O P E N R S C E W O P P O R T U N I T G

Summer School

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Partners Contribution

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Lectures 1-4: Problem Analysis & Project Definition / Data Collection & Data Preparation

- Lecture 1: A review of methods and tools of geoinformation science and technology
- Preparing for the hands-on exercise 1: Theories, techniques and tools
- Hands-on exercise 1: Catchment delineation and stream network: from raster DEM to a geospatial database
- Lecture 2: Geospatial problems with a focus on water and environment
- Lecture 3: Coupling GIS-T tools and methods with environmental models
- Lecture 4: Geospatial environmental information systems: approaches and architectures
- Preparing for the hands-on exercise 2: Theories, techniques and tools
- Hands-on exercise 2: Processing terrain data: from lidar data to a raster DEM

Materials

- http://www.geoinformatics.fi/Girona/
  - These slides
  - Exercise handouts
  - Chapter 10 of Environmental modelling, software and decision support (Elsevier: Developments in integrated environmental assessment) *(please, do not distribute!)*
- Computational methods for water resource assessments – an exercise kit
  - http://www.iemss.org → Books

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Lecture 1: A review of methods and tools of geoinformation science and technology

- Geographic problems
- Geographic information
- FOSS technology for solving geographic problems

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Geoinformation science?

- What is science?
  - "*systematic enterprise of gathering knowledge about the world and organizing and condensing that knowledge into testable laws and theories*" (Wikipedia)
- What is information?
  - "*information has many meanings, it is closely related to notions of constraint, communication, control, form, instruction, knowledge, meaning, mental stimulus, pattern, perception, and representation*" (Wikipedia)

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Geographic problems

- Problems related to location, route, area
  - (Simple) planning problems
- Problems related to spatial interactions
- Spatial decision making problems
- Technological problems
  - Problems of obtaining, managing and exploiting geographic or spatial information
  - Problems of coupling geospatial software with other software

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Geospatial problems

- The presentation problem
  - How to render effective maps?
- The interaction problem
  - How to elicit geospatial data?
  - How to provide planning or decision support?
- The modeling problem
  - How to arrange the geoinformation
  - How to describe the processes
  - How to describe the management/planning problem
- The development problem
  - Which tools to use?

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Modeling of geoinformation: fields

- Two types of things: all-present (fields) and discrete objects (features or events)
  - Concept of *density* sometimes links these: objects per area
- Field has a value at every location
  - For example terrain has an elevation at each point
- Value is nominal, ordinal, interval, ratio, ratio or cyclic
  - This applies to values of attributes of objects too!

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Modeling of geoinformation: objects

- Object is something, which has a location, well-defined boundaries, and attributes
- Classification of objects
  - For example buildings: by function, by age, by building material, …
- Relationships between classes
  - is_a or inheritance
  - a_part_of or composition
- Attributes of a class have values
- Object have spatial relationships with other objects

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Modeling of geoinformation: processes

- What is a process?
- What kind of information do we have of spatial processes?
- Spatial correlation and autocorrelation
  - s. autocorrelation = cross-correlation of a field with itself
- Spatial cause-effect relationships
- The effect of scale
- Spatial simulation models
  - Simulation of flow, movement, interaction, ...

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Method families for spatial analysis

- Spatial relationships and operations for geometries
- Searches of features based on spatial and non-spatial predicates
- Statistical methods for description and modeling of spatial data (usually points)
- Terrain analysis methods for hydrology, visibility, soil mechanics, etc
- Search methods for solutions to network problems (routing, capacity, location – allocation, …)
- Methods based on modeling, AI techniques, etc

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The FOSS4G stack

- Modelling and data analysis tools
- Web mapping applications
- Desktop applications
- Document serving
- Data management, serving, processing and integration
- System software

FOSS4G opportunities for research

- What kind of research?
- Use the FOSS and FOSS4G stack
- Collaborate
- Contribute

