POLITECNICO DI MILANO

PhD School of Politecnico di Milano

Regulations of the
PhD Programme in Environmental and Infrastructure Engineering
XXIX Cycle

Campus: Milano Leonardo

1. General Information

PhD School of the Politecnico di Milano

PhD Programme: Environmental and Infrastructure Engineering

Official Language(s): English

PhD Programme campus: Milano Leonardo

PhD School Website: **http://www.ricerca.polimi.it/phd**

PhD Programme Website: http://www.diiar.polimi.it

2. General presentation of the PhD Programme:

Profile A - "Hydraulic Engineering"

Major research topic of Hydraulic Engineering include: fluid mechanics; fluid-structure interactions; hydraulic measurements; river hydraulics; hydraulic risk assessment and management; flow and transport processes in porous systems; hydraulic networks. Experimental, modeling and methodological aspects are considered. Key research areas include:

1. *Fluid mechanics*.Emphasis is devoted to the analysis of physical processes observed at various scales and their depiction in the context of appropriate interpretive models. Research and educational activities comprise analysis of advanced methodologies of computational and experimental fluid dynamics (e.g., image analysis techniques for hydraulic processes on multiple observational scales) and modeling of processes of fluid-structure interactions for environmental, civil and industrial engineering applications.
2. *River hydraulics and sediment mechanics*.The key research topics are associated with optimization of approaches and technologies for land protection. Research and educational activities include modeling of free surface flows, local and general scour processes, hyper-concentrated flows, flooding and hydraulic risk analysis.
3. *Flow and transport processes in porous systems*.Key research topics include: characterization of hydraulic properties from pore-scale to aquifer systems; well testing; inverse modeling; flow and multicomponent reactive transport process in heterogeneous media under uncertainty; multiphase flows; scaling of hydrogeological quantities; mixing processes in coastal aquifers; geothermal fluxes at the reservoir and basin scales.A major focus is the study of theoretical and operational bases for the assessment of hydro-geo-chemical processes governing the distribution and residence time of solutes in the subsurface to provide the building blocks for reliable technologies to mitigate environmental risk and restore polluted aquifer systems.

Profile B - "Hydrology, hydraulic construction, water resources and coastal engineering"

“Profile B” has its main research activities in the field of water resources spanning from hydrology to coastal engineering. The research activity constituting the core of the profile is fully recognised by the national and international research community. Research activities place PhD students in the network of international research and allow them to improve the state of knowledge with outstanding work in the fields of hydrological sciences, hydrological extremes, network hydraulic infrastructure as well as maritime hydraulics. The research topics and methodological approach make the student's curriculum fully acknowledged by the main academic schools, private enterprises and national and international organisations as demonstrated by career opportunities gathered from former PhD students. A short description of the main research branches is given in the following.

1. *Hydrology and water resources*: addresses in-depth understanding of the main physical processes of the hydrological cycle which determine flood as well as drought phenomena and pollution migration. Measurement and modeling of variables active in water and energy budgets (radiation, evapotranspiration, snow mantle dynamics, hydrological losses) are carried out. In situ data as well satellite data of the earth's surface are used to understand the processes and their representative scales. Continuous distributed water balance models are developed for simulating and monitoring flood as well drought processes.
2. *Hydrogeological hazard and mitigation strategies focuses on the analysis of* hydrological extremes, frequency of floods, droughts and precipitation. Probabilistic, stochastic and physically based models are used together with field observation to study and reproduce rainfall fields, floods and droughts. Early warning operative systems are developed for shallow land sliding, snow avalanching and flood risk.
3. *Hydraulic networks engineering* addresses the evaluation of design variables for urban sewage and aqueducts. In particular, water quality and quantity in drainage networks and effects of local and diffused structures for flood and pollution controls are investigated. Aqueduct efficiency and monitoring of water losses and pollution diffusion in a pressurized network are investigated.
4. *Hydraulic and coastal engineering* addresses the hydrodynamics of wave motion, marine currents, littoral dynamics, wave-structure interactions, Lagrangian and Eulerian numerical models.

Profile C - “Environmental technologies”

The full range of research topics offered by the PhD Programme in Environmental technologies covers the following:

1. Water supply technology and treatment, disposal and reuse of wastewater, advanced biological and physical-chemical water and wastewater treatment; sludge management and disposal; anaerobic digestion processes.
2. Management and planning of environmental resources: source apportionment of pollutant loads and assessment of their effects on the receiving water bodies/ environmental components; water quality modelling, scenario analysis and knowledge-based decision support systems of management alternatives.
3. Solid wastes and sludge minimization and management (composting the organic fraction of solid wastes, waste-to-energy plants, sanitary landfill, leachate treatment, hazardous waste solidification);
4. Phenomenology of atmospheric environment and treatment of gaseous emissions: statistical models of air quality data, sampling and speciation of fine particulate in the atmosphere, emission

models from mobile sources, emissions of micro-pollutants from waste incineration processes, organic volatile control by biofiltration techniques.
5. Contaminated soils and their remediation, groundwater protection and treatment: risk assessment related to contamination levels of soil and its use, sampling methodologies, statistical analysis and mapping of contamination data, in-situ and on site bio-remediation.

Profile D – "Transport infrastructures"

The main research topics considered as fundamental for the development of research activities concerning transport infrastructures could be summed up in four main topics, reciprocally connected to the topics related to other PhD research profiles.

1. *Transport networks*. Complex transport network modelling (both homogeneous and non-homogeneous modal networks), also considering the functional interactions with regional, national and international territory.
2. *Sustainable development*. Analysis of the complex phenomenology characterizing the dynamics of development and its relations with the infrastructure system. Interaction between tunnels and underground hydraulic systems.
3. *Technological innovation*. Analysis of methods, criteria and indicators for the performance characterization of infrastructure construction and maintenance techniques.
4. *Risk management*. Analysis and development of improvement measures concerning both the construction and management of road infrastructures, aimed at reducing risk for both workers and users. Geological risk deriving from the construction of transportation infrastructures.
5. *Applied geology*. a) the analysis of the hydrogeological risk linked to the underground excavation in rocks (e.g., water inflow, piezometric drawdown); b) forecast of landslides hazard (to assess the influence of some hydrogeological parameters, as permeability and heterogeneity coefficient, on slope instability); c) water resources identification and management, pollution problems, also in coastal aquifers.
6. Methods: Modeling and systematizing of decision processes, at both a strategic, tactical and operative level, characterizing road infrastructure design, construction and management (including Project Management, Pavement Management Systems, Bridge Management Systems).

Profile E – "Geomatics"

This wide-ranging profile includes all disciplines dealing with positioning, global and local reference system establishment, surface surveying and reconstruction from a global scale down to the scale of the individual architectural manufact, representing data by graphical or virtual tools, archiving and cross-referencing spatial information in terms of geographic information systems.

