

Final project report

Project ID: 2002/8.3
Title: ARES -Active and passive remote sensing of the Southern Ocean for the monitoring of the biological parameters

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Duration: 2 years
Assigned funding: € 50.000,00

Activities and results

The main aim of ARES project is to build up thematic maps merging active and passive remote sensing data collected during Italian Antarctic expeditions in order to improve our understanding of Southern Ocean (SO) and Ross Sea (RS) ecosystems, with a particular concern to the evolution of phytoplankton classes and dissolved organic matter over a large scale and in the polynya areas.

The study has been carried on with the optical remote sensing instruments, a lidar fluorosensor, already developed in the frame of the Technological Sector of PNRA, operated on board of the R/V Italica ship during the XVIII Antarctic expeditions (January – February 2003), and passive satellite radiance data, over the same area, and local sampling techniques, the latter for calibration and integration purposes.

The spectrally resolved Lidar data, continuously collected during the XVIII campaign, have been released in form of thematic maps of the investigated area thus allowing to distinguish contributions from natural chromophoric groups in the dissolved organic matter (CDOM), to identify algal pigments peculiar of different phytoplankton classes and differently involved in photosynthesis (i.e. phycoerythrin, phycocyanin, chlorophyll-a; Chl-a). The fluorescent database, after proper calibration with in-situ samples, have been employed to develop regional bio-optical algorithms for radiance satellite frames of the same area, in particular ocean color SeaWiFS images. As results, weekly based lidar calibrated thematic maps of the CDOM and Chl-a, in the SO and RS area, have been obtained thus allowing to follow the dynamical process during the 2003 Antarctic summertime (phytoplankton blooms evolutions).

Successively, merging the main satellite physical (Sea Surface Temperature, ice coverage) and lidar biological (CDOM, Chl-a) parameters, a primary productivity model have been implemented for the RS. The model has been extended with historical data, stored in previous oceanographic campaigns, thus to retrieve monthly and annual based primary productivity, disentangled in off-shore and polynya areas.

Products

A – papers in scientific magazines

1. Fiorani L., Barbini R., Colao F., Fantoni R., Palucci A. "Comparison between satellite and laser remote sensing of the Southern Ocean" Journal of Computational Technologies 7, 110-120 (2002).
2. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, M. Galli, A. Palucci, E. S. Artamonov, "Remotely sensed primary production in the western Ross Sea: results of in situ tuned models" Antarctic Science 15, 77-84 (2003).
3. R. Barbini, S. Ceradini, F. Colao, R. Fantoni, G. M. Ferrari, A. Palucci, S. Sandrini, L. Tositti, O. Tubertini "Simultaneous measurements of remote lidar chlorophyll and surface CO2 distribution in the Ross Sea" Int. J. Remote Sensing, 24, 1-13 (2003).
4. R. Barbini, F. Colao, R. Fantoni, G. M. Ferrari, A. Lai, A. Palucci "Application of a lidar fluorosensor system to the Continuous and remote monitoring of the Southern Ocean and Antarctic Ross sea: results collected during the XIII and XV Italian oceanographic campaigns" Int. J. Remote Sensing, 24, 3191-3204 (2003).
5. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci "Lidar fluorosensor calibration of the SeaWiFS chlorophyll algorithm in the Ross Sea" Int. J. Remote Sensing, 24, 3205-3218 (2003).

