Mapping Lake-water area at sub-pixel scale using Suomi NPP-VIIRS imagery

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Background

- importance of monitoring lake-water area
  - understanding regional water balance
  - support local ecological study
  - …

- advantage of using remote sensing
  - efficient
  - multi-scale
  - multi-temporal
  - economic
  - …

- issues of remote sensing for monitoring lakes
  - trade-off between the spatial and temporal resolutions of remote sensing data
    - high spatial resolution, but low temporal resolution (Landsat)
    - high temporal resolution but low spatial resolution (MODIS, Suomi NPP-VIIRS)
  - mixed pixel problem around lake shorelines

- one possible solution
  - mixed pixel decomposition and reconstruction
    - (1) mixed pixel decomposition (pixel unmixing): can be achieved through soft classification
    - (2) mixed pixel reconstruction: can be achieved through sub-pixel mapping

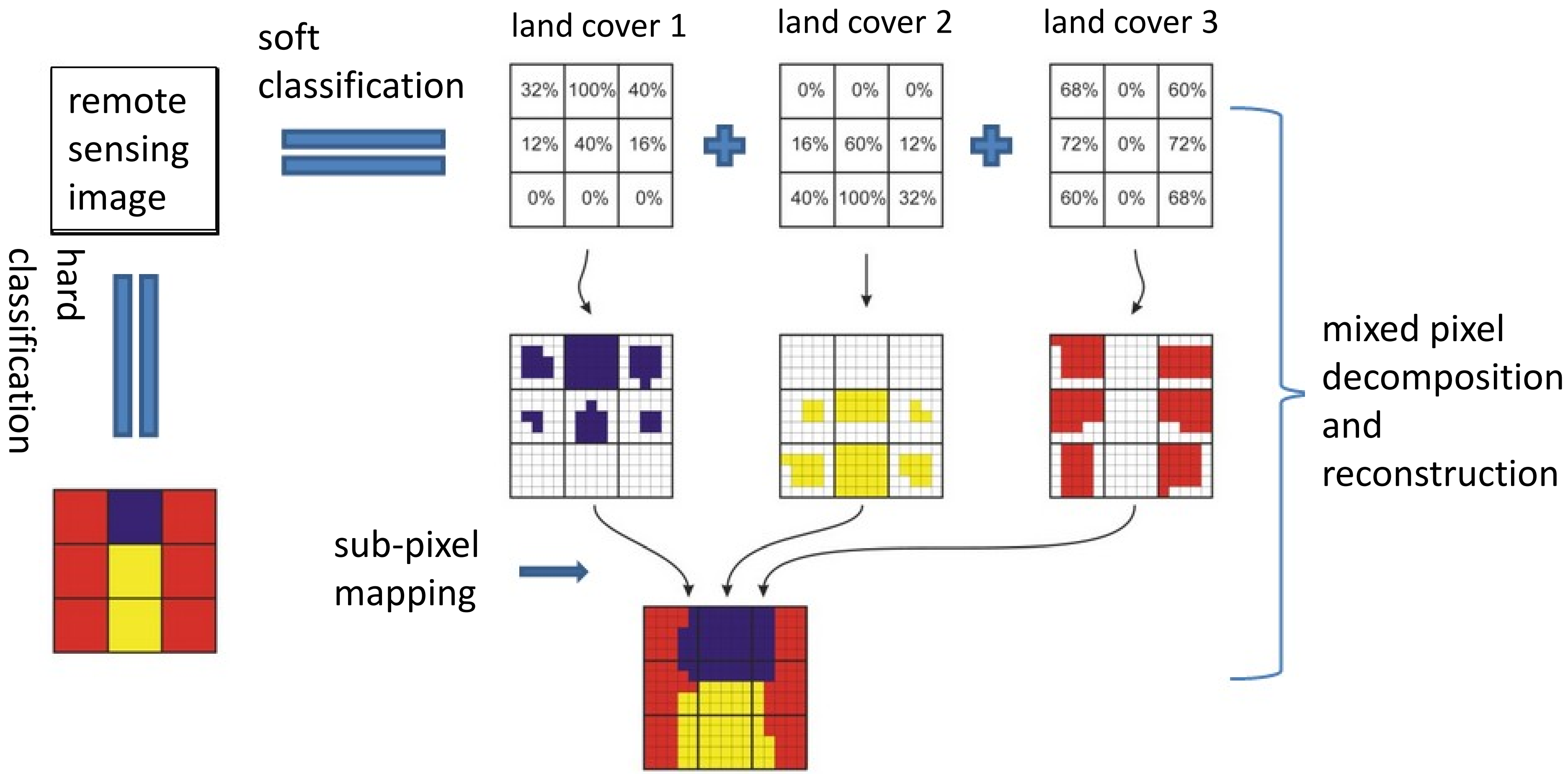
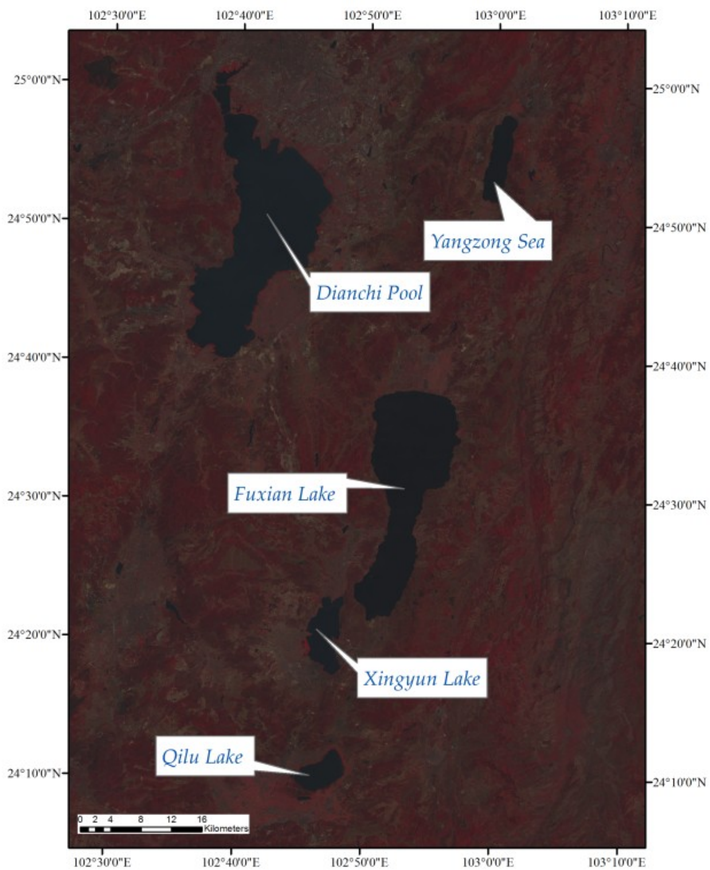


