Climate and Water Sensitive Urban Design (ENV-526)

Teaching Staff

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Guests:	ALICE Laboratory, Luca Rossi (LR), Christoph Bachofen (CB)

Teaching period: Spring

Lectures: 2 Hour(s) per week x 12 + 2 weeks (Wednesday 08-10, INR 219)
Group work: 2 Hour(s) per week x 12 + 2 weeks (Wednesday 10-12, INR 219)
Credits: 4

Summary
This project-based course introduces students to the field of urban climate and hydrology, with a focus on nature-based solutions for the design of climate and water resilient cities.

Description
The course introduces students to the field of urban climate and hydrology, with a focus on nature-based solutions for the design of climate and water resilient cities. The course describes the characteristics of urban systems, their impact on the water cycle (e.g. water budget, runoff generation, flood risk), and the creation of distinct urban climates (e.g. radiation, energy balance, urban heat islands). Students will learn the physical principles governing urban-induced changes in climate and hydrology and will explore how urban design can mitigate climate-related risks and improve citizens' wellbeing by means of green and blue infrastructures. The course is intended for students with different backgrounds, from environmental sciences and engineering to urban planning and design.

Content
- INTRO: Cities and global climate change
- PART 1: Water
    - Introduction to urban hydrology
    - Runoff modelling, flood risk and mitigation
    - Conventional vs Sustainable Urban Drainage Systems
    - Water sensitive design
- PART 2: Climate
    - Introduction to urban climate (airflow, radiation, energy balance)
    - Urban heat and dry islands

- Air pollution
- Climate sensitive design

Learning outcomes

By the end of the course, the students must be able to:

- Explain how cities modify land surface processes on multiple temporal and spatial scales;
- Quantify the physical processes governing the climate and hydrology of cities (e.g., urban heat and dry islands, air pollution, runoff generation, flood risk);
- Apply urban physics concepts in urban design;
- Propose nature-based solutions to design more sustainable and resilient cities

Teaching methods

- Weekly lectures (L): carried out at the blackboard and with the aid of projected material
- Weekly design tutorials/exercises (E): students will work in multidisciplinary teams (composed of IA and IE students) on a group project for the entire duration of the course
- Case study workshop: group project presentation and review
- Urban climate walk[1]

Methods of assessment

40% Individual test

60% Group project (40%) with individual components (20%).

Group Project

Work in groups of 4-5 students and produce a detailed plan to improve climate and water management at the EPFL campus using nature-based solutions. The deliverables should include (1) a portfolio and (2) a technical report with individual contributions (see description in Moodle).

[1] For an example, see here: https://climatelondon.org/events/urban-climate-walk/

Course Schedule 2025

Week	Date	Lecture type	Duration	Topic	Staff members
1	19.02	L	2h	Course description, Cities and global climate change	GM
		L	2h	Design tutorial/Group Work (project description, study site)	GM+AN
2	26.02	L	2h	Introduction to urban hydrology (rainfall, runoff, drainage)	GM
		E	2h	Campus Pieton, Design tutorials/Group Work	ALICE+AN
3	05.03	L	2h	Conventional vs Sustainable Urban Drainage Systems	GM
		E	2h	Design tutorials/Group Work (Project + InVEST model)	AN
4	12.03	L	2h	SuDS (continuation)	GM
		E	2h	Design tutorials/Group Work (SOLWEIG/TARGET models)	AN+MS
5	19.03	L	2h	Water sensitive design (Sponge cities, EPFL campus) + *Mid-term course review*	LR
		E	2h	Design tutorials/Group Work	AN+MS
6	26.03	L	2h	Introduction to urban climate (airflow, radiation, energy balance)	AB
		E	2h	Design tutorials/Group Work	AN+MS
7	02.04	L	2h	Introduction to urban climate (continuation)	AB
		E	2h	Design tutorials/Group Work	AN+MS
8	09.04	L	2h	Urban heat and dry islands	GM
		E	2h	Design tutorials/Group Work	AN
9	16.04	L	2h	Climate sensitive design	CB
		E	2h	Design tutorials/Group Work	AN
Easter Break					
10	30.04	L	2h	Design tutorials/Group Work	AB, AN
		E	2h	*Urban climate walk (outdoor activity)*	AN+AB
11	07.05	L	2h	Projects Review (*mandatory portfolio presentations*)	GM + guests
		E	2h	Design tutorials/Group Work	AN
12	14.05	L	2h	Individual test	GM+MS
		E	2h	Design tutorials/Group Work	AN
13	21.05	no lecture		-	
		E		Group Work	
14	28.05	no lecture		-	
		E		Group Work	

