ESTIMATING THE CONTRIBUTION OF PLANT GROUNDWATER UPTAKE TO TOTAL EVAPOTRANSPIRATION IN A SEMI-ARID OAK SAVANNA

Gretchen Miller, Xingyuan Chen, Yoram Rubin, and Dennis Baldocchi

University of California - Berkeley

Background

Rationale:

- Tracer studies (Lewis and Burgy 1964) indicate potential to tap deep water sources ($\leq$ 23 m)

Objective:

- Estimate quantity and timing of blue oak groundwater uptake

Portion of tap root from a mature oak, from LandscapeOnline.com.

Hypotheses:

1. Mature blue oaks are obligate phreatophytes
2. Dependency occurs during dry summer months

Site typical of semi-arid woodlands

Satellite photo courtesy Google Earth

- Semi-arid
  - ~500 mm yr^{-1} rainfall
  - ~400 mm yr^{-1} ET
- Mediterranean climate
- Open canopy (40% cover)
  - Deciduous blue oaks
  - Herb and grass understory
- 60 cm rocky silt loam soil
- Fractured rock aquifer
  - 10 m to groundwater

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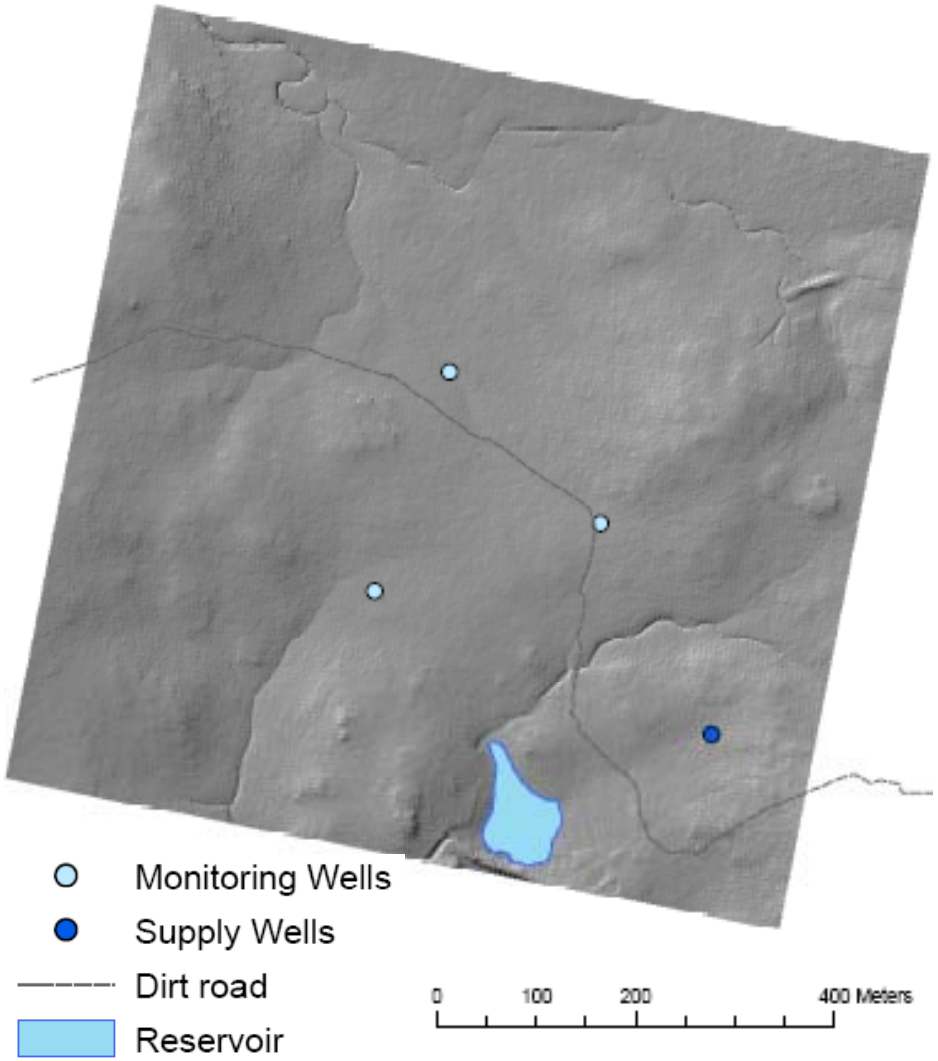

