# Soil Organic Carbon Observatory:

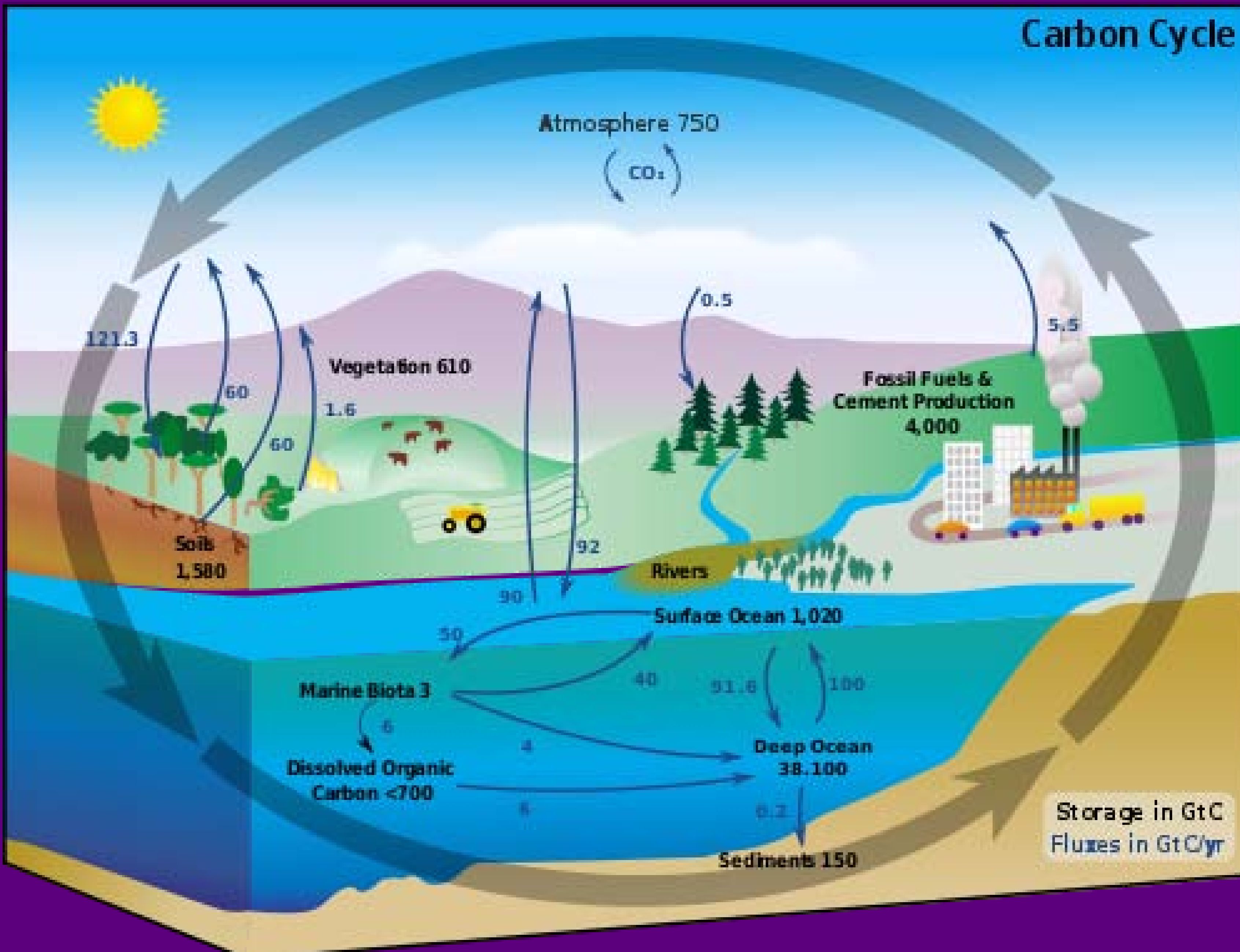
## Combined Imaging Spectrometry, Modeling and Ground Measurement for Assessing Changes in Soil Organic C