illustration of mixed pixel decomposition and reconstruction

- The objective of this study is to propose a methodology for mapping lake-water area at sub-pixel scale using Suomi NPP-VIIRS imagery.
- By doing this, we can improve the spatial resolution of lake mapping, while keeping the high temporal resolution of Suomi NPP-VIIRS data, and also alleviate mixed pixel issue.

Study area and materials



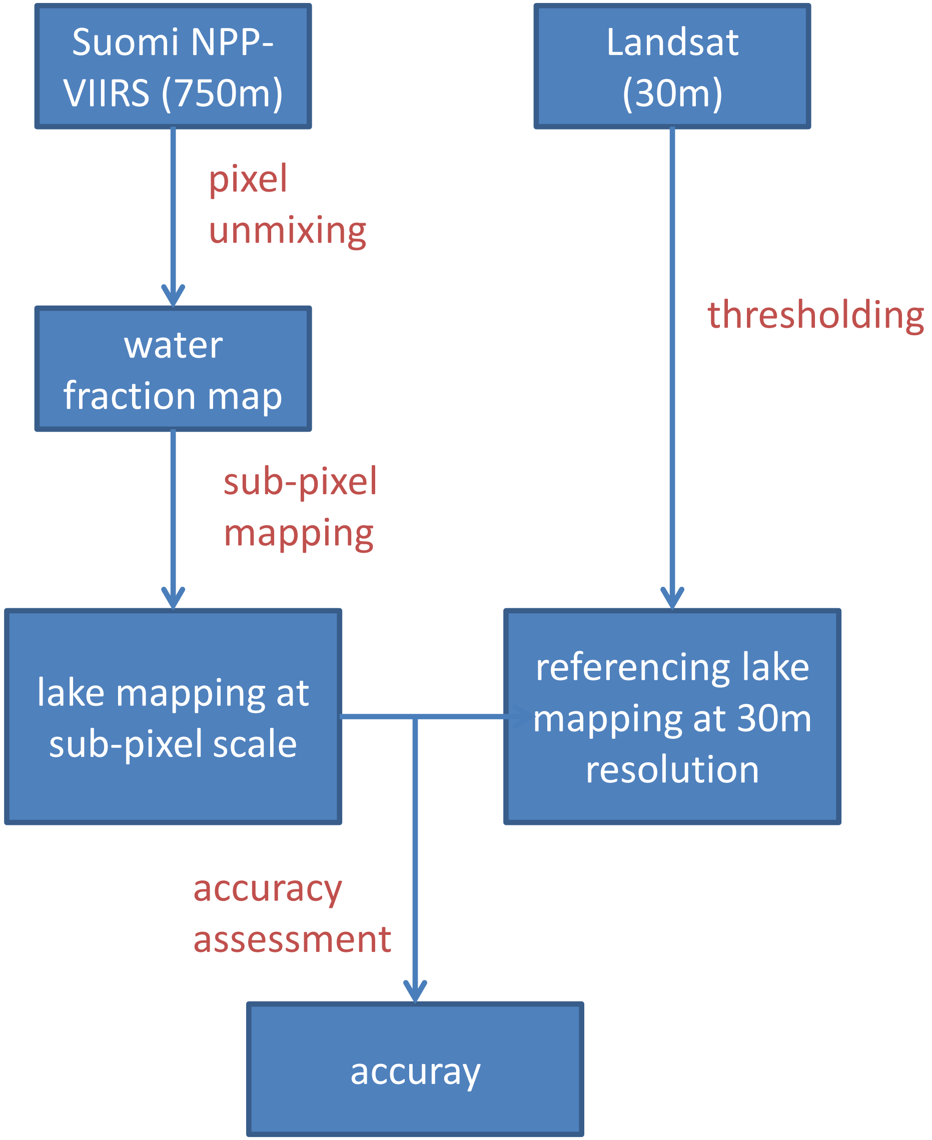
study area

materials

Image type	Image date	Acquisition time	Path/Row	Spatial resolution
NPP-VIIRS	02/02/2014	06:39:57	--	375m
Landsat OLI	02/02/2014	03:36:02	129/43	30m

