

# **IMPROVEMENT in GLOBAL DROUGHT WATCH FROM S-NPP VEGETATION HEALTH (VH)**

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**JPSS**

**August 27, 2015**

# Drought (D) as Natural Disaster

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

# World Population Affected by Natural Disasters 1967-1991

%		
Disaster Type	Affected	Killed
	<u>Weather</u>	
<b>Drought</b>	<b>51</b>	<b>38</b>
Flood	38	9
Hurricane etc.	8	27
	<u>Geological</u>	
Earthquake	2	18
Volcano	<1	<1

Total People Affected: **2.8 billions**

Total People Killed: **3.5 millions**

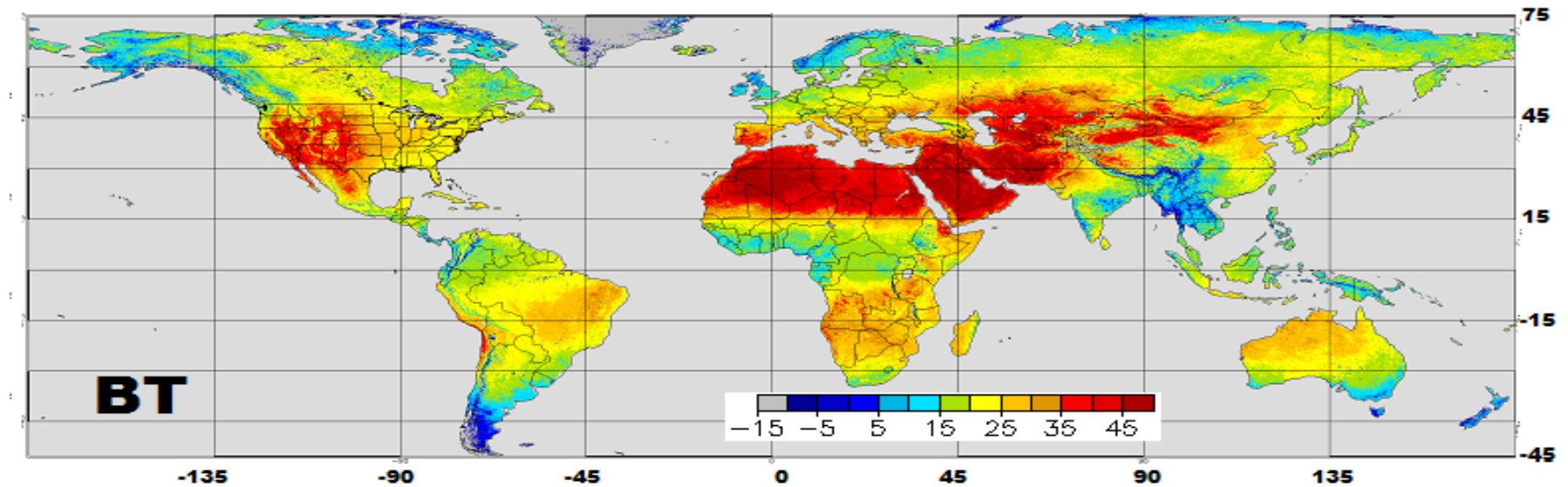
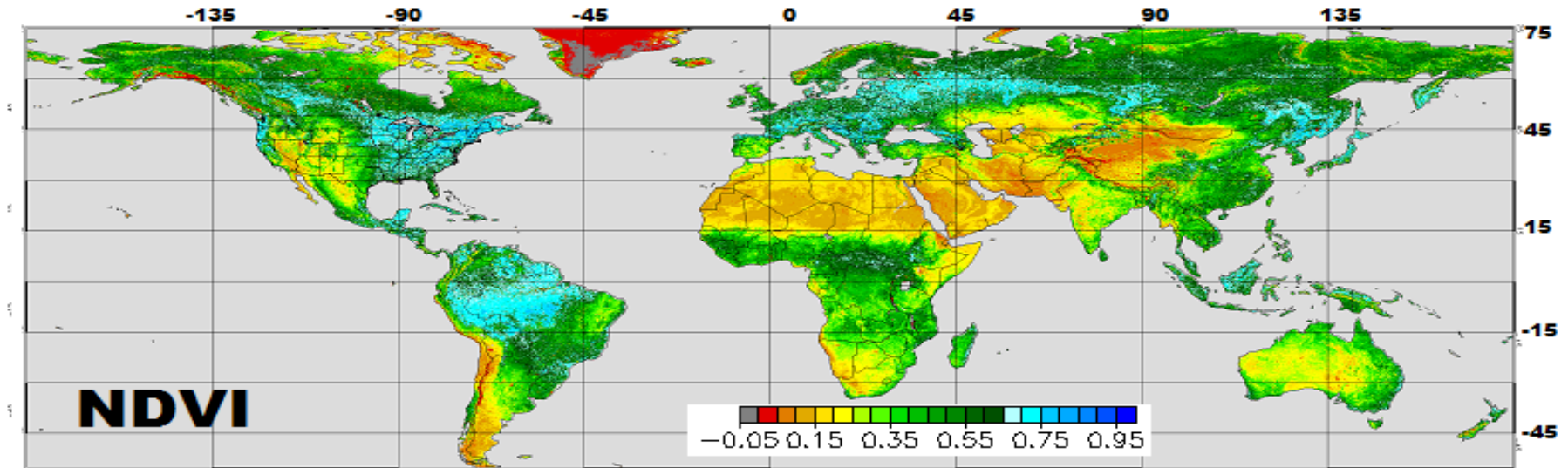
# Drought Disasters during 1980-2008

- **No of people affected**  
India 2002 - 1,551,455,112  
300,000,000
- **No of people killed**  
Ethiopia 1983 - 558,565  
300,000
- **Economic damages**  
China 1994 \$ 13.8 bil  
Australia 1981 \$ 6.0 mil  
USA 1988 \$ 40-60 bil  
USA 2006-2015 California \$ 2.7 bil (21,000 job loss)

# Drought Unique Features

- **Start** unnoticeably
- **Build-up** slowly
- **Develop** cumulatively
- **Impact** cumulative & not immediately observable
- **Mitigation:** When damage is evident it's too late to mitigate the consequences
- **Drought type:** Meteorological, Agricultural, Hydrological, Socio-Economic

# Normalized Difference Vegetation Index & Brightness Temperature

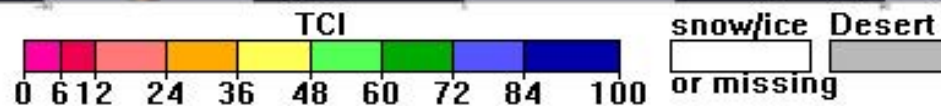
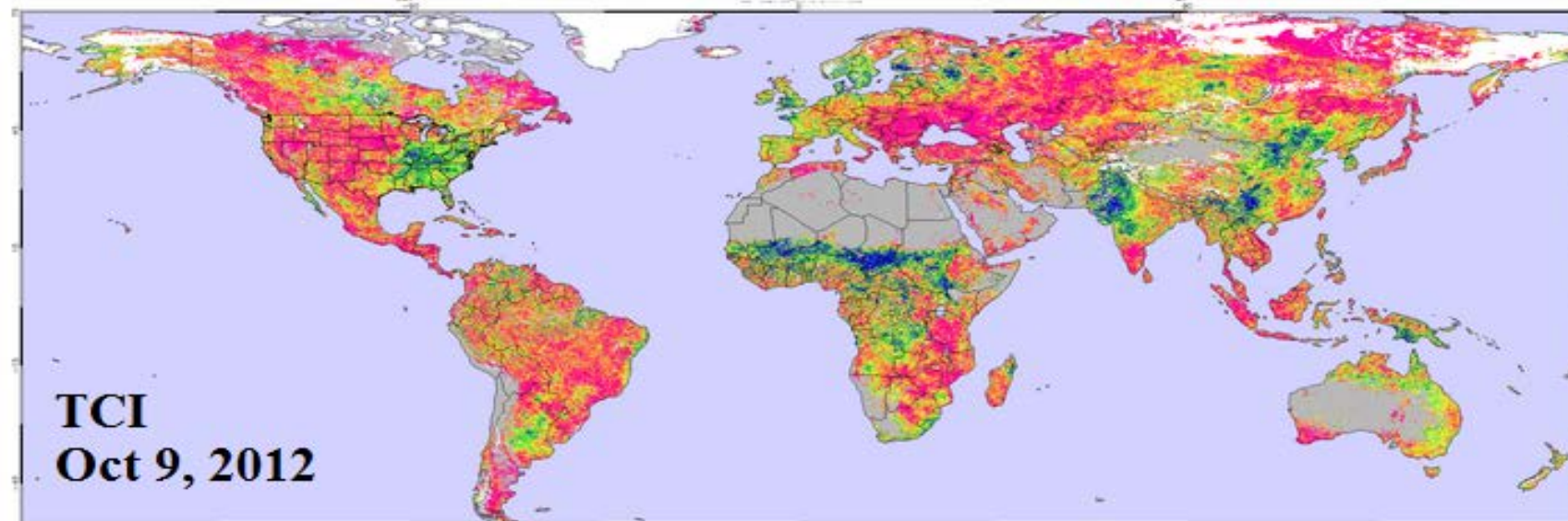
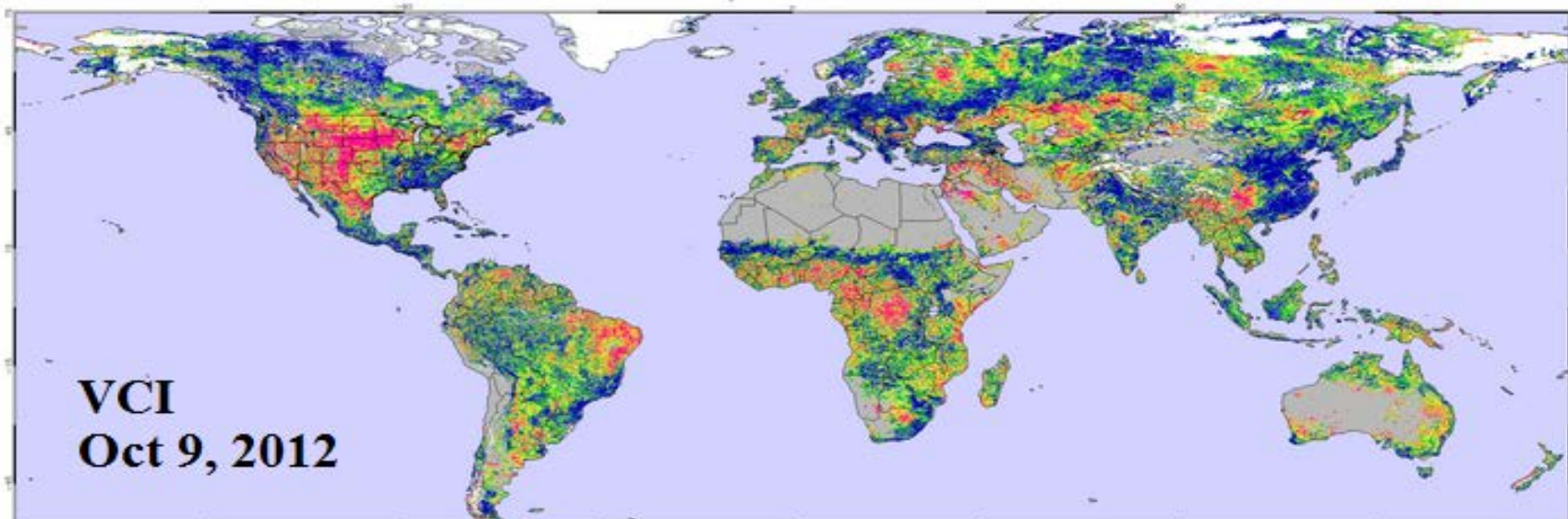