Summarizing, we can identify the following education and research topics:

1. *Physical geodesy and satellite geodesy*, including estimation and representation of the gravity field at all scales and its geophysical interpretation.
2. *Positioning and navigation*, with the use of both classical and satellite techniques, such as GPS.
3. *Surface surveying with optical or other sensors*, such as SAR, LIDAR, etc., at different scales from regional down to the manufact scale.
4. *Digital photogrammetry and image analysis*, including the development of photogrammetric software for the geometrical reconstruction of surfaces and feature extraction.

5. *Remote sensing*, namely the problem of identifying, by suitable spectral analysis, specific geographic information.
6. *Geographic information systems*, with application of the most modern technology for internet GIS and mobile GIS.
7. *Cultural heritage reconstruction and archiving*, with the solution of complex problems of combination of different data into a unique data base, providing three-dimensional virtual models that preserve full geometrical and metrical information.

3. Mission and Goals:

The Ph.D. is awarded upon completion of at least three years of advanced study and research for a total of 180 credits. Out of these 180 credits, a minimum of 30 credits (Section 6)mustbe acquired through *PhD level courses*. A key objective of this PhD Curriculum is the development of autonomous research abilities of the PhD student in the context of inter- and multi-sectoral subjects. The PhD Programme is structured according to the five areas/profiles illustrated in Section 2, i.e., *Hydraulic Engineering*, *Hydrology, hydraulic structures, water resources and coastal engineering*, *Environmental technologies*, *Transport infrastructures*, and *Geomatics*.

Introductory courses provide the preparatory knowledge needed as a basis for the general framework presented in the PhD Programme and provide the common knowledge background to Ph.D. students that may be derived from various branches of Engineering and related fields. Research training is provided through mentoring by highly qualified Faculty members. Key elements of the programme include: (a) an improved fundamental preparation of candidates, as required by the PhD School, with the introduction of new opportunities for student evaluation through written exercises or oral examinations, and (b) development of a close connection with industry to foster the emergence of outstanding professional abilities attractive to industry.

To fulfil the education needs required by any researcher operating in the field of environmental and civil engineering, “teaching” activities are very delicate, mainly due to the wide cultural base required. PhD courses will exploit the long experience and know-how in laboratory activities and will offer training activities on essential research tools such as the Environmental, Hydraulics and Engineering and Geomatics Laboratory, Environmental Monitoring, Environmental Reactors.

Contacts with bodies other than Universities have been established through participation both in specialised seminars and refresher courses given by experts from industry, together with short training internships for Ph.D. students at highly qualified companies.

The most qualifying activity of the entire Ph.D. Programme is development of the thesis. This should reflect the leading and unconditioned role of research and cannot ignore the requirements and needs of authorities, public bodies and private firms.

The long-desired innovation in ecosystem services and industry should not be a fleeting fruit of fantasy but rather a long-lasting product of sound research activity which only a University can provide, especially for the benefit of small and medium-size enterprises which cannot afford the burden of an autonomous research centre.

A research experience at International Research Centers and/or Universities is considered essential for Ph.D. students to complete their education and to exchange research experience and expertise.

4. Professional opportunities and employment market

A PhD in Environmental and Infrastructure Engineering should provide highly qualified personnel to cover key positions and roles in research centers, top level management in Public Bodies and Authorities involved in environmental policies, as well as senior consultants for engineering companies.

5. PhD Programme Enrolment

5.1 Admission requirements

Italian and foreign citizens can apply. They are required to have graduated in accordance with the pre-existing laws MD 3.11.1999 n. 509 or to have a master of science degree in accordance with MD 3.11.1999 n. 509 or a master of science in accordance with MD 22.10.2004 n. 270 or similar academic qualification obtained abroad, equivalent in duration and content to the Italian qualification and for an overall duration of university studies of at least five years. Knowledge of the English language to at least B2 level is required.Admission to the programme will be based on evaluation of the academic curriculum, letter of intent and PhD research project description which candidates must submit together with their application form in reply to the admission call.

5.2 Admission deadlines and number of places available

The number of places available is indicated in the call for admission to the 29th PhD Programme cycle: http://www.polimi.it/phd
Scholarships both on general and on specific topics are available, as detailed in the admission call.

6. PhD Programme Contents

6.1 Qualification attainment requirements

Completion of the PhD curriculum in Environmental and Infrastructure Engineering requires a full time equivalent of at least three years, includingdevelopment of study and research activities associated with the development of the PhD thesis.

The PhD in Environmental and Infrastructure Engineering foresees a minimum of 30 credits from PhD level courses to be acquired as indicated in Section 6.3.Credits foreseen by the PhD programme and associated with research activities may also be attained by participation to national and international seminars and summer schools, evaluated a posteriori by the tutor.

6.2 Development of research and the PhD thesis

The aim of PhD programmes at the Politecnico di Milano is the development in candidates of a research-oriented mind-set, with expertise and skills in specific research topics.
To develop a research-oriented mind-set, candidates must acquire problem-solving capabilities in a complex context, including in-depth analysis of the problem, identification of an original solution and the capability of evaluating a solution and its applicability in given contexts.
These skills provide PhD candidates with major opportunities of development in their research both in the academic field and in public and private organizations.
The main objective is the development of an original research contribution. The PhD thesis must contribute to increasing knowledge in the research field of the candidate. In addition, it must be coherent with the research topics developed in the department in which the PhD Programme selected by the candidate is performed.
Results of research activities must be submitted via a PhD thesis which contains and discusses the original contribution.
The PhD research will be developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities regarding the development of the thesis. The supervisor is not required to be a member of the Academic Board and can also belong to an institution other than the Politecnico di Milano. The supervisor can be supported by one or multiple co-supervisors.
To develop the capability of carrying out research activities, the candidate must attend courses according to the PhD programme requirements. These courses arerequired to be passed them with a positive evaluation.
A member of the Academic Board is appointed as tutor to each candidate admitted to the program. The tutor supervises and supports the candidate during the overall training path and informs the Academic Board on the progresses of the candidate, including the assignment of credits for his/her activity. A supervisor belonging to the PhDAcademic Board can also act as tutor. The selection of courses will be overseen by the tutor, and will be formalized in a study plan and approved by the Coordinator of the PhD Programme.
Other activities for the development of personal skills and research expertise are encouraged during the PhD programme. The candidate must acquire the capability to present and discuss his/her work in

his/her research community. Participation to international conferences and exposure of research results in international peer-reviewed journals are required.
Candidates are also encouraged to perform part of their research activities in the context of collaborations with international research groups in their field of interest. Research visits of at least three months at internationally recognized research groups are strongly encouraged.
The duration of the programme is typically three years.

6.3 Objectives and overview of teaching activities

The PhD Programme and the PhD School may activate various types of training activities with different valences (courses, seminars, project workshops, laboratories). These activities aim at:

- creating common starting knowledge for the PhD programme;
- examining the basic research issues (problems, theories, research methods) which represent the cornerstone of the PhD Programme and which identify clearly its cultural setting;
- providing improved knowledge on key research issues connected with the problems developed in the thesis.

