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Impacts of Sea Breeze Dynamics on Heat Stress in Coastal African Cities of Durban and Accra

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Abstract

In coastal cities, mesoscale circulations such as sea breezes are often assumed to provide thermal relief; however, their net impact on outdoor thermal comfort remains poorly understood. This study investigates the influence of sea-breeze dynamics on urban heat stress in Durban, South Africa and Accra, Ghana using high-resolution of 500 m Weather Research and Forecasting (WRF) simulations. Model outputs show a very good agreement with observations, capturing the diurnal variability of near-surface meteorological conditions across both cities. Results indicate that sea breezes, driven by land–ocean thermal contrasts, exhibit pronounced diurnal cycles and substantially modify near-surface temperature and moisture fields. During active sea-breeze periods, air temperatures decrease, particularly in the afternoon, with cooling effects extending into the central business districts of both cities. However, this cooling is accompanied by increased relative humidity due to enhanced marine moisture advection. As a result, the Universal Thermal Climate Index (UTCI) increases slightly, indicating elevated human heat stress despite lower air temperatures. The characteristics of sea-breeze events, including onset, intensity, inland penetration, and duration vary considerably between Durban and Accra, influenced by differences in coastal geometry, background synoptic flow, and boundary-layer dynamics. These findings demonstrate that sea breezes can simultaneously mitigate thermal conditions while exacerbating physiological heat stress through humidity effects. This study provides insights into sea breeze–heat stress interactions in African coastal cities and highlights the need for climate-resilient urban planning strategies that account for such competing effects.

Keywords: Sea Breeze, Dynamics, Heat Stress, Coastal, Modelling