Next Generation Climate Science for Oceans | Research projects 2020-2023

Preprint · October 2020

DOI: 10.13140/RG.2.2.13326.18246

8 authors, including:

Speich Sabrina
Ecole Normale Supérieure de Paris
187 PUBLICATIONS **9,185** CITATIONS
SEE PROFILE

Richard Bellerby
Norwegian Institute for Water Research
174 PUBLICATIONS **8,481** CITATIONS
SEE PROFILE

Anne-Marie Treguier
French National Centre for Scientific Research
164 PUBLICATIONS **7,343** CITATIONS
SEE PROFILE

Jpi Oceans
JPI Oceans
4 PUBLICATIONS **1** CITATION
SEE PROFILE

JPI OCEANS

JPI Climate

Next Generation Climate Science for Oceans

Research projects 2020 - 2023

Contributions:

Dr. Anne Marie Tréguier, Dr. Daniela Matei, Prof. Richard G. J. Bellerby, Prof. Sabrina Speich

Publication editing:

Lavinia Giulia Pomarico & Willem de Moor

Suggested reference:

JPI Oceans & JPI Climate (eds.) (2020). Next Generation Climate Science for Oceans - Research projects 2020 - 2023. Brussels, Belgium.

Photo credit frontpage:

Cesar Couto on Unsplash

Table of Contents

Next Generation Climate Science for Oceans Research Projects 2020-2023

Funding for the project was provided under the framework of JPI Climate and JPI Oceans by:

The Joint Programming Initiatives Connecting Climate Knowledge for Europe (JPI Climate) and Healthy and Productive Seas and Oceans (JPI Oceans) are coordinating platforms open to all EU Member States and Associated Countries.

Vision: Actively inform and enable the transition to a low emission, climate resilient economy, society and environment that is aligned with Europe's long-term climate policy objectives.

Mission: Provide new knowledge and inform climate action using our strategic mechanism of connecting research funders, performers and users.

More information: www.jpi-climate.eu

Vision: Enabling the transformation to a sustainable blue economy whilst fostering the health and productivity of seas and oceans.

Mission: Facilitating the efficient provision of expert knowledge and innovative solutions to enable informed policy delivery and economic development ensuring sustainably healthy and productive seas and oceans.

More information: www.jpi-oceans.eu

Introduction

Oceans play a key role in the climate system and are also affected by climate change. As confirmed by the recent IPCC special report on ocean and cryosphere, ocean dynamics are a major modulator of weather and climate including future trends and extremes. However, there are still uncertainties in the understanding and quantification of key climate-ocean interactions and the ocean's buffering capacities for absorbing heat and CO_2 which calls for more progress in those areas on understanding, observation and modelling. In response to that, JPI Climate and JPI Oceans partners launched a joint call for research proposals which resulted in the selection of four transnational projects:

MEDLEY | MixED Layer hEterogeneitY | Coordinator: Dr. Anne Marie Tréguier, Laboratoire d'Océanographie Physique et Spatiale, France.

ROADMAP | The Role of ocean dynamics and Ocean-Atmosphere interactions in Driving cliMAte variations and future Projections of impact-relevant extreme events | Coordinator: Dr. Daniela Matei, Max-Planck-Institut für Meteorologie, Germany.

EUREC4A-OA | Improving the representation of small-scale nonlinear ocean-atmosphere interactions in climate models by innovative joint observing and modelling approaches | Coordinator: Prof. Sabrina Speich; L'École normale supérieure - Laboratoire de météorologie dynamique (ENS-LMD), France.

CE2COAST | Downscaling Climate and Ocean Change to Services: Thresholds and Opportunities | Coordinator: Prof. Richard Bellerby, Norwegian Institute for Water Research (NIVA), Norway.

The projects are conducting research on interactions between oceans and climate by analysing model simulations and observational data. The research aims to better understand upper ocean variability and dynamics and ultimately improve the performance of climate models. The results of the four projects will help inform adaptation policy to increase resilience and adaptation measures for vulnerable areas, especially in coastal and low island areas.

This booklet provides an overview of the scope and objectives of the projects and their (consortium) partners.

