ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Specialized Courses

Table of Contents

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Compulsory Courses

Statistical Methods for Climate Change Analysis

Total number of hours: 24
Type of lectures: frontal and exercises
LEAD: Matteo Farné (UNIBO-DSS)
Lecturers: Matteo Farné, Luca Trapin (UNIBO-DSS)

The course introduces (some) statistical methods for analysis of climate change data. The emphasis is on time series analysis, aimed at studying dynamics, trends, periodicities, seasonality and patterns and at making predictions. The focus will be on ideas, intuition, interpretation of results. Practical exercises with R software will be also proposed.

Contents (MF, LT):

Introduction to climate data
Descriptive statistics and data visualization
Notions of probability theory
Statistical Inference
Applied regression analysis
Introduction to time series
Smoothing
Predictive modelling
Time series regression analysis
Applications and case studies

Textbook/Course Material:

There is no official textbook for this course. Lecture notes will be made available electronically. The following text may prove useful:

Storch, H., & Zwiers, F. (1999). Statistical Analysis in Climate Research. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511612336

Final Test

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Short written essay on a Course’s topic.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

HPC and Artificial Intelligence Fundamentals

Total number of hours: 12
Type of lectures: frontal and exercises
Lecturers: Giorgio Pedrazzi (Cineca), Roberta Turra (Cineca), Matteo Angelinelli (Cineca), Eleonora Bergamaschi (Cineca), Michele Visciarelli (Cineca)

Lecturers: Giorgio Pedrazzi (CINECA), Roberta Turra (CINECA), Matteo Angelinelli (Cineca), Eleonora Bergamaschi (Cineca), Michele Visciarelli (Cineca)

Content of the lectures

The increasing amount of scientific data collected through sensors or computational simulations can take advantage of new techniques for being processed in an HPC environment to extract new insights out of raw data. The purpose of this introductory set of lectures is to present researchers and scientists with methods, tools and techniques for applying Machine Learning techniques to different data sets. After an introduction to Machine Learning relevant concepts, Cineca data scientists will introduce data analytics techniques and hold hands-on sessions. A specific lecture will be dedicated to Deep Learning.

1st Module (2 hours)
Introduction to Data Analytics.
Machine Learning techniques – Supervised (theory).
2nd Module (2 hours)
Machine Learning techniques – Unsupervised (theory).
Introduction to R and Python.
3rd Module (2 hours)
Hands-on session on Unsupervised Learning using R.

- Clustering methods
- Association Rules

4th Module (2 hours)
Hands-on session on Supervised Learning using R.

- Regression methods
- Classification methods

5th Module (2 hours)
Deep Learning.

- Introduction to Deep Learning
- Computer Vision
- Meteo

- Large Language Model

6th Module (2 hours)

Introduction to Supercomputing.

- Introduction to basic Linux commands
- Introduction to the scheduling manager SLURM
- Simple utilization of GPU with Python

Recommended reading

- Vishal Maini, Samer Sabri: Machine Learning for Humans https://medium.com/machine-learning-for-humans/why-machine-learning-matters-6164faf1df12 Part1-3
- James, G., Witten, D., Hastie, T., Tibshirani, R. (2013). An Introduction to Statistical Learning with Applications in R, Springer Texts in Statistics. http://www-bcf.usc.edu/~gareth/ISL/index.html
- Wickham, H., & Grolemund, G. (2017). R for Data Science. O'Reilly.

Final test

To assess the level of comprehension of the lectures content, students will be given a set of questions with multiple answers.

Thematic A Courses

1. Numerical modeling for the coupled ocean-ice-atmosphere and hydrology system

Total number of hours: 24
Type of Lectures: frontal
LEAD: Dorotea Iovino (CMCC)
Lecturers: Carmen Alvarez-Castro (CMCC), Dorotea Iovino (CMCC), Giorgia Verri (CMCC)

Module 1: Ocean and sea-ice modeling, Iovino– 8hr

This module will introduce fundamental formulations, numerical methods and parameterizations, in ocean and sea ice models. Starting from simple idealized applications, we will explore models with increasing complexity to represent ocean circulation and sea ice (thermo)dynamics. Strategy for developing future model generation will be discussed.

Module 2: Atmospheric modeling, Alvarez-Castro– 8hr

The atmospheric modeling course will provide an overview of the basic concepts underlying the atmospheric general circulation models, such as numerical methods, parameterization of sub-grid processes etc. Furthermore, the course will also provide the fundamental knowledge to understand how they work, with an hands-on session.

Module 3: The hydrosphere and the hydrological modeling, Verri– 8hr

An overview of the literature and a detailed description of the WRF-Hydro system. A focus on the thermodynamics of the estuarine transitional systems which modulate the freshwater inputs into the sea. Introduction to the CMCC Estuary Box model which links the riverine freshwater and the coastal ocean water at mesoscales. The challenge of representing the land and the marine waters in a seamless way and some examples of modeling the river-estuary-coastal sea continuum.

Textbook/Course Material: notes of the Lecturers, textbook chapters and scientific papers

Final Test: Exercises and/or written questions covering the three topics.

