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Proba-V QWG #11, 25.-26.06.2020

ProbaV Cloud C2

Validation of cloud detection in different ProbaV resolutions

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Brockmann Consult

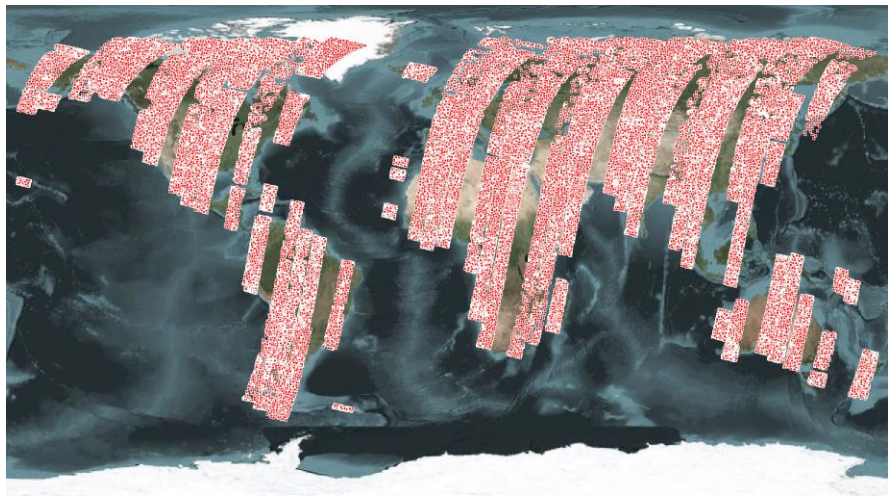
3 Datasets

- 333m
  - Re-use existing dataset from Round Robin, analysis completed
  - 50 000 pixels from 50 products (minus 10 000 pixels used for training)
- 100 m
  - collection and analysis completed
  - 100 000 pixels from 55 products minus 10 000 provided to UVal
  - from this 25% were used for validation
- 1km
  - Collection and analysis completed
  - 26 600 pixels from 81 products

global distribution of reference pixels

333 m

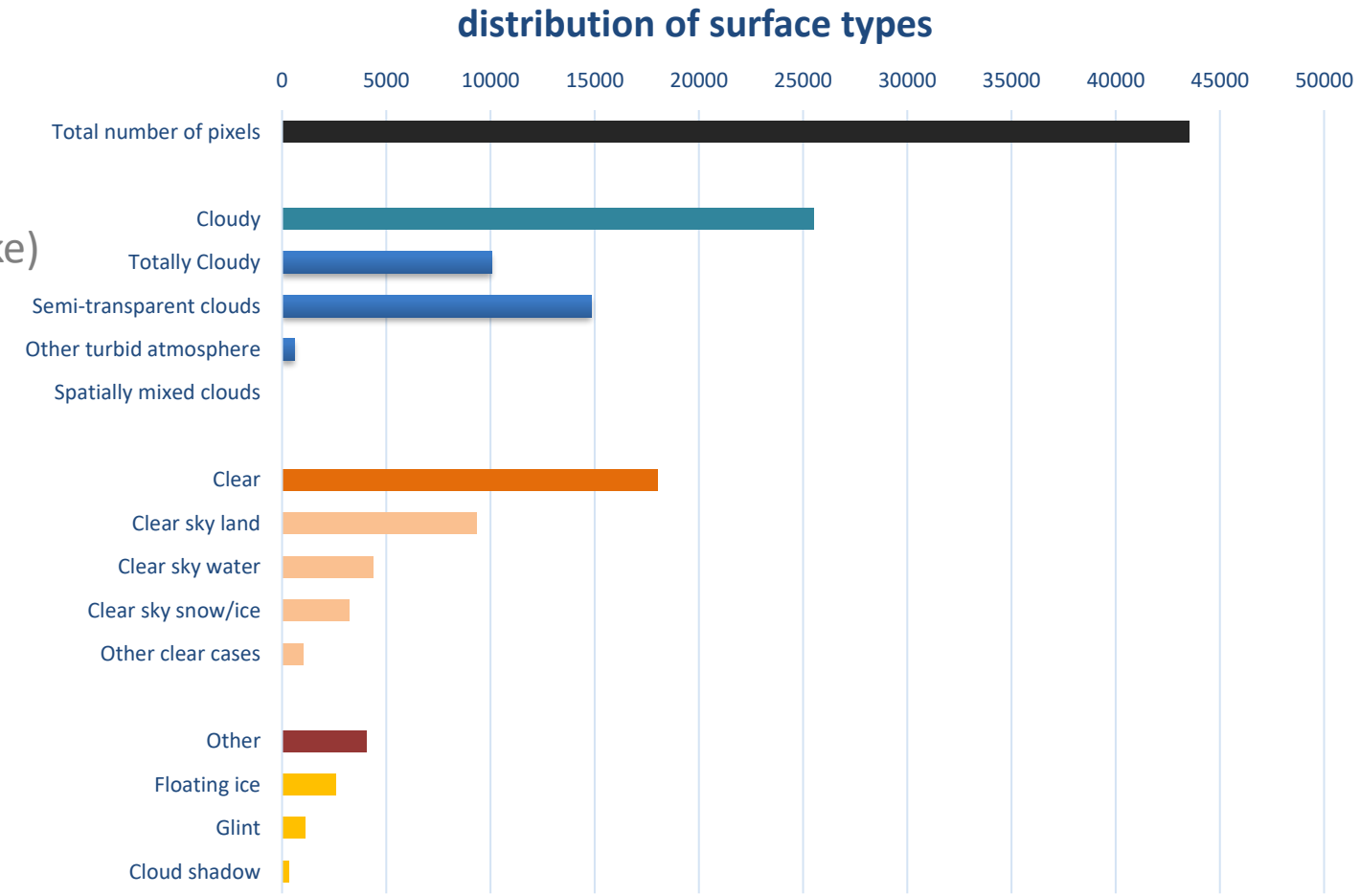
1 km



100 m

333m collection surface characteristics

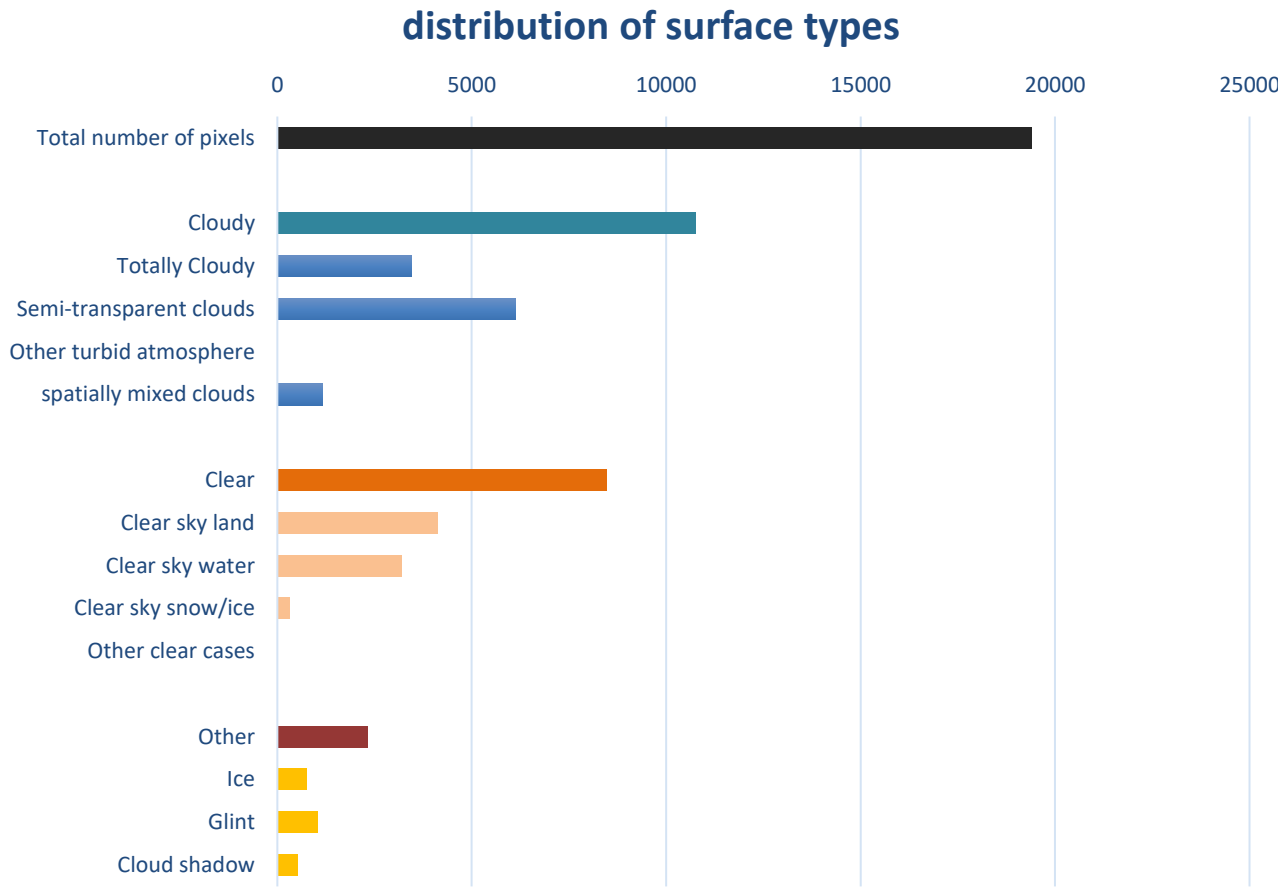
- **Clouds**
  - Totally cloudy (opaque clouds)
  - Semi-transparent clouds
  - Other turbid atmosphere (e.g. dust, smoke)
- **Clear surfaces**
  - Clear sky land
  - Clear sky water
  - Clear sky snow/ice
  - Other clear cases
- **Other**
  - Floating Ice
  - Glint
  - Cloud shadow



Note: original data set minus 10.000 pixels that have been provided to UVal, used for validation/improvement of the NN.

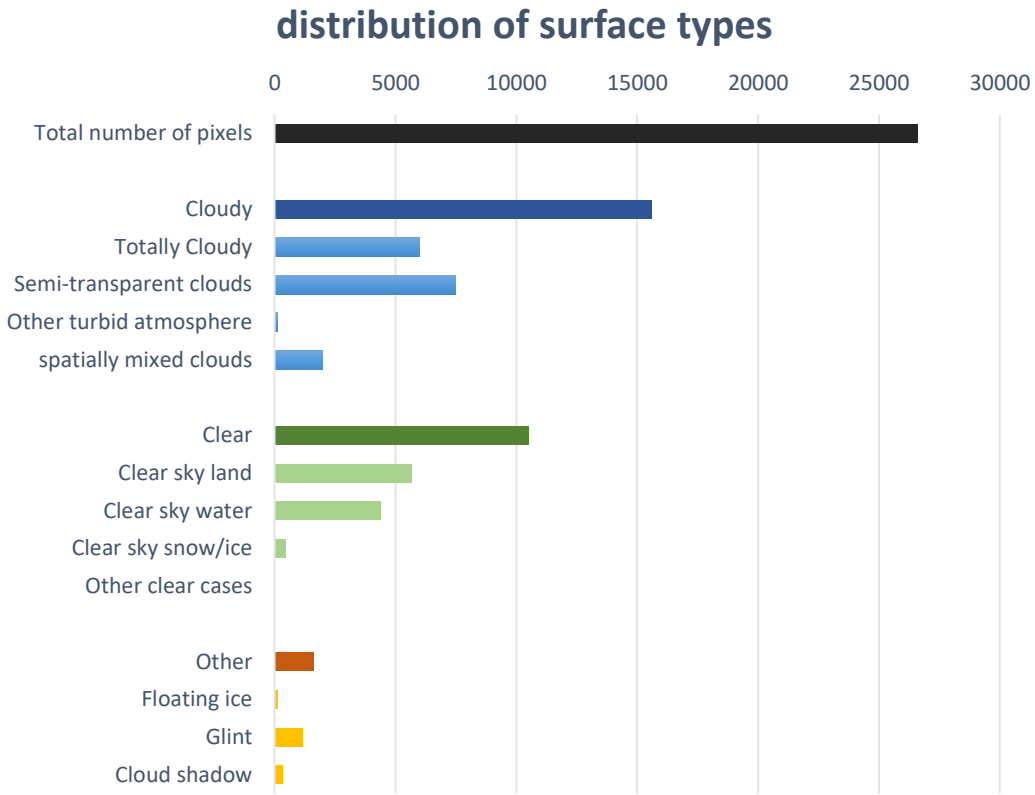
100m Final Collection - Statistics

- **Clouds 56.5%**
  - Totally cloudy (opaque clouds) 18%
  - Semi-transparent clouds 32%
  - Spatially mixed clouds 6.2%
  - Other turbid atmosphere (e.g. dust, smoke) 0.7%
- **Clear surfaces 41.7%**
  - Clear sky land 20.8%
  - Clear sky water 15.9%
  - Clear sky snow/ice 5%
- **Other 1.8%**



1km Final Collection - Statistics

- **Clouds 59%**
  - Totally cloudy (opaque clouds) 22%
  - Semi-transparent clouds 28%
  - Spatially mixed clouds 7.5%
  - Other turbid atmosphere (e.g. dust, smoke) 0.4%
- **Clear surfaces 39%**
  - Clear sky land 21%
  - Clear sky water 16%
  - Clear sky snow/ice 1.2%
- **Other 1.8%**



PixBox Validation

333m

PixBox data

SM_FLAGS \ PixBox data	clear	cloud	Sum	U A	E
CLEAR	15642	1007	16649	94.0	6.0
CLOUD	1357	20130	21487	93.7	6.3
Sum	16999	21137	38136		
P A	92.0	95.2		OAA:	93.8
E	8.0	4.8			

100m

PixBox data

SM_FLAGS \ PixBox data	clear	cloud	Sum	U A	E
CLEAR	7938	1386	9324	85.1	14.9
CLOUD	552	7323	7875	93.0	7.0
Sum	8490	8709	17199		
P A	93.5	84.1		OAA:	88.73
E	6.5	15.9			

1km

PixBox data

SM_FLAGS \ PixBox data	clear	cloud	Sum	U A	E
CLEAR	9732	1081	10813	90.0	10.0
CLOUD	1137	11171	12308	90.8	9.2
Sum	10869	12252	23121		
P A	89.5	91.2		OAA:	90.41
E	10.5	8.8			

Cloud Pixbox =
opaque cloud +
thick semi-trans +
medium semi-trans +
spatially mixed

PixBox Validation

333m

PixBox data

SM_FLAGS \ Class	clear	cloud	Sum	U A	E
CLEAR	15642	411	16053	97.4	2.6
CLOUD	1357	18054	19411	93.0	7.0
Sum	16999	18465	35464		
P A	92.0	97.8		OAA:	95.01
E	8.0	2.2			

100m

PixBox data

SM_FLAGS \ Class	clear	cloud	Sum	U A	E
CLEAR	7938	462	8400	94.5	5.5
CLOUD	552	7074	7626	92.8	7.2
Sum	8490	7536	16026		
P A	93.5	93.9		OAA:	93.67
E	6.5	6.1			