# **VH Requirements**

- **Real time NDVI and BT**
- **Climatology of NDVI and BT**



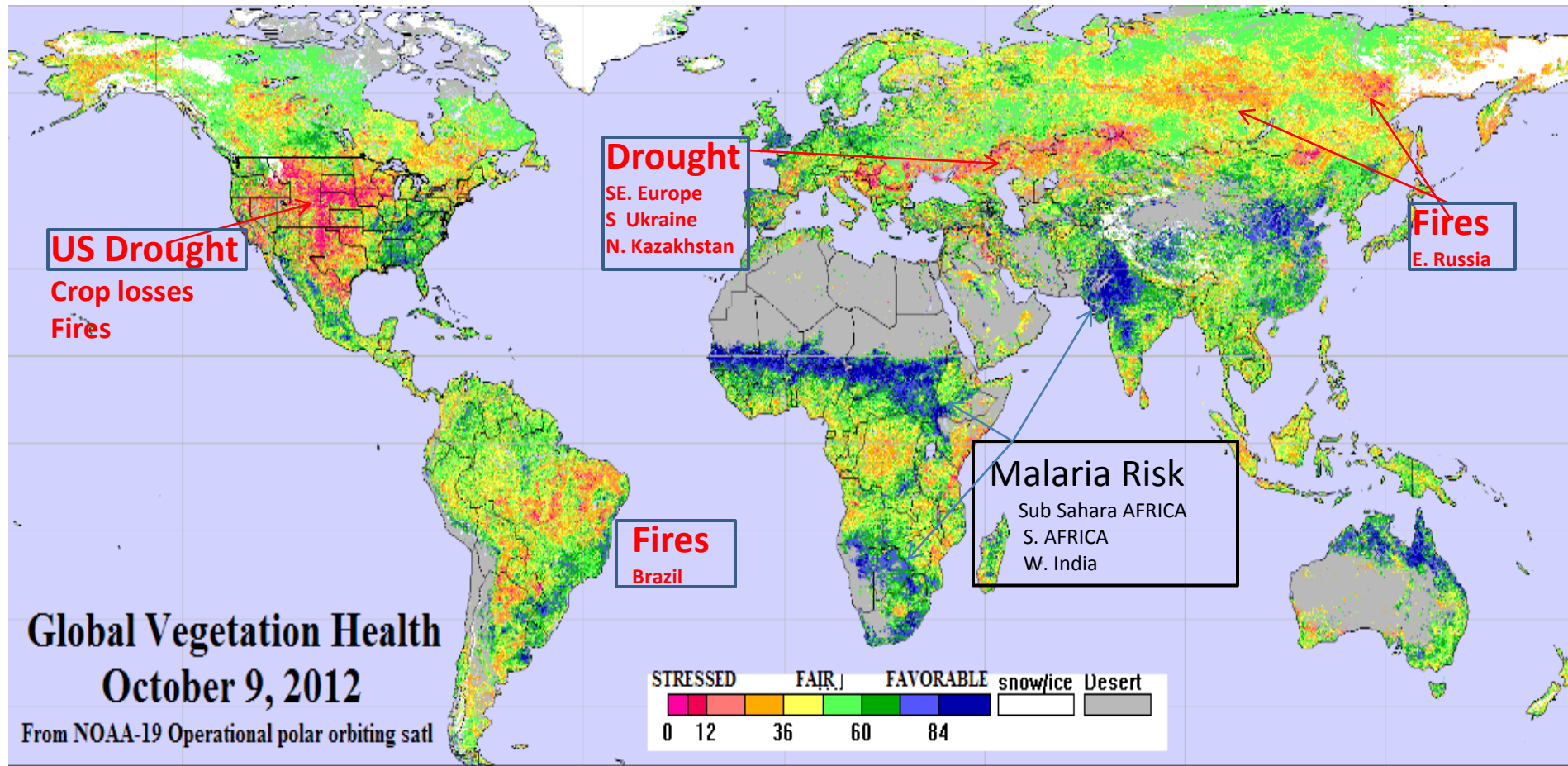
# Vegetation Condition (VCI) and Temperature condition (TCI) indices





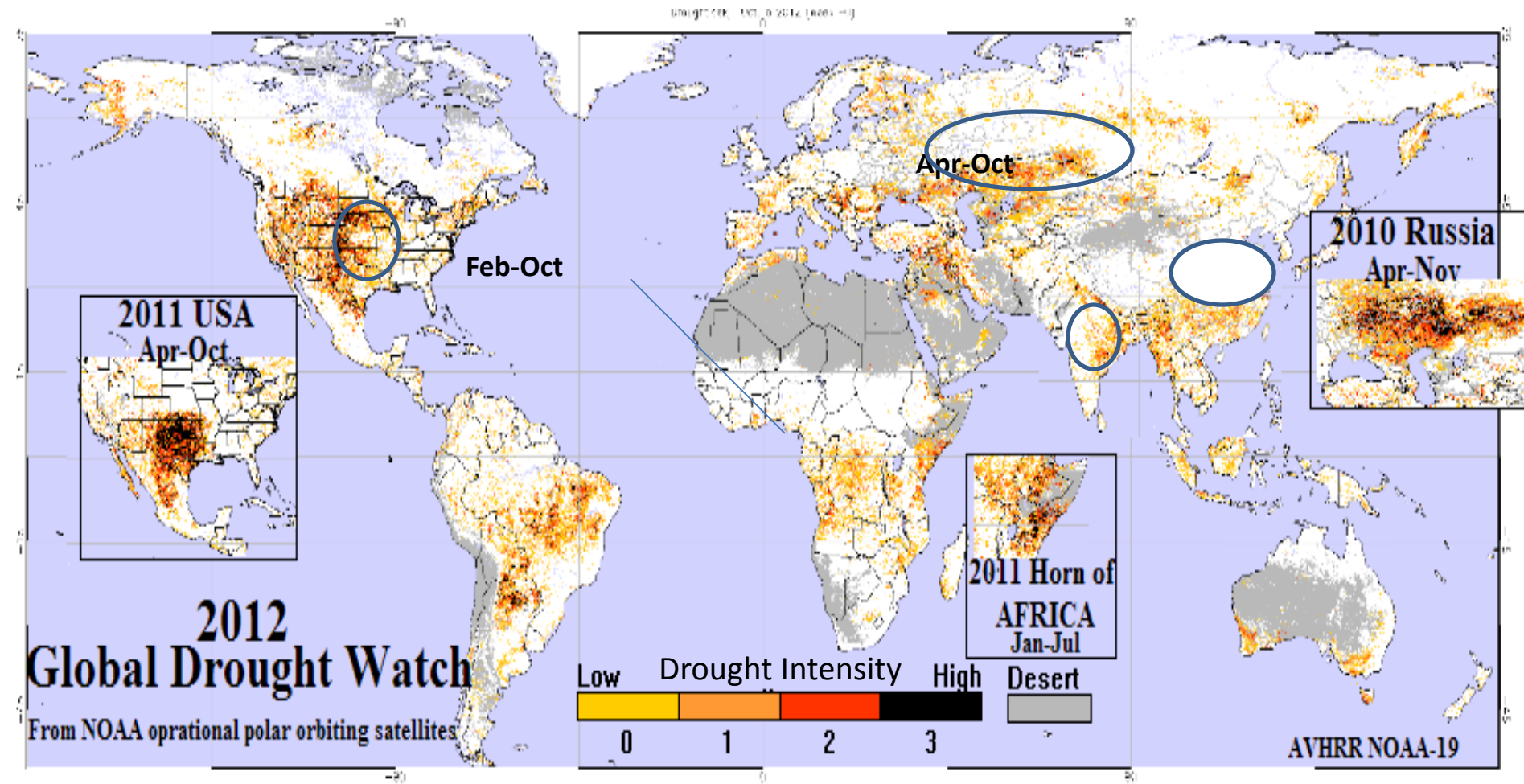
# 2012 Global Vegetation Health (VH)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite



<http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php>

# Global Droughts from operational satellites



- 2012- Extreme drought in the USA, southern UKRAINE, northern KAZAKHSTAN,
  - Severe drought in eastern INDIA, Kenya & South America
- 2011 – Exceptional drought in Texas (USA) and the Horn of AFRICA
- 2010 - Exceptional drought in RUSSIA and UKRAINE

# USDA user (August 8, 2015)

**Eric Luebehusen, Analyst for FAS & WAOB  
([ELuebehusen@oce.usda.gov](mailto:ELuebehusen@oce.usda.gov))**

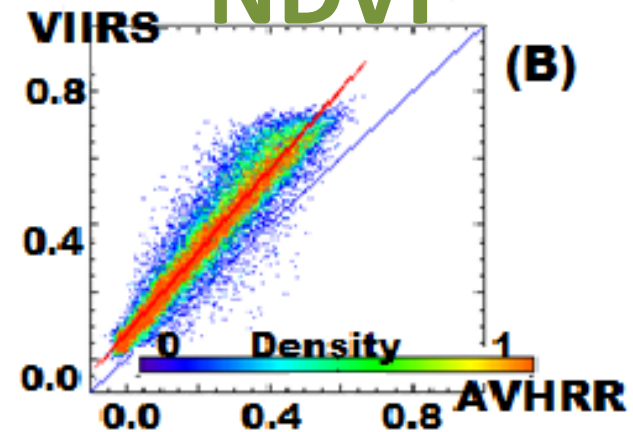
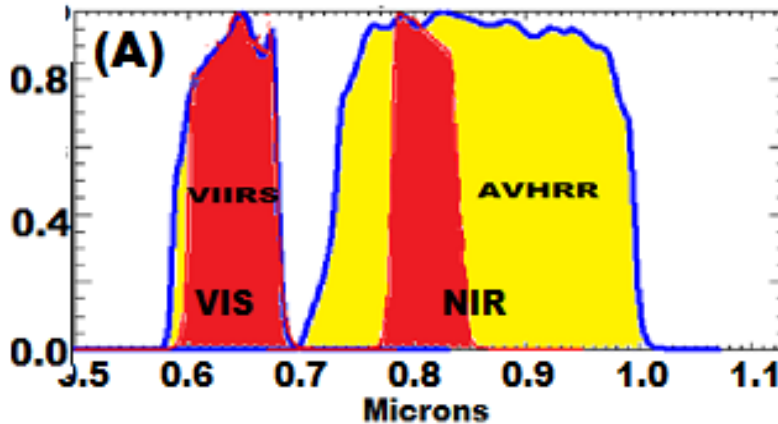
**“the 4km VHI is a very big hit at USDA with senior level staff, economists, and meteorologists. I often get specialized requests for maps of the 4 km VHI “as soon as it’s available”, and the data is used to support our monthly crop yield and production estimates, particularly in the mid-latitudes”**

# VIIRS versus AVHRR

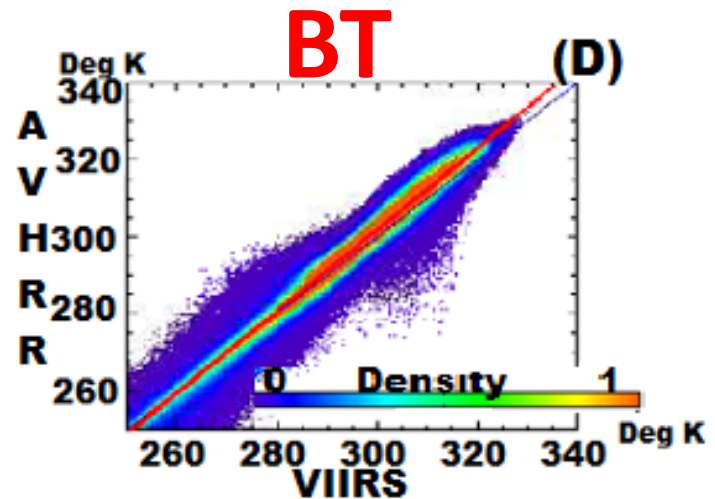
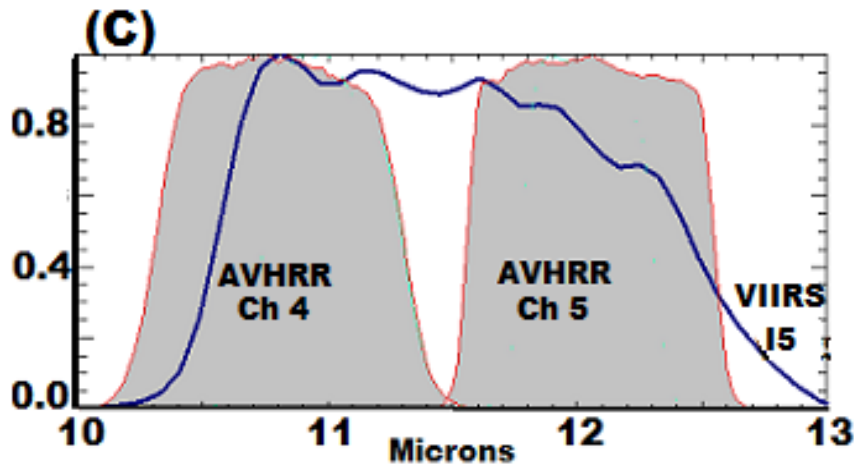
## Channels

Climate data records problems

NDVI



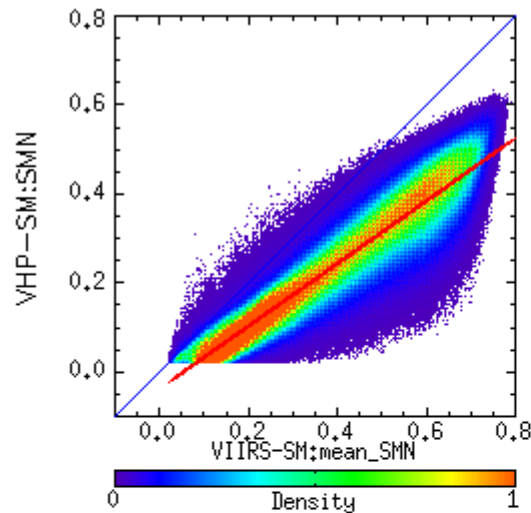
Normalized Difference Vegetation Index (NDVI)



Brightness Teperature (BT)



