Early Detection & Monitoring North America Drought from Space

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Mexico 2006

Topics

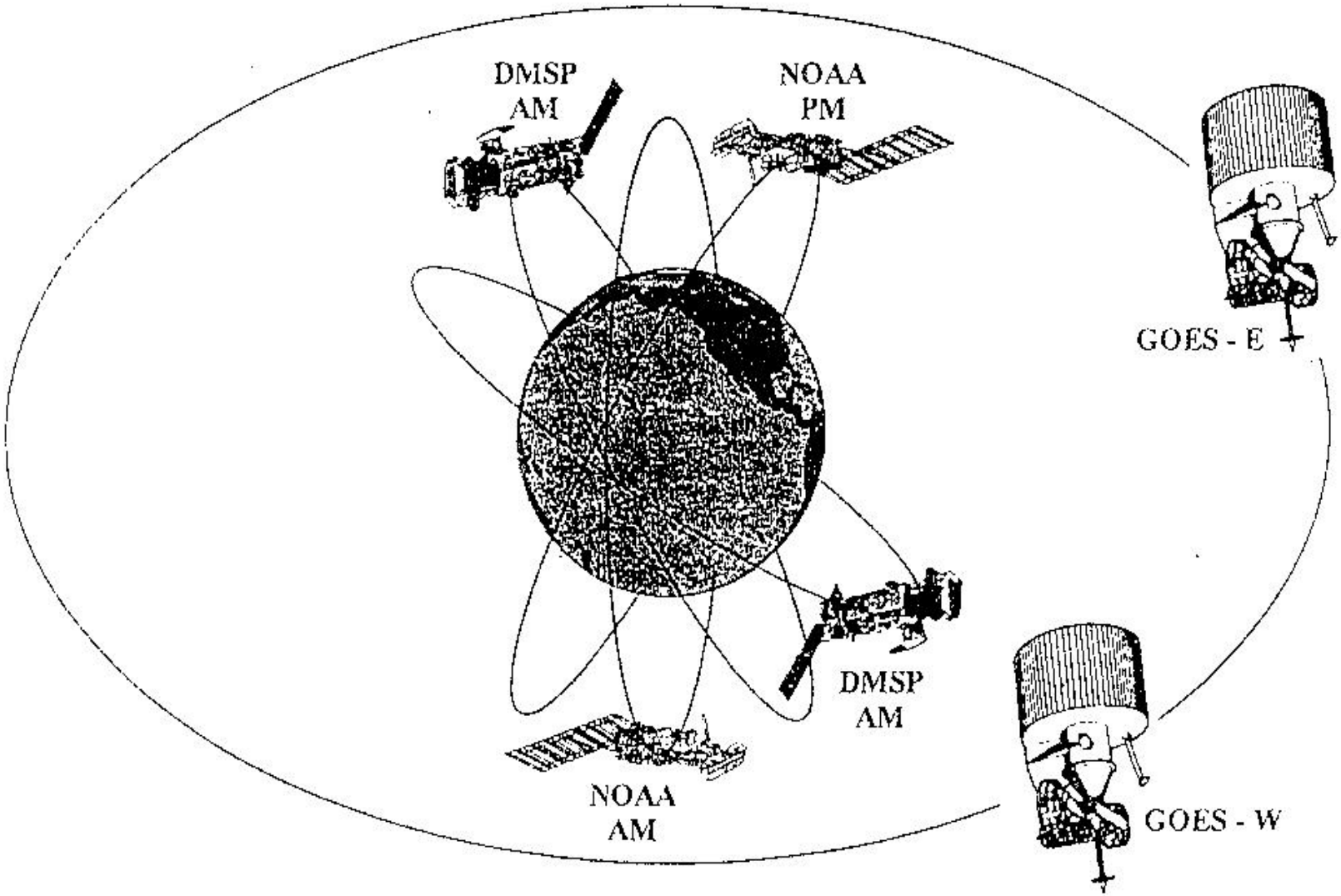
- **Background**
- **AVHRR Data**
- **Theory**
- **Method**
- **Product**
- **Application**
- **Validation**
- **New, 4 km 26-year data set**

Drought as Natural Disaster

- **Drought (D) is a part of earth's climate**
- **D. occurs every year**
- **D. does not recognize borders, political & economic differences**
- **D. affects the largest number of people**

- **D. unique features**
  - **Start unnoticeably**
  - **Build-up slowly**
  - **Develop cumulatively**
  - **Impact cumulative & not immediately observable**
  - **When damage is evident it's too late to mitigate the consequences**

NOAA Operational Environmental Satellites



DATA from NOAA operational polar orbiting satellites

Sensor: *Advanced Very High Resolution Radiometer (AVHRR)*

Satellites: *NOAA-7, 9, 11, 14, 16, 18 (afternoon.), 17*

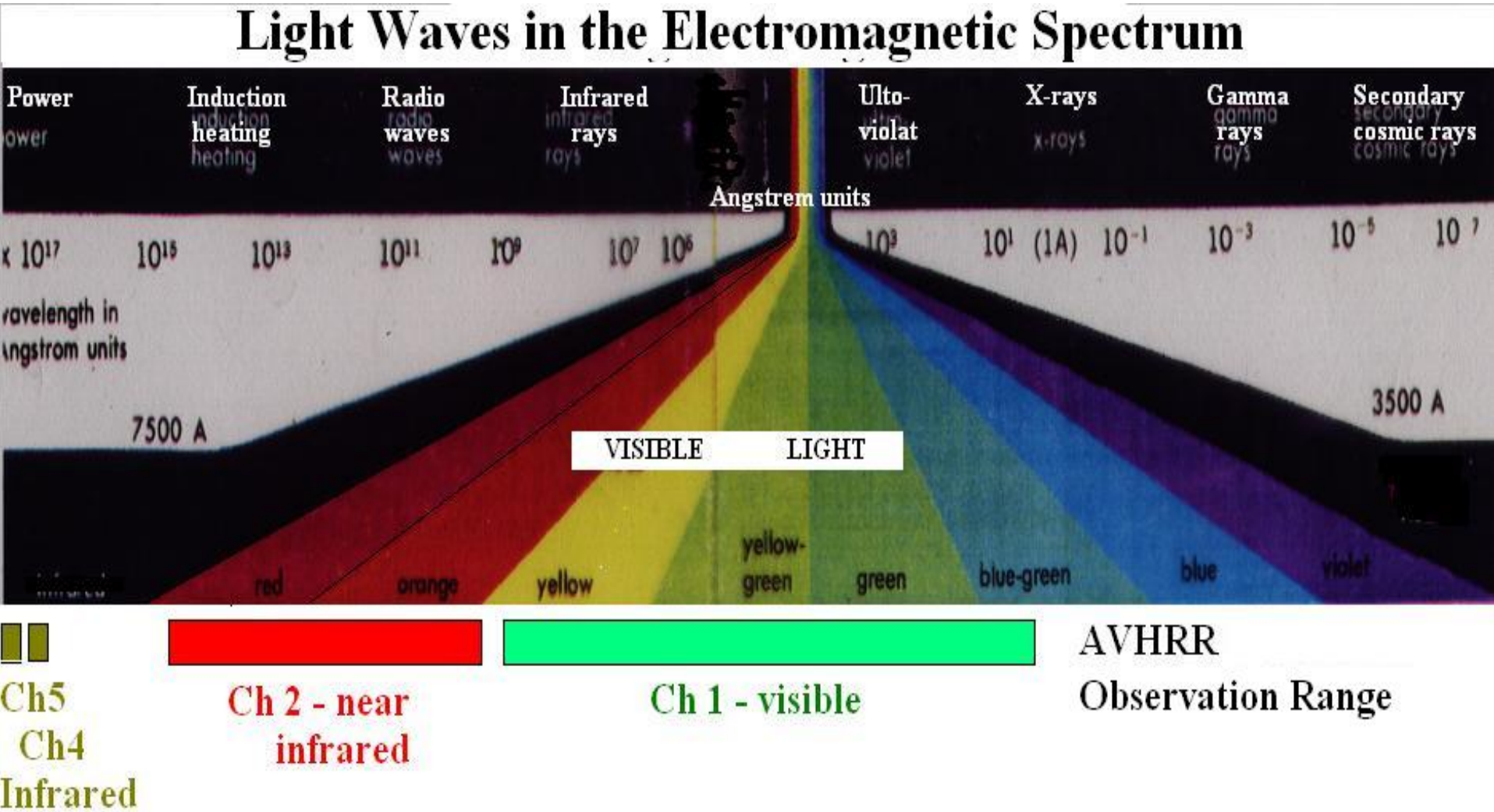
Data Resolution: *Spatial - 4 km GAC, sampled to 16 km; Temporal - 7-day composit*

Period: **1981-2006**

Coverage: **World** *(75 N to 55 S)*

Channels: **VIS (ch1), NIR (ch2), Thermal (ch4, *ch5)***

AVHRR observations

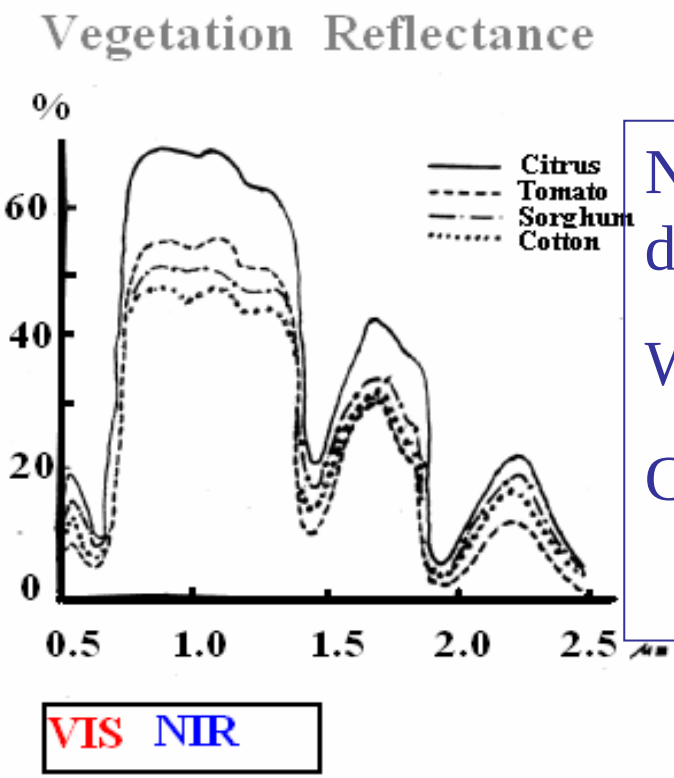


Typical Vegetation Reflectance

VIS reflectance depends on

CHLOROPHYLL

CAROTENOID



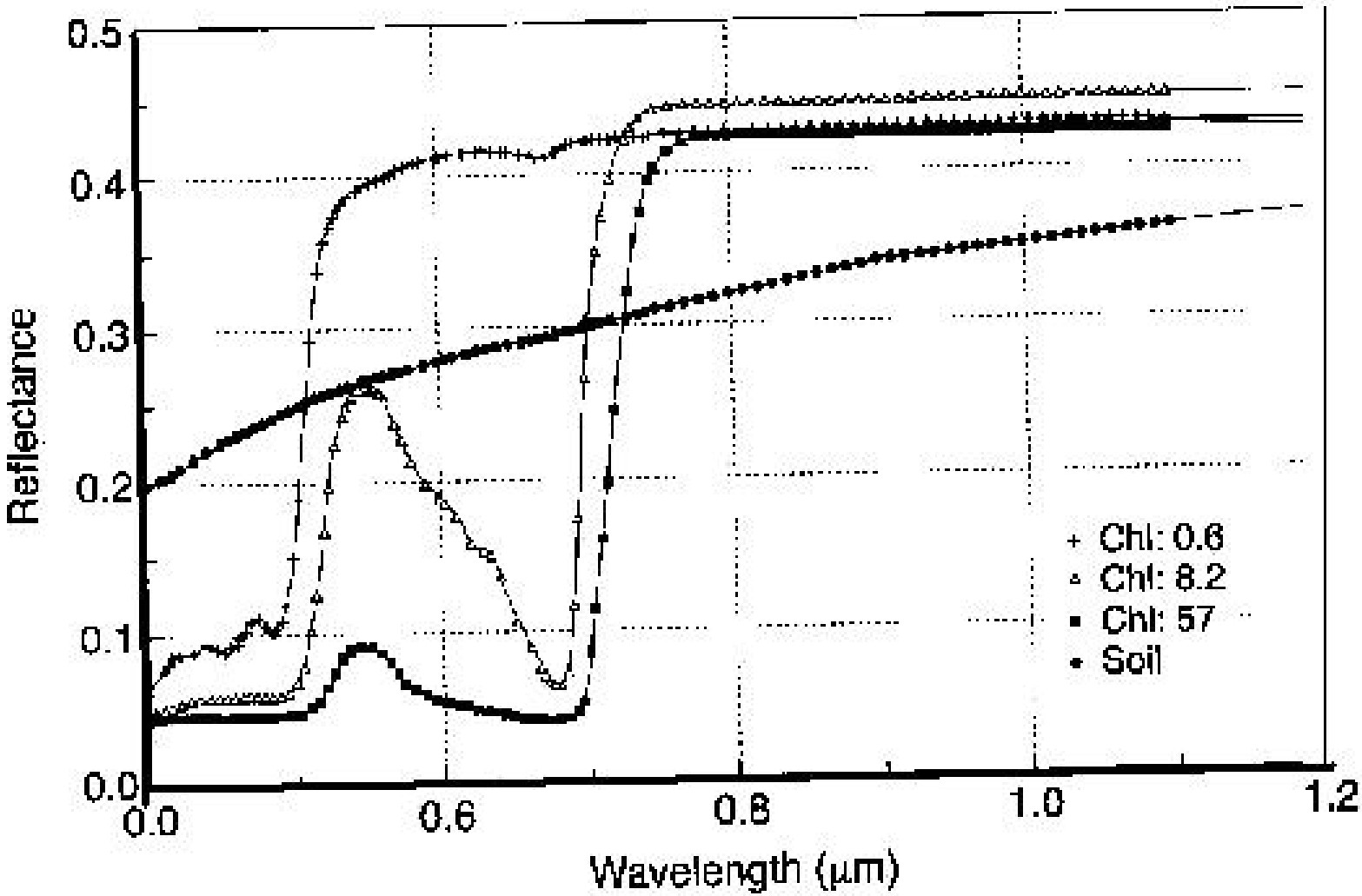
NIR reflectance depends on

WATER CONTENT

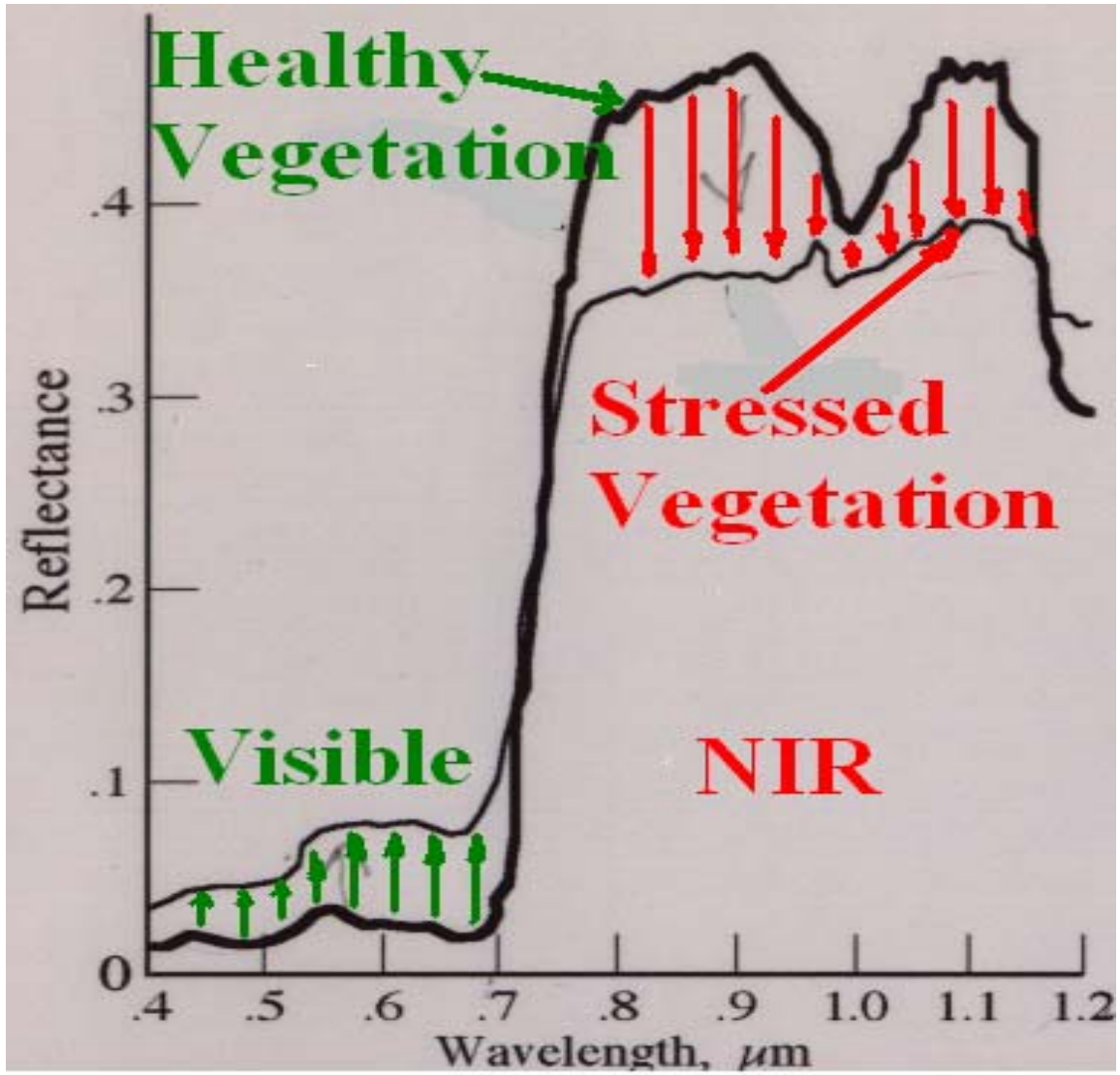
CELL STRUCTURE

NDVI = (NIR-VIS)/(NIR+VIS)

Reflectance & chlorophyll

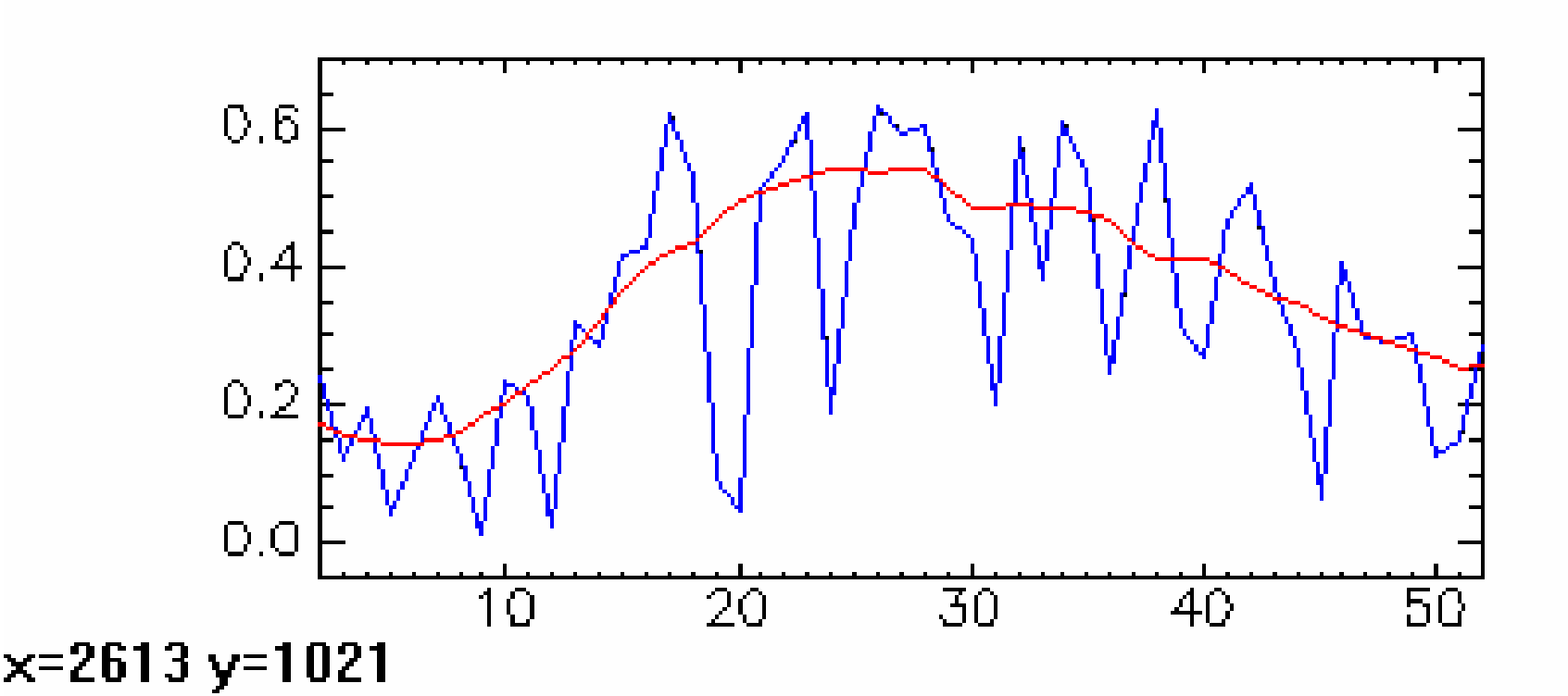


AVHRR Reflectance



NDVI=(NIR-VIS)/(NIR+VIS)

