Monitoring Drought & Impact on Vegetation from Space

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Outline

- Drought as Natural Disaster
- Data and Background
- Vegetation Products
- Application
- Summary

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**
  - **Drought type: Meteoro-logical, Agricultural, Hydrological, Socio-economic**

AVHRR Data for Land Use

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

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

Data Resolution: ***Spatial - 4 km (GAC), 8 & 16 km;***

Temporal - 7-day composit

Period: **1981-2008**

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

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

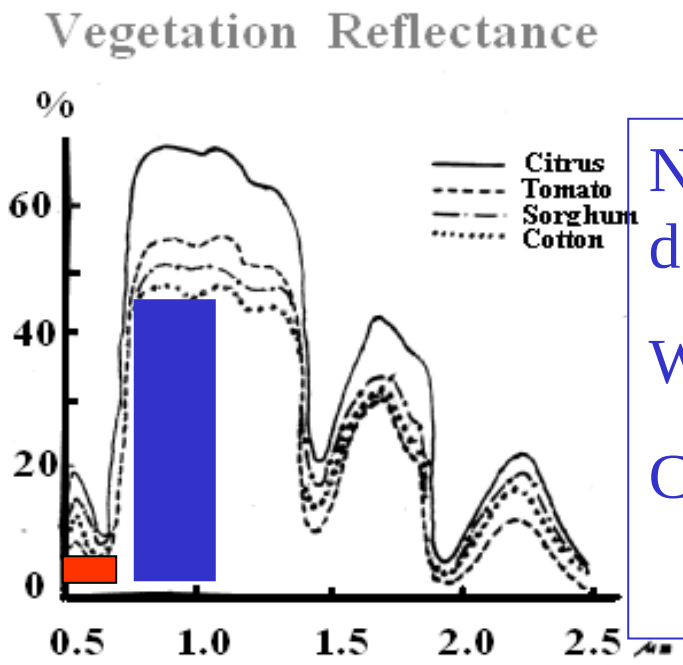
Typical Vegetation Reflectance

Theory

VIS reflectance depends on

CHLOROPHYLL

CAROTENOID



NIR reflectance depends on

WATER CONTENT

CELL STRUCTURE

VIS NIR *AVHRR VIS/NIR bands*

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

NDVI & Reflectance

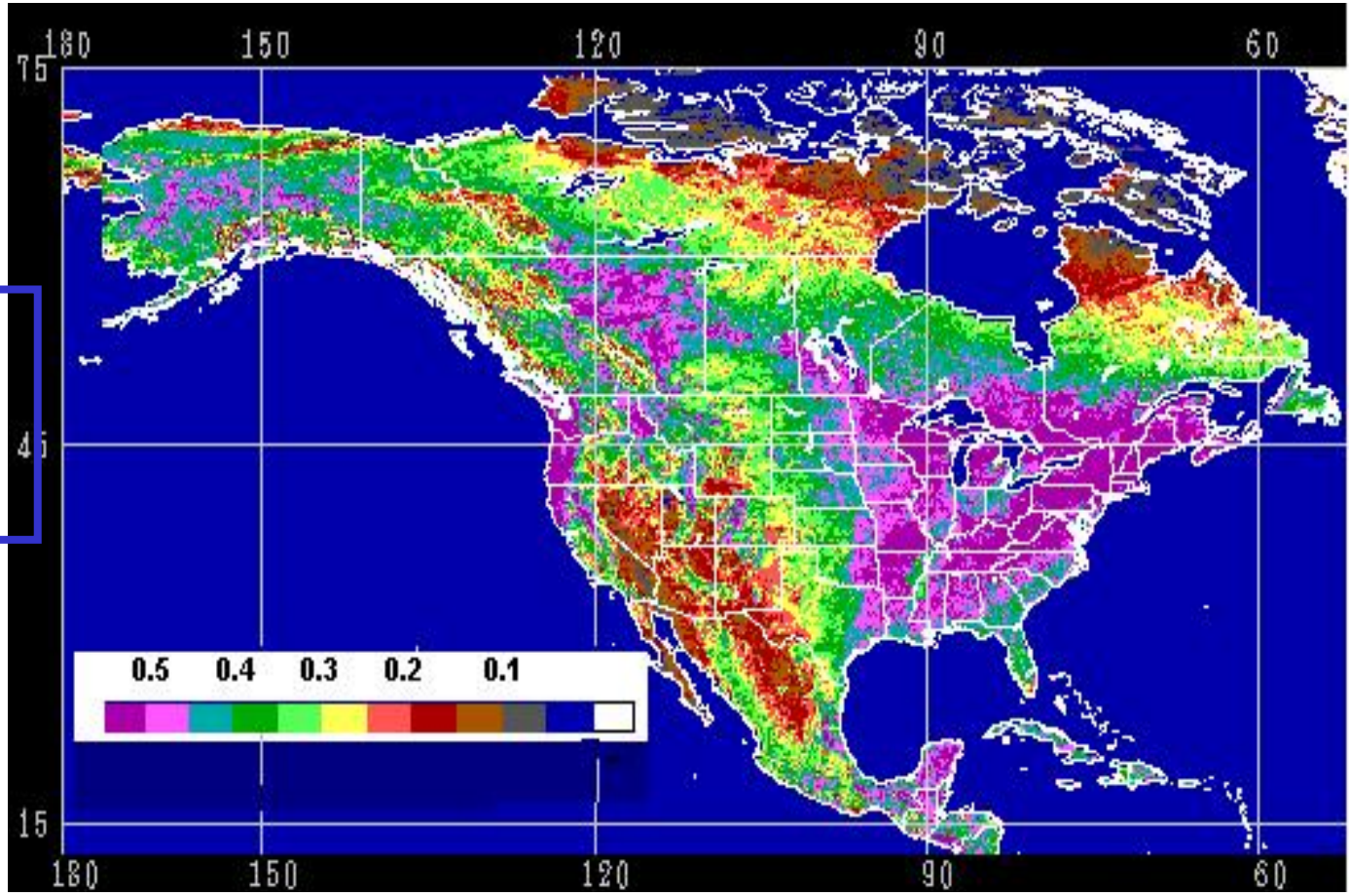
Theory

Cover Type	Ch1	Ch2	NDVI
Vegetation: Dense	.050	.150	**0.500**
Medium	.080	.110	**0.140**
Light	.100	.120	**0.090**
Bare Soil	.269	.283	**0.025**
Clouds	.227	.228	**0.002**
Water	.022	.013	**-0.26**

NDVI= (Ch2-Ch1)/(Ch2+Ch1)

