UCLouvain

lphys2264

2021

Oscillations and instabilities in the climate system

5.00 credits	30.0 h	Q2

This biannual learning is being organized in 2021-2022

Teacher(s)	Crucifix Michel ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	Having followed the courses LPHYS2114, LPHYS2162 and LPHYS2163 is an asset.
Main themes	Elementary concepts of dynamical stability, fundamental notions of geophysical fluid dynamics, linear waves in shallow-water, linear wave theory and applications (equatorial waves, sea-waves, tides), unstable waves, linear theory (Kelvin-Helmholtz, baroclinic and barotropic instability), oscillation and relaxation phenomena in the ocean-atmosphere system across scales (annual to millennial) and their contribution to the spectrum of variability, critical phenomena.
Learning outcomes	**At the end of this learning unit, the student is able to :** a. **Contribution of the teaching unit to the learning outcomes of the programme (PHYS2M and PHYS2M1)** • 1.1, 1.2, 1.5 • 2.3, 2.5 • 3.1, 3.2, 3.3 • 4.2 • 5.1, 5.2, 5.3, 5.4 • 6.1, 6.2, 6.3, 6.5 • 7.1, 7.2, 7.3, 7.4, 7.5, 7.6 • 8.1 **b. Specific learning outcomes of the teaching unit** 1 At the end of this teaching unit, the student will be able to : 1. Explain the principle of linear stability analysis; 2. Derive the shallow-water model and explain its interest for atmospheric and ocean waves 3. Apply the principle of linear stability analysis to derive theories for atmospheric and oceanic waves (gravity waves, Rossby waves, Kelvin waves) and instabilities (baroclinic and barotropic instability) 4. Explain the principle of a climatic oscillation in terms of dynamical systems theory 5. Demonstrate the link between these theories and actual phenomena in the ocean-atmosphere system (El-Nino, Madden-Julien instability, Atlantic oscillations, abrupt desertification) and discuss their limitations and importance for our understanding of the ocean-atmosphere dynamics 6. Analyse a specific phenomenon involving atmospheric and oceanic waves, instabilities, or oscillations on the basis of available literature and communicate this analysis to colleagues. 7. Criticise the presentation and provide constructive feedback to colleagues on the scientific aspects of the presentation. 8. Synthesise current concerns about oscillations and instabilities in the climate system
Evaluation methods	Feedback during the flipped classes. Case studies : oral presentation and final report.
Teaching methods	Lectures for the fundamentals (with syllabus) Applications presented and prepared by the students according to the flipped classroom principle. A portfolio of reference texts made available by the teacher
Content	1. Motivation • the climate variability spectrum • basic concepts of dynamic stability

	2. Linear waves • shallow-water model • gravity waves, Poincare waves • two-layer model and effective gravity • equatorial waves • Kelvin coastal waves (and tides) • Rossy waves 3. Hydrodynamical instability (linear theory) • general principle • Kelvin-Helmholtz instability • baroclinic and barotropic instability 4. Oscillations and relaxation phenomena in the climate system • general background and principles • applications and conceptual models 5. Critical Phenomena • mod#le conceputels of climate instability • contemporary issues 6. Case studies (to be presented by students)
Bibliography	B. Cushman-Roisin et J. M. Beckers, Introduction to Geophysical Fluid Dynamics, Volume 101, Elsevier H. Dijkstra, Nonlinear climate dynamics, Cambridge University Press
Faculty or entity in charge	PHYS

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Geography : Climatology	CLIM2M	5		
Master [120] in Physics	PHYS2M	5		
Master [60] in Physics	PHYS2M1	5		