Synergy of HR Optical and SAR Imagery with Altimetric Data to Monitor Sensitive Areas of East Dongting and Anhui Province Lakes

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Context

Lakes in the basin of the **Yangtze River**, play a **fundamental** role in regional **bio-geochemical cycles** and provide major services to the communities, **provisioning services** (drinking water, fishing…) and biodiversity keeping. However, the **extreme** temporal and spatial **variability** of these massive but extremely shallow ecosystems **prevents** a **reliable quantification** of their dynamics with respect to changes in climate and land use.
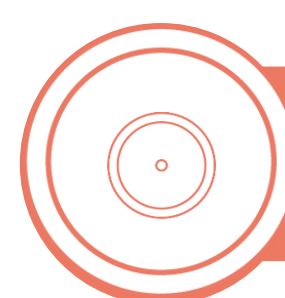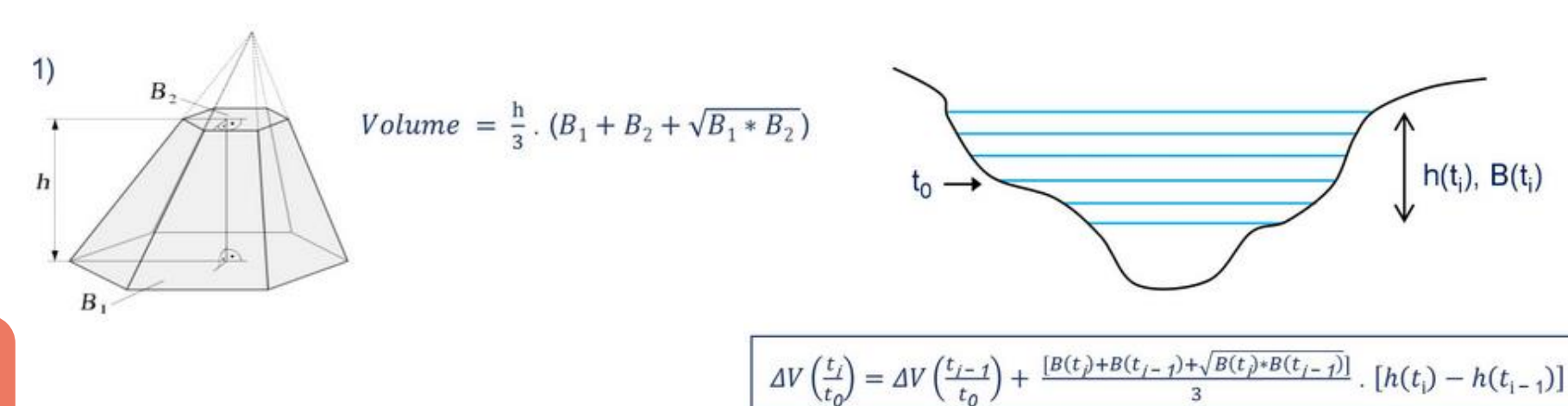
Objectives

- Monitoring **Lake Water Extent (LWE)** and **Lake Water Level (LWL)** during **7 years** from **2017 to 2023** in the middle and lower reaches of the Yangtze river; focused on 5 Anhui lakes and 6 East Dongting sub lakes.

- Estimation of water volume variations that marked each lake.

- Map and explain the **spatio-temporal changes** in biodiversity.

Location of the Anhui study cases, Caizi, Baidang, Shengjin, Wuchang East and West, lakes having an hight biodiversity value and Sentinel-2 tiles.
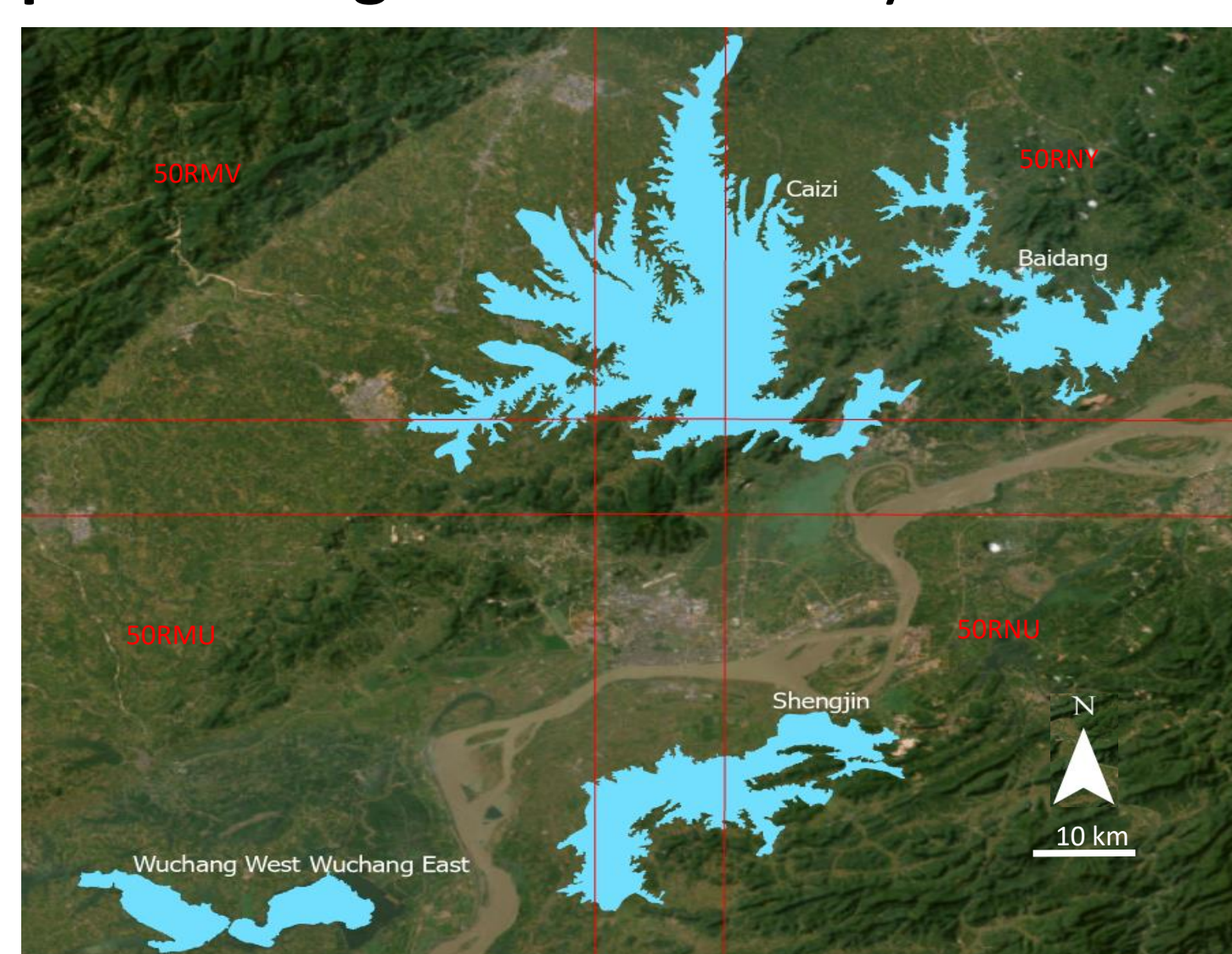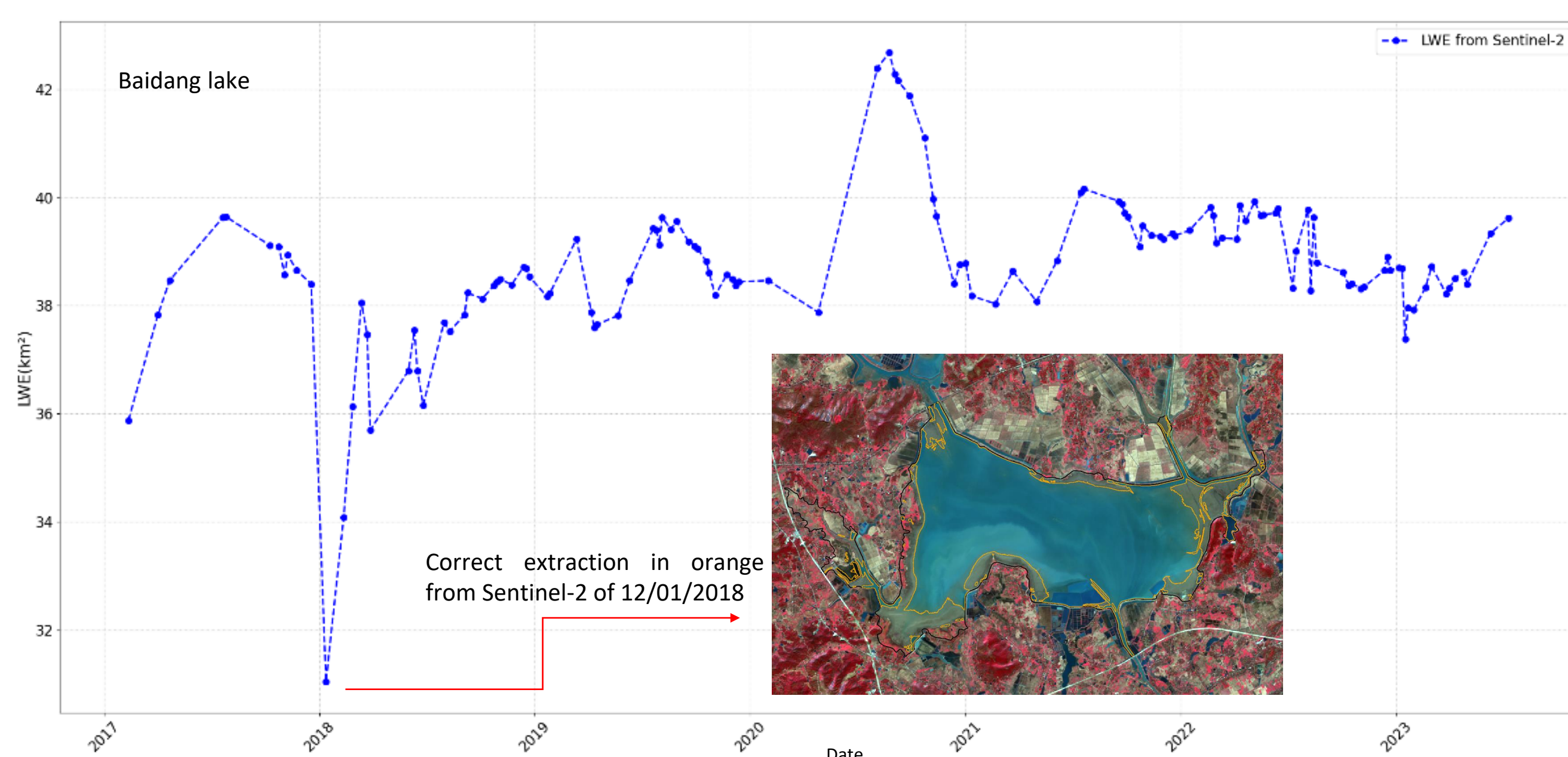
Methods

- Extraction of water extent processing over **800 Sentinel-2 image/tile** using **ExtractEO** and **quality validation** comparing to Pleiades Neo image (30 cm of resolution) with up to **85% in precision**.

- Generation of **LWE time series** and **annual water occurrence maps**.

- Exploitation of **SAR data** (RADARSAT-2 and ICEYE) during key periods.

- **LWL** time **series** based on **IceSAT-2** and **Sentinel-3**.

- **Volume variation** estimations by **combination** of **LWE** and **LWL** based on a quadratic hypothesis assuming that the change in volume can be approximated by that of a truncated pyramid (1). (Quellec and Cretaux, 2019)

$$Volume = \frac{h}{3} \cdot (B_1 + B_2 + \sqrt{B_1 \times B_2})$$

$$\Delta V\left(\frac{t_i}{t_0}\right) = \Delta V\left(\frac{t_{i-1}}{t_0}\right) + \frac{[B(t_i) + B(t_{i-1})] + \sqrt{B(t_i) \cdot B(t_{i-1})}}{3} \cdot [h(t_i) - h(t_{i-1})]$$

Results

➤ Lake Water Extent

Correct extraction in orange from Sentinel-2 of 12/01/2018

Baidang **LWE time serie** after processing **Sentinel-2** image with **0% cloud coverage** and after removing **outliers** (incomplete extractions due to **sunglint**). Low water extractions in 2018 are due to an important lake's draining whereas highest values correspond to the 2020 major flood event affecting the Yangtze intermediate basin.

➤ EEO Occurrence Maps show water presence throughout 2017-2023 over East Dongting lake and sub lakes, as well over Baidang lake.
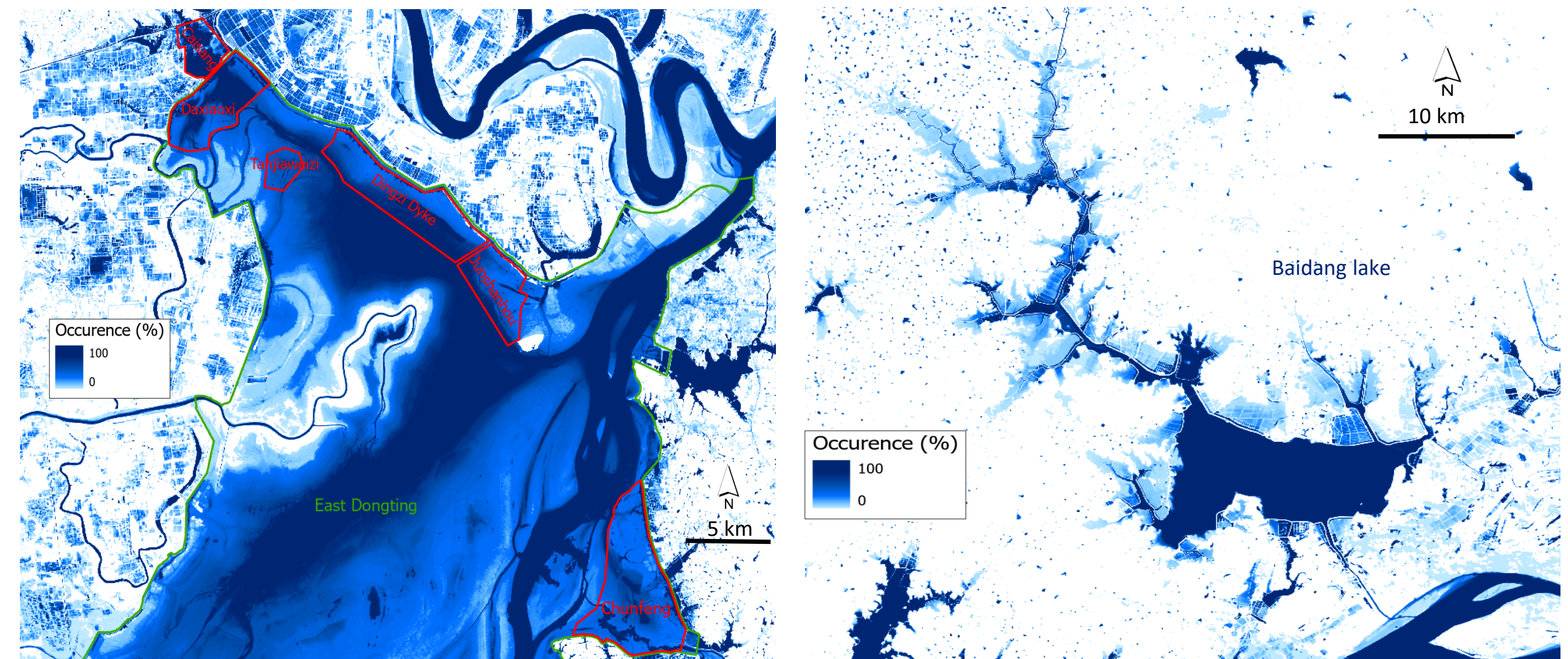
➤ Lake Water Level

IceSAT-2 elevations are reported as orthometric heights above the WGS84 ellipsoid and are **averaged by day** to generate LWL time series; also compared to S3 time series.

On the right, IceSAT-2 water surface height tracks over Baidang Lake.

➤ Volume Variation

Volume variation time series were generated for 5 Anhui lakes and the East Dongting lake monitored during 7 years. The LWEs used to estimate volume variations are also retrieved from SAR data when its available in order to densify the time series.