Classes are provided in English. Some teaching activities allow acquiring ECTS credits (structured teaching activities). Certain activities (typically specialised seminars and participation in Conferences and Workshops) are directly evaluated by the PhD School Board and the resulting grade is not quantified in terms of ECTS.

The PhD programme offers students a number of PhD courses on methodological subjects common to all the 5 areas . Additionalcredits are obtained from courses offered by the PhD School, following the tutor's advice. Each area offers a series of specific courses. All institutional courses are associated with the evaluation (grade A-B-C-D) of each student by the course instructor.

The following tables illustrate the educational training activitieswhich are typically foreseen for PhD candidates. The programme requires that the candidate focuses on research activities in a continuousmanner, in collaboration with his/her supervisor and the PhD School Board.

Courses and other activities	*Possible details or reference to following tables*	*Number of credits (min)*	*Note*
Courses characterising the PhD Programme	*See Table A*	*20*	
PhD School Courses	*See Table B*	*5*	
Other PhD Level Courses	*See Table C*	*0*	
Other activities	*Participation to conferences, national and international summer schools*		

PhD LEVEL COURSES

A) The PhD Programme in Environmental and Infrastructure Engineering offersa series of **Characterizing Courses** (see Table A). Acquisition of a minimum of 20 credits associated with such courses is **mandatory** for admission to the final exam.Admission to the second and third year respectively requires attainment of 60 and 120 credits. These arerecognized by the Academic Board on the basis of the suggestion of the tutor, considering the credits achieved from institutional courses and other activities carried out by the student.

B) The PhD School organises general and Interdoctoral courses and courses with foreign professors on anyearly basis. Acquisition of **at least 5 credits** is **mandatory** from type B courses.

C) Other PhD courses. Example: 5 of the 30 mandatory credits can be obtained from type A or B PhD courses or from other courses provided by other PhD programmes of the Politecnico and/or external entities (in this case prior approval of the supervisor, of the tutor and of the coordinator is required).

PREPARATORY COURSES

The supervisor and the tutor might require that the candidate attends preparatory courses (typically selected among the courses which are active at the Politecnico di Milano). The Academic Board of the PhD programme can then assign a number of extra-credits to be acquired for completion of the training programme.There is only one course delivered by the PhD which can be considered of this kind. This is a short, 3 credits introductory course illustrating the general research activities carried on in the different areas defining the programme. These credits will be considered as additional to the mandatory credits to be acquired with PhD courses.

SPECIALISTIC COURSES, SEMINARS

A detailed list of courses which will be active during the 2013-14 and 2014-15 academic years is provided in Table A.It is possible that other courses are subsequently activated at the PhD School.In this case candidates will be promptly informed to enable them to insert these new courses in their study plan.

Table A: PhD COURSES CHARACTERIZING THE PHD PROGRAMME

SSD (optional, also more than one)	**Course**	**Professor** (optional)	**A.Y./Semester**	**Language**	**Credits**
	Introduction to the research topics of the IAI PhD programme			English	3
ICAR/02-06	Statistic methods (2 integrated modules)	F. Sansò C. De Michele		English	5+5
ICAR/06	Numerical methods	L. Mussio		English	5
ICAR/01	Fluid mechanics	V. Armenio	2013 (2nd semester)	English	5
ICAR/01	Groundwater	A. Guadagnini	Alternate years (next edition: February 2014)	English	5
	Granular Matter: from packing to flow	D. Berzi; F. Calvetti C. di Prisco;		English	5
ICAR/02	Climate Change Hydrology			English	2
ICAR/02	Sustainable Urban Water Systems	G. Becciu J. Sansalone		English	2
ICAR/02	Dam and Reservoir Engineering			English	2
ICAR/02	Water and Food Security	M.C. Rulli		English	3
ICAR/02	Remote Sensing in Hydrology	M. Mancini C. Corbari		English	2
ICAR/02	Hydrology of Alpine areas	D. Bocchiola		English	5
ICAR/02	Sea Waves and Hydropower	A. Bianchi G. Passoni		English	4
ICAR/02	Dam and Reservoir Engineering	R. Rosso		English	2
ICAR/02	Climate Change Hydrology	R. Rosso		English	2
ICAR/03, BIO/07, BIO/19	Environmental Chemistry and Applied Microbiology	M. Antonelli	Alternate years,heldin November	English	6
ICAR/03	Environmental reactors and biological processes applied to environmental-sanitary engineering	E. Ficara R. Canziani	Alternate years held in May	English	4
ICAR/03	Statistics applied to Environmental Engineering	A. Azzellino	Alternate years held in February	English	5
ICAR/04	Performance characterization of materials	M. Crispino		English	6
ICAR/04	Methods of laboratory experimental analysis	M. Crispino		English	6
ICAR/06	Positioning	B. Betti		English	5

ICAR/06	Advanced Geographycal Information Systems	D. Carrion		English	5
ICAR/06	Photogrammetry and Image Analysis	L. Pinto V. Casella		English	5
ICAR/06	Data Processing meets Human Sciences	L. Mussio		English	5
ICAR/06	WebGIS and Geoservices	M.A. Brovelli		English	4
ICAR/06	Satellite geodesy	F. Migliaccio		English	4
ICAR/06	DTM generation	R. Barzaghi		English	4

Table B SUGGESTED CROSS –SECTORAL COURSES OR WITH A FOREIGN PROFESSOR

SSD (optional, also more than one)	**Course**	**Professor** (optional)	**A.Y./Semester**	**Language**	**Credits**
	Courses offered by the PhD School of the Politecnico di Milano can be selected				

Table COTHER PhD LEVEL COURSES

SSD (optional, also more than one)	**Course**	**Professor** (optional)	**A.Y./Semester**	**Language**	**Credits**
	All courses offered by the PhD programmes of the Politecnico di Milano and/or external organizations(*)				

(*)prior approval of the supervisor, of the tutor and of the coordinator is mandatory

6.4 Study plan submission

Each PhD candidate must submit his/her study plan. Candidates will have the opportunity to review it periodically (typically every three months) to adapt it to possible changes in the training offer or to needs justified by the development of the plan. The study plan is approved by the Coordinator of the PhD Programme, following the advice of the tutor, according to the procedures established by the Academic Board of the PhD Programme.

6.5 Annual exam procedures

The candidate is subject to yearly evaluations for admission to the following year. Admission of the candidate to the final exam (held by the external Commission) is assessed on the basis of the third-year evaluation. Admission of first-year students to the second year of the PhD Programme is based on the examination of student activities and a written report which will be approved by the student tutor. Admission to the third (and possibly following) year is additionally associated with an oral presentation of the candidate who presents his/her work to the Academic Board. After each annual

evaluation, the candidate will receive an evaluation mark (A/B/C/D). In the case of insufficient marks the candidate will be qualified as a "Repeating candidate (Er)" or "not allowed to continue with the PhD (Ei)". After completion of the three years, candidates having achieved sufficient results but who need more time to write their thesis may obtain an extension up to a maximum of 12 months.