MEDLEY

Mixed layer heterogeneity

Project Description

Coordinator: Dr. Anne Marie Tréguier
Laboratoire d'Océanographie Physique et Spatiale, CNRS, France

The future climate of our planet depends on the way heat and carbon dioxide are absorbed by the ocean. The top 50-200 metres, the ocean's surface layer, is well mixed by turbulence from wind, waves and convective circulations. This mixed layer mediates the transfers between the atmosphere and the deep ocean.

Transfers of heat, energy and gases through the mixed layer are extremely complex and spatially heterogeneous. The discontinuous and dynamic sea ice cover, and the occurrence of eddies, fronts and filaments at the kilometre-scale, are important heterogeneities which regulate the thickness and properties of the mixed layer. Large discrepancies in mixed layer depths are found among climate models used for IPCC scenarios, partly due to a misrepresentation of the integrated effect of these heterogeneities. This limits the usefulness of climate models in assessing the impacts of future climate change on European climate and marine ecosystems.

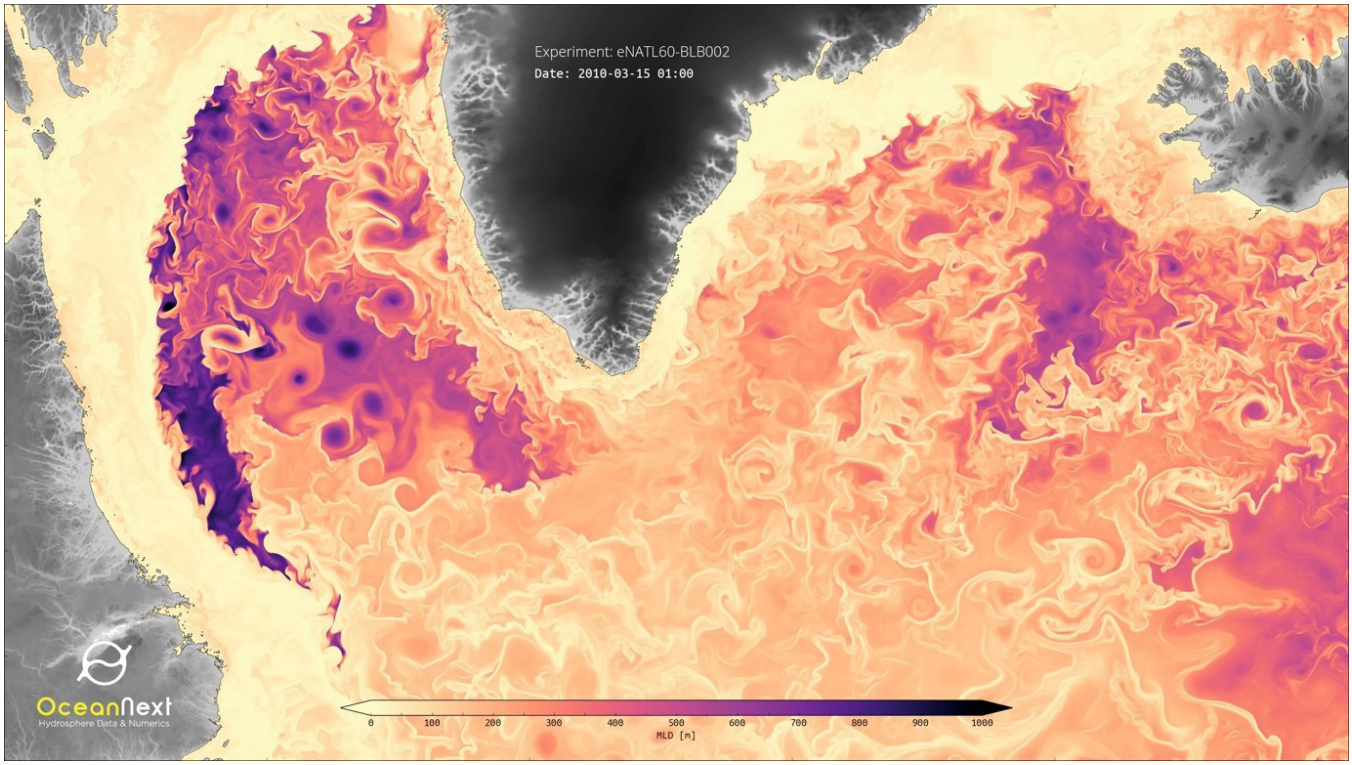
MEDLEY (MixED Layer hEterogeneitY) will further our understanding of mixed layer heterogeneity in the North Atlantic a hotspot of anthropogenic CO_2 storage, and in the rapidly warming Arctic Ocean.