NDVI & Smoothed NDVI

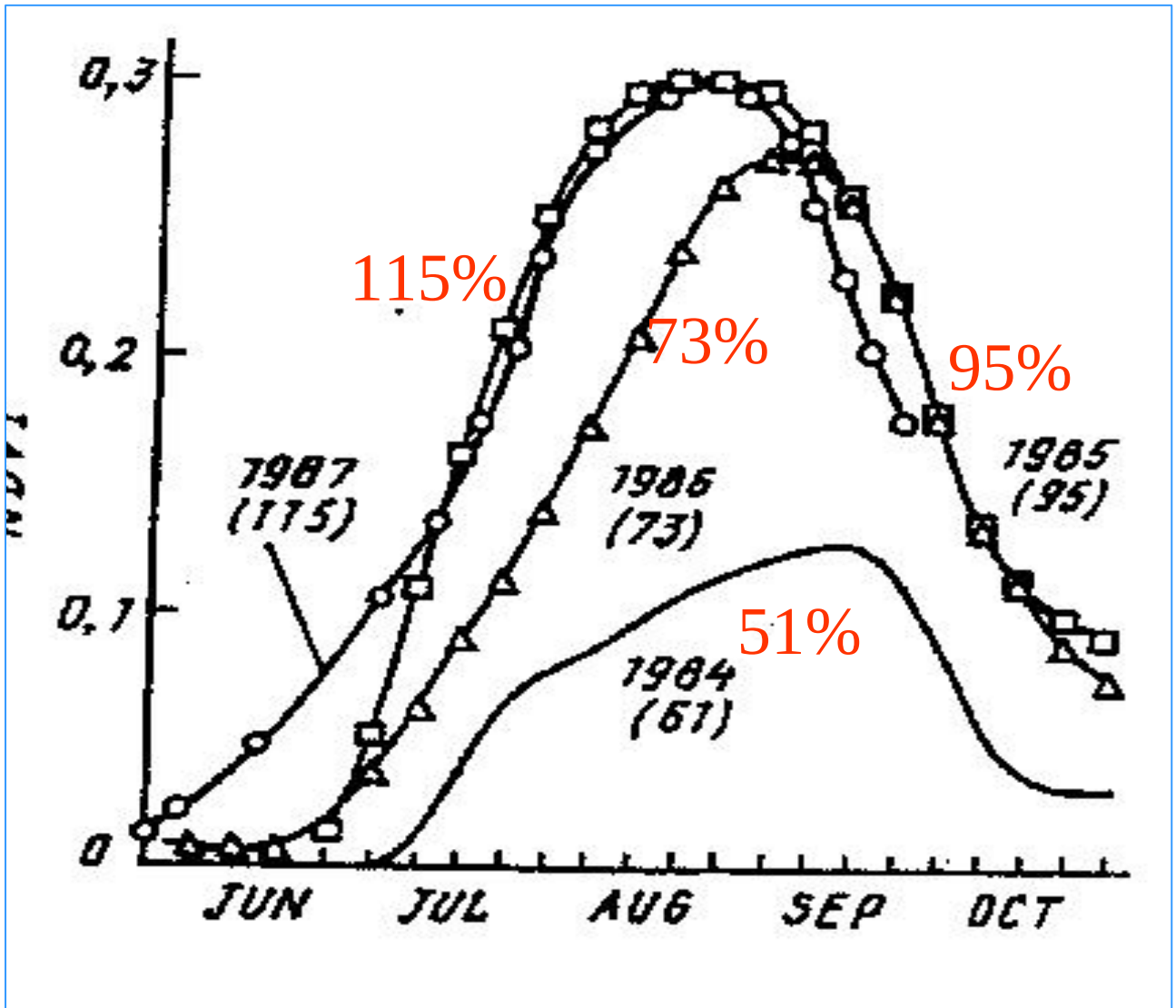


Eliminate high frequency noise

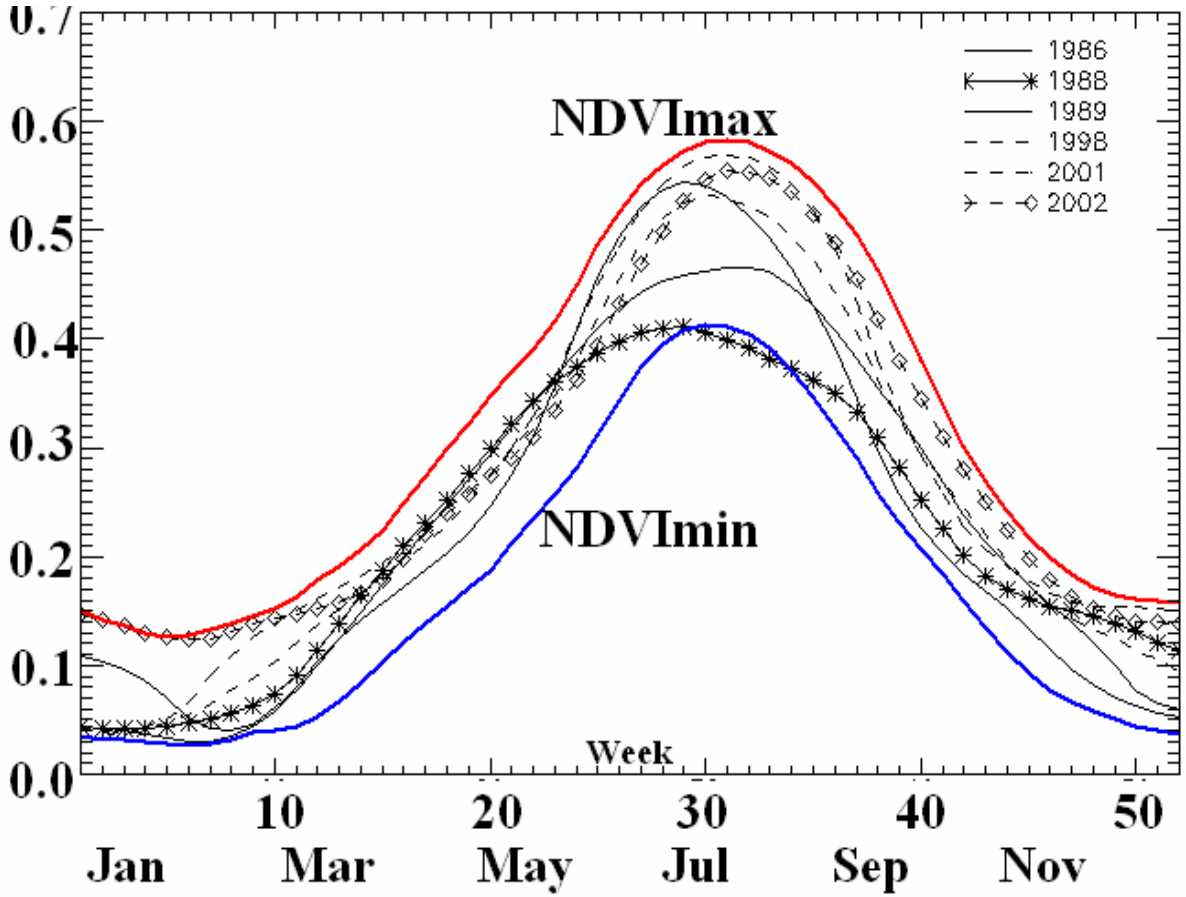
Emphasize seasonal cycle

Separate medium & low frequency variations

NDVI & Rainfall (% mean), SUDAN

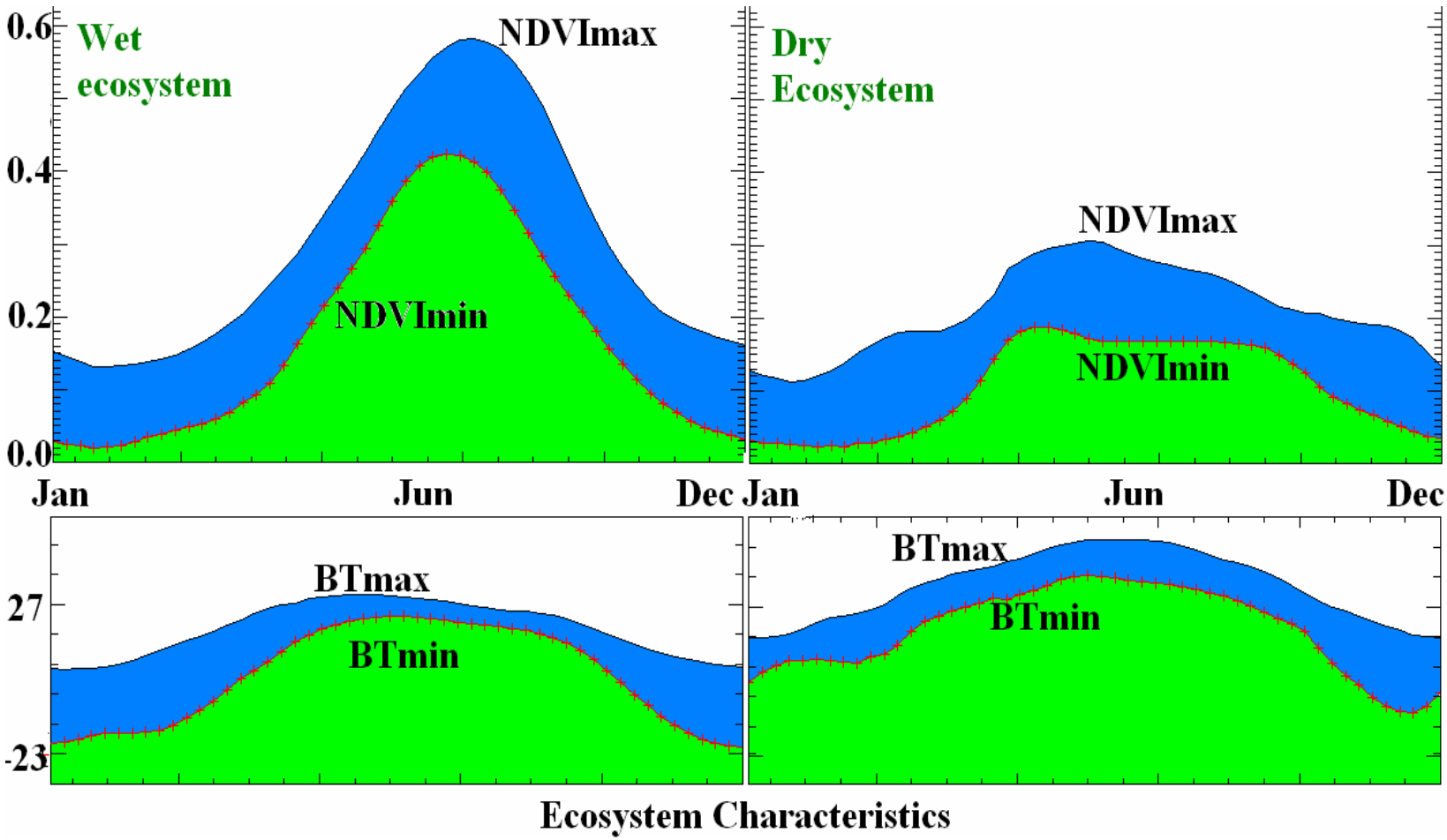


NDVI annual time series, Illinois, USA



NDVI time series, Illinois, USA

Weather & Ecosystem Components in NDVI & BT, Central USA



PRODUCTS

Vegetation condition index (VCI), values 0 - 100

$$VCI=(NDVI-NDVImin)/(NDVImax-NDVImin)$$

NDVImax, and NDVImin – climatology (1981-2000 maximum and minimum NDVI for a pixel;

Temperature condition index (TCI), values 0 - 100

$$TCI=(BTmax-BTmin)/(BTmax-BTmin)$$

NDVImax, and NDVImin – climatology (1981-2000 maximum and minimum NDVI for a pixel

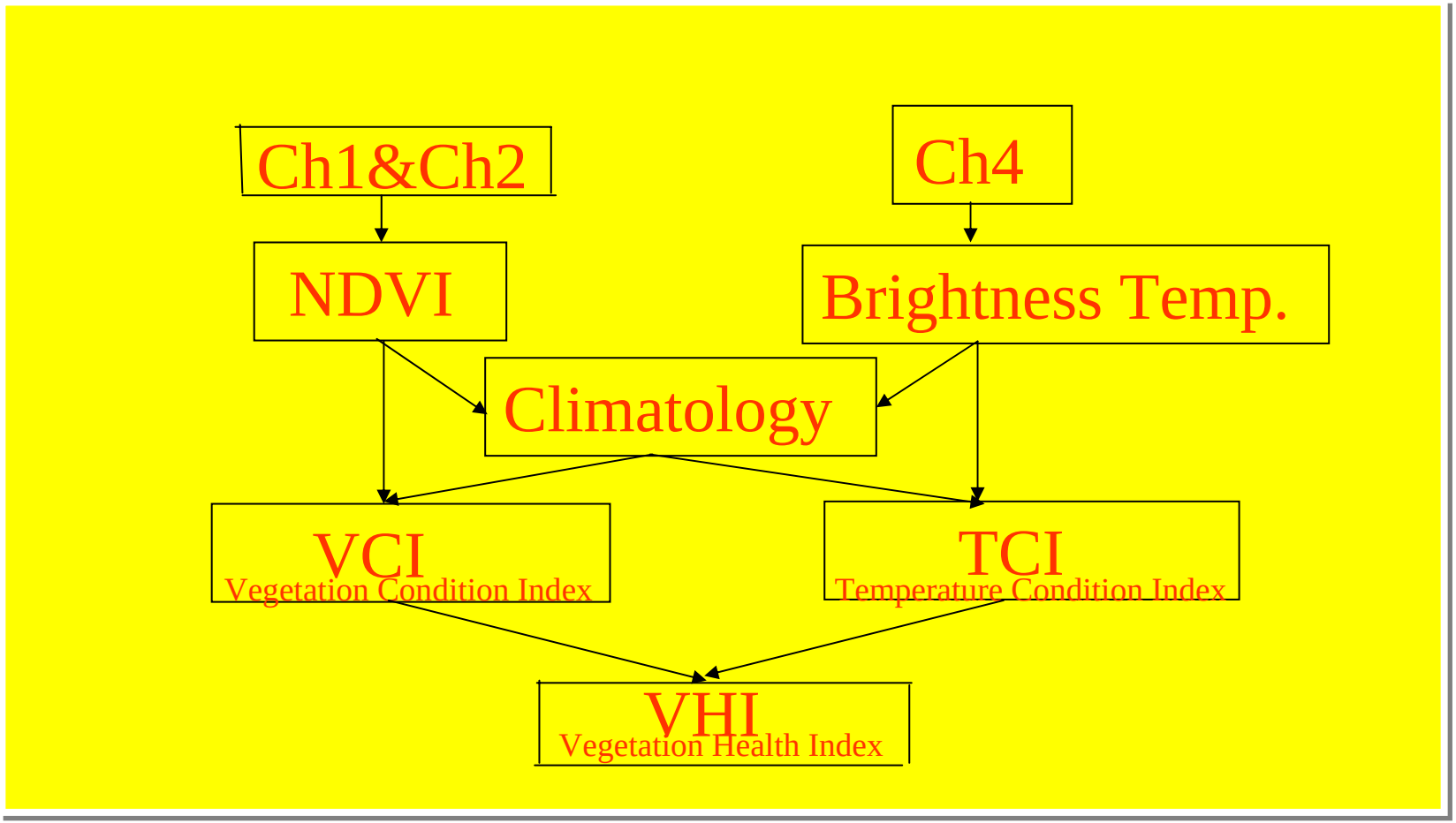
Vegetation Health Index (VHI), values 0 – 100

$$VHI=a*VCI+(1-a)*TCI$$

0 – indicates extreme stress

100 – indicates favorable conditions

Vegetation Health Indices Algorithm



What Vegetation Health Indices Assess?

Moisture Condition (VCI)

Thermal Condition (TCI)

Vegetation Health (VHI)

Fire Risk (FRI)

Drought Start (DS)

Drought Area (DA)

Drought Dynamics (DD)

Vegetation Products

ECOSYSTEMS (distribution & change)

WEATHER (droughts)

FORESTRY (fire risk)

NWS MODELS (vegetation fraction)

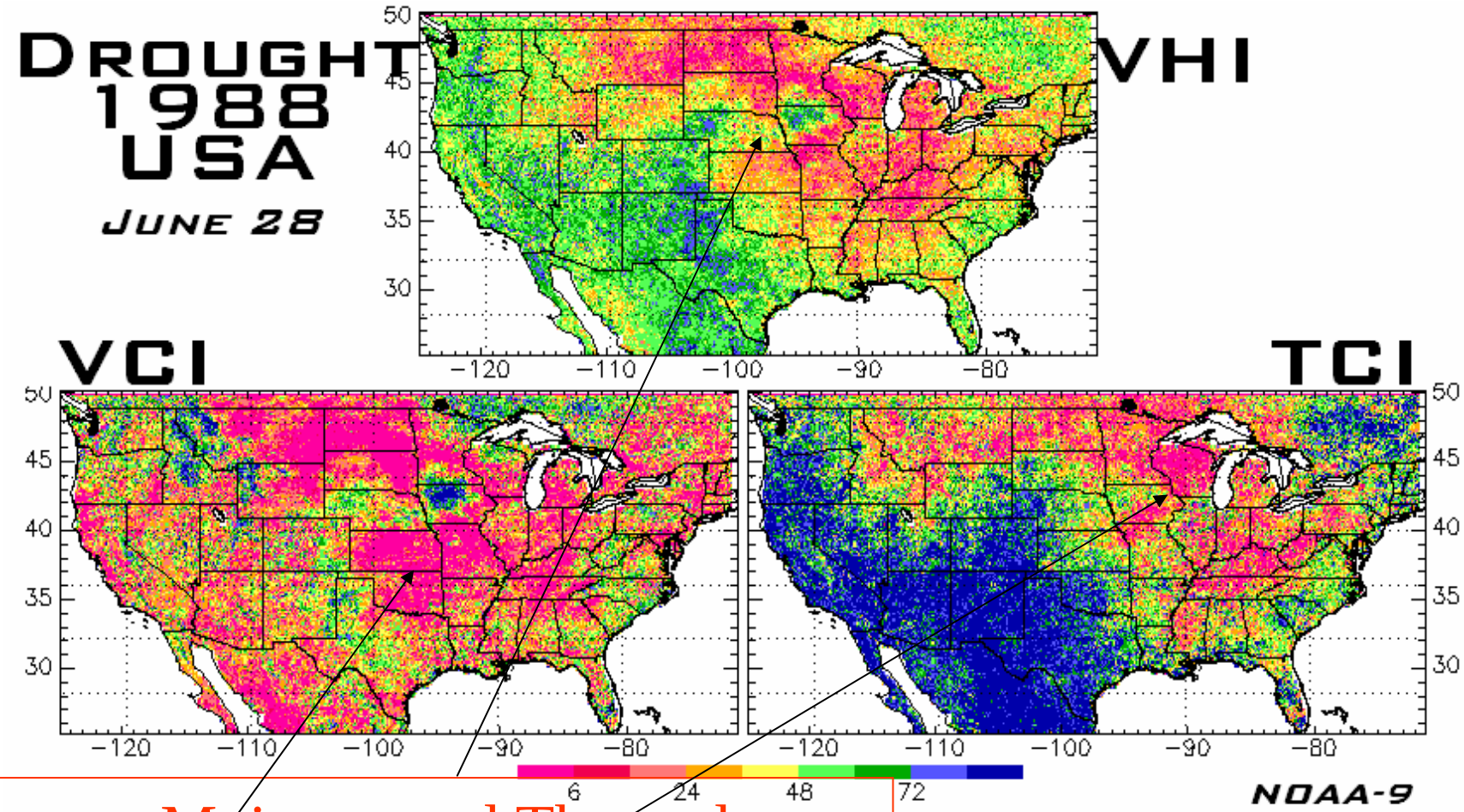
AGRICULTURE (production)

CLIMATE (ENSO)

HUMAN HEALTH (epidemics)

