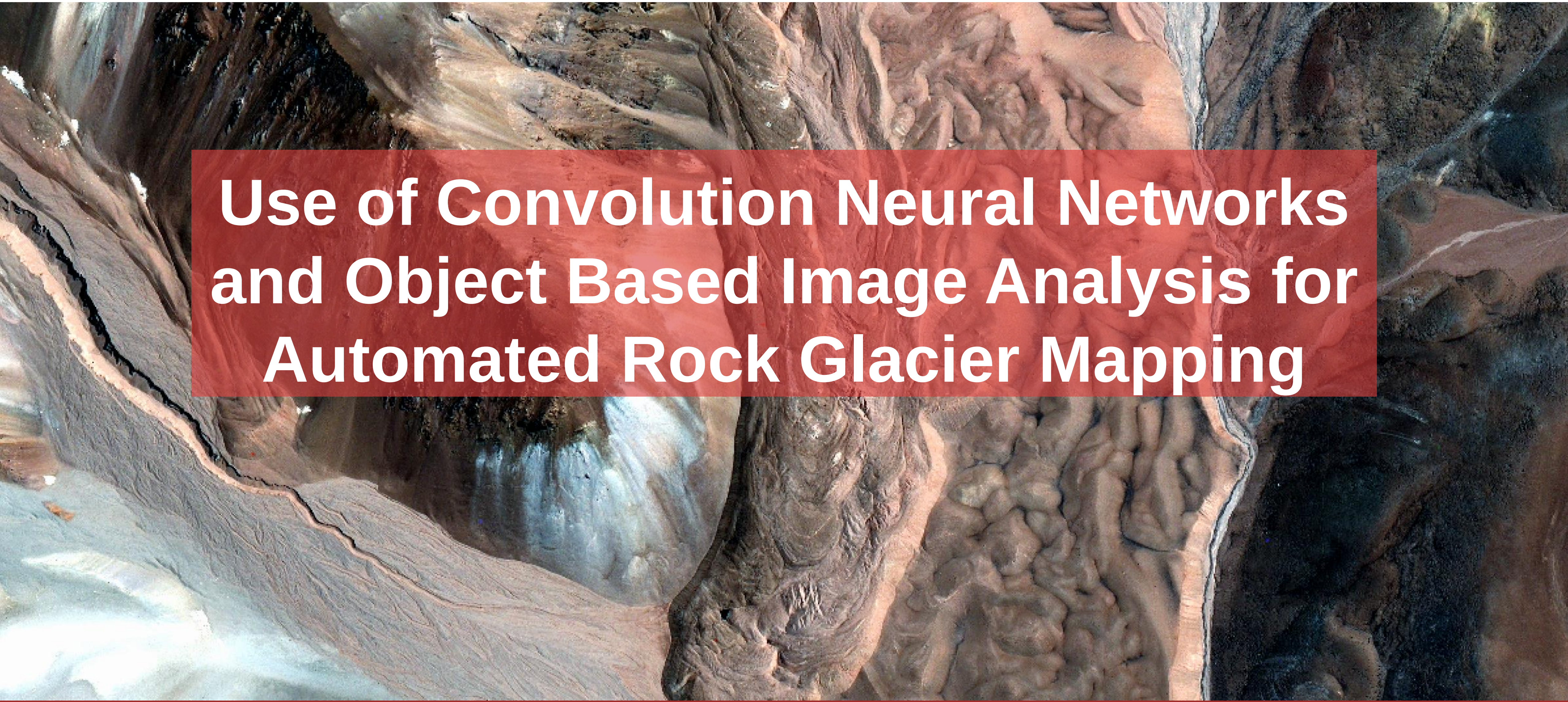
Use of Convolution Neural Networks and Object Based Image Analysis for Automated Rock Glacier Mapping



