

SDB Production Suite: Technical User & Developer Manual

Version 1.0.2 | QGIS Plugin ID 4946

1. Introduction & Theoretical Foundations

1.1 Satellite-Derived Bathymetry (SDB) Physics

Satellite-Derived Bathymetry relies on the selective attenuation of light in the water column across different wavelengths of the electromagnetic spectrum. As solar radiation penetrates the water surface:

- Short wavelengths (Blue, ~490 nm) penetrate deepest in clear coastal waters.
- Medium wavelengths (Green, ~560 nm) attenuate at moderate depths.
- Long wavelengths (Red, ~665 nm & NIR, ~842 nm) are rapidly absorbed within the top 1 to 2 meters of the water column.

By modeling the exponential decay of bottom-reflected radiance as a function of depth, statistical machine learning models (such as Random Forest regression) map non-linear relationships between multi-band surface reflectances (r_{how}) and surveyed target depths.

1.2 Atmospheric & Glint Correction via ACOLITE

To derive accurate seafloor depths, raw Sentinel-2 Top-Of-Atmosphere (TOA) imagery must undergo atmospheric correction to isolate water-leaving radiance (r_{how}). The **ACOLITE** processor (developed by RBINS) applies Dark Spectrum Fitting (DSF) or Rayleigh glint corrections to remove:

1. Atmospheric aerosol and molecular scattering.
2. Sun glint reflections from surface waves.
3. Sky radiance reflected off the water-air interface.

Outputs from ACOLITE (specifically Level-2R reflectance bands and turbidity indices like `TUR_Nechad`) serve as primary inputs for the SDB Production Suite.

2. Installation & System Requirements

2.1 Supported Environments

- **QGIS Version:** 3.44 to 4.5
- **Operating Systems:** Windows 10/11, macOS, Linux

2.2 Installing Dependencies

Ensure the required scientific Python stack is installed in your QGIS environment:

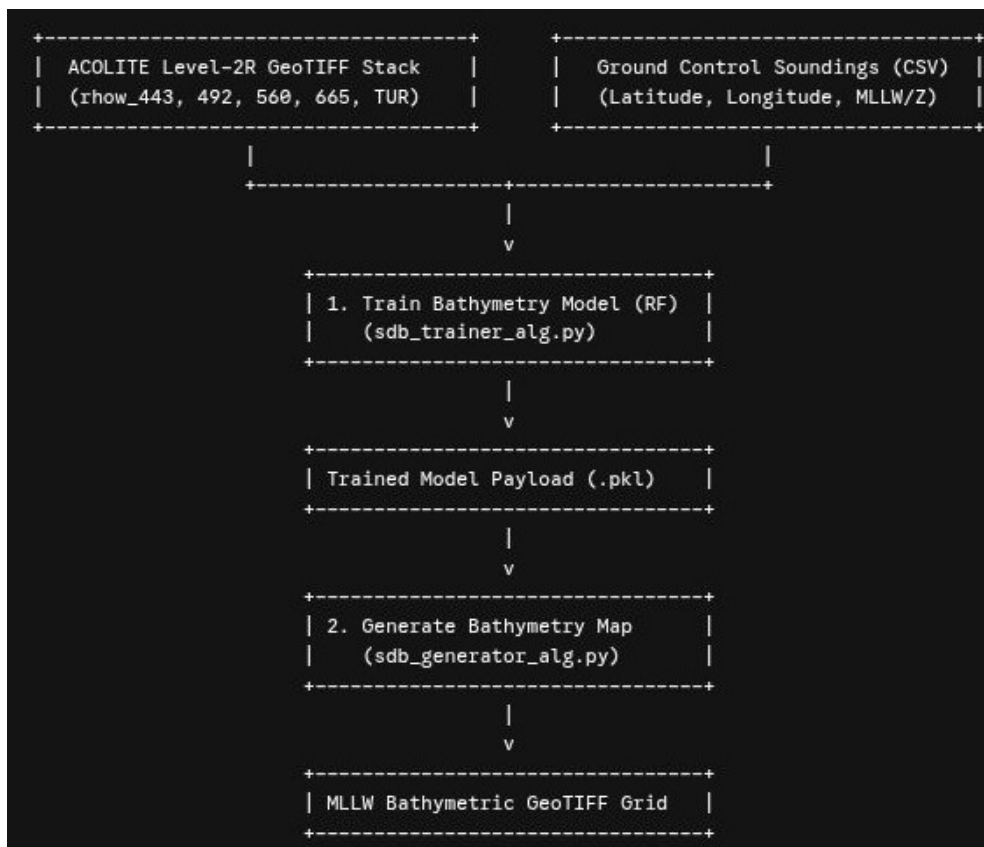
Windows (OSGeo4W Shell as Administrator):

```
pip install scikit-learn joblib rasterio pandas
```

