New estimates of primary production in the Ross Sea derived from in situ, lidar and satellite data

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Introduction

The Southern Ocean plays an important role in the global carbon cycle with the Ross Sea as one of the more productive regions due to strong phytoplankton blooms occurring in spring and summer.
Southern Ocean monitoring of ocean colour has been ameliorated in recent years (CZCS, SeaWiFS, MODIS and MERIS). However, due to the persistent cloud coverage, their data do not allow realistic estimates of the seasonal and interannual variability of chlorophyll concentrations in Antarctic surface waters.
New algorithms, on regional or large scale, have improved the accuracy of chlorophyll estimates in the Southern Ocean. More precise and systematic *in situ* optical data in parallel with classical primary production measurements are recommended.
In summer 2001, ENEA lidar fluorosensor (ELF) recordings were performed during an oceanographic campaign, the XVI Italian research expedition in the Ross Sea, from January 10 to February 23. A good correlation was found between lidar and spectrofluorometric Chl *a* measurements and these data were used for the calibration of SeaWiFS images as well as for the accurate mapping of Chl *a* distribution. Furthermore, surface primary production estimates for the entire Ross Sea were obtained using mean photosynthetic parameters as obtained from PvsE experiments for different Ross Sea regions.

ELF (ENEA lidar fluorosensor) maps

The ELF laboratory is equipped with local and remote instruments, installed on the R/V Italica, including a compact lidar fluorosensor capable of single or dual laser excitation of the sea surface, a lamp spectrofluorometer, a solar radiance detector and a GPS receiver. Surface waters are investigated by measuring the water Raman scattering and both Chl *a* and CDOM fluorescence emissions on different channels.

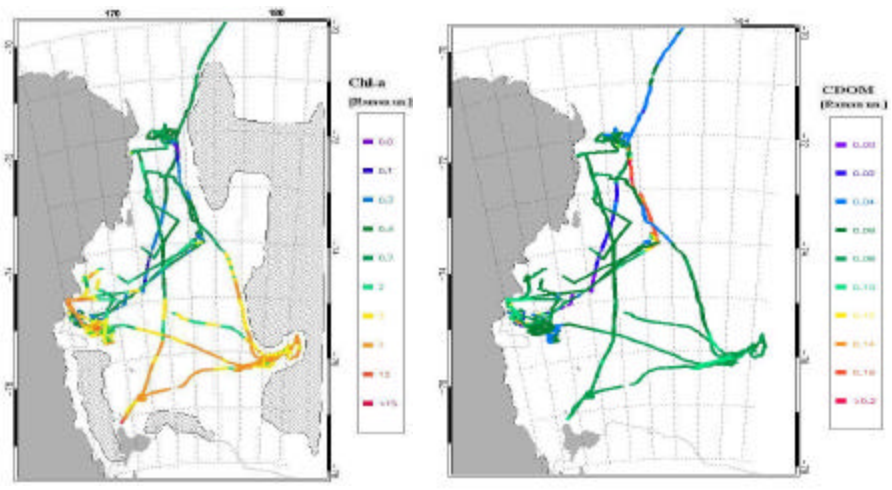

Figure 1 - Lidar recordings in the Ross Sea, summer 2001: a) Chl *a* and b) CDOM

Chl *a* CDOM correlation

In the Antarctic inner basins, the continental ice melting and the large bloom evolution both contribute as remarkable sources of the CDOM stocks. In the Ross Sea, the CDOM content is much lower with respect to continental waters and dissolved and particulate phases reaches approximately 10% and 90% of the total organic matter, respectively.
The remote (lidar) and local (spectrofluorometer) Chl *a* and CDOM fluorescence emissions have been compared and cross correlated after weekly averaging. A significantly different trend is observed for the two fluorescent channels: CDOM slowly increases in time along the ship's track, while Chl *a* sharply increases in the Ross Sea and remains high until the ship left the continental shelf area. A general low correlation between the two emission channels was observed, however after five weeks the correlation increases, likely due to release of exudates and organic compounds.
Work is in progress to develop lidar calibrated bio-optical algorithms for the CDOM mapping from SeaWiFS data.

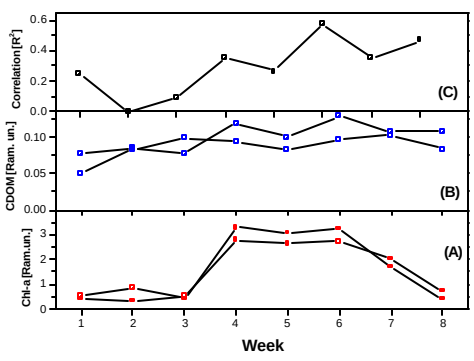

Figure 2 - Lidar (open square) and spectrofluorometer (closed square) weekly averages of Chl *a* (A) and CDOM (B). Chl *a* – CDOM correlation (C).