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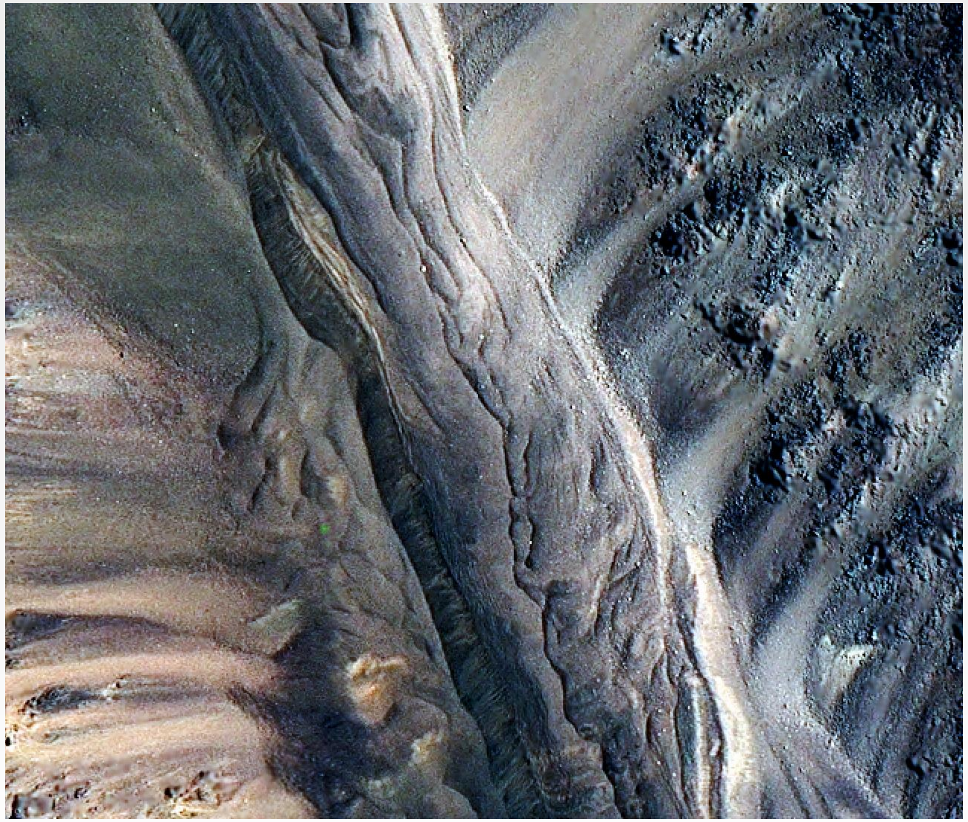
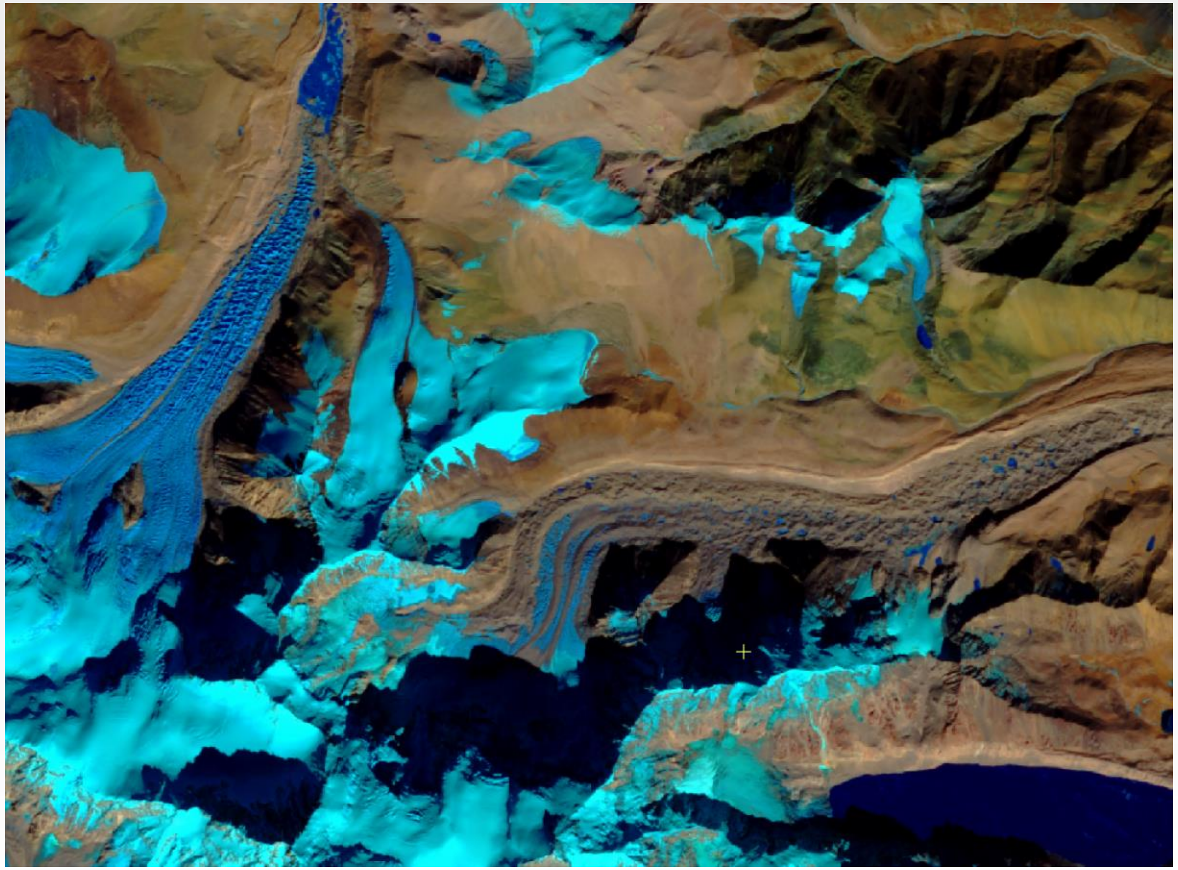
The problem

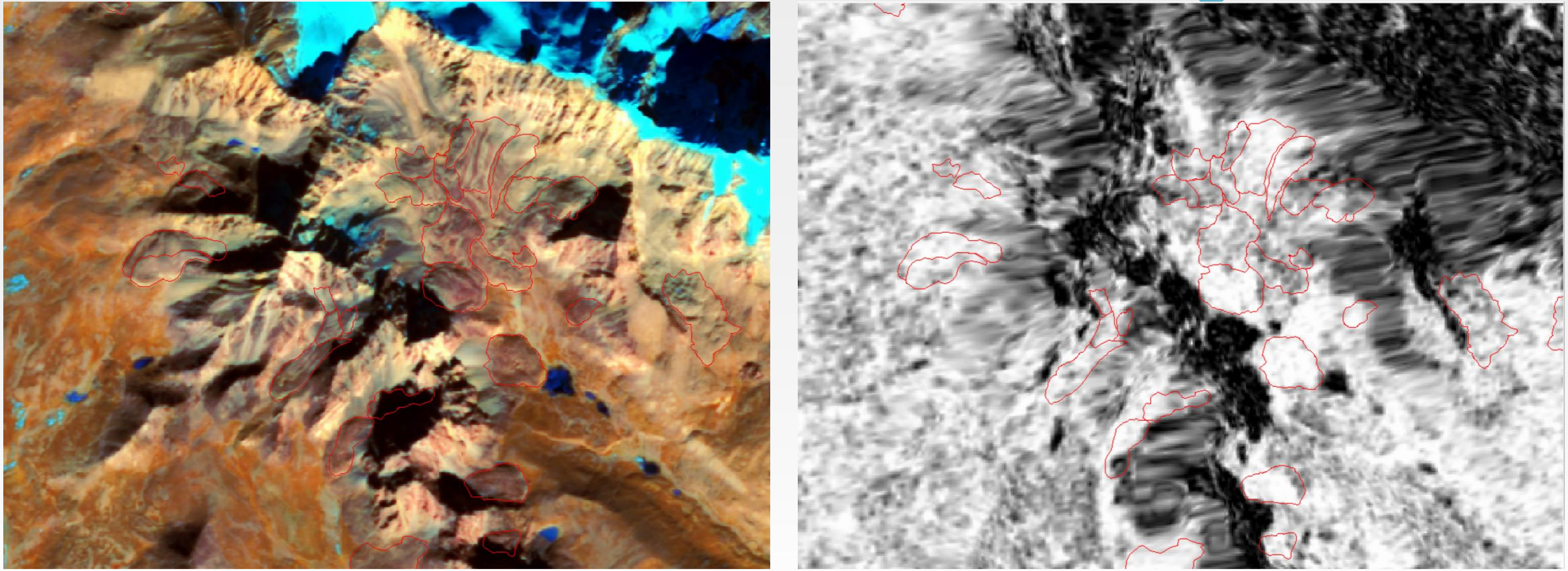
- Rock glaciers can contain significant amounts of ice
- Yet are spectrally inseparable from the surrounding terrain
- As such, most rock glacier inventories are based on time consuming and subjective manual interpretation

