Mangrove Growth Monitoring Using Multi-temporal UAV-LiDAR

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Abstract

Mangrove forests, occupying tropical and subtropical coastal areas, serve as coast protector, water filter, spot of attraction and an exceptional carbon reservoir. Despite these extraordinary ecological and economic functions, our understanding of the mangroves is limited because field survey is hard to conduct in the intertidal mangrove habitats. While satellite remote sensing provides good spatial and temporal coverages globally, data availability at the tropical latitudes is limited due to frequent cloud contamination. The quickly emerging unmanned aerial vehicle (UAV) technique enables data collection under almost all weather conditions, thus provides new opportunities. By mounting light detection and ranging (LiDAR) sensors on UAVs, the 3D structure of mangroves can be accurately characterized even at individual tree level. The basic tree parameters such as tree height and crown size can be easily extracted, which then enables the estimation of biomass, carbon stock and other important ecological indices. This study uses high density (>100 pt/m2) UAV-LiDAR data collected at four consecutive years to detect the growth rate and pattern of mangroves. The change detection is done at individual tree level. The dependence of mangrove growth pattern on tree species and clumpingness are analyzed. The output will allow scientists and environment managers to know mangroves better and to manage them effectively and efficiently.

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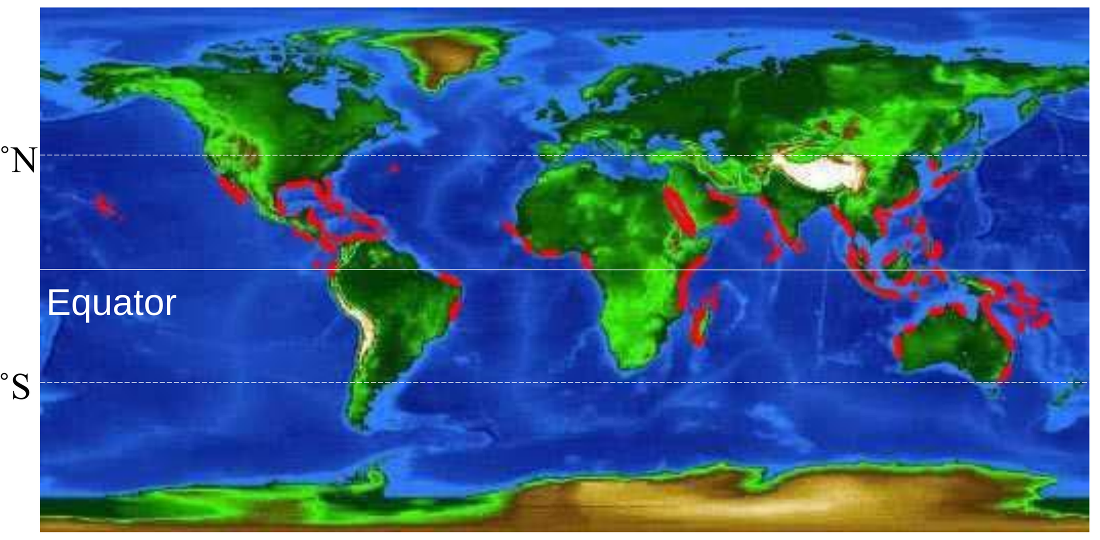
I. Background - Mangrove

