swarm

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Hydrological and Hydraulic Modelling

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders

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MODELLING IN WATER MANAGEMENT
&
HYDROINFORMATICS

Content

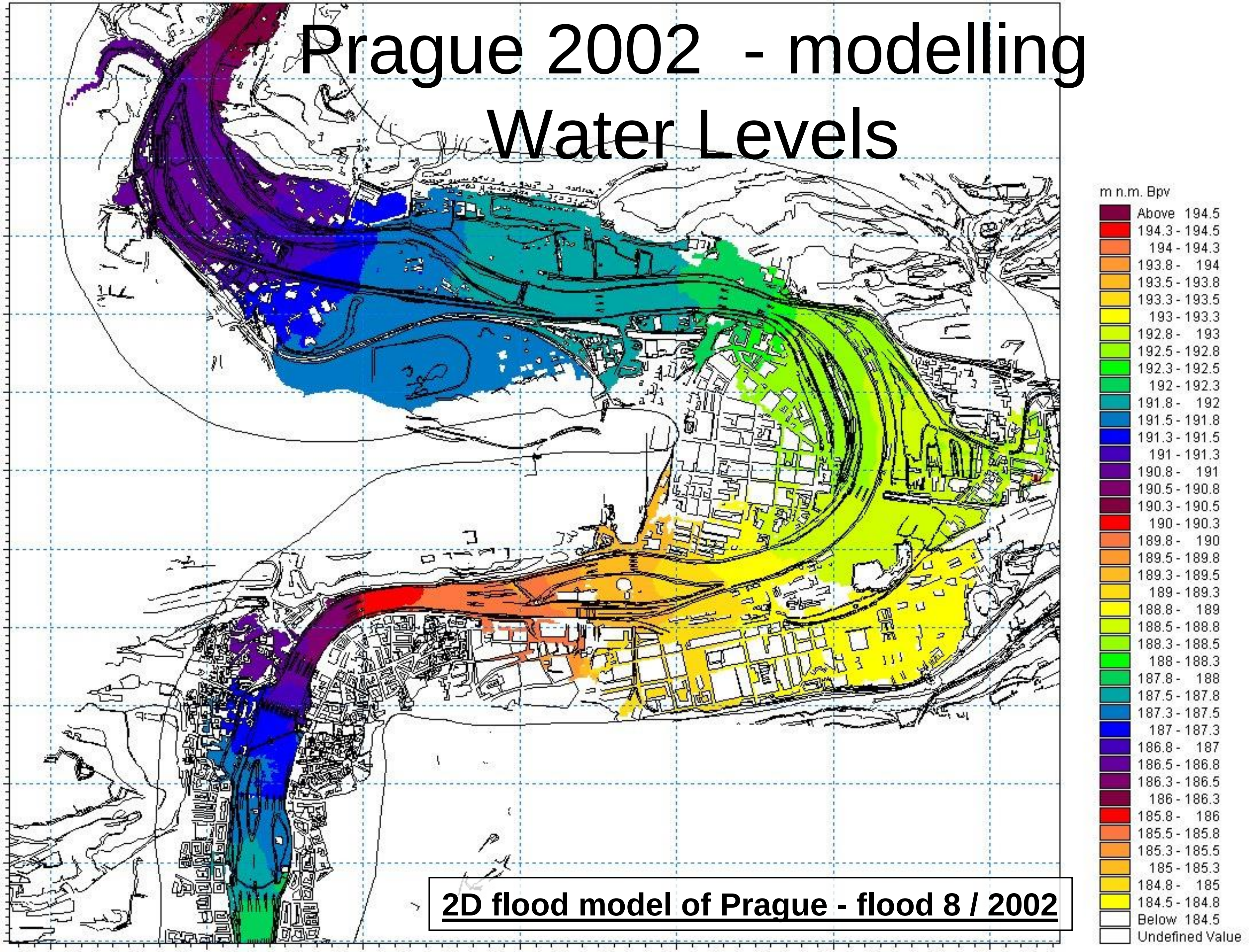
- Introduction – Hydroinformatics (HIS)
- Historical context of HIS
- Definition of Hydroinformatics
- Influence of HW and SW on development of HIS
- Simulation models – cornerstone of HIS
- Data for HIS
- Information systems and HIS
- Practical HIS - role or consultant
- Future Trends

