EOF 2022

ISMS 2022 LAS PALMAS DE GRAN CANARIA
VIII INTERNATIONAL SYMPOSIUM ON MARINE SCIENCES

VII EXPANDING OCEAN FRONTIERS CONFERENCE

LAS PALMAS DE GRAN CANARIA, JULY 06-08

ULPGC Universidad de Las Palmas de Gran Canaria
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Universidad Católica de Valencia San Vicente Mártir
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Wednesday, 6th July 2022

09:00 **Opening Ceremony**

09:30 **Plenary Session 1**
María Damanaki, Greece
Former European Commissioner Maritime Affairs and Fisheries

SESSION A.
Large to Small Scale Processes
Moderator: *M.B. Aguiar González*

10:30 **Invited Conference**
Jesús García Lafuente
THE MEDITERRANEAN SEA – STRAIT OF GIBRALTAR SYSTEM: THE FUNDAMENTAL ROLE OF HYDRAULICS

11:00 **EOF-012 ONLINE**
B. Barceló-Llull et al. DESIGN OF IN SITU SAMPLING STRATEGIES TO RECONSTRUCT FINESCALE OCEAN CURRENTS IN THE CONTEXT OF SWOT SATELLITE VALIDATION

11:15 **EOF-013**
M. Claret et al. WAVE-EDDY INTERACTIONS IN THE GULF OF LION: BRIDGING OCEAN GENERAL CIRCULATION MODELS AND PROCESS OCEAN SIMULATIONS

11:30 **Coffee Break**

12:00 **EOF-032**
L. Ferrer et al. ADRIFT IN THE BAY OF BISCAY

12:15 **EOF-034**
J. López-Parages et al. POTENTIAL SST DRIVERS FOR CHLOROPHYLL-A VARIABILITY IN THE ALBORAN SEA: A SOURCE FOR SEASONAL PREDICTABILTY?

12:30 **EOF-035**
S. Sammartino et al. COUPLED ECHOSOUNDER AND DOPPLER PROFILER TO IMPROVE CURRENT MEASUREMENTS ACCURACY

12:45 **EOF-063**
V. Zoeller et al. STABLE 3D QUASI GEOSTROPHIC EDDIES WITH VANISHING VORTICITY

13:00 **EOF-075**
I. Vallès-Casanova et al. WATER MASS TRANSPORTS AND PATHWAYS IN THE NORTH BRAZIL-EQUATORIAL UNDERCURRENT RETROFLECTION

13:15 **ISMS-270**
Ruiz-Urbaneja et al. SEASONAL VARIATIONS OF THE UPPER OCEAN IN THE SCOTIA SEA AND WEST OF THE ANTARCTIC PENINSULA: OBSERVATIONS FROM INSTRUMENTED SEALS

13:30 **EOF-020**
Hernández-García et al. Hybridisable Discontinuous Galerkin skill for ocean modelling

SESSION B
Coastal Oceanography
Moderator: *A. Rodríguez Santana*

13:45 **EOF-001**
M.F-Pedrera Balsells et al. RELATIONSHIP BETWEEN THE BIOLOGICAL VARIABLES AND HYDRODYNAMIC FACTORS IN A MICRO-TIDAL ESTUARY. THE CASE OF FANGAR BAY (EBRO DELTA)

14:00 **BREAK**

15:30 **Plenary Session 2**
Lynne Talley, USA
Physical Oceanographer Scripps Institution of Oceanography

16:30 **EOF-008**
J. Ramos et al. EXTREME SEA LEVEL EVENTS IN THE WESTERN MEDITERRANEAN: ANALYSIS OF THE MAIN CONTRIBUTIONS BASED ON HIGH FREQUENCY TIDE GAUGE RECORDS

16:45 **EOF-009**
I. Manso-Narvarte et al. SIMULATING ANCHOVY EGGS AND LARVAE ADVECTION IN THE SE-BOB

17:00 **EOF-016**
J. Villalonga et al. THE SEA LEVEL REPONSE TO THE HUNGA TONGA – HUNGA HA'APAI VOLCANO ERUPTION: A GLOBAL METEOTSUNAMI

17:15 **EOF-023**
J. Reis et al. INTERNAL WAVES GENERATION ON A DEEP-SEA ISLAND

17:30 **EOF-029 ONLINE**
P. Muñoz López et al. MODELLING TIDAL FLAT RESTORATION IN THE GUADALQUIVIR ESTUARY (SW SPAIN)

17:45 **EOF-036**
I. Nadal et al. HYDRODINAMIC CONNECTIVITY AND DISPERSAL PATTERNS IN THE STRAIT OF GIBRALTAR: IMPLICATIONS FOR A TRANSBOUNDARY SPECIES

18:00 **EOF-041**
A. Rubio et al. LAGRANGIAN OBSERVATIONS OF MARINE LITTER AGGREGATIONS IN THE COASTAL AREA OF THE SOUTHEAST BAY OF BISCAY

18:15 **EOF-059 ONLINE**
T. Fernández-Montblanc et al. UNDERWATER CULTURAL HERITAGE RISK ASSESSMENT TO WINDS WAVES: A MODELLING CASE STUDY IN THE BAY OF CADIZ

18:30 **POSTER SESSION AND COFFEE**

Thursday, 7th July 2022

08:45 **Plenary Session 3**
Julián Blasco, Spain
Department of Ecology and Coastal Management

10:00 **EOF-061**
I. Ortigosa et al. PATÍA A VELA AS AN OCEANOGRAPHIC PLATFORM

10:15 **EOF-065**
E. Verger et al. STUDY OF THE VARIABILITY OF THE COASTAL WATERS OF BARCELONA FROM A SUSTAINABLE BOAT AND DURING EPISODES OF HEAVY RAINS: THE PATÍ CIENTÍFIC

SESSION D.

Oceanography and Climate Change
Moderator: *Anna Rubio*

10:30 **EOF-073**
J. J. Gomiz-Pascual et al. IDENTIFICATION OF VULNERABLE AREAS TO THE ACCUMULATION OF POLLUTANTS IN SAN FERNANDO AND CADIZ SALT MARSHES BY USING A HIGH RESOLUTION HYDRODYNAMIC MODEL

10:45 **EOF-003**
V.Caínzos et al. THIRTY YEARS OF GOSHIP AND WOCE DATA: ATLANTIC OVERTURNING OF MASS, HEAT AND FRESHWATER TRANSPORT

11:00 **EOF-005**
M. Viñes et al. ANALYSIS OF WAVE EVOLUTION (TRENDS) IN THE CANTABRIAN COAST. VARIABILITY OR CLIMATE CHANGE?

11:15 **EOF-006**
S. Assimenidis et al. EVOLUTION OF THE HISTORICAL MARINE STORMS IN THE CATALAN COAST

11:30 **COFFEE BREAK**

12:00 **EOF-074**
J: L. Pelegrí et al. SAGA: THE SOUTH ATLANTIC GATEWAY

12:15 **EOF-018 ONLINE**
J. Lin-Ye et al. AUTOMATIZED DELAYED-MODE REPROCESSING OF THE CMEMS SEA LEVEL MEASUREMENTS

12:30 **EOF-028 ONLINE**
X. Sánchez-Artús et al. MODELLING COASTAL FLOODING AND EROSION AT DNIESTER'S BARRIER BEACH (UKRAINE)

12:45 **EOF-030**
J. Soto-Navarro et al. IMPACT OF THE OCEAN-ATMOSPHERE COUPLING ON HIGH RESOLUTION FUTURE PROJECTIONS FOR THE MEDITERRANEAN SEA AND SURROUNDING CLIMATE FROM THE MED-CORDEX ENSEMBLE

13:00 **EOF-040**
A. Mosquera Giménez et al. LONG TERM CHANGES IN THE WATERS SURROUNDING THE CANARY ISLANDS

13:15 **EOF-052**
C. Arumí-Planas et al. THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC) IN THE SOUTH ATLANTIC GATEWAY (SAGA)

13:30 **EOF-057**
C. Melo et al. IMPACTS OF SEA LEVEL VARIABILITY ON SEA WATER INTRUSION INTO MEDITERRANEAN COASTAL AQUIFERS

13:45 **EOF-014**
T. Pereira-Vázquez et al. A MODEL STUDY OF THE VOLUME TRANSPORT DRIVEN BY THE WESTERN BOUNDARY CURRENT SYSTEM OF THE WEDDELL GYRE

14:00 **EOF-019**
Gutiérrez-Guerra et al. A NEW INDEX TO DETERMINE THE CHANGES IN THE FOUR PRINCIPALS EASTERN BOUNDARY UPWELLING SYSTEMS UNDER CLIMATE CHANGE

14:00 **BREAK**

15:30 **Plenary Session 4**
Penny Lindeque, United Kingdom
Head of Science: Marine Ecology and Biodiversity
University of Plymouth

16:30 **EOF-077 ONLINE**
C. González-Pola et al. LANDERPICK, A REMOTE OPERATED TOWED VEHICLE TO COST-EFFECTIVELY DEPLOY AND RECOVER LIGHTWEIGHT OCEANOGRAPHIC LANDERS

SESSION C

Remote Sensing and Numerical Oceanography
Moderator: *M.D. Pérez Hernández*

16:45 **Invited Conference**
Ana Mancho
A GEOMETRICAL EXPLORATION OF TRANSPORT ACROSS THE ATLANTIC MERIDIONAL OVERTURNING CURRENT

17:15 **EOF-017**
G. García-Sánchez et al. ASSESSMENT OF GLOBAL OCEAN REANALYSIS AND FORECAST MODELS BY MEANS OF LAGRANGIAN UNCERTAINTY QUANTIFICATION

17:30 **EOF-067 ONLINE**
M. Umbert et al. 3D RECONSTRUCTION OF UPPER OCEAN DYNAMICS IN THE NORDIC AND BEAUFORT SEAS. ASSESSMENT OF THE SURFACE QUASI-GEOSTROPHIC APPROACH

17:45 **EOF-010**
L. Gómez-Navarro et al. IMPACT OF HIGH-FREQUENCY MOTIONS ON OCEANIC SURFACE DISPERSION

18:00 **EOF-011 ONLINE**
E. Makarova et al. DEVELOPMENT OF A 11-YEAR ERA* HIGH RESOLUTION OCEAN FORCING DATASET

18:15 **EOF-053**
E. Cutolo et al. OCEAN STATE RECONSTRUCTIONS THROUGH REMOTE-SENSING, IN-SITU SPARSE OBSERVATIONS AND DEEP LEARNING

18:30 **POSTER SESSION AND COFFEE**

21:00 **Conference Dinner**

Friday, 8th July 2022

08:45 **Plenary Session 5**
Gotzon Basterretxea, Spain
Department of Ecology and Marine Resources
IMEDEA (UIB-CSIC)

09:45 **Invited Conference**
Eric Delory et al. ADVANCES OF EUROPEAN MARINE RESEARCH INFRASTRUCTURES IN OCEAN ECOSYSTEM MONITORING CAPACITY

10:15 **EOF-048**
E. Olmedo et al. EVIDENCE OF INTENSIFICATION OF THE WATER CYCLE

10:30 **EOF-051**
M. Cubas Armas et al. ACOUSTIC PROPAGATIONG OF SIMULATIONS OF SPERM WHALES' VOCALIZATIONS IN CANARIAN WATERS

SESSION F

Operational Oceanography
Moderator: *F.J. Machín Jiménez*

10:45 **EOF-049**
J.A. Jiménez-Rincón SPREADING AND MIXING OF ANTARCTIC INTERMEDIATE WATER IN THE EASTERN NORTH ATLANTIC SUBTROPICAL GYRE

11:00 **EOF-078**
M.G. Sotillo et al. THE COPERNICUS MARINE IBI REGIONAL PRODUCTS FOR THE SPANISH WATERS: STATUS AND SHORT-TERM EVOLUTION

11:15 **EOF-037 ONLINE**
Martínez-Fernández et al. HF RADAR LAGRANGIAN VALIDATIONS WITH GPRS AND SPOT BUOYS

11:30 **COFFEE BREAK**

13:10 **Plenary Session 6**
Ronald Benner, USA
Carolina Distinguished Professor University of South Carolina

13:00 **Closing Ceremony**

15:30 **Visit "Aquarium Poema del Mar"**

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LARGE TO SMALL SCALE PROCESSES

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Universidade de Vigo

DESIGN OF IN SITU SAMPLING STRATEGIES TO RECONSTRUCT FINE-SCALE OCEAN CURRENTS IN THE CONTEXT OF SWOT SATELLITE VALIDATION

Bàrbara Barceló-Llull*[1] and Ananda Pascual[1]

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Abstract:

Over the last few decades, remote sensing observations of sea surface height (SSH) have greatly increased our understanding of the global ocean large and mesoscale circulation. Altimetric observations provide global coverage of the ocean surface on a daily basis, however the mean effective resolution of gridded maps is ~130 km wavelength for the Mediterranean Sea. The new Surface Water and Ocean Topography (SWOT) satellite mission will be launched in 2022 and it is considered to be the next major breakthrough in satellite ocean observation. The SWOT mission aims to provide SSH measurements in two dimensions along a wide-swath altimeter track with an expected effective resolution down to wavelengths of 15–30 km. In this context, our goal is to optimize the design of multi-platform in situ experiments aimed at validating the first available tranche of SWOT data. To achieve this goal, a set of Observing System Simulation Experiments (OSSEs) are developed to evaluate different sampling strategies and their impact on the reconstruction of fine-scale SSH fields and ocean currents. Observations from rosette CTD, underway CTD and gliders are simulated from three nature run models (eNATL60, WMOP, CMEMS) to study the sensitivity of the results to the model used. With different configurations of the simulated observations we test the impact on the reconstructed fields of the spatial and temporal resolution and maximum depth of the measurements. We also evaluate the impact of changing rosette CTD casts for a continuous underway CTD or gliders, and the temporal variability. The reconstructed fields are obtained after applying optimal interpolation to the different configurations. The analysis focuses on the western Mediterranean Sea, in a region located within a swath of SWOT during the validation phase. Our study provides recommendations for the design of multi-platform in situ experiments aimed at reconstructing fine-scale ocean currents, such as those that will be conducted for SWOT validation.

Key words: OSSEs, multi-platform experiments, altimetry, in situ observations, mesoscale

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WAVE-EDDY INTERACTIONS IN THE GULF OF LION: BRIDGING OCEAN GENERAL CIRCULATION MODELS AND PROCESS OCEAN SIMULATIONS

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Abstract: Near-inertial waves (NIWs) are of major relevance to the global ocean circulation as they inject wind energy from the surface to the ocean interior and represent a primary source of energy to the internal wave continuum. Eddies and fronts play a significant role in the downward penetration of NIW energy (from generation to propagation) and subsurface dissipation. Much of our understanding of NIW interactions with submeso- and mesoscale flows comes from limited observations as well as idealized theoretical and numerical processes, but these do not typically consider the presence of temporally evolving larger-scale flows. On the other hand, more realistic and time-evolving eddy fields from submesoscale-resolving Ocean General Circulation Models (OGCMs) forced with winds show truncated spectra at the subsurface due to the lack of vertical resolution -the subgrid vertical scale is 1-2 orders of magnitude larger than the scale at which dissipation occurs. Since OGCMs are indeed very attractive tools to quantify global-regional impacts of small-scale phenomena, we propose to gain understanding of their biases in terms of wave-eddy interactions by using a novel approach.

This approach consists of nesting a non-hydrostatic Boussinesq model (Flow_Solve) into an OGCM configuration (NEMO-GLAZUR64) for the Gulf of Lion with O(1 km) horizontal and O(30 m) vertical resolution. Preliminary analysis of NEMO-GLAZUR64 output reveals a highly energetic NIW field with intriguing distribution patterns relative to the eddies. We zoom into these patterns by following eddies with our nesting approach. The Boussinesq model provides a magnifying glass into dynamical processes that are either parameterized or fully unresolved in the OGCM. Wave energy budgets inferred from high-resolution process studies with Flow_Solve and NEMO- GLAZUR64 are then compared in order to better constrain model uncertainty in OGCMs due to NIW dynamics.

Key words: submesoscales, internal waves, numerical modeling

HYBRIDISABLE DISCONTINUOUS GALERKIN SKILL FOR OCEAN MODELLING

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Abstract:
Oceanographic processes are highly variable and cover a wide range of scales. Therefore, ocean models must be able to capture all the different features spanned over different time and spatial scales simultaneously. Most of the existing methods in ocean modelling can achieve this with a Finite Difference (FD) approach, requiring a high computational cost which might be a limiting factor.