Methodology

- pixel unmixing
- sub-pixel mapping
- accuracy assessment



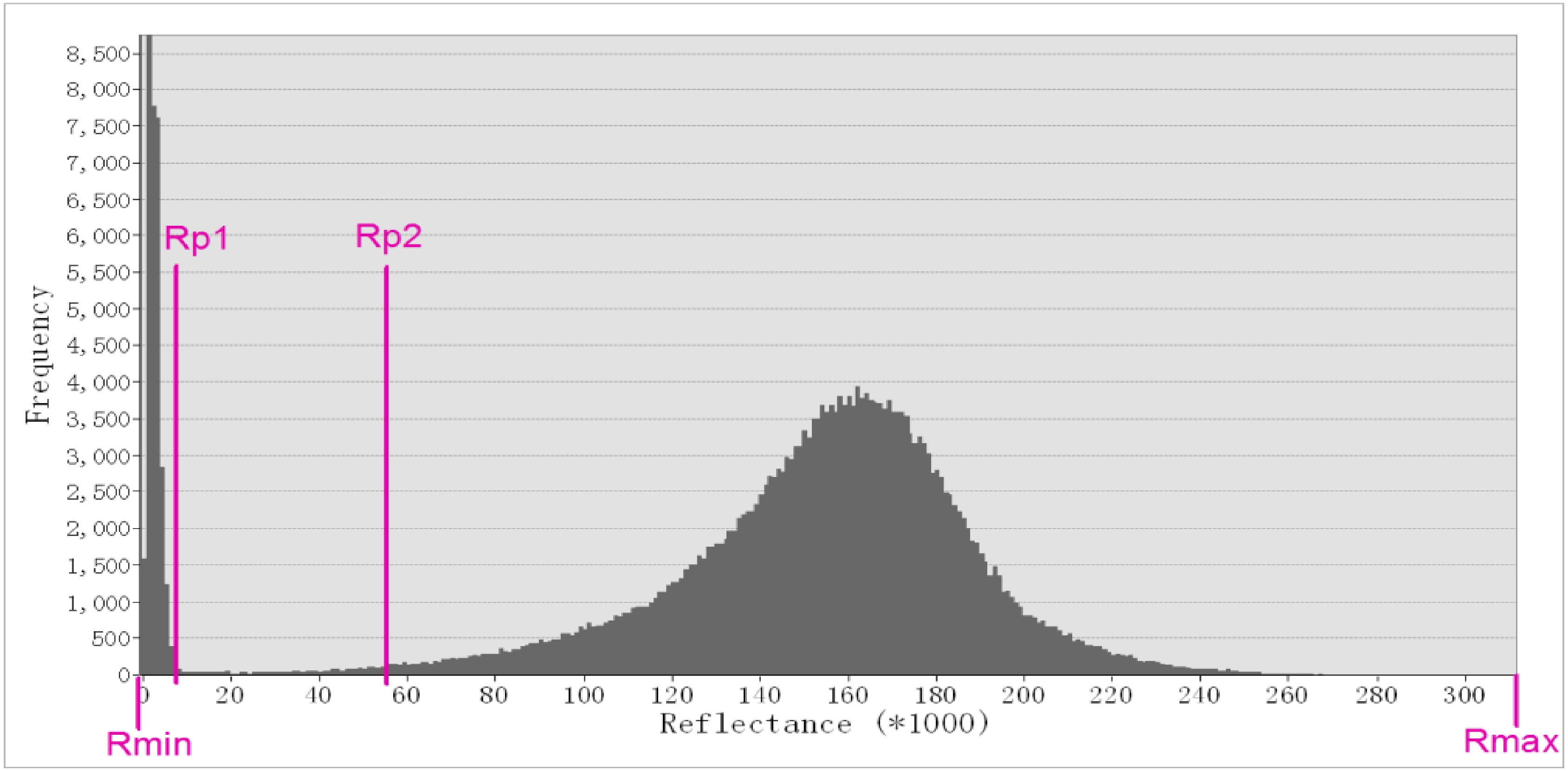
pixel unmixing

- Based on Linear Spectral Mixture Model (LSMM), water fraction can be estimated using

$$f = \frac{R_{\mathrm{land}} - R_{\mathrm{mix}}}{R_{\mathrm{land}} - R_{\mathrm{water}}}$$

where R_{mix} is the reflectance of mixed pixel, R_{water} and R_{land} are reflectance of pure water and pure land pixels, respectively.