Prague Flood in 2002

Prague Flood protection – 8/2002 – mobile flood control

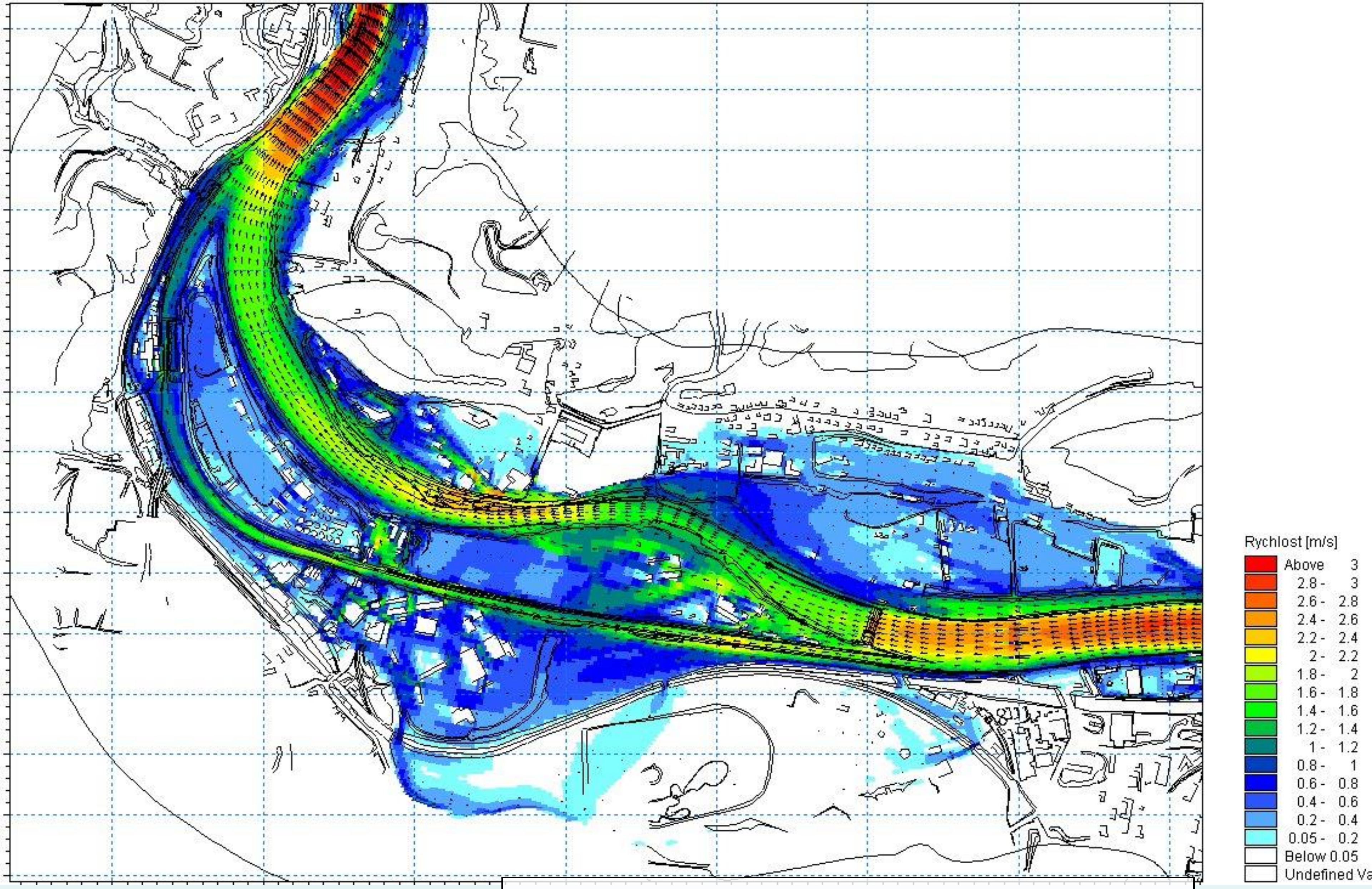
Prague Flood protection – 8/2002 – mobile flood control

