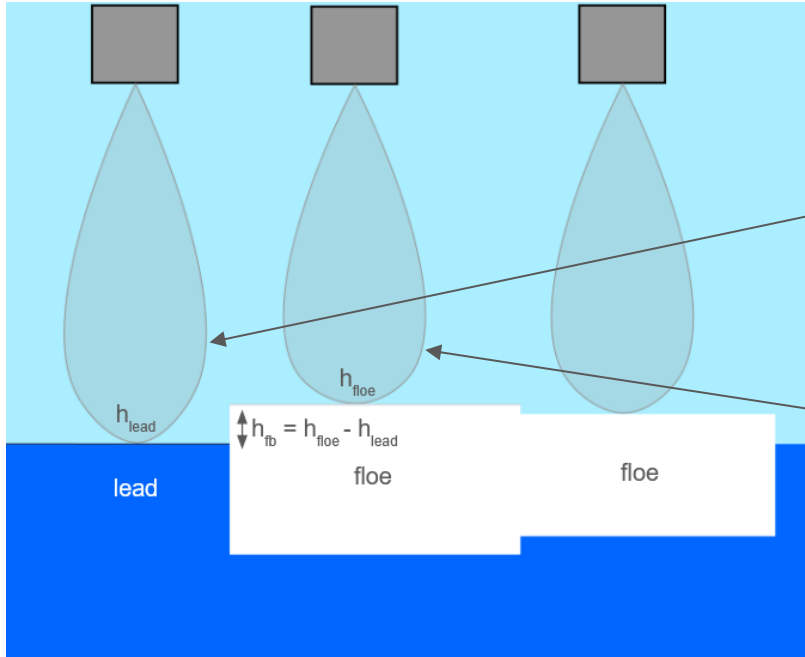


## **Comparison of the floe/lead classification of the SRAL measurements with OLCI images for sea ice thickness retrieval**

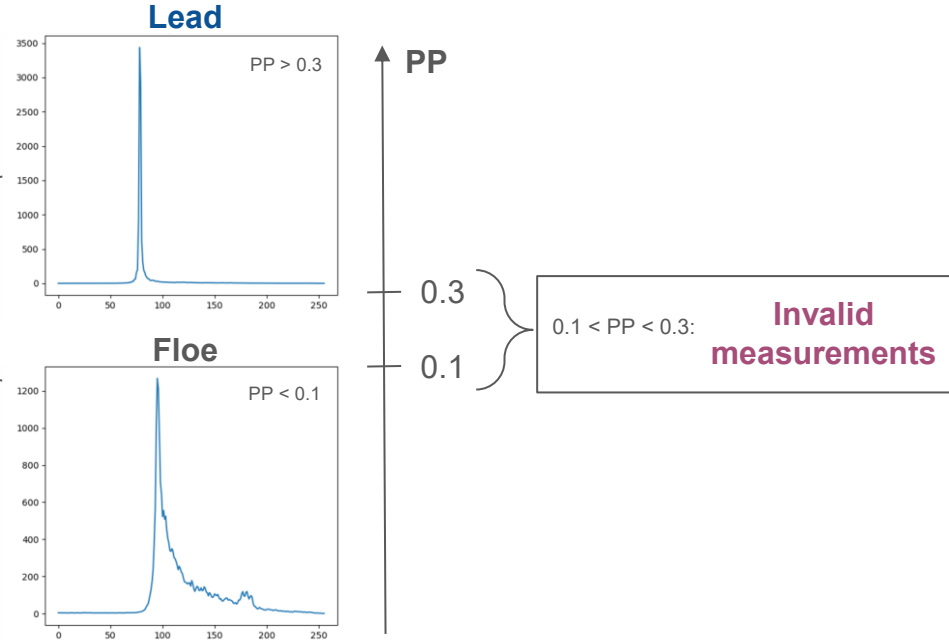
Laura Orgambide (ONERA/CNES)  
Flora Weissgerber (DTIS, ONERA)  
Sara Fleury (LEGOS, CNRS)  
Frédéric Champagnat (DTIS, ONERA)  
Carlos Yanez (CNES)

# HOW TO ESTIMATE SEA ICE THICKNESS?

Freeboard method:



Pulse Peakiness (PP) criteria  
for altimetric floe/lead  
classification:



