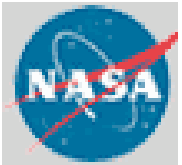
LAND USE AND SEASONAL GREEN VEGETATION COVER OF THE CONTERMINOUS USA FOR USE IN NUMERICAL WEATHER MODELS

Kevin Gallo, NOAA/NESDIS/Office of Research & Applications

Tim Owen, NOAA/NCDC

Brad Reed, SAIC/EROS Data Center



SATELLITE-DERIVED LAND USE AND SEASONAL GREEN VEGETATION COVER OF THE CONTERMINOUS USA FOR USE IN NUMERICAL WEATHER MODELS

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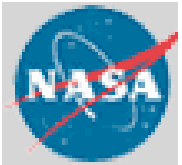


Historical Aspects of Data Used in Numerical Models

Key factors: data/instruments
science of data assimilation
computer and communications capacity

1960	**1990**	2000	**2002**
• Insitu data	• **Limited use of derived sounding data in models**	• Satellite radiances ~85 % of data in models	• **Satellite radiances ~97% of data**
	• All LEO	• Nearly all LEO	• Predominantly LEO; some GEO
	• 250K obs/day	• 1 million obs/day	• 95 million obs/day
	• Atmosphere	• Surface/ocean atmosphere	• Surface/ocean atmosphere

Alternate Title/Initial Question: Should land cover classes and associated information be aggregated for use in Numerical Weather Models?

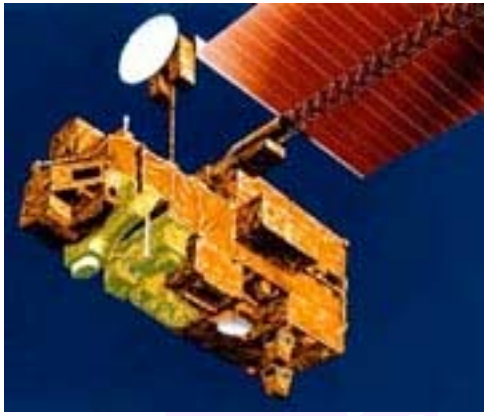
Introduction

Land Use/Land Cover

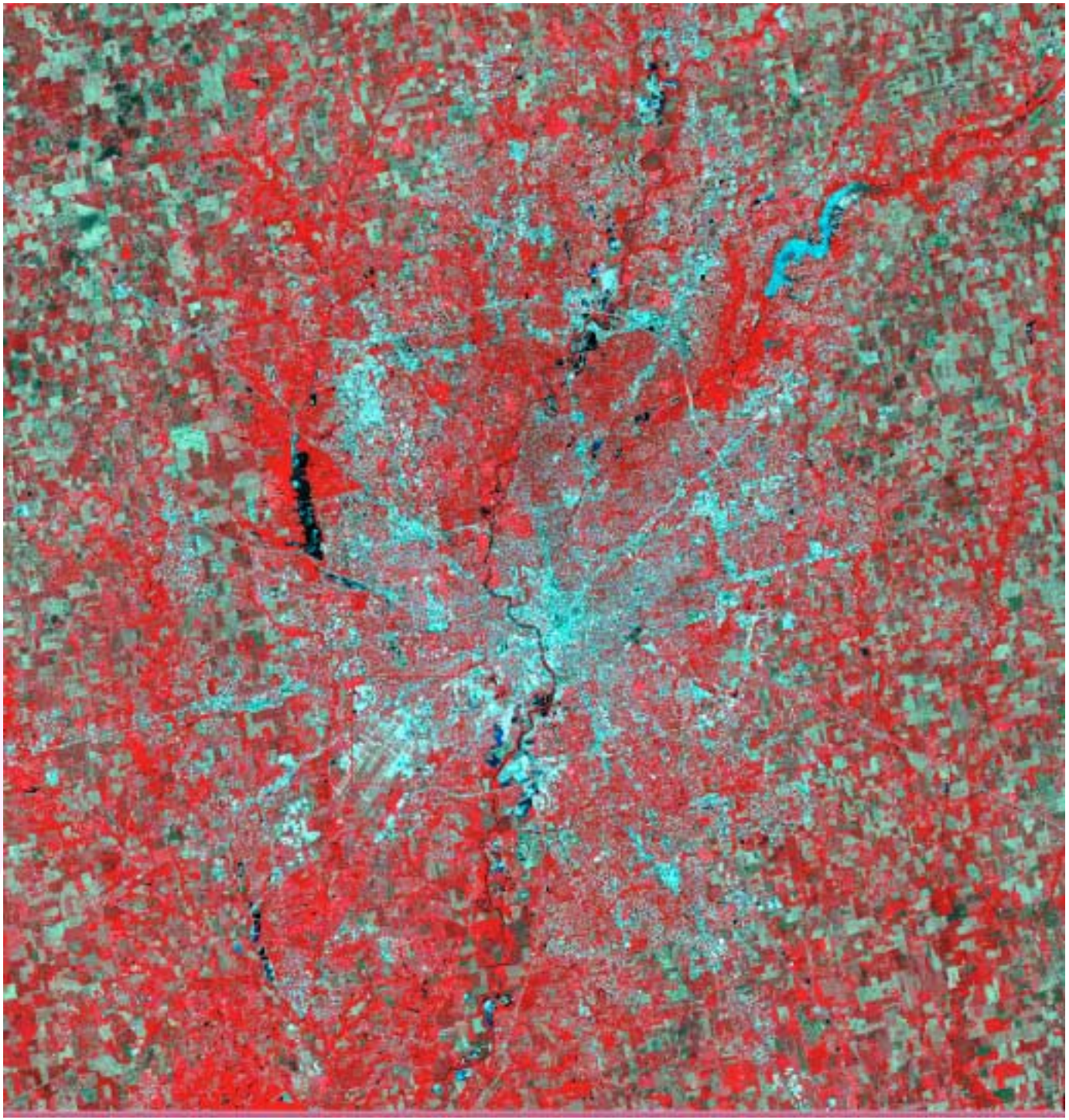
Season changes in Land Cover

Introduction

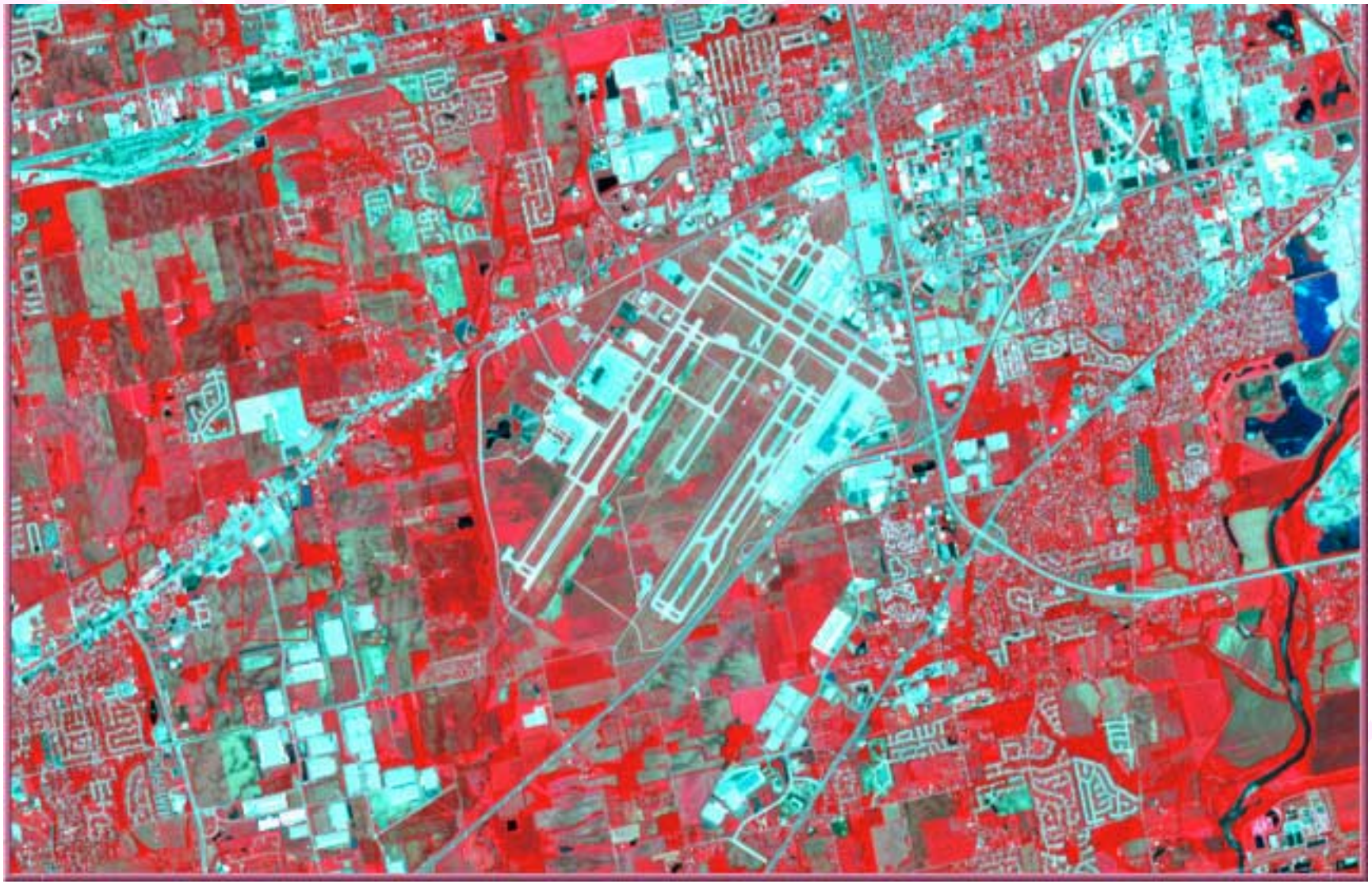
What is land surface contribution to energy budget/weather?

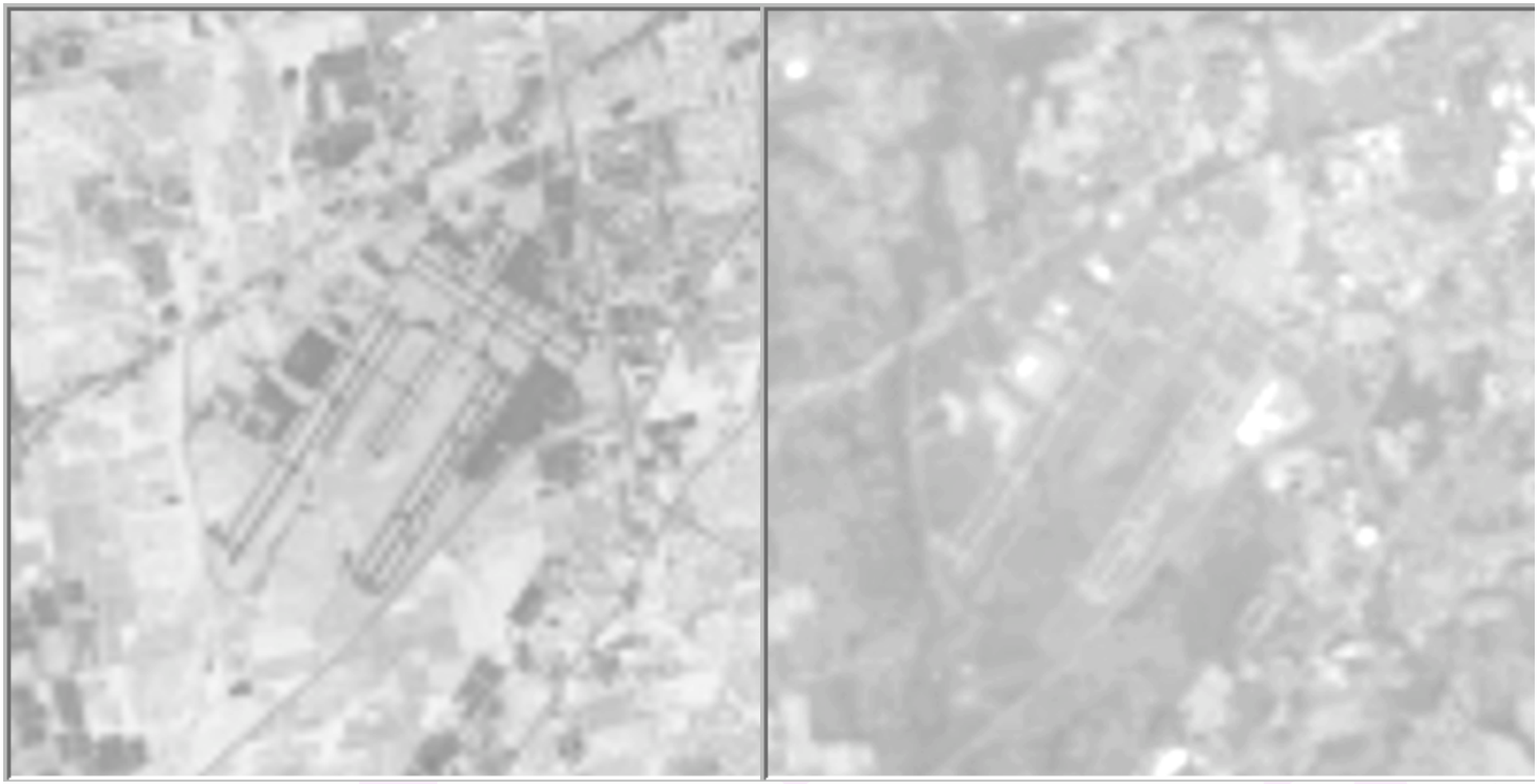


Indianapolis ASTER image acquired 16 June 2001



Simulated color-IR of Indianapolis airport (from ASTER data).



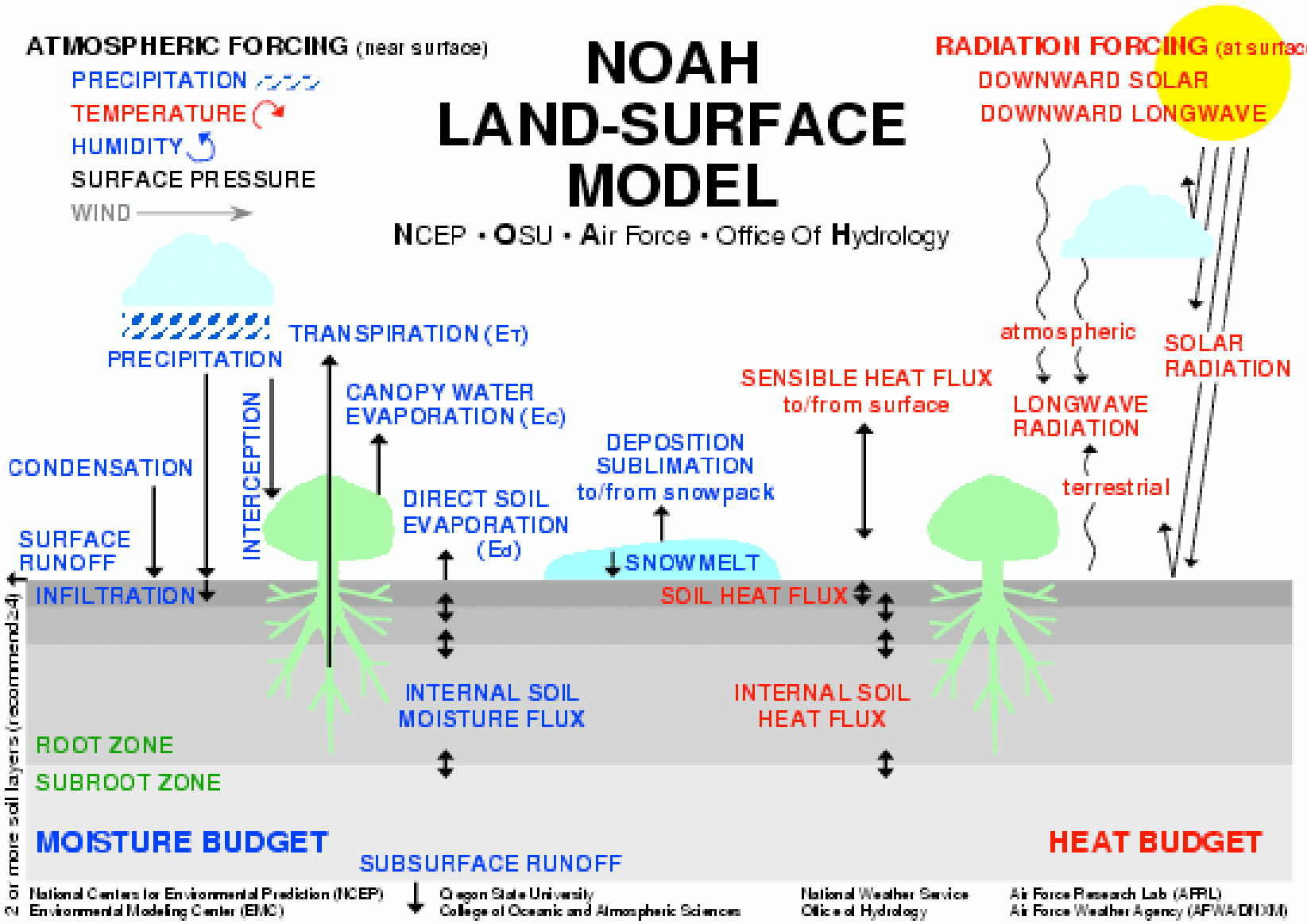


NDVI

Radiant Surface Temperature

NOAH LAND-SURFACE MODEL

NCEP • OSU • Air Force • Office Of Hydrology



National Centers for Environmental Prediction (NCEP)
Environmental Modeling Center (EMC)

