Application of functional classification on high resolution oceanographic data in Canaries current large marine ecosystem: toward fine scale analysis

The understanding of the fine scale process occurring in the ocean needs high resolution data and ad hoc analysis approach to improve the knowledge of ecosystem functioning. During an international survey carry out in 2014 ‘AWA’ on-board the research vessel Thalassa (Ifremer, Brest) along the coast of Mauritania and Senegal we have used simultaneously multifrequency scientific echosounder and a Scanfish, both system allow a continuous acquisition of high-quality data at high spatial and temporal resolution over long distance. The functional data analyses have recently raising in serval field of statistics and appear to be well adapted for the analysis of this dataset. In fact this data have spatial-functional nature and may be considered as observations of a stochastic process $X$ in a space of continuous functions over an interval $T$. Let $X(t), X_n(t), ..., X(T)$ be the collection of $n$ observations from $X$. To study an eventual horizontally or vertically variation of the acoustic intensity, we consider for a given frequency (200 kHz) and one vessel radial the two cases : vertical and horizontal variations of the acoustic intensity.

**FUNCTIONAL CLASSIFICATION TO ANALYZE VERTICAL ACOUSTIC INTENSITY VARIATIONS**

Fig. 2: Smoothed $S_v$ curves measured overnight at depths smaller than 126.5 m. All the curves used in this application are smoothed (to be functional objects) using B-spline basis which are more suited than Fourier basis for non periodic data.

**FUNCTIONAL CLASSIFICATION TO ANALYZE HORIZONTAL ACOUSTIC INTENSITY VARIATIONS**

Fig. 3: Depth by cluster per day and night. For the $S_v$ measured overnight two clusters (deep and shallow) identified while for the $S_v$ measured during day the process suggests to consider three clusters.

**DISCUSSION**

The statistical functional classification applying to this case study appear powerful, ad hoc for ecological studies of marine ecosystem and could be generalized to others surveys and data set. The approach can led to scrutinize at fine scale the processes occurring in 3 dimensions in the pelagic environment. The perspective will be to model the spatial structuration of the pelagic ecosystem according to water physico-chemical parameter which will allow to improve the forecast of the effect of climate change or any other perturbation on marine ecosystem.

**MATERIAL**

The present application considers acoustic intensity data for the fourth frequency (200 kHz) and one radial (NumRadial=3), Start date : 2014-03-01 00:17:46 / End date : 2014-03-01 09:42:26 CET. We have used 652 elementary sampling units ‘ESUs’ of 0.1 nmi echointegrated, registered between these previous dates, see Fig.1. We have 348 ESUs among the previous ESUs at which acoustic intensity ($S_v$ in $\text{dB}$) are measured at depth above 126 m. This is done in order to have acoustic intensity for all depth and ESUs in a given day.

**Vertical variation of the acoustic intensity**

We consider a set of curves as the acoustic intensity ($S_v$) in an ESU with respect to several depths. An ESU is viewed as an individual while a depth represents a point at which the acoustic intensity is measured. That is the first individual data (curve), is the acoustic intensity at several depths observed at the first ESU. Spatial unsupervised model based functional classification is used. The acoustic groups of curves are separated according to the importance of the intensity for low and high depths.

**Horizontal variation of the acoustic intensity**

Related directly to variation between the depths. To investigate an eventual heterogeneity between depths, one can consider the random function $X$ as the acoustic intensity ($S_v$) at some depth with respect to several ESUs ordered with respect to the geographical order (of Fig 1) and are in $T = [1; 300]$. Here unsupervised model functional classification is used, a partition with 2 classes is considered. The results are in the following figure where the two acoustic groups of curves are separated according to the importance of the intensity.