Erasmus Mundus Programme
Flood Risk Management
Syllabus

1st Semester at TU Dresden

Module number	Module name	Professor in charge
	Hydraulic Engineering	**Prof. Stamm**
Contents and qualification aims	On the basis of the hydrological water cycle hydraulic structures for flood protection (levees, water retention reservoirs), for use of water (weirs, dams, water power stations) are discussed with respect to water management, ecological and economic aspects. Environmental friendly structures, sustainability and renewable energies are dealt with emphasis. In addition navigation engineering are also reported. The aim of qualification is achieve knowledge about the design, operation and calculation of hydraulic structures	
Teaching form	2 hours a week lectures, Stamm 1 hour a week tutorial, 1 hour a week lab training, Haufe	
Pre-requisite of attendance	knowledge in physics, higher mathematics Literature: **Novak,P.; Moffat, A.I.B.; Nalluri, C.; Narayanan, R.** Hydraulic Structures, (1996), ISBN 0-419-20070-3 **Hasen, H.; Zipparr, V.J.Davis**`Handbook of Applied Hydraulics, (1993), ISBN 0-07-073002-4 **Sentürk, F.**: Hydraulics of Dams and Reservoirs, WRP, 1994, ISBN 0-918334-80-2	
Usage	The module is a mandatory module and especially designed for students in environmental sciences and civil engineering. The contents are harmonised with the parallel course hydromechanics. The student work is jointly organised with hydromechanics.	
Pre-requisite to achieve credit points	The credit points are earned if the student passes the module exam. The module exam is a written exam, 90 minutes, a study work (30 hours) is a pre-requisite to participate in the exam.	
Credit points and marks	The module earns 5 cr.	
Frequency of the module	The module is offered each winter semester. The module mark is identical to the exam mark.	
Work load	The student’s work load is 150 hours.	
Duration of the module	The module is finished in one semester.	

Module number	Module name	Professor in charge
	Hydromechanics	**Prof. Pohl**
Contents and qualification aims	Starting with the physical characteristics of water the hydrostatics and subsequent the mainly steady hydrodynamics will be discussed with emphasis on the principles of conservation of energy, mass and momentum, pipe hydraulics, open channel hydraulics. The aim of qualification is to answer hydromechanical questions in engineering. This means: (i) Identification of hydromechanical problems in engineering and (ii) its quantitative solution for dimensioning and design of hydraulic structures and devices. Application of the results also to scientific problems	
Teaching form	2 hours a week lectures, 1 hour a week tutorials	
Pre-requisite of attendance	knowledge in physics, higher mathematics Literature: **White, F. M.**: Fluid Mechanics, McGraw-Hill, 1994, ISBN 0-07-113765-3 **Levi, Enzo**: The Science of Water, The foundation of Modern Hydraulics; ASCE, 1995,ISBN 0-7844-0005-9 **Gray, Donalds D., P. E.**: A First Course in Fluid Mechanics for Civil Egineers, WRP, 2000, ISBN 1-887201-11-4 . ISBN 1-887201-11-4, Publ. 2000 WRP.	
Usage	The modul is a mandatory module and especially designed for students with a first degree in environmental sciences.	
Pre-requisite to achieve credit points	The credit points are earned if the student passes the module exam. The module exam is a written exam (90 minutes).	
Credit points and marks	The module earns 5 cr. The module mark is identical to the exam mark.	
Frequency of the module	The module is offered each winter semester.	
Work load	The student’s work load is 150 hours.	
Duration of the module	The module is finished in one semester.	

Module number	Module name	Professor in charge
	Ecology	**Prof. Dudel**
Contents and qualification aims	Know how to define and to get knowledge in ecology as a pure and applied science; hierarchy of living systems and the ecosystem concept; physical and chemical determinants of biosphere and of here parts; evolution and coevolution of living beings and entire biosphere; Effect of environmental conditions on individuals, populations and communities and contrast between conditions and resources (availability, aquisation and trade offs); demographic processes (growth, birth, death, migration, life cycles), intra- und interspecific competition, coexistence and mutualism (e.g. symbiosis) as well as interaction and regulation in food webs; flux of energy-, matter - and information between organisms and through ecosystems; biodiversity in different spatial and temporal scales; global change and sustainability (ecological dimension); To get understanding and knowledge on causes and effects of fast change of dynamic steady states in species populations, communites and of entire biosphere as well as to understand our capacities and limitations for control, utilization, rehabilitation and conservation of species populations and ecosystems.	
Teaching form	2 hours a week, lectures, 1 hour a week, tutorial, 1 hour a week, practical training for the study work	
Pre-requisite of attendance	basic knowledge in physics, chemistry and biology Literature: **Townsend C.R., Begon, M., Harper, J.L.** (2005), Essentials in Ecology Blackwell Scientific	
Usage	The module is a mandatory modul. It is suitable especially for courses of studies of the environmental sciences.	
Pre-requisite to achieve credit points	The credit points are earned if the student passes the modul exam. The modul exam is alternatively:A study work (PO § 7) and an oral presentation (PO § 10) **or** a written exam (90 minutes) and an oral presentation (PO § 10), Pre-requisit to participate in the written exam is the regular attendance of the seminar,	
Credit points and marks	The module earns 5 cr. The total mark is formed by 25% from rating of the oral presentation in the seminar and by 75% from the rating of the written exam **or** the study work.	
Frequency of the module	The module is offered each winter semester.	
Work load	The student's work load is 150 hours.	

Duration of the module	The module is finished in one semester.