Oregon State University
College of Oceanic and Atmospheric Sciences

National Weather Service
Office of Hydrology

Air Force Research Lab (AFRL)
Air Force Weather Agency (AFWA/DNXM)

STATE VARIABLES

- SKIN TEMPERATURE
- SOIL TEMPERATURE
- SOIL WATER
- SOIL ICE
- CANOPY WATER
- SNOW WATER
- SNOW DENSITY

SURFACE PARAMETERS

- VEGETATION TYPE
- GREEN VEGETATION FRACTION
- SOIL TEXTURE
- ROUGHNESS
- ALBEDO
- SLOPE FACTOR

RATIONALE

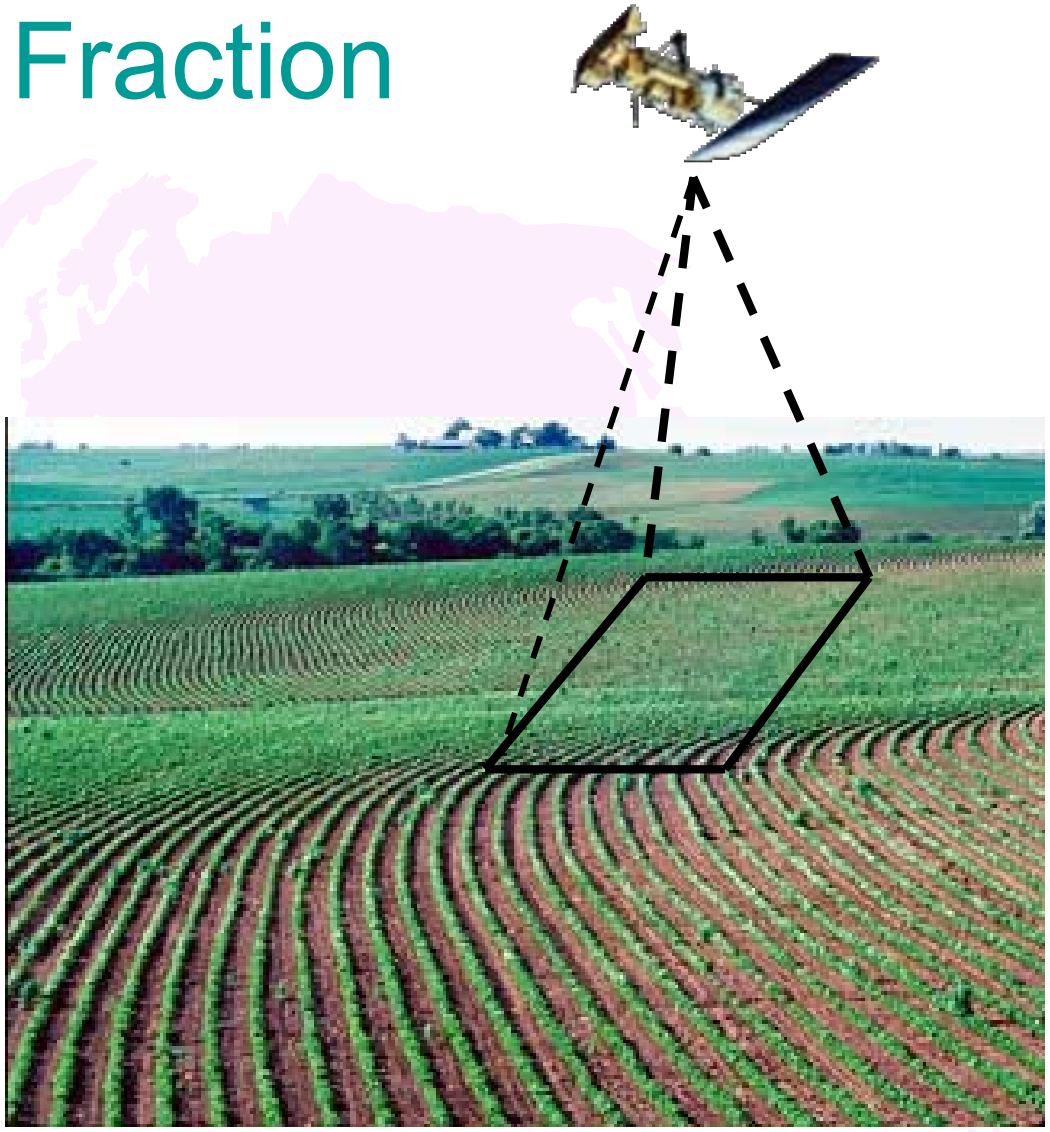
Current coupled land-atmosphere models require information about the type of land surface, and the seasonal changes associated with the land surface.

SPRING

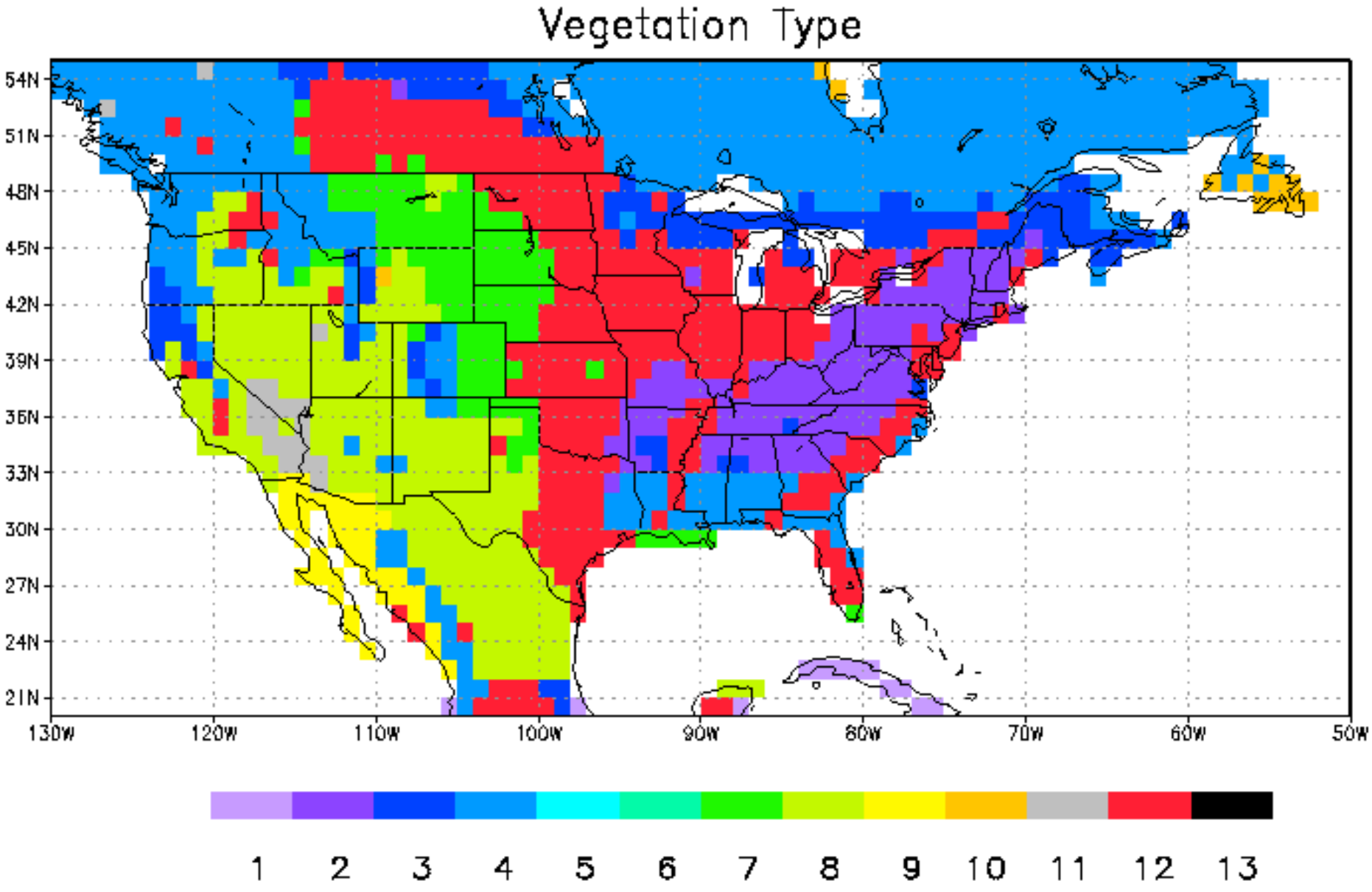
SUMMER

Green Vegetation Fraction (Fgreen)

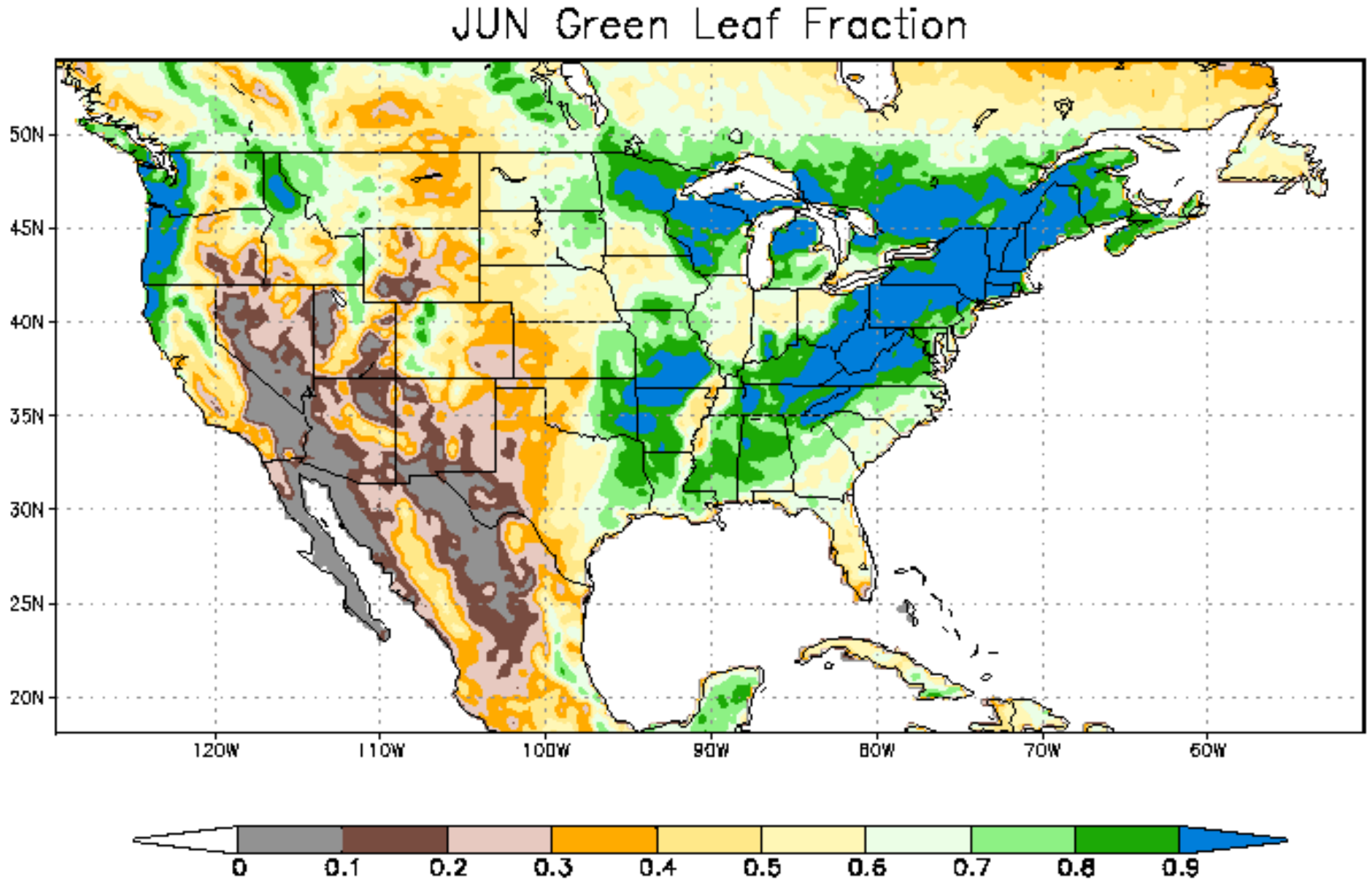
Fgreen is defined as the fraction of horizontal area associated with the photosynthetically active green vegetation that occupies a model grid cell.



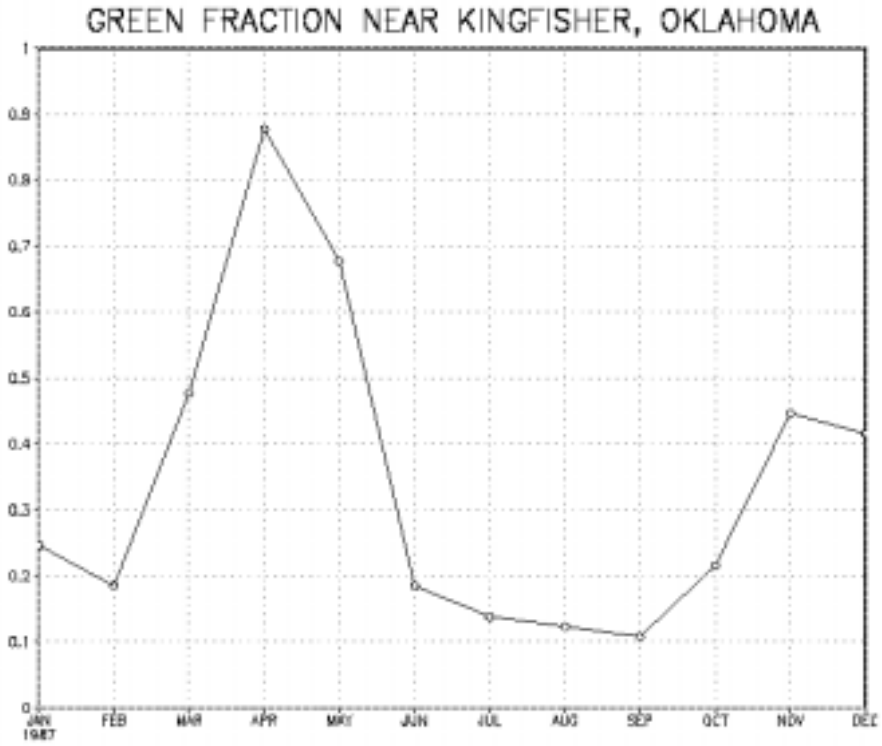
Operational Vegetation Type Database at NCEP (currently 1 vegetation type per 15 km grid cell)



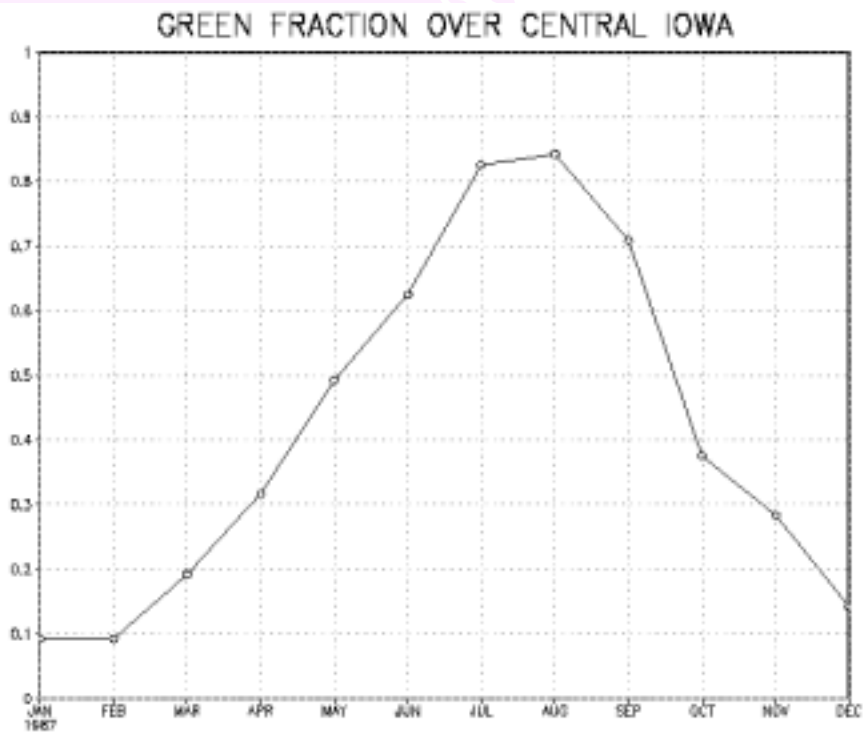
June Green Vegetation Fraction
(also 1 value per 15 km grid cell)



