Mapping glacial lakes and their changes using cloud processing of satellite images

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Image: National Geographic

Glacial lakes

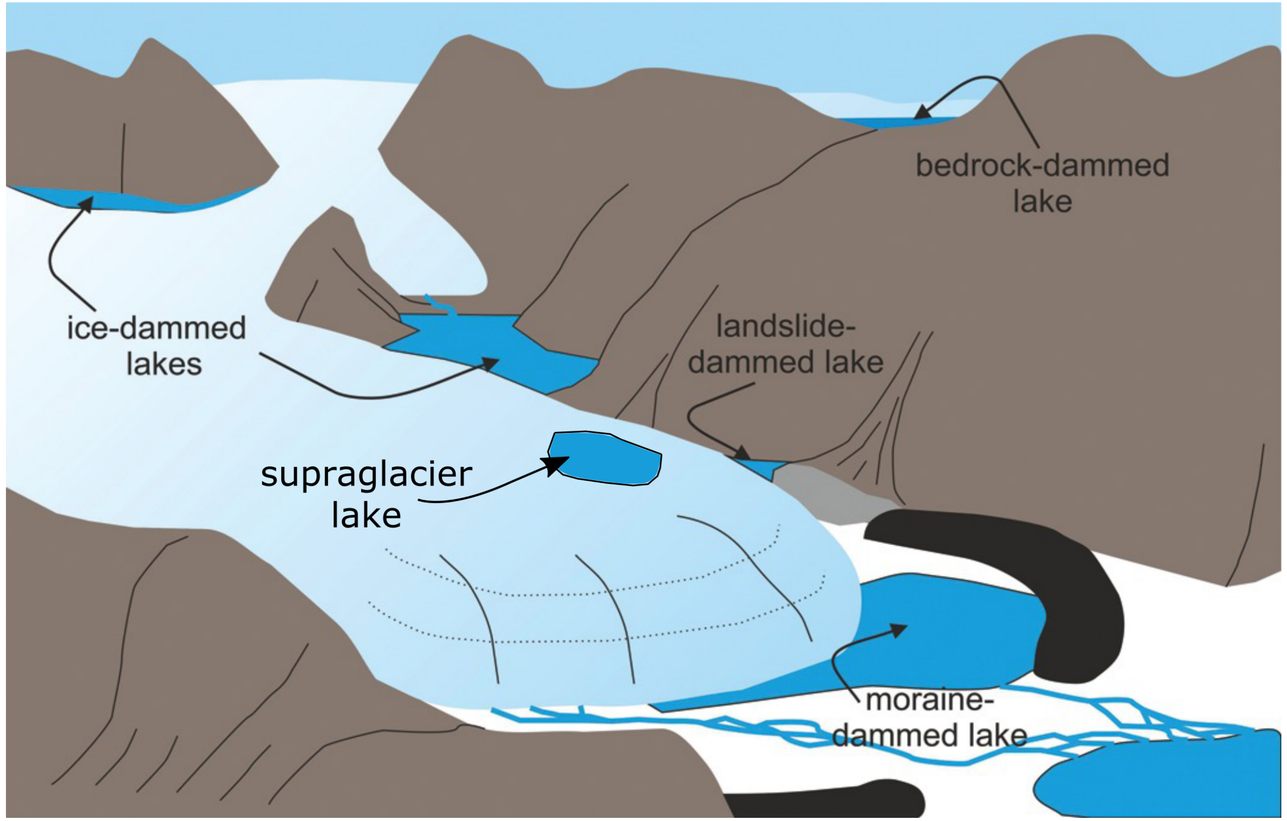
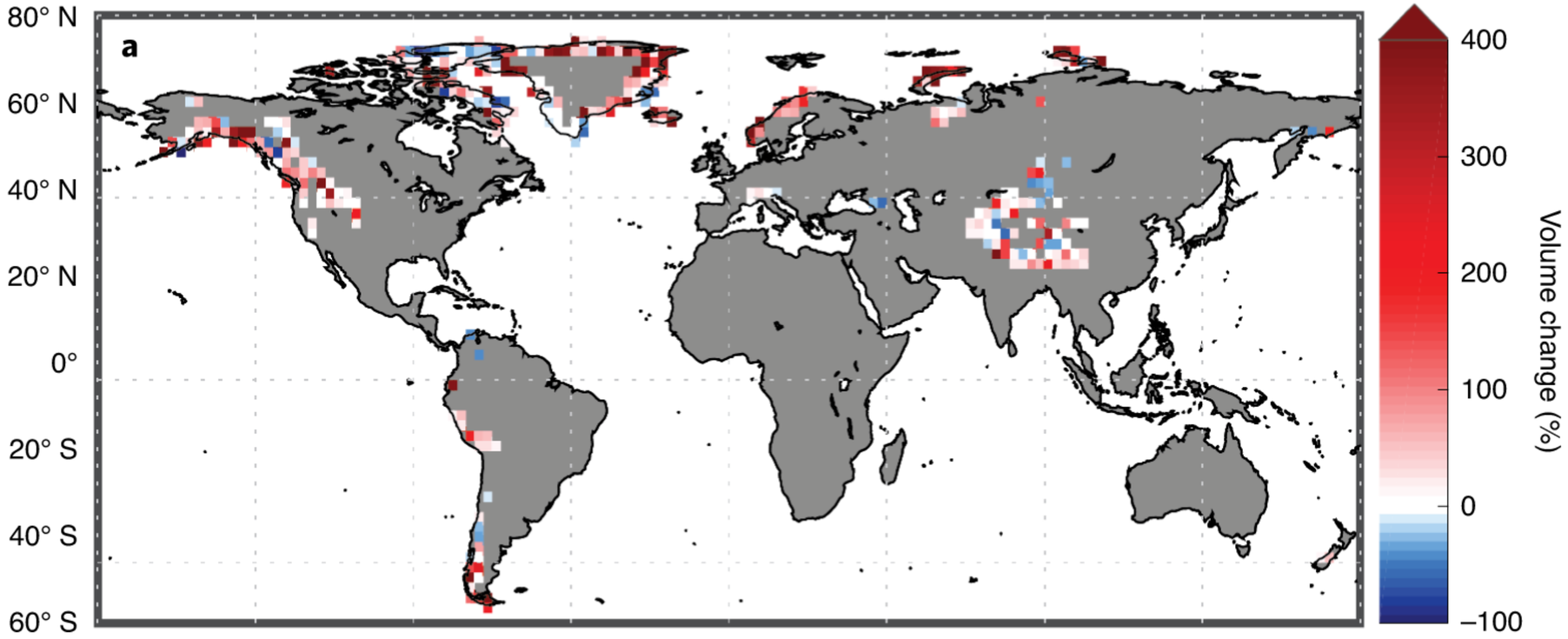


