Paleo Tibetan Lake Extent Mapping from High-Resolution Satellite Imagery and SRTM Digital Elevation Models

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Introduction

With a pronounced temperature rise of 0.16oC per decade, the Tibetan Plateau is one of the world's most vulnerable areas to global change. Recent dating of Tibetan lake deposits showed that the Greatest Lake Period (GLP) appeared in between ~40 and 25 ka BP. Tibetan lakes have shrunk greatly since then. A key science question for the region is **"How much have the Tibetan lakes shrunk since the late Pleistocene?"**

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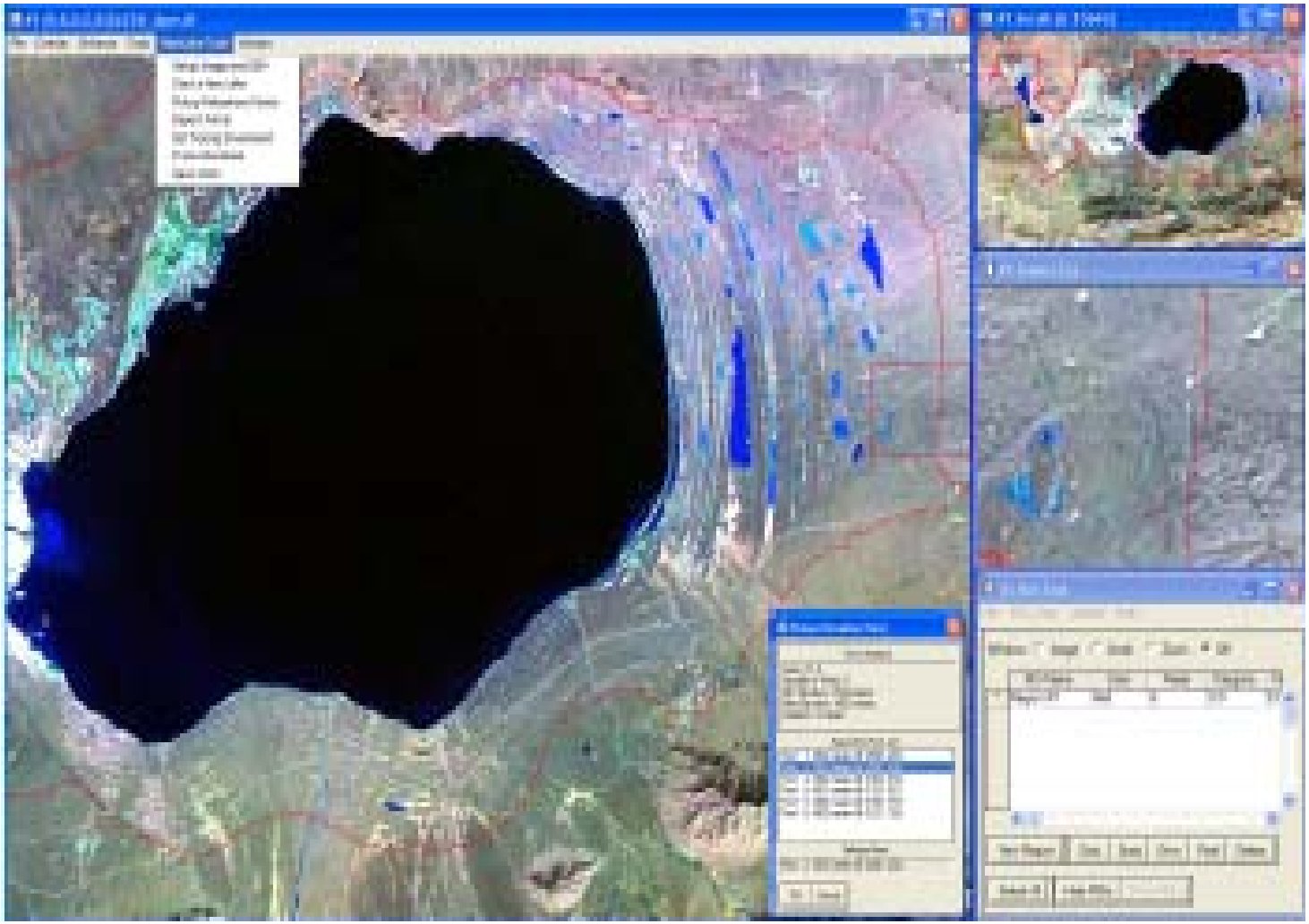
Methods

