EOMAP Satellite-Derived Bathymetry (SDB)

What is it?

Satellite-derived bathymetry (SDB) is the mapping of water column depth using imagery collected from space-borne satellites. Since this imagery is typically densely packed with information in every pixel, SDB effectively provides a continuous 3D model of seafloor topography. For those familiar with geospatial information products, this is the equivalent to an underwater digital elevation model (DEM).

What are the advantages of SDB?

SDB is experiencing increased uptake because it is now becoming an operational and robust technology. Its primary advantage is that it offers the ability to rapidly and non-intrusively survey remote, extensive, or in-accessible areas at between 5-10 times less costs than most traditional methods. Some of the specific advantages of SDB are listed below:

- **Cost effective**, with 5-10 times the costs of conventional methods
- **Rapid**, >1000 sq km of high resolution bathymetric data can be produced and accessed within less than one months time
- **Up to date,** SDB data can be processed from up-to-date satellite imagery data.
- **Remote areas,** access areas which cannot be physically sampled due to political, environmental or security constrains.
- **High resolution,** SDB data can deliver bathymetric information with a horizontal resolution of 0.5x0.5m (equivalent to image pixel size).
- **Seafloor optical properties,** an additional information layer which enables classifying seafloor habitat and bottom properties
- **No campaign planning** is required in contrast to conventional techniques.
- **Environmental friendly,** SDB is a carbon neutral and none-destructive mapping technique

> *"For this location and coverage, we estimated to have made a* ***cost saving of approximately one million dollars*** *(90% cost savings) compared to a traditional executed bathymetry and/or topographic LiDAR survey. The speed in which the final products were delivered greatly added to the usefulness and importance of the data in the tendering and planning phase of the seismic campaigns"* Siermann et al. (2014) at the International Petroleum Conference, Doha. Oatar

What is it for?

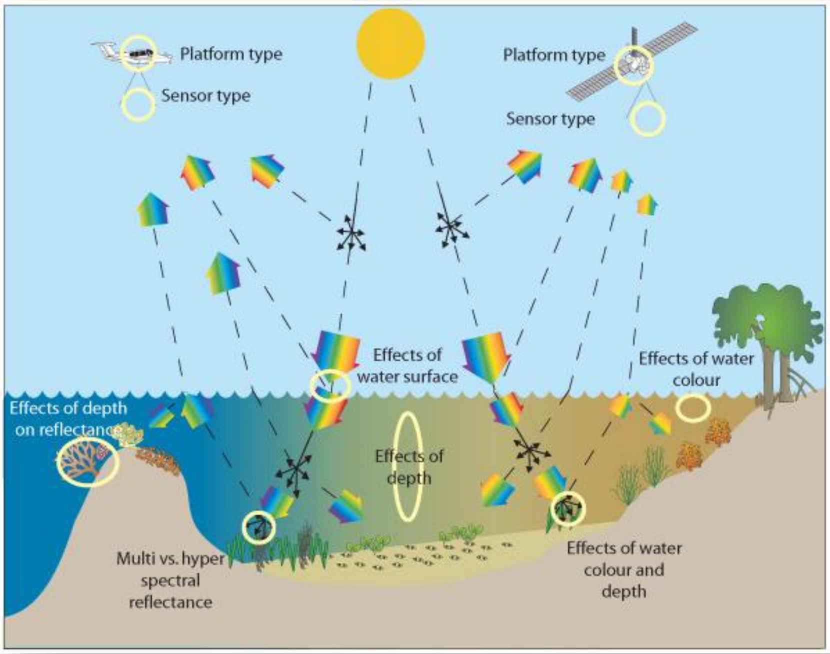
SDB is seeing increasing uptake across a range of uses. These include: environmental monitoring, modeling and baseline derivation; construction and development planning; exploration, and to some extent, navigational applications.

A complimentary product to SDB is the seafloor reflectance, or seafloor color map. This can be interpreted into ecological information (e.g. maps of coral and sea grass distributions) which has important uses in environmental applications such as establishing baseline information and monitoring change.

How does it work?

Briefly, SDB relies on 1) satellite sensors that detect sunlight reflected from the seafloor, and 2) algorithms that use this sunlight information to calculate water column depth (as well as seafloor reflectance, or color).

