Groundwater Dynamics with Surface-Water Interactions in the Critical Zone

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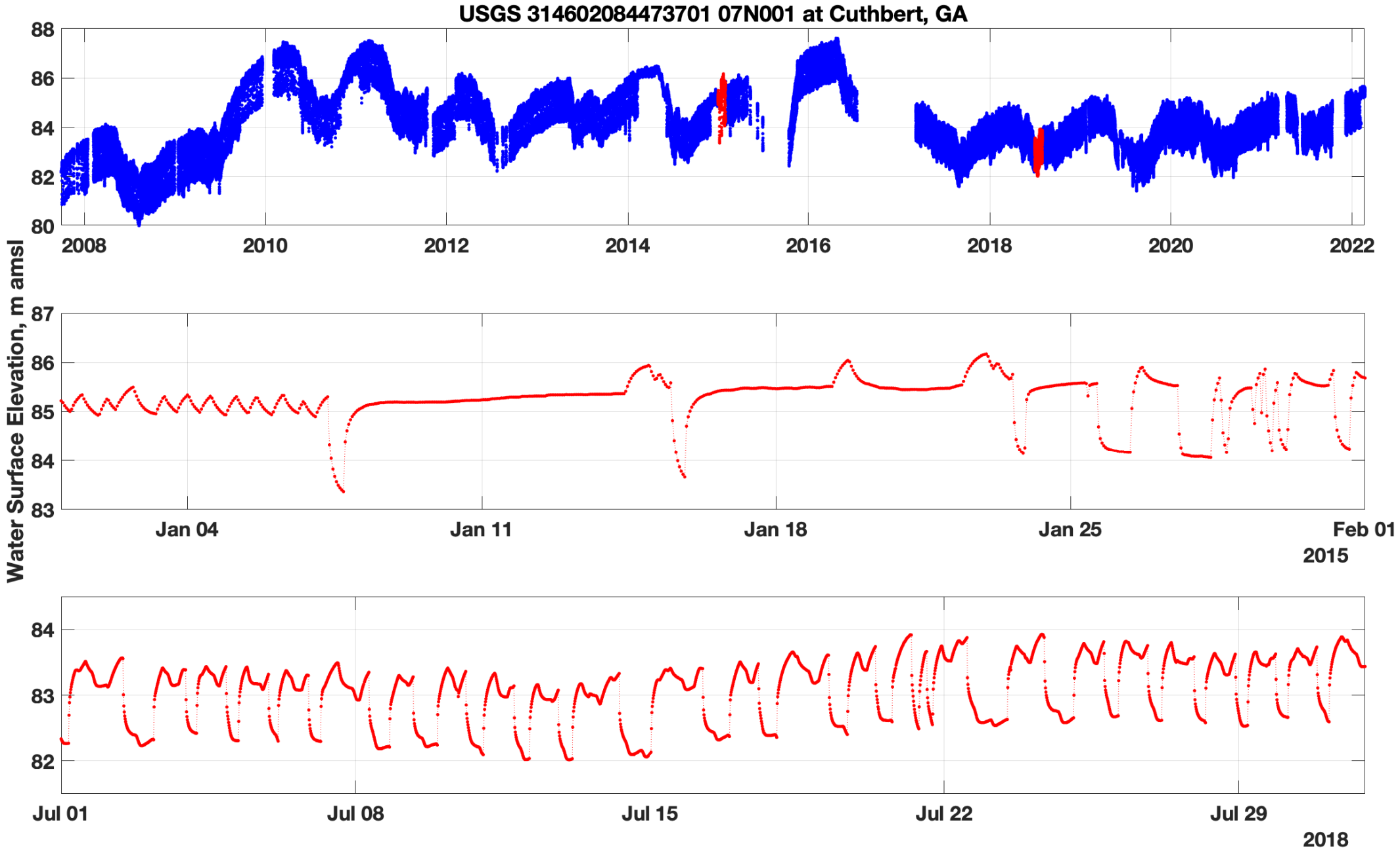
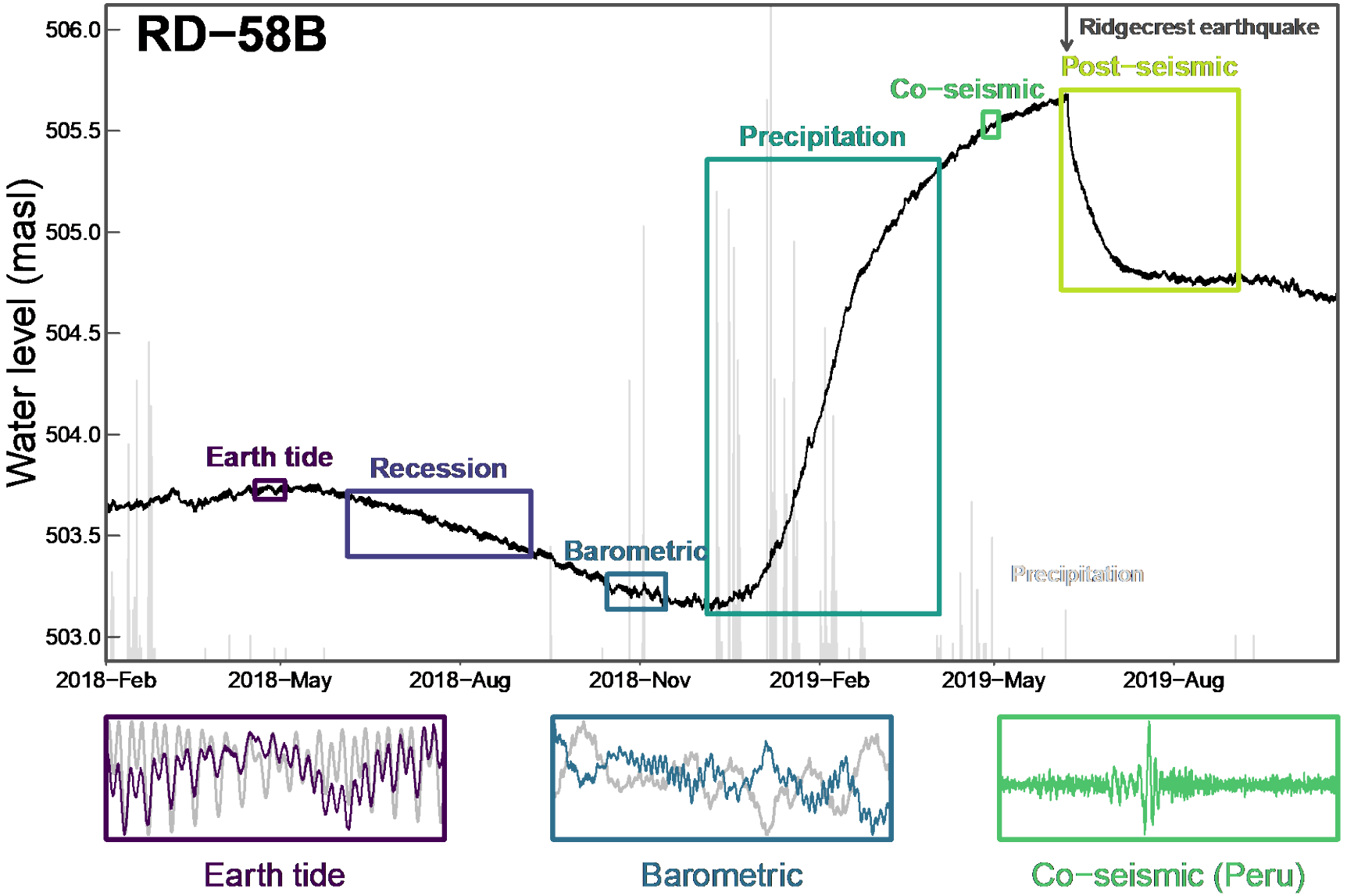
Groundwater levels affected by natural and human disturbances



