CSREES's National Research Initiative—Soils related priorities and Climate Change Programs: Agroecosystems

Soil Processes: Latest Priorities (draft)

- **Interdisciplinary studies: the interrelationships among soil physical, chemical, and biological characteristics and processes related to soil quality and sustainability**
- **Multi-scale research that can help bridge the gap between molecular and microscopic site process studies and field landscape and/or watershed-scale studies relating to soil quality.**
- **Development and/or application of new or improved technologies, methodologies, tools, or strategies to enhance our understanding of biological, biogeochemical, and physical processes and dynamic soil properties, at multiple scales where appropriate.**

NRI: Changes for 2009

- **New project type: REENet**
- **Purpose is to move the field forward or create new research directions or opportunities though increased coordination, networking, and synthesis.**
- **Proposals that coordinate networking activities around one of the research priorities, specifically related to soil carbon stabilization and vulnerability.**
- **May also coordinate the development of new tools and methods and generate community resources such as databases, sample archives, or instructional materials or facilities.**

Global and Climate Change FY 2007-8

- Joint with NASA: Carbon cycle research—focus on regional studies and key baseline data
- Joint with EPA: intersection of land use and land cover change, global change, and invasive species

Global and Climate Change FY 2009 (proposed)

- Joint with EPA
- Focus on ecosystem services
- Includes multiple stressors, including land degradation, thresholds of irreversible change, reactive nitrogen, invasive species, water resources

CSREES &NRI
Farm Bill, other changes

- Integrated proposals-minimum (not maximum) 32% of funds
- Legislative authorities for research and integrated merged to one—implications for eligibility and strengthening funds
- New name: NIFA (National Initiative for Food and Agriculture)
- Appointed chief scientist a la NSF

Carbon- a key area: Some soil functions related to C stabilization

- Transport or production at depth (below 50 cm)
- Aggregate stability-especially microagregates
- Panels like to se coordination with NRCS, preliminary data
- Active carbon
- Soil function-say ecosystem services

Natural Resources and Environment Programs

Program Name	National Program Leader	Program Specialist
Soil Processes	Nancy Cavallaro	Alexandra Raver
Integrated Water Quality (406)	Michael O'Neill	??
Water and Watersheds	Mary Ann Rozum	Alexandra Raver
Air Quality	Raymond Knighton	??

Natural Resources and Environment Programs

Program Name	National Program Leader	Program Specialist
Managed Ecosystems	Diana Jerkins	Alexandra Raver
Long-term Agricultural Research (proposed)	TBD	Alexandra Raver
Biology of Weedy and Invasive Species	Michael Bowers	Alexandra Raver
Global and Climate Change	Nancy Cavallaro & Luis Tupas	Alexandra Raver

Soil Processes

Funding Year	2005	2006	2007
# of proposals	144	107	110
# of proposals awarded	17	17	16
% success	11.8	15.9	14.5
Average award size (standard)	352,300	280,000	332,000
Average award duration	2.6	2.4	2.9

Managed Ecosystems

Goals & Priorities:

- Agroecosystem functions –mechanisms and biogeochemical processes to improve agricultural productivity and environmental quality;

- Multifunctional management systems that *concurrently* provide for both agricultural productivity and ecosystem services; and

- Monitoring systems quality – Develop interdisciplinary approaches and processes to monitor agroecosystems to quantify improvements in production quality and environmental quality or ecosystem changes due to implementation of multifunctional management systems and strategies.

National Integrated Water Quality (406)

Goals & Priorities:

- • Developing tools and expanding knowledge to make more efficient use of existing water supplies and conserve water in agricultural, rural, and urbanizing communities.
- • Understanding the role of ecosystems in maintaining water availability and quality.
- • Expanding knowledge on water use efficiency and water quality protection to improve water policy implementation and compliance.

Water and Watersheds

Goals & Priorities

- Understand the sources, fate, and transport of pathogens such as bacteria, protozoa, and viruses in soil and in surface and ground water systems of agricultural and rural landscapes and watersheds to reduce zoonotic pathogens in the environment—synthesis activities
- Moving toward antibiotics and veterinary pharmaceuticals
- Identify, evaluate, and understand producer management behaviors that improve agricultural water conservation, especially at spatial scales greater than a single field.

Biology of Weedy and Invasive Species

Goals and Priorities

- Research that establishes mechanisms determining the abundance and distribution of weedy and invasive species. Development, delivery and implementation of ecologically-based, invasive species management programs and/or strategies; and
- Early detection–rapid response control strategies, especially those that use remote sensing and mapping.

Air Quality

Goals & Priorities

- Measurement and Monitoring Integrated projects are solicited to improve measurement protocols/instrumentation and remote sensing to measure and characterize particulate matter and gases for within field/facility and edge-of-field/facility boundaries.
- Fate and Transport Integrated projects are needed on the fate and transport of emitted particulates and gases with specific emphasis placed on ammonia and nitrous oxide.
- Mitigation Integrated projects on the efficacy of methods for mitigating emissions of nitrogen and other agricultural air pollutants to the atmosphere and the development of best management practices are solicited.

