

# Lakes and reservoirs storage changes from SWOT and ancillary database in Quebec (Canada)

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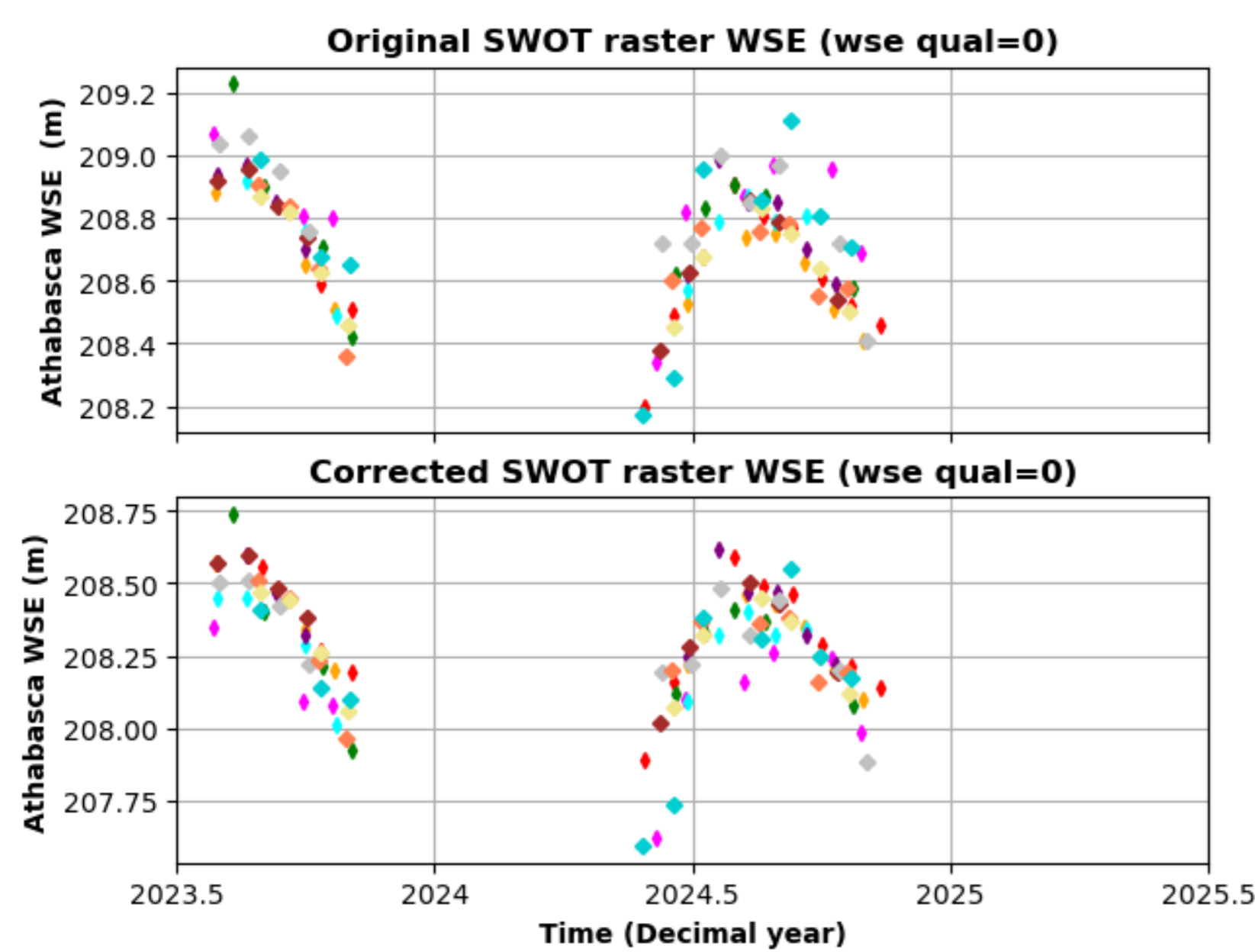