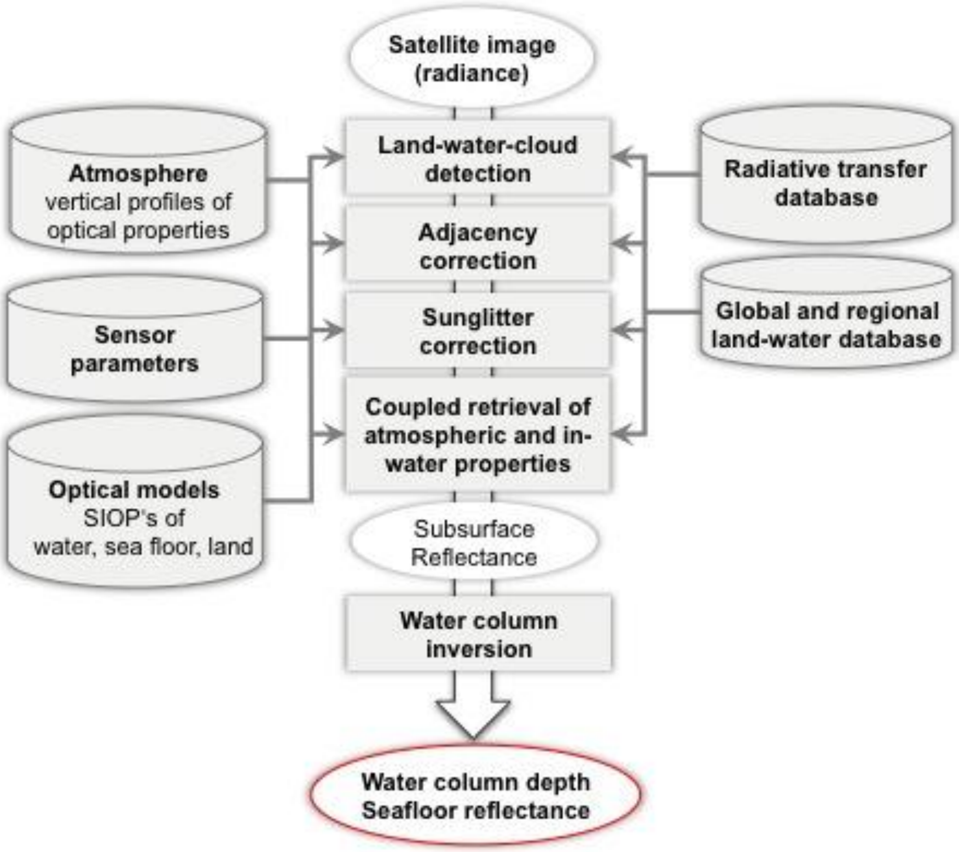
As an aside, this means that SDB is dependent on water clarity, and typically only retrieves depths down to approximately 30 meters. As it happens, this is the depth interval that is the most challenging and costly for traditional, ship-based bathymetry surveying.



Schematic illustrating the path of the sunlight signal, interacting with the atmosphere, water column and seafloor, and finally being measured by a space-borne or airborne sensor. Image courtesy of the Centre for Spatial Environmental Research, University of Queensland.

The science of deriving water depth from satellite data has been in research and developed for over 30 years. Initially, empirical methods were used. The advantage of these methods is that they are relatively straightforward, and computationally fast. The primary drawback of these methods is that they require known depth information for the area being studied in order to 'tune' the satellite information into retrieving accurate depths.

Physics-based methods on the other hand, require no known depth information for the study area, and can therefore be applied independent of satellite type and study area. These methods rely on fully describing the physical relationship between the measured light signal and the water column depth, and require more sophisticated algorithms and powerful processing capacity. EOMAP is the world leader in providing these physics based methods, using EOMAP's proprietary Modular Inversion Processor (MIP).



Schematic of the MIP modules for water depth and seafloor reflectance processing. The MIP is compatible with most accessible satellite data (sensor independent), is standardized within its workflows and enables rapid processing of Gigabytes of data.

