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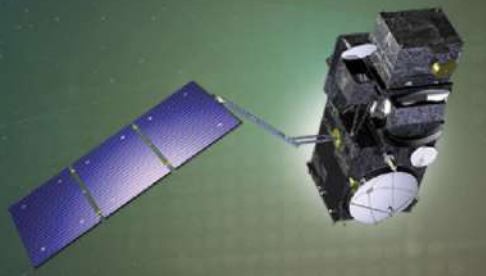

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Comparisons between official OLCI L2 Marine collection 2 and 3 cloud detection over water using the PixBox approach

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Cloud Screening for Sentinel-3 OLCI L2 Water Products

3 main flags: CLOUD, CLOUD_AMBIGUOUS, CLOUD_MARGIN - based on NN cloud classification with additional spectral tests

- CLOUD: NN cloud classification. Everything defined as CLOUD is masked during L2 processing.
- CLOUD_AMBIGUOUS: based on NN cloud classification and additional spectral tests. Pixels marked as CLOUD_AMBIGUOUS are kept during L2 processing.
- CLOUD_MARGIN: buffer around CLOUD and CLOUD_AMBIGUOUS; 2 pixels in RR, 4 in FR.

From previous validation exercises for CLOUD, based on the NN approach

- The OLCI-A based NN performs very well on OLCI-B
- This means the cloud screening NN is robust against slight spectral differences.
- A single NN can be used for OLCI-A & OLCI-B
- It is also worth mentioning that the performance of the cloud screening is stable since the first implementation.

What is new between Collection 2 and Collection 3

CLOUD_AMBIGUOUS flag

- Additional test introduced to prevent the use of the ANNOT_* flags (especially ANNOT_DROUT) which were removing too many good pixels from analyses (user feedback).
- Test based on Wang and Shi (2006) algorithm: clouds are differentiated from bright water in the NIR and small particle aerosols by taking an advantage that clouds are spectrally flat. The method allocates thresholds to Rayleigh corrected reflectance and reflectance ratio in the NIR: ρRC (865) ≥ 0.08 and εRC (753,865) ≤ 1.04 (for OLCI), where
  - ρRC (λ) = ρTOA (λ) – ρR(λ)
  - εRC (λi,λj) = ρRC (λi) / ρRC (λj)

PixBox: Pixel collection OLCI A + B 2019

Based on Dec 2018 to Sep 2019 data

Total pixel number: 20202, A: 51% (78 files), B: 49% (125 files)

Land (total 48%)

- Land 39%
- Town 4%
- Desert 5%
- dry/salt lake 0.4%

Water (total 51%)

- coastal waters 22%
- open ocean 22%
- Lake 3.0%
- River 1.6%

Others 2.7%

sun glint 2.8%

Clouds

- Clear 48%
- Cloudy 52%
  - opaque 18%
    - Oversaturated 1.8%
  - semi-transparent total 32%
    - Thick 8%
    - Average 11%
    - Thin 10%
    - spatially mixed 3.3%
  - over sun glint 0.8%

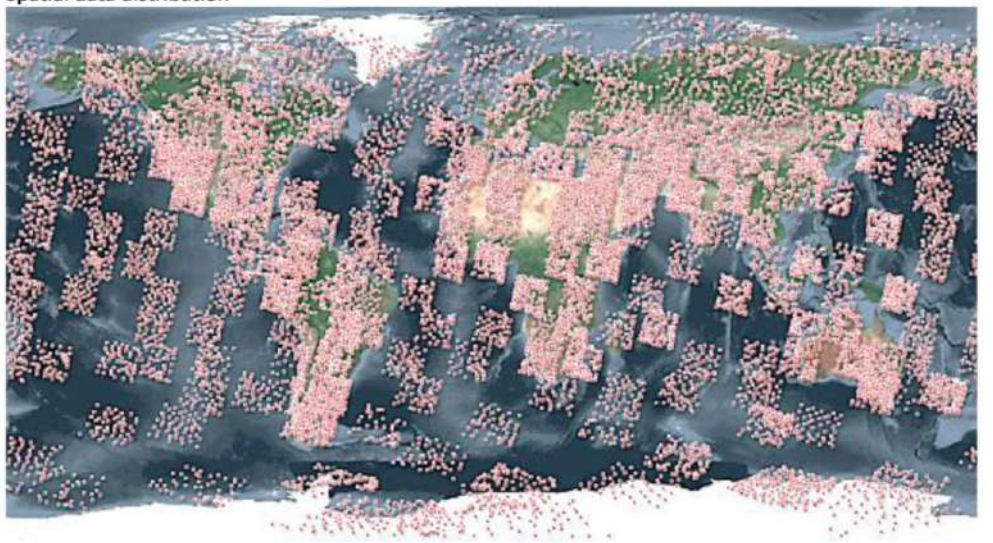
Snow / Ice

- land/mountain ice 11%
- floating ice 5%

Shadow

- over land 1%
- over water 0.3%

Spatial data distribution



Confusion Matrix – only CLOUD

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 2 -
CLOUD only
In-Situ Database

OLCI Collection 2

Class	Clear	Cloud	Sum	U A	E
CLEAR	1978	311	2289	86.4	13.6
CLOUD	133	3140	3273	95.9	4.1
Sum	2111	3451	5562		
P A	93.7	91.0		OA:	92.02
E	6.3	9.0		BOA:	92.35

Scotts Pi: 0.833
Krippendorfs alpha: 0.833
Cohens kappa: 0.833

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 3 -
CLOUD only
In-Situ Database

