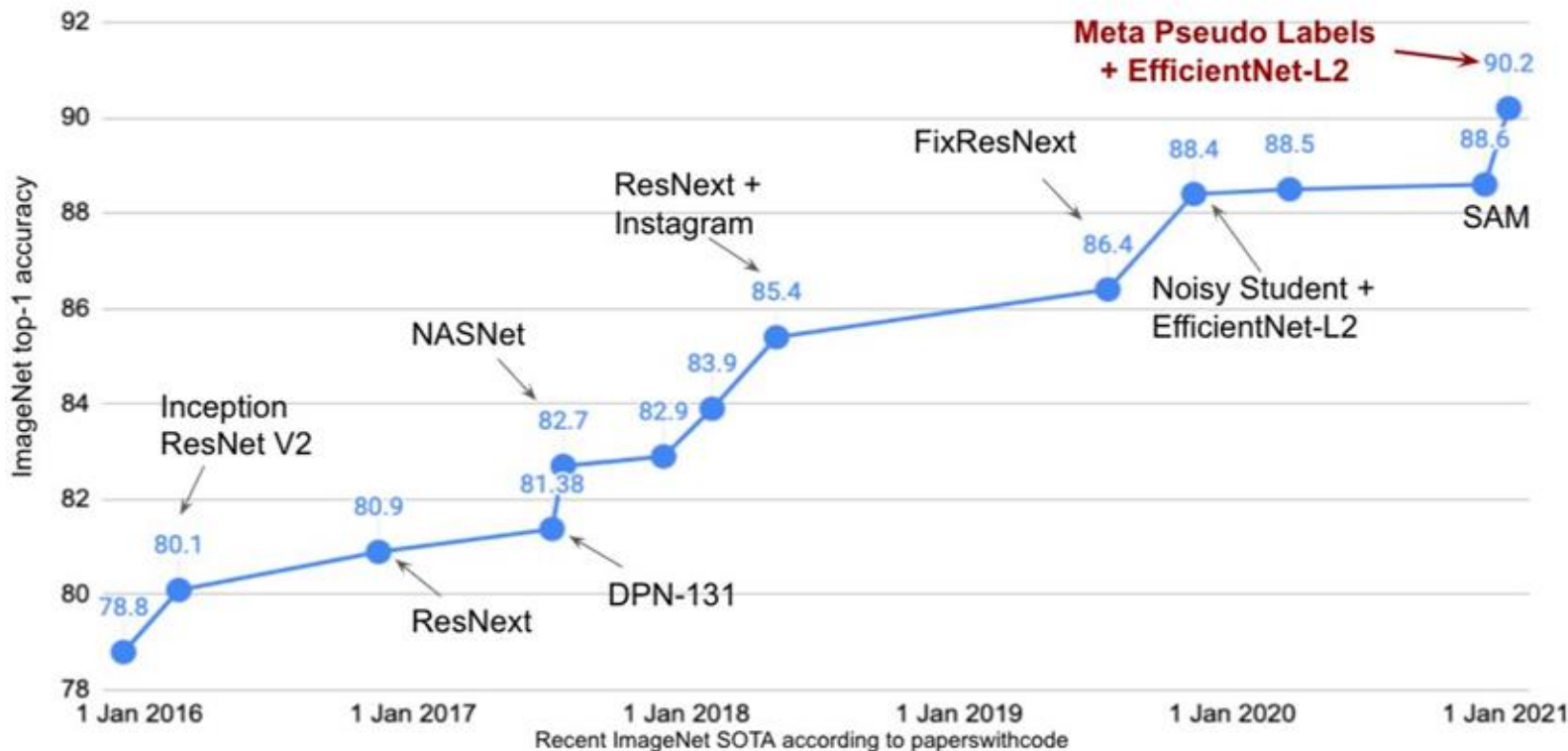


Automated Machine Learning for Sea Ice Concentration Charting

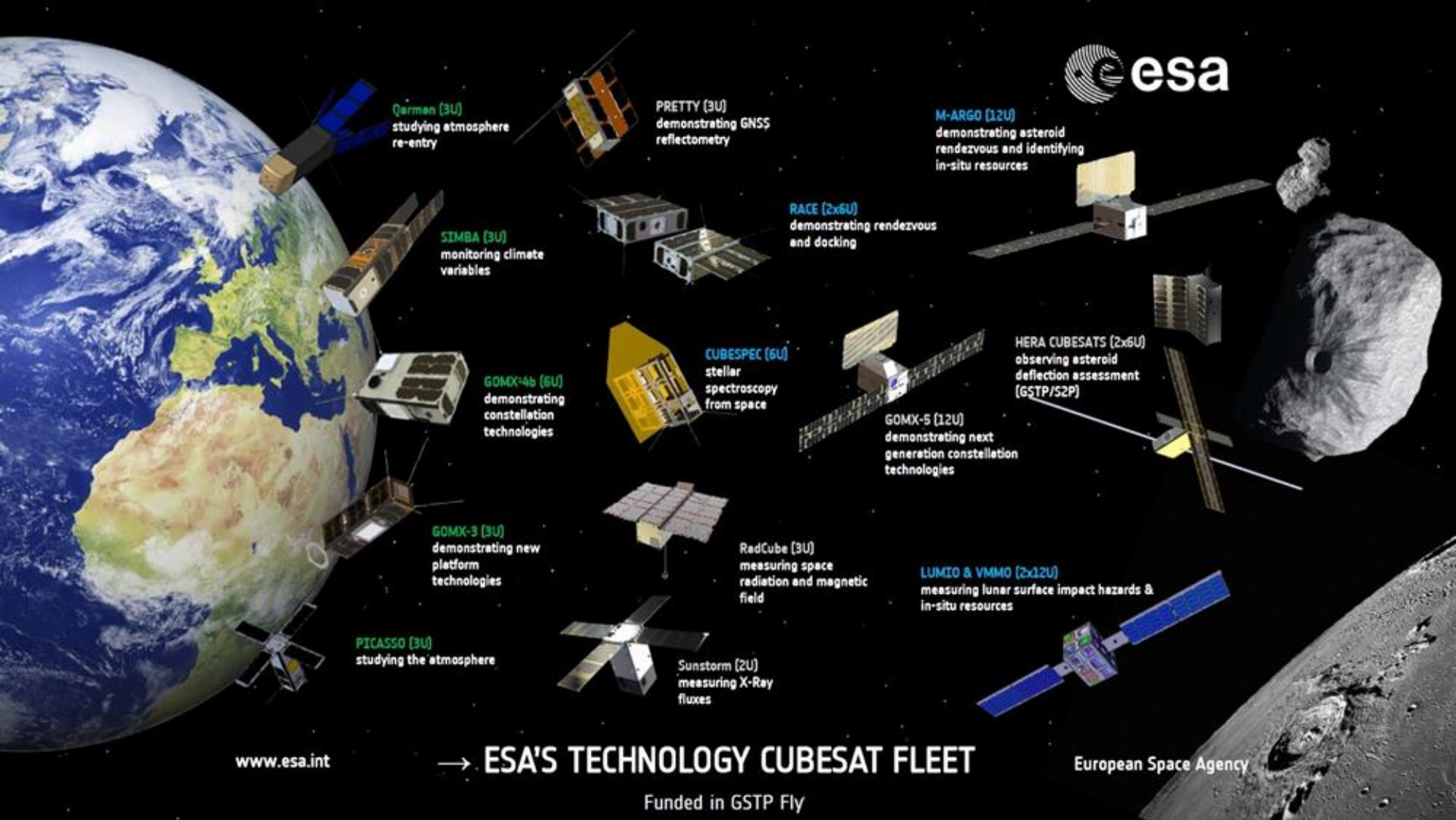
Sven van Collenburg, Andreas Stokholm, Holger Hoos, Jan van Rijn

ImageNet – Progress of the State of the Art



After TabPFN, why still NAS?