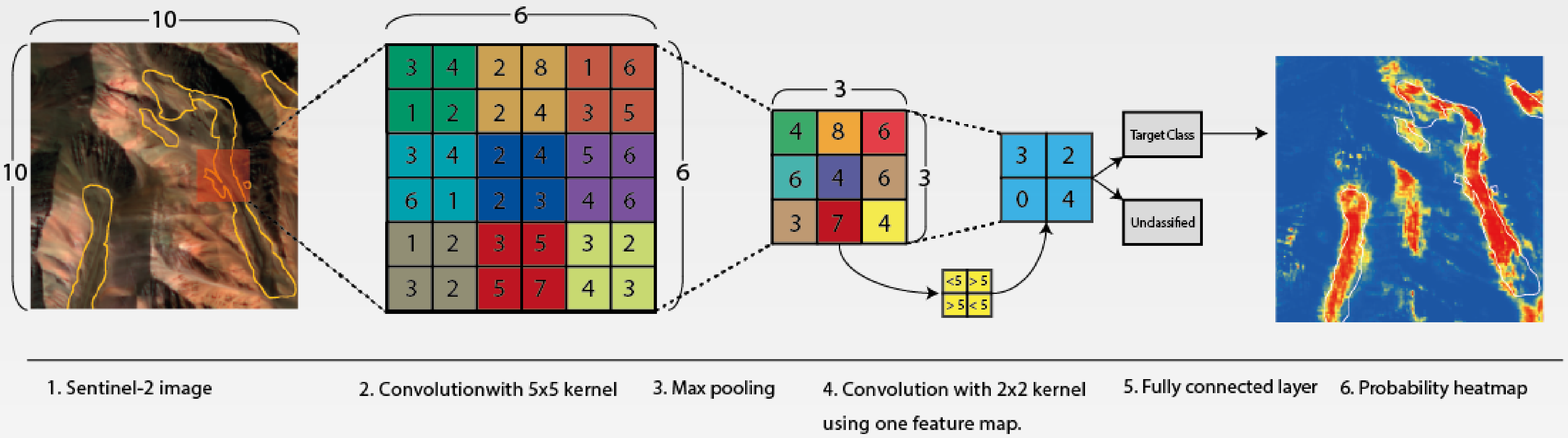


Clean ice and debris-covered ice can be identified with multispectral and SAR coherence data respectively



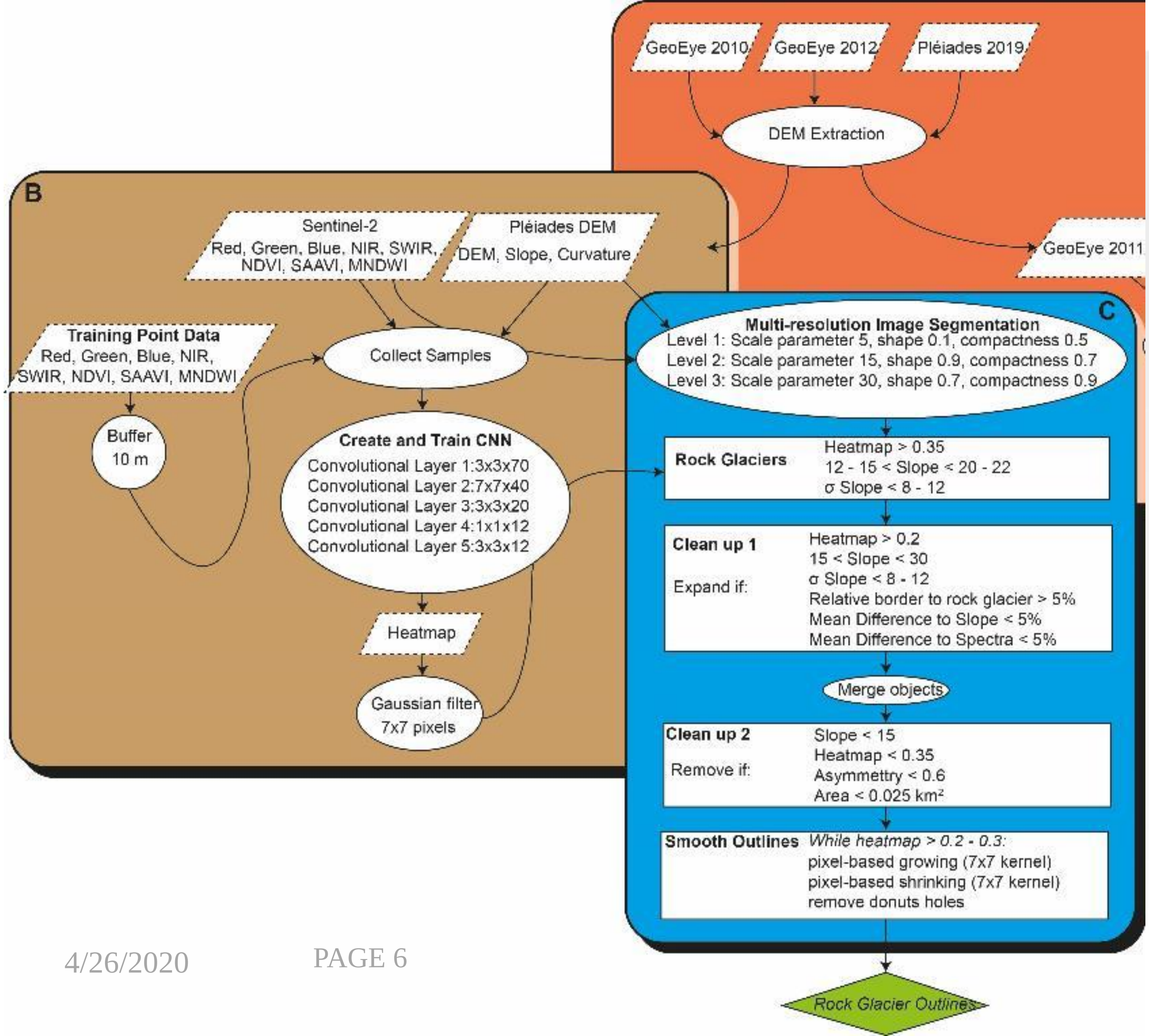
The same does not work for rock glaciers





