Proba-V Cloud Detection Round Robin

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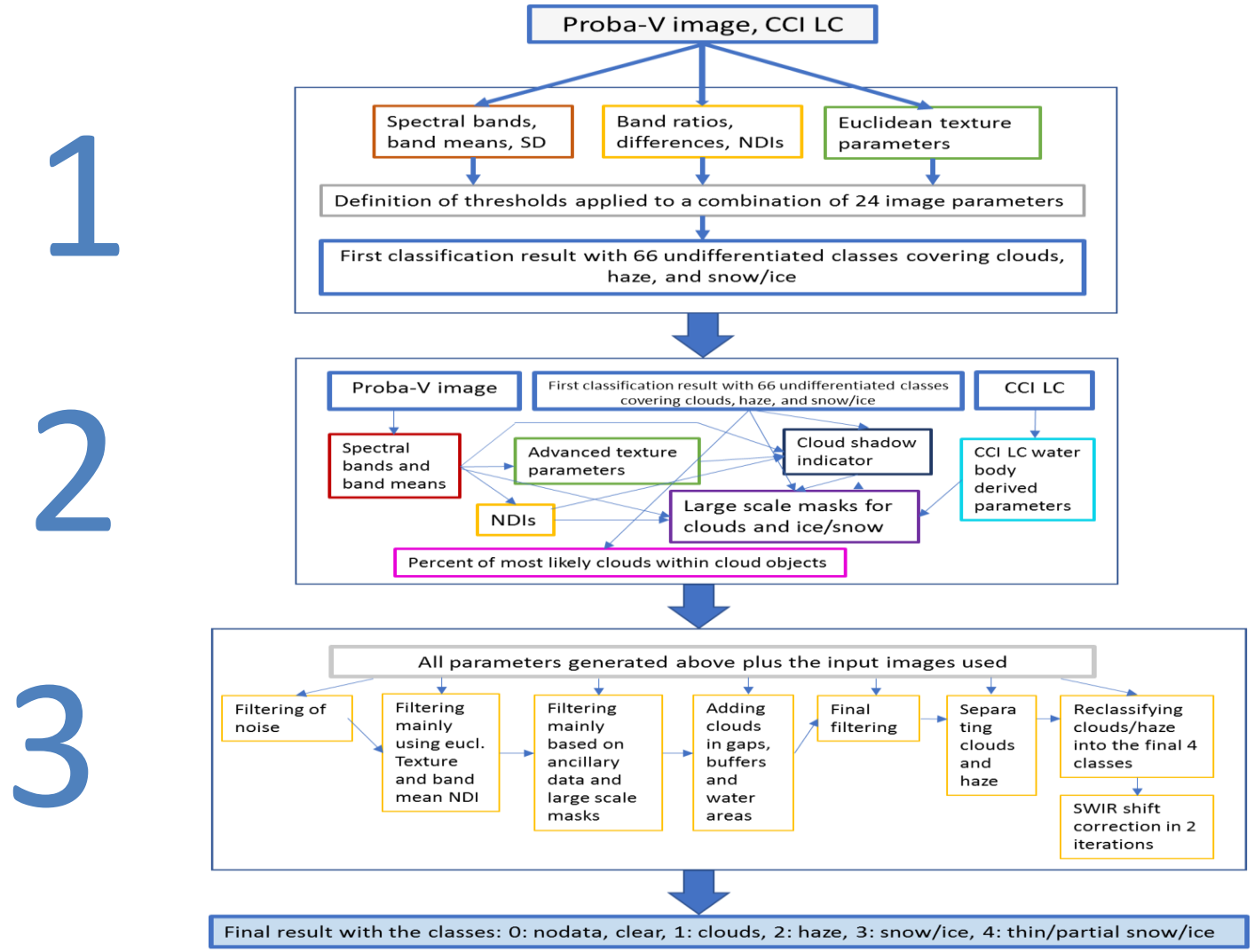
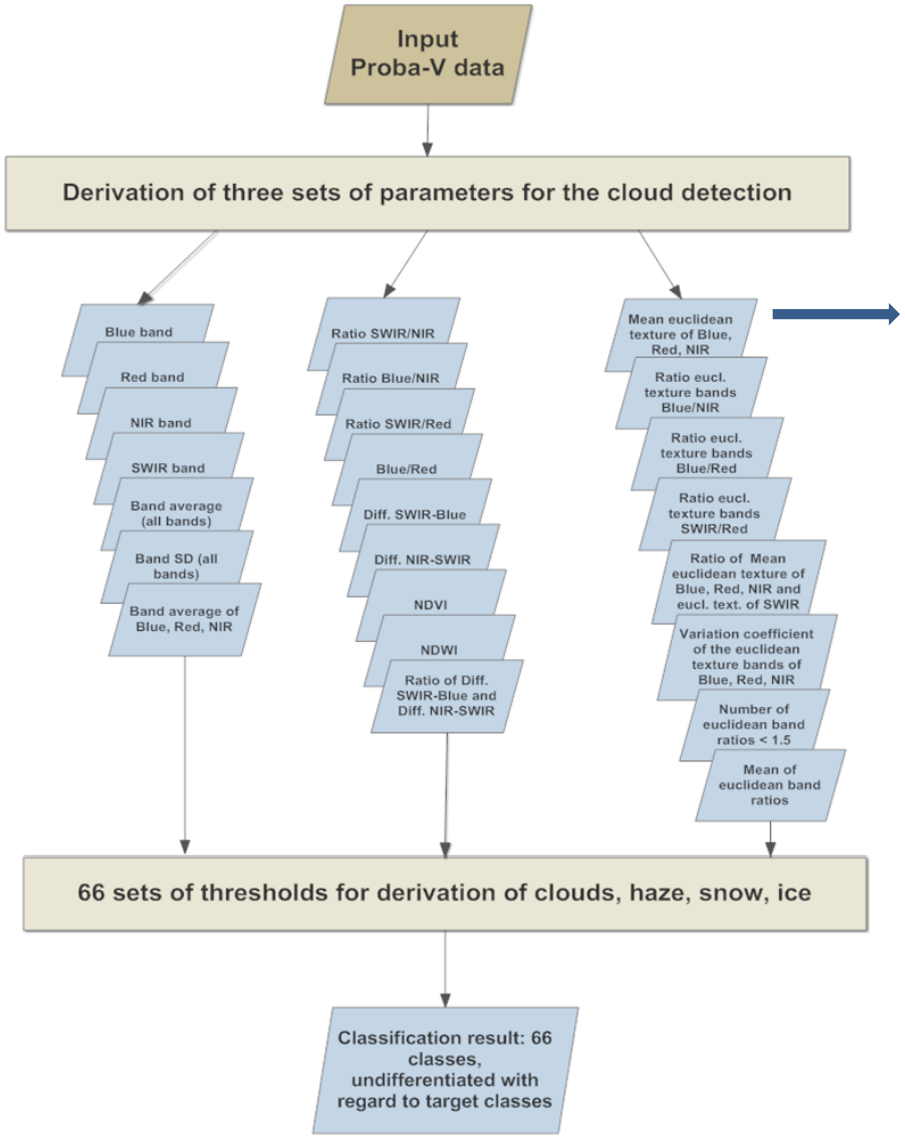
Algorithm Overview

- Advanced legacy methodology:
  - Thresholding approach using multiple spectral and texture features (thresholds determined visually and in training AOIs)
  - Complex filtering strategy
  - Segment (object) based analyses
  - Regional analyses
  - Ancillary data: CCI LC
- Implementation with ERDAS IMAGINE (2016) Spatial Model Editor
- Fully automatic and globally uniform processing