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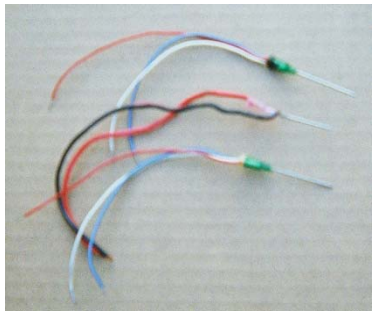
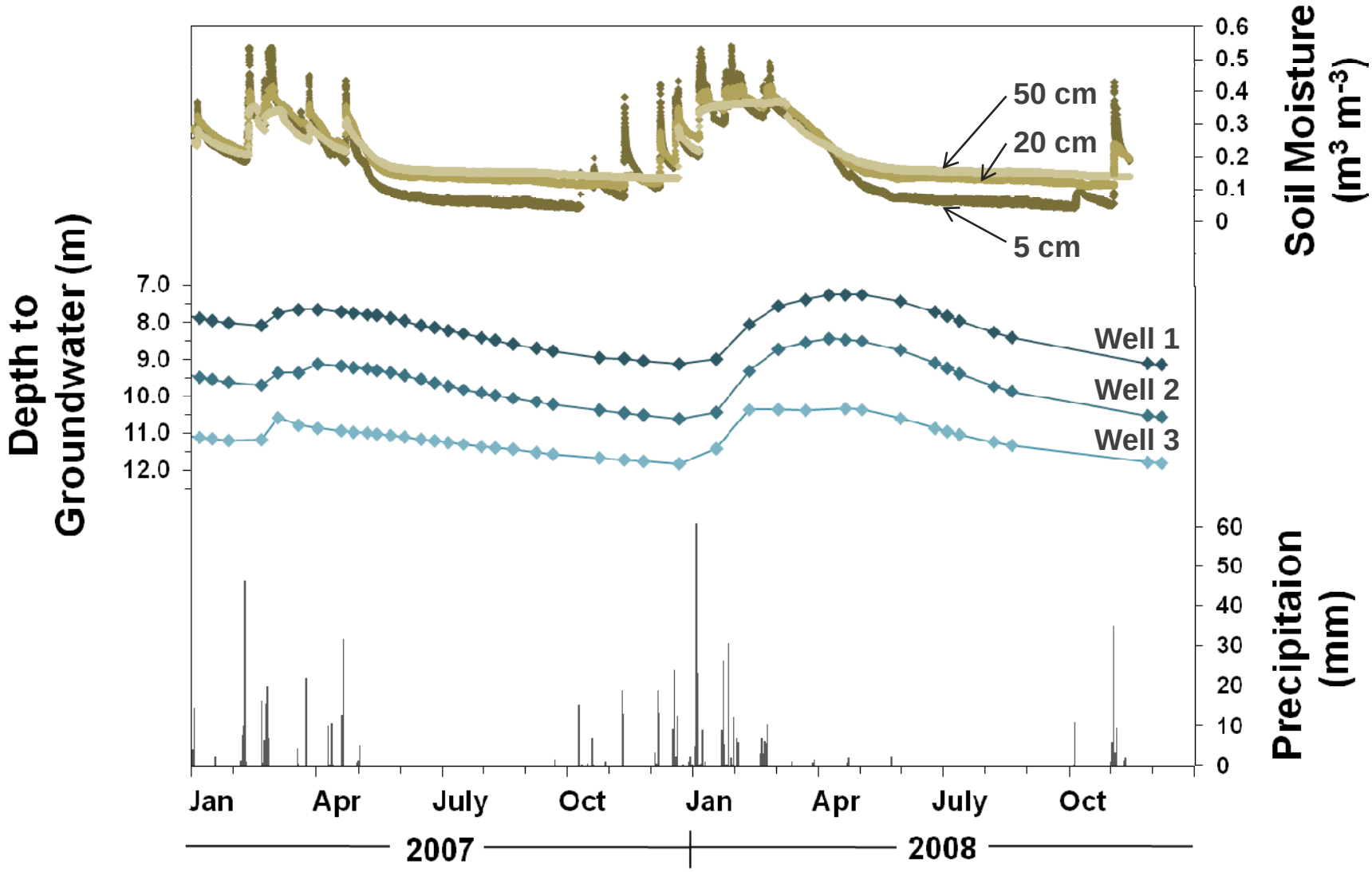
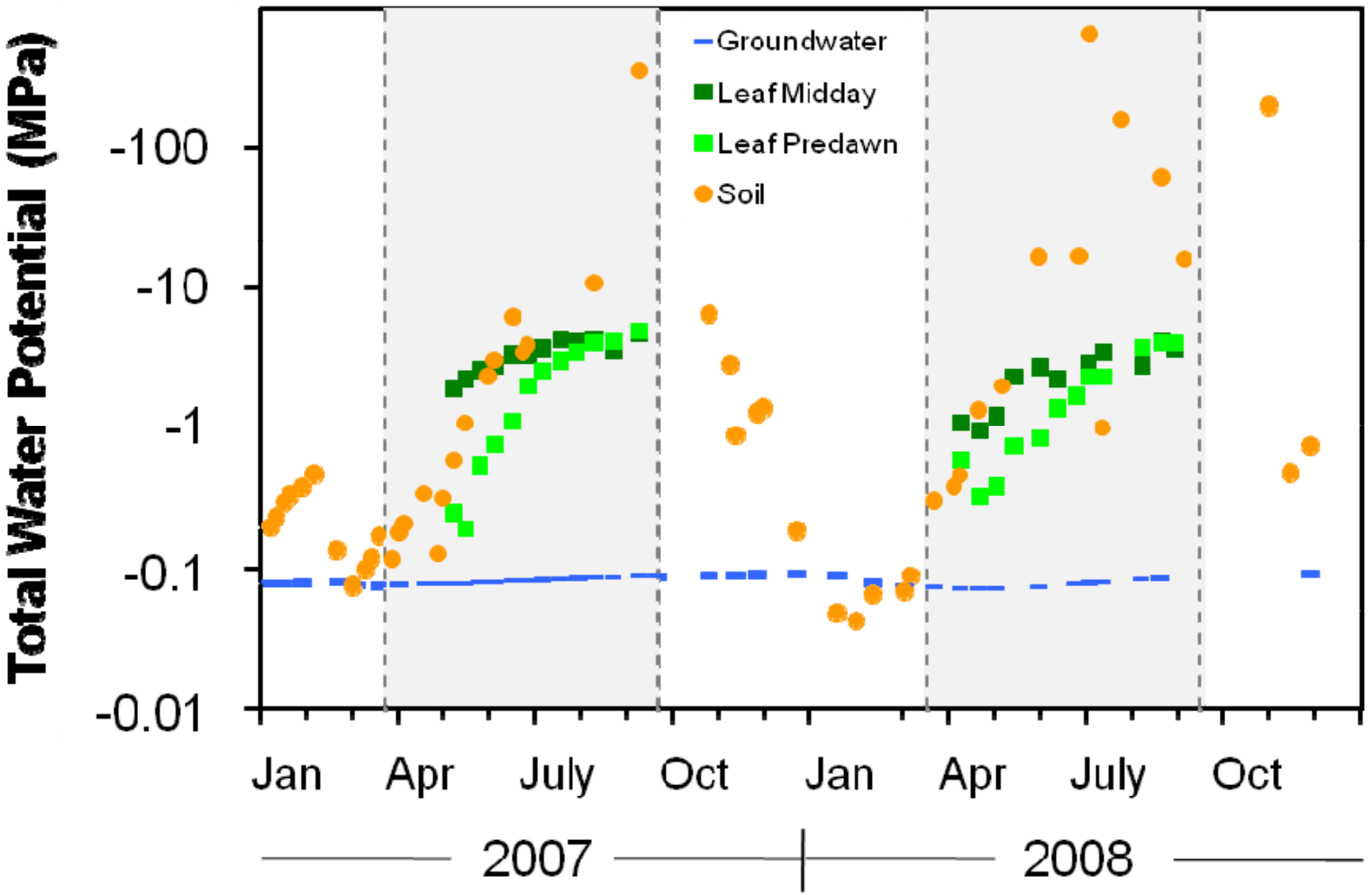
Ecohydrological Measurements



