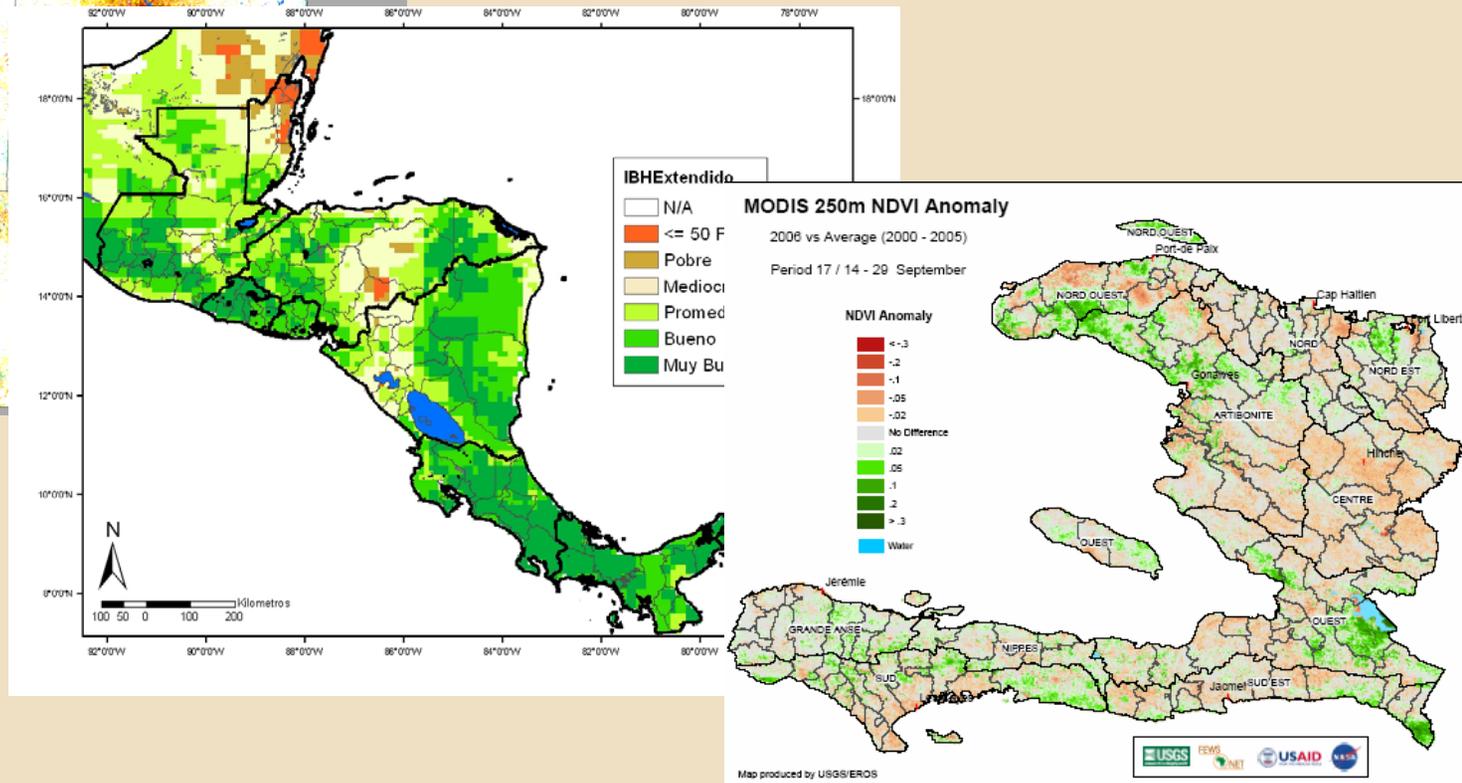


Application of Remote Sensing to Drought Monitoring



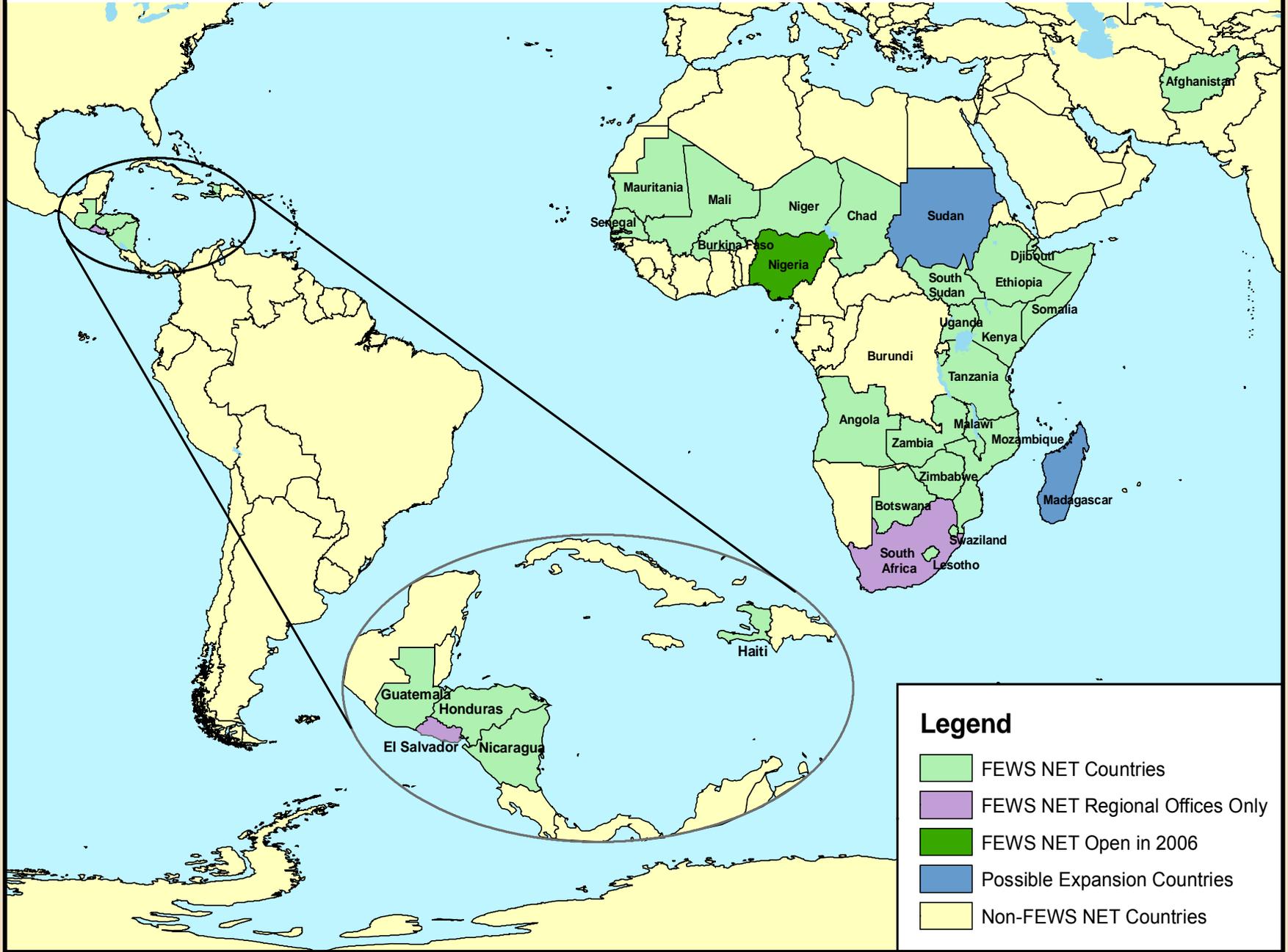
J. Verdin, L. Aguilar, J. Brown, D. Pedreros, M. Budde, and J. Rowland

Drought Monitoring Projects at USGS/EROS

- **USAID - Mesoamerican Food security Early Warning System (MFEWS)**
 - *with NOAA/CPC, NASA/GSFC, USDA/PECAD, INSIVUMEH (Guatemala)*
- **USGS – Phenology and Drought Monitoring**
 - *with NDMC, USDA, NOAA*
- **NASA - Drought Early Warning Using Hydrologic and Ecologic Observations from NASA Satellite Data**
 - *with NASA/JPL, NDMC, NOAA/CDC*



FEWS NET Coverage



Legend

-  FEWS NET Countries
-  FEWS NET Regional Offices Only
-  FEWS NET Open in 2006
-  Possible Expansion Countries
-  Non-FEWS NET Countries

Famine Early Warning Systems Network

MFEWS seeks answers to key questions:

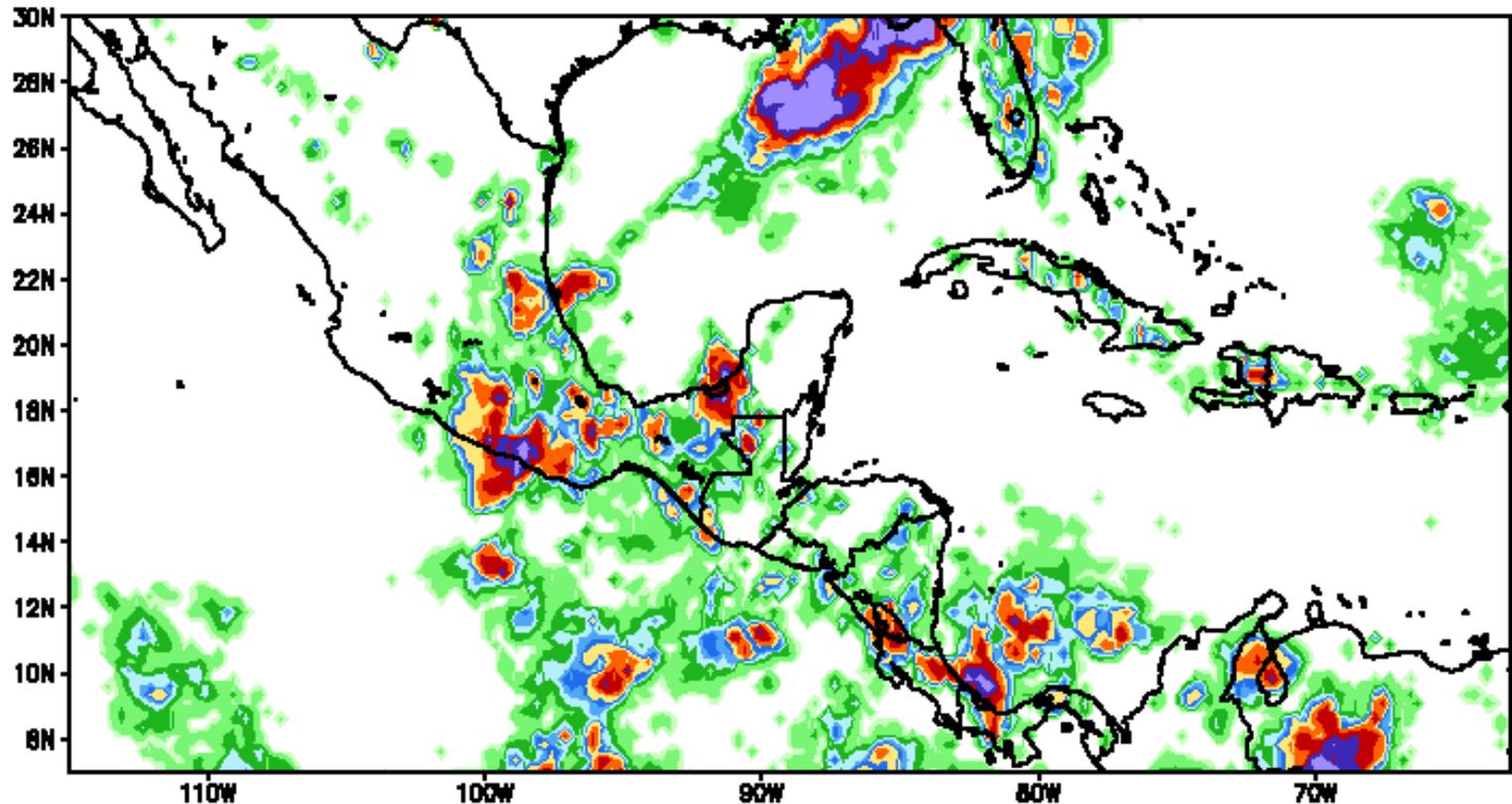
“Which population groups are facing food insecurity, and for how long?”

“What are the best ways to mitigate adverse trends or shocks to livelihood systems?”