Mapping the paleo lake extent is challenging due to the inaccessibility and inhospitable environment of this remote plateau. We address the problem using high-resolution satellite imagery (i.e., Landsat/ ETM+) and SRTM digital elevation models (DEMs). As the lakes shrank, abandoned paleo shorelines were left as evidenced by lake-formed cliffs, shore clays, and sand bars. Such paleo-shorelines commonly surround many contemporary lake basins, indicating past lake extent during various periods since the GLP. The GLP shorelines at the highest elevations are normally preserved, and therefore represent the maximum GLP lake extent. These relict paleo-shorelines are commonly visible in high-resolution satellite imagery. Therefore, through data fusion of high-resolution satellite imagery with DEMs, both paleo lake areas and corresponding bench elevations can be obtained. The highest paleo shorelines or coastal features can be identified in high-resolution imagery, and its corresponding elevations of paleo lake water level can be determined from the DEM data. Paleo lake extent can thus be recovered from the DEM data as the contour line at the identified paleo shoreline elevation. We developed a user-friendly mapping environment in ENVI®/IDL® to facilitate paleo-lake mapping.

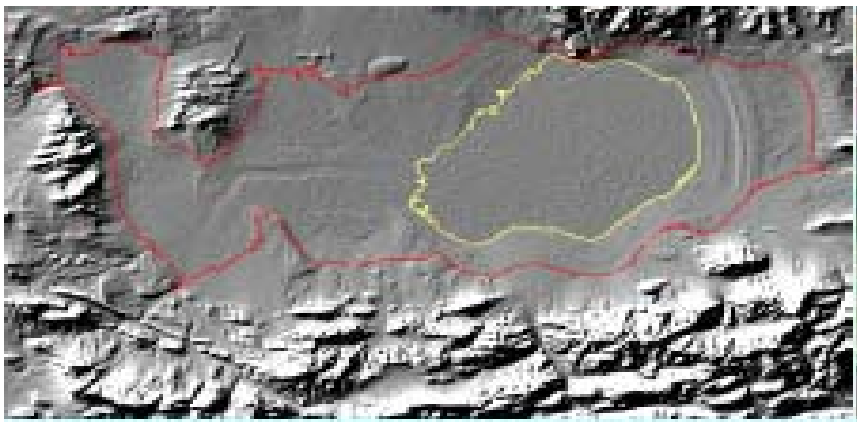
Interactive Mapping Environment



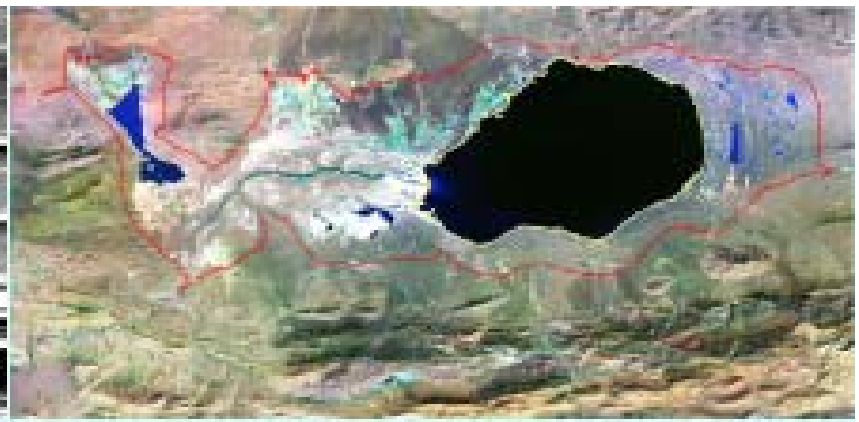
Paleo Dagze Lake Recovery

Dagze Lake, one of inland lakes in central Tibet, presently occupies an area of 243 km2 with its water level at ~4466 m a.m.s.l. The lake exhibits a typical pattern of shrinkage in a 2000 summer Landsat/ETM+ image. The paleo lake extent is recovered with following results.