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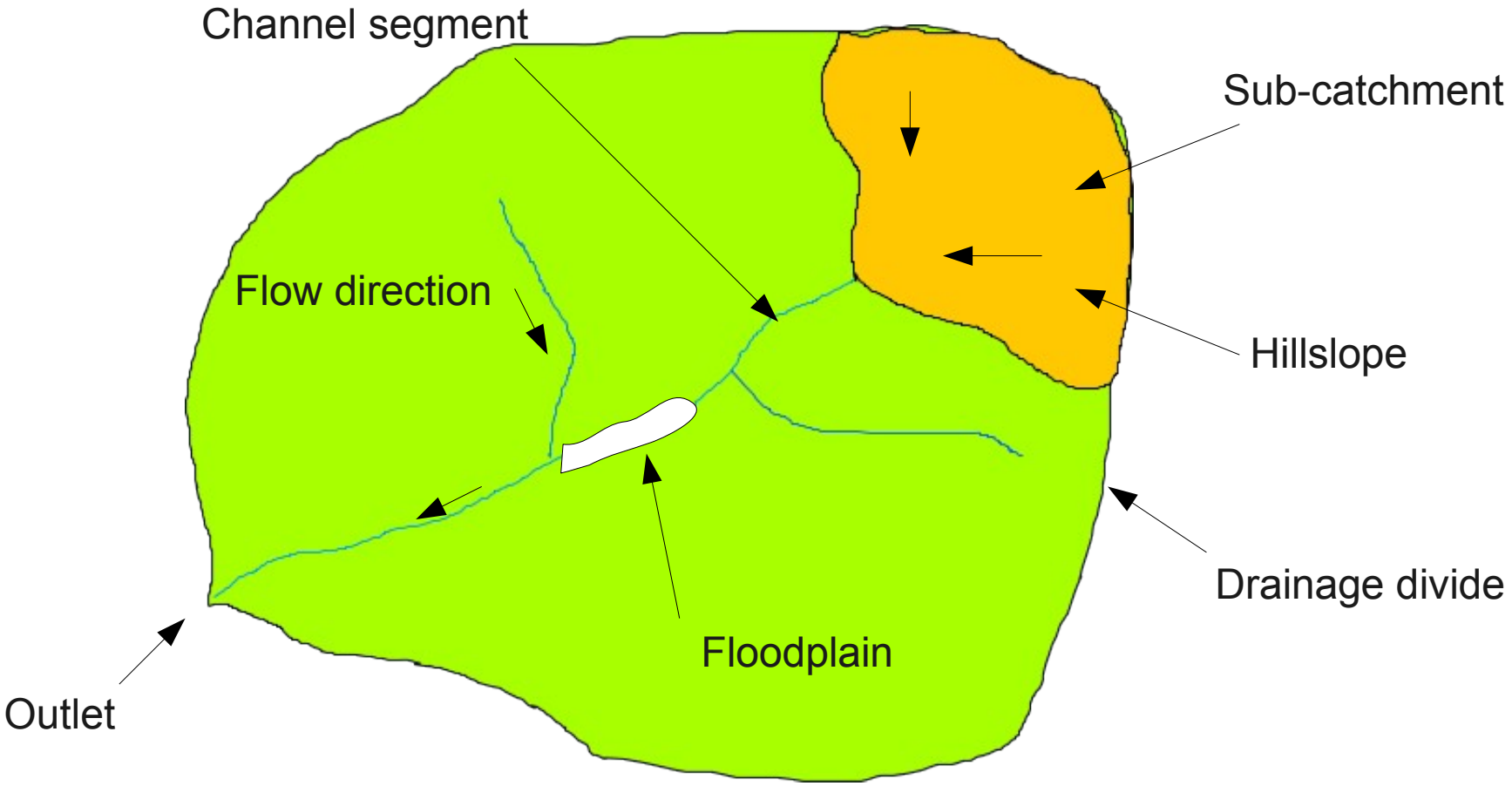
Hands-on exercise 1: Catchment delineation and stream network: from raster DEM to a geospatial database