Usual answer: Robustness, Hardware-awareness, and Sustainability



QARMEN (3U)
studying atmosphere
re-entry

PRETTY (3U)
demonstrating GNSS
reflectometry

M-ARGO (12U)
demonstrating asteroid
rendezvous and identifying
in-situ resources

SIMBA (3U)
monitoring climate
variables

RACE (2x6U)
demonstrating rendezvous
and docking

GOMX-4b (6U)
demonstrating
constellation
technologies

CUBESPEC (6U)
stellar
spectroscopy
from space

HERA CUBESATS (2x6U)
observing asteroid
deflection assessment
(GSTP/S2P)

GOMX-5 (12U)
demonstrating next
generation constellation
technologies

GOMX-3 (3U)
demonstrating new
platform
technologies

RedCube (3U)
measuring space
radiation and magnetic
field

LUMIO & VMMO (2x12U)
measuring lunar surface impact hazards &
in-situ resources

PICASSO (3U)
studying the atmosphere

Sunstorm (2U)
measuring X-Ray
fluxes

www.esa.int

→ **ESA'S TECHNOLOGY CUBESAT FLEET**

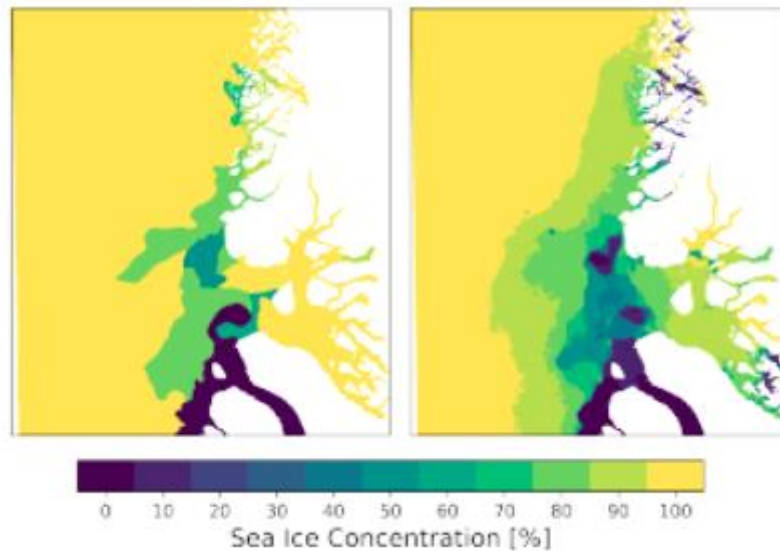
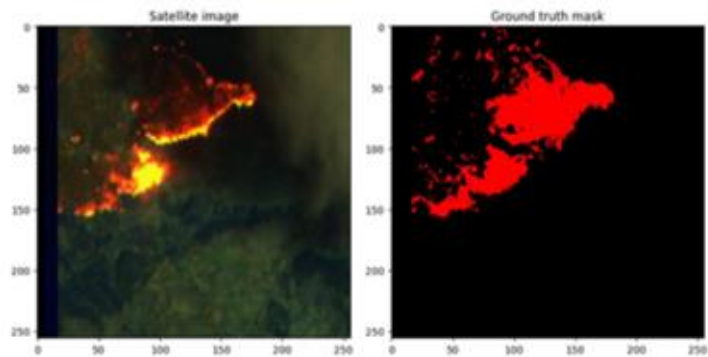
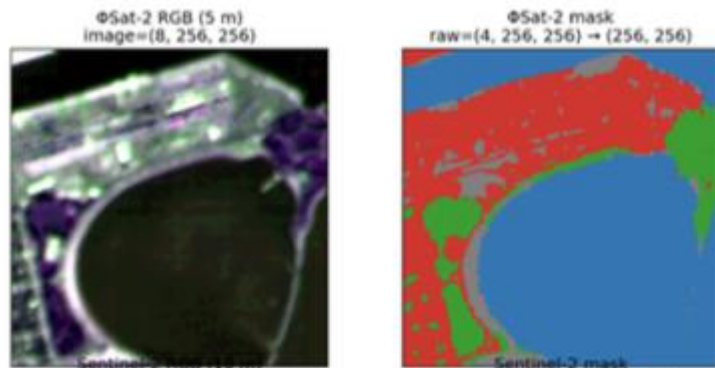
European Space Agency

