

THE CHALLENGE: FINDING A NEEDLE IN A HAYSTACK OF ICE



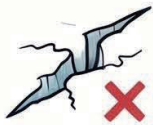
MOULIN
($<5\text{m}$ radius)



STANDARD SATELLITE PIXEL (10m)

INVISIBLE OR BLURRY?

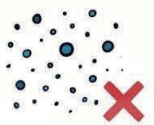
IMPOSTER FEATURES



CREVASSE



DESICCATED STREAM



NOISE/ARTIFACTS

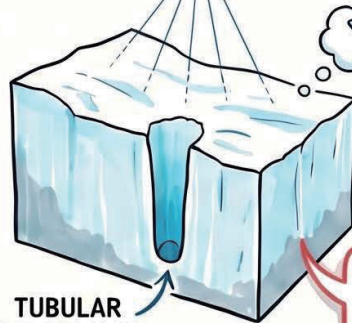
Traditional methods struggle to distinguish.

Mapping the Veins of the Ice Sheet: The GrIS-MDM Framework for Moulin Detection

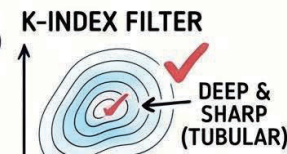
STEP 1: TOPOGRAPHIC HUNTING (DEM ANALYSIS)



Analyzing DEMs to find spots where elevation drops rapidly.



TUBULAR DEPRESSION



AREA CONSTRAINTS:
Filters for closed contours below -78.5 m^2 (since entrances $<5\text{m}$ radius).

PROVEN INNOVATION

20% ACCURACY LEAP

GrIS-MDM (F1-score: 8.76) vs. ELEVATION-ONLY METHODS (Lower F1)

20.4% improvement over simple methods.



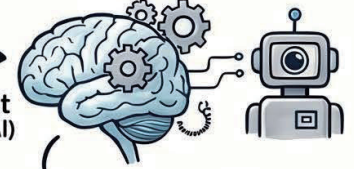
ENHANCED HYDROLOGICAL MODELING:
Improved spatial consistency of river networks by $>5\%$ (crucial for mass balance).



FUTURE SCALABILITY:
High transferability (effective on 2m satellite data)

STEP 2: THE AI EYE (DEEP LEARNING & DOM)

MAResU-Net (Lightweight AI)



SEGMENTING SUPRAGLACIAL RIVERS (0.06m resolution)

AUTOMATED TRAINING SAMPLES
Innovation: Auto-collects samples from "safe" regions (no manual labeling!)

HIGH-PRECISION VISION

IoU SCORE: 0.861
For outperforming pixel-based methods.

STEP 3: THE SYNTHESIS (HYDROLOGY KNOWLEDGE)



TRUE MOULIN (AT RIVER END)

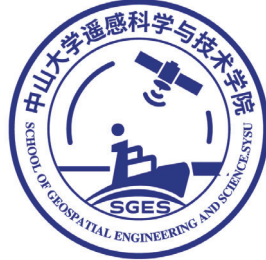


FALSE DEPRESSION (RIVER INTERIOR)

Screens out depressions in middle of stream.



CONNECTING THE DOTS:
Realistic river network reconstruction.



GrIS-MDM: A hydrology knowledge-based framework combining deep learning network for moulin detection using ultrahigh-resolution UAV Imagery. IEEE TGRS, 2024

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