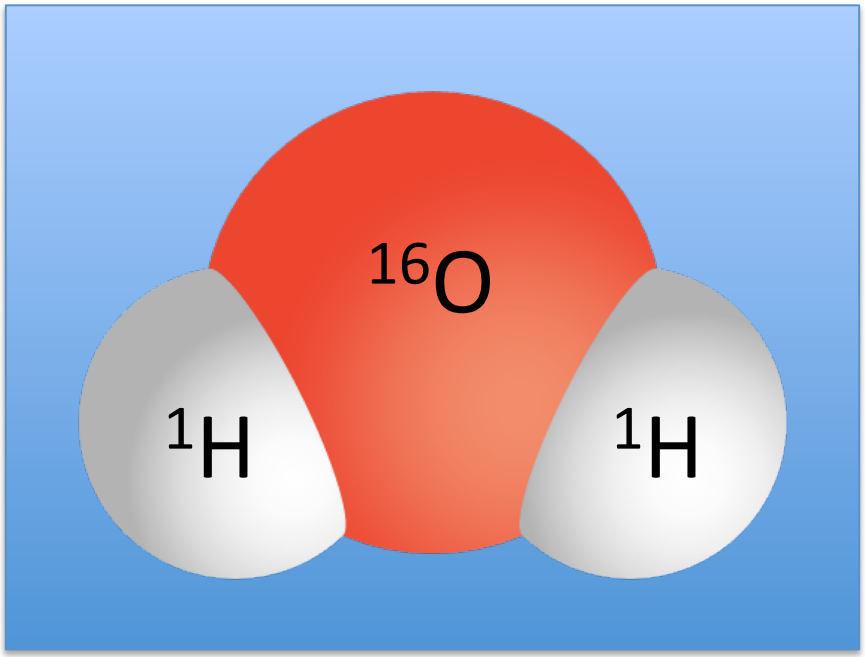
Soil Water Isotopes and You

Erik Oerter
iUTAH Postdoctoral Scholar
Global Change and Sustainability Center
Department of Geology and Geophysics
University of Utah

Water Stable Isotopes

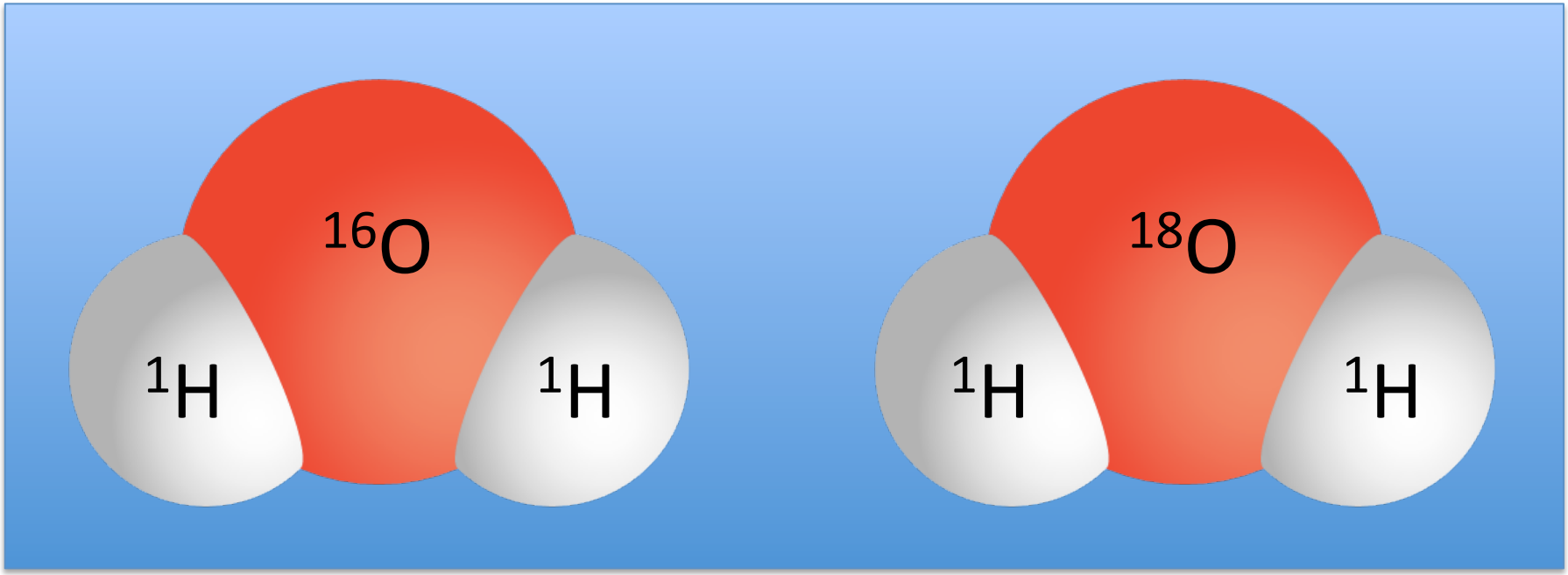


molecular weight of $H_2{}^{16}O = 18$

evaporates more easily

99.8% of all water on Earth

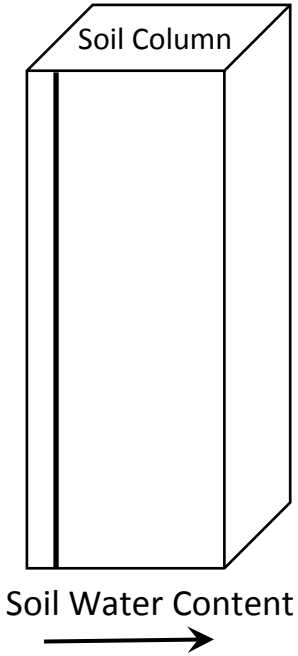
Water Stable Isotopes



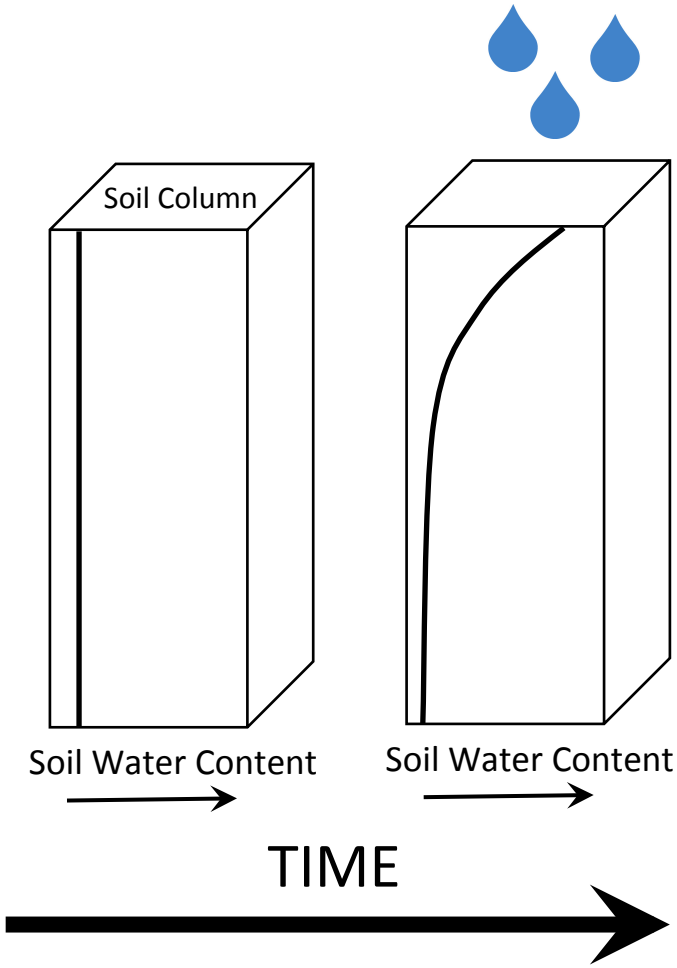
molecular weight of $H_2{}^{16}O = 18$
evaporates more easily
99.8% of all water on Earth

molecular weight of $H_2{}^{18}O = 20$
evaporates less easily
0.2% of all water on Earth

