王 铮 中国科学院科技政策与管理科学研究所

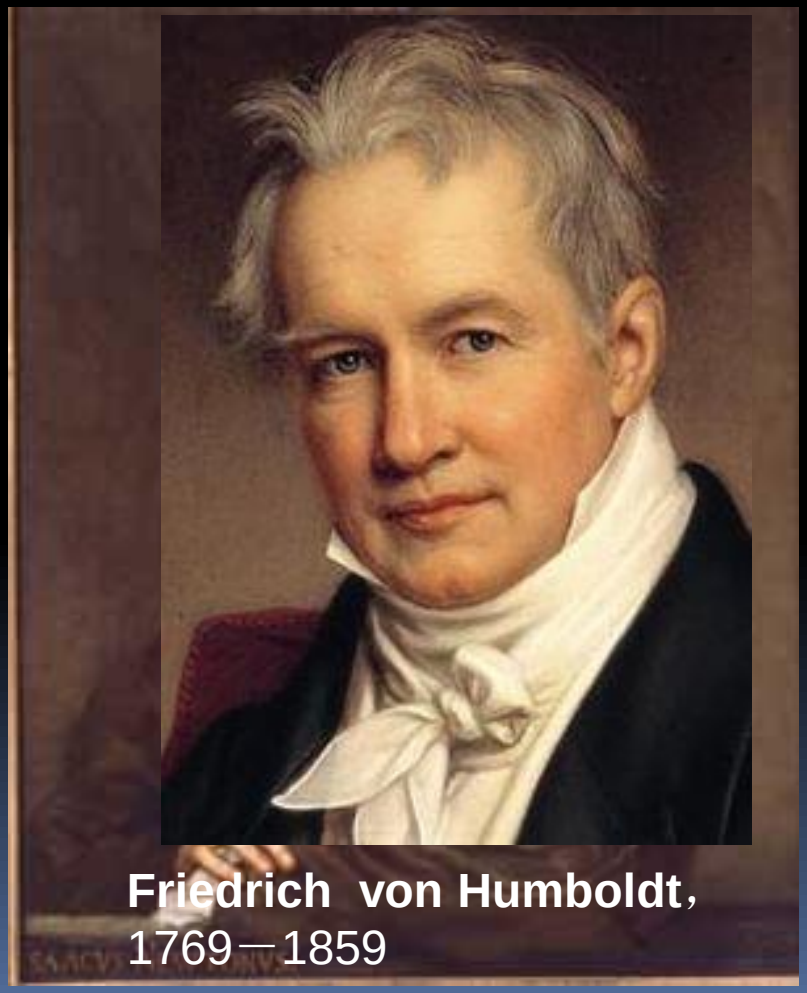
地理学分析中基于自主体建模的原理讨论

A DISCUSSION ON THE PRINCIPLE OF AGENT-BASED MODELING FOR GEOGRAPHICAL ANALYSIS

王铮 Zheng Wang
Institute of Policy and Management, Chinese Academy of Sciences

Difficult on geography analysis

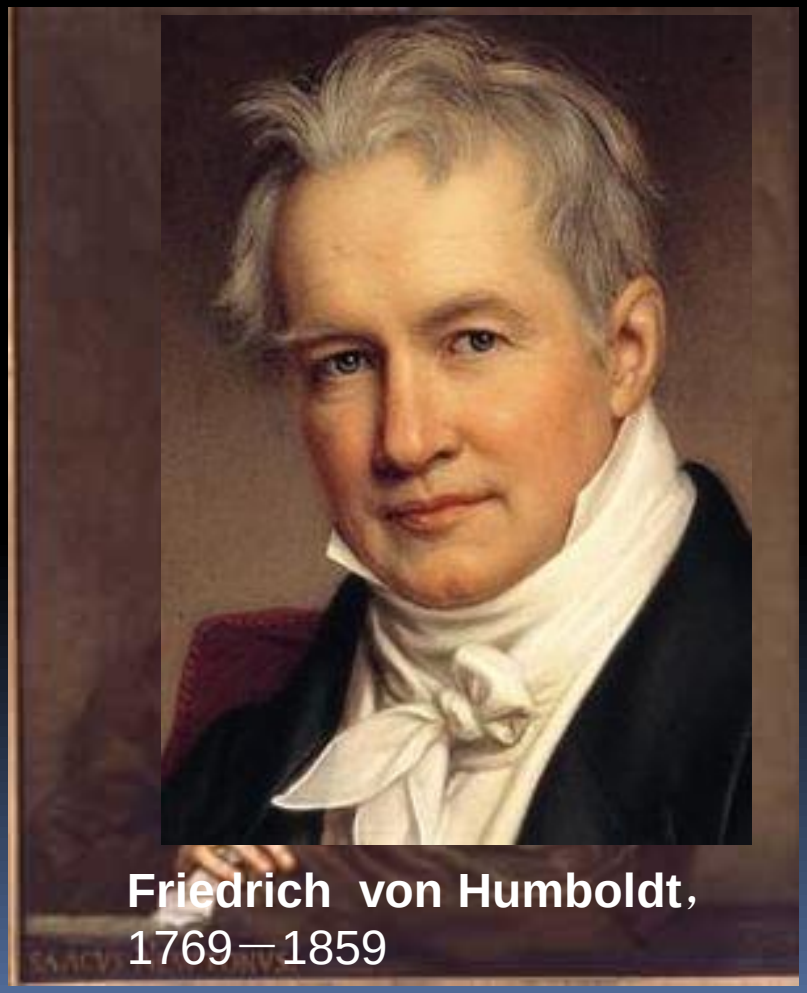
- Modern scientific methods from Newton
- Humboldt hope to establish that kind of geography like Physics, so we have Physical Geography. Then, Physical Geography failed to develop a like physics has as a complete analysis system
- WHY?