Prague 2002 - modelling Water Levels



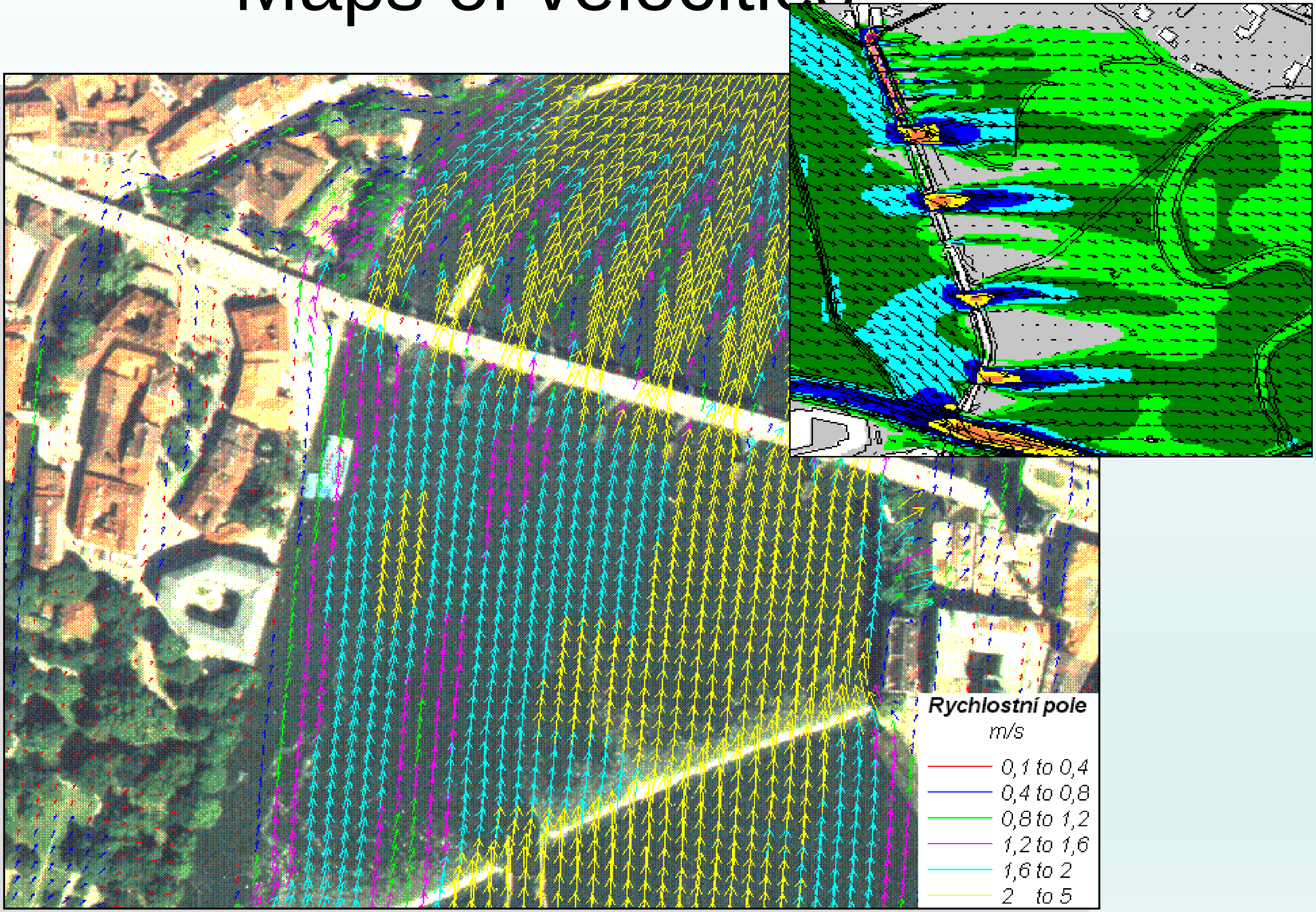
2D flood model of Prague - flood 8 / 2002

The Sample of Results - Velocities



2D flood model of Prague - flood 8 / 2002

Maps of velocities



Hydroinformatics

Definition of Hydroinformatics:

Technological discipline (Abbott 1987) integrating computationan hydraulics, Hydrology, Hydraulics, Informatics, information technologies into the framework, which affects evolutory development of society

The simulation model describing the aquatic system is a basic element of hydroinformatics.

Teoretical fundaments of Hydroinformatics

- Hydraulics (physics of aquatic systems) – long tradition – fundamental scientific discipline
- Hydrology – technological discipline
- Computational hydraulics (Abbott - 1969)
  - Def.: *scientific discipline integrating hydraulics, numerical mathematics, numerical methods and programming into unified framework*
- Informatics
- Ecology, Biology, Chemistry

Goals of Hydroinformatics

- To provide predictive tools for analysis of aquatic component of living environment
- To verify effects of interventions into ecosystems using “if-then” scenarios
- To integrate protection of living environment in the engineering business
- To provide managerial tools for complex aquatic systems
- To optimize investment policy
- To offer training “of-line” systems (operational games)
- To support other technological areas (e.g. GIS, Expert systems, DSS)
- To provide foundation for legislations
- To optimize engineering design work