NASA TRMM Multi-Satellite Estimates

TRMM June 07 2003

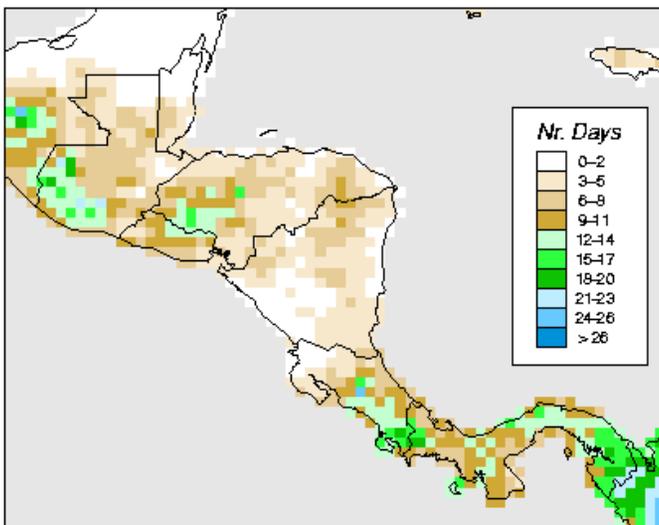


The raw TRMM data is courtesy of the NASA GSFC (<http://trmm.gsfc.nasa.gov/>)

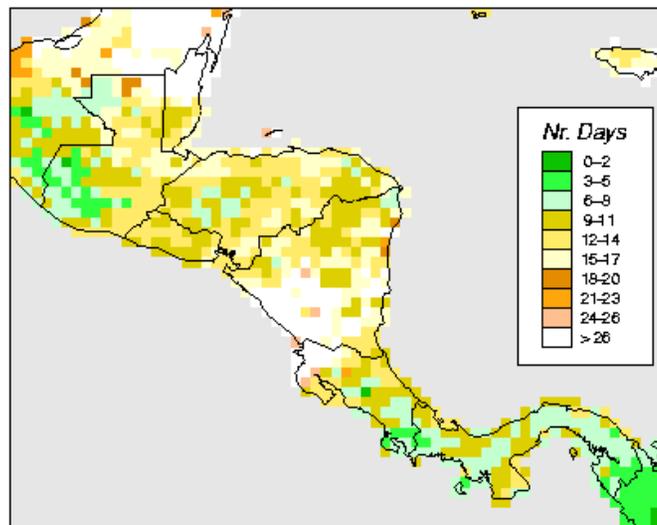


*North American Drought Monitor Workshop
Mexico City – October 18-19, 2006*

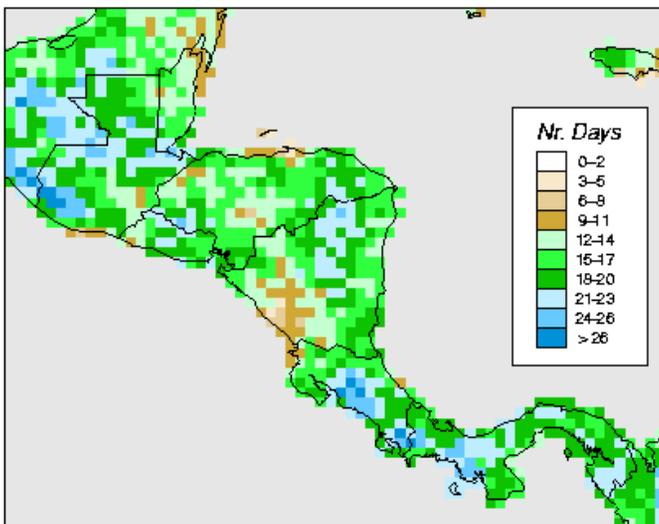
Number of Rain Days
in past 30 days, as of 10 May 2006



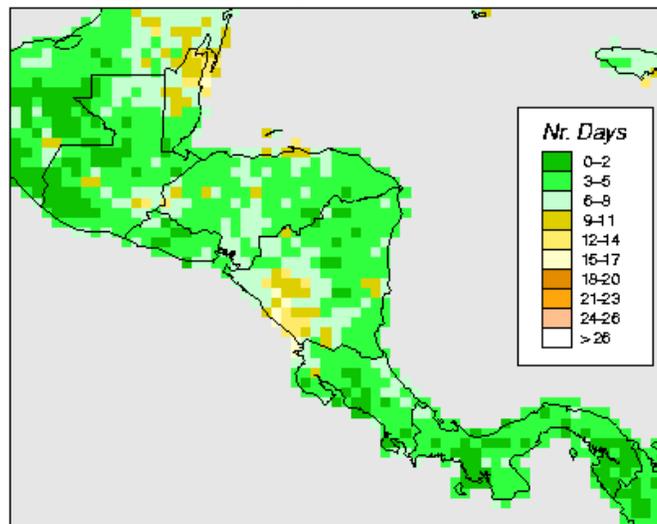
Maximum Consecutive Dry Days
in past 30 days, as of 10 May 2006



Number of Rain Days
in past 30 days, as of 15 Oct. 2006



Maximum Consecutive Dry Days
in past 30 days, as of 15 Oct. 2006



Tracking the Onset of Rains

Onset of Rains
(2006-09-3)

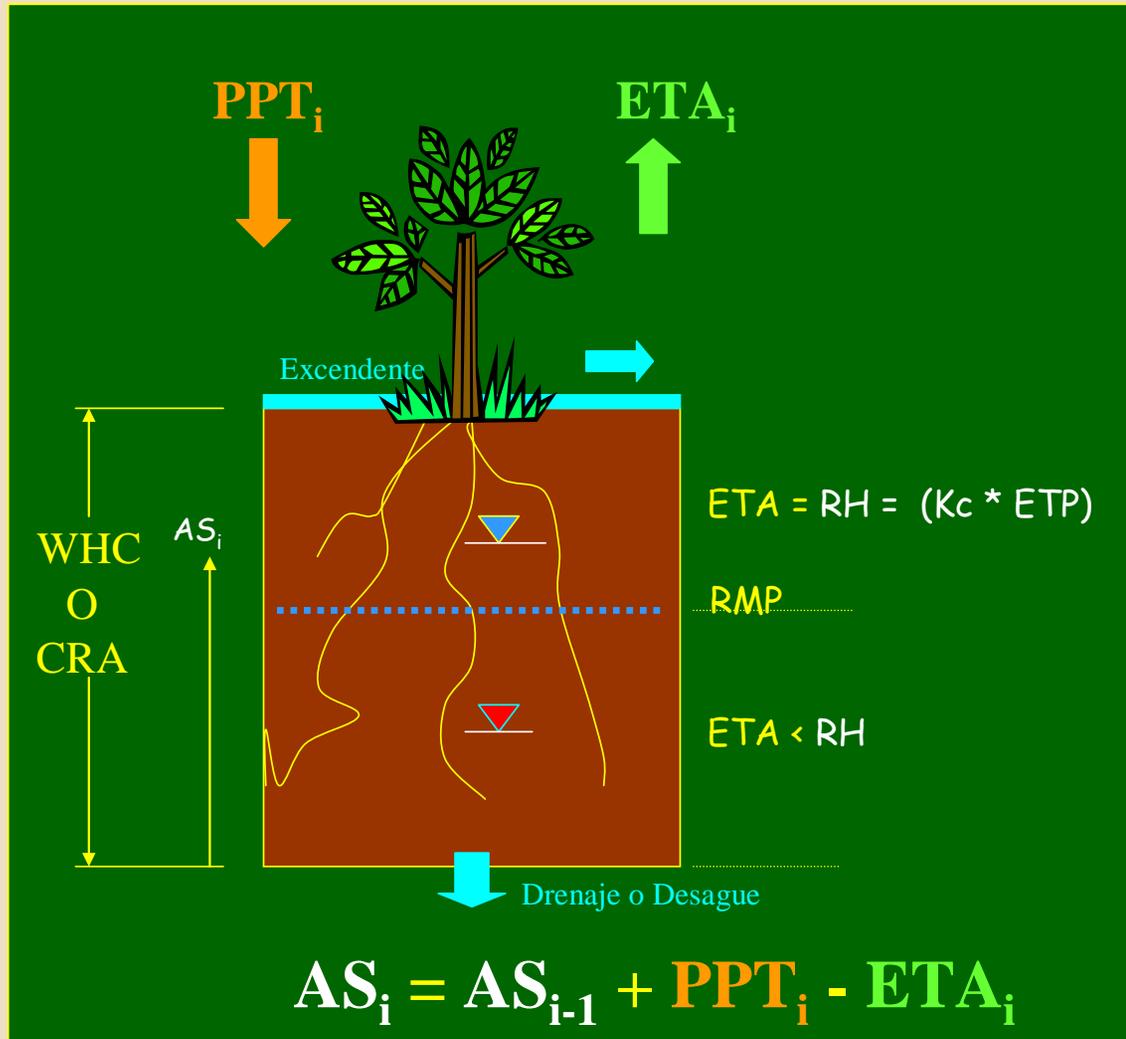


SOS Anomaly
(2006-09-3)

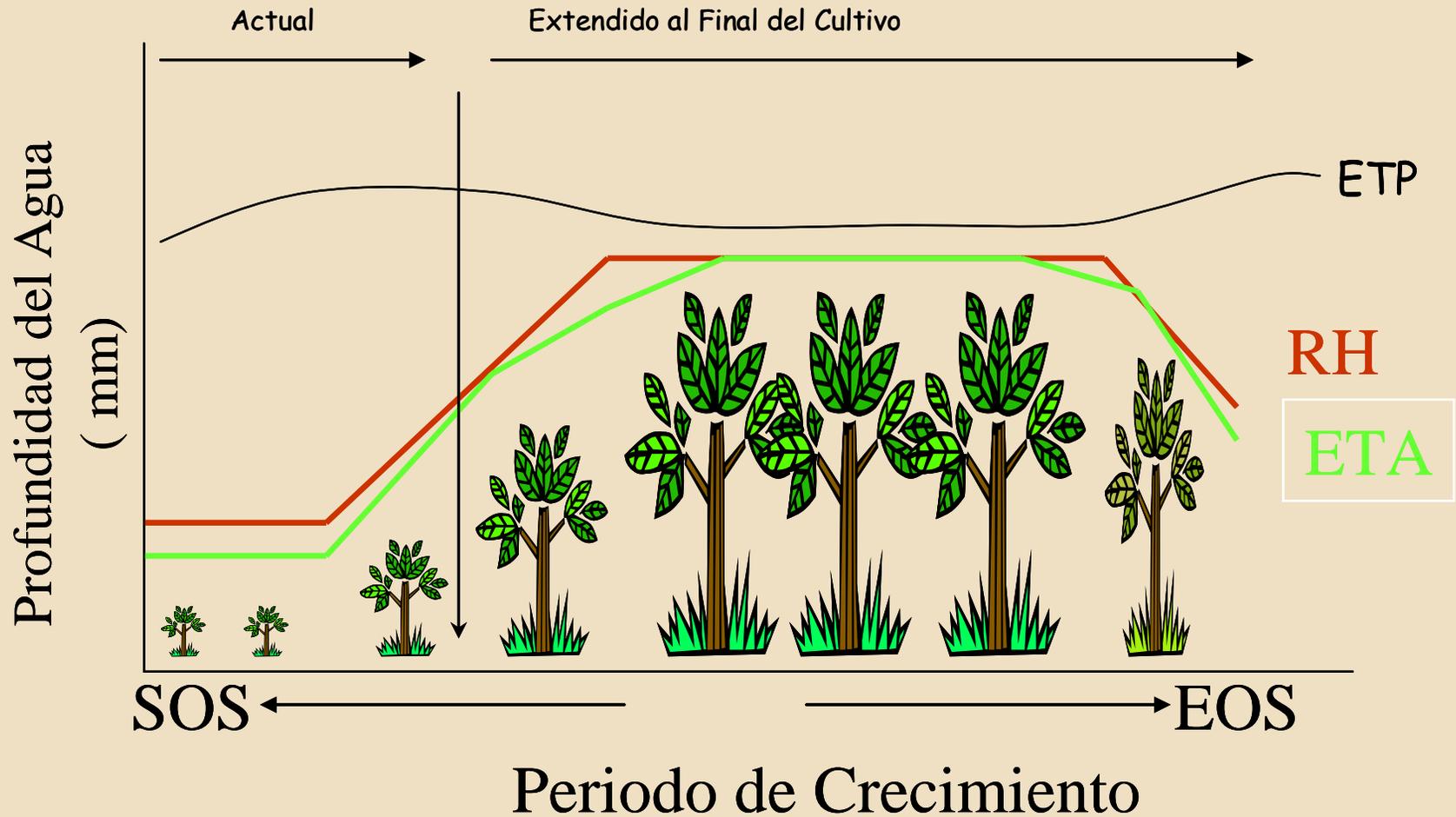


First dekad >25 mm, followed by two dekads summing to at least 20 mm more

Grid Cell Crop Water Balance Modeling



Grid Cell Crop Water Balance Modeling

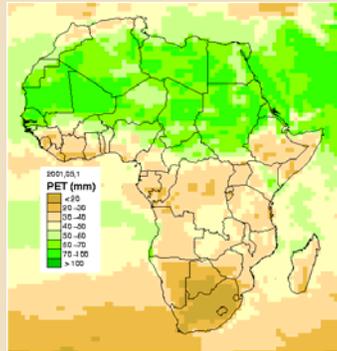
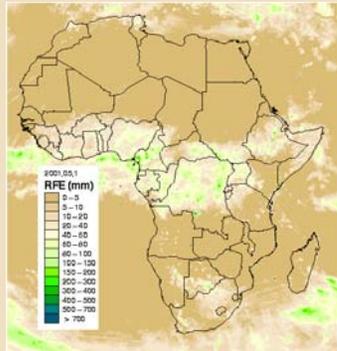


Water Requirement Satisfaction Index (WRSI) - Indice de Balance Hídrico (IBH)

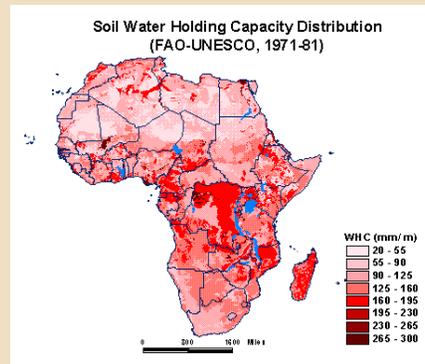
$$\text{WRSI} = f(\text{ppt}, \text{pet}, \text{WHC}, \text{Crop Type}, \text{SOS}, \text{EOS}, \text{LGP})$$

calculated from
NOAA GDAS
at EROS

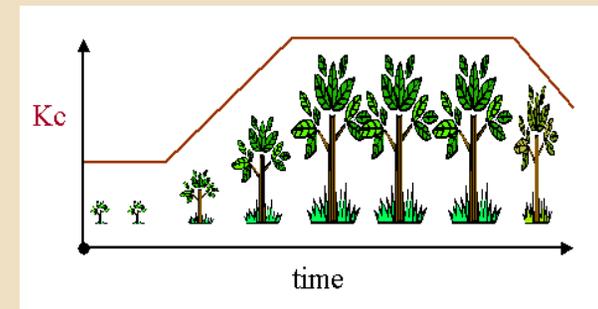
RFE
(NOAA or NASA)



