Lake Volume determination with SWOT

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SWOT will product water height and water contours as shapefile on cycle and pass based time interval

Final product will be water storage change at same time interval

Computation of the volume of a lake is only possible using bathymetry but:

SWOT will not produce bathymetry

Bathymetry exist only on a very little number of lakes

⇓

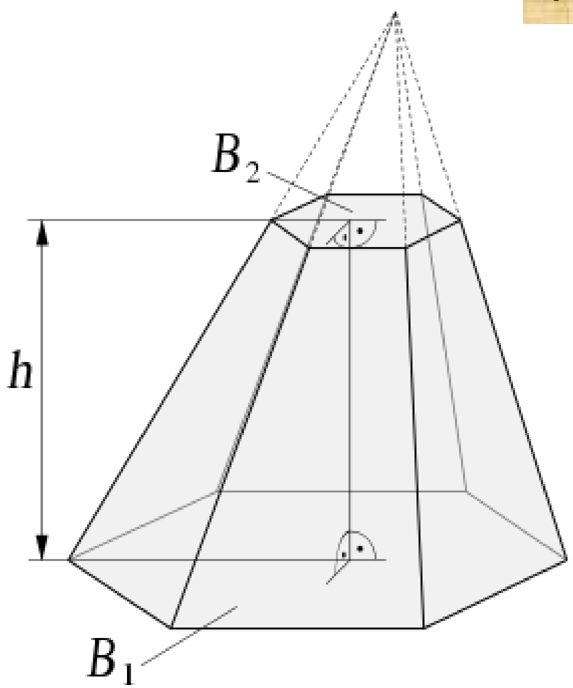
Only storage change will be available and approximation must be done

⇓

We need to simulate first the validity of the calculation

We need to implement the algorithm to make the calculation

Volume calculation with SWOT products (H, B)

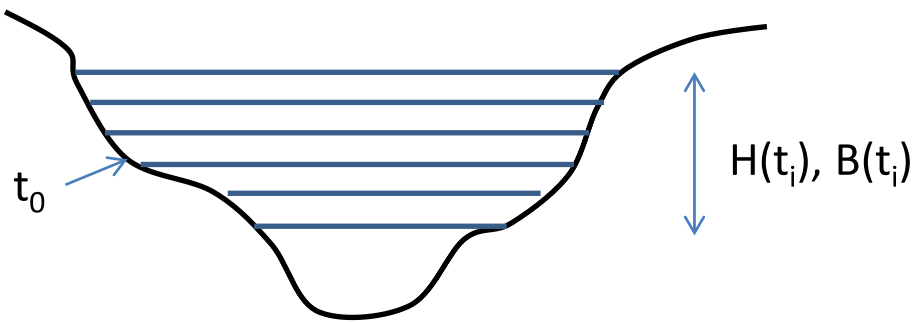


-We consider that we have the final H & B SWOT product

-We assume that the volume change can be approximate to the volume difference of two pyramides

$$Volume = \frac{h}{3} \cdot \left(B1 + B2 + \sqrt{B1 \cdot B2}\right)$$

With SWOT



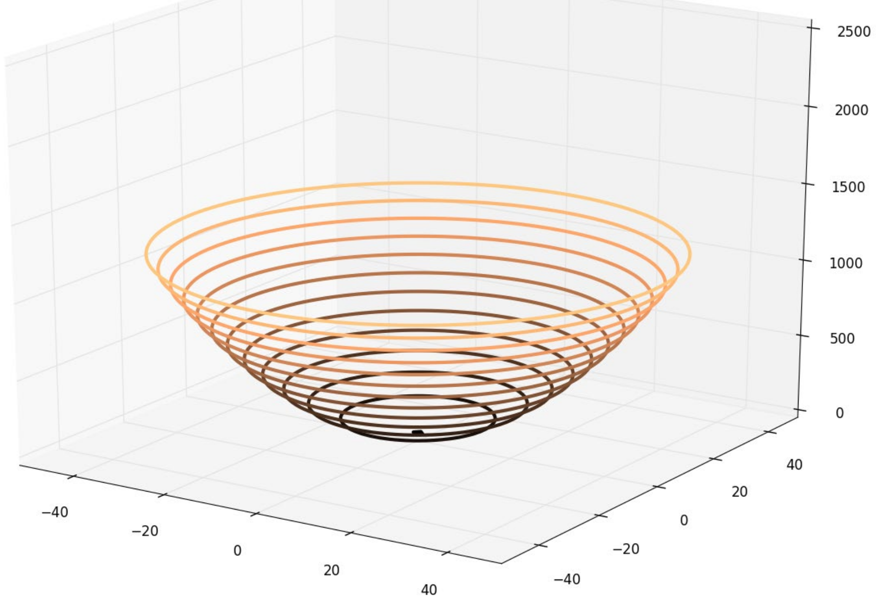
$$\Delta V\left(\frac{t_i}{t_0}\right) = \Delta V\left(\frac{t_{i-1}}{t_0}\right) + \frac{[(H(t_i) - H(t_{i-1})] * [B(t_i) + B(t_{i-1}) + \sqrt{B(t_i) * B(t_{i\_1})}]}{3}$$

