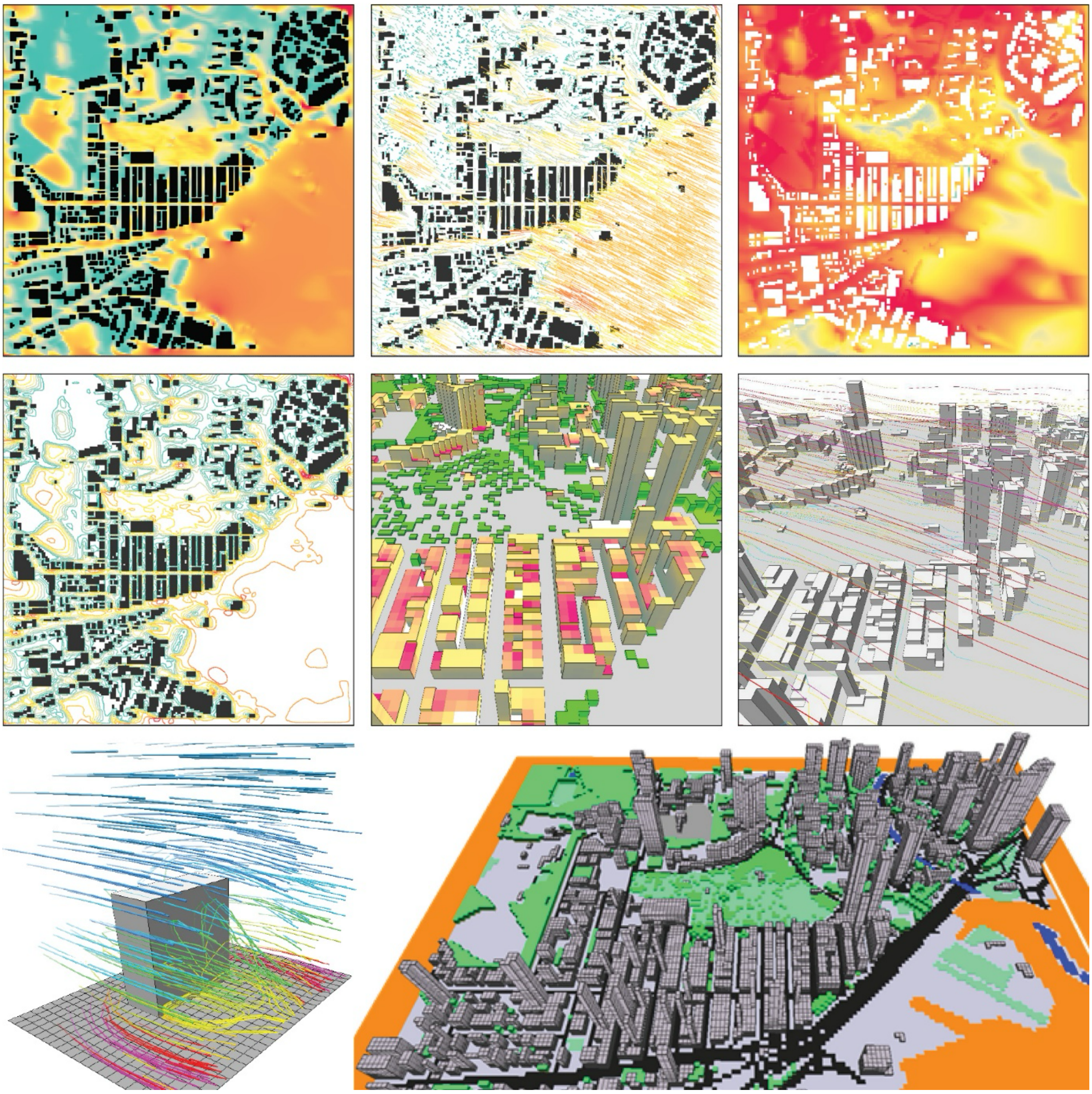

Climate-Responsive Design and Advanced Simulation Tools

INSTRUCTOR

HE, Yueyang
yueyanghe@cuhk.edu.hk

ISSUE

Reports from the Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO) underscore the growing threat posed by climate change, particularly through the increased frequency of extreme heat events and prolonged hot summers. These changes have the potential to exacerbate vulnerabilities in both built and natural systems, pushing their performance beyond typical operational thresholds. Addressing this challenge, the 2030 UN Agenda for sustainable development calls for climate-responsive strategies that are smarter, more systemic, and swifter in their application.