6.6 Other foreseen reviews

N/A

6.7 PhD thesis preparation procedures

Full time study and research activities will be performed during the three years of the PhD programme. The possibility of internships or study periods at Italian or foreign companies/research institutions/universities is foreseen. The main objective is the development of an original research contribution.The PhD thesis should contribute to increase the knowledge in the research field of the candidate. The thesis should be consistent with the research activities developed in the department within which the PhD programme is carried out.The candidate will present the original thesis to a board of examiners, discussing its contribution to the state of the art in the research field. The PhD research will be developed with the mentoring of a supervisor, who will provide the day-to-day support required by the PhD student and assist in defining the educational objectives and research work. Admission of the candidate to the final exam will be evaluated by the Academic Board upon termination of studies. A final exam for attainment of the PhD is then required in which the research work and the thesis will be evaluated by an examination Committee composed byat least three members (at least two of the Committee members are external to the PhD Programme).

7. Laboratories, PhD Secretary Services

Profile A - “Hydraulic Engineering” and Profile B - “Hydrology, hydraulic construction, water resources and coastal engineering”

The *LaboratoryGaudenzioFantoli* was first established in 1939. It comprises areas devoted to research and educational activities. Two main floors, each covering an area of about 800 m^2, are currently devoted to laboratory activities. The Lab staff comprises 4 people. Major hydraulic facilities include:

- *Free surface flume*: a 30m $\times$ 1.0m $\times$ 0.6m flume with adjustable floor and glass sides, a fixed floor flume with glass sides. It is provided with the tools to convert the structure into a wave flume (piston wavemaker, artificial beach, wave gauges).
- *Hydraulic channel:* a 6 m × 0.5 m × 0.5 m free surface flume designed for studying fluid-structure interaction by means of direct measurement of forces, stress distributions, displacements and velocity distributions. Image analysis techniques are employed for kinematic measurements.
- Test plant for flow resistances: a water flow loop, provided with flowmeter and pressure transmitters, dedicated to measure the loss coefficient and other characteristics of regulation devices (*e.g.* valves, resistors, connectors, ect.). The plant is also provided with high pressure pumps.
- *Transparent pressurized duct*: specifically built for sediment transport and scour experiments with image processing measurements. The duct length is 5.8 m with a cross section 40 cm wide and 16 cm deep. In the central part of the duct is a recess section with a length of 2 m and depth of 0.5 m.

The hydraulic head in the duct is imposed by a Bazin weir located in the downstream tank; the upstream tank is provided with a streamlined inlet to avoid wakes in the flow.

- *Dam-break flume*: used to investigate the dam-break wave (unsteady flow) of a hyperconcentrated mixture of water and cohesionless granular matter. It consists of a 6 m long, square section (0.5 x 0.5 m) flume of adjustable slope. Failure of the dam is simulated by means of a pneumatic rising sluice-gate (opening time t = 0.3 s). One of the side walls of the flume is made of glass in order to record of wave propagation by means of a digital camera.
- *Rotating drum*: this device is used to investigate the behavior of a steady dry granular flow over a loose bed. It consists of a cylinder (inner diameter D = 1 m and axial length W = 250 mm) half-filled with granular material, which is mounted on a pair of friction rollers and rotates around its axis at a constant angular velocity. One of the endplates of the cylinder is made of 10 mm thick glass to allow optical measurement of the flow fields through a progressive CCD scan camera.

Other site facilities include: a series of calibrated basins with a total capacity of 50 m^3, a computer centre, an electronics workshop for construction and repair of instrumentation; a mechanical workshop for the construction of experimental facilities, laboratory instrumentation for measuring most hydraulic parameters (including an automated system to detect and measure river-bed shapes), and field instrumentation to measure hydrodynamic processes. The Lab has been certified within the SQA (Quality Assurance Protocol of the Politecnico) within the context of hydraulic parameter measurements, determination of characteristic curves of hydraulic machinery and field and laboratory scale flow rate determination. The laboratory is a SIT certified Calibration Centre for measurement of liquid flow rates (range: 3-80 l/s). Finally, a total free area of 600 m^2 is available for set-up of hydraulic models. The area is served by an overhead traveling crane of 1500 kg_p and by a piping system allowing a maximum flow rate of about 600 l/s.

Profile C - "Environmental technologies"

Laboratory for environmental monitoring and control (LANCI)

The Laboratory currently extends over 580 m^2 and is divided into two sections: the analytical section with different working areas (wet chemistry, sample preparation, analytical instrumentation, and biology) and the pilot-plant section. The Laboratory staff comprises 5 permanent staff (2 graduates) and one temporary position (graduate). The main activities of Laboratory are: (a) sampling and determination of pollutants in different environmental matrices (water, air, soil, sludge, solid waste); (b) evaluation of remedial technologies with laboratory pilot plants; (c) planning and management of demonstrative wastewater treatment pilot plant; (d) tests of biodegradation and treatability of wastewaters by means of titration/respirometric sensors and a microcalorimeter. Analytical instrumentation includes: electrometry, nephelometry, molecular absorption spectrophotometry, atomic absorption spectrometry, liquid chromatography (ionic and HPLC), gas-chromatography, X-ray spectrometry, polarography, voltammetry, TOC analyser, ion-coupled plasma mass Spectrometry (ICP-MS). The Laboratory is also equipped with instrumentation for sampling of liquid, solid and gaseous pollutants.

The pilot plant section is equipped with: aerobic and anaerobic reactors for activated sludge and fixed biomass processes, membrane bioreactors, batch reactors for contaminated soil remediation, reactors for chemical oxidation and water disinfection, biosensors for the study of microbial activity. Experimental activity through pilot-plants is frequently carried out at public institutions and private firms.Since many years the Laboratory takes part in ring comparison tests (both national and

international) and participates in working groups promoted by UNICHIM and IRSA for the development of analytical methods.

