Land Surface Hydrology Research Group

UCLA

Estimating reservoir storage volume with SWOT observations

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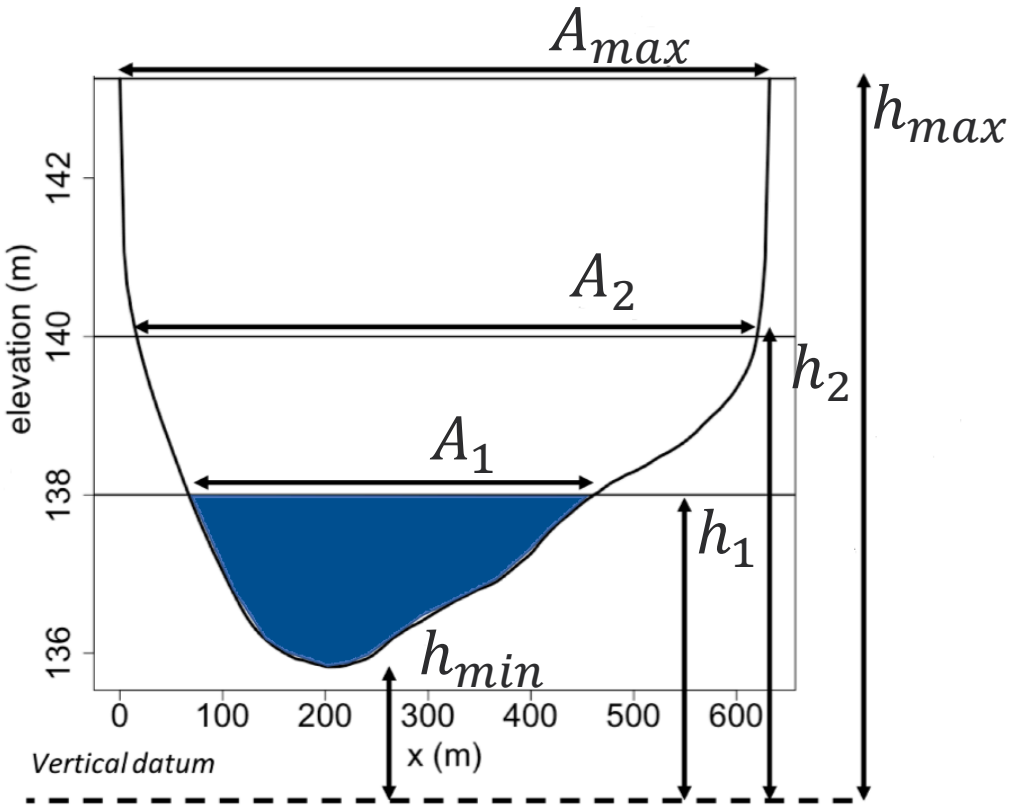
Reservoir estimation with SWOT observation

- *Repeated water surface elevation (h) and area (A) measurements from SWOT*
- *Allow to quantify storage change (ΔV), but not the volumetric storage (V)*
- *V is an important quantity, especially in dry years*