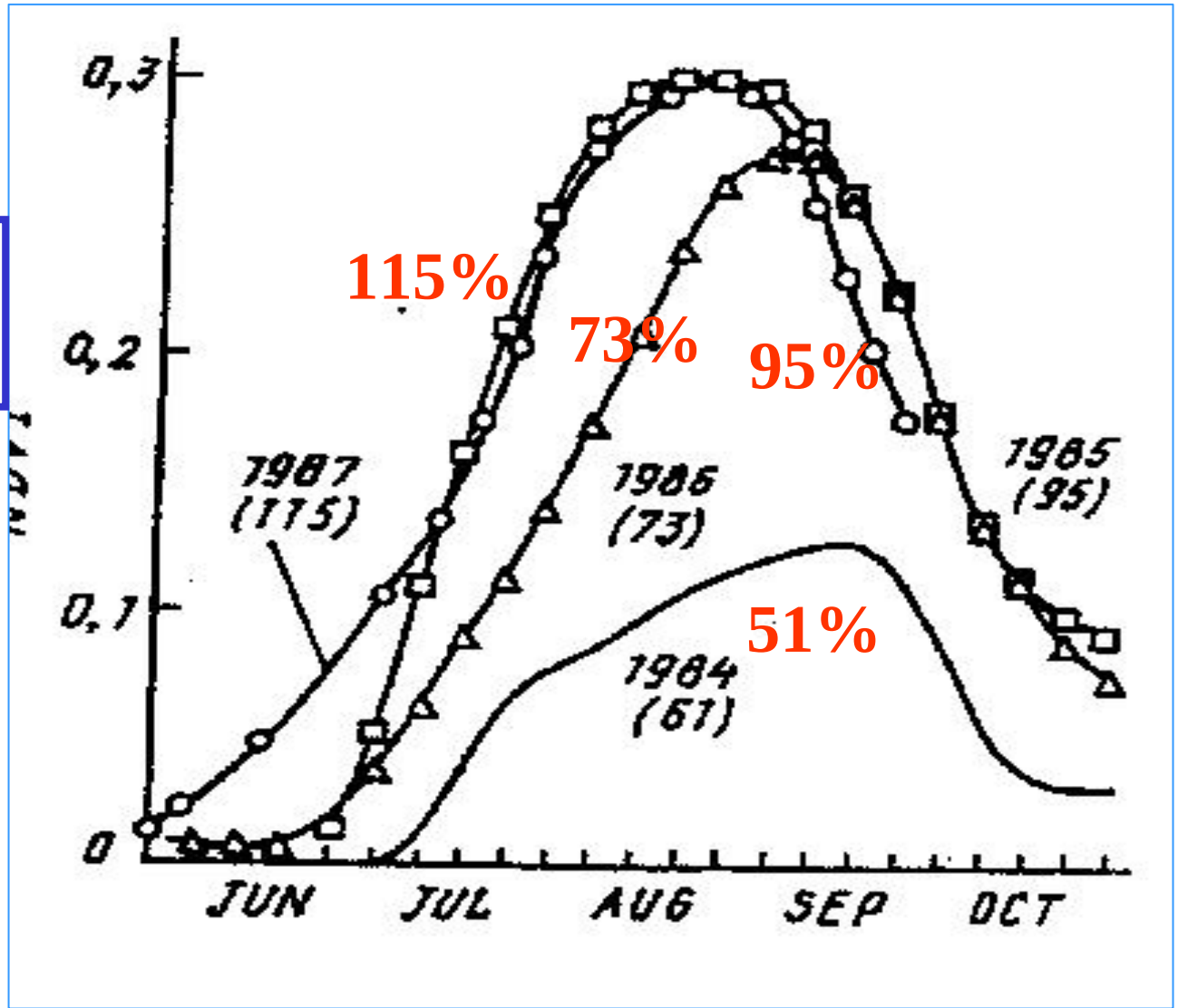
NDVImax in July

NDVI shows
VEGETATION DISTRIBUTION

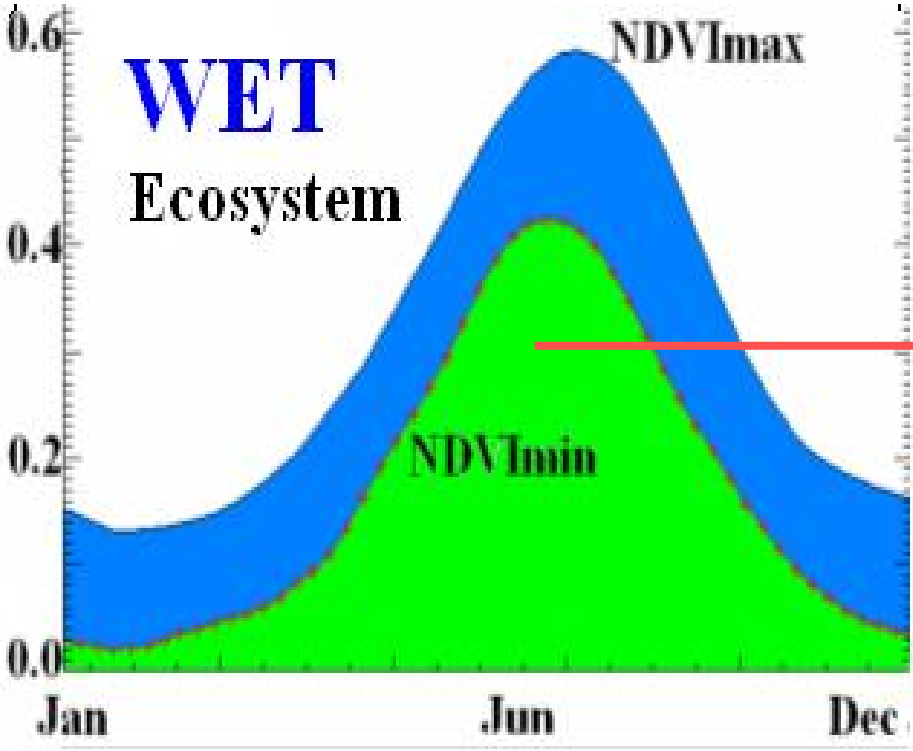


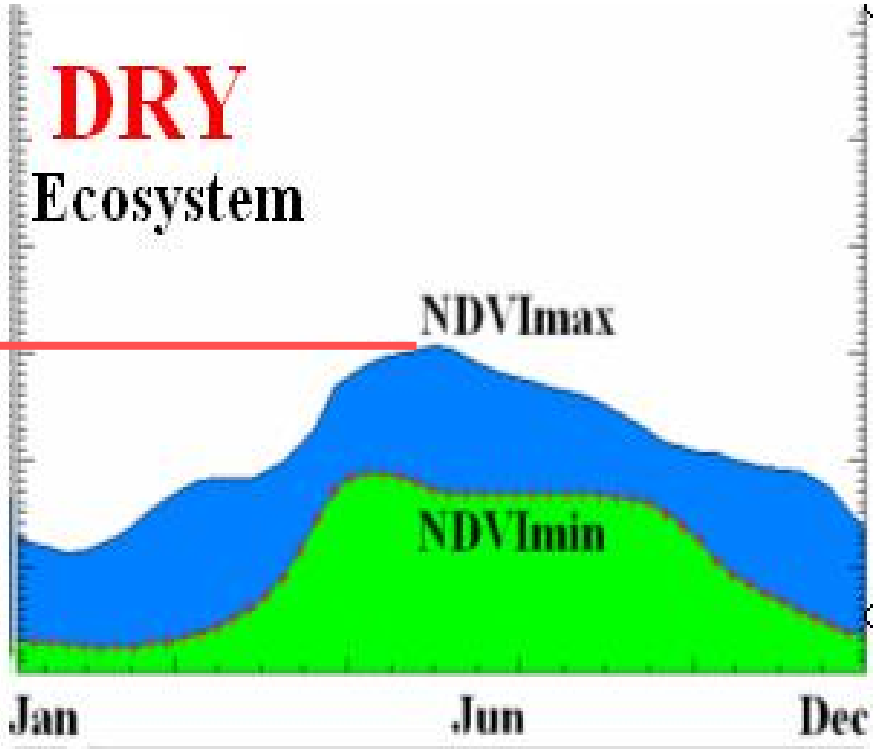
NDVI & Rainfall (% of mean), SUDAN

NDVI sensitive to RAINFALL



NDVI in Wet & Dry Ecosystems, CENTRAL USA

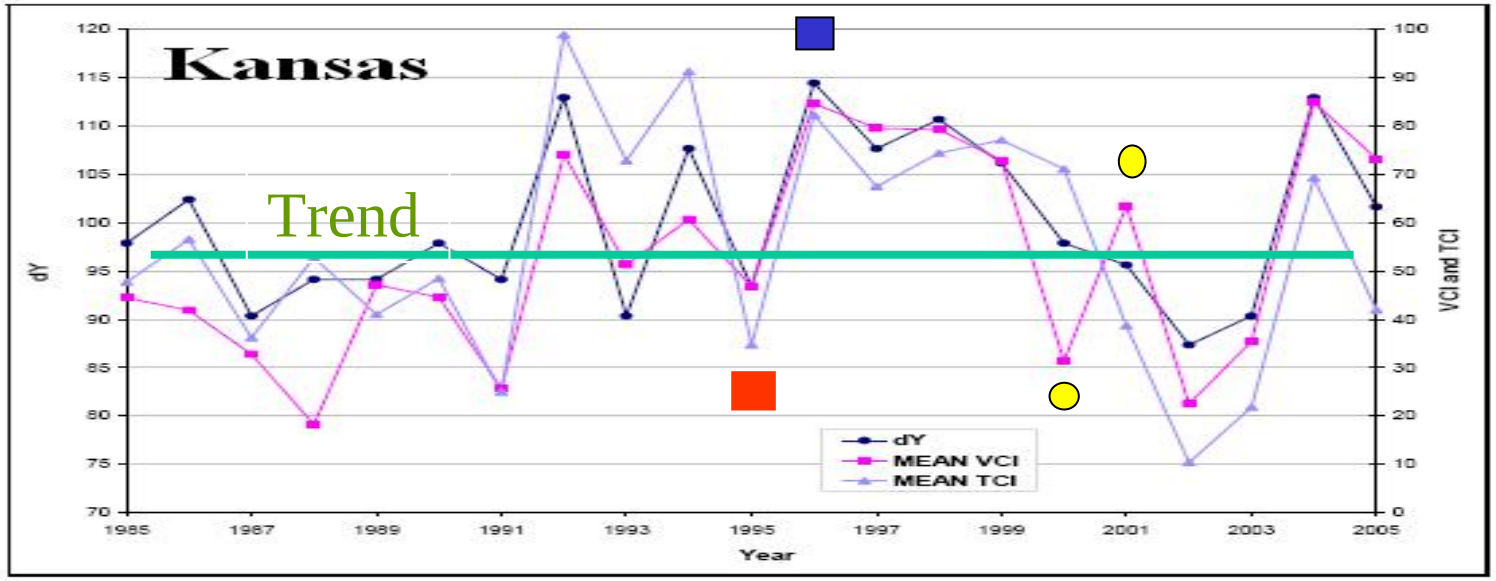


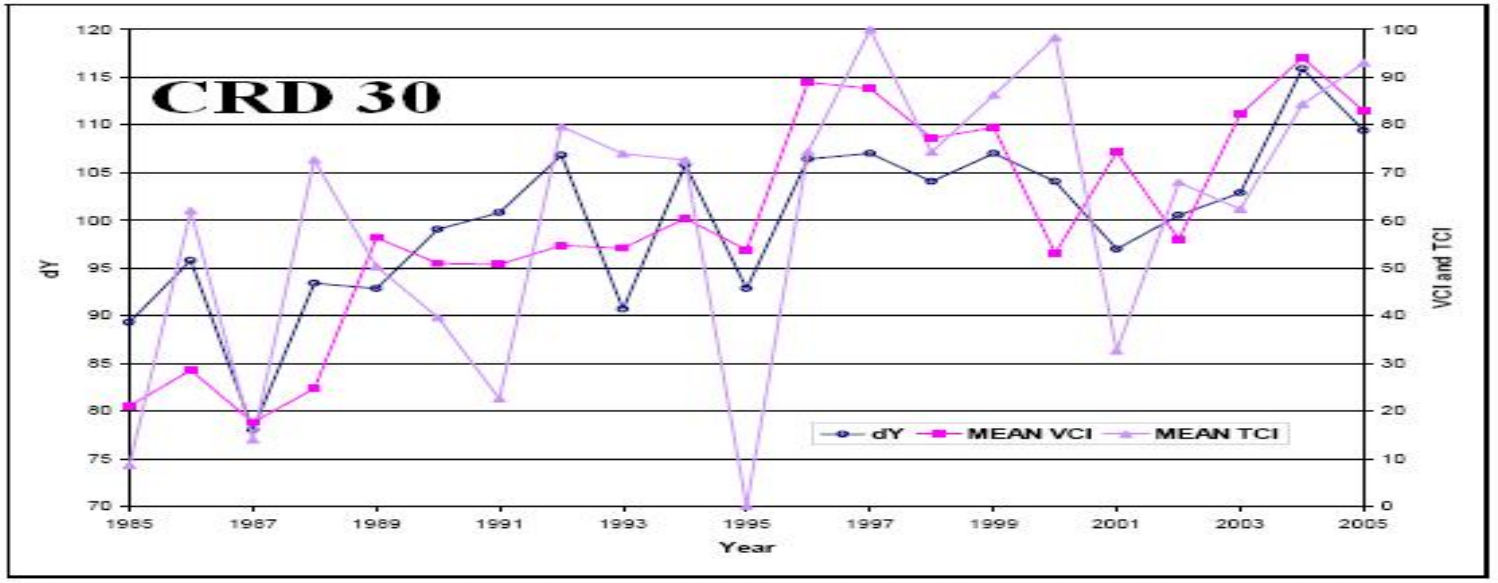


* **NDVImax** indicates **HEALTHY** vegetation

* The same NDVI indicates **HEALTHY** vegetation in **DRY** and **UNHEALTHY** in **WET** ecosystems

dY, VCI & TCI: 1985-2005





Dynamics of dY, VCI, TCI, 1985-2006

AVHRR-based VH Indices

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;