Annual Time Series of Green Vegetation Fraction

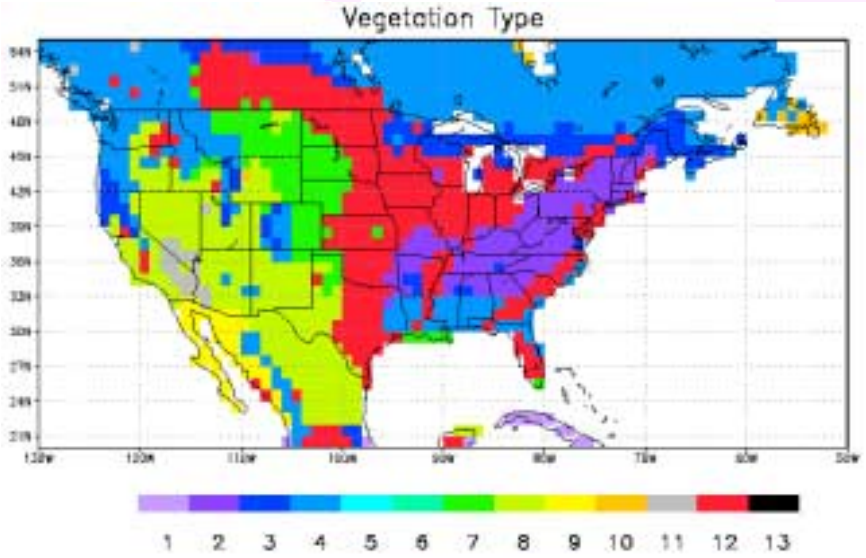


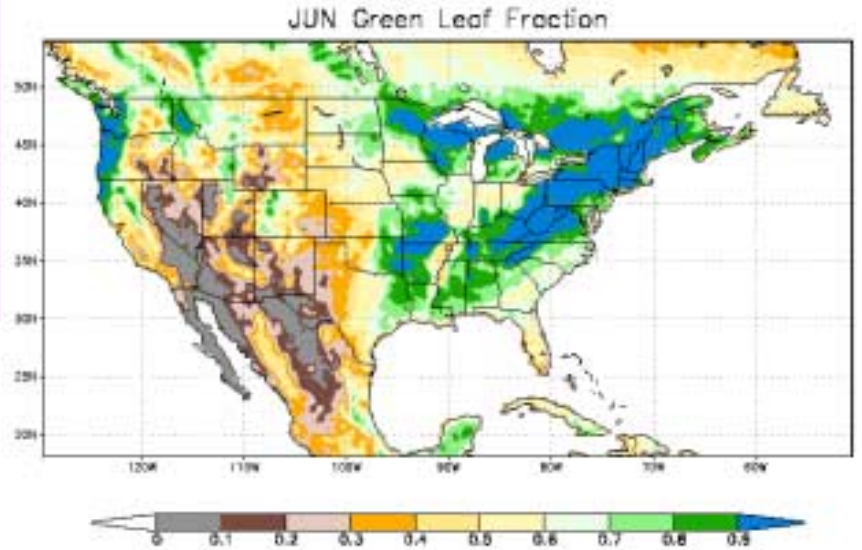
- Oklahoma (Wheat)



- Iowa (Corn/Soybeans).

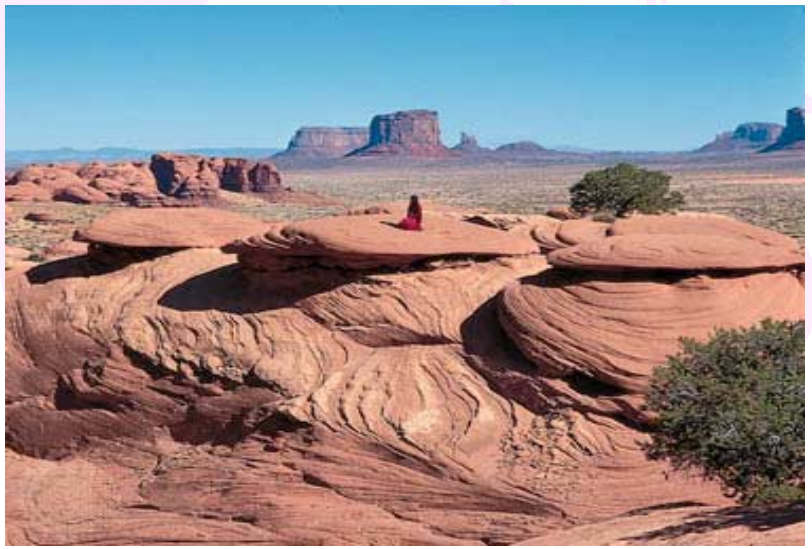
Does the number of LULC classes and Fgreen signatures/signals vary greatly enough within a 20 km grid cell to warrant >1 class per grid cell?





Underlying OBJECTIVE

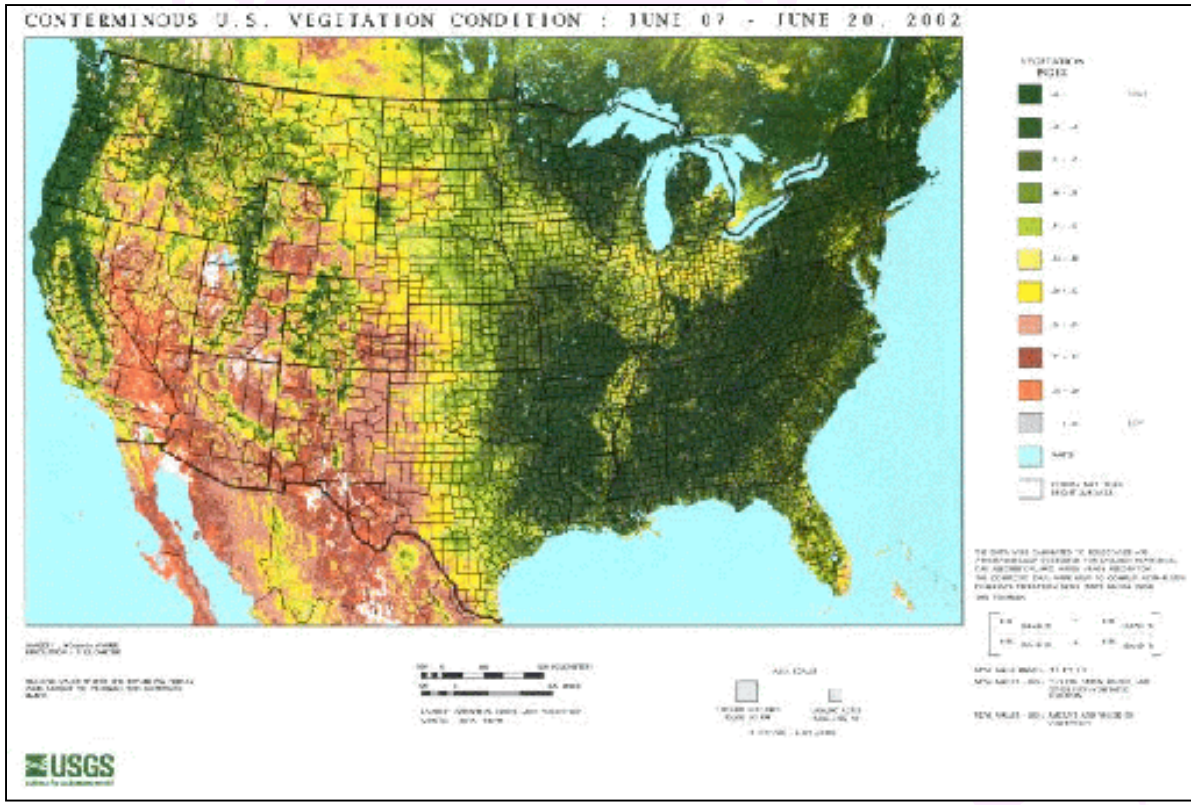
Develop improved high-resolution data sets that represent the seasonal characteristics of global land surfaces.



Land Surface Variables

METHODOLOGY

Study Area:
Conterminous USA+
Source Data:
1 km AVHRR products (historical availability); visible & near-IR reflectance, vegetation index, & …

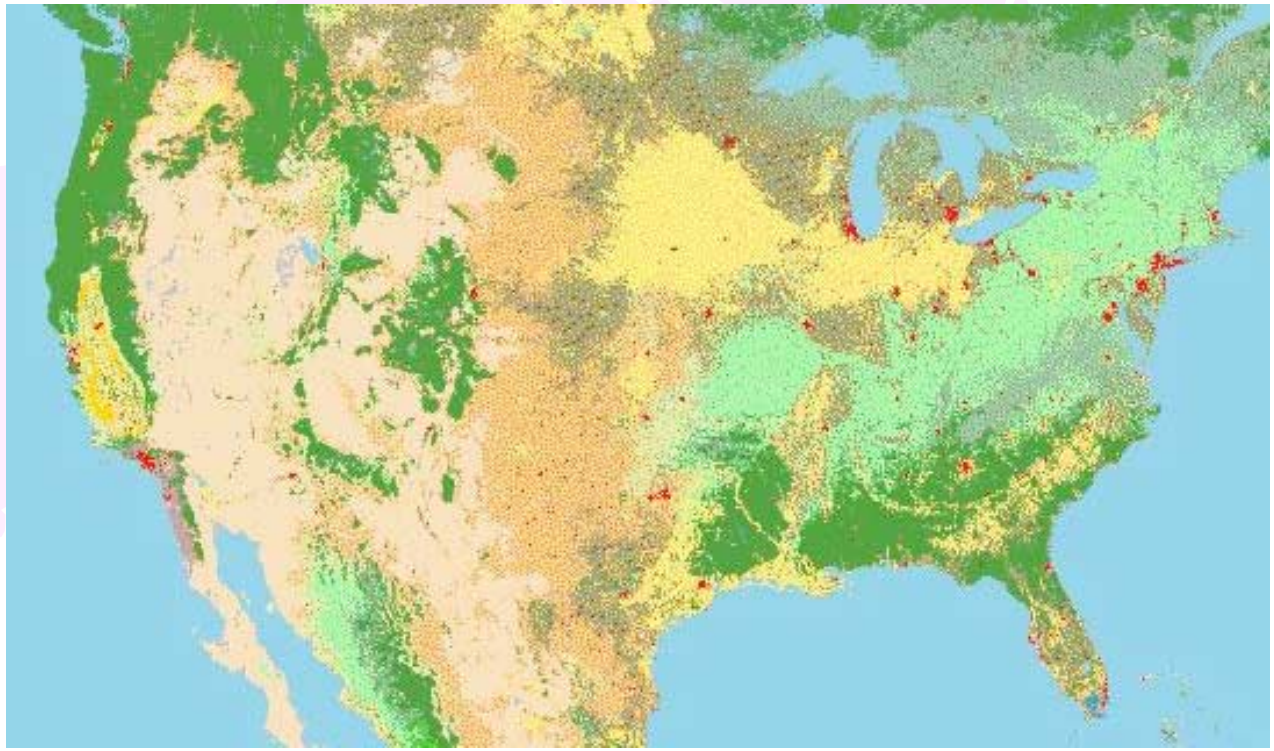


CONUS+ NDVI

METHODOLOGY cont.

Source Data:

1 km-based IGBP land cover classes from AVHRR used to derive the most dominant land cover classes in each model grid cell (initially 20 km).

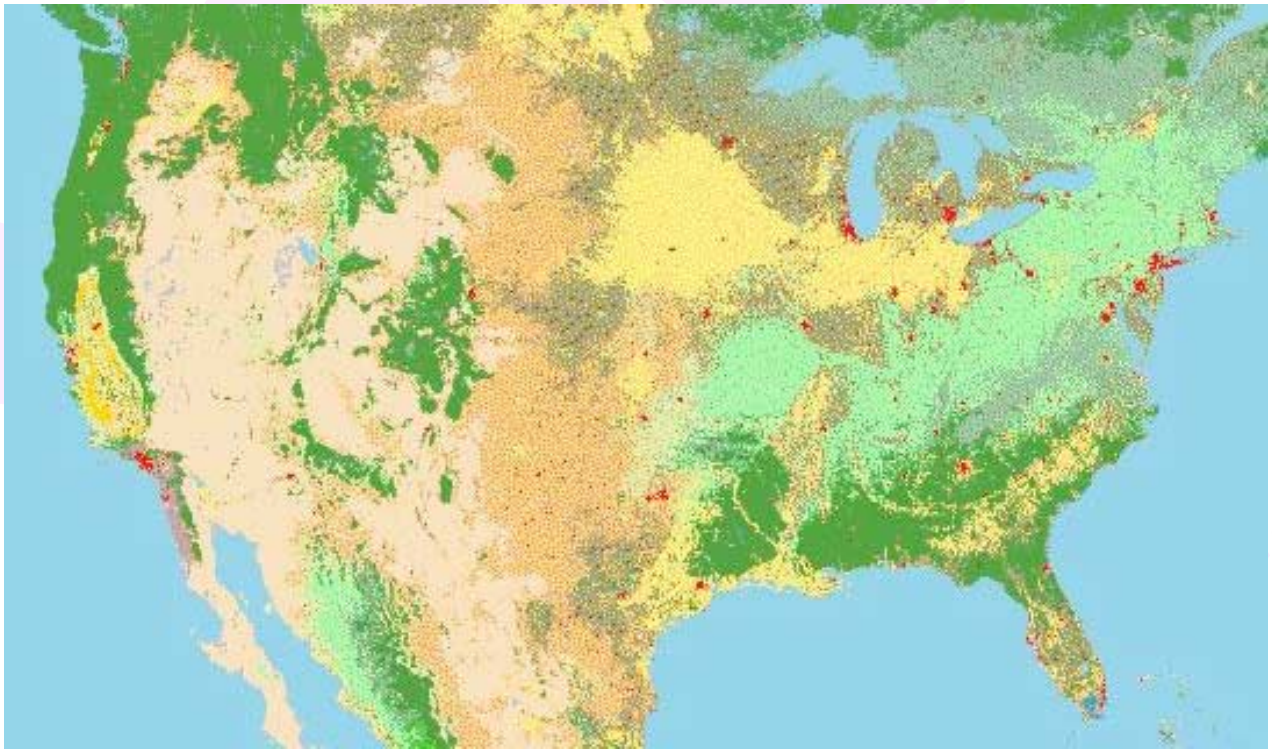


Land Use/Land Cover

METHODOLOGY cont.

Source Data:

1 km-based IGBP land cover classes from AVHRR used to derive the most dominant land cover classes in each model grid cell (initially 20 km).



METHODOLOGY

1 km pixels within 20 x 20 km grid cells

near Miles City, MT

Grassland 69.0%

Cropland 31.0

Chicago, IL

Urban 93.2%

Open Shrub 5.5

Grassland 1.2

CIGBP Land Cover Classes

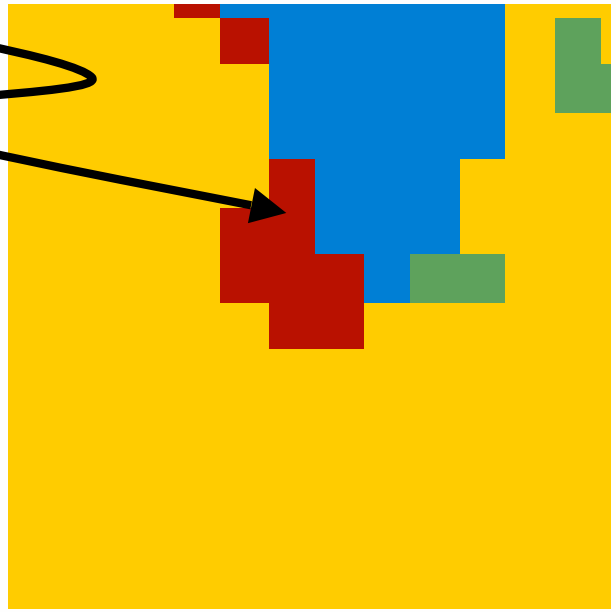
- Mixed Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Closed Shrubland
- Open Shrubland
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands/Natural Vegetation Mosaic
- Urban or Built-Up
- Snow and Ice
- Barren or Sparsely Vegetated
- No Land Classes/Water Bodies

