# LASER RADARS FOR MARINE MONITORING

Luca Fiorani, Federico Angelini, Francesco Colao, Marcello Nuvoli, Antonio Palucci
Nuclear Fusion and Safety Technologies Department, ENEA, Via Enrico Fermi 45, 00044 Frascati, Italy – luca.fiorani@enea.it

XXII International Symposium on High Power Laser Systems and Applications, October 9-12, 2018, Frascati, Italy

## Introduction

Phytoplankton biomass plays a crucial role in marine biogeochemical cycles and food chain dynamics. As a consequence, its spatiotemporal detection and accurate quantification are of great interest in the study of marine ecosystems. Moreover, through its photosynthetic activity, phytoplankton contributes to the biological pump which is responsible for the conversion of $CO_2$ in organic matter.

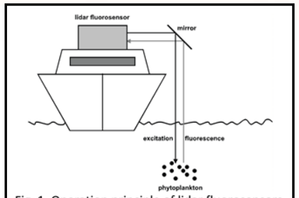

Fig. 1. Operation principle of lidar fluorosensors.

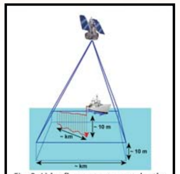
Fig. 2. Lidar fluorosensors can be the "connecting ring" between satellite radiometers and in situ instruments.

## Instruments and methods

A lidar fluorosensor is a laser radar detecting the fluorescence of the target (Fig. 1). Laser techniques are interesting because they are insensitive to clouds, free from atmospheric corrections and accurate in coastal waters (Fig. 2). Lidar measures continuously and real-time chromophoric dissolved organic matter (CDOM), chlorophyll a (Chl a) and other algal pigments (Fig. 3).

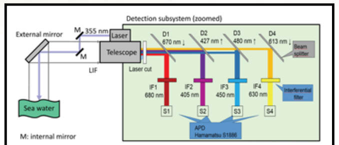

Fig. 3. Scheme of the lidar fluorosensor. D1 and D4 reflect wavelengths longer than 670 and 613 nm, respectively. D2 and D3 reflect wavelengths shorter than 427 and 480 nm, respectively. M: mirror. APD: avalanche photodiode.

## Results and discussion

The lidar fluorosensor operates continuously during campaigns. The measurements of CDOM and Chl a, carried out in the Southern Ocean from January 5 to February 20, 2014 are given in Fig. 4. The lidar fluorosensor was able to follow the fast variation of pigments concentration. As one can expect, some covariance between Chl a and CDOM is discernible: CDOM is high where Chl a peaks. Fig. 5 shows the measurements corresponding to the RoME 1, RoME 2 and RoME 3 mesoscale experiments of the XXIX (2014) Italian Oceanographic Campaign in Antarctica and demonstrates that the lidar fluorosensor is able to detect algal blooms. In 2018 ENEA deployed its lidar fluorosensor during the High North 18 campaign (Fig. 6) and a compact version of it – developed in collaboration with INSIS SpA (Fig. 7) – during the Flex 2018 campaign: data analysis is ongoing.

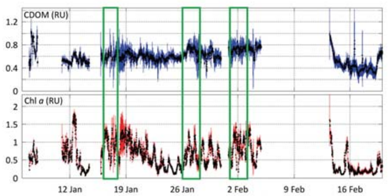

Fig. 4. CDOM (top) and Chl a (bottom) concentrations (RU) measured by the lidar fluorosensor during the XXIX (2014) Italian Oceanographic Campaign in Antarctica.

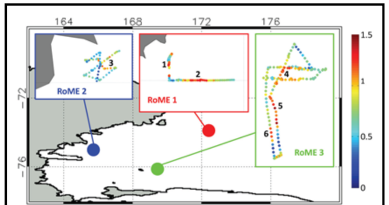

Fig. 5. Chl a (RU) measured by the lidar fluorosensor during the RoME 1, RoME 2 and RoME 3 mesoscale experiments. The main blooms are indicated by numbers.

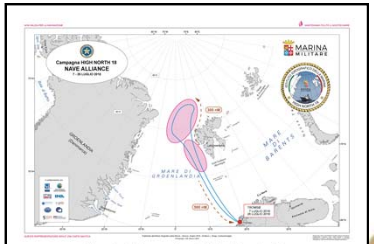
Fig. 6. Ship track of High North 18.

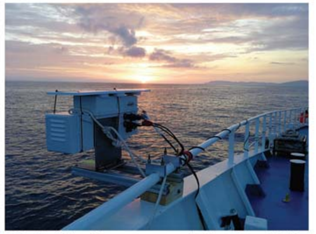
Fig. 7. Lidar fluorosensor during Flex 2018.

## Conclusions

The Diagnostics and Metrology Laboratory of ENEA develops lidar fluorosensors since the nineties. A new prototype operated in polar regions in 2014, 2016 and 2018. This remote sensor carried out real-time sounding of surface Chl a concentration continuously, except for rare and short maintenance stops. A compact version of the lidar fluorosensor was operated in 2018.