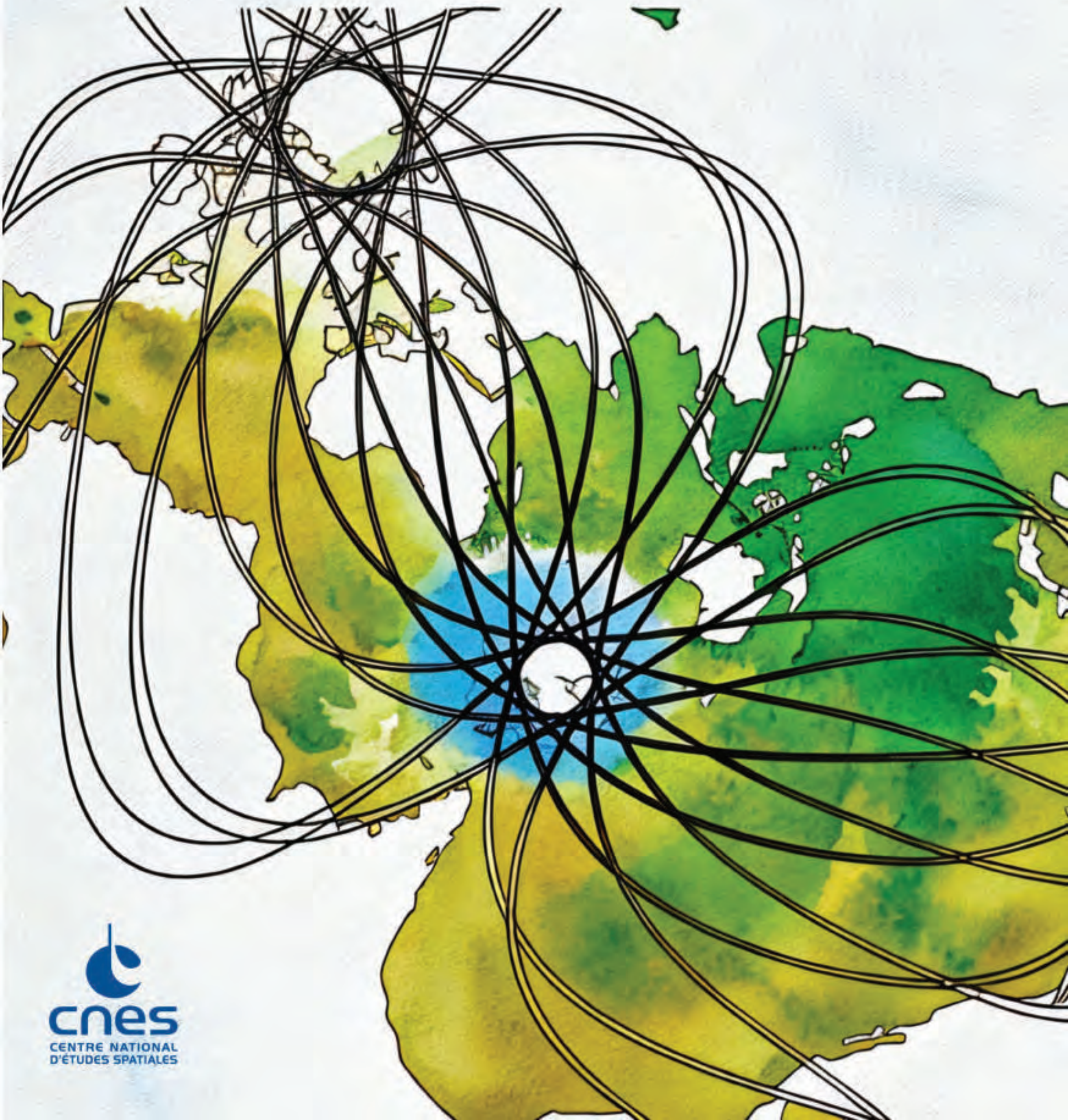
SWOT and the new wave of oceanographers

Early Career Researchers speak about SWOT



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SWOT and the new wave of oceanographers.
Early career researchers speak about SWOT.

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Preface

At the end of summer 2022, during the FilaChange workshop in Paris (France), Rosemary Morrow suggested I interview early career researchers involved in SWOT science.

At the time, Rosemary was the French SWOT Science Lead for Ocean, and I was collaborating with Francesco d'Ovidio (who has now taken the role of Rosemary) as Communication Officer of the SWOT Adopt-A-Crossover initiative.

During this international, multisite workshop, presentations by early career researchers significantly outnumbered those by senior scientists. Everyone I spoke with expressed genuine excitement about the new era in oceanography that was coming about with SWOT—and about the impressive cohort of early career researchers poised to contribute.

I immediately embraced Rosemary's idea and shared it with Francesco, who warmly gave me "carte blanche" to move forward. Together, we launched the "The New Wave of Oceanographers" interview series, reaching out to early career scientists with these questions:

- What is your field of research, and how did you choose it?
- How does your research relate to SWOT?
- What excites you about SWOT and the SWOT AdAC campaign you will be part of? How do you plan to contribute?
- What are your plans after analyzing SWOT data?

The first interviews were published on the SWOT AdAC website in February 2023, just days after SWOT delivered its initial nadir data. More followed before and after mid-April 2023, coinciding with SWOT Project Teams' release of preliminary images of SWOT-derived sea surface height and backscatter maps generated with data acquired by the SWOT KaRIn instrument.

As one SWOT Science Team member remarked at the time, "We all savored the historic moment when, for the first time in oceanography, the fine-scale landscape of sea surface height was revealed to our eyes!" That excitement and enthusiasm for the new era of oceanography opened by SWOT resonate strongly throughout the interviews.

Following the conclusion of SWOT's fast-sampling phase in summer 2023, the interviews paused but resumed in spring 2025. This time, the questions were asked retrospectively, and we included inquiries about the most exciting results to date.

Many readers reached out, expressing how much they enjoyed the interviews and found them an excellent way to highlight early career researchers' contributions to this new era of oceanography.

Francesco and I decided to share this energy more widely, and compiled the interviews into this ebook.

What follows is a collection of 52 interviews with early career researchers. Our definition is broad, including graduate students seeking a PhD, as well as assistant professors and postdocs within 10 years of earning their doctorate.

The interviews are grouped geographically into three parts, with the title of each chapter aiming to highlight the researcher's main scientific focus. As you will discover, this is no easy task—the research interests of this new wave of oceanographers span a diverse, dynamic ocean of ideas flowing in many directions.

We found these interviews to be truly inspiring, and we trust that you will enjoy reading them just as much as we did!

Tosca Ballerini

Introduction

Although science advances mostly incrementally, there are some special times when a novel concept, discovery, or technological advancement makes a revolution and suddenly changes the view that we have on a class of natural phenomena. The beginning of 2023, when SWOT transmitted the first kilometer-scale images of sea surface elevation obtained with its innovative interferometric radar altimeter, marked one of these rare moments for researchers studying the dynamics of the ocean surface

The excitement around SWOT data came from two main improvements. Before SWOT, maps of sea surface elevation – a key variable directly related to horizontal currents and indirectly to vertical movements – suffered by lack of resolution due to the fact that conventional satellite altimetry could only observe a point under the satellite. As a consequence, many tracks from different satellites had to be interpolated together in order to get two dimensional maps. Instead, SWOT's KaRIn instrument collects data along a cross-track band of about 120 km, allowing SWOT to directly map two-dimensional swaths of sea surface elevation and slope for deriving surface currents. KaRIn also provides a revolutionary increase in the accuracy of sea surface height measurements, with an accuracy improvement by about a factor of 30.

The days of the first acquisitions from SWOT were thrilling and nerve-racking. Besides the risks faced by any satellite mission, KaRIn was the first of its kind, and many uncertainties remained about noise and its performances under various sea conditions. From the very first data, we saw that the KaRIn signal-to-noise ratio surpassed even the more optimistic expectations, unlocking the observability of km-scale – and possibly smaller – sea surface elevation spatial variability. This resolution was more than one order of magnitude finer than what was previously available with conventional altimetry. At this scale, a complex seascape emerged of internal waves, vortices, and filaments. In some cases, even the swell was measurable. In March 2023, the impression was that someone turned on the light over an oceanic regime that until that moment had remained in the dark.

The existence of an energetic and dynamical regime in the 1-100 km range (sometimes referred as the "fine scales") was not by itself a surprise. High resolution models have predicted such motions for a few decades. Nevertheless, SWOT bridges a long standing gap between models and observation, and allows us to test and push forward the approximations and theories over which models stand. Consequences are far reaching and touch virtually any field of research related to ocean dynamics. Coastal circulation, mixing, heat and carbon sequestration, sea ice dynamics, ocean forecasting, as well as plankton diversity are only some of the examples of the subjects that are mentioned in the interviews of this book. Less than three years from SWOT's launch, there are already hundreds of SWOT-related contributions to conferences, special issues, and scientific journals.

SWOT is exciting to oceanographers because it is a next-generation altimeter that brings a new perspective to ocean dynamics. It is thus fitting that many exciting research discoveries from SWOT are being carried out by a new generation of oceanographers that also bring a new perspective to ocean dynamics. Tribute to their great contributions to SWOT science, this book is an attempt to document the thoughts of the generation of researchers who will help chart the course of oceanography's future, and provide a snapshot of their views through the lens of SWOT.

This book and its conception is also the result of the meticulous work of our great Communication Officer Tosca Ballerini. Thanks to CNES support, Tosca has been accompanying the SWOT «Adopt-A-

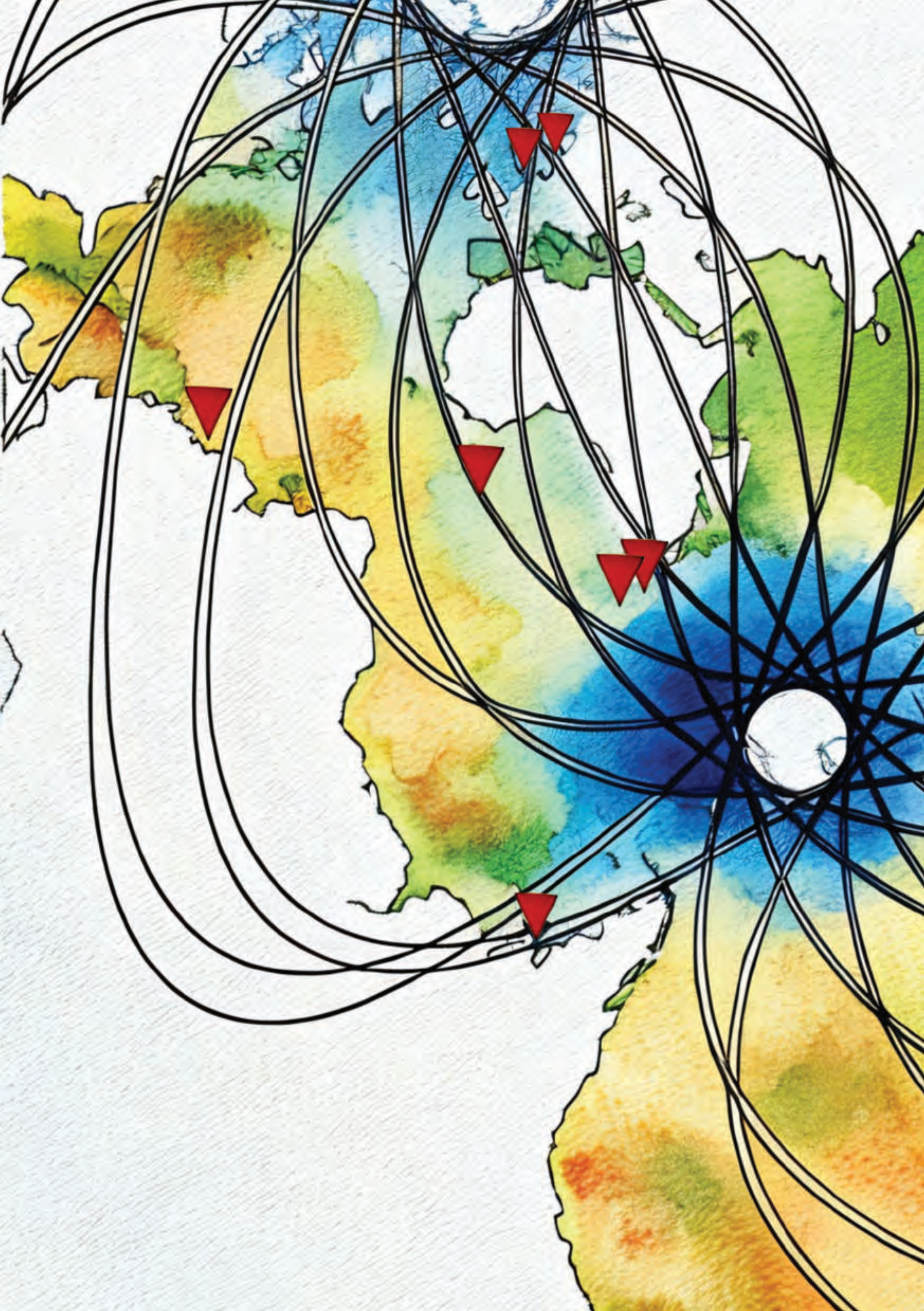
Crossover» (AdAC) community with hundreds of communications, conference support, and the SWOT AdAC web site since 2020. Tosca is still part of our team and we are sure that we will see other ideas coming out of her mind!

Before concluding, we need to note that SWOT goes beyond oceanography. Its high resolution observations of water level also covers continental waters and the cryosphere, and are providing exciting results in those fields. While this book covers mostly early-career researchers in oceanography, its forthcoming edition will extend to the hydrology and cryosphere community. The forthcoming edition will also be the occasion to add at least some of the many early-career researchers who have slipped out of this 2025 edition.

The SWOT Ocean PIs
Francesco d'Ovidio
Tom Farrar
Rosemary Morrow
Lee-Lueng Fu

PART 1

- Baltic Sea
- North Atlantic
- Amazon Shelf
- Tropical Atlantic
- Eastern South Atlantic
- Cape Basin
- Patagonian Continental Shelf



Identifying the specific pathways that control and affect the Baltic overturn circulation

Natalia Herrán

Nathalia earned her PhD from the Leibniz Centre for Tropical Marine Research (ZMT) and the University of Bremen, both located in Bremen, Germany. At the time of the interview, she was working as a postdoctoral researcher at the Leibniz Institute for Baltic Sea Research (IOW) in Warnemünde, Germany.

MAR 2023 - My field of research is physical oceanography and geomorphology. In this project I will be focusing on the understanding of specific pathways that control and affect the Baltic Sea overturn circulation. I grew up in a small coastal town, watching the power of tides and the ocean daily. When I was 12 years old, I started surfing, which became my hobby and real passion in life. Thanks to this sport I started to be aware of how beautiful and unique marine ecosystems are and how physical interactions play such an important role by shaping, for example, the functionality of such ecosystems.

In the CONWEST-DYCO (Circulation and Mesoscale Dynamics of the Eastern Gotland Basin – model comparison and coupling of high resolution in situ observations combined with Surface Water and Ocean Topography satellite (SWOT) and regional ocean models) campaign we are interested on the overturning circulation of the Baltic Sea. In particular the mesoscale dynamics on the Eastern Gotland Basin. The macro eddy formed there works as major forcing function for the overturning circulation of the Baltic Sea. The SWOT mission will provide valuable high resolution altimetry data, which give us a unique opportunity to depict high resolution geostrophic motion and flow in the Baltic Sea.

The development of new methodologies usually comes with high rewards but also great challenges. I am curious to see in high resolution the geostrophic motion of the Eastern Gotland Basin, which until now was only possible by using numerical models. Now we will be able to see if the theory deviates or not from the observations.

Hopefully, after the end of the CONWEST-DYCO campaign we will be able to continue, depending on funding opportunities, with the improvement of mesoscale numerical models in the Baltic Sea based on observational data. The continuation of this kind of research is highly relevant in the Baltic Sea because it is a very sensitive system to global warming. The increase of thermal stratification can affect substantially the whole thermohaline circulation and subsequently residence times in the Baltic Sea which is now thought to be 25 to 30 years.

Calculating energy fluxes across different scales to advance the understanding of oceanic energy cascades

Minghai Huang

Minghai currently holds a postdoctoral scholar position at Texas A&M University, in Texas. Prior to this appointment, he was affiliated with the University of Delaware, Newark, Delaware.

MAY 2025 - Multiscale processes are ubiquitous in the ocean and atmosphere. Related are many critical and intriguing problems such as hydrodynamic instability, frontogenesis, and eddy shedding, to name a few. I primarily study mesoscale eddies, focusing on their characteristics, energetics, and relationships with climate forcing. These studies were geographically along the western boundary current in the North Atlantic from the North Brazil region to the Gulf Stream. I am drawn to studying (sub)mesoscale eddies not only for their dynamic intrigue but also for their captivating aesthetic, as their intricate patterns and swirling movements create a visually stunning, natural beauty.

The energy cascade I've worked on in the past is more related to mesoscale eddies and relies more on models. SWOT can evaluate the spatiotemporal variability of small-scale current systems, allowing for accurate measurement of kinetic-energy fluxes at fine scales — a significant breakthrough in understanding ocean dynamics. Since SWOT captures various ocean processes such as mesoscale and submesoscale eddies, internal waves, and swells, the key is to distinguish these processes and calculate energy fluxes across different scales, which deepens our understanding of oceanic energy cascades.

SWOT is the first altimetry mission with a wide-swath and high precision, designed to capture small-scale features down to sub-100 km. It can detect phenomena such as mesoscale and submesoscale eddies, internal waves, and various coastal processes. SWOT can resolve features at several kilometres using unsmoothed 250m postings, surpassing the prelaunch KaRIn noise specifications and extending its range of applications beyond initial expectations. The evolution of the wavenumber spectrum across the globe at sub-100 km scales can be determined through the SWOT mission.

After the SWOT AdAC campaign, I will continue my academic career and keep applying the SWOT data.


SWOT

The interaction of internal solitary waves with mesoscale eddy dynamics

Chloe Goret

Chloé commenced her undergraduate studies in Marine Sciences at Aix-Marseille University (Marseille, France), where she specialized in the integration of physical oceanography and biogeochemistry, a focus she developed during her master's degree. She then completed her final internship at the Laboratoire d'Océanographie et du Climat : Expérimentations et Approche Numérique (LOCEAN) in Paris (France), after which she began her first professional role as a CNRS engineer within the Climate Environment Coupling Uncertainty (CECI) research group at the Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS) in Toulouse, France.

JUN 2025 - I am currently working on the detection of internal solitary waves and their interaction with mesoscale eddy dynamics off the Amazon shelf. Studying the interaction between mesoscale processes is a natural continuation of my academic background and my master's internship, during which I developed theoretical and technical skills that I can now apply to a new study region. But why internal waves? Because they play a structuring role in marine ecosystems and influence climate regulation. Understanding their variability and their interaction mechanisms is a major scientific challenge. What particularly motivates me is the dual scientific and technical challenge they pose. These structures are difficult to observe and model due to their nonlinear nature. Studying them requires combining high-resolution satellite observations, in situ data, and numerical modeling. This multi-sensor approach makes the subject even more stimulating. Finally, I chose this field because it offers the opportunity to work in an international context, collaborating with other research teams tackling similar global issues.

I use SWOT data to detect internal solitary waves which leave a clear signature on sea surface height. The objective of our study is to extract this signature from SWOT observations in order to characterize how internal solitary waves properties change when interacting with different types of eddies. We also plan to cross-analyze these observations with outputs from the AMAZON-36 model and with in situ data collected along a mooring deployed during the AMAZOMIX campaign. This comparison will allow us to test and validate hypotheses regarding the mechanisms of interaction between internal solitary waves and eddies. Furthermore, for SWOT, internal solitary waves represent both a scientific target and a signal that needs to be corrected in order to isolate other dynamic ocean processes. Detecting them is therefore essential to distinguish internal solitary waves from other mesoscale structures, such as fronts and filaments, which occur at similar spatial scales.

What excites me most about SWOT is its ability to revolutionize our observation of the ocean by providing, for the first time, high-resolution spatial measurements on a global scale. It is the first time that we can clearly observe the signature of solitary internal waves using altimetry data! These observations will allow us to validate the internal solitary wave/eddy interactions observed in the AMAZON-36 model. In the longer term, the success of the mission paves the way for a new generation of satellite missions, capable of revealing meso- and submesoscale structures that were previously difficult to detect. As I'm just beginning my career, I haven't yet had the opportunity to participate in SWOT AdAC campaigns, but I would really like to contribute to them.

After working on internal solitary wave/eddy interactions using SWOT data, I would like to pursue a PhD focused specifically on the detection methods for internal solitary waves in SWOT observations. My goal is to contribute to the broader challenge of extracting the signal of internal waves in altimetric measurements, which remains a major scientific and technical issue in the analysis of high-resolution altimetric data.

The ageostrophic components of ocean surface currents in the tropical Atlantic

Julio Leonel Donfack

Julio earned a Master's degree in Mathematics and Fundamental Applications with a focus on Probability-Statistics and Finance from the University of Yaoundé I (Yaoundé, Cameroon). He subsequently pursued a Master's in Physical Oceanography and Applications at ICMPA–UNESCO Chair (Abomey-Calavi, Benin) in partnership with the University Toulouse III – Paul Sabatier (Toulouse, France), which he successfully defended in September 2024. His Master's research internship was conducted at the Institute of Environmental Geosciences (IGE), CNRS, Grenoble (France), where he collaborated with Emmanuel Cosme and Clément Ubelmann on satellite altimetry and surface current reconstruction.