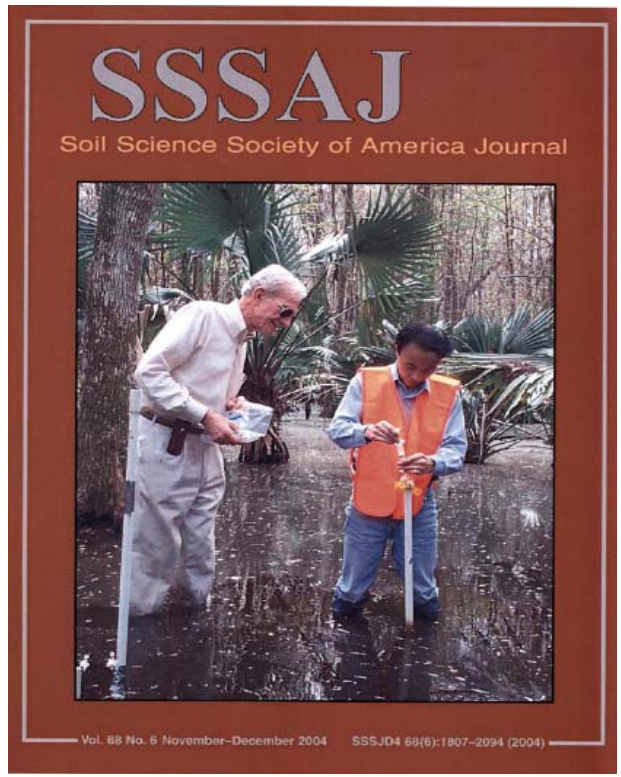
Long-term Agricultural Research (proposed)

- Assess farming practices and integrate into knowledge about soil carbon dynamics
- Assess the role of climate variability on soil carbon loss
- Conduct comprehensive carbon audits for farm operations

Other opportunities, various agencies

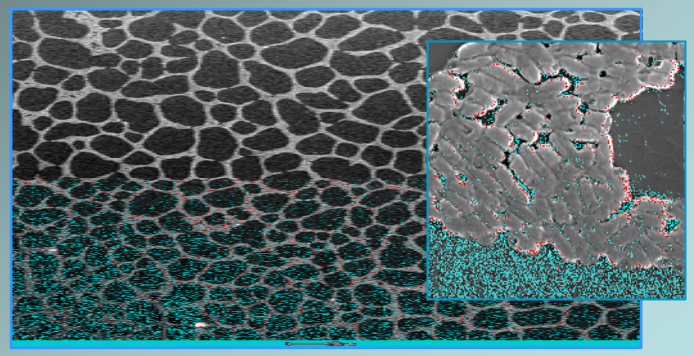
- Biofuels – overall environmental accounting
- North American Carbon Program
- Molecular processes and ecosystem studies
- Climate change – Land Use, ecosystems, water, carbon movement, greenhouse gases

Wetlands: Control the Nitrogen, mobilize the phosphorus? Method to look at nanosites and phosphorus reactions with mixed minerals, microorganisms, varying redox→which wetlands will control both.



Rice production: methane and N2O source? Controlling water and redox potential to minimize GHG release. Efficient production, high yields→methane sink, not source

Physics, water, microorganisms



Dehydration and rehydration: effects on microorganisms, mobility/retention

Salts, pores, soil type, soil structure, virus type→effect on movement and viability of viruses

How and when do colloids/mo's move in unsaturated pores: coffee stain effect, statistics sticking factor, open channel flow, new model

