RIVER BASIN EROSION

Course: 102-0287-00L
Instructor: Peter Molnar
Credits: 3 ECTS (14 weeks)
Semester: Autumn
Programme: Master in Environmental Engineering
Language: English

Thursday 13:45-15:30, HIL E 6 (Hönggerberg Campus)

Course Moodle (NETHZ only):
https://moodle-app2.let.ethz.ch/course/view.php?id=23826
Instructor webpage:
http://www.hyd.ifu.ethz.ch/the-group/people/person-detail.html?persid=100330
Video recording (NETHZ only):
https://www.video.ethz.ch/lectures/d-baug/2024/autumn/102-0287-00L.html

DESCRIPTION

The course presents *hydrological and sedimentological processes* acting on and shaping the river basin. The river basin and the fluvial system it creates, is viewed in terms of the production of sediment on hillslopes, transfer pathways to channels, the topology of river networks, and fluvial processes in channels, the riparian zone, and floodplain, with river basin water and sediment management implications in mind. The scales addressed are hillslope to catchment scales. The course has *two fundamental aims*: (a) to provide future environmental engineers with a process understanding of river basin change, understanding where and when sediment is produced; and (b) to provide quantitative skills in making simple and more complex predictions of sediment fluxes and changes using a range of models (from landscape evolution models to state-of-the-art physically-based spatially distributed approaches) and observations.

The course *consists of five main sections*: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including connectivity and timescales of change, and climatic and human activities acting on the system. (2) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, mass events such as landsliding, and the modelling of the individual processes involved from landscape evolution models (LEMs), to soil loss estimates by versions of the USLE method, to hillslope scale physically-based erosion modelling (Topkapi-ETH-sed). (3) Defining catchment sediment budgets, methods to measure the terms, and examples of sediment cascade models and their application, including climate change impact assessment. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, basics of riparian vegetation structure on floodplains. (5) Overview of river basin sediment management options, contrasting local and catchment-scale actions, with some examples.

River Basin Erosion is a course in the Master of Science in Environmental Engineering programme at ETH Zürich. Also Environmental Sciences and Earth Sciences students may find sections on the analytical/modelling parts in the course useful and complementary to their study program. The level is not explicitely intended for PhD students unless they are beginners in the field. The course materials consist of a series of lectures and exercises on alpine catchments, using current research. The course is continuously developing and changing as new scientific advancements are made.

CONTENT

1. Fluvial systems, forms and processes
   - elements of the fluvial system
   - geomorphic concepts of landscape change (equilibrium, thresholds, SOC, optimality)
   - landscape connectivity and coupling, timescales of response
   - soil formation, long-term soil balance
   - human impacts, the global effect of dams on sediment fluxes

2. Drainage basin sediment production (hillslope erosion and landslides)
   - principles of sediment transport on slopes
   - detachment and transport-limited approaches
   - physical properties of water and sediment
   - landscape evolution modelling (SOC, TTLEM, slope-area diagram)
   - dariange basin sediment production (sheet-rill-gully erosion)
   - the Universal Soil Loss concept (USLE, RUSLE)
   - physically-based soil erosion modelling (Kineros)
   - spatial sediment transport modelling (TOPKAPI-ETH-sed)
   - hillslope hydrology (infiltration and saturation excess mechanisms)
   - the soil-topographic index
   - landslides (classification, prediction), the infinite slope model
   - modelling landslide susceptibility (TRIGRS, SINMAP)
   - uncertainty analysis in landslide modelling (validation and accuracy statistics)

3. Sediment budgets
   - development of a conceptual sediment budget
   - measurement of sediment budget terms
   - examples of sediment trapping, indirect measurement, sediment fingerprinting, DoDs
   - the sediment cascade concept (SedCas), explanation of model concept
   - application to Illgraben and climate change and sampling uncertainty

4. The river, floodplain and riparian zone
   - river network topology (morphological and fractal descriptors)
   - hydraulic geometry (at a station, downstream)
   - methods for deriving channel-forming flow
   - natural flow and floodplain ecosystems
   - riparian vegetation dynamics (floodplain structure, drivers of spatial patterns)

5. Concepts of river basin management
   - sediment disturbance
   - local and catchment actions, examples

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RIVER BASIN EROSION – COURSE SCHEDULE 2024

Date	Topic	Instructor/s
19.9.	Lecture 1: Introduction into course. Elements of the fluvial system. Geomorphic concepts of landscape change (equilibrium, thresholds, SOC, optimality).	PM
26.9.	Lecture 2: River basin connectivity, disturbance and response times. Soil process rates (production, erosion, yield). Tolerable soil loss. The human role in sediment fluxes.	PM
3.10.	Lecture 3: The soil-hillslope evolution model equation. Detachment and transport capacity limitations. Hydraulic variables describing overland flow. **PRESENTATION OF PROJECT TASKS (45 mins)**	PM+SD+LA
10.10.	Lecture 3: Landscape evolution models. The slope-area diagram and longitudinal river profiles. Examples of simulations for check dam removal.	PM
17.10.	Lecture 4: River basin sediment production. The RUSLE concept. The flow path concept. Examples of Swiss, EU and global estimates of soil loss.	PM
24.10.	Lecture 5: Hillslope erosion modelling: planar models, 2d models. Use of physically-based models (Topkapi-ETH-sed) for sediment source tracing. **PROJECT PROGRESS PRESENTATIONS DAY 1 (45 mins)**	PM+SD+LA
31.10.	Lecture 6: Landslides as sediment sources. The infinite slope model. SINMAP. Validation of spatial predictions. Rainfall intensity-duration curves for mass movements.	PM
7.11.	Lecture 7: Sediment budgets and measurement methods: sediment trapping, indirect measurement, fingerprinting, river monitoring, DoDs.	PM
14.11.	Lecture 7: The sediment hillslope-channel cascade. Simulation example. Climate change impact analysis. Partitioning uncertainty. **PROJECT PROGRESS PRESENTATIONS DAY 2 (45 mins)**	PM+SD+LA
21.11.	Lecture 8: The river network. Morphological and fractal descriptors of river networks. Channel geometry. Channel-forming flow. River planform.	PM
28.11.	Lecture 9: Floodplains and riparian ecosystems. Role of flow variability and hydrologic alteration. Aquatic habitat analysis. Riparian vegetation establishment. River-aquifer exchange.	PM
5.12.	Lecture 10: River basin sediment management: local and catchment scales of management. **OPEN DISCUSSION (45 mins)**	PM+SD+LA
12.12.	**STUDENT FINAL PRESENTATIONS (no lecture)**	PM+SD+LA
19.12.	**STUDENT FINAL PRESENTATIONS (no lecture)** Course wrap-up	PM+SD+LA

BOLD are sections during the course where students will make an input.

PM = Peter Molnar
SD = Sophia Demmel
LA = Ludovico Agostini

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