Friedrich von Humboldt，1769—1859

地理学分析的困难

- 牛顿开始了现代科学分析，他建立了Physics体系
- 洪堡希望建立Physics那样的地理学，但是，Physical Geography 不能实现Physics的分析功能
- 这是为什么



Friedrich von Humboldt，1769－1859

Difficult on geography analysis

- Geography problems often do not have the background of continuous space, calculus analysis method based on continuous media is failure
- Geography developed the analytical methods on geography map (ISARD). The map analysis suitable for the analysis of the space with not- continuous, but lacks the power of logical analysis .
- Quantitative Geography is of based on mathematical statistics, it lack of the function of dynamical analysis

地理学分析的困难

- 地理学问题经常没有性质连续的空间背景，基于连续背景的数值计算也往往是不可能的；
- Isard说地理学发展了特有的地图分析方法，地图方法适合分析空间背景问题但是缺少逻辑分析功能；
- 数量地理学基本上基于数理统计方法因此缺乏动态分析功能

Agent-Based Modelling

- 19th century, the development of statistical physics from thermodynamics， after **Humboldt**

- A large number of particles system, the particle systems can be statistics
- Agent concept evolved by particles, but the agent can be identified, there is autonomy
- ABM theory from the theory of complex systems, complexity theory result from statistical physics

Ludwig Eduard Boltzmann (1844 – 1906) was an Austrian physicist and philosopher

Agent-Based Modelling

- 洪堡以后的19世纪从热力学发展起来了统计物理学。
- 它的粒子思想是大量粒子组成了粒子系统，这里粒子系统是可统计的。
- 自主体的概念来自粒子，但是必要时可以识别而且具有自主性。
- ABM 理论来自复杂系统论，复杂系统理论是统计力学的发展，统计力学观念来自波尔兹曼