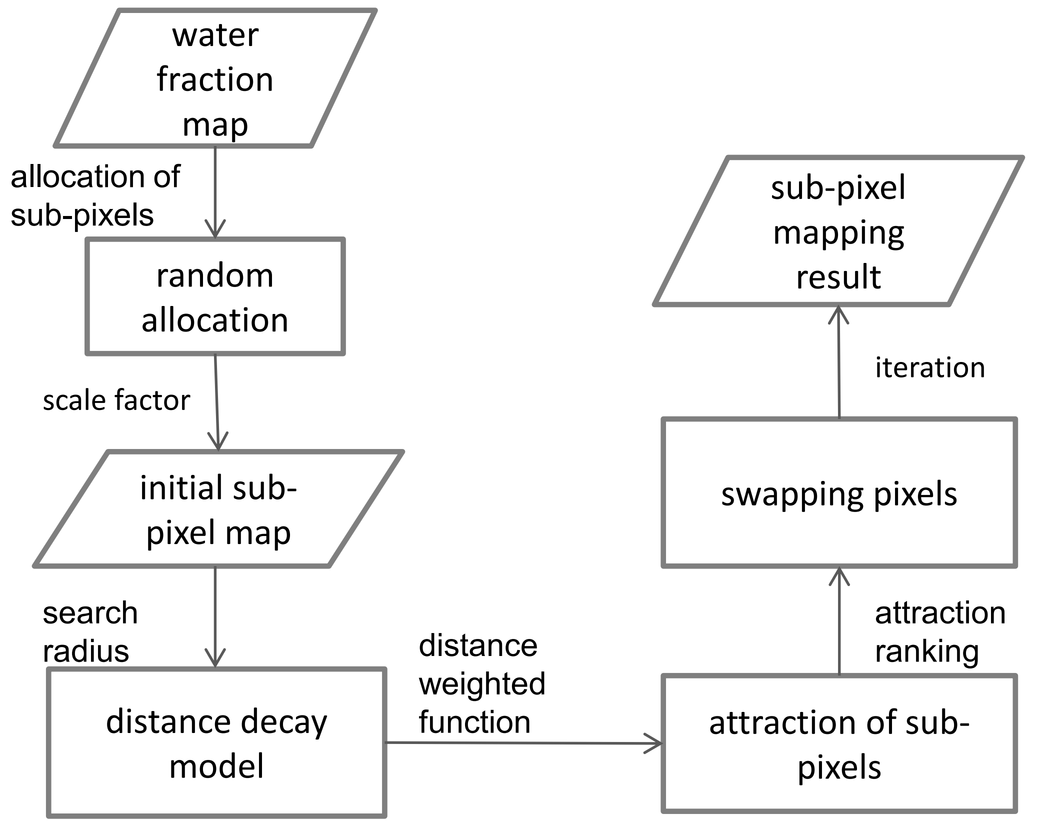
- determine feasible ranges for R_{water} and R_{land} from the histogram
- automatically find pixel reflectance within these ranges using a moving window approach.

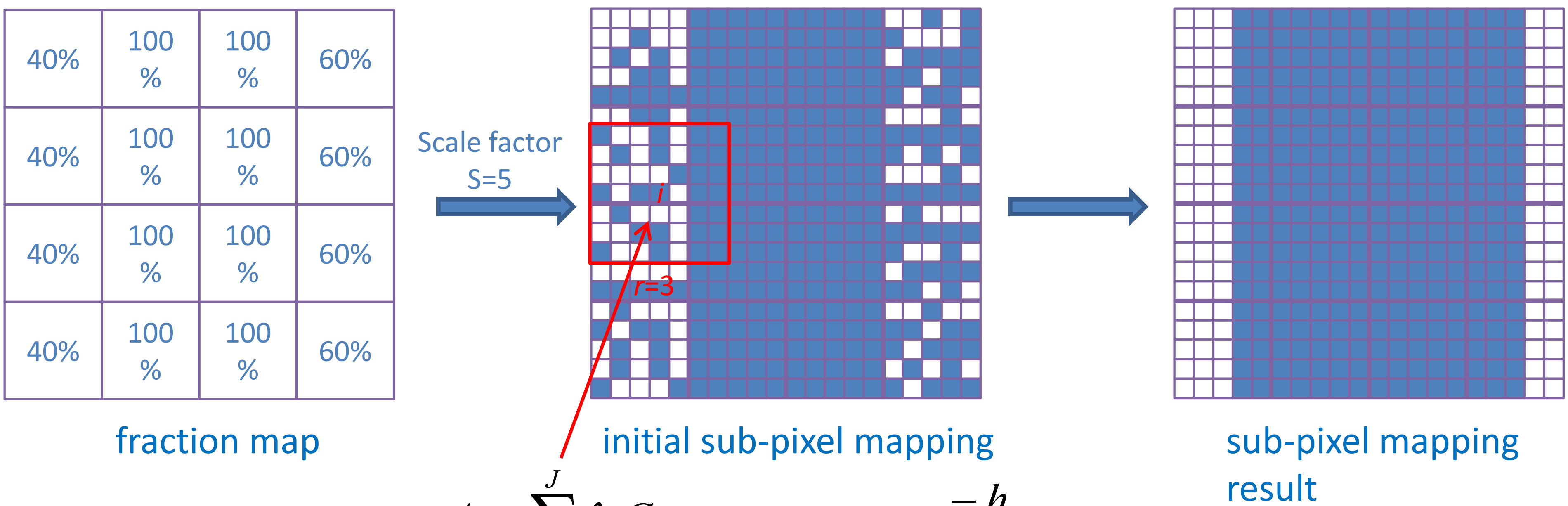


Huang et al. 2015 in *Remote Sensing Letters*

sub-pixel mapping

- Pixel Swapping (PS) algorithm (Atkinson 2005)