Our main goal is to assess the skills of an alternative method to produce a reliable and fast solution to ocean models. In particular, the Hybridisable Discontinuous Galerkin method (HDG), based on the Finite Element method (FE), is a computationally efficient method with conservative properties that can work with unstructured meshes; these properties are fundamental for modelling the fluid equations in the ocean (Giacomini et al., 2021).

Our interest is focused on the formation and evolution of mesoscale eddies south of the Canary Islands, formed by baroclinic instabilities in the African upwelling front and the island effect (Sangrà et al., 2009). Current ocean models are too coarse to capture in detail the physical processes involved in this context, so our approach with an adapted mesh would provide a solution with a significant increase in the spatial resolution in the required zones compared to classical FD methods.

Key words: Ocean modelling, Finite elements, Hybridisable Discontinuous Galerkin, Shallow Water, Mesoscale eddies

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ADRIFT IN THE BAY OF BISCAY

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Abstract: A summary of the surface ocean circulation experiment carried out in the Bay of Biscay since 2015 is hidden under the above title. Using ships of opportunity and research vessels, we released a large number of Identified Floating Objects (IFOs) to study surface water circulation patterns. Our IFOs were very small surface drifting buoys and natural cork stoppers for wine bottles. These were released in different areas of the Bay of Biscay. Understanding the surface circulation patterns in this bay is of great theoretical and practical importance. This will allow us to predict the most likely drift of algal blooms, eggs and larvae, sediments, oil spills, marine litter and peculiar organisms living at the air-sea interface, such as *Velella velella* (by-the-wind sailor) and *Physalia Physalis* (Portuguese man-of-war). The forecast of this drift is essential for aquaculture and fisheries management, environmental impact studies and beach clean-up activities. For example, it is common to find in the Bay of Biscay algal blooms after strong river discharge events and tiny *V. velella* (< 5 mm long) during the spring season. Here we show that the wind, directly or indirectly, is the main mechanism controlling the drift of our IFOs. We found that our IFOs drift, on average, towards the east. This means that their drift depends more on the cyclonic conditions than on the anticyclonic ones. Furthermore, we found that it is a difficult task for our IFOs to leave the Bay of Biscay, suggesting that this bay acts as a retention region. Our results demonstrate how IFOs can help to understand the surface water circulation. We anticipate our experiment with IFOs to be a starting point for obtaining a sophisticated and realistic drift model. This model will allow us to study a wide range of processes in the open and coastal ocean regions.

Key words: Bay of Biscay, buoy, drift, IFOs, wind

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POTENTIAL SST DRIVERS FOR CHLOROPHYLL-A VARIABILITY IN THE ALBORAN SEA: A SOURCE FOR SEASONAL PREDICTABILTY?

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Abstract: This study investigates the link between large-scale variability modes of the Sea Surface Temperature (SST) and the surface chlorophyll-a (Chl-a) concentration in spring along the northern flank of the Alboran Sea. To this aim, surface satellite-derived products of SST and Chl-a, together with atmospheric satellite variables, are used. Our results indicate that both the tropical North Atlantic and El Niño Southern Oscillation (ENSO) could trigger the development of anomalous distribution patterns of Chl-a in spring in northern Alboran. This anomalous feature of Chl-a is, in turn, associated with the alteration of the usual upwelling taking place along the Spanish coast at that time of the year (Ramírez et al., 2005; Macías et al., 2007; Lazzari et al., 2011). The skill of the related SST signals, over the tropical North Atlantic and the tropical Pacific, as predictors of the aforementioned Chl-a response in Alboran, has been also assessed through a statistical prediction model with leave-one-out crossvalidation. While the skill of the tropical North Atlantic seems to be limited, the results identified confirm the predictive skill of ENSO to realistically estimate the Chl-a response in Alboran. In particular, during El Niño/La Niña years, this Chl-a response can be robustly predicted with 4 months in advance. Furthermore, in those years when the tropical North Atlantic signal precedes ENSO, the Chl-a response can be also reasonably well predicted. This would enhance, for specific years, the predictive horizon to at least 7 months. The results presented here could contribute to develop a future seasonal forecasting tool of upwelling variability and living marine resources in northern Alboran.

Key words: Alboran Sea, Chlorophyll-a, SST, Climate teleconnection, Seasonal predictability

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COUPLED ECHOSOUNDER AND DOPPLER PROFILER TO IMPROVE CURRENT MEASUREMENTS ACCURACY

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Abstract: Since 2004, high resolution profiles of the 3D velocity of the water column have been collected at the westernmost sill of the Strait of Gibraltar (Espartel Sill), with the aim of monitoring the Mediterranean water outflow and evaluating its short and long term variability. Initially equipped with a 75 kHz up-looking Acoustic Doppler Current Profiler (ADCP) and a Conductivity/Salinity (CT) probe, the mooring line has been upgraded through years adding more, and more technologically advanced, instruments. In 2016, a 500 kHz ADCP was installed in down-looking mode, with the aim of covering the so far unsampled bottom layer, below the buoy deployed ~20 m above the seafloor. Despite the implicit variability of such a long series, the averaged profile of the observed along-strait current systematically showed local minima ~50 m above seafloor, which have been interpreted as the result of the interaction between diurnal and semidiurnal tidal currents (Sammartino et al., 2015). The prevailing semidiurnal tide drives periodic accelerations of the westward Mediterranean current flowing at the bottom, whereas diurnal constituents slow them down few meters above seafloor, giving rise to those local minima in amplitude. This mechanism is often related to severe drops in measurements accuracy. In 2019, the main ADCP was replaced by a 100 kHz model capable of collecting high resolution echograms of the water column with an additional vertical beam. This new information reveals the key role of scatterers concentration, which undergo diel vertical migrations, and affect the accuracy of current observations, which in turn rely on the amplitude of scattered echo recorded by the instruments. Actually, echo amplitude reaches average correlations of 0.7 with measurements uncertainty. In light of these new insights, accurate updates of the Mediterranean outflow calculations are performed (García-Lafuente et al., 2021) and new estimations of trend and long-term variability, are provided.

Key words: Strait of Gibraltar, Current measurements, Diel vertical migration, Echo sounder, Acoustic Doppler Current Profiler.

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HOW DO WIND CONDITIONS AFFECT THE SURFACE CIRCULATION AND TRANSPORT OF PROPERTIES THROUGH THE STRAIT OF GIBRALTAR?

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Abstract: This study analyzes the effect that local wind has on the surface circulation in the Strait of Gibraltar as well as its associated biological consequences. To this aim a multi-approach analysis has been carried out, e.g., trajectories of Lagrangian drifters, High Frequency Radar measurements and satellite imagery. Westerly winds, *Ponientes*, favor coastal surface transport (e.g., trace metals, phytoplankton) from the Gulf of Cádiz towards the Alborán Sea. These wind conditions favor the lowest residence times of the transported coastal water along the coastal margin throughout several submesoscale structures emplaced along the coastal margins of the Strait. Also, in these situations high values of Chlorophyll-*a* concentration constrained to the coast line are observed. Once the transported properties reach the Alborán Sea join the so-called Atlantic Jet (AJ) and are either transported towards the Western Alborán Gyre or towards the Estepona Coastal Cyclonic Gyre. During easterly winds events, *Levantes*, the mentioned connection along the Strait of Gibraltar is disrupted. Cyclonic structures are enhanced in the area (e.g., Trafalgar or north Moroccan coast) and Lagrangian drifters showed high residence times around the Trafalgar area or further east of Tarifa. The coastal eastward circulation from Trafalgar remained stopped until easterlies ceased. In addition, the presence of a cyclonic gyre at the easternmost Strait is observed under persistent and intense easterlies. Such structure could trigger the southward shifting of the AJ or even its reversion. The location of this structure is in agreement with an accumulation of trace metal that are being transported towards the Alborán Sea from the Gulf of Cádiz. Moreover, by this time a Coastal Counter Current is observed along the Málaga coast that favor the eastward transport of water along the Malaga coast towards the eastern mouth of the strait and prolonged here over the northern coastal margin further west.

Key words: coastal transport, winds, submesoscale, Lagrangian drifters

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STABLE 3D QUASI GEOSTROPHIC EDDIES WITH VANISHING VORTICITY

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Abstract: Long-lived eddies are found over all the oceans. Monopolar spiral eddies in the South Atlantic (Beron-Vera, 2008), warm core rings in the Gulf of Mexico (Meunier et al., 2021) or Mediterranean eddies are only some examples of long-lived, monopolar and three-dimensional (3D) baroclinic vortices in the ocean. These eddies consist of an inner vorticity core and an outer ring of opposite vorticity sign, and are found in an approximately axisymmetric isolated state where the azimuthal velocity rapidly vanishes with the radial distance beyond the radius of maximum speed (Viudez, 2021). We called them neutral vortices, as they carry a zero amount of potential vorticity anomaly.
However, sign changing potential vorticity gradients cause flow instabilities, implying that isolated geophysical vortices, should be unstable (Benilov, 2003), contradicting the long persistence of those eddies. This paradox has been considered previously in a theoretical and numerical way using rings of piecewise-constant vorticity (Benilov, 2003; Carton, 2009; Flierl, 1988; Kloosterziel & Carnevale, 1992). In particular, some piecewise-constant neutral vorticity monopoles were found to be stable when the outer ring was sufficiently thick relative to the vortex core (Flierl, 1988). Moreover, Viudez (2021) found two-dimensional numerical solutions of axisymmetric neutral vortices which remain robust to small amplitude vorticity perturbations. We will continue the work of Viudez (2021) and expand these solutions to 3D quasi geostrophic geophysical flows. In this work we present the first exact solutions of stable neutral axisymmetric vortices under the QG approximation in 3D.
The vorticity field analyzed is a finite combination of truncated, shifted and normalized spherical Bessel modes of order zero $j_0(kr)$, each one occupying a circular layer, whose boundary radius kr_p is given by a zero $kr_p = j_{3/2,p}$ of the first-order spherical Bessel function $j_1(kr)$. In this approach, each PV layer-mode carries the same amount of QG PV anomaly.

Key words: Stability, Vortices, Quasi Geostrophic Approximation, 3D

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WATER MASS TRANSPORTS AND PATHWAYS IN THE NORTH BRAZIL-EQUATORIAL UNDERCURRENT RETROFLECTION

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Abstract:
The northward warm North Brazil Current (NBC) in the western tropical Atlantic is the main cross-equatorial pathway of the Atlantic Meridional Overturning Circulation (AMOC). An important part is distributed through the recirculation pathways of the interior basin, which mostly take place through a complex retroflection system. The Equatorial Undercurrent (EUC) arise from the NBC retroflection at the equator transporting thermocline waters from the western to eastern equatorial Atlantic basin.

In this study we characterize this NBC-EUC retroflection with temperature, salinity and velocity data acquired in the framework of MOC2 oceanographic cruise in April 2010. Moreover, we expand our analysis by performing off-line Lagrangian modelling on the 3D velocity field form the ocean-reanalysis GLORYS2v4. From particle trajectories, and their associated transport, we reveal four main water sources and water mass transformations from tropical and subtropical North and South Atlantic regions that feed the NBC-EUC retroflection. The predominant water contribution changes as we shift between density classes and each one is dominated by distinct retroflection latitudinal pathway. Additionally, we describe the seasonal-to-interannual transport variability associated with the coupled ocean-atmosphere tropical Atlantic system. Outstandingly, we show a transport increase of tropical South Atlantic waters from 2008 onwards consistent with the recently reported Subtropical Cells (STCs) intensification.

Key words: Tropical Atlantic, Equatorial Undercurrent, AMOC

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RELATIONSHIP BETWEEN THE BIOLOGICAL VARIABLES AND HYDRODYNAMIC FACTORS IN A MICRO-TIDAL ESTUARY. THE CASE OF FANGAR BAY (EBRO DELTA)

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Abstract: Phytoplankton primary production in coastal bays and estuaries is influenced by multiple physical variables, such as wind, tides, freshwater inputs or light availability (Alekseenko et al., 2013; Cerralbo et al., 2015; W. R. Geyer, 1997; Xie & Li, 2018). In a short-term perspective these factors may influence the composition of biological variables such as phytoplankton biomass, as well as the amount of nutrients within the waterbody (Geyer et al., 2018; Jiang et al., 2020; Jou et al. 2019). Observations in Fangar Bay, a small, shallow, stratified and micro-tidal bay in the Ebro Delta (NW Mediterranean Sea), have shown that during wind episodes the biological variables undergo sudden variations in terms of concentration and distribution within the bay (F-Pedrera Balsells et al., 2021). The Regional Ocean Model System (ROMS) coupled with a nitrogen-based nutrient, phytoplankton, zooplankton, and detritus (NPZD) model has been applied to understand this spatio-temporal variability of phytoplankton biomass in Fangar Bay. Idealised simulations prove that during weak wind events (< 6 m·s^{-1}), the stratification is maintained and therefore there is no dynamic connection between surface and bottom layers, penalizing phytoplankton growth in the whole water column. Conversely, during intense wind events (> 10 m·s^{-1}) water column mixing occurs, homogenising the concentration of nutrients throughout the column, and increasing phytoplankton biomass in the bottom layers. In addition, shifts in the wind direction generate different phytoplankton biomass distributions within the bay, in accordance with the dispersion of freshwater plumes from existing irrigation canals. Thus, the numerical results prove the influence of the freshwater plume evolution on the phytoplankton biomass distribution, which is consistent with remote sensing observations. The complexity of the wind-driven circulation due to the bathymetric characteristics and the modulation of the stratification implies that the phytoplankton biomass differs depending on the prevailing wind direction, leading to sharp Chl *a* gradients and complex patterns.

Key words: phytoplankton biomass, ROMS-NPZD model, wind, biological parameters, physical parameters, Fangar Bay.

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EXTREME SEA LEVEL EVENTS IN THE WESTERN MEDITERRANEAN: ANALYSIS OF THE MAIN CONTRIBUTIONS BASED ON HIGH FREQUENCY TIDE GAUGE RECORDS

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Abstract:

Sea level extremes cause significant environmental damage and affect the well-being of populations living in coastal regions. As a consequence of climate change, sea level rise is progressively adding to positive sea level extremes, increasing coastal damages. Furthermore, the variability of sea level extremes is also associated with different climate drivers that influence the intensity and occurrence of these events (Marcos et al., 2015; Torres & Tsimplis, 2014). Therefore, understanding the mechanisms behind those events is important to ensure robust projections (Vilibić & Šepić, 2017).

Most observational analysis of sea level extremes in the Western Mediterranean have based on hourly data from tide gauges. In this work, we aim to produce a detailed characterisation and to achieve a deeper understanding of extreme sea level events in that region through the analysis of high temporal resolution (1 min) tide gauge series from the Puertos del Estado, SOCIB and VENOM networks. Key parameters such as the magnitude and duration of the events or the return periods will be first determined. Next, we will quantify the relative contribution of the different mechanisms affecting extreme sea levels. For this purpose, the sea level series will be decomposed into different physical components such as storm surge, seasonal cycle, or astronomical tides, paying special attention to the remaining high frequency residuals. The weight of each of these processes in the extreme event statistics will be analysed. The spatio-temporal variability of the extreme events will also be analysed and related to the variability of the different components. Finally, the role of wind waves on extreme events will also be discussed based on the outputs of coastal wave models.

Key words: Extreme events, Tide gauges, Return periods, Storm surge.

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SIMULATING ANCHOVY EGGS AND LARVAE ADVECTION IN THE SE-BOB

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Abstract:

Coastal transport processes regulate the fate of eggs and larvae of pelagic fish species, as the European anchovy (*Engraulis encrasicolus*), in the SE Bay of Biscay (SE-BoB). Their spawning peaks in May (Motos et al., 1996) and eggs and larvae are usually located in the upper water column. The oceanic circulation in May affects their distribution with a general drift towards the southwest, driven by the seasonal winds. Besides, other oceanic features such as eddies have been also hypothesized to play an important role in the recruitment and the anchovy population dynamics (Irigoien et al., 2008). Thus, it is valuable to further study the effects of hydrodynamics at seasonal, mesoscale and submesoscales on the larvae distributions in the area.

To this end, the fate of anchovy larvae (considered as passive particles) was simulated in the SE-BoB with the Lagrangian module of the MOHID model for periods of one month in several years. Simulations started from egg abundance distributions obtained at -3 m and -10 m during the BIOMAN oceanographic surveys for 2011-2018. They were run at -3 m forced with HF radar data and with 3D velocity fields reconstructed from HF radar and ADCP observations by means of a reduced order optimal interpolation (ROOI) method. Simulations were also run at -10 m based on reconstructed velocities.