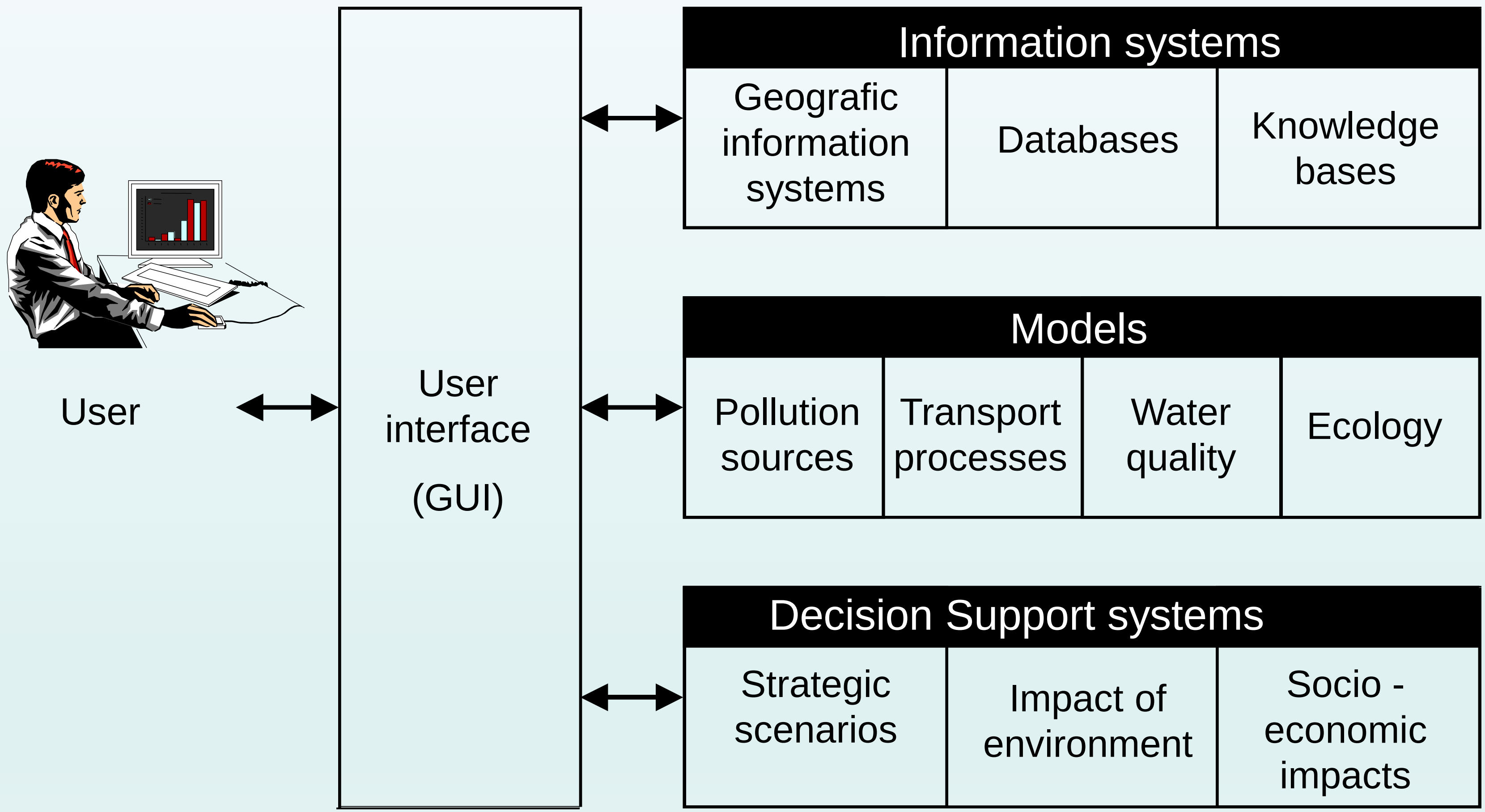
Hydroinformatic system (HIS)

Set of interconnected tools acting as one unified system and comprising substantial volume of information and knowledge in digital form originating mainly from

- hydraulics
- hydrology
- results of applied research
- area of law and legislation
- area of social and economic espects
- protection of environment (EIA)
- informatics
- data collection and monitoring

Hydroinformatic System (HIS) = Decision Support System (DSS)

Hydroinformatic System (HIS)



Conditions for Formation of Hydroinformatics

- Development of computational hydraulics-simulation models
- Foundation of information technology
- Trend for management of complex systems
- Development of data acquisition, monitoring and methods for data collection and analysis
- Need for communication among distinct scientific and engineering disciplines
- Need for presentation technologies (animations)
- Impacts of personalities (Abbott, Cunge, Ionescu, Price, aj.)
- Effects of institutions (NHL, DHI, DH, Hr, IAHR, IAHS)

Historical development of HIS

- Hardware development – personal computers
  - 1980 - IBM PC
  - ..
  - ..
  - 2005 – Intel = 2 Core processors

- Software development
  - operational systems (unification)
  - application software -(text editors, tabular processors, graphical modules)
  - specialized SW - simulation models
  - standard databases connected to GUI
  - existence systémů grafické podpory