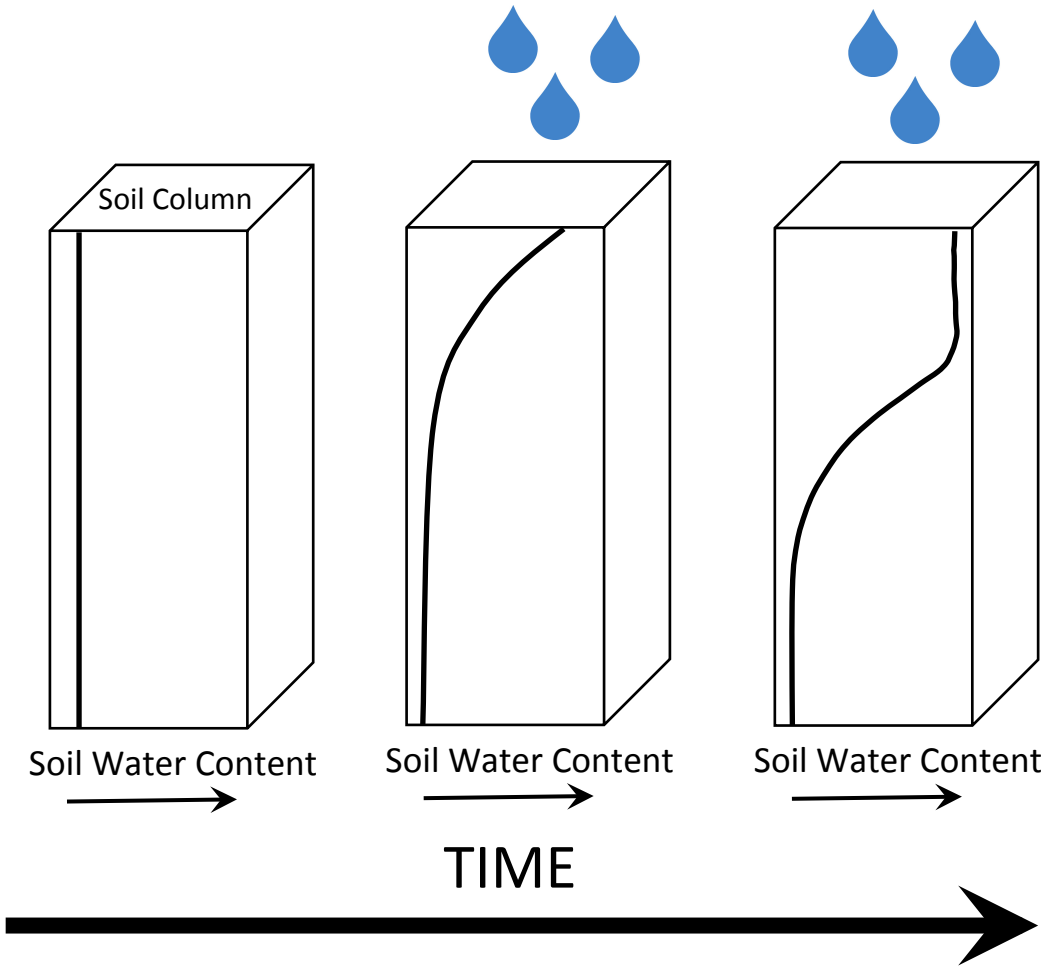
Soil Water: Origins in Precipitation



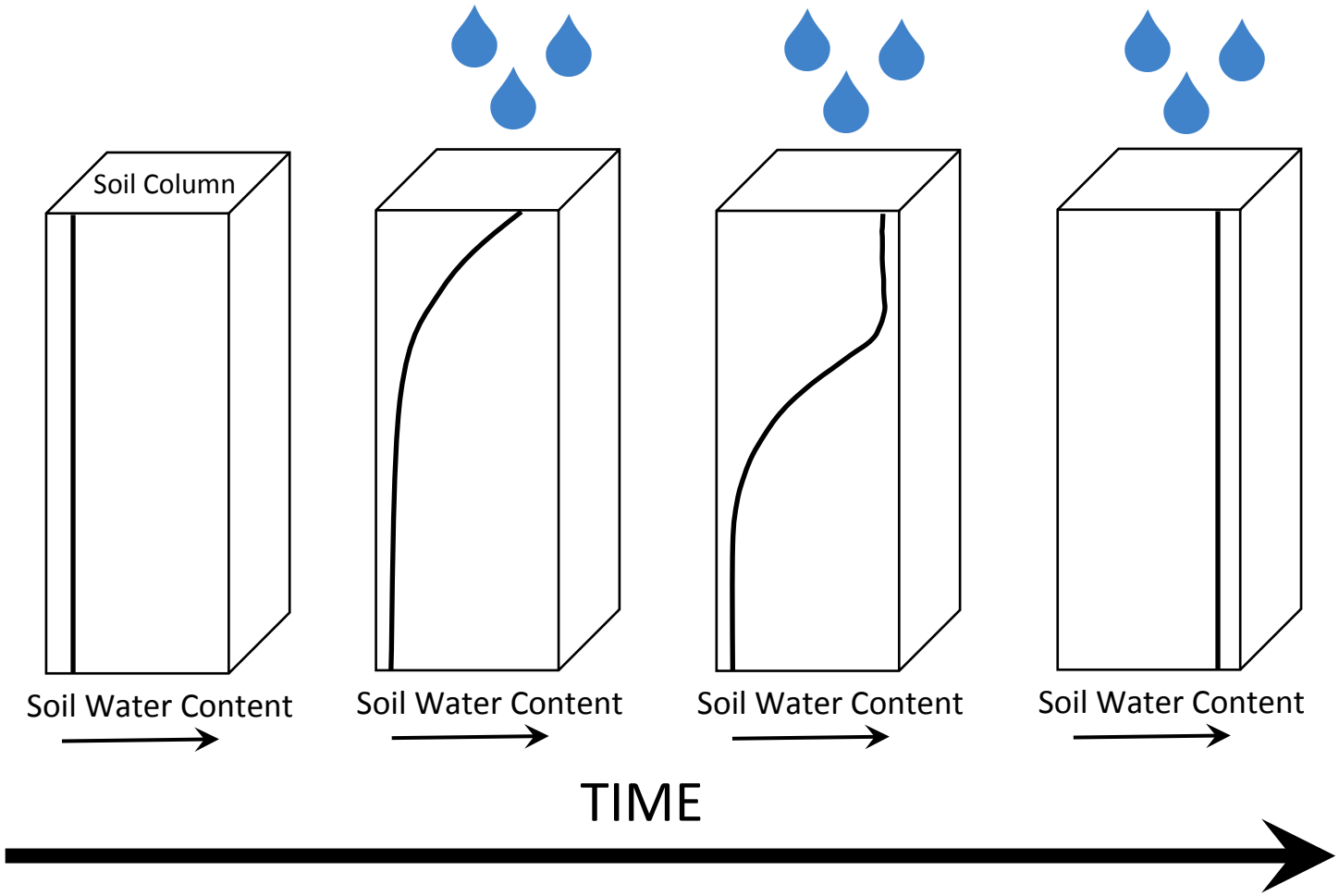
Soil Water: Origins in Precipitation



Soil Water: Origins in Precipitation

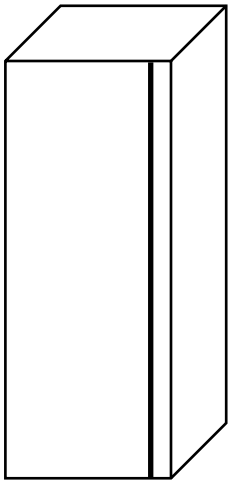


Soil Water: Origins in Precipitation



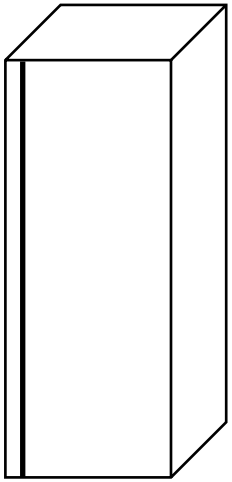
Soil Water Isotopes: Rain is the Reset

Soil Water Content



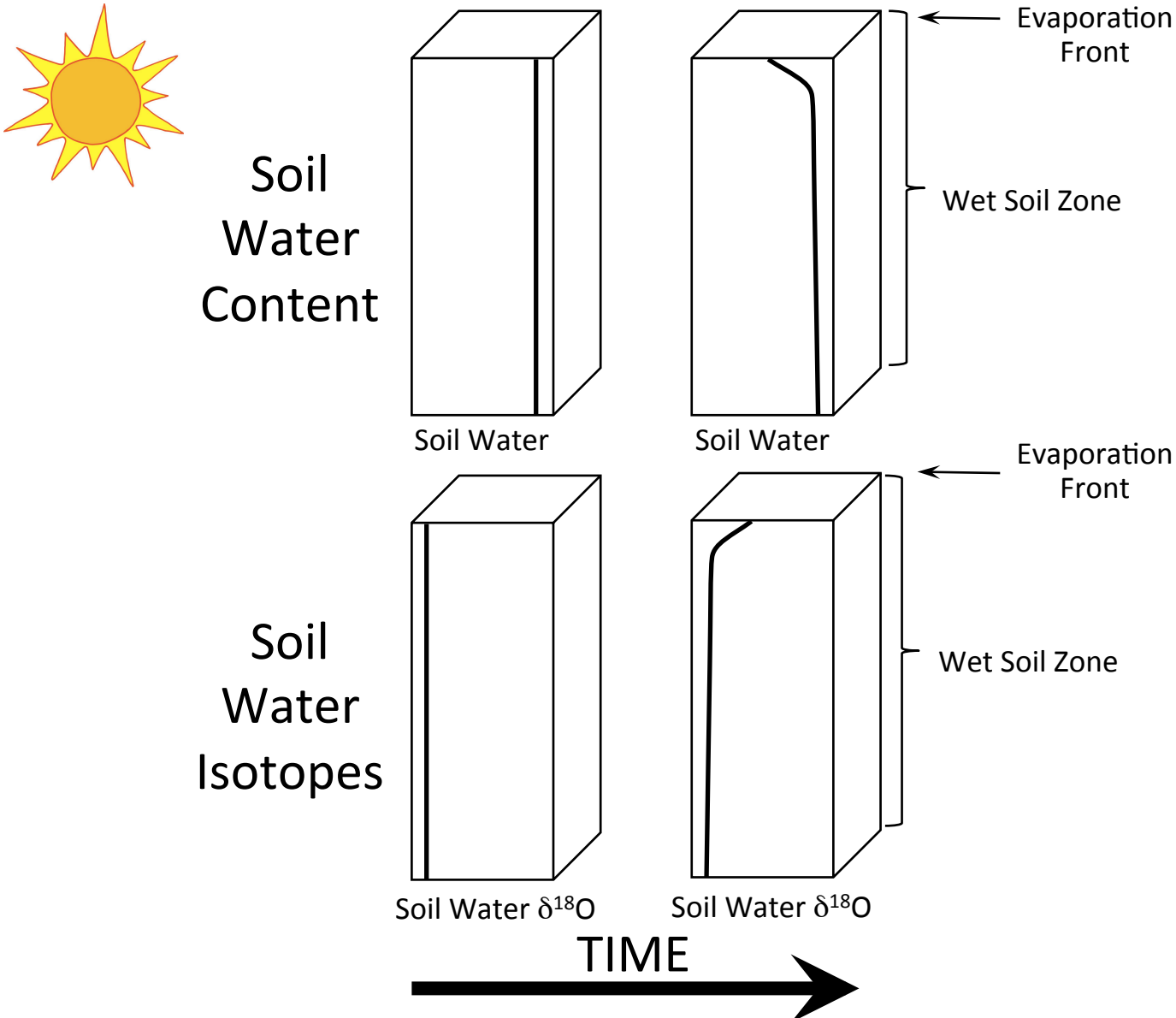
Soil Water

Soil Water Isotopes

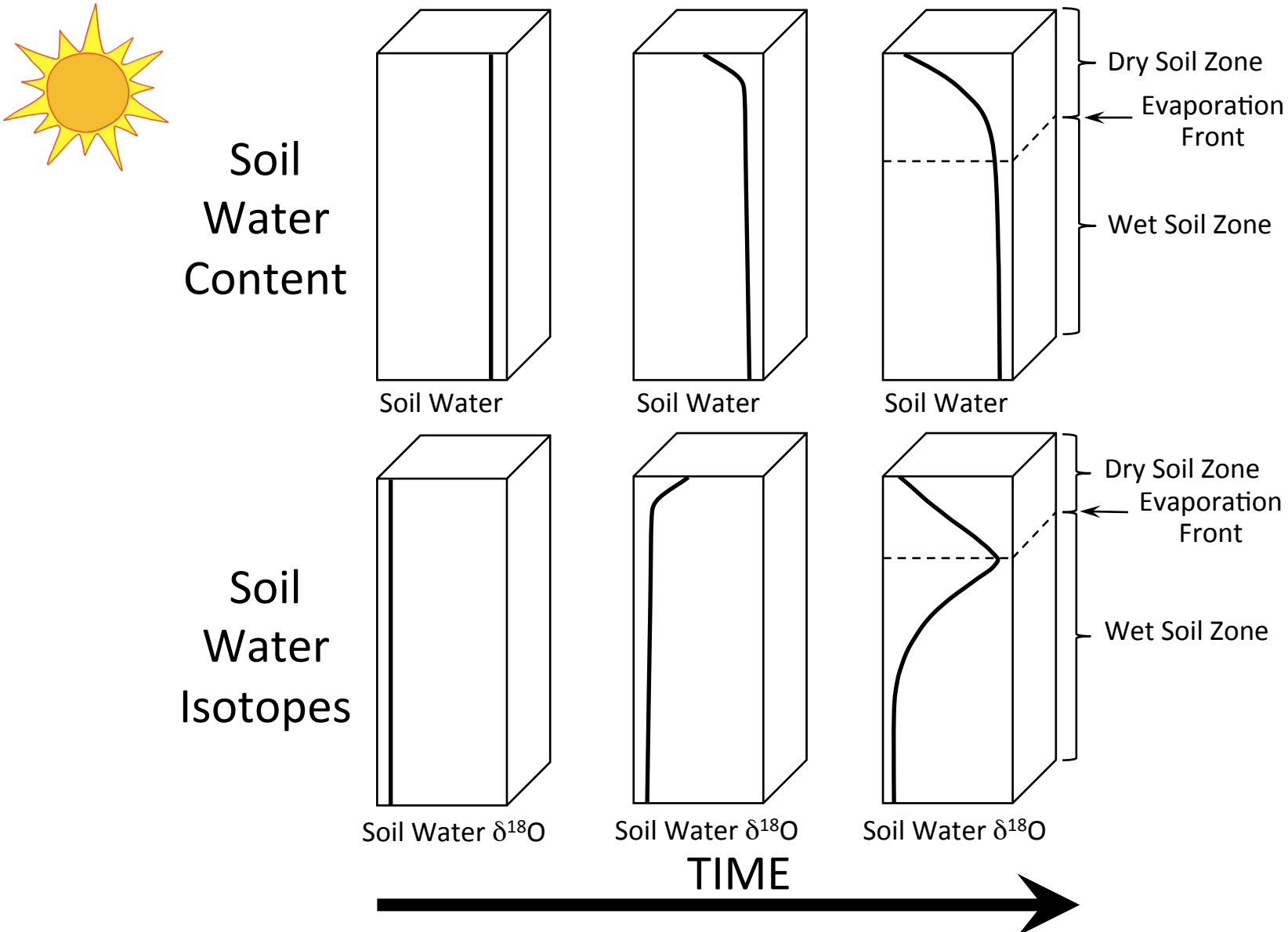