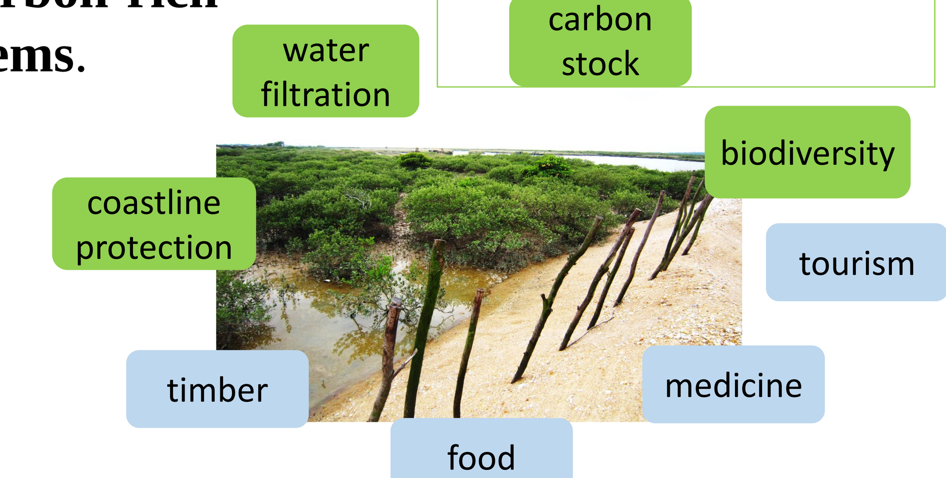


World distribution map of mangroves (red color).
(Image courtesy: Florida Museum of Natural History)

Mangroves: trees and shrubs at tropical and sub-tropical coastal zones

Mangroves provide a variety of unique environmental and social services and are among the **most carbon-rich ecosystems**.

v.s. terrestrial ecosystems:
- Area <0.4%
- Comparable carbon storage

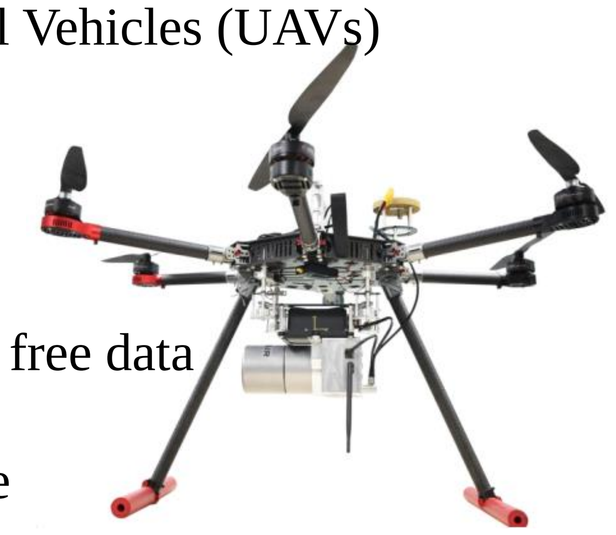


II. Gap

The swampy environment, and the very dense canopy and roots make the mangrove forests mostly **not accessible**.

The height dynamics of mangrove forests have **not** been investigated, especially for large areas.

Opportunity:
Unmanned Aerial Vehicles (UAVs)
Remote sensing



- Cloud and tide free data
- Affordable
- Easy to capture

III. Objectives and VI. Findings

We propose the first study to monitor mangrove height dynamics using UAV-LiDAR.

- What is the growth rate of mangrove trees?
  On average, 7.1 cm·yr^{-1}
- Does different species have different growth rates?
  Yes.
  × *Rhizophora stylosa* : 9.8 cm·yr^{-1}
  × *Avicennia marina* : 9.2 cm·yr^{-1}
  × *Kandelia candel* : 5.9 cm·yr^{-1}
  × *Aegiceras corniculatum* : 3.0 cm·yr^{-1}

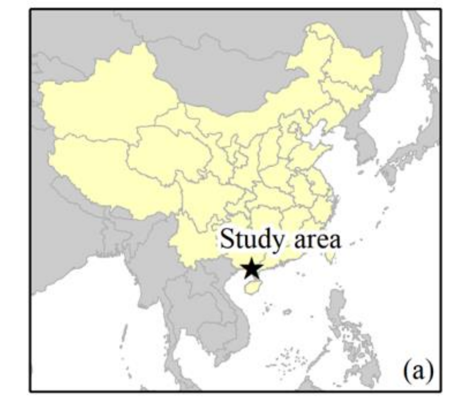
  Plant *Rhizophora stylosa* and *Avicennia marina* for faster growth and protection.
- Does environment (clumped vs. isolated) affect the growth rate?
  Yes.*
  × Isolated : 10.6 cm·yr^{-1}
  × Boundary: 6.7 cm·yr^{-1}
  × Clumped: 6.4 cm·yr^{-1}