Creation of a simulator to determine the error budget

First step

a Simple case of a paraboloid

$$Volume = \pi \cdot h^2 \cdot p$$



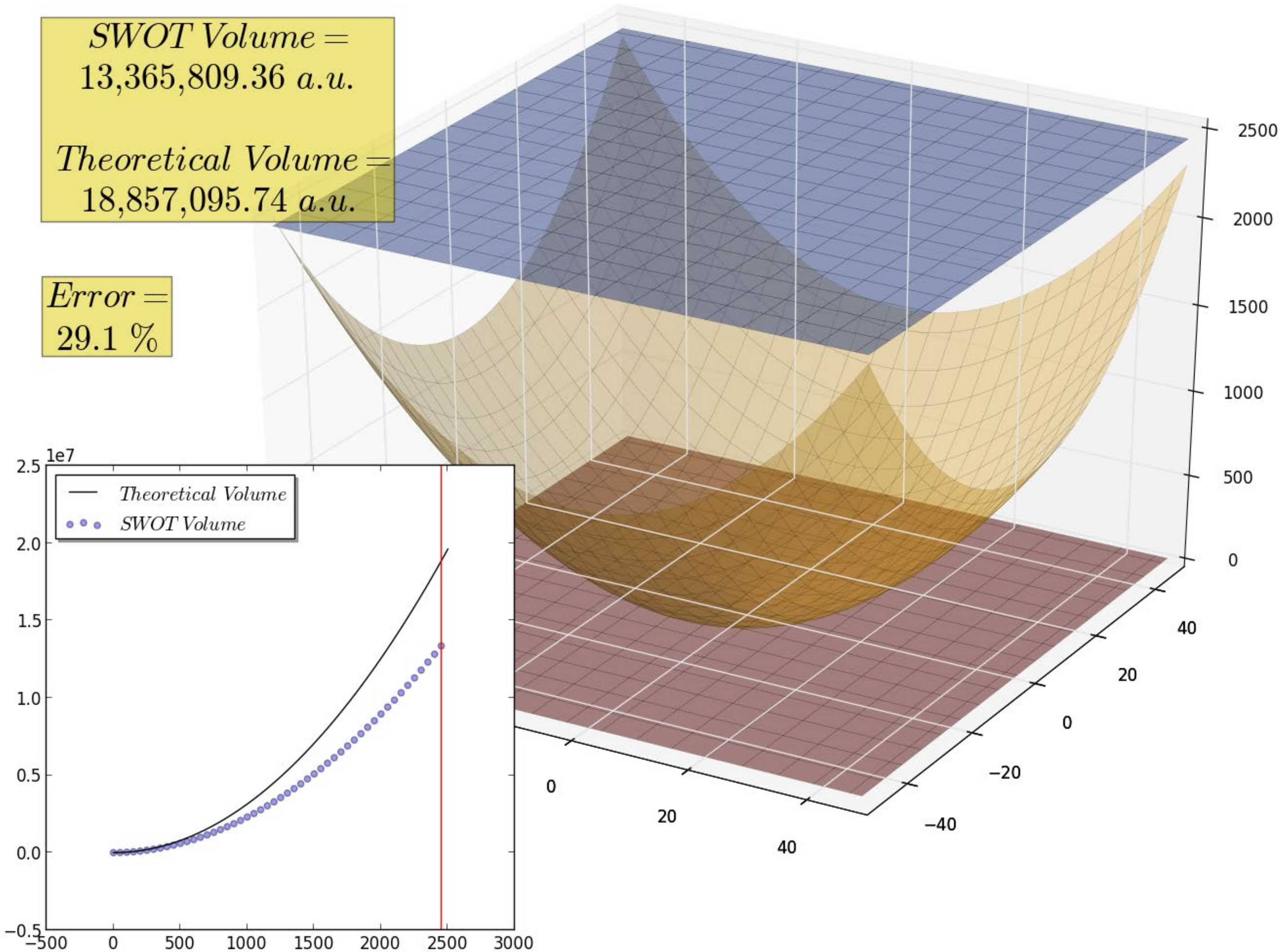
- Volume is calculated by the difference between two paraboloids
- Height difference varies from small values to large values in order to estimate the sensitivity of volume errors to the dynamic of shrinkage or flooding of a lake between two SWOT cycles

