USING A MULTI-BEAM AUTONOMOUS PORTABLE LASER EQUIPEMENT TO STUDY OPTICAL BEHAVIORS IN SHALLOW WATERS

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In recent years, Airborne Laser Bathymetry (ALB) has proven to be a timely and costly effective method for surveying extensive coastal regions. Along with gathering precise topographic and bathymetric data, ALB systems are now being considered for small target detection, water column characterization, sediment budget evaluation, and nearshore environmental classification. In fact, various environmental features can be classified by correlating the returning laser signal intensities of the ALB systems to the reflectance of specimens sampled on the field. Currently, ALB systems can identify a few marine facies including: bedrock, algae communities, different types of unconsolidated sediments, and the morphology of basic sedimentary structures [1]. However, since simultaneous ground and air sampling is impossible, only limited precision can be achieved between field and flight data.

To solve this problem, a Multi-beam Autonomous Portable Laser Equipment (MAPLE) simulating functions of ALB systems has been developed. MAPLE emits two continuous laser beams of different wavelengths: an infrared signal of 1064 nm and a green signal of 532 nm. This system mounts on a sliding tripod support capable of achieving a maximum height of four meters. MAPLE’s optoelectronic module is enclosed into a splashproof stainless steel casing which comprises a Campbell Scientific CR1000 datalogger. In addition to recording both laser beams departure and return signals, the CR1000 also records the distance between the laser sources and the specimen, the system’s internal and external temperatures, and the system’s inclination. MAPLE’s low power requirement of 12V makes it transportable and autonomous to allow for the execution of controlled and semi-controlled tests in laboratory and field settings. The intensity difference between output and input signals of one laser beam provides information about the reflectance of a specimen’s surface. The calibration equations of the external variables such as the system’s internal temperature, the distance between the laser sources and the specimen, and the incident angle of the laser beam, were determined. From these equations, a program was developed such that the influence of these external variables on MAPLE’s reflectance measurement could be removed; only leaving the reflectance resulting from the physical properties of the specimen’s surface.

Learning more about the interaction between light and underwater environmental features is essential in order to improve the precision of ALB systems depth measurements and seafloor classifications. MAPLE was used to study how underwater specimens reflect light as a function of their mineral composition, pigmentation, porosity, water content, and more. Experiments concerning the attenuation of a light beam through a turbid water column, Lambertian theory of natural surfaces, optical signatures in heterogeneous environments, bioturbation levels and mud densities in wetland areas, near bottom turbidity layers, and seafloor sedimentary features were also accomplished. Interesting results were obtained such as a strong relationship between reflectance and grain size of unconsolidated sediments. In fact, as porosity decreases with grain size, light is better reflected. However when a critical grain size value of less than 63 um is reached, a decrease in signal is observed. Another non linear function was observed between the returned light intensity and the concentration of suspended clastic particles in the water column. As the concentration increases, a steady decrease of the returned signal is observed. However, when a critical value is reached, backscattered light becomes more important and an increase in the returning signal is observed. Also, experiment on the Lambertian properties of seafloor surfaces demonstrated that from fine sand to gravel, the slope steepness of the function between reflectance and the laser beam incident angle changes by a factor of 40[2].

Multi-sensor fusion methods combining MAPLE to other types of specialized equipment such as a CT-scan were performed. The CT-scan was simultaneously operated with a hydraulic flume to reproduce turbidity currents. MAPLE was able to characterize reflectance variations caused by changes in density and composition of turbidity layers [3].

The new algorithms developed from MAPLE's optical measurement of natural specimens will increase the versatility and performance of ALB systems. This new tool really fills a gap between remote sensing technology and ground calibration.

REFERENCES

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