Soil Water $\delta^{18}O$

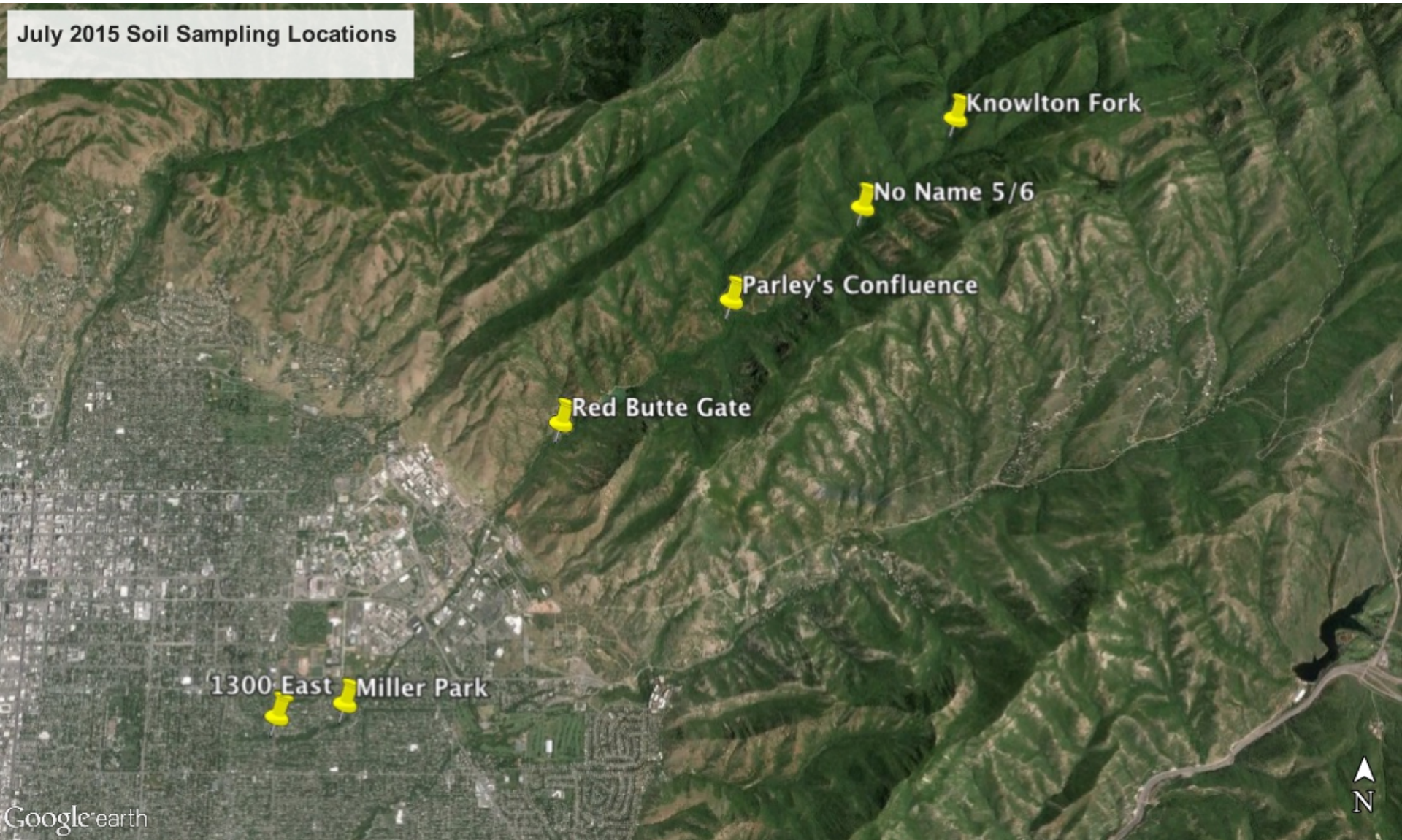
Soil Water Isotopes: Evaporation



Soil Water Isotopes: Evaporation



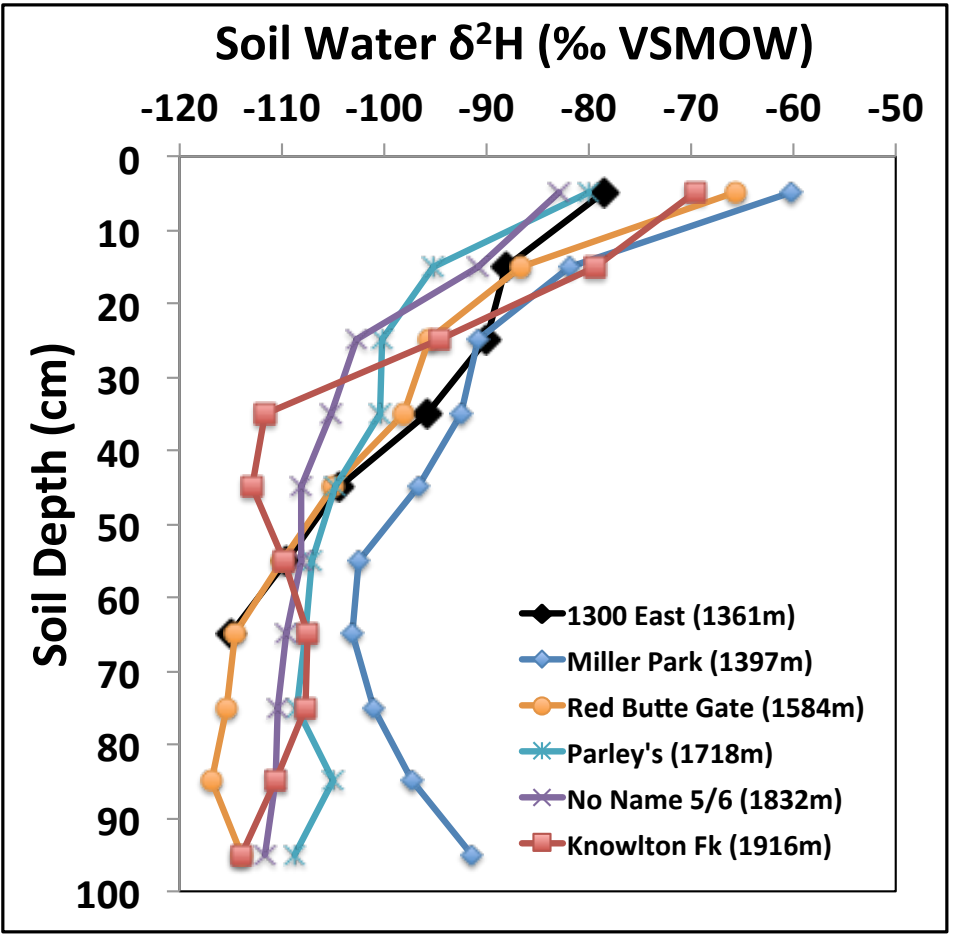
Red Butte Creek: July Synoptic Sampling

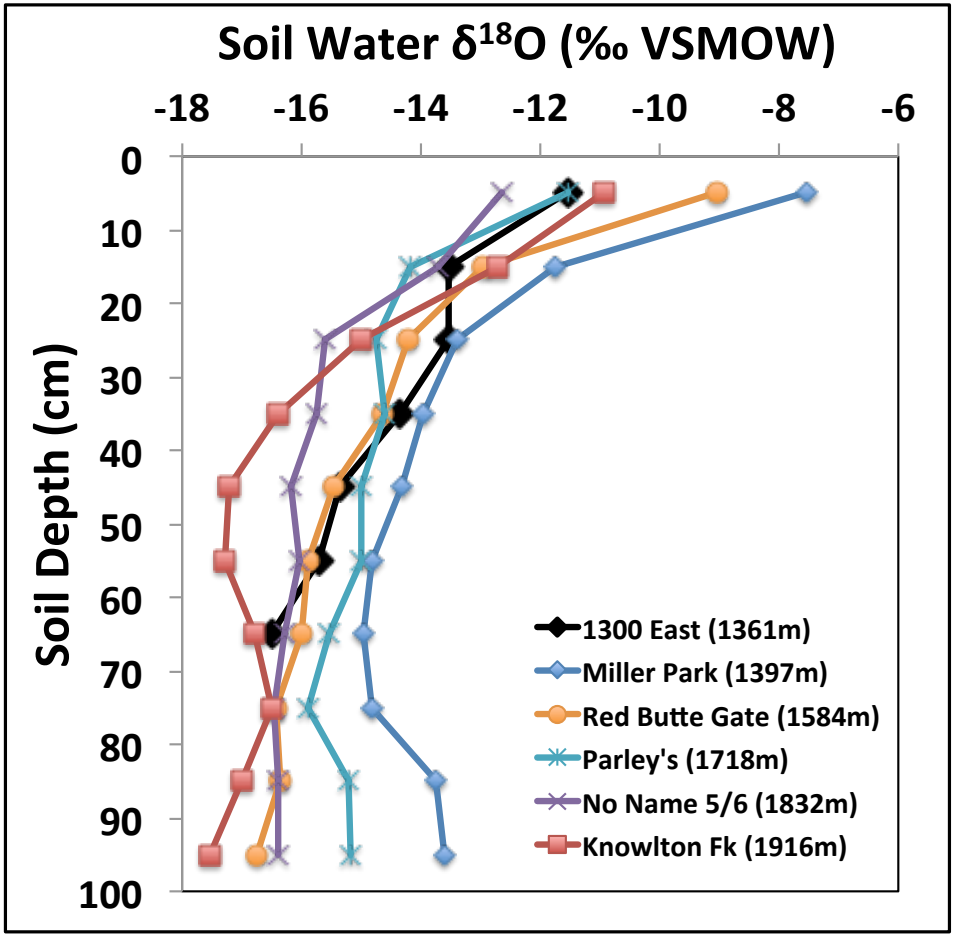


Red Butte Creek: July Synoptic Sampling

Red Butte Creek: July Synoptic Sampling

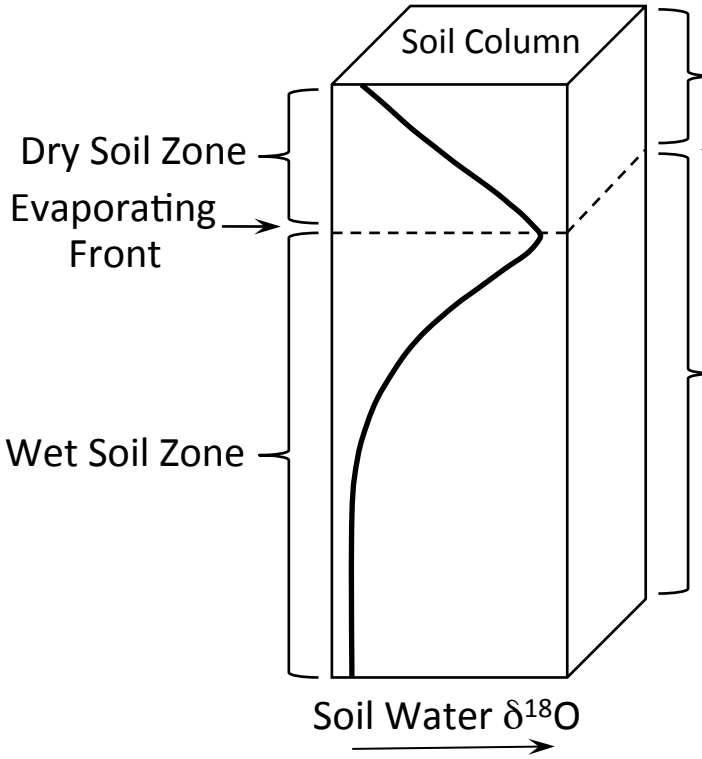
- Evaporative influence on water isotope depth profiles
- Deep soil water isotope values reflect precip at differing altitude