Synchrotron methods, electrons, computed tomography

Advanced Photon source at Argonne National Lab for USAXS, McCarthy

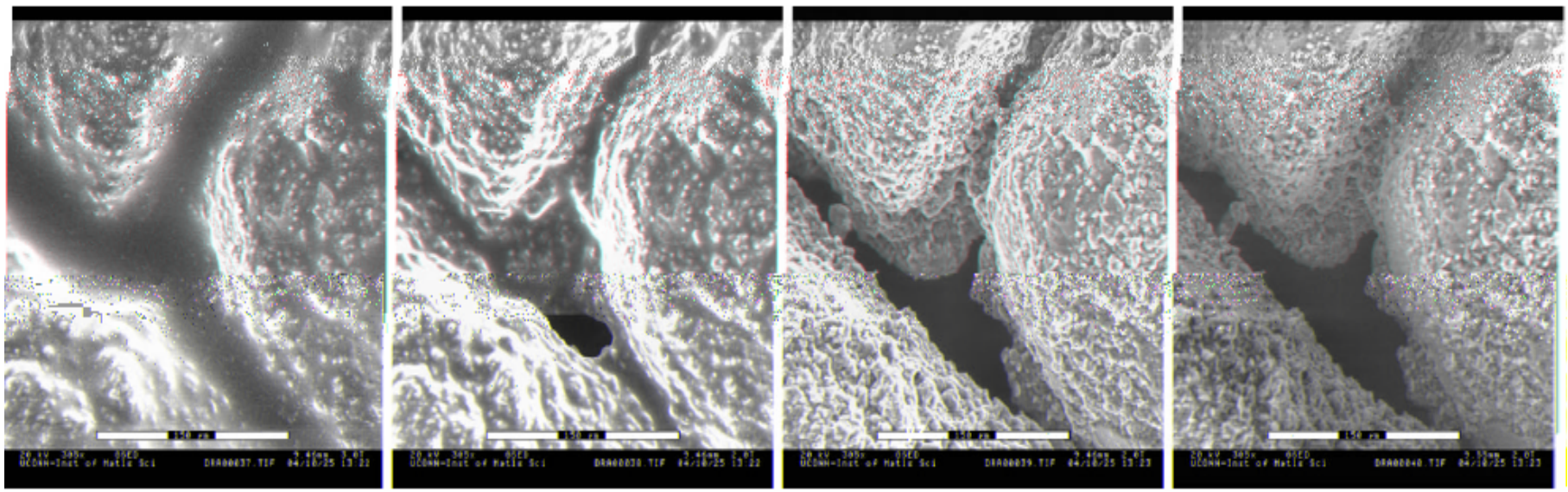


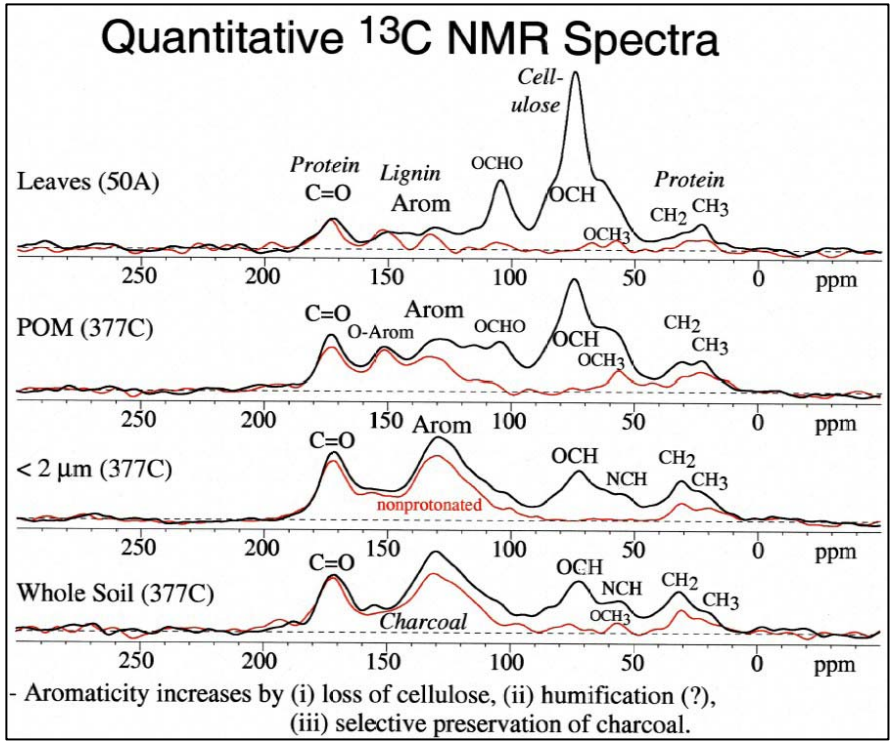
Fig.5: Sequence of ESEM micrographs showing the evolution of a mesopore between sand grains under drying conditions.

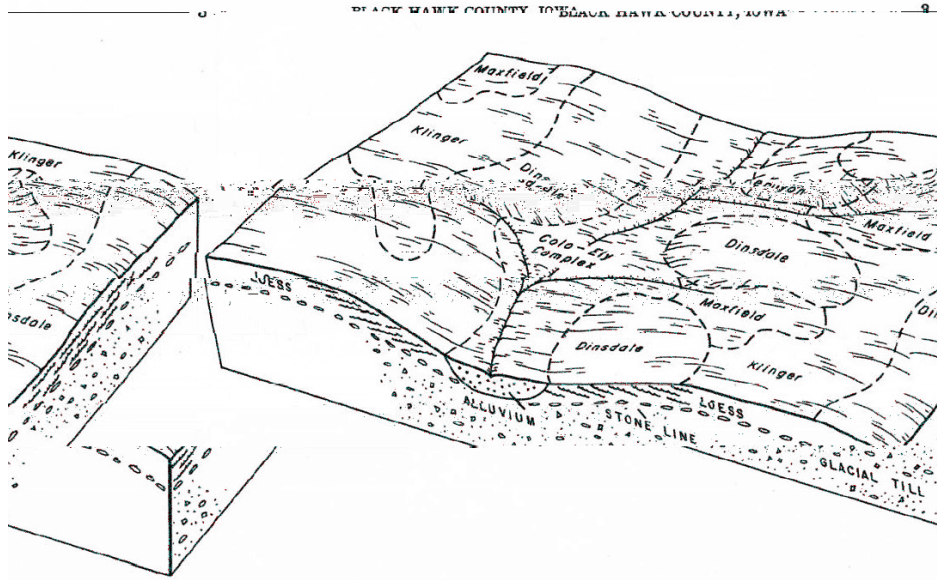
Tuller

Carbon and Nitrogen: Interdisciplinary studies

- Can we sequester C and also provide nutrients? How do Carbon and nitrogen interact? biodiversity, fertilization, increased CO2
- Carbon in coastal wetlands and estuarine soils,
- Physical and chemical fractionations, molecular studies, synchrotron radiation methods, aggregates, pedological studies, isotopes, colloid composition and mobility
- Toward understanding carbon in soil from landscape to microsite and processes that SOM controls.
- Methods developed for looking at these at micro and nanoscales up to landscape and regional scales.