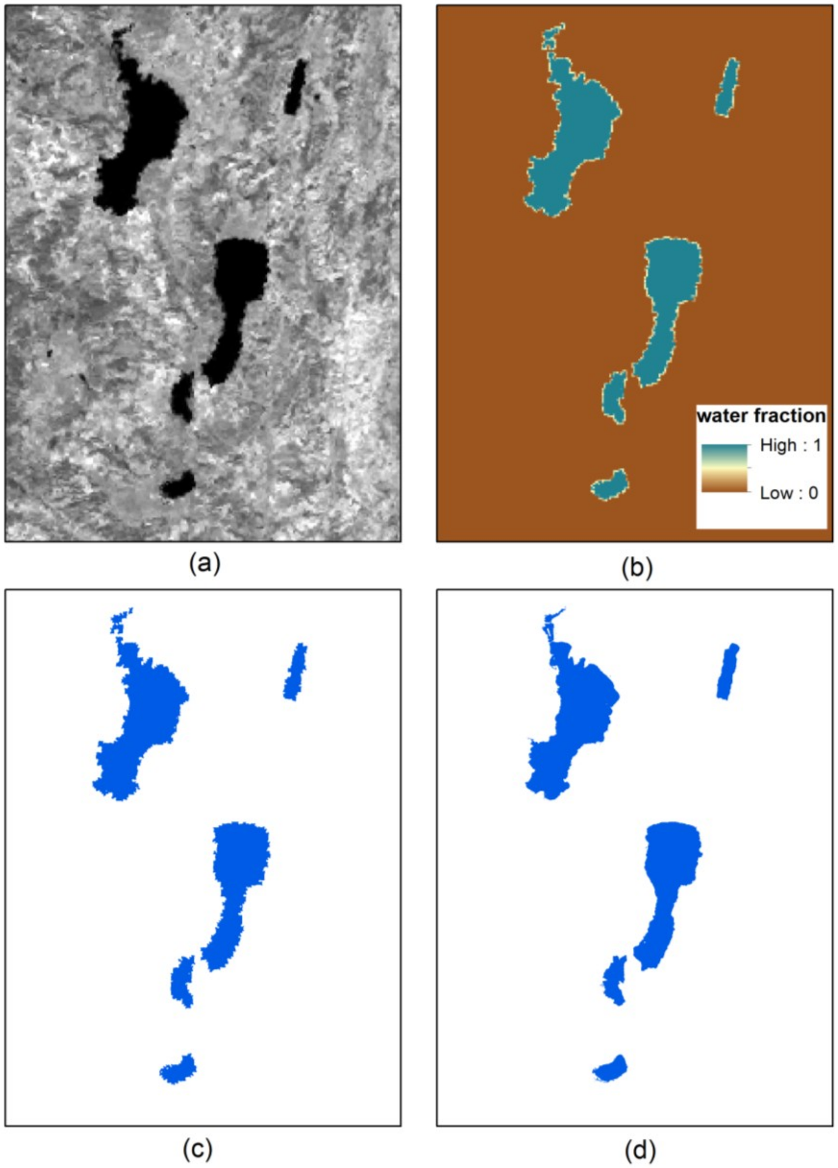
$$A_i = \sum_{j=1}^{J} \lambda_{ij} C_j \qquad \lambda_{ij} = \exp\left(\frac{-h_{i,j}}{\alpha}\right)$$

