# Lake extraction and classification in Tibet Plateau

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## Introduction

Known as the Third Pole of the world, Tibet Plateau is very sensitive to climate change. The high concentration of lakes and glaciers in Tibet offers a way to better understand the impact of global warming. This study aims to use digital elevation model (DEM) and satellite imagery to classify the lakes and evaluate their changes in response to global warming. Specifically, this study contains four parts:

1. Delineate the lake catchments in Tibet based on DEM
2. Extract all the lakes greater than 10 km² based on DEM
3. Classify the lakes based on their positions: the inflow/outflow lakes, the glacier/non-glacier supplied lakes and the upstream lakes
4. Conduct a case study: focus on a glacier-supplied and non-glacier supplied lake respectively. Extract the lakes based on Landsat data, calculate their area changes respectively and compare them, which reflect how climate change impacts on the lakes.

## Study area & data

- Tibet
  - the 30 meter Shuttle Radar Topography Mission (STRM) Elevation data
  - land use data of Tibet in 2018
  - map of river system and drainage map of China
- Lake Nam co and Lake Bam co (for case study)
  - Landsat 8 OLI/TIRS C1 Level-1
    date: 04/27/2016 10/23/2017 10/29/2010
  - Landsat 4-5 TM C1 Level-1
    date: 05/25/1991 10/02/1992 10/08/1994
  - the climate data of Lhasa during 1980-2015