- Space in hydrological and hydraulic models

Spatial division of a catchment



Space in hydrological simulation models

- Lumped models
  - Catchment as one point
- Semi-distributed models
  - Identification of hydrologically similar areas within catchments
- Distributed models
  - Catchment discretized with a mesh

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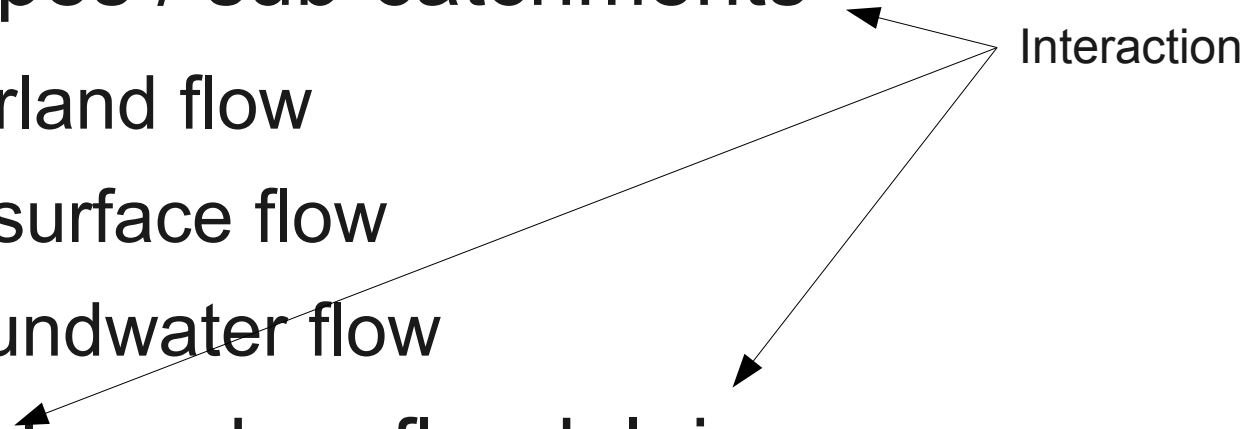
Routing of water

- On hillslopes / sub-catchments
  - Overland flow
  - Subsurface flow
  - Groundwater flow
- In channels and on floodplains
- Problems/issues: flooding, water quality and transport of pollutants, stream and riparian ecology, erosion, etc.



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Hydraulic modeling

- Division of the stream into segments and cross-sections
- Simulation of a steady-state situation
  - Interest for example: Water quality during a low flow situation
  - Task: map the WQ conditions in the stream network
- Simulation of dynamic events
  - Interest for example: Flood mapping
  - Task: map the flooded area in different situations

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The Geoinformatica stack

- GTK+ dialogs for geolayers and geoprocessing
- GTK+ windowing toolkit
- Perl modules for geodata
- Perl
- Libral
- GDAL and OGR
- GEOS
- Geodata access and storage tools and libraries

Lecture 2: Geospatial problems with a focus on water and environment

- Problem classes

Classes of problems

- Environmental Impact Assessment (EIA)
- Management of development (sustainable development)
- Planning
- Risk Management

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Impact assessments

- Association for Impact Assessment (IAIA) defines an environmental impact assessment as "*the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made.*"
- EIA is an ex ante (before the event) method. Two approaches exist, either there is
  - spatial coexistence, or
  - spatial transport mechanism
- between the source and the receptor. Ex ante methods rely on predictive models. Ex post methods rely on empirical modeling of observation data.

Sustainable development

- development that "*meets the needs of the present without compromising the ability of future generations to meet their own needs.*"
- Balance the needs of the environment, economics, and societies
  - What are the requirements for natural resources (food, habitat, water, ...) of biological species?

