Syllabus

Course Title

Climate System: Theoretical Foundations and Key Concepts

General Information

General description of the required education/training, outlining the main objectives and explaining the necessity of the education/training at the organizational/country/regional level

The relevance of the course "Climate System: Theoretical Foundations and Key Concepts" is determined by the growing role of climate knowledge in the modern world, where global climate change significantly affects natural processes, the economy, society, and environmental security. The formation of scientifically grounded understanding of the structure and functioning of the climate system is the basis for training specialists capable of analyzing the interaction of its components (the atmosphere, hydrosphere, cryosphere, biosphere, and lithosphere), assessing the dynamics of climate processes, and forecasting their changes.

The study of the course provides master's students with an understanding of the fundamental patterns of the climate system, mastery of key concepts of modern climatology, and forms competencies necessary for research activities, the development of climate models, and the practical application of knowledge in the field of climate services.

The aim of this course is to train professional meteorologists, meteorological managers of senior and middle level, and master's students in natural sciences to interpret the state of the climate system using available results of climate models and data sets.

Audience

The main target audience of the course and any secondary audience, if it may influence decisions regarding the structure or content of the course

Expected level of knowledge and skills of the main audience (current or minimally required), as well as other factors (for example, cultural characteristics, level of technical training, access to the Internet) that should be considered when planning the course, as they may affect the choice of teaching methods, materials, and approaches to interaction with the audience

Master's students in natural science fields (E4 "Earth Sciences," E2 "Ecology," G18 "Geodesy and Land Management").

Employees of meteorological services, managers, and leaders who face risks from climate change and wish to learn about methods to mitigate the impacts of global warming.

It is expected that participants in the course will have a basic background in the following areas:

- Physical foundations of atmospheric processes.
- Climate process modeling: the ability to use numerical models to forecast climate changes and understand their consequences.
- The ability to apply information-analytical technologies to collect, process, and present climate information.

Knowledge in ecology, economics, and risk management will also be useful, as climate

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change has a wide range of impacts on society and the economy.

Competencies

Training needs at the individual or organization/country/regional level, as well as a description of how these needs were identified and recognized as relevant.

Competencies targeted by the training.

C1. Formulate and illustrate complex interconnections between the various components of the nonlinear, unified Earth system.

C3. Apply forecasts and scenarios to support evidence-based decision-making in the sustainability of economic sectors and sustainable planning, as well as identify and classify uncertainties in different contexts.

Learning outcomes and performance criteria

Learning outcomes and performance criteria formulated with regard to the knowledge and skills to be acquired during the training process.

LO1. Demonstrate knowledge and understanding of the main components of the climate system, including the atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere, and explain their individual roles in climate dynamics.
LO2. Explain the interactions between the components of the climate system, focusing on key feedback mechanisms such as albedo changes, permafrost thaw, soil degradation, and wildfire frequency, as well as their impact on global climate patterns.

LO1. Effectively use available visualized empirical and modeled climate data to describe the state of the climate system and assess its changes.

Course Content

Provide a content outline that corresponds to the learning objectives and outcomes. This may be a course outline as it will be presented to students, but not necessarily a complete curriculum.

Include a general list of all topics that you consider necessary to cover. If you believe it would help clarify the scope, indicate what will NOT be covered.

Module 1. Components of the Climate System

Demonstrate knowledge and understanding of the main components of the climate system, including the atmosphere, hydrosphere, cryosphere, lithosphere, and biosphere, and explain their individual roles in climate dynamics.

Module 2. Interactions and Feedbacks

Explain the interactions between the components of the climate system, focusing on key feedback mechanisms such as changes in albedo, permafrost thaw, soil degradation, and wildfire frequency, as well as their impact on global climate patterns.

Module 3. Climate Information

Effectively use available visualized empirical and modeled climate data to describe the state of the climate system and assess its changes.

Learning Solutions and Methods of Implementation

List the learning solutions (teaching methods) that will be used and explain why they were chosen. For example: classroom learning, online learning, blended learning, workplace learning, online resources for self-study, coaching or mentoring, etc.

Classroom-based course – organized according to the main lecture and practical topics. Some practical exercises can be completed by students at home or in groups in the classroom, supporting each other. Learning materials will be distributed online, and the lecturer will be available at scheduled times for questions and consultations.

Learning modalities: online, blended learning, workplace-based, online resources for independent study.

Learning Strategies

Consider which learning strategies you will use. Provide justification for why you intend to apply them, including reasons why they will help participants achieve the planned learning outcomes.

Combine different learning strategies to create a diverse learning environment that accommodates different learning styles of participants. This will increase the effectiveness of learning and help achieve the planned learning outcomes. This section does not require a detailed description of specific activities.