MOISTURE

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

THERMAL

Vegetation Health Index (VHI), values 0 – 100

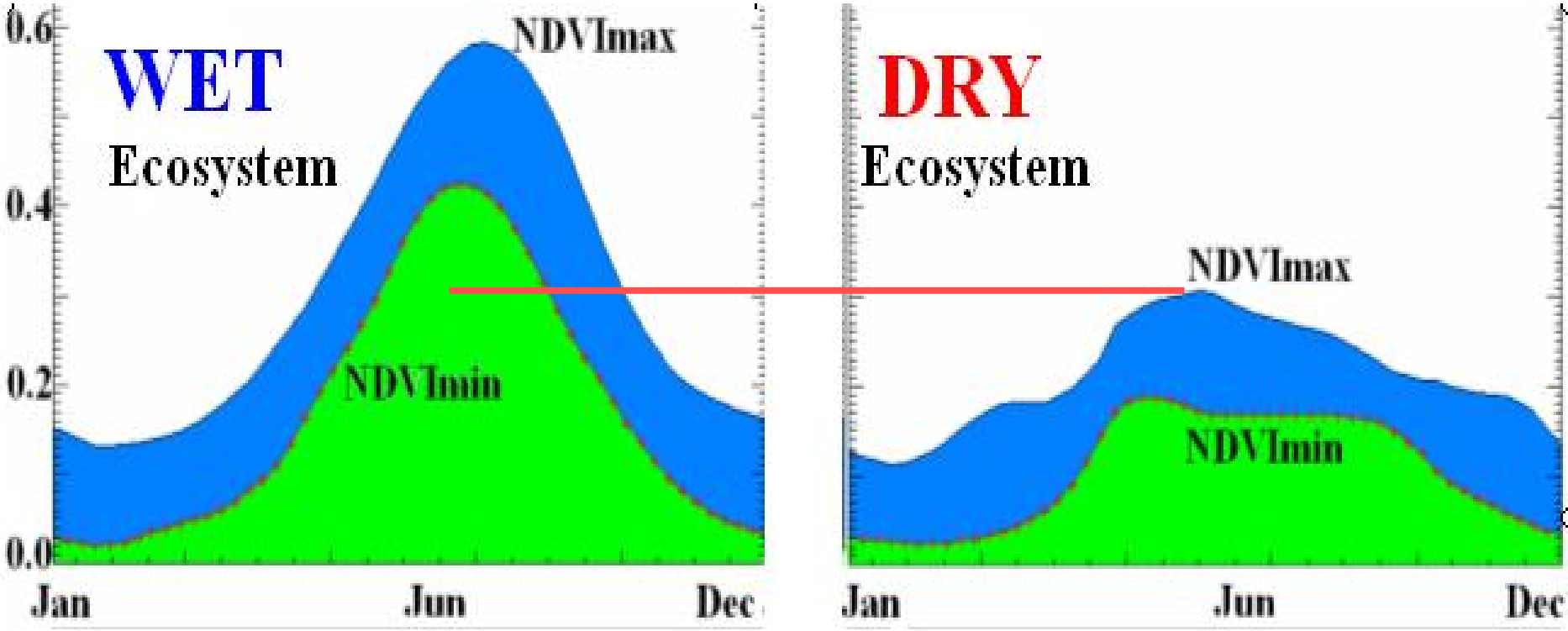
VHI=a*VCI+(1-a)*TCI

VEG. HEALTH

0 – indicates extreme stress

100 – indicates favorable conditions

NDVI in Wet & Dry Ecosystems, CENTRAL USA



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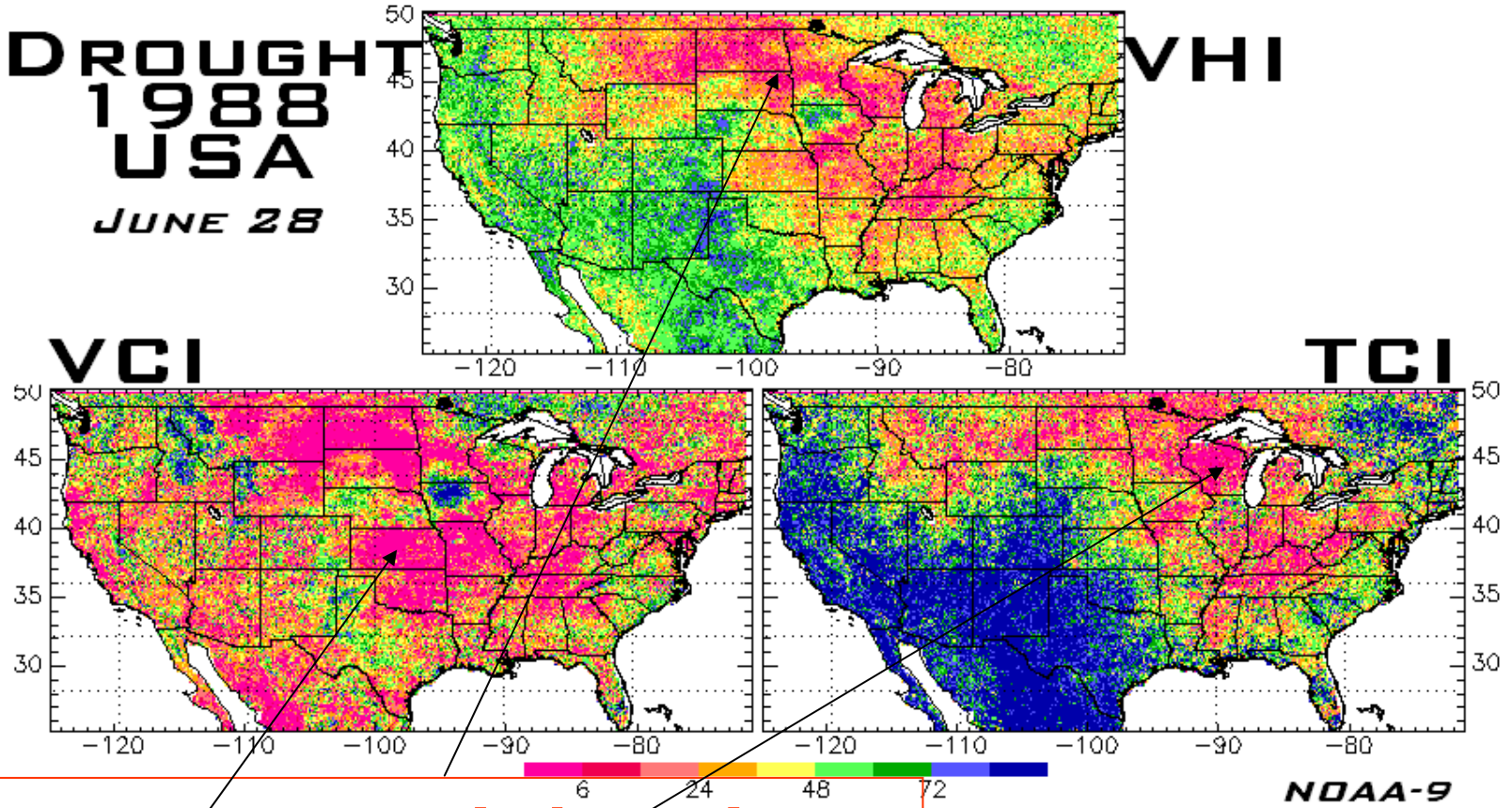
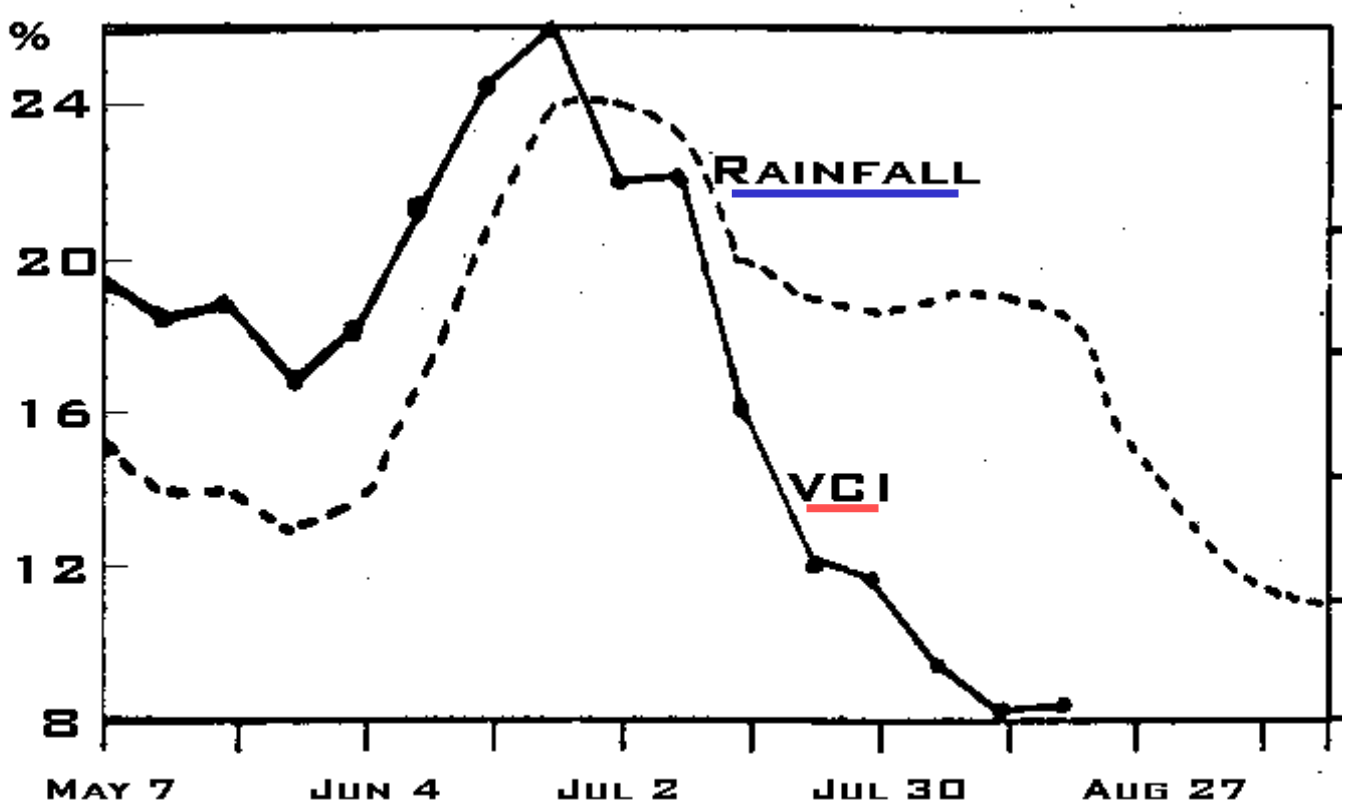
Drought 1988



Severe Moisture and Thermal Vegetation Stress

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

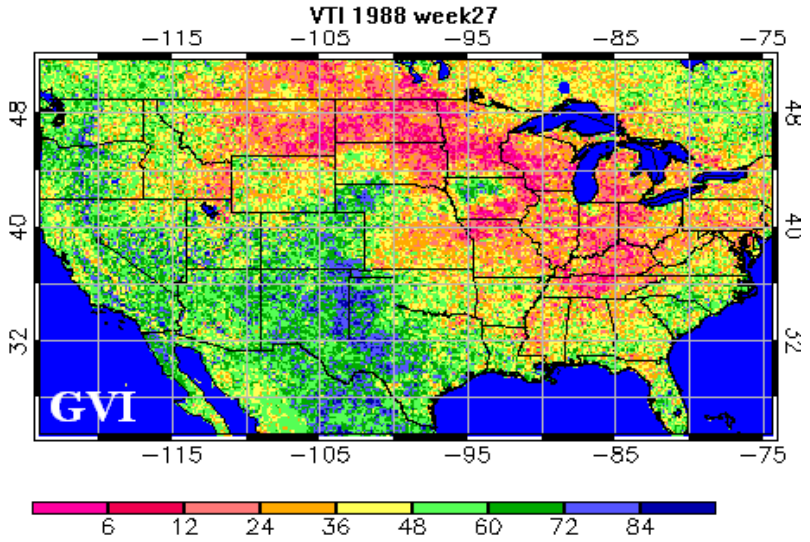


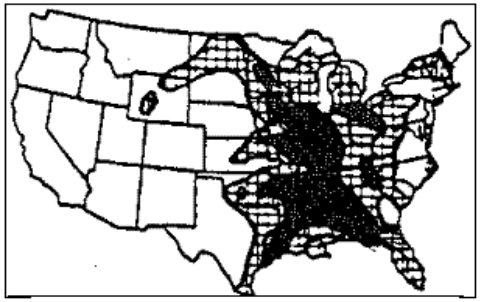
Percent of United States with less than 50% of normal rainfall and VCI below 10%