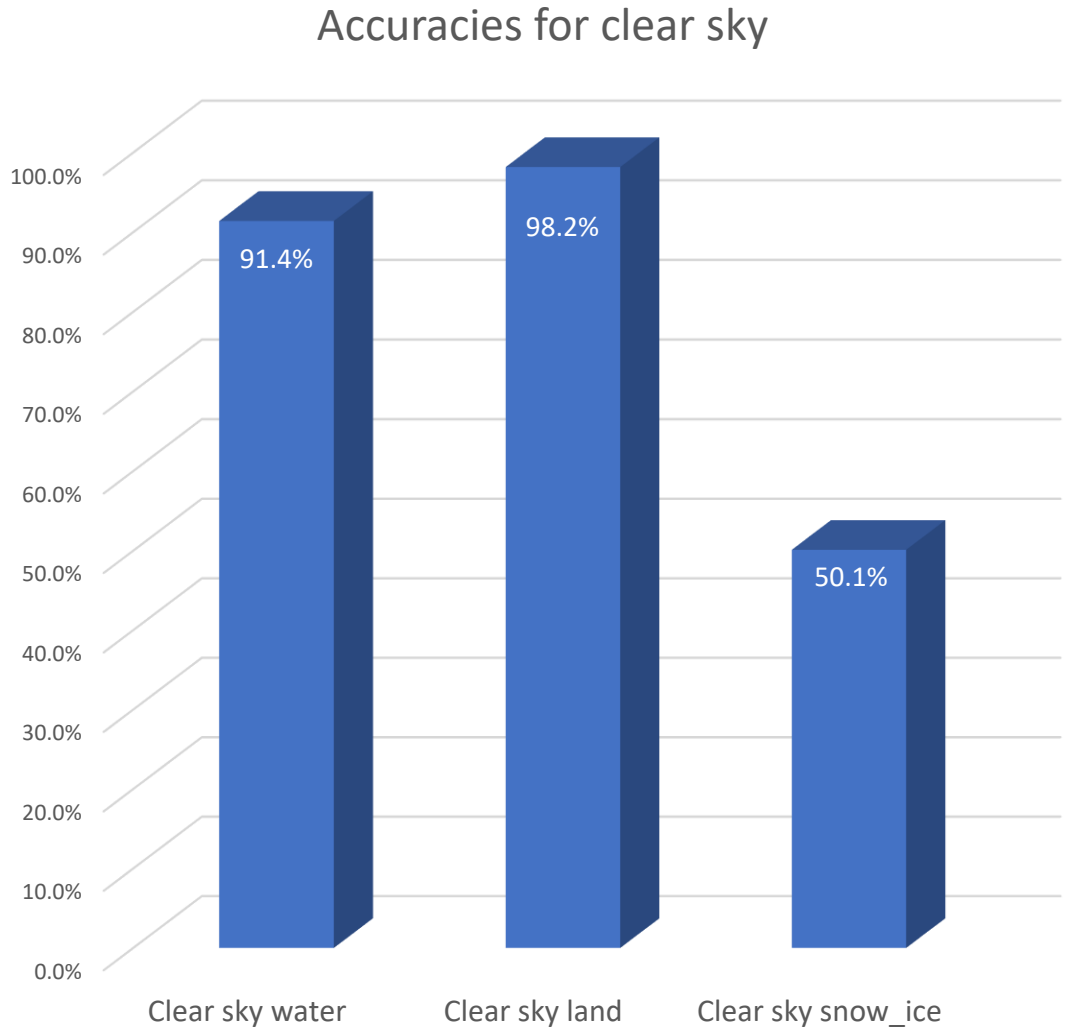
1km

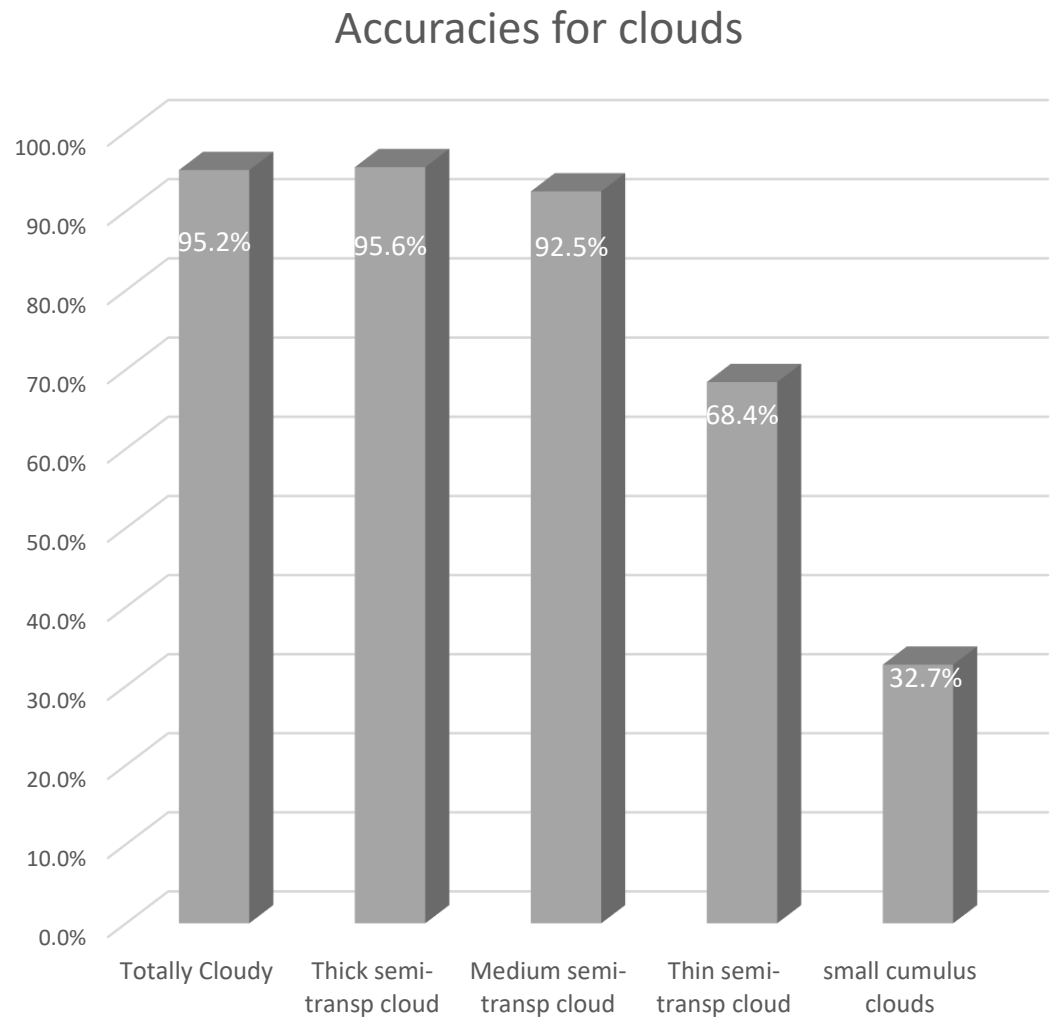
PixBox data

SM_FLAGS \ Class	clear	cloud	Sum	U A	E
CLEAR	9732	503	10235	95.1	4.9
CLOUD	1137	9764	10901	89.6	10.4
Sum	10869	10267	21136		
P A	89.5	95.1		OAA:	92.24
E	10.5	4.9			

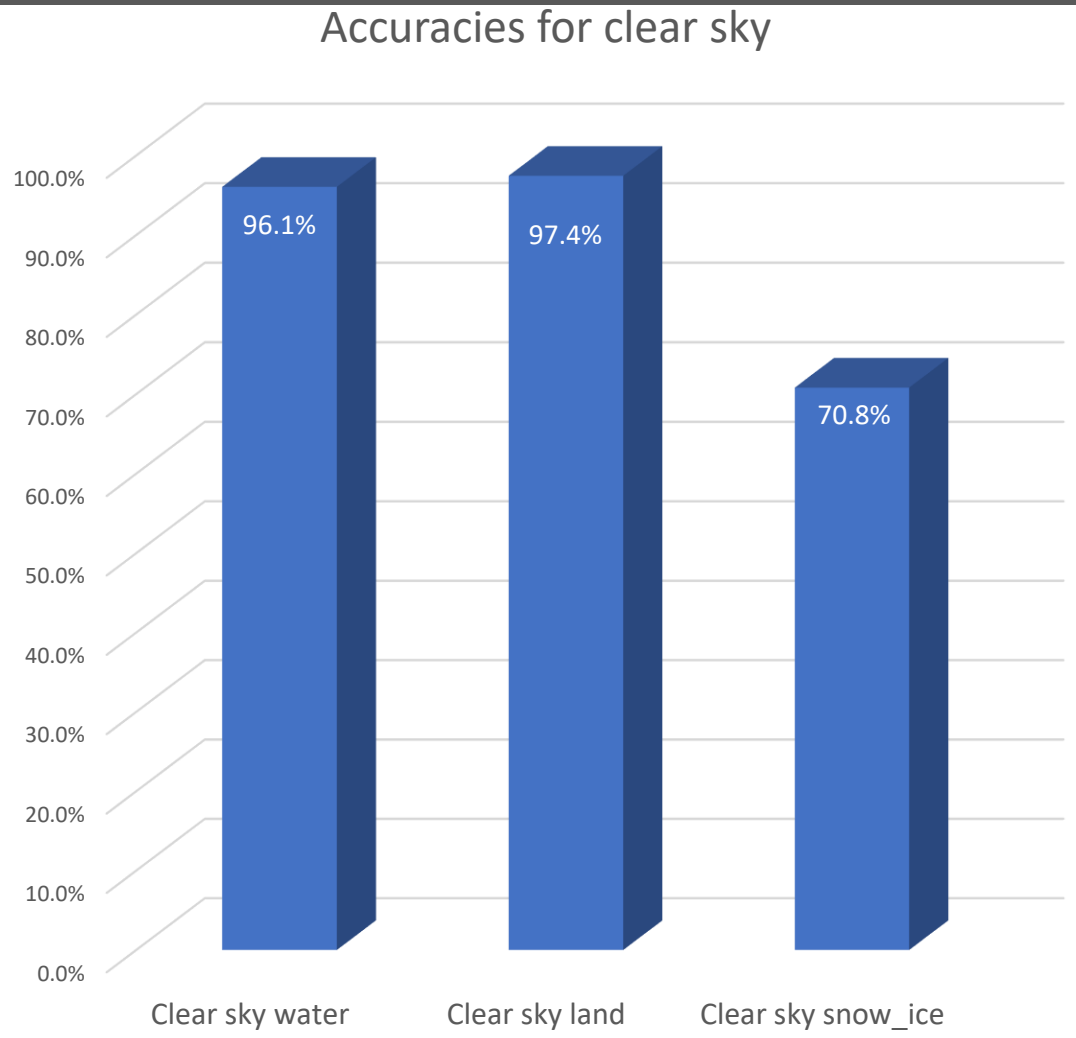
Cloud Pixbox =
opaque cloud +
thick semi-trans +
medium semi-trans

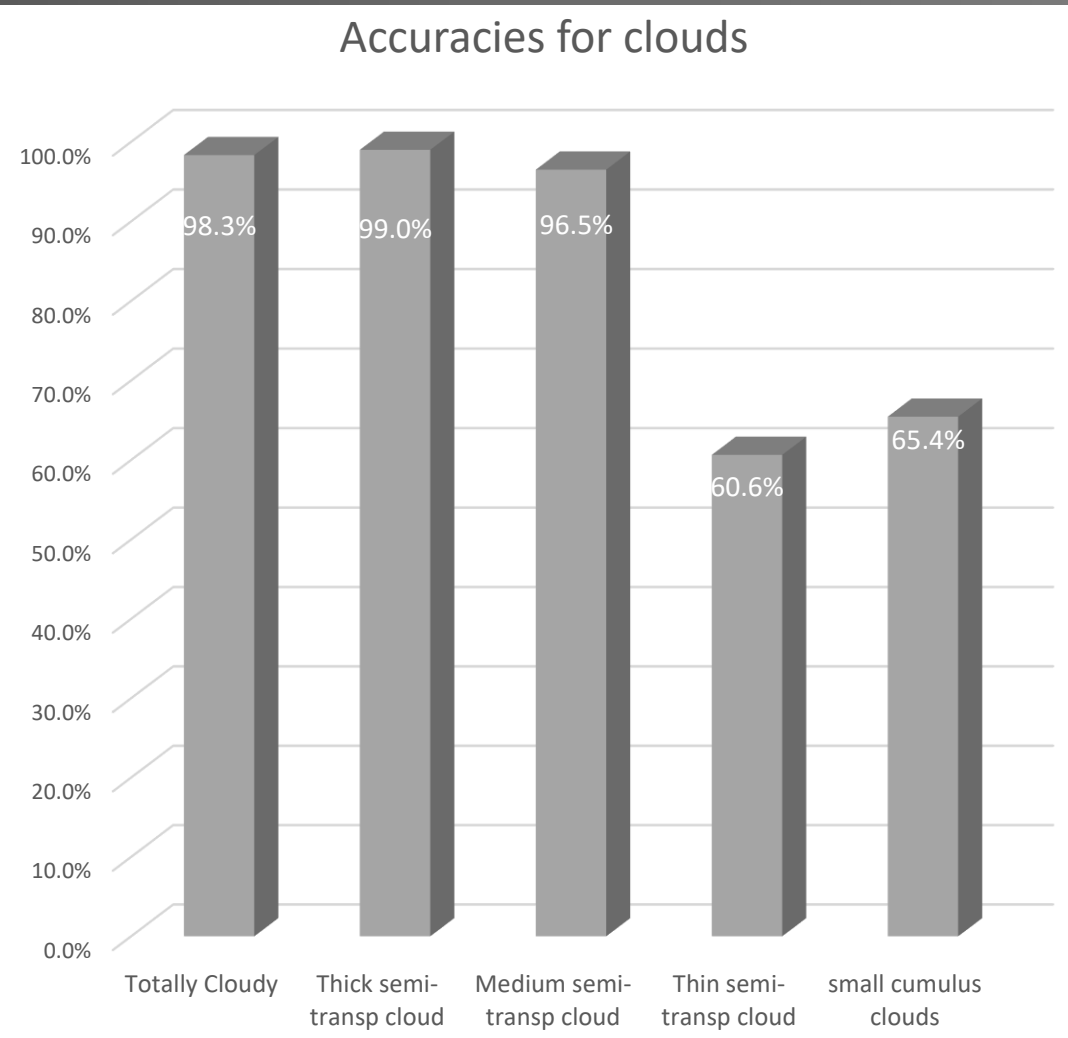
Performance of clear and cloudy surfaces – 100m



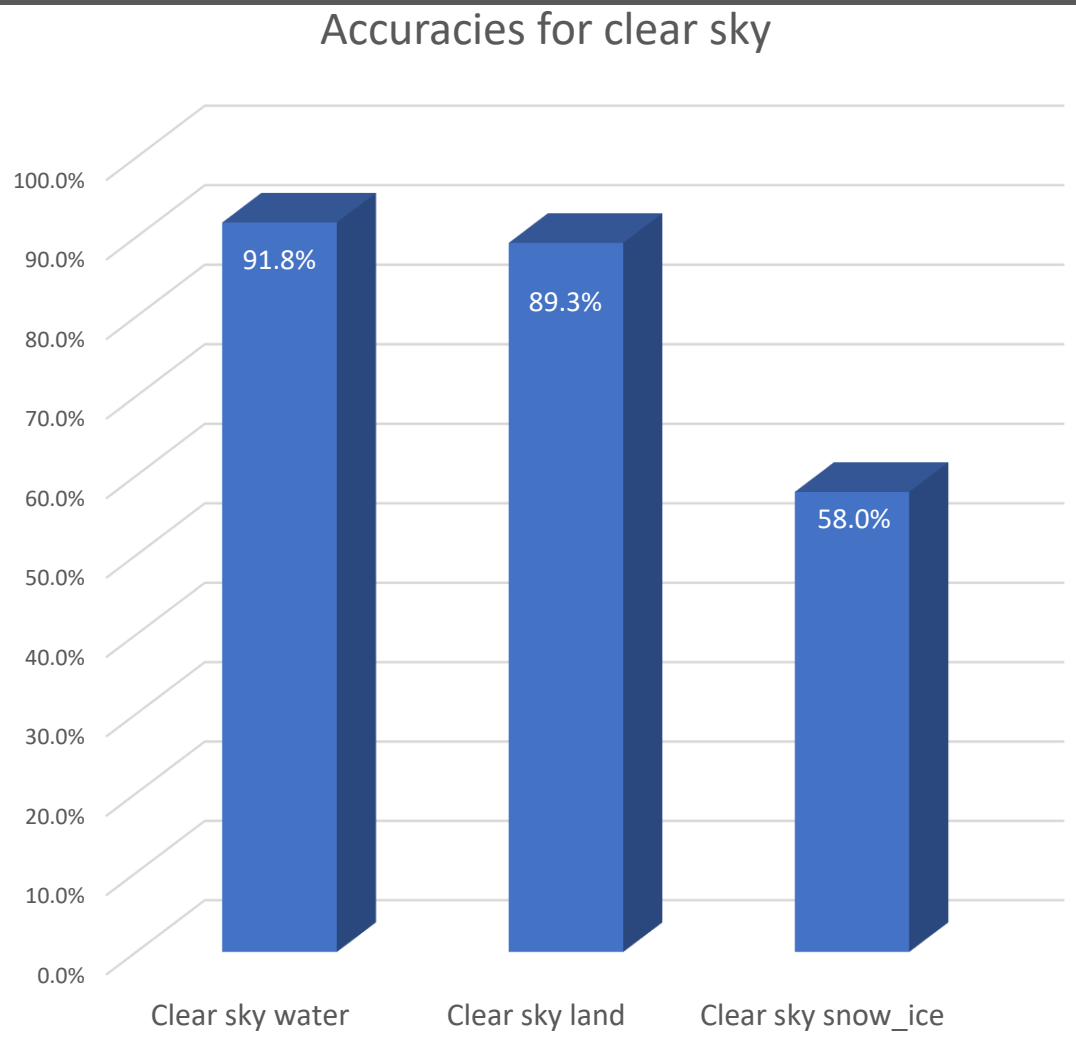


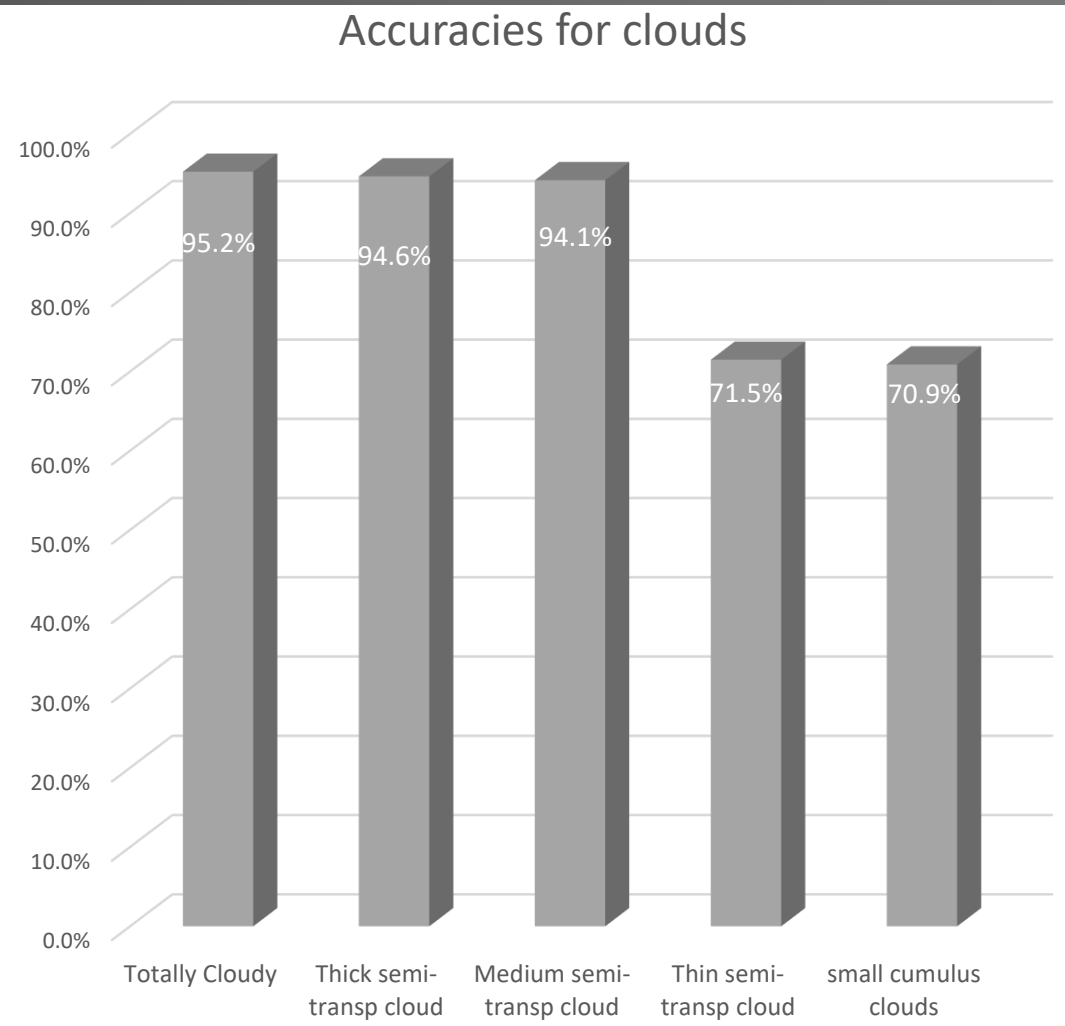
Performance of clear and cloudy surfaces – 333m