Overall Algorithm Flowchart



Flowchart of Algorithm Part 1



279	252	245
278	314	368
369	456	516

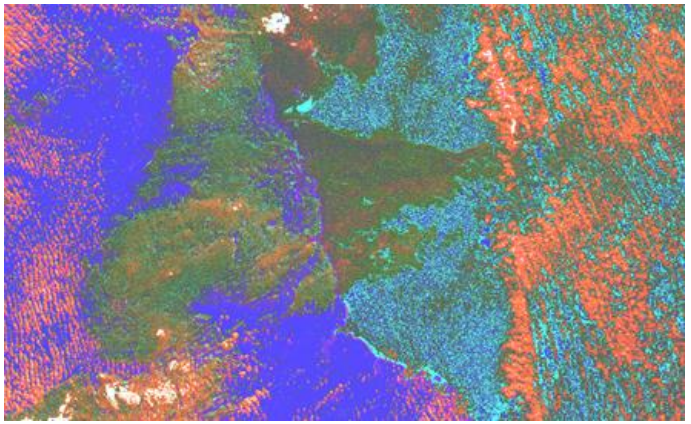
Example 3x3 pixel window of band 1

35	62	69
36		54
55	142	202

absolute differences between center value and pixel values

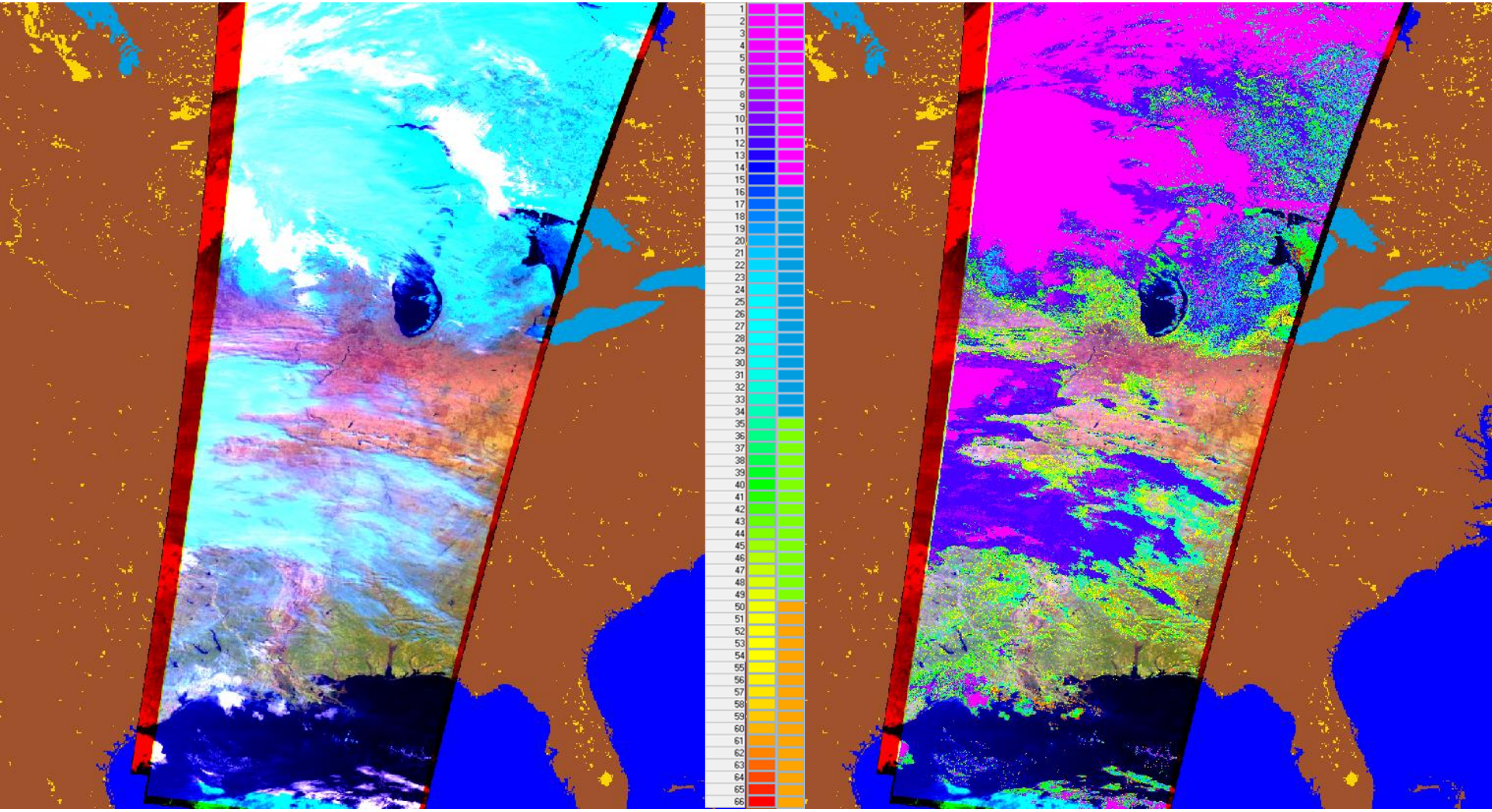
	81.88	

average of the 8 absolute differences



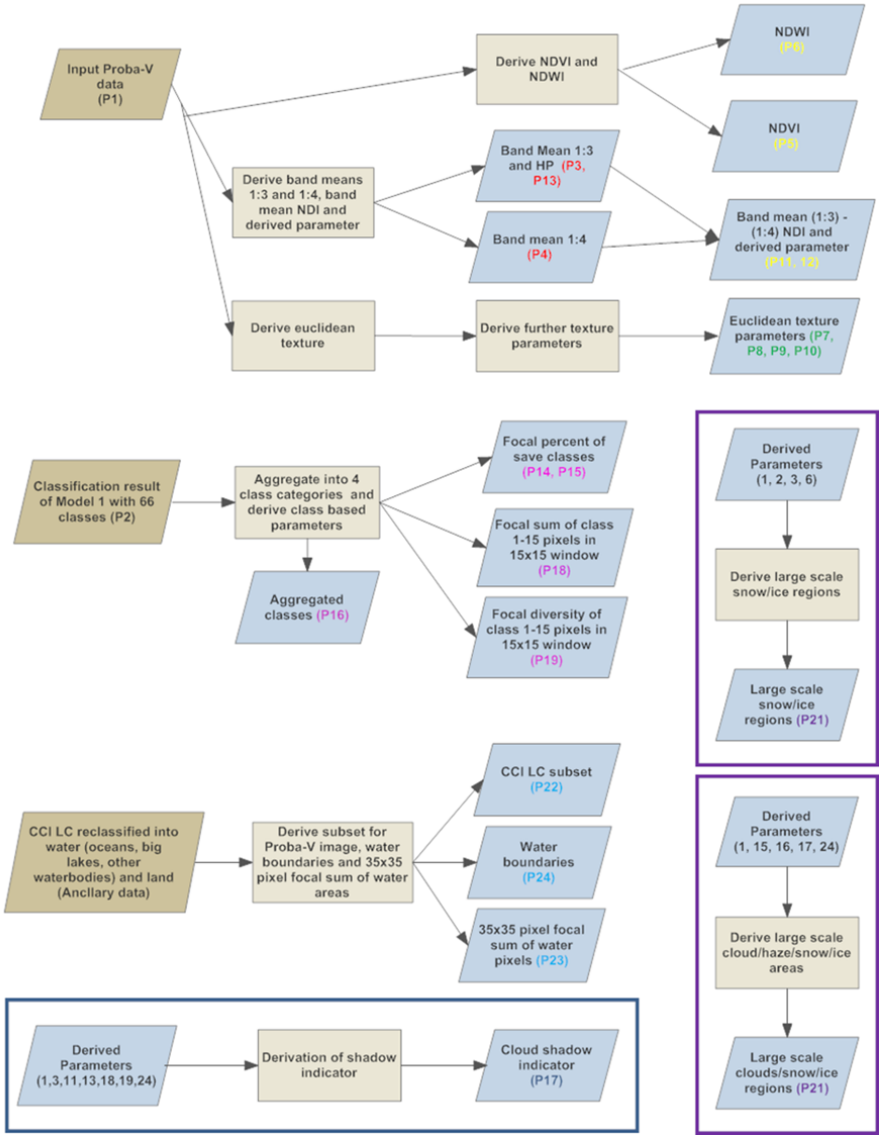
Euclidean texture composite using bands 1-3-6-(RGB

Proba-V 20140321-162957_3 (left) and initial 66 classes



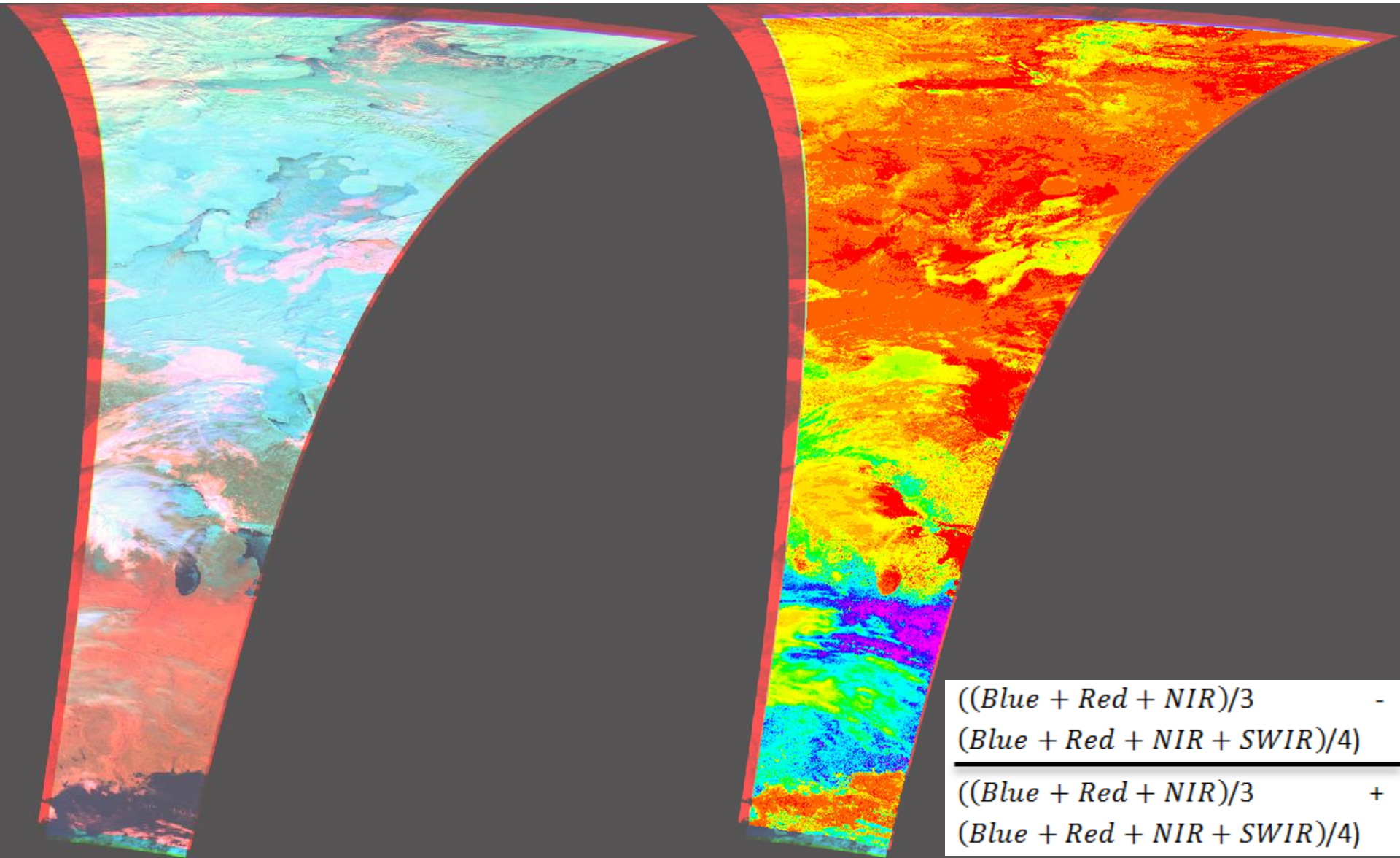
SWIR – NIR – BLUE RGB; background: CCI LC (aggregated to water (3 classes) and land)