1.Paleo water level: ~4523 m with a variation of 3 m;
2.Paleo lake extent: ~846 km2;
3.Water loss: ~ 30.4 km3 water;
4.Paleo lake broke into modern Dagze Lake and 30+ smaller lakes.



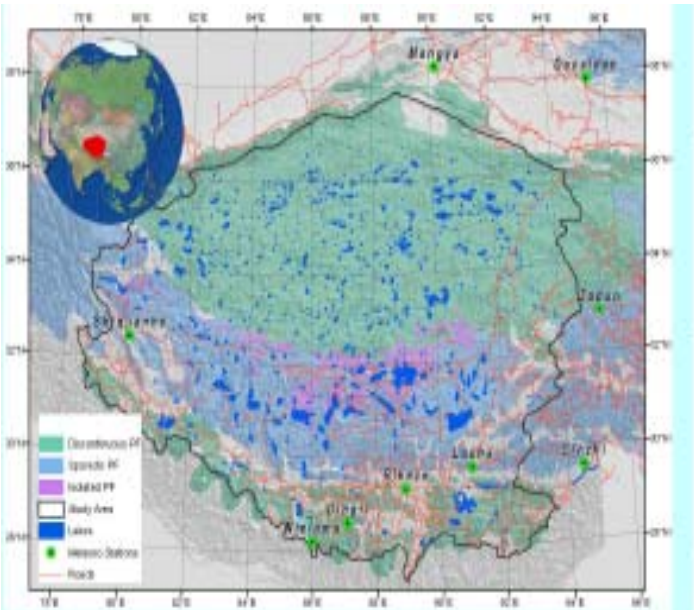
Paleo lake extent is traced using DEM data

