Estimating depth to groundwater table in a disturbed Peatland in Alberta using photogrammetric point clouds

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Introduction

Peatlands cover >30% of Alberta's boreal zone, store a large amount of soil carbon and exchange greenhouse gases (GHG) with the atmosphere. Fluctuation in depth to groundwater table at the plot level has been shown to strongly affect peatland Greenhouse Gas (GHG) emission (Harris and Bryant, 2009). Therefore, to estimate GHG emissions at the local and regional level across different types of peatlands, it is necessary to accurately map the depth to groundwater table without the need to install numerous groundwater monitoring wells. Considering this scenario, the objective of this research is to:

- **Develop an operational method to map groundwater table in a disturbed bog using UAV data and photogrammetric techniques.**

Study Area

Our study area is located north of Peace River, AB within the Shell-Carmon Creek Lease (Figure 1). The site covers an area of ~700 m X 700 m, primarily representing an open to dispersedly treed bog.

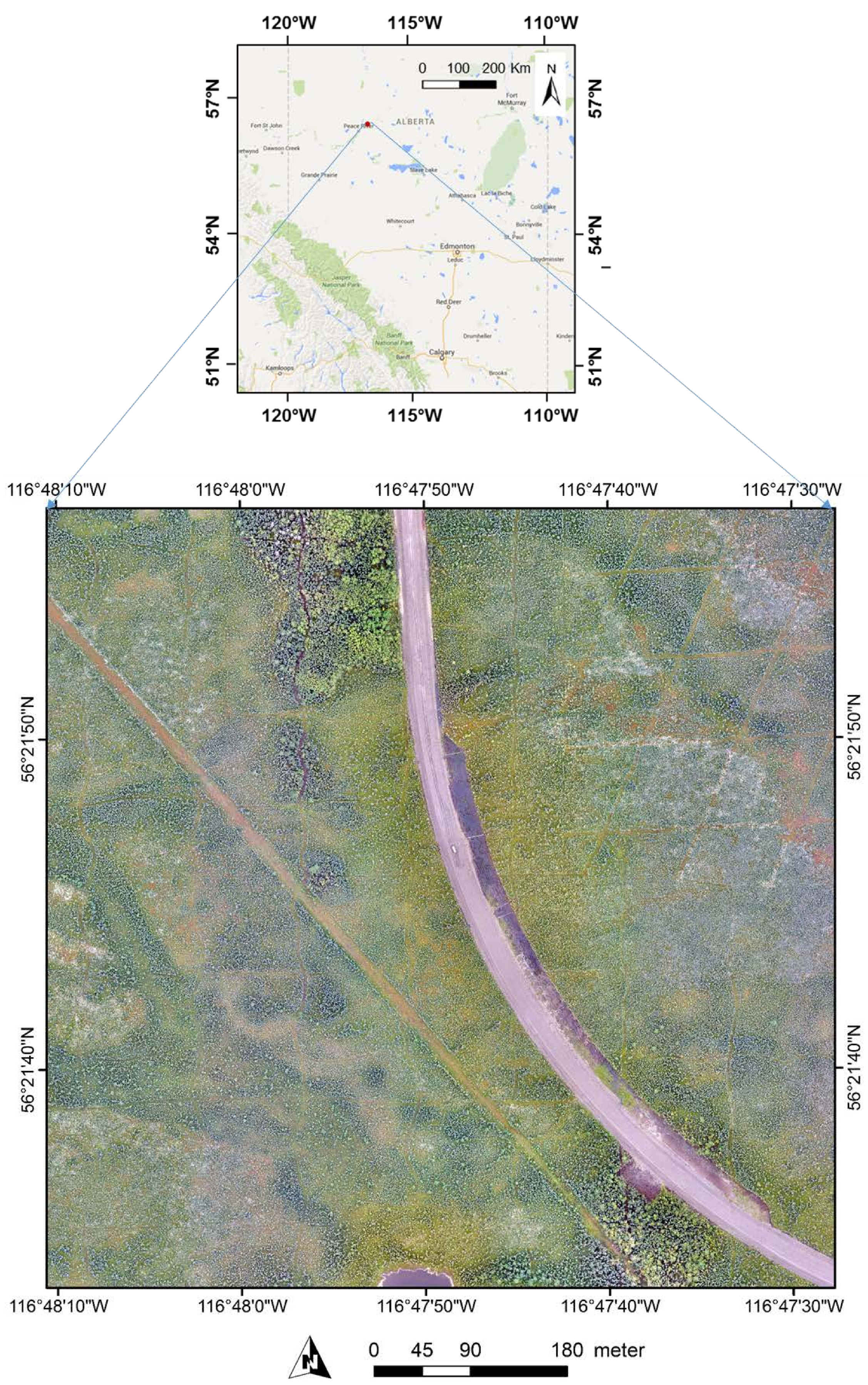

Figure 1: Location of the study area.