Second steps => generate more complex theorical lake bed

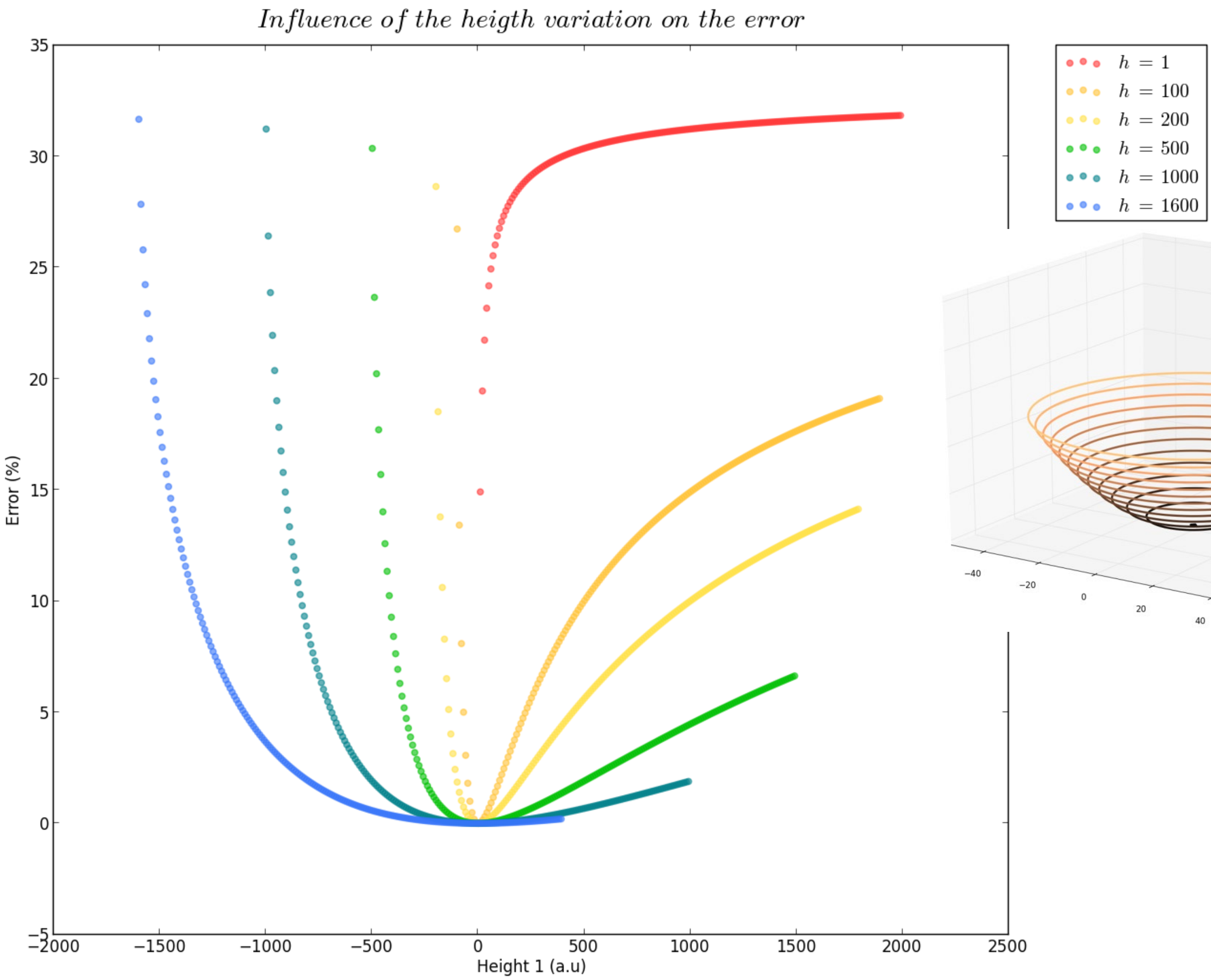
Third steps => upload real bathymetry in the simulator and fill the lake at different height intervals

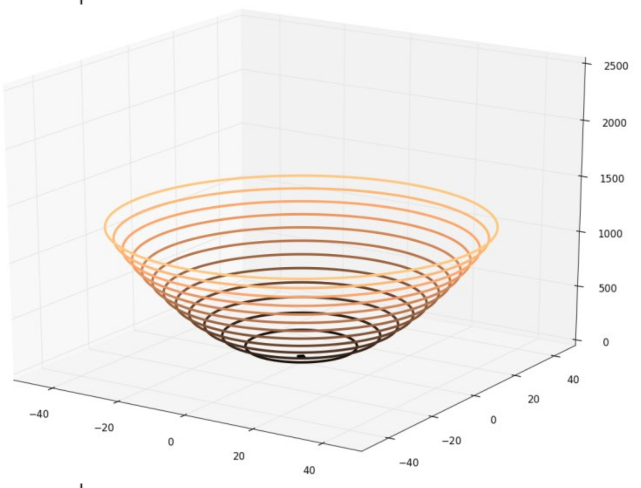
Fourth steps => build hypsometry and *usefull* bathymetry with a set of ~50 vectors:H,B, contours

Results of the simulation (1/2)



Results of the simulation (2/2)



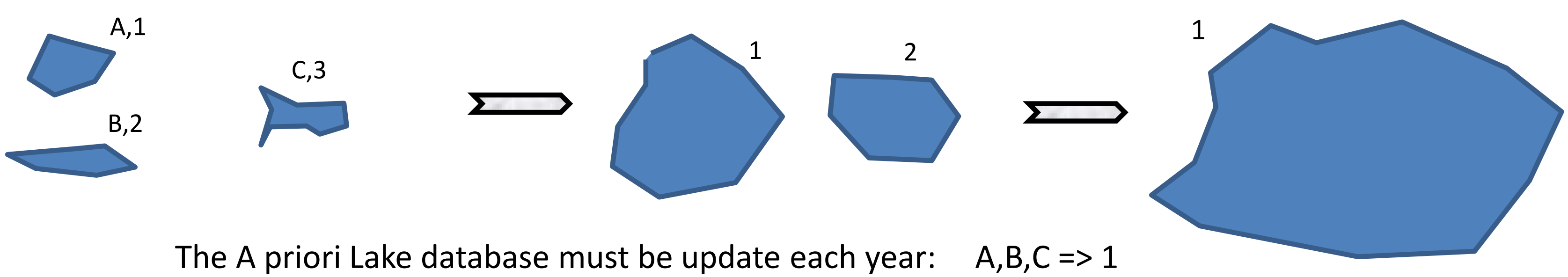


Second step: create more complex theorical bathymetry in the simulator (1/2)