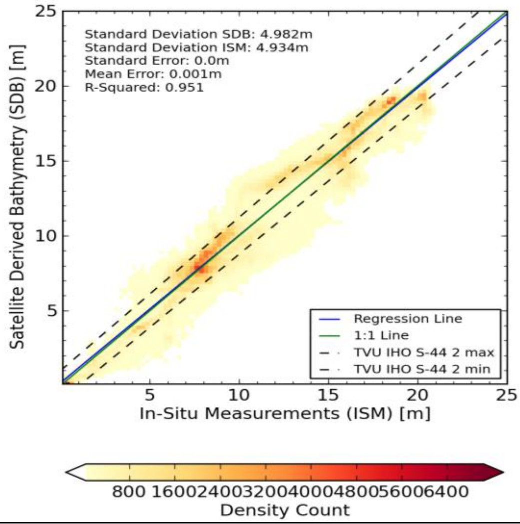
What is the horizontal accuracy of EOMAP's SDB?

The horizontal accuracies of SDB is a function of the spatial resolution of the satellite sensor used. It normally lies within the accuracy of one pixel, e.g. for a 2m resolution product the horizontal accuracy is <2m, for a 5m resolution product it is <5m, etc.

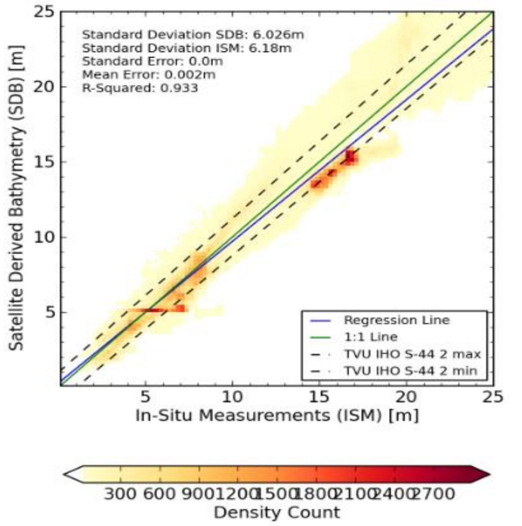
What is the vertical accuracy of EOMAP's SDB?

The CE90 vertical accuracy of SDB is given by a general offset of 0.5m and a depth dependent factor of 10-20%. As an example, for 10m water depth the CE90 accuracy lies within ±1.5 to 2.5m. The depth-dependent factor varies due to local water and seafloor conditions, where areas with increased turbidity and dark bottom reflectance tend to have lower accuracies and areas with sediment and clear water have very high accuracy. EOMAP SDB products are delivered with pixel-wise quality information, providing information on the reliability. The plots in the figures below correspond to validation results from previous EOMAP studies, and give a good representation of the SDB outputs.

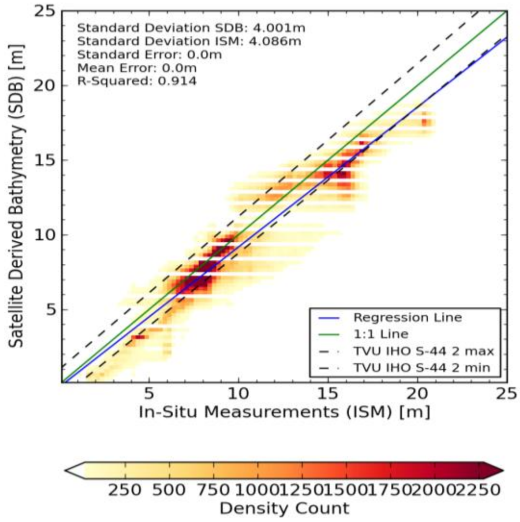
2m SDB product validated against Lidar data.



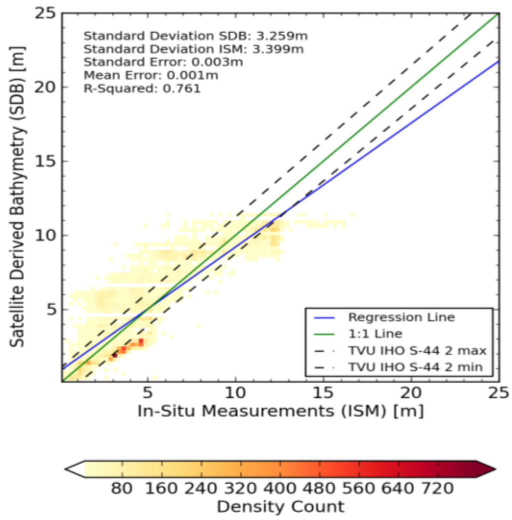
2m SDB product validated against MBES data.