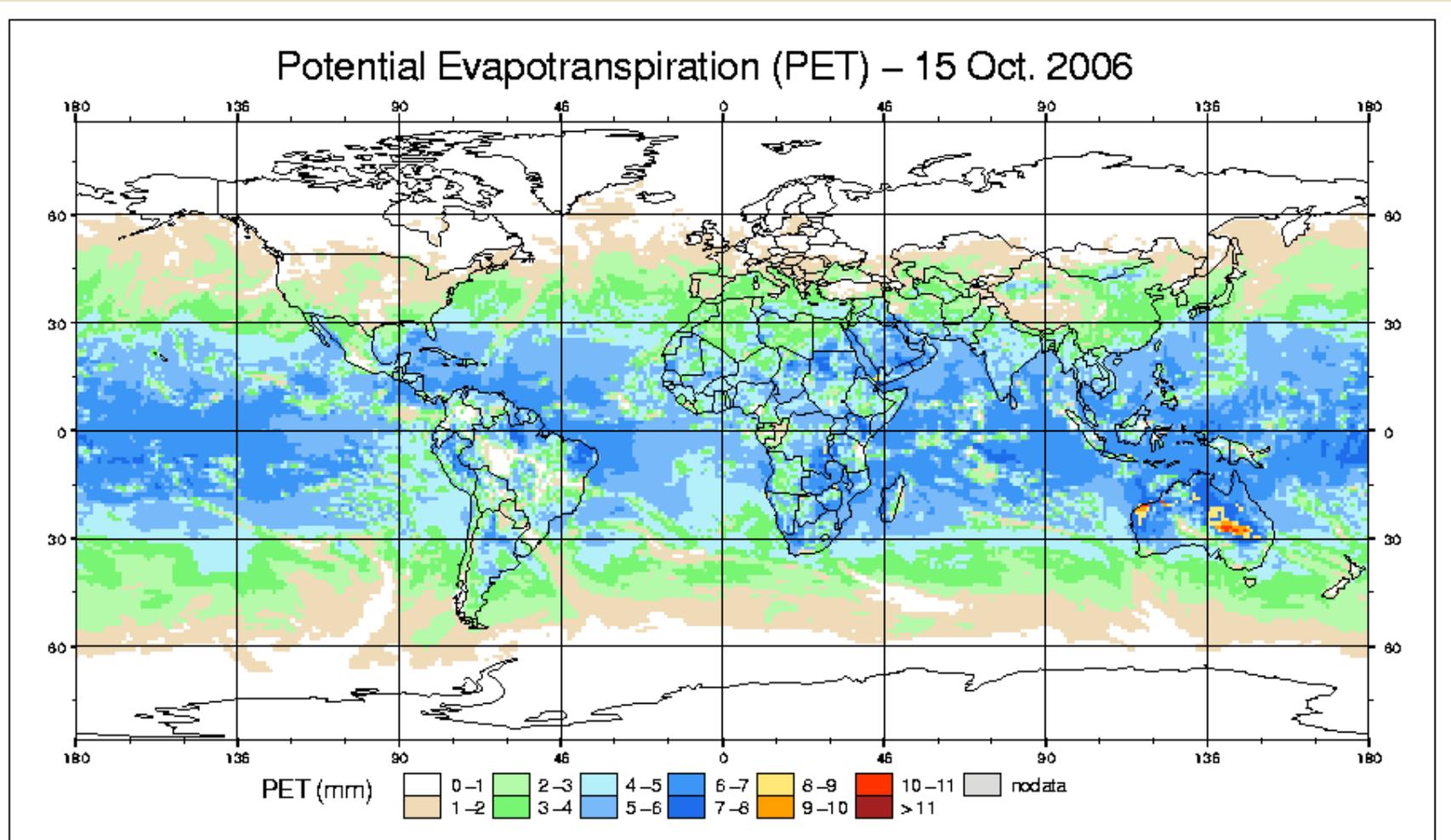
FAO soils map
of the world



Kc (FAO)

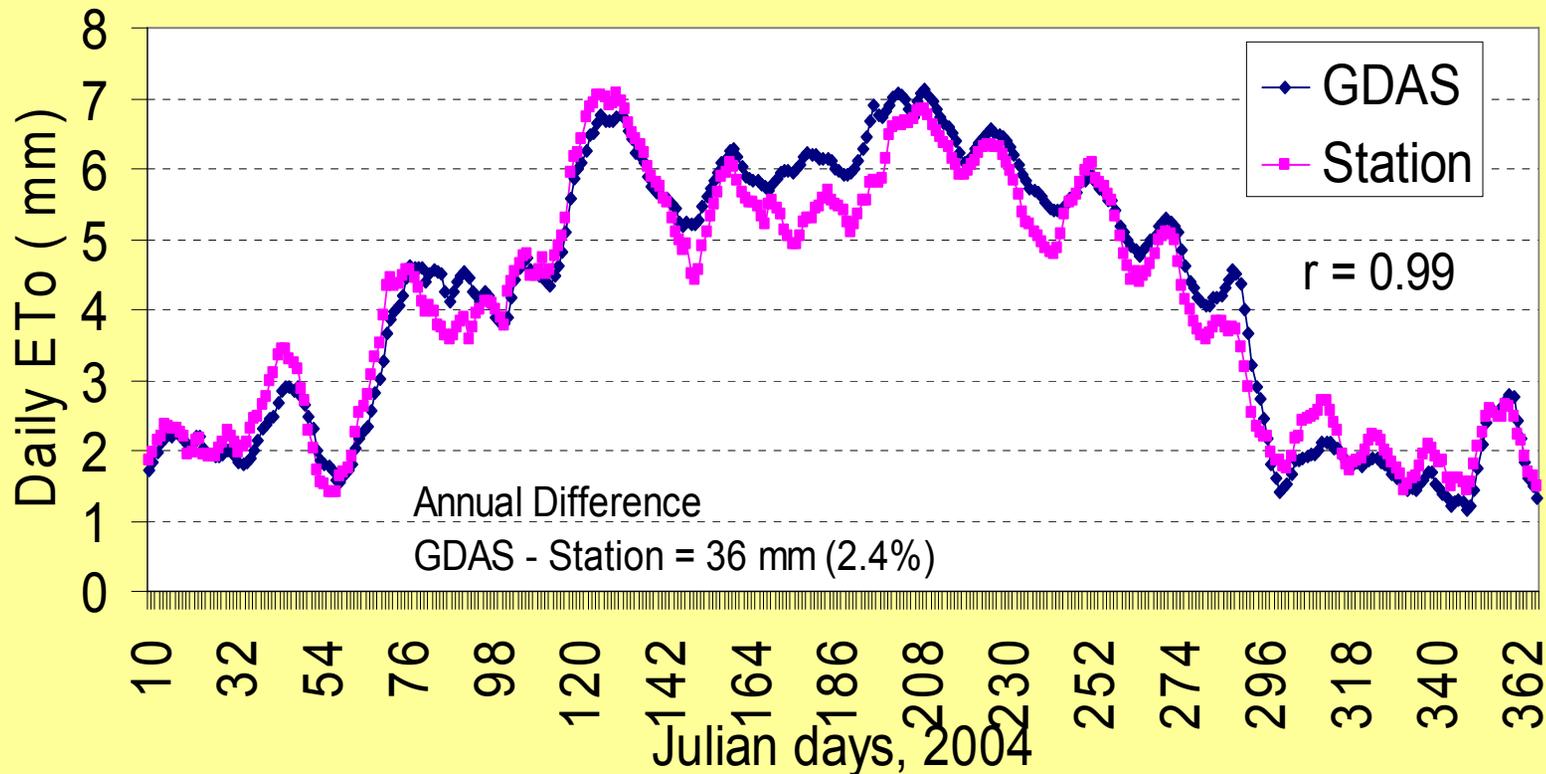


Global Daily Grids of PET at 1°

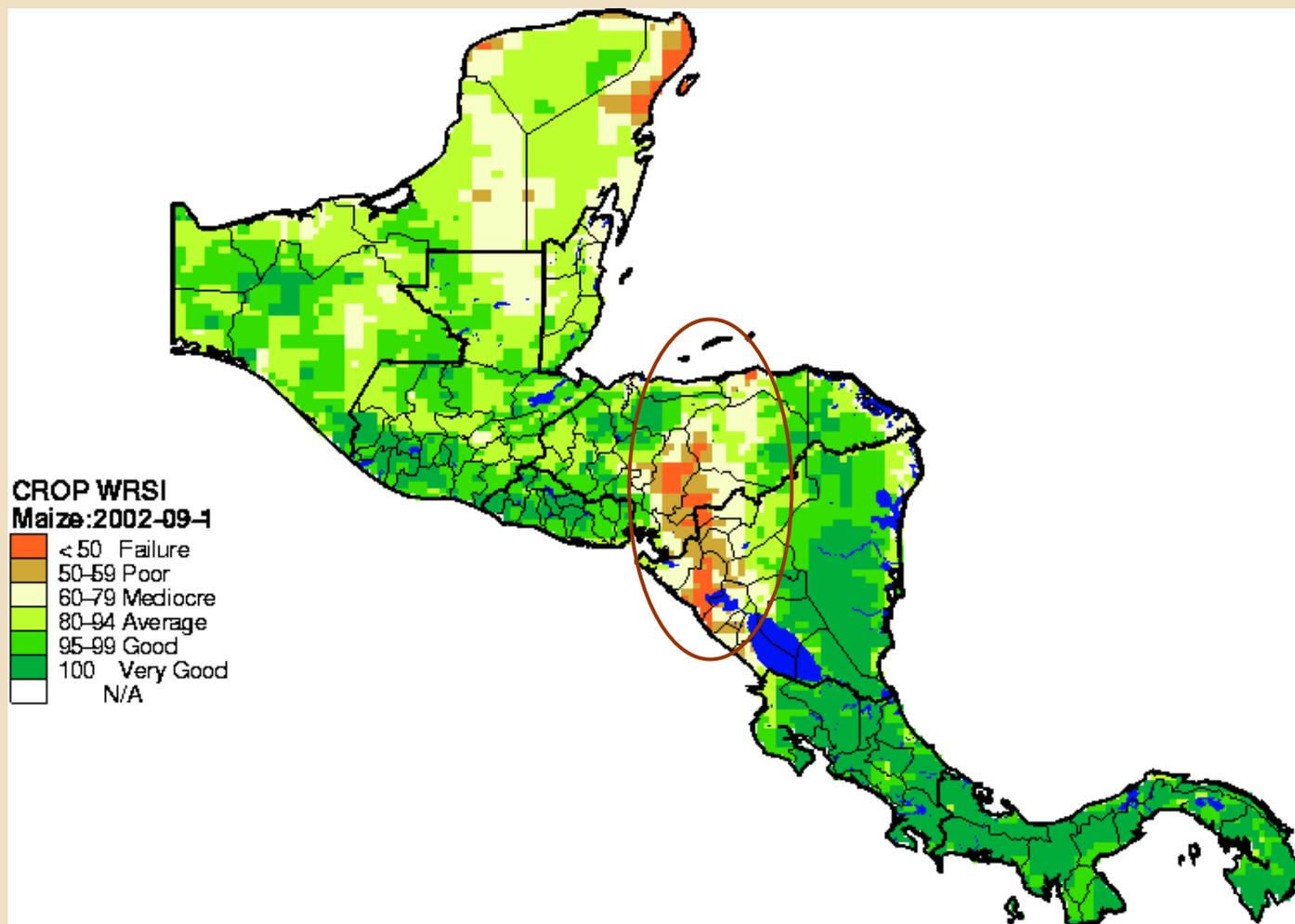


Validation of 1° PET Grids with California Station Data

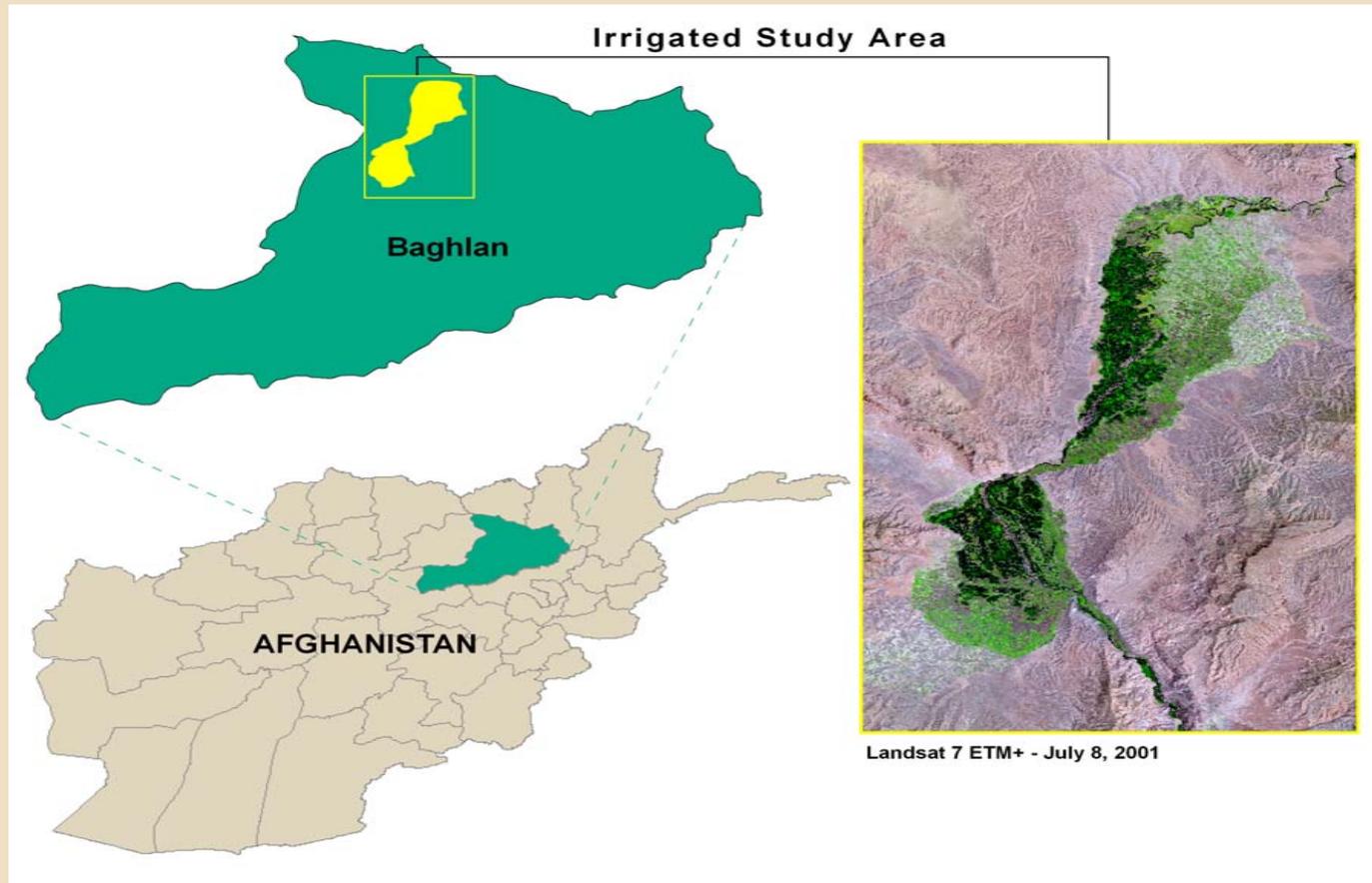
Riverside (44): 2004 ETo Comparison
GDAS vs Station (moving 8-day average)
Elevation (m): GDAS/Station, 1160/311



