BROCKMANN CONSULT

ProbaV Cloud Contest

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Brockmann Consult

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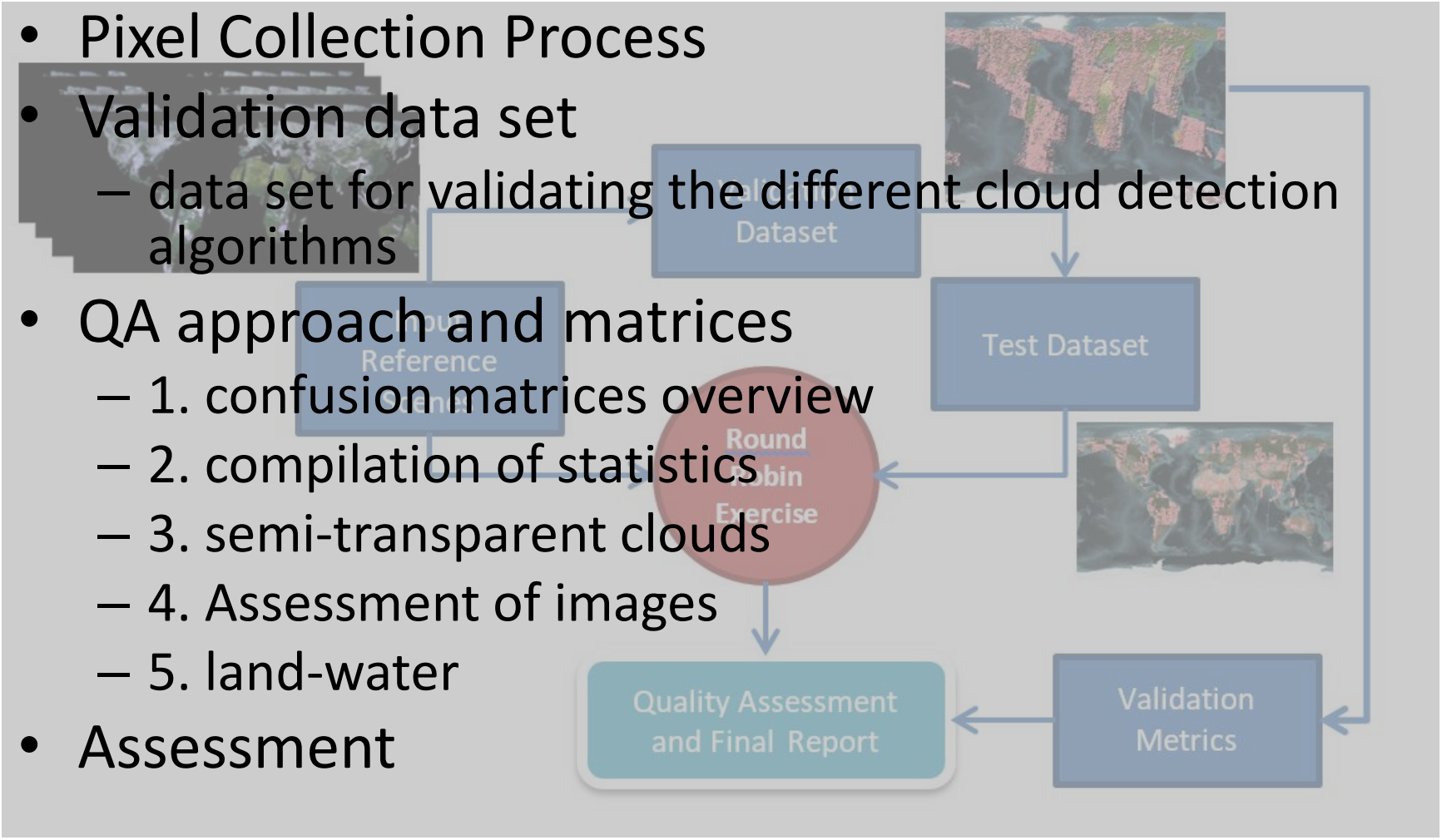
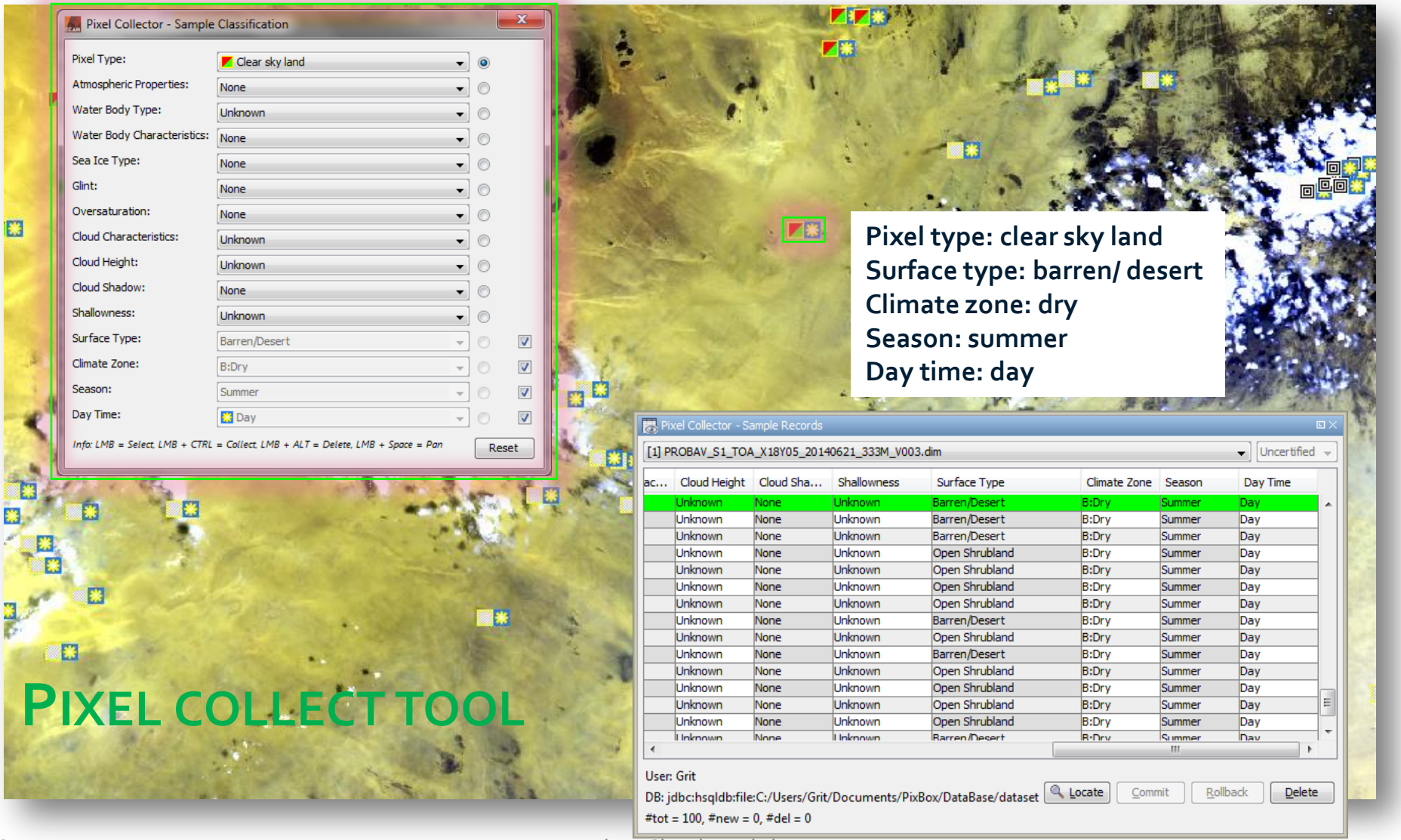
Content

- Pixel Collection Process
- Validation data set
  - data set for validating the different cloud detection algorithms
- QA approach and matrices
  - 1. confusion matrices overview
  - 2. compilation of statistics
  - 3. semi-transparent clouds
  - 4. Assessment of images
  - 5. land-water
- Assessment

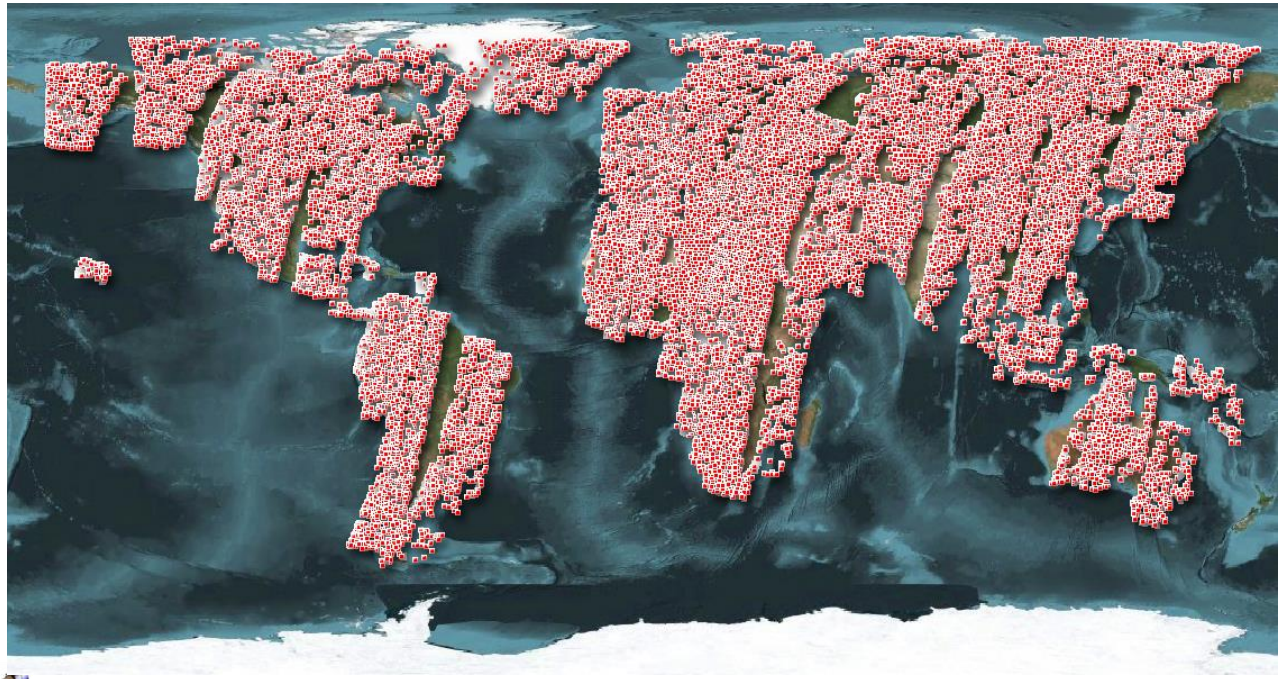


Validation Data Set Pixel Collection



Validation Data Set

- 61 input products
- 53000 pixels



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28 PROBAV_L2A_20140321_213533_3_333M_V001
29 PROBAV_L2A_20140321_214913_1_333M_V001
30 PROBAV_L2A_20140621_005600_3_333M_V001
31 PROBAV_L2A_20140621_011810_3_333M_V001
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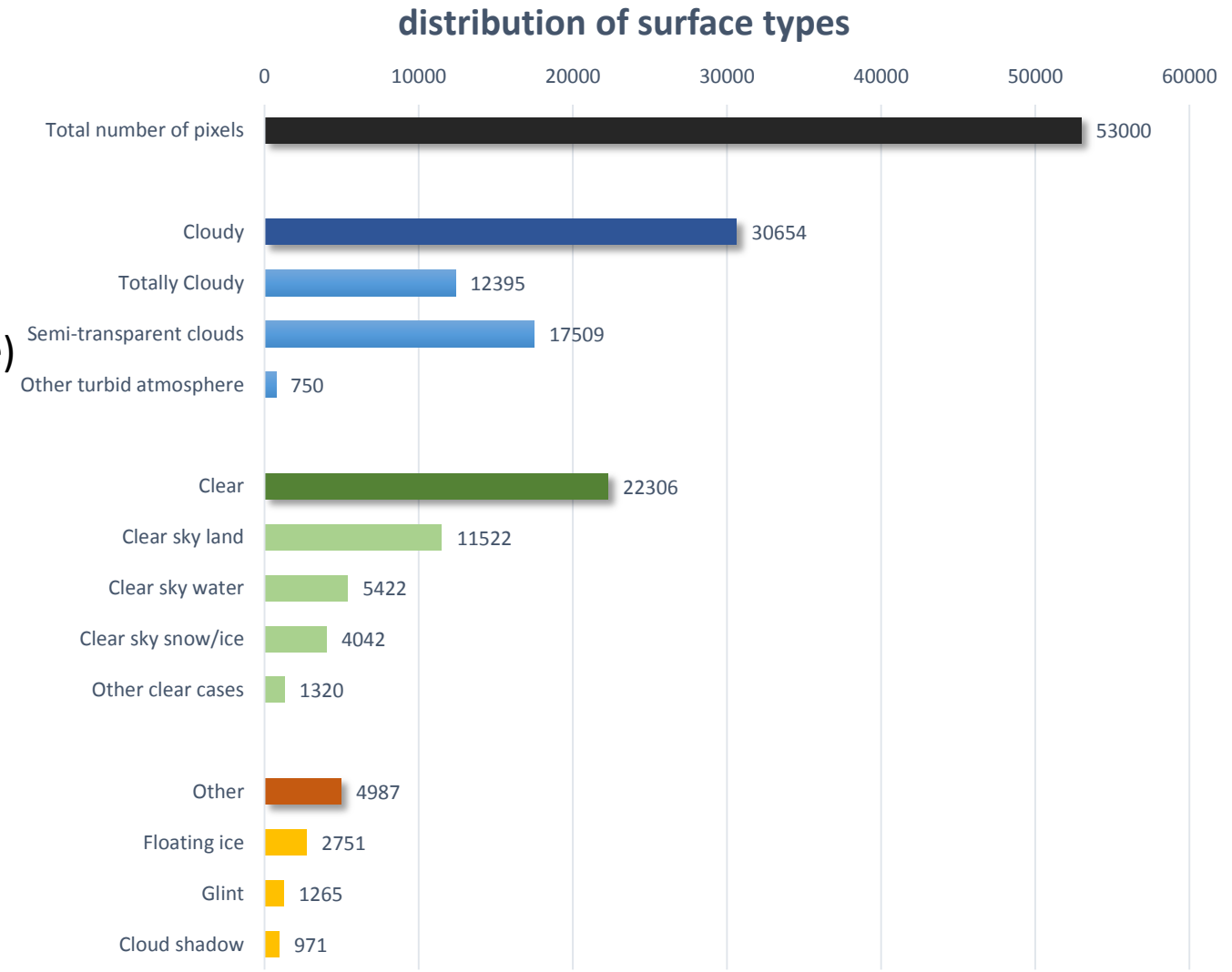
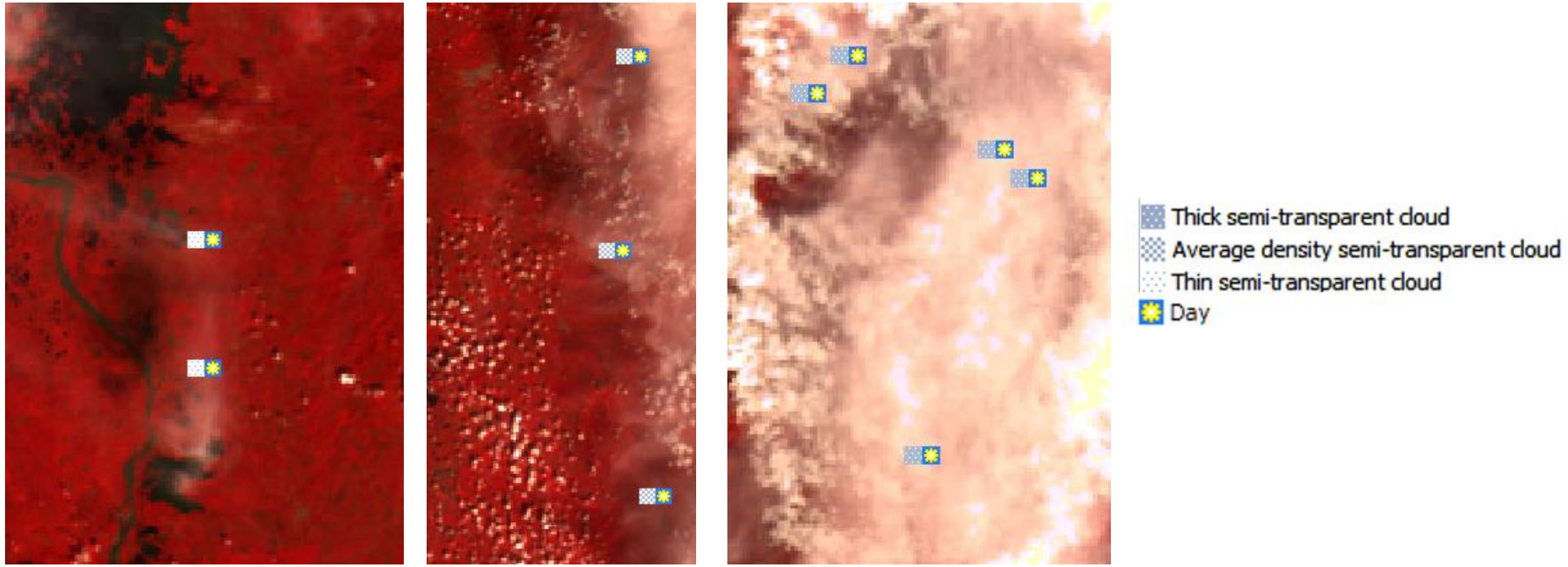
Surface characteristics

- **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



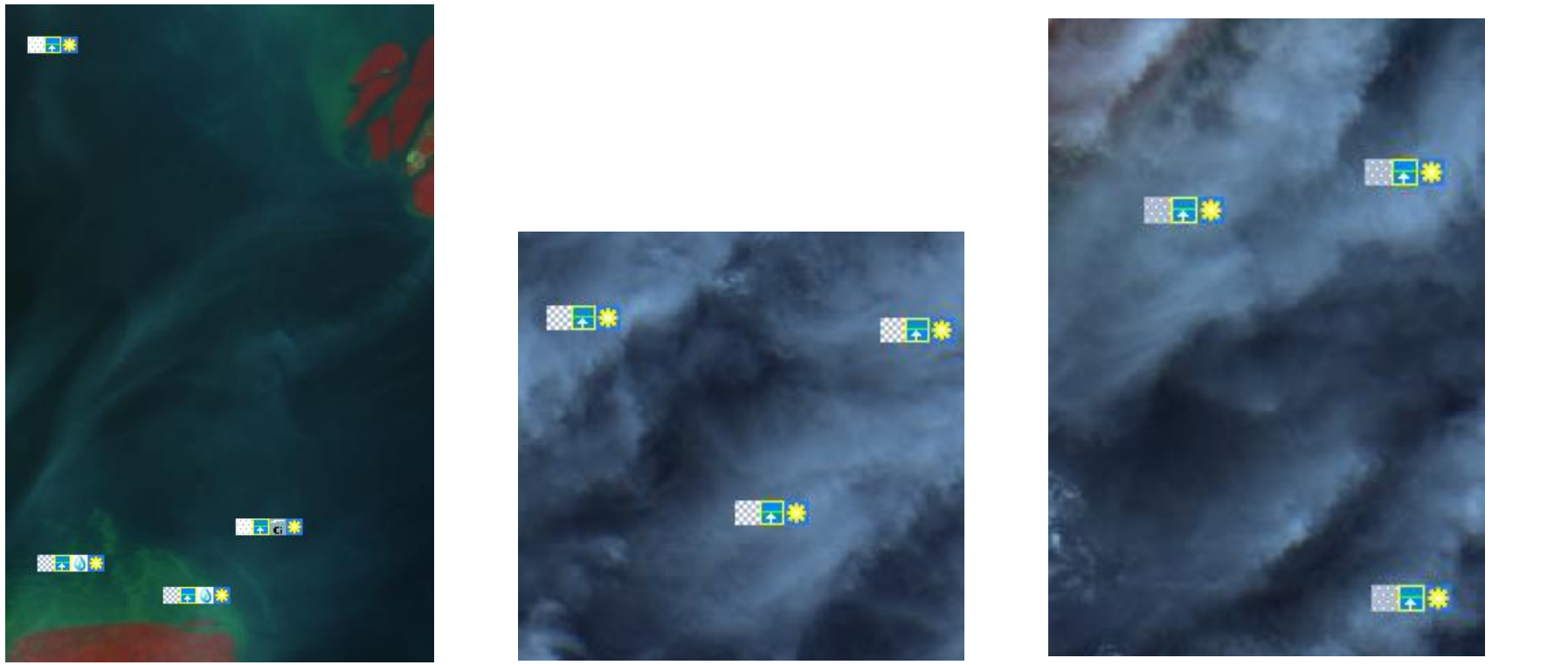
Semi-transparent clouds

- Thick semi-transparent cloud
- Average or medium dense semi-transparent cloud
- Thin semi-transparent cloud



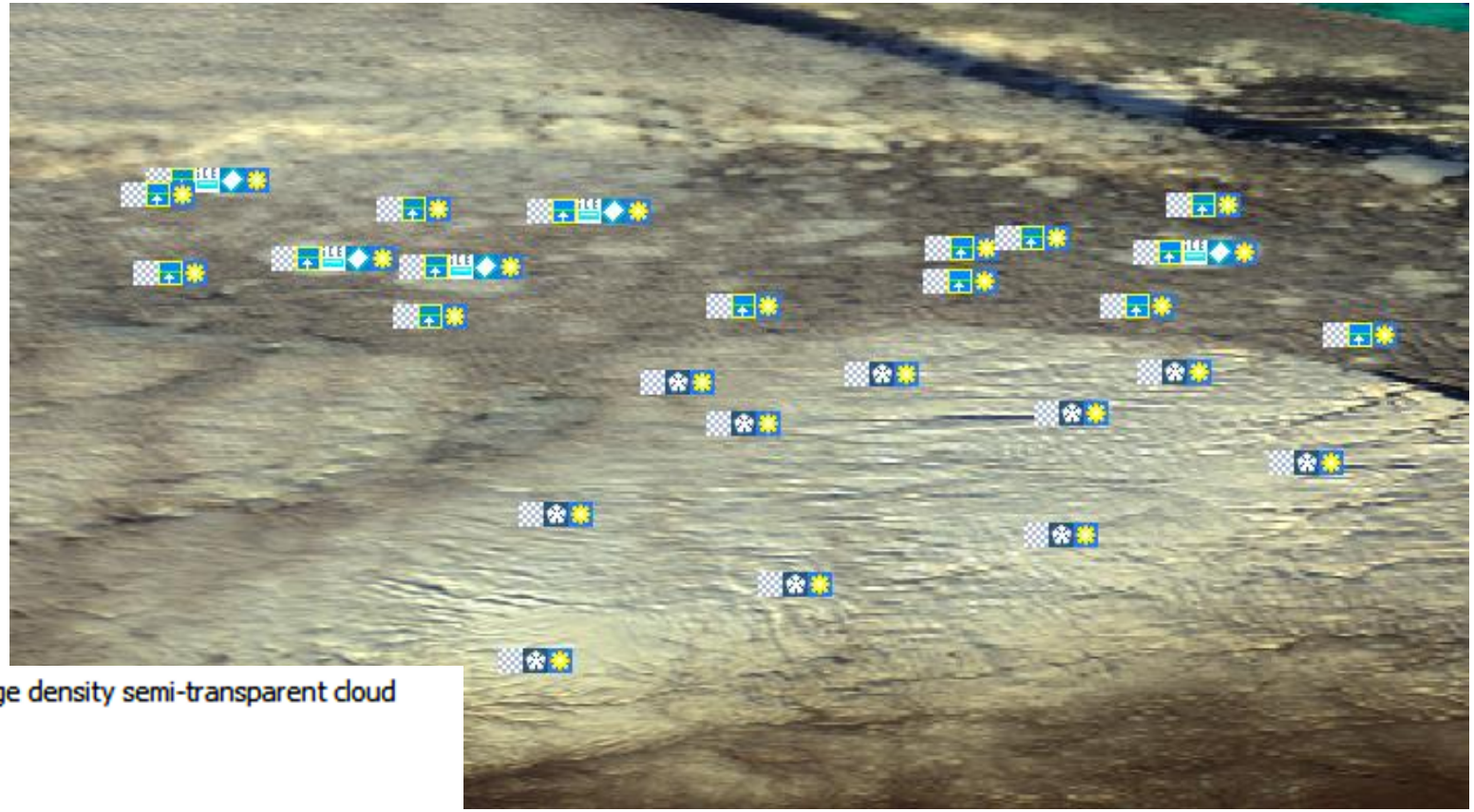
Semi-transparent clouds

- Over water



Semi-transparent clouds

- Over ice

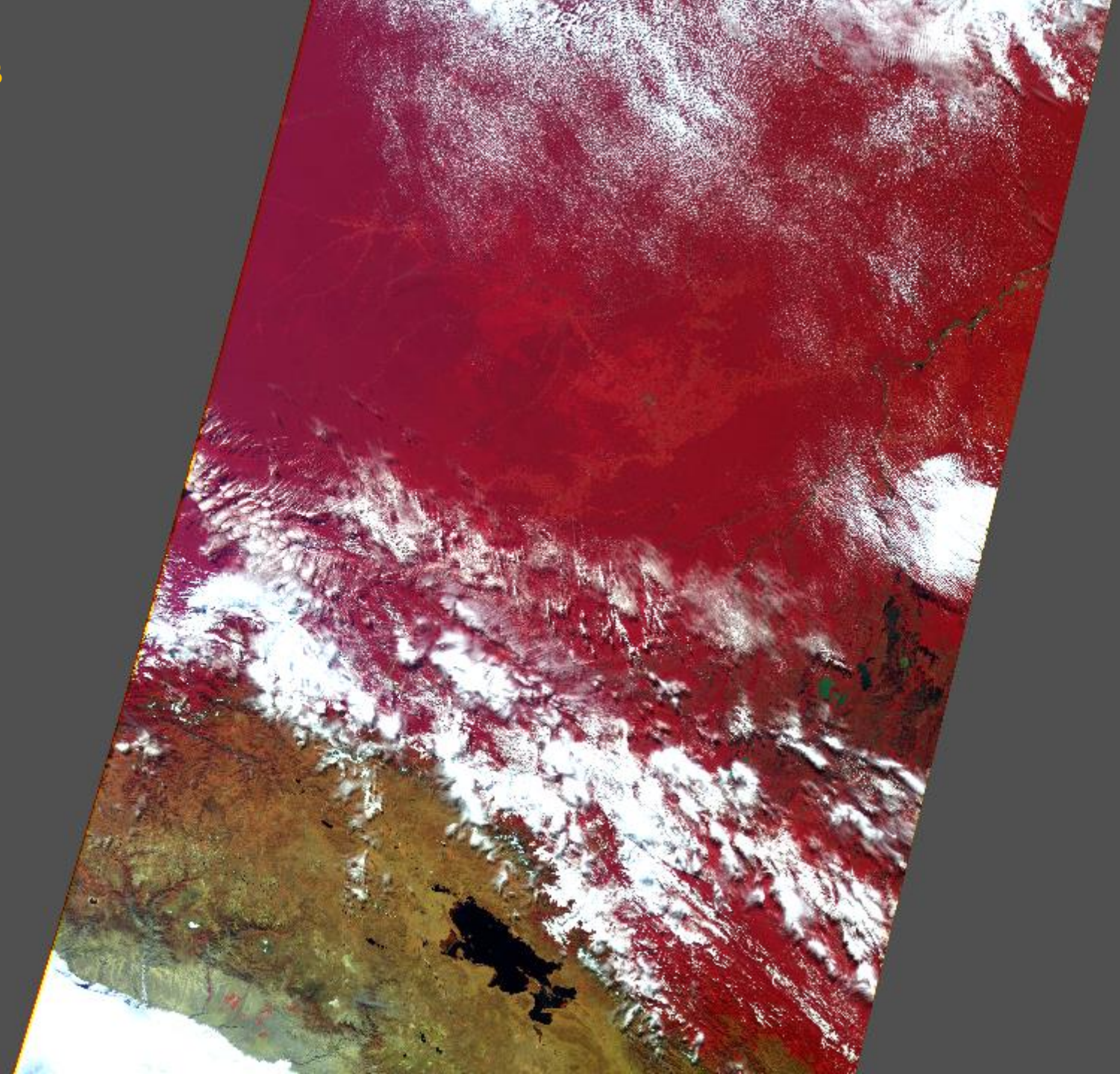


RR Algorithms and Flags

Algorithm	Method	CLOUD	CLEAR	SEMITRANS	ICE/SNOW	THIN SNOW	CL- SHADOW	INVVALID
Algo 1	Discriminant Analysis trained with SEVIRI & MODIS	x	x					x
Algo 2	Discriminant Analysis trained with SEVIRI	x	x					x
Algo 3	Discriminant Analysis trained with MODIS	x	x					x
Algo 4	Multi-spectral and multi-textural thresholding	x		x	x	x		
Algo 5	Neural Network	x	x					x
Algo 6	Self-Organizing Feature Maps	x	x	x				x
Algo 7	Dynamic threshold on the Blue band	x	x		x		x	x
Algo 8	Classification of Cloud Optical Thickness	x	x	(x)	(x)			x

Example images for first assessment

RGB

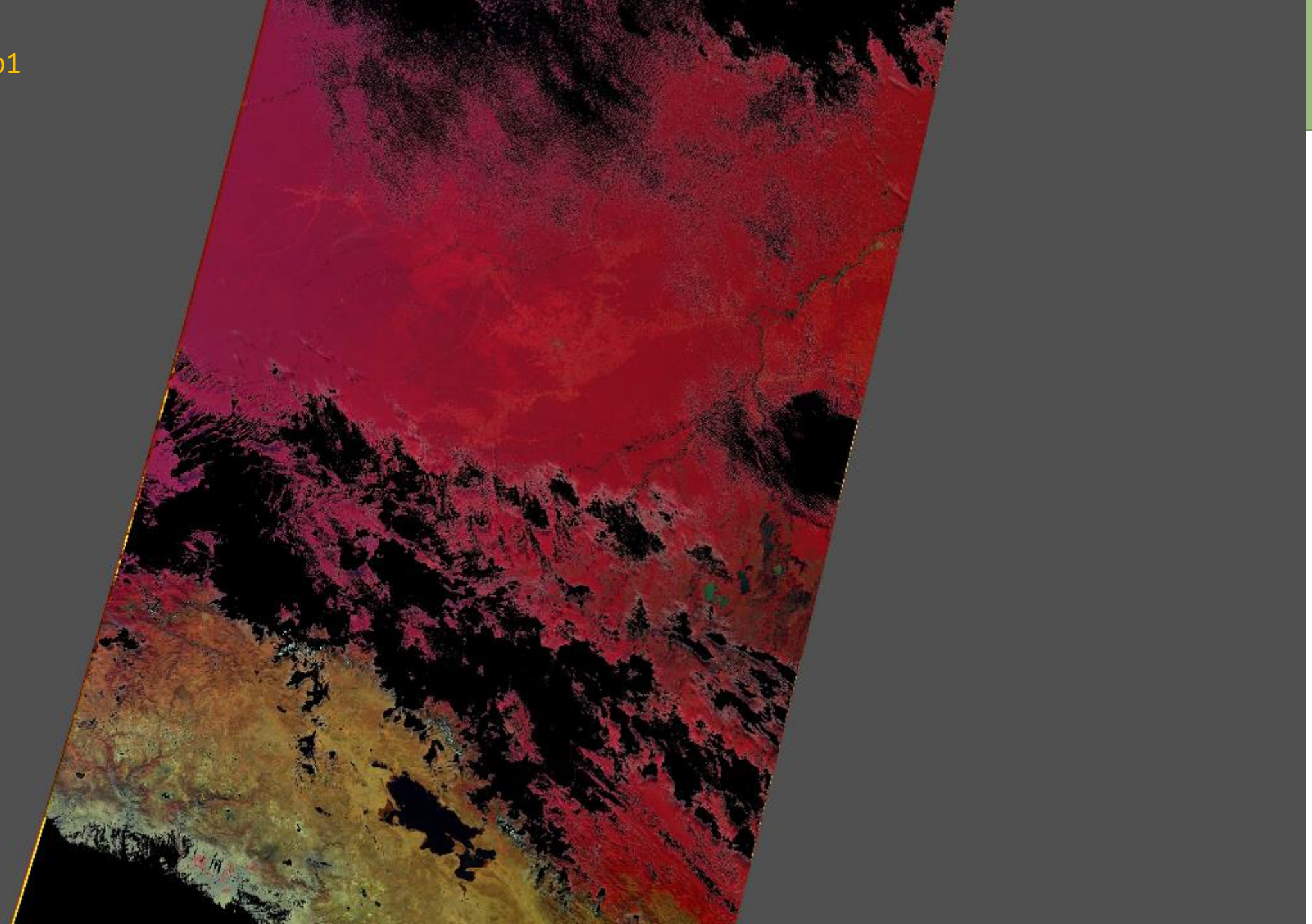


PROBAV_L2A_20140621_144249_3_333M_V001

IDEAS

Brockmann Consult

Algo1



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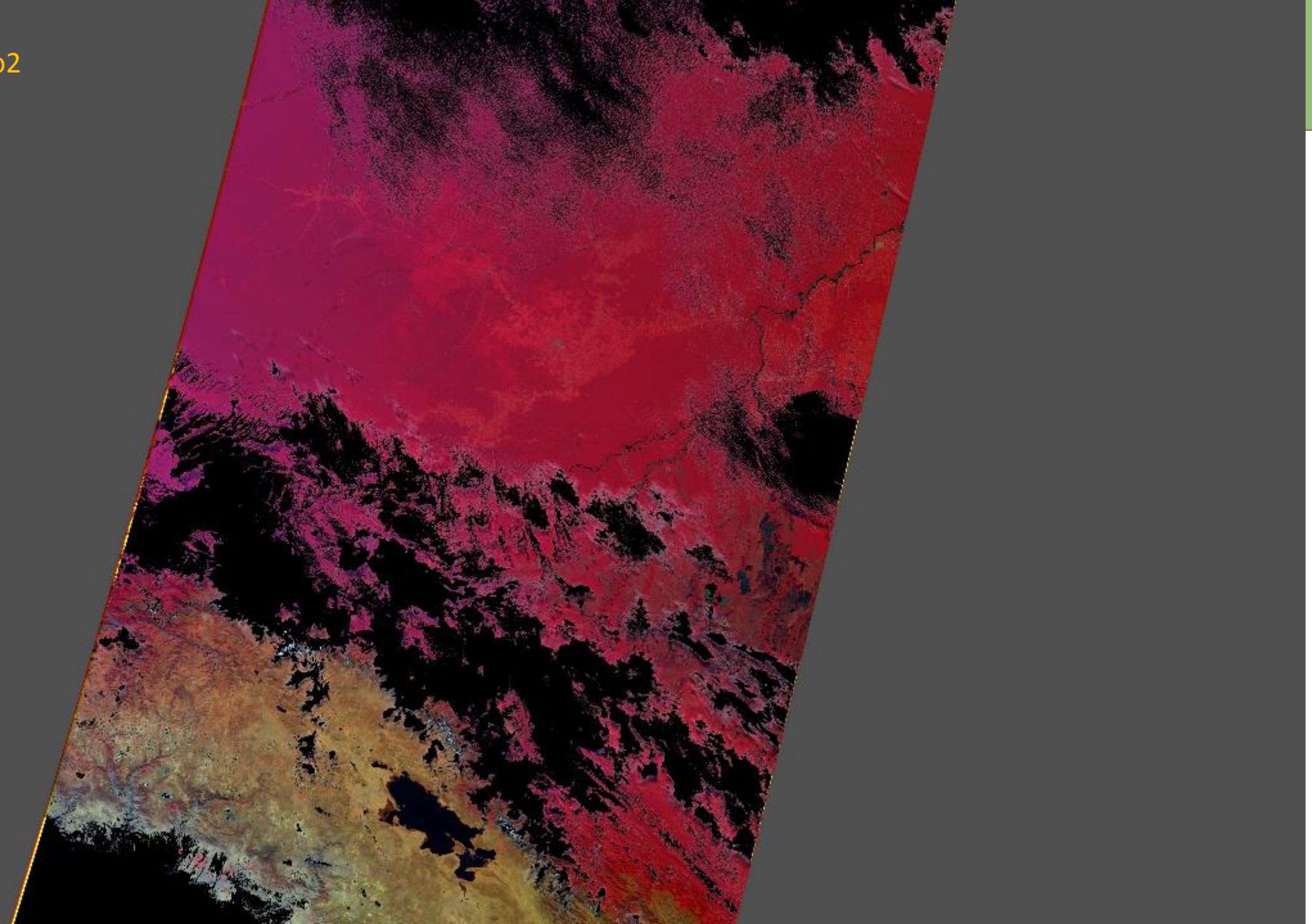
Algo2



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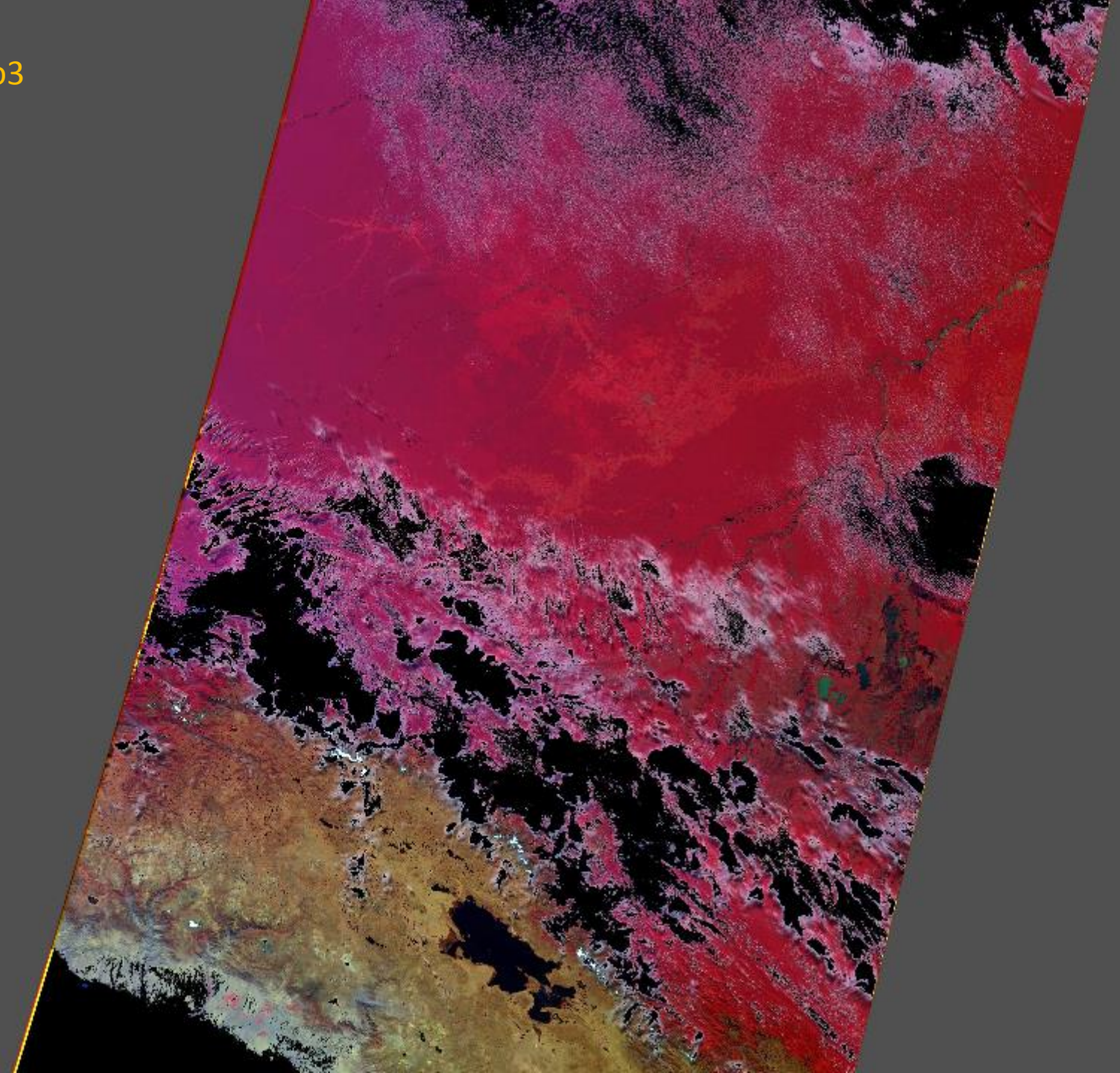
Algo3