2. Fundamentals of Atmosphere-ocean physics and dynamics

Total number of hours: 24
Type of Lectures: frontal
LEAD: Silvana Di Sabatino (UNIBO-DIFA)
Lecturers: Silvana Di Sabatino (UNIBO-DIFA), Erika Brattich (UNIBO-DIFA), Simona Masina (CMCC)

Module 1: Atmospheric dynamics, Silvana Di Sabatino Erika Brattich - 12 hr

Atmospheric dynamics. This module will introduce the concept of vorticity and its role in mesoscale atmospheric circulation. It also introduces the potential vorticity equations and the application to planetary waves and cyclone dynamics. It also derives the Eady model and discusses its application to weather forecast.

Module 2: Ocean large-scale dynamics, Simona Masina- 12 hr

An overview of the response of the ocean to transient and steady winds and buoyancy forcing will be presented in tropical and extra-tropical regions. The steady circulation (horizontal gyres, western boundary currents and ventilated thermocline) will be derived, as well as the equatorial adjustment including the role of the waves.

3. Advanced Geophysical Fluid dynamics

Total number of hours: 24
Type of Lectures: frontal
LEAD: Nadia Pinardi (UNIBO-DIFA)
Lecturers: Paolo Oddo (UNIBO-DIFA), Nadia Pinardi (UNIBO-DIFA)

Module 1: Advanced Geophysical Fluid Dynamics – Part I, Oddo – 12 hr

Topics:

- Rossby number perturbation expansion for the primitive equations
- Geostrophic and quasi-geostrophic approximations.
- Equatorial Rossby and Kelvin waves.
- Dynamical interpretation of ENSO.

Module 2: Advanced Geophysical Fluid Dynamics – Part I, Pinardi – 12 hr

Topics:

- Rayleigh-Taylor instability in fluids and atmosphere/ocean
- Barotropic Instability theory and hurricanes
- Baroclinic instability theory: cyclone development and frontal dynamics
- Large scale turbulence, vortex merging and the spontaneous emergence of equilibria

Recommended book:
Introduction to geophysical fluid dynamics, Cushman-Roisin, Prentice Hall, Chapters 1,2,3,4, 6 and 15

Reference material: Notes and articles by the teachers
Final Test: Exercises and/or written questions covering the topics.
The final exam consists of an essay on one of the topics of the course. The essay should concentrate on at least two of the earth subsystems and it could document either the experimental evidence or the theoretical solutions. The score will consider:
the overall scientific language (7/30);
the explanation given of the formulas (8/30);
the synthesis of the relevant concepts (15/30).

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

4. Global biogeochemical cycles

Total number of hours: 24
Type of Lectures: frontal
LEAD: Laura Tositti (UNIBO-CHIM)
Lecturers: Laura Tositti (UNIBO-CHIM), Marco Zavatarelli (UNIBO-DIFA)

Module 1: Marine biogeochemistry, Zavatarelli – 12 hr

This module aims to provide a basic and broad knowledge of the biogeochemical processes defining and controlling the transformation and the flow of matter in the main ocean biogeochemical cycles (Carbon, Nitrogen, Phosphorus, Oxygen) that are relevant also for the comprehension of the climate dynamics, including the analysis and description of the coupling with the main physical processes responsible for the forcing and the multiscale variability of the marine biogeochemical functioning.

Module 2: Chemical controls on Climate Change, Tositti -12 hr

Climatically active species are not controlled uniquely by concentration, intensity and number of sources, nor by dilution/redistribution effects on the global scale. Each of the species contributing to the overall radiative forcings has peculiar properties in terms of chemical reactivity and consequent atmospheric residence time which strongly affects their likelihood of transport and eventually their role in radiative transfer. The course therefore will cover the chemical implications implicit in the IPCC radiative forcing estimates with focus on CO_2, CH_4, Halogen derivatives, reactive greenhouse gases including ozone, airborne particulate matter.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

5. Observations of the ocean-atmosphere system: satellite and in situ data

Total number of hours: 24
Type of Lectures: frontal
LEAD: Federico Porcù (UNIBO-DIFA)
Lecturers: Bianca Maria Dinelli (CNR-ISAC), Federico Porcù (UNIBO-DIFA), Tiziano Maestri (UNIBO-DIFA), Paolo Oddo (UNIBO-DIFA), Poulain (CMRE)

Module 1: Observation of the Earth Atmosphere in clear sky from satellite and ground based remote sensing instruments, Dinelli – 6h

Description of the different measurement techniques of the atmospheric composition and temperature in clear sky conditions. Radiative transfer equation and spectroscopic properties of the gaseous molecules. Inversion methods to compute atmospheric quantities. How the errors affecting the retrieved quantities can be computed.
Examples of remote sensing instruments (on different platforms) that have measured or are measuring the atmosphere in clear sky and examples of their observations results.

