SEA BOTTOM CLASSIFICATION BY MEANS OF BATHYMETRIC LIDAR DATA

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1. AIRBORNE BATHYMETRIC LIDAR (ABL)

Airborne Laser Topographic Mapping (ALTM)

© http://ihrc.fiu.edu/loc/research/airborne_laser_mapping/

Airborne Bathymetric Laser Mapping (ALBM)

© Admiralty Coastal Surveys AB

2. STUDY AREA

PARTNERS:
SGPM (Ministry of Agriculture) - Contractor
INTA (Aerospace Institute of Spain) - Project Management
ETSITGC/UPM (Polytechnic University of Madrid) - Coastal Surveys

Flight Surveys and LIDAR data acquisition:
BLOM AEROFILMS - Hawk Eye MK II LIDAR, operating modes: infrared (1.064 nm) for topographic information, and green (532 nm) mode registering hydrographic information in shallow waters domain.
3. COASTAL SURVEYS

3.1. WATER TURBIDITY MEASUREMENTS

3.2. GEODE蒂C SURVEYS

3.3. GEODE蒂C QUALITY CONTROL

3.4. HYDROGRAPHIC QUALITY CONTROL

3.1. TURBIDITY MEASUREMENTS

Secchi disk at different depths

04-05 April, 2008
Max. 21 m

27-28 April, 2008
Max. 22 m

21-22 May, 2008
Max. 22 m
3.3. GEODETIC QUALITY CONTROL

High precision multibeam device Elac Hydrostar 4300

3.4. BATHYMETRIC/DEPTH QUALITY CONTROL
4. DERIVED PRODUCTS

RANGE DATA (PULSES) + POSITIONING + INERTIAL OBSERVATIONS

LIDAR PROCESSING

TOPO-BATHYMETRIC MAPS

4. DERIVED PRODUCTS

TOPOGRAPHY | BATHYMETRY | TOPO-BATHYMETRY

TOPOGRAPHY

BATHYMETRY

TOPO-BATHYMETRY

Legend:
- 0 m
- 15 m
- 30 m

Scale:
- 0 km
- 2.5 km
- 5 km
4. DERIVED PRODUCTS
4. DERIVED PRODUCTS

4. DERIVED PRODUCTS. THEMATIC DOCUMENTS

- RANGE DATA (PULSES) + POSITIONING + INERTIAL OBSERVATIONS
- LIDAR PROCESSING
- TOPO-BATHYMETRIC MAPS
- THEMATIC LAYERS
4. DERIVED PRODUCTS. THEMATIC DOCUMENTS

5. SEA BOTTOM CLASSIFICATION

- RANGE DATA (PULSES) ↔ PULSE INTENSITY
- TOPO-BATHYMETRIC MAPS
- THEMATIC MAPS
5. SEA BOTTOM CLASSIFICATION

\[
P_R = \frac{P_T \cdot N \cdot \rho \cdot F \cdot A \cdot \cos^2 \theta}{\pi \cdot (n \cdot H + D)} e^{(-2 \cdot \Lambda \cdot \kappa \cdot D \cdot \sec \varphi)}
\]

**\( P_T \)**: transmited Power  
**\( N \)**: losses due to transmitter/receiver optical combination  
**\( \rho \)**: bottom reflectance  
**\( F \)**: loss due to insufficient FOV  
**\( A \)**: spot size of the receiver on air-water interface  
**\( \theta \)**: lidar nadir angle  
**\( n \)**: index of refraction of water  
**\( H \)**: altitude of LIDAR above water  

**\( D \)**: water depth  
**\( \Lambda \)**: water suppression on signal due to temporal disperssion  
**\( \kappa \)**: attenuation coefficient of water  
**\( \varphi \)**: lidar nadir angle after entering the water

*C.K. Wang & W.D. Philpot (2002)*
5. SEA BOTTOM CLASSIFICATION

- The laser pulse transmitted from the LIDAR system through the water column and reflected by the bottom surface back to the sensor, is exponentially attenuated with depth. Since complementary factors are correctly maintained and loss terms properly controlled, Wang & Philpot (2007) consider the use of the following physical expression in order to describe this process:

\[ P_R = P_T \cdot W \cdot \rho \cdot e^{-2\kappa \cdot D} \]

- Where \( P_R \) is the returned power, \( P_T \) is the transmitted power, \( W \) combine all loss factors of the system and is considered constant, \( \rho \) is the benthic reflectance, \( k_{sys} \) the water specific attenuation, and \( D \) the bottom depth. Applying a natural log to the previous expression, yields an equation that is linear in depth:

\[ \ln(P_R) = \ln(P_T \cdot W \cdot \rho) - 2\kappa \cdot D \]

- Considering as a constant term: \( \ln(P_T W \rho) \)

- The natural log of the received power is a lineal function of the system attenuation length. For a specific area where this coefficient is also constant, benthic types with different reflectances will describe parallel lines in a graphic, whose Cartesian axes are \( \ln(P_R) \) and \( D \). Therefore, the ability to detect bottom material changes will depend on the accuracy depth estimate and the uncertainty in the system attenuation coefficient (Wang & Philpot, 2007).
5. SEA BOTTOM CLASSIFICATION

- Identification of Clusters and assignment of benthic categories

5. SEA BOTTOM CLASS. - CLUSTERING EXAMPLE, ‘SAND’
5. SEA BOTTOM CLASS. - CLUSTERING EXAMPLE, ‘VEGETATION’

INCREASING DEPTH

Veg.1 (dense)  Veg.3 (sparse)  Veg.5 (sparse)

5. SEA BOTTOM CLASSIFICATION. FINAL CLUSTERING RESULT

INCREASING DEPTH
5. SEA BOTTOM CLASSIFICATION. RESULTS (VALIDATION)

MATERIALS:

ESPACE (1999-2007)

ESTUDIO DE LA PLATAFORMA CONTINENTAL ESPAÑOLA
©Instituto Español de Oceanografía (IEO)
©Secretaría General de Pesca Marítima (SGPM)

Hydrographic, Geologic, Geophysical, Benthic information, from 10 to 180 m depth of the continental shelf.

http://www.ieo.es/ESPACE/descripcion_ESPACE.htm

POSIDONIA (dense) POSIDONIA (sparse)
5. SEA BOTTOM CLASSIFICATION. RESULTS (VALIDATION)

6. CONCLUSIONS

1. ABL has proven to be a suitable technique for mapping shallow waters.

2. In addition to bathymetric information, other derived thematic information could be extracted.

3. Need for in-situ benthic surveys for a complete validation.

4. Analysis of different variables and parameters of the general equation, that have been considered constant in this initial research.

5. This previous research allows to advance in additional clustering methodologies.
THANK YOU FOR ATTENTION

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