Profile D - "Transport infrastructures"

Road Research Laboratory (RRL)

The Road Research Laboratory (RRL) refers to the Road Infrastructure Section and performs experimental activities associated with road materials (soils, rocks, inerts, binders, asphalt concrete, cement bound materials and cement concrete), soil analysis (sub layers, foundations and rises), pavement analysis, preliminary and validation investigations concerning road, railway and airport works as well as dumps and embankments.The RRL has at its disposal equipment for qualification and characterization tests related to road materials, such as inerts, soils, bituminous binders, asphalt and cement concrete. The RRL also has equipment for in-situ tests, such as bearing capacity, roughness and adherence, for the quality control of materials and working phases, in accordance with current Italian and European regulations.
The RRL is also equipped with a full scale test area of approx. 50000m² in Carpiano (MI), at the Bacchi Enterprise, and also with equipment, work machines and plant for the implementation of full scale tests regarding road, railway and airport infrastructures (pavement, sub layer, etc.). This area is used for full scale tests when the limits of the laboratory scale need to be overcome, checking the critical states of construction techniques as well as validating laboratory tests. Much experimental analysis already carried out and in progress in the full test area show the remarkable potential and effectiveness of full scale testing which could be effectively use for both internal and commissioned research, under the control of the RRL. Adjacent to the full scale test area is a fully equipped laboratory for carrying out further traditional tests on road materials (soils, inerts, cement and asphalt concrete, etc.), as well as innovative tests (flexion and indirect tensile fatigue tests, complex modulus, dynamical creep, etc.). The laboratory directly cooperates with plants producing asphalt and concrete cement in order to test real mixtures and overcome the limits due manufacturing mixtures in the laboratory.

Profile E - "Geomatics"

The recent development of the subject has fostered activities in new fields of advanced research such as spatial geodesy, navigation, photogrammetry, remote sensing, numerical cartography, geographic information systems (GIS), as well as a return to the field of geophysics.This research is conducted by the Department with the support of structures such as:
- the International Geoid Service, which can be considered as an IT laboratory for the gravity field
- the laboratory of geomatics, which is partly instrumental and partly IT.

The main instruments, software and activities conducted in the laboratory are illustrated in the following.

<u>Surveying and monitoring</u>:
- GPS instrumentation from a permanent station to low cost receivers
- measurements to monitor ground, buildings and structures
- photogrammetric surveying of architectural manufacts

- thematic mapping
- infrastructure land registry

Data management and interpretation:
- gravimetric data interpretation
- geoid determination
- spatial mission analysis
- GPS permanent network analysis
- Statistical methods in surveying and monitoring
- integration of images and maps
- management of GIS data bases
- evaluation of uncertainty and reliability.

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8. Internationalization and other activities

The PhD Program strongly encourages research and educational collaboration with other Universities / Research Institutions. The University also offers the possibility of PhD programmes with foreign universities as well as double and joint PhD programmes. Further information can be found on the PhD School and PhD programme websites.

Attachment A1 – PhD Advisory Board

Composition of the Advisory Board

Surname	Name	Authority/Corporation	Position
Sanchez-Vila	Xavier	Politechnical University of Catalonia, Barcelona (SP)	Associate Professor
Ruffo	Paolo	ENI	Senior scientist
Sansalone	John J.	Florida University	Professor
Burlando	Paolo	ETH Zurigo	Professor
Marino	Carlo	ARPA Lombardia	President
Bortone	Giuseppe	Regione Emilia Romagna	Chief SettoreRisorseIdriche
Fanelli	Roberto	Istituto M. Negri Milano	DirectorDip. Ambiente e Salute
Bernet	Nicolas	LBE – INRA, Narbonne (F)	Chief équipe ingénierie des procédés
Losa	Massimo	Università di Pisa	Associate Professor
Colomina	Ismael	Instituto de Geomatica de Catalunya (SP)	Director
Dermanis	Athanasios	Aristotle University of Thessaloniki (GR)	Professor
Radicioni	Fabio	Università di Perugia	Professor

Attachment A2.1 (Only for courses of new activation or with substantial changes)

Summary Form

Year	2013/2014		
Assignment type	Doctoral		
Course	Sustainable Urban Water Systems		
Professor	John J. Sansalone/Gianfranco Becciu		
Cfu	2.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Sustainable Urban Water Systems

Detailed Programme and foreseen learning results:

- **Urban Water Systems**
  - Influence of urban watersheds: hydrological losses; natural and artificial river network; flow routing on urban basin surfaces; quality of sewage and rainfall water; accumulation and washing of pollutants on urban surfaces; sedimentation, removal and dismissal of sediments in drainage network; routing of pollutants in water bodies; control structures (diversion and storage).
  - Integrated modeling of water quality and quantity in urban network, in control structures and water bodies: types of models; lumped and distributed modelling of quantitative and qualitative processes.
  - Real time monitoring and control of urban water systems
- **Sustainable Strategies for Water Management in Urban Areas**
  - Urban Water needs and their management
  - Physical and chemical characteristics of stormwater, greywater and foul water
  - Water quality and environmental issues
- **Sustainable Strategies for Flood Control**
  - Modified urban hydrologic cycle
  - Urban rivers
  - Flood risk and control
  - Sewer overflows and flood tanks
  - Water infiltration facilities
  - Green roofs
  - Water reuse

- **Sustainable Strategies for Water Protection**

    - First Flush tanks
    - Bioritention and biotreatment facilities
    - Urban wetlands

Bibliography

Slides used during lessons and other scientific documentation given during the Course.

Teaching Mix

Lectures and other complementary activities (bibliographical in depth surveys and computer applications)

Didactical issue type	Didactical hours
Lesson	12.0
Training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Deepening activities are foreseen, with a final written report (or oral exam with evaluation).

Professor's notes

Attachment A2.2

Summary Form

Year	2013				
Assignment type	Doctoral				
Course	Hydrology of Alpine Areas				
Professor	Daniele Bocchiola				
Cfu	5.00			Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	TITLE

Detailed Programme and foreseen learning results:

Hydrology of Alpine areas is multifaceted, involving enhanced climatic forcing due to orography, soil response and runoff production, due to rainfall and snowmelt during spring. The presence of glaciers, also covered in debris and the water balance therein, also affects hydrology of the system. Liquid precipitation leads to hydrologic response over short time-scales (few hours to few days), thus providing flash floods. Snow precipitation is fundamental, as it influences over the short scales accumulation and redistribution of snow mass and water equivalent, including snow avalanches, while on longer scales it influences hydrological fluxes and water resources. Not last, Alpine areas hydrology is heavily impacted by transient climate change.
The purpose of the course is to provide some basic tools for understanding and modelling the physical processes here mentioned. First, some theoretical basis will be given of snow and avalanche sciences, then the hydrological cycle of mountain areas will be addressed.
Some case studies will be shown, drawn from the researches carried out at the Dept.ICA,Politecnico di Milano.

Detailed programme will include

Snow and its properties.Estimates of SWE using statistical methods.Stochastic modelling of snow precipitation. Snow avalanches. Stability of snow crust.Displacement, physical and statistical approach.Rheology of snow and dynamic modelling, use of a simple model (Voellmy-Salm).

Meteo-hydrological monitoring of Alpine areas.In stream flux monitoring. Snow and ice melt, degree day approach and energy balances. Debris covered glaciers.Hydrological models for Alpine areas.

Impact of climate change upon Alpine hydrology.

