Groundwater-Modeling Software Development in the USGS WAUSP

Paul Barlow, USGS Office of Groundwater

WAUSP Project Status, Updates, and Issues Call; November 9, 2015
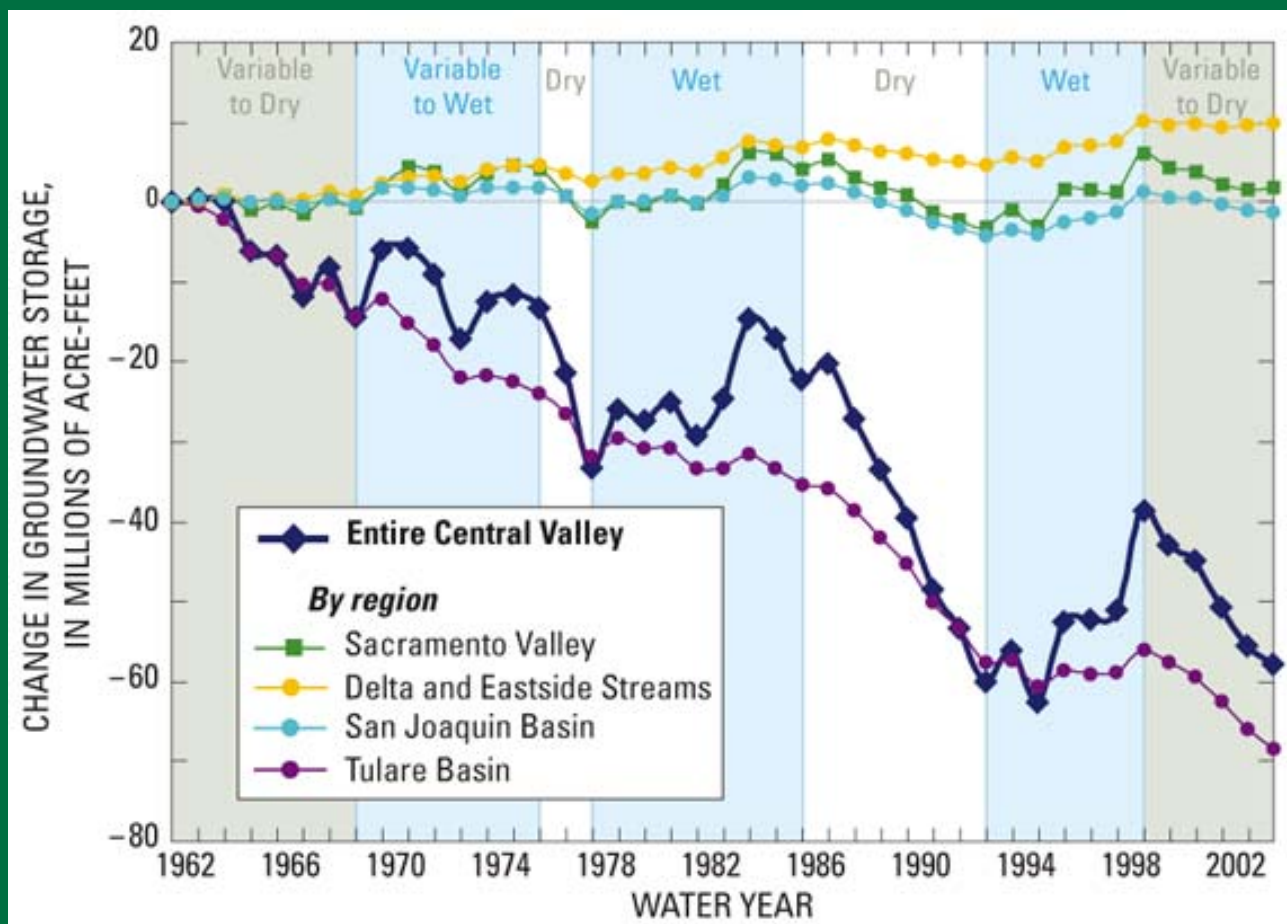
U.S. Department of the Interior
U.S. Geological Survey

Why Develop Groundwater-Modeling Software?