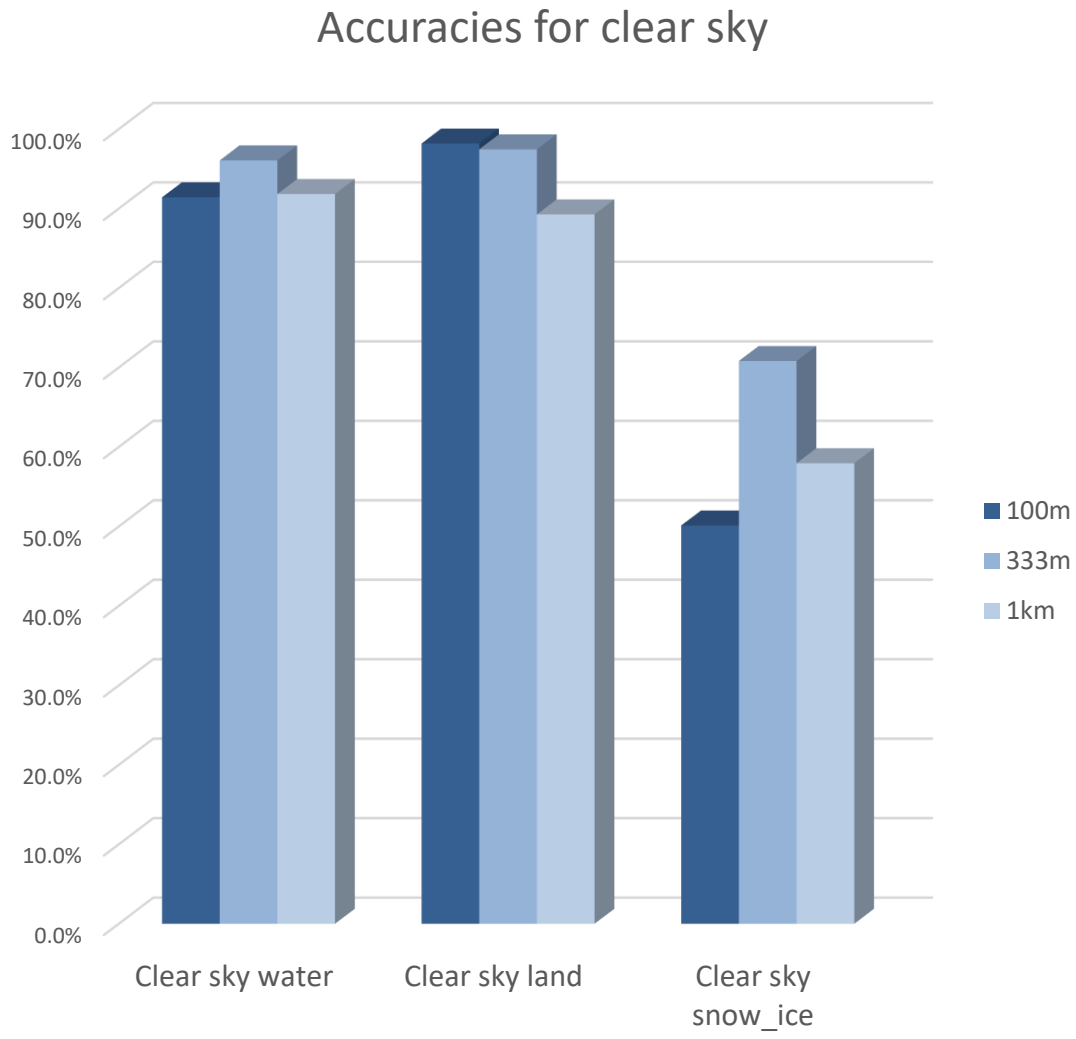


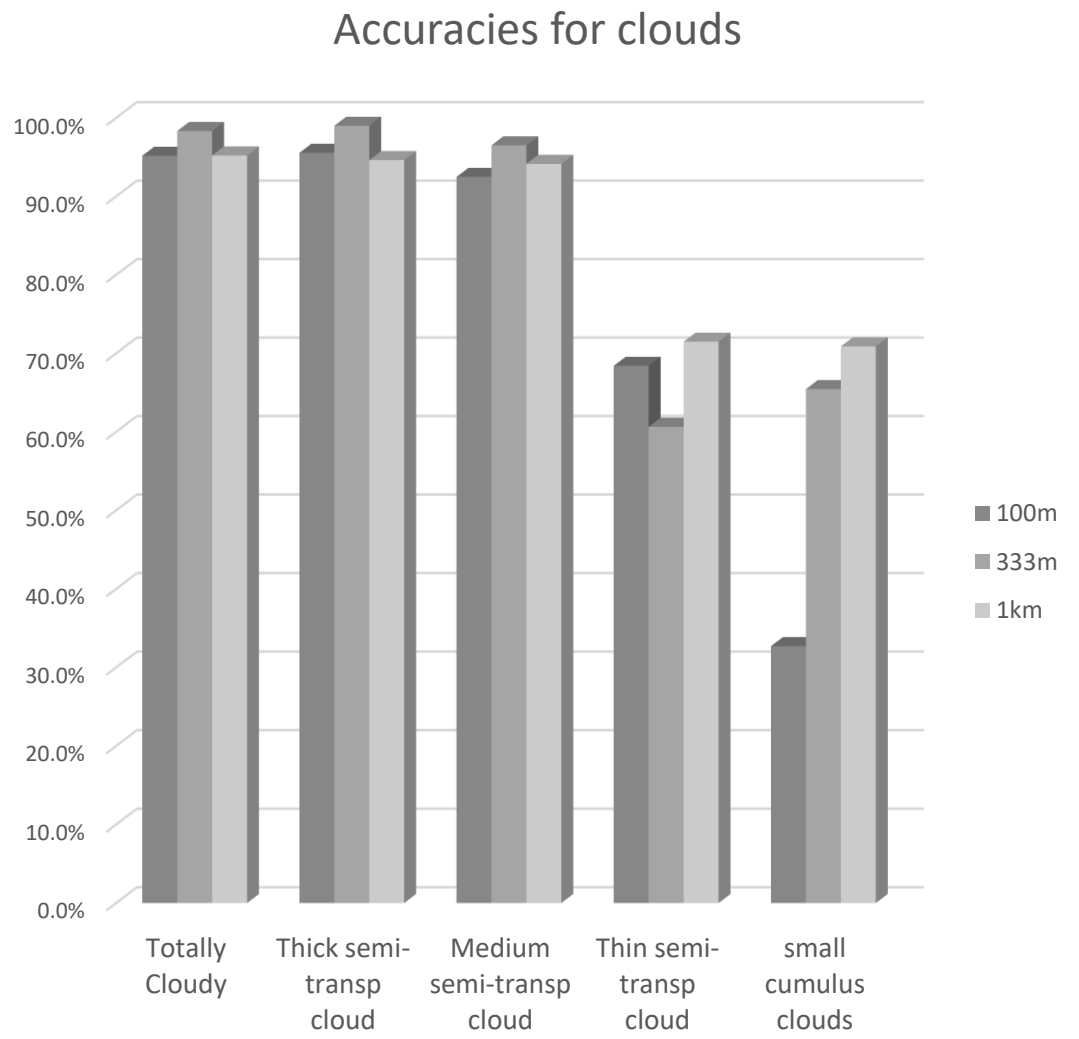
Performance of clear and cloudy surfaces – 1km





Comparison all resolutions

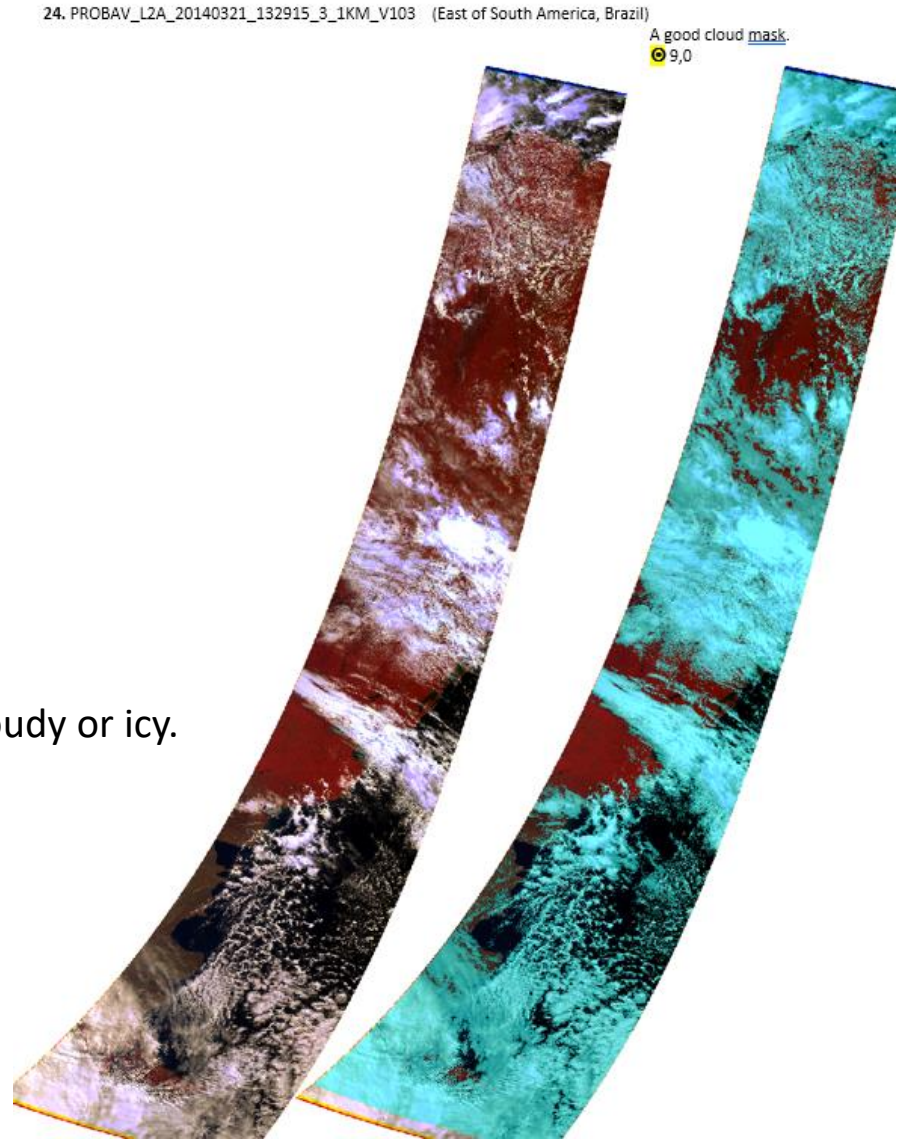




Visual inspection

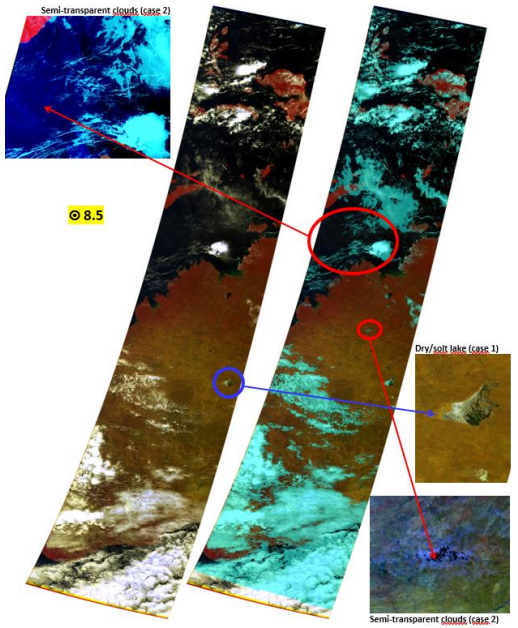
- Assessment per randomly selected products
- Development of assessment criteria

- - Cloud-free pixels are marked as clouds.
- - Cloudy pixels (except very thin ones) are marked as clear sky.
- - Well done cloud/snow mask.
- - Thin and very thin clouds are **not** marked as clouds.
- - Oversaturated cloud pixels are incorrectly identified as ice.
- - A clear sky land/sea snow/ice pixels are marked as cloudy.
- - The dark, melting clear sky ice pixels are **not** marked as such.
- - Sun glint was incorrectly recognized as cloudy.
- - Cloud-free salt lake (as well as dry lakes/rivers) pixels are incorrectly marked as cloudy or icy.
- - Sand storm, dust, aerosols are masked as cloudy.
- - Spatially-mixed snow covered pixels are **not** recognized as such.
- - Shadow sizes are defined incorrectly.



Visual inspection

- 1km: 81 products
- 100m: 80 products
- 333m: 22 products



1. PROBAV_L2A_20140321_012314_1_1KM_V103 (Pacific Ocean in the east of Kamchatka Peninsula)
A well done cloud-, land snow, floating ice mask.

2. The same Fragment.
Some clear sky land ice pixels are wrongly marked as cloudy.

3. The same Fragment.
Some clear sky land ice pixels are wrongly marked as cloudy.

4. PROBAV_L2A_20140321_000131_1_1KM_V103 (New Caledonia, Vanuatu, Pacific Ocean)
A well done cloud mask.

5. The same Fragment.
Sun glint pixels are wrong recognized as cloudy.

6. PROBAV_L2A_20140321_000656_2_1KM_V103 (East Australia, Pacific Ocean)
Oversaturated cloud pixels are incorrectly identified as ice.

…

Summary visual inspection

Overall assessment for different **cloud** types (assessment if clouds are detected as cloud)

Cloud type	***Surface***	***SCMQR 100m***	***SCMQR 333m***	***SCMQR 1km***
Thick clouds		++	++	++
Small cumulus clouds	over land	+	+	++
	over water	+	+	+
	over water (at sun glint)	+	+	+
Semi-transparent clouds „usual“	over land, water	++	+	++
Sem-itransparent clouds „very thin“	over land, water	o		o

Summary visual inspection

Overall assessment for different **surface** types (assessment if clouds are detected as cloud)

Clouds	***Surface***	***SCMQR 100m***	***SCMQR 333m***	***SCMQR 1km***
Clouds over land (all cloud types)	over „usual“ land	++	++	++
Clouds	over desert	+	+	++
Clouds	over salt lake	+	+	+
Clouds	over urban area	+	+	+
Clouds	over ice/snow	+	+	+
Clouds over water (all cloud types)	over water	++	++	++
Clouds	over Inland water	++	++	+
Clouds	over floating ice	+	+	+
Clouds	over sun glint	+		+

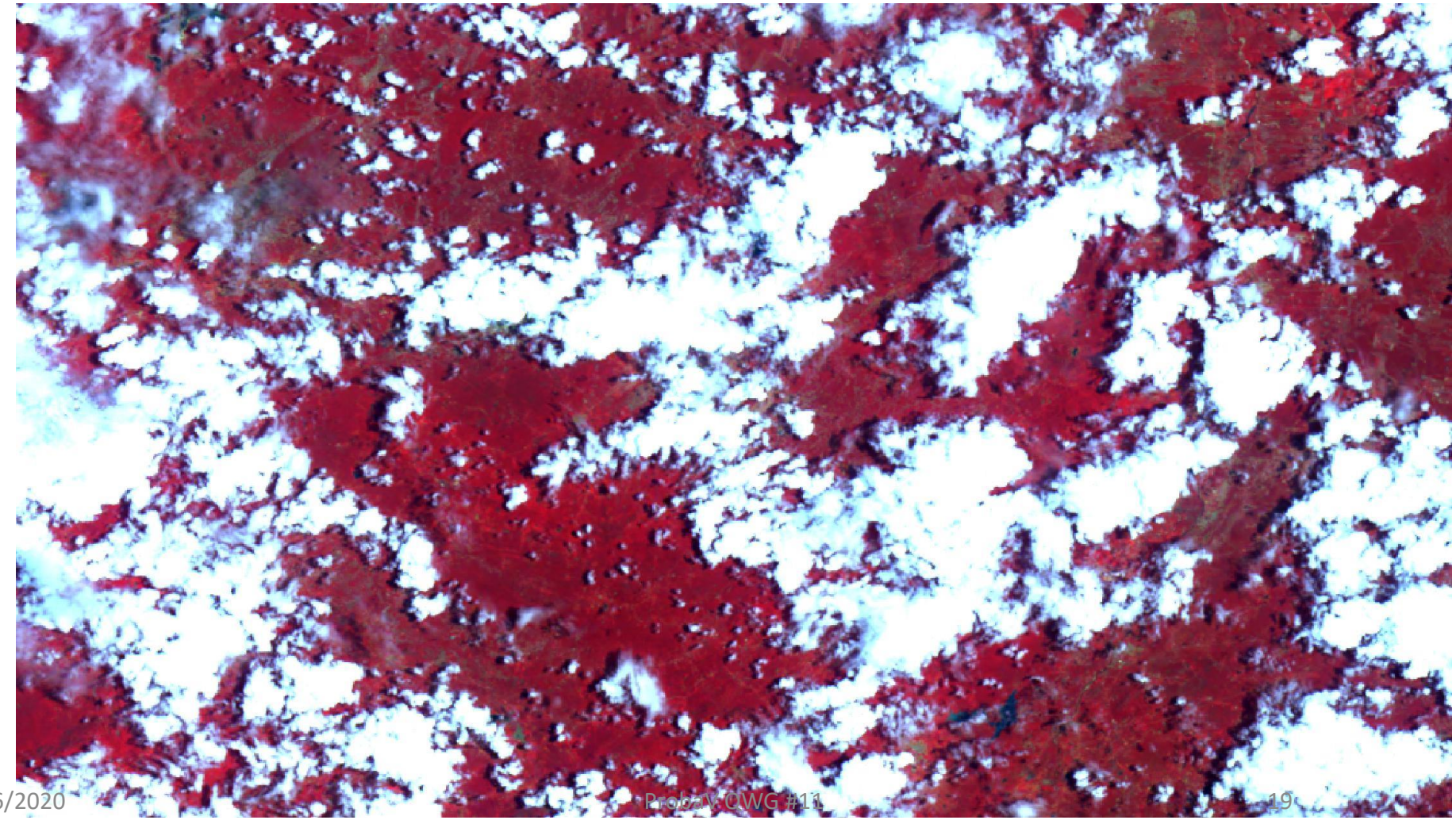
Summary visual inspection

Overall assessment for clear surfaces (assessment if clear surfaces are clear)