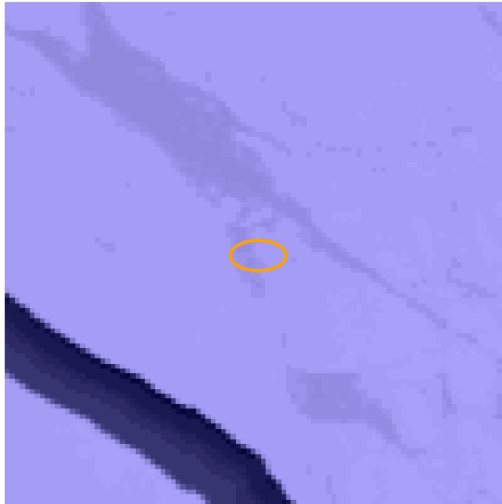
- total sea ice thickness: 
$$h_i = \frac{\rho_w}{\rho_w - \rho_i} h_{fb}$$

*How to validate the altimetric floe/lead classification method?*

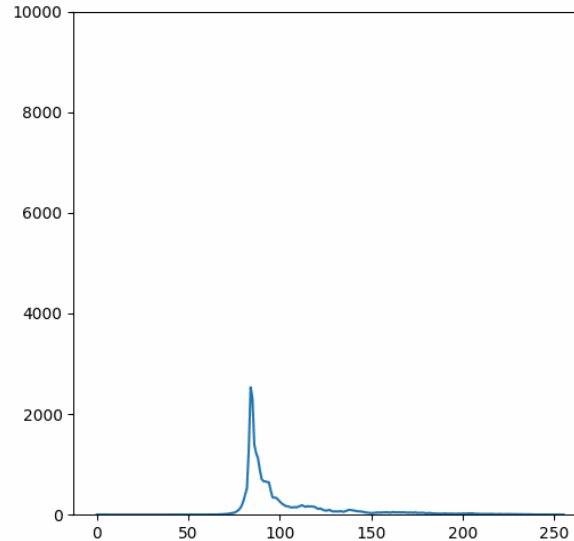
# SENTINEL-3 OLCI/SRAL: A UNIQUE OPPORTUNITY TO STUDY COINCIDENT ALTIMETER MEASUREMENTS WITH IMAGES

→ take advantage of the Sentinel-3 coincident SRAL altimeter data with OLCI images

*OLCI*  
*(300 m de résolution)*



*SRAL*



→ OLCI as reference data to:

1. validate the altimeter floe/lead classification
1. improve the altimeter floe/lead classification using OLCI classified images

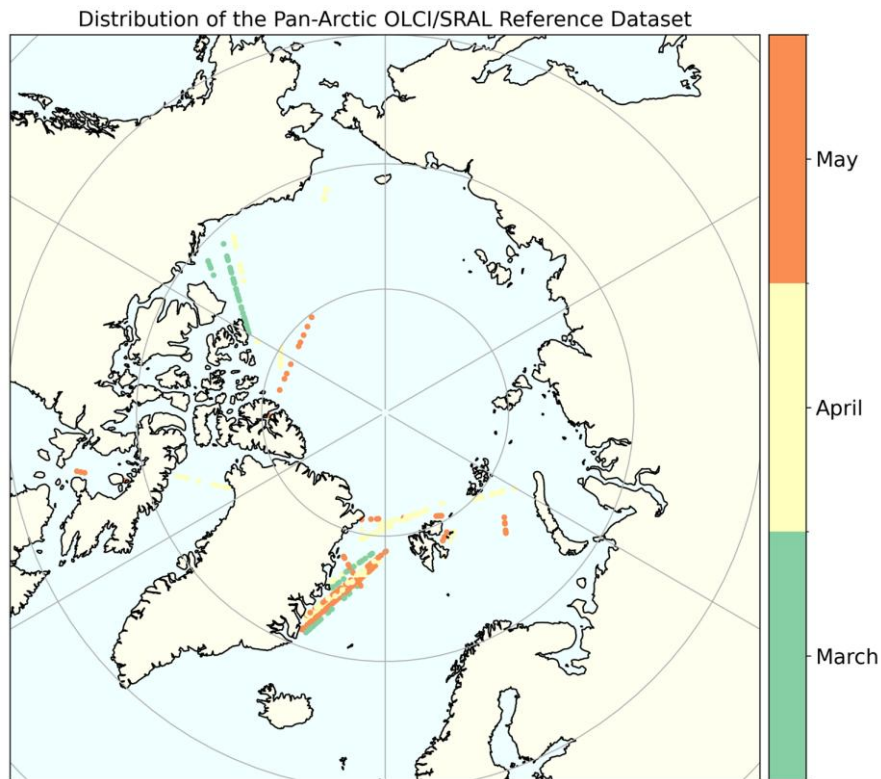
product  
reference:

OL\_1\_EFR

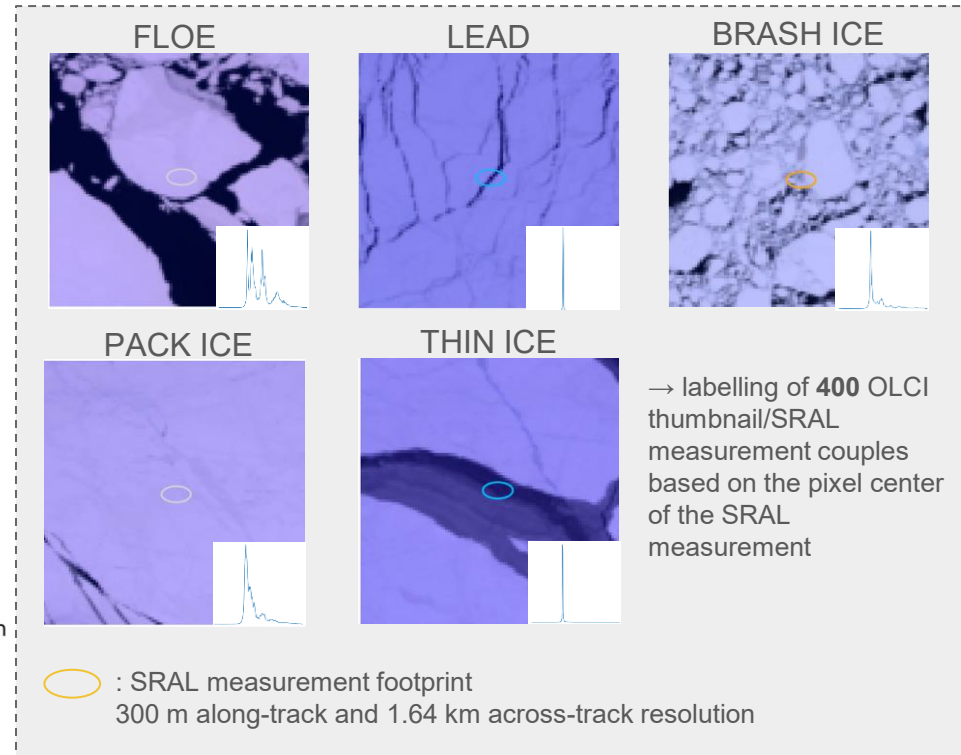
LEGOS SR\_2\_LAN

# A PAN-ARTIC OLCI/SRAL REFERENCE DATASET

*For altimetric floe/lead classification validation*



## OLCI/SRAL REFERENCE DATASET



→ different types of ice: fragmented ice in Fram Strait and concentrated ice in Beaufort Sea

→ unusable data from June to July due to melt ponds / unavailable data from September to November