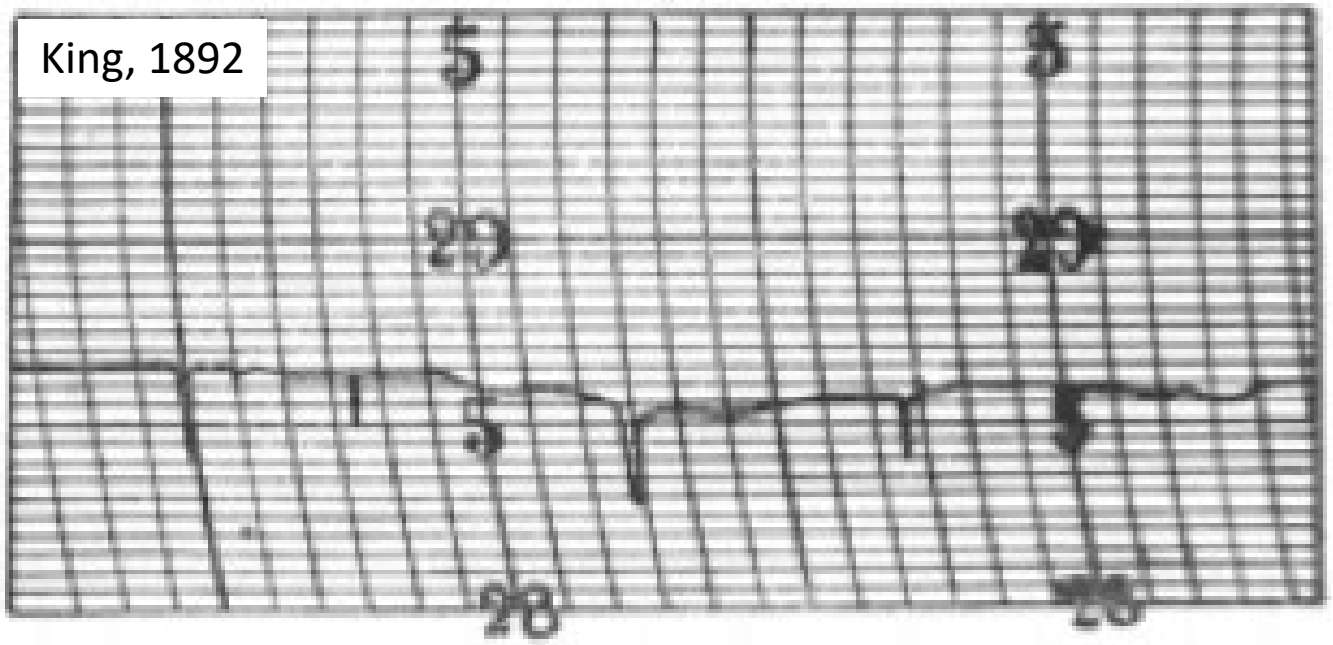
Groundwater hydrograph showing hydrodynamic responses to multiple inputs (Kennel, 2020).