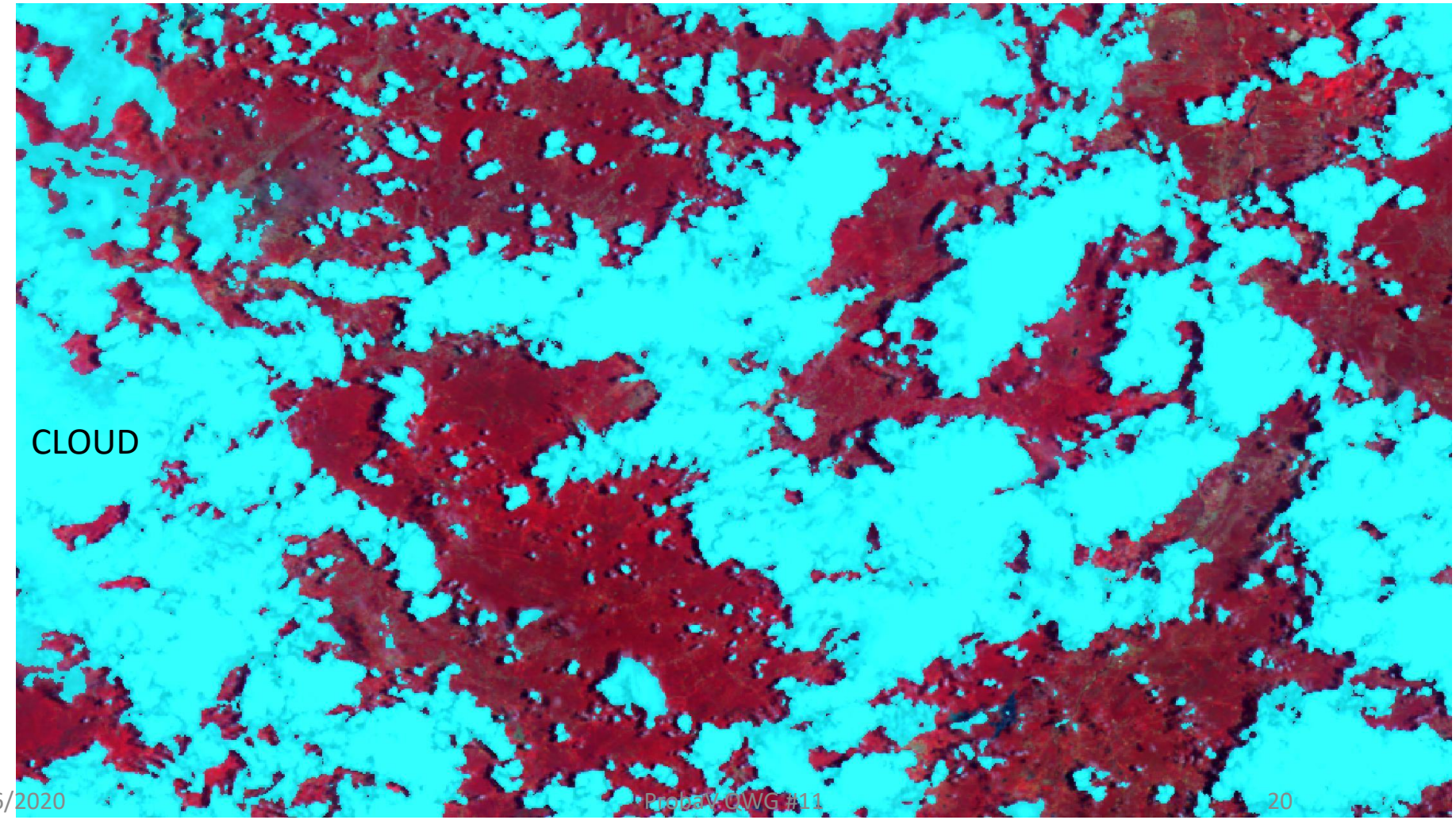
Clear	*Surface*	*SCMQR 100m*	*SCMQR 333m*	*SCMQR 1km*
Cloud free over land	over „usual“ land	++	+	++
	over desert	++	+	++
	over salt lake	o	o	o
	over urban area	+	+	+
	over ice/snow	o	+	o
Cloud free over water	over water	++	++	++
	over Inland water	++	++	++
	over floating ice	+	+	o
	over sun glint	o		o

Image examples

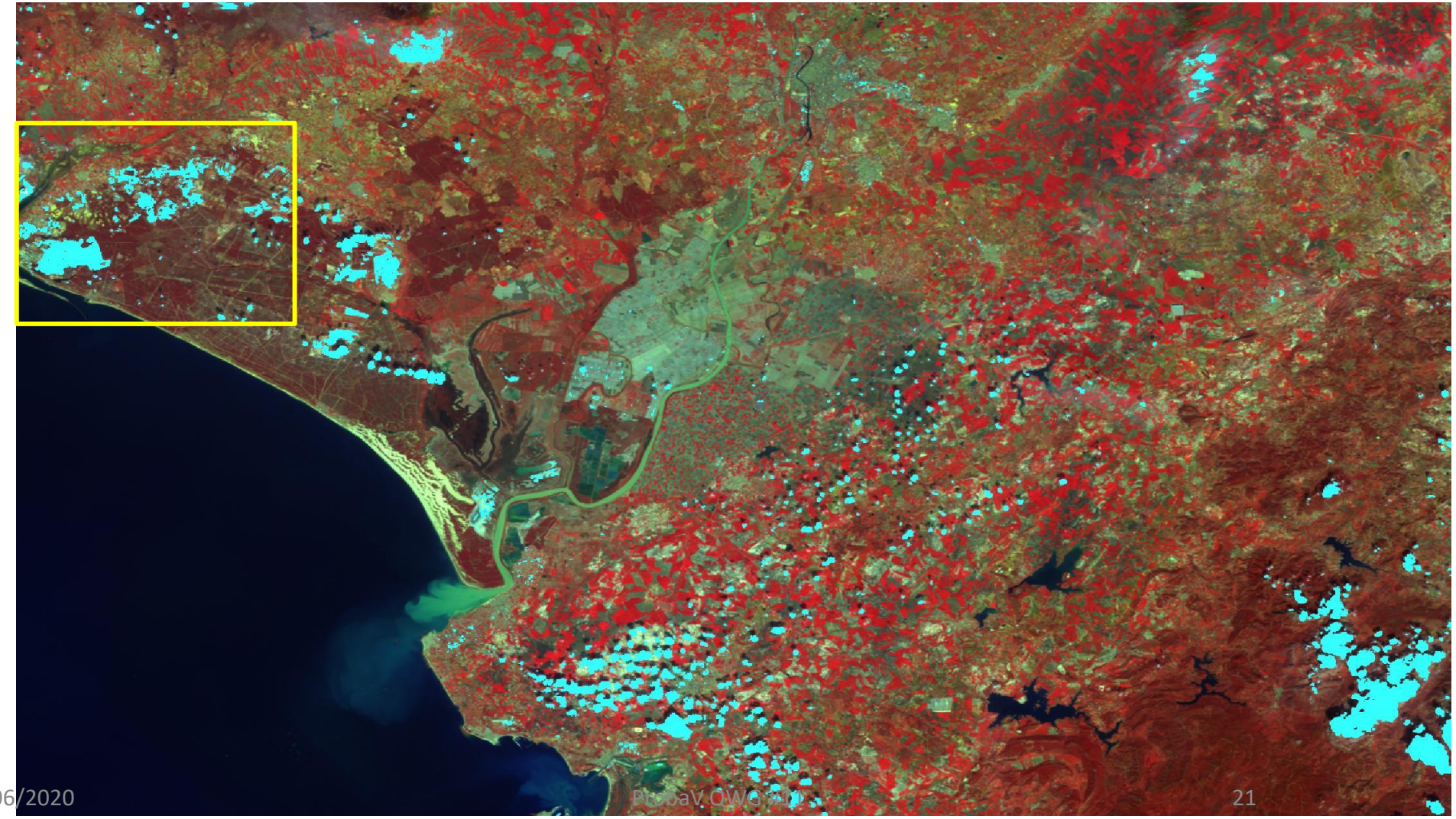
ProbaV 100m Clouds – standard cases



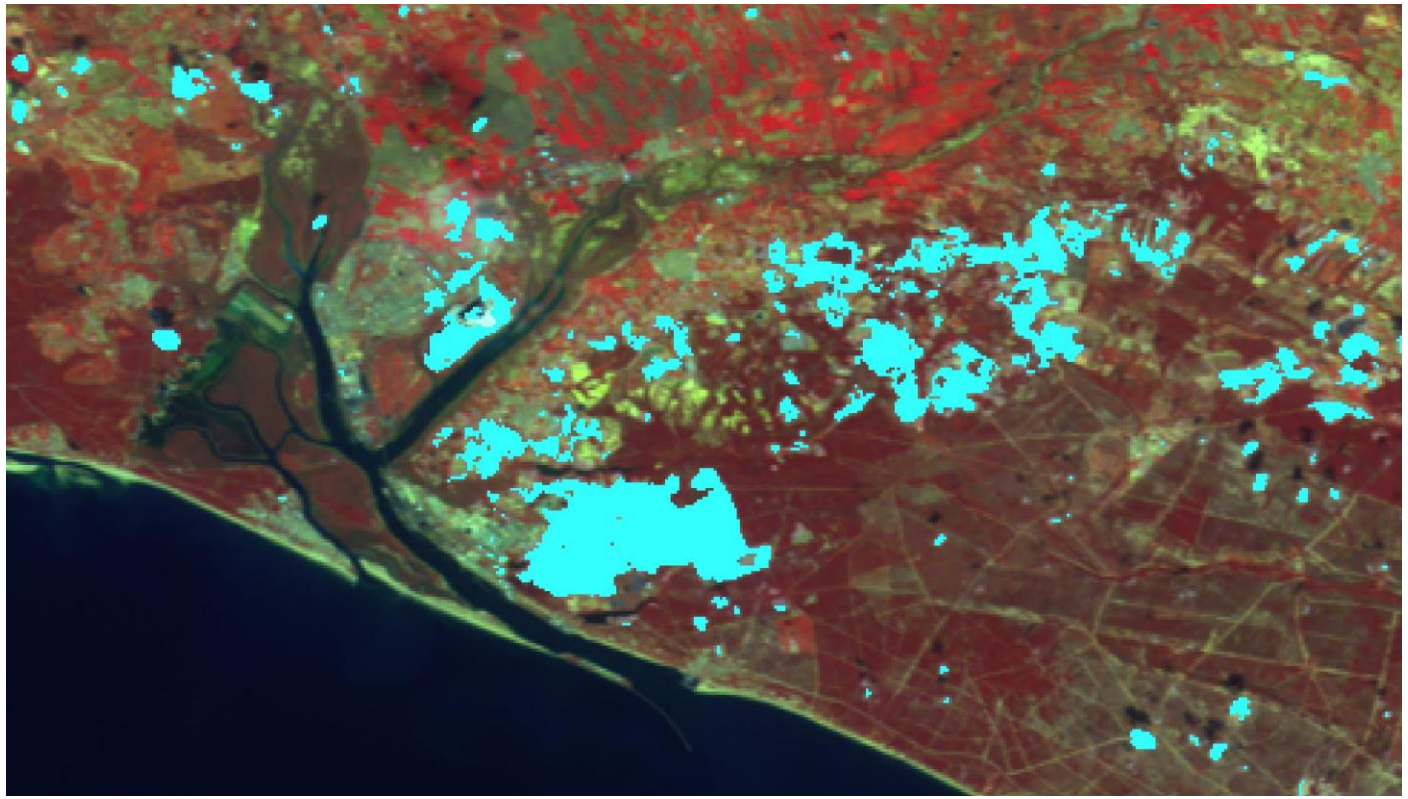
ProbaV 100m Clouds – standard cases



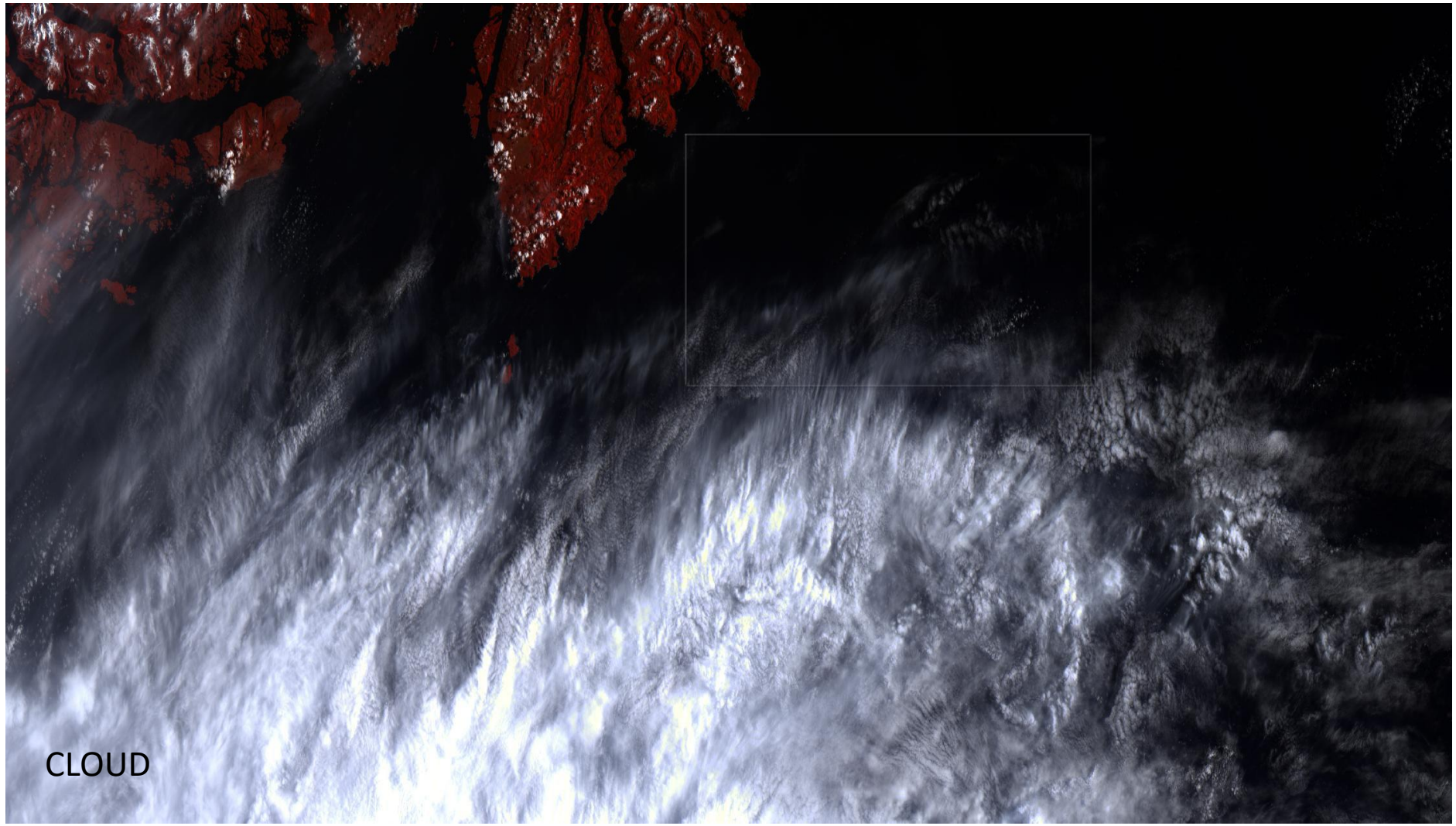
ProbaV 100m - good example for difficult cases