Image: modified after (Tweed and Carrivick, 2015)

Image: swisseduc.ch

Image: Dmitry Monastirsky

Glacial lake volume changes (%) since 1990 (Shugar et al., 2020)



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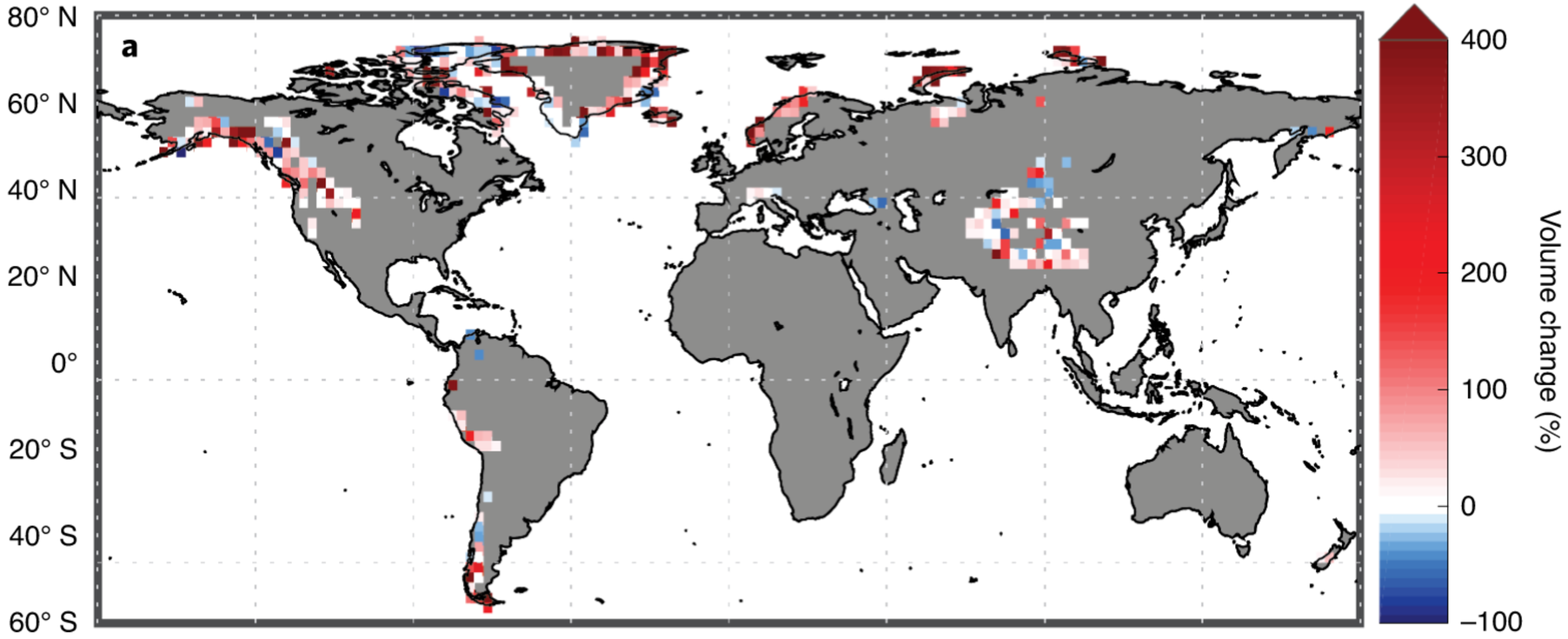
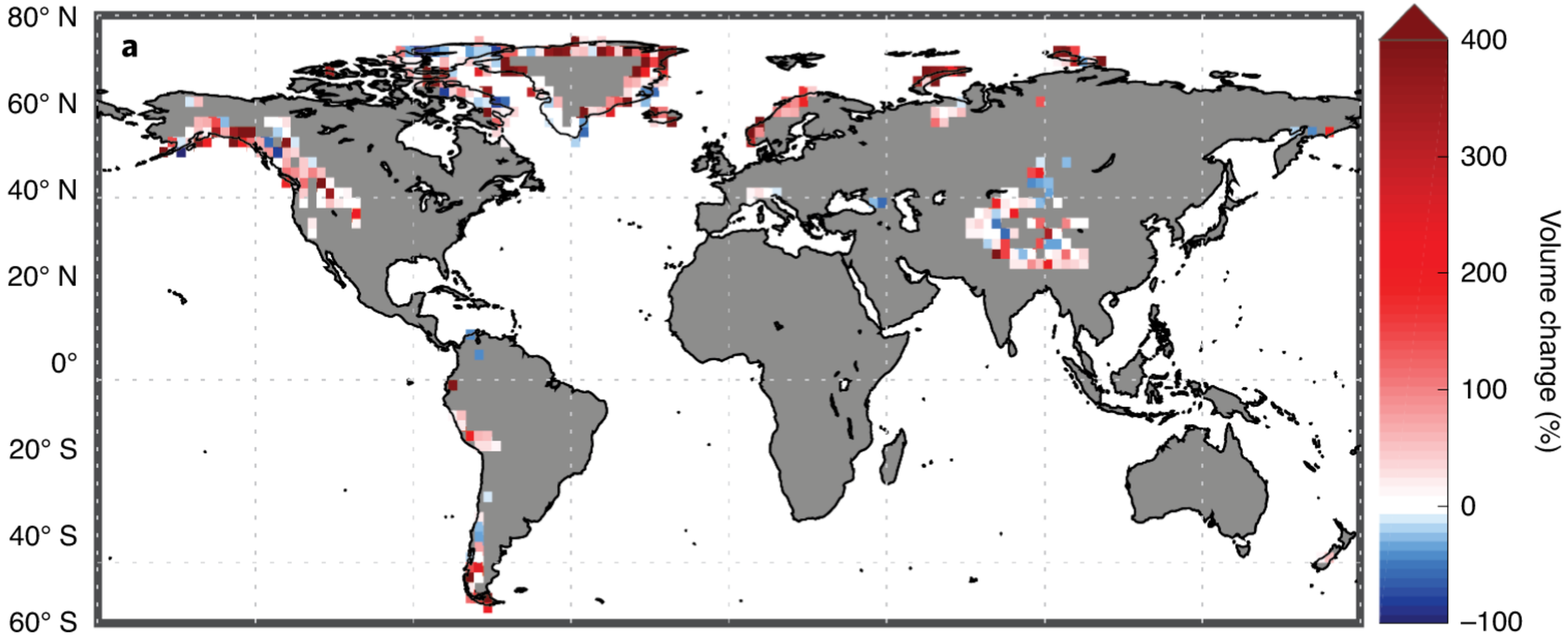