Drought Corridor of 2002 Primera Season

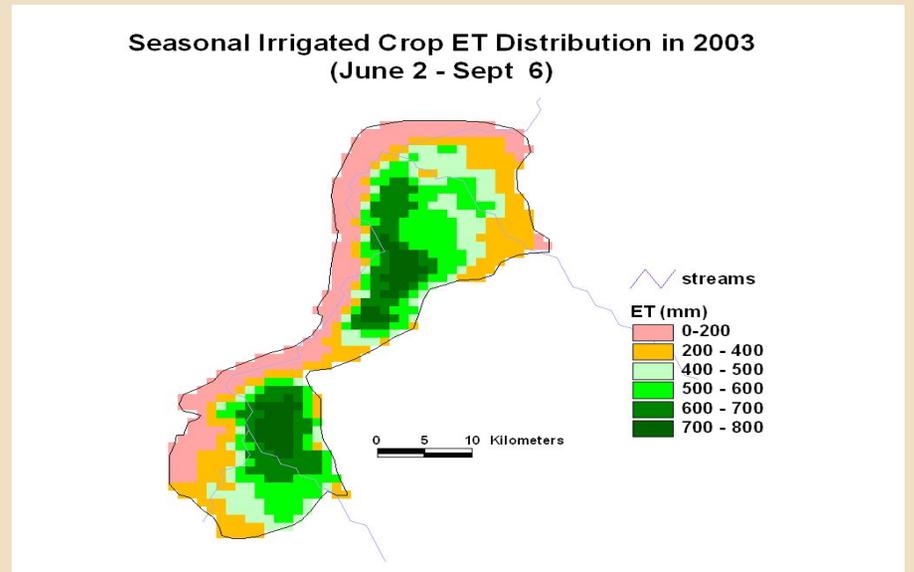
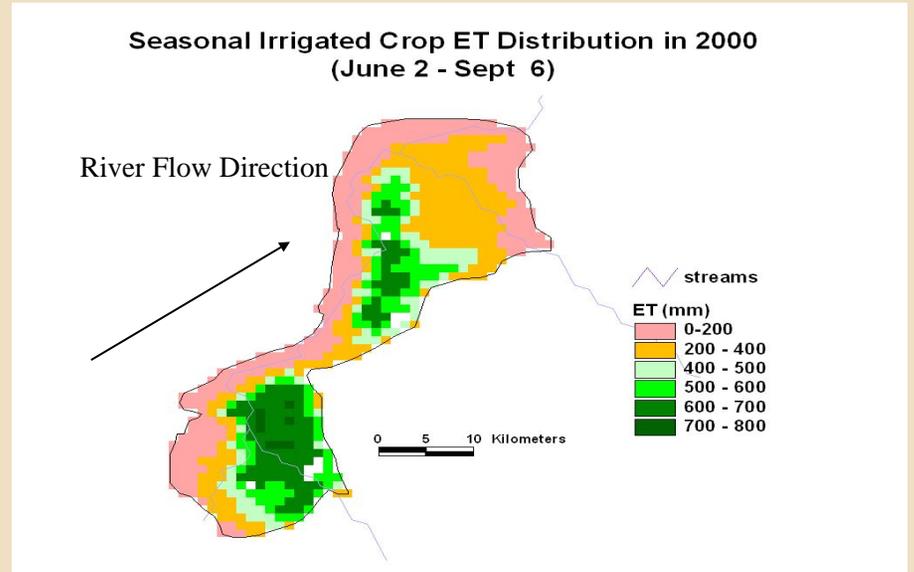


Estimating Irrigated Crop Water Use with a MODIS Thermal-based ET Fraction Approach

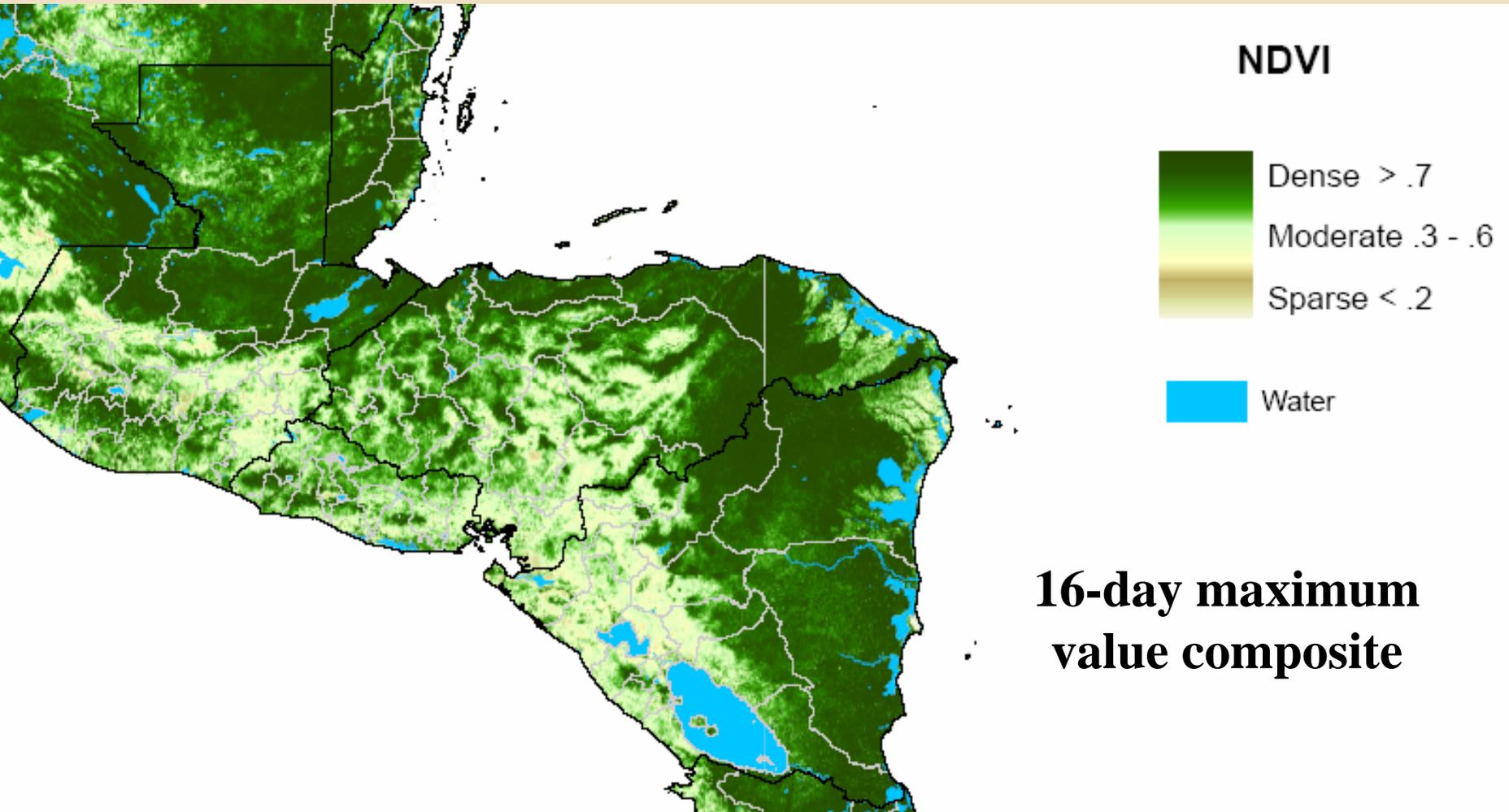


$$\text{ET frac} = \frac{T_{\text{hot}} - T_x}{T_{\text{hot}} - T_{\text{cold}}}$$

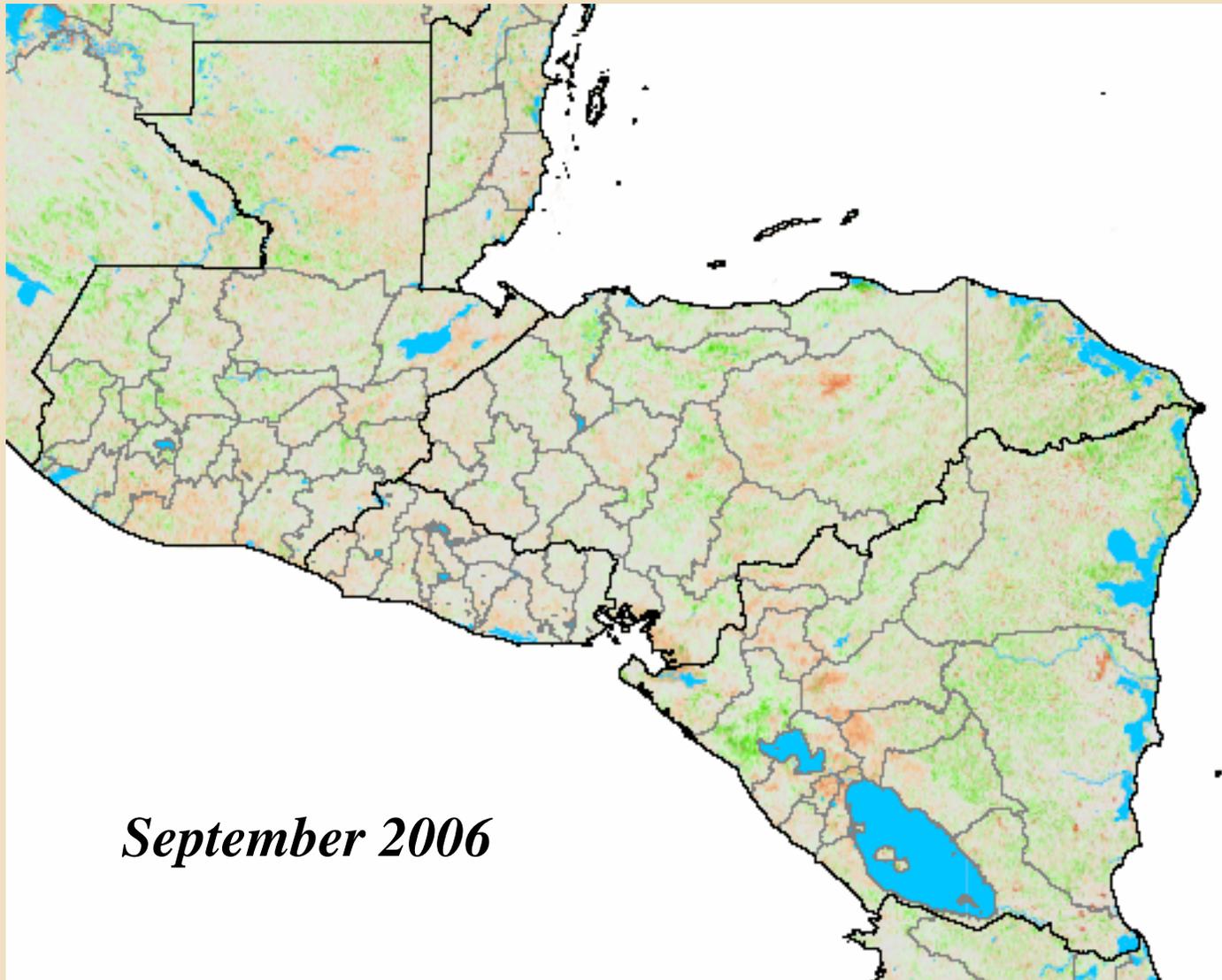
$$\text{ET act} = \text{ET frac} * \text{ET ref}$$