# NDVI (SMN): AVHRR-VIIRS time series

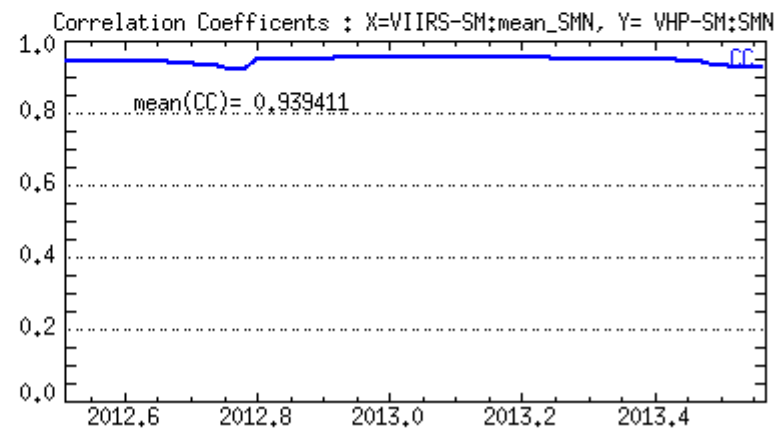
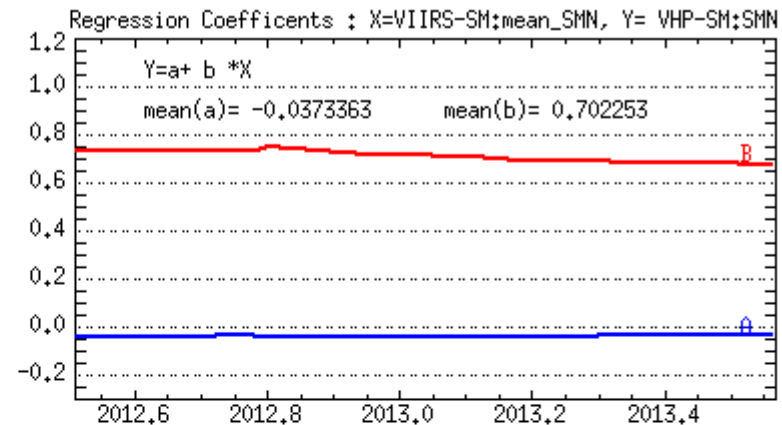


$$Y = a + b * X$$

$a = -0.0374925$   
 $b = 0.703031$

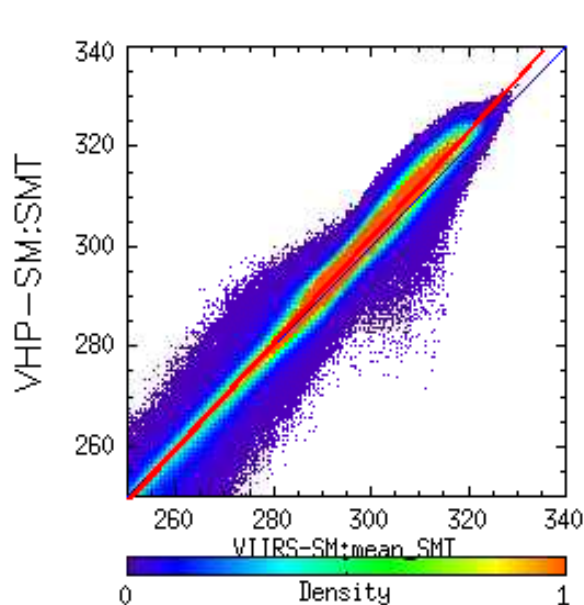
Nsamples=4963003  
CC = 0.9374  
RMSE = 0.0486750

lon=[-180.00, 180.00] lat=[-40.00, 40.00]



Data used: 2012 week 27 to 2013 week 30

# BT (SMT): AVHRR-VIIRS COR and TSer



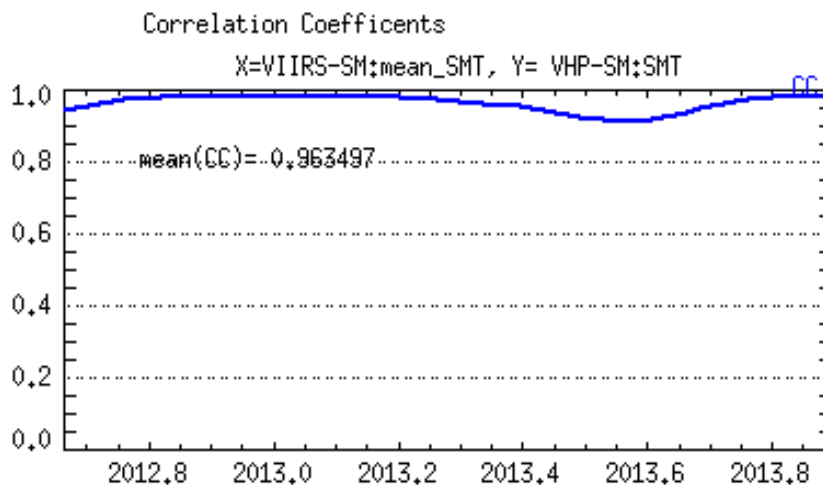
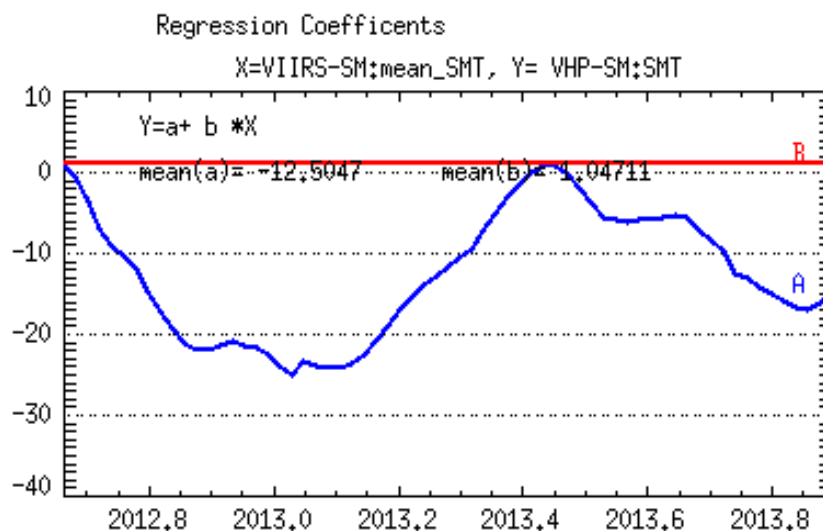
$$Y = a + b * X$$

$$a = -15.3288$$

$$b = 1.05696$$

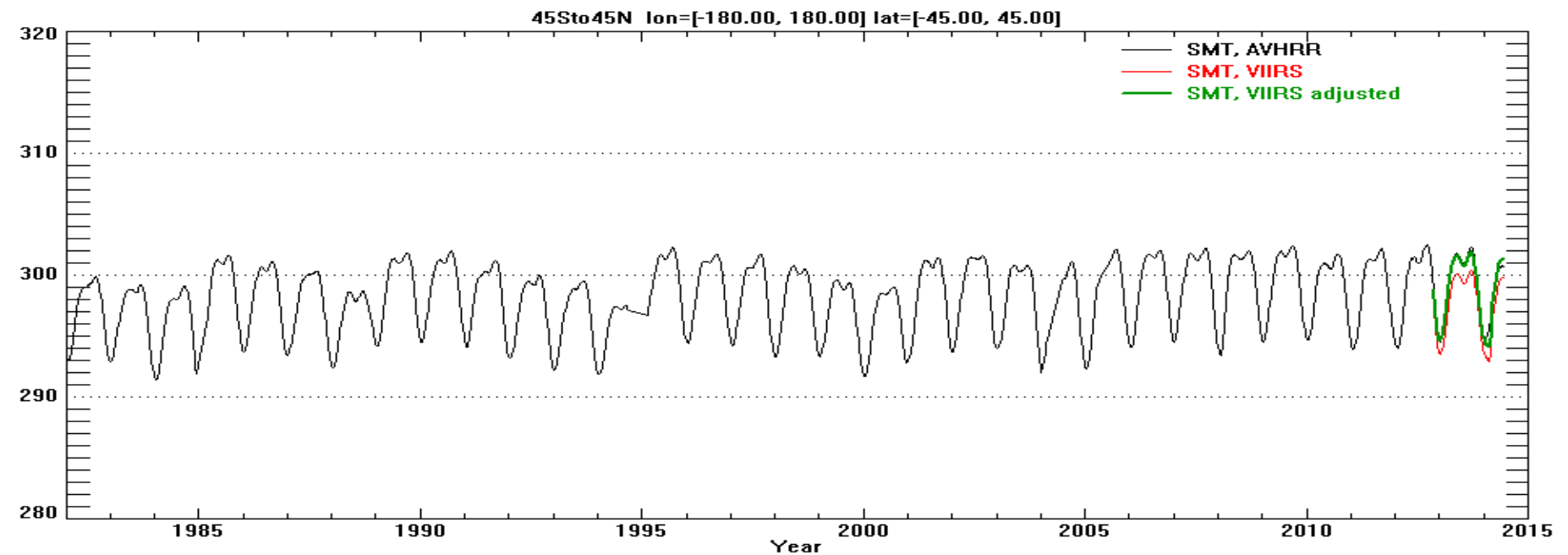
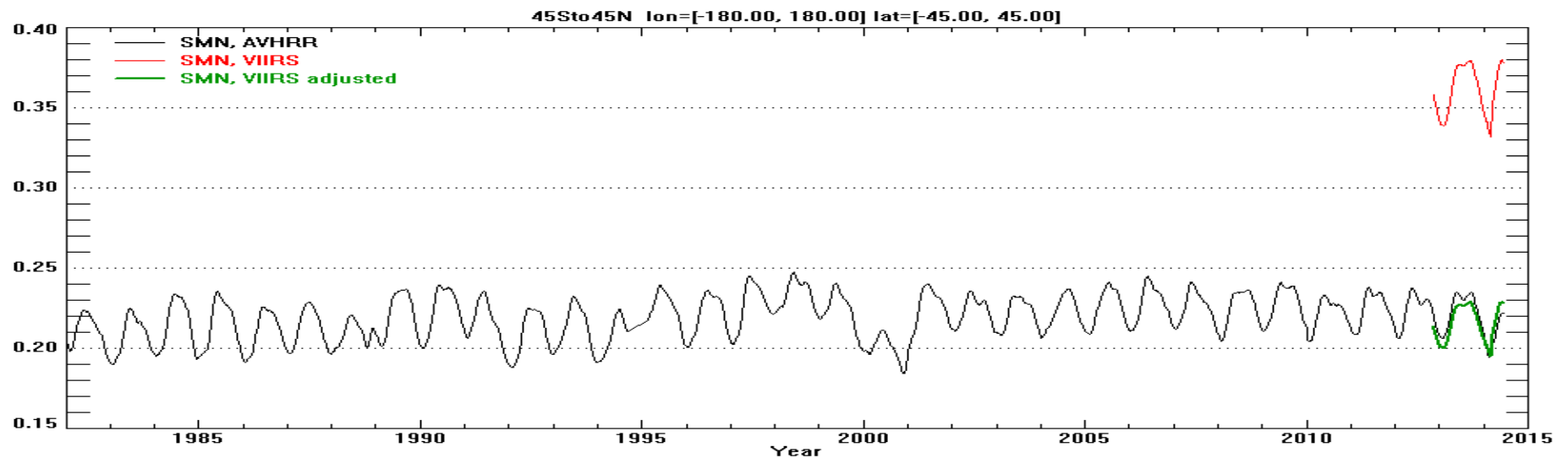
Nsamples=8638092  
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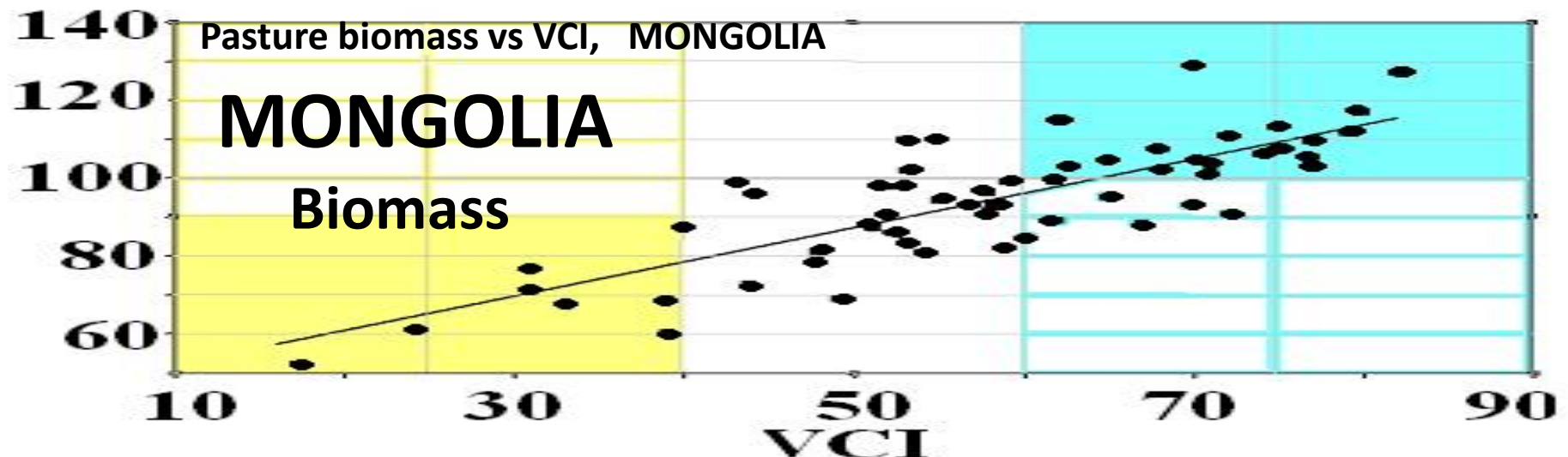
Data used: 2012 week 35 to 2013 week 47

