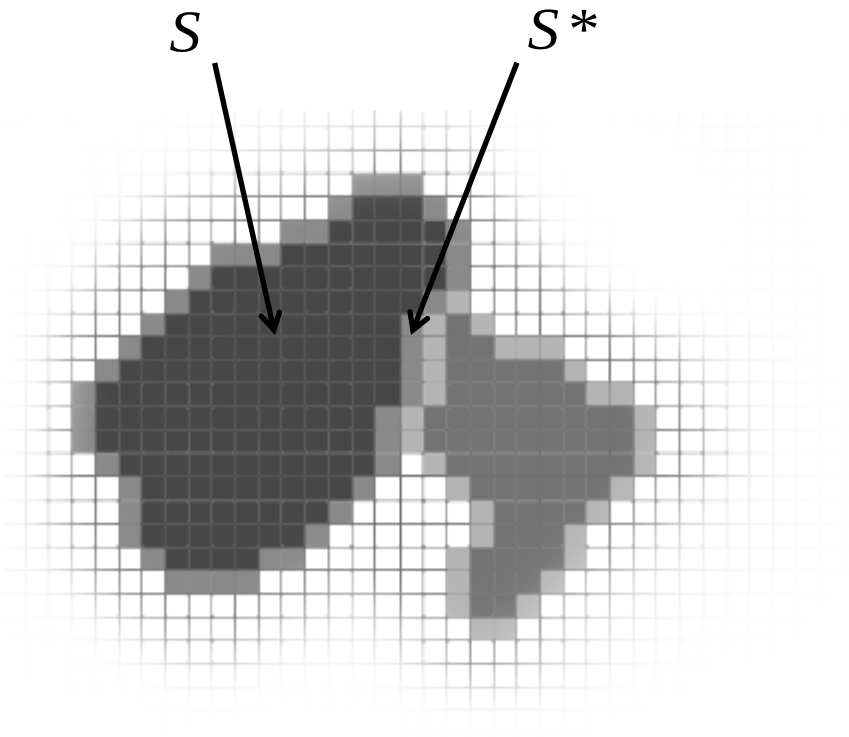
Simulation model of geopolitical interactions

1. Theoretical principles

$$S_{t+1} = S_t - \delta S_t$$

$$S^*_{t+1} = S_t + r_0 S_t (1 - S_t)$$

$$\overline{S_{i,t}} = \frac{\sum_{\{x,y\} \in i} S_{x,y,t}}{A_{i,t}}$$

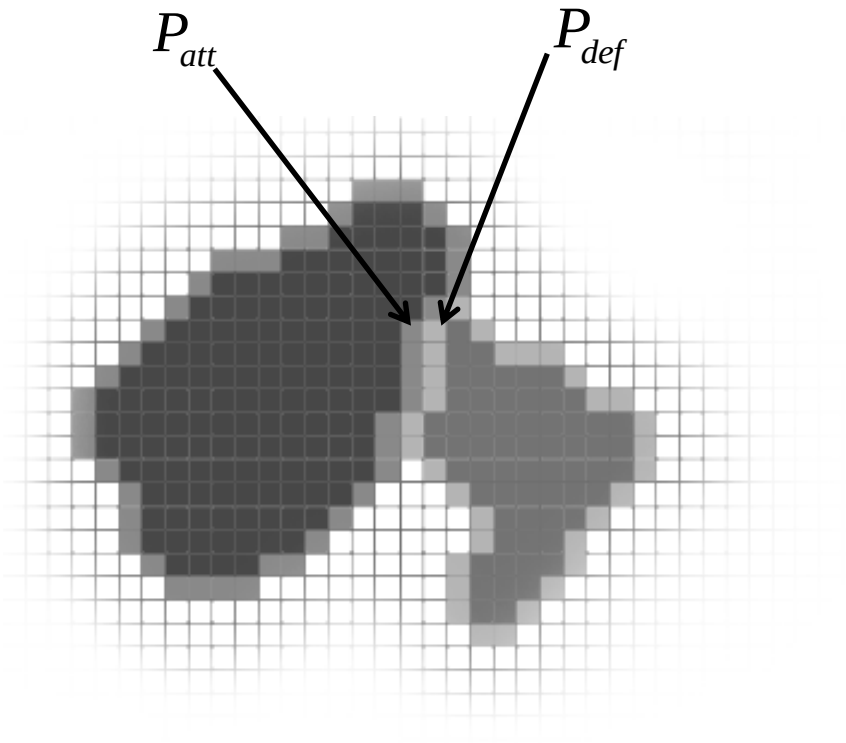


Simulation model of geopolitical interactions

1. Theoretical principles

$$P = A\overline{S}e^{-\frac{d}{h}} + rR$$

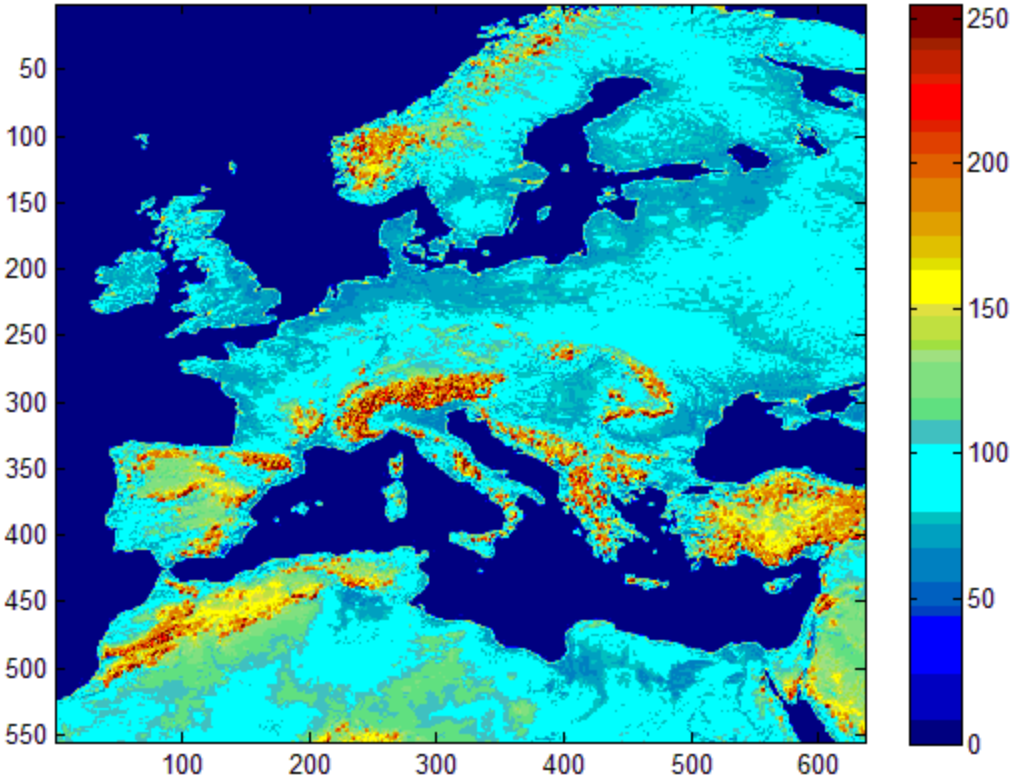
$$\left|P_{att} - P_{def}\right| > \Delta P$$



