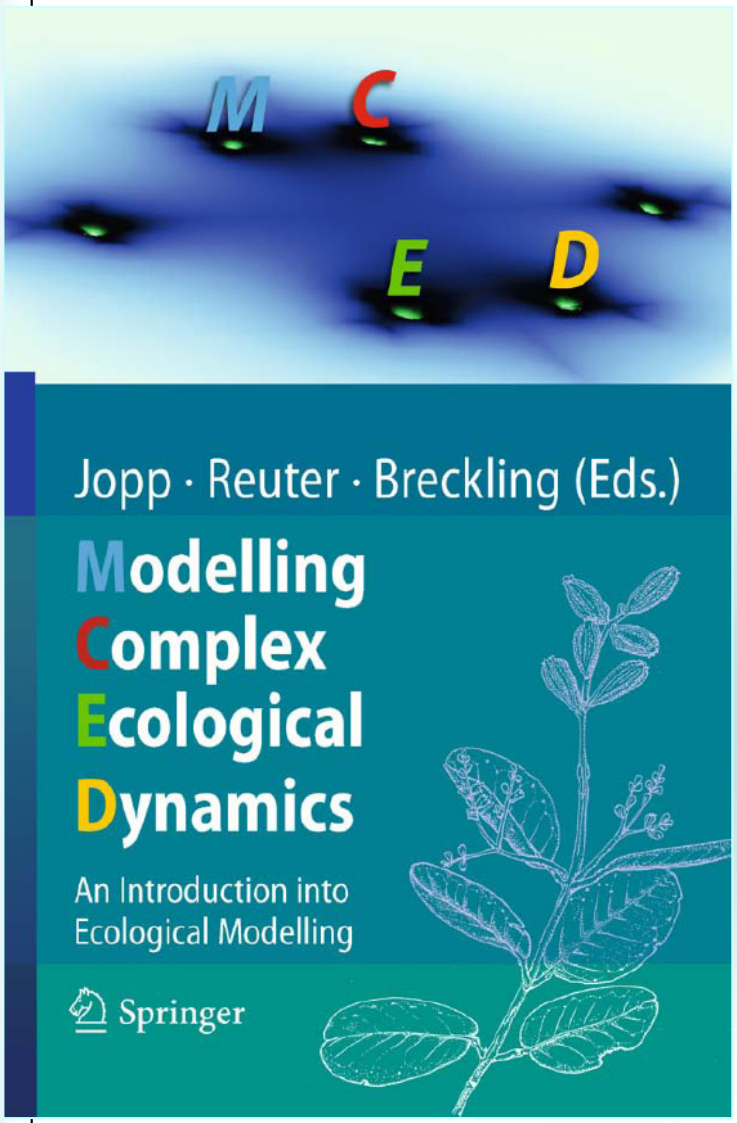
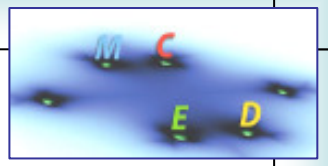
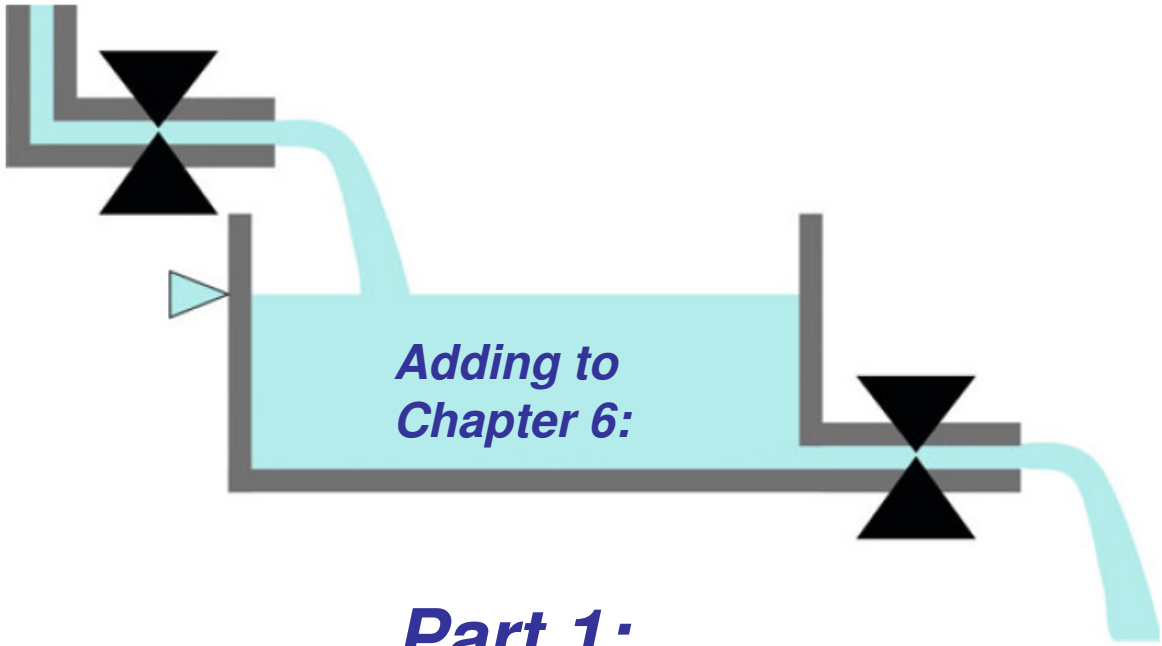