**Charles W. Rice**

**University Distinguished Professor**

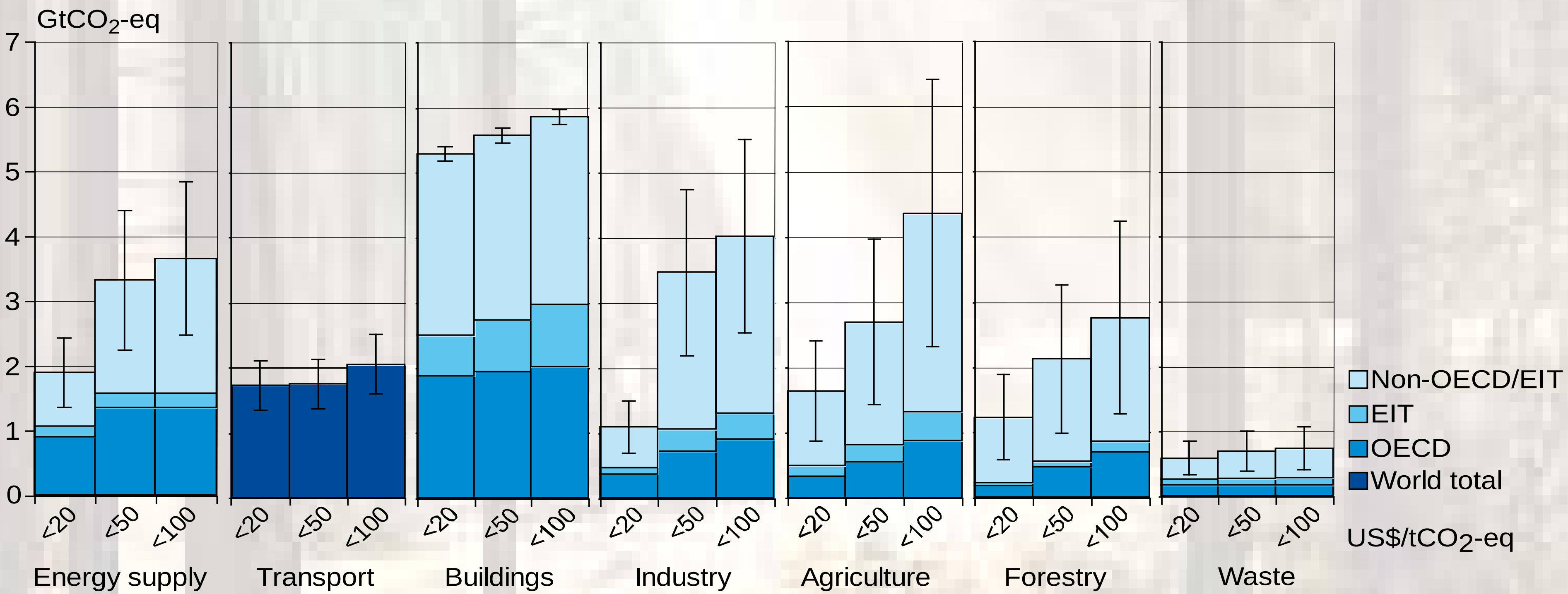
**Department of Agronomy**


***K-State Research and Extension***



Carbon Cycle
Atmosphere 750
$CO_2$
121.3
60
60
1.6
Vegetation 610
0.5
5.5
Fossil Fuels &
Cement Production
4,000
Soils
1,580
92
90
Rivers
Surface Ocean 1,020
50
40
91.6
100
Marine Biota 3
6
4
Dissolved Organic
Carbon <700
6
Deep Ocean
38.100
0.2
Sediments 150
Storage in GtC
Fluxes in GtC/yr

# Global economic mitigation potential for different sectors at different carbon prices



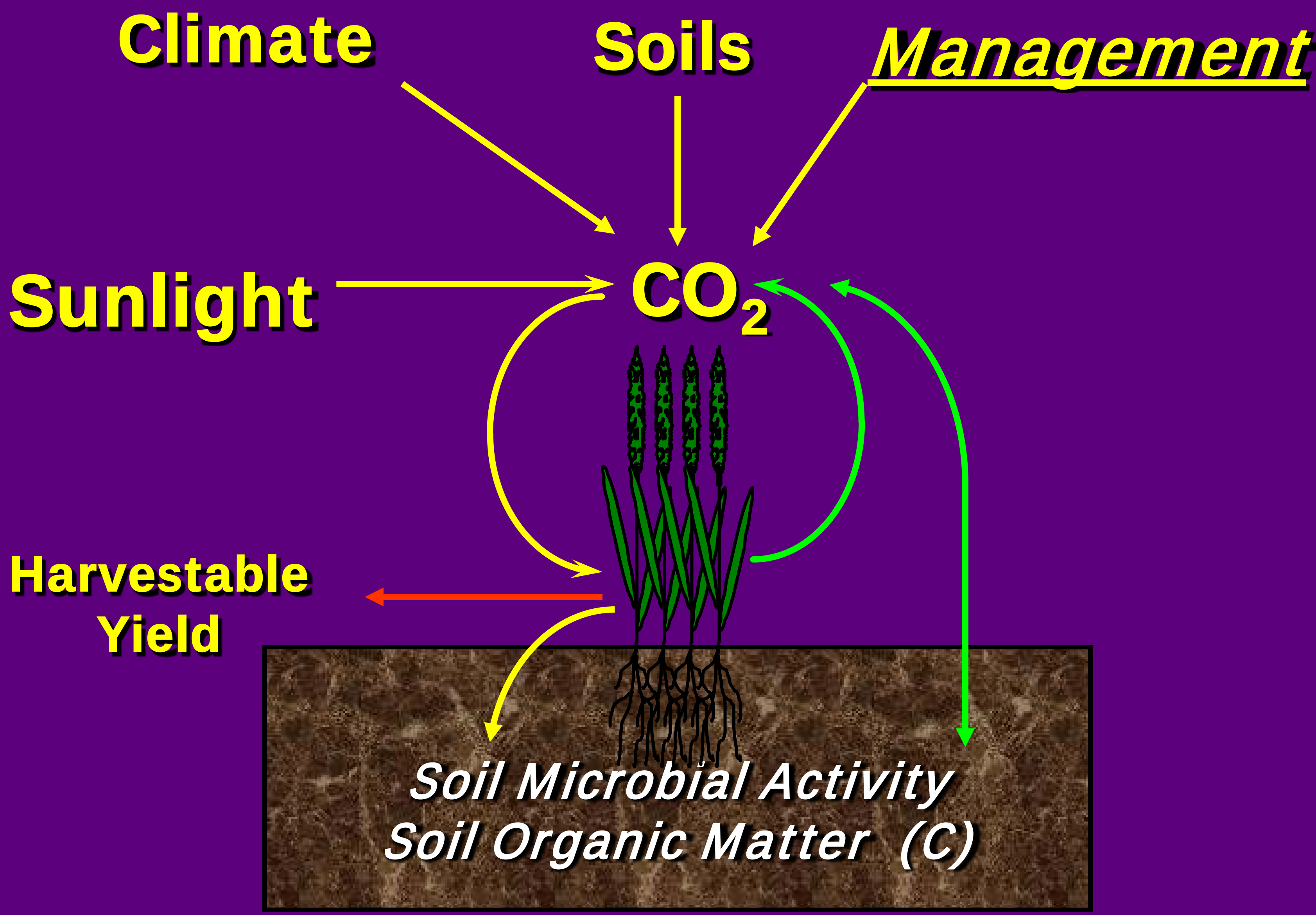

IPCC, 2007

# Agriculture

- A large proportion of the mitigation potential of agriculture (excluding bioenergy) arises from soil C sequestration, which has strong synergies with sustainable agriculture and generally reduces vulnerability to climate change.