The results show that the distribution varies interannually, driven by the instantaneous current dynamics; however, it is generally observed that larvae do not tend to drift towards open ocean. Moreover, by means of Lagrangian Coherent Structures we can observe that eddies, current-topography interaction in the slope and the vicinity of canyon areas, and sea surface fronts strongly affect their distributions. Besides, strong and persistent winds and in some years a combination of all these factors are also observed to play a key role.

Key words: Bay of Biscay, HF radar, ROOI, anchovy, eddies, fronts

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THE SEA LEVEL REPONSE TO THE HUNGA TONGA – HUNGA HA'APAI VOLCANO ERUPTION: A GLOBAL METEOTSUNAMI

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Abstract: On January 15, 2022 at 04:20 UTC the Hunga Tonga - Hunga Ha'apai volcano, located in the South Pacific Ocean, erupted in a historical event. The explosion, with a strength equivalent to 4 to 14 megatons of TNT (Adam, 2022), generated perturbations in the ocean and in the atmosphere. The atmospheric perturbation propagated far from the source as a Lamb wave, with a velocity close to 320 m/s (Amores et al., 2022). Its signature in surface atmospheric pressure (jumps of a few hPa) was measured in barographs worldwide at least six times during the days after the volcano eruption.

Tide gauges around the world also recorded significant high frequency sea level oscillations caused by the volcano eruption. Two different mechanisms were responsible for these oscillations: 1) a tsunami wave was generated by the explosion contributing to the maximum sea level oscillations, exceeding 1 meter, on the Pacific Ocean; 2) high frequency oscillations were recorded worldwide resulting of the amplification of the sea level response to the volcano-generated atmospheric wave which we identify here as meteotsunamis.

The analysis of 472 sea level and 894 atmospheric pressure time series recorded worldwide has allowed a broad view of the event at the global scale. Our results show that the atmospheric and oceanic signals were spatially heterogeneous, but they provide evidence of the occurrence of a global meteotsunami with maximum amplitudes exceeding 0.5 meters. We based on the data analysis to infer the mechanisms that may have played a role in the sea wave amplification. Harbour resonance and the constructive interference of shelf waves are likely the main contributors to the intensification of the sea level oscillations. The heterogeneity in the atmospheric wave characteristics and in the regional bathymetric features would explain the diversity of sea level responses observed around the world.

Key words: Tonga, Meteotsunamis, Sea Level, Lamb Waves

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INTERNAL WAVES GENERATION ON A DEEP-SEA ISLAND

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Abstract: In coastal regions, the interaction of tidal currents with seamounts or sills often generates internal waves (IW) as in the Strait of Gibraltar. This activity has an important biological implication. On Madeira Island, we found the ideal conditions for the generation of these IW: a stratified ocean and a sudden change in bathymetry created by the submarine ridge existing between the island of Madeira and the Desertas Islands. The interaction of rather intense tidal currents with the ridge topography, under these stratification conditions, leads to the creation of hydraulic jumps, that evolves to the generation of internal bores. These bores can shift from the upstream to the downstream side of a sill, in synchrony with the tidal flow. Different dynamical regimes however, can cause downslope (supercritical, Fr>1) and upwelling (subcritical, Fr<1) currents to form over the sill. Solitons were also observed shedding leeward of the generation site. The first evidence of internal waves activity in the SE of Madeira Island combines data from SAR images, *in-situ* campaigns and moored instruments. Spectral analysis showed 6-12h periods, for the peak IW activity, just after the ebb phase, during spring tides. Also, cross wavelet analysis showed a strong coherence between current speed and tidal flow.

Key words: Internal waves, Solitons, Internal tide, deep-sea Island.

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MODELLING TIDAL FLAT RESTORATION IN THE GUADALQUIVIR ESTUARY (SW SPAIN)

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Abstract:

The Guadalquivir (SW Spain) is a complex estuarine system where many factors converge: navigation of cargo ships, water intake and outtake for agricultural and aquaculture uses, its location bordering the Doñana National Park, etc. Recently, shore and marshes restoration are being considered [1,2]. For years the recovery of tidal marshes in the lower part of the estuary has been suggested as a solution to the degradation of the shores and to counteract possible negative consequences associated to bathymetric changes in the estuary [3]. However, recent studies have been carried out only with exploratory 1D models [3]. These studies, which are enough to provide a primary evaluation of trends, demand more detailed investigations with more complex computational models such as the one GOFIMA has developed in the Guadalquivir estuary using Delft3D. In this work, different domains that simulate a tidal flat have been created. These experiments test different surfaces, depths and locations for two different connections of the tidal flat with the navigation channel. The results are compared with a no-tidal flats configuration where only the main forcing (astronomical tide) is considered and where constant boundary conditions (ecological discharge ∼110 km from the mouth and salinity at the mouth) are fixed. This work aims to understand the effect of the recovery of marshes in the lower part of the estuary, assessing the modifications they originate on the tidal harmonics of surface oscillations and currents as well as salinity distribution along the estuary. It raises that the amount of water exchanged with the restored tidal flat and its location are the critical variables for the induced changes in tidal and saline dynamics. Future studies will include other physical variables such as temperature and possibly address more realistic cases of tidal marsh restoration.

Key words: Guadalquivir estuary, tidal flat, marsh recovery, modelling, Delft3D.

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HYDRODINAMIC CONNECTIVITY AND DISPERSAL PATTERNS IN THE STRAIT OF GIBRALTAR: IMPLICATIONS FOR A TRANSBOUNDARY SPECIES

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Abstract:

The blackspot seabream (*Pagellus bogaraveo*) is a highly appreciated demersal species that has an important target of the Spanish and Moroccan fisheries in the transcontinental waters of the Strait of Gibraltar area (Gil, 2006). It is also one of the most exploited resources of the region, which has led to a notable drop of catches over the years, arriving to a vulnerable status nowadays. Consequently, a reduction of fishing mortality towards sustainability levels was recommended (GFCM, 2021). Improving our knowledge on the interaction of this species with its physical environment is a key issue in the efforts towards rebuilding the fishery target population until its maximum sustainable yield (Cowen et al., 2006). To gain insight into this interaction, a high-resolution circulation model coupled to a lagrangian tracking module has been employed, using eggs and larvae (early-life-stages, ELS) as purely passive particles advected by simulated currents. Several spawning scenarios consisting of different temporal (tidal phase and strength) and spatial (depths and sites) initial conditions have been analyzed to identify the most likely pathways of ELS dispersion. Eastward transport by the Atlantic Jet exiting the Strait of Gibraltar is the most influencing process in that dispersion. Regarding temporal fluctuations, fortnightly tidal modulation appears to be the prevailing factor determining the horizontal paths of ELS, being the spring tide responsible of the greatest scattering of eggs and larvae. Interestingly, the spatial distribution numerically simulated is consistent with results of larvae distribution obtained from samples collected during recent scientific surveys. The results presented in this study can be certainly different attending to the species strategy. The role of other important larval traits not included in this study requires also further research that may help decision-makers to establish biological rest periods that lead to maximize connectivity and sustainability.

Key words: Alboran Sea, blackspot seabream, early-life-stages (ELS), hydrodynamic connectivity, transboundary stock

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LAGRANGIAN OBSERVATIONS OF MARINE LITTER AGGREGATIONS IN THE COASTAL AREA OF THE SOUTH-EAST BAY OF BISCAY

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Abstract: The distribution of marine litter at coastal zones is governed by different temporal and spatial scales processes, which transport, aggregate and scatter marine litter and are still difficult to predict. Understanding the role and the importance of the different processes, and namely those at spatial scales from 1m to 10 km where the vertical motions play a relevant role, is key to develop suitable solutions. Recent studies have shown that, in coastal waters of the South-East Bay of Biscay, floating marine litter tends to accumulate in aggregations or streaks of floating material that are visible to the naked eye, named "marine litter windrows" (Ruiz et al., 2020), and which not only aggregate marine litter but also plankton and prey-size plastics that can be ingested by mistake (Gove et al., 2019). In April 2022, a 3-day in-situ trial survey has been performed in this area aimed at characterizing these frontal processes by means of the deployment of several clusters of surface drifters of different designs, high resolution transects with a 600MHz towed ADCP, HF-radar hourly surface fields, numerical simulations, and visual observations. The use of simultaneous observations of drifter triplets in each windrow has enabled to assess, in addition to their advection and fates, the geometry of the 2D surface dispersion regimes in the study area. The methodological approach and the first preliminary results are presented here. A second survey in the area is foreseen in the period of developed stratification (October 2022) following a similar approach. Future work includes using observational data combined with numerical coastal model predictions to evaluate their performance and improve the modelling results, by refining turbulence parameterizations and the use of data blending techniques.

Key words: coastal ocean, marine litter windrows, Lagrangian particle aggregation, drifter triplets, HF radar, ADCP

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UNDERWATER CULTURAL HERITAGE RISK ASSESSMENT TO WINDS WAVES: A MODELLING CASE STUDY IN THE BAY OF CADIZ

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Abstract: waves can be considered as a major source of hazard for the underwater cultural heritage (UCH) in coastal areas. Waves can cause a direct physical impact, promote e sediment abrasion, or produce scour in underwater archaeological sites. This contribution presents a novel methodology for a risk assessment of wave driven hazard in coastal UCH. It is applied in the outer Bay of Cádiz, characterized by a high richness of UCH sites and declared as Special Archaeological Protection Area. The UCH risk index approach allows to calculate the risk as a function of vulnerability and hazard for the UCH sites registered in the archaeological database (ADB). Vulnerability index (*Vi*), ranging 1-5, were stablished considering the characteristics of the dominant archaeological materials, its response to the different hazards and the environmental factor (slope and seabed typology). Three hazard has been considered (DEcontextualization; SCouring and ABrasion hazard) and the risk assessment has been performed indecently for each hazard. Hazard was calculated using the historical wave hindcast (SIMAR-44) propagated in the study area through the SWAN model implemented in a regular mesh (~37m resolution). The time series of DE was calculated using Soulsby (1997) equation for movement of rocks, SC using Summer et al (2000) equation for scour and AB as the kinetic energy of sediment multiply by the sediment concentration (Van Rijn, 1993). Hazard index (*Hi)* was obtained fitting an extreme value distribution, selecting return period and scoring in 5 categories (0 to 5). UCH is considered at risk for Risk index ($Ri = \sqrt{Hi \cdot Vi}$) > 3.2. Results allow to identify the high-risky UCH sites: 11% potentially damaged by decontextualization, 9 % by scouring and 2% are potentially impacted by abrasion. This methodology allows to the UCH managers to prioritize those sites where protection measures should be implemented to mitigate the loss of archaeological information.

Key words: wave modelling, scour, shipwreck, risk, conservation

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"Proyecciones dinámicas de nivel del mar y oleaje en el golfo de Cádiz y mar de Alborán: impacto del cambio climático en la vulnerabilidad costera y el patrimonio cultural litoral" JÓVENES INVESTIGADORES CEI·MAR 2020; and the project “Vulnerabilidad del Patrimonio Cultural Litoral frente a agentes ambientales: impacto del Cambio Climático (VOLICHE)" (PID2020-117812RB-I00) (Ministerio de Ciencia e Innovación).

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PATÍA A VELA AS AN OCEANOGRAPHIC PLATFORM

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Abstract: The coastline of big cities such as Barcelona are affected by meteorological events and by the anthropogenic influence. Despite the easy access to the marine environment, coastal waters are undersampled both in time and space [1], due the difficulty of setting oceanographic platforms that can carry out continuous sampling next to the coastline and because of the limited accuracy and spatiotemporal resolution of satellites in the shelf waters. In order to improve this lack of sampling, we propose a local strategy for monitoring the Barcelona inner-shelf waters with the participation of sailors that use the *patí a vela* (PV), a sailing recreational boat widely used in Catalonia. We present the adaptation of the PV with a low-cost temperature profiler to turn it into an oceanographic sampling platform, the *scientific patí a vela* (SPV). First, the good performance of the low-cost temperature profile has been confirmed through a favorable comparison with a commercial oceanographic instrument. Second, the temperature profile data within an area of about 3 km x 3 km, in the sea from the Barcelona coastline to about 40 m, for the summer-fall of 2021 are presented. Finally, the results obtained through 15 sampling are used to explore the response of the water column to specific meteorological events. The temperature-depth profiles show that the mixed-layer depth increases and the overall temperature depth-gradient decreases from summer to fall. SPV turns out to be an inexpensive and maneuverable oceanographic platform, therefore SPV can grow as an inclusive and collaborative citizen science platform that will provide an improved monitoring and understanding of the inner continental shelf, particularly near densely populated areas. It also provides the necessary knowledge of natural and anthropogenic seasonality.

Key words: scientific sailing boat, low-cost sensors, temperature-depth profiler, citizen science

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Ortigosa, I.; Bardaji, R.; Carbonell, A.; Carrasco, O.; Castells-Sanabra, M.; Figuerola, R.; Hoareau, N.; Mateu, J.; Piera, J.; Puigdefabregas, J.; et al. (2022) Barcelona Coastal Monitoring with the "Patí a Vela", a Traditional Sailboat Turned into an Oceanographic Platform. *Journal of Marine Science and Engineering*, 10, 591. https:// doi.org/10.3390/jmse10050591

STUDY OF THE VARIABILITY OF THE COASTAL WATERS OF BARCELONA FROM A SUSTAINABLE BOAT AND DURING EPISODES OF HEAVY RAINS: THE *PATÍ CIENTÍFIC*

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Abstract: The shelf waters near the city of Barcelona are a good example of a degraded coastal marine environment as a result of unsustainable anthropogenic activity, which includes several storm episodes per year that bring polluted runoff waters to the coastal environment. There is a shortage of reliable data in the near coastal zones because of the limited spatiotemporal resolution of remote-sensing satellites and the technical and economic difficulty of establishing conventional oceanographic platforms. The citizen-science project *Patí Científic* (Ortigosa et al., 2022) arises as an alternative to supply this lack of coastal sampling, engaging citizen in this endeavor. This is an innovative project whose main objective is the monitoring of coastal waters through the adaptation and equipment with low-cost instrumentation of a patí vela, which is a widely used individual rudderless catamaran in Catalonia, turning it into a scientific patí. This study consists of determining the optimal methodology and instrumentation to monitor the spatiotemporal variability of temperature and salinity, in particular related to heavy rain episodes during spring 2022. The approach includes sampling the area in front of Somorrostro's beach where spillway discharges appears, including six reference stations. After many instrumentation tests, the scientific patí has been equipped with a low-cost temperature-depth profiler and a CTD-CastAway used as a continuous thermosalinograph along the sailing pathway. Our first results show that high precipitation and moderate winds allow the formation of an extensive plume of brackish waters. The main characteristics of this plume, in terms of spatial extension and temporal persistence, are presented.

Key words: scientific sailing boat; low-cost sensors; citizen science; coastal plumes; thermohaline sampling; *Patí Científic*

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IDENTIFICATION OF VULNERABLE AREAS TO THE ACCUMULATION OF POLLUTANTS IN SAN FERNANDO AND CADIZ SALT MARSHES BY USING A HIGH RESOLUTION HYDRODYNAMIC MODEL

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Abstract: The importance of the collaboration between administrative and scientific institutions become everyday most important to provide adequate solutions in the management of several environmental issues. With this aim born the motivation for the present work in which we focus on the results of the collaboration between the Andalusian Government (environmental agency) and the applied physics department of the University of Cádiz.
These semi-enclosed water bodies undergo the rising of intensive aquaculture activities in an area where there is an important anthropogenic impact due to the drastic increment of the population of surrounding cities population in summer time. These circumstances worry the administration and bound it to a thorough study of the exploitation licences and requirements to maintain this area with a good water quality which must allow the recreational use of the affected water bodies. This is the point where the researching groups of the scientific institutions can aid to the administration facilitating tools that allow the making of decisions. In this work we used a high resolution hydrodynamic model (spatial resolution of 20 meters and temporal of 6 minutes) coupled with a lagrangian model to identify the vulnerable areas to the pollutants accumulation in the studied water bodies. Several simulations were performed with the releasing of particles at several points of wastewater discharges with the characteristics flow rates previously facilitated by the administration. Later, several concentration maps were built in order to describe the evolution of the spills along various tidal cycles. The final result is summarised through a map where the most vulnerable areas sorted as areas with a medium risk, where regular controls are recommended, and areas with low risk where a sporadic controls may be sufficient.

Key words: Salt marshes, hydrodynamic model, lagrangian model, spills.