Flowchart of Algorithm Part 2



Proba-V 20140321-162957_3

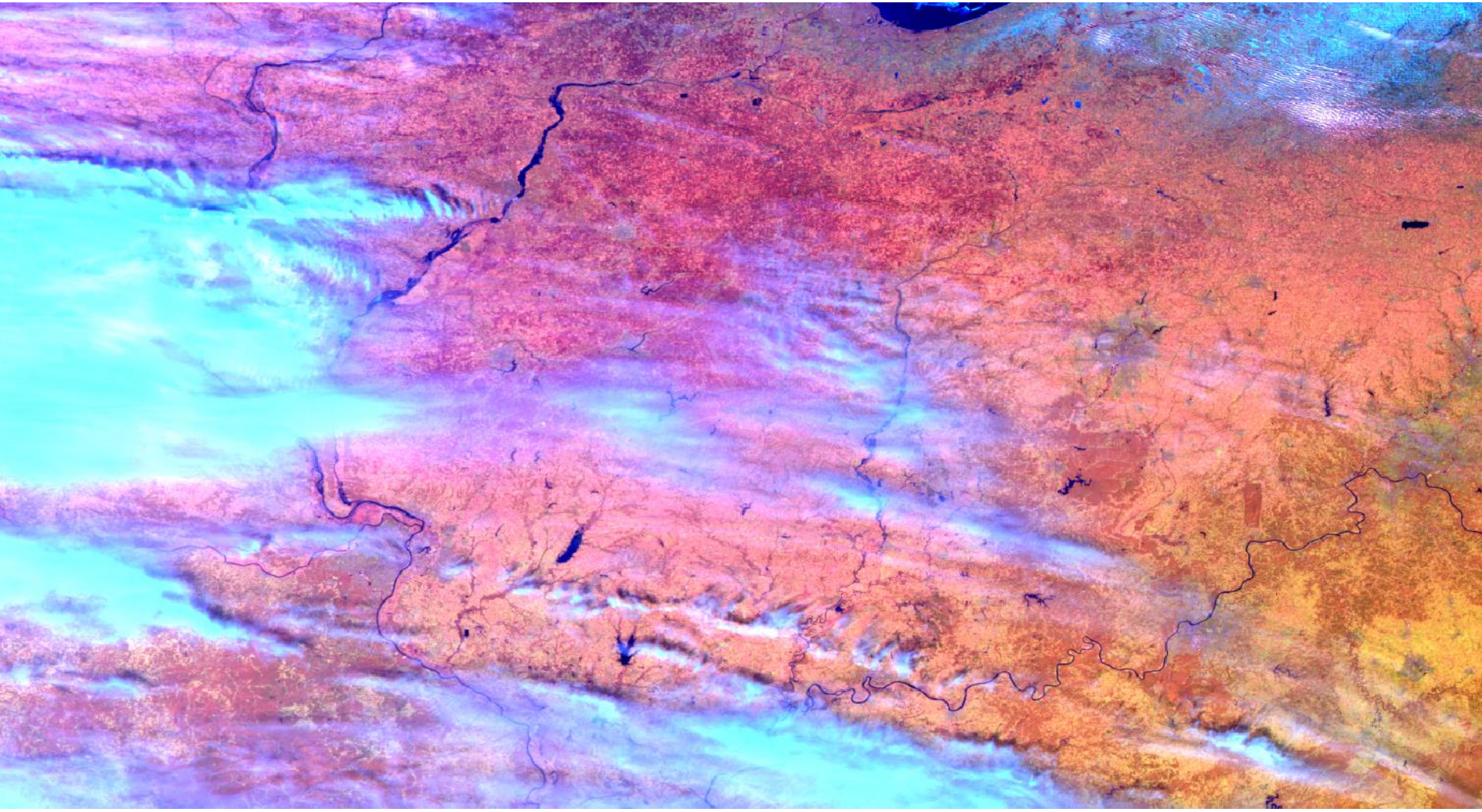
SWIR-NIR-Blue RGB and Band mean 1:3/1:4 NDI



$$\frac{((Blue + Red + NIR)/3 - (Blue + Red + NIR + SWIR)/4)}{((Blue + Red + NIR)/3 + (Blue + Red + NIR + SWIR)/4)}$$

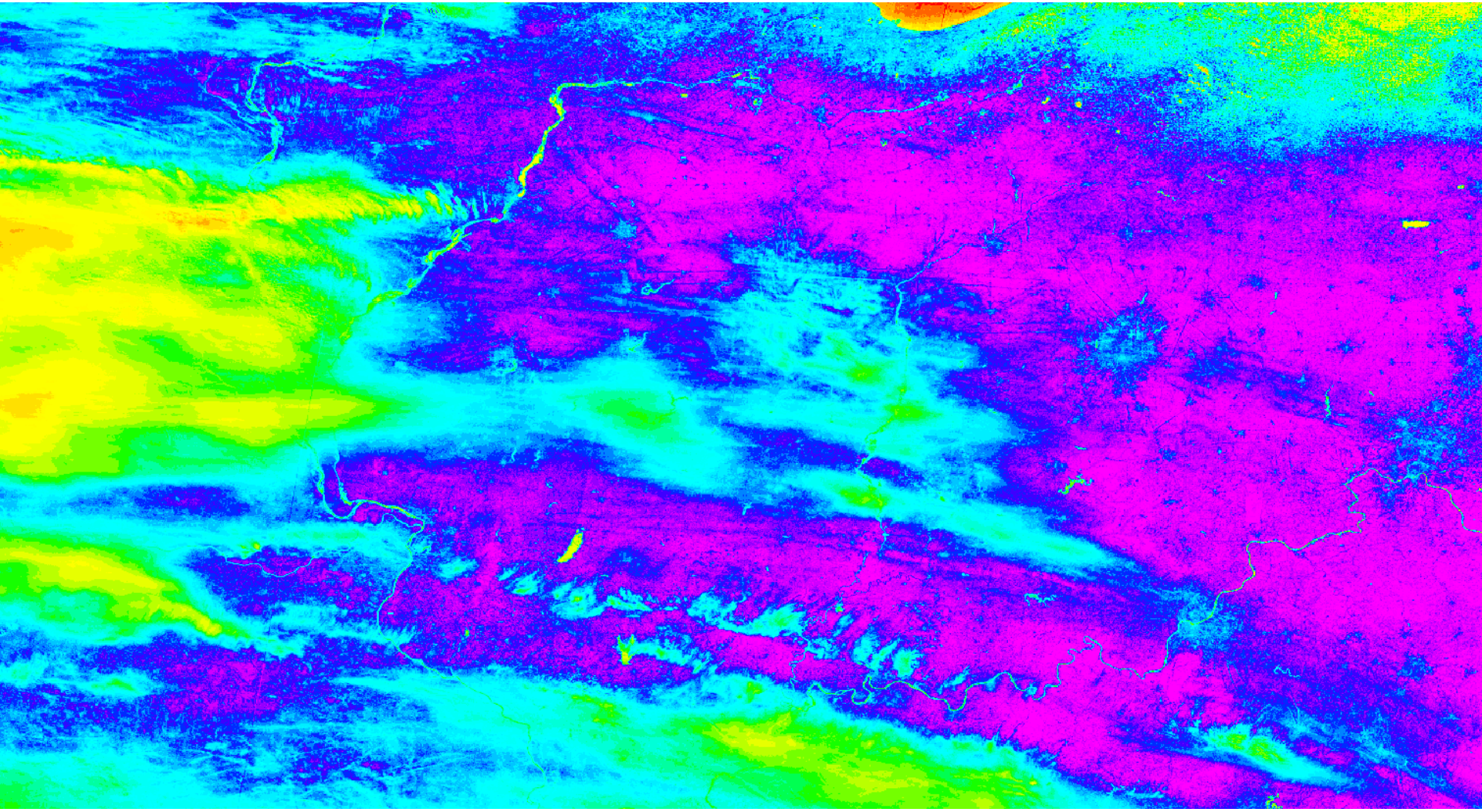
Proba-V 20140321-162957_3:

Partly semitransparent clouds and Band Mean 1:3/1:4 NDI

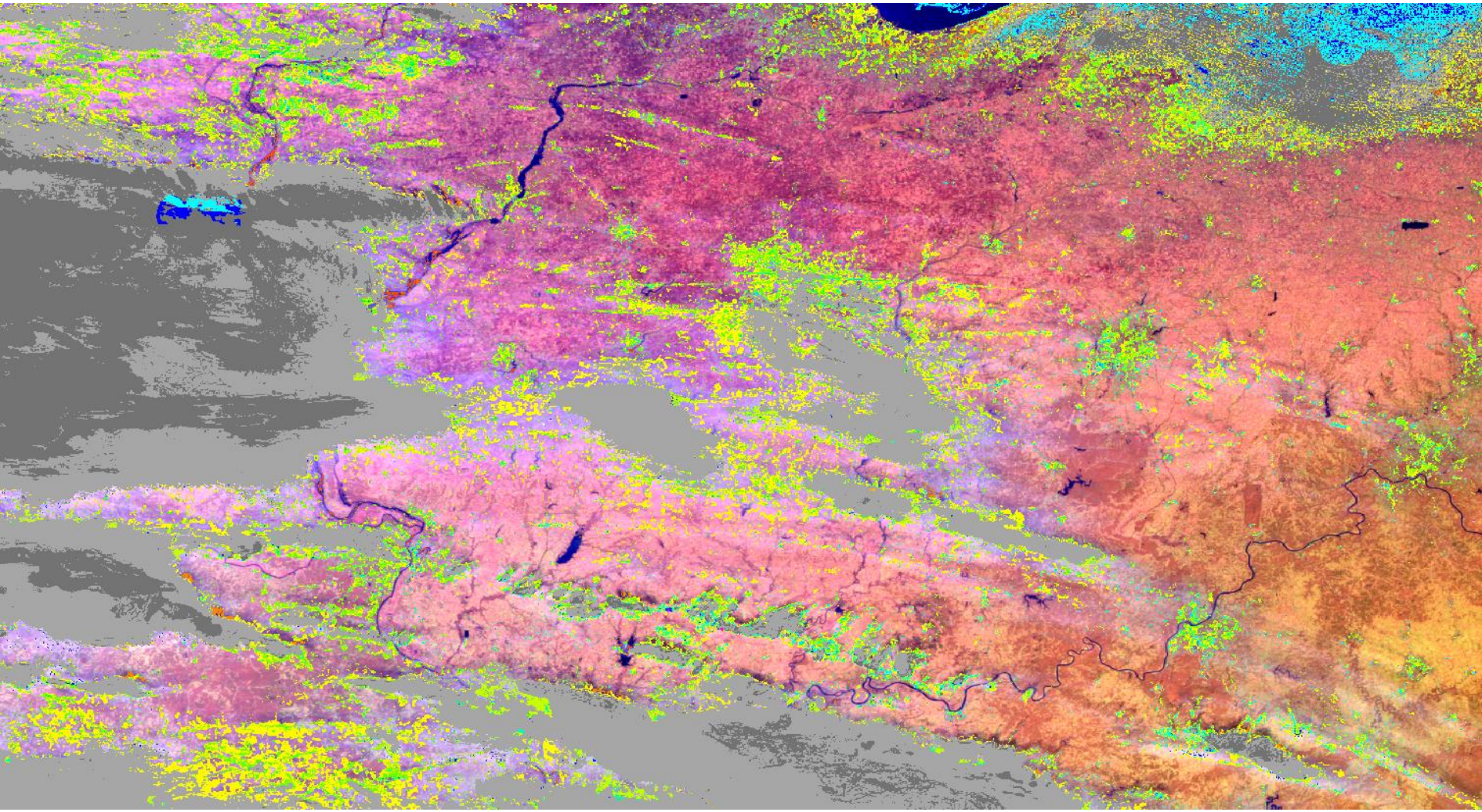


Proba-V 20140321-162957_3:

Partly semitransparent clouds and Band Mean 1:3/1:4 NDI

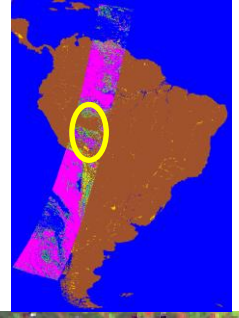


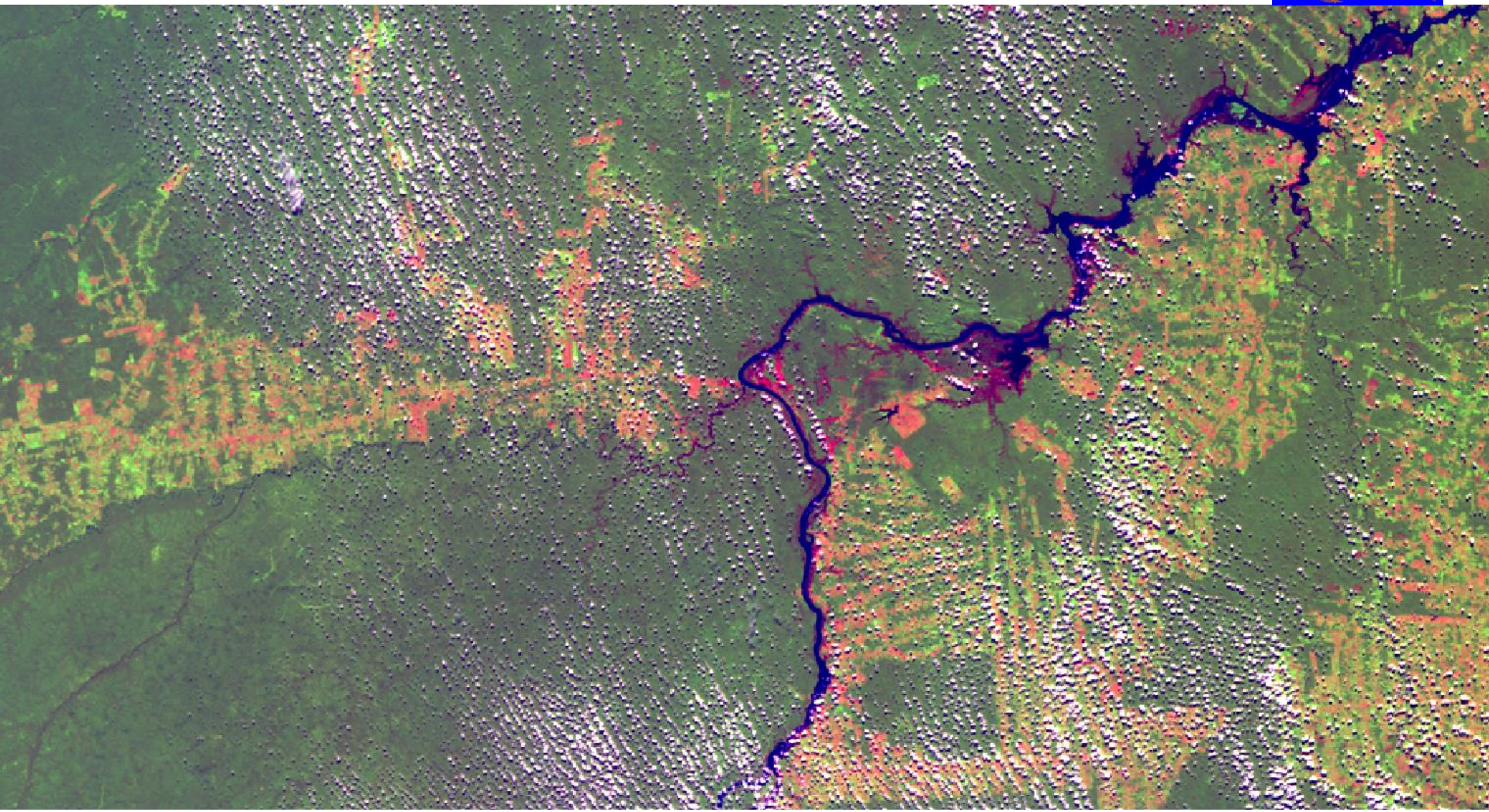
Final cloud classes (dark and light gray)



Finaly retreived clouds (dark gray), semi transparent clouds (light gray), snow/ice (blue) and partial snow/ice (cyan). Not all of the originally captured clouds (yellow/green) could be kept to avoid overly large commission errors.