ELF calibration

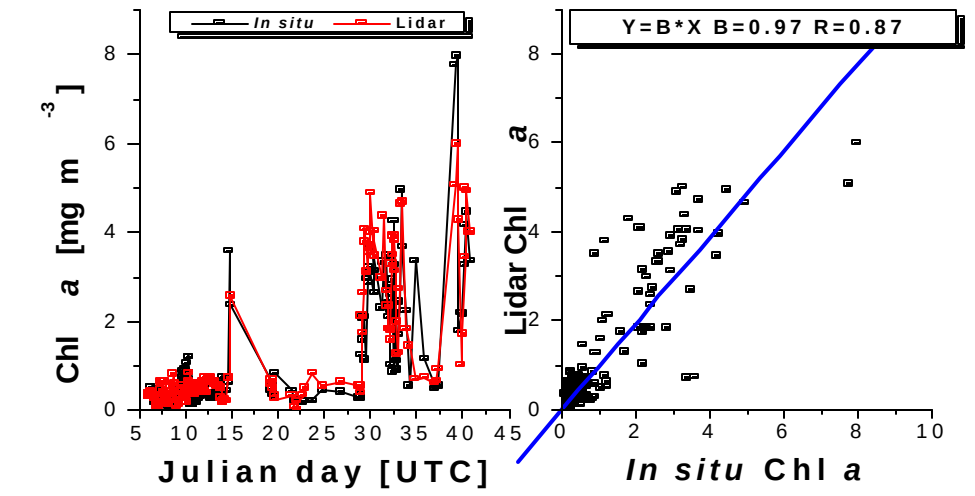

Figure 3 - Lidar data were calibrated using several hundred spectrofluorometric measurements performed on surface samples along the ship's track.

Correction of SeaWIFS imagery

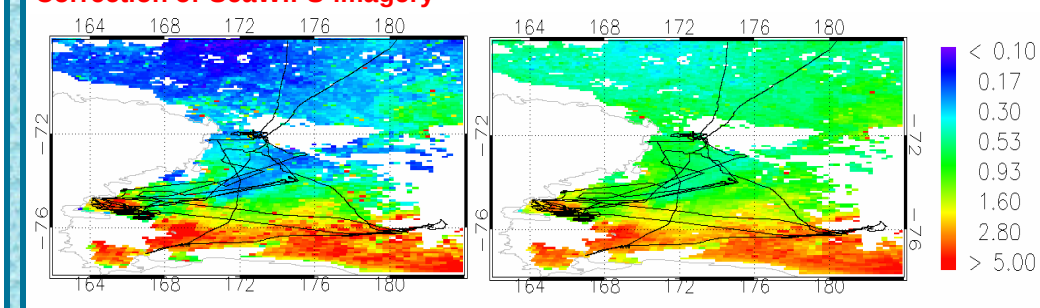

Figure 4 - Surface Chl *a* concentration as measured by SeaWiFS with the standard (left) and the ELF-calibrated (right) bio-optical algorithm in summer 2001. Black line: ship track.

Primary production

The phytoplankton biomass and primary production maps were designed using the entire lidar data base, with over 23.000 measurements.
Ross Sea areas were revisited several times during the campaign (fig. 1). However, only minor variations in biomass distributions were observed.
Summer 2001 was characterized by extensive ice coverage. A considerable spatial variability in phytoplankton biomass was observed with high Chla concentrations recorded along the southern and eastern ice edges and in the coastal area of Terra Nova Bay (TNB). Differences in primary production between Ross Sea regions were even more pronounced with very high values at surface in the south western area.

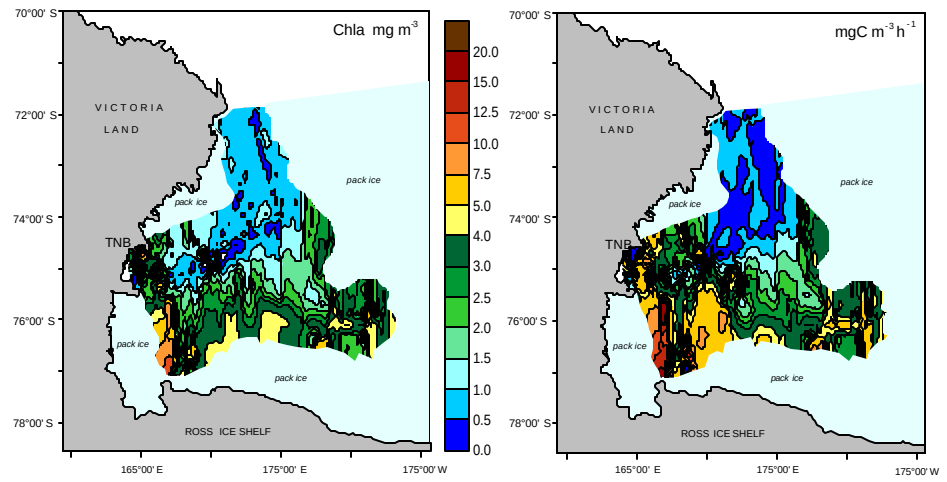

Figure 5 - Surface distribution of phytoplankton biomass and primary production

Chl *a* values was calculated with the ELF-calibrated bio-optical algorithm (fig.4).
Primary production was calculated with:
- all Chl *a* values as described above
- average photosynthetic coefficients (?, ?, PB_S and E) of phytoplankton surface populations for different Ross Sea areas
- daily irradiance

(For further details see the poster of Saggiomo et al., this section).

Concluding remarks

ELF measurements allowed us a continuous monitoring in a large area of the Ross Sea, especially in coastal and marginal ice zones (fig. 1). Moreover, lidar data are unaffected by cloud coverage and by the unavoidable uncertainties linked to atmospheric corrections and bio-optical algorithms used for the analysis of satellite imagery. This large amount of *sea truth* data stream has been used for the study of the CDOM – Chl *a* correlation (fig. 2) and for a new calibration of the Chl *a* bio-optical algorithm (fig. 4).
Merging Lidar fluorescence measurements and photosynthetic coefficients for each Ross Sea sub region allowed for a fairly accurate estimate of surface primary production over two months in summer 2001 (fig. 5).

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