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26/03/2015

WATER BODIES V2 ALGORITHM

USING PROBA-V 10 day mean composites multispectral data

Copernicus
The European Earth Observation Programme

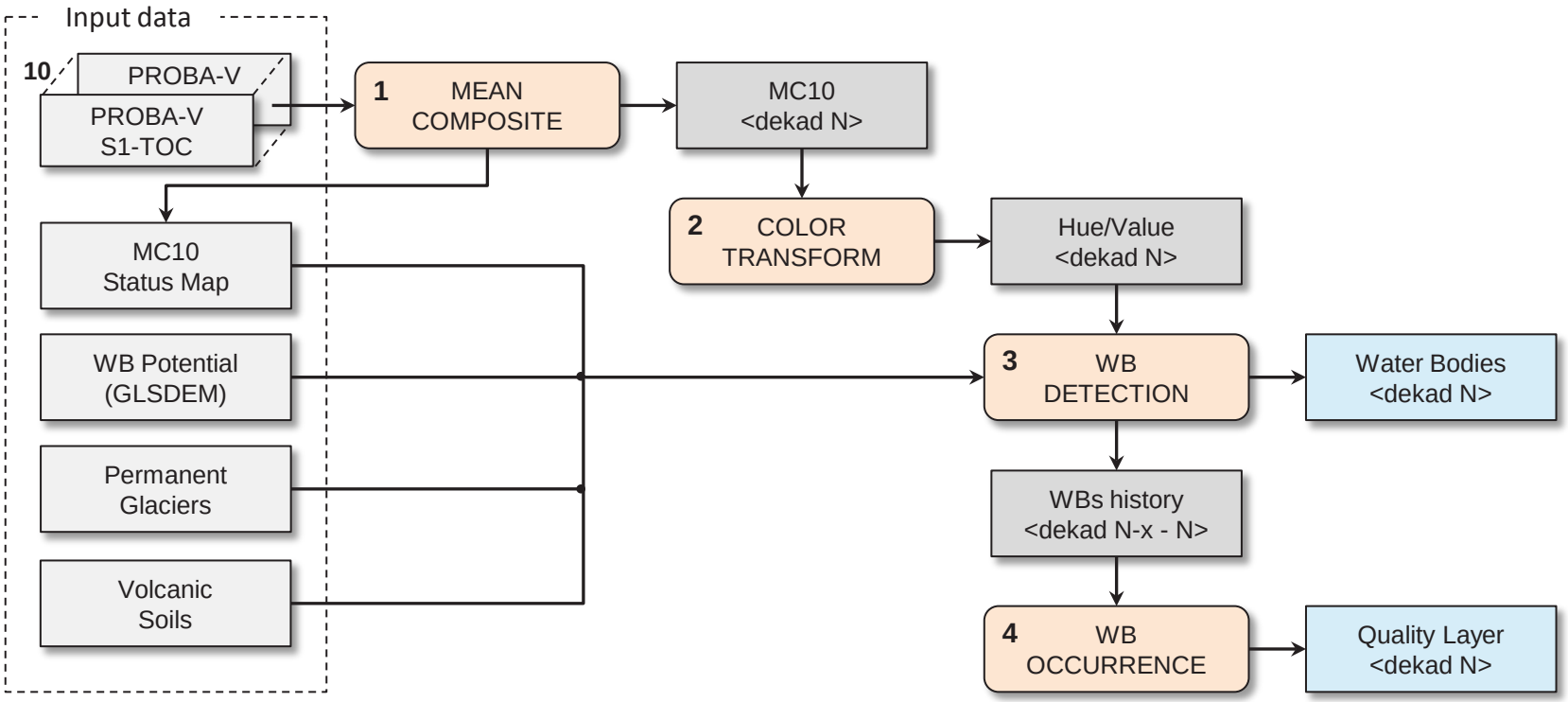
Water Bodies V2 – PROBA-V

- μ-satellite, gap filler SPOT <-> Sentinel
- PROBA-V S1-TOC synthesis products
  - full daily coverage: Lat. 35°N and 75°N
    Lat. 35°S and 56°S
  - full coverage every 2days at the equator
  - spectral bands:

Spectral band	Wavelength (μm)
BLUE	0.477 - 0.493
RED	0.610 - 0.690
NIR	0.770 - 0.893
SWIR	1.570 - 1.650

  - S1 TOC data at 1km spatial resolution
    (atmospheric correction: SMAC 4.0)
    (Berthelot and Dedieu, 1998)

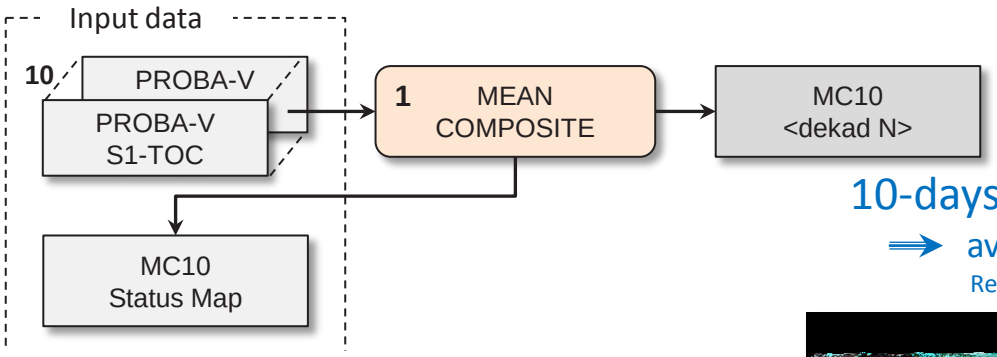
Water Body Detection Algorithm (WBDA) – General overview



Main processing steps:

- mean compositing
- color transformation
- water body detection
- water body occurrence calculation

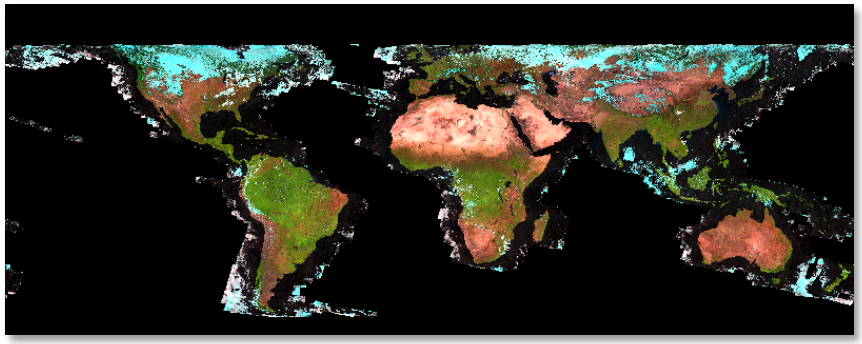
Processing step 1: Mean Compositing



10-days mean compositing

⟹ averaging the valid reflectances

Ref. Vancutsem *et al*. (2007)

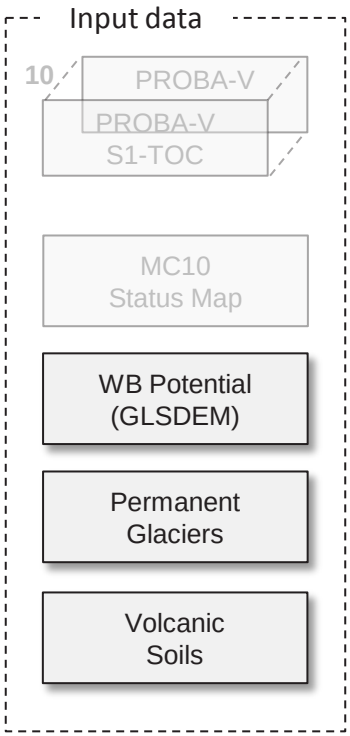


01 Dec. 2013

MC10 status map

Bit	Name	Description
1 -3	Observation	000: clear 010: undefined 011: cloud 100: snow / ice
4	Land/sea mask	0: sea 1: land
5	Mean composite SWIR quality flag	0: bad mean composite 1: good mean composite
6	Mean composite NIR quality flag	0: bad mean composite 1: good mean composite
7	Mean composite RED quality flag	0: bad mean composite 1: good mean composite
8 (Most significant)	Mean composite BLUE quality flag	0: bad mean composite 1: good mean composite

WB detection - Input data



Water body potential mask

- Global Land Survey Digital Elevation Model (GLSDEM)

Ref.: USGS (2008), GLSDEM, 90m scene GLSDEM_p123r024_utmz13, Global Land Cover Facility, University of Maryland, College Park, Maryland. (http://glcf.umd.edu/data/glsdem/)

Permanent glacier mask

- National Snow and Ice Data Centre (NSIDC)

Ref.: GLIMS and NSIDC (2005, updated 2014): Global Land Ice Measurements from Space glacier database. Compiled and made available by the international GLIMS community and the National Snow and Ice Data Center, Boulder CO, U.S.A. DOI:10.7265/N5V98602. (http://glims.colorado.edu/glacierdata/)

⟹ Downloaded as shape and rasterized to the PROBA-V 1 km world size.