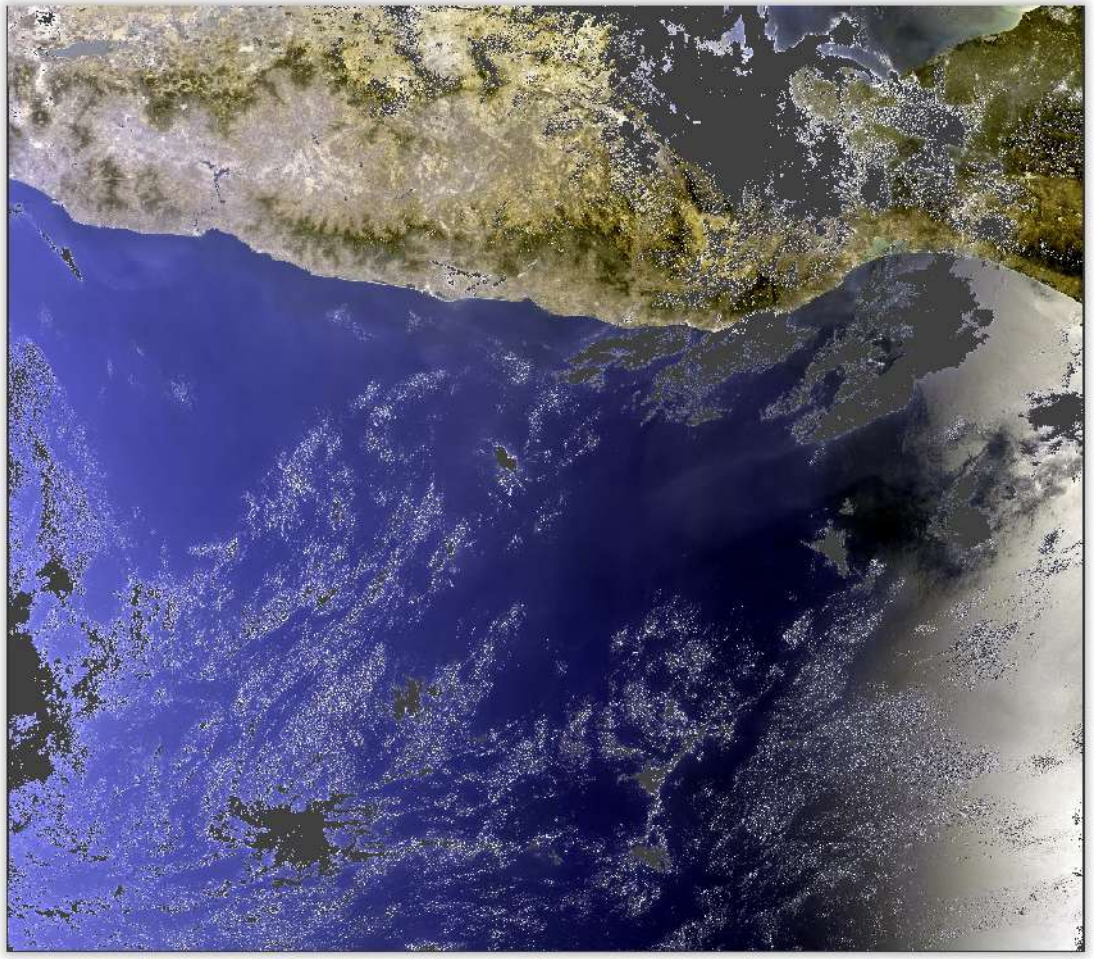
OLCI Collection 3

Class	Clear	Cloud	Sum	U A	E
CLEAR	1979	309	2288	86.5	13.5
CLOUD	132	3142	3274	96.0	4.0
Sum	2111	3451	5562		
P A	93.7	91.0		OA:	92.07
E	6.3	9.0		BOA:	92.35

Scotts Pi: 0.834
Krippendorfs alpha: 0.834
Cohens kappa: 0.834

✓ No change for CLOUD between Collection 2 and Collection 3 , to be expected and welcome since CLOUD definition has not changed.

CLOUD Collection 2



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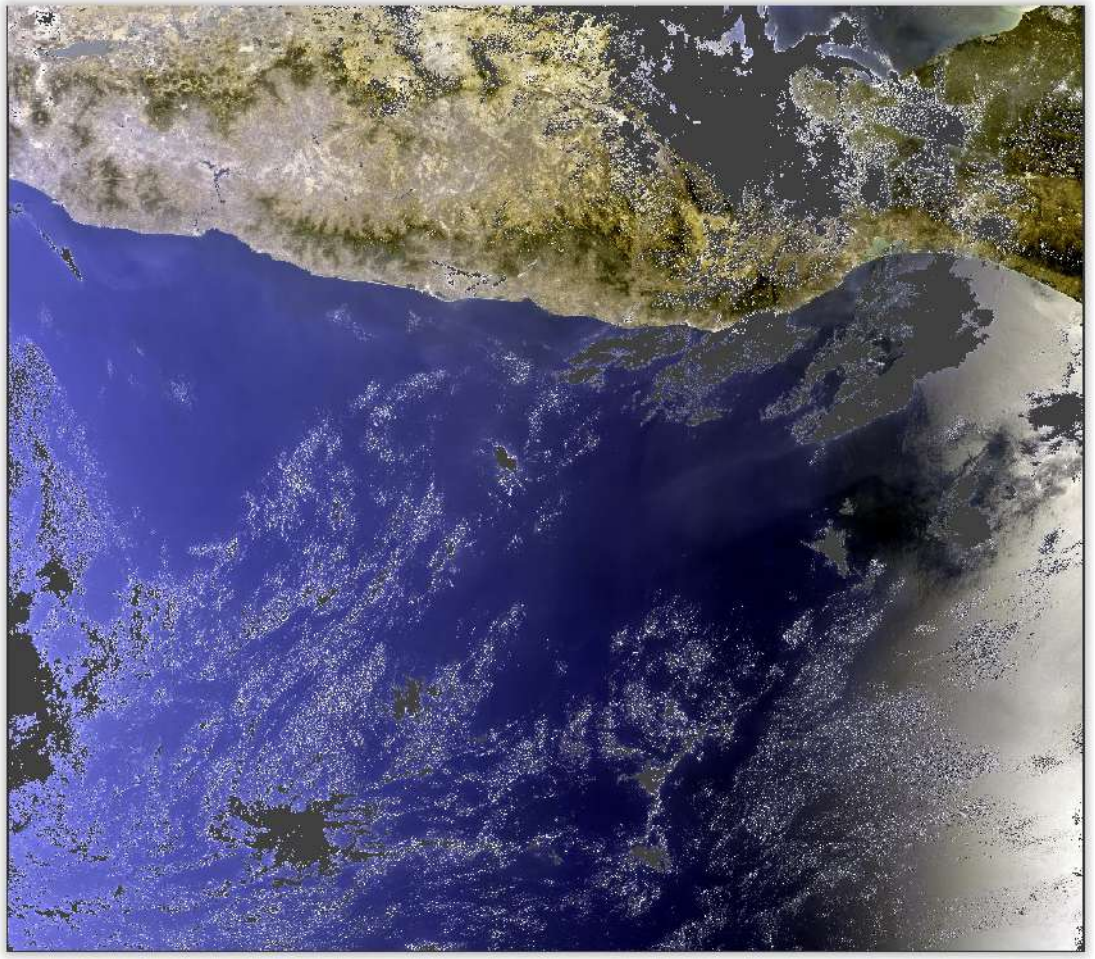
CLOUD Collection 3



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Confusion Matrix – all clouds (CLOUD, CLOUD_AMBIGUOUS, CLOUD_MARGIN)

OLCI A&B Dec2018-Mar2019 - ocean surfaces
- Collection 2 -
all cloud flags
In-Situ Database

OLCI Collection 2	Clear	Cloud	Sum	U A	E
CLEAR	1889	205	2094	90.2	9.8
CLOUD	222	3246	3468	93.6	6.4
Sum	2111	3451	5562		
P A	89.5	94.1		OA:	92.32
E	10.5	5.9		BOA:	91.8

Scotts Pi: 0.836
Krippendorfs alpha: 0.836
Cohens kappa: 0.836

OLCI A&B Dec2018-Mar2019 - ocean surfaces
- Collection 3 -
all cloud flags w/o turbit_atm
In-Situ Database

OLCI Collection 3	Clear	Cloud	Sum	U A	E
CLEAR	1683	190	1873	89.9	10.1
CLOUD	428	3261	3689	88.4	11.6
Sum	2111	3451	5562		
P A	79.7	94.5		OA:	88.89
E	20.3	5.5		BOA:	87.1

Scotts Pi: 0.758
Krippendorfs alpha: 0.758
Cohens kappa: 0.758

With the new CLOUD_AMBIGUOUS: User Accuracy reduced (89.9% instead of 90.2%)
Overall Accuracy reduced (88.89% instead of 92.32%)

BUT Producer Accuracy increased (i.e. better cloud detection)

→ Why did we „lose“ some accuracy?