Hong Kong, located in the subtropical humid climate zone, faces specific climatic challenges characterized by intense heat, high humidity, typhoons, and heavy precipitation. These conditions complicate efforts to achieve urban cooling and maintain human thermal comfort. As future architects and designers, it is crucial that we integrate sustainable and climate-adaptive principles into our urban and landscape design practices to create environments that prioritize thermal health and resilience.

DESCRIPTION

This elective is designed to equip students with a deep understanding of urban climate mechanisms and study methods, alongside practical skills in using microclimate simulation software. By learning to simulate and analyse microclimates, students will be able to support and optimize environmental designs, making informed decisions that enhance the liveability of urban spaces. Additionally, the course will explore climate-responsive design strategies aimed at mitigating urban overheating, improving air quality and achieving thermal comfort. Students will engage with case studies, theoretical frameworks, and hands-on projects to develop a comprehensive approach to sustainable design in high-density cities.

IMPACT AND SUSTAINABILITY

1. Short-term impact
Upon completing this course, students will become proficient in the use of numerical microclimate simulation tools. These tools can be seamlessly integrated into other design coursework and studios, providing essential support for site analysis, environmental assessment, and design visualization. The climate-responsive design methodologies covered in this course will not only enhance students' technical skills but also foster a deeper understanding of sustainability principles. Through practical applications and case studies, students will gain insights into sustainable design practices that can be applied across various projects and disciplines.

2. Long-term impact
The knowledge and skills acquired in this course will provide students with a strong foundation in sustainable environmental assessment and design. This expertise will enhance their competitiveness in the job market, particularly in roles related to environmental design, urban planning, and green consulting. The course content is designed to broaden students' perspectives, instilling confidence in their ability to tackle complex environmental challenges. By equipping students with both theoretical knowledge and practical tools, the course will open up diverse career opportunities and empower them to make meaningful contributions to sustainable urban development.

COURSE SYLLABUS

TOPIC 1: High-density Cities and Urban Environment
This topic explores how urbanization in high-density cities leads to environmental challenges, including the impacts on temperature regulation, air quality, and precipitation.

TOPIC 2: Urban Overheating and Health Risks
This topic introduces the concepts of the urban heat island effect and climate change, examining their contributions to increased health risks in urban populations.

TOPIC 3: Urban Atmosphere, Climate Resilience, and Sustainable Design
This topic delves into the structure and processes of the urban atmosphere, the importance of microclimate resilience, and the critical role of sustainable design in mitigating climate impacts.

TOPIC 4: Methods of Studying Urban Climate
topic provides an overview of four key methods used to study urban climate, including observational techniques, physical modelling, numerical modelling, and empirical models.

TOPIC 5: Air Ventilation Design Strategies
This topic introduces air ventilation design guidelines aimed at improving urban microclimates, focusing on strategies that enhance air flow and reduce heat and pollutant accumulation in built environments.

TOPIC 6: Urban Greenery Design Strategies
This topic covers greening design guidelines that contribute to the improvement of urban microclimates, emphasizing the role of vegetation in cooling and enhancing urban spaces.

TOPIC 7: Quantitative Assessment of Design Strategies
This topic presents well-established quantitative assessment methods and systems used to evaluate the environmental impacts of urban design strategies, providing a basis for evidence-based decision-making.

TOPIC 8: Numerical Modelling Tools
This topic familiarizes students with the basic workflow of numerical modeling software, integrating lectures and hands-on tutorial exercises to build proficiency in simulation techniques.

TOPIC 9: Urban Climate Map
This topic introduces urban climatic analysis and recommendation maps, exploring how geographical information systems (GIS) can assist in urban planning and decision-making processes.