Reading List

Urban Climate:

Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). Urban climates. Cambridge University Press. Available online at: https://www.cambridge.org/core/books/urban-climates/A02424592E1C7F9B9CD69DAD57A5B50B

Urban Water:

Guo, J. C., Wang, W., & Li, J. (2022). Urban Drainage and Storage Practices. CRC Press. Available online at: https://www.taylorfrancis.com/books/mono/10.1201/9781003284239/urban-drainage-storage-practices-james-guo-wenliang-wang-junqi-li

CIRIA (2015. The SuDS Manual. Available online at: http://www.scotsnet.org.uk/documents/nrdg/ciria-report-c753-the-suds-manual-v6.pdf

Other useful readings:

Broadbent, A. M., Coutts, A. M., Nice, K. A., Demuzere, M., Krayenhoff, E. S., Tapper, N. J., & Wouters, H. (2019). The Air-temperature Response to Green/blue-infrastructure Evaluation Tool (TARGET v1. 0): an efficient and user-friendly model of city cooling. Geoscientific Model Development, 12(2), 785-803.

Butler, D., Digman, C., Makropoulos, C., & Davies, J. W. (2018). Urban drainage. Crc Press.

Ferranti, E.J.S and Futcher, J. and Salter, K. and Hodgkinson, S.P.B and Chapman, L. (2021) First Steps in Urban Heat for Built Environment Practitioners. Technical Report. Trees and Design Action Group. Available online at: http://epapers.bham.ac.uk/3452/

Hamel, P., Guerry, A. D., Polasky, S., Han, B., Douglass, J. A., Hamann, M., ... & Daily, G. C. (2021). Mapping the benefits of nature in cities with the InVEST software. Npj Urban Sustainability, 1(1), 1-9.

Jay, O., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., ... & Ebi, K. L. (2021). Reducing the health effects of hot weather and heat extremes: from personal cooling strategies to green cities. The Lancet, 398(10301), 709-724.

Masson, V., Lemonsu, A., Hidalgo, J., & Voogt, J. (2020). Urban climates and climate change. Annual Review of Environment and Resources, 45, 411-444.

Veerkamp, C. J., Loreti, M., Benavidez, R., Jackson, B., & Schipper, A. M. (2023). Comparing three spatial modeling tools for assessing urban ecosystem services. Ecosystem Services, 59, 101500.

Wilson, W. (2011). Constructed Climates, Available online at: https://people.duke.edu/~wgw/ConClim/index.html

Wong, N. H., Tan, C. L., Kolokotsa, D. D., & Takebayashi, H. (2021). Greenery as a mitigation and adaptation strategy to urban heat. Nature Reviews Earth & Environment, 2(3), 166-181.

World Bank (2021). A Catalogue of Nature-Based Solutions for Urban Resilience. World Bank, Washington, DC. Available online at: https://openknowledge.worldbank.org/handle/10986/36507

Woods-Ballard, B., Kellagher, R., Martin, P., Jefferies, C., Bray, R., & Shaffer, P. (2007). The SUDS manual (Vol. 697). London: Ciria.

InVEST Tutorials

- https://www.youtube.com/watch?v=bur8aTUkNWQ
- https://www.youtube.com/watch?v=7TVM6lN9utI

SOLWEIG Tutorials

- UMEP 2: Outdoor Thermal Comfort Modelling - Introducing SOLWEIG for QGIS
- UMEP 6: Climate-sensitive planning (scenario modelling) of outdoor thermal comfort with SOLWEIG