Module 2: Ground-based and satellite observations of precipitation, lightning and wind, Porcù– 6 hr

Precipitation structure and observables - direct measurements and interaction between precipitation sized particles and microwave radiation; ground-based and space-borne precipitation radar; radiometers for precipitation estimates; ground-based networks and satellite sensors for lightning detection; conventional, microwave and VIS-IR techniques for wind analysis.

Module 3: Observation of clouds and aerosol from satellite and ground based remote sensing instruments, Maestri – 6 hr

The equation of radiative transfer in presence of scattering layers and comparison with clear sky. Approximate methods for special conditions. Cloud and aerosols parameters and spectral radiative features. Inversion of cloud properties from passive remote sensing. Overview of satellite missions dedicated to cloud observations (active and passive measurements). Cloud and aerosols properties databases.

Module 4: Observing the Ocean from Space, Ships and autonomous platforms, Oddo, Poulain– 6 hr

Introduction to the methods and measurements used by observational physical oceanographers. What instruments are common to oceanography? How are these measurements used? Topics covered include platforms such as autonomous gliders and ships, services such as satellite measurements, Lagrangian platforms such as drifter or ARGO and acoustic based platforms (HF radar or ADCP).

Textbook/Course Material:
notes of the Lecturers

Final Test
Short written essay on a Course's topic.

6. Atmospheric and Ocean predictability and forecasting

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Total number of hours: 24
Type of Lectures: frontal
LEAD: Emanuela Clementi (CMCC)
Lecturers: Thomas Gastaldo (ARPAE), Valentina Pavan (ARPAE), Emanuela Clementi (CMCC), Lorenzo Mentaschi (UniBO-DIFA)

Module 1 and 2: Numerical Weather Predictions and extended/seasonal forecasting, Pavan and Gastaldo – 14 hr

Theoretical framework for understanding predictability in the atmosphere, Numerical Weather Prediction, Data assimilation, extended and seasonal forecasting with coupled ocean-atmosphere models and ensemble methods. Operational Numerical Weather Prediction in Europe. Theoretical framework for tropical and extratropical atmospheric response to local forcing. Main modes of global and Euro-Atlantic low frequency large-scale atmospheric variability and their predictability. Probabilistic multi-model ensemble approach for seasonal predictions. Statistical downscaling methods and their applications to climate services.

Module 3: Ocean predictions, Clementi – 6 hr

Introduction to ocean forecasting and ocean operational forecasting. The components of the ocean forecasting systems: observational near real time ocean data infrastructure, data assimilation and the numerical modelling. Coupled models for forecasting: hydrodynamics, waves and biogeochemistry. An overview of the ocean prediction system as set up by the Copernicus Marine Service in Europe. Analysis of the forecast error structure , ocean forecast skill scores. Limited area and relocatable ocean forecasting (coastal forecasting). Ocean Ensemble forecasting. Products and quality of the ocean forecasting service. The reanalysis principles and the reconstruction of the past climate variability. Value added products: oil spill forecasting and hazard mapping.

Module 4: Surface wave predictions, Mentaschi– 4 hr

Longer time scales predictions on multi-year and decadal time scales are now experimental and the new methodologies will be discussed.

Textbook/Course Material:

Notes of the Lecturers

Readings:

Ocean Forecasting: conceptual basis and applications, 2002. N.Pinardi and J.Woods, Springer

M. Tonani, N. Pinardi, J. Pistoia, S. Dobricic, S. Pensieri, M. de Alfonso, and K. Nittis, 2009."Mediterranean Forecasting System: forecast and analysis assessment through skill scores" Ocean Sci., 5, 649-660, doi:10.5194/os-5-649-2009

Adani, M., S. Dobricic, N. Pinardi, 2011: Quality Assessment of a 1985–2007 Mediterranean Sea Reanalysis. J. Atmos. Oceanic Technol., 28, 569–589., doi:10.1175/2010JTECHO798.1

Pinardi N, Bonazzi A, Dobricic S, Milliff RF, Wikle CK, Berliner LM, 2011. Ocean ensemble forecasting. Part II: Mediterranean Forecast System response, Q. J. R. Meteorol. Soc, 137, 879-893, doi:10.1002/qj.816

Final Test

Short written essay on a Course’s topic or questions on the 4 modules

7. Data assimilation in geosciences

Total number of hours: 24
Type of Lectures:
LEAD: Ali Aydogdu (AA)
Lecturers: Ali Aydogdu (AA - CMCC), Alberto Carrassi (AC - UniBO & University of Reading), Giovanni Conti (GC - CMCC), Luis Gustavo De Goncalves (LG - CMCC), Eric Jansen (EJ - CMCC)

Module 1: Theoretical aspects and data assimilation algorithms - 12hr

In this module, basic mathematical concepts in data assimilation are introduced using a Bayesian formulation. We will describe Gaussian approaches as special cases: the Kalman filter/smoother and their variants as well as the variational (e.g. 3DVar, 4DVar) algorithms. We will then present Monte Carlo based approximations that lead to ensemble DA methods such as the ensemble Kalman filter (EnKF) and smoother (EnKS) and their modern hybrid ensemble-variational approaches, particularly suitable for highly nonlinear and high dimensional problems. An outlook on two special, state-of-art, research topics will be presented: how dynamical system theory and modern machine learning methods are nowadays leading to novel DA formulation.