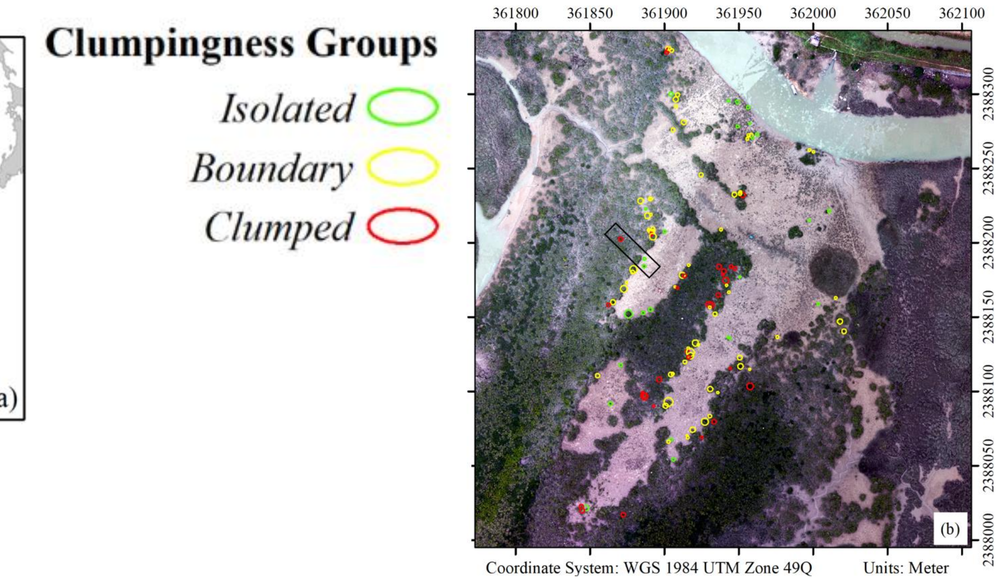
  Leave space inbetween for faster growth and protection.

  (*Needs more work.)

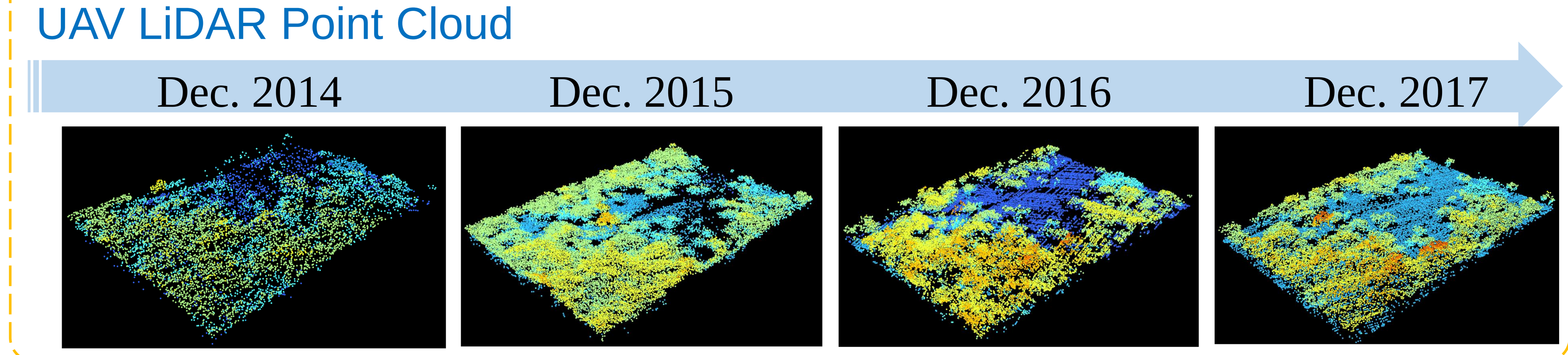
IV. Data and Methods

Shankou National Mangrove Nature Reserve, Guangxi, China.