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6. Barbini R., Colao F., De Dominicis L., Fantoni R., Fiorani L., Palucci A., Artamonov E. S. "Analysis of simultaneous chlorophyll measurements by lidar fluorosensor, MODIS and SeaWiFS" *Int. J. Remote Sensing*, 25, 2095-2110 (2004).
7. Guglielmo L., Carrada G.C., Catalano G., Cozzi S., Dell'Anno A., Fabiano M., Lazzara L., Lorenzelli R., Mangoni O., Misic C., Modigh M., Pusceddu A., Saggiomo V. "Trophodynamic and biogeochemistry in the annual sea ice at Terra Nova Bay (Ross Sea, Antarctica)" *Chemistry and Ecology*, 20: 43-55 (2004)
8. Lazzara L., Nardello I. e Gallo C. "La microflora simpagica bioindicatrice di condizioni ambientali estreme nell'ecosistema pack-ice". *Biol. Mar. Medit.* 11: 242-254 (2004)
9. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, I.G. Okladnikov, A. Palucci "Lidar calibrated satellite sensed primary production in the Southern Ocean" *Journal of Optoelectronics and Advanced Materials*, 7, 1091-1101(2005).
10. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, I.G. Okladnikov, A. Palucci "Comparison of SeaWiFS, MODIS-Terra and MODIS-Aqua in the Southern Ocean" *International Journal of Remote Sensing*, 26, 2471-2478 (2005).
11. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, N.V. Kolodnikova, A. Palucci "Laser remote sensing calibration of ocean color satellite data" *Annals of Geophysics*, 49, 35-43 (2006).
12. R. Barbini, M. Cabrini, F. Colao, R. Fantoni, L. Fiorani, S. Fonda Umani, N.V. Kolodnikova, L. Lazzara, A. Palucci, F. Parmigiani "Biogeochemical properties of the Ross Sea retrieved from in situ and remote optoelectronics devices during the Austral summer 1997-98" *Journal of Optoelectronics and Advanced Materials*, 8, 1565-1573 (2006).
13. L. Fiorani, I.G. Okladnikov, A. Palucci "First algorithm for chlorophyll-a retrieval from MODIS-Terra imagery of sun-induced fluorescence in the Southern Ocean" *International Journal of Remote Sensing*, 27, 3615-3622 (2006).
14. L. Fiorani, A. Palucci "Local and remote laser sensing of bio-optical parameters in natural waters" *Journal of Computational Technologies*, 11, 39-45 (2006).
15. L. Fiorani, I.G. Okladnikov, A. Palucci "Lidar-calibrated regional models for satellite retrieval of primary productivity in the Southern Ocean" *Journal of Optoelectronics and Advanced Materials*, 9, 3939-3945 (2007).

B – book chapters

1. Fiorani L. "Laser and satellite remote sensing of the ocean" Martellucci S. and Santarsiero M. Eds., *Free and Guided Optical Beams*, (World Scientific, Singapore 2004) pp. 237-243.
2. Palucci. "Optical and morphological characterization of selected phytoplanktonic communities". *Proceedings of the NATO Advanced Research Workshop on Fluorescence and other Optical Properties of Biological Particles for Biological Warfare Agent Sensors*, Novosibirsk, Russia, 3-6 October 2005. Series: NATO Science Series II: Mathematics, Physics and Chemistry, Vol. 238 Hoekstra, Alfons; Maltsev, Valeri; Videen, Gordon (Eds.) 2006, XI, 267 p., Softcover ISBN-10: 1-4020-5501-3 ISBN-13: 978-1-4020-5501-0.
3. L. Fiorani "Environmental Monitoring by Laser Radar" in "Lasers and Electro-optics Research at the Cutting Edge", Larkin S.B. Ed. (Nova Science Publishers, Hauppauge, USA 2007) Chapter 4.
4. L. Fiorani "Environmental Monitoring by Laser Radar" in "Optics and Electro-optics Research", Berzilla A.V. Ed. (Nova Science Publishers, Hauppauge, USA 2007) Chapter 3

C - proceedings of international conferences

1. Sandrini, S., Tositti, L., Tubertini, O., Ceradini, S., Palucci, A., Barbini, R., Fantoni, R., Colao, F., Ferrari, G.M. Summer distribution of CO₂ partial pressure in the Ross Sea, Antarctica, and relations with biological activity. European Geophysical Society, General Assembly Nice 22-26 Aprile 2002.
2. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci, S. Sandrini. Remote lidar chlorophyll and surface CO₂ distributions in the Antarctic Ross sea. Seventh International Conference Remote Sensing for Marine and Coastal Environments Miami, Florida 20-22 May 2002.
3. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci Lidar Tuning Of The Seawifs Algorithms In the Antarctic Ross Sea: Preliminary Results Seventh International Conference Remote Sensing for Marine and Coastal Environments Miami, Florida 20-22 May 2002.
5. Palucci. Synoptic studies of the Antarctic Ross Sea with the ENEA lidar fluorosensor *Proceedings SPIE Conference on Lasers, Applications and Technologies (LAT 2002)*, Moscow, Russia, June 22 - 28, 2002. SPIE proceedings, vol. 5149, 283 - 291 (2003).
4. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci. Comparison between SeaWiFS and lidar data in the Ross Sea. VIII International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics 24-29 June 2001 Irkutsk Russia, SPIE proceedings, vol. 4678, 204 - 210 (2002).
5. R. Barbini, F. Colao, L. De Dominicis, R. Fantoni, D. Ferrante, L. Fiorani, I. Menicucci, A. Palucci Enea lidar Fluorosensor mobile apparatus for oceanographic continuous monitoring. 3rd GR-I International Conference on New Laser Technologies and Applications, Patras, Greece (September 5-8, 2002).
6. Palucci. The lidar remote sensing activities in Antarctic and oceanic seawaters. International Conference on Environmental Observations, Modeling and Information Systems as tools for urban/regional pollution mitigation ENVIROMIS-2002, July 6-12 2002, Novosibirsk -Ob' river-Tomsk. Invited lecture.
7. E. Artamonov, R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci. Ocean color from space: comparison and validation of satellite radiometers. International Conference on Environmental Observations, Modeling and