The core objectives of MEDLEY are:

- to evaluate the spatial heterogeneity of fluxes and of the processes controlling the ocean mixed layer
- to improve the representation of the transfers through the mixed layer in climate models by taking this heterogeneity into account

The project integrates state of the art observational datasets and basin scale ocean models resolving the kilometre scale, an innovative sea-ice model, and the latest generation of climate models with an eddying ocean component. Building on interdisciplinary collaborations between its members, MEDLEY will take advantage of the most recent data analysis methods (e.g., machine learning-based classification).

The MEDLEY consortium is well connected to European climate infrastructures such as the Infrastructure for the European Network for Earth System Modelling (IS-ENES) and to the Nucleus for European Modelling of the Ocean (NEMO) European ocean-ice modelling platform, thus ensuring that MEDLEY findings are built into European climate models. MEDLEY aims at a better tuning and consistency of mixed layer representation (parameterizations) in NEMO, gained through multi-scale modelling and validation by recent high-resolution observations. MEDLEY will further create new diagnostics for model evaluation to ensure that the mixed layer transfer function is better constrained in future climate models that inform the next IPCC assessments and further constrain the scientific basis for the Paris Agreement.



Kilometre-scale model simulation of the depth of the surface mixed layer in March in the North Atlantic, demonstrating its heterogeneity and the huge imprint of ocean turbulence (eddies). Courtesy of L. Brodeau and J. Le Sommer.

Consortium

Organisation	Acronym	Country
Laboratoire d'Océanographie Physique et Spatiale	LOPS - CNRS	FRANCE
Institut des Géosciences de l'Environnement	IGE	FRANCE
Université Catholique de Louvain la Neuve	UCLouvain	BELGIUM
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC	ITALY
Nansen Environmental and Remote Sensing Cente	NERSC	NORWAY
Institute of Oceanology of the Russian Academy of Sciences	IORAS	RUSSIA

ROADMAP

The role of ocean dynamics and ocean-atmosphere interactions in driving climate variations and future projections of impact-relevant extreme events

Project Description

Coordinator: Dr. Daniela Matei
Max-Planck-Institut für Meteorologie, Germany

Societies are vulnerable to weather and climate extremes which put agriculture, infrastructure (e.g. electricity supply and transport) and human life at risk. For example, heat waves, droughts and heavy rainfall with related flash and large-scale flooding have become more frequent and intense in recent years, posing increasing threats to societies. Likewise, extratropical cyclones, like Mediterranean mesoscale cyclones, become more hazardous, especially in the densely populated coastal areas.