Applications: Drought

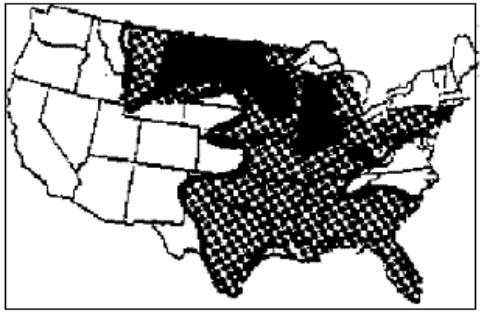
VH & In Situ Data

USA,1988, Week 27





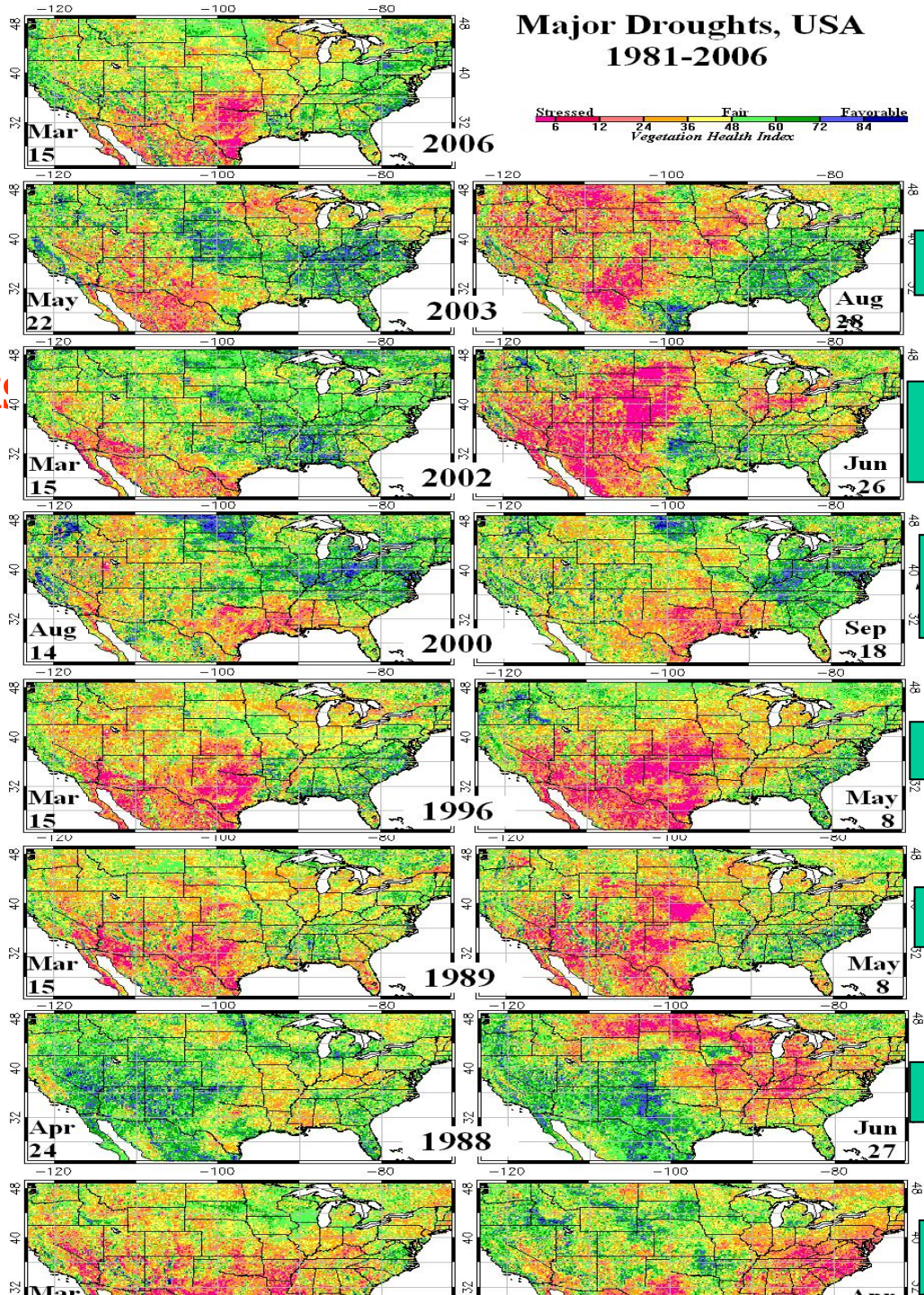
Precipitation Anomaly 3-6 in April-June, 1988