- **Provide Up-To-Date Quantitative Tools to Meet USGS Science Needs and Strengthen Our Interpretive Programs at all Levels:**
  - **Federal Program Needs**
  - **Local Water Science Center Needs**
  - **International Applications and Training**

  - **215 Active GW Modeling Projects at time of last National Survey (2012)**
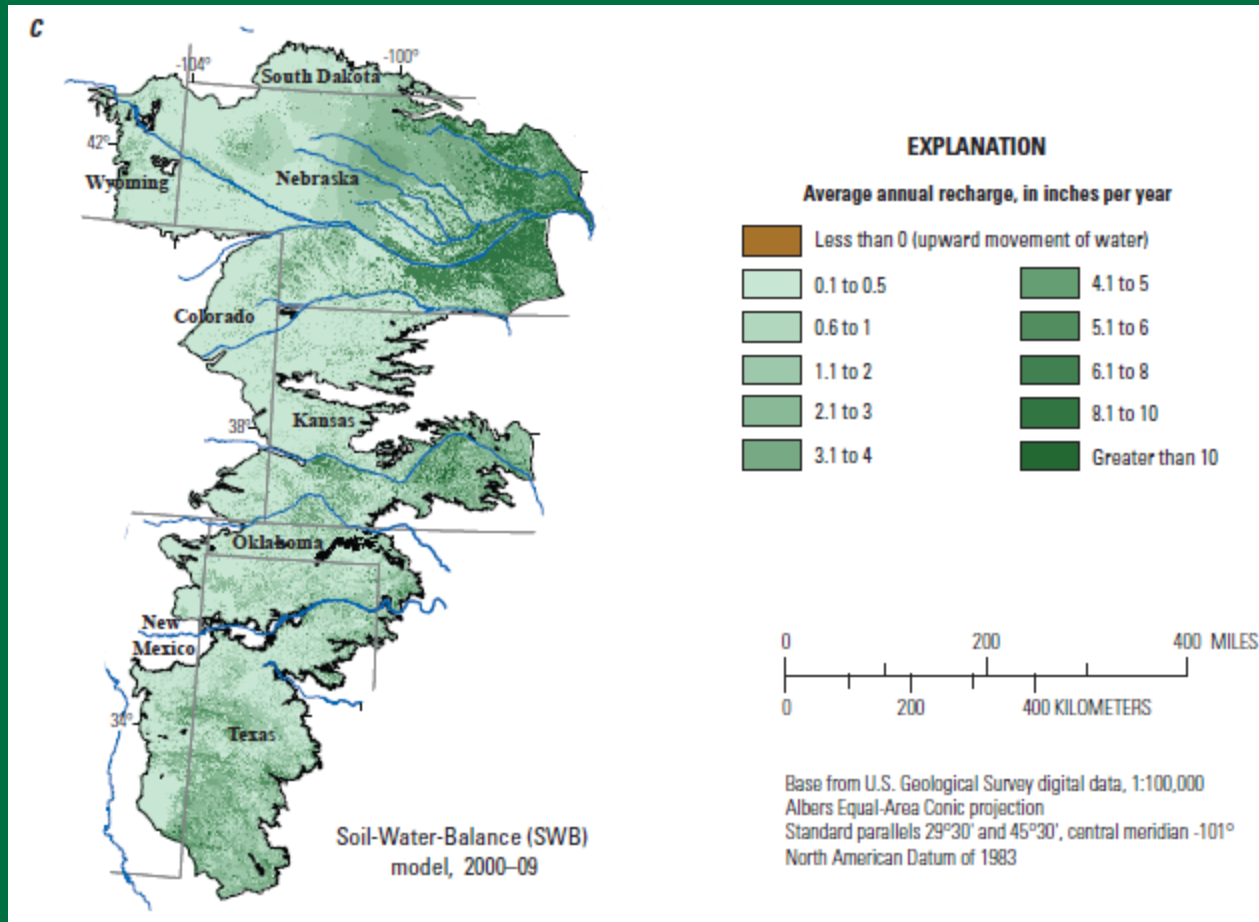
≈USGS

