Automated Water Body Mapping and Potential Application in Asian Pacific Region

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Introduction

- Water bodies are important components of Earth's environment
- Water body mapping is one of the most relevant application of optical remote sensing
- Conventional automated water body extraction is based on NDWI, MNDWI or AWI.
- Reliability of these methods depends on selected thresholds and geographical regions
- Automation of analysis is limited over large area composed of multi scenes.

- We introduce a new method for fully automated water body extraction using spectral patterns
- The new method works for all Landsat data series TM, ETM+ and OLI after processing to Collection one products.

Materials

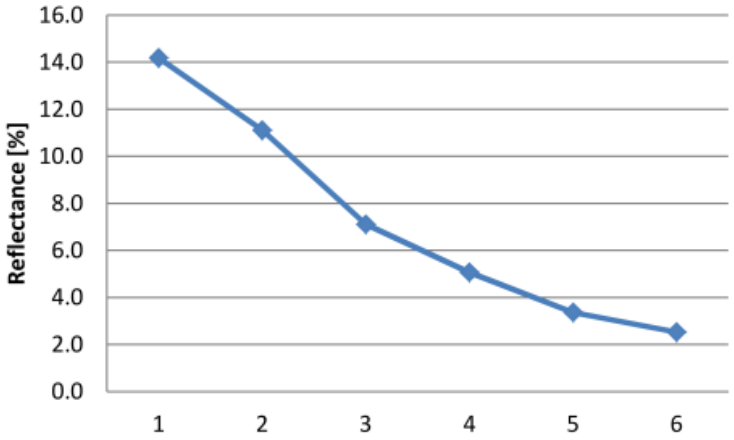
- Data used in this study includes Landsat scenes over Aral Sea in 1987 and 2016; Meghna River in Bangladesh in 1989 and 2017; Tonle Sap Lake from 1989 to 2017 with cloud coverage less than 10% (196 scenes in total); central Vietnam and southern Laos in 2015 and 2001.

Methods

- In Landsat image data, pixel value vector is defined by six values.
- Pixel value vector can be graphically visualized as spectral pattern
- Conventional classification methods use numerical values for analysis (computation of Index)
- We use shape of spectral pattern to classify land cover objects including water.

Pixel value vector {14.2, 11.1, 7.1, 5.1, 3.4, 2.5}

Spectral Pattern



Simplified Spectral Pattern

000000000000000

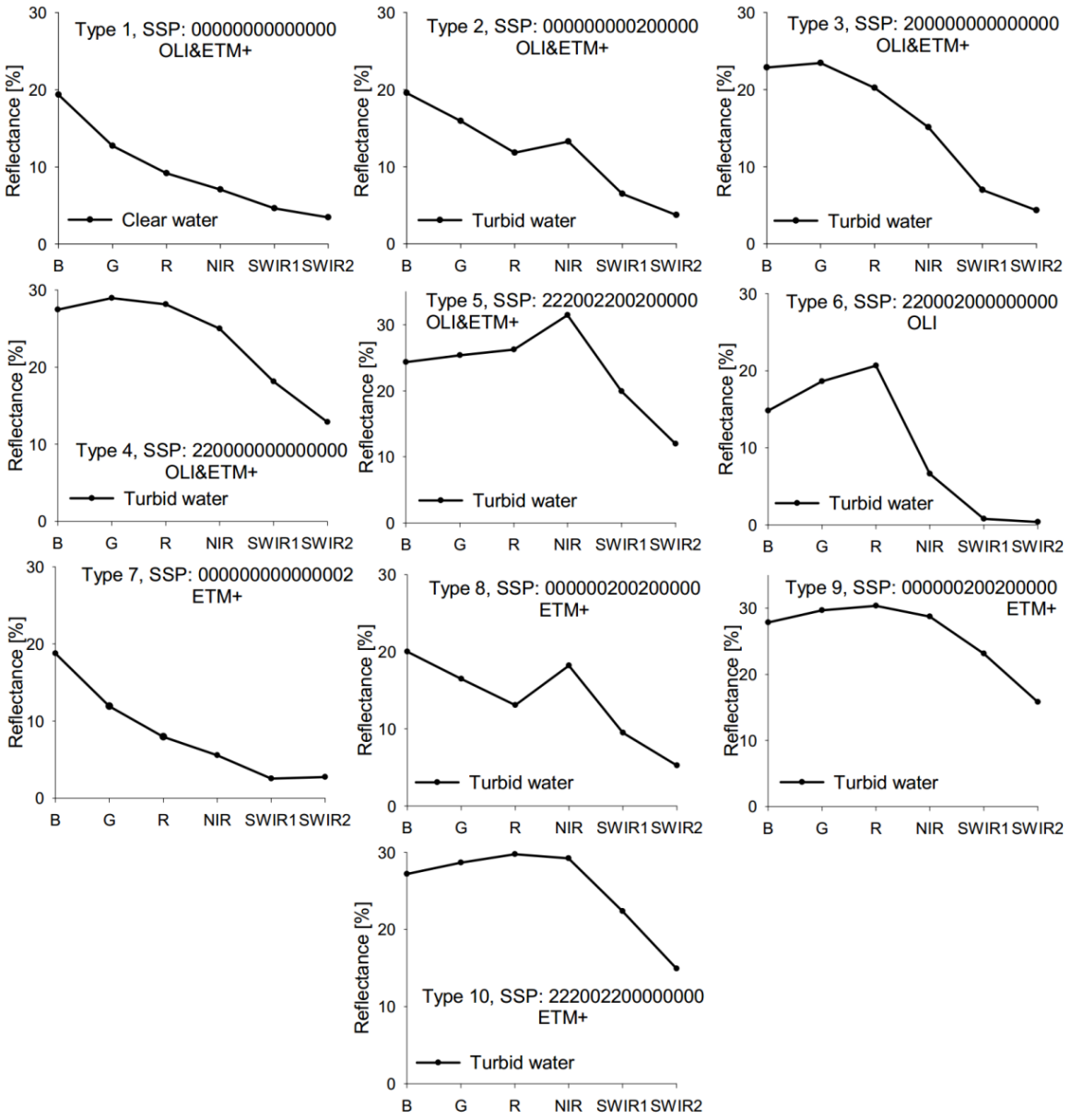
We developed a special method for transformation of spectral pattern from analogue to digital form which can be used for water extraction

$$m_{1,2}m_{1,3}m_{1,4}m_{1,5}m_{1,6}m_{2,3}m_{2,4}m_{2,5}m_{2,6}m_{3,4}m_{3,5}m_{3,6}m_{4,5}m_{4,6}m_{5,6}$$

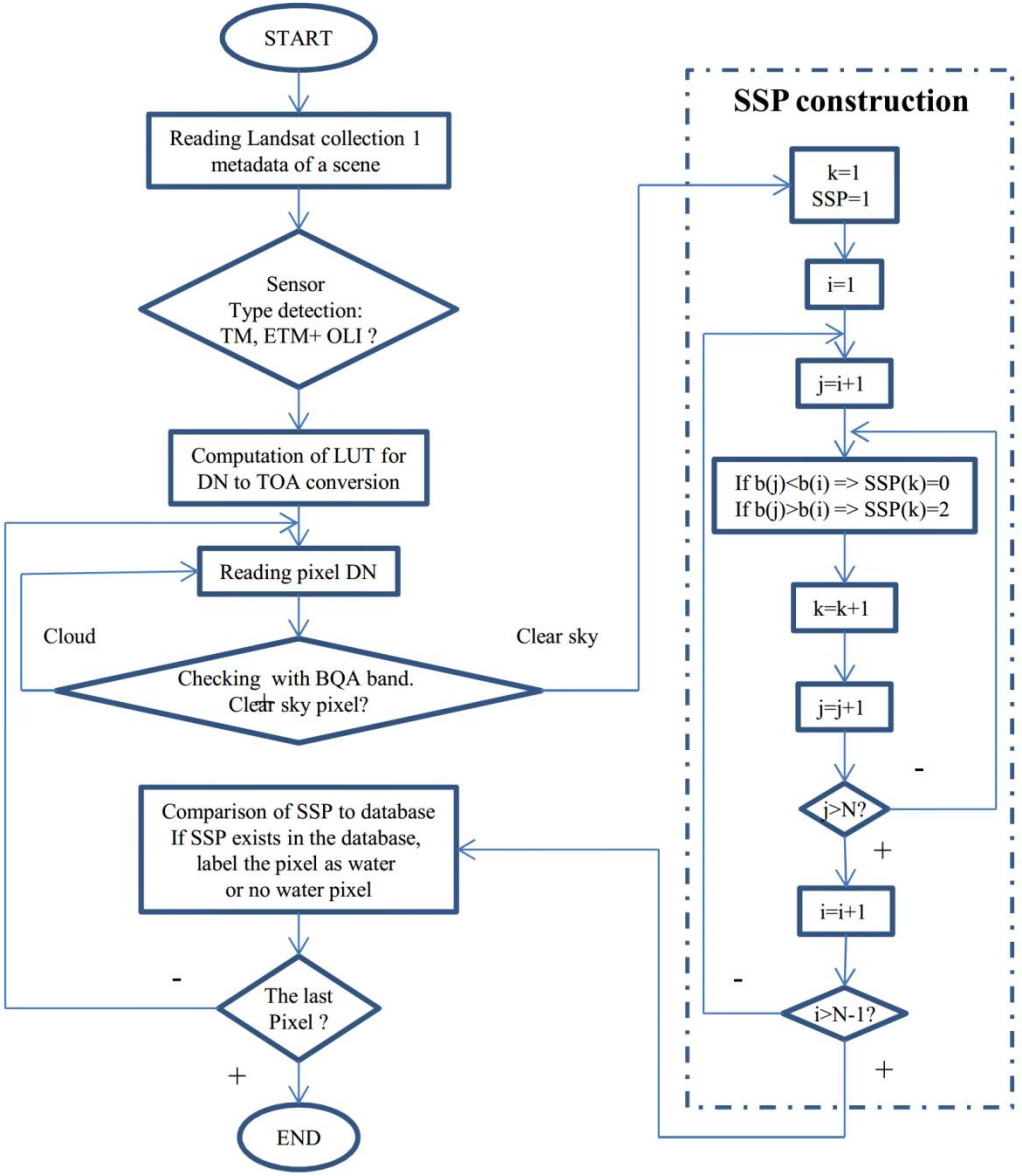
Where $m_{i,j}$ is the result of comparison between the reflectance of b_i and b_j and has values of 0 (if $b_j < b_i$.), 1 (if $b_j = b_i$), or 2 ($b_j > b_i$)

