

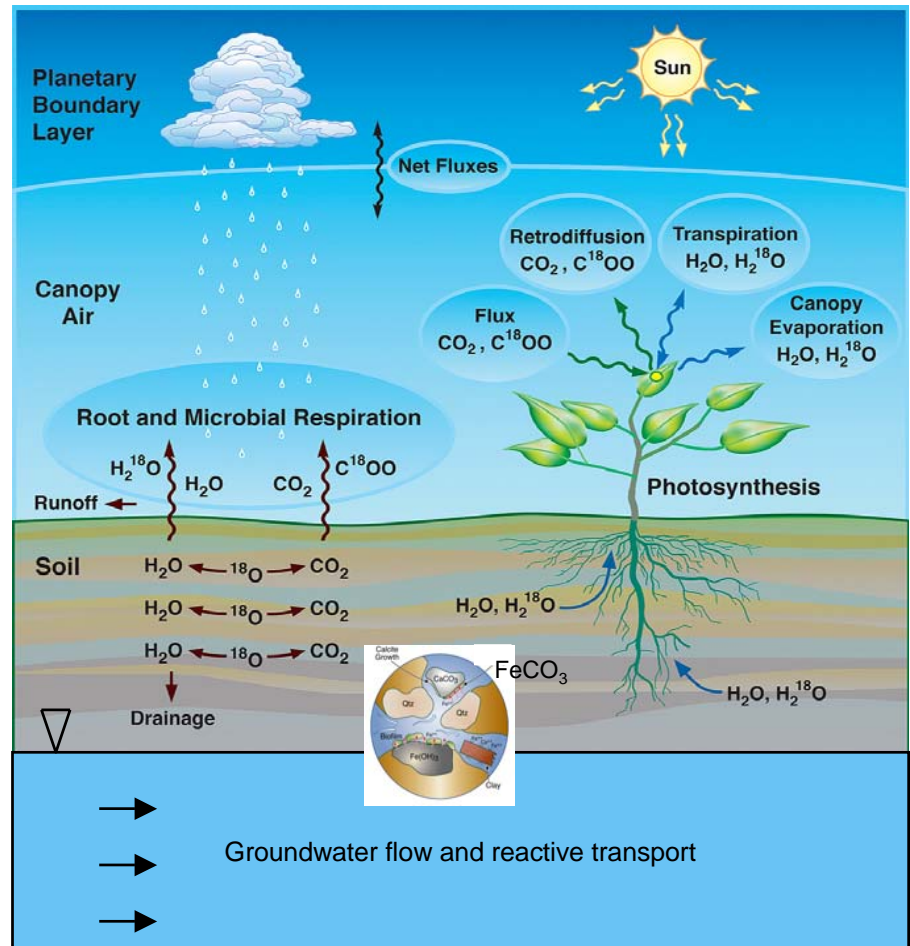
# Modeling of Hydrology and Nutrient Cycling



- **Principal Investigators:**  
Curt Oldenburg, Norm Miller,  
Bill Riley, and Carl Steefel
- **Budget:** \$149k/yr for 3 yrs.
- **Potential Sponsors:**  
NASA, CEC, NSF, CalEPA
- **Overall Objectives:**  
Develop models for coupled  
hydrology and nutrient cycling.  
Supports LBNL collaboration with



- **Impact:** This work synthesizes  
capabilities for advancing  
understanding of emerging water  
issues.