# Towards NDVI & BT Climatology

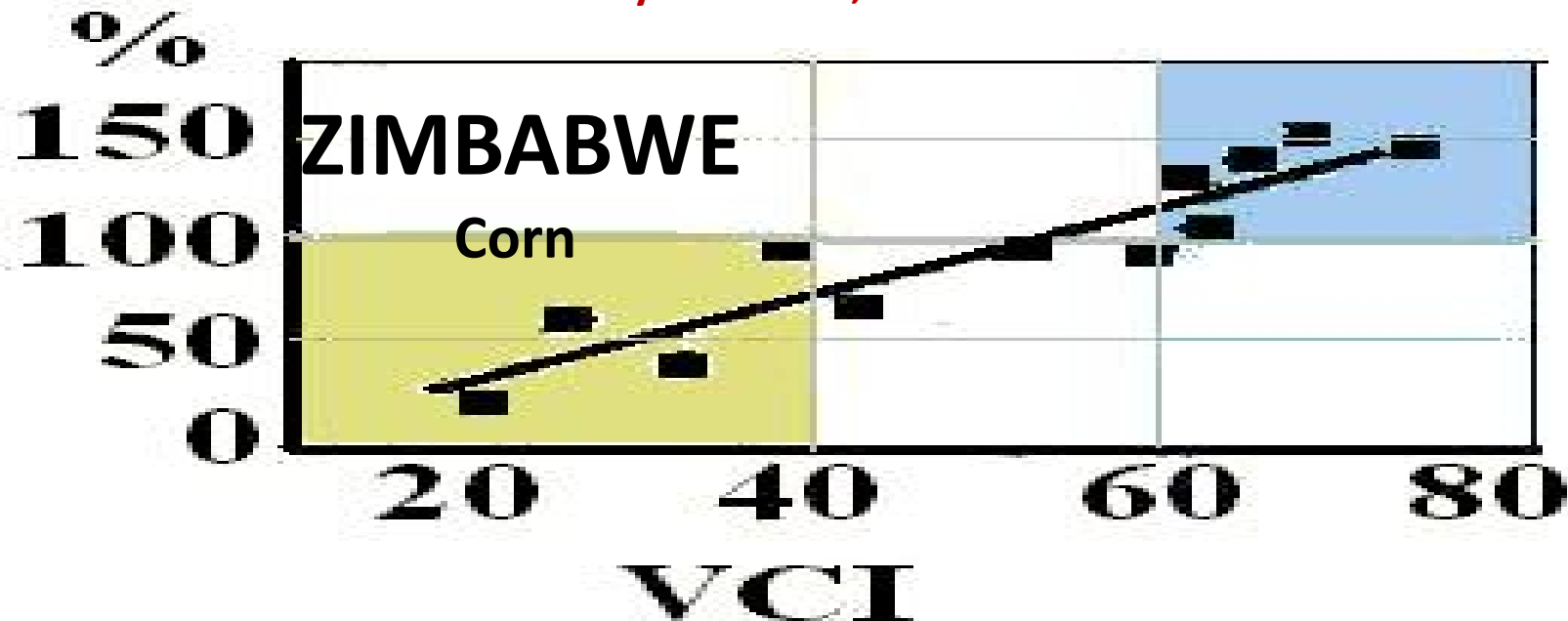




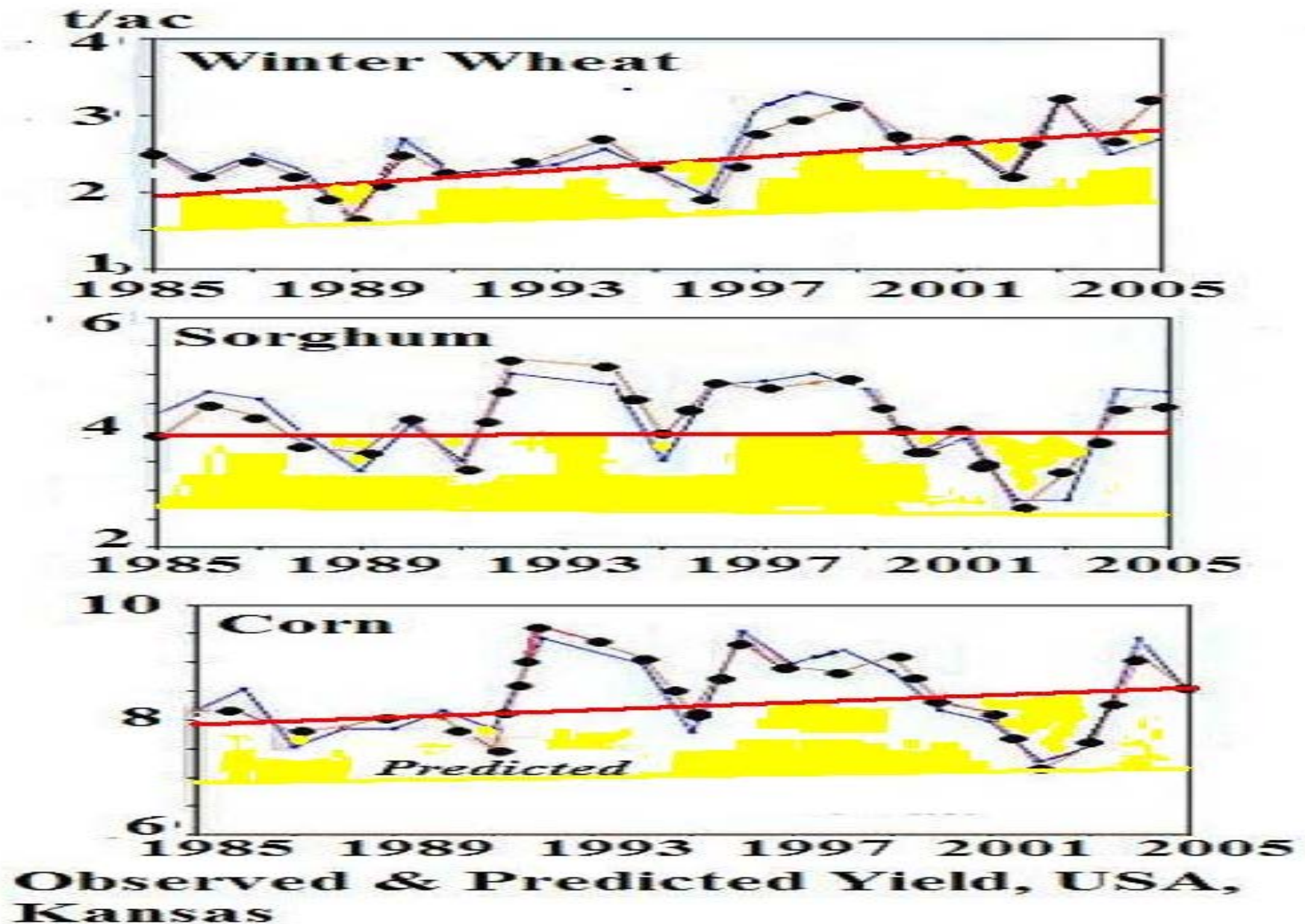
# CAL/VAL: VH-Biomass & Corn Yield Modeling & Prediction



Corn yield vs VCI, ZIMBABWE

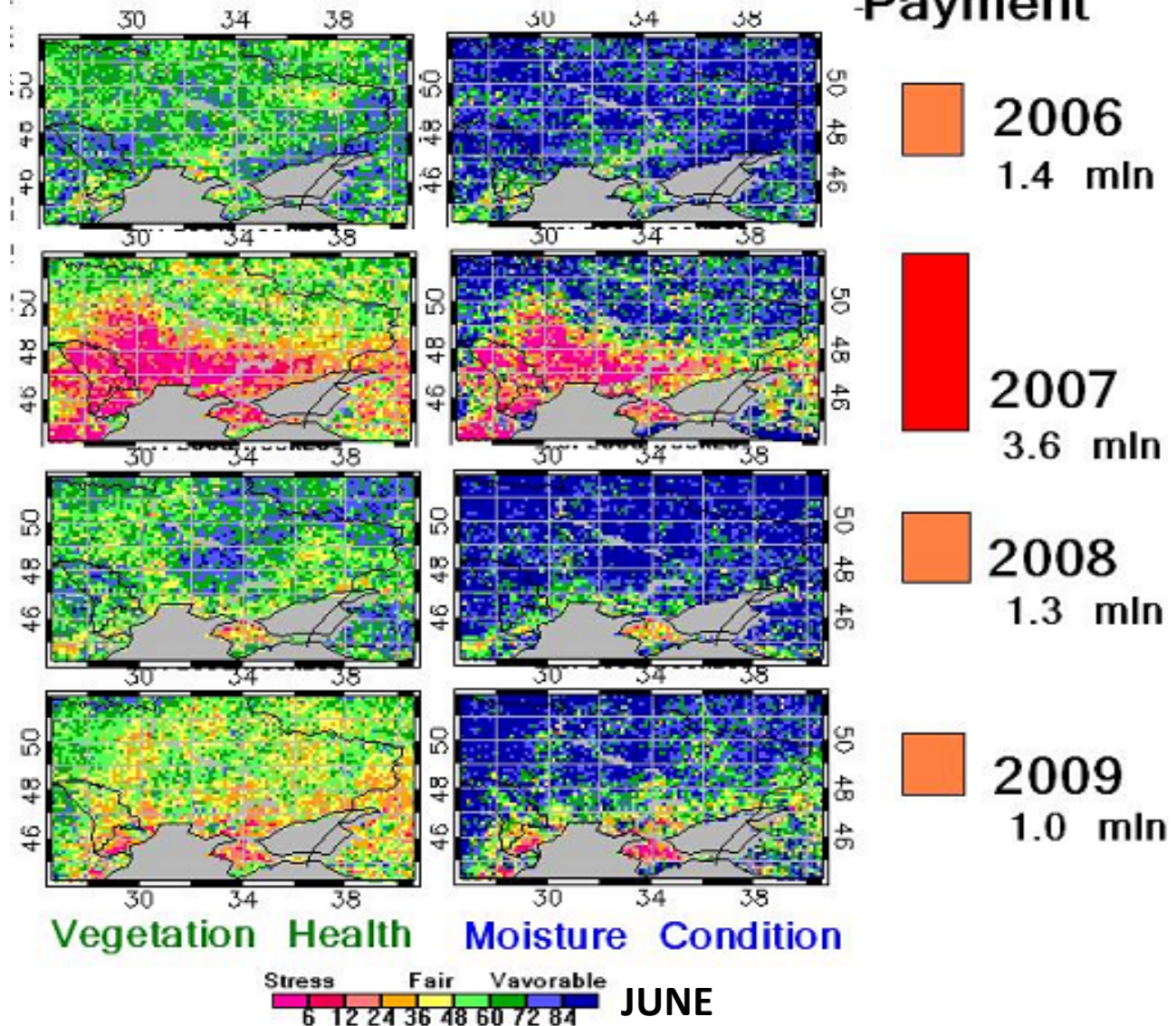


# CAL/VAL: VH-Crop Losses Prediction: USA, Kansas



# AVHRR-based VHI & VCI

## Insurance Payment



## VH-based crop condition & Insurance payment (Grivna), UKRAINE

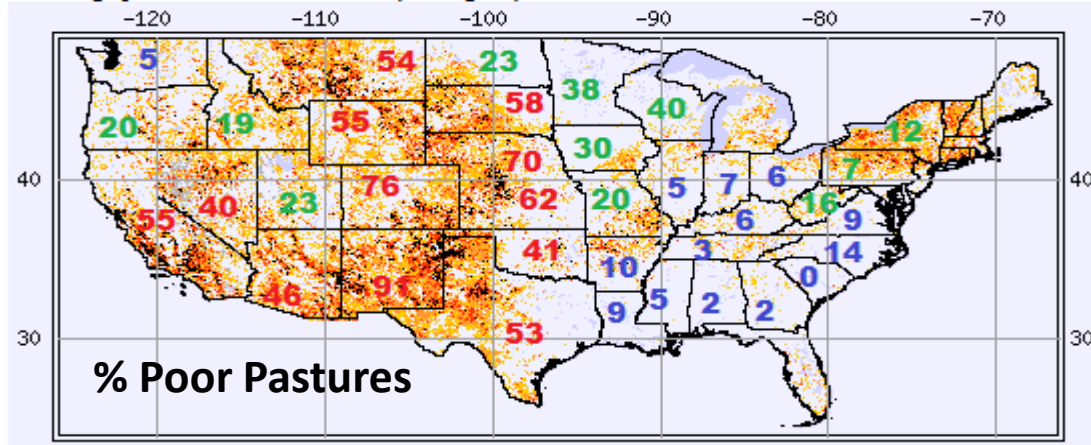
August 10-11, 2010  
San Francisco, CA

Source: NOAA and "Strahovaia Grupa TAC"

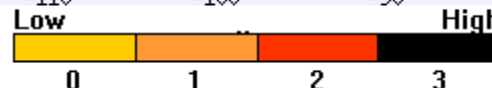
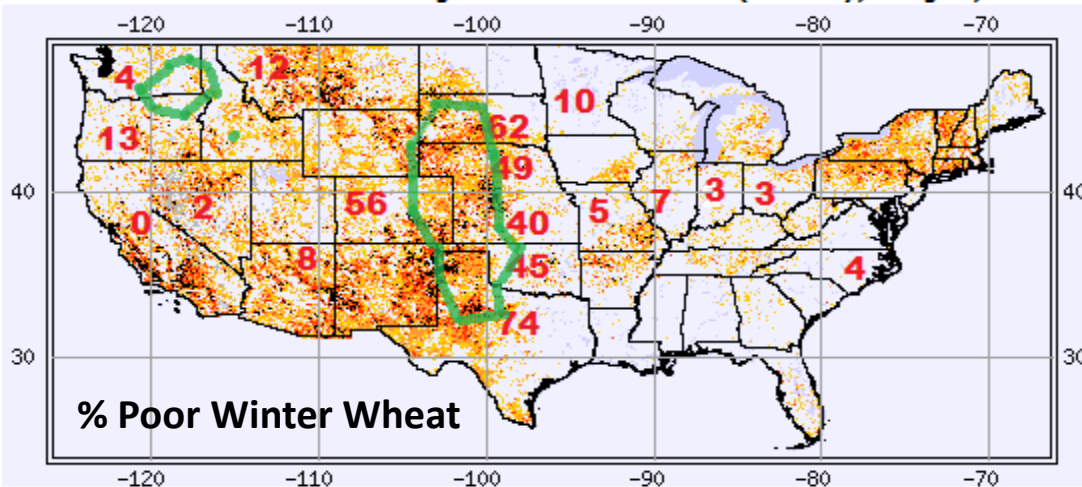