**Main objectives and study domain:** The SWOT and Northern laKeS – Phase 2 (SNORKS2) project is a contribution to the SWOT ST and aims to investigate errors that could be expected from the official SWOT level 2 lake products (PIXC, Raster, LakeSP) and computation of lakes and reservoirs storage changes over Canada

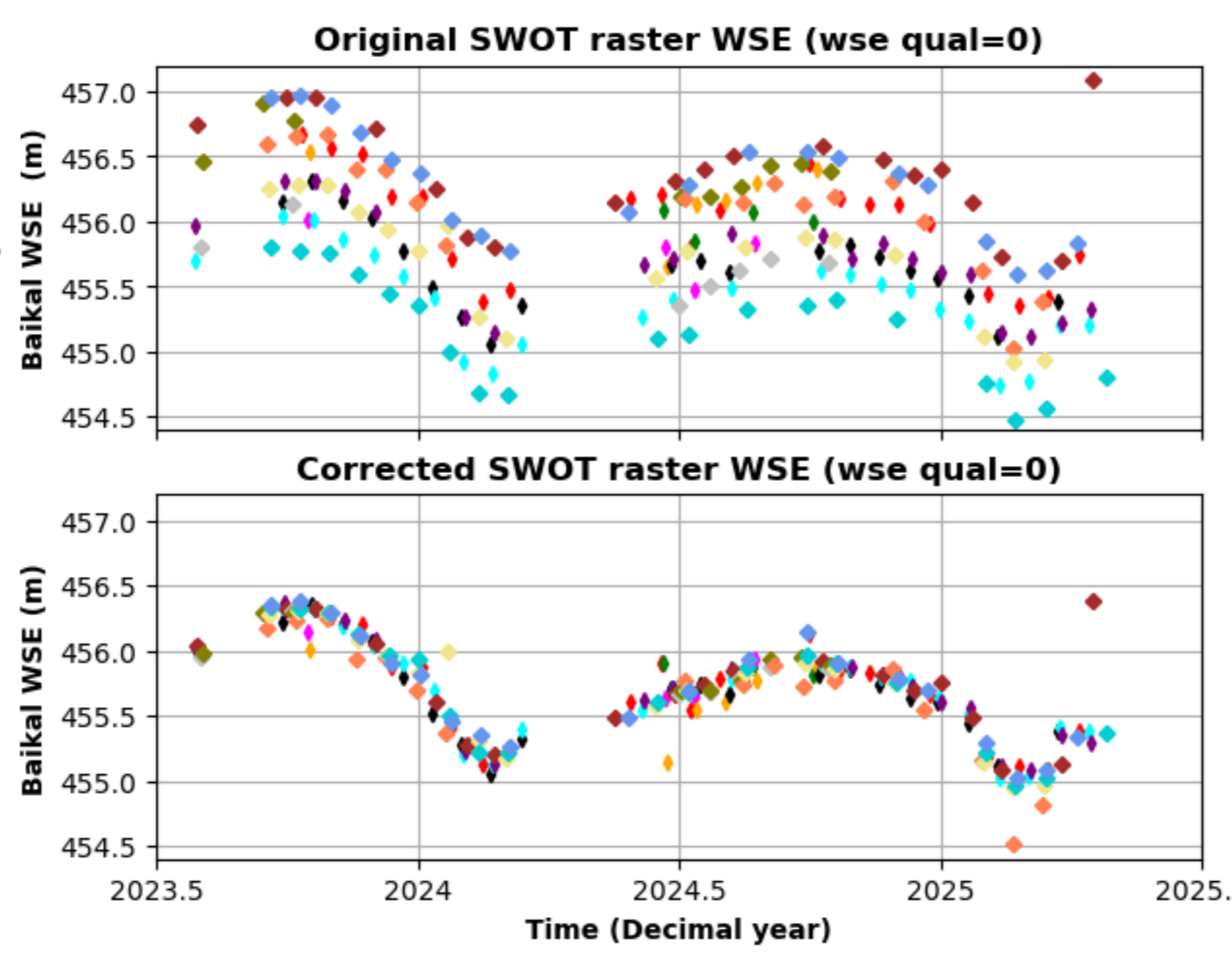
## Impact of geoid on WSE time series and SWOT products

