DOE Water Cycle Initiative

Water Cycle Research Strategy

Dr. Wanda R. Ferrell
Department of Energy
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DOE Water Cycle Program

USGCRP Background

- “. . . large uncertainties in . . . understanding of the global water cycle.”
- “. . . understanding . . . limited by measurement uncertainties and deficiencies in models. . .”
- Three questions on which to focus
  - Underlying causes of variation
  - Predictability of variation
  - Water variability links to other processes

DOE Water Cycle Role

- Water Cycle is Integral Element of Climate Modeling and Prediction
- Water Cycle is Directly Linked to Environmental Carbon Issues
- DOE Requires Improved Representation of the Water Cycle for More Accurate Impact Assessments
- DOE Has the Resources!

DOE Water Cycle Program

Primary Focus

"To What Extent are Variations in the Regional Water Cycle Predictable?"

DOE Water Cycle Program

Secondary Focus

"How to Take Advantage of DOE Talents, Facilities and Capabilities to Attack the Primary Scientific Objective"

DOE Water Cycle Program

DOE Assets

- Observational Facilities (ARM, ABLE, etc)
- Computational and Data Mgmt Capabilities
- Laboratory Research Strengths
  - Regional Modeling
  - Atmospheric Chemistry and Carbon Cycle
  - Groundwater Processes
- State-of-the-Art Instrumentation

DOE Water Cycle Program

Multi - Stage DOE Strategy Adopted

- Exploratory Proof-of-Concept Study (Pilot Study)
- Develop Strategy for a Continuing DOE Program
- Full Implementation of Observational and Modeling Effort Aimed at Improved Regional Predictive Models

DOE Water Cycle Program
Anticipated Outcomes

- A Water Cycle Simulation System
- Regional Observational Testbeds - i.e. Long Term Sites for Continuous Data Streams
  - Regional River Basins
  - Smaller Embedded Basins
- Integrated and Coupled Model Testbeds in a High Performance Computing Environment
  - Improved and Integrated Process Models (Physical, Chemical, Geological, and Biological)
  - Cross-scale for Local and Regional Effects

USGS River Basin Regions

DOE Water Cycle Program
Pilot Study

Pilot Study Proposed to Address Two Questions:

- Can the predictability of the regional water balance be improved using high-resolution model simulations that are constrained and validated using new water isotope and hydrospheric water measurements?

- Can water isotopic tracers be used to segregate different pathways through the water cycle and predict a change in regional climate patterns?

