USGS Groundwater Program Methods Development

with focus on data collection and modeling

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Briefing to
ACWI Workgroup
How to Sustain and Enhance High Quality
Water Monitoring under Constrained Budgets
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GW Methods Development

- Caveat: The topics presented are not comprehensive
- Focus is on Water Levels, Hydrogeophysics, and Modeling
- The GW Methods Development mission within the Office of Groundwater is to:

  …….support the Water Mission Area in the development and application of water-level data collection techniques, hydrogeophysical techniques, and software to enhance groundwater resource assessment, modeling and monitoring

- Restated: Moving science methods from "research" into "production"

Water Levels

- Non-contact water-level measurement
  - Sonic measurements
  - Radar measurements
- Cost-effective data collection
  - Lower cost transducers and data transmission
  - Value engineering studies
  - Field computer applications

- Water table measurements (imprecise)
  - GPR
  - Resistivity
  - Seismic
  - (Gravity)

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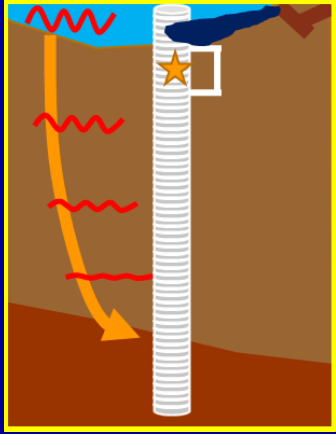
Hydrogeophysics

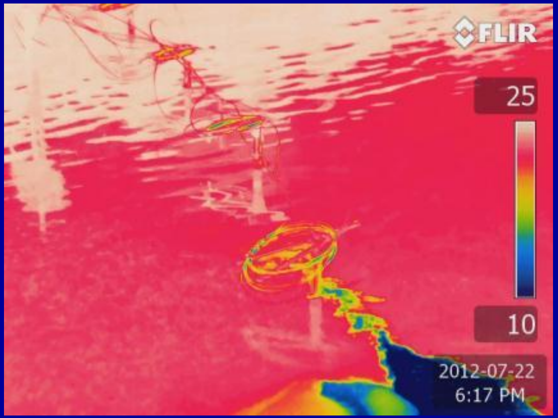
- Temperature Methods for GW/SW Exchange
  - Discrete vertical and horizontal data collection (30-plus years)
  - Fiber Optic Distributed Temperature Sensing (2006)
  - Thermal Camera (2010)
  - Continuous High-Resolution Temperature Sensors (2011)
  - Software to process (2012)

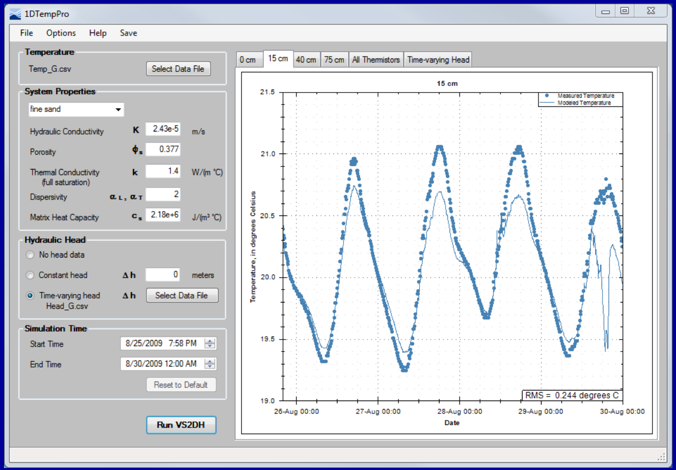
USGS

GW/SW Exchange



- 1 meter length
- 5 cm radius
- 1.4 cm vertical resolution

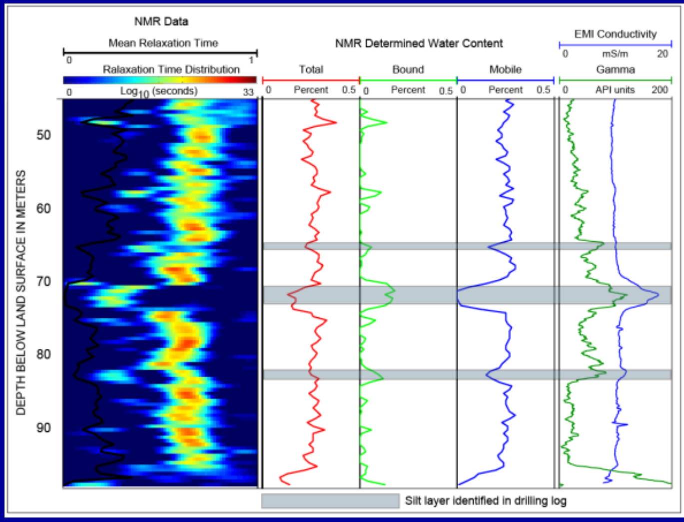




Hydrogeophysics: Subsurface Characterization

- HSVR (Passive Seismic)
  - Low-cost approach “imported” from Europe
  - Bedrock/unconsolidated interface