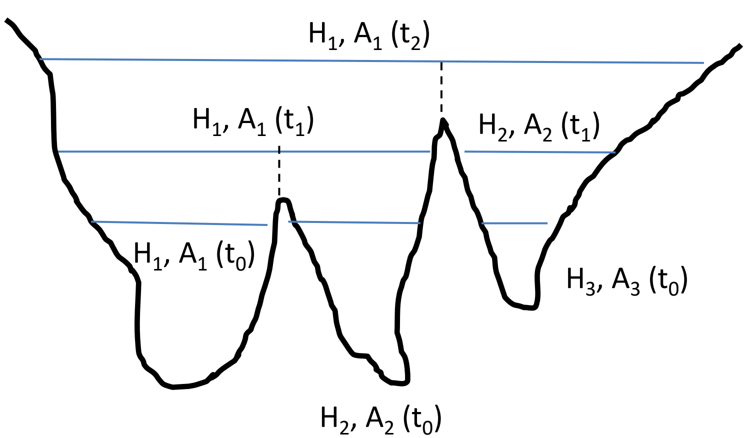
A,B,C: A priori LDB
1,2,3: SWOT obs

Complex multi lakes case

A priori data base & t_0 (from SWOT observation) | t_1 (from SWOT observation) | t_2 (from SWOT observation)



The A priori Lake database must be update each year: A,B,C => 1



At t_1

$$\Delta V_1\left(\frac{t_1}{t_0}\right) = \Delta V_A\left(\frac{t_1}{t_0}\right) + \Delta V_B\left(\frac{t_1}{t_0}\right)$$

$$\Delta V_{A,B}\left(\frac{t_1}{t_0}\right) = \frac{[H_1(t_1) - H_{1,2}(t_0)].[\alpha_{1,2}.A_1(t_1) + A_{1,2}(t_0) + \sqrt{\alpha_{1,2}.A_1(t_1) * A_{1,2}(t_0)}]}{3}$$

$$\Delta V_2\left(\frac{t_1}{t_0}\right) = \Delta V_C\left(\frac{t_1}{t_0}\right) = \frac{[(H_2(t_1) - H_3(t_0)] * [A_2(t_1) + A_3(t_0) + \sqrt{A_2(t_1) * A_1(t_0)}]}{3}$$

$$\alpha_{1,2} = \frac{A_{1,2}(t_0)}{A_1(t_0) + A_2(t_0)}$$

At t_2 $\rightarrow$ $\Delta V_1\left(\frac{t_2}{t_0}\right) = \Delta V_1\left(\frac{t_1}{t_0}\right) + \Delta V_A\left(\frac{t_2}{t_1}\right) + \Delta V_C\left(\frac{t_2}{t_1}\right)$

Iteration after 1 year

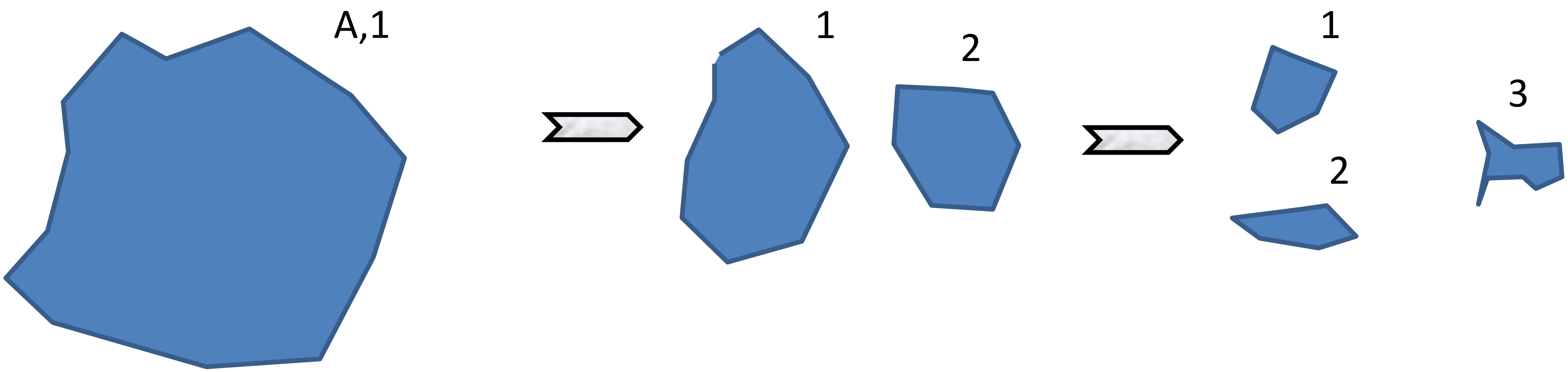
$$\Delta V_1\left(\frac{t_i}{t_0}\right) = \Delta V_1\left(\frac{t_{i-1}}{t_0}\right) + \Delta V_A\left(\frac{t_{i-1}}{t_i}\right) + \Delta V_B\left(\frac{t_{i-1}}{t_i}\right) + \Delta V_C\left(\frac{t_{i-1}}{t_i}\right)$$

