Module no. M15	SIMULATIONS FOR GEOPHYSICAL MODELLING
Module code and mode of delivery	Code EEP55C24 Delivery mode: Hybrid (See Below)
Module ECTS Weighting	5 ECTS
Semester of delivery	2
Module Contact Hours	Scheduled hybrid lectures (synchronous online and in-situ f/f) 22 hours, Independent student reading/Reflection using asynchronous materials in VLE 55 hours, Tutorials (f/f in-situ as appropriate) 22 hours, Continuous assessment 16 hours, Summative assessment 10 hours.
Module Coordinator	Prof Biswajit Basu
Module teaching staff and academic titles	Dr. Calin I. Martin (U. Vienna), Prof Biswajit Basu
Module description—content	Climate dynamics is a topical area of study but is complex due to the influence ocean, atmosphere and the Earth systems and their interactions have on climate. The associated geophysical processes and their simulation is the subject of this module. The geophysical simulations are essential components in studies related to oceanography, aquatic life, marine environment, food and ecology; numerical weather simulations, ocean energy; and costal and offshore engineering. The module provides the foundation for theoretical modeling and simulation of geophysical processes related to ocean and atmosphere. The module will emphasize theory, mathematical modeling and application with practical coding.
Module learning aims/objectives	1. To enable students to develop dynamical models for geophysical processes. 2. To develop capabilities to formulate algorithms for simulation of large-scale dynamics of atmosphere and ocean.
Module learning outcomes	On successful completion of the module students should be able to: **MLO15.1** Describe the basic thermodynamics and fluid dynamics of geophysical fluids. **MLO15.2** Formulate the dynamics of rotating planets and apply the equations for assessing the effect on geophysical flows in oceans.

	MLO15.3 Critically assess and describe how shallow water wave and geostrophic theory are used for oceanography, numerical climate simulation, coastal and offshore engineering. **MLO15.4** Apply special techniques for simulation of non-linear partial differential equations for simulating nonlinear waves such as Rossby waves, gravity waves and internal waves. **MLO15.5** Formulate problems related to stratified flows and critically assess flows with stratification. **MLO15.6** Solve problems and perform numerical simulations related to turbulence. **MLO15.7** Describe various types of instabilities in geophysical flows. **MLO15.8** Describe state-of-art models for wind driven gyres. **MLO15.9** Formulate and simulate overturning circulation and thermoclines including Antarctic Circumpolar currents. **MLO15.10** Formulate and simulate Equatorial undercurrent including El Nino.
Module assessment, separate components and their weighting to be mapped into SITS	The module contains a mixture of tutorials and conventional lab sessions where students will be able to seek assistance on their assignments. There will be 22 lecture hours (i.e., 2 lecture hours per week from the start of the semester). The guideline for a 5 ECTS module is for 125 hours of student effort including class hours. ASSESSMENT MODE(S) Assessment will be based on 60% Continuous Assessment and 40% final exam. Continuous Assessment will be a mixture of algorithm design assignments and in-class tests. The students on the course will be guided through adapting assignments to complement their chosen project if possible. SYLLABUS • Introduction to Geophysical Fluid Flow – Mass, Momentum, Thermodynamics, Entropy, Energy budget • Equations and dynamics of rotating planet – Rotating frame of reference, Spherical co-ordinates, Geostrophic and Thermal wind balance • Shallow water wave theory – Conservation, Geostrophic adjustment, Variational approach • Geostrophic theory – Stratified flows, Friction, Ekman layers • Nonlinear waves – Rossby waves, Gravity waves • Instabilities – Kelvin-Helmholtz instability, Baroclinic instability • Turbulence – Diffusion, Spectral theory, 2D turbulence, Geostrophic turbulence

	• Wind-driven gyres – Sverdrup balance, Ocean gyres, Arctic gyres • Overturning circulation – Antarctic Circumpolar current • Equatorial undercurrent – El Nino, Unstable air-sea interaction READING LIST: Essentials of atmospheric and oceanic dynamics (2019) by G.K. Vallis. CUP