Ludwig Eduard Boltzmann (1844 – 1906)，奥地利物理学家，哲学家

Agent-Based Simulation

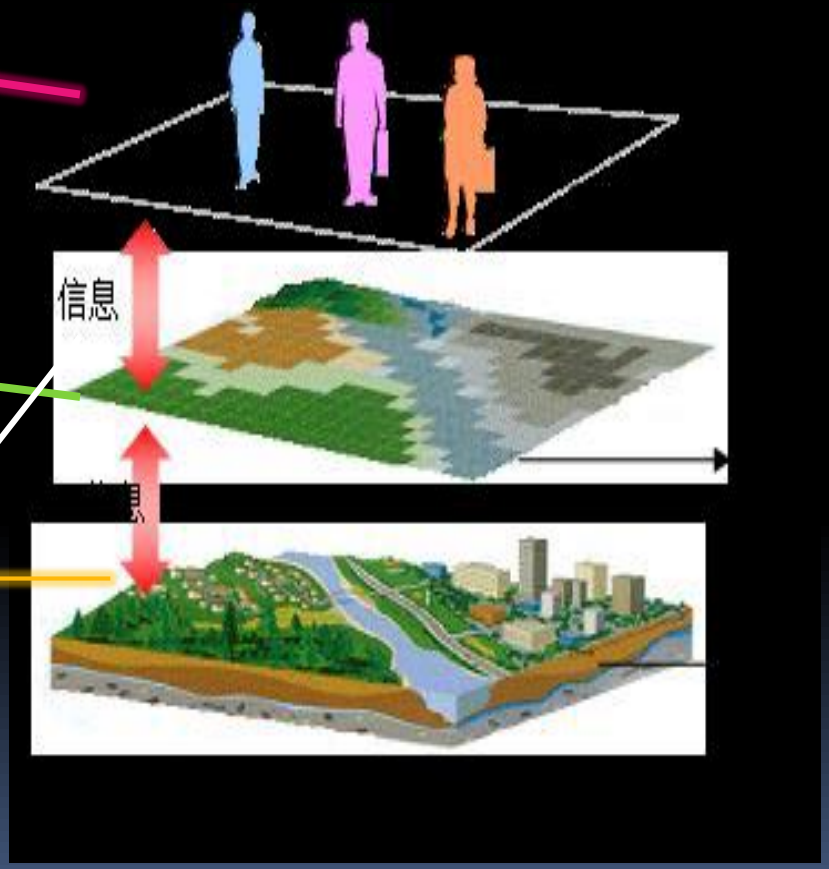
- We can apply the principles and methods of statistical mechanics to analyze geographical problem
- Adhering agents can be formed by a so-called multi-agent larger aggregates, the stable statistical characteristics of this aggregate, we can characterize the geographical features
- Due to the movement of the individual agent, aggregate statistical characteristics also change dynamically. Through simulation on individual agent , we simulates the geographical process or the economic process.

Agent-Based 模拟

- 我们能够应用统计力学原理和方法与解析地理问题、经济问题
- 集合自主体进形成所谓多自主体的聚集，聚集的结果形成集体特性，形成具有“宏观”表现的地理现象和经济现象。
- 由个别自主体的运动，聚集统计特性也动态地改变。通过模拟自主体，我们可以模拟地理过程或者经济过程

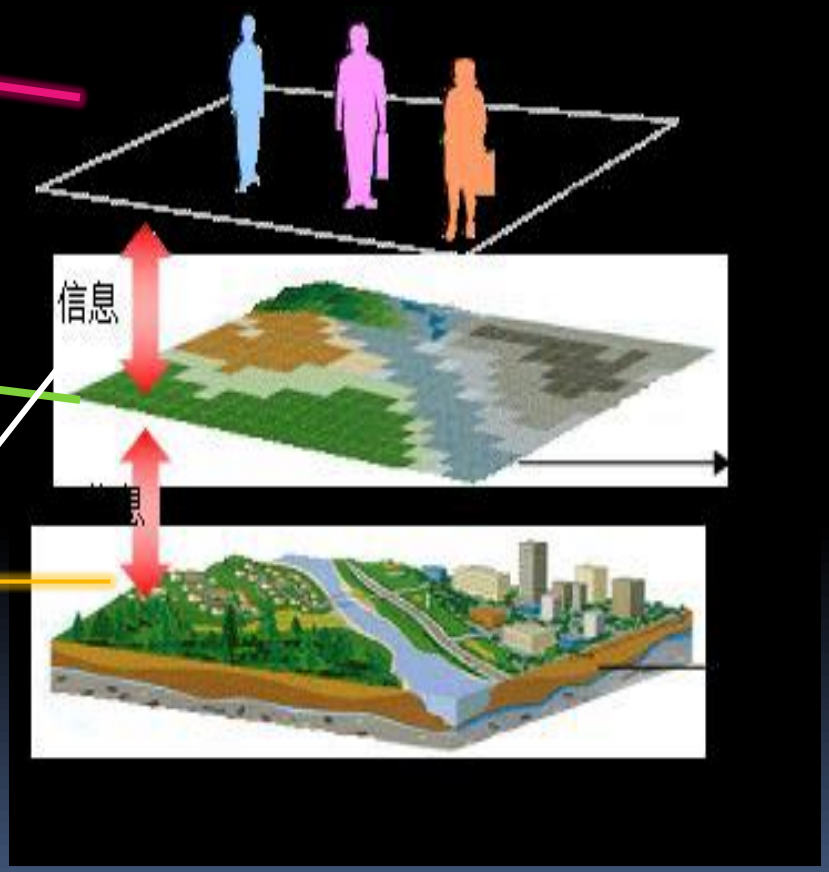
ABS for geography

- The agent behavior described by other disciplines, economic，social or other subject
- Geographical features are portrayed as a spatial context
- This spatial context can change dynamically
- Geographical environment can interact with the agent， but only CA



