Monitoring Phenological Trends from Satellite Imagery

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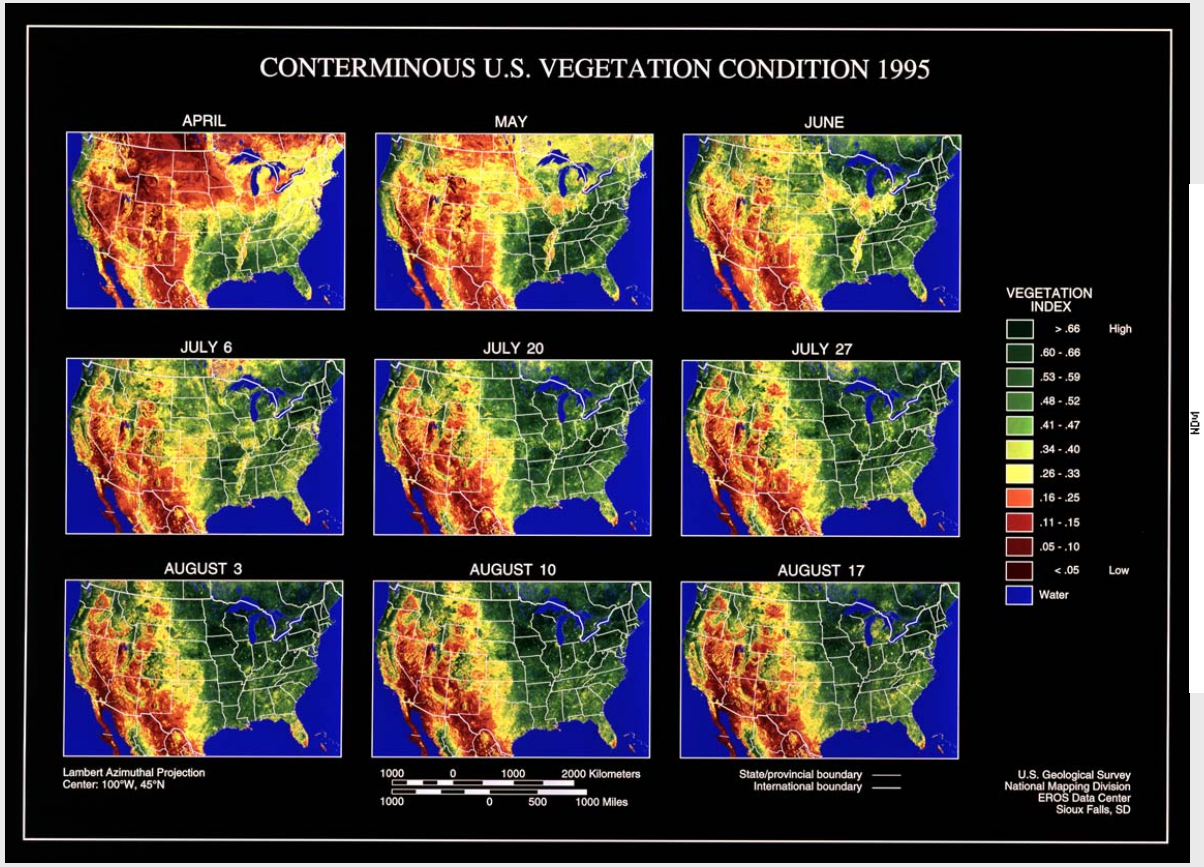
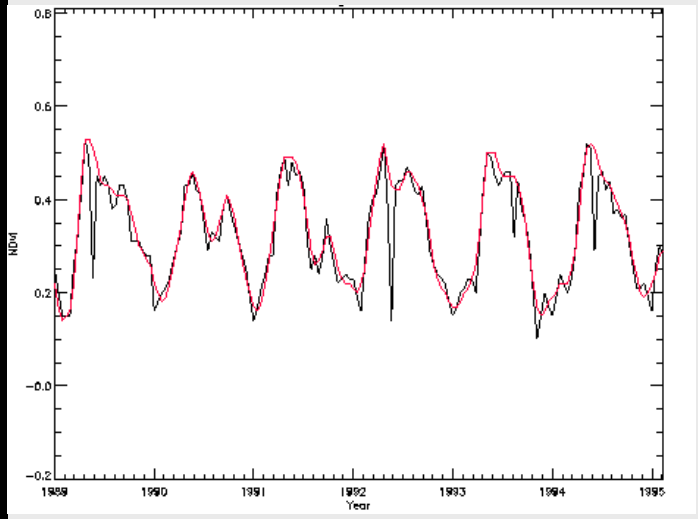
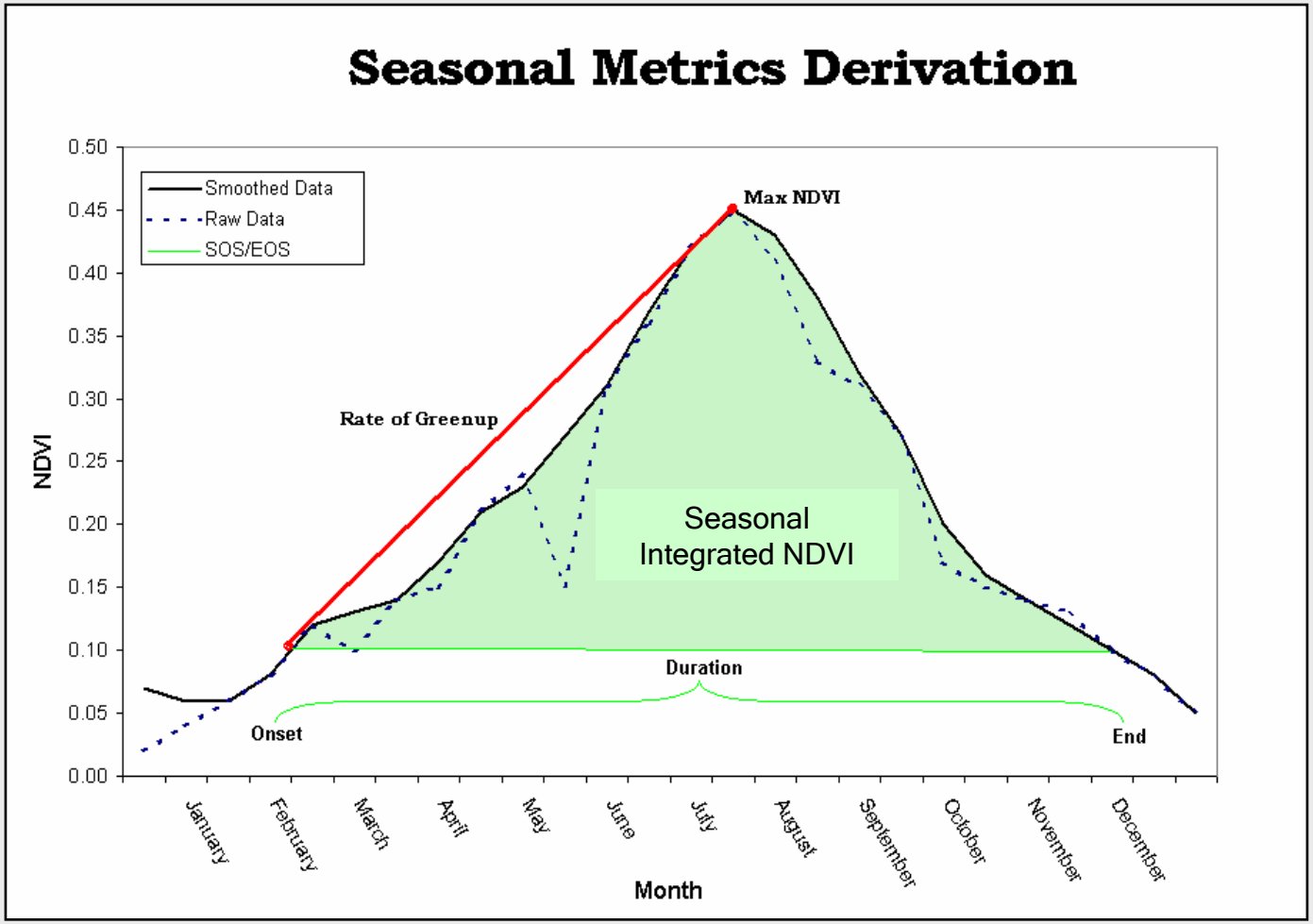
Remote Sensing of Phenology





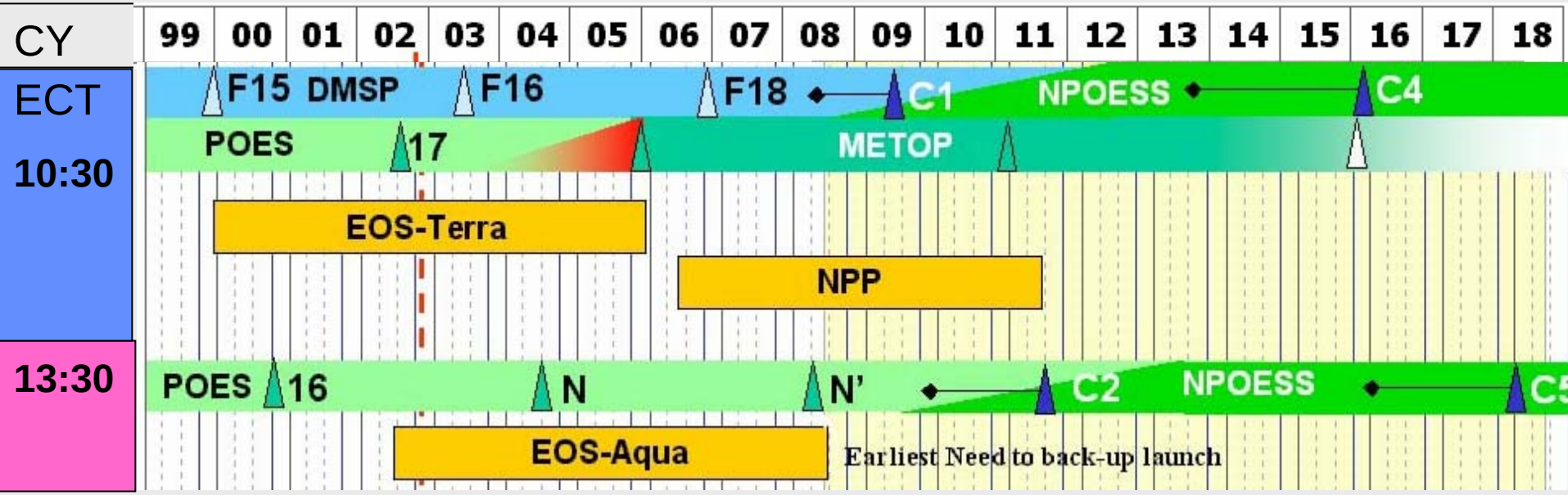
NDVI is linked to photosynthetic capacity

Phenological Metrics can be consistently derived from the annual VI cycle



Transition to new generation sensors

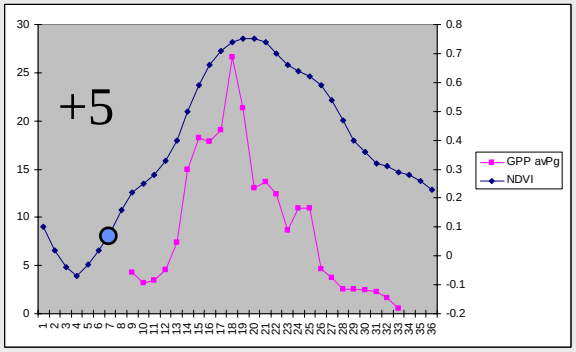
AVHRR ⟶ MODIS ⟶ NPP ⟶ NPOESS



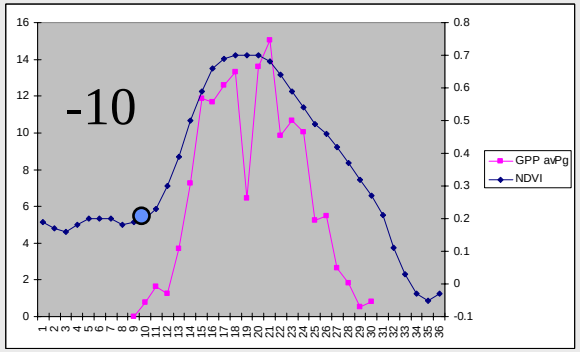
Satellite SOS vs. GPP estimates

(USDA-Agriflux towers)

