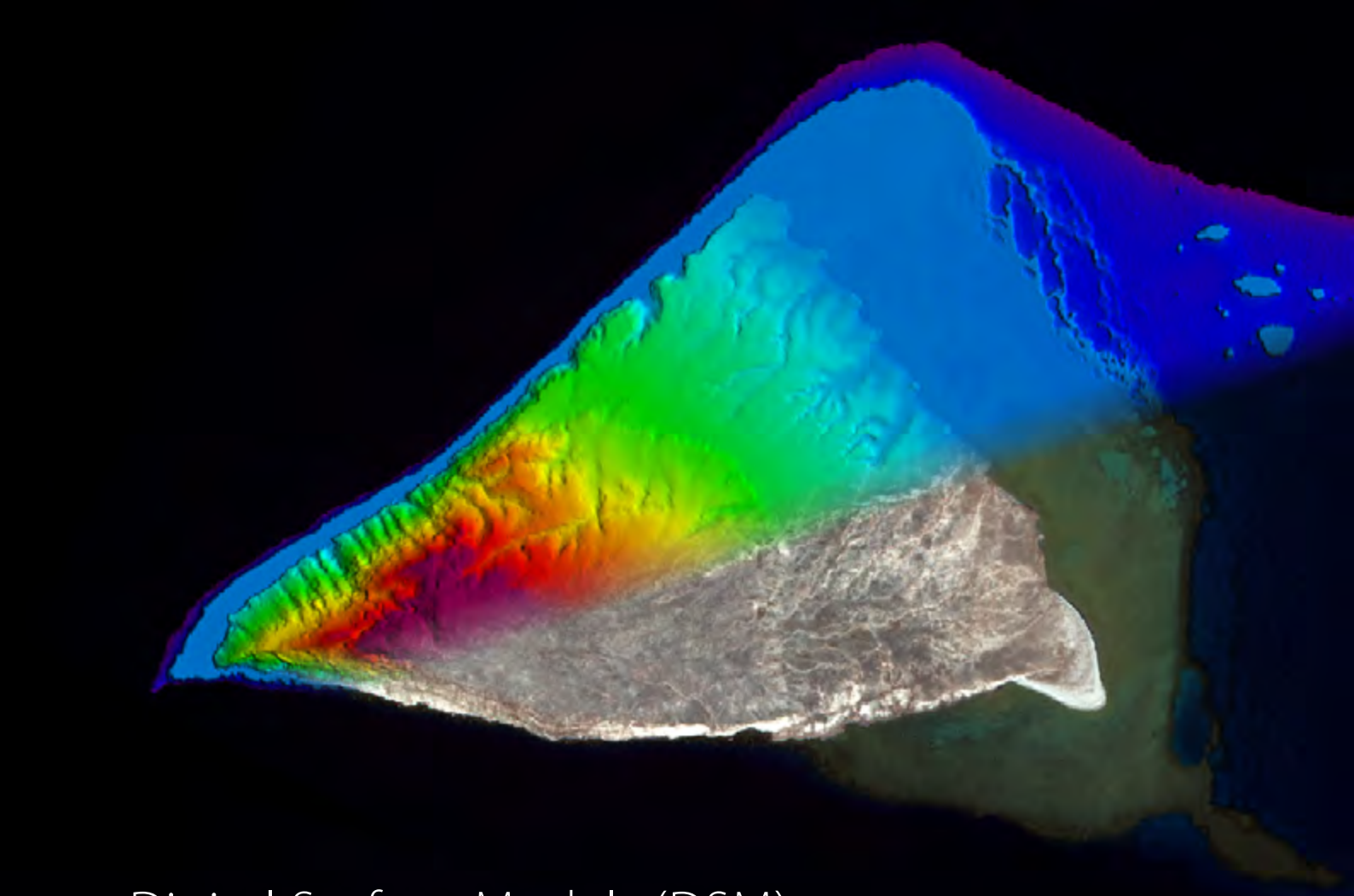

Digital Surface Models (DSM) and Digital Terrain Models (DTM)
Technical Deep Dive

This paper describes EOMAP's methodology for deriving Digital Elevation Models from satellite data.
In addition, it includes details on the resolutions we provide, how we calibrate the models and which satellite sensors we use.

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Content

What are Digital Surface and Terrain Models?