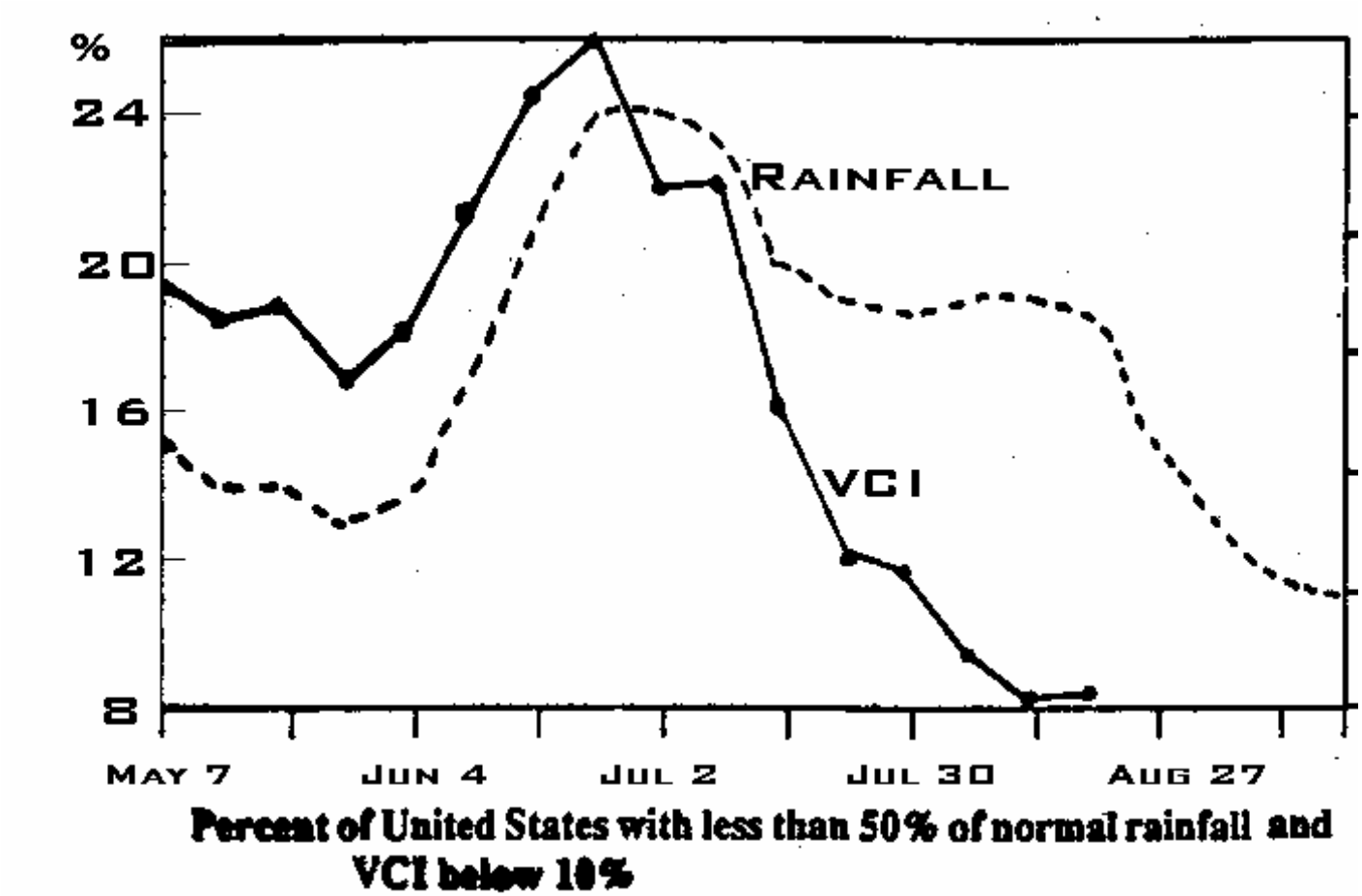
WATER (irrigation)

Drought 1988

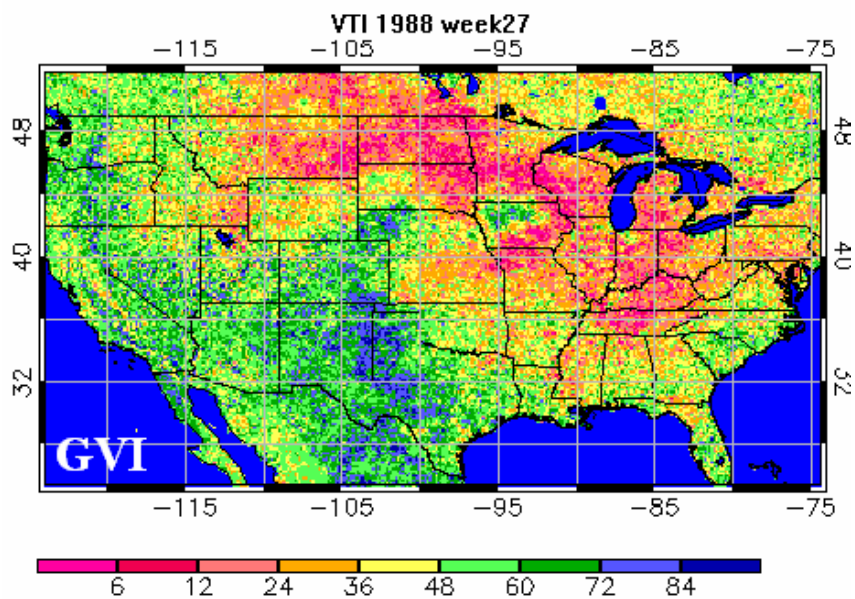


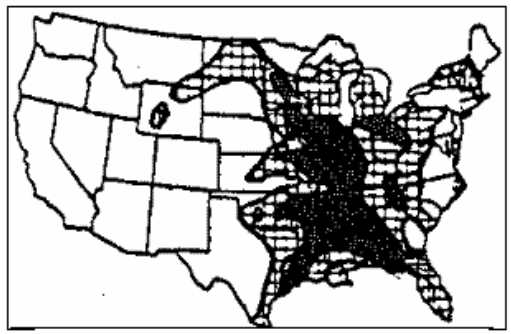
Severe Moisture and Thermal Vegetation Stress

Percent of USA with rainfall < 50% and VCI < 10

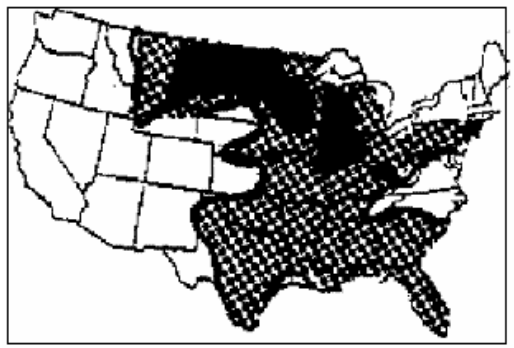


Drought 1988, Satellite & In Situ Data





Precipitation Anomaly 3-6 in April-June, 1988



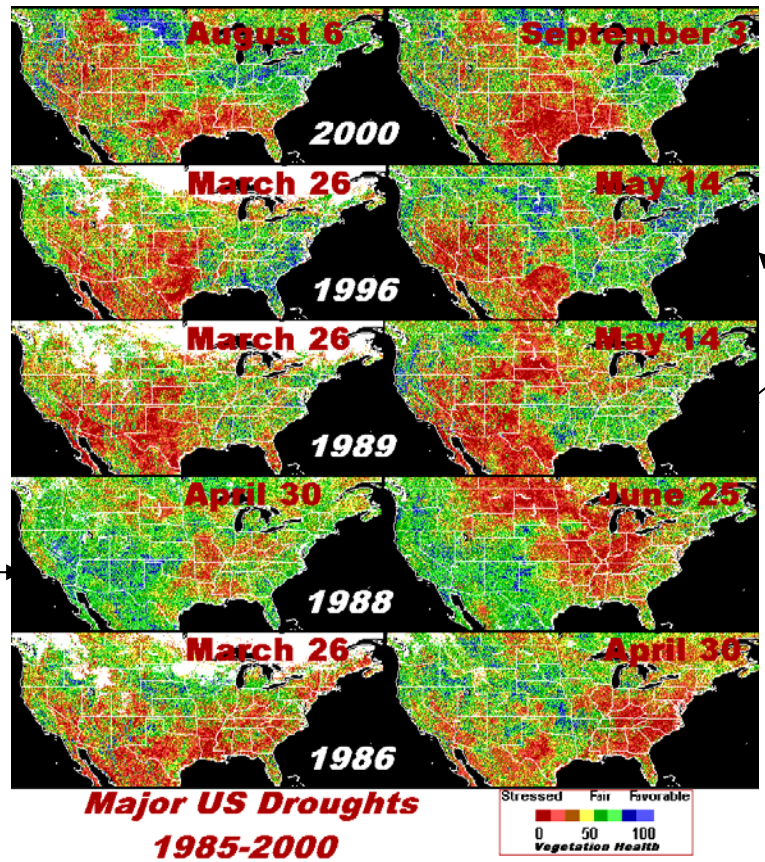
1988 Corn Yield Anomaly (15-30%)

Drought 1988, USA

Major US Droughts

1985-2000

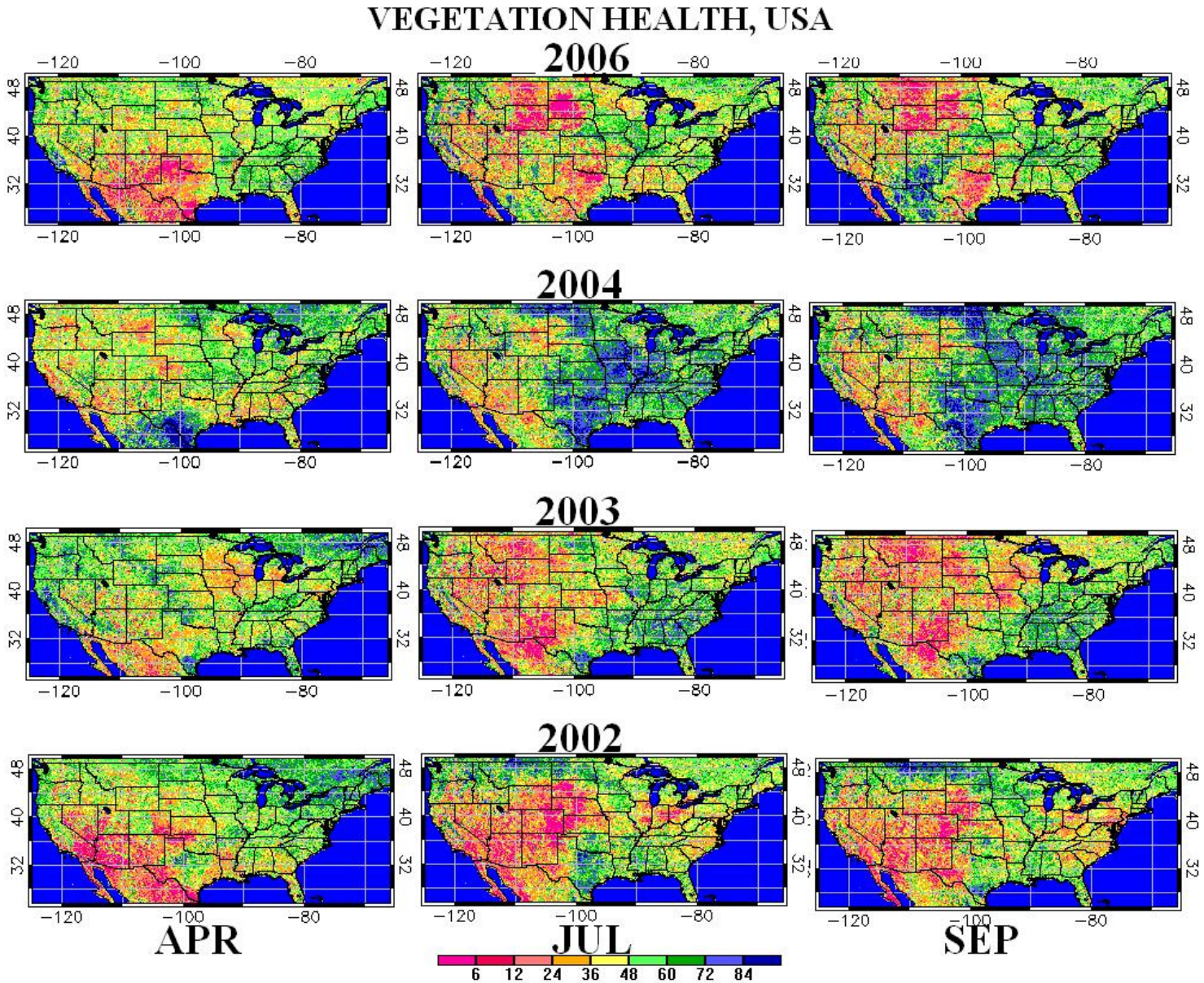
Late season drought



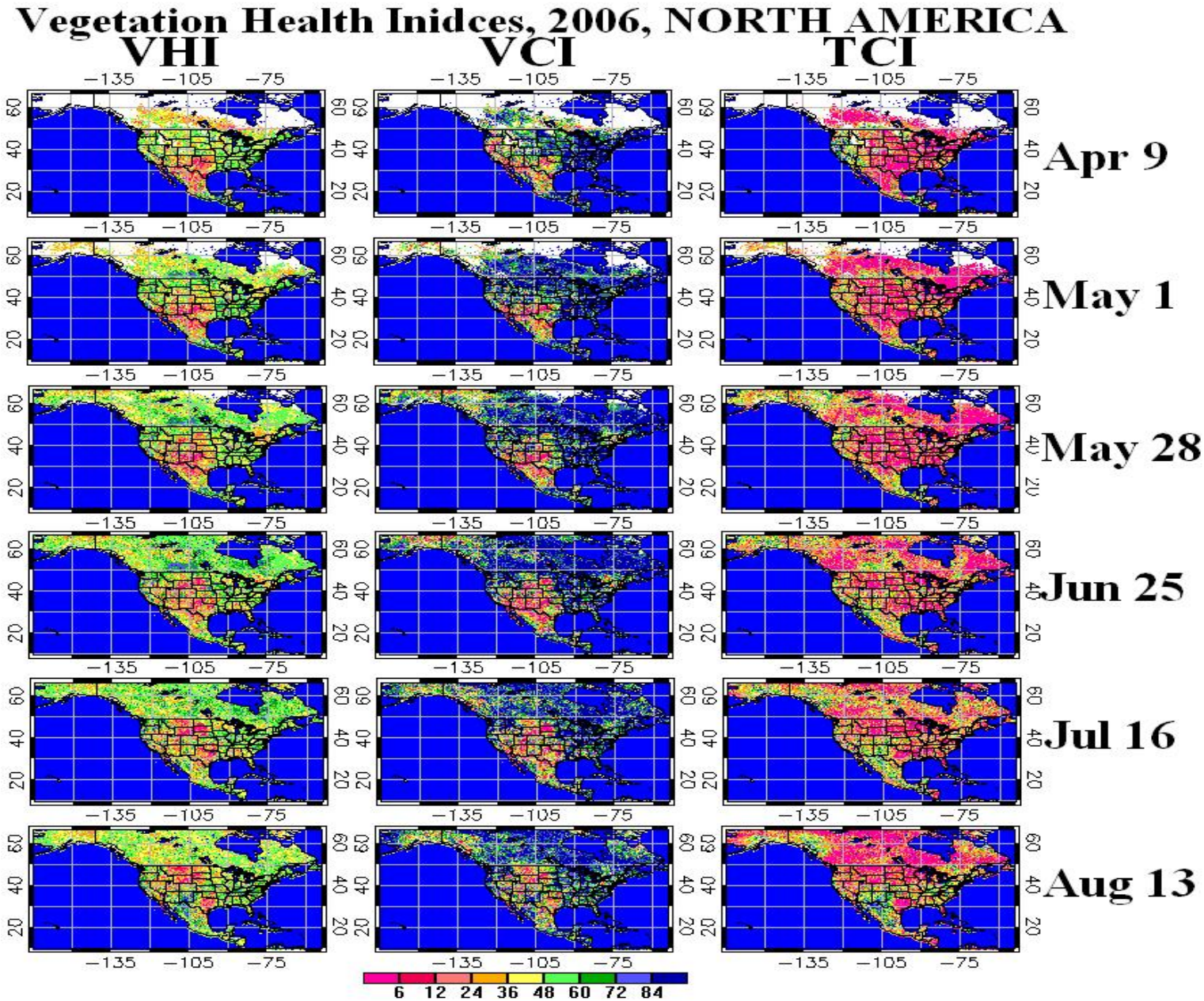
Early season Drought, Winter Wheat affected

Mid-season drought, corn affected

Major US Droughts, 2001-2006



Vegetation Health Indices 2006
North America



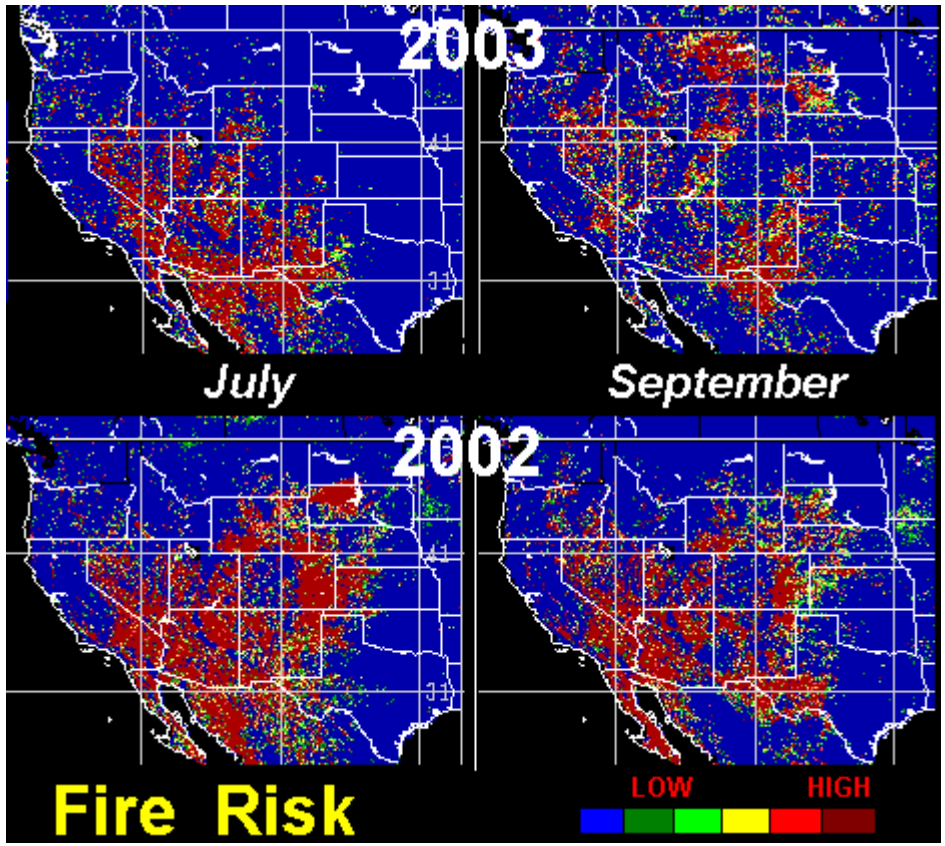
Fire Risk
Western USA

Index is based on:

DROUGHT INTENSITY (VHI<30)

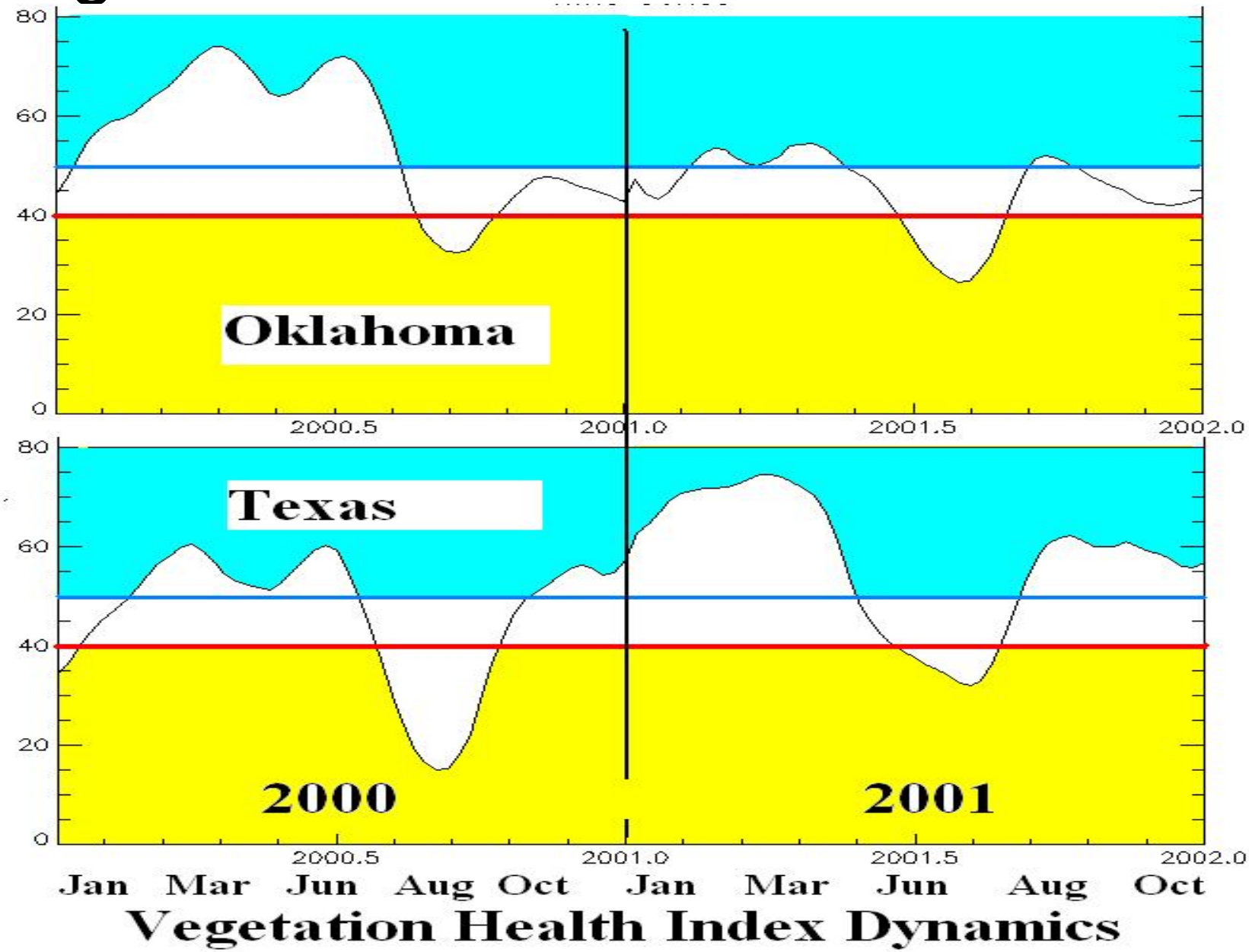
and DURATION

(1-5 weeks)