Volcanic soil mask

- The Holocene Volcano List

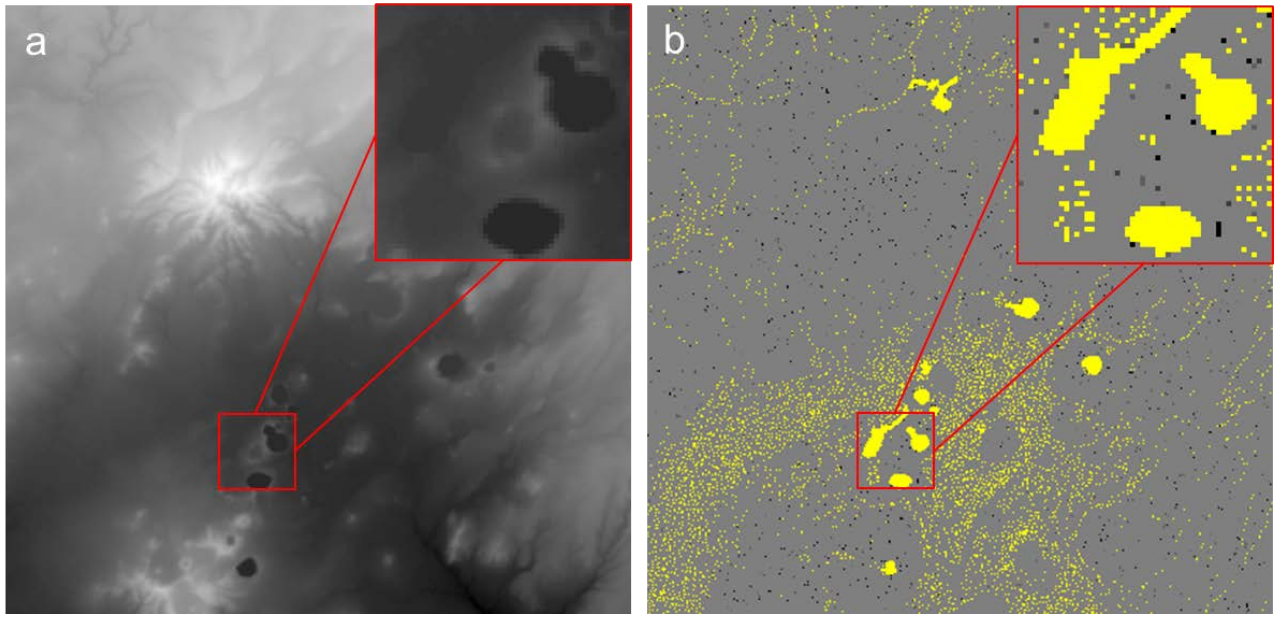
Ref.: Smithsonian Institution, National Museum of natural History, Global Volcanism Program. (http://www.volcano.si.edu/)

⟹ Delineated on Google Earth and rasterized to the PROBA-V 1 km world size.

Input data – Constructing the WB potential mask

1. Search for the lowest points in the terrain

Pixel elevation ≤ elevation of its eight neighbors



a) GLSDEM (↔ 90 m; ↕ 1 m)

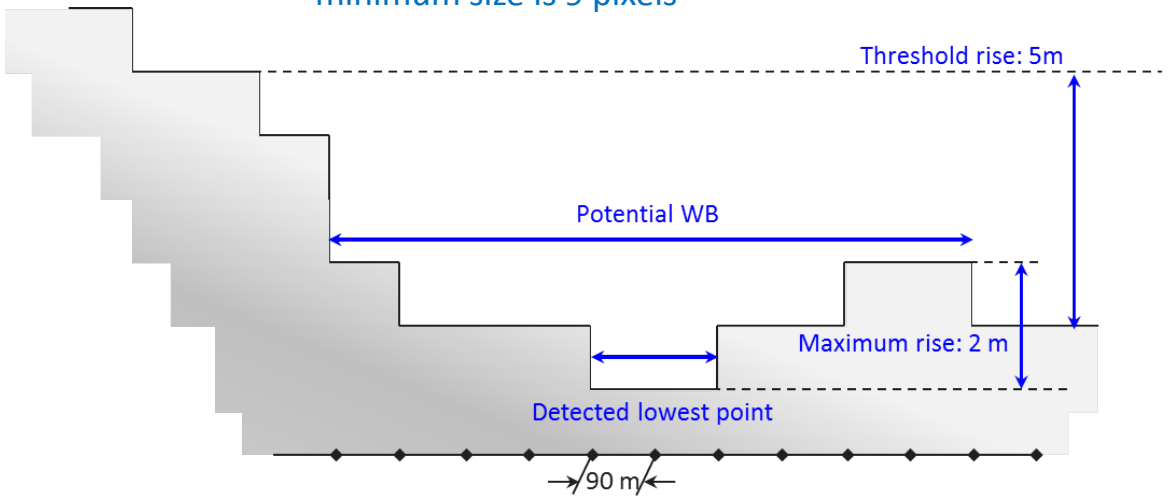
b) detected lowest points

Detected pixels with 8 neighbors of equal elevation→ **Level 1** otherwise → **Level 2**

Input data – Constructing the WB potential mask

2. Filtering and expanding the detected lowest points

- an imaginary water level is raised in steps of 1m
- the maximum rise of 5m is reached
- minimum size is 9 pixels