JUN 2025 - My research focuses on the analysis of ocean surface currents in the tropical Atlantic, particularly the study of ageostrophic components using a combined approach of drifter data and satellite altimetry, including SWOT. Coming from a background in applied mathematics and statistics, I was drawn to oceanography because it brings together theory, data, and societal impact. I was inspired by the potential to apply mathematical tools to real-world ocean challenges like climate change, marine resource management, and pollution tracking.

I discovered the SWOT mission during my Master's program in Physical Oceanography. At that time, several PhD students and academic mentors often mentioned the name of Babette Christelle

Tchonang, a fellow Cameroonian who had made remarkable contributions to the validation of SWOT data through Observing System Simulation Experiments (OSSEs). She had recently been recruited by NASA, and her journey deeply inspired me — she became a true role model. I told myself: "I will follow in her footsteps." I am also very grateful for her continued support, as she never hesitates to advise and guide me in my academic path. Later on, during a course on ocean modeling with Python taught by Professor Emmanuel Cosme in Cotonou, he also discussed the SWOT mission. He proposed a single research topic, and I chose it. The topic focused on the reconstruction of surface currents using drifting buoys and altimetric products. Initially, it did not include SWOT data — but I was so passionate about the mission that I pushed to integrate them. I first conducted analyses using CMEMS products and drifter data to reconstruct surface currents. My supervisor considered this sufficient for a Master's thesis. However, with about two months remaining in my internship, I asked if I could also analyze SWOT data to assess their added value compared to conventional nadir altimetry. He agreed, and that marked a turning point for me. Working with such revolutionary satellite data was both exciting and rewarding.

In my Master's research, I used SWOT sea surface height (SSH) data to compute geostrophic surface currents and compared these to velocities derived from drifting buoys in the tropical Atlantic. I investigated how well SWOT captures both geostrophic and ageostrophic components of currents, particularly in regions where fine-scale dynamics are important. I applied filtering techniques to SWOT's swath data and analyzed directional discrepancies—finding, for example, that the zonal component of velocity correlated more strongly with drifter data than the meridional one, due to swath geometry and SSH gradient sensitivity.

My dream is to pursue a PhD focused on the integration of SWOT data into operational oceanographic models and data assimilation systems for the tropical Atlantic. I want to contribute to improving short-term current forecasts, which are critical for sea rescue, oil spill monitoring, fisheries management, and navigation. I also hope to help build capacity in West and Central Africa, where satellite altimetry and ocean data science remain underdeveloped. Ultimately, I would like to combine research, teaching, and scientific outreach to bridge the gap between cutting-edge Earth observation missions like SWOT and the needs of vulnerable coastal communities. Additionally, I have a scientific question that I hope to explore further during my research: Can SWOT help predict the trajectories of drifting buoys in the Atlantic Ocean? This question emerged during my previous research, and I'm keen to explore its potential implications for improving oceanographic predictions in this region.

Measuring meso- to sub mesoscale turbulence

Ilmar Leimann

> Ilmar completed his undergraduate and graduate studies at the University of Kiel (Kiel, Germany), in partnership with the GEOMAR Helmholtz Centre for Ocean Research, specializing in Climate Physics, Meteorology, and Physical Oceanography. At the time of the interview, he was pursuing his PhD at MARUM and the Institute of Environmental Physics (IUP) at the University of Bremen (Bremen, Germany).

MAR 2023 - Over the years, I have participated on several scientific cruises with different research institutes and worked with diverse measurement devices. Based on these experiences, I got hooked up with the question, "How could we measure and estimate meso- to submesoscale turbulence in the ocean?" My aim is to assess turbulence regimes and quantify horizontal wavenumber spectra for the upper ocean on the meso- to submesoscale. To achieve my objectives, I will be using and combining observational data from surface drifters, satellite gliders, ship ADCP, lowered ADCP, wave radar, and microstructure turbulence. Additionally, to better interpret the observational results, I'm using a high-resolution ICON submesoscale telescope simulation, which is based on an unstructured grid and allows us (for a short time period) to use extremely fine spatial resolutions of up to 600m in the focus region. Thus, we could find small-scale coherent structures in the model that we associate with the submesoscale and define as being smaller than the Rossby radius of deformation.

Determining Meso- to Submesoscale Turbulence and energy cascade in the ocean are challenging since they depend on the horizontal resolution of data sets. Gridded satellite data give a good global overview, but have been over the years barely resolving the Rossby radius resolving. The SWOT mission will close this cap since it provides 10 times the resolution of ocean measurements than the data from other satellites. Additionally, it will provide the data over the whole year, and one aim of my thesis is to estimate and understand the seasonality of the submesoscale turbulence and energy cascades in the area around the Walvis Ridge, which is characterised by internal tides emanating from the ridge and (sub-)mesoscale eddy activity.

Our SONETT campaign, in which I will be participating, is a project within TRR181, 'Energy Transfers in Atmosphere and Ocean'. The campaign will take place partly in parallel with the Cal/Val phase of the SWOT satellite mission, and the region (the area around the Walvis Ridge) lies just below the path of SWOT when in a repeated day orbit, thus giving us a great opportunity to compare the SWOT-data with our measurements. Our observational program includes the study of mixed-layer processes, mesoscale and submesoscale circulation, horizontal mixing processes, internal waves, and energy dissipation. It is complemented by a modelling project where a general circulation ocean model is set up with a telescoping grid for the target region to evaluate the consistency of the observations as well as validate the models with the observations. The instrumentation includes two short-term moorings, an underway CTD system, gliders, drifters, wave radar, and microstructure turbulence measurements.

After the campaign, the first thing on my list is to print out my poster for EGU23, Vienna. Later on, I will concentrate on the observational data processing of SONETT and on a more detailed comparison with SWOT data. Additionally, I hope for further collaborations and future projects within the SWOT community.

The role of fine scale dynamics in controlling oxygen supply in the Arabian Sea

Estel Font

Estel holds a Bachelor's degree from the Universitat Autònoma de Barcelona (Barcelona, Spain) and earned her Master's degree from the University of Gothenburg (Gothenburg, Sweden), where she is currently completing her PhD in the Department of Marine Sciences.

MAR 2023 - I am a physical oceanographer looking at fine scale dynamics in the Gulf of Oman and their role in ventilation of the Arabian Sea oxygen minimum zone using underwater autonomous vehicles.

We use gliders to measure fine scale fronts and structures that SWOT will be able to see form space and capture their variability.

During the SWOT fast-sampling phase, I will take part in the QUICCHE campaign, in the Cape Basin region. I'm very excited to see a lot of different observations and instruments (Lagrangian and Eulerian in the ocean) working together with the high-resolution satellite observations for a common goal. Also, expanding my knowledge to another region! I will be deploying 2 underwater autonomous vehicles (SeaExploer gliders) measuring turbulence, currents, and biogeochemical fluxes (nitrate, oxygen…).

After the end of the campaign, I will keep working on fine scale observations in the Gulf of Oman (PhD research topic) and hopefully at some point look at the data collected by QUICCHE. I'm sure there are a lot of points in common with the datasets and research questions.

JUL 2025 - Participating in the QUICCHE SWOT AdAC campaign was an enriching experience. We navigated storms in the Cape Cauldron, South Africa, alongside a diverse and empowering team. I had the opportunity to lead the deployment of two SeaExplorer gliders equipped with turbulence probes and biogeochemical sensors. I was also involved in collecting data from a wide range of platforms, from traditional CTDs to a diverse set of platforms, such as Lagrangian drifters, the Wire Flyer, surface platforms (Sailbuoy, Wave Gliders), VMPs, APEX floats, CPIES, and moorings. It was exciting to witness how the combination of satellite observations and such a diverse suite of in situ tools can deepen our understanding of submesoscale and fine-scale ocean processes.

Although my PhD research was already defined and didn't allow me to analyze the QUICCHE dataset directly, exciting research using the data collected has already been published and more is underway! Moreover, this experience resulted in being invited to contribute to a special issue Tools of the Trade of Nature Reviews & Environment, where I had the unique opportunity to explain how autonomous gliders have become indispensable tools in modern oceanography.

Besides SWOT, my research focuses on the oxygen minimum zone of the Arabian Sea, with a particular interest in the role of fine-scale dynamics in controlling oxygen supply. The Arabian Sea hosts the world's most intense oxygen minimum zone, where a delicate and still poorly understood balance exists between physical processes and biological activity.

I use data from ocean gliders, autonomous floats, and numerical models to examine how key water masses - from surface and mode waters, to the dense outflows of the Persian Gulf - contribute to the ventilation of the upper boundary of the Arabian Sea oxygen minimum zone. I investigate the mechanisms driving stratification and oxygen supply across a range of spatial and temporal scales, from monsoonal cycles and synoptic wind events, to mesoscale eddies, submesoscale fronts, and turbulent mixing. The findings highlight the key role of physical processes in modulating oxygen variability and offer new insights into the dynamics sustaining one of the ocean's most oxygen-depleted regions.

How the interactions between fine-scale fronts and winds modulate turbulence

Isabelle Giddy

Isabelle earned her PhD through a collaborative program involving the Southern Ocean Carbon-Climate Observatory (SOCCO), the Council for Scientific and Industrial Research (CSIR), the University of Cape Town (Cape Town, South Africa), and the University of Gothenburg (Gothenburg, Sweden). At the time of the interview, she was beginning a postdoctoral fellowship in the Polar Gliders research group at the University of Gothenburg.

MAR 2023 - I currently study the role of wind-driven turbulence in mediating momentum and heat flux in the upper ocean using high resolution observations made by autonomous underwater vehicles (gliders). My PhD research looked at submesoscale flows in the ice-impacted Southern Ocean. I first became interested in this field because of the importance of the Southern Ocean in regulating our climate, and then also because of the tight link between the technological innovations related to gliders and the scientific research questions that their observations facilitate.

I research the interaction between submesoscale fronts and winds. SWOT will provide high resolution observations of sea surface height and anomalies which will allow me to better understand and characterize the fronts that we are observing in the ocean.

The high spatial and temporal observations of sea surface height made by SWOT will provide an unprecedented view of the submesoscale ocean. During the SWOT fast-sampling phase I will take part in the QUICCHE campaign, which is located in the epicenter of probably the highest eddy kinetic energy region in the world, the Cape Cauldron. It will be incredibly exciting to link the observations from SWOT with in situ observations we will make with underwater gliders in this turbulent region.

After the end of the campaign, I will be starting a postdoctoral research fellowship, using fine scale (<10 km) observations made during the QUICCHE cruise, together with a range of observations from the Southern Ocean to research how the interactions between fine scale fronts and winds modulate turbulence.

Analyzing heat fluxes between the atmosphere and the ocean interior

Johan Edholm

At the time of the interview, Johan was serving as a research assistant in the Polar Gliders research group at the Department of Marine Sciences, University of Gothenburg (Gothenburg, Sweden).

MAR 2023 - My field of research lies within observational physical oceanography, and my interests include the transfer of heat and momentum between the atmosphere and the upper ocean, specifically in the Southern Ocean as this is an area that is globally very significant in terms of absorbing anthropogenic carbon and heat. In my work, I examine atmospheric weather systems and submesoscale ocean dynamics that can affect key climate variables over time and space scales. As a part of the Polar Gliders research group, we use a combination of observations from autonomous ocean robotics, atmospheric forecasting models, satellites, and ship-based measurements. Recently, I've overseen the group's data curation, and produced beautiful and useful figures for our recent field campaign, SO-CHIC. I spent my childhood in the archipelago just south of Gothenburg, fishing, tinkering with boat engines, and solving everyday problems around the house. This has led to an intense curiosity for the ocean, and how it all works.

SWOT will capture the sea surface height at an unprecedented resolution. This in turn will allow us to categorize and detect ocean eddies and filaments with a much higher resolution than before. Comparing these data with our in situ data collected by uncrewed surface vessels means that we can evaluate the leakage of heat and carbon from the Agulhas current to the South Atlantic, and eventually the meridional overturning circulation.

Growing up with an interest in technology and watching NASA launches since the late 90's, I think it is super cool to end up with "your own" satellite. I am super excited to go to sea again, on the QUICCHE cruise. The pandemic really shut that type of science down, and we are all happy to start again! Secondly, I will be using our in situ data from the cruise, together with the SWOT, to analyze heat fluxes between the atmosphere and the ocean interior.

After the QUICCHE campaign, I plan to be working on the data we will have collected, which can seem like a boring answer, but I'm very excited about that part as well! I think the science community will benefit greatly from this campaign, especially physical oceanography.

Atmospheric and oceanic coupling processes in the Cape Basin

Michaela Edwinson

At the time of interview, Michaela was a Master's student at the University of Gothenburg (Gothenburg, Sweden), conducting research in the Polar Gliders group,with a focus on air-sea fluxes.

FEB 2023 - Atmospheric and oceanic coupling processes have always fascinated me, that's when I decided I wanted to learn more. This got me into a project of air-sea fluxes in the Cape Basin together with the Polar Gliders group led by Sebastiaan Swart at the University of Gothenburg and the QUICCHE campaign. As I'm just entering the field related to my current master thesis, I'm excited to learn more and find relations between heat flux, high energy eddies, storms and to have a look at how accurate reanalysis models, such as the ERA5, are together with this in situ data.

Quantifying Interocean fluxes in the Cape Cauldron Hotspot of Eddy kinetic energy, the QUICCHE campaign will collect new observations in the Cape Basin, a global hotspot for eddy kinetic energy due to Aghulas leakage, during March 2023. Investigated regimes will be used to quantify heat fluxes among other things, and the QUICCHE operations will be in one of the SWOT daily crossovers. The collaboration will go two ways where QUICCHE observations will be used to evaluate SWOT by providing in situ measurements of sea surface height and stratification and SWOT will provide information about surface dynamics at time- and spacescales not seen before.

SWOT AdAC campaigns are a very exciting, new contribution in giving a new tool for scientists all over the world to understand the oceans dynamics better. I will contribute by joining in field of the QUICCHE campaign, departing from Cape Town 5th of March 2023 and help with operations on board, such as with gliders, sail-buoys, moorings, CTDs and more. I will also take care of daily quality control of meteorological, temperature and salinity data as well as computing heat flux with this data on board.

After the campaign I will keep on working on my master's thesis for about a year to get a master's degree in physical oceanography in June 2024.

The influence of heat and salt exchange on the Atlantic Meridional Overturning Circulation

Nikita Qosholo

Nikita completed his undergraduate studies at the University of Cape Town (Cape Town, South Africa), earning a Bachelor of Science degree with majors in Marine Biology and Ocean & Atmospheric Science. At the time of the interview, he was pursuing an Honours Degree in Oceanography at the same university.

My field of research is physical Oceanography. I am beginning my Honours research project using observational data from autonomous surface vehicles - a Sailbuoy and a Waveglider - to identify and characterize submesoscale features present in the Cape Basin. The Cape Cauldron is a highly dynamic region of the South Atlantic where Agulhas rings transport warm salty water from the Indian Ocean into the South Atlantic. Studies on the dynamical processes that occur here are crucial for understanding heat transport in the ocean. Personally, I chose this project because of the role that ocean heat and salt exchange in this region has on regulating our climate through its influence on the Atlantic Meridional Overturning Circulation. I was thrilled to get the opportunity to join the QUICCHE research cruise, and be part of collecting my own data.

SWOT data is providing us with a completely new view of the ocean surface. Seeing the first images feels almost like the moment when earth was first seen from space. I am excited to interpret the in situ data I am collecting while at sea within the larger scale context that the SWOT satellite will provide. I'm also happy to be part of such cutting-edge science.

After the end of the QUICCHE campaign I intend to continue in oceanographic research and get my PhD.

Nutrients in the Cape Basin region

Nothando Duma

Nothando earned both her Bachelor of Science and BSc Honours degrees in Marine Biology from the University of KwaZulu-Natal (Durban, South Africa). At the time of the interview, she was pursuing a Master's degree in Applied Ocean Sciences at the University of Cape Town (Cape Town, South Africa).

MAR 2023 - My field of research is Marine Biology. For my Masters dissertation, I specifically focused on examining and identifying Late Cretaceous fossil bryozoans from Needs Camp, South Africa. I chose Marine Biology because I was interested in working in marine science. I got the opportunity to become part of the QUICCHE cruise, collecting nitrogen and dissolved organic nitrogen, and other nutrients. My participation has given me field experience and exposed me to the various deployments of physical oceanographic instruments, which originally is not part of my academic background.

I find SWOT exciting because of its high-resolution data collection that reveals finer scale oceanographic features, helping us in understanding them. My contribution to this campaign is assisting in various oceanographic instrument deployments and data collections.

After the end of the QUICCHE campaign I plan on continuing my studies by finding a PhD project.


OPEN

The effect of warm and salty Indian Ocean water leakage on the dynamics of the Cape Cauldron region

Sijing Shen

Sijing obtained her Bachelor of Science degree from the College of Marine Sciences at Shanghai Ocean University (Shanghai, China). She subsequently earned her Master of Science degree from the School of Ocean Science at Bangor University (Bangor, United Kingdom), where she was also pursuing her PhD at the time of the interview.

APR 2023 - My field of research is mainly on Physical Oceanography, concentrating on the impact of warm and salty Indian Ocean water leakage into the Cape Cauldron region of the southeast Atlantic. In my research, I figure out the long-term trends in ocean heat content distribution across the Cape Basin with satellite and reanalysis hydrographic data including temperature, salinity, and height. After that, vertical and horizontal mixing rates from eddies and filaments across the Cape Basin will be examined with echosounder data and VMP (Vertical Microstructural Profile) data. Finally, I will combine these physical processes with the ecosystem in Cape Basin. Fed by the warm and salty Agulhas Current leakage, the Cape Cauldron is a global hotspot of eddy kinetic energy, tied with the stability of the Atlantic Meridional Overturning Circulation (AMOC) and climate change. So far, how much energy influences the AMOC has not been quantified. That is the reason why I choose this research as my PhD project. My current research is part of the QUICCHE (Quantifying inter-ocean fluxes across the Cape Cauldron hotspot of eddy kinetic energy) project. QUICCHE is one of the campaigns in the SWOT AdAC Consortium.

It is challenging to collect not only high-resolution but also large-region data during the cruise but these data are the key to unlock several important ocean questions. SWOT can fill this 'data gap'. I feel excited and look forward to using SWOT satellite data. I will be participating in the QUICCHE project, one of the SWOT AdAC campaigns. I will help interpret and exploit SWOT data in Cape Cauldron with in situ observational data.

After the campaign, I will keep going in academia. I plan to apply for a postdoctoral position or an academic job in Oceanography. The positions which are related to SWOT will be my preference.

Autonomous gliders to measure CO_2 concentration

Tesha Toolse

Tesha completed a BSc (Hons) degree in Ocean and Atmosphere Science, followed by an MSc specializing in Physical Oceanography, both at the University of Cape Town (Cape Town, South Africa). At the time of the interview, she was pursuing her PhD with the Southern Ocean Carbon-Climate Observatory (SOCCO-CSIR), in affiliation with the University of Cape Town.

MAR 2023 - My field of research is the synoptic scale air-sea exchange of carbon dioxide in the Southern Ocean using insight from autonomous gliders. To be more specific, how storms and sub-mesoscale features like eddies impact the air-sea exchange of carbon dioxide.

During the SWOT fast-sampling phase, I took part in the QUICCHE expedition in the Cape Basin region. The high-resolution altimetry data that will be provided by SWOT would be beneficial in the identification of sub-mesoscale features and improve on the largely lacking high resolution observations of such features. During the QUICCHE expedition, we've deployed a wave glider which will record carbon dioxide observations of the surface ocean and the atmosphere at one of the crossovers of SWOT.

The Wave Glider has the ability to take meteorological measurements as well as atmospheric and oceanic CO_2 observations, amongst others, making them crucial observing platforms in remote parts of the ocean. I joined the QUICCHE team to help deploy one of those

Wave Gliders and take underway CO_2 measurements from the ship. These efforts will help enhance our understanding of the sub-meso-scale air-sea CO_2 exchange which governs the Agulhas leakage. What makes QUICCHE a one-of-a-kind expedition for me is the use of a large array of instruments which include gliders, CTD, profiling floats, vertical microstructure profiler, wireflyer, moorings, drifters, and of course, all collocating with the SWOT crossover! An Oceanographer's pot of gold, right?

After the QUICCHE campaign, I plan to continue my PhD work in the Southern Ocean until the SWOT dataset will be made available and the analysis of the data from QUICCHE may begin.

Cross frontal exchanges and eddy heat fluxes

Ali Johnson

At the time of the interview, Ali was a PhD candidate at the University of Rhode Island Graduate School of Oceanography (Rhode Island).

MAR 2023 - I am an observational physical oceanographer interested in submeso- to large scale ocean dynamics. I currently study cross frontal exchange and eddy heat flux across jets of the Antarctic Circumpolar Current in the lee of major topographic features.

I hope to look at various spatial scales of horizontal diffusivity within a mixing length framework in the Cape Cauldron region as part of the QUICCHE campaign. SWOT data will help me characterize the largest scales of mixing at high spatial and temporal resolution to compare with measurements collected during our cruise in March 2023.