Confusion Matrix – only CLOUD_AMBIGUOUS

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 2 -
CLOUD_AMBIGUOUS only
In-Situ Database

OLCI Collection 2

Class	Clear	Cloud	Sum	U A	E
CLEAR	2108	3442	5550	38.0	62.0
CLOUD	3	9	12	75.0	25.0
Sum	2111	3451	5562		
P A	99.9	0.26		OA:	38.06
E	0.1	99.7		BOA:	50.08

Scotts Pi: -0.444
Krippendorfs alpha: -0.444
Cohens kappa: 0.0

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 3 -
CLOUD_AMBIGUOUS only
In-Situ Database

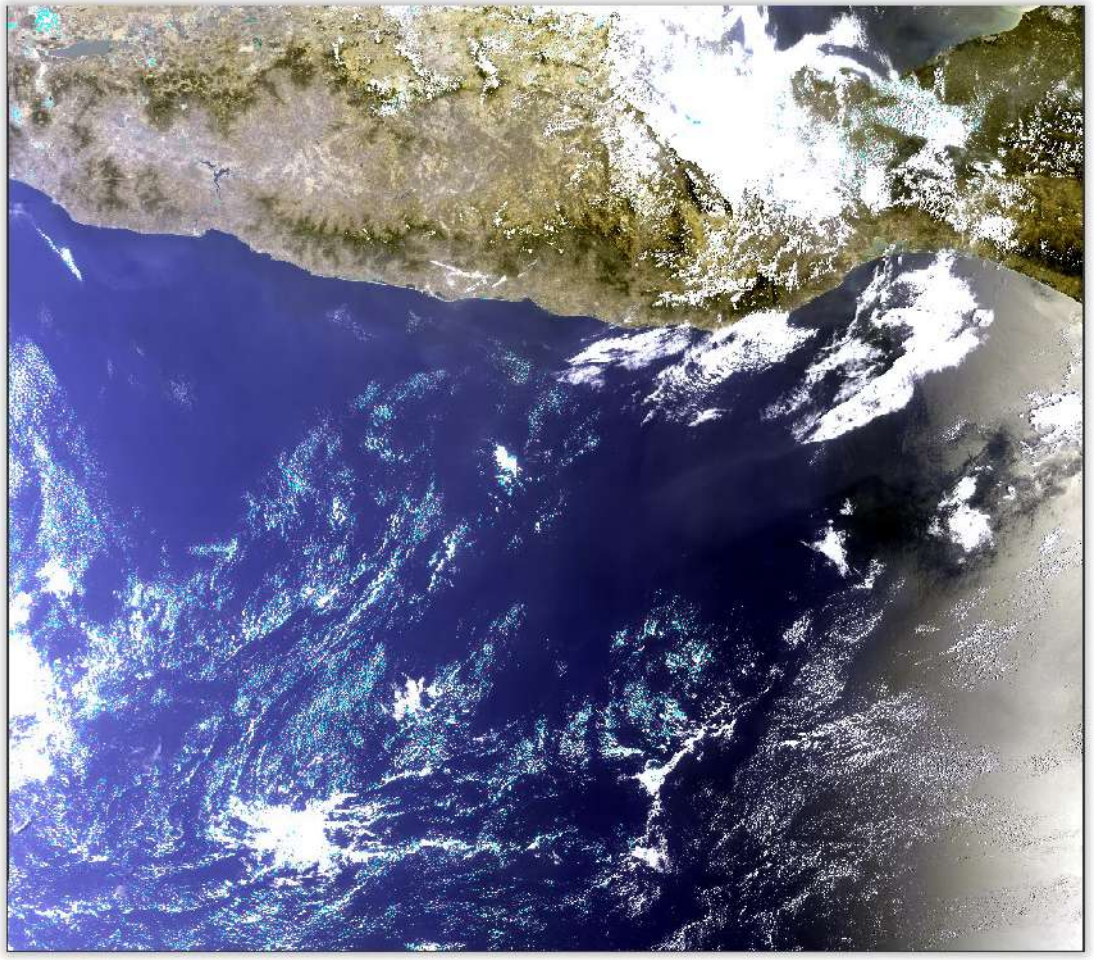
OLCI Collection 3

Class	Clear	Cloud	Sum	U A	E
CLEAR	1901	3404	5305	35.8	64.2
CLOUD	210	47	257	18.3	81.7
Sum	2111	3451	5562		
P A	90.1	1.4		OA:	35.02
E	9.9	98.6		BOA:	45.75

Scotts Pi: -0.461
Krippendorfs alpha: -0.461
Cohens kappa: -0.066

CLOUD_AMBIGUOUS detects more cloud, but at the detriment of flagging many pixels classified as clear in the collection.
→ Let's look at some images