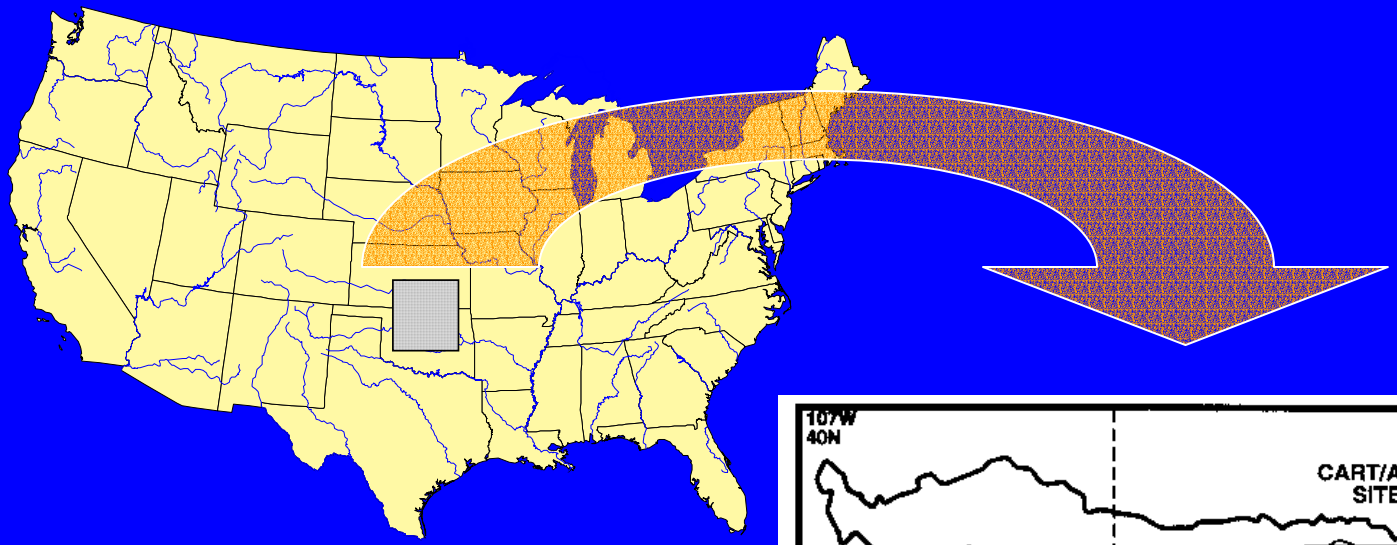
Pilot Study - Objectives

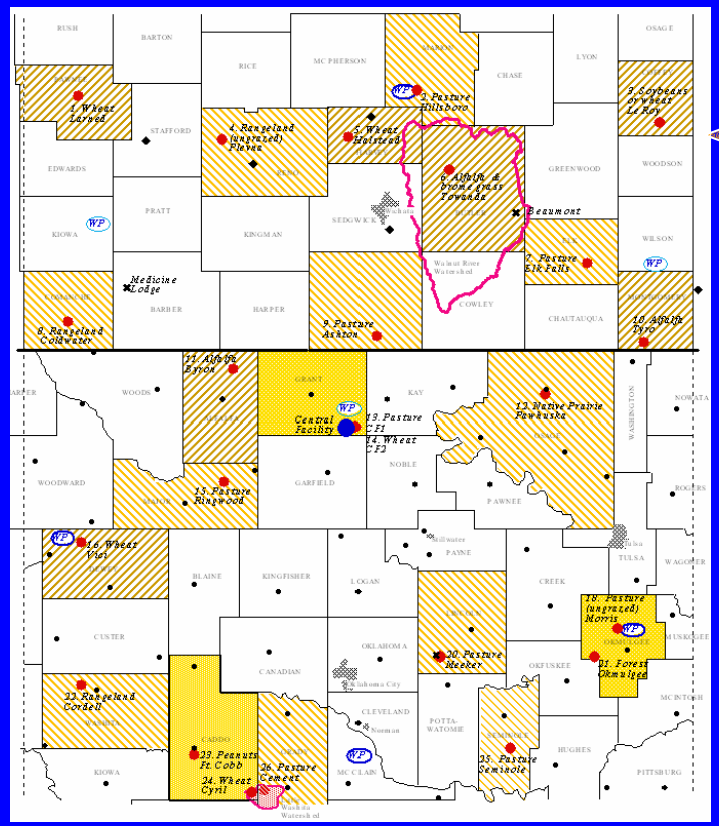
- Evaluate Water Budget Predictions in a Selected Watershed Using a Set of Nested Models With Different Spatial Resolutions With Existing and New Data.
- Evaluate Multi-scale Water Isotope Modeling As a Means of Tracing Sources and Sinks Within and External to the Selected Watershed.
- Identify Water Budget Model Improvements and Data Needs to Guide Future Studies.

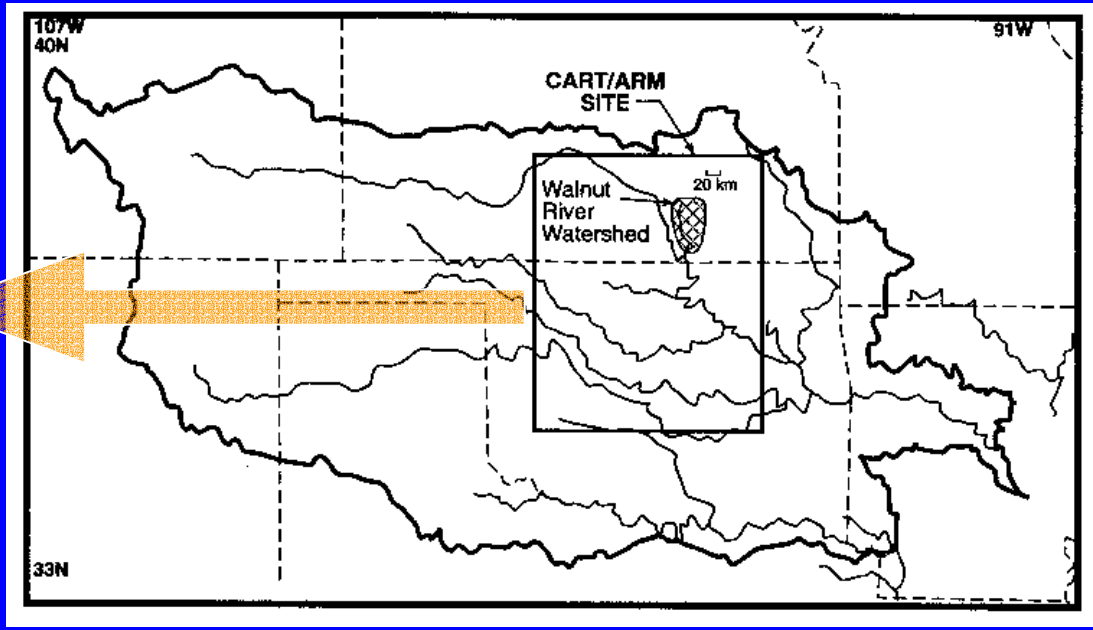
"Can We Demonstrate Closure of the Water Budget for a Carefully Selected Watershed"