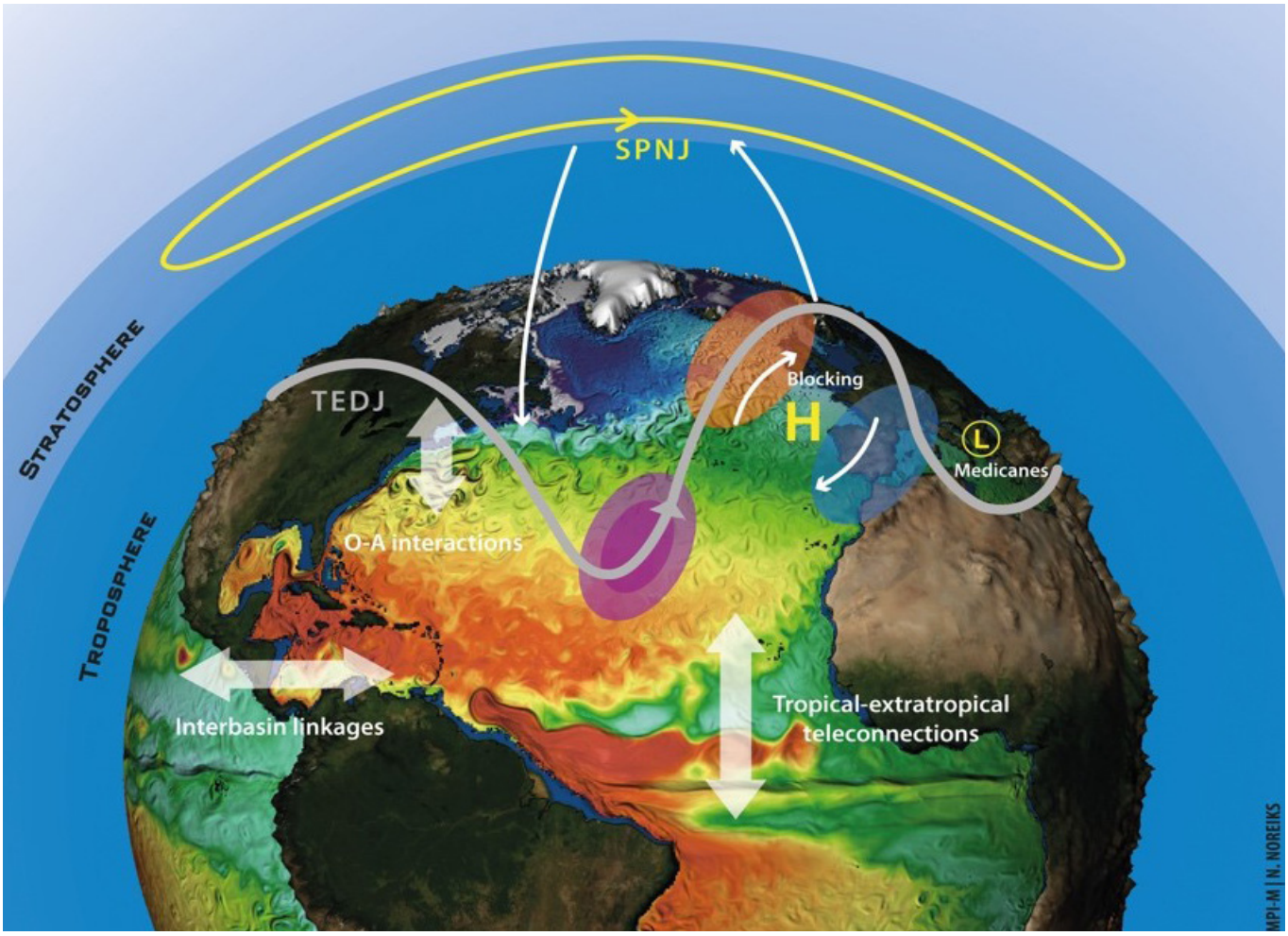
Weather and climate variability in the mid-latitudes are largely controlled by variations in the atmospheric jet streams and associated storm-tracks, which in turn are modulated by the temperature field in the underlying oceans (see schematic figure). Changes in the North Atlantic thus have the potential to affect millions of people in Europe and North America. The main objective of ROADMAP (The Role of ocean dynamics and Ocean-Atmosphere interactions in Driving cliMAte variations and future Projections of impact-relevant extreme events) is to better understand how the ocean shapes the climate and associated extreme events in the northern hemisphere on seasonal time scales but also over multiple decades as climate-change progresses.

Specifically, ROADMAP will address:

- Ocean circulation effects on sea surface temperature
- Future changes in the Gulf Stream and its Pacific counterpart, the Kuroshio Current
- Impact of extratropical ocean conditions on jet streams, cyclones, atmospheric blocking events and their links to weather and climate extremes
- Influence of tropical surface ocean temperatures on extratropical atmospheric circulation
- Effects of Arctic sea ice and ocean temperatures on climatic extremes
- How intensity and frequency of intense Mediterranean mesoscale cyclones will change under global warming
- Interactions between oceanic and atmospheric patterns of variability

ROADMAP builds on and extends our knowledge of climate variability and predictability by bringing together experts from across the climate and ocean sciences. We aim to deepen our understanding of the predictable component of climate variability and better estimate the climate change impacts on the extratropical atmospheric circulation and extreme events in the North Atlantic and North Pacific. The project will take advantage of the worldwide wealth of model simulations. We will go well beyond the state-of-the-art by analysing the latest high-resolution climate models and observations with advanced statistical-dynamical techniques and concepts from information theory. Additionally, ROADMAP will conduct dedicated experiments employing cutting-edge numerical techniques based on data assimilation and interactive ensemble modelling.