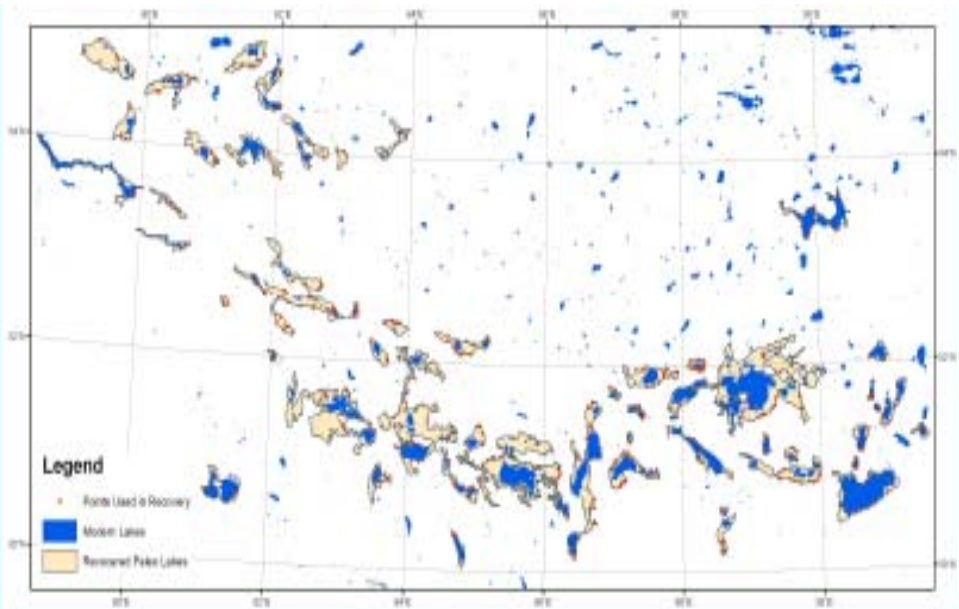


Recovered paleo lake extent matches lake features

Mapping Paleo Lakes Across the Plateau

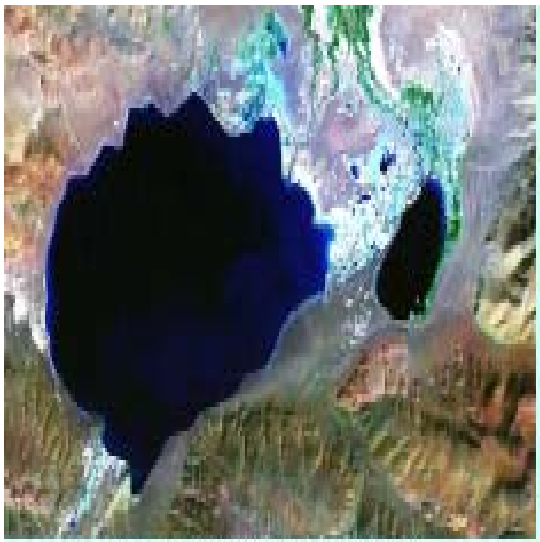
Like Dagze Lake, modern lakes surrounded by paleo shorelines are common in ETM+ imagery across the Tibetan Plateau. We currently have recovered 56 paleo lakes using the developed interactive mapping environment. These paleo lakes evolved into ~400 modern lakes with a total area of 16,279 km2. The total area shrinkage and water loss are estimated at >31,000 km2 and >2,000 km3, respectively.



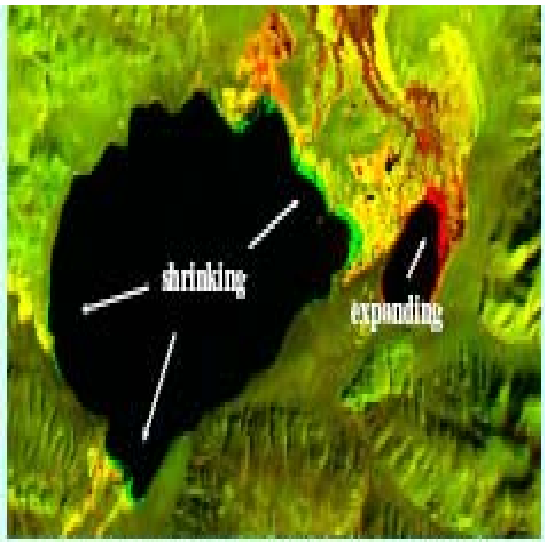


Monitoring Recent Lake Dynamics

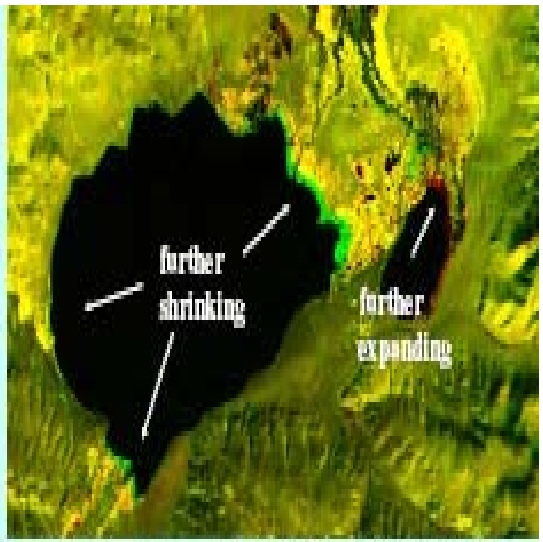
This project will also examine recent lake dynamics in the second year and analyze lake dynamics mechanisms in the third year.



ETM+ image of Dawa Lake (10/28/2000)



Lake change between 10/15/1976 (MSS) and 11/10/1990 (TM)



Lake change between 11/10/1990 (TM) and 10/28/2000 (ETM+)