Earth Remote Sensing data for extraction coastal information and bathymetry

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Having updated and precise information about the seabed is crucial for coast development, construction of offshore oil production facilities, seaport operations, ensuring safe functioning of ships at the sea, and conducting scientific research.

Using high-resolution multispectral satellite imagery is a new approach to acquiring information about the seabed terrain. Along with traditional spectral bands, modern remote sensing satellites have extra channels, which are used for atmospheric correction, water quality and vegetation control and many other tasks.

QuickBird and WorldView-2 spectral bands cam be seen in Fig.1

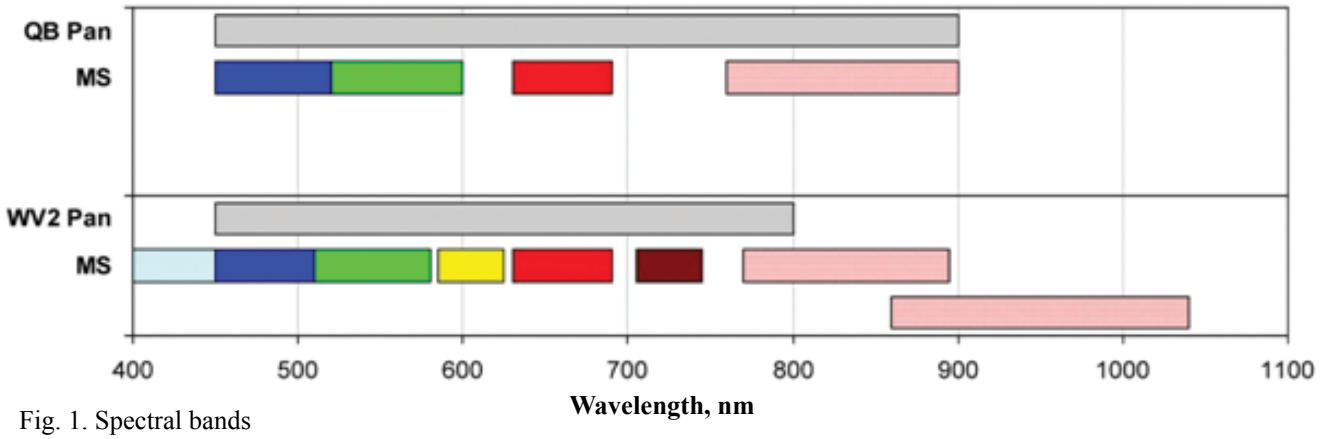

Fig. 1. Spectral bands

The violet or "coastal" band penetrates water better than any other channel does. This band makes taking deep water measurements possible, which cannot be done using traditional spectral bands. At the same time, water quality is very important for the coastal channel that is why using it may sometimes be impossible. When there is much suspended or organic matter in coastal waters we use other bands – yellow and green – which are correlated with the violet channel best of all. Depth measurements can be recalculated into absolute values. For this we need to have information about storm surges and tides at the time of image acquisition.

Using satellite images fully exclude expenses on transportation of equipment and employment of manpower, any damages to equipment when measuring depths in not very deep waters. Also there is no need to get clearances or licenses for taking bathymetric measurements; no visas are required to pass country borders.

Getting bathymetric data from satellite images is much less expensive than measuring the seabed in the traditional way. It takes less time to process satellite images than lidar data, allowing us to get bathymetric measurements worth of 5,000 km2 every month.

PRIME GROUP acquired bathymetric measurements in the part of the Vyborg Bay between the Vyborg Port and Vikhrevoy Island. You can see the area of interest in Figure 2.

Fig 2. Area of interest

WorldView-2 and GeoEye-1 imagery was used to get these measurements. After analyzing the weakening of penetration of light in the water in relation to the water-air level, 50 cm resolution raster images with depth values were acquired. Initially, it was planned to measure water down to 5 meters, but due to high turbidity the maximum measured depth was 2.5 meters. A sample of the resulting data is shown in Fig. 3.