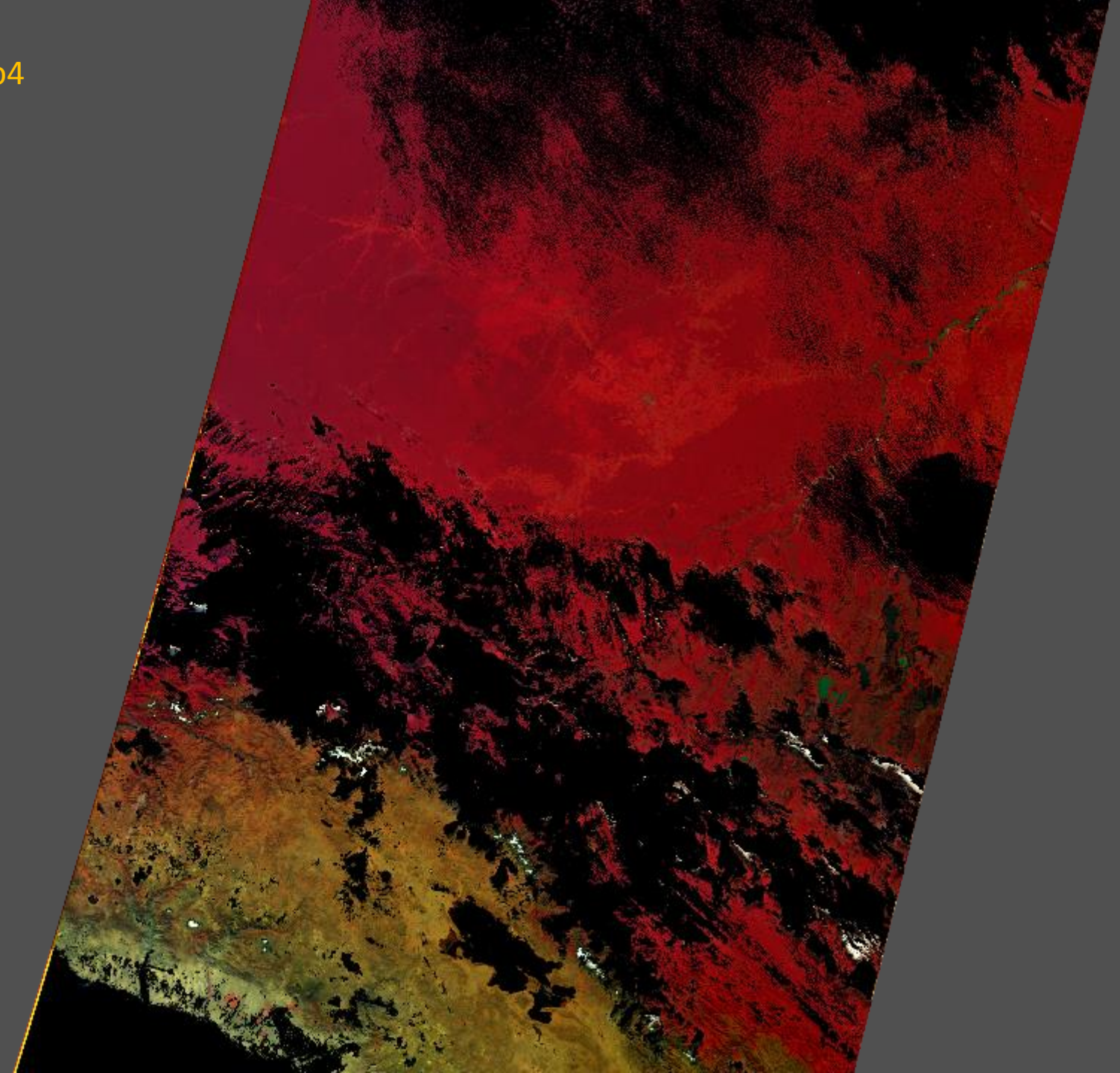


PROBAV_L2A_20140621_144249_3_333M_V001

IDEAS

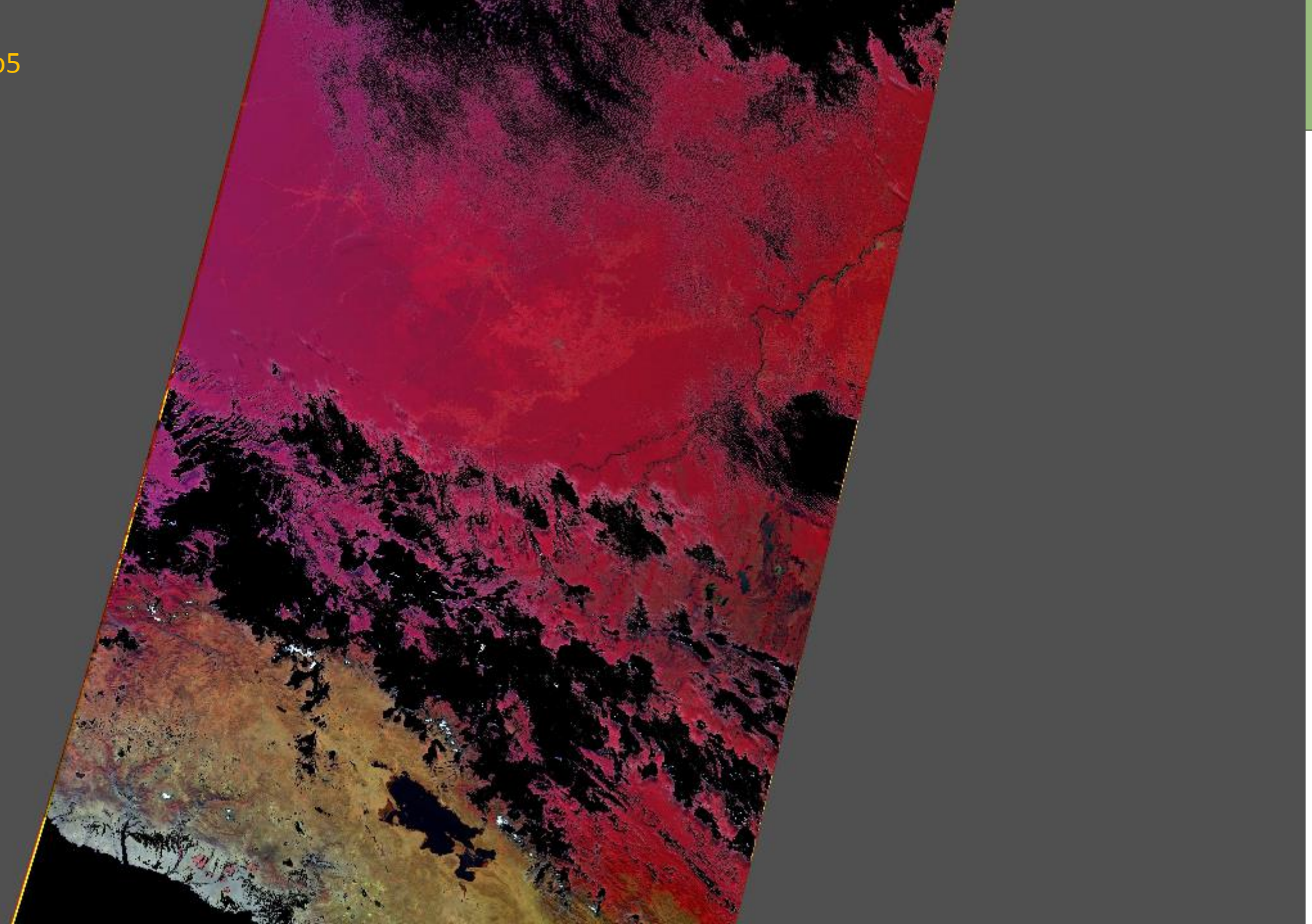
Brockmann Consult

Algo4



PROBAV_L2A_20140621_144249_3_333M_V001

Algo5



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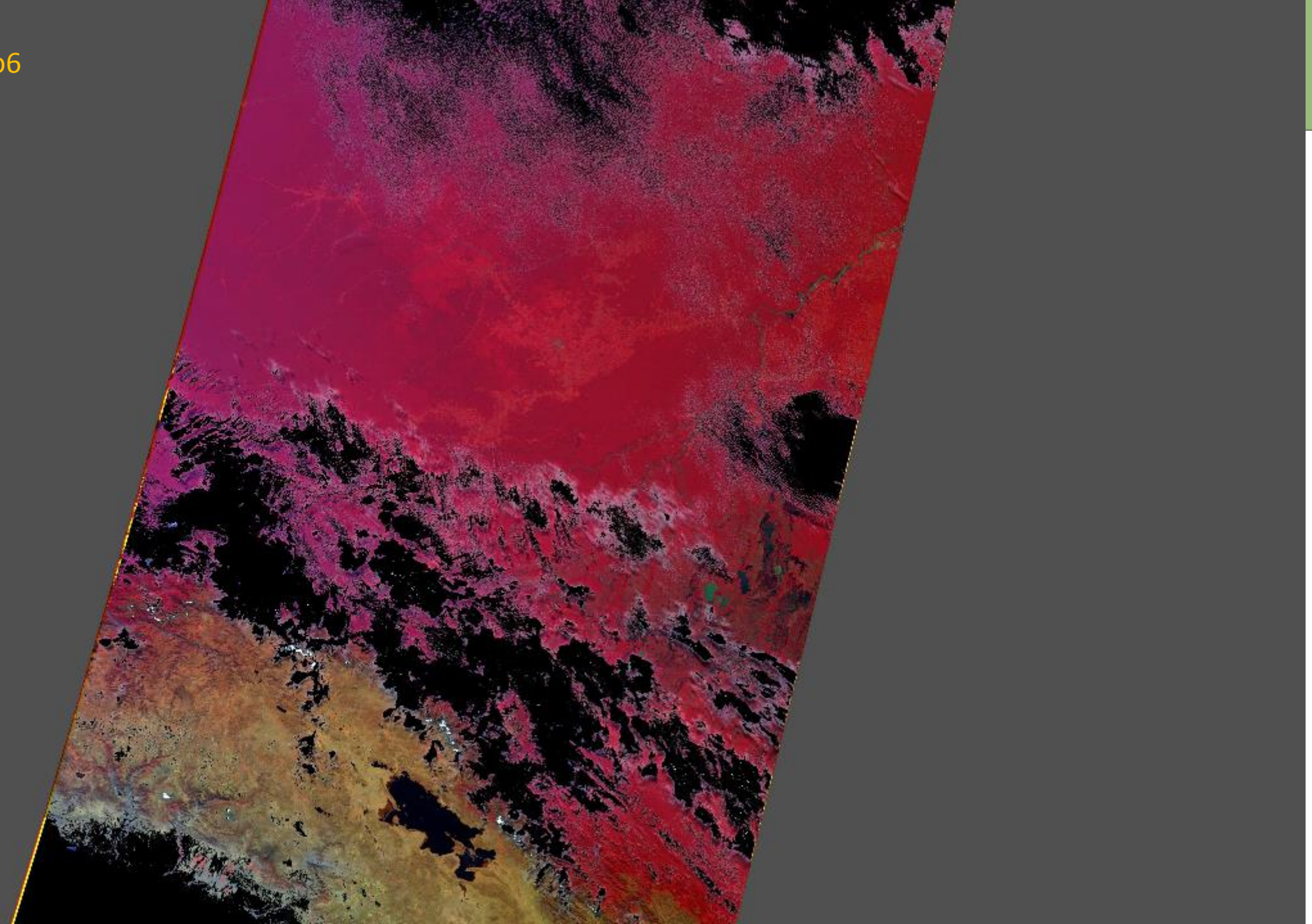
Algo6



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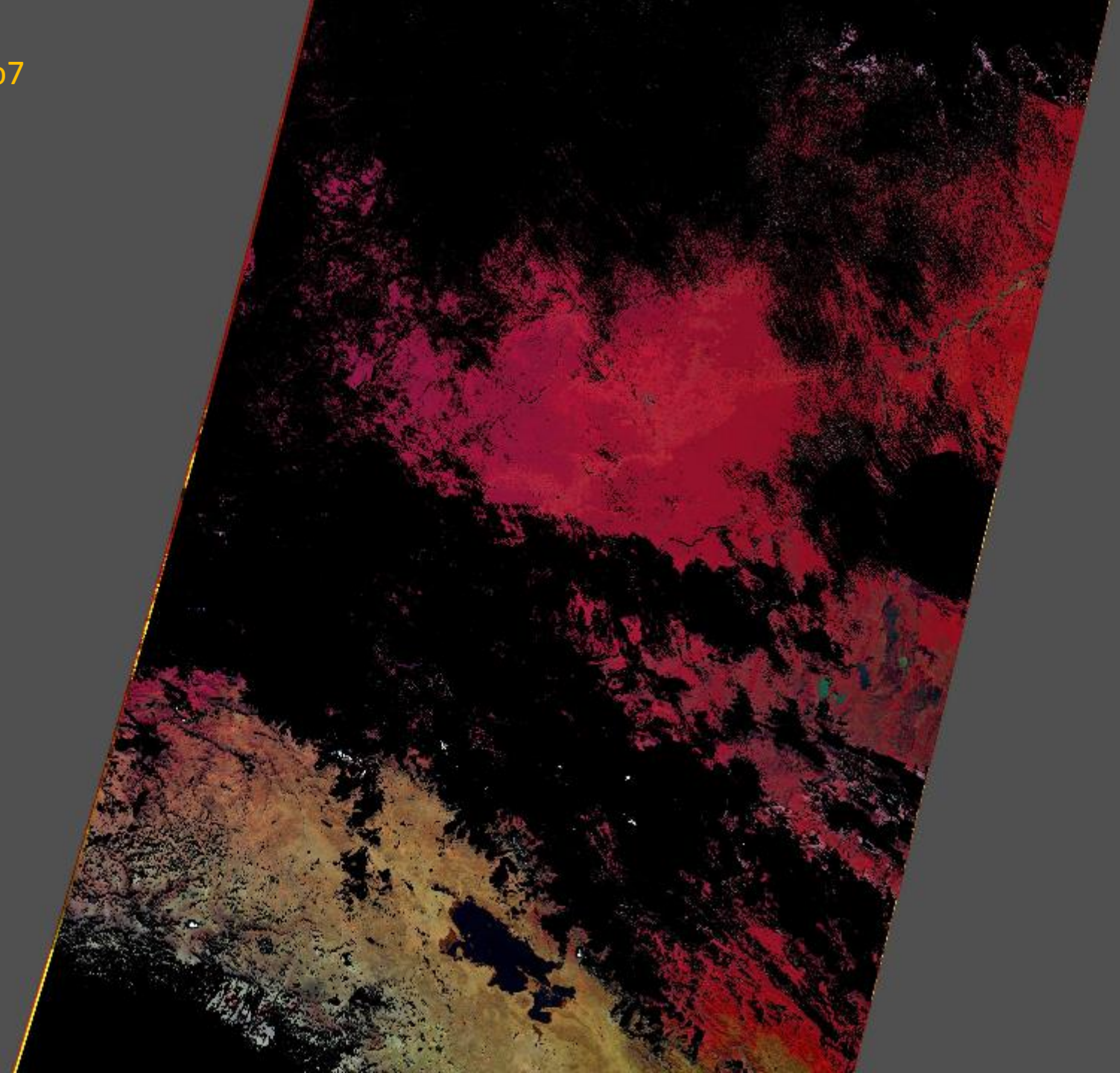
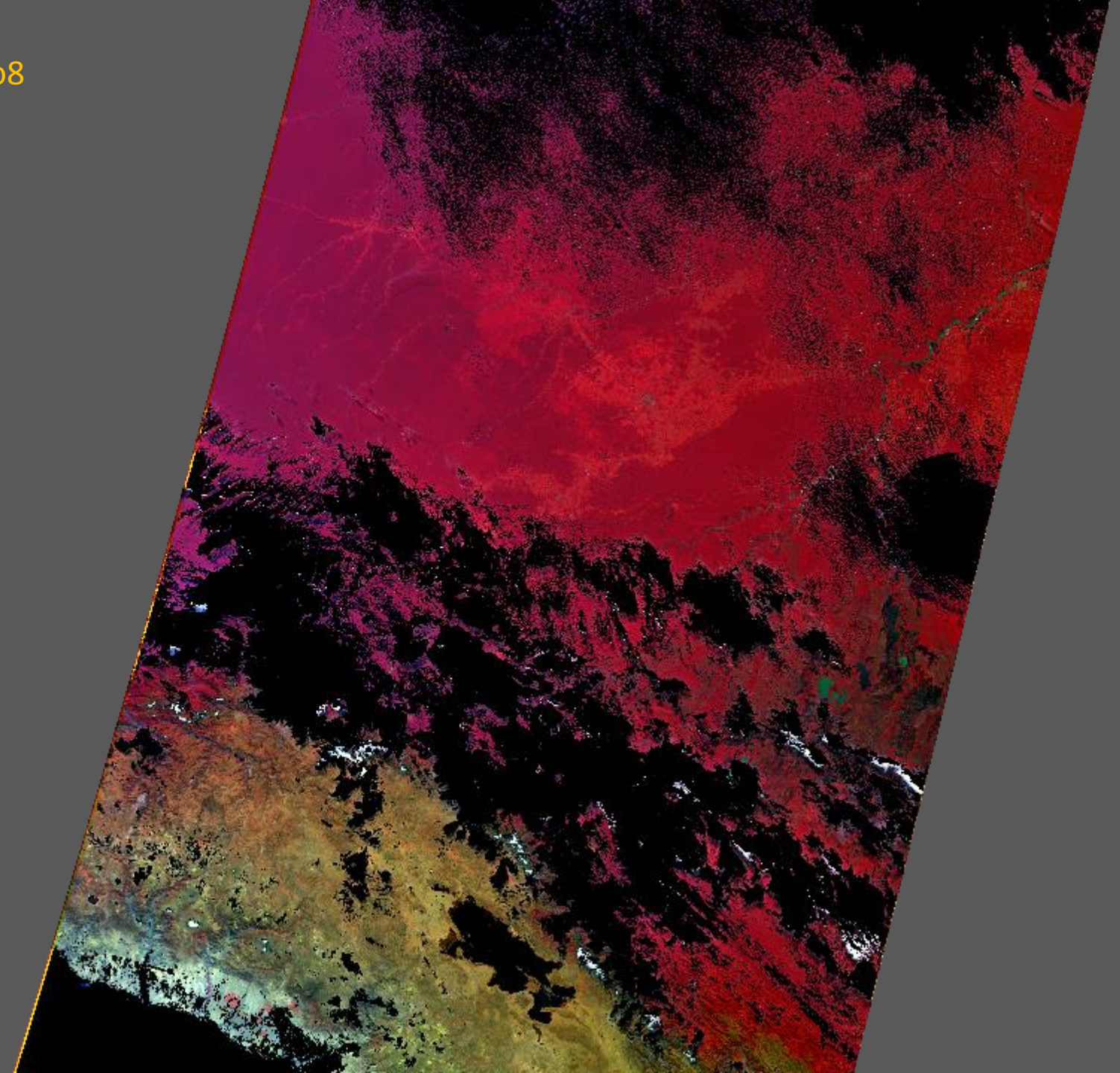
Algo7



PROBAV_L2A_20140621_144249_3_333M_V001

Algo8



PROBAV_L2A_20140621_144249_3_333M_V001

Matrices for the assessment

ProbaV Cloud Classification Version 1.0 - all surfaces (clo+semi)

In-Situ Database

ProbaV	Class	Clear	Clo+semi	Sum	U A	E
	CLEAR	4986	1298	6284	79.3	20.7
	CLOUD	525	6345	6870	92.4	7.6
	Sum	5511	7643	13154		
	P A	90.5	83.0		OAA:	86.14
	E	9.5	17.0			

Scotts Pi: 0.719
Krippendorfs alpha: 0.719
Cohens kappa: 0.72

Cloud conservative algorithm

- A CLOUD classified pixel is quite sure a cloud
- Less clouds are classified as CLOUD

ProbaV RR Algo_3 - all surfaces

In-Situ Database

CLOUDMASK	Class	Clear	Cloud+Semi	Sum	U A	E
	CLEAR	15522	4916	20438	75.9	24.1
	CLOUD+SEMI	1320	21465	22785	94.2	5.8
	Sum	16842	26381	43223		
	P A	92.2	81.4		OAA:	85.57
	E	7.8	18.6			

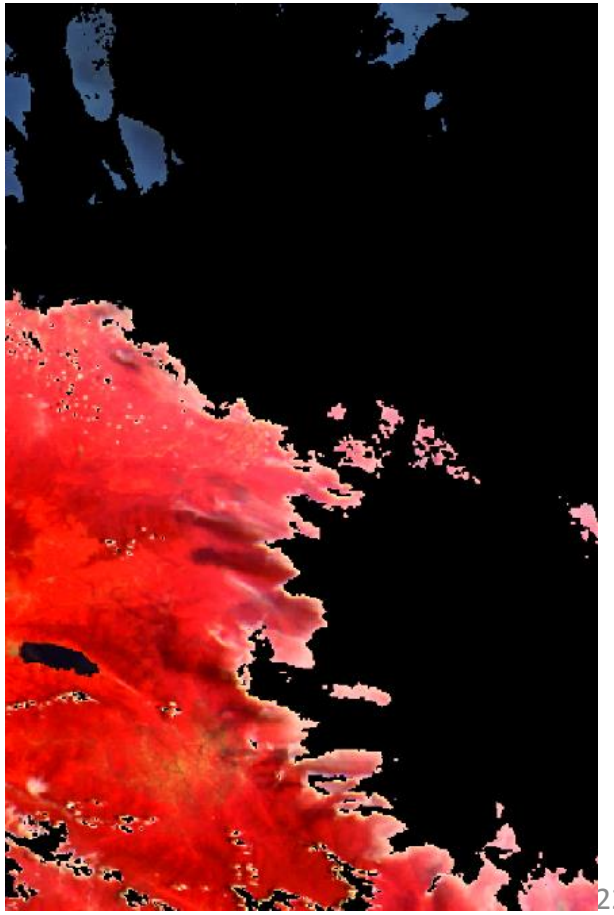
Clear-sky conservative algorithm

- A CLEAR classified pixel is quite sure a clear
- More clouds are classified as CLOUD

ProbaV RR Algo_2 - all surfaces

In-Situ Database

CLOUDMASK	Class	Clear	Cloud+Semi	Sum	U A	E
	CLEAR	14058	1746	15804	89.0	11.0
	CLOUD+SEMI	2784	24635	27419	89.8	10.2
	Sum	16842	26381	43223		
	P A	83.5	93.4		OAA:	89.52
	E	16.5	6.6			



Assessment 1 – Confusion Matrices

ProbaV RR Algo_1 - all surfaces

In-Situ Database

CLOUDMASK	Clear	Cloud+Semi	Sum	U A	E
CLEAR	13468	1866	15334	87.8	12.2
CLOUD+SEMI	2333	23633	25966	91.0	9.0
Sum	15801	25499	41300		
P A	85.2	92.7		OAA:	89.83
E	14.8	7.3			

ProbaV RR Algo_2 - all surfaces

In-Situ Database

CLOUDMASK	Clear	Cloud+Semi	Sum	U A	E
CLEAR	14058	1746	15804	89.0	11.0
CLOUD+SEMI	2784	24635	27419	89.8	10.2
Sum	16842	26381	43223		
P A	83.5	93.4		OAA:	89.52
E	16.5	6.6			

ProbaV RR Algo_3 - all surfaces

In-Situ Database

CLOUDMASK	Clear	Cloud+Semi	Sum	U A	E
CLEAR	15522	4916	20438	75.9	24.1
CLOUD+SEMI	1320	21465	22785	94.2	5.8
Sum	16842	26381	43223		
P A	92.2	81.4		OAA:	85.57
E	7.8	18.6			

ProbaV RR Algo_4 - all surfaces

In-Situ Database

CLOUDMAK	Clear	Cloud+Semi	Sum	U A	E
CLEAR	16161	2854	19015	85.0	15.0
CLOUD+SEMI	688	22847	23535	97.1	2.9
Sum	16849	25701	42550		
P A	95.9	88.9		OAA:	91.68
E	4.1	11.1			

Assessment 1 – Confusion Matrices

ProbaV RR Algo_5 - all surfaces

In-Situ Database

CLOUDMAK	Class	Clear	Cloud+Semi	Sum	U A	E
	CLEAR	15697	2500	18197	86.3	13.7
	CLOUD+SEMI	1145	23883	25028	95.4	4.6
	Sum	16842	26383	43225		
	P A	93.2	90.5		OAA:	91.57
	E	6.8	9.5			

ProbaV RR Algo_6 - all surfaces

In-Situ Database

CLOUDMAK	Class	Clear	Cloud+Semi	Sum	U A	E
	CLEAR	16069	4051	20120	79.9	20.1
	CLOUD+SEMI	771	22332	23103	96.7	3.3
	Sum	16840	26383	43223		
	P A	95.4	84.6		OAA:	88.84
	E	4.6	15.4			

ProbaV RR Algo_7 - all surfaces

In-Situ Database

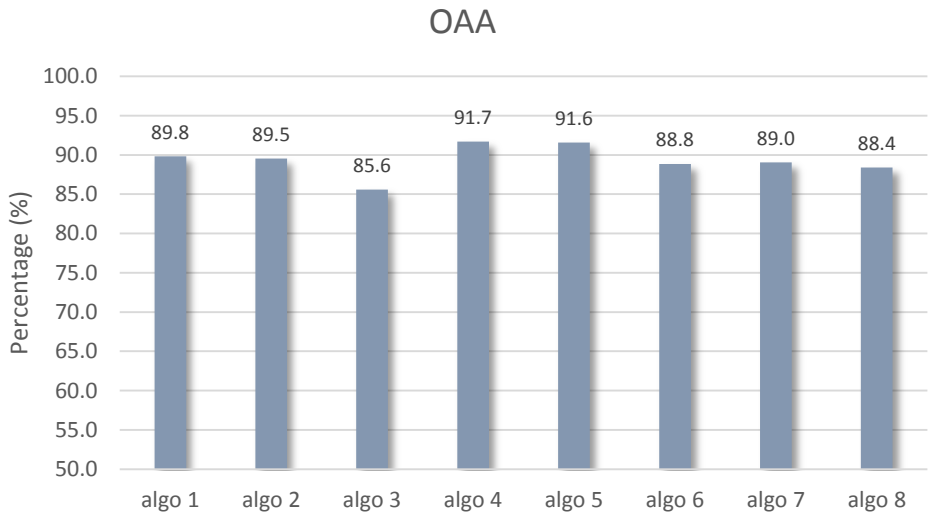
CLOUDMAK	Class	Clear	Cloud+Semi	Sum	U A	E
	CLEAR	13095	1655	14750	88.8	11.2
	CLOUD+SEMI	2934	24140	27074	89.2	10.8
	Sum	16029	25795	41824		
	P A	81.7	93.6		OAA:	89.03
	E	18.3	6.4			

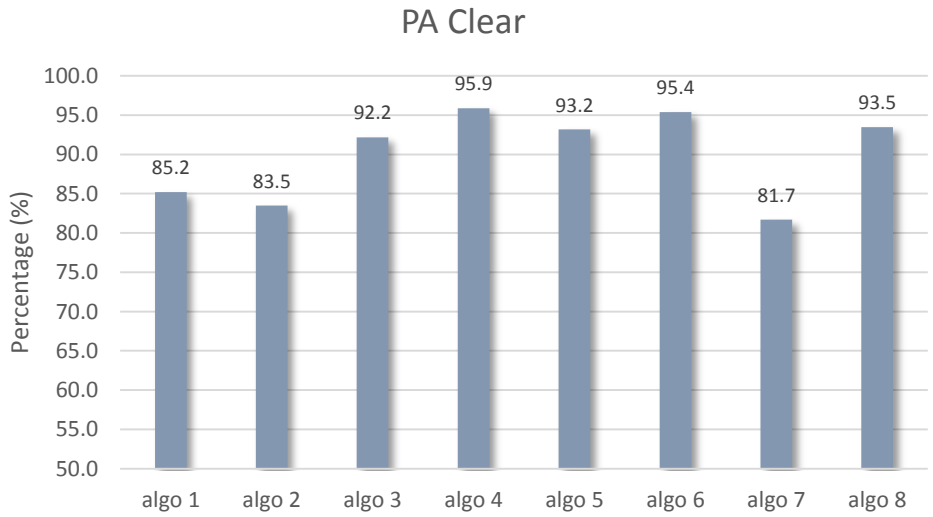
ProbaV RR Algo_8 - all surfaces

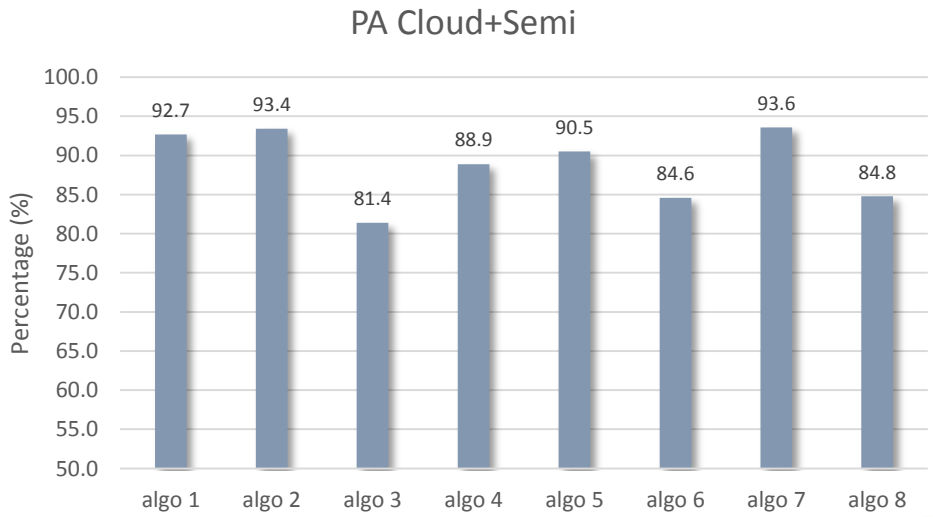
In-Situ Database

CLOUDMASK	Class	Clear	Cloud	Sum	U A	E
	CLEAR	15797	3576	19373	81.5	18.5
	CLOUD	1093	19954	21047	94.8	5.2
	Sum	16890	23530	40420		
	P A	93.5	84.8		OAA:	88.45
	E	6.5	15.2			

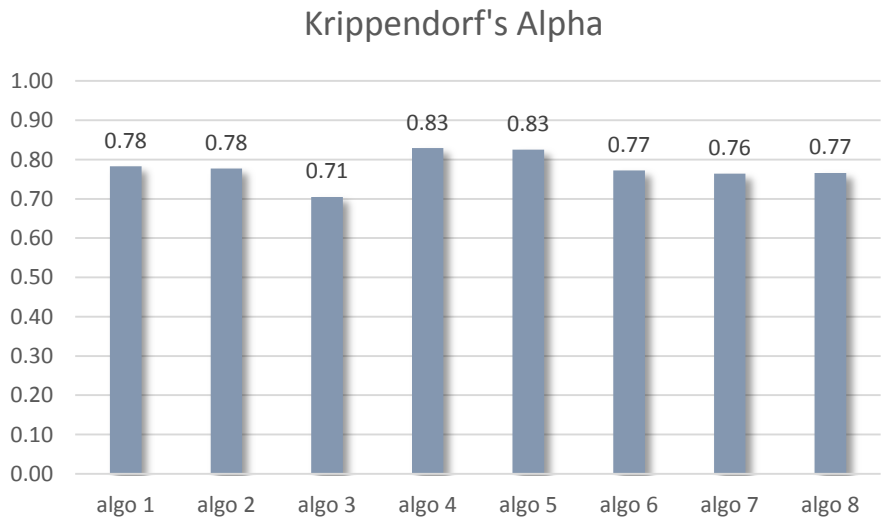
Assessment 2 – Compilation of statistics

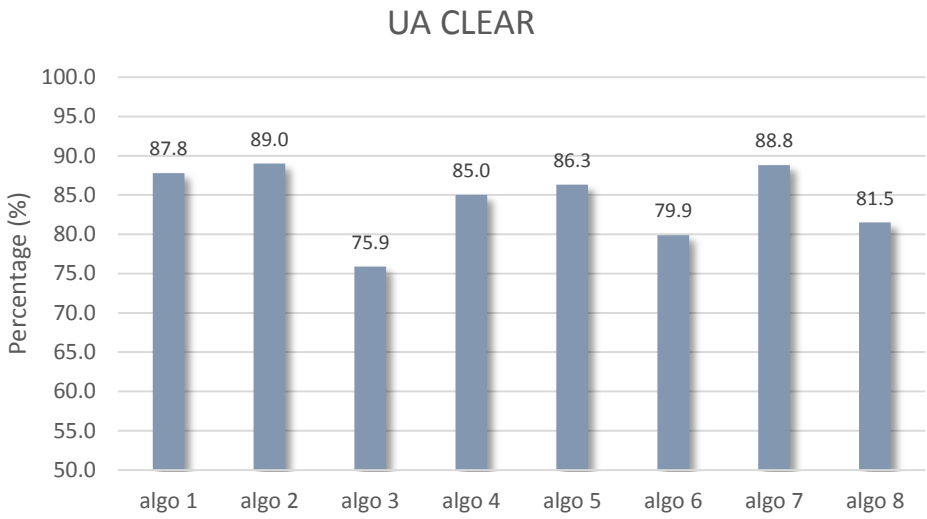


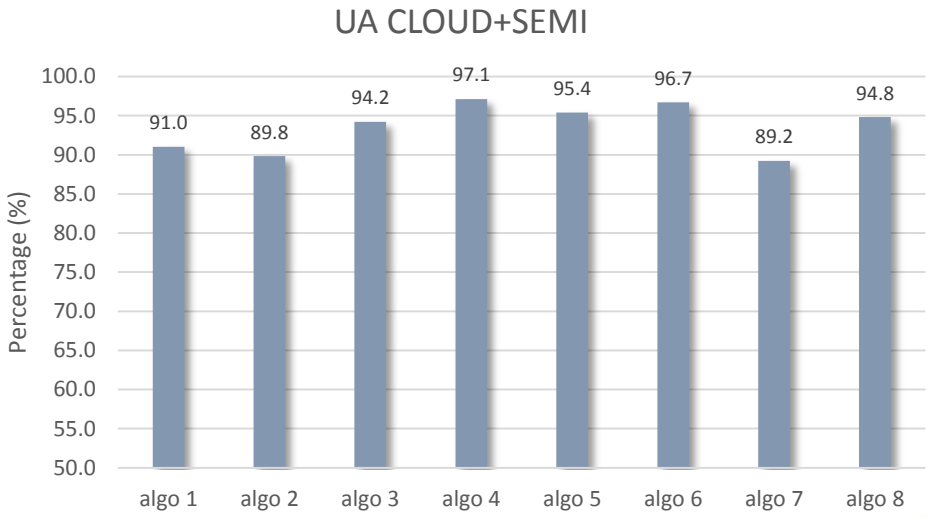




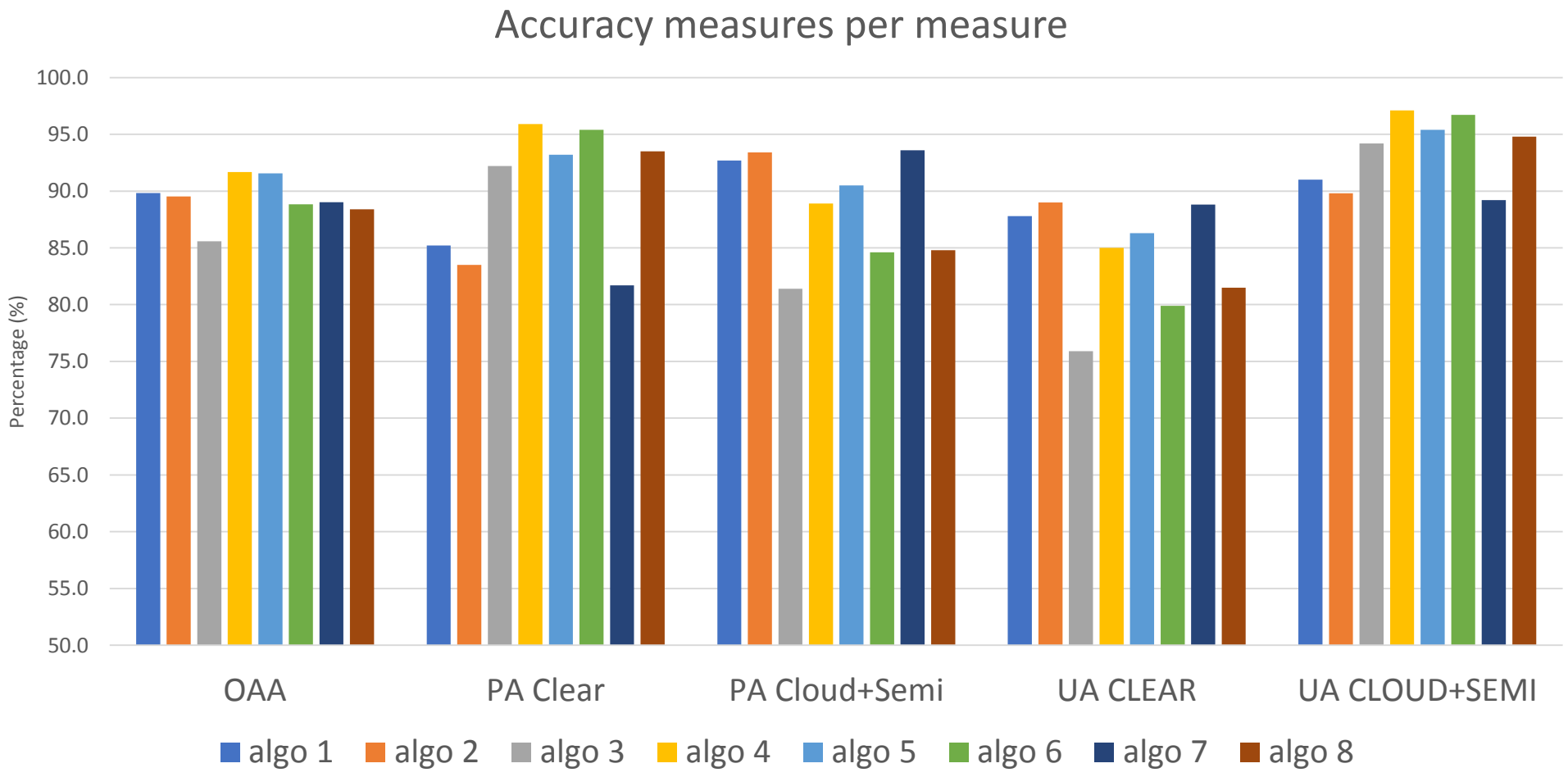
Assessment 2 – Compilation of statistics



