Multibeam Echosounder Errors Characterization on Dumped Rocks Areas

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OUTLINES:

- Introduction
- Datasets description
- Data quality control
- Comparison results
- Conclusion
**Comparison results**

**Introduction**

**Datasets description**

**Data quality control**

**Comparison results**

**Conclusion**

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**Investigation of systematic depth error made in surveying dumped rocks areas with MBES**

**Boskalis observation:**

filling up the hole between rocks with concrete was ten centimeter higher than the expected results from the dumped rock survey

**These errors may induce:**

- Dangers for navigation in very shallow water areas
- Huge costs for coastal engineering contractors who performs rock dumping operation

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**Analysis of four different MBES systems**

Comparison to a reference digital terrain model obtained from a fixed 3D laser scanner
**MBES survey systems**

- SIMRAD EM3002
- Reson 8101
- Sonic 2024
- Tritech Horizon

<table>
<thead>
<tr>
<th>Swath line</th>
<th>Sounding number</th>
<th>Mean density (number of soundings per meter square)</th>
<th>Swath number</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM3002</td>
<td>2 060 137</td>
<td>1 290</td>
<td>3</td>
</tr>
<tr>
<td>Reson 8101</td>
<td>1 279 735</td>
<td>493</td>
<td>4</td>
</tr>
<tr>
<td>Horizon</td>
<td>5 684 552</td>
<td>3 337</td>
<td>12</td>
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<tr>
<td>R2sonic</td>
<td>1 549 953</td>
<td>634</td>
<td>2</td>
</tr>
<tr>
<td>Scanner 3D</td>
<td>685 745</td>
<td>448</td>
<td>-</td>
</tr>
</tbody>
</table>

Leica HDS6100 Laser installed on the quay in front of the rocky area.
Depth uncertainty estimation

MBES swathes versus Laser Scanner DTM on the beach

Laser scanner reference DTM
Depth uncertainty estimation

MBES performances results

Depth uncertainties at the 95% confidence level

Normalized histograms of the residual values

Beam angles

Residual values
Tests were carried out on a concrete beam

A straight line was fitted to the laser soundings belonging to this front using a least square procedure

X and Y distances between nadir beam MBES soundings and the reference line were then computed

Statistics based on 9 datasets

Mean values: \( (\Delta x, \Delta y) = (-2.2\text{cm}, -0.7\text{cm}) \)

Standard deviations: \( (\sigma_{\Delta x}, \sigma_{\Delta y}) = (2.8\text{cm}, 0.9\text{cm}) \)
MBES sounding datasets compared to the laser scanner reference DTM: EM3002 example

The tendency is the same **whatever the swath**: Compared to the histogram obtained on the beach area, the distribution of the residual values is **asymmetric**. Positive residual values are in large number meaning that **MBES soundings are deeper** than the scanner laser DTM.
MBES sounding datasets compared to the laser scanner reference DTM

The tendency is the same *whatever the sensor*:

- **Asymmetric distributions**, more or less noticeable depending on the echosounder
- The positive residual values can reach **70%**
DTM impact on the seabed analysis

DTM were built from each MBES dataset using a grid cell size of 5cm.

Differences between each of the MBES DTM and the laser scanner reference DTM were computed measuring the interpolator impact.
Impact of the grid cell size on the DTM analysis

Normalized histograms of the residual values – EM3002 swathes
Differences between MBES soundings and the scanner laser DTM

Whatever the sensor and the swath:

High residual values are grouped in aggregates

These aggregates are located around the rocks

Most of the higher residual values affects the outer beams, on the upper part of the slope
Local analysis

Aggregates of high residual values may be explained by the lack of scanner laser soundings.
Nevertheless, rocks description differs from one MBES to others.

Profile across the rock:
Local analysis

3D representation of the TIN built from the Scanner laser soundings

Profile across the rock:
- EM3002 soundings
- Laser scanner soundings
Laser scanner 3D dataset acquired from one point of view: cavities between are not described

Multiple returns, side lobe detections or time window filtering may explain high residual values near cavities
CONCLUSIONS:

- Boskalis observation are confirmed.

- Analysis has to be carried on:
  - With the acquisition of a second laser scanner dataset acquired from a different point of view.
  - With the analysis of raw data MBES (Tritech Horizon).

- Results in terms of rocks normalized diameter:
  - $D_{n50} = 120\text{mm}$, Error = $0.9 \times D_{n50}$
  - $D_{n50} = 1002\text{mm}$, Error = $0.2 \times D_{n50}$