AMBIGUOUS Collection 2



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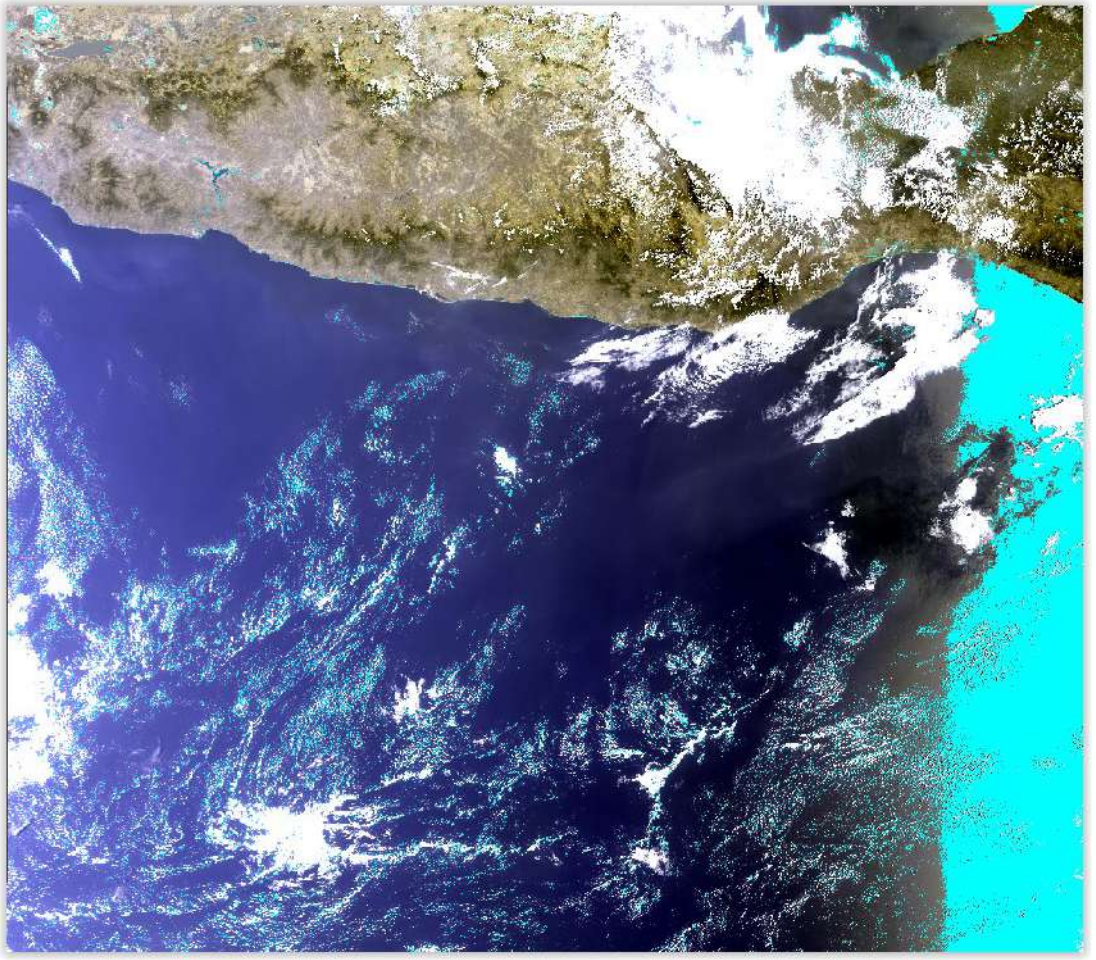
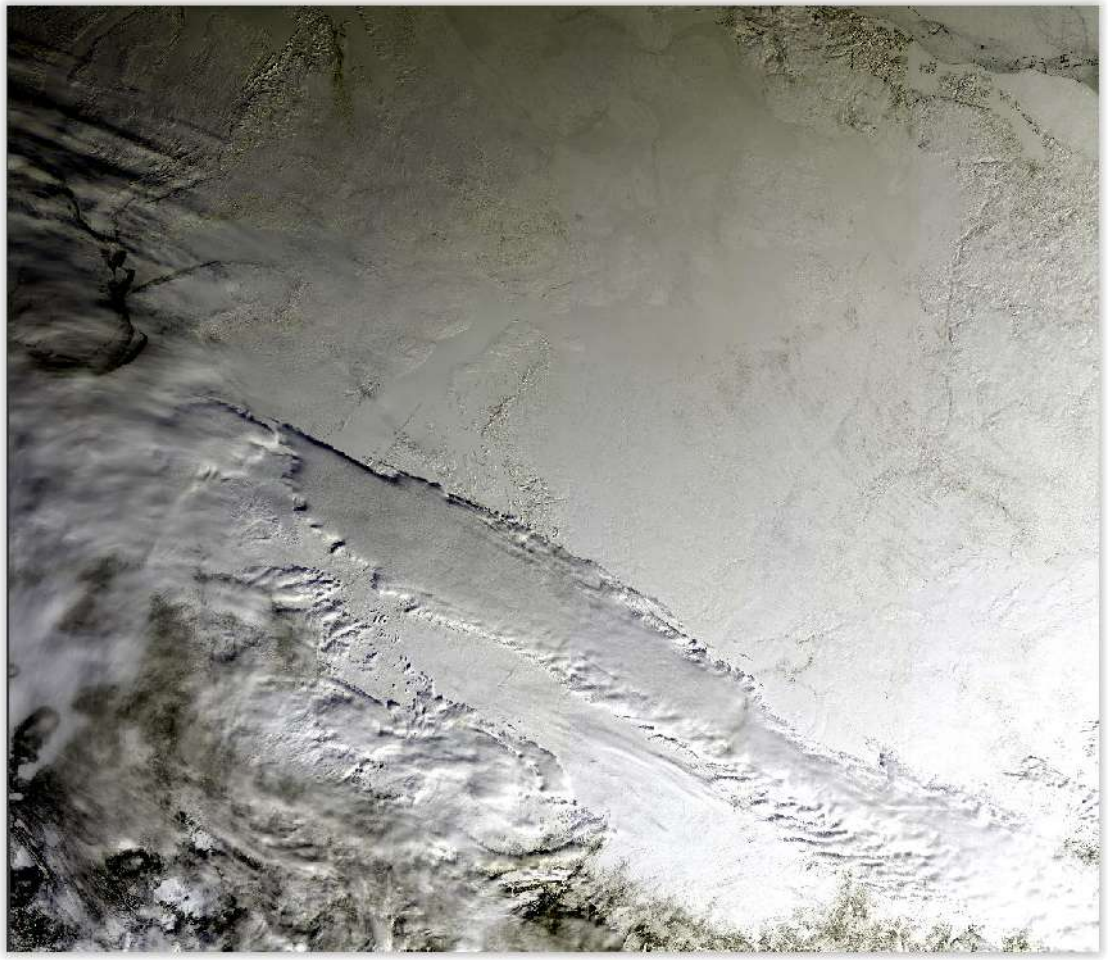
AMBIGUOUS Collection 3

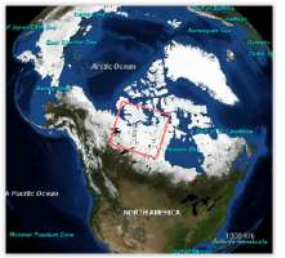


With the new spectral test, CLOUD_AMBIGUOUS flags in glint areas.