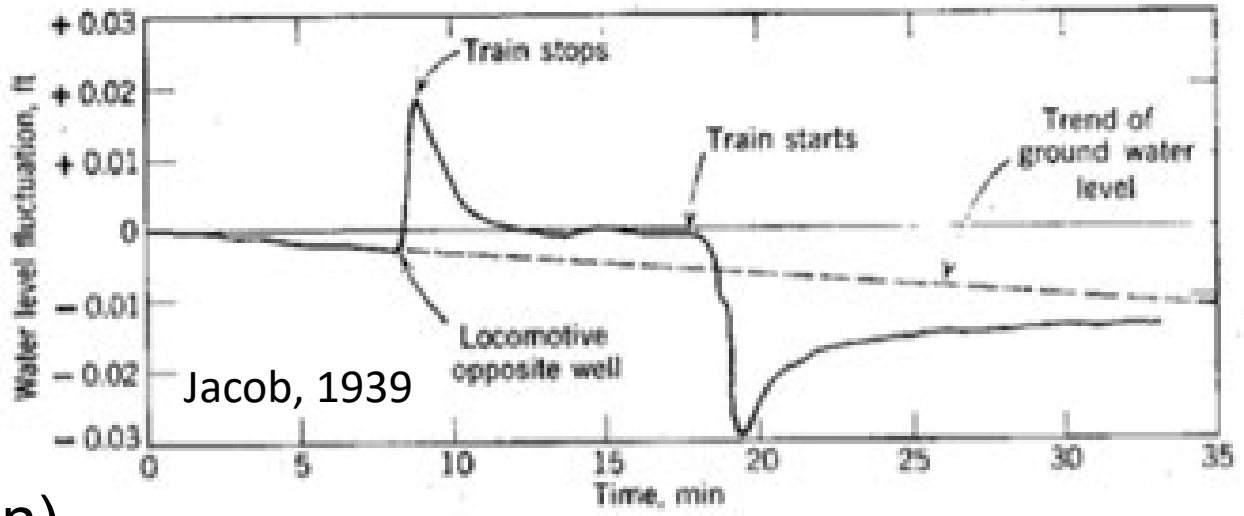


Interpretation of groundwater "noise"

- Influenced by:
  - Mass flow (recharge, pumping)
  - Mass loading (soil moisture, snow, evapotranspiration)
  - Earth tides (solar and lunar)
- Useful for estimating aquifer properties
  - Permeabilities (T, K, C, K')
  - Storage coefficients (S, S_s, S_y)
  - Diffusivity (D = T/S = K/S_s)
  - Leakance (L)
  - Recharge & Discharge
  - Reservoir Volume
  - Safe Yield
- Estimation techniques
  - Time domain (regression deconvolution)
  - Frequency domain (Fourier, HALS)

