TRACKING THE VOLUME CHANGES OF LAKES IN WEST AFRICA WITH REMOTE SENSING

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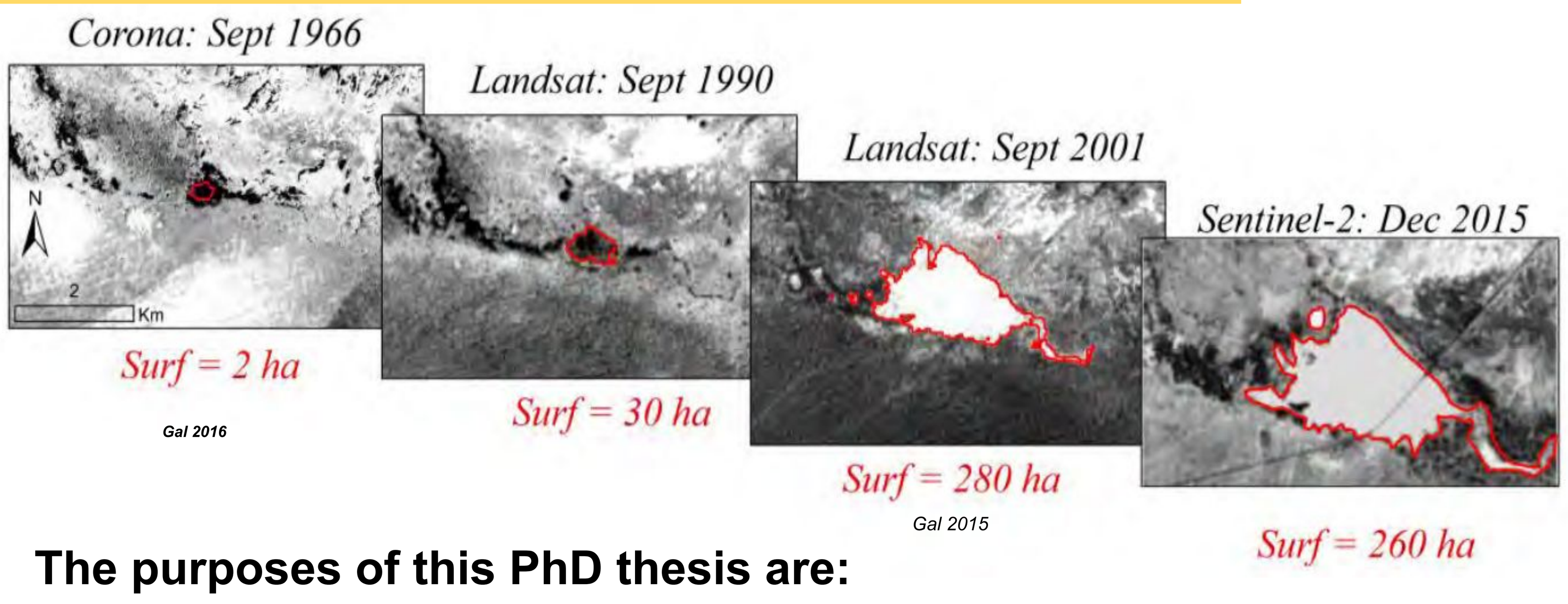
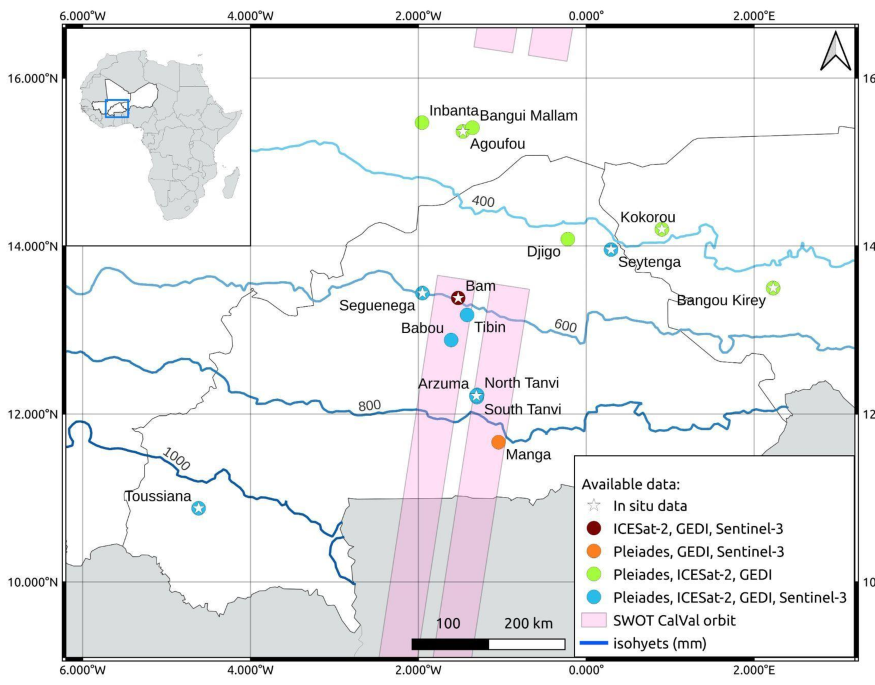
La Région Occitanie Pyrénées - Méditerranée