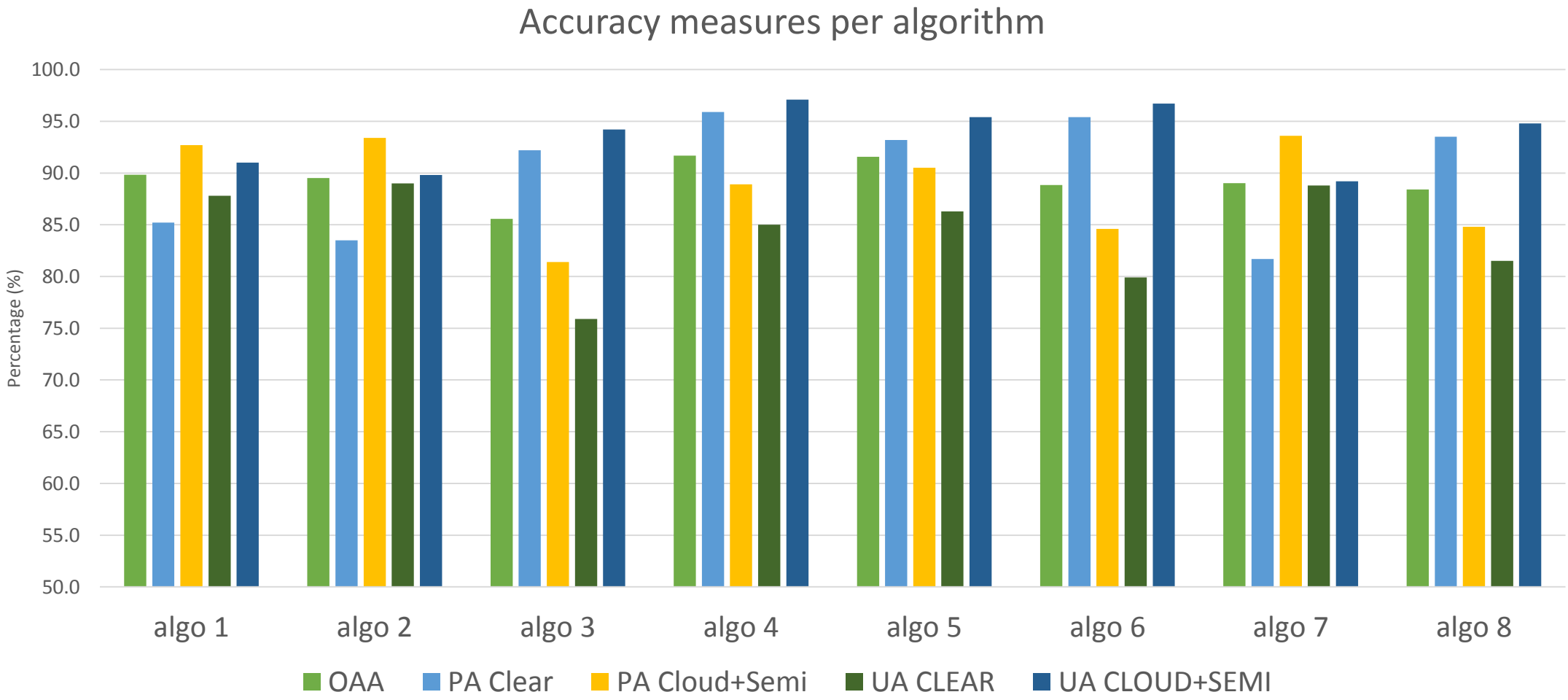




Assessment 2 – Compilation of statistics

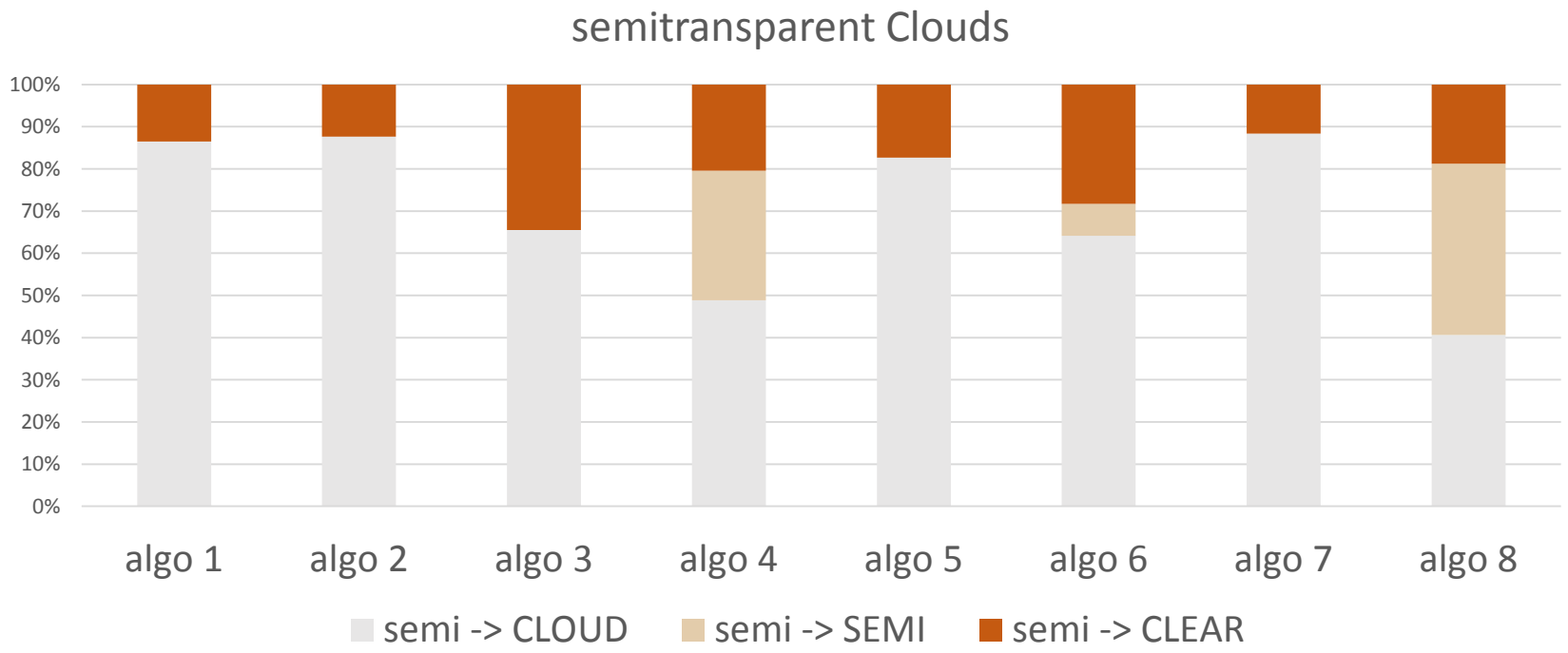


Assessment 2 – Compilation of statistics

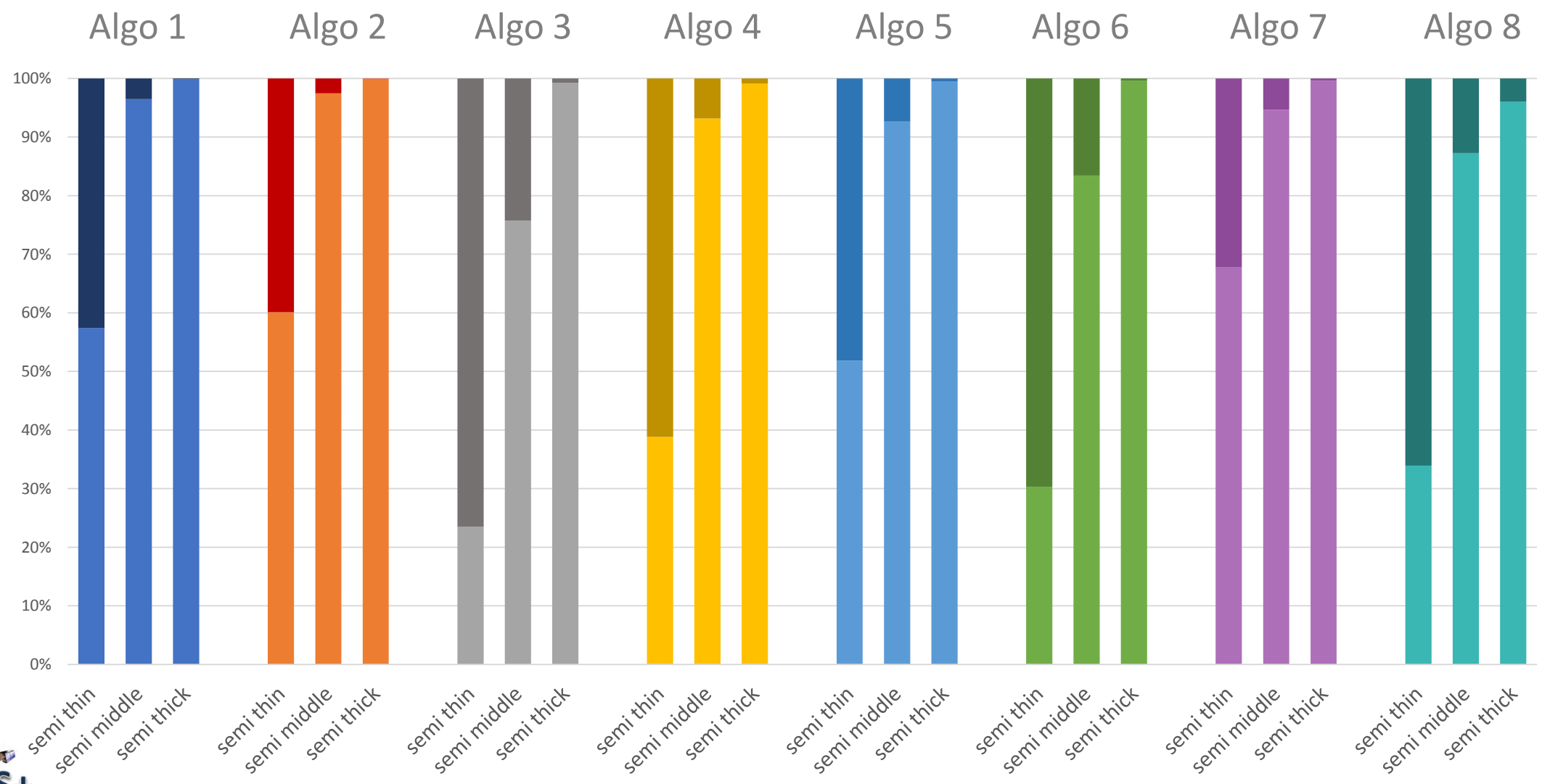


Assessment 3 - Semi-transparent Clouds

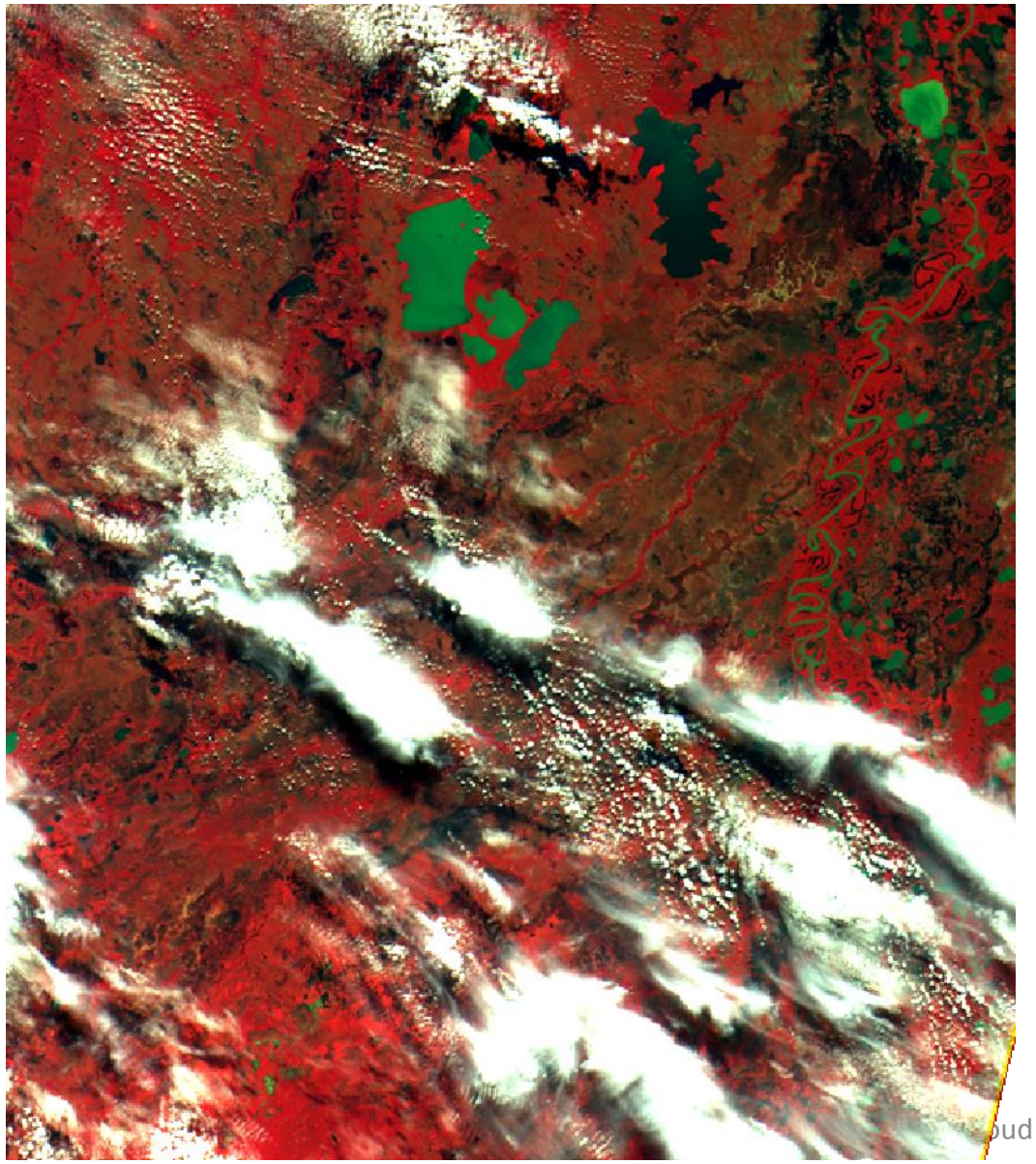
- How do the semi-transparent clouds behave.
  - Clear-sky conservative: (semi-transparent) clouds are flagged as CLOUD
  - Cloud conservative: (semi-transparent) clouds are flagged as CLEAR

