D4S Q&A #5

Recent advances in tropical peatland water table depth measurement

Update March 2026, Aljosja Hooijer and Ronald Vernimmen
(https://www.dataforsustainability.com/contact.html)

Water table depth (WTD) is the key control on tropical peat decomposition and carbon emission, as well as the health of the swamp forest that formed the peat in recent millennia. Robust relations between WTD and emissions were established in recent years, allowing determination of carbon budgets based on WTD information. So what methods exist to measure WTD, and what are the pros and cons?

Some considerations based on our experience and insights:

Why are WTD time series needed, does a single measurement not suffice?

Tropical peatland water levels fluctuate with rainfall and evapotranspiration, being higher in wet periods than during droughts. In regions with high rainfall variability, the annual WTD fluctuation range can exceed 1 m in some years, while being less than 0.5 m in others. To determine an 'average' WTD that can be used in carbon emission calculations, this variation must be captured in a time series of measurements, preferably a record of monthly measurements over at least 3 years. The longer the record, the more confident the emission estimate will be.

How many measurement locations are needed to determine a robust WTD?

This depends on the size of the area of interest, as well as the variation in hydrological conditions within it. It is best to first divide a project / study area into relatively uniform zones, e.g. 'drained for agriculture', 'within 500 m from single canal', 'peat swamp forest more than 500 m from a canal'. Each zone should then have sufficient measurement points, where 3 is usually considered the minimum. The shorter the monitoring record, the more measurement points are needed for confident quantification of WTD ('space for time' principle).

Measuring WTD on the ground seems simple and reliable, but is this true at a large scale?

On the ground, WTD is usually measured in 'dipwells', perforated PVC tubes that are inserted in auger holes, preferably into the underlaying mineral subsoil for stability (this allows measurements of surface subsidence as well). This brings advantages of replicability and verification. However there are several risks to data integrity in our experience: [a] dipwell location selection can be biased accidentally (e.g. easy access locations are chosen that are not representative for the larger area) or on purpose (e.g. a lower peat surface is selected to demonstrate higher water level); [b] installation errors that limit water level fluctuations in the tube (a low number of perforation holes, or holes being too large so the tube fills up with peat particles); [c] the ground surface relative to the dipwell top is not measured correctly; [d] reading / writing errors by local staff; [e] numbers can be 'made up' altogether. Apart from these risks, the cost and effort of installation and frequent monitoring can be high (and sometimes these are mitigated by making up numbers), especially for large studies / projects that can involve hundreds or even thousands of dipwells.

Can tropical peatland WTD be measured using LiDAR, from space?

LiDAR (laser) technology can not penetrate the peat surface. However it can accurately measure the elevation of the peat surface as well as the water surface in canals, so it can determine the depth of the canal water table below the surrounding peat surface (CWD) as was demonstrated using airborne LiDAR (i.e. collected from an airplane). Satellite LiDAR is becoming available recently (since 2018; ICESat-2, GEDI); this data allows the same measurements as airborne LiDAR. Satellite LiDAR has low spatial density compared to airborne LiDAR, but brings the advantage of repeat measurements of an area over the years, and it comes at no cost. Once the CWD is known, it may be used as a proxy for WTD as the difference in tropical is usually found to be less than 0.1 m (this is explained by the very high water transmission capacity of tropical peat). If required, the CWD / WTD relation may be determined for a site of interest, through field measurements.

Can tropical peatland WTD be measured using optical and radar data, from space?

Some progress has been made in indirect WTD estimation in peatlands using optical and radar data to estimate soil moisture conditions and are mostly focused on colder-climate peatlands that typically have low vegetation (heath and mosses). In tropical peatlands promising results were reported for areas with limited vegetation cover, relying on calibration for different vegetation types. However in common tropical conditions where industrial plantations and restoration areas tend to have a dense cover of trees and undergrowth, that varies in time with crop cycles and tree regrowth rates, such indirect approaches may be of limited practical use. Our current assessment is that this approach may be of some value used in parallel with, and possibly calibrated by, more accurate but geographically sparse LiDAR data.

SELECTED FURTHER READING (D4S PUBLICATIONS)

Subsidence and carbon loss in drained tropical peatlands (https://bg.copernicus.org/articles/9/1053/2012/)

A new method for rapid measurement of canal water table depth using airborne LiDAR, with application to drained peatlands in Indonesia (https://www.mdpi.com/2073-4441/12/5/1486)

Benefits of tropical peatland rewetting for subsidence reduction and forest regrowth: Results from a large-scale restoration trial (link: Benefits of tropical peatland rewetting for subsidence reduction and forest regrowth: Results from a large-scale restoration trial (https://www.nature.com/articles/s41598-024-60462-3)