地理学中的ABS

- 自主体的行为可以由其他学科认识的行为描述，比如说经济学、社会学等
- 地理特征可以通过空间信息刻画来表述
- 空间内容可以通过动态规律的认识来动态化
- 地理环境能够与自主体互动；仅有元胞自动机是不够的。



建模要点

- 略

Example: Technology diffusion and capital flow simulation

- The China 362 cities defined as capital organization, this is equivalent to the existence of 362 enterprises Agent in the system.
- Agent enterprise engaged in production activities, the input factors for capital and effective labor
- Wage rates and population crowding compare workers Enterprise Agent to decide whether to migrate, migration of workers will bring production technology diffusion
- Return on capital and capital Comparison of Enterprise Agent market size determines the direction of investment.
- Workers and capital flows and transfer along the road network.

生产系统特征模型

- 空间距离
- D_{ij}

$$\bar{D} = \sum_i \sum_j D_{ij} w_i \Big/ n(n-1)$$

- 生产函数

$$Q = h^{\alpha} L^{\beta} K^{1-\beta}$$

- 工资率

$$W_t = d_{L,t} \cdot P_t = \beta h^{\alpha} L^{\beta-1} K^{1-\beta} \cdot P_t$$

技术扩散模型

- 技术扩散计算

$$h_{j,t} = \frac{\sum_i m_{ij} h_{i,t-1} + (P_{j,t-1} - \sum_j m_{ij}) \cdot h_{j,t-1}}{P_{j,t-1} - \sum_j m_{ij} + \sum_i m_{ij}}$$

- 总迁入人口
- $\sum_i m_{ij}$
- 总迁出人口

$\sum_j m_{ij}$

人口与资本扩散

- 劳动力迁移率

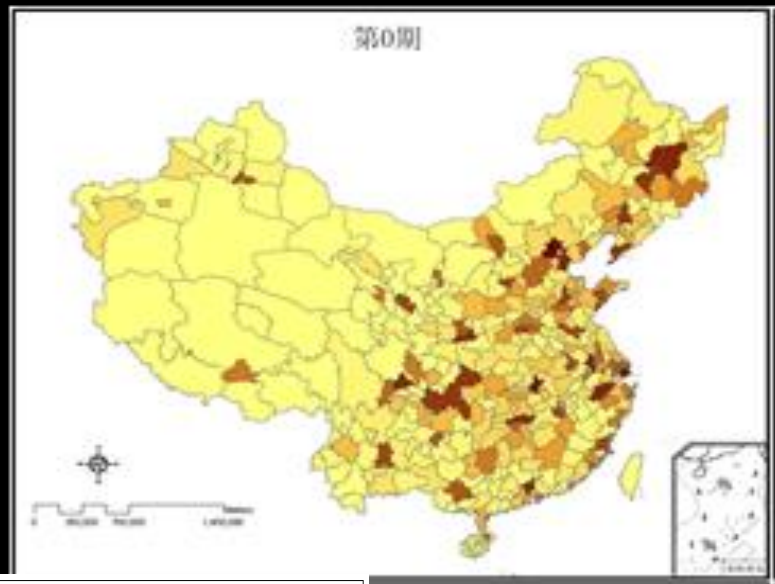
$$TP_{ij} = AL_i W_j \exp(ef_i - ef_j)\exp(-\eta D_{ij})$$

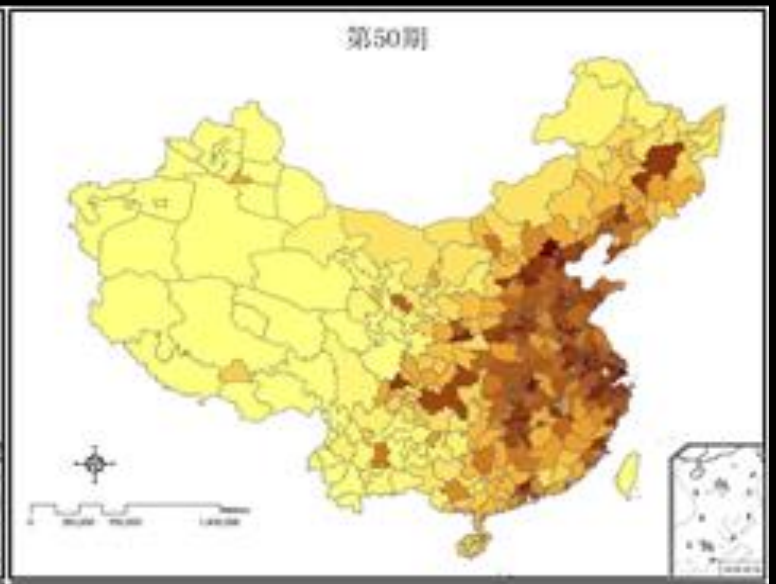
$$m_{i,j} = L_i \frac{TP_{i,j}}{\sum_i \sum_j TP_{i,j}} \qquad i \neq j$$

