Project nr 1

Exploiting gridded altimetry products in the Mediterranean Sea: from daily to monthly and seasonal time-scales

Mentors: Jesús Gómez-Enri (University of Cadiz, Puerto Real, Spain); Alfredo Izquierdo González (University of Cadiz, Puerto Real, Spain).

Short Introduction

The sea level can be analysed at different spatio-temporal scales. Satellite-derived sea level anomalies using the multi-mission approach allows daily products at a global scale with an unprecedented spatial resolution (0.125º x 0.125º in areas such as the Mediterranean Sea). Thus, time series of sea level anomalies can be used to analyse the variability at time scales from daily to yearly, including seasonality and trends. Sea level anomalies are referred to a mean sea surface, but from an oceanographic point of view it is possible to derive other products by changing the reference surface. This is the case of the absolute dynamic topography, which uses the geoid as zero datum. Assuming the geostrophic assumption, it is also possible to retrieve absolute (or anomalies) of the zonal/meridional components of the surface geostrophic currents. Within this project, students will learn how to download, process and interpret (in the temporal and spatial domain) essential climate variables, such as the sea level and currents, derived from satellite altimeter products.

Outline of proposed analysis:

1. An introduction to the European Seas Gridded L4 Sea Surface Heights and derived variables reprocessed dataset (SEALEVEL_EUR_PHY_L4_MY_008_068 in the case of the Mediterranean Sea).
2. Downloading the selected daily data from Copernicus Marine Service. Selection of the regions of interest and time period of analysis. Depending on the process analysed daily or monthly products will be used.
3. Basic statistical analysis of the data: estimation of monthly and seasonal means, trends.
4. Basic plotting tools in Matlab. If needed, other tools such as CDO or ncview will be used.
5. Formulating the hypothesis for the reasons responsible for the characteristic patterns observed in the Mediterranean Sea.
6. Testing the hypothesis - students should be able to envisage steps of how this can be done based on what was done in (1)-(4)

Summary on targets/deliverables of the project

Through the proposed project mode, students will learn how to:

1. Find and download data from data providers.

2. Read the NetCDF file format.
3. Apply basic statistical spatial/temporal analysis to large data sets.
4. Use basic plotting tools for a better comprehensive view of satellite data.
5. Derive, plot and interpret oceanographic features in the study area.

Students will also increase their competences on:

1. Analytical thinking.
2. Setting research hypothesis.
3. Envisaging research steps to confirm or reject hypothesis.
4. Doing research both as individuals and as a team.
5. Presenting research results.

Suggested tools, methods, and software
Students should have access to MATLAB. Students will be given basic codes and explanations necessary to work on project mode.

Project nr 2

Assessment of cloudiness for use in environmental marine research

Mentors: Maciej Markowski (Institute of Geography, University of Gdansk, Poland); Anna Panasiuk (Institute of Oceanography, University of Gdansk, Poland); Marcin Paszkuta (Institute of Oceanography, University of Gdansk, Poland)

Short Introduction

The progress in modern operational oceanography is associated with satellite-aided remote sensing methods. Consequently, extremely important becomes information on the cloud cover, as it very often decides on the availability and quality of information derived from satellite imagery. The knowledge whether the signal received by a satellite-borne radiometer has been altered by the cloud cover is of utmost importance for correct estimation of a number of hydro-meteorological, physicochemical and biophysical parameters. For many reasons, it is difficult to define cloudiness, moreover an unambiguous definition being hard to find in meteorology. For environmental monitoring of the Baltic Sea, global solutions do not always meet restricted requirements of cloudiness products i.e. the extent of cloud cover. Therefore, for regions of large sunbeam incidence angles (i.e. Baltic Sea), finding an appropriate method with which to determine cloudiness is highly challenging, especially for the winter season. The scope of this project will be to analyse and process satellite imagery/data from Meteosat Second Generation – 12 channel scanning radiometer in order to extract a suitable method for cloud detection over the Baltic Sea basin.

Outline of proposed analysis:

1. An introduction to the Baltic Sea Satellite Imaginary dataset (http://www.satbaltyk.pl/en/)
2. Downloading the selected instantaneous data from SatBaltic Service
3. Basic statistical analysis of the acquired data
4. Introduction to the cloud detection concept-method
5. Applying defined method to the selected data
6. Formulating the hypothesis
7. Testing the hypothesis - students should be able to envisage steps of how this can be done based on what was done in (1)-(6)

Summary on targets/deliverables of the project

Through the proposed project mode, students will learn how to:

1. search and download data from data providers

2. read/process the geotiff file format
3. apply basic statistical spatial/temporal analysis to the large data sets
4. apply the remote sensing methodology in applied oceanography .

Students will also increase their competences on:

6. analytical thinking
7. geospatial data processing
8. setting research hypothesis
9. envisaging research steps to confirm or reject hypothesis
10. doing research both as individuals and as a team - collaboration
11. presenting research results

Suggested tools, methods, and software
Students should have access to MATLAB/OCTAVE (on-line platform). Students will be given basic codes and explanations necessary to work on project mode.