Method

We propose a new method that maps groundwater table by creating an interpolated surface of open water level (elevation) obtained from a UAV based orthophoto and photogrammetric point clouds. Our method offers direct estimation of depth to groundwater table in contrast to the existing traditional models (Lowry et al., 2007; Harris et al., 2005; Koblinsky et al., 1993) that describe a passive relation between the biophysical variables (moisture content, composition and distribution of vegetation, etc.) and the groundwater table depth. Figure 2 summarizes the method used in this study. Table 1 shows the overall accuracy of the model calculated using 37 grounds sample points (wells) across the site.

Table 1: Overall error estimates of the depth to groundwater model based on 37 ground sample points

Mean Error (m)	Standard Deviation (m)	Mean Absolute Error (m)
-0.07	0.190	0.149
Maximum Absolute Error (m)	**Minimum Absolute Error (m)**	**RMSE (cm)**
0.653	0.0003	0.203

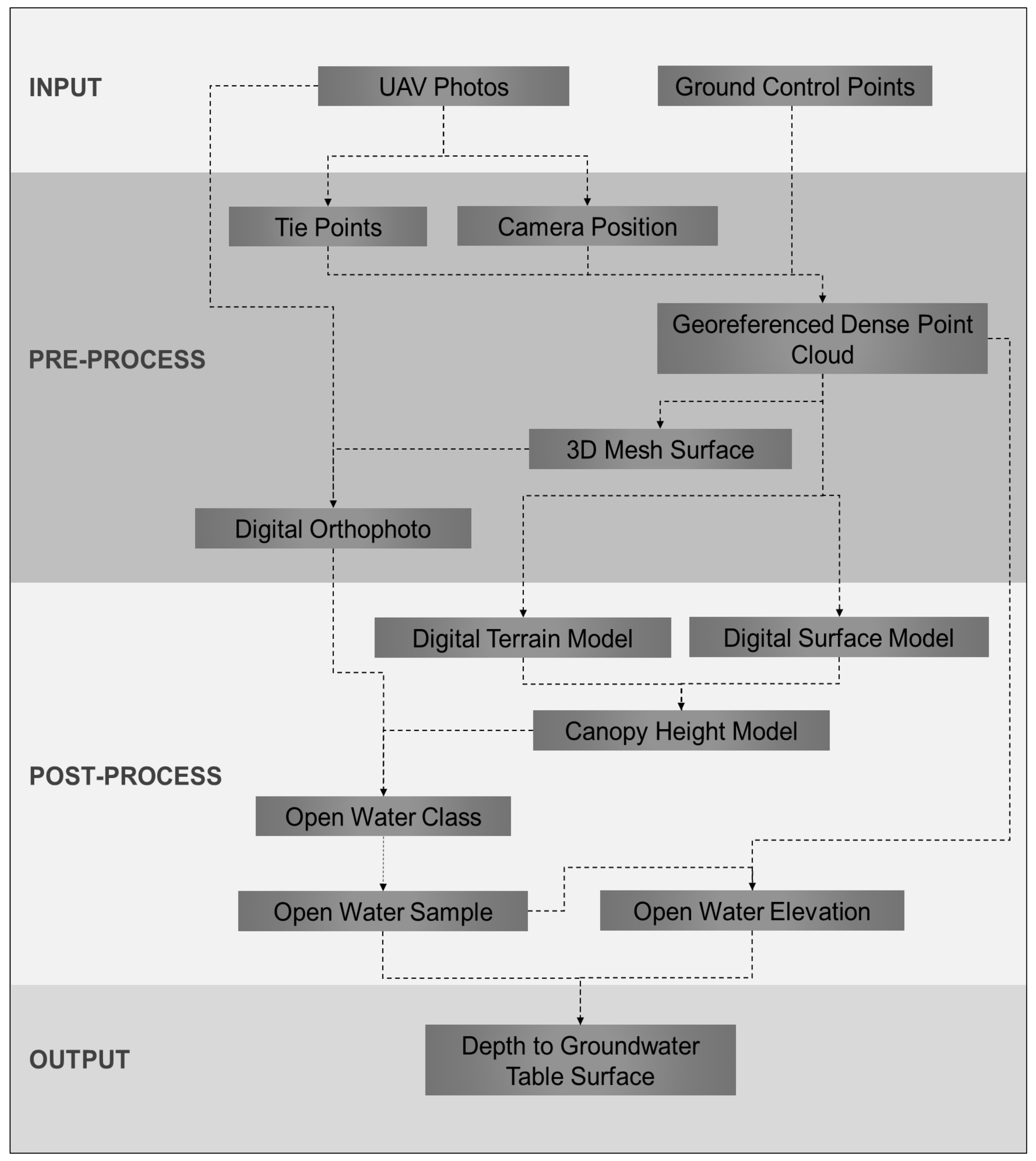

Figure 2: Methodology flow chart

Results

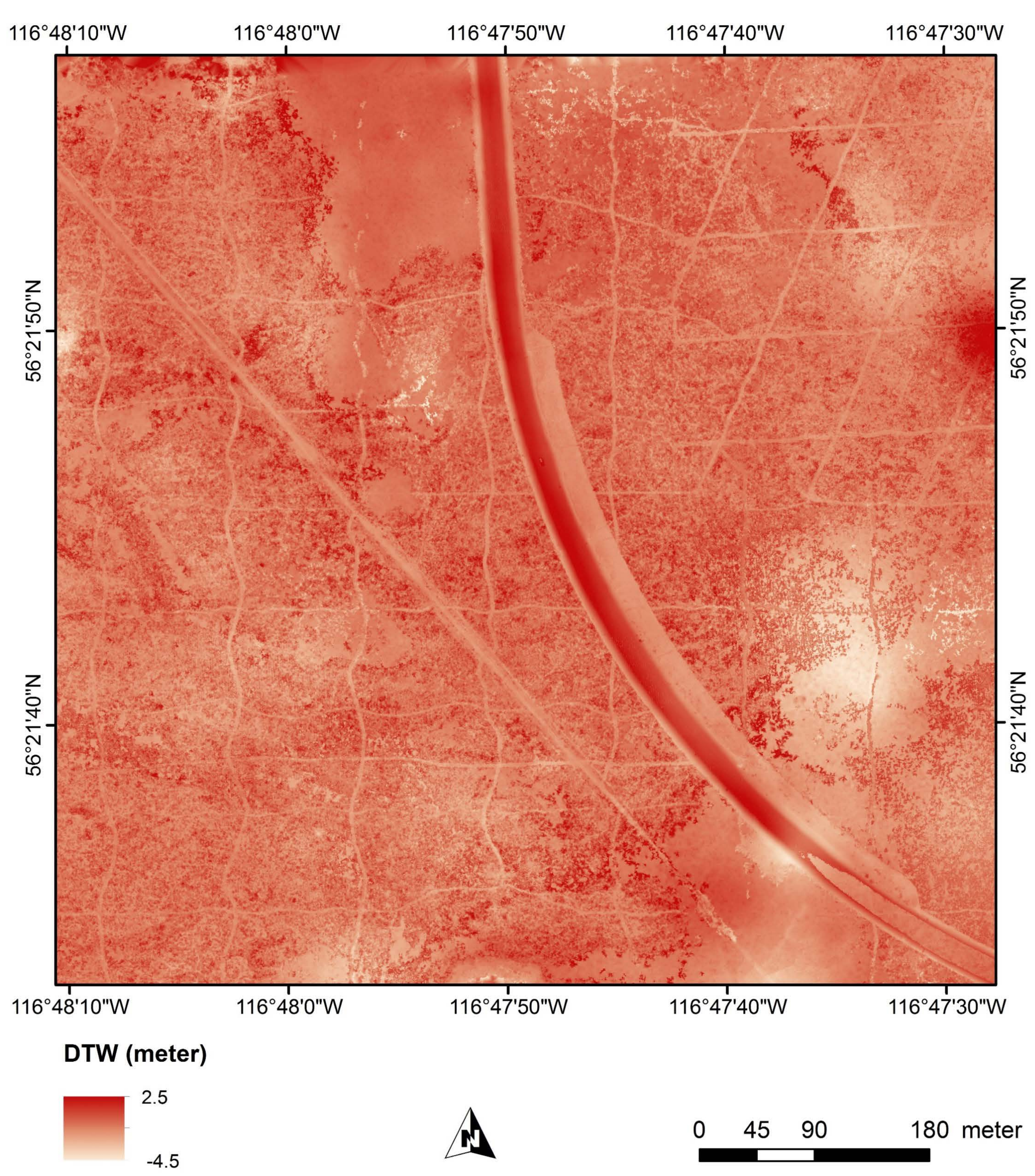

Figure 3: Depth to groundwater (DTW) surface using different shades of red color.