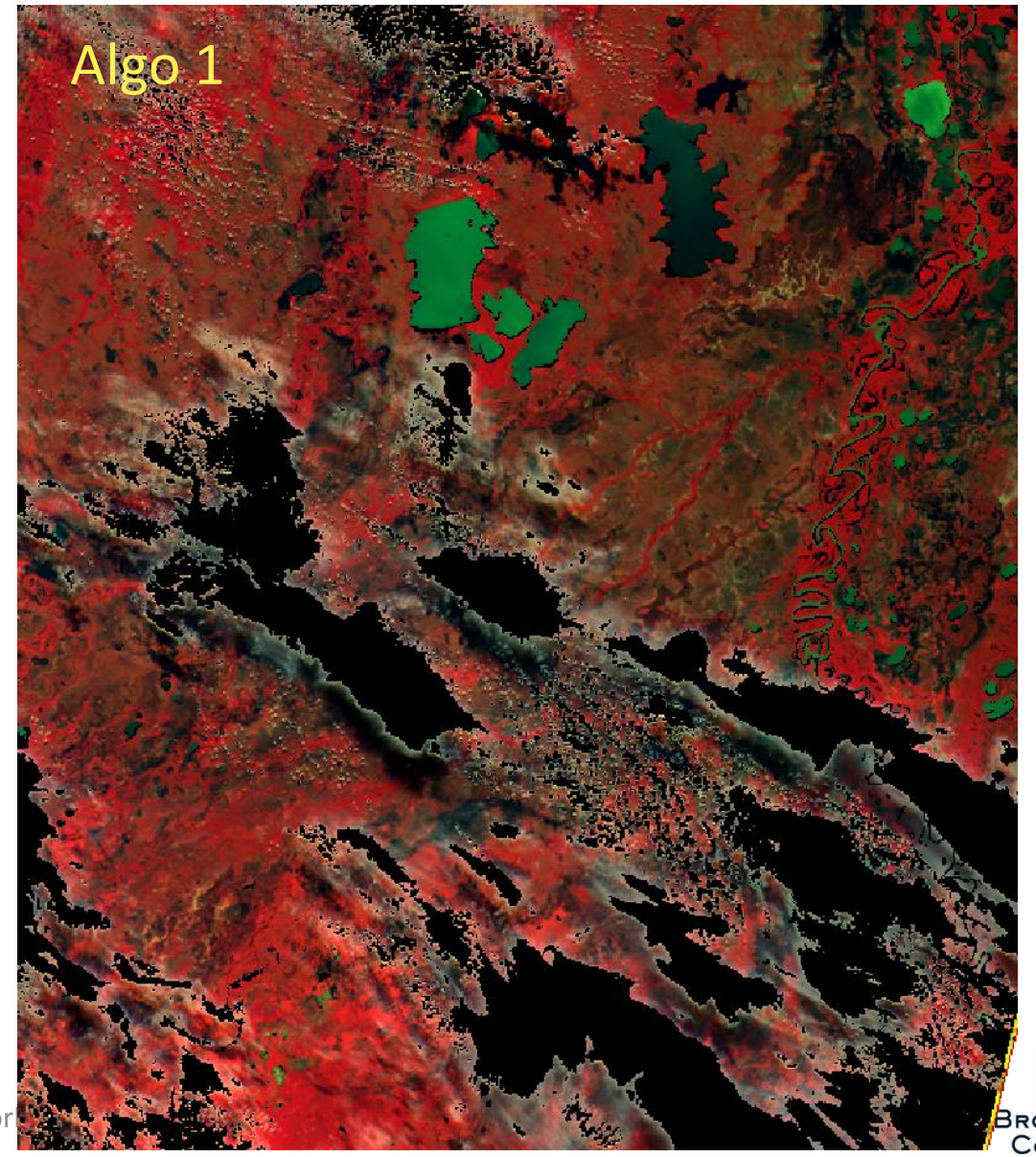


Assessment 3 - Semi-transparent Clouds

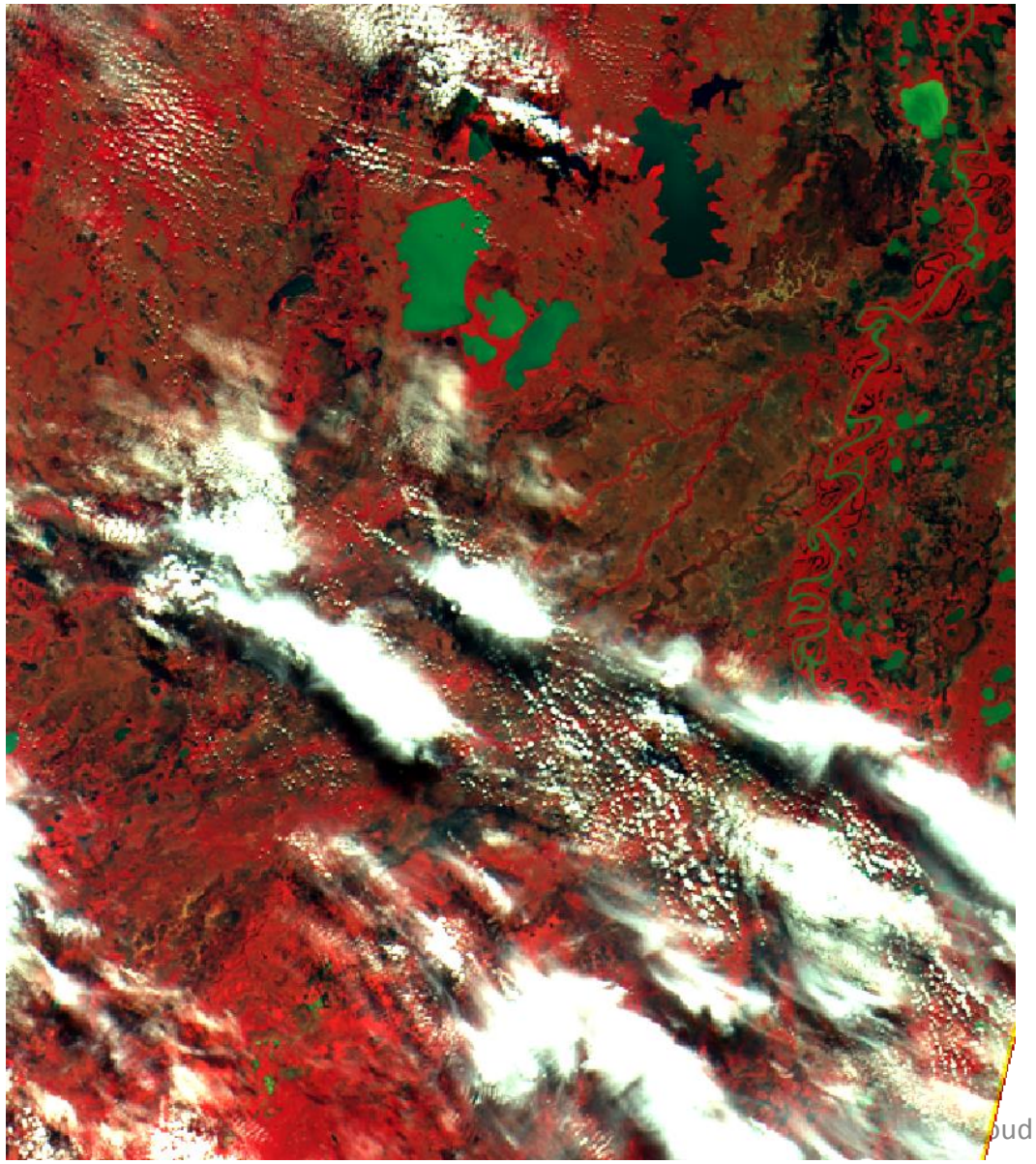


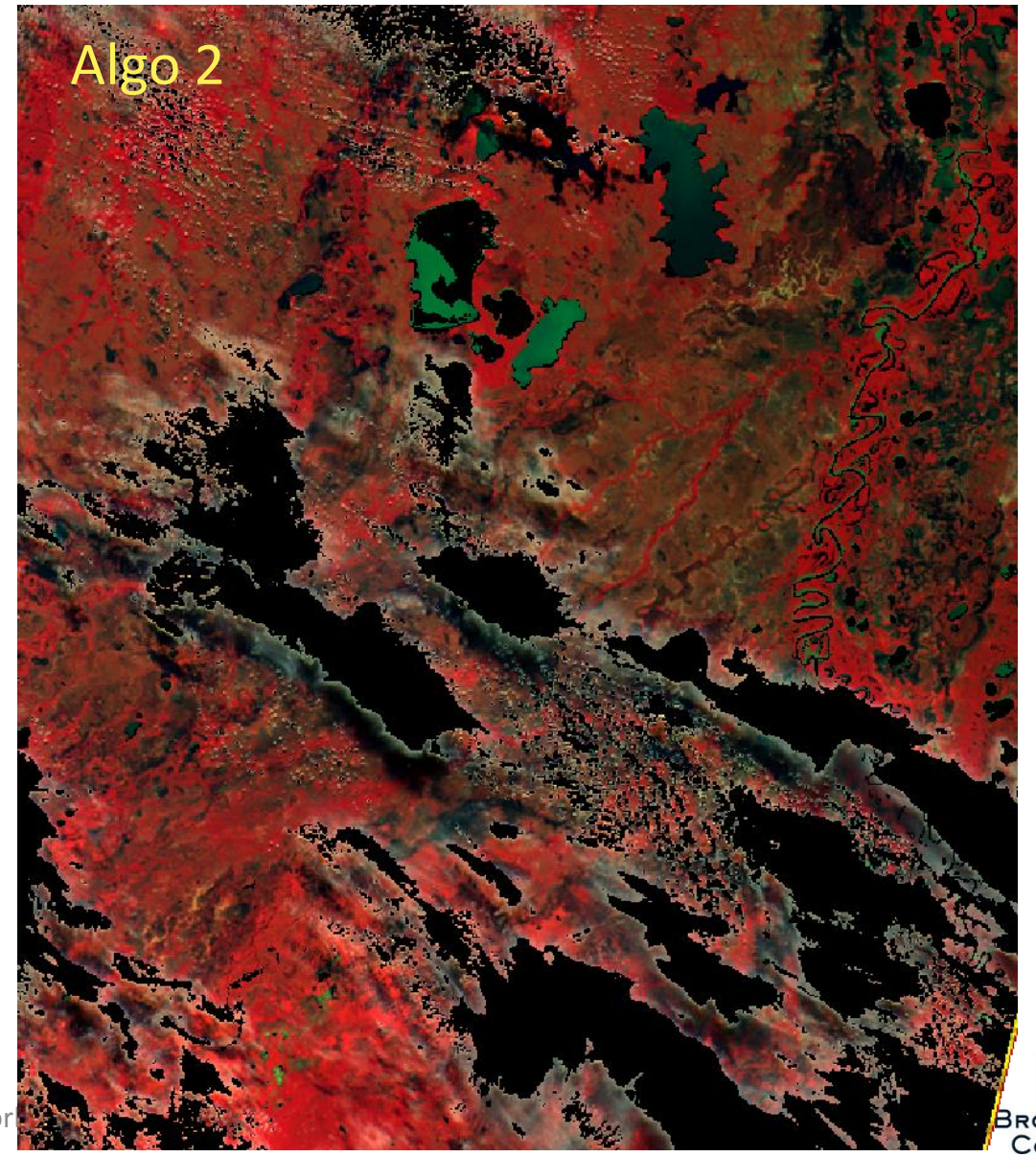
Assessment 4 – Cloud flags in images



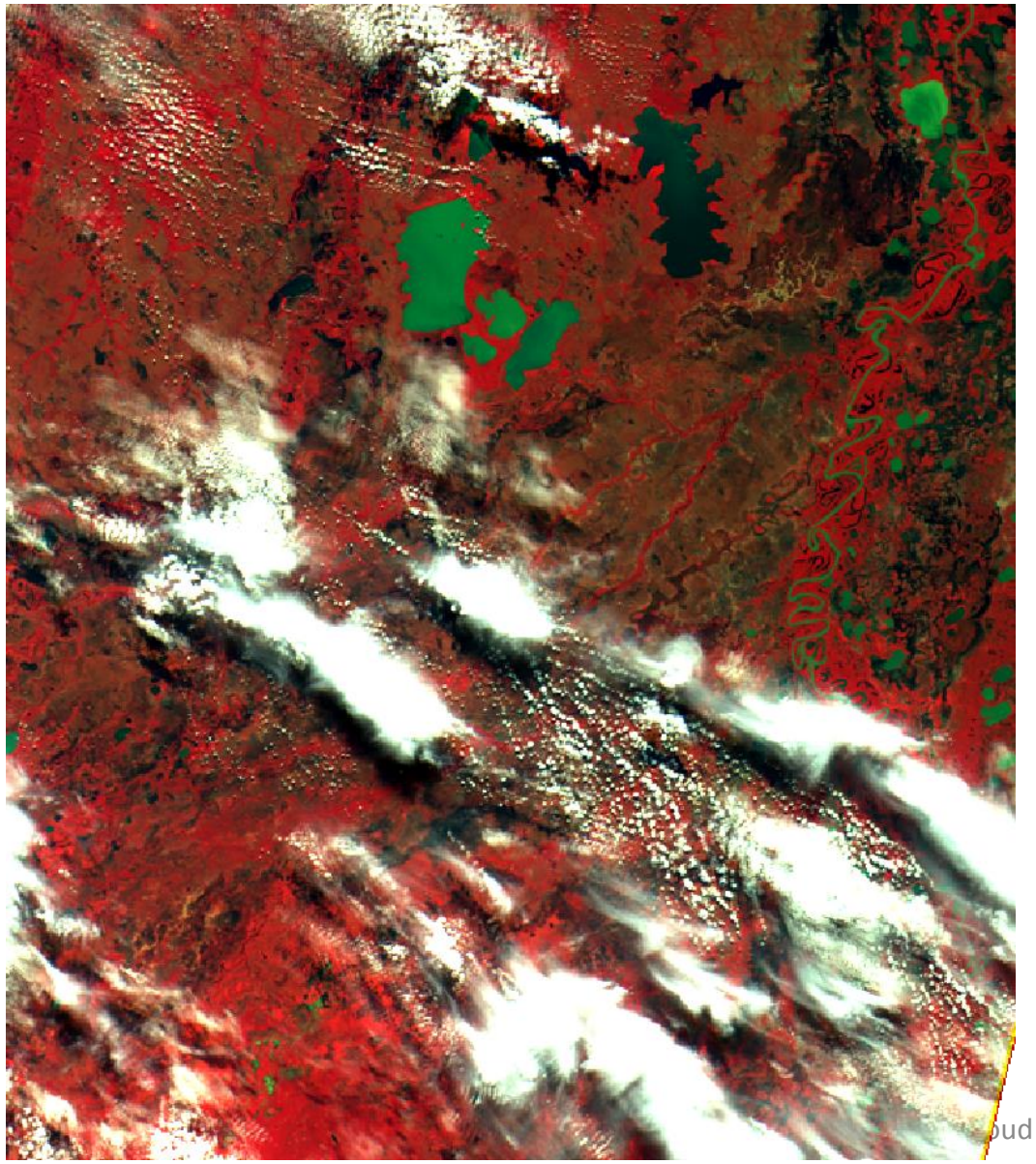


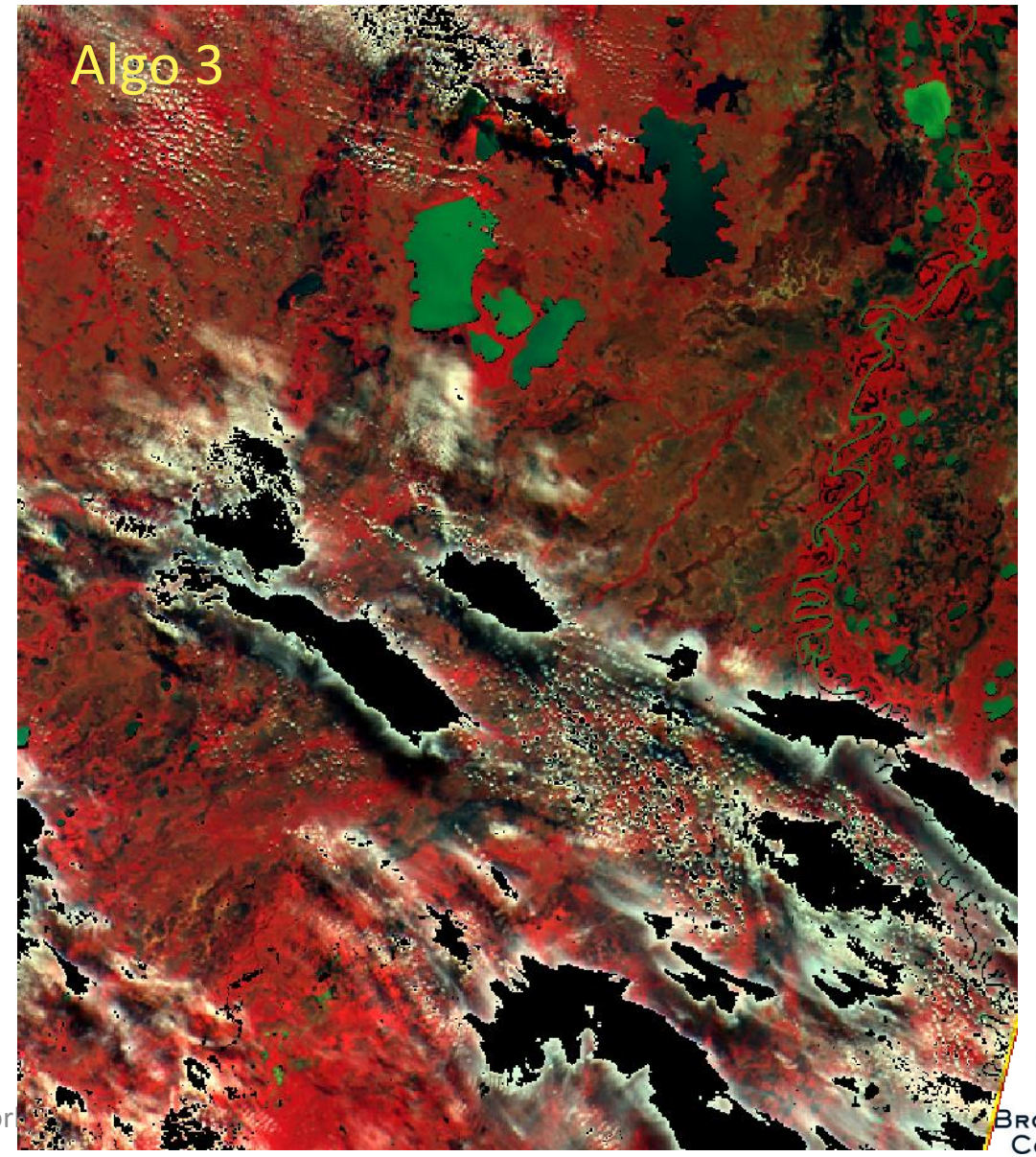
Assessment 4 – Cloud flags in images



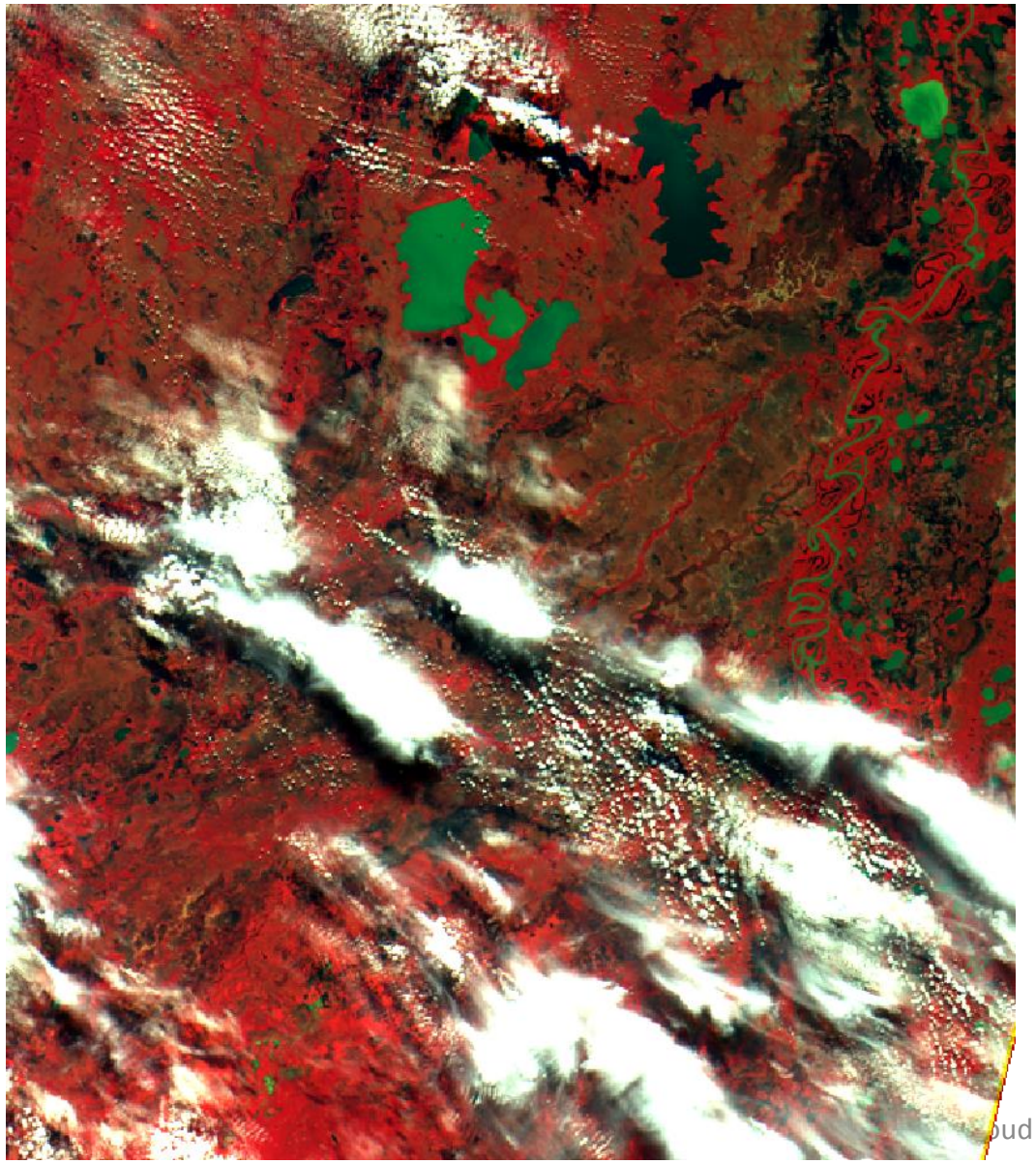


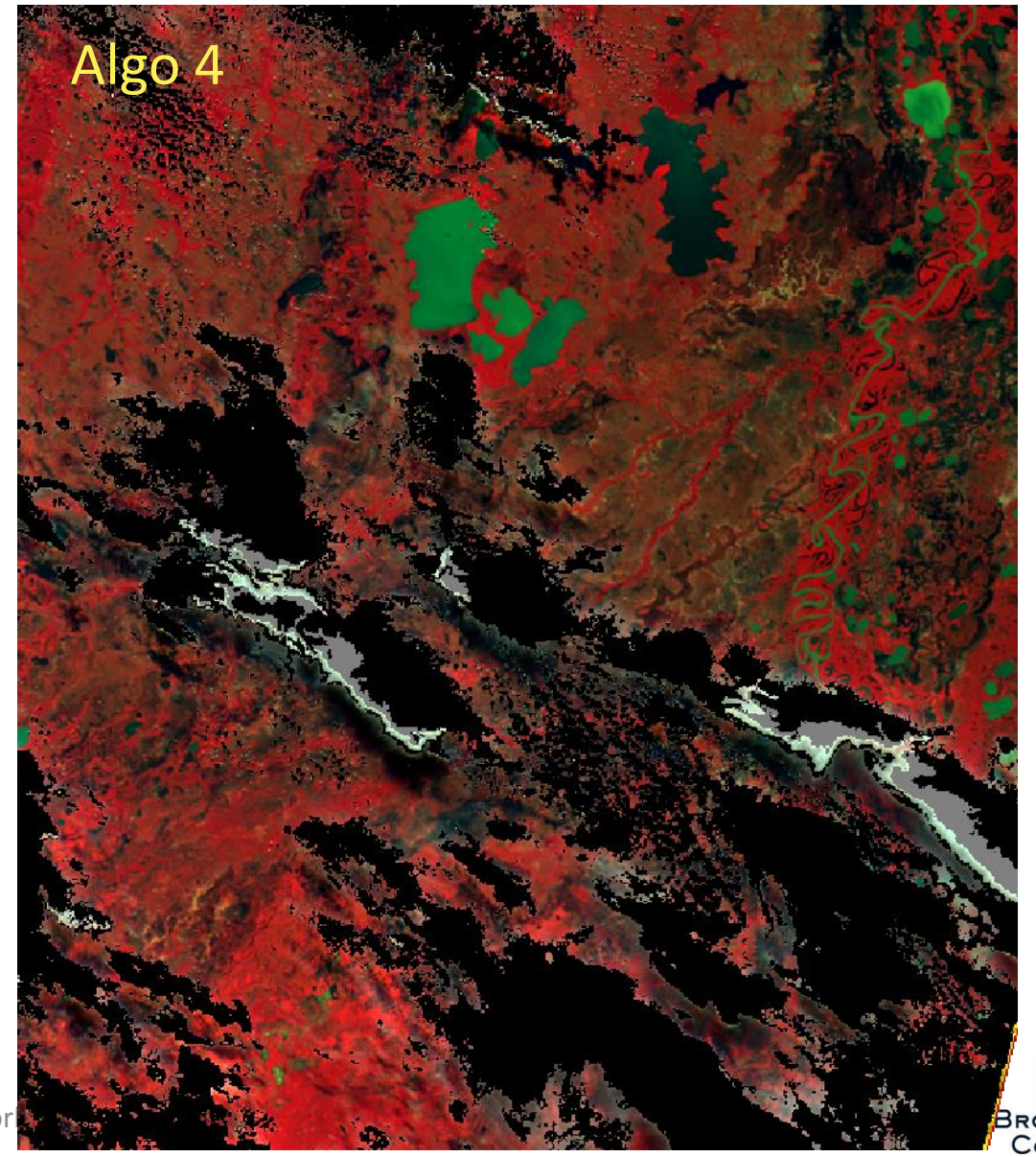
Assessment 4 – Cloud flags in images



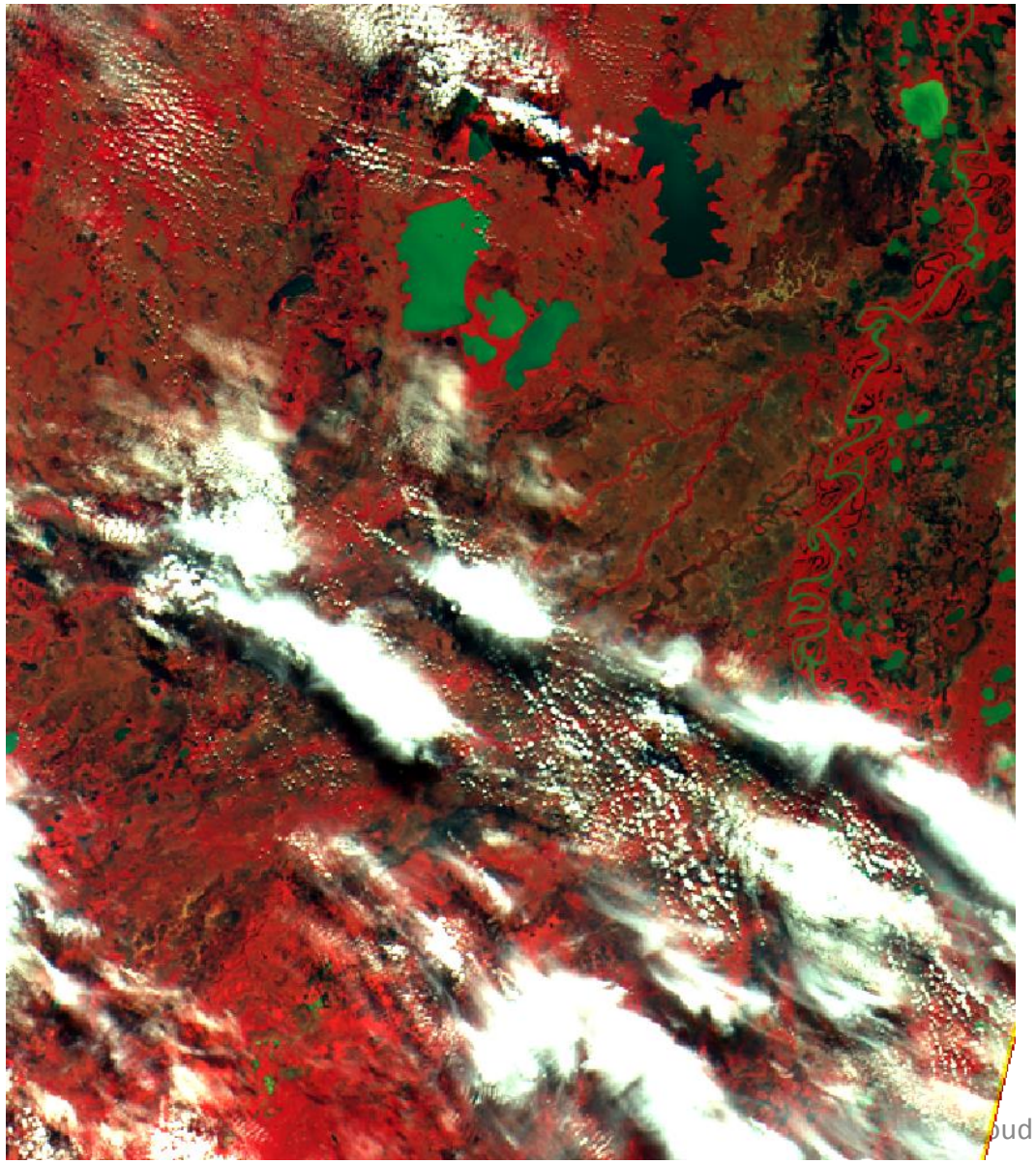


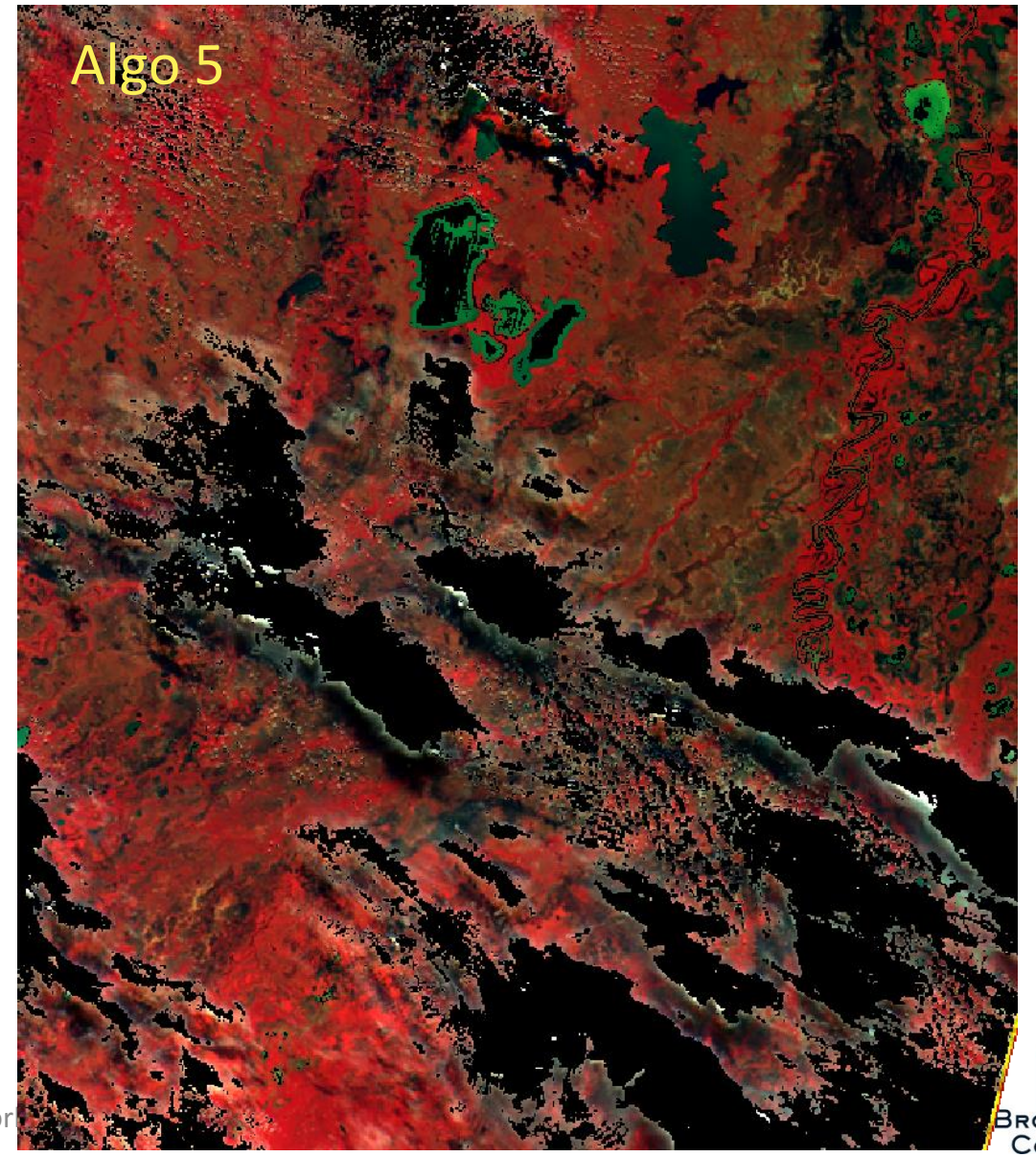
Assessment 4 – Cloud flags in images



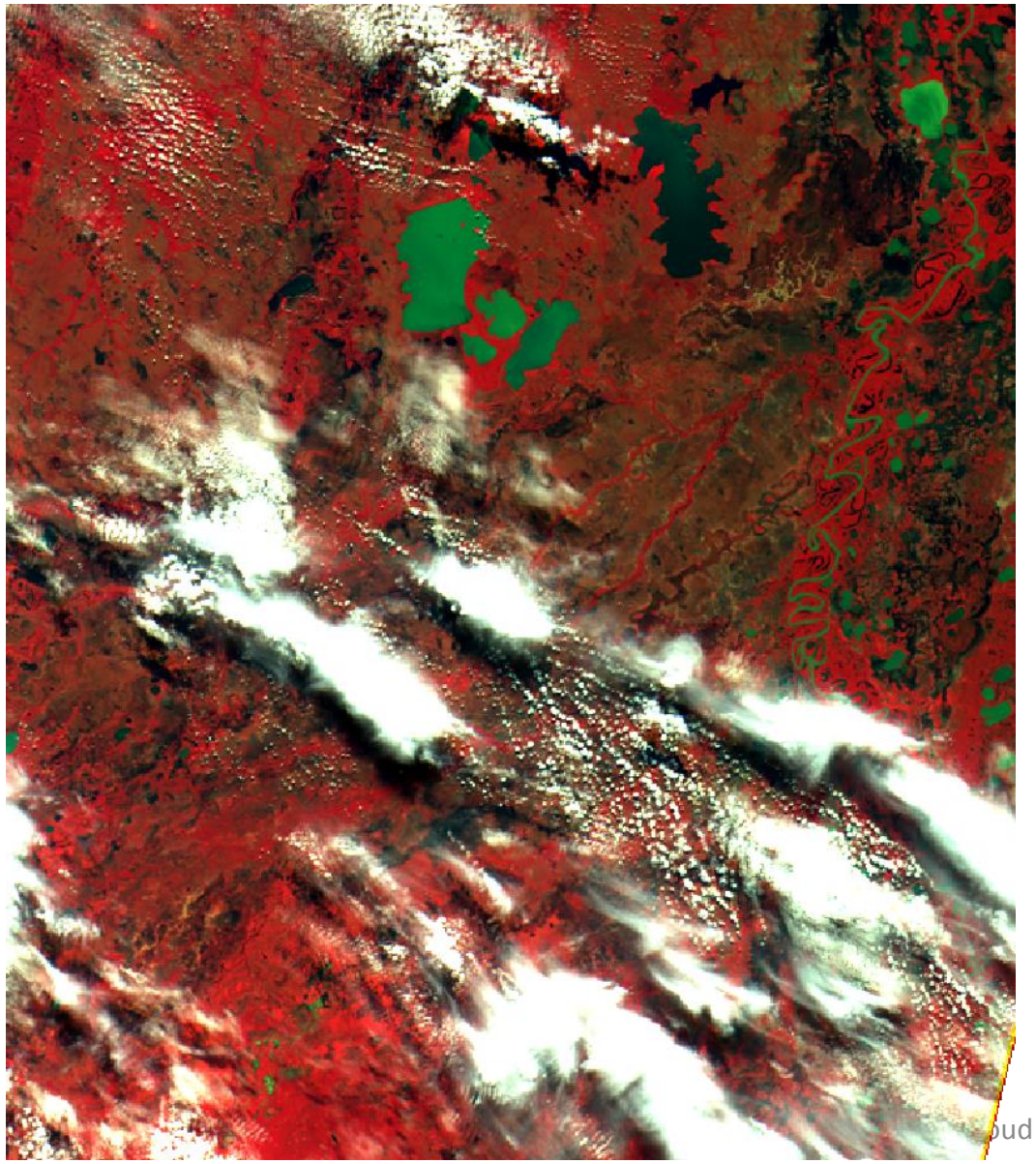


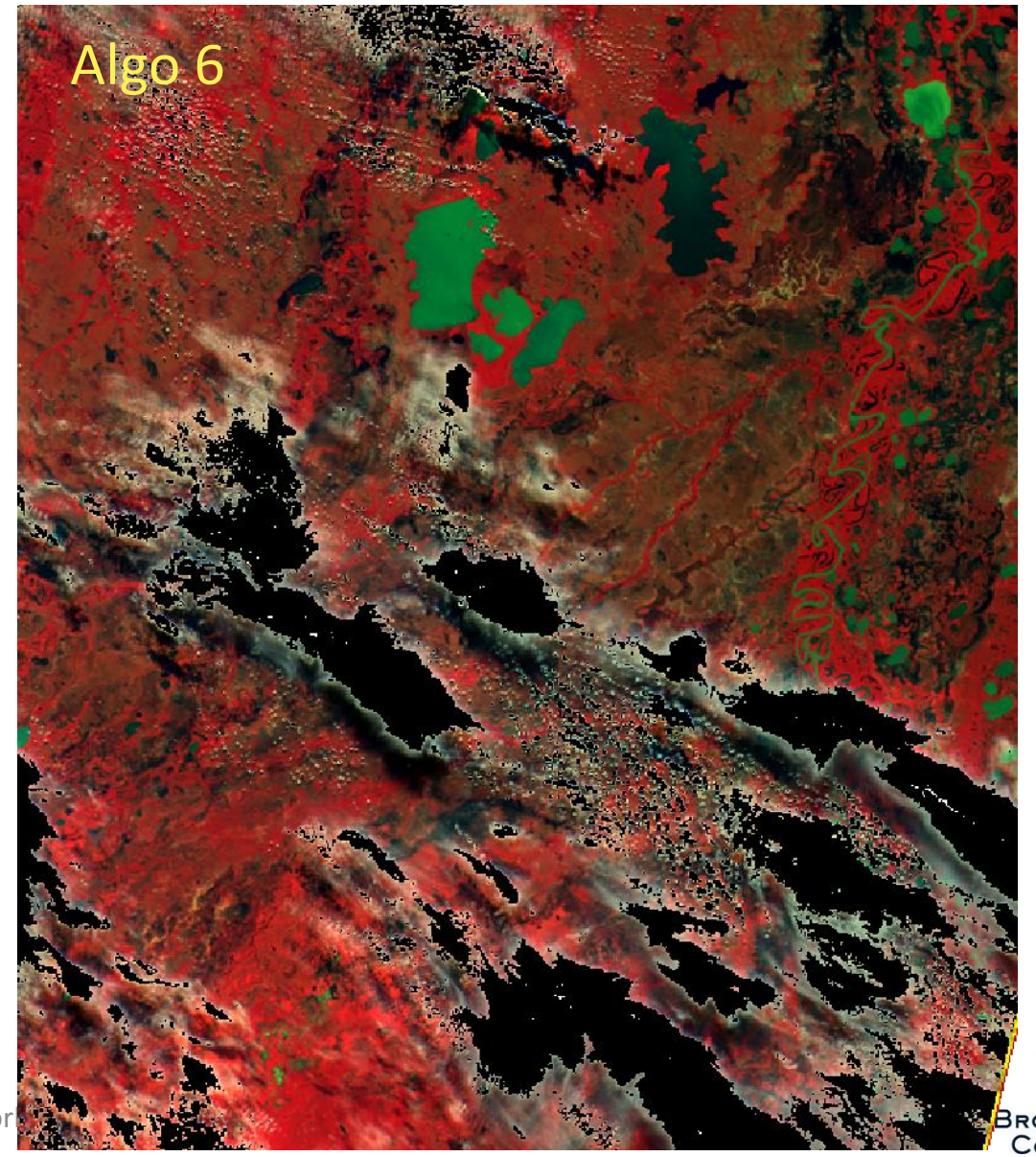
Assessment 4 – Cloud flags in images





Assessment 4 – Cloud flags in images





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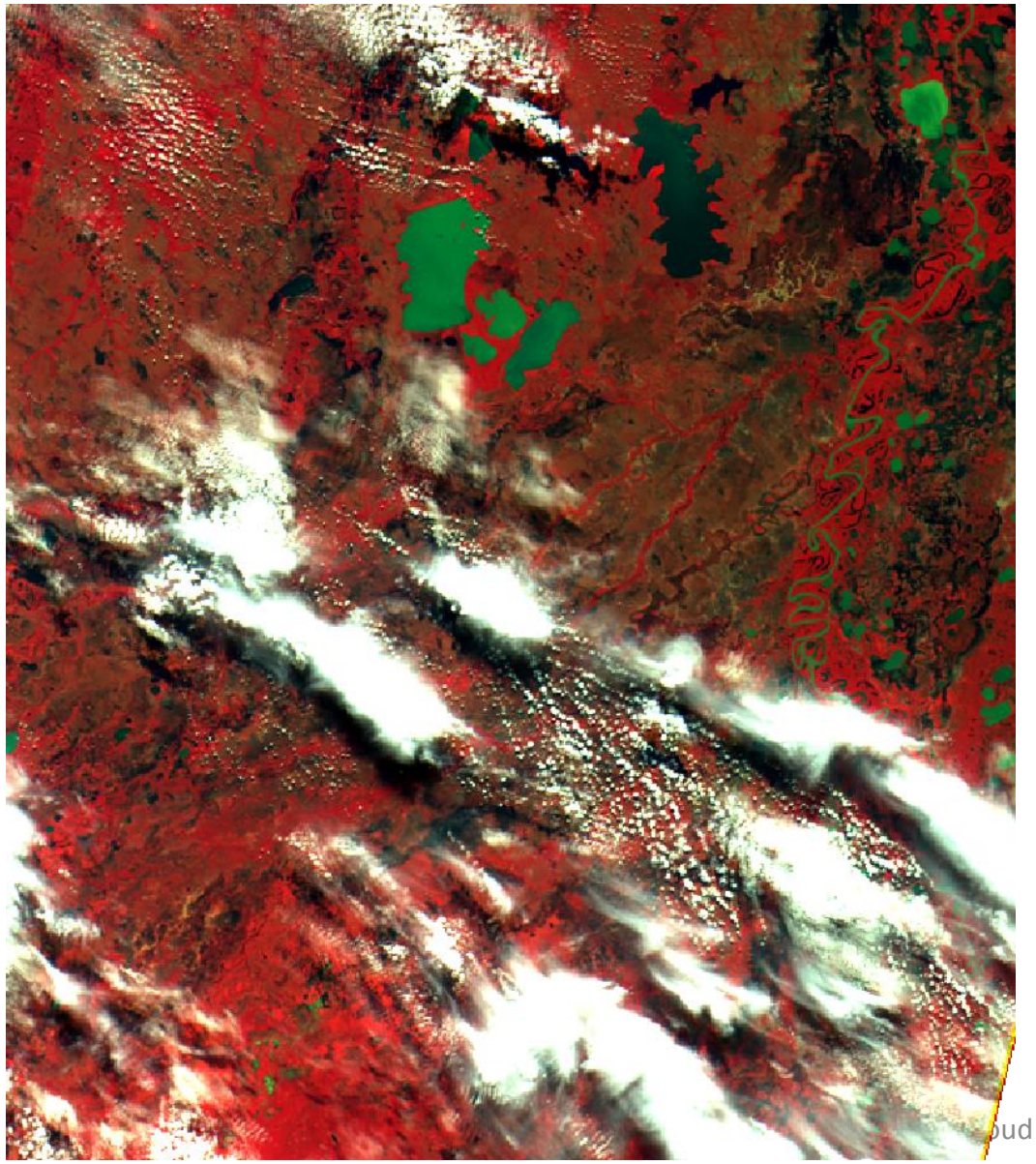

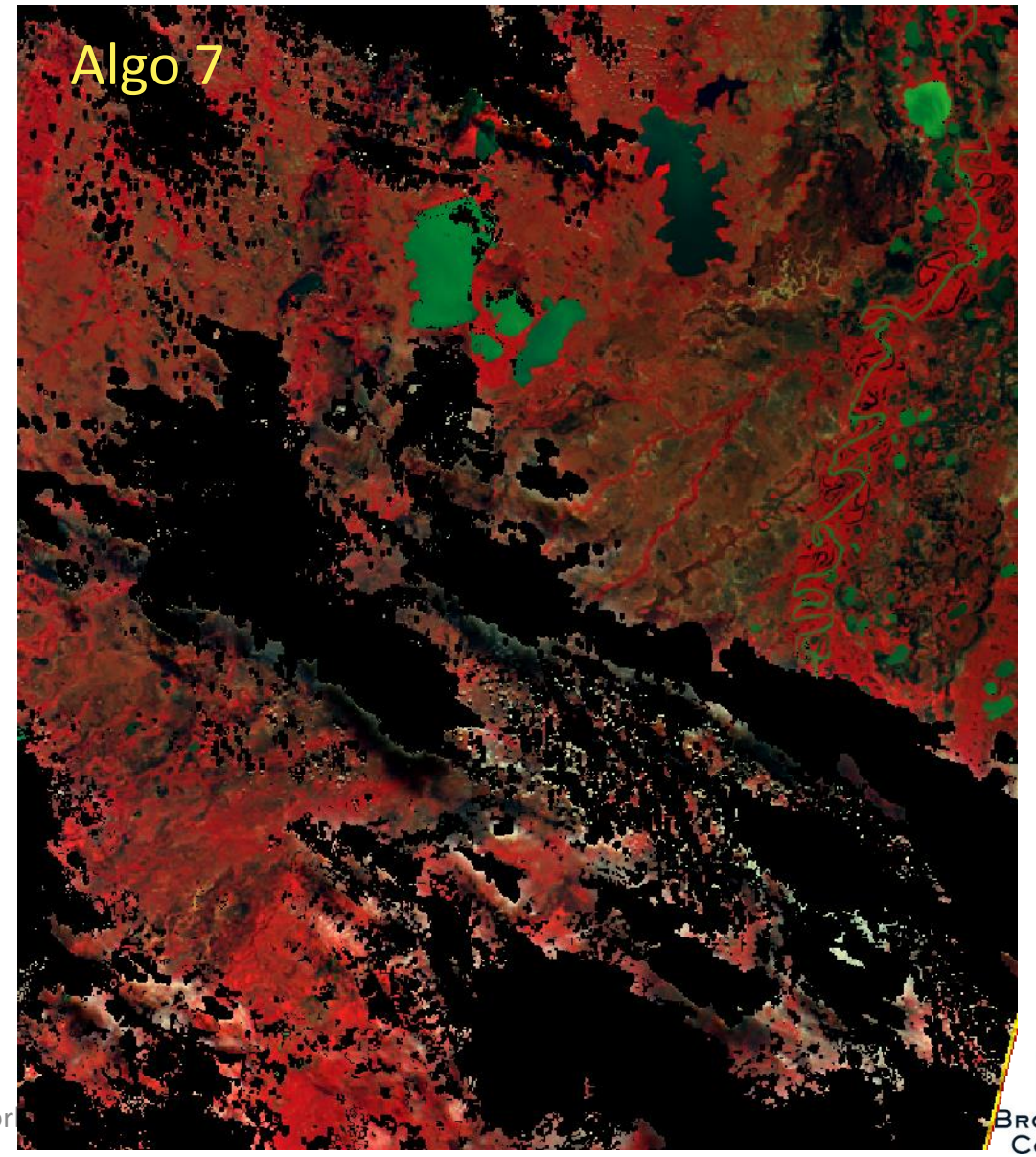

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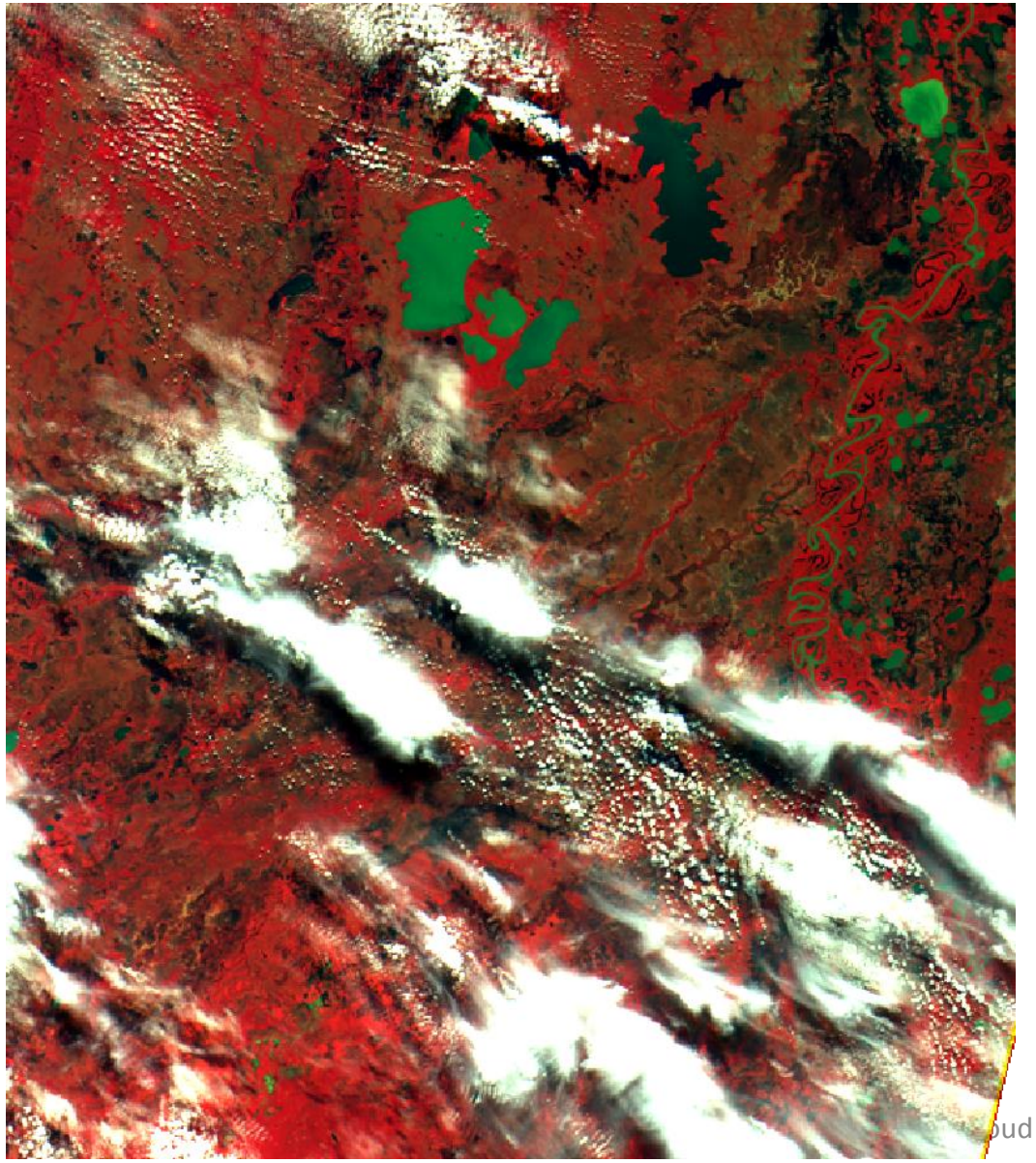

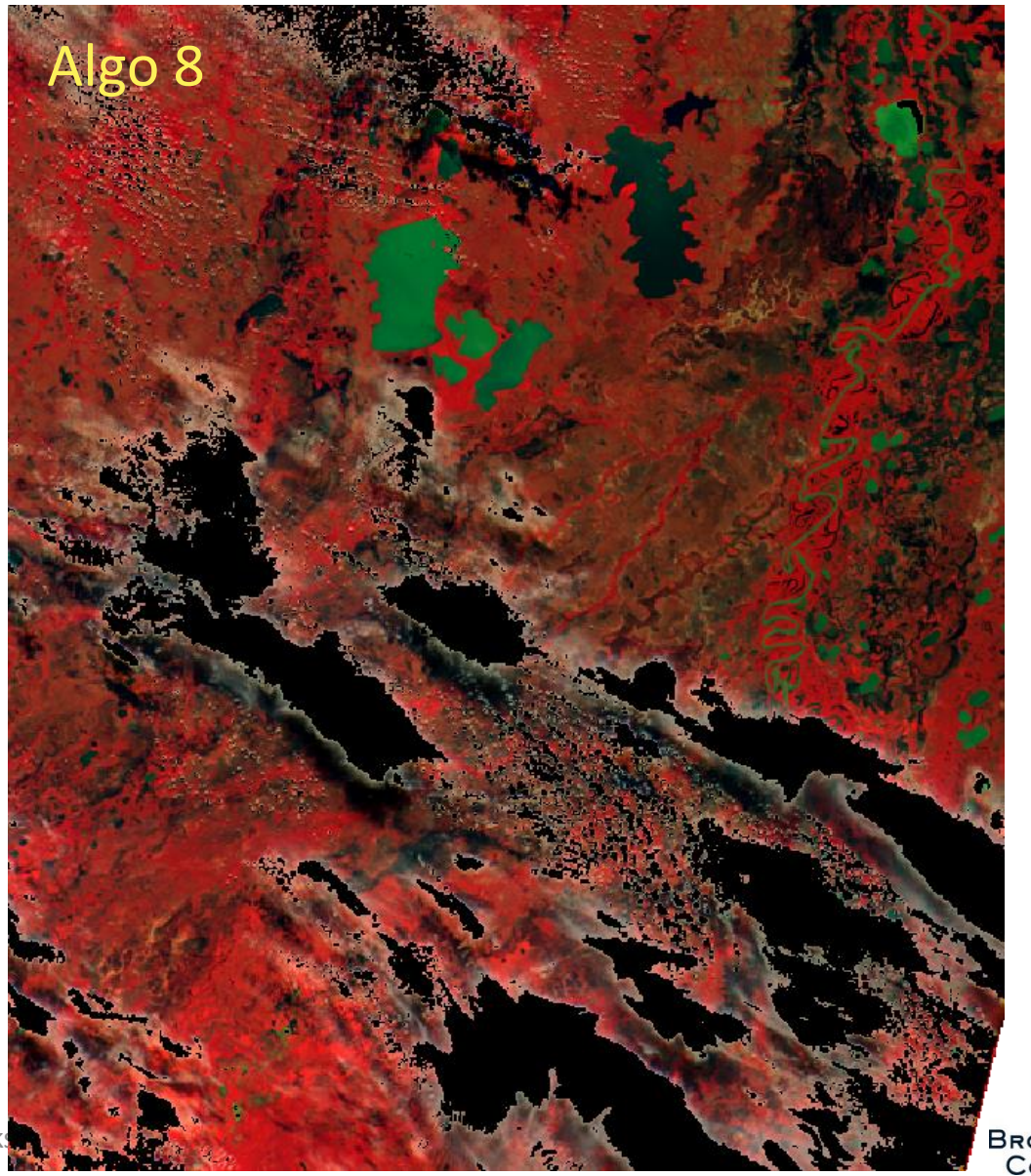

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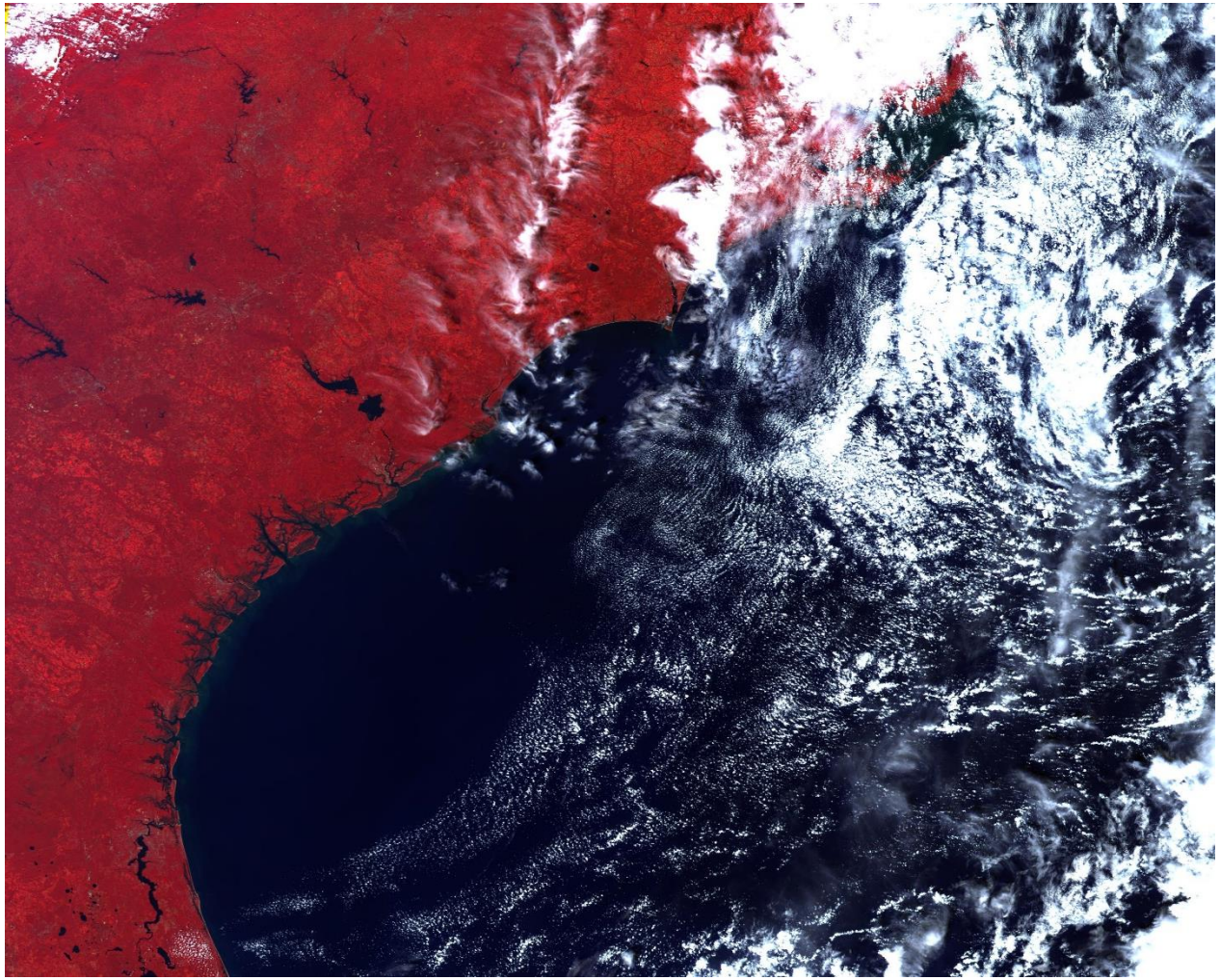

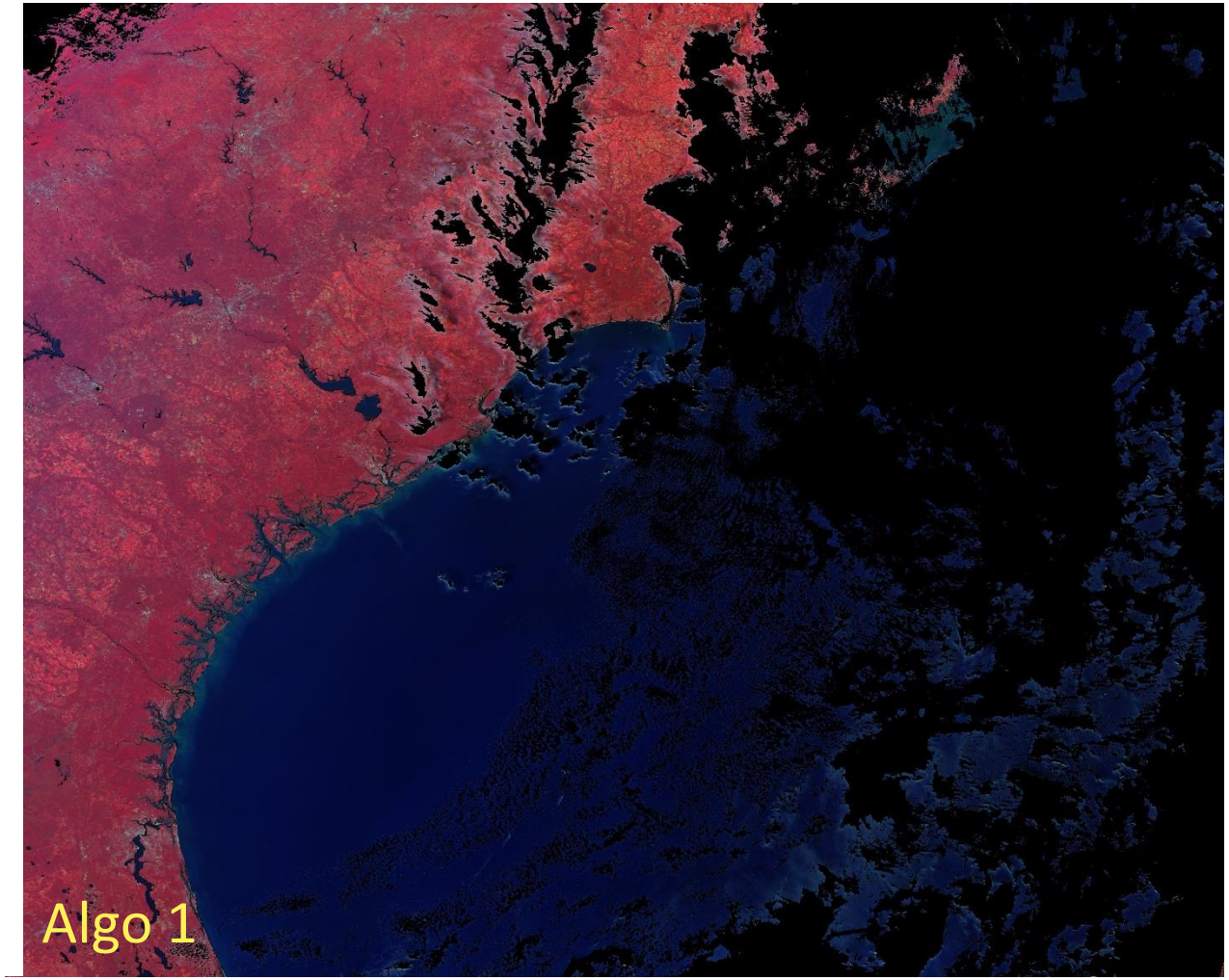

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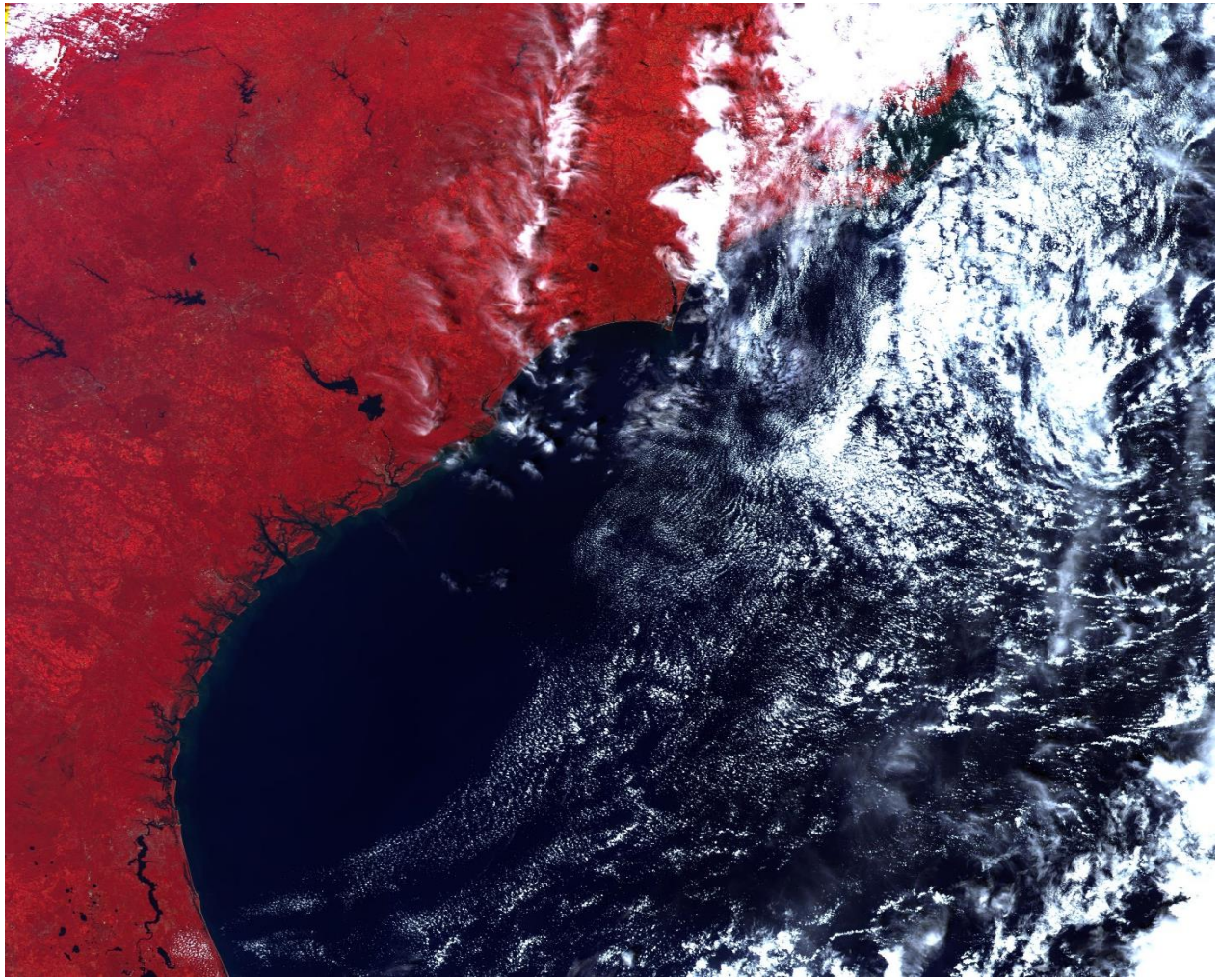