Curt Oldenburg Presentation to BWC's SAC,  
April 2006

# Overall Objectives and Approach

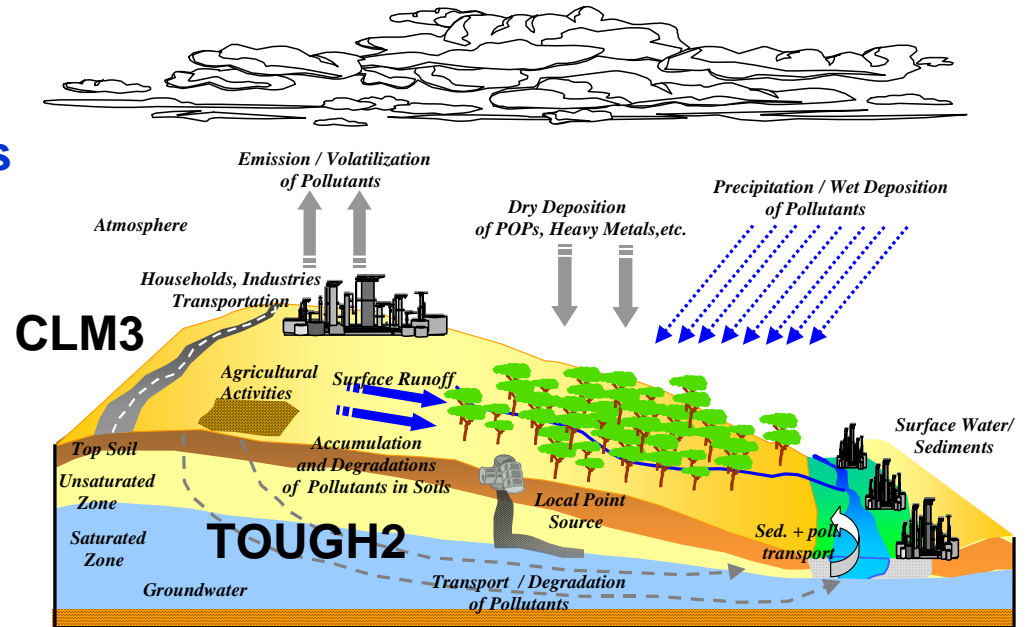


- **Technical Objectives:**  
Develop coupled hydro-bio models to develop understanding of interactions between climate, hydrology, vegetation, and nutrient cycling over diverse scales.

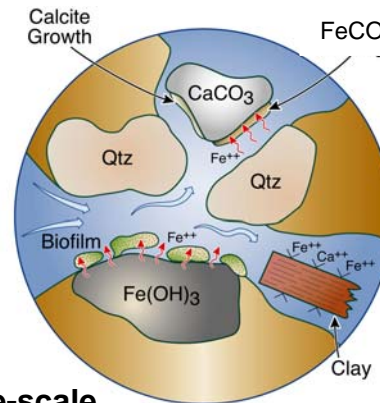
Apply the models to understand and solve problems relevant to water quality and supply.

- **Approach/Expected Results:**  
Collaborate with BWC by supporting two postdocs.

Develop integrated models using CLM3, TOUGH2, TOUGHREACT, and CRUNCH.



Site-scale to regional scale



Pore-scale

**CRUNCH,  
TOUGHREACT**

# Motivation and Specific Objectives



- **Motivations:**
  - Climate and land-use changes are occurring in California.
  - What are the local and regional impacts of these changes on water quality and the environment?
- **Objectives:**
  - Enhance modeling capabilities of TOUGH2 for regional-scale water, nutrient, and elemental fluxes.
  - Develop ability to understand and predict the effects of climate and land-use changes.
  - Build stronger ties between LBNL/ESD and UC Berkeley.

# Approach

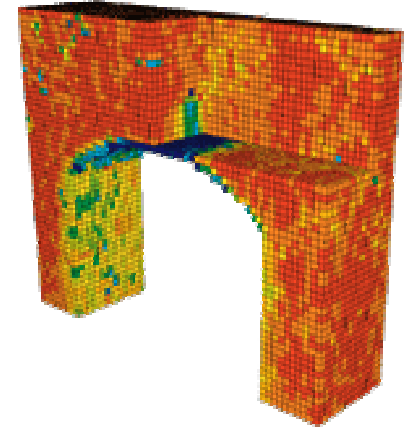


- **Build on existing expertise in ESD:**
  - **Subsurface chemical transport with coupled biogeochemistry**
  - **Coupled landsurface and subsurface hydrology**
  - **Landsurface chemical and nutrient cycling**
  - **Regional Climate System Modeling (RCSM)**
- **Hire two post docs:**
  - **One works on coupled biogeochemistry of Nitrogen in subsurface (e.g., TOUGHREACT, CRUNCH) and in CLM3.**
  - **The other focuses on TOUGH-CLM coupling systematics for later coupling of TOUGHREACT and CLM3.**