Proba-V 20140621_144249_3 with cumulus clouds

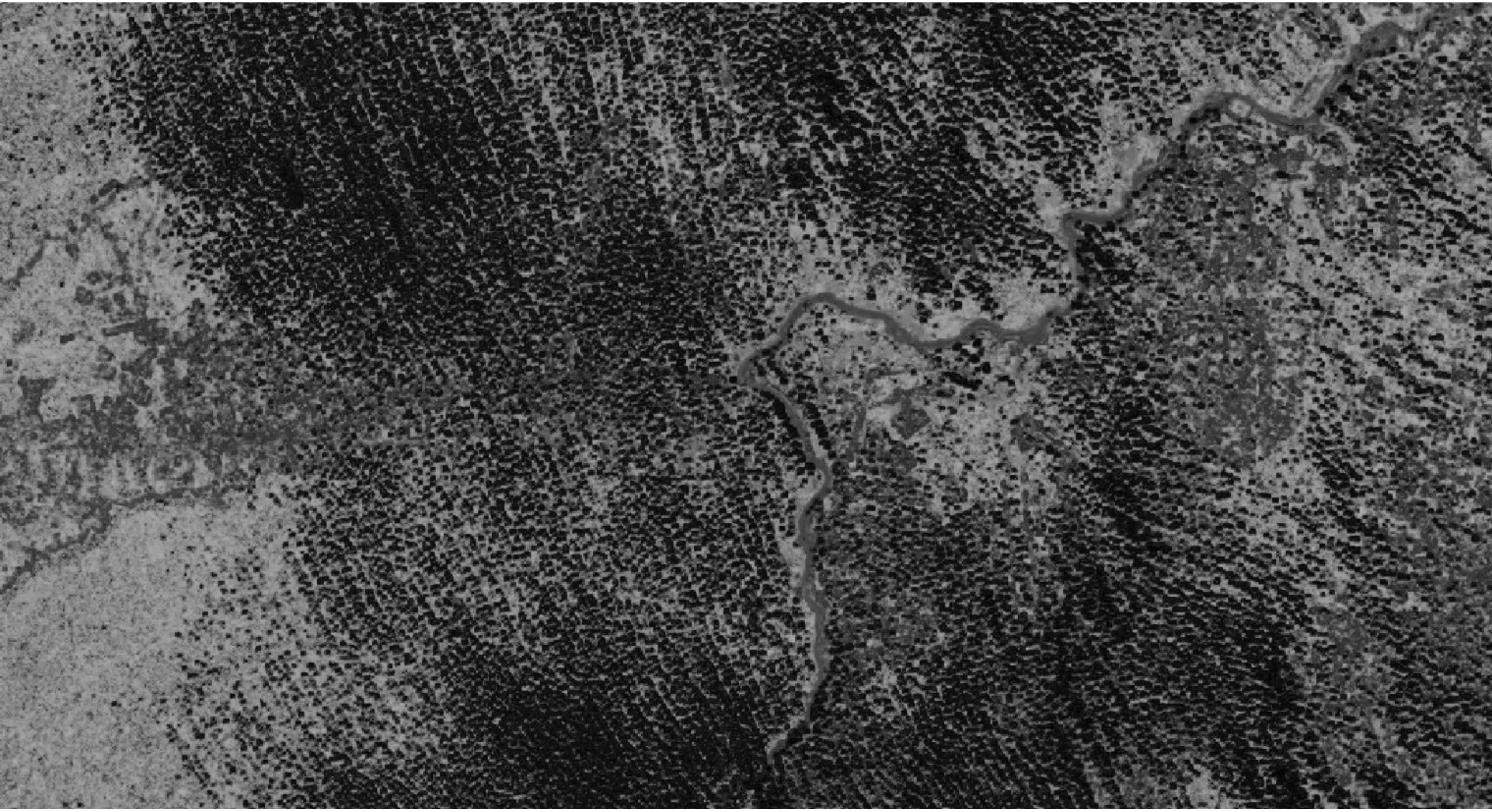




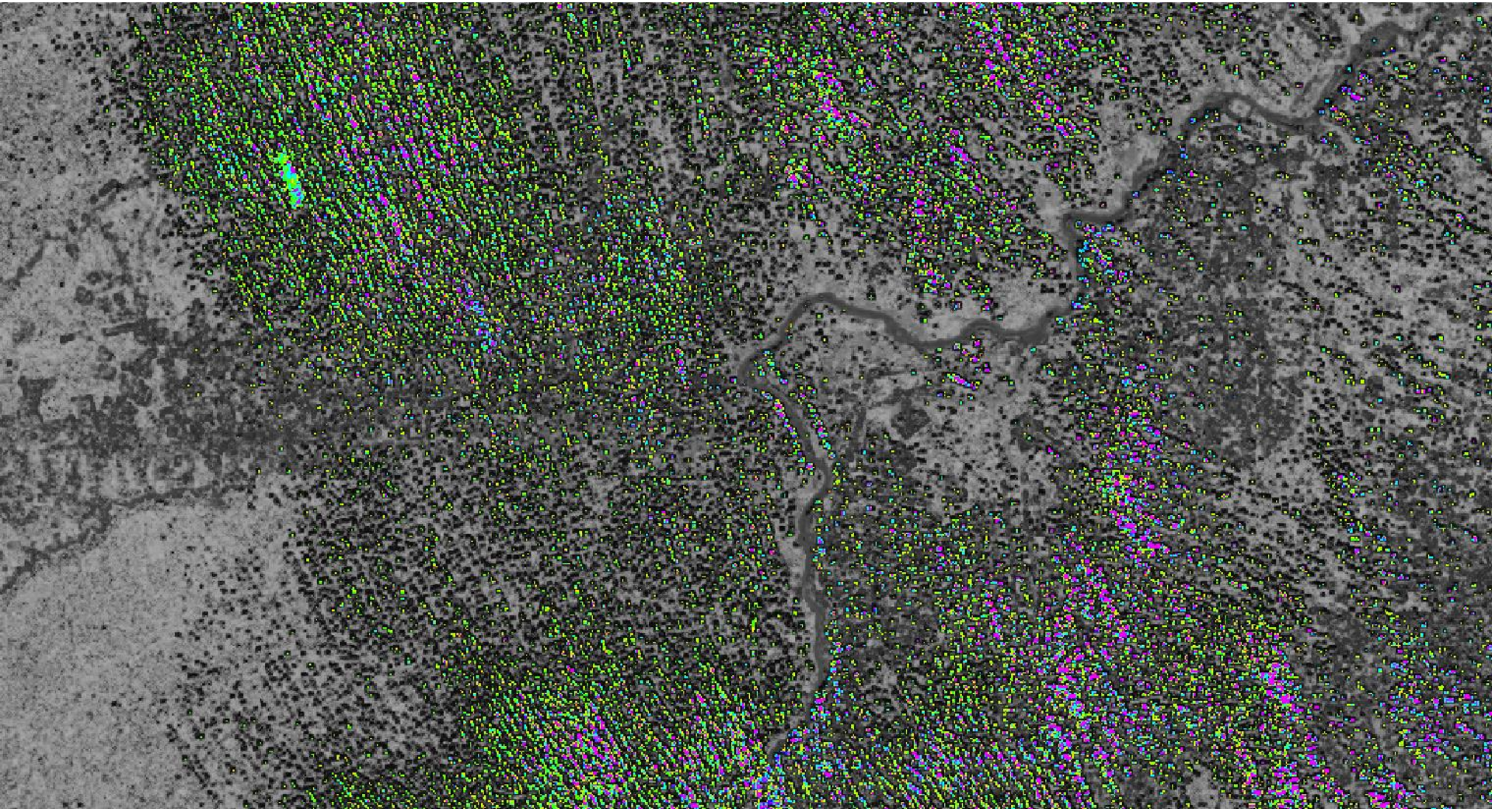
SWIR – NIR – BLUE RGB

Euclidean Texture Mean of bands B,R,NIR

Euclidean Texture CV of bands B,R,NIR

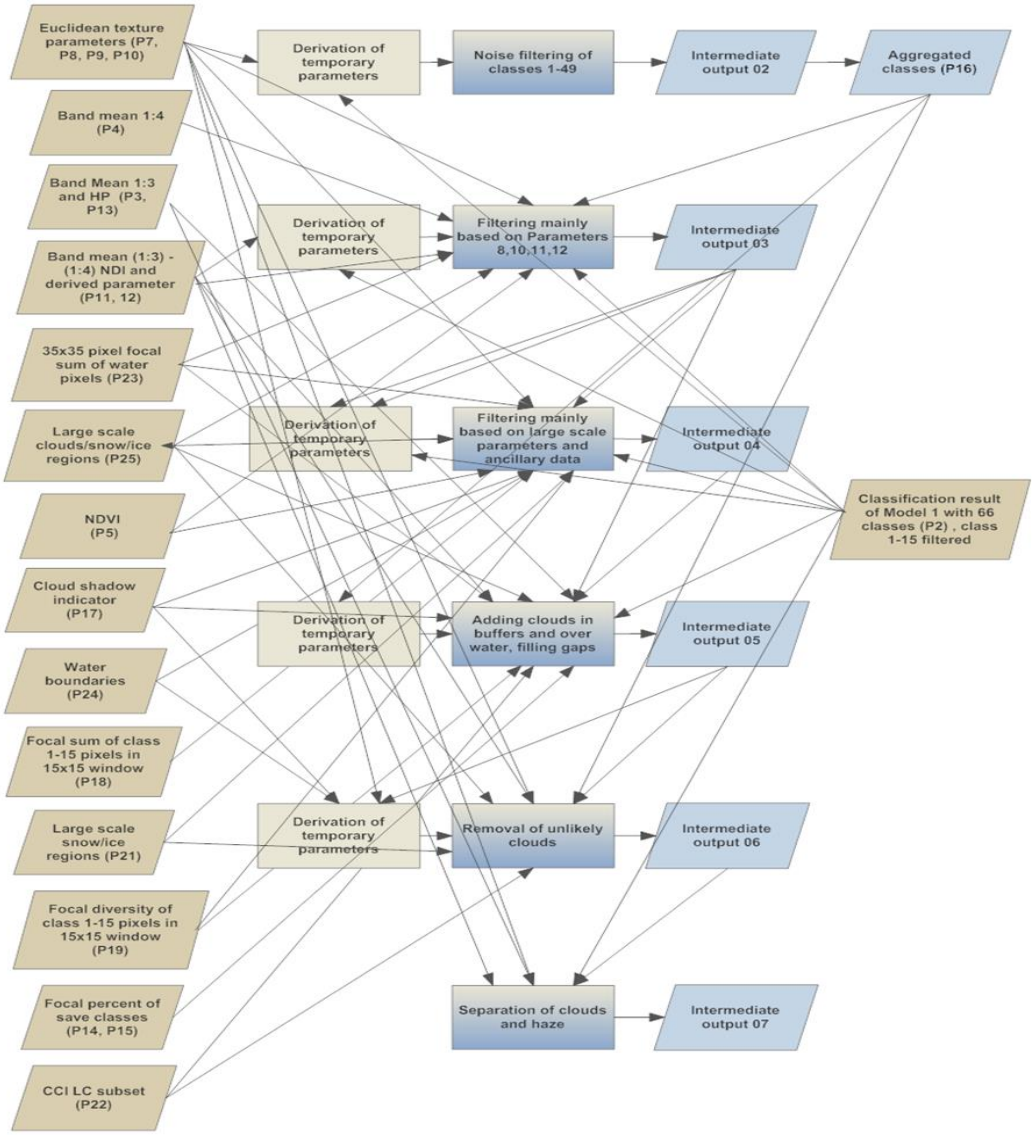


Initial 66 classes over euclidean Texture CV



Cloud retrieval could be further improved based on the euclidean texture parameters: not all of the dark patches are covered by the 66 classes. However, this would require carefully defined additional multi-parameter filtering steps.