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- Information Systems as tools for urban/regional pollution mitigation ENVIROMIS-2002, July 6-12 2002, Novosibirsk –Ob' river-Tomsk.
8. L. Fiorani, E. Artamonov, R. Barbini, F. Colao, R. Fantoni, A. Palucci. Calibration and validation of satellite oceanic data by lidar fluorosensor measurements. International Conference on Environmental Observations, Modeling and Information Systems as tools for urban/regional pollution mitigation ENVIROMIS-2002, July 6-12 2002, Novosibirsk –Ob' river-Tomsk.
 9. R. Barbini, F. Colao, R. Fantoni, L. Fiorani, A. Palucci. Laser remote sensing calibration of ocean color satellite data Workshop on Airborne Remote Sensing for Geophysical and Environmental Applications - 14-17 April 2003, CNR Rome Italy.
 10. Palucci A., Mangoni O., Barbini R., Carrada G. C., Colao F., Fantoni R., Fiorani L., Modigh M., Saggiomo V. New estimates of primary production in the Ross Sea derived from in situ, lidar and satellite data. A Sea of Change: JGOFS Accomplishments and the Future of Ocean Biogeochemistry Final Open Science Conference 5-8 May 2003, Washington, DC, USA.
 11. Fiorani Luca, Barbini Roberto, Colao Francesco, Fantoni Roberta, Palucci Antonio. Remote sensing by laser and satellite for the biogeochemical characterization of the Southern Ocean during Austral summer. A Sea of Change: JGOFS Accomplishments and the Future of Ocean Biogeochemistry Final Open Science Conference 5-8 May 2003, Washington, DC, USA.
 12. L. Fiorani, R. Barbini, F. Colao, L. De Dominicis, R. Fantoni, & A. Palucci, ENEA, Frascati, E.S.. Artamonov, Combination of Lidar, MODIS and SeaWiFS sensors for simultaneous chlorophyll monitoring. EARSeL Workshop on Lidar Remote Sensing of Land and Sea, Workshop Ghent, Belgium, 5-7 June 2003.
 13. Palucci, R. Barbini, F. Colao, R. Fantoni & L. Fiorani, S. Sandrini, L. Tositti & O. Tubertini, S. Ceradini, G. M. Ferrari, Primary productivity monitored with combined local and remote techniques in coastal and ice edge areas of Antarctic Ross Sea. EARSeL Workshop on Lidar Remote Sensing of Land and Sea, Workshop Ghent, Belgium, 5-7 June 2003.
 14. Palucci A., F. Colao, R. Fantoni, L. Fiorani, N.V. Kolodnikova, I.G. Okladnikov. "Sea waters laser induced fluorescence Remote spectroscopy: An approach to develop accurate satellite regional bio-optical algorithms" XIX Reunion Nacional De Espectroscopia, Las Palmas de Gran Canaria, 4-9/7/2004, Conf. Proceed. pag. 11-12. Invited Plenary Lecture.
 15. Barbini R., Cabrini M., Colao F., Fantoni R., Fiorani L., Fonda Umani S., Kolodnikova N., Lazzara L., Palucci A., Parmiggiani F. "Biochemical Structure And Properties Of The Ross Sea During The Austral Summer 1997-98" Proceed. XXVIII SCAR Open Science Conference, Martina Kunz-Pirrung, Manfred Reinke Eds, Berlin 25-31/7/2004.
 16. Okladnikov I. G., Colao F., Fantoni R., Fiorani L., Palucci A. "Comparison of chlorophyll concentrations in the Southern Ocean obtained with lidar and satellite-based instruments" International Conference on Environmental Observations, Modeling and Information Systems ENVIROMIS, SCERT, Tomsk, Russia 15-17/7/2004.