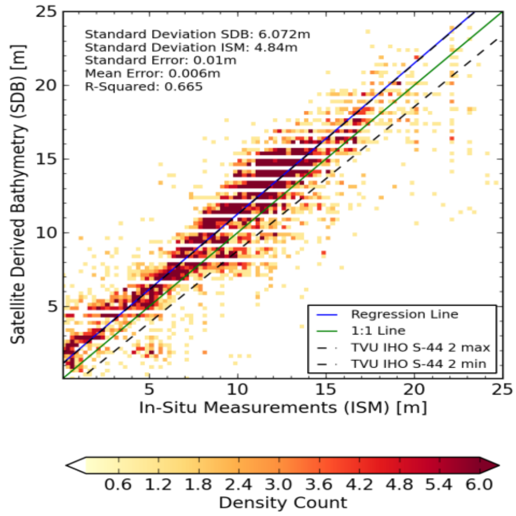
2m SDB product validated against Lidar data.



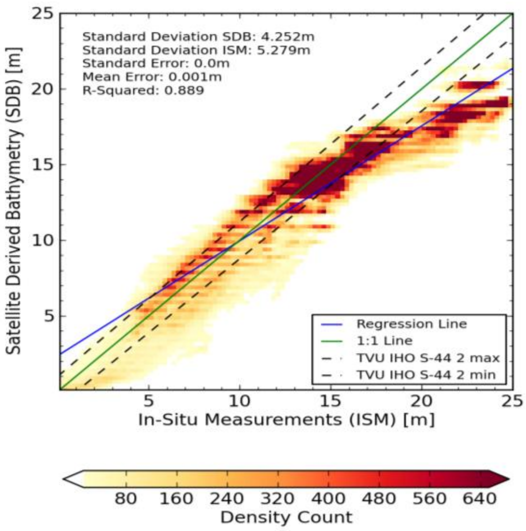
5m SDB product validated against vari. data



30m SDB product validated against nautical charts of various age, methodologies and scale



30m SDB product validated against Lidar



What are the limits of SDB?

SDB techniques can be applied to optically shallow water areas. These are asareas, where the seafloor contributes to the spectral signal (= color) recorded at the satellite sensor. Water turbidity is the most dominant factor in limiting the maximum retrievable water depth using SDB. As a rule of thumb it can be expected that SDB can produce data to the depth of Secchi Disk Depth. The table below lists examples of this, based on experience from previous EOMAP projects.

Site description	Approx. max. depth of SDB
Clear waters, such as the Caribbean Sea, Mediterranean Sea, Red Sea or islands in the Pacific and Atlantic	25-35 m
Moderate turbid waters, such as found in the Arabian Gulf and coastal regions worldwide	10-25m
Turbid waters, such as found in the Baltic, Caspian Sea, Black Sea, inland lakes and close to river estuaries	5-10m
Very turbid waters, such as found in estuaries, rivers and inland lakes	0-5m

What is included in an EOMAP SDB delivery?

EOMAP's SDB deliveries include the following data:

- SDB data, stored in a geo-referenced raster format (GeoTIFF) and as ASCII XYZ file
- SDB metadata, in an INSPIRE-compatible XLS file. Metadata include all relevant information on data source, resolution, data capture, tidal correction, units, contact points, etc
- SDB map

EOMAP is flexible in including additional formats, such as KMZ files for Google Earth, SD files for the Fledermaus software or any other format required.

EOMAP's advances in technology

It'll be briefly described what's EOMAP can offer as innovative solution and advances in technology.