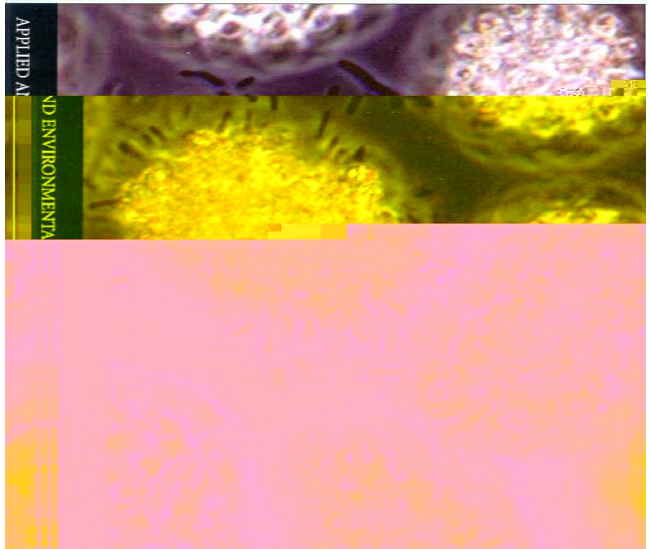
- **Soil aggregates and non-linear build up of resistant soil carbon (McCarthy).**
- **Interactive effects of CO_2 and O_3 (King)**
- **C/N ratio observations→ new understanding of recalcitrant N in soils (Sollins).**
- **Priming effect of roots and litter (Cheng, Lajtha)**
- **Changes due to biofuels production shift (Pierce)**
- **Pedogenic and climatic thresholds in carbon stabilization (Kramer)**
- **Soil Organic Carbon Response to Long-Term Gradual CO_2 enrichment. (Loeke)**





- **Spectroscopic Assessment of Recalcitrant Soil Organic Matter in Iowa Mollisols (Thompson)**
- **Rapid assessment (VNIR) and modeling soil carbon changes across landscapes (Grunwald)**

N fixation, methane oxidation, Quorum sensing in soil conditions, biodegradation, microbial processes



APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Mar. 2005, p. 1291–1299 Vol. 71, No. 30099-2240/05/$08.00_0
doi:10.1128/AEM.71.3.1291–1299.2005
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Rapid Acyl-Homoserine Lactone Quorum Signal Biodegradation (Leadbetter)

Buckley: 15N isotopic labeling of DNA to follow microbial processes
Identified free living methane oxidizers that fix nitrogen: *15N2–DNA–stable isotope probing of diazotrophic, methanotrophs in soil*, Daniel H. Buckley, Varisa Huangyutitham, Shi-Fang Hsu, Tyrrell A. Nelson, In Press, *Soils and Soil Biology*

Soil environments: the rhizosphere, microbial communities, biodiversity,microsite sampling

- Microbial diversity versus plant biodiversity, productivity
- Enhanced biodegradation at microsites, innoculations—patent pending
- Fungal (Pseudomonas, Tricoderma) control of pathogenic bacteria
- Censuses, libraries

(McSpadden-Gardener, Ohio State)

Soil Structure and visualization

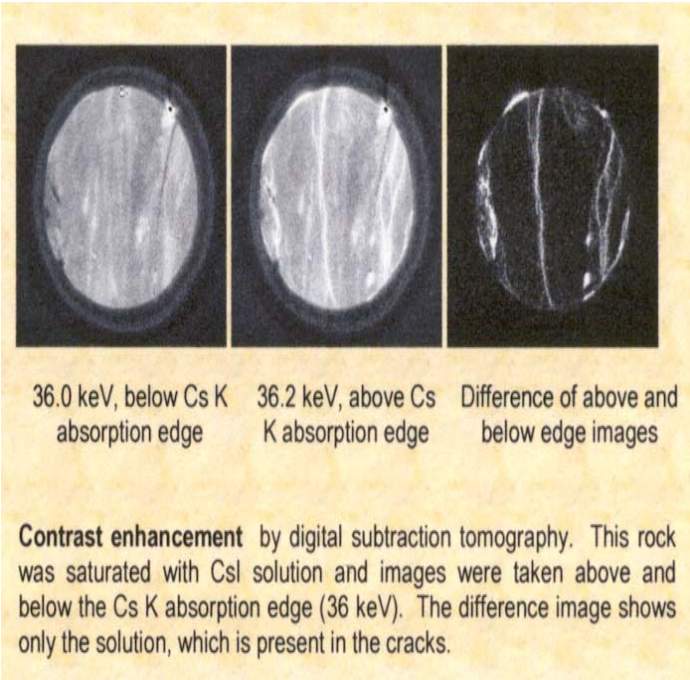


Fig. 2. Taken from the GeoSoil EnviroCARS poster "X-ray Computed Microtomography at the GeoSoil EnviroCARS by M. Rivers, S. Sutton, and P. Eng, (Used by permission).

- X-ray Computed Microtomography to visualize soil pores, 3D imaging,microstructural dynamics, air-water interfaces (Brusseau, Or, Tuller, Jin, Wraith), microsampling (Garcia-Pichel)

- New understanding of the 3D dynamics of pores and interfaces affecting gas exchange, colloid and contaminant transport, sorption, microsite biochemical processes, soil crusts

Projects, global and climate change

- Black Carbon Stocks in Soils of the United, Lehmann, Cornell University
- Assessing the Impacts of Fire & Insect Disturbance on the Terrestrial Carbon Budgets of Forested Areas in Canada, Alaska, & the Western U.S., McGuire, Univ. Alaska
- Carbon Dioxide and Methane Fluxes in Disturbed Southwester Ponderosa Pine Forests, Kolb, N. Ariz. Univ
- CO2 Fluxes Between Agricultural Lands and the Atmosphere: Towards More Complete Accounting by Integrating Remote Sensing with simulation modeling, Ogle, Colorado State Univ.
- Interactive Drivers of Land-Use/Land-Cover Change in Agricultural Areas: Climate and Land Manager Choices, Kling, Iowa State Univ.
- Using Remote Sensing to Assess NRCS impacts on Environmental Quality

National Soil Carbon Network

The National Soil Carbon Network (NSCN) is a multi-component, science-based network that will:

- assemble databases,
- identify and fill gaps in data coverage, and
- through modeling and experimentation provide national spatially-explicit assessments of soil carbon turnover and vulnerability.