Soil Water Isotopes: Evaporation

At steady state:



$$R_w(z) = \frac{z(R_{w,ef} - R_a)}{h_z z_{ef}} + R_a$$

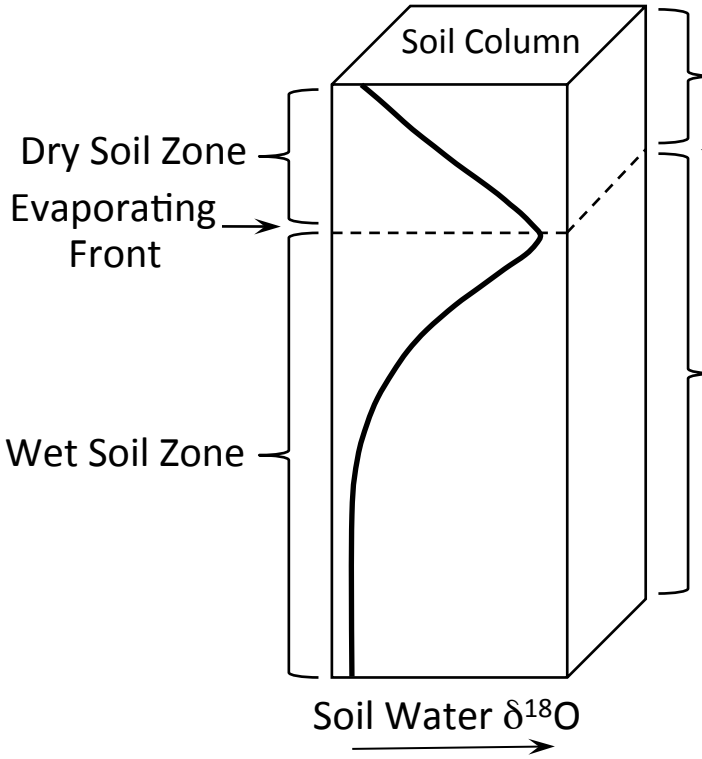
$$R_{w,ef} = \propto_{evap} (1-h) R_{w,res} + \propto_{eq} h R_a$$

$$R_w(z) = \left[\frac{1 - e^{-\frac{E(z - z_{ef})}{D}}}{1 - e^{-\frac{E(L - z_{ef})}{D}}} \right] \left(R_{w,res} - R_{w,ef} \right) + R_{w,ef}$$

(Barnes and Allison, 1983, 1988; Criss, 1999)

Soil Water Isotopes: Evaporation

At steady state:



$$R_w(z) = \frac{z(R_{w,ef} - R_a)}{h_z z_{ef}} + R_a$$

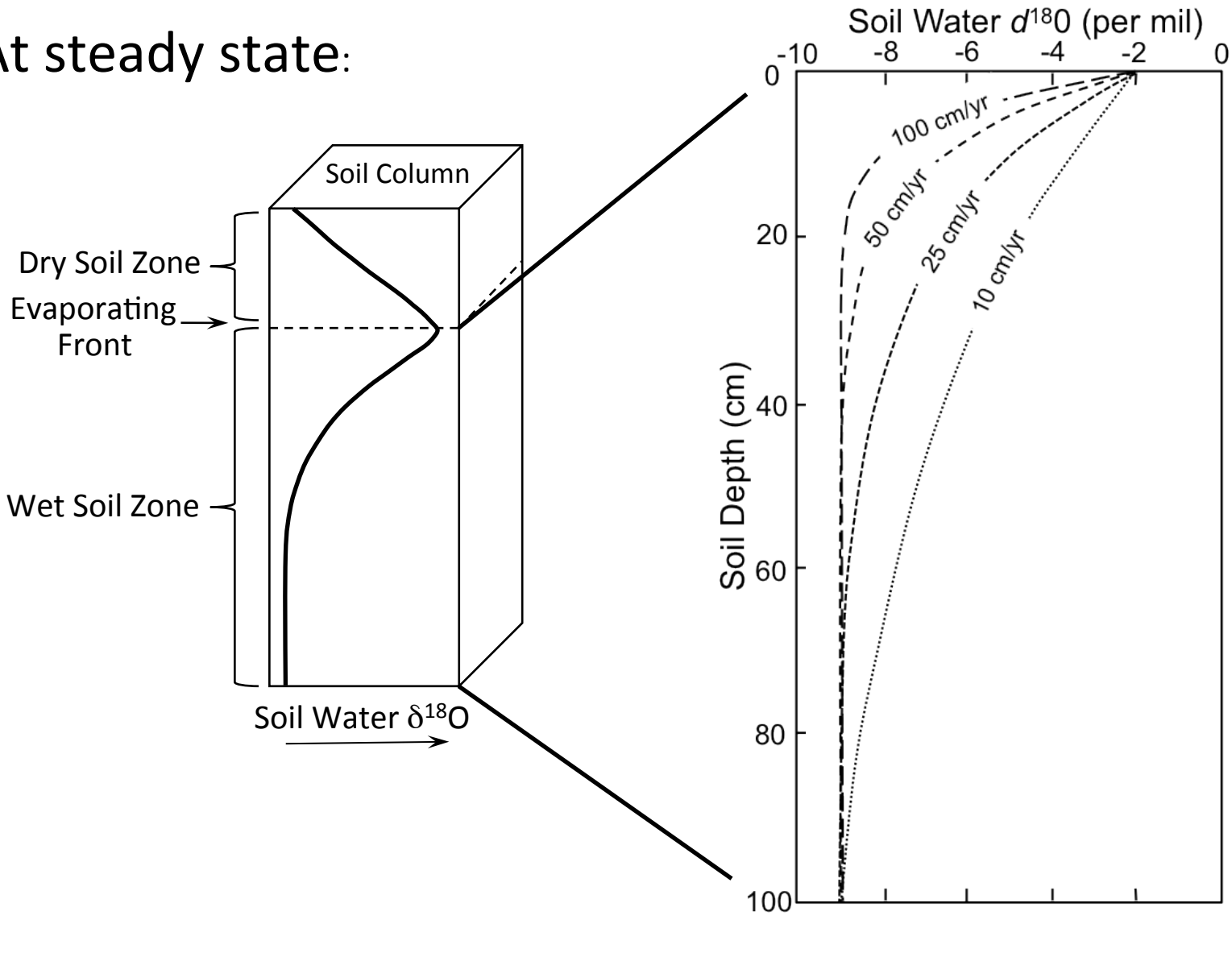
$$R_{w,ef} = \propto_{evap} (1-h) R_{w,res} + \propto_{eq} h R_a$$

$$R_w(z) = \left[\frac{1 - e^{-\frac{E(z - z_{ef})}{D}}}{1 - e^{-\frac{E(L - z_{ef})}{D}}} \right] (R_{w,res} - R_{w,ef}) + R_{w,ef}$$

(Barnes and Allison, 1983, 1988; Criss, 1999)

Soil Water Isotopes: Evaporation

At steady state:



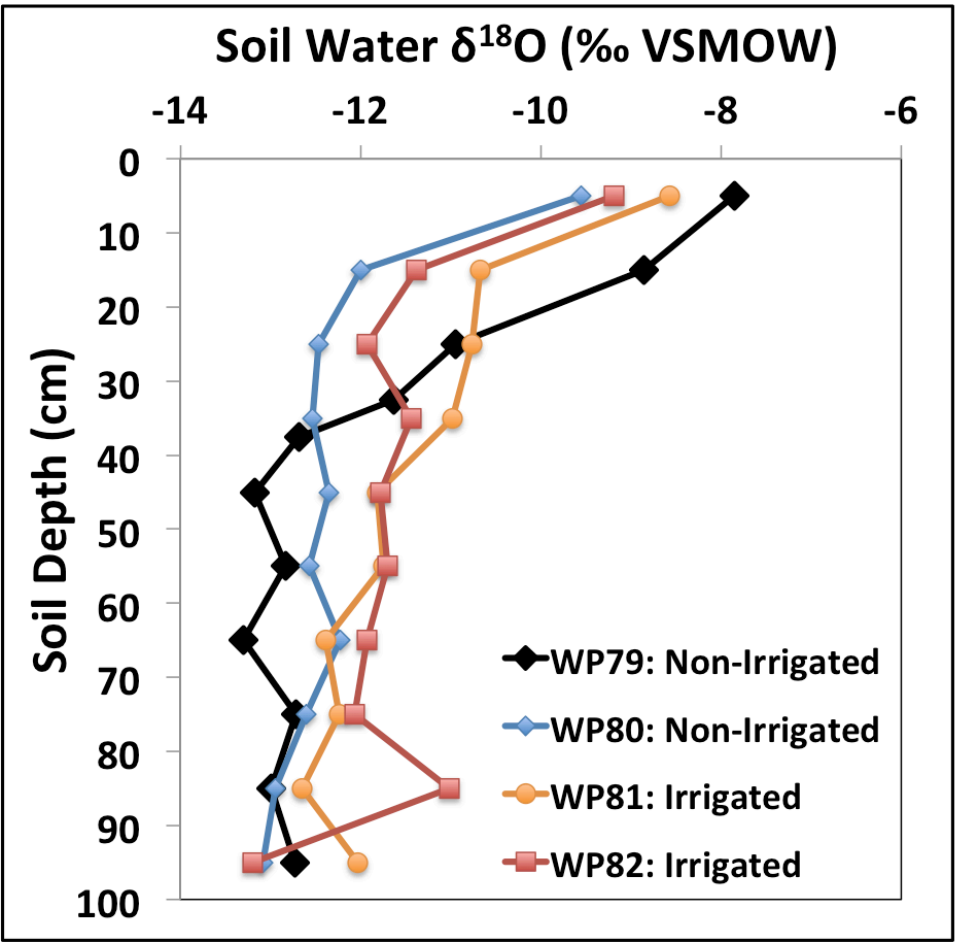
Testing the Evap Model at Steady State

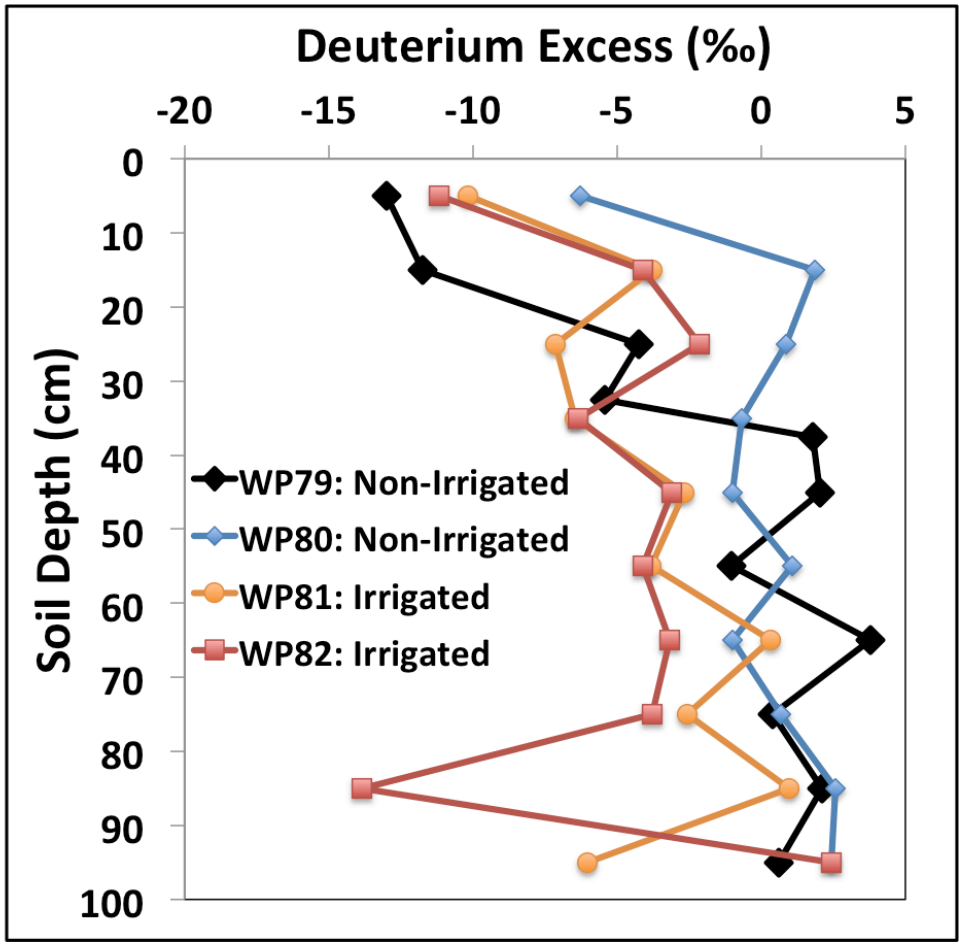
Gilmore Ranch near SLC Airport

Gilmore Ranch near SLC Airport

Gilmore Ranch near SLC Airport

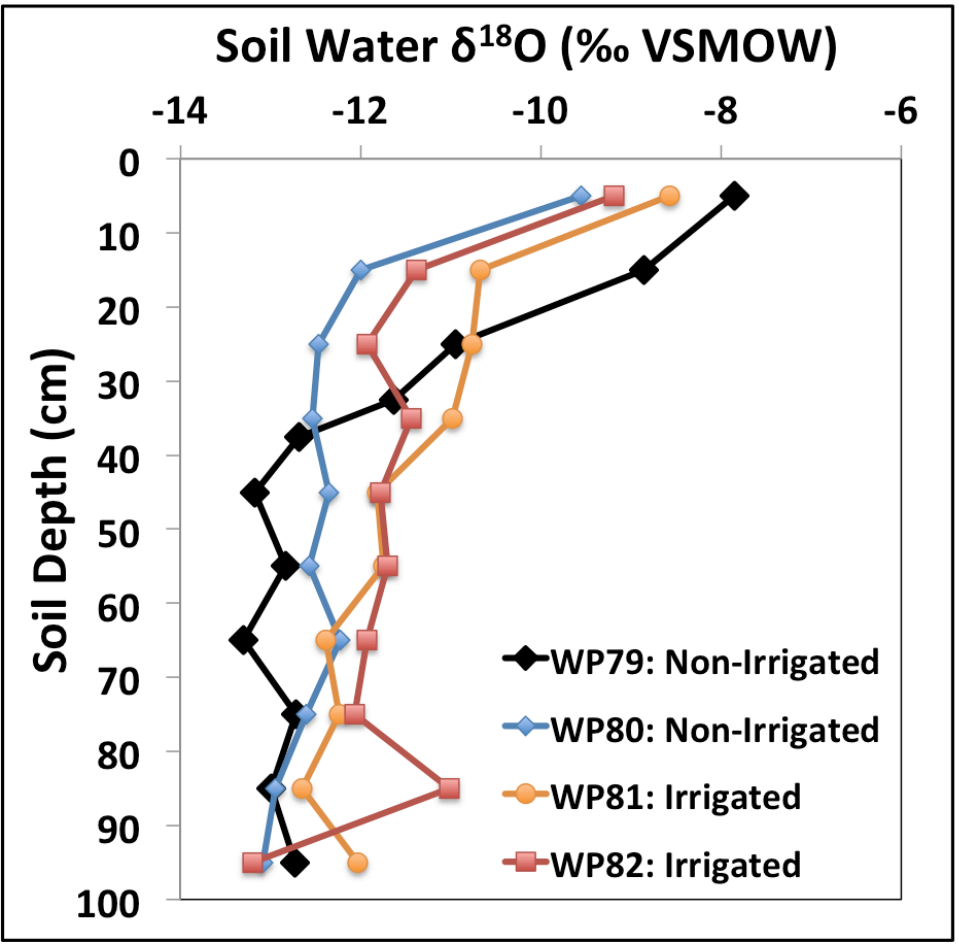
- Evaporative influence at shallow depths