Module 2: Applications in geosciences and hands-on practice - 12 hr

Practical aspects of the algorithms and methods introduced in module 1 are discussed. Observations in ocean and atmosphere are discussed in relation to the observation operators, geophysical balance models as well as statistical properties such as bias and its correction. Applications in the atmosphere, land and ocean as well as other geophysical systems will be covered. Some further application areas of data assimilation such as observing system design are introduced. Finally, DA methods taught are practiced with open source softwares using simple models representing dynamical systems (e.g. Lorenz models, Kuramoto-Sivashinsky, Lotka-Volterra).

Recommended review papers / textbooks / materials

- Carrassi, A., Bocquet, M., Bertino, L., & Evensen, G. (2018). Data assimilation in the geosciences: An overview of methods, issues, and perspectives. *Wiley Interdisciplinary Reviews: Climate Change*, *9*(5), e535.
- Evensen, G., Vossepoel, F. C., & van Leeuwen, P. J. (2022). *Data assimilation fundamentals: A unified formulation of the state and parameter estimation problem* (p. 245). Springer Nature. Open Source
- Asch, M., Bocquet, M., & Nodet, M. (2016). *Data assimilation: methods, algorithms, and applications* (Vol. 11). SIAM.
- Lahoz, W., Khattatov, B., Ménard, R. (Eds.). (2010). Data Assimilation - Making Sense of Observations. Springer

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Final examination: A practical exercise on DA applications using low-dimensional models

Outline of the course (Each lecture 45+45 minutes)

13 Feb 16-18 Lecture 1 Introduction to Data Assimilation [AA]

15 Feb 14-16 Lecture 2 Algorithms: Nudging [GC]

20 Feb 16-18 Lecture 3 Algorithms: variational methods (3D-Var/4D-Var)[EJ]

22 Feb 14-16 Lecture 4 Practical aspects of DA (observation operators, state space, diagnostics) [EJ]

27 Feb 16-18 Lecture 5 Algorithms: Statistical methods (EnKF/EnKS) [AA]

29 Feb 14-16 Lecture 6 Advanced techniques (hybrid / ensemble variational methods) [AA]

7 Mar 14-16 Lecture 7 Applications in geosciences [AA]

12 Mar 16-18 Lecture 8 Applications in meteorology [GC]

14 Mar 14-16 Lecture 9 Applications on land surface [LG]

19 Mar 16-18 Lecture 10 Applications in oceanography [EJ]

21 Mar 14-16 Lecture 11 Practical hands-on session [AA]

4 Apr 14-16 Lecture 12 Data assimilation in dynamical system and their discovery through machine learning in DA [AC]

8. Advanced Climate and early warning services

Total number of hours: 24
Type of Lectures: frontal
Lead: Giovanni Coppini
Lecturers: Giulia Galluccio (CMCC), Emanuela Clementi (CMCC), Francesco Palermo (CMCC), Megi Hoxhaj (CMCC), Annamaria Mazzoni (CMCC)

Syllabus

Module 1*: Copernicus Marine and Copernicus Climate Services – Coppini (2hrs), Clementi (2hrs)- tot 4hrs*

The Module 1 aims to present the general characteristics of the Copernicus Marine and Copernicus Climate Services. This introductive module will present the different relevant products and will highlight some of main aspects and methodologies such as satellite, reanalysis, ocean forecasting, seasonal forecasting.

By the end of this module 1 the students will be able to:

- Describe the potential value of using Copernicus Marine and Copernicus Climate products; Identify relevant Copernicus Marine and Climate products that would be appropriate for you to use
- Navigate the Copernicus Marine and Copernicus Climate product catalogue

Textbook/Course Material:
notes of the Lecturer
Copernicus Marine Service web site: https://marine.copernicus.eu/
Copernicus Climate Service web site: https://climate.copernicus.eu/

Module 2 *Climate indicators, adaptation plans and early warning services– Giulia Galluccio (2hrs) Annamaria Mazzoni (2hrs), and Giovanni Coppini (2hrs) - Tot 6hrs*
The module 2 will describe what are climate indicators, how they are designed with users and how they are used for climate assessment activities and for climate adaptation plans. In addition the module 2 will introduce to early warning systems such as the one related to coastal storm surge which are based on Copernicus Marine Service products.

Textbook/Course Material:

Module 3 *Climate and ocean data processing. Hoxhaj, Palermo 14h*

The Module 3 will consists of a practical hands on training sessions which have been designed to train existing as well as new Copernicus Marine and Copernicus Climate Services users. The audience will learn about the use of the Copernicus Marine Service and Copernicus Climate products and services and their possible applications.