Mandan, ND



1999



2000

Days offset

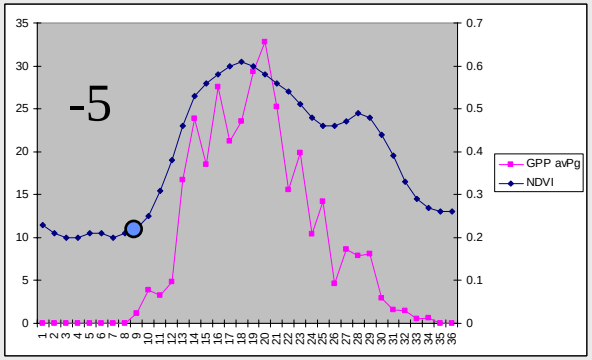
$n = 13$

$\bar{x} = 2.23$

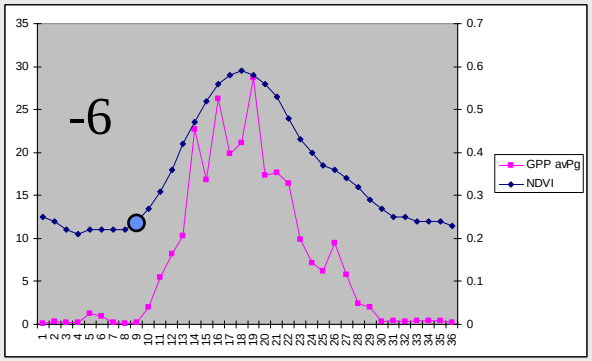
std = 8.21

● = Start of Season

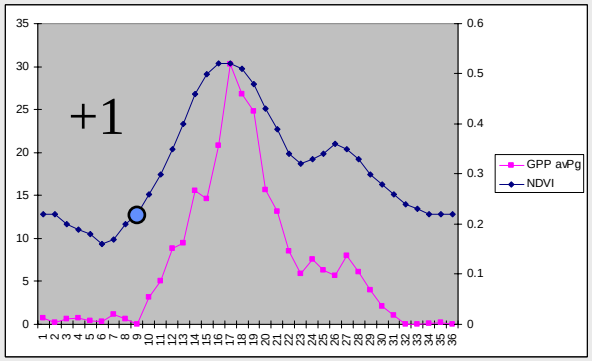
Woodward, OK



1999



2000



2001

1989

1990

1991

1992

1993

1994

1995

1996

1997

1998

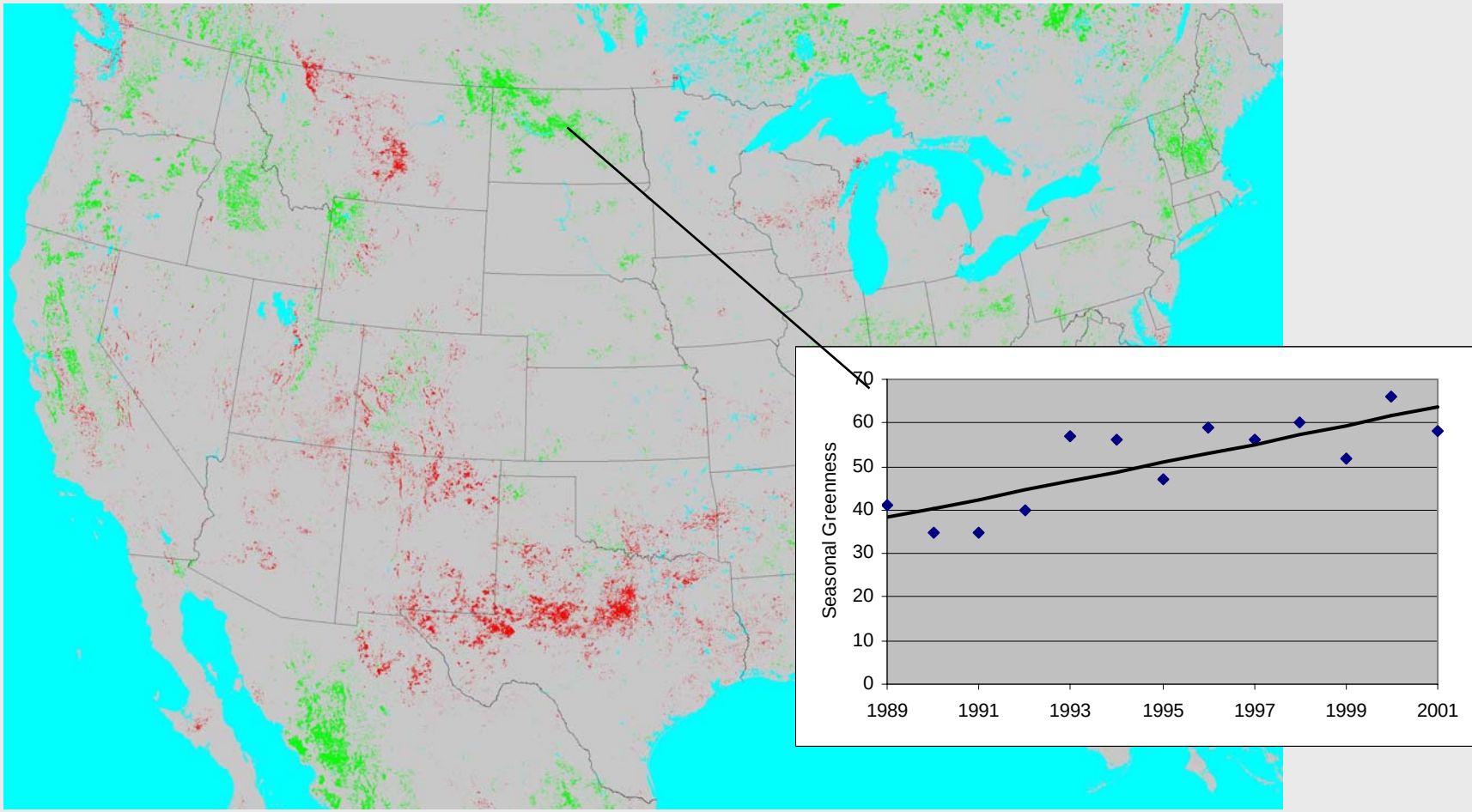
1999

2000

2001

Trends in Phenological Metrics: SiNDVI=Annual Greenness

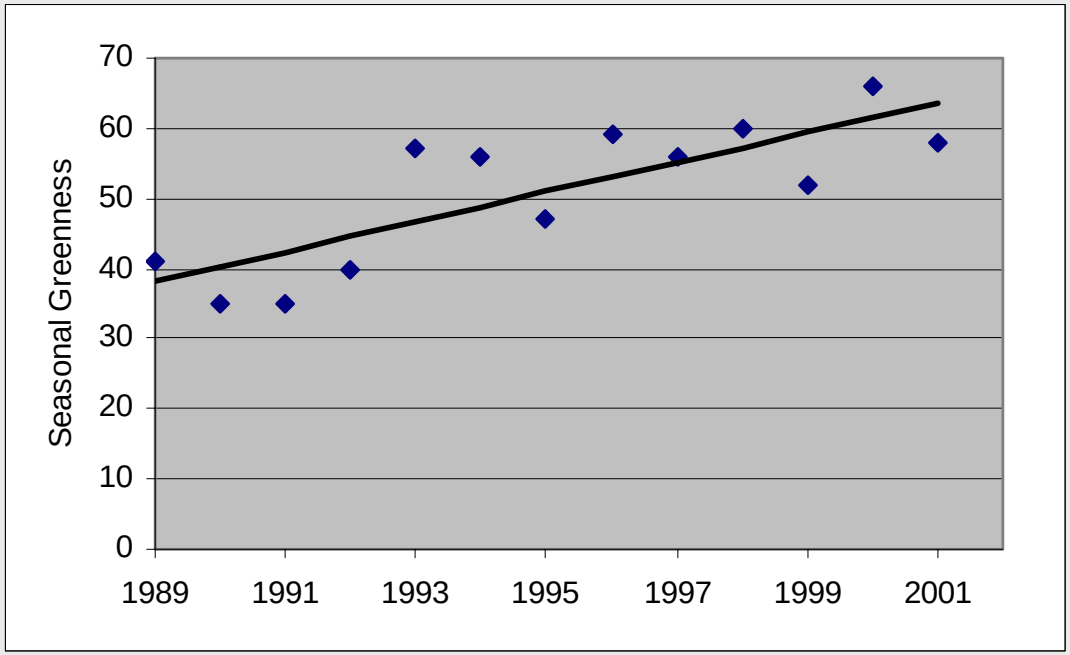
Regions with Significant Trends in Annual Greenness: Is the slope (b) of best-fit line significantly different from 0?



Decreasing Greenness

Increasing Greenness

Regions with Significant Trends in Annual Greenness:
Is the slope (b) of best-fit line significantly different from 0?