Strong relationship between precipitation, soil moisture, and groundwater



Uptake thermodynamically favorable



$$\Psi_{i,T} = \Psi_i + zg\rho_w$$

$$\Psi_{GW} = 0$$

$$\Psi_{soil}, \Psi_{leaf} =$$

measured values

z = distance from ground surface

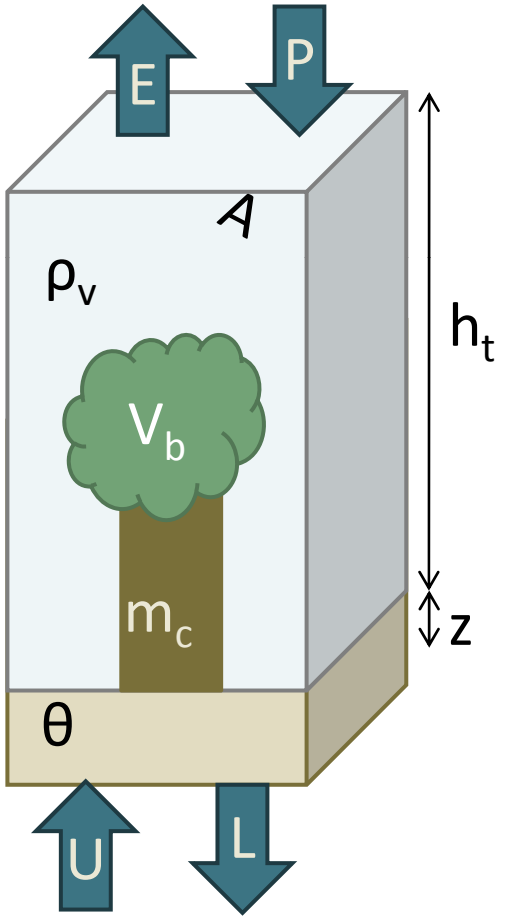
Three Analysis Methods

- Water balance at sap flow (tree)
- Water balance at flux tower (stand)
  - Find G_w = U - L
    - Positive G_w – root uptake below soil
    - Negative G_w – leakage to aquifer

