Course title: Earth's climate and its past, present, and future changes

Modality: CFT- Transversal Training Course

Orientation:

- [x] **Ocean Observation and Global Change**
- [ ] Sustainable use of Marine Resources
- [ ] Integral Management of the Sea
- [ ] Technological progress. Engineering and Business Management

Dates: 1-5-7-12-14 March

Timetable: 11:00-13:00h (2 hours per lecture)

Duration: 10 hours

Location: Universidade de Vigo, Campus Lagoas Marcosende, 36310 Vigo, Spain.

Language: English

Academic coordinator:

Name	Institution	e-mail
Gianluca Marino	Universidade de Vigo	gianluca.marino@uvigo.es

Lecturers

Name	Institution	e-mail
Gianluca Marino	Universidade de Vigo	gianluca.marino@uvigo.es

General description:

Climate change is progressing at unprecedented pace, thereby posing major scientific, economic, and societal challenges. The latest report of the Intergovernmental Panel on Climate Change (IPCC) has concluded that human activities and the associated greenhouse gas emissions are the ultimate cause of the ongoing global warming. In addition, the report signals that global temperature is likely cross the 1.5℃ threshold in the next few decades. The scientific community is therefore faced with a pressing demand for deciphering the short- and long-term impacts of a global temperature rise by 1.5℃ (or more) above pre-industrial levels.

Our ability to address this problem hinges on the knowledge of how: (*i*) the atmosphere, hydrosphere, cryosphere, land surface, and biosphere function as an integrated and synergistic system; (*ii*) the various forcing, feedback, and response mechanisms – each operating at a characteristic timescale – produce a continuum of global climate variability; and (*iii*) climate change and variability depend on the underlying climate state. Although there is substantial direct observation that documents recent and ongoing patterns of climate change and variability, the somewhat more fragmented and proxy-based evidence of past climate change – the so-called palaeoclimate record – has proven essential to provide a comprehensive view of the temporal and spatial scales of natural (pre-anthropogenic) climate fluctuations and their dependence on the underlying climate state.

This postgraduate course covers a broad spectrum of topics in climate science. It provides a comprehensive overview of the Earth's climate system based on the physical principles of planetary climate as well as on the evidence of climate change and variability from both instrumental and palaeoclimate records. The course shows how this wealth of information is central to hone the projections of future climate change and to effectively size

climate mitigation strategies.

Contents:

Part I | Introduction to Climate Science

1. Climate science: principles and methods;
2. Climate change *versus* climate variability;
3. The Earth's energy budget: forcing, feedback, and response mechanisms;
4. The metrics of climate change: (*i*) transient climate response; (*ii*) equilibrium climate sensitivity; and (*iii*) Earth system sensitivity;
5. Seasonal and interannual climate variability and extreme events.

Part II | The instrumental record of climate change

1. Global temperature change;
2. The role of the ocean and the ocean heat content;
3. The increase in greenhouse gas concentrations.

Part III | Climate Change on tectonic to orbital timescales

4. Plate tectonics, weathering, CO_2, and long-term climate change;
5. Greenhouse and icehouse climates;
6. Astronomical control of solar radiation;
7. Insolation control of climate.

Part IV | Millennial- and centennial-scale climate variability

1. Patterns and mechanisms of sub-orbital climate variability;
2. The roles of the Atlantic Meridional Overturning Circulation, Northern Hemisphere ice sheets; and solar output.

Part V | Future climate

- The 1.5°C warming problem and the "climate thresholds";

1. CO_2 emissions and ocean acidification;
2. Mitigation strategies.

Teaching methodologies:

The course contents are developed using topical lectures, discussion groups, flipped classrooms, practical exercises, and/or presentations.

Evaluation system:

A final, short report on a topic related to the course contents.

Brief CV of the lecturers:

Gianluca Marino (coordinator and lecturer) is a Distinguished Researcher and a Beatriz Galindo Fellow at the Universidade de Vigo. Previously, he was Honorary Senior Lecturer and postdoctoral fellow at the Research School of Earth Sciences, the Australian National University (Australia), has worked at the Universitat

Autònoma de Barcelona (Spain) and Utrecht University (The Netherlands), where he obtained his PhD in 2008. He has been visiting scientist at several world-class academic institutions, such as the National Oceanography Centre Southampton (UK), University of Cambridge (UK), and the Lamont-Doherty Earth Observatory of the Columbia University (USA). Gianluca's research hinges on a wide portfolio of geochemical, micropaleontological, sedimentological, and statistical tools to quantitatively determine the timing, magnitude, and rates of (past) ocean and climate change. He has received funding from several national and international organizations, (co)authored 36 publications in the most prestigious general and specialised journals and presented his research at international congresses, topical workshops, and research institutions in the form of invited and keynote lectures. His involvement in supervision and teaching spans all levels of academic education, while his numerous outreach activities centre on promoting climate change topics within the popular science media and non-academic public.

Relevant references:

Archer, D.E., 2010. *The Global Carbon Cycle*. Princeton Primers in Climate.

Holland, H.D., Turekian, K.K., 2014, *Treatise on Geochemistry, Second Edition*. Oxford: Elsevier.

Manabe, S., Broccoli, A.J., 2020. *Beyond Global Warming: How Numerical Models Revealed the Secrets of Climate Change*. Princeton University Press

Maslin, M.A., 2021. *How to save our planet: the facts*. Penguin Life.

Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B., 2021. IPCC, 2021: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Pierrehumbert, R.T., 2010. *Principles of Planetary Climate*. Cambridge University Press.

Rohling, E.J., 2017. *The oceans: a deep history*. Princeton University Press.

Ruddiman, W. F., 2014. *Earth's Climate. Past and Future*. W. H. Freeman and Company.

Schmittner, A., Chiang, J., Hemmings, S., 2007. *Ocean Circulation: Mechanisms and Impacts*. Geophysical Monograph Series 173.