Flowchart of Algorithm Part 3a

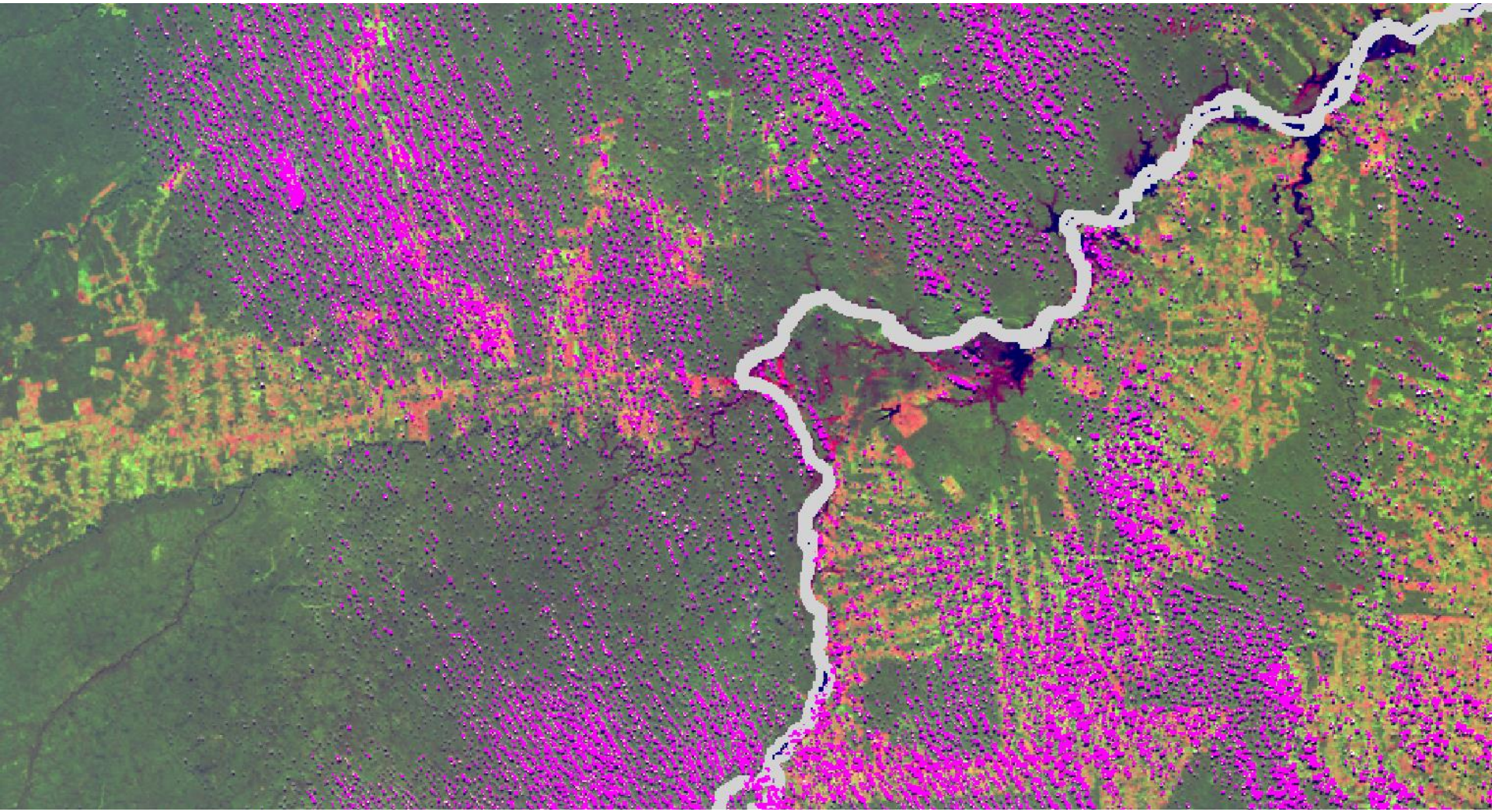


Filtering is in all cases based on multiple image parameters.

For instance, in the case of water boundaries, clouds are omitted only if they fulfill several criteria besides their location, e.g., size, euclidean texture parameters, etc.

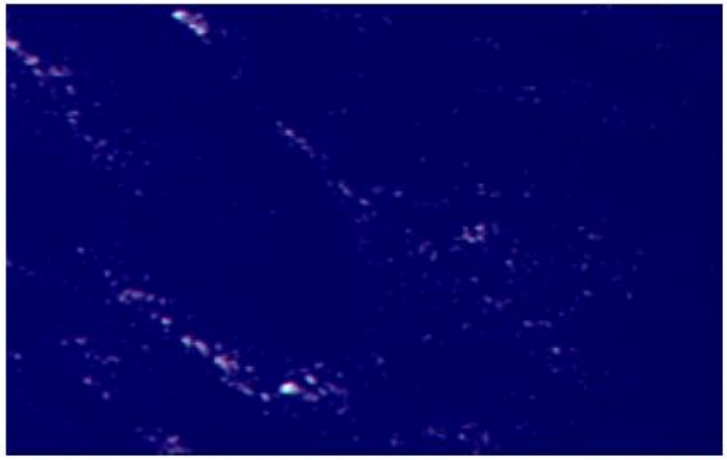
The thresholds used sofar may be further optimized in some cases, according to the findings of the validation report.

Final cloud map with water boundaries

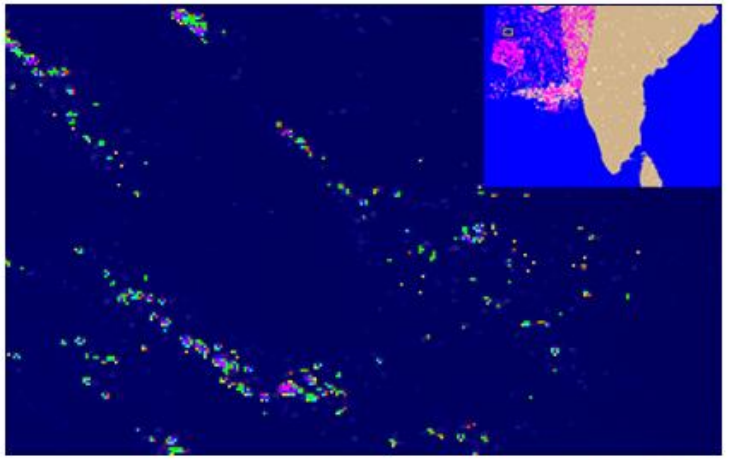


By further optimizing the masks derived with CCI LC and the filter parameters, results can be further improved

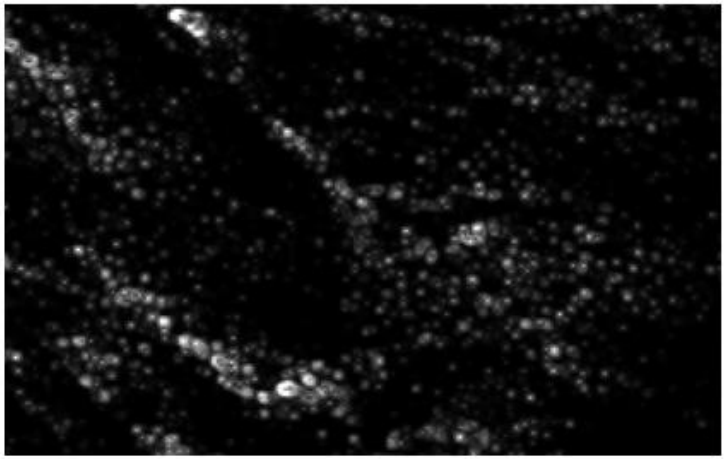
Adding clouds over open water



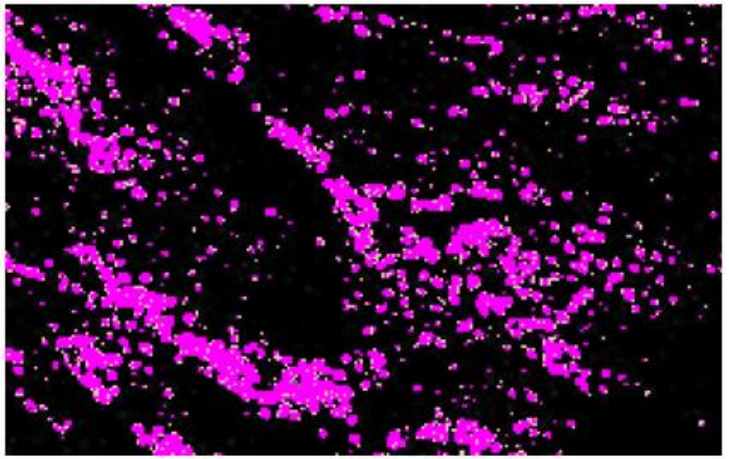
Detail of probav_l2a_20140921_053508_3_333m_v001.tif, SWIR-NIR-Blue RGB, contrast stretch optimized for land in southern part