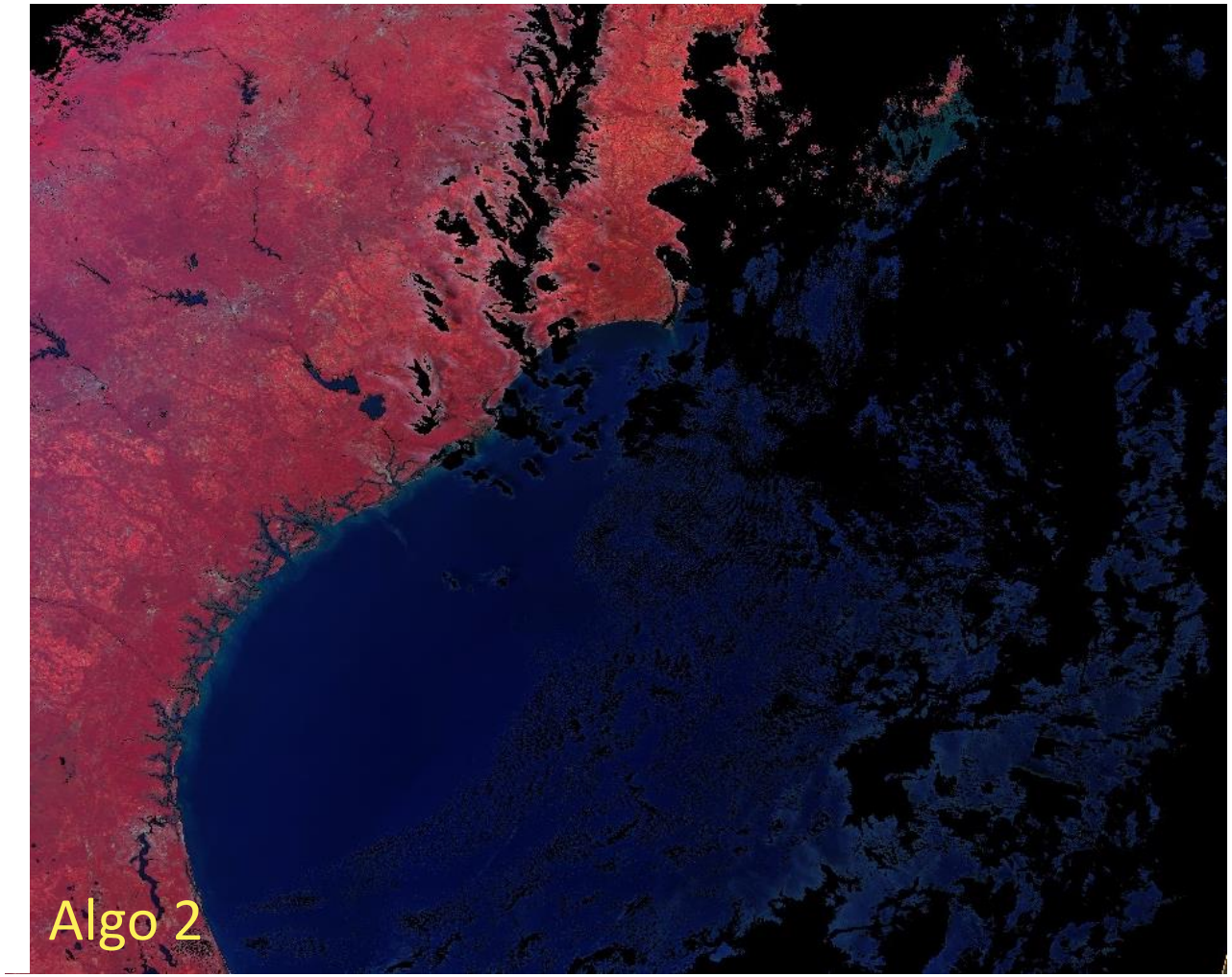

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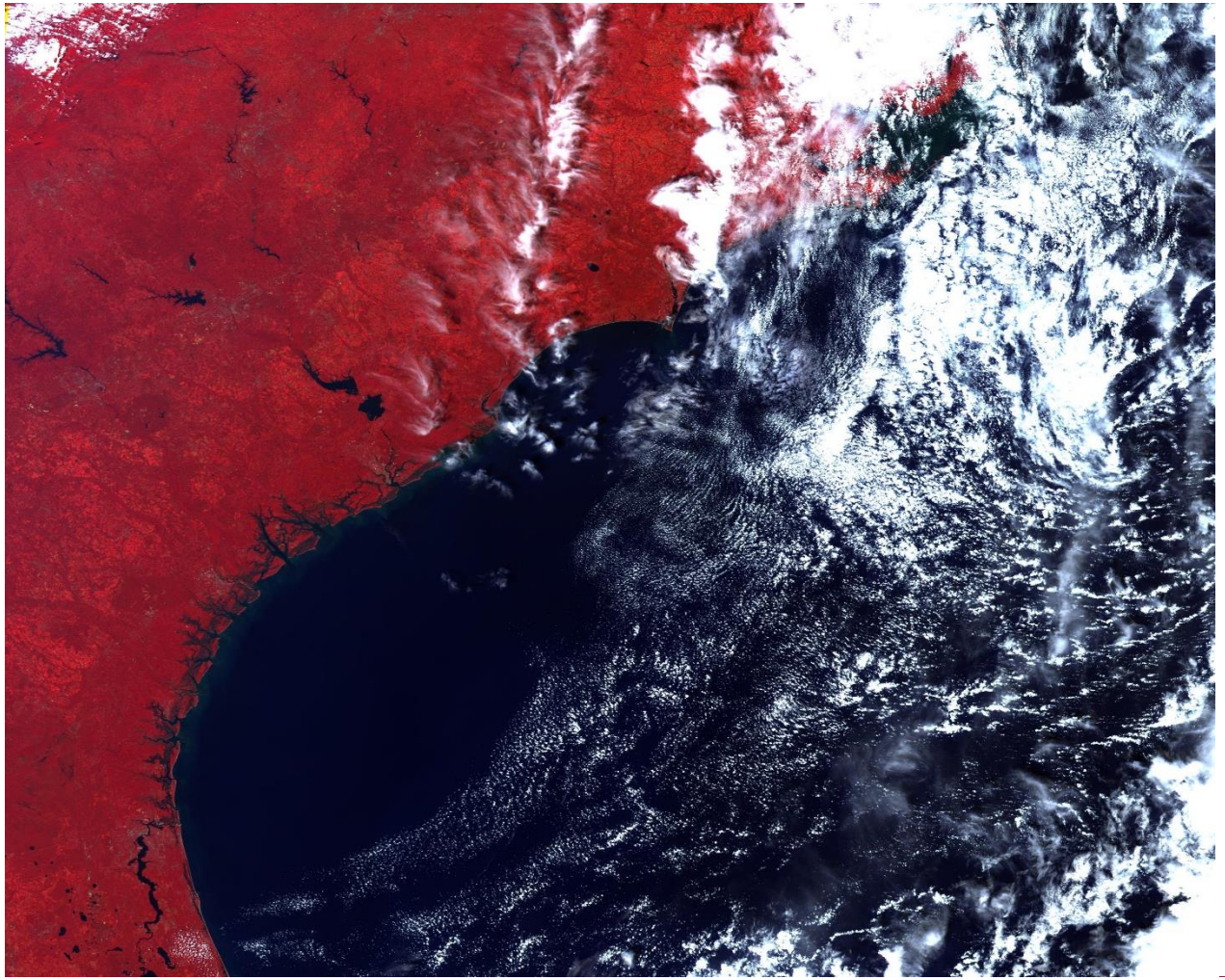
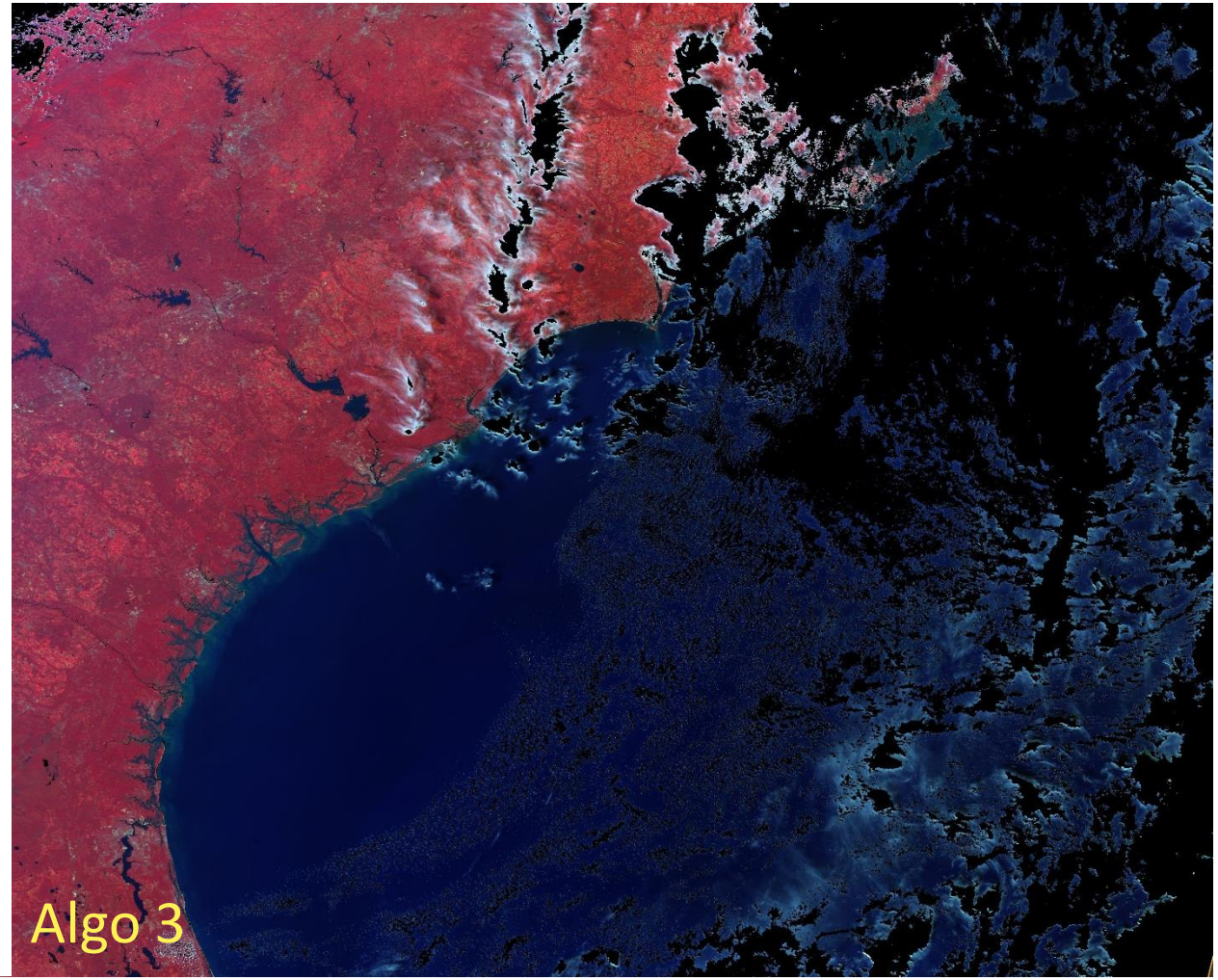
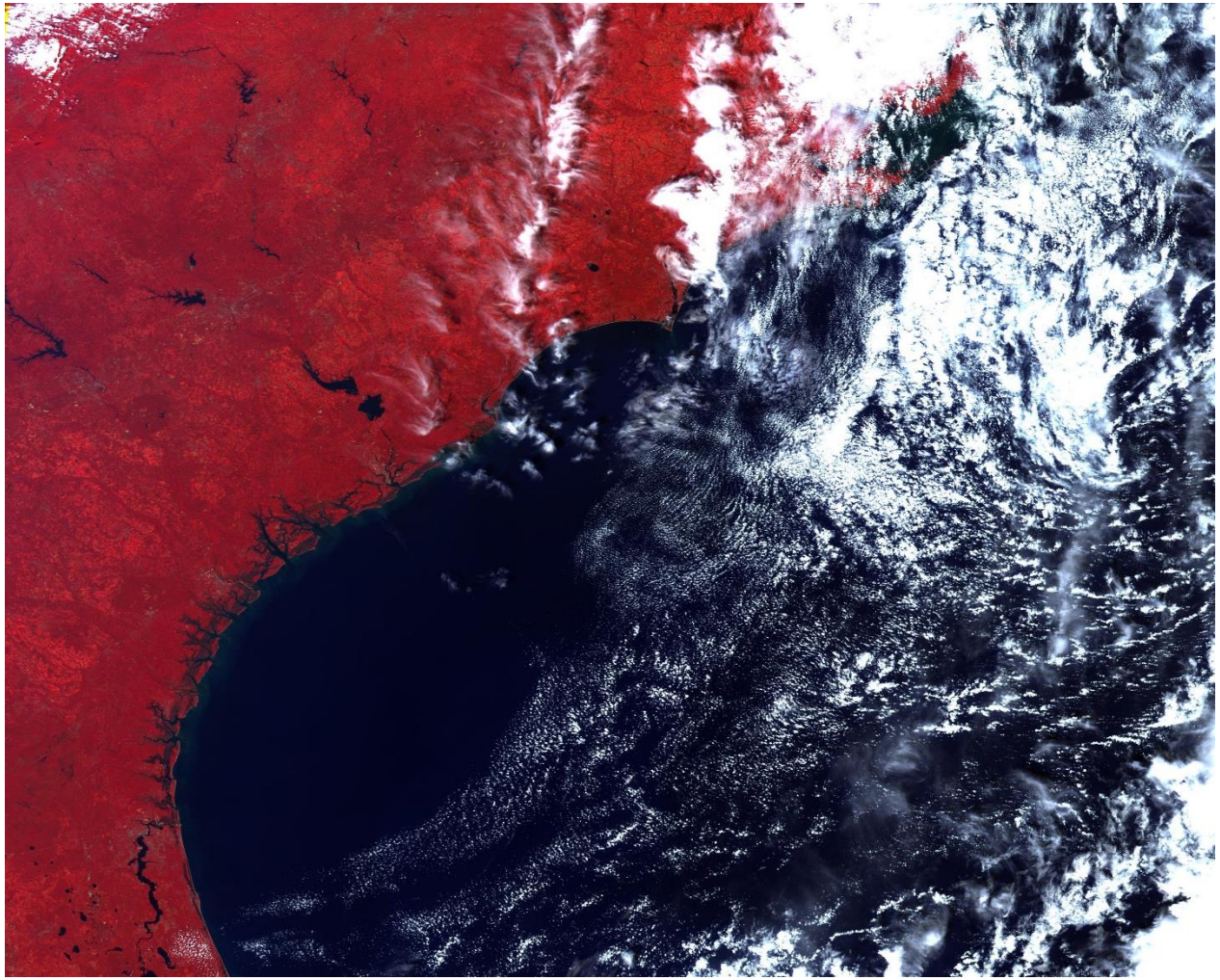
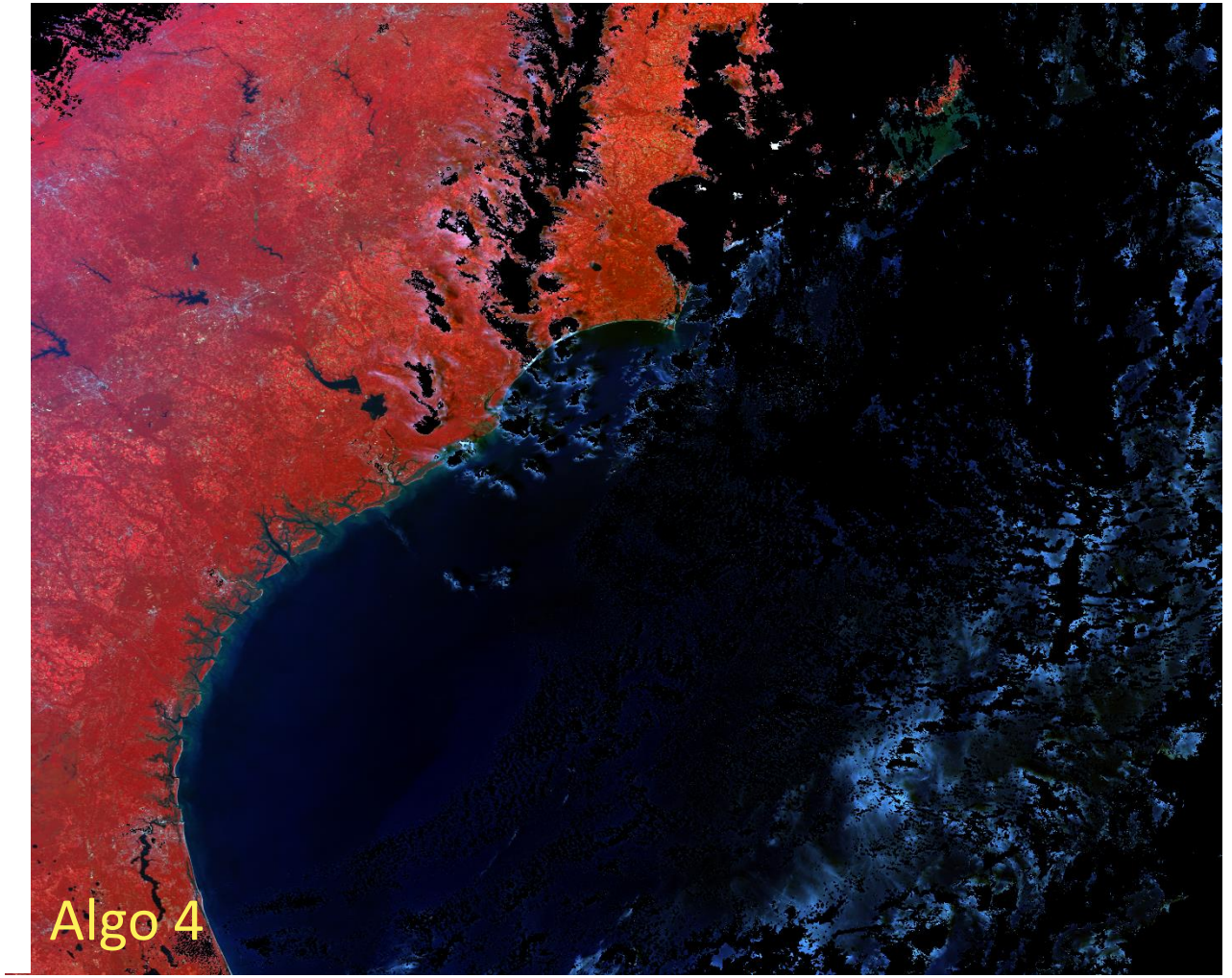




First impressions - images





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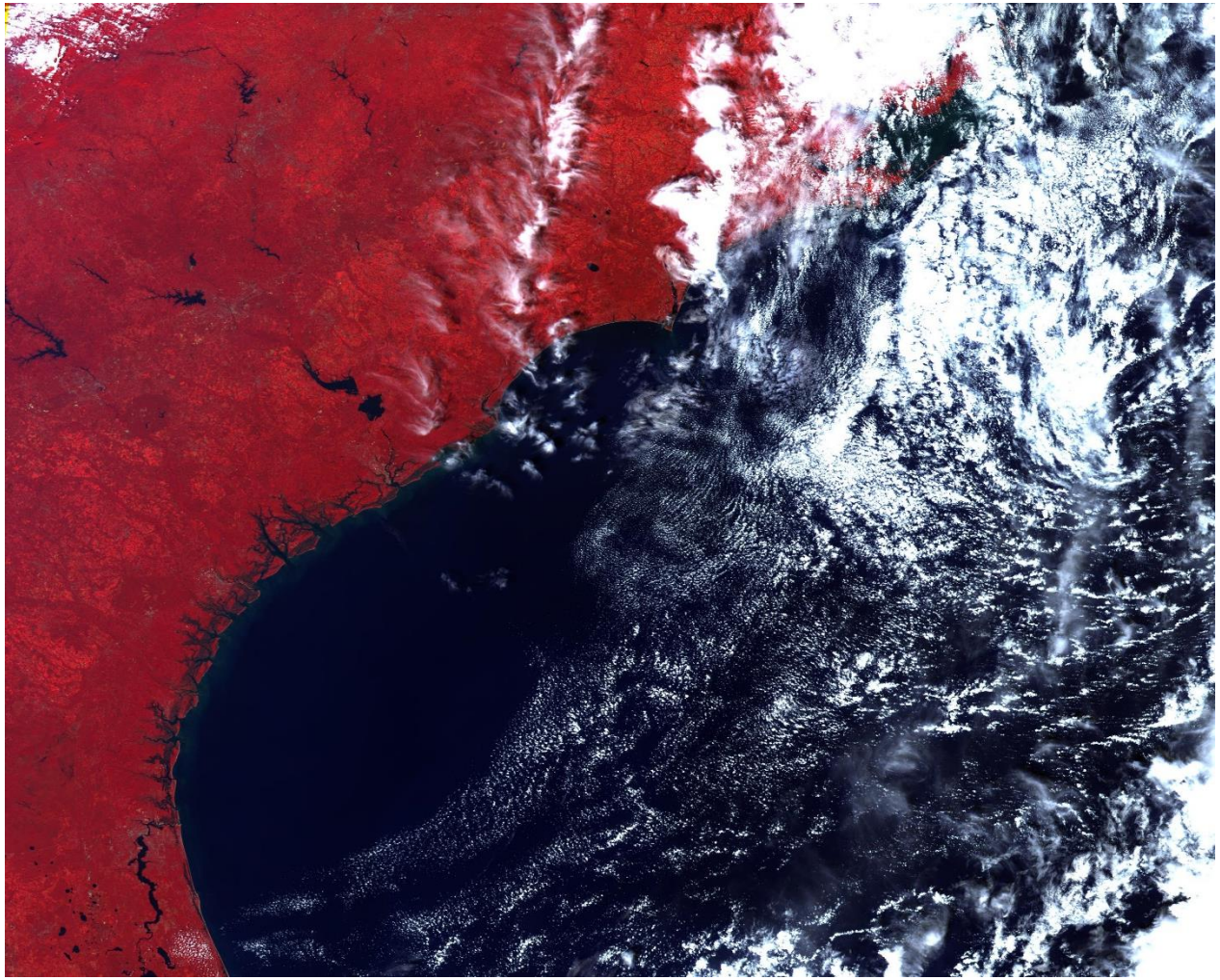

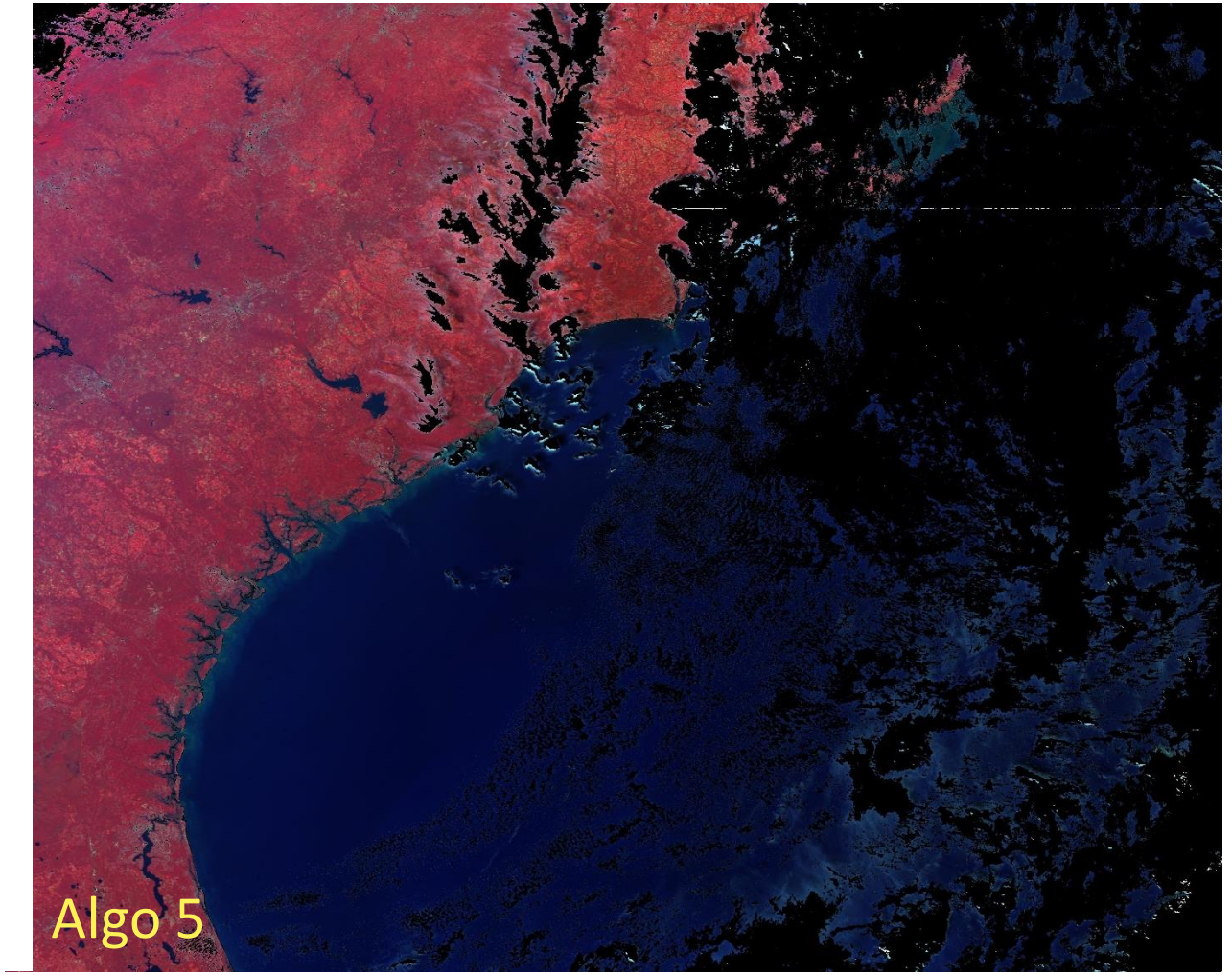

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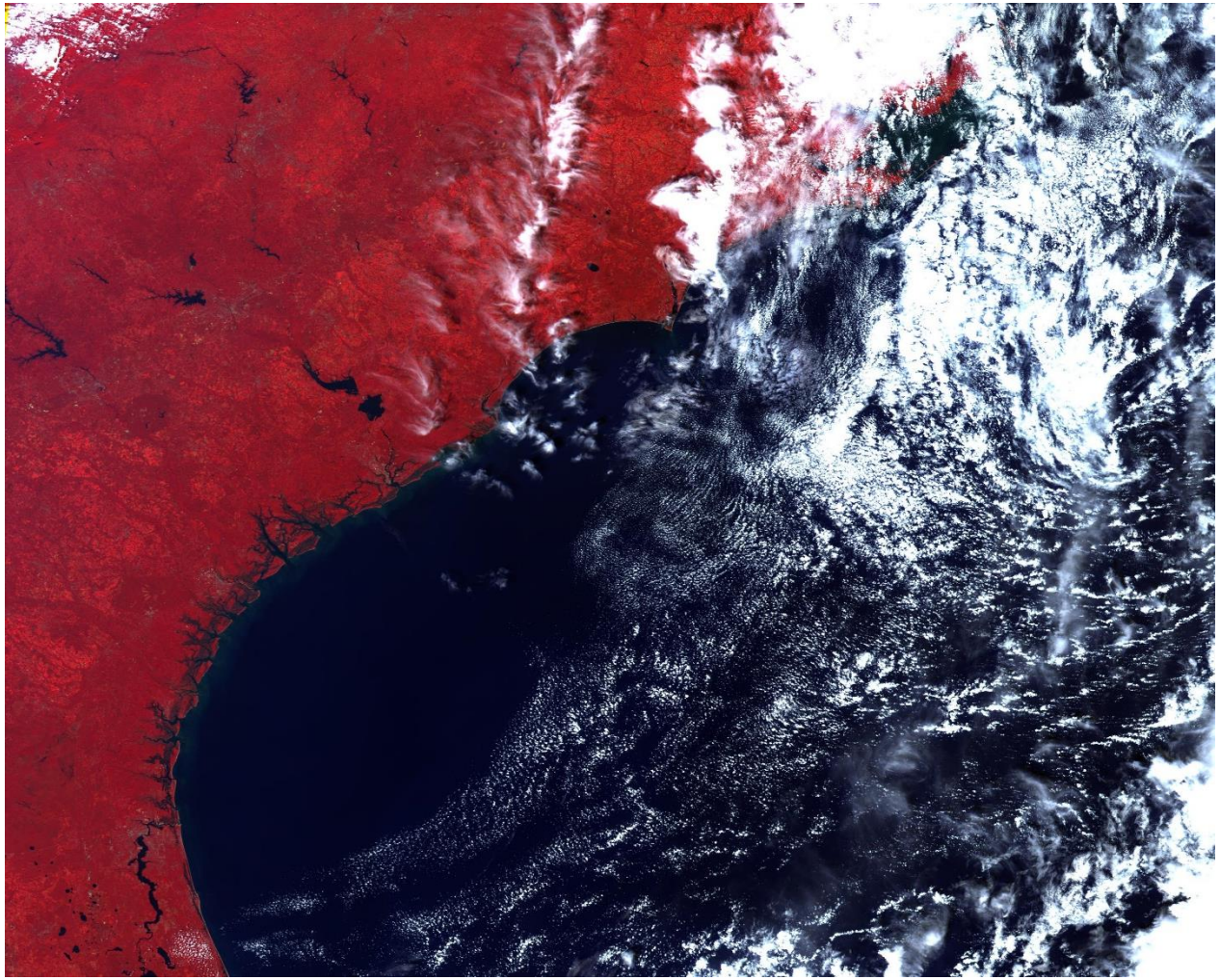

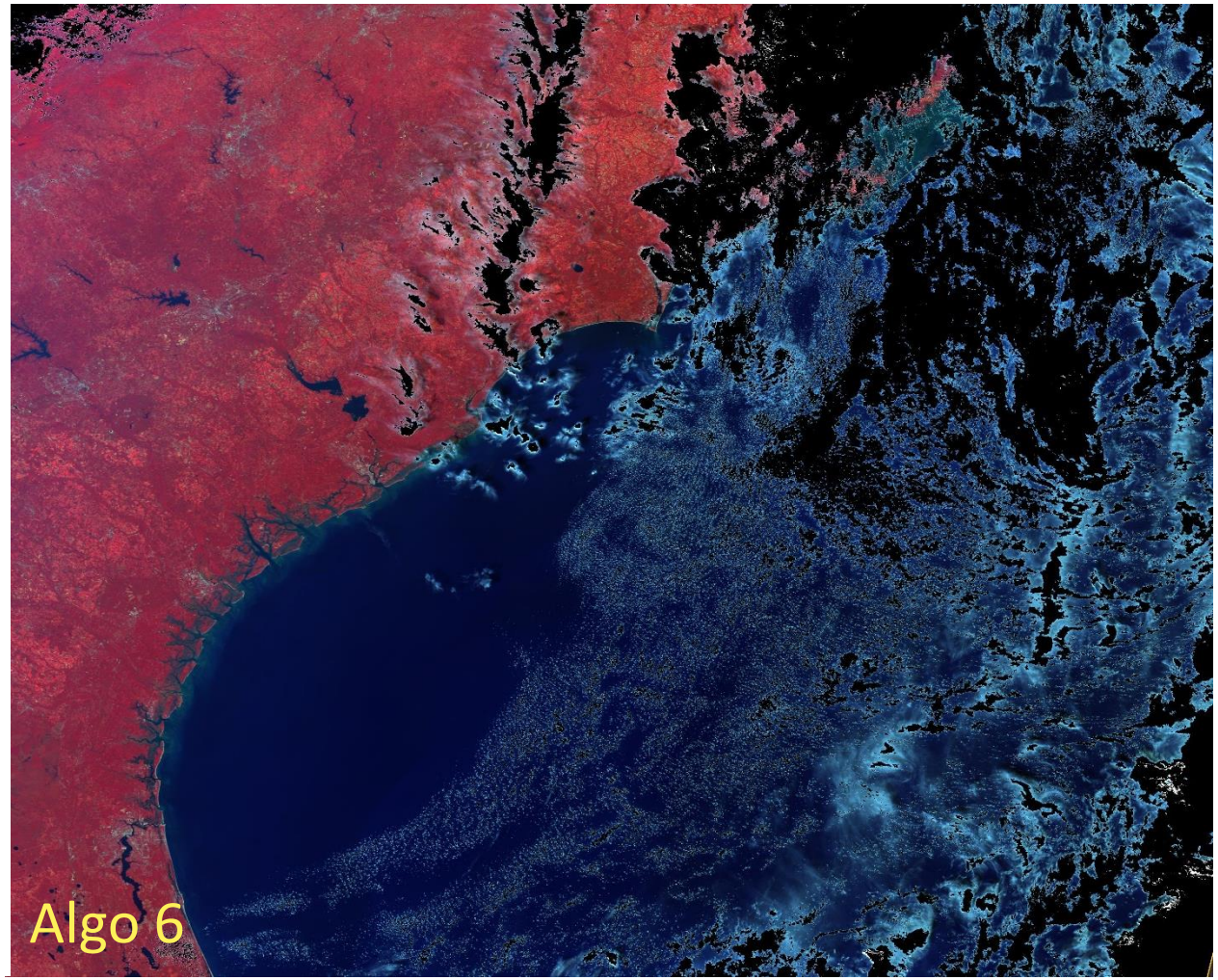

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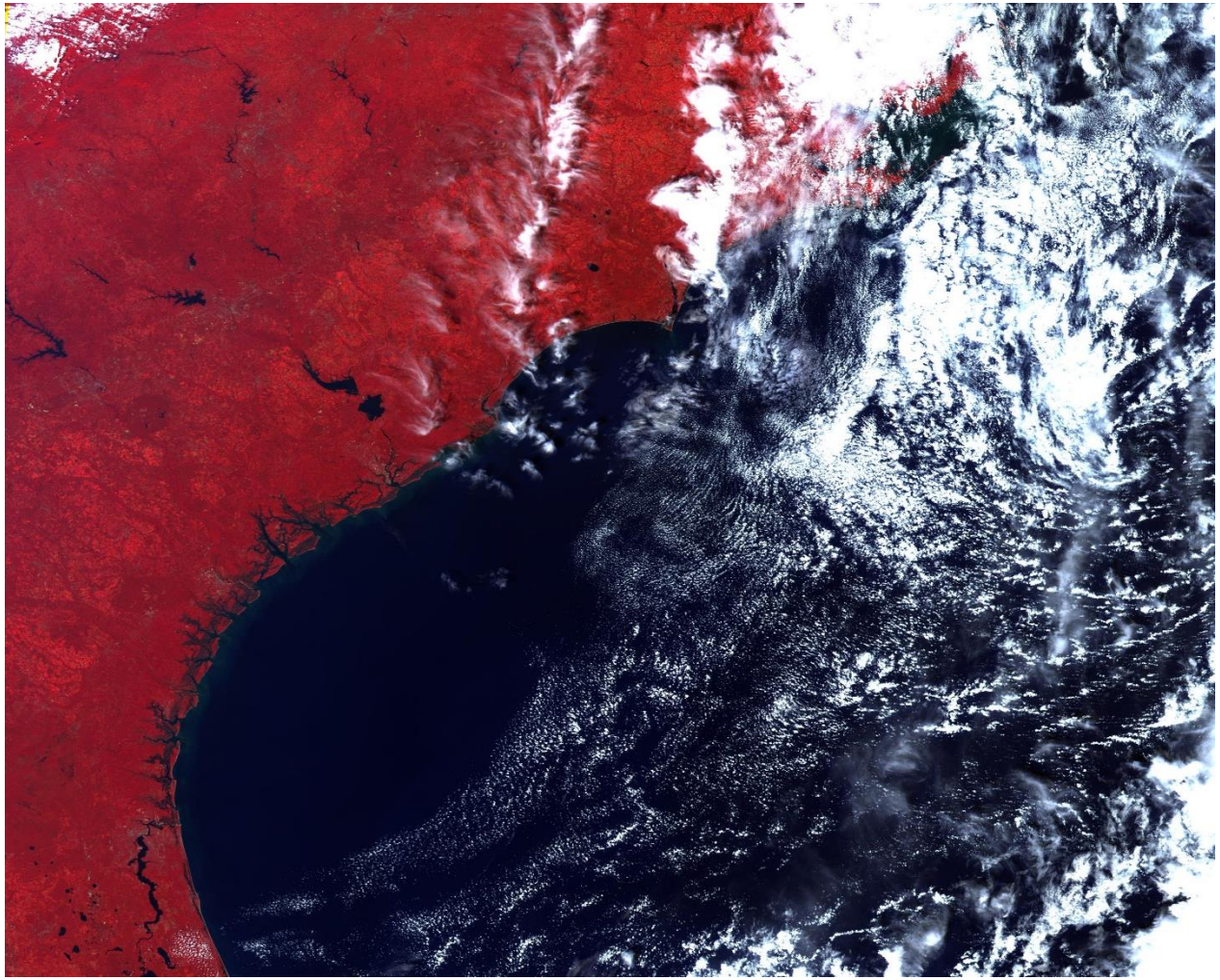