- Issue: Accuracy of EGM08 might be too crude for big lakes -> mean surface elevation needs to be taken into account to combine WSE from different tracks
- For some big Canadian, US and Russian lakes (Athabasca, Erie, Michigan, Onega, Ontario, Winnipeg, Winnipegosis) there is negligible or moderate impact of geoid uncertainty compared to the mean lake topography
- Important impact of EGM08 inaccuracy on big lakes in the US, Russia and other (Argentino, Baikal, Balkhash, General Carrera, Huron, Issykkul, Ladoga, Malawi, Superior, Tanganika, Titicaca, Victoria)

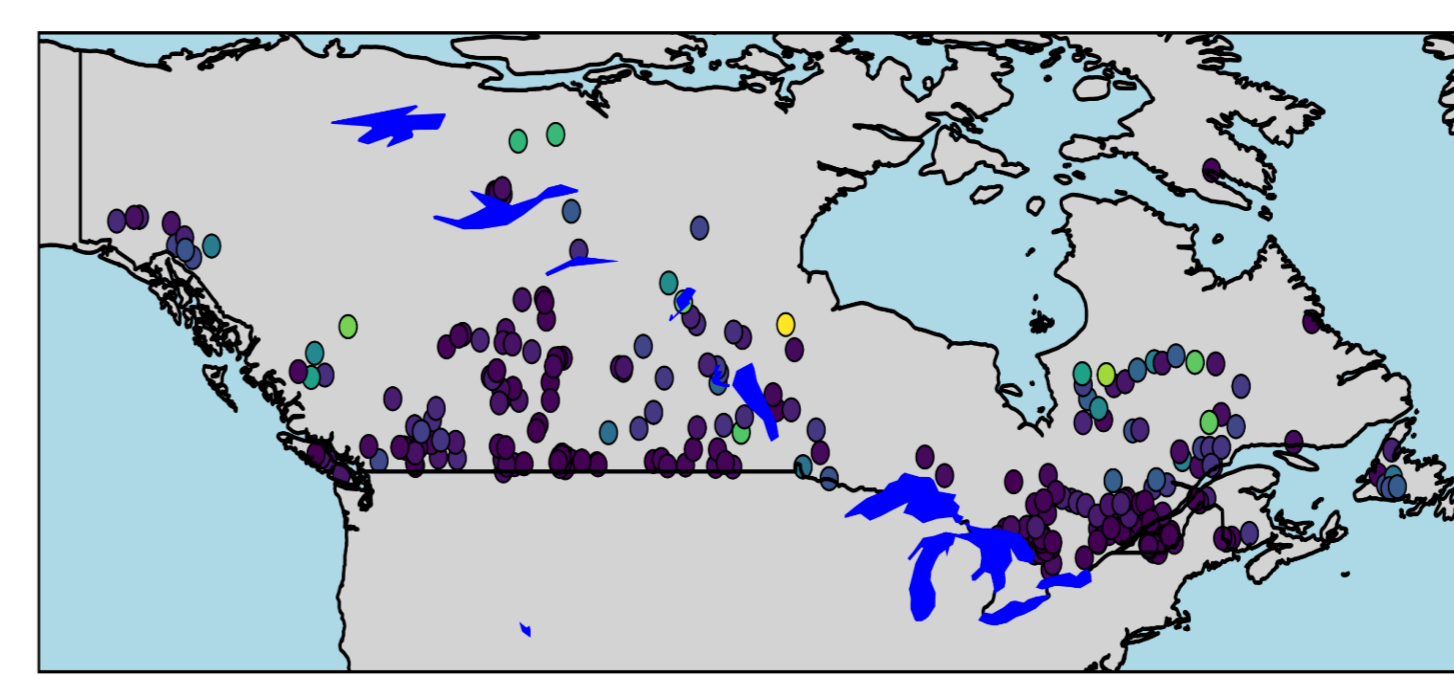
- Issue: Variability of the geoid on lakes could be up to few meters -> the mean lake WSE in LakeSP product will then have bias when compared to in situ gage WSE located on a lake shore
- To compare LakeSP WSE to in-situ WSE, the bias between the mean geoid of the valid SWOT pixels used to compute LakeSP WSE and the geoid value at the in-situ station need to be computed
- Variations in WSE can be observed between passes that cover different parts of the lake with varying mean geoids. Variations can also occur when dark water covers different parts of the lake.