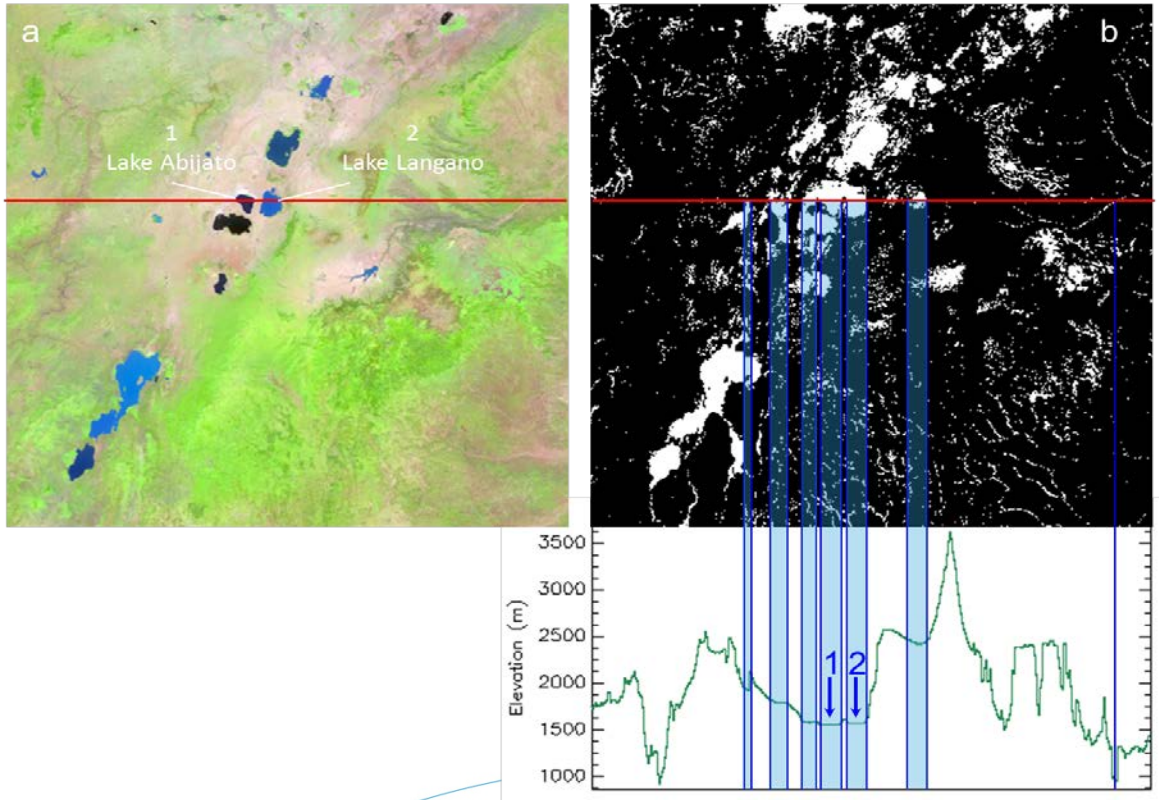
- Added pixels → **Level 2**

Input data – Constructing the WB potential mask

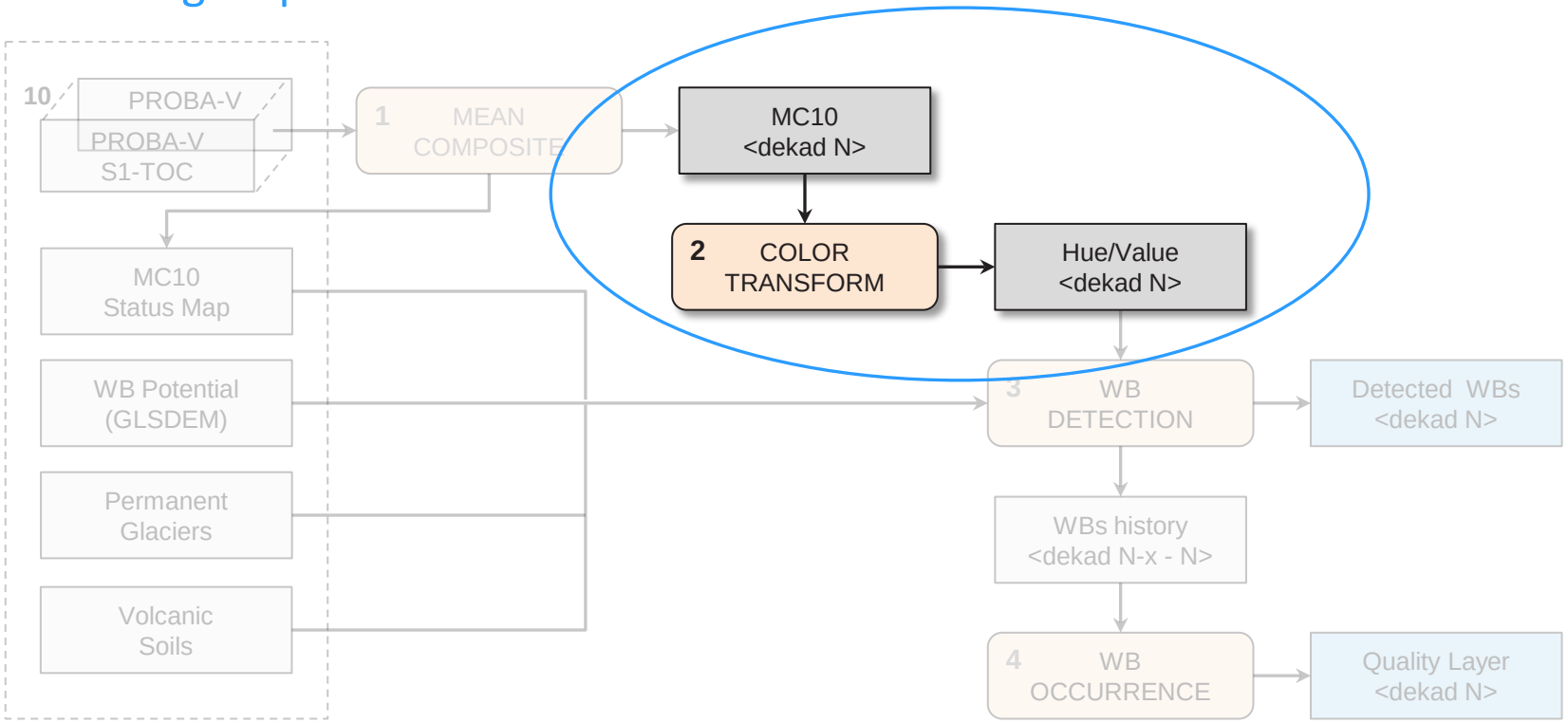
3. Deriving the 1 km WBPM from the 90 m potential WBs

Set the WBPM pixel when:

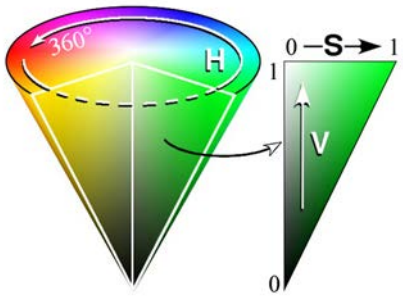
- at least one of the corresponding pixels has ‘Level 1’
- minimum 9 of corresponding pixels have ‘Level 2’



Processing step 2: HSV color transform



Red – NIR – SWIR

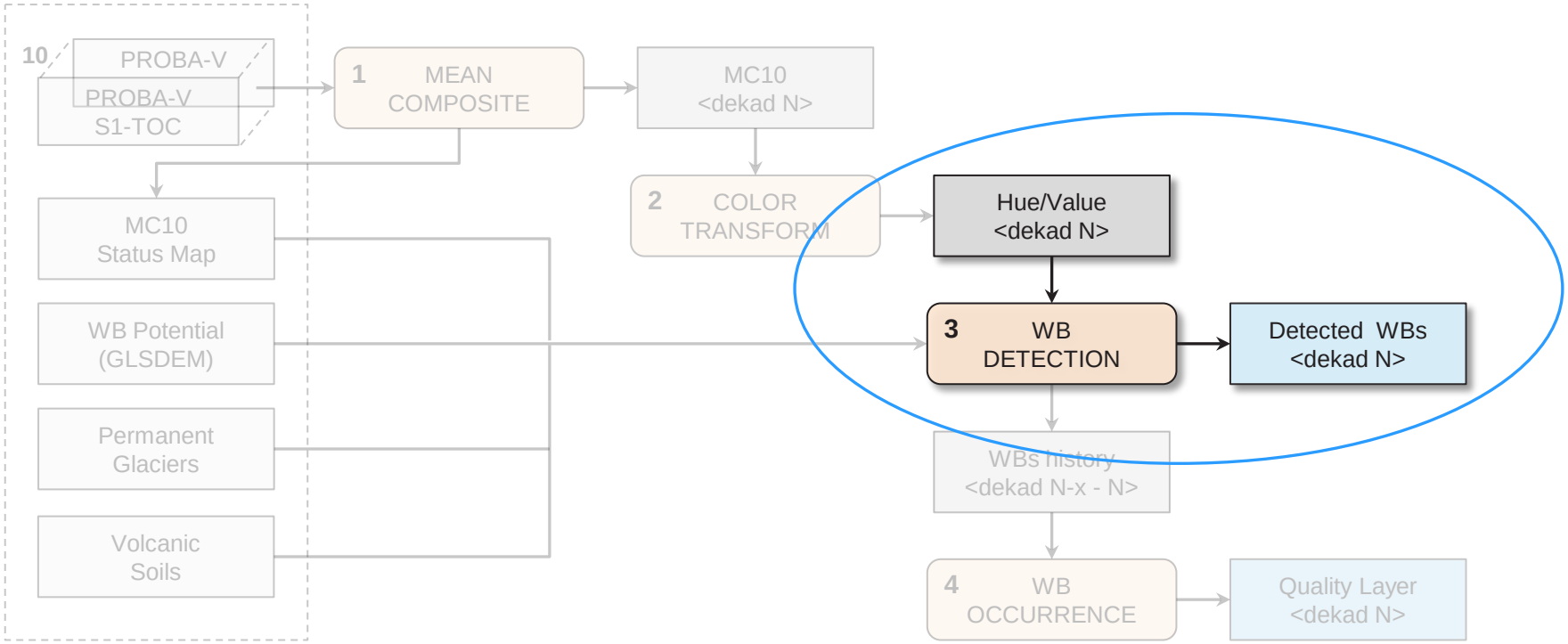


- HUE → dominant wavelength
- Saturation → the degree of purity of the color
- VALUE → brightness approximation

⟹ use HUE and VALUE for WB detection

Ref. Pekel *et al*. (2014)

Processing step 3: Water Body detection



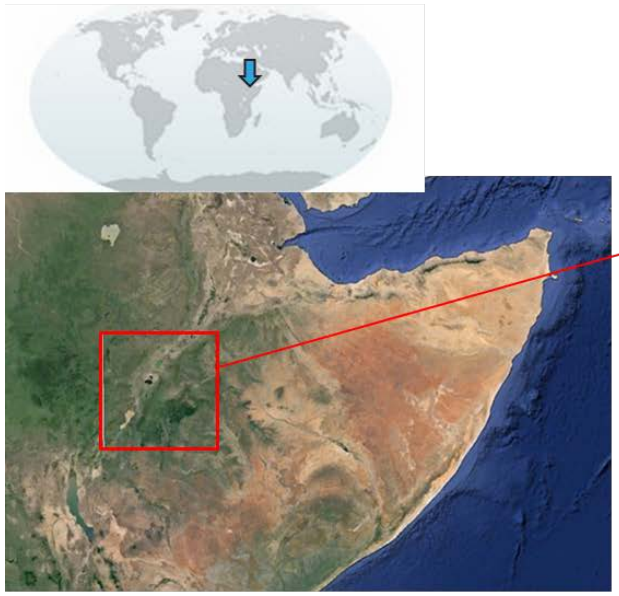
⟹ Defining the thresholds on HUE and VALUE

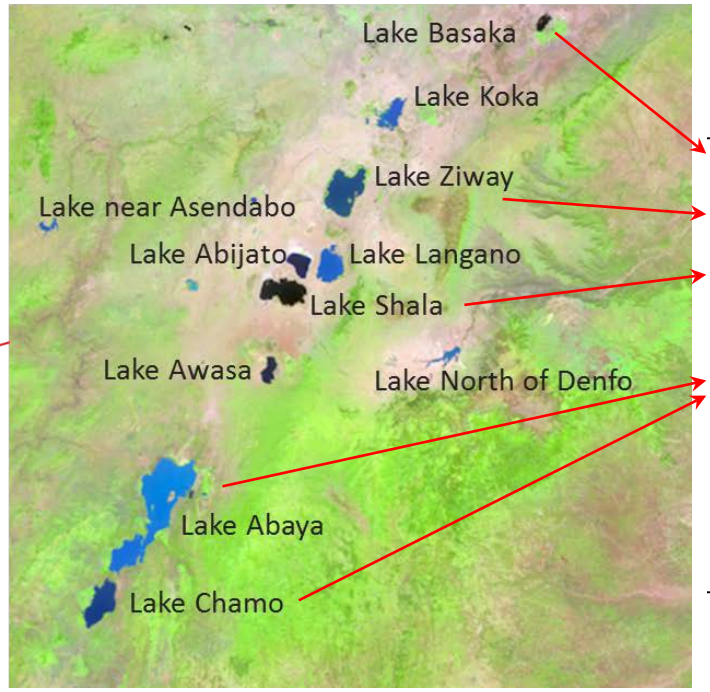
- Empirically & Iteratively

Water Body detection – The Ethiopian Rift Valley

One of the focus areas for developing the WBDA
⟹ Some typical values for HUE and VALUE

