Take a Virtual Shortcourse
EMMA Spreadsheet URL Developed by Rick Hooper, USGS

http://www.cof.orst.edu/cof/fe/watershd/shortcourse/schedule.htm#schedule
What Minimum Samples and Data are Needed?

- Continuous measurement of stream discharge
- Bulk sample of rainfall or snowmelt
- Baseflow stream sample and samples collected throughout the storm
Basic Pre-requisite for Isotope Hydrograph Separation

- Significant difference in isotopic content between new and old water
  - Cross over a problem
  - Other basic issues
Classical assumptions for isotope hydrograph separations
(Fritz *et al.*, 1976; Sklash and Farvolden, 1982)

1. **Groundwater and baseflow** are equivalent and have a constant isotopic composition

2. The rain or snowmelt can be characterized by a single isotopic composition, or the variations are documented

3. The rain water is significantly different from the prestorm water

4. Contributions from soil water are negligible, or the composition is identical to groundwater

5. Surface-water storage contributions are negligible
Hydrograph Separation

Kendall, used with permission
Temporal rainfall variability
Temporal rainfall variability

From McDonnell, 1989
A Simple Rainfall Weighting Equation

McDonnell et al. (1990; WRR)

\[ \delta x_w = \frac{\sum_{i=1}^{n} P_i \delta_i}{\sum_{i=1}^{n} P_i} \]
Temporal snowmelt variability

Data from Shanley, USGS
Spatial rainfall variability
Mean $\delta O_{18}$ of the Columbia Watershed vs distanz from the West Coast

Errorbars = 2x Stdev $O_{18}$

Starke, McDonnell and Kendall, in prep
Spatial variability of soil water

McDonnell et al., 1991 WRR
How to quantify uncertainty in a 2-Component Model

\[
W_{fp} = \left\{ \left[ \frac{f_p}{(C_e - C_p)} \ W_{C_p} \right]^2 + \left[ \frac{f_e}{(C_e - C_p)} \ W_{C_e} \right]^2 \right\}^{1/2} + \left[ \frac{-1}{(C_e - C_p)} \ W_{C_s} \right]^2 \right\}^{1/2}
\]

(Genereux, 1998; WRR)
Uncertainty

(Genereux, 1998)
Spatial variations in groundwater

(Stallard, McDonnell and Gu, 2001; HP)
Weizu Gu, used with permission
Weizu Gu, used with permission
Event spatial patterns

![Graph showing event spatial patterns with δ²H and δ¹⁸O data over time and soil depth. The graph includes a legend indicating δ¹⁸O values from -3 to +3‰.](image)
Persistence of spatial patterns over 4 months
At the hillslope scale

Effect of drainable porosity on event / pre-event water ratios and time source mixing
Groundwater at Panola Mountain, Georgia

Figure 4. The $\delta^{18}O$ of groundwater from about 30 wells at Panola Mountain, a 41-ha watershed in Georgia. In general, shallow hillslope wells (open squares) show more temporal variability than the deeper and/or near-stream wells (solid squares) that approach the composition of average rain.

Soil water vs groundwater variability