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AQUABIO – Novel Insights of the Water Cycle and Flood Dynamics using ESA BIOMASS Cal/Val Data

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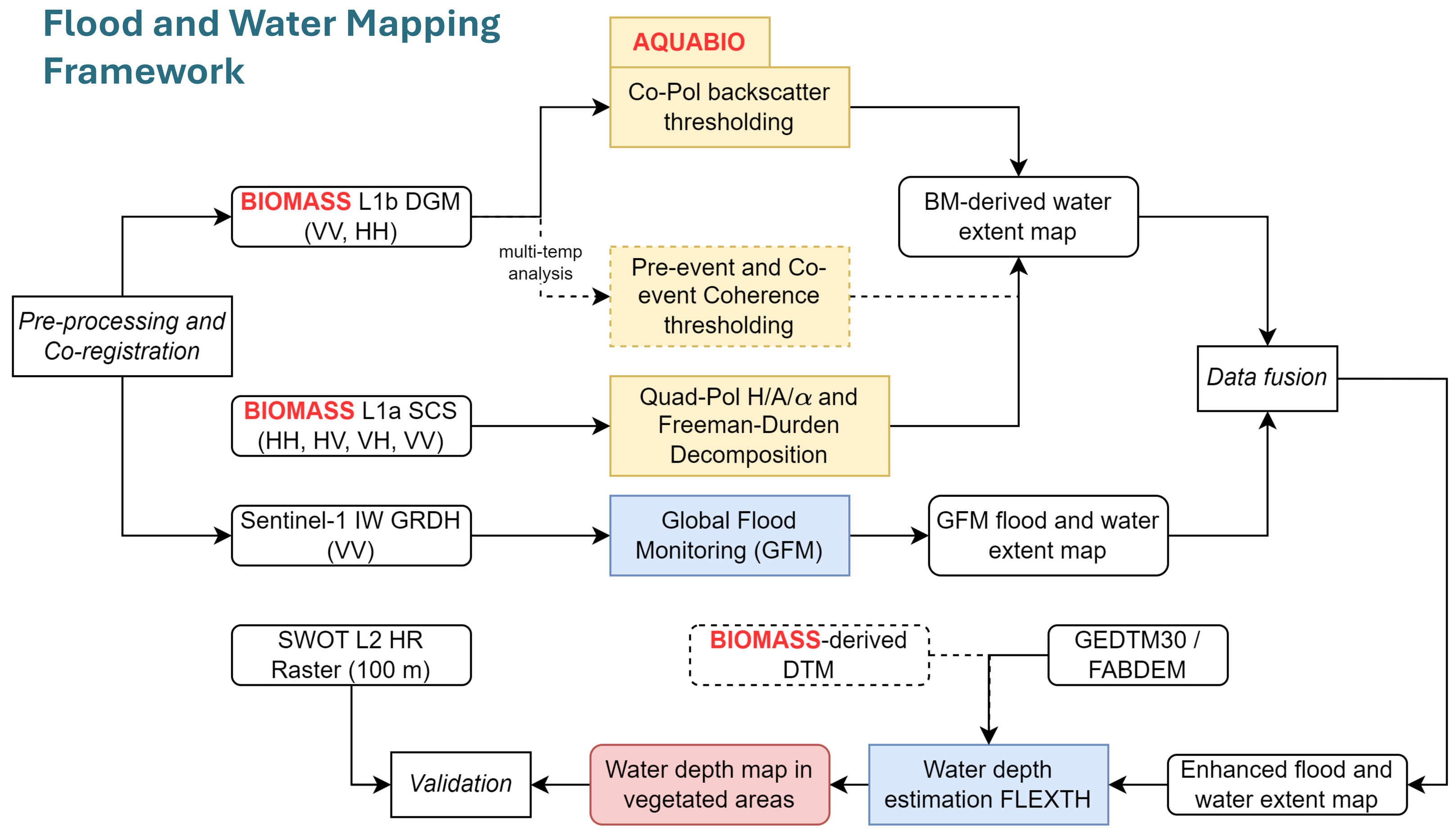
Introduction

Monitoring flood dynamics within forested and densely vegetated regions remains a major challenge due to the limited penetration of conventional radar frequencies through canopy layers. This work investigates the comparative potential of P-band synthetic aperture radar (SAR) observations from the ESA BIOMASS mission and C-band SAR data from Sentinel-1 for detecting flooded areas beneath vegetation cover. The analysis is conducted within the BIOMASS Calibration and Validation (Cal/Val) framework, aiming to assess how multi-frequency SAR observations can enhance hydrological and ecohydrological monitoring in complex environments.