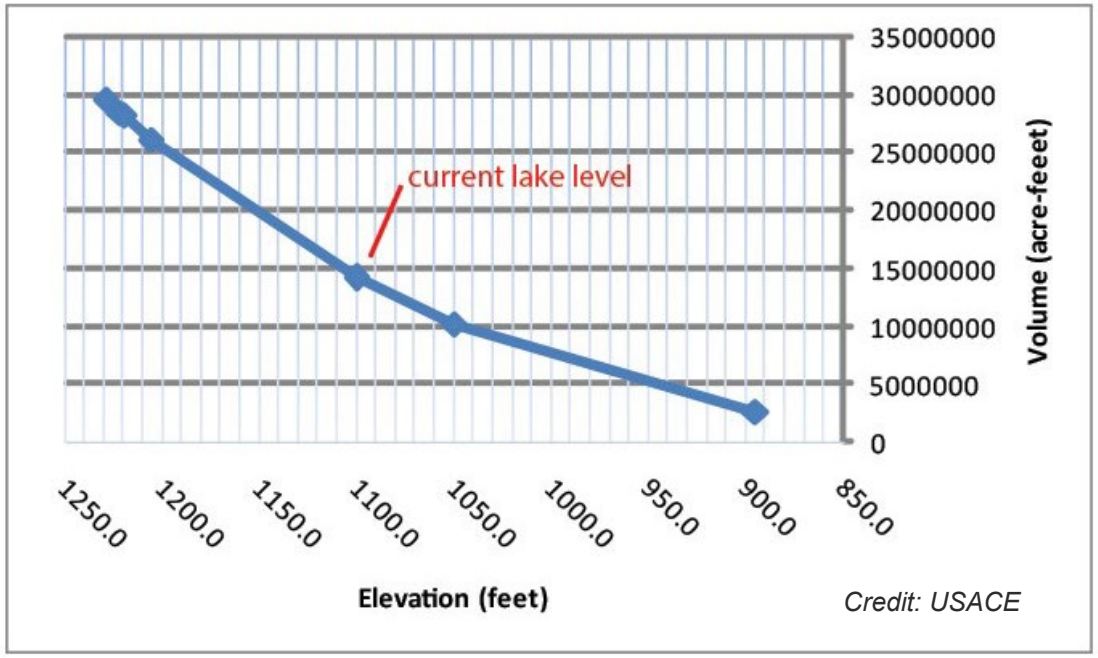



Historically low Lake Mead in 2022
Credit: The Atlantic

Storage-elevation relationship

- *Storage-elevation relationship exists for well-gaged reservoirs*
- *Such relationship are absent or outdated for many reservoirs, especially in developing regions*

Lake Mead storage-elevation curve

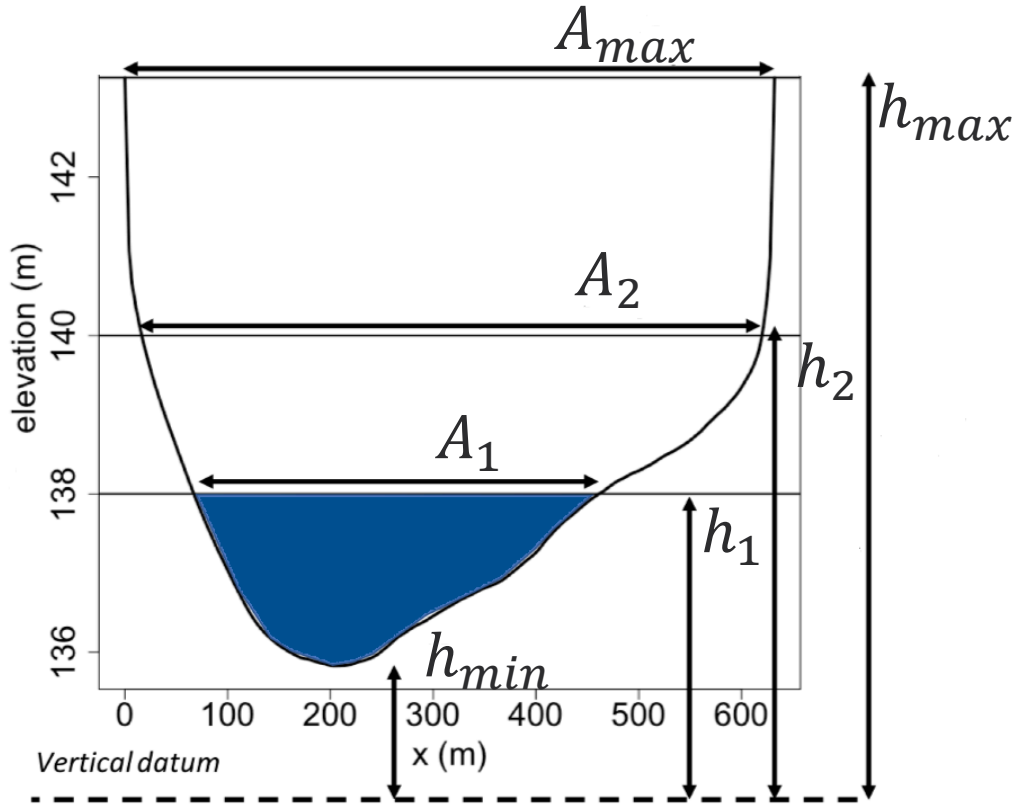


Research question:

To what extent can SWOT help develop storage-elevation relationships to quantify the storage volume of reservoirs with different sizes?