MODIS Vegetation Index Imagery at 250 m

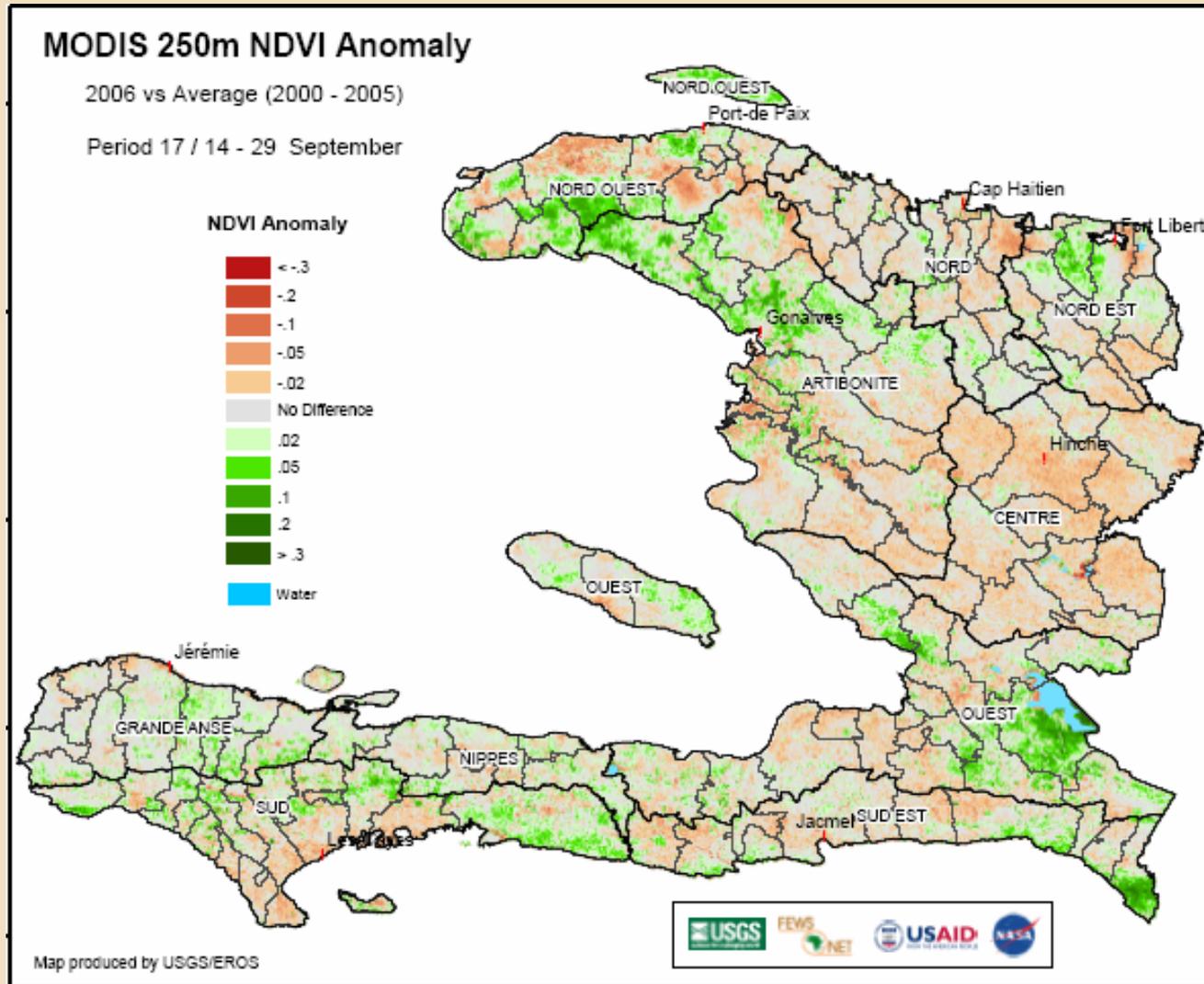


MODIS Vegetation Index Imagery - Anomalies

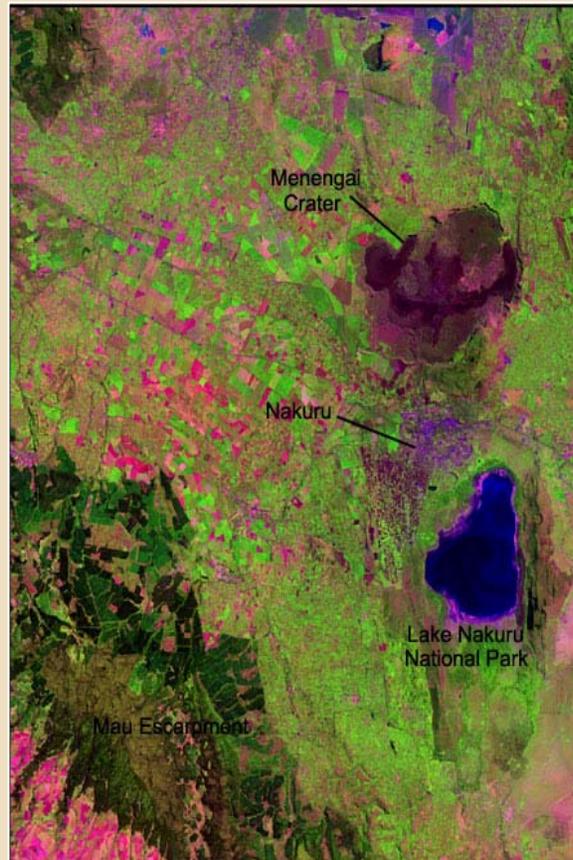


September 2006

MODIS Vegetation Index Imagery - Haiti



Landsat Kenya drought of 2000



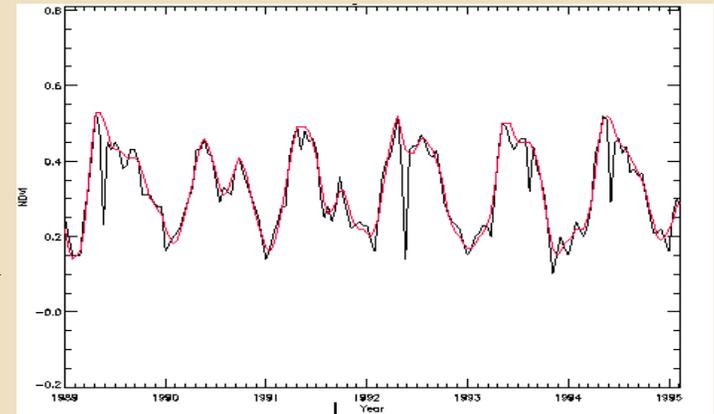
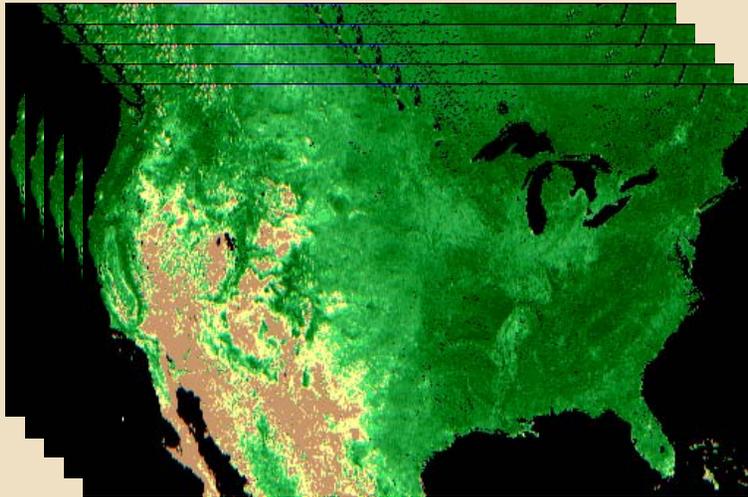
June 24, 1987



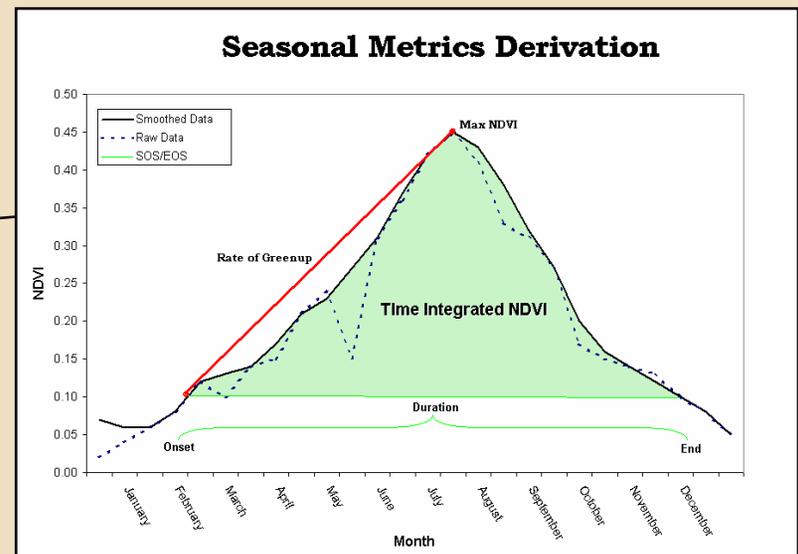
May 18, 2000

Time-series Vegetation Index Imagery of the U.S.

17+ Years of NOAA AVHRR Data at USGS/EROS



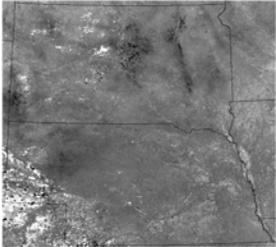
Start of Season
End of Season
Length of Season
Growing season greenness
Greenness “to-date”



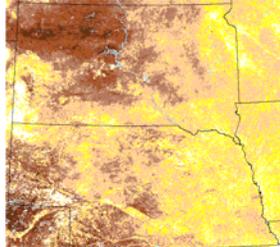
Vegetation Drought Response Index - VegDRI

Model Input Layers

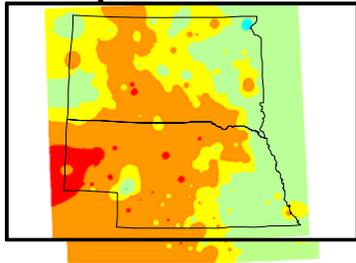
Start of Season
Anomaly



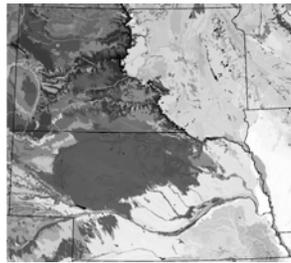
Seasonal Greenness
Anomaly



Standardized
Precipitation Index

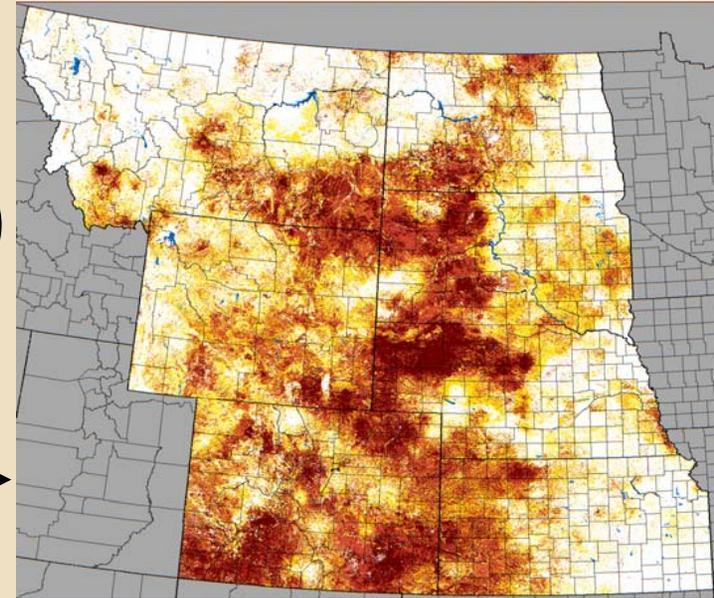


Available Water
Capacity

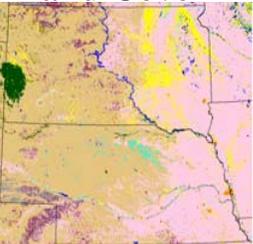


Regression Tree
Modeling

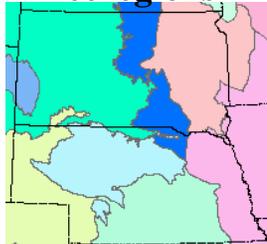
VegDRI



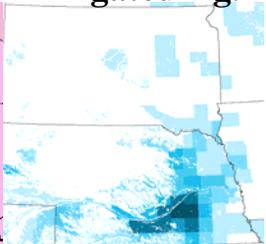
Land Cover



Ecoregions



Irrigated Ag.