Simulation model of geopolitical interactions

2. Preparatory materials

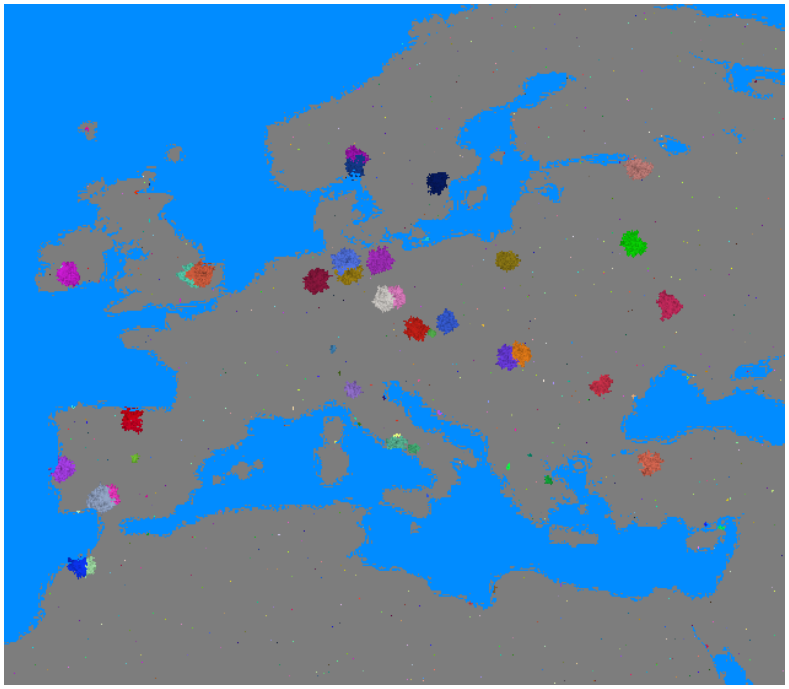
R



Relief map of Europe

Simulation model of geopolitical interactions

3. Implementation of the model

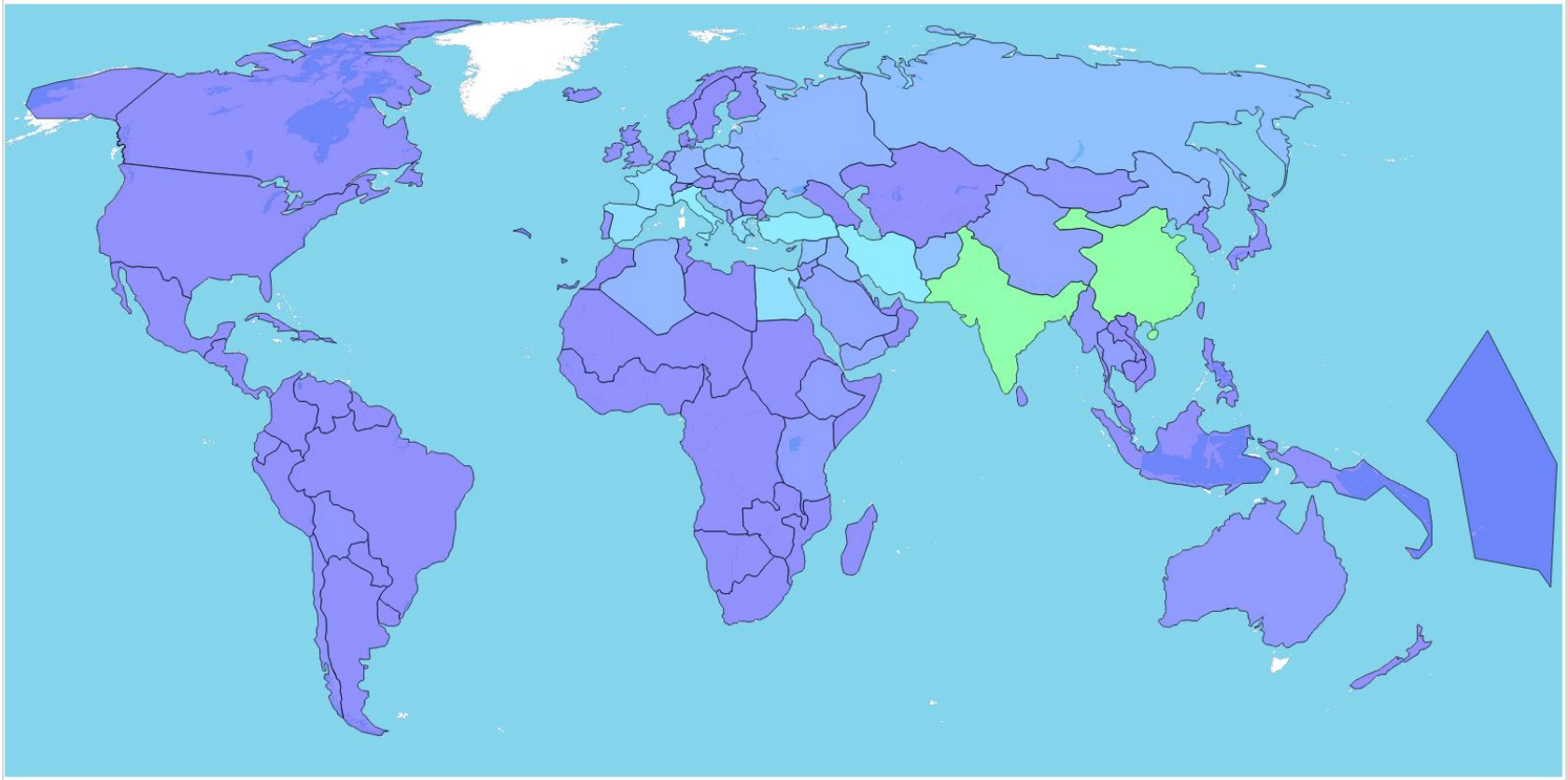


The proposed spatial simulation models

Model migration interactions

Simulation model of the migration interactions

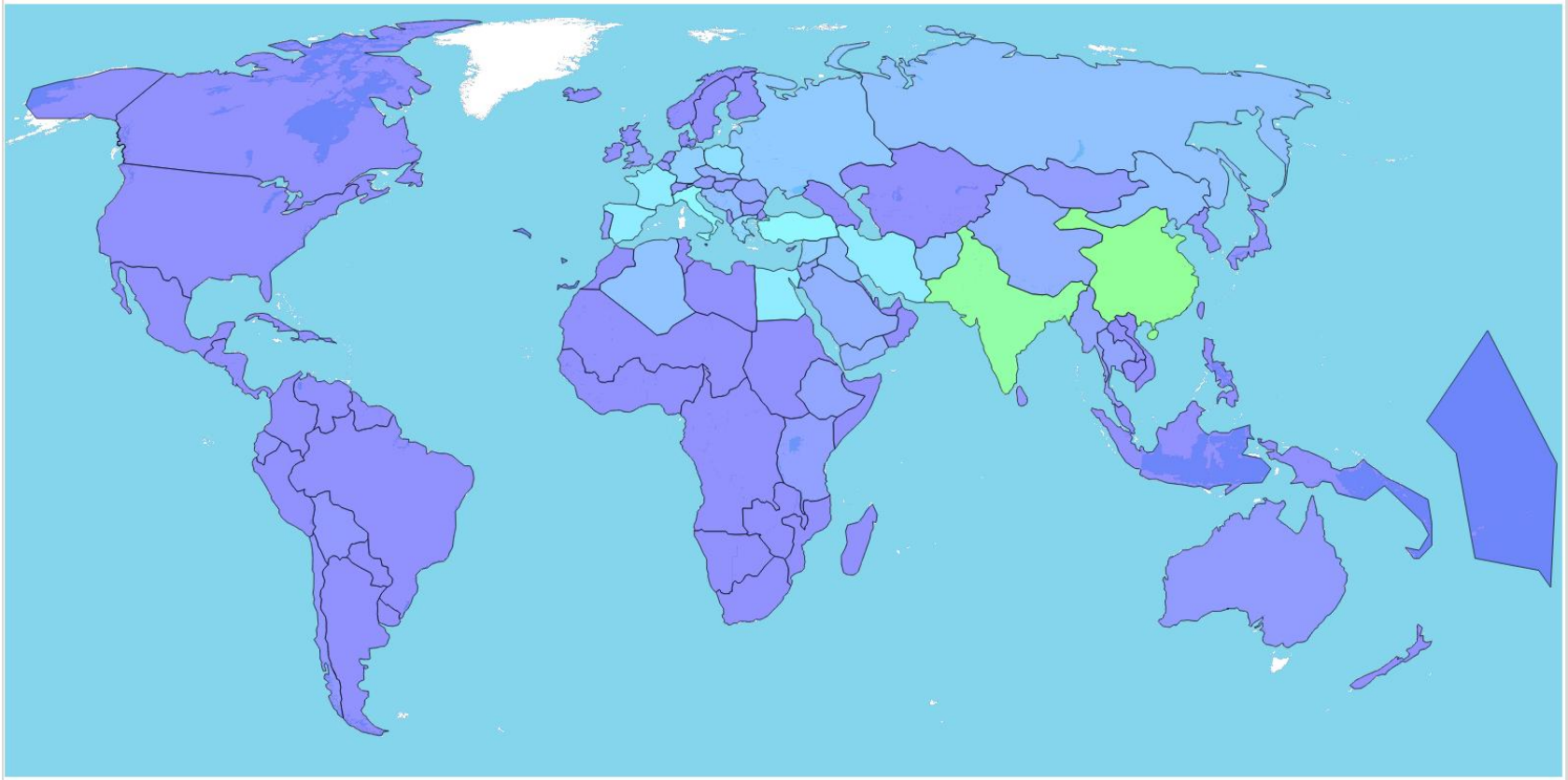
1. Empirical data



Map of world population in 400 B.C.

Simulation model of the migration interactions

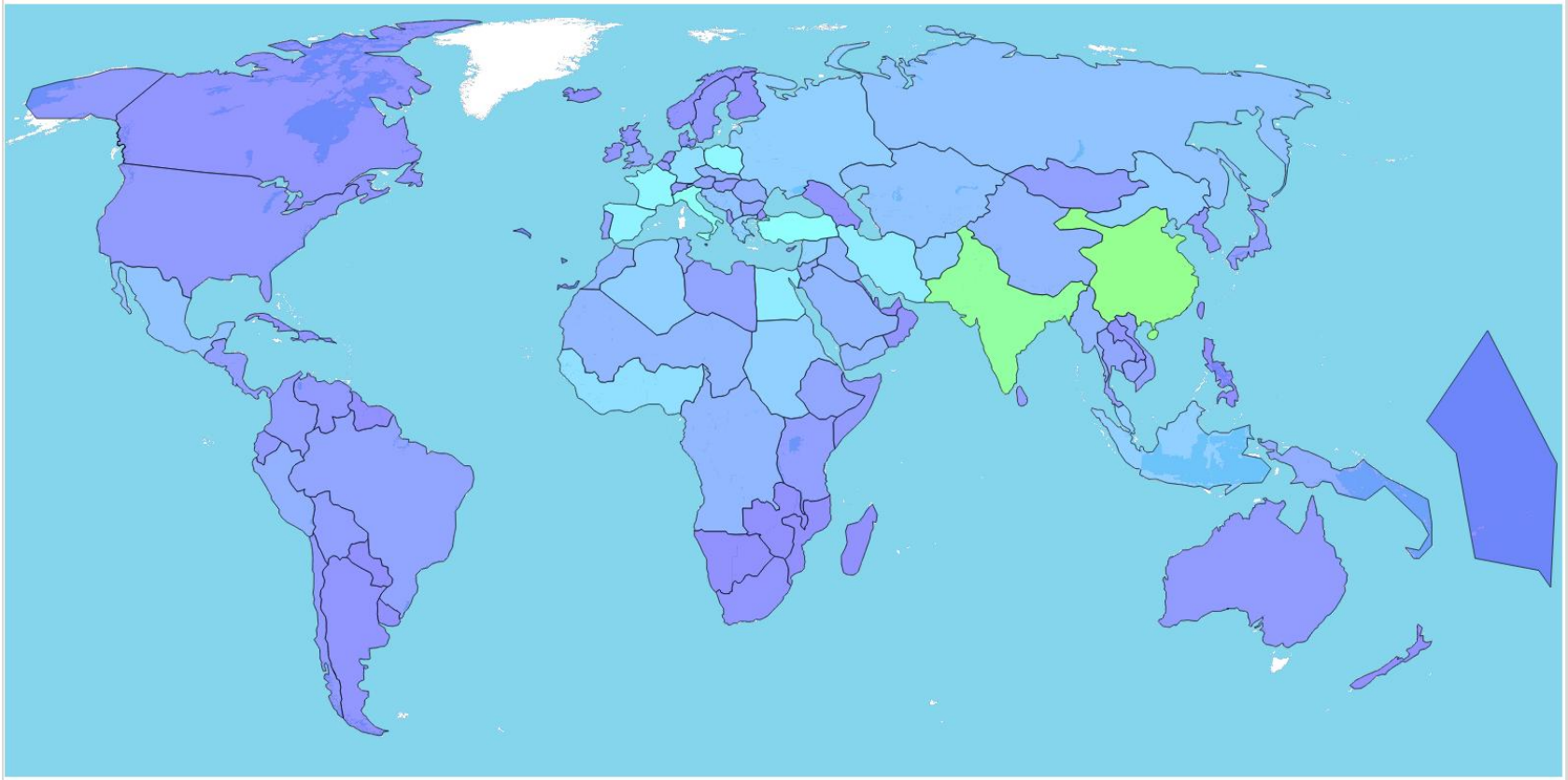
1. Empirical data



Map of world population in 200 B.C.