- Agricultural practices collectively can make a significant contribution at low cost
  - By increasing soil carbon sinks,
  - By reducing GHG emissions,
  - By contributing biomass feedstocks for energy use

- ***There is no universally applicable list of mitigation practices; practices need to be evaluated for individual agricultural systems and settings***



Climate
Soils
Management
Sunlight
$CO_2$
Harvestable Yield
Soil Microbial Activity
Soil Organic Matter (C)

# **Many** opportunities for GHG mitigation!

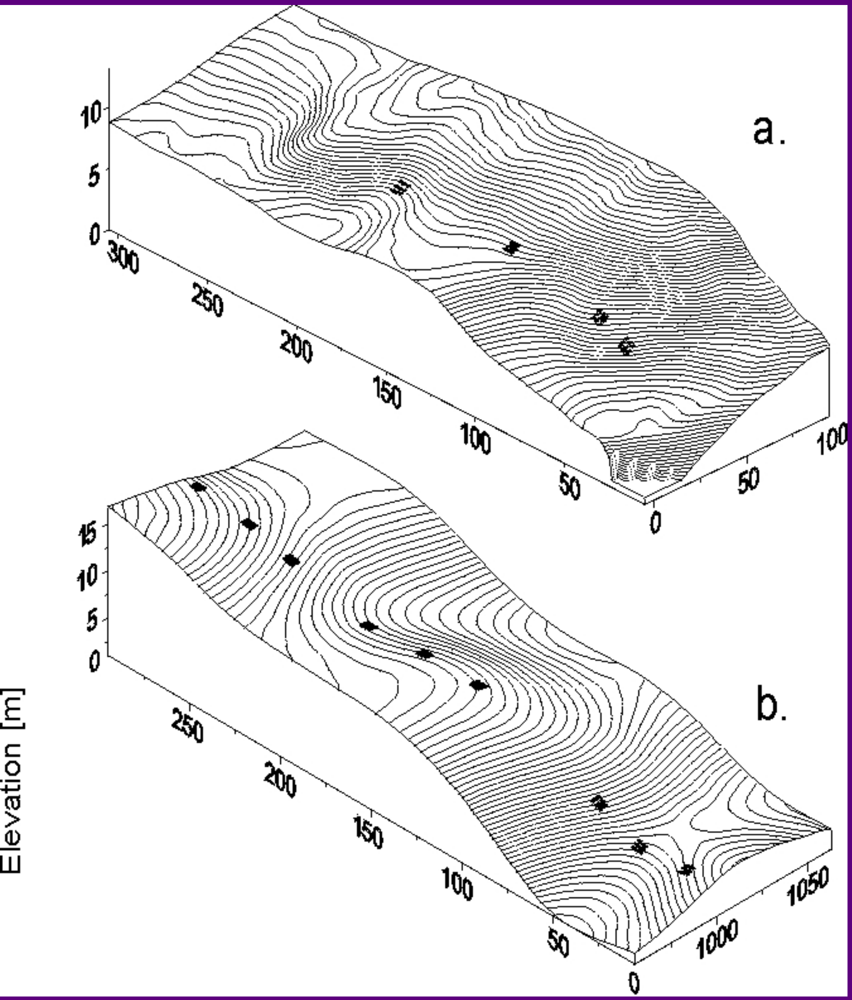
## Cropland

- Reduced tillage
- Rotations
  - Reduced bare fallow
  - Increased intensity
- Cover crops
- Fertility management
  - Nitrogen use efficiency
- Water management
  - Irrigation management

# Traditional Assessment of Soil C

- Soil C analysis accurate
- Soil Sampling
  - Labor intensive
  - Time consuming
  - Landscape variation
  - Scaling issues
- Bulk density measurements highly variable

# Sampling strategies:  account for variable landscapes

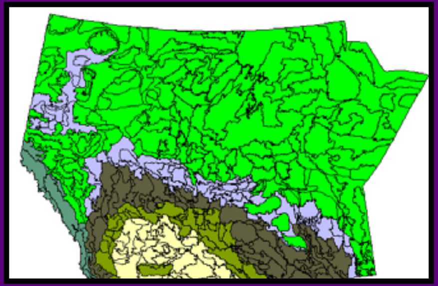



- Landscape modifications affect many processes
  - Cycling of water, carbon and nitrogen
  - Heat exchange between the land and the atmosphere
  - Lateral transport of soil by wind and water
  - Rate and extent of physical, chemical, and biological soil reactions