Module number	**Module name**	**Professor in charge**
	Statistics	**Prof. Franz**

Contents and qualification aims	Aims of the course are the development of knowledge and abilities for applied work with statistical methods and procedures (by use of fitted software). For the contents: descriptive statistics, discrete and continuous probability distributions, parameter estimation, confidence intervals, hypothesis testing and nonparametric hypothesis tests (for example goodness-of-fit tests), correlation and regression methods.
Teaching form	2 hours a week, lectures, 1 hour a week, seminar
Pre-requisite of attendance	Basic knowledge of mathematics for engineers, in particular solving of equation systems, differential and integration calculus and probability methods Literature: **Anderson, C.W., Loynes, R.M.** (1993): The teaching of practical statistics. Wiley New York. **Brown, Ch.E.** (1998): Applied multivariate statistics in geohydrology and related sciences. Springer Berlin-New York. **Rees, D.G.** (2001): Essential statistics (4th ed.).Chapman-Hall, London-New York.
Usage	The module is a mandatory module. Skills corresponding to the module could be used for practical work, for instance for project works
Pre-requisite to achieve credit points	The successful students have to pass the module exam. It consists of a written exam (90 minutes).
Credit points and marks	The module earns 5 cr.
Frequency of the module	The module is offered each winter semester.
Work load	The student’s work load is 150 hours.
Duration of the module	The module is finished in one semester.

Module number	Module name	Professor in charge
	Meteorology and Hydrology	**Prof. Bernhofer,** Dr. Lennartz
Contents and qualification aims	The class transports fundamentals on the basic processes in the atmosphere and hydrosphere. Energy budget and water budget are presented physically: radiation, precipitation, evapotranspiration and above and below ground runoff, as well as relevant storages are treated. Also climate and climatic variability are captured. Students learn to deal critically with meteorological and hydrological information (data, forecasts and consulting) and with its application for water management (planning, designing, and management of water plants). The student achieves knowledge on the relevant processes in atmosphere and hydrosphere, as well as on methods of observation and modelling. This implies basic principles, and includes estimation technologies for all components of the water cycle. The module is the basis for all water quantity related modules of the master course.	
Teaching form	2 hours a week, lectures, Bernhofer 2 hours a week, lectures, Lennartz	
Pre-requisite of attendance	Pre-requisite of attendance: basic knowledge in physics and mathematics Literature: **Oke, T.R.**, 1987: Boundary Layer Climates. **Dingman, W.L.**, 1994: Physical Hydrology.	
Usage	The module is a mandatory module.	
Pre-requisite to achieve credit points	The successful students have to pass two module exams. It consists of a written exam (90 minutes). It is a mandatory pre-requisite for the written exam to take part in a one day excursion.	
Credit points and marks	The module earns 5 cr. The mark is identical to the weighted mean of the written exams.	
Frequency of the module	The module is offered each winter semester.	
Work load	The student’s work load is 150 hours.	
Duration of the module	The module is finished in one semester.	

Module number	Module name	Professor in charge
	Climate Change	**Prof. Bernhofer**
Contents and qualification aims	The module covers „Climate Change“ (CC). Climate change is a major challenge to the water resources, as the water supply depends on both, the demand and the availability of water in an ecological and economical context. CC and CE are used to demonstrate the handling with limited resources in a changing world. It is the aim of the module to improve system understanding of global change by integrative treatment of climatological processes. Evaluation techniques (e.g., ecological balances) and conflict understanding of questions relevant to water resources, as well as exemplary treatment of general questions at system level are handled. Climate change is a major component of global change. Its understanding requires knowledge in the earth-atmosphere system. The class is focussing on the state of the art of climate research (data, methods and results) including the feedbacks with the hydrosphere and biosphere. Guest lectures and student talks complete the programme.	
Teaching form	2 hours a week, lectures, Bernhofer 1 hour a week, student seminars 1 hour a week, model and practical training, Bernhofer et al.	
Pre-requisite of attendance	Pre-requisite of attendance: basic knowledge in physics and mathematics Literature: **Oke, T.R.**, 1987: Boundary Layer Climates. **IPCC**, Summary for Policy Makers, Shanghai, 2007. www.ipcc.ch	
Usage	The module is an optional module in Hydro Science and Engineering.	
Pre-requisite to achieve credit points	The successful students have to pass the module exam. It consists of a written exam (45 minutes), and an oral presentation in climate change.	
Credit points and marks	The module earns 5 cr. The mark is the weighted mean of the marks achieved at the written exam (50%), the oral presentation (50%).	
Frequency of the module	The module is offered each winter semester.	
Work load	The student’s work load is 150 hours.	
Duration of the module	The module is finished in one semester.	

Module number	Module name	Professor in charge
	Geodesy	**Prof. Wanninger**
Contents and qualification aims	The module provides an introduction to the various aspects of geodetic techniques including sensor technology and collection, administration, and visualization of spatial information in hydro science. At the end of the module the students know the most important geodetic techniques of data acquisition and data processing. They will be able to select appropriate geodetic techniques for various applications.	
Teaching form	2 hours a week lectures, 1 hour a week, tutorial	
Pre-requisite of attendance	Basic knowledge of mathematics, statistics, and physics. Literature: **Wolf, P.R., Ghilani, C.D.** (2005): Elementary Surveying. 11th edition, Pearson Prentice Hall, Upper Saddle River, NJ, USA. **Kavanagh, B.F.** (2003): Geomatics. Prentice Hall, Upper Saddle River, NJ, USA.	
Usage	The module is a mandatory module.	
Pre-requisite to achieve credit points	Credit points are achieved by passing the written exam of 90 minutes. Pre-requisite for the participation in the exam is the successful participation in at least 70% of the offered practicals which include assignments.	
Credit points and marks	The module earns 5 cr. The mark is based on the result of the written exam.	
Frequency of the module	The module is offered once a year in the winter semester.	
Work load	The work load is 150 hours.	
Duration of the module	The module is finished in one semester.	