→ manual search of not cloudy scenes along the altimeter track

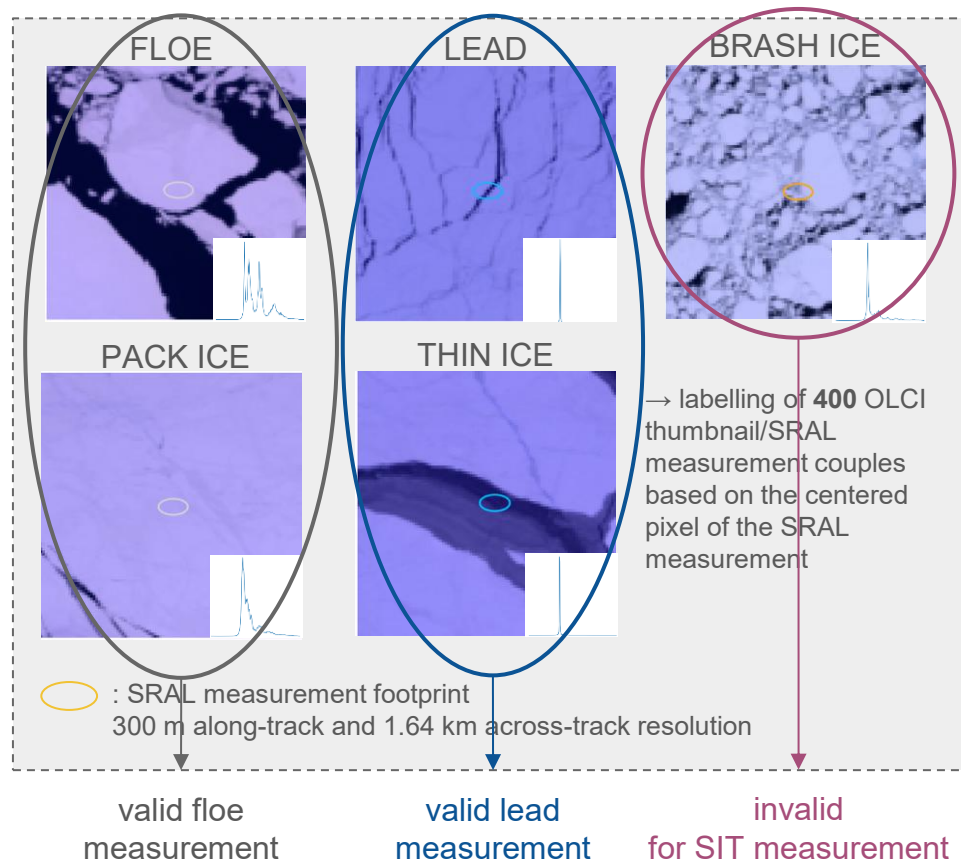
# ASSESSMENT OF THE ALTIMETRIC FLOE/LEAD CLASSIFICATION

## Label correspondences

OLCI hand label	valid_lead	invalid_lead	valid_floe	invalid_floe
lead	45 (54.88%)	0 (0.00%)	12 (8.05%)	32 (19.51%)
thin_ice	16 (19.51%)	1 (9.09%)	1 (0.67%)	35 (21.34%)
floe	2 (2.44%)	0 (0.00%)	73 (48.99%)	20 (12.20%)
pack_ice	0 (0.00%)	1 (9.09%)	47 (31.54%)	15 (9.15%)
brash_ice	19 (23.17%)	9 (81.82%)	16 (10.74%)	62 (37.80%)