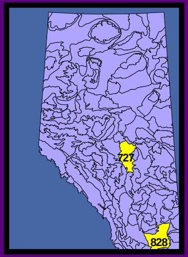

# Upscaling from sites to regions across time

Time arrow

Databases, remote observations

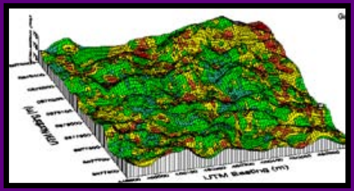


$10^{12}$ m$^2$




$10^9$ m$^2$

Experiments



$10^6$ m$^2$

$10^3$ m$^2$

$10^1$ m$^2$

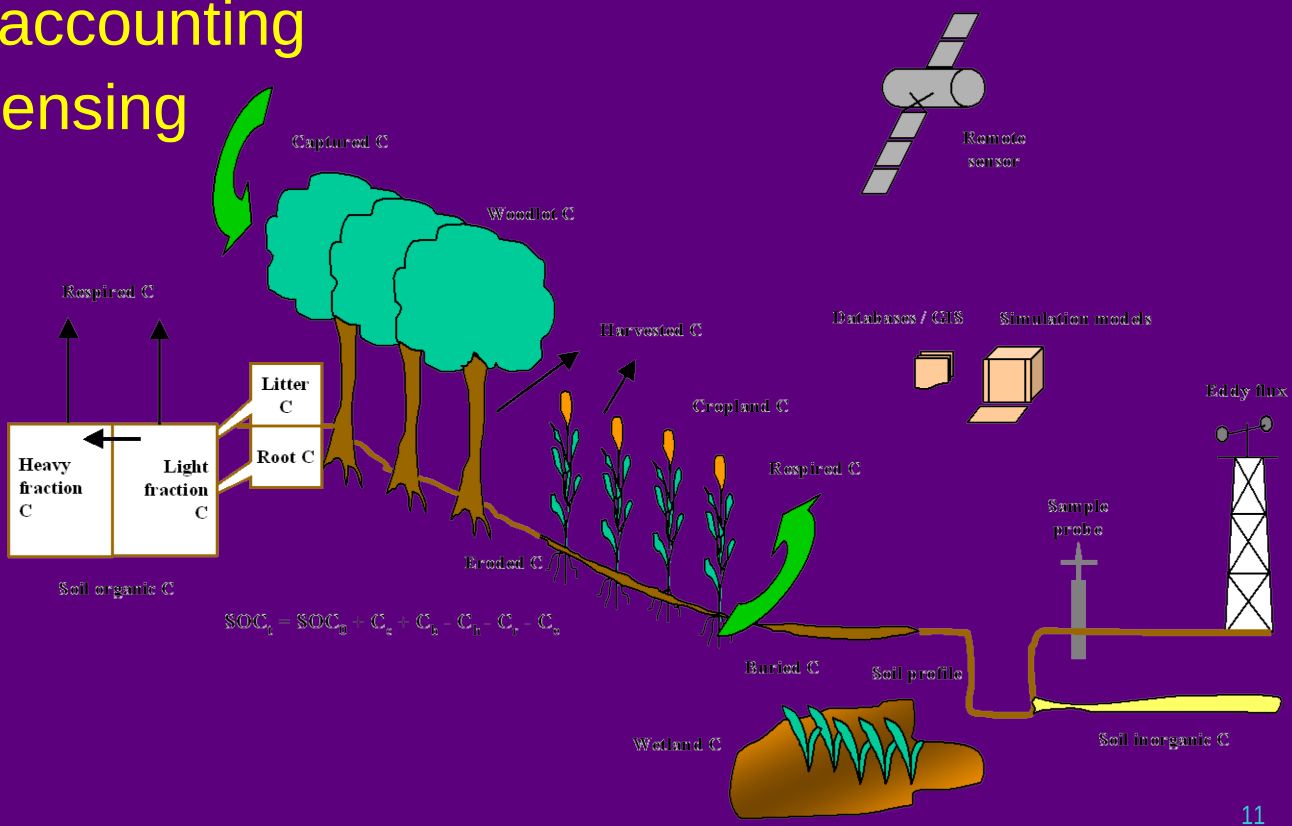
$10^{-6}$ m$^2$

Simpler models, metamodels?

Process models, landscape models

# Measurement, Monitoring and Verification

- Methods for detecting and projecting soil C changes
  - Direct methods
    - Field measurements
  - Indirect methods
    - Accounting
      - Stratified accounting
      - Remote sensing
      - Models

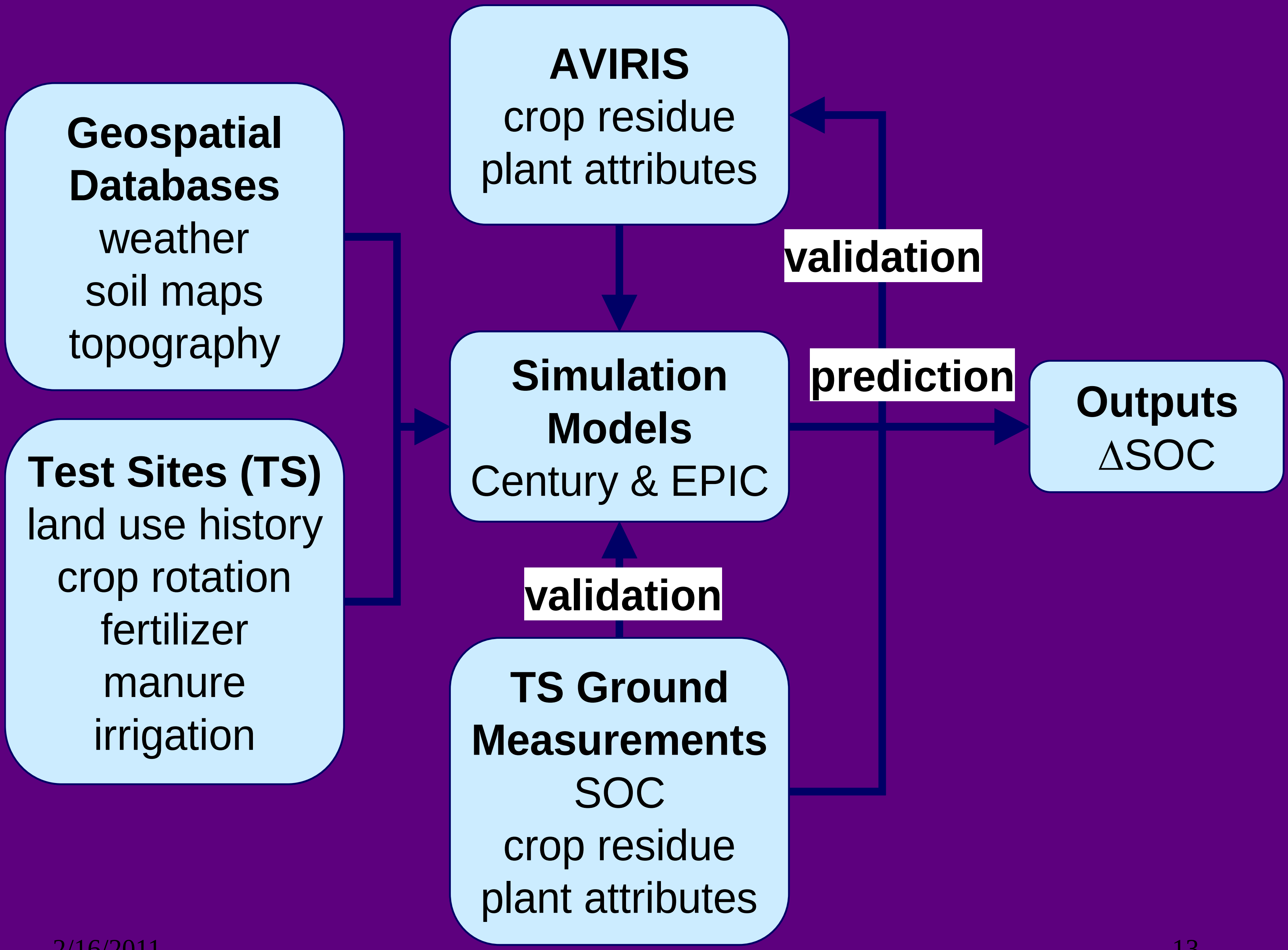



Post et al. (2001)

# Soil Organic Carbon Observatory

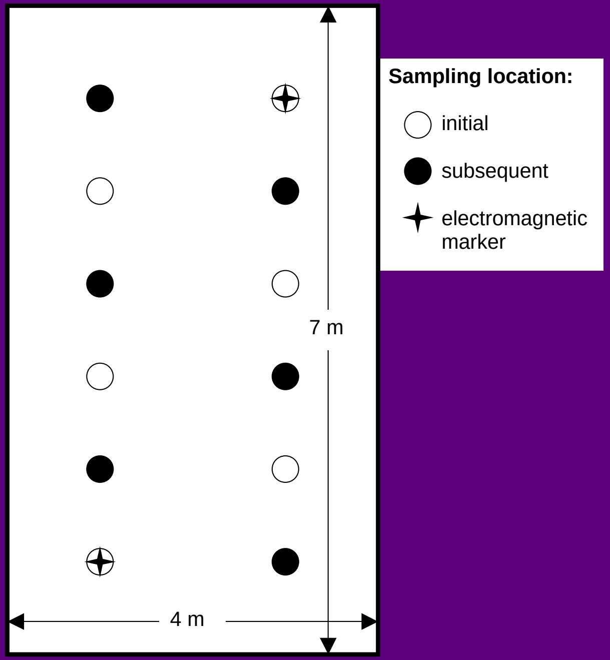
- Quantify regional SOC changes at the resolution of individual agricultural management units for diverse environmental conditions and cropping systems.