First classification result with 66 classes (output of Model 1)



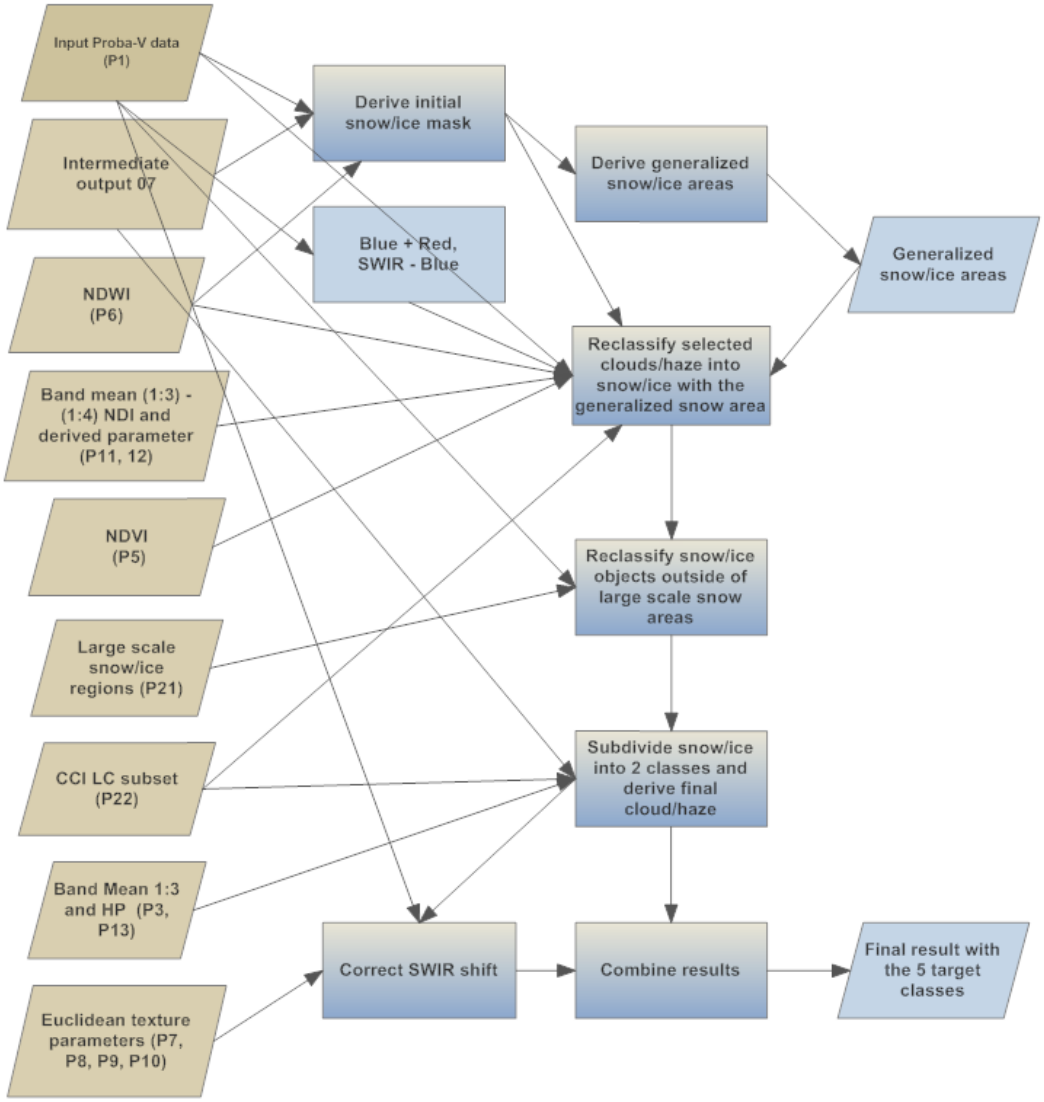
Mean Euclidean distance texture: euctext_b1-3_mean.img



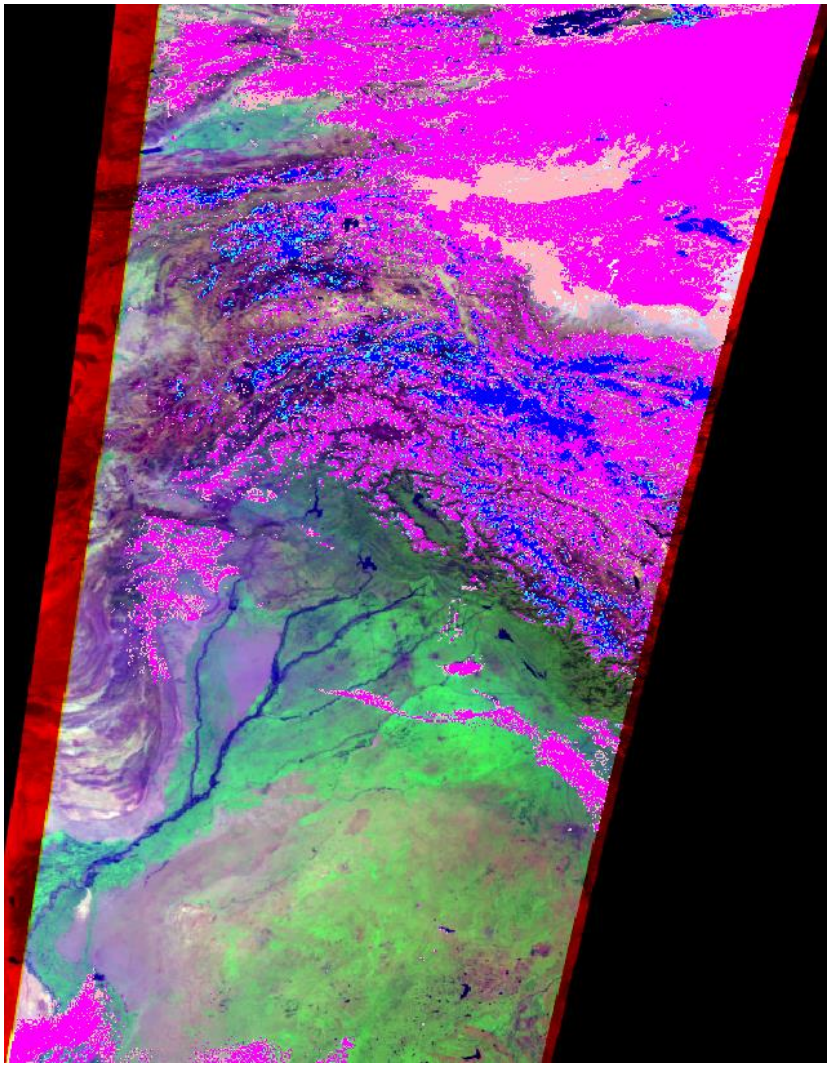
Final classification result, with water pixels added using euctext_b1-3_mean.img

Flowchart of Algorithm Part 3b:

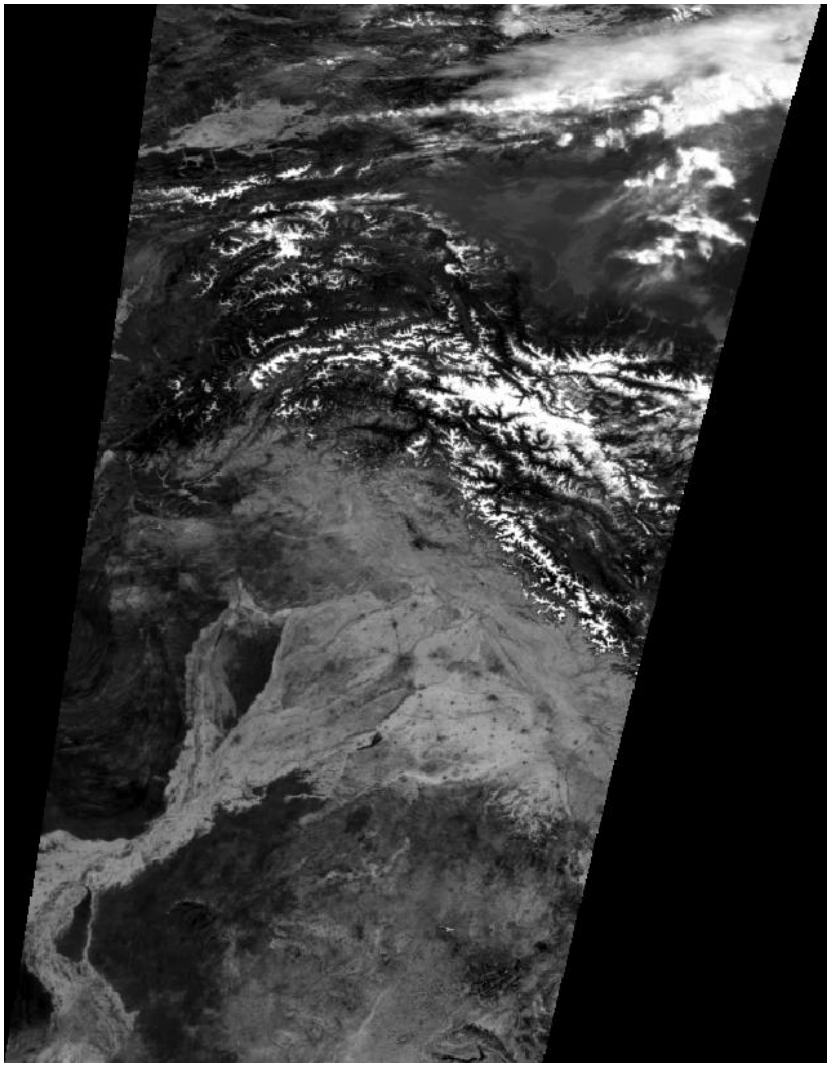
Reclassification into clouds and snow/ice