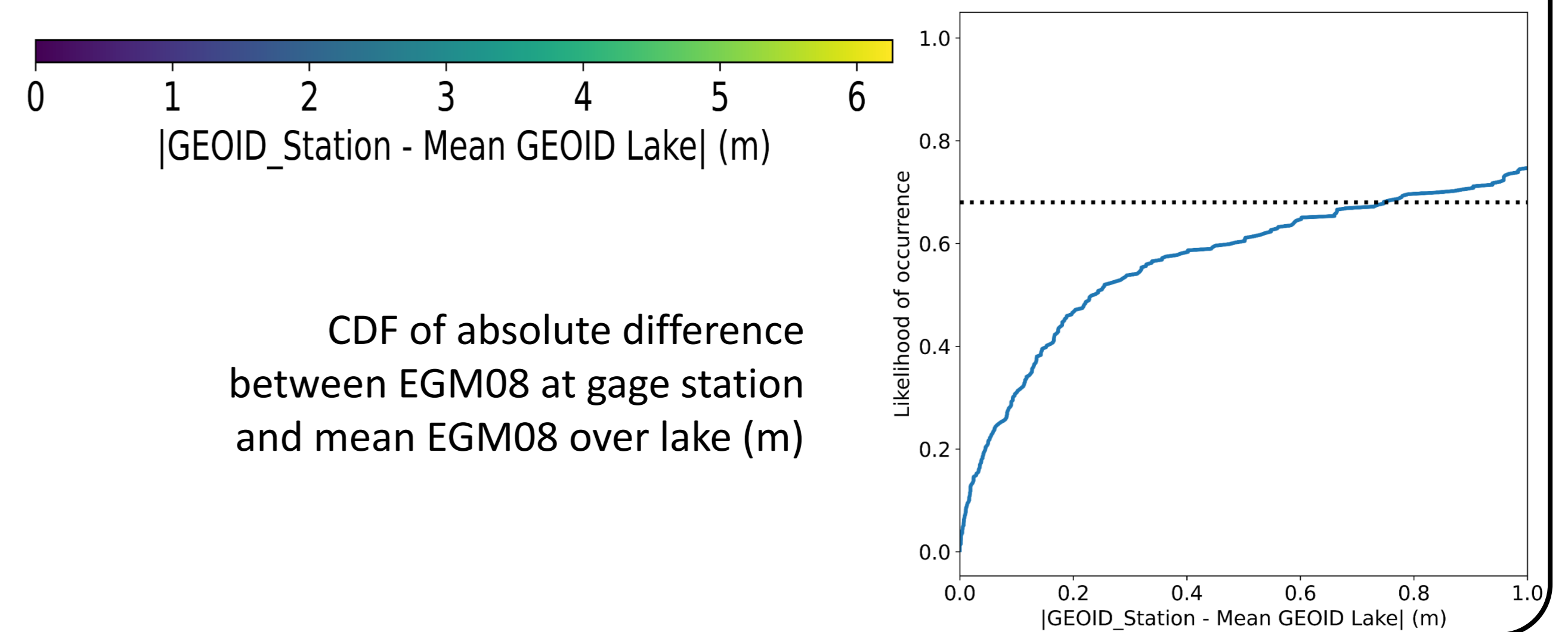
Initial SWOT WSE from **raster product** (upper panel) and Corrected SWOT WSE with mean lake topography from Bergé-Nguyen et al. (2021) (bottom panel) on the **Athabasca** lake. The different colors represent different passes.



Initial SWOT WSE from **raster product** (upper panel) and Corrected SWOT WSE with mean lake topography from Bergé-Nguyen et al. (2021) (bottom panel) on the **Baikal** lake. The different colors represent different passes.