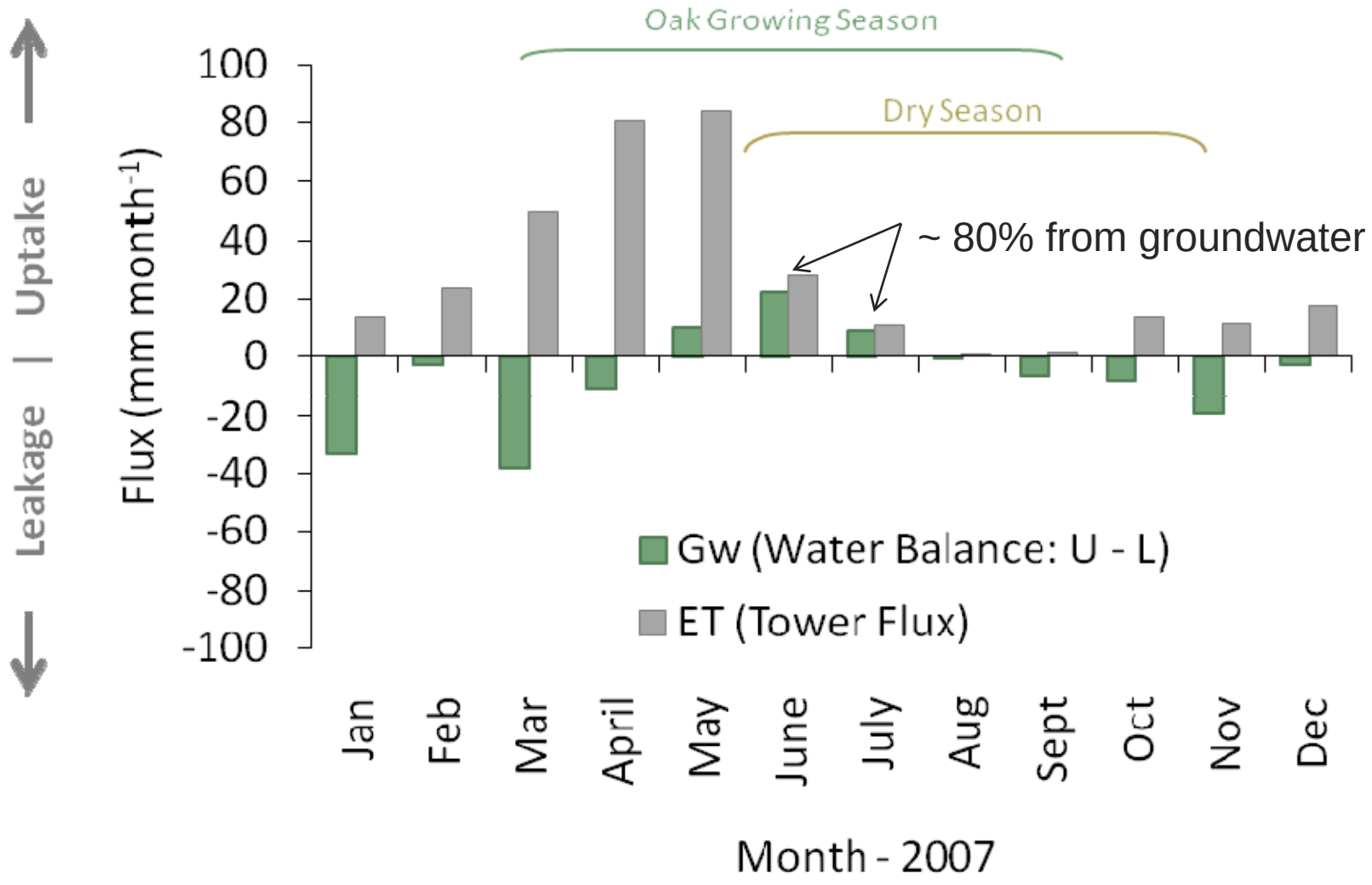
$$G_w = E - P + z\frac{\partial\theta}{\partial t} + \frac{V_b}{A}\frac{\partial m_c}{\partial t} + \frac{h_t}{\rho_w}\frac{\partial\rho_v}{\partial t}$$

- Diurnal groundwater fluctuations
  - White (1932), Vincke & Thiry (2008)