Land Use/Land Cover

1 km grid cells

Chicago, IL

20 km grid cells

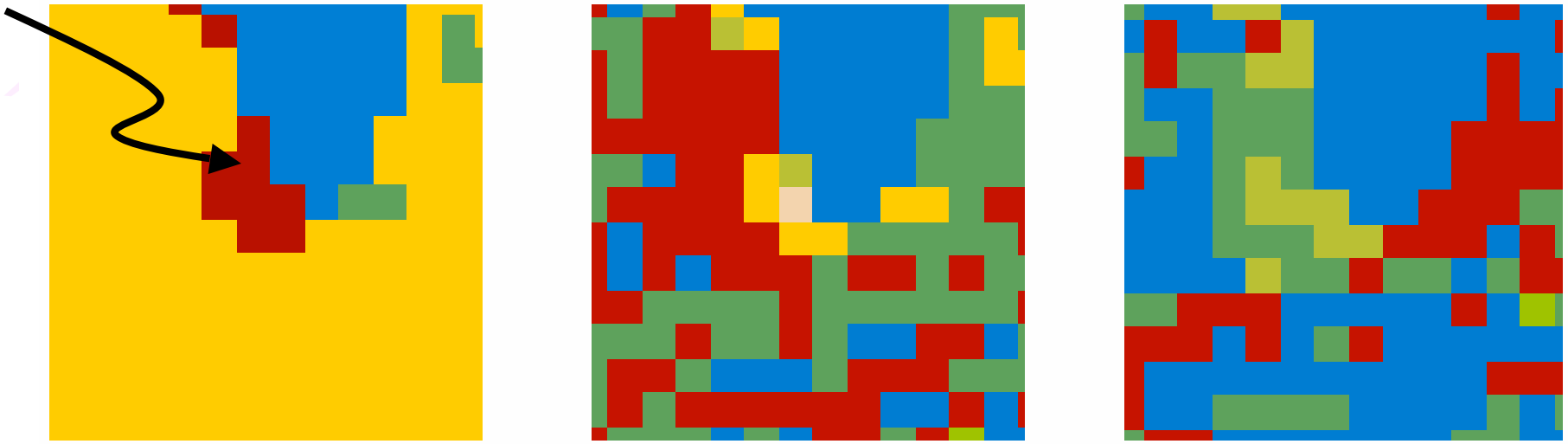


Most dominant classes

Urban 93.2%
Open Shrub 5.5
Grassland 1.2

CHICAGO, IL

20 km grid cells



FIRST SECOND THIRD

IGBP COVER CLASSES (REVISED) PREDOMINANT, 20 km GRID CELL

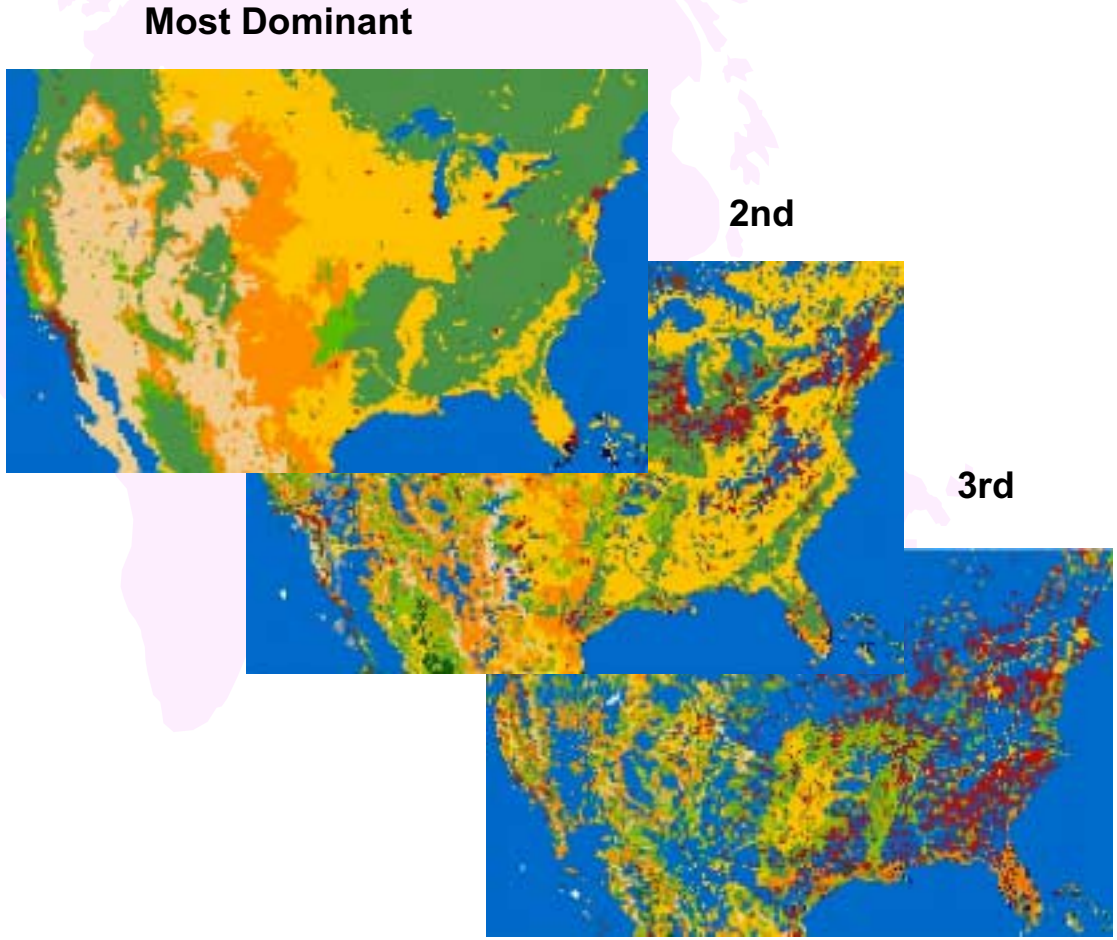
- Mixed Forest
- Open Shrubland
- Woody Savannas
- Grasslands
- Croplands/Natural Vegetation
- Urban or Built-Up
- No Land Classes/Water Bodies

Land Use/Land Cover

PRODUCTS

The three most dominant land cover types (IGBP) per 20-km model grid cell have been identified for conterminous USA.

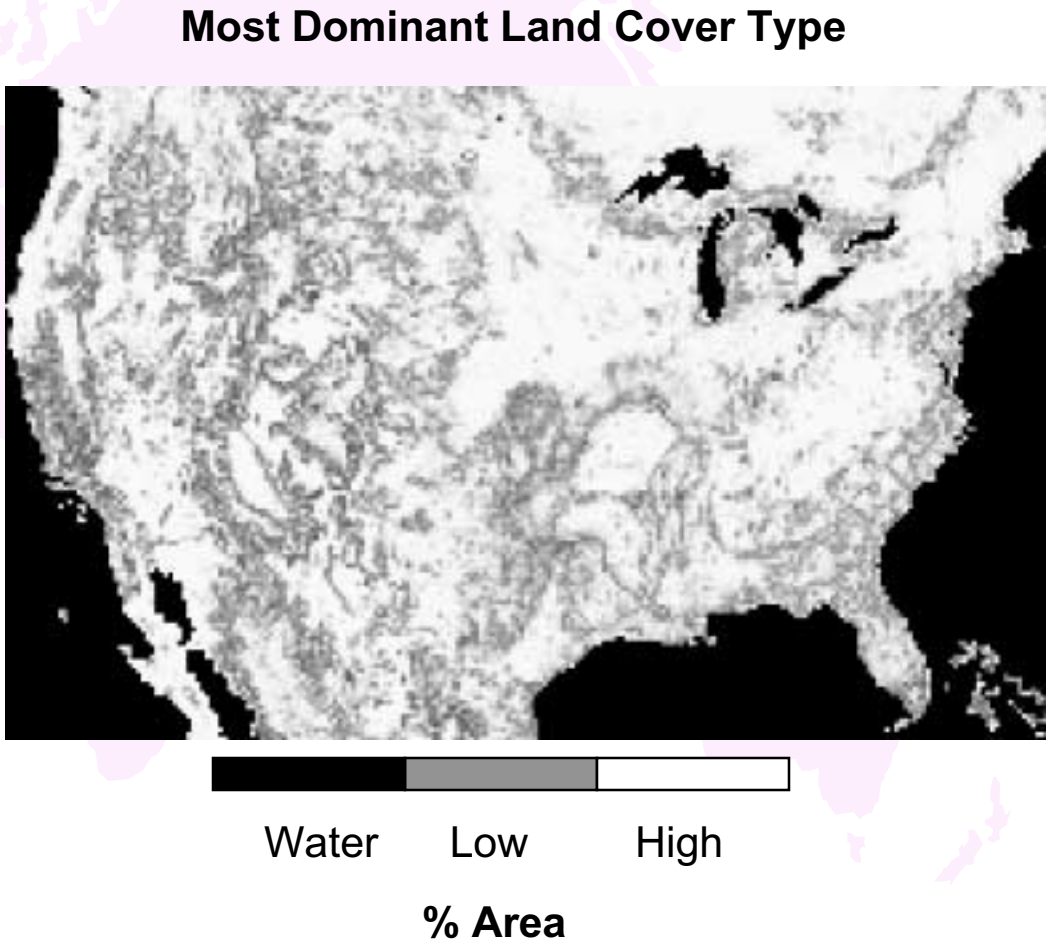
Additionally….



Land Use/Land Cover

PRODUCTS cont.

- % area per 20 km grid cell associated with each of 3 most dominant land cover types, and
- % area per 20 km grid cell defined as water.

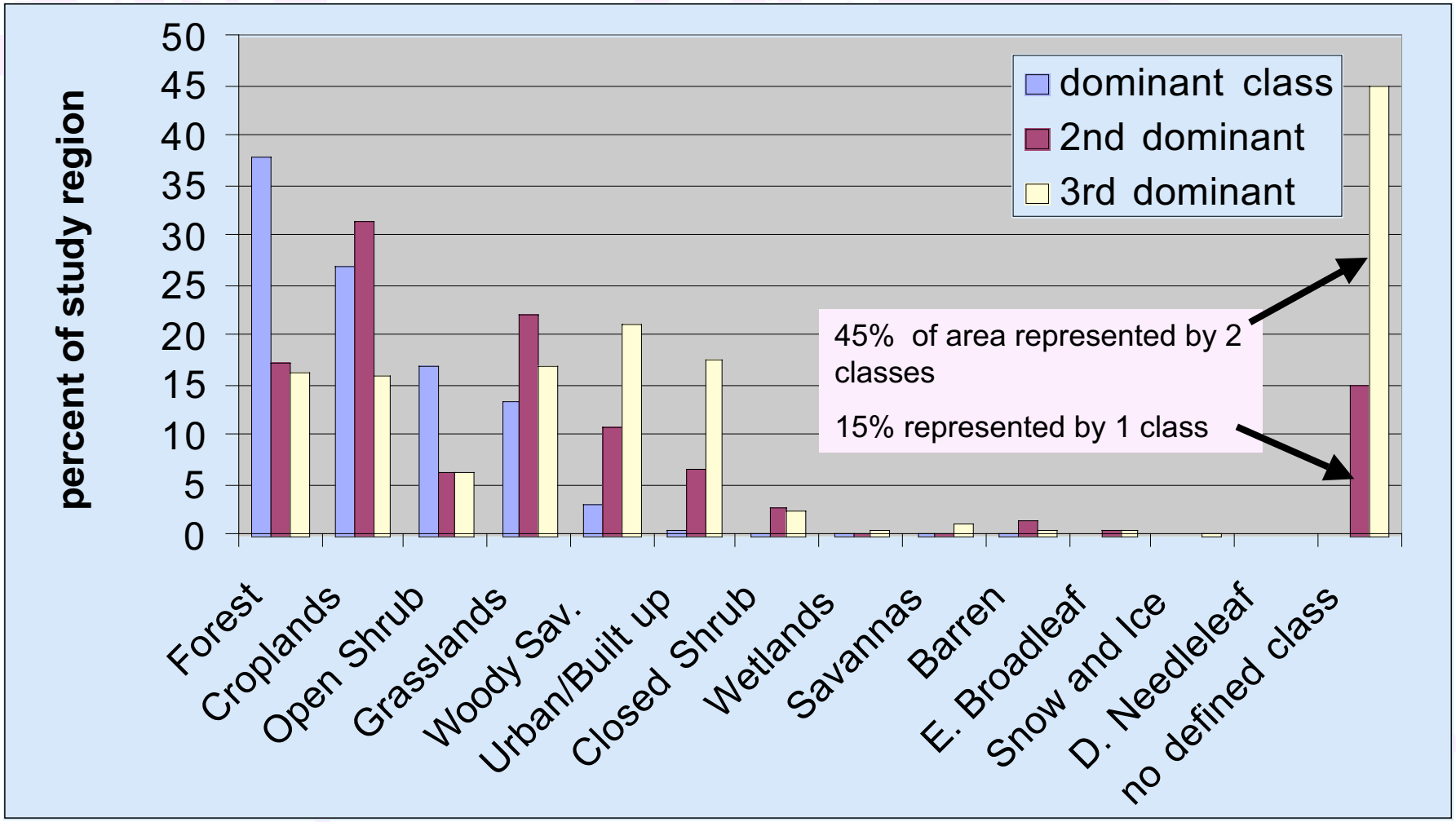


CONUS+ LULC Comparison

(Most dominant land cover type)

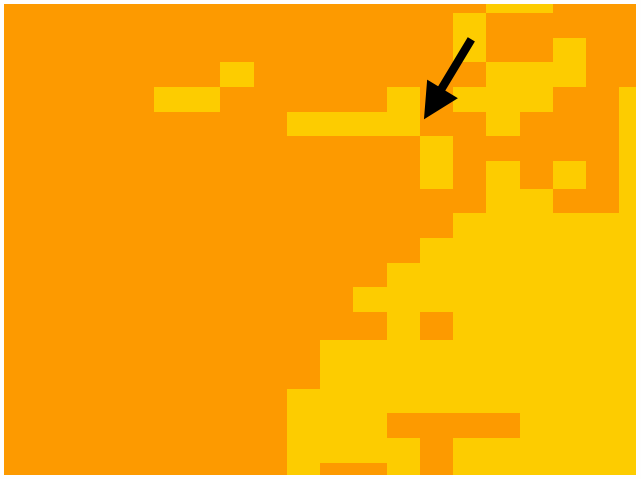
LULC	% area
Forest	36.3
Cropland	26.8
Open Shrubs	16.3
Grasslands	14.4
W. Savanna	4.1
Urban	0.8

Percent area associated with three most dominant cover types.



Are three classes per grid cell sufficient to represent grid cell LULC?

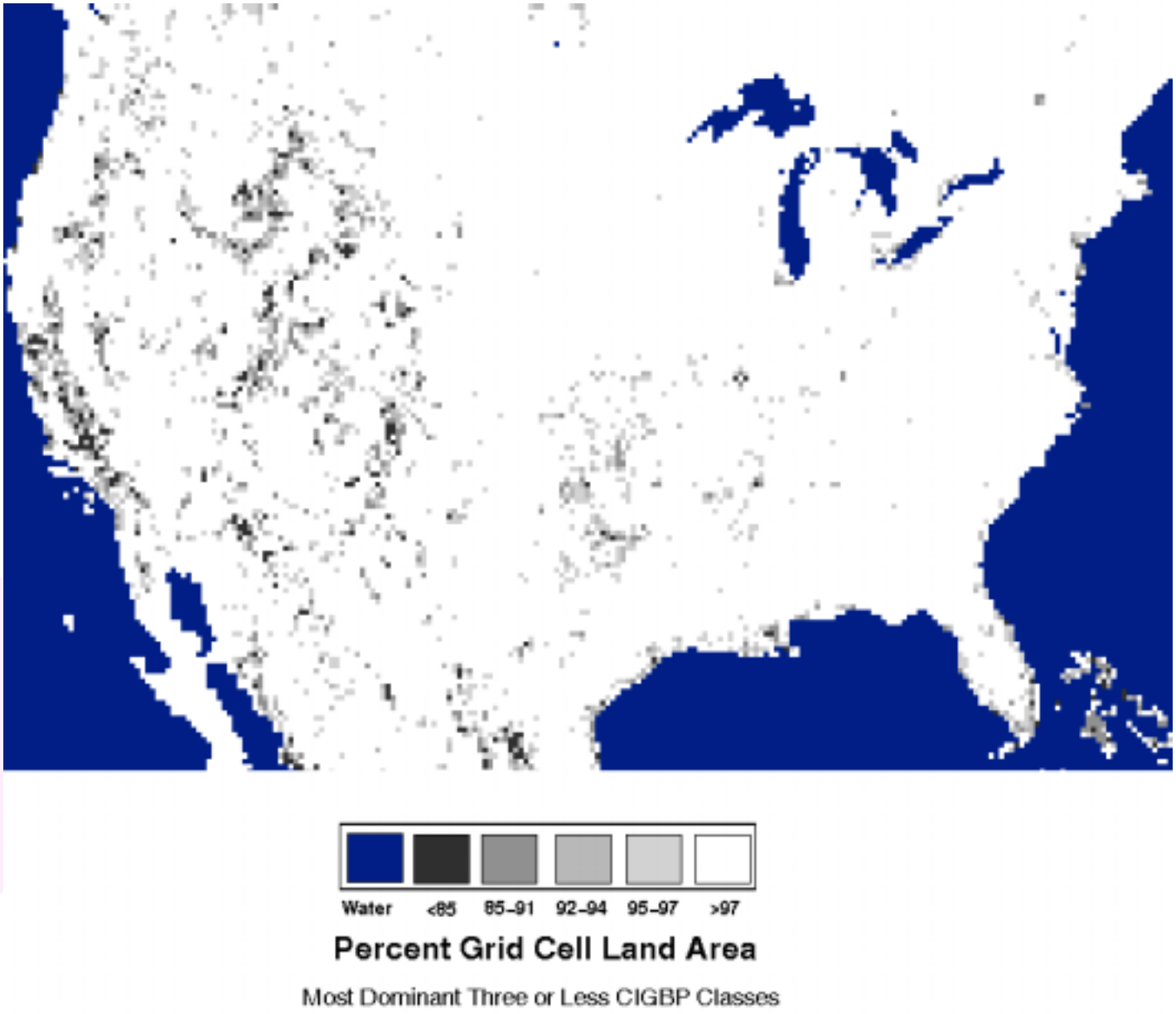
1 km pixels within 20 x 20 km grid cells