Storage estimation from SWOT observations

- *Start from storage change (ΔV) between two satellite overpasses:*

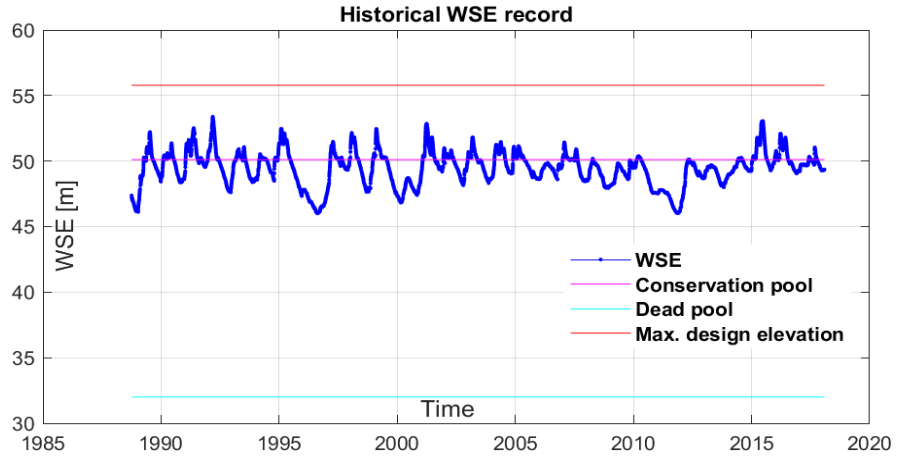


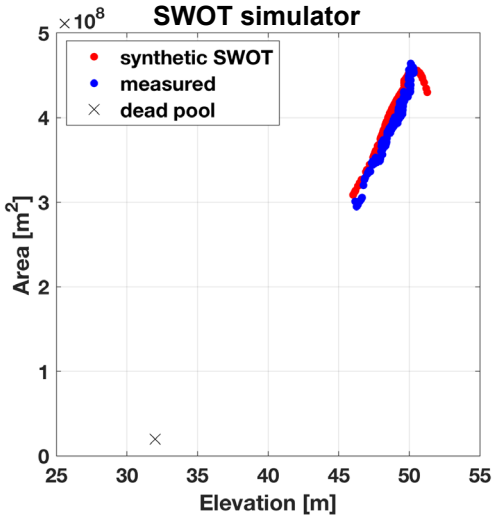
$$\Delta V = \int_{h_1}^{h_2} A(h)\, dh$$

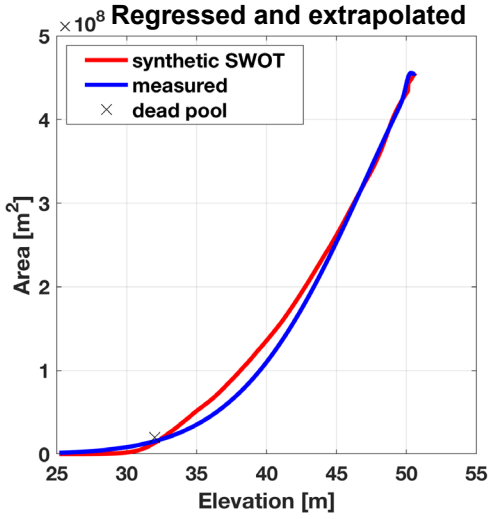
To estimate the absolution storage (V):

- **Task 1:** represent A as a function of h
- **Task 2:** the lower bound needs to be the dead-pool elevation