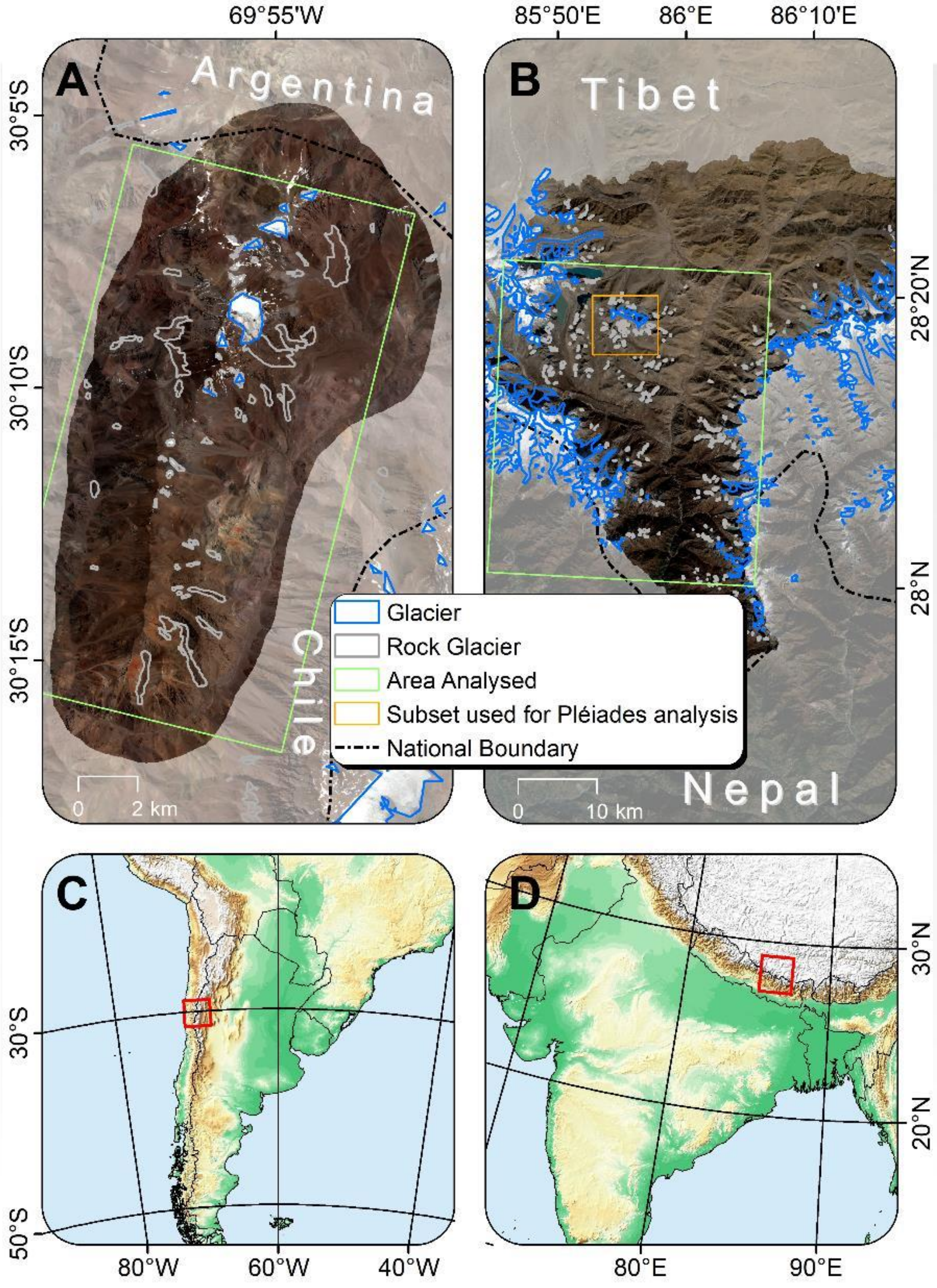
Convolutional Neural Networks (CNN)

A simplified example of a Convolutional Neural Network workflow. A convolution based on a 5x5 moving window is applied to an input image, resulting in the first convolutional layer. Note that the process has been simplified and most CNNs would involve additional convolution and pooling layers, feature maps, and additional input bands.