The purpose of the QUICCHE experiment is to make observations of mixing at unprecedented temporal and spatial scales. Only SWOT provides the level of resolution required to aid in the parameterization of these processes. I'm excited to be able to use some of the first data from the SWOT missions!

After the end of the campaign, I plan to use data from the QUICCHE campaign in concert with data collected during a month-long cruise in the Cape Cauldron region of the South Atlantic to finish my Ph.D. work. I will likely look for post-doc positions and hope to continue working with the QUICCHE team.

Exploring how surface variability relates to mixing and ventilation in the ocean interior in the Cape Basin region

Renske Koets

Renske holds a Bachelor's degree in Applied Physics and a secondary teaching qualification in Physics from Eindhoven University (Eindhoven, Netherlands). She is currently pursuing a Master's degree in Physical Oceanography within the Polar Gliders Research Group at the University of Gothenburg (Gothenburg, Sweden).

APR 2025 - Growing up in a coastal town in the Netherlands, I developed a strong connection to the ocean. I often checked wind and wave forecasts to plan my surf and sail sessions, which gradually led to a deeper interest in the physics behind the ocean conditions. In high school, I built a simple model to predict the best windsurf sail based on real-time data we collected at sea. Later, for my bachelor thesis, I studied the physical processes behind sand ripple formation on beaches. I've always been fascinated by how small-scale ocean physics can drive larger-scale processes and influence the global climate. That interest led me to study fine-scale ocean ventilation, where I focus on how these processes affect the transport of oxygen and particles from the surface to deeper layers in the ocean.

SWOT's high-resolution sea surface height data offers new insights into fine-scale ocean features. When combined with in situ observations, it allows us to link surface signatures to subsurface processes.

This can improve our understanding of ventilation and the fine-scale processes that transport oxygen and particles into the ocean interior.

SWOT provides a detailed view of the ocean surface that was previously hard to resolve, making it an effective tool for studying submesoscale processes. The QUICCHE campaign brought this data together with in situ observations, allowing me to explore how surface variability in the Cape Basin relates to mixing and ventilation in the ocean interior.

After completing my Master's, I plan to pursue a PhD focused on submesoscale ocean dynamics and ventilation. I want to combine in situ and satellite observations to better understand how small-scale processes influence physical and biogeochemical cycling. With this knowledge, I aim to contribute to improving ocean models and enhancing climate predictions.

The spatio-temporal variability of vertical velocities

Solange Coadou-Chaventon

Solange studied at the Geosciences Department of the École Normale Supérieure (ENS) in Paris (France) before specializing in Physical Oceanography during her final year of the Master's program at the Institut Polythecnique (IP) de Paris, following the WAPE (Water, Air Pollution and Energies) program. In 2022, she began a joint PhD program between the Laboratoire de Météorologie Dynamique (LMD) at ENS Paris and the University of Gothenburg (Gothenburg, Sweden), within the Polar Gliders Research Group.

MAY 2025 - My PhD investigates ocean fine-scale features (<10 km) across contrasting regions, making use of high-resolution data sets collected by autonomous platforms (Saildrones, gliders) and satellite observations. Choosing to study the ocean was almost an obvious choice given my strong attraction for this environment and its main role in regulating our climate. As soon as I realized that maths and physics could be used to describe the patterns and structure of oceans, I became fully convinced. However, the choice of my current field of research is the happy result of discussions and encounters. At first, I was determined to work on polar regions given their high vulnerability under climate change and, to be honest, in the hope of getting to discover these remote environments through field work, which I have since reconsidered. While looking for a PhD, I was introduced to the Polar Gliders group in Gothenburg, Sweden. Given the expertise of Sabrina Speich and Sebastiaan Swart, we decided to frame a PhD project on oceanic fine scales. In the end, I chose this field of research because of the people I had an opportunity to work with, which I consider a vital part of what science means to me. Over time, I've made this topic my own and I've discovered where and how I want to navigate within this ocean filled with fine scales.

SWOT is providing a two-dimensional view of the Sea Surface Height across a 120-km wide swath at 2-km resolution. The first observations have confirmed its ability to detect features at spatial scales 10 times smaller than conventional altimeters, resolving structures down to 5 km. So far, the dynamics of submesoscale features have been mainly studied from geophysical fluid dynamics theories, high-resolution numerical simulations, and sparse in situ observations. This has limited our ability to assess the representativeness of these in situ measurements and evaluate the accuracy of high-resolution ocean models. Using SWOT observations in synergy with other data sets will hopefully help us fill this gap.

I haven't been on any of the SWOT AdAC campaigns and only started working with SWOT about a year ago. However, I've already enjoyed being a part of the scientific community working on this new dataset. It also offers a great opportunity to interact with people from all over the world. To me, the most exciting aspect of working with the SWOT observations is that everything has yet to be explored! There isn't much literature yet on the actual data, which leaves a lot of freedom and space to think outside the box.

So far, I have been using in situ observations from a Seaglider and from more than 100 CARTHE drifters deployed during the QUICCHE campaign, to validate the SWOT observations in the Cape Basin. By comparing SWOT observations in the Agulhas Retroflection region with previous altimetric products, we revealed that SWOT captures on average 15% more fronts. Agulhas Current's frontal features were also found to be significantly sharper in SWOT, in particular smaller and high Rossby number fronts.

I'm at the end of my PhD and currently working on my last chapter. I'm applying the effective Surface Quasi-Geostrophy theory to the SWOT observations from the science phase over the Agulhas region. With almost two full years of data available, this will allow me to investigate the spatio-temporal variability of vertical velocities, which are closely related to vertical fluxes of tracers. With the WHIRLS experiment coming up in June 2026, this study could be very helpful in guiding the sampling strategy of autonomous platforms in particular. After my PhD, I intend to look for a postdoc, ideally focusing on SWOT observations and linking them with vertical fluxes of properties at the air-sea interface and in the ocean interior.


CROSSFIT

Sea level anomaly dynamics on the Patagonian continental shelf

Laura Ruiz-Etcheverry

Laura earned her PhD at the Centro de Investigaciones del Mar y la Atmósfera (CIMA), University of Buenos Aires (Buenos Aires, Argentina). She then spent three years as a postdoctoral researcher at the International Pacific Research Center, University of Hawaii at Manoa (Hawaii). Currently, she is an assistant researcher at CIMA and an associate professor at the University of Buenos Aires.

MAR 2023 - My field of research is physical oceanography with focus on sea level anomaly dynamics. I chose oceanography when I was in high school. I have always loved the ocean and I enjoyed snorkeling and scuba diving. Marine biology was an option for me until I heard about physical oceanography, and it caught my attention. I was curious about the physics of the waves. Once I was at the university, I discovered more about the ocean, and I decided to apply my knowledge through satellite altimetry. Nowadays, I'm involved in three main projects: 1) sea level trends in the Southwestern Atlantic using altimetry data and model data; 2) sea level variability due to density effect, the so-called steric effect at different temporal scales using model data and high resolution in situ date; 3) the dynamics of CO_2 in the Drake Passage.

I have been working with altimetry data since my Ms Thesis in a region where there is a lack of in situ data. Our work group, led by Dr. Saraceno, has made the effort to validate altimetry data and to study the dynamics of the Southwestern Atlantic at different time/spatial scales. SWOT is a natural product to be excited about and be able to understand the sub-mesoscale in a region where the available gridded altimetry product has shown high kinetic energy. In the same way, SWOT data will provide new information about the Patagonian Continental Shelf, one of the most productive areas of the world. One of the SWOT tracks will cover the Patagonian continental shelf, and I am involved in a project in which one of the objectives is to deploy instruments under the track and validate the data.

SWOT is an exciting mission technologically and scientifically. It was great to watch the launch online and share the excitement with people all around the world. I am thrilled to see and analyze the 90-day data record over the selected tracks. I am expecting to see fine filaments and structures such as in chlorophyll images without worrying about clouds. In the past I have been part of oceanographic campaigns for regional studies. It is now exciting to be part of a campaign to collect in situ data to exploit with SWOT data in collaboration with international research groups and be part of the group that represents South America. My role in the campaign for the deployment of the instruments is to help in the preparation and organization.

After the deployment of the instruments under the SWOT pass number 7, we will put our energy into preparing the campaign for the recovery of those instruments. It is not that easy to have access to a ship, and we will share it with other groups. Then, I hope to find enthusiastic undergraduate and PhD students to process and analyze the in situ data collected and to prepare to analyze SWOT data.

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JUL 2025 - The recovery of one ADCP moored during the Cal/Val period was successfully done in August 2024 after two failed attempts. Thus, the expectation of the in situ data was high, especially because we couldn't recover the second instrument. We downloaded the data in a computer in our office and we were very worried about making a mistake! We took photos and filmed the process and celebrated when we saw the time series on a plot. The data is analyzed by Sebastián Cornejo-Guzmán, a PhD from University of Buenos Aires. The main result of his study indicates that the tide and atmospheric corrections are a source of error in the Patagonian Shelf. It is necessary to evaluate regional corrections for a better performance of SWOT SSH. The main objective of validating daily SWOT data was to capture a rapid wave (period of ~4-5days) that propagates northward along the shelf. Sebastián found out that the periodicity of the wave is not well captured by SWOT, observing an aliasing effect.

Fortunately, I am a PI of a project funded by CNRS in the framework of ROSES – TOSCA call. The project, PATASWOT - Comprehending the Physical processes impacting the Patagonian Southwestern Continental Shelf and adjacent open ocean using SWOT data, is multidisciplinary and gathered researchers from Argentina, Italy and France. Currently, we are preparing an oceanographic cruise on board the vessel R/V Falkor (too) to deploy ADCP, temperature and salinity recorders and drifters, among others. The objective is to generate new knowledge on the interaction between submarine morphology associated with submarine canyons on the Argentine Continental Margin (ACM) and the oceanographic dynamics linked to the Malvinas Current (MC), in two key sectors of the shelf break: the Patagonian region (from now on Southern System, 44-45°S) and the Bonaerense region (from now on Northern System, 40-41°S). Research activities are scheduled between September 22 and October 22, 2025.

The impact of mesoscale and submesoscale processes on biogeochemistry and ecosystems

Sebastián Cornejo-Guzmán

Sebastián earned his degree in Geophysics from the University of Concepción (UdeC) in Chile. Following graduation, he worked as a research assistant in both the Department of Geophysics and the Department of Oceanography at UdeC. During this period, he was also affiliated with the Millennium Institute of Oceanography (IMO-Chile) and the Center for Ecology and Sustainable Management of Oceanic Islands (ESMOI). Currently, he is a PhD candidate at the Department of Atmospheric and Oceanic Sciences (DCAO) at the University of Buenos Aires in Argentina, associated with the Center for Research of the Sea and Atmosphere (CIMA), and holds a doctoral fellowship from the National Scientific and Technical Research Council (CONICET).

JUL 2025 - My research splits into two main areas: first, the physical oceanography of mesoscale and submesoscale processes and their impact on marine biogeochemistry and ecosystems. Second, I focus on marine spatial planning and the anthropological interaction with coastal zones and the blue economy. The story of how I chose this path began with an early interest in both the exact and social sciences, sparked by childhood passions for paleontology and astronomy, which later evolved into physics, climate change, and political science in my teenage years—I have to admit, Lisa Simpson was a key fictional role model (haha). When I arrived at university, these varied interests found a perfect niche in geophysics, thanks to Dr. Carolina

Parada. She is a biologist in a world of physicists who, amidst equations, guided me and my peers toward the biophysics and biogeochemistry of marine ecosystems. This scientific path, combined with my personal worldview—a holistic perspective on our planet shaped by the Buddhist-anarchist ideas of Gary Snyder, the teachings of Murray Bookchin and his book "Social Ecology and Communalism," and the punk scene—allowed me to find a true synergy between my humanist leanings and my passion for physical reasoning through these two converging lines of inquiry.

If you ask me how my field of research is related to SWOT, I will answer: It's related to EVERYTHING! My first steps in ecosystem oceanography were through numerical modeling, where I fell in love with the chaotic structures of mesoscale processes and how they clearly influenced ecosystem variability through biogeochemistry, especially in remote areas. This opened up two worlds that would define my scientific path: satellite data (primarily altimetry and chlorophyll-a) and the emerging papers on submesoscale dynamics back in 2015-2016, shaping my interest in the identification, tracking, characterization, and ecological influence of processes such as eddies and fronts. So, how does SWOT fit in? The possibility of having access to SWOT's unprecedented resolution data was truly a dream when I began my first studies 10 years ago, during my initial research projects as an undergraduate student. To be completely honest, back in those days as a mere infant in science, unaware of many of the developments taking place, I never thought they would arrive so soon. This data is a dream come true and an absolute luxury that allows us to understand the scales of these fine processes that, until just a few years ago, we could only study through models or limited satellite data. Today, thanks to those studies—despite their limitations—we know these processes have significant relevance for marine biology, climate change, and ocean energy. Now we have taken another step forward thanks to SWOT to truly understand the dynamics of these structures. It's fascinating to think about what we'll be able to achieve now with this breakthrough.

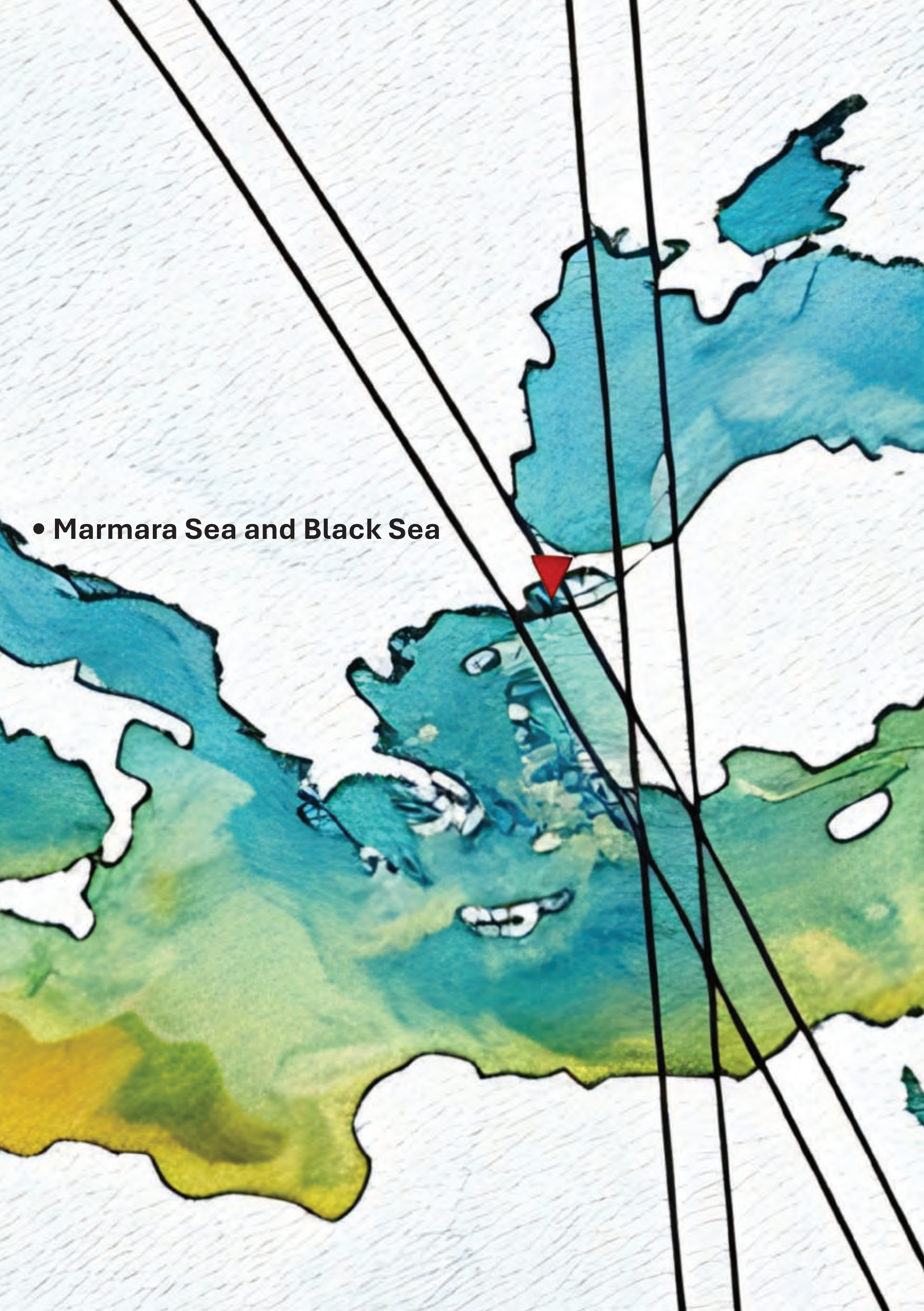
The sheer complexity of the challenge is what excites me. Having access to such high-resolution data is an unprecedented adventure, no matter where you are on the planet. For the Patagonian Shelf—a region that is already dynamically complex due to the strong effects of tides, westerly winds, and the unique Malvinas Current—the process of validating and understanding SWOT's measurements during the Cal/Val phase is an immense undertaking. This is compounded by the fact that it is a region with very little in situ data, meaning our work could yield groundbreaking results for both the region and our global understanding of ocean dynamics. That curiosity about what we will find, especially having in situ data for the first time in the southern shelf area (~52ºS), is what drives me. It's worth noting that the deployment and recovery of the instruments for the PATASWOT Initiative (led by Dr. Laura Ruiz-Etcheverry) were far from easy. I wasn't there for the deployment, as I was still in Chile, but the videos clearly show how challenging the conditions are. I did participate in one of the three attempts to retrieve the moorings—yes, it took three trips because the region's environmental conditions twice prevented us from recovering the southern mooring. This was frustrating, but it also built incredible anticipation to see what data we had captured and how it would correlate with SWOT's observations. Although one of the moorings was lost, fate and the perseverance of my PhD advisor (Dr. Martín Saraceno) allowed us to incorporate sea-level data from offshore platforms along the Cal/Val track 007. This has been fundamental. It strengthened our comparative analyses and the validation of SWOT in the region, highlighting the critical need for accurate tidal and atmospheric corrections. Now, it allows me to confidently begin analyzing the physical processes identified by SWOT, and this is my core contribution to the initiative.

Coming from the Southern Hemisphere, where satellite data is a primary tool for understanding regional dynamics, my goal is to continue strengthening confidence in the use of high-resolution data for environmental, economic, and operational decision-making in the ocean. I aim to add value to SWOT data by developing products that are directly relevant to ecosystem health and the advancement of a sustainable blue economy for this part of the planet.

Besides SWOT, I continue to collaborate with the Department of Geophysics at UdeC on analyses of mesoscale influence on biogeochemistry and its variability under climate change scenarios in the Juan Fernández Archipelago. This is an ecologically significant system of islands and seamounts off the coast of Chile (~33ºS), designated as a Marine Protected Area and home to one of the world's oldest sustainable fisheries, which is highly sensitive to climatic shifts. And, I am also collaborating on evaluating deep learning algorithms for identifying and tracking eddies to better understand the complexity of these mesoscale processes. Furthermore, I am working with the Department of Ecology at the Pontificia Universidad Católica de Chile to determine the influence of environmental factors on the spatiotemporal distribution of coccolithophore and diatom communities along the central Chilean coast and in remote oceanic ecosystems. Independently, I am involved in identifying, evaluating, and implementing socio-scientific outreach mechanisms through an initiative called Anarcomedia (holistic science, humor and comedy), which began in Concepción, Chile. This work has led me, as a member, to collaborate and build ties with the Network of Young Researchers in Marine Sciences (Red de Jóvenes Investigadores en Ciencias del Mar, JICmar) in Argentina.

PART 2


• NW Balearic Sea
• NE Balearic Sea
• Gulf of Lion



- **Marmara Sea and Black Sea**

The impact of vertical motions on marine ecosystems

Bàrbara Barceló-Llull

Bàrbara Barceló-Llull completed her PhD at the Universidad de Las Palmas de Gran Canaria (Gran Canaria, Spain). Following that, she undertook postdoctoral fellowships at IMEDEA (Esporles, Mallorca, Spain) for one year and at the University of Washington, Seattle, for 18 months. Since 2020, she has been the task leader of the H2020 EuroSea project at IMEDEA.

APR 2023 - My line of research is the analysis of in situ and satellite ocean observations to understand mesoscale and submesoscale dynamics (spatial scales between ~1-100 km), as well as the inference of vertical motions and their impact on marine ecosystems. After finishing my degree in Physics, I decided to investigate the ocean because I am an islander in love with the sea and also because I found a good mentor. During my first research, I studied vertical motions in mesoscale features and I chose to continue with this line of research because (sub)mesoscale dynamics have an important role in the exchange of tracers in the ocean, but there are still many questions to be answered, such as what is the role of these structures on the climate system or on the biological pump.

SWOT will allow, for the first time, the observation of fine scales globally from space. This will have a huge impact on our understanding of these features and will open new lines of research.

With SWOT we will have the opportunity to look at the scales that have an important role on the regulation of Earth's climate and on the distribution of nutrients and carbon. We only know that these structures are important, but we haven't "seen" them in detail and globally. SWOT opens a new door for physical oceanographers, and we expect amazing discoveries from it. With Fast-SWOT we will validate the first observations from SWOT near Mallorca (Spain), which is already interesting per se, but we will additionally study the 3D dynamics associated with the fine-scale features observed by SWOT, i.e., we will provide additional observations below the surface layer. This will allow a complete understanding of the 3D dynamics associated with the structures detected by SWOT.