Ethiopia, Rift Valley test area ($\pm$ 150 km^2)

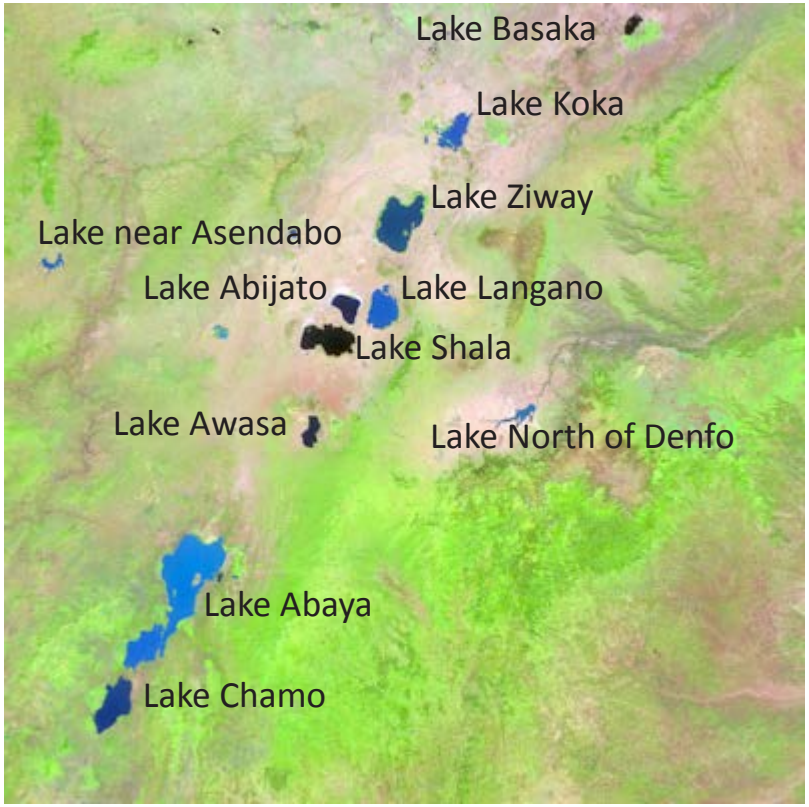




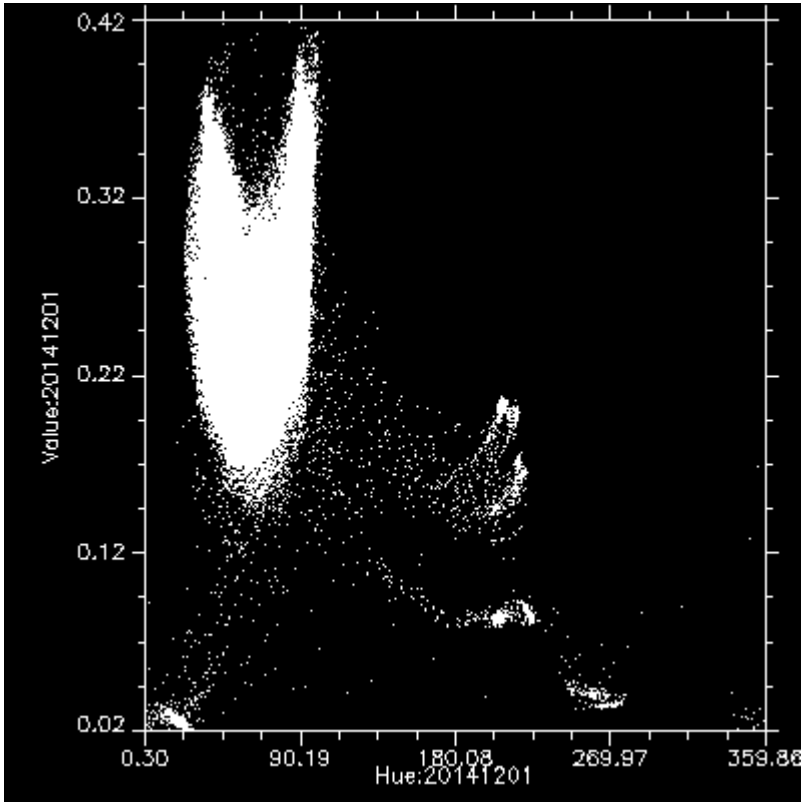
Dekad 20131021: SWIR, NIR & Red → RGB channels

Water body	# Pixels	Hue	Value
Lake Basaka	56	17	0.03
Lake Koka	182	216	0.20
Lake Ziway	456	200	0.10
Lake Abijato	134	257	0.04
Lake Shala	313	26	0.02
Lake North of Denfo	56	205	0.15
Lake Awasa	95	265	0.03
Lake Abaya	1256	209	0.21
Lake Chamo	326	224	0.10
Lake Chilotes	1	61	0.13
Lake Wonchi	3	66	0.06
Lake Guda	1	66	0.15
Lake Chelekleka	2	99	0.16
Lake Hora	2	77	0.16
Lake Bishoftu	1	71	0.12