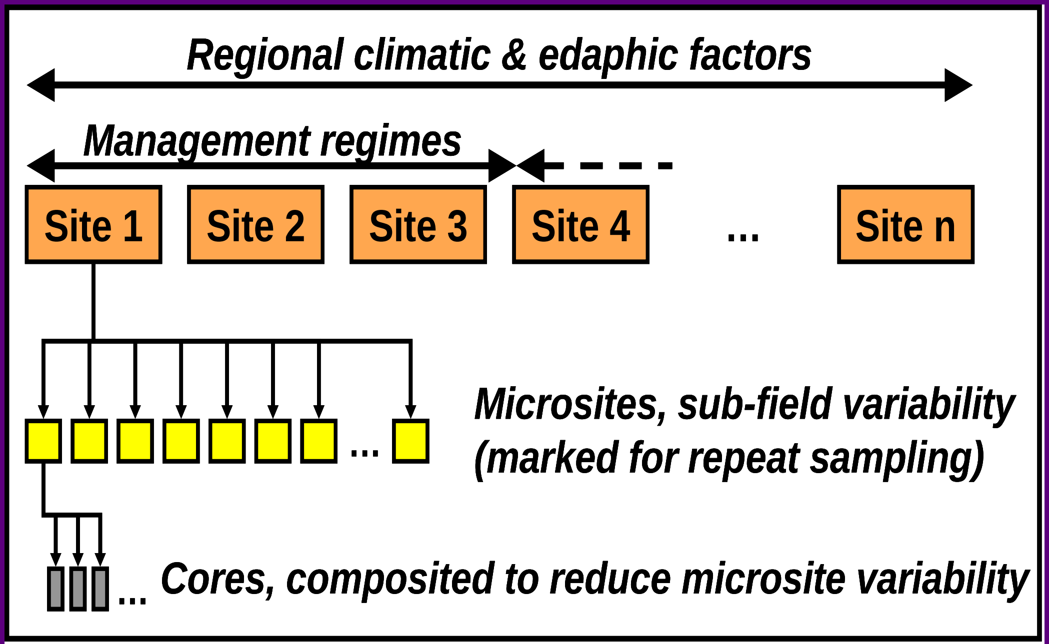
- Evaluate the relative contributions of management factors, environmental conditions, and cropping systems for SOC changes.


AVIRIS
crop residue
plant attributes
Geospatial Databases
weather
soil maps
topography
validation
Simulation Models
Century & EPIC
prediction
Outputs
ΔSOC
Test Sites (TS)
land use history
crop rotation
fertilizer
manure
irrigation
validation
TS Ground Measurements
SOC
crop residue
plant attributes