Simulation model of the migration interactions

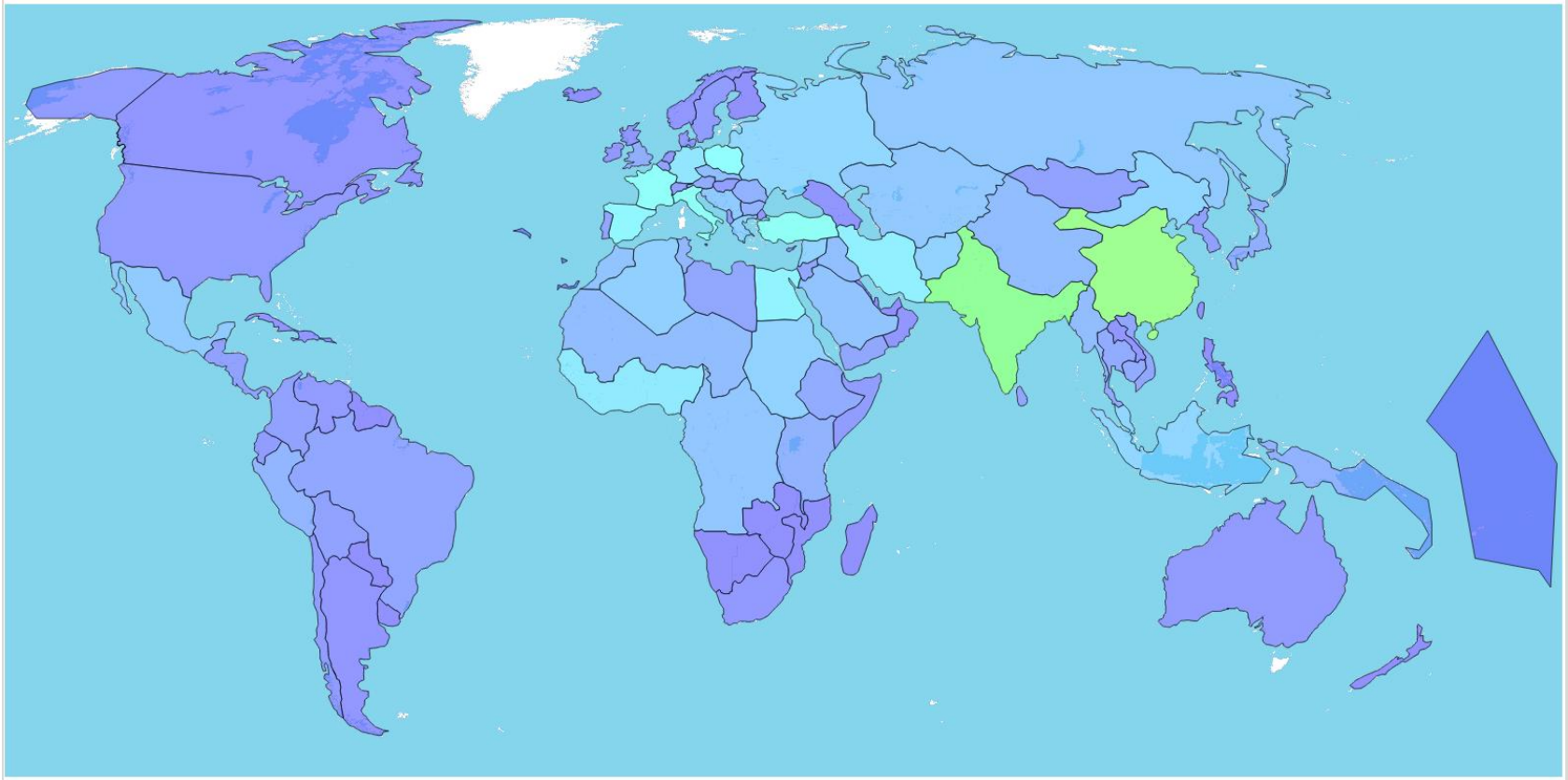
1. Empirical data



Map of world population in 0

Simulation model of the migration interactions

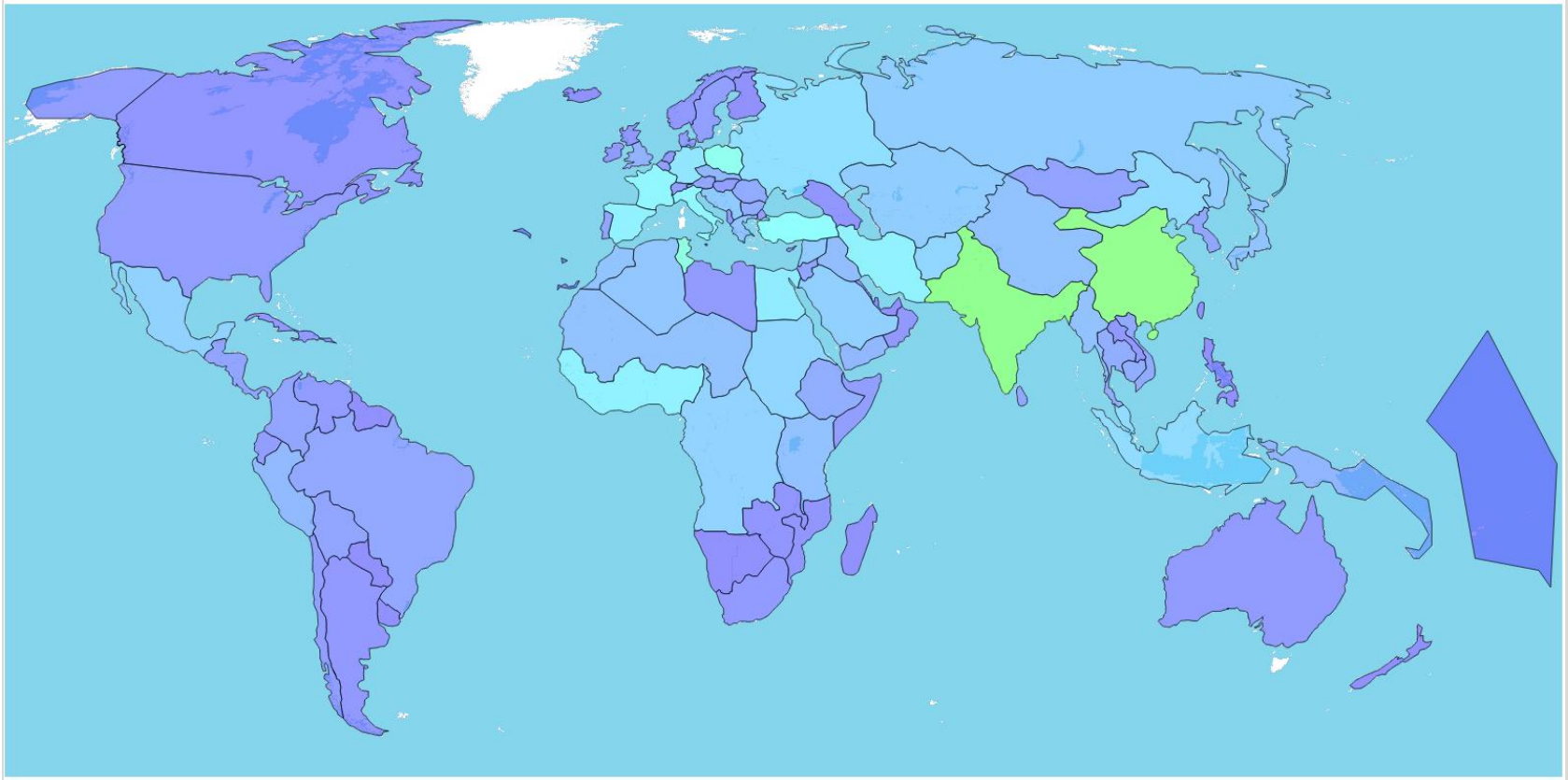
1. Empirical data



Map of world population in 200

Simulation model of the migration interactions

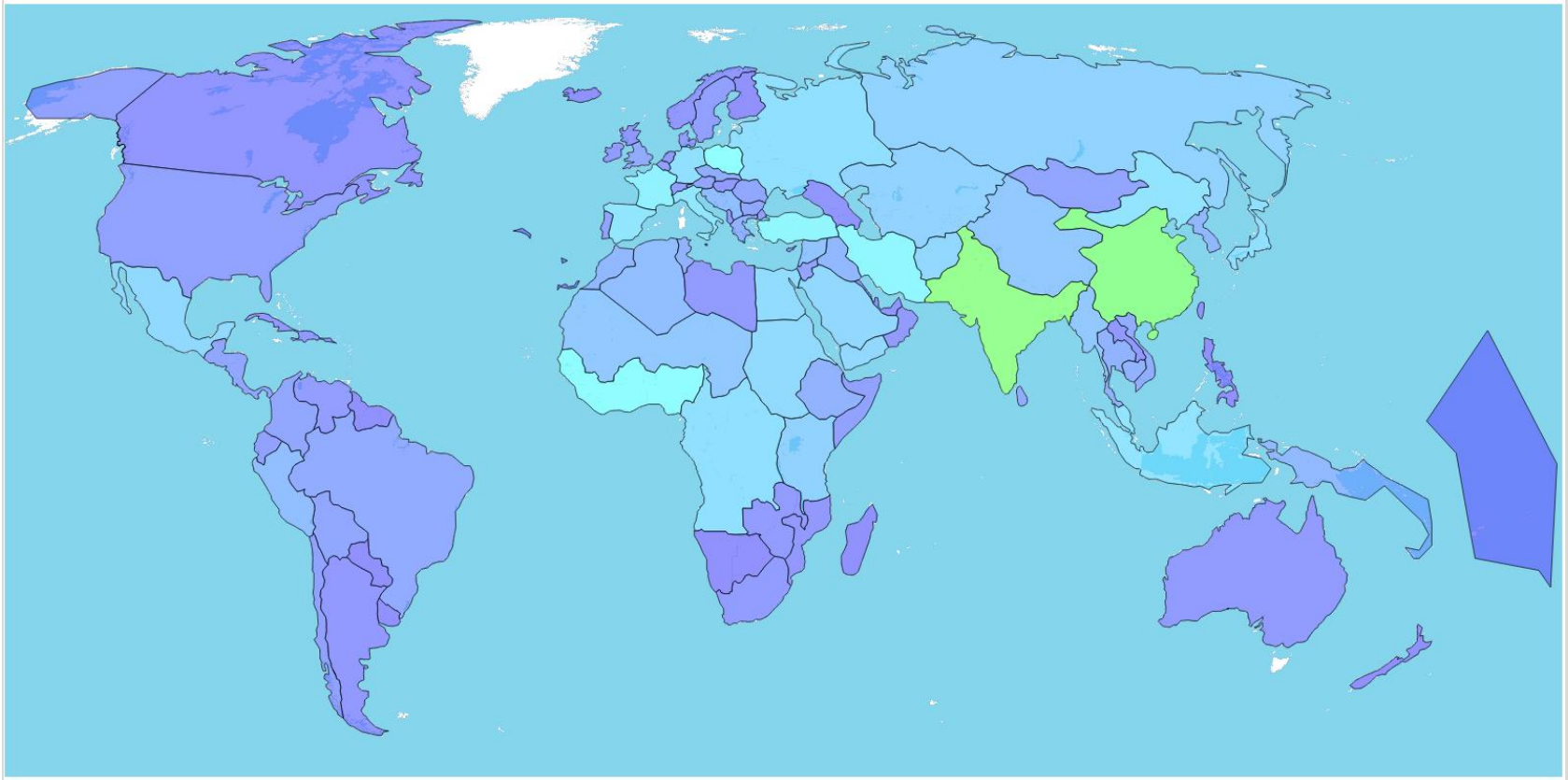
1. Empirical data



Map of world population in 400

Simulation model of the migration interactions

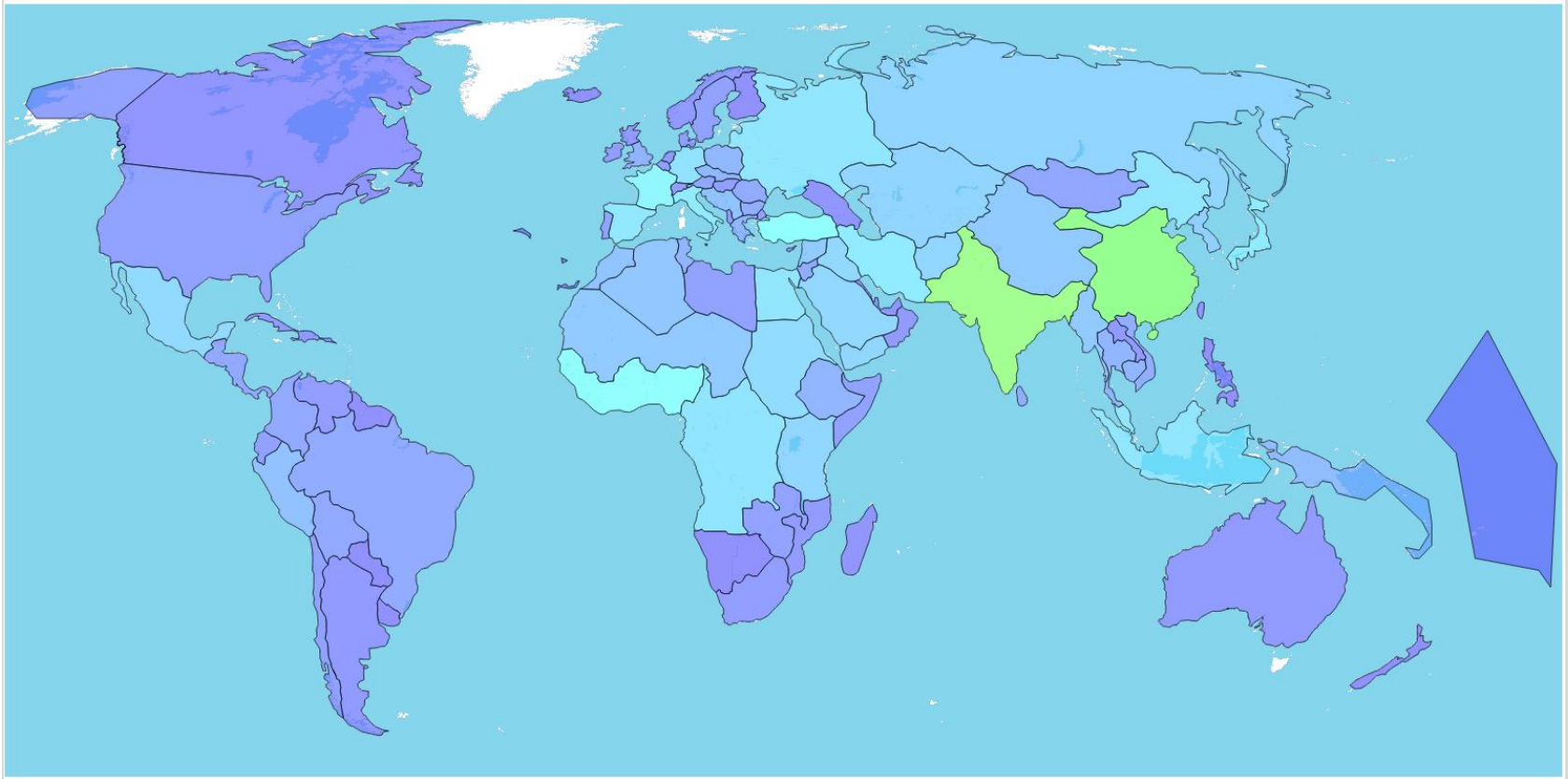
1. Empirical data



Map of world population in 600

Simulation model of the migration interactions

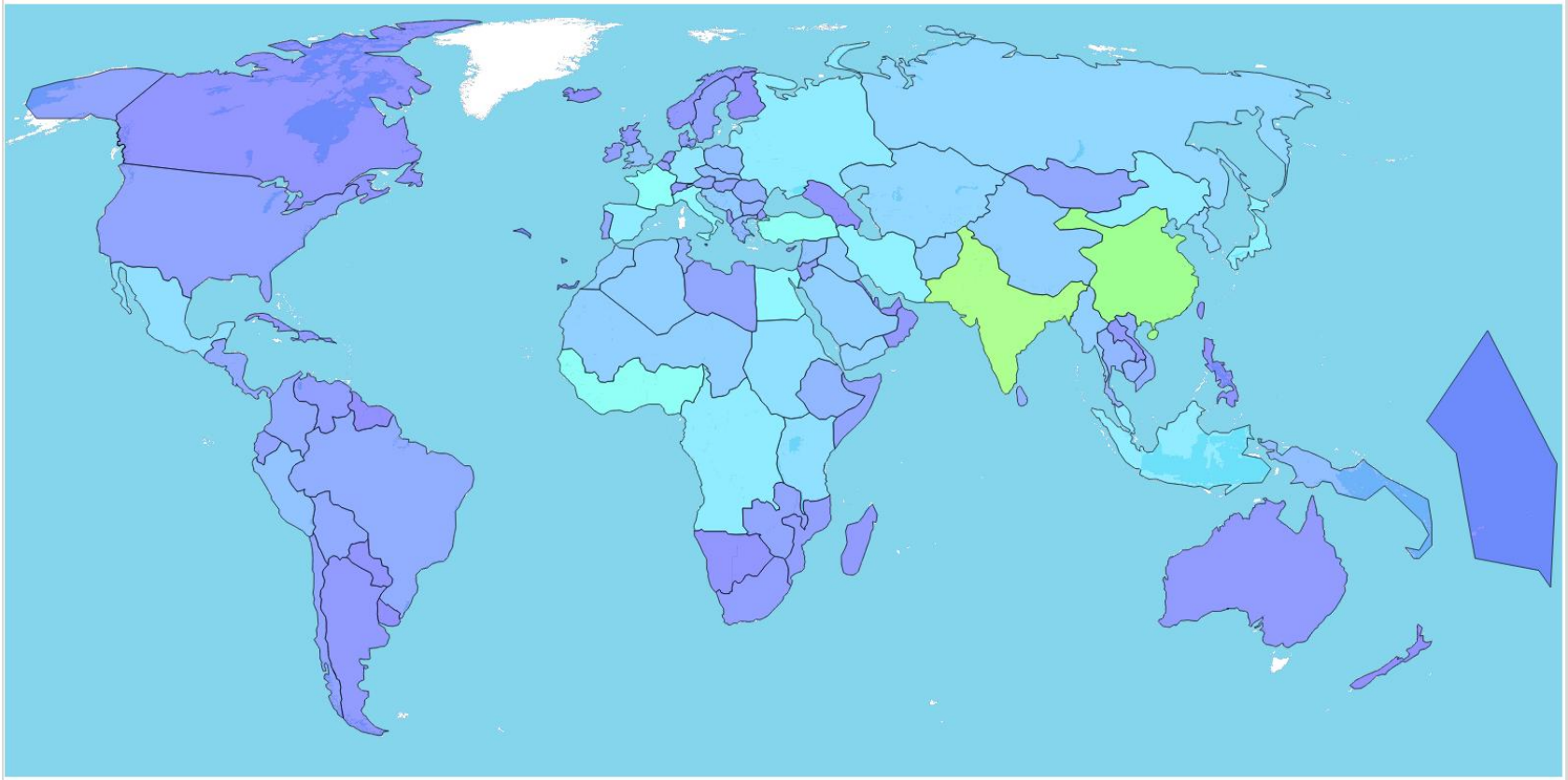
1. Empirical data



Map of world population in 800

Simulation model of the migration interactions