Interactive Web Map Viewer

USGS
Drought Monitoring [Back to Main Page](#)

Home Overview Methods Data Links

Zoom
[Icons for zoom in, zoom out, pan, XY coordinates]

Query
[Icons for information, layers, scale]

Tools
[Icons for pan, zoom, print, query]

Documents
[Icons for home, search, help]

Scale Information
Out [Scale bar] In
Scale ~ 1:13,508,444

Layers

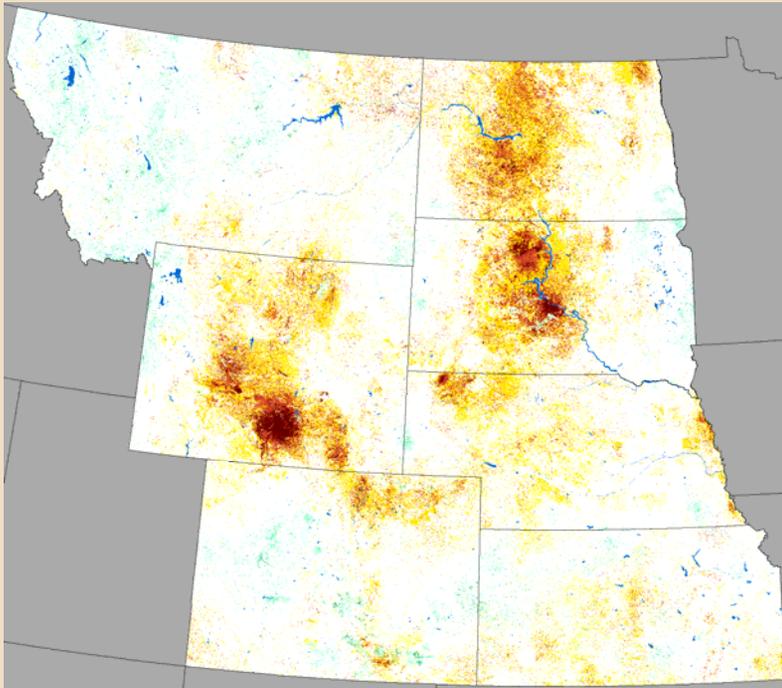
- ▶ Places (Names)
- ▶ Boundaries
- ▶ Transportation
- ▶ Hydrography
- ▶ U.S. Drought Monitor
- ▶ Standardized Precipitation Index
- ▶ Land Cover
- ▼ VegDRI
 - VegDRI 09/05/06
 - VegDRI 08/22/06
 - VegDRI 08/08/06
 - VegDRI 07/25/06
 - VegDRI 07/11/06
 - VegDRI 06/27/06
- ▶ Percent of Avg. Seasonal Greenness
- ▼ Elevation
 - USGS Shaded Relief
 - NED shaded relief (1 arc second)

U.S. Department of the Interior | U.S. Geological Survey | USGS for Earth Resources Observation and Science (EROS)
URL: /Website/Drought_Monitoring/ | Last Update: 4/26/2005 || Maintainer: Comments and Suggestions | Disclaimer

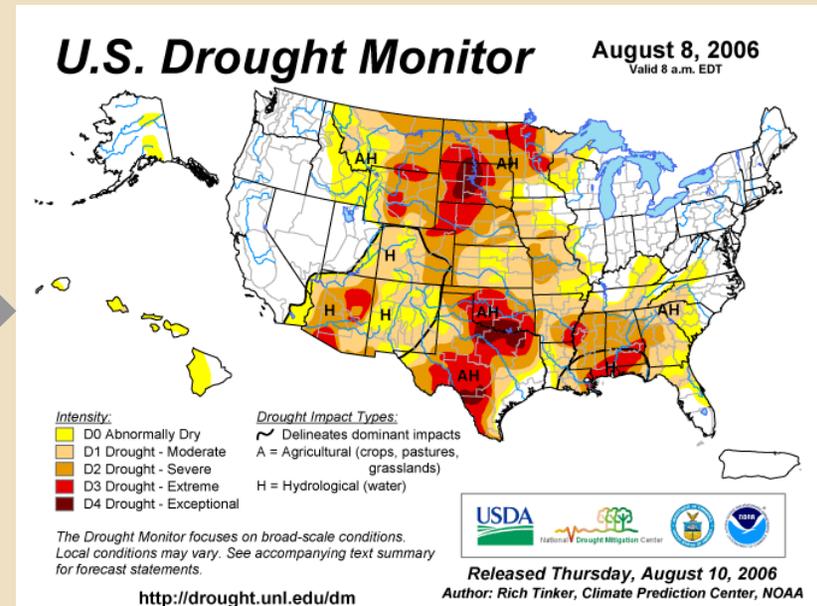


*North American Drought Monitor Workshop
Mexico City – October 18-19, 2006*

Seasonal metrics and VegDRI as input to USDM authors



VegDRI - July 27, 2006

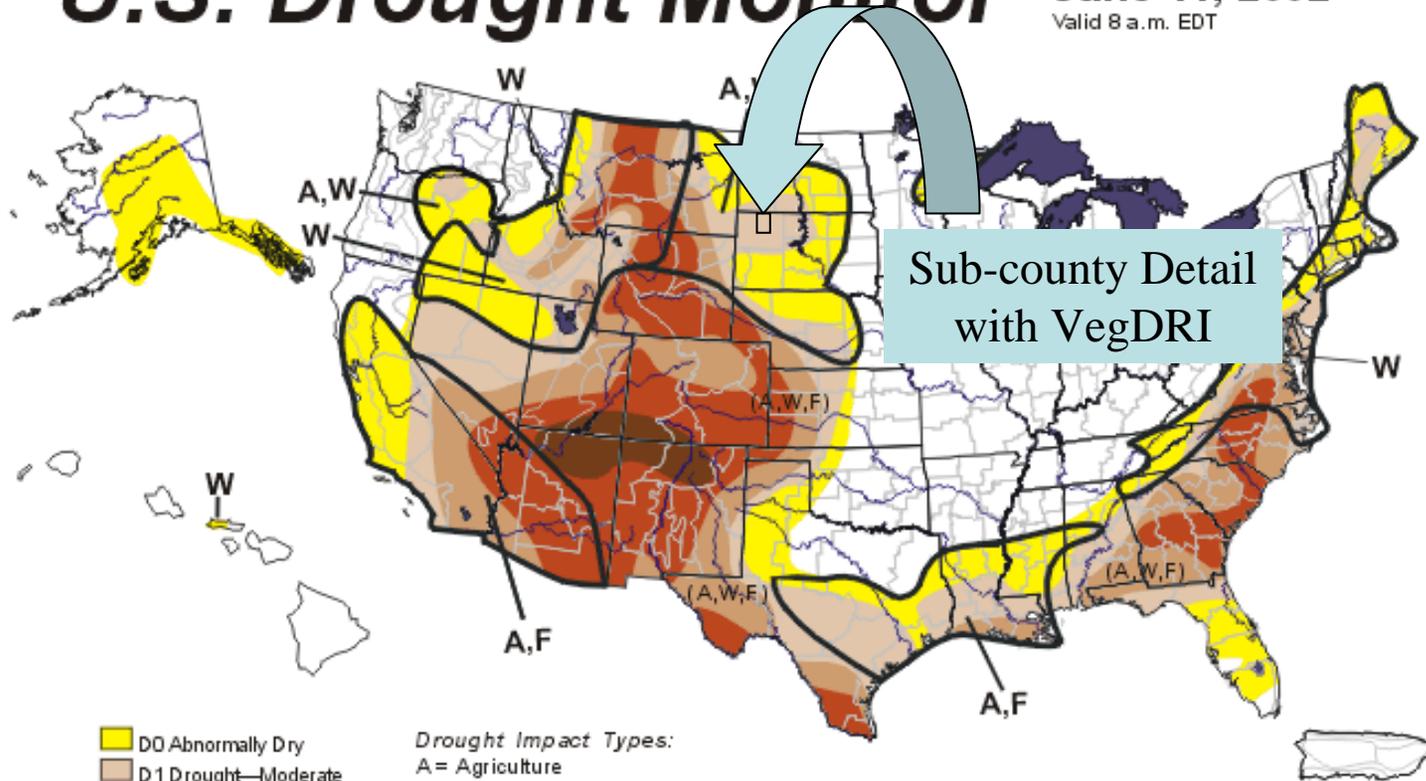


USDM – August 8, 2006

U.S. Drought Monitor

June 11, 2002

Valid 8 a.m. EDT



- D0 Abnormally Dry
- D1 Drought—Moderate
- D2 Drought—Severe
- D3 Drought—Extreme
- D4 Drought—Exceptional

Drought Impact Types:
A = Agriculture
W = Water (Hydrological)
F = Fire danger (Wildfires)
/ Delineates dominant impacts
(No type = All 3 impacts)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>



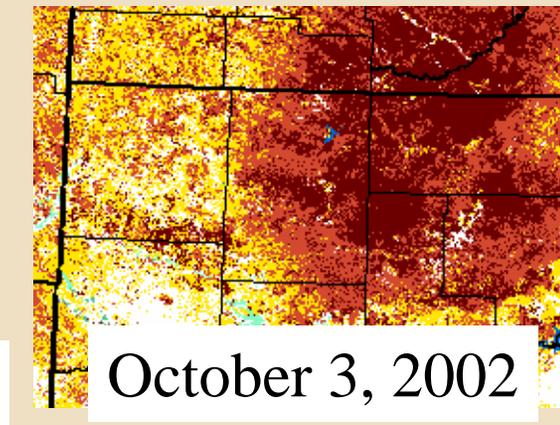
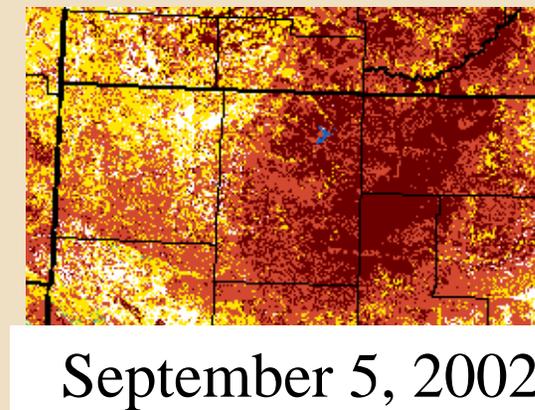
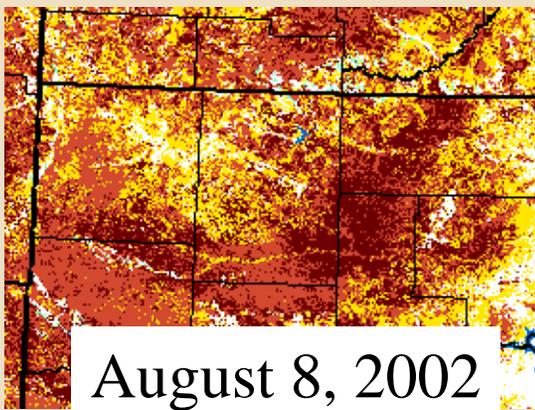
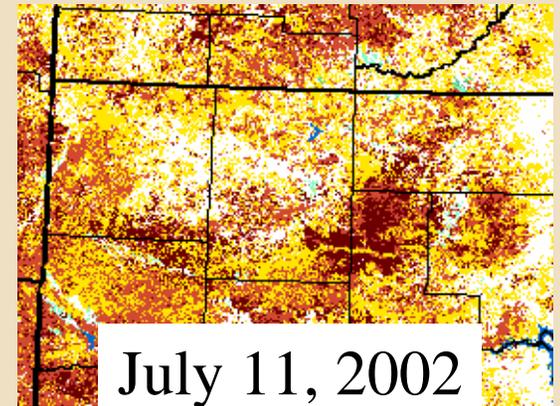
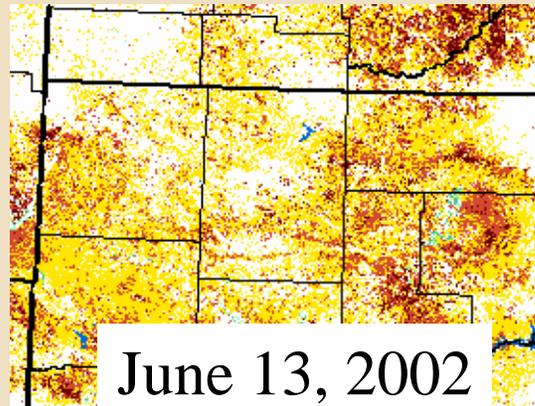
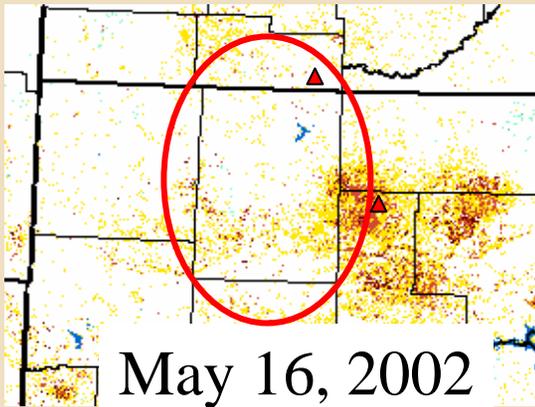
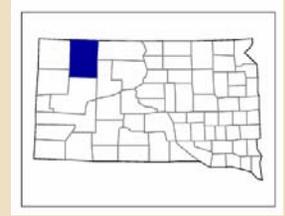
Released Thursday, June 13, 2002

Author: Douglas Le Comte, NOAA A/CPC



*North American Drought Monitor Workshop
Mexico City – October 18-19, 2006*

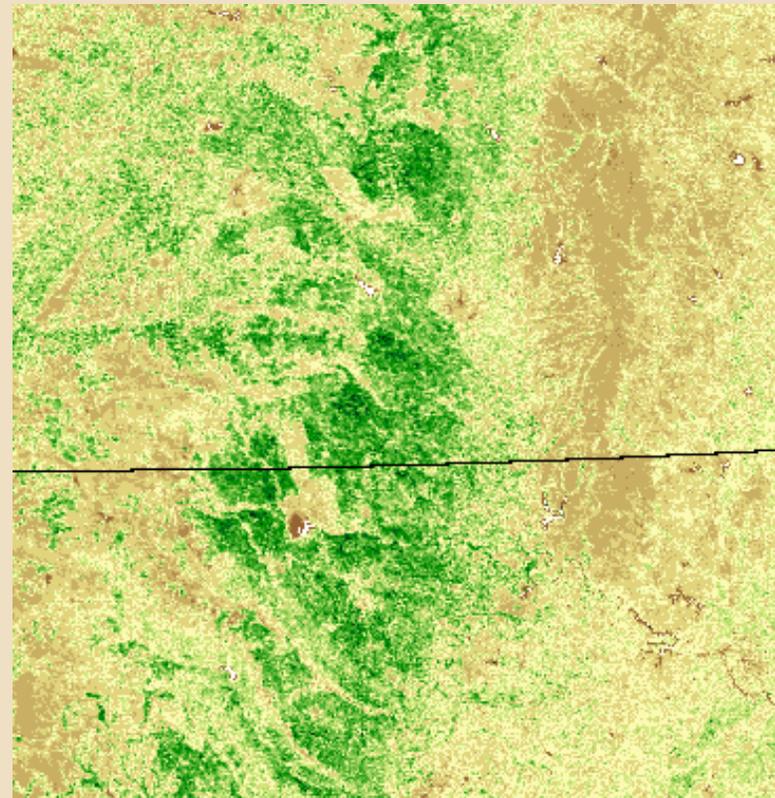
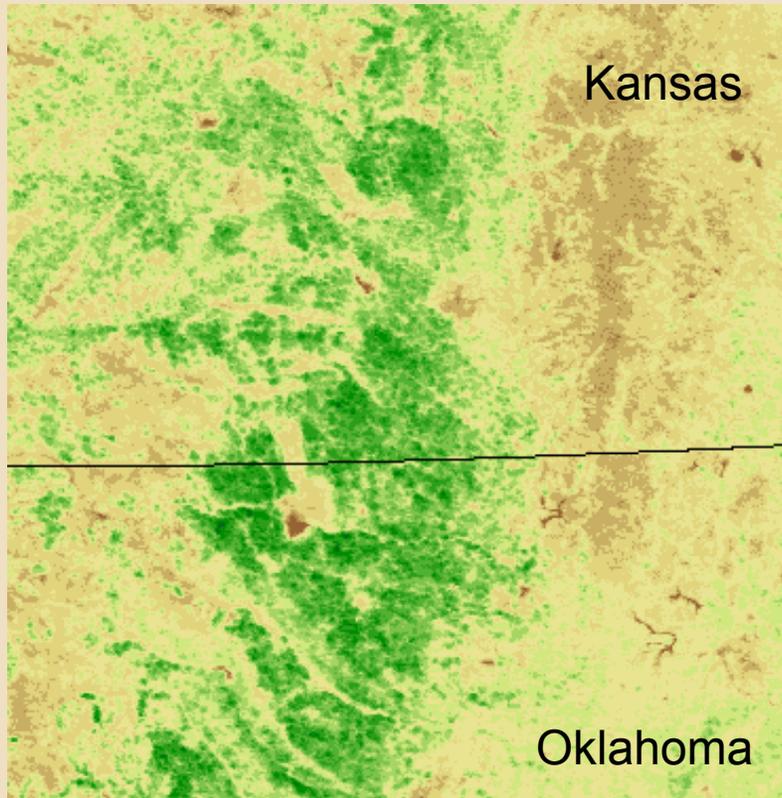
Perkins County, South Dakota – VegDRI 2002