- Can we suggest a **method for water mapping using optical satellite images, that will be applicable to the glacier lakes?**
- **How can problems be avoided**, that are commonly associated with water mapping in high-mountain glaciated environments?
- Is there a way to **make a complete inventory of lakes and find GLOFs** on a global scale?

Glacial lake volume changes (%) since 1990 (Shugar et al., 2020)



Methods

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- **How can problems be avoided**, that are commonly associated with water mapping in high-mountain glaciated environments?

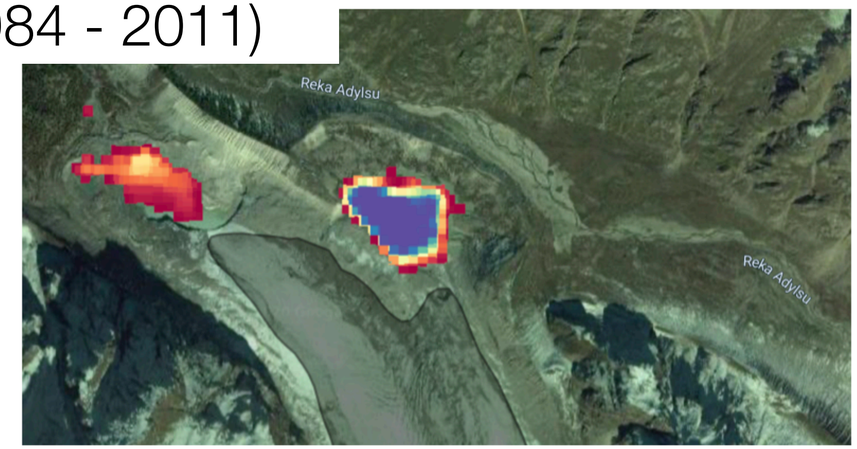
Application

- Is there a way to **make a complete inventory of lakes and find GLOFs** on a global scale?

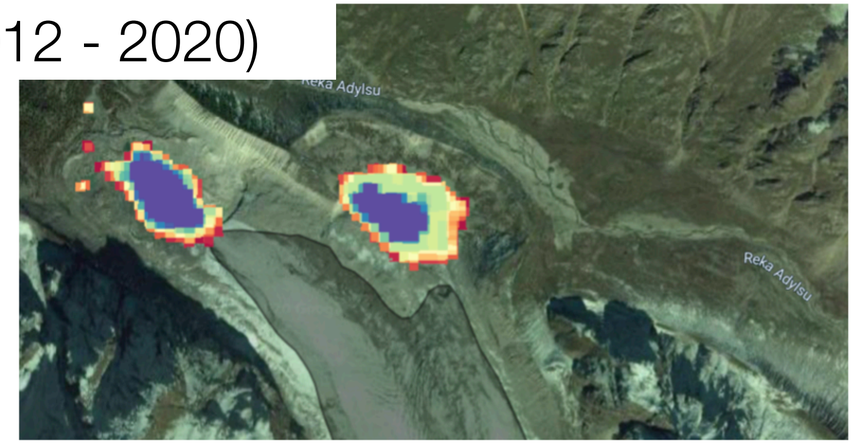
GLOF detection:

satellite revisit temporal scale

Data: Landsat 5
(1984 - 2011)



Data: Landsat 8
(2012 - 2020)



low high

water occurrence/frequency

Bashkara, Caucasus: bursted out on 1.9.2017

Landsat 5–7

Landsat 8

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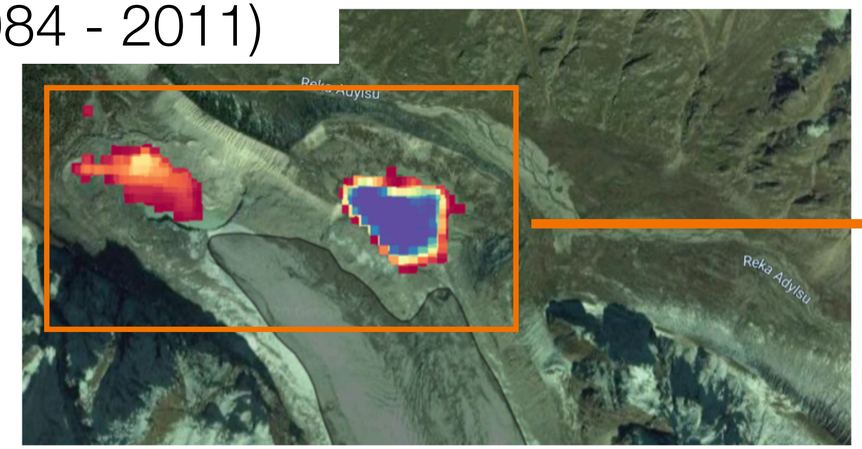

