Mathematical models
in
environmental, crop and food sciences

STAAA

Doctoral School in Agricultural, Environmental and Food Sciences
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Models & Modelling

- Technology
- Machines & Games
- System Theory

Model Languages

- Model
- Math Formalism

PART III - Simulation

- **Programming**
- **Case studies with Matlab**

SIMULATION

SIMulate = Trying something SIMilar

What is SIMULATION for ?

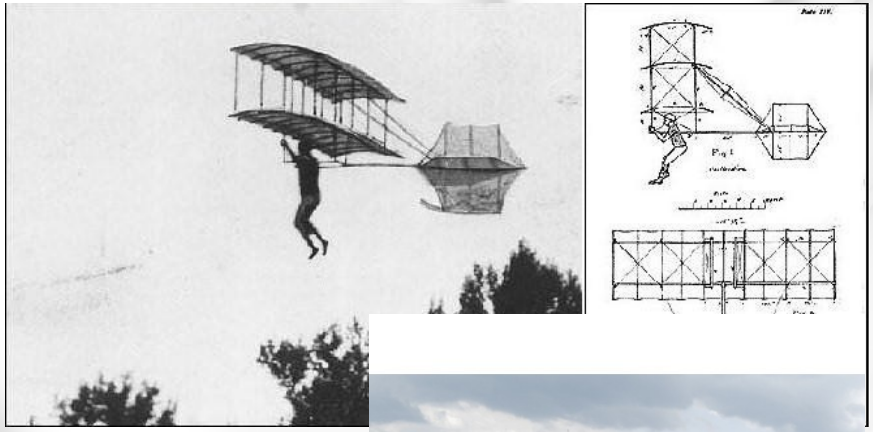
- **Looking for** NEW Solutions – Theories
- **Propose** .. an innovative control system
- **Observe** .. analize expected behavior
- **TEST** .. the response of a model
- **Evaluate NON OBSERVABLE STATE VARIABLES**

WHY SIMULATION

We ONLY learn from mistakes,

Therefore man is looking for ways to reduce risks

Octave Chanute, 1894



www.devongardenmachinery.co.uk
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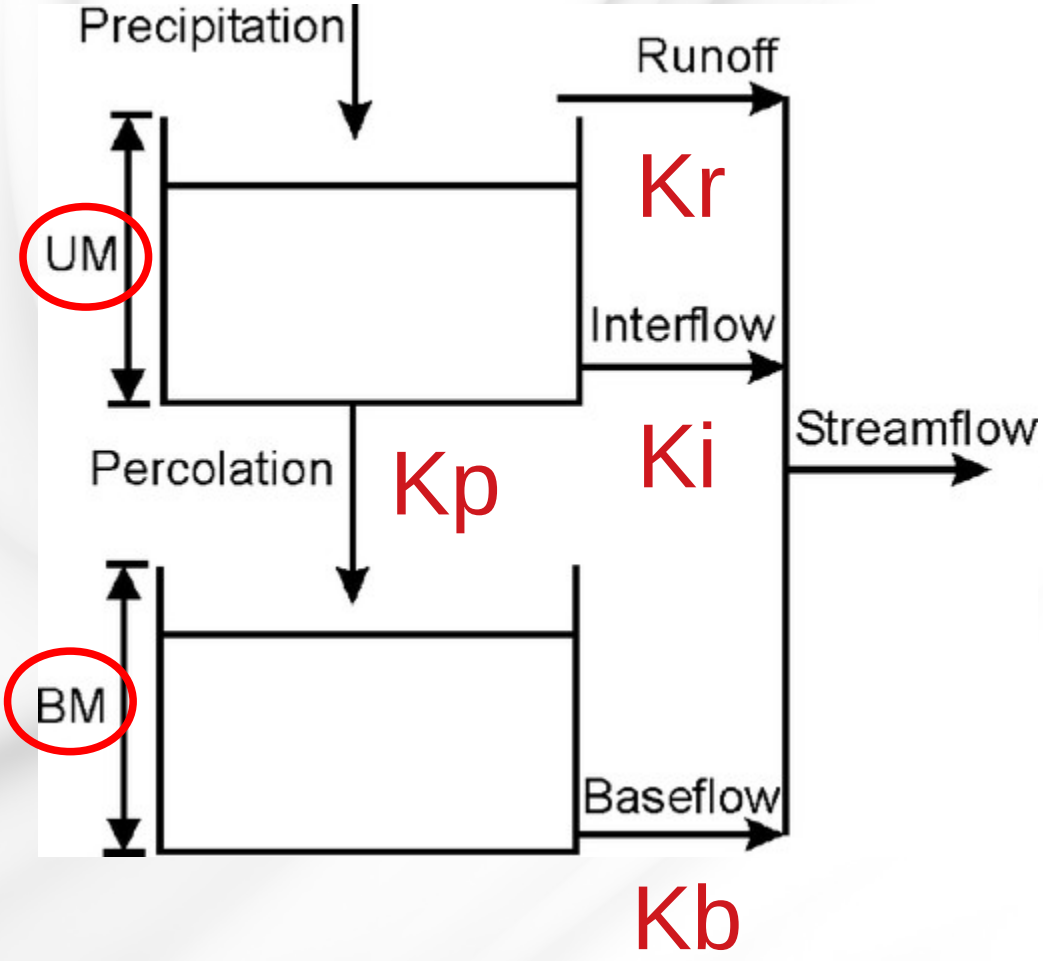
A matter of Economy
Simulation makes one spare: risks, time, cost