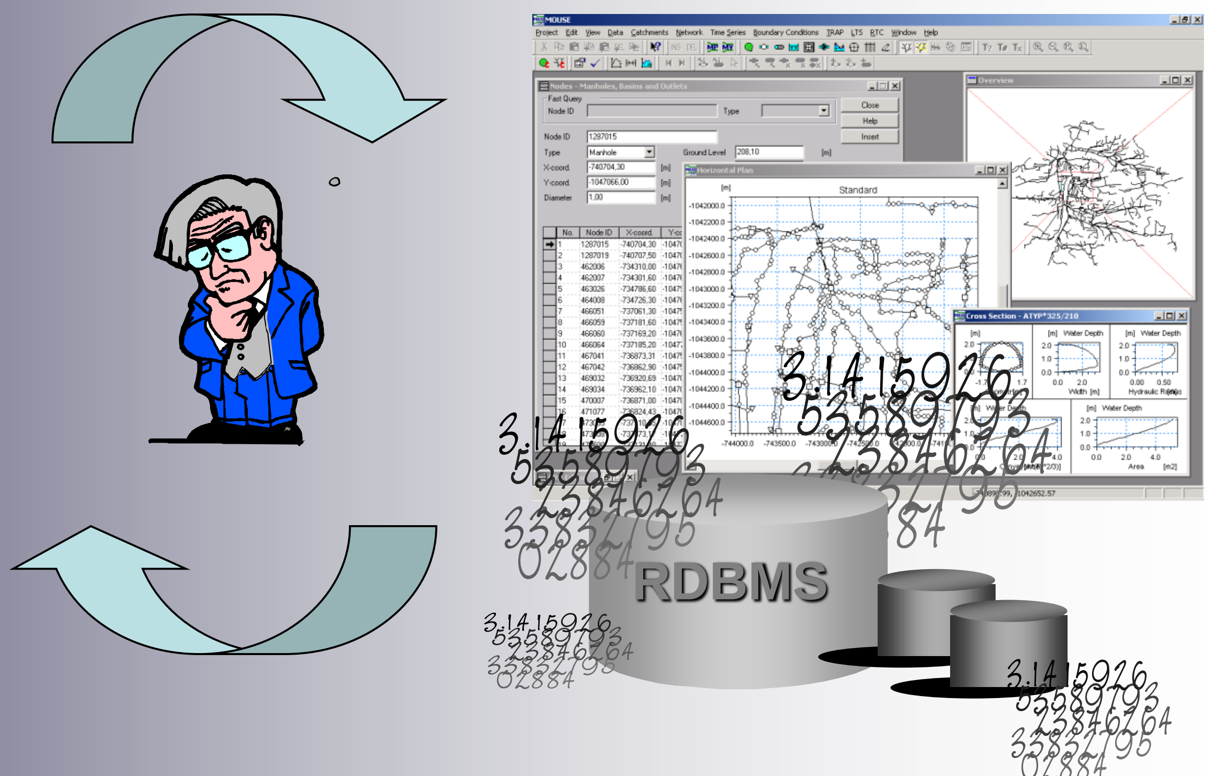
- Increasing use of simulation models in practical engineering life

Historical development of HIC

Generations of simulation tools

- 1.generation - calculation of formulas - analog
- 2.generation - one-off models 60s, big labs
- 3.generation – more general matematical models – 70s, variability of inputs
- 4.generation - menu-driven system technology based on PC, DOS, weak graphics, low standardization – 80s – 90s
- 5.generation - today UNIX x WINDOWS, DB, quality graphics, GIS, server client
- 6. generation - future (KBS, UI), RTC, max safety, ?

Simulation model
the Core of HIS system



Simulation - modelling

Models are tools able to simulate long term behaviour of physical system by means of interpretation of dominant proccesses

- **Conceptual Models**

  Application of concept, that substitute for natural process (nonlinear reservoir)

- **Deterministic Models**

  Mathematical solution of differential equations describing the natural process (hydrodynamic equations, continuity equation)

- **Stochastic models**

  Based on solution of natural processes by means of statistical methods

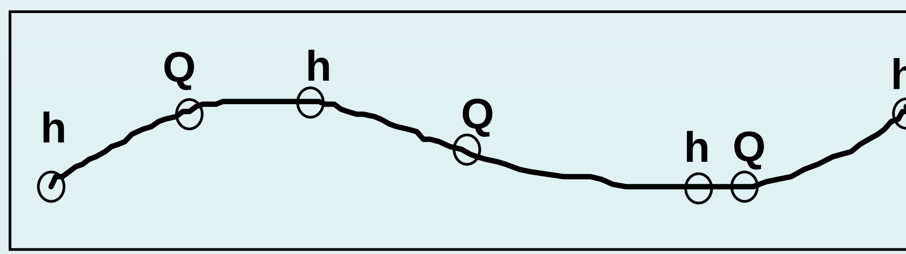
Deterministic Simulation Models

- „digital copy“ of a physical system (1, 2, 3D)
- simulation of physical processes important for the for the studied phenomena (non – stationarity, dynamics, continuity)

$$\frac{\partial Q}{\partial t} + \frac{\partial\left(\frac{Q^2}{A}\right)}{\partial x} + gA\frac{\partial y}{\partial x} + gAi_E = gAi_0$$