TOPIC 10: Urban Renewal Project Design and Evaluation
This topic guides students through the stages of an urban renewal project, including qualitative assessments, design scenario proposals, and quantitative evaluations, culminating in a group project that synthesizes course learnings.

METHODS

This elective will be delivered through a combination of the following methods:

1. Lectures
The instructor will deliver lectures covering key theories, concepts, and case studies related to urban

climate, microclimate simulation, and climate-responsive design. These sessions will provide the foundational knowledge necessary for students to engage with the practical components of the course.

2. Software tutorials
Students will be required to bring their laptops to class to learn the operation of numerical simulation software. The instructor will provide step-by-step guidance, ensuring that students can effectively use the software to model and analyze microclimates. Throughout the tutorials, students will complete individual practice assignments, such as creating models or generating simulated visualizations, to reinforce their learning.

3. Student presentations
Students will work in groups to present their mid-term and end-term projects, which will include assessments of the thermal environment and human thermal comfort at specific sites. These presentations will also showcase the students' climate-responsive design solutions, demonstrating their ability to apply the knowledge and skills gained throughout the course. The presentations will be an opportunity for students to receive feedback, refine their work, and collaborate with peers in a professional setting.

DELIVERABLES

Students will be required to submit a final report that comprehensively documents their environmental design study process. This report will deliver an evaluation of the effectiveness of their redevelopment design scenario in improving the thermal and wind environments of a high-density urban area. Students will be expected to clearly articulate the methods they used, the decisions they made, and the insights they gained throughout the course.

To support the development of the final report, the course will provide structured guidance for each tutorial exercise and presentation. This will ensure that students approach their tasks in a consistent and organized manner, allowing them to build a coherent narrative for their final submission. A detailed list of deliverables, including specific requirements for each assigned task, will be provided to guide students through the process.

LEARNING OUTCOMES

Upon completing this elective, students will be able to:

1. Understand urban environmental challenges:
Grasp the fundamental mechanisms that drive urban environmental challenges, including heat, wind, and precipitation, and how these factors interact within the built environment.

2. Assess human comfort and health:
Gain knowledge of principles related to human comfort and health, enabling them to assess and analyse urban environmental issues effectively using appropriate study methods and climate service datasets.

3. Apply climate-responsive strategies:
Recognize the practical significance of urban climate in shaping climate-responsive urban planning and design strategies, and apply this understanding to create more sustainable and resilient urban environments.

4. Utilize numerical simulations:
Become proficient in the basic workflow of numerical simulations, using these tools to visualize and evaluate environmental design strategies, enhancing their ability to make data-driven design decisions.

ASSESSMENT SCHEME

SPECIFIC ASSESSMENT

Assessment	**Mode**	**Weight**
Exercise × 4	Individual practice	10% × 4
Project presentation stage A	Group work	10%
Project presentation stage B	Group work	10%
Final report of group project (maximum 3500 words)	Group work	40%
Total	/	**100%**

COURSE FORMAT

1. Teaching days
Students must attend for F2F teaching during these teaching hours.
Teaching Day: 02:30PM – 05:15PM, Wednesday

2. Student study effort (total: 140 hrs)
Class Contact: 39 hours (Lecture, Tutorial, Presentation)
Other Student Study Effort: 100 hours (Studio / Self Study)

REQUIRED READINGS

- Oke, T. R., Mills, G., Christen, A., & Voogt, J. A. (2017). Urban Climates. Cambridge University Press.

- Oke, T. R. (2002). Boundary Layer Climates. Routledge.

- Ng, E. (2009). Policies and Technical Guidelines for Urban Planning of High-Density Cities - Air Ventilation Assessment (AVA) of Hong Kong. Building and Environment, 44(7), 1478-1488. https://doi.org/10.1016/j.buildenv.2008.06.013

- Blocken, B. (2014). 50 years of computational wind engineering: past, present and future. Journal of Wind Engineering and Industrial Aerodynamics, 129, 69-102. https://doi.org/10.1016/j.jweia.2014.03.008

