MVSem – Chaotic, Complex, and Evolving Systems 6 CP, 180 h workload

This is one of the Master seminars to choose from in environmental physics. It loosely follows the parallel course on "Chaotic, Complex, and Evolving Environmental Systems (CCEES)".

Possible topics are from the fields (i) nonlinear and possibly chaotic systems, (ii) complex systems, from patterns formation to population dynamics, and (iii) evolution, from the emergence of cooperation to the coupling of ecology and evolution.
Approaches include (i) the study and model representation of real systems, (ii) exploring and possibly expanding existing numerical models (cellular automata and agent-based models), and (iii) for the keen and experienced C++ experts, the development of own numerical models.

Suggestions for topics, roughly in the order of presentation:

- Nonlinearity & Chaos
  - highly abstracted representations of oceanic and atmospheric flows (Stommel51, Lorenz84, Lorenz96), possibly forced externally (climatic change)
  - temporal dynamics of non-spatial (uniform) landscapes
  - tipping points and critical transitions
- Complexity
  - dynamics of vegetation patterns (forest fires) and river-mountain systems
  - interacting populations in uniform and non-uniform environments
  - non-spatial food- and interaction-webs
  - spatial games and beyond
- Evolution
  - environment and evolution coupled (from the Great Oxygenation Event to niche construction)
  - resource-consumer networks
  - emergence of cooperation, its stability and necessity for evolutionary transitions

Format

1. In general, 2...3 students form a team, ideally with different individual strengths. They explore and work out a topic or sub-topic together and present their part individually.
2. Exploration: A starting point will be provided. It contains at least some research papers, in some cases also a simulation code or code fragment. Further insight is to be gained from the internet (Google Scholar, Wikipedia,...) and through own thinking and exploration.
3. Working out: Acquire, understand, and condense the material. Depending on the specific focus, different weight may be put on phenomenology, formulation of process models, theoretical background, or numerical simulation.
4. Oral presentation: An in-depth talk of some 50 minutes followed by an intensive 40 minutes discussion. Active participation in the discussions by all participants is an integral part of this seminar.

5. A report in one of three forms:
   (a) a traditional report, 5…20 pages per author (a team may hand in a joint report),
   (b) a documented code, including a short description of the scientific background, the algorithm, discussed exemplary runs, and an operational implementation in Python or C++,
   (c) a 5…10-minutes movie of a TED-like talk including a transcript with background material.
6. The seminar will start with an introduction into the general theme, its concepts, and some basic methods.

All the material will eventually be available electronically.

Grading

This seminar has three essential aspects that are graded individually: (i) presentation and discussion (40%), (ii) participation in discussions (20%), (iii) report or equivalent (40%).

Schedule

The seminar is on Tue 16:15–17:45. Regular attendance is mandatory.

Registration

The seminar has about 10 slots, hence can accommodate some 20 students. Registration is required either at the first meeting on April 17, 2018, or by sending email to `kurt.roth@iup.uni-heidelberg.de` before.

Mandatory Prerequisites

Solid understanding of *at least one* of

- chaotic,… systems, e.g., by attending the parallel course on CCEES, or
- numerical methods including solution of differential equations.

As the weight on different aspects of a topic can be chosen, one field of expertise suffices even if the other one is blank. “Cross-learning” is one of the goals of this seminar.