The formal network will provide:

- a framework for common scientific protocols and collaborative decision support tools,
- shared scientific and logistical infrastructure,
- products beneficial to stakeholders and scientists,
- shared data and recognition, and
- opportunities for synergistic interactions.

Multi-state projects

- Can lead to spin-off funded projects
- Can serve as preliminary data
- Southern region mineralogy group wants to start a project on interlayered phylosilicate minerals-geographic extent, physical properties range, management implications, interpretation

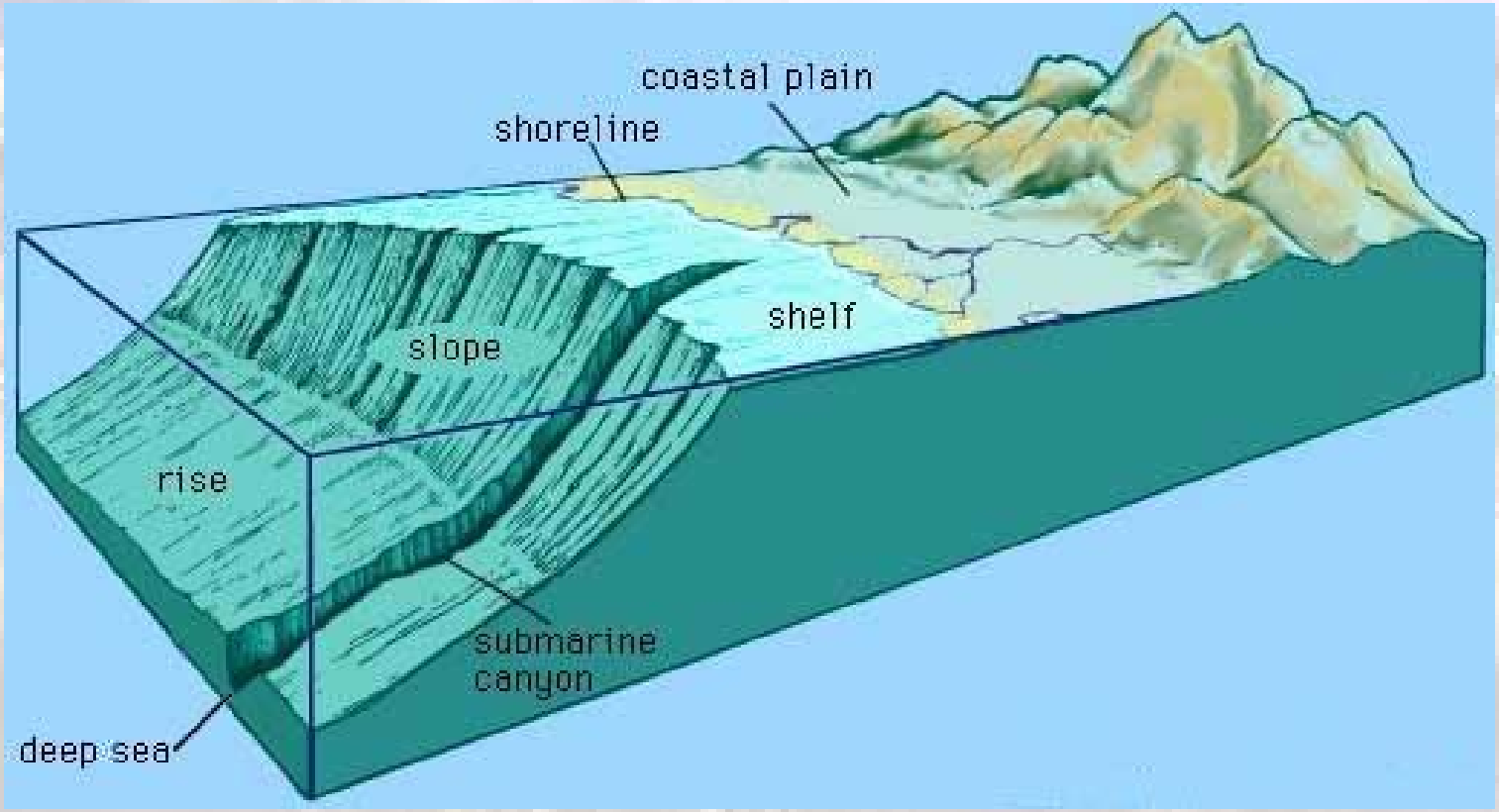
North American Carbon Program: Soil Carbon Storage and dynamics

- Goals:
  - Develop quantitative scientific knowledge, robust observations, and models to determine the emissions and uptake of CO_2, CH_4, and CO, changes in carbon stocks, and the factors regulating these processes
  - Develop the scientific basis to implement full carbon accounting on regional and continental scales.
  - Support long-term quantitative measurements of fluxes, sources and sinks of atmospheric CO_2 and CH_4, and develop forecasts for future trends