$$\frac{\partial Q}{\partial x} + b_x \frac{\partial H}{\partial x} = 0$$

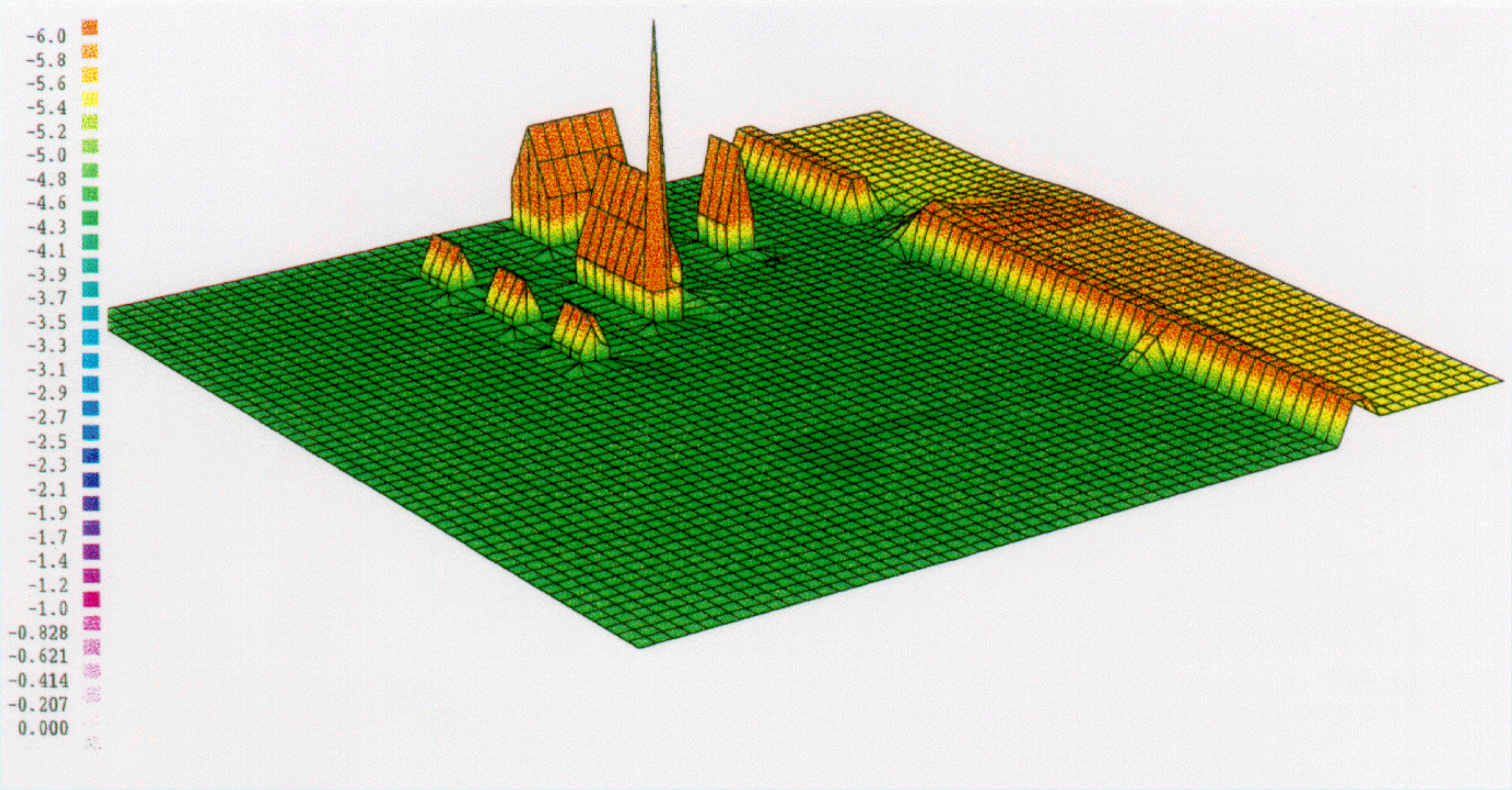
- the same response to outer impuls like in nature
- difficult to obtain input data



Forecasts:

„What happens, when......“

Simulation Model like virtual reality



Simulation models

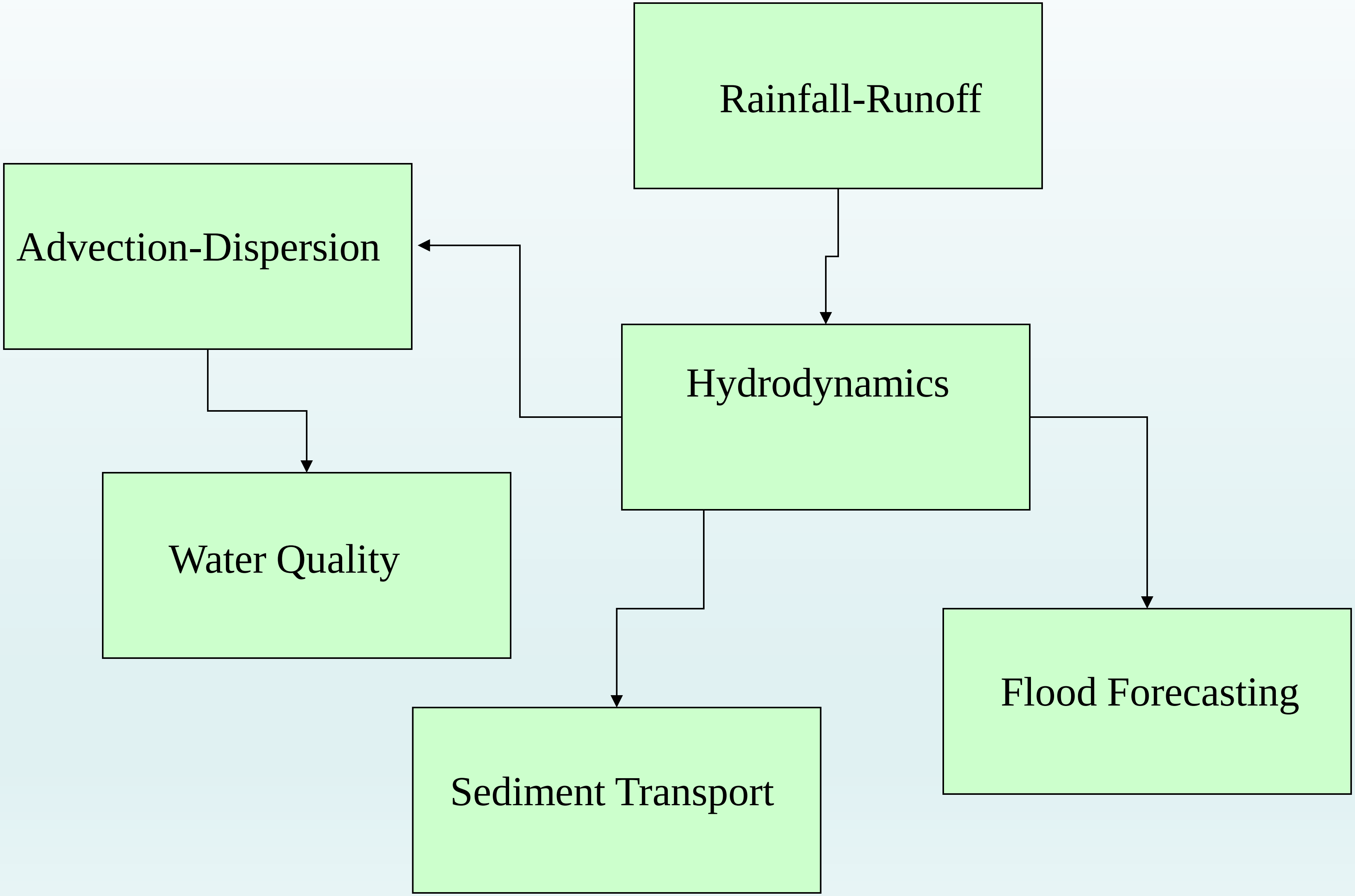
Definition

- program (digital code)
- model (tool for user able to simulate reality)
- matematical model x physical model
- simulation tool

Model build :

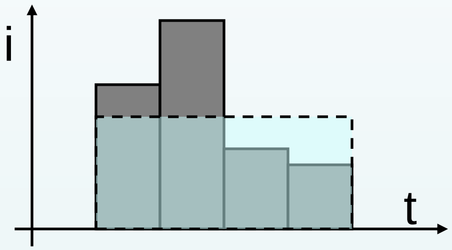
- 1. problem definition
- 2. schematization (space and time)
- 3. governing equations
- 4. dependend, independent variables
- 5. empirical and complementary formula
- 6. algoritmization of task
- 7. boundary and initial conditions
- 8. calibration
- 9. verification
- 10. simulation