Linux / macOS Terminal:

```
qgis-python -m pip install scikit-learn joblib rasterio pandas
```

3. Step-by-Step Processing Workflow



Step 1: Training the Random Forest Model

1. Open QGIS and locate **SDB Suite** in the Processing Toolbox.
2. Double-click **1. Train Bathymetry Model (RF)**.
3. Configure the input parameters:
 - **Input Control Soundings CSV:** Path to your ground-truth CSV file.
 - **Min Depth / Max Depth:** Define the valid depth band (e.g., 0.5m to 20.0m).
 - **Save Model (.pkl):** Specify output file path for the trained model artifact.
4. Click **Run**. Review the Out-of-Bag (OOB) validation metrics (R^2 , RMSE, MAE, Bias) in the processing log.

Step 2: Generating the Bathymetry Raster Grid

1. Double-click **2. Generate Bathymetry Map**.
2. Configure parameters:
 - **Satellite Multi-band TIF:** Select the ACOLITE L2R surface reflectance stack.
 - **Model File (.pkl):** Select the model file generated in Step 1.
 - **Band Index Mappings:** Set the correct band positions for 443nm, 492nm, 560nm, 665nm, and TUR.
 - **Depth Stretch & Bias Correction:** Adjust vertical calibration factors if necessary (default: Stretch 1.0, Bias -0.14m).
 - **Final Bathymetry Raster:** Specify output path for the GeoTIFF raster.
3. Click **Run**. The output grid will be generated using low-memory chunked processing and loaded onto the QGIS canvas.

4. Hydrographic Quality Assurance & IHO S-44 Evaluation

Model accuracy is evaluated using Out-of-Bag (OOB) cross-validation against ground-truth soundings.

4.1 Evaluation Metrics Summary

- **OOB R^2 (Coefficient of Determination):** Quantifies spectral model fit. Values > 0.85 indicate strong correlation across shallow zones.
- **OOB RMSE (Root Mean Square Error):** Measures absolute vertical accuracy in meters.
- **Vertical Bias:** Identifies systematic offsets (positive values indicate deep prediction bias; negative values indicate shallow bias).

4.2 IHO Precision Classification Thresholds

The plugin formats feedback logs based on Total Vertical Uncertainty (TVU) ratios across target depths:

Error Ratio (RMSE / Max Depth)	Classification Label	Survey Suitability
< 5%	Elite / Survey Grade	IHO Order 1b Candidate
5% - 10%	High Precision	IHO Order 2 Candidate
10% - 20%	Moderate / Acceptable	Coastal Reconnaissance / Planning
> 20%	Low Precision	Requires ACOLITE Re-processing or Masking

5. Developer Governance & Open Source Compliance

5.1 GPL-2.0-or-later Licensing

The SDB Production Suite is fully copyleft-compliant under the GNU General Public License v2.0 or later. All source code is un-obfuscated and publicly inspectable.

5.2 Human-in-the-Loop Development Statement

In alignment with open-source project standards and community guidelines (such as QEP 428):

- All codebase logic, PyQGIS execution paths, GDAL raster routines, and UI connections have undergone direct human developer profiling and auditing.
- Depth calculations are governed strictly by deterministic machine learning and physical band-ratio algorithms.