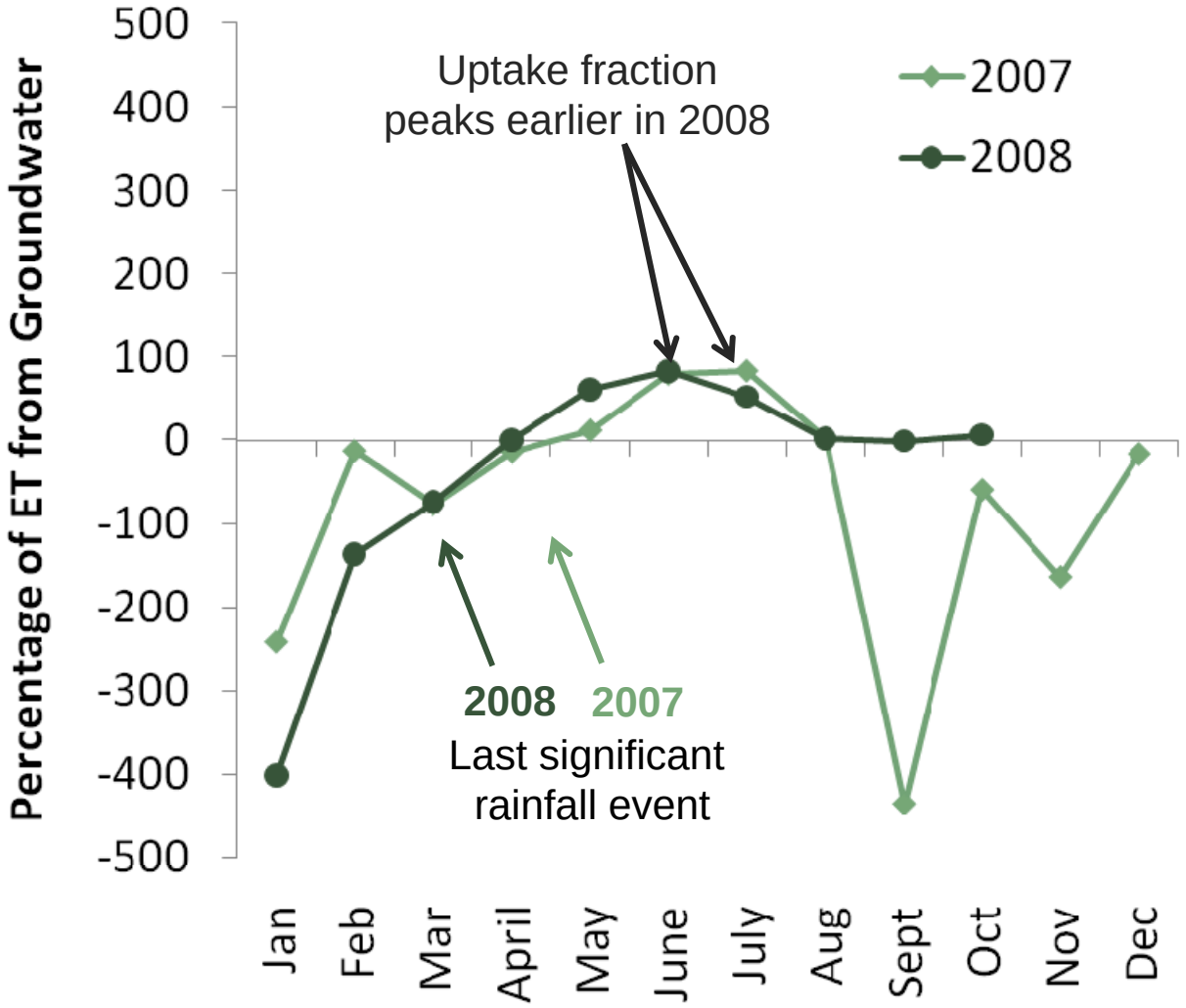
$$ET_g = S_y\left[R + \left(H_1 - H_2\right)\right], \quad S_y \approx 0.04$$