Project nr 3

Extracting characteristic patterns of marine variables using machine learning

Mentors: Frano Matić (Institute of Oceanography and Fisheries, Split, Croatia); Jadranka Šepić (Faculty of Science, University of Split, Split, Croatia)

Short Introduction

We are all witnesses to abundance of atmospheric and ocean conditions at areas where we live. At the first sight, these conditions are all unique; at the second site, however, (and following a lot of detailed analyses!) most of these conditions can be classified within a limited number of classes – combinations of which accounts for most of the observed natural variability. One example which we might choose to investigate within this project mode, is a typical circulation of the northern Ionian Sea which – depending on the forcing and inflow/outflow to and from the adjacent seas – can be either cyclonic or anticyclonic. Or we might choose to study sea level extremes of the Adriatic Sea, revealing that depending on the prevailing wind and atmospheric pressure systems, these extremes might be strongest at the eastern, northern or the western coast of the Adriatic. Within this project mode, we will analyse chosen marine data (e.g. temperature, salinity, sea surface height, current data) originating from the Mediterranean Sea Physics Reanalysis data set – and extract characteristic spatial patterns of these variables at the Mediterranean Sea. We will also study temporal evolution of these patterns. An attempt to link the extracted patterns with the prevailing atmospheric conditions over the area will also be made – resulting with knowledge on an underlying reason for occurrence of the characteristic Mediterranean marine patterns.

Outline of proposed analysis:

1. An introduction to the Mediterranean Sea Physics Reanalysis dataset (doi.org/10.25423/CMCC/MEDSEA_MULTIYEAR_PHY_006_004_E3R1)
2. Downloading the selected monthly data from Copernicus Marine Service
3. Basic statistical analysis of the data: monthly and annual means and variability
4. Introduction to the Neural Gas method, one of the machine learning techniques
5. Transformation of the data to fit the Neural Gas method
6. Applying the Neural Gas method to the selected data and extracting the characteristic patterns
7. Formulating the hypothesis for the reasons responsible for the characteristic patterns
8. Testing the hypothesis - students should be able to envisage steps of how this can be done based on what was done in (1)-(7)

Summary on targets/deliverables of the project

Through the proposed project mode, students will learn how to:

1. find and download data from data providers
2. read the NetCDF file format
3. apply basic statistical spatial/temporal analysis to large data sets
4. apply the Neural Gas method.

Students will also increase their competences on:

1. analytical thinking
2. setting research hypothesis
3. envisaging research steps to confirm or reject hypothesis
4. doing research both as individuals and as a team
5. presenting research results

Suggested tools, methods, and software
Students should have access to MATLAB. Students will be given basic codes and explanations necessary to work on project mode.

Project nr 4

Analysis of spatial and temporal wave energy flux variability along the southern coast of Europe and northern Africa

Mentors (at least two): Tomás Fernández Montblanc (Earth Sciences Department, University of Cádiz), Alfredo Izquierdo González (Department of Applied Physics, University of Cádiz)

Short Introduction

Waves are one of the main mechanisms for transferring energy from the atmosphere to the ocean. The large amount of energy accumulated in the whole ocean in form of wind waves is released in a small portion of the ocean, the littoral area. This area is densely populated and rich in diverse infrastructures serving to a large variety of coastal uses. Therefore it is important to characterize the mean and extreme wave climate in the ocean and coastal areas. Studies of wave climate lie on the basis of decision-making processes and policies in many aspects relative to the conservation and exploitation of the marine and coastal areas. Among other applications, the knowledge of wave characteristics and wave climate can help to better characterize the pollutant transport in the ocean, to establish optimum ship routing, to undertake coastal protection measures, and to design coastal infrastructures and wave energy farms.

The students enrolled in this project will have the opportunity to work with different typology of wave data (in situ measurements and model/reanalysis outputs) to understand their advantages, constrains and synergies between them. They will learn to download and use ERA5 reanalysis and in situ measurements from Puerto del Estado, a Spanish measurement network linked to Emodnet data portal.
The project consists in the characterization of the wave energy flux along the southern coast of Spain and northern Morocco. The student will evaluate the mean and extreme wave energy flux in the study area. They will analyse the long term variability and spatial pattern of wave energy flux in terms of direction and magnitude along the study area. Additionally, the student will learn to evaluate the wave model performance and the reliability of model outputs by comparison with in situ measurements using different skill scores.

Outline of proposed analysis:

1. Brief description and main characteristics of the ERA5 reanalysis (https://cds.climate.copernicus.eu/) and Physics data in Emodnet (https://emodnet.ec.europa.eu/en) for in situ measurement
2. Download wave data from the Copernicus climate portal corresponding to the ERA5 reanalysis

3. Basic processing of the netcdf files to prepare data to be used for wave climate characterization. Visualization, extraction of subsets, concatenate files, etc.
4. Compute basic statistics for the mean wave characterization including wave energy flux for a given spatial domain.
5. Extraction of time series in some locations (wave buys location and coastal points) for the different wave parameters.
6. Assessment of ERA5 wave hindcast performance by comparison with in situ measurements using different skill scores
7. Characterization and representation of the mean and extreme wave climate from the wave time series
8. Analysis of spatial pattern and long term variability of wave energy flux along the coastline of the study area

Summary on targets/deliverables of the project

Through the proposed project mode, students will learn how to:

1. Find and download wave data from different sources and data providers
2. Deal with netcdf files and data analysis of large oceanographic dataset
3. Assessment of wave hindcast quality by comparison with in situ wave measurement to validate wave hindcast
4. Statistical analysis for spatial/temporal characterization of waves

Students will also increase their competences on:

1. Analytical thinking
2. Programming skills
3. Apply research steps and scientific methodology
4. Doing research both as individuals and as a team
5. Oral and written communication of research results

Suggested tools, methods, and software

The student will receive different matlab scripts to analyse the data. They will be requested to modify, complete and develop their own scripts with the guidance of the mentors.

Software: the students would need access to a full version of Matlab. Including all the toolbox.