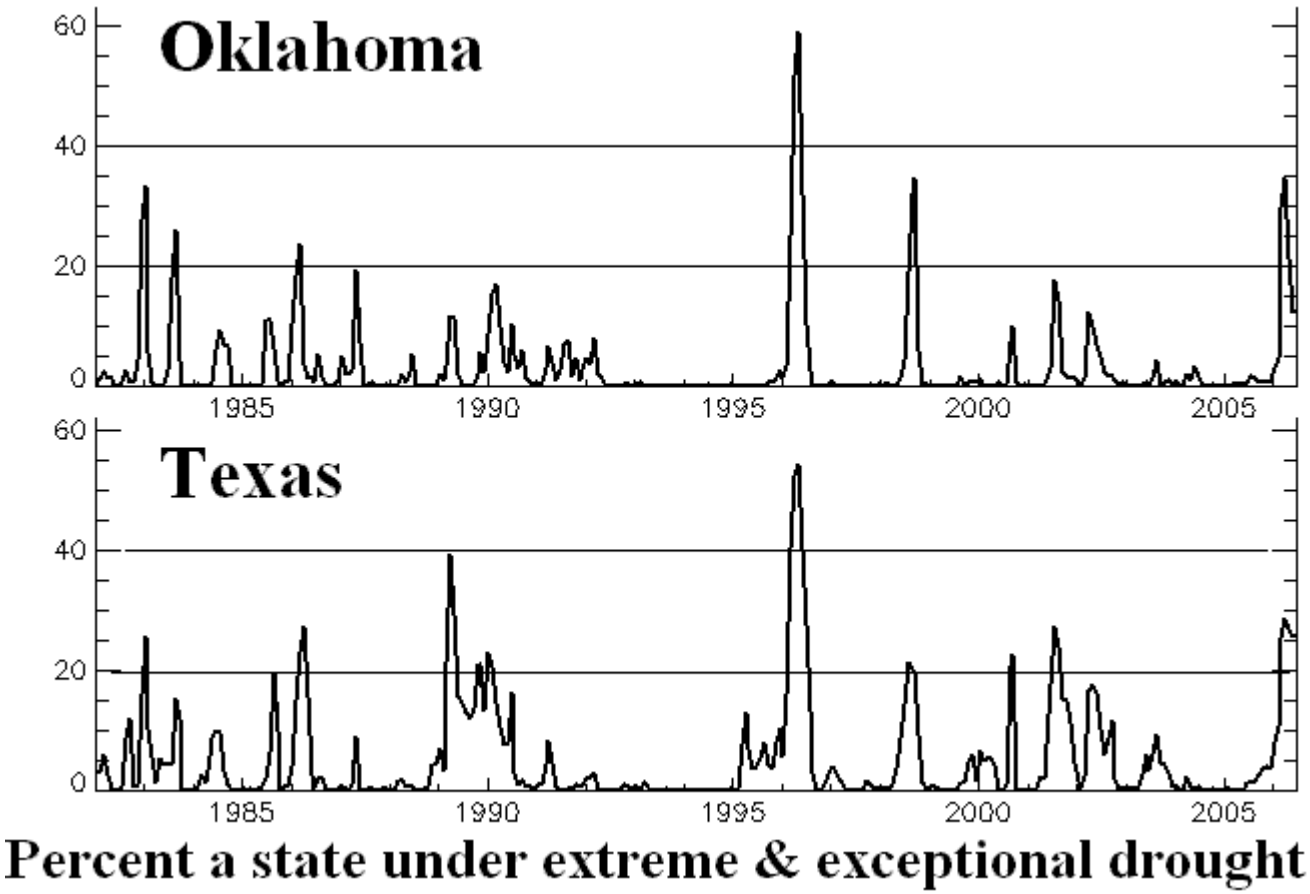


Fire Danger is estimated from VHI based on intensity and duration of vegetation stress

Vegetation Health Index 2000-2001

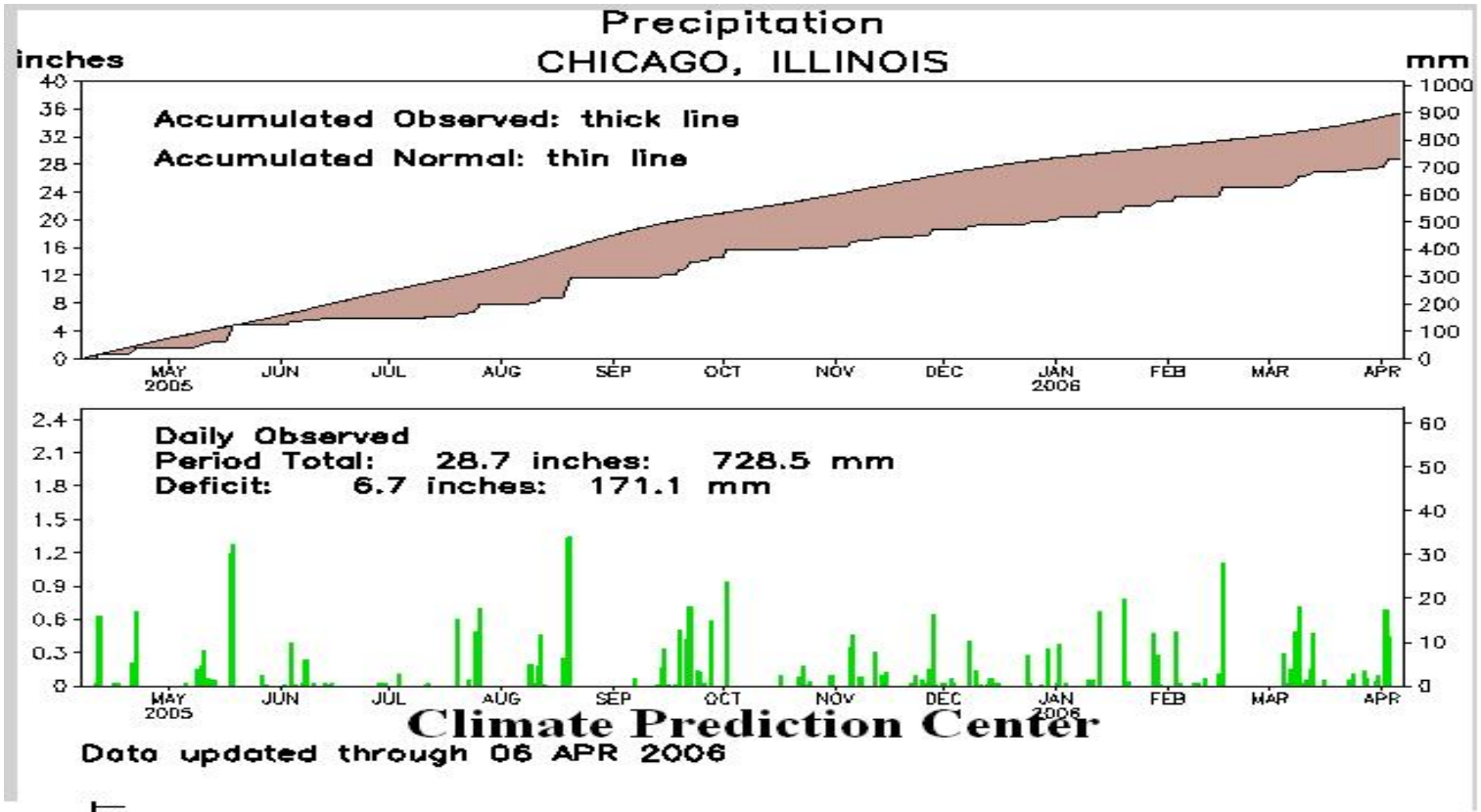


Percent of a state with extreme & exceptional drought

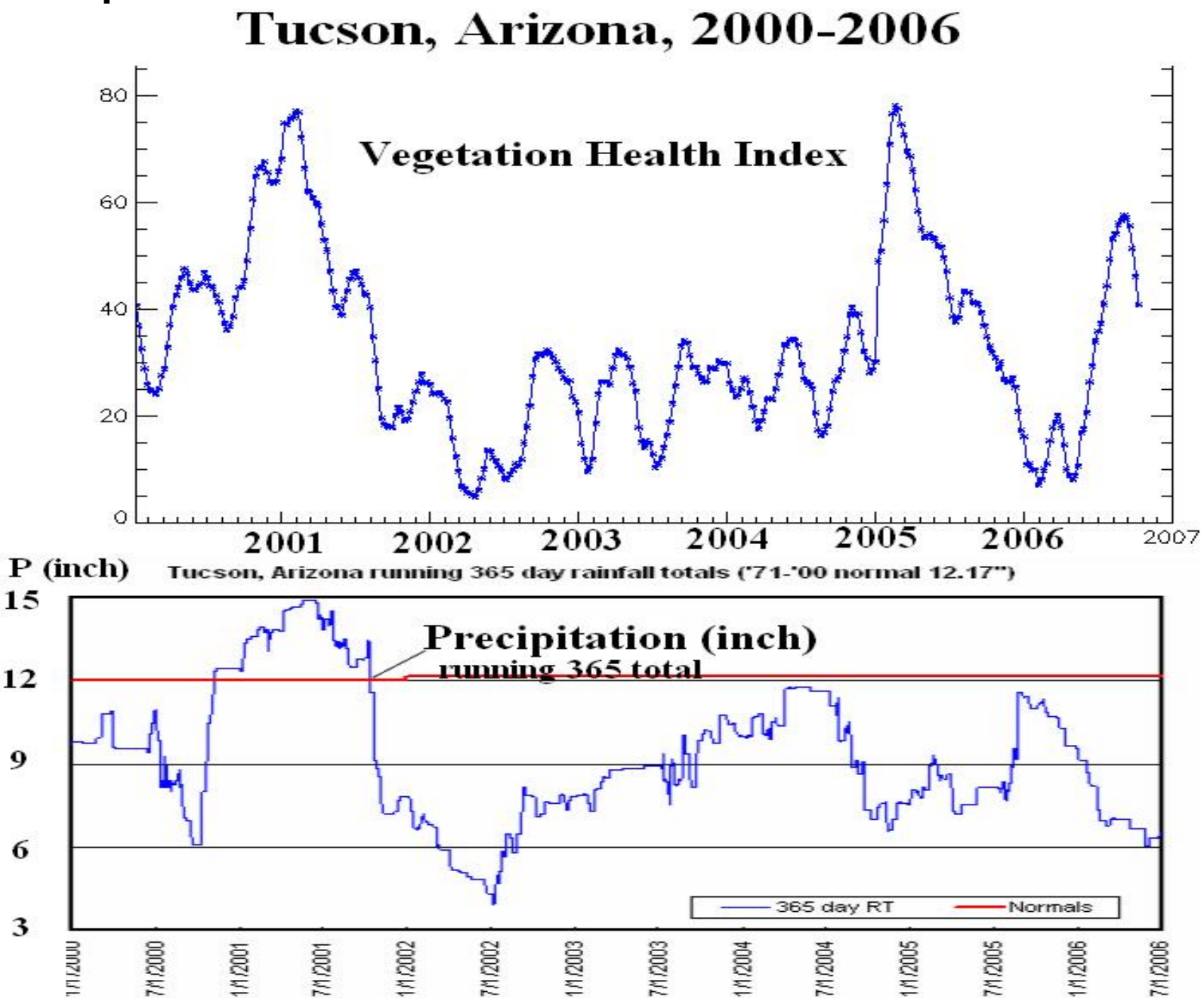


Percent a state under extreme & exceptional drought

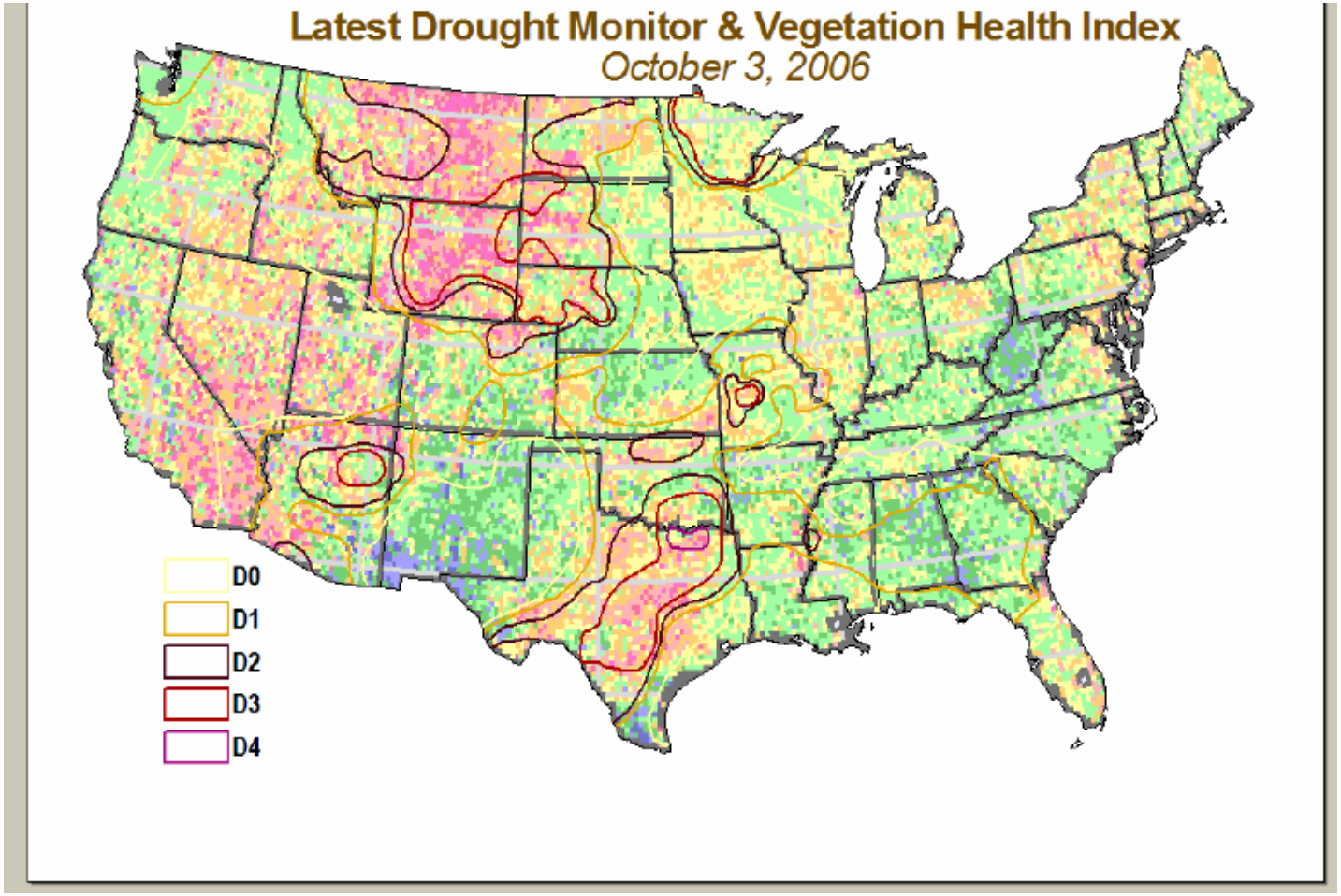
Precipitation and VHI, Chicago 2005-2006



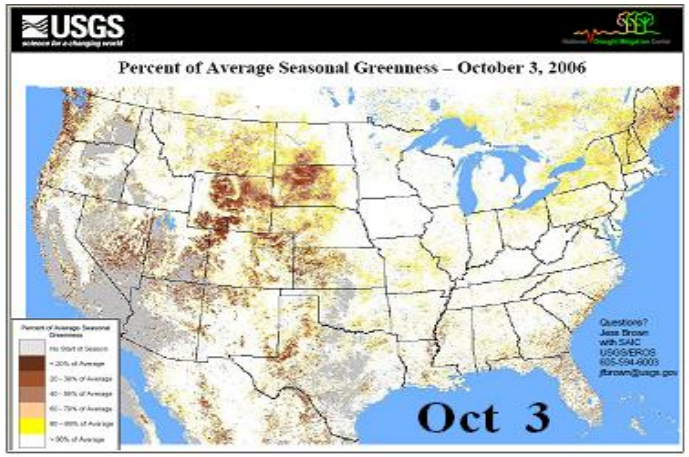
Precipitation & VHI, Tucson, AZ, 2000-2006



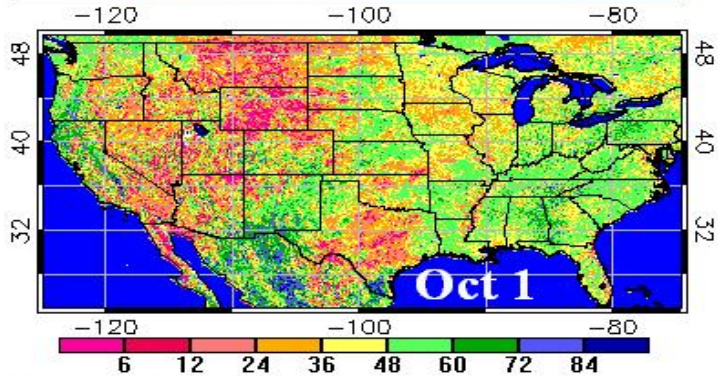
VHI vs Drought Monitor



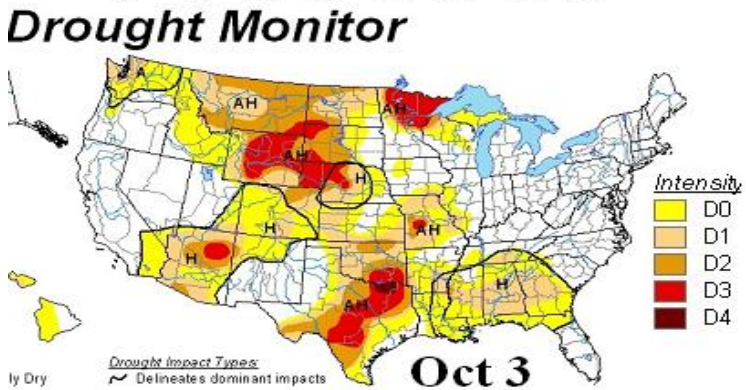
Greenness (USGS) vs VHI (NESDIS) vs DM



GREENNES



VHI



DM

Drought estimates, October 2006
First week

CRD Winter Wheat Production, Kansas

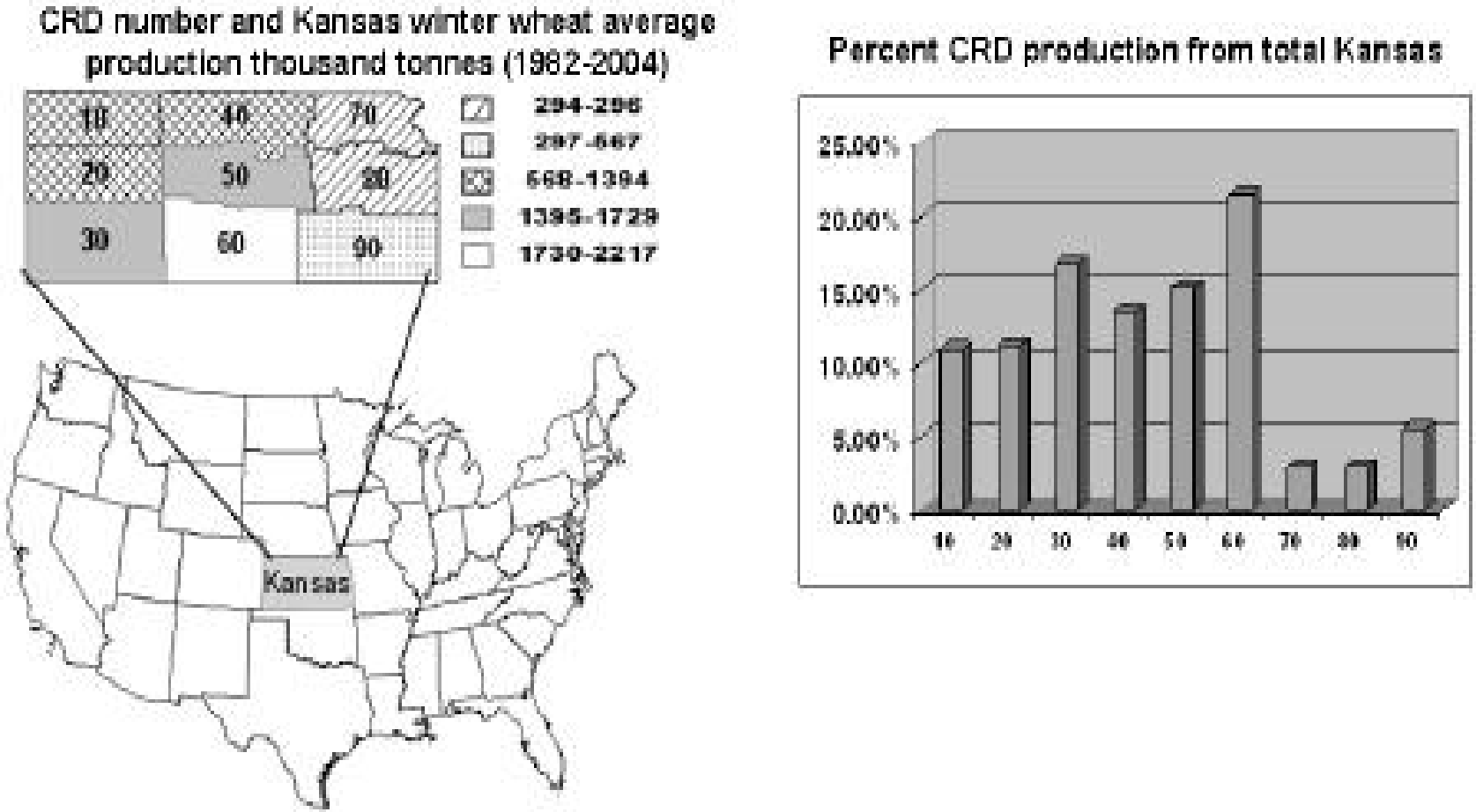


Figure 1. Area of study, Kansas CRDs and Kansas average winter wheat production (1982-2004)