1988 Corn Yield Anomaly (15-30%)

Drought 1988, USA

Major US Droughts



Summer

Spr/Sum

Sum/Fall

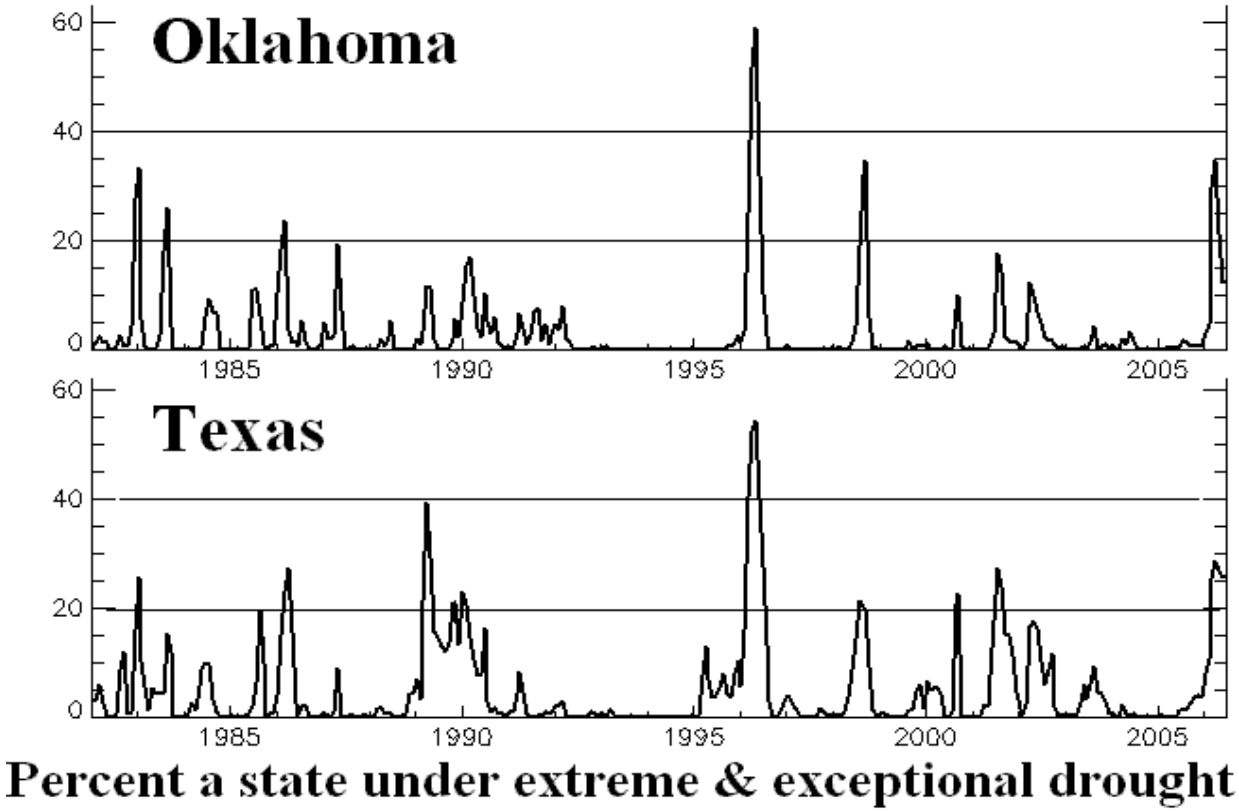
Spring

Spring

Summer

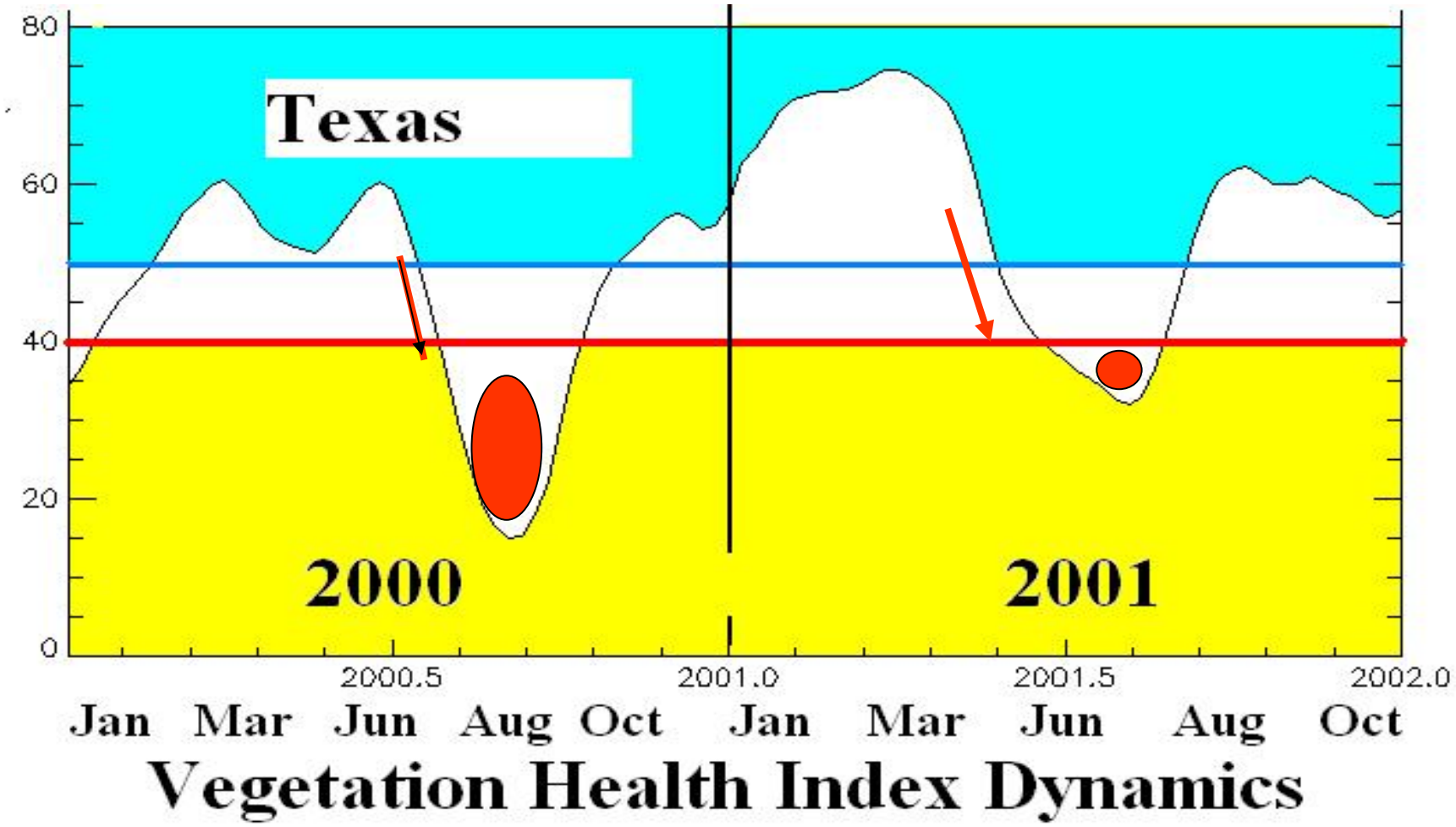
Spring

Percent of a state with extreme & exceptional drought

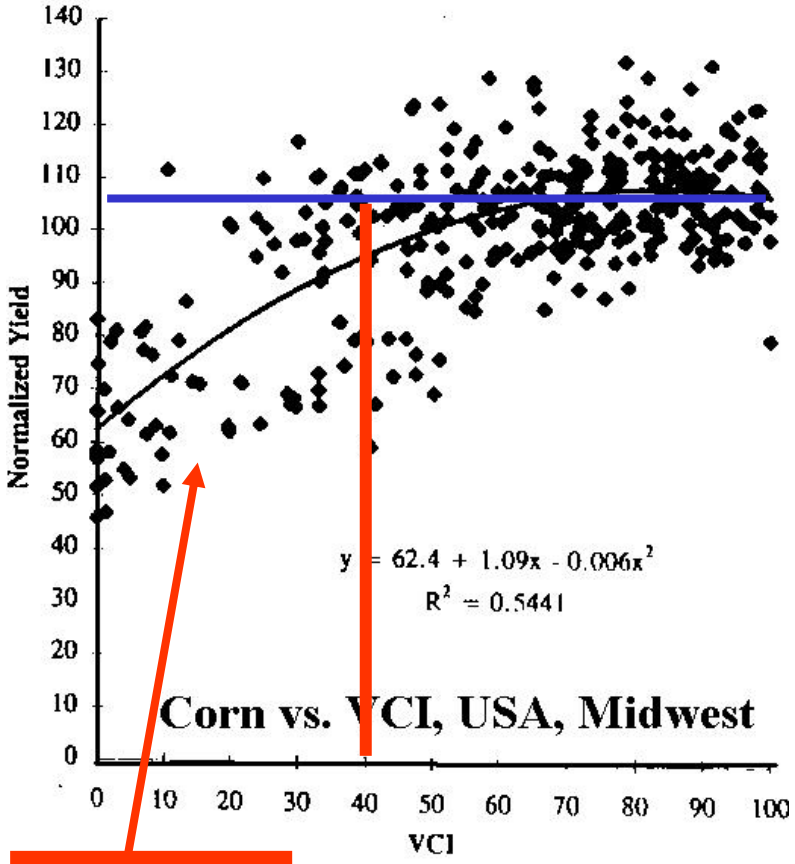


Percent a state under extreme & exceptional drought

Vegetation Health Dynamics



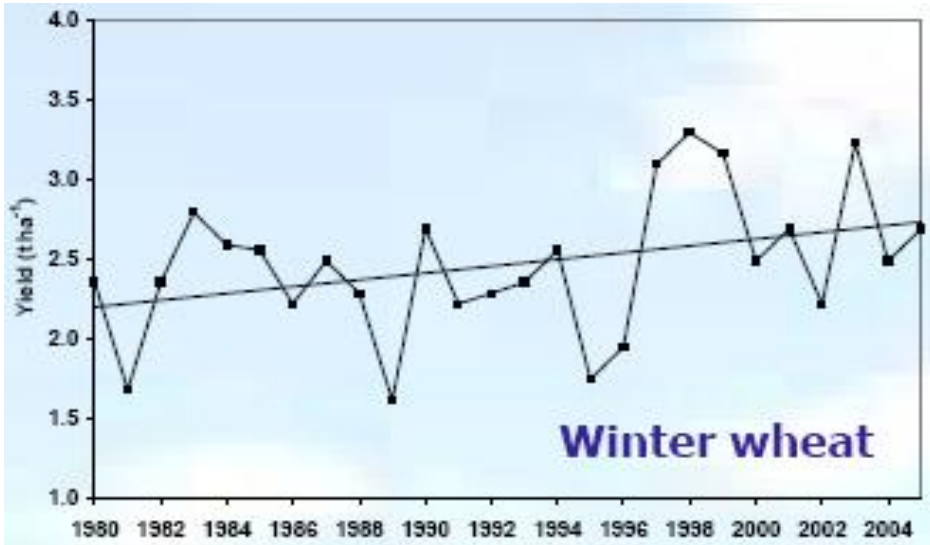
Corn Yield vs CRD's VCI Midwest, USA

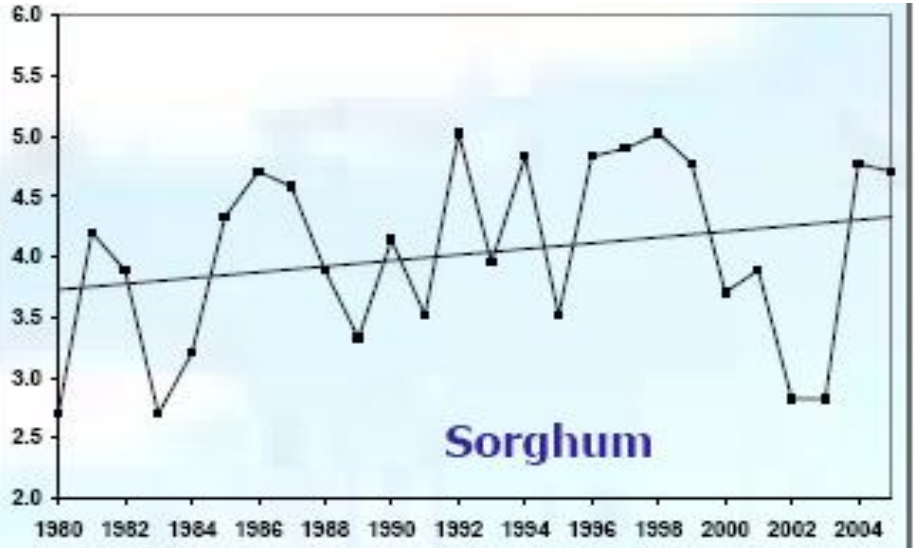


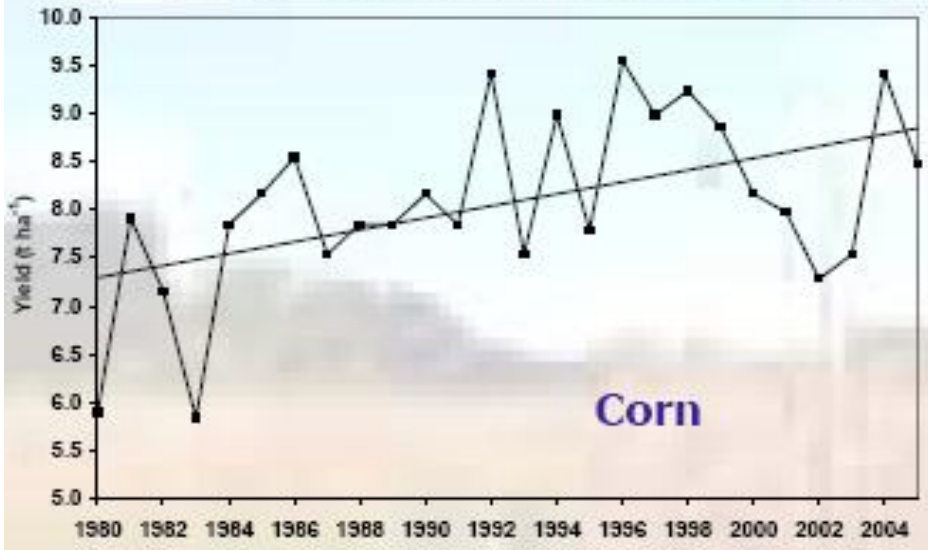
Yield Reduction

Corn Yield - normalized for Midwestern CRD

Yield & Trend
Kansas 1980-2005







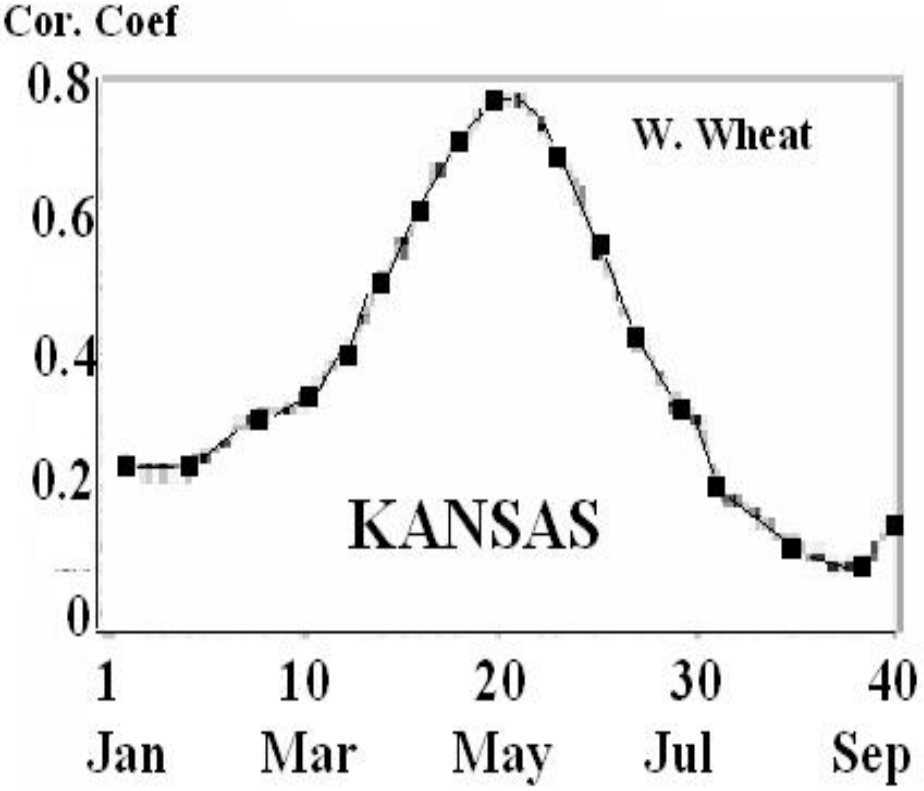
- Yield time series were approximated by