S3A_OL_1_EFR____20190315T163215_20190315T163515_20190316T225452_0179_042_254_2700_MAR_O_NT_002.SEN3

AMBIGUOUS Collection 2





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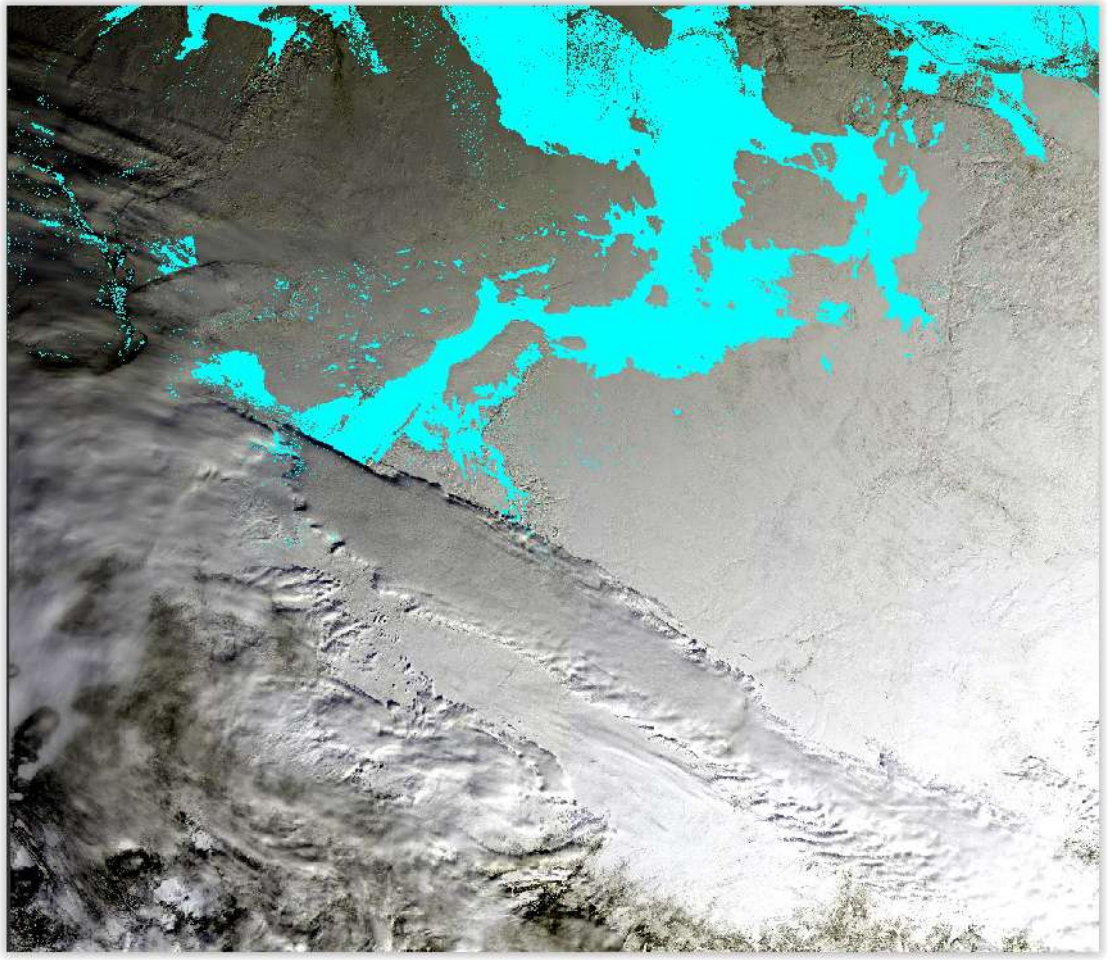
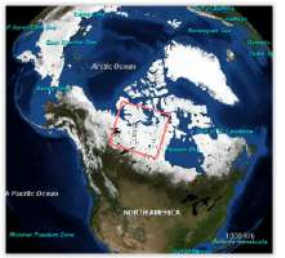
AMBIGUOUS Collection 3



With the new spectral test, CLOUD_AMBIGUOUS flags in sea ice areas.



S3A_OL_1_EFR____20190315T175815_20190315T180115_20190317T002605_0179_042_255_1800_MAR_O_NT_002.SEN3

CLOUD, CLOUD_AMBIGOUS, CLOUD_MARGIN – no ICE, no GLINT

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 2 -
all cloud flags - no ice no glint
In-Situ Database

OLCI Collection 2	Clear	Cloud	Sum	U A	E
CLEAR	1479	144	1623	91.1	8.9
CLOUD	71	2802	2873	97.5	2.5
Sum	1550	2946	4496		
P A	95.4	95.1		OA:	95.22
E	4.6	4.9		BOA:	95.25

Scotts Pi: 0.895
Krippendorfs alpha: 0.895
Cohens kappa: 0.895

OLCI A&B Dec2018-Mar2019 - ocean surfaces
- Collection 3 -
all cloud flags w/o turbit_atm - no ice no glint
In-Situ Database

OLCI Collection 3	Clear	Cloud	Sum	U A	E
CLEAR	1458	141	1599	91.2	8.8
CLOUD	92	2805	2897	96.8	3.2
Sum	1550	2946	4496		
P A	94.1	95.2		OA:	94.82
E	5.9	4.8		BOA:	94.65

Scotts Pi: 0.886
Krippendorfs alpha: 0.886
Cohens kappa: 0.886

Without ICE and GLINT, we see the improvement in the cloud detection.

CLOUD and CLOUD_AMBIGUOUS without CLOUD_MARGIN – no ICE, no GLINT

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 2 -
all cloud flags wo MARGIN - no ice no glint
In-Situ Database

OLCI Collection 2

Class	Clear	Cloud	Sum	U A	E
CLEAR	1511	203	1714	88.2	11.8
CLOUD	39	2743	2782	98.6	1.4
Sum	1550	2946	4496		
P A	97.5	93.1		OA:	94.62
E	2.5	6.9		BOA:	95.3

Scotts Pi: 0.883
Krippendorfs alpha: 0.883
Cohens kappa: 0.883

OLCI AB Dec2018-Mar2019 - ocean surfaces
- Collection 3 -
all cloud flags no MARGIN - no ice no glint
In-Situ Database