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REMOTE SENSING AND NUMERICAL OCEANOGRAPHY

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Universidade de Vigo

Encuentro de Oceanografía Física 2022 (EOF)
Las Palmas de Gran Canaria (Spain), 6-8th July 2022

IMPACT OF HIGH-FREQUENCY MOTIONS ON OCEANIC SURFACE DISPERSION

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Abstract:

Understanding the oceanic surface dispersion has important applications in ocean pollution scenarios. Of the different ocean pollution events, some of which have the most impact both on the marine environment and, on society and economy are: marine plastics, oil spills and *Sargassum* inundation events.

Understanding the ocean dynamics that affect their trajectories is vital to simulate their pathways, and thus know their sources and sinks. This can then be used to implement clean-up strategies and to better manage marine protected areas. It can also help reduce the impact of ocean pollution on the marine environment and some major economic sectors like tourism.

High frequency motions have an important impact on the surface dynamics, but high temporal resolution data is necessary to study their effects. New datasets (like high resolution ocean general circulation models) and methodologies have allowed to obtain better representations of high frequency motions. Here, we specifically focus on the high frequency motions due to tides (like for example internal waves), as well as inertial oscillations.

Using the OceanParcels framework, we simulate surface trajectories of these three different type of particles: plastic, oil and Sargassum. We focus on three regions in the Atlantic Ocean: Açores Islands, North Atlantic and Tropical Atlantic, respectively. For the plastic simulations we look at the effect of tides by using velocity outputs from a high-resolution ocean general circulation model which is a twin simulation without and with tidal forcing.

For the oil spills and *Sargassum* outputs we use a new surface currents product generated by combining velocity data from drifters, high-frequency winds and altimetry to reconstruct high-frequency surface currents.

We find that considering high-frequency motions is key to correctly simulate their surface trajectories, but that further work is necessary to understand the ocean dynamics at the fine-scales that can drive the variability in these Lagrangian trajectories.

Key words: Marine pollution, high-frequency motions, Lagrangian particles, Surface trajectories

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DEVELOPMENT OF A 11-YEAR ERA* HIGH RESOLUTION OCEAN FORCING DATASET

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Abstract:
In the framework of the European Space Agency (ESA) World Ocean Circulation project (WOC), the enhanced ocean wind forcing product (ERA*) has been developed to address the growing demand for accurate forcing from the ocean modelling community. The ERA* is a corrected reanalysis product that optimally combines the capacities of scatterometer observations and model reanalysis stress equivalent wind (U10S) output, by means of a geolocated scatterometer-based correction (SC) applied to the European Centre for Medium-range Weather Forecasts (ECMWF) Fifth reanalysis U10S output (ERA5). The SC consists of accumulated ERA5-scatterometer U10S component (zonal and meridional) differences over time windows of typically a few days to a month, at each ocean grid point (Trindade et al. (2020)).

ERA* is able to introduce true smaller scale signal into ERA5 that corresponds to the physical processes absent or misrepresented by the latter, e.g., strong current effects (such as WBCs, highly stationary), wind effects associated with the ocean mesoscales (SST), coastal effects (land see breezes, katabatic winds), parameterization errors, and large-scale circulation effects, e.g., at the ITCZ. This is verified by comparing both products against independent scatterometer observations (e.g., HSCAT on HY-2A and HY-2B) and buoys winds.

The ERA* product is generated for the period 2010-2020. An optimized configuration of ERA* in terms of the varying scatterometer constellation over the period of interest is sought. In particular, the optimal SC time window size will depend on the scatterometer sampling, i.e., the larger the number of scatterometers in orbit is, the smaller is the time window required. The ERA* reduces the vector root-mean-square difference by 10% (5%) against independent scatterometers (buoys), with respect to that of ERA5. The new ERA* product, which thus significantly outperforms ERA5, will be freely available from the WOC webpage (https://www.worldoceancirculation.org/).

Key words: ocean forcing, high resolution, scatterometer, NWP

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ASSESSMENT OF GLOBAL OCEAN REANALYSIS AND FORECAST MODELS BY MEANS OF LAGRANGIAN UNCERTAINTY QUANTIFICATION

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Abstract: There exists an increasing amount of ocean products, generated by modellers that provide ocean data for the same domains using different approximations. As more and more oceanic data becomes available, the interest in understanding their reliability for specific applications is increasing. Typically models are benchmarked against in situ Eulerian measurements of the velocity fields, but methodologies to compare them regarding the transport they produce are less frequent. . Methodologies to qualify ocean data sets are of particular interest, to address important transport applications derived from events such as oil spills, and chemical or plastic pollution. In this work, we use a recently introducedLagrangian Uncertainty Quantification (LUQ) [1] to assess the performance of different ocean products in the same domain. LUQ is a new quantifier for forward time uncertainty for trajectories that are solutions of oceanic models. We address the analysis of the uncertainty associated with the transport of the global ocean reanalysis and forecast products offered by Copernicus Marine Environmental Service (CMEMS). We perform our analysis in the Gulf stream and the Atlantic Ocean, based on drifters observations in the area and the dynamical structures describing the underlying transport problem, in the spirit of [2].

Keywords: Uncertainty Quantification, Lagrangian Descriptors, Ocean Modelling

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ACOUSTIC PROPAGATION OF SIMULATIONS OF SPERM WHALES' VOCALIZATIONS IN CANARIAN WATERS

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Abstract: The passive acoustic and acoustic propagation modelling have been used in the ocean to acquire truthful and accurate information about the environmental state of the ocean concerning the noise levels that are supported by the marine ecosystems due to anthropic activities. This project aims to evaluate the efficiency of passive acoustic to use the clicks of the sperm whales' vocalizations as a measure to mitigate the collisions of these whales with ships, as they are a very vulnerable species, particularly in Canarian waters. To achieve this goal, an acoustic propagation model was carried out based on ray tracing to simulate the vocalization of sperm whales. Sperm whales are a highly vocal species that vocalize at a high intensity when they dive to hunt. Because of that, they could be easily localized with hydrophones. In this simulation, a sperm whale that is sinking with an inclination of 40-60 degrees from the surface was considered . Moreover, we modelled two different location at three different frequencies: a sperm whale vocalizing at 200 m and 600 m depth at 5, 10, and 20 kHz added to give an RMS of 220 dB re1μPa^2.. For these frequency ranges, the software Bellhop was used. The water column sound velocity was obtained from temperature and salinity data, and, together with bathymetric information and a geo-acoustic model of the seafloor transmission loss maps for the whole water column in different transects were obtained. Once obtained the transmission loss, the sound pressure level and its comparison with the ambient noise levels were carried out. With the results obtained in this work, we aim to detect with hydrophones the sperm whales' vocalizations and at what distance from them.

Keywords: acoustic propagation models, sperm whales, ocean noise

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OCEAN STATE RECONSTRUCTIONS THROUGH REMOTE-SENSING, IN-SITU SPARSE OBSERVATIONS AND DEEP LEARNING

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Abstract: Artificial intelligence (AI) has grown significantly in recent years and is revolutionizing the field of data processing. In this work, we used a Deep Learning approach based on a Convolutional Neural Network (NN) to combine remote-sensing images: Chlorophyll, Sea Surface Temperature (SST), Sea Surface Height (SSH), and sparse in-situ observations to estimate the 3D state of the ocean. In the context of satellite oceanography, end-to-end architecture AI schemes are already available for space-time interpolation and short-term forecasting (Fablet et al., 2021). However, with the inclusion of in-situ observations, a further step towards comprehending/reconstructing 3D small-scale phenomena is possible. Studying the small features of the ocean is fundamental for understanding the vertical transport of nutrients and pollutants in a climate-change environment. We obtained significant improvements compared to the classical Optimal Interpolation scheme performing different Observing System Simulation Experiments (OSSE) based on realistic ocean model outputs. Finally, we explored the possible application in a real case scenario using our NN to combine glider observations and Chlorophyll images.

Key words: remote-sensing, submesoscale, deep learning

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3D RECONSTRUCTION OF UPPER OCEAN DYNAMICS IN THE NORDIC AND BEAUFORT SEAS. ASSESSMENT OF THE SURFACE QUASI-GEOSTROPHIC APPROACH

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Abstract: We have assessed the capability of Surface Quasi-Geostrophy (eSQG) to reconstruct the three-dimensional (3D) dynamics in two key areas of the Arctic Ocean: the Nordic and the Beaufort Seas. We reconstructed the upper ocean dynamics from sea surface height (SSH), surface buoyancy (SSB) and surface velocities and validated the results with the classical geostrophic and original TOPAZ reanalysis velocities. When compared to geostrophic velocities, the results demonstrated that the reconstruction of upper ocean dynamics using SSH fields is in high agreement, with correlation coefficients greater than 0.8 for the upper 400 m. SSH reconstructions outperforms surface buoyancy reconstructions also in places near freshwater inputs from river discharges, melting sea ice and glaciers. Surface buoyancy fails due to the uncorrelation of SSB and subsurface potential vorticity (PV). Reconstruction from surface currents correlates to TOPAZ velocities with correlation coefficients greater than 0.5 up to 200 meters. Due to a deeper thermocline and halocline, the performance of the eSQG approach is better in the fall and winter than in the spring and summer. Our results demonstrate that using only surface information from SSH or surface velocities, it is possible to effectively reconstruct upper ocean dynamics in the Arctic and Subarctic Seas up to 400 meters. Future remote sensing missions in the Arctic Ocean, like Seastar, WaCM, CIMR, and CRISTAL, will give improved and enhanced SSH and surface velocities observations, allowing SQG schemes to characterize upper ocean 3D dynamics.

Key words: arctic; ocean dynamics; ocean currents; surface quasi-geostrophy; physical oceanography;

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ORAL COMMUNICATIONS

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Encuentro de Oceanografía Física 2022 (EOF)
Las Palmas de Gran Canaria (Spain), 6-8th July 2022

THIRTY YEARS OF GOSHIP AND WOCE DATA: ATLANTIC OVERTURNING OF MASS, HEAT AND FRESHWATER TRANSPORT

Verónica Caínzos*[1], Alonso Hernández-Guerra[2], Gerard D. McCarthy[3], Elaine L. McDonagh[4,5], Melania Cubas Armas[6], M. Dolores Pérez-Hernández[7], Daniel Santana-Toscano[8], Cristina Arumí-Planas[9]

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Abstract: The Atlantic Meridional Overturning Circulation (AMOC) transports northward surface, thermocline and intermediate waters with relatively high temperatures, carrying a large amount of heat from southern to northern latitudes. Accurately assessing the strength of the Atlantic Meridional Overturning Circulation with *in situ* data and models has been a challenge for oceanographers for decades now. Furthermore, no consensus has been reached yet regarding the slowdown of the overturning circulation, and the driving mechanisms are still poorly understood. We have gathered hydrographic data from zonal sections across the Atlantic from three decades using data from WOCE and GOSHIP repeating sections. For each decade, we have built an inverse model depicting the circulation for the whole Atlantic basin, attending to horizontal and vertical transports between sections. The circulation pattern describes two counter-rotating cells in the upper and abyssal ocean, which follows the path of the main water masses of the Atlantic – the northward upper layers of the thermocline and intermediate waters, the southward deep layers of the North Atlantic Deep Water and the abyssal layers flowing northward with Antarctic Bottom Water. Our results show no changes in the AMOC for all sections analysed over the whole Atlantic for the last thirty years. We also find an increased export of freshwater from the South Atlantic associated with an increase in upper salinity.

Key words: AMOC, decadal variability, heat transport, freshwater transport

ANALYSIS OF WAVE EVOLUTION (TRENDS) IN THE CANTABRIAN COAST. VARIABILITY OR CLIMATE CHANGE?

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Abstract: Studies of mean and extreme wave climate are nowadays essential for both coastal (e.g. for coastal infrastructure design) and offshore (e.g. shipping route design) planning and management. As far as wave records are concerned, there are often limitations in the time series (either in length or continuity). For that reason, this work will focus on the comparison of wave records from the Cantabrian coast (Santander and Bilbao) from different time spans in order to compare the records, analyze the mean and extreme climate of both samples, make a trend analysis and determine if the records present variations related to climate change.
The data for the study were provided by the Spanish Institute of Oceanography (IEO) were measured by the Augusto González de Linares (AGL) buoy covering the period from 2009 and 2015 while the data from Bilbao (Bilbao-Vizcaya Deep Water Buoy) were acquired from the data history of Puertos del estado, covering the period from 1990 to 2022. The study will start with a direct comparison between the time series of both series considering the same time interval as the AGL buoy, focusing on the significant wave height (Hs), in order to quantify possible differences between both records. A priori, no substantial differences are expected between the records of both buoys, since they are separated by approximately 34 nautical miles, although due to the size of the series, the characterization of the mean and extreme weather may differ substantially.
Finally, a comparative analysis of the wave records with climate indices (e.g. NAO, TNA, MOI) provided by NOAA will be performed to determine similarities/dissimilarities and possible cause/effect relationships.

Key words: Extreme climate, Trend analysis, Climate indices, IEO, NOAA, AGL

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EVOLUTION OF THE HISTORICAL MARINE STORMS IN THE CATALAN COAST

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Abstract:
Extreme marine storms are natural events that have economic, physical, and social repercussions on the coast, where the sea state is the main factor. During the last decades, these phenomena have caused serious damage. Economically, affects ports, boats, fishing activities and has a direct impact on coastal engineering. As a consequence of the anthropogenic climate change, the ocean waves will experience an increase in their significant wave height (Hs) (Wang et al. 2014) and change in its direction (Molina et al. 2011). The aim of this work is to evaluate the sea state and the evolution up to date of the most relevant maritime storms on the Catalan coast, using observation and numerical modelling at very high spatial and temporal resolution during the period 1990-2020.

The observations come from buoys belonging to both the XIOM (Catalan Regional Government) and Puertos del Estado (Spanish Government) networks. The numerical models are the reanalysis model ERA-5 (Dee et al., 2011), used to have a reliable sea state in the buoys during the study period, and the SWAN model (Booij et al., 1996) used to simulate marine storms on the Catalan coast.

We have applied statistical techniques for the wave parameters (maximum Hs, total energy, and duration) to select the extreme marine storms and characterize its climatic tendency. The results show an increase in Hs in 4 buoys (Barcelona, Palamós, Roses, and Tortosa), up to 2.13 cm/year. The Begur, Llobregat, and Tordera buoys, on the other hand, show a decrease up to 1.28 cm/year.

In addition to this, we used the ClaSynCat tool (Objective Synoptic Classification, Miró et al., 2020) to determine the synoptic pattern associated with each selected storm. The results for all the calculated variables show a positive trend for all the easterly advection-type storms with a cold drop.

Key words: Ocean waves, Marine storms, Climate change, Significant wave height, Numerical models

Acknowledgments: The authors would like to thank Puertos del Estado and the Catalan Government for providing the buoy data. This study was done within the framework of the Spanish project PIMA Adapta Costas.

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A MODEL STUDY OF THE VOLUME TRANSPORT DRIVEN BY THE WESTERN BOUNDARY CURRENT SYSTEM OF THE WEDDELL GYRE

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Abstract: The Weddell Sea, located east of the Antarctic Peninsula in the Southern Ocean, is a basin-scale cyclonic gyre driven by wind and thermohaline forcing as well as topographic steering. The Western Boundary Current System (WBCS) of the Weddell Sea gyre leakages near-freezing subsurface waters into Bransfield Strait. These waters are known as Transitional Weddell Sea Water (TWW), and have been recently suggested to maintain regionally low rates of glacier retreat within Bransfield Strait[1]. At deeper levels, the Weddell Sea represents one of the major sources of Antarctic Bottom Water (AABW) to the global thermohaline circulation[2]. Thus, a better understanding of the natural mode of variation of the WBCS is key to studies of future case scenarios.

We use a global eddy-resolving ocean model (GLORYS12V1, available at https://marine.copernicus.eu) to assess the major modes of variability governing the volume transport driven by the WBCS. We do this along and extended version of the historical ADELIE transect[3], which captures the hydrography and dynamics of the western branch of the gyre before water masses start exiting the basin.

Results indicate a mean volume transport about 20.2 ± 2.8 Sv over the period 1993-2018, which agrees well with previous observational-based estimates[4, 2]. The monthly-average of the modelled volume transport also reveals a strong seasonal cycle with an amplitude about 7-8 Sv stronger during the winter (31 Sv) as compared to summer (24 Sv). As one could reasonably expect from a wind-driven gyre, previous works attribute this cycle to a seasonal strengthening of the wind stress curl forcing the gyre[5], suggesting that modelled seasonal variations of the volume transport are, to a large extent, wind-driven. Currently, we are testing whether the atmospheric forcing of GLORYS12V1 accounts for the described seasonal cycle, as well as for the interannual variations eroding the annual signal over specific years. Nearly significant as well, a semimanual signal is recurrently present in wavelet analysis performed through the volume transport time series.