$$Y_t = T_t + dY_t$$

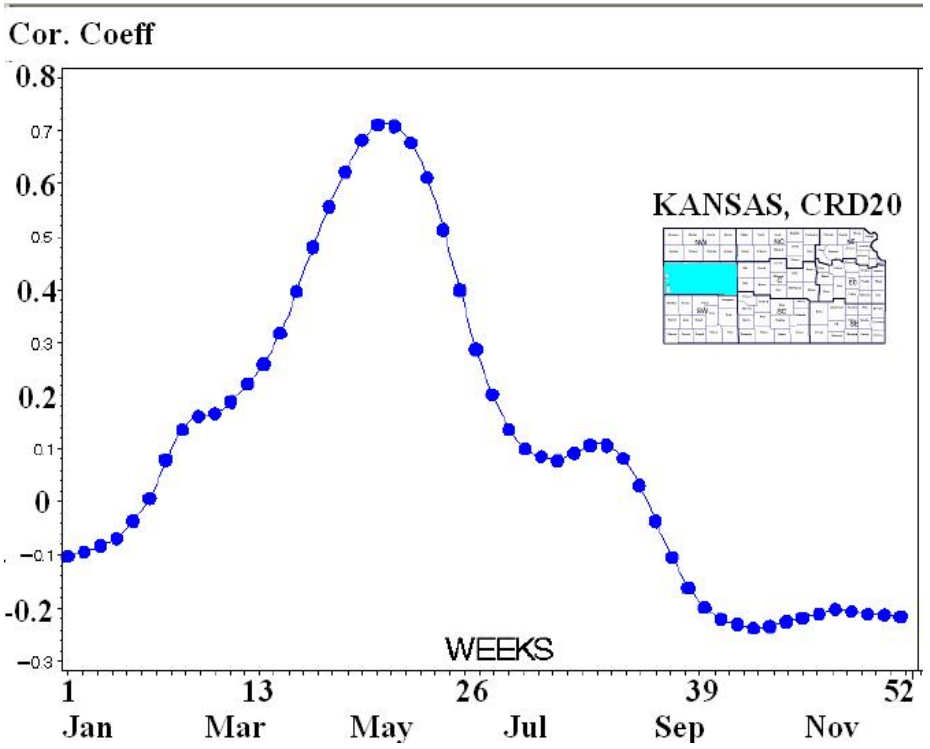
  - Trend - $T = a_0 + a_1 t$
  - Yield anomaly - $dY = Y - T$