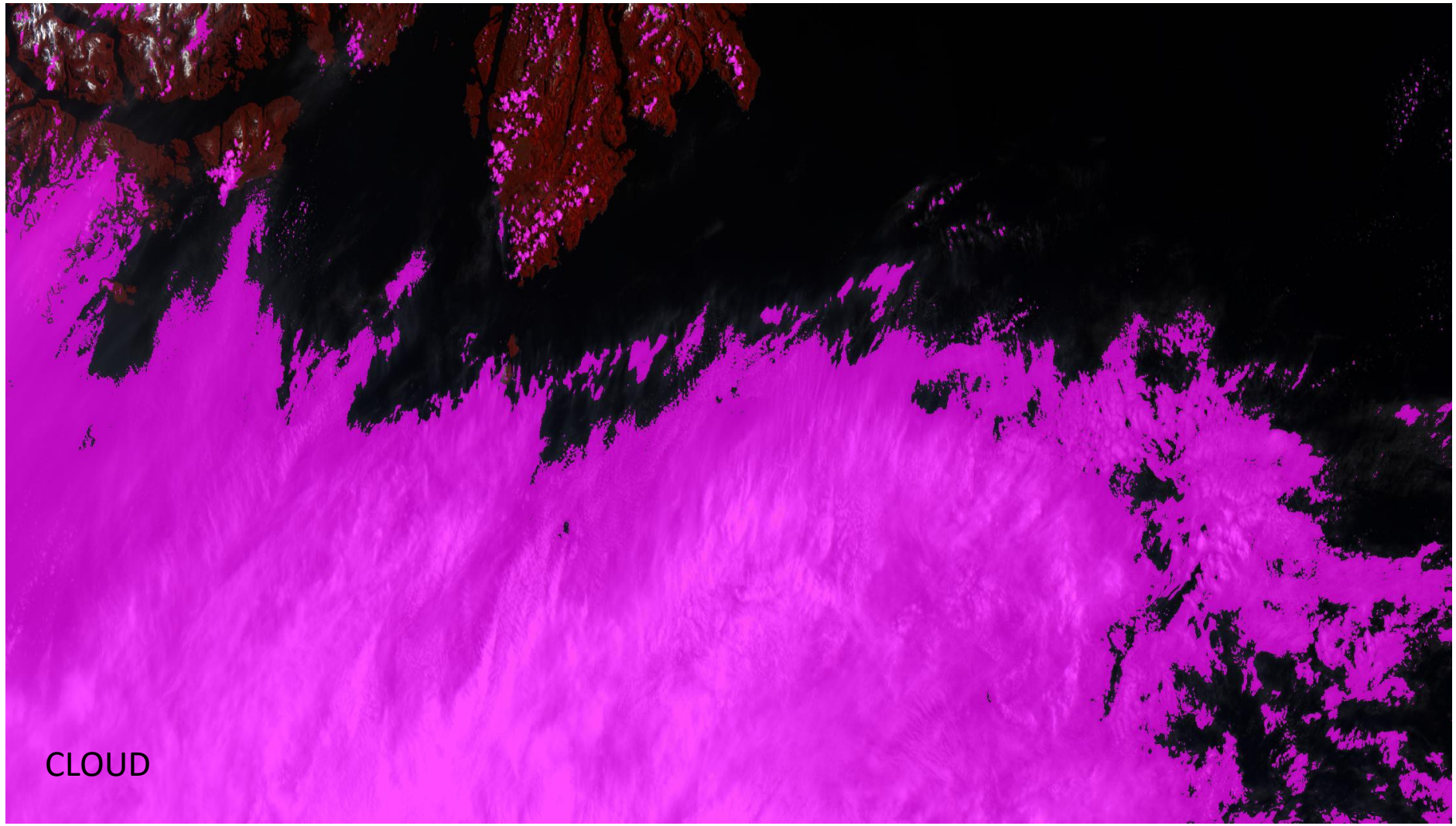
ProbaV 100m - example for difficult cases



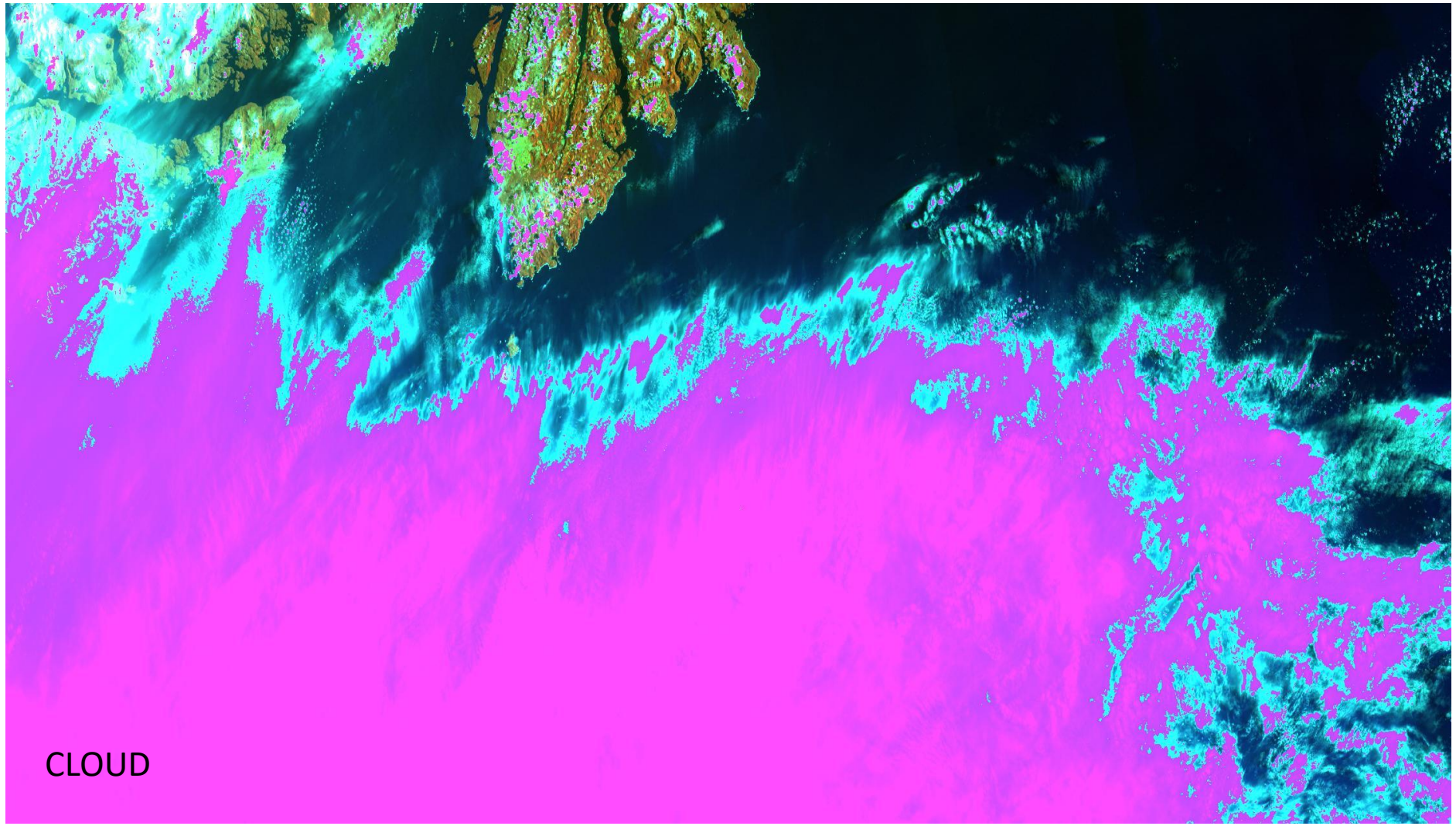
ProbaV 100m - Clouds – water – semi-transparent



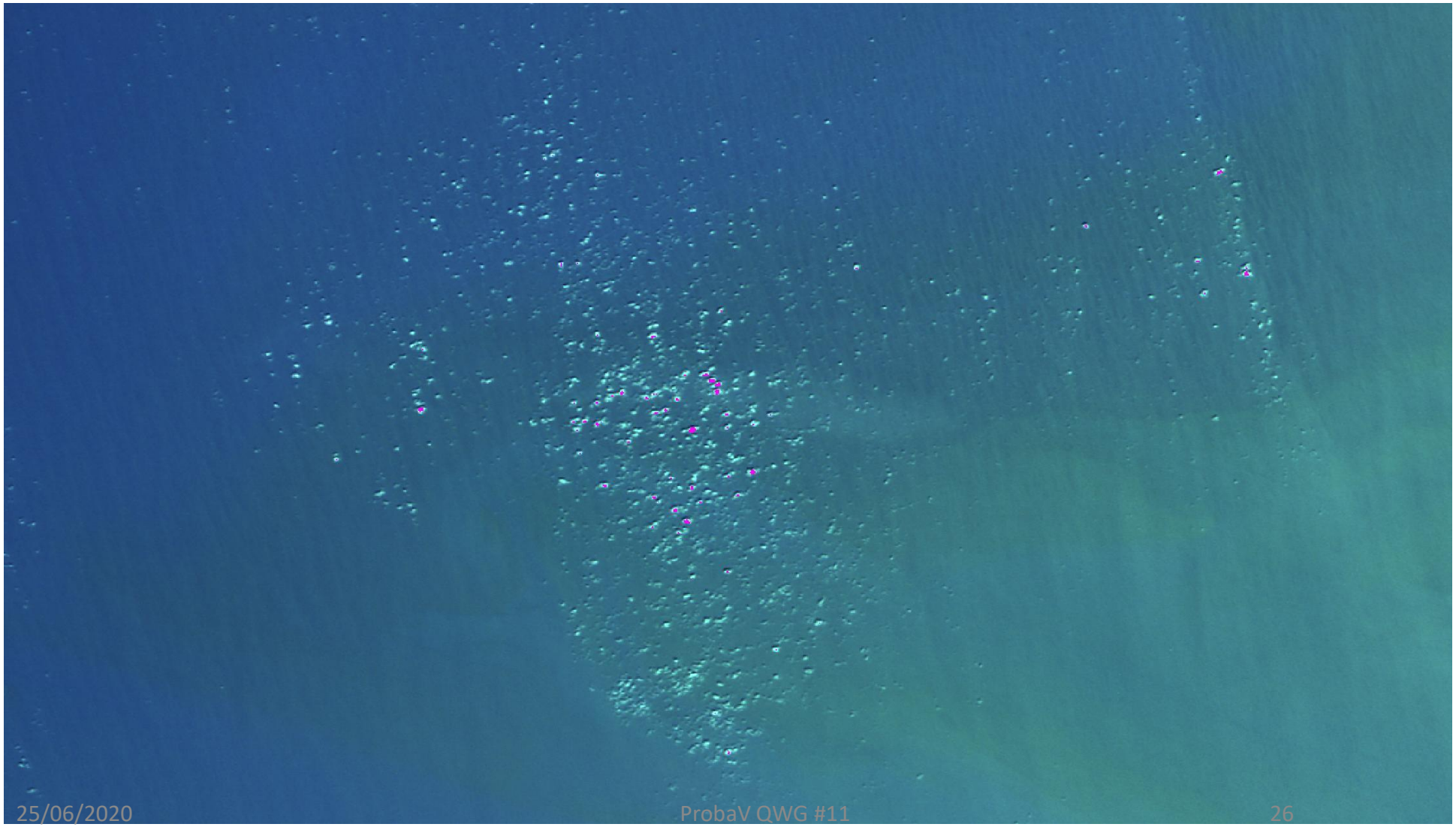
ProbaV 100m - Clouds – water – semi-transparent



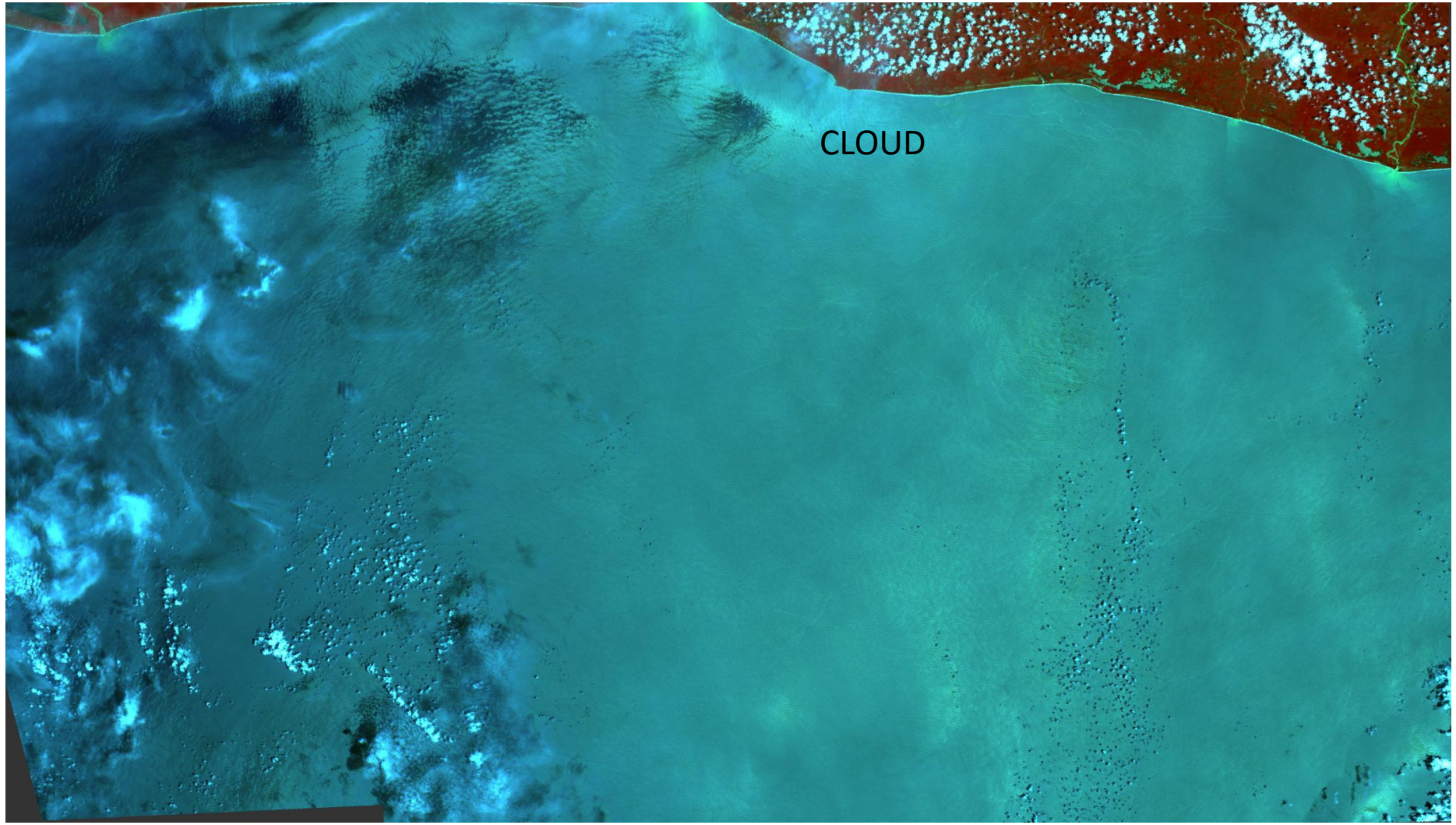
ProbaV 100m - Clouds – water – semi-transparent