Inverse problems
example: the SIXPAR learning model



From **Analogic** to **Numerical** Models

- *Analogical* > Mathematical > Numerical Model
- Numerical Models are Discrete approximations of a continuous Mathematical
- Numerical Models can be solved by numerical procedures based on **solution algorithms**

Programming Languages / Code

- STATIC / Declarative
  - Formatting Languages (e.g. HTML)
  - DATA format (e.g. XLS
- Procedural Languages
  - Level / Compilability
  - Platform / Editing
  - Syntax / Library
  - Debugging / Versioning
  - **Design / Documenting**

What is a Program

A program is a procedure to be run to perform some (**repetitive**) elaboration on some data

- **Code** (=program, routines, functions)
- **Components** (libraries, modules, add-on)
- **Interfaces**
  - Data (database)
  - Network (client/serve)
  - Devices (hardware)
  - User interface (GUI)

a Program in short

A program is a set of **statements** written in a given language (**code**) including:

- Variable Type Definition and Dimensioning
- Algebraic calculations
- Writing results e.g. to disk file or **console**

Code execution is ruled by:

- **Logics (if-then-else, case)**
- **Flow Repetion (loop, while, for)**

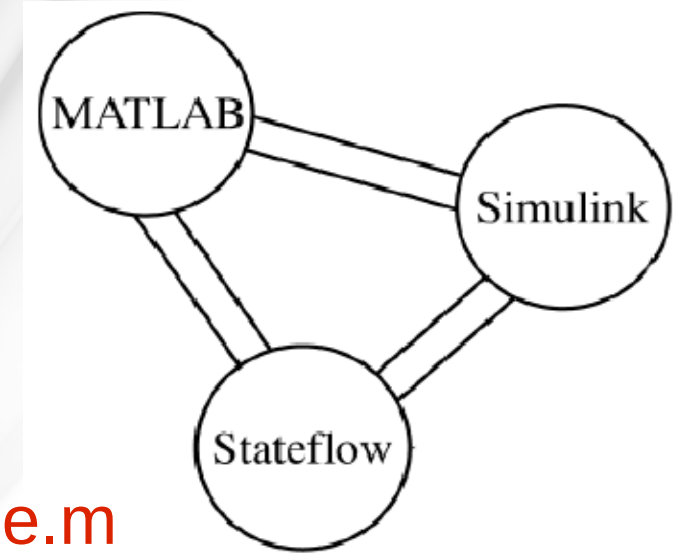
Which is the BEST language ?

- There is not a BEST language
- Each language has been designed to make easy to model some problems
- It is not possible to code EVERY problems with ONE language (easily)
- The choice of the language will be the one of your TEAM: learning (tricks, libraries) and debugging may take a long time !

Modeling process

- State the problem: **well posedeness**
- **Find similar problems**, try to write down a conceptual model, develop some diagram
- Simplifying: apply **Occam razor**
- Always check the **Diagram be CLOSED**
- **Interact with some experienced modeler** (in case enroll one in your team)
- Try to **formalize** relations by math expressions

From DIAGRAM to SIMULATION without programming !