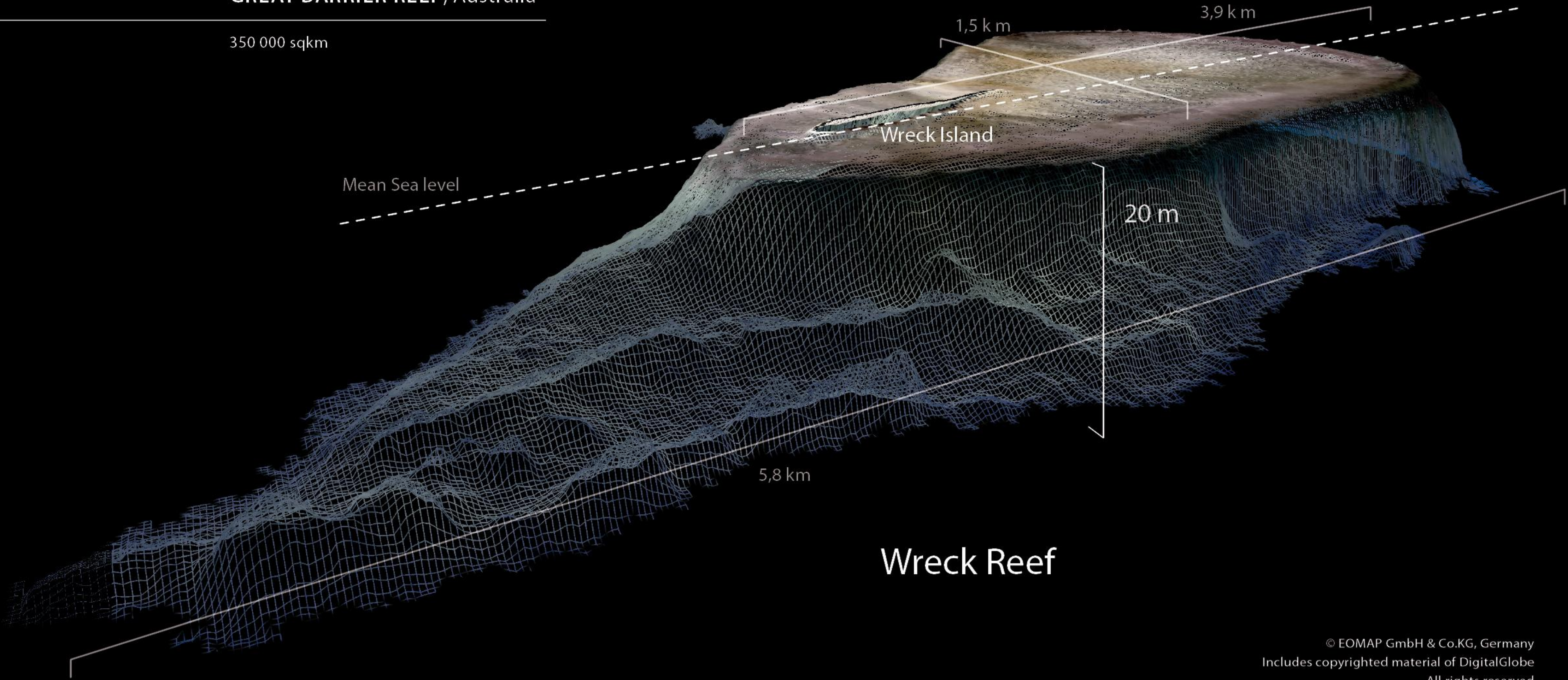
Advances in technology	Description
Operational processing system	EOMAP's EWS system handles all the different algorithm modules, which guarantees a most operational and standardised processing of SDB products.
Proven project record	EOMAP has provided SDB services to clients, including Oil&Gas, Environmental Agencies and hydrographic offices.
More than 15 years of SDB experience	Since the early 1990ties EOMAP's algorithms have been improved and been used for SDB processing
Off-The-Shelf production, currently covering approx. 500,000 sq km	Since 2013, EOMAP has started the Off-The-Shelf production of bathymetric data in 15m spatial resolution of huge shallow water areas. The recent coverage includes the Arabian Gulf, Red Sea, Great-Barrier Reef, Caribbean, and other selected regions.
Advances in technology: Adjacency correction	The effect of the adjacent land areas, affecting the spectral signal of the water surface is known as adjacency effect. EOMAP is currently the only company which can offer the correction of this effect. Without this correction, the near coastal areas are known to be mapped as too shallow.
Advances in technology: Atmospheric correction	EOMAP hold a unique method to correct for atmospheric effects. The system includes a pixel-wise atmospheric correction, which is combined with the retrieval of optical water constituencies. It takes the bi-directional effects of the water and its surface into account.
Highly educated staff, with proven SDB project experience	EOMAP's SDB stuff deals with SDB and relevant topics in their day to day work. All of the staff has proven project experience and holds either a Masters or PhD degree in natural science.
Standardised products	The delivered products are processed within a most standardised way. Each deliverable comes with INSPIRE conform metadata (XML) and common standards of geodata storage and handling are done.