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Planning

- Planning = creating and maintaining a procedure to achieve an objective
- A sequence of concrete, specific actions
  - What, when, where: location, routing, land use
- Often using template designs
- Dimensioning
  - How large: min, max, average flow
  - How much: space needed, required abatement of pollutants

Risk management

- Risk is defined in ISO 31000 as *the effect of uncertainty on objectives* (whether positive or negative)
- Identification, assessment, and prioritization of risks
- Coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events

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Lecture 3: Coupling GIS-T tools and methods with environmental models

- Aims of integration
- Technologies of coupling

Aims of Integration

- GIS
  - Spatial data management
  - Geoprocessing
  - Cartographic visualization
- Environmental Modelling, Assessment, Decision Support
  - Simulation, Prediction, Exploratory analysis, Communication, Learning, Risk analysis, Policy setting, ...

Basic technologies of coupling

- Data transfer
  - Shared data formats (ASCII, Shapefiles)
    - Import and export
  - Shared data frameworks (XML, namespaces)
    - Some shared schemas
- Sharing of data
  - Agreed-upon data formats
  - Use of same data repository
- Embedding
  - Model or tool implemented as an extension to GIS or vice versa

FOSS4G opportunities for coupling

- Exploit FOSS4G components
- Extend
- Use standards

Lecture 4: Geospatial environmental information systems: approaches and architectures

- Design philosophies
- Development philosophies
- Technologies: from desktop to web-based to mobile
- The case of Decision Support Systems

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Starting points for information system design

- **The existing system**: Systems analysis to find out
- **Workflow**: What steps, what data/documents in, what out
- **Use cases**: Users and tasks
- **User**: The interface of the system: end-user needs, wants and limitations
- **Requirements**: Analysis of user requirements, which are about the application domain (not the system or its interface)
- **It can be done**: New technology has become available
- ...

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Design philosophies

- KISS (think about Occam's razor)
- TIMTOWDI (let the users be creative … compare to the zen of Python)
- Unix: “Write programs that do one thing and do it well. Write programs to work together. Write programs to handle text streams, because that is a universal interface.”
- Use and User Centered Design
- Apple: Don't follow your customers; lead them. Temper engineering with Art.

Development philosophies

- Eric S. Raymond: The Cathedral and the Bazaar
- Agile methods (focus on individuals and interaction, working code, collaboration with users, responding to change)

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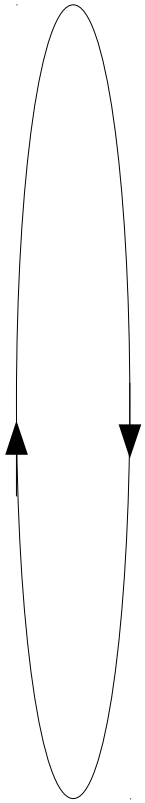
The analytical process

1. Problem formulation
2. Planning: what data? what kind of analysis?
3. Data gathering
4. Exploratory analysis
5. Hypothesis formulation
6. Modeling and testing
7. Consultation and review
8. Reporting and implementation



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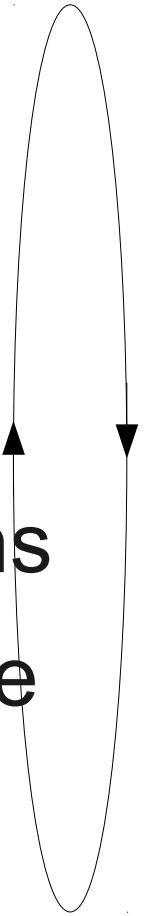
The decision making process

1. Problem formulation
2. Define requirements for a solution
3. Define goals for solutions
4. Develop alternative solutions
5. Develop criteria for comparing solutions
6. Apply a methodology for comparing the solutions
7. Implement and check



Hands-on exercise 1: Processing terrain data: from lidar data to a raster DEM

- Theories, techniques and tools