Water Body detection – Defining the thresholds

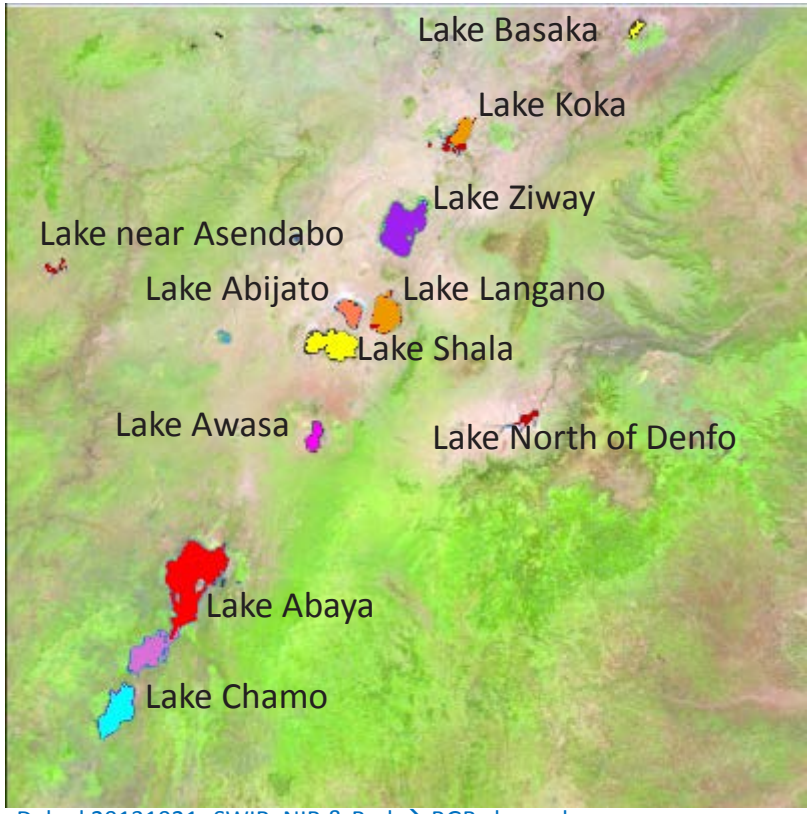


Dekad 20131021: SWIR, NIR & Red → RGB channels

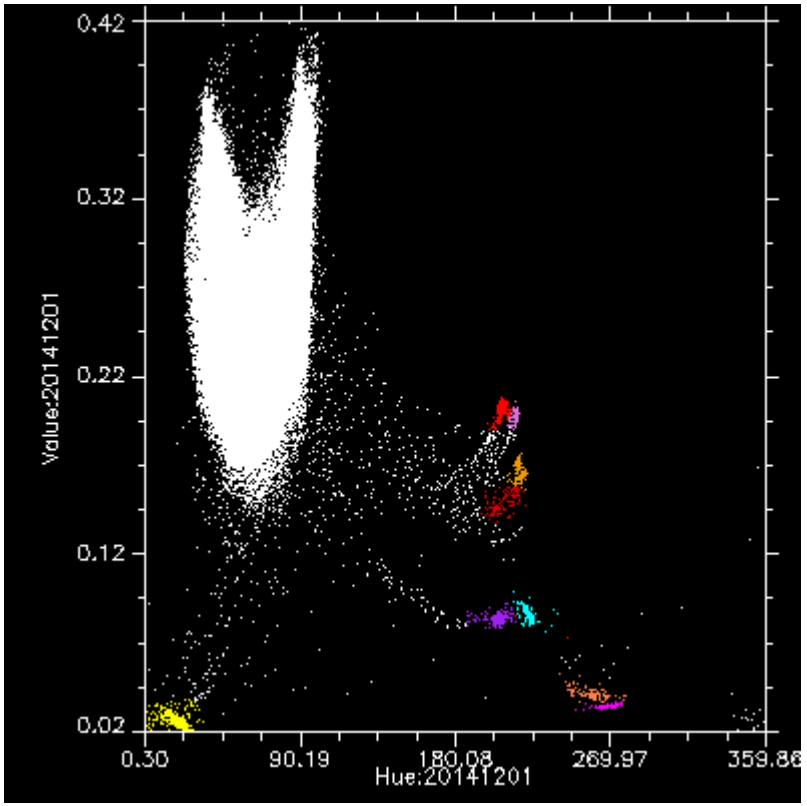


2D scatter plot: HUE - VALUE

Water Body detection – Defining the thresholds



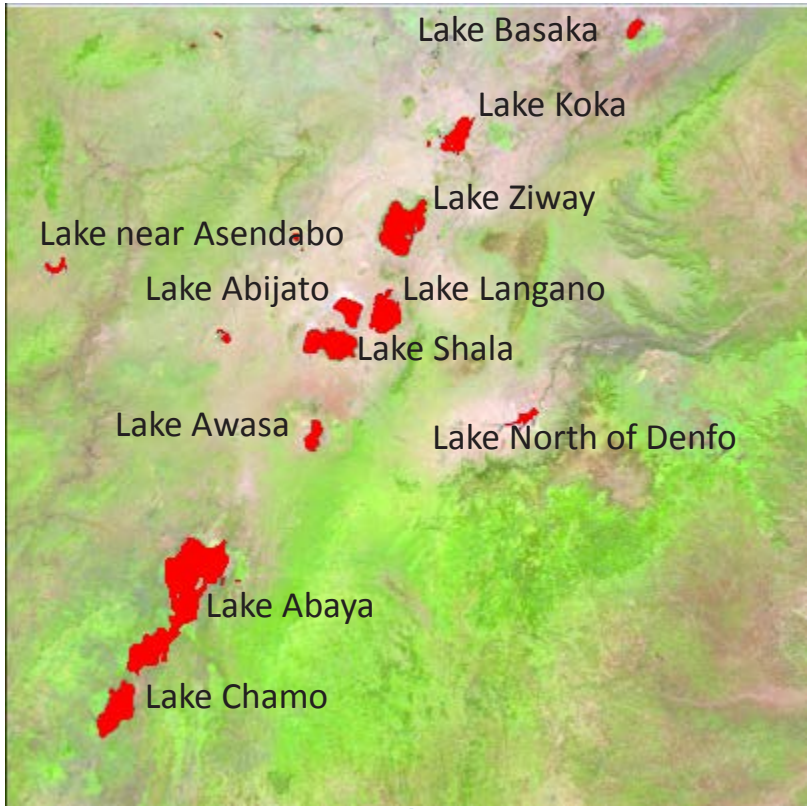
Dekad 20131021: SWIR, NIR & Red → RGB channels



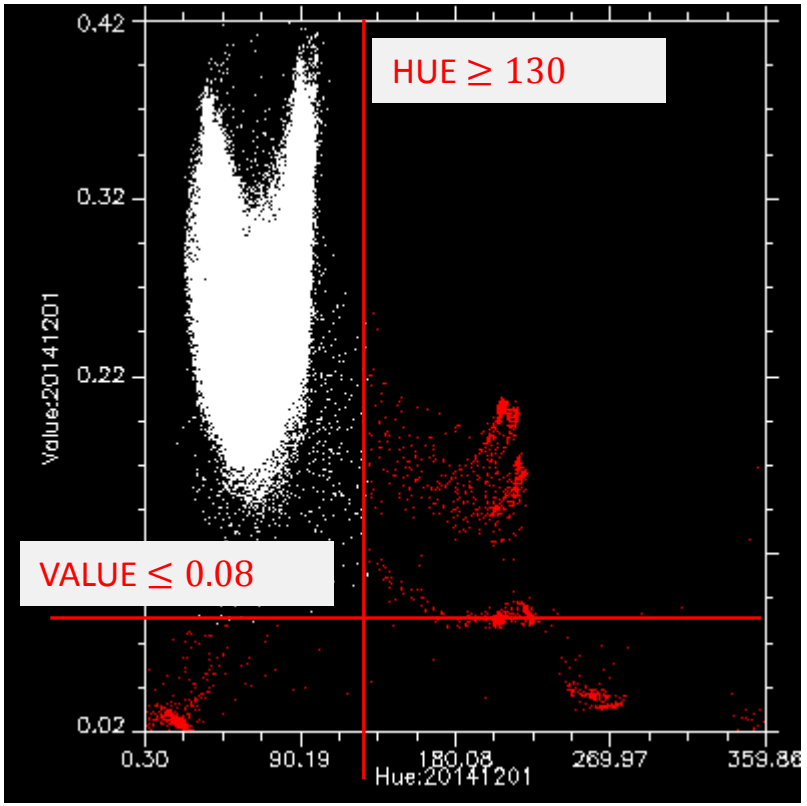
2D scatter plot: HUE - VALUE

Water Body detection – Defining the thresholds

20 lakes are detected
Further refining the thresholds considerably increased the commission errors

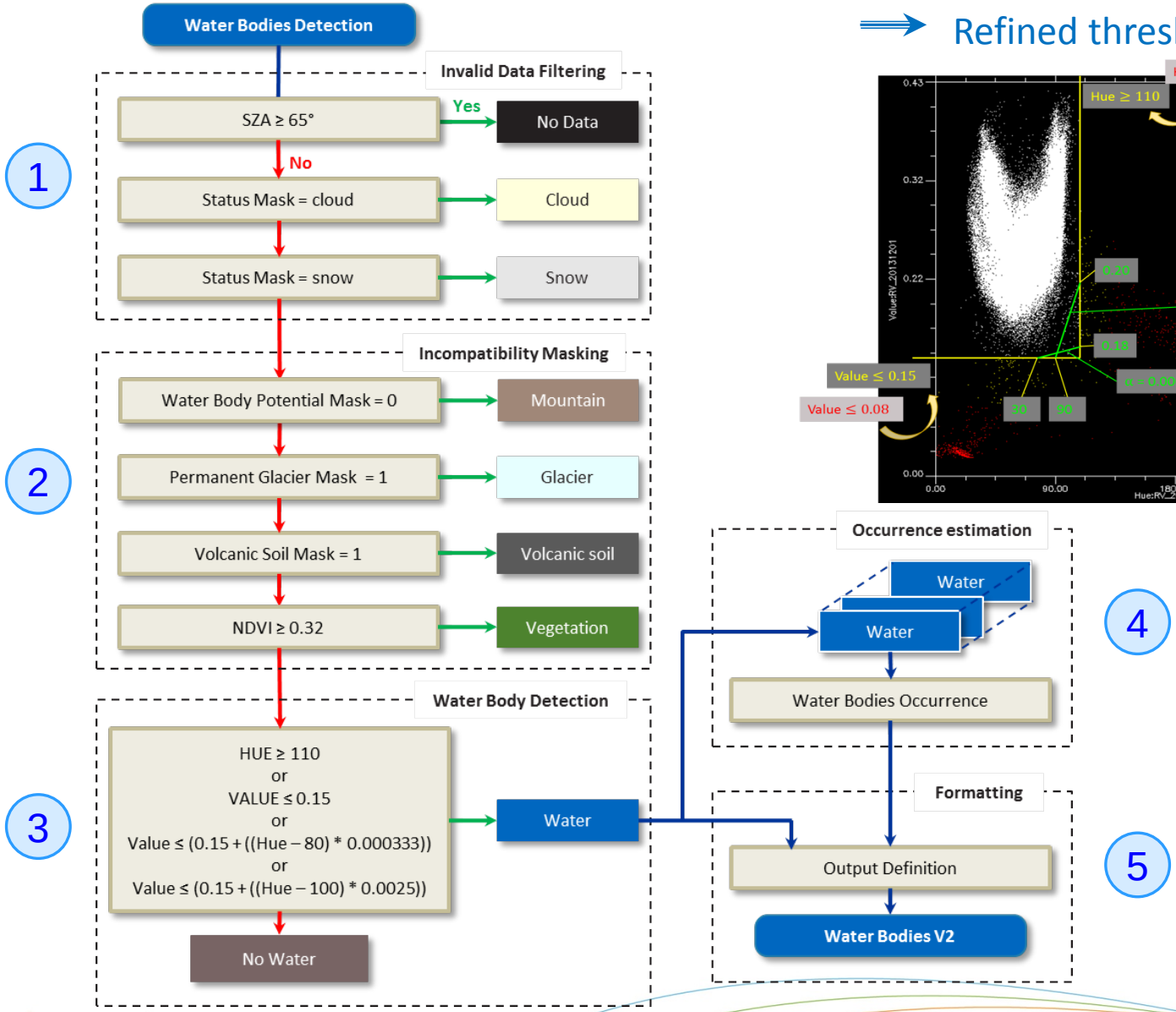


Dekad 20131021: SWIR, NIR & Red → RGB channels



2D scatter plot: HUE - VALUE

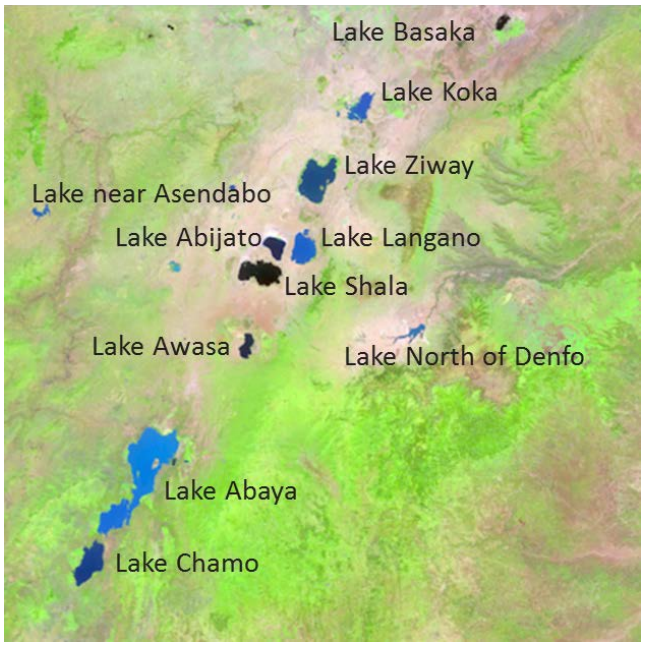
Water Body detection – Decision Tree Classification