2nd Semester at UNESCO-IHE

Computational Intelligence and Control Systems	**WSE/HI06 HIFRM**
4-23 March 2013	**5 ECTS Credit Points**

Mentor:	D. P. Solomatine					
Tuition form & study load:	*Topic*	*Contact hours*			*Study load [hrs]*	*Examination/weight*
		Lec-ture	*Exer cise*	*Work shop*		
	Introduction to optimisation	4	2	4	20	Exercise report (10%)
	Real time control of water systems	16		12	60	Written exam & exercises (45%)
	Data driven modelling and computational intelligence	14		18	60	Written exam (25%) Exercise report (20%)
	(total contact hours 70)				Total 140	
Pre-requisites:	Module 5					
Learning objectives:	After completing the module participants should be able to: 1. Understand the main optimisation techniques 2. Understand and explain how real-time control systems work 3. Identify the potential of control to solve hydrological problems 4. Sketch a general plan for a regional real-time control system 5. Know the main techniques of data-driven modelling from machine learning (neural networks, model trees, fuzzy systems, etc.) 6. Correctly classify a modelling problem as a physically-based, data-driven, or hybrid 7. Select proper methods and tools for building data-driven models					
Content:	**Introduction to optimisation, D. P. Solomatine (IHE)** Classical optimisation. Linear and non-linear optimisation. Derivative-based and direct methods. Dynamic programming. Global (multi-extremum) optimisation. Genetic and evolutionary approaches. Multi-objective optimization. Applications in water sector. Exercises and workshops: optimal water allocation; automatic model calibration					
	Real time control of water systems, A. Lobbrecht (IHE), S.J. van Andel (IHE), L. Alfonso (IHE) Introduction to Real-Time Control; Modelling hydrological systems and optimal control problems with AQUARIUS; Control-systems functions and techniques; Hardware and software components; Control systems in industry; Identifying control system components**;** One day field trip to North-West Netherlands.					
	Data driven modelling and computational intelligence, D. P. Solomatine (IHE) and B. Bhattacharya (IHE) Modelling in the framework of Hydroinformatics. Data-driven and physically based models. Overview of machine learning and computational intelligence. Main types of machine learning: classification, association, clustering, numeric prediction. Decision, regression and model trees. Artificial neural networks. MLP and RBF networks. Instance-based learning. Fuzzy logic and fuzzy rule-based systems. Exercises and workshops: using data driven methods in hydrological forecasting.					
Course materials:	Solomatine. *Lecture notes on Data-driven modelling.* Solomatine. *Reader on optimization.* Mitchell. Machine learning. McGraw-Hill, 1997. Witten and Frank. Data mining. Morgan-Kaufman, 2000. Lobbrecht: *Lecture notes on Real time control of water systems* Modelling software: AQUARIUS; Exercises Modelling software: WEKA; GLOBE; Exercises Optimisation software: LINGO; Exercises					
Didactics	Formal lectures; classroom exercises; home assignments; exercises and workshops in computer lab; classroom workshops on case study analysis					
Additional reading:	Proceedings of the Hydroinformatics Conferences. Selected papers. Practical Hydroinformatics (Abrahart, See, Solomatine, eds.). Springer, 2008. Artificial neural networks in hydrology, Govindaraju, Rao (eds). Kluwer, 2000.					

River Basin Modelling	**WSE/HI07** **HIFRM**
2-20 April 2013	**5 ECTS Credit Points**

Mentor:	A. Jonoski

Tuition form & study load:

Topic	*Contact hours*			*Study load [hrs]*	*Examination/weight*
	Lect -ure	*Exer cise*	*Work shop*		
					Exercises reports on three topics
River basin management	4	4	8	28	(10%)
Groundwater modelling	8	4	8	40	(20%)
Catchment modelling	12	16	4	72	(30%)
					participation
(total contact hours 68)				Total 140	& oral exam (40%)

Pre-requisites:	Hydrology and Hydraulics; Fluid dynamics, information technology and computer science; Information management and numerical methods
Learning objectives:	On completion of this module the participants are able to 1. Understand and explain the multi-purpose nature of river basins and approaches for their integrated planning and management 2. Know how to model flow processes in porous media 3. Use MODFLOW to simulate groundwater flow in the saturated zone 4. Know how to model hydrological processes in catchment rainfall-runoff 5. Use NAM to simulate rainfall runoff in a natural catchment 6. Know how to use MIKE-SHE to model both surface and groundwater flow in a natural catchment, including the unsaturated zone
Content:	**River basin management, A. van Griensven (IHE), W. van der Krogt (Deltares)** Introduction to the management of river basins; water resources; catchment yield; land use and agriculture; storage; groundwater; flood mitigation; irrigation; power generation; navigation; demand forecasting; dealing with droughts. Exercises and workshops with SWAT and RIBASIM.
	Groundwater modelling, A. Jonoski (IHE) The continuum approach; definitions; Darcy's law; groundwater flow in the saturated zone: equations for 1D, 2D and 3D flow; modelling approaches; modelling protocol; contaminant transport through advection and diffusion; exercises and workshops with the MODFLOW software package to solve a water resources analysis problems: problem definition, model building; Exercise report
	Catchment modelling, M. Butts (DHI), A. Jonoski (IHE) and I. Popescu (IHE) Types of hydrological models: empirical/data-driven/black box; conceptual and physically based models. NAM lumped-conceptual model: model-set-up of a catchment & calibration from rainfall & discharge records. Focus on distributed physically based catchment modelling with MIKE-SHE: 1) introduction to the modelling exercises and workshops; presentation of MIKE-SHE software package and the catchments used for the exercises; 1) Initial model building - saturated zone; 2) Overland and river flow modelling - comparison of models with and without the river network; 3) Unsaturated zone modelling 4) Fully integrated catchment model: river + drainage + saturated + unsaturated zone; Exercise report.
Course materials:	*Lecture Notes*: Price and van Griensven: *River basin management* Refsgard: *Introduction to hydrological modelling: Modelling of the processes of the land phase of the hydrological cycle* *PowerPoint slides:* Jonoski: *Groundwater modelling* Butts: *Catchment modelling* *Handout*: Jonoski and Popescu: *Catchment modelling with MIKE SHE (handout)* van der Krogt: *RIBASIM user manual* van Griensven: *SWAT* (*handout*) *Modelling software*: RIBASIM, MODFLOW; NAM and MIKE-SHE; MIKE11
Didactics	Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab

Additional reading:	

Introduction to River Flood Modelling	**WSE/HI8 HIFRM**
22 April- 11 May 2013	**5 ECTS Credit Points**

Mentor:	I. Popescu
Tuition form & study load:	(see table below)

Topic	*Contact hours*			*Study load [hrs]*	*Examination/weight*
	Lecture	*Exercise*	*Workshop*		
Application domains of Hydroinformatics: floods, urban systems and environment	4		2	14	
Climate change and its impact on hydrology	4		2	14	Written exam 10%
Environmental processes and water quality	4		2	14	
Intro to modelling with 1D applications (for short course only)	4		2	14	
Introduction to 1D2D, 2D modelling	2		2	8	Exercise report (50%)
Flood analysis, river flood modelling and 1D flood routing	8	22		68	Oral exam (40%)
New data sources to support flood modelling		2	2	6	
(total contact hours 62)				Total 138	

Pre-requisites:	Basic knowledge of hydraulics and hydrology
Learning objectives:	On completion of this module the participants are able to: 1. Understand and explain the main flood management problems; 2. Understand and explain the governing processes of flood generation and propagation 3. Identify the proper modelling methodology for a given problem 4. Utilise their hands-on experience in the step-by-step modelling procedure (geometry, bathymetry, boundary conditions, forcing) needed to carry out a practical study with MIKE11, SOBEK 1D or HEC-RAS package; 5. Know how the river flood model may be used for structural and non-structural measures for flood mitigation
Content:	**Application domains of Hydroinformatics: floods, urban systems and environment, R. K. Price (IHE), Z. Vojinovic (IHE) and A. Mynett IHE)** Introduction to floods and flooding. Introduction to urban floods and urban water systems. Introduction to environmental systems.
	Climate change and its impact on hydrology, P.D.A. Pathirana (IHE) Climate change problematique. Global, regional and local climate models, development of climate change scenarios. Effects of climate variability on the hydrology that affects rainfall-runoff processes in river-basins.
	Environmental processes and water quality, H. J. Lubberding (IHE) Environmental processes. Water quality problems from a modelling point of view: outfalls, BOD-DO, eutrophication, toxic substances, best technical means approach, water quality objectives approach; Properties of the natural system from a modelling point of view, residence times, time scales of transport processes compared with those of water quality processes, spatial scales of phenomena, link between transport of substances and water quality processes.

	Introduction to 1D2D, 2D modelling, I. Popescu (IHE) Introduction to the basic principles of 1D2D and 2D modelling.
	Flood analysis, river flood modelling and 1D flood routing, R.K. Price (IHE), I. Popescu (IHE), B. Bhattacharya (IHE) Nature and characteristics of floods: flood analysis – e.g. flood probability - probability and return period analysis of hydrological events and design floods - and estimation of peak flows (using Flood Estimation Handbook (FEH and ReFH) methods, catchment characteristics method, storm hydrographs and unit hydrograph methods River Flooding Modelling: -The significance of overbank flow, floodplain behaviour and stage discharge prediction (using the Ackers Method and Conveyance Estimate System) -Modelling flood propagation - flood routing -hydrological methods – Muskingum, reservoir routing, HEC-HMS -1D hydraulic flood routing/modelling in rivers -The Conveyance Estimate System; modelling resistance for discharge estimation. -Introduction to 'HEC-RAS' software; -Discussion of sustainable flood alleviation methods
	New data sources to support flood modelling, G. Di Baldassarre (IHE) Introduction to new generations of data to support river flood modelling. Remote sensing: satellite and airborne flood imagery. Wireless sensors to assist inundation modelling. Freely and globally available space-borne data to monitor floods.
Course materials:	*Lecture notes on River flood management and flood routing* Presentation slides; Modelling packages with user manuals;
Didactics	Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab
Additional reading:	Papers and other material provided by the course lectures.

Fieldtrip				**WSE/HI09 HIFRM**
21 May – 8 June 2013				**5 ECTS Credit Points**
Mentor:	S.J. van Andel			
Tuition form & study load:	*Topic*	*Contact hours*	*Study load [hrs]*	*Examination/weight*
	Study tour	80	112	Fieldtrip report
Pre-requisites:	*N. A.*			
Learning objectives:	On completion of this module the students are able to: Have an overview of water-related problems, projects and schemes in Florida, USA, particularly the Everglades Comprehensive Restoration project			
Content	This is an exposure tour with 'on site' explanation of hydrological, hydraulic and environmental projects in USA. Specific supplements to the taught part of the programme are the visits to projects with implemented Hydroinformatics components, or various centres involved in Hydroinformatics research.			