- Tominaga, Y., Mochida, A., Yoshie, R., Kataoka, H., Nozu, T., Yoshikawa, M., & Shirasawa, T. (2008). AIJ guidelines for practical applications of CFD to pedestrian wind environment around buildings. Journal of Wind Engineering and Industrial Aerodynamics, 96(10-11), 1749-1761. https://doi.org/10.1016/j.jweia.2008.02.058

- Air Ventilation, Chapter 11: Urban Design Guidelines, Hong Kong Planning Standards and Guidelines. https://www.pland.gov.hk/pland_en/tech_doc/hkpsg/full/pdf/ch11.pdf

- Technical Circular NO. 1/06 – Air Ventilation Assessment. https://www.devb.gov.hk/filemanager/en/content_679/hplb-etwb-tc-01-06.pdf

- Sustainable Building Design Guidelines APP-152. https://www.bd.gov.hk/doc/en/resources/codes-and-references/practice-notes-and-circular-letters/pnap/APP/APP152.pdf

- Brown, R.D. and T.J. Gillespie. 2019. Microclimatic Urban Design.

- Coccolo, S., et al., *Outdoor human comfort and thermal stress: A comprehensive review on models and standards.* Urban Climate, 2016. 18: p. 33-57. https://doi.org/10.1016/j.uclim.2016.08.004

- Wong, N.H., et al., *Greenery as a mitigation and adaptation strategy to urban heat.* Nature Reviews Earth & Environment, 2021. 2(3): p. 166-181. https://doi.org/10.1038/s43017-020-00129-5

IMPORTANT NOTE TO STUDENTS

Expectations for Professional Conduct
The motto of The Chinese University of Hong Kong (CUHK) is "Through learning and temperance to virtue". This motto places equal emphasis on the intellectual and moral education of students. In addition to pursuing academic excellence, students of CUHK are expected to maintain and uphold the highest standard of integrity and honesty in their academic and personal lives, respect the rights of others and abide by the law. More information on Postgraduate studies can be found in the PG Student Handbook. https://www.gs.cuhk.edu.hk/

Attendance
Class attendance is required in all courses. For an excused absence, the instructor must be notified and presented with documentation of illness or personal matter. Please note: **Three (3)** or more unexcused absences may result in a failing grade for the course.

Academic Honesty
The Chinese University of Hong Kong places very high importance on honesty in academic work submitted by students and adopts a policy of zero tolerance on academic dishonesty

Attention is drawn to University policy and regulations on honesty in academic work, and to the disciplinary guidelines and procedures applicable to breaches of such policy and regulations. Details may be found at: http://www.cuhk.edu.hk/policy/academichonesty/.

With each assignment, students may be required to submit a statement that they are aware of these policies, regulations, guidelines and procedures.

Third-Party Assistance
All intellectual work essential to the design project must be completed by the student and cannot, under any circumstance, be outsourced to a third party (including, but not limited to a company, consultant, alumni, and/or friend).

In the design studio context, students may utilize external resources, such as printing services for presentation materials, and/or laser cutting and 3D printing services for prototyping purposes. Use of such third-party services constitutes non-intellectual work done by others. It is only permitted with prior written consent from the studio tutor and acknowledgment of such work done by the third party.

Assistance from other students or friends for aspects of project production also constitutes non-intellectual work done by others; this is allowed only if declared and acknowledged in a written statement attached to any such work that has received assistance.

Under all circumstances, students must declare all work done by others by completing the school's designated form before assessment. This form must include a detailed explanation of the third party's identity (name and relationship to the student), when and how they were utilized, and the specific tasks they performed in the project. The completed form, signed by the student, must be endorsed by the tutor and presented during the final review. The school will collect and retain this form for record-keeping purposes.

Failure to follow this code of conduct may be considered a case of academic dishonesty, to be reviewed by a disciplinary board, and possible failure of the course.

Artificial Intelligence
Unless approved by the Programme or School Director, any use of AI tools such as ChatGPT or image generation tools (Midjourney) etc. is strictly prohibited and may result in disciplinary action in accordance with university policy on academic honesty. Students may refer to the CUHK 'Use of Artificial Intelligence tools in Teaching, Learning and Assessments' – A Guide for Students.