near Miles City, MT

Chicago, IL

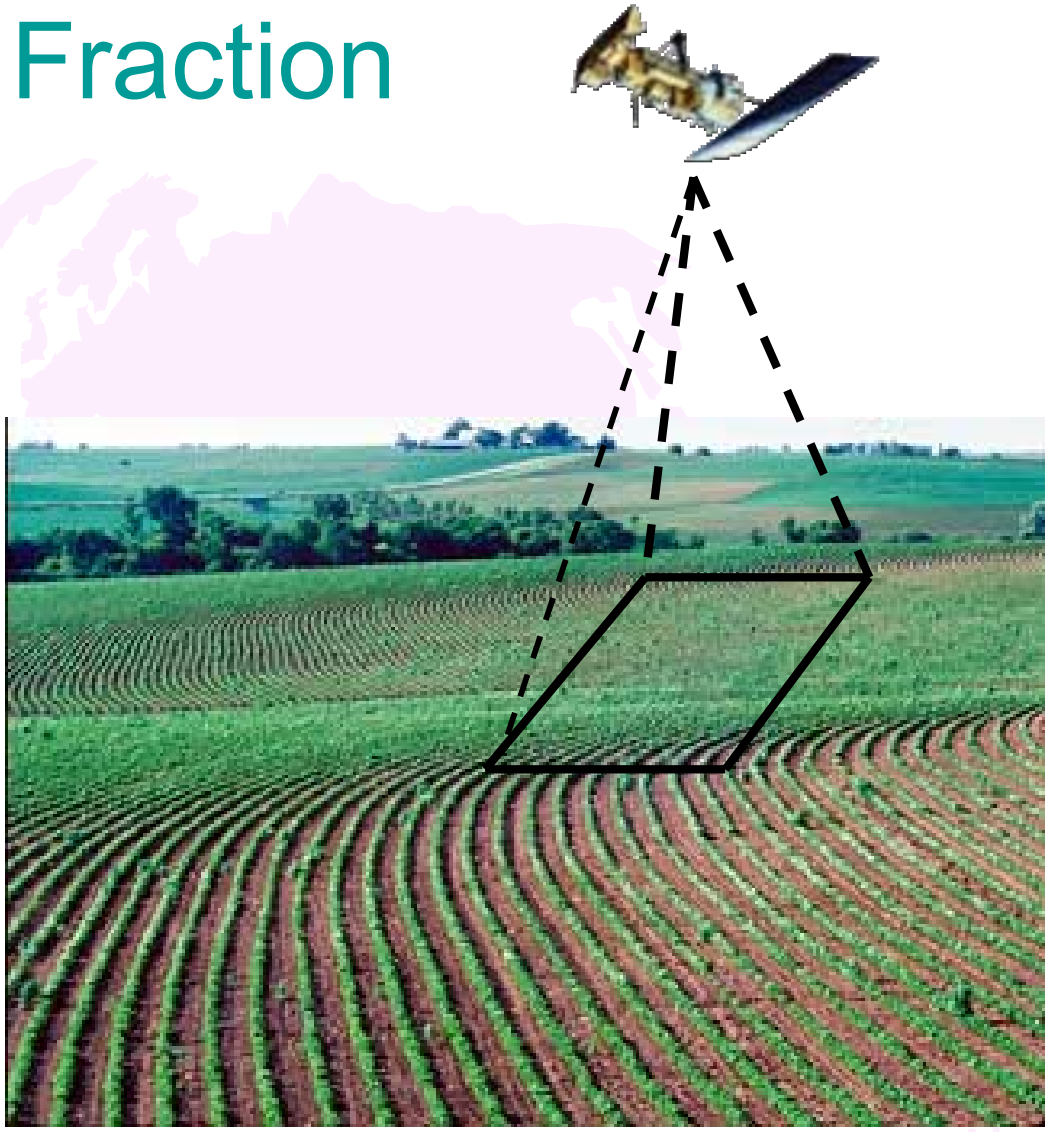
More than 90% of the 20 km land grid cells have > 98% of their land area identified by 3 or less CIGBP classes.



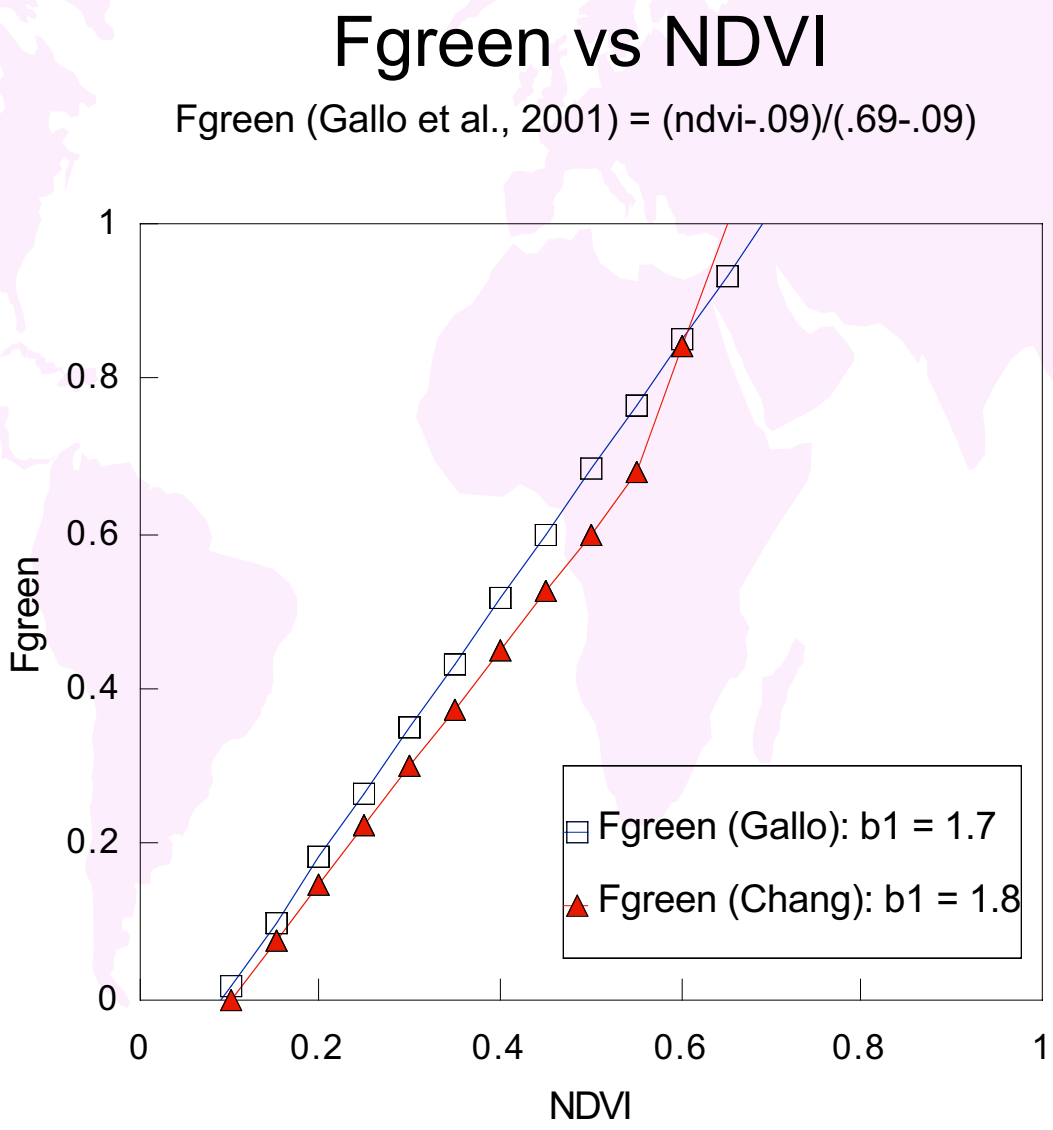
Seasonal changes in Land Cover

Green Vegetation Fraction (Fgreen)

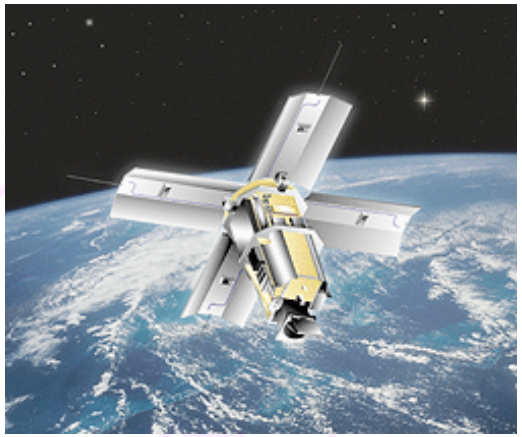
Fgreen is defined as the fraction of horizontal area associated with the photosynthetically active green vegetation that occupies a model grid cell.

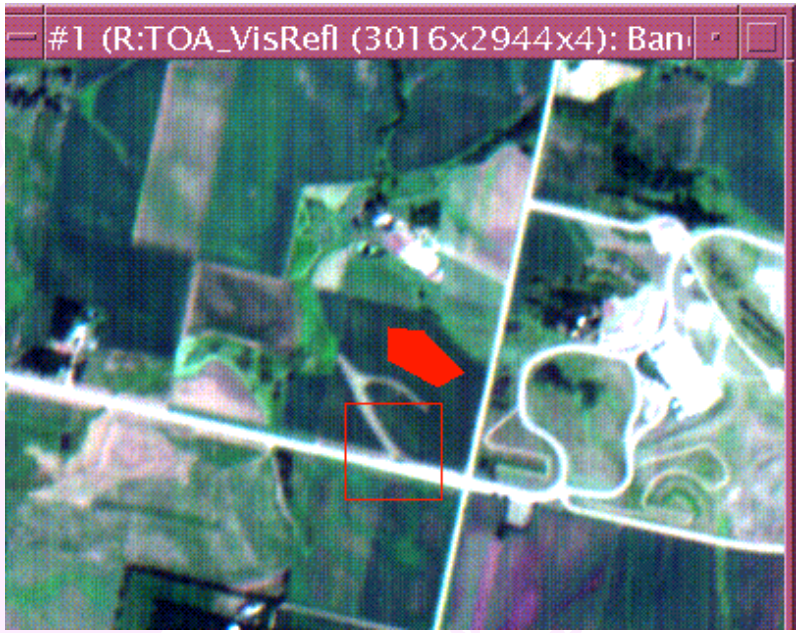


Fraction Green Vegetation (Fgreen)



Fgreen validation

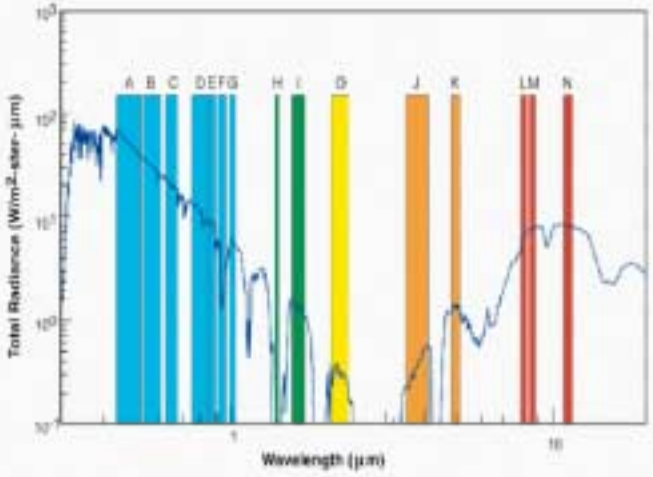


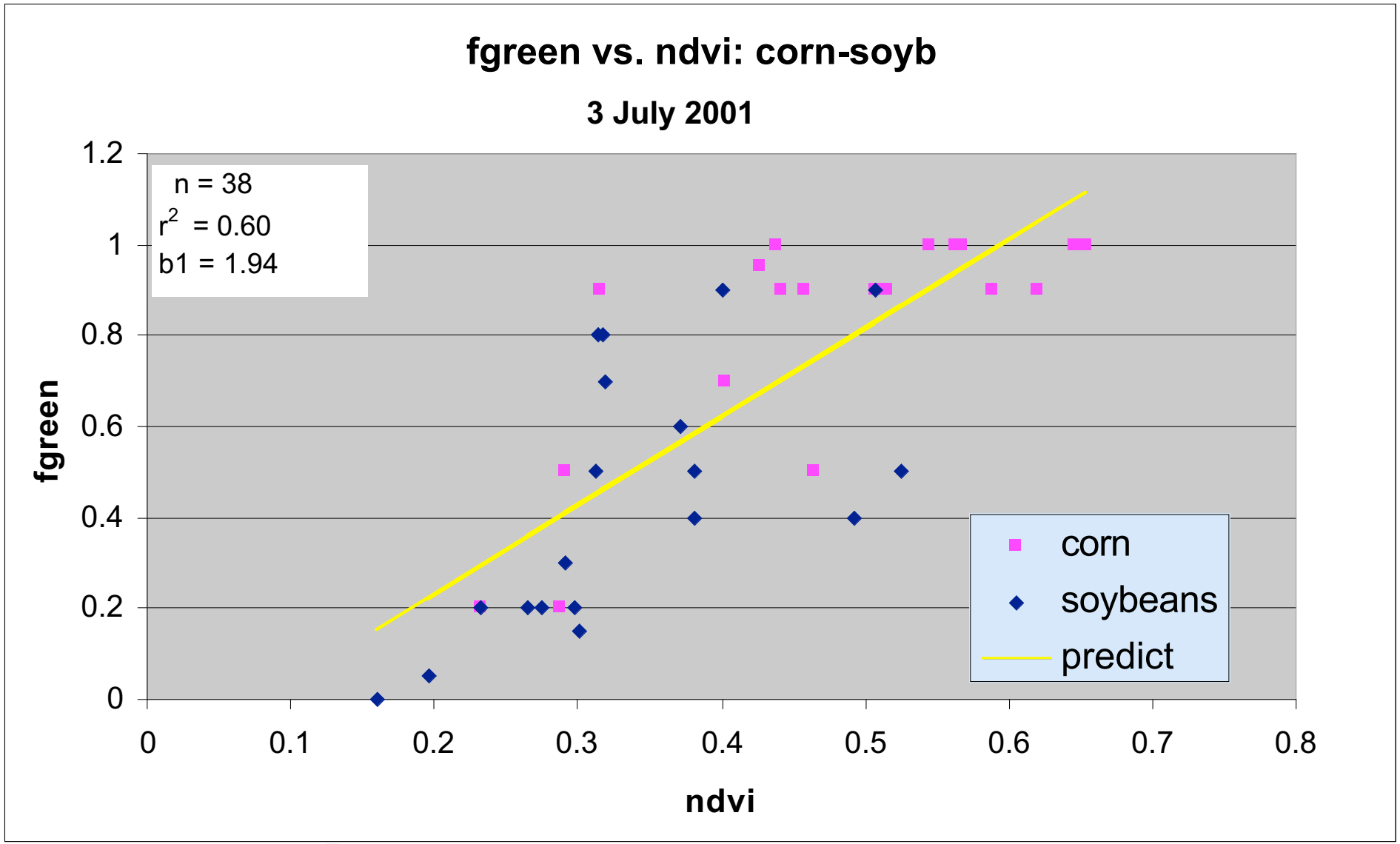


MTI MULTISPECTRAL THERMAL IMAGER

Sandia National Laboratories
Los Alamos National Laboratory
Savannah River Technology Center

Spectral Band Selection



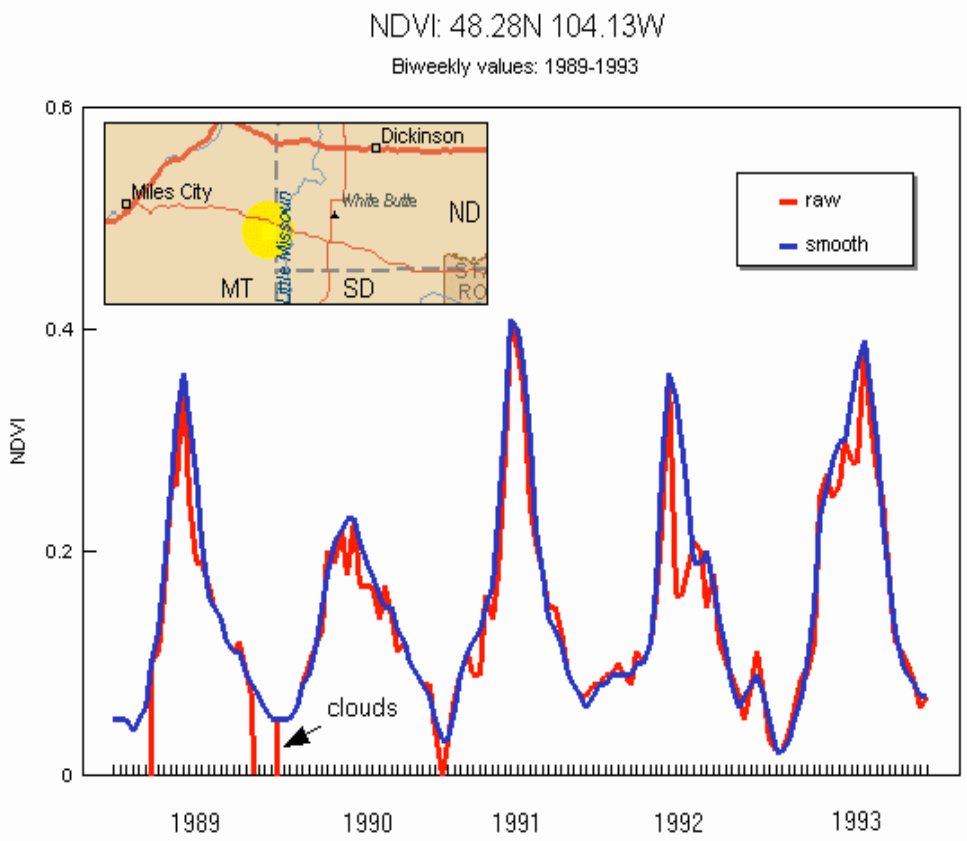

fgreen vs. ndvi: corn-soyb
3 July 2001
n = 38
r2 = 0.60
b1 = 1.94
fgreen
ndvi
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
corn
soybeans
predict