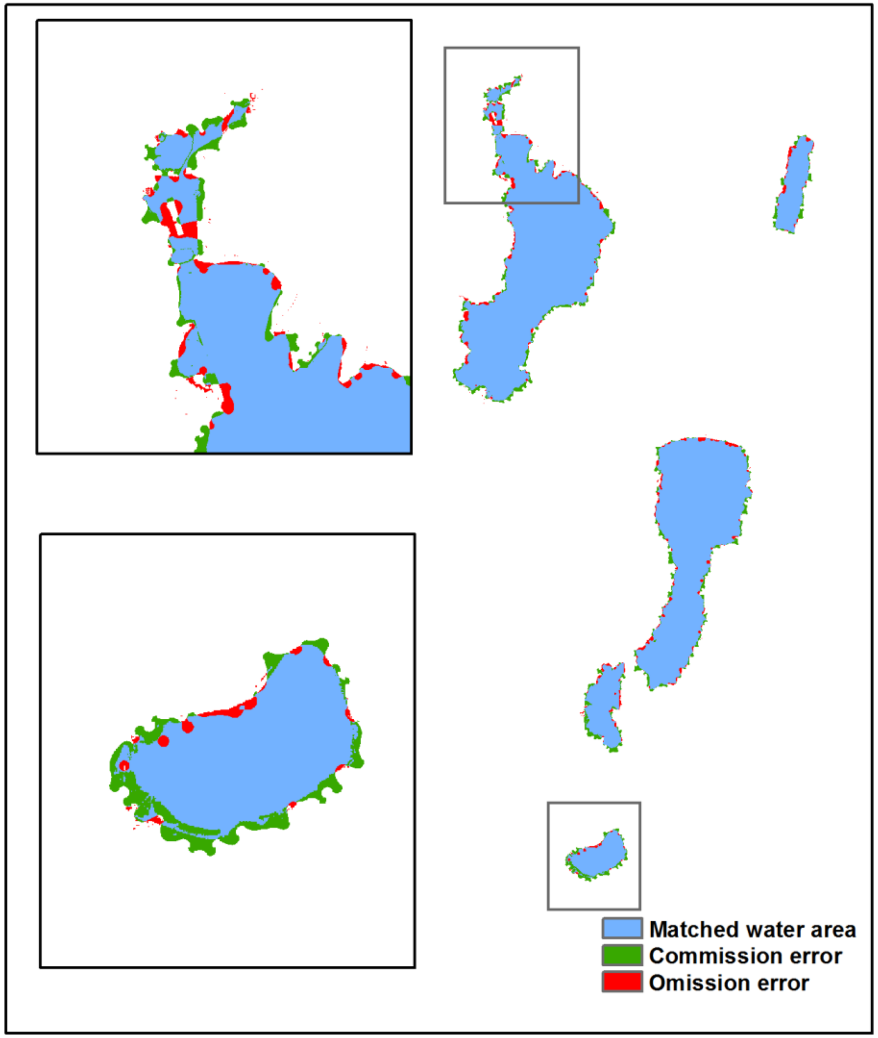
accuracy assessment

- detection lake-water area from referencing Landsat SWIR band
- overlay sub-pixel mapping result with referencing lake map
- calculate accuracy indices, such as overall accuracy and Kappa coefficient.

Result

(a) Suomi NPP-VIIRS I3 band,
(b) water fraction map from (a),
(c) subpixel mapping result of (b),
(d) referencing lake map from Landsat





Accuracy assessment map of NPP-VIIRS downscaling result

Accuracy indices showing the evaluation result of different lakes on NPP-VIIRS downscaling result

Lake	**Commission error (%)**	**Omission error (%)**	**Overall accuracy (%)**	**Kappa coefficient**
Dianchi Lake	14.31	7.28	78.41	0.57
Yangzonghai Lake	15.30	7.58	77.12	0.54
Fuxian Lake	13.85	6.89	79.26	0.59
Xingyun Lake	16.81	6.38	76.81	0.54
Qilu Lake	21.56	2.12	76.32	0.54

Discussion and conclusion

- Lake map could be downscaled from NPP-VIIRS image and achieve a moderate accuracy through a two-step procedure. This is a feasible and promising approach to improve the detection resolution of coarse-resolution sensors while keeps their high temporal resolution.
- However, it is also noticed that the accuracy of sub-pixel scale lake mapping is not very high. The accuracy might be affected by:
  - the co-registration between the NPP-VIIRS and referencing Landsat
  - resampling process during the data preparation
- But the main reason for the low accuracy is the overestimation of water fraction in pixel unmxing.

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