Bibliography

1) Bocchiola, D., Medagliani, M., Rosso, R., *Regional snow depth frequency curves for avalanche hazard mapping in central Italian Alps*, Cold Regions Science and Technology, 46, 3, 204-221, 2006.
2) Bocchiola, D., Rosso, R., *The distribution of daily Snow Water Equivalent in the Central Italian Alps*, Advances in Water Resources, 30, 135–147, 2007.
3) Bocchiola, D., Rosso, R., *The use of regional approach for hazard mapping at an avalanche site in northern Italy*, Advances in Geosciences, 14, 1-9, 2007.
4) Simaityte, J., Bocchiola, D., Augutis, J., Rosso, R., *Use of a snowmelt model for weekly flood forecast for a major reservoir in Lithuania*, Ann. Glaciol., 49, 33-37, 2008.
5) Bocchiola, D., Medagliani, M., Rosso, R., *Use of a regional approach for long term simulation of snow avalanche regime: a case study in the Italian Alps*, Arctic Antarctic and Alpine Research, 41,3, 285-300.
6) Bocchiola, D., Diolaiuti, G. *Evidence of climate change within the Adamello Glacier of Italy*, Theor. App. Climat., 100, 3-4, 351-369, 2009, doi: 10.1007/s00704-009-0186-x.
7) Bocchiola, D., *Regional estimation of Snow Water Equivalent using Kriging: a preliminary study within the Italian Alps*, GeografiaFisica e DinamicaQuaternaria, GFDQ, 33, 3-14, 2010.
8) Bocchiola, D., Groppelli, B., *Spatialestimation of Snow Water Equivalent at different dates within the Adamello Park of Italy*, Cold Regions Science and Technology, 63(3), 97-109, 2010.
9) Bocchiola, D., Mihalcea, C., Diolaiuti, G., Mosconi, B., Smiraglia, C., Rosso, R., *Flow prediction in high altitude ungauged catchments: a case study in the Italian Alps (Pantano Basin, Adamello Group)*, Advances in Water Resources, 33, 1224-1234, 2010.
10) Diolaiuti, G., Maragno, D., D'Agata, C., Smiraglia, C., Bocchiola, D., *A contribution to the knowledge of the last fifty years of Alpine glacier history: the 1954-2003 area and geometry changes of Dosdè Piazzi glaciers (Lombardy-Alps, Italy)*, Progress in Physical Geography, 35(2), 161-182, 2011.
11) Bocchiola, D., Diolaiuti, G., Soncini, A., Mihalcea, C., D'Agata, C., Mayer, C., Lambrecht, A., Rosso, R., Smiraglia, C. *Prediction of future hydrological regimes in poorly gauged high altitude basins: the case study of the upper Indus, Pakistan*, Hydrol. Earth Syst. Sci., 15, 2059-2075, 2011.
12) Groppelli, B., Soncini, A., Bocchiola, D., Rosso, R., 2011. *Evaluation of future hydrological cycle under climate change scenarios in a mesoscale Alpine watershed of Italy*, NHESS,11, 1769-1785. doi:10.5194/nhess-11-1769-2011.
13) Soncini, A., Bocchiola, D., *Assessment of future snowfall regimes within the Italian Alps using general circulation models*, CRST, 68, 113-123, doi:10.1016/j.coldregions.2011.06.011.
14) Confortola, G., Maggioni, M., Freppaz, M., Bocchiola, D., *Modelling soil removal from snow avalanches: a case study in the North-Western Italian Alps*, CRST,doi:10.1016/j.coldregions.2011.09.008.
15) Diolaiuti, G., Bocchiola, D., D'agata, C., Smiraglia, C., *Evidence of climate change impact upon glaciers' recession within the Italian alps: the case of Lombardy glaciers*, Theoretical and Applied Climatology, 109(3-4), 429-445. DOI:10.1007/s00704-012-0589-y. http://www.springerlink.com/content/jp57023765r31436/
16) Diolaiuti, G., Bocchiola, D., Vagliasindi, M., D'agata, C., Smiraglia, C., *The 1975-2005 glacier changes in Aosta Valley (Italy) and the relations with climate evolution*, PPG, 36(6), 764-785, 2012. Available at Online first, http://ppg.sagepub.com/content/early/2012/08/13/0309133312456413.abstract?rss=1
17) Bocchiola, D., Diolaiuti, G., *Recent (1980-2009) evidence of climate change in the upper Karakoram, Pakistan*, Theoretical and Applied Climatology, Online first,December 7th 2012, doi: 10.1007/s00704-012-0803-y.

Teaching Mix

Lectures, classworks and other complementary activities (bibliographical in depth surveys and laboratory experiences)

Didactical issue type	Didactical hours
Lesson	10.0
Training	0.0
IT laboratory	0.0
Test laboratory	0.0

Project	2.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Supportavailable in English

Notes about the evaluation modalities

Application of the concepts taught within the course will be carried out for some case studies. Exercises will be assigned, and a final written report will be required for credits assignment.

Professor's notes:

Attachment A2.3

Summary Form

Year	2013		
Assignment type	Doctoral		
Course	Remote sensing in hydrology		
Professor	Mancini Marco /Corbari Chiara		
Cfu	2.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Remote sensing in hydrology

Detailed Programme and foreseen learning results:

Remote sensing is the process of inferring surfaceparameters from measurements of the reflected and emitted upwelling electromagnetic radiation from the land surface from visible, to thermal infrared and microwave bands. Remote sensing can have a great impact in hydrology mainly due to the potential of providing information distributed in space and continuous in time over entire river basins or even at globe scaleovercoming the scarcity of in situ meteorological forcing data in different region of the world. However problems related to algorithms definition for parameters calculation and suitable spatial and temporal resolutions arise.
The use of hydrologic modelling in conjunction with remote sensing data can help in controlling mass and energy fluxes in each pixel of the analyzed domain for operative water management in gauged catchment as well as in poorly gauged basins for flood, precise irrigation practice and drought definition.
States and fluxes of the water and energy balances can be quantified using remote sensing data, and in particular: land surface temperature, near-surface soil moisture, evapotranspiration, snow cover/water equivalent, land use and vegetation cover, vegetation indices, groundwater storage. Meteorological forcings are also available from remote sensing such as precipitation, air temperature and radiation.

The aim of the course is to review some fundamental basics of remote sensing with an overview of the different satellite mission useful for hydrological parameters/variables retrieval.Subsequently it focus on hydrological modeling of mass and energy fluxes for water cycle components estimates at different spatial scale. Finally, different applications on evapotranspiration, land surface temperature and soil moisture retrieval at basin as well at agricultural district scale will be analyzed from the

experiences of the research group.