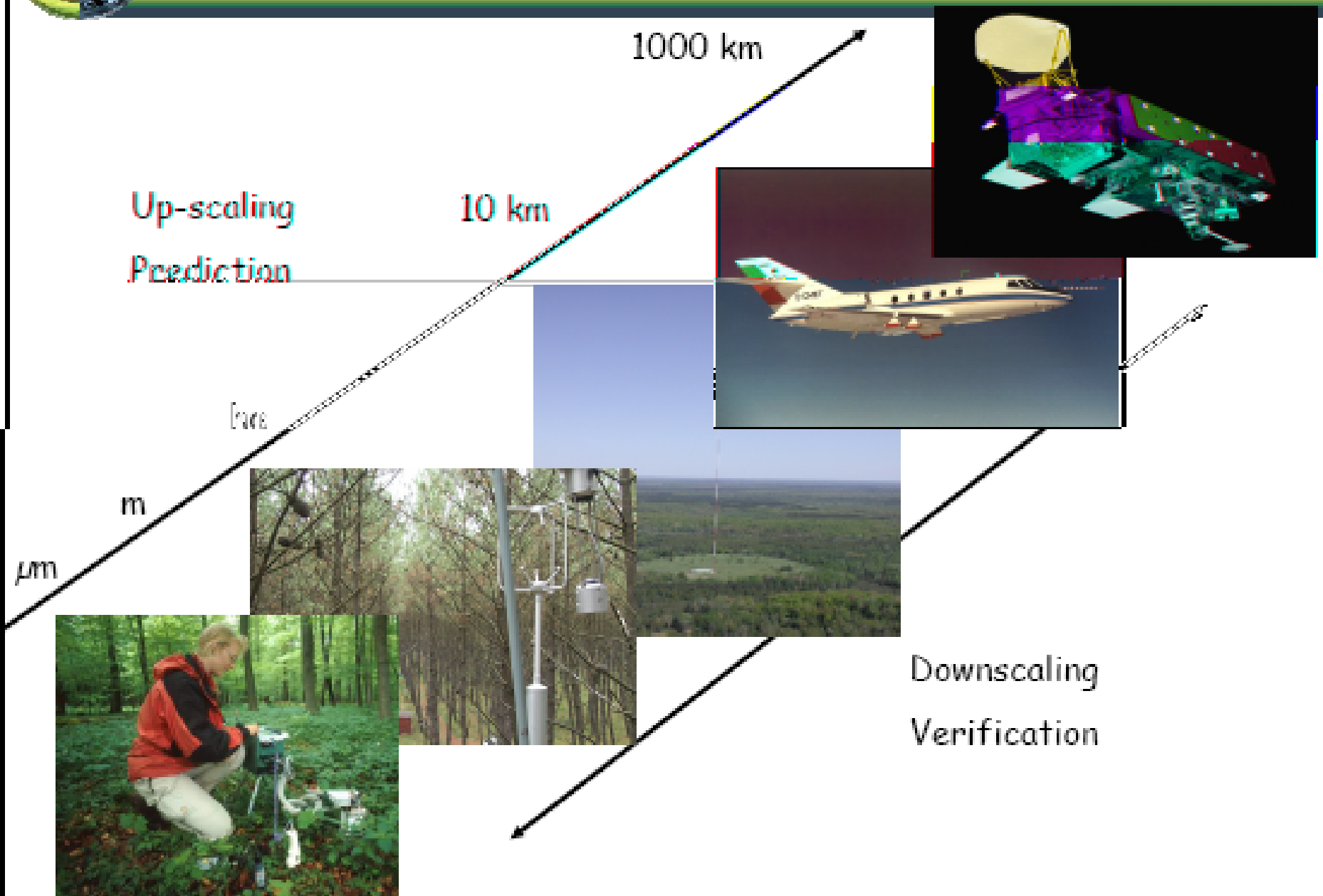
North American Carbon Program: Soil Carbon Storage and dynamics

- Science questions:
  - What is the carbon balance of North America and adjacent oceans? What are the geographic patterns of fluxes of CO_2, CH_4, and CO and how is the balance changing over time? (**diagnosis**)
  - What processes control the sources and sinks of CO_2, CH_4, and CO, and how do the controls change over time? (**processes**)
  - Are there potential surprises (could sources increase, could sinks disappear? (**prediction**)
  - How can we enhance and manage long-lived carbon sinks (sequestration) and provide resources to support decision makers? (**decision support**)

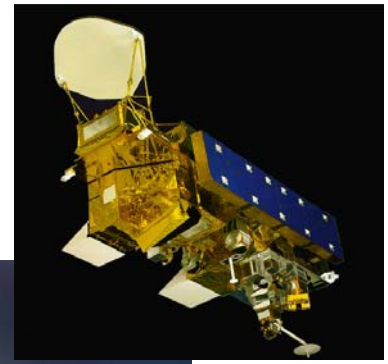
NACP goes to edge of ocean shelf, OCCC goes to shoreline→overlap and check

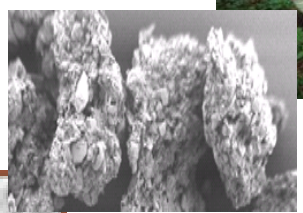


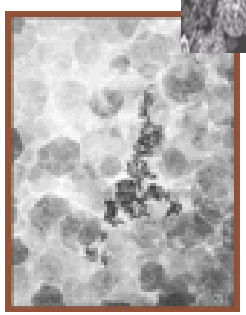
Multiple-Scale Observations and Experiments



Many scientists fail to appreciate the potential of the depth of the soil (including submerged soils) nor the importance of the details of soil processes