Volume variations of Baidang lake from Sentinel-2 and RADARSAT-2 LWE and IceSAT-2 LWL.
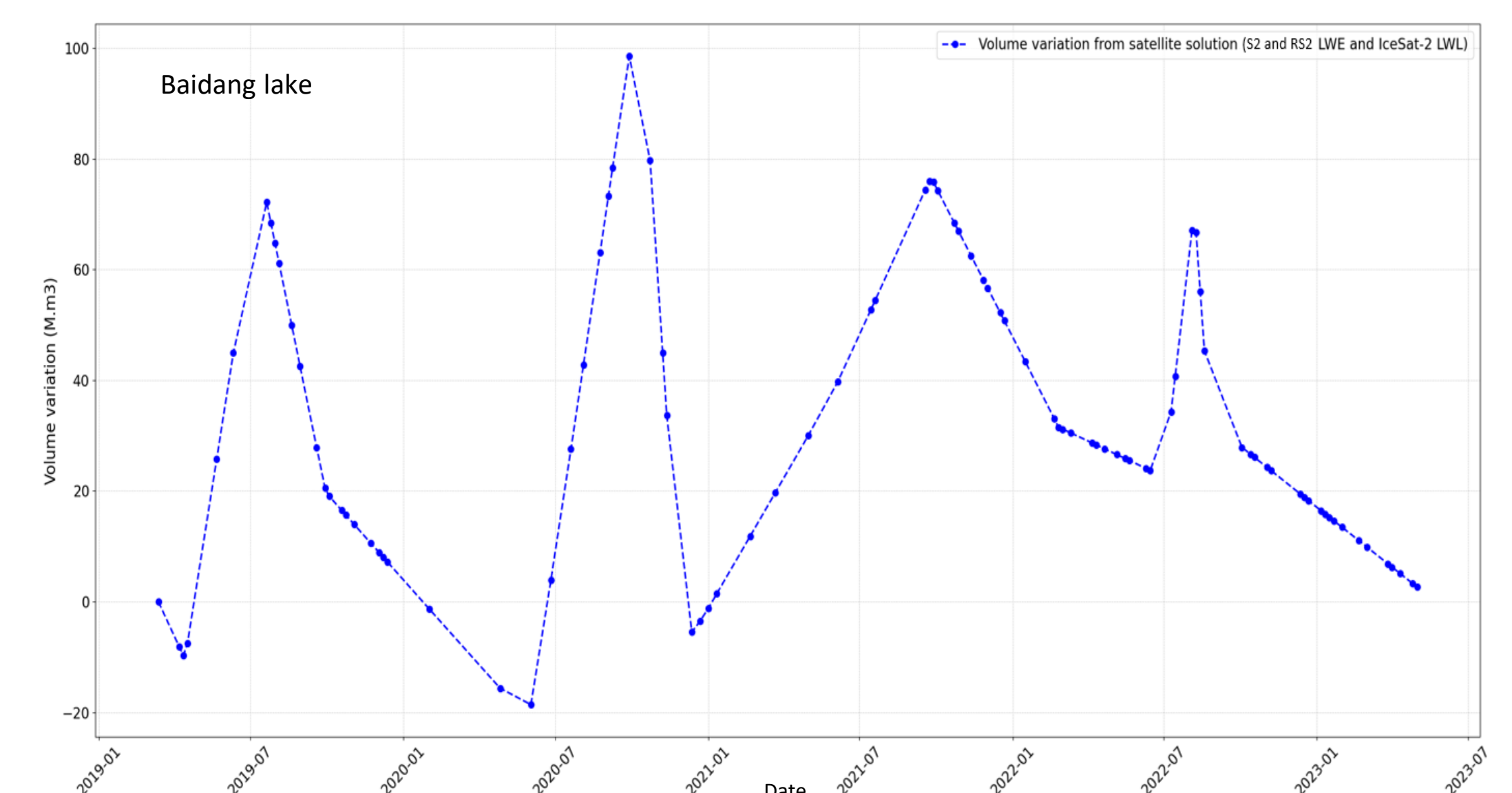
Discussion

- **EEO** water **extractions** using **NDWI** and **SWIC** indexes depend mainly on the **quality** of the **image** and the **type** of **lake** in the Anhui basin:
  - ✓ NDWI differentiates between water and sludge or mixed water-vegetation pixels.
  - ✓ SWIC is used instead of NDWI when images have sunglint effect.
- **SWIC** is very **effective** for **East Dongting lake** with its special variations and shallow ecosystems.
- Different **water** bodies and wetlands **dynamics** thanks to **occurrence maps** and **volume variation estimations.**

Conclusion and future work

- **Complexity** of **sensitive ecosystems** such as the Anhui lakes.
- Possibility to monitor water extent and level over short or long periods.
- **Identification** of **flood** and **drain** episodes.
- More use of **SAR** data to **densify** gaps in Sentinel-2 LWE **time series** due to cloud coverage; especially during important events.
- Set up a **reference database** for further **SWOT** products, ie LWL and LWE, **validation.**

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