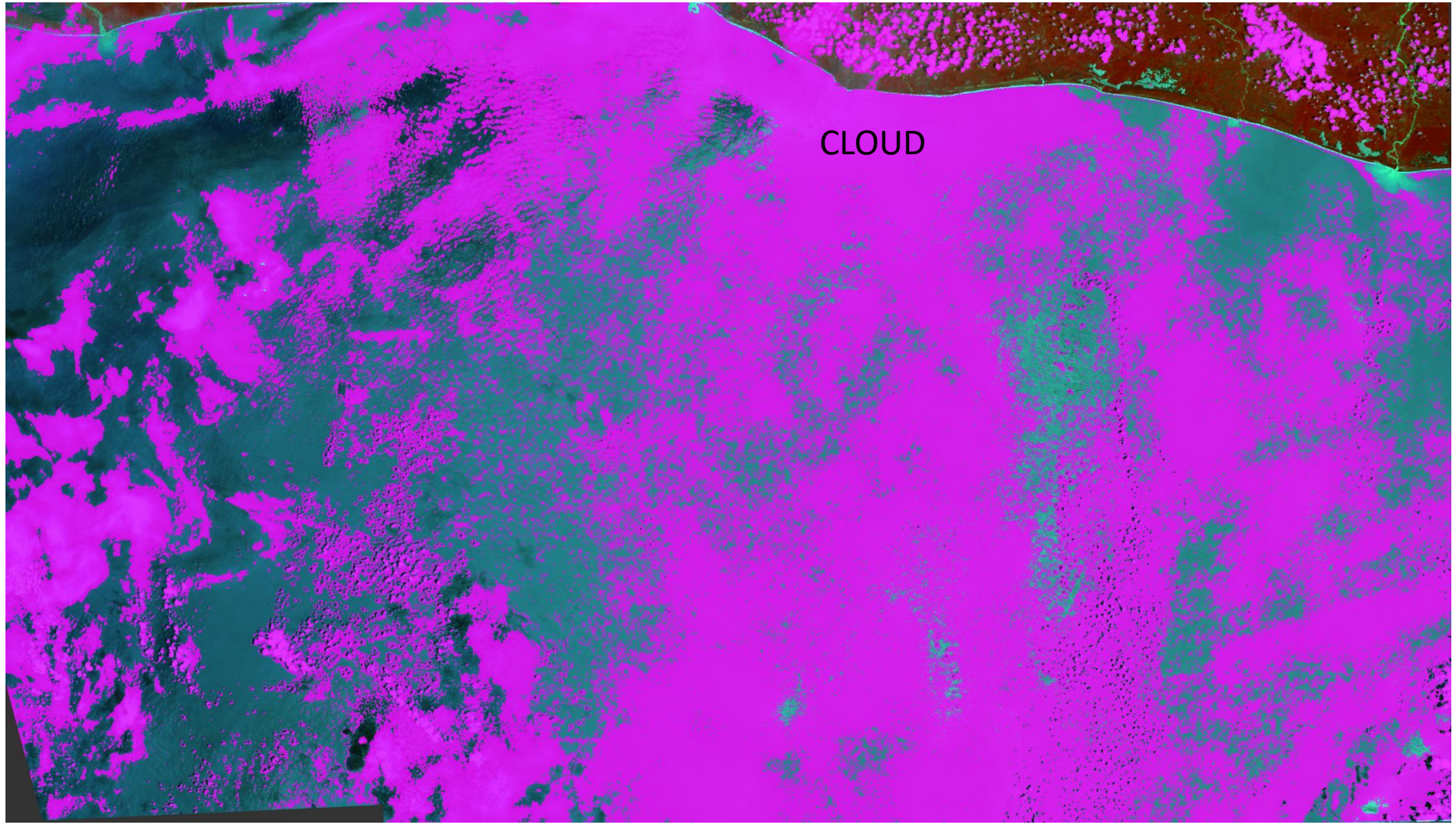
ProbaV 100m - cumulus clouds



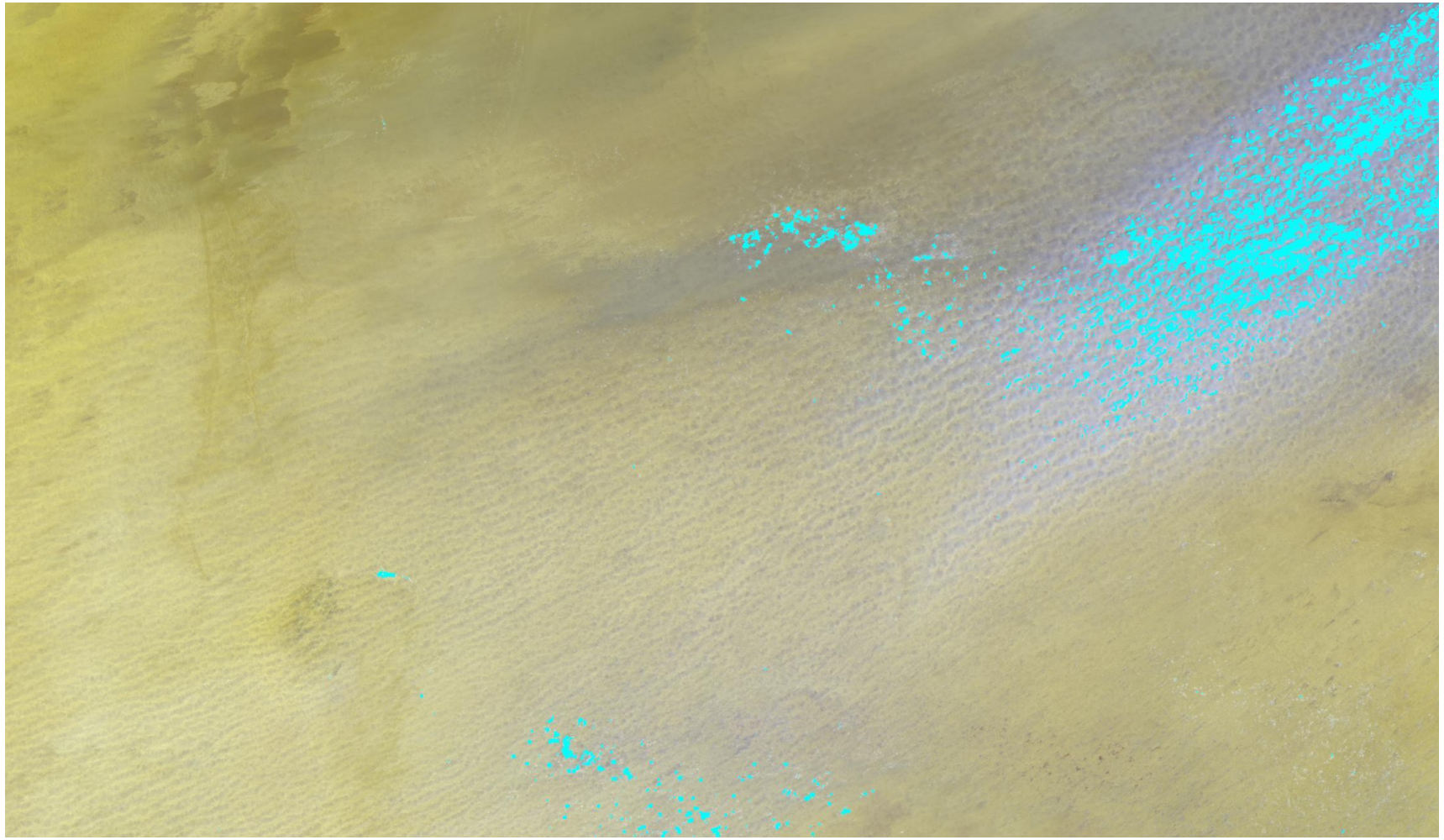
ProbaV 100m - water – sun glint



ProbaV 100m - water – sun glint

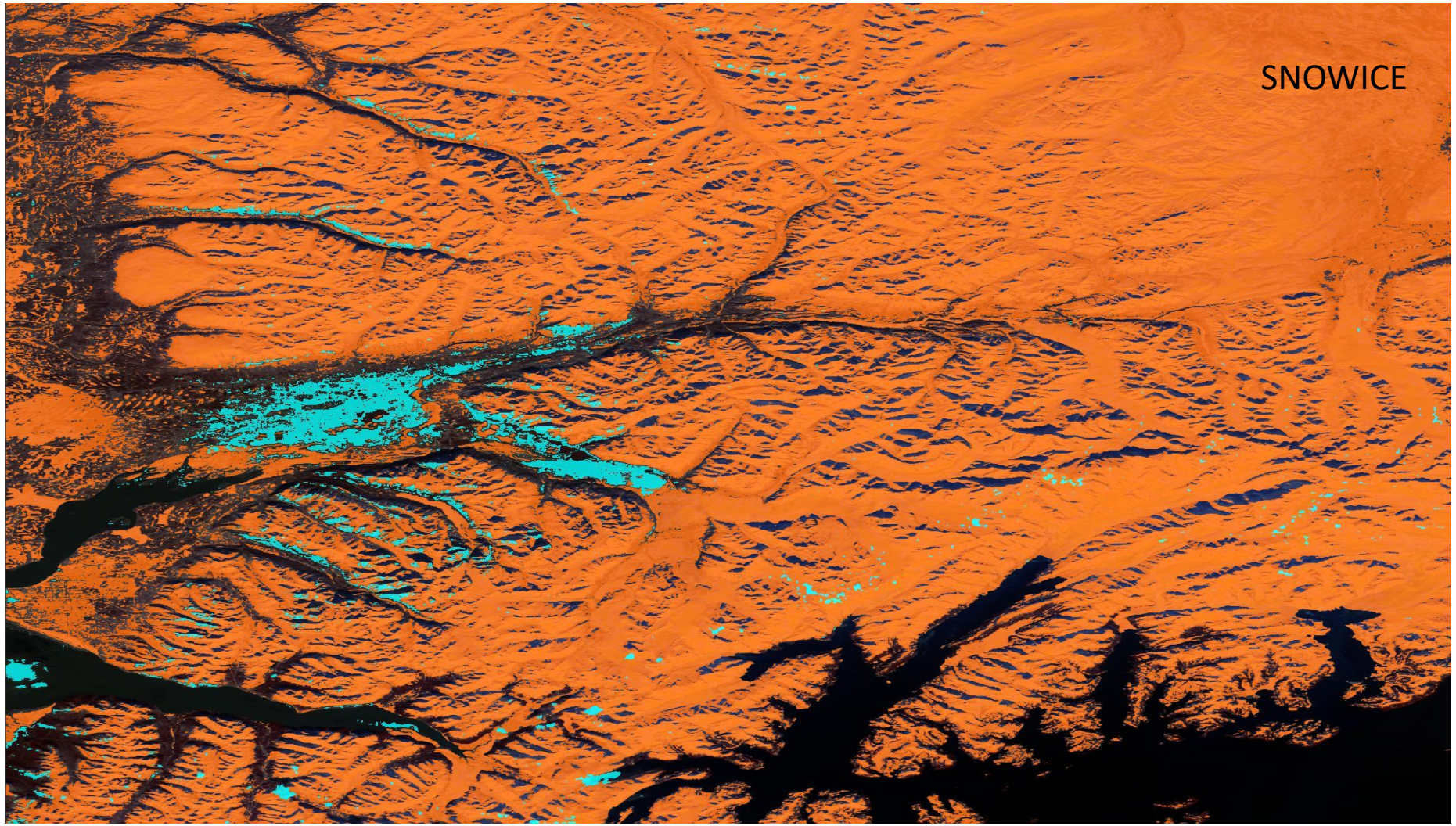


ProbaV 100m - bright surfaces – semi-transparent clouds

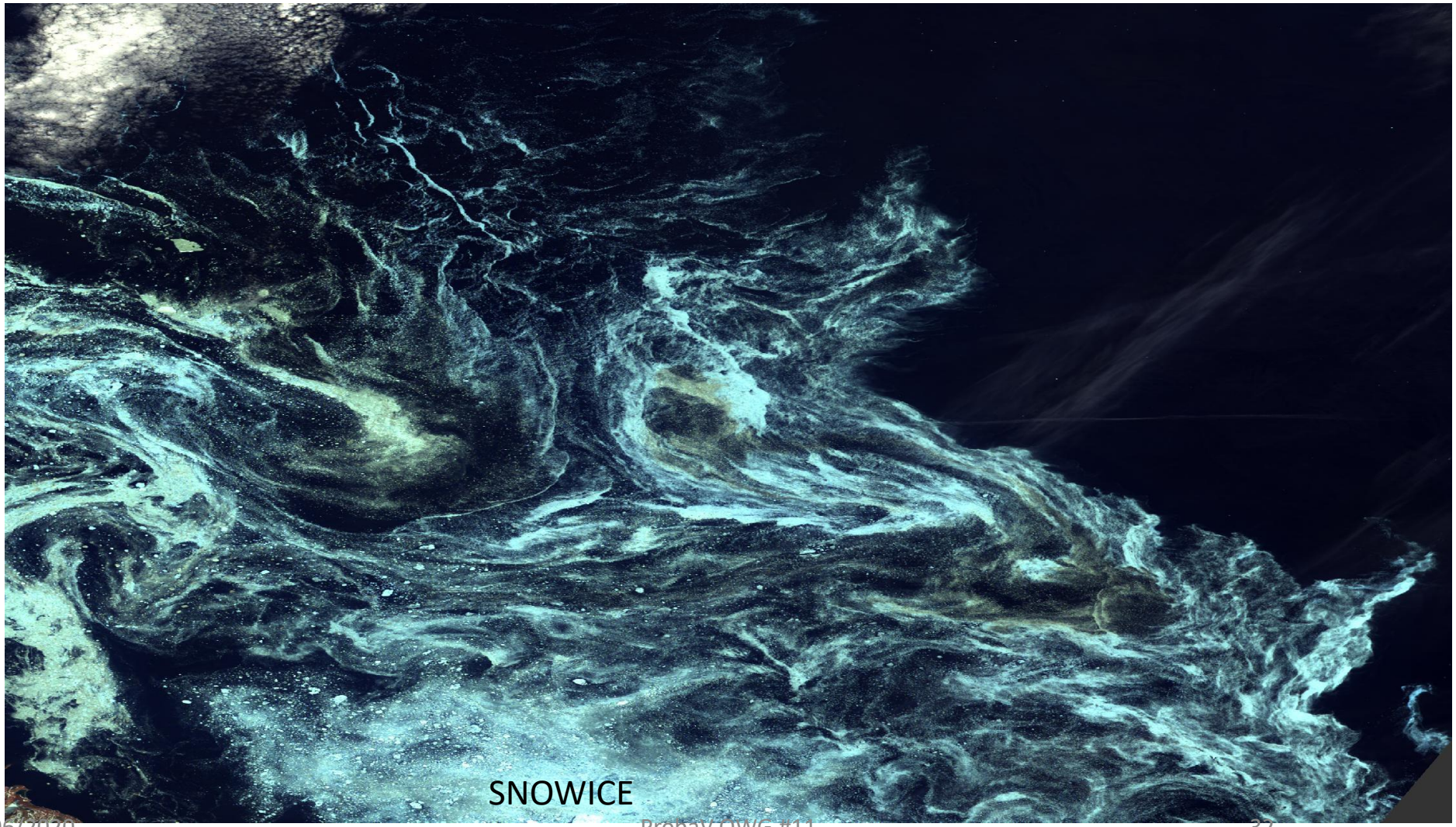


ProbaV 100m - snow - mountains

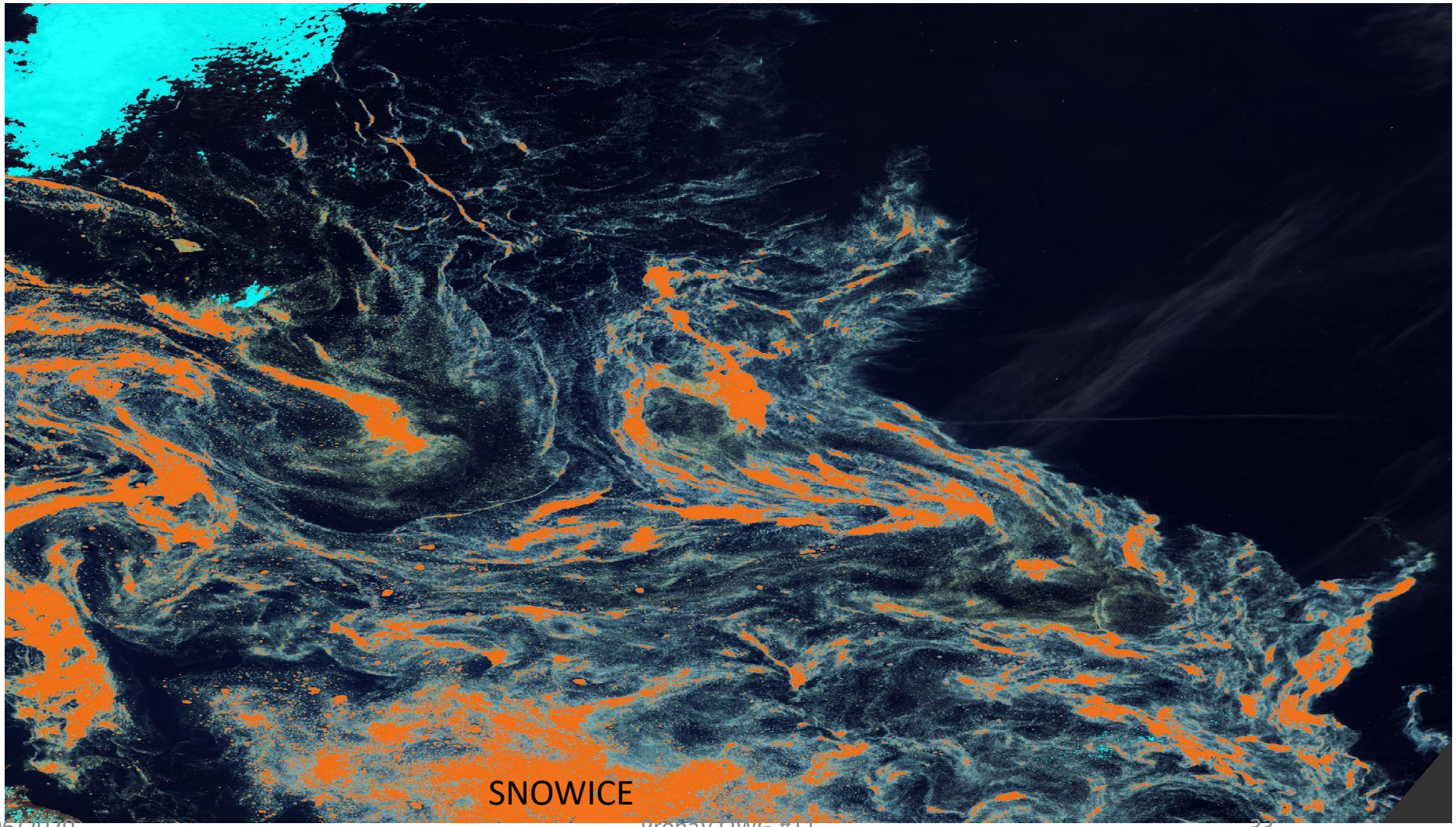
