VM-ADCP backscatter data management using QGIS

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INTRODUCTION

Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP) are regularly operating on board several research vessels with the aim of providing 3-D ocean currents fields. Along with ocean currents, these instruments also provide acoustic backscatter profiles that can be of great advantages for several environmental investigations among which the zooplankton distribution. Despite the spatial and temporal resolution of VM-ADCP sampling obtained during most of the oceanographic campaigns cannot always accommodate the need for such investigation, the huge amount of backscatter data collected are of great values and deserve appropriate management.

GIS can be a power tool to manage, analyze and visualize this kind of data, characterized by a seasonal distribution and by a strong daily vertical variability. A-GIS base application developed by IIM to manage and give added values to VM-ADCP data is here presented. The area chosen for the case-study is the Ligurian Sea (Western Mediterranean), due to the availability of data collected during several oceanographic campaigns performed in the region. Main objective of this application is to elaborate and visualize backscatter data to identify zooplankton presence and distribution.

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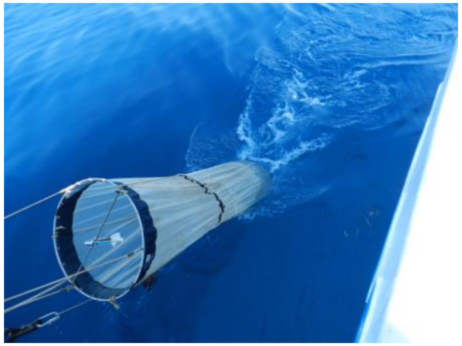

Data and SW for the test-case

GIS

QGIS applied to the Ligurian Sea including:

Ligurian Sea bathymetry from IIM data-base

Ephemeris computed for Genoa

Oceanographic campaigns and measurements

-R/V Minerva2 CNR 20-25 April 2017
Acoustic Backscatter data from RD&I VM-ADCP 150 kHz
CTD profiles

-ITS/ARETUSA IIM 3-6 September 2018
Acoustic Backscatter data from RD&I VM-ADCP 150 kHz
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Other data

Time series of ADCP RD&I 300 kHz backscatter data from fixed mooring

In situ samples of zooplankton (biomass/ m^3) from WP2 plankton net

The area considered for the test-case with the route of the campaigns and the position of the available measurements

Acoustic Data Processing

In order to make comparable backscatter data obtained from different RDI ADCPs, Mean Volume Backscatter Strength is computed according to the Field service Technical paper 003 (1998).

Then, slant-range correction is applied on each profile to compensate for the signal attenuation with the depth. Available CTD data were used for sound speed (UNESCO, 2010), and absorption computation (Aislie 1998).

c = speed of sound at the scattering layer being measured
P = transmit pulse length
T_x = temperature of the transducer
R = range along the beam to the scatterers
α = absorption coefficient of water

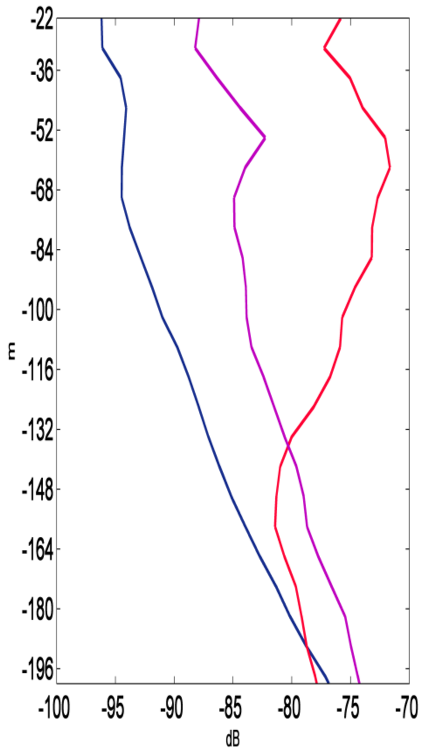
$$S_v = 10\log_{10}\left[\frac{4.47\times10^{-20}\,K_2\,K_s\,(T_x+273^*)\left(10^{K_c(E-E_r)/10}-1\right)R^2}{c\,P\,K_1\,10^{-2\alpha R/10}}\right]$$

R: slant range to a depth cell (m) - This value is the range to the relevant scattering layer along the beam.