Funded in GSTP Fly

Machine Learning tasks for Satellite data

- Large amounts of open data (Copernicus data)
- Freely accessible input data (labels are a challenge)
- Image Segmentation (not all ML-libraries match)
- Mean intersection over Union (mIoU)
- Several student thesis have been executed in our group with or at ESA

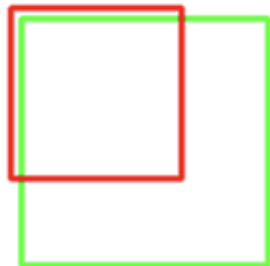
Projects within ESA



Mean Intersection over Union

$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$


IoU: 0.4034



Poor

IoU: 0.7330



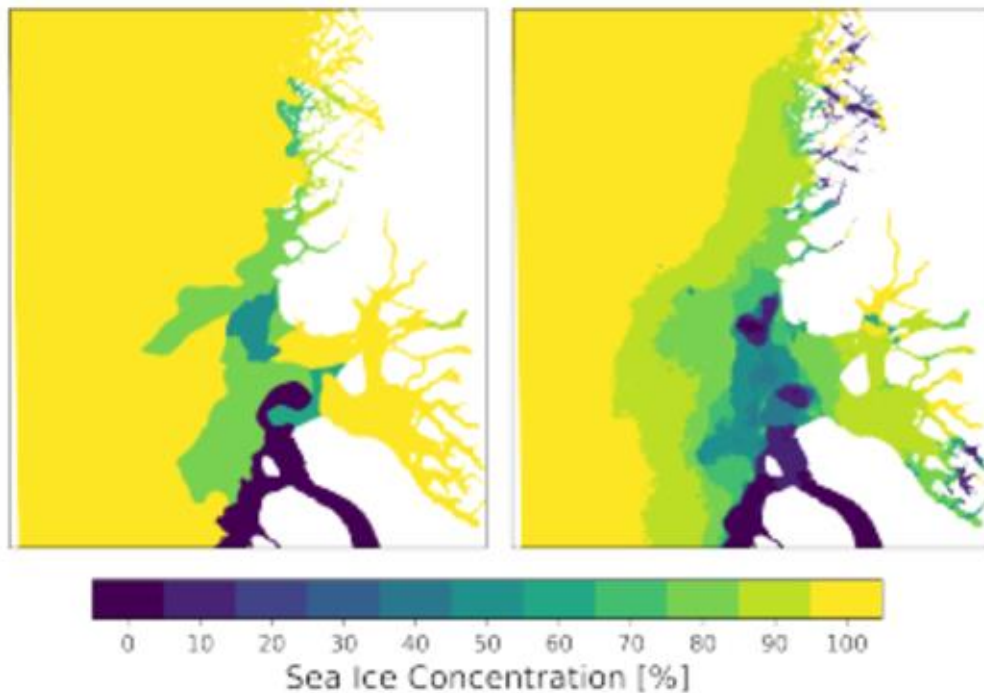
Good

IoU: 0.9264



Excellent

Sea ICE Chart

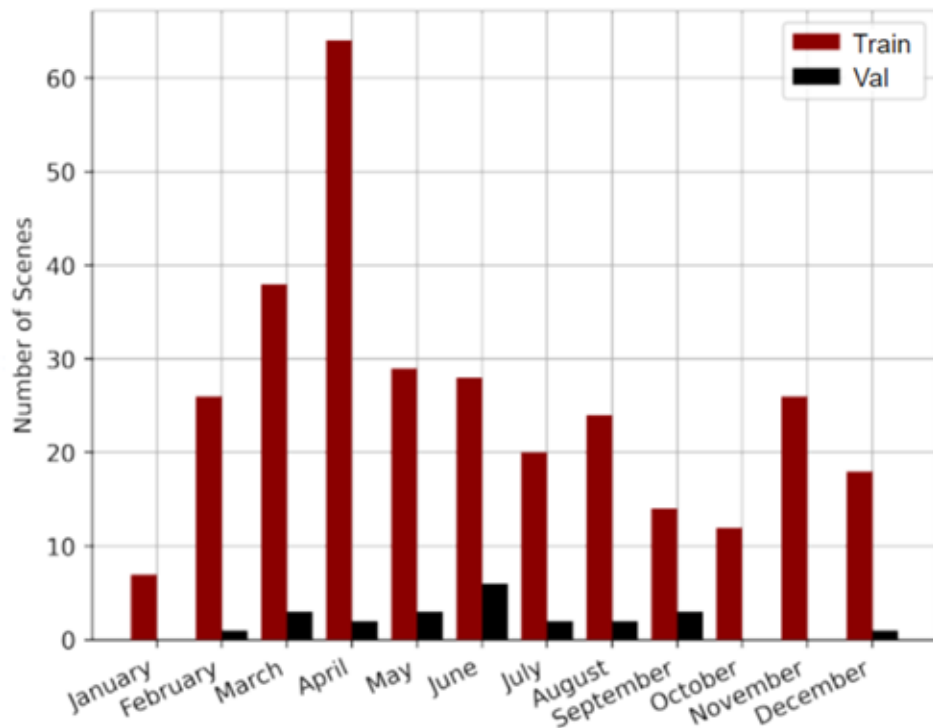


- Traditionally drawn by experts
- Plane or SAR satellite
- Proxy for Sea Ice Concentration based on sun reflection

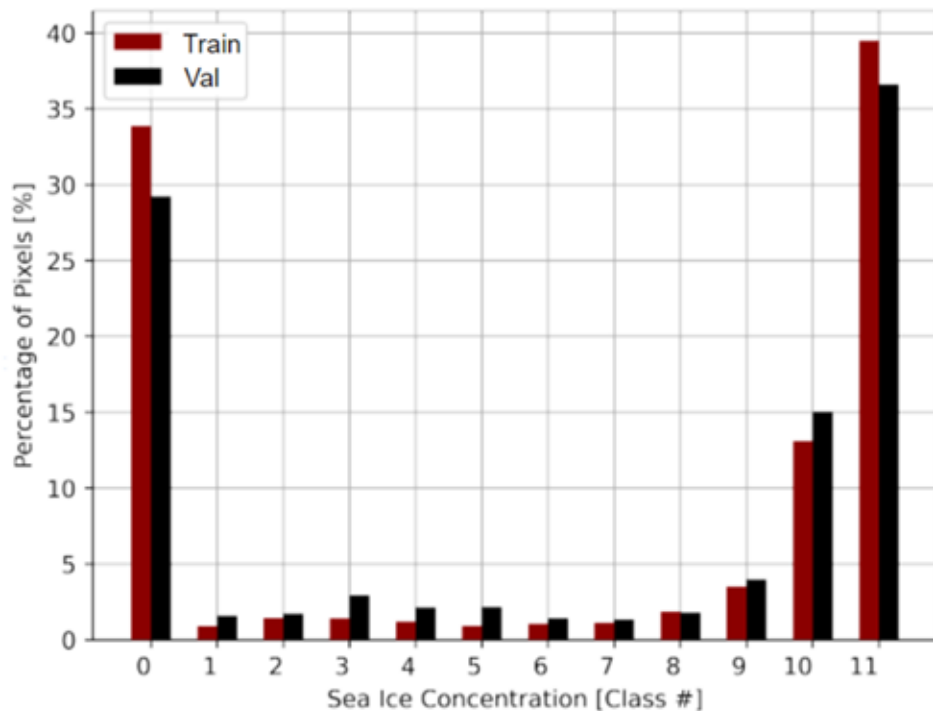
Challenges:

- Acquiring labels [but dataset released]
- discrepancy between annotators
- seasonality

Seasonal effects



(a)



(b)

Synthetic-Aperture Radar (SAR)



