Klamath Natural Flow Study Surface Hydrology Modeling

Model Purpose

The purpose of the surface hydrology modeling is to quantify how distributed precipitation recharge has changed from developed to pre-development conditions. The distributed recharge output from the surface hydrology model will be input into the groundwater model.

Model Selection and Input Data

The Precipitation Runoff Modeling System (PRMS) surface hydrology model was used to simulate distributed precipitation recharge. Conceptual diagram (backside) includes a list of input data and sources for model development.

Natural Flow Representation

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

- Landcover designation
- Forest density
- Wetland extent

Sensitivity & Uncertainty Analysis

To quantify the sensitivities of the model & understand the uncertainties associated with these precipitation recharge values, a range of uncertainty and sensitivity analyses were performed.

- Sensitivity analyses changed each calibrated parameter by 1,5,10% (increase and decrease) and quantified their impact on distributed recharge, and streamflow timing/volume.
- Uncertainty analyses compared recharge from National Hydrologic Model and Risley et al. (2019) model.
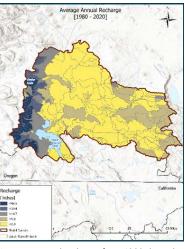
Model Products

PRMS outputs daily recharge for each Hydrologic Response Unit (HRU) which is then aggregated seasonally and distributed to each groundwater model cell by spatial averaging.

Key References

Average annual recharge from 1980 through 2020 for each HRU above Upper Klamath Lake.

Risley, John C. et al. 2019. "Using the Precipitation-Runoff Modeling System to Predict Seasonal Water Availability in the Upper Klamath River Basin, Oregon and California." U.S. Geological Survey Scientific Investigations Report 2019–5044, 37.

Hagmann, R. Keala, Andrew G. Merschel, and Matthew J. Reilly. 2019. "Historical Patterns of Fire Severity and Forest Structure and Composition in a Landscape Structured by Frequent Large Fires: Pumice Plateau Ecoregion, Oregon, USA. Landscape Ecology." Vol. 34. https://doi.org/10.1007/s10980-019-00791-1.

Regan, R.S., et al.. 2018. "Description of the National Hydrologic Model for Use with the Precipitation-Runoff Modeling System (PRMS): U.S. Geological Survey Techniques and Methods, Book 6, Chap B9, 38 P." https://doi.org/10.3133/tm6B9

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Surface Hydrology Modeling → Distributed Precipitation Recharge

Legend:
- = Primary Data Input
- = Model/Data Export
- = Model
- = Products

Daily Gridded Climate Data
gridMET: tmin, tmax, precip., ETr, solar radiation

Spatially averaged across each HRU

Basin Physical Characteristics:
-aspect, elevation, area, slope, vegetation canopy densities, soil type, % impervious, land type: USGS DEM data, Risely 2019 model, NHM model

Held constant throughout simulation duration

Calibration → **PRMS** → **Daily Precipitation Recharge for each HRU**

Aggregated seasonally & remapped to gw grid (spatial avgs)

Groundwater Model — *Baseflow* → **Mass Balance Modeling (RiverWare)**

Three simulations:
1. *Standard-only landcover change*
2. *Less Dense: landcover change & 19% decrease in canopy density*
3. *Least dense: landcover change & 28% decrease in canopy density*

Naturalized Streamflow (calibration)
- Monthly consumptive use: 2014 Upper Klamath Basin Comprehensive Agreement (all basins)
- Modoc Point Canal Diversions (Williamson)
- UKL basin: $Q_{constructed} = Q_{net\ inflow} + EVAP_{lake} + ET_{wetlands} + CU - Pr_{lake}$
    - $Q_{net\ inflow}$:KBAO (dissagg. Using UGS Williamson gage)
    - $ET_{wetlands}$: Risley model AET – PET (*0.90 in growing season; Stannard et al. 2013)
    - ET_{lake} : CRLE (see open water evaporation modeling)
    - Pr_{lake} : gridMET precip over lake HRU

Pre-project modifications
- Landcover change: 1880s (Gannet et al. 1887) & 1930s survey of forest resources. [reparameterization of calibrated parameters based multiple linear regressions & soil/landcover groupings.]
    - predictor variables: percent wetland, summer canopy density, elevation, aspect & percent impervious.
- Canopy density change : pre-development -1920s forest inventory on Klamath reservation (Hagmann et al. 2019); post - project - 2017 LEMMA GNN

Wetland Extent
- Pre-development: Pre-development wetland extent estimated by plate maps from various sources (Gannett et al. 1887; Lippincott, Murphy, and Humphreys 1905; Humphreys and Reaburn1905; Reclamation 1908)
- Current Conditions: a combination of phreatophyte boundary maps and datasets, DEM, gSSURGO soils data (USDA 2017), high resolution aerial imagery of the National Agriculture Imagery Program (NAIP), Landsat land surface temperature and vegetation indices, and Oregon Water Resources Department (OWRD) groundwater level data. All agricultural boundaries were removed (CA DWR field boundaries OR USDA CLU boundaries)