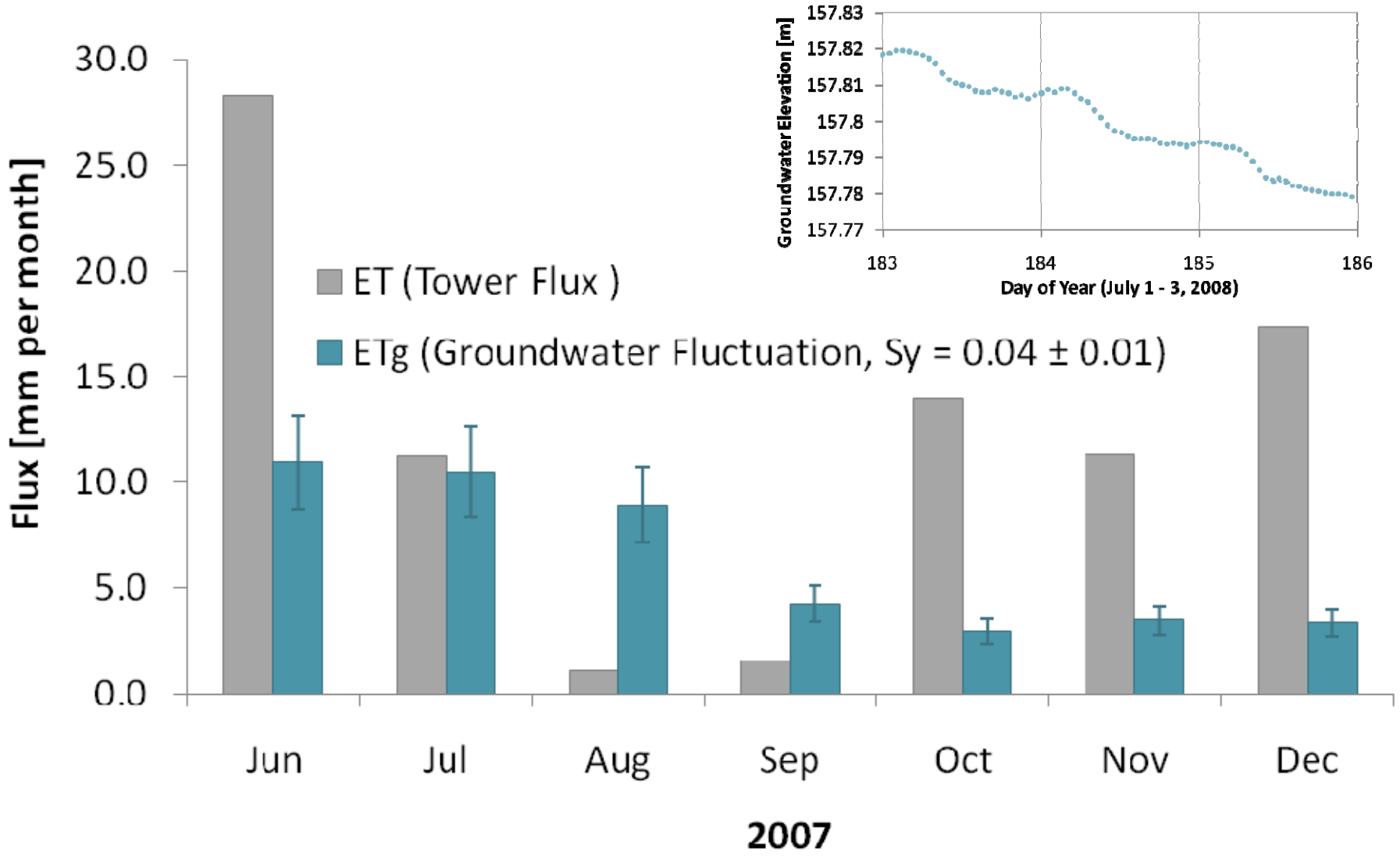
Stand scale water balance indicates seasonal groundwater uptake



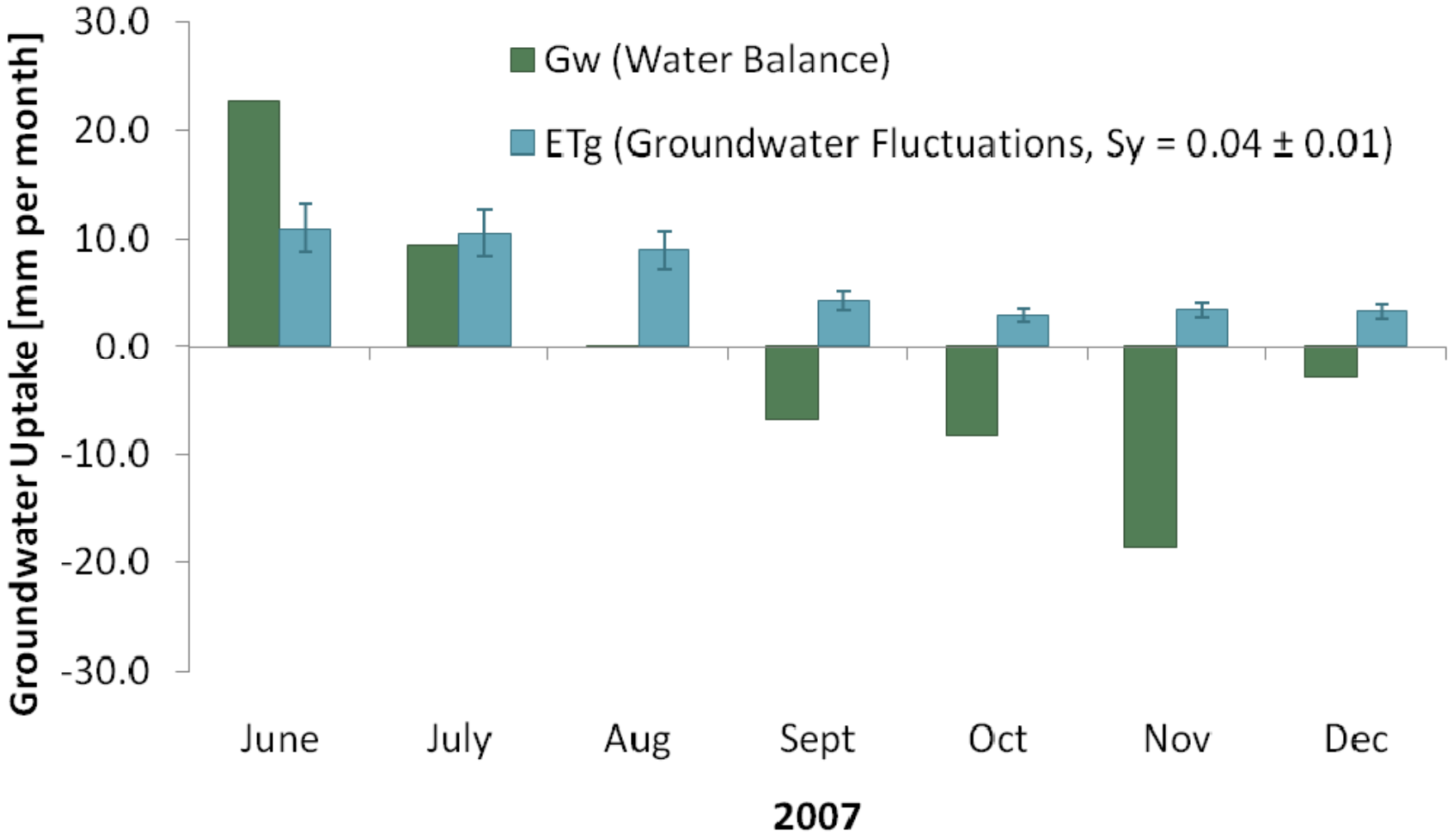
Rainfall cessation affects uptake timing and interannual variability