CLS COLLECTE LOCALISATION SATELLITES

Hydrological context in West Africa



Water in Sahel is crucial for agriculture, domestic use and livestock. Besides, the distribution and dynamics of Sahelian water bodies is poorly known. The last 50 years has been highly marked by changes in rainfall. In particular, **Central Sahel experienced a severe drought during the 70s-90s**, which had a significant impact on vegetation, soils encrustation and hydrology. Since then, **an increase in surface water quantity** has been observed and represents what is called « **the Sahelian paradox** ». In parallel, human pressures on the water cycle increased in West Africa through the **construction of multiple reservoirs** for irrigation and hydropower management.



The 16 studied lakes and reservoirs across Burkina Faso, Mali and Niger

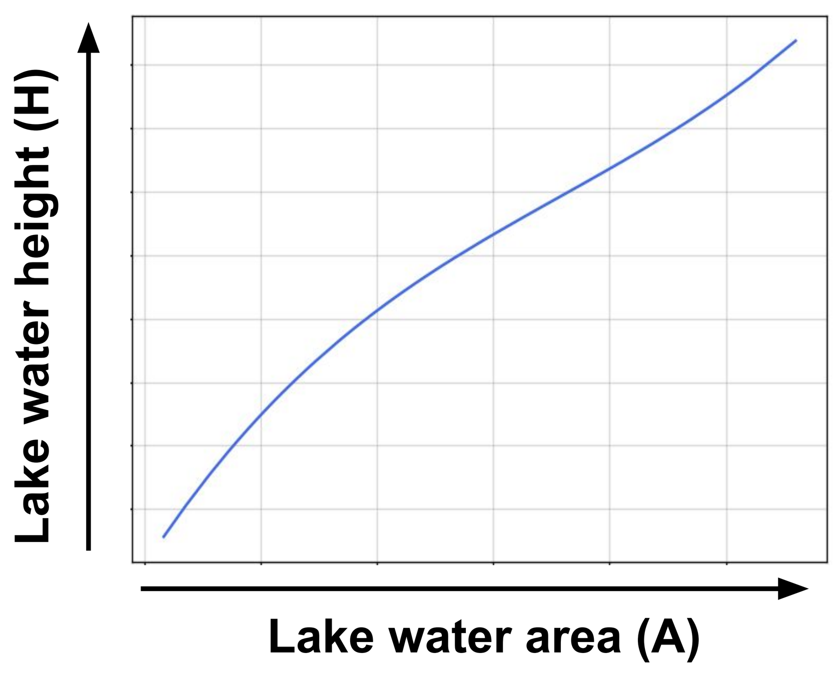
The purposes of this PhD thesis are:

- developing **new methods** for water volume monitoring
- better understanding **water volume dynamics** of Sahelian water bodies
- **estimating the water resources changes** in West Africa over the past 4 decades and link them to climatic variations