We can clearly see that the mineral road has high depth to groundwater table as it is elevated from its surrounding with mineral soil (Figure 3). The bog micro-topography (hummocks and hollows) is visible across the site, corresponding to changes in groundwater table depth. The seismic lines have lower depth to groundwater table compared to its surrounding. Also, the bog micro-topography appeared to be lost on those lines.

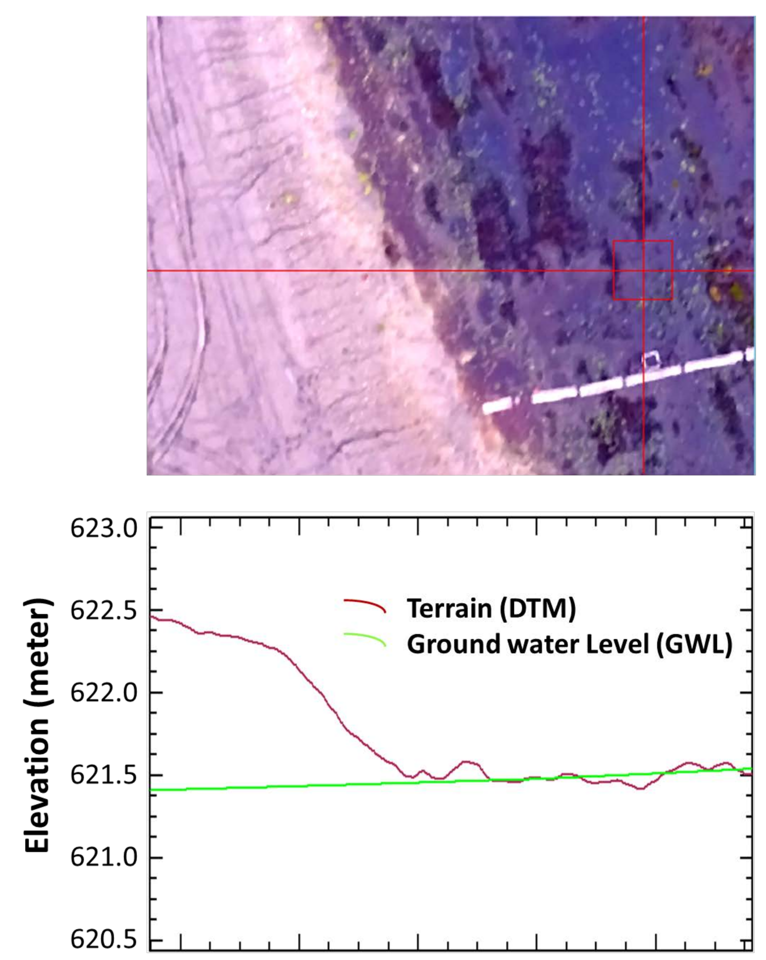

Figure 4: Vertical profile example of DTW

The image on the top shows a sample area where the access road is constructed with mineral soil from surrounding uplands. Figure 4 displays the Digital Terrain Model (DTM) (red line) that is generated using photogrammetric point clouds from UAV and the GWL estimated from our model (representing the horizontal green line in the figure). .

Findings and Conclusions

This research reveals the following findings:

- Stable open water can be used to map groundwater table with acceptable accuracies.
- Compared to a undisturbed bog, seismic lines represent less micro topographic variability (hummocks and hollows) and lower overall depth to water table compared to its surroundings.
- Mineral roads across a wetland ecosystem (such as a bog) alter its hydrology.
- The accuracy of the model is influenced by the point cloud and the DTM generated from UAV data.
- As the surface complexity increases (partially to completely covered ground by canopy), it becomes increasingly difficult to see the ground and thereby to model the terrain and the groundwater table.

The proposed method offers a great potential option for deriving depth to groundwater table in disturbed and undisturbed peatlands and low lying wetland areas, and thereby aids in estimating the GHG emissions from these ecosystems. Once successfully verified over different peatland types (bog, fen, swamp), our research will provide a pragmatic solution to reliably mapping depth to groundwater table using advance remote sensing and photogrammetric techniques, which has numerous application across disciplines.

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