Giant Antarctic icebergs – Segmentation using a deep neural network

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Motivation

- Iceberg calving accounts for ~50% of ice loss from Antarctica
- Iceberg melting affects the Antarctic environment (ocean properties, biological production, sea ice formation)

→ **We need to know where icebergs melt how much**

- Freshwater flux can be calculated from satellite imagery and altimetry
- **Bottleneck**: Deriving **iceberg outlines** manually

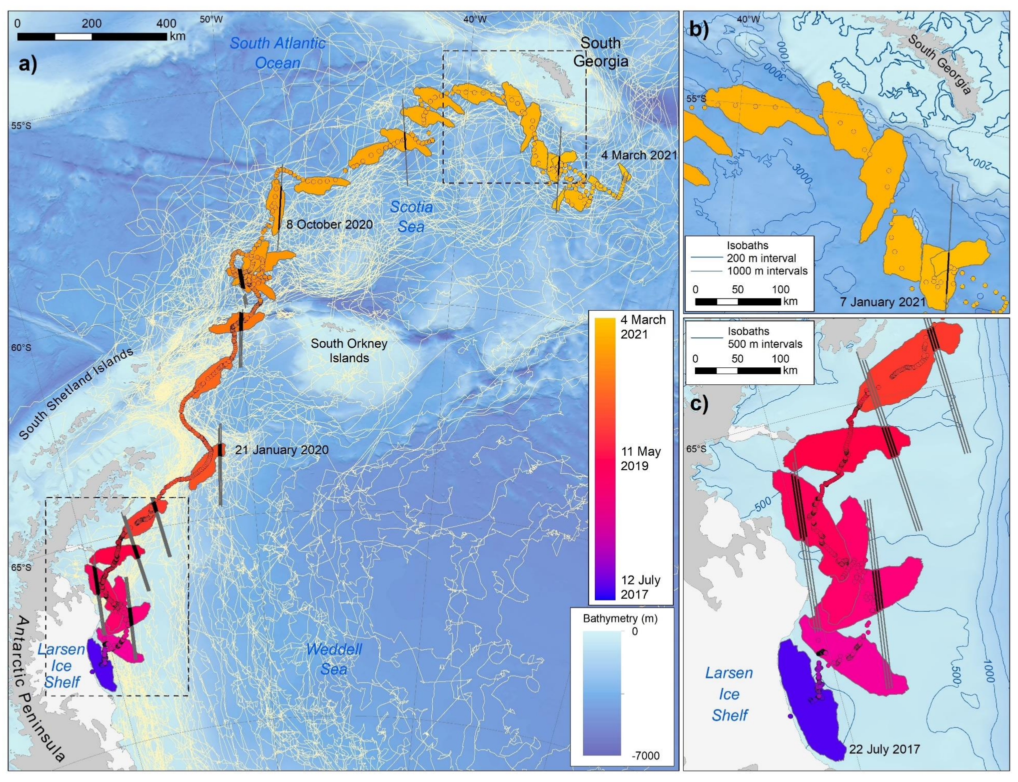


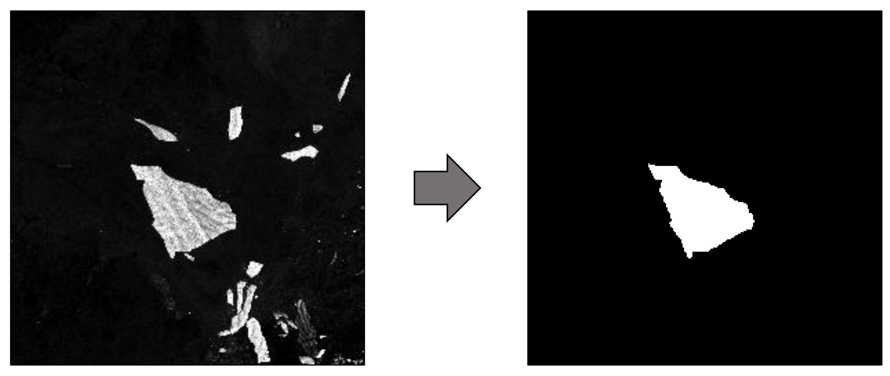
Figure: Braakmann-Folgmann et al. (2022)

Goal: Segment biggest iceberg in each image

- Rough position is known

→ Inputs contain iceberg

- **Goal:** Segment this berg, discard other fragments



Data: Sentinel 1 images

- 143 training images of 5 different icebergs for training and 24 images of 1 unseen iceberg for validation and testing each
- Ground truth outlines derived manually