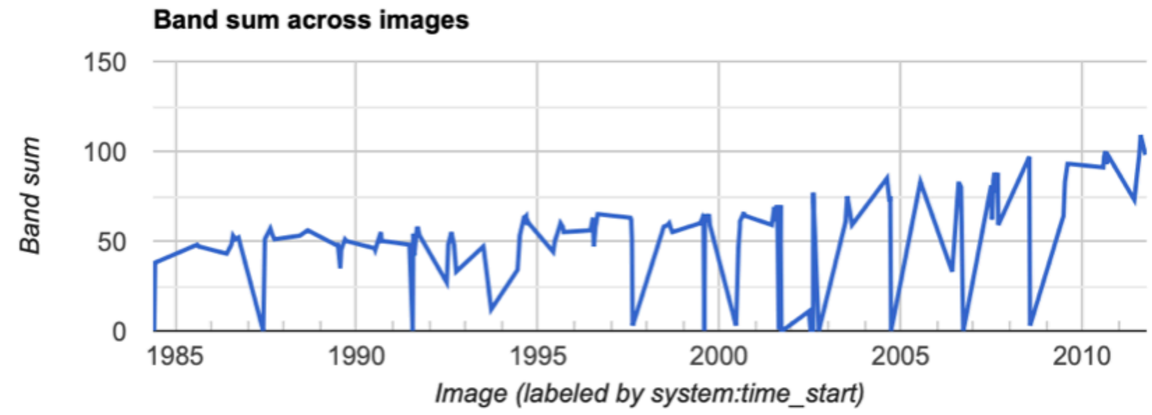

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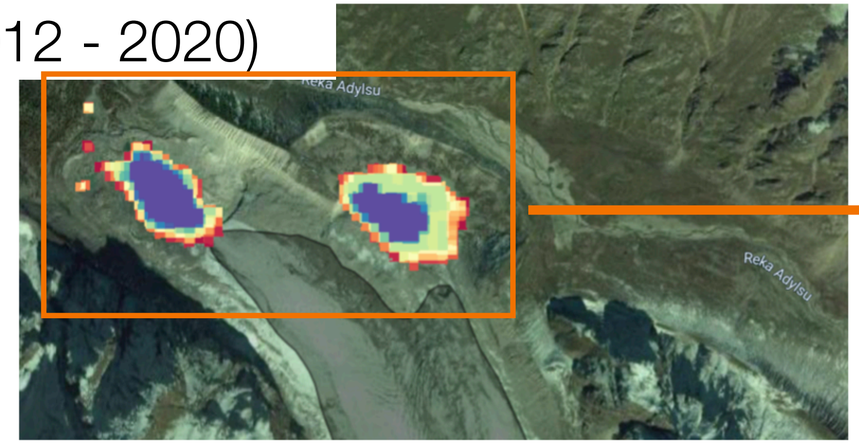
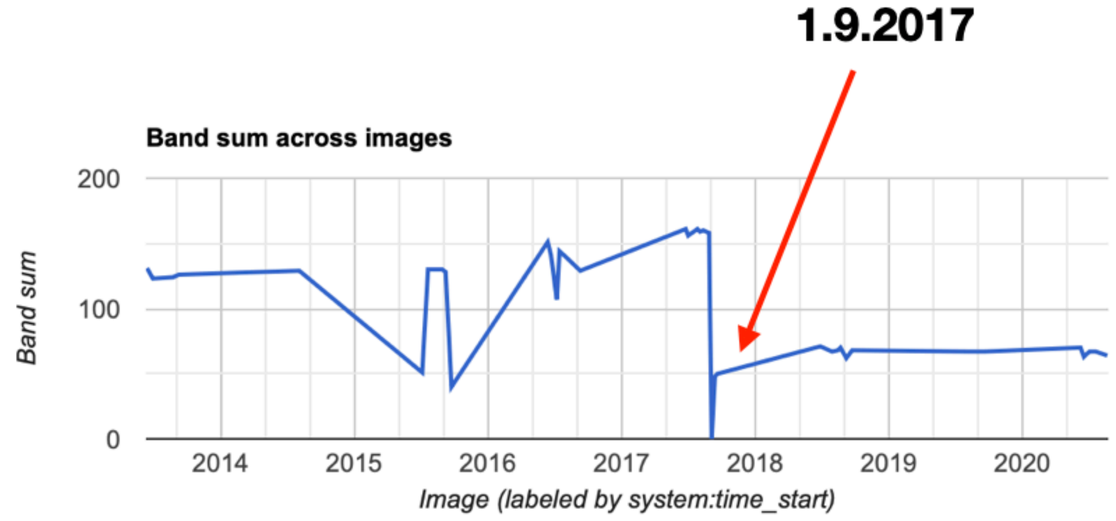