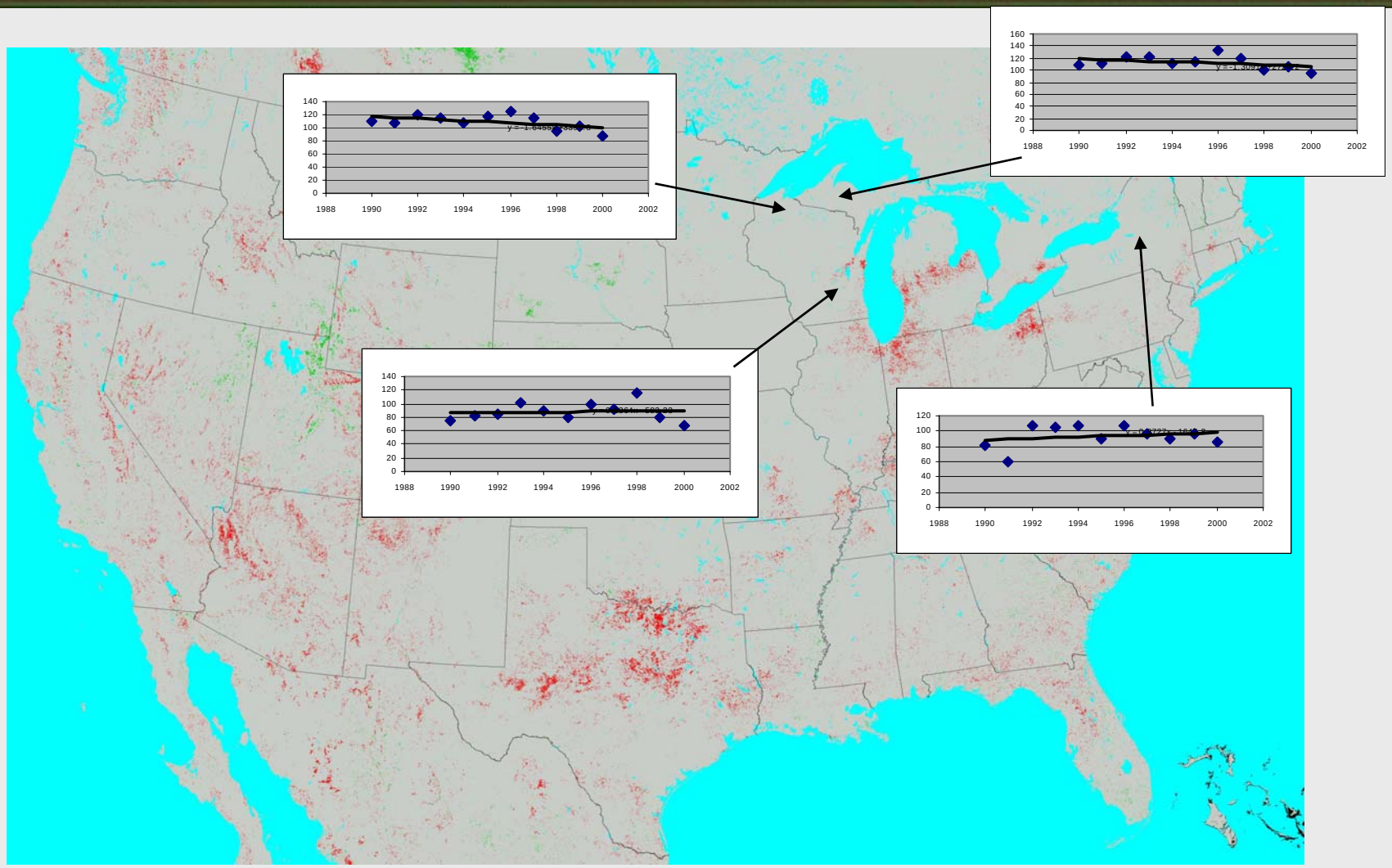
b = 2.12

standard error (s) = 0.46

t-test: t = b/s = 4.60

t-distribution at 0.05 level of significance and df = 11 = 2.201,

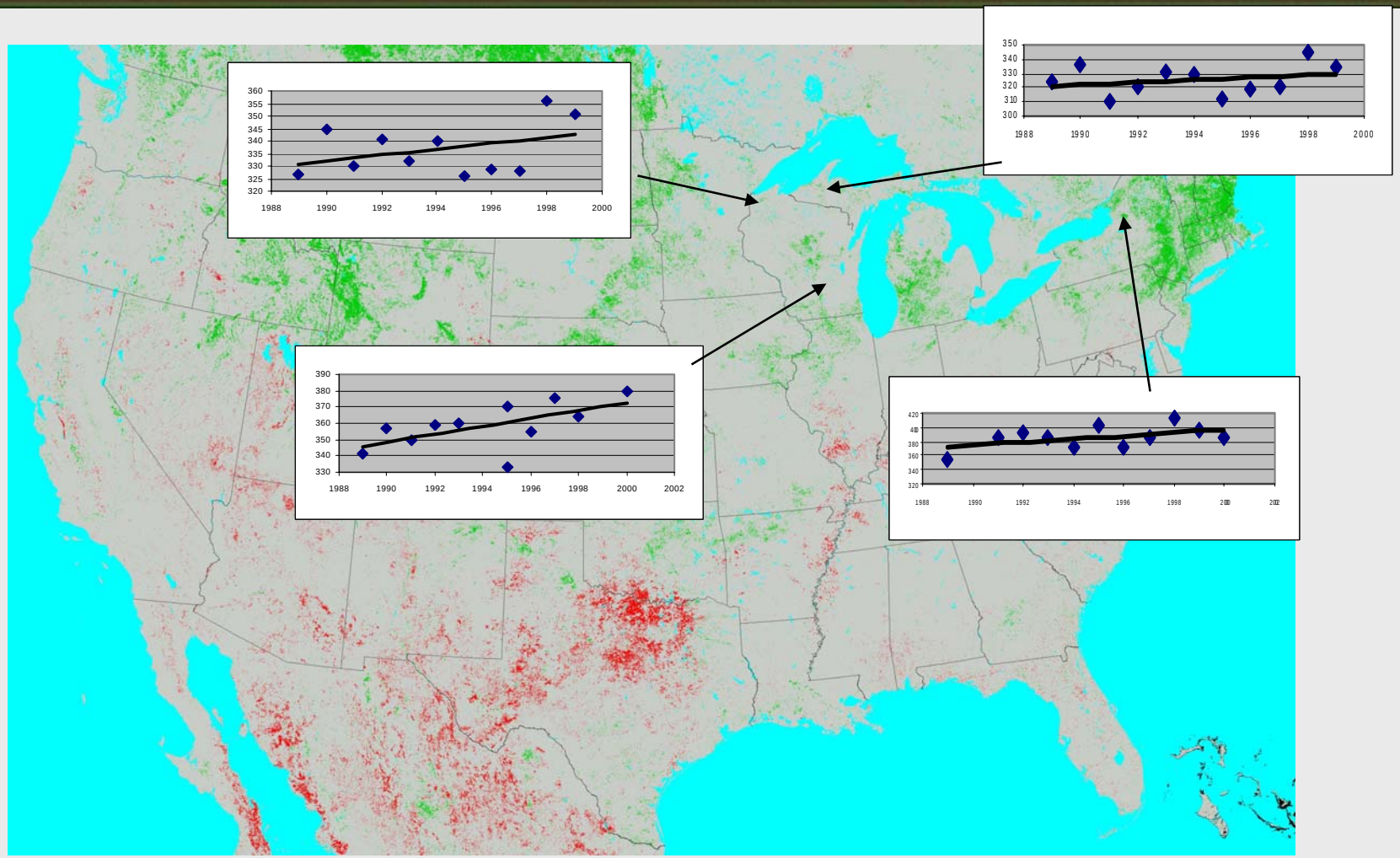
4.60 > 2.201, therefore is significant



Earlier SOS

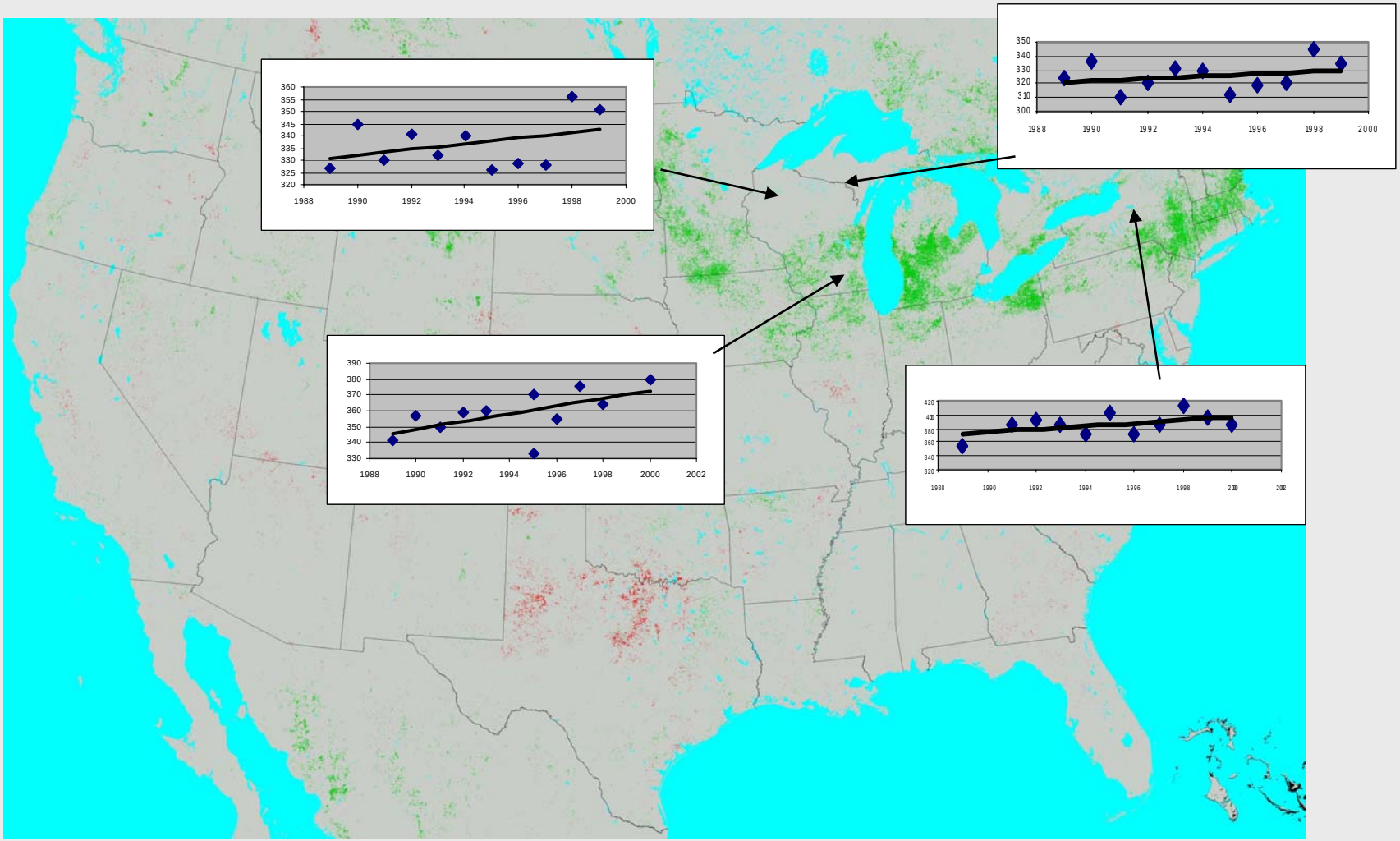
Later SOS

Trends in SOS Time 1989-2001 and trends in time of lake thaw



Trends in EOS Time 1989-2001 and trends in time of lake freeze

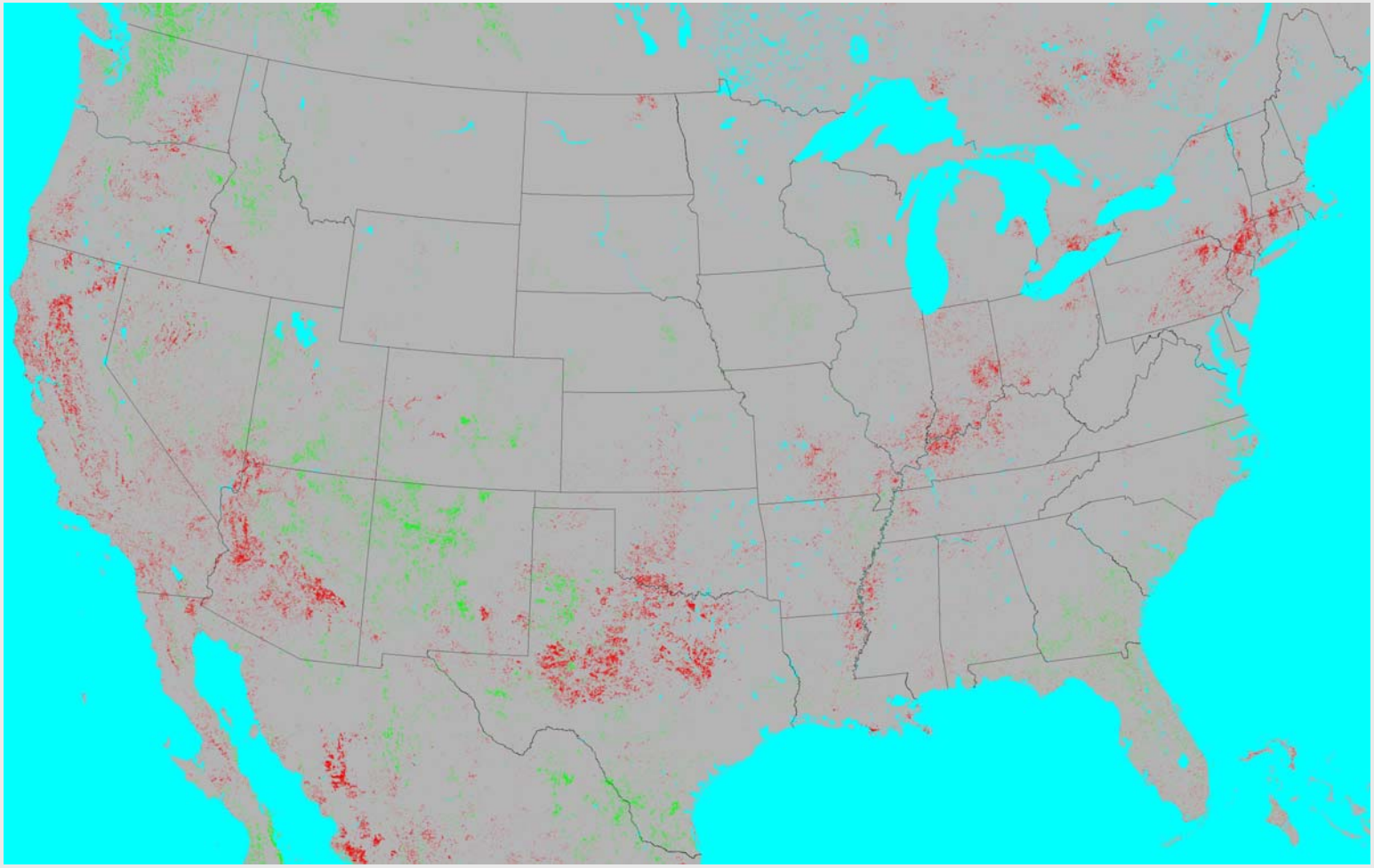
- Earlier EOS
- Later EOS



Shorter Duration
Longer Duration

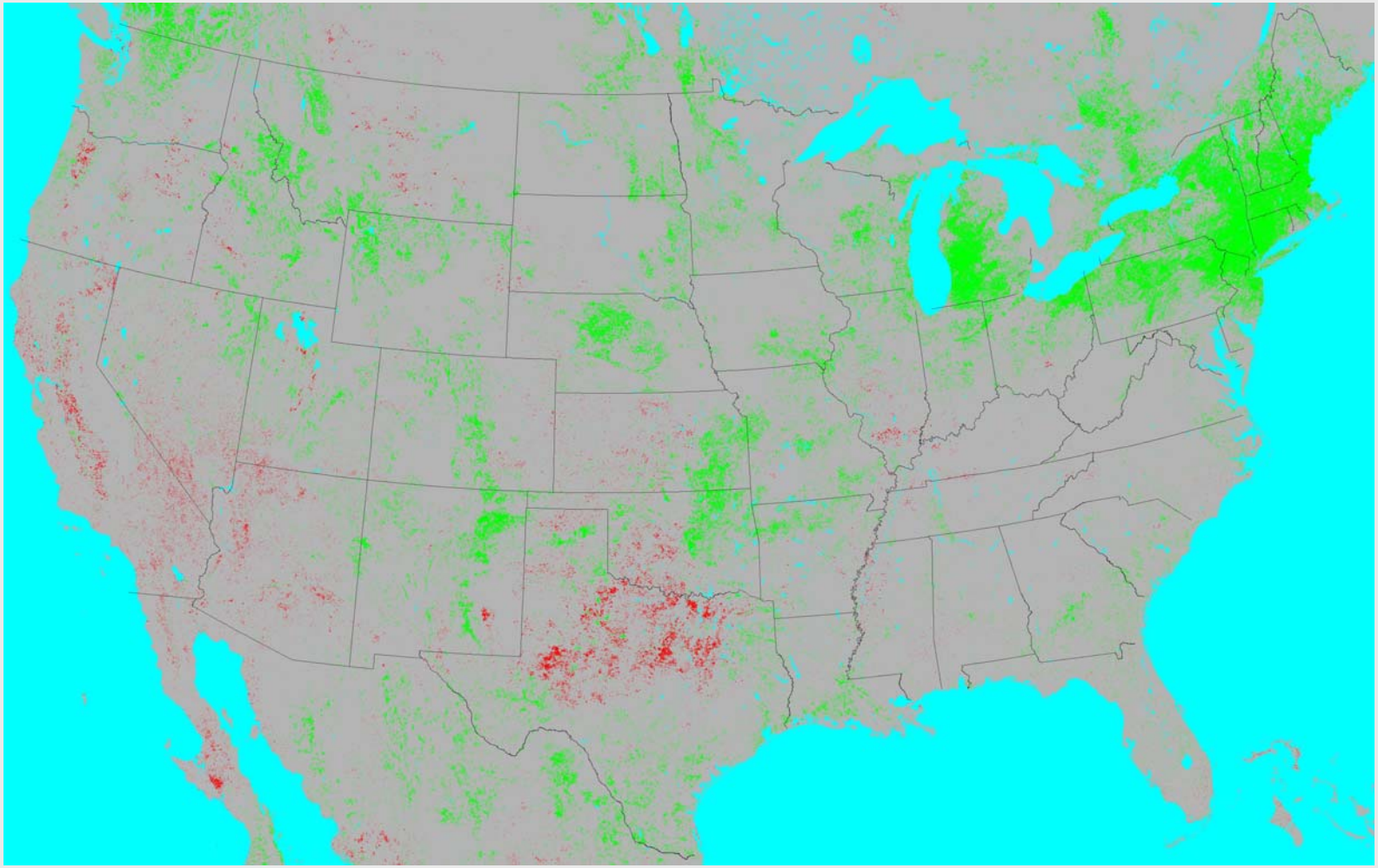
Trends in Duration of Season 1989-2001 and trends in length of lake freeze-free period