Absolute difference between EGM08 at gauge station and mean EGM08 over lake (m)

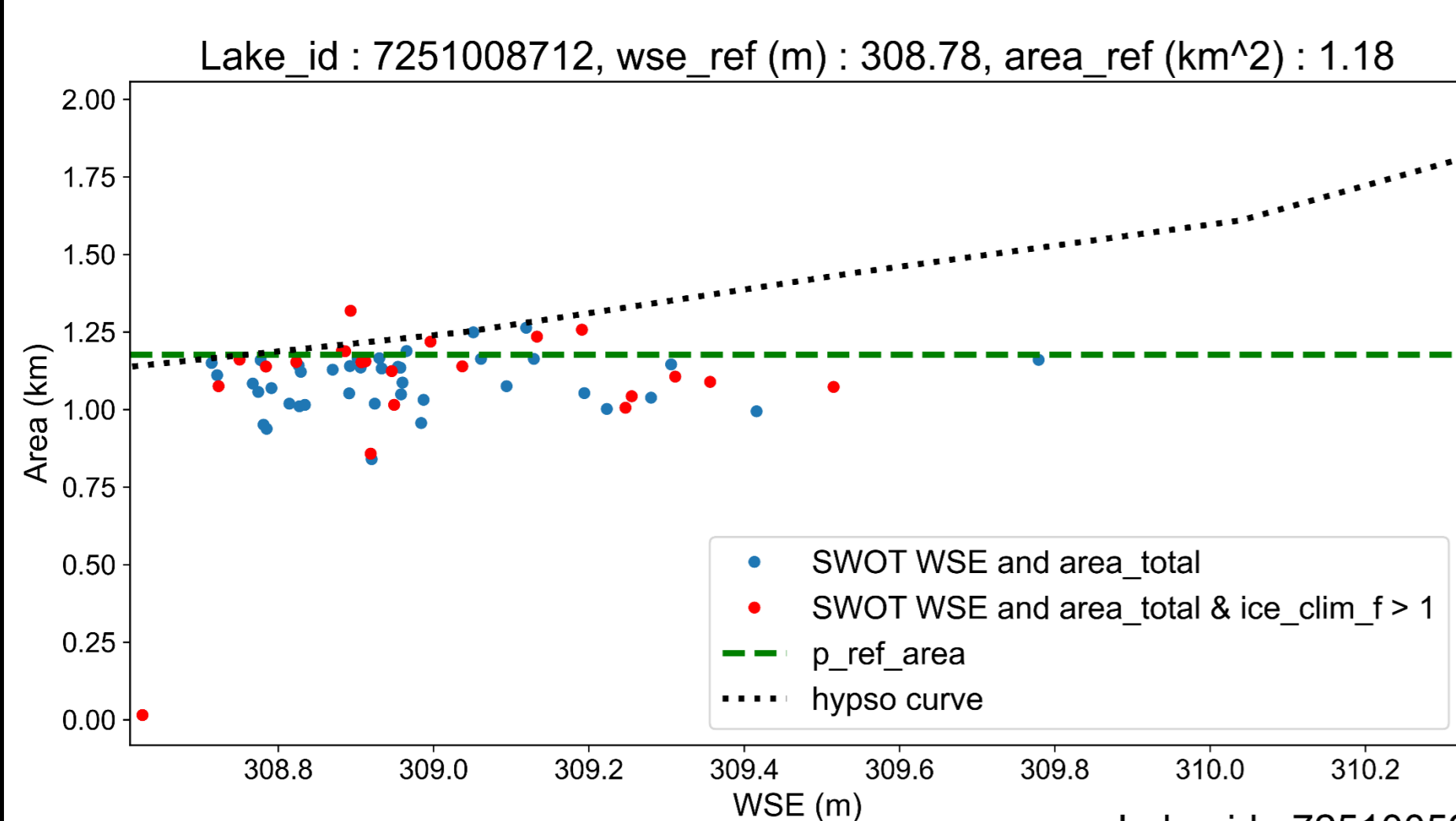


CDF of absolute difference between EGM08 at gage station and mean EGM08 over lake (m)