Refined thresholds

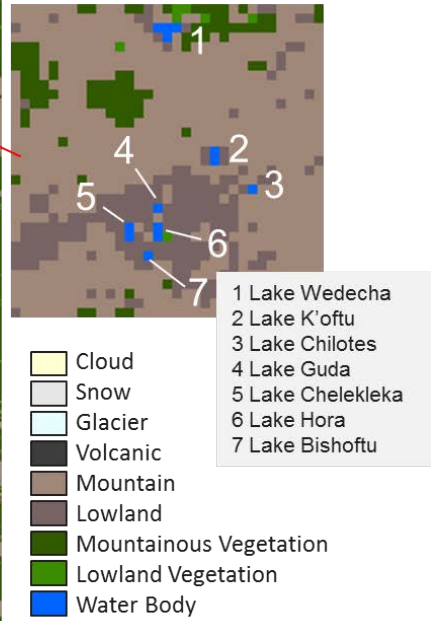
Water Body detection – Decision Tree Classification result

In total 32 WBs were detected on dekad 21 Oct. 2013
20 WBs were detected using the rough thresholds
12 WBs were detected using the refined thresholds

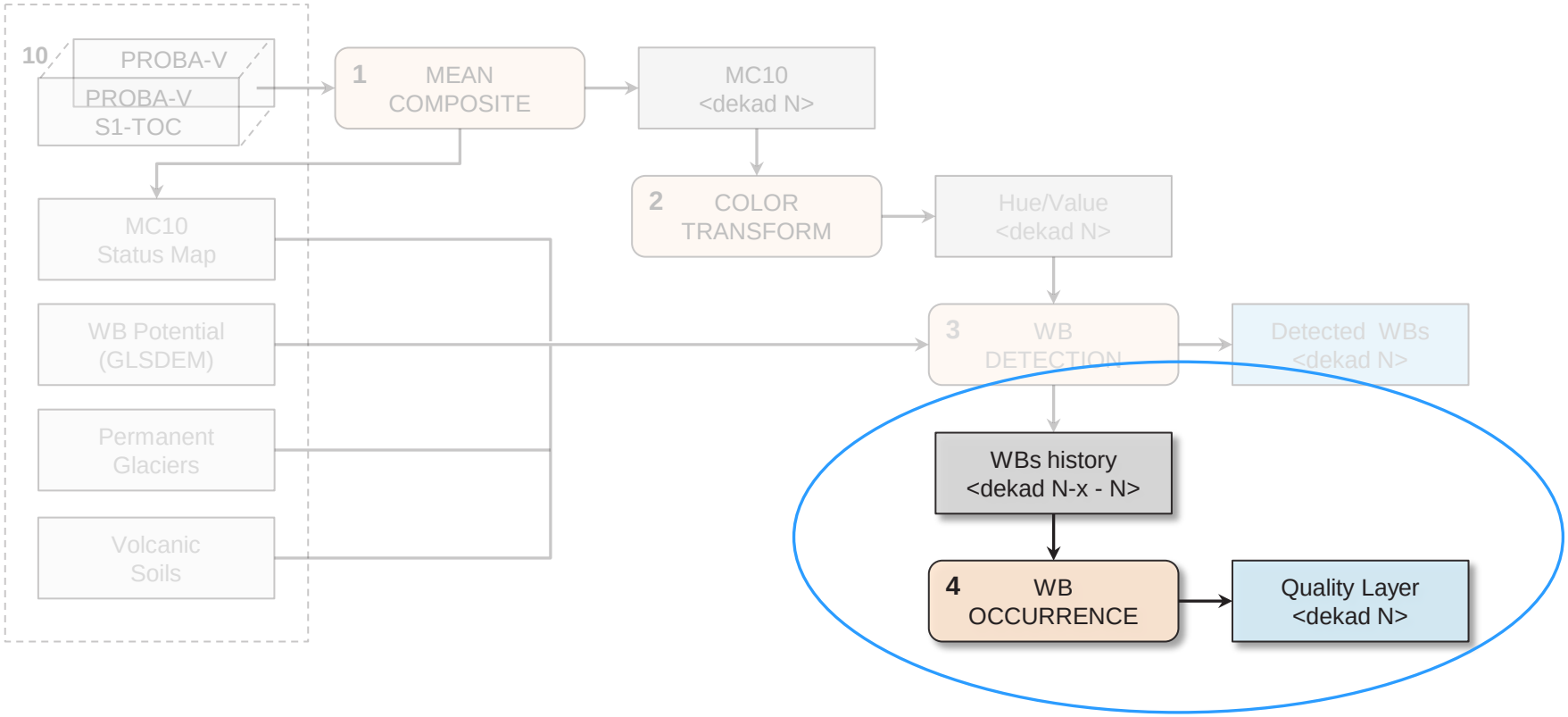


Dekad 20131021: SWIR, NIR & Red → RGB channels

DTC result



Water Body – Occurrence estimation

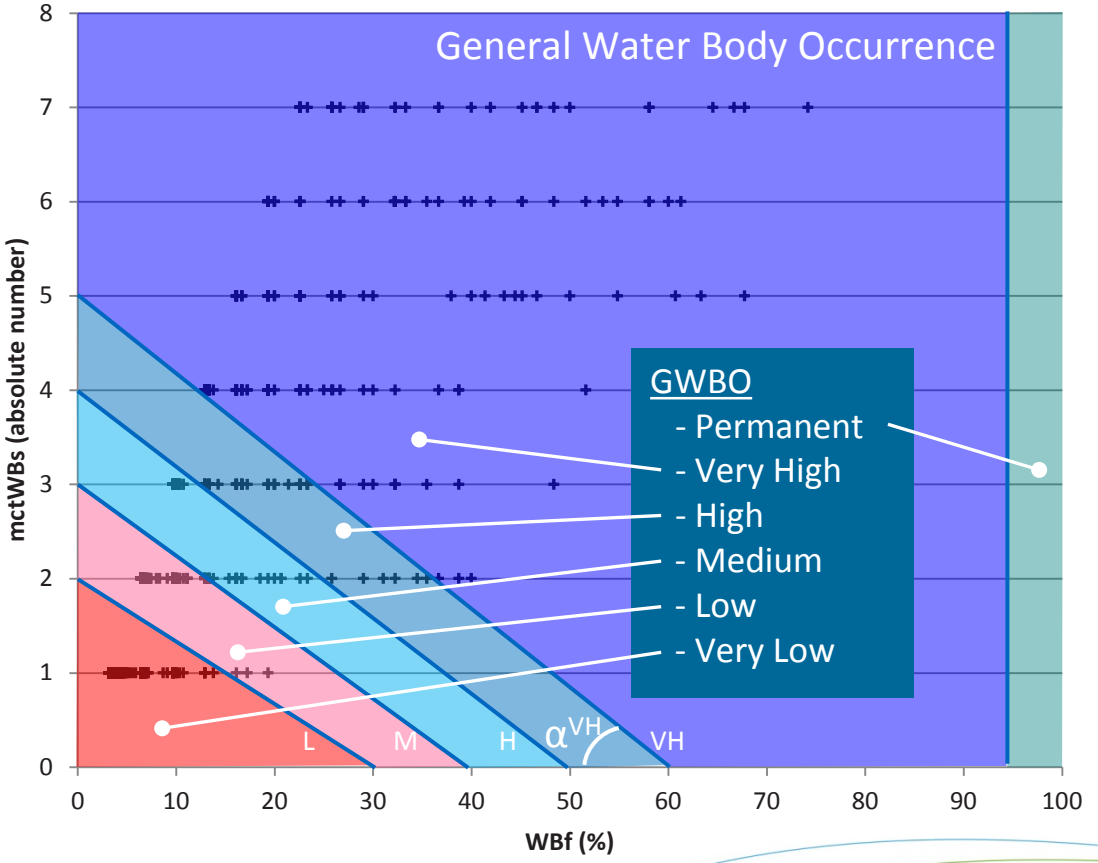


⟹ To qualify the occurrence of the detected water bodies

Water Body – Occurrence estimation

Deriving the General WB Occurrence using per pixel temporal-sequential statistics:

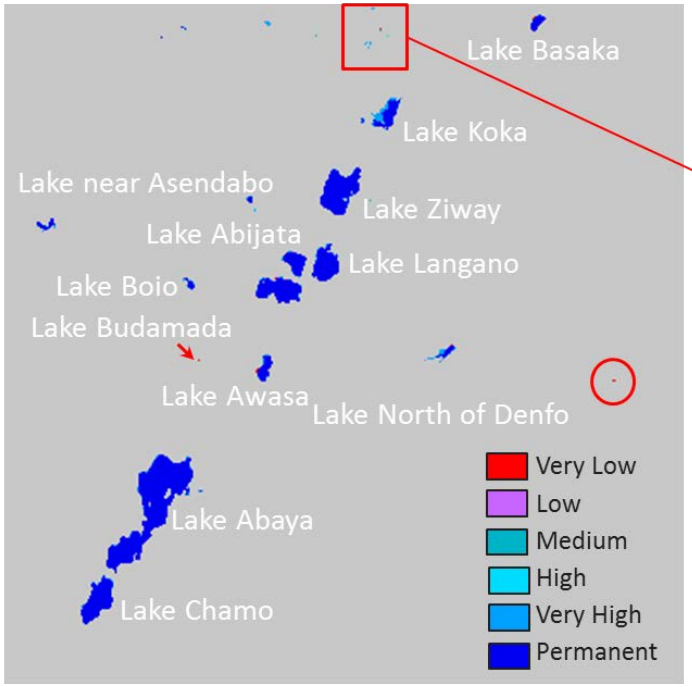
- Total number of temporal cloud free observations (*ntObs*)*
- Total number of temporal WB detections (*ntWBs*)
- Maximum number of continuous temporal WB detections (*mctWBs*)



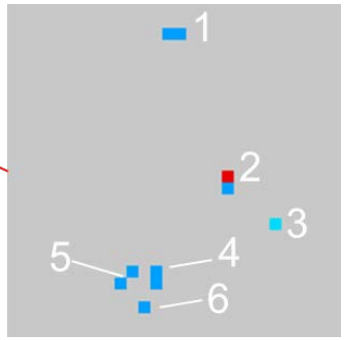
* *Max 64 dekads*

$$WB\ frequency = \frac{ntWBs}{ntObs}$$

Water Body – Occurrence estimation

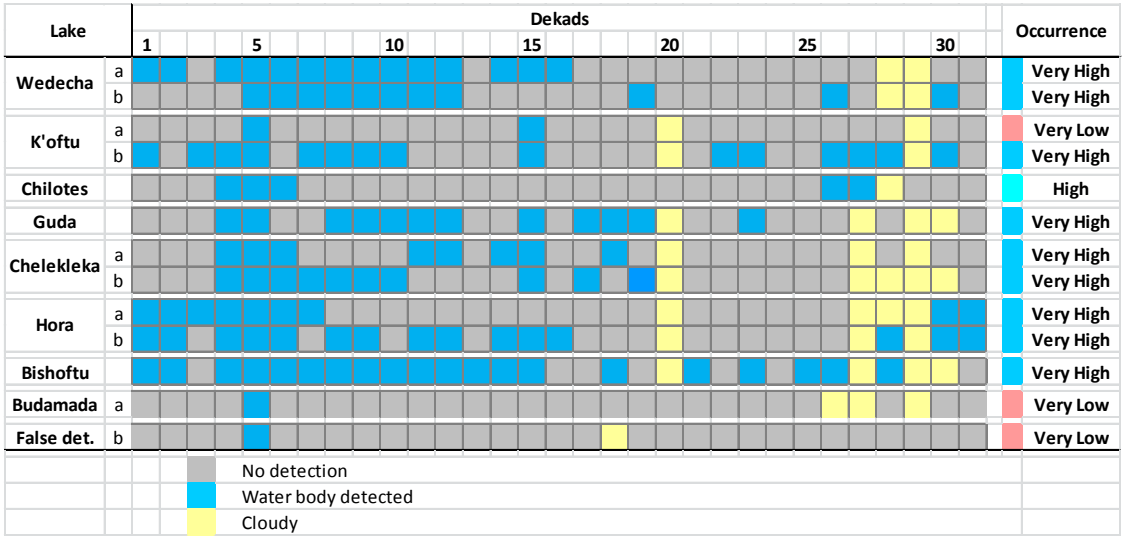


WB Occurrence – MC10_20131201



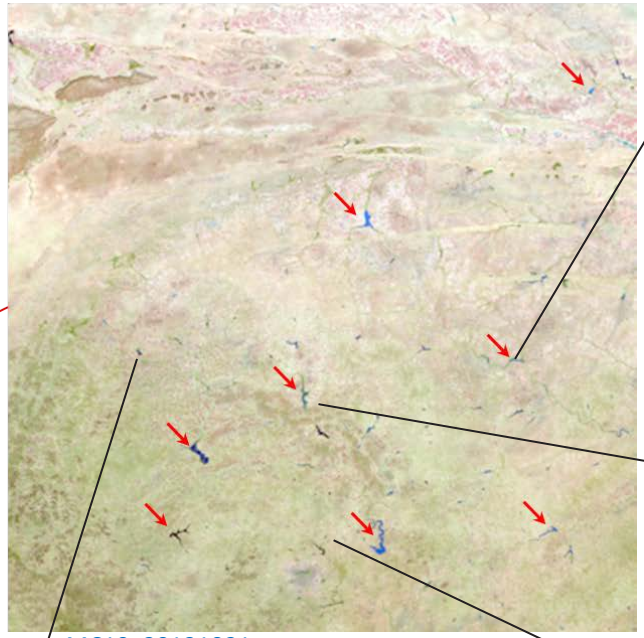
1 Lake Wedecha
2 Lake K'oftu
3 Lake Chilotes
4 Lake Chelekleka
5 Lake Hora
6 Lake Bishoftu

From MC10_20131021 (1) till MC10_20140821 (31)

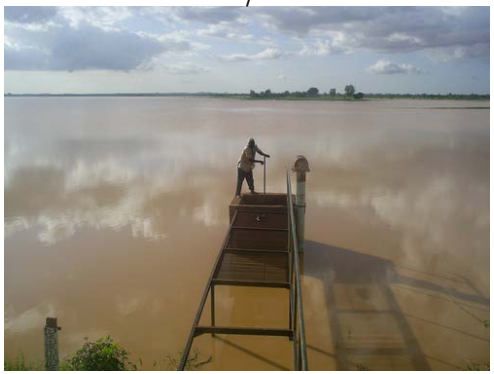


Water Body – The Sahel test area

Sahel test area ($\pm$ 150 km^2)