Presentation material accompanying

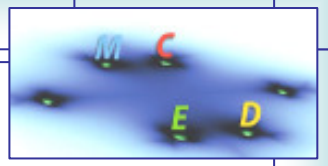
Chapter 6: Differential Equations



Modelling Complex Ecological Dynamics



Part 1:
Basic aspects of Dynamic Systems



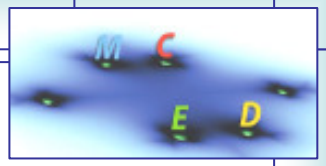
Preface

- *The presentation is free for use in non-commercial teaching context.*

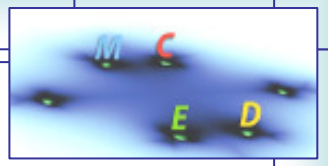
- *The content was based on lecture material developed (among others) for the course "Systems Analysis" in the Master of Science Programme "International Studies in Aquatic Tropical Ecology" at the University of Bremen during the years 1999 – 2011*

- *Because of the page restriction this presentation partially extends the content covered in MCED Chapter 6 Differential Equations.*

Broder Breckling
Hauke Reuter
Uta Berger

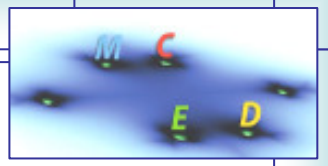


Basic aspects of Dynamic Systems



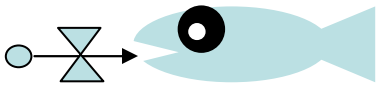
Dynamic Systems

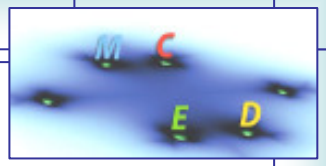
- Dynamic systems investigate the quantitative change of variables connected in a system over time.
- Discrete systems describe stepwise changes from one point in time to the next without specifying systems state between the steps.
- Continuous systems describe the development of the variables which make up the systems state in successive, infinitely small intervals covering a continuum of time



Basic Aspects of Dynamic Systems

- Dynamic systems can deal with any context expressed in formal terms of:

Elements	Flows	Relations
		
food fish (biomass)	transferred quantity	fish biomass change = function of fish and food
(what...)	(material changes...)	(when... how much…)



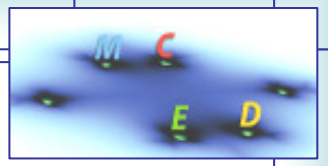
Basic Aspects of Dynamic Systems

Elements

are considered as pure quantity, as internally *homogeneous* (if this is not applicable, the entity has to be divided in sub-entities...)

- the quantities of the elements in a given point of time characterise the state of the system
- the only type of change which is considered in a dynamic system is the change of quantity of elements.

- examples
  - Chlorophyll concentration in water
  - microscopic particles suspended in a gas



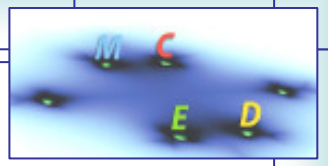
Basic Aspects of Dynamic Systems

Flows

represent changes of the quantity of elements

- inflow: an element increases in quantity
- outflow: an element decreases in quantity
- quantity can pass from one element to another.
- quantity that enters a system "from outside“ is called source
- quantity that leaves a system is called sink
- the flow-pattern represents the dynamics of the system

- examples - algal growth
  - energy exchange between the particles



Basic Aspects of Dynamic Systems

Relations

represent the causal structure of the system

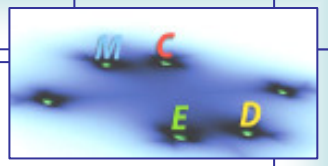
- functions which specify the flows for any given situation.

functions may have different input:

- the state of the system or parts of it
- external impact
- intermediate calculations

- examples - Logistic growth function
  - diffusion equation

autonomous system:
no relations from outside influence the system's internal state



