**Polygon-Informed Cross-Track Altimetry (PICTA) derived river level profiles for the Bengal Tiger habitats in Nepal**

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**Abstract**

The Karnali River in Bardia National Park (BNP), Nepal, is crucial for sustaining the habitats of endangered Bengal Tigers. However, gathering data to analyze this remote river’s behavior presents significant challenges due to the remote and mountainous terrain of BNP.

This thesis explores an approach using the altimetry satellite Sentinel-6 to measure river water surface elevations (WSEs), specifically utilizing the innovative Polygon-Informed Cross-Track Altimetry (PICTA) method. By integrating fully-focused Synthetic Aperture
Radar (FF-SAR) data from Sentinel-6 with a static river polygon, we aimed to retrack WSEs and unlock new insights into the Karnali River’s dynamics.

The objective of this thesis was to evaluate the performance and potential of the PICTA method in deriving precise river level profiles for the Karnali River. The research questions addressed include: How does PICTA compare to in-situ water surface height measurements? How well does it align with the SWOT mission, which also measures river water levels? How do river level profiles change over time? And how does the use of a static river polygon influence water level uncertainty for the dynamic Karnali River?

The PICTA method successfully derived water surface elevations for a 10-kilometer-long section of the Karnali River. Over a year-long period from February 2023 to February 2024, we generated 38 detailed PICTA river level profiles. These profiles revealed the relationship between measured WSE fluctuations, river slope, and river width over time. We observed that both WSE fluctuations and river slope decreased at sections where the Karnali River could overflow its banks during high water. Notable gaps in the profiles, such as transitions from
a single channel to a multichannel system, provided insights into the interaction between river characteristics and the PICTA algorithm.
The PICTA-derived WSE time series closely matched in-situ measurements at the river gauge station at Chisapani, Nepal, showing similar seasonal trends and peak differences. When comparing PICTA and SWOT profiles, we observed a mean bias near zero and a scaled MAD of approximately 20 cm. Dynamic river polygons based on SWOT data further improved the agreement, reducing the scaled MAD by 10 cm and increasing retracked PICTA data points. Using a static river polygon introduced WSE uncertainties ranging from 5 cm in the summer to 20 cm in the winter, averaging 10 cm over time. This study suggests that dynamic polygons could enhance the accuracy of PICTA derived WSEs. Ultimately, PICTA’s ability to capture and relate seasonal trends to local hydraulic behavior underscores its significant potential. This research advances our understanding of the Karnali River’s dynamics and demonstrates
PICTA’s ability to derive river water levels in a remote, mountainous region. These insights could constribute to support better conservation efforts for BNP’s vital Bengal Tiger habitats.