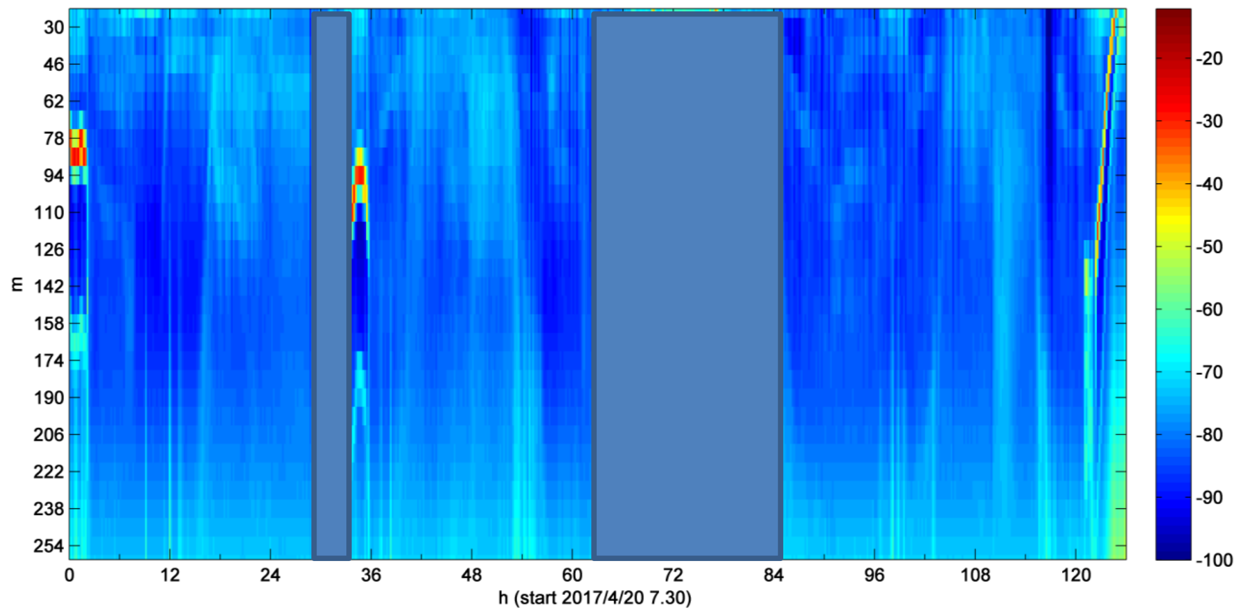
$$R = \left[\frac{B+\left|(P-D)/2\right|+(N\times D)+(D/4)}{Cos\Theta}\right]\times\frac{c'}{1475.1}$$

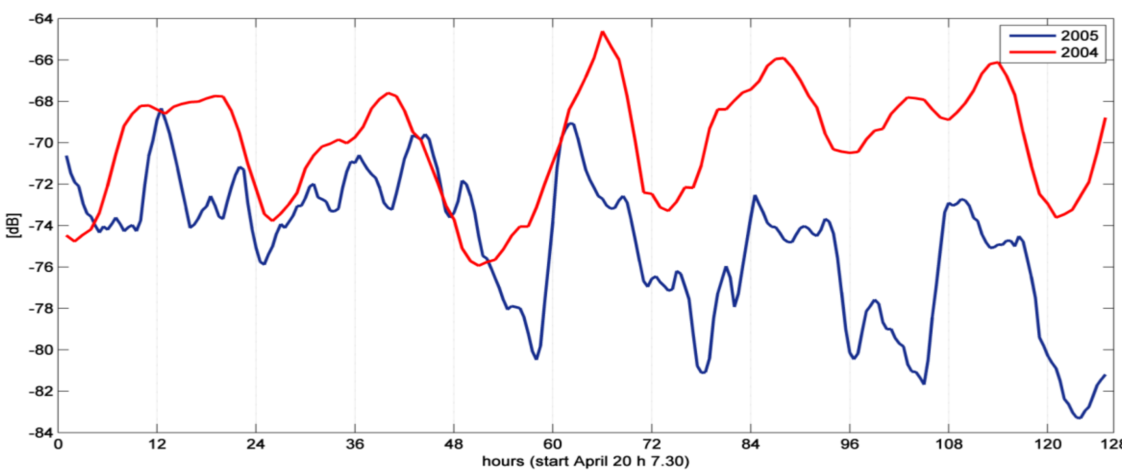
Raw VM-ADCP 150 kHz backscatter data during April 2017 campaign. 10-min averaged profiles are plot as a function of time. Red-orange pixel are due to the presence of the bottom when approaching the coast. Dark and light blu alternates, indicating migrating pattern. Shadow areas indicate not operating ADCP.

Below a comparison with ADCP 300kHz hourly time-series of backscatter data at 46 m depth collected from a fixed mooring located in the area (43°47.77' N; 9°02.85 E). The two selected samples cover the same year period of 2017 campaign but in 2004 and 2005.