Problem solving for task 1 and 2

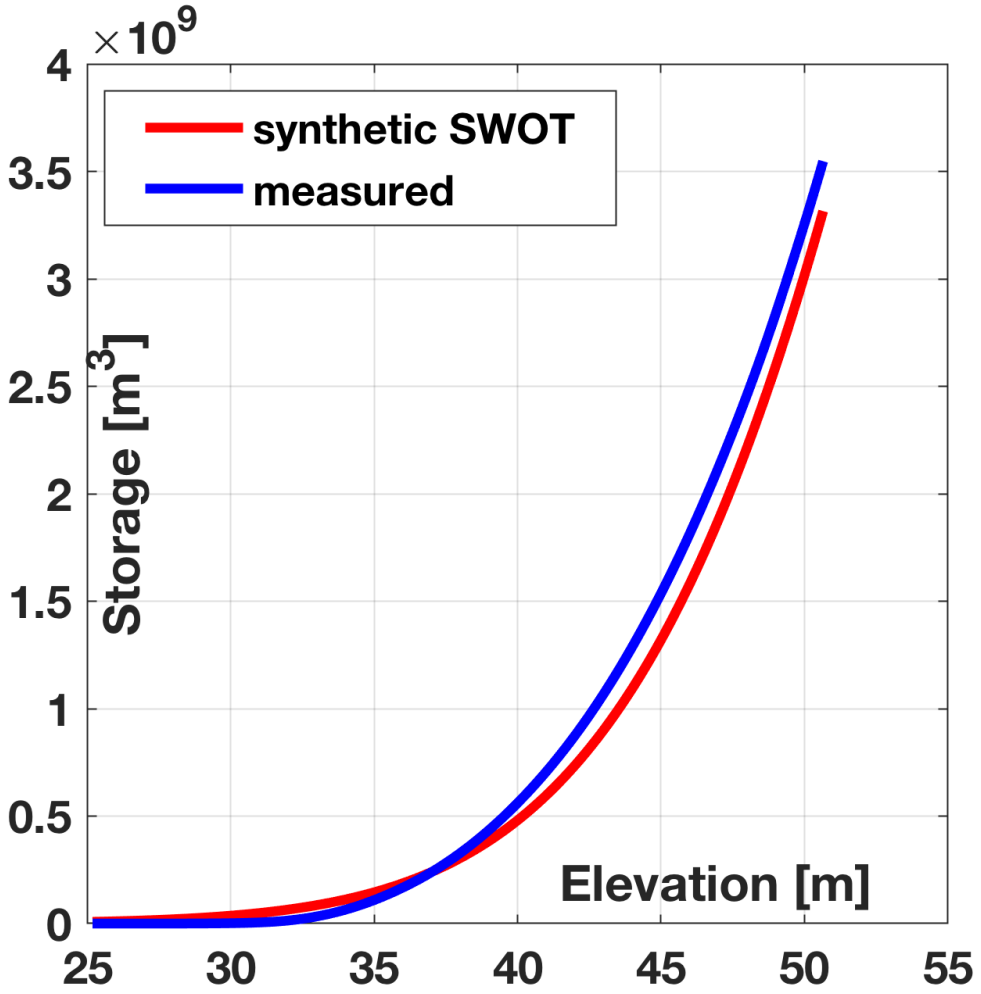






- **Sam Rayburn Reservoir**
  - 2nd largest reservoir in Texas
  - Long-term continuous measurements
- **For task 1: run SWOT simulator to get water surface elevation (h) and area (A). Conduct regression**
- **For task 2: extrapolate the regression to the dead-pool elevation and area**

Developing storage-elevation relationship

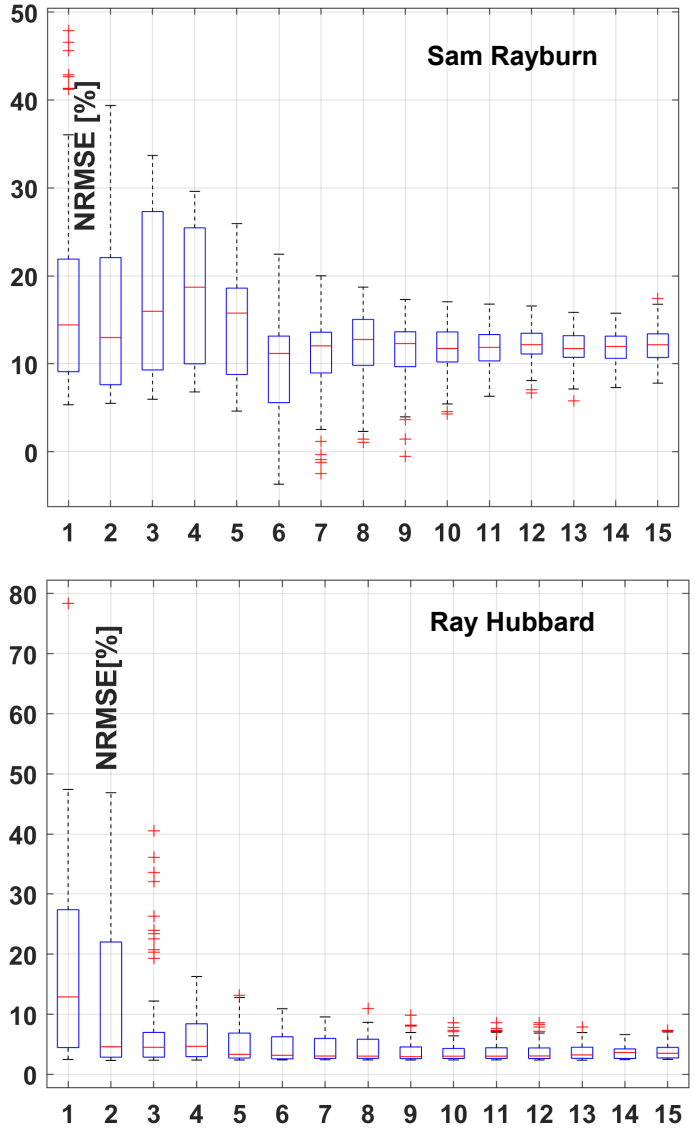


- Deriving the storage volume *V* from SWOT measured *h* at observation time *t*

$$V_t = V_{\max} - \left(A_t + A_{\max}\right) \times \frac{h_{\max} - h_t}{2}$$

- Relative storage error: 8% average, 15% largest

Sensitivities to obs. length and reservoir size



- **Observation length**
  - 1, 2, 3, … ,14, 15 years
  - Each length has an ensemble of 100 members selected from a 25-year SWOT simulator run with random starting dates
- **Reservoir size**
  - Large: Sam Rayburn
  - Medium: Ray Hubbard, 10% of Sam Rayburn's capacity
- **For large reservoirs**
  - SWOT effectively reduces large storage errors
  - Insignificant improvement in overall accuracy until year 6
- **For medium size reservoirs**
  - Constrain large errors, and significantly reduces the overall storage error within designed life

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