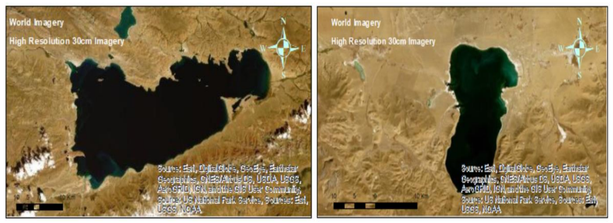


**Fig.1.** (a) Lake Nam co (glacier supplied); (b) Lake Bam co (non-glacier-supplied)

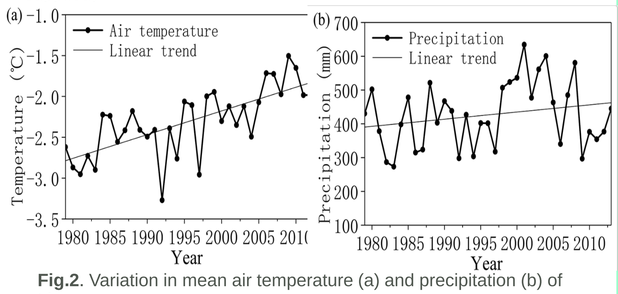


**Fig.2**. Variation in mean air temperature (a) and precipitation (b) of Lhasa

## Methods

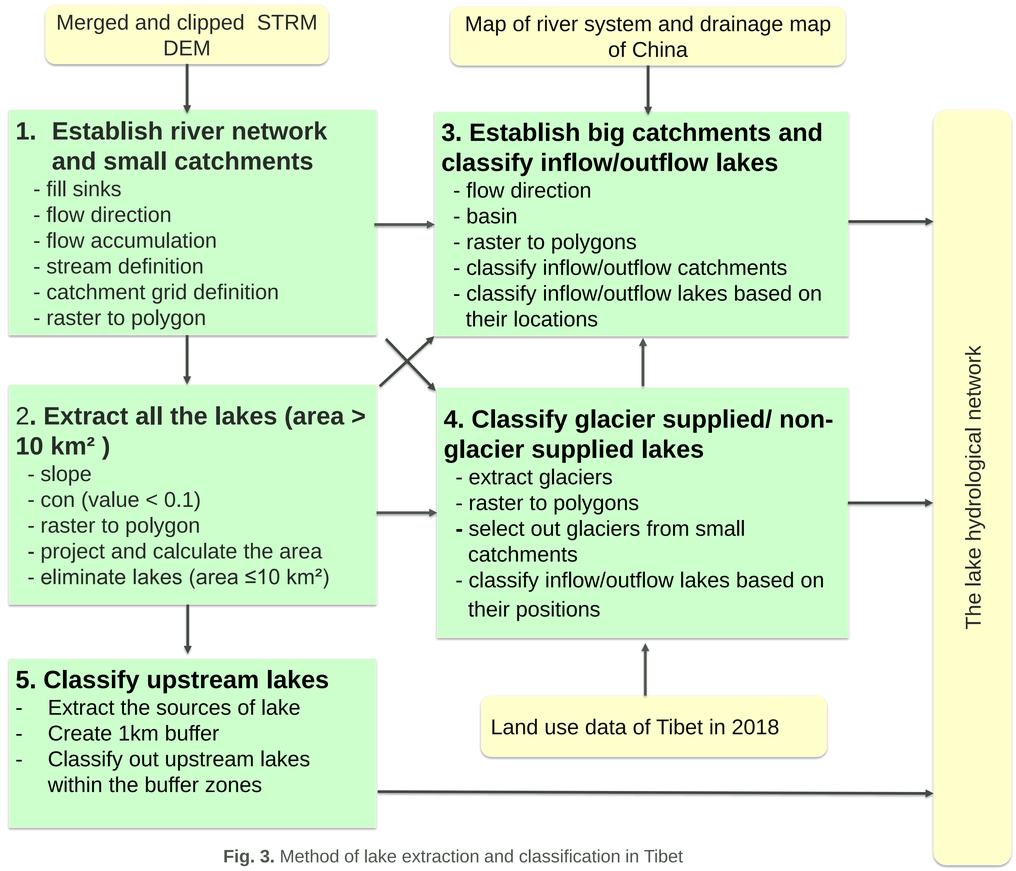


**Fig. 3.** Method of lake extraction and classification in Tibet

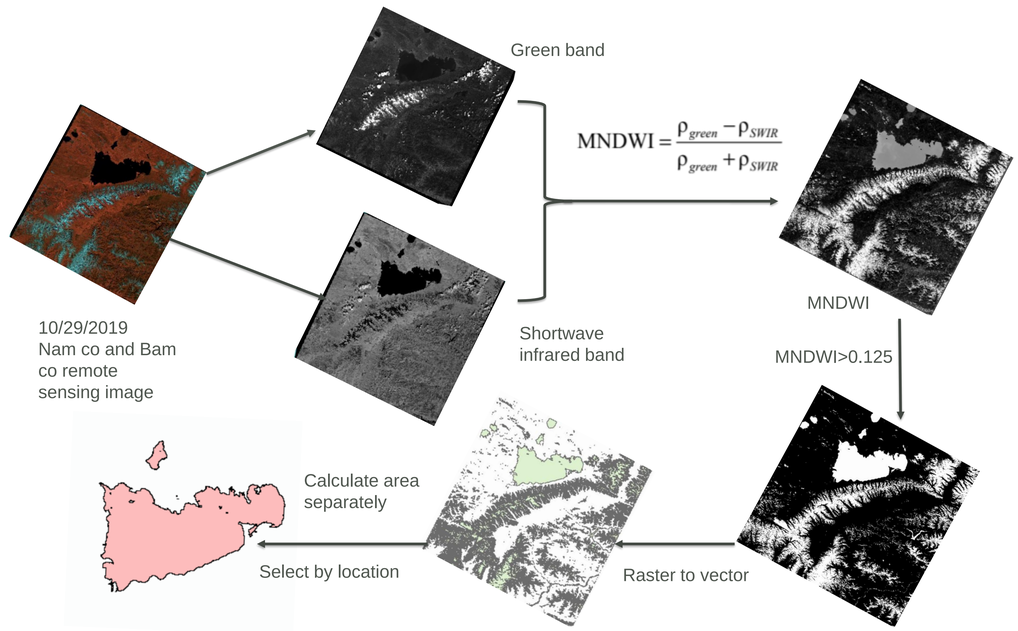


**Fig.4.** Flow diagram of Lake Nam co and Lake Bam co extraction (MNDWI =Modified Normalized Difference Water Index)

## Results

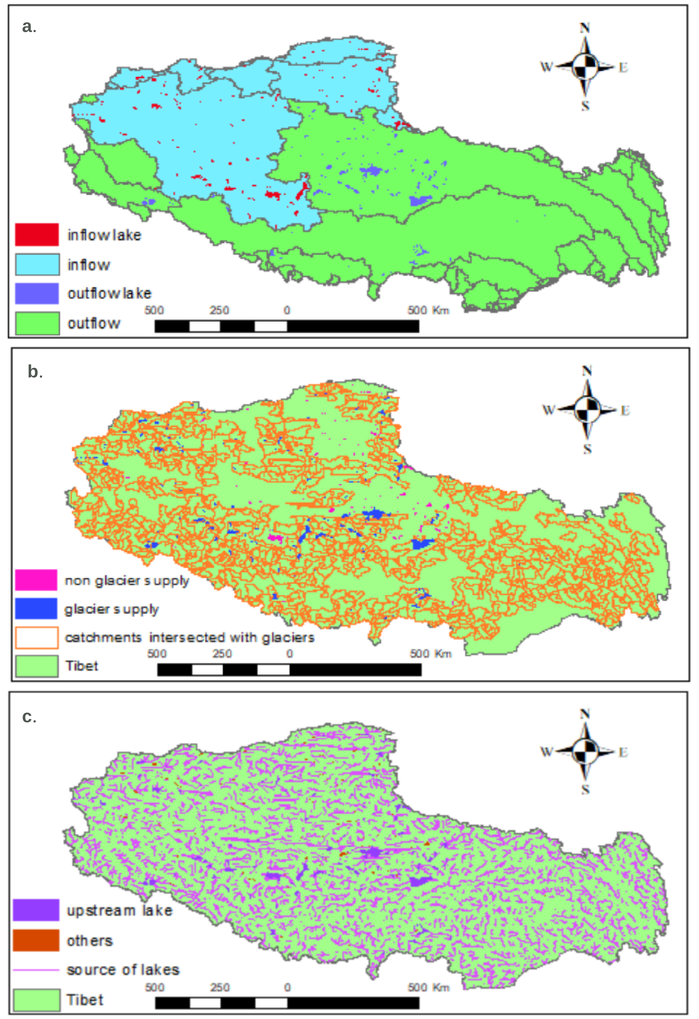


**Fig.5.** Classification of lakes in Tibet: (a) the inflow and outflow; (b) glacier supplied and non-glacier supplied; (c) upstream lakes.

| | Nam co lake (glacier supplied) | | Bam co lake (non-glacier supplied) | |
|---|---|---|---|---|
| date | Area (km²) | area change rate | Area (km²) | area change rate |
| 5/25/1991 | 1960.34 | - | 45.06 | - |
| 10/2/1992 | 1963.95 | +1.84% | 45.18 | +0.27% |
| 10/8/1994 | 1961.28 | -1.36% | 44.22 | -2.13% |
| 4/27/2016 | 2013.40 | +2.66% | 48.30 | +9.22% |
| 10/23/2017 | 2020.22 | +0.34% | 48.57 | +0.58% |
| 10/29/2019 | 2026.18 | +0.3% | 48.28 | -0.61% |

**Fig.6.** Area and change rate of Lake Nam co and Lake Bam co.

## Conclusion

- With the inspection to Google earth, based on DEM and the Landsat data, the lake extraction result is generally accurate.
- Although the increase in glacier meltwater has contributed significant to its supplied lake, lake without glacier supply, like Bam co, have also expanded significantly, which suggests other climate change factors(increased precipitation and decreased lake evaporation) might also contribute to recent lake growth.
- The hydrological network and the relationship between the different types can provide a basis for additional research in hydrology. For future goals, following the workflow in this study, an automatic watershed delineation can be considered and this approach can be applied to more regions.

## References

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