I contribute to the FaSt-SWOT experiments through the planning of the sampling strategy. During the H2020 EuroSea project, I conducted Observing System Simulation Experiments to evaluate different sampling strategies to validate SWOT. The experience gained during the EuroSea project has been the base to design the FaSt-SWOT experiments.

I have applied for a post-doctoral contract in the framework of the FaSt-SWOT project. If I am selected, I will analyze the first observations from SWOT in the Balearic Sea, and also the measurements collected during FaSt-SWOT. So exciting!


Front

SWOT data to study and characterize extreme coastal events

Diego Vega-Giménez

Diego earned his bachelor's degree in Marine Science and his master's degree in Oceanography at Vigo University (Vigo, Spain), specializing in Physical Oceanography and Climatology. After completing his master's, he undertook two research internships, one at the Environmental Physics Laboratory (EPhysLab) in Vigo and another at the Centre for Environmental and Marine Studies (CESAM) in Aveiro, Portugal. He later worked for a year at the Balearic Water and Environmental Quality Agency (ABAQUA) in Spain. Currently, Diego is a PhD candidate at the Institut Mediterrani d'Estudis Avançats (IMEDEA, CSIC-UIB) in Mallorca, Spain.

JUL 2025 - My main research field focuses on the use of remote sensing data and modeling to study and characterize extreme coastal events, particularly those associated with hurricanes and storm surges. I became fascinated by the ocean–atmosphere interaction during my MSc, especially in the context of climate change and sea level rise.

My work is strongly tied to SWOT through the validation and application of KaRIn data in coastal regions. During the Cal/Val phase, I focused on validating SWOT KaRIn Level 3 observations along the coasts of the western Mediterranean Sea. This involved analyzing the daily high-frequency sampling provided by SWOT to evaluate its ability to detect sea level variability closer to the coast than conventional altimeters. In addition to comparing SWOT with corrected tide gauge observations and testing experimental high-resolution Dynamic Atmospheric Corrections (DAC), the validation also involved comparison with hydrodynamic model outputs (SCHISM) to assess the consistency of KaRIn-derived sea level anomalies with simulated coastal dynamics. I am also validating altimetric gridded products (L4) that incorporate KaRIn data near the coast, in order to assess how the inclusion of SWOT observations improves sea level estimates in these challenging regions. A central part of my research focuses on checking SWOT's capabilities to detect extreme sea level events primarily driven by hurricanes, which generate storm surges. This offers innovative new opportunities for coastal observation, especially in regions with limited in situ monitoring.

What excites me most about SWOT is its potential to redefine coastal altimetry by resolving fine-scale structures and capturing sea level signals that were previously undetectable near the coast. During the FaSt-SWOT campaign, I contributed by: Validating SWOT KaRIn L3 data against corrected tide gauge records in the western Mediterranean; Exploring the properties and statistical consistency of the SWOT signals; Investigating SWOT's ability to detect the signature of storm surges.

One of my future objectives is to create virtual tide gauges based on SWOT L3 data along the coast, which could serve as a complementary system for sea level monitoring in regions with poor in situ coverage. Additionally, I plan to extend my analysis to different coastal basins and storm events, using SWOT data to assess extreme sea level under diverse dynamical and meteorological conditions.

Besides SWOT, I'm also involved in a novel line of research using the MPAS atmospheric model in a high-resolution unstructured grid configuration. I force MPAS with counterfactual SST fields to simulate how hurricanes might behave without climate change, and then use the atmospheric output to drive a high-resolution hydrodynamic model (SCHISM). This setup allows me to quantify the impact of anthropogenic warming on hurricane intensity and storm surges —a critical question for future coastal risk assessment.

Reconstructing vertical motions within an eddy

Elisabet Verger-Miralles

Elisabet holds a Bachelor's degree in Marine Sciences and Technologies from the Universitat Politècnica de Catalunya (UPC) in Barcelona, Spain, and a Master's degree in Advanced Physics and Applied Mathematics from the Universitat de les Illes Balears (UIB) in Spain. She completed her master's thesis at IMEDEA (CSIC-UIB) in Mallorca, Spain, as part of the FaSt-SWOT project, and is currently in the second year of her PhD there.

JUL 2025 - I have always been interested in understanding the ocean, and in particular, I've been fascinated by the key role it plays in regulating Earth's climate. This curiosity led me to pursue studies in marine sciences and eventually guided me toward the field of physical oceanography. My research aims to improve the understanding of the ocean's three-dimensional dynamics associated with mesoscale and submesoscale currents in the Western Mediterranean Sea. These small-scale structures, such as eddies and filaments, play a crucial role in ocean mixing and transport, yet they remain challenging to observe and model. To investigate them, I use a combination of high-resolution numerical simulations, satellite remote sensing, and multiplatform in situ data.

My PhD research is strongly connected to the SWOT mission through the FaSt-SWOT project. I began my research career just after the satellite launch, which gave me a unique opportunity to work directly with its first real ocean observations. During the calibration and validation phase, SWOT provided daily measurements over specific regions, including the Balearic Sea in the Western Mediterranean. The FaSt-SWOT project focuses on validating these early observations and improving our understanding of small-scale ocean dynamics in this area. As part of the project, we conducted two high-resolution, multi-platform field campaigns during SWOT's fast-sampling phase. These focused on a small anticyclonic eddy and collected data from a CTD rosette, a Moving Vessel Profiler, ADCP, thermosalinograph, drifters, and underwater gliders. A large part of my work has involved processing and analyzing this unique set of in situ observations to validate SWOT data. I am currently working on reconstructing the vertical motions associated with the eddy to better understand its dynamics, combining SWOT observations, field measurements, and high-resolution numerical simulations. We are also exploring how different datasets can be assimilated to improve the WMOP regional model.

The improvements already seen with SWOT, especially its higher spatial resolution compared to previous altimeters, open up a lot of new possibilities for physical oceanography studies. What I find particularly exciting about the SWOT AdAC campaigns is the opportunity to have coordinated in situ measurements collected simultaneously around the world. This represents a unique international collaborative effort, allowing us to capture high-resolution multiplatform data from different regions, which is extremely valuable for understanding ocean dynamics across multiple scales. I participated in the FaSt-SWOT campaign as a master's student. It was a very special experience, not only because it was my first oceanographic field campaign, but also because of the coordinated multi-platform approach. Before the experiment, I contributed by analyzing daily satellite imagery to help define the sampling strategy. After the campaign, I was involved in the full data analysis process, including the validation and processing of CTD and MVP profiles, as well as comparing in situ data from drifters, gliders, and ADCPs with SWOT and other altimetry products.

I believe there is still much to do to fully exploit and understand SWOT data. With more than two years left in my PhD, my short-term priority is to continue advancing my research. In the near future, I have planned a research stay with Amala Mahadevan's lab at the Woods Hole Oceanographic Institution (WHOI), where I will focus on expanding my knowledge of mesoscale and submesoscale ocean dynamics.

I recently returned from the ESA Ocean Training Course (https://oceantrainingcourse2025.esa.int/), which was an incredibly enriching experience. As part of the course, we spent a month and a half aboard the tall ship Statsraad Lehmkuhl, sailing from Tromsø to Nice, with stops in Reykjavík and Maó. During the cruise, we collected a wide range of in situ data, including ADCP measurements, drifter trajectories, CTD profiles, and more. This hands-on fieldwork gave me the opportunity to start analyzing the collected data together with other students, working in synergy with satellite observations. It was a fantastic opportunity to exchange knowledge and ideas in a collaborative, international environment. I'm very excited about the possibility of continuing this collaboration and further exploring the datasets we gathered.

SWOT capability to detect and characterize coastal eddies

Laura Fortunato

Laura graduated from the University of Naples Parthenope (Naples, Italy), where she is currently completing the final year of her PhD in Environmental Phenomena and Risks.

Over the years, my academic path has combined marine biology, coastal monitoring, and physical oceanography. My current research focuses on the interactions between ocean dynamics, pollutants, and marine organisms, with the aim of deepening our understanding of these complex relationships and contributing to the protection of marine ecosystems. I chose this field because I believe that understanding ocean movements is fundamental to protecting marine environments. The sea is in constant motion, and studying these dynamics helps us see how ecosystems function, how they are impacted by human activities, and how we can safeguard them for the future.

My work integrates in situ measurements, numerical models, and satellite data. In this context, the SWOT mission is a breakthrough: it offers an unprecedented level of detail and accuracy in coastal regions, which are crucial areas for my research. SWOT allows me to better capture the fine-scale processes that drive the transport and fate of pollutants in the ocean.

Although I have not had the opportunity to take part in a SWOT campaign, I have worked extensively with altimetry data in my research. In particular, I investigated the capability of SWOT data to detect and characterize coastal eddies in the Balearic Sea, demonstrating how the mission can provide valuable insights into fine-scale ocean processes in complex coastal environments. What excites me most is how SWOT represents a significant step forward compared to conventional altimetry: its accuracy and resolution are remarkable, especially in coastal areas. It is fascinating to see how this technological progress can transform the way we study ocean dynamics and their implications for the marine environment.

After completing my work with SWOT data, I would like to apply the knowledge I have gained to support marine conservation and management strategies, particularly in vulnerable coastal zones. My long-term goal is to bridge the gap between science and decision-making, so that satellite missions like SWOT can directly contribute to protecting the ocean.

Alongside SWOT-related work, I am also engaged in research on coastal monitoring and the impact of pollutants on marine ecosystems. I am especially interested in how ocean circulation shapes the pathways and accumulation of pollutants such as plastics and contaminants, and how these processes affect marine life. What I enjoy most about this research is its multidisciplinary nature: it combines fieldwork, data analysis, and numerical models, giving me the chance to look at the ocean from many different perspectives.

Lagrangian tools to develop adaptive satellite-based sampling strategies for oceanographic cruises

Louise Rousselet

Louise completed her PhD at the Mediterranean Institute of Oceanography (MIO), Aix-Marseille University (Marseille, France), followed by a postdoctoral position at the Scripps Institution of Oceanography, University of California San Diego (California). At the time of the interview, she was based at LOCEAN-IPSL in Paris (France), serving as science officer for SWOT AdAC.

FEB 2023 - I study ocean circulation from large to small scales to better understand global heat and salt transport and exchange between large ocean basins. I am also interested in the influence of currents (and of physics more globally) on the distribution of biogeochemical and biological elements, particularly to understand how fine-scale structures (fronts, eddies) can structure and influence phytoplankton dynamics (horizontal and vertical distribution, growth rates…). For this I use data from global numerical models, in situ observations, and satellite measurements that I analyze using Lagrangian tools (numerical particle trajectories). This research theme is of particular interest to me because it allows me to make the link among the major fields of oceanography (physics/biogeochemistry/biology) and to understand the ocean as a complex interconnected system. Indeed, understanding the physical environment in which phytoplankton species evolve can explain certain behaviors and patterns.

The SWOT mission is going to measure finescale structures from space. It's going to give me access to higher resolution, global scale data. This will allow me to better understand how fine-scale structures influence biology on a global scale and not just in scattered regions sampled at high resolution. SWOT will greatly contribute to my research theme by providing high temporal and spatial frequency data. From the high-resolution maps of surface currents, I will be able to derive many Lagrangian diagnostics that detect fine-scale structures in order to better localize them. What excites me about SWOT is the diversity of scientific questions that this mission brings together: from issues related to coastal circulation, to the study of internal and vertical transport.

During the SWOT fast-sampling phase, I will contribute to the BioSWOT-Med campaign, which brings together about thirty scientists from different fields: from cellular and molecular biology to genetics which will be used to understand the observed ecosystem, to chemists and biogeochemists who will evaluate carbon, nitrogen and phosphate balances, not to mention physicists specializing in turbulence and vertical velocity measurements. This multidisciplinary process induces a very positive and enriching dynamic for my research work. What is exciting about BioSWOT-Med is that it is a campaign specifically designed for the study of physical-biological coupling at fine-scale. Thus, all aspects and measurements of the campaign will bring new light to the questions of the influence of fine scales on biology. For this campaign I am part of the "physical" team, and I am responsible for the implementation of the SPASSO software (Software Package for an Adaptive Satellite-based Sampling for Oceanographic cruises) which provides daily maps of satellite data and Lagrangian diagnostics that allow to guide in real time the campaign in a region of interest through the analysis of environmental parameters detected by satellite.

After the BioSWOT-Med campaign (and all the other SWOT AdAC campaigns) I will most certainly take some time off! The SWOT fast-sampling period is going to be very busy, helping to prepare all SWOT AdAC campaigns but also supporting BioSWOT-Med. Once the campaigns are over, I will be able to focus more on the scientific part. I will participate in the analysis of the measured data (physical data). I would also like to link the observations collected on the different cross-over regions of the SWOT satellite in order to provide a global picture of the fine scales observed almost simultaneously during the SWOT fast-sampling phase. This work could provide a better understanding of the variability of fine scales at the global ocean scale.

Measuring vertical velocity as part of fine-scale dynamics

Caroline Comby

Caroline began her studies at the University of Perpignan Via Domitia (UPVD) in Perpignan, France, and completed her final undergraduate year at Aix-Marseille University in Marseille, France. At the time of the interview, she was pursuing her PhD at the Mediterranean Institute of Oceanography (MIO) at Aix-Marseille University, focusing on ocean dynamics through fine-scale observations.

FEB 2023 - My research field is the study of ocean dynamics through the observation of fine-scale processes. More specifically, my thesis work consists in solving the question of measuring vertical oceanic velocities in fine-scale processes by combining instrumental development, experiments at sea, the analysis of in situ data and modeling. I chose this field of study as a continuation of my training as a physical oceanographer, motivated by my passion for field work and the challenge of developing new in situ measurement techniques. It was important for me to maintain a balance in my research between the theory of physical oceanic processes and the reality of the field.

The new SWOT satellite provides a very high-resolution view of the dynamics of surface currents, and such a resolution will allow us to characterize the vertical transport. My research work on direct in situ measurements of the vertical component of currents will complement the surface synoptic view provided by SWOT by adding localized observations at specific points in the ocean from the surface to the depths. The application of my work during the BioSWOT-Med campaign will allow me to collect a lot of data in order to be able, at first, to make an inter-comparison with the surface estimates from the satellite. The final objective is to obtain a 3D understanding of the ocean dynamics supporting vertical exchanges.

In a couple of months, I will take part in the BioSWOT-Med campaign, as part of the SWOT AdAC Consortium. What I find exciting is the international dimension offered by the SWOT orbit, with the gathering of many oceanographic researchers carrying out joint missions almost simultaneously on different parts of the ocean and seas of the world. Moreover, the BIOSWOT-Med campaign emphasizes interdisciplinarity and will couple the study of physical processes with biological processes. I find it very interesting not to stop at understanding the dynamic processes from a purely physical point of view, but to consider the fine-scale circulation as a driver of planktonic biodiversity. During the BIOSWOT-Med campaign, I will be responsible for the acquisition and analysis of vertical velocity measurements, which requires the use of several different sampling techniques and measuring instruments. More broadly, I will also participate in the acquisition of other current data. The analyses will be done in real time and will allow us to intervene in the sampling strategy by adapting the navigation plan of the mission if necessary.

Immediately after the cruise, I will pool all the current data that was collected during BIOSWOT-Med, in order to provide a global analysis of the hydrodynamic context of the mission. It turns out that this will represent the culmination of my research work since this campaign comes in my last year of PhD. My biggest project will be to transcribe the evolution and the conclusions of my work in the form of a thesis manuscript.

Internal waves interactions and their impact the energy cascade

Robin Rolland

Robin earned his bachelor's degree in Biology and his master's degree in Marine Sciences at Aix-Marseille University (Marseille, France). He completed his PhD at Sorbonne University and the Laboratoire d'Océanographie et du Climat : Expérimentations et Approche Numérique (LOCEAN) in Paris (France). As of summer 2025, he is a postdoctoral researcher at MARUM, the Center for Marine Environmental Sciences at the University of Bremen (Bremen, Germany).

MAR 2023 - I am interested in internal wave-mesoscale interactions and their impact on the energy cascade. That is, how these interactions modulate energy transfers between currents of different spatial scales. I am studying this around the Sicilian Channel which has many topographic and bathymetric constraints. It is also one of the few areas in the Mediterranean Sea where there is a significant tide. I will also be interested in this question in the Algerian basin, where I will participate in the BioSWOT-Med campaign to measure turbulence at (deci)metric scales. This subject was proposed to me by my Master 2 supervisor Francesco d'Ovidio, coordinator of the SWOT AdAC consortium, as well as Pascale Bouruet-Aubertot and Yannis Cuypers, both specialists in internal waves. The internship went well and the subject interested me because it dealt with fine scales, although I knew little about internal waves at that time. So I chose to defend this subject at the doctoral school. I was able to discover a whole new exciting part of physical oceanography.

SWOT will allow us to observe ocean currents that have a spatial scale of a few tens of kilometres or even a few kilometres. At these scales, the signal from internal waves (tidal waves in particular) is significant and mixes with that of the balanced (geostrophic) dynamics of the ocean, which can already be observed by satellite today. The internal wave-mesoscale interactions I am interested in occur at scales that SWOT will be able to observe. We hope to take advantage of these data as well as the BioSWOT-Med data to learn more about these interactions, and to compare model data with satellite and in situ observations. More generally, current knowledge of currents at the scales that SWOT will observe is largely model-based, but there are few observations to validate this knowledge. SWOT will partially fill this gap. For the energy exchange issues I am interested in, these observations will be of great help!

There are so many things I find exciting about SWOT the BioSWOT-Med campaign in which I will take part. First, it is the breakthrough that SWOT will enable in the observation of ocean surface currents and the technological feat that makes it possible. Second, it's the number of projects and research topics that SWOT has helped stimulate years before its launch. There is a real buzz in the community that is very exciting as a young researcher. As far as the BioSWOT-Med campaign, it is a unique opportunity to be able to cross-reference campaign data with satellite data at high spatial and temporal resolutions (1-2 satellite passes per day). The SWOT data will be valuable for the interpretation of the data collected in situ, to give a broader view of the surface dynamics of the sampled area. More generally, a campaign is always a unique experience! During the BioSWOT-Med campaign, I will be in charge of turbulence measurements at (deci)metric scales using a Vertical Microstructure Profiler. The analysis of the campaign data and SWOT data will be an integral part of my thesis.

After the end of the BioSWOT-Med campaign, I will first carry out the analysis of the campaign. I also have other projects underway, including Lagrangian analyses in the Sicilian Channel. Currently, I am finalizing a first paper that I hope to submit before the start of the campaign. Concerning the post thesis, I don't know yet. For the moment, I would like to continue in research but I do not close any doors.

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JUL 2025 - There are a lot of exciting results from the BioSWOT-Med cruise! On the physical oceanography side, we were able to target and sample a fine-scale anticyclonic eddy with a diameter of 25 km, well captured by SWOT and elusive to gridded nadir products. The strong winds we experienced during the campaign generated intense near-inertial internal waves that were trapped inside the eddy, which in turn generated strong turbulence. Using various instruments, we were also able to estimate the wave properties (frequencies, wavelengths, etc.) and the vertical energy flux induced by the wave propagation, usually difficult to estimate from in situ data. This process of trapping has been widely studied in large anticyclones but we provide here the first observation in a fine-scale eddy, which are much more numerous in the ocean.

A few weeks ago, I started a postdoc at the MARUM in Bremen (Germany), with Maren Walter and Martin Losch. I am writing these lines onboard the R/V Sonne (Louisville Ridge cruise, SO313), taking part in the Louisville Ridge project. I am interested in the circulation around seamounts on the northern part of the Louisville Ridge seamount chain in the southwest Pacific. I will use in situ data from the cruise and outputs from a model I will develop after the cruise. Far from SWOT unfortunately, but an exciting project!

How is phosphorus used by phytoplankton?

Emily Wagonner

> At the time of the interview, Emilie was a third-year PhD candidate in Biological Oceanography in the Department of Molecular and Cellular Biology at the University of Arizona (Arizona). Working in Solange Duhamel's lab, her research focused on the forms of phosphorus available to phytoplankton and the enzymes that enable their utilization. She also participated in the BioSWOT-Med campaign, and in this interview she discusses the importance of measuring polyphosphates and organophosphate esters, as well as the instruments used for these measurements.

MAY 2023 - I've always been drawn to the ocean, spending summers at the coast as a kid. I met Dr. Solange Duhamel onboard the R/V Endeavor in 2018 and since then, I've been enamored by phytoplankton and how they survive in regions with little to no phosphorus for growth. My PhD work focuses on understanding the various forms of phosphorus that phytoplankton can use and the enzymes that help support this.

In the BioSWOT-Med cruise I will be responsible for measuring polyphosphates and organophosphates esters. Phosphorus is essential for cells to function and grow. In the Mediterranean Sea, where phosphate is a limiting nutrient, polyphosphates can be used as an alternative source of phosphorus for phytoplankton. Emerging pollutants, such as organophosphate esters, are present in the Mediterranean Sea and may also play a role in the phytoplankton community.