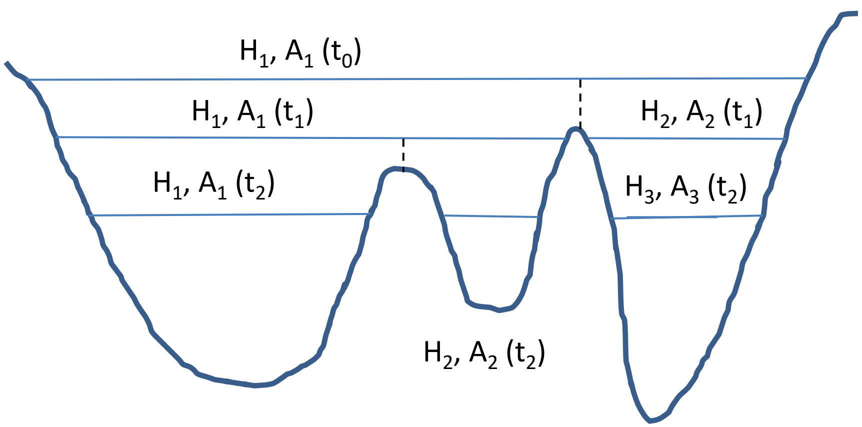
Pb if one of the A,B or C lake disapears totally at t_i => the corresponding storage change is set to zero.

Second step: create more complex theorical bathymetry in the simulator (2/2)

Complex multi lakes case

t_0 (from a Priori data base) | t_1 (from SWOT observation) | t_2 (from SWOT observation)





$$\Delta V_A\left(\frac{t_1}{t_0}\right) = \Delta V_{A1}\left(\frac{t_1}{t_0}\right) + \Delta V_{A2}\left(\frac{t_1}{t_0}\right)$$

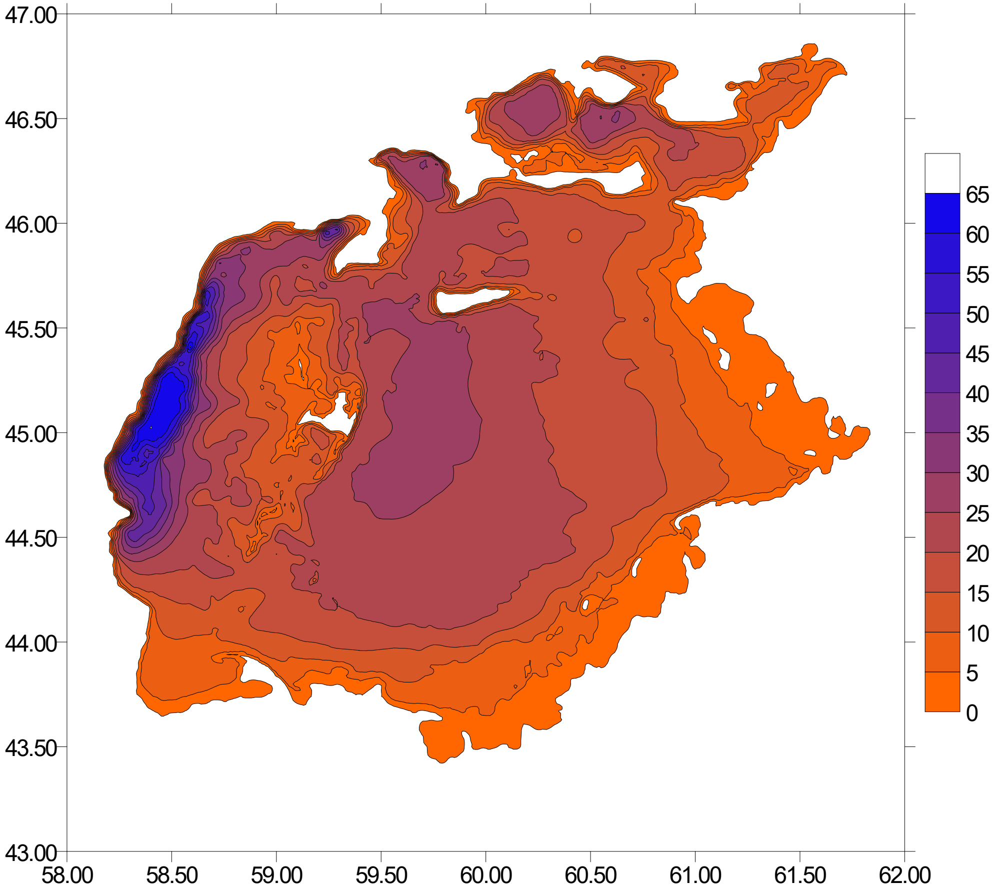
$$\Delta V_A\left(\frac{t_2}{t_0}\right) = \Delta V_A\left(\frac{t_1}{t_0}\right) + \Delta V_{A1}\left(\frac{t_2}{t_1}\right) + \Delta V_{A2}\left(\frac{t_2}{t_1}\right) + \Delta V_{A3}\left(\frac{t_2}{t_1}\right)$$

