A UAV-RTK-Lidar system measurements of wave energy dissipation over a sandy beach and an algal-reef area

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INTORDUCTION

Wave energy dissipation is a significant factor affecting coastal hydrodynamics, coastline morphology, wave height transformation, and the nutrient uptake in the coral reef (Huang, Lenain et al. 2012). However, it is difficult to be measured since accurate and spatial-distributed measurements of sea surface elevations are required to compute this quantity. We used a UAV-RTK-Lidar system (Figure 1) to test the possibility for the measurements of wave energy dissipation. The UAV system was validated to able to measure the ocean wave properties (Huang, Yeh et al. 2018).

METHODOLOGY

Two field experiments of measuring energy dissipation were conducted over an algal-reef and a sandy beach site, respectively. Nine and eight flights of UAV measurements on the algal reef and sandy beach were conducted for one tidal cycle. The measurements of wave properties by UAV were compared with those of in-situ instruments using pressure sensors. The Root Mean Square errors for measurements of water depth and significant wave height (Hs) between the two techniques are 3 cm and 9 cm over the algal reef and are 4 cm and 9 cm over the sandy beach, respectively. Figure 2 shows the comparisons of water depth and Hs from the measurements of pressure sensors (dark and grey lines) and the UAV system (circle).

The wave energy dissipation D is calculated from the difference of the energy flux dF over the distance dx of two locations and the wave direction θ, which are

$$D = \frac{-dF}{dx \cdot cos\,\theta}. \qquad (1)$$

We also used the UAV system to observe the bottom roughness of the two sites for the parameterization of frictional dissipation. Then, we calculate the percentage of the dissipation caused by the bottom friction.

RESULTS

The UAV system measured two locations in one flight. W1 is the outer location, and W2 is the inner one. Figure 3 shows the measurements of UAV over the algal-reef site. Panel (a) to (e) are the plotting of water depth, energy flux, wave direction, energy dissipation, and the breaking index, respectively. The error of energy flux and energy dissipation is considered. We observed that the wave energy dissipation is within 5 Wm^{-1} and 15 Wm^{-1} over the algal reef and the sandy beach, respectively. The results of parametrization show that more than 70% of the total energy dissipation is attributed to the bottom friction on the algal reef, while that is only 42% on the sandy beach. From the results over the two sites, the UAV-RTK-Lidar system provides the potential to measure the wave energy dissipation.

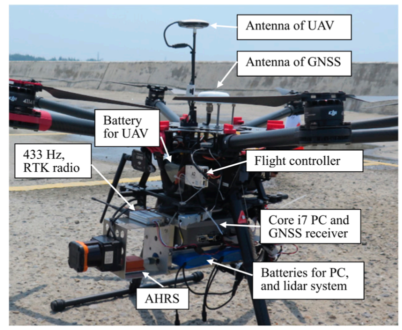

Figure 1 - The UAV-RTK-Lidar system

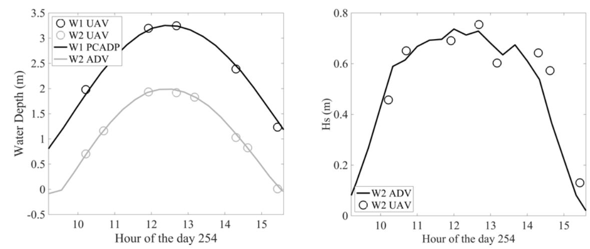

Figure 2 - The comparisons of water depth and significant wave height from two techniques

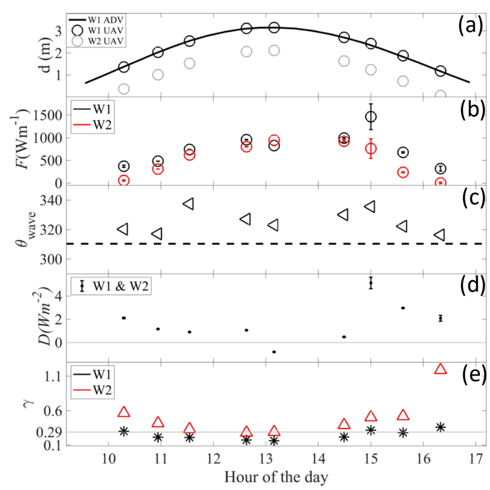

Figure 3 - The results of UAV-measured wave energy dissipation over the algal-reef site

REFERENCES

Huang, Z.-C., L. Lenain, W. K. Melville, J. H. Middleton, B. Reineman, N. Statom and R. M. McCabe (2012). "Dissipation of wave energy and turbulence in a shallow coral reef lagoon." Journal of Geophysical Research: Oceans 117(C3).
Huang, Z. C., C. Y. Yeh, K. H. Tseng and W. Y. Hsu (2018). "A UAV-RTK Lidar System for Wave and Tide Measurements in Coastal Zones." Journal of Atmospheric and Oceanic Technology 35(8): 1557-1570.