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

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Introduction

Starting from the first data supply in the end of October 2013, our team has received 21 HICO images featuring different regions of the Black Sea. Of them, 13 were totally or heavily clouded precluding identification of marine processes. The rest 8 images were mostly taken over the northeastern part of the sea, the Novorossiisk region (4) and Kerch Strait (3), and 1 image featured the southeastern part of the sea near the town of Poti.

The images were processed and incorporated into the database of the See the Sea geoportal, a tool developed by IKI RAS to aid in complex processing of oceanographic data for scientific purposes. The HICO data were analyzed jointly with available satellite and metocean data with the aim to reveal and investigate submesoscale dynamic structures manifested through the drift of various types of water pollutants. The analysis involved visual data from Landsat-8 OLI, Landsat-7 ETM+, TM Landsat-5 and Terra/Aqua MODIS and Envisat ASAR synthetic aperture radar data.

Assimilation of HICO data into the analysis procedures helped to better identify and detail river outflows, some coastal water circulation elements, such as eddies, and an intrusion of the Azov Sea waters into the Black Sea through the Kerch Strait.

Case study: retrieval of coastal mesoscale dynamics in northeastern Black Sea

The region of Novorossiisk lies at the foothills of the Caucuses Mountains. In periods of heavy rainfall, anthropogenic pollution carried into the sea with river outflows increases many times. This is augmented by masses of mud washed by flood waters. The rise in river outflows lasts for 2-3 days, which are marked by large scale pollution of the sea. Satellite imaging is known to provide good evidence of the process of propagation of turbid waters.

After the rainfall of 7 and 8 November 2013 in the Novorosiisk region, we observed a sharp increase in the area of coastal waters rich in suspended matter. A joint analysis of HICO, Landsat-8 OLI and Terra/Aqua MODIS images along with metocean data available for the closest dates was performed. We used HICO data of 10.11.2013, 09:44 GMT, Terra MODIS data received 16 minutes later, at 10:00 GMT, and Landsat-8 OLI data obtained the day before, 09.11.2013 at 08:09 GMT (Figure).

The color composite of Landsat-8 OLI (bands 4, 3, 2) bears clear evidence of strong river outflows caused by the rainfall. However, despite high spatial resolution (30 m), sparse spectral bands of the sensor preclude the retrieval of any detail of suspended matter motion. HICO and Terra MODIS turbidity patterns agree in outlining the areas of turbid waters. In the meantime, it is only HICO that, due to its high spatial and spectral resolution, provides a far more detailed

picture of suspended matter distribution in water and makes it possible to reveal various types of mesoscale eddies and jets carrying pollutants away from the coastal zone to open sea. This is a valuable contribution to our understanding of the local mechanisms of "self-cleaning" of coastal waters in the Black Sea.