Example: GW Availability Studies

Simulated Change in Groundwater Storage, Central Valley, CA

(Faunt and others, 2009)
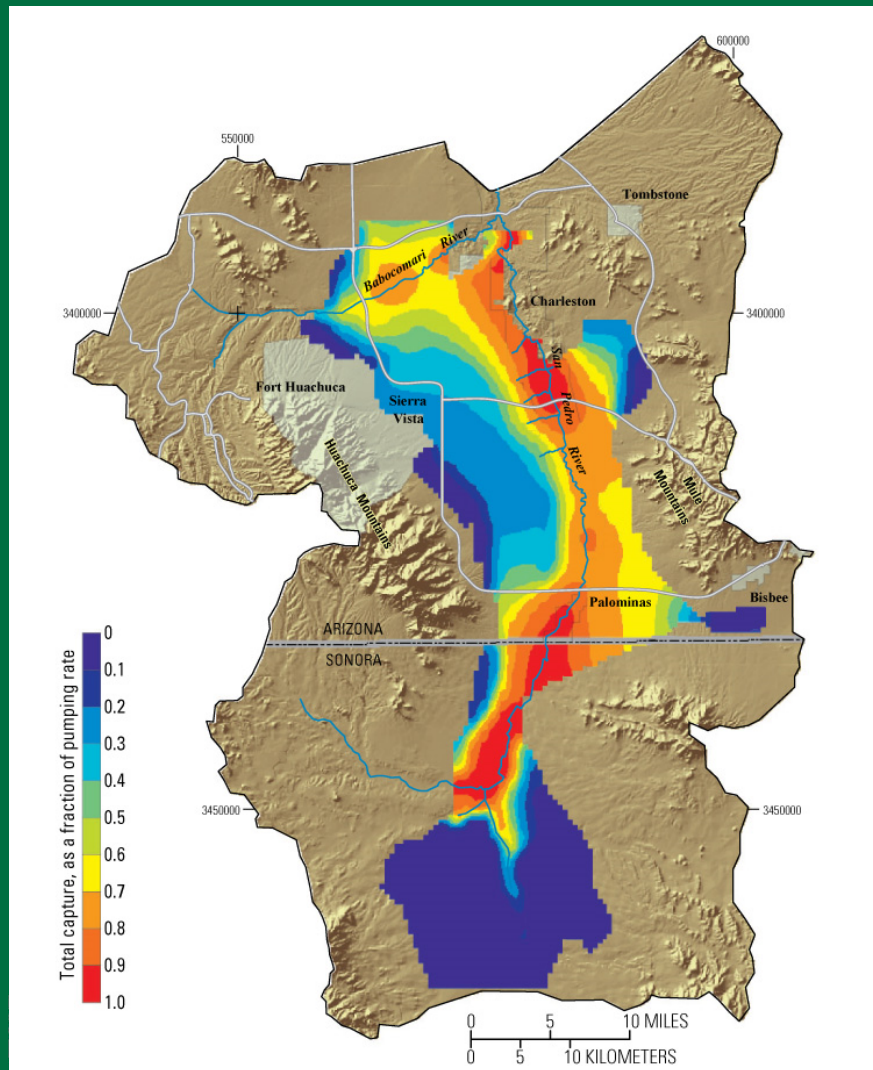
Example: Water-Budget Components

Soil-Water-Balance (SWB) Model

Estimated average annual potential recharge, High Plains Aquifer, 2000-2009.

(Stanton and others, 2011)

Example: Innovative Modeling Applications

Groundwater-Pumping Capture Maps, Upper San Pedro Basin, AZ

(Leake and others, 2008)

Why Develop Groundwater-Modeling Software?