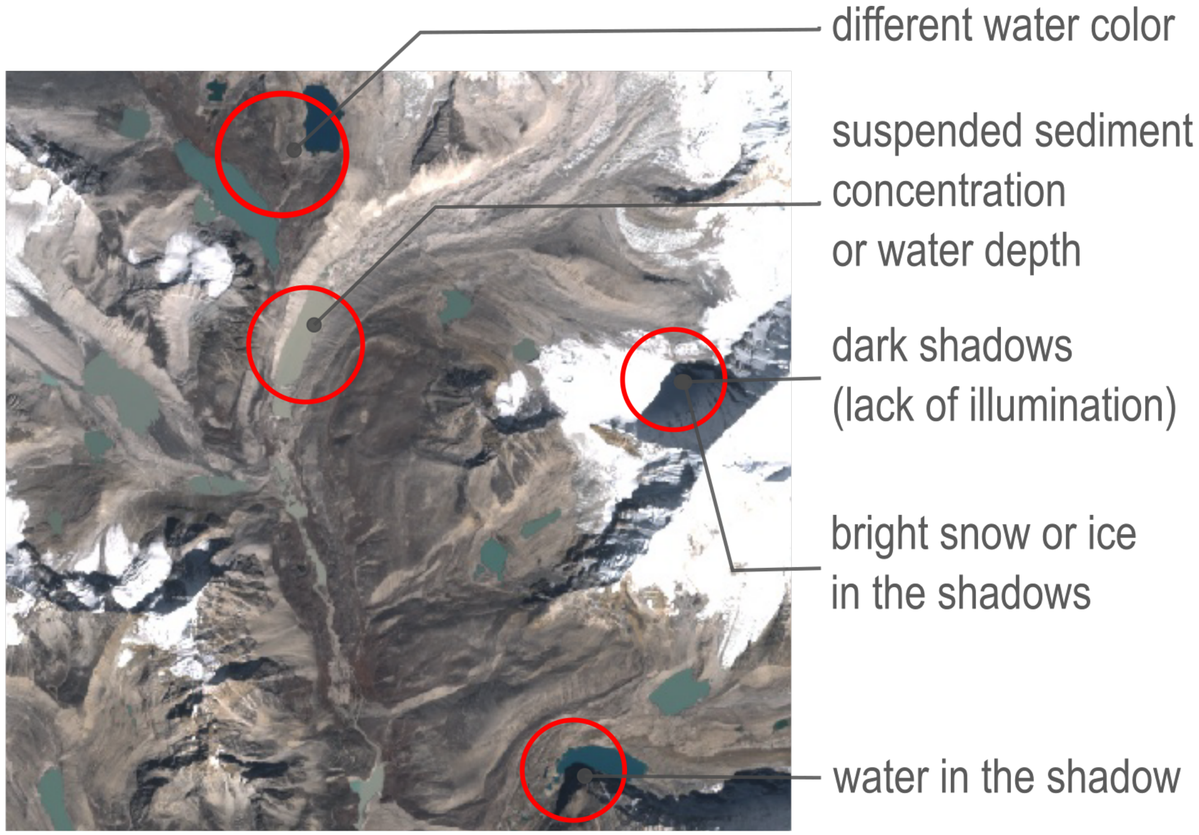


Landsat 8

low high

water occurrence/frequency

What are the problems?



Natural Color Composite

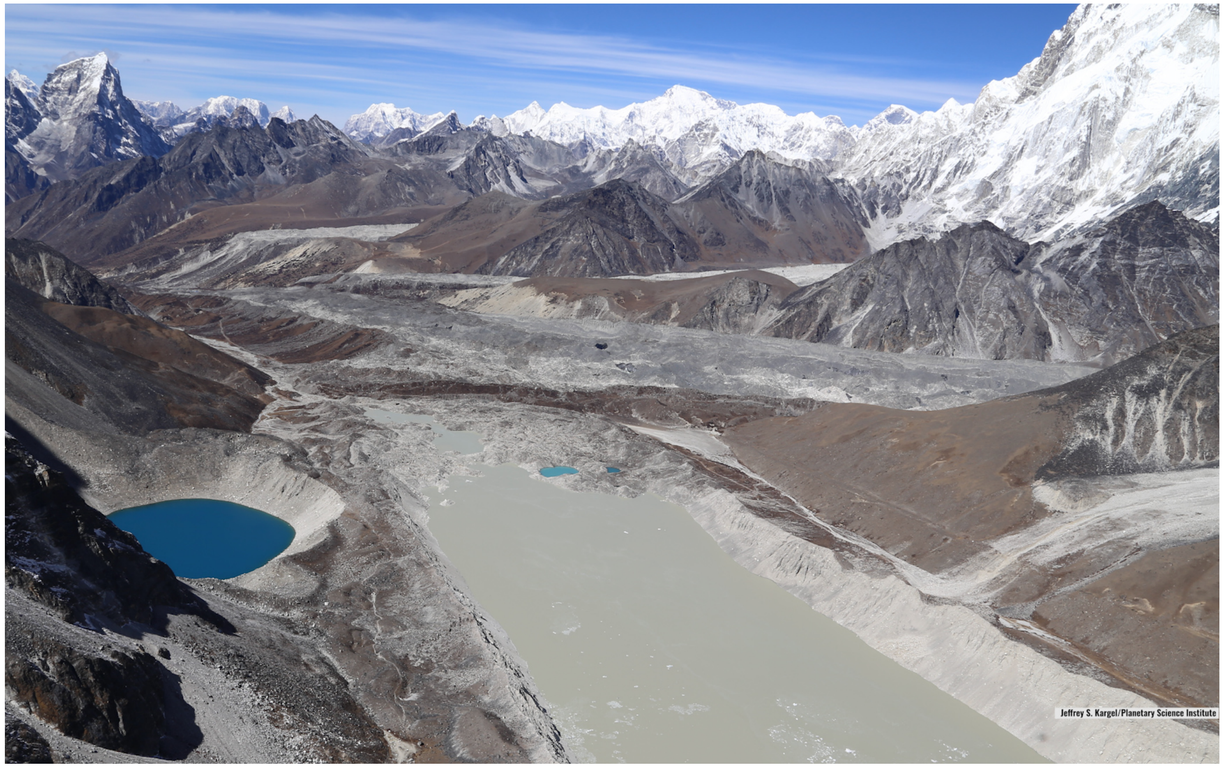
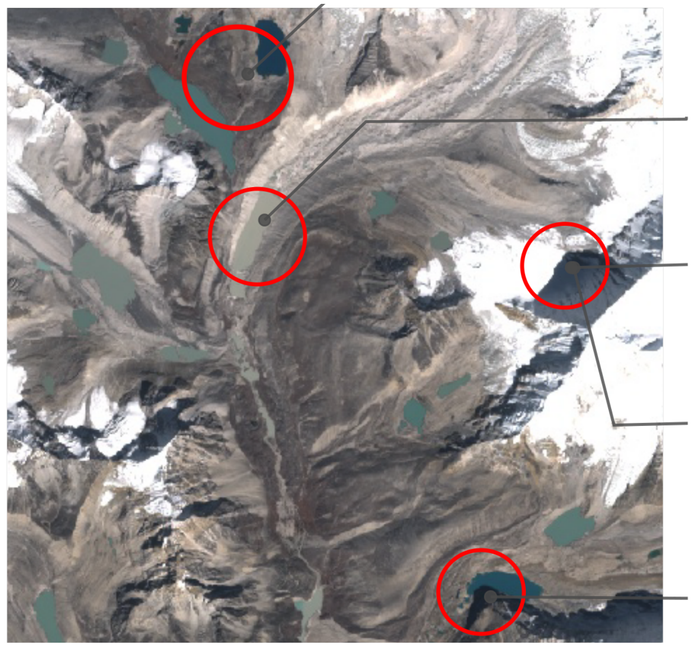