Winter Wheat Yield, Kansas, 1981-2003

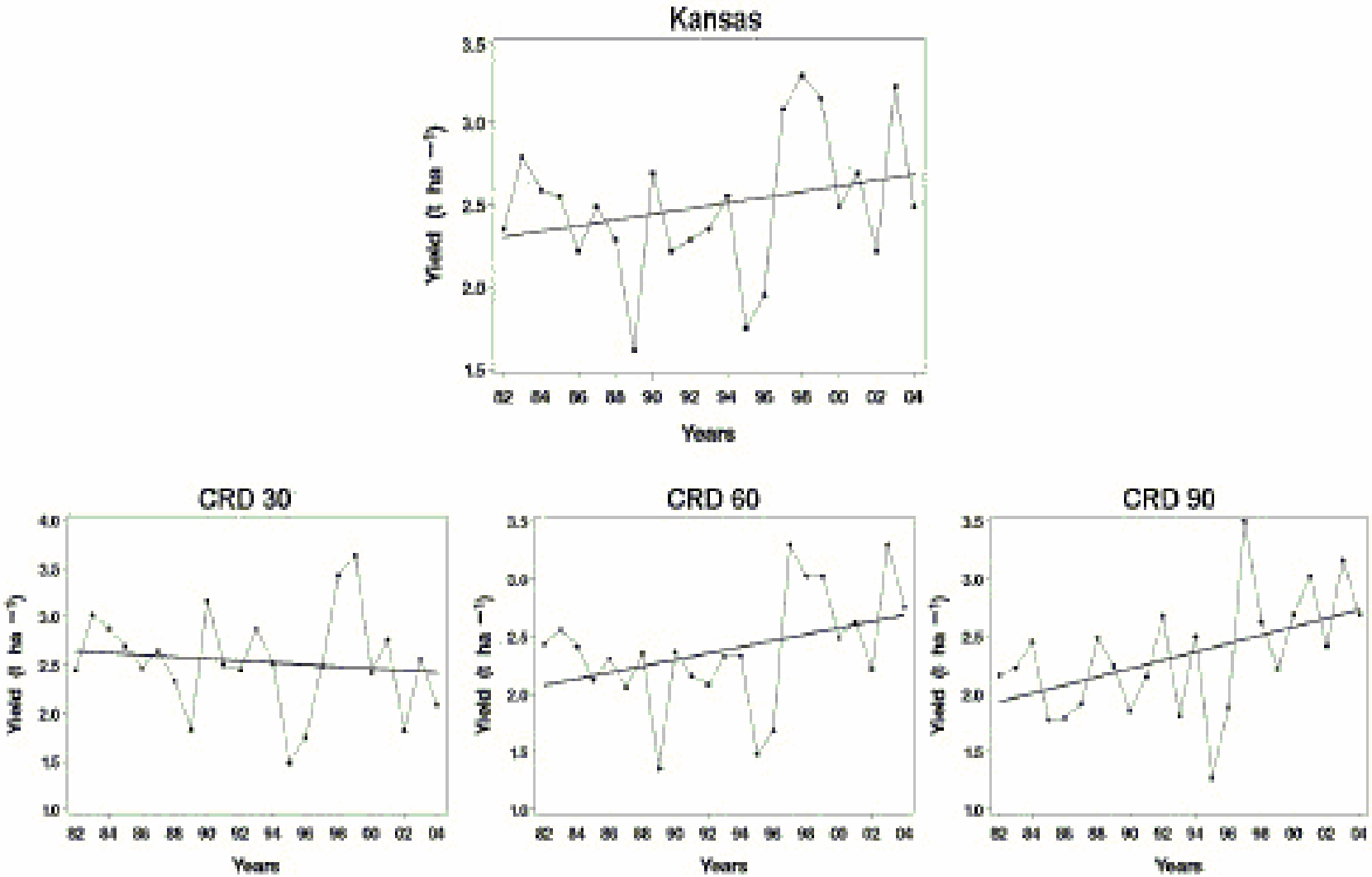
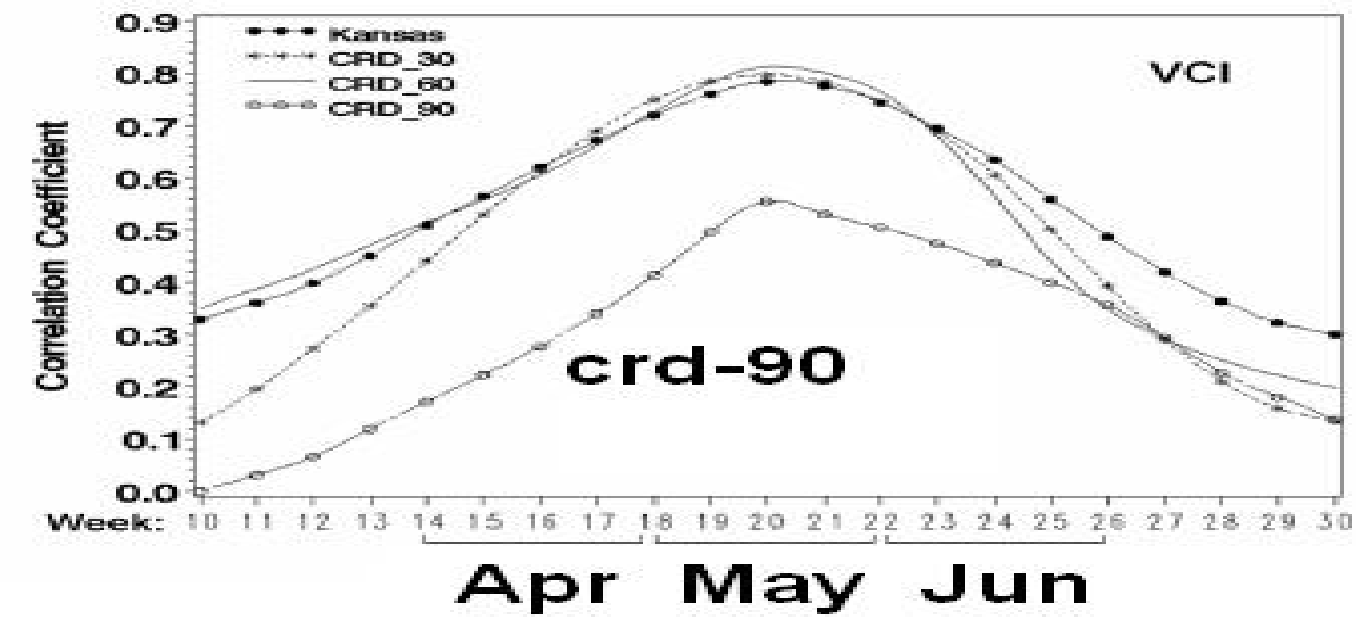
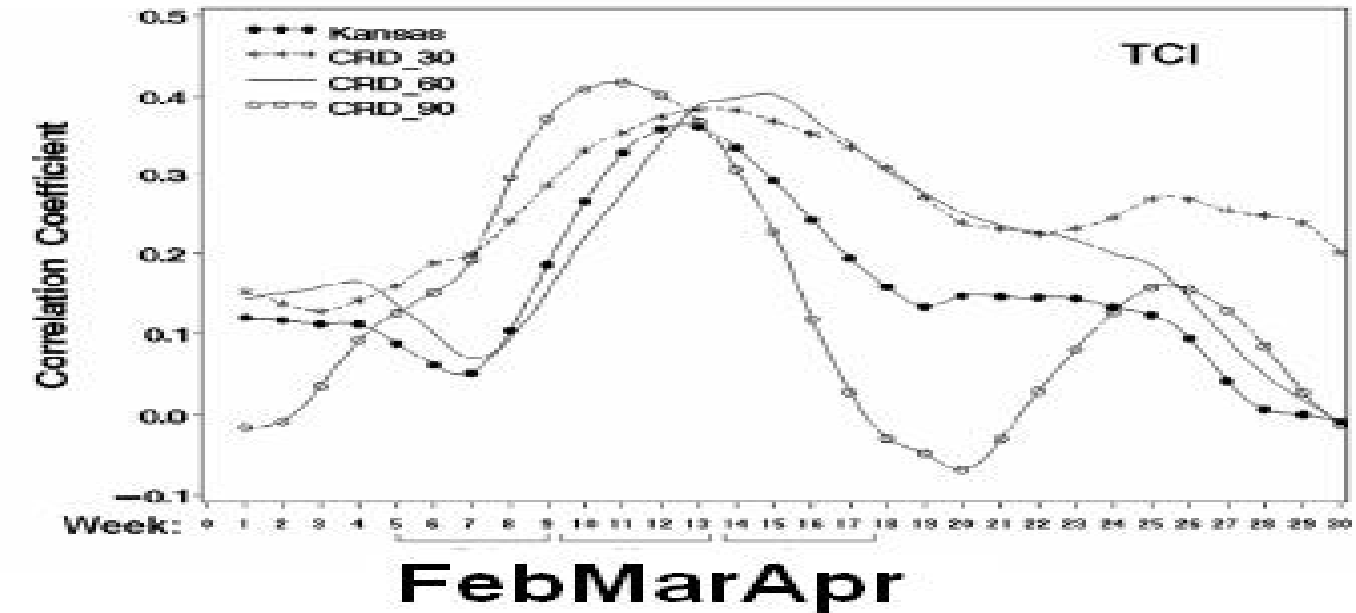


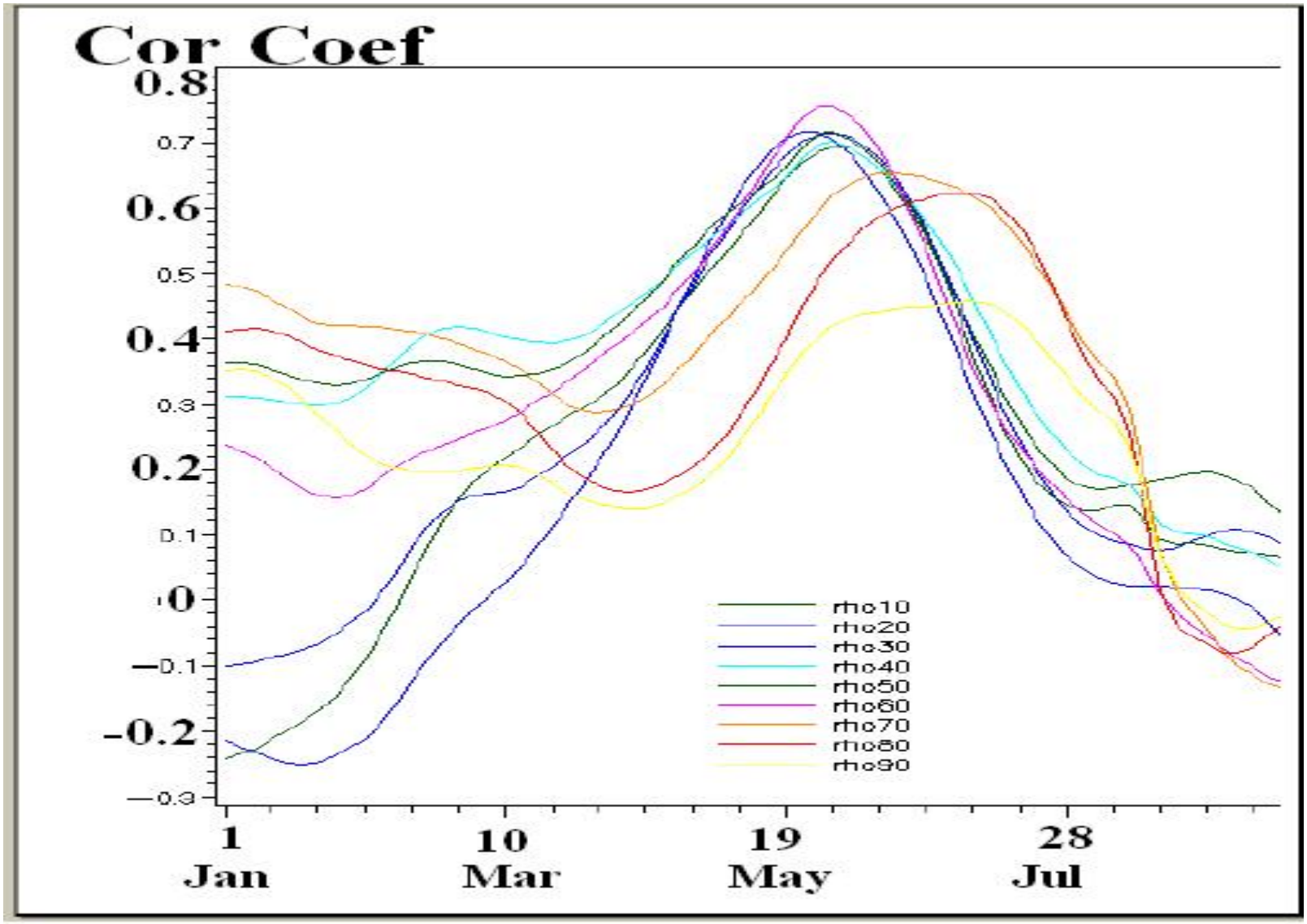
Figure 2. Winter wheat yield time series