 17. Fiorani L., Barbini R., Colao F., Fantoni R., Okladnikov I. G., Palucci A. "Combination of active and passive remote sensing: seven years of Southern Ocean study". Ocean Optics XVII, ONR, NASA & OS, Fremantle, Australia 25-29/10/2004.
 18. Lazzara L., Nardello I., Gallo C. "La microflora simpagica bioindicatrice di condizioni ambientali estreme nell'ecosistema pack-ice". 34° Congr. SIBM, Port El Kantaoui (Tunisia), 31/5-5/6/2003.
 19. Barbini R., Colao F., De Dominicis L., Fantoni R., Ferrante D., Fiorani L., Menicucci I., Palucci A. "ENEA lidar fluorosensor mobile apparatus for oceanographic continuous monitoring" Carabelas A., Baldacchini G., Di Lazzaro P., Zevgolis D. Eds., SPIE Proceedings, Vol. 5131 (SPIE, Bellingham, USA 2003) 239-243.
 20. Fiorani L., Barbini R., Colao F., De Dominicis L., Fantoni R., Palucci A., Artamonov E. S. "Combination of lidar, MODIS and SeaWiFS sensors for simultaneous chlorophyll monitoring" EARSeL eProceedings, 3, 8-17 (2004).
 21. R. Fantoni, L. Fiorani, I.G. Okladnikov, A. Palucci. "Lidar fluorosensor and satellite integrated approach: seven years of Southern ocean investigation". Proceed. of LAT 2005 International Conference on Lasers, Applications, and Technologies, St. Petersburg, Russia, 11-15 May 2005. Proceedings SPIE Vol. 6284, pp. 628402-1 - 628402-10 (2006)
 22. R. Fantoni, L. Fiorani, I.G. Okladnikov, A. Palucci, L. Lazzara, I. Nardello. "Lidar calibrated satellite sensed CDOM in the Southern Ocean". 25th EARSeL Symposium and General Assembly, Porto, Portugal, 6 - 9 June 2005.
 23. Palucci, R. Fantoni, L. Fiorani. "Remote and in situ bio-optical determinations during the 2002-03 Italian oceanographic campaign in Western Ross Sea". 25th EARSeL Symposium and General Assembly, Porto, Portugal, 6 - 9 June 2005.
 24. L. Fiorani, R. Barbini, F. Colao, R. Fantoni, I. G. Okladnikov, A. Palucci. "Integration of shipborne lidar and spaceborne radiometer: application to the Antarctic coastal environment". Optics and Photonics, San Diego, US, 31 July - 4 August 2005. Proceedings of SPIE Vol. 5885, pp. 174-181 (2005).
 25. Palucci, "Optical and morphological characterization of natural phytoplanktonic communities". NATO Advanced Research Workshop on Optics of Biological Particles, Novosibirsk, Russia, 3 - 6 October 2005.
 26. L. Fiorani, A. Palucci. "Local and remote laser sensing of bio-optical parameters in natural waters". ENVIROMIS 2006, International Conference on Environmental Observations, Modeling and Information Systems, Tomsk, Russia, 1 - 8 July 2006, relazione su invito.
 27. I.G. Okladnikov, L. Fiorani, A. Palucci. "Active and passive remote sensing of the ocean: lidar calibrated satellite imagery of CDOM". ENVIROMIS 2006, International Conference on Environmental Observations, Modeling and Information Systems, Tomsk, Russia, 1 - 8 July 2006.