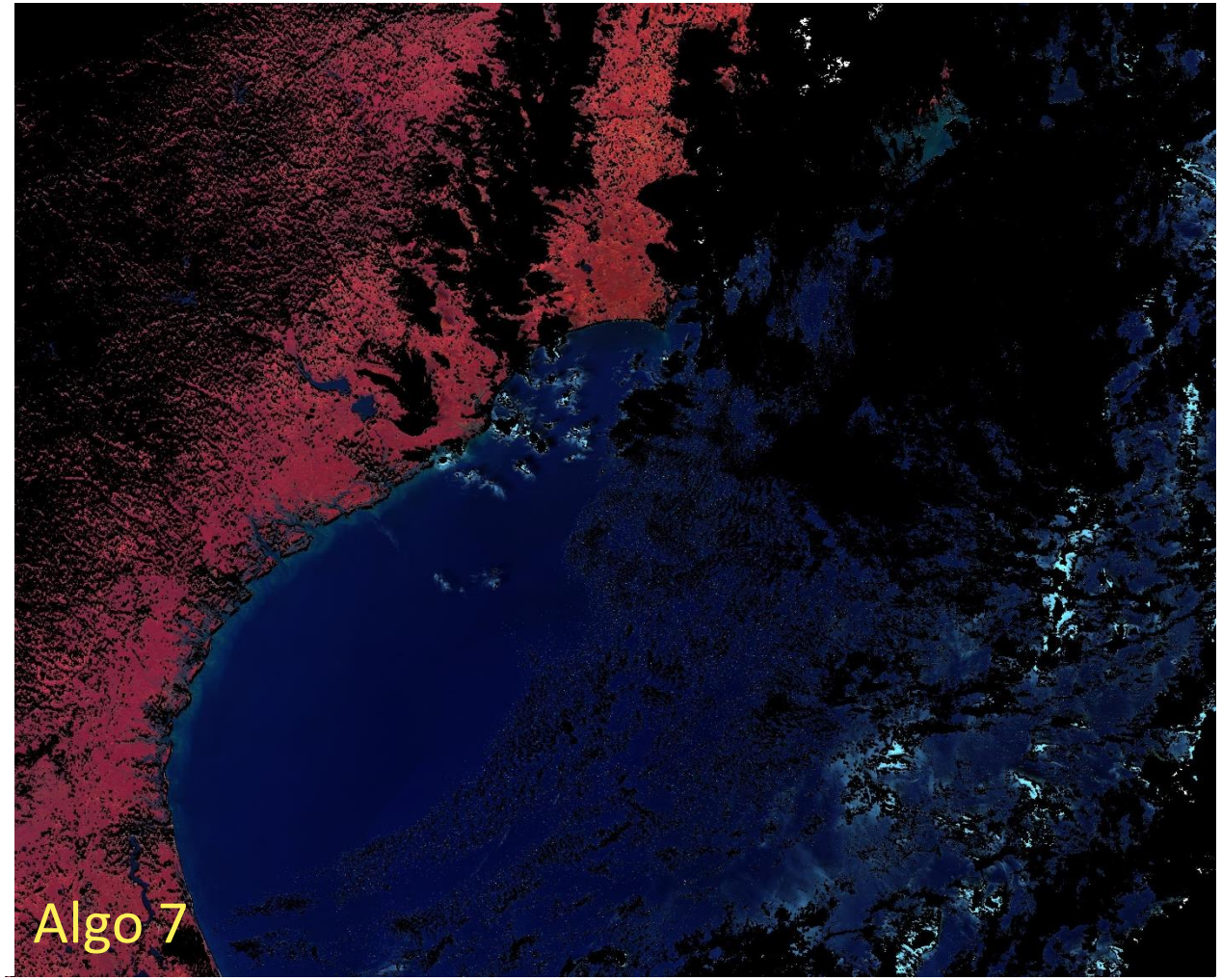

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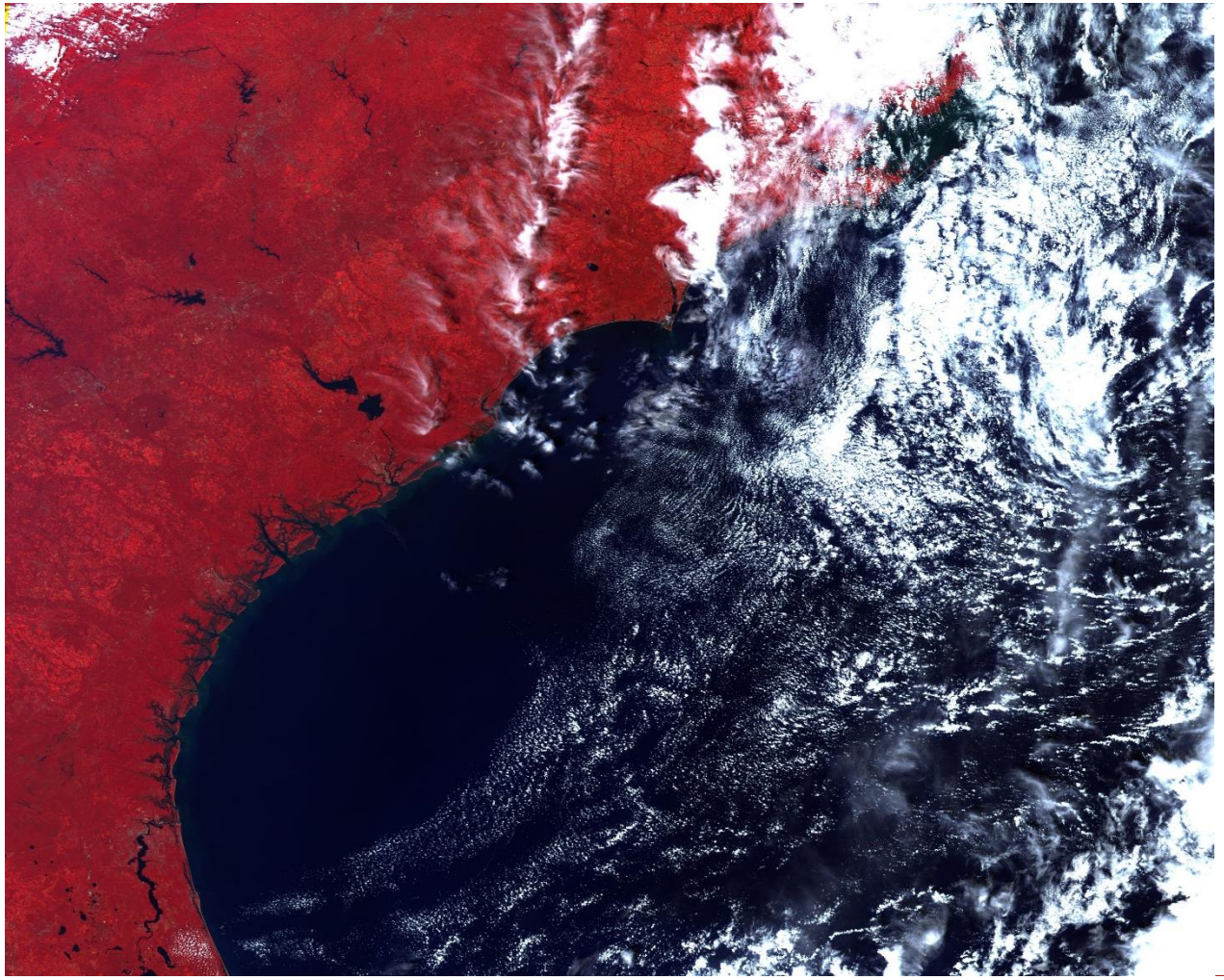

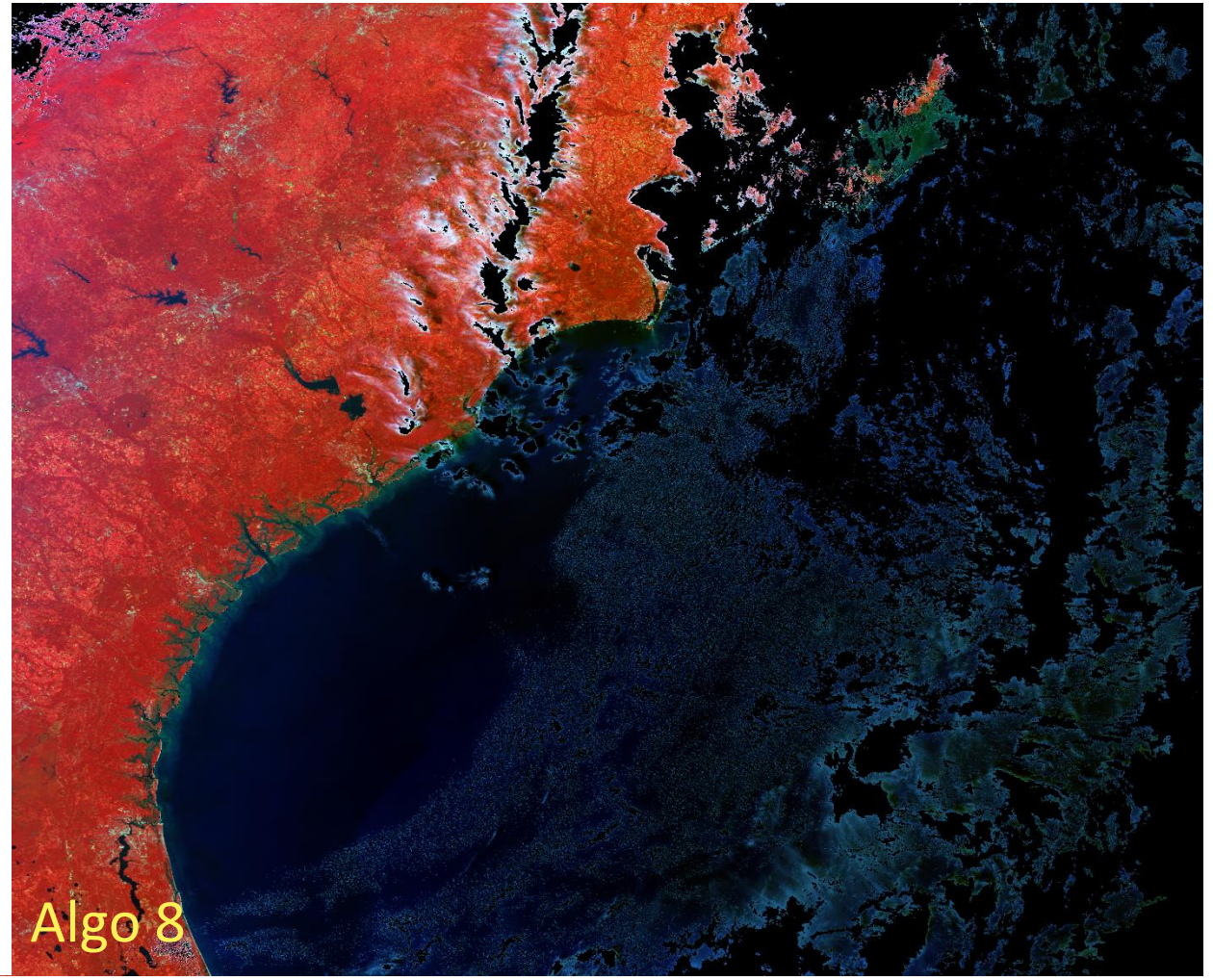

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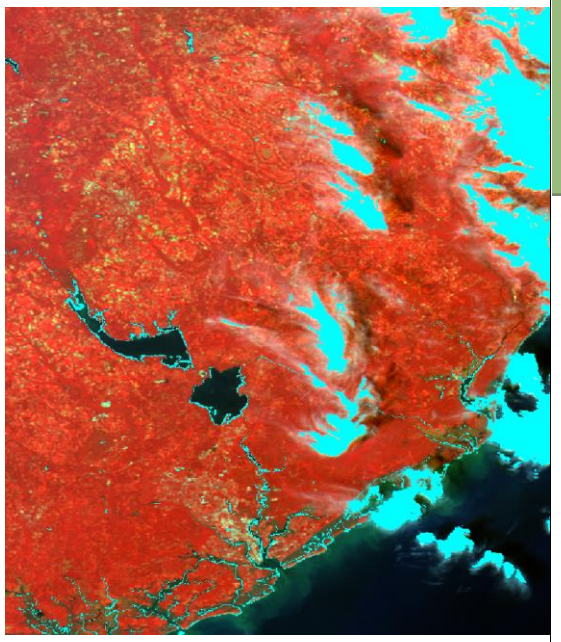

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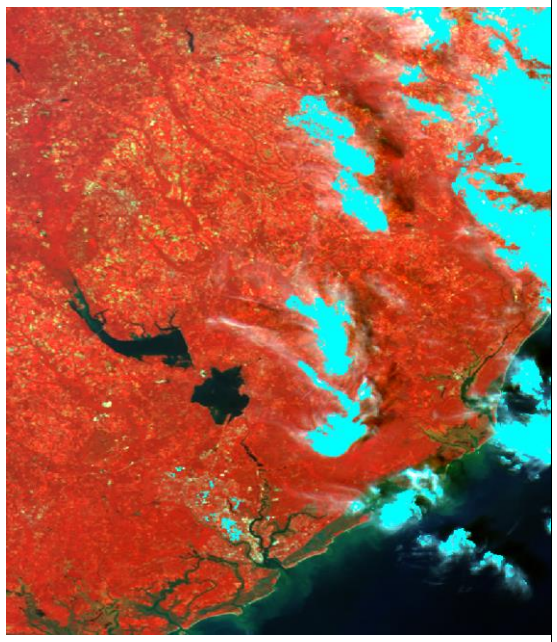

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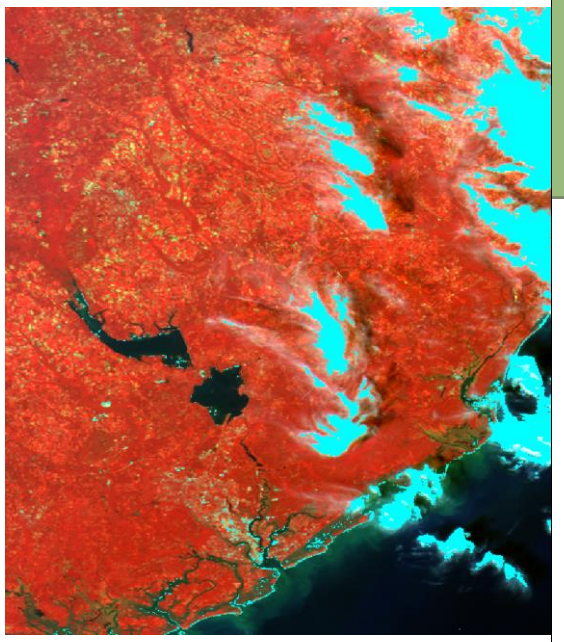

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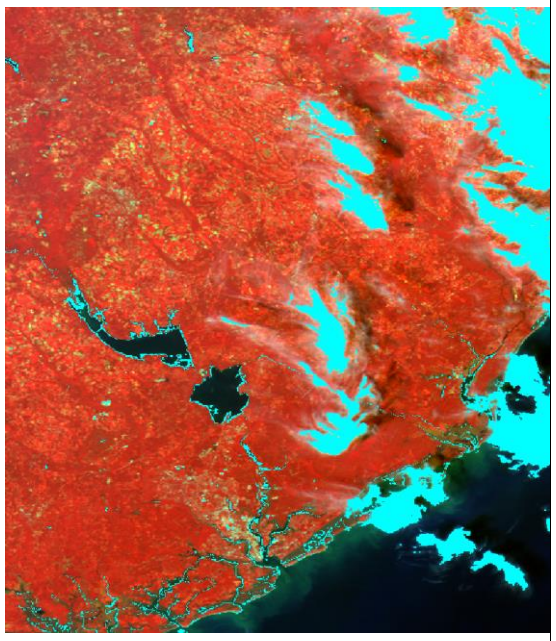

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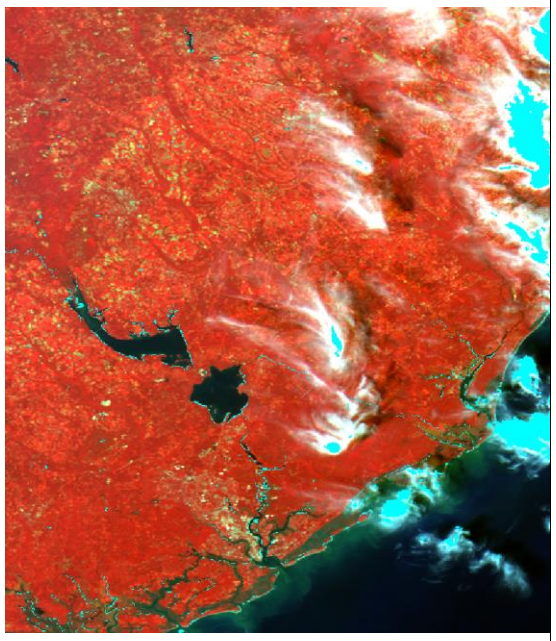

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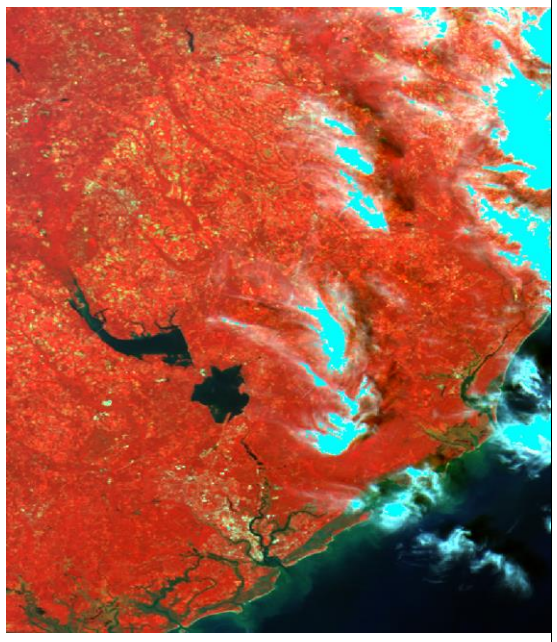

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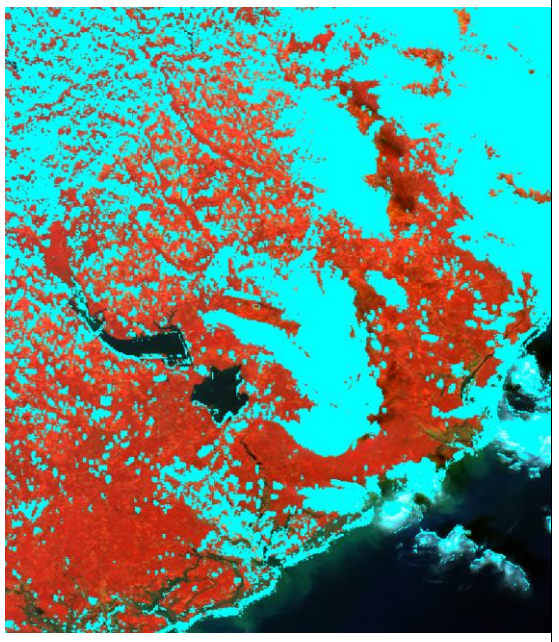

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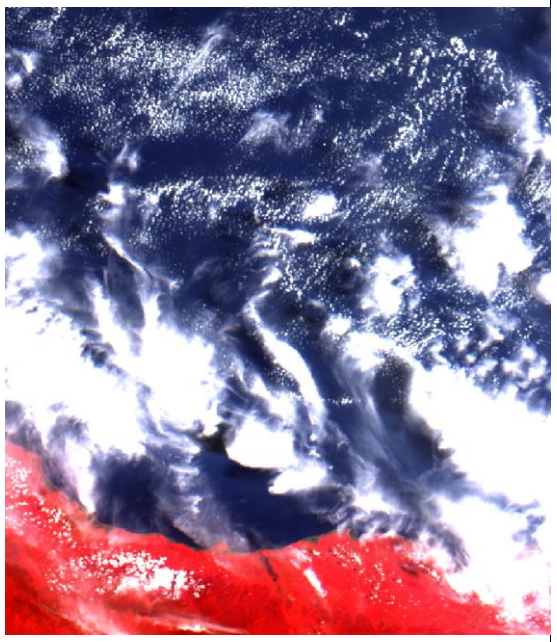

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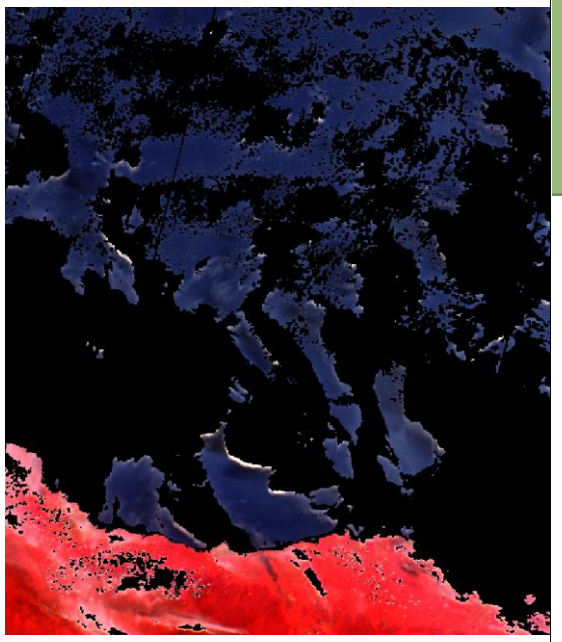

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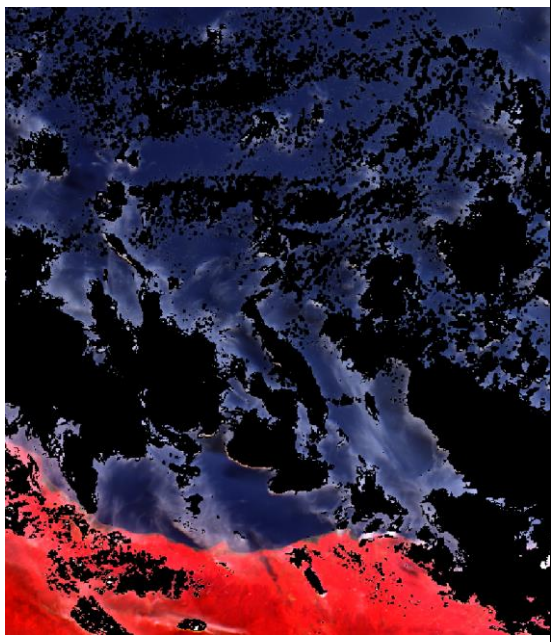

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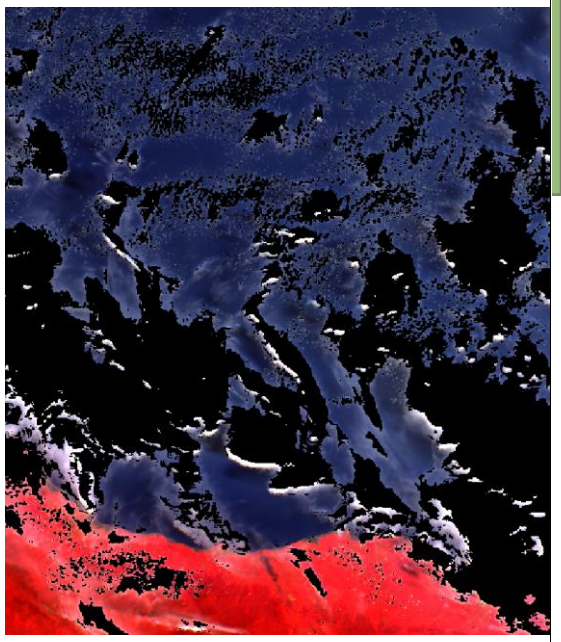

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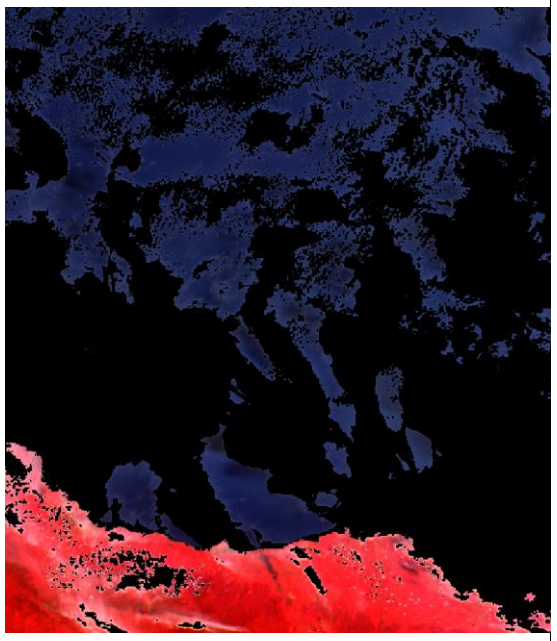

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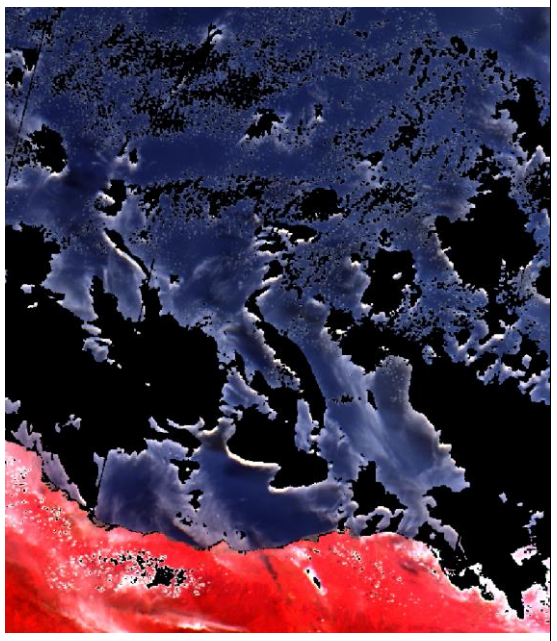

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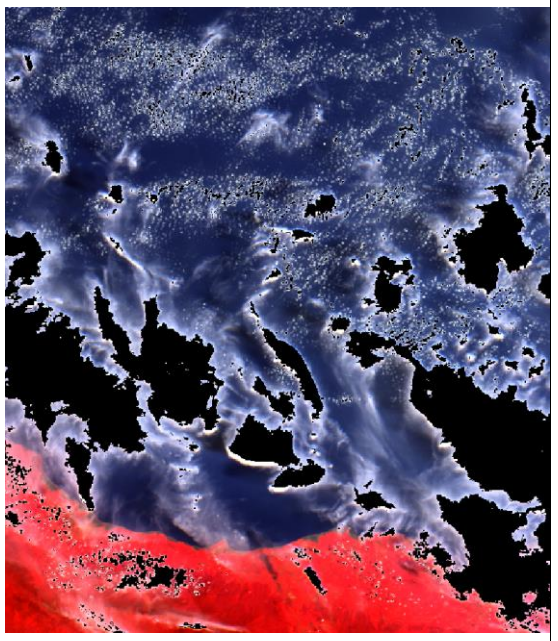

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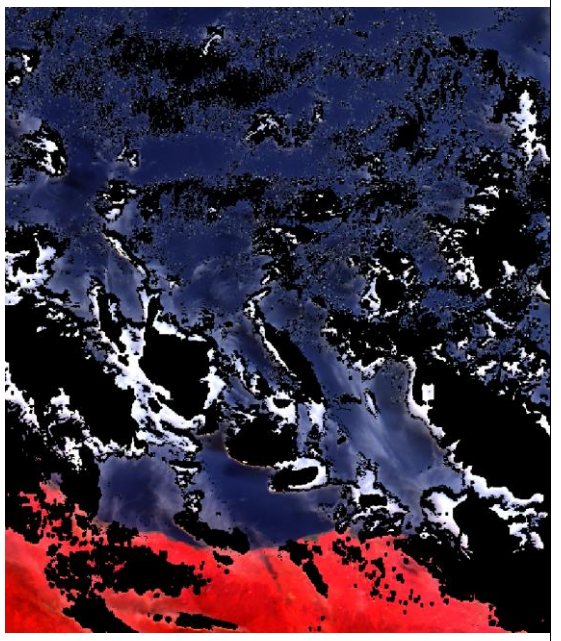

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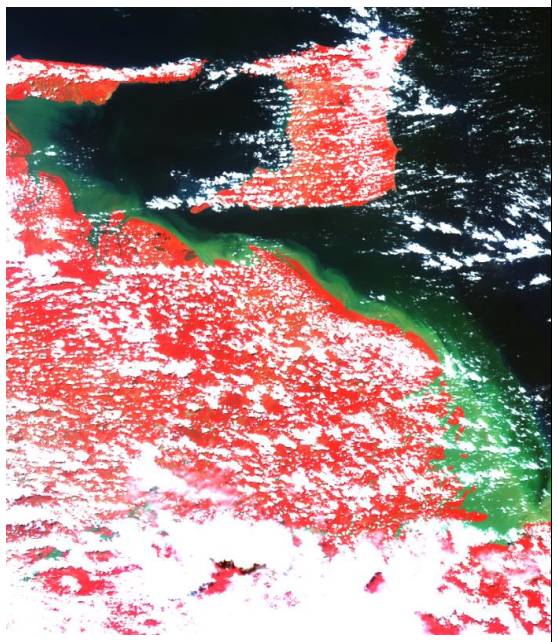

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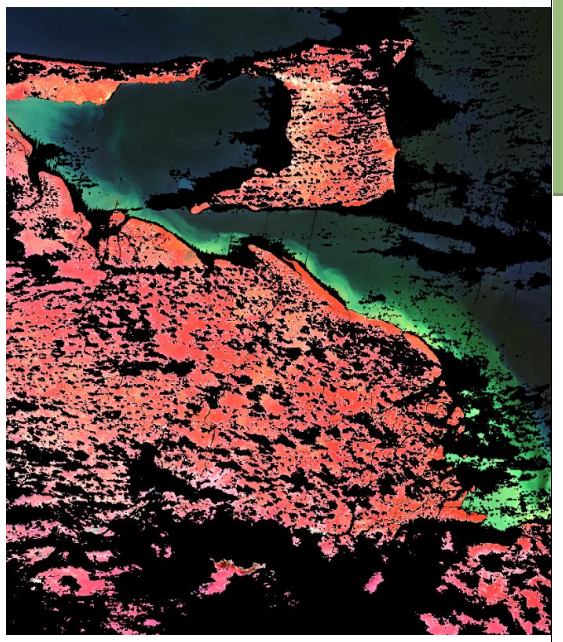

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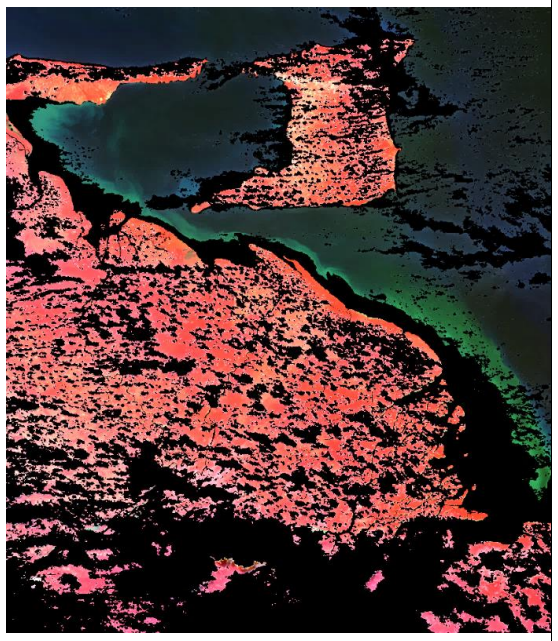

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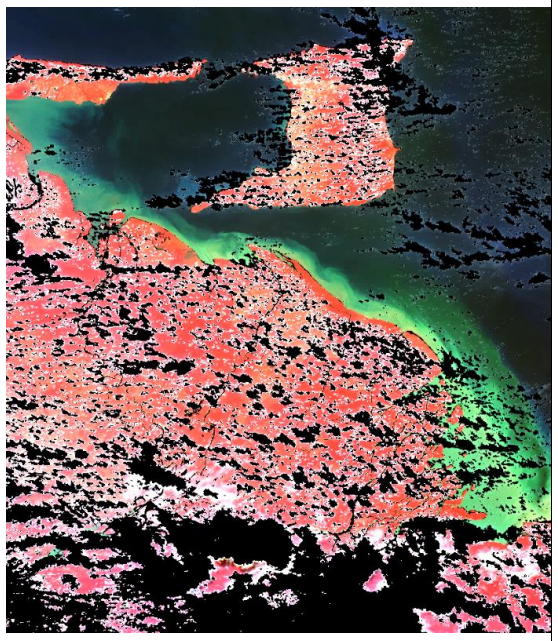

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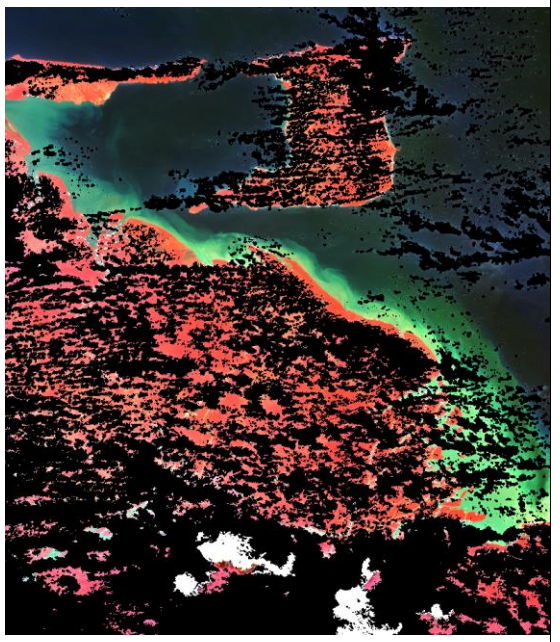

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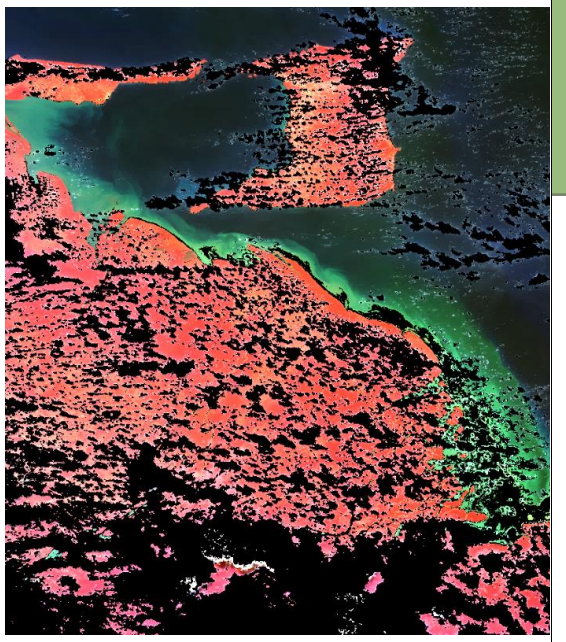

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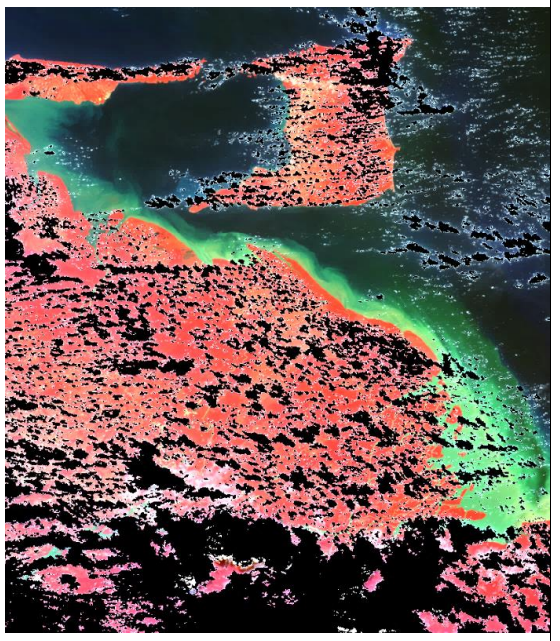

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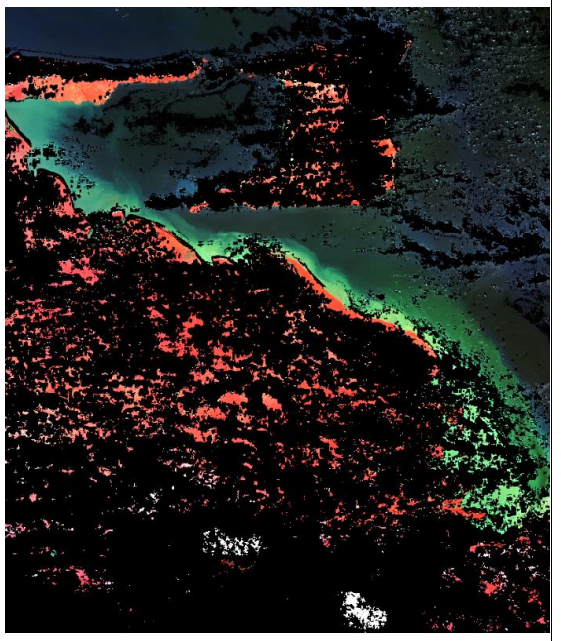
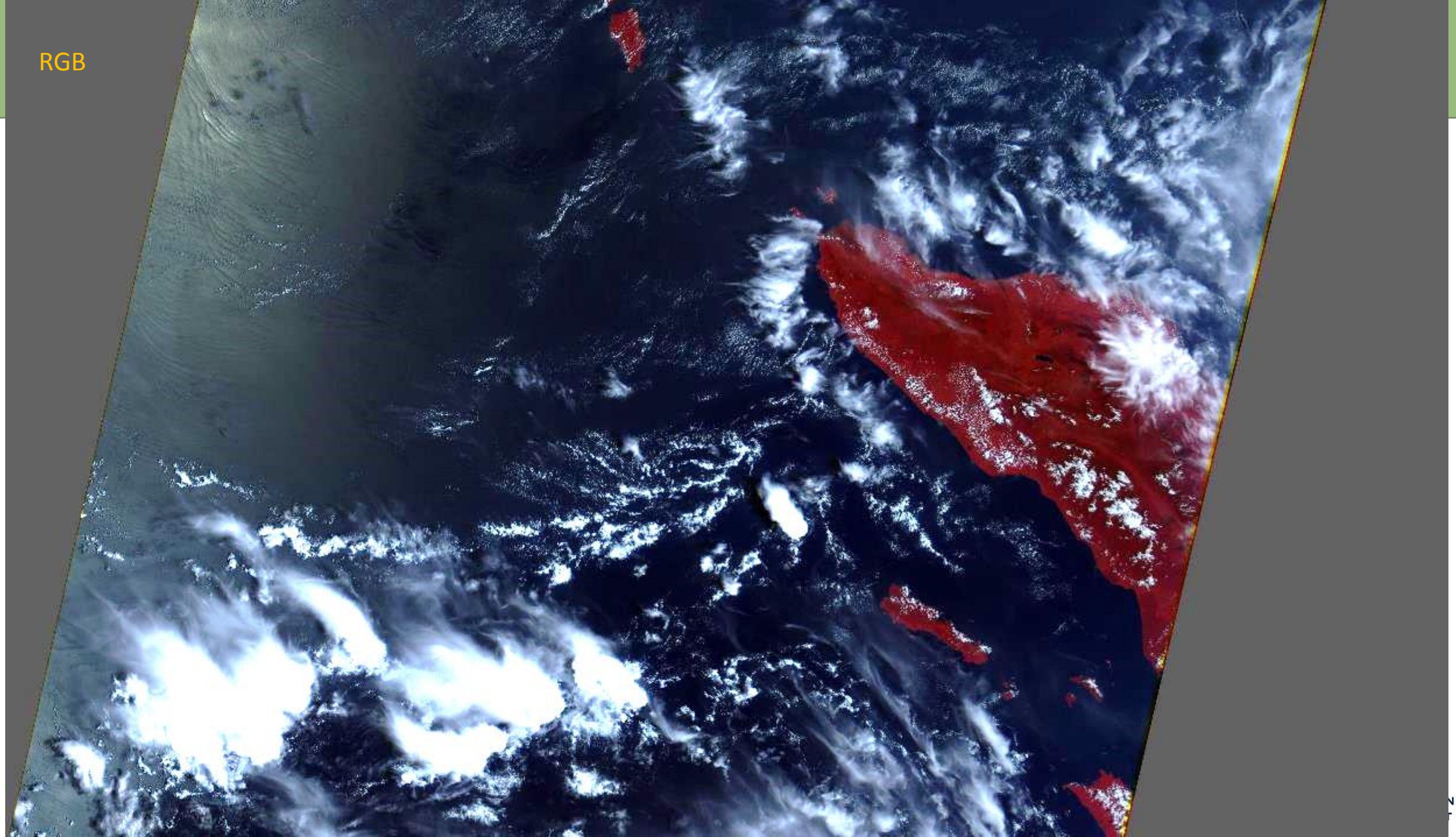