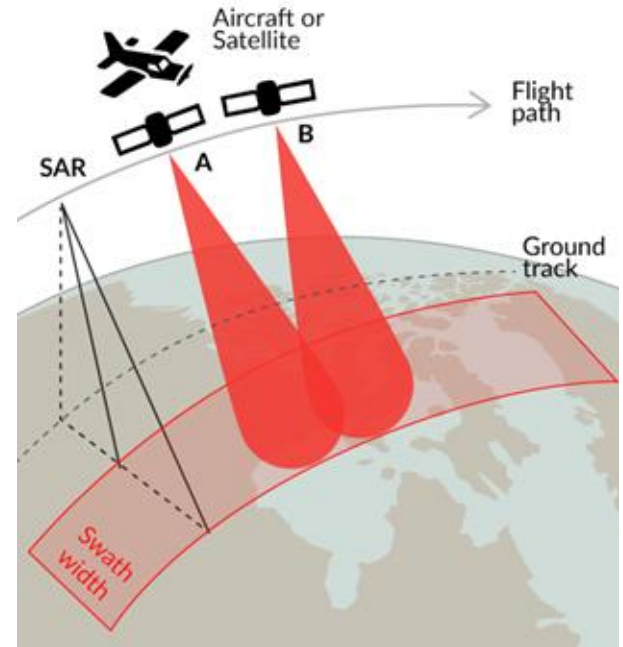
GNO-SYS

(SAR)

SYNTETHIC-APERTURE RADAR

The swath is always visible to the satellite while traveling from Point A to B.

The data can be processed similarly as if it were the aperture of a huge radar.



DL libraries (APIs) for building up
DL pipelines



TensorFlow



TensorFlow Keras API

AutoDL libraries (APIs) for
tuning DL pipelines



Keras Tuner



AutoKeras

Configurable

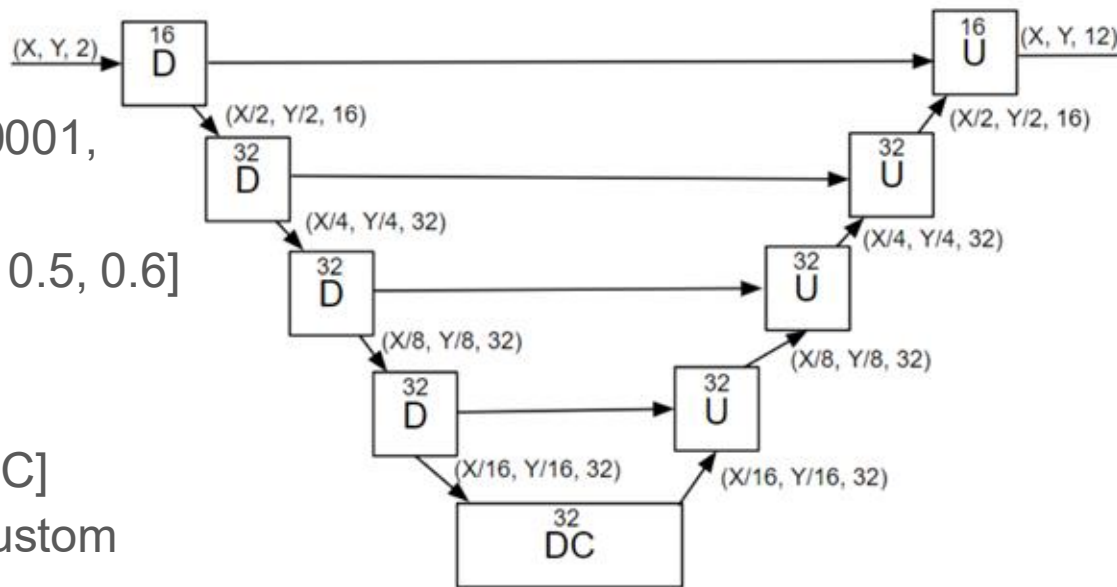
More customizable arguments and
structures of DL pipelines with more
complex APIs and use cases