Correlation Dynamics: WW dY vs VHI's, KANSAS





Correlation of dY vs VCI, Winter Wheat
KANSAS CRD



Dynamics of Correlation Coefficients dY vs VCI
Winter Wheat, CRD in Kansas, USA

Model Verification, Kasas, Winter Wheat

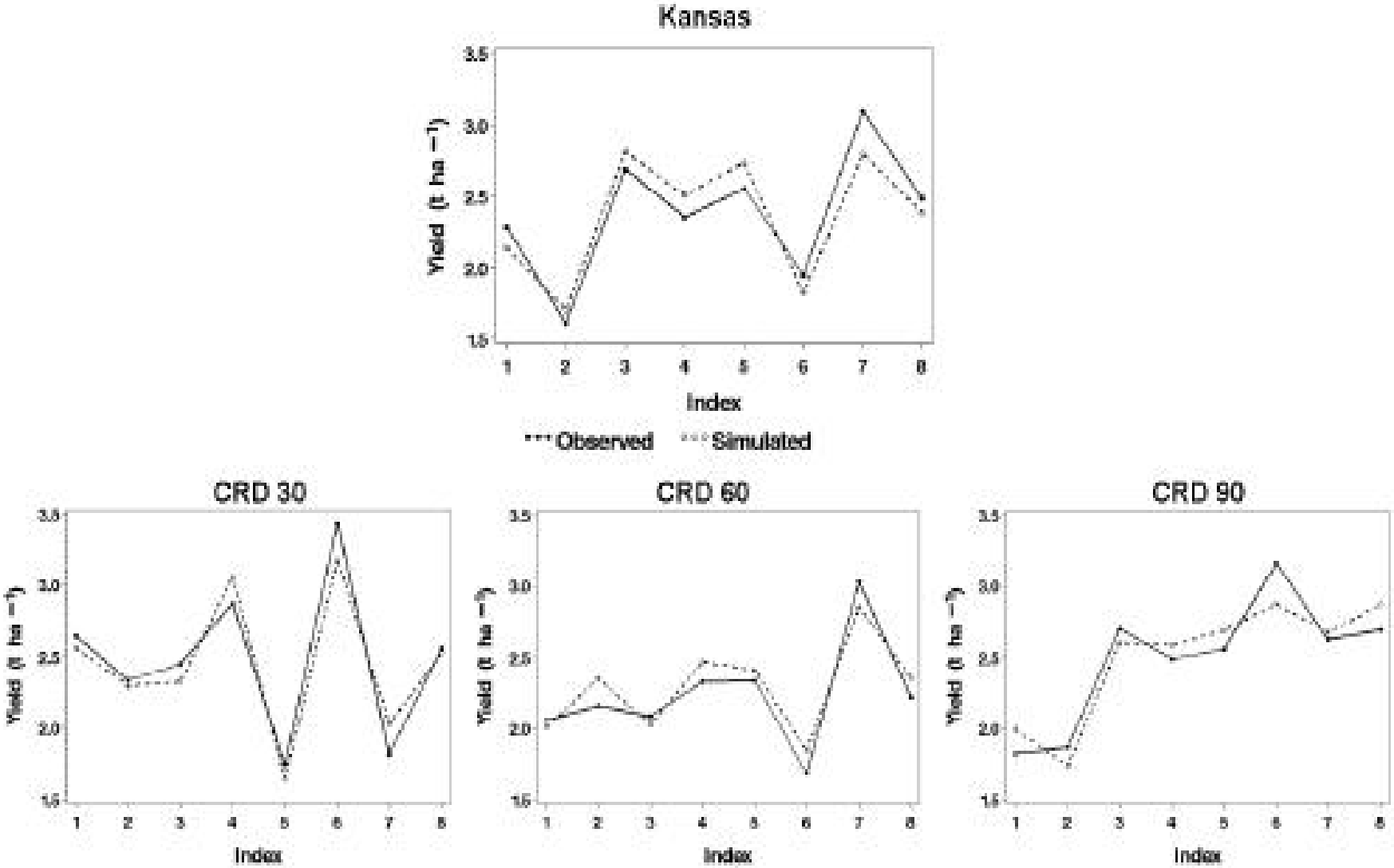


Figure 4. Simulated versus observed winter wheat yield independent testing

CRD CORN Production, Kansas

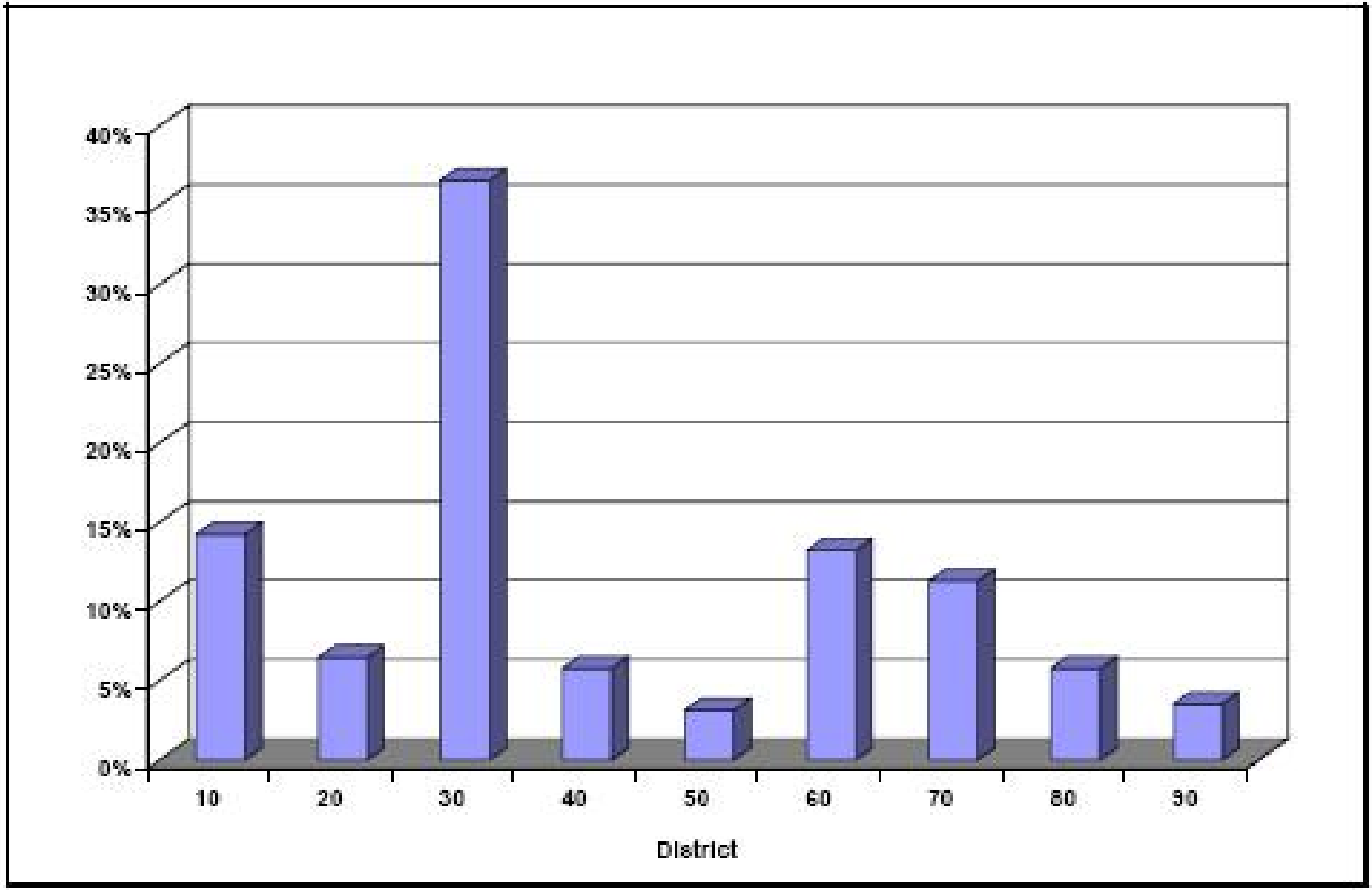
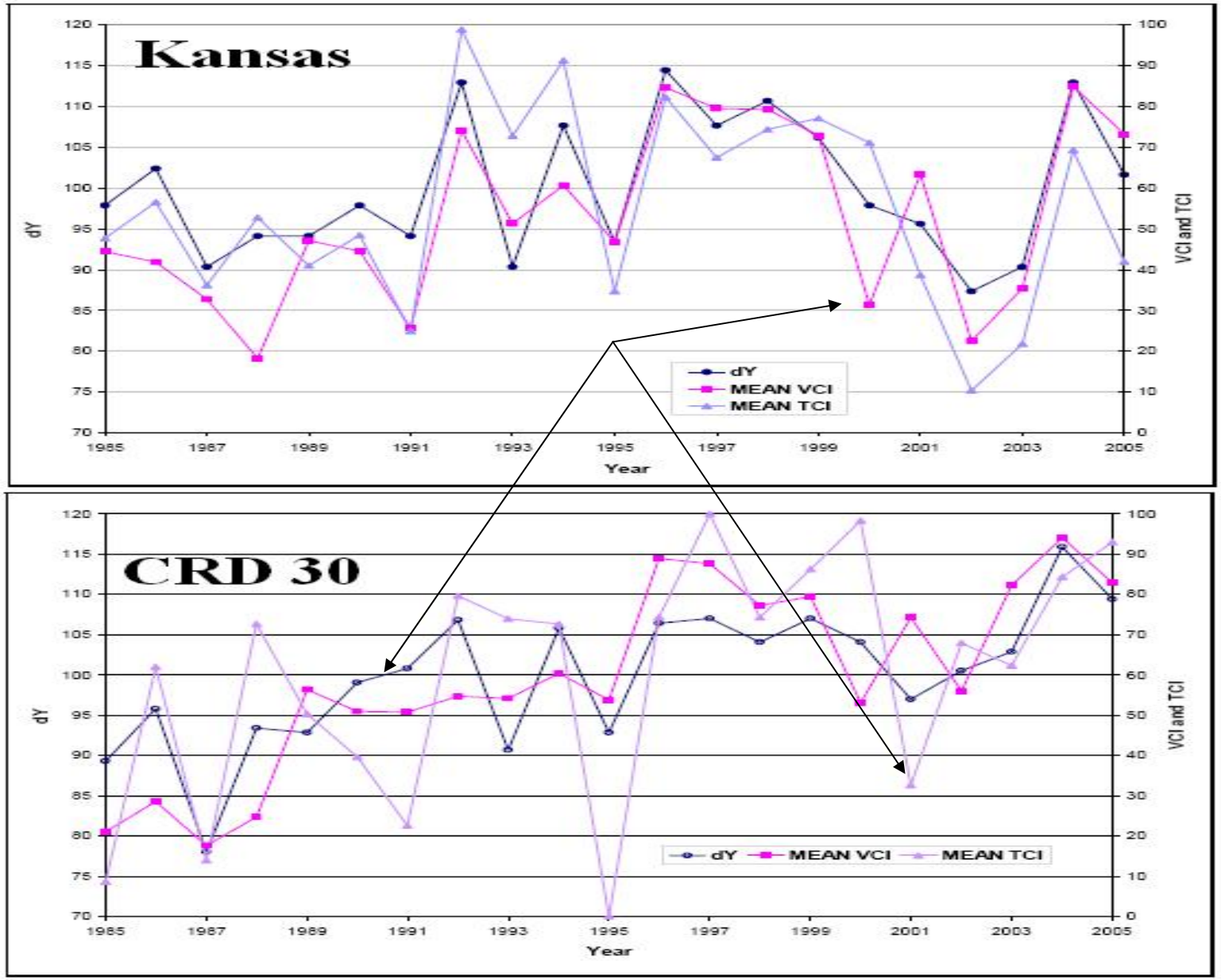


Figure 2: Percent CRD production from total Kansas (USCRB 2005)

DYNAMICS of dY vs VCI & TCI, Kansas, CORN, 1985-2006



Dynamics of dY, VCI, TCI, 1985-2006

Corn Yield, Haskell Co, Kansas

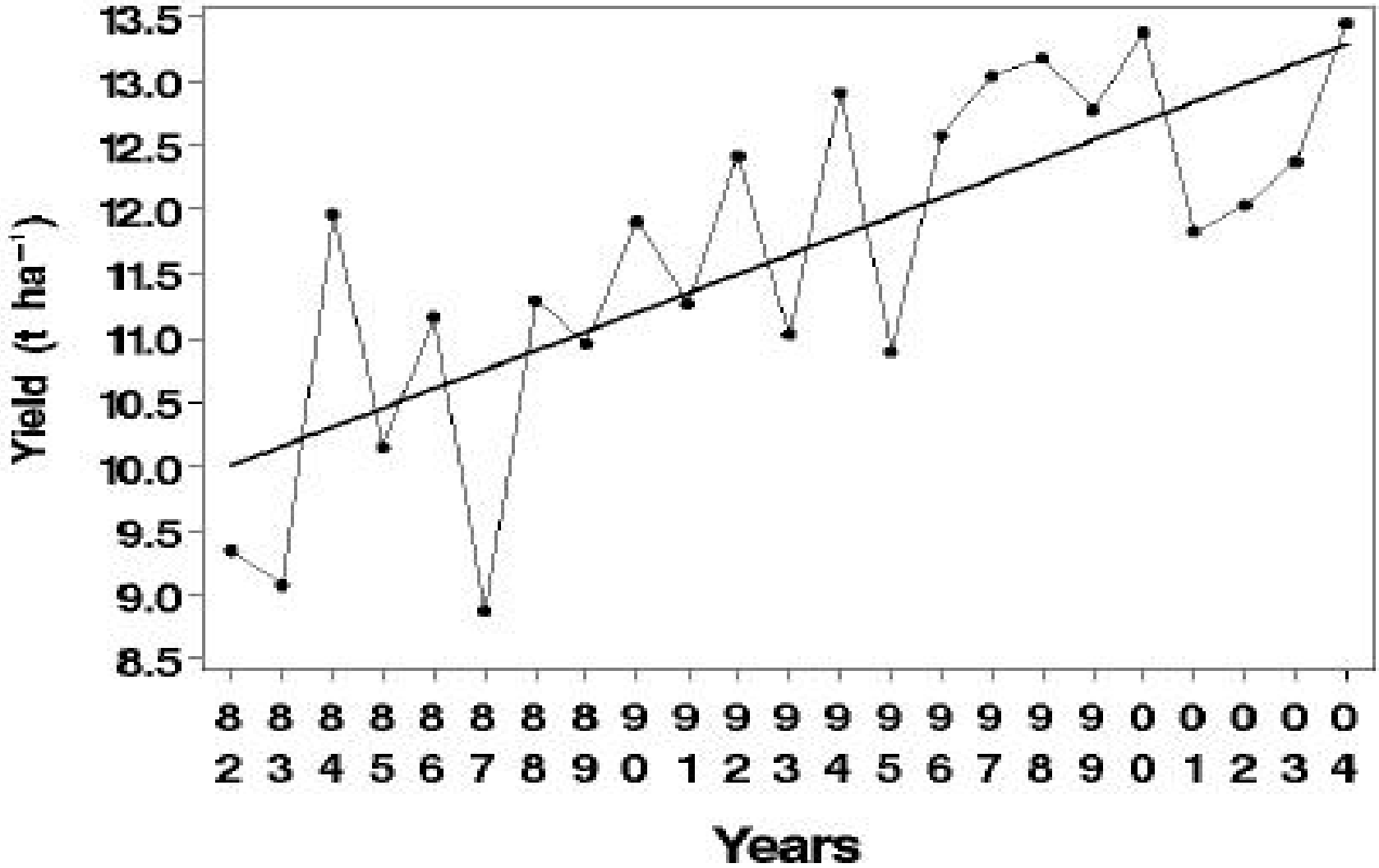
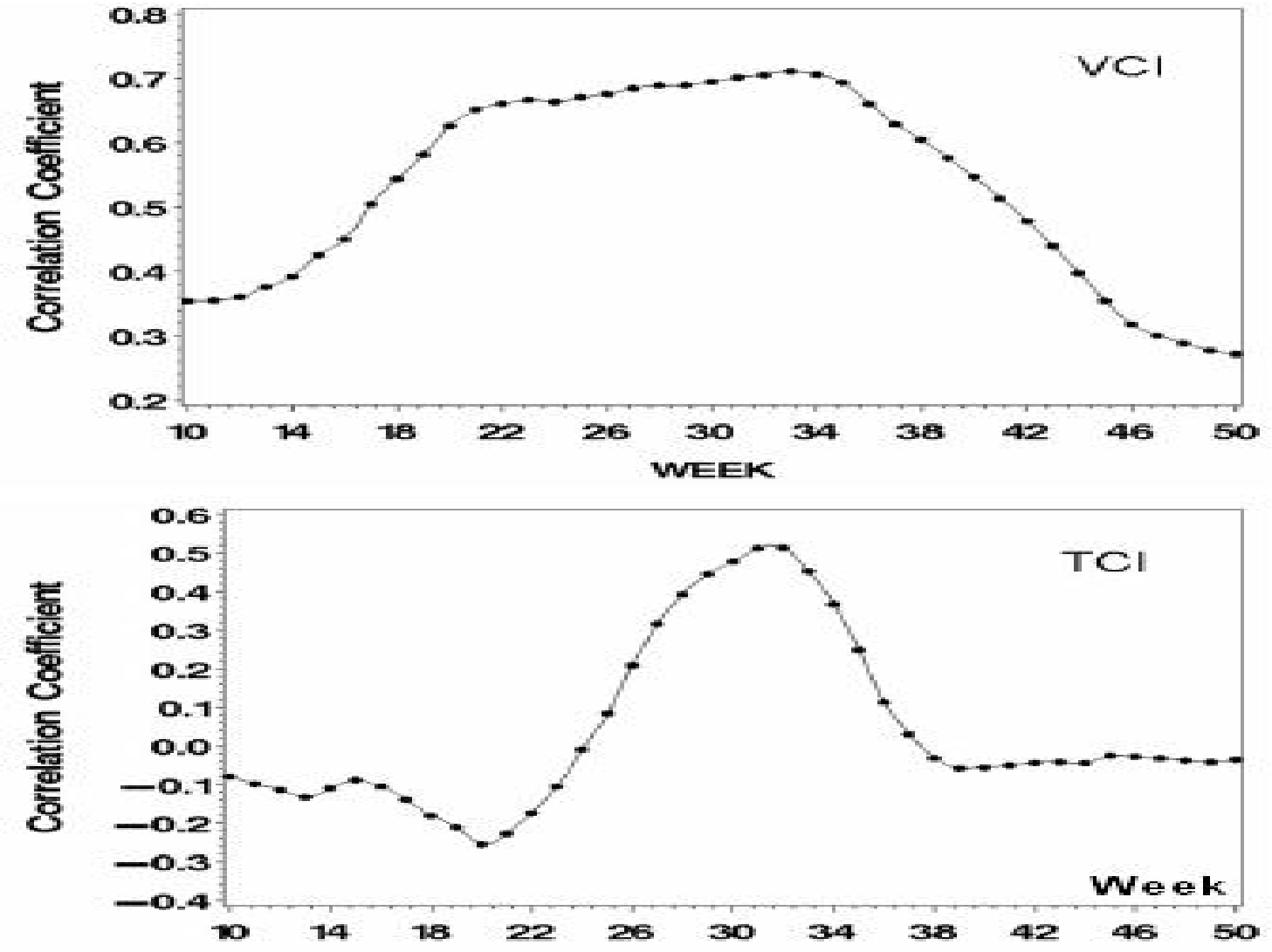
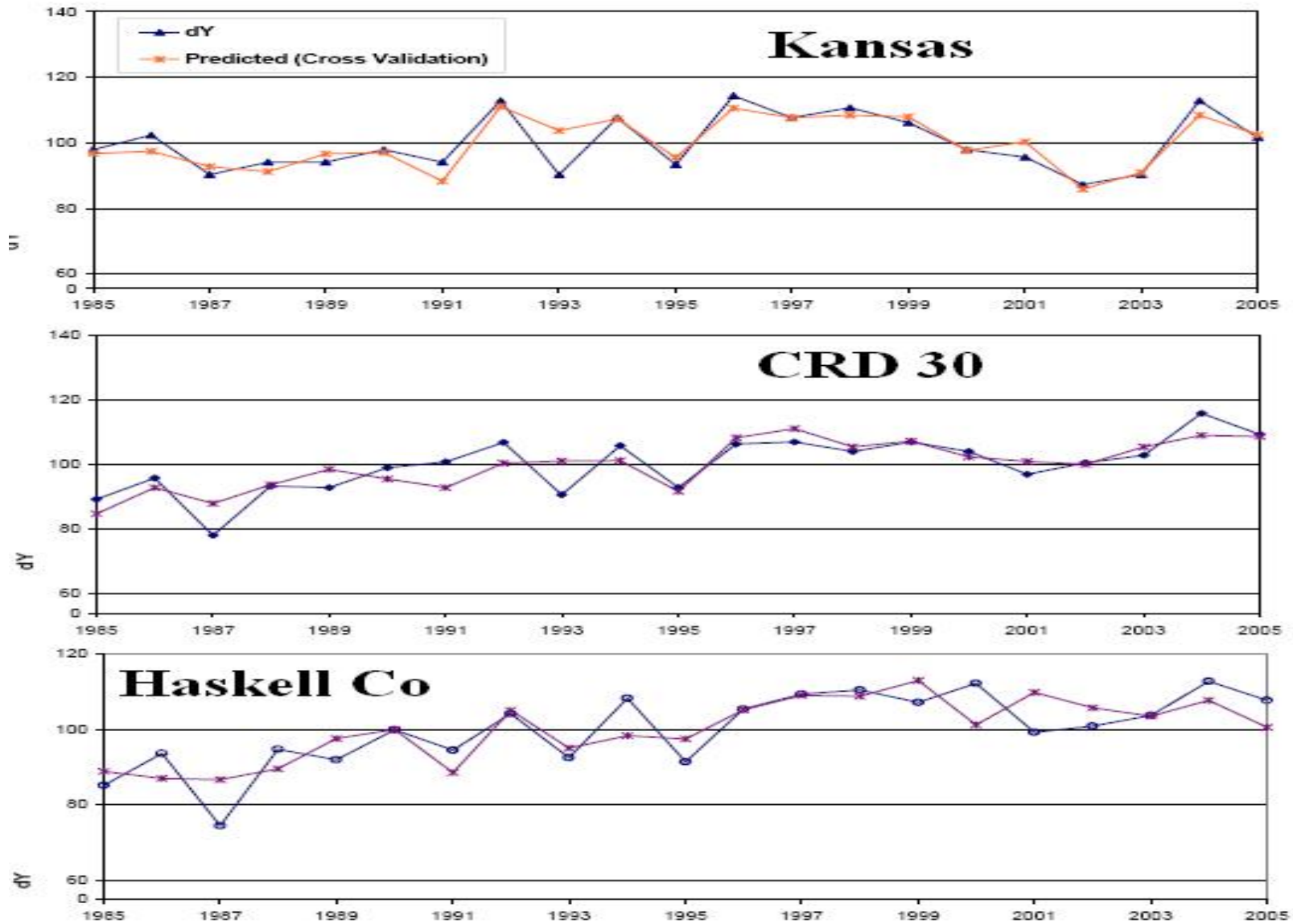