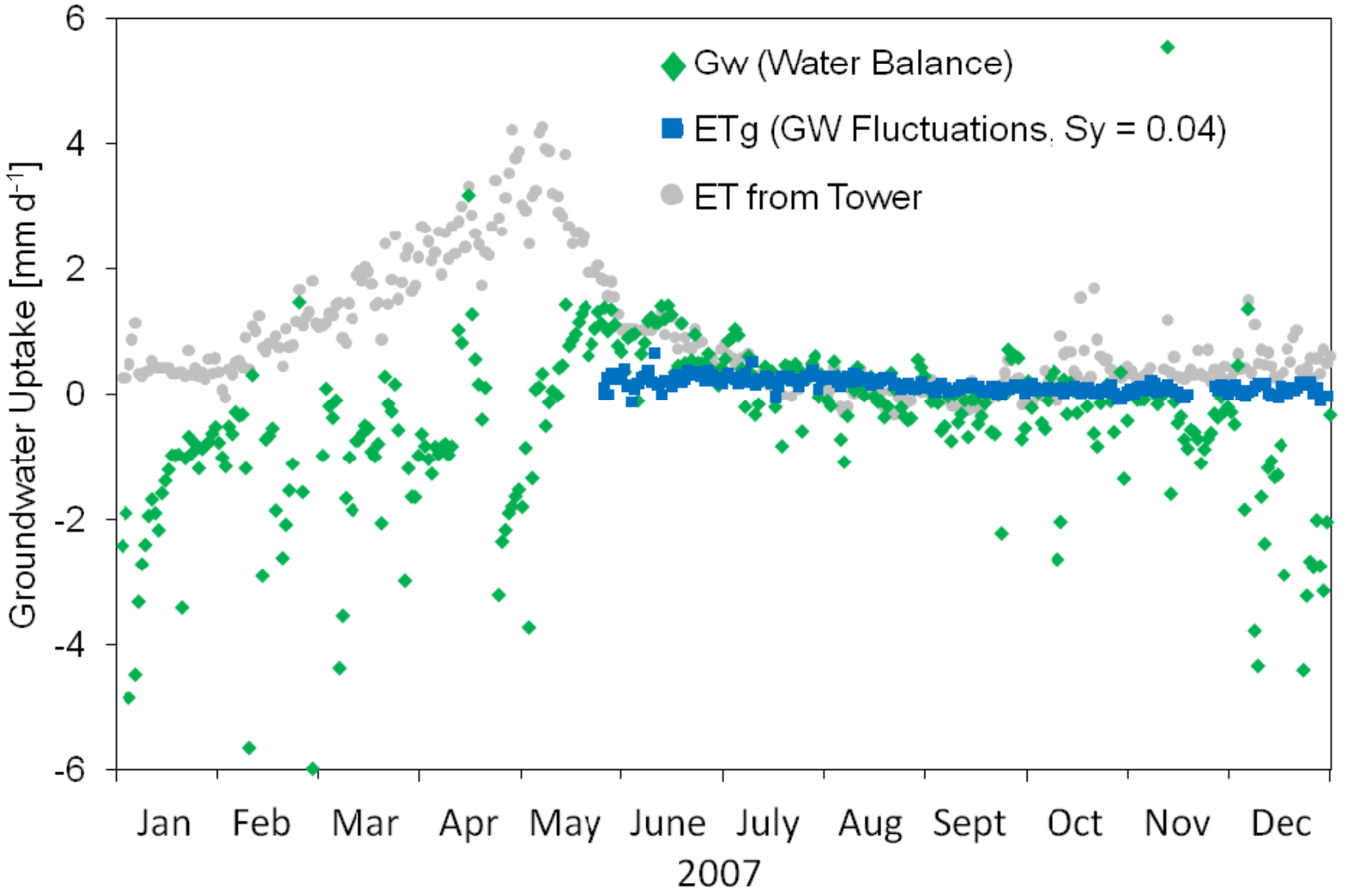
Diurnal fluctuations show uptake (ET_g) greater than transpiration (ET)



