MULTIDISCIPLINARY DATA SETS AND MODELLING STUDIES

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Abstract

Different spatial and temporal scales interact in the Mediterranean dynamics. An efficient interaction between adequate observations and modelling is needed to improve the present understanding of this dynamics. The scales of several biological processes are not the same than the scales of the different hydrodynamic processes that can influence them, and the corresponding sampling methods or strategies appear sometimes to be incompatible. The present development of new sensors and instruments, together with coherent approaches and strategies in the study of the Mediterranean system, will progressively generate consistent multidisciplinary data sets, as a first step to the construction of realistic ecological models.

Key -words: Mesoscale phenomena, Models, Sampling methods

Sampling the Mediterranean

The Mediterranean, as any oceanic system, has a lot of spatial and temporal scales interacting on its dynamics. Mesoscale plays a significant role in driving or modifying the general circulation of the different Mediterranean water masses, and in forcing biogeochemical fluxes. In most of subbasins the mean currents are weak and mesoscale features can be more energetic. An extreme example of this is the Algerian basin, where the circulation variability is much more linked to strong mesoscale events than to seasonal or longer scale forcings. Remote sensing has been a key tool in shifting our image of the Mediterranean circulation from the traditional "smoothed" patterns computed by Ovchinnikov (1) to a more complex system with frontal currents and intense mesoscale activity, as the one first proposed by Millot (2) in 1987.

Taking into account that the Rossby radius of deformation in the Mediterranean is of the order of 15-20 km, it is obvious that a good description of its dynamics requires a much higher spatial resolution for in situ sampling than it was done in the past, and than it is done in the open oceans. This strategy was closely faced by the different experimental efforts done from the early eighties, as the joint international actions POEM(3) and WMCE (4), and later PRIMO (5). And also by the numerical modelling activities, that had to progressively reduce their mesh dimensions, and also substitute the traditional climatological forcings by more realistic data analysis. During the first phase of MTP we have seen several examples of fruitful interactions between observational and numerical modelling approaches to the understanding of different Mediterranean phenomena, as EUROMODEL and MERMAIDS projects (6, 7). The experimental results are continuously raising questions about the functioning of the system that require a precise modelling to be answered. And models show features that could be checked or require inputs that can only come from dedicated observations. An adaptation in the two different "languages" is needed to improve this exchange of information, for example by arranging similar procedures for the presentation of both kinds of results, as can be sections across channels or time series in specific locations.

In spite of this, not always a full agreement is achieved when comparing both kinds of results. One should in principle think that the mistake comes from the modelling side: unresolved phenomena, inadequate parameterisation of any process, inappropriate boundary conditions ... Although problems can also come from the sampling, or the analysis or interpretation of its results, for example those coming from a lack of synopticity in the measurements. Recently, several examples exist of accurate control of the sampling strategy by real-time remote sensing, or of a precise checking of the data interpretation, by running synopticity tests besides objective analysis of the significance of the different spatial scales.

Modelling the ecosystem

When leaving the physical dynamics and looking at a more complex aspects of the Mediterranean system, as biogeochemical or ecological, the problem of *in situ* sampling, data analysis and modelling appears to increase its difficulty. Of course a major problem is modelisation itself, that is when trying to express the several relationships between the different parts of the system into mathematical formulae, able to be numerically integrated. Even one of the apparently more simple aspects, the hydrodynamical advection and diffusion of passive particles in any marine environment, is not always an easy job. But let's only concentrate on the problems of measuring, that is how to obtain adequate interdisciplinary data sets for modelling, and forget for the moment how models will work with these data.

The scales of several biological processes are not the same than the scales of the different hydrodynamic processes that can influence or even determine them. In addition to this, the sampling methods or strategies in biology are sometimes (let's say most of the times) incompatible with the sampling of the hydrodynamic parameters unavoidably linked to them. Is this an unsolvable problem? Or just a result of traditional methods that come from times when nobody was worried about this, or the available technology did not allow a different approach? Can we really build multidisciplinary sets where all the data are comparable and, for example, physical and biological information can be used to help each other in increasing the understanding of the different dynamical processes?.

To sample the Mediterranean mesoscale structures we have now instuments that measure the physical parameters (CTD, ADCP, underway water pumping to deck sensors...) at a quite reasonable high speed. Although this is not so simple, as can be seen when performing synopticity tests or examining time series of satellite imagery in highly energetic areas. In fact, sampling a moderately large area (say 100 x 100 km^2) from an oceanographic vessel, even in the Mediterranean where everything is quite small, strictly poses a problem of mixing spatial with temporal variability, that not always has a satisfactory solution.

Some of the approaches traditionally used to study the marine ecosystem should be changed if one expects to understand which is the real dynamics. To keep the vessel in a theoretically fixed point for 24 or 48 h to sample any biological cycle can be completely nonsense if the environmental hydrodynamic conditions (three-dimensional) are not measured accordingly: who can discriminate whether observed changes are due to the studied process or to modifications of the physical dynamics? However, some questions will never be answered if one is not able to sample the system not only with the adequate spatial and time resolution, but also by discriminating for example the effect of diel cycles. In summary, the obtention of a multidisciplinary data set useful to validate, or to feed, an ecological model is most of occasions a hard task.

Another major problem has also to be mentioned. While most of physical variables are measured world-wide under very well defined standards (*i.e.* sensors in commercial probes that can be strictly calibrated and give final physical values after brief computations), this is not the case with a lot of chemical, and especially biological variables. In these fields the obtained data values can strongly depend on methods or protocols, and full calibration is not always a feasible task. Hard work has to be done with quality control and inter-comparison procedures to ensure a really confident use of data coming from different sources. This, together with extra handling problems dealing with supports and formats, is the reason why most of operative oceanographic data bases only contain standard CTD profiles and similar information.

At present several instruments have been developed, and others are under development, to push the biogeochemical information collection close to the approach of in situ electronical sensors: light cells, flow cytometers, fluorimeters, chemical sensors ... Of course the technology is far from being operative for large ranges of variables, but this approach, completed with surface information obtained by