Measuring lake volume changes with current satellites

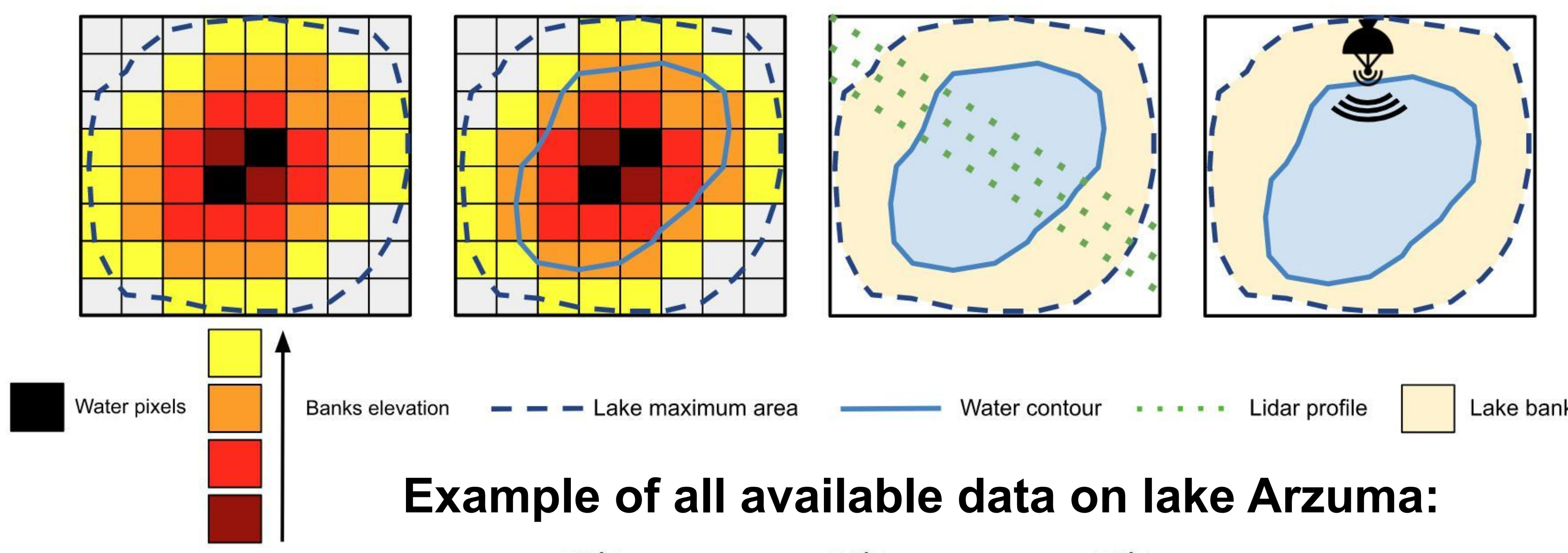
Satellites are able to measure **water height** through altimetry or digital elevation model (DEM), and **water area** thanks to radar and optical imagery. These two parameters allows to retrieve **volume change** by **integrating the H-A curve** between two observations of the lake.

The H-A curve is a 1D representation of the lake bathymetry, and **informs on how lake water height** (or volume) **evolves with lake water area**. It also allows for computing volume change only with either water area or water height measurements.

