Leveraging Red-Band Reflectance to Detect Ice Phenology in Small Mountain Lakes

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Introduction

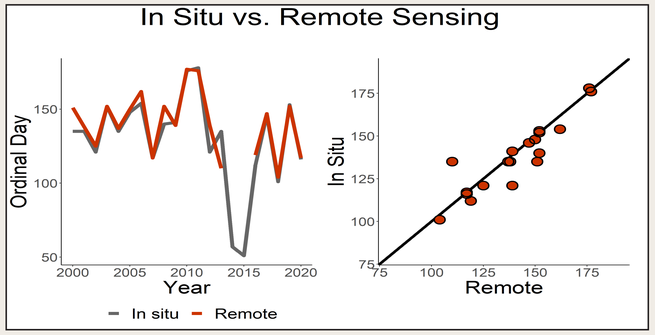
Background:

Trends show **ice phenology** changing with **later freeze timing** and **earlier breakup timing** [1]. These studies largely focus on long-term in situ observations in lowland lakes. **Mountain lakes** may be losing ice more quickly [2], but they remain unexplored due to sampling challenges and dangerous winter conditions [3].

Objectives:

- Use **Moderate Resolution Imaging Spectroradiometer** (**MODIS**) to build a robust dataset of ice phenology in mountain lakes as small as 0.1 km^2.
- Analyze remotely sensed dataset for **regional and global patterns in ice phenology**, incorporating nonparametric standardization to driver and response variables.

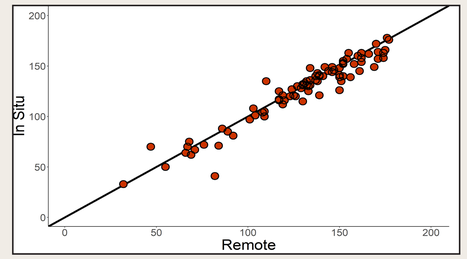
Results



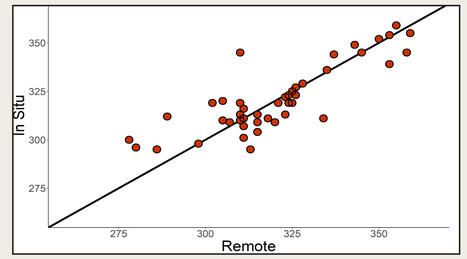
Example results from **Castle Lake**, California (SA = 0.2 km^2), show **good agreement** between **in situ** (grey) and **remotely sensed** (red) data with a **mean absolute error of 5.7 days**.

Years **2014** and **2015** were **severe drought** years according to the U.S. Drought Monitor and were punctuated by sporadic ice cover. Identification of ice freeze and breakup dates was not possible.

Ice off results displayed on a one-to-one plot for all study lakes (n = 5) with in situ data. The mean absolute error is **6.5 days**.



Ice on results for all study lakes with in situ data. The mean absolute error is **7.2 days**. Ice on had **fewer data points** owing to **more cloudy days** across systems.

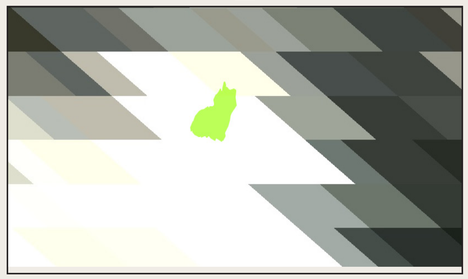


Methods

Method derived from Zhang & Pavelsky (2019) [4]

1. Apply cloud mask to **MODIS red-band** imagery (MOD09Q1).
2. Compare MODIS red-band against **Landsat Fmask** (cloud and snow filter).
3. Determine **ice fraction** cover of lake polygon.
4. Remove outliers from ice fraction using **ERA-5 mean temperature**.
5. Make final selection of **ice freeze and breakup dates**.

1.



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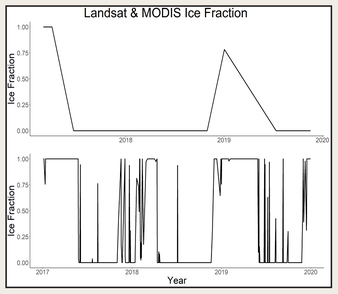

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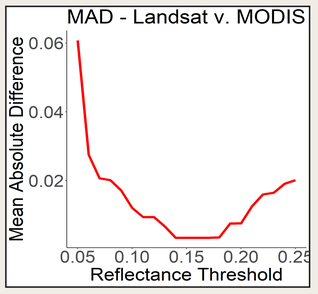

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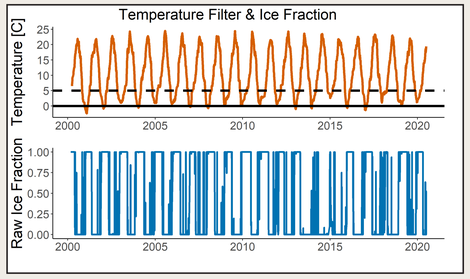

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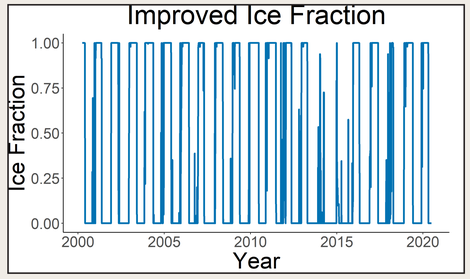

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Conclusions & Future Work

- The results demonstrate the algorithm's ability to detect ice phenology in lakes smaller than 1km^2.
- In situ data for mountain lakes is scarce, which supports the necessity of the work but proves challenging for validation.
- Next steps include:
  1. Expanding the dataset to include HydroLAKES [5]
  2. Use nonparametric standardization to create a global dataset
  3. Use model II regression to test relationships between ice phenology and climate, as well as morphological drivers

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References

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