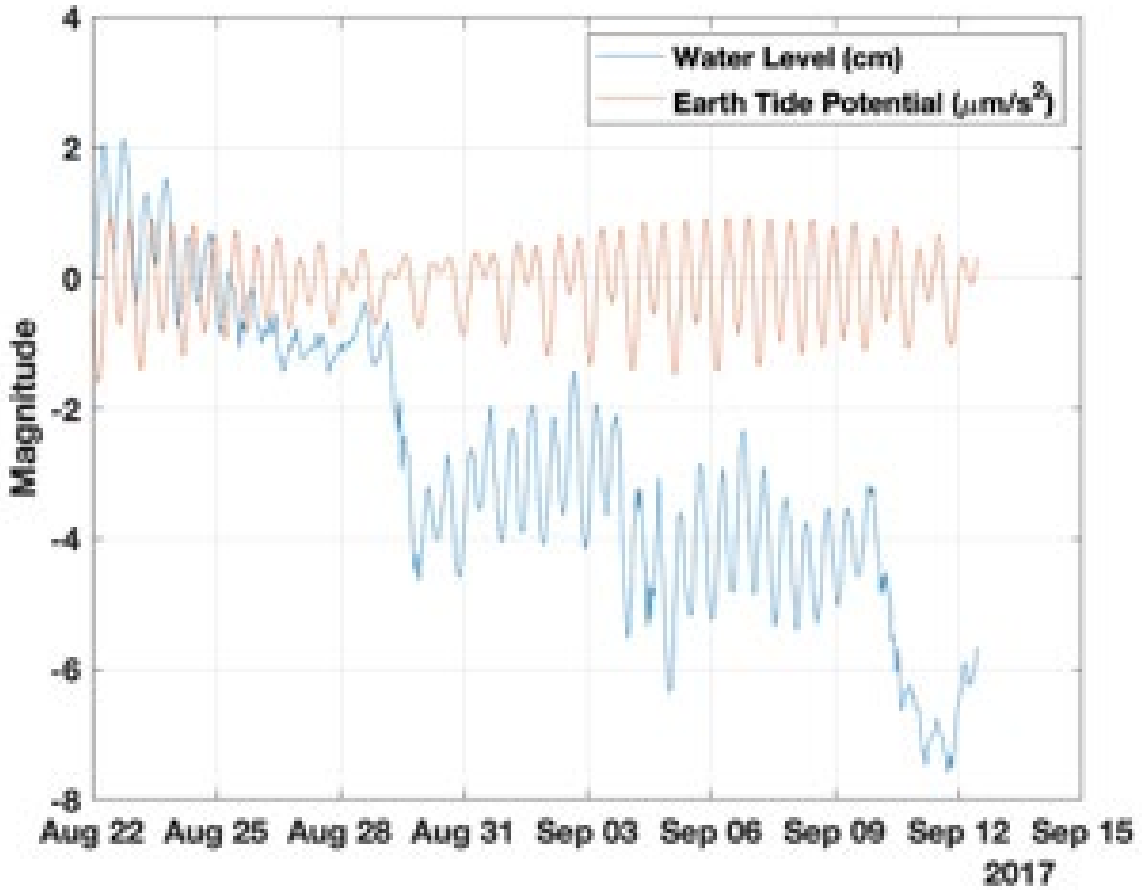
Effects of a trains on water levels in wells.