MC10_20131021



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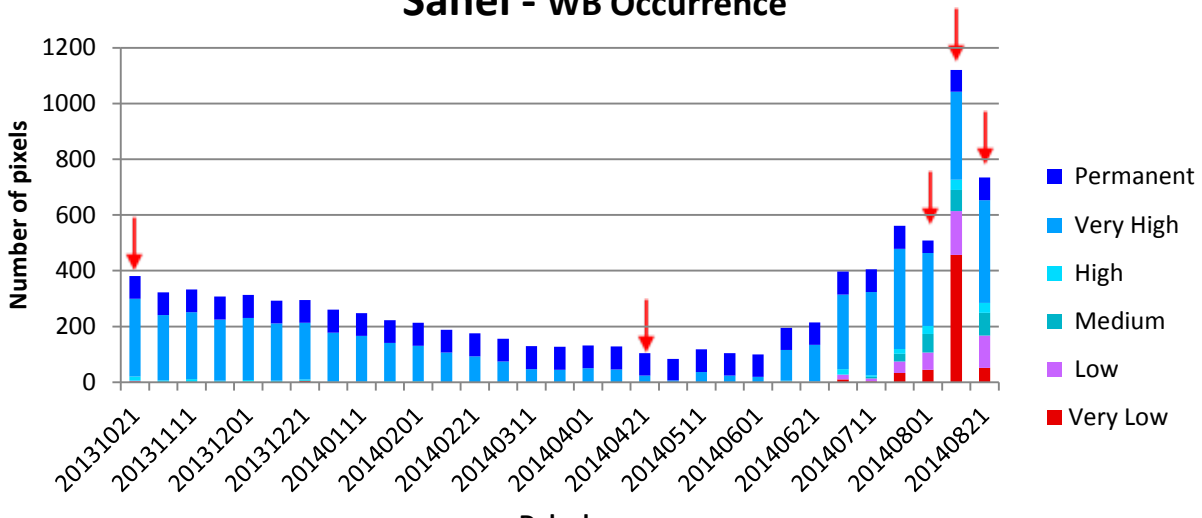
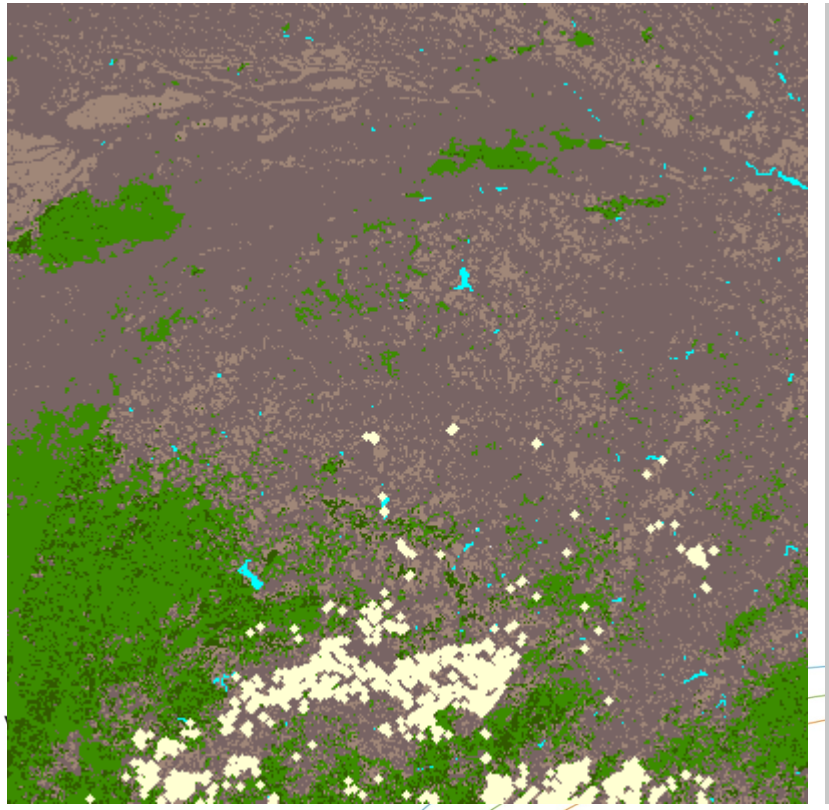
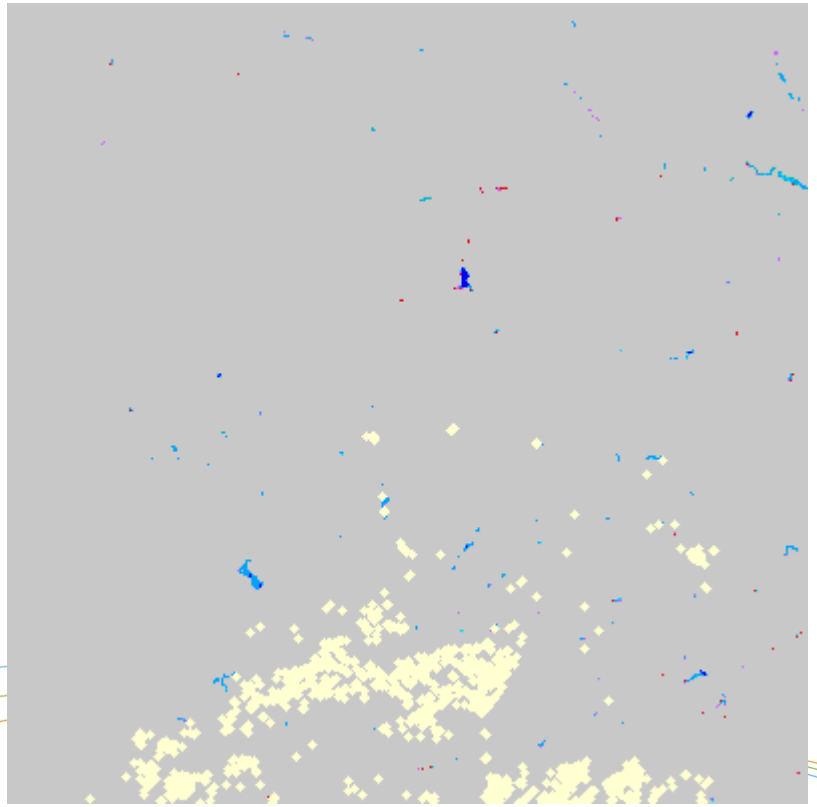
Sahel - WB Occurrence



Decision Tree Classification



Water Body Occurrence



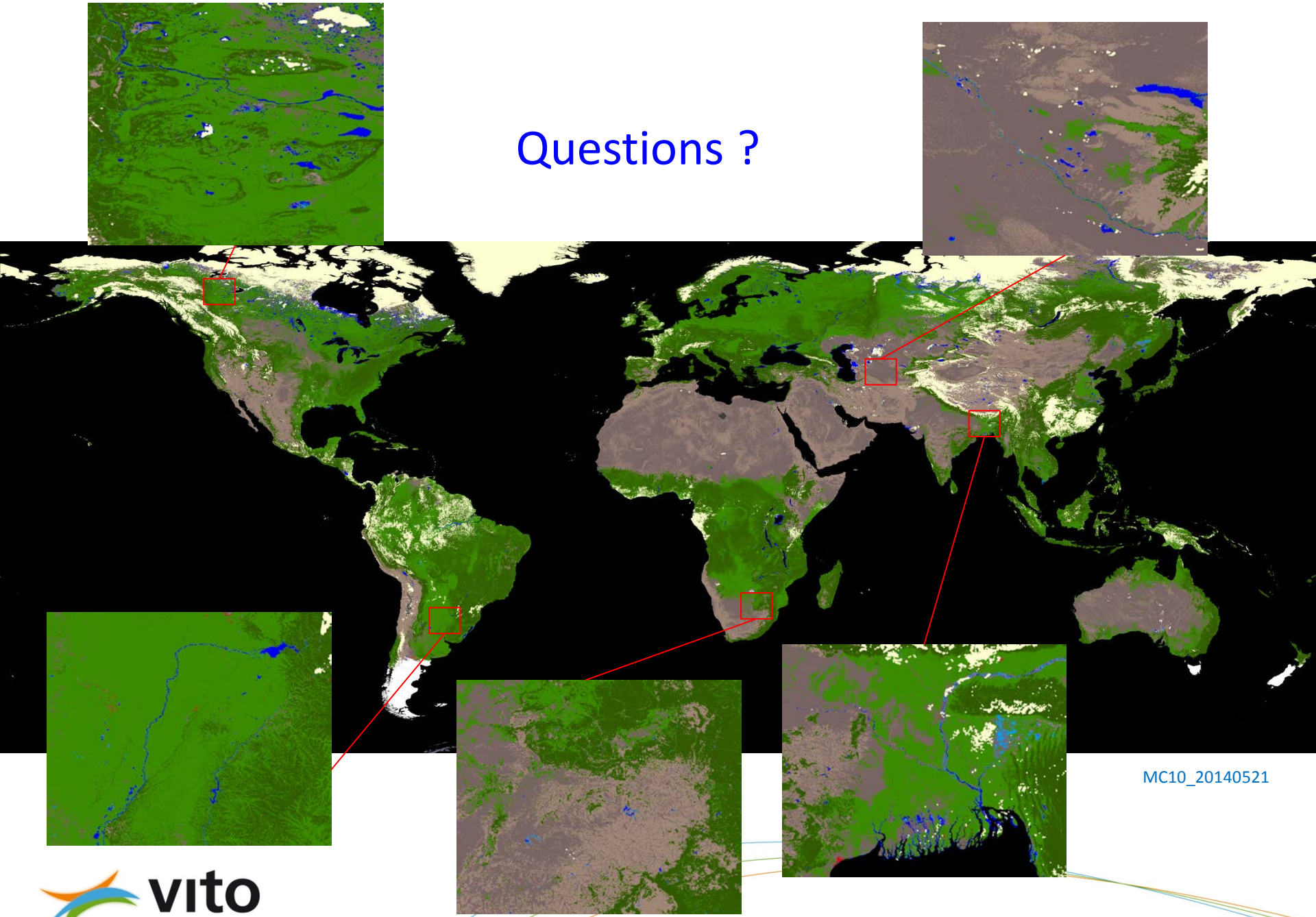
Water Body Detection – Conclusion

- Water body detection using HSV transformed Red – NIR –SWIR bands proved to be successful (MODIS, Pekel 2014).
- Applying the adapted WBDA to PROBA-V 1km revealed successful WB detection.
- Applying the Water Body Potential Mask considerable decreased the commission errors.
- The Water Body Occurrence reflects the history of the WBs and therefore adds additional information to the product.

Water Body Detection – Upcoming

- Adapting the WBDA for historical SPOT-VGT processing (1999 – 2014)
- Adapting the WBDA for PROBA-V 300m & 100m processing

Questions ?



MC10_20140521

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Water Body – A first Quality Assessment

- Detailed observations of detected WBs on 7 areas selected worldwide
- Validation using Google Earth (not always possible)

		Top - Left		
Id	**Name**	**Lat**	**Lon**	**Remark / Observations**
1	Sahel	15.611617	-3.2	Detected WBs show a good correlation with the rain season
2	South Africa	-27.665162	24.334789	Several WBs could not be validated (mining, salt planes ?)
3	India	26.566970	73.254424	Confusion with dark soils (not in the VSM)
4	China	36.084826	115.299060	Confusion with dark industrial areas, large cities → SZA !
5	Argentina	-30.343735	-67.602697	Confusion with salt planes & desert → flooded Yes/No ?
6	Canada	55.727680	-126.799116	Confusion with dense dark vegetation → SZA & NDVI !
7	Poland	53.406252	14.629433	Small WBs masked due to adjacency with vegetation

A full quality assessment will be done according the Service Validation Plan [GIOGL1-SVP], for the year 2014.