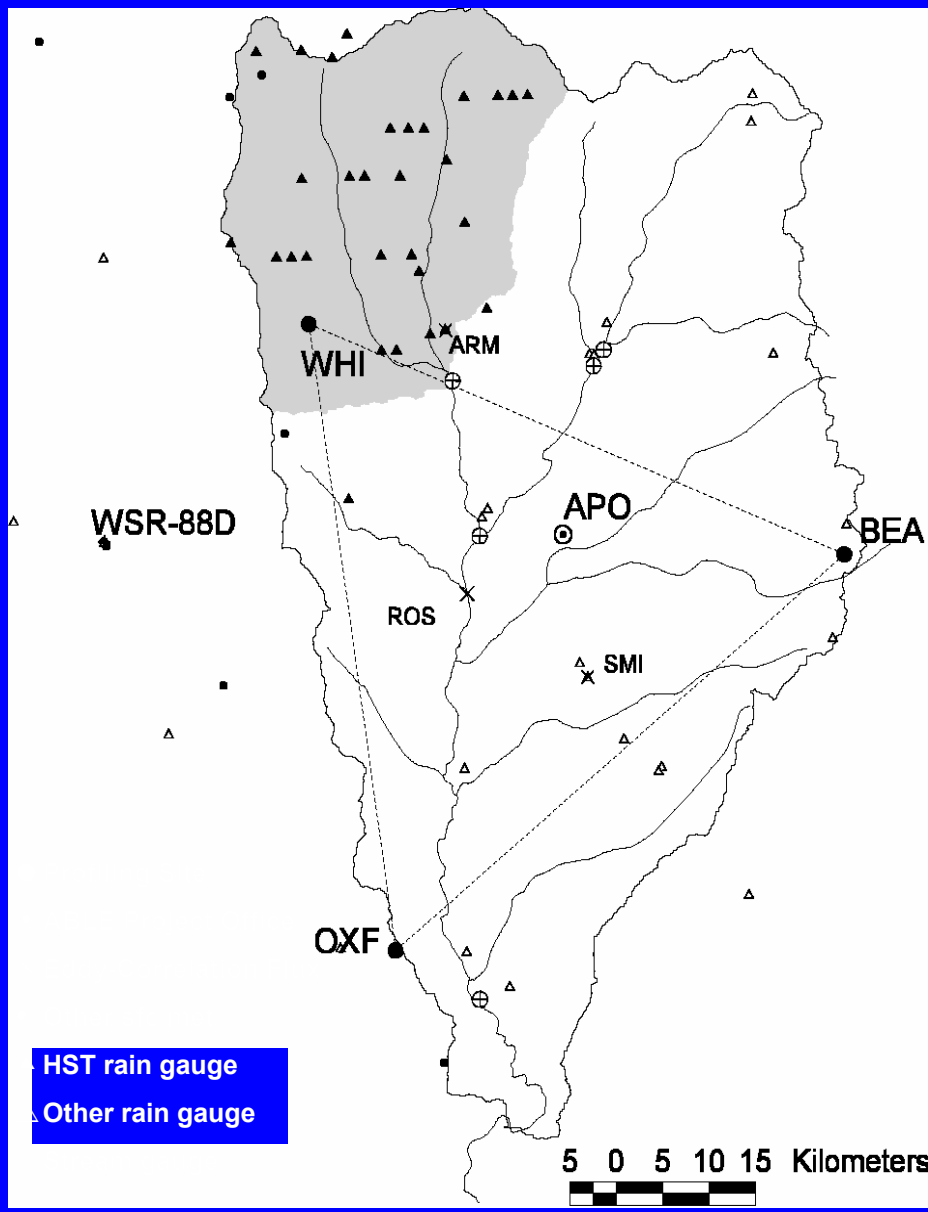
Pilot Study- Approach

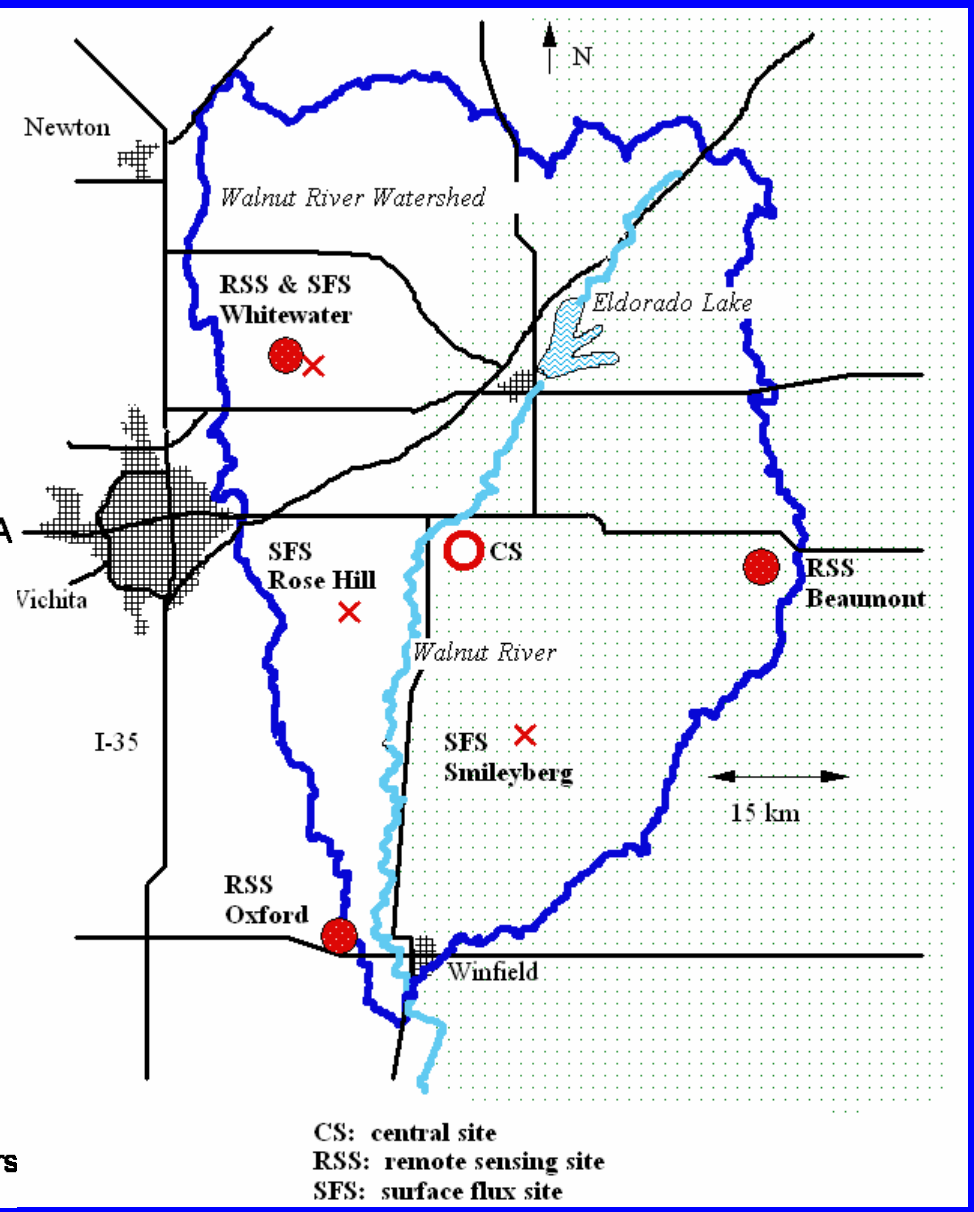
- Use Established DOE Capabilities; Exploit the DOE ARM Site and the Instrumented Walnut River Watershed
- Link Process Studies and Multi-scale Modeling.
- Apply Isotopic Tracers to Water and Vapor Transport
- Use Existing Data From ARM and ABLE, Plus Limited Additional Data, for Model Evaluation