1. **Setting clear learning objectives**. It is important that students understand what outcomes are expected of them. Objectives should be challenging yet achievable, motivating students to reach high standards.
2. **Flipped classroom strategy**. The flipped classroom principle involves students acquiring new material independently at home, while classroom time is dedicated to practical work – completing exercises, tasks, laboratory and practical studies, as well as individual consultations with the instructor.
3. **Competency-based approach**. This approach focuses on developing practical skills and abilities that students can apply in professional activities. It integrates theoretical knowledge with practical tasks that reflect real working conditions.
4. **Project-based learning.** Engaging students in real projects allows them to apply acquired knowledge in practice, develop analytical and research skills, and enhance teamwork abilities.
5. **Individualized learning**. Adapting the learning process to the needs and interests of each student, including the option to choose topics for research or practice, promotes deeper engagement and motivation.

Learning Activities

Describe the main learning activities that will be included, such as lectures, readings, case studies, discussions, exercises, practical assignments, simulations, role-playing games, etc.
Also describe the roles of instructors and students during these activities.

The learning activity will consist of lectures and practical exercises (in-class or online). Case studies will be conducted using time series of meteorological and climate data, enabling students to obtain the spatial and temporal distribution of climate indicators for the analysis of extreme climate events and climate change.

Practical exercises will be provided for obtaining climate data from different sources and creating purpose-specific time series. The main tasks during the training will focus on the calculation of basic climate products such as normals, anomalies, and climate indices in order to determine the dynamics of the climate system.

Students will use software to create graphs, maps, and reports based on climate forecasts and projections.

Roles of instructors during the learning process:

1. Introducing students to the course content.
2. Conducting classes according to the schedule.
3. Checking practical assignments and providing feedback.
4. Assessing the effectiveness of student learning.
5. Critical analysis of collaboration between students and instructors.

Roles of students during the learning process:

1. Studying the provided course materials.
2. Active participation in practical classes.
3. Independent work.
4. Collaboration with instructors.
5. Participation in group work.

Assessment of Learning

Describe the assessment plan for participants before, during, and/or after the course, including tests, exercises, activities, and projects that will be assessed. Indicate whether self-assessment or peer assessment will be used.

Explain how the assessment is linked to the learning outcomes.

The total number of points each student can earn is 100. The maximum score for the theoretical module (M1) is 40 points, and for each practical module (M2 and M3) – 40 points.

Module 1: A test consisting of 20 questions (40 points).

Practical Modules 2 and 3: 30 points for complete completion of the task and 10 points for the defense of the practical work.

Thus, the total maximum score a student can achieve upon successful completion of the course is 100 points, and the minimum passing score for the course is 60 points.

Storyboard of Learning (Learning Storyboard)

Use this to create a visual scenario of your blended learning activity

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Learning resources and tools

List the available resources that will be used for different types of learning activities and recommended to students.

Describe the technologies that will be used to implement learning solutions, including educational technologies and operational equipment (hardware, software, collaboration tools).

Classroom setup: a room for 5–10 students equipped with a projector for blended learning.

1. Laptops or tablets with Internet access.
2. Moodle website (https://re.climed.network/course/), where course information is uploaded: objectives, calendar, participants, test information, forum, presentations, modeling, grades, and any additional materials.
3. Several online sessions to connect students with the instructor.
4. Online learning modules, e.g., conceptual models and verification.
5. Presentations and exercises developed by trainers.
6. Registration and access to climate data portals; meteorological data sources where participants will have access to real-time data, NWP products from different centers, observational data, etc.

URLs:

1. https://climatedataguide.ucar.edu/ — Description of climate data bases
2. http://www.ipcc.ch/index.htm — Assessment reports
3. http://www.esa.int/Our_Activities/Observing_the_Earth/Space_for_our_climate/ — Use and interpretation of satellite information in climatology
4. Infrastructure for the European Network for Earth System Modelling. Climate4Impact Portal: https://is.enes.org/sdm-c4i-portal/

Books:

1. Stepanenko S.M. (2013). Dynamics and Climate Modeling. Odesa, Ecology Publishing, 204 p. (electronic textbook) http://eprints.library.odeku.edu.ua/id/eprint/6173/
2. Stepanenko S.M., Polyovyi A.M., Loboda N.S. (2015). Climate Change and Its Impact on the Economic Sphere of Ukraine. Odesa State Environmental

University, Odesa, 520 p.
http://eprints.library.odeku.edu.ua/id/eprint/2269
3. Wilks, D. S. (2011). Statistical Methods in the Atmospheric Sciences. 3rd ed. Academic Press, pp. 2–676.
4. Neelin, J. David (2011). Climate Change and Climate Modeling. Cambridge University Press, Cambridge, 282 p. (electronic textbook)
5. Stocker, Thomas (2014). Introduction to Climate Modelling. Springer, ISBN 978-3-642-00773-6, 174 p. (electronic textbook)
6. Pierrehumbert, Raymond T. (2010). Principles of Planetary Climate. Cambridge University Press, Cambridge, UK, 680 p. (electronic textbook)

WMO guiding documents:
WMO-No. 100 (Guide to Climatological Practices), 2018, 153 p.
https://biotech.law.lsu.edu/blog/100-2018_en.pdf

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