- Portable scientific calculator
- Programming environment > file.m
- **GUIDE** a GUI development framework > file.fig
- Simulation environment: **Simulink**
- Discrete STATE simulation: **Stateflow**

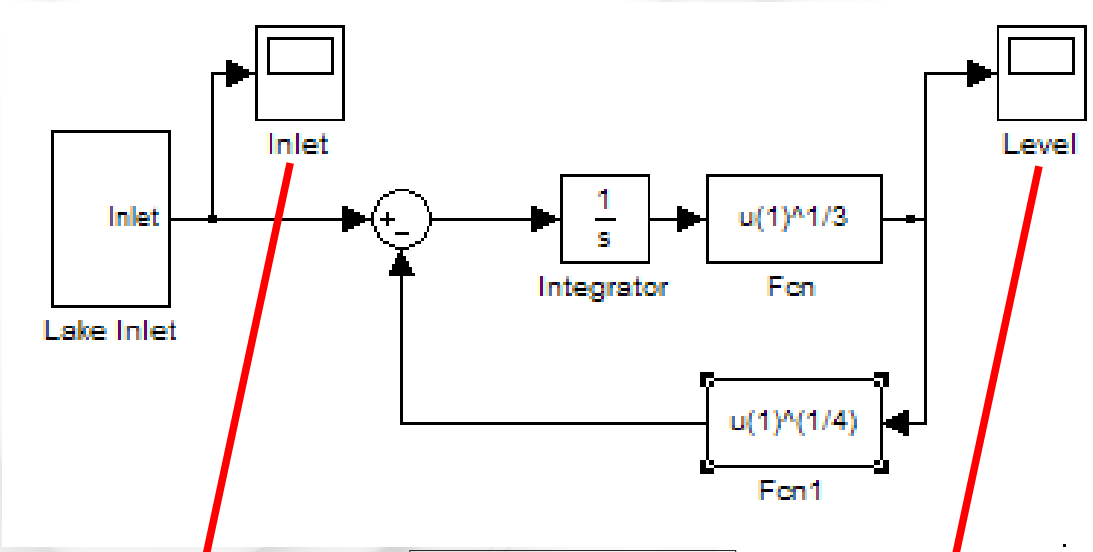
What is SIMULINK ?

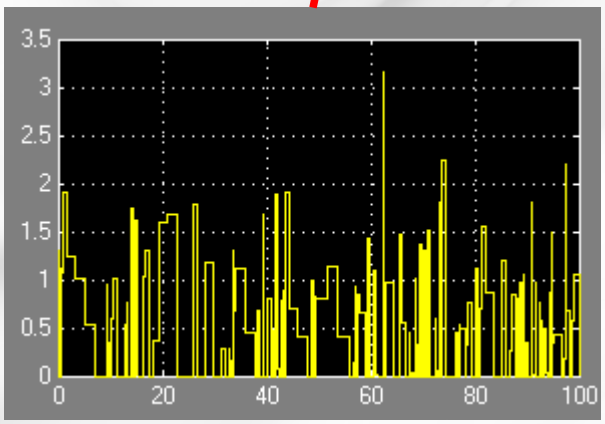
- **Dynamic simulation graphic development environment**
- Numerical SOLVER
- Oriented to Continuous Systems
- *May include STATE MACHINES (StateFlow)*
- Based on ***blocks*** and ***oriented edges***
- Does not require programming skillness
- Integrates user-defined functions or matlab routines
- ***May be integrated into Matlab Programs***
- ***May use Matlab Routines***