The SSP for Landsat data is composed of 15 digits

Simplified spectral patterns from ETM+ and OLI sensors



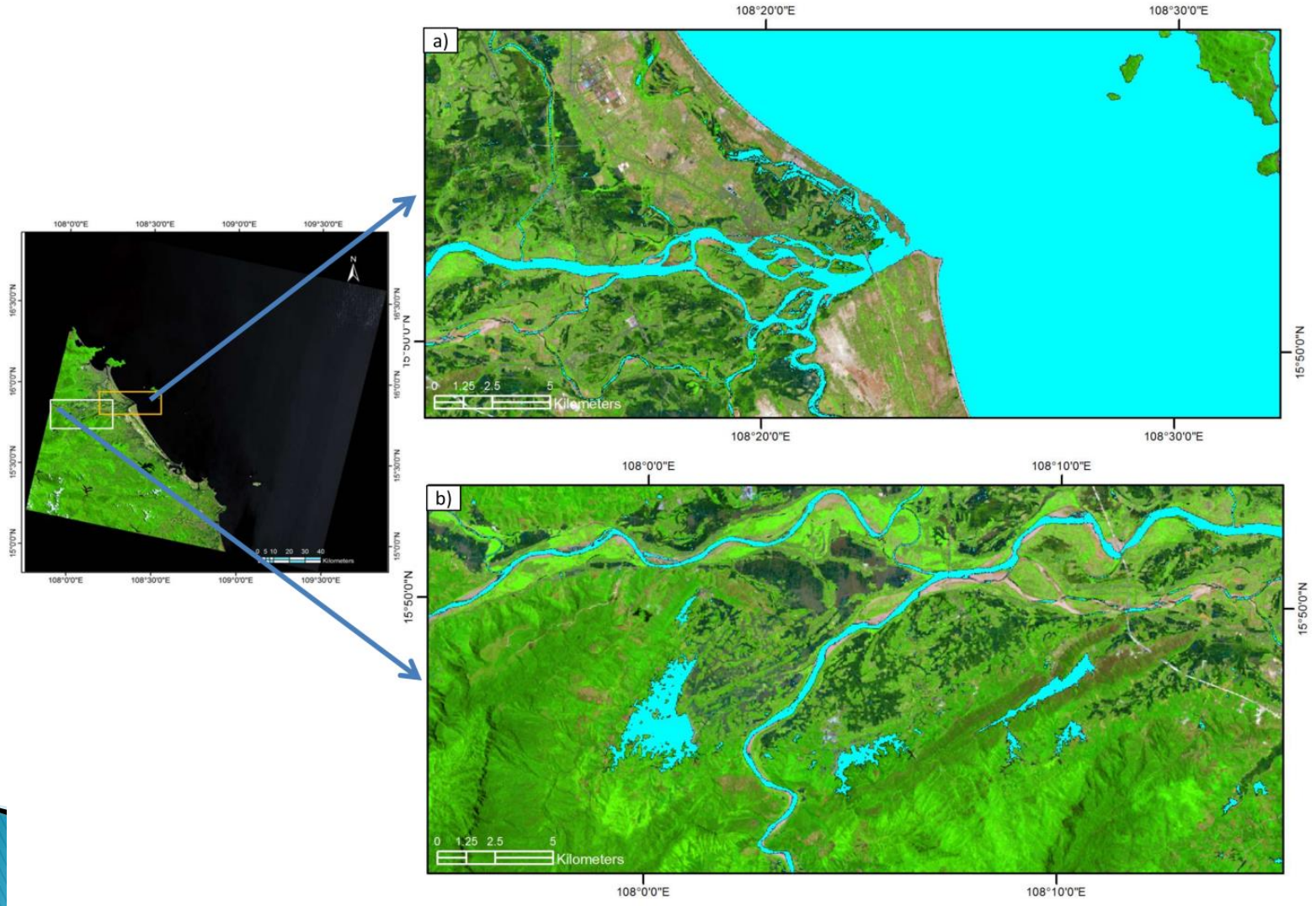
Schematic diagram of the algorithm for automated water body extraction using SSPs