SRAL label

## OLCI/SRAL REFERENCE DATASET



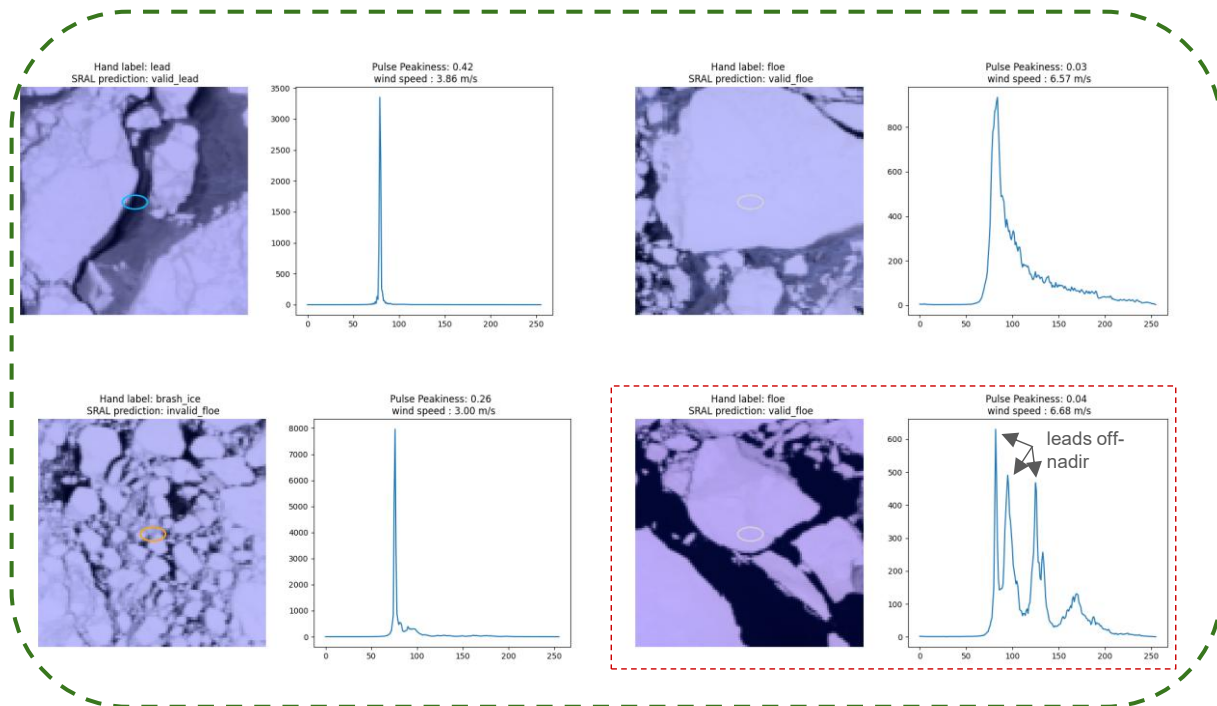
# ASSESSMENT OF THE ALTIMETRIC FLOE/LEAD CLASSIFICATION

## Pulse Peakiness criteria

→ altimetric floe/lead classification accuracy: 62%

OLCI hand label	SRAL label			
	valid_lead	invalid_lead	valid_floe	invalid_floe
lead	45 (54.88%)	0 (0.00%)	12 (8.05%)	32 (19.51%)
thin_ice	16 (19.51%)	1 (9.09%)	1 (0.67%)	35 (21.34%)
floe	2 (2.44%)	0 (0.00%)	73 (48.99%)	20 (12.20%)
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## WELL-CLASSIFIED WAVEFORMS



→ PP criteria allows to classify altimeter measurements for typical and ambiguous waveforms

→ but some untypical waveforms should not be classified as valid

# ASSESSMENT OF THE ALTIMETRIC FLOE/LEAD CLASSIFICATION

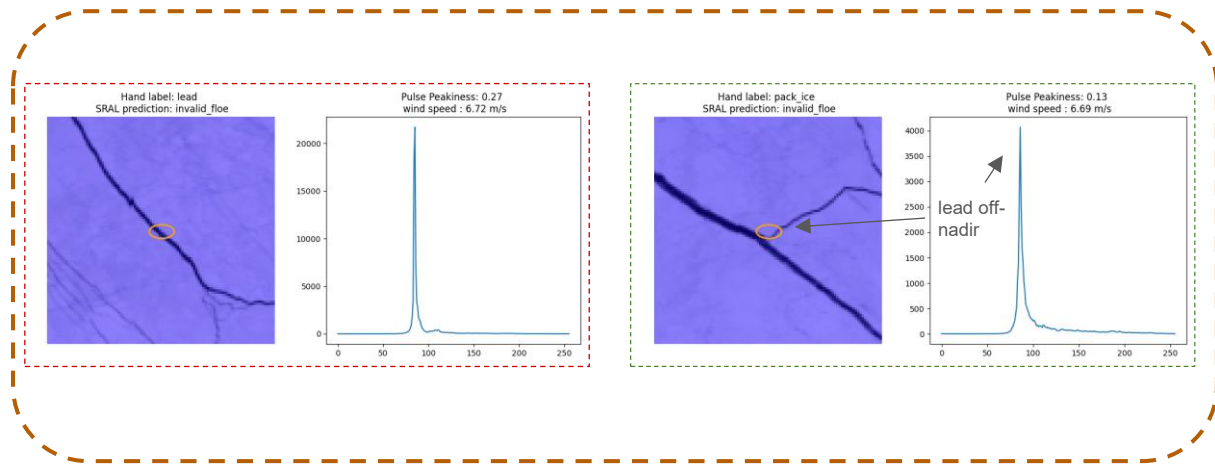
## Pulse Peakiness criteria

→ altimetric floe/lead  
classification accuracy: 62%

OLCI hand label	valid_lead	invalid_lead	valid_floe	invalid_floe
lead	45 (54.88%)	0 (0.00%)	12 (8.05%)	32 (19.51%)
thin_ice	16 (19.51%)	1 (9.09%)	1 (0.67%)	35 (21.34%)
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brash_ice	19 (23.17%)	9 (81.82%)	16 (10.74%)	62 (37.80%)

SRAL label

## AMBIGUOUS WAVEFORMS



→ PP criteria rejects ambiguous waveforms

→ 2 cases:

- measurements that could be used to derive sea ice thickness. Rejecting them reduces precision in the sea ice thickness estimation.
- measurements that must not be used to derive sea ice thickness. Rejecting them removes biases in the sea ice thickness estimation.

