# 離岸氣象塔量測資料對海表面粗糙度之數值解析

# On the quantities describing the ocean surface roughness reduced from the offshore met tower data


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## 摘　要


在使用GNSS-R來獲取海面風場資訊時，一項極為重要的物理參數便是由風力所驅動海浪所造成的海表面粗糙度。在考慮從海面散射而來的GNSS訊號功率時(Juang et al，2016)，海浪的均方傾度(mean square slope, MSS)對NBRCS(Normalized bistatic radar cross section)具有關鍵影響。在描述海面粗糙度方面，文獻中常見三種指標：其一是粗糙高度$ks$，用以描述完全粗糙平板紊流邊界層(Clauser, 1956；Schlichting, 1968)，因為所考慮的大氣邊界層可視為此類型之一；其二是粗糙長度$z_0$，此為描述空氣與海洋交互作用現象的經驗公式中常見參數(Charnock, 1955)；第三則是前述的波浪均方斜率MSS。在本研究中，透過在台中港外海氣象塔所同步量測的風與波浪資料，使得這三種粗糙度參數之間得以進行比較。我們利用超音波風速儀取得的風速資料，分析了粗糙高度$ks$與粗糙長度$z_0$在不同風速條件下的相關性。從理論上來看，$ks$與$z_0$兩者應具備關聯性，因為它們皆被用於對數律速度剖面中。同時，結合由氣象塔上波浪儀所得的MSS資料，我們也探討了MSS與$ks$(或$z_0$)之間的相關性；這些參數經由摩擦速度($u^*$)與空氣動黏度($\nu$)無因次化後進行分析。值得一提的是，從本研究波浪資料推算出的MSS值，與CYGNSS任務在距離氣象塔70公里以內觀測地點所報告的數值具有良好的一致性。



本研究由TASA支持(合約編號: TASA-S-1130505)，並致謝永傳能源股份有限公司提供離岸氣象塔為本研究使用。

關鍵字：GNSS-R、海表面粗糙度、均方傾度


## Abstract


In using the GNSS reflectometry method to retrieve the information of wind over an ocean surface, a physical parameter of great importance is the roughness of ocean surface which is due to wind driven waves essentially. In considering the power of GNSS signals scattered from the ocean surface (Juang et al. 2016), the mean square slope of waves on the ocean surface plays a key role affecting the normalized bistatic radar cross section (NBRCS). For characterizing the roughness of ocean surface, in fact they are three ways readily found in the literature, namely, the roughness height ks characterizing a fully-roughened flat-plate turbulent boundary layer (Clauser 1956; Schlichting 1968) since the atmospheric boundary layer under consideration can be regarded as one of this kind, the roughness length zo which is appeared in an empirical relation concerned with the phenomenon of the air-sea interaction (Charnock 1955), and the mean square slope of waves, MSS, mentioned above. In this study, a comparison of the three quantities was

enabled with the wind and wave data obtained simultaneously on an offshore met tower near Taichung Harbor. A correlation between the two quantities of ks and zo was examined over a range of wind speeds based on the data obtained from an ultrasonic anemometer. Theoretically speaking, ks and $z_0$ should be correlated because they are introduced in the respective log-law velocity profiles. Along with the MSS values reduced from the wave gauges on the met tower, a correlation between MSS and ks (or $z_0$), which were non-dimensionalized by the friction velocity (u*) and the kinematic viscosity of air ($\nu$), was examined as well. It is worthwhile to mention that the MSS values reduced from the present wave data were in good agreement with those reported by CYGNSS mission at the locations near the met tower within a distance less than 70 km.

This work is supported by TASA under the contract number: TASA-S-1130505. Acknowledgement should also be given to Taiwan Generations Corp. for the use of the offshore met tower.

Key words: GNSS-R, ocean surface roughness, mean-square slope (MSS)

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