RUSH
BARTON
RICE
MC PHERSON
MARION
CHASE
LYON
OSAGE
1. Wheat Larned
STAFFORD
4. Rangeland (ungrazed) Flavia
2. Pasture Hillsboro
3. Wheat Halstead
9. Corbexx or Wheat Le Roy
EDWARDS
PRATT
KIOWA
KINGMAN
SEDGWICK
6. Alfalfa & prairie grass Towanda
GREENWOOD
WOODSON
Beaumont
WILSON
Walnut River Watershed
7. Pasture Elk Falls
Medicine Lodge
BARBER
HARPER
COWLEY
CHAUTAUQUA
8. Rangeland Coldwater
9. Pasture Ashton
10. Alfalfa Tyro
11. Alfalfa Byron
WOODS
GRANT
KAY
Central Facility
13. Pasture CF1
14. Wheat CF2
12. Native Prairie Pawhuska
WASHINGTON
NOWATA
WOODWARD
GARFIELD
NOBLE
15. Pasture Ringwood
PAWNEE
ROGERS
16. Wheat Vici
Stillwater
PAYNE
TULSA
WAGONER
BLAINE
KINGFISHER
LOGAN
CREEK
18. Pasture (ungrazed) Morris
CUSTER
OKLAHOMA
20. Pasture Meeker
OKFUSKEE
21. Forest Okmulgee
MUSKOGEE
22. Rangeland Cordell
CANADIAN
Oklahoma City
CLEVELAND
Norman
POTTA-WATOMIE
MCINTOSH
CADDO
23. Peanuts Ft. Cobb
24. Wheat Cyril
26. Pasture Cement
MC CLAIN
25. Pasture Seminole
HUGHES
KIOWA
PITTSBURG
Washita Watershed


107W
40N
91W
CART/ARM SITE
Walnut River Watershed
20 km
33N


WSR-88D
WHI
ARM
APO
BEA
ROS
SMI
OXF
HST rain gauge
Other rain gauge
5 0 5 10 15 Kilometers