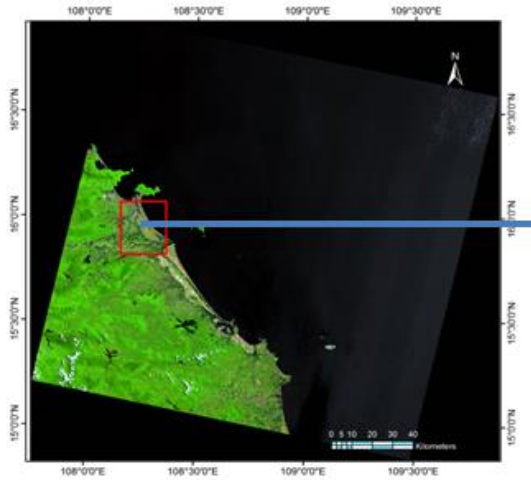


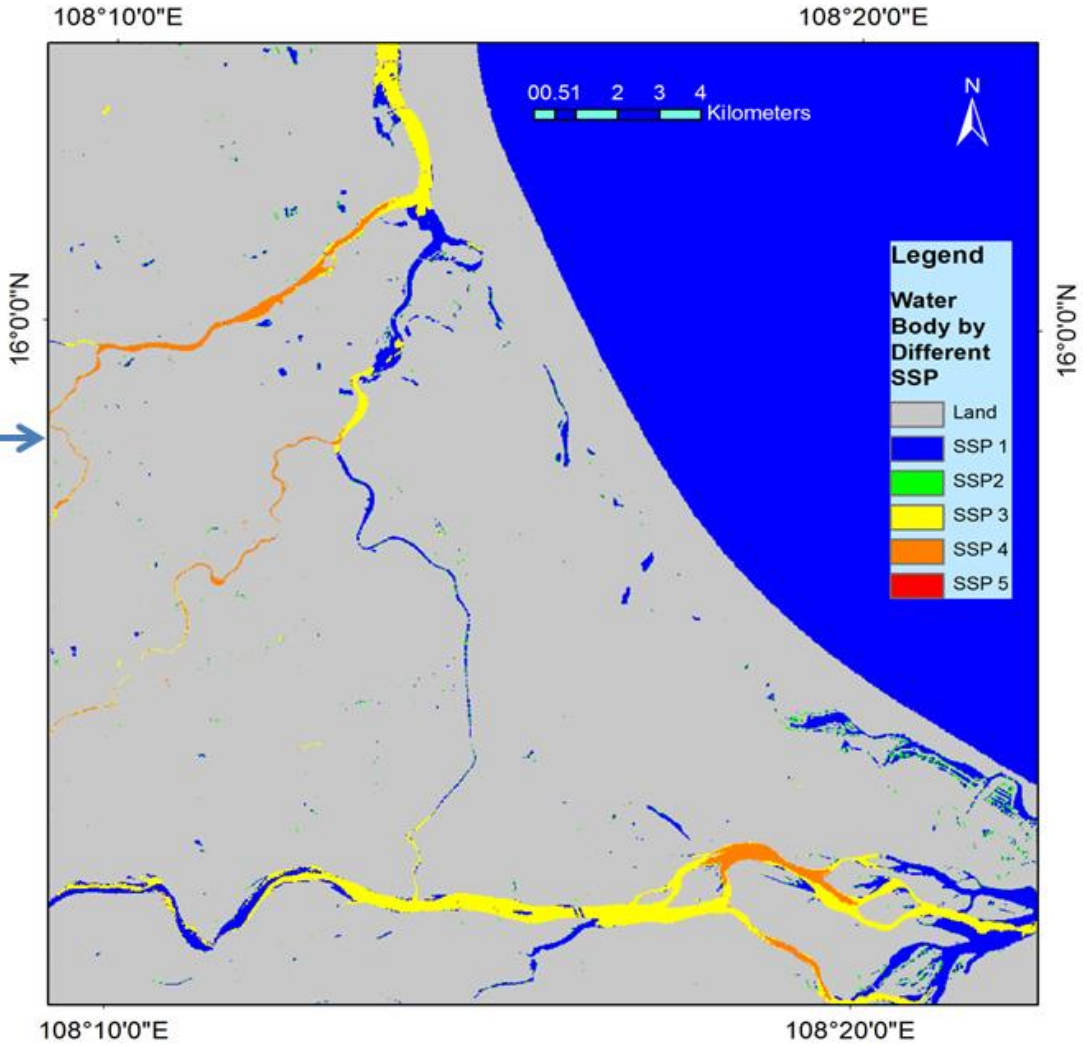
Implementation

- Implementation on Amazon Cloud computing AWS using EC2 platform
- Image data is retrieved from USGS EarthExplorer website by Python utility
- Water extraction module coded in C++ can process TM, ETM+ and OLI data
- Satellite image data retrieval is time consuming.
- The Landsat Collection one dataset is used as input for analysis

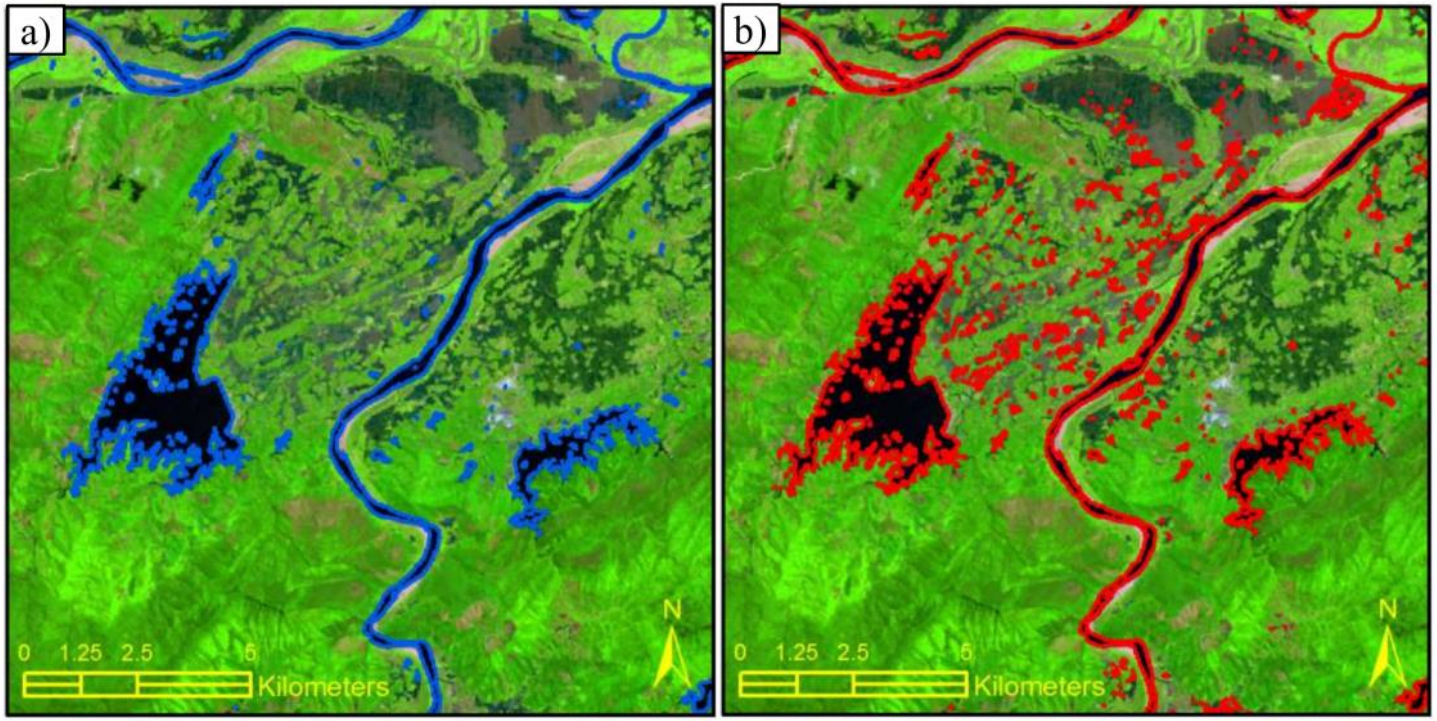
Case studies – Vietnam and Laos




108°0'0"E
108°30'0"E
109°0'0"E
109°30'0"E
N
0 5 10 20 30 40
Kilometers


108°10'0"E
108°20'0"E
16°0'0"N
00.51 2 3 4
Kilometers
N
Legend
Water Body by Different SSP
Land
SSP 1
SSP2
SSP 3
SSP 4
SSP 5

Comparison of water classification by a) NDWI and b) the proposed SSP method using scene LC812404920 15161LGN00



Comparison of water classification using the a) GIW dataset and b) proposed SSP method using scene LE71240492001082SGS00

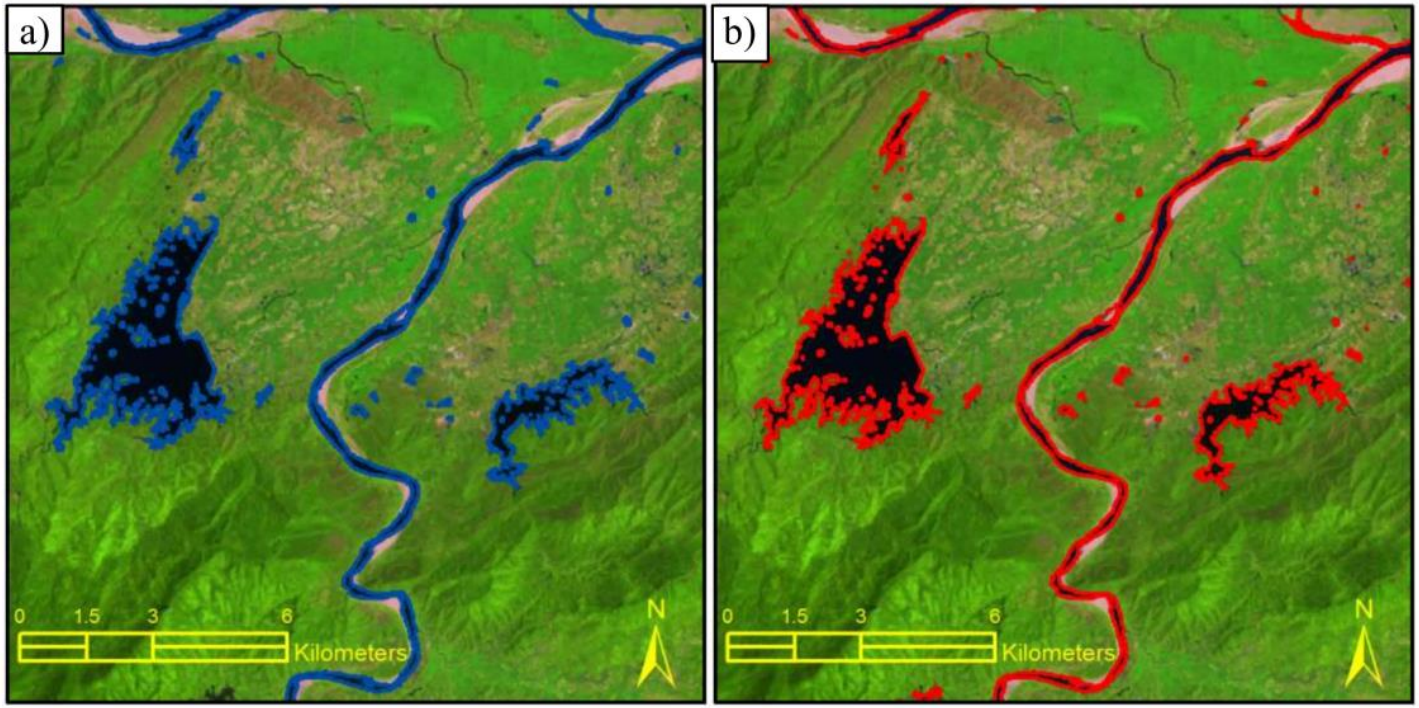
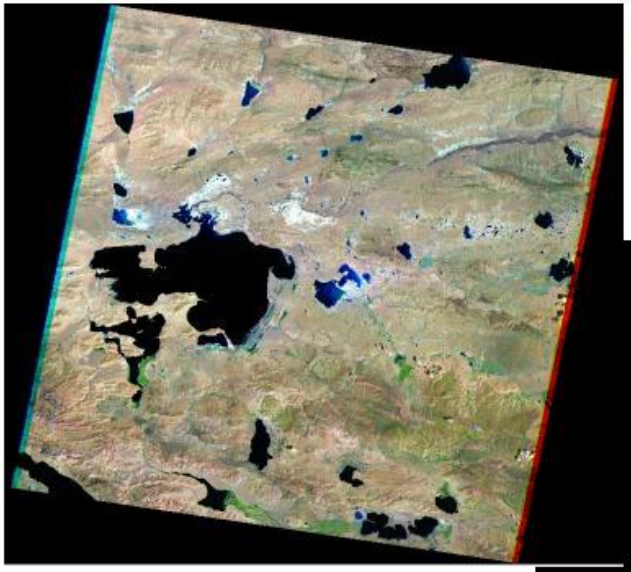