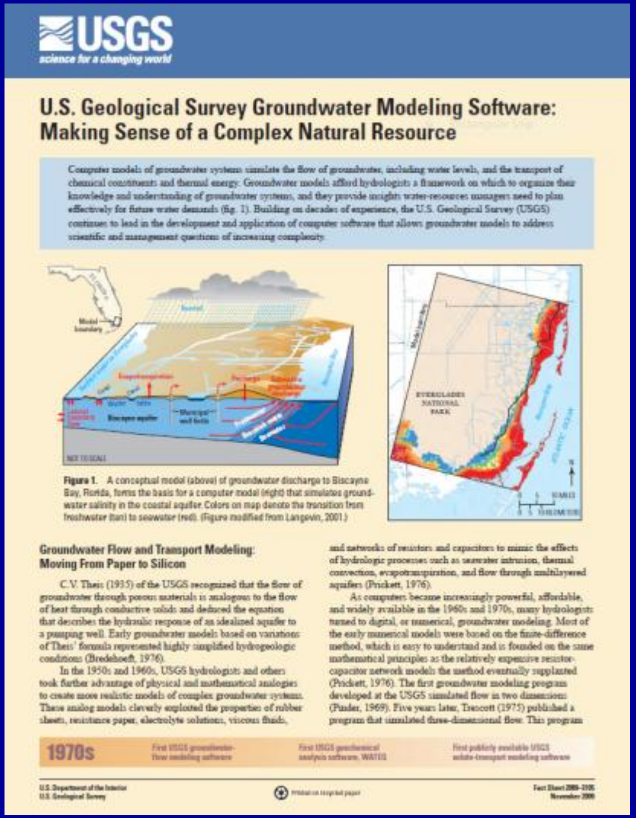
- Nuclear Magnetic Resonance (NMR)
  - “imported” from petroleum industry
  - Direct measure of “free” water



USGS

GW Modeling

- MODFLOW
  - MODFLOW-NWT
  - MODFLOW-USG
  - SEAWAT
  - MODPATH
- GSFLOW
- Variety of other codes and packages….



USGS
science for a changing world

U.S. Geological Survey Groundwater Modeling Software: Making Sense of a Complex Natural Resource

Computer models of groundwater systems simulate the flow of groundwater, including water levels, and the transport of chemical constituents and thermal energy. Groundwater models afford hydrologists a framework on which to organize their knowledge and understanding of groundwater systems, and they provide insights water-resources managers need to plan effectively for future water demands (fig. 1). Building on decades of experience, the U.S. Geological Survey (USGS) continues to lead in the development and application of computer software that allows groundwater models to address scientific and management questions of increasing complexity.

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NOT TO SCALE

Figure 1. A conceptual model (above) of groundwater discharge to Biscayne Bay, Florida, forms the basis for a computer model (right) that simulates groundwater salinity in the coastal aquifer. Colors on map denote the transition from freshwater (tan) to seawater (red). (Figure modified from Langevin, 2001.)

Groundwater Flow and Transport Modeling: Moving From Paper to Silicon

C.V. Theis (1935) of the USGS recognized that the flow of groundwater through porous materials is analogous to the flow of heat through conductive solids and deduced the equation that describes the hydraulic response of an idealized aquifer to a pumping well. Early groundwater models based on variations of Theis' formula represented highly simplified hydrogeologic conditions (Bredehoeft, 1976).

In the 1950s and 1960s, USGS hydrologists and others took further advantage of physical and mathematical analogies to create more realistic models of complex groundwater systems. These analog models cleverly exploited the properties of rubber sheets, resistance paper, electrolyte solutions, viscous fluids, and networks of resistors and capacitors to mimic the effects of hydrologic processes such as seawater intrusion, thermal convection, evapotranspiration, and flow through multilayered aquifers (Prickett, 1976).

As computers became increasingly powerful, affordable, and widely available in the 1960s and 1970s, many hydrologists turned to digital, or numerical, groundwater modeling. Most of the early numerical models were based on the finite-difference method, which is easy to understand and is founded on the same mathematical principles as the relatively expensive resistor-capacitor network models the method eventually supplanted (Prickett, 1976). The first groundwater modeling program developed at the USGS simulated flow in two dimensions (Pinder, 1969). Five years later, Trescott (1975) published a program that simulated three-dimensional flow. This program

1970s

U.S. Department of the Interior
U.S. Geological Survey

http://pubs.usgs.gov/fs/2009/3105/

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