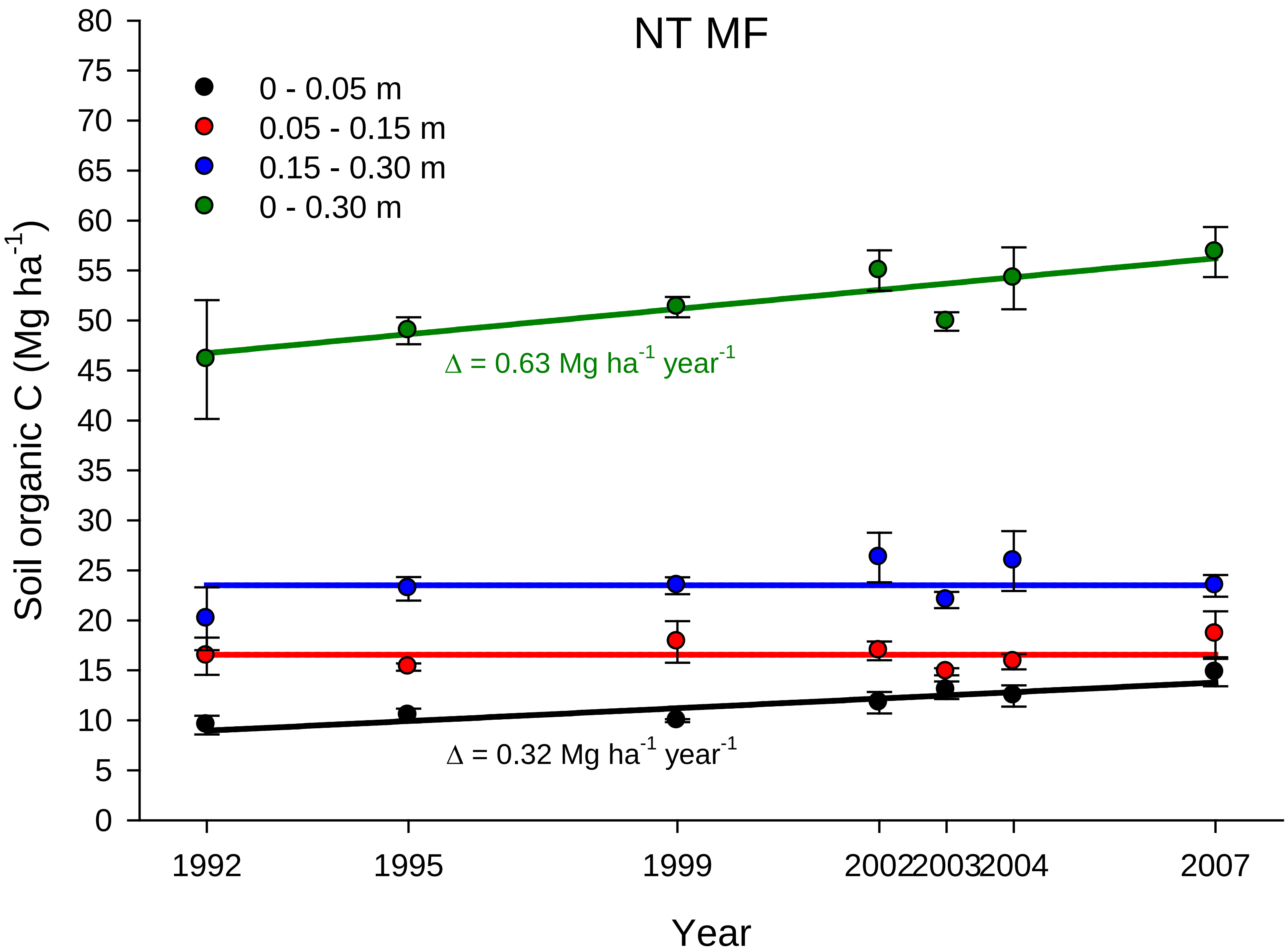
# Geo-reference microsites

- Microsites reduces spatial variability
- Simple and inexpensive
- Used to improve models
- Used to adopt new technology
- Soil C changes detected in 3 yr
  - 0.71 Mg C $ha^{-1}$ – semiarid
  - 1.25 Mg C $ha^{-1}$ – subhumid



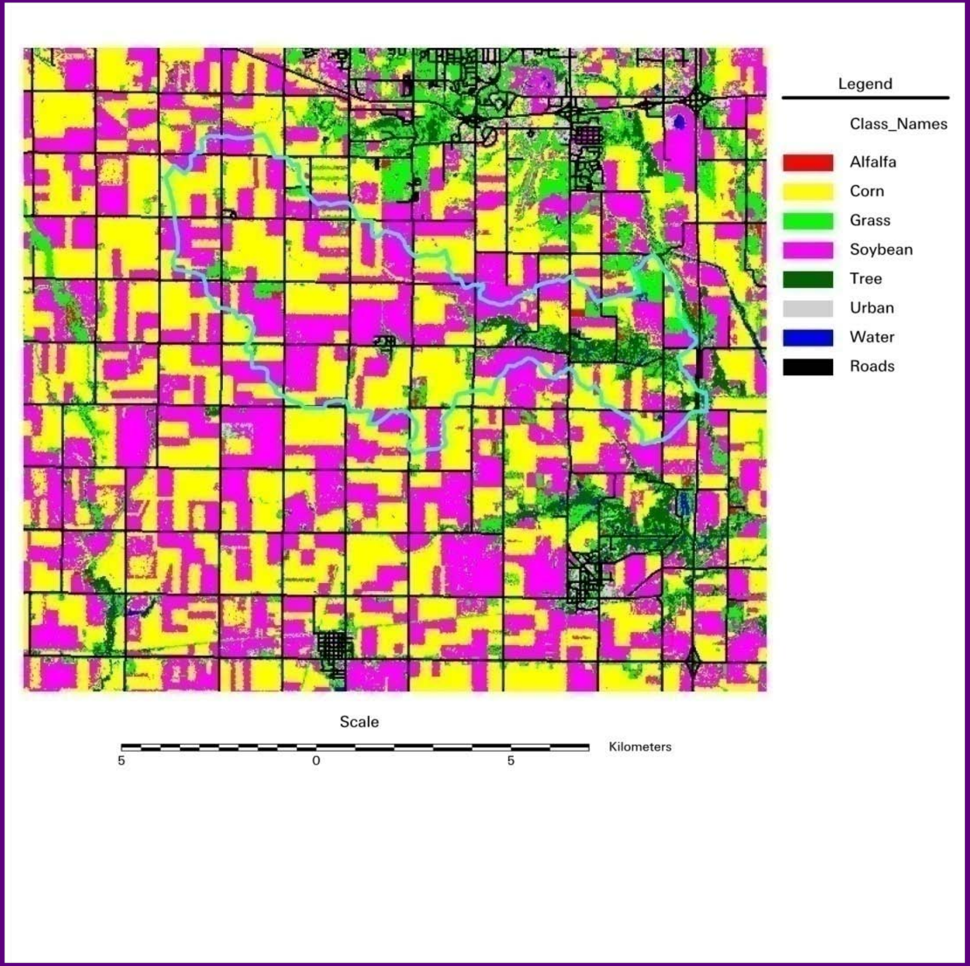




Ellert et al. (2001)