A Digital Elevation Model (DEM) is a digital representation of the Earth's surface. DEM can be split into two different categories Digital Surface (DSM) and Digital Terrain (DTM) models. A DSM is a digital representation of the Earth's surface that includes man-made (buildings, bridges, roads) and natural objects (forests or any other type of vegetation) visible on the surface of the ground. A DTM is a digital representation of the bare ground surface without man-made or natural objects (buildings, vegetation), with a focus on the topography of a specific area. DSM are used for many applications such as urban planning and 3D modelling, Line-of-sight analysis, telecommunications (antenna placements) and vegetation and canopy studies. Likewise, DTM data also finds many applications, such as hydrological modelling, earthwork and construction planning, geology and landform analysis and flood risk assessment.

Remote Sensing - the technology behind

EOMAP provides digital elevation data (DSM and DTM) at very high resolution down to 1-2 m grid size. The approach is based on stereo satellite data which have been recorded with different viewing geometries (Figure 1). Depending on the local environmental conditions, convergence angles (also called stereo angle) between 15-40° are considered suitable. Pre-processing and stereo processing are fully automatised.

Steps that images go through during stereo processing

Aligning process. Using automatically generated tie-points and filtered if required to reduce artefacts in noisy images.

Correlation process. To find matches for every pixel in the two images. This is a computation-intensive process, which makes use of a pyramid approach to reduce runtime at the cost of resolution. EOMAP uses a modified version (Beyer et al. 20181) of the popular Semi-Global Matching (SGM) approach (Hirschmüller 20082) developed at the German Aerospace Center (DLR). The generated disparity image is then refined on the subpixel level. Those two steps are iterated in case the number of matches found during correlation is insufficient.

Triangulation process. Once the correlated pixels are defined, the 3D location is computed in the triangulation step considering the camera specifications.