Combining CNNs with Object OBIA

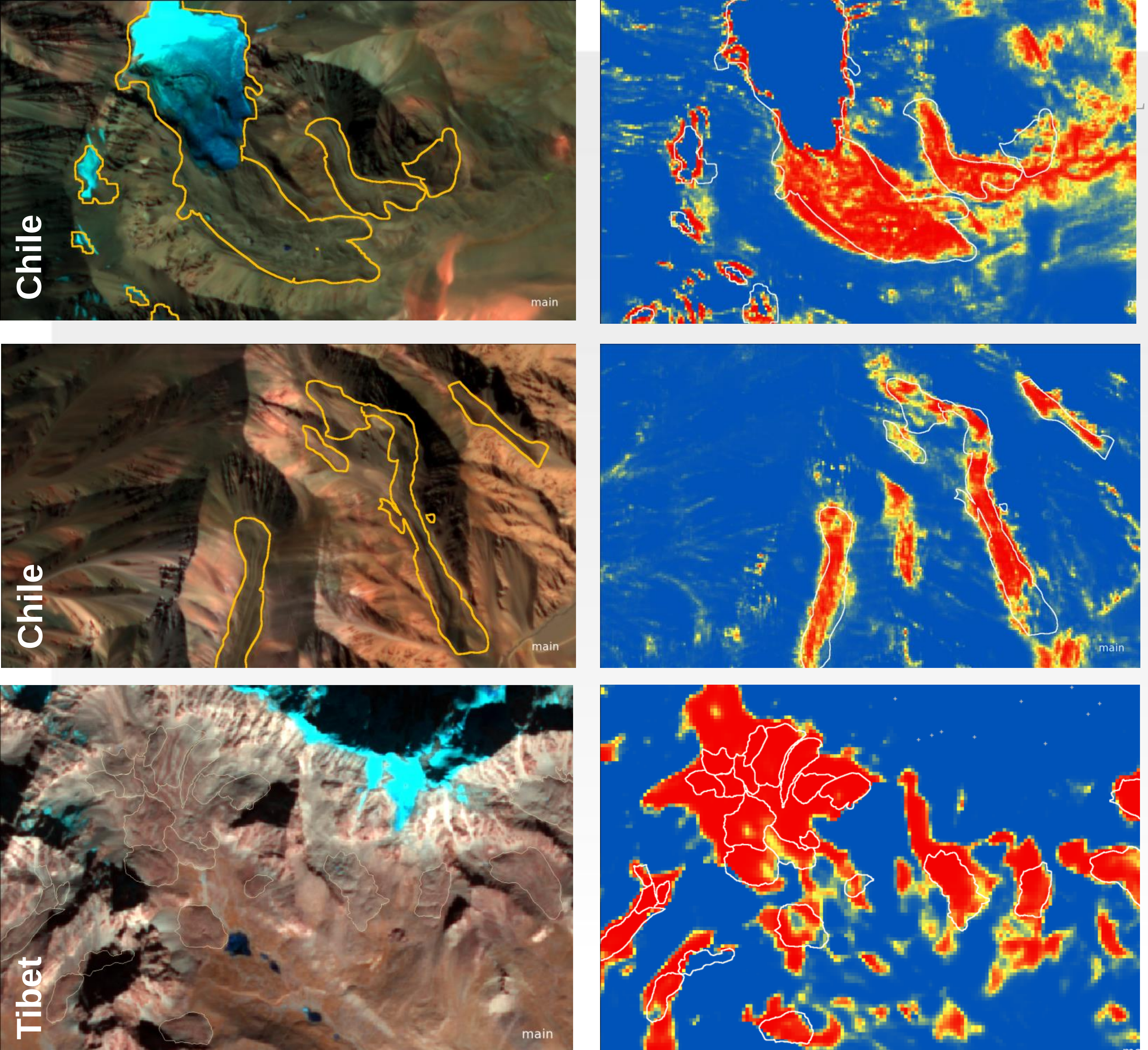
- Split rock glacier inventory into 30% validation and 70% training
- Also used RGI for glacier outlines
- Train CNN to generate probability heatmap
- Reshape and refine in OBIA