Image ID	User's accuracy	Producer's Accuracy	Kapa Coefficient
LC81240492015161LGN00	97.3	97.3	0.89
LC81250492015024LGN00	100.0	90.5	0.92
LC81240502015065LGN00	97.1	91.7	0.91
LC81250502015104LGN00	100.0	100.0	1.0

Accuracy assessment analysis with 100 random points for each Landsat scenes using high spatial resolution images of Google Earth

Case study in Tibet

Ca



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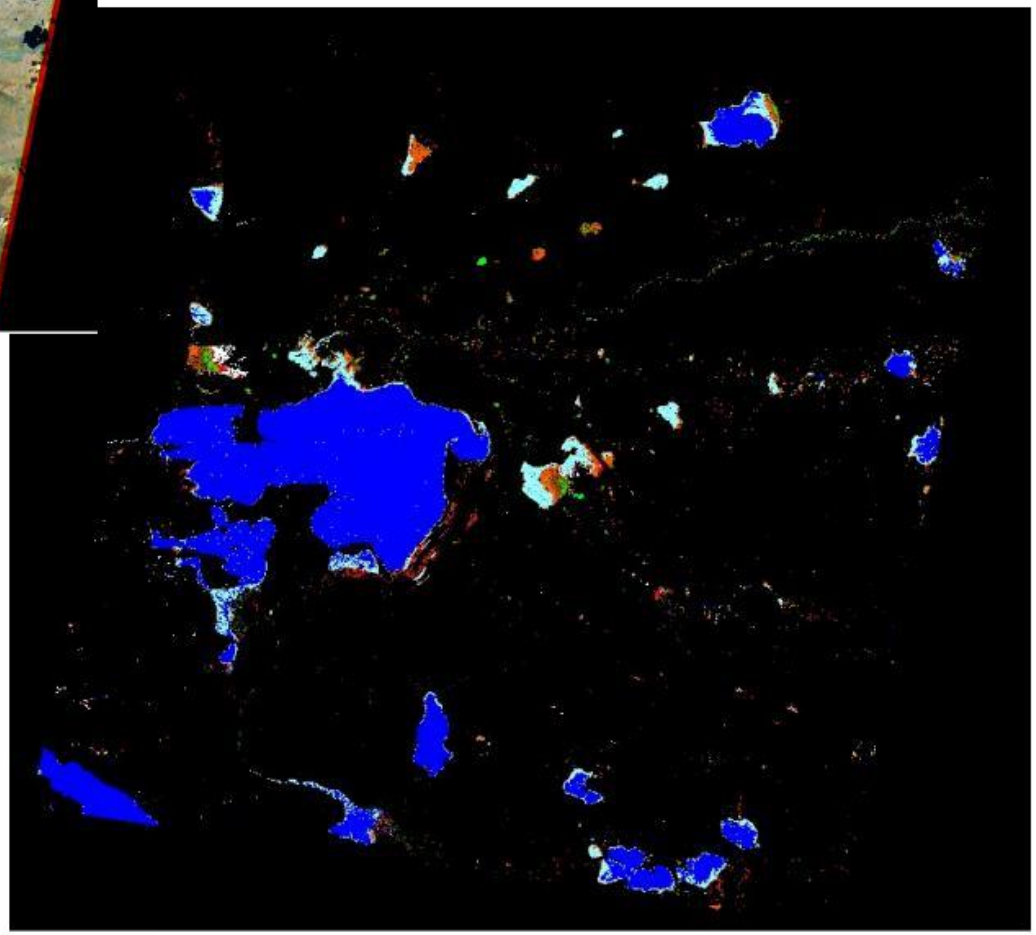
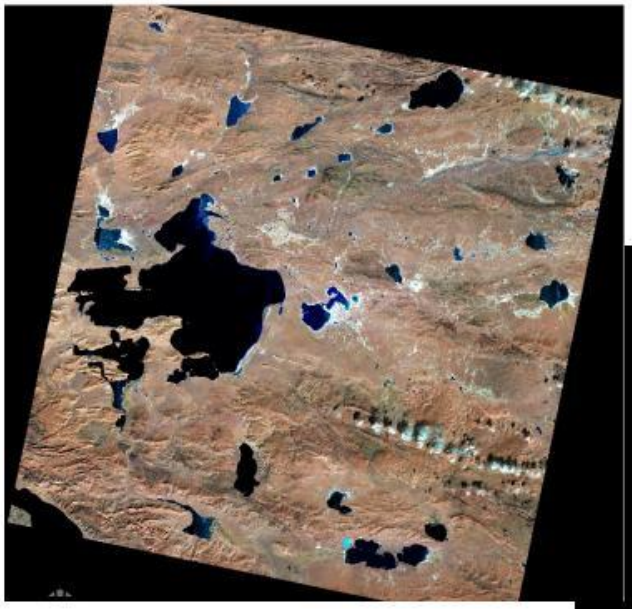