# VHP-drought stress & USDA pasture & winter wheat condition, May 6, 2013

**VH-based Drought Stress & % state with pasture & range land in poor & very poor conditions, May 6, 2013**

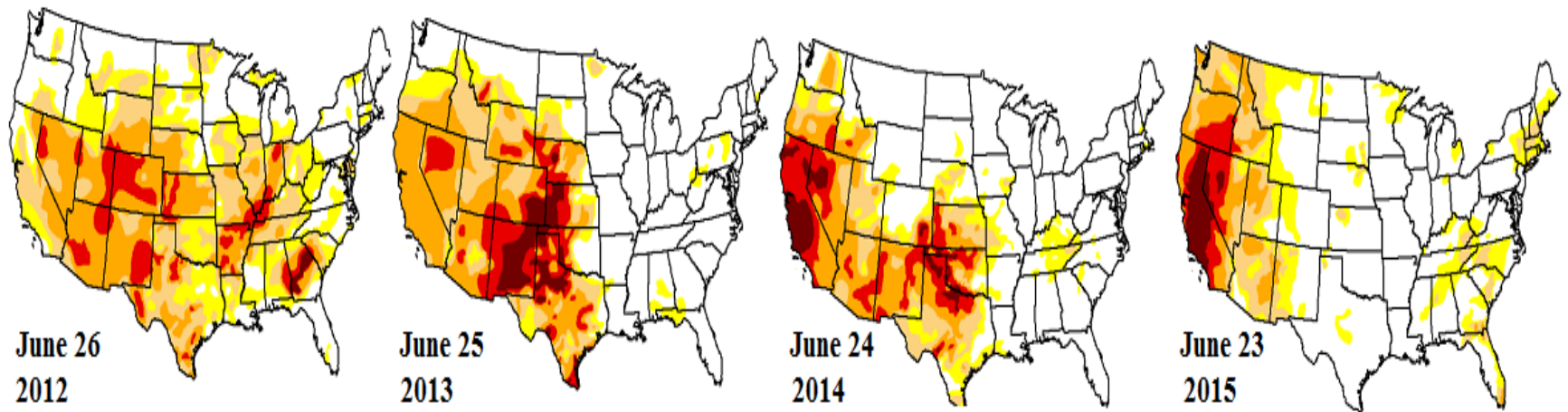


**VH-based Drought Stress (NOAA), May 6, 2013 & Percent Winter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013**

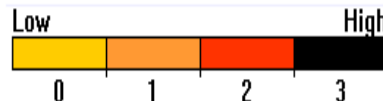
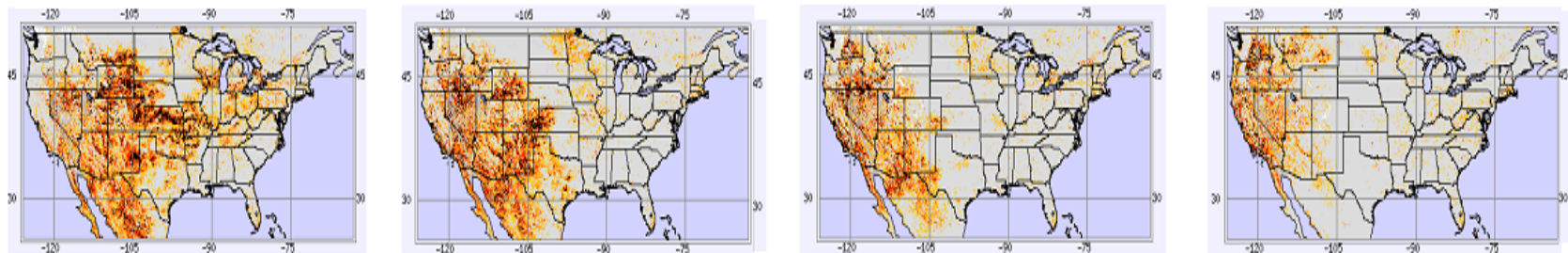


Winter Wheat (hard, soft & white) major area

# USA Drought from USDM & VHI

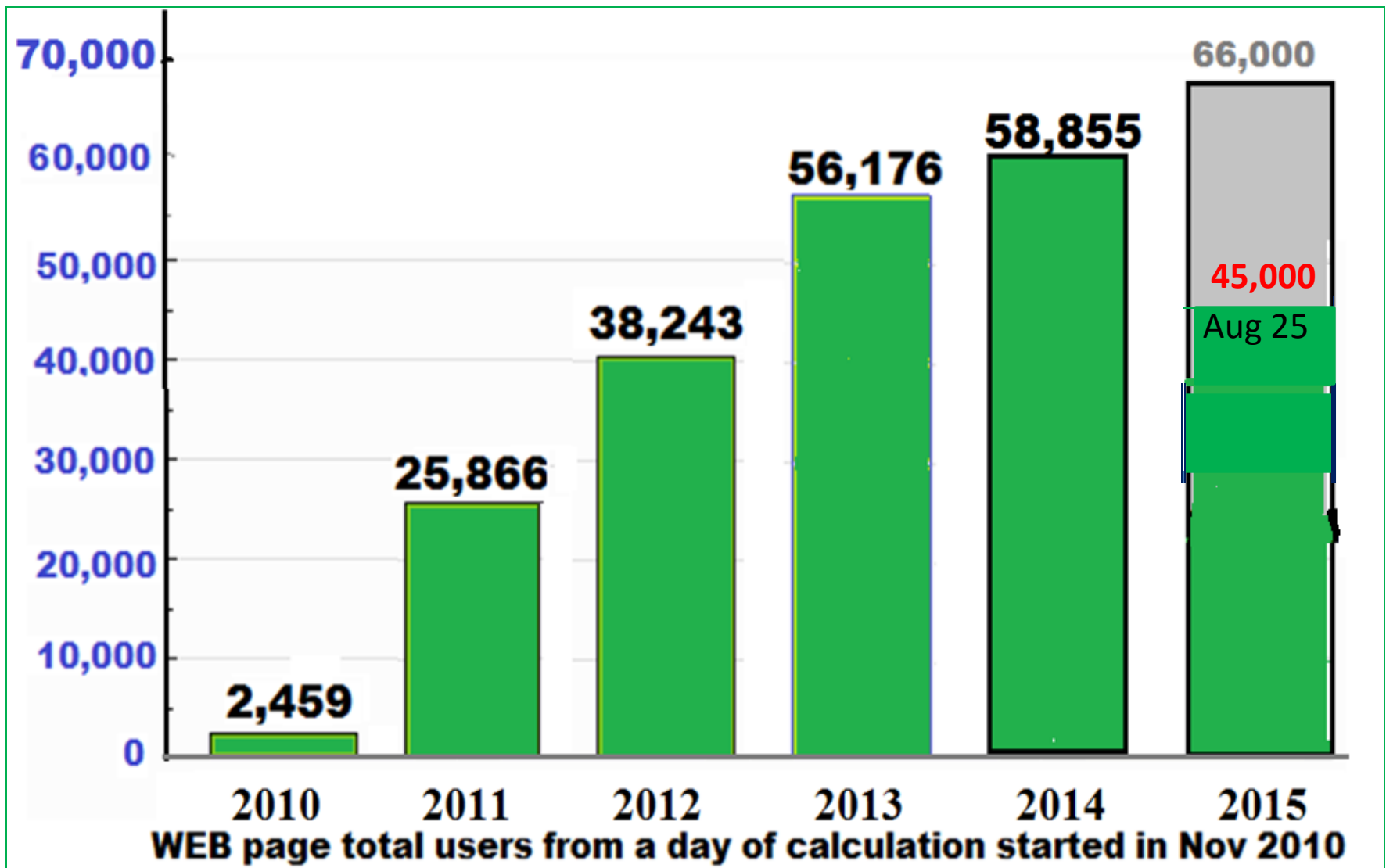


**Drought from US Drought Monitor (USDM)**



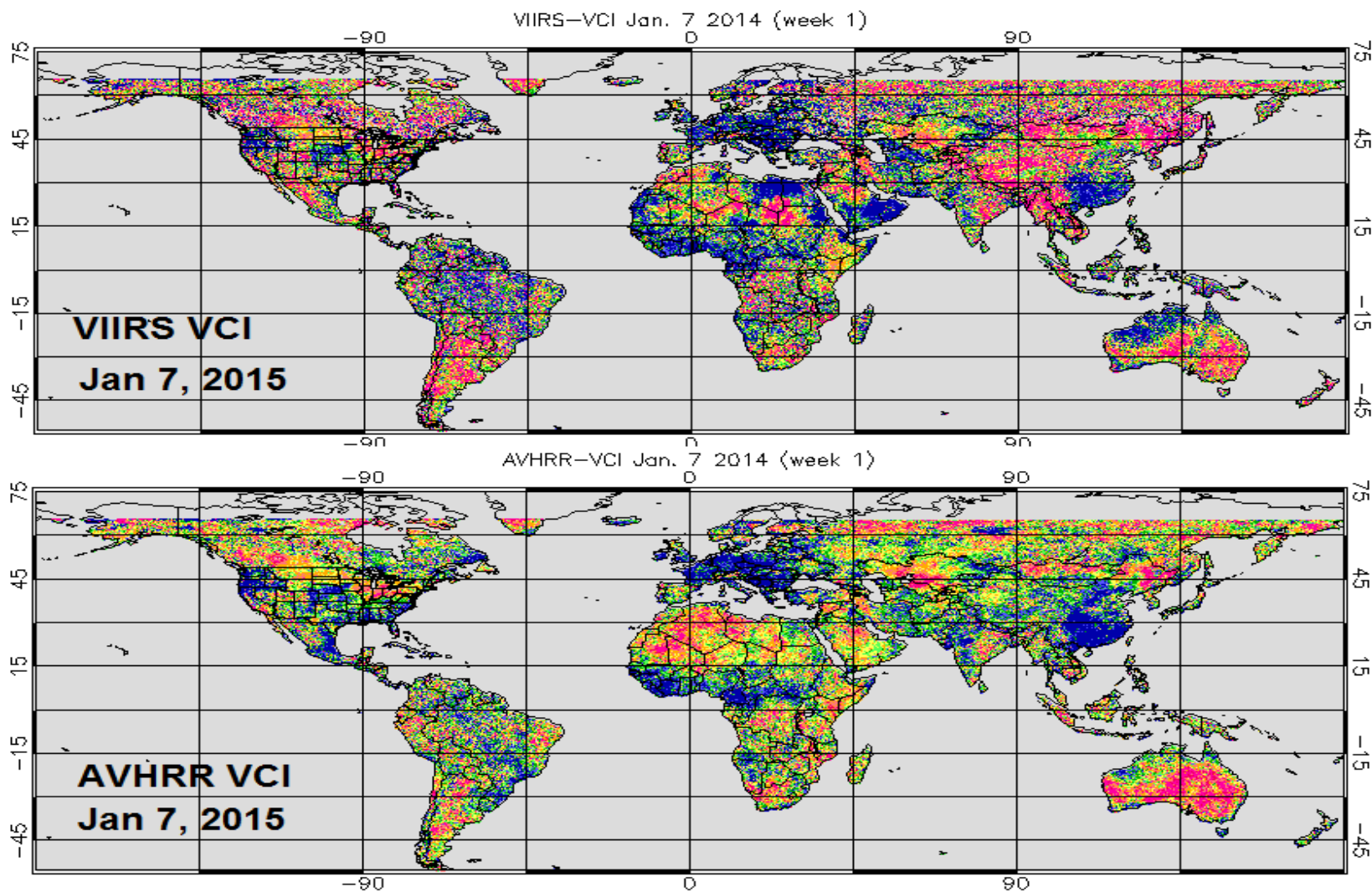
**Drought from NOAA-19/AVHRR Vegetation health index (VHI)**

