發展適用於印度洋之氣旋風暴潮預報系統
Develop a cyclone storm surge forecast model suitable for the Indian Ocean

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摘　　要

印度洋北方之孟加拉灣地區常遭受熱帶氣旋侵襲。由於當地沿海人口密度高且多為低窪之泥沼地，熱帶氣旋所引起之氣旋風暴潮往往對當地造成嚴重破壞。如1970年發生於孟加拉灣之波拉氣旋（Cyclone Bhola）所引發之氣旋風暴潮，導致近50萬人死亡，為人類史上死亡人數最高之熱帶氣旋。本研究旨於以台灣COMCOT-SS風暴潮預報系統為基礎，發展適用於印度洋之氣旋風暴潮速算系統。由於印度洋之熱帶氣旋，其結構與強度皆有別於太平洋之颱風和大西洋之颶風，因此發展適合印度洋熱帶氣旋之參數化風場與風暴潮模式為本研究之重點。本研究以3個歷史案例（2020年安芬氣旋（Cyclone Amphan）、2014年赫德赫德氣旋（Cyclone Hudhud）以及2013年費林氣旋（Cyclone Phailin）），分析3種不同參數化風場及NCEP大氣模式於氣旋風暴潮生成之準確度。本研究並以Holland（2010）模式做為基礎，透過上述案例之觀測風速及觀測暴潮水位之比對，校正出當參數B=0.742時，其風速、氣旋風暴潮之溢淹範圍及時序潮位高程上與觀測資料有最佳之匹配，而此B值不同於適用於太平洋及大西洋常用之B值，亦代表印度洋之氣旋風場結構有別於太平洋之颱風及大西洋之颶風。文末，以本研究所建立之參數化風場及COMCOT-SS風暴潮模式對全球風暴潮事件最嚴重之1970年Cyclone Bhola進行案例還原，由於該場事件僅有颱風路徑，時序之氣壓資料及風速資料並沒有保存，目前僅知當時之最低氣壓及最高風速，因此在事件還原上，進行大氣壓力優先與風剪力優先等兩種情境進行。在大氣壓力優先之情境下，熱帶氣旋影響範圍較小，純因風暴潮所造成之內陸溢淹範圍涵蓋孟加拉國Barisal以南之Kuakata、Burir Char、Patharghata等沿海地區。而風剪力優先之情境下，熱帶氣旋影響範圍較大，溢淹範圍除涵蓋大氣壓力優先之範圍外更往內陸地區沿伸，其最遠可達孟加拉國Patuakhali。

關鍵字： 印度洋孟加拉灣、氣旋風暴潮、COMCOT-SS、參數化風場、Holland 模式B值

Abstract

The Bay of Bengal in the northern part of the Indian Ocean is often hit by tropical cyclones. Due to the high density of local coastal populations and mostly low-lying muddy land, cyclone storm surges caused by tropical cyclones often cause severe damage to the local area. For example, the cyclone storm surge triggered by Cyclone Bhola in the Bay of Bengal in 1970 caused nearly 500,000 deaths, making it the tropical cyclone with the highest death toll in human history. This research aims to develop a cyclone storm surge calculation system suitable for the Indian Ocean based on Taiwan's COMCOT-SS storm surge forecasting system. Since tropical cyclones in the Indian Ocean are different in structure and intensity from typhoons in the Pacific and hurricanes in the Atlantic, the development of parametric wind fields and storm surge models suitable for tropical cyclones in the Indian Ocean is the focus of this research. This study adopts 3 historical cases (Cyclone Amphan in 2020, Cyclone Hudhud in 2014, and

the 2013 Cyclone Phailin), to analyze the accuracy of 3 parametric wind fields, as well as NCEP atmospheric models in the generation of cyclone storm surges. Based on the Holland (2010) model, this study obtained peakness parameters B=0.742 which performs well in these 3 historical cases by comparing the model results with the observation data. This B value is different from the usual B value applicable to the Pacific and Atlantic oceans. It also indicates that the structure of the cyclone wind field in the Indian Ocean is different from the Pacific ocean's typhoon and the Atlantic ocean's hurricane. At the end of this paper, a case study of Cyclone Bhola in 1970, the most serious storm surge event in the world, is carried out by using the parameterized wind field and COMCOT-SS storm surge model. In this case, only the cyclone track, the minimum pressure, and maximum wind speed are recorded. Therefore, two scenarios, atmospheric pressure prioritize, and wind shear stress prioritize, are used for event reconstruction. In the scenario of atmospheric pressure prioritize, the impact area of the tropical cyclone is relatively small, and the inland overflow caused by storm surge covers Kuakata, Burir Char, Patharghata, and other coastal areas south of Barisal, Bangladesh. However, in the scenario of wind shear stress prioritize, the impact area is relatively large, and the flooding area reaches as far as Patuakhali, Bangladesh. Detailed information can be found in the content.

Keywords: Bay of Bengal, Indian sea、Cyclone storm surge、COMCOT-SS、Parametric wind field, Holland Model B value