Bibliography

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2. Troch P., M. Mancini , E. Wood and C. Paniconi, Evaluation of a distributed catchment scale water balance model, Water Resources Research, vol 29 (6) pp. 1805-1817, 1993
3. Lin D. S., E. F. Wood, P. Troch, M. Mancini and T. Jackson, Comparison between remotely sensed and model simulated soil moisture on a heterogeneous watershead, Journal of Remote Sensing Environ., vol 48., 159-171, 1994.
4. Giacomelli A., U. Bacchiega, P.Troch, M.Mancini, Evaluation of surface soil moisture by means of SAR remote sensing techniques and conceptual modelling, Journal of Hydrology, 166, 445-459, Elseweir, Amsterdam The Netherlands, 1995;
5. Giacomelli, A., Mancini, M. & R. Rosso, Assessment of flooded areas from ERS-1 PRI data: an application to the 1994 flood in northern Italy, Physical Chemical Earth (20), pp. 469-474, 1996, Elsevier Science Ltd, Great Britain, 1996.
6. Mancini, M., R. Hoeben, P.Troch, Multifrequency radar observation of bare surface soil moisture content: a laboratory experiment, Water Resources Research,35 (6),1827-1838, 1999
7. Corbari, C., Ravazzani, G., Martinelli, J., and Mancini, M.(2009), Elevation based correction of snow coverage retrieved from satellite images to improve model calibration, Hydrol. Earth Syst. Sci., 13, 639-649.
8. Corbari, C., Sobrino, J. A., Mancini, M., and Hidalgo, V.(2010)Land surface temperature representativeness in a heterogeneous area through a distributed energy-water balance model and remote sensing data, Hydrol. Earth Syst. Sci., 14, 2141-2151, doi:10.5194/hess-14-2141-2010.
9. Sobrino J. A., B. Franch, C. Mattar, J. C. Jiménez-Muñoz, C. Corbari, (2012), A method to estimate soil moisture from Airborne Hyperspectral Scanner (AHS) and ASTER data: application to SEN2FLEX and SEN3EXP campaigns.," Remote Sensing of Environment 117 (2012) 415–428
10. Corbari, C., Sobrino, J. A., Mancini, M., and Hidalgo, V. (2013), Mass and energy flux estimates at different spatial resolutions in a heterogeneous area through a distributed energy-water balance model and remote sensing data, International Journal of Remote Sensing, 34 (9-10), 3208-3230.

Teaching Mix

Didactical issue type	Didactical hours
lesson	12.0
training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Written report

Professor’s notes

Attachment A2.4

Summary Form

Year	2013		
Assignment type	Doctoral		
Course	Sea Waves and Hydropower		
Professor	Alberto Bianchi-Giuseppe Passoni		
Cfu	4.00	Course type	Integrated Corse

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Sea Waves and Hydropower

Detailed Programme and foreseen learning results:

Sea Waves: Generation and Propagation. Wave-Structures Interaction. Dynamics of Floating Bodies.Main Technologies for Wave-Current Energy Conversion.

Hydropower plants: Energy Problems.; Electricity Requirements and Electricity Production. Type and Parts of Hydropower Plants.

The purpose of the course is to give the students a general overview of the emerging and more conventional technologies for energy conversion from wave and current, the underlying physics and the modeling approaches.

Textbooks

1. R.G. Dean, R.A. Dalrymple, Water Wave Mechanics for Engineers and Scientists, World Scientific, 2000.
2. S.K. Chakrabarti, Handbook of offshore engineering, Elsevier Science, 2005
3. McCormick, M.E. Ocean Wave Energy Conversion, Dover Publications, 2007
4. G. Evangelisti, Impianti idroelettrici, Vol. I e II, Editore: Patron, Bologna, Anno edizione: 1964
5. Nuovo Colombo - Manuale dell'ingegnere, 85a ed., Hoepli, 2012 - A. Bianchi, Impianti Idroelettrici, Section H, Cap. 3.11 pag. 285-301 A. Bianchi, Impianti di accumulazione mediante pompaggio, Section H, Cap. 3.12 pag. 301-303 A. Bianchi, Impianti mareomotori, Section H, Cap. 3.13 pag. 303-314
6. C. Penche, Layman's Guidebook on how to develop a small Hydropower site, Editor C. Penche
7. C. Penche: Guidaall'idroelettricominorehttp://www.microhydropower.net/download/guida2.pdf edited by Directorate General for Energy, European Commision, September 1998

Teaching Mix

Class lectures

Didactical issue type	Didactical hours
Lesson	24.0
Training	0.0
IT laboratory	0.0
Test laboratory	0.0
Project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Application of the concepts taught within the course will be carried out for some case studies.

Professor’s notes:

Attachment A2.5

Summary Form

Year	2014		
Assignment type	Doctoral		
Course	Granular Matter: from packing to flow		
Professor	Claudio di Prisco; Diego Berzi; Francesco Calvetti		
Cfu	5.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
Environmental and Infrastructure Engineering	A	ZZZZ	Granular Matter: from packing to flow

Detailed Programme and foreseen learning results:

The Course will illustrate the state of the art on the mechanics of granular materials, whose behaviour ranges from solid-like to gas-like, with the aim of simulating/understanding civil and industrial processes, with particular emphasis on transport phenomena
The course is divided into three modules. The first will be held by Claudio di Prisco, and will deal with granular packing. The second will be held by Diego Berzi and will focus on kinetic theories of granular gases, with examples of applications to simple flow configurations. The third will be held by Francesco Calvetti and will deal with the numerical simulations of granular matters.
The detailed program of the Course is the following:

- granular packing: constitutive relationships for granular materials; from micro to macro-under quasi-static/dynamic monotonic and cyclic perturbations; critical state theory; failure and mechanical instabilities.
- Granular flows: classic kinetic theory of granular gases; extended kinetic theory of granular gases; persistent contacts; phenomenological laws for dense shear flows.
- Applications: simple shear flow; steady, fully developed, inclined flow.
- Numerical simulations of granular matters: discrete element modelling and contact dynamics.

Bibliography

Brilliantov, N.V. and Pöschel, T. (2004). Kinetic Theory of Granular gases, Oxford University Press, Oxford , UK.
Muir Wood D. (2004). Geotechnical modelling. Spon Press, New York, USA.

Teaching Mix

Lectures, classworks and other complementary activities (bibliographical in depth surveys)

Didactical issue type	Didactical hours
lesson	26.0
training	4.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Group homeworks with final oral discussion: the students will be invited to form 3 or 4 groups and analyse in details a particular topic treated during the Course. The critical reading of two scientific papers will also be required.

Attachment A2.6

Summary Form

Year	2013-2014		
Assignment type	Doctoral		
Course	Water and Food Security		
Professor	Maria Cristina Rulli		
Cfu	3.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Water and Food Security

Detailed Programme and foreseen learning results:

Description

The course is aimed to analyses the linkages between water and food security. Starting with an overview of the concept of water and food security the course looks at the influence of water security in food security. The course will consist of 4 seminars addressing themes aimed at the comprehension of the food security nexus that are: a) the virtual water concept and the water footprint metric; b) The virtual water trade; c) The influence of the large scale Foreign Direct Investment in Agricultural land on water resources and water security; c) The influence of virtual water trade and Foreign Direct investment in agriculture on food security.

