Development a novel tracer technique for evaluating drip rates in caves using Rn-222

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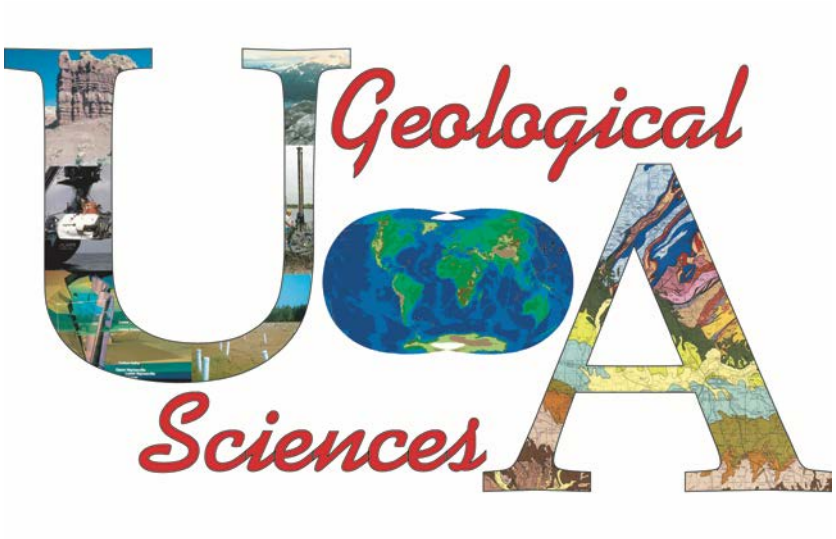