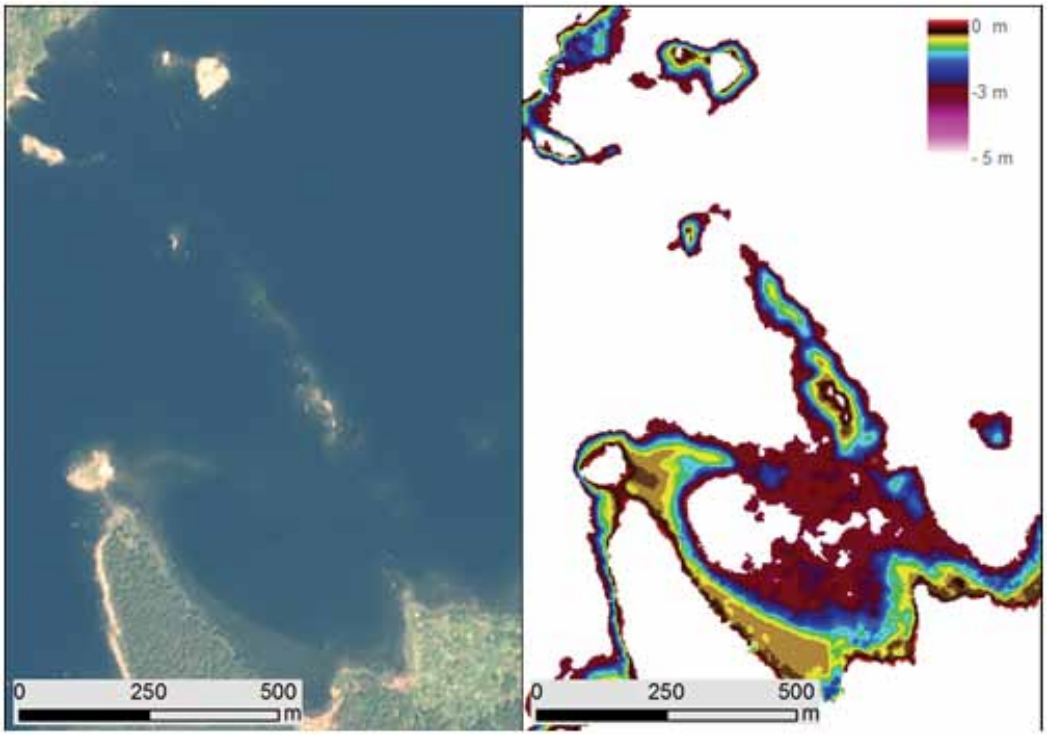

Fig. 3. Satellite and raster depth map

Raster data were interpolated into vector layers – bottom contours with 0.2 meter sections and pinpoint layer showing depth measurements with a 50 cm grid. The resulting data were compared to the measurements taken by a hydrographic vessel in the Vyborg Bay in 2006. Discrepancies were analyzed in those areas where these measurements and satellite derived bathymetric data overlapped. Then, differences between depth measurements derived from satellite images and acquired by depth sounders were defined.

As a result, huge inconsistency was found at depths under 1.8 meters. For depths above 1.8 meters the roof-mean-square-deviation between the actual depth measurements and calculated depth measurements was 42 cm. An overlapping data sample is shown in Fig. 4.

This analysis made it clear that using satellite images it is impossible to measure depths under 2 meters in the Gulf of Finland. It also showed extensive errors in the depth measurements. Final results are much affected by the quality of water, presence of silt on the sea bottom and the level of light on the latitude of the area of interest.