By the end of this module you will be able to:

1. Navigate the Copernicus Marine and Copernicus Climate product catalogues
2. Confidently use appropriate tools and products from the catalogue
3. Provide inputs for future design and development of Copernicus Marine and Copernicus Climate Service tools and products

Textbook/Course Material:

Example of previous Copernicus Marine Service training: https://marine.copernicus.eu/events/copernicus-marine-service-online-training-workshop-mediterranean-sea

notes of the Lecturer, training material

Final Test

Students will elaborate, in written form, answers to different questions, one test for the entire course.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

9. From Faults to Faults

Total number of hours: 24
Type of Lectures: frontal
LEAD: Eleonora Rivalta (UNIBO-DIFA)
Lecturers: Maria Elina Belardinelli (UNIBO-DIFA), Barbara Lolli (INGV), Enrico Baglione (UNIBO-DIFA), Eleonora Rivalta (UNIBO-DIFA)

Module 1: Fault mechanics, Belardinelli – 8hr

The module introduces the conditions for faults to be earthquake sources through the following subjects: fault strength and stability, rock friction, Coulomb criterium of failure, fault interactions, rate- and state-dependent friction, seismic and aseismic behavior.

Module 2: Seismic hazard and prediction, Baglione/Lolli – 8hr

The module illustrates the characteristics of seismic catalogs (hypocentral parameters and the different type of magnitudes) and provides an overview of Probabilistic Seismic Hazard Analysis (PSHA), a method that integrates various earthquake source parameters along with their uncertainty to forecast intensity of shaking at a specific site.

Module 3: Seismic deformation, Eleonora Rivalta– 8hr

The module illustrates how faults can be characterized by signals measured at the Earth'surface. Free surface models will be used to analyze and discuss, based on MATLAB codes, the displacement fields due to fault sliding and compare it with observations from seismic areas.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

10. Tsunamis

Total number of hours: 24
Type of Lectures: frontal
Lead: Alberto Armigliato (UNIBO-DIFA)
Lecturers: Alberto Armigliato (UNIBO-DIFA), Filippo Zaniboni (UNIBO-DIFA)

Module 1: General overview and earthquake-induced tsunamis, Armigliato – 12hr

- General introduction on tsunamis
- Phenomenology and data
- Mechanism of tsunami generation by earthquakes: processes and modelling
- Modelling of tsunami propagation in the open ocean
- Interaction of tsunami waves with coastal topography: the run-up problem
- Tsunami models benchmarking
- Brief outline of the different approaches to tsunami hazard assessment

Module 2: Non-seismic tsunamis, Zaniboni – 12hr

- Tsunamigenic mechanisms
- General overview on landslides
- Modelling of landslide stability and dynamics
- Landslide-tsunamis: characterisation and modelling
- Tsunamis from volcanic-related events and other sources: meteotsunamis, calving tsunamis.

Suggested readings

Bryant, E.: Tsunami – The Underrated Hazard. Springer-Verlag Berlin Heidelberg, 330 pp., 2008.

Grezio A, Babeyko A, Baptista MA, Behrens J, Costa A, Davies G, Geist E, Glimsdal S, Gonzales FI, Griffin J, Harbitz C, LeVeque RJ, Lorito S, Lovholt F, Omira R, Mueller C, Paris R, Parsons T, Polet J, Power W, Selva J , Sorensen MB, Thio HK: Probabilistic Tsunami Hazard Analysis: Multiple Sources and Global Applications, Reviews of Geophysics 55, DOI:10.1002/2017RG000579, 2017.

Harbitz, C.B, Lovhølt F., Bungum H.: Submarine landslide tsunamis: how extreme and how likely? NatHazards 72:1341–1374. doi:10.1007/s11069-013-0681-3, 2014.

"Indicazioni, 2018": PRESIDENZA DEL CONSIGLIO DEI MINISTRI - DIPARTIMENTO DELLA PROTEZIONE CIVILE - DECRETO 2 ottobre 2018. Indicazioni alle componenti ed alle strutture operative del Servizio nazionale di protezione civile per l'aggiornamento delle pianificazioni di protezione civile per il rischio maremoto. (18A07309) (GU Serie Generale n.266 del 15-11-2018), e relative Allegati (in Italian).

Levin, B. W., and Nosov, M. A.: Physics of Tsunamis, 2nd Edition, Springer, 399 pp., 2016.

MCDEM: Tsunami Evacuation Zones- Director's Guideline for Civil Defence Emergency Management Groups [DGL 08/16] February 2016 . ISBN 978-0-478-43515-3. Published by the Ministry of Civil Defence & Emergency Management – New Zealand, 2016.