Fgreen

Temporally refined

1 km NDVI data

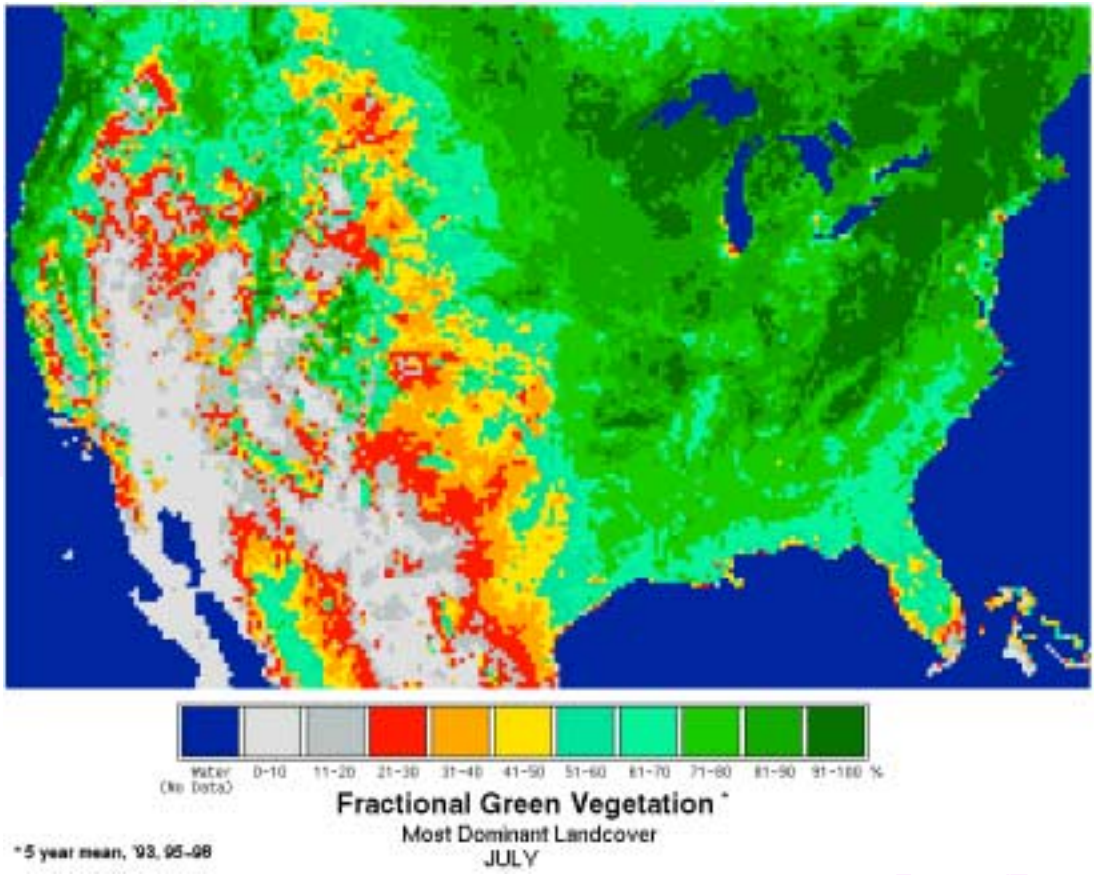
- Processed (Swets et al., 1999) to remove NDVI signal perturbations.
- Conterminous USA+ region,
- Monthly (15th of month) basis 1993, 1995-98.



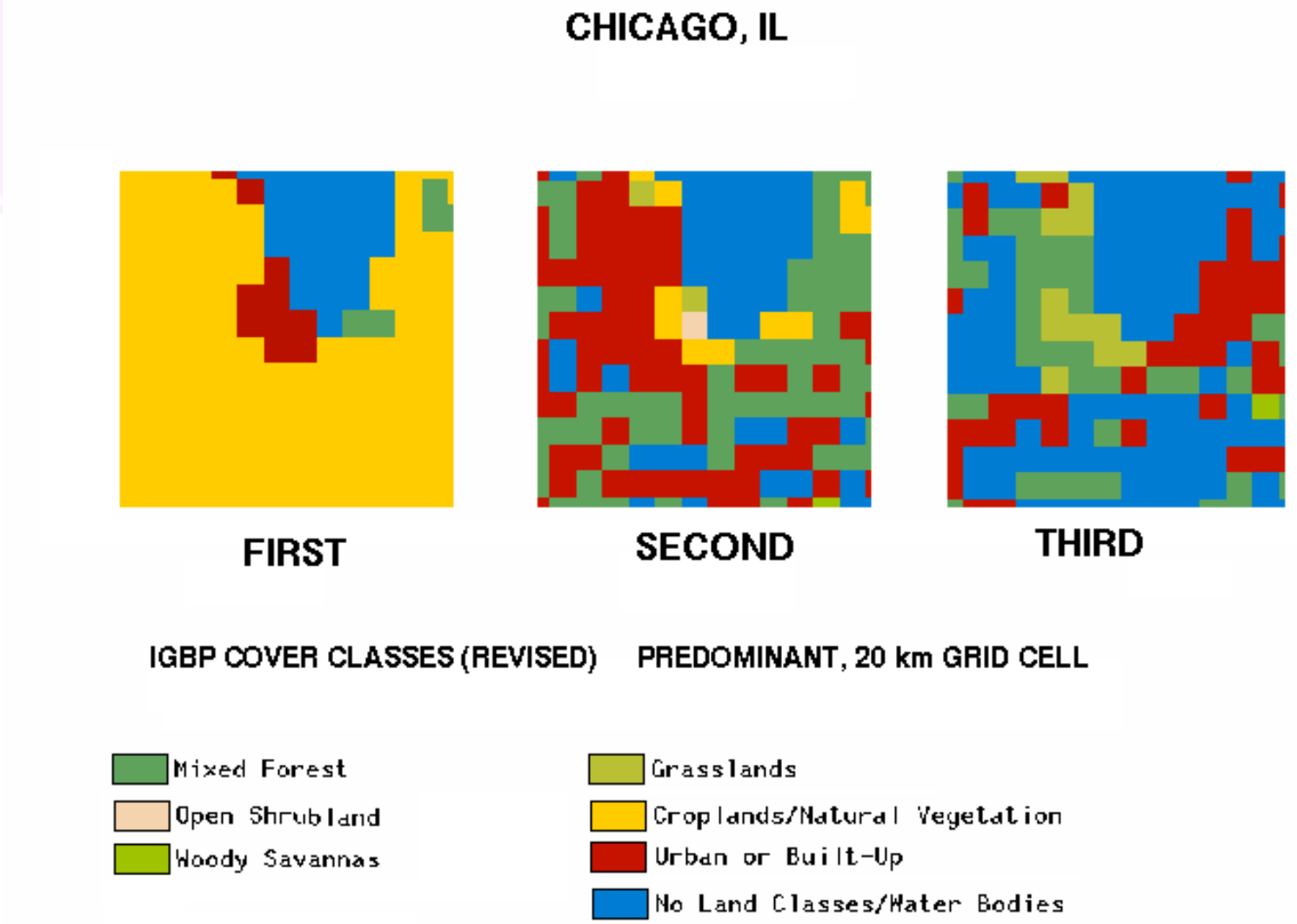
Fgreen

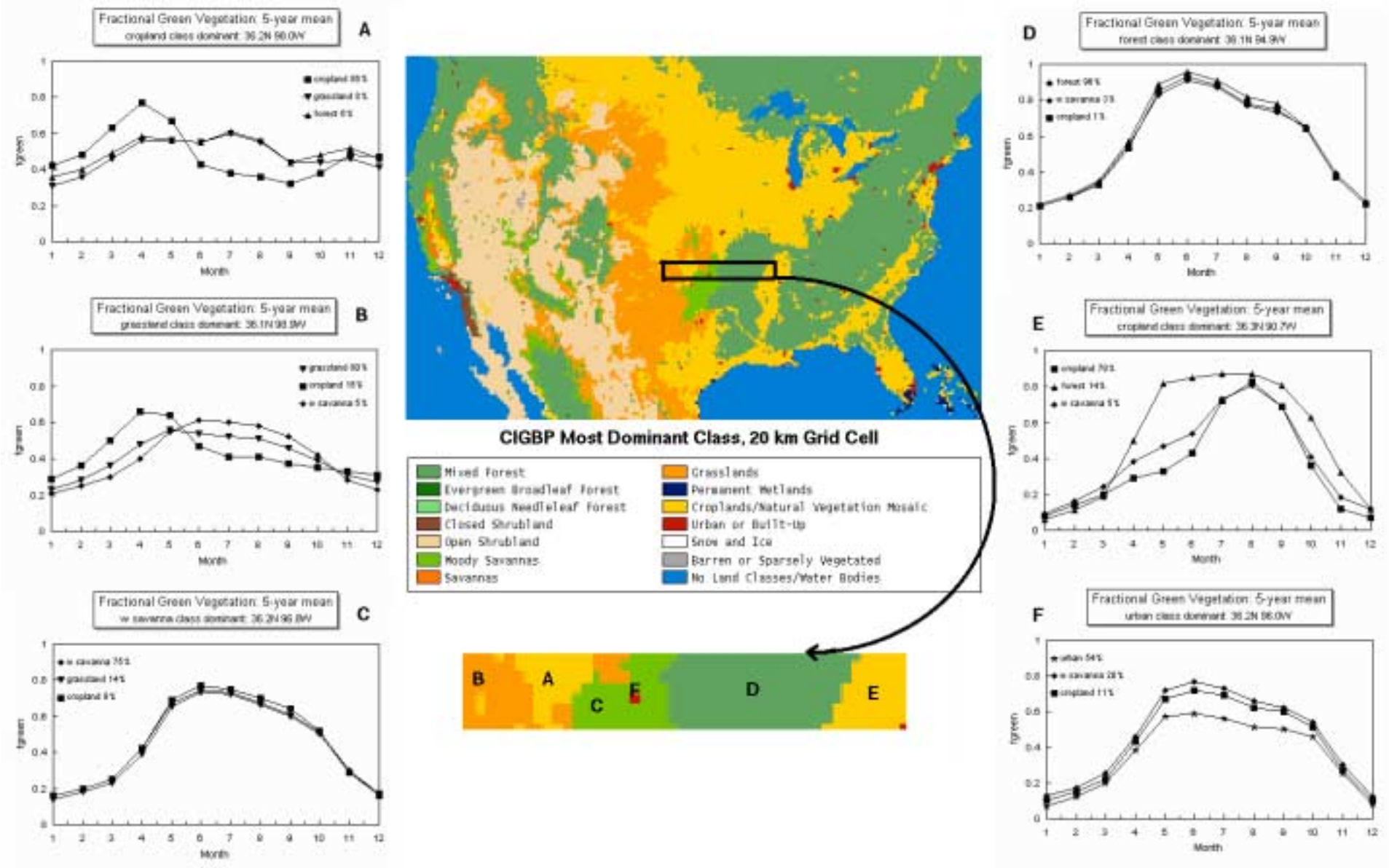
PRODUCTS

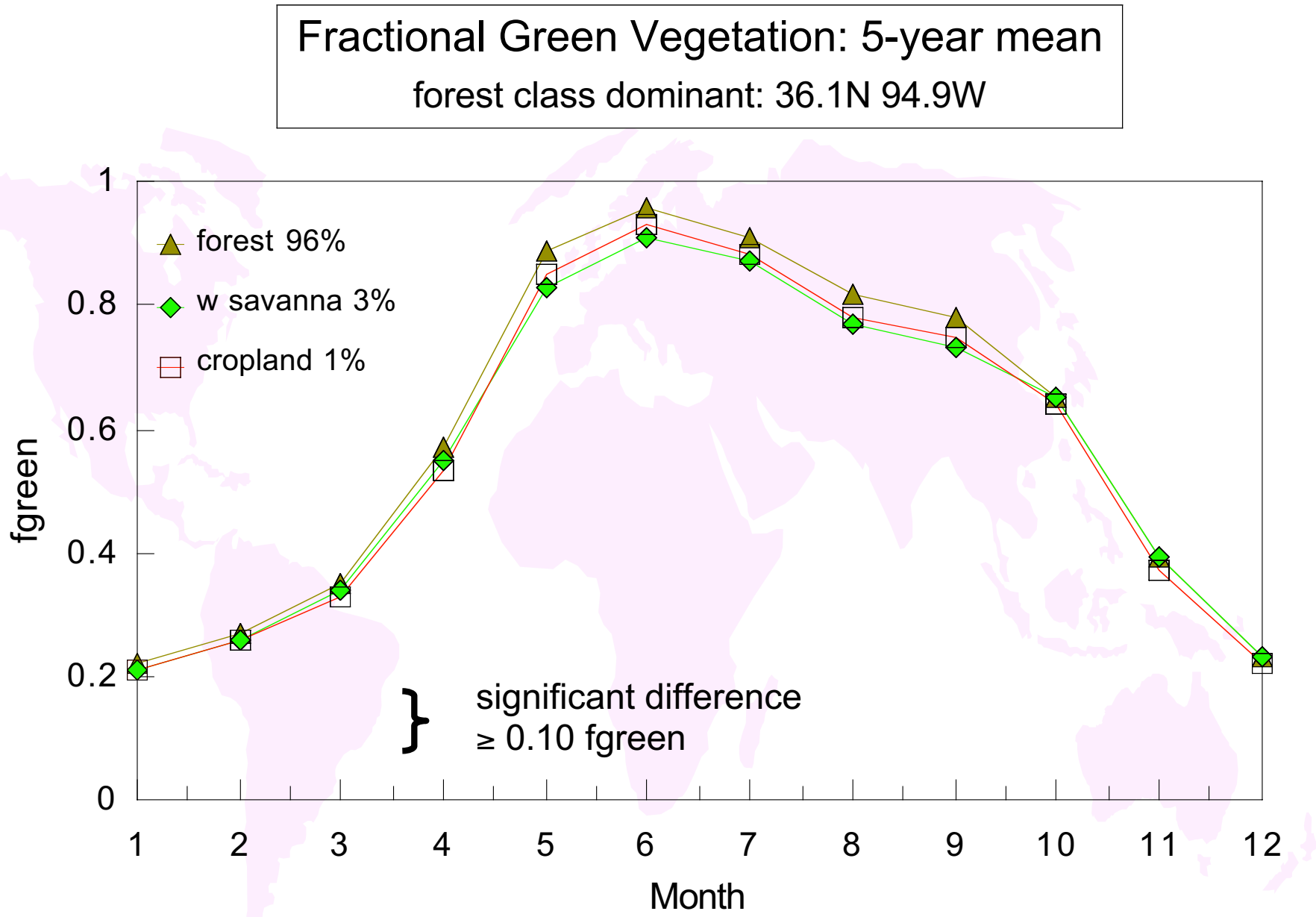
Version 1.0 of monthly fractional green vegetation has been produced for the 3 most predominant land cover types per 20-km grid cell based on 5 year climatology of NDVI & Fgreen.

