



Klamath Natural Flow Study

Open Water Evaporation Modeling

Model Purpose

The purpose of the open water evaporation modeling is to quantify how evaporation rates have changed from current to pre-developed conditions. These evaporation rates will be used in the Riverware mass balance model.

Model Selection and Input Data

The Complementary Relationship Lake Evaporation (CRLE) model was used to estimate open water evaporation. The CRLE model accounts for water temperature, albedo, emissivity, and heat storage effects to estimate monthly evaporation. The conceptual diagram (backside) includes a list of input data and sources.

Natural Flow Representation

To simulate natural flow (undeveloped) conditions, the following features are modified in the CRLE simulations. More details on the modifications can be found on the back of this handout.

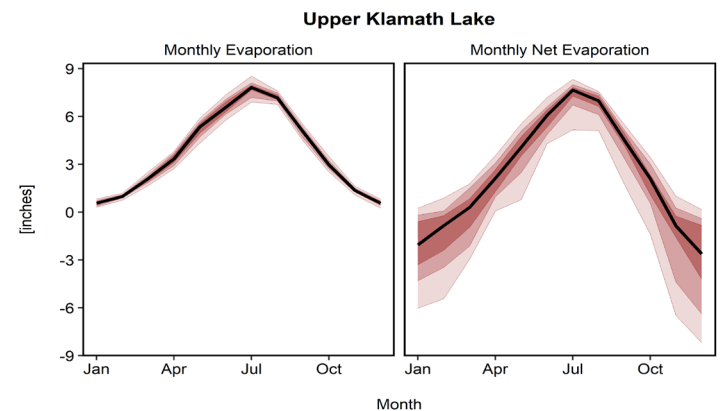
- Average depth of each waterbody (CRLE)
- Reservoir or lake surface area (in Riverware)
- Area capacity relationship of each waterbody (hydraulics)

Sensitivity & Uncertainty Analysis

To assess model sensitivity and range of reasonable results, analyses were run for a range of observed depths for each waterbody. CRLE was run for the 5th, 25th, 50th, 75th, and 95th depth percentiles and evaporation rates reported. Uncertainty was quantified by comparison to Global Lake Evaporation Volume (GLEV) dataset.

Model Products

The CRLE model outputs monthly evaporation rates (length/time) that are then disaggregated to a daily timestep using gridMET daily reference ET as a training dataset. These daily rates are then multiplied by the reservoir surface area to estimate volumetric rates of open water evaporation.



Graphs showing monthly and monthly net evaporation for Upper Klamath Lake.

Key References

- Morton, F. I. (1986). Practical estimates of lake evaporation. *Journal of Climate & Applied Meteorology*, 25(3), 371–387. [https://doi.org/10.1175/1520-0450\(1986\)025<0371:PEOPLE>2.0.CO;2](https://doi.org/10.1175/1520-0450(1986)025<0371:PEOPLE>2.0.CO;2)
- Reclamation. (2015). West-Wide Climate Risk Assessments: Irrigation Demand and Reservoir Evaporation Projections. *Bureau of Reclamation, Technical*.
- Stannard, D. I., et al. (2013). Evapotranspiration from Wetland and Open-Water Sites at Upper Klamath Lake, Oregon, 2008 – 2010. *Scientific Investigations Report 2013 – 5014*, 2008–2010
- Zhao, G., Li, Y., Zhou, L., Gao, H. (2022) Evaporative water loss of 1.42 million global lakes. *Nature Communications*. <https://doi.org/10.1038/s41467-022-31125-6>

Technical Contacts:

TSC Modeling Lead: Kristin Mikkelson

TSC Peer Review: Katie Holman

External Peer Review: Justin Huntington (DRI)

Collaborators:

Rachel Esralew, Steve Pilson, &
John Vradenburg (FWS)

Open Water Evaporation

- = Primary Data
- = Model/Data Export
- = Model
- = Products