Siling Lake in the Tibet captured by Landsat 5 TM sensor in 1991, Sep. 1



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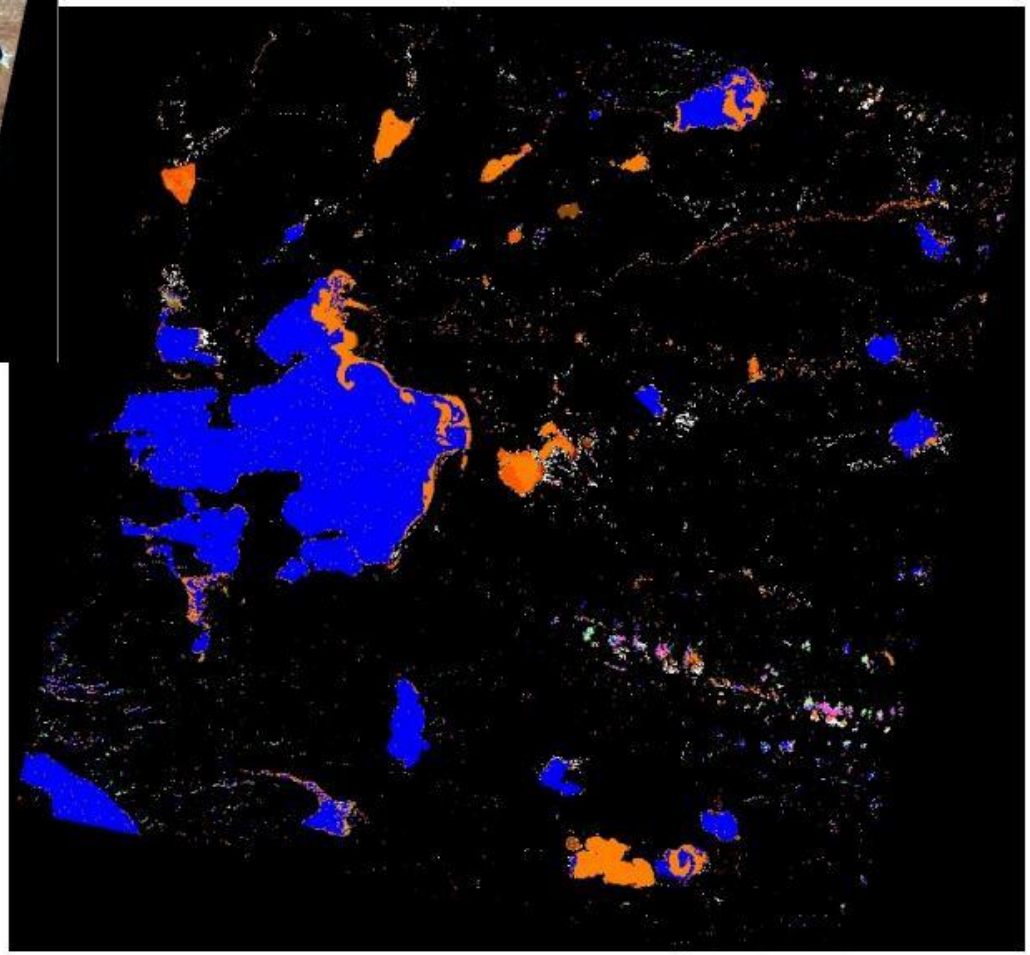
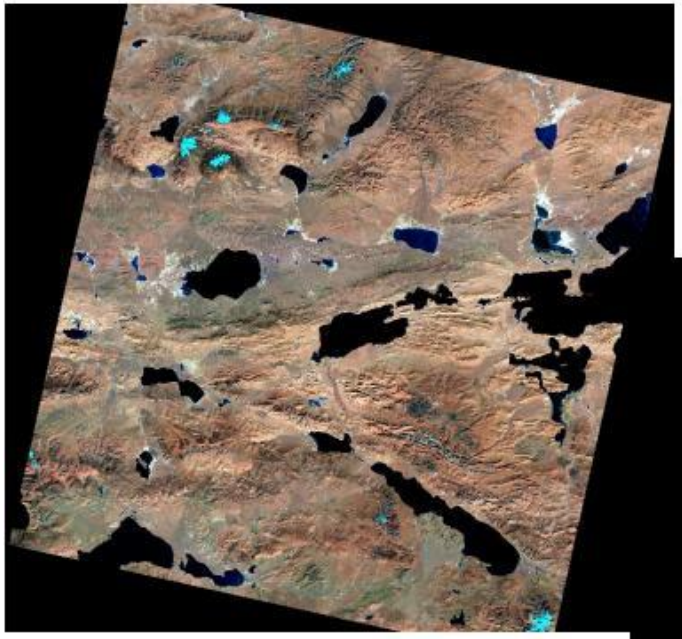


Siling Lake in the Tibet captured by Landsat 8 OLI sensor in 2016, Nov. 28



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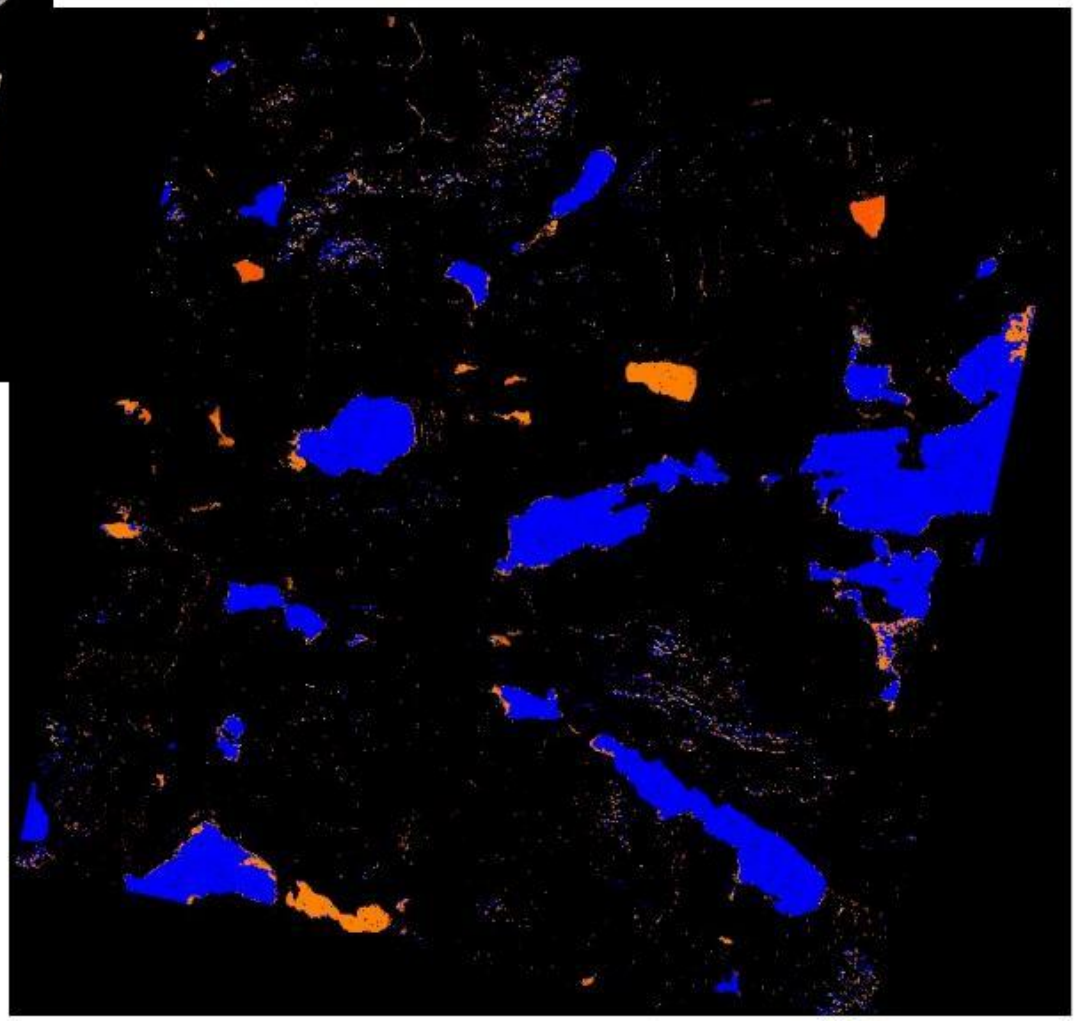
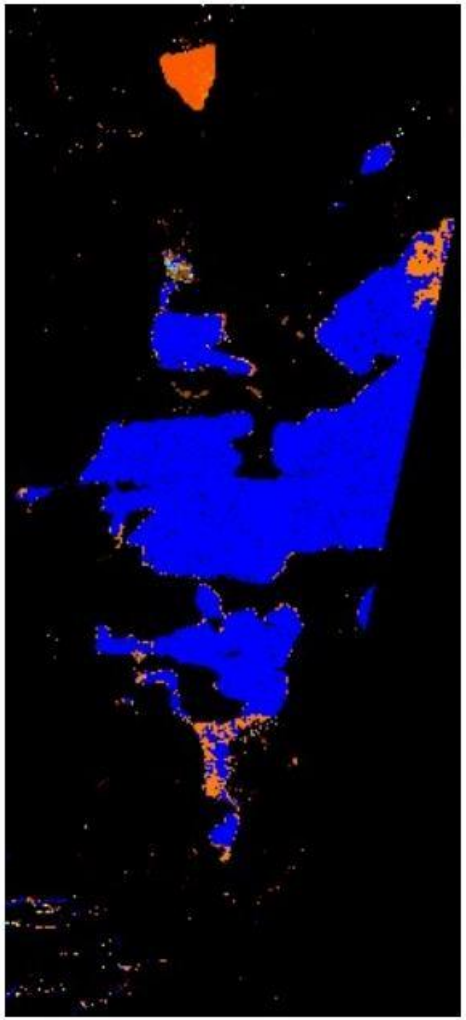


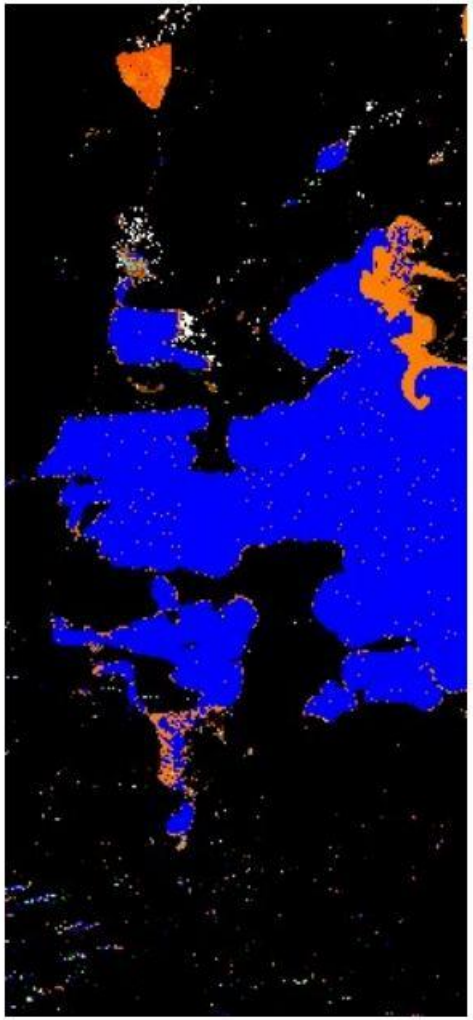
A part of the Siling Lake in the scene 140/38 observed in 2016 Nov. 19 by Landsat 8 OLI

