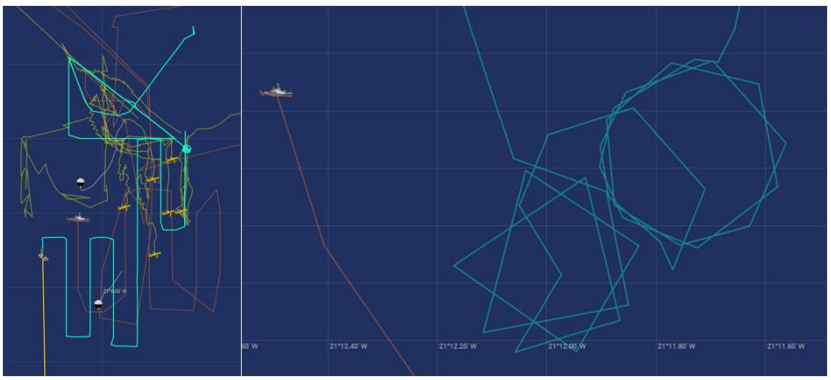
Weekly Report 3: 2.-8.12.2019: From the large to the smale scale…

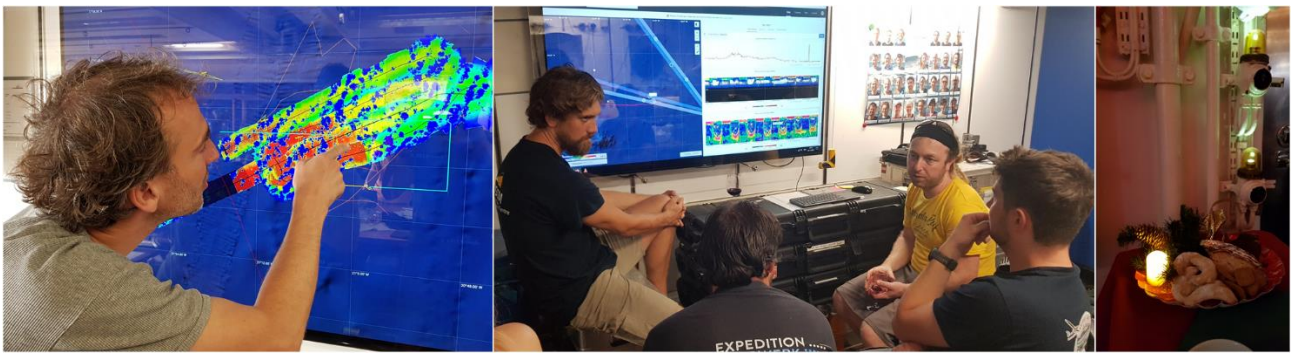
In the 3rd weekly I would like to give you some insights into our research concept in addition to current information on the course of the expedition. The large-scale measurement of the eddy 250 km northeast of the island of Sal has been completed. The "electrodes" I mentioned earlier were also all applied to our two "patients". The combination of different autonomous vehicles allows us to look at different characteristics of the eddies at the same time. The 11 ocean gliders we have in operation "fly" up and down in the ocean like gliders, allowing us to obtain information from the upper 200 to 1000 meters, depending on their diving depth. This allows us to "look" into the ocean interior at different points simultaneously. Since their range is limited to about 30 kilometers per day, we use them to study specific areas of the eddies more closely. We have two options for autonomous surface vehicles: The wave glider is a vehicle consisting of a kind of high-tech surfboard full of sensors, computers and communication components, which – like a mini research ship – travels through the ocean remotely controlled by us. It is powered by a fin element suspended from a 7-meter-long umbilical cord under the "surfboard" harvesting the energy of the waves, while the sensors are powered by solar panels. This gives it complete autonomy for many months. With it, we can sail distances of 100 kilometers a day. We are even more agile with the Saildrone, which sails completely remote-controlled with a sail in the form of an airplane wing and is full of sensors from the mast top to the keel. They thus offer the most complete observation program and can even cover 200 kilometers a day – if required, they automatically cross against the wind.



As the cruise tracks of RV Meteor and all our autonomous platforms show, Santa Claus visited us together with his donkey on Dec. 6 and even brought us some Christmas decorations.

Through these various automatic observations as well as the underway measurements of the moving ship (see 2nd weekly report) we can put the data from the extensive water sampling carried out with the CTD rosette into the spatial and temporal context. For us, the samples, some of which are already being measured on board, but most of which have to be analysed after the expedition in extensive laboratory work, represent the essential link between the physical conditions in the ocean and the associated biogeochemical and biological distribution patterns. In the end, we hope to achieve a complete picture of the physical-chemical-biological coupling of processes and phenomena in ocean vortices and to better understand their role for the biological carbon pump in the ocean.