<table>
<tr><td colspan="2">Flood Risk Management</td><td colspan="6" align="right">WSE/HI10
HIFRM</td></tr>
<tr><td colspan="2">10 - 29 June 2013</td><td colspan="6" align="right">5 ECTS Credit Points</td></tr>
<tr><td>Mentor:</td><td colspan="7">B. Bhattacharya</td></tr>
<tr><td rowspan="3">Tuition form & study load:</td><td rowspan="2">Topic</td><td colspan="3">Contact hours</td><td rowspan="2">Study load [hrs]</td><td rowspan="2" colspan="2">Examination/weight</td></tr>
<tr><td>Lec ture</td><td>Exer cise</td><td>Work shop.</td></tr>
<tr><td>Flood risk management
Flood modelling: methods and techniques (advanced features)

(total contact hours 64)</td><td>20</td><td>8
28</td><td>6
2</td><td>82
58

Total 140</td><td colspan="2">Exercise reports (40%)

Written exam on all subjects (60%)</td></tr>
<tr><td>Pre-requisites:</td><td colspan="7">Hydraulics, hydrology, river basin and flood modelling, statistics</td></tr>
<tr><td>Learning objectives:</td><td colspan="7">On completion of this module the participants are able to:
1. Understand and explain the main principles of flood risk management;
2. Understand the Hydroinformatics tools available for flood risk management;
3. Conceptualise the main principles of EU flood directive and have knowledge about European experience in flood risk management;
4. Understand and explain the main principles of flood forecasting and warning and uncertainty issues associated with flood forecasts;
5. Familiarise with the different flood forecasting models;
6. Utilise their hands-on experience in the step-by-step modelling procedure to build flood inundation models.</td></tr>
<tr><td rowspan="2">Content:</td><td colspan="7">Flood risk management, B. Bhattacharya (IHE), P. Samuels (HR Wallingford), F. Klijn (Deltares), M. Werner (IHE)
Introduction to flood risk management. Quantifying flood risk – probabilistic and statistical approaches. Risk-based decision making. Case studies. Introduction to risk analysis of flood defence structures. Case studies. Flood vulnerability and resilience.
European experience in managing floods. EU framework directive on floods. Other national (eg UK) flood directives.
Flood disaster management (Pre-, post- and during flood). Flood emergency response and flood preparedness. Flood fighting, recovery and insurance. Evacuation management.
Flood forecasting and warning. Objectives. Lead time considerations. Data requirements. Flood forecasting models. Issuance of flood warning and response.
Uncertainty issues in flood forecasting. Modelling uncertainty and its benefits.
Social issues.

Where possible lectures and exercises will be given in conjunction with Module 10 of the Hydraulic Engineering and River Basin Development Specialisation.</td></tr>
<tr><td colspan="7">Advanced river flood modelling, I. Popescu (IHE), B. Bhattacharya (IHE), G. Di Baldassarre (IHE) and S. J. van Andel (IHE)
2D, 1D2D river flood modelling. Dam break modelling. Flood modelling, in 2D, in support of flood mitigation strategies (including flood risk maps. Structural and non-structural approaches in flood mitigation. Engineering solutions - flood routing and flood alleviation: channel & reservoir routing, flood banks, channel improvements, diversion schemes, flood storage on-stream and off-stream ; and non-structural issues - approaches to the reduction of flood impacts, flood risk maps.</td></tr>
<tr><td>Course materials:</td><td colspan="7">Lecture notes on Hydroinformatics for flood management, EU framework directive, flood risk management
Lecture notes on Flood modelling
Presentation slides;
Modelling packages with user manuals;</td></tr>
<tr><td>Didactics</td><td colspan="7">Formal lectures; classroom exercises; home assignments; exercises and workshops in computer lab;</td></tr>
<tr><td>Additional reading:</td><td colspan="7"></td></tr>
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Hydroinformatics for Decision Support	**WSE/HI11** **HIFRM**
1 – 20 July 2013	**5 ECTS Credit Points**

Mentor: A. Jonoski

Tuition form & study load:

Topic	*Contact hours*			*Study load [hrs]*	*Examination/ weight*
	Lecture	*Exer-cise*	*Work shop*		
System analysis in water resources	8	6	6	42	Assignments (35%)
Decision support systems	6	4	4	30	Assignments (30%)
Software technologies for integration	4	10	10	42	Assignments (20%)
Integration of weather prediction and water models	8		2	26	Assignments (15%)
(total contact hours 68)				Total 140	

Pre-requisites: Hydrological and hydraulic modelling concepts, basic programming skills

Learning objectives:

On completion of this module the participants are able to:

1. Understand the role of system analysis in water resources planning and management
2. Formulate and solve water resources problems as optimisation problems
3. Distinguish and properly use different types of decision support methods for water problems
4. Build simple software applications that integrate data and models, both as stand-alone and Internet-based
5. Understand the potential of newly available data sources (e.g. remote sensing, web resources, data generated from climate and meteorological models) in advanced integrated modelling and decision support

Content:

Systems analysis in water resources, D.P. Loucks (Cornell University)
Definition and role of systems analysis in engineering planning; Basic concepts; Multi-objective models and the concept of trade-offs between conflicting objectives; Development and use of static and dynamic stochastic simulation models of river systems.; Introduction to decision support systems and geographic information systems and their use; Exercises in multipurpose integrated river basin (or regional) water resources management modelling

Decision support systems, A. Jonoski (IHE) and I. Popescu (IHE)
Introduction to decision making process; objectives and alternatives. Optimisation in decision support (single and multi-objective0. Multi-attribute decision methods and tools: formulation of decision matrix, generating and using weights, compensatory and non-compensatory decision methods. Introduction to mDSS4 decision support software; exercises and assignments with case studies implemented in mDSS4

Software technologies for integration, A. Jonoski (IHE), L. Alfonso (IHE), A. Almoradie (IHE)
Introduction to methods and tools for software integration of models and data: file conversions exercises. Object-oriented integration approaches.
Software integration across networks: Client-server programming, Web protocols, Technologies for integrating distributed resources: web-interfaces technologies; creating web-based applications with assignment exercise.

Integration of weather prediction and water models, S.J. van Andel (IHE), A.H. Lobbrecht (IHE)
Approaches and methods for integration of weather models with hydrologic and hydraulic models. Integration of remote sensing data. Downscaling and upscaling issues.