Algo 7 CLOUD

RGB



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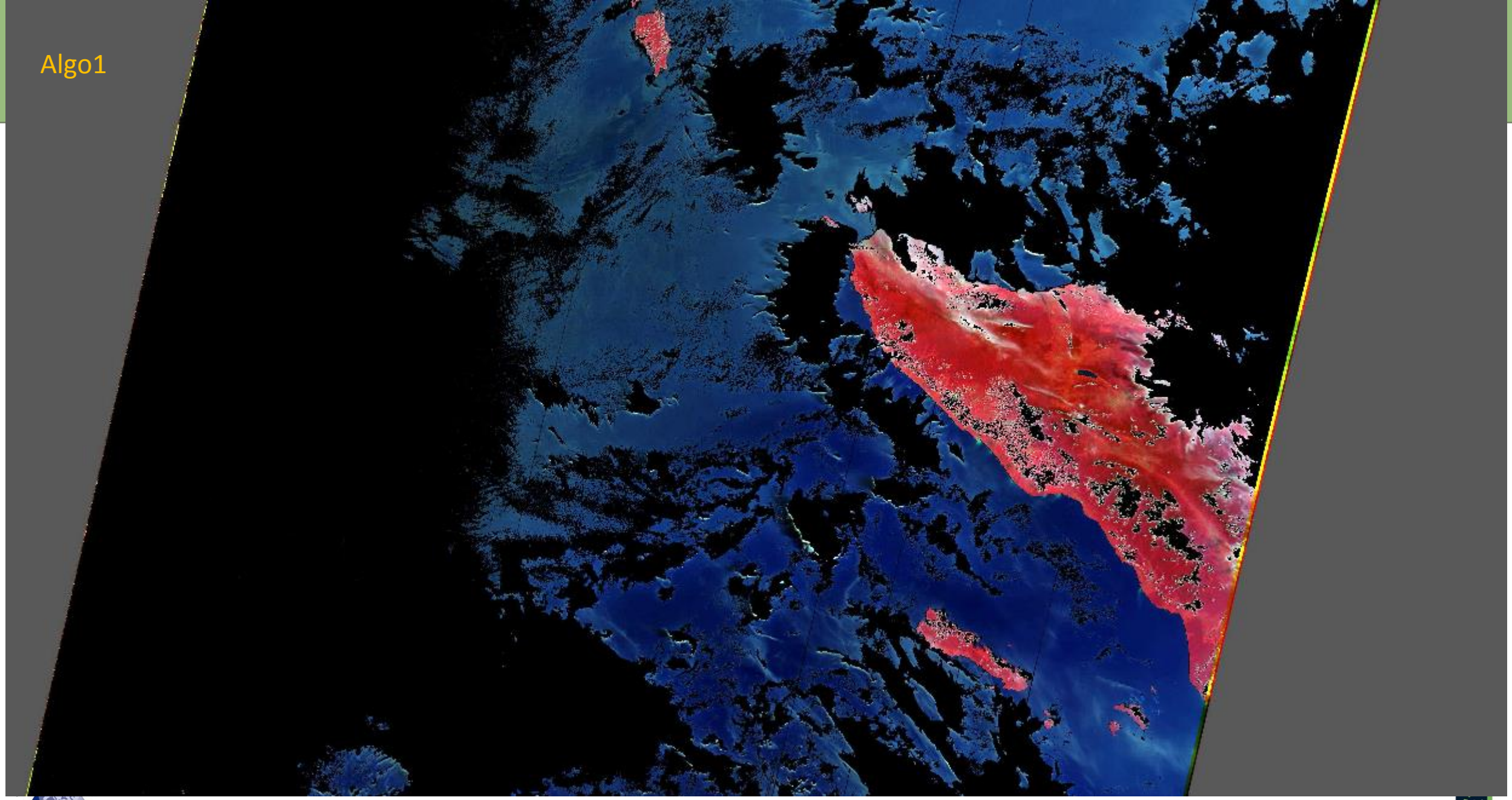

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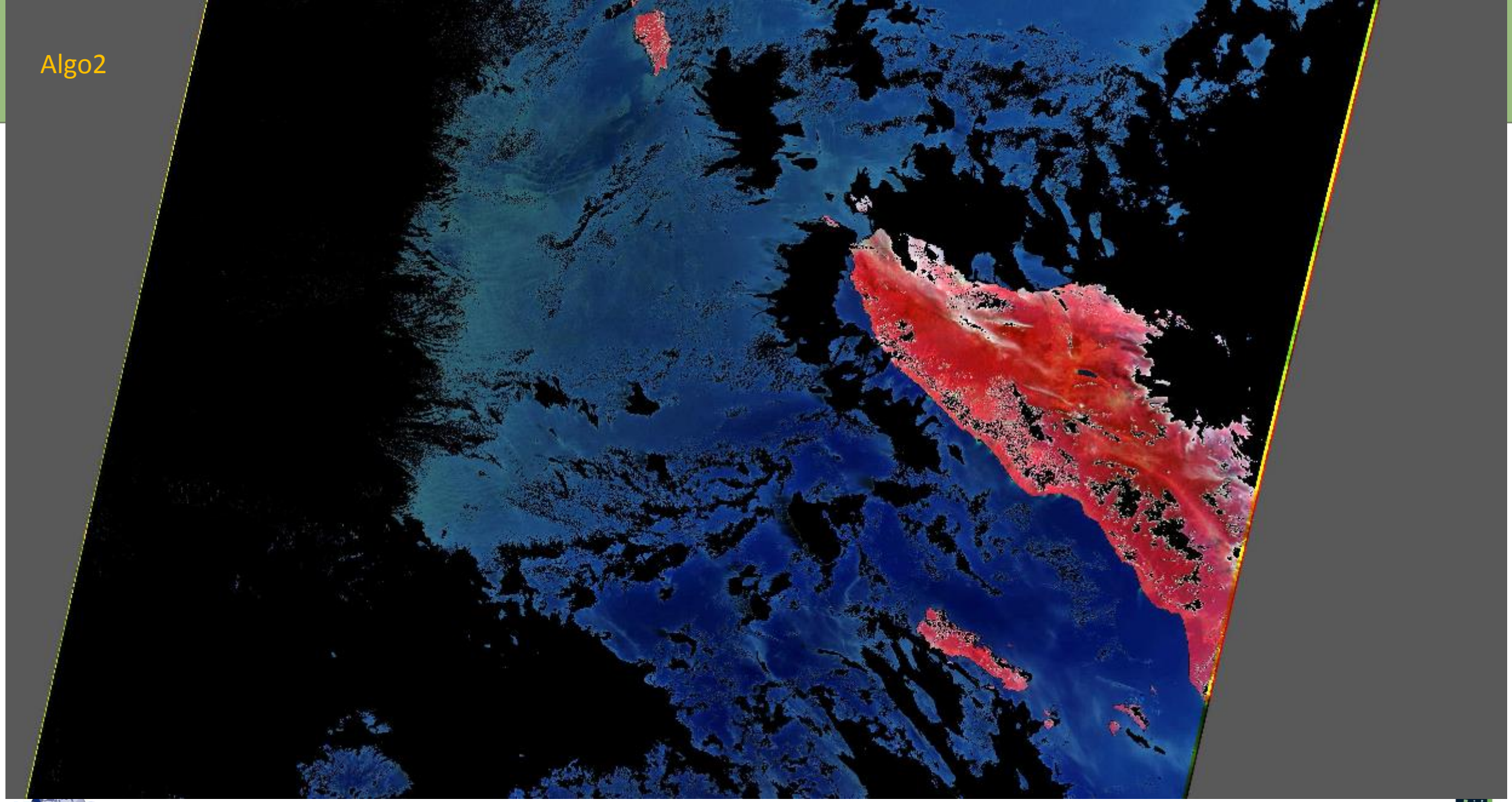

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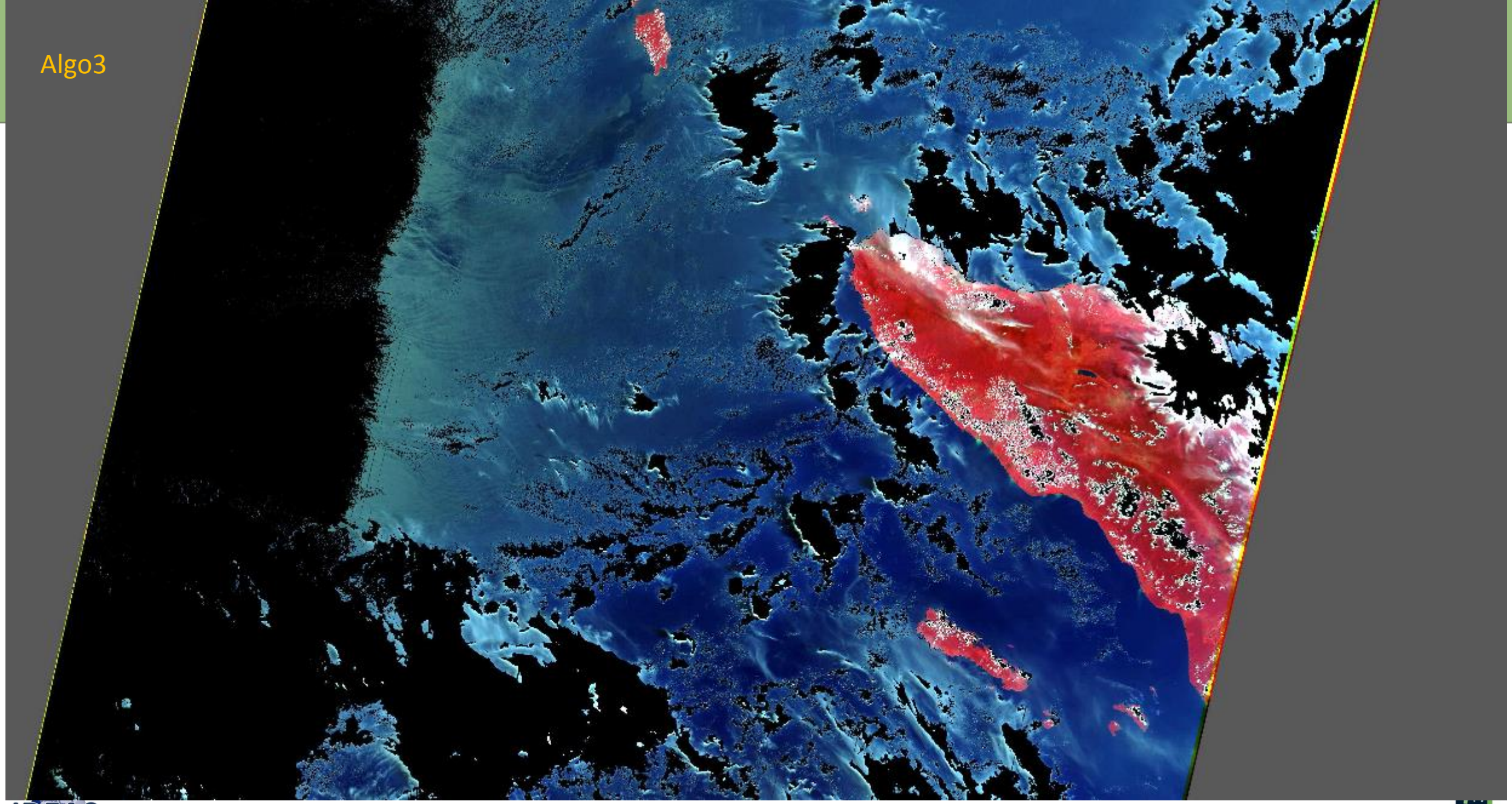

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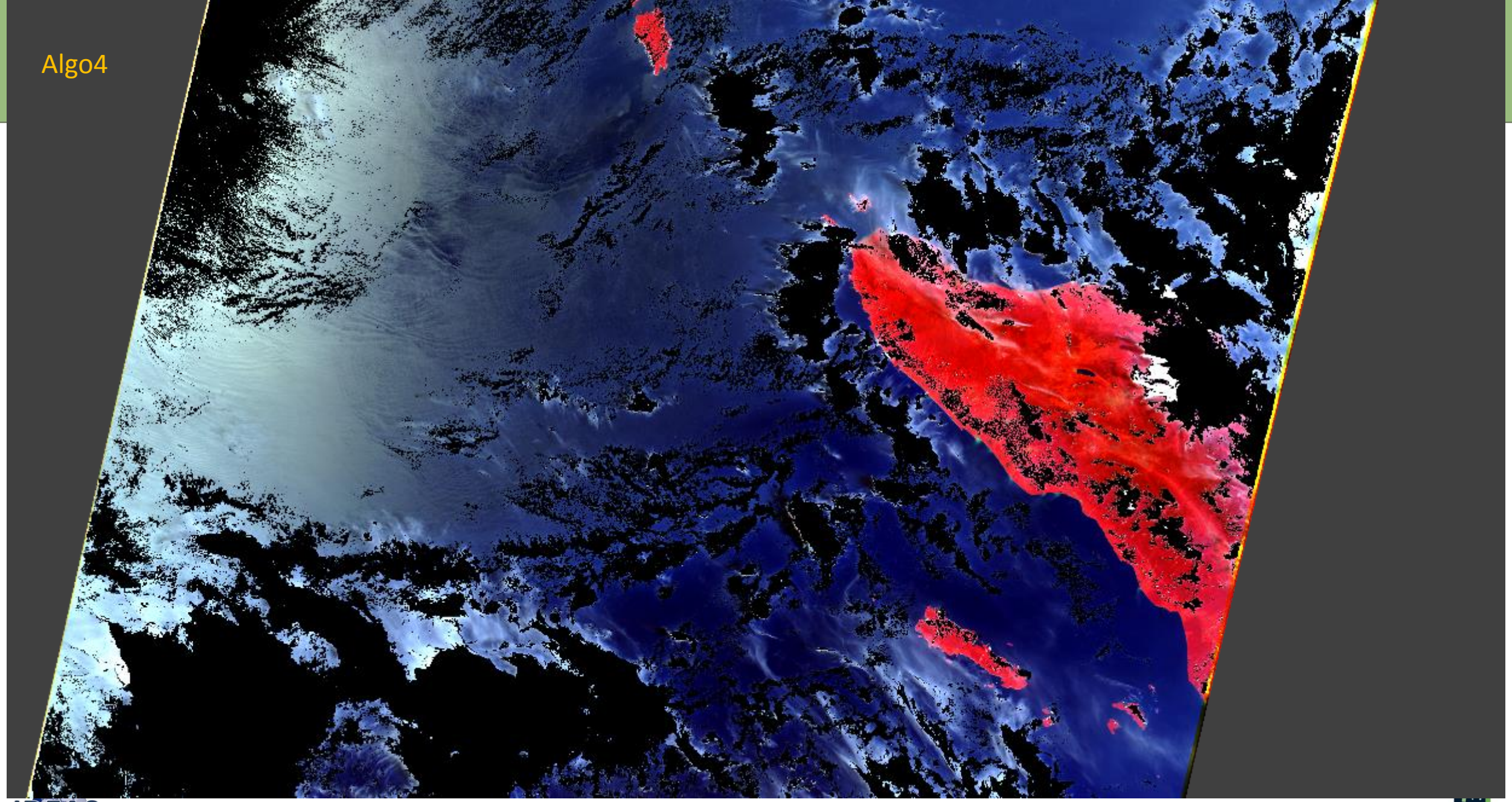

PROBAV_L2A_20140321_044547_1_333M_V001

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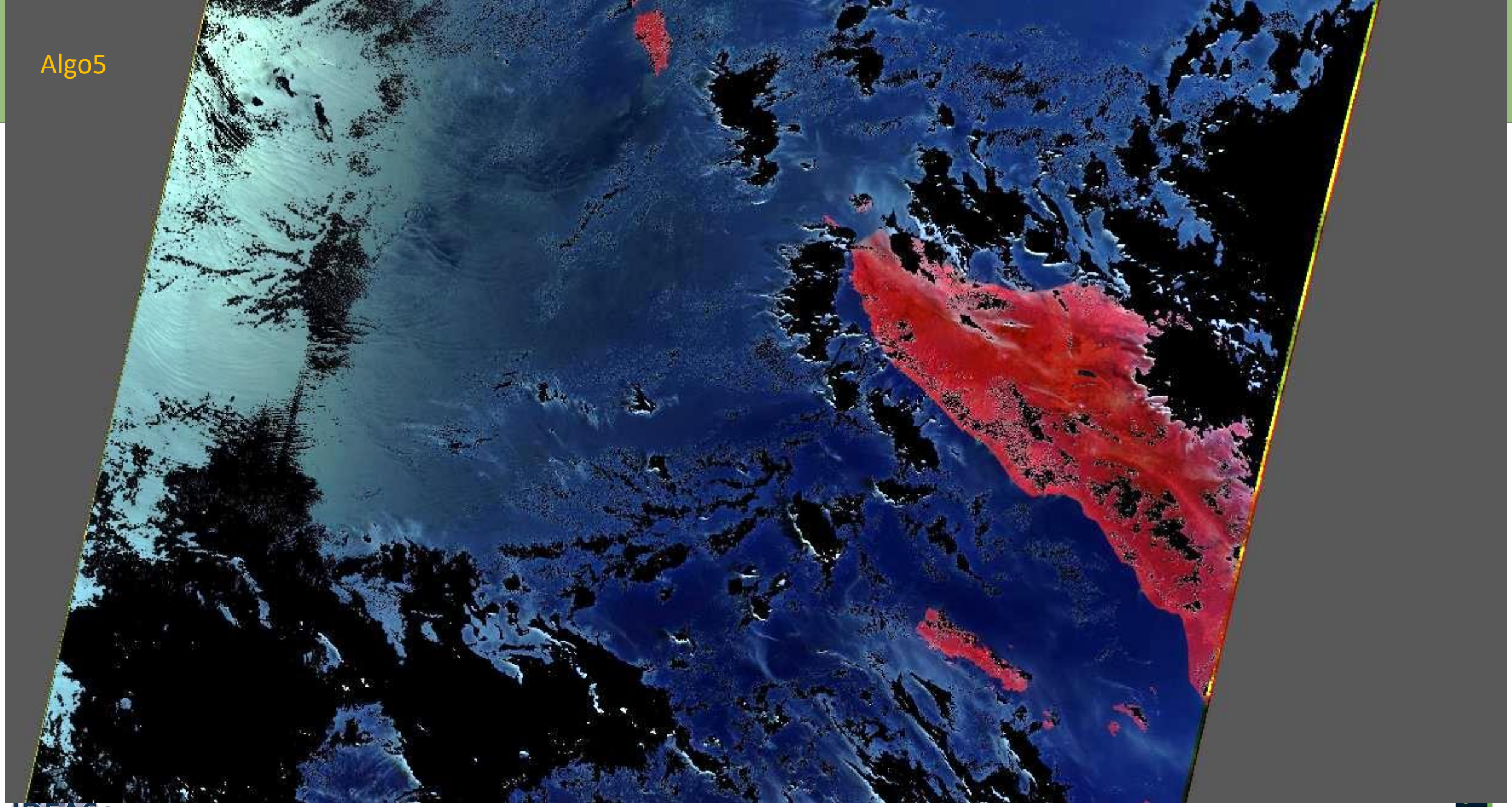

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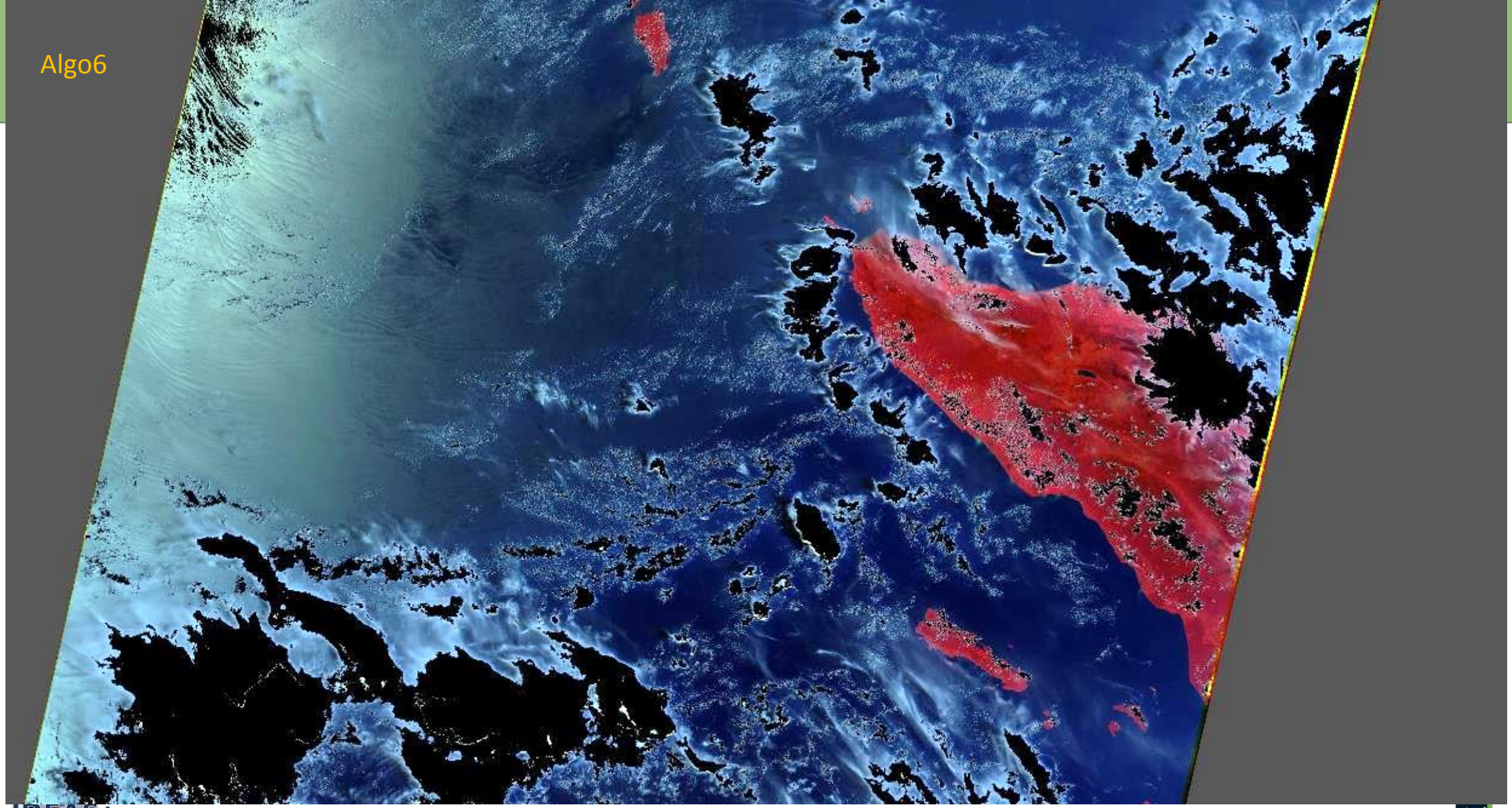
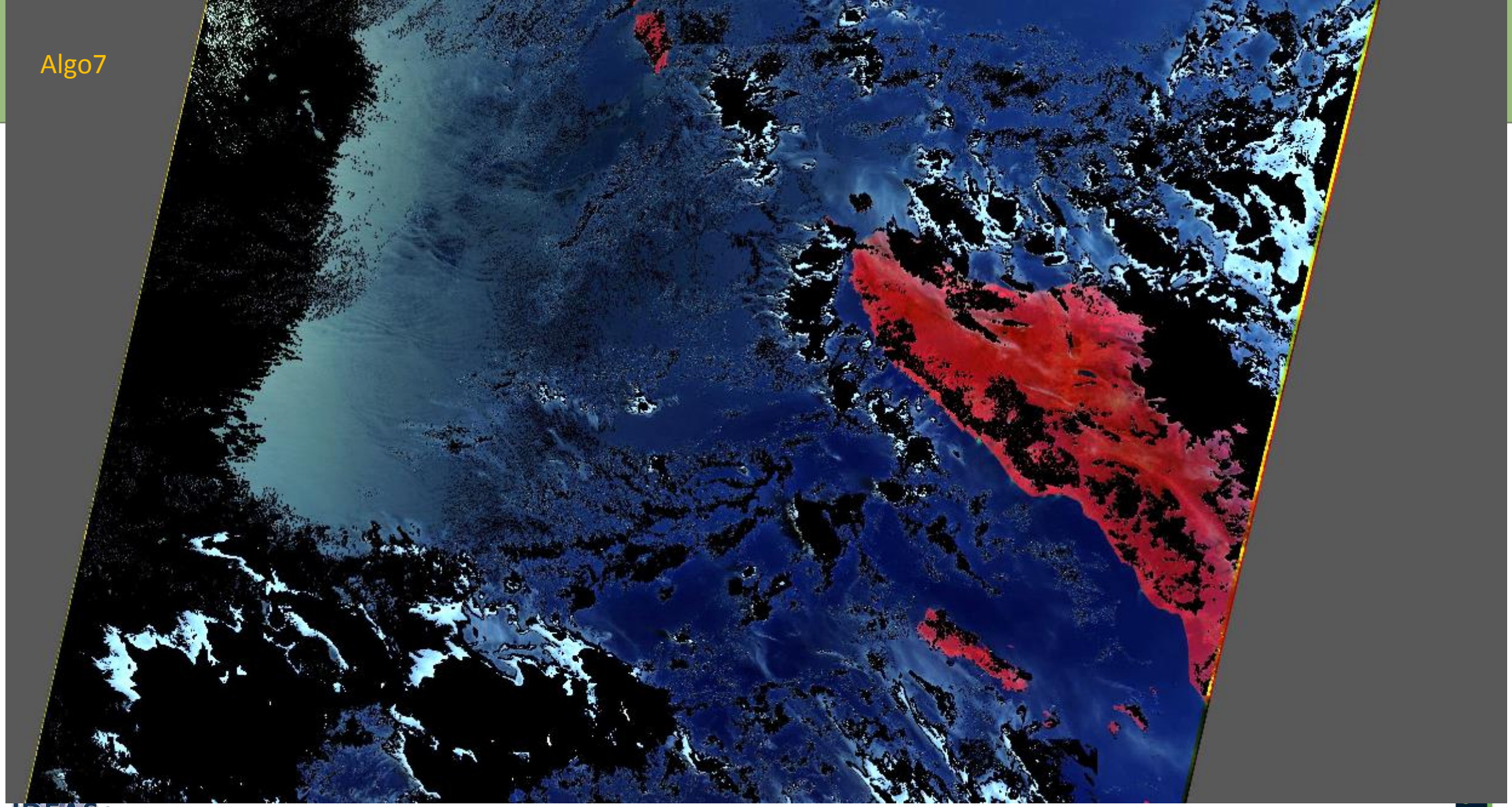


IDEAS+

Brockmann Consult

Algo7



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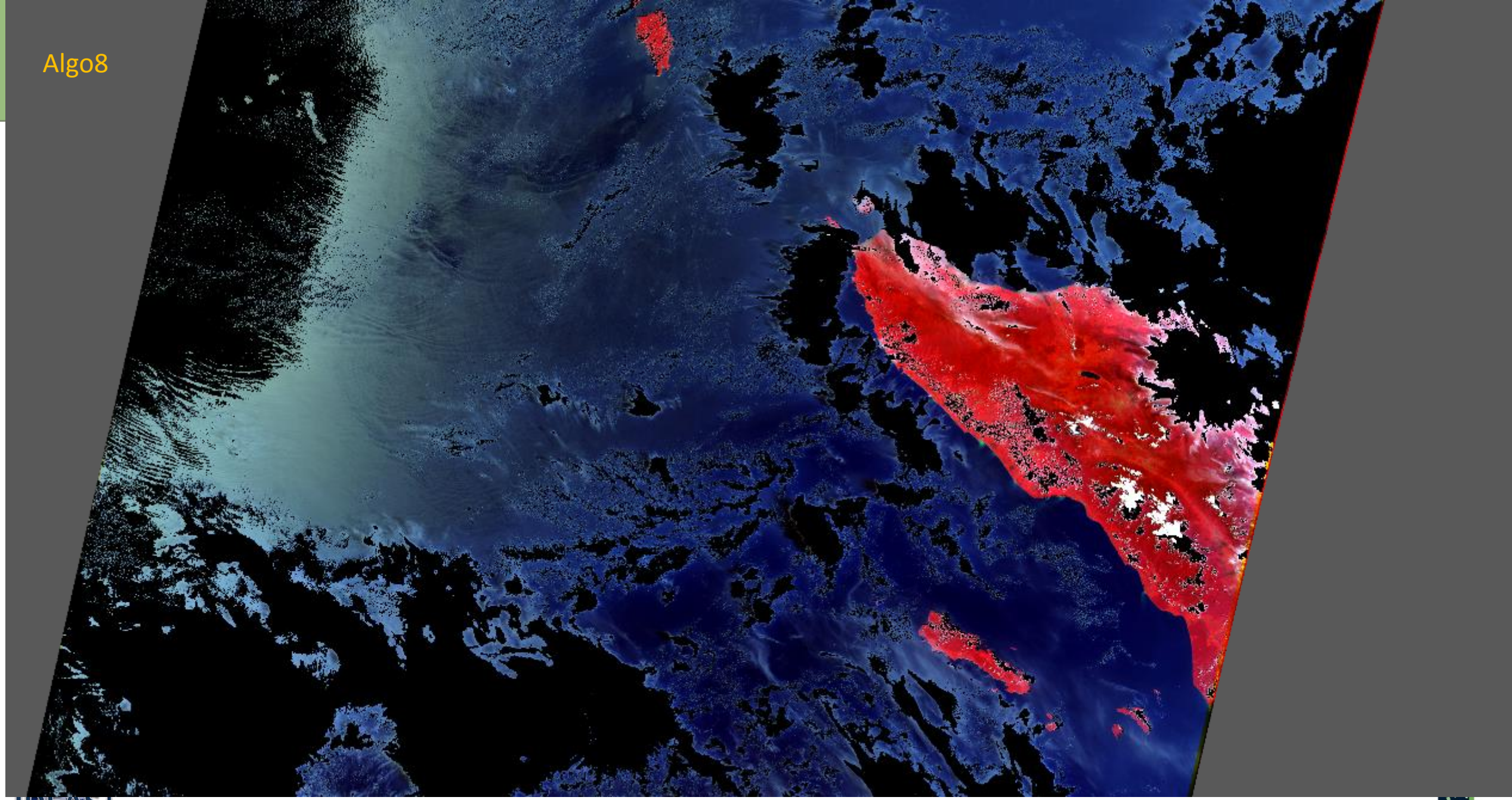

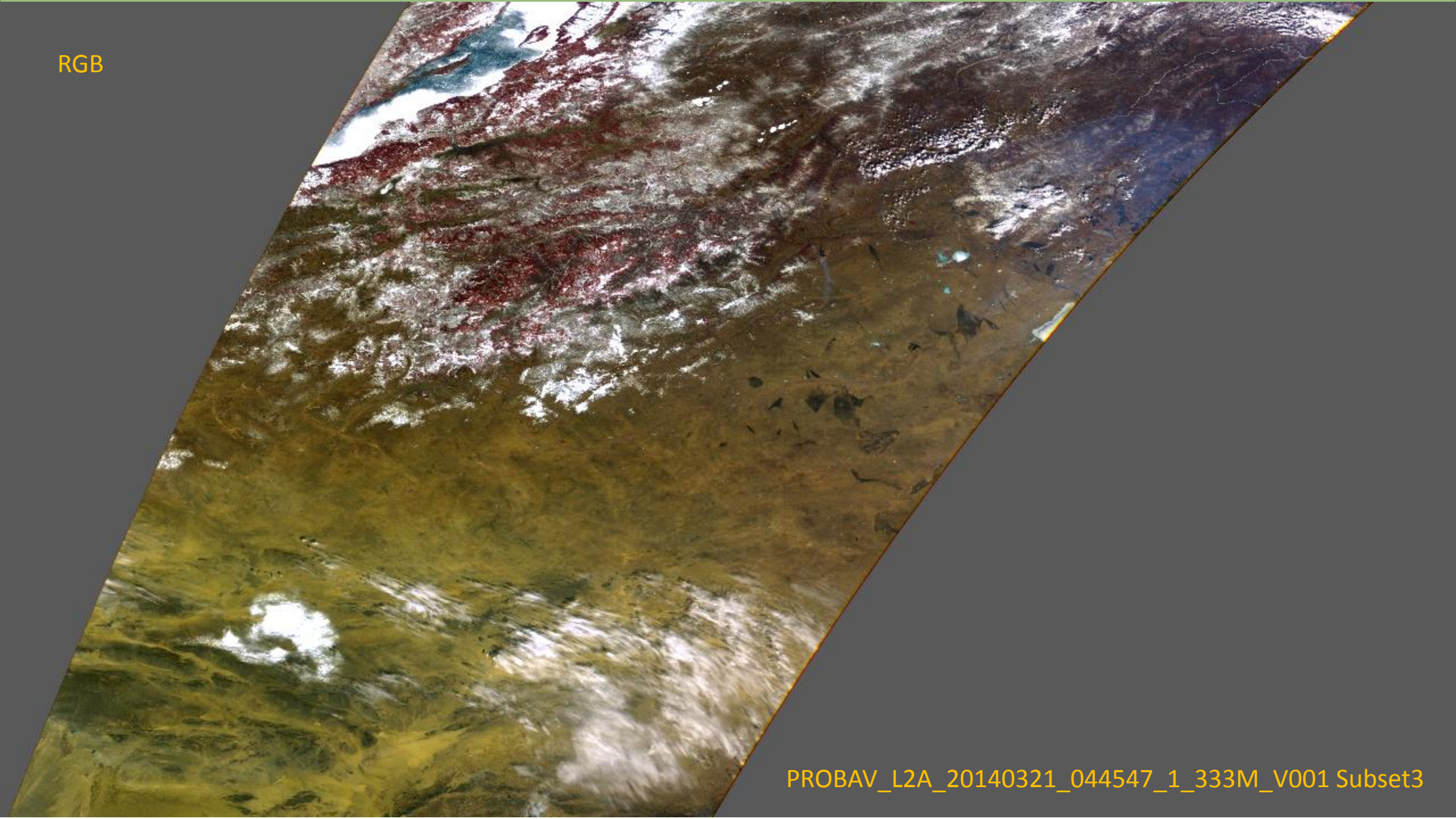
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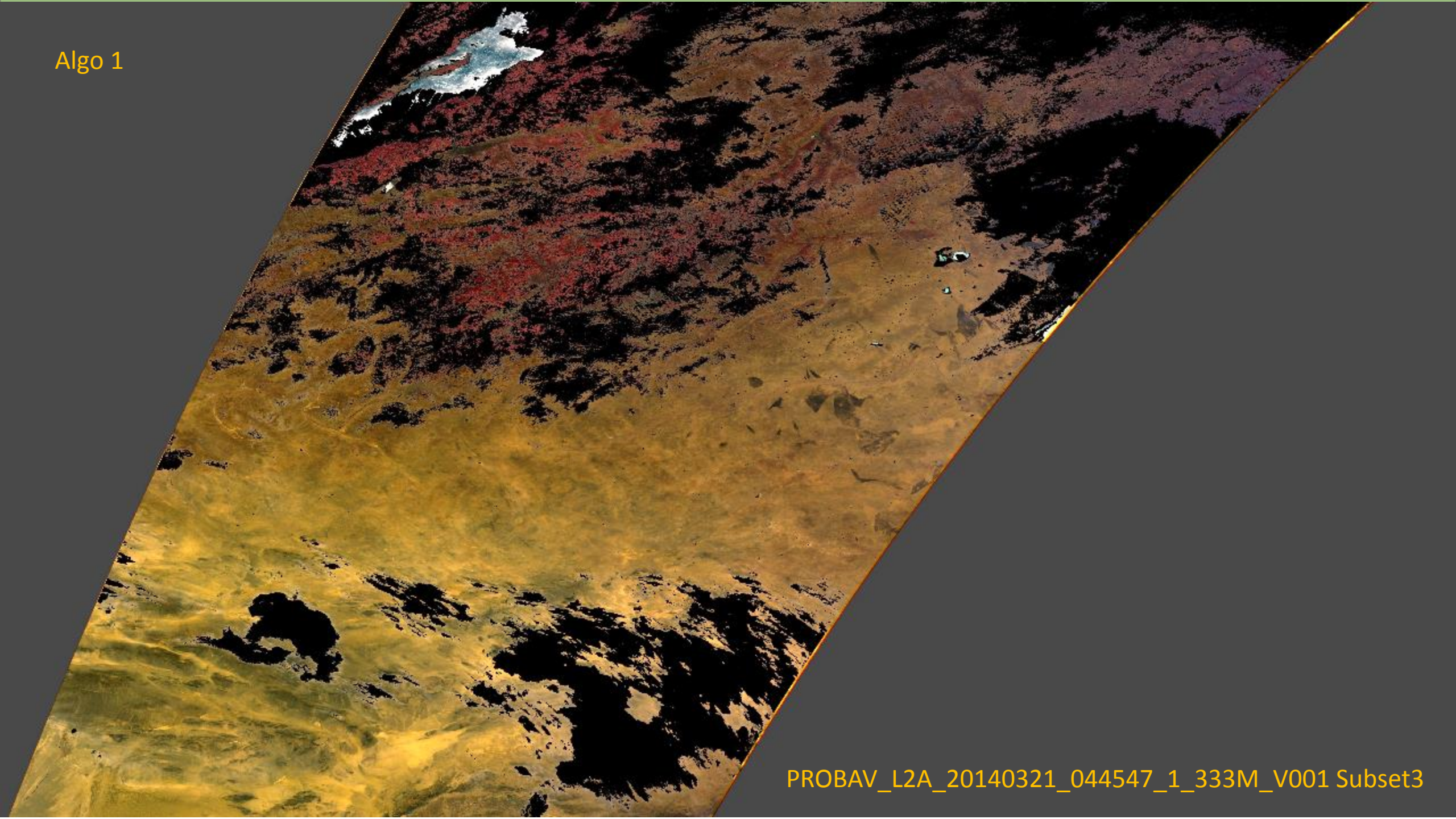