ROADMAP will lead to a better understanding of regional climate variability and change, as well as more reliable predictions of regional weather and climate extremes, including statements about the incidence of extratropical cyclones. More reliable climate predictions and projections can improve disaster prevention as well as adaptation and mitigation strategies. They can also make the business sector more resilient and competitive and optimize stakeholder decision. ROADMAP ensures the dissemination of its key findings to the scientists, stakeholders, climate services and the general public.



Western boundary currents, thermohaline circulation, tropospheric jets and blockings, and the stratospheric vortex in a changing climate: How do they interact and how do their changes impact the intensity and frequency of atmospheric and marine extremes?

Consortium

Organisation	Acronym	Country
Max-Planck-Institut für Meteorologie	MPI-M	GERMANY
GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel und Universität Kiel	GEOMAR/UNI KIEL	GERMANY
Magdenburg-Stendal University of Applied Sciences - H2 & Postdam Institute for Climate Impact Research	H2/PIK	GERMANY
Royal Meteorological Institute of Belgium	RMIB	BELGIUM
Laboratoire d'océanographie et du climat: expérimentations et approches numériques	LOCEAN	FRANCE
Laboratoire de météorologie dynamique	LMD	FRANCE
Maynooth University	MU	IRELAND
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC	ITALY
Institute of Atmospheric Science and Climate of the National Research Council	CNR	ITALY
Nansen Environmental and Remote Sensing Center	NERSC	NORWAY
University of Bergen	UiB	NORWAY
FCiências.ID (Instituto Dom Luiz)	IDL	PORTUGAL

EUREC4A-OA

Improving the representation of small-scale nonlinear ocean-atmosphere interactions in climate models by innovative joint observing and modelling approaches

Project Description

Coordinator: Prof. Sabrina Speich
École normale supérieure - Laboratoire de météorologie dynamique (ENS-LMD), France

The ocean and atmosphere off the Caribbean Islands and South America are the stage of a large international study to address two major climate unknowns: clouds and small-scale ocean dynamics. The EUREC4A-OA project (Improving the representation of small-scale nonlinear ocean-atmosphere interactions in climate models by innovative joint observing and modelling approaches) has gathered teams from four European countries (France, Germany, Italy and Norway), joined by teams from the US and the UK, to undertake the largest field observations experiment ever organized, complemented by a range of model simulations of the regional ocean-atmosphere system. The project makes use of numerous innovations in both observing techniques and numerical modelling, with the ambition to reduce uncertainties about the rate and extent of global warming and climate impacts in the future.

Over the last 40 years, climatologists have been grappling with a key parameter on which the extent of future global warming depends: the sensitivity of the climate system to increasing CO_2 concentration in the atmosphere. However, they now know that the way in which the ocean and clouds react to global warming lies at the heart of the problem.

In an attempt to get a clearer picture, the EUREC4A–OA project focuses on ocean small-scale dynamics, how these affect the exchanges of properties with the atmosphere and the formation and evolution of cumulus clouds. To initiate and rapidly develop actions to strengthen society's resilience to climate change, numerical predictions and climate projections systems require advances in phenomena understanding and model innovations.

The ocean is the main regulator of the world's climate and is especially turbulent in the North Tropical Atlantic Ocean, with many small vortices (less than 100 km in diameter) stirring up water that is warmer than its surroundings. Researchers suspect that these eddies play a fundamental role in the exchange of gases and energy between the ocean and the atmosphere, such as the uptake of CO_2 and heat by the ocean. Such turbulent ocean processes and their exchanges with the atmosphere are poorly understood and only summarily represented in climate models.

Researchers in the EUREC4A-OA project study in unprecedented detail phenomena within the boundary layers of the ocean and atmosphere zooming in on spatial scales smaller than 100 km. During the field experiment they deployed simultaneously, in the ocean and atmosphere, more than 100 state-of-the-art instruments and innovative observing platforms. In parallel they set up a vast modelling effort involving 25 different institutions across Europe and the US. These studies will further link with purely airborne observations and novel modelling of clouds physics that represent another major source of uncertainties in weather forecast and climate change projections alike.

Finally, the EUREC4A-OA project has the potential to improve the information gain from satellite remote sensing and to ultimately deliver the design for a more capable fit-for-purpose observing system.