During BioSWOT-Med, onboard R/V L'Atalante, we will filter seawater for both polyphosphates and organophosphate esters, store the samples, and analyze everything back in the lab. For polyphosphates, this includes collecting phytoplankton on a filter and measuring polyphosphate by either mass spectrometry (identifying polyphosphate by the compound mass/charge ratio), or staining with a fluorescent dye. We can also look at the polyphosphate specific to phytoplankton groups by first sorting the cells.

Organophosphate esters are collected by passing seawater through a column that retains the compounds. In the lab we can transfer the compounds to a vial which is then analyzed by coupled gas-chromatography mass spectrometry. The sample is vaporized and each compound "breaks apart." The way each compound separates is consistent and we can use that pattern to identify which compound we're looking at and the quantity.

The distribution of phosphorus and nitrogen in the water column

Laura Giraud

Laura earned a bachelor's degree in Earth Sciences and a Master's 1 degree in Geosciences from the École Normale Supérieure and the University of Tours (Tours, France). She then pursued studies in physics–biogeochemistry at the Mediterranean Institute of Oceanography (MIO), Aix-Marseille University (Marseille, France). At the time of the interview, she was completing her Master's 2 internship at the MIO.

MAY 2023 - I am currently conducting research in marine biogeochemistry with Elvira Pulido and Thierry Moutin at the Mediterranean Institute of Oceanography, focusing on phosphorus and nitrogen dynamics in the oligotrophic ocean, particularly within the Mediterranean Sea.I try to understand how phosphorus and nitrogen are distributed spatially and within the water column. I've always been fascinated by biogeochemical cycles, ever since my degree at Tours. I first became interested in Carbon, then I discovered the importance of Phosphorus and Nitrogen for phytoplankton in the oligotrophic ocean (60% of the ocean surface). What interested me in working in biogeochemistry is to be able to do chemistry while still being able to work on ocean physics.

Working on the horizontal and vertical distribution of phosphorus and nitrogen, the impact of fine-scale structures on this distribution and on the fluxes of phosphorus and nitrogen to the surface is of importance, as these structures are ubiquitous in the ocean. SWOT provides access to very fine-scale altimetry and surface velocity data. As a result, these structures are easier to detect using satellite measurements. This will enable us to precisely target a frontal structure in order to sample on either side of it as part of our biogeochemical studies.

What excites me about SWOT is the resolution of the maps it makes available to us thanks to its measurements from space. Being able to work on satellite maps with such precision is very exciting. During BioSWOT-Med I'll help to measure high-resolution dissolved phosphate and nitrogen, as well as the activity of an enzyme (phosphatase) in water samples taken at the surface and in the water column on both sides, as well as on the front.

After the campaign, the idea is to continue the analyses on the samples we have taken and frozen. We also want to measure organic phosphorus and nitrogen at high resolution, as well as taking measurements of phosphorus and nitrogen in particulate matter. In this way, we want to study the nitrogen and phosphorus profiles on either side of the structure and try to quantify the fluxes of these elements to the surface due to physics and biology.

The ecological processes and physical structures at fine scales that determine phytoplankton distribution

Laurina Oms

At the time of the interview, Laurina was pursuing a PhD in physical oceanography at the Mediterranean Institute of Oceanography (MIO), Aix-Marseille University in Marseille, France.

MAR 2023 - I chose to study oceanography because it is a multidisciplinary field that allows the study of natural processes, taking into account that they all work in synergy. The study of the ocean is the study of a fluid in motion where the skills of physicists, chemists, biologists… are required to advance. I therefore chose oceanography because it allows us to better understand that nature functions as a whole.

I study the link between physics and biology at fine oceanic scales. For this purpose, different approaches are used and complement each other. First of all, I have a modeling approach where I numerically simulate the physical and biological processes of interest, but also an in situ approach where we collect our data directly at sea. For this second approach, we use satellite observations that allow us to have a general view of our study area and to target the physical and biological structures that we want to study. SWOT will thus bring us a high-resolution observation of the ocean surface.

I am very curious to see how SWOT high resolution data from the surface of the ocean can improve both the general knowledge of the physical dynamics of the ocean, and help me in answering my own scientific questions, namely: the peculiarities of fine-scale physical structures and their role on the distribution of phytoplankton communities. For this question, during the BioSWOT-Med campaign I will use flow cytometry to measure the abundances of the different populations of phytoplankton present in the region, and to report these results on maps indicating the abundance points and some physical features such as the direction and speed of the currents

After the campaign I will analyze the physical and biological data in situ, and from that feed my numerical model. The idea is to understand the common history of water masses and organisms during the cruise and to extend these results to define more generally the fine-scale features in the ocean.

Innovative tools to inform adaptive ocean management strategies

Alice della Penna

Alice earned her degree in Physics, followed by a specialization in Physics of Complex Systems at the Università degli Studi di Torino (Turin, Italy). She then completed a PhD jointly between Université Paris 7 (France, Doctoral School Frontiers in Life Sciences) and the University of Tasmania (Australia) through the Quantitative Marine Science Program. Afterward, she worked as a research engineer at the Mediterranean Institute of Oceanography in Marseille, France, and as a postdoctoral fellow at the Applied Physics Laboratory, University of Washington, in Seattle, in collaboration with the University of Western Brittany (Brest, France). In 2020, she joined Waipapa Taumata Rau, the University of Auckland, New Zealand. Reflecting on her journey, Alice notes, "I'm really grateful that I got to learn from very different people with a range of expertise and backgrounds".

JUN 2025 - I work at the interface between ocean physics and marine ecology. I originally studied physics, but then got more and more interested in trying to understand how the complexity of the fluid dynamics of the ocean shapes the landscape hosting marine ecosystems, especially in the pelagic environment. I stumbled on this topic almost by chance watching a seminar when I was doing my M.Sc. and learning that not only a lot of the theoretical approaches I was studying had very concrete implications providing tools to identify the skeleton of ocean circulation, but also that it was possible to quantify microalgae from space. I still remember the surprise!

In most of my research I have been using 'conventional' altimetry and while it is a very powerful tool, I was excited to learn about the possibilities that SWOT offers, getting to finer scales, but also being able to approach challenging research questions in coastal areas, that are so crucial for marine spatial planning, management, and conservation.

I loved the strong interdisciplinarity of the BioSWOT-Med and being able to carry out a mesocosm experiment to quantify the impact of vertically migrating zooplankton on the near-surface community. This was quite new to me (but I'm very excited about it!) and it was very challenging. Something I particularly enjoyed is that, since I had to collect a wide range of measurements from the mesocosm and had to tackle quite a few logistical challenges, I received a lot of help from pretty much every participant of the campaign and ended up learning a lot. Now the experience continues as we work together to interpret the results of the experiment.

I'm involved in a range of projects, but I'm currently discussing with some of the physical oceanographers about a possible follow up for the experiment, aiming to quantify the turbulence inside the mesocosms and potentially connecting it with plankton interactions. Outside of BioSWOT-Med, I'm also working on analysing data from another SWOT-related voyage, in the East Australian Current (led by Prof. Moninya Roughan and supported by the Australian Marine National Facility). I have carried out some preliminary analyses, but there is much more to be done and I'm looking forward to focusing on it.

Besides SWOT, I'm involved in many other exciting research projects, and if you ask me to speak about one, it's hard to choose! At the moment, I'm leading a project aiming to use light attenuation measurements to study the deep ocean: it's an exciting but very challenging project as the deep ocean is a dark place and we are trying to measure very small differences in light to infer how deep water organisms are distributed. I'm also collaborating with other researchers looking, among other projects, at the role of lanternfishes in ecosystems, how ocean conditions can affect the physiology and health of New Zealand seabird species and how we can use oceanographic data to support and update the design of marine protected areas. I see these pieces of research, that are quite diverse, as steps towards a better relationship with the sea and hopefully tools to support decisions that can promote ocean management that accounts for the dynamic nature of the ocean.

The influence of fine-scale structures on the distribution of mid-trophic level organisms

Lloyd Izard

Lloyd earned both his Bachelor's and Master's degrees in Biological Oceanography and Marine Ecology at Aix-Marseille University (Marseille, France), before completing a PhD at Sorbonne University in Paris (France). During his career, he conducted research at the Mediterranean Institute of Oceanography (MIO, Marseille) and at the Laboratoire d'Océanographie et du Climat: Expérimentations et Approche Numérique (LOCEAN, Paris), where he also served as the SWOT AdAC Data Officer. He now works as an external consultant with CNRS (France) and the Voice of the Ocean Foundation (Sweden).

FEB 2024 - During my Ph.D., my research focused on studying the distribution of marine organisms from the ocean surface down to a depth of 1000 m, covering the twilight zone—an enigmatic and 'unknown' layer of the ocean that potentially harbors the largest biomass of organisms in the global ocean. To detect these organisms, I analyzed active acoustic data collected from hull-mounted echo-sounders in the Southern Indian Ocean. One could describe my research field as Quantitative Marine Ecology! I "chose it" during my studies when I realized that descriptive statistics could effectively explain complex spatiotemporal patterns observed in the ocean!

Research has revealed that fine-scale structures influence the distribution of mid-trophic level organisms, as seen in observations of increased fish concentration at fine scales in the open ocean. With active acoustics providing high horizontal and vertical sampling resolution of these systems, the integration with SWOT will allow us to explore this phenomenon in greater detail than ever before. I am truly excited about the future advancements in our understanding of the coupling between biology and physics, and how it reverberates along the trophic chain.

During the SWOT fast-sampling phase, I was finalizing my PhD and could not participate in a campaign. However, during my Master's internship, I studied phytoplankton dynamics in contrasting water masses using data from the PROTEVS-SWOT cruise, which preceded the BioSWOT-Med cruise.

As SWOT AdAC Data Officer, my responsibilities will include compiling information on in situ data collected during the SWOT AdAC cruises, assisting with technical work for validating SWOT with in situ observations and proposing synergies in research topics. I have already participated in meetings related to the BioSWOT-Med and FaSt-SWOT cruises and will soon be reaching out to the rest of the cruises to gain an overview of collected, analyzed, and available data for the community.

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JUL 2025 - One exciting result from the BioSWOT-Med campaign was the discovery of a distinct phytoplankton community associated with the North-Balearic Front, revealed through 24-hour continuous high-resolution sampling guided by SWOT. This frontal community showed an increased contribution of non-dominant phytoplankton groups, highlighting how fine-scale features enhance community diversity even in oligotrophic and moderately energetic environments like the Mediterranean Sea. This work is now under review for scientific publication.

Besides SWOT, I recently published a study exploring how sonar frequency choice affects our interpretation of pelagic ecosystems across latitudes. Analysing data collected in the Indian Ocean Subantarctic Front, we found that 38 kHz and 18 kHz sonar reveal different patterns due to changes in fish swimbladder size with latitude. Our results show that without accounting for this resonance effect, biomass estimates from sonar can be misleading, especially in subantarctic regions. This has important implications for large-scale monitoring of mid-trophic organisms. Now, I'm shifting back to fine-scale processes, analysing acoustic data from the BioSWOT-Med cruise to understand how mid-trophic communities respond to fine-scale features in moderately energetic regions.

The impacts of fine scales on the biodiversity of the lower levels of the plankton food web

Ludivine Grand

After earning a bachelor's degree in Biology of Organisms, Populations, and Ecosystems in Clermont-Ferrand (France), Ludivine went on to complete a master's degree in Ecology and Evolution at the University of Toulouse (Toulouse, France). During her master's internships at the Mediterranean Institute of Oceanography (MIO) in Marseille (France) she analyzed biological data from the BioSWOT-Med campaign. She is now pursuing a PhD at the MIO, where her research focuses on how fine-scale ocean circulation influences biodiversity at the base of the plankton food web, continuing to draw on BioSWOT-Med data.

JUL 2025 - My research field is marine microbial ecology. I'm interested in how fine-scale oceanic structures influence the distribution of unicellular planktonic communities, from viruses to nanoflagellates, including phytoplankton and bacteria. To study this, I use flow cytometry to analyze seawater samples collected between 0 and 500 meters during the campaign. This allows me to examine not only their distribution across water masses but also their vertical variability, linked to the strong physico-chemical gradients in the water column.

I honestly think this topic chose me rather than the other way around! I wasn't particularly passionate about plants or animals, but I loved studying microorganisms during my studies. Then, I was mainly interested in studying lakes, but during my master's, I did an internship in oceanography that I really enjoyed. What I appreciate about this field is its multidisciplinary nature: everything is connected, and we can't explain biodiversity without understanding the physical and chemical environment!

I don't use SWOT data directly in my research. But SWOT enabled the detection and tracking of oceanic structures within which the microorganisms I study were sampled!

I did not participate in a SWOT AdAC campaign, but what I find particularly exciting is finally being able to carry out Lagrangian sampling in a low-energy area of the Mediterranean where BioSWOT-Med was focused! Indeed, most studies concentrate on highly energetic zones, which aren't very representative of the global ocean. I hope this will allow us to untangle the different scenarios of fine-scale influence on plankton! I contribute to the SWOT AdAC effort by analyzing plankton data collected during the BioSWOT-MED campaign. I am mainly responsible for the statistical analysis of these data, in relation to the physical and chemical environmental data collected.

After I've finished analyse the data from the BioSWOT-Med campaign… I plan to analyzing data from other campaigns! The WIRLS campaign, scheduled for next summer in the Agulhas Current eddy field, and the Kuroshio Extension / North West Pacific campaign, which took place in summer 2024 in the Kuroshio Current off Japan. We aim to determine whether the mechanisms by which fine-scale processes influence plankton, identified during BioSWOT-MED, are similar and have the same significance in these other contrasting systems with distinct environmental conditions.

Applied statistics to understand how environmental conditions drive the dynamics and distributions of marine organisms

Théo Garcia

Théo holds a Master's degree in Dynamics of Aquatic Ecosystems from the Université de Pau et des Pays de l'Adour (France) and a PhD from Aix-Marseille Université (Marseille, France). His doctoral research, conducted at the Mediterranean Institute of Oceanography (MIO), focused on analyzing long-term zooplankton time series in the Bay of Marseille. In October 2024, he began a postdoctoral position at the Institut de Mathématiques de Marseille (France), where he is working with SWOT data.

MAY 2025 - My main research interest is in understanding how environmental conditions drive the dynamics and distribution of aquatic organisms (mainly plankton). I am particularly interested in the use of applied statistics to disentangle complex ecological processes. Although my Master's degree was mainly focused on continental waters (rivers, lakes), I was able to do two internships in oceanography, one at the Universidad del País Vasco (Bilbao, Spain) and one at the Institute of Marine Research (Tromsø, Norway). I really enjoyed discovering this field and therefore decided to continue with a PhD in oceanography.

I am currently investigating how fine-scale oceanic structures (1-100 km) affect the spatial distribution of phytoplankton. SWOT allows us to observe these fine-scale structures in the ocean better than conventional altimetry.

Unfortunately, I did not take part in the Mediterranean campaigns! I contribute mainly by analysing the campaign data in a project involving oceanographers and statisticians (RODEO project). In particular, we developed a novel statistical approach to study the data collected during the PROTEVSMED-SWOT campaign, which took place in the Western Mediterranean before the launch of the SWOT satellite in 2018.

After I've finished analyzing SWOT data, I plan to … analyse SWOT data again! After analysing phytoplankton distribution from local in situ data, I plan to assess the relationship between fine scales and phytoplankton distribution but now using satellite data on a global scale – i.e. with ocean colour data to characterise phytoplankton diversity and altimetry (SWOT) to characterize fine scales. That is the aim of my postdoctoral project, SPAce-rODeo (Satellite Phytoplankton Analysis in an Ordered and Disordered turbulent ocean), which is funded by the CNES for the next two years.

The impacts of vertical velocities in the chemistry and biology at fine scales

Maxime Arnaud

Maxime is a PhD student at the Mediterranean Institute of Oceanography (MIO), Aix-Marseille University (Marseille, France). Her research focuses on understanding three-dimensional ocean velocities and their role in fine-scale processes.

JUL 2025 - My research interest focuses on ocean dynamics and in particular tridimensional ocean velocities involved in fine scale processes. The core of my work is the measurement and the understanding of vertical velocities with all the complexity and uncertainty that this raises. After two master internships on the surface transport in one case of plastic debris (Toulon, France) and in the other of cnidaria (Sydney, Australia), I wanted to deepen my understanding of ocean dynamics and especially to unlock knowledge on vertical velocities. And as a physicist, I wanted to identify their impact through different points of views by working with chemists and biologists. I contacted Anne Petrenko and Stéphanie Barrillon, both specialists in fine scale dynamics, to apply for a PhD on vertical velocities. I was thrilled to finally discover field work and teamwork around a common topic.

As my research work focuses on fine scale processes (dozens of km / days to weeks), the SWOT mission provides altimetry measurements at an unprecedented resolution. The Cal/Val phase of SWOT was concomitant with the BioSWOT-Med cruise, leading to combined daily in situ and satellite measurements in a frontal area which is rapidly evolving both spatially and temporally.

I was not on board with the BioSWOT-Med team as my PhD started a few months after the end of the cruise. But a huge part of my thesis will be dedicated to physics-driven dynamics data analysis from BioSWOT-Med. I really think this is a promising first step in better understanding structures with high spatial and temporal variability. Such an international and interdisciplinary project is a real breakthrough and we expect to reach a whole new step in measurements inter-validation and ocean dynamics comprehension.

I chose to do my PhD on the BioSWOT-Med cruise results especially because there is a lot of work to be done. And even if I work for 2 years on these data, a whole lot of work will still have to be done with these data at the end of my PhD. And I will continue to work on fine scale processes in this new era opened by SWOT.

Besides working with SWOT data, I spent the first year of my PhD working on the acoustic current profiler mooring line JULIO offshore Marseille (France) covering a decade of observations in a coastal area. This study highlighted wind-induced fine scale dynamics with intense vertical velocities combining direct measurements and multi method analysis.

The physical processes generated in submarine canyons

Lénaïg Brun

Lénaïg began her studies at the École nationale supérieure d'électrotechnique, d'électronique, d'informatique, d'hydraulique et des télécommunications (ENSEEIHT) in Toulouse (France), specializing in fluid mechanics and the environment. In parallel, she pursued a double degree with the Master's program in Oceanography, Atmosphere, and Climate Sciences. She then moved to Brest (France) to undertake a PhD at the Laboratoire d'Océanographie Physique et Spatiale (LOPS), focusing on submarine canyons. She is now a postdoctoral researcher in physical oceanography at the Scottish Association for Marine Science (SAMS) in Oban, Scotland (UK).

MAR 2023 - My field of research is physical oceanography. My goal is to identify the physical processes generated in submarine canyons, to understand how submarine canyons interact with their environment and to improve their representation in numerical models. I am particularly focused on the Cassidaigne canyon in the Mediterranean Sea and the Capbreton canyon in the Atlantic Ocean.

Passionate about the ocean since I was a child, I wanted to combine this interest with my future career. Consequently, I wanted to focus my studies on oceanography. I searched for PhD offers on the Ifremer [Institut français de recherche pour l'exploitation de la mer] website. When I came across the presentation of this PhD on submarine canyons, I was immediately attracted. On the one hand, the subject interested me a lot and on the other hand, the subject is inserted in multidisciplinary fields such as oceanographic campaigns, numerical modeling and data analysis.

My study is not related to SWOT because submarine canyons do not affect the top 100 meters of the water column. In my PhD, I will not analyze the data measured by SWOT. However, the Cassidaigne canyon is located in the satellite track. Moreover, it interacts with larger processes such as the Northern Current or wind-induced processes whose dynamics are observed by SWOT.

The WEMSWOT campaign is my first campaign. Having always conducted my study from my computer, I find it exciting to go on a field mission, to learn how to collect in situ data and to discover how the measuring devices work. More generally, I find it exciting to discover life on board.

My contribution to the campaign is mainly linked to the measurements made in the Cassidaigne canyon. With the help of Ivane Pairaud, we defined the location of moorings along the axis of the canyon that will collect data for one year. We also determined the location of many measurements in the canyon to collect data and water samples at different depths to measure the density, the number of particles, the salinity or the chlorophyll in the water column. In this process, I selected different depths of interest to quantify the number of particles suspended in the studied areas. In order to recover the collected particles, I proceeded to filter all recovered water samples, 20L per measured area. I will also start the analysis of some of the collected data in order to compare them with my previous observations and possibly bring new information on the dynamics of the canyon.

After the WEMSWOT campaign, I intend to continue my research on submarine canyons. First, I will analyze the dynamics of the Cassidaigne canyon from the results of a numerical model. Second, I will begin to study the Capbreton canyon. In one year, I hope to recover the data collected by the moorings placed during the WEMSWOT campaign in the Cassidaigne canyon in order to continue my study on its dynamics.

JUL 2025 - Red mud has been discharged in the Cassidaigne canyon from a pipe located 320 m down in the eastern part of the canyon head, between 1967 and 2015. In 2014, during the BATHYCOR1 cruise high concentration of sediments were recorded near the seabed in the canyon head lobes, downstream of the pipe. CTD and turbidity measurements conducted in and around the Cassidaigne canyon during the WEMSWOT campaign in 2023 showed similar results to the one observed in 2014. Moreover, high turbidity levels have also been recorded at shallowest stations in the western part of the canyon head, indicating a sediment transport to the west by up-canyon flows. These first observations suggest a strong variability in sediment concentration related to the end of the discharge and to the occurrence of turbidity events in the canyon.