Basic Aspects of Dynamic Systems

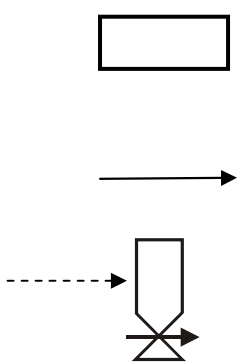
This is a flow chart representation

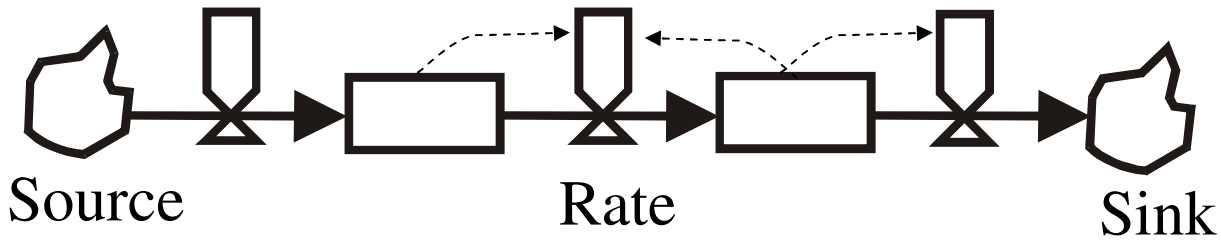
Classical system dynamics: compartment models

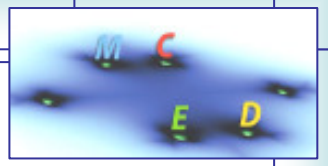
Elements ➔ **C**ompartments

Flows ➔ **C**onnections

Relations ➔ **C**ontrols





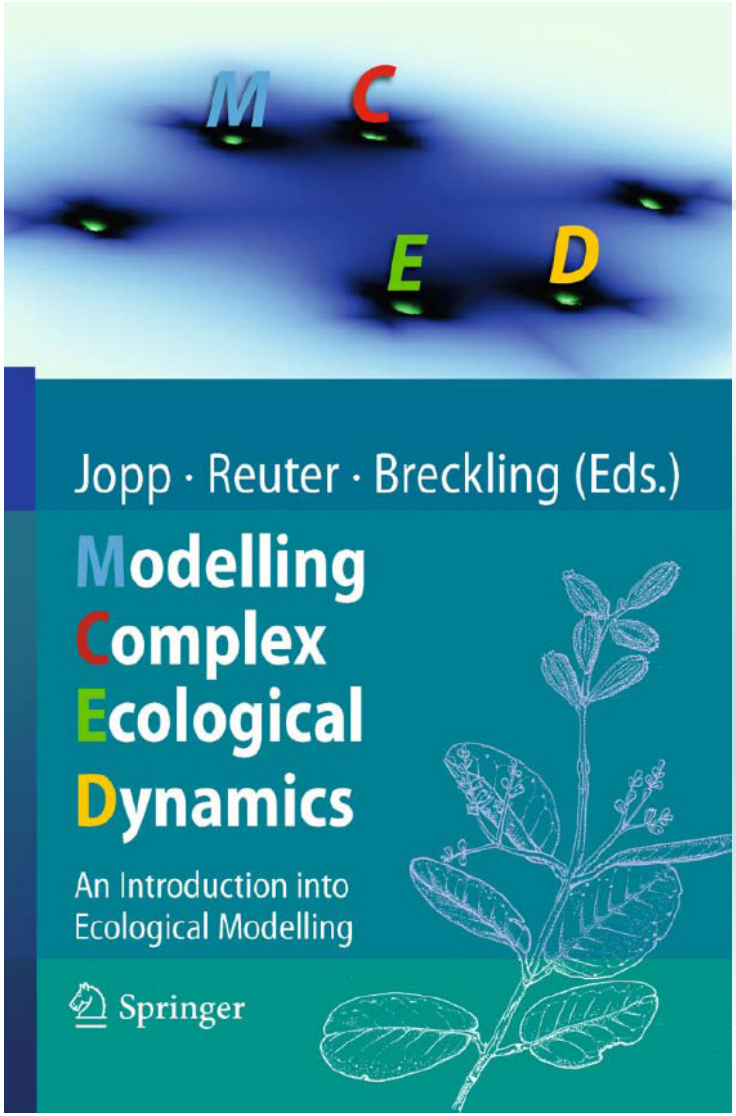


What we discuss in further details

- Part 2:
  Difference equations (discrete systems)

- Part 3:
  Differential equations (continuous systems)
  - Predator-prey modelling
  - *Exercises of models with different behaviour*

- Part 4:
  Stability considerations



This was the starter,

the fun continues

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