Bio-optical Characterization of the Arctic Ocean by Lidar Fluorosensor

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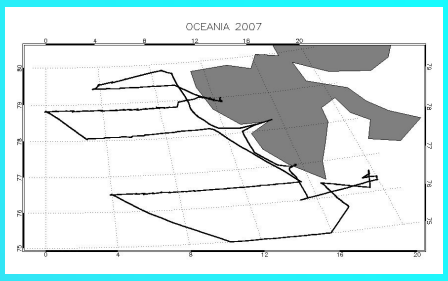
INTRODUCTION

Arctic Ocean is the smallest and shallowest of the world's five major oceans, and is one of the major source regions for the surface waters of the subpolar seas in which weak stratification leads to deep convection, a key part of the global thermohaline circulation. Arctic Ocean is probably the water body more affected by global warming. In this ocean, the greatest inflow of water comes from the Atlantic by way of the Norwegian Current, which then flows along the Eurasian coast. Water also enters from the Pacific via the Bering Strait. The East Greenland Current carries the major outflow.

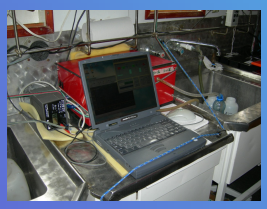
Svalbard islands are positioned on the north end of the warm Gulf Stream, the northernmost lobe of the world Ocean conveyor belt, and this archipelago serves as an optimal Arctic research environment to investigate climate changes.

In the framework of a collaboration between the ENEA and the Institute of Oceanology of the Polish Academy of Science in Sopot, the Laser Applications Section have the access to the polar research infrastructures (ships) and therefore have a peculiar test site for new technologies developed in the frame of national or international cooperations. The Polish Institute of Oceanology conducts regular scientific research with the Research Vessel (R/V) Oceania in the European Arctic Seas with devoted oceanographic AREX (Arctic Experiment) campaigns.

The ENEA team, already participated to a preliminary AREX 2006 campaign, deployed the Lidar Fluorosensor (ELF) and local spectrofluorometer CASPER on-board the R/V Oceania during the 2007 oceanographic expedition off the Svalbard Islands from 6 to 23 July 2007. ELF sounded remotely the water surface operating H24. As a results, it provided a spatio-temporal picture of CDOM and algal pigments in a wide oceanic region. That information can be used for cal/val of ocean color satellite radiometers and, together with the temperature, salinity and water speed profiles measured by Polish researchers, can improve our understanding of the biogeochemical cycles taking place in the oceanic stream east of the Svalbard Islands.



Course of oceanographic vessel "Oceania"



CASPER during the oceanographic campaign

ELF during the oceanographic campaign

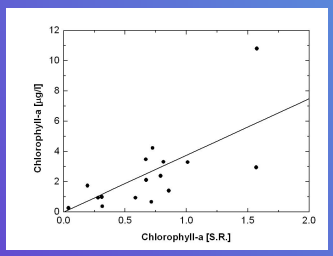
INSTRUMENTS

ELF (ENEA Lidar Fluorosensor): instrument based on LIF (Laser Induced Fluorescence).It consists mainly of a frequency-tripled Nd:YAG laser at 355 nm (transmitter) and of a telescope to the detectors (receiver). The telescope collects the backscattered light at different wavelengths: 404 nm (corresponding to Raman scattering by water), 450 nm (Chromophoric Dissolved Organic Matter, CDOM), 580 nm (Phycoerythrin), 650 nm (Phycocyanin) and 680 nm (Chlorophyll-a).

CASPER (Compact and Advanced laser SPEctrometer for Riade): laser spectrofluorometer based on double filtration (30 µm and 0.22 µm) and double excitation (frequency quadrupled Nd:YAG laser emitting at 266 nm and diode laser emitting at 405 nm) in order to detect both dissolved and particulate components of natural waters. CASPER analyzed water samples at different depths. It provided information about pollutants (oils, poly aromatic hydrocarbons, etc.), proteins, dissolved organic matter (CDOM), chlorophyll-a and other algal pigments. CASPER provides measures in absolute concentrations (it is calibrated with known samples), so it is used for the ELF Calibration.

ELF CALIBRATION

Data measured by CASPER (µg/l) and ELF (Raman Units) have been compared and a good correlation has been found. The correlation coefficent between fluorescence-to-Raman ratio and absolute concentration was 0.719

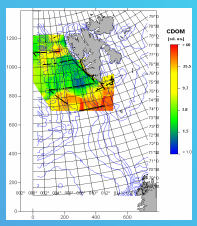


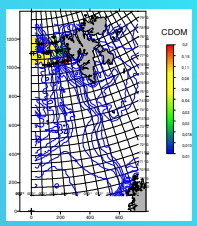
Y=B*X , B=3,746 , R=0,719

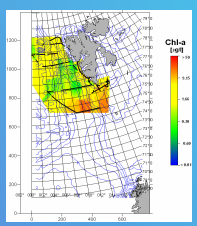
Chl-a measured by CASPER vs chl-a measured by ELF during the oceanographic campaign of 2007

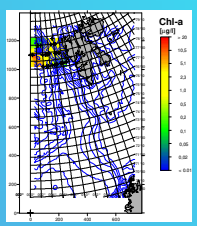
ELF MAPS CASPER MAPS

(Superficial data)



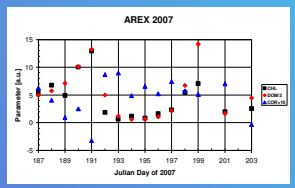






CONCLUDING REMARKS

CHLa and CDOM are probably the most important parameters for the bio-optical characterization of the marine waters.
It has long been recognized that phytoplankton release DOC. Therefore the research was aimed at investigating phytoplankton as a direct source of CDOM in estuarine and marine enviroments. In this context is important to study the trend of CHLa vs CDOM.
ELF data, due to the short distance from the target, are unchanged by atmosferic effect. So they can be considered "sea truth data" and used for the study of the CDOM-CHLa correlation and for a new calibration of the CHLa bio-optical algorithm for the MERIS data.
Work is in progress to merge all the data measured during three campaign, from 2006 to 2008, and for the development of the bio-optical algorithm thus resulting in a more detailed biological and physical interpretation of ELF and CASPER data.



Trend of CHLa, CDOM and theire correlation.
(There is a good correlatione only for low value of both parameters).

Polish Research Vessel Oceania