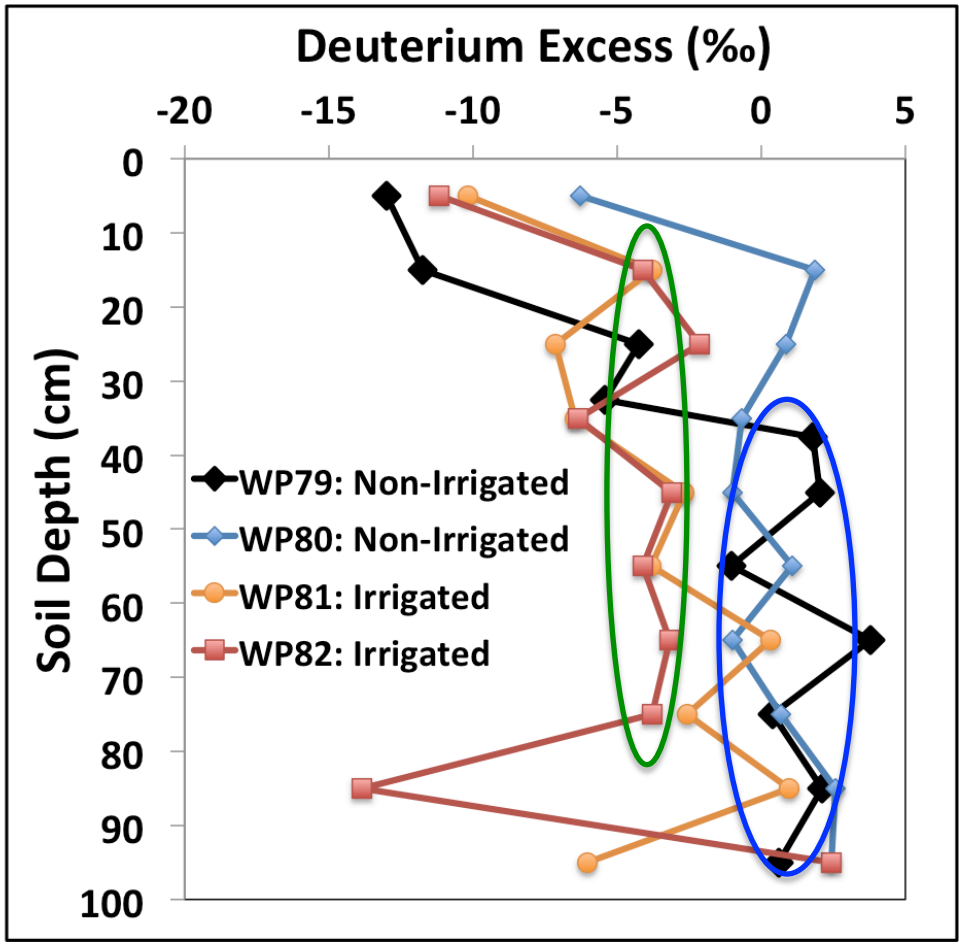




Gilmore Ranch near SLC Airport

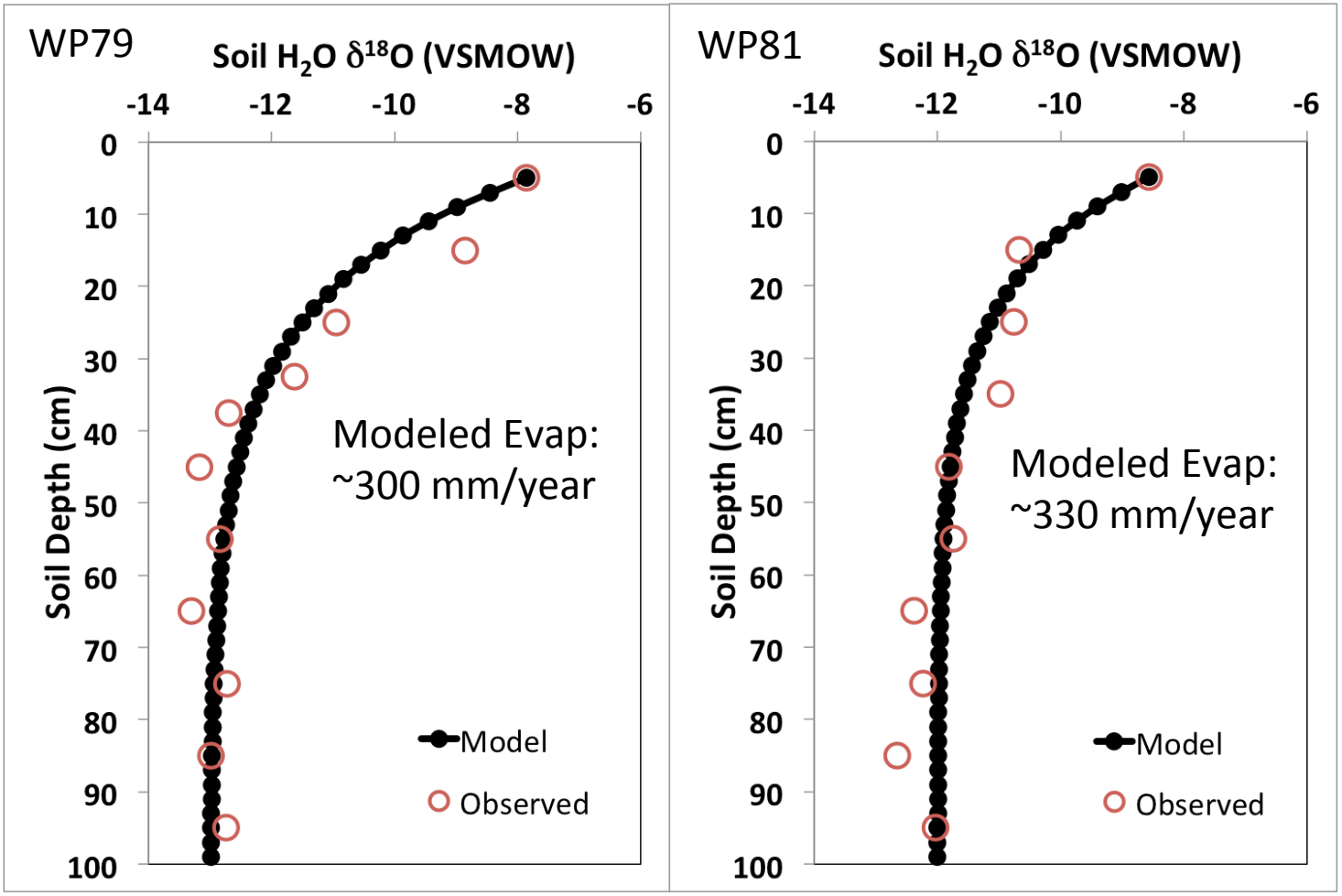
- Evaporative influence at shallow depths
- Deuterium Excess reveals source water differences





