GLOMAR

Ph.D. Defence

Michael Kyei Agyekum

Title of the Thesis Colloquium:

Canopy gap dynamics in mangrove forests: exploring global patterns and drivers

19 January 2024 - 10.00 hrs.
ZMT, Fahrenheitstr. 6, large seminar room
and online via Zoom

Canopy gap dynamics in mangrove forests: exploring global patterns and drivers

Mangrove forests are located at the interface between land and sea in tropical and subtropical latitudes. They provide several valuable ecosystem services, including carbon sequestration, habitat for diverse fauna, coastal protection, and serving as a source of fuel and timber for coastal communities. However, the unique location of mangrove forests in a highly dynamic environment, makes them susceptible to disturbances which leads to the formation of canopy gaps. Mangrove canopy gaps may counteract senescence, contributing to maintaining the mangrove forest in a rejuvenated and regenerated state. The rejuvenation and regeneration of canopy gaps have implications for the integrity of the numerous valuable ecosystem services that mangrove forests offer. Despite the socio-ecological implications of canopy gaps on mangrove forests, knowledge regarding their global and local extent, drivers, occurrences, densities, and closure rates remains limited.

This thesis addresses the knowledge limitation by conducting a comprehensive investigation of the distribution patterns and dynamics of canopy gaps in mangrove forests on both global and local scales. The investigation employs a multifaceted approach, encompassing extensive literature reviews, remote sensing techniques, and predictive models, to explain the patterns of canopy gaps formation, closure dynamics and reveal their underlying drivers while validating their regeneration capacity.

Canopy gaps are found in 133 mangrove patches distributed across 35 countries spanning America, Africa, Asia, and Oceania. Significant variations in canopy gap sizes, canopy gap densities, and percentage of canopy gaps coverage in mangrove patches across different regions were observed. The occurrence of canopy gaps on a global scale is mainly driven by lightning strikes, and precipitation of the coldest quarter, while their density is driven by lightning strikes, the precipitation of the wettest and driest months, and the maximum temperature of the warmest month. Overall, these climatic factors have the potential to act synergistically thus contributing to canopy gap occurrences and density within a given mangrove forest patch.

On a local scale, the thesis showed clustered spatiotemporal patterns in South Africa's largest mangrove forest at uMhlathuze (80% of the total mangrove coverage in the country) near Richards Bay. Beachwood canopy gaps primarily exhibited random patterns with some spatial clustering, along with random temporal patterns. The patterns at both sites support the hypothesis that lightning strikes, insects or pathogen attacks or competition potentially contribute to canopy gap formation. Spatial distribution of canopy gaps was linked to high canopy height at both uMhlathuze and Beachwood, supporting the lightning strikes hypothesis. Canopy gaps at uMhlathuze remained open for at least 23 years. In contrast, no canopy gap at Beachwood had closed over the time span of 18 years that the study covers. These findings highlight the need for active (re-)establishment of canopy gaps, as the very slow natural regeneration might result in loss of valuable ecosystem services provided by mangroves, such as carbon sequestration and long-term storage of carbon.

Furthermore, the canopy gap closure dynamics and factors influencing their closure across 10 countries and two biogeographical realms—the Atlantic East Pacific and Indo West Pacific were investigated. At higher latitudes above the equator a pattern of relatively shorter canopy gap closure durations and increased annual percentage of canopy gap closure was observed. Approximately 70-100% of the canopy gaps had undergone closure in eight countries. Conversely, during the timeframe encompassed by the study, over 70% of the canopy gaps in Australia exhibited a persistent lack of closure for at least 18 years. Canopy gap closure duration was found to be significantly influenced by the mean temperature of the wettest quarter of the year. Similarly, the annual percentage of canopy gaps closing was significantly influenced by mean temperature of the wettest quarter, mean temperature of the driest quarter, pH, and salinity. This highlights the potential impact of climate change on mangrove forests, as rising temperatures directly influence the closure of canopy gaps at higher latitudes consistent with the expansion of mangrove forests poleward.

The thesis emphasizes the significance of prioritizing the (re-)establishment of mangrove forest areas with non-closing gaps. This is crucial for ensuring the integrity of long-term carbon storage, coastal protection, habitats for diverse fauna, and a sustainable timber supply that supports local livelihoods under climate change.

Overall, this thesis contributes to providing baseline data on mangrove areas with canopy gaps and their potential drivers, both globally and on regional and local scales. It highlights the factors influencing canopy gap closures and mangrove areas facing a lack of regeneration, emphasizing the urgent need for human assistance in (re-)establishing those canopy gaps.