Ongoing efforts focus on elucidating the driving forces of the observed variability over the period 1993-2018 at seasonal and interannual scales, assessing the potential impact of likely changing scenarios of wind and thermohaline forcing, especially relevant at a location where water masses exit the Weddell Gyre to feed the global thermohaline circulation.

Key words: Southern Ocean, Cyclonic Weddell Gyre, Western Boundary Current, Eddy-Resolving Model, Volume Transport.

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AUTOMATIZED DELAYED-MODE REPROCESSING OF THE CMEMS SEA LEVEL MEASUREMENTS

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Abstract: Hundreds of tide gauges have been operating and providing coastal in-situ sea level data around the Globe as far as the late XIX century. These stations are managed by different national institutions and their data integrated in different data portals at global (GLOSS: Global Sea Level Observing System) and European scales (e.g.: the Copernicus Marine Service), with different levels of quality control and processing. The 639 recorded sea level datasets nowadays available at the Copernicus Marine Service all undergo, at least, an automatized near-real-time quality control. However, currently, there is not any coordinated and homoegeneous delayed mode quality control and reprocessing for this variable. This step will be taken by 2022-2023, by adding new tools and algorithms specific for delayed mode data, and extended to the GLOSS network by 2024. The quality control has to be ruled by a homogeneized set of criteria, which is not trivial, given the heterogeneity of the physical processes near the station, as well as the diverse precision of the instruments. Another aspect is that part of the quality control relies on adequate detiding of sea level data. The specific issues raised by problematic data sets are discussed, along with the solution given to properly flag the bad data. As for 2022, over 90% of the bad data that are identifiable in a manual quality control can be automatized. Therefore, it is possible to maintain a sustainable operational automatized reprocessing quality control all tide gauges in the Copernicus Marine Service, by 2023, and the GLOSS network, by 2024.

Key words: tidal gauge, reprocessing, automatization

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Encuentro de Oceanografía Física 2022 (EOF)
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A NEW INDEX TO DETERMINE THE CHANGES IN THE FOUR PRINCIPALS EASTERN BOUNDARY UPWELLING SYSTEMS UNDER CLIMATE CHANGE

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Abstract: The Eastern Boundary Upwelling Systems (EBUSs) provide valuable natural resources due to the high primary production, however anthropogenic forces could affect directly the basis of these ecosystems: the upwelling. Therefore, assessing the impacts of Global Warming on the upwelling processes is crucial for efficient ecosystem management. In spite of that, there is high uncertainty about the future of these upwelling systems under climate change. Bakun, (1990), suggested an increase in the intensity of upwelling due to an increase in the ocean-land pressure gradient. To elucidate the evolution of these ecosystems, this study uses deseasonalized sea surface temperature (SST) data from remote sensing as a proxy for the effect of the upwelling; validate used *in-situ* observations. The trends of SST in upwelling cells trends are used in relation to open ocean waters to develop a new index that characterizes upwelling increases in Large Marine Ecosystems -larger classifications that englobe surrounding non EBUS areas-. The Benguela ecosystem has the greatest intensification of permanent upwelling, and, to a lesser extent, an intensification of the Canary and Humboldt upwelling system is found. The California ecosystem, on the other hand, does not have enough statistical evidence to affirm the existence of an upwelling intensification using the index developed in the present study, being the lowest of the four systems.

Key words: Eastern Boundary Upwelling System, Climate Change, Bakun's Hypothesis, Sea Surface Temperature, long-term trends, Upwelling Intensification Index.

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MODELLING COASTAL FLOODING AND EROSION AT DNIESTER'S BARRIER BEACH (UKRAINE)

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Abstract: The barrier beach of the Dniester river (Ukraine) has a length of about 10 km and a width of 100 m at its narrowest point. The original natural foredune has been almost completely removed and, at present, the barrier is completely occupied by a road, a railway, houses and touristic resorts. Due to its low-lying nature, the area is considered as a highly sensitive coast of the Black Sea (Tătui et al.; 2019) and such characteristic will be intensified in the future due to sea level rise induced by climate change.

The aim of this study is to determine the vulnerability of Dniester barrier beach to wave storms through the use of the morphodynamic numerical model XBeach.

The topography of the Dniester area has been taken from the NASADEM meanwhile the bathymetry is gathered from EMODNET. A variable rectangular grid has been built, with a resolution up to 50m offshore and 2-5m at the zone of interest. Emerged beach sediment samples were collected at the north, centre and south, resulting on a D50 of 0.37, 0.51 and 0.42 mm respectively. A study of the wave climate has been performed using the ERA5 wave data set by fitting a Gumbel probability distribution function using the maxima of the year method (Bocharov, 2021). The maximum wave height of the time series for the effective directions, which are 70-205º, corresponds to 5.46m with an associated wave period of 8.14s. In October 2016, a coastal flooding episode at the south of the barrier was reported by the media causing severe infrastructure damages. This event has been used to qualitatively validate the model.

A detailed description of the methodology and the results for different hydrodynamic scenarios will be presented to help on the future management of the barrier.

Key words: Barrier beach, Coastal flooding, XBeach, Erosion, Protection, Modelling.

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IMPACT OF THE OCEAN-ATMOSPHERE COUPLING ON HIGH-RESOLUTION FUTURE PROJECTIONS FOR THE MEDITERRANEAN SEA AND SURROUNDING CLIMATE FROM THE MED-CORDEX ENSEMBLE

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Abstract: Med-CORDEX is an international initiative that aims at developing fully coupled high resolution Regional Climate System Models (RCSMs) for the Mediterranean basin. After 11 years of work an ensemble of more than 25 multi-model and multi–scenario climatic simulations is now available (Darmaraki et al., 2019; Soto-Navarro et al., 2020). In this study, we analyze the impact of the high-resolution representation of the Mediterranean Sea and of the interaction between ocean and atmosphere, explicitly resolved in the Med-CORDEX simulations, in the projected evolution of the most relevant climatic variables for the Mediterranean basin and the adjacent regions during the 21st century. The final goal is to quantify up to what extent including the explicit and high-resolution representation of the ocean-atmosphere coupling is relevant for regional climate projections. The preliminary results show that, in general, higher resolution coupled simulations project a lower increase in the Sea Surface Temperature (SST) than lower resolution runs. This translates in a smaller input of heat and humidity to the atmosphere that, in turn, affect the cloud cover and precipitation over the basin and the adjacent continental areas. These changes are the result of a better representation of the Mediterranean Sea functioning in the Med-CORDEX RCSMs. In particular, they resolve better the mesoscale processes of the basin, which are partly responsible of the heat transport from the surface to deeper layers, and the ocean-atmosphere feedback that regulates the heat exchange.

Key words: Mediterranean Sea, Ocean Modelling, Scenario Projections, Multi-Model Ensemble.

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LONG TERM CHANGES IN THE WATERS SURROUNDING THE CANARY ISLANDS

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Abstract: The Atlantic Meridional Overturning Circulation (AMOC) transports 18 Sv of water that carries more than 1.5 PW of heat from the equator to high latitudes, playing a determining role in the regulation of the climate in Europe. An important component of the AMOC is the Subtropical Gyre, the largest oceanic structure of the North Atlantic. The Canary Basin sits at the boundary between the Subtropical Atlantic Gyre and the upwelling waters form the Canary Current Large Marine Ecosystem (CCLME) off the coast of northwest Africa, being an ideal place for the study of the Subtropical Gyre variability.

In order to understand the mechanisms governing the internal variability of the ocean, and therefore the climate, long systematic observations are needed. For this reason, since 2006, the Spanish Institute of Oceanography carries out the program deep hydrographic section around the Canary Islands (RAPROCAN), to establish the scales of variability in the decadal-subdecadal range in the eastern margin of the Subtropical Gyre. RAPROCAN takes place twice a year, in spring and autumn, and comprises of about 50 stations where current velocity, temperature, salinity, pressure, oxygen, turbidity and fluorescence (CTD) are measured.

The data record shows an overall warming and an increment of salinity for the upper-layer (200 – 800 m) oceanic waters, while in the Coastal Transition Zone (CTZ), between Lanzarote and Africa, the surface waters show a non-statistically significant cooling and freshening. In the intermediate waters (800 – 1400 m), weak cooling and decreasing salinity has been observed, and in the upper NADW (1700 – 2600 m) there has been a week increase in temperature and in salinity, neither of which are statistically significantly different from zero. However, in the strata corresponding to the NADW (2600 – 3600 m), a marginally statistically significant freshening can be observed, although without confirmed trend for temperature.

Key words: AMOC, Subtropical Gyre, Canary Current Large Marine Ecosystem, NADW.

Acknowledgments: RAPROCAN (Radial Profunda de Canarias), is part of the IEO ocean observing system and it is cofounded by the European Maritime and fisheries Fund.

THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC) IN THE SOUTH ATLANTIC GATEWAY (SAGA)

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Abstract: The South Atlantic Ocean plays a critical role in the returning flow of the Atlantic Meridional Overturning Circulation (AMOC), as it transports heat transport northward to compensate the deep southward transport of the North Atlantic Deep Water (NADW). We have analyzed three hydrographic cruises carried out at 24ºS in 2018, at 34.5ºS in 2017 and at 10ºW in 2021 in the South Atlantic Subtropical Gyre to identify the water masses, infer geostrophic circulation and mass transport. Geostrophic velocities are initially adjusted by referencing them to velocity data from Shipboard Acoustic Doppler Current Profiler (SADCP) and/or Lowered Acoustic Doppler Current Profiler (LADCP) data and later to velocities estimated with an inverse box model applied to an ocean divided into 11 neutral density layers. We have estimated the upper strength of the AMOC (14.5 $\pm$ 0.9 Sv at 24ºS, and of 10.8 $\pm$ 1.1 Sv at 34.5ºS), as well as the related equatorward heat transport (0.68 $\pm$ 0.05 PW at 24ºS, and 0.22 $\pm$ 0.06 PW at 34.5ºS) and the loss of freshwater (- 0.09 $\pm$ 0.12 Sv at 24ºS, and -0.25 $\pm$ 0.12 Sv at 34.5ºS) expected in the Subtropical South Atlantic. Our results show non-significant differences between uncertainties in the mass transports of the Brazil (-11.0 $\pm$ 0.7 Sv at 24ºS to -19.4 $\pm$ 1.7 Sv at 34.5ºS), Benguela (8.8 $\pm$ 1.7 Sv at 24ºS, and of 32.3 $\pm$ 1.8 Sv at 34.5ºS), and Deep Western Boundary Currents (-20.9 $\pm$ 4.0 Sv at 24ºS and of -17.6 $\pm$ 3.9 Sv at 34.5ºS) if compared with previously published results.

Key words: South Atlantic Ocean, Global Circulation, Physical Oceanography.

IMPACTS OF SEA LEVEL VARIABILITY ON SEA WATER INTRUSION INTO MEDITERRANEAN COASTAL AQUIFERS

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Abstract: Groundwater resources are a key component in water management affairs in the Mediterranean coastal areas since they represent one of the main sources of water supply for drinking water and other socio-economic activities (K. Mazi et al., 2013). The groundwater quantity and quality of aquifer systems depends on different factors, such as precipitation recharge, pumping for water demand, nitrate contamination from irrigation, among others. Furthermore, in the case of coastal aquifers, the hydrodynamics between fresh groundwater and marine saltwater, may additionally impact the quality of the fresh groundwater by seawater intrusion (SWI), which is the inland encroachment of seawater. In this sense, there is a great concern about how projected sea level rise will affect groundwater resources.

In the present study, we address SWI processes in coastal aquifer systems in the island of Mallorca, Spain, under present conditions and future scenarios. We combine observations and analytical equations to understand the sea and fresh water hydrodynamic interactions in Mallorca. To do so, we have gathered an observational dataset of aquifer water depth and salinity, spanning from 2000 to 2020 for a total of 49 (24) monitoring sites of water levels (quality). The results show that SWI is currently taking place in most of the analyzed coastal aquifer of Mallorca, as a result of the interaction between sea level variations and the socio-economic demand of groundwater resources. This impacts the groundwater levels and quality threatening the use of groundwater resources for human activities. Furthermore, the results also show that a future 1 m sea level rise, in addition to variations in the surface water budged due to global warming, would lead to a considerable decrease in the total groundwater storage capacity as the fresh-saline interface would shift further inland. Thus, under a high-end climate change scenario, the level of impact in the available space to store fresh groundwater will range between a 5 to 33% reduction.

Key words: Groundwater, climate change, sea level rise, Mediterranean Sea, coastal impacts.

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SAGA: THE SOUTH ATLANTIC GATEWAY

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Abstract: The opposite directions of the North and South Atlantic upper-thermocline western boundary currents, the Gulf Stream flowing north and the Brazil Current proceeding south, lead to very different behaviors of the Atlantic Meridional Overturning Circulation (AMOC) in the northern and southern basins. One consequence is that the only southern pathway for the returning AMOC is a zonal westward portal along the verge of the South Atlantic subtropical and tropical gyres, in what constitutes the South Atlantic GAteway (SAGA). A gravest empirical mode (GEM) analysis of historical GO-SHIP, NOAA and Argo data, when combined with altimetry data, shows substantial differences at central and intermediate levels (down to 1500-2000 m) between the subtropical and tropical gyres, with the intermediate waters that flow along the rim of both gyres diverting either south or north once they reach the western boundary. The GEM study is complemented with the analysis of water parcels arriving and departing from the SAGA array, calculated using the GLORYS12 reanalysis velocity fields and the OceanParcels tracking code. Specifically, we explore which waters arrive directly from the Southern Ocean through the SAGA and towards the equator along the western boundary and which waters recirculate, and how many times, within the tropical and subtropical gyres. The water-trajectory analysis confirms the validity of the GEMS-altimetry method to establish whether the zonal flow belongs to the subtropical- tropical gyres or it can be associated to the returning limb of the AMOC.

Key words: South Atlantic Ocean, subtropical gyre, tropical gyre, Atlantic Meridional Overturning Circulation

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SPREADING AND MIXING OF ANTARCTIC INTERMEDIATE WATER IN THE EASTERN NORTH ATLANTIC SUBTROPICAL GYRE

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Abstract:

A set of observations from several different platforms is used to study the distribution and propagation pathways of Antarctic Intermediate Water (AAIW) in the Canary basin. The multiplatform data set comprises traditional observations, obtained through oceanographic research vessels, along with up-to-date technologies such as ARGO profiling floats and ocean gliders. An exhaustive quality control, complemented by a crossover analysis, was applied prior to analyze the data. The results show that the observed AAIW propagates poleward along the eastern edge of the North Atlantic as a kind of tongue of minimum salinity and dissolved oxygen. Upon encountering the Canary Islands archipelago, it follows its northerly direction along two main pathways, one to the east along the African coast, and the other to the west of the archipelago. However, it has been established that a certain amount of AAIW flows through the channels between the islands. The high spatio-temporal resolution provided by the gliders has allowed the identification of double-diffusion patterns in the mixing of the AAIW just north of the Canary Islands. Namely, salt-fingering with the overlying Eastern North Atlantic Central Water (ENACW) and diffusive convection with the underlying Mediterranean Water (MW) were detected.

Key words: AAIW, ARGO, glider, oceanographic campaign

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THE COPERNICUS MARINE IBI REGIONAL PRODUCTS FOR THE SPANISH WATERS: STATUS AND SHORT-TERM EVOLUTION

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Abstract: The Copernicus Marine Service delivers through the IBI-MFC (Iberia-Biscay-Ireland Monitoring & Forecasting Centre) and the IBI regional component of the INS-TAC (In-situ Observation Thematic Assembly Centre) a comprehensive portfolio of products with systematic regional information (from models and in-situ observational data sources) on the state of the ocean for the European Atlantic façade, supporting all kinds of marine applications. Nologin, through its environmental division NOW (Nologin Ocean Weather systems), is a Copernicus Marine Service provider in both components, co-leading with Mercator Ocean International the IBI-MFC (joint with MeteoFrance and CESGA) and being part of the InS-TAC partnership, with responsibilities (shared with PdE) in the operations, validation and service evolution of the in-situ products and services for the IBI area.
This contribution reviews the status of these Copernicus Marine regional services (in which NOW is involved), highlighting main upgrades achieved during the last years (within the Copernicus1 phase; Sotillo et al, 2021) and the planned evolutions to be developed in this new Copernicus-2 phase (2022-2024 period), as well as the potential impacts that they may have on the monitoring and forecasting capabilities at Spanish waters. Among others, increased resolution in the IBI-MFC model products is expected (e.g., multiplying by 3 the resolution of current IBI Multi-Year (MY) products); additionally, delivering Near-Real-Time (NRT) forecasts and MY reanalysis for ocean physics, waves and biogeochemistry in a single common grid is one of the major IBI-MFC service evolution goals. A new interim stream will be implemented to update IBI MY reanalysis closer to present time, and the NRT ocean forecast will extend its horizon up to 10 days. In the INS-TAC observational side, the development and first delivery of a new sea level MY reprocessing product, derived from tide gauge observations (Lin-Ye et al., 2022), is one of the main milestones.