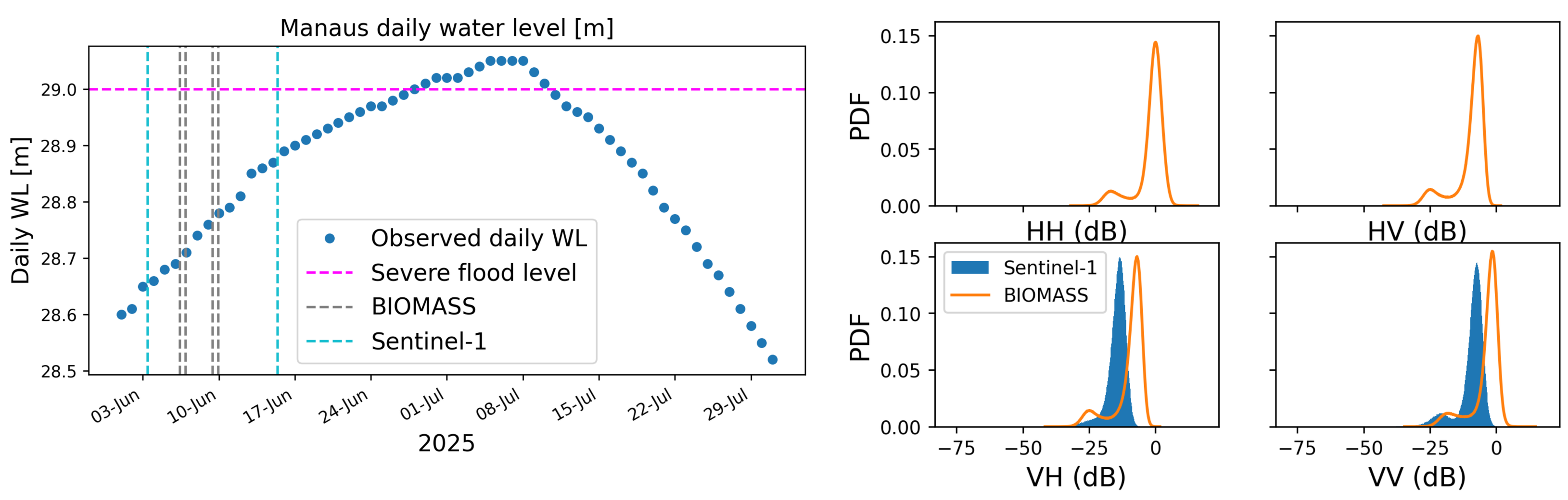
Method

Flood and Water Mapping Framework



Summary of used EO data

Satellite	Datetime	Polarization	Orbit	Geometry
Sentinel-1	**2025-06-03T09:48:02**	VH, VV	59480	D
BIOMASS	**2025-06-06T09:56:37**	HH, HV, VH, VV	558	A
BIOMASS	2025-06-06T22:14:29	HH, HV, VH, VV	566	D
BIOMASS	2025-06-09T09:56:37	HH, HV, VH, VV	602	A
BIOMASS	2025-06-09T22:14:29	HH, HV, VH, VV	610	D
Sentinel-1	2025-06-15T09:48:02	VH, VV	59655	D



Left: Daily water level at Manaus (source: Serviço Geológico Do Brasil)
Right: Histograms from BIOMASS (2025-06-06) and Sentinel-1 (2025-06-03).