Corn dY vs VHI Correlation
KANSAS & CRD20

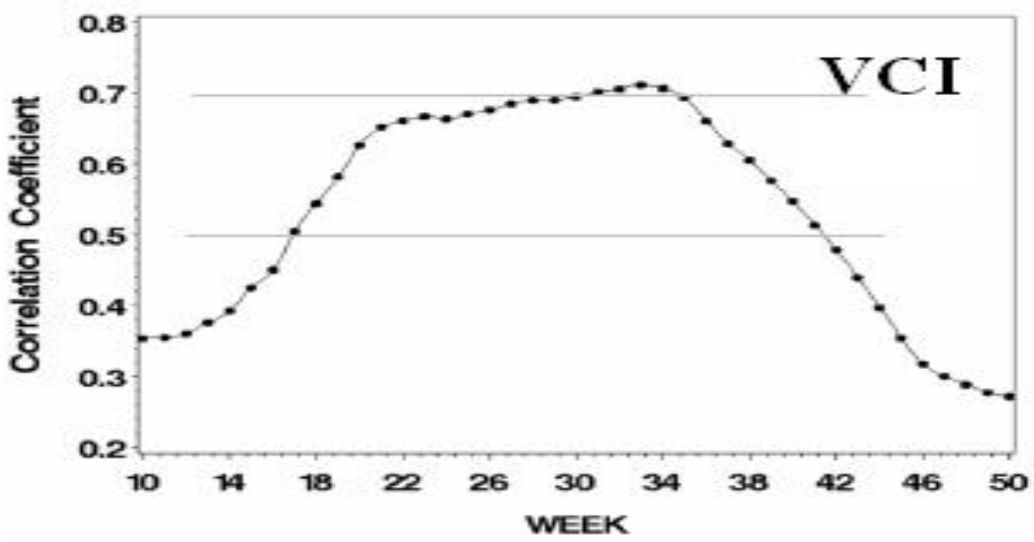
KANSAS State

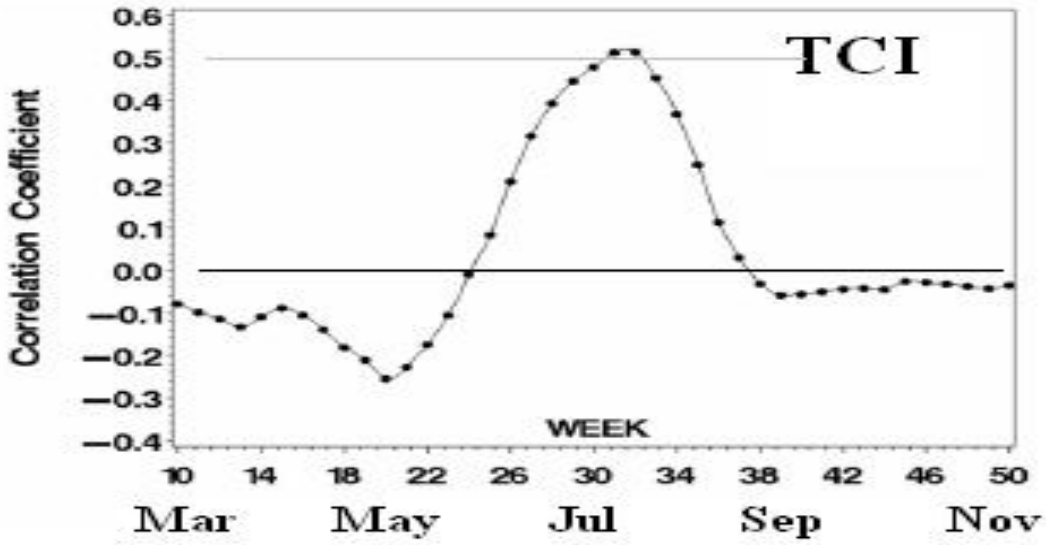


CRD20



dY vs VCI & TCI Correlation
Haskell CO, KANSAS, Corn

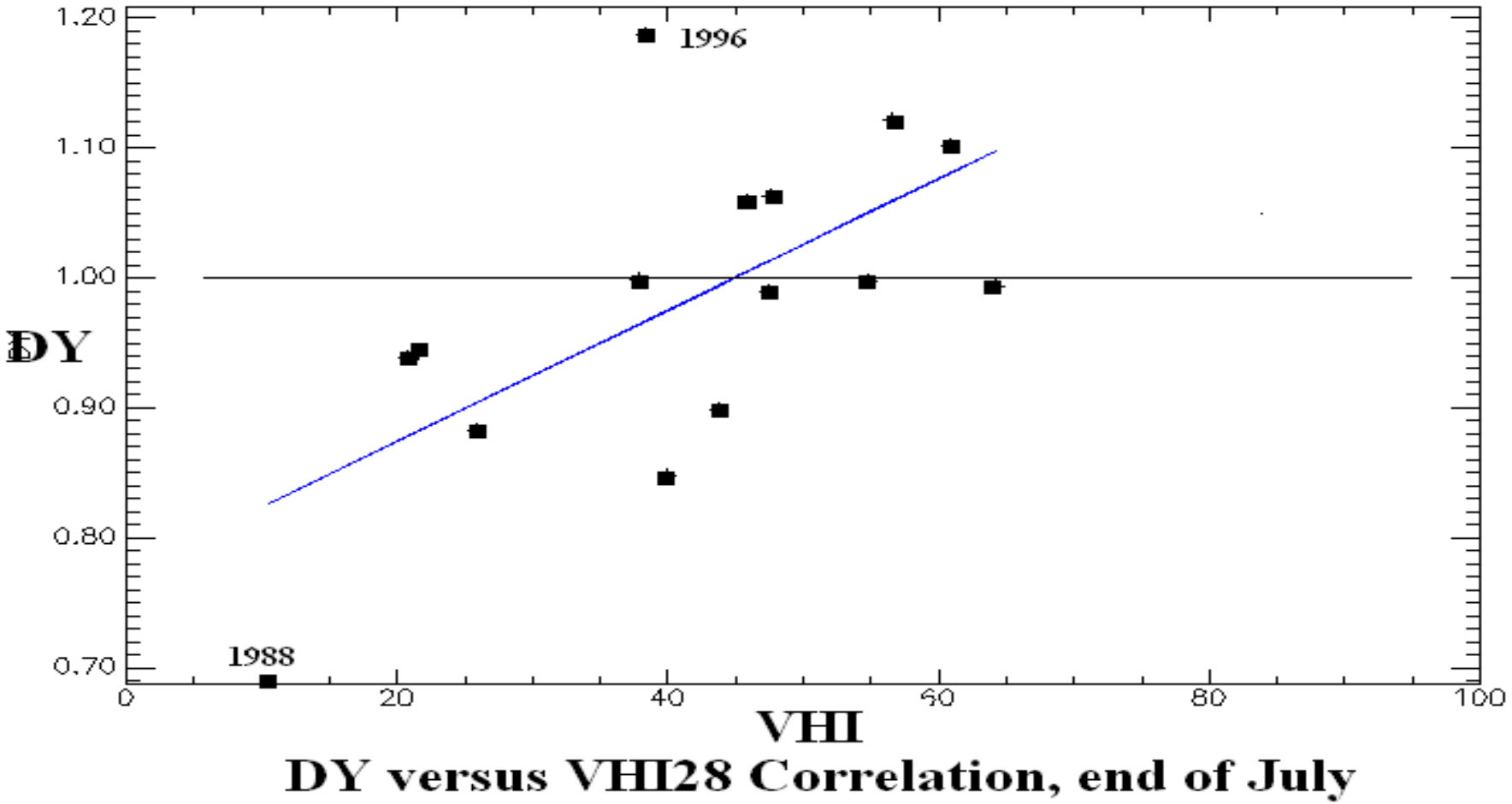




Haskell CO, KANSAS Corn

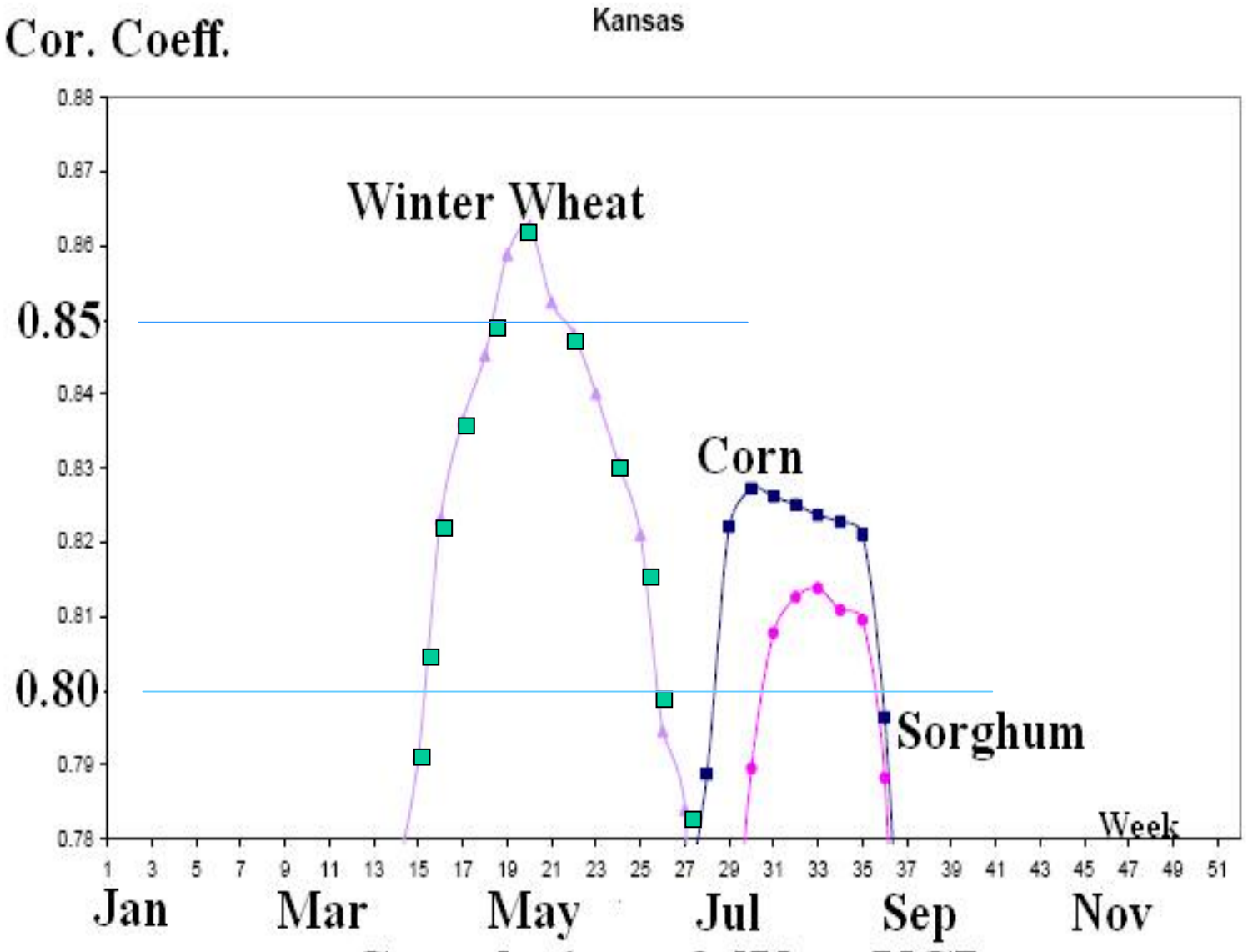
Corn dY vs VHI28

Illinois, Ohio, Mr. Fordham farm (41.55N, 89.47W)



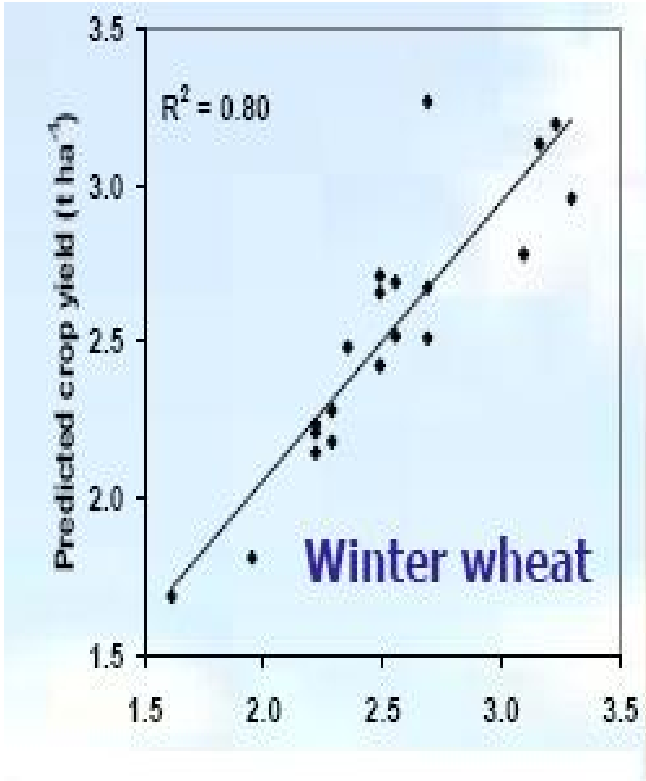
DY versus VHI28 Correlation, end of July