Figure 1. Corn yield time series

Correlation Corn dY vs VHIs Haskell Co, Kansas

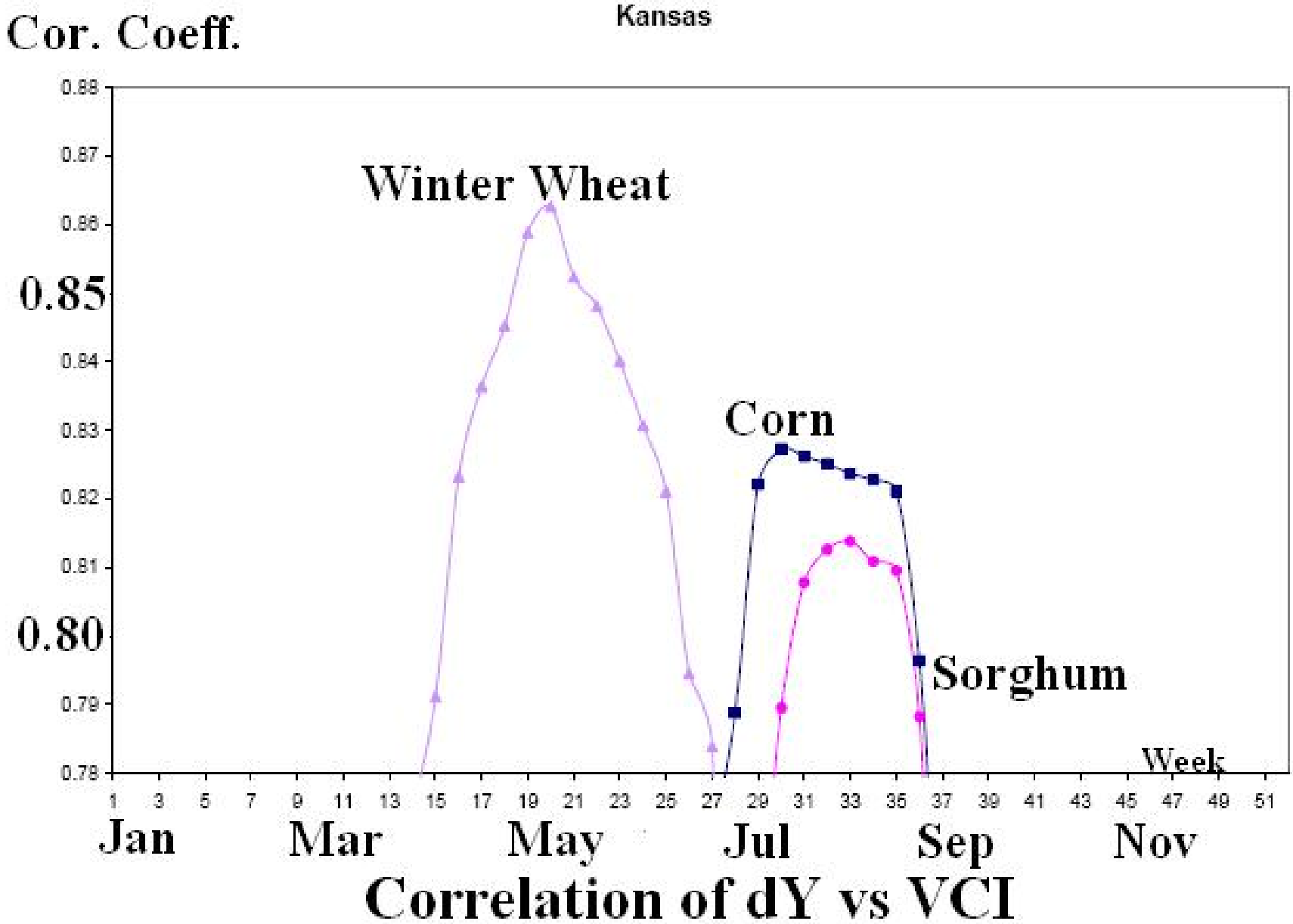


Independent model verification, Kansas, CORN, 1985-2005



Independent model verification, Kansas
1985-2005

Correlation of dY vs VCI, Kasas

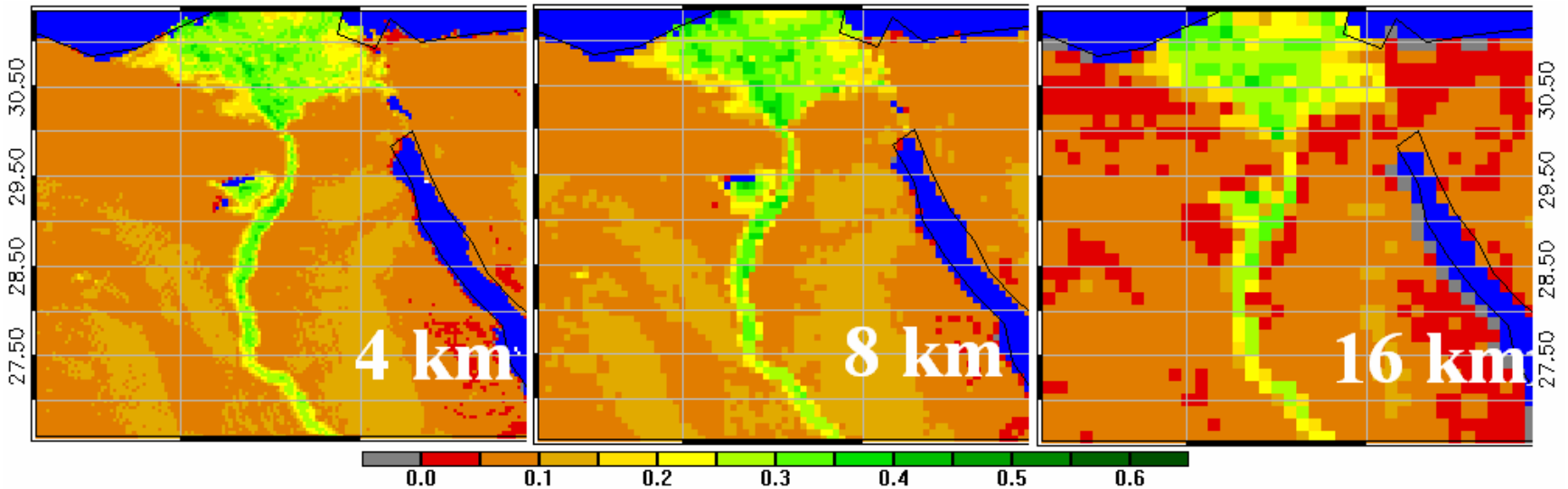


GVI-x: New 26-year, 4-km, 7-day Composit AVHRR Data Set for Land Cover & Climate Study

Conditions

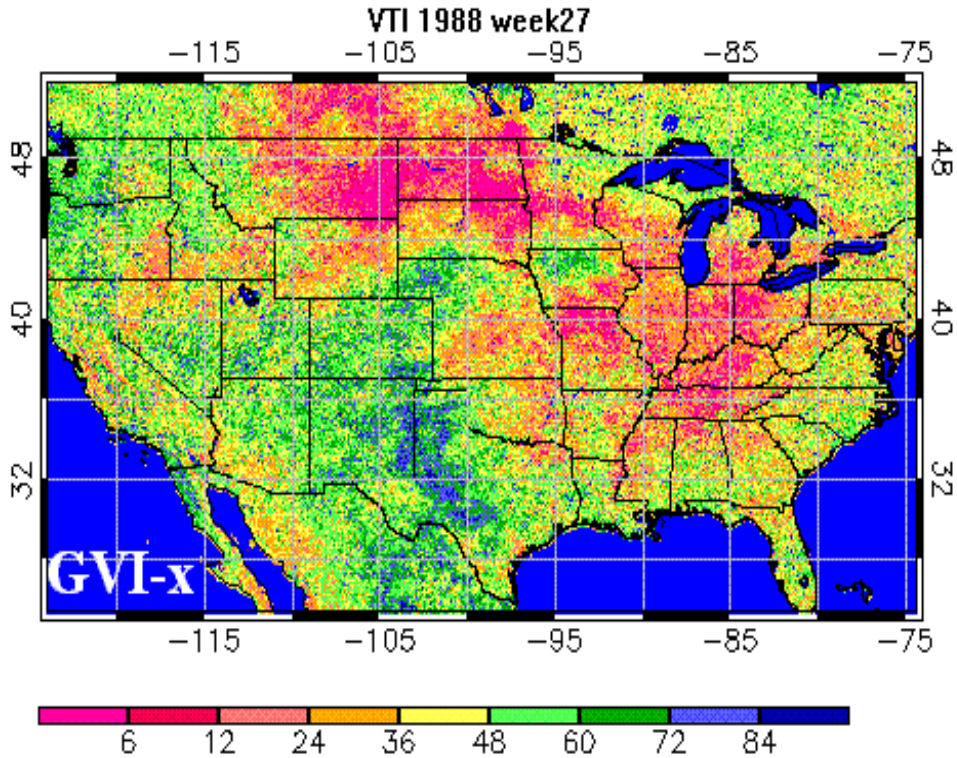
- **Data set must be:**
  - Longest
  - Highest resolution:
  *** spatial**
  *** temporal**
  - Contain maximum original parameters
  - Contain products
  - Compatible with geography
  - Validated against in situ data
  - High accuracy
  - Easy understandable nomenclature

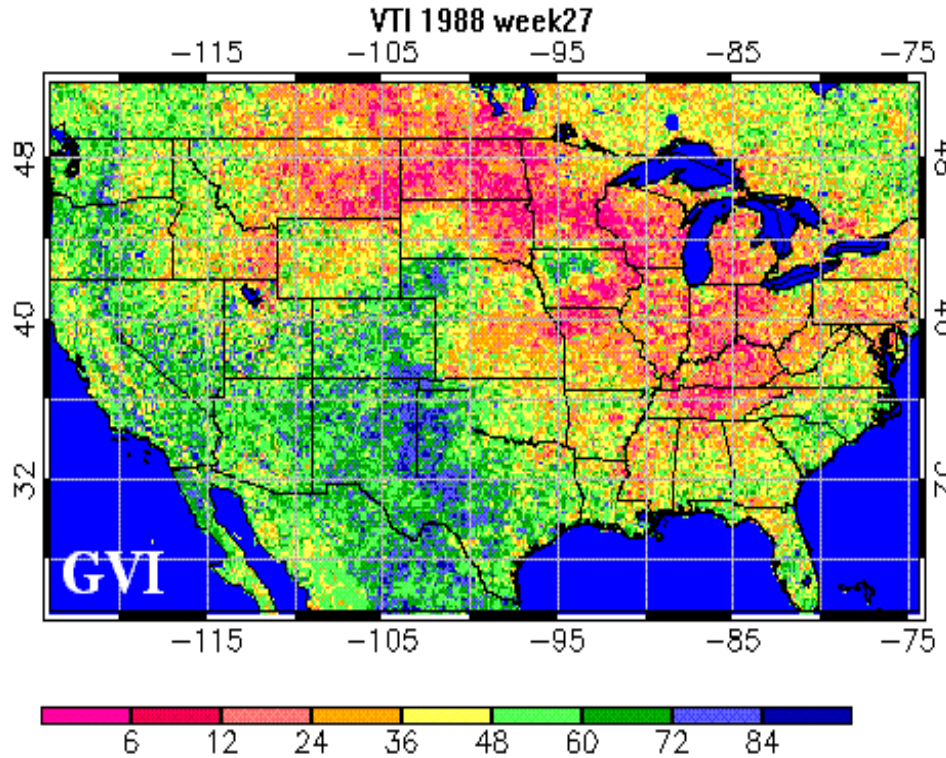
Normalized Difference Vegetation Index (NDVI)



NDVI, May 2005

Vegetation Health Index
USA, 1988, week27
GVI-x vs GVI2

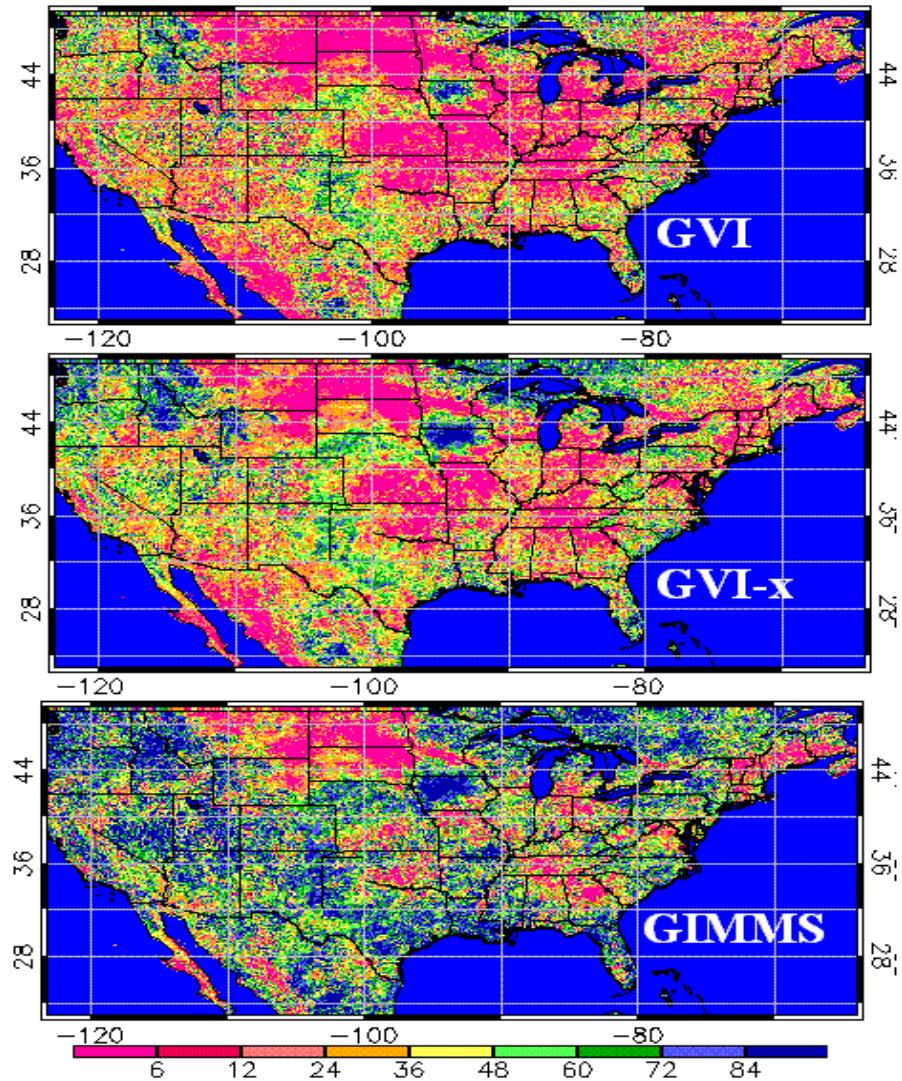


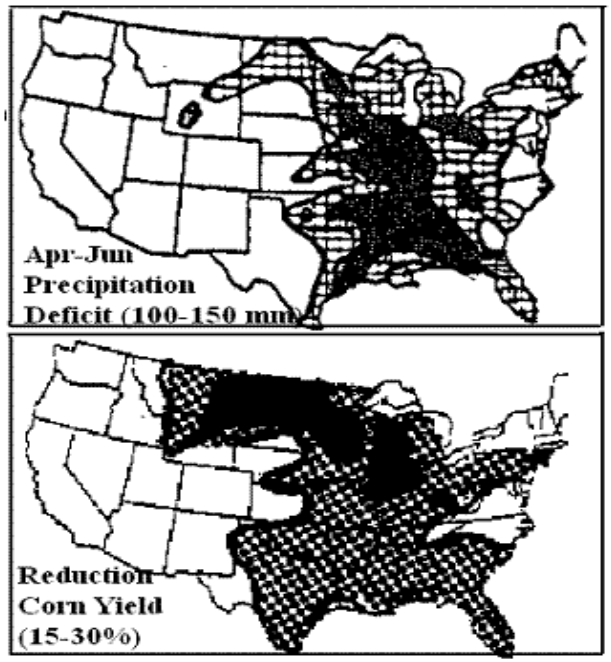


Global Long-Term Land Data Sets

	GVI	Pathfinder	ISLSCP/ Fasier	GIMMS	GVI-x
Period	1981-2005	1981-2000	1981-2002	1981-2002	1981-2005
Resolution: Spatial Temporal	16 km 7-day	8 km 10-day	111 km 30-day	8 km 15/16-day	4 km 7-day
Projection	Lat/Long			Albers equal area	Lat/Long
Parameters available	7 NDVI C1, 2, 4, 5, SZA, SCA	1 NDVI	1 NDVI	1 NDVI	14 NDVI C1, 2, 4, 5 A1,A2,BT4 SZA,SCA, RAZ Pix.Jul. Day Pix. Time, Cloud mask
Products available	8 smn, smt VHI,VCI TCI,Climatology Drought Fire risk				8 smn, smt VHI,VCI, TCI,Climatology, Drought Fire risk
Data Precision	1-byte	1-byte	1-byte	4-byte (tiff)	2-byte (HDF)
Validation	Well done	Partial	No	Partial	No
Producer	NOAA	NOAA/NASA	Wales Univ.	NASA/Maryland Univ.	NOAA
Year produced	1985	1991	2003	2003	2005

1988 US Drought
Satellite and Ground Data





1988 Drought Satellite and Ground Data

File View Collect Data Tools Help

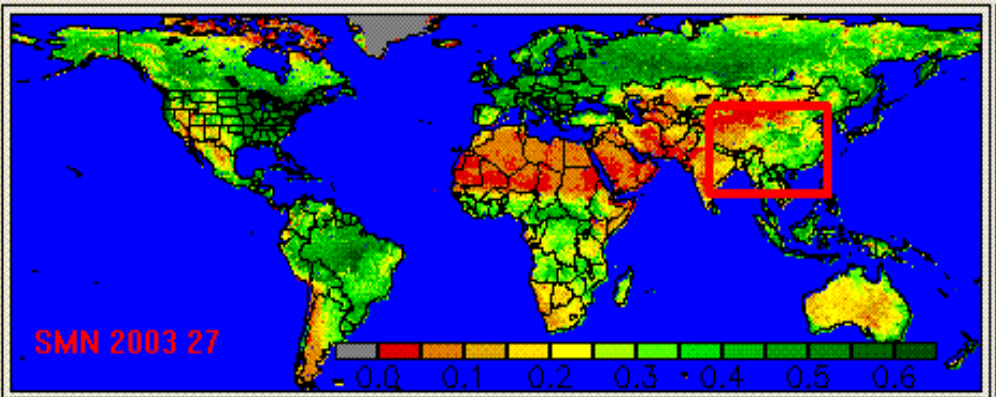
Year1 2003 Week1 2 Year2 2003 Week2 14 Interval 1

Lat1 19.570 Lon1 104.13 Lat2 20.000 Lon2 104.67 Set as Selected Region

Folders I:\GVIX\GVIX_V099_VH_G16; I:\GVIX\GVIX_V099_VH_G16; I:\GVIX\GVIX_V0

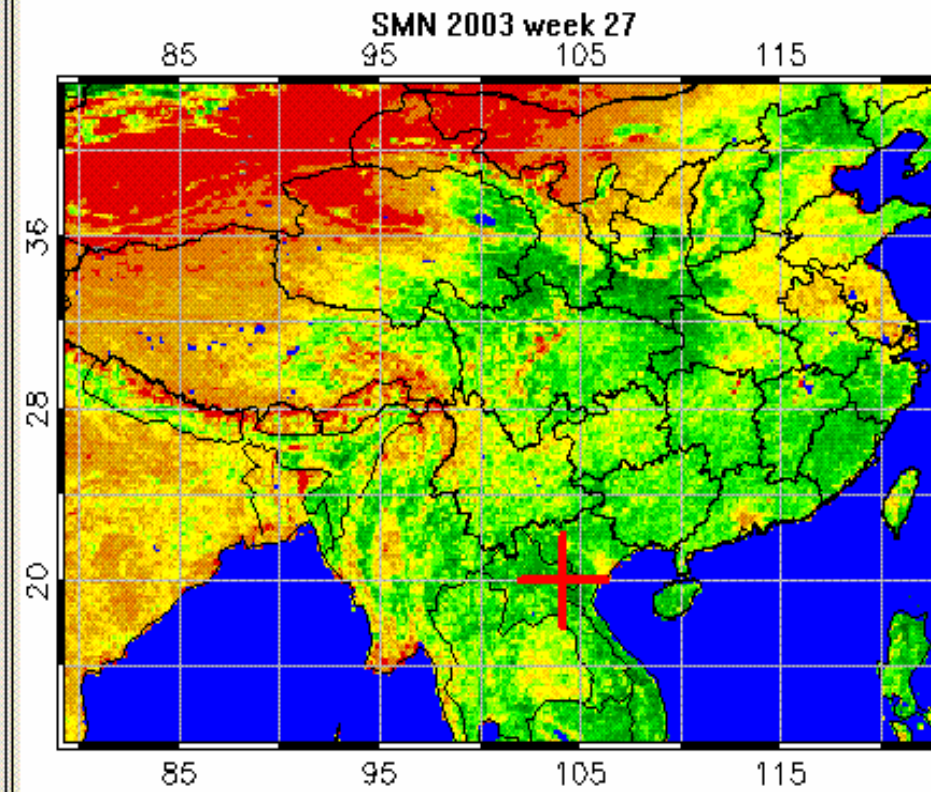
Result Folder Z:\Results Region Name GW1

GVI-x 16km SMN Year 2003 Week 27 I:\GVIX\GVIX_V099_VH_G16\SMN\GVIX_NL_G16_C07_SMN_Y2003_P27.hdf

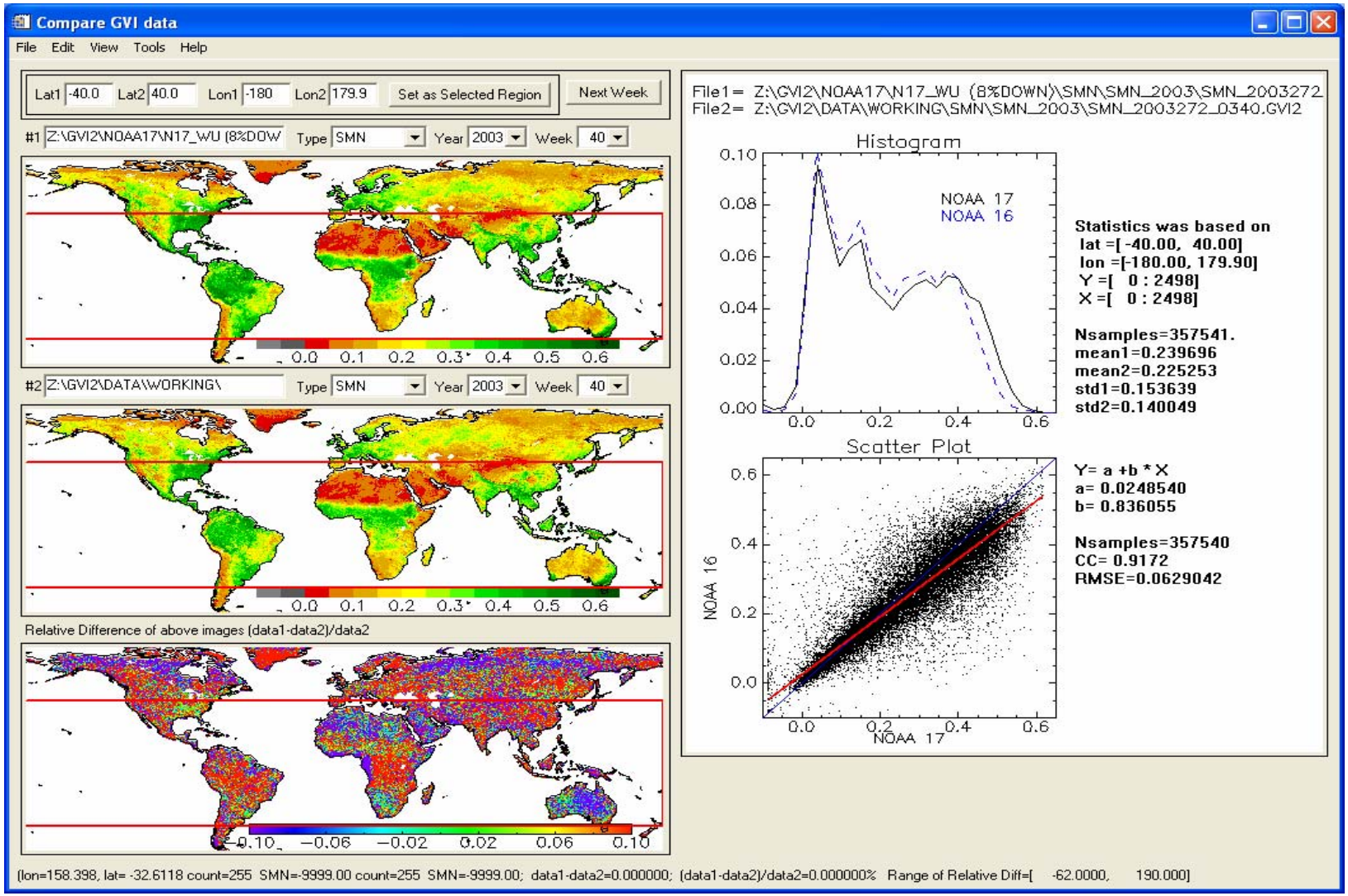


lon=104.671, lat= 19.6775, x=1976, y= 384

NVI= 0.622000	ch1_count= 130
BT4= 299.400	ch2_count= 476
SMN= 0.465000	albedo1= 4.82656
SMT= 294.100	albedo2= 24.9591
VCI= 93.4800	ch4_temperature= 299.382
TCI= 0.000000	ch5_temperature= 295.418
VTI= 46.7400	cell_jday= 185
MXN= 0.483000	cell_time= 6.95747
MNN= 0.207000	sensor_zenith= 10.0133
MXT= 292.500	solar_zenith= 26.1033
MNT= 274.100	relative_azimuth= 157.323
	packed_cloud_mask= 1