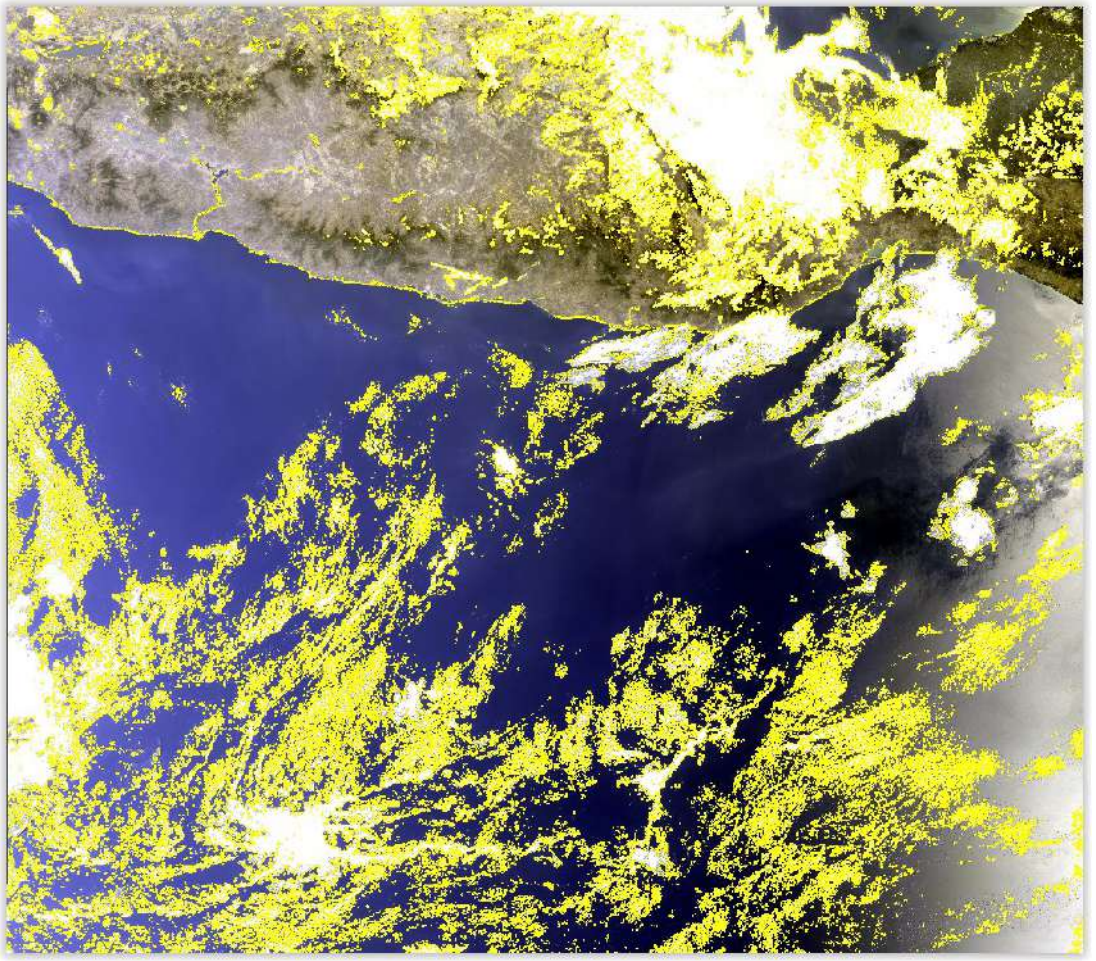
OLCI Collection 3

Class	Clear	Cloud	Sum	U A	E
CLEAR	1497	188	1685	88.8	11.2
CLOUD	53	2758	2811	98.1	1.9
Sum	1550	2946	4496		
P A	96.6	93.6		OA:	94.64
E	3.4	6.4		BOA:	95.1

Scotts Pi: 0.883
Krippendorfs alpha: 0.883
Cohens kappa: 0.883

Without MARGIN, the overall accuracy also increases between Collection 2 and 3 ← better cloud detection with adding a margin can lead to clear pixels collected within the margin to be classified as cloud.