Course materials:

D.P. Loucks: *Lecture Notes on Water Resource Systems Modelling: Its Role in Planning and Management* (chapters 2, 3, 4, 10 and 11)
A. Jonoski: *Introduction to Decision Making and Decision Support Systems* (PowerPoint Slides)
A. Jonoski: *Software Technologies for Integration* (PowerPoint Slides)

Didactics	Formal lectures; classroom exercises; home assignments; exercises & workshops
Additional reading:	

3rd Semester
1st part at UPC Barcelona
2nd part at University of Ljubljana

1nd part of Semester 3, UPC

Global warming effects, Flood and Drought Management.	
	3 ECTS Credit Points

Mentor:	A. Bateman					
Tuition form & study load:	*Topic*	*Contact hours*			*Study load [hrs]*	*Examination/weight*
		Lect -ure	*Exer cise*	*Work shop*		
						Exercises reports on three topics
	Climate change effects on hydrological cycles.	2	2	4	10	(10%)
	Drought management.	5	5	10	20	(30%)
	Water resources management on climate change scene.	3	3	8	15	(20%)
					Total 87	& oral exam (40%)
	(total contact hours 42)					
Pre-requisites:	Hydrology and Hydraulics; Fluid dynamics, information technology and computer science; Flash Flood, Drought and Climate change; Information management and numerical methods					
Learning objectives:	Description of global warming and the hydrological consequences into a river basin is presented to the student; river flows and water resources. Assess the effect of climate change due to green effect mechanism. Change in water resources and river flows over time and finally changes in water quality. A short introduction of drought assessment and management affected by the global warming effect is studied. Hydrological and meteorological droughts assess. Study of climate generators its utilities and difficulties					
Content:	– Global warming and the impact on river flows and water resources. – What is Climate Change? The green house effect, climate change and the hydrological processes. – The green house effect, climate change and the hydrological processes in Flood, FF and DF forecasting. – Changes in water resources, Changes in Flow regimes, implications of water management. – Global Warming and Hydrological Uncertainity – River flood management – Evaluation of Meteorological Drought – Evaluation of hydrologic drought – Drought in water management – Parametric and no parametric climate generators					
Course structure:	1. Conventional class activities 2. Optional seminars 3. Personal course work will consist in a selection, review and final report of a selected research paper regarding radar topic and application in hydrologic problems. The student may read, understand and redact a summary-report on the topic. Finally, the student will present the paper and the report in public. The amount of hours will depend on followed seminars. 4. Round tables will be planned to discuss the results of the home work.					
Didactics	Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab					
Additional reading:						

Coastal flooding: impacts, conflicts and risks (UPC, 7 ECTS)

Coordinator

Prof. Agustín Sánchez-Arcilla

Aims

To present the coastal zone as a dynamic zone submitted to an increase in pressures of use and, thus, with a high level of risk for the infrastructures/activities that "rigidize" it. To present the main driving factors for coastal dynamics in terms of the risk that they produce. To present how the risk does develop, how to manage it and its perception by the "agents" that live at and use the coast.

Description

Introduction. Coastal zone. Estuarine areas. Dynamics and risks. Evaluation of environmental impacts in the marine environment. Environmental control at the costal zone. River flooding risks. Precipitation, floods and river mouth discharges. Erosion and flooding risks at the coastal fringe. Pollution risks. Sources, dispersion and evolution. Vulnerability, resilience and risk. Operational models and services. Risk management.

Teaching staff: UPC staff

Teaching and Learning Methods: Motivation talks with emphasis on
- Problem approach
- Some examples to illustrate the dimension of the problem
- Some examples of results to illustrate the tools to solve the problem

Assessment: Conventional exam and/or a case study, to be chosen by the student or group of students with the agreement of the supervisor (maximum 3), to be resolved at a conceptual level as follows
- Problem
- Approach
- Solution

With an approximate extension of 15 pages corresponding to a workload of approximately 10 hours

Course structure

5. Conventional class activities
6. Optional seminars
7. Personal course work (amount of hours depending on followed seminars). Critical review of the state of art on one of the following subjects:
    a. Probabilistic distributions for two related variables (e.g. waves and mean water level)
    b. Extreme distributions (e.g. for waves)
    c. A hot research issue within the course contents

These subjects will be developed with information from the Catalan coast and with information, if available, from a case study in the country of the participant students.
The structure of the critical review will follow the one suggested below:

i. Introduction
ii. Main aims
iii. State of the art
iv. Future work
v. References

The estimated number of self work hours for this course goes between 80 and 100, depending on the student conditions.

Course Content

- Presentation. Impacts, conflicts and risks
- Coastal risks due to climatic variability

- Impacts on Coastal Zones
- Practical assessment of risk and impact: a case study
- The coastal zone. Estuarine areas. Dynamics and risks
- Flooding and discharges at the river mouth
- Precipitation and flooding
- Sources and decay of pollutants
- Marine flooding and erosion risk
- Wave evolution and wave forecasting
- Risk forecasting. Operational models
- Dispersion and evoluton of pollutants
- Risk assessment. Vulnerability and resilience

Debris Flow and Flash Flood. Risk, Vulnerability, Hazard and Resilience concepts						
	6 ECTS Credit Points					
Mentor:	A. Bateman					
Tuition form & study load:	*Topic*	*Contact hours*			*Study load [hrs]*	*Examination/weight*
		Lect -ure	*Exer cise*	*Work shop*		
						Exercises reports on five topics
	Debris Flow, concepts and modelling.	7	7	10	25	(15%)
	Flash Floods, concepts and modelling.	7	7	10	25	(15%)
	Drought concepts and modelling.	4	4	9	10	(10%)
	Vulnerability and Uncertainty.	4	4	9	10	(10%)
	Experimental works (Fluvial Morphodynamics Laboratory GITS)	2	2			(5%)
	Field Trip to a case study.				12	participation (5%)
	(total contact hours 86)				total 168	& exam (40%)
Pre-requisites:	Hydrology and Hydraulics; Fluid dynamics, information technology and computer science; Information management and numerical methods					
Learning objectives:	The principal objective of the present course is to introduce the student to new phenomena as the debris flow and flash flood. The students learn how to evaluate the debris flows and flash floods mathematics and how to delimitate flooded areas, and also to calibrate and create new models. The students learn and apply concepts as risk, vulnerability and resilience.					