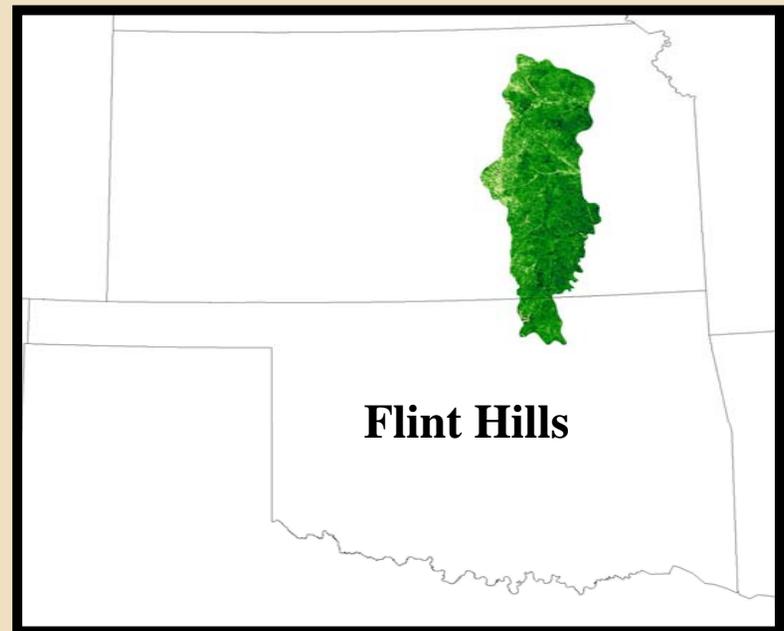
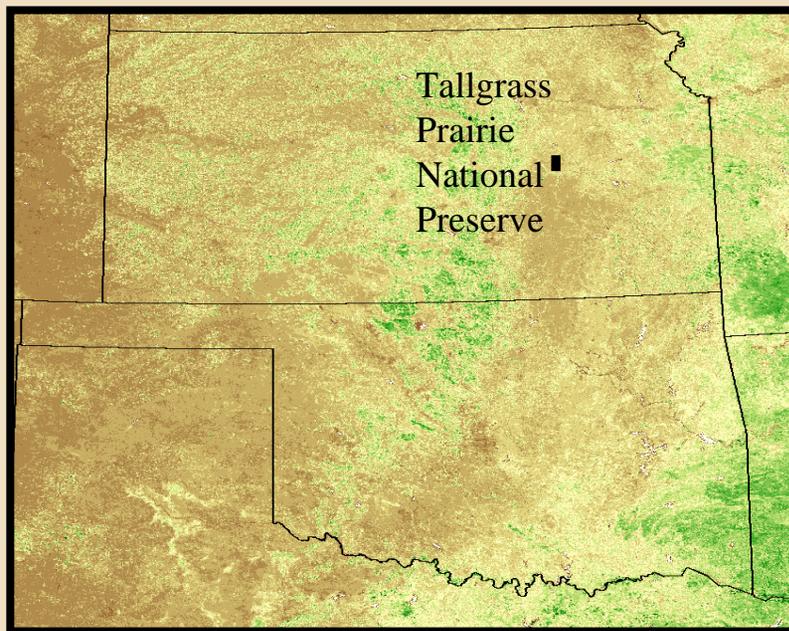
Transition from AVHRR to MODIS

1-km AVHRR NDVI

500-m MODIS NDVI

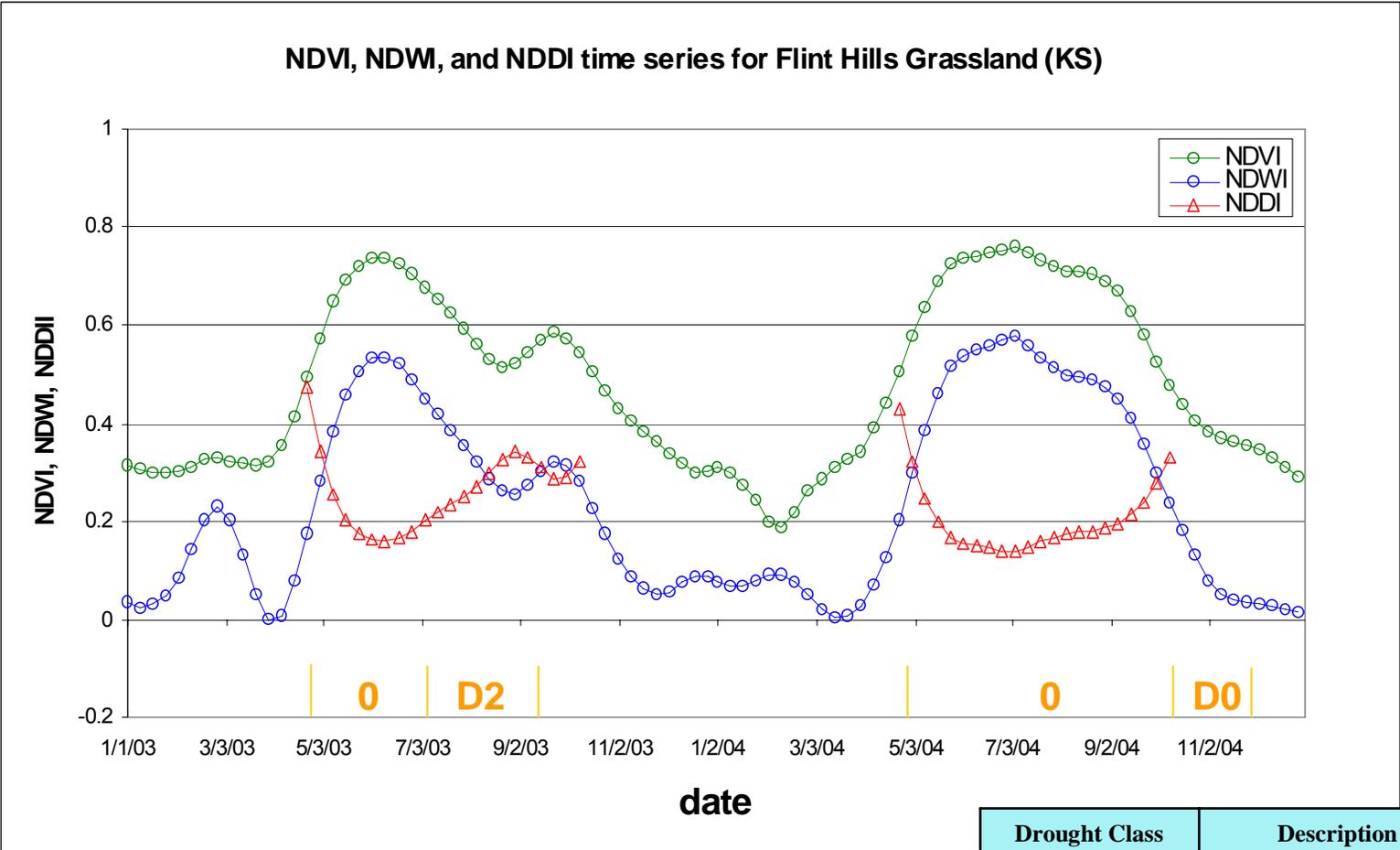


Normalized Difference Water Index (NDWI) vs. NDVI Flint Hills, Tall Grass Prairie study area



NDWI apparently more drought sensitive than NDVI

NDVI, NDWI, and NDDI time series for Flint Hills Grassland (KS)

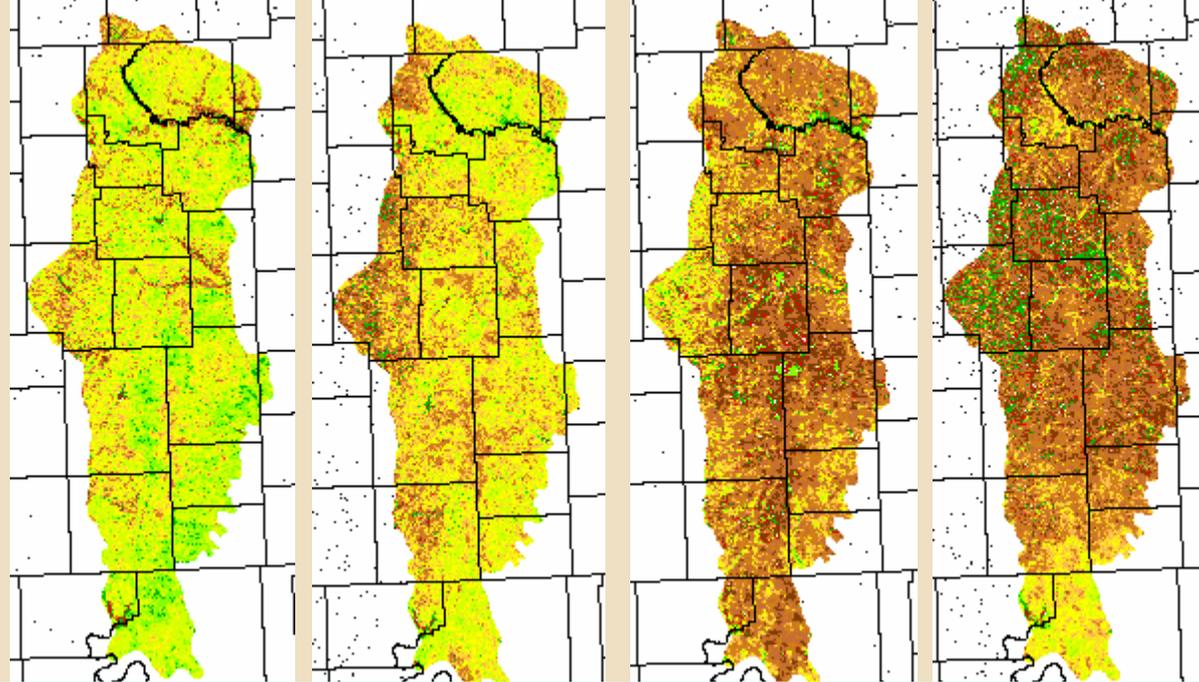
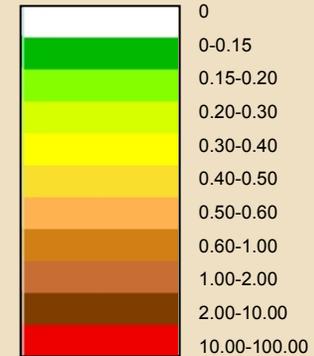


Drought Class	Description
0	Non-drought
D0	Abnormal dry
D1	Drought - moderate
D2	Drought - severe
D3	Drought - extreme

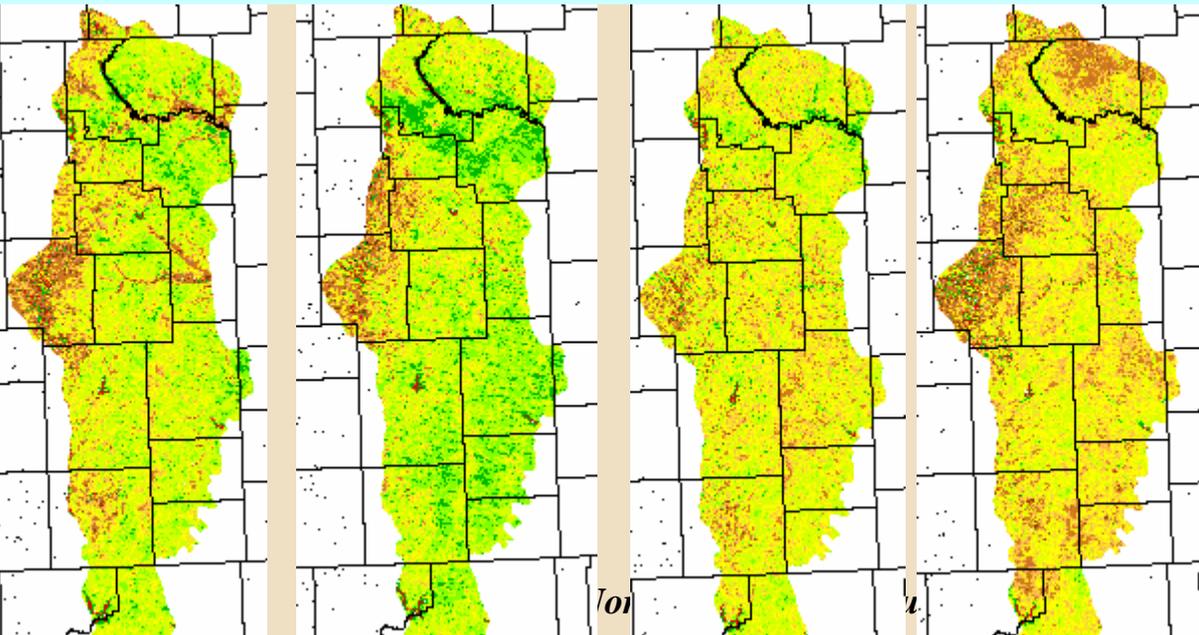


Normalized Difference Drought Index (NDDI)