Three profiles showing different vertical structures

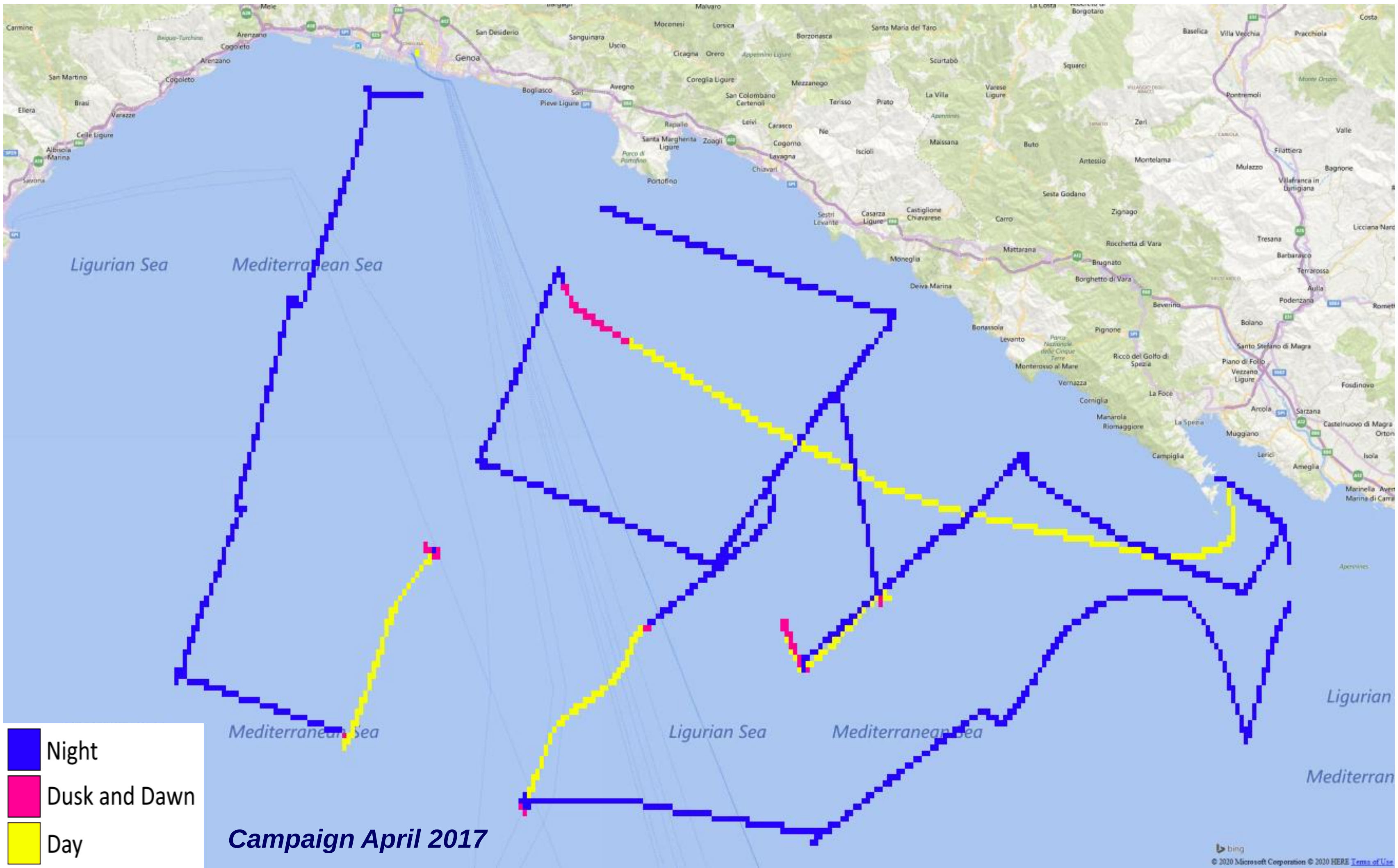




Day and Nigth

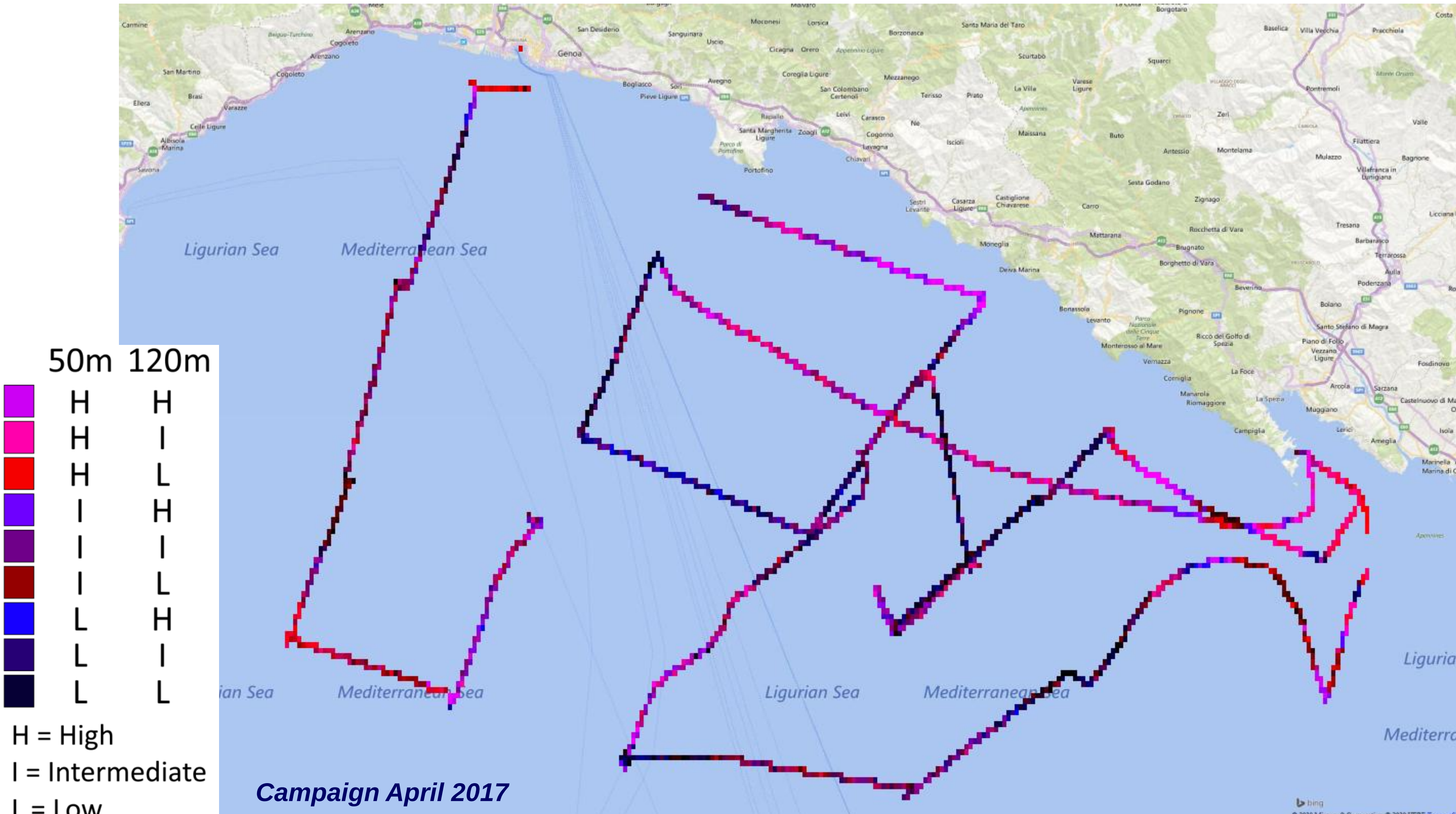
Most of the zooplankton organisms vertically migrate from deep layers, where they are generally found during the day, to the surface that is reached after dusk .

The use of the ephemeris allows to precisely identify the data corresponding to the different phase of the dayligth (dusk, nigth, dawn,day) which are represented in the maps by different colours. In the example night is blu, day is yellow, dusk and dawn are purple.



Surface and depth

False-colour composite using two bands: red for surface (50 m) high intensity backscatter and blue for high backscatter intensity at deeper (120 m) layer. This technique shows the horizontal distribution of backscatter profiles having similar vertical structure. Combined with day/night maps can help to define migration patterns. Moreover, it is possible to identify “anomalies” such as the higher intensity in front of Genoa Port, probably to be ascribed to high sediment concentration. The high backscatter values due to the bottom can be eliminated by integration with the layer of the bathymetry.



Final Remarks

GIS has proven to be a powerful tool for the management of sparse -in both time and space- data

GIS-application to VM-ADCP backscatter data allows to support investigations about zooplankton distribution, giving added values to ADCP data collected during oceanographic campaigns, even when planned for different scientific objectives.

Future Developements

Increase the VM-ADCP data set including data from more campaigns

Add moon-cycle from the ephemeris

Integrate data of other parameters collected during the campaigns such as continuos surface clorophyll-a from Ferry-Box