Needs/Questions related to soil mineral-organic matter interactions

- Estmates have put the carbon contained in soils at 2/3 to ¾ of the terrestrial carbon stocks
  - How much? Why and how is it being sequestered?
  - Dynamics/processes that control flux from soils--what is the relative importance of chemical and biochemical processes, mineralogy, soil physics, coupled processes?
  - How will changing inputs, land use, temperature, CO_2 affect these dynamics
  - One key to science question 3 (surprises) may be coupling processes—soil processes←→plant responses←→ microbial processes←→ atmospheric processes←→climate/weather←→land management←→soil processes…

Carbon storage and potential for storage –management/land use:

- No till may increase C storage, may decrease it (semi-arid), or may just change the depth distribution
- Rice paddies and wetlands may be sources or may be sinks for CH_4, CO_2, N_2O
- Increased litter deposits may “prime” the forest soil system and increase CO_2 flux out of the soil
- Increased C inputs from roots may prime the decomposition of old soil organic matter (CO2 fertilization→increased SOM decomposition→N and P fertilization→ What will the final C balance be? Will it reach a new equilibrium at higher or lower SOM?
- Does nitrogen play a key role in sequestering carbon by enhancing retention by mineral surfaces?

Department of Energy

- AmeriFlux Network Research
  - Projects = 17
  - Expected Products

Department of Energy

- Atmospheric CO_2 Observations
  - Projects = 5
  - Expected Products
    - Time series atmospheric CO2 and isotopic data (Keeling observations)
    - Virtual ring-of-towers atmospheric CO2 data
    - ARM-CLASIC atmospheric CO2 data set
    - Isotopic data on EC flux and soil CO2 flux from AmeriFlux sites
- Modeling and Analysis
  - Projects = 4
  - Expected Products
    - Integrated carbon budget and sink analysis at different scales
    - Assimilation of ecosystem carbon process data
    - Inverse analysis using MCI CO2 observations and flux

Department of Energy

- FACE Research
  - Projects = 5
  - Expected Products
    - Data sets on physiological carbon transformations and above- and below-ground carbon processes and sinks
    - Extensive observations and data on response of forest ecosystems to CO2 enrichment
    - Modeling and syntheses reports
- Synthesis Research
  - Projects = 2 (West Coast, Eastern US)
  - Expected Products
    - Scaling flux results & integration with biometric & land surface information for estimating regional carbon budget & sink
    - Integration of flux, biometric, remote sensing information for estimating carbon budget & sink - CARBIUS

NASA

Remote Sensing Data Products & Analyses

- Forest Disturbance products for North America (NA)
  - High spatial resolution (Landsat-scale): Masek (LEDAPS & ACCESS); Goward/Cohen/Masek)
  - Moderate spatial resolution: Tucker
- Incident PAR for North America (Liang)
- Freeze-thaw dynamics products for NA (Zhang; McDonald)
- Biomass/carbon stock estimates for NA (Kellndorfer (SRTM); Saatchi)
- ACCESS: Custom MODIS products for NA; temporally and spatially continuous LAI time series now available (Morisette)

Orbiting Carbon Observatory (OCO)

- OCO will measure CO_2 & O_2 globally from space
- Data will be used in tracer transport models to characterize sources and sinks

NASA

Methods, Analyses, Process Studies

- Spatial scaling strategies:
  - RS to extrapolate/interpolate observations from flux tower sites (Ollinger/Hollinger; Rahman; Bolstad/Kolka; Roberts; Kimball/Oechel/McDonald)
- Regional CO2 & CO Budgets (Wofsy; Eluszkiewicz)
- Controls on carbon fluxes (CA: Goulden/Reilly; Insects: Townsend/Sturtevant; Gower)
- Evaluation of lidar-based approaches for carbon stocks (Lefsky; Nelson; Roberts)
- Carbon storage in woody encroachment regions of SW U.S. (Asner; Chopping)
- Fire effects on carbon
  - in boreal NA (Kasischke)
  - in Mexico & U.S. (Hao)