Global Area NDVI
NOAA-17 vs NOAA-16



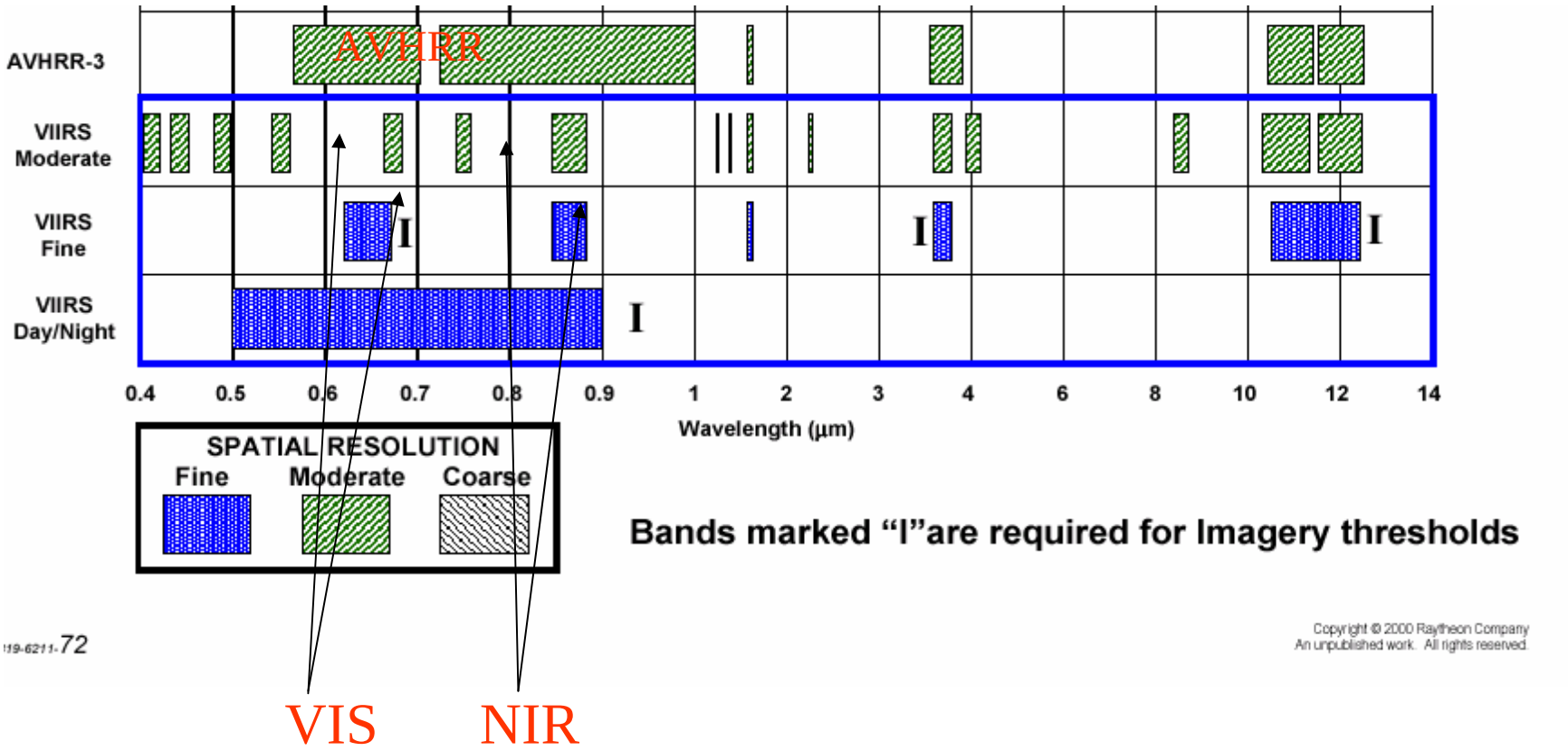
Web

http://www.orbit.nesdis.noaa.gov/smcd/emb/vci

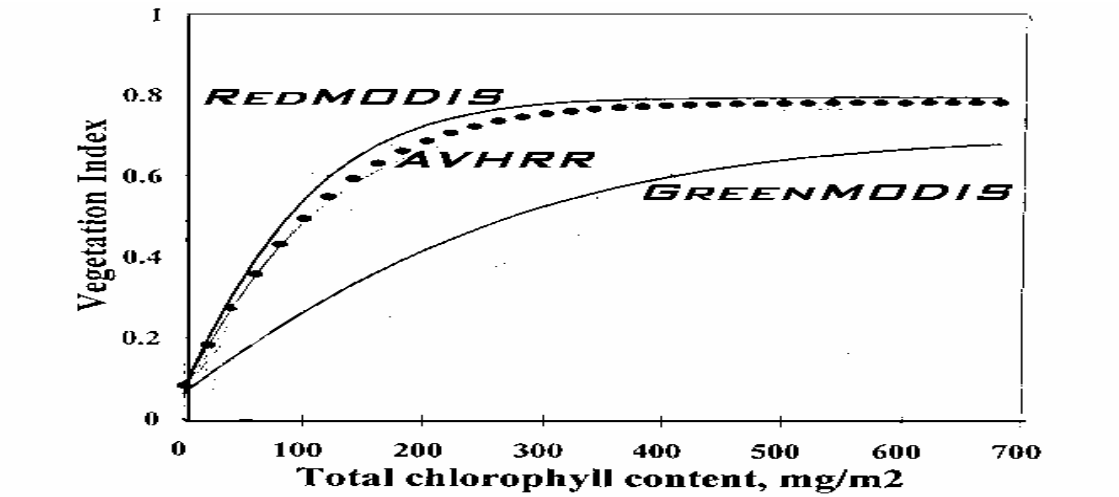
Every Monday new information on Vegetation Conditions & Health is posted

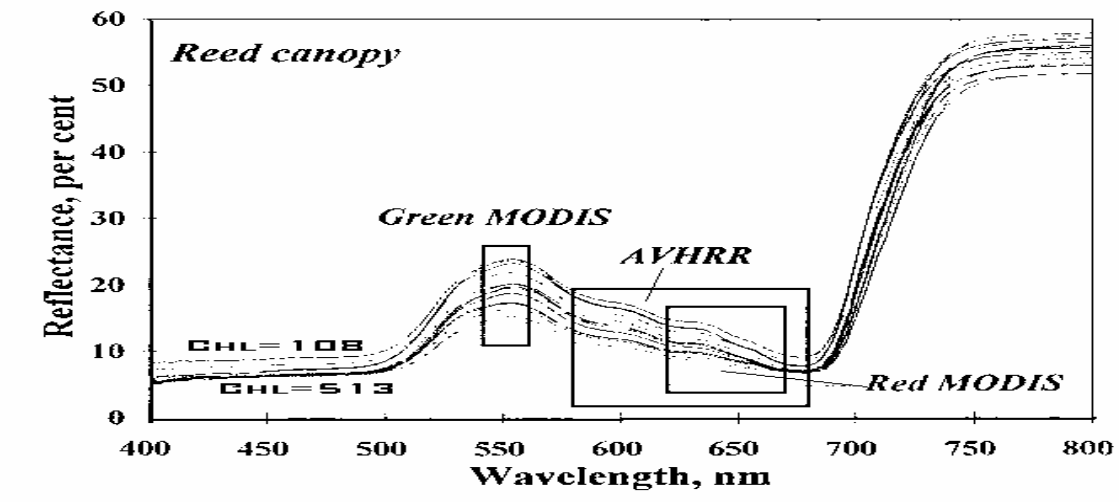
E-Mail: Felix.Kogan@noaa.gov

VIIRS vs AVHRR



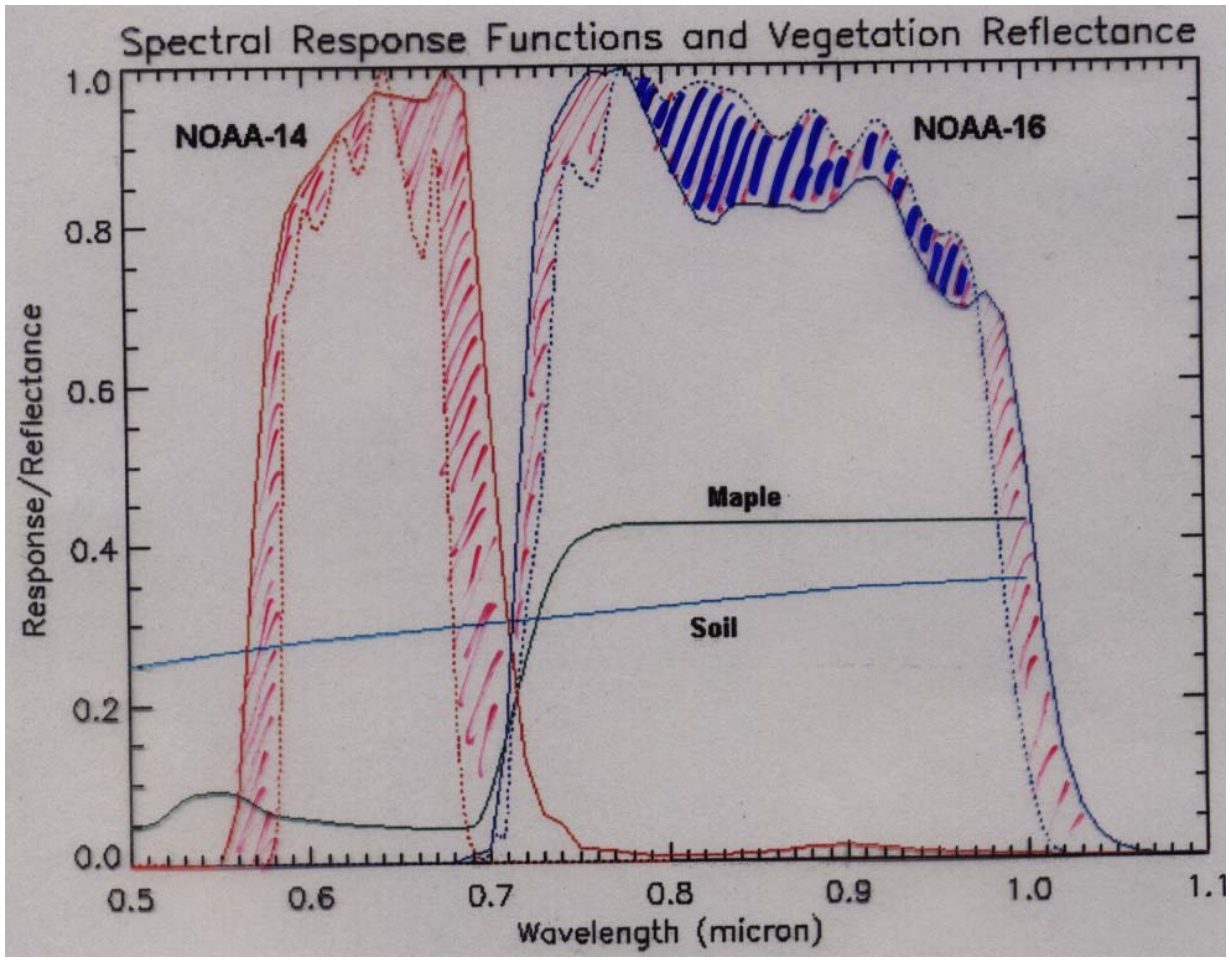
AVHRR vs MODIS



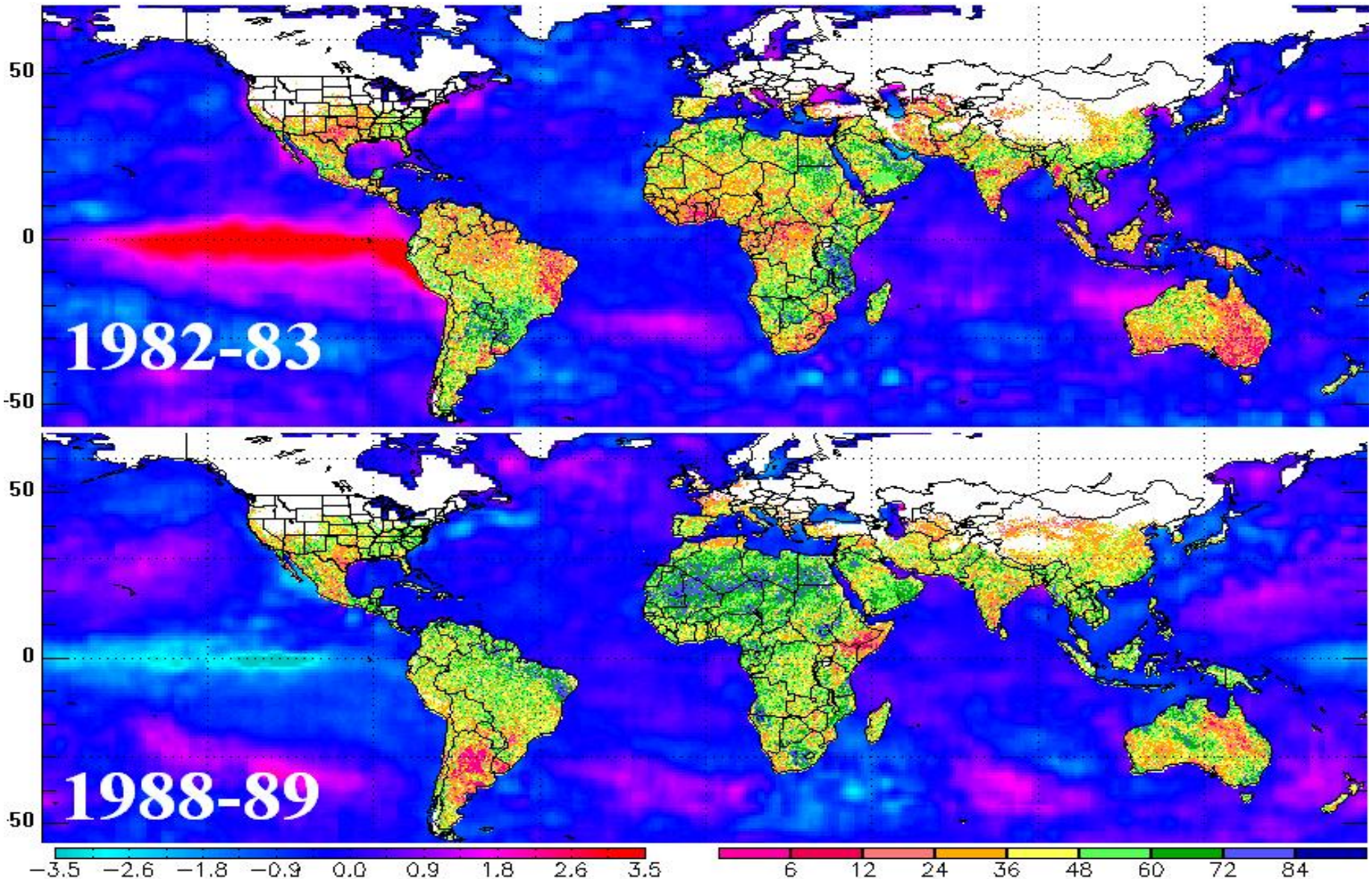


Thank You

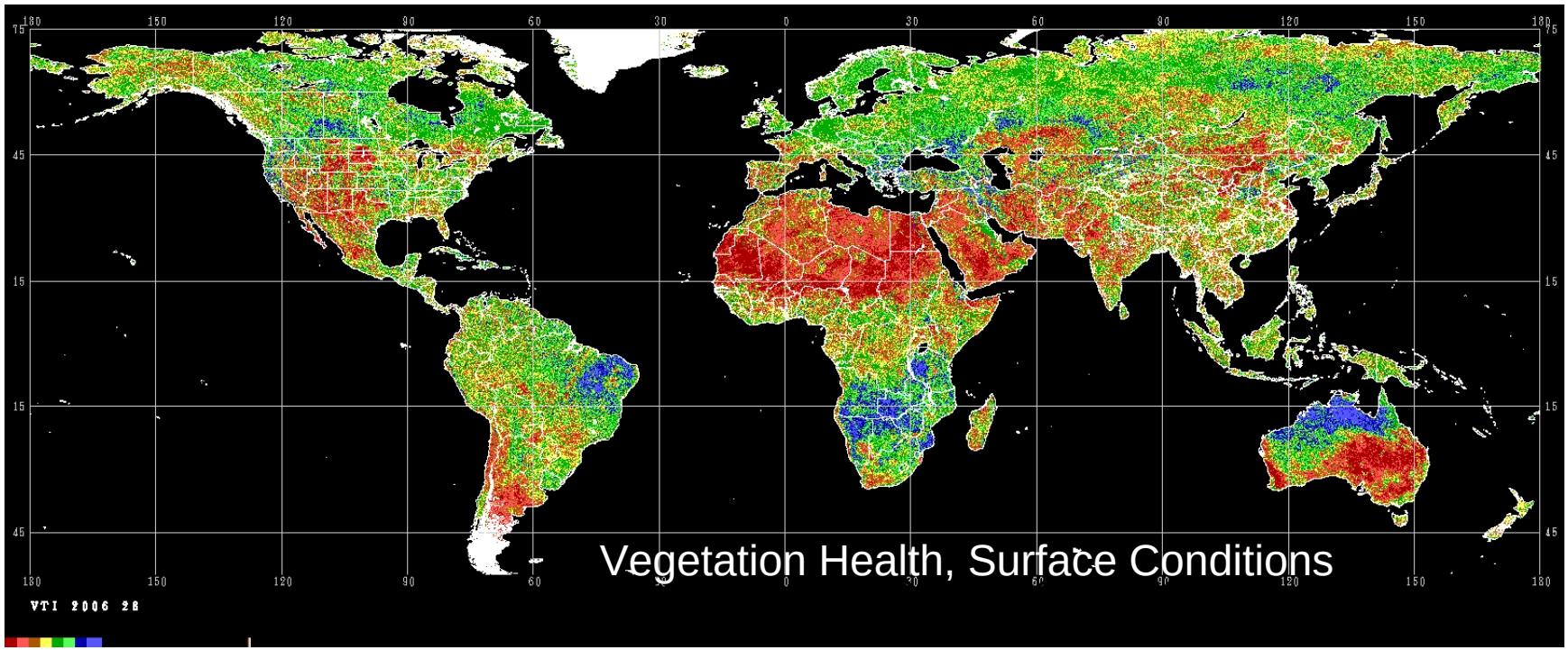
Spectral Response Function & Vegetation Reflectance



SST anomaly & Vegetation Health
El Nino & La Nina
December



Vegetation Health, Mid-July 2006



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Processing

- Pre-Launch Calibration VIS, NIR
- Post-Launch Calibration VIS, NIR
- Correct response function difference VIS, NIR
- Calculate NDVI and BT (from IR4)
- Apply non-linear correction to BT
- Remove high frequency noise NDVI and BT
- Derive 1981-2005 NDVI & BT climatology
- Calculate Vegetation health indices (VHIs)