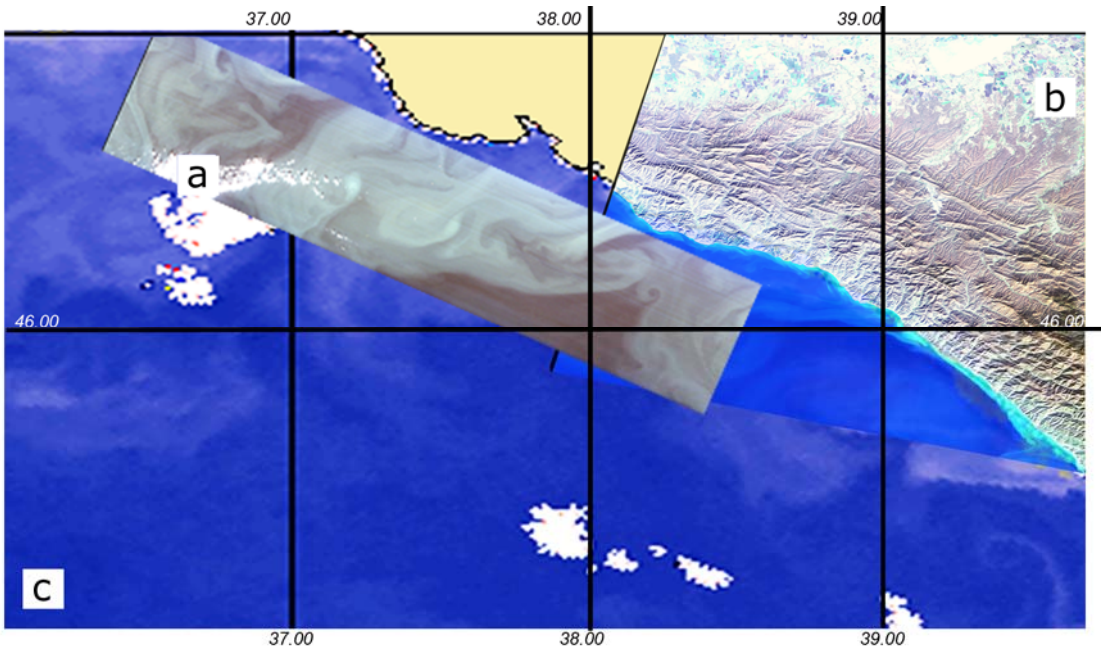

Figure.

a) HICO of 10.11.2013, 09:44 GMT, resolution 100 m, spectral bands – R: 0,512 μm (32), G: 0,536 μm (24), B:- 0,467 μm (12);

b) Landsat-8 OLI of 09.11.2013, 08:09 GMT, resolution 30 m, spectral bands - R: 0,630 – 0,680 μm (4), G: 0,525 – 0,600 μm (3), B: 0,450 – 0,515 μm (2);

c) water turbidity map derived from Terra MODIS of 10.11.2013, 10:00 GMT, resolution 500 m, spectral band 0,551 μm.

Conclusion

Our first experience of using HICO data proved their high potential for the study of sea water pollution and mesoscale dynamics. A large number of spectral channels makes it possible to effectively distinguish between various types of pollution and reveal details of local currents.

Introduction of HICO data into our analysis procedures allowed to reconstruct in detail the dynamic pattern of suspended matter mass in the shelf zone of the northeastern Black Sea.

Georeferencing of HICO data is somewhat inaccurate and can be improved only if there are ground control points.

A great advantage is the possibility provided by the HICO team to request imaging of particular regions.

Upcoming publications

1. Lavrova O.Yu., Mityagina M.I., Loupian E.A., Uvarov I.A., Vyyavlenie i raspoznavanie razlichnykh tipov vod v pribrezhnoi zone Chernogo morya i v ozerakh Kryma na osnove analiza

giperspektral'nykh dannykh (Detection and recognition of various water types in Black Sea coastal zone and in lakes of Crimea based on hyperspectral data analysis), *Sovremennye problemy distantsionnogo zondirovaniya Zemli iz kosmosa*, 2014, Vol. 11, No.1, in print (in Russian).

2. Uvarov I.A., Loupian E.A., Matveev A.M., Mazurov A.A., Lavrova O.Yu., Mityagina M.I. Organizacija raboty s dannymi sputnikovyh giperspektral'nyh nabljudenij dlja issledovanija processov v Mirovom okeane (Management of hyperspectral remote sensing data for studies of world ocean processes), *Sovremennye problemy distantsionnogo zondirovaniya Zemli iz kosmosa*, 2014, Vol. 11, No.1, in print (in Russian).

3. Lavrova O.Yu., Mityagina M.I., Uvarov I.A., Loupian E.A., Hyperspectral observation of anthropogenic and biogenic pollution in coastal zone. *COSPAR Assembly 2014*, 02-08 August 2014, Moscow, Russia.

4. Lavrova, O.Yu., E.A. Loupian, M.I. Mityagina, I.A. Uvarov, A new technology powered by the See the Sea geoportal for the study of ocean coastal zones focusing on complex analysis of hyperspectral data, *Modern Information Technologies in the Earth Sciences International Conference*, 8-13 September, 2014, Petropavlovsk on Kamchatka, Russia.

5. Mityagina M., Lavrova O., and I. Uvarov, Multi-user information system for the investigation of processes in coastal zones on the base of joint analysis of satellite data, particularly hyperspectral data, *SPIE Remote Sensing 2014 Conference,* 22-25 September 2014, Amsterdam, the Netherlands.