Simple

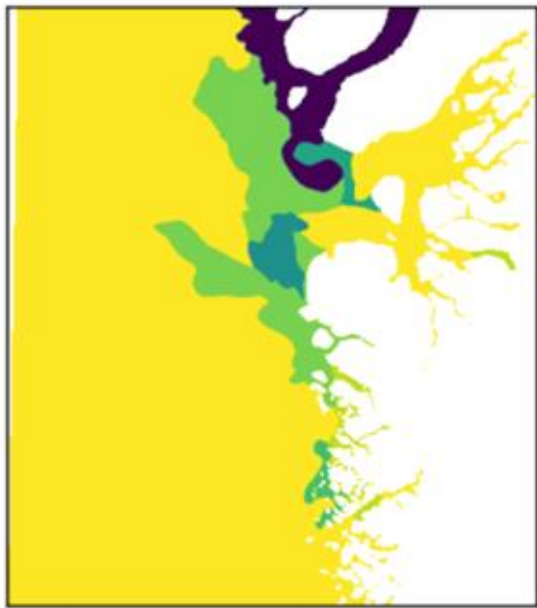
Less customizable arguments and
structures of DL pipelines with simpler
APIs for modeling and tuning

UNET with residual layers + hyperparameters

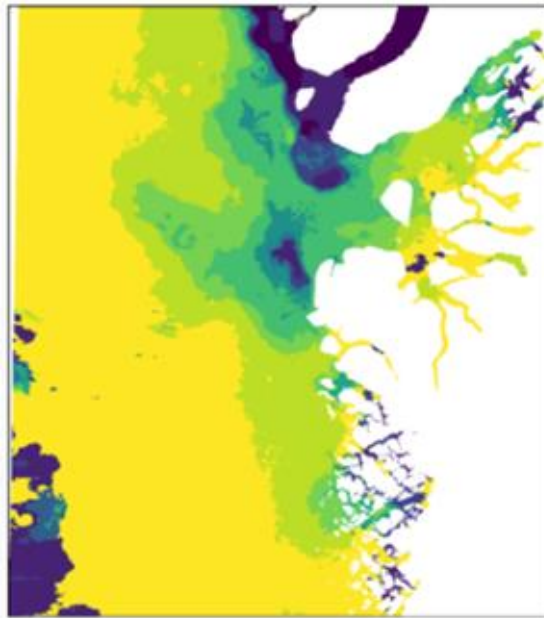
- num levels : [4, 5, 6, 7, 8]
- learning rate: [0.000001, 0.00001, 0.0001, 0.001, 0.01, 0.1]
- dropout: [0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6]
- max level size: [32, 64, 128]
- load randomly: [True, False]
- noise reduction: [ESA, NERSC]
- weights: [None, Ignore 11, Custom]