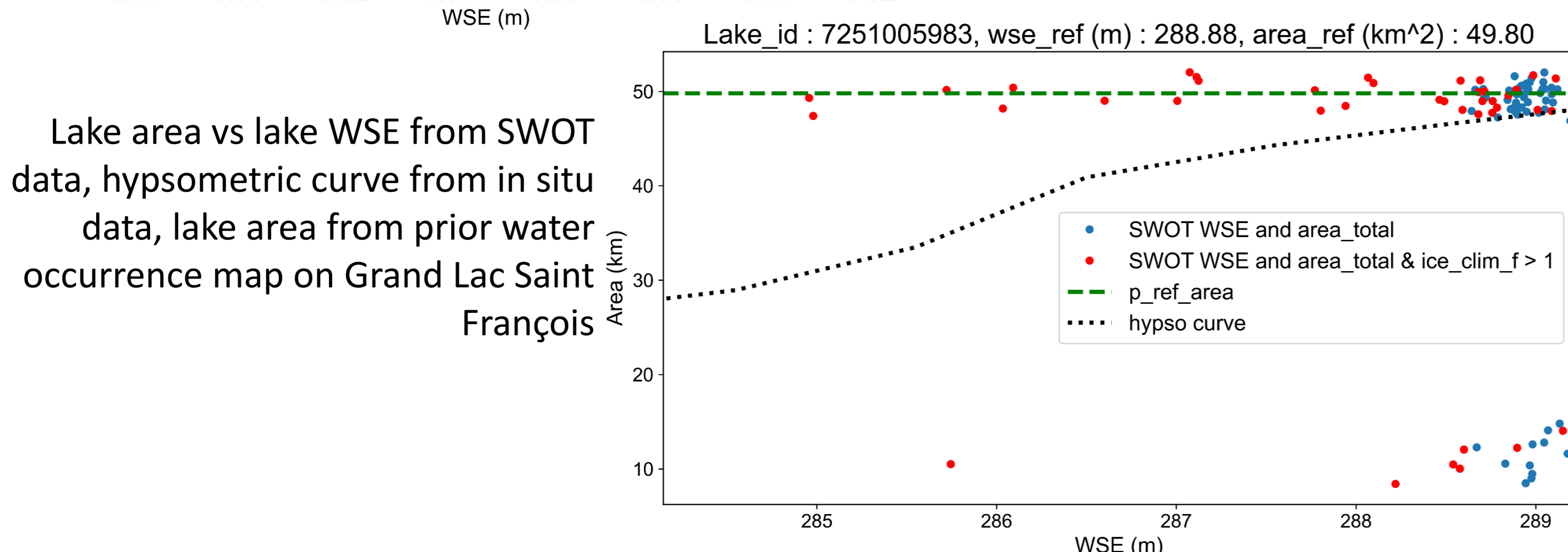
## SWOT lake storage change from (filtered) LakeSP product

### Hypsometric curve (area vs WSE)

- Lowest lake areas in *area\_total* are overestimated because of the prior water occurrence map used to fill dark water (see LakeSP product ATBD)
- Lake ice: WSE could be computed even with ice, but lake area is more complex
- Natural lake could have lowest WSE during summer (better for area estimation), but reservoirs have lowest WSE during winter in Canada (very bad for area estimation)
- More difficult to get accurate area from SWOT -> impact to compute hypsometric curve



