Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year (New format)	AY2024-2025
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Assoc Prof Steve Yim
Course Author Email	steve.yim@ntu.edu.sg
Course Title	Introduction to Earth Environmental Simulations and the Applications
Course Code	ES4302
Academic Units	3
Contact Hours	39
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	Year 3 & 4 students who meet the following pre-requisites, ES2001 Computational Earth Systems Science; ES0002/ES7023 Fundamentals of Data Science for Earth and Environmental Systems Science; and ES1007 - Climate Change
Co-requisites	NA
Pre-requisite to	NA
Mutually exclusive to	NA
Replacement course to	NA
Remarks (if any)	

Course Aims

The aim of this course is to introduce the basic knowledge of earth environmental model simulations. Numerical models serve as important tools for earth environmental research and operations. While the topic of earth environmental modelling is broad, this course will focus on the fundamental concepts of numerical modelling, such as temporal and spatial discretizations, parameterizations, model uncertainty and evaluation. Various components of earth system model will be introduced, including atmospheric general circulation model, regional climate model, weather prediction and land surface model, oceanic general circulation model, air quality model, health assessment model and integrated assessment model. In addition, this course will discuss numerical model design, application and testing. Practical exercises such as weather forecast and air quality prediction are also provided for students to gain technical skills and hands-on experience in modelling.

Particular aims are shown as follows:

- to understand basic concepts and theories of earth environmental modelling,
- to learn numerical model design, application and testing,
- to gain technical skills and practical experiences of earth environmental modelling,
- to select appropriate models for solving given earth environmental problems, and
- to apply the knowledge of numerical modelling on their research and career.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	to understand basic concepts and theories of earth environmental modelling
ILO 2	to learn numerical model design, application and testing
ILO 3	to gain technical skills and practical experiences of earth environmental modelling
ILO 4	to select appropriate models for solving given earth environmental problems
ILO 5	to apply the knowledge of numerical modelling on their research and career

Course Content

The course introduces the basic knowledge of earth environmental model simulations. Numerical models serve as important tools for earth environmental research and operations. While the topic of earth environmental modelling is broad, this course will focus on the fundamental concepts of numerical modelling, such as temporal and spatial discretizations, parameterizations, model uncertainty and evaluation. Various components of earth system model will be introduced, including atmospheric general circulation model, regional climate model, weather prediction and land surface model, oceanic general circulation model, air quality model, health assessment model and integrated assessment model. In addition, this course will discuss numerical model design, application and testing. Practical exercises such as weather forecast and air quality prediction are also provided for students to gain technical skills and hands-on experience in modelling.

Reading and References (if applicable)

Required readings:

- Philip J. Rasch, Climate Change Modeling Methodology: Selected Entries from the Encyclopedia of Sustainability Science and Technology, Springer; 2012 edition, 2012.
- Eugenia Kalnay, Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 2002.
- Martin Beniston, From Turbulence to Climate: Numerical Investigations of the Atmosphere with a Hierarchy of Models, Springer, 1997.
- Ronald G. Prinn, Development and application of earth system models, PNAS, 110(1), 3673-3680, 2013.

Recommended readings:

- Luca Bonaventura, René Redler, Reinhard Budich. Earth System Modelling - Volume 2 [electronic resource]: Algorithms, Code Infrastructure and Optimisation. Berlin, Heidelberg : The Authors 2012.
- Jonathan L. Bamber and Antony J. Payne. Mass balance of the cryosphere: observations and modelling of contemporary and future changes. Cambridge ; New York : Cambridge University Press 2004.
- Mark Z. Jacobson, Fundamentals of atmospheric modelling. Cambridge ; New York : Cambridge University Press 1999.
- Philip W Mote; Alan O'Neill. Numerical modelling of the global atmosphere in the climate system. Dordrecht ; Boston : Kluwer Academic Publishers c2000.
- John H. Seinfeld, Spyros N. Pandis. Atmospheric chemistry and physics : from air pollution to climate change. New York : John Wiley c1998.
- Asante-Duah, Kofi. Public Health Risk Assessment for Human Exposure to Chemicals. Dordrecht: Springer 2017.