Student Work
Submission of studio documentation must be complete and correctly formatted. Missing or incomplete submission of the documentation folder will result in the grade for the course being withheld. This will prevent registration for the following term or delay graduation. In addition, a grade deduction of *one letter grade* will be made.

Term 2: 6 January 2025 (Monday) – 17 May 2025 (Friday)

WEEK 1		
08.JAN	**LECTURE**	**High-density Cities and Urban Environment** ▪ Course introduction ▪ High-density cities ▪ Urbanization and environmental issues
WEEK 2		
15.JAN	**LECTURE & TUTORIAL**	**Urban Overheating and Health Risks** ▪ Urban heat island and climate change ▪ Extreme hot weather events and health risks ▪ Exercise 1 – Use of climatological database
WEEK 3		
22.JAN	**LECTURE**	**Urban Atmosphere, Climate Resilience, and Sustainable Design** ▪ Urban atmosphere structure and processes ▪ Microclimate and climate resilience ▪ Why sustainable design matters
WEEK 5		
05.FEB	**LECTURE**	**Methods of Studying Urban Climate** ▪ Qualitative assessment methods ▪ Field observation methods ▪ Modelling methods
WEEK 6		
12.FEB	**LECTURE**	**Air Ventilation Design Strategies** ▪ Introduction to group project (stages A and B) ▪ Aerodynamics for planners and designers ▪ Urban air ventilation design guidelines
WEEK 7		
19.FEB	**LECTURE**	**Urban Greenery Design Strategies** ▪ Greenery-related cooling mechanism ▪ Greenery in urban design ▪ Urban greenery projects and policies
WEEK 8		
26.FEB	**PRESENTATION**	**Project Presentation Stage A** ▪ Presentation of qualitative assessment methods ▪ Presentation of qualitative assessment results ▪ Q&A and instructor's comments
WEEK 10		
12.MAR	**LECTURE & TUTORIAL**	**Quantitative Assessment of Design Strategies** ▪ Quantitative assessment methods ▪ Sustainable building design guidelines ▪ Air ventilation assessment (AVA) methods ▪ Exercise 2 – Use of site wind availability data
WEEK 11		
19.MAR	**LECTURE & TUTORIAL**	**Numerical Modelling Tools – Part 1** ▪ Mechanism of numerical modelling ▪ Numerical modelling workflow ▪ Exercise 3 – Modelling validation
WEEK 12		
26.MAR	**LECTURE & TUTORIAL**	**Numerical Modelling Tools – Part 2** ▪ Skills for preparing urban models ▪ Skills for presenting modelling result ▪ Exercise 4 – Modelling for an urban area
WEEK 13		

02.APR	**LECTURE**	**Urban Climate Map** ▪ Urban climatic analysis and recommendation maps ▪ Wind information maps and practices ▪ Spatial analysis using geographical information systems (GIS)
WEEK 14		
09.APR	**LECTURE**	**Guest Lecture on Virtual Singapore Project**
WEEK 15		
16.APR	**PRESENTATION**	**Project Presentation Stage B** ▪ Presentation of quantitative assessment methods ▪ Presentation of quantitative assessment results ▪ Q&A and instructor's comments

GRADE DESCRIPTOR

Grade	Descriptor	Criteria	Points
A	Excellent	Outstanding performance on all learning outcomes.	4
A-	Very Good	Generally outstanding performance on all (or almost all) learning outcomes.	3.7
B+	Good	Substantial performance on all learning outcomes, OR high performance on some learning outcomes which compensates for less satisfactory performance on others, resulting in overall substantial performance.	3.3
B			3
B-			2.7
C+	Fair	Satisfactory performance on the majority of learning outcomes, possibly with a few weaknesses.	2.3
C			2
C-			1.7
D+	Pass	Barely satisfactory performance on a number of learning outcomes.	1.3
D			1
F	Failure	Unsatisfactory performance on a number of learning outcomes, OR failure to meet specified assessment requirements.	0

Written Feedback to Students

Term: ______________________ **Grade:** ______________________

Course: ______________________ Date: ______________________

Assignment: ______________________ Student Name: ______________________

Studio Tutor: ______________________ Student ID: ______________________

Feedback from Studio Tutor:

Achievements:

Challenges: