

Updating Landsat Satellite-derived Bathymetry Procedure

In the IHO-IOC GEBCO Cook Book

The General Bathymetric Chart of the Oceans (GEBCO) is an international body of experts that develops bathymetric datasets and products that are made available for public use. Among these products is the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) GEBCO Cook Book that provides the international community with a set of procedures for processing and analysing bathymetry data. Landsat 8 was launched in February 2013. The imagery from this new multispectral satellite is free and publicly available. This paper discusses updates in the IHO-IOC GEBCO Cook Book chapter on using Landsat imagery to derive bathymetry.



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The IHO-IOC GEBCO Cook Book provides easy steps to follow for users that do not have a background in Hydrography or Geographic Information Systems (GIS) (<http://www.gebco.net>). One of the procedures provided in the Cook Book is for Landsat satellite-derived bathymetry (SDB), as outlined in Chapter 11 (version 6.10.13) (Figure 1). The SDB procedure provides a quick reconnaissance of the nearshore bathymetry at low cost

Landsat Imagery

There are several commercial multispectral satellite platforms (e.g., Ikonos and WorldView) that can be used for deriving bathymetry. But for users with limited funds, Landsat imagery provides a free and publicly available resource (<http://earthexplorer.usgs.gov/>). Early this year (2013), the eighth Landsat imagery satellite was launched. Similar to its predecessors, a multispectral-scanning radiometer

In addition, the stated positional accuracy of Landsat 8 has improved to 14m from the 50m accuracy stated for Landsat 7 imagery.

Procedure Updates

A major difference between Landsat 7 and Landsat 8 is the number of bands and the wavelength ranges that are available in the imagery (Figure 3). The updated procedure provides the user with the recommended bands to



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The SDB procedure is only a reconnaissance tool

and allows the user to identify bathymetric changes between two satellite images from different periods or between a current satellite image and a nautical chart. Key steps in the updated SDB procedure are: pre-processing, water separation, radiometric correction for clouds and sun glint, applying the bathymetry algorithms, and referencing the bathymetry to the chart datum.

mounted on the satellite continuously collects imagery with a swath-width of 185km and an image resolution of up to 28.5m. The Landsat imagery is ortho-rectified and referenced to the WGS84 ellipsoid. The new radiometer, called operational land imager (OLI), provides nine spectral bands at a larger dynamic range compared to the previous scanner mounted on Landsat 7, the Enhanced Thematic Mapper plus (ETM+) (Figure 2).

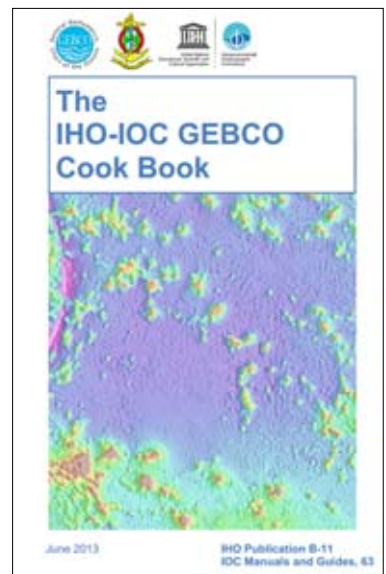


Figure 1: Cover page of the IHO-IOC GEBCO Cook Book.

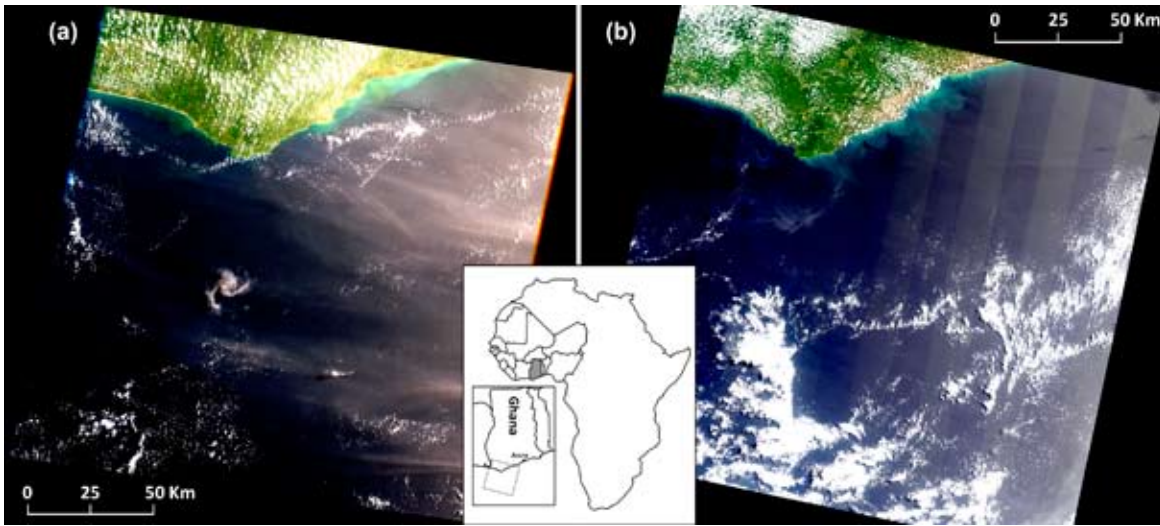


Figure 2: Landsat imagery over Accra, Ghana: (a) Landsat 7 (21 April 2002) and (b) Landsat 8 (4 April 2013).

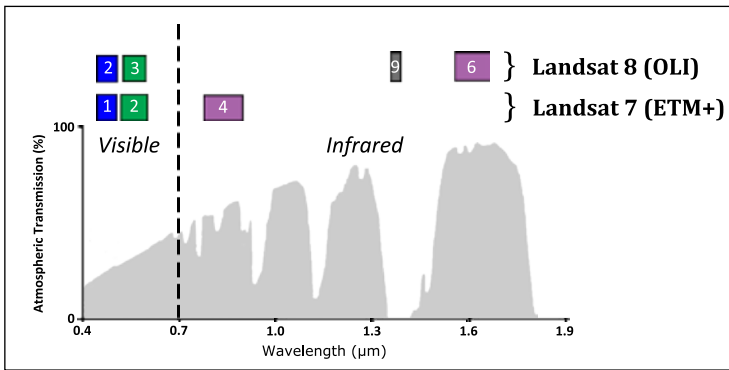


Figure 3: Bands of Landsat 7 and 8 imagery used in the SDB procedure.

use for each of the satellites images. The main differences in the procedure using the two satellite imagery datasets are:

Bathymetry — Although the bathymetry is calculated using similar wavelength ranges, the band number for blue and green bands have changed from band 1 (0.45 - 0.51µm) and 2 (0.52 - 0.60µm) in Landsat 7 to bands 2 (0.45 - 0.52µm) and 3 (0.53 - 0.59µm) in Landsat 8.

Land/water separation — Band 4 (0.77-0.90µm) in the near infrared is used to separate the submerged areas from dry land, whereas band 6 in the short-wave infrared (1.57 - 1.65µm) is used for Landsat 8 imagery.

Clouds — Landsat 8 imagery provides a new band (Band 9) in the infrared (1.36 - 1.38µm) that can map cirrus ice clouds. Data from this band can be used to correct some of the atmospheric contributions from the derived bathymetry.