Platforms and infrastructures shared during the EUREC4A campaign in Barbados, January-February 2020 © EUREC4A

Consortium

Organisation	Acronym	Country
Laboratoire de météorologie dynamique	LMD	FRANCE
Laboratoire d'études en géophysique et océanographie spatiales	LEGOS/CNRS	FRANCE
Laboratoire d'océanographie et du climat : expérimentations et approches numériques	LOCEAN/CNRS	FRANCE
Centre national de recherches météorologiques	CNRM/CNRS	FRANCE
Université de Bretagne Occidentale, Laboratoire d'Océanographie Physique et Spatiale	UBO-LOPS	FRANCE
GEOMAR Helmholtz Centre for Ocean Research Kiel	GEOMAR	GERMANY
Max Planck Institute for Meteorology	MPI	GERMANY
Helmholtz-Zentrum Geesthacht	HZG	GERMANY
Università degli Studi di Milano Bicocca	UNIMIB	ITALY
Centro Internazionale In Monitoraggio Ambientale	CIMA	ITALY
Nansen Environmental and Remote Sensing Center	NERSC	NORWAY
University of Bergen	UIB	NORWAY

CE2COAST

Downscaling climate and ocean change to services: thresholds and opportunities

Project Description

Coordinator: Prof. Richard Bellerby
Norwegian Institute for Water Research (NIVA), Norway

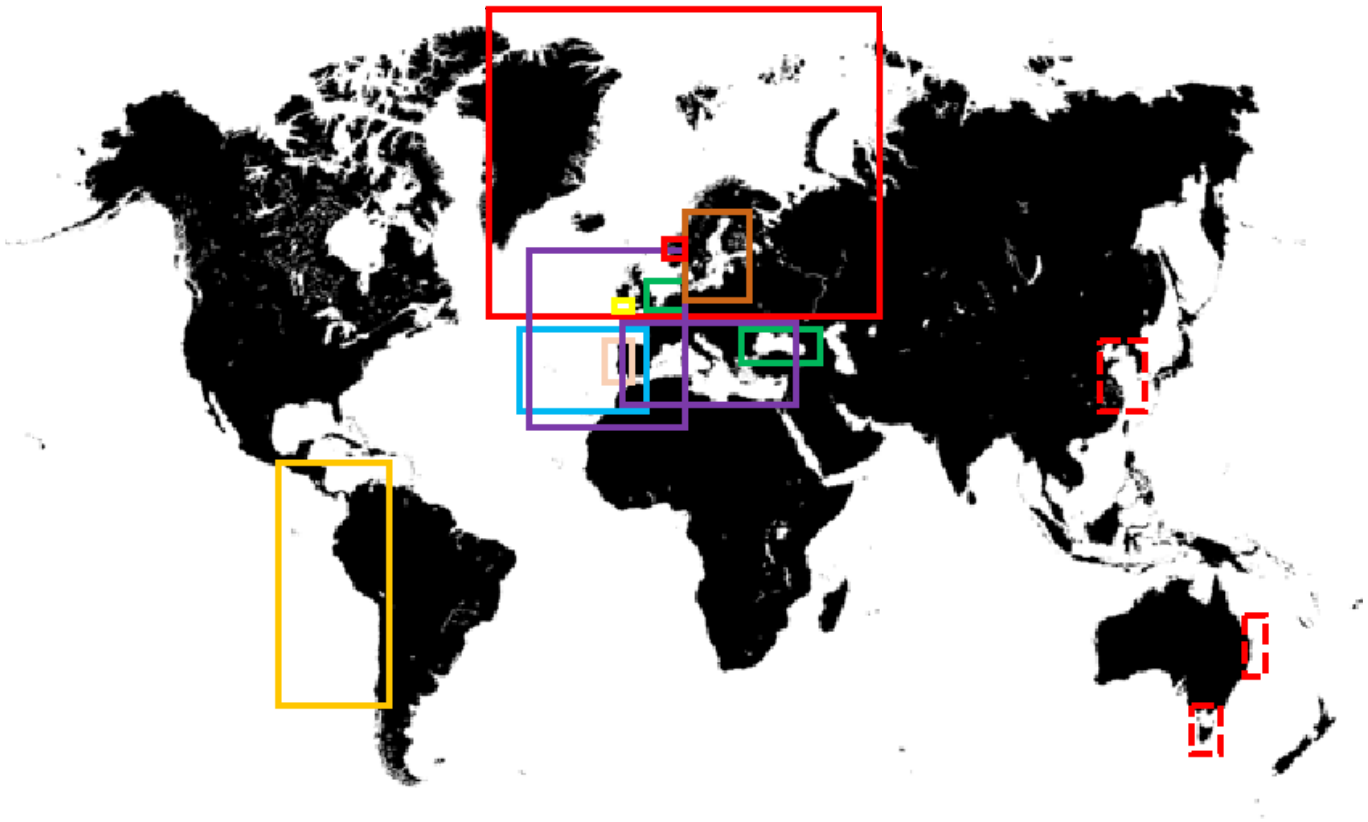
Human-made global change will have significant impacts at regional and coastal scales on marine systems, dependent socio-economies and ocean services. These can strongly interact with regional and local human-activity induces pressures such as fishing, pollution, and eutrophication. The challenges of understanding climate and ocean change at European and global scales require expertise exceeding that available from one single nation. CE2COAST (Downscaling Climate and Ocean Change to Services: Thresholds and Opportunities) adds transnational value by strategically combining national expertise across the disciplines of oceanography, marine biogeochemistry, marine ecology, data and database management, earth system, marine and ecosystem modelling and science and policy communication.