Content:	Description of debris flow phenomenon and basic concepts are presented. Description and definition of flash flood assessment. This course transport to the student to new concepts on flood phenomena produces by debris or water. The student learns mathematical models adapted to both phenomena, learn how to apply different rheologies. Learn to create flood (debris or water) risk maps from simple and complex models. – Debris Flow theories, triggering variables, rheology, mathematical modelling. – Debris Flow modelling aspects, 0D, 1D and 2D numerical models. Delimitation of occurrence zones and run-off. Shalstab, Triggs, Sinmap, FLATModel (Gits-2d Model), GITS1D. – Flash Flood modelling and analysis. Simplified methods. – The socio economical aspects at the Maresme Basins, usually basins with high level of risk and FF events. – Translation of hydraulic models output variables into hazard – Spatial Planning. Structural risk analysis, bridges, streets, abutments, other elements in rivers, Scouring. – Translation of Drought models output variables into hazard – Translation of Debris Flow models output variables into hazard – Translation of coastal models output variables into hazard – Methodologies to evaluate vulneranbility as a quantitative values. – Application of uncertainty to risk assessment – Methodologies to evaluate uncertainity as a quantitative values. – Construction of Hazard Maps from DF & FF. Using GIS and different models (Hydraulic and Debris kinds) – Residual risk evaluation – Optimal design of structural measures. Economic appraisal of flood risk mitigation projects.
Course structure:	8. Conventional class activities 9. Optional seminars 10. Personal course work will consist in a selection, review and final report of a selected research paper regarding radar topic and application in hydrologic problems. The student may read, understand and redact a summary-report on the topic. Finally, the student will present the paper and the report in public. The amount of hours will depend on followed seminars. 11. Round table will be planned to discuss the results of the home work.
Didactics	Formal lectures; classroom exercises; home assignments; exercises & workshops in computer lab
Additional reading:	

The application of radar-based rainfall observations and forecast in Early Warning Systems and Flood Forecasting. (Compulsory, 3 ECTS)

Coordinator

Prof. Daniel Sempere Torres

Aims

Flood risk management and decision making is highly dependent on rainfall forecast and the use of meteorological radar has become a useful tool in rainfall forecast. The research and methodologies regarding the application of radar measurements to hydrologic forecast has been improved in the last decades and operative early warning systems are taking advantage of high spatial and temporal resolution radar-based rainfields.

Description

The course introduces to the principles of quantitative precipitation estimates (QPE) using the radar data: procedures, chain correction of errors and Z-R application in order to assess the rainfall estimation. Hydrological application of radar QPE is included in the course, as well as the description and examples of Quantitative Precipitation Forecast (QPF) based on radar rainfields. Case studies in the catalonian region will be presented. The application of rainfall forecast in operational early warning systems will be introduced, both in the catalonian region (EHIMI) and the European domain (EFAS, European Flood Alert Systems). Finally, students can visit different hydrometeorological agencies as ACA (Catalan Water Agency) the SMC (Catalan Weather Service) and CECAT (Catalonian Emergency Center), as well as the Consell Comarcal del Maresme (Regional counsel of the Maresme region), which assess the different municipalities in rain forecast.

Teaching staff: UPC staff

Teaching and Learning Methods: Motivation talks with emphasis on the radar data processing in order to highlight the necessity of an accurate correction of intrinsic measurement errors (beam blocking, ground clutters, attenuation…). Also, the methods for the interpolation of rainfall at the ground from the radar data volume will be described. In general, limitations of radar QPE will be exposed, as well as the advantages in the hydrological application, particularly in Flash Floods at medium-small basins. Some examples and case studies to illustrate the application to hydrological forecast will be presented, as well as the description of the current software and tools for the flood risk management. Demos and didactic interactive software (student-oriented) will be used in the practical session.

Assessment: Conventional exam and/or a case study, to be chosen by the student or group of students with the agreement of the supervisor (maximum 3), to be resolved with an approximate extension of 15 pages corresponding to a workload of approximately 10 hours.

Course structure

- Conventional class activities
- Optional seminars
- Personal course work will consist in a selection, review and final report of a selected research paper regarding radar topic and application in hydrologic problems. The student may read, understand and redact a summary-report on the topic. Finally, the student will present the paper and the report in public. The amount of hours will depend on followed seminars.

The estimated number of self work hours for this course goes between 80 and 100, depending on the student conditions.

Course Content

The application of radar-based rainfall observations and forecast in Early Warning Systems and Flood Forecasting.

- Principles of quantitative precipitation estimates (QPE) using radar data. Associated errors and correction methods.
- Hydrological applications of radar QPE. Derived products for water management. Short term Quantitative Precipitation Forecast (QPF) based on radar data. Applications in real time and historical series reanalysis.
- Processes and elements of a hydrological forecasting system based on QPE and QPF.
- Simplified Early warning systems based on radar QPE and QPF. The European Flood Alert System (EFAS): A case study.
- Fieldtrips, visit to hydrometeorlogical and civil protection agencies (SMC, Consell Comarcal Maresme, ACA, CECAT)

2nd part of Semester 3, University Of Ljubljana

Spatial planning for flood protection	
Three weeks in December	5 ECTS Credit Points

Mentor: A. Prof.dr Andrej Pogačnik, pro.dr Mitja Brilly

Tuition form & study load:

Topic	*Contact hours*			*Study load [hrs]*	*Examination/weight*
	Lecture	*Exercise*	*Work shop*		
Introduction and to spatial planning, foundations of sustainable planning and overview of legal foundations of spatial planning	14		6	30	Written exam (20%)
Planning with respect to flood protection on state, regional and local levels	10		15	55	Written exam & exercises (40%)
Local and site planning with respect to flood control and protection and flood mitigation by spatial planning	10		15	55	Written exam & exercises (40%)
(total contact hours 70)				Total 140	

Pre-requisites: Module ?