# Users attending Vegetation Health WEB



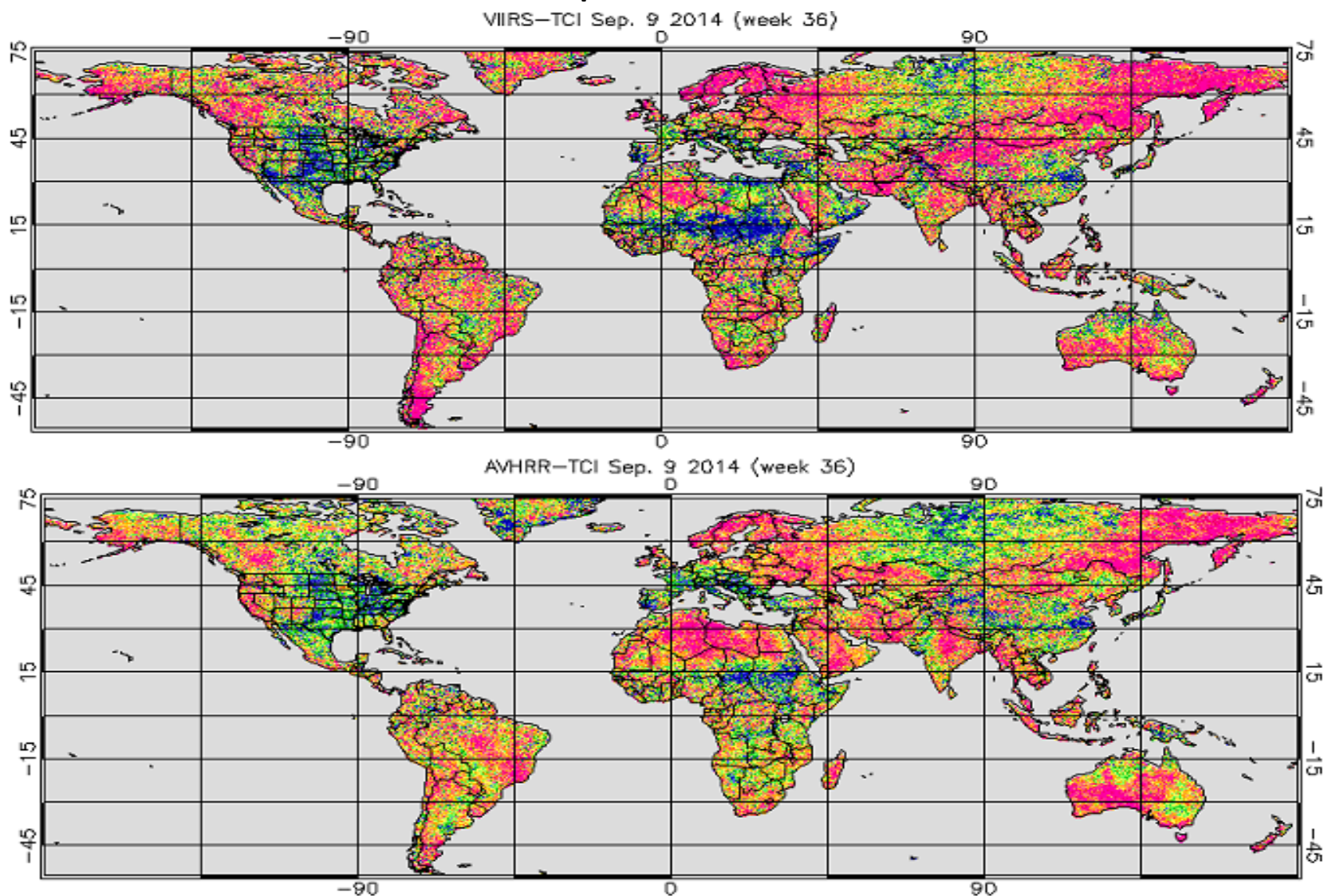
<http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php>

# VALIDATION: VCI/VIIRS vs VCI/AVHRR

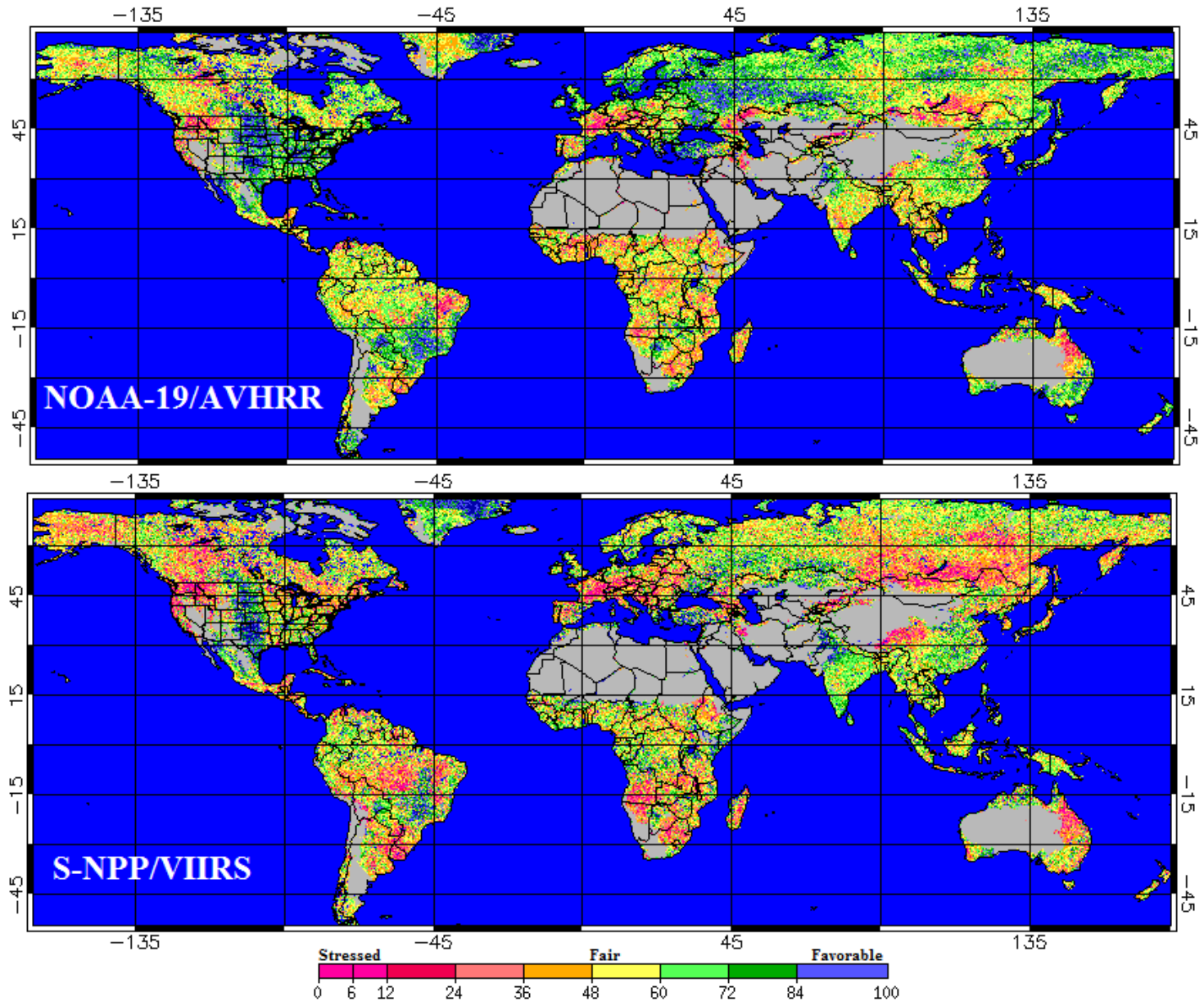




# VALIDATION: TCI VIIRS vs AVHRR Sep 9, 2014



# Vegetation health (VHI)

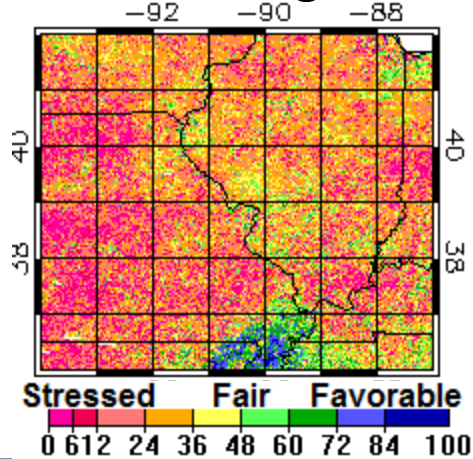


VEGETATION HEALTH, August 6, 2015

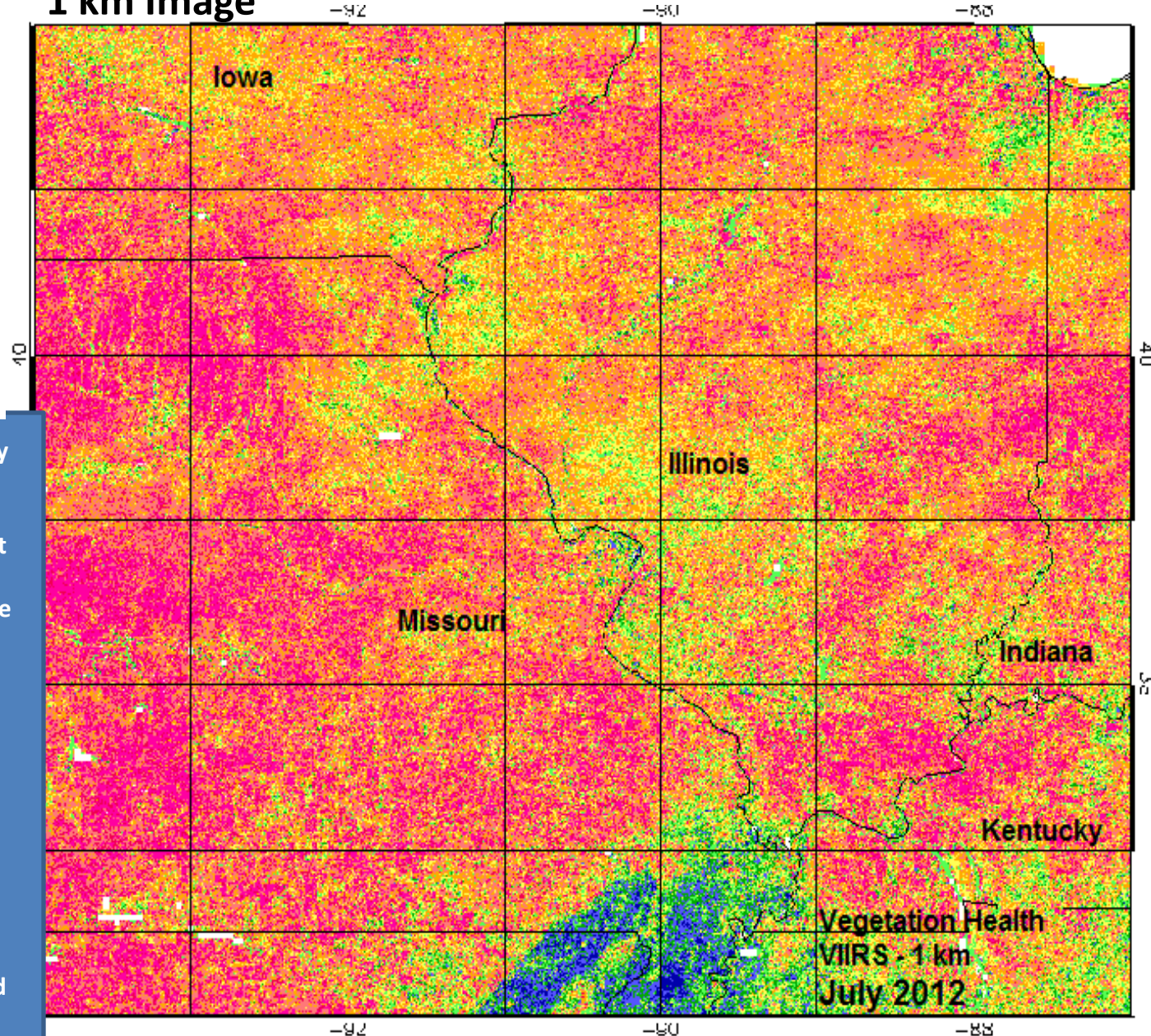


# SNPP/VIIRS VHI & DROUGHT, USA Midwest, July 2012

## 4 km Image



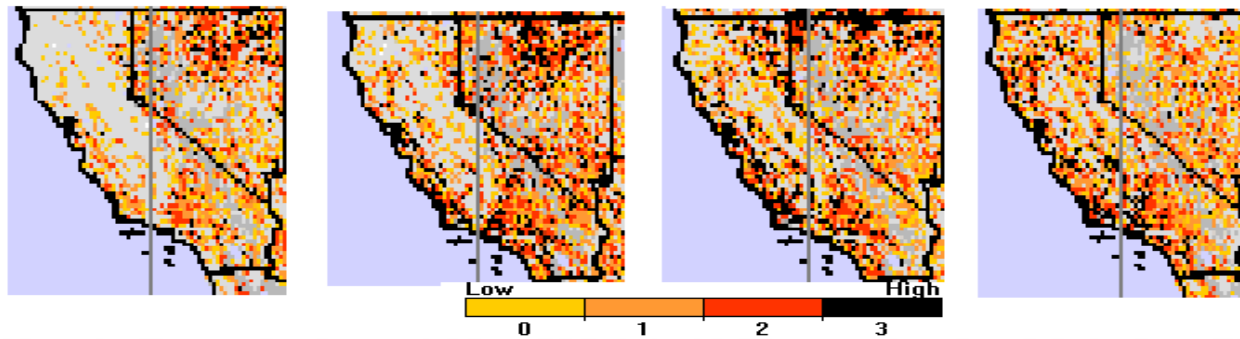
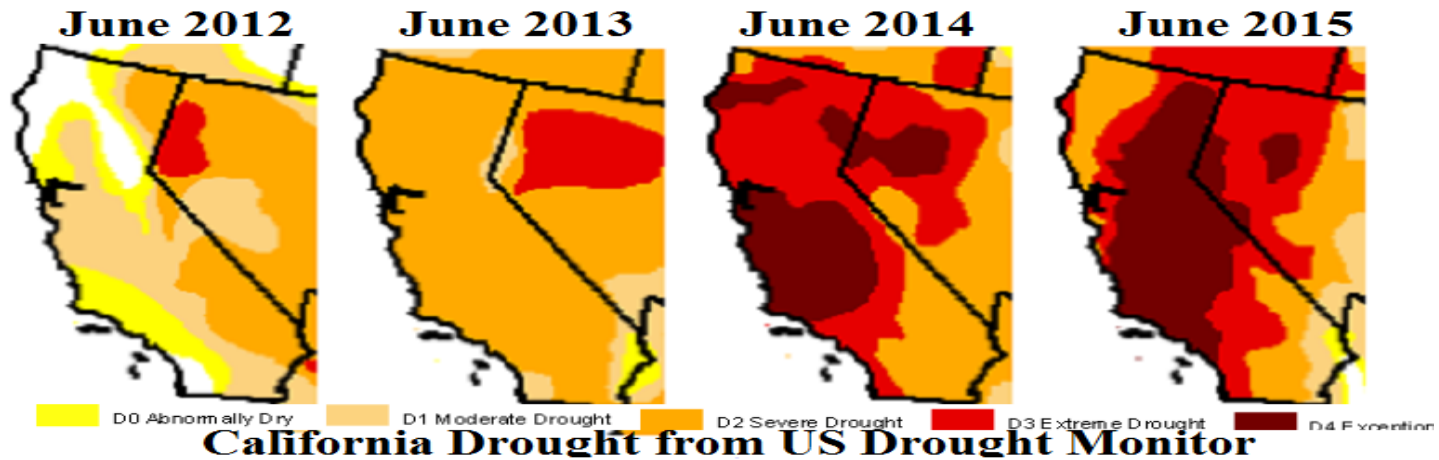
## 1 km Image