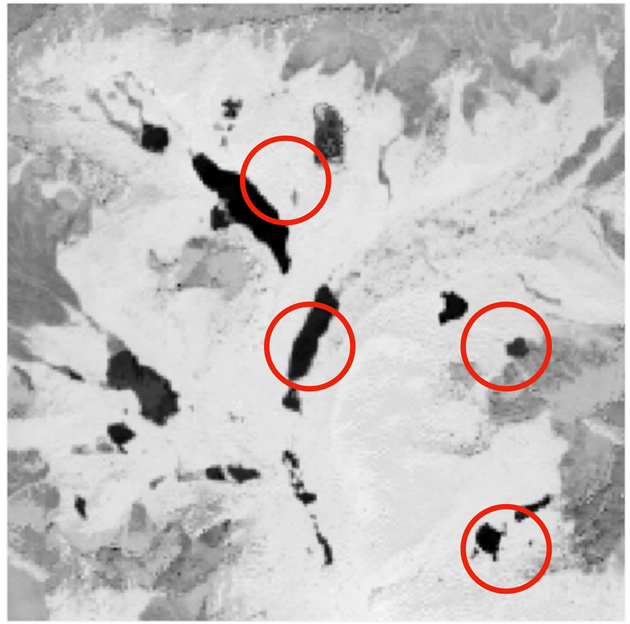
Image: NASA

How can we avoid the problems? image “stacking” (annual resolution)