I am currently part of an exciting new project: POLOMINTS (Polar Ocean Mixing by Internal Tsunamis). In the ocean, mixing is a key process contributing to the distribution of heat, nutrients, carbon or sediments for example. In polar regions, such as Antarctica, this process is mainly induced by winds and tides. However, recent discoveries demonstrated a significant role of underwater tsunamis, induced by ice-calving events, in mixing. My part of the project aims at better understanding calving-induced internal tsunamis (propagation, occurrence, impact on the physical properties of the water column) through data mining, modeling and field experiments.

Surface dynamics at fine scales

Margot Demol

At the time of the interview, Margot was pursuing her PhD at the Laboratoire d'Océanographie Physique et Spatiale (LOPS) in Plouzané, France focusing on ocean surface dynamics at fine scales.

MAR 2023 - I study the physics of the ocean, and more specifically the circulation and surface dynamics at fine scale (i.e. processes with spatial extent less than 100 km and temporal scales less than one month such as eddies, fronts or internal wave signatures). Already passionate about physics, I chose this discipline because I was attracted by the ocean, where I grew up. Many of the physical processes that occur in the ocean are still relatively unknown and observations are limited, so it is a fantastic field of research.

One way of observing surface ocean circulation and dynamics is by measuring sea level changes with satellite altimetry. The SWOT satellite is equipped with a brand-new generation KaRIn (Ka-band Radar Interferometer) that will provide us with these sea level measurements with unprecedented coverage, accuracy and spatial resolution, allowing us to observe finer scale surface processes.

SWOT is expected to revolutionize our observation of the ocean by perhaps finally allowing us to observe sub-mesoscale processes through altimetry. During the first months of its orbit and the C-SWOT campaign, the satellite will pass over the Mediterranean Sea every day and then every 20 days, which is also a great opportunity to observe rapid temporal variability. The measurements condensed during this campaign – altimetry, drifting buoys, moorings, salinity/temperature profiles – constitute a very complete set of observations, giving hope for great analyses and discoveries. My job on board will be to design and implement the deployment of drifting buoys (small buoys that follow the currents and whose displacement is tracked by GPS) under the satellite swaths.

After the end of the campaign, I will continue my thesis and study how the synergy of the different data from this campaign (and hopefully from other SWOT AdAC campaigns) allows us to define and better understand the fine-scale surface ocean dynamics. I will also contribute to the Calibration/Validation of the SWOT data by comparing them with other in situ data sources.

Near real-time maps derived from satellites as tracers to reveal dynamical structures

Alexandre Barboni

Alexandre earned a master's degree from the Geosciences Department at ENS Paris (France) before specializing in physical oceanography and beginning his PhD in 2020. At the time of the interview, he was collaborating with three oceanographic institutions: LMD at École Polytechnique near Paris, as well as SHOM and LOPS, both based in Brest, France.

APR 2023 - I study the interactions between atmosphere and meso and fine oceanic scales. I'm particularly interested in dynamics evolution over long timescales, typically months to years, and my field of expertise is the Mediterranean Sea. Despite its small size the Mediterranean Sea can be considered as a small ocean with a wide variety of dynamical structures and remarkable data coverage.

Eddying structures evolve in time and over the vertical, modifying temperature and salinity properties. As mesoscale features account for about 60% of ocean kinetic energy, it is an important source of energy and heat below the ocean surface. Meso and fine scales also greatly influence the mixed layer, the uppermost layer of the ocean exchanging with the atmosphere. These structures can then in return greatly impact air-sea exchanges for momentum, heat and atmospheric gas. One key aspect of my subject is then to link in situ data at depth with satellite remote-sensing.

The SWOT mission is expected to greatly enhance our vision of ocean surface current through its 2D sea surface height measurement. Smaller scales features should then be more accurately detected and tracked in time. An improved eddy tracking would enable us to go beyond a simple surface current diagnostic and enhance our knowledge on energy and heat pathways. Detecting finer scale structures would also greatly help to diagnostic lateral exchanges, such as filament or eddies instabilities. These dynamics can currently only be watched in temperature or chlorophyll from satellites but not really measured. This satellite should be a real step forward in ocean surface current detection, particularly in regions where eddies tend to be small such as the Mediterranean Sea. We really expect to see new and detailed structures from SWOT.

My contribution to the C-SWOT mission is the production of near-real-time maps with high resolution (~1km) satellite data such as chlorophyll and sea surface temperature. These measurements can be considered as tracers to reveal dynamical structures, like oceanic fronts or sheared filaments, and will enable comparison with in situ current measurements from the ships. As time series are also key for observations, I will also keep an eye on a cytometer for the BioSWOT-Med campaign. A cytometer is an automatic sensor to track phytoplankton, and BioSWOT-Med, will follow C-SWOT in approximately the same region. It will then allow almost two months of continuous phytoplankton measurements.

I expect to defend my PhD in about 6 months, there is then first a report to finish. Afterwards I'm currently planning a postdoc project, continuing to work on eddying structures. There are still lots of interactions to explore between high-resolution remote-sensing, such as SWOT altimetry, and ocean currents. One I would be interested to study is its complex and multi-scale relation with biology.

Combining satellite and Automatic Identification System data to study mesoscale and sub-mesoscale dynamics

Camille Cardot

Camille is a PhD student in physical oceanography at the Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France, working in collaboration with the company eOdyn (Plouzané, France).

JUN 2025 - My PhD focuses on mesoscale and submesoscale dynamics, combining satellite and AIS (Automatic Identification System) data. I chose to study these dynamics because they are key to the ocean's energy transfer and the movement of tracers such as sea temperature, chlorophyll_a and carbon.

My PhD explores combining new datasets (SWOT and AIS). These datasets provide incredible opportunities to study these dynamics. One dataset offers high resolution (SWOT with 2 km), and the other provides access to total current data (AIS). Therefore, AIS and SWOT are innovative, and understanding the physical signals associated with these two new opportunities is a real—and exciting—challenge.

Although I didn't have the opportunity to participate in a SWOT AdAC campaign, I was included in the BioSWOT-Med group. This is a valuable opportunity for me to participate in the meetings. I also use the data collected during the campaign to validate AIS and SWOT data. This approach provides me with a sense of coherence before I study the dynamics represented. I think it's a great initiative that helps create a community with shared objectives.

Currently, I'm working on ocean velocities from SWOT satellite and AIS measurement. Moreover, in collaboration with Elisa Carli (ESA), I'd like to study the vertical velocities that can be reconstructed from various data sets. Therefore, the end of the SWOT data analysis never ends.

Remote sensing and autonomous instruments to study shelf break dynamics

Anıl Akpınar

Anıl earned his PhD in physical oceanography at the Institute of Marine Sciences, Middle East Technical University (METU) in Erdemli, Mersin (Turkey). He then worked as a postdoctoral researcher at the Institut français de recherche pour l'exploitation de la mer (Ifremer) (France) and at the National Oceanography Centre (Southampton, UK). Afterward, he returned to Turkey, where he is now an assistant professor in the Department of Oceanography at METU.

FEB 2023 - I'm an observational physical oceanographer with a keen interest in remote sensing and autonomous instruments. My research interests include, but are not limited to: water mass formation, cross-shelf exchanges, general circulation/hydrography and their impact on the ecosystem in shelf seas. I'm mostly interested in shelf seas because of their dynamic nature and their significance for the world ocean (e.g. productivity, biogeochemical cycles).

My research often evolves around meso-scale and sub-mesoscale features in the ocean. I often use satellite data in my research, particularly from altimeters. Present satellite altimetry data is not sufficient to resolve certain features we observe in shelf seas. For example, I am currently investigating fronts and cross-frontal exchanges and in doing so I'm mostly limited to sea surface temperature and ocean-color satellites as they provide the necessary resolution, while existing altimetry satellites do not. SWOT will fill this gap. Furthermore, SWOT will provide a synoptic view of the surface circulation, of which our knowledge is limited (e.g. seasonal sampling) for certain regions.

My research includes the shelf-break, which is the key area for shelf and open ocean exchanges. Unfortunately, there is no dedicated sampling array for the shelf-break, unlike the open ocean (e.g. Argo floats), and existing altimetry data have low resolution. Overall, SWOT will be a significant tool for my research, along with ship-borne and autonomous measurements.

SWOT will enhance our knowledge of ocean circulation, particularly in under sampled regions, such as in the Marmara Sea and Black Sea, where our SWOT AdAC campaign will take place. Unfortunately, existing altimetry missions cannot resolve the dynamics in Marmara Sea, a unique and very dynamic region with dense human activity. In recent years outbreaks of mucilage (i.e. sea snot) have increased both public/media attention and research in the region, however observations of Marmara Sea circulation are limited to in situ measurements. SWOT will provide a synoptic sampling for the surface circulation of this dynamic shelf sea. In this campaign, we will combine in situ measurements and modelling efforts with SWOT data and we will have a chance to observe and test the impacts of meso-scale and submesoscale features on phytoplankton blooms and observed hypoxia in Marmara Sea. I will contribute to the design of the in situ sampling strategy and participate in the sampling as well as in the interpretation of collected data.

I plan to use SWOT data regularly in my future research and I'm hoping SWOT data will help me investigate the questions I already have, particularly on smaller scales.

I also hope that the SWOT AdAC consortium will lead to further collaborations and future projects.

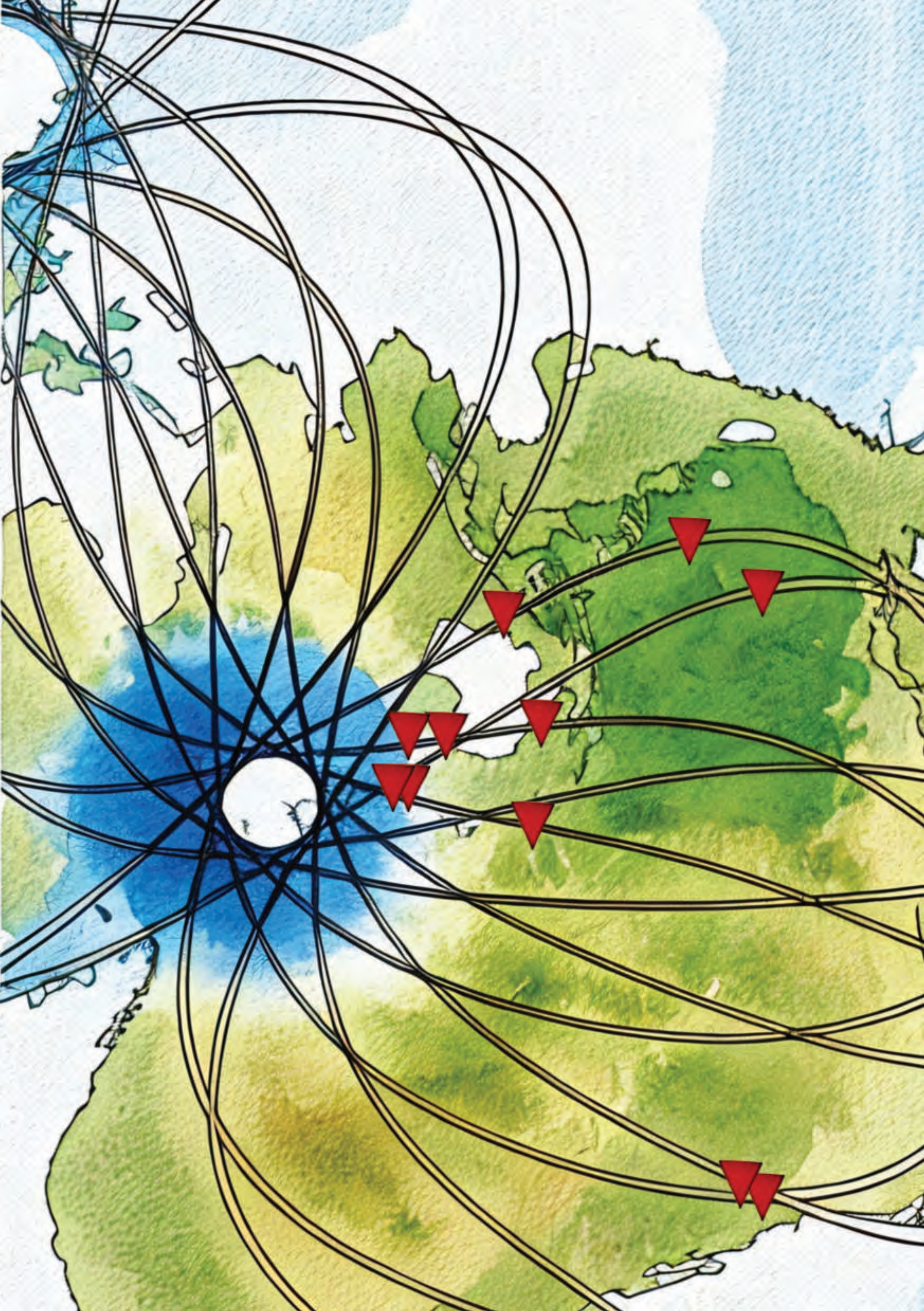
JUL 2025 - The Marmara Sea campaign showed distribution of oxygen-rich Mediterranean waters associated with submesoscale activity, which was also confirmed by a glider mission in 2024. The Black

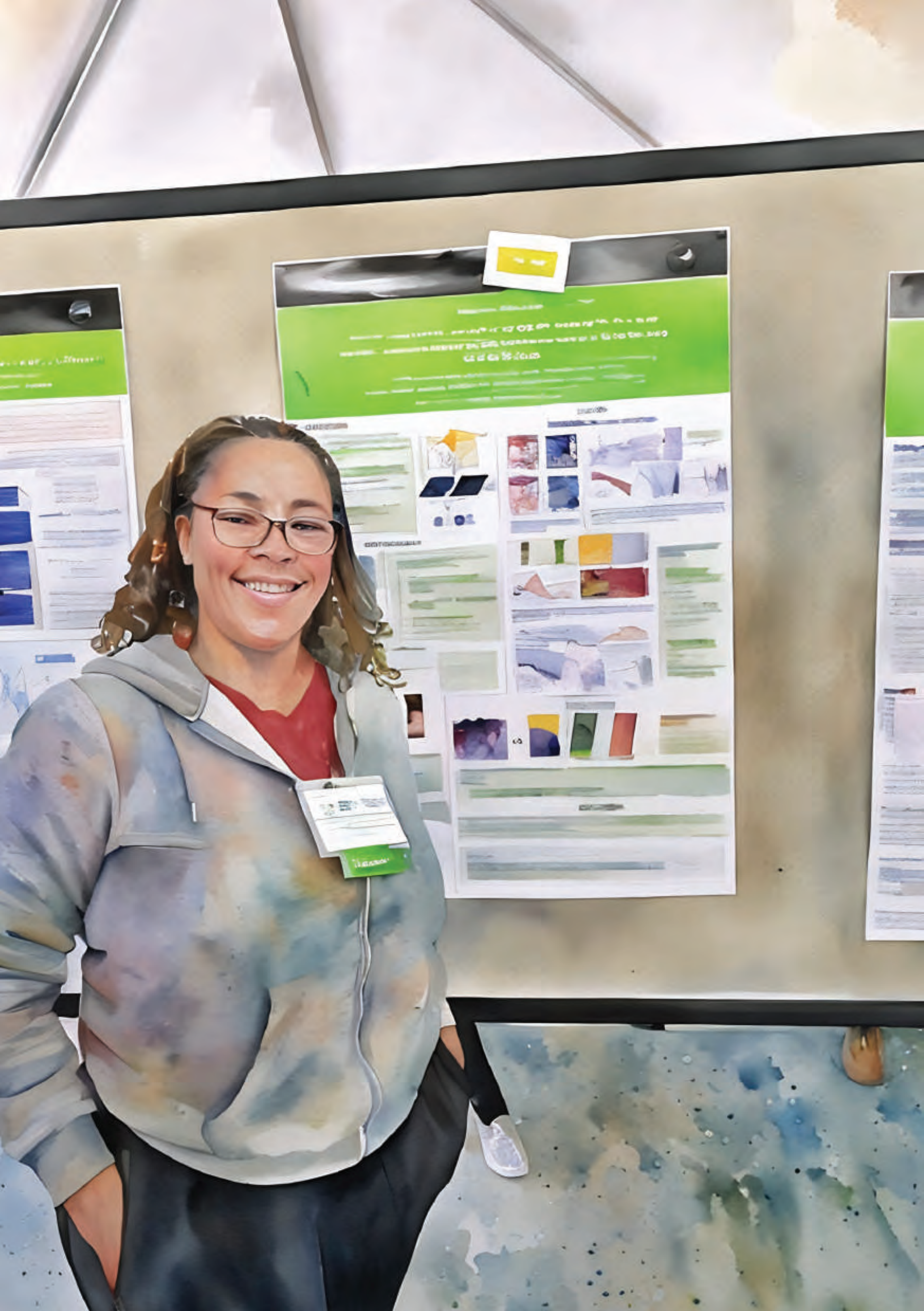
Sea campaign resulted in observations of submesoscale signals on the periphery of a mesoscale anticyclonic eddy. Both seas are oxygen-poor and depend on oxygen-rich Mediterranean inflows. The SWOT AdAC campaigns underlined the role of fine scales on the distribution of oxygen.

Besides SWOT, I investigate frontal variability, associated mesoscale and submesoscale features and their manifestations on transport, in the Mediterranean and Black Seas. Currently investigating the (sub) mesoscale signals observed during the SWOT AdAC campaign with glider deployments in these regions.

PART 3

- California Current
- North West Pacific
- South China Sea and Western Pacific
- New Caledonia
- Bass Straight
- Great Barrier Reef
- North West Australia Shelf
- Southern Ocean





Integrating SWOT data in operational oceanography

Babette Tchonang

Babette earned a bachelor's degree from the University of Dschang (Dschang, Cameroon) and a master's degree through a joint program between the University of Toulouse III – Paul Sabatier (Toulouse, France) and the University of Abomey-Calavi (Benin). She went on to complete a PhD with Mercator Ocean International (Toulouse, France) and CNES before working as a postdoctoral researcher at NASA's Jet Propulsion Laboratory (California). She is currently a researcher at the Naval Research Laboratory (NRL) and Florida State University (Florida).

My field of research is physical oceanography, with a focus on operational oceanography; Altimetry data processing; Satellite, models and in situ data analysis; Data assimilation; Signal processing. I work on integrating satellite data with in situ measurements and models to better understand ocean dynamics at regional and global scales. I chose this field because of a deep desire to contribute to environmental research that has real-world impact.

My field of research in physical oceanography is directly connected to SWOT and began during my Ph.D., where I studied the impact of SWOT on ocean analysis and forecasting using Observing System Simulation Experiments (OSSEs). This work continued during my postdoctoral fellowship, where I contributed to several projects related to the SWOT satellite mission. I participated in the development of an experimental application of the ECCO (Estimating the Circulation and Climate of the Ocean) data assimilation framework to a submesoscale-resolving model at the SWOT Calibration/Validation site off the coast of California. I later collaborated with the U.S. Naval Research Laboratory (NRL) to assess the performance of the Navy Coastal Ocean Model (NCOM), comparing its assimilation of SWOT data and in situ observations—each independently—against mooring and glider measurements. This project is currently ongoing. In addition, I investigated SWOT's ability to retrieve surface current velocities by comparing SWOT-derived geostrophic velocities with in situ measurements from ADCPs and surface drifters. This validation work is essential for the SWOT community to better understand the relationship between fine-scale sea surface height and surface current velocity. Most recently, I have started working on the Navy Earth System Prediction Capability (ESPC) system, with a focus on ocean data analysis and SWOT-related applications within that framework.

What I find most exciting about SWOT is its ability to capture sea surface height at an unprecedented horizontal resolution, revealing fine-scale ocean dynamics such as submesoscale eddies, filaments, and fronts that were previously invisible to conventional satellite altimetry. This opens a new era for physical oceanography, allowing us to better understand ocean circulation, energy cascades, and the coupling between physical and biogeochemical processes. I did not personally participate in the SWOT AdAC campaign, but I contributed by working closely with in situ datasets, including mooring arrays, glider observations, and ADCP velocity measurements, to compare and validate geostrophic velocities derived from SWOT. I also used these in situ data to evaluate model outputs, such as the NCOM assimilating SWOT observations, and I will soon extend this work to the ESPC system.

After completing the analysis of SWOT data, my goal is to integrate the knowledge and tools developed during the SWOT mission into long-term ocean monitoring and forecasting systems, particularly in understudied and data-sparse regions like the Gulf of Guinea.

Beyond my research with SWOT, I'm also leading an initiative that I'm truly passionate about — the creation of the Gulf of Guinea Ocean Sciences Summer School (GGOSSS). The program aims to build scientific capacity in oceanography across French-speaking countries of the Gulf of Guinea. The first edition will take place in August 2025 at the University of Dschang in Cameroon, bringing together students, early-career researchers, and international experts for a week of intensive training. The curriculum includes in situ oceanography, satellite oceanography, numerical modeling, ocean circulation, and the impacts of climate change on coastal regions. This initiative is being carried out with the support of key partners, including Copernicus Marine Service, the Coastal Ocean Environment Summer School (Nigeria & Ghana),SCOR capacity building, and the Partnership for Observation of the Global Ocean (POGO). Our shared goal is to create a sustainable and recurring platform that empowers local scientists with the tools, knowledge, and networks they need to address ocean and climate challenges in the region.