# TOUGH Codes (Subsurface)



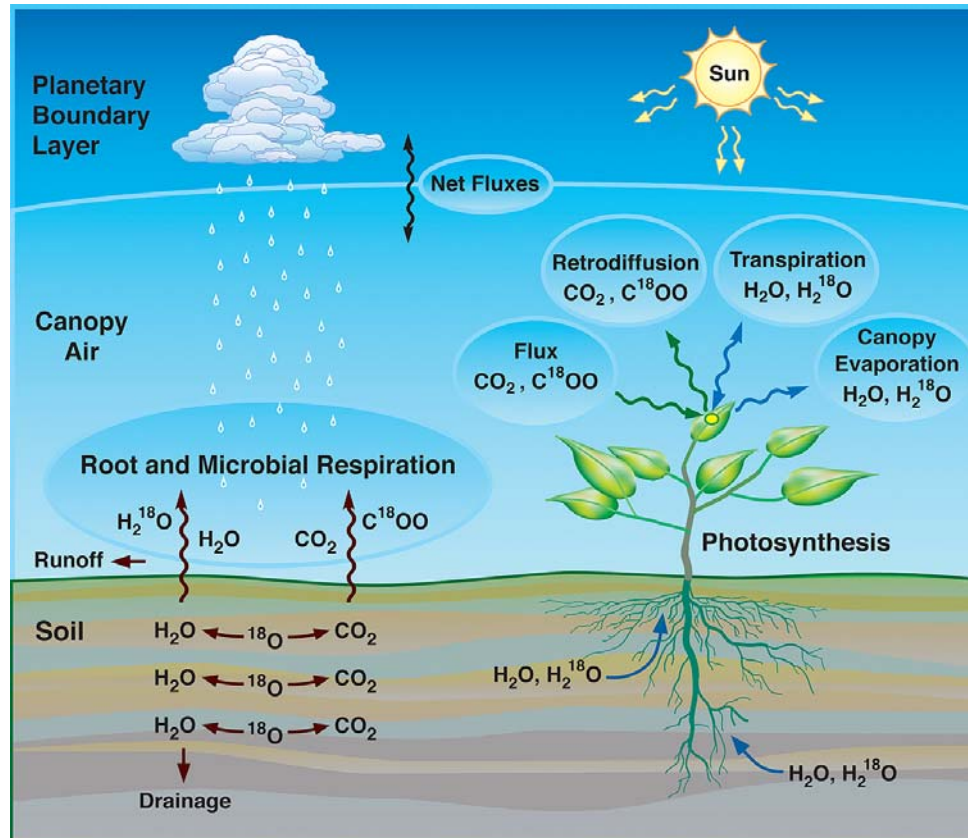
## Subsurface multiphase and multicomponent flow and transport



The TOUGH family of codes is a suite of computer programs for the simulation of multiphase fluid and heat flows in porous and fractured media. Many modifications and enhancements have been made to TOUGH, at LBNL and elsewhere, from the time it was first released in 1987 to the present TOUGH2 Version 2.0. TOUGH2 and its various descendants (such as iTOUGH2, T2VOC, TMVOC, EWASG, TOUGHREACT, and many more) are currently in use in approximately 300 research laboratories, private companies, and universities in 33 countries.

<http://esd.lbl.gov/TOUGH2>

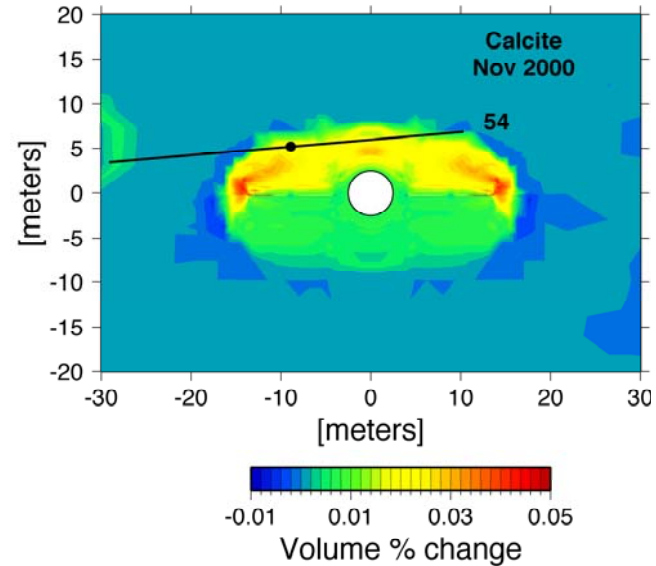
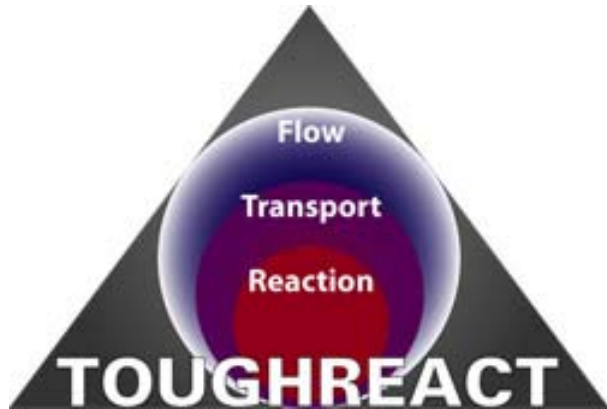
# CLM3 (Atmosphere, surface, and soil)



Example shows isotopic fractionation in plants and soil.