Bibliography

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Falkenmark, M. J., J. Rockström, and H. Savenjie, Balancing Water for Humans and Nature, Earthscan, London, 2004.

Mekonnen M.M., and Hoekstra A.Y. 2011. National Water Footprint Accounts: The Green, Blue And Grey Water Footprint of Production And Consumption Volume 2: Appendices. Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, The Netherlands http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol2.pdf

Rockstrom, J., M. Falkenmark, M. Lannerstad, and L. Karlberg (2012), The planetary water drama: Dual task of feeding humanity and curbing climate change, Geophys. Res. Lett., doi:10.1029/2012GL051688

Rulli, M.C., A Saviori, and P. D'Odorico, Global land and water grabbing, *Proc. Natnl Acad. Sci, USA*, PNAS, doi: 10.1073/pnas.1213163110, 2013.

Suweis, S., A. Rinaldo, A. Maritan, and P. D'Odorico, Water-controlled wealth of nations, *Proc. NatnlAcad. Sci, USA*, PNAS, doi: 10.1073/pnas.1222452110, 2013.

Teaching Mix

Lectures

Didactical issue type	Didactical hours
lesson	18.0

Information in English to support internationalisation

Course completely offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Deepening activities are foreseen, with a final written report (or oral exam with evaluation).

Professor’s notes

Attachment A2.7

Summary Form

Year	2013/2014		
Assignment type	Doctoral		
Course	**Climate Change Hydrology**		
Professor	**Renzo Rosso**		
Cfu	**2.00**	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Climate Change Hydrology

Detailed Programme and foreseen learning results:

- **Climate system and water cycle**
  - The greenhouse effect
  - Greenhouse effect enhancement and hydrologic cycle at different spatial scales
  - Positive and negative feedbacks
  - AGCM and AOGCM models vs regional models
  - Upscaling in the calibration mode
  - Downscaling in the ensemble scenario forecasting mode
- **Water supply and flood vulnerability**
  - Water stress plus increasing demand: geographical distribution of the challenge over the 2050 horizon
  - Increasing flood vulnerability across the worlds: the role of urbanization
- **Warning and adaptation strategies**
  - Flood and landslide hazard: looking for a comprehensive approach

Bibliography

Slides used during lessons, journal papers and other scientific reports/documents will be shared during the Course.

Rosso, R., Effetto Serra: Istruzioni per l'Uso, SecondaEdizione, Progetto Leonardo, Bologna, 1997.

Salvadori, G., De Michele, C., Kottegoda, N.T. & R. Rosso, Extremes in nature. An approach using copulas, Springer, New York, 294p., 2007.

Guzzetti, F., A. Montanari, , R. Rudari, F. Castelli,M. Chiarle,P. Claps, P. Mercogliano,M. Parise, M. Pizziolo, G. Rianna, R. Rosso, P.Salvati, R.Archetti, C. Giupponi,P.Viaroli, M.Vurro, M.Zavatarelli,*StrategiaNazionale di AdattamentoaiCambiamentiClimatici per l'Italia, Rapporto di SintesidelleConoscenzeScientifiche: DissestoIdrogeologico*, Ministerodell'Ambientee dellaTutela del Territorio e del Mare, Roma,2013.

Teaching Mix

Lectures and other complementary activities (reference surveys,cross-reference investigations)

Didactical issue type	Didactical hours
Lesson	12.0
Training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English, Italian also
Study material/slides available in English, Italian and German
Textbook/Bibliography available in English and Italian
It is possible to take the examination in English (compulsory)
Support available in English and Italian

Notes about the evaluation modalities

Short cross-reference report (alternatively: oral exam with evaluation, to be individually assessed at the beginning of the course).

Professor's notes

Attachment A2. 8

Summary Form

Year	2013/2014		
Assignment type	Doctoral		
Course	Dam and Reservoir Engineering		
Professor	Renzo Rosso		
Cfu	2.00	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Dam and Reservoir Engineering

Detailed Programme and foreseen learning results:

Reservoirs and dams. Italian directives for dam building and management. Risk and evolution of dam directives.Sustainable development of river impounding systems; e. large dams in Italy.Hydrological risk evaluation (design flood and risk scenarios, reservoir management during major floods, downstream risk evaluation under regular and emergency operation of flood gates).

Bibliography

Slides used during lessons,journal papers and specific governmental reports will be shared during the Course. A novel paper in this research area is expected to be published in Water Resources Research this year by the teacher. This will provide the basic knowledge to approach the problems involved in riparian safety on impounded rivers

Teaching Mix

Lectures and other complementary activities (these could include field surveys, depending on support availability)

Didactical issue type	Didactical hours
Lesson	12.0
Training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course completely offered in English and/or Italian
Study material/slides available in English and/or Italian
Textbook/Bibliography available in English and/or Italian
It is possible to take the examination in English and/or Italian
Support available in English

Notes about the evaluation modalities

Short cross-reference report (alternatively: oral exam with evaluation, to be individually assessed at the beginning of the course).

Professor's notes

Attachment A2. 9

Summary Form

Year	2013		
Assignment type	Doctoral		
Course	Web GIS and Geoservices		
Professor	Maria Antonia Brovelli		
Cfu	4	Course type	Monodisciplinary

PhD Course	From (inclusive)	To (exclusive)	Title of the Course
MI (1360) – INFRASTRUCTURE AND ENVIRONMENTAL ENGINEERING	A	ZZZZ	Web GIS and Geoservices

Detailed Programme and foreseen learning results:

The course is designed as an introduction to WebGIS and to Web Geoservices.
Instruction is provided in commonly used open source GIS and related programming tools for customizing web-based mapping applications and development of distributed web services for GIS.
It focuses on

- basics of WebGIS system architecture
- Interoperability
- ISO and OGC standards
- basic geospatial web services (WMS, WFS, metadata and CSW, WCS)
- advanced geospatial web services (SWE, WPS)
- Spatial Data Infrastructures and Geospatial Web
- mashups
- multiframe and multidimensional geovisualization
- virtual globes
- geoportals and web2.0 technologies
- geo crowdsourcing and VGI (Volunteered geographic information)

Bibliography

Slides of the Course
OGC and ISO standards
Documentation on the websites of the various geospatial tools
SDI Cookbook http://www.gsdidocs.org/GSDIWiki/index.php/Main_Page

Teaching Mix

Didactical issue type	Didactical hours
lesson	20.0
training	0.0
IT laboratory	0.0
Test laboratory	0.0
project	0.0
Project laboratory	0.0

Information in English to support internationalisation

Course complete
ly offered in English
Study material/slides available in English
Textbook/Bibliography available in English
It is possible to take the examination in English
Support available in English

Notes about the evaluation modalities

Deepening activities are foreseen, with a final written report (or oral exam with evaluation).

Professor’s notes