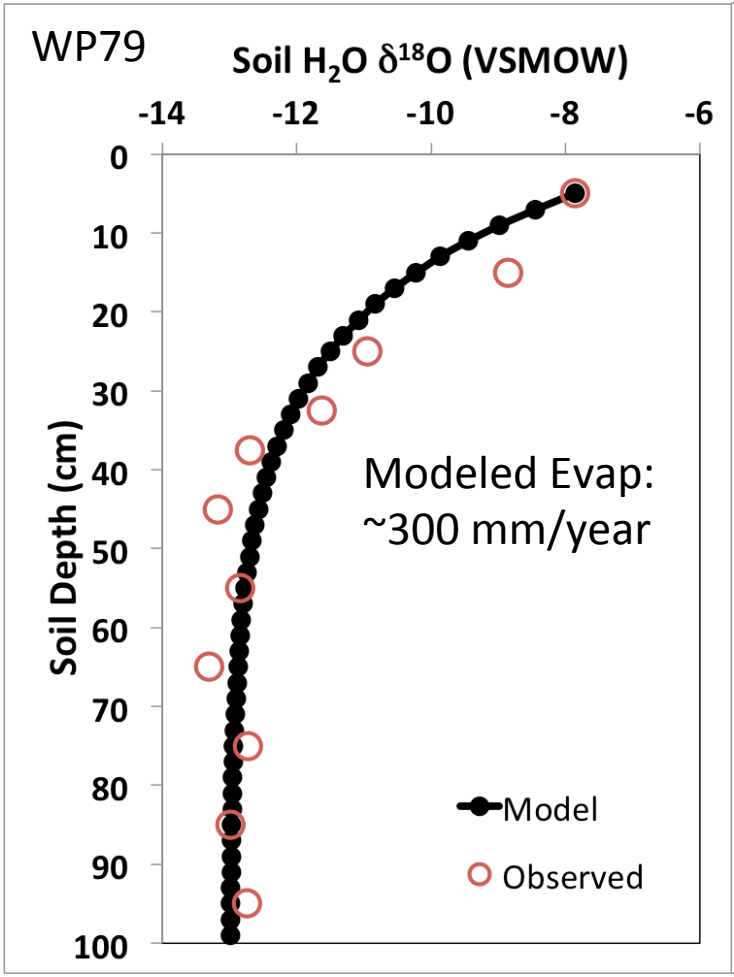
Testing the Evap Model

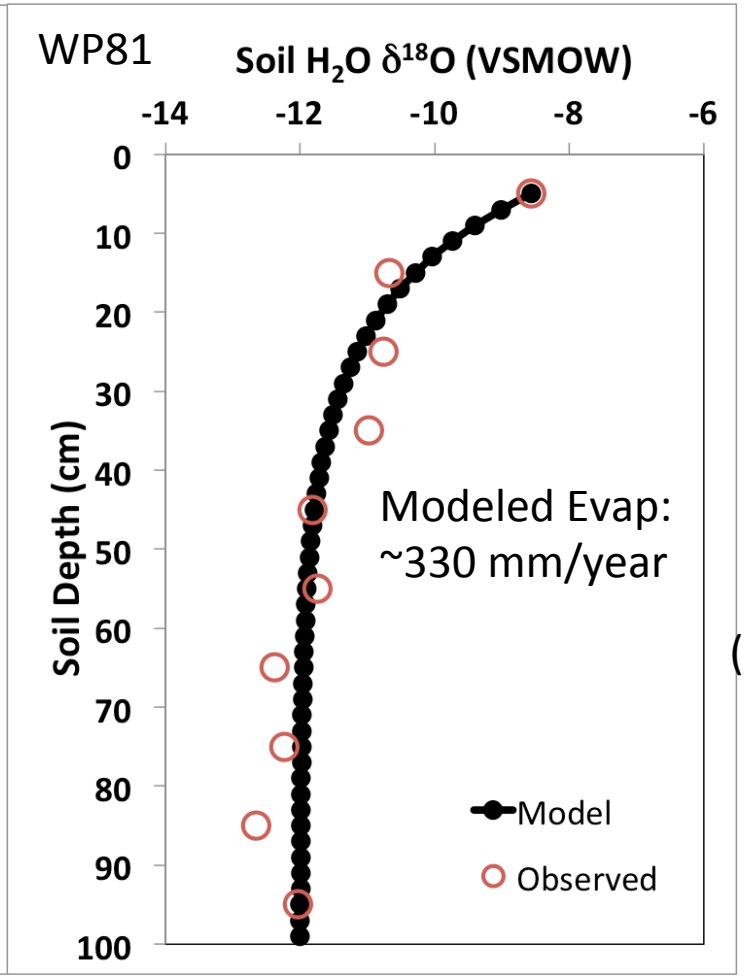
- Quasi-steady state soil water due to shallow water table



Testing the Evap Model

- Quasi-steady state soil water due to shallow water table





Comparison

Estimated Evapotranspiration: 510-600 mm/year (Sanford et al., 2013)

↓

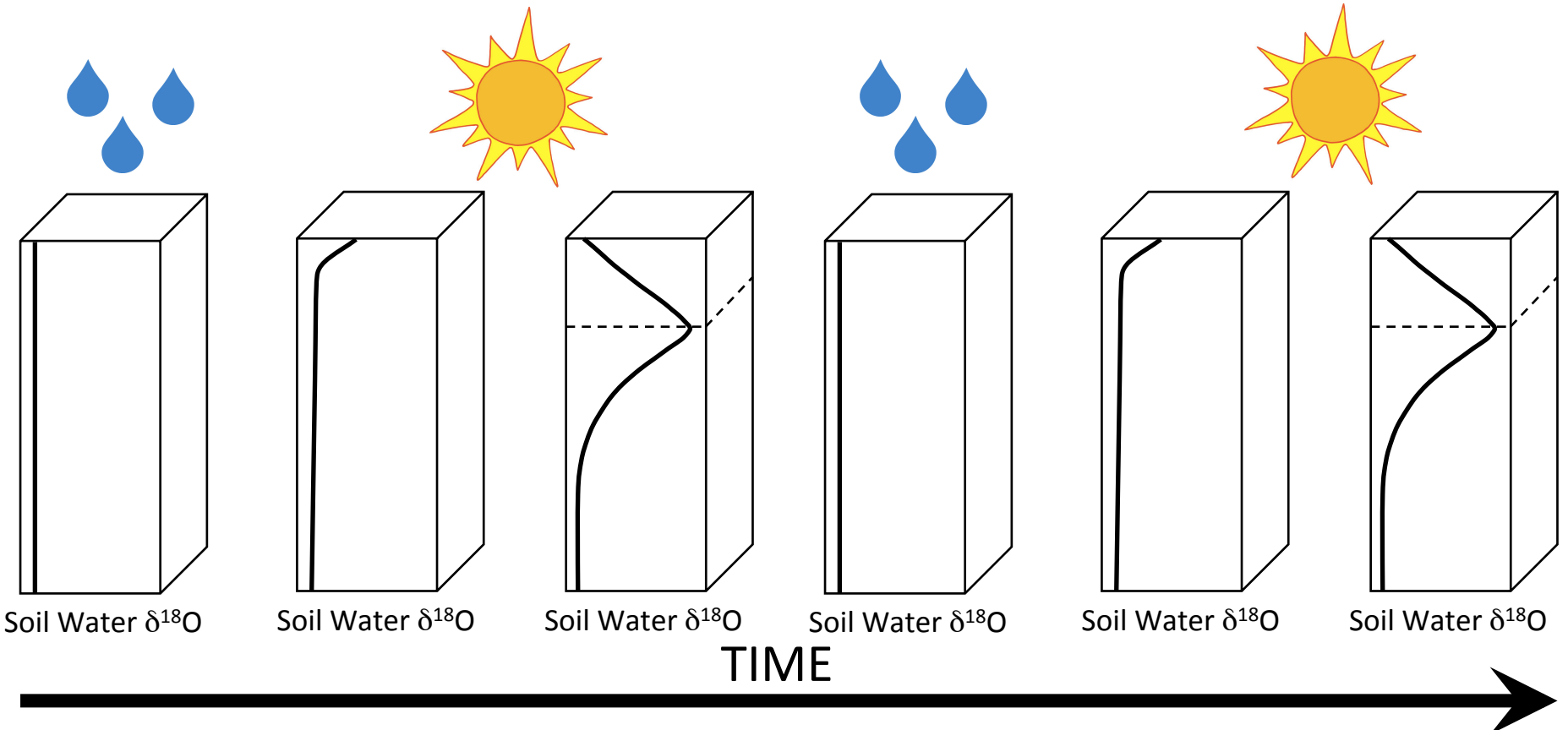
Evap is ~70% of Evapotranspiration in desert shrublands (Reynolds et al., 2000)