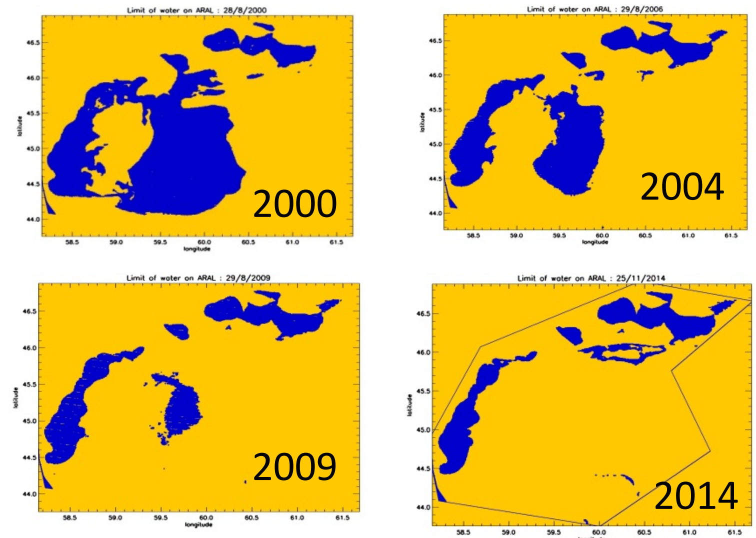
$$\Delta V_A\left(\frac{t_i}{t_0}\right) = \Delta V_A\left(\frac{t_{i-1}}{t_0}\right) + \sum_j \left(\Delta V_{Aj}\left(\frac{t_{i-1}}{t_i}\right)\right)$$

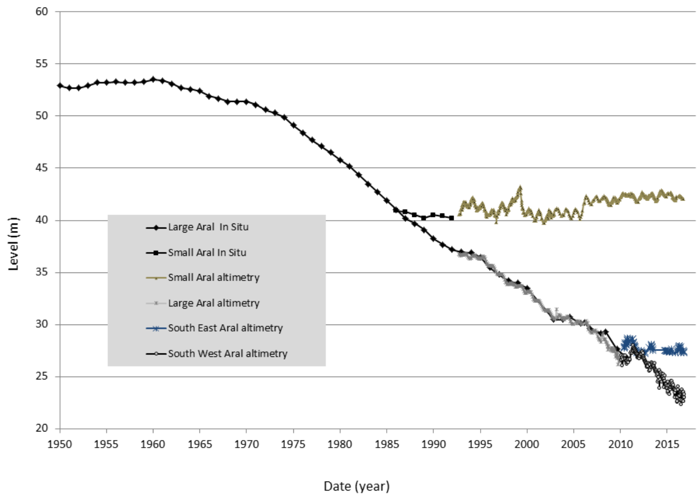
Third steps => upload real bathymetry in the simulator and fill the lake at different height intervals

Example of a shrinkage followed by separation into several small lakes

Aral Sea

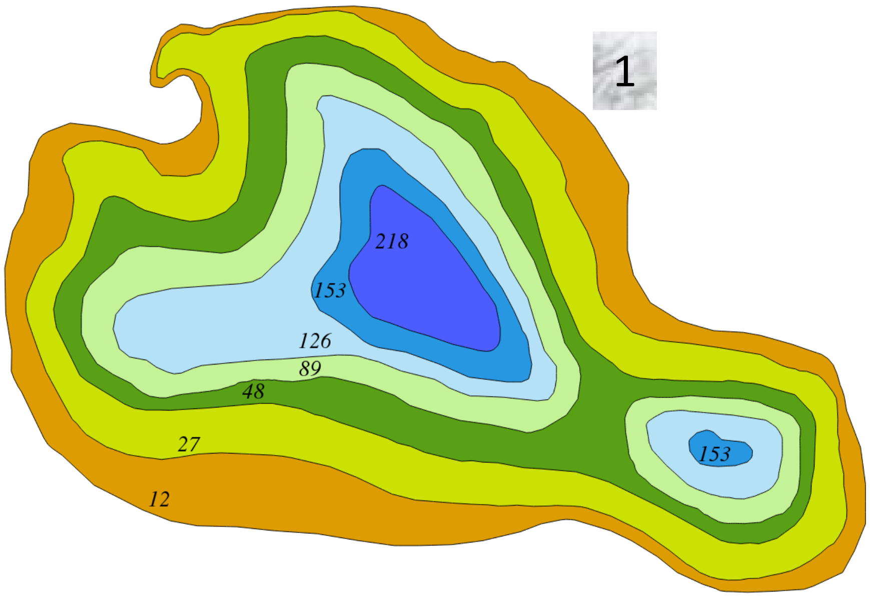






Fourth step: => build hypsometry and *usefull* bathymetry with a set of ~50 vectors:H,B, contours & recompute the volume using bathymetry

1



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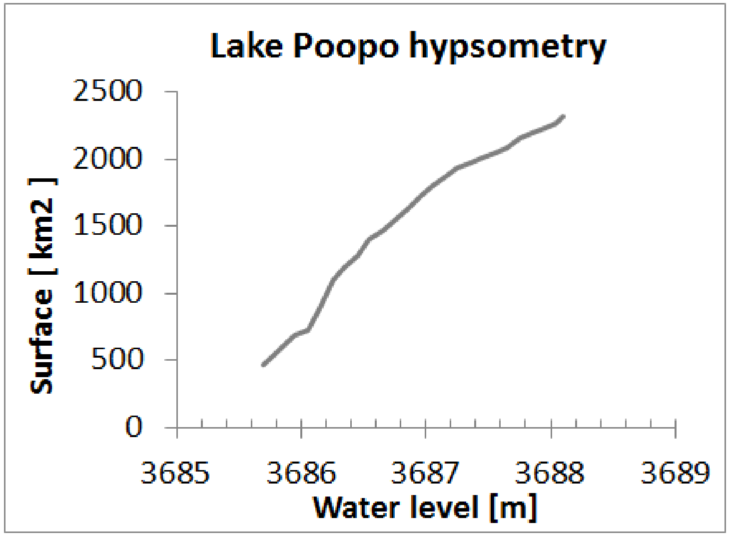