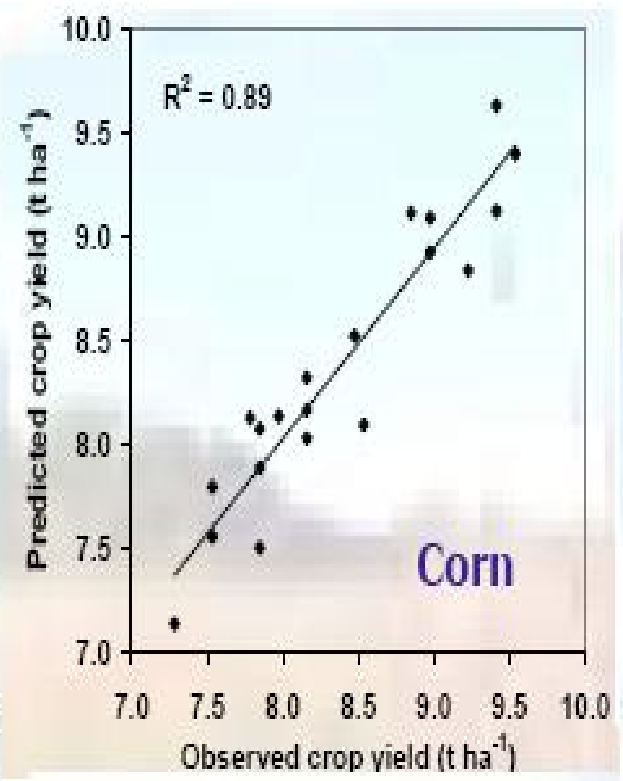
dY vs VCI Correlation, KANSAS

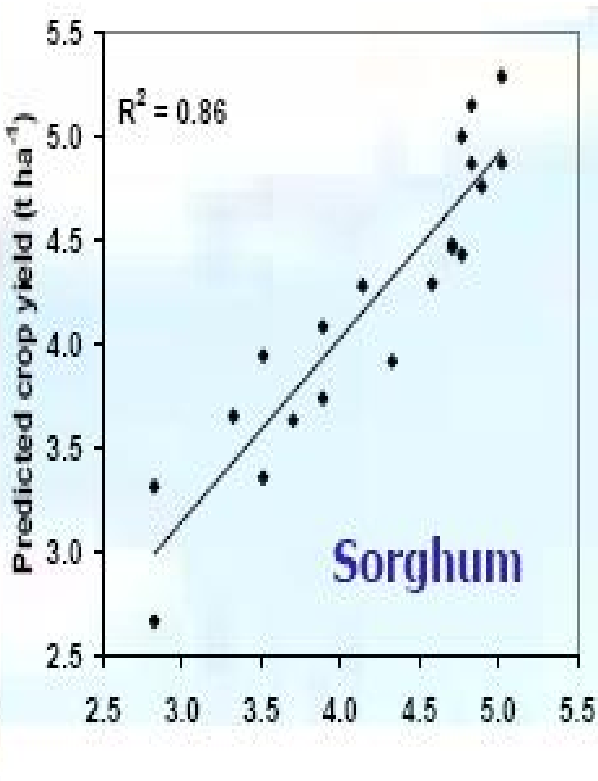


Independent Model Validation

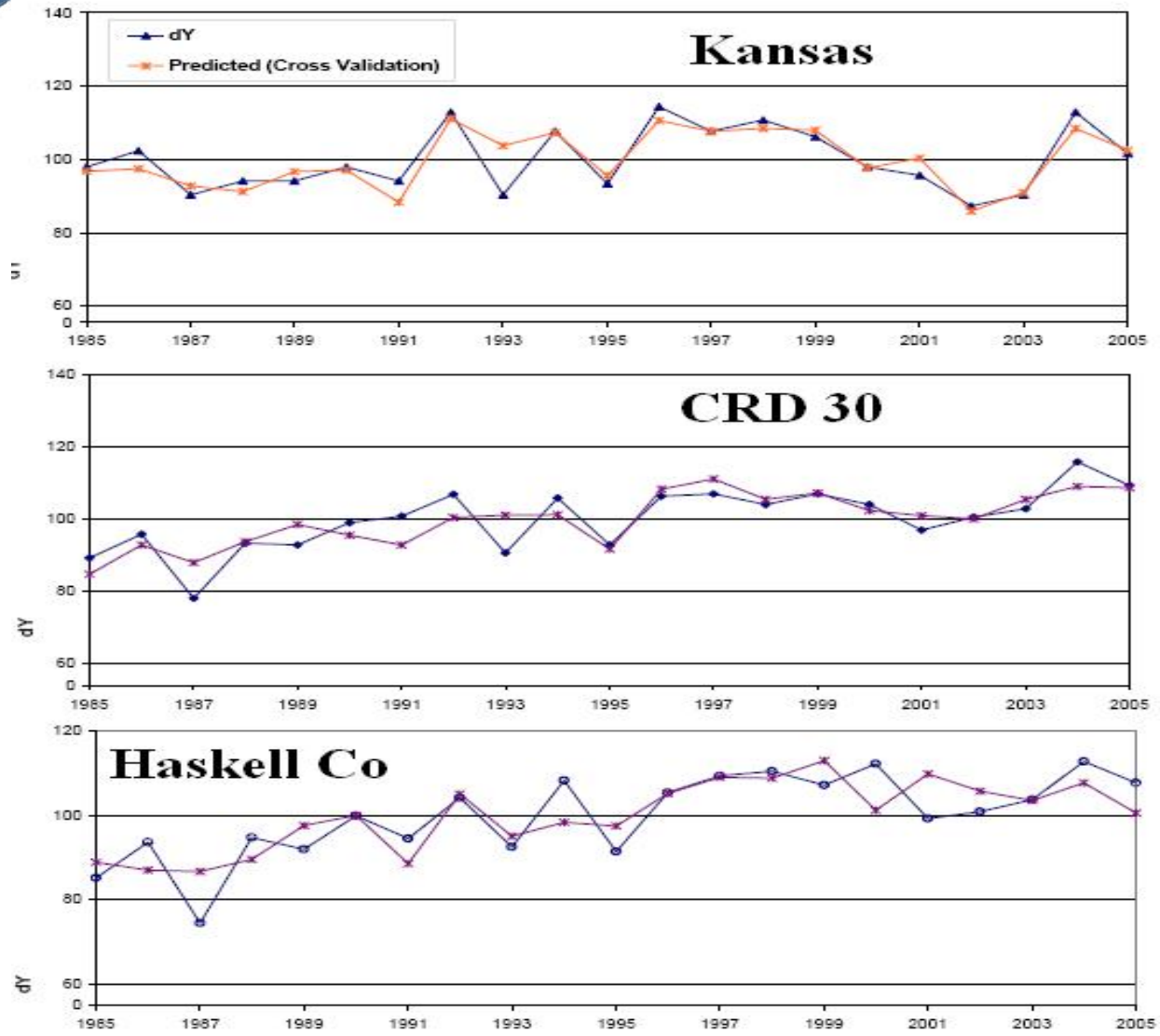
KANSAS







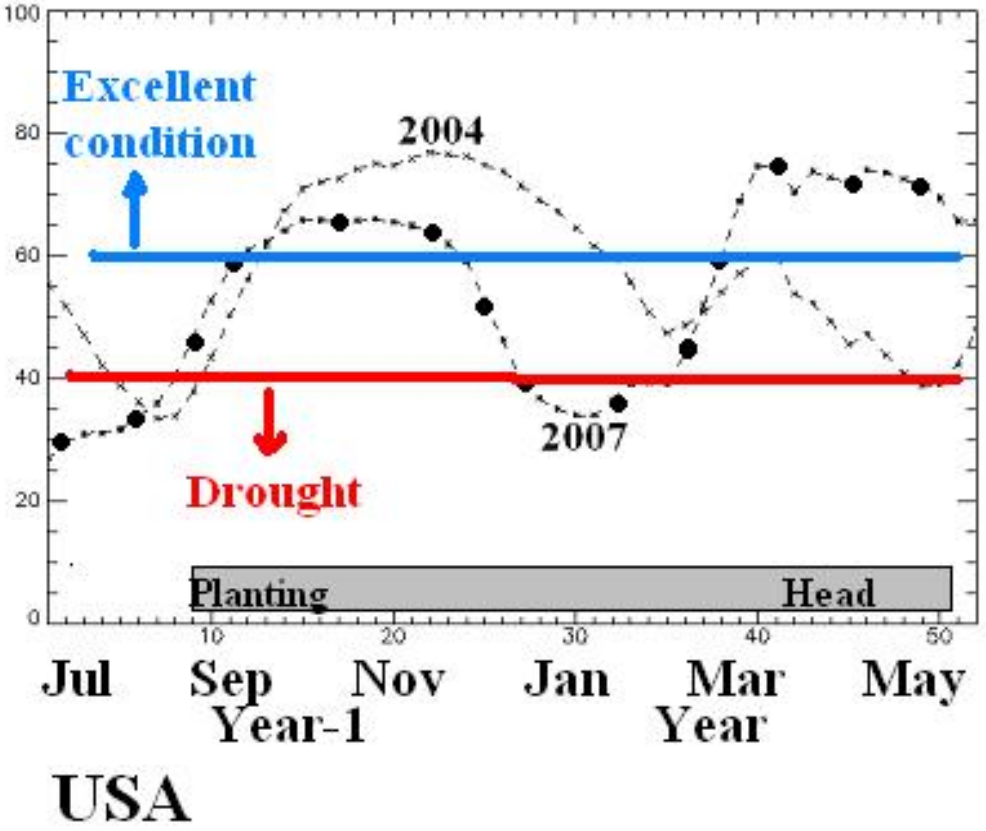
Winter Wheat Cross Validation



Independent model verification, Kansas 1985-2005

2007 Wheat Yield

USA



USA

WINTER WHEAT Moisture condition (VCI)

Summary: BUMPER CROP

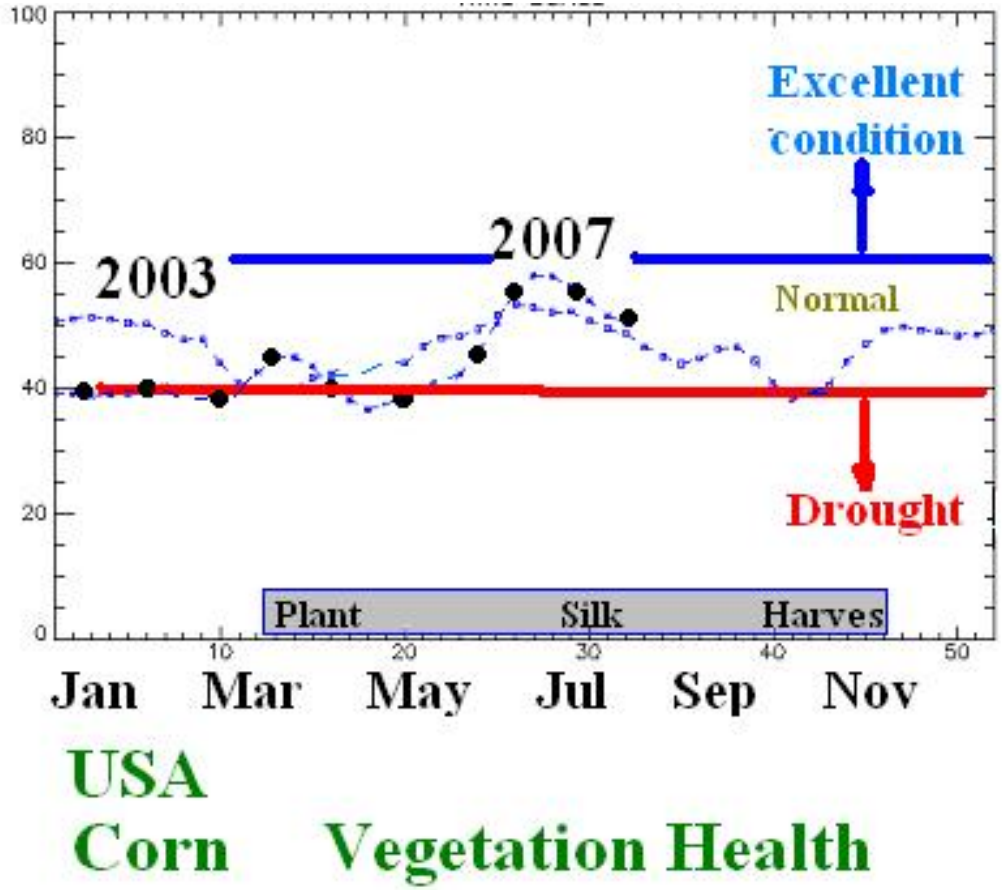
- Winter wheat (WW) provides 75% & spring wheat (SW) - 25% of USA wheat
- Figure shows dynamics of moisture condition (MC)
- Analogue of 2007 WW was 2004 moisture condition (MC)
- Before and during HEADING, (critical period) MC were excellent, especially in 2007

WW yield – 10% above the long-term trend (LTT)

SW yield - at the LTT

Total W – 5-7% above LTT (2.92 t/ha) or 3.1 t/ha

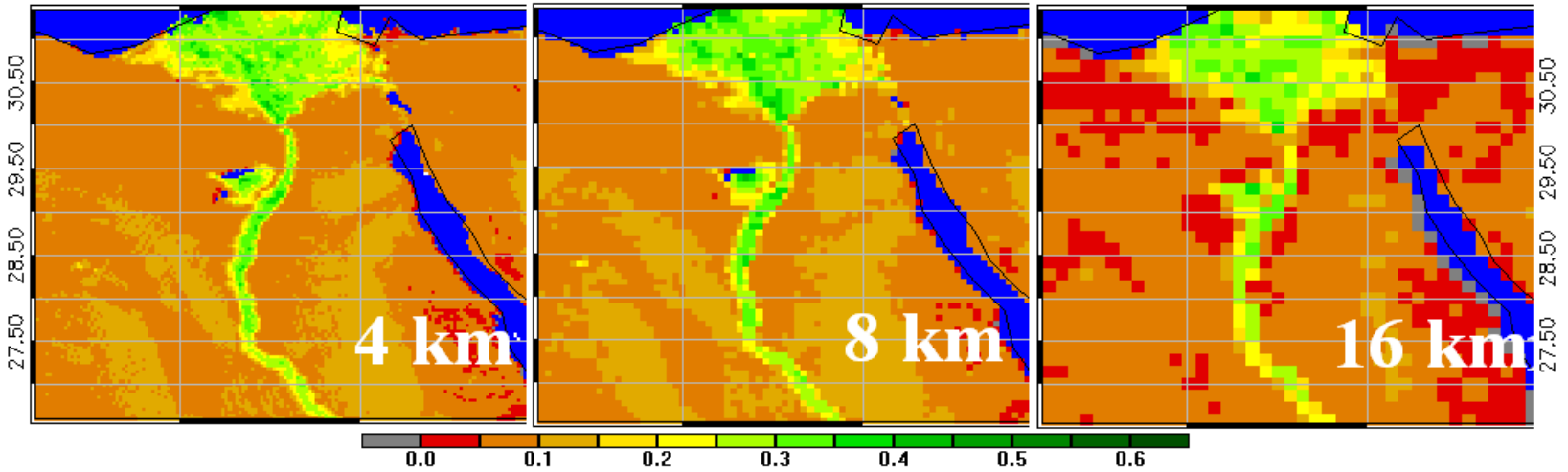
Corn USA



- Major states producing corn: Illinois, Indiana, Iowa, Ohio, Nebraska, Minnesota
- Figure shows dynamics of Vegetation health (VH): moisture and thermal conditions
- Analogue of 2007 for US corn was 2003 VH
- During silk (critical period) VH was inside normal range limit

USA CORN YIELD is expected 1-3% above long-term trend (LTT=9.1 t/ha) or **9.2-9.4 t/ha**

NDVI from
GVI-x Data Set & Products



NDVI, May 2005

References

- **Salazar, L., F. Kogan and L. Roytman, 2007.** Use of remote sensing data for estimation of winter wheat yield in the United States. ***Int. J. Rem. Sens.*, (Vol 25, No 1, 227-236)**
- **F. Kogan, 2002**: World Droughts in the New Millennium from AVHRR-based Vegetation Health Indices. ***Eos, Trans. of Amer. Geophys. Union*, 83, No 48, 26 November, 557-564**.
- **Kogan, F.N., 1997**: Global Drought Watch from Space. ***Bull. Amer. Meteor. Soc*. 78, 621-636.**

- **WEB: http://www.orbit.nesdis.noaa.gov/smcd/emb/vci/VH/index.html**

GVI-x Product

Table 2. GVI-x Product Description

Item	Description
Products	NDVI, BT, SMN, SMT, VCI, TCI, VHI, NDmax, NDmin, BTmax, BTmin
Availability	Operational, in 2008 on Tuesday
Coverage	From 75º N to 55º S
Resolution	Temporal – weekly; Spatial – 4 km²
Period	1981-present
Gaps	Sep 1994-Feb 1995
File format	HDF, 16-bit integer, scaled (see documentation)
Data problems to address	Correction for Mt. Pinatubo aerosols; Orbit degradation in 1993, 1994 and 2000

NDVI, SMN, NDmax, NDmin - Normalized difference vegetation index: raw, smoothed, multi-year maximum and minimum data, respectively; BT, SMT, BTmax, BTmin – Brightness temperature: raw, smoothed, multi-year maximum and minimum data, respectively; VCI,TCI,VHI – indices: Vegetation condition, Temperature condition and Vegetation health