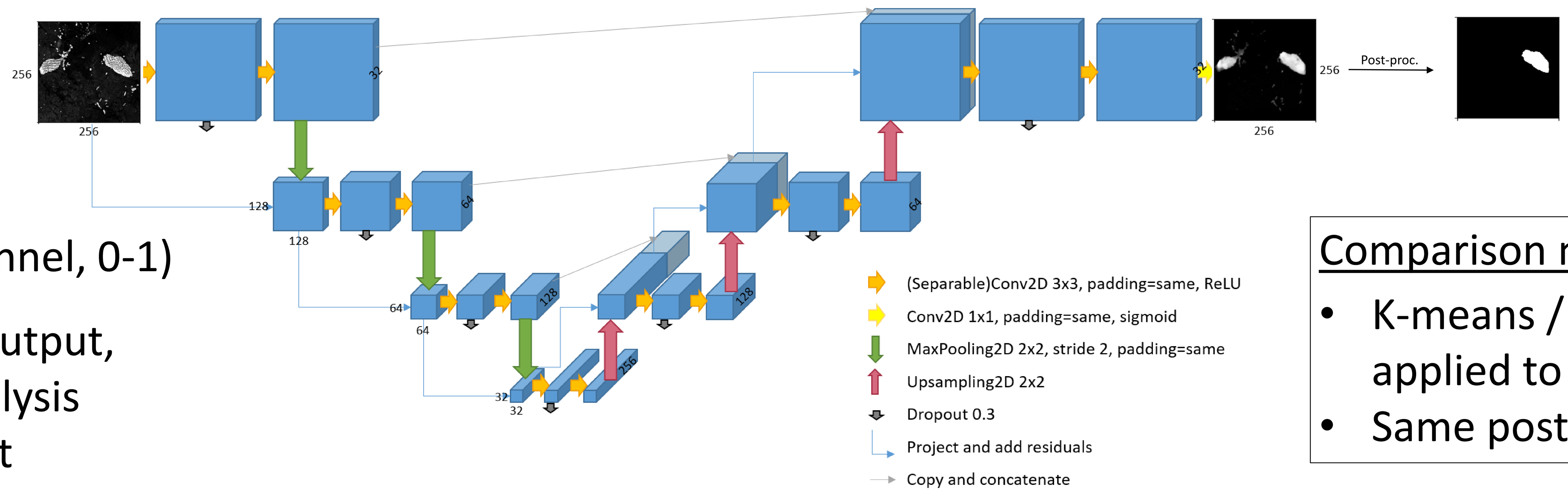
Training data | Validation data | Test data

Method: U-net

Input: Normalized backscatter (1 channel, 0-1)

Output: Iceberg/Background (1 channel, 0-1)