Key words: Operational Oceanography, Copernicus Marine Service, IBI zone, regional ocean forecasts, in-situ observations

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HF RADAR LAGRANGIAN VALIDATIONS WITH GPRS AND SPOT BUOYS

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Abstract: After adding the Leça de Palmeira (13.5 MHz) HF Radar antenna to the Galician (5 MHz) HF Radar system the project RADAR_ON_RAIA has established an international cross-border (Spain-Portugal) HF Radar network consisting in 5 sites, from Leça de Palmeira to Cabo Prior [1]. This network (Leça, Silleiro, Fisterra, Prior and Vilán) estimates the currents in the first 2 meters of the water column on shelf overlapping areas. In addition, there is another HF Radar system in the Ría de Vigo, formed by two sites (Toralla and Cíes) that works at 42.6MHz, providing high-spatial resolution observations of surface velocities in the first 0.5m of the water column.

In order to correct the signals received at each station, the antennas are routinely calibrated with transponders, obtaining the Antenna Pattern Measurement (APM) used in the corrections [2]. However, to assess the quality of the data gathered by the antennas an external validation with other independent sources of velocity observations is advisable. One of the best options to undertake such a task is the use of drifting buoys [3].

To validate de data obtained by the antennas, a comparison between the surface current velocity given by the radial and total vectors with the velocity of the buoys at certain positions is done. The comparisons are based on metrics such as the root mean square error (RMSE) and the statistics derived from the linear regressions (slope, intercept, coefficient of determination and probability of rejection). In the comparisons, the standard deviations (variances) of both the data from the buoys and the HF Radar are taken into account to increase or decrease the number of data, and their quality, which enters into the comparisons.

Key words: Drifting Buoy, HF Radar, Observing System, Lagrangian validations.

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LANDERPICK, A REMOTE OPERATED TOWED VEHICLE TO COST-EFFECTIVELY DEPLOY AND RECOVER LIGHTWEIGHT OCEANOGRAPHIC LANDERS

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Abstract: Landers are modular structures equipped with miscellaneous sensors and equipment which are positioned directly on the seabed to operate autonomously for a defined timeframe. A drawback of landers intended to operate for prolonged periods is the high cost of recovery systems, typically depending on buoyancy modules plus expendable ballast, or requiring ROVs assistance. LanderPick concept consists of the design of a specific towed vehicle to deploy and recover lightweight oceanographic landers not provided with recovery elements, but having a capture mesh that facilitates their hitching. The LanderPick vehicle is technically a ROTV (Remote Operated Trawled Vehicle) controlled through a standard coaxial electromechanical cable that allows real-time control from the vessel. Navigation is enabled by a low-light high-definition camera, aided by spotlights. Small propellers aid in the final precision approach maneuvers. A mechanical release allows the precise placement at the sea bottom of landers carried as a payload, as well as their recovery by means of a triple hook. Pilot deployments started in 2021 in southern Biscay, consisting of short-term deployments for lapse-time photos and mid to long term arrays of several landers at complex topography spots (a canyon and a seamount). More than 20 deployments and 15 recapture operations were made so far at depths from 200 to 1000 meters without failures. The LanderPick novel cost-effectively approach allows to conceive monitoring systems based on the deployment of swarms of low-cost landers, thus bridging the gap between the large spatial- but not temporal-coverage of ROV-type systems versus the extensive temporal- albeit low spatial- coverage of a single-point eulerian system (Brandt et.al. 2016). Experiments in which it is necessary to locate landers with great precision are also feasible.

Key words: Landers, ROTV, sea-floor characterization, environmental monitoring.

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LanderPick demonstrative video available at https://www.youtube.com/watch?v=fCteTEEm_iw

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DIAPYCNAL MIXING IN THE OXYGEN MINIMUM ZONE OFF CENTRAL CHILE: THE ROLE OF SALT FINGERS

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Abstract: Recent studies have highlighted the importance of double diffusion instabilities in the diapycnal transport of dissolved substances in large regions of the oceans. Off central Chile (30-38°S) waters with very low dissolved oxygen are present at intermediate depths (between about 50 m and 400 m depth) in a region where double diffusion instabilities can take place. This oxygen minimum layer (OML) is closely related to Equatorial Subsurface Waters (ESSW), a relatively salty and warm water mass that is transported poleward along the continental slope by the Peru-Chile Undercurrent (PCUC). Thus, this water mass –and so the OML– is delimited between two water masses of southern origin that are well-ventilated, relatively fresh and cold, namely: the Eastern South Pacific Intermediate Water (ESPIW) and the Antarctic Intermediate Water (AAIW). In this study we analyzed the role of the diapycnal mixing in the dissolved oxygen fluxes in the upper and lower oxyclines that delimit the OMZ in the water column off the central coast of Chile (~36.5°S). We put special emphasis on evaluating the contribution of salt fingers to these fluxes. For this purpose, we use a set of observations of fine structure (1-10 m) and microstructure (<1m) using a microprofiler model VMP-250 along with CTD casts and current profiles obtained with ADCPs. The net diapycnal mixing is estimated using mixing models that allows to separate the relative contributions of turbulent shear processes and instabilities associated with salt fingers. The thermohaline contrast in the ESSW-AAIW transition conditions the region for the development of double diffusion instabilities by salt fingers, which significantly contribute to the oxygen transport from the lower oxycline, thus favoring the ventilation of the OMZ from the AAIW.

Key words: diapycnal mixing, deoxygenation, salt fingers, Oxygen Minimum Zone.

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IMIRABILIS2: CABO VERDE OCEANOGRAPHIC INSIGHTS

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Abstract: Cabo Verde Islands are located between the North Equatorial Current (NEC) and the North Equatorial Counter Current (NECC). When the NECC reaches Africa, it splits in two currents, an eastward and a northward flow. This later flow joints the NEC forming a front known as the Cabo Verde Frontal Zone, that acts as a barrier between the North Atlantic Central Waters (NACW) and the South Atlantic Central Waters (SACW). In addition, this northward flow produces a cyclonic circulation in the region of Cabo Verde, called the Guinea Dome, and therefore an upwelling in this area.

In order to study the area of Cabo Verde, the multidisciplinary iMirabilis2 expedition took place from the 31st of July to the 30th of August 2021. During this expedition, 22 CTD cast and several ADCP transects were performed in order to characterize the hydrographic conditions and to determine the water mass distribution in the main study areas, to find out its effects on the distribution of benthic organisms. Especial attention was put on the characterization of the Cadamosto seamount.

Seamounts are underwater mountains which create a perturbation in the oceanic flow. This perturbation under idealized circumstances, known as Taylor columns, has the potential to isolate the oceanic circulation over the summit from the ocean circulation in the open waters. This can lead to the occurrence of upwelling phenomena that enrich the ecosystem (Boehlert and Genin, 1987; Mohn *et al.*, 2009; Lavelle and Mohn, 2010).

Oceanographic conditions compatible with an upwelling were found at the summit of the Cadamosto seamount. However, due to the spatial scale of the seamount, smaller than the Rossby radius, a Taylor column might not be developed (Chelton *et al.*, 1998), and it could be the result of the particular circulation of this area, composed mainly by cyclonic and anticyclonic gyres.

Key words: CTD, seamount, upwelling, Taylor columns.

Acknowledgments: The iMirabilis2 expedition has been supported by the Spanish Ministry of Science and Innovation. The iAtlantic project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818123 (iAtlantic). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein. The authors very much appreciate the continuous help and support of the administration from IEO-CSIC, the logistic from UTM-CSIC and the RV Sarmiento de Gamboa.

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MONITORING OF OCEANIC INTERNAL TIDES USING FIBRE OPTIC TELECOMMUNICATION CABLES

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Abstract: Ocean mixing plays a crucial role in the Earth's climate as it balances the meridional overturning circulation that buffers global warming. Quantifying mixing is challenging because energy enters the ocean at basin-scale but it dissipates at cm-scale over the vast ocean. One common element in the cascade of energy towards small scales is the transfer of energy to internal waves, which may turn unstable and drive much of the ocean mixing. Energy transfer to the internal wave field is largely enhanced through flow interactions with topography. Observations of wave-topographic interactions are, however, scarce and its mechanistic understanding comes mainly from idealized process ocean studies, which lack a direct benchmark against nature.

We present novel observations of wave-topographic interactions at unprecedented spatio-temporal resolution. The new data has been gathered using fibre-optic cables by means of a revolutionary technology developed in the field of seismology. The potential of these observations to identify ocean-mixing hotspots remains, however, unknow. To shed light on this, we use numerical advanced modelling, the basis of which is presented here. The model is semi-spectral with open boundaries allowing to create a suite of nested simulations that resolve the transfer of energy from the large-scale (hundreds of km) down to turbulence-length scales (cm). The proposed approach integrates a variety of approaches and disciplines and could eventually be implemented at global scale with the aim to better close energy budgets and improve mixing parametrizations in climate change models.

Key words: ocean mixing, internal tides, wave-topographic interactions, distributed acoustic sending, numerical modeling

DIAPYCNAL MIXING IN CAPE VERDE FRONTAL ZONE THERMOHALINE INTRUSIONS

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Abstract Thermohaline intrusions are layers on 10–50 m thick and with horizontal scales of 1–100 km. During November 2017 was carried out a multidisciplinary survey FLUXES II (FLUXES project) in the Cape Verde Frontal Zone (CVFZ). Temperature-Salinity and microstructure data were collected using a towed undulating CTD (SeaSoar) with high spatial resolution (SeaSoar) along several sections. This survey provided an excellent opportunity to study the intrusions and interleaved features across the Cape Verde thermohaline front.
The vertical distributions of Turner Angle (Tu) and the Gradient Richardson Number (Ri) showed diapycnal mixing processes due to Double Diffusion and vertical shear instabilities. With the assumption of a steady-state stage of interleaving, the slope of intrusions relative to isopycnal surfaces was studied, finding cases where salt-finger density fluxes exceed those of diffusive convection and vice versa. Also, we explore the effect of vertical shear on the double diffusion processes analyzing the role of baroclinicity in driving intrusive motions.

Key words: Cape Verde Front, Double Diffusion, Double-Diffusive Interleaving, Vertical Shear Instabilities.

Acknowledgments: This work has been supported by the Spanish government (Ministerio de Economía y Competitividad) through project FLUXES (CTM2015-69392- C3-3- R).

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LAGRANGIAN OBSERVATIONS OF THE INTERACTION BETWEEN NEAR-INERTIAL WAVES AND ANTICYCLONIC MESOSCALE EDDIES

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Abstract: Trajectories of drifters dragged below the surface mixed layer, are used to analyse the interaction between near-inertial waves and anticyclonic mesoscale eddies. The drifters were deployed within eddies generated downstream of Canary and Madeira islands between 1998 and 2014. Rotatory wavelet analysis of Lagrangian velocities shows a clear relationship between the near-inertial waves' intrinsic frequencies and the eddy angular velocities. The results reveal that near-inertial waves reach a maximum effective inertial period of twice the local inertial period in the inner core of anticyclonic eddies rotating with its largest possible angular velocity ($f/2$). The highest energies of the observed inertial motions are observed within the core of the anticyclonic eddies when sudden wind shifts occur, evidencing significant trapping of the near-inertial waves. The generation of near-inertial waves is sometimes observed at the periphery of eddies especially when the vortex becomes elliptical.

Key words: Near-inertial waves, anticyclonic eddies, eddies, wavelet analysis

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COASTAL OCEANOGRAPHY

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VARIABILITY AND PREDICTABILITY OF SURFACE CHLOROPHYLL CONCENTRATION IN THE ATLANTIC UPWELLING SYSTEMS

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Abstract: Marine ecosystems are seriously threatened by human activities. A better knowledge of the drivers determining the variability of these ecosystems is essential for their prediction and sustainable management. Eastern boundary upwelling systems (EBUS) are among the most productive worldwide. In these regions, wind-driven upwelling promotes the emergence of nutrients from the seabed and determines the abundance of organisms capable of photosynthesis (first link in the trophic web). Many of the changes in wind regimes that alter these regions are caused by climate teleconnection patterns. Due to the high thermal inertia of the ocean, some of these teleconnections can be predicted months ahead using sea surface temperature (SST) information.

In this work, the variability and predictability of satellite-observed surface chlorophyll concentration (Copernicus) are evaluated over the period 1998-2019 and over the Senegal-Mauritania EBUS, from which West African countries are notably dependent. To this aim, the main SST drivers of chlorophyll variability in the Senegal-Mauritania coast are identified using a Maximum Covariance Analysis (MCA). A leave-one-out cross-validated hindcast is then performed to assess seasonal chlorophyll concentration predictability.

Our results highlight the important role of Atlantic Niños and Pacific Niñas as predecessors of Tropical North Atlantic (TNA) cold SST anomalies. This SST configuration promotes the enhancement of surface chlorophyll on the Senegal-Mauritania coast (and vice-versa). In this study, the physical mechanisms behind all these relationships are evaluated in depth.

Key words: marine ecosystems, chlorophyll concentration, SSTs, teleconnections, statistical prediction.

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INSULAR SHELF CIRCULATION IN OCEANIC ISLANDS

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Abstract:
Thus far, the existing literature has suggested that coastal dynamics on deep oceanic islands is mainly influenced by open sea processes (e.g., Branson et al., 2018; Dong et al., 2007). A series of in situ observations around Madeira Island (32.6˚N, 16.8˚W) showed that coastal processes result from the interaction of the insular-shelf with the local winds and tides, often decoupled from the far-field circulation. To study island shelf circulation the Regional Ocean Circulation Model was used considered four different case studies: a) tidal forcing; b) local wind forcing; c) global model (geostrophic) forcing, and d) all together (a-b-c). The results obtained from these simulations aided to discern the predominant coastal patterns and frequencies in each scenario. Model results are compared with in situ data for validation. Ocean currents were analysed using empirical orthogonal functions and Morlet wavelet methods. The results suggest that the wind forcing dominates the ocean circulation patterns on the island's western flank. On the east side, tides act as a significant influence on the set-up and maintenance of a coastal current, including the generation of coastally trapped waves. On the north coast of the island, a considerable impact comes from the Basin Scale Atlantic (offshore) circulation, namely the Azores current and the incoming mesoscale eddies that reach the island. We have concluded that coastal dynamics in oceanic islands are complex and respond to local and far-field processes. Generic wake studies often miss these relevant insular shelf-dynamics.

Key words: Deep-sea islands, Island shelf, Island circulation, coupling modelling, Air-sea interaction, Internal Waves.

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HYDROGRAPHIC VARIABILITY (1994-2020) IN THE RÍA DE VIGO AND ADJACENT SHELF (NW IBERIA)

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Abstract: The Spanish Institute of Oceanography (IEO-CSIC) carries out monthly oceanographic samplings at across-shelf sections off the northern Spanish coast under the monitoring program RADIALES (https://www.seriestemporales-ieo.net/). This is a multidisciplinary marine research effort addressing long-term variability issues at the ecosystem level (Bode et al., 2015; Valdés et al., 2002). Currently, the monitoring program includes 5 perpendicular coastal transects in Northern Spain: Santander, Gijón, Cudillero, A Coruña and Vigo. Focusing on the section located in the Ría de Vigo and adjacent shelf, we have analysed a 27-year time series (1994 - 2020) of temperature and salinity obtained through CTD profiles in three stations, two inside the Ría (~30 and ~40 m depth) and one in the mid-shelf (~90 m depth). This study summarizes the hydrographic variability in the region through the construction of a local climatology. In addition, long-term trends and interannual changes in seasonality are examined. The results show a change in the salinity regime in medium depth waters in 2013, although not in temperature. Near the surface, the temperature undergoes a negative shift from 2016, in correspondence with the entry of the AMO into a new negative phase.

Key words: RADIALES, CTD, temperature, salinity, Ría de Vigo

Acknowledgments: Data shown in this study has been recorded on board several research vessels. We express our sincere thanks to the crew of RV J.M. Naváz, B/O Ramón Margalef and B/O Ángeles Alvariño. We are grateful to many colleagues who made this study possible.