- **Strengthen Our Workforce to Maintain National and International Leadership in the Theory and Development of Groundwater-Modeling Software**
  - **MODFLOW has become the most recognized and widely used groundwater-flow model in the world**

  - **Groundwater-Model Development in the USGS occurs throughout the organization: Technical Offices, NRP, Water Science Centers**
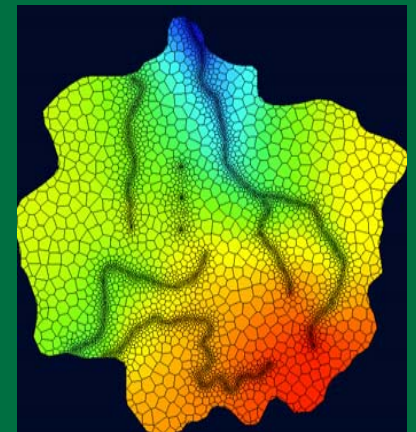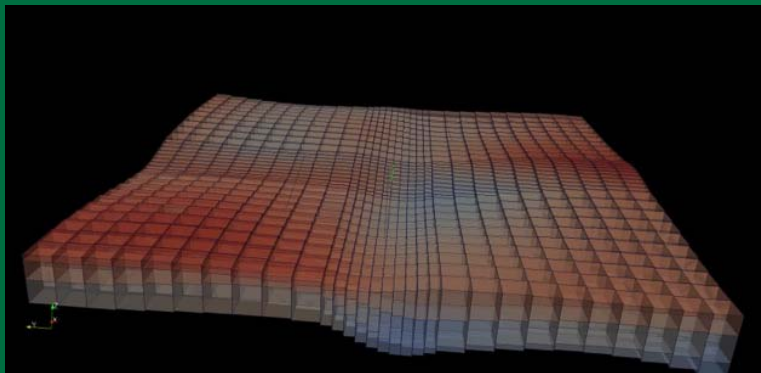
≈ **USGS**

Why Develop Groundwater-Modeling Software?

- **Build Model-Use Expertise Throughout the Organization: Model Developers Become Trainers and Mentors to Our Model Users**
  - **Collaborations and Feedbacks Develop Among Model Users and Model Developers**

≋USGS

Current Model-Development Efforts:

- **Modeling Groundwater Flow: MODFLOW**
  - Many recent enhancements: NWT, USG, SWR, etc
  - MODFLOW version 6:
    - Update and modernize the MODFLOW framework to incorporate new process models
    - New grid options
    - Revise input structure and capabilities
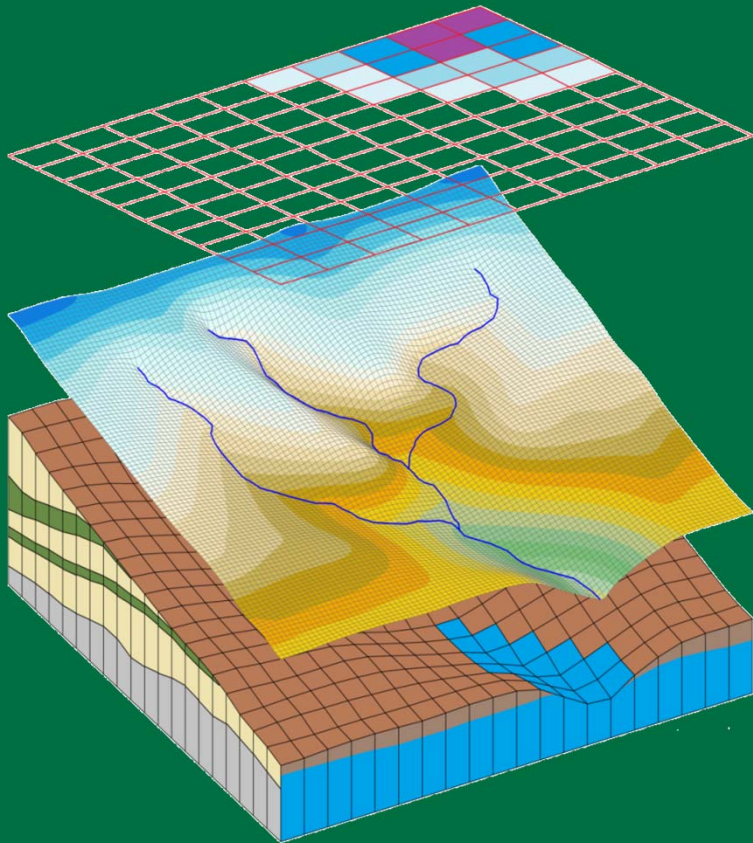   - Langevin, Hughes, Banta, Niswonger