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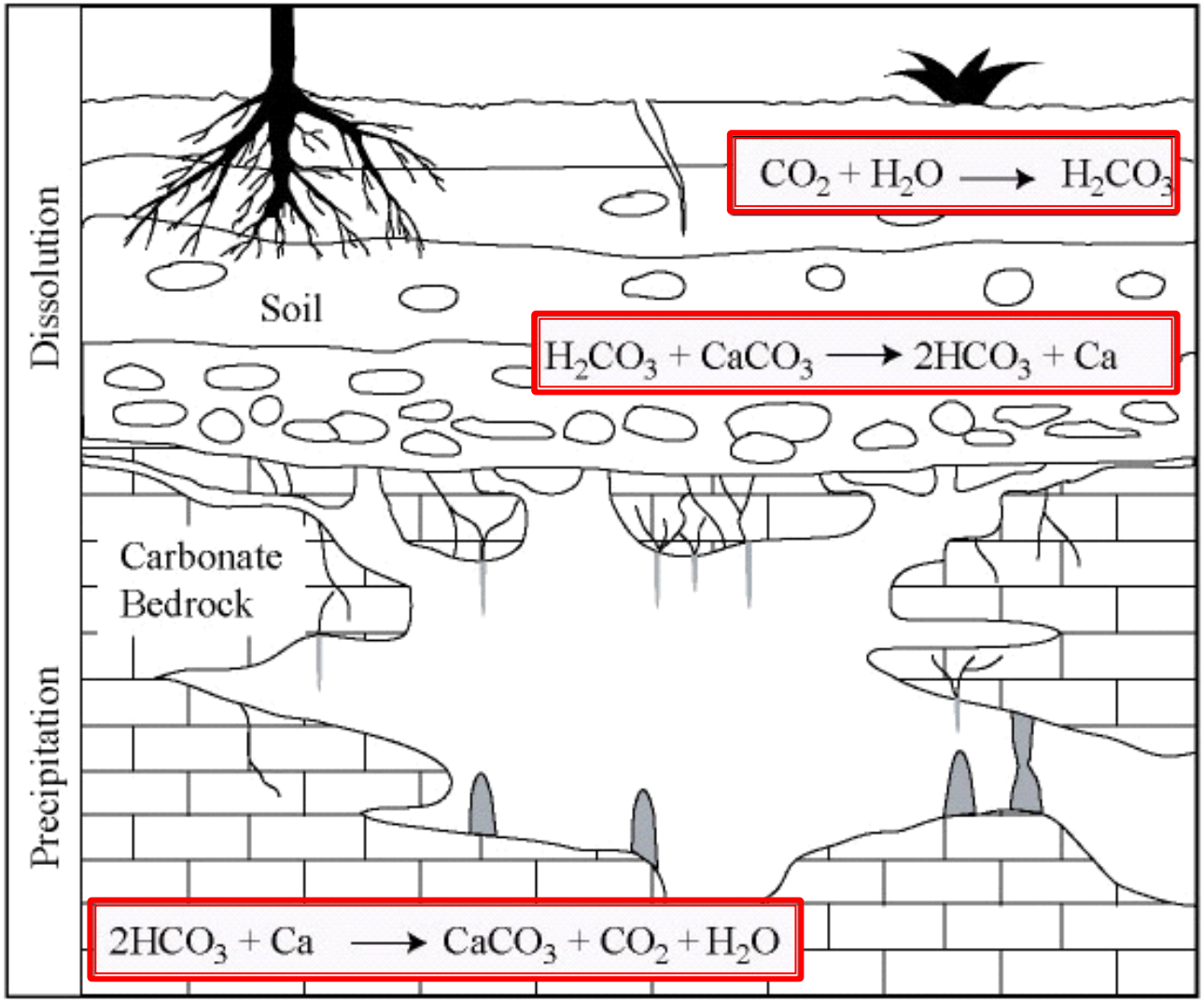
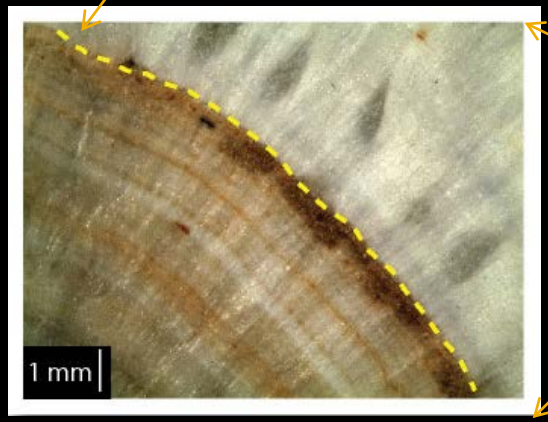
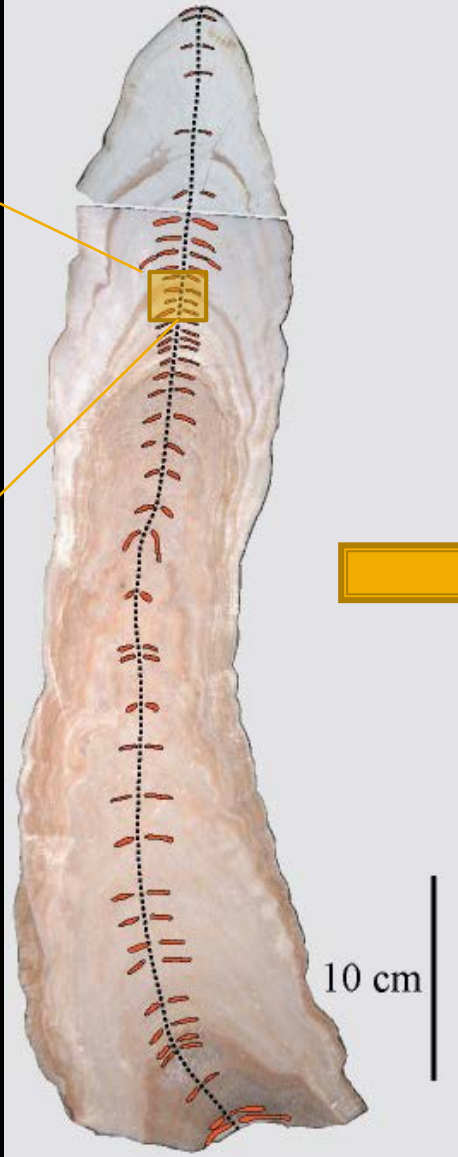
Groundwater karts systems