Selva, J. S. Lorito, M. Volpe, F. Romano, R. Tonini, P. Perfetti, F. Bernardi, M. Taroni, A. Scala, A. Babeyko, F. Løvholt, S. J. Gibbons, J. Macías, M. J. Castro, J. M. González-Vida, C. Sánchez-Linares, H. B. Bayraktar, R. Basili, F. E. Maesano, M. M. Tiberti, F. Mele, A. Piatanesi & A. Amato (2021): Probabilistic tsunami forecasting for early warning. Nat Commun 12, 5677 (2021). https://doi.org/10.1038/s41467-021-25815-w

Selva, J. , A. Amato, A. Armigliato, R. Basili, F. Bernardi, B. Brizuela, M. Cerminara, M. de' Micheli Vitturi, D. Di Bucci, P. Di Manna, T. Esposti Ongaro, G. Lacanna, S. Lorito, F. Løvholt, D. Mangione, E. Panunzi, A. Piatanesi, A. Ricciardi, M. Ripepe, F. Romano, M. Santini, A. Scalzo, R. Tonini, M. Volpe & F. Zaniboni (2021): Tsunami risk management for crustal earthquakes and non-seismic sources in Italy. Riv. Nuovo Cim. 44, 69–144. https://doi.org/10.1007/s40766-021-00016-9

Yavari-Ramshe, S., &Ataie-Ashtiani, B.: Numerical simulation of subaerial and submarine landslide generated tsunami waves—recent advances and future challenges. Landslides, 13(6), 1325–1368. https://doi.org/10.1007/s10346-016-0734-2, 2016.

Vilibic I., Šepic J., Rabinovich A.B. and Monserrat S.: Modern Approaches in Meteotsunami Research and Early Warning. Front. Mar.Sci. 3: 57. doi: 10.3389/fmars.2016.00057, 2016.

Plus other references indicated during the course.

The slides presented in the two modules will be made available through a Dropbox shared folder and/or in the course's Teams room.

Final test

Students will elaborate, in written form, answers to two different questions, one per each module of the course.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Thematic B Courses

1. The challenge of global change for biodiversity in terrestrial and marine ecosystems

Lead: Juri Nascimbene (BIGEA, UNIBO)

MOD 1 - Terrestrial ecosystems – 12 h
1) Methods and challenges in quantifying biodiverisity in ecosystems - Prof. Roberto Cazzolla-Gatti - 2 h
2) Biodiversity conservation: an urgent need for sustainability - Prof. Roberto Cazzolla-Gatti - 2 h
3) Scientific reporting by LaTeX - Prof. Duccio Rocchini - 4 h
4)The response of plant species and communities to Global Change - Prof. Juri Nascimbene - 2 h
5) Extreme organisms in extreme environments: lichens - Prof. Juri Nascimbene - 2 h

MOD 2 - Marine ecosystems – 12 h
1) The past, the present, and the future of marine biodiversity conservation – Prof.ssa Federica Costantini - 3 h
2) Laboratory of multidisciplinary approaches to climate change impacts on marine ecosystems – Prof. Erik Caroselli – 2 h
3) Corals and coral reefs ecosystems in the face of climate change – Prof. Stefano Goffredo - 3 h
4) Ecological shifts in marine and coastal benthic communities – Prof. Massimo Ponti - 2 h
5) Multiple stressors on marine communities: challenges for a sustainable use of biological resources – Prof. Michele Casini - 2 h

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Thematic C Courses

1. Energy demand, production and distribution in the residential sector

Total number of hours 24
Type of Lectures: frontal
LEAD: Andrea Boeri
Module 1: Energy needs in residential sector (12 hours) – Andrea Boeri + Jacopo Gaspari
Module 2: HVAC solutions for IAQ and indoor thermal comfort (12 hours) – Giovanni Semprini

2. Energy systems and environmental impact

Total number of hours: 24
Type of Lectures: frontal
LEAD: Francesco Melino
Module 1: Energy systems and environmental impact (24 hours) – Francesco Melino

3. Sustainable chemistry

Total number of hours: 24
Type of Lectures: frontal
LEAD: Fabrizio Cavani
Module 1: Sustainability in Chemistry (6 hours) – Fabrizio Cavani
Module 2: Electrochemical processes for a sustainable chemistry (6 hours) – Patricia Benito Martin
Module 3: Sustainable catalytic processes (6 hours) – Dimitratos Nikolaos
Module 4: Environmental sustainability in anthropogenic material cycles (6 hours) – Luca Ciacci

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Thematic D Courses

1. Social Sciences and Climate Change: Debates, Approaches, Frameworks and Instruments

Coordination: Department of Political and Social Sciences, Department of Sociology and Business Law
Total number of hours: 24
Type of Lectures: frontal, seminars

Module 1, Area of Social and Political Communication: 8 hrs

Lead: Riccardo Prandini

- Media System and Narratives on Climate, Environment and Nature by Augusto Valeriani, 2 hrs
- Storytelling, Science and Climate Change by Antonella Mascio, 4 hrs

Module 2, Area of International and Area Studies: 6 hrs

Lead: Massimiliano Trentin

- Climate Change, Resource and Conflicts by Francesco Moro, 2 hrs
- Climate Change in the case of the Middle East by Giorgia Perletta, 2hrs
- Climate Change in the case of North Africa by Giulia Cimini, 2 hrs
- Climate Change in the case of Sub-Saharian Africa, by Arrigo Pallotti, 2 hrs

Module 3, Area of Sociological Studies: 6 hrs

Lead: Alessandra Landi

- Adaptation and mitigation approaches: a sociological reading,.by Alessandra Landi, 4 hrs
- From Urban Sprawl to Zero Land Development? Some national and international trends, by Gabriele Manella, 2 hrs

Module 4, Area of Law: 4 hrs

Lead: Massimiliano Musi

- Legal perspectives of Climate Change: European law and legal instruments by Massimiliano Musi, 2 hours
- Principles of environmental law and integrated perspective of climate change by Olivia Pini, 2 hours.