CLOUD_MARGIN Collection 2



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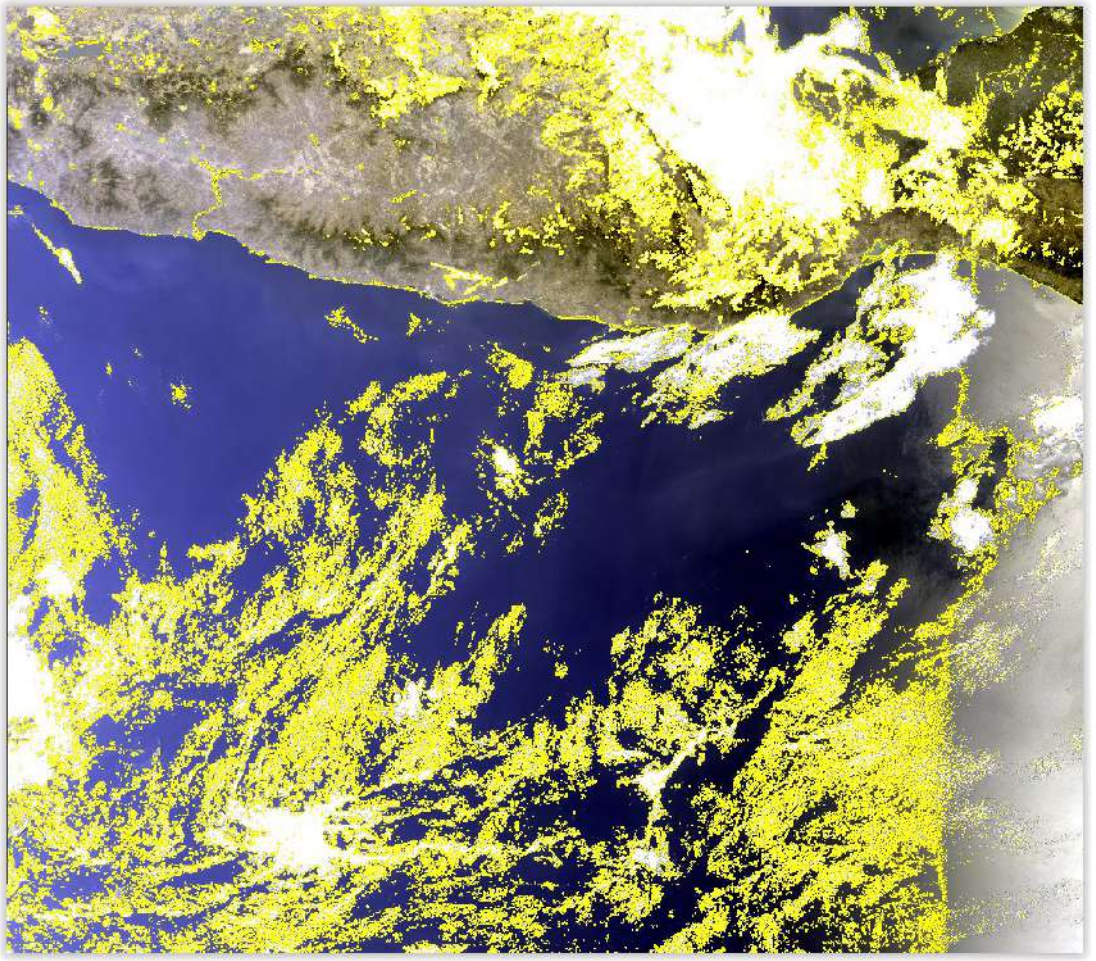
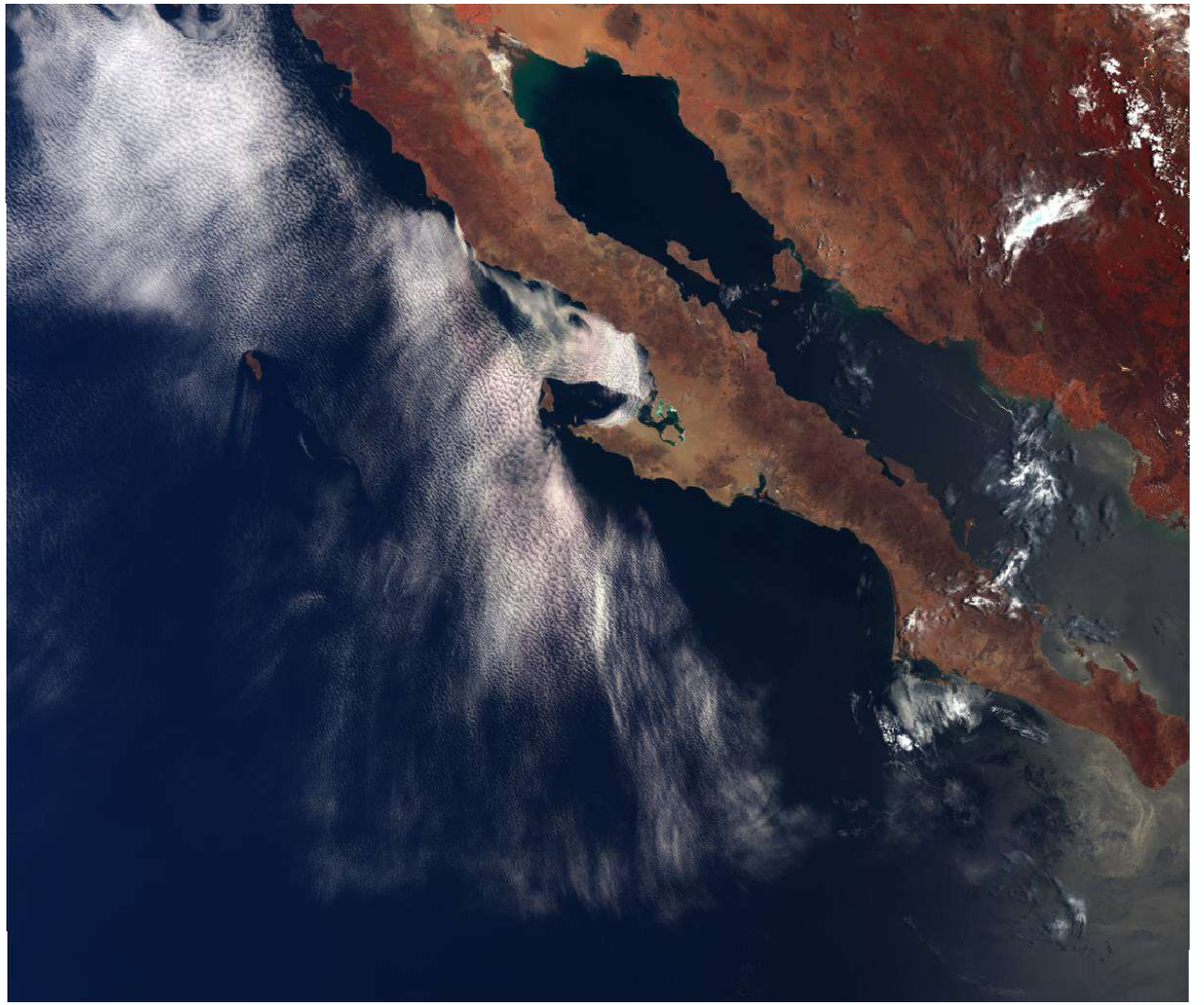
CLOUD_MARGIN Collection 3