Remote Sensing - the technology behind

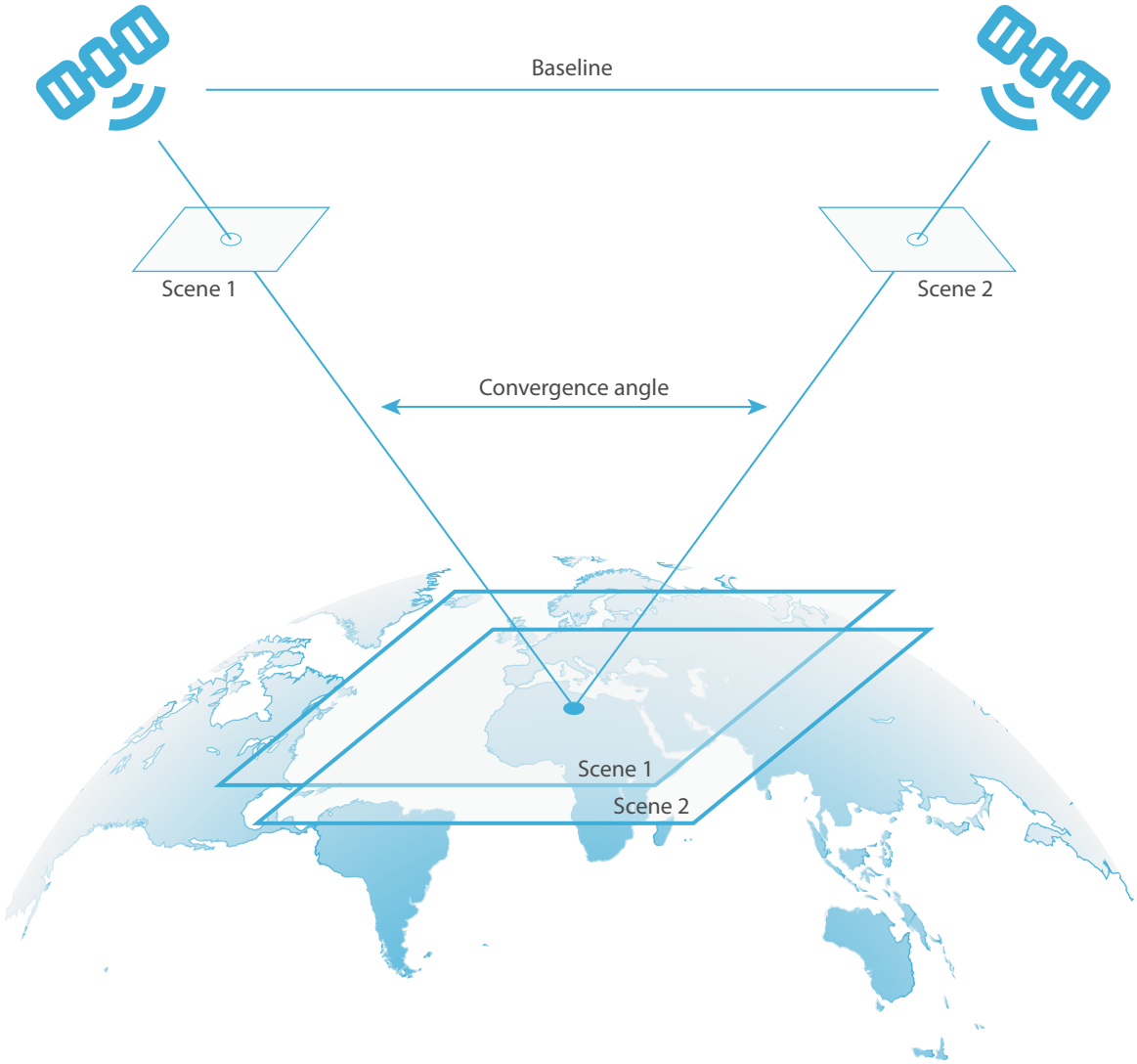


Figure 1: Stereo photogrammetric approach

The point cloud resulting from triangulation is rasterised and inspected for the ray intersection error and unhandled artefacts. If quality control is passed, the elevation raster is postprocessed and adapted to user requirements (e.g. correction to custom datum and/or calibration using GCPs). This process permits us to improve the vertical and horizontal accuracy of the products reaching a vertical linear error <= 1m in 90% of the measurements (LE90) and a circular error <= 1.5m in 90% of the measurements (CE90).

EOMAP uses Satellite Lidar data from ICESat-2 ATLAS to calibrate the Digital Surface Models and derive Digital Terrain Models (bare surface models) by Machine Learning techniques.

Satellite Data Sources

The data sources are very high resolution satellite data from commercial service providers, which does come with additional data costs.

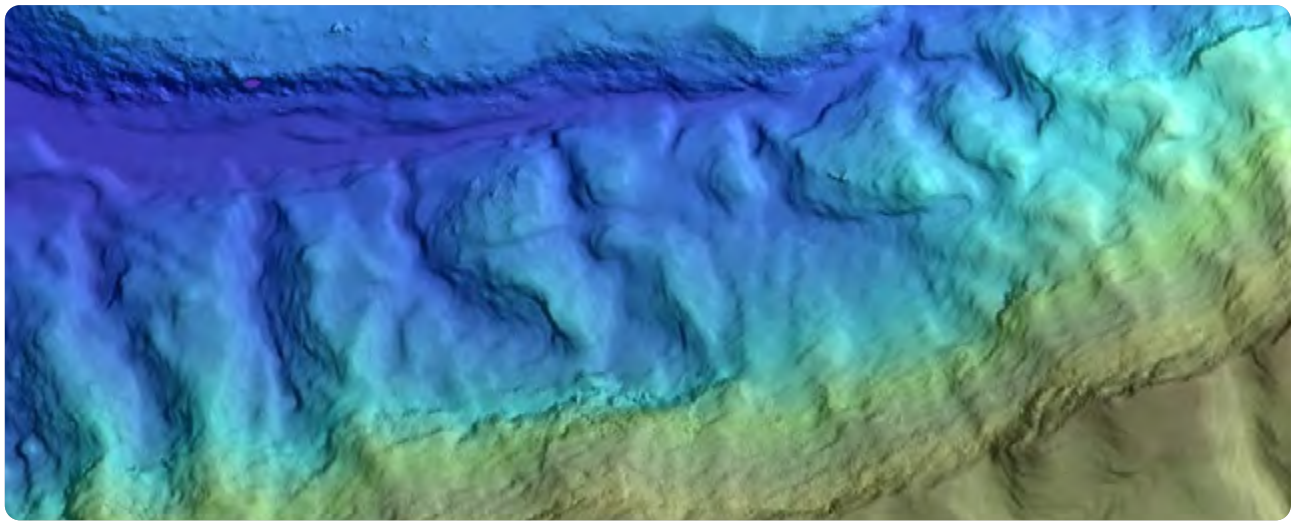
Please contact us to discuss the most appropriate set of satellite sensors for your needs.

Satellite / Sensor	Derived Spatial Resolution of DSM/DTM	Temporal Resolution	Start and End Date	Data Source
Maxar WorldView 1/2/3/4	1m	upon request	2009 - now	Commercial
Pleiades 1 A/B	1m	upon request	2012 - now	Commercial
Pleiades Neo 3, 4	1m	upon request	2021- now	Commercial
SPOT 5/6	5m	upon request	2021 - now	Commercial

Table 1: Overview of commonly used satellite sensors with temporal and spatial specifications

Use Cases

EOMAP has provided DTM and DSM to different clients worldwide such as engineering firms, research institutes and consultancy firms. Due to confidentiality agreements and client privacy EOMAP is not at liberty to disclose the clients and the location of the projects.



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