# ASSESSMENT OF THE ALTIMETRIC FLOE/LEAD CLASSIFICATION

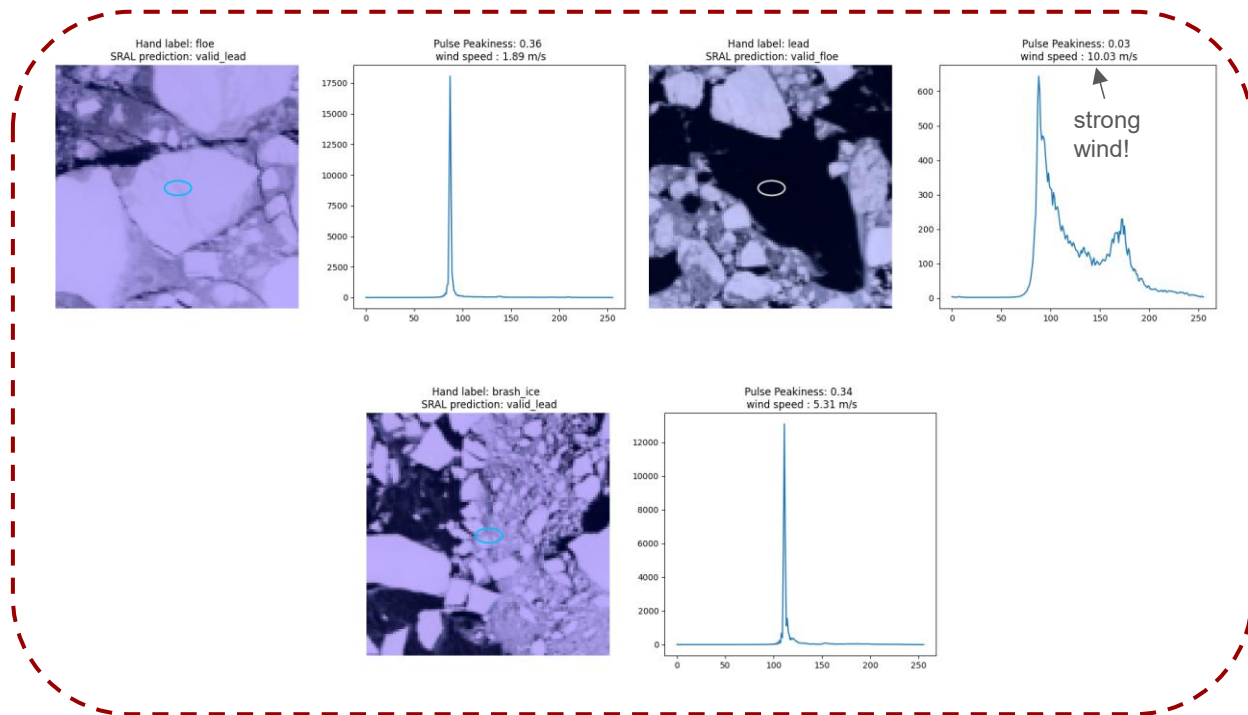
## Pulse Peakiness criteria

→ altimetric floe/lead  
classification accuracy: 62%

OLCI hand label	valid_lead	invalid_lead	valid_floe	invalid_floe
lead	45 (54.88%)	0 (0.00%)	12 (8.05%)	32 (19.51%)
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SRAL label