ProbaV 100m - snow - mountains



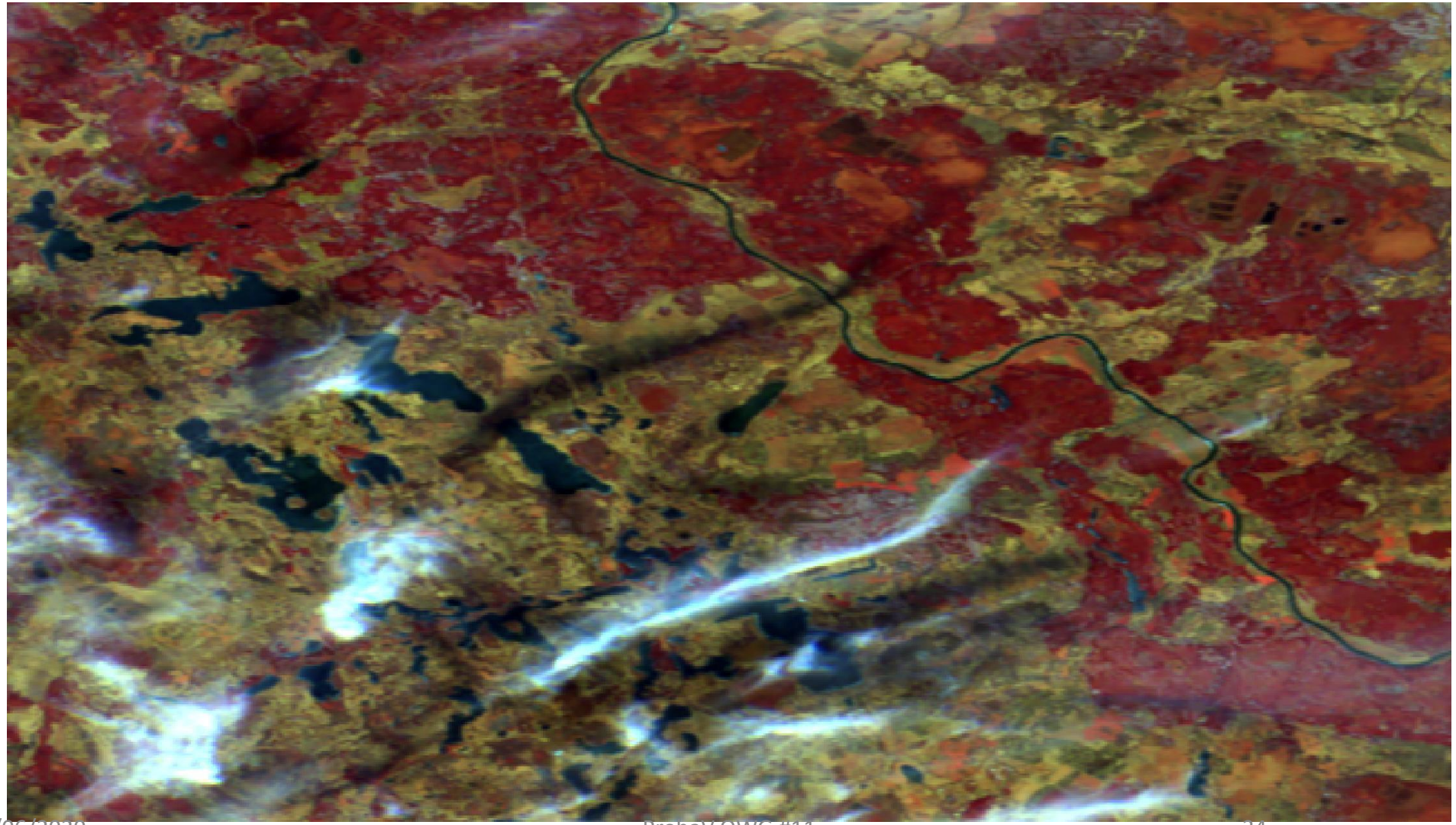
ProbaV 100m - floating/melting ice



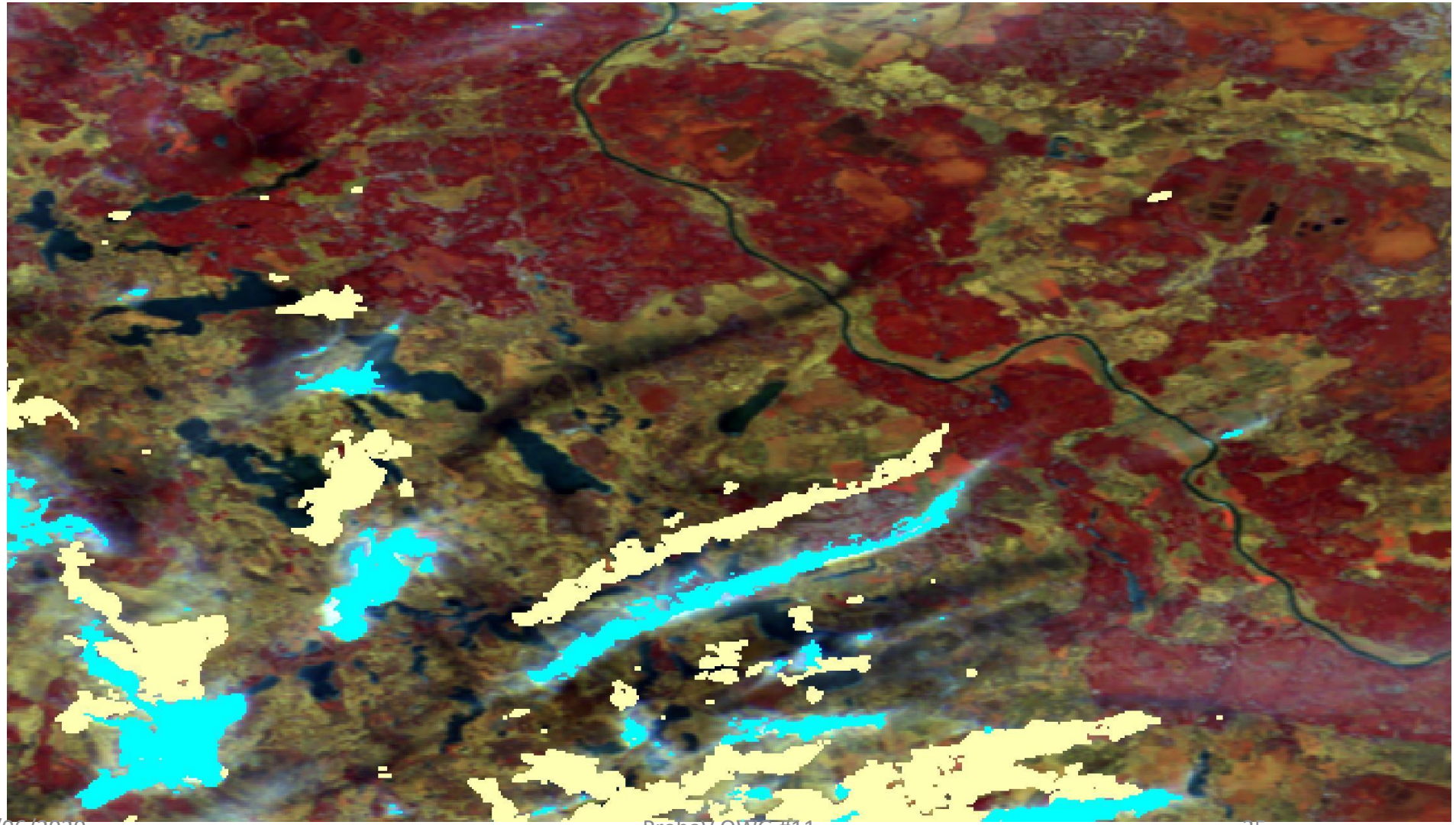
ProbaV 100m - floating/melting ice



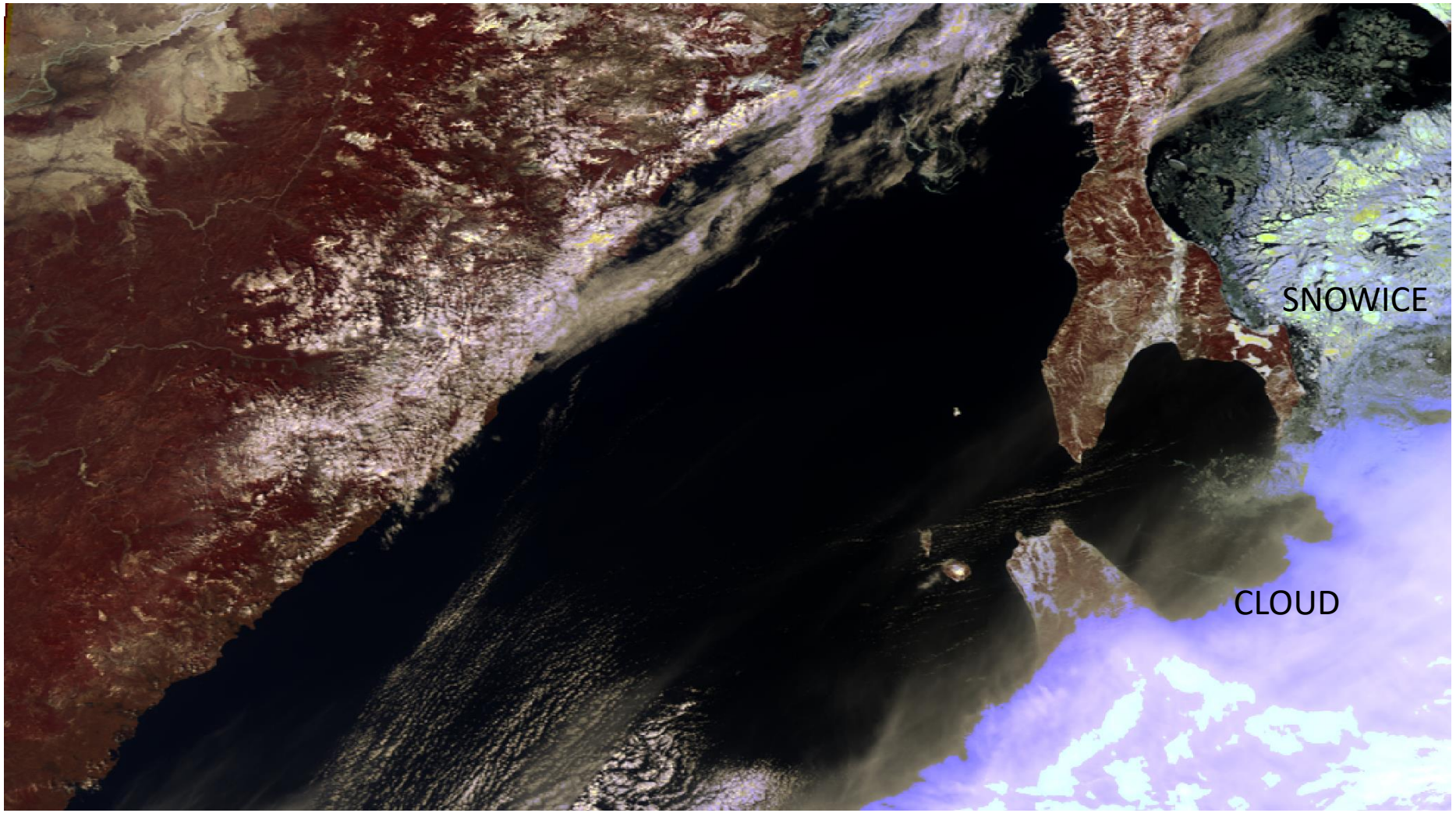
ProbaV 100m - cloud shadow



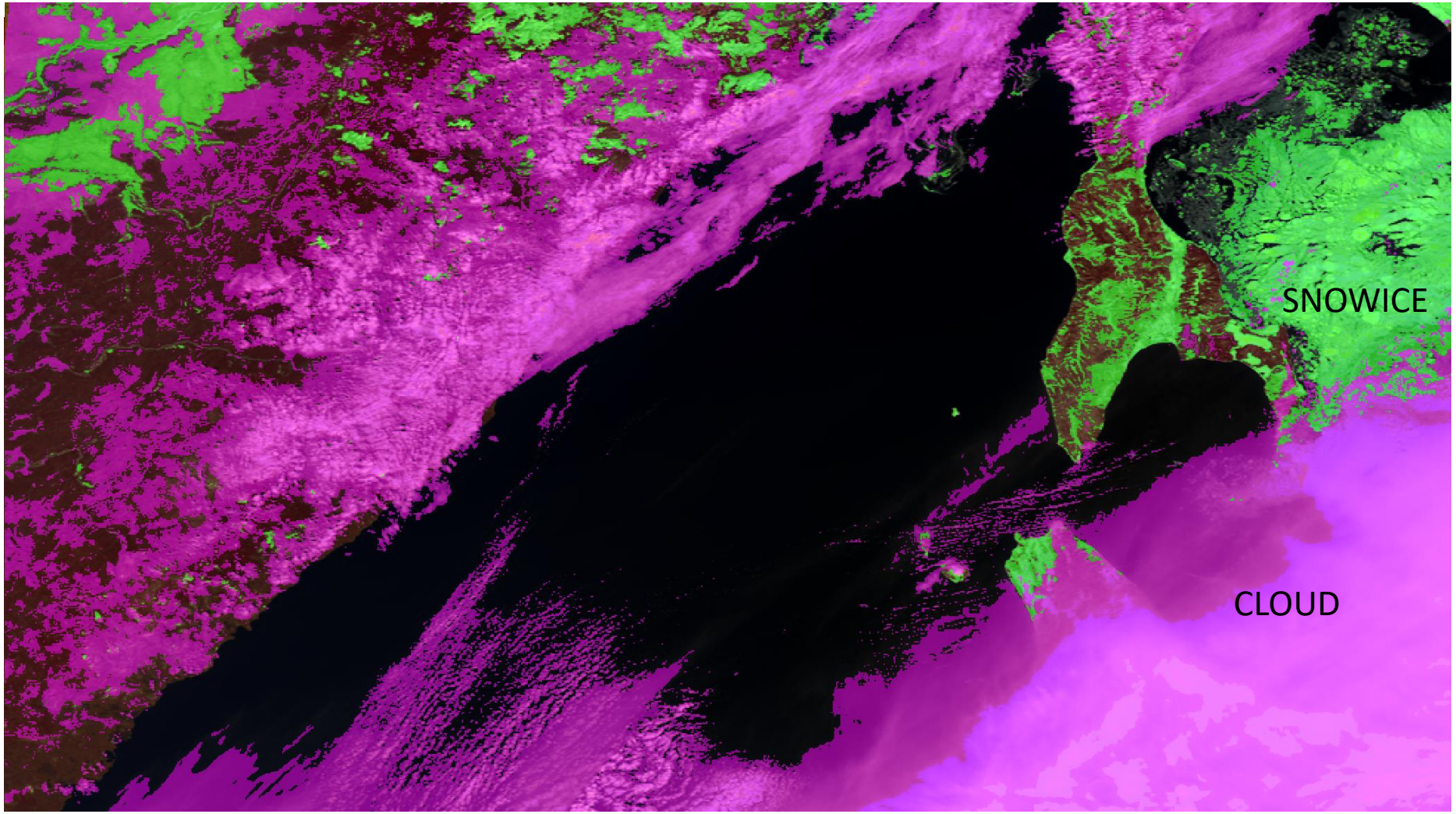
ProbaV 100m - cloud shadow



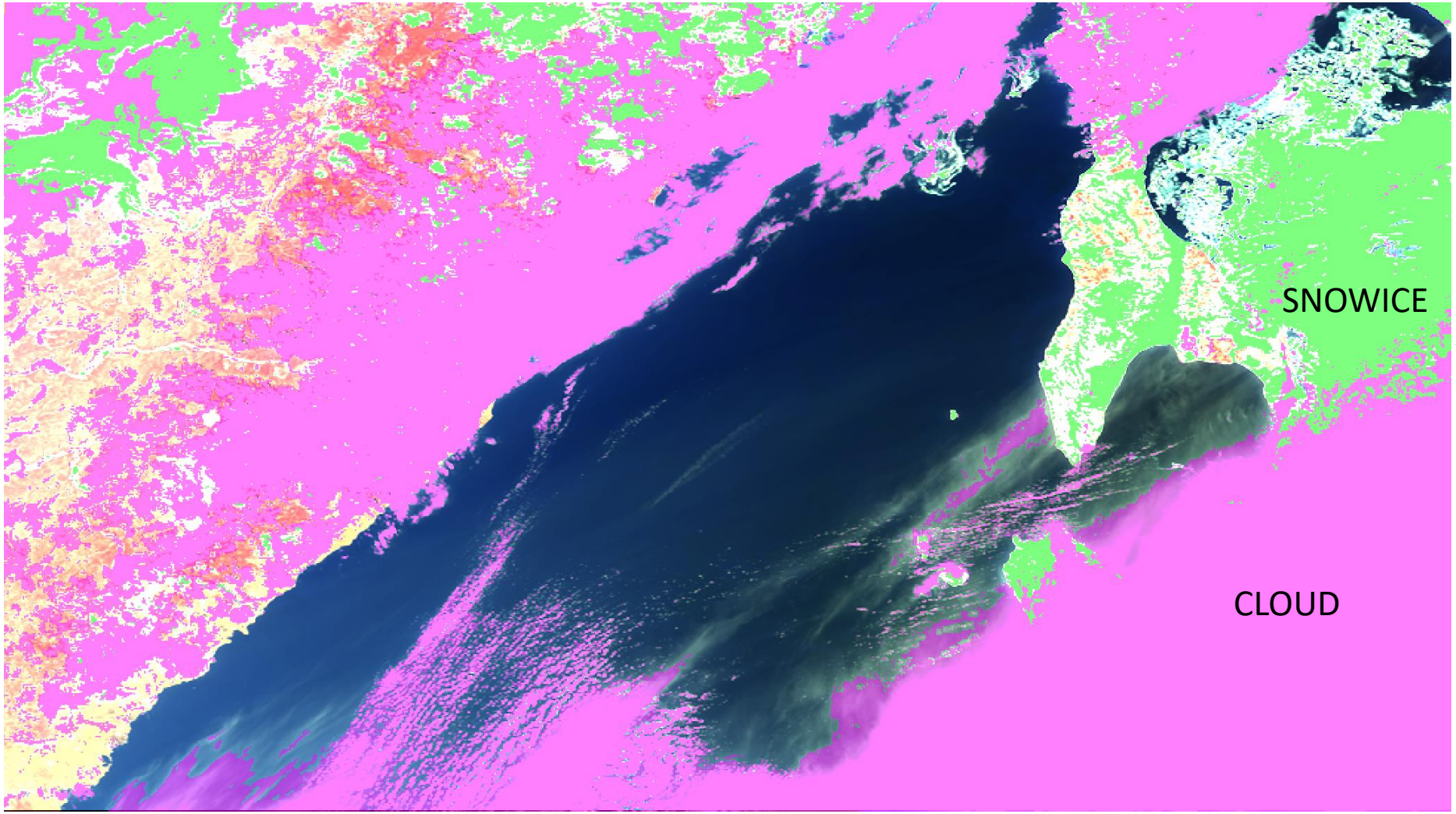
ProbaV 1km Clouds and ice – standard cases