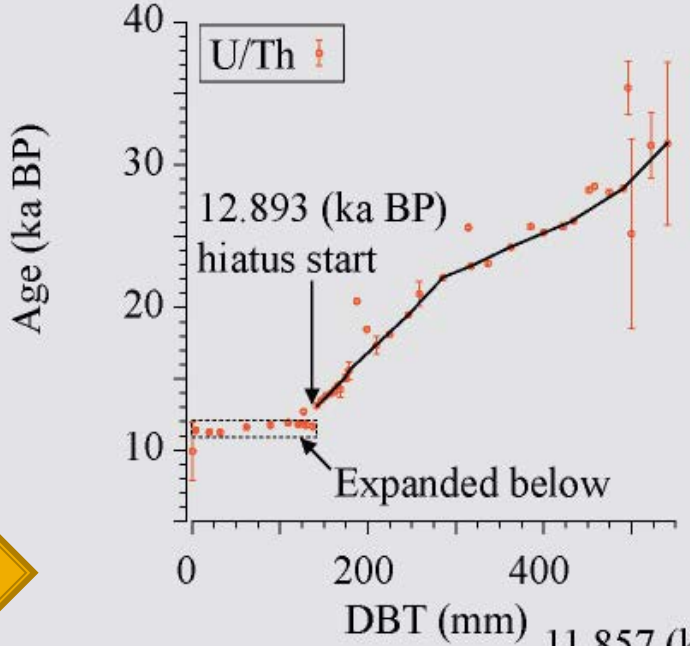


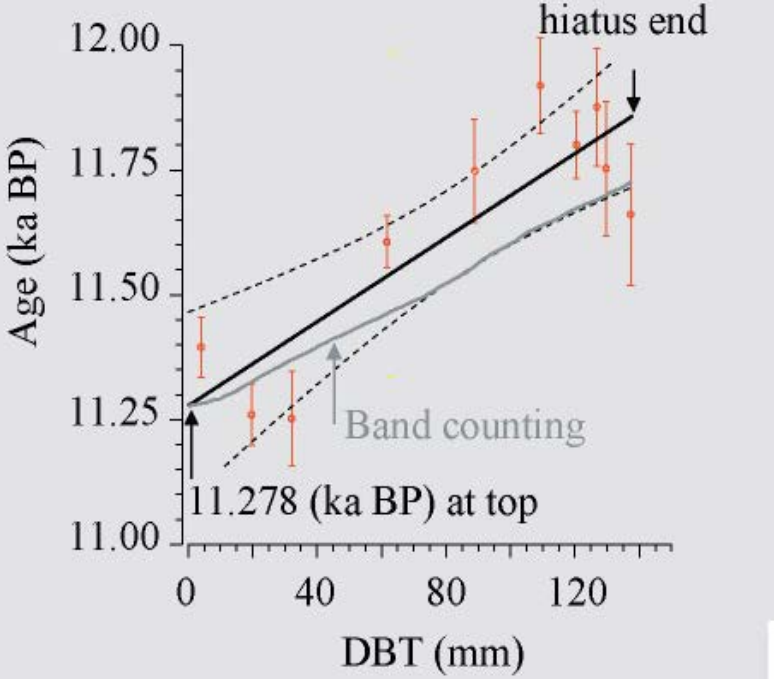
hiatus



Paleo-climate reconstruction



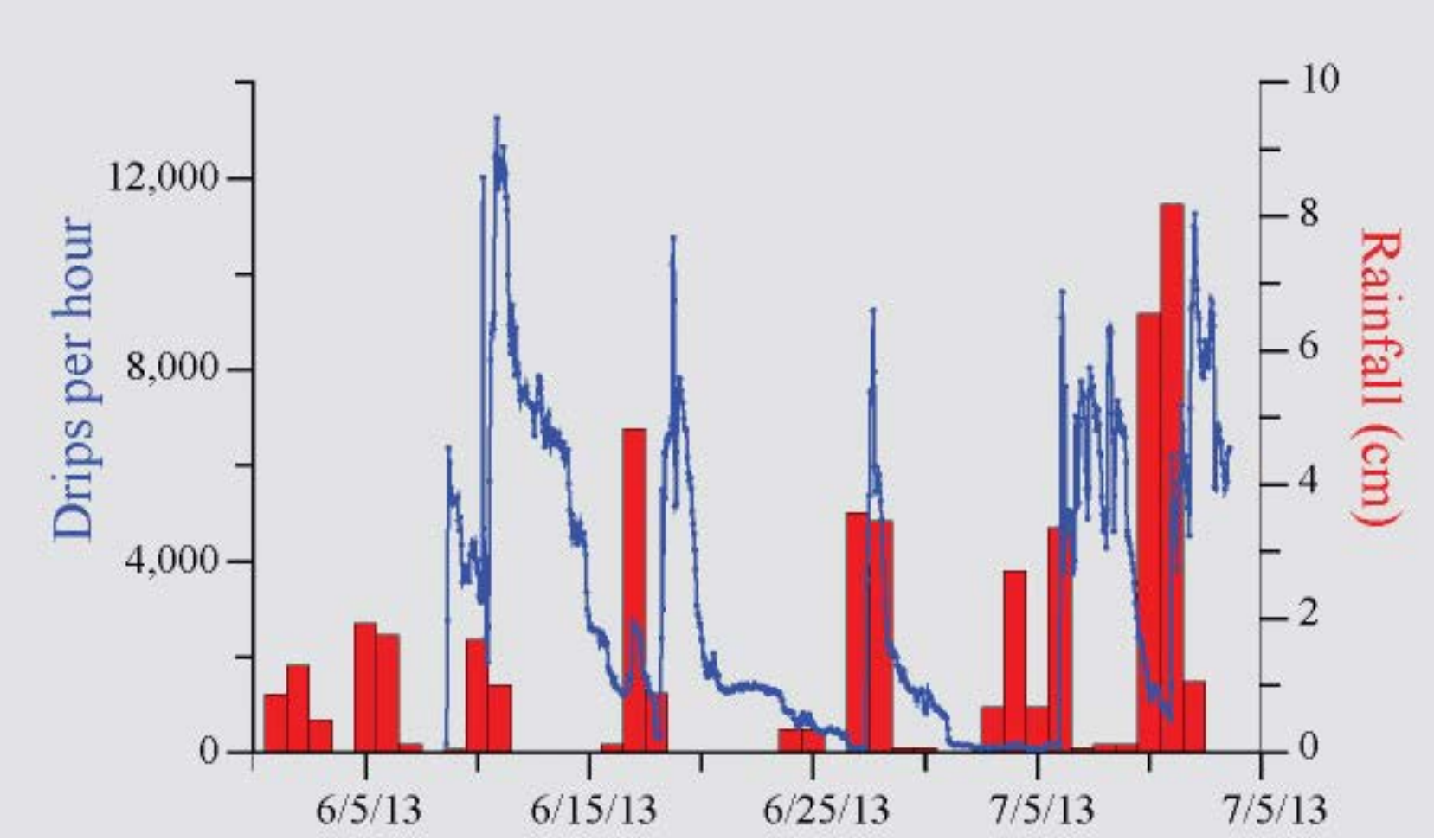