Trialed in two distinct periglacial catchments

- La Laguna Catchment, Chile
- Poiqu Catchment, Tibet

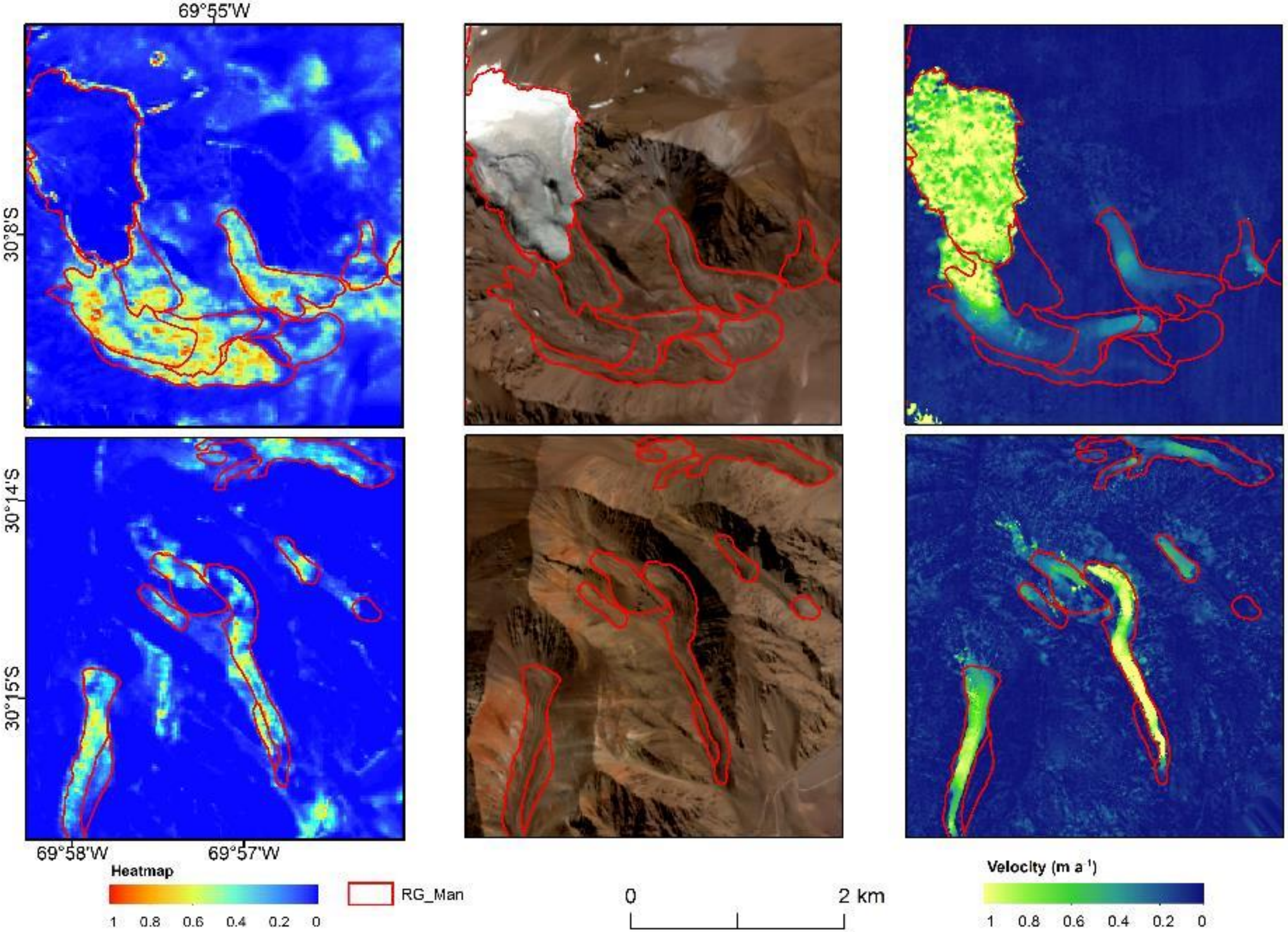
- **Data**: Sentinel 2, Sentinel 1 coherence, DEM



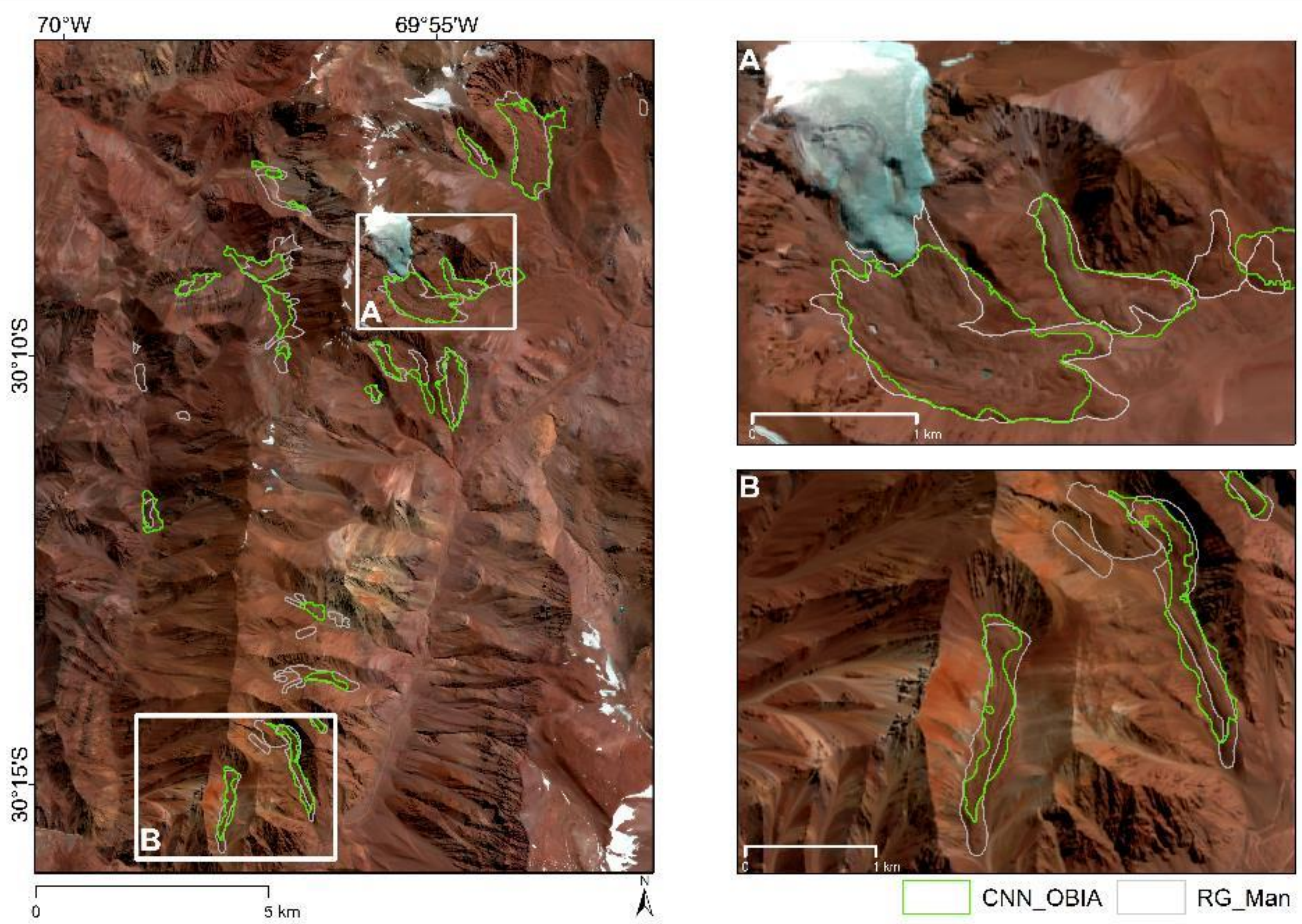
Results: Generation of probability map

Higher pixel values (shown in red) indicate a higher probability a pixel is a rock glacier