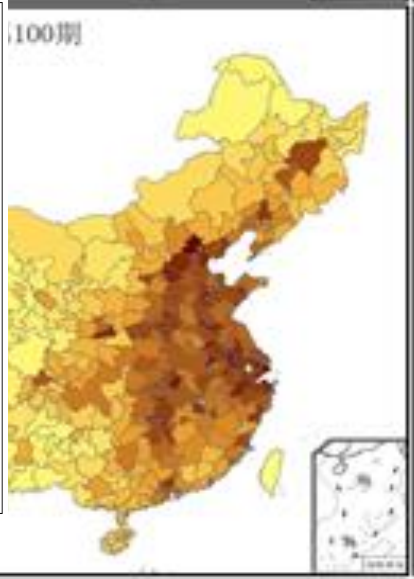
- 资本流

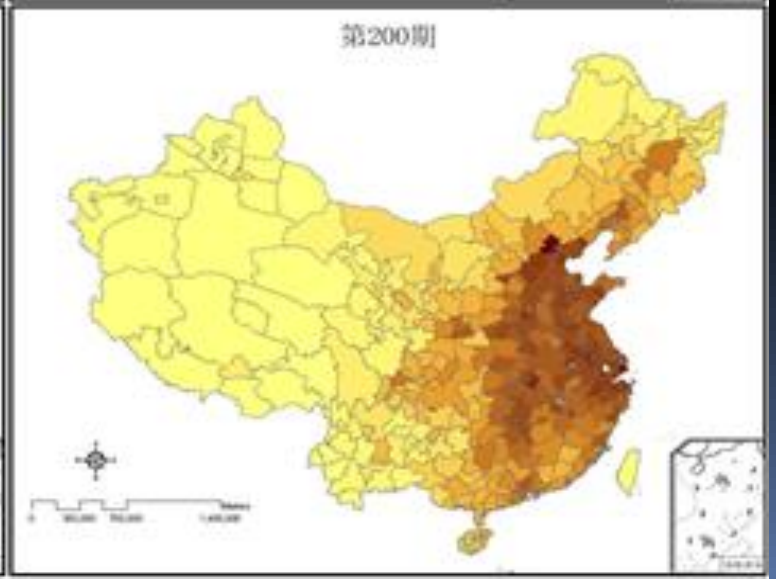
$$TK_{i,j} = w_j P_j \pi_j \exp(-\varepsilon D_{i,j})$$

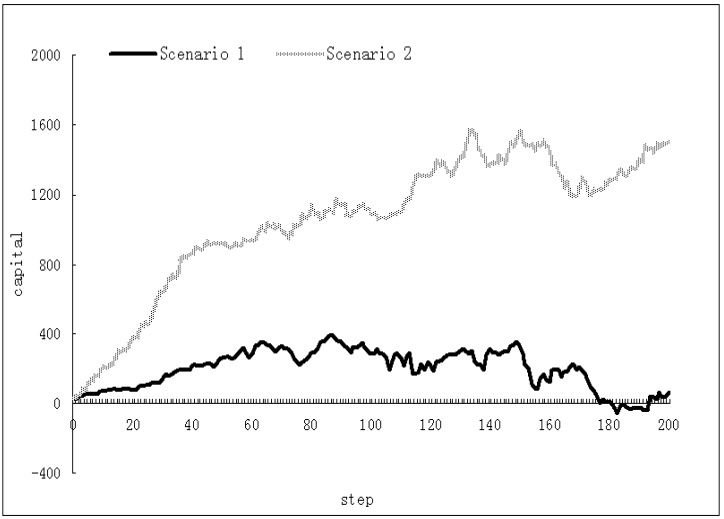
中国的技术水平演化


第0期


第50期


100期


第200期


Scenario 1
Scenario 2
2000
1600
1200
800
400
0
-400
capital
0
20
40
60
80
100
120
140
160
180
200
step

中国科学院
CHINESE ACADEMY OF SCIENCES

谢谢

thank you for your attention