Modular structure of simulation model

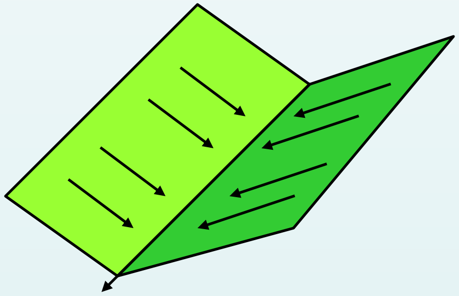


Rainfall-runoff processes

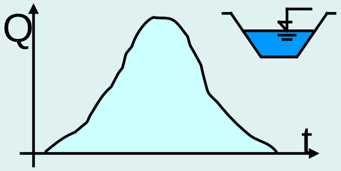
Precipitation



River Catchment

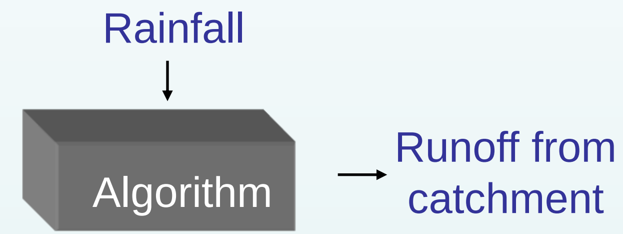


Receiving water

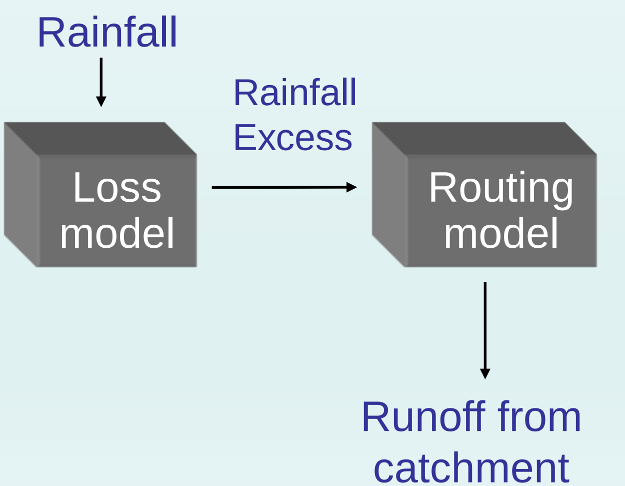


Rainfall-Runoff Processes

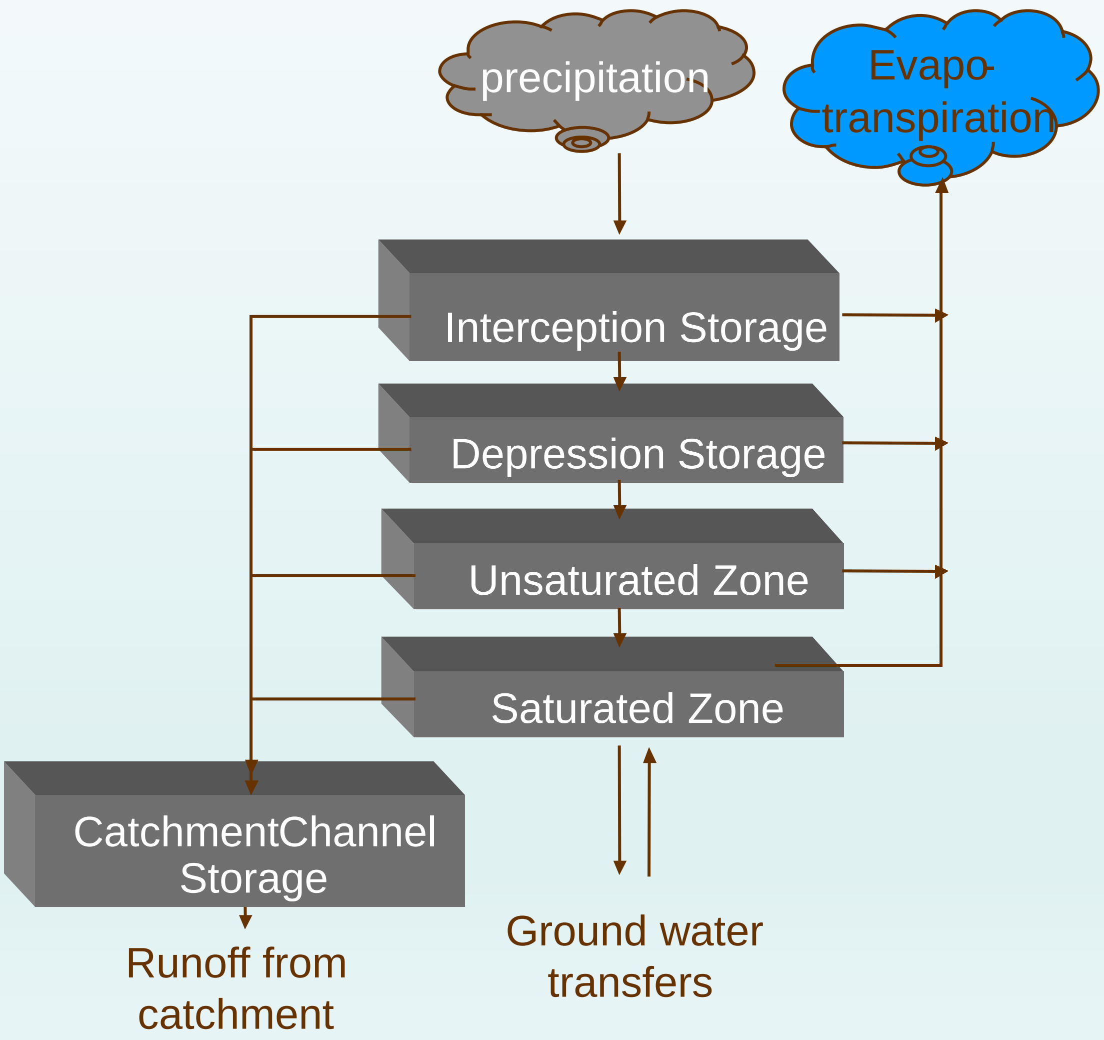
„Black Box“ models



Loss-routing models



Physical process models



Hydrodynamic Processes

- System description
  - Looped network (1D, 1D+)
  - 2D horizontal mesh
- Hydraulic phenomena
  - Backwater effects
  - Flood Routing
  - Wave propagation
  - Energy dissipation
- Hydraulic Structures
  - Weirs
  - Culverts
  - Bridges
  - Regulation
  - Gates
  - Pumping
  - Control Structures
  - Dambreak Failures