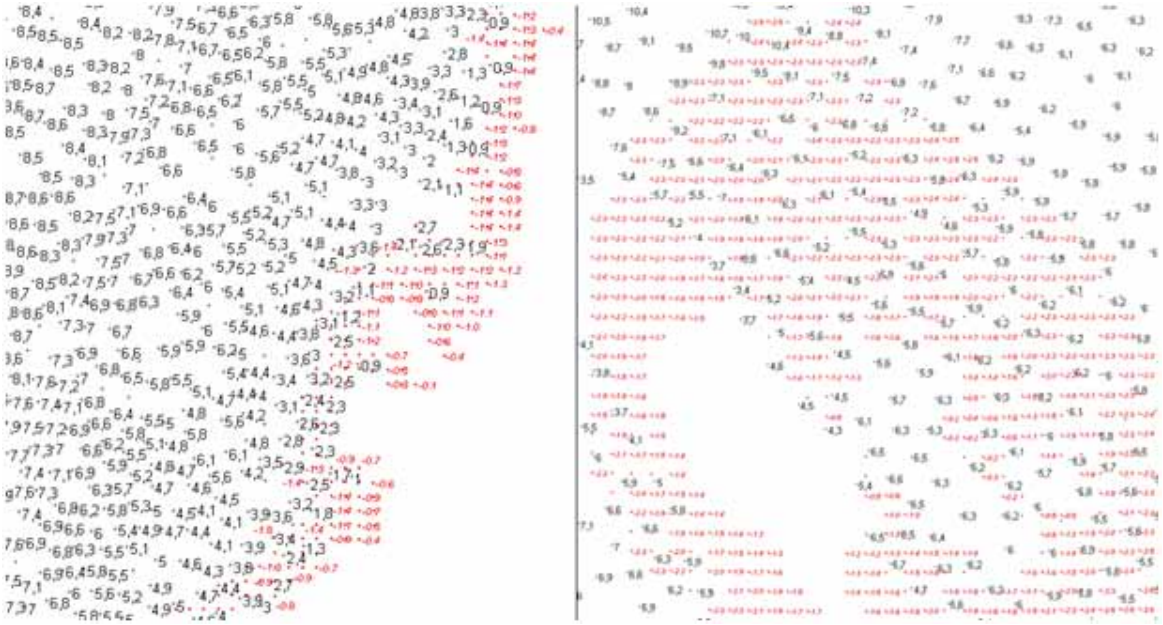

Fig. 4. Depth sounder data and calculated values overlap

It is worthwhile to mention that in good quality water and with enough light we can derive information about the sea bottom using conventional natural color (RGB) images. Our company experts selected and delivered satellite imagery to the Russian Academy of Sciences Egyptian Studies Center for underwater archeological studies.

The Russian Academy of Sciences Egyptian Studies Center was invited by the Supreme Councel of Antiquities of Egypt (SCA) for archeological research in a large area in the sea near Alexandria, extending from the Anfushi cape in the east to the Agami cape in the west. The area of interest is shown in Fig. 5. According to estimates, the sea level near Alexandria has risen by 7 - 8 meters since ancient times. This means that the bigger part of the coast with its precious archeological artifacts was flooded and is 6-8 meters underwater now. Thus, the primary task for The Russian Academy of Sciences Egyptian Studies Center in Alexandria was to study the coastal lines and map out the area of research using various methods of data acquisition.

Without the West Port and fairways, the area of interest covers 30 km2 with depths ranging from 1 meter down to 40 meters. The depths in the area under research do not measure more than 10 meters, which allows using satellite images to get more details about the condition of the sea bottom. The Russian Academy of Sciences Egyptian Studies Center scientists measured depths exceeding 8 meters with a Klein- 3000 side scan sonar.

Fig. 5. Areas of research

PRIME GROUP experts selected very high-resolution images available over the areas of interest. After analyzing historical weather conditions in that area, we chose images for further analysis. Crucial factors included the presence and height of waves, water transparency, flares on wave tops. Finally, a QuickBird image taken on May 13, 2013 was selected. After processing the image it became possible to identify seabed features at depths down to 8 meters. A part of this image is shown in Fig. 6.

The Russian Academy of Sciences Egyptian Studies Center launched a geographic information system, which includes historic maps of the port dating back to the 17th-19th centuries, as well as modern navigation charts and maps created with data from side scan sonars. The analysis of satellite images, historic and modern maps made it possible to map out the location of artifacts on the sea bottom and determine diving sites.

Fig. 6. Image over the area of research

Divers found remnants of ancient port buildings, a large breakwater made of lime blocks, and several shipwreck sites. Research results indicate possible sites of medieval fortresses, which were built on islands – now underwater - adjacent to the port. Due to the marine transgression of about 8 meters in this area, there remains a possibility of finding flooded town blocks, which were a part of ancient and medieval Alexandria.

Bigliography

A.A. Belov, The Russian Academy of Sciences Egyptian Studies Center underwater archaeological mission to Alexandria, Egypt. Moscow, 2014.