SOST 1989-2003



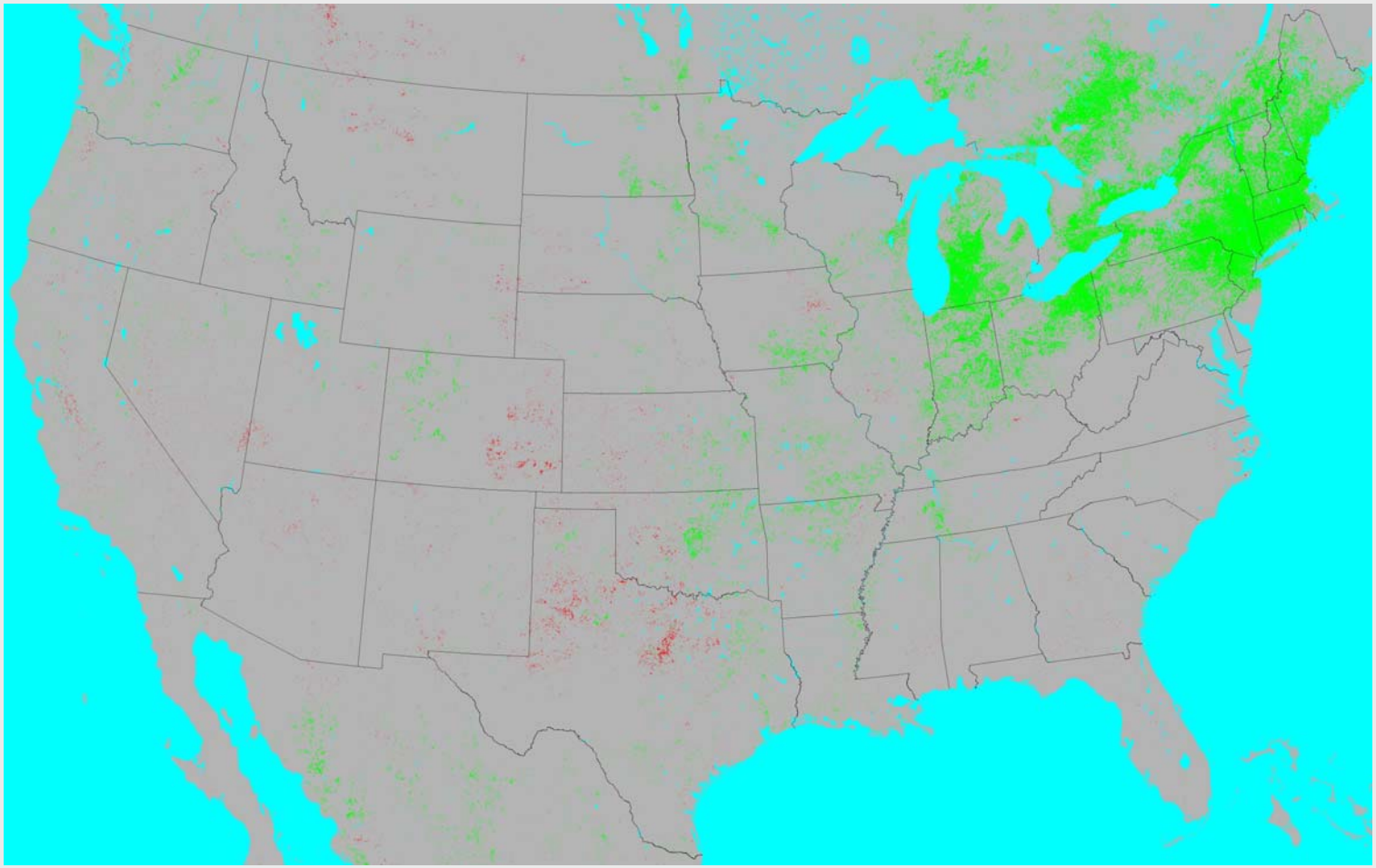
Earlier SOS
Later SOS

EOST 1989-2003



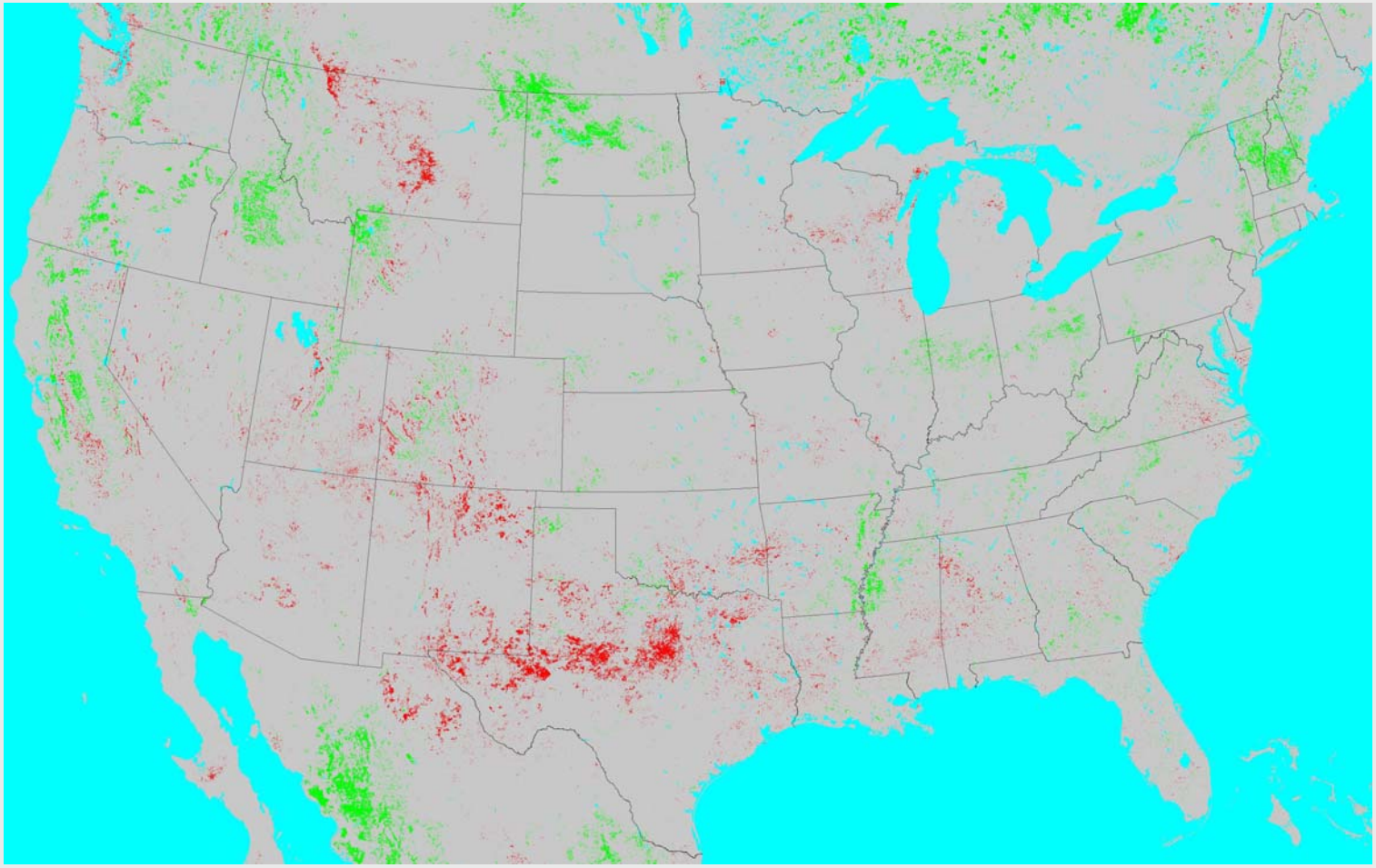
Earlier EOS
Later EOS

Trends in Duration of growing season 1989-2003



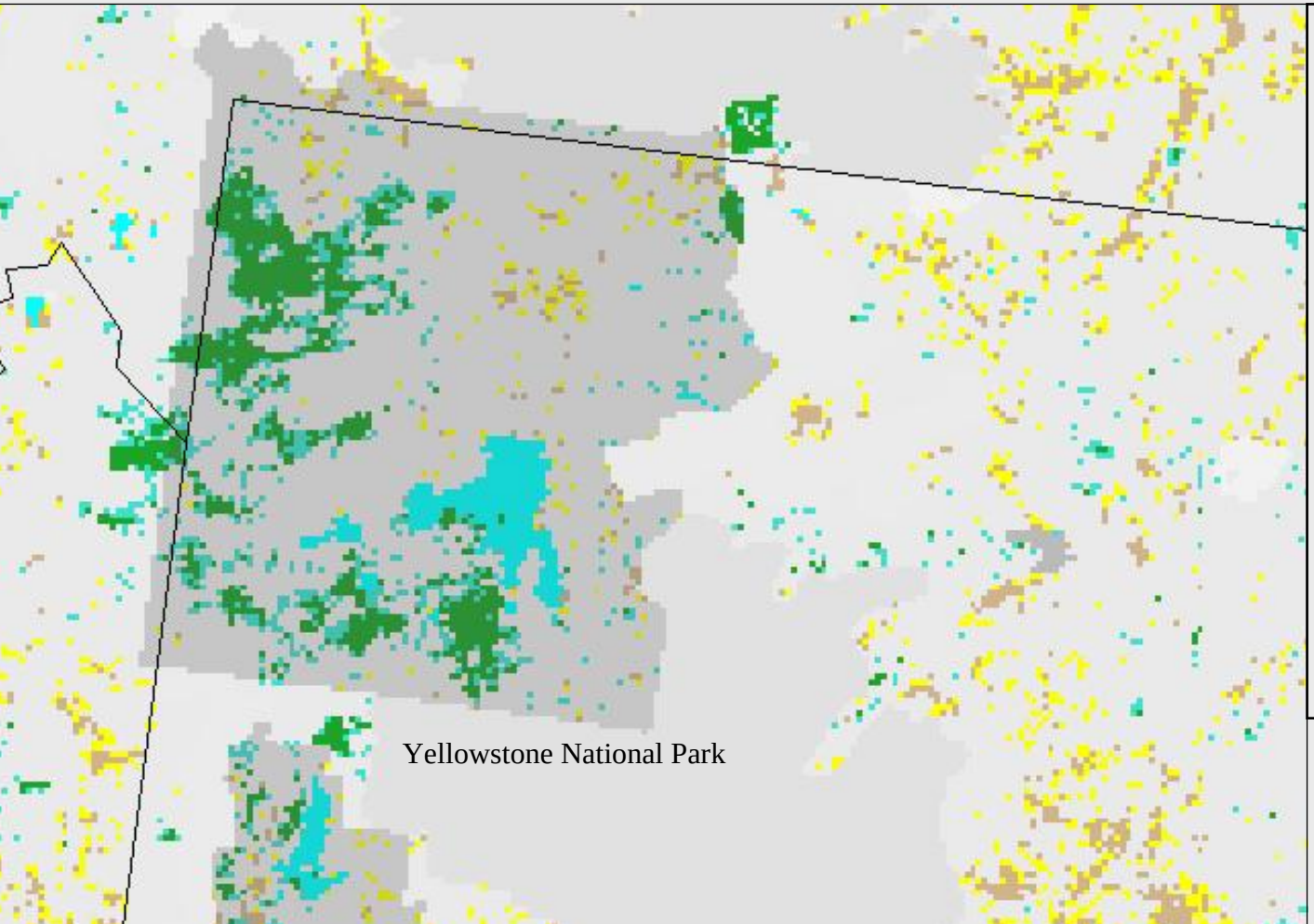
Shorter Duration
Longer Duration

Trends in Integrated NDVI 1989-2003



Decreasing Greenness
Increasing Greenness

Analysis of Trends



Driving Forces

Fire recovery

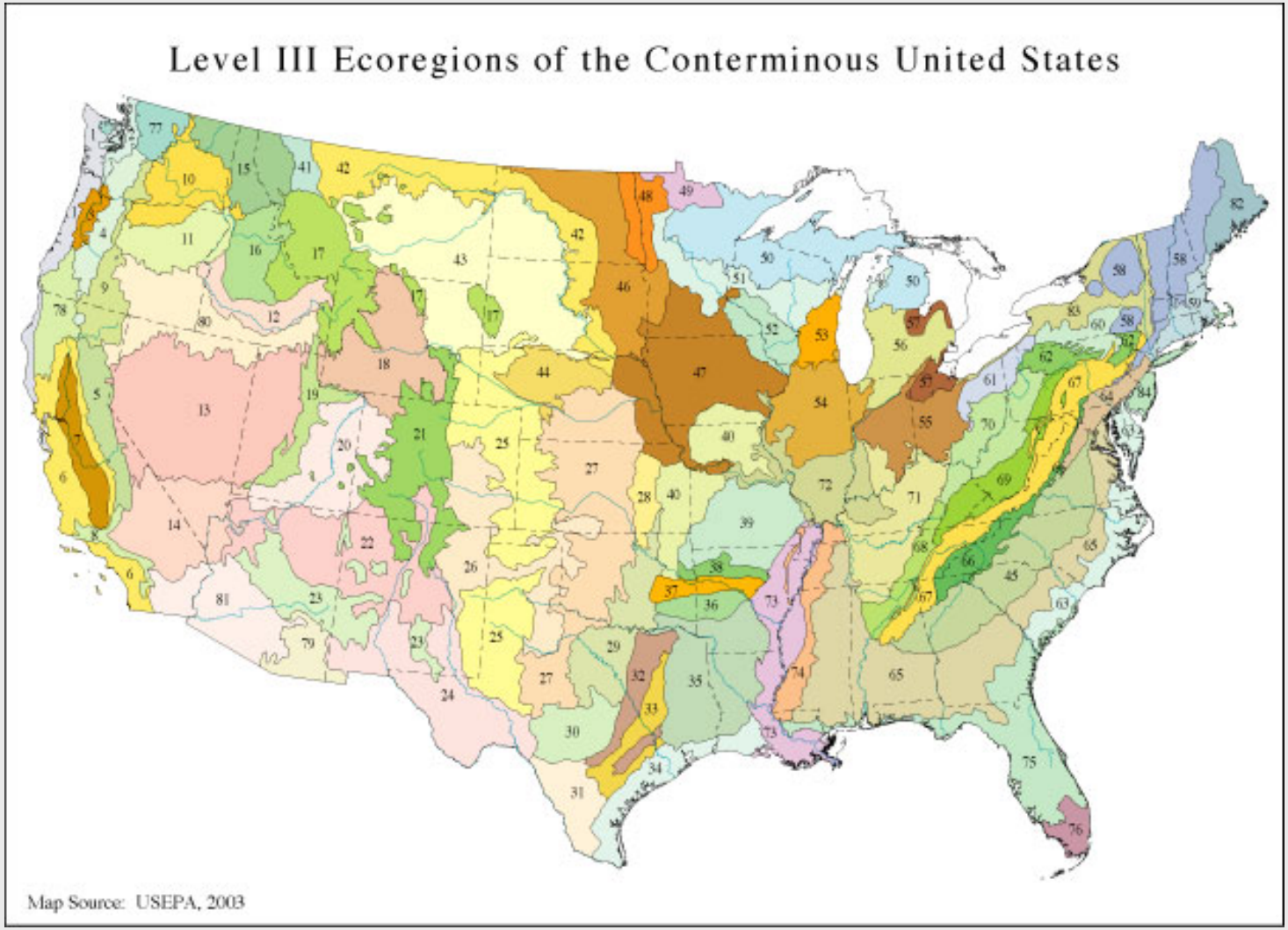
Land use change

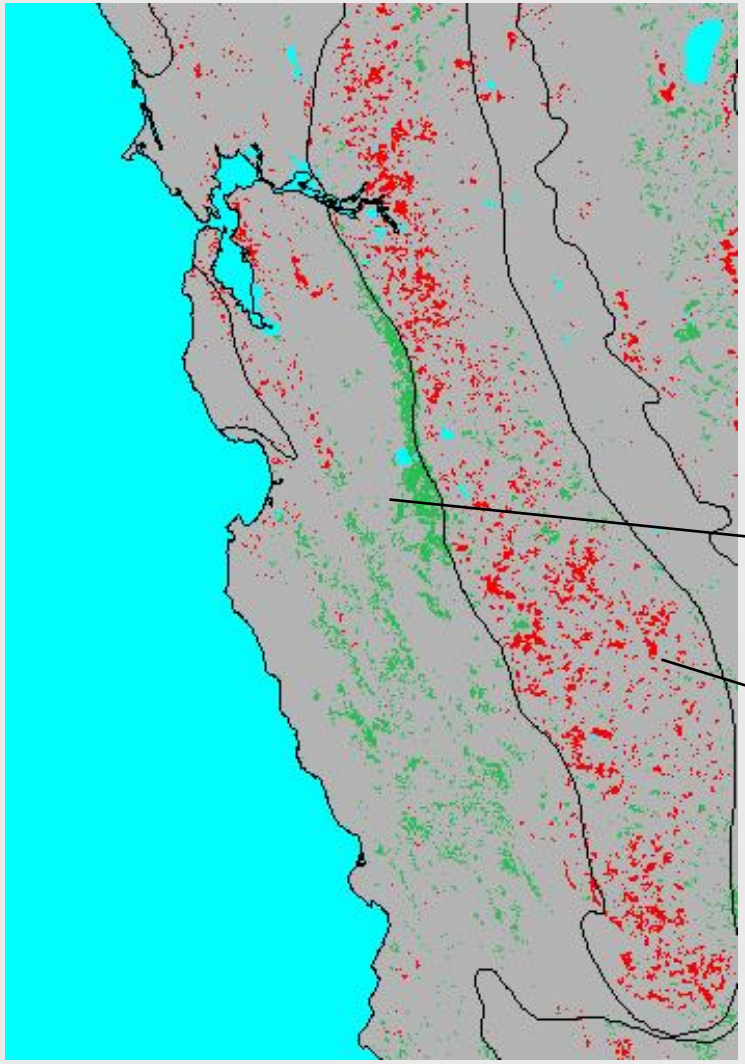
Land use practice

Biological succession

Short and long-term climate change

Analysis by Ecoregion



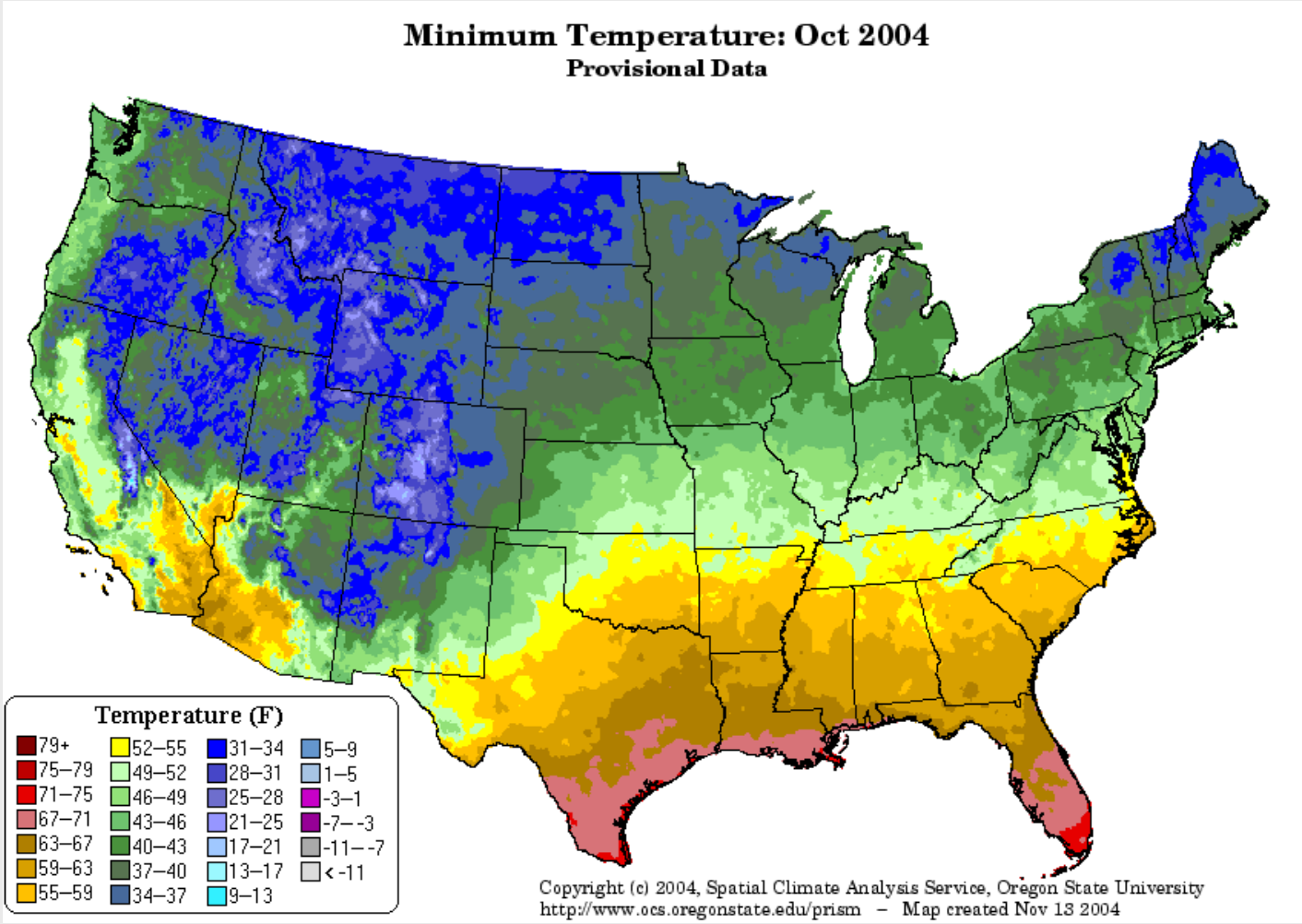


In many, but not all, instances trends follow ecoregion boundaries.