Complications of R2



target



-9.21%



-0.0068%

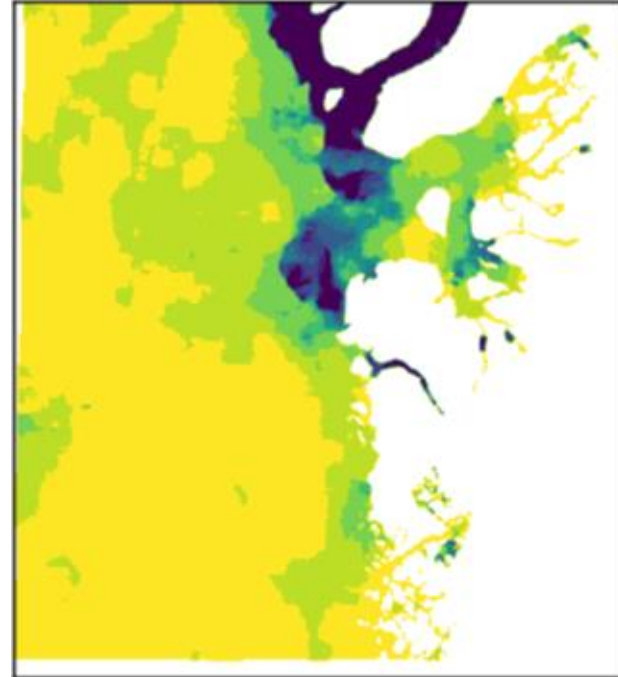
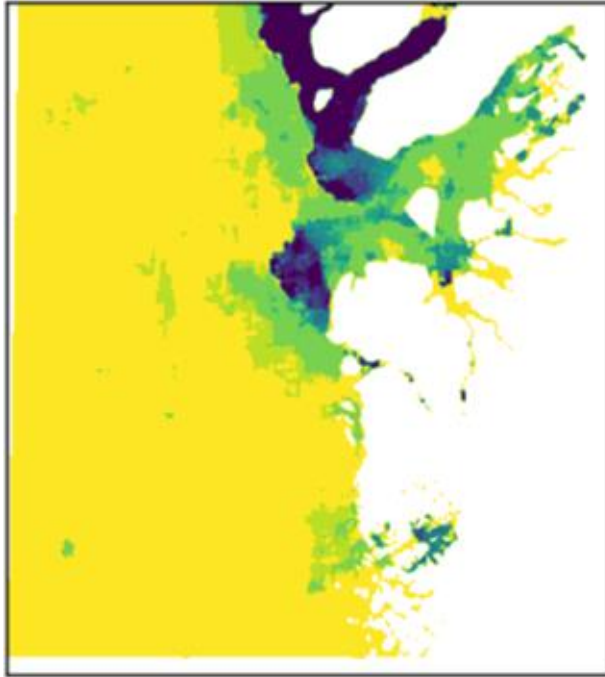
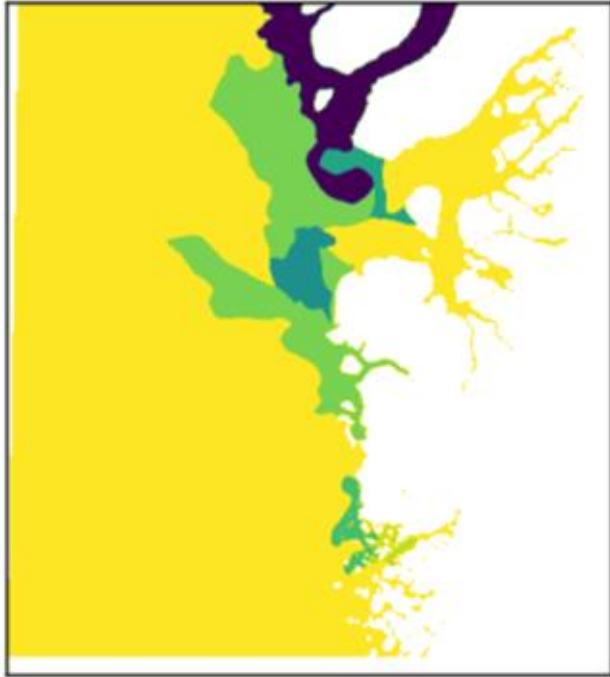
Baselines (Average Class)

R^2	RMSE	rounded R^2	rounded RMSE	Accuracy
-1.94	4.24	-1.80	4.21	0.03%

Results

#	lvl	learning	drop	size	rand	noise	weights	Accuracy	RMSE	R^2
1.1	6	1.39e-4	0.0	64	False	NERSC	None	72.30%	1.62	86.01%
1.2	6	1.71e-4	0.0	64	False	NERSC	None	71.51%	1.63	85.86%
1.3	5	1.89e-04	0.0	128	False	NERSC	None	73.13%	1.66	85.39%
2.1	7	5.17e-5	0.0	128	True	NERSC	Ignore_11	72.48%	1.72	84.23%
2.2	7	2.57e-4	0.3	128	True	SAR	None	72.33%	1.90	80.69%
2.3	6	6.74e-5	0.1	128	True	NERSC	Ignore_11	72.41%	1.91	80.64%
3.1	6	1.09e-4	0.0	128	False	NERSC	None	67.06%	1.62	86.03%
3.2	8	2.66e-4	0.1	64	False	NERSC	None	66.83%	1.87	81.32%
3.3	6	4.39e-4	0.1	128	False	SAR	None	72.43%	1.90	80.84%

What does these images look like?



Conclusions

- ESA data full of interesting test cases
- Sea Ice Charting important for shipping routes
- Can be automated by AI, based on satellite data
- Mean intersection over union
- Able to reach close to human level performance