
Geosimulation using fields and agents

JUDITH A. VERSTEGEN & OLIVER SCHMITZ

02-09-2021, OPENGEOHUB SUMMER SCHOOL

A solid orange horizontal bar at the bottom of the slide.

Motivation

irrigation →
water shortage

ag. expansion →
habitat
fragmentation

air pollution →
respiratory
diseases



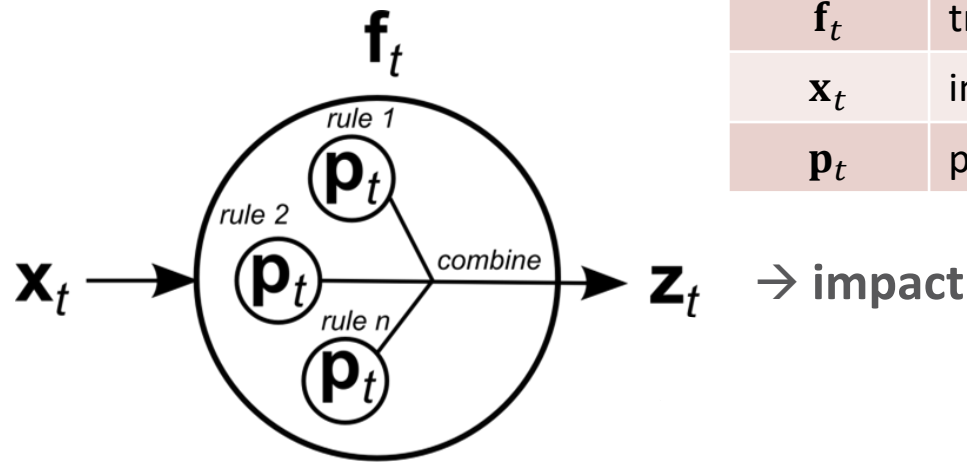
deforestation →
carbon
emissions

urban expansion
→ impermeability
→ floods

land
abandonment →
erosion

coreymondello.com

Defining Geosimulation

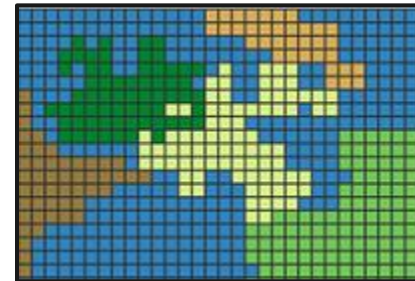
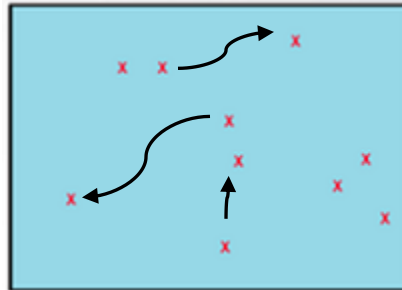


variable	description
t	time step
z_t	system state at t
f_t	transition function
x_t	inputs/drivers at t
p_t	parameters at t

Data-driven	Spatio-temporal models	Process-driven
Start with <u>empirical data</u>		Start with a <u>theory</u> (system description)
Based on correlations between drivers and the system state		Based on known/assumed cause-effect relations between drivers and system state
Also called: empirically-based model, statistical model, machine learning model		Also called: process-based model, physically-based model, geosimulation model