Southern and Central California Chaparral and Oak Woodlands

Central California Valley

Climate Data Source: PRISM



5km Grid

Temperature

$\bar{x}$ Monthly max
$\bar{x}$ Monthly min

Precipitation

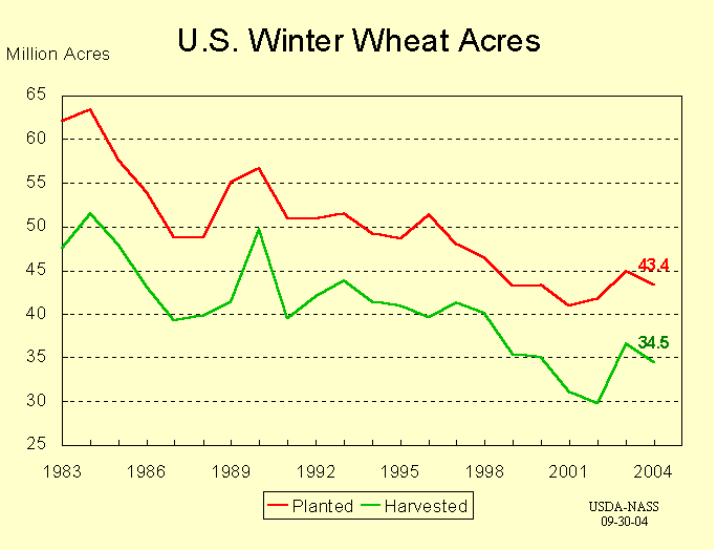
Monthly Total

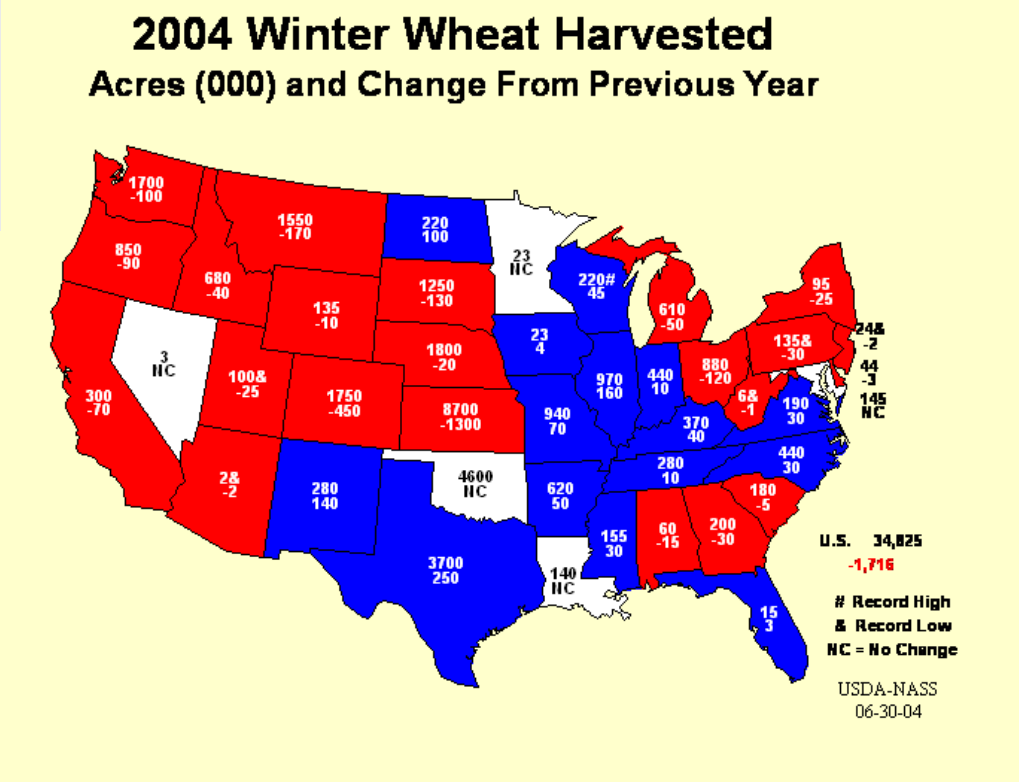
Agricultural Data

Source: USDA National Agricultural Statistical Service

County-level data for all crops

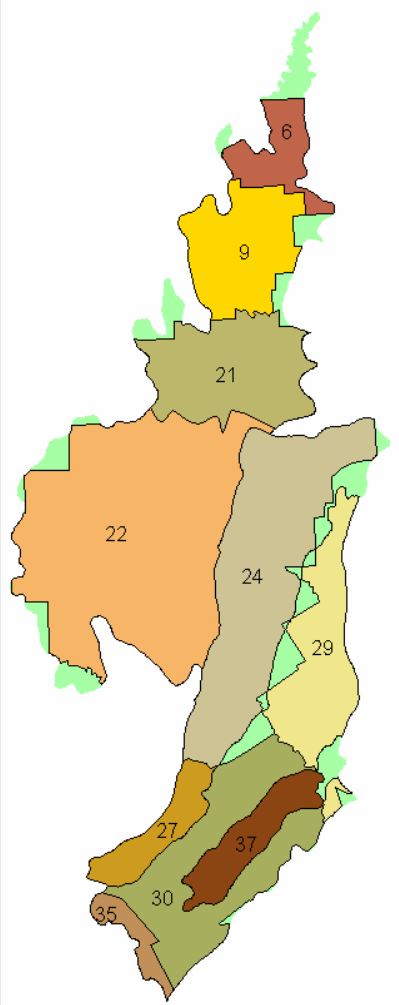
- Acres planted
- Acres harvested
- Yield
- Production