S3A_OL_1_EFR____20190315T163215_20190315T163515_20190316T225452_0179_042_254_2700_MAR_O_NT_002.SEN3

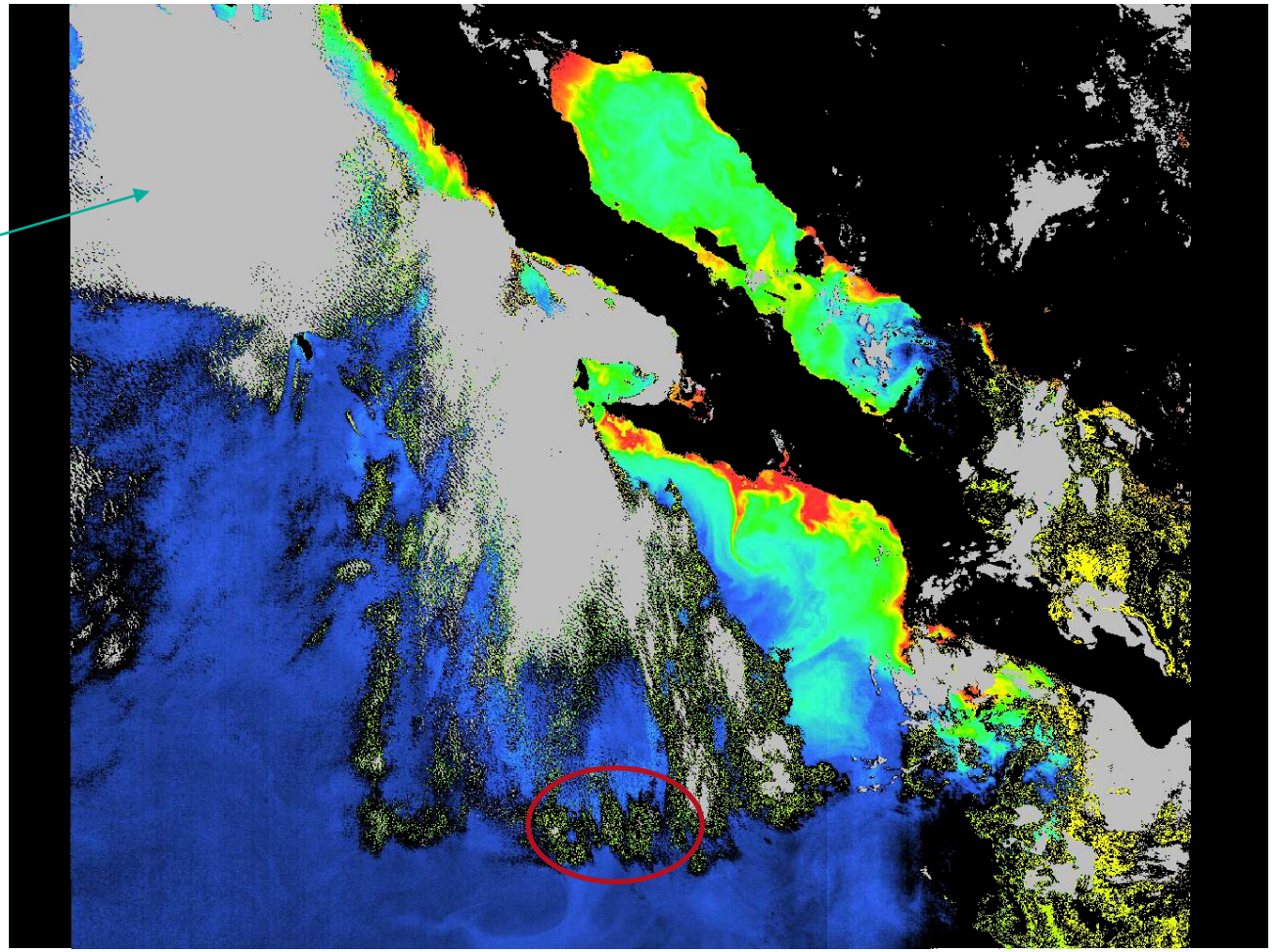
RGB

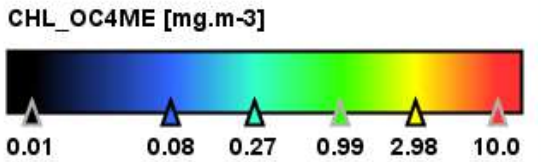


S3A_OL_1_ERR____20190702T172158_20190702T180621_20190703T235022_2663_046_269_____MAR_O_NT_002.SEN3

CHL_OC4ME Collection 2

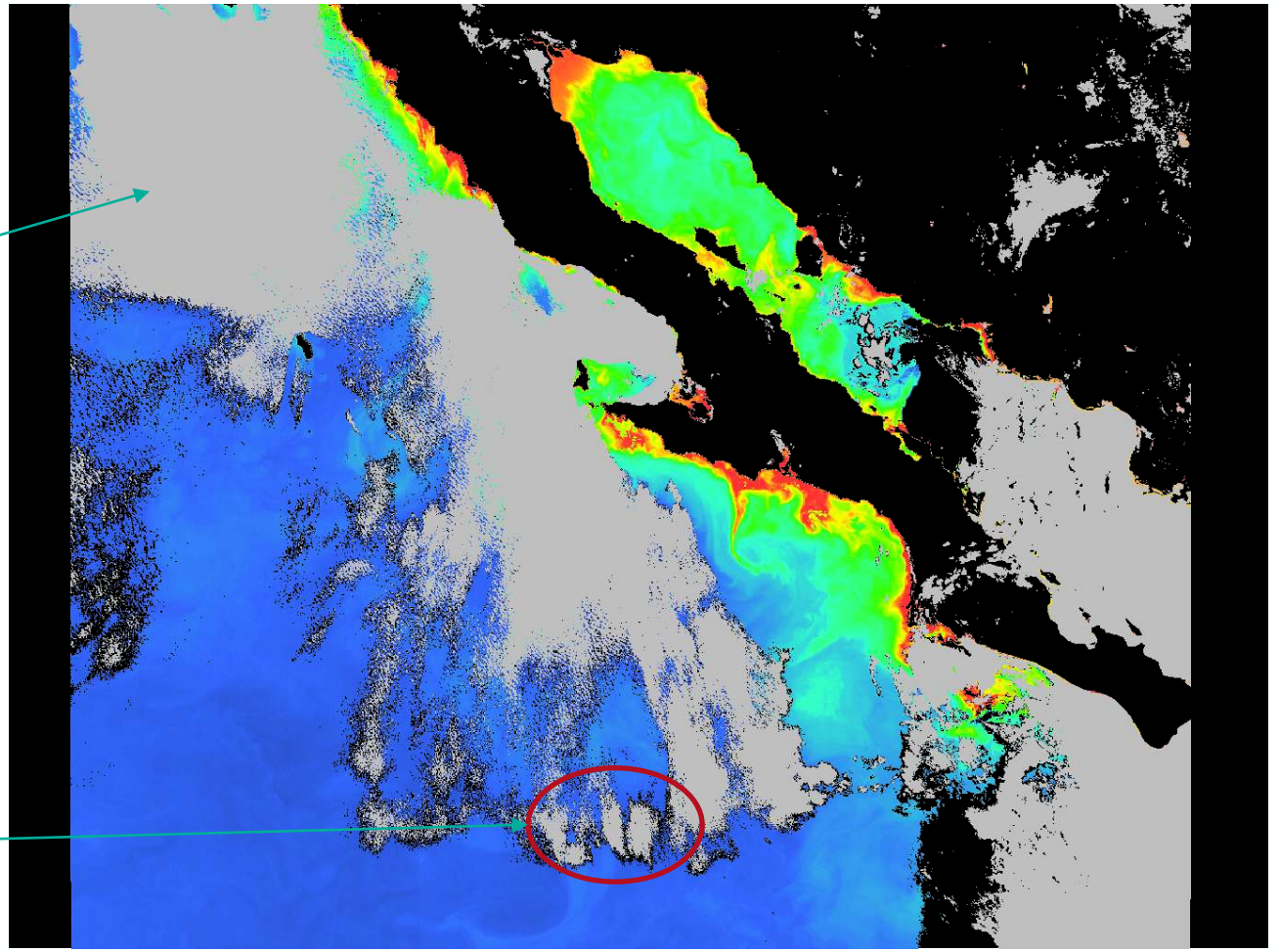
CLOUD and CLOUD_AMBIGUOUS flags are ON in light grey





S3A_OL_1_ERR____20190702T172158_20190702T180621_20190703T235022_2663_046_269_____MAR_O_NT_002.SEN3

CHL_OC4ME Collection 3



CLOUD and CLOUD_AMBIGUOUS flags are ON in light grey

Dubious pixels better(correctly) flagged

S3A_OL_1_ERR____20190702T172158_20190702T180621_20190703T235022_2663_046_269_____MAR_O_NT_002.SEN3

Summary

- From Statistics
  - New test introduced in CLOUD_AMBIGUOUS flags shows slight improvement on cloud detection, but also flags in SEA ICE and GLINT areas compared to Collection 2
  - This is ok for users only interested in good water pixels (bad pixels are flagged no matter) but is not 100% accurate definition-wise.
- From L2 comparisons
  - show clear improvement in the image quality for water products
  - impact from ambiguous not really seen in statistics since such „complicated“ pixels are not per se the majority of the PixBox Collection. We do see an improvement although we see more clear pixels flagged as ambiguous.
- To keep in mind: the better the cloud definition and detection is, i.e. the better CLOUD and CLOUD_AMBIGUOUS are at removing clouds, the higher the risk that CLOUD_MARGIN will flag clear water pixels
  - we may need to revise the extent of the CLOUD_MARGIN when we achieve a very good cloud flagging.