Comparison of water body extraction in overlap of scenes 139/38 and 140/38 with 9 days observation difference. The results look almost similar

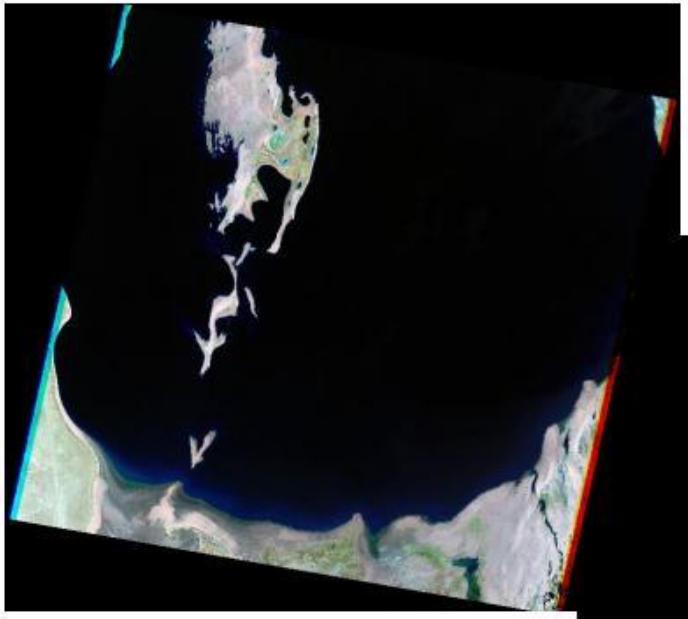
2016/11/19



2016/11/28



Aral Sea



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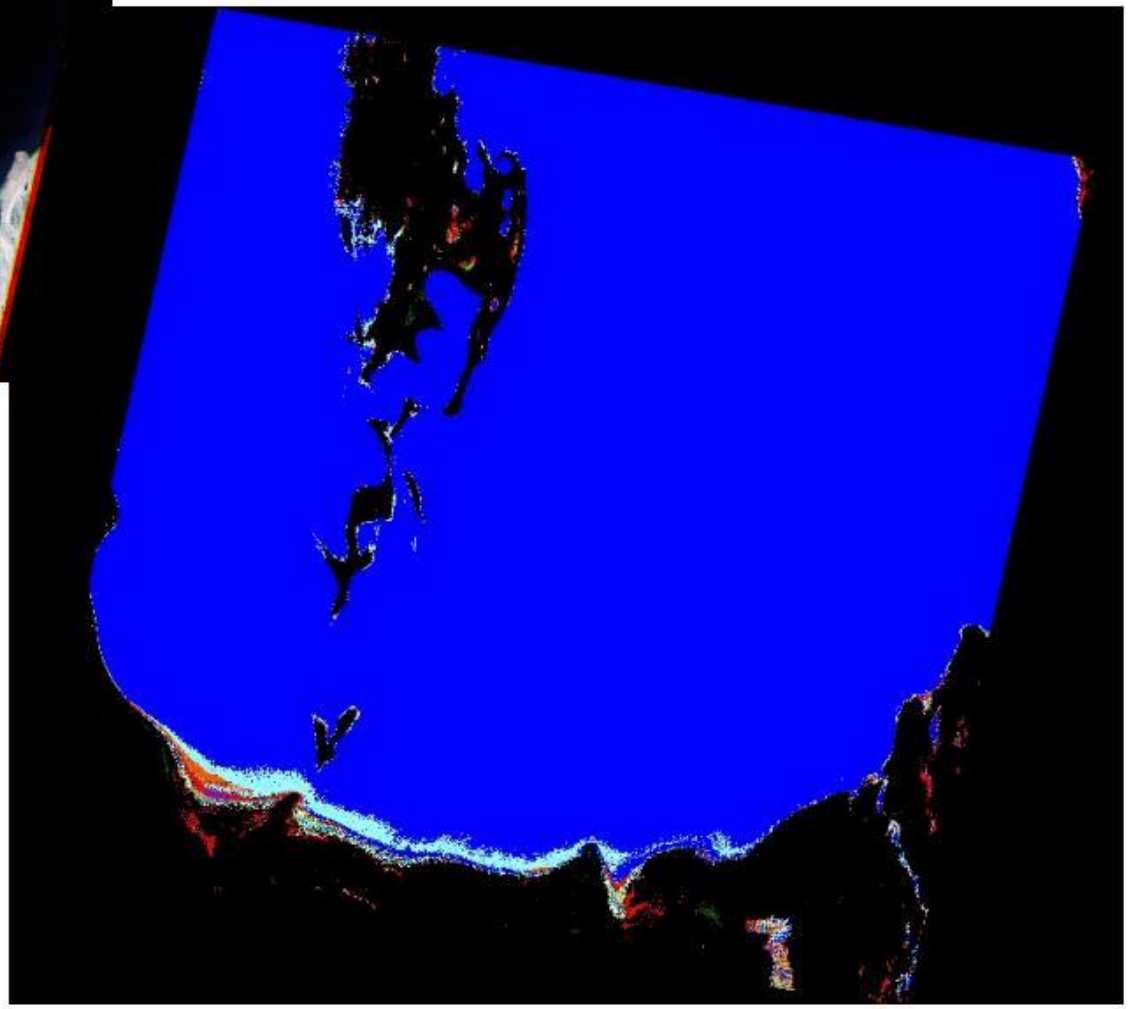
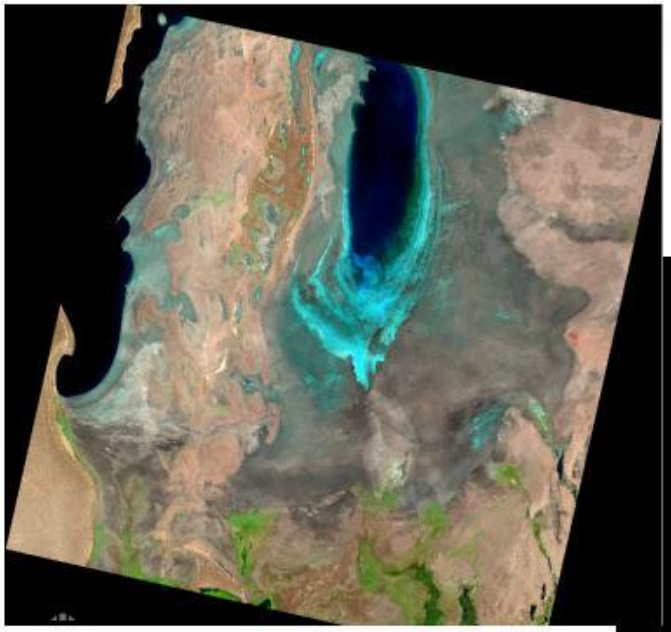