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28. L. Fiorani, A. Palucci. "The Southern Ocean primary productivity estimation by lidar fluorosensor and satellite radiometer integration approach". SCAR Open Science Conference, Hobart, Australia, 12 - 14 July 2006.
29. L. Fiorani, I.G. Okladnikov, A. Palucci. "Remote Sensing of the Southern Ocean by MERIS, MODIS, SeaWiFS and ENEA lidar". Ocean Optics XVIII, Montréal, Canada, 9 - 13 October 2006.
30. L. Fiorani, A. Palucci, I.G. Okladnikov. "Intercomparison and lidar-calibration of ocean color satellite radiometers in the Southern Ocean". 3rd Workshop on Remote Sensing of the Coastal Zone, Bozen, Italy, 4 - 7 June 2007.

D – proceedings of national meetings and conferences

1. Barbini R., Colao F., Fantoni R., Fiorani L., Palucci A. Controllo delle acque di mare con sistemi integrati lidar fluorosensore e immagini da satellite. Elettro Ottica 2002, Atti del 7° Convegno Nazionale Strumentazione e metodi di misura Elettroottici, Montecatini Terme, pag. 221-228, 2002.
2. E. Cupini, G. Ferro, R. Barbini, F. Colao, A. Palucci, J. Fernandez. V. Molinari, V. Scot. A Monte Carlo Tool For Simulation Of Lidar Experiences In Marine Environments 5th International Topical Meeting on Radiation and Radioisotope Measurements Applications 9-14 Giugno 2002, Bologna.
3. Palucci. Destinazione fredda: Dal porto di Ravenna fino ai mari dell'Antartide. Il Mare A Milano – VII Edizione. Oceano: Ultime Frontiere. Acquario Civico di Milano, Milano 8 Aprile 2003.
4. Lazzara L., Nardello I., Bricaud A., Claustre H., Gallo C. "In situ bio-optical and biogeochemical properties in the Western Ross Sea, during austral summer 2002-03" XVI Congresso AIOL – IV Convegno CoNISMa, Terrasini 18-22/10/2004.
5. R. Fantoni, L. Fiorani, S. Loreti, A. Palucci, L. Lazzara, I. Nardello. "Remote and in-situ Seawater Bio-Optical Description during the XVIII Oceanographic Expedition". 3rd International Conference on the Oceanography of the Ross Sea Antarctica, Venice, Italy, 10 - 14 October 2005.
6. R. Fantoni, L. Fiorani, I. G. Okladnikov and A. Palucci. "Comparison of Seawifs, Modis-Terra, Modis-Aqua and MERIS Satellites In The Southern Ocean". 3rd International Conference on the Oceanography of the Ross Sea Antarctica, Venice, Italy, 10 - 14 October 2005.
7. R. Fantoni, L. Fiorani, I. G. Okladnikov and A. Palucci. "Local observations of primary production in the Ross Sea: results of a Lidar-Calibrated Satellite Algorithm". 3rd International Conference on the Oceanography of the Ross Sea Antarctica, Venice, Italy, 10 - 14 October 2005.
8. L. Fiorani, L. Lazzara, A. Palucci. "Stima della produttività primaria dell'oceano meridionale integrando le informazioni del lidar fluorosensore e del radiometro satellitare". 17° Congresso Nazionale dell'Associazione Italiana di Oceanologia e Limnologia, Naples, Italy, 3 - 7 July 2006.
9. F. Colao, L. Fiorani, R. Fantoni, L. Lazzara A. Palucci. "Il laboratorio integrato di telerilevamento laser-satellite: impiego nella oceanografia antartica". 5° Convegno Nazionale per le Scienze del Mare "Il Mare: Centralità d'Interessi nel XXI secolo - Capacità Scientifiche Italiane e Risorse nel Competere", Viareggio, Italy, 14 - 18 November 2006.

E – thematic maps

Different Chl-a, CDOM and primary productivity distribution thematic maps, weekly, monthly and yearly based in the SO, RS, for the 2003 summer Antarctic season and previously from 1997.

F – patents, prototypes and data bases

Lidar fluorosensor database collected in the XVIII expedition and satellite images.

G – exhibits, organization of conferences, editing and similar

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H - formation (PhD thesis, research fellowships, etc.)

Thesis on Naturepreservation and management (Florence University, Science Faculty) Innocenti Andrea, Bio-optical characterization of the Ross Sea during the 2003 austral summer.

Fellowship position, annual base, Cecilia Gallo "Spectral variations and optical properties of the autotrophic communities in Southern Ocean "

Research units

Date:

Notes

The following activity reports have been also obtained:

1. Colao F., Fantoni R., Fiorani L., Palucci A., Okladnikov I. G. "Lidar and satellite observations of the Southern Ocean" ENEA RT/2004/65/FIS.
2. R. Fantoni, L. Fiorani, A. Palucci, I.G. Okladnikov "Regional models for satellite measurements of primary productivity in the Ross Sea" Technical Reports of the Italian Agency for New Technologies, Energy and the Environment (ISSN 0393-3016), Rome, Italy, RT/2005/17/FIS (2005)
3. R. Fantoni, L. Fiorani, A. Palucci, I.G. Okladnikov "New algorithm for CDOM retrieval from satellite imagery" Technical Reports of the Italian Agency for New Technologies, Energy and the Environment (ISSN 0393-3016), Rome, Italy, RT/2005/19/FIS (2005)
4. L. Fiorani, A. Palucci, I.G. Okladnikov "Remote sensing of chromophoric dissolved organic matter by ocean color radiometers calibrated by laser induced fluorescence" Technical Reports of the Italian Agency for New Technologies, Energy and the Environment (ISSN 0393-3016), Rome, Italy, RT/2005/57/FIS (2005).