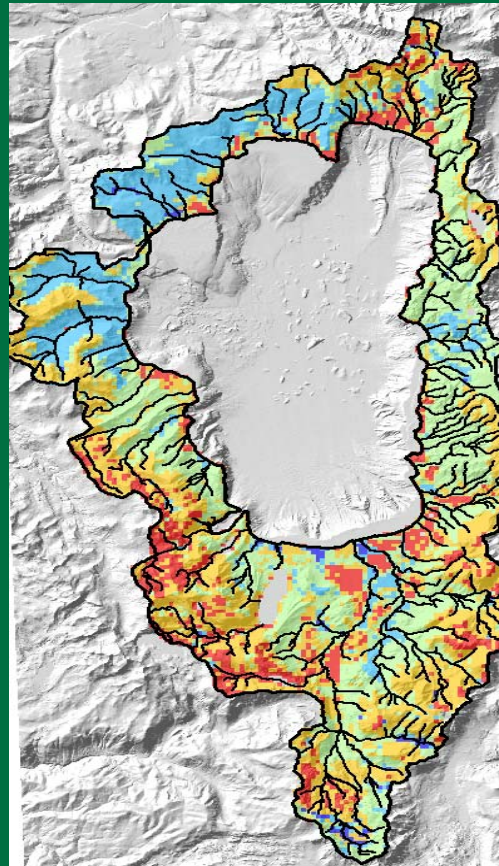

≈USGS

Current Model-Development Efforts:

- **Modeling Coupled Groundwater-Watershed Hydrology: GSFLOW**
  - Comprehensive, basin-scale simulation of watershed hydrologic processes and feedbacks at daily time steps
  - Built on MODFLOW and PRMS
  - Relevance to water availability and use, ecological flows, groundwater-dependent ecosystems
  - Niswonger, Regan, Markstrom, Maples, Barlow
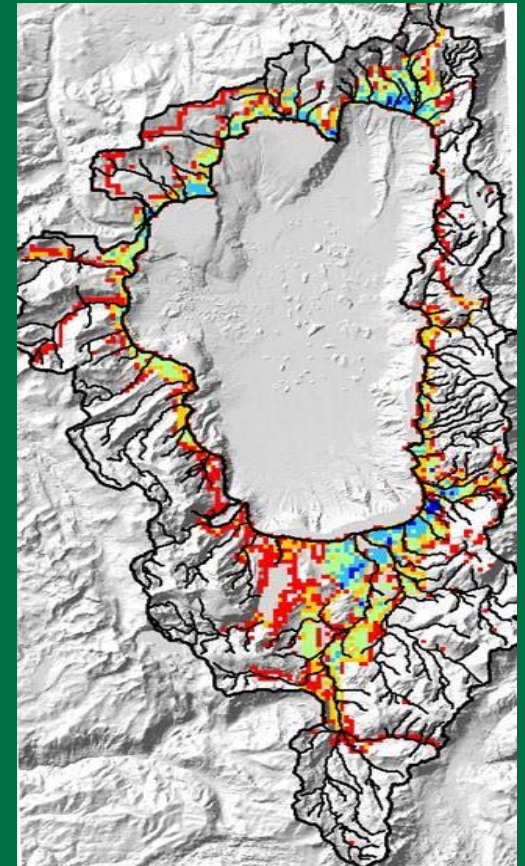   - Links to the PRMS NHM team