## CLASSIFICATION ERRORS

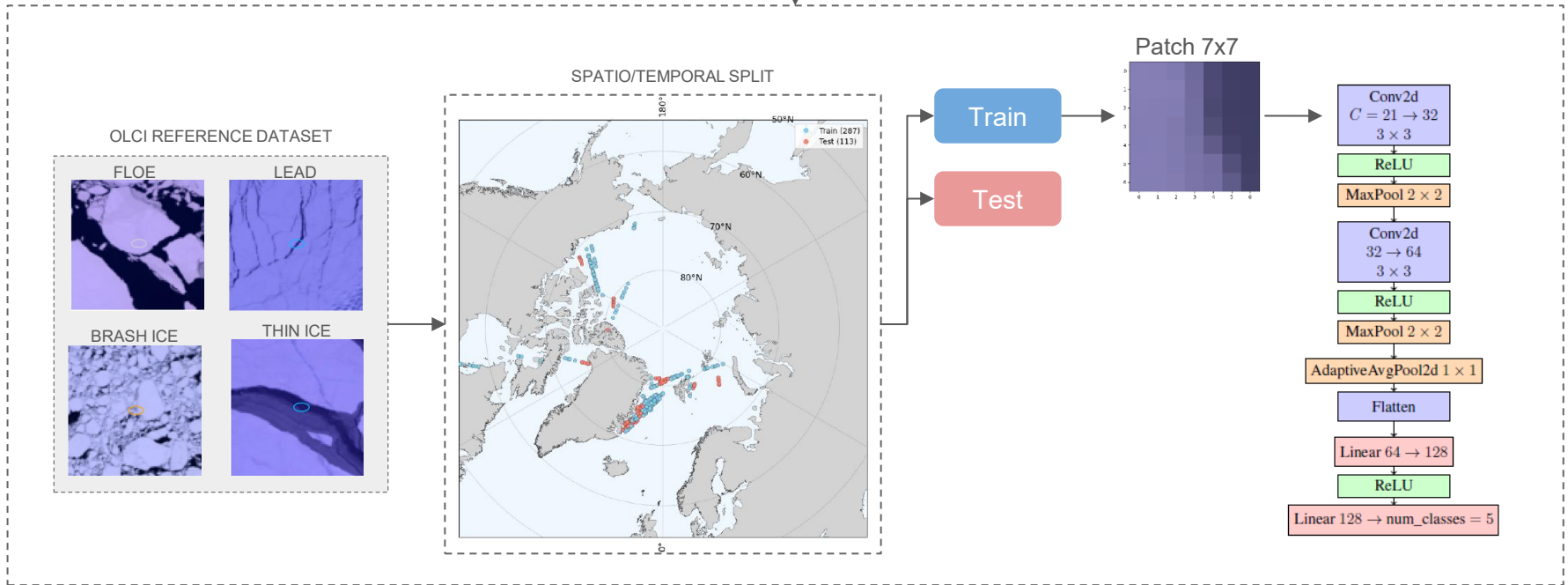


→ PP criteria is not robust to sea ice surface variability

# FLOE/LEAD CLASSIFICATION FOR OLCI IMAGES : TRAINING OF A CNN

OLCI image floe/lead classification

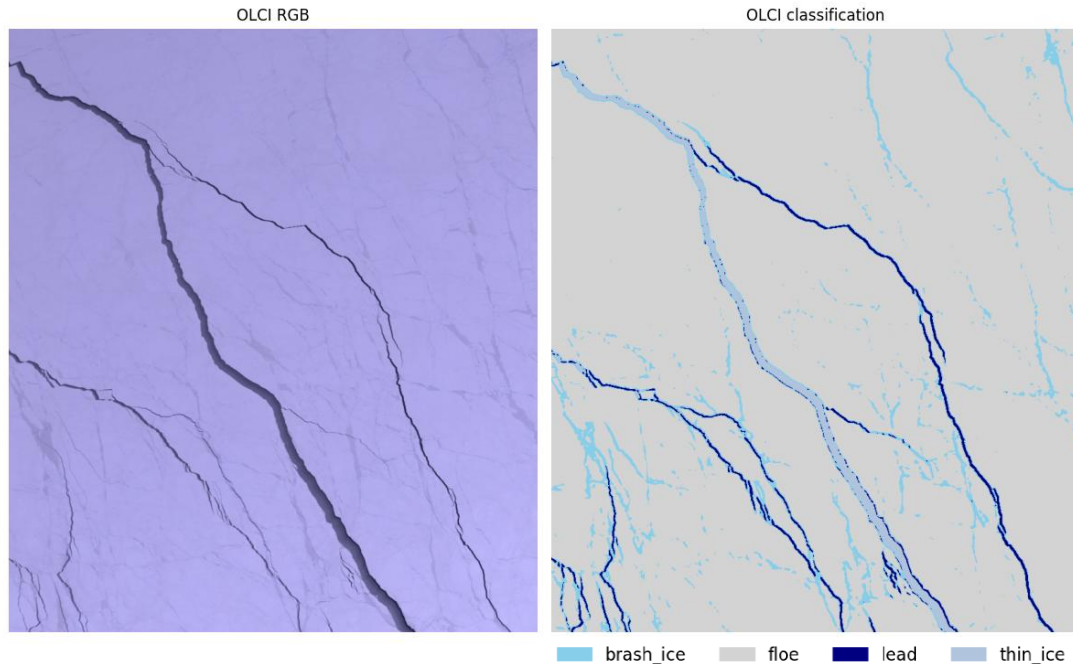
work of E. Senigout



# OLCI FLOE/LEAD CLASSIFICATION MODEL PERFORMANCE

Confusion Matrix

OLCI hand label \ OLCI automatic label	lead	thin_ice	floe	brash_ice
lead	23 (85.19%)	3 (27.27%)	0 (0.00%)	1 (3.70%)
thin_ice	1 (3.70%)	6 (54.55%)	0 (0.00%)	3 (11.11%)
floe	1 (3.70%)	0 (0.00%)	45 (93.75%)	5 (18.52%)
brash_ice	2 (7.41%)	2 (18.18%)	3 (6.25%)	18 (66.67%)

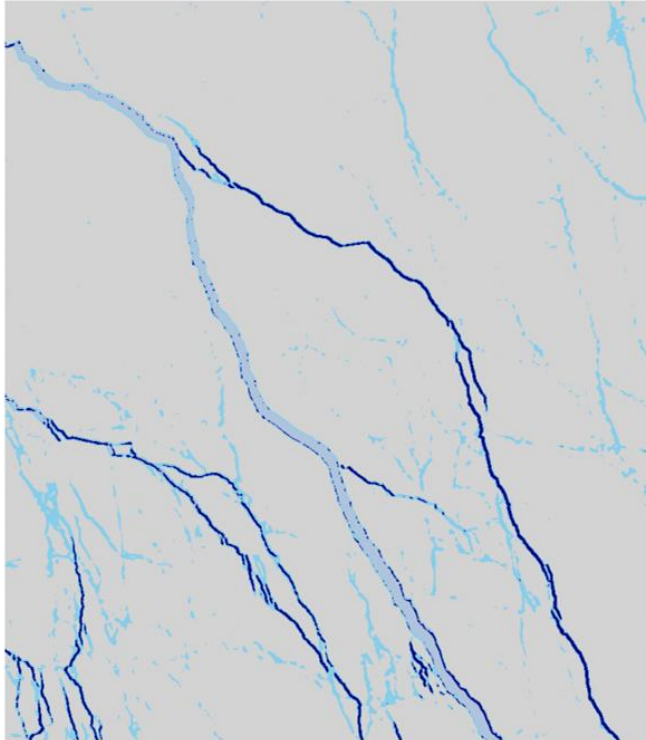


→ OLCI classification accuracy: 81%

→ OLCI classification accuracy from altimeter perspective: 85%

# FURTHER APPLICATIONS OF THE OLCI CLASSIFIED IMAGE DATASET

## OLCI CLASSIFIED IMAGE DATASET



brash\_ice   floe   lead   thin\_ice

*1 - Improve our understanding of the altimeter measurements*

**Estimate the influence of the leads off-nadir**

**Study the impact of melt ponds**

*2 - Improve the altimetric floe/lead classification*

**Use the image labels to train a waveform classifier independent of images**

*3 - Improve the spatial resolution of altimeter data*

**Extend the nadir SRAL measurements to the OLCI classified image (3D image similar to SWOT measurements)**

## CONCLUSION

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→ the proposed floe/lead classification for OLCI images can be used to automatically **validate** any altimetric floe/lead classification method

→ the proposed floe/lead classification for OLCI images can:

1. improve our understanding of the altimeter measurements
2. improve the floe/lead classification method using deep-learning method
3. improve the spatial resolution of the altimeter data

## ROADMAP

→ to facilitate the search of exploitable OLCI images, need to know the **cloud coverage (percentage or mask)**

→ on-going work with the SIN'X project conducted by NOVELTIS (see Caroline Ribere's presentation)

## CONTACT

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- [sara.fleury@cnr.fr](mailto:sara.fleury@cnr.fr)