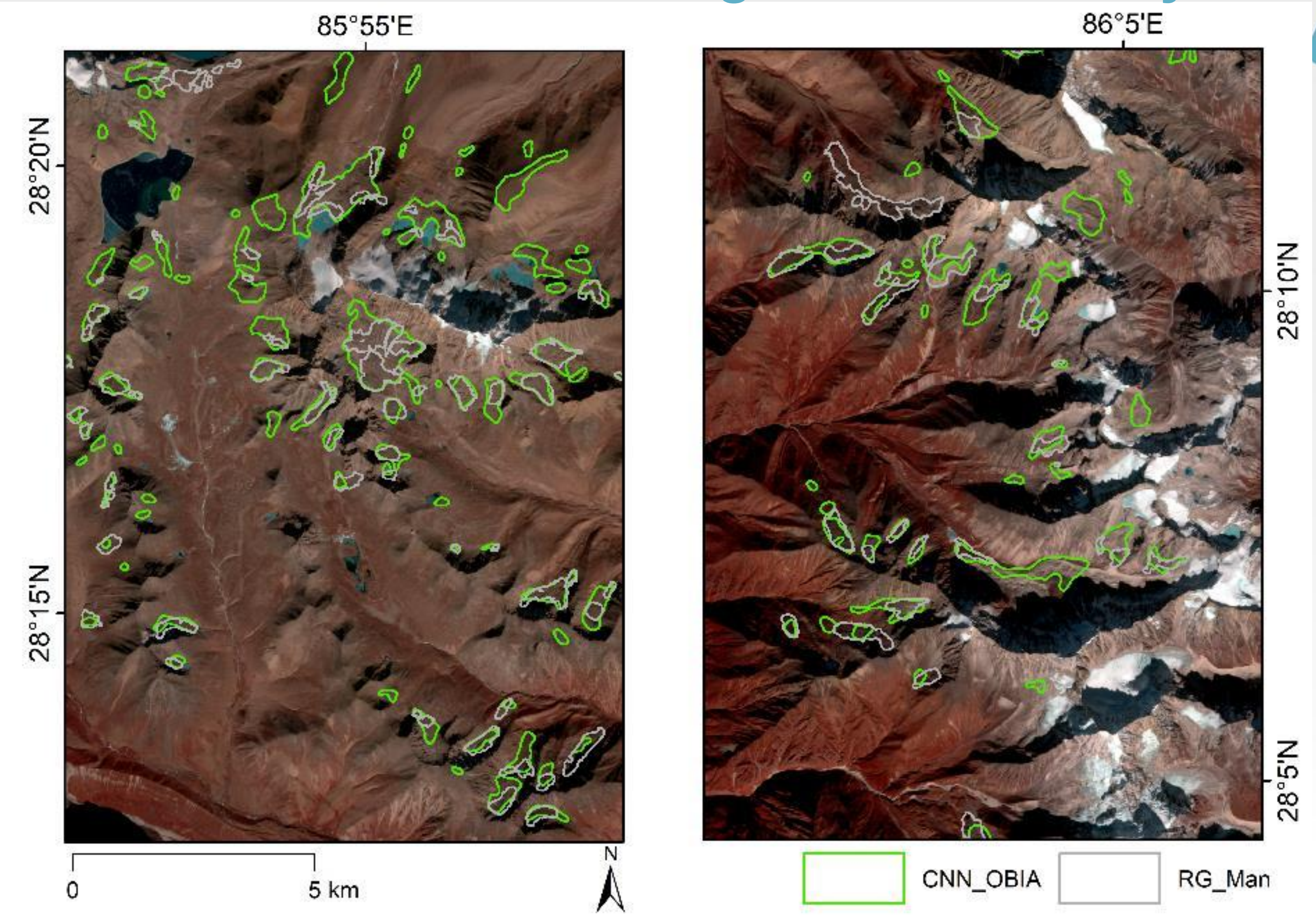
Comparison of automated outlines with optical image based surface velocities