≋USGS

GSFLOW

Grid Concepts: Climate, Surface, Subsurface

Fully Distributed Hydrology

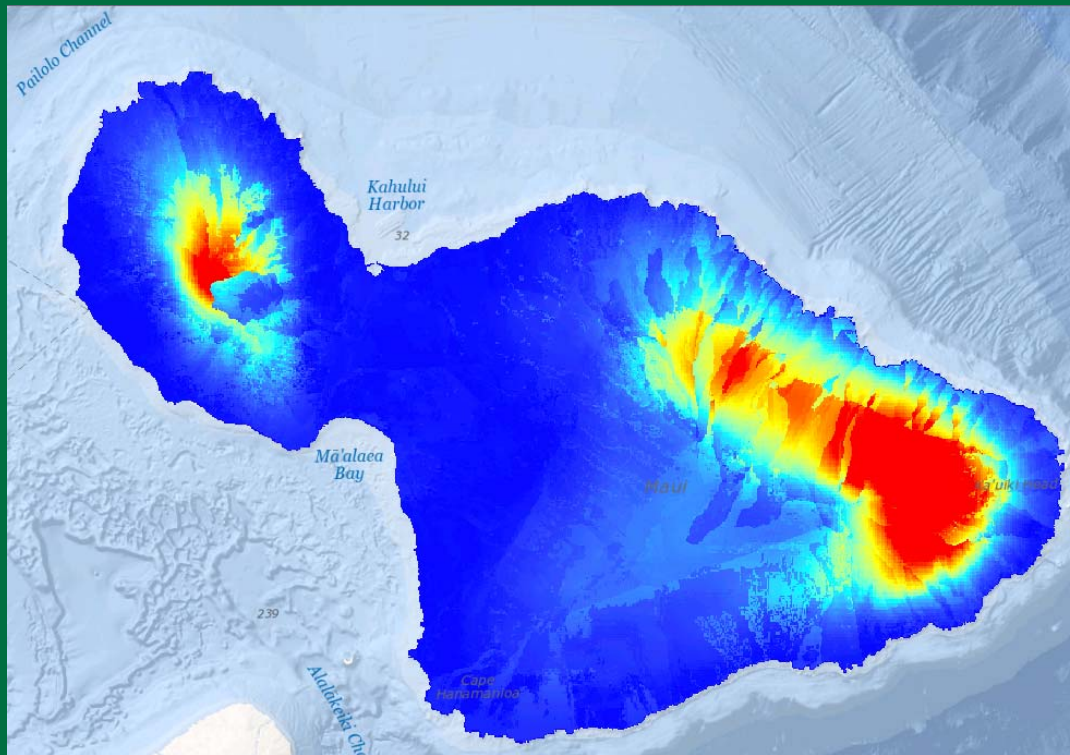Soils storage

Vegetation density

≋USGS

Current Model-Development Efforts:

- **Modeling Groundwater Transport: MT3D-USGS**
  - MT3D: Most widely used MODFLOW-based transport code
  - Advection-dispersion-reaction equation for non-interacting species
  - Includes streamflow, lake, and unsaturated-zone transport simulations
  - Collaborative effort between USGS (Morway, Langevin) and S.S. Papadopulos and Associates

≋USGS

Current Model-Development Efforts:

- **Modeling Recharge: SWB**
  - Grid-based code designed to estimate potential recharge, taking full advantage of gridded land use, soils, and climate datasets
  - Version 2.0 under development: Processes for tropical-island hydrology, crop irrigation demand estimated using FAO-56 methodology, other enhancements and modifications
  - Westenbroek, Engott

≋USGS

SWB: Many recent and ongoing applications, including GW Availability Studies

Application to Hawaii Volcanic-Rock Aquifers

≋ USGS

- ➢ Pacific Northwest
- ➢ Williston and Powder River
- ➢ North Atlantic Coastal Plain
- ➢ Floridan
- ➢ Appalachian Plateaus
- ➢ Hawaii Volcanic Rock
- ➢ States of Maine and Wisconsin

Current Model-Development Efforts:

- **Hydrograph Analysis: GW Toolbox**
  - **A GIS-based Graphical User Interface for Analysis of Hydrologic Time-Series Data**
  - **Initially developed for streamflow-hydrograph analysis: base-flow separation (PART, HYSEP, BFI) and recharge estimation (RORA, RECESS)**
  - **Derived from USEPA BASINS**
  - **Collaborative effort between USGS (Barlow, Cunningham, Flynn) and Aqua Terra Consultants (RESPEC)**

Application to Appalachian Plateau GW Availability Study (Nelms and others, 2015)

≋USGS