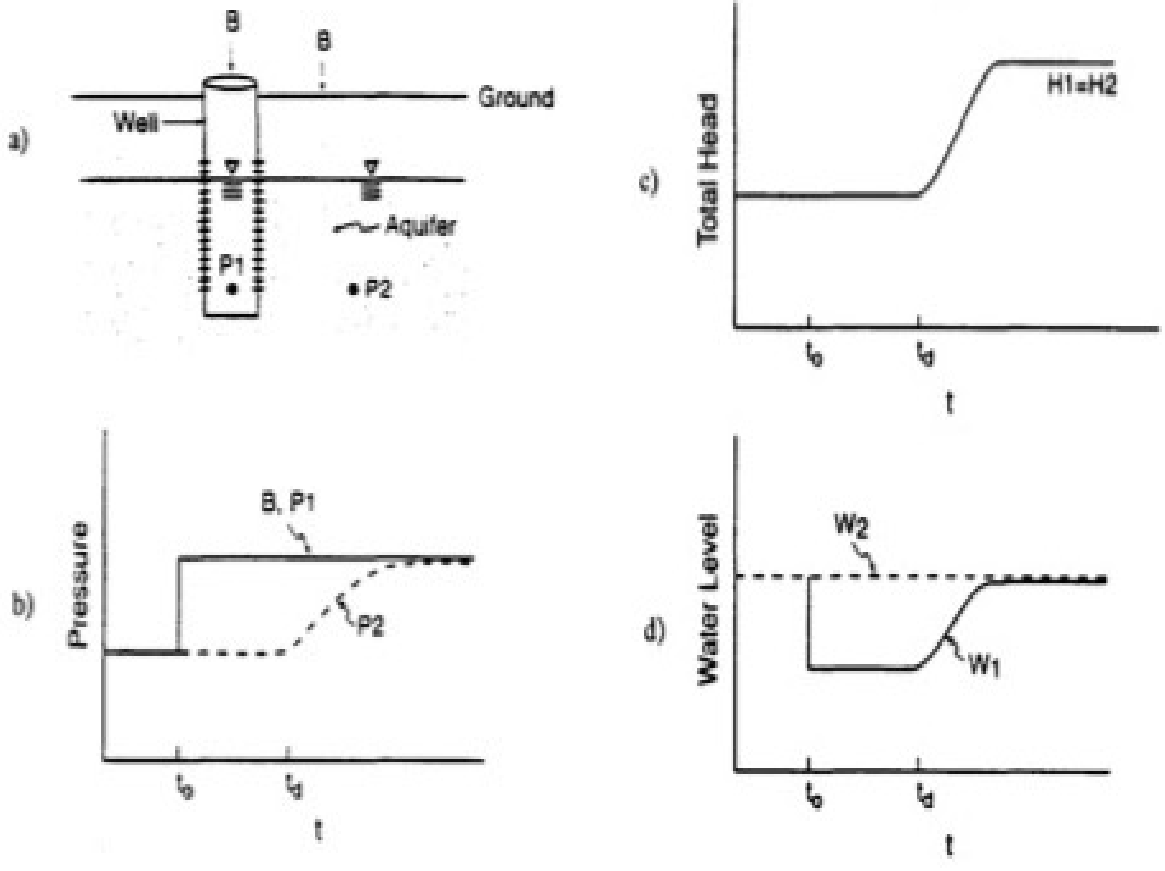


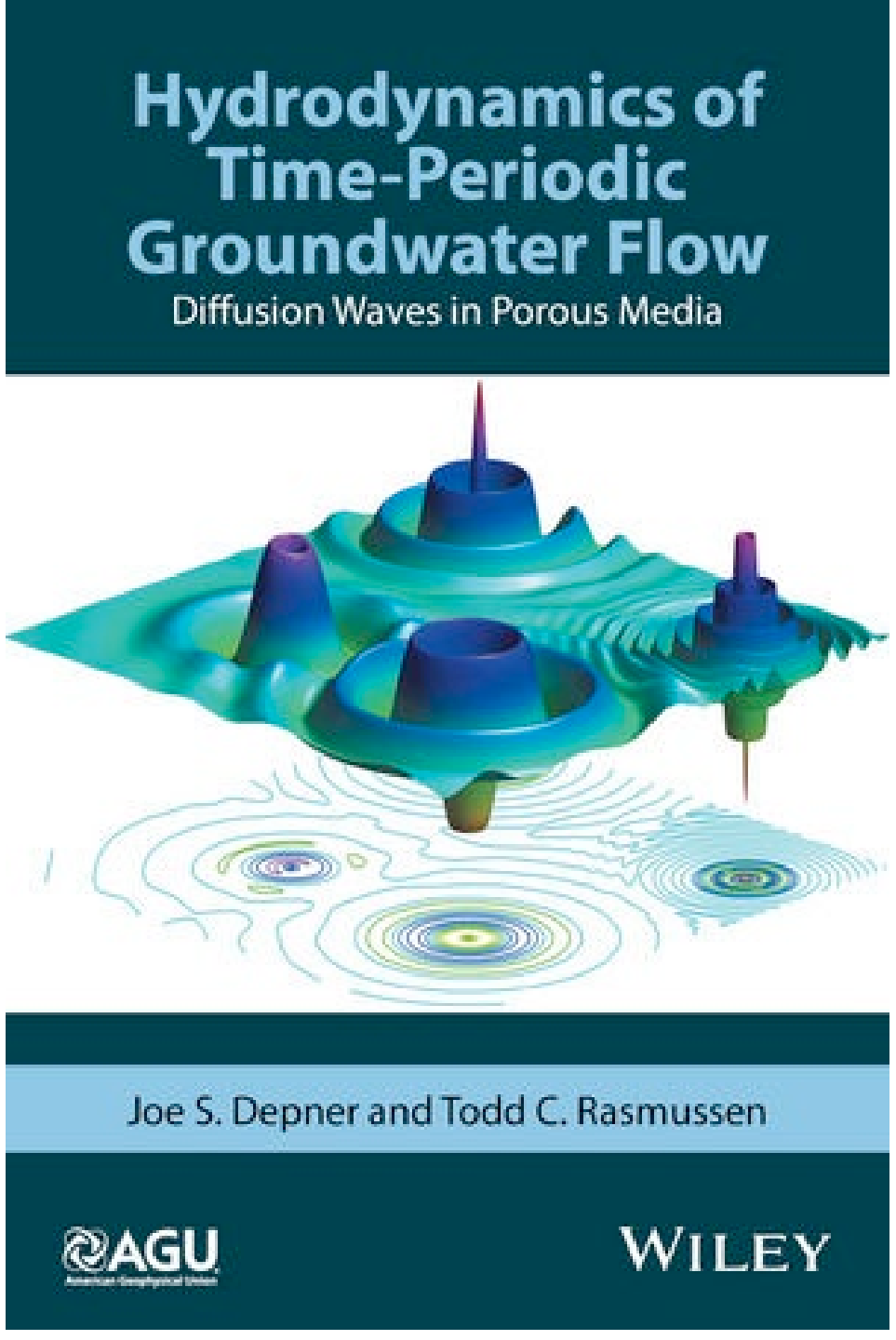
Barometric Pressure

Earth Tides (Solar and Lunar)



