# Savanna-Bio: Biomass estimation with new spaceborne missions for MRV in Dry Forests and Savannas


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## Introduction

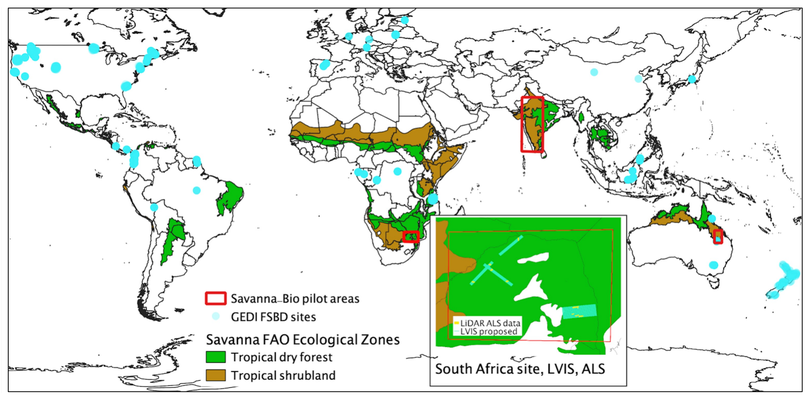
The aim of our CMS research is to develop prototype aboveground biomass and change products for selected tropical savanna regions (India, South Africa and Australia), using NASA's GEDI and ICESat-2 spaceborne lidar data to reduce the uncertainty of SAR-based models (Sentinel-1A/1B, ALOS PALSAR-1/2, NASA/ISRO NISAR)

**The specific objectives of this research are:**

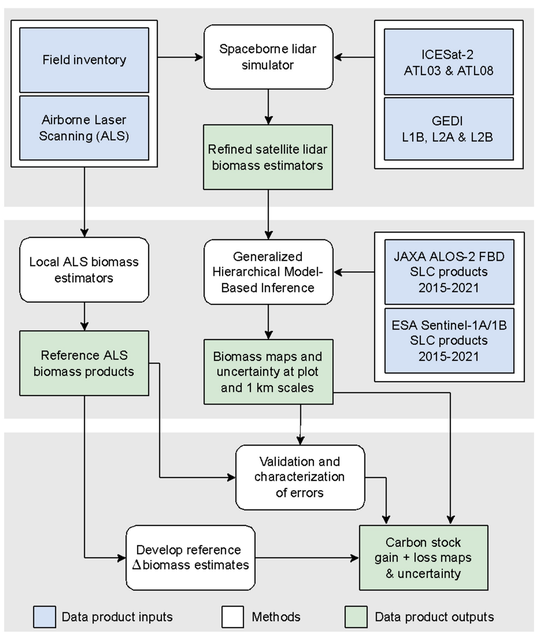
1. Develop prototype height and aboveground biomass products for international pilot sites using satellite lidar and SAR time-series (Sentinel-1A/1B and ALOS PALSAR-2) datasets.
2. Use independent field and airborne data to validate the products and evaluate the uncertainty of aboveground biomass estimates from 0.25 ha to 1 km$^2$ scales following the CEOS Land Production Validation good practices protocol.
3. Quantify the impacts of woody degradation and regrowth on aboveground biomass and carbon stock change with reference to existing MRV activity data employed by selected international stakeholders in India, South Africa and Australia.

## Study Sites

Three international sites (red squares) are located within global Savannas (FAO Tropical Dry Forests and Shrubland) in Australia, India, and South Africa. They include Committee on Earth Observation Satellites (CEOS) Biomass Reference Measurement (BRM) sites (Duncanson et al., 2021). The inset shows the location of planned LVIS flights during the JAXA RA-3 period (light blue) and existing ALS data (yellow) in South Africa.

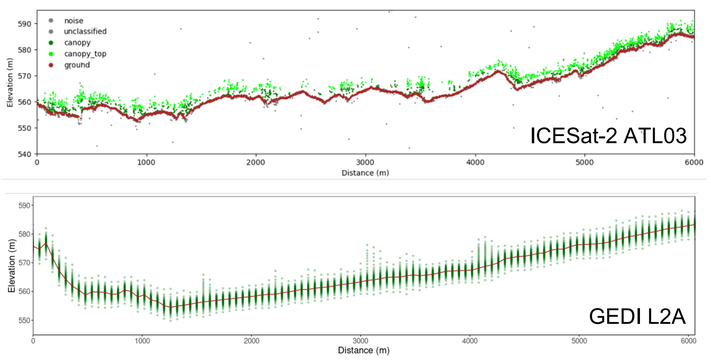


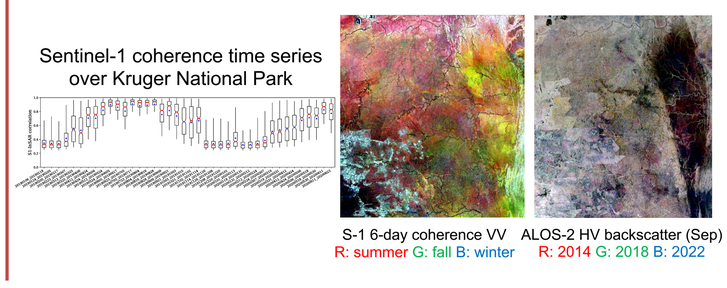

## Methods




- Our work will refine GEDI and ICESat-2 height, cover and biomass algorithm calibration and validation for savannas.
- With the relationships between canopy structure and AGB being established using GEDI and ICESat-2 data, the companion technology makes use of the temporal decorrelation signature available from repeat-pass InSAR for mapping of Forest Stand Height *(Lei & Siquiera 2014; Lei et al 2019)*.
- We will use Generalized Hierarchical Model-Based (GHMB) inference *(Qi et al., 2019; Saarela et al., 2022)* as a basis for estimating mean aboveground biomass and its uncertainty.
- By focusing on Savannas with lower biomass, we shall develop methods that are more sensitive to the magnitude of biomass changes (e.g. 20-80 Mg/ha) associated with forest regrowth and degradation.