Proba-V 20140921_053508_3

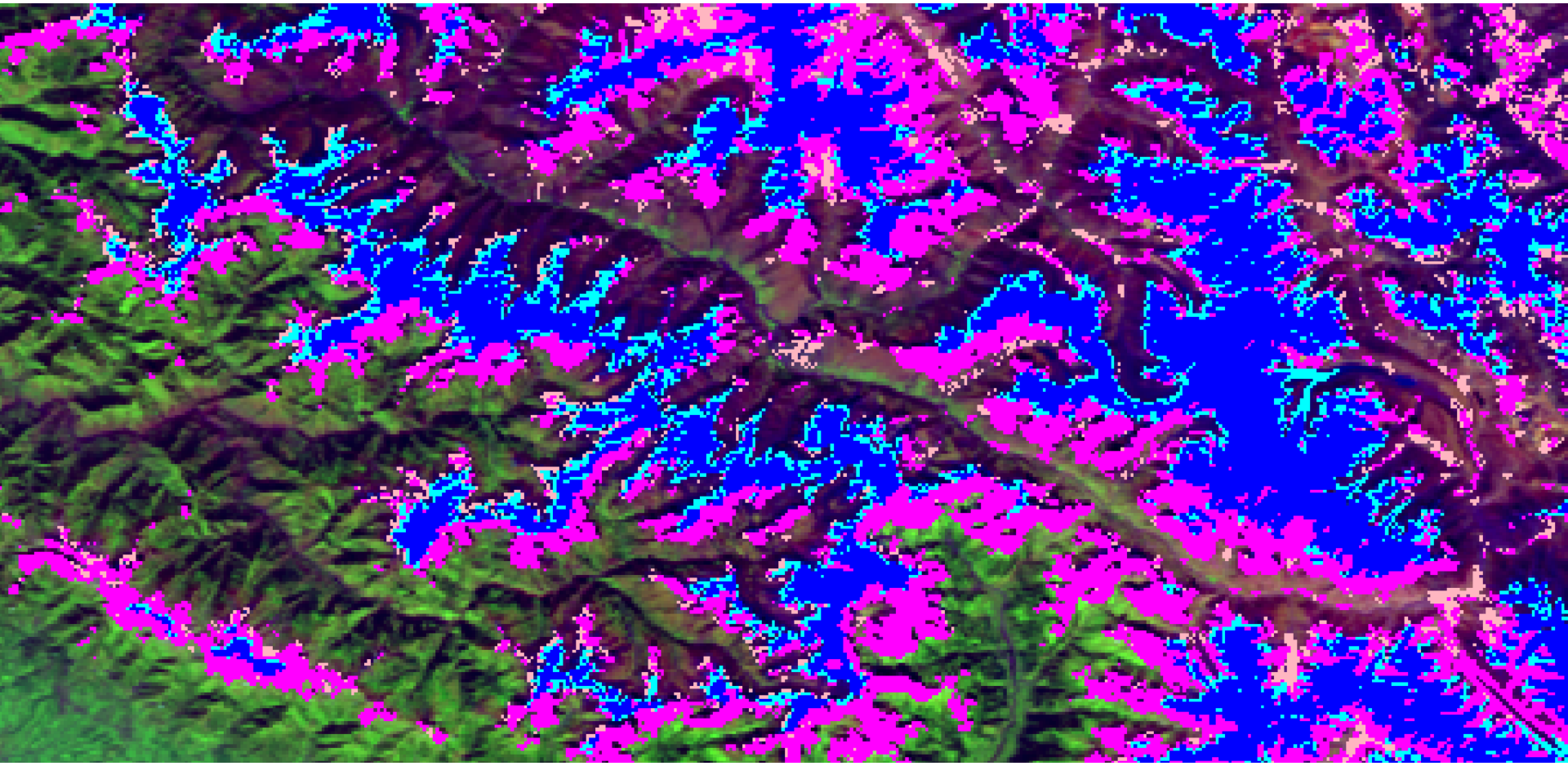


Left: SWIR-NIR-BLUE RGB



Right: NDWI : (NIR-SWIR)/(NIR+SWIR)

Detail of Proba-V 20140921_053508_3

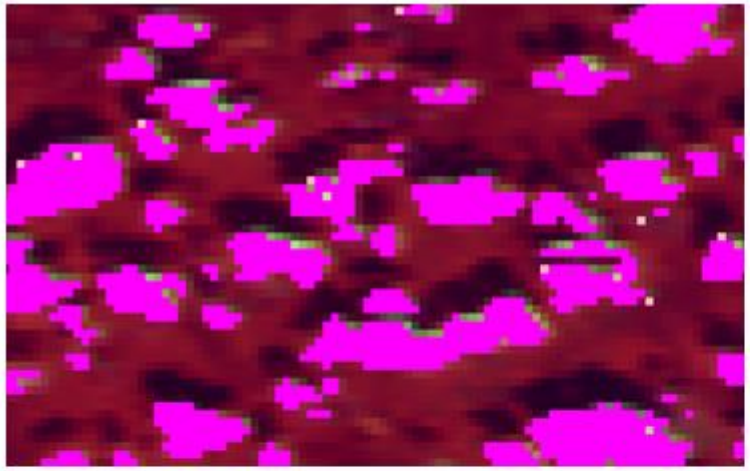


Mixture of snow and clouds: in some cases, snow edges are falsely classifies as clouds, especially where snow towards the edges does not have the typical snow reflectance due to mixed signals

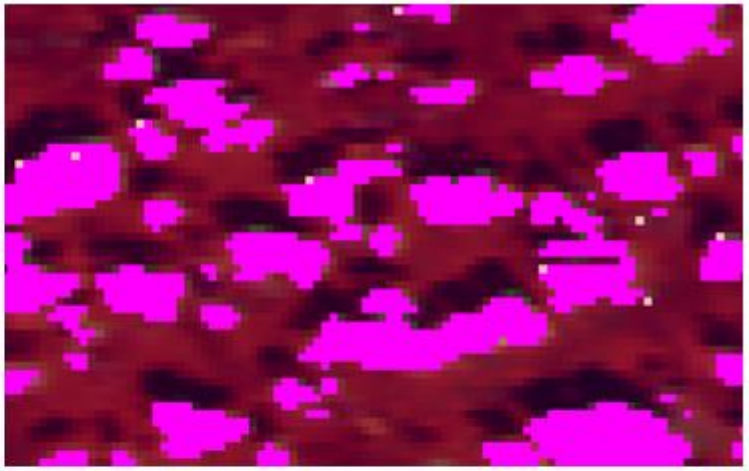
Detail of Proba-V 20140921_053508_3

Mixture of snow and clouds: in some cases, snow edges are falsely classifies as clouds, especially where snow towards the edges does not have the typical snow reflectance due to mixed signals. Some improvement using filtering techniques is also possible in these cases.

Result of the SWIR Shift correction



The bright green edges on the upper side of the clouds come from the SWIR band that reaches beyond the other spectral bands



Here the SWIR shift has been corrected by adding one or two cloud pixels on the upper (northern) side to the clouds

Figure 18: Effect of the correction of the SWIR shift

In a final processing step, the SWIR shift corrected clouds and haze and the snow and ice classes are combined to receive the final result with the classes:

0: Nodata and clear areas

1: Clouds

2: Haze

3: Snow and Ice

4: Thin or partial snow and ice cover

Summary

- The developed cloud/haze/snow/ice retrieval method is in some respects a legacy approach,
- but with regard to the image parameters used and the multiple ways they are combined, the method can be considered at least advanced, if not new.
- It works largely well, both in a qualitative and quantitative sense
- Nevertheless, there are limitations and there is potential for improvements
- A disadvantage is the relatively long computation time

Current limitations and possible improvements

- Certain land cover types can hardly be excluded from being falsely flagged as clouds: especially certain wetlands (often coastal wetlands), salt lakes, a few very dry surfaces, agricultural fields.
- With monotemporal methods, solutions for such areas may only be found by their delineation and extra tuning of the parameters within these areas.
- Opaque clouds misclassified as snow/ice (assumably iceclouds) can be partly avoided through additional maneuvers, but complete avoidance seems to be only possible with further ancillary data (e.g., DEM etc.).
- Vice versa, false clouds that occur around snow and are actually snow, are often hard to be correctly coded, as they may not exhibit typical snow reflectances. This is especially true in areas with thin and partial snow cover. To some degree, they can be corrected with filtering methods.

Thank You !