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THE OCEANOGRAPHIC VESSEL "UCADIZ": A CONSOLIDATED INFRASTRUCTURE FOR OCEANOGRAPHIC RESEARCH, EDUCATION MISSIONS, AND SCIENTIFIC DISSEMINATION IN ANDALUSIA

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Abstract: The remodeling and start-up of the UCADIZ was a historical aspiration of the Andalusian universities. It has meant a strengthening of the scientific infrastructures of the CEIMAR (Campus of International Excellence of the Sea), becoming an essential tool for the advancement of studies in Oceanography.

This Regional general-purpose research vessel has proven to have adequate equipment and dimensions that enable it to be a tool for coastal oceanography at a regional level, with a total of almost 100 days of navigation and ten campaigns carried out last year, in fields such as underwater archaeology, oceanography or bathymetric surveys, both for research and for teaching or dissemination to society.

The oceanographic vessel UCADIZ, and despite the extraordinary situation caused by the COVID-19 crisis, all the activities that were requested in 2021 could be carried out. In addition, the number of users and campaigns has increased compared to previous years.

Key words: Oceanographic Vessel, infrastructures, coastal oceanography

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ANALYSIS OF THE INTERACTION BETWEEN THE MACROALGAE *RUGULOPTERYX OKAMURAE* (OCHROPHYTA) AND THE HYDROLOGICAL PROPERTIES OF THE ALBORAN SEA OVER THE PAST YEARS

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Abstract:

Since its first detection in the Strait of Gibraltar in 2015 (Altamirano, 2016), the exotic brown-algae *Rugulopteryx okamurae* has massively expanded through the westernmost coasts of the Mediterranean Sea. This species occupies shallow rocky bottoms with coverages ranging from 80-100%, producing serious impacts over the benthic communities previously established, and causing accumulations of thousands of tons in the coastal shores of the Strait of Gibraltar, Alboran Sea and Gulf of Cadiz, affecting fisheries and tourism. Currently, there is no consensus about the reasons explaining its invasive capacity and rapid dispersal, although favorable environmental conditions in the Mediterranean Sea have been recently suggested as the key factor (Muñoz et al., 2019). To gain insight into the invasion and settlement of *Rugulopteryx okamurae*, time-series of nutrients, temperature, and salinity were analyzed in the Strait recently by Mercado et al. (2022). The present work extends the analysis of these authors to investigate the long-term variability and anomalies of environmental variables (SST, salinity, current velocities, organic and inorganic nutrients, phytoplankton abundance, chlorophyll, and solar radiation) in the Strait of Gibraltar, Alboran Sea, and Gulf of Cadiz. Some preliminary results are presented.

Key words: *Rugulopteryx okamurae*, Bioinvasion, hydrological characterization

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ANALYSING THE ANTHROPIC EFFECTS ON THE GUADALQUIVIR RIVER HYDRODYNAMICS USING NUMERICAL SIMULATIONS

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Abstract:

The Guadalquivir River estuary is a highly mixed and elongated estuary located in the southwest of Spain (Siles-Ajamil et al., 2019) whose hydrodynamics is mainly dominated by tides. The multiples anthropogenic activities developed along the river such as dredging, dams, etc., may originate important changes in the hydrodynamic patterns of the estuary. In this work, we analyze the hydrodynamic behavior of the Estuary using a non-linear one-dimensional hydrodynamic model conveniently validated with observations. The model has a high horizontal and temporal resolution of 25 m and 1 s respectively and uses the more recently available bathymetry of the Guadalquivir River. In situ observations from current profiler and tide gauges have been used to calibrate and validate the model with a successful result, demonstrating a high reliability in model outputs (R^2> 0.85, RMSE <0.2). Also, a transport and dispersion module has been coupled to the hydrodynamic model, allowing the study of the spatio-temporal variability of salinity along the river. The results show an amplification of the M_2 tidal wave in Seville being higher than its amplitude at the mouth of the Estuary. This demonstrates the important changes that the tidal hydrodynamics of the river has experienced in the last years, caused by the human activity developed on the Seville Port, i.e., the dragging of its channel. The maximum of salinity is found at Bonanza and a second maximum can be developed 10-15 km from the mouth of the Estuary. It is shown that the use of an updated and realistic bathymetry accounting for the changes of the transversal areas along the channel is needed to get and accurate enough description of the spatio-temporal saline wedge evolution

Key words: Hydrodynamic Model, Guadalquivir River, Tidal influence, Salinity, Estuary.

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AULAMAR: A SCHOOL PROJECT FOR COASTAL OCEANOGRAPHY

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Abstract: We present the ongoing educational project AULAMAR, born with the objective of promoting a harmonic relation between the citizens of Barcelona and the sea. Today, Barcelona's coastal ecosystem is in a state of vulnerability due to the pressure of urban activity and climate change (Harley *et al.*, 2006). Furthermore, the the pressure of tourism during the last decade has reduced the possibility that the citizen be fully aware of the health and emotional values of its marine environment. In order to help revert this situation, we have design AULAMAR, a real oceanographic research project for the youngest generations. AULAMAR is a science education project for high school students in the framework of citizen science, willing to offer tools to better understand the city's coastline and encourage critical reflection. AULAMAR is the continuation of the successful experience of the Patí Científic, a citizen science project (Oritgosa *et al.*, 2022) where sensor prototypes were developed and installed in sustainable boats or other recreational sailing devices (*i.e.*, rowing, surfing kayaking). In the frame of AULAMAR, high school pupils will build seawater monitoring low cost instruments during educational workshops, in particular temperature-depth profilers, bathymetric probes, multi-parametric fixed stations and micro-plastics tow nets. The participating schools will have the possibilities to make their own instruments and take the measurements, which will be available on an open database. In this way, schools will be able to actively participate towards a better knowledge of the health of their coastal environment. The measurements and other activities, such as workshops, are expected to increase the awareness of non-specialized public about the interaction between coastal cities and marine ecosystems. Moreover, these oceanographic instruments will help increase the amount of physical variables measured through sustainable boats and devices. We will present the first results already achieved with different scholar groups.

Key words: Citizen science, coastal oceanography, education, scientific sailing boat.

Acknowledgments: AULAMAR (Fundació Bit Habitat, ref. ID253). The ICM authors also recognize the institutional support of the Spanish Government through the Severo Ochoa Center of Excellence accreditation (CEX2019-000928-S). Special thanks go to the Club Patí de Vela de Barcelona staff.

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POSTER COMMUNICATIONS

REMOTE SENSING AND NUMERICAL OCEANOGRAPHY

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THE CONTRIBUTION OF THE VENDÉE GLOBE RACE TO IMPROVED OCEAN SURFACE INFORMATION. A VALIDATION OF THE REMOTELY SENSED SALINITY IN THE SUB-ANTARCTIC ZONE

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Abstract: The Vendée Globe is the world's most famous solo, non-stop unassisted sailing race. The Institute of Marine Sciences and the Barcelona Ocean Sailing Foundation, decided to install a MicroCT to the One Ocean One Planet Spanish boat raced by Dídac Costa. He completed the round trip in 97 days, from November, 8th of 2020 to February 13th of 2021, providing 1 measurement of surface temperature and conductivity every 30 seconds during navigation. More than half of the ship's trajectory was lying on sub-Antarctic zone, between the tropical and polar fronts crossing areas of oceanographic interest such as the Southern Patagonia (affected by glacier melting), Brazil-Malvinas confluence, the Southern Pacific Ocean, near the Nemo Point (the farthest point in the ocean from any land) and the whole Southern Indian Ocean, where the polar front is in its northernmost position. The One Ocean One Planet survey offered a new opportunity to get *in situ* measurements in these remote zones, and validate products of remotely sensed sea surface salinity using data from boat measurements. In the present study, the products being compared are SMOS SSS L3 v2 - 9 Days (BEC), SMOS SSS L3 v5 - 9 Days (CATDS-CECOS-LOCEAN), SMAP SSS L3 v5.0 - 8-Day running (JPL), and SMAP SSS L3 v4 - 8-Day running (RSS). Due to the decreased sensitivity of brightness temperature to salinity in cold seas, retrieving sea surface salinity at high latitudes remains a major challenge. Satellite data can usually only be validated with ARGO data in those latitudes, although the fact that their shallowest observations are between 5 and 10 m depth, may introduce a significant bias. Because the race route includes infrequently sampled places, the real surface data gathered by One Ocean One Planet have great value in the validation of remotely sensed SSS products, even if some of the vessel measurements had to be discarded due to foam and air bubbles in many intervals.

Key words: Sea Surface Temperature and Salinity, ocean circumnavigation, ships of opportunity, SMOS.

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ASSESMENT OF REMOTELY SENSED OCEAN CURRENTS PRODUCTS IN THE BEAUFORT AND CHUKCHI SEA

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Melting of glaciers, loss of sea ice, and acceleration of hydrological cycle have an impact on the Arctic Ocean. When ice melts, large amounts of freshwater are released into the ocean, causing the sea level to rise and the salinity to vary. Changes in salinity and temperature modify seawater density, directly affecting ocean currents. Freshwater in the Arctic Ocean is not uniformly distributed; it accumulates primarily in the Canadian basin, especially in the Beaufort Gyre, the Arctic Ocean's largest freshwater reservoir. We inter-compare three operational surface current products: Globcurrent (Rio *et al.*, 2014), OSCAR (Bonjean and Lagerloef, 2002), and CPOM (Armitage *et al.*, 2016). The first results highlight the differences in data coverage and the scales that are being resolved. Globcurrent and OSCAR have less data coverage and higher spatial and temporal resolution than the CPOM product. The higher data coverage observed in CPOM, attends to its simplicity, since it solves the geostrophic currents beneath the sea ice. However, CPOM is a smoother product that resolves lower spatio-temporal scales. Monthly mean currents are calculated between 2010 and 2020 along the Beaufort Gyre and the temporal evolution within this period is then analyzed. The surface current intensity within the Beaufort Gyre is found to increase during this period, with tendencies of $1.6*10^{-6} m \cdot s^{-1}$, which is consistent with findings of Proshutinsky et al. (2015) and Armitage et al (2017). The Beaufort gyre's intensification is linked to an anticyclonic wind pattern and a freshwater increase in the area. Both the acceleration and the accumulation of freshwater, have a significant impact on stratification and on the sea ice formation. Our results are an example of how remote sensing helps on the monitoring of the changing dynamics of the Arctic Ocean and to better understand the polar regions and their role in the climate system.

Key words: Arctic Ocean, Surface Current, Beaufort Gyre, Remote Sensing, Polar Oceanography

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GLOBAL WARMING TO REDUCE THE INTENSITY OF DENSE WATER FORMATION IN THE EASTERN MEDITERRANEAN

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Abstract: Deep and intermediate water formation in the Eastern Mediterranean (EMed) is essential in sustaining the Mediterranean overturning circulation. Changes in the sources of dense water in the EMed can perturb the circulation and the water properties of the Mediterranean Sea. Here we examine with a regional climate system model the changes in the deep and intermediate water formation in the EMed through the twenty-first century. The model has demonstrated good skills reproducing the average rate and the interannual variability of dense water formation in the EMed during the present climate (1980-2012). Our analysis under the RCP8.5 emission scenario shows a shift in the dominant source of Eastern Mediterranean Deep Water (EMDW) from the Adriatic Sea to the Aegean Sea at the first half of twenty-first century. The dense water formation rate projects a reduction of 77% for the Adriatic Sea and 83% for the Aegean Sea by the end of the century. We also find a shoaling in the winter mixed layer depth of 42% for the main sources of EMDW and almost of 50% for the Levantine Intermediate Water (LIW) generation area. The reduction in the intensity of dense water formation is related to hydrographic changes of surface and intermediate water, that strengthen the vertical stratification hampering the vertical mixing and thus the convection. Those changes have an impact in the water that flows through the Sicilian Strait to the Western Mediterranean, potentially affecting the Mediterranean overturning circulation.

Key words: deep water formation, Eastern Mediterranean, climate change, regional climate system model

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CLIMATE CHANGE IN THE CANARY CURRENT UPWELLING SYSTEM: THE ROLE OF OCEAN STRATIFICATION AND WIND

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Abstract: The Canary Current Upwelling System (CCUS) is one of the most important Eastern Boundary Upwelling systems (EBUSs). In the last decades, many authors have studied the climate change effects in the EBUSs, due to their ecological and large socio-economic importance as major fishery grounds. However, EBUSs future behaviour is still uncertain due to the limitations of the global climate models to properly represent the coastal processes because of their coarse resolution. Here, we use a high resolution regional climate system model to examine the climate change signal over the CCUS, identifying the upwelling favourable winds along with the ocean stratification as key factors in the future changes in the CCUS. Under RCP8.5 scenario, the upwelling favourable winds increase (decrease) in the Iberian upwelling system and decrease (increase) for the African upwelling in summer (winter). The model simulations show that the Azores high is the main responsible of those variations in winter, while in the summer the changes are due to the air temperature increase at the end of the 21st century over the Iberian Peninsula. Our analysis reveals an increase of the upper ocean stratification, which may partially hamper the upward ocean mass transport. This effect becomes more acute as global warming increases. Thus, the ocean stratification may limit the upward nutrient-rich transport to surface at the end of the 21st century, becoming the main driver of change in the CCUS.

Key words: Climate change, Canary current, Upwelling favourable winds, Ocean stratification, Regional climate system model.

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VARIABILITY OF THE WATER MASSES IN THE NORTH ATLANTIC SUBRTROPICAL GYRE

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Abstract: To fully understand the variability of water masses and ocean circulation in the North Atlantic Subtropical Gyre (NASG) is necessary to study long term-changes and interannual variability. This study is carried in two steps. First, three hydrographic cruises for the 24.5ºN section (WOCE program A05 section) carried in 1981, 1998 and 2015 are selected to understand the full basin changes of the NASG. Second, a deeper study focussing on the eastern boundary of the NASG is done. For this purpose, the eastern side of the 24.5ºN section is used together with four hydrographic cruises from the RaProCan program carried out in 1997, 2007, 2014 and 2017 north of the Canary Islands (29ºN). The Bindoff & McDougall (1994) analysis is done to identify whether the observed changes are due to a vertical displacement of isoneutrals or due to changes along isoneutrals (differences in water properties). Results show, for all interannual differences of 24.5ºN, a warming in surface, central and intermediate layers, these changes are linked to changes in salinity. In contrast, a cooling and freshening tendency is observed in the deep layers. Controversially, the eastern boundary shows for all years, except for 2014, cooling in most of the water column. The layer that shows the highest variability is the intermediate due to the different seasonal contribution of Antarctic Intermediate Water *versus* Mediterranean Water. The variability in south of the islands is harder to infer due to the presence of mesoscale activity.

Key words: Atlantic Ocean, Bindoff, Canary Basin, eastern boundary, Interannual variability, North Atlantic Subtropical Gyre

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SPATIO-TEMPORAL VARIABILITY OF THE PENINSULA FRONT AND THE CHLOROPHYLL-A BLOOM IN THE BRANSFIELD STRAIT

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Abstract: The Bransfield Strait (BS) is a relatively narrow region enclosed between the South Shetland Islands (SSI) and the tip of the Antarctic Peninsula (AP). The hydrography is characterised by two inflows: the Bransfield Current, which transports westwards Transitional Zonal Water with Bellingshausen influence (TBW) characterised by well-stratified, relatively warm (Θ > -0.4ºC) and fresh (<34.45) waters; and the Antarctic Coastal Current, which transports eastwards Transitional Zonal Water with Weddell influence (TWW), distinguished by homogeneous, colder (Θ < -0.4ºC) and saltier (>34.45) waters (Sangrà *et al*., 2017). These two water masses confront each other forming the Peninsula Front (PF; García *et al.*, 1994; López *et al.*, 1999). Interestingly, the spatial distribution of chlorophyll-a (chl-a) in the BS has linked to the governing water masses features and their column vertical stability, among other factors (Lipski and Rakusa-Suszczewski, 1990; Basterretxea and Arístegui, 1999). Thus, higher chl-a concentrations have been reported around the SSI and Gerlache Strait where TBW flows, whereas lower concentrations have been found north off the SSI and closer to the AP coastline, where more homogeneous surface waters prevail (AASW and TWW, respectively) (Corzo *et al*., 2005).