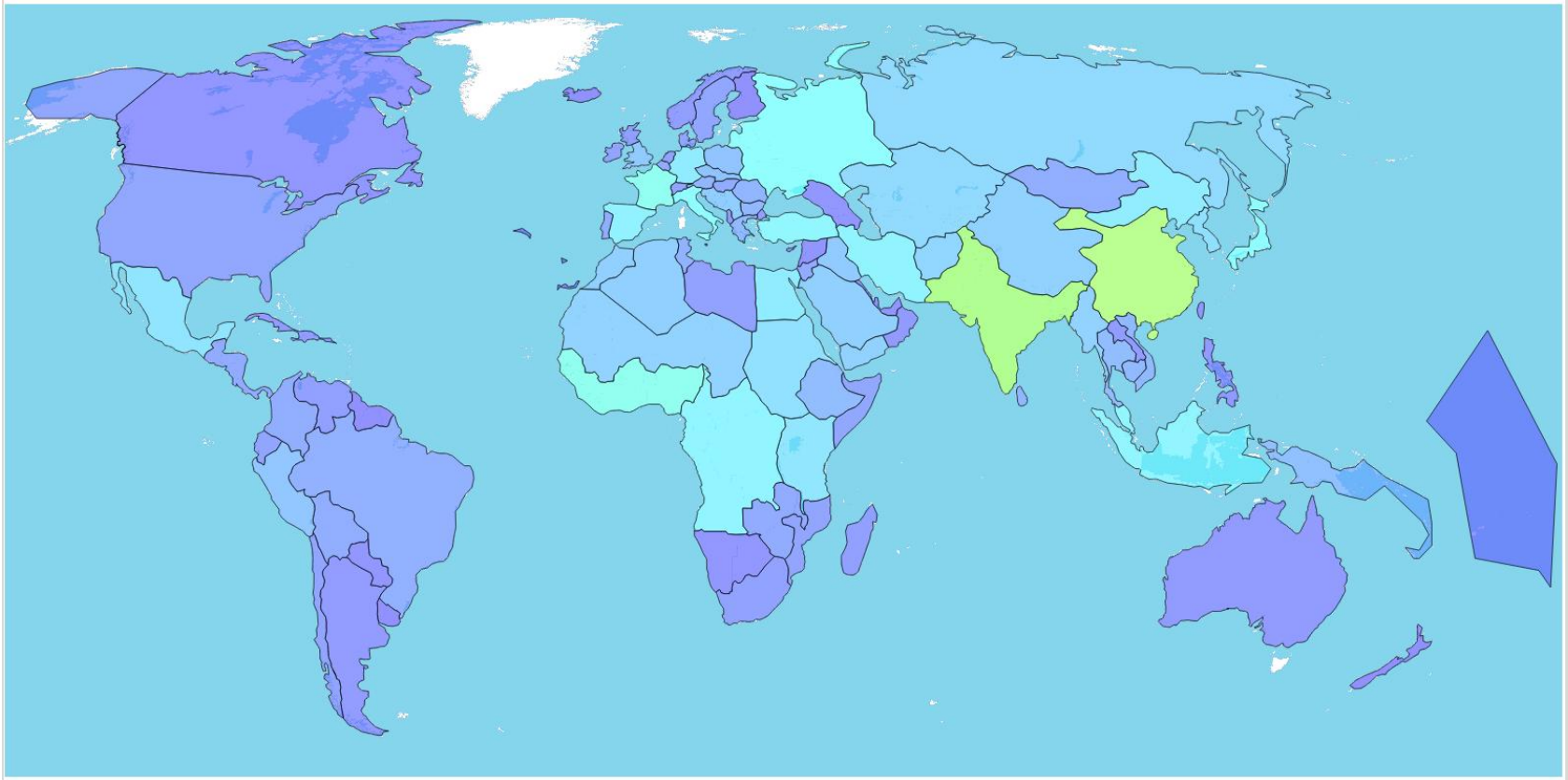
1. Empirical data



Map of world population in 1000

Simulation model of the migration interactions

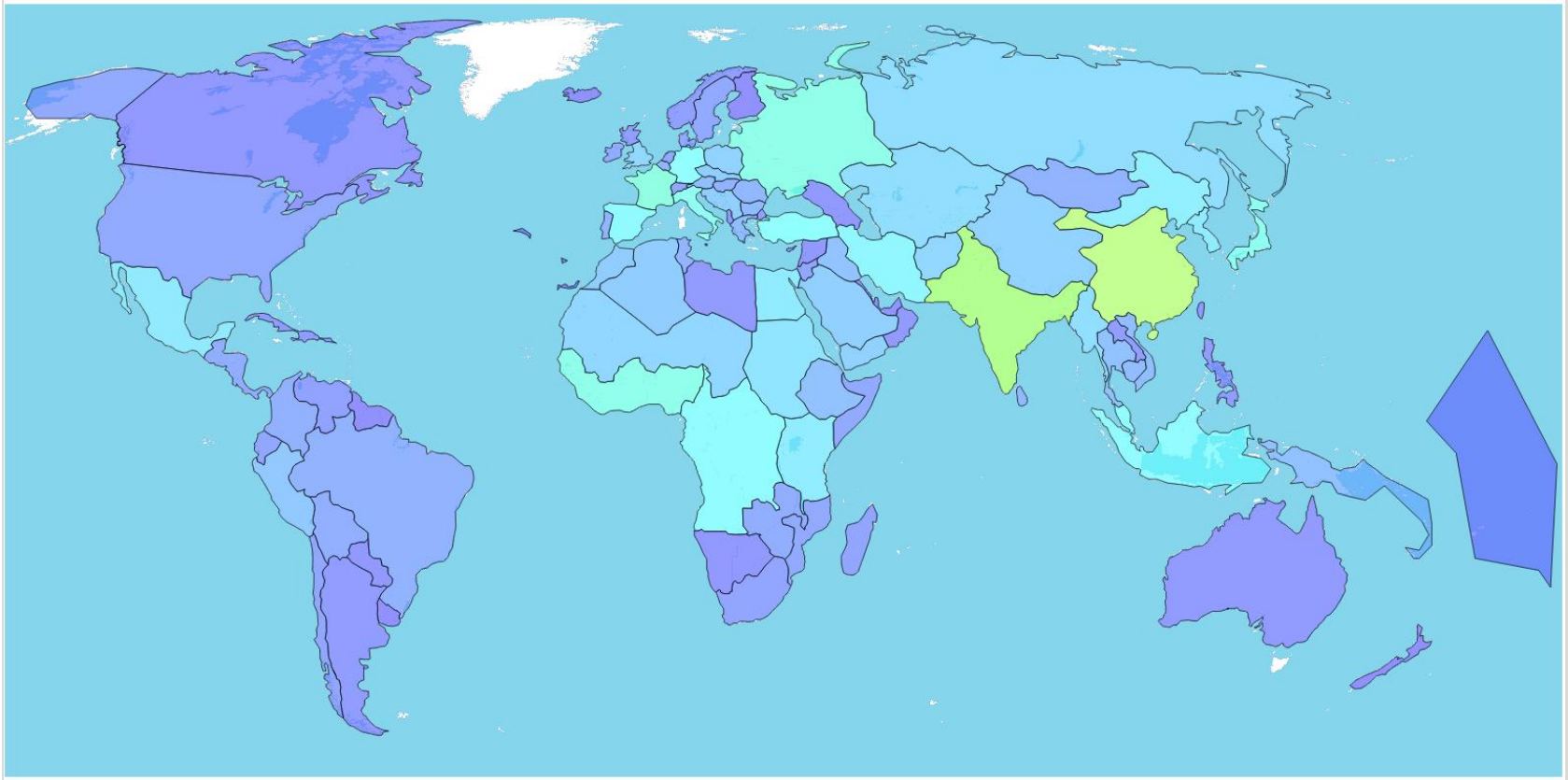
1. Empirical data



Map of world population in 1100

Simulation model of the migration interactions

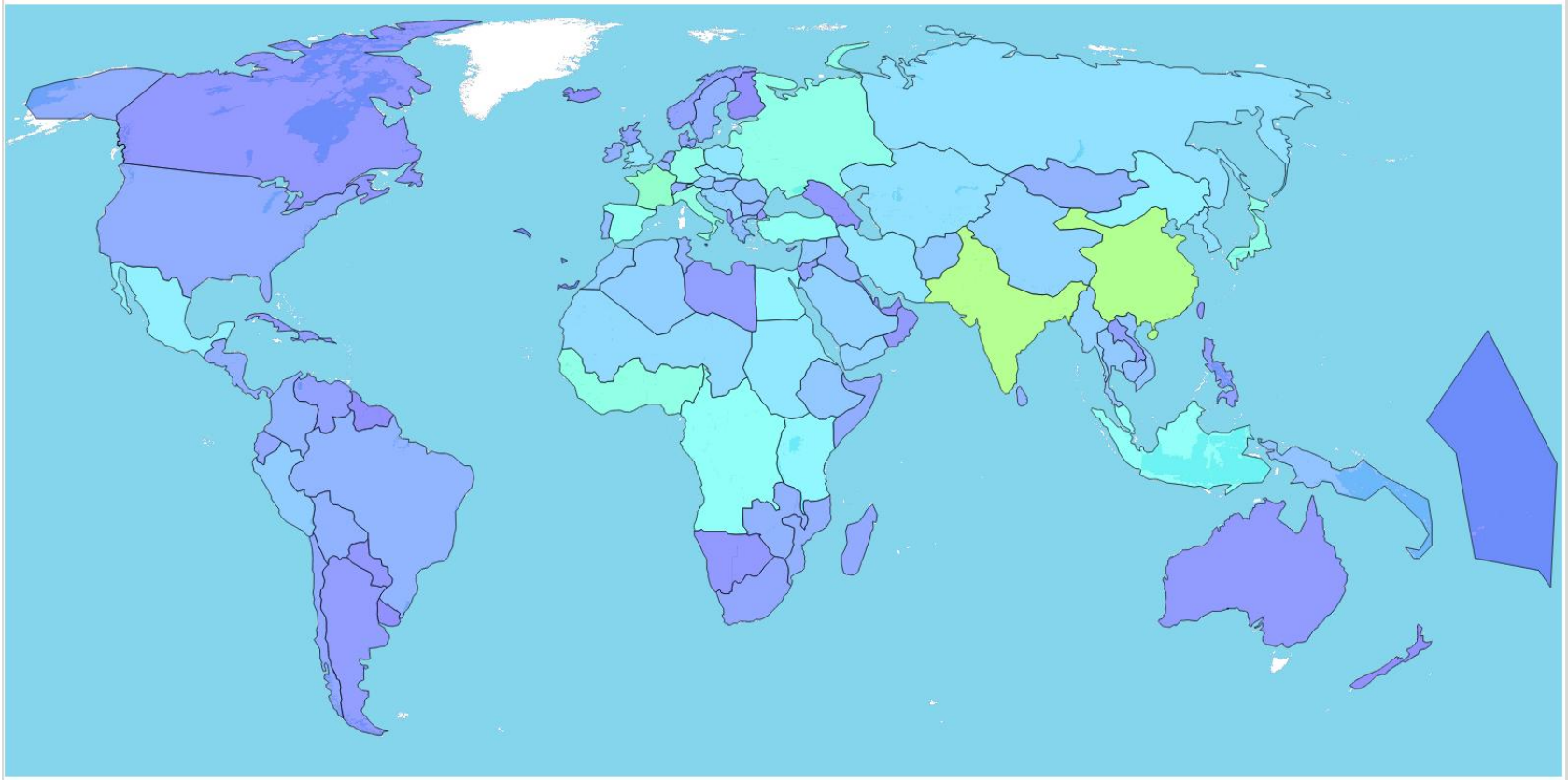
1. Empirical data



Map of world population in 1200

Simulation model of the migration interactions

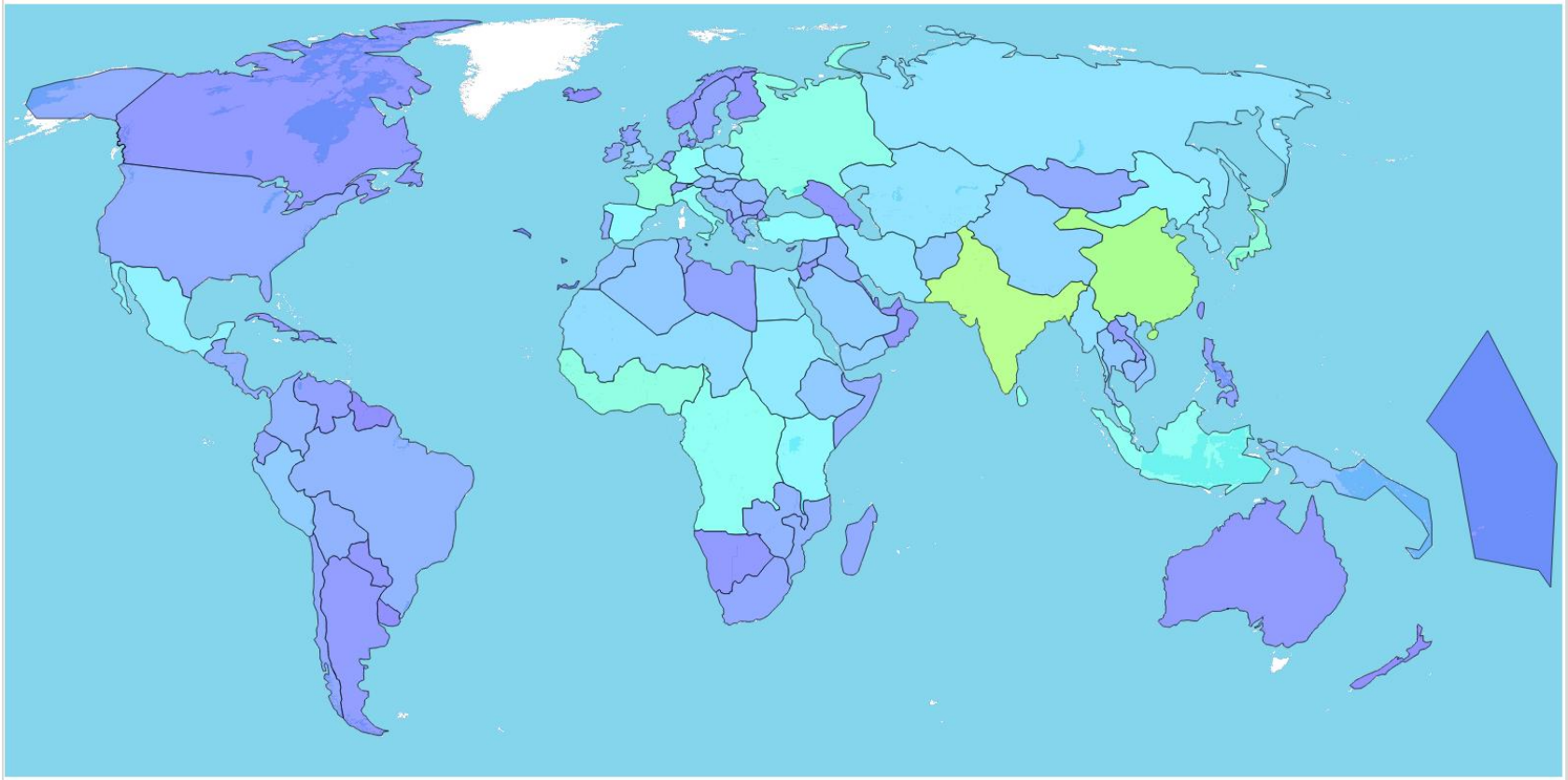
1. Empirical data



Map of world population in 1300

Simulation model of the migration interactions

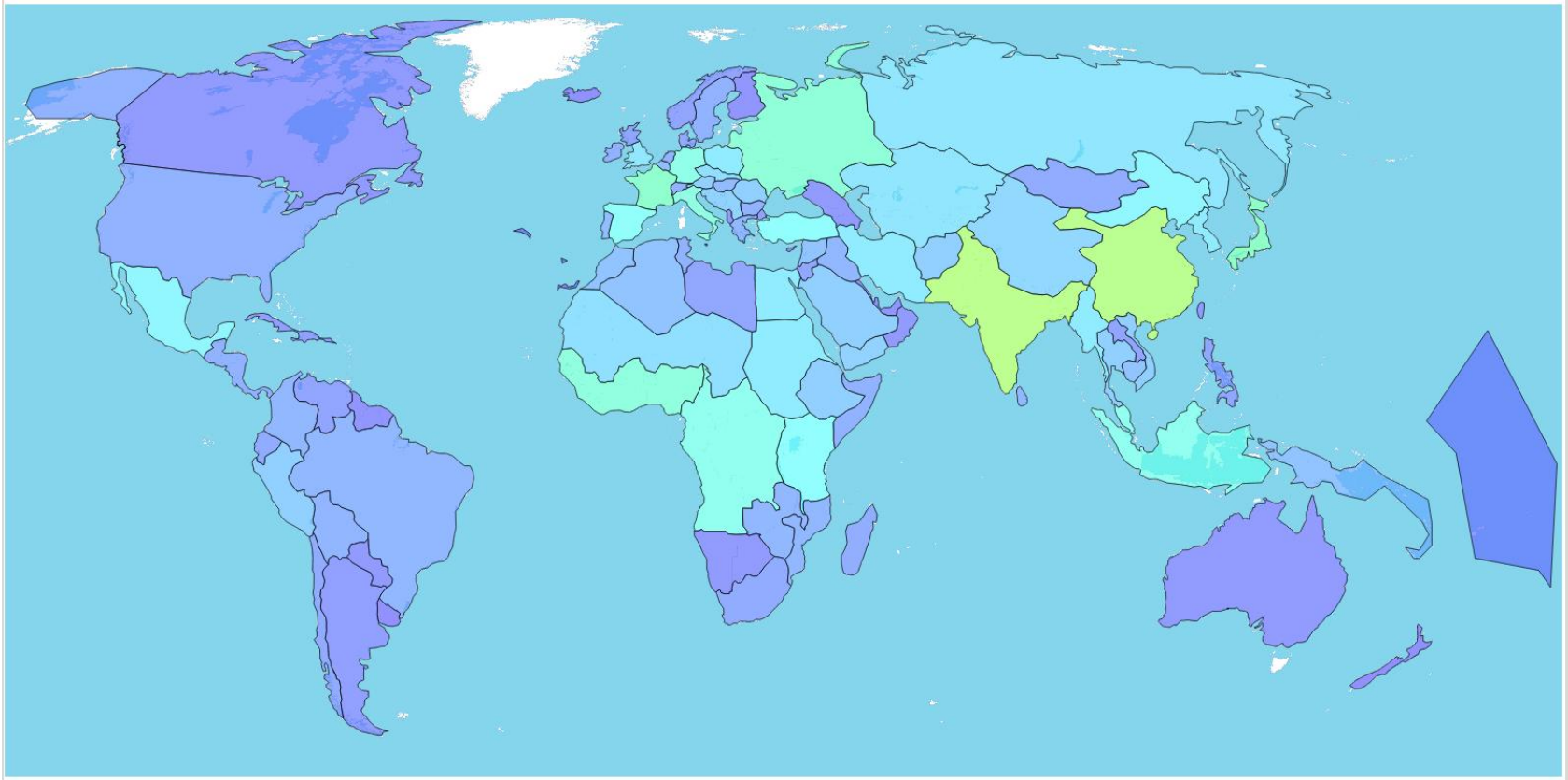
1. Empirical data



Map of world population in 1400

Simulation model of the migration interactions

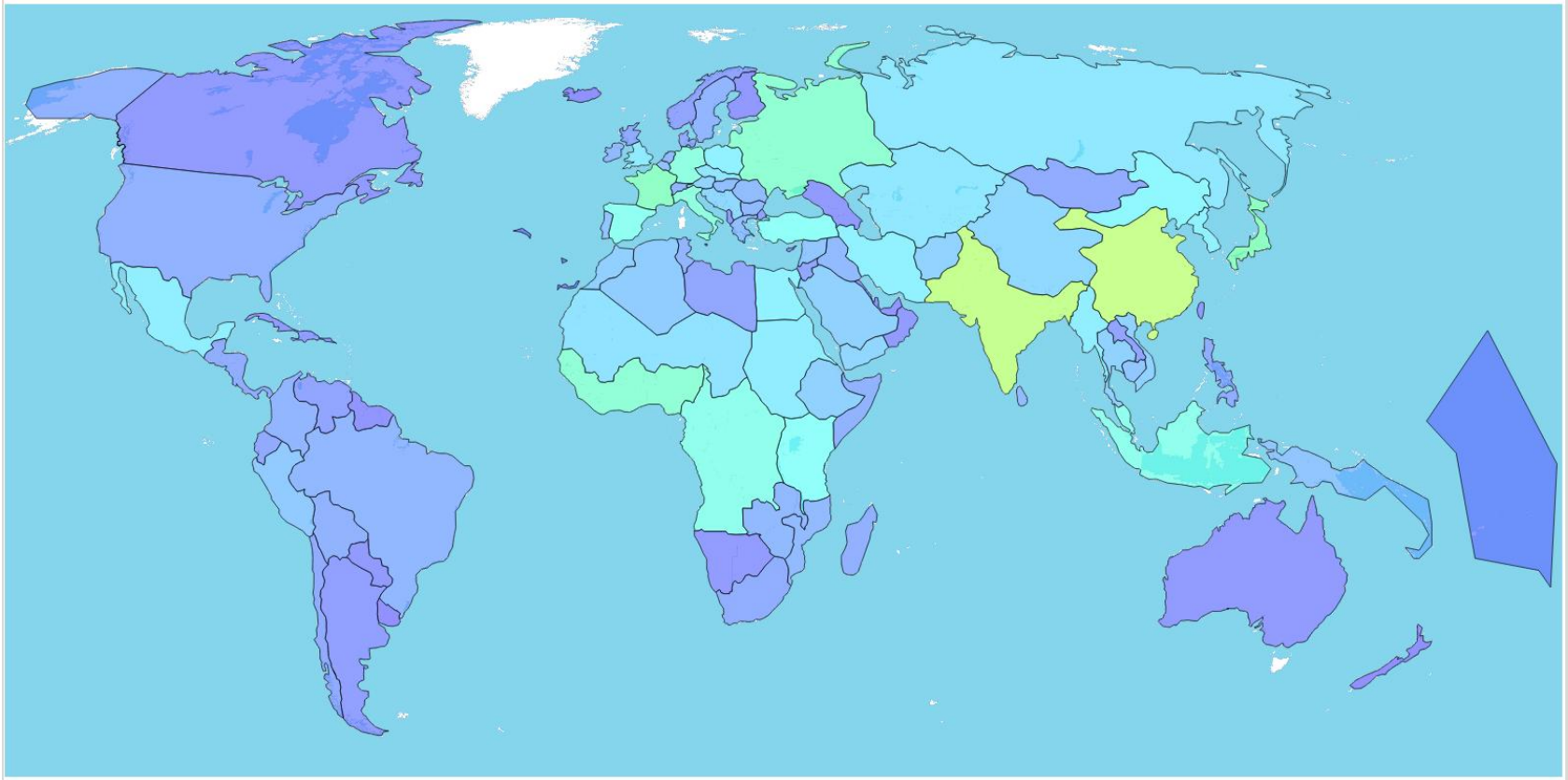