Learning objectives:

8. Overview of principles of sustainable planning on different scales
9. Knowledge of the aims, methods and techniques of spatial planning
10. Understand the problems of water management and flood control in the open channels and within settlements
11. Ability for team work on regional, urban and local plans with respect to flood control
12. Design flood control together with land use planning, planning the infrastructure, nature 2000 other protected areas

Content:

Introduction and to spatial planning, foundations of sustainable planning and overview of legal foundations of spatial planning A. Pogačnik (UL)
Overview of state of the art in spatial planning in EU countries. International planning. Planning on state level. Regional planning. Urban and landscape planning. Local and detail planning. Flood control on all level of spatial planning.
Legal aspects of spatial planning. Comprehensive and sect oral planning. Sustainable planning. Examine of good practice.

Planning with respect to flood protection on state, regional and local levels, Local and site planning with respect to flood control and protection and flood mitigation by spatial planning
A. Pogačnik (UL) M. Brilly (UL)
Methods and .techniques. Site analysis. Spatial data collection and procession. Attractiveness vulnerability mapping, Flood impact analysis, environmental impact analysis and spatial planning
Methods and techniques of urban planning with respect to flood control. Project planning and flood protection by structural and non-structural measures.
Workshop: Students work out together a plan of a region or town in terms of its development and flood control

Course materials:	Colley B.C. Practical manual of land development, Mc Graw Hill, 2005 De Chiara Time saver standards for regional development Fukuoka S., Floodplain riska management, Balkema AA, 1998
Didactics	Formal lectures; classroom and home workshops; field work on case study analysis
Additional reading:	EU commission: European spatial development and floods directives CESDP, POTSDAM FLOODS Directive 1999 Stiftel B.,Watson C., Dialogues in urban and regional planning. Routledge Espon Atlas selection topics, 2005 Wegener M. Button K., Nijkamp P., Planning history and methodology, EE Pugusnik, UK selected topics, 2007 The World Bank, Environmental assessment source book, Washington, Chapters 1-3, 1991 EU flood research reports, AWARE, URBEM

<table>
<tr><td colspan="7">Socioeconomical assessment of flood protection</td><td colspan="2"></td></tr>
<tr><td colspan="7">First three weeks in January</td><td colspan="2">5 ECTS Credit Points</td></tr>
<tr><td>Mentor:</td><td colspan="8">B. Prof.dr. Brilly M. Prof.dr Kos D., Prof.dr Polič Prof.dr M. Kovač B.</td></tr>
<tr><td rowspan="3">Tuition form & study load:</td><td rowspan="2">Topic</td><td colspan="3">Contact hours</td><td rowspan="2">Study load [hrs]</td><td colspan="3" rowspan="2">Examination/weight</td></tr>
<tr><td>Lec-ture</td><td>Exer cise</td><td>Work shop</td></tr>
<tr><td>Introduction in socioeconomics aspect of water policy and flood protection

Involve of stakeholders and public in communication and decision making process

Economy of flood protection

(total contact hours 70)</td><td>8

12

14</td><td>

4</td><td>10

14

8</td><td>40

50

50

Total 140</td><td colspan="3">Exercise report (10%)
Written exam & exercises (45%)
Written exam (25%)
Exercise report (20%)</td></tr>
<tr><td>Pre-requisites:</td><td colspan="8">Module ?</td></tr>
<tr><td>Learning objectives:</td><td colspan="8">After completing the module participants should be able to:
13. Understand the importance of socioeconomics questions in flood management
14. Understand the role of communication and public participation in decision making process;
15. Estimate level of social support of particular solution;
16. Have acquired a basic understanding of social processes and estimate social capital;
17. Select proper methods and tools for economical analysis of flood protection</td></tr>
<tr><td rowspan="3">Content:</td><td colspan="8">Introduction in socioeconomics aspect of water policy and flood protection, Brilly M. (UL)
Basic principles of water policy. Social and economical aspects of decision making process. Different cultural and political aspect in up-down and down-up decision making process. Historical overview.</td></tr>
<tr><td colspan="8">Understanding o social assessment problems of flood protection, D. Kos (UL), Polič M. (UL)
Communication and public participation in water policy (Aarhus c.). Sociological aspects of flood risk perception. Legitimization and communication of emergency information. Public opinion v. expert knowledge. Public perception of floods and emergency information vulnerability. Stakeholders competences in communicating flood warnings</td></tr>
<tr><td colspan="8">Economy of flood protection, Kovač B. (UL)
Cost-benefit analyse of flood protection measures and decision making. Economical methods for damage evaluation. Economic incentives for flood prevention and regulative aspects. Risk management.</td></tr>
<tr><td>Course materials:</td><td colspan="8">Becker H., Social Impact assessment, UCL Press, London, 1997.
Harper L.C., Environment and Society – human perspective on environmental issues, Pearson, New Jersey, 2004
Milleti D.S., Disaster by Design, Joseph Henry Press, 1999</td></tr>
<tr><td>Didactics</td><td colspan="8">Formal lectures; home assignments; classroom workshops on case study analysis.</td></tr>
<tr><td>Additional reading:</td><td colspan="8">Public Participation in Making Local Environment Decisions, (2000) The Aarhus Convention Newcastle Workshop. London: Good Practice Handbook, Department of the Environment.
Hart U.R.P., Flood response and Crisis Management in Western Europe, Springer, 1998
Correira F.N., Institutions for Water Resources management in Europe, AA Balkema, 1998</td></tr>
</table>

Semester 4: Masters thesis in one of the partner institutes or with the Associated Partners