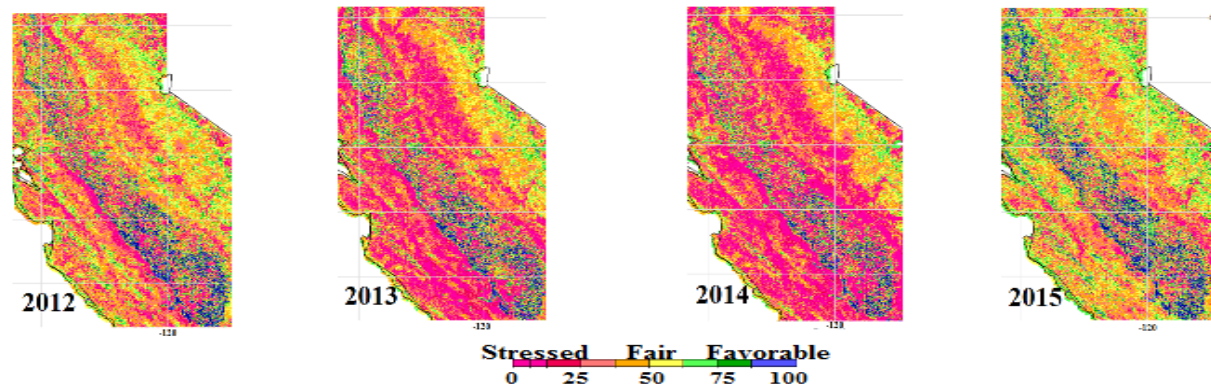
- Drought affects Global Food Security by reducing agricultural production below consumption.
- Since 2000, this occurred 8 years out of 13.
- Early drought detection and accurate monitoring its area, intensity, duration & impacts is important for mitigation drought consequences.
- Vegetation health(VH) method applied to SNPP/VIIRS data greatly improve drought watch & impact assessment.
- The two images showing similar patterns, indicate much more details of drought/no drought areas along the rivers: at the background of drought (red) no drought (yellow and green) is observed along the rivers (western part of 1 km image).



# California Drought from USDM & VHI



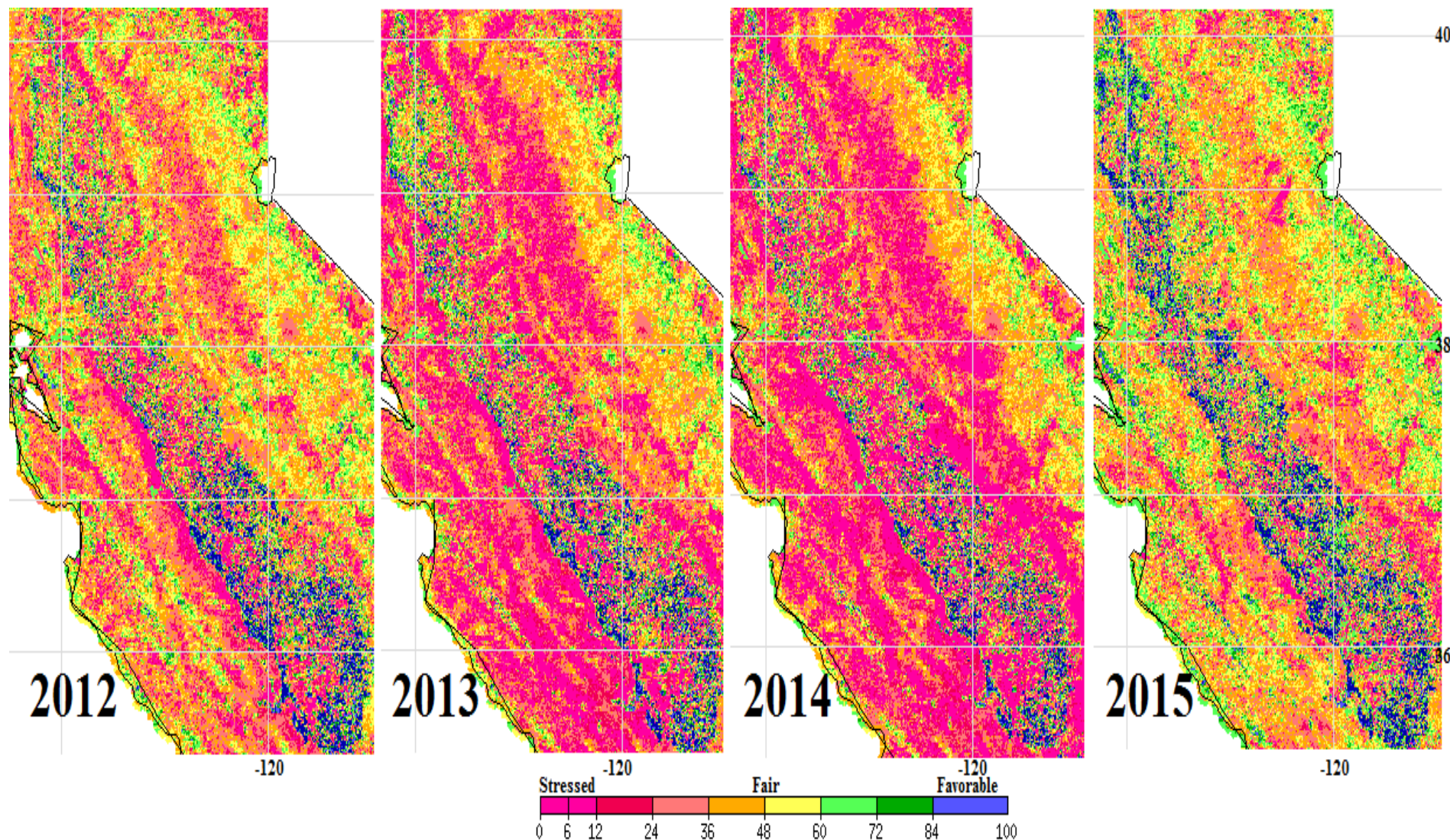
**California Drought from 16 km NOAA-19 Vegetation health index (VHI)**



**California Drought from 0.5 km S-NPP/VIIRS Vegetation health index**



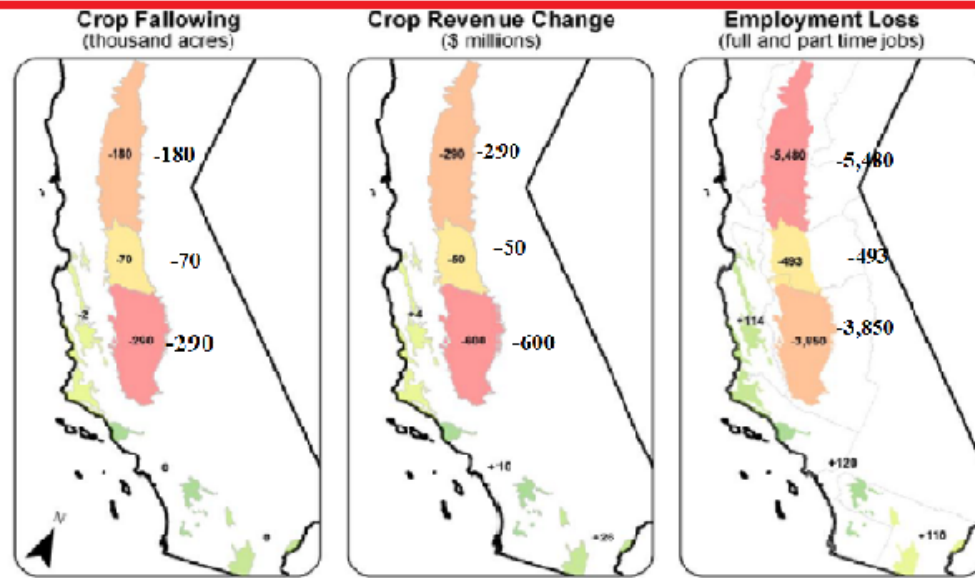
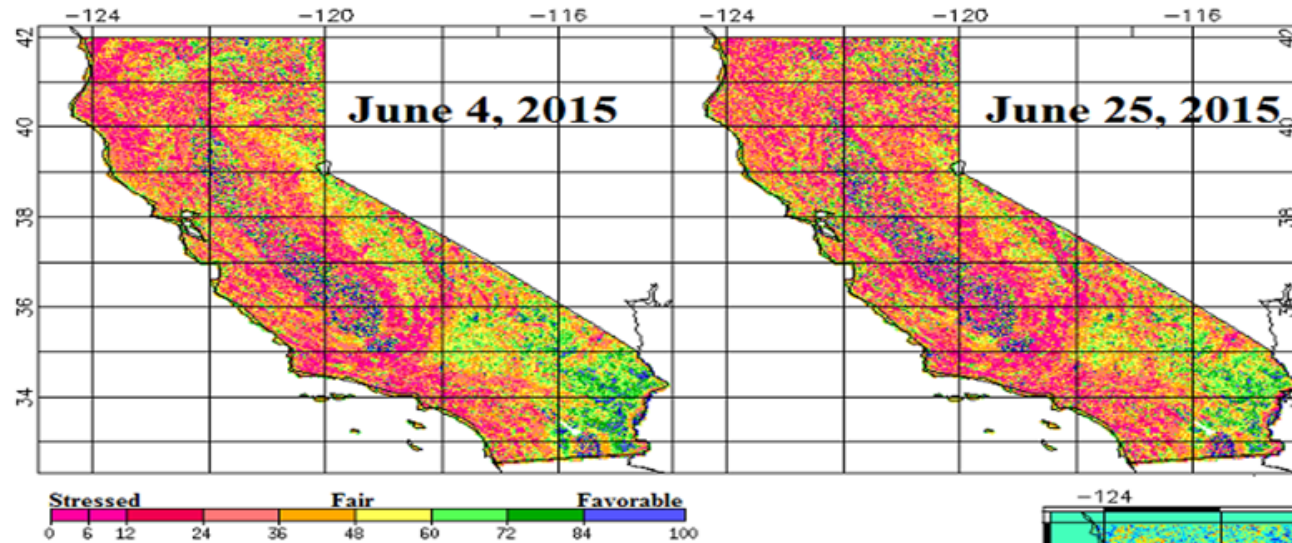
# S-NPP/VIIRS Vegetation Health



**S-NPP/VIIRS-500m Vegetation health, June 12, USA, California, Central Valley**

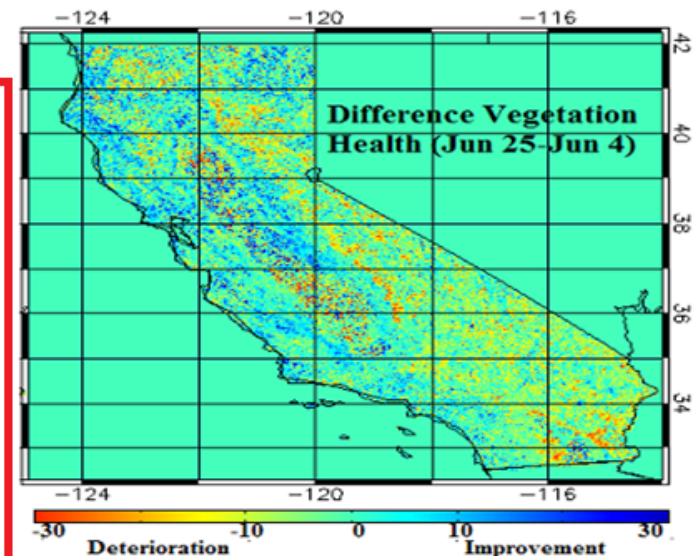


# California Drought Dynamics & Economic Impacts in 2015



## Economic Impacts of California Drought

Howitt R., D. MacEwan, J. Medellín-Azura, J. Lund & D. Sumner 2015. Economic Analysis of the 2015 Drought for California Agriculture. UC Davis Center for Watershed Science, University of California Davis, Davis, CA, 16 pp.