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Introduction to earth environmental modelling	1, 2	In-person	Lecture	Philip J. Rasch, Climate Change Modeling Methodology: Selected Entries from the Encyclopedia of Sustainability Science and Technology, Springer; 2012 edition, 2012.
2	Basic concepts of numerical modelling (part 1)	1, 2	In-person	Lecture	Eugenia Kalnay, Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 2002.
3	Basic concepts of numerical modelling (part 2)	1, 2	In-person	Lecture	Eugenia Kalnay, Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 2002.
4	Atmospheric general circulation modelling	1, 3, 4	In-person	Lecture	Philip W Mote; Alan O'Neill. Numerical modelling of the global atmosphere in the climate system. Dordrecht ; Boston : Kluwer Academic Publishers c2000.
5	Weather prediction modelling	1, 3, 4	In-person	Guest lecture	Mark Z. Jacobson, Fundamentals of atmospheric modelling. Cambridge ; New York : Cambridge University Press 1999.

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
6	Land surface modelling	1, 3, 4	In-person	Lecture	Luca Bonaventura, René Redler, Reinhard Budich. Earth System Modelling - Volume 2 [electronic resource]: Algorithms, Code Infrastructure and Optimisation. Berlin, Heidelberg : The Authors 2012.
7	Oceanic general circulation modelling	1, 3, 4	In-person	Lecture	Luca Bonaventura, René Redler, Reinhard Budich. Earth System Modelling - Volume 2 [electronic resource]: Algorithms, Code Infrastructure and Optimisation. Berlin, Heidelberg : The Authors 2012.
8	Air quality modelling	1, 3, 4	In-person	Guest lecture	John H. Seinfeld, Spyros N. Pandis. Atmospheric chemistry and physics : from air pollution to climate change. New York : John Wiley c1998.
9	Health and integrated assessment modelling	1, 3, 4	In-person	Guest lecture	Asante-Duah, Kofi. Public Health Risk Assessment for Human Exposure to Chemicals. Dordrecht: Springer 2017.
10	Model design, application, and testing	1, 2, 5	In-person	Lecture	Eugenia Kalnay, Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 2002
11	Model uncertainty and evaluations	1, 2, 5	In-person	Lecture	Eugenia Kalnay, Atmospheric Modeling, Data Assimilation and Predictability, Cambridge University Press, 2002

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
12	Project presentation	3, 4, 5	In-person	Lecture	No reading
13	Project presentation	3, 4, 5	In-person	Lecture	No reading

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lectures	Lectures will be offered to develop the basic knowledge and skills of different types of models. Real cases will be discussed so that students can link what they learnt in the lecture to daily examples.
Group project	The group project will engage students to work together in a modeling project and apply what they learn in the lectures into a modelling problem in their real life.
Final examination	Final examination will encourage students to review all the materials at the end of the semester.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Report/Case study(Lab report (to be done in tutorials))	1,2,3		40		Individual	Analytic	Multistructural
2	Continuous Assessment (CA): Project(Group project)	2, 3, 4		20		Team	Analytic	Multistructural
3	Summative Assessment (EXAM): Final exam(Term end examination)	1, 2, 3, 4, 5		40		Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

Lab report-Lab reports need to be submitted after each lab section
Project-Project presentation and report
Term end examination-A final examination for assessing the students' understanding of the course materials

Formative Feedback

In addition to the course evaluation, both at the beginning and end of the course, students are encouraged to provide feedback to the course teacher and/or tutors through email. You are also welcome to discuss with Prof. Yim by an appointment through email.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Care for Environment	Basic
Digital Fluency	Intermediate
Critical Thinking	Advanced

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

Diversity and inclusion policy
Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
If you feel like your performance in the class is being impacted by your experiences outside of class;
If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;
Please speak to your teaching team, our school pastoral officer Christina Tee Siew Khiaw or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

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Last Updated By: Siti Nur Amirah Binte Suhari