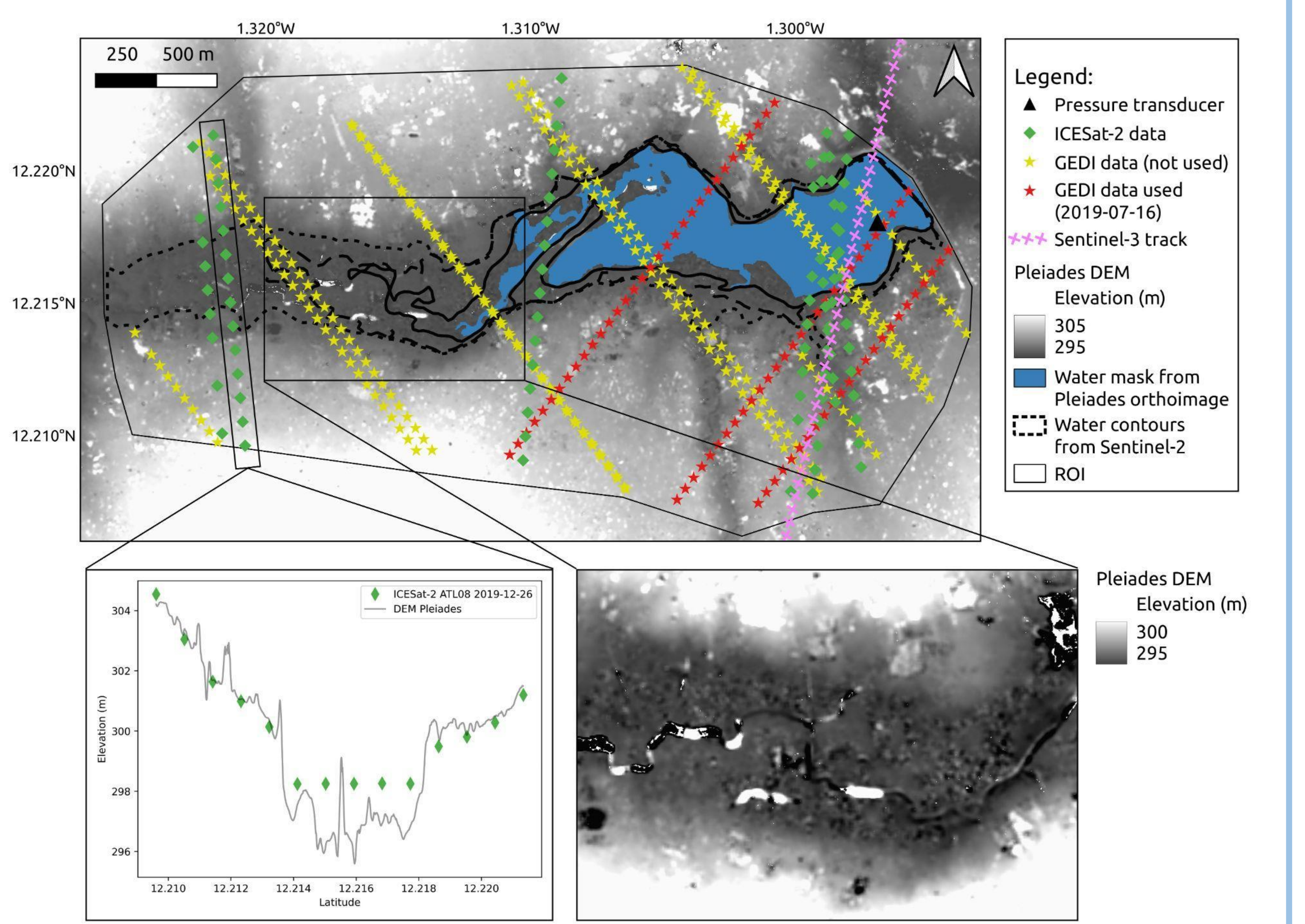


$$\Delta V = \int_{A_1}^{A_2} H(A)\,dA$$

Methods to build the H-A curve:



Example of all available data on lake Arzuma:

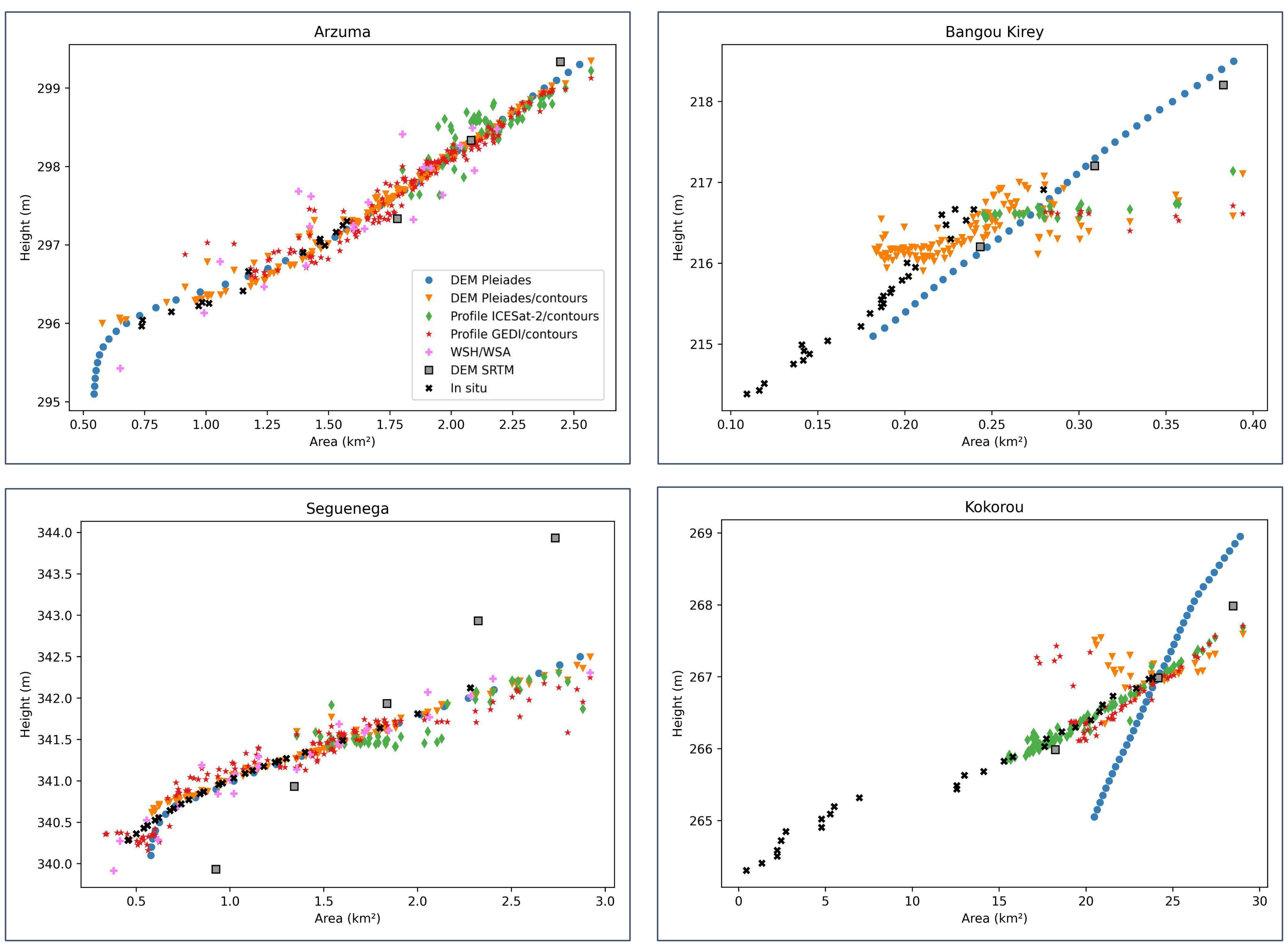


Comparison of resulting H-A curves

Assessment criteria

The comparison of the hypsometric curves reveals the pros and cons of each method in terms of:

- **accuracy** and **dispersion**
- extent of **observable** water storage **dynamics**
- **sensitivity** to remote sensing **data quality** and **surface features**



Early conclusions

- Good agreements between methods are achieved for most studied lakes.
- ICESat-2 and GEDI data offer promising possibilities with relatively low data quantity and better spatial coverage than that of radar altimeters. Pleaides DEMs also perform well but are neither free nor open-access. For theses methods, acquisition dates condition the extent of the hypsometric curves.
- DEM vertical and horizontal resolutions are crucial. SRTM hypsometric curves accuracy is usually worse than any other methods.
- Pleiades DEMs sensitivity to pixels correlation errors and surface roughness (trees, riparian vegetation) impacts the hypsometric curve quality. Adding water contours mitigates these effects as well as that of nearby unconnected water bodies, but remains unhelpful when DEM quality is bad.
- Combining altimetry and water areas needs time interpolation, and radar altimeters waveforms are sensitive to backscattering context. These aspects often lead to more dispersion in the hypsometric curve.

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