Modelling paradigms

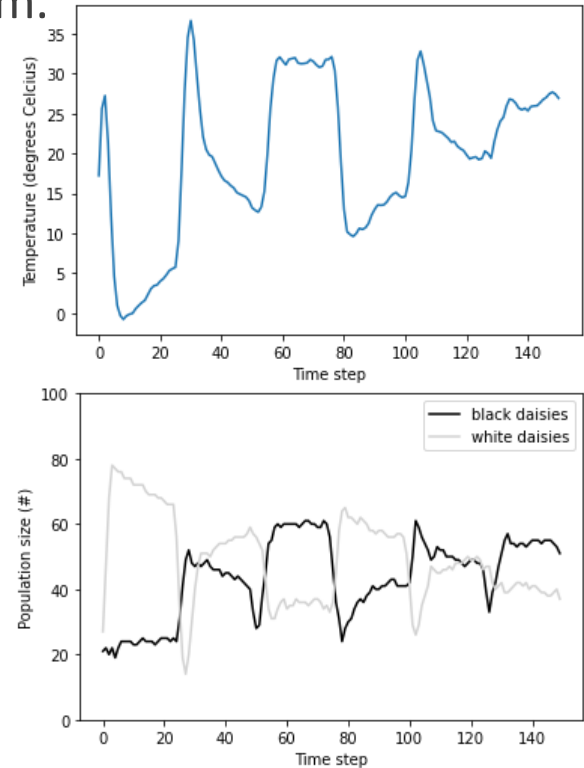
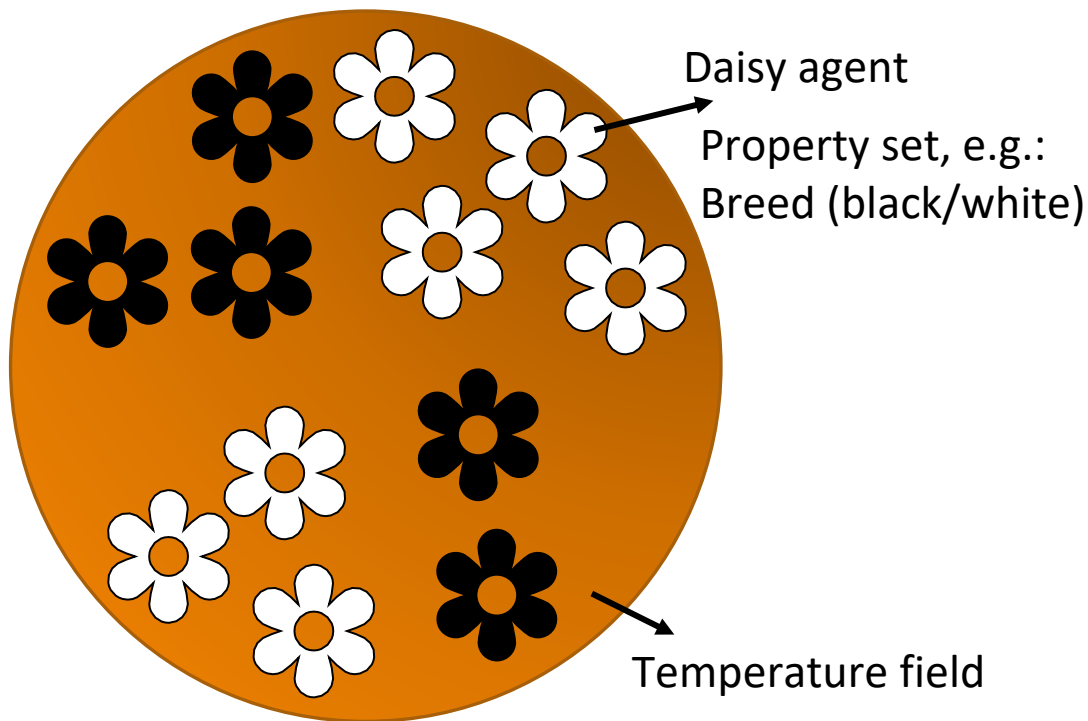
	Agent-based modelling (multi-agent systems)	Field-based modelling (cellular automata)
system state	Set of discrete objects	Continuous or discrete
attribute(s)	Is linked to the agent	Has a value everywhere
processes	Behavior of a single agent, potentially moving	Behavior of cells that remain in their location



Systems have multiple phenomena that do not fit into one paradigm!

Example: Fields & Agents!

DaisyWorld was introduced by James Lovelock and Andrew Watson (1983), to illustrate the Gaia Hypothesis that organisms interact with their surroundings, creating a self-regulating system.