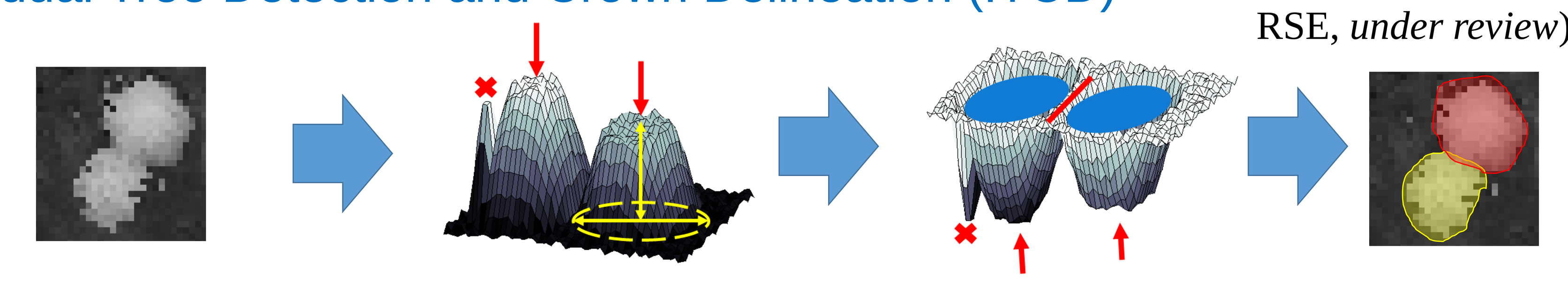


UAV LiDAR Point Cloud



Individual Tree Detection and Crown Delineation (ITCD)

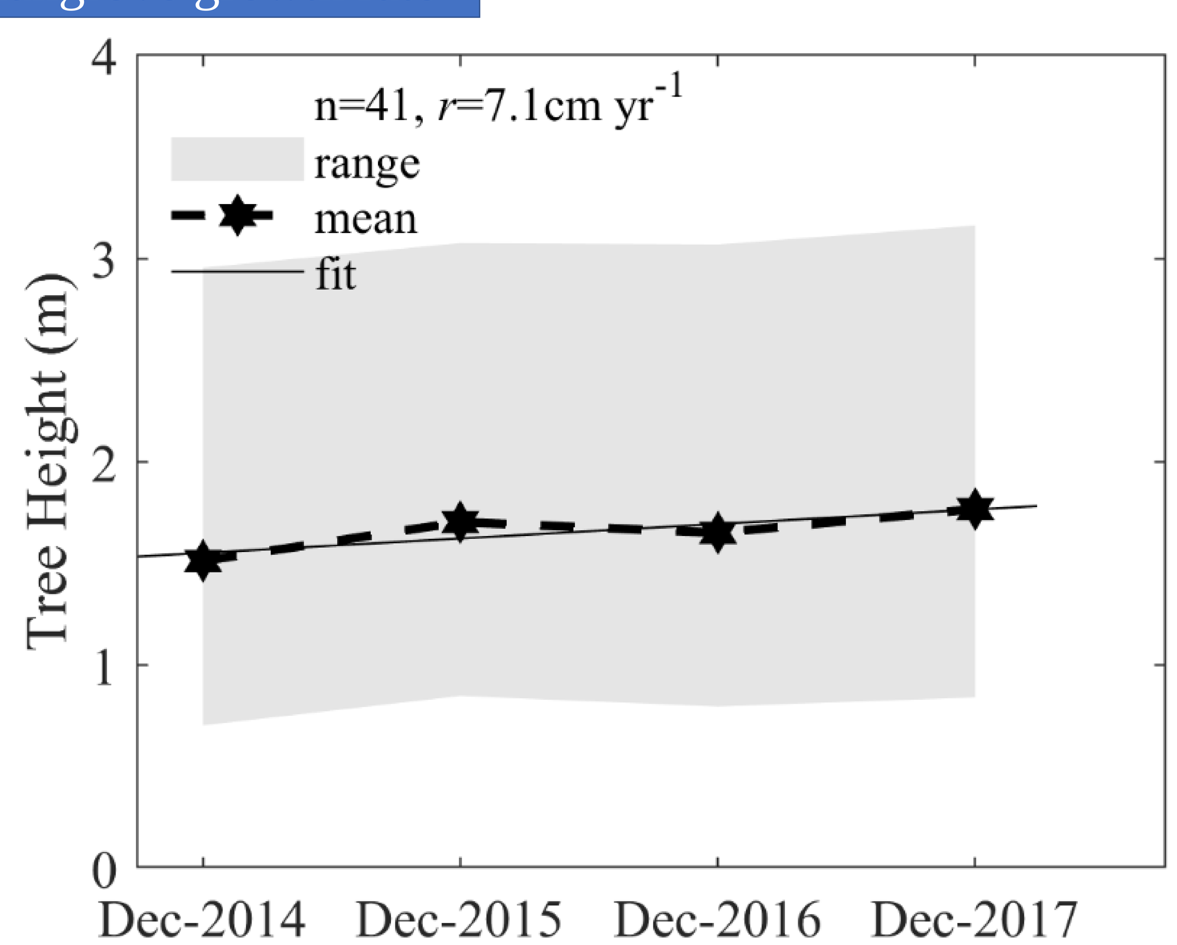
(Yin and Wang, RSE, *under review*)