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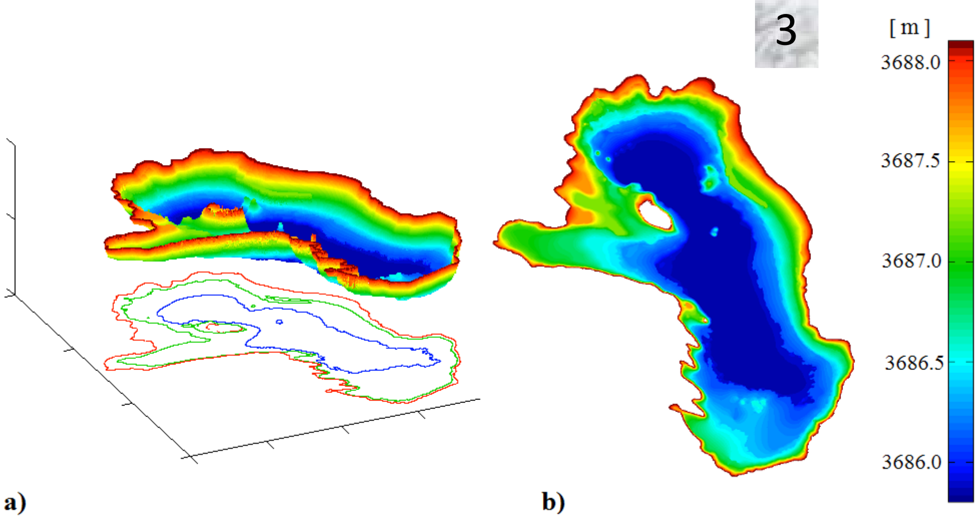

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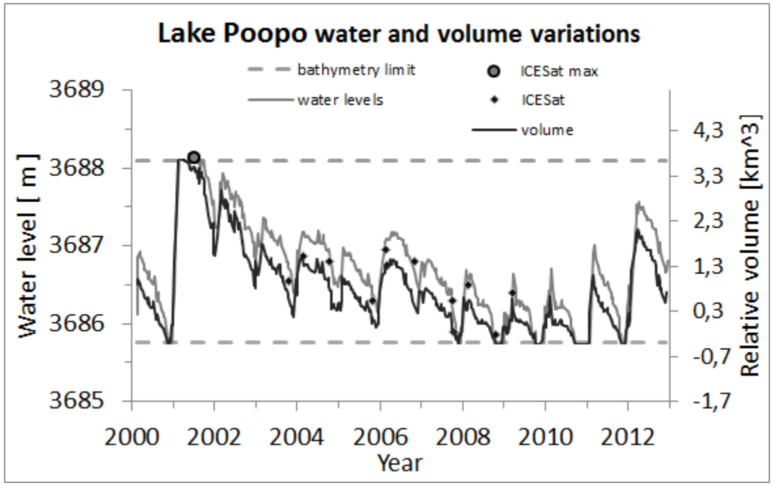
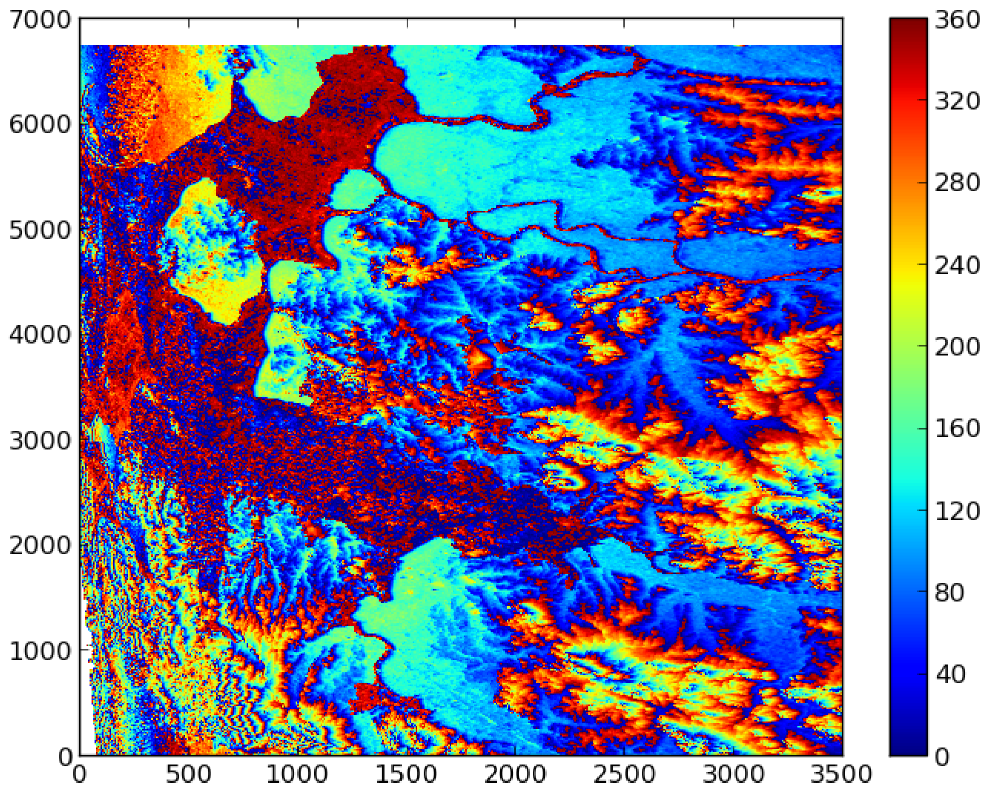