## SAR and Lidar Datasets

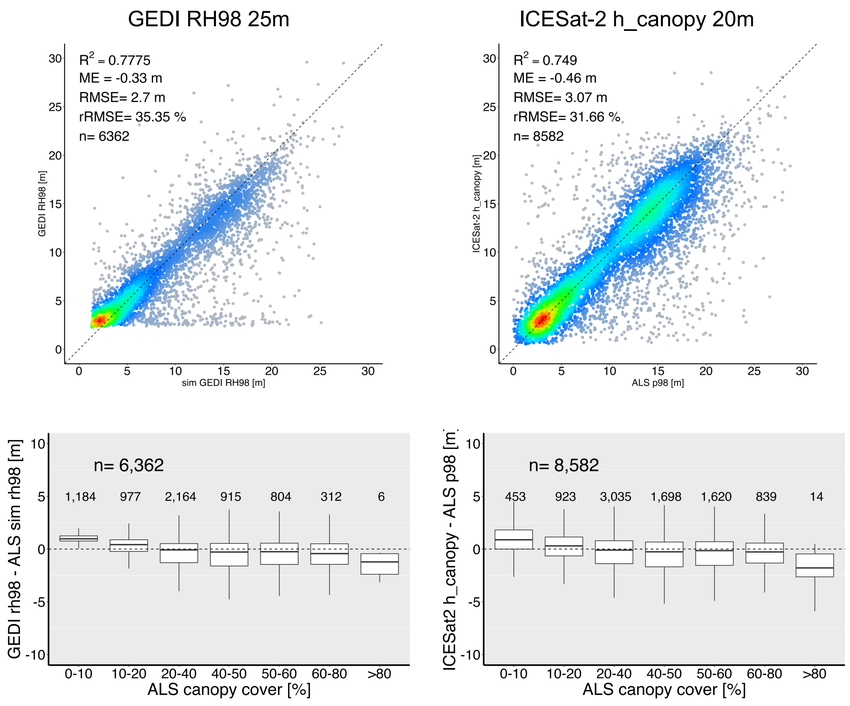


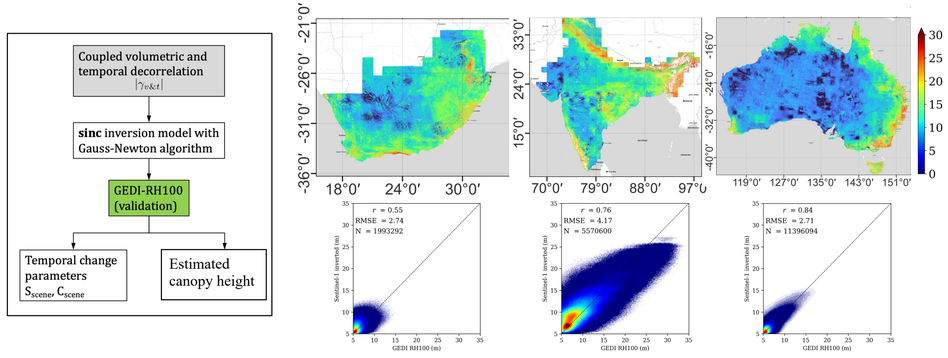

- For large area mapping we develop a tiled processing framework on the NASA Multi-Mission Algorithm and Analysis Platform (MAAP).
- The framework standardizes ICESat-2 ATL03 photon metrics, GEDI Level 2A and 2B footprint metrics, and Sentinel-1 coherence and radar cross-section (RCS), and ALOS-2 PALSAR-2 RCS into a common reference frame based on the Military Grid Reference System (MGRS).
- These datasets improve and localise the calibration of the height and biomass estimation algorithms currently being investigated.

## Results and Next Steps

### Efficacy of GEDI and ICESat-2 for height estimation in savannas




### Vegetation height estimation using Sentinel-1 coherence




- From a repeat-pass InSAR Sentinel-1 pair (t=12 days) the volume & temporal InSAR correlation ($\gamma_{v\&t}$) is derived.
- Inversion of canopy height requires local calibration of temporal change parameters from GEDI or ICESat-2.
- The preliminary results shown here slightly overestimate the height, but they do show sensitivity across the range of observed height at this site.
- We are yet to compare this mode of estimation to more common backscatter regression approaches, as well as to an ALOS-2 height inversion approach.

### Our next steps include

1. Extending the applicability of GEDI and ICESat-2 canopy structure measurements to global savannas: improvement and integration of GEDI and ICESat-2 canopy structure measurements for training SAR canopy height and aboveground biomass estimation models
2. Evaluation and improvement of GEDI footprint level biomass estimators for Australian, Indian and Southern African savannas
3. Completion of field and airborne campaigns in Kruger National Park and central Queensland for the generation of reference canopy height and biomass change datasets
4. Generation of high-resolution canopy height and biomass change maps using Sentinel-1 and ALOS-2 time-series over each of the pilot sites

NASA Carbon Monitoring System