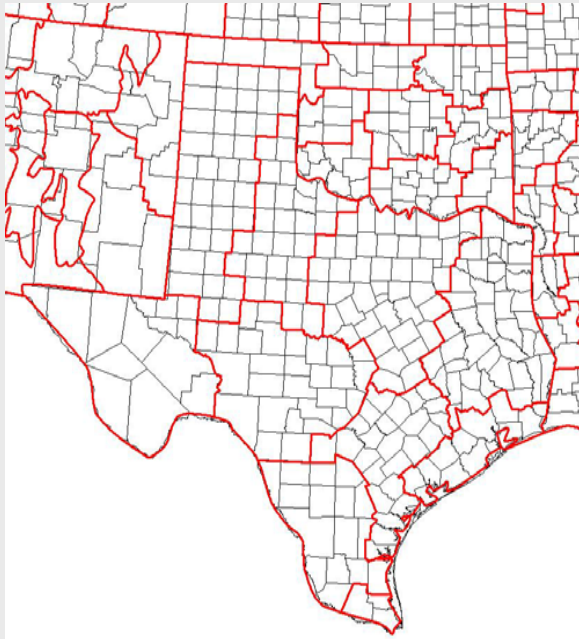


Evaluation of Trends

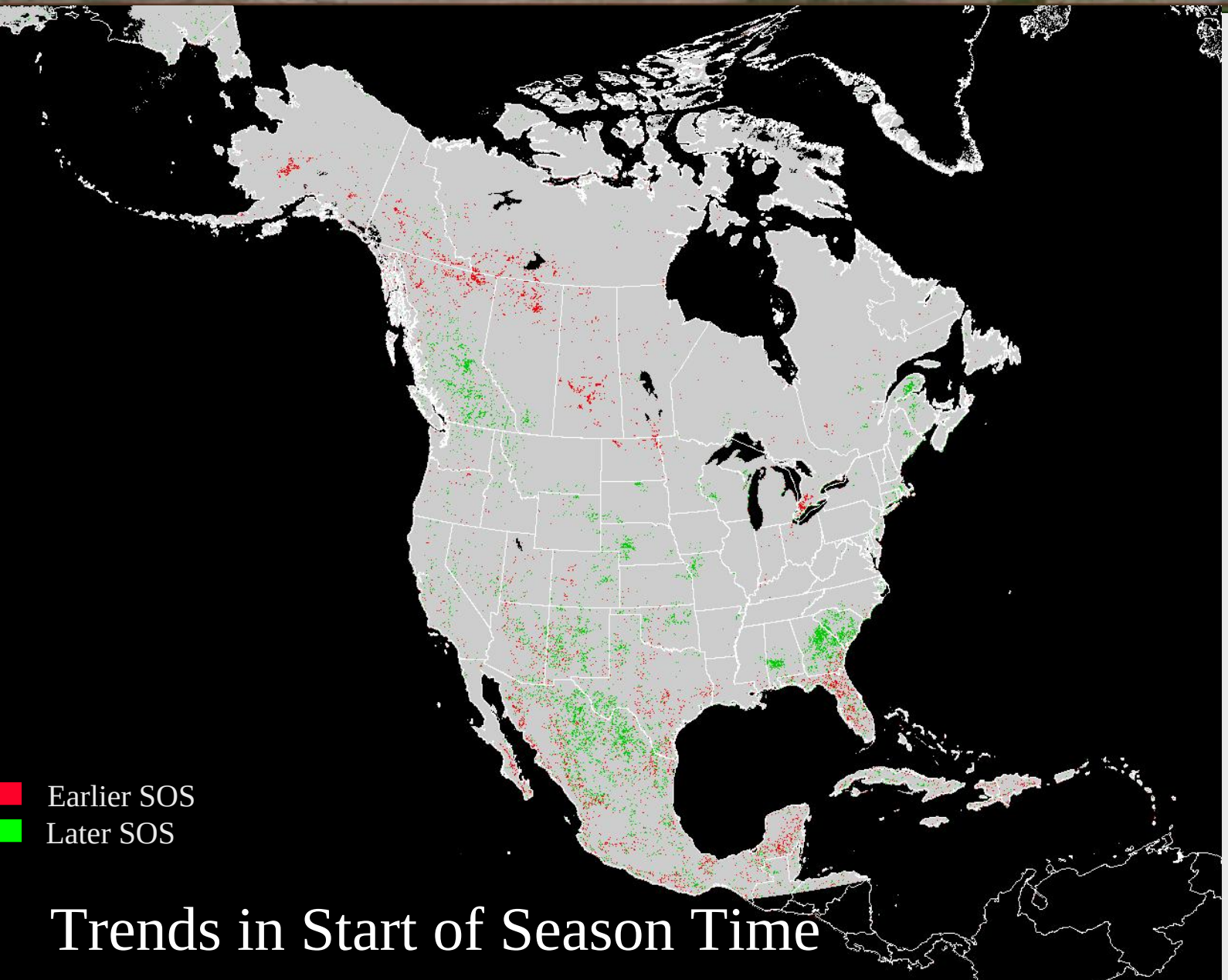
Sub-ecoregion-level analysis



Climate division summaries of temp/precip from PRISM

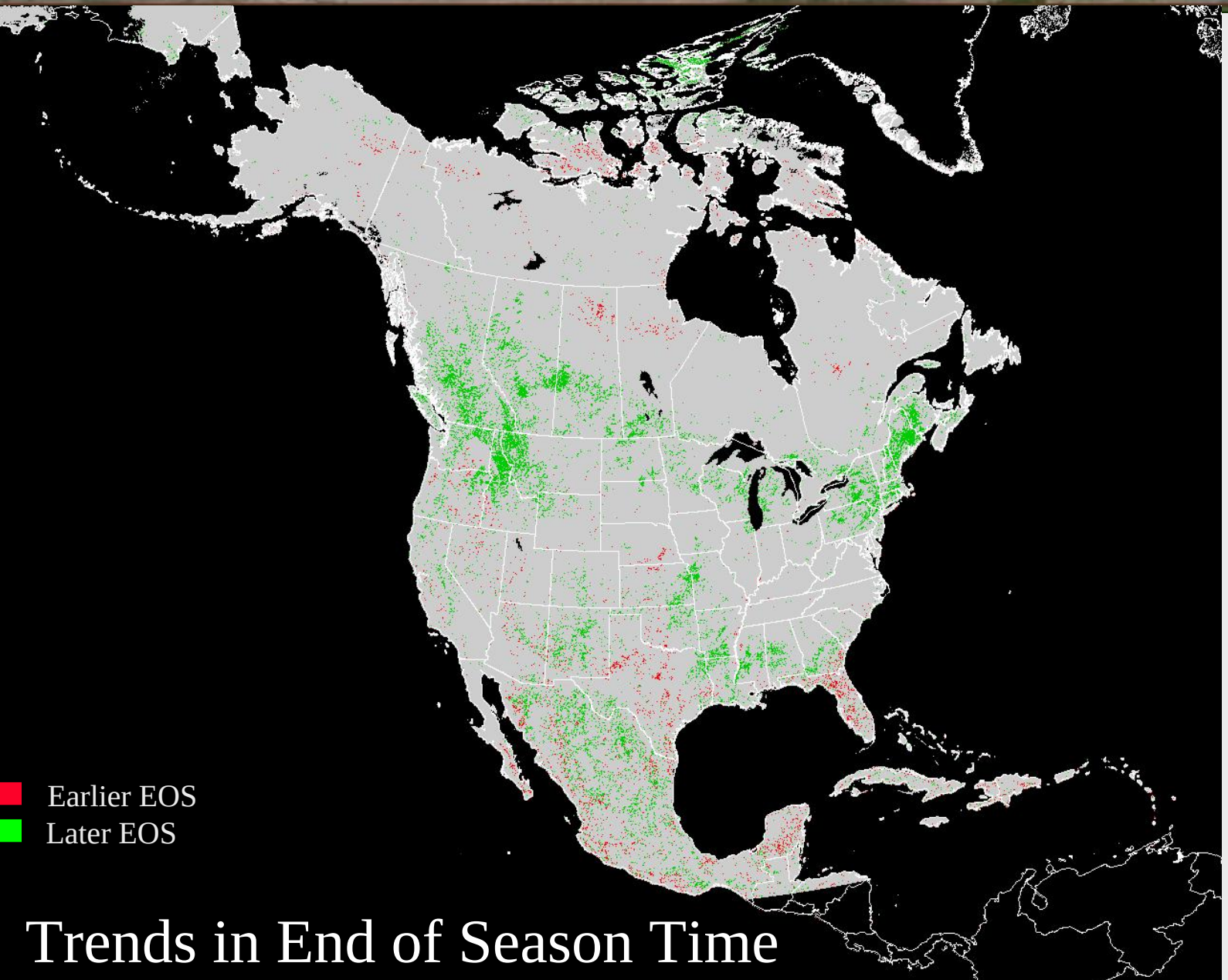


County-level agriculture statistics

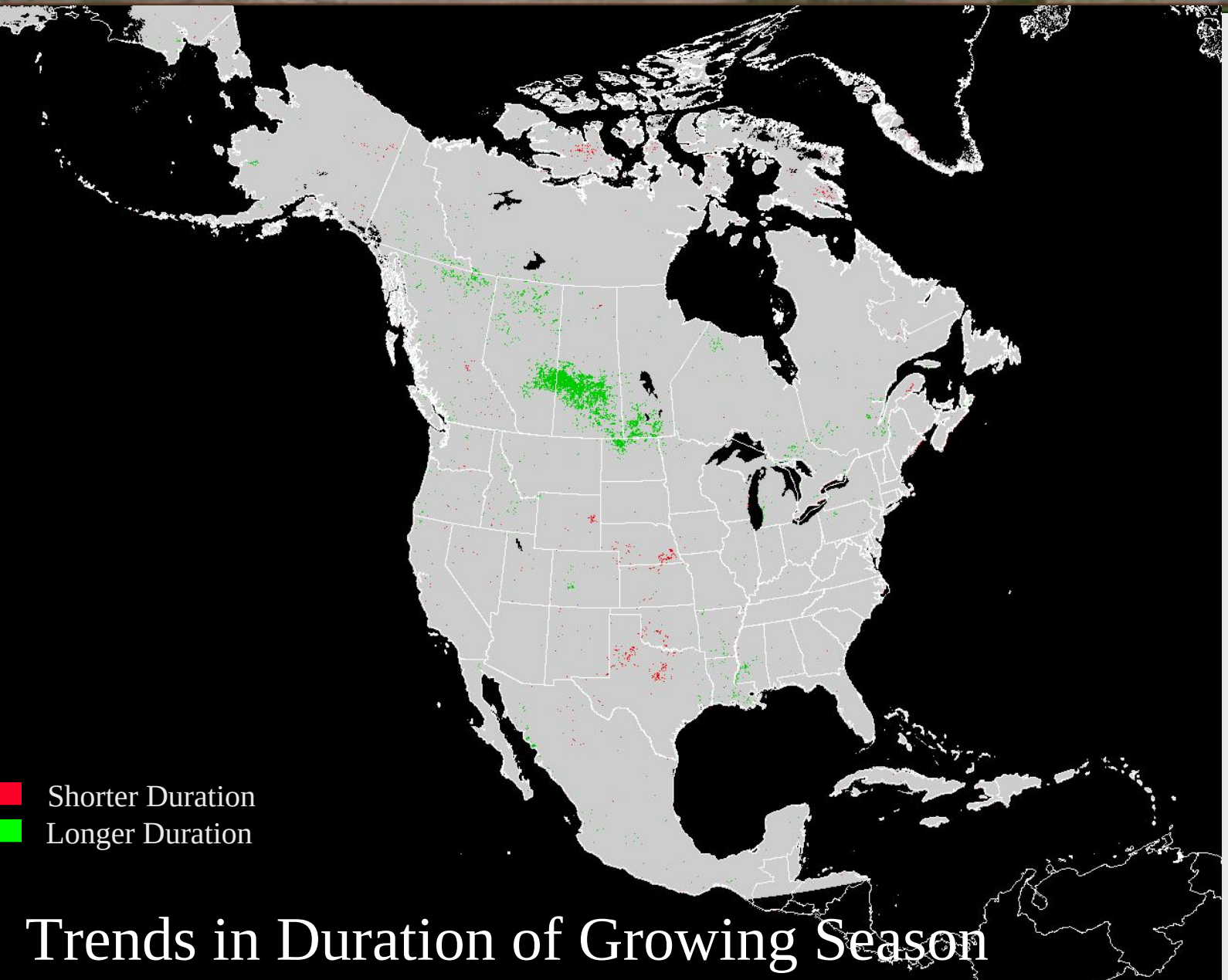


Trends in Start of Season Time

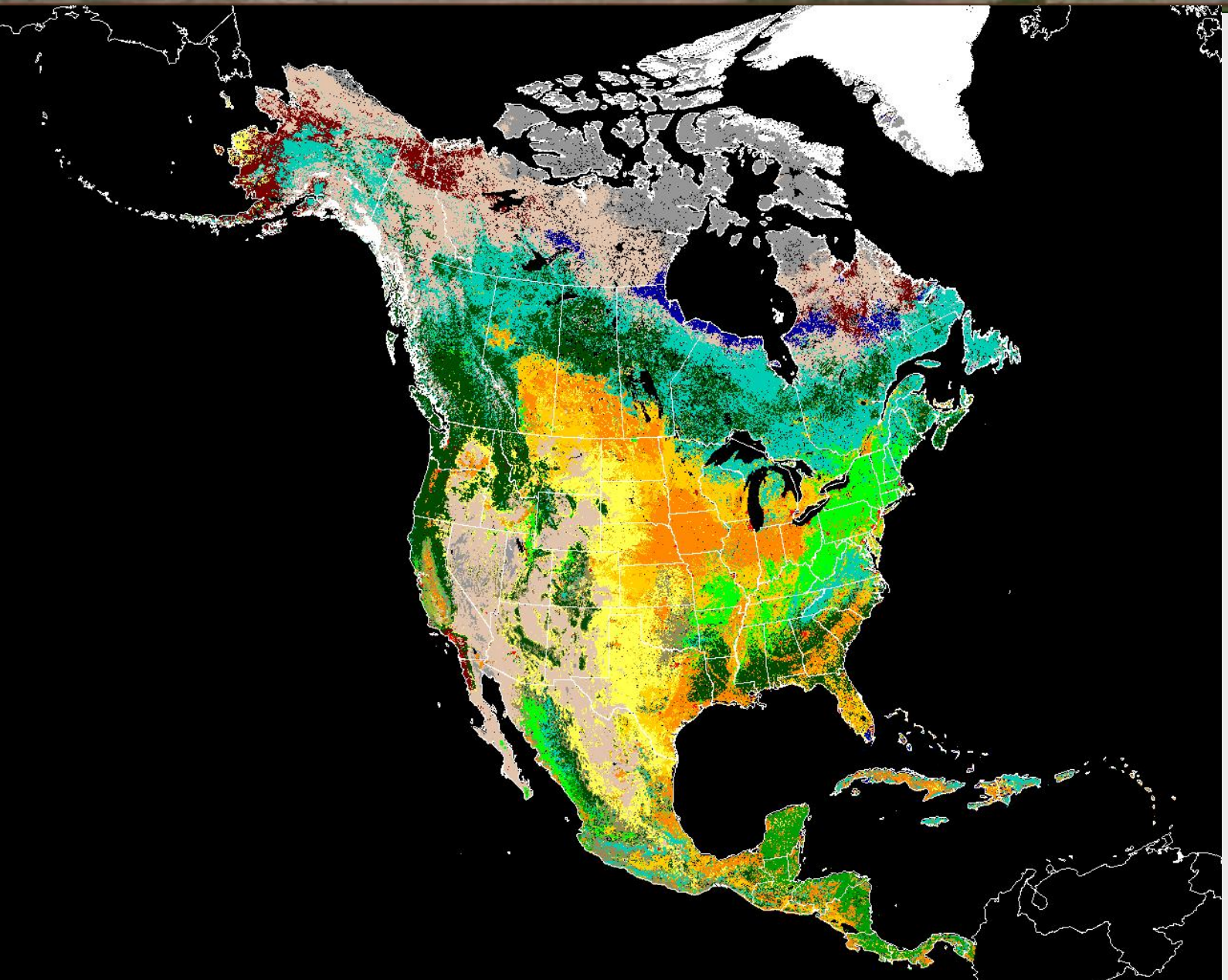
Analysis based on GIMMS (aka Jim's) 8-km AVHRR data from 1982-2003