↓

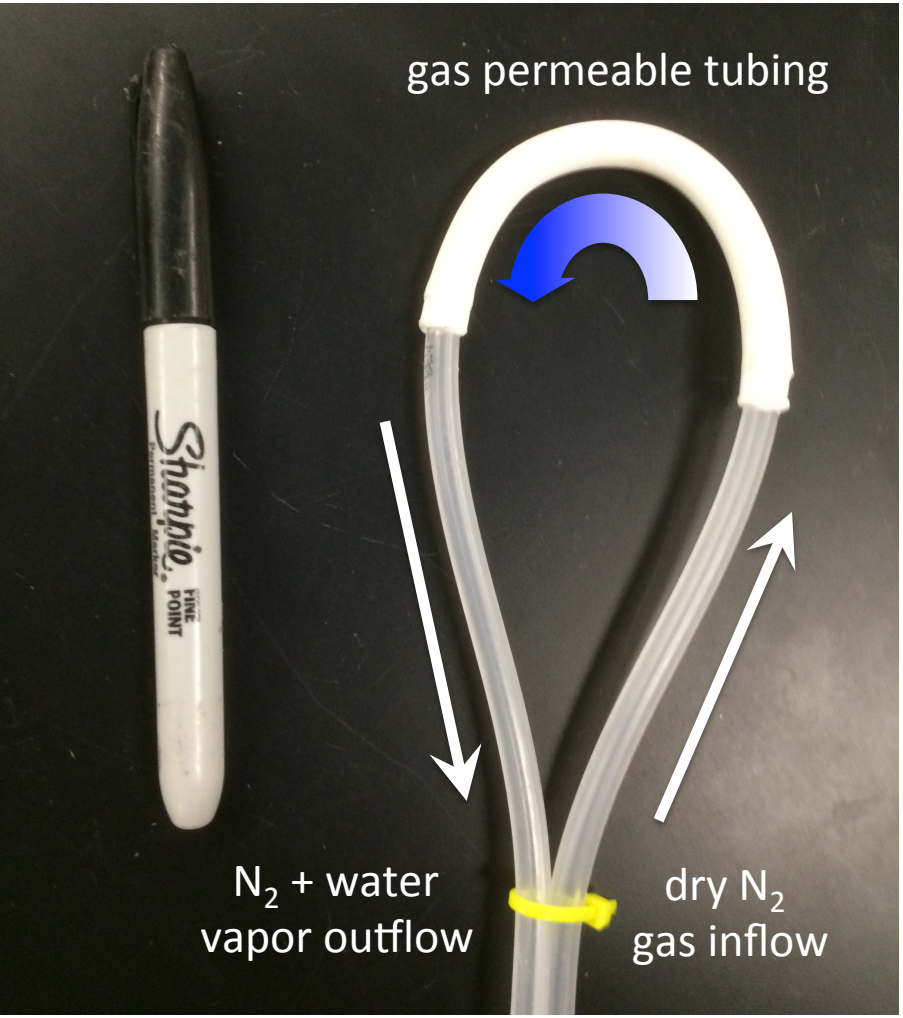
Est. Evaporation: 357-420 mm/year

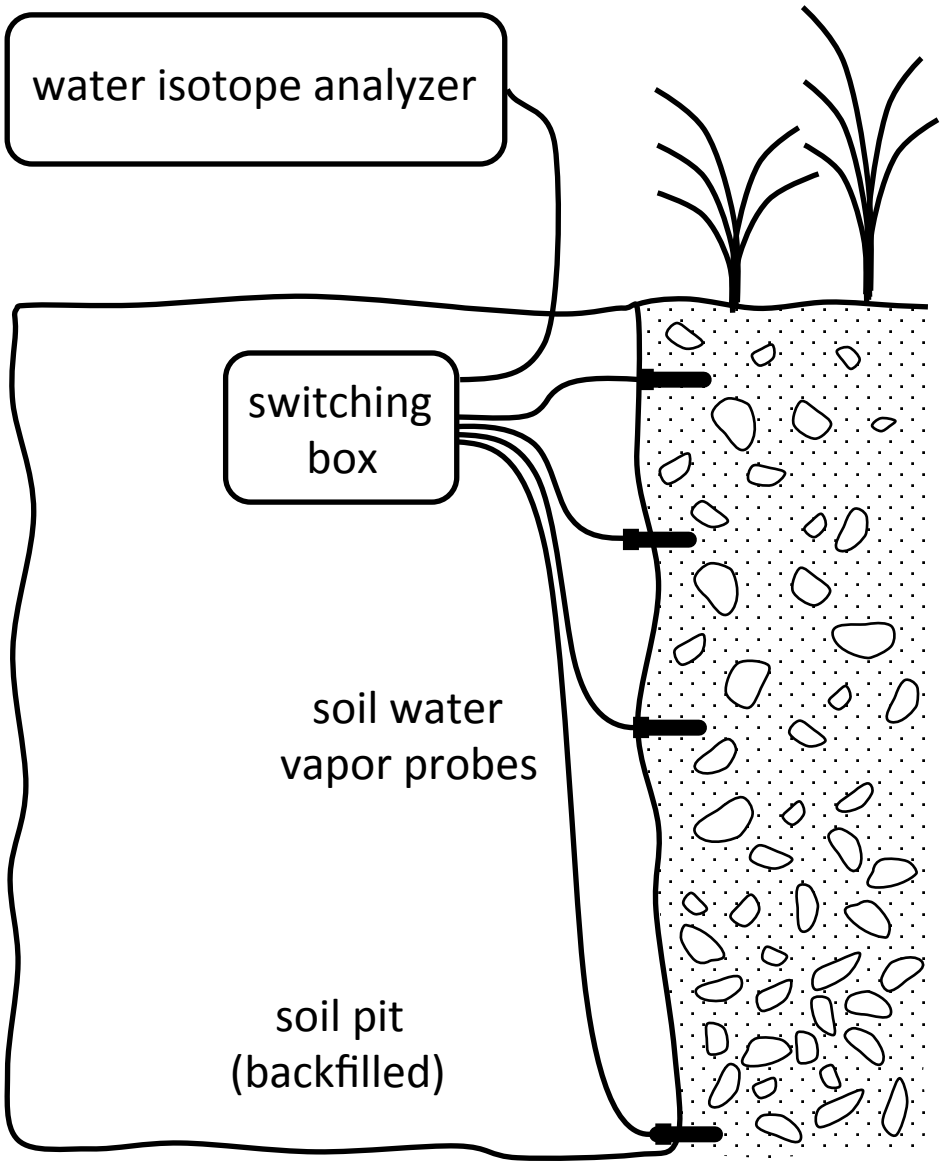
Need for Non-Destructive Sampling

- Very few soils have soil water conditions that are at steady state
- Repeat sampling at the same location would be useful



Vapor Permeable Water Isotope Probes

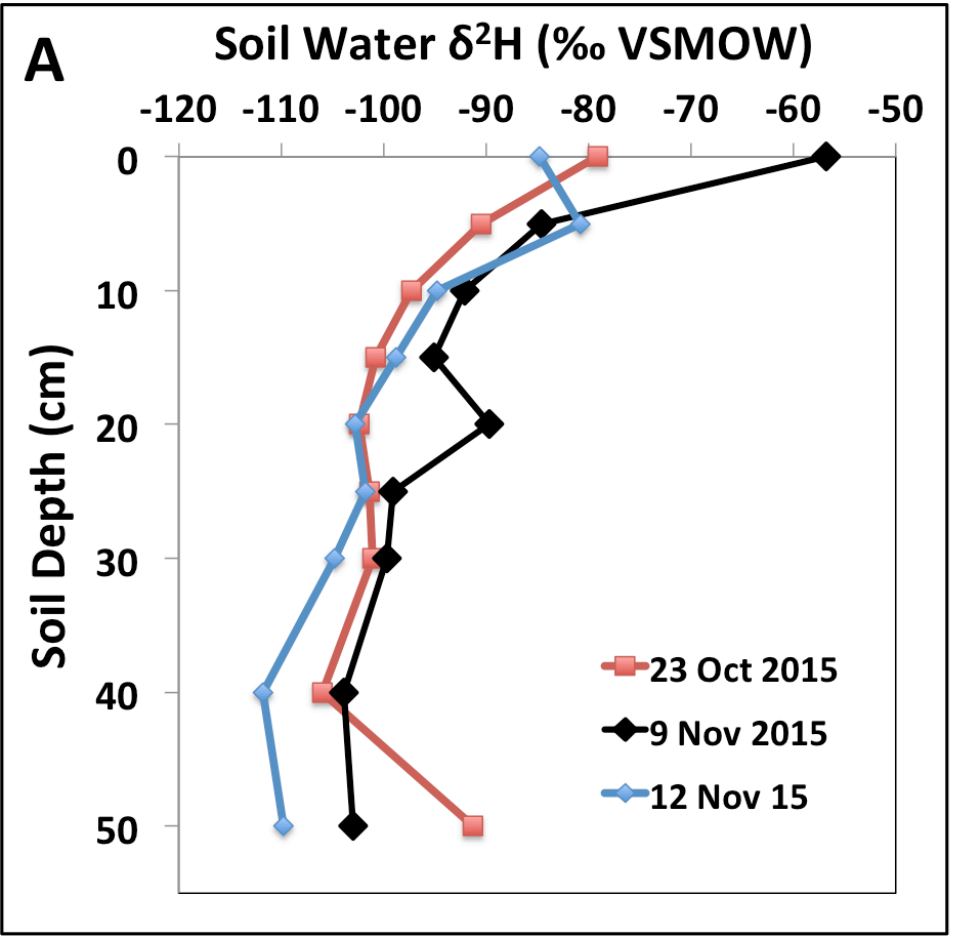


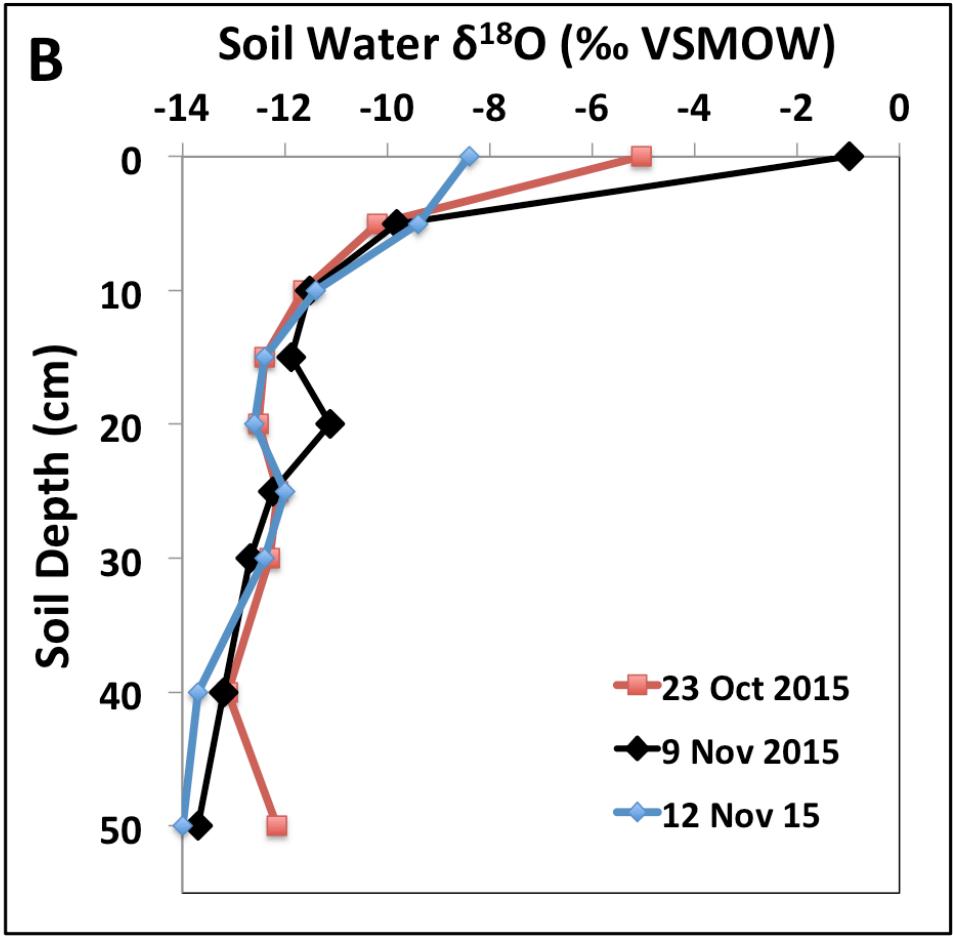


Mobile In Situ Water Isotope Analysis

Repeated *In Situ* Isotope Analyses

- Good reproducibility, calibration is in development
- Complex evaporative profile in this irrigated soil





Data shown with preliminary calibration

iUTAH In Action: Public Outreach

iUTAH In Action: Teaching

A Day in the Life of a Novel Ecosystem

A Day in the Life of a Novel Ecosystem

Soil Water Isotopes and You

Applications:

Separate ET into evaporation and transpiration

Examine soil and groundwater recharge by snowmelt

Measure water vapor flux in snowpack

Other things with water in them…

What kinds of novel ecosystems do you work in?

To collaborate, please get in touch
soilwaterisotopes@gmail.com
erik.oerter@utah.edu