1. Empirical data



Map of world population in 1500

Simulation model of the migration interactions

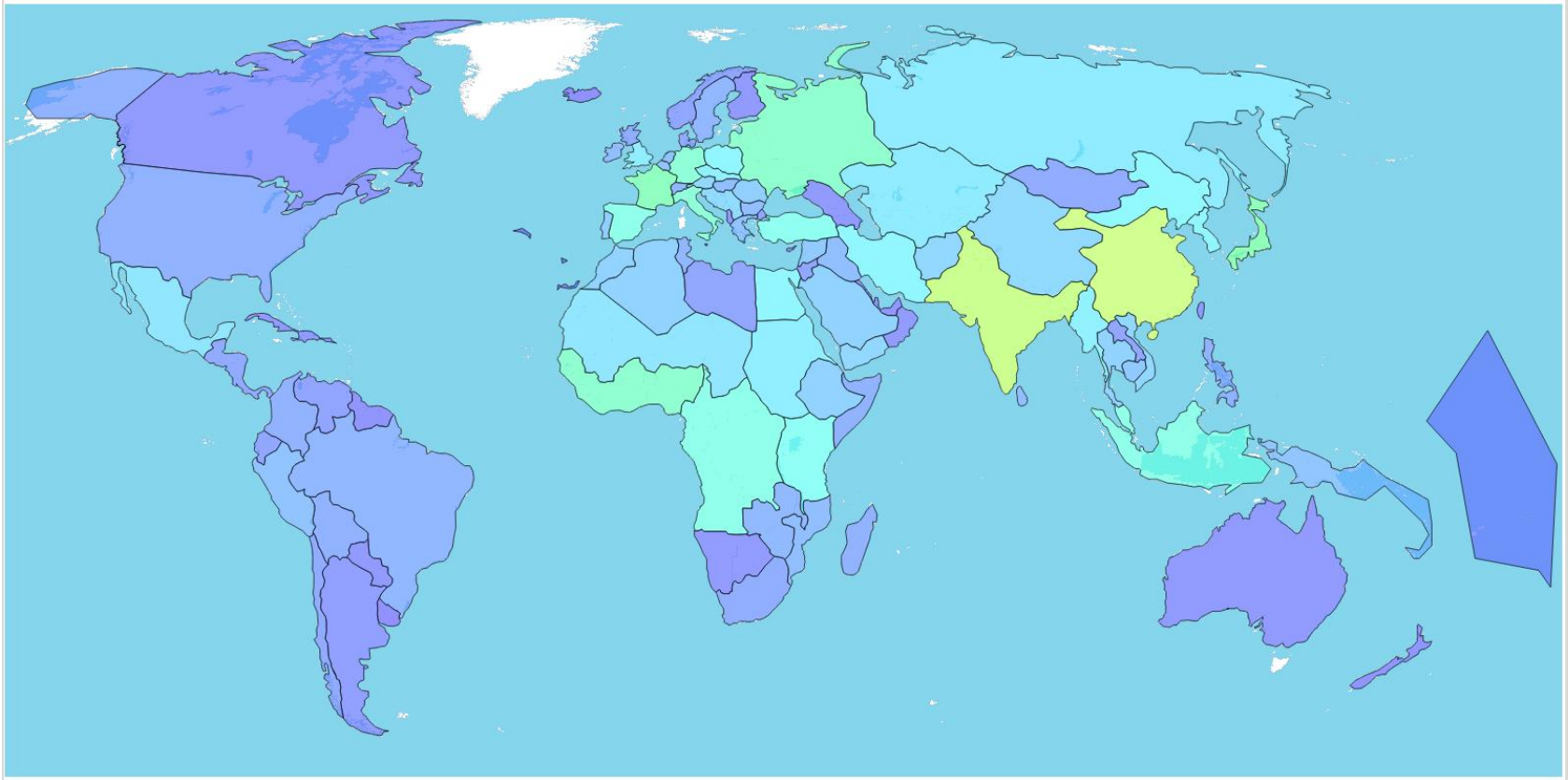
1. Empirical data



Map of world population in 1550

Simulation model of the migration interactions

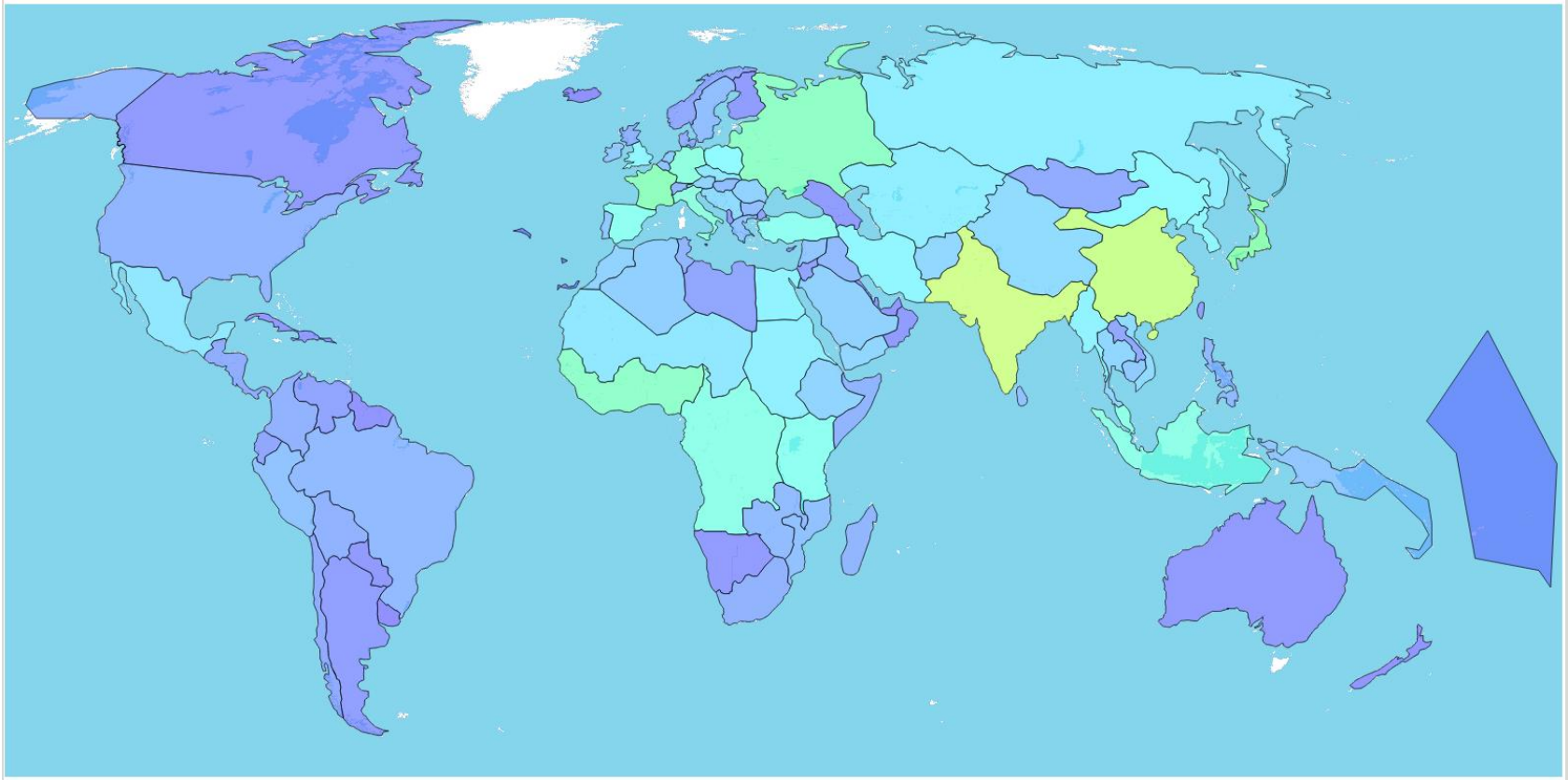
1. Empirical data



Map of world population in 1600

Simulation model of the migration interactions

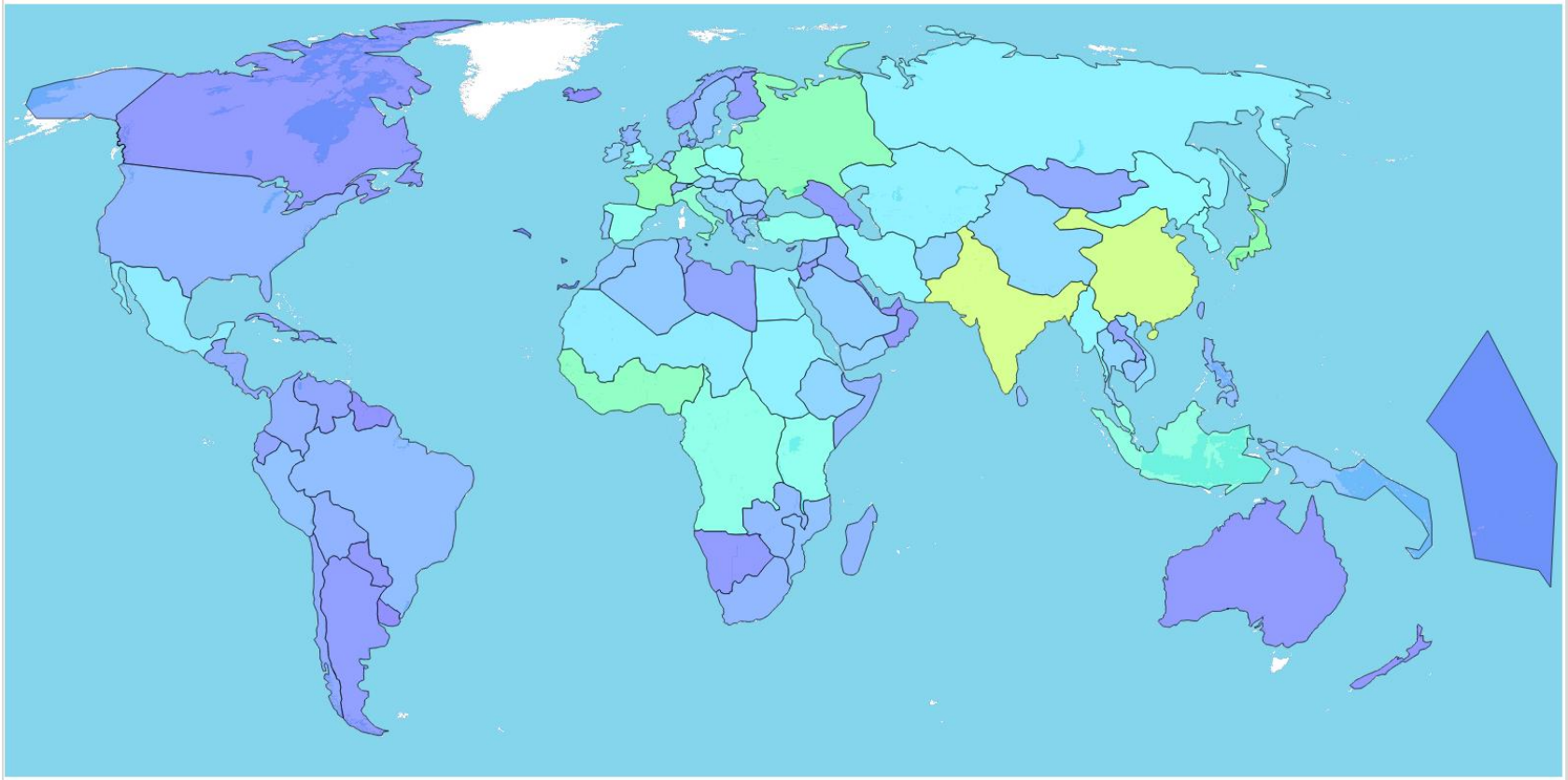
1. Empirical data



Map of world population in 1650

Simulation model of the migration interactions

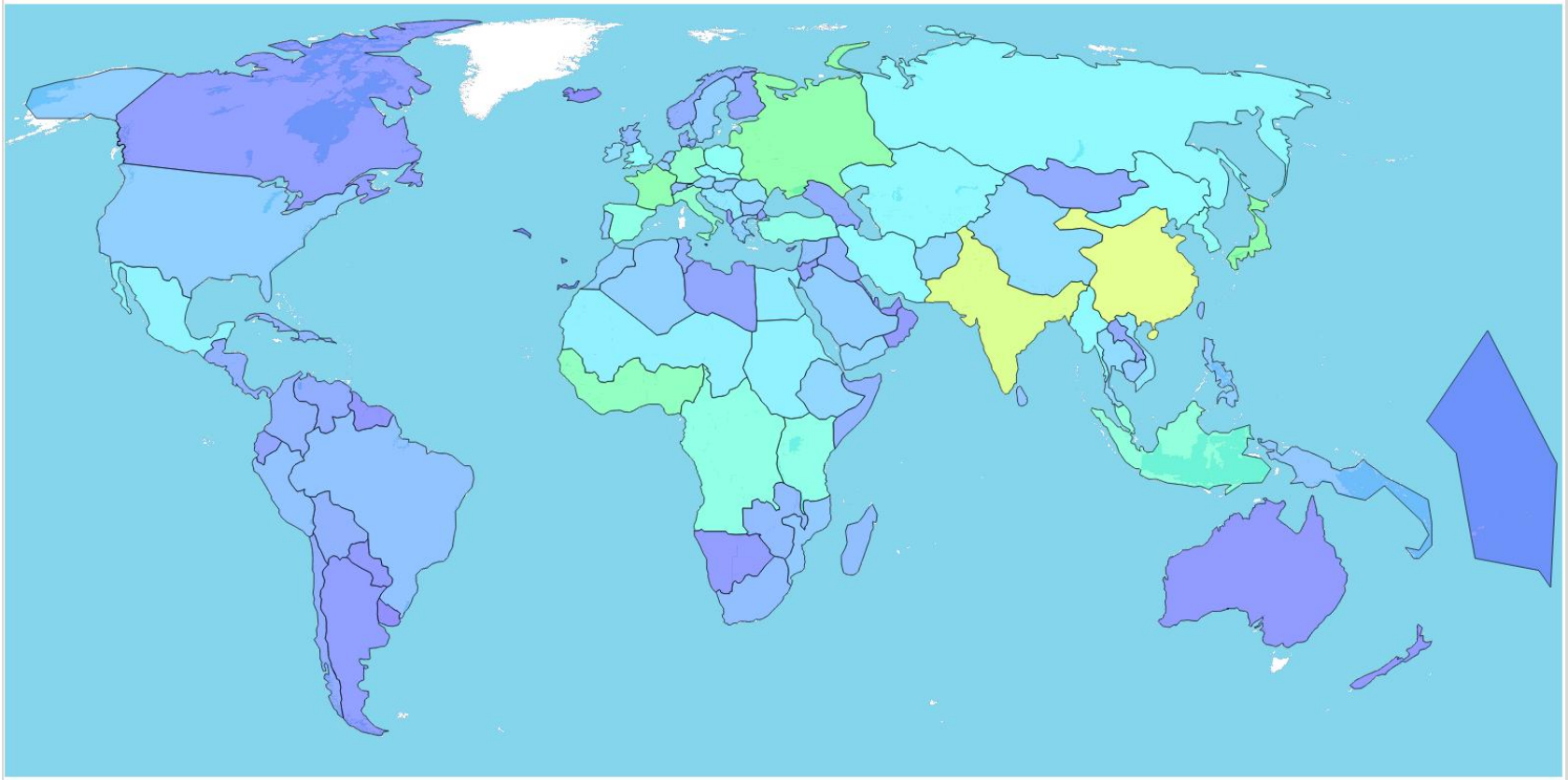
1. Empirical data



Map of world population in 1700

Simulation model of the migration interactions

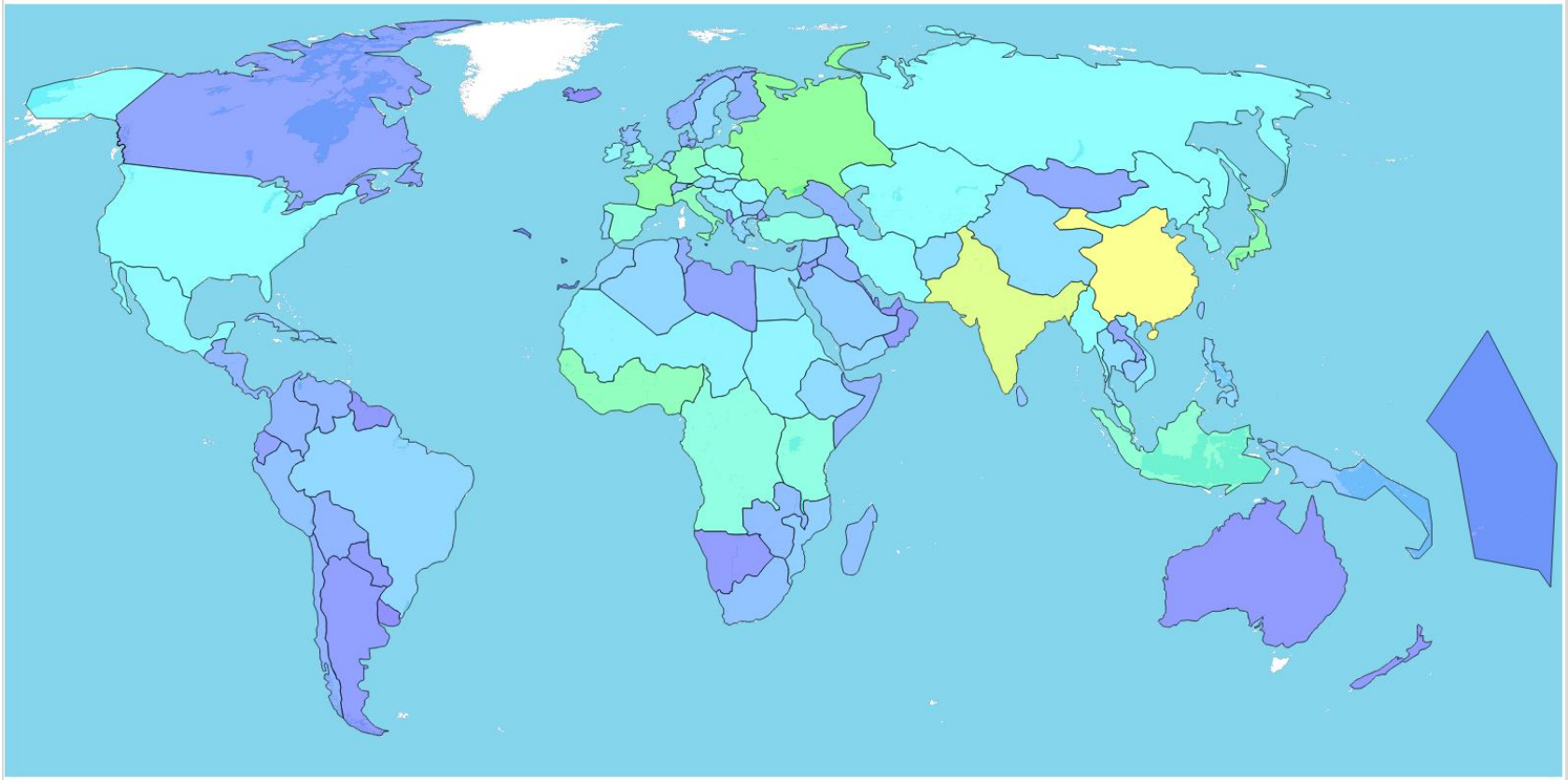
1. Empirical data