Lake products the full chain and associated algorithms (1/2)

1

HR simulator

Generation of the multi-temporal interferogram and generate height & pixel cloud



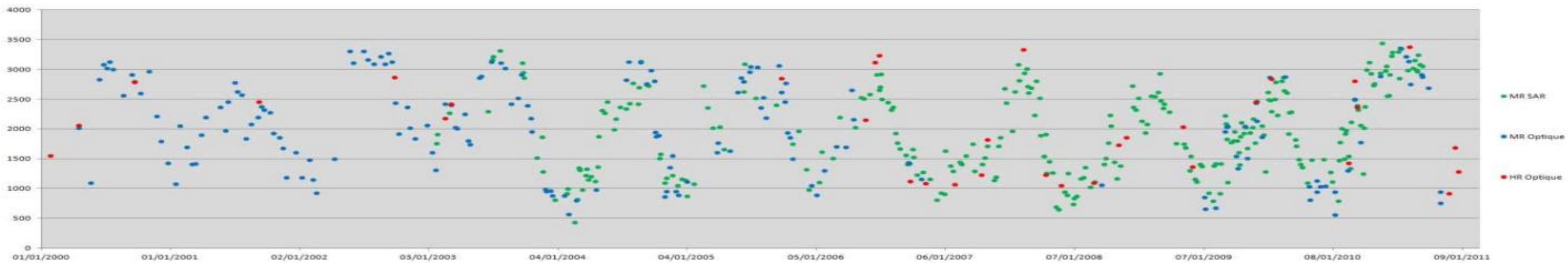
2

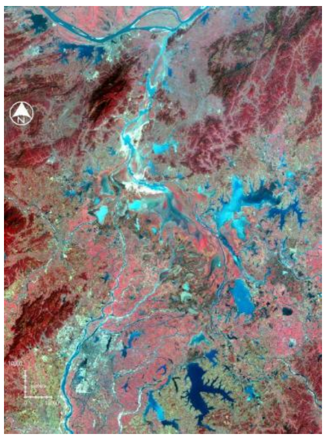
LakeObs

- F1 — •Identify all separate entities in the water mask = label connected regions in 2D pixel cloud in radar geometry
- F2 — •Retrieve pixels corresponding to lakes and new objects entirely inside the tile
- F3 — •Refine pixels geolocation
- F4 — •Compute lake product
- F5 — •Link to the *a priori* database (intersection of polygons)

Lake products the full chain and associated algorithms (2/2)

3 SimVol / CalVol Use lake products, H & B & shapefiles released from LakeObs



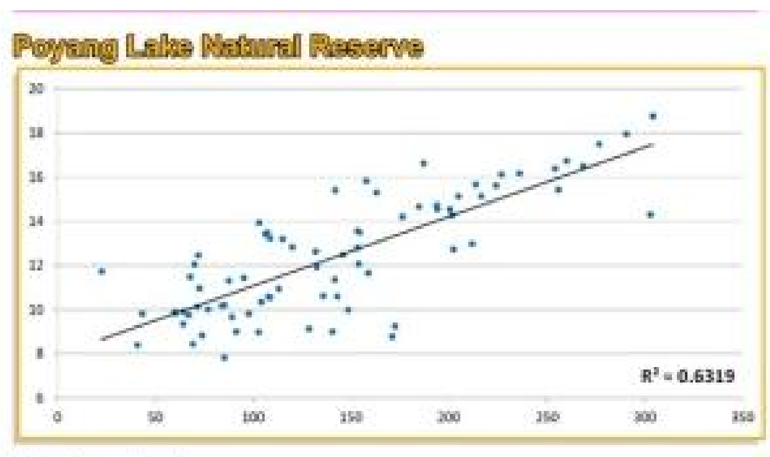


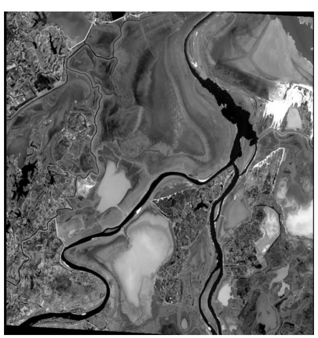
Winter/dry Season

Spring/summer wet Season

Generate volume variations on pass and cycle based time intervals using Cal/Vol

Generate hypsometry at the end of the mission





Reconstruct « useful » bathymetry

Recompute lake volume changes for the whole mission lifetime