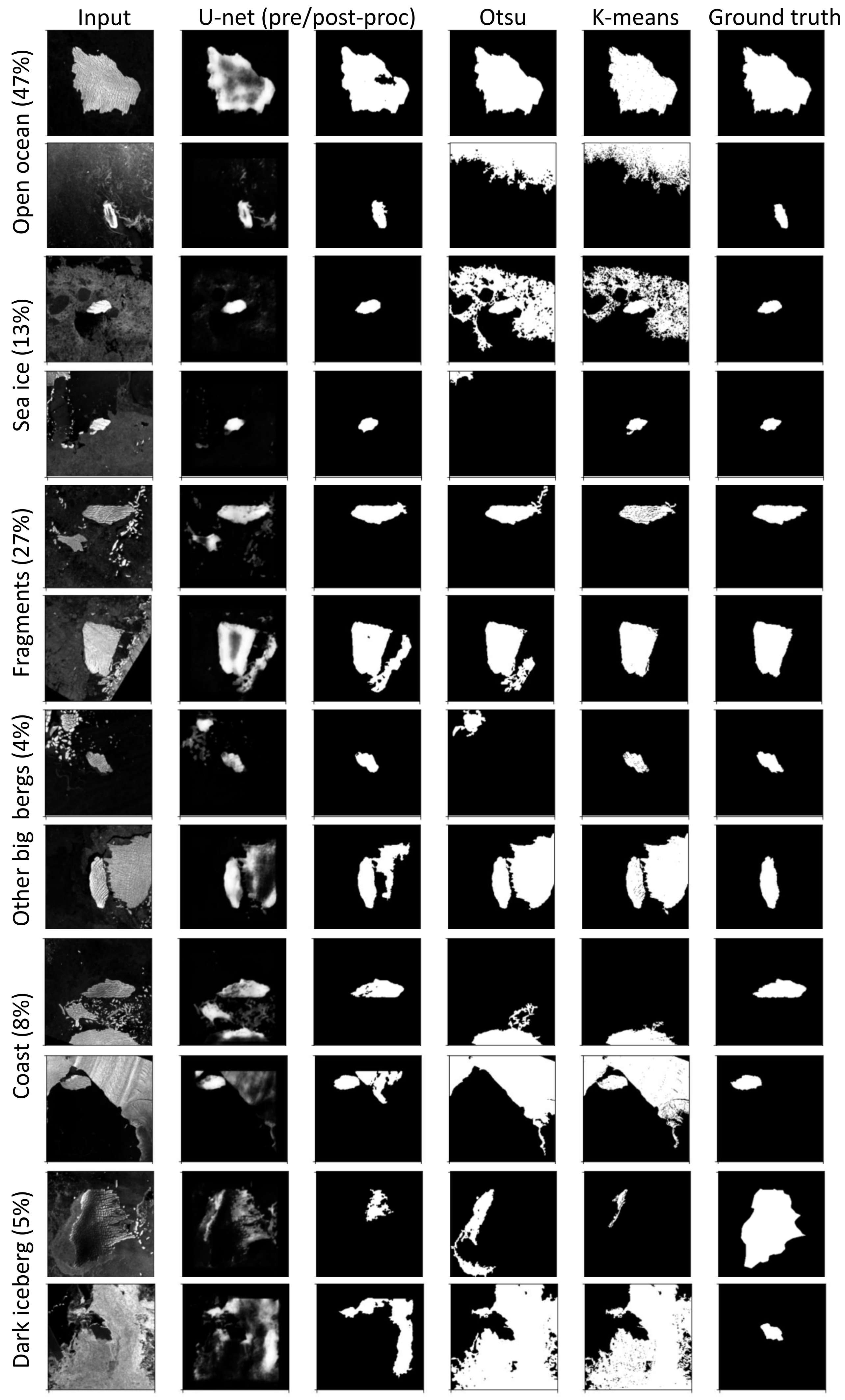
Post-processing: Thresholding the output, applying connected component analysis and selecting the largest component



Comparison methods:

- K-means / Otsu threshold applied to input
- Same post-processing

Results



- U-net, Otsu and K-means are applied to input images in different conditions
- F1 Score (= dice) and median area deviation are calculated

		Overall		Validation data		Test data	
		F1-score	Area dev.	F1 Score	Area dev.	F1 Score	Area dev.
Ocean	U-net	**0.97**	**2%**	0.96	6%	0.97	**2%**
	Otsu	**0.97**	**2%**	**0.98**	**1%**	**0.98**	3%
	K-means	0.96	3%	0.92	14%	**0.98**	5%
Sea ice	**U-net**	**0.94**	6%	**0.91**	**6%**	0.96	8%
	Otsu	0.72	**4%**	0.80	16%	**0.98**	**3%**
	K-means	0.74	5%	0.81	21%	**0.98**	**3%**
Fragments	**U-net**	0.88	7%	**0.93**	**4%**	0.97	**2%**
	Otsu	**0.91**	7%	0.92	11%	**0.98**	4%
	K-means	0.88	**6%**	0.75	21%	0.97	6%
Bigger Bergs	**U-net**	**0.45**	**11%**			**0.33**	**10%**
	Otsu	0.12	127%			0.00	111%
	K-means	0.19	**11%**			0.09	13%
Coast	**U-net**	**0.60**	**33%**	**0.92**	**12%**		
	Otsu	0.12	1189%	0.36	58%		
	K-means	0.11	1166%	0.00	30%		
Dark bergs	U-net	0.20	87%			0.03	258%
	Otsu	0.13	186%			0.03	2690%
	K-means	0.10	114%			0.03	2391%

Conclusions

- We present a **novel approach using a deep neural network** to segment giant icebergs in Sentinel 1 images
- **U-net outperforms state-of-the-art** approaches in **difficult conditions** (sea ice, berg fragments, nearby coast, ..)
- Dark icebergs, too much coast, other bergs of similar size and lots of nearby fragments remain a problem for all techniques