Validating SWOT data in coastal regions

Luke Kachelein

Luke earned his PhD at the Scripps Institution of Oceanography, University of California, San Diego (California). He is currently a postdoctoral researcher at NASA's Jet Propulsion Laboratory, California Institute of Technology (California).

MAY 2025 - My research broadly focuses on the remote sensing of physical oceanographic phenomena. In my postdoc, I have been working towards validating SWOT against other observations, with one project focusing on steric height from in situ moorings, and another comparing currents derived from SWOT with surface currents from a coastal radar network. In grad school I focused on questions about diurnal-and-faster coastal processes, such as "how predictable are tidal currents?" and "how coherent are diurnal currents and winds?". Overall, I'm interested in the complicated dynamics that exist near coasts and how much of that variability we can observe, and I was drawn to this field partly by exposure from growing up in a seaside community, and partly because I think it's fascinating and enjoyable! It's a simple but no less valid reason to learn about some small aspect of the universe.

I am lucky enough to analyse SWOT data directly, so all the work I am conducting at the moment ties back to the mission. Both of my current projects involve validating SWOT against independent observations, so its relevance to SWOT is to determine just how useful SWOT observations are to different goals, e.g. if currents derived from SWOT SSH are indeed sufficient to resolve small eddies near the coast of California (which is very well monitored by other networks) then what studies might this allow us to conduct about coastal dynamics in less well monitored regions?

With SWOT's unprecedented spatial resolution, we are now afforded a direct view of processes that could previously only be observed by ship or highly local observation networks. Now, we can experimentally validate ideas that have long been explored by theoreticians and modelers. Like every ambitious mission, there are also unexpected findings that inevitably lead to expanding oceanographic knowledge in ways we didn't expect; for example, tiny sub-10 km cyclonic eddies with notably cold cores have long been observed by satellite SST missions, but the signals they exhibit in SWOT are starker than I think was anticipated, meaning they can be spotted by SWOT even when clouds would block them from SST-observing instruments. How such small surprises are interpreted by various teams will almost certainly yield greater knowledge of the world's oceans. On a smaller scale than potential scientific breakthroughs, I was personally excited to participate in the post-SWOT redeployment of a state-of-the-art mooring to continue a years-long data record that started during the Cal/Val period; I finally got to participate in seagoing research after an entire PhD of data analysis, a change that I highly recommend!

In the immediate term, I plan to finish my postdoc with another coastal SWOT validation project at smaller scales than I have examined so far. Beyond that, I am hoping to participate in coastal studies that incorporate satellite, other remotely-sensed data, and in situ data to better monitor processes relevant to the resilience of coastal communities and marine ecosystems. Hopefully a mission extension and/or SWOT follow-on would enable many more years of high-resolution sea surface height data.

The role of surface gravity waves at the air-transition zone

Gwendal Marechal

At the time of the first interview, Gwendal was a postdoctoral researcher at the Colorado School of Mines (Golden, Colorado), where he studied surface gravity waves as part of the S-MODE campaign. He is now a researcher at the Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France, working within the Multiscale Ocean Atmosphere Numerical Approaches (MOANA) team.

APR 2023 - I am a physical oceanographer focusing on surface gravity waves. I try to understand what are the roles of these waves at the air-sea transition zone, and how they mediate the heat, momentum, and mass exchanges between the upper ocean and the lower atmosphere. For this aim, I mostly use remote-sensing data (airplane and satellites) and wave numerical models. I chose this field of research certainly because I grew up close to the sea, in Brittany, France, and I've always been passionate about field work at sea, whether it was during fishing off-shore during my childhood or instrument deployment on platforms/vessels during my Master. My choice was oriented to physical oceanography because these were the courses where my grades were not the worst during high school. The choice of surface gravity waves field of study was certainly motivated because of the surf that I started when I was 12.

During my PhD I focused on the effects of surface currents on the wave height and I realized that the operational current products that were available at the time were not sufficiently resolved, especially in space, leading to the fact that a lot of the current-induced spatial variability of the wave height were not captured in numerical model. Thanks to the new geostrophic currents derived from the Sea-Surface-Height (SSH) measured by SWOT, we hope that we will be able to capture current effects on the wave at shorter scales. It will be the opportunity to model how surface currents modify the spatial variability of the wave-induce-air-sea fluxes (wave breaking, gas emission, …). Also, waves represent a source of noise in the SSH measurements (sea-stats bias, layover effects). One of the goals of the next IOP Submesoscale Ocean Dynamic Experiment (S-MODE) campaign is the SWOT Cal/Val. In addition to current and water property measurements (lagrangian floats, CTD, GPS-buoy, …), waves and current will be measured at the same time with two airplanes. It will be the opportunity to estimate the effects of the waves on the bias in the SWOT SSH.

I'm really looking forward to using SWOT data for my research. As said before, I want to have a better idea about the effects of currents on the wave height. However, today we do not have access to high-resolution surface current measurements, so characterization of the current-induced wave property spatial gradients is very limited. Numerical models suggested that the statistics of the wave field is proportional to the surface Kinetic Energy. One consequence of this relationship is that it would be possible to infer current properties from waves measurements. SWOT measurements will provide a ground truth to confirm, or not, this inversion. Something crucial to know, we have a very poor knowledge of surface currents, whereas this variable is crucial for a wide range of applications (climate, marine debris, food chain, …). During the S-MODE campaign I will work on wave measurements provided by lidar. On the boat, I will be in the night shift in charge of CTD casts. This part of the experiment will focus on the three-dimensional characterization of submesoscale fronts (oceanic features with a horizontal scale smaller than a few kilometers). This is also a topic that I care about as a wave-guy; actually, high resolved oceanic simulations suggest that wave-induced circulations modify the submesoscale dynamics down to the first meters of the ocean.

In the near future I plan, first, to get closer to the sea. Although Colorado's mountains are amazing, I miss the sea too much. I plan to start a new project about wave effects on the upper ocean from the data acquired during the S-MODE campaign (Pilot, IOP-1, IOP-2). During the previous campaign we were able to see strong inhomogeneities in the wave field at scale associated with submesoscale fronts as whitecap fronts. At these locations we expect a strong three-dimensional dynamic with a large effect of waves-induced circulation on the underlying flow. This study will be the opportunity to see where the energy from the wind goes, how it drives ocean currents, it grows surface waves, and forces vertical mixing.

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JUL 2025 - Besides SWOT, I am involved through my supervisors and colleagues in the Ocean DYnamics and Surface Exchange with the Atmosphere (ODYSEA) satellite project that is currently in competition for NASA's Earth System Explorers Program. The satellite aims to jointly measure surface currents and low-level wind speed, with an unprecedented spatial and temporal resolution.

Submesoscale ocean dynamics and their impacts on phytoplankton communities and carbon distribution

Sarah Lang

Sarah holds a Bachelor's degree from the University of Virginia (Charlottesville, Virginia) and is currently pursuing a PhD at University of Rhode Island's Graduate School of Oceanography (Narragansett, Rhode Island).

APR 2023 - My research lies at the intersection of physical and bio-optical oceanography. I am interested in how submesoscale ocean dynamics affect phytoplankton communities and carbon distributions. My work involves the coupling of fine-scale airborne remote sensing estimates of advection and vertical velocities at the surface, hyperspectral ocean color, and corresponding in situ datasets. My goal is to characterize the influences of vertical velocities, lateral stirring, and mixing underpinning phytoplankton community distributions across submesoscale fronts.

By coupling NASA DopplerScatt (fine-scale Scatterometer) and NASA PRISM (fine-scale hyperspectral ocean color), I hope my work can inform the ways we can couple physical and biological remote sensing data. Particularly, I am interested in my work informing the coupling of NASA SWOT and NASA PACE (first hyperspectral ocean color satellite, launch Jan. 2024).

Recent studies suggest that submesoscale biological and physical processes in the ocean play an important role in the climate system, yet these processes are not well-understood. By providing global altimetry data at an unprecedented spatial resolution (ca. 10 km), SWOT will be able to partially resolve submesoscale processes. This will further our understanding of the importance of submesoscale processes to global circulation, the ocean's role in climate, and biogeochemical cycling. I am contributing to the campaign through my involvement in S-MODE. During this upcoming cruise (Spring 2023), which I will be a part of, we will take a wide range of high-resolution physical and biological measurements from aircrafts, unmanned platforms, and ships with corresponding SWOT overpasses (1-day repeat crossover offshore of CA). In situ measurements are crucial for validating and evaluating satellite data, and I am excited to be able to contribute to this process for SWOT!

After the SWOT fast-sampling phase, I will continue to study the ways that submesoscale dynamics structure phytoplankton ecosystems and evaluate the ways that remote sensing can help illuminate these processes. In my current work, the coupling of DopplerScatt and PRISM could illuminate new remote sensing techniques. My goal is to further assess the feasibility of these techniques directly applied to SWOT and PACE.

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JUL 2025 - I participated in NASA's Submesoscale Ocean Dynamics Experiment, or S-MODE, which was a Earth Ventures Suborbital investigation conducting three field campaigns between 2021-2023. S-MODE helped advance the observational understanding of submesoscale dynamics using new remote sensing techniques, such as DopplerScatt and DoppVis (SIO MASS). The last S-MODE field campaign took place during SWOT's calibration and validation phase. This allowed for the comparison of currents measured by DopplerScatt, DoppVis, and other platforms with SWOT sea surface height anomalies (SSHa) and derived currents. SWOT resolves smaller spatial scales than previous space-based altimeters. Hence, ageostrophic currents become more significant and relationships between SWOT SSHa and surface velocities become more complicated. Understanding the relationships between SSHa and currents is critical for the derivation and interpretation of currents derived from SWOT. SWOT and S-MODE comparisons are currently being led by others on the S-MODE science team.

My focus in S-MODE involves combining airborne, satellite, and in situ measurements of currents, ocean color, and temperature to look at the impacts of submesoscale dynamics on phytoplankton and particulate organic carbon. Specifically, I merged concurrent physical and bio-optical measurements from an airborne instrument platform (SIO MASS) to uncover relationships between surface kinematics and phytoplankton. In another project, I merged DopplerScatt velocities and Sentinel-3 ocean color to estimate submesoscale vertical fluxes of particulate organic carbon and heat at a dynamic upwelling front. Spatial distributions of fluxes from remote sensing provided evidence that fluxes were associated with isopycnal transport at the restratifying front and the subduction of submesoscale filaments. Corresponding high-resolution, ship-based surveys measured the hydrographic and bio-optical vertical structure of the front and provided evidence for isopycnal transport and filament subduction below the mixed layer. Flux estimates are also further corroborated by direct estimates of vertical velocities from a Lagrangian float. Lastly, I am working on a project with my team from the 2024 NASA PACE Hackweek, merging SWOT with hyperspectral ocean color from NASA PACE and vertical measurements from BGC-Argo floats to uncover how Gulf Stream eddy dynamics impact the evolution of phytoplankton community groups.

Eddy heat transport and its impact on climate

Peiran Yang

Peiran earned her PhD at the Ocean University of China in Qingdao (Shandong Province, China) and is currently a postdoctoral researcher at Laoshan Laboratory, also in Qingdao.

FEB 2023 - I'm now investigating the dynamics of mesoscale and submesoscale processes focusing on the generation of vertical eddy heat transport and its impact on climate. It is one of the frontiers in physical oceanography as the role of fine-scale processes in the climate system remains unclear. Although the mesoscale and submesoscale processes show strong nonlinearity and complexity, it is attractive to unravel their dynamics with the help of powerful computational power. It is like playing a puzzle game with the help of governing equations and ocean simulations.

The mesoscale processes are resolved and the submesoscale processes at mid- and low-latitude are partly resolved by the SWOT altimetry measurement with a spatial resolution of ~10 km. Therefore, the SWOT mission will help to understand the distribution and the variability of the fine-scale process and test the dynamics we obtained from simulations.

In the past, oceanic fine-scale processes could only be studied using simulations and single position mooring arrays. SWOT provided the first tool to look into them with global coverage and long temporal coverage. This will revolutionize our understanding of the distribution and variability of fine-scale processes. I will help with validating the SWOT data collected in the fast-sampling phase and estimating the vertical heat and buoyancy transport with mooring, glider, and SWOT observations at the location of the North West Pacific campaign. This will advance our understanding of the role fine-scale process plays in the ocean energy pathway and shaping the thermal structure of the upper ocean.

After the North West Pacific campaign, I will continue to work on the dynamics of mesoscale and submesoscale processes. With the help of SWOT altimetry datasets, other observational datasets, and model simulations, I tend to refine the existing parameterization of vertical eddy heat transport in climate models.

SWOT observations for marine gravity recovery

Daocheng Yu

Daocheng earned his PhD from the Department of Civil Engineering, National Yang Chiao Tung University (Taiwan). He is now an Associate Professor at the School of Geomatics, Liaoning Technical University (China).

MAR 2023 - My field of research is Geodesy, and in particular marine gravity recovery from satellite altimetry.

[If I think about SWOT, I think:] How exciting it is to reveal seafloor secrets from space! Satellite altimeter observations are helpful for us to explore seafloor topography. The sea surface heights measured by satellite altimeters can be used to derive marine gravity anomalies, which are useful for mapping the seafloor topography and determining the tectonic structures of the seafloor. Most of the seafloor tectonics are detected by the satellite-derived marine gravity field. It makes sense for me to further improve the accuracy and spatial resolution of the marine gravity field to discover uncharted tectonic features.

The accuracies of the current marine gravity fields are about 3-5 mgal. The nominal grid intervals of these fields are 1×1 min, but the actual signal resolution (half-wavelength) may exceed 6 km. The accuracy and resolution of marine gravity fields depend on the accuracy and resolution of the sea surface heights (SSHs) measured by satellite altimeters. A nadir-looking radar altimeter measures only SSHs along the satellite ground tracks to obtain one-dimensional SSH observations. The cross-track spacing of exact repeat missions (ERMs) is hundreds of kilometres, while that of geodetic missions (GMs) can be a few kilometres. Thus, GM data are mainly used to derive marine gravity field; however, the accuracies of GMs are lower than those of ERMs. Moreover, there are systematic and random errors in the SSH observations from different tracks, leading to spatially non-uniform SSH observations. In contrast, SWOT measures wide-swath SSHs with a nominal 2-km spatial resolution with unprecedented accuracy. Therefore, SWOT's swath SSH observations outperform radar altimeter data in both spatial resolution and accuracy, leading to much improved marine gravity fields.

My past research has indicated that SWOT sea surface height (SSH) observations have the potential of deriving a high-accuracy marine gravity field. The north and east components of the deflection of the vertical (DOV), which can be used to recover marine gravity anomalies, determined from the current nadir-looking altimeters have different qualities. The accuracy of the north DOV component is better than that of the east DOV component because most satellites are in near-polar orbits. In theory, SWOT wide-swath observations can obtain the north and east DOV components with the same accuracy, which will improve the quality of the marine gravity field.

In the South China Sea and western Pacific campaign, our team proposes to recover the marine gravity field from SWOT 1-day repeated measurements in the South China Sea, which can be assessed by the shipborne gravity data. It is exciting that the marine gravity field derived from SWOT is better than that derived from conventional radar altimeters.

In the South China Sea and western Pacific campaign, I will preprocess the SWOT SSH observations in the fast-sampling phase, and then derive marine gravity anomalies in the South China Sea. Because SWOT first observes wide-swath SSHs, some problems may arise when deriving marine gravity anomalies from SWOT data using the methods for processing the one-dimensional data from conventional altimeters. I will overcome these problems to obtain the optimal gravity field. I will combine the altimeter data from all the current altimeters to recover a best marine gravity field in the South China Sea, which is used to compare to the SWOT-derived gravity field. Also, I will detect sub-mesoscale oceanic eddies from SWOT measurements.

After the end of the fast-sampling phase and of your field campaign, I plan to recover a high-accuracy and high-resolution marine gravity field in the South China Sea from the SWOT data in the science phase. I will improve the current methods for deriving marine gravity from the nadir-looking altimeters and even develop a new gravity recovery method for SWOT data. I will summarize optimal data processing for SWOT data. I hope that the best gravity field will discover some uncharted tectonic features of the seafloor. If I have enough resources, I will determine a global marine gravity grid from 21-day repeated SWOT SSH measurements.

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JUL 2025 - We used SWOT Version C Level 2 data from the fast-sampling phase in the South China Sea to validate SWOT's performance in recovering marine gravity fields. The 95 cycles of fast-sampling phase data are equivalent to about 5.5 years of data from the science phase, offering sufficient repeat data to evaluate the potential of SWOT for deriving long-term, stacked marine gravity fields. We outline optimal processing strategies for refining SWOT sea surface heights (SSHs) to derive marine gravity anomalies. These strategies include rejecting outliers, mitigating ocean variability by removing sea level anomaly, correcting tilts across the entire SWOT swath segment using a three-dimensional plane, and averaging geoid gradients to reduce random errors. SWOT demonstrates the capability to derive north and east gradient components and marine gravity fields at finer scales compared to conventional altimeters, particularly over rough seafloor areas where SWOT can observe high-wavenumber SSHs. SWOT reveals continental shelf margins more clearly than conventional altimeters. Marine gravity anomalies from 3 months of SWOT data have an accuracy of 2.28 mGal, which is 12% better than the accuracy achieved with 14 years of data from conventional nadir altimeters. The gravity recovery procedures developed using SWOT fast-sampling phase data can be extended to derive optimal local and global marine gravity fields during the mission's science phase.

My research is primarily centered on the SWOT mission. Before its launch, I carried out simulation-based studies to evaluate its capability for marine gravity recovery. Following the availability of real SWOT observations, I have been applying the data to develop high-accuracy and high-resolution marine gravity fields. I have proposed novel methods for estimating the north and east components of the deflection of the vertical based on wide-swath SWOT altimetry. In parallel, I also use data from multiple conventional nadir-looking altimetry missions to construct marine gravity fields.

How internal tides are expressed in the spectral space

Arne Bendinger

Arne began his academic career at the University of Kiel in collaboration with the GEOMAR Helmholtz Centre for Ocean Research (Germany), where he specialized in physical oceanography. During his studies, he gained extensive field and research experience by participating in several offshore projects, working as a student assistant within a GEOMAR research group, and joining an exchange program at the University Centre in Svalbard (Norway). These experiences inspired him to pursue a PhD within the DYNOTROP group at the Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France.

FEB 2023 - During my studies in Kiel, in fact during an offshore campaign in the Labrador Sea, I was fascinated by the dynamics of ocean turbulence, i.e. ocean eddies, and the way we can study them using in situ observations and altimetry. This is why I chose to work in the context of SWOT and SWOT AdAC. Here at LEGOS in Toulouse, I am going even further, trying to understand how eddies interact with other small-scale dynamics. This concerns in particular the internal tides (internal waves at the tidal frequency) that are widely present around New Caledonia in the ubiquitous eddy field. Moreover, this raises the question of the distribution of energy between different spatial scales and the role of physical processes at the fine scale on the global energy balance of the ocean.

From an oceanic perspective, SWOT's goal is to observe meso- and sub-mesoscale dynamics at scales up to 15 km in wavelength, a resolution ten times higher than current altimetry products. However, with these high scales resolved, the challenge is to disentangle the dynamics that contribute to the SSH signal. And since these dynamics can have similar wavelengths, such as eddies and internal tides, this limits our ability to observe meso- and sub-mesoscale structures. My studies attempt to contribute to the understanding of how internal tides are expressed in spectral space, i.e. in SWOT measurements, and how a correction for these internal tides can potentially increase the SWOT observability of meso- and sub-mesoscale dynamics. To do this, we first need a detailed study of the internal tidal field in my region of interest around New Caledonia. We have therefore set up a high-resolution regional numerical simulation that also serves as a reference for planning and optimizing the in situ experiment that is conducted in the SWOTALIS campaign.

With respect to SWOT, I am fascinated by our ability to measure the small-scale physics associated with meso- and sub-mesoscale dynamics from space and on a global scale at a resolution never before achieved. I am also curious about the insights we will gain into energy transfer across a wide variety of scales. The SWOTALIS campaign is an excellent opportunity not only to evaluate SWOT measurements, but also to use the unique opportunity of having high resolution, high frequency (one day repeat orbit) SSH data to study the temporal evolution of local dynamics. In addition, we will be able to measure the three-dimensional water column using in situ observations, which will help us understand how local dynamics are expressed in SSH. Our SWOT AdAC campaign will take place in southern New Caledonia. This is the region that is identified as being subject to both strong internal tides and mesoscale eddies. In addition, this region lies just below the path of SWOT when in a repeated day orbit. To accomplish this, we have planned several experiments, including oceanographic moorings, repeated hydrography and velocity sections, and fixed stations for microstructure measurements to estimate turbulence and energy dissipation. I will be participating in one of the campaigns planned for March-April 2023. My work is related to fine-scale physics measurements in the area of tidal energy propagation and dissipation. These datasets will be very valuable in furthering our understanding of the internal tidal dynamics in southern New Caledonia from an observational perspective that can also be used to evaluate our numerical simulation.

After the cruise, my first goal will be to finish my PhD. However, the at-sea campaign will provide a large amount of data. In the long term, we plan to continue our collaboration to analyze the collected datasets before comparing them to the actual SSH data from SWOT. These measurements will also provide a first look at local dissipation induced by vertical mixing, which should be of great importance to New Caledonia's ecosystem, biodiversity and marine habitats, for which New Caledonia is internationally known.