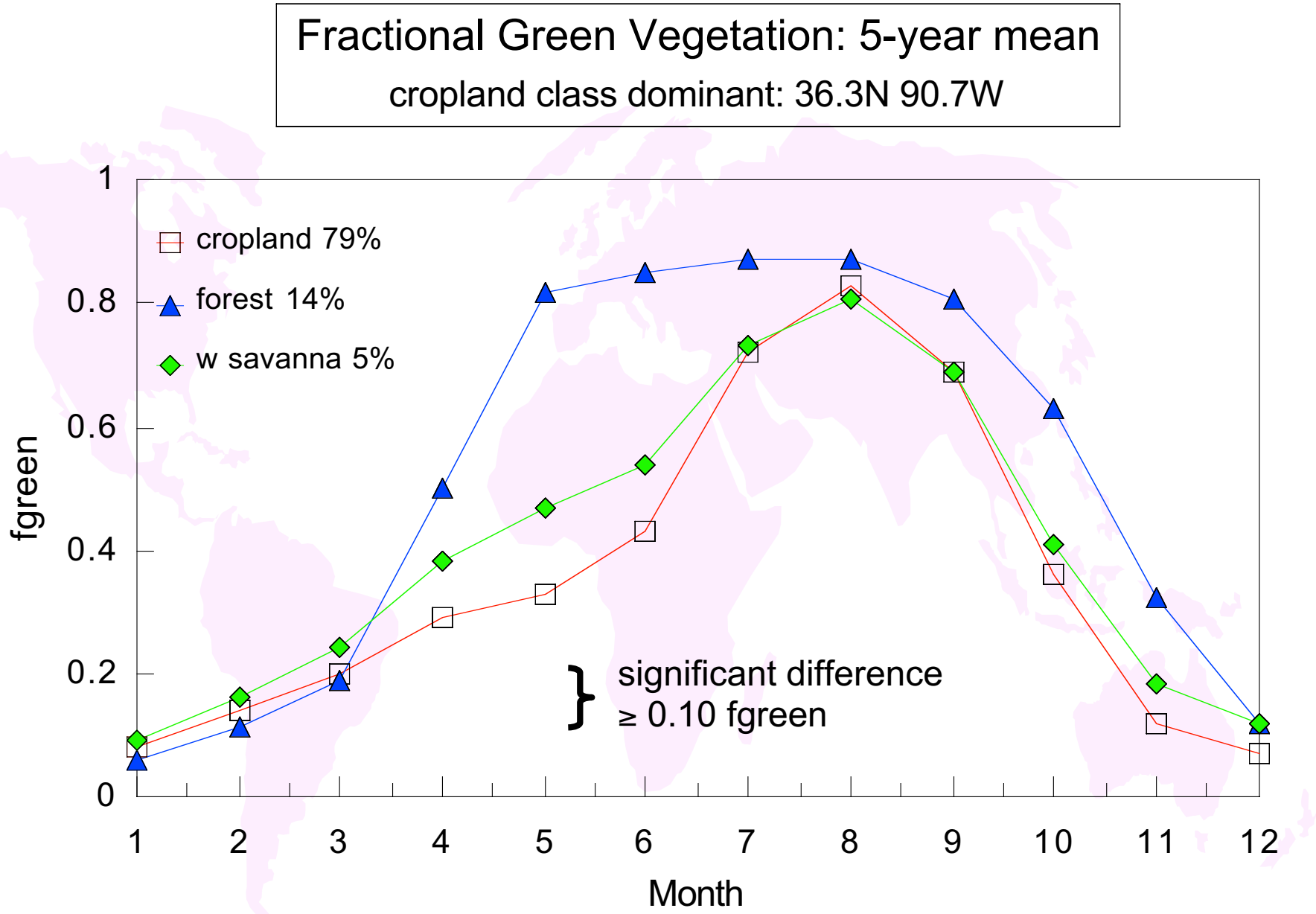


Are three classes per grid cell needed to represent grid cell Fgreen?



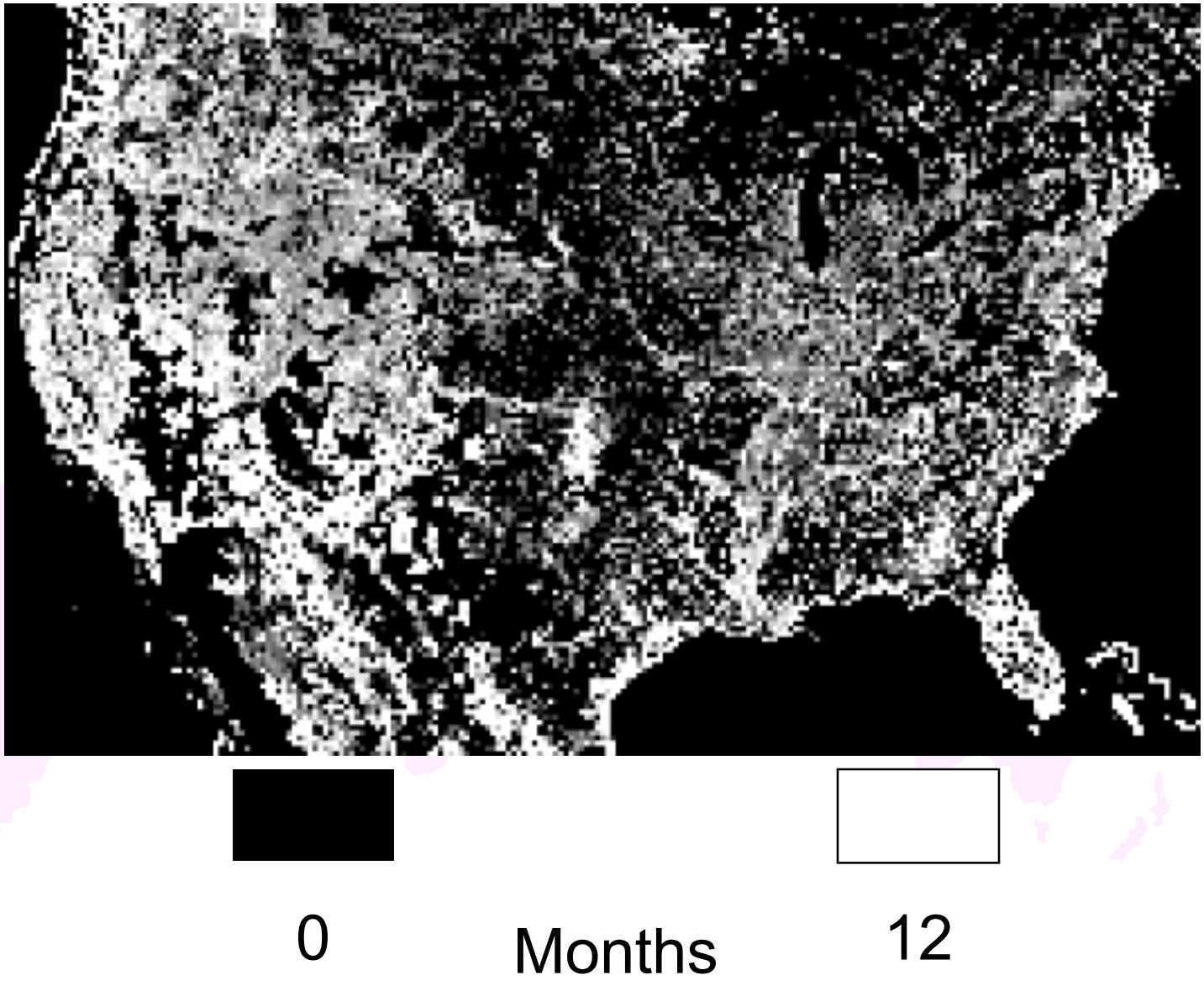

Fractional Green Vegetation: 5-year mean
cropland class dominant: 36.2N 98.0W
A
cropland 85%
grassland 8%
forest 6%
fgreen
Month
Fractional Green Vegetation: 5-year mean
grassland class dominant: 36.1N 98.8W
B
grassland 80%
cropland 15%
w savanna 5%
fgreen
Month
Fractional Green Vegetation: 5-year mean
w savanna class dominant: 36.2N 96.8W
C
w savanna 75%
grassland 14%
cropland 9%
fgreen
Month
CIGBP Most Dominant Class, 20 km Grid Cell
Mixed Forest
Evergreen Broadleaf Forest
Deciduous Needleleaf Forest
Closed Shrubland
Open Shrubland
Woody Savannas
Savannas
Grasslands
Permanent Wetlands
Croplands/Natural Vegetation Mosaic
Urban or Built-Up
Snow and Ice
Barren or Sparsely Vegetated
No Land Classes/Water Bodies
B
A
C
E
D
E
Fractional Green Vegetation: 5-year mean
forest class dominant: 39.1N 94.9W
D
forest 96%
w savanna 3%
cropland 1%
fgreen
Month
Fractional Green Vegetation: 5-year mean
cropland class dominant: 36.3N 90.7W
E
cropland 70%
forest 14%
w savanna 9%
fgreen
Month
Fractional Green Vegetation: 5-year mean
urban class dominant: 38.2N 96.0W
F
urban 54%
w savanna 28%
cropland 11%
fgreen
Month


Fractional Green Vegetation: 5-year mean
forest class dominant: 36.1N 94.9W
forest 96%
w savanna 3%
cropland 1%
significant difference
≥ 0.10 fgreen
fgreen
Month
0
0.2
0.4
0.6
0.8
1
1
2
3
4
5
6
7
8
9
10
11
12


Fractional Green Vegetation: 5-year mean
cropland class dominant: 36.3N 90.7W
cropland 79%
forest 14%
w savanna 5%
significant difference
≥ 0.10 fgreen
fgreen
Month
0
0.2
0.4
0.6
0.8
1
1
2
3
4
5
6
7
8
9
10
11
12

Number of Months with Significant Difference in Fgreen

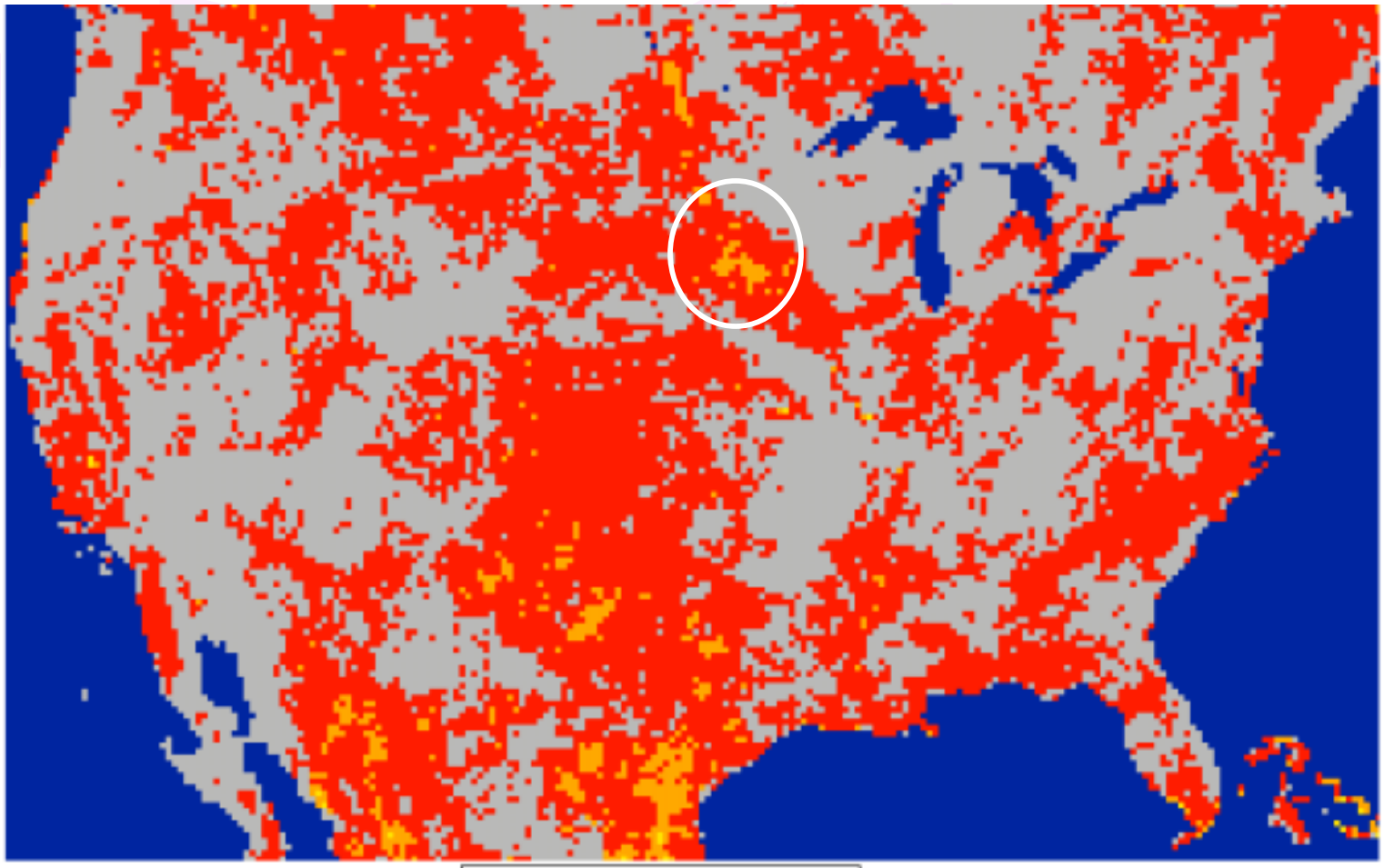
58% of grid cells had 1 or more months with significant differences (>10%) in fgreen.



Percent of grid cells in CONUS+ with significant differences in monthly values of Fgreen.

# of Months	% of grid cells
0	42%
≥1	58
≥ 2	53
≥ 6	29
12	7

Standard Deviation of Fgreen

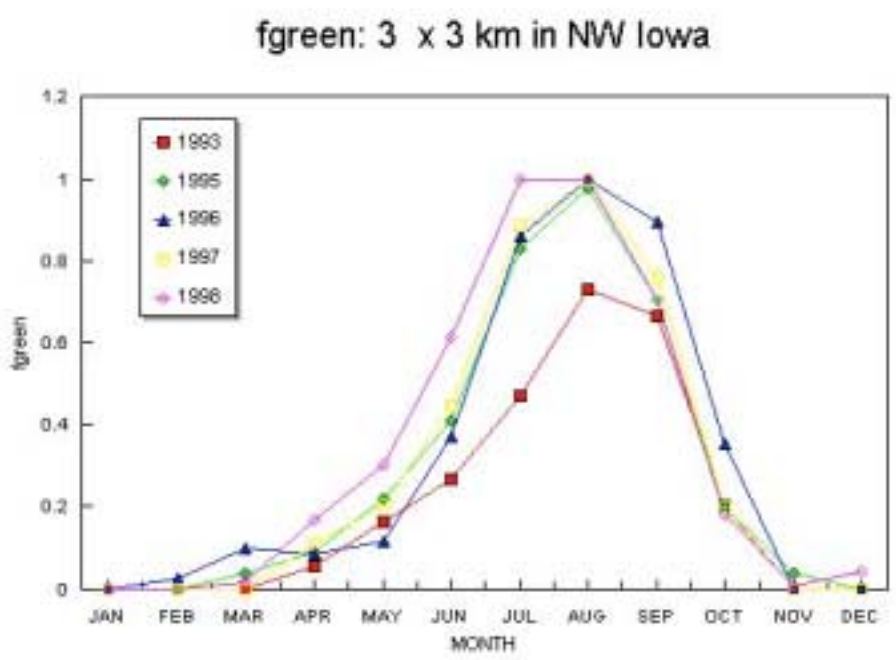


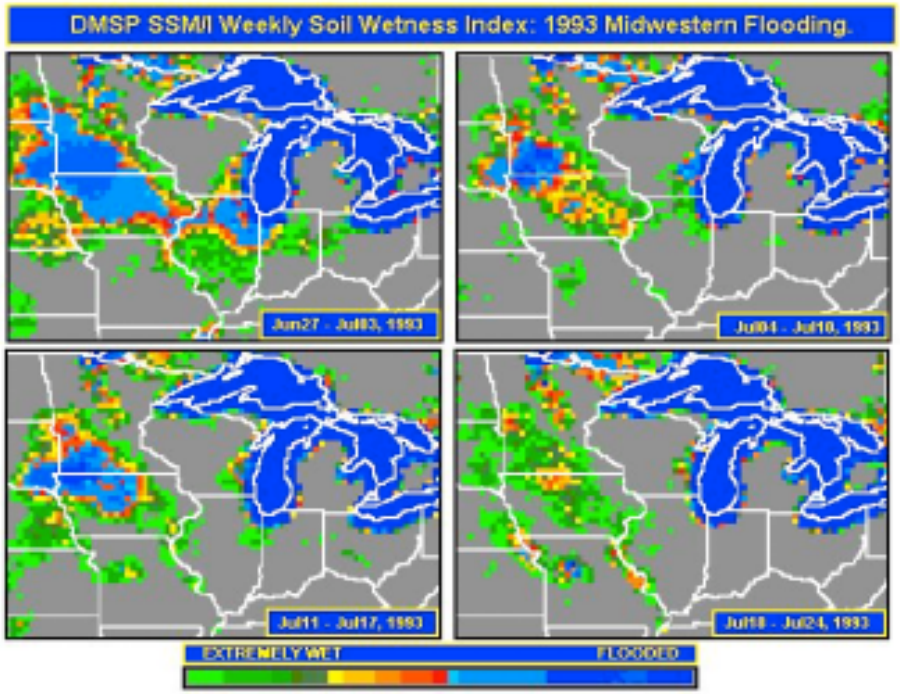
Standard Deviation of Fractional Green Vegetation *

Most Dominant Landcover
JUNE–JULY –AUGUST

* 5 years '93, 95–98

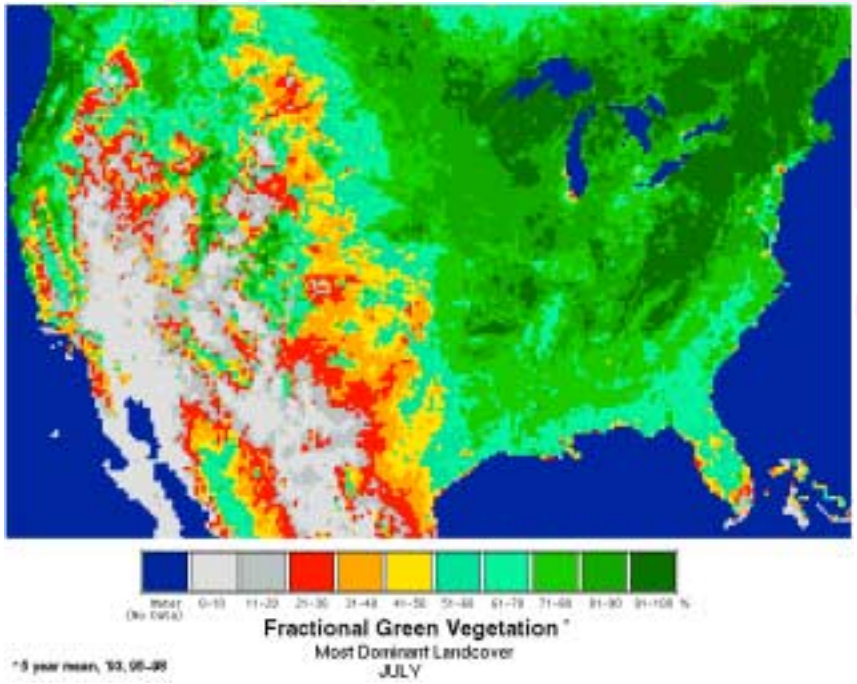
Relatively large standard deviation in Fgreen within NW Iowa and S. Minnesota (left) a result of heavy rains during 1993 as observed with SSM/I soil wetness index (right).