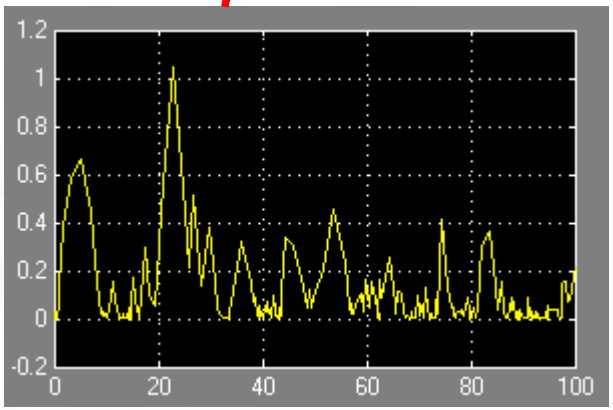
Simulink - basic blocks

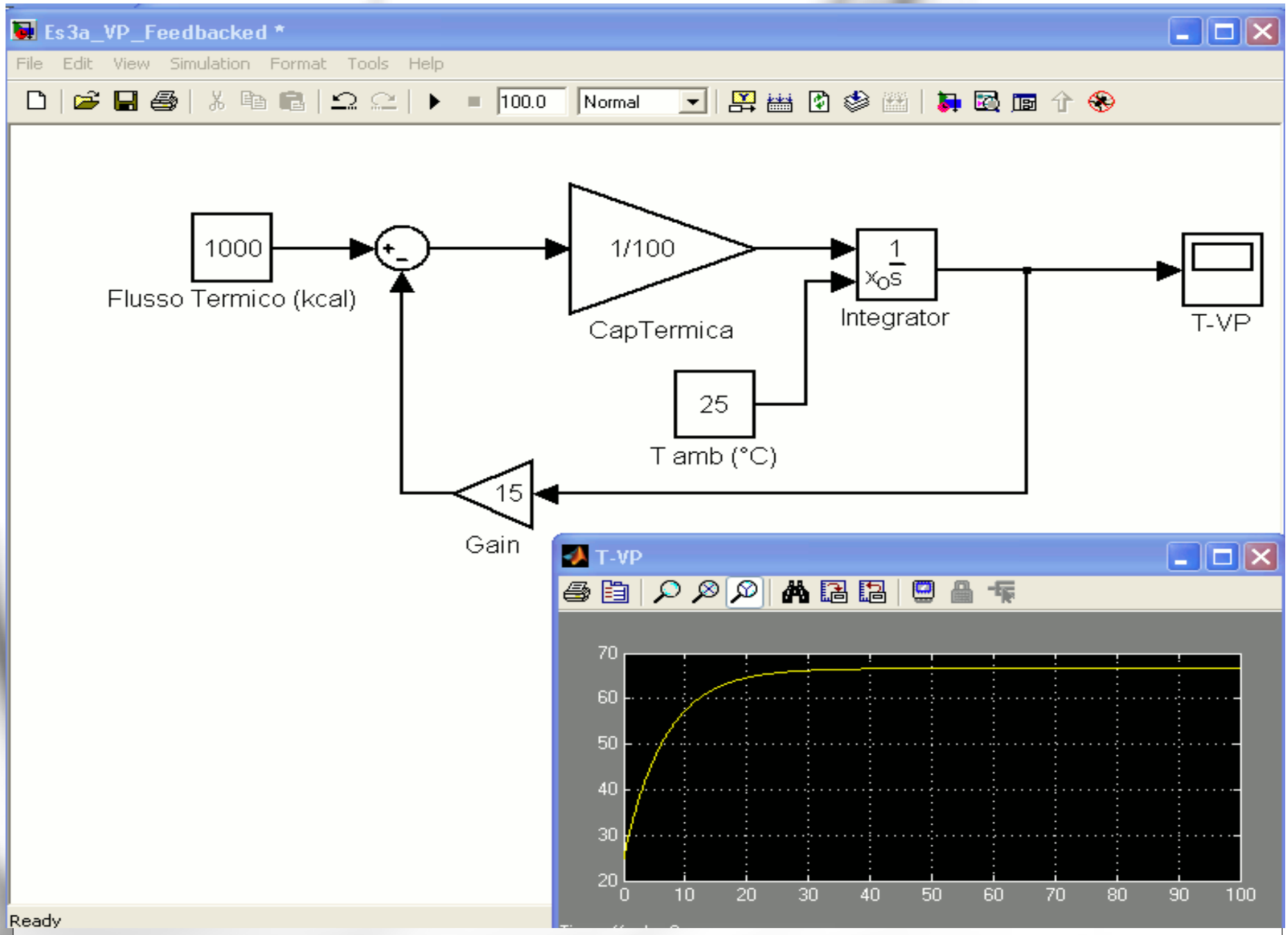
- SOURCES: outputs only
  - Constant value / parameter
  - CLOCK: time
- SINKS: input only
  - SCOPE: observer
- Operators
  - Algebraic (+,-,x,:)
  - Functions (user defined): instant output
  - Integrate / Derivative

Example 1: the LAKE system





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Ready

.. very last concepts

- simulation
- program & APP
- programming languages
- Matlab
- Simulink

CONCLUSIONS

Expected achievements

- Understand the importance of languages *of modeling*
- Understand the power of diagrams
- Understand the role of math
- Understand what system dynamics is
- Understand the role of a modeler
- Learned how to communicate with a modeler
- Get closer to modeling operativity

Thanks
for
your attention

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Case studies

- Simple programming
- Integration
- Lake w&wo outlet
- VPJ regulation vs control
- Population - Exponential
- Population – Logistic
- Population – Prey-Predator
- Crop w&wo feed-back