References:

Module 1

- Dunlap, R. E., & Brulle, R. J. (2015). *Climate Change and Society: Sociological Perspectives*. Oxford University Press. Chapter 8.
- Fisher, D. R., & Nasrin, S. (2020). Climate activism and its effects. *WIREs Climate Change*, *12*(1), 1–11.
- Boulianne, S., Lalancette, M., & Ilkiw, D. (2020). "School Strike 4 Climate": Social Media and the International Youth Protest on Climate Change. *Media and Communication*, *8*(2), 208–218.
- Jensen K. B. (2017). Speaking of the weather: Cross-media communication and climate change. *Convergence.* 23(4), 439-454. doi:10.1177/1354856517700379
- Couldry, N. (2012), *Media, Society, World. Social theory and digital media practice*, Cambridge, Malden: Polity Press.
- Jenkins, H., Ford, S., Green, J. (2013), *Spreadable Media. Creating value and meaning in a networked culture*, New York: New York University Press.
- Castells, M. (2009), *Communication Power*, Oxford: Oxford University Press.
- Engesser, Sven, and Michael Brüggemann. "Mapping the minds of the mediators: The cognitive frames of climate journalists from five countries." *Public understanding of science* 25.7 (2016): 825-841.

Module 2

- Salehyan, I. (2014). Climate change and conflict: Making sense of disparate findings, Political Geography, 50.
- Van Baalen, S., & Mobjörk, M. (2018). Climate change and violent conflict in East Africa: integrating qualitative and quantitative research to probe the mechanisms. *International Studies Review*, *20*(4), 547-575
- Robert D., O'Donoghue S. (2013). Urban Environment Challenges and climate change in Durban, South Africa. *Environment and Urbanization* 25(2), 299-319.
- Cimini, G. (2023). 'Environmental security in the Middle East and North Africa: Interpretations and patterns of policy and activism'. In *Handbook of Middle East Politics*, edited by S. Akbarzadeh, Edward Elgar, pp. 368-384.
- Moneer A. (2020). Environmental Activism in the Post-Arab Spring: It is not about a Mere Clean Environment. In *Euromed Survey of Experts and Actors. Civil Society and Social Movements in the Euromediterranean Region,* pp. 66-73. IEMed - European Institute of the Mediterranean

- Seagle A. (2019). "Environmental (In)Security in the Middle East." In Regional Security in the Middle East Sectors, Variables and Issues, edited by B. Koch and Y.A. Stivachtis, pp. 80-97. Bristol: E-International Relations
- Selby, Jan. "The geopolitics of water in the Middle East: fantasies and realities." Third World Quarterly 26.2 (2005): 329-349.
- Madani, Kaveh. "Water management in Iran: what is causing the looming crisis?." Journal of environmental studies and sciences 4 (2014): 315-328.
- El-Sayed, Mustapha Kamel, and Rasha Soheil Mansour. "Water scarcity as a non-traditional threat to security in the Middle East." India Quarterly 73.2 (2017): 227-240.
- Iran's Khuzestan: Thirst and Turmoil, Crisis Group, 21 August 2023.

Module 3

- Sampson R.J. (2017), "Urban sustainability in an age of enduring inequalities: Advancing theory and ecometrics for the 21st-century city", PNAS, 114, pp. 8957-8962. available at http://www.pnas.org/content/pnas/114/34/8957.full.pdf (article).
- Bueno-Suárez c., Coq-Huelva d. (2020), Sustaining What Is Unsustainable: A Review of Urban Sprawl and Urban Socio-Environmental Policies in North America and Western Europe, in "Sustainability", 12, 11, https://www.mdpi.com/2071-1050/12/11/4445
- Landi A., Rimondi T. (forthcoming), *Investigating urban inequalities in a climate crisis scenario: the contribution of Big Data to environmental justice studies, FUORILUOGO.*

Module 4

- Sikora A. "European Green Deal – legal and financial challenges of the climate change", ERA Forum: https://doi.org/10.1007/s12027-020-00637-3

2. Dynamic Models for Environmental Economics

Prof. Luca Lambertini

Total number of hours: 24

Course description

The aim of the course is to deliver an overview of the extant debate on the impact of firms' behaviour on global warming and natural resources, both renewables and non-renewables, including investment in green technologies and exploration/repopulation, and the design of regulatory tools. The explicit aim of Module II consists in illustrating the tradeoff between resource exploitation and economic development, as well as the interplay between resource extraction and global warming, and then the related policy recommendations emerging from a unified view.

The exposition encompasses the analysis of the tragedy of commons dating back to the Lotka-Volterra model and the Hotelling model, related to renewables and non-renewbles, respectively. The course is open to any doctoral students interested in these issues across the PhD programmes activated by the University of Bologna. With this in mind, although the course belongs to the PhD in Economics, the exposition will have a transdisciplinary flavour.

