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=21020
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/2023/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 along hillslopes to channels, the topology of river networks and channel morphology, and interactions of fluvial processes in the riparian zone and floodplain, with some river basin management implications. The scales addressed are hillslope to catchment scales. The course has *two fundamental aims*: (a) it aims to provide future environmental engineers with a process understanding of river basin change at hillslope and catchment scales, understanding where and when sediment is produced; and (b) it aims to provide quantitative skills in making simple and more complex predictions of sediment fluxes and changes therein using a range of models (from landscape evolution models, through USLE, to state-of-the-art physically-based spatially distributed approaches) and observations.

The course *consists of four 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 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. The course closes with an 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 programs. 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. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor and his group. This course is continuously developing and changing as new scientific advancements are made.

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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 2023

Date	Topic	Instructor/s
21.9.23	Introduction into course. Fluvial systems: elements of the fluvial system; geomorphic concepts of landscape change (equilibrium, thresholds, SOC, optimality)	PM
28.9.23	River basin connectivity, disturbance and response times; soil process rates (production, erosion, yield); human role in sediment fluxes	PM
5.10.23	Soil-hillslope evolution model equation; detachment and transport capacity limitations; the slope-area diagram PRESENTATION OF PROJECT TASKS	PM SD+LA
12.10.23	Landscape evolution models LEMs; examples; simulation of tolerable erosion rates	PM
19.10.23	River basin sediment production: RUSLE, the flow path concept; examples of Swiss, EU and Global estimates PROJECT UPDATE (15 mins)	PM SD+LA
26.10.23	Hillslope erosion modelling: planar models, 2d models; use of physically-based models (Topkapi-ETH-sed) for sediment source tracing, example	PM
2.11.23	Landslides as sediment sources: infinite slope model, SINMAP; validation of spatial predictions; rainfall intensity-duration curves PROJECT UPDATE (15 mins)	PM SD+LA
9.11.23	Sediment budgets: examples, measurement methods (trapping, indirect measurement, fingerprinting, river monitoring, DoDs); the sediment cascade concept	PM
16.11.23	The river network: morphological descriptors, fractal descriptors; channel geometry; channel-forming flow; river planform PROJECT UPDATE (15 mins)	PM SD+LA
23.11.23	Floodplains and riparian ecosystems: flow effects; sediment; riparian vegetation; river-aquifer exchange	PM
30.11.23	PROJECT DISCUSSION DAY (no lecture) Discussion for the preparation of final presentations	SD, LA
7.12.23	River basin sediment management: local and catchment scales of management; examples	PM
14.12.23	STUDENT PRESENTATIONS (no lecture)	PM+SD+LA
21.12.23	STUDENT PRESENTATIONS (no lecture) Course wrap-up	PM+SD+LA

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