U/Th sample locations

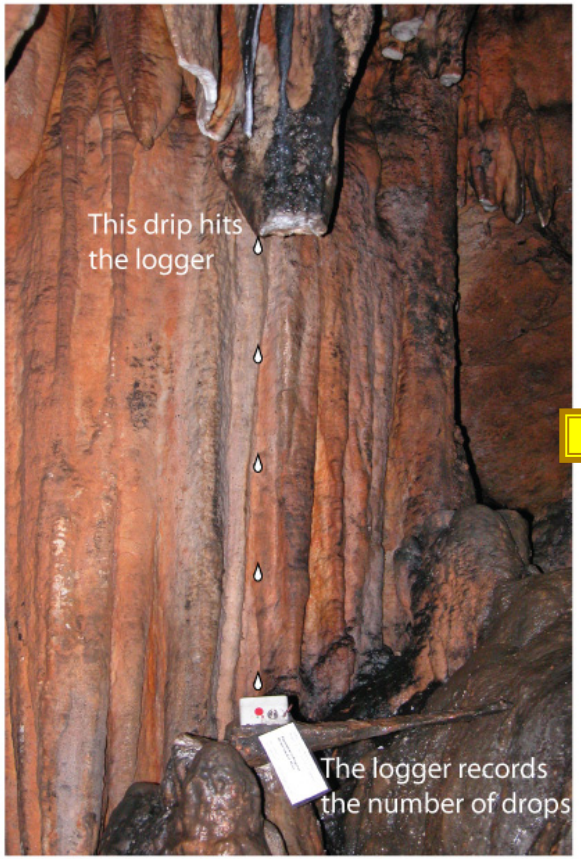
Stable isotope profile

Drip record versus precipitation



Lambert and Dimova, unpubl.

