

HICO Data User's Proposal

Study of submesoscale water dynamics in coastal zones of the Black, Azov and Caspian Seas

Principal Investigator

Dr. Olga Lavrova
Ocean Satellite Remote Sensing Laboratory
Space Research Institute (IKI RAS)
Russian Academy of Sciences
84/32 Profsoyuznaya Str.
Moscow 117997, Russia

Phone: +7(495)3334256

Fax: +7(495)3331056

olavrova@iki.rssi.ru

Co Investigators:

Dr. Marina Mityagina, IKI RAS, mityag@iki.rssi.ru
Dr. Svetlana Karimova, IKI RAS, feba@list.ru
Ms. Tatiana Bocharova, IKI RAS, tabo@iki.rssi.ru
Dr. Ivan Uvarov, IKI RAS, uvarov@d902.iki.rssi.ru

Abstract/project summary

The project aim is to use HICO data to improve our understanding of submesoscale water dynamics in the near surface seawater layer of coastal zones of the Black, Azov and Caspian Seas. Since submesoscale water dynamics is best manifested through film patterns on the sea surface (slicks in SAR and VIS images), close investigation of surface films will be a major task. The basic approach will be joint analysis of all available satellite (SAR, VIS and IR) data, metocean parameters, ship and ground measurement data. The HICO data is intended to be assimilated into the existing data analysis techniques in order to improve the quality and reliability of the results to be obtained and, potentially, foster development of novel data interpretation techniques.

Special emphasis will be laid on the study of submesoscale eddies. The input of various factors, such as local current instability, bottom topography, abrupt change of wind forcing, cascade destruction of larger eddies, etc., into eddy generation and evolution mechanisms in particular coastal zones will be assessed. Characteristic scales of different eddy structures, their interannual and seasonal variability, formation frequency and spatial distribution will be evaluated. Also the contribution of eddies to coastal water exchange, drift and redistribution of pollutants will be estimated.

The developed data analysis techniques incorporating HICO data will be tested and adjusted during regular field experiments on a Black Sea test site.

1. Statement of work/project description

Submesoscale water dynamics is among the most important and interesting elements of water circulation and has always been in the focus of oceanographers. However, these structures, scaled from a few hundreds of meters to tens of kilometers, still remain considerably poorly studied due to obvious reasons. For instance, submesoscale eddies are a difficult subject of investigation by traditional techniques because of their small sizes, non-stationary character, sporadic occurrence and short lifetimes. Satellite IR and VIS sensors commonly used to investigate eddies are unable to resolve eddy structures of less than 20 km in size. Some authors report on investigations of submesoscale eddies based on SAR data (DiGiacomo and Holt, 2001), leaving important questions unanswered.

We develop a comprehensive approach to the study of submesoscale eddies and current fine structure suggesting joint analysis of various satellite (SAR, VIS and IR) data, metocean, contact ground and ship measurements. The data basis of the project is represented by a large bank of previously accumulated and newly acquired satellite data, including ERS SAR, Envisat ASAR, RADARSAT, TerraSAR-X, Aqua/Terra MODIS, NOAA AVHRR, Landsat ETM+ and HICO.

A number of authors demonstrate (Wettle et al., 2009; Leifer et al., 2012), that using hyperspectral sensors data give promising results concerning oil spill/slick investigation, which will be a significant part of this study. Others (Brando and Dekker, 2003) suggest estimating important water parameters such as temperature, chlorophyll, suspended matter at better spatial and spectral resolution. Therefore, provided the access to HICO data is granted, we anticipate considerable enhancement of this study results.

This study test areas include the Black, Azov and Caspian Seas. The required HICO data should cover the following areas:

Black and Azov Seas: 26°50'E ÷ 41°55'E; 40°10'N ÷ 47°30'N;

Caspian Sea: 46°20'E ÷ 55°00'E; 36°20'N ÷ 47°30'N.

The proposed project activities include:

- 1) discrimination of surface films entrained into submesoscale dynamic structures by nature and origin;
- 2) estimation of the contribution of different factors into the generation and evolution mechanisms of submesoscale eddies in coastal zones of the Black, Azov and Caspian Sea;
- 3) evaluation of interannual and seasonal variability of vortical activity, generation frequency and spatial distribution of submesoscale eddy structures;
- 4) assessment of the input of submesoscale eddy structures into processes of water exchange and replacement, drift and redistribution of pollutants.

2. Biographical sketch and available facilities

Dr. Olga Lavrova has been the Head of the Ocean Satellite Remote Sensing Laboratory, Space Research Institute of the Russian Academy of Sciences since 2002. The Lab has been engaged in regular monitoring and investigation of Russia's seas as well a number of projects devoted to other parts of the

world ocean. The Lab has good cooperation relations with many domestic and foreign oceanographic institutions.

Since 1999, Dr. O. Lavrova has led her research group in a dedicated monitoring effort of the coastal zone of the Black Sea, employing SAR, VIS and IR sensors and in-situ data. The focus was on investigation of (a) dynamic phenomena, such as eddies, internal waves, fronts, (b) anthropogenic and biogenic pollution, (c) chlorophyll distribution, (d) monitoring of underwater sewage outflows, etc. (Shcherbak et al., 2008; Lavrova et al., 2008; Mityagina et al., 2008, Mityagina et al., 2012, Lavrova et al., 2012).

Regular experimental activities are conducted on the Black Sea test site near the town of Gelendzhik, where contact data are collected, including ADCP measurements from a boat.

Observations of algae bloom in the Baltic Sea have been conducted for several years based on SAR and optical data. Eddy structures were revealed due to scattering at the algae. (Lavrova et al., 2008, Karimova et al., 2012).