The primary novelty of CE2COAST will be an observation-driven synthesis of statistical and dynamical downscaling methodology. The higher process resolution and detailed system representations are tailored address environmental pressures and services in regional and coastal domains. The researchers will analyze fit-for-purpose (driven) marine datasets from existing and new case study observations of ocean climate, biogeochemistry and ecosystems.

CE2COAST will deliver benchmarked single and ensemble Earth System Model simulations. These will be downscaled to study regional and coastal ocean domains by hindcasting changes in the physical, biogeochemical and climatic fields over the past 40 years and projecting them up to 80 years into the future. This will enable CE2COAST to deliver estimates of natural and forced variability of oceanic processes as well as regional and local mean states and trends of pressures on ocean services.

A capacity to understand and predict these impacts on regional seas and coasts is essential for developing robust strategies for adaptation and mitigation. To inform adaptation policies to oceanic and coastal change, CE2COAST will deliver key knowledge to end-users through a range of dissemination activities. Stakeholder clusters will enable participation in decision making throughout the project and facilitate co-production of science products tailored to specific scientific, management, regulatory, industrial and ecosystem service assessments. Crucially, CE2COAST has a strong educational and early researcher focus with a dedicated postdoctoral position. Plans include to develop a Continuous Professional Development module and to organise a summer school.

To combat the consequences of ocean change CE2COAST will pursue strategic coherence of national observation strategies where collective learning and slipstreaming leads to faster progress, ultimately delivering an integrated European evaluation of marine health and challenges. As such, CE2COAST has the potential to contribute knowledge for the alleviation of economic, scientific and social disparity across Europe. The project's targets for knowledge transfer and information sharing include JPI Climate, JPI Oceans, IPCC, UN Sustainable development goals, IPBES, UN DECADES, MSP, CFP, MSFD, WFD and the Arctic Council.



The CE2COAST project study domains

Consortium

Organisation	Acronym	Country
Norwegian Institute for Water Research	NIVA	NORWAY
NORCE Norwegian Research Centre AS	NORCE	NORWAY
Université de Liège	ULiège	BELGIUM
Institut de Recherche pour le Developpement	IRD	FRANCE
Marine Institute	MI	IRELAND
National University of Ireland Galway	NUIG	IRELAND
Marine and Freshwater Institute	MFRI	ICELAND
Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici	CMCC	ITALY
Latvian Institute of Aquatic Ecology, Agency of Daugavpils University	LHEI	LATVIA
University of Latvia	UL	LATVIA
Instituto Superior Técnico - University of Lisbon	IST	PORTUGAL
Atlantic International Research Centre	AIR CENTRE	PORTUGAL
Intergovernmental Oceanographic Commission - UNESCO	IOC-UNESCO	

Published by:

JPI OCEANS

JPI Oceans AISBL | Company number: 0691.970.779 | Rue du Trône 4
1000 Brussels | Belgium
Tel. +32 (0)2 626 16 60 | info@jpi-oceans.eu

www.jpi-oceans.eu

In collaboration with:

JPI Climate

www.jpi-climate.eu