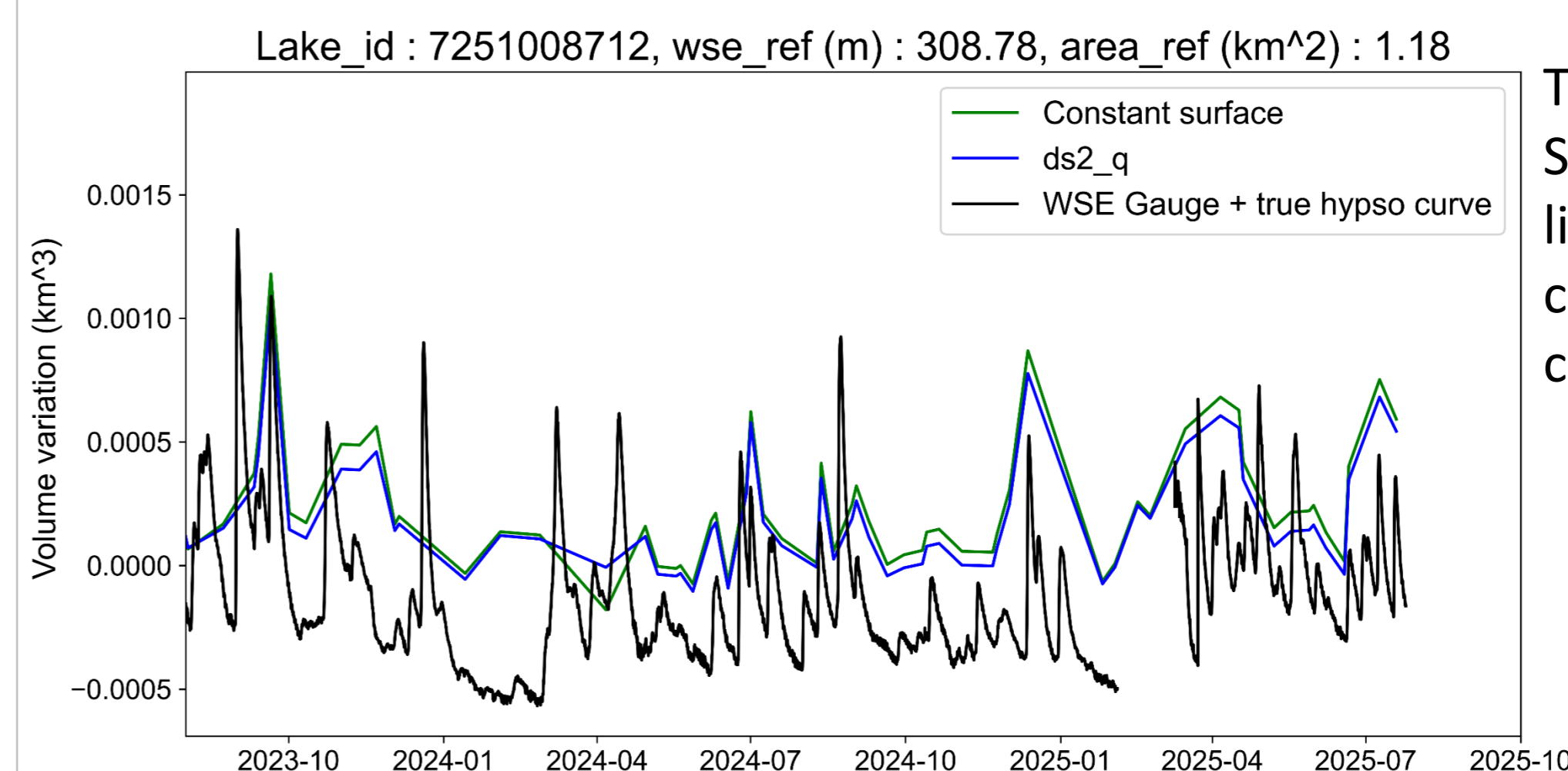
Lake area vs lake WSE from SWOT data (blue points with no ice from climatology, red points with ice), hypsometric curve from in situ data, lake area from prior water occurrence map on Bolduc lake