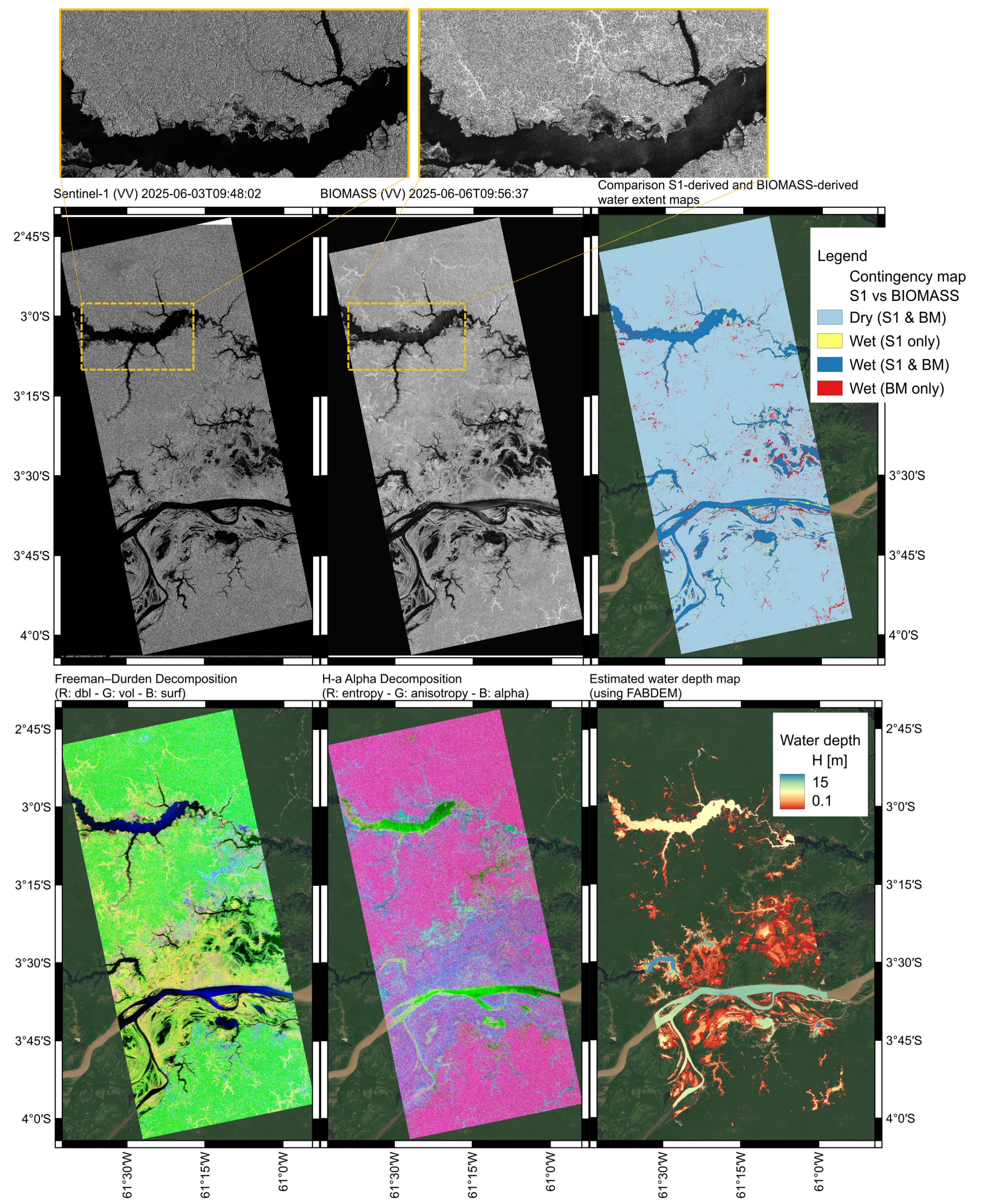
Background

Double-bounce backscattering represents the key process to detect flooded vegetation. Penetrated radar pulses is backscattered from the horizontal water surface and lower sections of the vegetation (trunks and branches) → Increased signal return in comparison to dry conditions (Martinis et al., 2015; Pierdicca et al., 2017). However, the signal return from partially submerged vegetation is complex and depends on radar parameters (e.g., wavelength, incidence angle, and polarization) and environmental parameters (canopy type, structure, and density). According to (Martinis et al., 2015), over wetland dominated by woody vegetation, the backscatter coefficient can be described as:

$$\sigma^0 = \sigma^0_{canopy} + \tau_c^2\tau_t^2\left(\sigma^0_{grd.\,surface} + \sigma^0_{tree\ trunk} + \sigma^0_{dbl.\,bounce} + \sigma^0_{multi\ path}\right)$$

where τ_c is transmission coefficient of the vegetation canopy and τ_t attenuation of the SAR signal by the tree trunks. Polarimetric decomposition-based methods (Plank et al. 2017) have demonstrated great results in mapping flooded vegetation with ALOS-2.

First Results



Conclusion

- Preliminary water mapping (pre-flood peak) results over Amazon River basin (Rio Solimões & Manacapuru).
- Demonstrating added value of P-band SAR BIOMASS in flood monitoring under vegetation, complementing C-band Sentinel-1 flood observations (e.g. Global Flood Monitoring / GFM service).
- Strong double-bouncing effects over vegetated areas with water presence underneath the canopy.
- Resulting fused Sentinel-1 & BIOMASS water depth maps shows promises when comparing to SWOT-derived water surface elevation.

Perspectives

- ❑ Fully automatic classification framework.
- ❑ Multi-temporal analysis with more BIOMASS data after Cal/Val period.
- ❑ In-depth investigation on the impact of forest vertical structure/density and incidence angle.
- ❑ Integrate other EO data (Sentinel-2, Landsat-8, CYGNSS) and SWOT SLC/PIXC
- ❑ Large-scale validations over pre-selected test sites.
- ❑ Improve water depth estimates with BIOMASS-derived DTMs.

Acknowledgments

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