Much of Dr. O. Lavrova's expertise and results are presented in a monograph dedicated to satellite monitoring of Russia's seas (Lavrova et al., 2011).

The Lab headed by Dr. O. Lavrova has accumulated a large bank of satellite data, including Landsat-5 TM, Landsat-7 ETM+, Envisat MERIS, Terra/Aqua MODIS, NOAA AVHRR, ERS SAR, Envisat ASAR, Radarsat, TerraSAR, etc. Currently, the RADARSAT-2 and TerraSAR-X imagery is provided under project "Detecting and Tracking Small Scale Eddies in the Black Sea Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery (DTEddie)".

For field experiments, the Lab possesses an ADCP instrument, CTD probes and a compact meteorological station. Satellite images are processed using ENVI and IDL software.

3. Output and deliverables

The following results and products will be achieved using the HICO data:

- 1) a technique developed to discriminate surface films entrained into submesoscale dynamic structures by nature and origin;
- 2) contribution of various factors into eddy generation and evolution mechanisms in particular coastal zones of the Black, Azov and Caspian Seas established and assessed.
- 3) maps of interannual and seasonal variability of vortical activity, generation frequency and spatial distribution of submesoscale eddy structures in the Black, Azov and Caspian Seas compiled;
- 4) characteristic sizes of submesoscale eddy structures calculated for each sea;
- 5) submesoscale dynamics structures impact on the drift and evolution of pollutants established and assessed;
- 6) a novel technique suggested to retrieve current fine structure parameters.

The results of the project will be reported at international conferences, corresponding papers will be submitted to scientific journals. Annual reports to the HICO team meetings will be delivered.

4. References

- Brando, V.E., Dekker, A.G.: "Satellite hyperspectral remote sensing for estimating estuarine and coastal water quality"; *IEEE T. Geoscience and Remote Sensing* (2003) 1378-1387.
- DiGiacomo, P. M., and B. Holt, "Satellite observations of small coastal ocean eddies in the Southern California Bight", *Journal of Geophysical Research*, Vol. 106, No. C10, pp. 22,521-22,543 (2001).
- Karimova, S. S., O. Yu. Lavrova, and D. M. Solov'ev. "Observation of Eddy Structures in the Baltic Sea with the Use of Radiolocation and Radiometric Satellite Data" // ISSN 0001-4338, *Izvestiya, Atmospheric and Oceanic Physics*, 2012, Vol. 48, No. 9, pp. 1006-1013. © Pleiades Publishing, Ltd., 2012.
- Lavrova, O., M. Mityagina, T. Bocharova, and M. Gade, "Multisensor observation of eddies and mesoscale features in coastal zones," *Remote Sensing of the European Seas*, Barale, Vittorio; Gade, Martin (Eds.) Springer. pp. 463-474, 2008.
- Lavrova, O., M. Mityagina, T. Bocharova, A. Kostianoy, V. Krovotyntsev, "Multisensor approach to operational oil pollution monitoring in coastal zones," 2008 IEEE International Geoscience & Remote Sensing Symposium. Proceedings of IGARSS 2008, July 6-11, 2008, Boston, Massachusetts, U.S.A.
- Lavrova, O., A. Kostianoy, S. Lebedev, M. Mityagina, A. Ginzburg, N. Sheremet, "Complex satellite monitoring of Russian seas," Moscow, IKI RAS, 2011, 470p. (in Russian).

- Lavrova, O., A. Serebryany, T. Bocharova, and M. Mityagina, "Investigation of fine spatial structure of currents and submesoscale eddies based on satellite radar data and concurrent acoustic measurements," Proc. SPIE 8532, Remote Sensing of the Ocean, Sea Ice, Coastal Waters, and Large Water Regions 2012, 85320L (2012).
- Leifer, Ira, William J. Lehr, Debra Simecek-Beatty, Eliza Bradley, Roger Clark, Philip Dennison, Yongxiang Hu, Scott Matheson, Cathleen E. Jones, Benjamin Holt, Molly Reif, Dar A. Roberts, Jan Svejksky, Gregg Swayze, Jennifer Wozencraft, "State of the art satellite and airborne marine oil spill remote sensing: Application to the BP Deepwater Horizon oil spill," Remote Sensing of Environment, Volume 124, September 2012, Pages 185-209.
- Mityagina, M., O. Lavrova, "Satellite survey in the Black Sea coastal zone," International Water Technology Journal. 2012. Vol. 2. Issue 1. P.67 – 79.
- Mityagina, M., O. Lavrova, "Dynamic phenomena in the coastal waters of the north-eastern black sea retrieved from satellite data," 2008 IEEE International Geoscience & Remote Sensing Symposium. Proceedings of IGARSS 2008, July 6-11, 2008, Boston, Massachusetts, U.S.A.
- Shcherbak, S. S., O. Yu. Lavrova, M. I. Mityagina, T. Yu. Bocharova, V. A. Krovotyntsev, A. G. Ostrovskii, "Multisensor satellite monitoring of seawater state and oil pollution in the northeastern coastal zone of the Black Sea," International Journal of Remote Sensing, Volume 29, Issue 21, November 2008, pages 6331 – 6345.
- Wettle Magnus, Paul J. Daniel, Graham A. Logan, Medhavy Thankappan, "Assessing the effect of hydrocarbon oil type and thickness on a remote sensing signal: A sensitivity study based on the optical properties of two different oil types and the HYMAP and Quickbird sensors," Remote Sensing of Environment, Volume 113, Issue 9, September 2009, Pages 2000-2010.