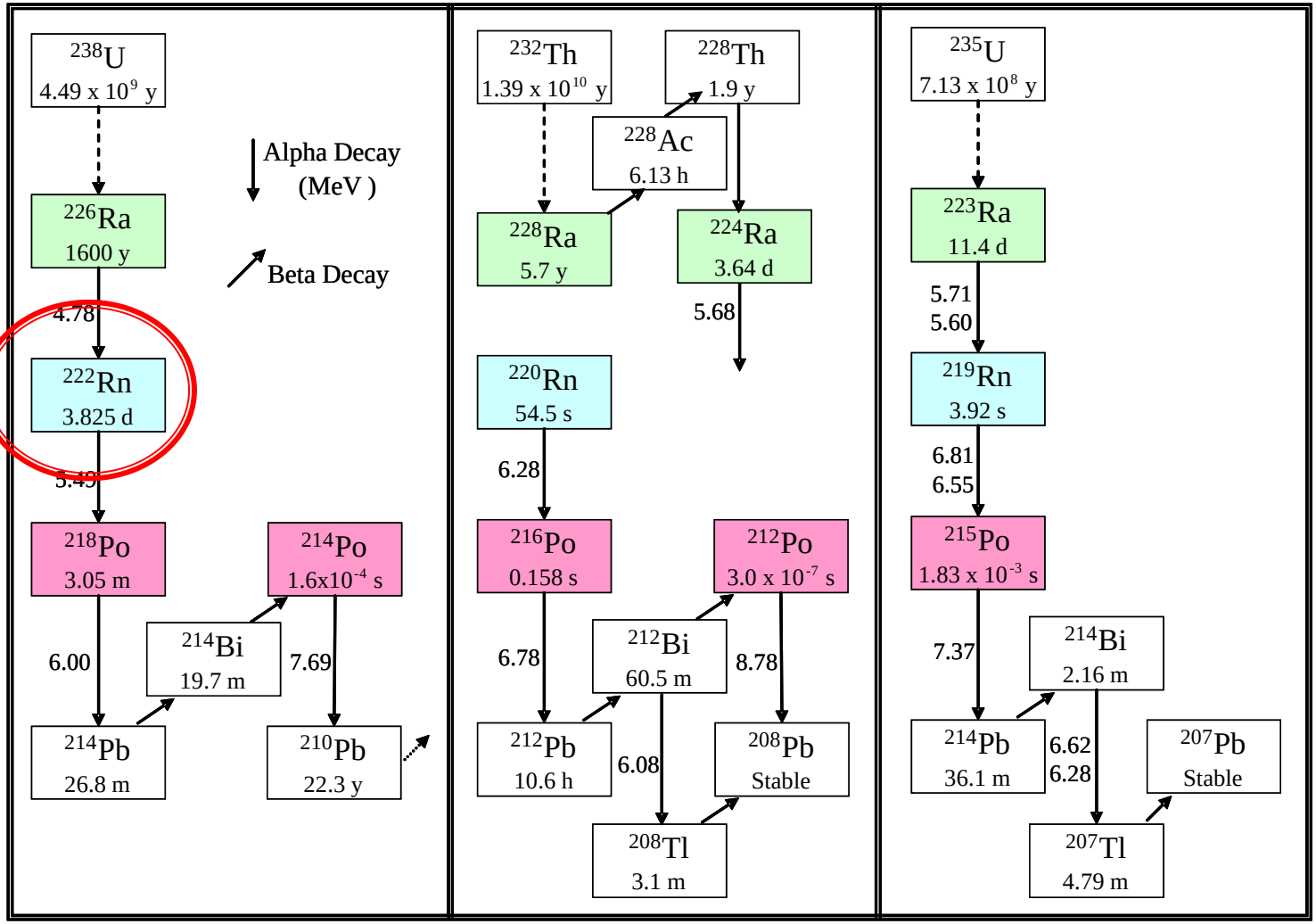
What is the traditional approach



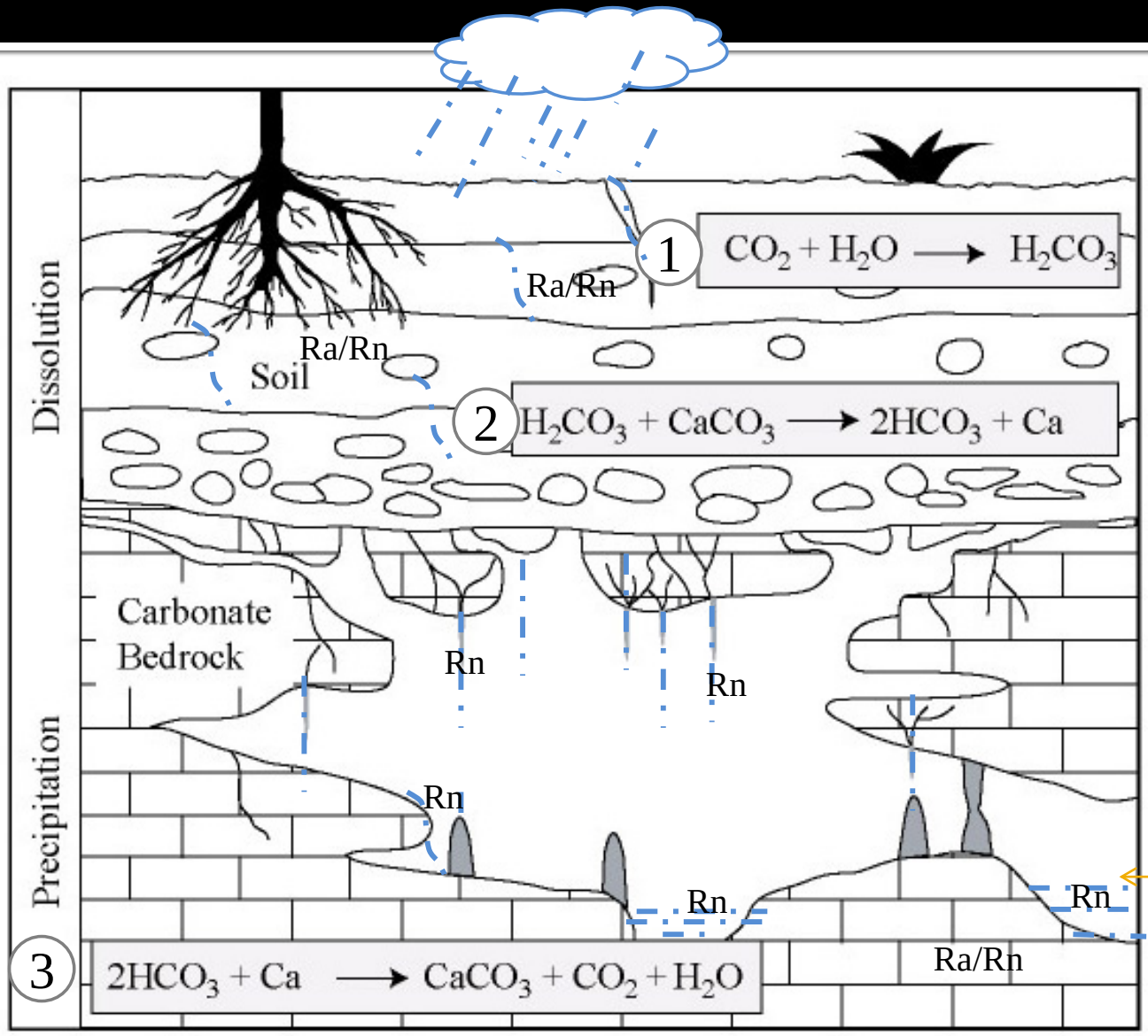
One drip logger…

Or multiple data loggers for more accurate estimate

…or I suggest ^{222}Rn: U/Th- decay series



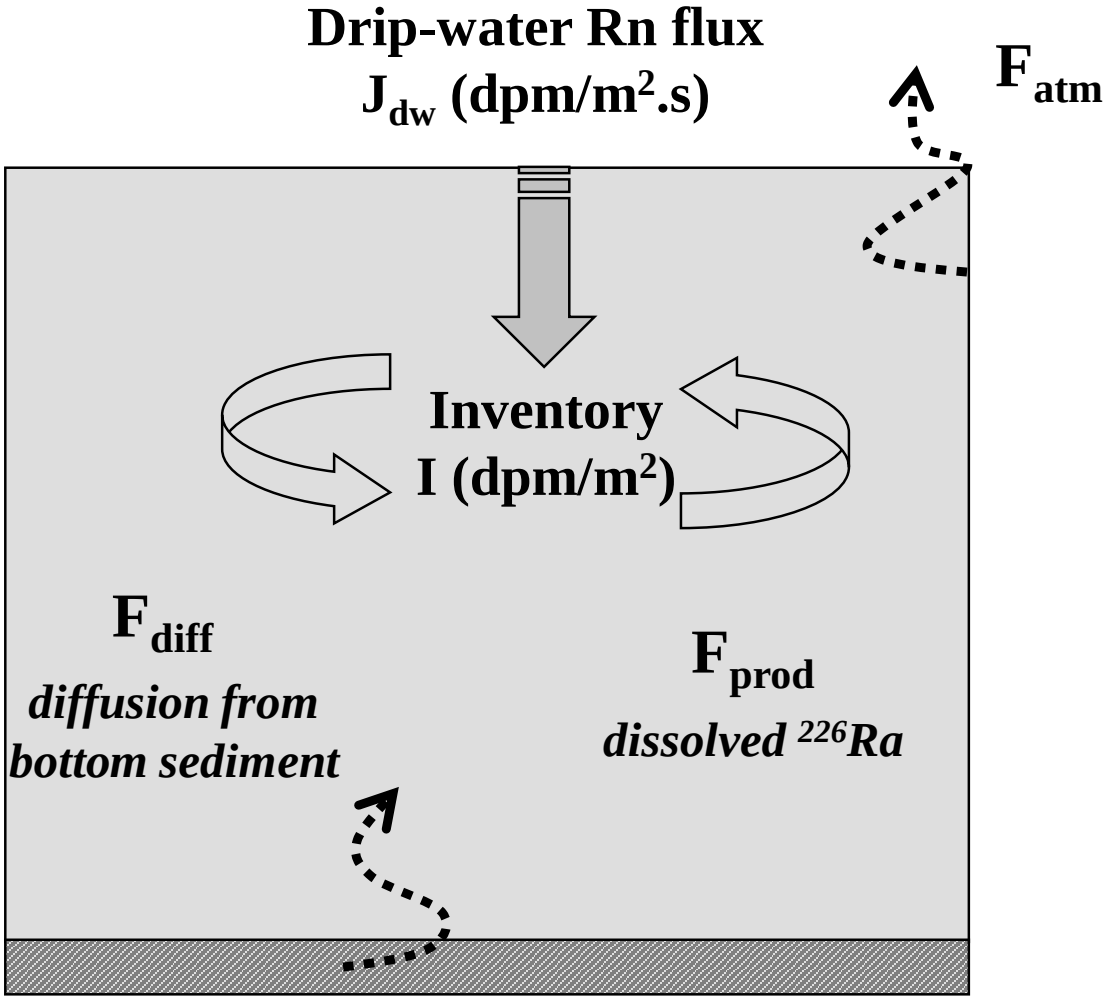
How does it work?



Cave caprock: rain water infiltrates and Rn accumulates

Cave pools of drip water enriched in Rn

Principle: "gw model" upside down



Rn mass balance in the cave pool

$$J_{dw} + F_{prod} + F_{diff} = F_{atm} + \lambda \times {}^{222}Rn$$

- J_{dw}: Dissolve d ^{226}Ra in pool water
- F_{prod}: Diffusion of ^{222}Rn from underlying bedrock
- F_{diff}: ^{222}Rn gas loss
- F_{atm}: ^{222}Rn decay for the time of measurement

Assumptions

1. Only significant ^{222}Rn input is via steady-state drip water flux
2. Well mixed water column
3. Only losses via decay and atm. evasion

Measurement technique: RAD AQUA

Continuous measurements of:

- ^{222}Rn conc. in the pool water for at least several hours
- Dimensions of the pool
- Temperature
- ^{222}Rn in drips (or groundwater)

^{226}Ra in the pool water (V=100-200L)