NDDI



June 02, 2003 July 04, 2003 August 05, 2003 September 06, 2003



June 02, 2004 July 04, 2004 August 05, 2004 September 06, 2004

$$NDDI = \frac{NDVI - NDWI}{NDVI + NDWI}$$

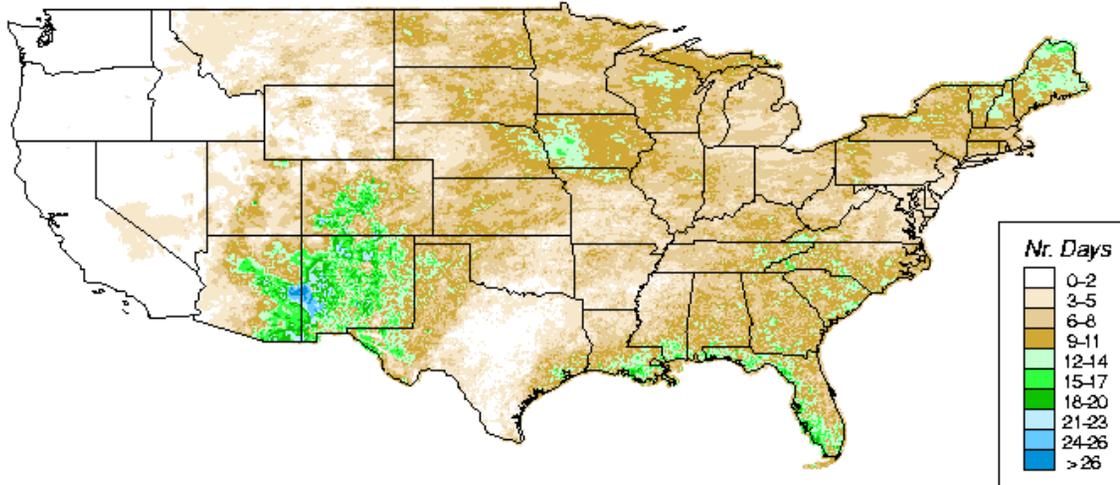
$$NDVI = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}$$

$$NDWI = \frac{\rho_2 - \rho_7}{\rho_2 + \rho_7}$$

$$NDDI(Red, NIR, SWIR) = \frac{\rho_7 - \rho_1}{\rho_2 - \frac{\rho_1}{\rho_2} \rho_7}$$

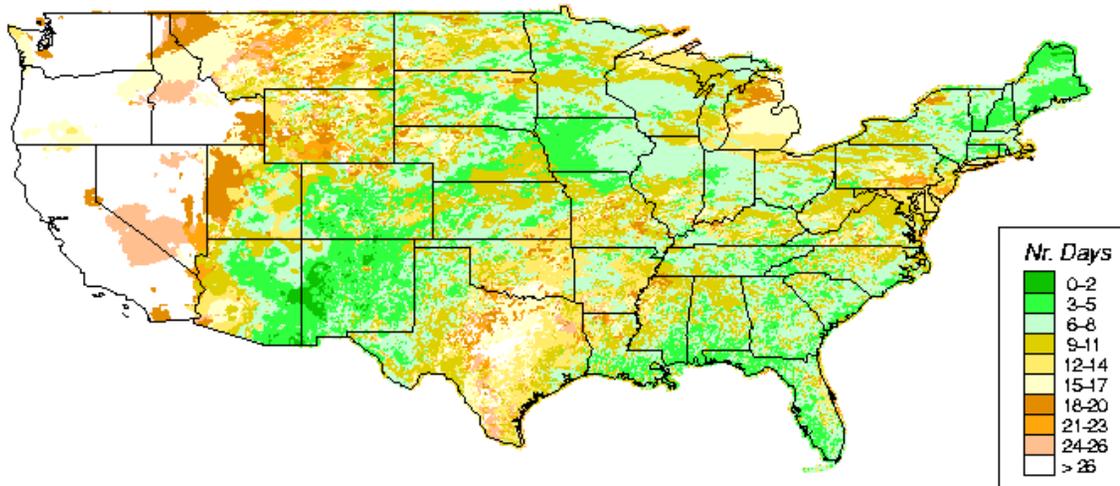
Where ρ_1 , ρ_2 , and ρ_7 are the reflectances at 645 nm (Red), 857 nm (NIR), and 2130 nm (SWIR) respectively

Number of Rain Days
in past 30 days, as of 21 Aug. 2006



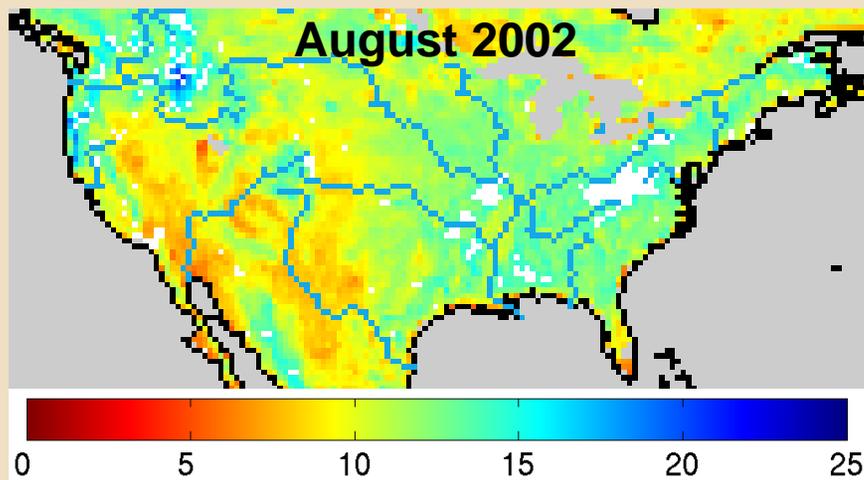
Number of Rain Days and Consecutive Dry Days

Maximum Consecutive Dry Days
in past 30 days, as of 21 Aug. 2006

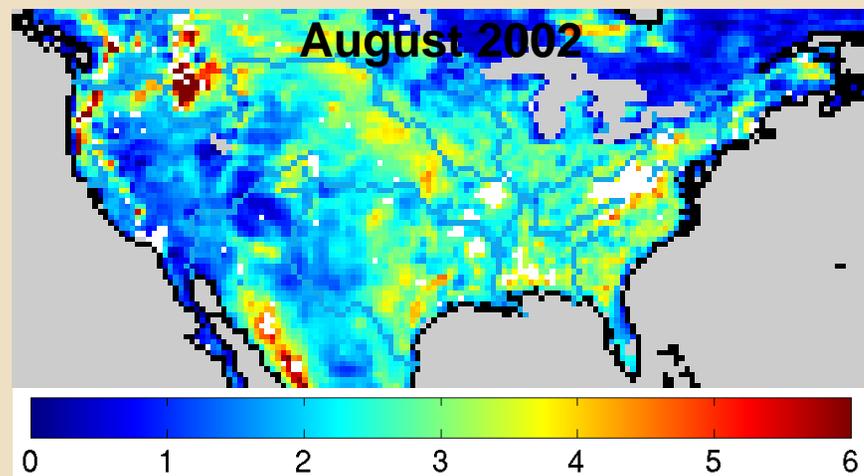


Based on NWS daily
precipitation analysis –
4 km grids
blending radar and
station data

AMSR-E Microwave Soil Moisture and Vegetation Water Content

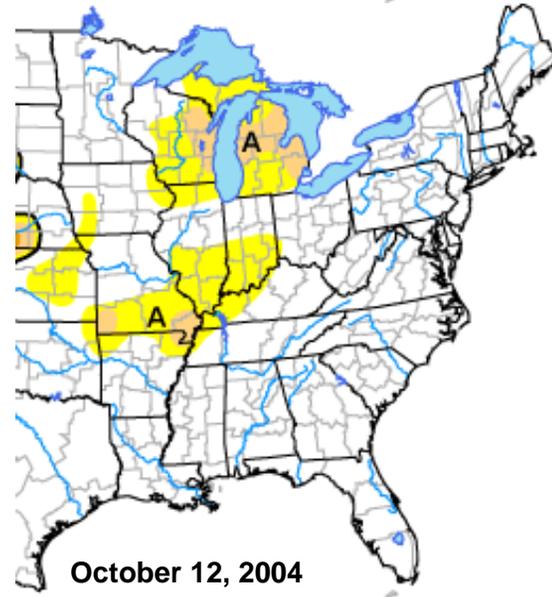
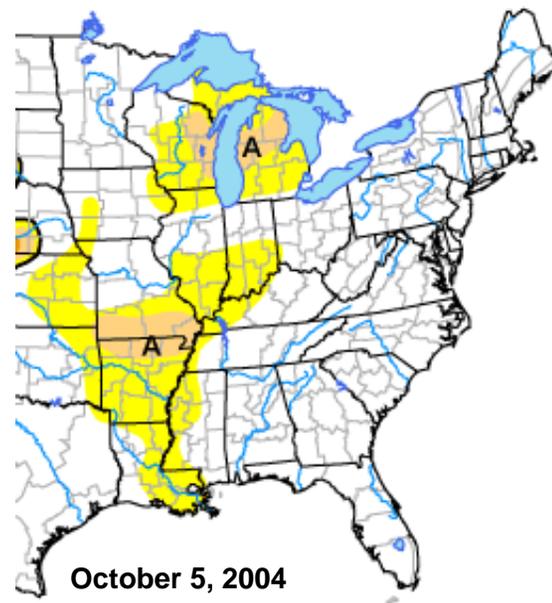
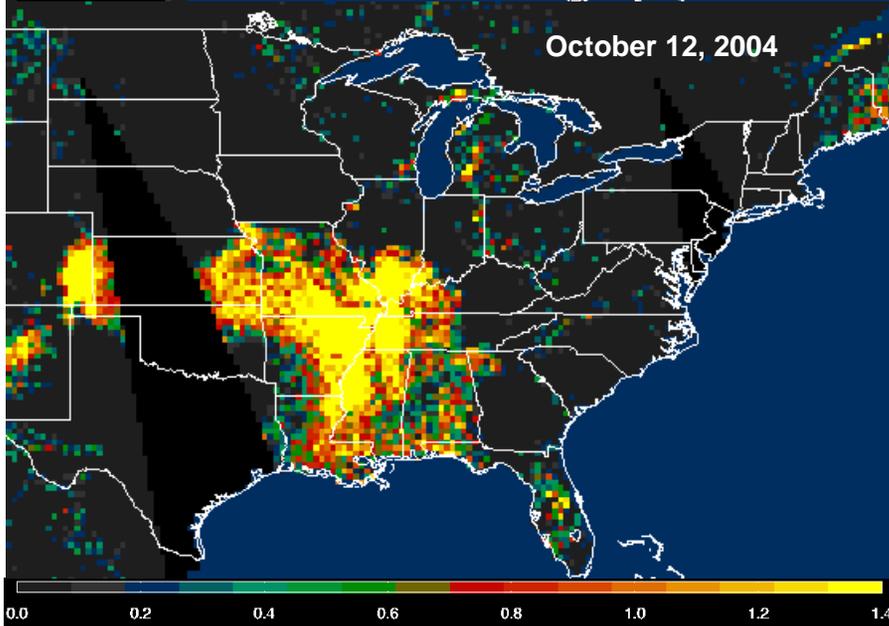
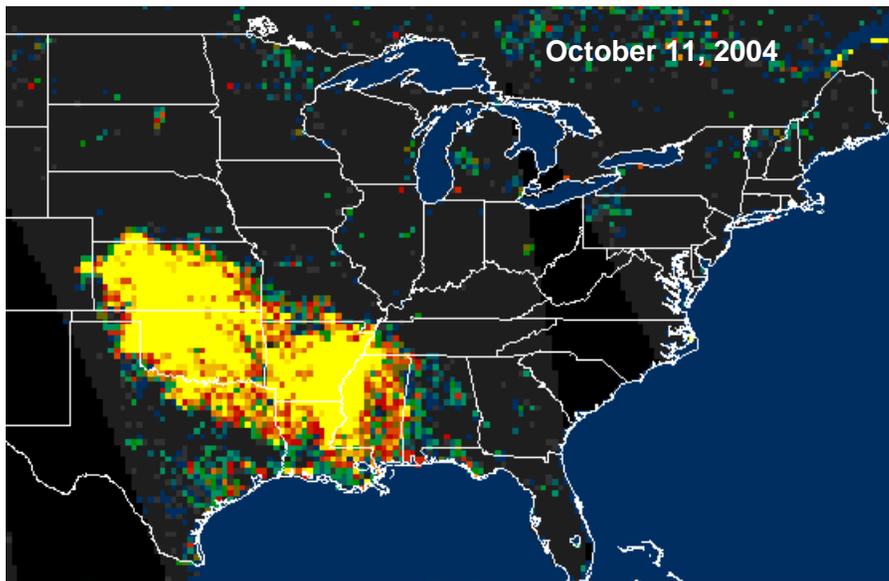


**Soil water content (v/v %):
pattern consistent with
the USDM**



**Veg. water content ($\text{kg}\cdot\text{m}^{-2}$):
higher vegetation water content
in eastern US may mask soil
signature**

QuikSCAT Result and USDM Comparison



END



*North American Drought Monitor Workshop
Mexico City – October 18-19, 2006*