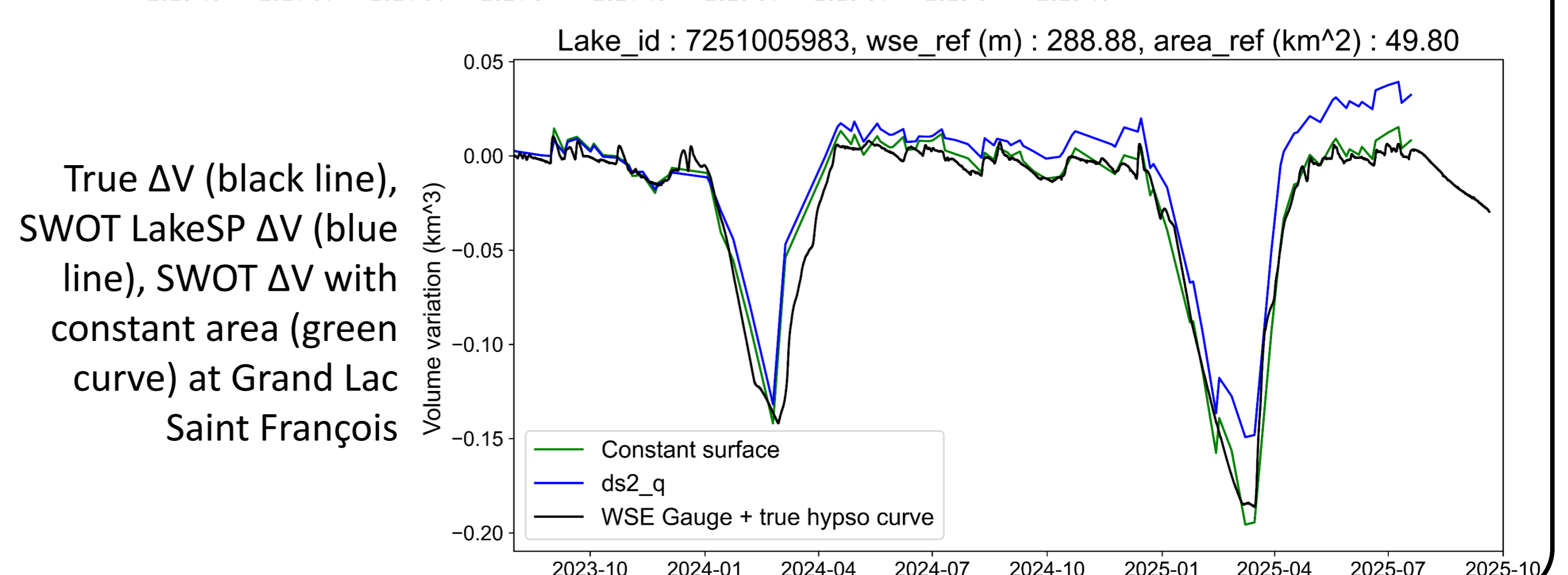
Lake area vs lake WSE from SWOT data, hypsometric curve from in situ data, lake area from prior water occurrence map on Grand Lac Saint François

### Storage change

- 4 different storage changes ( $\Delta V$ ) computed in LakeSP product (version PIC2 and above), from different: bathymetry approximation (1-  $\Delta V$  assumed to be a trapezoid, linear approx.; or 2-  $\Delta V$  as a truncated pyramid, quadratic approx.) and time reference (1-  $\Delta V$  is computed between the SWOT observation date and a reference state, direct approach; or 2- sum of all  $\Delta V$  between 2 consecutive valid SWOT obs., incremental approach)
- LakeSP data filtered with algo. from Jida Wang and Mélanie Trudel
- No main diff btw 4 SWOT  $\Delta V$ , similar results with SWOT  $\Delta V$  with constant area



True  $\Delta V$  (black line), SWOT LakeSP  $\Delta V$  (blue line), SWOT  $\Delta V$  with constant area (green curve) at Bolduc lake



True  $\Delta V$  (black line), SWOT LakeSP  $\Delta V$  (blue line), SWOT  $\Delta V$  with constant area (green curve) at Grand Lac Saint François

## Acknowledgements

- This work is supported by a CNES TOSCA funding to the SNORKS2 project, and a CSA/ASC grants (24AO3SHE16)
- Reference: SWOT Project (2023). Algorithm Theoretical Basis Document (ATBD) - Level 2 KaRIn high-rate lake single pass science algorithm software: Level 2 processing. CNES document SWOT-NT-CDM-1753-CNES, initial release.