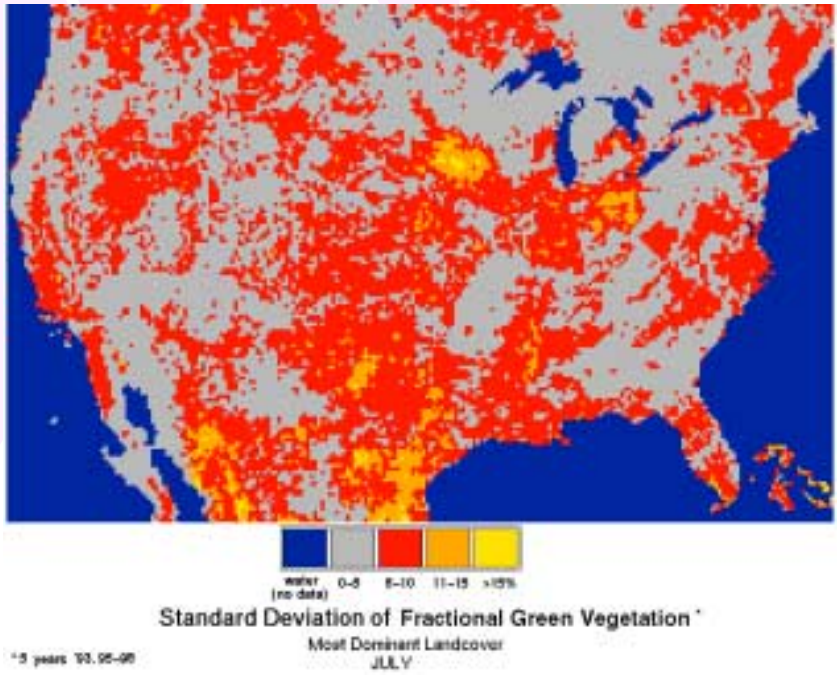




Summary

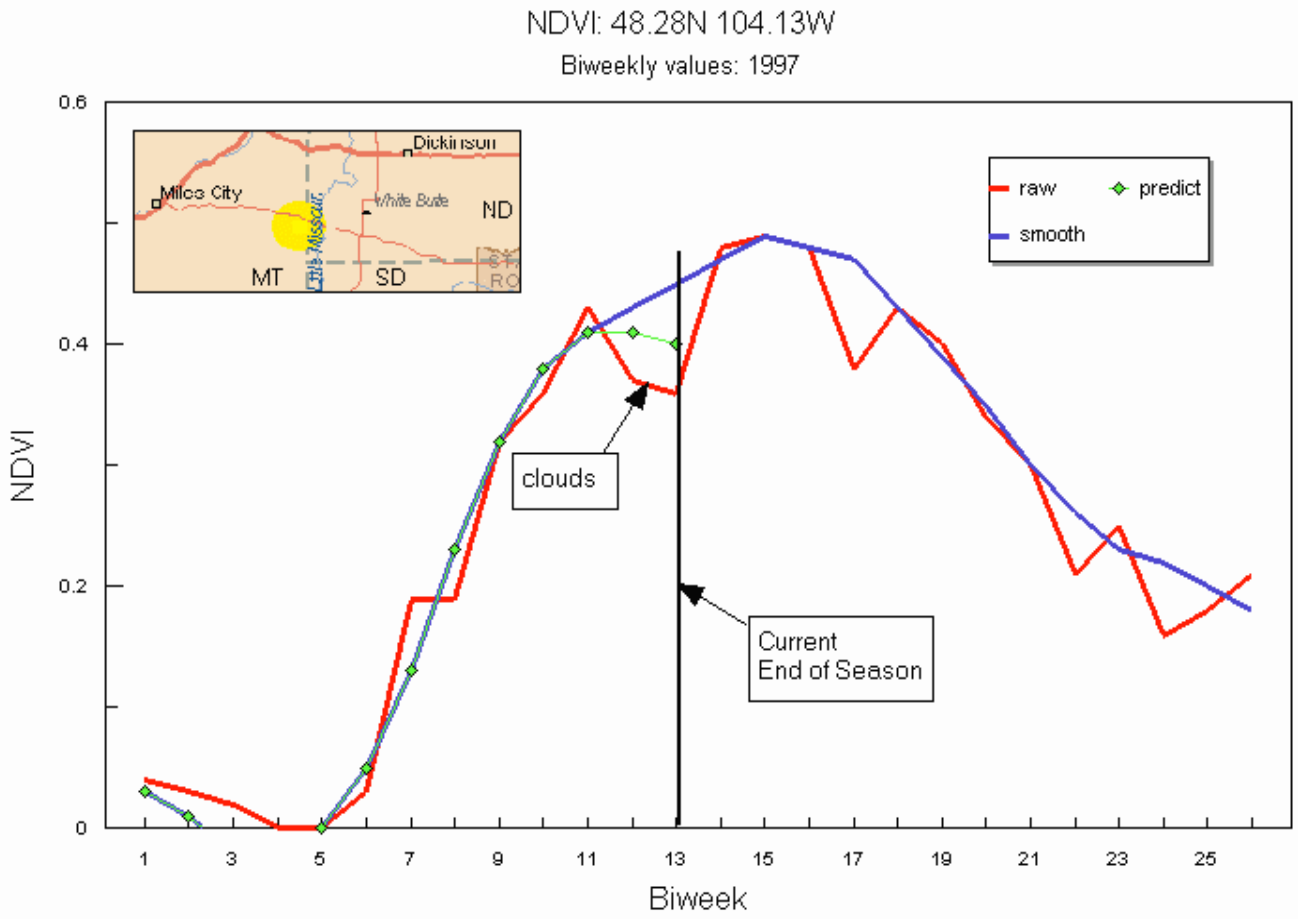
The results indicated that three land cover classes were warranted per 20 km grid cell to adequately characterize the land cover and seasonal changes in the land cover (fgreen) within the grid cell.





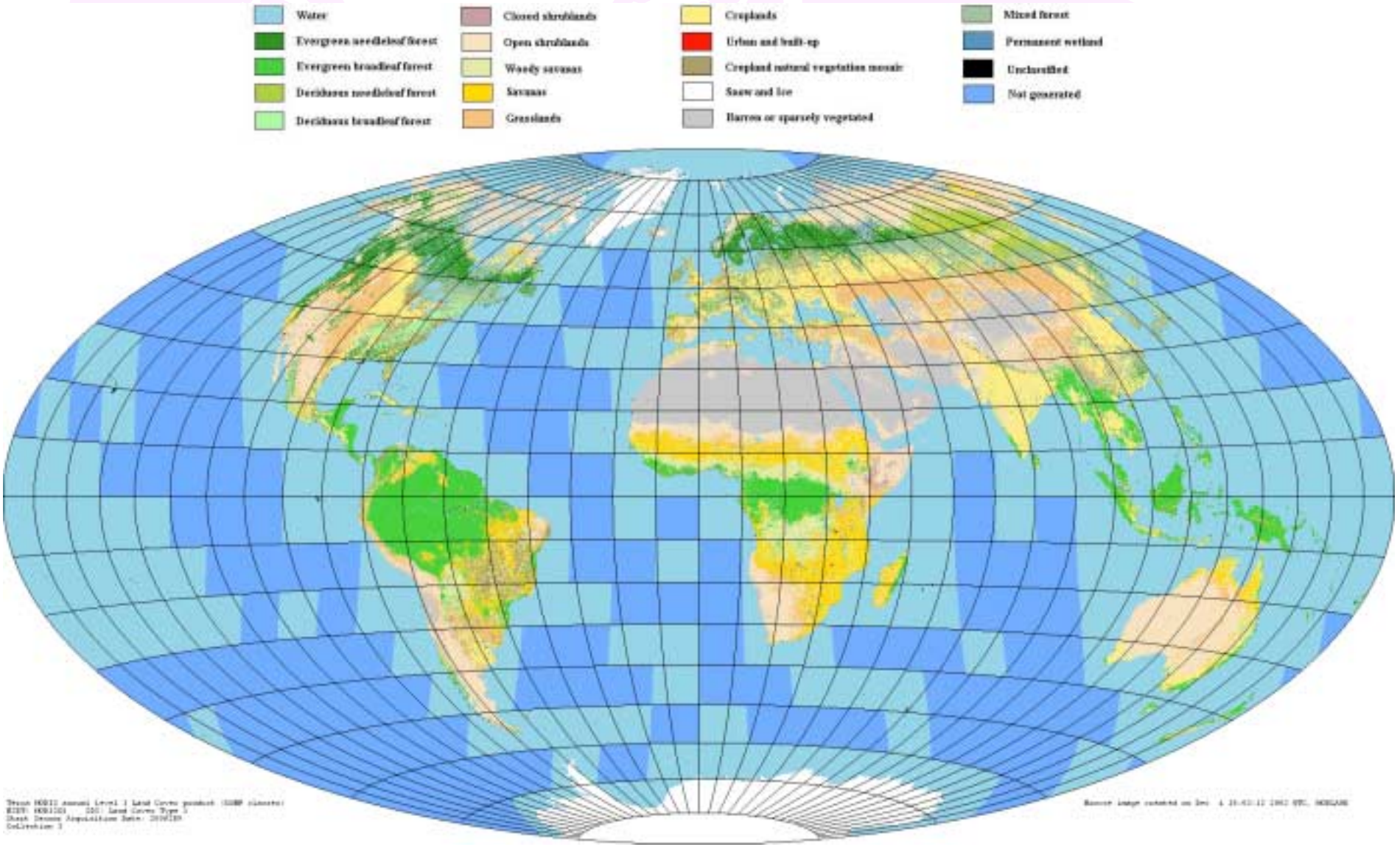
Future

Develop methodology for real-time NDVI-fgreen currently under development.



Future

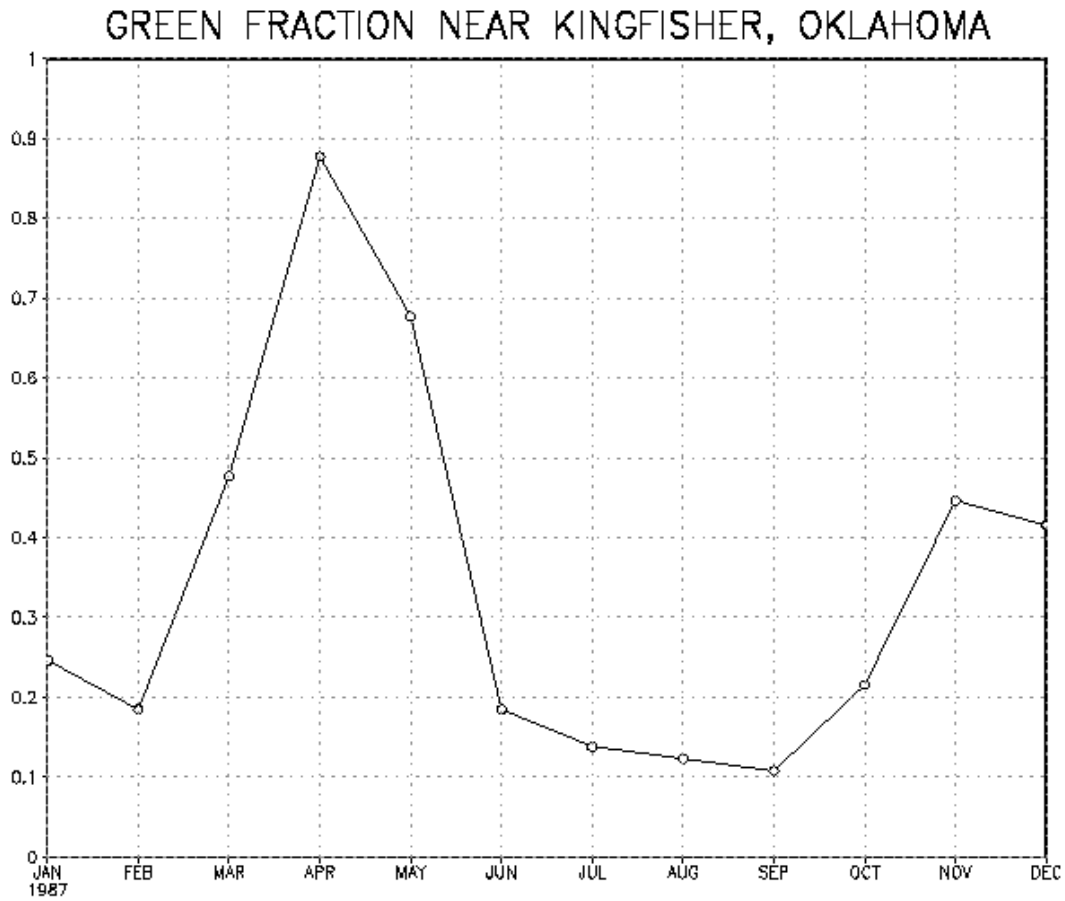
Assess MODIS derived Land Cover and NDVI.



Extra slides

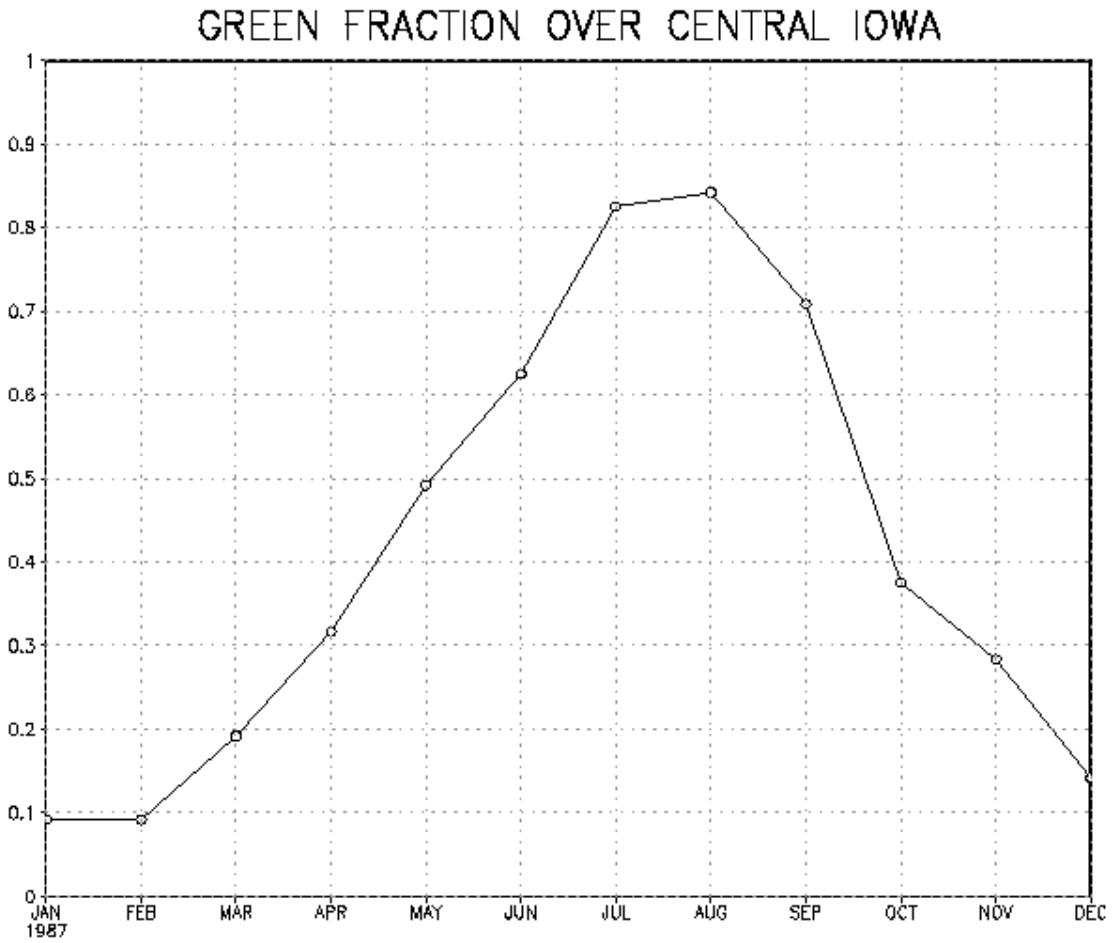
Annual Time Series of Green Fraction Over Oklahoma Wheat Country

- Early Spring intense green up.
- Rapid senescence.
- Harvesting and return of land to near bare soil by early Summer.
- Planting in Fall.



Annual Time Series of Green Fraction over Iowa Corn Fields

- Green-up and peak Fgreen of corn occurs less rapidly than for wheat.
- Corn harvested much later in the warm season than wheat.



Land Use/Land Cover