The early stage of the Module will include a short exposition of a key feature frequently characterising dynamic games in environmental and resource economics, namely, the degenerate feedback nature of open-loop Nash equilibria, relying on the notions of optimal control and differential game theory illustrated in the first module.

While most of the exposition will focus on the role of market power, the conclusive part will provide a compact view of the dynamics of environmental agreements where the relevant players are not firms but governments.

The syllabus contains essential readings in support of lectures and some hints for essays.

Topics

1. Getting acquainted with optimal control and differential game theory: open-loop, memoryless closed-loop and feedback solutions
2. Gym 1: monopoly models with either GHG emissions or resource extraction
3. Gym 2: an oligopoly game with sticky prices
4. Oligopoly and natural resources
5. Two eggs in one basket: resource extraction and global warming

6. International agreements as differential games

Teaching methods

The focus of Section 1 is essentially methodological, while Sections 2-3 rely on selected papers.

Assessment methods

The final mark has the following composition: 20% class participation, 30% essay, 50% exam in class. The essay's theme (which may be co-authored) must be agreed on with the lecturer. The exam in class (2 hrs) consists of a menu of four questions related to the material of the course (two for each module), from which the candidate has to pick two questions (one per module) according to her/his liking.

Syllabus

Benchekroun, H. (2008), "Comparative Dynamics in a Productive Asset Oligopoly", Journal of Economic Theory, 138, 237-61.
Benchekroun, H. and N.V. Long (1998), "Efficiency inducing taxation for polluting oligopolists", Journal of Public Economics, 70, 325-342.
Colombo, L., and P. Labrecciosa (2015), "On the Markovian Efficiency of Bertrand and Cournot Equilibria", Journal of Economic Theory, 155, 332-58.
Dockner, E.J. and N.V. Long (1993), "International Pollution Control: Cooperative versus Noncooperative Strategies", Journal of Environmental Economics and Management, 25, 13–29.
Feichtinger, G., L. Lambertini, G. Leitmann and S. Wrzaczek (2016), "R&D for Green Technologies in a Dynamic Oligopoly: Schumpeter, Arrow and Inverted U's", *European Journal of Operational Research*, **249**, 1131-38.
Feichtinger, G., L. Lambertini, G. Leitmann and S. Wrzaczek (2022), "Managing the Tragedy of Commons and Polluting Emissions: A Unified View", *European Journal of Operational Research*, 303, 487-99.
Fujiwara, K. (2008), "Duopoly Can Be More Anti-Competitive Than Monopoly", Economics Letters, 101, 217–19.
Groot, F., C. Withagen and A. de Zeeuw (2003), "Strong Time-Consistency in the Cartel-versus-Fringe Model", Journal of Economic Dynamics and Control, 28, 287–306.
Krutilla, J. and A. Fisher (1985), The Economics of Natural Environments, Washinton DC, Resources for the Future.

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

FRONTIERS
FUTURE EARTH, CLIMATE CHANGE AND SOCIAL CHALLENGES

Lambertini, L. (2013), Oligopoly, the Environment and Natural Resources, London, Routledge, chs 8 and 9.

Lambertini, L. and A. Mantovani (2014), "Feedback Equilibria in a Dynamic Renewable Resource Oligopoly: Pre-emption, Voracity and Exhaustion", Journal of Economic Dynamics and Control, 47, 115-22.

Lambertini, L. (2018), Differential Games in Industrial Economics, Cambridge, Cambridge University Press, chs 1, 2 and 7.

Lambertini, L. and G. Leitmann (2019), "On the Attainment of the Maximum Sustainable Yield in the Verhulst-Lotka-Volterra Model", Automatica, 110, article 108555, 1-5.

Tahvonen, O. and J. Kuuluvainen (1993), "Economic Growth, Pollution and Renewable Resources", Journal of Environmental Economics and Management, 24, 101-18.

Thematic E Courses

1. Health determinants at the human, animals and environment interfaces Journal Club

Lead: Alessandra Scagliarini (DIMES, UNIBO)

Learning outcomes

After completing the course the student is expected to gain knowledge into the diverse methodologies to identify and quantify all possible relationships and causal relationships in complex systems that can be at human/animal/environment interfaces, including microbiomes, to appropriately targeting resources towards disease detection, prevention, prophylaxis to maximize the impact of interventions.

Skills and abillity

Students will then be able to transfer their theoretical knowledge on diverse One health concepts to practical usage in their everyday research.

Judgement and approach

Students should develop critical appraisal and communication skills in the rapidly evolving one health field. Identify evidence based data to perform risk assessment.

Course content

Topics to be covered:

1. Transmission modelling for zoonotic diseases and their environmental persistence
2. Molecular and statistical Methodologies for the study of microbiomes using a One Health perspective
3. Determinants of health: nutrition, lifestyle, environment and genetic
4. Keys to robust data presentation in manuscripts and conferences
5. Effective peer-reviewing in scientific publishing.

Types of instruction

Reading assignments, presentations and Group discussion.

Language of instruction

The course is given in English.