Aral Sea captured by Landsat 5 TM in 1987, Jun. 16



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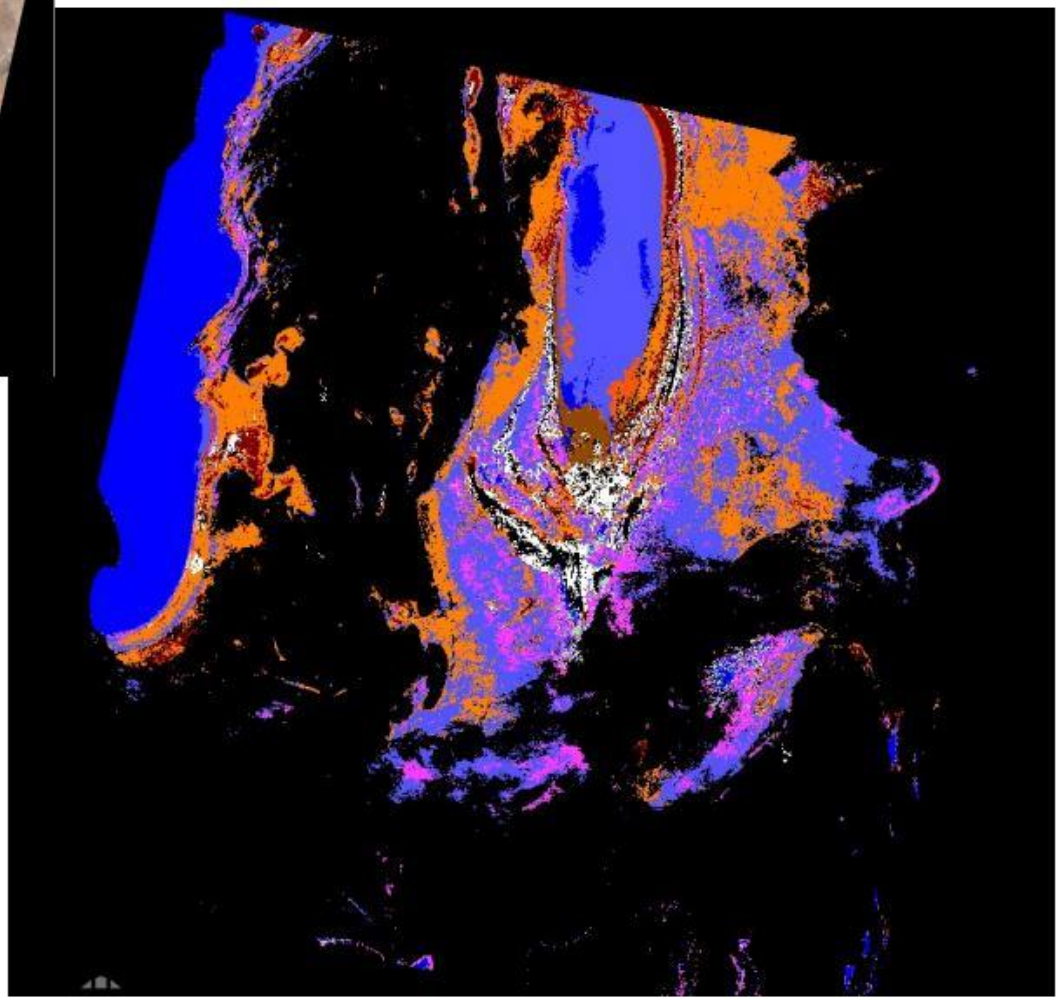
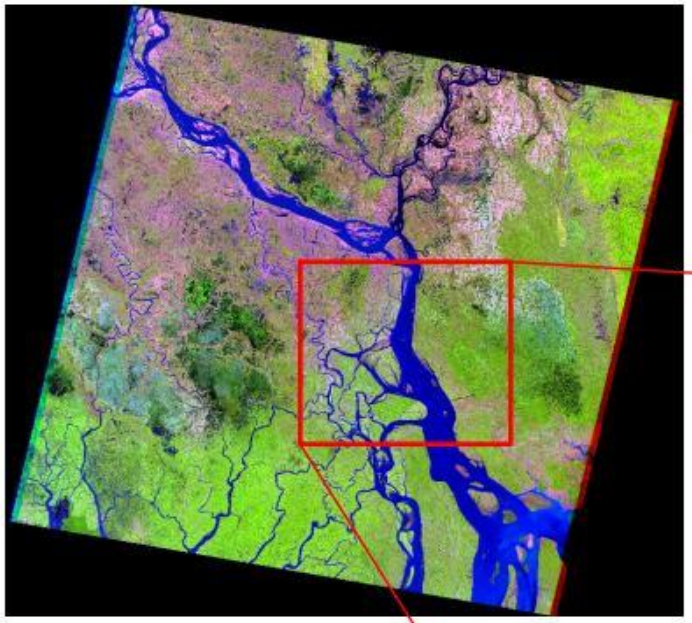


Aral Sea captured
by Landsat 8 OLI
in 2016, Aug. 2

Meghna River



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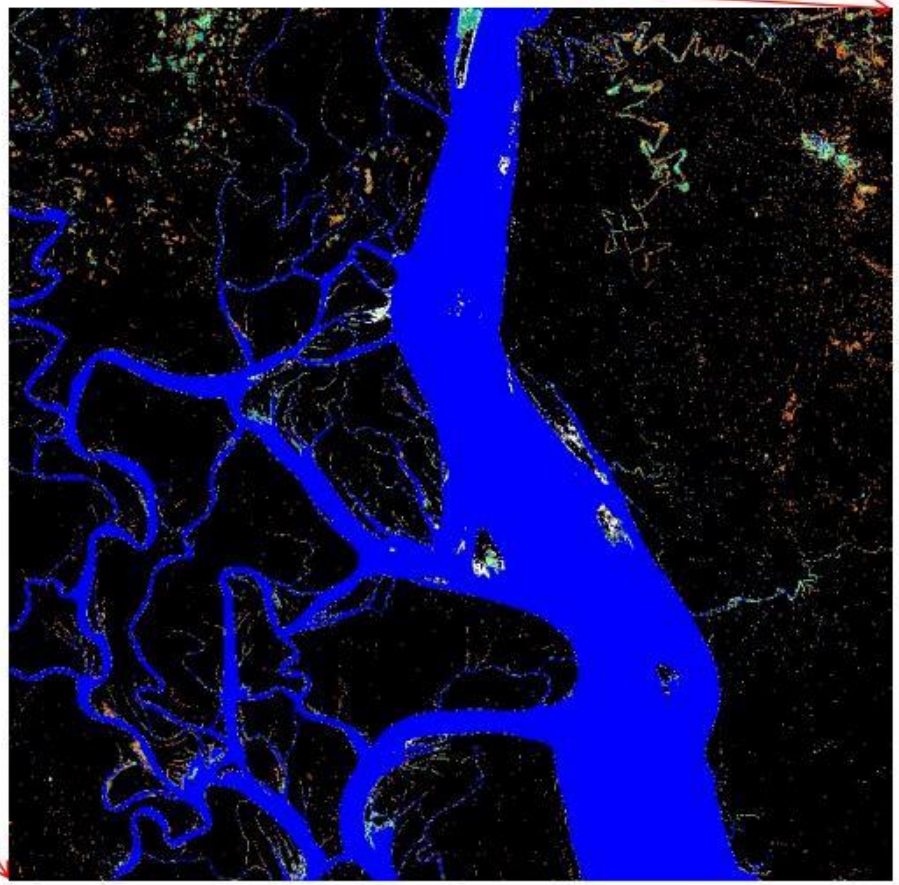
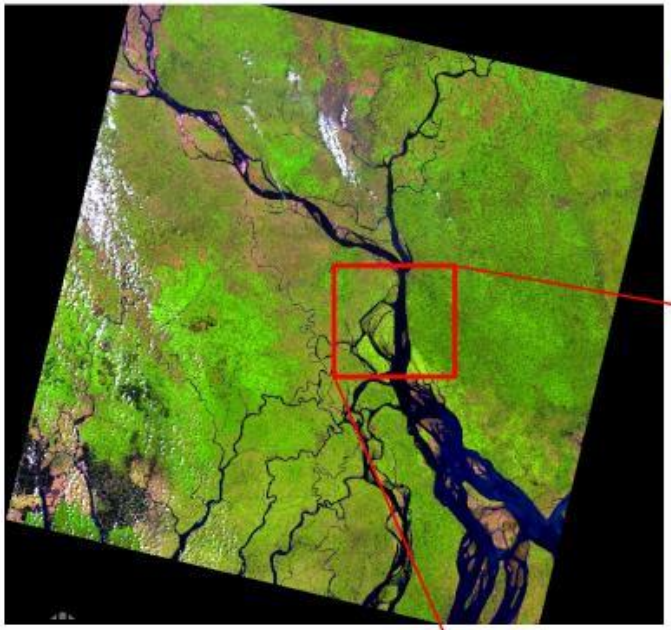


Meghna River in Bangladesh. The image was captured by TM sensor on board of Landsat 5 on 1989 Nov. 20. Different colors mean different water types