Map of world population in 1750

Simulation model of the migration interactions

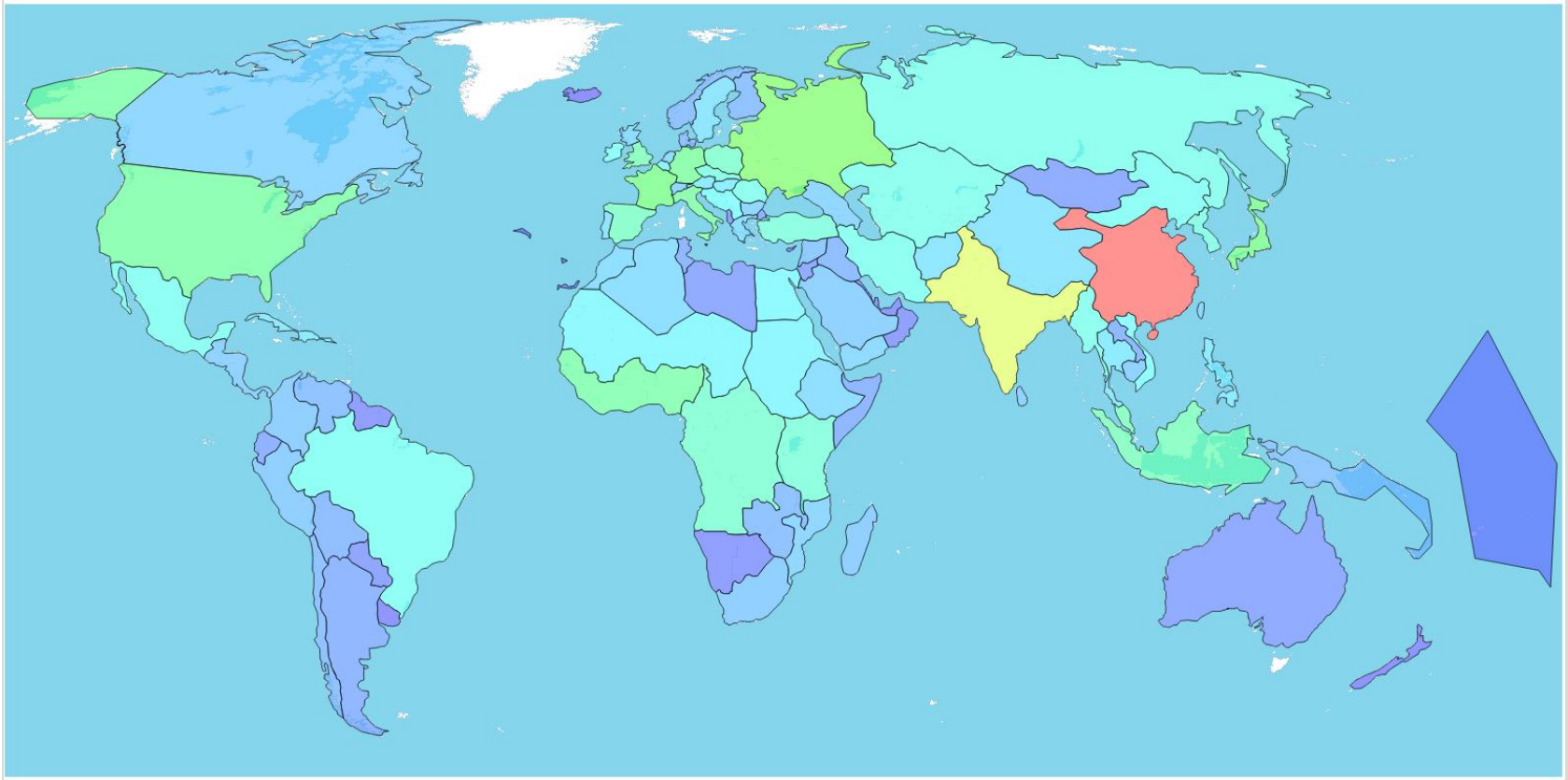
1. Empirical data



Map of world population in 1800

Simulation model of the migration interactions

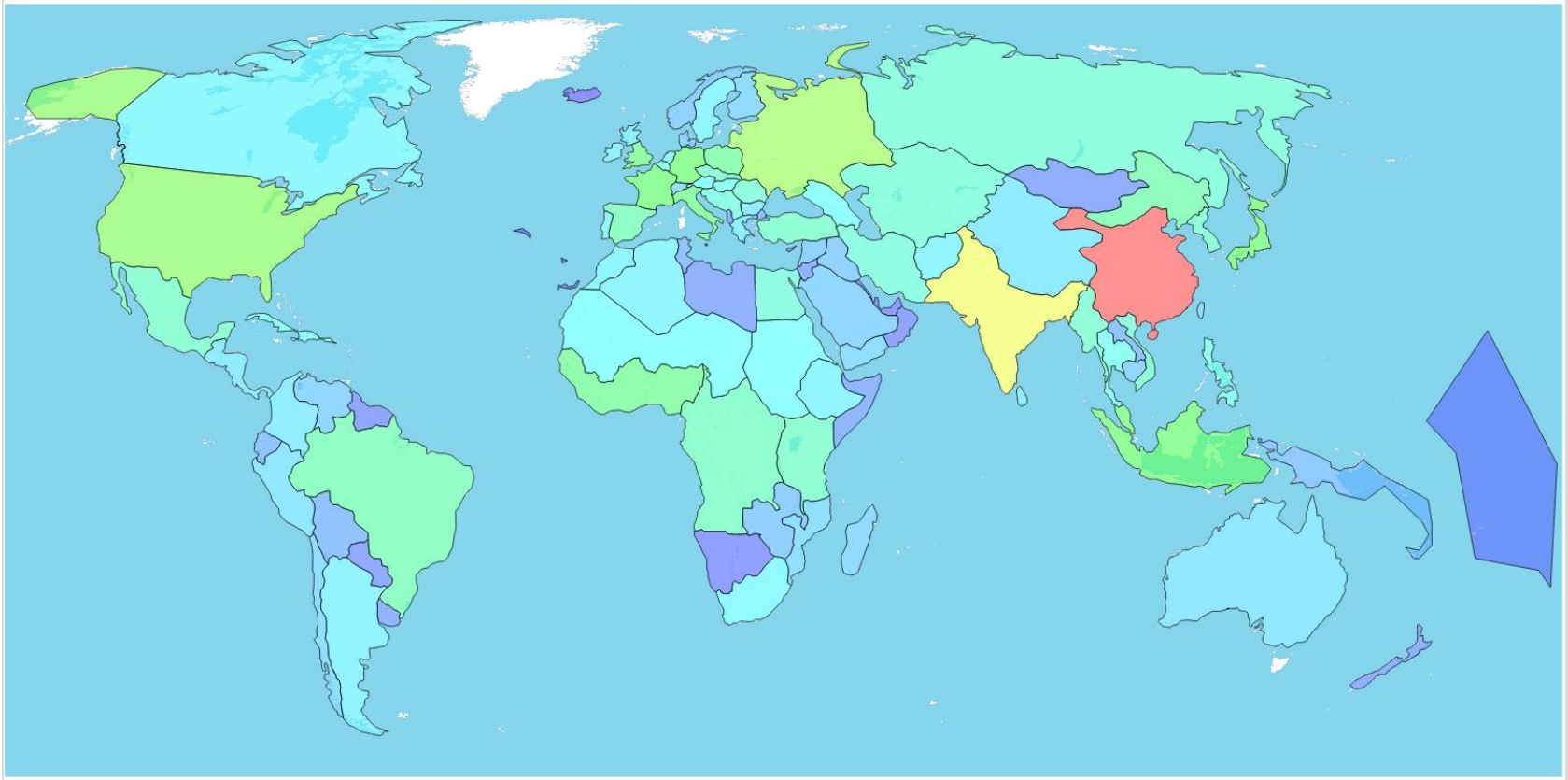
1. Empirical data



Map of world population in 1850

Simulation model of the migration interactions

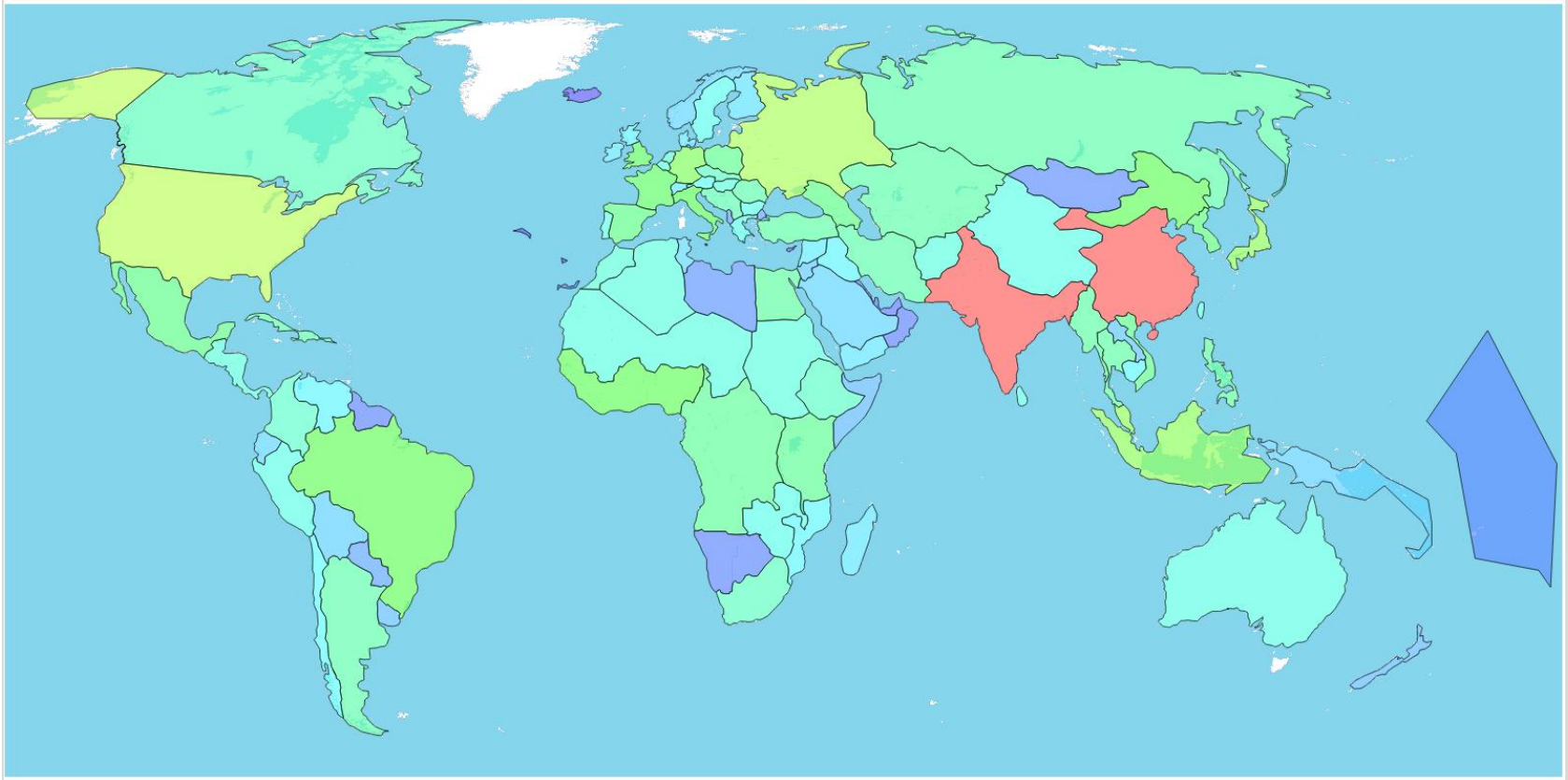
1. Empirical data



Map of world population in 1900

Simulation model of the migration interactions

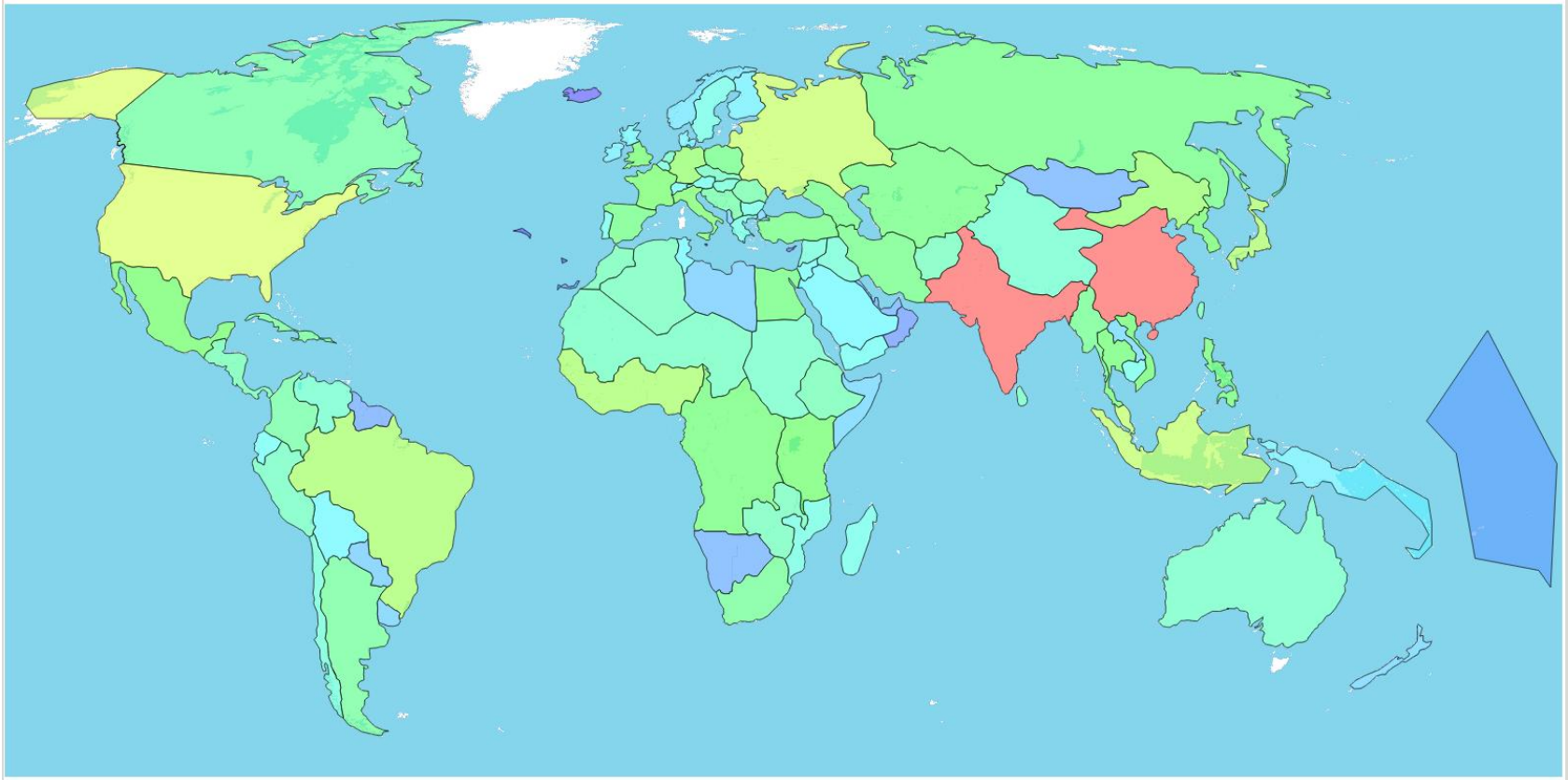
1. Empirical data



Map of world population in 1950

Simulation model of the migration interactions

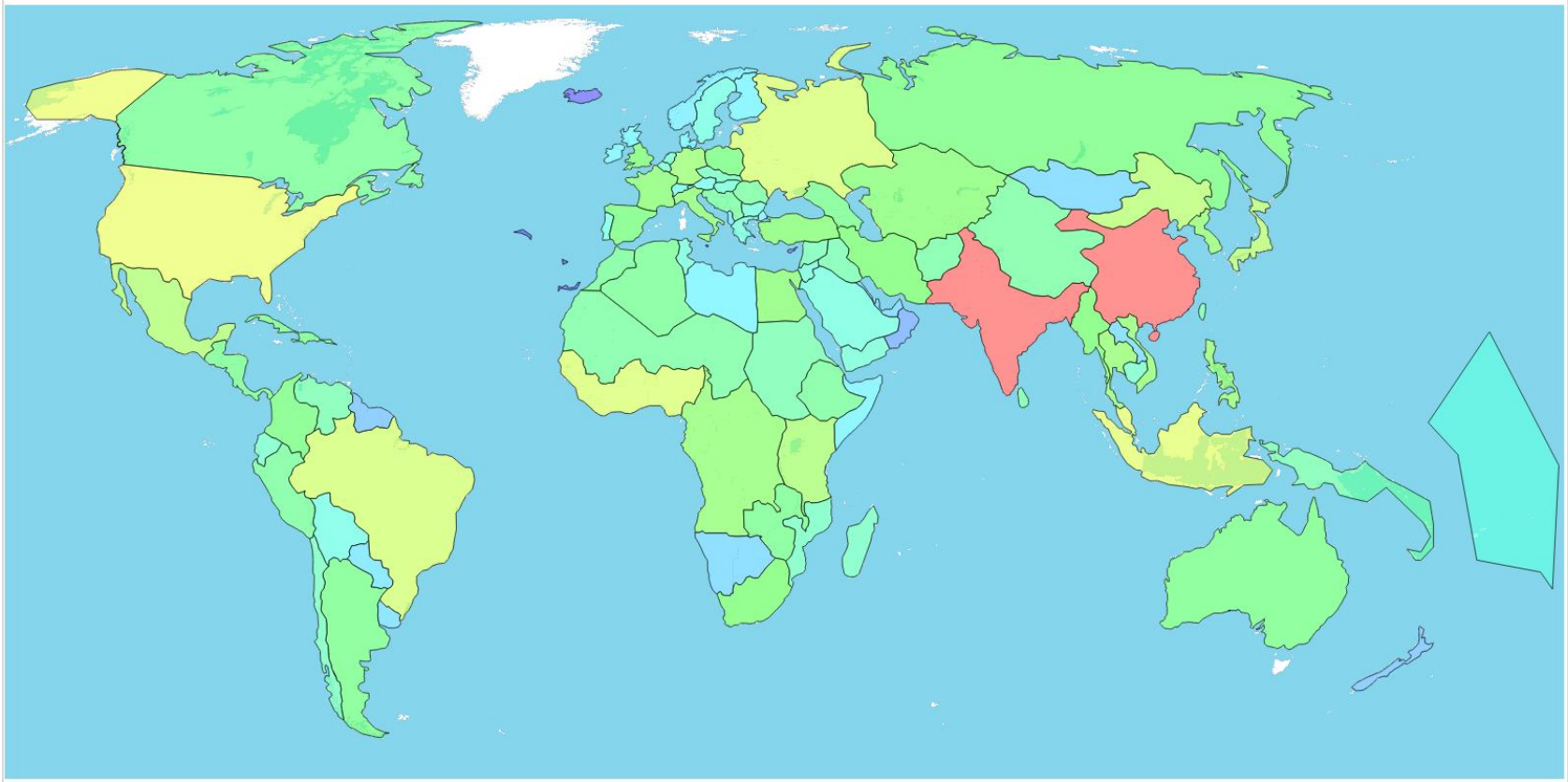
1. Empirical data



Map of world population in 1975