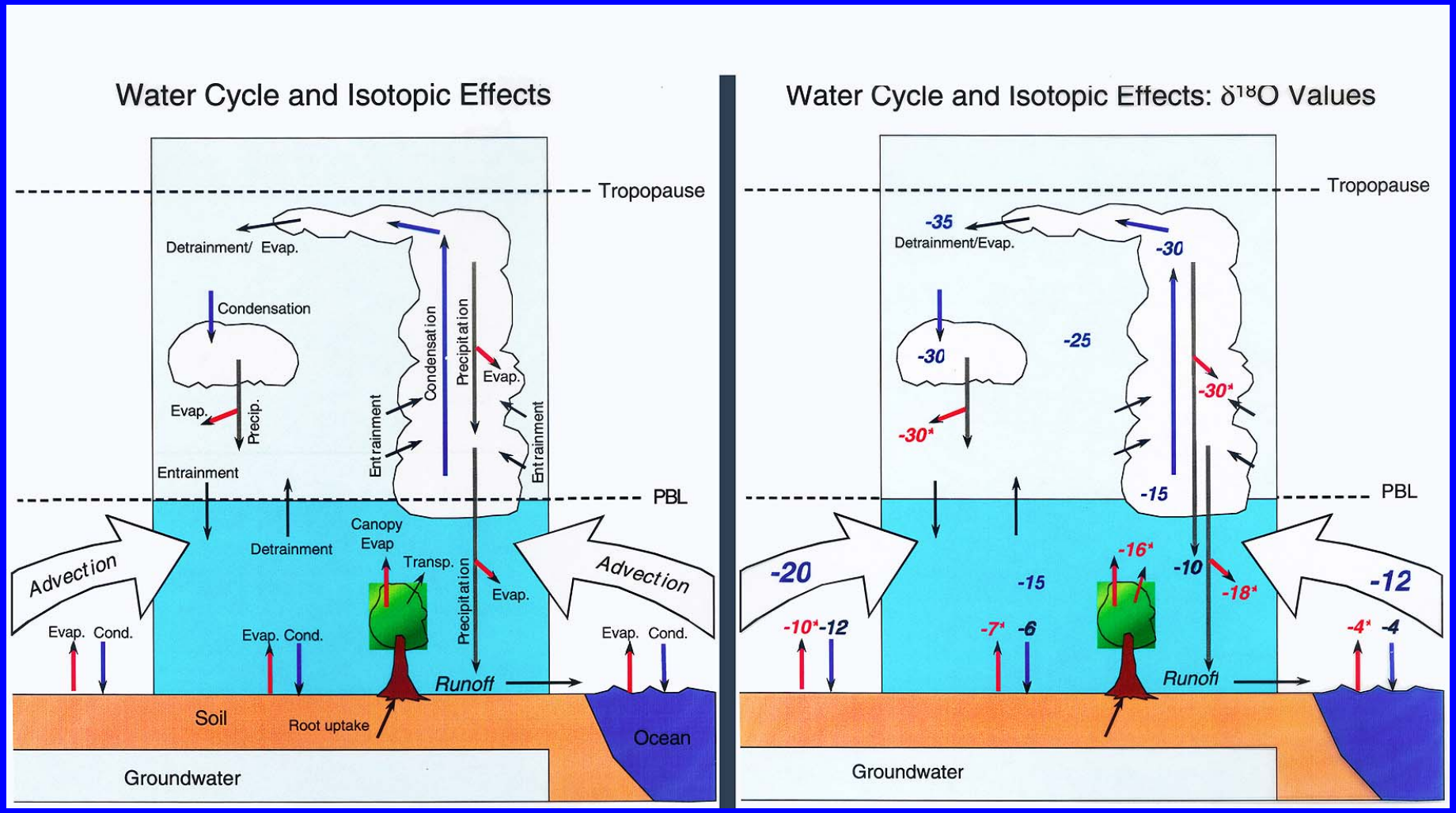

N
Newton
Walnut River Watershed
RSS & SFS
Whitewater
Eldorado Lake
Vichita
SFS
Rose Hill
CS
RSS
Beaumont
Walnut River
I-35
SFS
Smileyberg
15 km
RSS
Oxford
Winfield
CS: central site
RSS: remote sensing site
SFS: surface flux site

Pilot Study – Modeling Efforts

Water Budget Predictions

- Test MM-5 (4, 12, 48 Km Resolutions) and RAMS Predictions Against Measurements (Radar, Surface, Etc) of Water in Atmospheric System on Sub-basin, Walnut River Watershed and ARM Site Scales
- Invoke Hydrologic Modeling and Scale Analysis Using TOPLATS; Test Streamflow Predictions Against Measurements
- Test Soil Moisture Predictions Against Measurements

Pilot Study - Isotopic Sampling and Analysis



Pilot Study – Isotopic Studies

Evaluate Analyses of Isotopic Distributions Against Predicted Fluxes in Water Cycle Pathways

- Isotopic Sampling – Precipitation, Streamflow, Soil and Plant Water, Water Vapor
- Implement Isotope Mass Conservation Equations in High Resolution Models

Pilot Study - Status & Results

- Data Acquisition
  - Quarterly Data Set Acquired for Seasonal Variation
  - Precipitation Event Data for “Pre-,” “Mid-” and “Post-” Conditions Over a Small, Well-Instrumented Watershed
  - Good Airborne Data Set in and Above PBL

- Early Results
  - MM-5 Prediction Confidence Tied to Scale of Measurement Versus Scale of Prediction
  - Mass (e.g. Water) Conservation Fidelity for Isotopic Tracing Necessitating Use of NOAA “Weather Research and Forecast (WRF)” Model

DOE ARM Program
Water Cycle Impact

- ARM Contributions Re Water
  - Improved Performance of Standard Instruments
  - New Instruments Developed and/or Fielded for Routine Water or Water Vapor Observations
    - Raman Lidar
    - Cloud Radar
    - Microwave Water Radiometers
    - High Spectral Resolution IR Radiometers
    - Soil Water and Temperature Measurement Network

DOE ARM Program
Water Vapor Measurement

- Measurement Evaluation IOPs Conducted
  - Now Good Understanding of Measurements
- Standard Intercomparison of Data Streams from Different Sources
- Extensive Collaborations with Other Agencies and Programs (NASA FIRE, NOAA, GEWEX)

ARM Future Impacts

- ARM Considered a “DOE User Facility”
- ARM to Develop a Mobile Facility
- New and/or More Robust/Capable Instrumentation
- Collaborations Expanding in Time
  - EOS Validation and Ground-Truth
  - Possible Deployment of Precipitation Radar for GPCP

DOE Water Cycle Initiative
Summary

- DOE Has a Mandate to Predict the Impacts of Energy Policy on Regional and National Water Budgets.
- DOE Has the Scientific Capabilities, Instruments, Experimental Sites, and Computational Strength Needed
- Early Results of Pilot Study Encouraging
- ARM Site Capabilities Increasing
- DOE "Water Cycle Research Strategy" Submitted for Approval
- Near Term Funding Unlikely Due to Pressures on Federal Budget