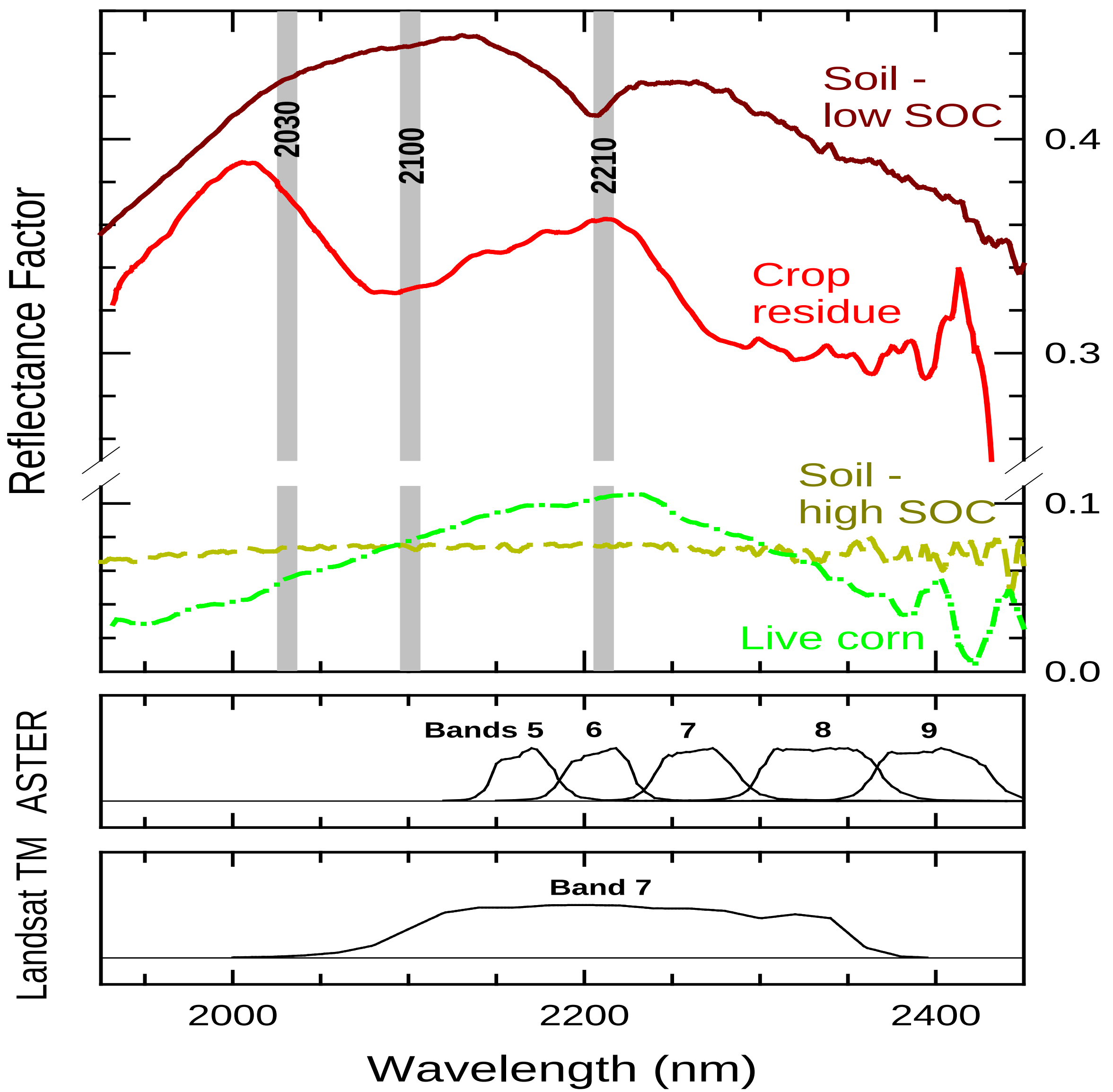

NT MF
0 - 0.05 m
0.05 - 0.15 m
0.15 - 0.30 m
0 - 0.30 m
Δ = 0.63 Mg ha-1 year-1
Δ = 0.32 Mg ha-1 year-1
Soil organic C (Mg ha-1)
Year
1992
1995
1999
2002
2003
2004
2007
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80

# Remote Sensing and Carbon Sequestration

- Remote sensing cannot be used to measure soil C directly unless soil is bare.
- Remote sensing useful for assessing:
  - Vegetation
    - Type
    - Cover
    - Productivity
  - Water, soil temperature
  - Tillage intensity




Crop identification for spatial modeling. Courtesy: P Doraiswamy, USDA-ARS, Beltsville, MD




Reflectance spectra of corn, low- and high-SOC soils, and crop residue in the shortwave infrared region showing the cellulose absorption feature at 2100 nm wavelength. Shown in the bottom two panels are the wavebands for NASA ASTER and Landsat Thematic Mapper indicating these sensors can not be used to estimate crop residue. Serbin, *et al.* (in press).

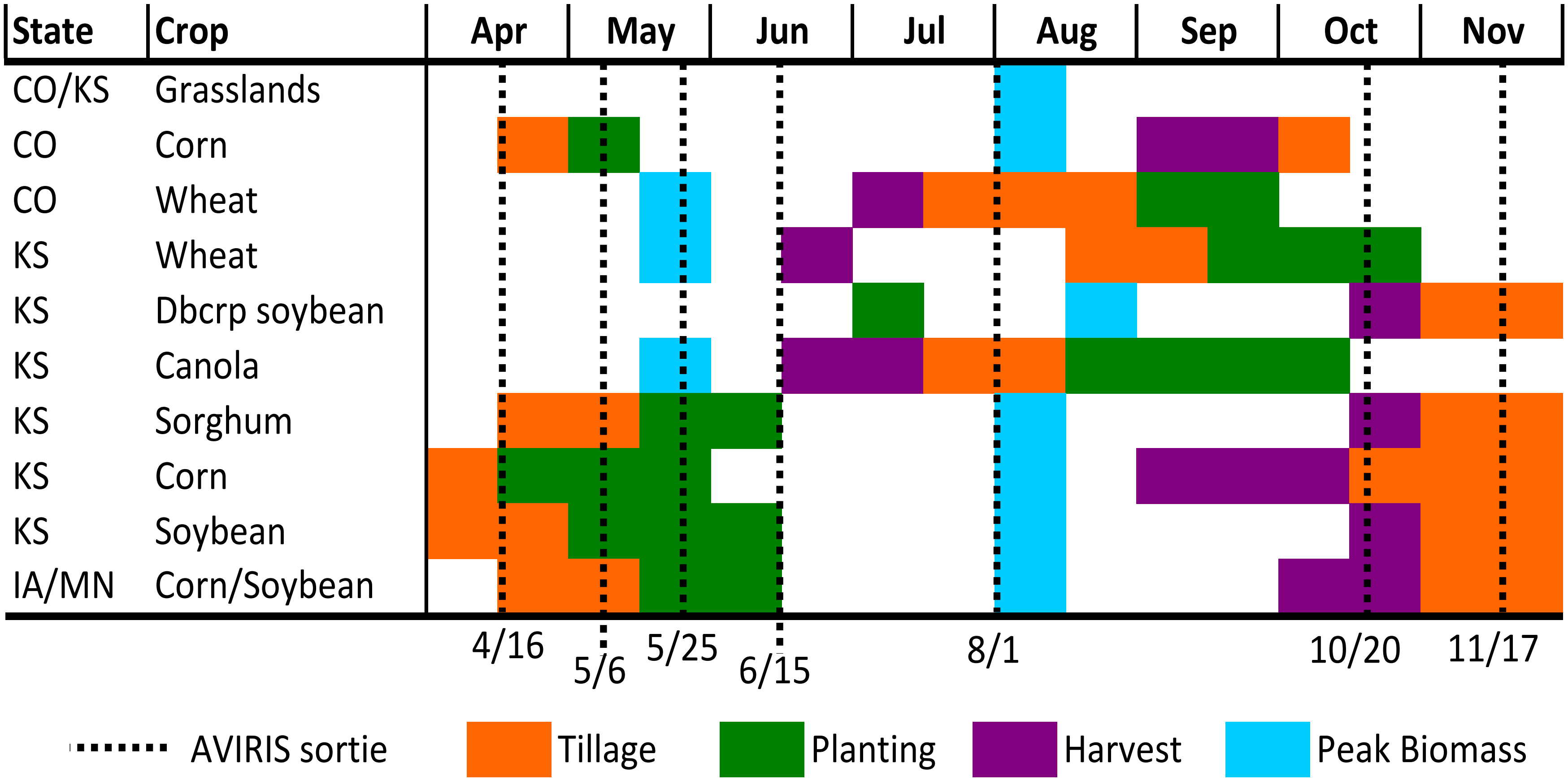
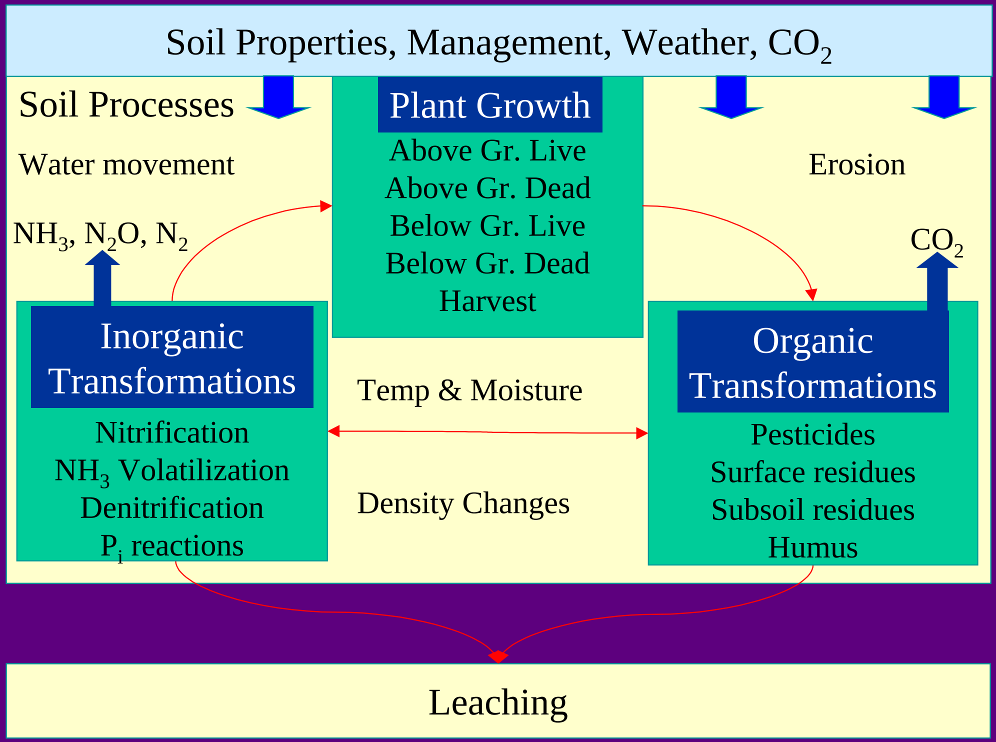