GREAT BARRIER REEF BATHYMETRY

Very high (2m) resolution mapping of bathymetry and seafloor

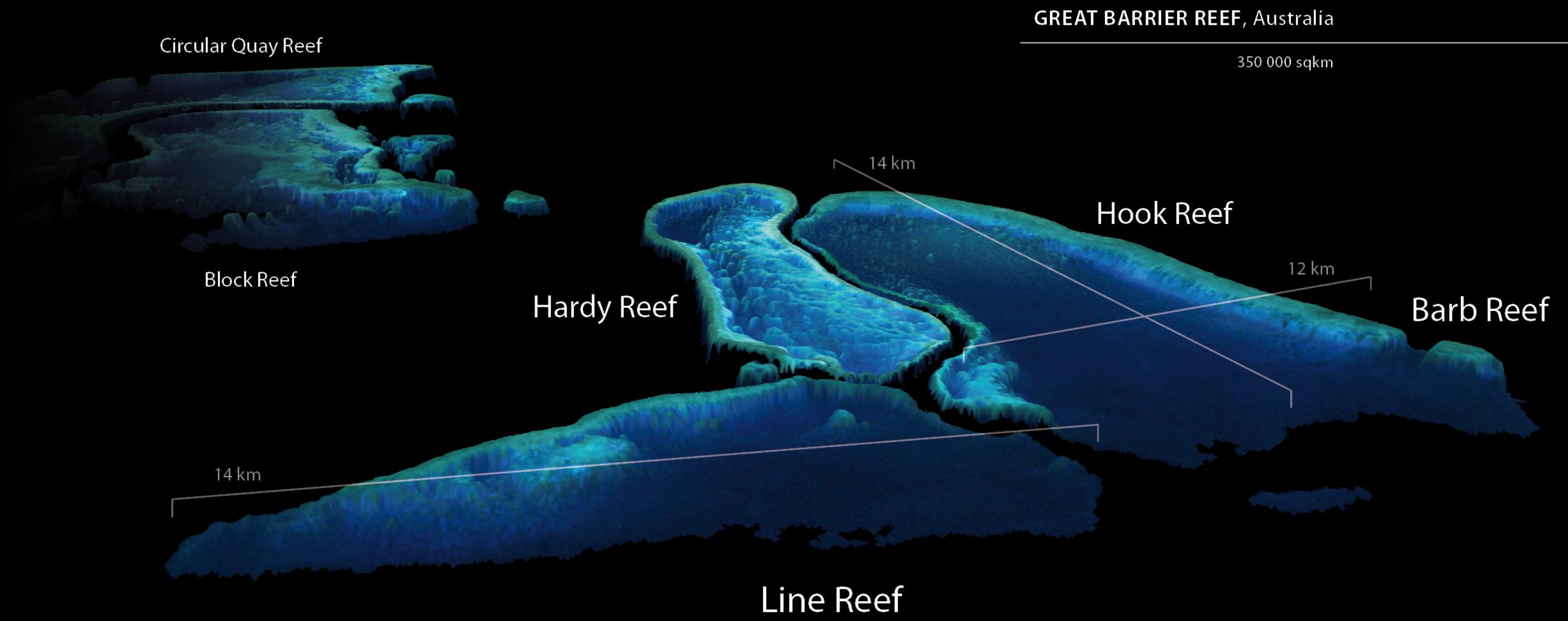
GREAT BARRIER REEF, Australia

350 000 sqkm



GREAT BARRIER REEF BATHYMETRY

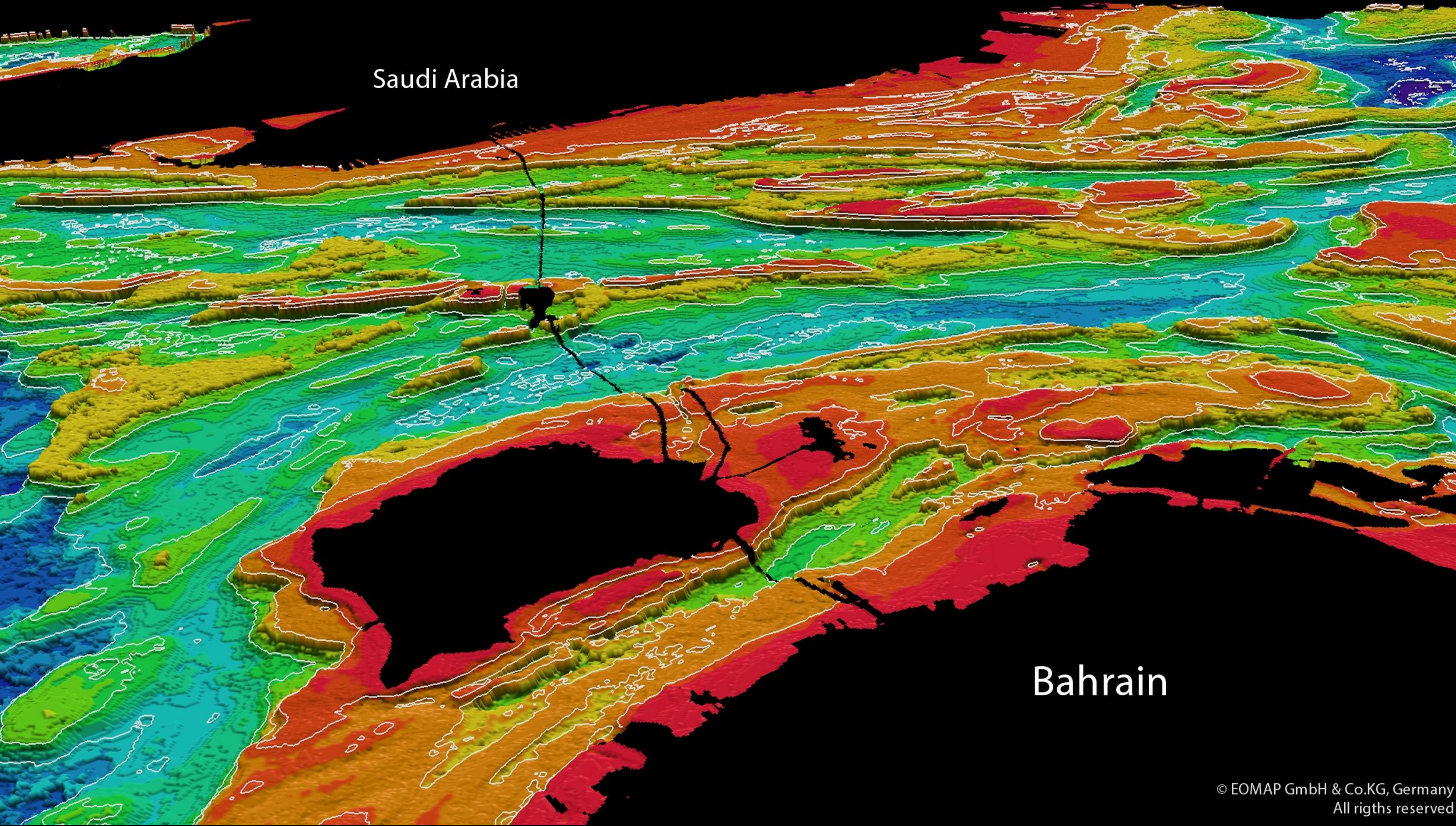
First high resolution map of the entire reef from the world's biggest high resolution satellite bathymetry survey



Satellite Data Source: USGS Landsat

Off-the-shelf bathymetry archive

Arabian Gulf, Australia, Caribbean, ...



RIVIERA MAYA, Mexico

High-resolution Bathymetry and Seafloor survey