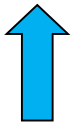
1. Convert C_{Rn} to inventories

$I_{meas}=(dpm/m^3).(depth)$

measured

2. Model Rn flux changes

$Flux_{(net)}=Flux_{(pw)}-Flux_{(atm)}$



temperature dependant

3. Convert to inventories

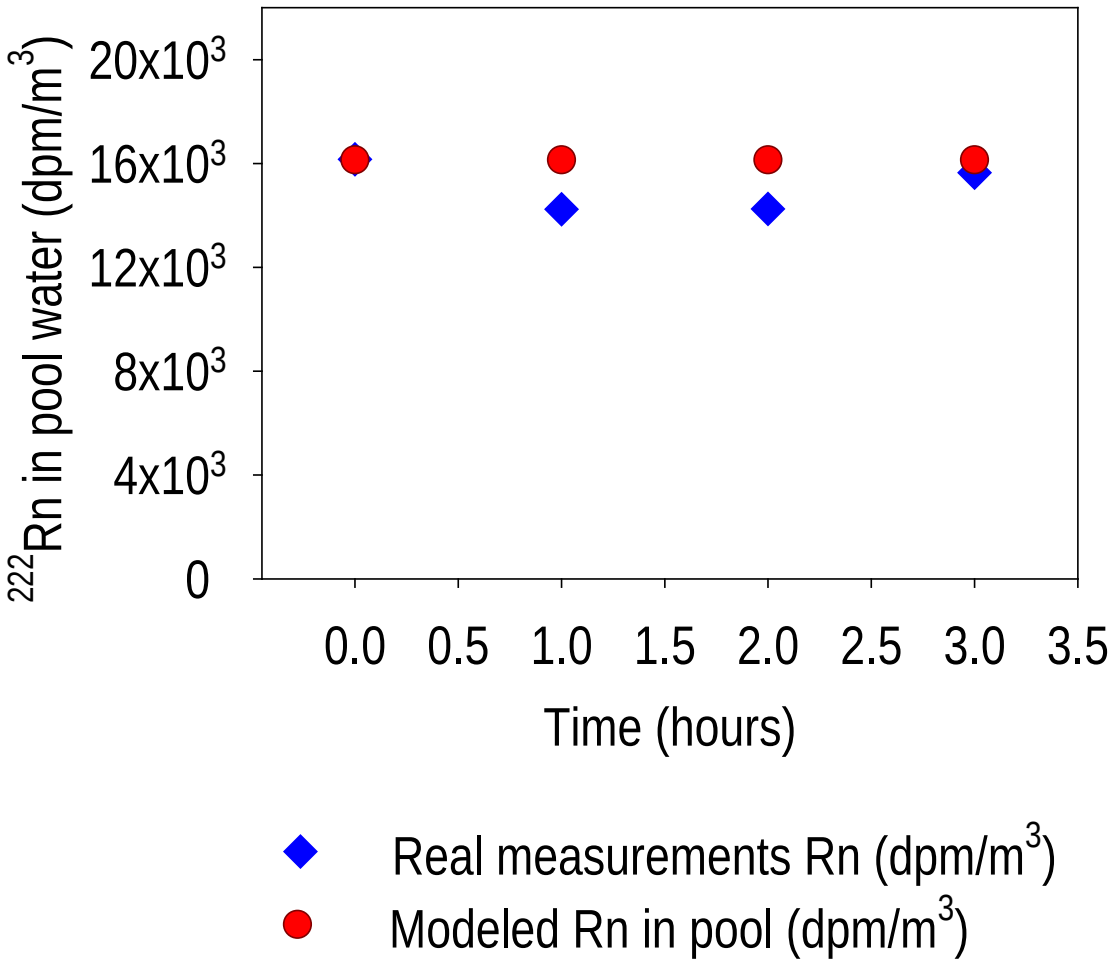
$I_{model}=Flux_{(net)}.(1-exp(-\lambda t))$

4. Convert to Rn conc.

$C_{Rn}=I_{model}/(depth)$

calculated

Example: Cathedral Caverns, AL



In this case our best match showed that J_{dw} has to be

J= 0.1264dpm/m2*hr

^{222}Rn in drip water concentration

144,000 dpm/m3

$DR=J_{dw}/Rn_{dw}$

DR= 3.66E-06 cm/day

Convert drip rate to volume

Area=13.9m²

X 3.7×10^{-6} m/day

$V = 5.1 \times 10^{-5}$ m³/day

DR (drip logger):

1.04×10^{-5} m³/day

8.64×10^{-3} m³/day

(Aharon et al, 2010)

Comparison and advantages

Advantage: the Rn approach integrates over larger cave areas (under multiple drip-spots) thus more accurate

Disadvantage: the Rn approach can be adjusted for long-term continuous record but requires more involvement than drip loggers.

Future work

- Calculating the loss of ^{222}Rn as the drips travel from the ceiling to the pool
- Examining the sensitivity of the method for different flow regimes: fast dripping rate (wet season) versus slow (dry season)

Questions?