**Figure 2.1-2.** Key crop growth and management events are captured with seven targeted AVIRIS surveys per year. Critical times include: (a) post spring tillage or spring residue if no tillage; (b) post crop emergence, after planting; (c) peak biomass; (d) post harvest; and (e) post following fall tillage.

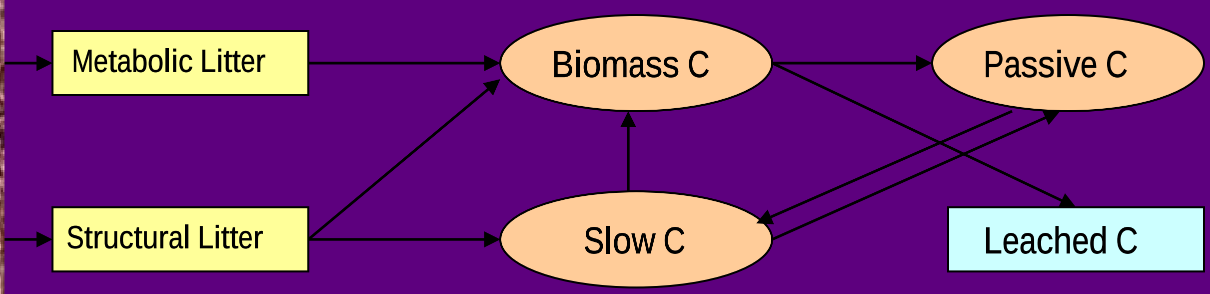
# Terrestrial ecosystem models

- Century
  - Century
  - DayCent
  - C-STORE
- EPIC
  - EPIC
  - APEX

## Processes and drivers




## Carbon and nitrogen flows

# Summary

- Provides template to quantify changes in soil C that support implementation of agricultural GHG mitigation strategies.
- Provides methodology for operational GIS and carbon models functional at field to regional scales.
- Provides a framework useful to land managers and policymakers on how to manage agro-ecosystems for maximum profitability at the farm level, maintaining food security, protecting natural resources and mitigating GHG emissions

# SOCO Team

- Management
  - Charles W. Rice, KSU
  - David I. Brown, JPL
  - Keith Paustian, CSU
  - Oh-ig Kwoun, JPL
  - Rob Green, JPL
  - Michael Eastwood, JPL
  - Bonny L. Schumaker, JPL
- Science Team
  - Charles Rice, Kansas State University
  - Keith Paustian, Colorado State University
  - Robert O. Green, JPL
  - Douglas Archibald, Penn State University
  - David J. Brown, Washington State University
  - E. Raymond Hunt, USDA Agricultural Research Service
  - Cesar Izaurralde, DOE Pacific Northwest National Laboratory
  - Kyle McDonald, JPL
  - Heather McNairn, Agriculture and Agri-Food Canada
  - Stephen Ogle, Colorado State University
  - Alain Plante, University of Pennsylvania
  - Kevin Price, Kansas State University
  - Guy Serbin, USDA Foreign Agricultural Service
  - Tristram West, DOE Pacific Northwest National Laboratory

Chuck Rice
Phone: 785-532-7217
Cell: 785-587-7215
cwrice@ksu.edu

- Websites

  www.soilcarboncenter.k-state.edu/

**_K-State Research and Extension_**