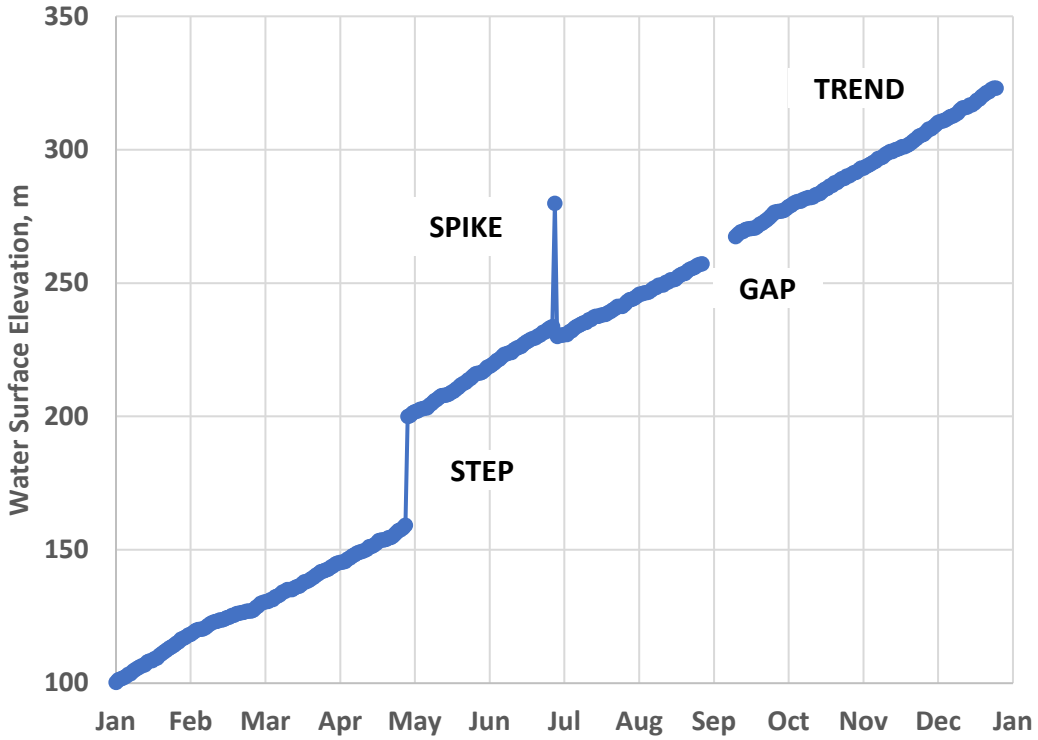
Response in an unconfined aquifer to a step increase in barometric pressure