Simulation model of the migration interactions

1. Empirical data



Map of world population in 2000

Simulation model of the migration interactions

2. Theoretical principles

$$\frac{\partial N}{\partial t} = aN\left(1 - \frac{N}{C}\right) + \mathrm{R}\,\Delta N$$

where N - population dynamics;

C – capacity

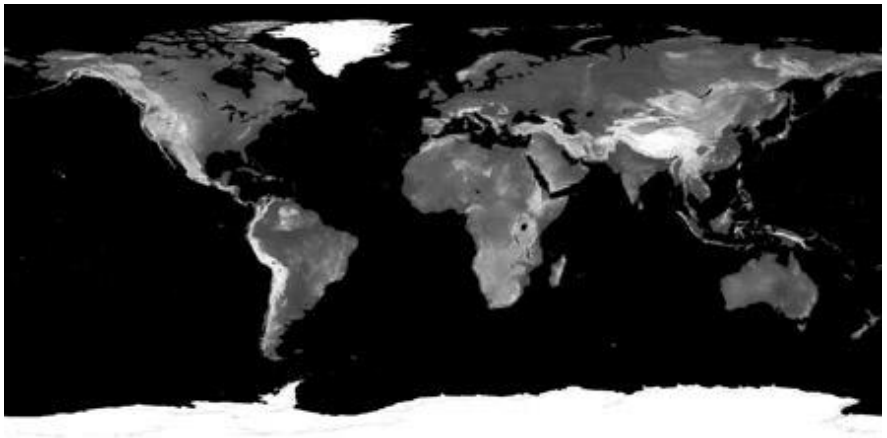
R – the influence of relief

$$\Delta = \frac{\partial^2 N}{\partial x^2} + \frac{\partial^2 N}{\partial y^2}$$

Simulation model of the migration interactions

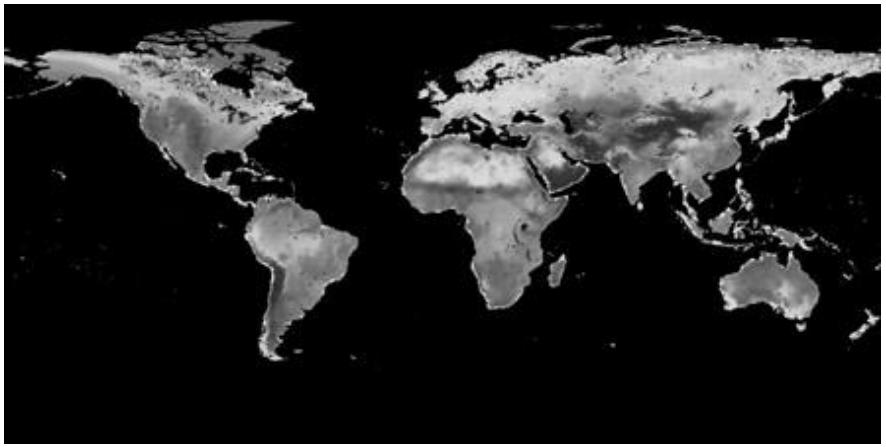
3. Preparatory materials

r



Relief map of the Earth

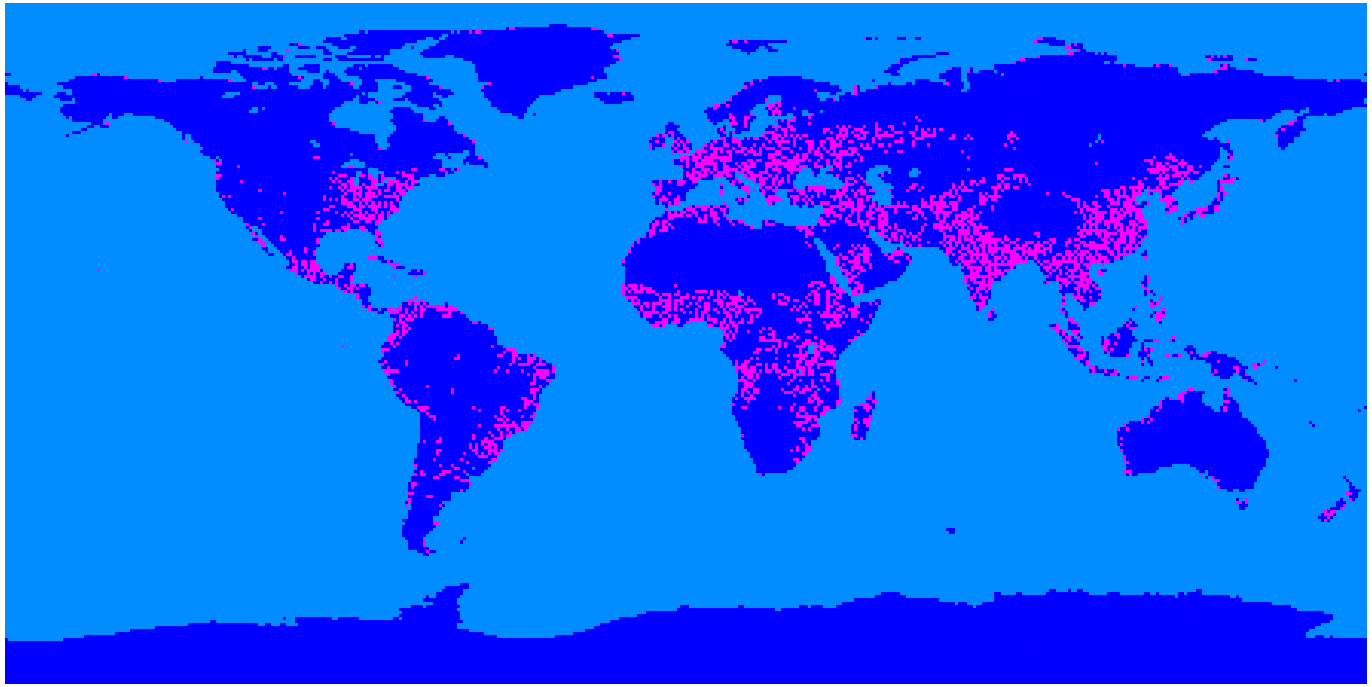
c



Map of soil data from the satellites

Simulation model of the migration interactions

4. Implementation of the model



The future development of the models

$$\begin{cases} \dfrac{dP}{dt} = \dfrac{\beta_1(1-\phi P)P}{1+\eta_1 E} - \delta_1 PE + r_1\Delta_1 P \\ \dfrac{dE}{dt} = \mu_1 P + \mu_2 \dfrac{P(1-\phi P)E}{1+\eta_1 E} - \dfrac{\delta_2 E}{1+\eta_2 S} + r_2\Delta_2 E \\ \dfrac{dS}{dt} = \gamma \dfrac{dE}{dt} - \sigma ES + r_3\Delta_3 S \end{cases}$$

$$\Delta_1 = \frac{\partial^2 P}{\partial x^2} + \frac{\partial^2 P}{\partial y^2}$$

$$\Delta_2 = \frac{\partial^2 E}{\partial x^2} + \frac{\partial^2 E}{\partial y^2}$$

$$\Delta_2 = \frac{\partial^2 S}{\partial x^2} + \frac{\partial^2 S}{\partial y^2}$$

where P - population dynamics; E - elite dynamics; S – state strength

Thank you for your attention!