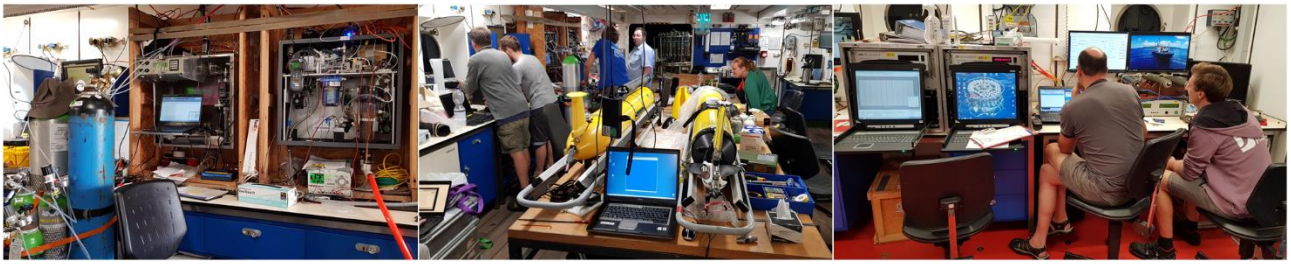
Last week we started another work component in addition to this one. This involves so-called submesoscale processes. By this we mean processes whose spatial scale ranges from a few kilometers down to a few meters. So we do not look at the eddies with their 100 kilometers in diameter in their entirety, but rather at their edges, where dynamic processes such as meanders, fronts, divergences or convergences can occur, which have a considerable influence on the eddies themselves. The study of submesoscale processes in the open ocean is a difficult undertaking and requires special methods, and this is precisely where cooperation with the Institute for Coastal Research at the Helmholtz Centre Geesthacht (HZG) comes into play. Among other things, they have specialized in the submesoscale and developed appropriate methods. These make it possible to measure currents and fronts on the surface (X-band radar) and in the surface ocean (300 kHz ADCP) very precisely. Exact information on the vertical distribution of temperature, salinity and density is obtained with the aid of a measurement chain towed behind the ship. This is a towing cable with a length of more than 400 meters, to which sensors can be connected at various depths, all of which can transmit their data inductively into the cable and thus onto the ship. We then tow this chain with about 2 dozen sensors behind the ship for up to 8 hours at 4-6 knots. Alternatively, the "Moving Vessel Profiler" is used, which consists of a tethered freefalling probe and a winch. With this probe we can obtain a high-resolution vertical profile of the upper 100 meters every 5 minutes from the moving ship in free fall. Depending on the requirements with regard to horizontal or vertical resolution, we choose between these two systems.



Board scenes: The latest temperature maps from the glider plane arrive by radio and are analysed (left); the current data situation is discussed on the large screen in the geolab before the next equipment deployment (centre); Still life at the “Christmas market” with mulled wine in front of the provision cool rooms (right).

Another core contribution of the HZG is remote sensing by aircraft with the help of the research motor glider plane Stemme of the University of Applied Sciences Aachen. The two-seater aircraft has infrared and hyperspectral cameras on board which record the surface temperature and color of the ocean with high resolution from an altitude of about 5000 meters. The aircraft currently operates from the international airport in Sal, where the mission is coordinated and carried out by Prof. Burkard Baschek, Head of the Institute for Coastal Research at the HZG. After initially having to overcome a few technical hurdles with the sensor package and the communication technology between the aircraft, ground station and ship and the cloud cover having put a spoke in the wheel for us on a few days, several successful measurement flights have now been carried out over the working area.

The contribution of GEOMAR to the submesoscale investigations consists in the deployment of a special water tracer. This tracer is an environmentally friendly dye that is usually only used for aquatic studies in rivers and lakes. In the first of the two planned experiments, we prepared about 35 kg of the dye in an aqueous solution, which we then deployed to a depth of 60 meters in the form of a dye strip of almost 2 kilometers long and only a few meters wide. The task was then to follow the deformation and dilution of this dye strip in the days that followed in order to draw conclusions about the small-scale mixing and transport processes. Such experiments usually last only a few days, since the dye is then already so heavily diluted that it can no longer be detected at all. The task, which we tackled in a concerted manner with the observation systems mentioned above, was correspondingly demanding. It was possible for us to detect the rapidly moving, spreading and deforming dye patch with particularly sensitive dye sensors over a period of 3 days. At the same time, we were also able to gain some new insights into how we could improve the second experiment even further.



Lab scenes: Automatic system for measuring CO_2 in surface water (left); gliders are being prepared for deployment in the geolab (center); the CTD watch is preparing for the next use of the CTD rosette system (right).

At the end of this week the work on the first eddy is almost finished. Now we have to slowly recover all our valuable autonomous platforms, which is made much more difficult by the strong trade wind with 7 Beaufort and rough sea with 2-3 meter swell plus wind sea. Therefore we have changed the work program a bit and will first carry out the sampling at the "Cape Verde Ocean Observatory", in order to resume gliders and wave gliders on Tuesday after expected weather improvement. Then we will take the fastest route across the Cape Verde archipelago, where another very concise and dynamic cyclonic eddy awaits us southwest of Fogo (see 1st weekly report), which we are already looking forward to and will apply our entire program to once again for another week.

With warm advent greetings from all of us,

Arne Körtzinger
GEOMAR Helmholtz Centre for Ocean Research Kiel