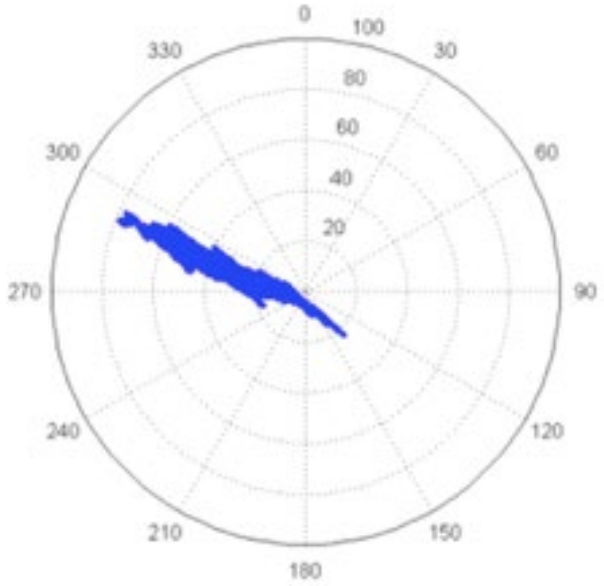




Data pre-processing

- Remove data anomalies (spikes, steps, gaps, trends)
- Types of pressure measurements (absolute, gauge, vacuum, differential)
  - Convert gauge to absolute pressures in open wells
- Effects of water density (temperature, salinity)
  - Convert water levels to freshwater head in deep wells with warm or saline water
  - Affects hydraulic gradients (magnitude and direction)



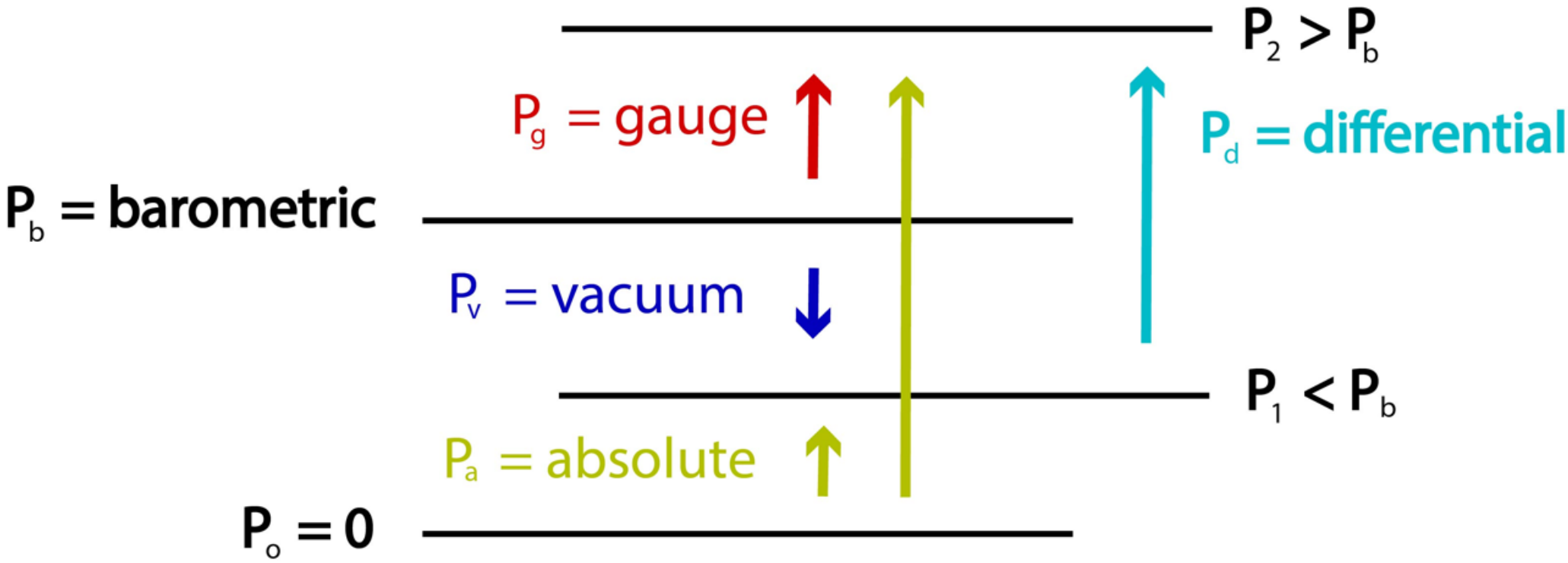


Polar plot of the horizontal direction and magnitude of the hydraulic gradient at the Savannah River Site over time.