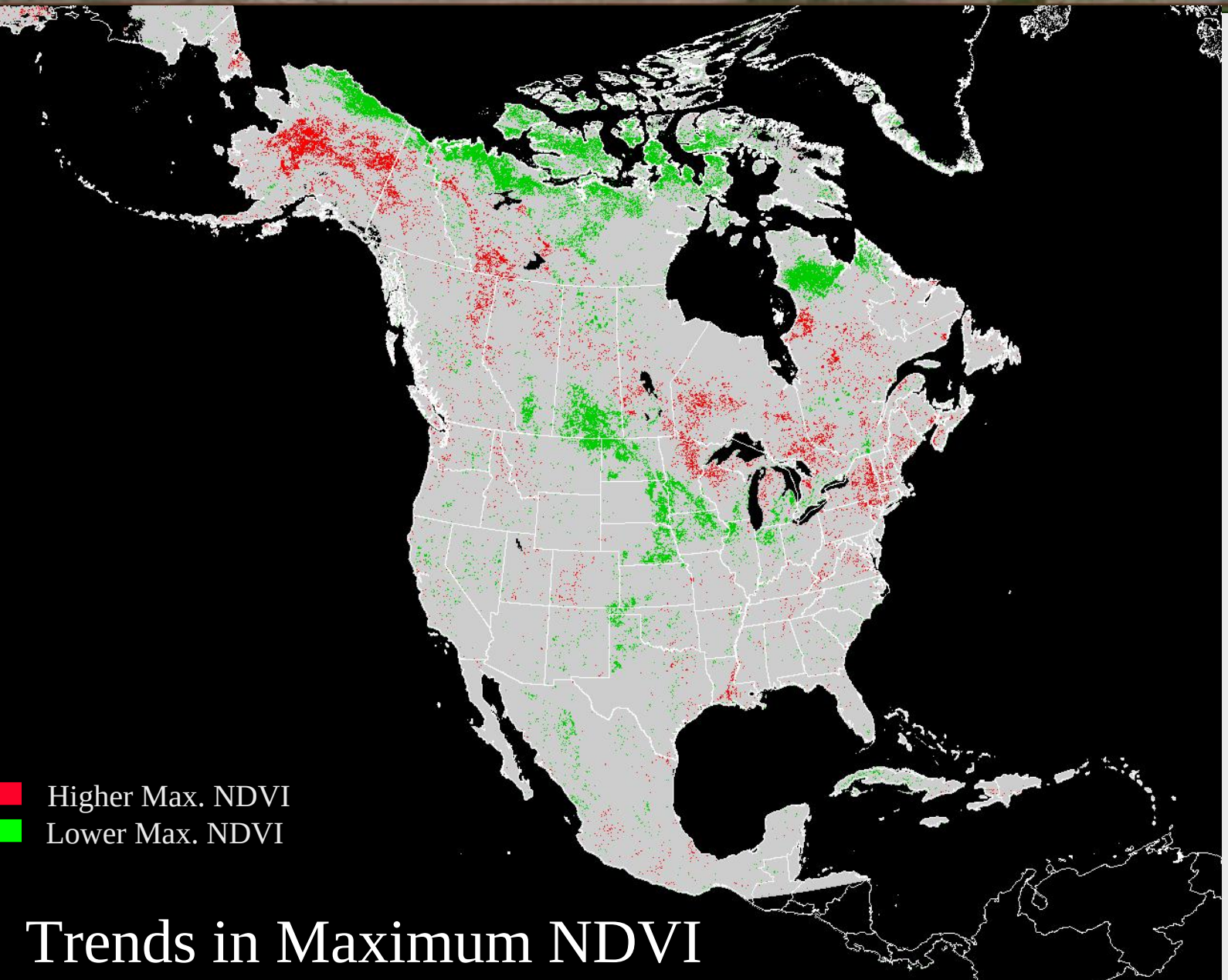


Trends in End of Season Time

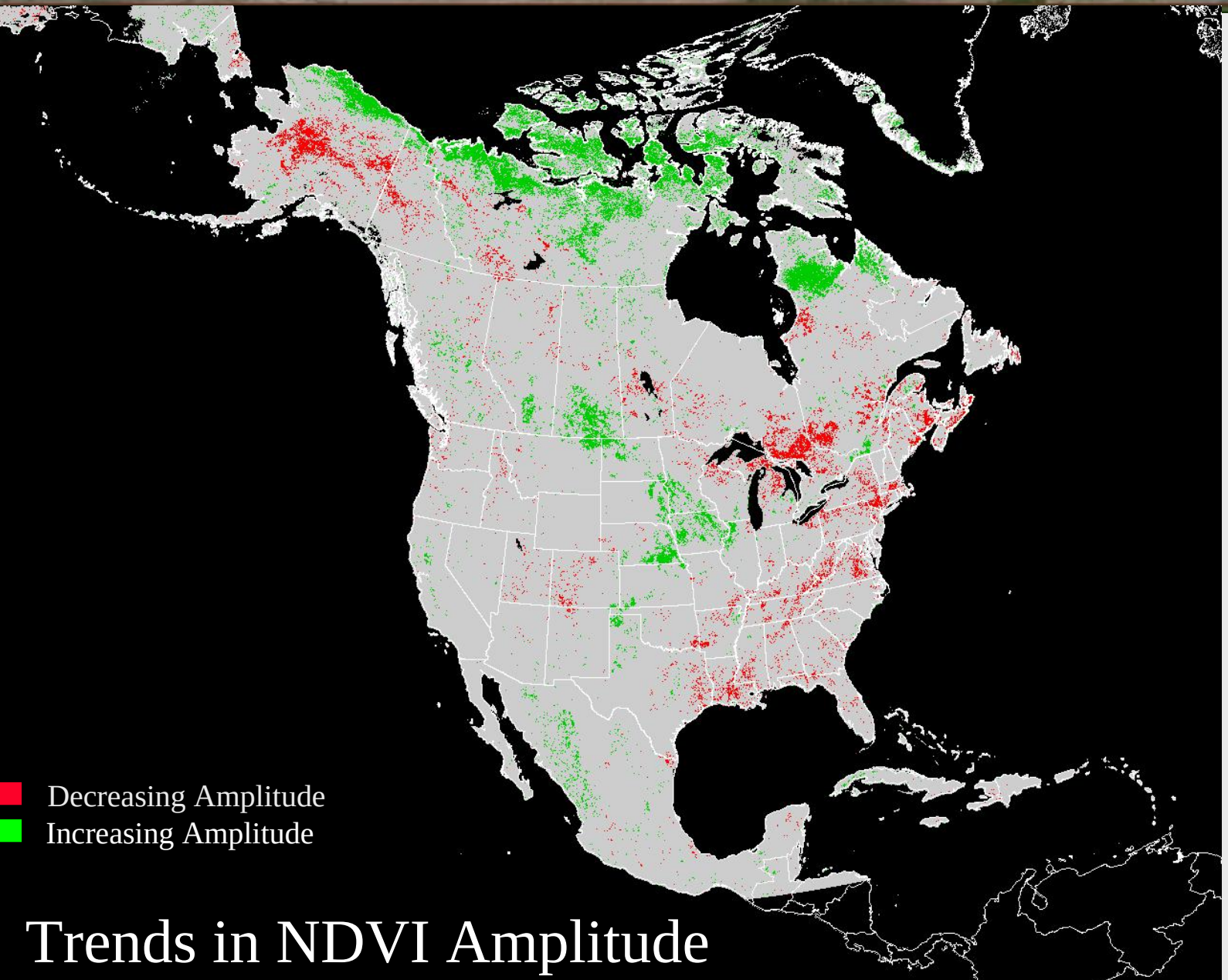


Trends in Duration of Growing Season

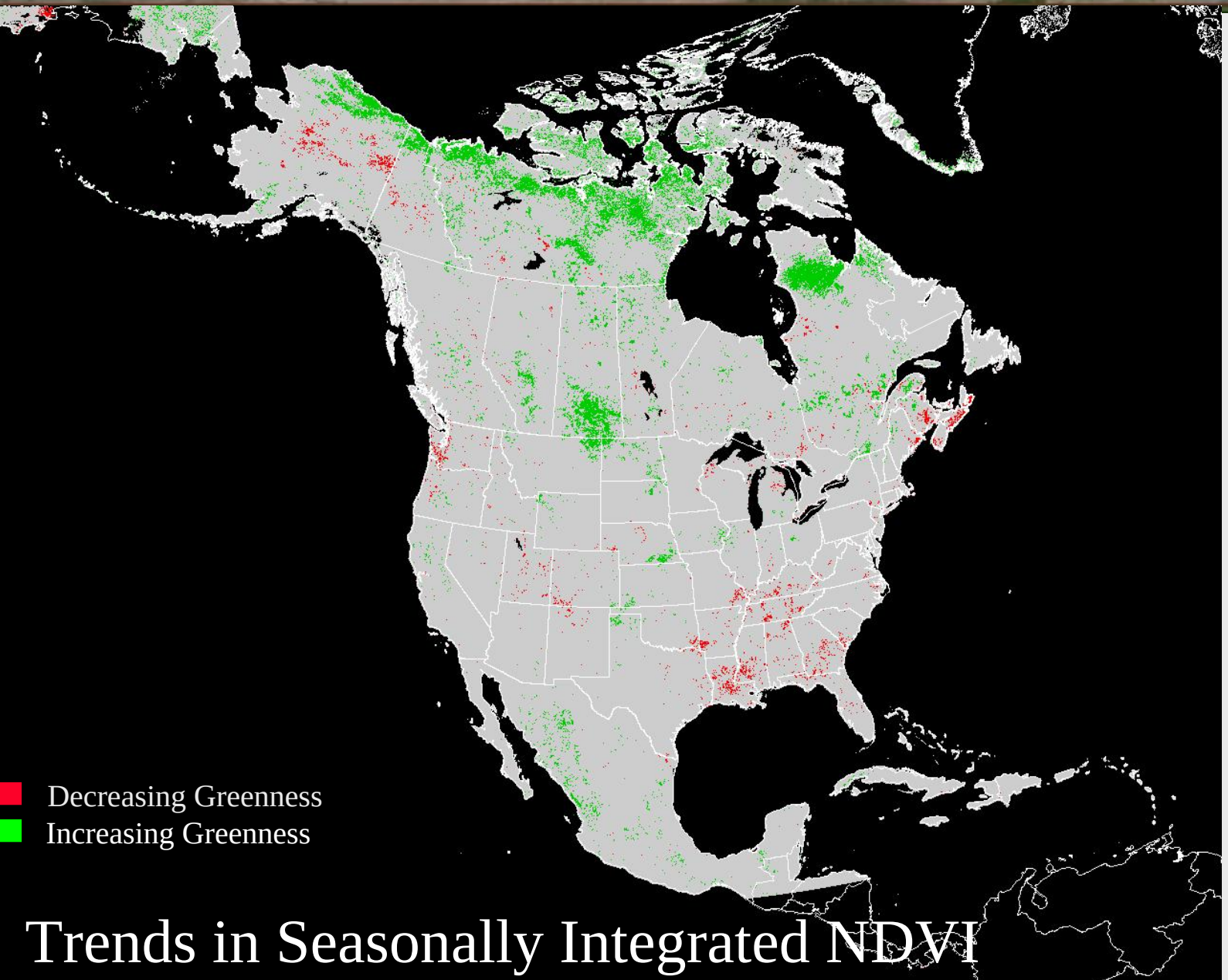




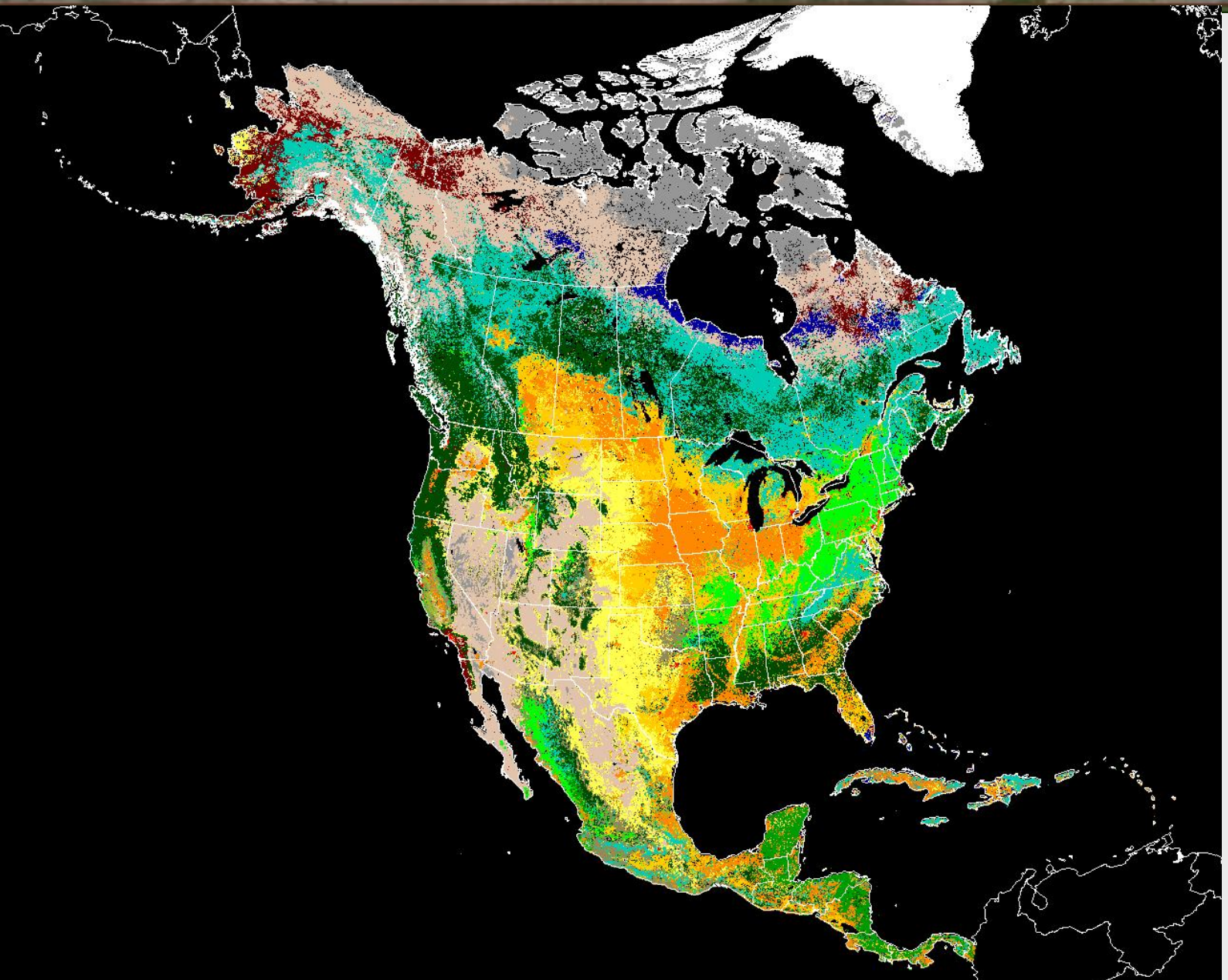
Trends in Maximum NDVI



Trends in NDVI Amplitude



Trends in Seasonally Integrated NDVI



Future of Trends in Phenology Research

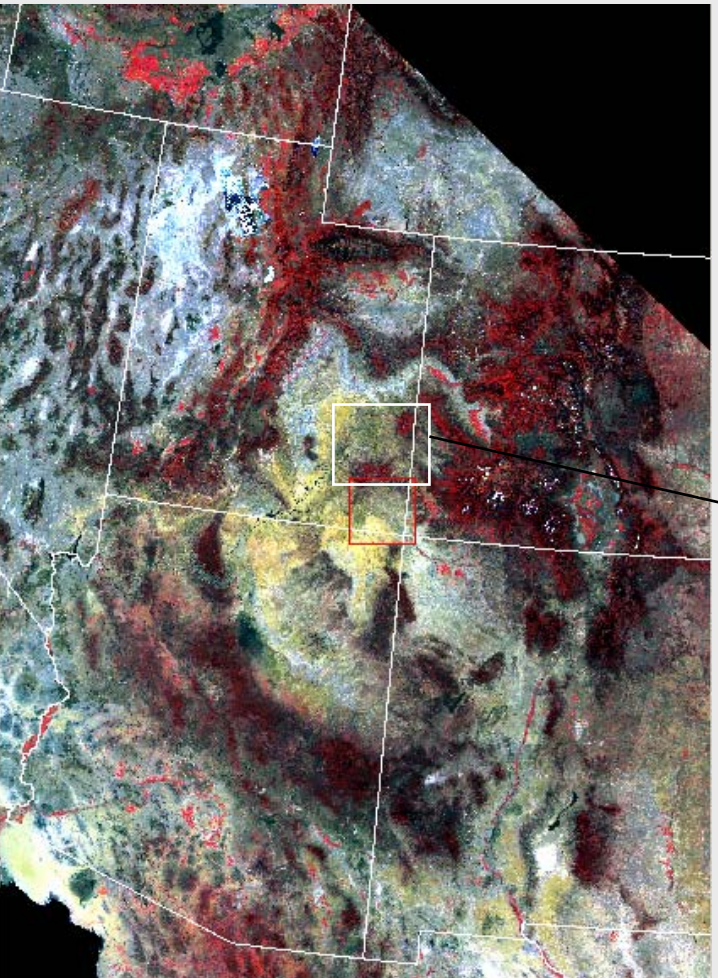
Input into USGS “Geographic State of the Nation” (Status and Trends Report)

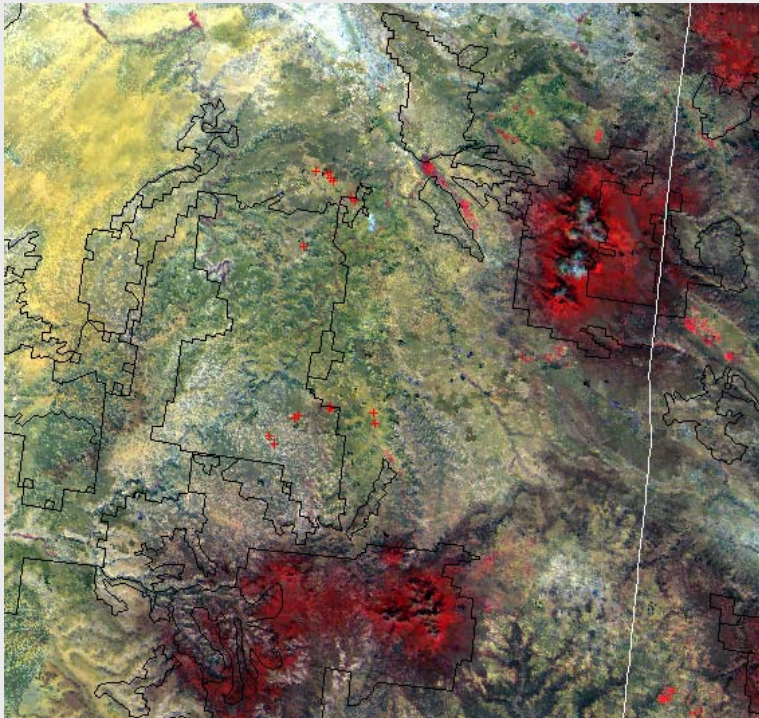
Expanding to North America, then to N. Hemisphere,
finally to globe

Real-time monitoring from MODIS Direct Broadcast system(s)