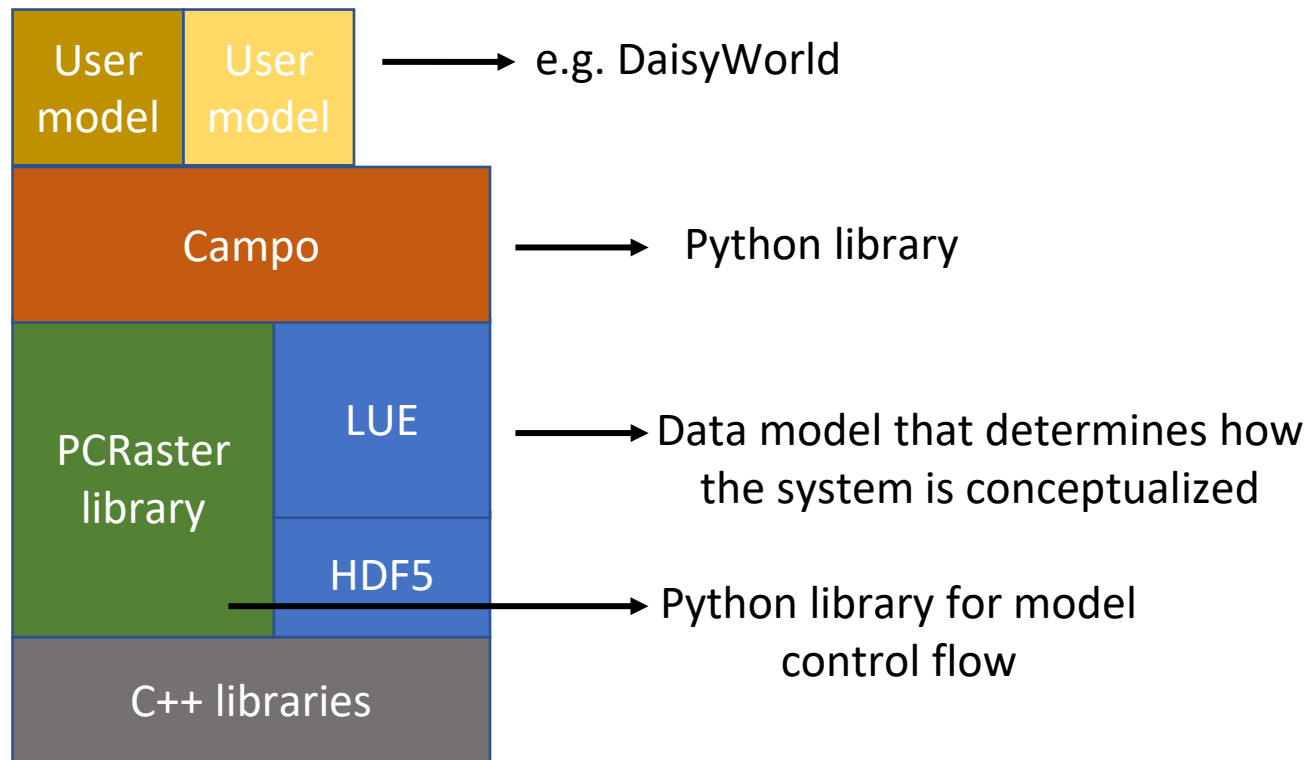


Problem statement

Current software:

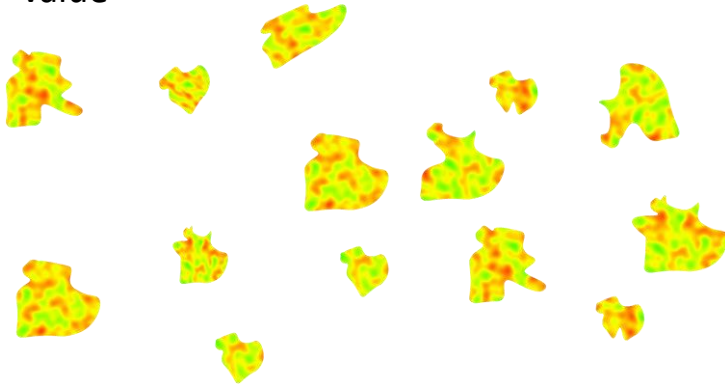
- Often departs from ABM, and approaches fields as sets of square objects
→ computationally sub-optimal
 - Has separate sets of functions for fields and agents
- No full integration between fields and agents

Campo



Phenomenon: agents or field

'Agents': Phenomenon containing >1 **Objects**,
areal coverage of each Object is where it has a
value

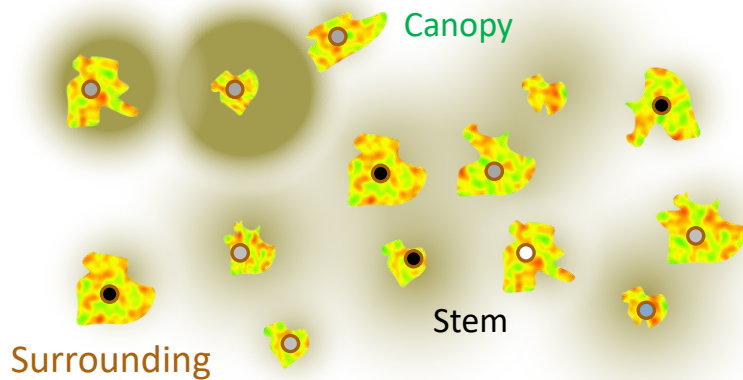


'Field': Phenomenon containing 1 **Object**,
areal coverage is 'modelling area'



Phenomenon has Property Sets, Property sets have properties

Forest system: trees, stems, tree canopy, seed dispersal..



Phenomenon **Trees**

Property Set **Stem**

Property Set **Surrounding**

Property Set **Canopy**

Property **NDVI**

*spatial domain of each **Object**:*

point at stem

circular centered at stem

crown

Single Algebra for Agents & Fields

Syntax:

```
a = a_function(b)
```

Calculates for each Object its property *a* as a function of property *b*

Referring to phenomena, property set, for instance:

```
trees.canopy.lai = a_function(trees.canopy.ndvi)
```

phenomenon property set property (attribute)

Framework for control flow

```
class MyFirstModel(DynamicModel):  
    ...  
  
    def initial(self):  
        # functions here are run once at start  
  
        # create/modify Phenomena for initial state of system  
  
        # I/O using framework functions  
  
    def dynamic(self):  
        # functions are run for each time step  
  
        # program time transition function  
  
        # I/O using framework functions
```

Future work

- Parallelization on supercomputers via HPX
- Add more functionality to Campo
- We're interested in your case studies with fields and agents!

Contact us via:

<https://campo.computationalgeography.org/>

judith.verstegen@wur.nl

o.schmitz@uu.nl