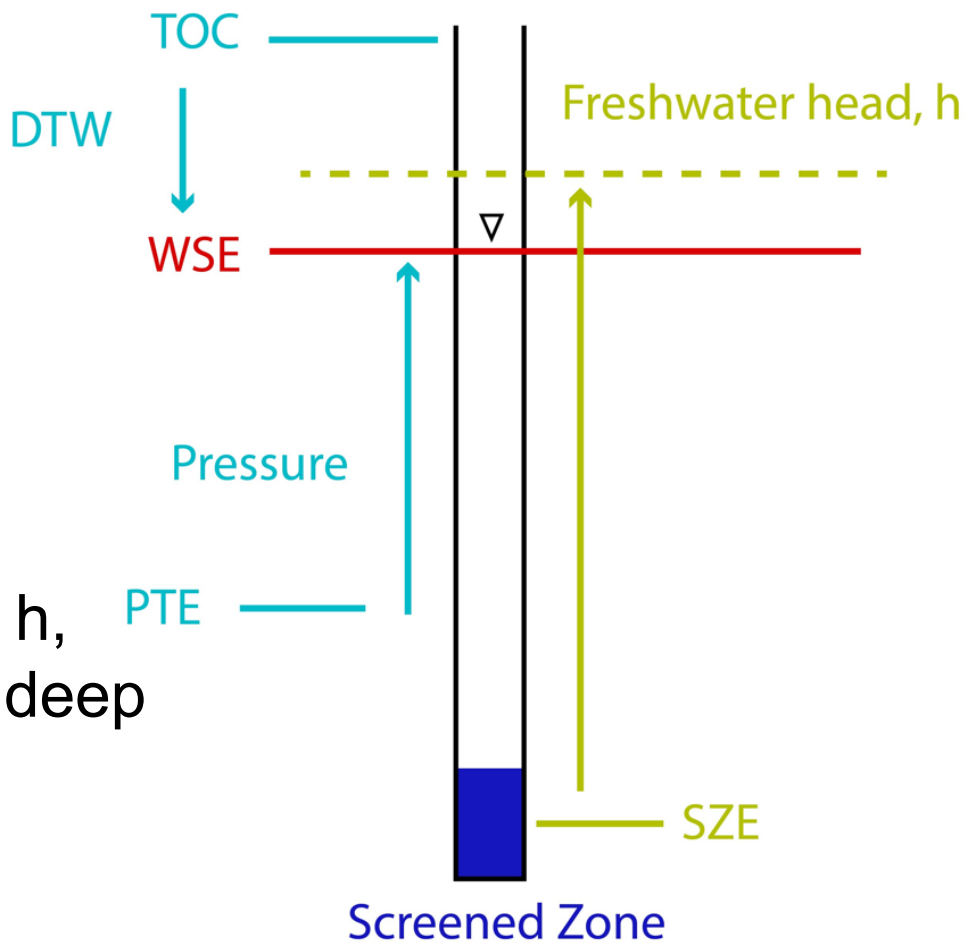
Types of pressure measurements

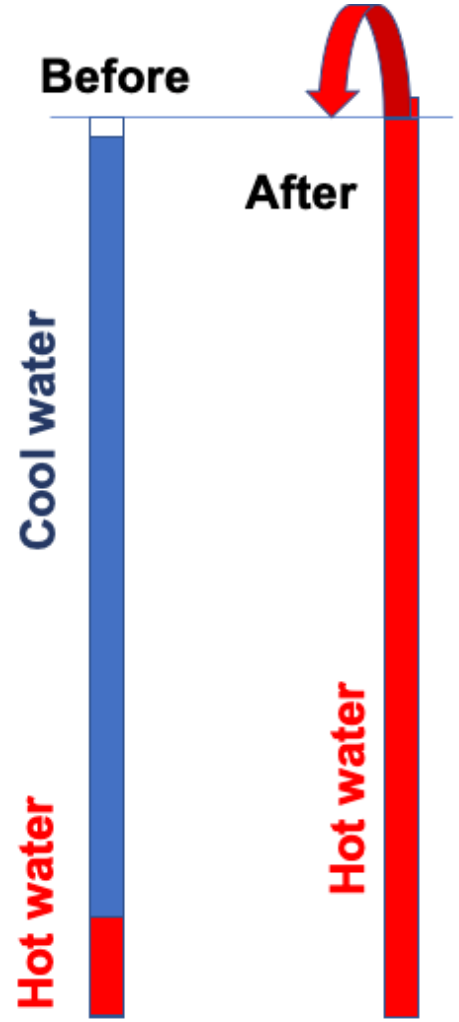
- Gauge, $P_g = P_2 - P_b$
- Vacuum, $P_v = P_b - P_1$
- Absolute, $P_a = P_1$, $P_a = P_2$
- Differential, $P_d = P_2 - P_1$

All measurements must be converted to total head, i.e., absolute pressure



Total heads must be converted to freshwater head





Determination of freshwater head, h, using pressure measurements for deep groundwater (saline, warm)

TOC = top of casing
DTW = depth to water
WSE = water surface elevation
PTE = pressure transducer elevation
SZE = screen zone elevation

Aquifer test at Hanford Nuclear Site where pumping a well caused water levels to rise because the fluid density changed as hot water replaced cold water in the well bore (right).

Example of how fluid density reverses the hydraulic gradient.