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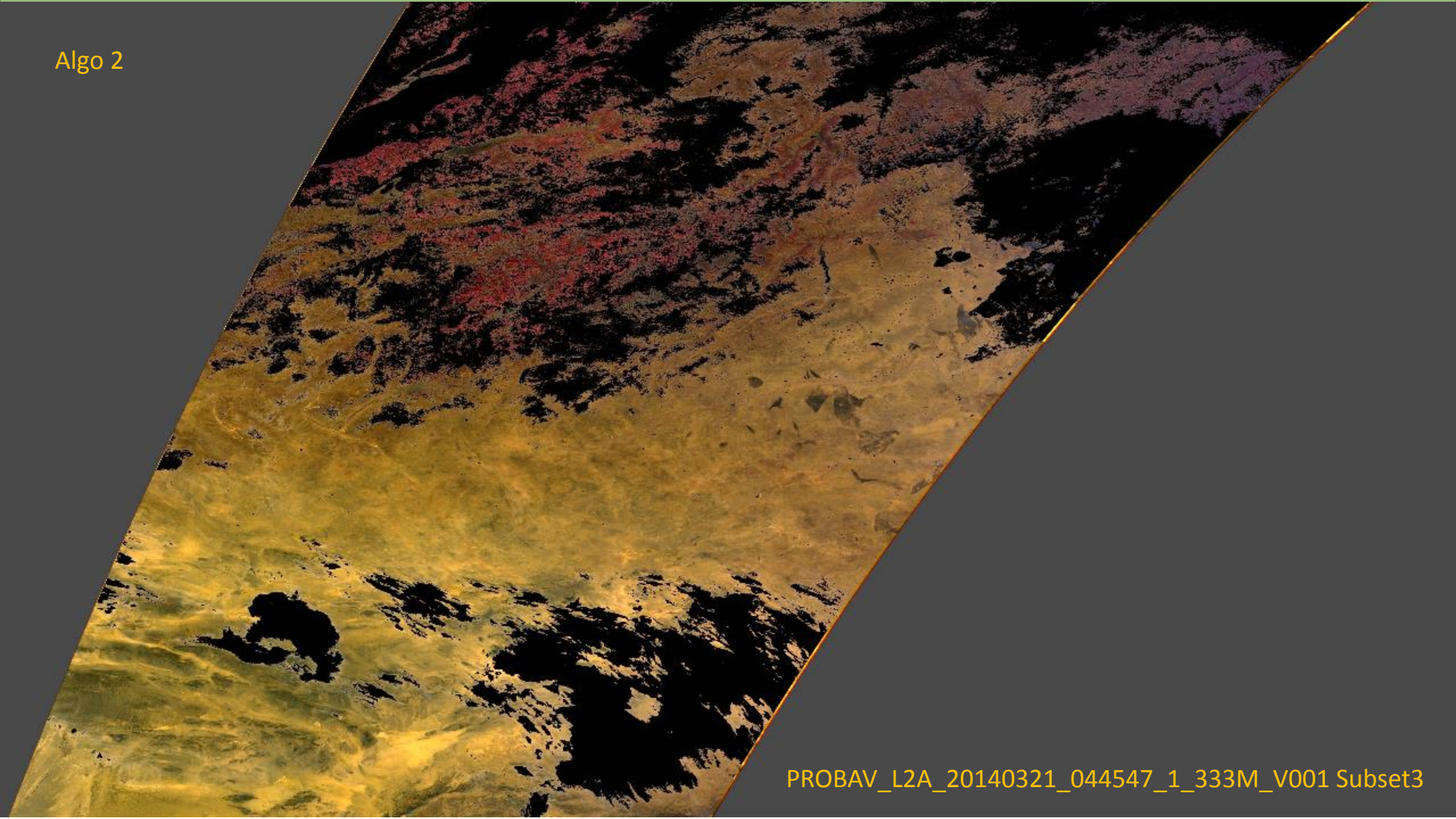
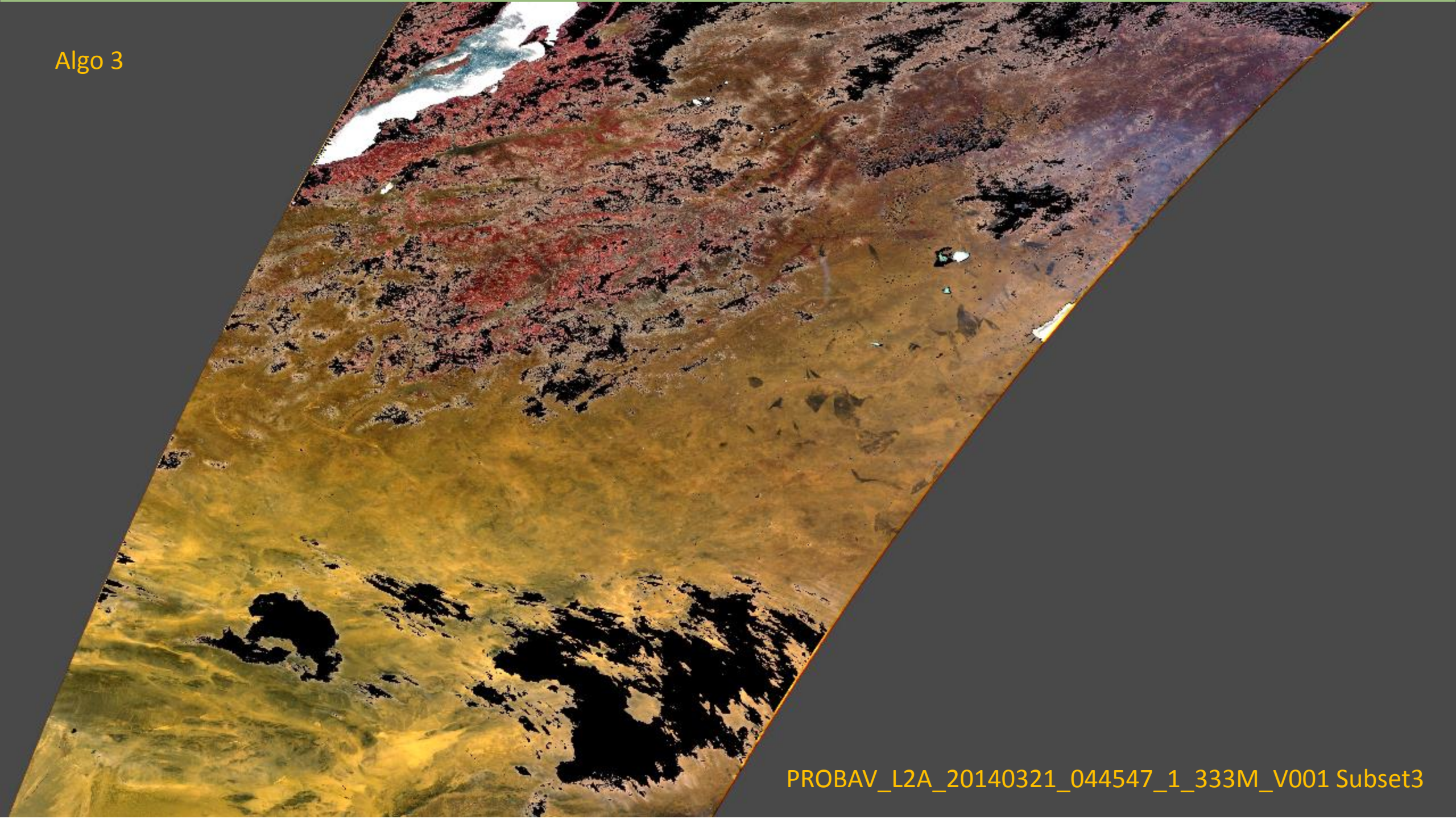


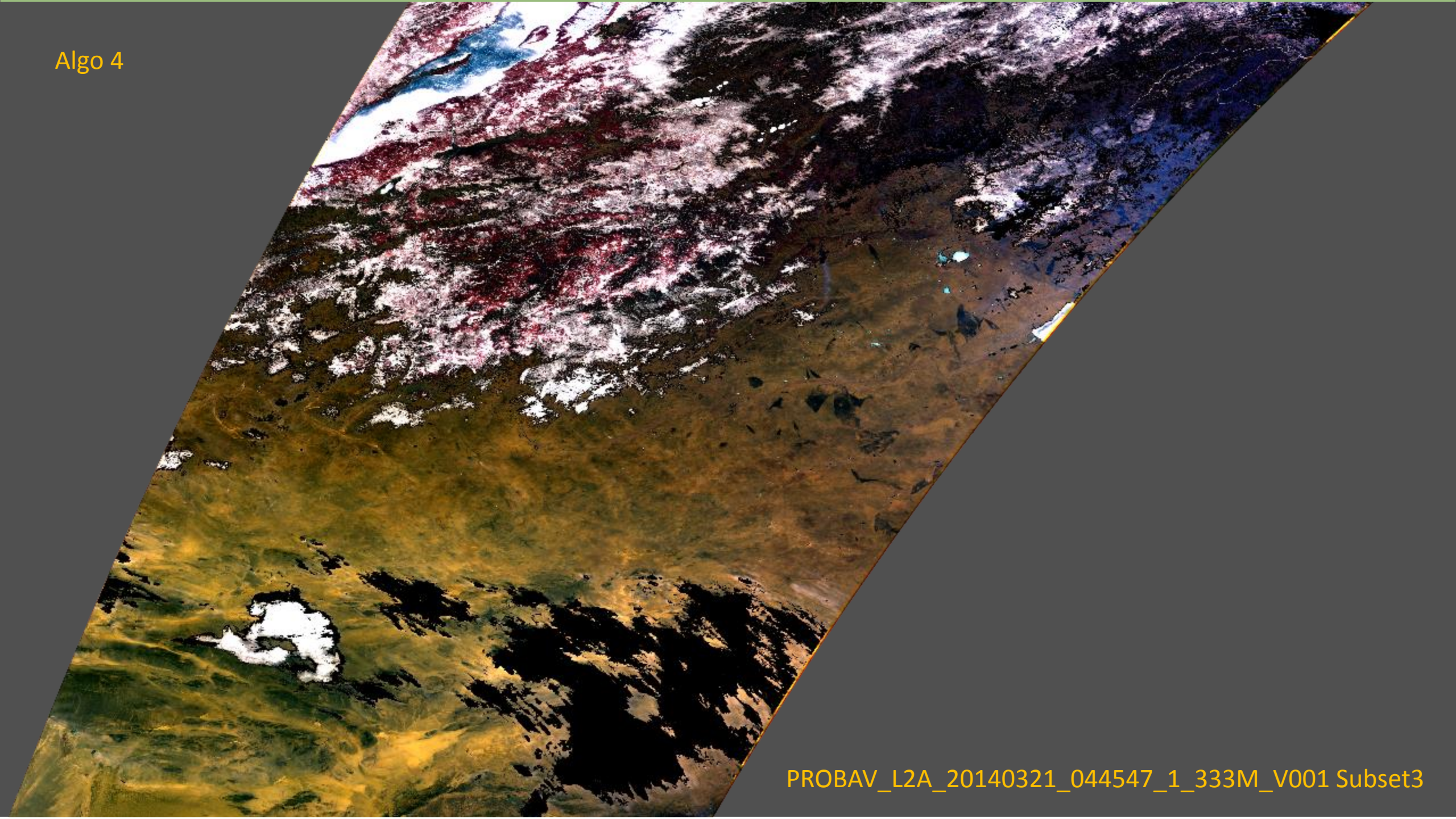
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo 3



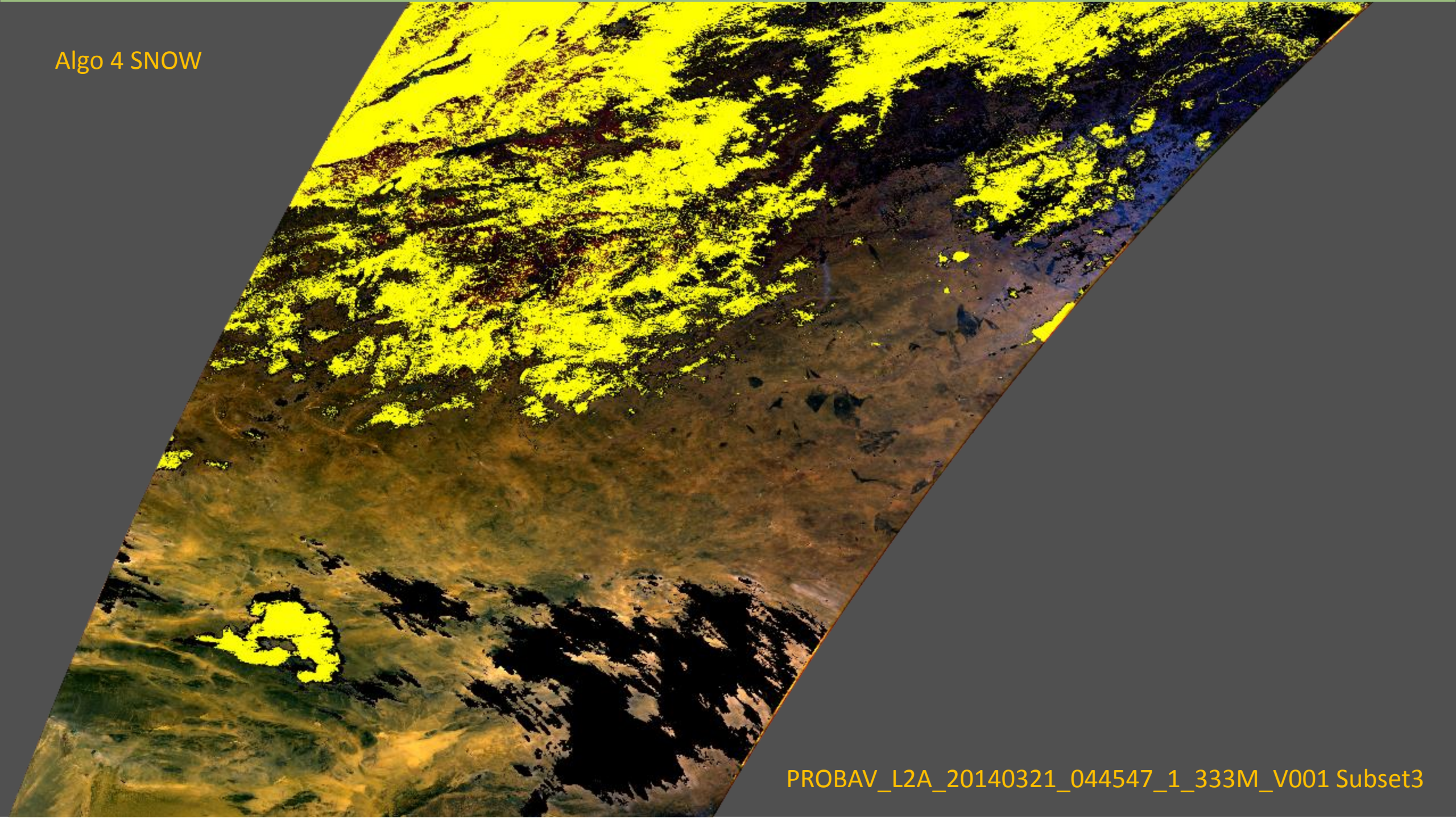
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo 4



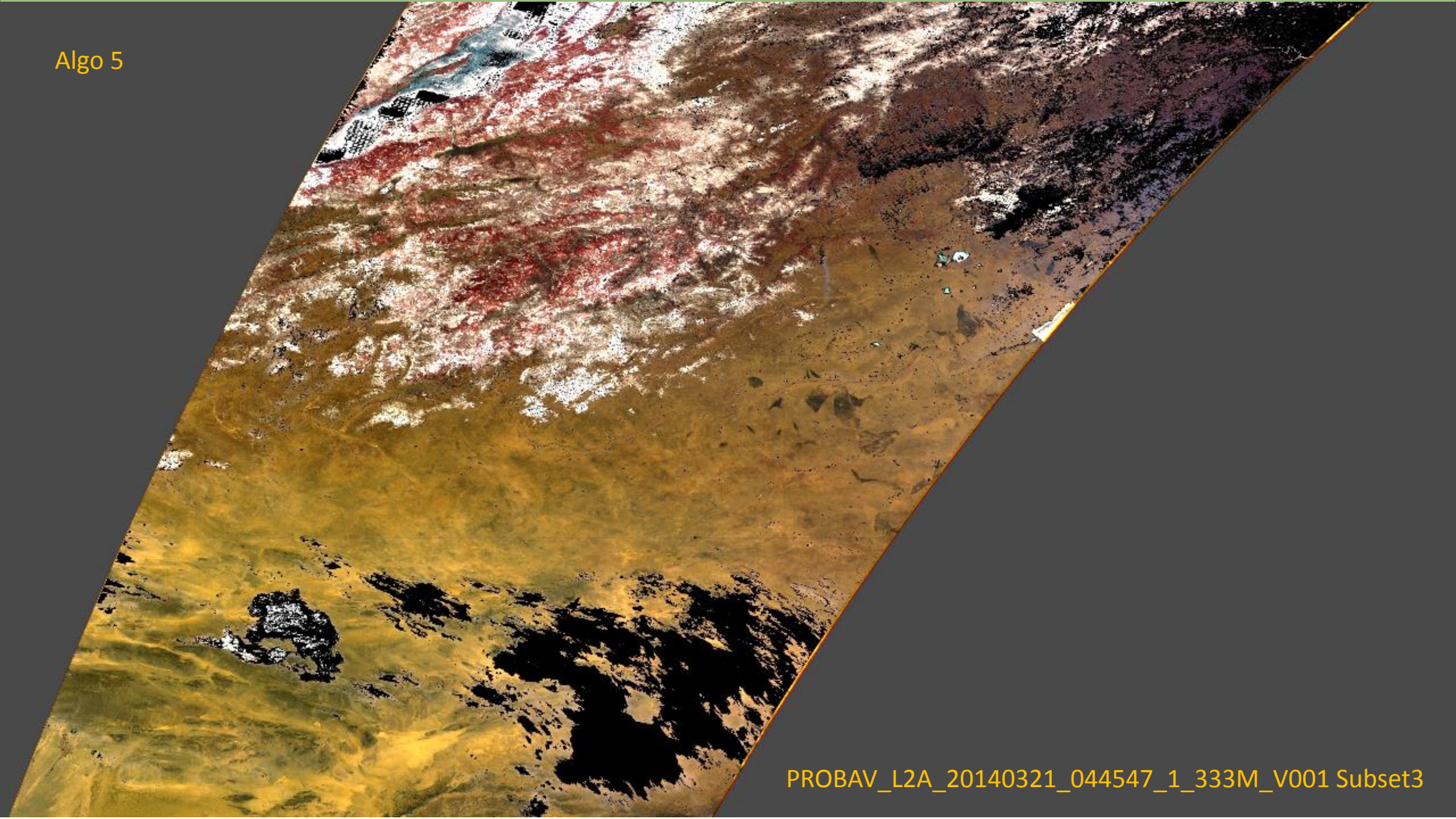
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo 4 SNOW



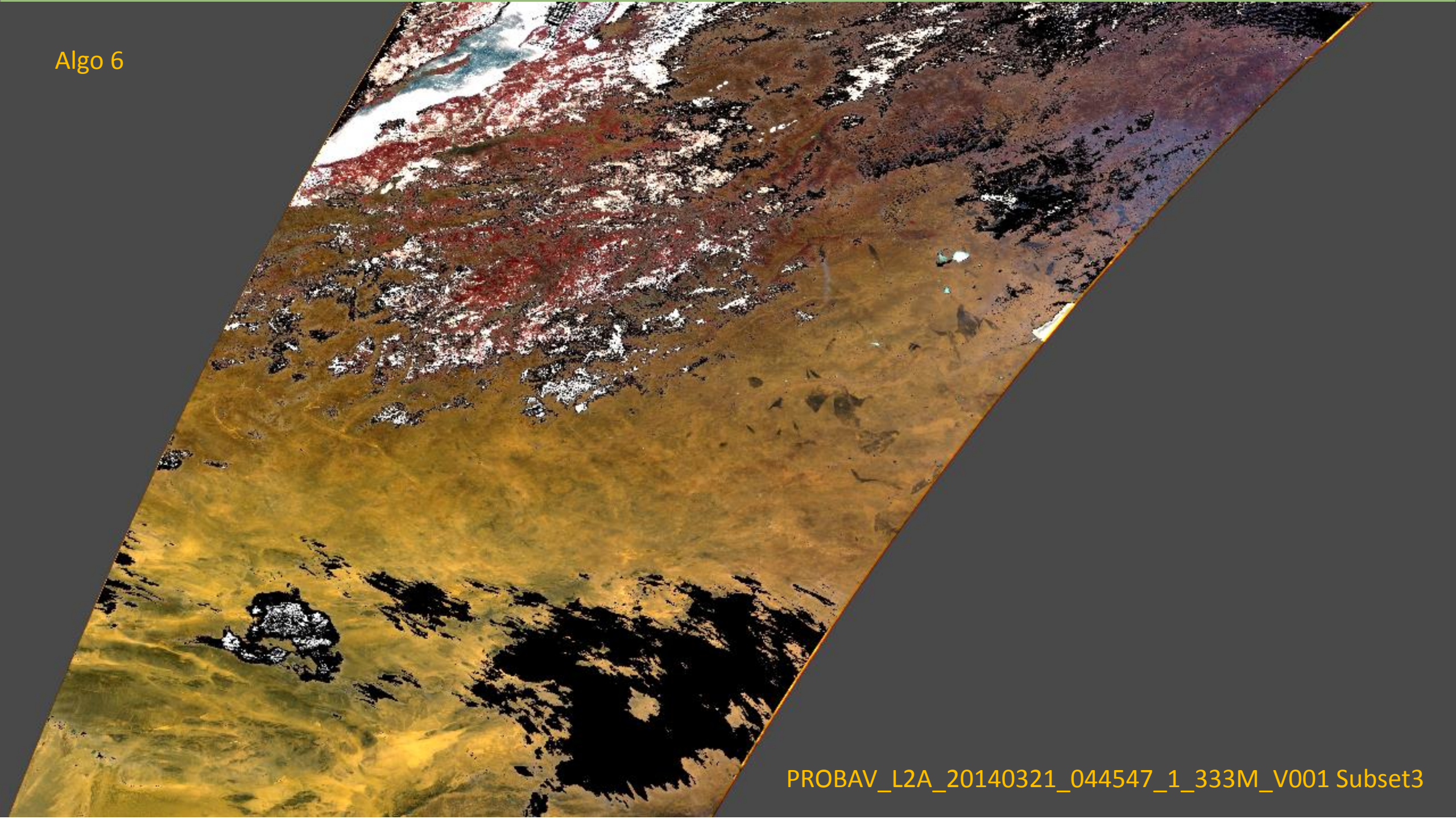
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo 5

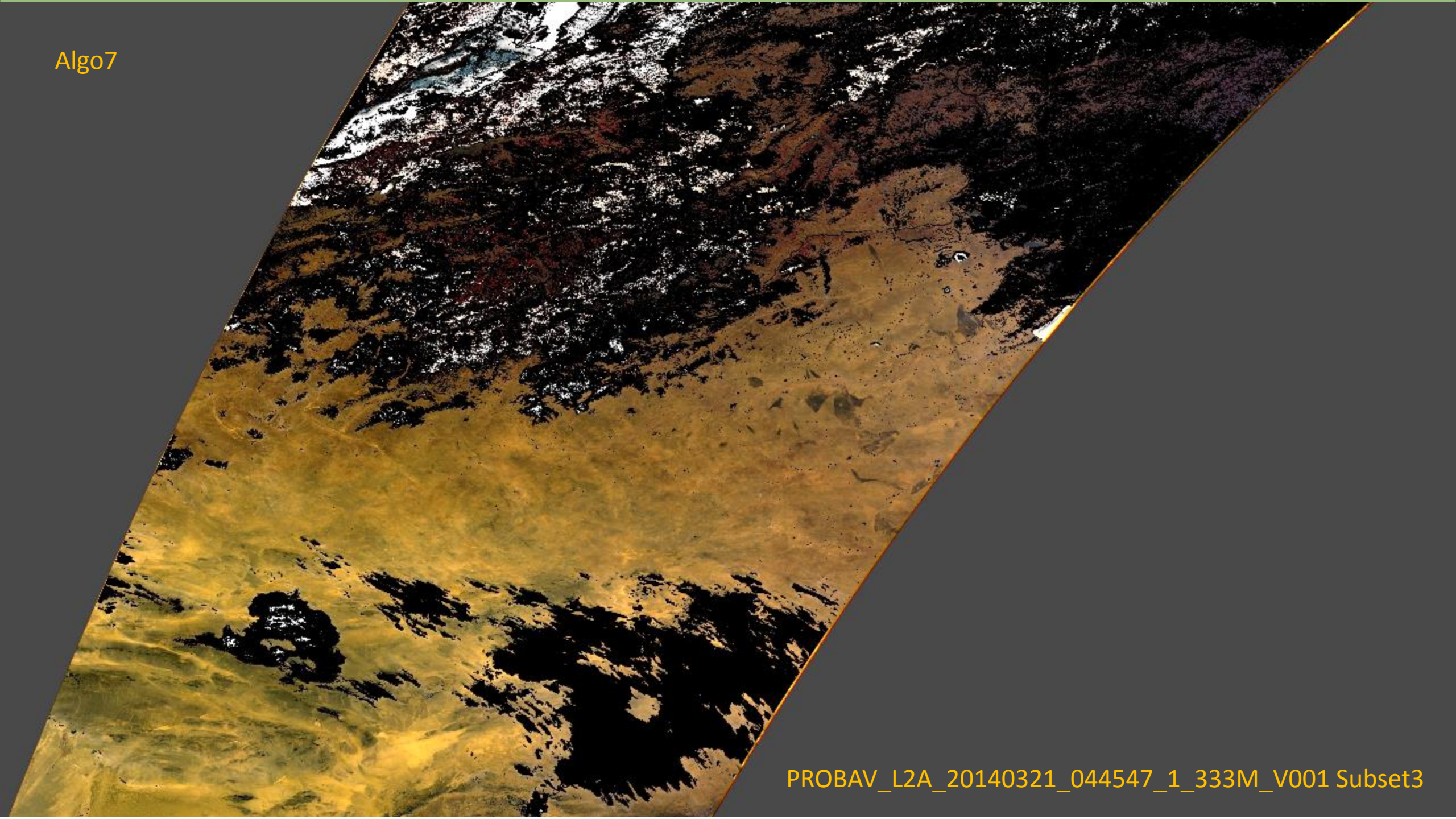


PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

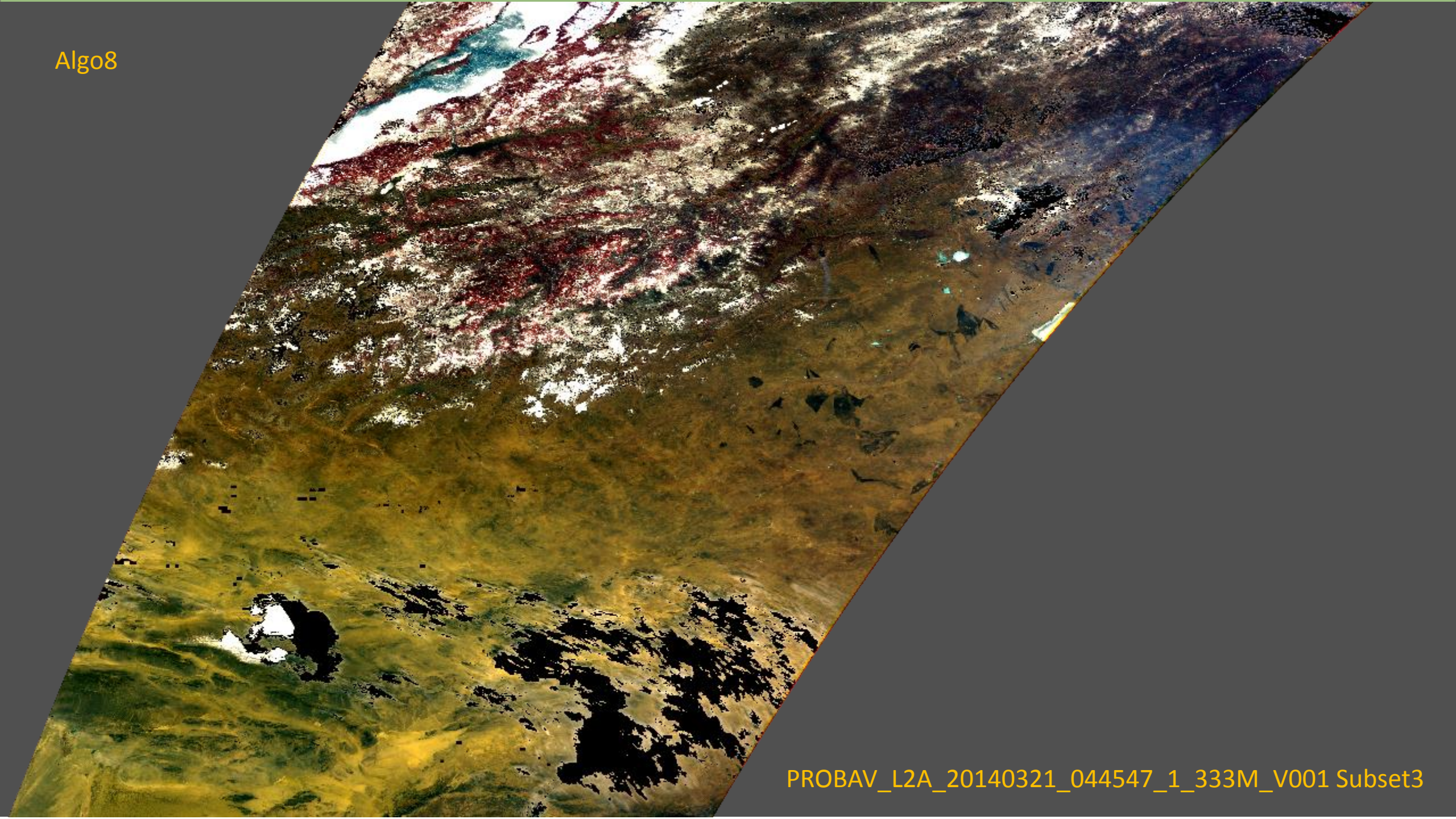
Algo 6



PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

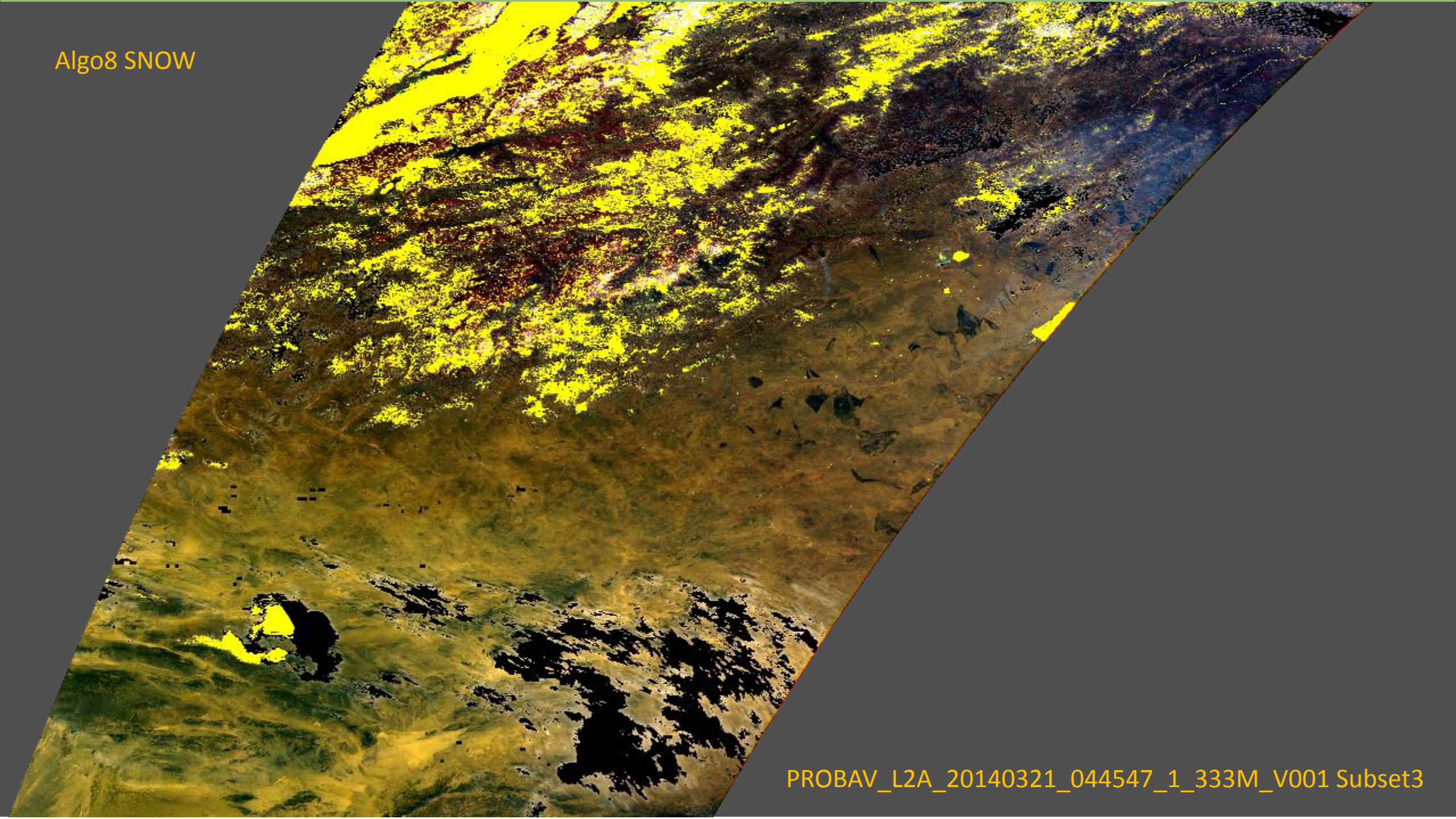

Algo7
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo8



PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Algo8 SNOW



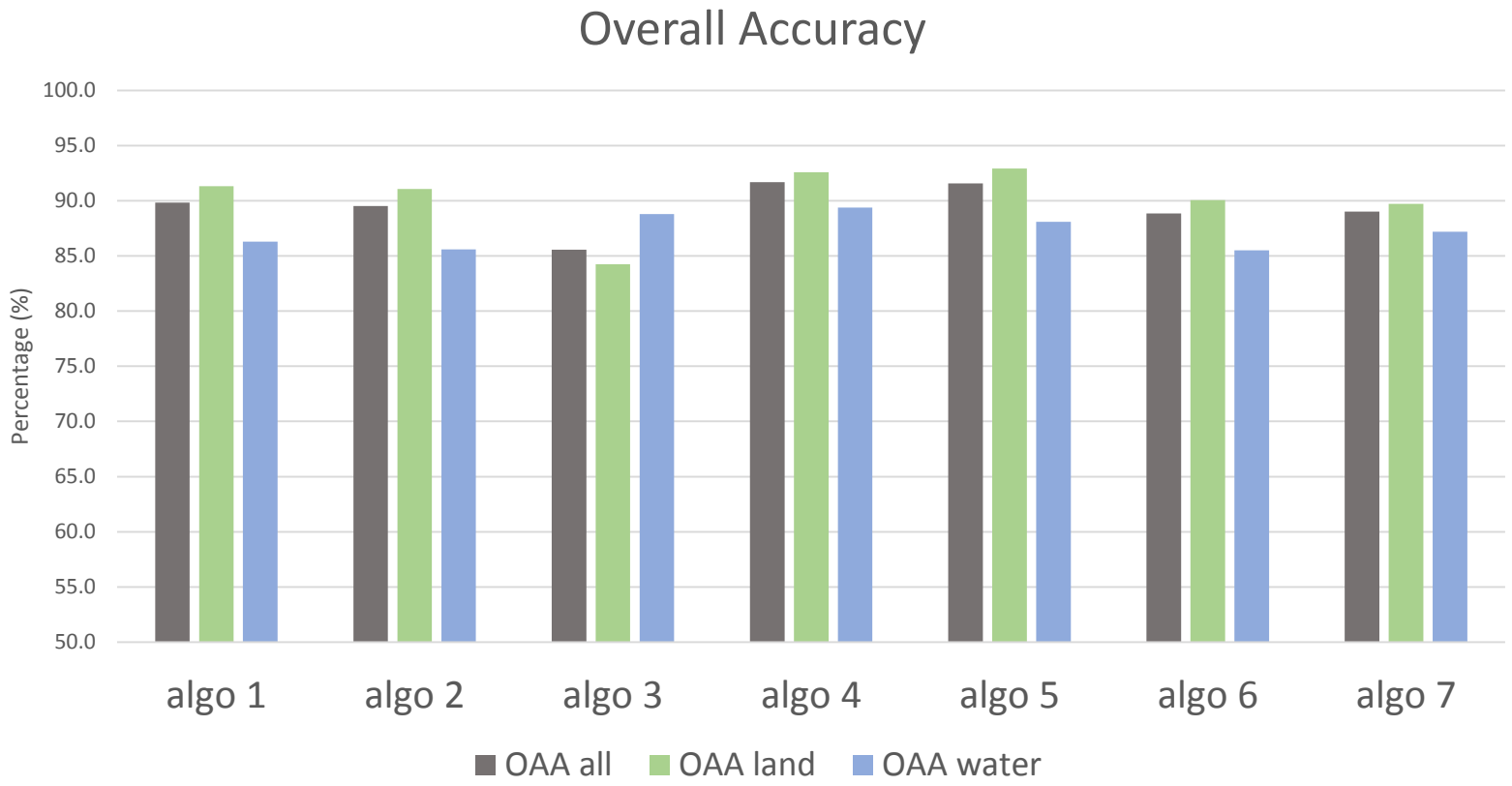
PROBAV_L2A_20140321_044547_1_333M_V001 Subset3

Assessment 4 – Cloud flags in images

	Algo 1	Algo 2	Algo 3	Algo 4	Algo 5	Algo 6	Algo 7	Algo 8
opaque clouds	1	1	1	2	1	1	4	1
small cumulus clouds	1	1	3	1	2	3	1	2
semi-trans water	1	1	3	2	1	3	1	1
semi-trans land	2	2	2	1	1	3	1	2
bright surfaces	2	3	2	1	2	2	2	1
turbid water	2	3	1	1	2	1	2	3
sun glint	3	3	3	2	1	1	2	2
inland water	2	3	1	1	3	1	3	1
coastline	3	3	2	1	2	1	3	1

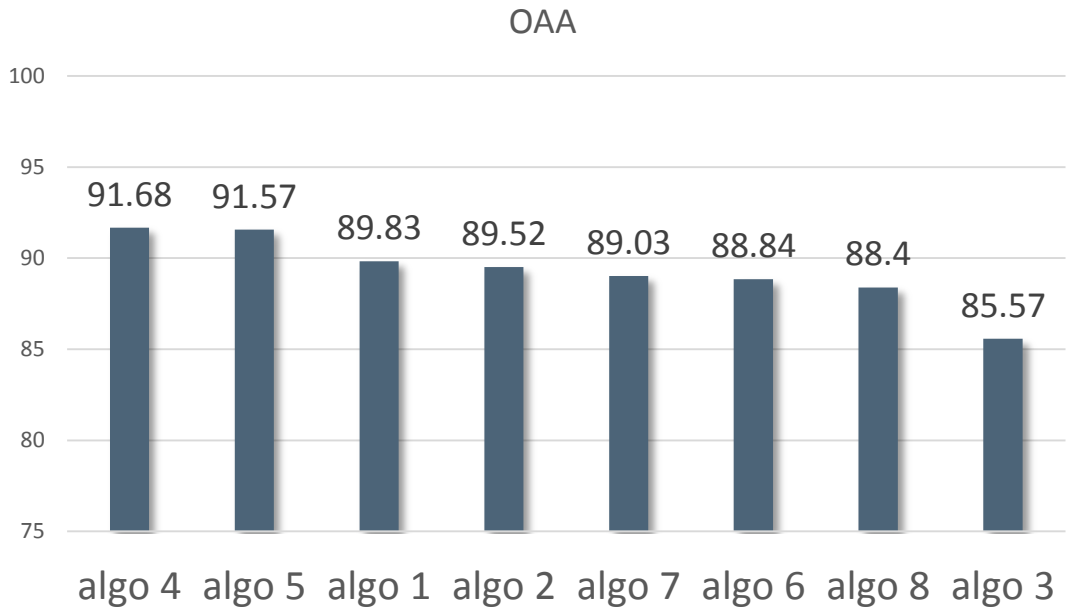
1	well detected
2	slightly, partly wrong
3	mainly wrong
4	problem

Assessment 5 – water - land separation



Overall Assessment

- Algo 4 and algo 5 show very high values in the statistics
  - Algo 5 is slightly more cloud conservative
  - Algo 4 is leaving out thick and bright clouds from the cloud mask.
- Algo 1 and algo 2 are very similar
  - algo 2 is more clear-sky conservative and flagging clear surfaces as cloud while having a good detection of semi-transparent clouds.



- Algo 3 and 6 are the ones detecting least clouds, but have very little commission errors, e.g. at coastlines or in inland waters or bright surfaces.
- Algo 7 is most clear-sky conservative and therefore detects small clouds, cloud borders and semi-transparent clouds but is flagging many clear pixels. Further, it shows artefacts at cloud borders over water.
- Algo 8 provided too late for final assessment

Additional criteria for assessment

- Need for ancillary data
  - Land use classification
  - Snow occurrence
  - Other sensors
- Multi-temporal or single temporal algorithm
- Processing time
- If cloud conservative or clear-sky conservative is preferred depends on sensitivity of L2 algorithm