NASA

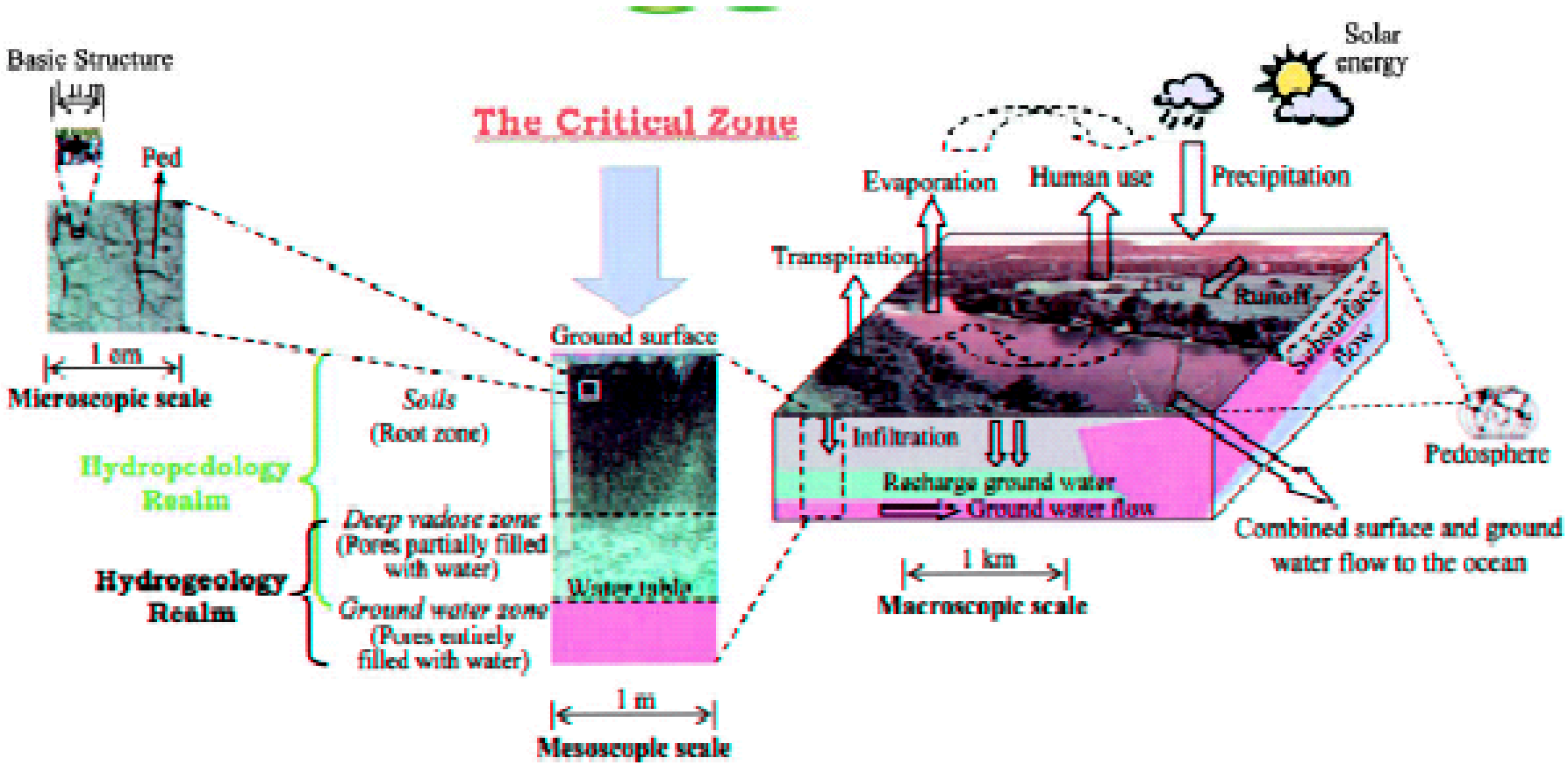
Data Fusion and Modeling

- Thematic data center for modeling and synthesis: assembly and re-formatting of needed data sets; modeling tools (Cook & Thornton)
- Carbon models (Houghton, S. Smith; Tian; Thompson; Collatz)
- Carbon data assimilation approaches (Michalak; Denning; Ojima; Kawa)
- Development and implementation of circulation, biogeochemistry, and carbon cycling models for the U.S. East Coast (Hofmann et al)
- Quantification and assessment of the coastal carbon cycle and related biogeochemical budgets along the tropical, subtropical, and subpolar North American West Coast (McWilliams et al)
- Interfacing of shelf models with climate models

Carbon Management / Decision Support

- Develop decision support tools and assessment framework to estimate NPP and soil organic C stock changes in agricultural lands (Ogle) and carbon stocks in forests (Goward, Birdsey)

NSF


Basic Structure
Ped
1 cm
Microscopic scale
The Critical Zone
Ground surface
Soils
(Root zone)
Hydropedology Realm
Deep vadose zone
(Pores partially filled with water)
Hydrogeology Realm
Ground water zone
(Pores entirely filled with water)
Water table
1 m
Mesoscopic scale
Solar energy
Evaporation
Human use
Precipitation
Transpiration
Runoff
Subsurface flow
Infiltration
Recharge ground water
Ground water flow
1 km
Macroscopic scale
Pedosphere
Combined surface and ground water flow to the ocean

NSF

- The Division of Environmental Biology (DEB) supports a wide range of terrestrial and aquatic carbon cycle research through its Ecosystem Studies Program. While funds are not specifically targeted to carbon cycle research, a rough estimate is that 50% of the annual budget of the Ecosystems Studies Program ($18 M) supports carbon cycle-related research.

- Carbon cycle research is also supported in other programs in the Biology Directorate, including Microbial Interactions and Processes, and Organism-Environment Interactions

- The NSF-wide Dynamics of Coupled Natural and Human Systems (CNH) competition promotes quantitative, interdisciplinary analyses of relevant human and natural system processes and complex interactions among human and natural systems at diverse scales. This program should be relevant to NACP investigators interested in Decision Support. The next deadline is December 13, 2007 and ~$9M is committed, including support from USDA/FS.

Agricultural Research Service

- **Continue building national data base of C storage for cropland and rangeland. Make data base publicly accessible (2009).**
- **Evaluation & comparison of GRACEnet models (CQESTR, EPIC-Century, CSM, ecosys, GLYSIM< DAYCENT, RSWQM), IPCC methodology, possible other methodologies (Soil Conditioning Index) for overall performance on data from GRACEnet sites.**
- **Decision support systems for reducing GHG intensity completed and tested in selected GRACEnet sites of cornbelt**
- **Technologies for mapping C fluxes (including crop residue) and soil carbon sequestration at local and regional scales**

USDA – Agricultural Research Service

- **May 2008 Global Change National Program Customer/Stakeholder and Assessment Workshop to set next 5 year research agenda**
- **Greenhouse gas Reduction through Agricultural Carbon Enhancement (GRACEnet) at 29 locations (crop land and rangeland) across US continuing with model development/validation**
- **Collaborations with NASA on mapping C fluxes and soil carbon sequestration at local and regional scales, and decision support systems development**
- **C measurement technologies continuing (hyperspectral for crop residue; spectroscopic for soil C)**