(Riley, Global Biogeochemical Cycles, 2002)

# TOUGHREACT (reactive biogeochemistry)



Reactive geochemical transport

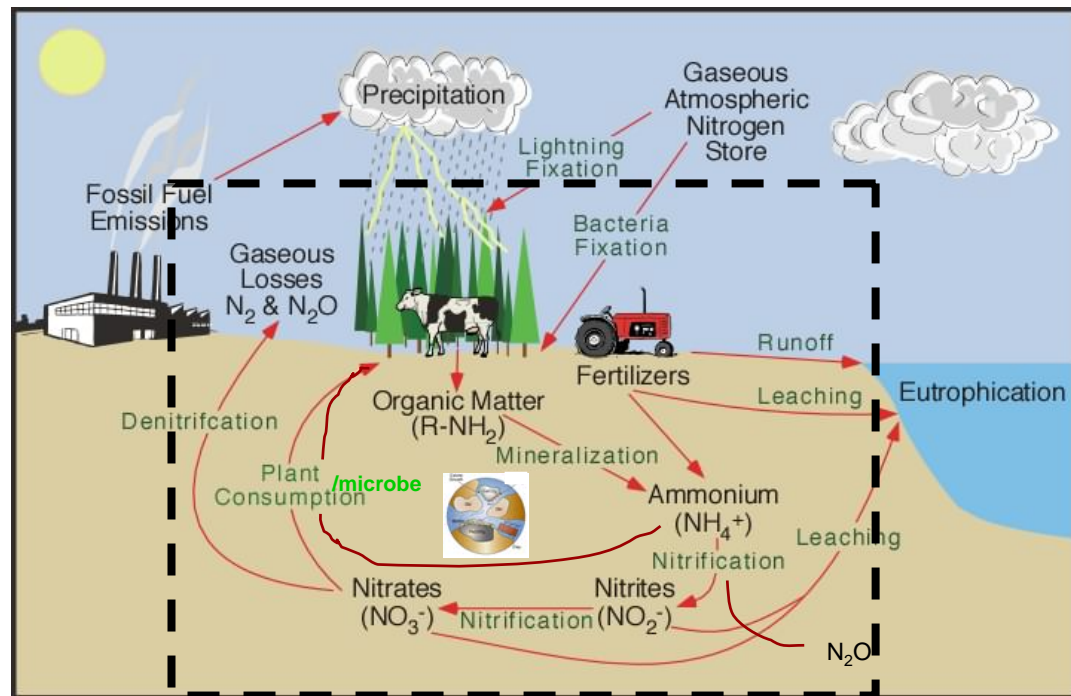
(Xu and Pruess, Am. J. Sci. 301, 2001)

<http://esd.lbl.gov/TOUGHREACT/>

# Expected Outcome: TOUGHR-CLM3-N



- TOUGHR-CLM3-N
  - Coupled TOUGHREACT-CLM3 with Nitrogen biogeochemistry.
- Study effects of
  - Climate on N-cycling.
  - Scale on process model results.
  - Sensitivities to various properties/parameters.



Rainfall, infiltration

Evapotranspiration

Groundwater flow

Transport (leaching)

Biogeochemical reactions (e.g., (de)nitrification)

# Opportunity and Importance



- **Significance: Hydrologic synthesis is needed to inform policy to deal with challenges of water quality and supply.**
- **Funding Opportunities:**
  - NASA (modeling, understanding)
  - CEC (regional problem solving)
  - NSF (new understanding)
  - Calfed (Sustainable California Water Resources)
- **Overall Importance to the ESD Division and to the BWC:**
  - This is a growth area for ESD due to climate change and growing demands for water and is well aligned with BWC goals.
  - ESD is poised to work closely together with BWC to make significant impacts in understanding and solving water problems.
  - ESD seeks to enhance its expertise in modeling biological processes coupled with climate and hydrology.