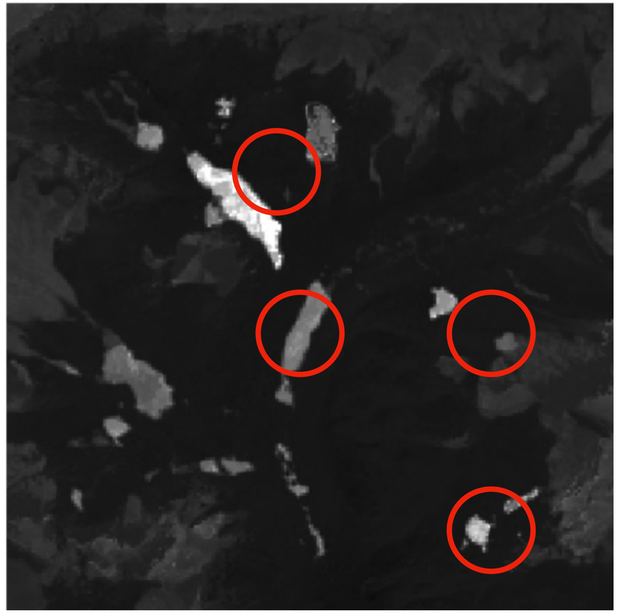
Natural Color Composite

“vegetation”: **annual-min** value



$$R_{veg} = \frac{Xnir}{Xred}$$

“water”: **annual-max** value



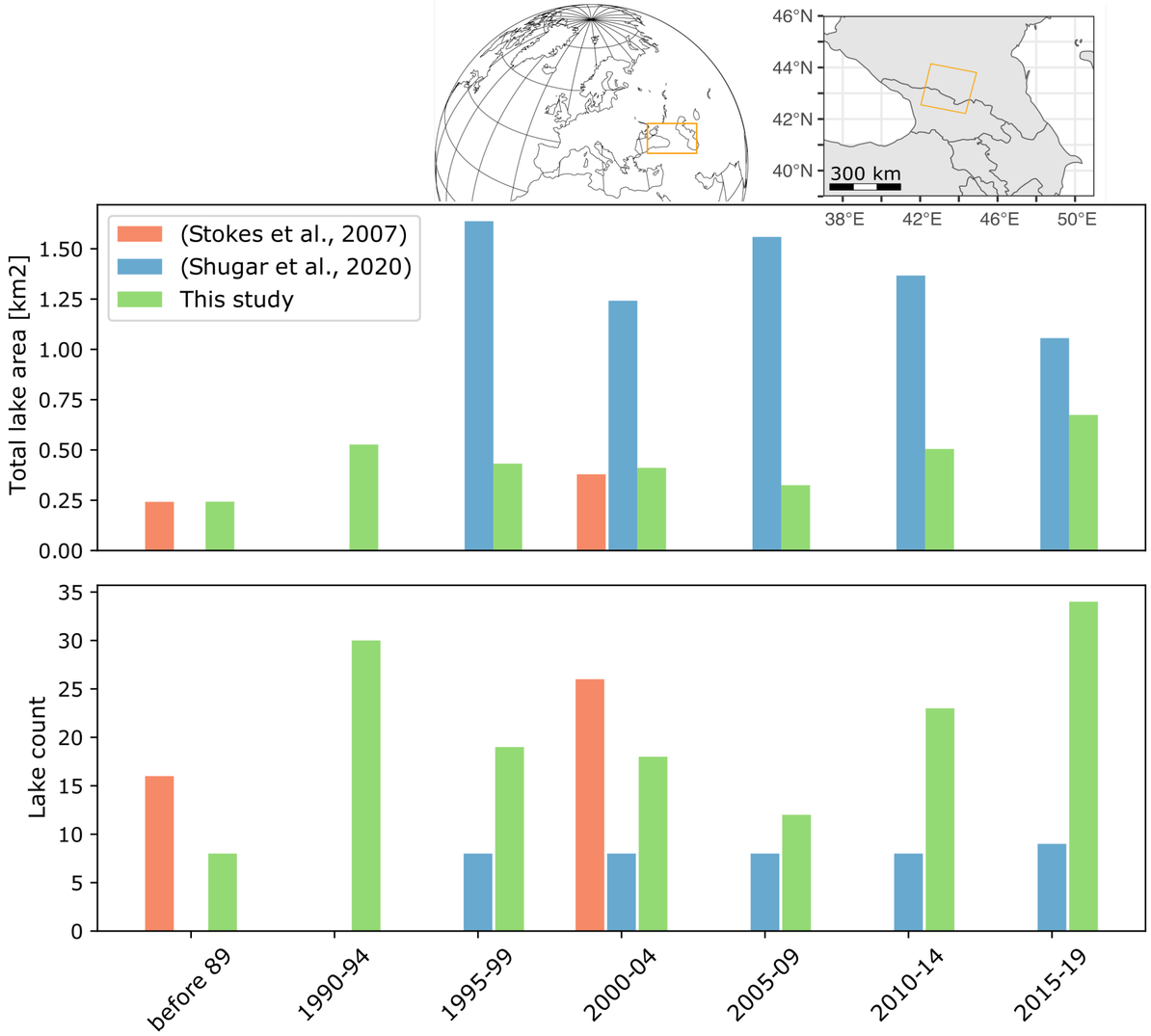
$$R_{water} = \frac{Xgreen}{Xnir}$$

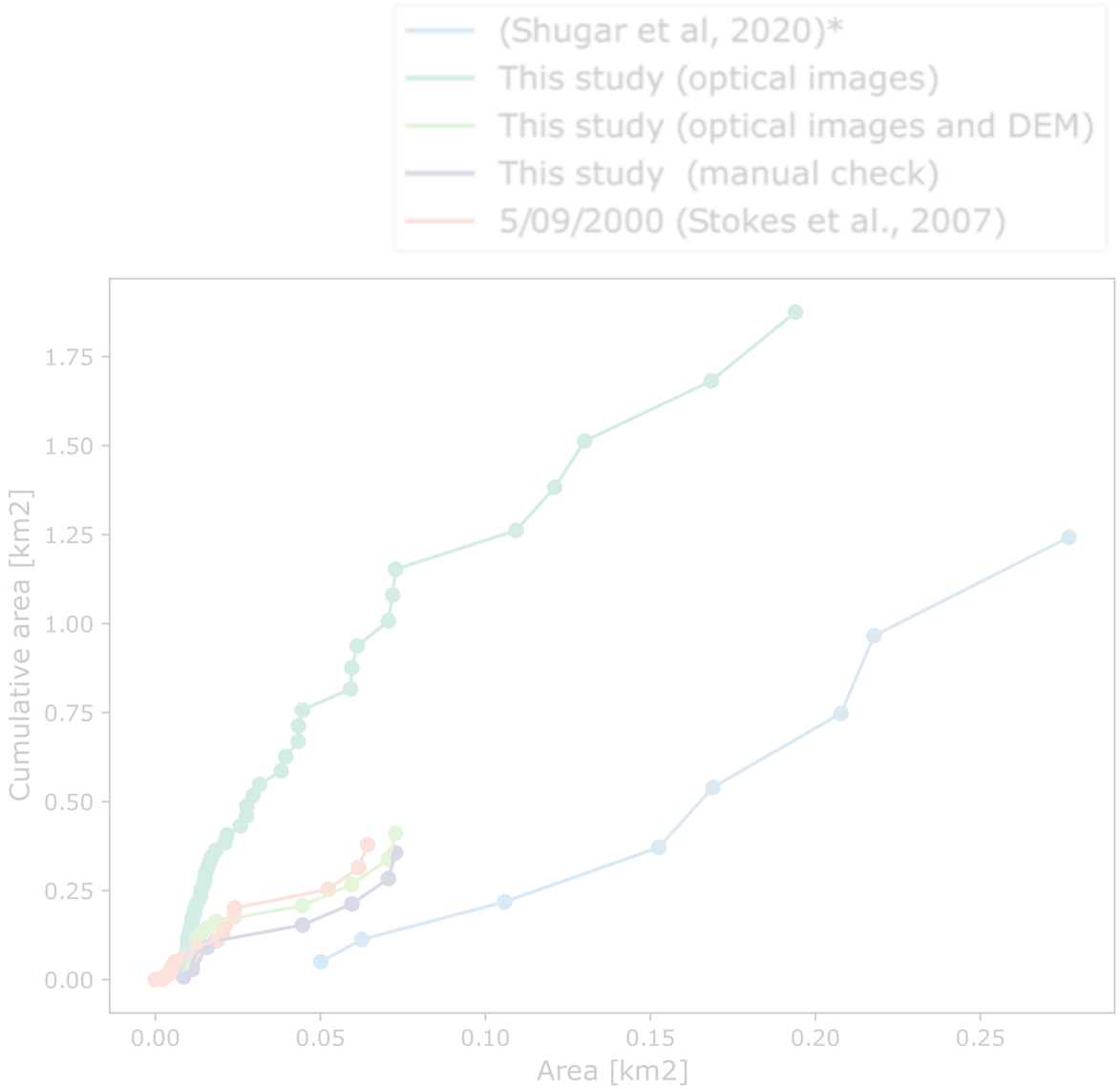
Are **2 band ratios enough** for glacial lake mapping on the annual scale: maximum value of «water» and minimum value of «vegetation»?

Almost, but not really….

→ Elevation range within the lake polygon (DEM)

Application:
glacial lake inventory for Central Caucasus





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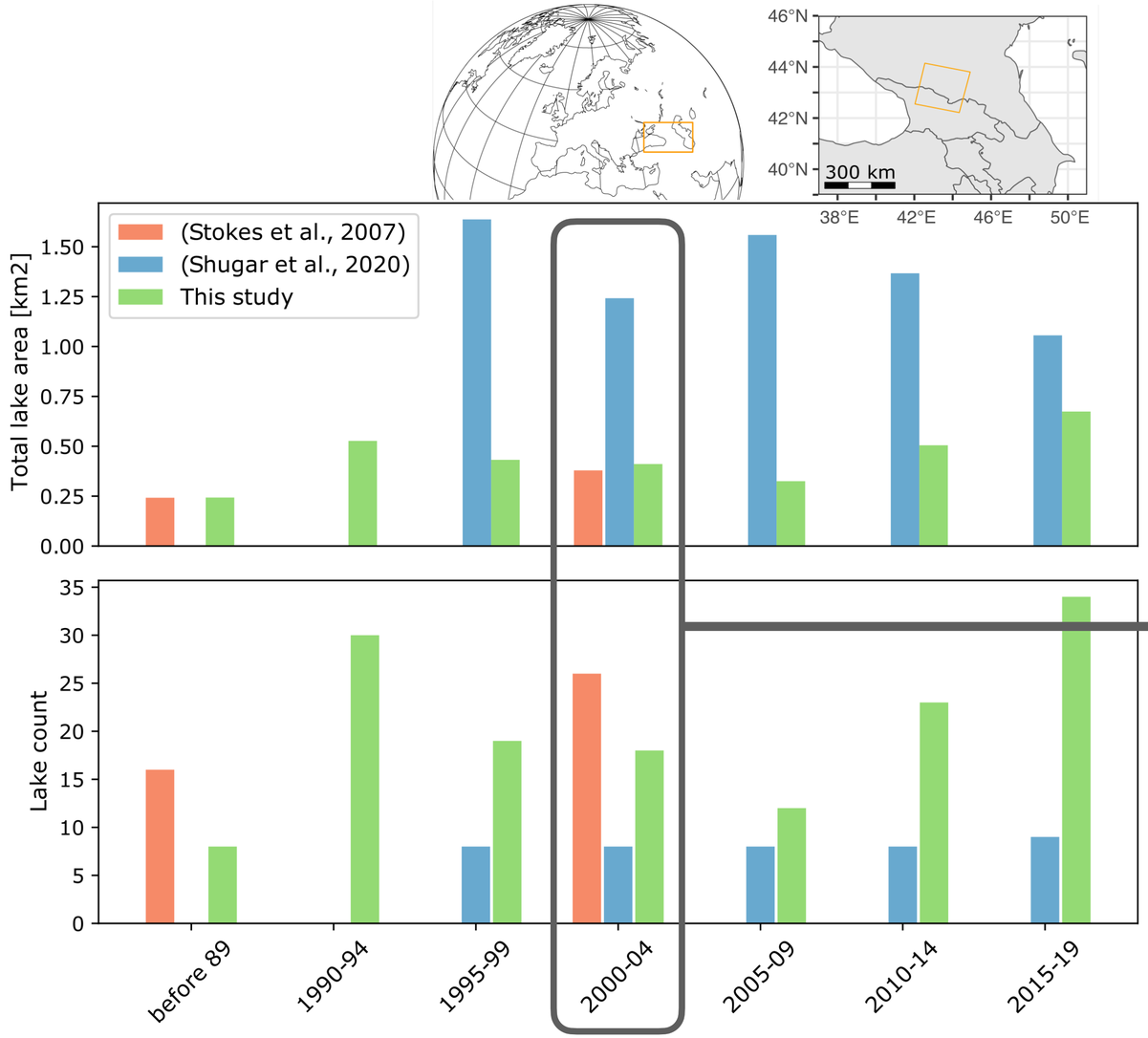

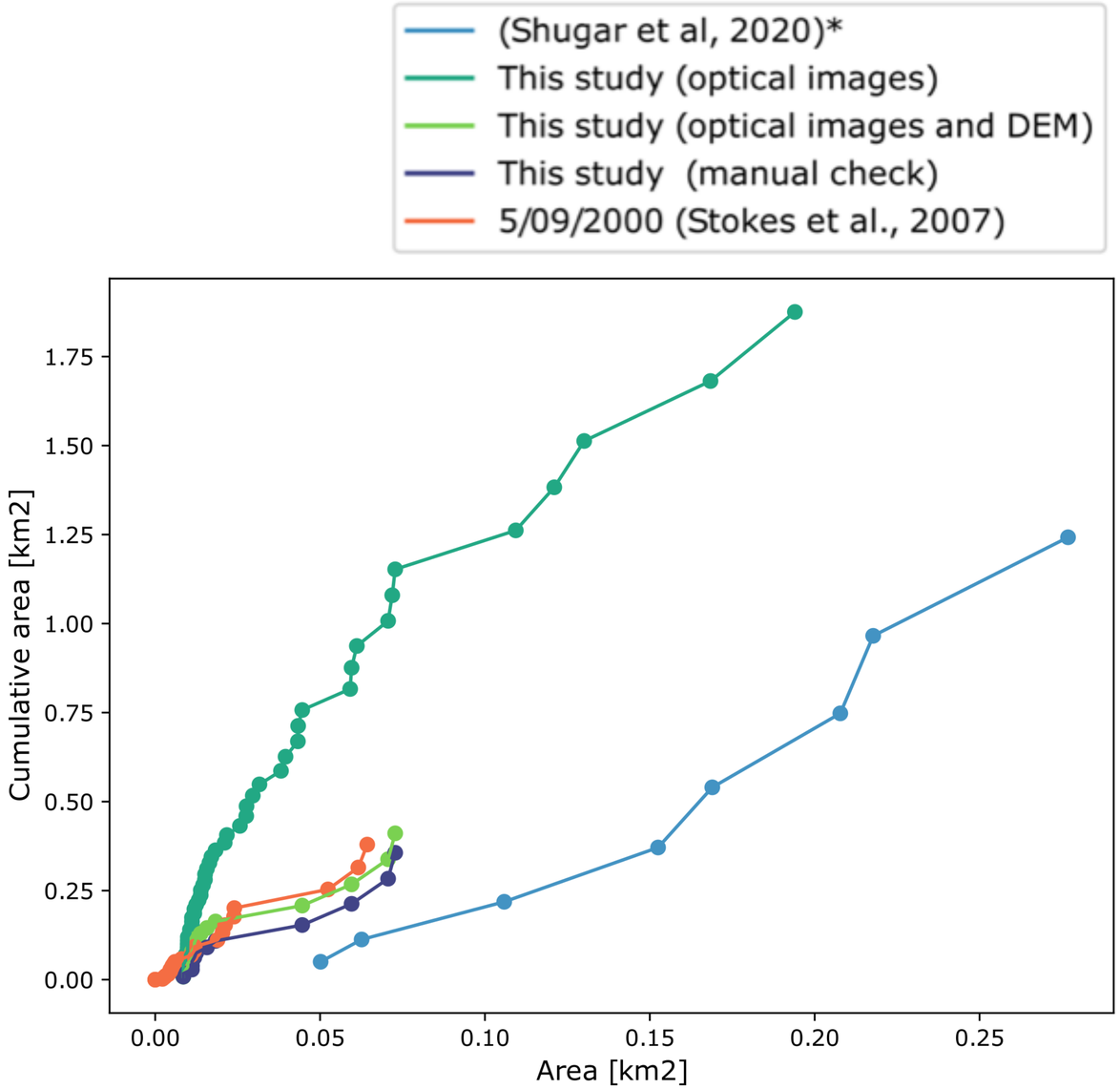

Conclusions

- Minimum and maximum reflection values of the stacked time-series of images allow to eliminate most problems, that are associated with optical satellite images, but reduces the resolution

- 2 band ratios prove to be (almost) enough for the annual scale mapping: maximum value of «water» ($\frac{Xgreen}{Xnir}$) and minimum value of «vegetation» ($\frac{Xnir}{Xred}$), elevation range within the

  mapped lake helps to filter out noise

- Size threshold matters and is region dependent, therefore a lot of small lakes are missing in the global scale inventories