In this work we aim to provide a further understanding on the bio-physical coupling occurring in the Bransfield Strait between the surface spatial distribution of the seasonal chlorophyll bloom and the location of the PF. To do this we use a variety of remotely sense observations: Sea Surface Temperature (SST), Sea-Ice Coverage (SIC), chlorophyll-a, wind stress and Photosynthetically Active Radiation (PAR) over the period 1998-2015. Preliminary results confirm the spatial distribution of the chl-a bloom in the Bransfield Strait is strongly influenced by the location of the PF, both seasonally and interannually. Also, a decadal shift in the strength of the chl-a bloom has been identified, where significantly weaker (stronger) events are found during the period 1998-2004 (2005-2015); chl-a bloom values are almost twofold greater with means about 0.90 mg m^{-3}. We hypothesize this shift might be linked to changes observed in the seasonal evolution of the SIC and SST over the same periods. Ongoing analyses attempt to elucidate the mechanisms accounting for these apparent bio-physical coupling in the Bransfield Strait.

Key words: Bransfield Strait, Remotely-sensed Observations, Sea Surface Temperature, Sea Ice Coverage, Chlorophyll-a, Spatial-temporal variability.

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SPATIAL VARIABILITY OF THE HORIZONTAL EDDY DIFFUSION AS INFERRED FROM OBSERVATIONAL DATA

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Abstract: The large-scale ocean circulation is very sensitive to the presence and magnitude of mesoscale and submesoscale eddies, with a high impact on the Earth's climate. Eddies continually stir water parcels along isopycnals surfaces, influencing both physical and biological systems (Roach et al., 2016). Here, we introduce a new method to estimate the cross-frontal eddy horizontal diffusivity and their depth variability, and present its application to the western South Atlantic Ocean. The method simulates the Argo, RAFOS, and GDP actual trajectories with numerical Lagrangian particles launched for each 10-days cycle at the same initial position and date, using the outputs of the GLORYS12 model (Lellouche et al., 2021). The radial dispersion between the observed and modelled positions displays a Gamma distribution, from which the diffusion coefficients are obtained. At depth, the lateral diffusion coefficients present an inverse relationship, reaching a maximum of 5413 m^2 s^{-1} at the ocean surface and decreasing rapidly to stabilize from 1000 m downwards with a mean coefficient of 796 ± 91 m^2 s^{-1}. Whereas the radial dispersion is higher in northern frontal subdomains with more kinetic energy, the cross-frontal diffusion coefficients increase considerably in the southern subdomains near the Antarctic continent. The cross-frontal lateral diffusion variability is much higher at the ACC surface, ranging from 2681 m^2 s^{-1} to 4248 m^2 s^{-1}, while at 1000 m depth it presents coefficients from 892 m^2 s^{-1} to 1245 m^2 s^{-1} with a low standard deviation of 141 m^2 s^{-1}. The coherence of the lateral diffusive estimates from different floats, depths, and frontal subdomains confirms the robustness of our approach. Our results illustrate a simple model-dependent method that effectively reproduces the variability associated with sub-grid eddy turbulence.

Key words: Horizontal diffusivity, Radial dispersion, Float trajectories, Lagrangian particles.

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TEMPORAL VARIABILITY OF THE SUBANTRCTIC FRONT AND THE POLAR FRONT ACROSS THE MALVINAS PLATEAU

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Abstract:
Both Subantarctic Front (SAF) and the Polar Front (PF), characteristics of the Antarctic Circumpolar Current, cross the Malvinas Plateau between 41ºW and 75ºW at the nominal latitude of 51ºS. The aim of this study is to analyze the temporal variability of both the SAF and PF across de Falkland Plateau over 26 years. Daily data from the 1/12º resolution Mercator Ocean GLORYS model has been downloaded for the time period comprised between January 1993, and December 2019. Using non-assimilated data from two cruises that took place in 1999 (ALABTROSS) and 2010 (MOC- Austral), a sensibility test has been performed. The temporal variability of hydrographic characterictics, the position and the velocity of the fronts have been studied at different time scales, ranging from seasonal to interanual scale. On average, the SAF present a core temperature of 6,04ºC, a salinity of 34,07 and a velocity of 0,25 m/s while the PF is characterized by lower core properties, being the temperature 5,1ºC, the salinity 34,01 and the velocity 0,17 m/s. Our results show that the position of the fronts can vary at different times of the year, being the larger horizontal shift (between -55,1ºW and -46,1ºW) in spring. Furthermore, it is observed that the Polar Front has its maximum vertical extend in spring. Changes in the SAF front influences the characteristic intermediate waters of this region.

Key words: SAF, PF, temporal variability, Flakland Plateau, velocity.

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CHANGES IN WATER MASSES PROPERTIES OF ATLANTIC OCEAN AT 30ºS

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The South Atlantic is not as well studied as the North Atlantic, thus a large uncertainly exists on it's interannual variability. The aim of this work is to study the variability of the South Atlantic at 30°S using the Bindoff and McDougall (1994) method. This method helps to understand whether interannual changes in the water masses are due to the vertical variation of the isoneutrals or to change in their properties. For this study, the hydrographic section A-10 of the WOCE program has been obtained for the different years 1992-2003-2011.

In 1992, the ocean surface temperature is higher than on the other two years (2003 and 2011). This is due to the fact that in this year there was a strong period of El Niño. During the El Niño period, warming over the South Atlantic is favored due to the weakening of the southeasterly trade winds and a strengthening of the westerlies winds. Also of this, the southward transport of tropical Ekman is reduced and contributes to the warming.

In addition, we explore the amount and characteristics of the Agulhas rings found in the area due to the nearby retroflection of the Agulhas current with water coming from the Indian Ocean. It is observed that, depending on the year, one or several rings can be found.

Key words: Agulhas rings, Bindoff and McDougall, El Niño, South Atlantic

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Bindoff, N. L., & Mcdougall, T. J. (1994). Diagnosing climate change and ocean ventilation using hydrographic data. Journal of Physical Oceanography, 24(6), 1137-1152.

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STENOPHAGOUS ORGANISMS UNDER CLIMATE CHANGE, THE NUDIBRANCH *Berghia stephanieae* AS A CASE STUDY

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Abstract:

Stenophagous organisms feed upon a specific diet, of a reduced number of species (Todd et al., 2001). One of such organisms is *Berghia stephanieae*, a sea slug that preys upon glass anemones, such as *Exaiptasia diaphana (*Dionísio et al., 2013). These anemones host photosynthetic dinoflagellate endosymbionts, commonly called zooxanthellae, that *B. stephanieae* acquires as a by-product of predating this anemone. However, under certain scenarios, such as during bleaching events impacting glass anemones, when the sea slug is deprived of symbiotic prey the prevalence of these photosynthetic dinoflagellate endosymbionts in *B. stephanieae* is significantly reduced (Silva et al., 2021). The present work validated a non-invasive and non- destructive approach to assess the persistence of the association between the sea slugs and the endosymbiotic photosynthetic dinoflagellates they acquire when consuming glass anemones. In this approach, chlorophyll fluorescence is used as a proxy to infer the prevalence of this sea slug/ dinoflagellate endosymbionts association. We successfully employed this approach to investigate a scenario mimicking a bleaching event, along with food deprivation. We found that when deprived of a prey hosting photosynthetic dinoflagellate endosymbionts *B. stephanieae* showed a rapid decrease of minimum fluorescence (Fo) and maximum photosynthetic efficiency (Fv/Fm) when compared to conspecifics fed with anemones harbouring endosymbionts. It was also possible to confirm that no true symbiotic association is established between the sea slug and the photosynthetic dinoflagellate endosymbionts, as a total loss of endosymbionts was recorded within only 8 days. With the present study, we have made available a valid approach to rapidly monitor in vivo and over time the prevalence of associations between sea slugs and photosynthetic dinoflagellate endosymbionts under climate change scenarios.

Key words: bleaching; *Exaiptasia diaphana*; pulse amplitude modulated (PAM) fluorometry; symbiosis

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IMPACT OF CUMULUS PARAMETERIZATIONS ON THE SIMULATION OF A TORRENTIAL RAINFALL EVENT OVER THE WESTERN MEDITERRANEAN SEA

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Abstract: The Western Mediterranean is located between the cold Atlantic region and the subtropical high-pressure belt, giving its characteristic weather, with irregular heavy rainfalls associated with polar fronts fed with warm and humid air masses from the Mediterranean Sea, forcing torrential convective storms (Davis et al., 1997; Gómez et al., 2011; Hénin et al., 2021). This kind of events over the Spanish East Coast have produced billionaire economic losses in the region (Hermoso et al., 2021). The episode simulated in this study, developed between 11th and 13th September 2019, was one of the biggest floods in the region. This event was simulated using the Weather Research and Forecasting model (WRF-ARW 4.3) to investigate different issues. Firstly, to evaluate different cumulus parameterizations to find out whether a specific scheme better reproduces the observed precipitation and the cumulus formation in the study case, and secondly to assess whether activating the corresponding cumulus parameterization in the higher resolution grid affects the model output. All experiments were configured using two nested grids. The outer one covers the whole Western Mediterranean Sea including the main mountain ranges with a 9 km resolution, and the inner one covers the Alboran and Balearic Sea, as well as the Southeast of the Iberian Peninsula with a 3 km resolution. The different cumulus parameterizations used for the experiments were Kain-Fritsch (Kain, 2004), Betts-Miller-Janjic (Janjić, 1994), and Grell-Freitas (Grell and Freitas, 2014) schemes. All experiments were compared with observational data from weather stations and different satellite products to include the maritime component of precipitation. The results and conclusions of this study are expected to produce a better understanding of the development, evolution and forecast of these weather extreme events, focusing both over land and over the sea.

Key words: WRF, Western Mediterranean, cumulus parameterization, torrential rainfall

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COASTAL-BREEZE SIMULATION WITH THE WRF MODEL: ANALYSING THE SENSITIVITY TO LAND/SEA SURFACE TEMPERATURE CHANGES

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Abstract: Coastal breezes are mesoscale winds formed in mid-latitude regions under fair-weather synoptic conditions, i.e., weak surface-pressure gradient and low winds. They are characterized by a typical wind-direction reversal twice per day, with onshore winds during daytime and offshore during the night. The impacts of these winds are broad and varied: they transport humidity and pollutants (among other physical properties) in the coastal region; they can initiate convection (and even trigger the formation of storms), and they also drive some of the surface oceanic currents formed close to the coast, among others. In this sense, recent surface current observations collected by the Gulf of Cádiz radar system point at the coastal breezes as important contributors to explain the behaviour of the surface currents variability in this region. From a societal point of view, the coastal breezes are crucial for wind power industry, air-quality forecasts, maritime sports, and simply for the refreshing impact that they cause in some warm areas in summer. Hence, a correct understanding of their physical characteristics is needed to correctly forecast them and to be able to investigate their future trends.

These phenomena are formed due to the pressure gradient associated with the temperature difference between the sea and the land surfaces. Therefore, both systems (the ocean and the atmosphere) are involved on the final characteristics that specific breeze events will have, impacting on the variability observed in the strength, duration, and vertical/horizontal extension of the breezes. In this work, we use the Weather Research and Forecasting (WRF) mesoscale model to investigate how the changes in the surface affect the features of this phenomenon through the design of different sensitivity experiments. These include artificial changes in the land and sea surface temperature, but also the use of more realistic (and higher resolution) data to initialise the model. Besides, other experiments are designed to investigate the impact of different technical aspects of the model on the correct simulation of the physical processes, such as the use of different vertical and horizontal resolution, the

choice of the planetary-boundary-layer scheme, or the activation or not of typical filters (smoothing) within the model.

Key words: coastal breezes, WRF model, land-atmosphere interactions, ocean-atmosphere interactions.

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CHARACTERIZATION OF THE MARINE HEAT WAVES IN THE CANARY BASIN

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Abstract: Marine Heat Waves (MHW) are under a growing scientist and social interest since 2010 (Hobday et al., 2018), not only due to impacts on the ecosystem but also to understand its possible climatic implications. Here we make a first MHW characterization in the Canary basin determining their frequency, duration, and intensity in the period from 1981 to 2019. We used daily gridded Sea Surface Temperature (SST) data from the reanalysis of the Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) with a spatial resolution of 1/20° (Good et al., 2020). We define a MHW as an anomaly warm discrete event, which overpasses a seasonal threshold (obtained from a percentile that lies between 90 and 99 above the SST original series), during at least for 5 consecutive days (Hobday et al., 2016).

For all over the region we have registered a total number of 58 events that in annual average take the values of 1.487 ± 0.24 events per year, with a duration of 18.688 ± 3.849 days per event and an intensity of 1.018 ± 0.026 °C. On the other hand, the spatial distribution of the MHW frequency, duration and intensity allows differentiating regions with different characteristics. For instance, there are 2.5 events per year in the Madeira region, a duration of the events up to 25 days on the Canary region, and maximum values of intensity up to 2.2 °C in the upwelling area.

Key words: Marine Heat Wave, Climate, Canary Basin, Sea Surface Temperature

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ASSESSING THE EXTENSION OF THE ARGO ARRAY TOWARDS THE DEEP OCEAN: AN ANALYSIS OF THE LONG-TERM STABILITY AND ACCURACY OF THE SBE61, SBE41 AND RBR CTD SENSORS.

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Abstract: The Argo network is the most important component of the Global Ocean Observing System, with 4000 floats that profiles every 10 days the upper 2000 m of the ocean. However, due to the role played by the deep ocean in the climate system and the Earth's energy balance, it is necessary to extend the coverage of the network to full ocean depth. Ensuring long-term stability and sensor accuracy to achieve reliable pressure, temperature and salinity measurements is a challenge facing the Argo community today. Within the framework of the EuroArgo-RISE project, an experiment was carried out to assess the performance of the new generation of Argo sensors: SBE61 and SBE41CP from *Sea-Bird Scientific* and the Concerto-3 CTD from *RBR*. All sensors were integrated simultaneously on Deep-Argo floats, allowing synchronization and comparison of in situ measurements. Throughout 2020 and early 2022, a total of two 3-headed floats (SBE4CP, SBE61 and RBR Concerto-3) and two 2-headed floats (SBE61 and RBR Concerto-3) were deployed in the Canary basin. The 3-headed floats analysis suggests that up to 4000 dBar, there is a pressure difference between the SBE61 and the RBR of almost 10 dBar, which lies outside sensor accuracy. Results from temperature sensors suggest that there is no pressure dependency below 500 dBar when SBE61 and SBE41 are compared, although temperature difference evolves when increasing pressure. Same behaviour when comparing SBE61 and RBR. These small differences in temperature between sensors yet lie within the sensor accuracy and are stable over time. Regarding salinity, on average, SBE61 shows a fresh bias for both floats in salinity between 2000-4000 dBar, while SBE41 shows salty and fresh biases respectively. The conductivity cell of both SBE sensors is pressure dependent. By using the manufacturer's correction coefficient (CPcorr) and the conductivity ratio (M), excellent agreement with the ship-based reference profile is provided.

Key words: Deep-Argo, CTD-sensor, accuracy, stability.

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SAGA10W CRUISE: IN SITU MONITORING OF THE ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)

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Abstract:
The South Atlantic Ocean is one of the central components of the climate system as it regulates the intensity of the Atlantic South Overturning Circulation (AMOC), which determines the amount of equatorward heat gained and transported to high latitudes (Garzoli and Matano, 2011).
The main goal of the SAGA10W oceanographic cruise, carried out between March 7 and April 15 2021, was installing the appropriate equipment to perform a long time monitoring of the interior-ocean zonal flows linking the eastern and western South Atlantic basins. The equipment selected to perform the monitoring as well as the logistic of its installation was not trivial. It consisted of four PIES (Pressure Inverted Eco Sounder), and three 2000-m instrumented moorings installed along 10°W on the spurs of the Mid-Atlantic Ridge between 34º20'S and 19º20'S. This vertical section takes place the verge of the subtropical and tropical gyres, in a region that has been recently identified as a pathway for both the starting and returning limbs of the AMOC: the South Atlantic Gateway (SAGA).
To properly install the four PIES and three moorings it was absolutely necessary to perform a previous study of the bottom topography with enough resolution to decide the right location. Considering the period of planned monitoring (4 yrs), it was absolutely necessary to adequately prepare all submerged instrumentation. The detailed multibeam scanning of the bottom relief was performed around the points selected by GEBCO. The multibeam scanning covered a 20x20 nautical mile square and consisted of 5 meridional tracks 5 miles apart that allowed to obtain a real acoustic image of the bottom relief with a spatial resolution of 25 meters.
Here, we present our experience in preparing the equipments, the cruise operations and the final setup of the entire SAGA array.

Key words: AMOC, SAGA, PIES, Current, Bottom relief, Multibeam

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