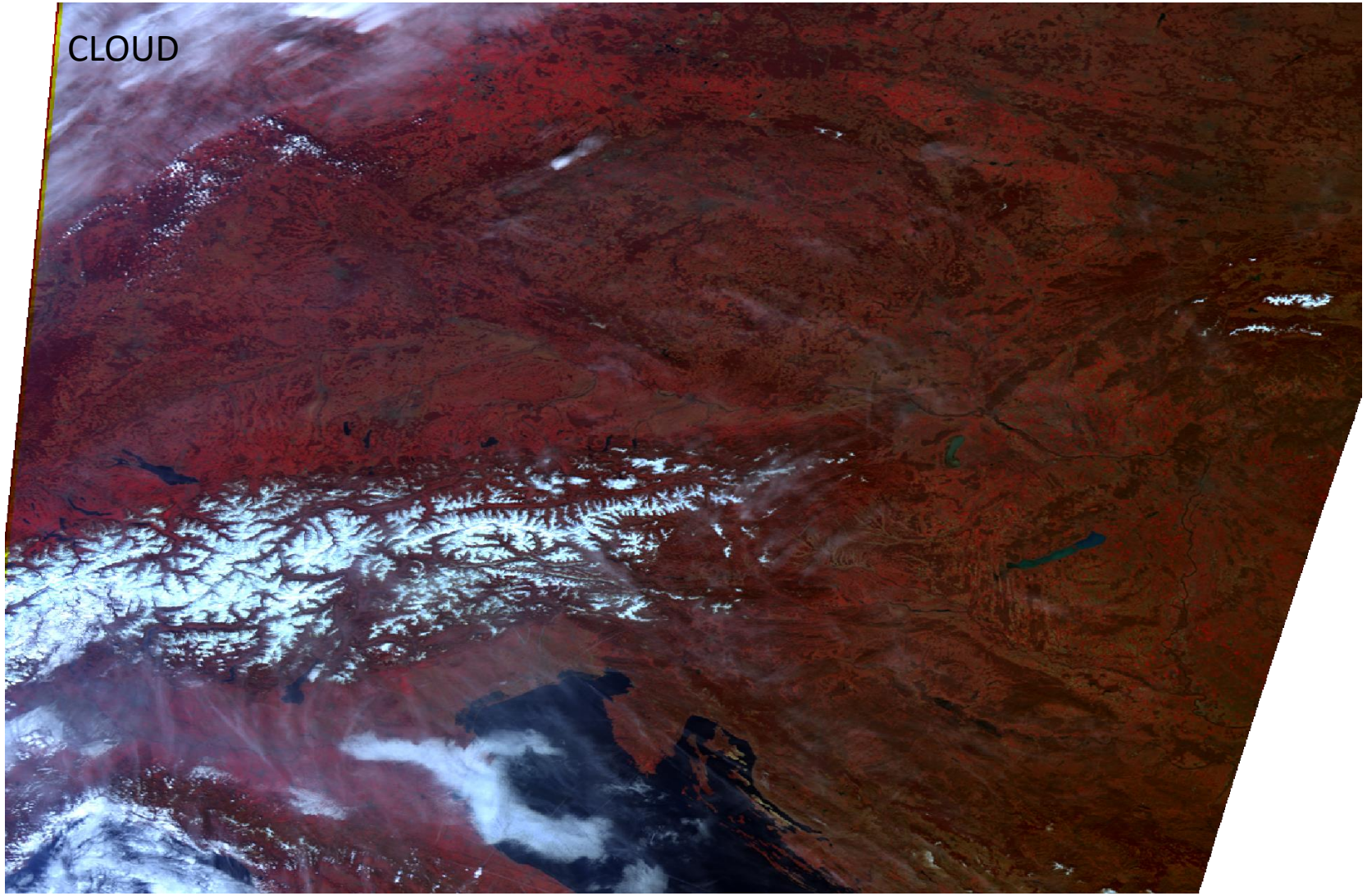
ProbaV 1km Clouds and ice – standard cases



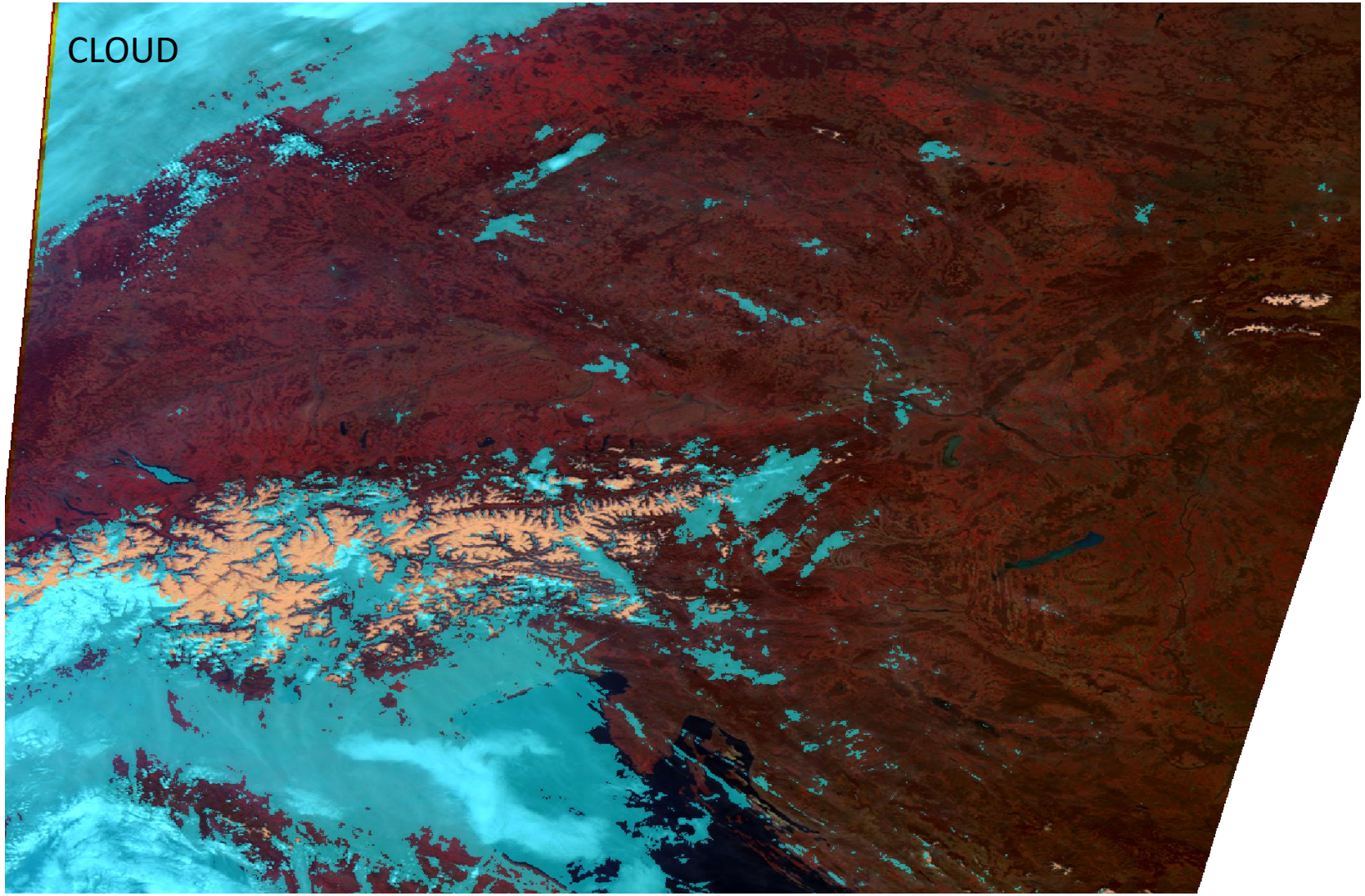
ProbaV 1km Clouds and ice – standard cases



ProbaV 1km Clouds and ice – standard cases

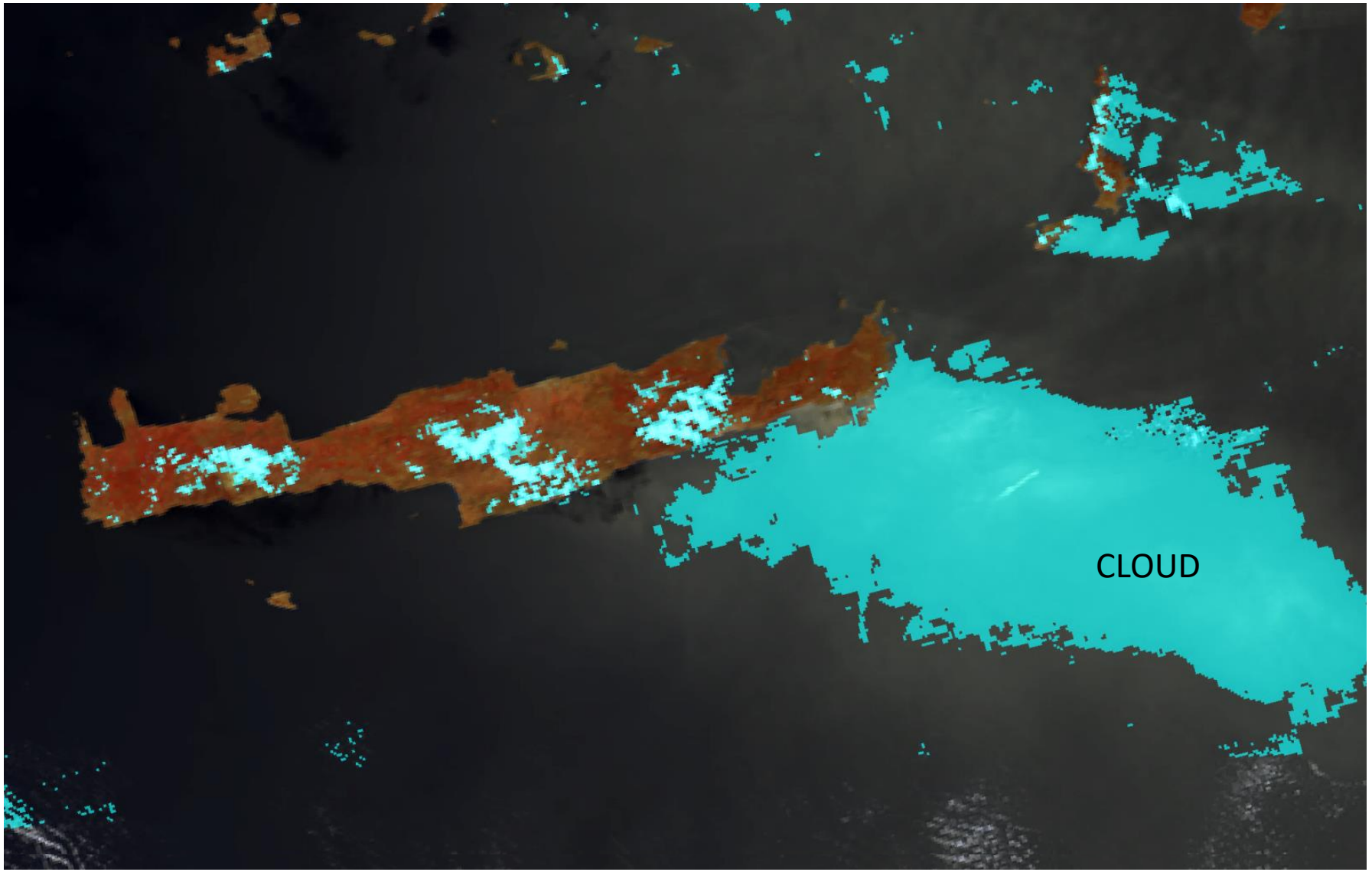


ProbaV 1km Clouds and ice – standard cases

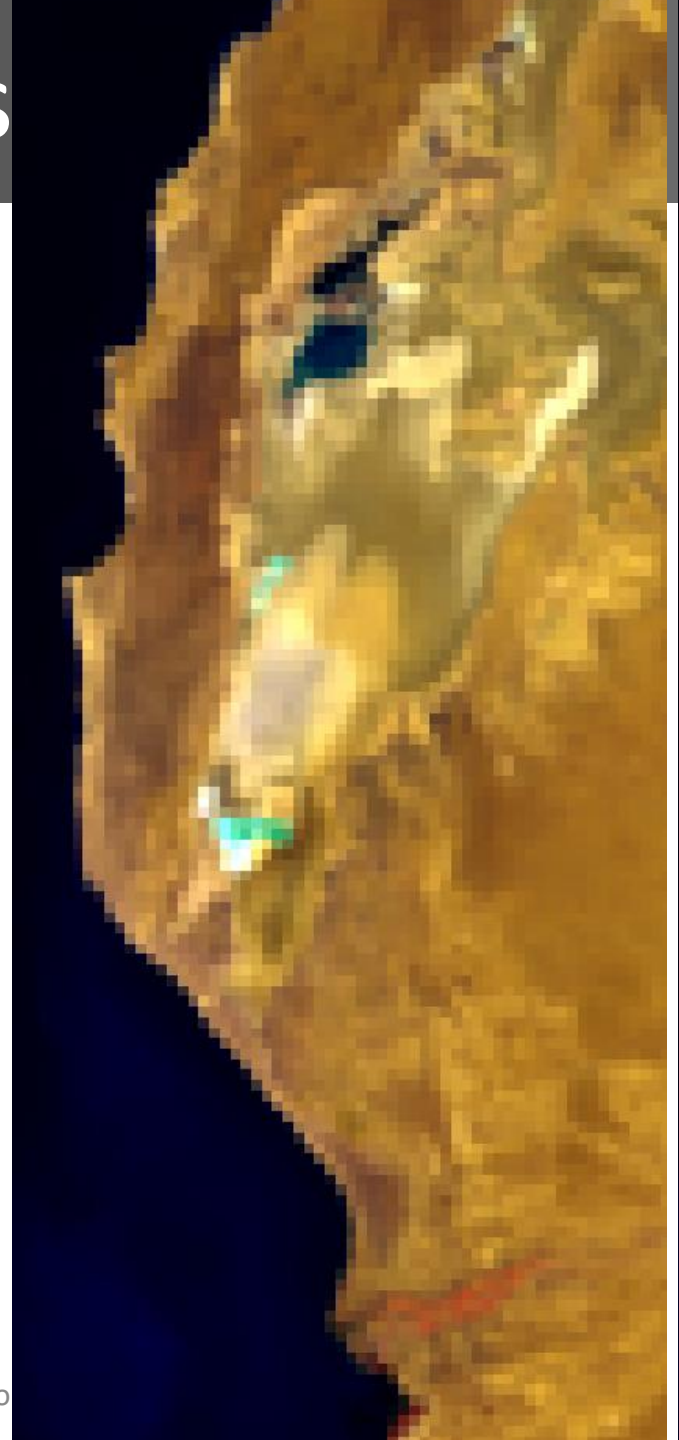


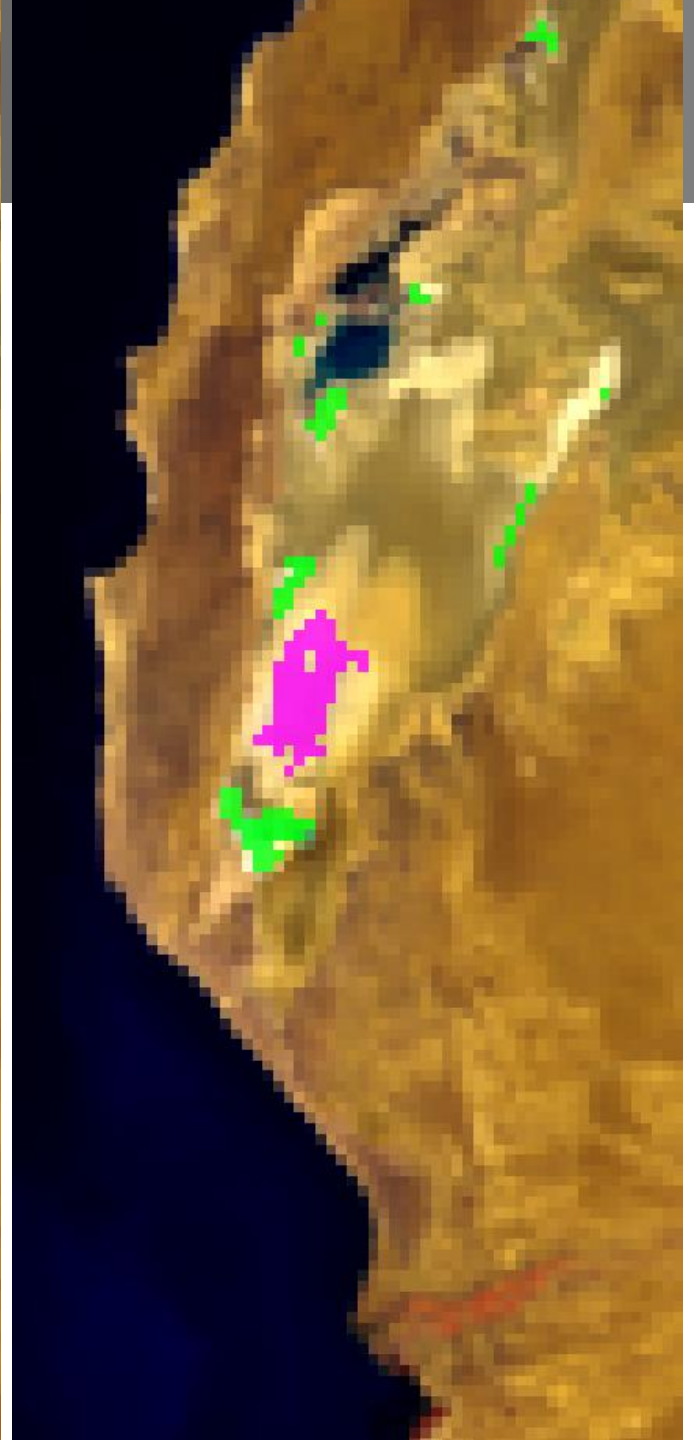
ProbaV 1km sun glint

ProbaV 1km sun glint



ProbaV 1km salt surfaces





Summary 100m products

- The masks work very well for “clear” cases
  - approx. 85% of all examined cases
  - opaque and undoubtedly semi-transparent clouds the masks work well
  - for constant snow cover the masks work well.
  - fog is marked as a cloud
- moderately to satisfactorily in the cases of
  - very thin (but still recognizable) semi-transparent
  - spatially mixed clouds
  - for semi-transparent clouds over ice and over desert (less good over deserts)
- least well working (to failing)
  - Dark, slightly melting sea ice is recognized as free water, sometimes as clouds
  - Above cloud-free, dry or salted lakes and over the sun glint areas
  - Spatially mixed snow not recognized as snow
  - Sun glint often flagged as cloud
- No fog or sand dust was found in the example images and could not be assessed
- The presence of <! SM_FLAGS.GOOD_BLUE> -Flag changes the quality for snow and cloud masks, but especially and more often for snow mask so that the rating drops in such situations.
- Cloud shadow
  - appears irregularly and only marks a part of the shaded pixels.

Summary 1km products

- The masks work very well for “clear” cases
  - approx. 85% of all examined cases
  - opaque and undoubtedly semi-transparent clouds the masks work well indeed
  - for constant snow cover the masks work well indeed.
  - fog is marked as a cloud.
- moderately to satisfactorily in the cases of
  - very thin (but still recognizable) semi-transparent
  - spatially mixed clouds
  - for semi-transparent clouds over ice and over desert
  - haze is moderate recognized
  - Aerosols (mostly sand dust but also smoke) are sensibly recognized as cloud
- least well working (to failing)
  - Dark, slightly melting sea ice is recognized as free water.
  - Above cloud-free, dry or salted lakes and over the sun glint areas
- The presence of <! SM_FLAGS.GOOD_BLUE> -Flag changes the quality for snow and cloud masks, but especially and more often for snow mask so that the rating drops in such situations.
- Cloud shadow
  - appears irregularly and only marks a part of the shaded pixels.