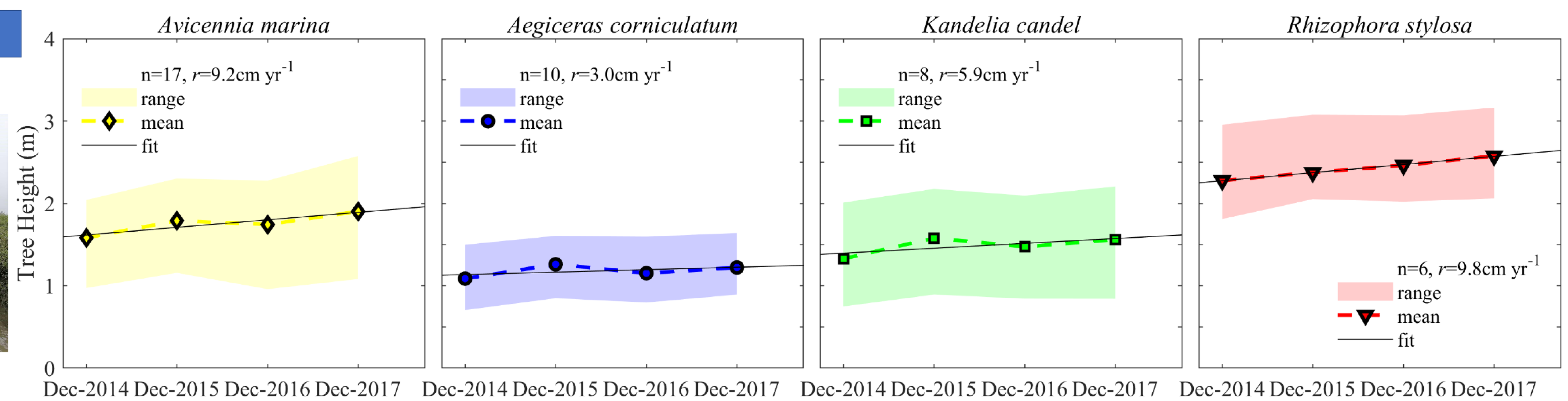
Multi-temporal comparison → Growth rate *r* (cm·yr^{-1})