Current-topography interactions

Clément Vic

Clément completed his PhD at the Laboratoire d'Océanographie Physique et Spatiale (LOPS) in Plouzané, France, where he investigated western boundary dynamics in the Arabian Sea using numerical ocean circulation models. He then held a postdoctoral position at the National Oceanography Centre in Southampton, UK, focusing on internal tidal waves and energy dissipation, while also gaining expertise in in situ observational methods. He is currently a researcher at Ifremer (Institut français de recherche pour l'exploitation de la mer) within LOPS.

MAR 2023 - I work on oceanic fine scales in general and current-topography interactions in particular. I came to these topics at the end of my thesis, taking into account the emergence of new processes that appear spontaneously in the models by increasing the resolution.

SWOT will allow us to sample the free surface of the ocean with better resolution than is currently done and to refine our knowledge of the propagation of internal tidal waves, as well as their interactions with low frequency currents.

I think this is a great opportunity to create synergy between several ocean analysis tools, between satellite measurements, in situ measurements, and numerical modeling of the regional circulation. During the SWOTALIS campaign, while on board, I will help deploy a microstructure profiler, which makes very high frequency measurements of velocity shear and allows us to infer energy dissipation.

After the SWOT AdAC campaign, I plan to … Take a vacation!

JUL 2025 - We are currently analysing mooring data, which reveals a tremendous variability in internal tide energy fluxes, both in amplitude and direction! We'll try to understand what drives that variability and what are the consequences in terms of mixing.

Validating SWOT data in the Bass Straight

Andrea Hay

> Andrea Hay earned her undergraduate degree at the University of Tasmania, where—at the time of the interview—she was pursuing a PhD in collaboration with CSIRO (Australia). Her doctoral research included participation in the SWOT AdAC campaigns in Bass Strait, the Southern Ocean (SOTS), and at Davies Reef in the Great Barrier Reef.

MAR 2023 - My field of research is the in situ validation of altimetry measurements. I chose it by spending three years as a surveyor, walking over paddocks and train tracks and roads with a GPS and thinking about what gets my brain the most excited. I am not quite sure why altimetry validation got the tick of approval – perhaps because I would walk my dog down towards the beach looking over Bass Strait every morning, and was grabbed by the sheer audacity of not only trying to measure *all that water* with a RADAR in SPACE, but then to measure it in situ as well!! With all the waves, and tides, and currents, and changes in gravity, and density, and circulation and on and on and on – it's amazing we get sub-meter accuracy, and here we are talking about the centimeter level. Isn't that just wild?!!

I feel lucky in that my work is directly related to SWOT, as I will be contributing to the validation of SWOT measurements!

The Bass Strait validation site has been gearing up to provide valuable data during (and beyond) the SWOT fast-sampling phase, and so it is very exciting to be part of the team working on this right now! In addition to the long-term facility in Bass Strait, I am excited to see the data from our Southern Ocean mooring and from the Great Barrier Reef, as this will give us quite a diverse dataset to work with when we get to dive into the SWOT comparisons. I will be contributing to the campaigns by helping with some instrument deployments, and processing a lot of GNSS data, and then comparing our in situ measurements to the SWOT observations.

My main plans directly after the campaign are to publish our findings and complete my PhD! After that… I think 'plans' is too strong a word for the post-PhD period. I suppose I would like to continue contributing what I can, where I am able to. Which is pretty non-committal isn't it… What I tell people, if they ask, is that "I'll do a post-doc if there are any sufficiently interesting ones that will have me!", but I have no idea what 'sufficient' looks like for my future self, and it will be another couple of years before I can make any guesses at my value to any institution as a researcher. So 'plans' are a bit tricky. There are some things I am sure I would like to do though. I would like to become more and more sensitized to the absurdity of the myths about 'eternal economic growth' and 'nature-as-resource' that our consumer driven society seems to be built on. I would like to find ways to question, resist, and go against these – to throw my tiny weight towards recognizing that 'ecosystems' and 'nature' are not something we are separate from, but something we are made of. That, of course, our sick and sickening societies cannot be healed while our planet continues to be degraded by them. I think any plan that aims at anything less than contributing towards deep cultural change is not ambitious enough. I'm not sure how to do that yet… (aside from the non-negligible nudges offered through poetry). Do get in touch with me if you have any ideas! Perhaps SWOT, offering this chance at a deeper understanding of our ocean, could also spark some deeper appreciation for it…

Turbulence, velocity, and atmospheric conditions at fine scales

Jen-Ping Pen

Jen-Ping is Research Associate at the Oceans Graduate School, University of Western Australia in Crawley (Australia). During the SWOT fast-sampling phase, he took part in the North West Australia Shelf campaign.

MAR 2023 - Broadly speaking, my field of research is physical oceanography, with special interests in fine-scale ocean dynamics, flow instability, and marine turbulence. The ocean is huge and provides essential environments for humans to live, however, we only know a little about it. I personally enjoy discovering things that exist but are hidden, and the ocean is the best place for my appetite as it is relatively easily accessible. SWOT aims to reveal fine-scale structures that are unable to be observed previously. This is exactly where my expertise lies. Our colleagues and I will be able to obtain a better understanding of fine-scale ocean dynamics, particularly their spatial variability, as users of SWOT satellite data. This is indeed very exciting. We will conduct a field campaign on the North West Australia Shelf, which will coincide with SWOT satellite flying over. I will be in charge of conducting intensive field observations to characterize fine-scale structures, hydrography, turbulence level, velocity, and atmospheric conditions. After the end of the campaign, I will analyze the in situ data. I am extremely looking forward to seeing and learning something new from both co-located SWOT and in situ data.

SWOT measurements to estimate submesoscale and sea surface currents

Rick de Kreij

Rick earned a Master's degree in fluid mechanics from the Eindhoven University of Technology (Eindhoven, Netherlands). During that time, he completed his graduation project at the University of Cambridge (Cambridge, UK) investigating the spread of airborne diseases in a train carriage. In March 2022, he started his PhD at the University of Western Australia (Australia) within the Ocean Dynamics group to research how satellite observations can be used to estimate surface currents.

FEB 2023 - I am investigating the use of satellite measurements to estimate submesoscale sea surface currents (SSCs). These SSCs drive the distributions of surface tracers, such as temperature, chlorophyll, and sea level. Unfortunately, the direct measurement of SSCs is difficult over large spatial scales. However, we are working on a novel method that allows us to estimate the SSCs from satellite sea surface temperature (SST) and sea surface height (SSH) data. The constructed framework is a statistical inversion method, built around a Gaussian Process Regression. The main benefit of this method is that it not only estimates the SSCs but also quantifies the uncertainty of the estimates. These novel methods aim to supply ground-breaking tools to study submesoscale features. In addition, this work will aid offshore oil and gas operations, pollution responses, and a variety of other applications. I have chosen this field of research due to my large interest in ocean dynamics and its relation to the global climate. The scale and complexity of the ocean are things that keep amazing me.

As mentioned before, my work focuses on estimating SSCs using SST and SSH. Here, the SSH of the high-resolution 2D SWOT measurements will be used to improve the SSC estimates. In our statistical approach, the geostrophic SSCs estimated from the SWOT data will be used as background flows. Subsequently, these flows will be combined with the SST inversion algorithms relying on Gaussian processes, promising to advance both the accuracy and precision of SSCs. The required techniques are developed based on the North West Australia Shelf and will be modified to be globally applicable.

I find the SWOT analysis and the North West Australia Shelf campaign exciting because they provide a unique opportunity of studying the dynamics of the ocean using SSH. Furthermore, it can be used to improve our understanding of ocean circulation and its role in the Earth's climate system. Additionally, the North West Australia Shelf campaign will allow me to participate in the analyses and directly incorporate the data in our research projects to improve the understanding of submesoscale SSCs. This is an exciting opportunity to be part of cutting-edge research that can have a significant impact on our understanding of the ocean and its role in the Earth's climate system.

After the campaign, I plan to continue my research in the estimation of SSCs from remotely sensed data. Furthermore, I aim to stay engaged in the network around the North West Australia Shelf campaign and to publish my findings in high-quality scientific journals. With the advanced technology of the SWOT mission, I am convinced this will result in many new research opportunities.

The influence of small-scale motions on large-scale ocean dynamics and poleward heat transport in the Antarctic Circumpolar Current

Yann-Treden Tranchant

Yann-Treden earned a Master's degree in Physical Oceanography from Brest University/IUEM (France) and later completed a PhD in coastal oceanography and altimetry at La Rochelle University with the LIENS laboratory (La Rochelle, France). He is currently a Research Associate with the Australian Antarctic Program Partnership at the Institute for Marine and Antarctic Studies, University of Tasmania (Hobart, Australia).

DEC 2023 - I am a physical oceanographer with a strong interest in satellite altimetry. During my PhD, I enjoyed playing with marine drone acquisition and hydrodynamic models to improve our understanding of altimetry measurements in coastal regions and enhance their exploitation, in the perspective of the launch of SWOT satellite. I have developed research affinities at the intersection of oceanography, geophysics, geodesy, and instrumentation, that I am now applying in climate-related research in the Southern Ocean with my current position of Research Associate as part of the Australian Antarctic Program Partnership. Here, I take part in the SWOT-ACC SMST (aka FOCUS = Fine-scale Observations of Currents Under SWOT) campaign.

My actual research is 'focused' on the influence of small-scale motions on large-scale ocean dynamics and poleward heat transport, particularly in an energetic meander of the Antarctic Circumpolar Current (ACC). With SWOT, we have a new (and amazing) view of the surface signature of fine-scale ocean dynamics, like filaments and small eddies, that are the 'dirt under the carpet' of present climate models, but impact greatly the heat transport across the Southern Ocean towards Antarctica. My interest is to assess how useful these SWOT observations are, when integrated with ancillary observing systems, satellite altimetry data, and ocean model outputs to quantify heat and carbon uptake and transfers in the Southern Ocean.

I'm feeling lucky, being an early-career researcher during a period of major technological and scientific advances in the field of satellite altimetry. In November-December 2023, I participated in the ambitious and intensive oceanographic FOCUS voyage on Australian CSIRO research vessel RV Investigator (part of the SWOT AdAC campaign). Having started my new position during the last months of preparation of the voyage, I have jumped into the deep end by being involved in the planning for the deployment of (semi-) lagrangian instruments, including drifters, EM-APEX, BGC-Argo (Argo float with biochemical sampling capabilities) and gliders. During the voyage, I was part of the team sampling the CTD rosette (a total of 111 CTD casts in one five-week voyage, what a baptism of fire !!). After (and before) years of processing remote-sensing and in situ data, it is very exciting to 'feel the physics' of the ocean in a high-energy zone of the Antarctic Circumpolar Current. Experiencing how oceanographic data is collected will greatly help my understanding of in situ data acquisition, their limitations and to realise their human-work (and financial) value. It is wonderful (and maybe indispensable) to have this and such memories in mind when one knows that the other part of the story also includes billions of hours sitting in front of a computer, struggling with coding or modeling frameworks.

After the campaign, I plan to do a dollop of data processing, a sprinkle of scientific discussions, a dash of writing, and another voyage, I hope! We collected a comprehensive dataset in a very energetic meander of the ACC, that includes acquisition from a tall mooring, hundreds of CTD casts, Triaxus tows, shipborne underway sensors, gliders, profile floats and surface buoys, etc., all concurrently with SWOT observation: enough to fill the days of many researchers for a while! I am with the Australian Antarctic Program Partnership as a Research Associate until 2026. In my new-found relationship with the Southern Ocean, I am discovering different types of physics, surrounded by brilliant researchers and technicians, and impressive technology. Against a background of dramatic change and exposed to constant data flow, I really feel that the new SWOT era will be cooperative and multi-disciplinary, thus I am also keen to start collaborative works with bio-geochemistry researchers as part of my position. By helping to fill some gaps in the complex story of the role of the Southern Ocean in the global climate system, I'll try to make meaningful contributions to climate-related research into poleward heat transport to Antarctic ice shelves.

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JUL 2025 - One of the exciting results of the FOCUS voyage is the demonstration that SWOT observations dramatically improve our ability to resolve fine-scale surface currents in the Antarctic Circumpolar Current. In a recently accepted publication, we show that surface currents derived from SWOT, using a dedicated method developed for this study, match drifting buoys observations with unprecedented accuracy. We also found that in this energetic region full of spinning eddies, the motion of these surface buoys is better described by a more complete dynamical balance that includes additional forces beyond classical geostrophy. It is a first, direct observational evidence, allowed by SWOT's high spatial resolution. Another demonstration of the advancements brought by SWOT observations is their ability to capture the dispersion of particles at the ocean surface, something that previous satellite observations were unable to do. As a small piece of a larger puzzle, these results have huge implications for better understanding and quantifying the transport and exchanges of heat and carbon in the Southern Ocean, and the global ocean more broadly.

Besides SWOT (but never very far from it these days...) and outcomes from the FOCUS voyage, I'm involved in exciting Australian and international collaborations, diving into high-resolution ocean modeling, particle-tracking experiments, and the reconstruction of vertical velocities driving vertical heat transport. My research aims to better constrain horizontal and vertical tracer fluxes in the Southern Ocean and to explore the role of fine-scale processes in heat and carbon budgets.

Vertical velocities to understand where the Southern Ocean acts as a source or a sink for heat and carbon

Elisa Carli

Elisa holds a PhD in Physical Oceanography from the Laboratoire d'Études en Géophysique et Océanographie Spatiales (LEGOS) in Toulouse, France. She is currently an Internal Research Fellow in Physical Oceanography at the European Space Agency (ESA) in Frascati, Italy.

APR 2025 - In my research I focus on the observation and analysis of mesoscale and submesoscale currents in the Southern Ocean with satellite altimetry, model simulations and in situ data. In particular, I am investigating the best methodologies to reconstruct the vertical dynamics of the water column from the surface fields observed by altimeters.

I discovered the profession of the physical oceanographer when I was working as an engineer for radar architecture. I immediately fell attracted to this for the importance that the ocean has in our everyday life and for its role as a mitigator for climate change. My PhD has allowed me to discover many aspects of this profession, from the processing of satellite and model data to the deployment of instruments to collect in situ data. Every part of it is fascinating for the great impact our science has on society and nature. Particularly, I got interested in the reconstruction of vertical dynamics from surface data because vertical currents move heat, carbon, nutrients and other tracers, but we cannot directly measure these quantities everywhere, at all times. Finding a way to accurately access this information from satellite observations will be extremely important for understanding and protecting our ocean.

SWOT is the central focus of my research. My PhD spanned the period between the final preparation of the mission, the launch, and the first data analysis. My main research question was related to the role of small-scale horizontal currents in the Southern Ocean and how SWOT would enhance their understanding compared to traditional altimetry observations. Once we understood the great potential of SWOT observations, we also advanced on the reconstruction of vertical velocities from the SWOT high-resolution sea surface height fields.

I see SWOT as a breakthrough in physical oceanography. The high-resolution surface fields are revolutionizing our understanding of ocean dynamics. Not to mention that SWOT is conceived as a scientific demonstrator. Thanks to the first results, future missions will use the same technology and overcome some of the limitations SWOT still has, such as the temporal resolution. The AdAC mission I participated in, the SURVOSTRAL campaign, aimed at sampling the upper ocean temperature at high resolution (one sample every 8 km) between Tasmania and Antarctica to validate SWOT observations. I performed the sampling strategy to account for the concurrent observations of SWOT and the crossing of the ocean fronts, and deployed instruments day and night! I then used the in situ temperature profiles as a reference in the area and compared them to the vertical velocities' structures reconstructed from the surface fields.

During my postdoc I am refining and extending the methodologies for reconstructing vertical velocities by combining satellite altimeter and in situ data. The aim is to evaluate in which locations the Southern Ocean acts as a source or sink of heat and carbon over the period of the SWOT mission. This will allow us to evaluate the most vulnerable, productive or active regions in order to improve climate models and protect our ocean.

Assimilating SWOT data into global ocean models

Ergane Fouchet

Ergane graduated in 2020 with an engineering degree in Fluid Mechanics and a research Master's in Ocean Dynamics. She then spent four years as a research engineer at NOVELTIS (Labège, France), a company specializing in space technologies and environmental monitoring. In March 2024, she began a PhD at Mercator Ocean International (Toulouse, France), focusing on operational oceanography and ocean forecasting.

JUN 2025 - My field of research mostly involves physical oceanography and satellite altimetry. My first job at NOVELTIS focused on tide modelling and coastal altimetry, along with some training and outreach activities. I've always loved space and satellites, but I also felt the need to do something socially meaningful and ethical, especially related to the climate crisis. Working at NOVELTIS was a great mix of both: I got to work on exciting projects with major space agencies while contributing to Earth observation and modelling.

I learned a lot during those four years, but eventually I wanted to get back into a more academic environment. I'm now doing a PhD at Mercator Ocean International, looking at the impact of assimilating SWOT data into global ocean models. I chose this subject because it brings together my background in ocean modelling and altimetry and gives me the chance to further learn about ocean physics and operational oceanography. Most of all, I was really excited to spend three years studying SWOT data.

During my first job at NOVELTIS, I was mainly specialized in tides and contributed to the development of the global tidal model FES2022, which is now used to correct barotropic tides in SWOT sea level anomaly (SLA) products. After SWOT was launched, we analyzed how its sea surface height (SSH) measurements (especially during the Cal/Val 1-day-repeat phase) could help better estimate the tidal constituents. Now at Mercator Ocean International, I'm doing a PhD focused on how to better assimilate SWOT data into global ocean forecasting systems. SWOT provides an unprecedented view of the global sea surface height at high resolution, but it only observes the surface, and with spatial and temporal gaps between the satellite revisits. This is why we still need ocean models: to physically and dynamically propagate this information in time, in depth, and across other physical variables. The goal of my PhD is to improve the way SWOT data is integrated into operational models. To do so, we need to understand what physical signals SWOT captures — especially at small mesoscales — and how that compares to what the model simulates. Our assimilation system has been tuned using simulated SWOT data, so now we're analyzing how it performs with the real satellite measurements. The idea is to identify the strengths and limits of the current system, and to quantify the added value of SWOT to ocean modelling and forecasting.

What I find most exciting about SWOT is the unique opportunity to observe the ocean's fine scales, to understand the energy transfer across scales and in the end to better understand how the ocean works and mitigates climate change. I didn't get the chance to participate in a SWOT AdAC campaign yet but I've been able to work with drifter data from S-MODE and QUICCHE campaigns. These datasets are incredibly valuable for validating both what SWOT observes and what the models simulate. Because they are completely independent from both the satellite observations and the assimilation system, they provide great references for understanding discrepancies and improving our analyses. I really enjoy how SWOT is bringing together a broad international community of oceanographers and altimetry experts. The AdAC campaigns are a great example of this collaboration, where we share data, methods, and results across teams, a nice demonstration of open science.

AI methods to study ocean scale interactions and the kinetic energy cascade

Scott Martin

Scott completed his undergraduate degree in Physics at the University of Oxford (Oxford, UK) and is now pursuing a PhD in Physical Oceanography at the University of Washington's School of Oceanography in Seattle (Washington).

AUG 2025 - My research has focused on (a) developing AI methods for improving how we retrieve high-resolution surface ocean currents from satellite altimetry and (b) applying these methods to studying ocean scale interactions and the kinetic energy cascade. When I started my PhD, I knew I wanted to focus on ocean eddy dynamics, then my advisor had a NASA grant for developing AI methods for satellite altimetry which I started working under which is how I got into working with SWOT and nadir altimetry. Beyond their scientific importance, I was captivated by the aesthetics of ocean eddies and seeing satellite images of fine-scale ocean eddies got me hooked!

A key technical challenge in interpreting the SWOT measurements is how to retrieve ocean velocities from the SSH measurement, and how to fill in the large spatiotemporal gaps between measurements. Existing statistical and dynamical approaches are not well suited for the challenging nature of SWOT data assimilation since submesoscale eddy time-scales are short compared to the gaps between measurements. My PhD has focused on developing data-driven AI methods that (a) can learn more complex SSH dynamics than can be represented with objective analysis methods, and (b) can synergize multiple satellite sensors (e.g. SSH and SST) to extract as much information as we can about ocean eddy dynamics from our satellite measurements. We first focused on nadir altimetry and developed a new global gridded SSH product 'NeurOST' which better resolves mesoscale eddies than the previous community-standard dataset by synergizing SSH and SST observations. More recently, I have been focusing on developing methods more applicable to interpreting SWOT data by training generative diffusion models to jointly reconstruct SSH, SST, SSS, and surface currents from satellite observations by pre-training on high-resolution numerical simulations. By learning realistic dynamical relationships between variables from high-resolution numerical simulations, we hope to be able to fill in the gaps between SWOT measurements and infer unobserved variables like surface currents.

The step change in SSH resolution and coverage provided by SWOT is so exciting! I feel so lucky to have been doing a PhD right when SWOT comes online. I feel like so much of our understanding of submesoscale dynamics is derived from numerical simulations, so I can't wait to see the ways in which SWOT measurements surprise us!

Once we have high-resolution surface ocean state estimates derived from SWOT, I plan to see what they tell us about the variability of the submesoscale-mesoscale upscale kinetic energy cascade.

Besides SWOT, I've recently been doing an internship with the NVIDIA AI for Weather & Climate Simulation research group where we've been exploring AI methods for long-range weather modeling.

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Image credits

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