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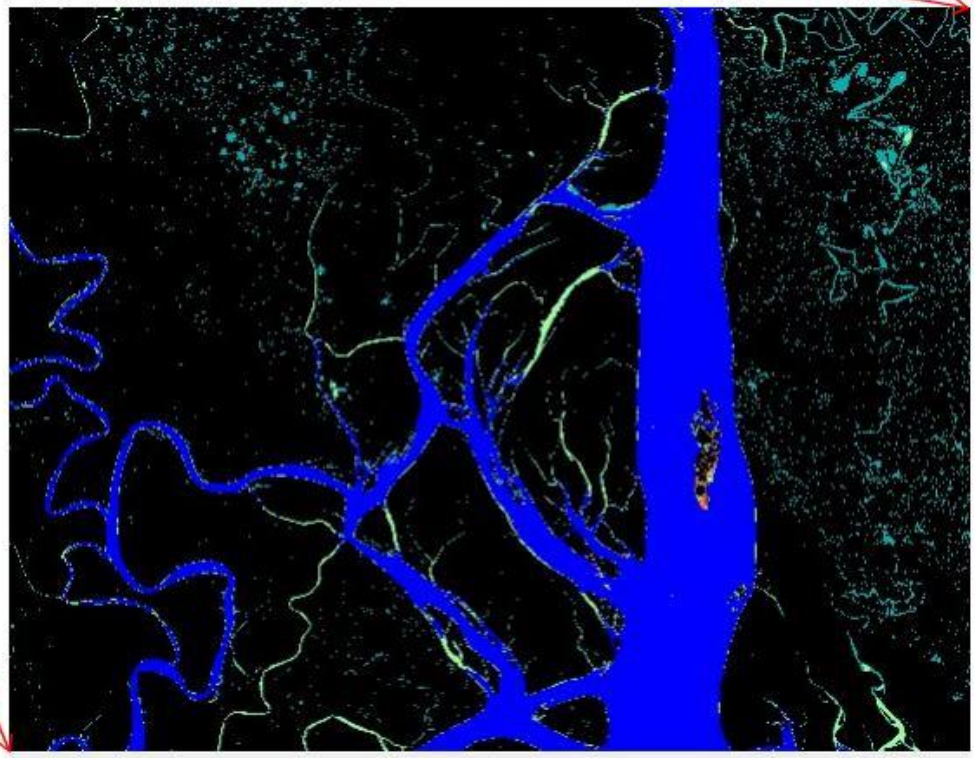
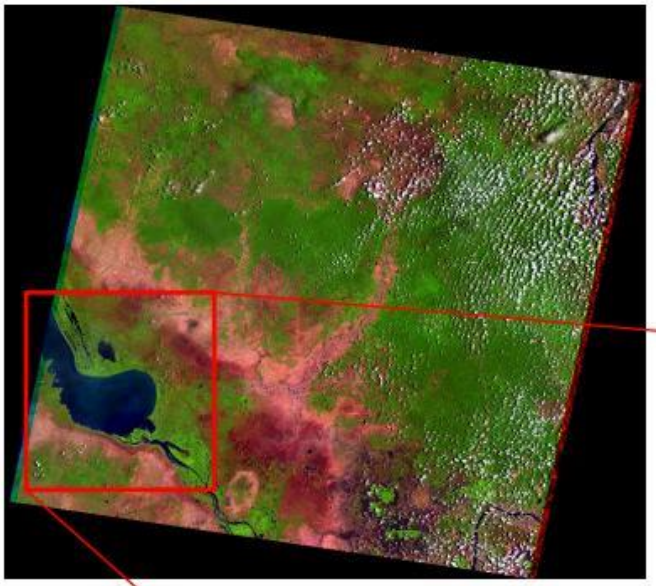


Meghna River in Bangladesh. The image was captured by OLI sensor on board of Landsat 8 on 2017 Mar. 22. Different colors mean different water types

Tonle Sap Lake



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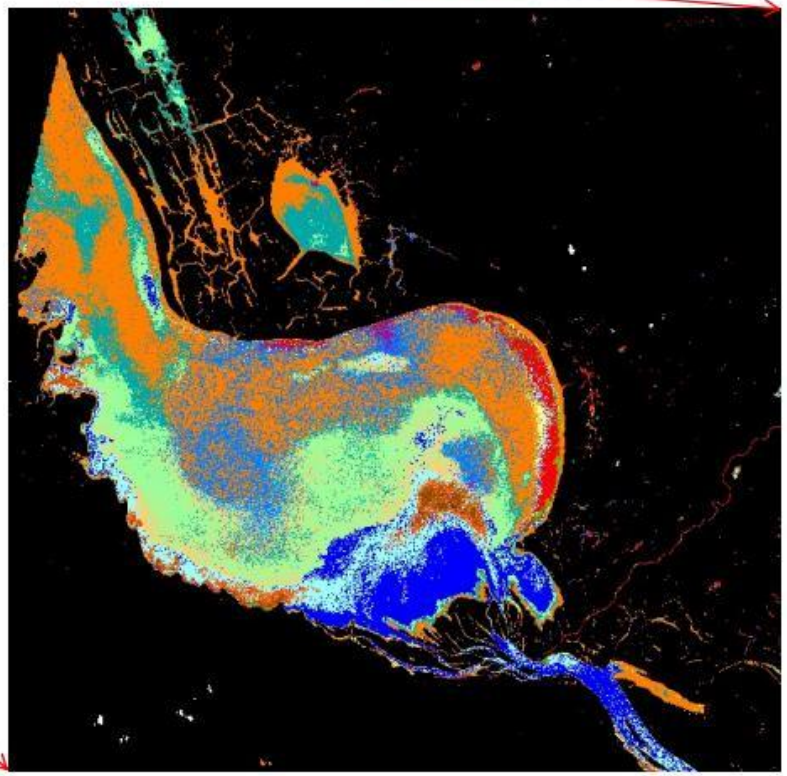
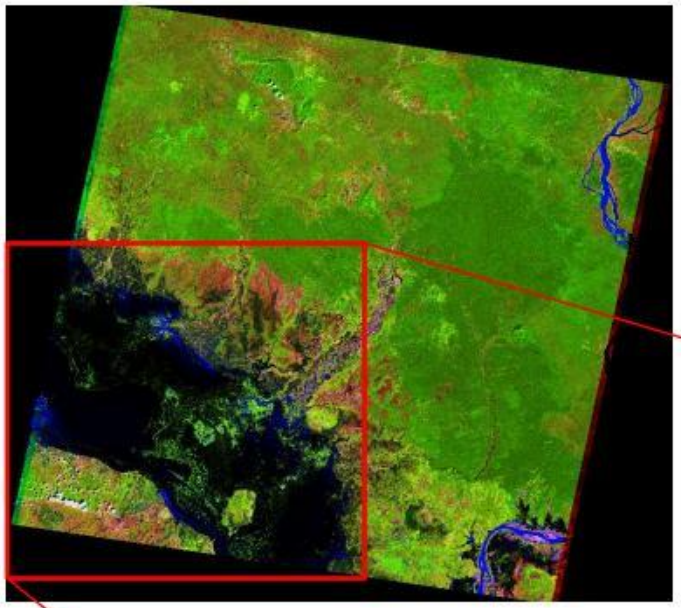


Tonle Sap Lake in Cambodia. The image was captured by TM sensor on board of Landsat 5 in 1990 Apr. 16. Different colors mean different water types



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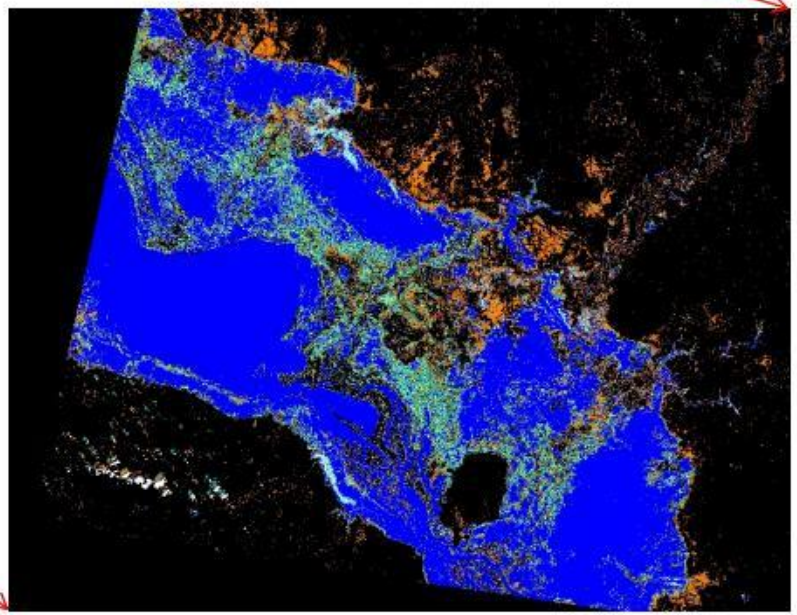

Tonle Sap Lake in Cambodia. The image was captured by TM sensor on board of Landsat 5 on 2000 Nov. 5. Different colors mean different water types

- 196 Landsat scenes of path/row 126/51 with cloud coverage less than 10% from 1989 to 2017 was analyzed
- Tonle Sap Lake over 30 years

Conclusion

- Our algorithm in water body mapping is a new one.
- Our algorithm allows fully automated analysis
- The algorithm is implemented in Amazon cloud computing platform. It allows to automatically map water bodies over large area in relatively short time with Landsat Collection one data
- We need collaboration with other scientist to explore the use of this new water mapping concept for understanding surface water changes over the last three decades.

Thank you for your attention