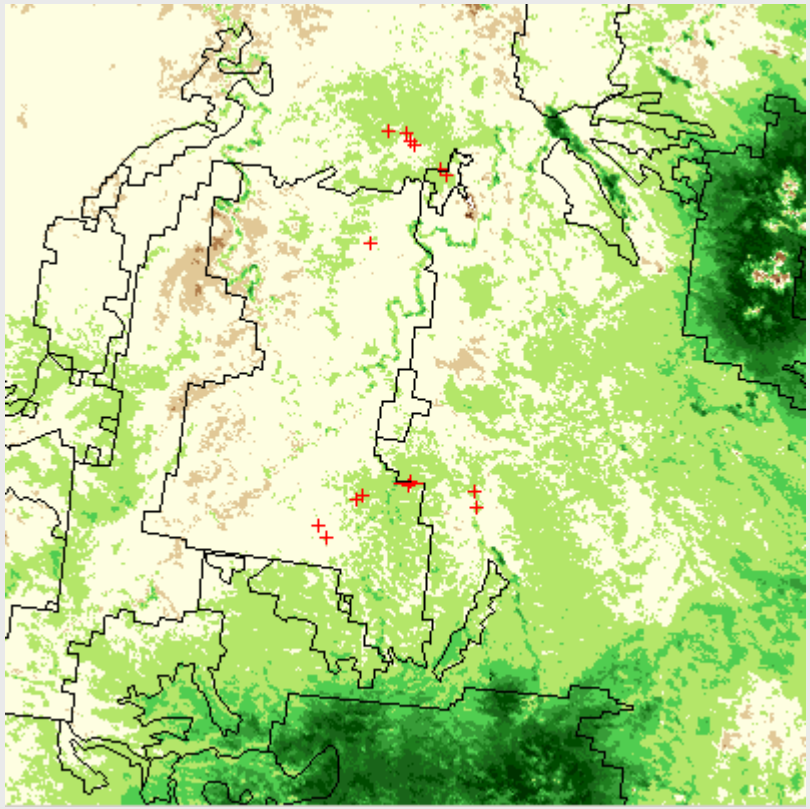
- will require DBS cooperative network

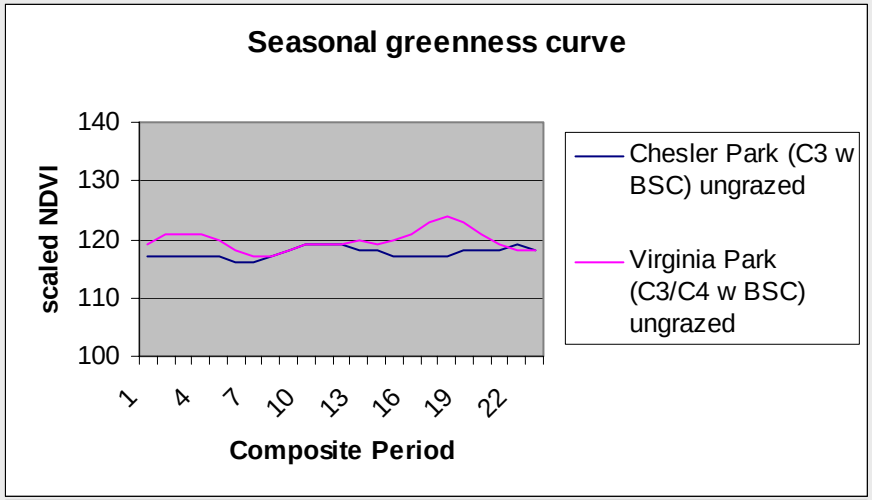
Colorado Plateau Pilot Study

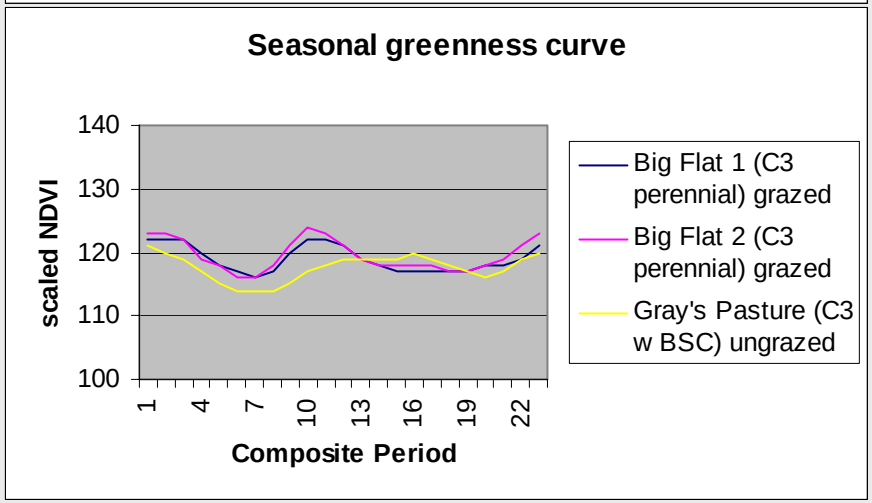


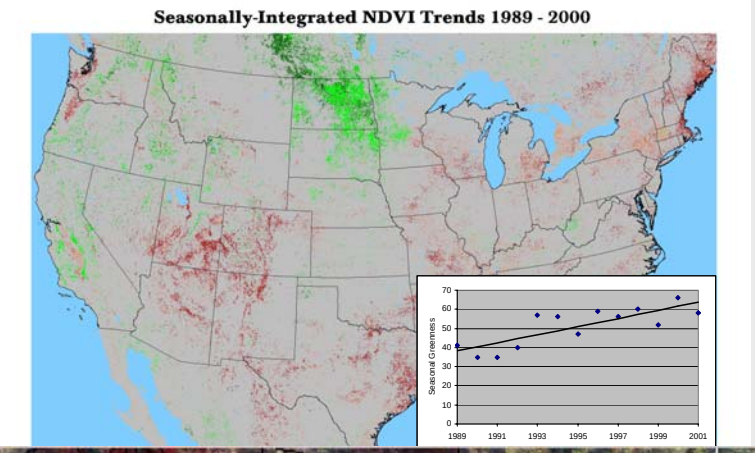


MODIS 250m temporal curves (2002)

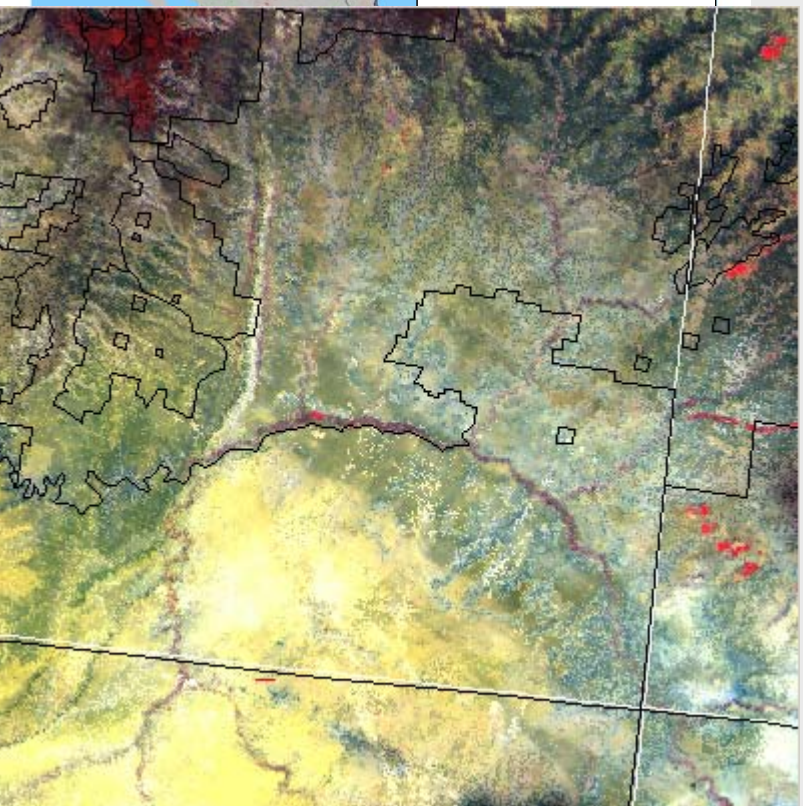


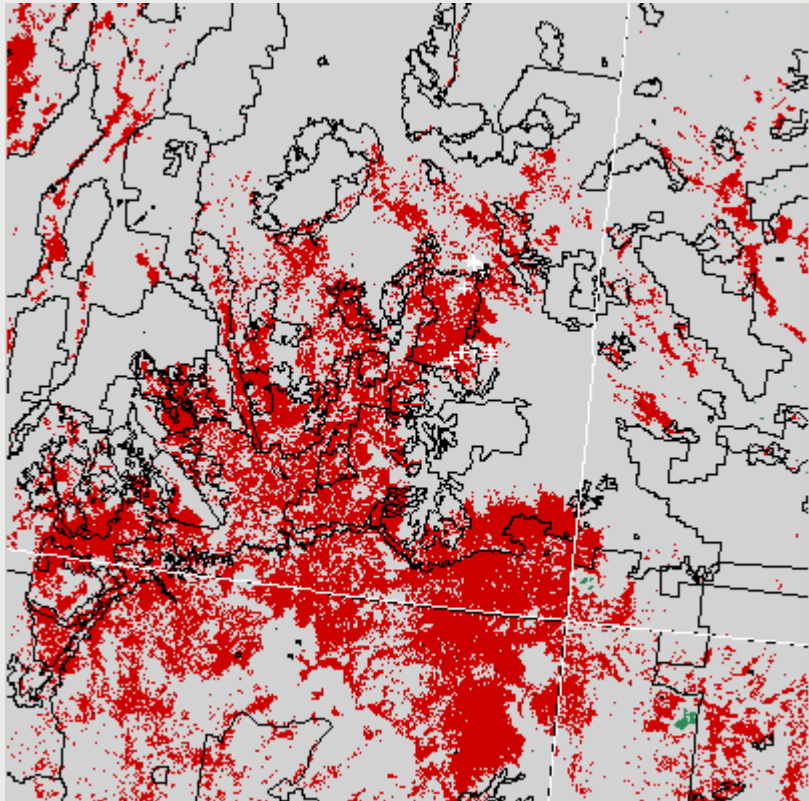






Trends in Seasonally integrated NDVI (1989-2002)





Objectives for NPS/SWAN Collaboration

1) Create a database of pertinent MODIS and ASTER data

2) Develop automated methods to collect, mosaic, reproject, and reformat MODIS data covering the network area on an ongoing, operational basis

3) Produce phenological metrics over the SWAN for each year beginning in 2000 from time-series VI data

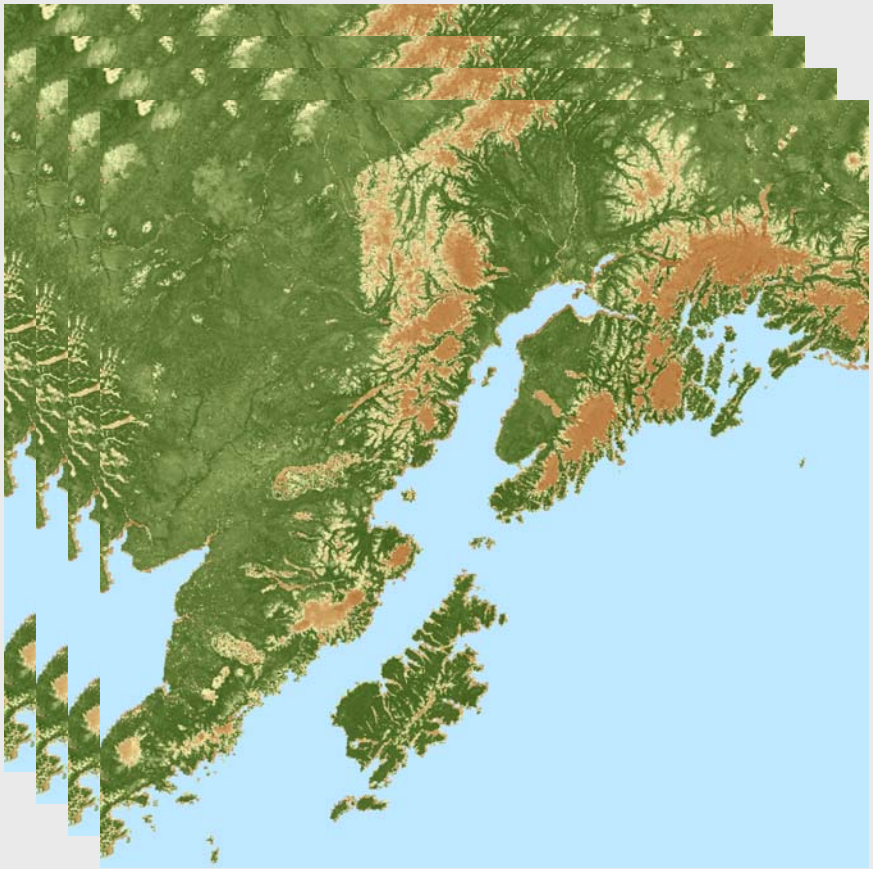
4) Investigate methods for estimating the presence of suspended sediments and their spatial extent using MODIS surface reflectance

5) Examine methods for estimating snow and ice cover using the MODIS snow cover extent product (separation of snow from cloud)

6) Develop monitoring protocols including standard operating procedures (SOPs)

Primary Tasks

1) Create a database of pertinent MODIS and ASTER data

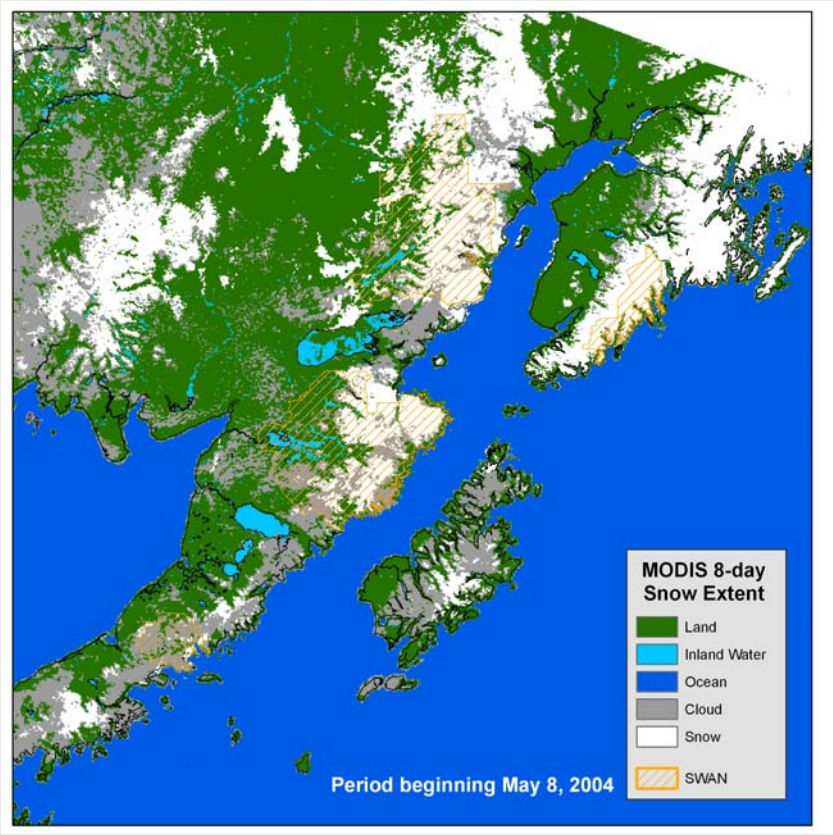


Time-series VI data

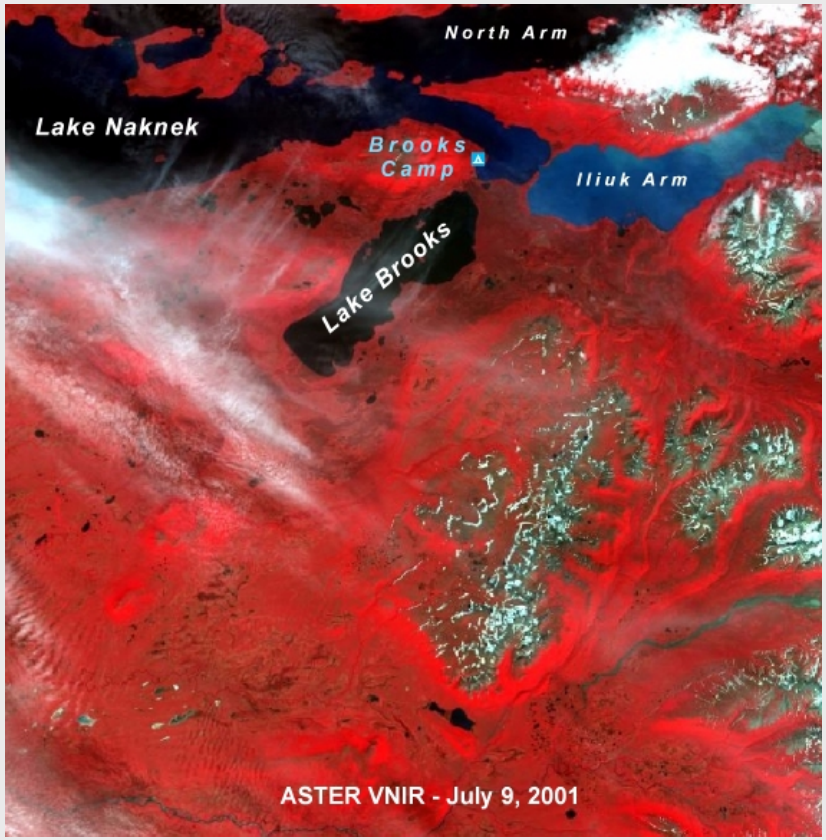
Surface Reflectance

Primary Tasks

1) Create a database of pertinent MODIS and ASTER data



Snow cover extent



ASTER