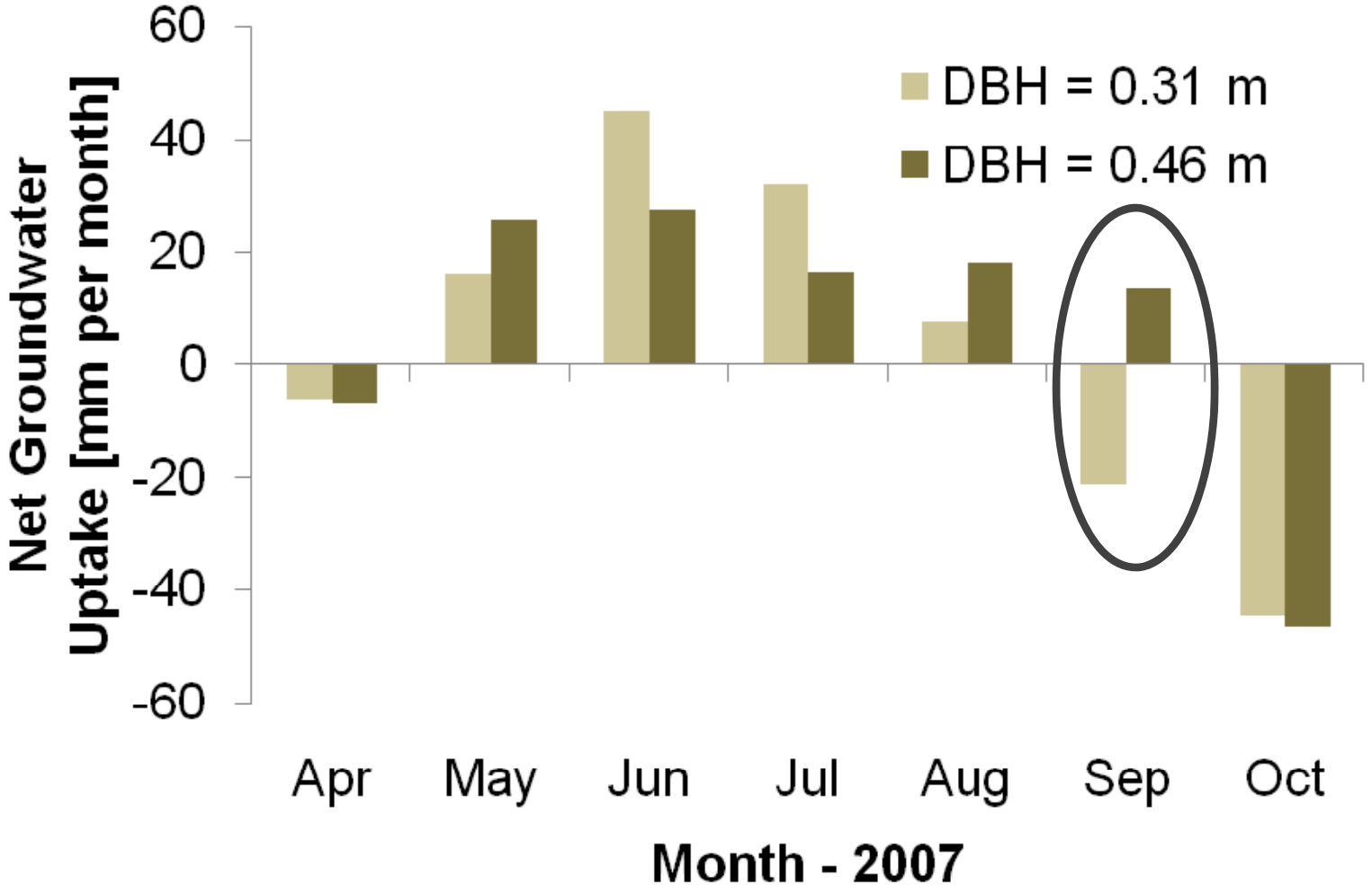
Groundwater fluctuations indicate uptake not captured by water balance



Why? Fluctuations insensitive to leakage events due to depth to water



Tree scale water balance shows longer uptake period for larger tree



Conclusions and ongoing work

- Groundwater and capillary fringe uptake favorable based on pressure
- Blue oaks very likely have obligate dependency
  - Uptake to evapotranspiration ratio (ETg :ET) large in summer
  - Uptake timing related to timing of rainfall cessation
- Groundwater table fluctuations and sap flow indicate larger uptake during late summer than tower
  - Large trees transpiring later into fall than previously assumed
  - Scaling issues? Measurement uncertainty?

Questions?

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