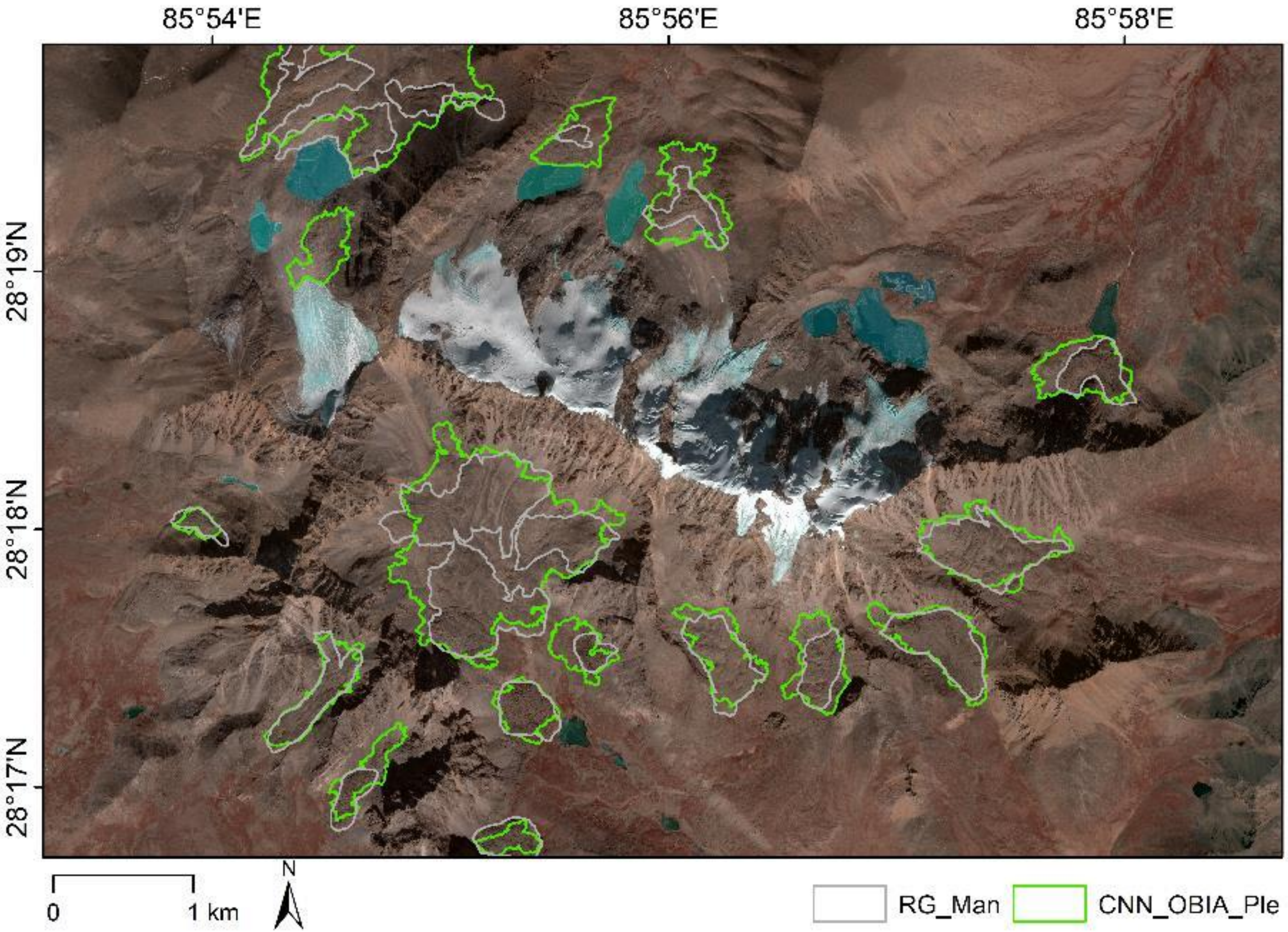
Comparison with manual rock glacier inventory – La Laguna



Comparison with manual rock glacier inventory - Poiqu



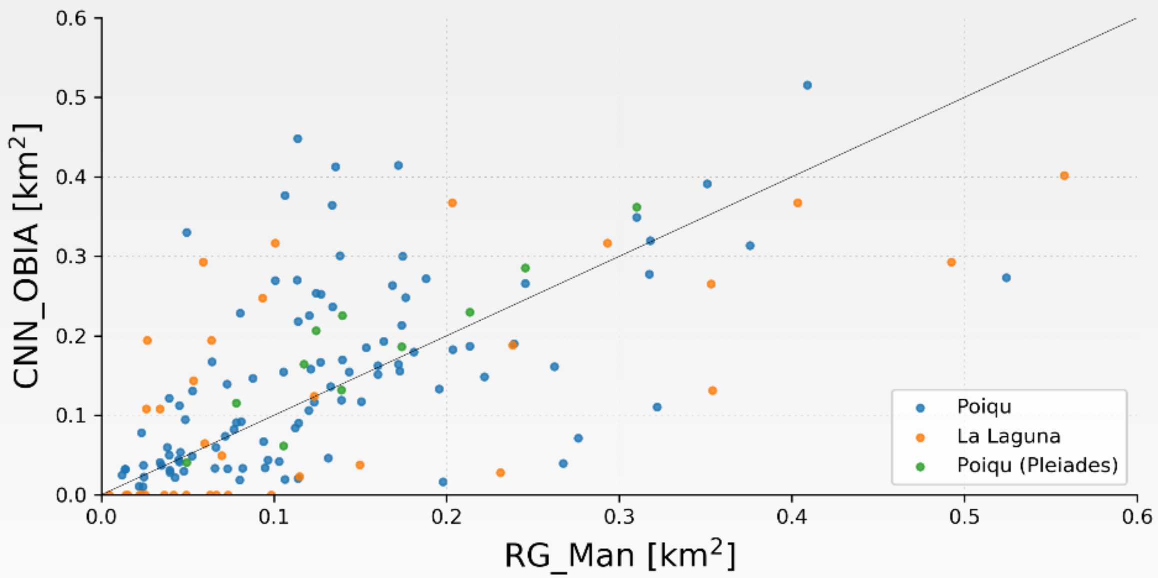
Comparison with manual rock glacier inventory – Poiqu



Analysis repeated on Pleiades imagery

Same accuracy, but smaller rock glacier mapped

Results - accuracy



Classification	User Accuracy (%)	Producer Accuracy (%)	Total Accuracy (%)	Kappa coefficient
La Laguna	63.9	75.4	97.1	0.67
Poiqu	68.8	75.0	56.5	0.72
Total (Sentinel)	65.9	71.4	72.0	0.68
Poiqu (Pléiades)	72.0	88.4	76.8	0.76

Conclusion

- A combination of CNNs and OBIA shows promise for creating rock glacier inventories from remote sensing data
- Future developments needed before the method can be used automatically for rock glacier inventories…
- …but our method reduces the amount of manual work needed