V. Results

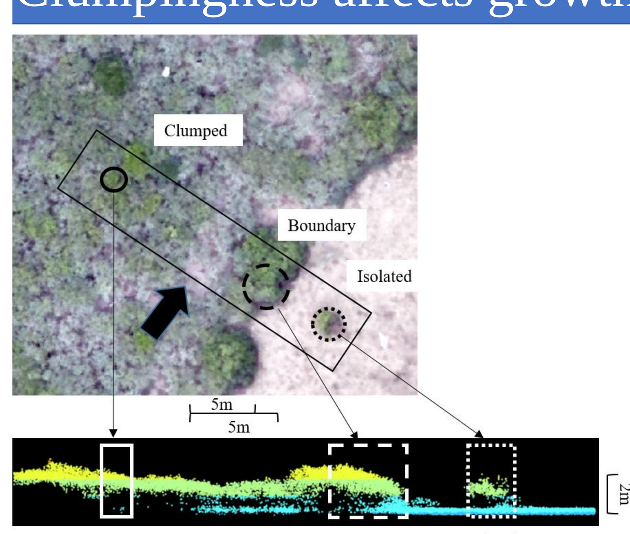
Mangrove growth rate

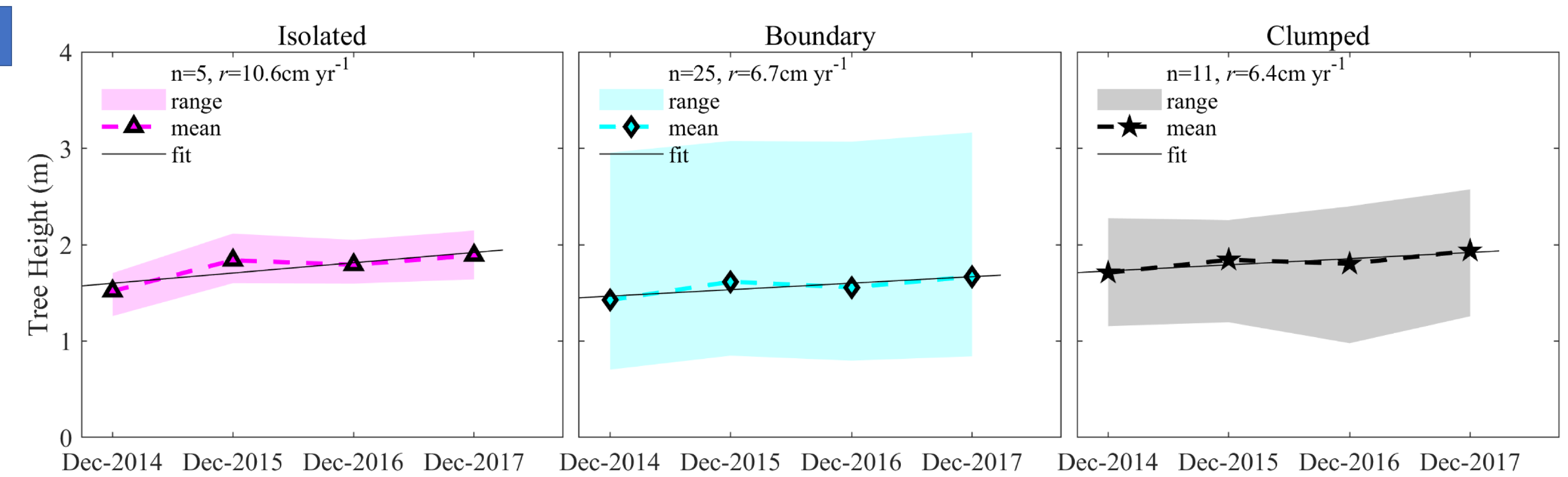


Species growth rate



Clumpingness affects growth rate?





VII. Limitations and Future Work

- Uncertainties in field measurement and LiDAR has not been investigated.
- Geo-referencing among different LiDAR / CHM datasets is worth exploration, especially in the mangrove forested area.
- ITCD accuracy can be further improved by adjusting algorithm parameters and refining ITCD algorithms.
- Change of biomass and carbon storage in the mangrove ecosystem can be analyzed by combining the current results with published allometric equations.