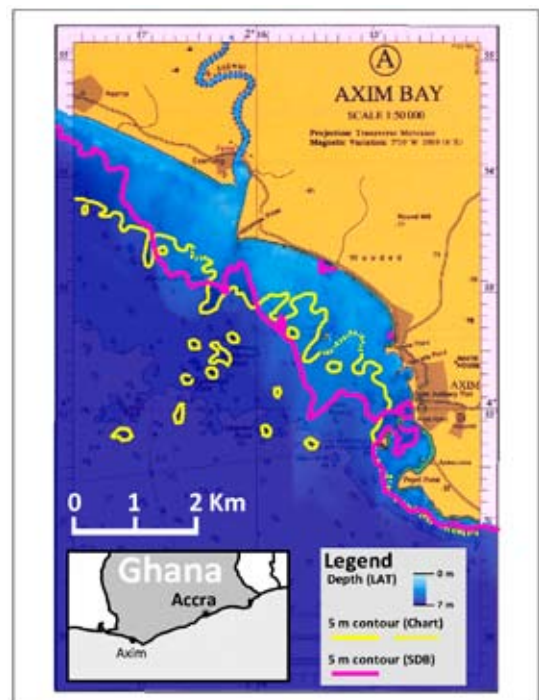
Ghana as a Test Site

The updated procedure was first tested over a US calibration study

site (Rockport, Massachusetts), using a reference Airborne Lidar Bathymetry (ALB) survey that was collected in 2007 by the US Army Corps of Engineers. Landsat 8 bathymetry was compared to bathymetry produced from Landsat 7. Although the time difference between the two images is 14 years and some sediment transport occurred around the inlets, the depth difference over the stable areas was small (less than 1m). After configuring for Landsat 8 imagery, the procedure was tested over the Axim Bay study site in Ghana. British Admiralty Chart 3113 at 1:50,000 scale was used to reference the bathymetry to the chart's datum, Low Astronomical Tide (LAT). The source diagram indicates that all surveys in the waters of Axim Bay are lead-line surveys that were conducted between 1911 and 1924. The satellite-derived results enabled the identification of areas where bathymetry has not changed since the last survey used for the chart. The water depth that bathymetry can be derived was 7m. Accordingly, a 5m contour line was used to visually compare changes in bathymetry in

the dataset (Figure 4). Around the mouth of the Ankwaio River (center of the figure), changes in bathymetry were noticed. These changes are probably transport of sediments influenced by large volumes of water coming out of the river.

Figure 4: Axim Ghana study site: SDB bathymetry overlaid on BA3113 Chart.



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Use of the IHO-IOC GEBCO Cook Book

The updated procedure using Landsat 8 is now available in the IHO-IOC GEBCO Cook Book and has also been used by the Marine Charting Division in NOAA to evaluate the coastal waters of Haiti. It is important to note that the SDB procedure is only a reconnaissance tool and is heavily dependent on water clarity and the quality of the chart soundings that are used to reference the Landsat imagery. In addition to

around the world. The Cook Book is continually maintained, and scientific contributions from the hydrographic community are encouraged (contact Karen Marks).

Acknowledgement

The authors would like to thank GEBCO and the Center for Coastal and Ocean Mapping/ Joint Hydrographic Center for facilitating the programme and this internship. The authors also thank the Office

Landsat imagery provides a free and publicly available resource

the SDB procedure, the Cook Book provides step-by-step instructions for producing grids from xyz data, procedures for processing, analysing, and imaging bathymetry data, an overview of available software, and available archives for datasets

of Integrated Ocean and Coastal Mapping programme at NOAA. In addition, we thank the UKHO for the copyright permission to use their charts for this study. Copyright permission for modifying Figure 3 was provided by USGS and NASA.

Further Reading

General Bathymetric Chart of the Oceans (GEBCO), 2013. GEBCO Cook Book V6.10.13: http://www.gebco.net/data_and_products/gebco_cook_book/.

U.S. Geological Survey, Landsat Missions, <http://landsat.usgs.gov/>.

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Karen Marks is a geophysicist at the NOAA Laboratory for Satellite Altimetry, in College Park, Maryland, USA. Her research focuses on satellite altimetry, bathymetric prediction, and marine gravity fields. She advises the General Bathymetric Chart of the Oceans (GEBCO) Technical Sub-Committee on Ocean Mapping (TSCOM) and is chief editor of the IHO-IOC GEBCO Cook Book. karen.marks@noaa.gov.

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