## Difference Vegetation Health

June 25 - June 4

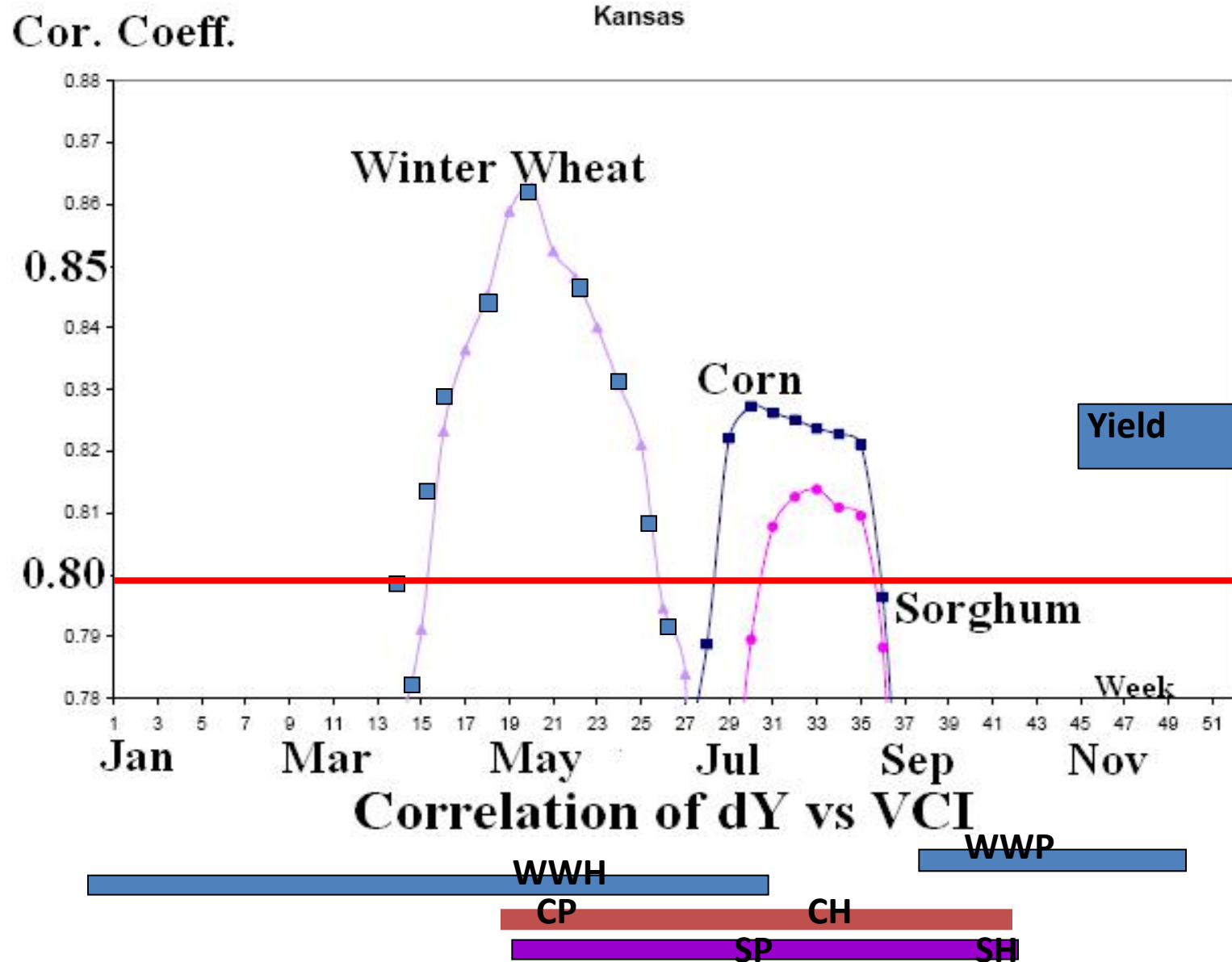
# SUMMARY

- **VH algorithm requires NDVI & BT:**
  - (a) **Real time (from VIIRS)**
  - (b) **Climatology (from AVHRR)**
- **VIIRS/VH indices (VHI, VCI & TCI) are validated against AVHRR/VH because AVHRR's VH are validated against in situ data**
- **VIIRS/ NDVI & BT are different than AVHRR**
- **VIIRS/NDVI & BT are adjusted to AVHRR (in order to use climatology)**
- **The adjustments are stable over time and correlation is strong**
- **FURTHER Development:**
  - (a) **New climatology from VIIRS**
  - (b) **High resolution VH**
  - (c) **New VH products**

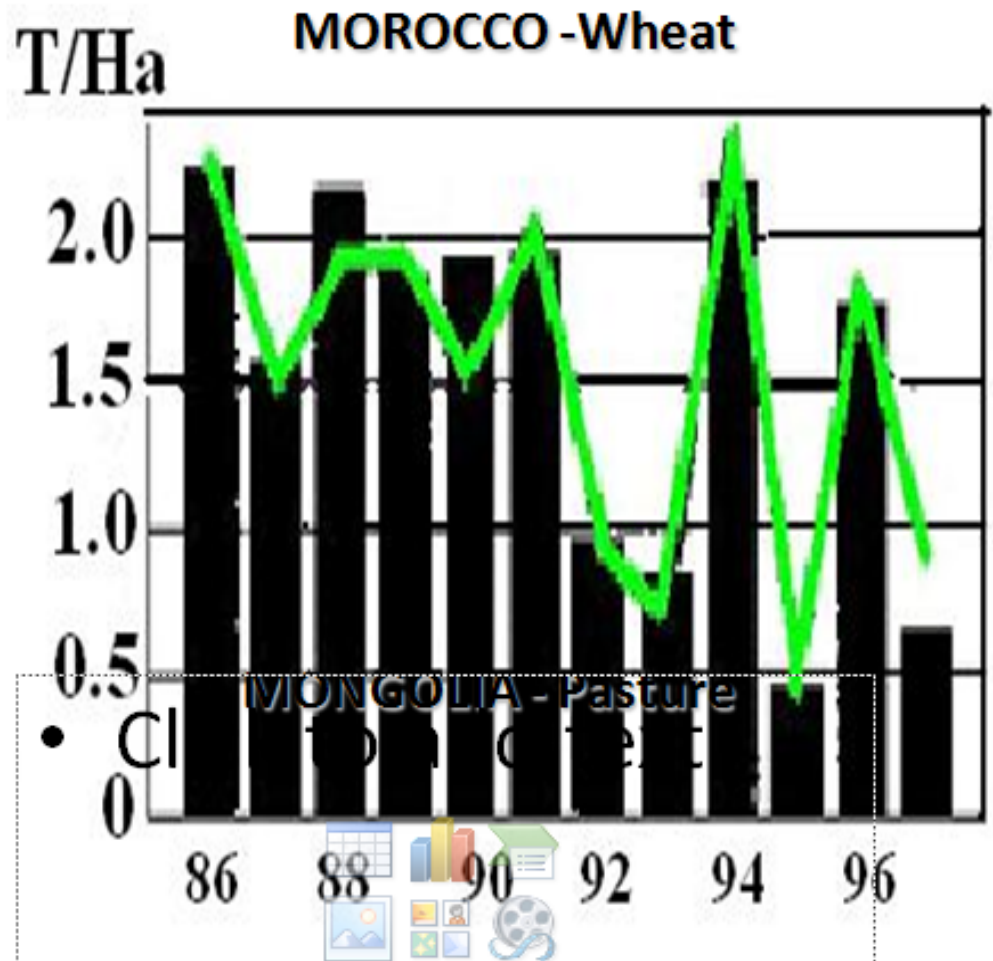
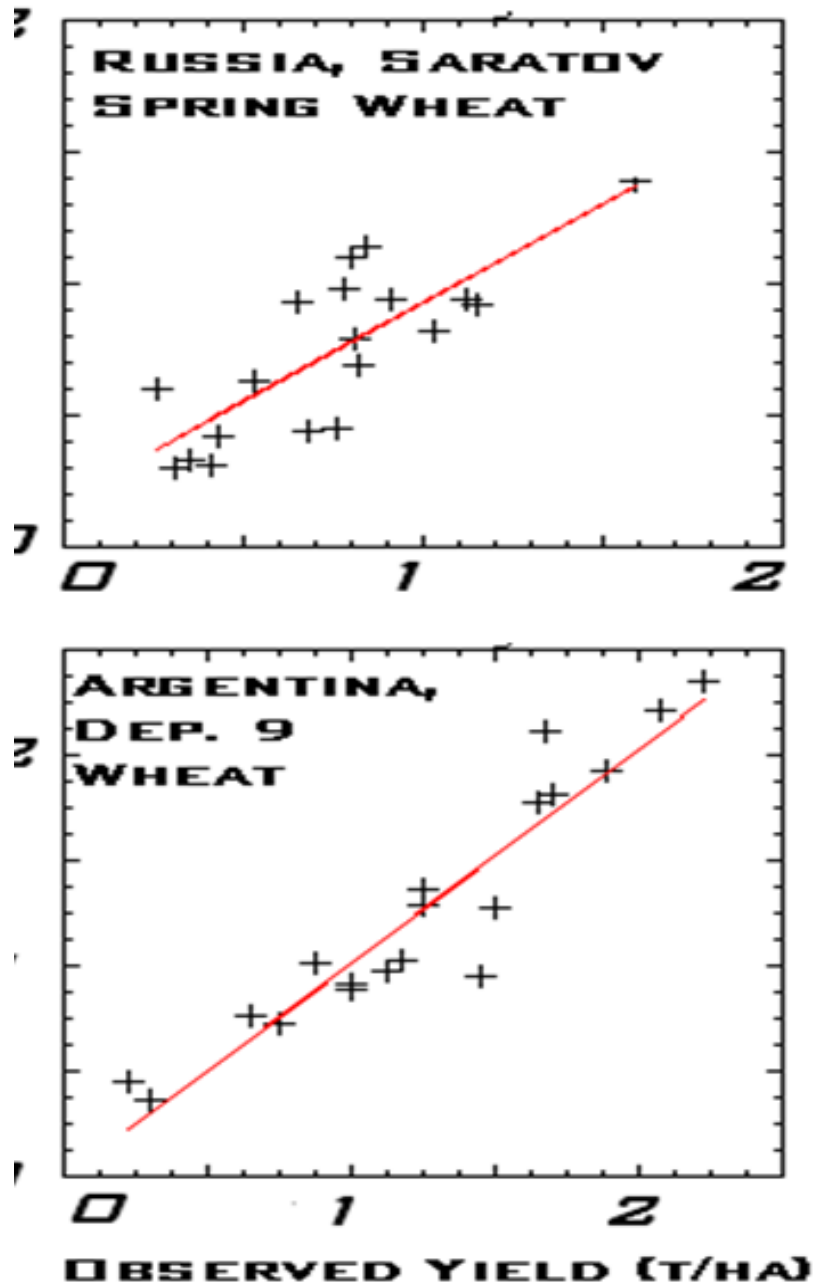


**BACK UP**

# Correlation: Yield anomaly (dY) vs VCI, Kansas, USA



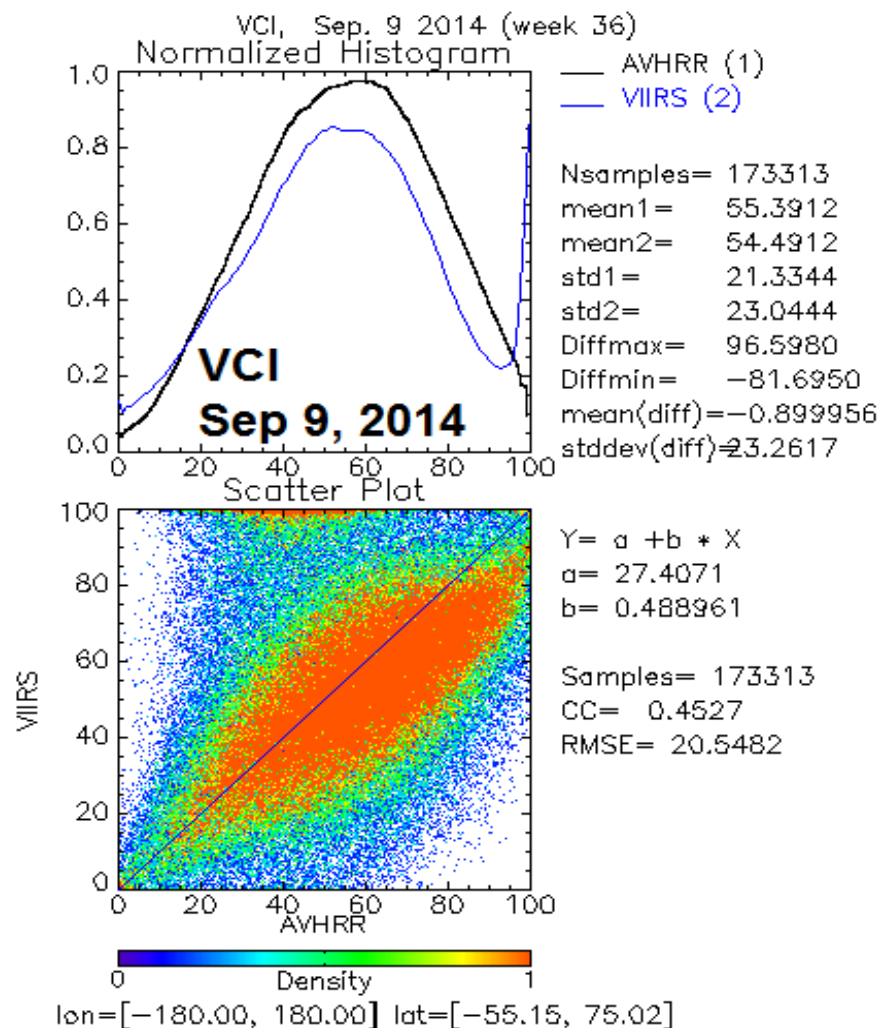
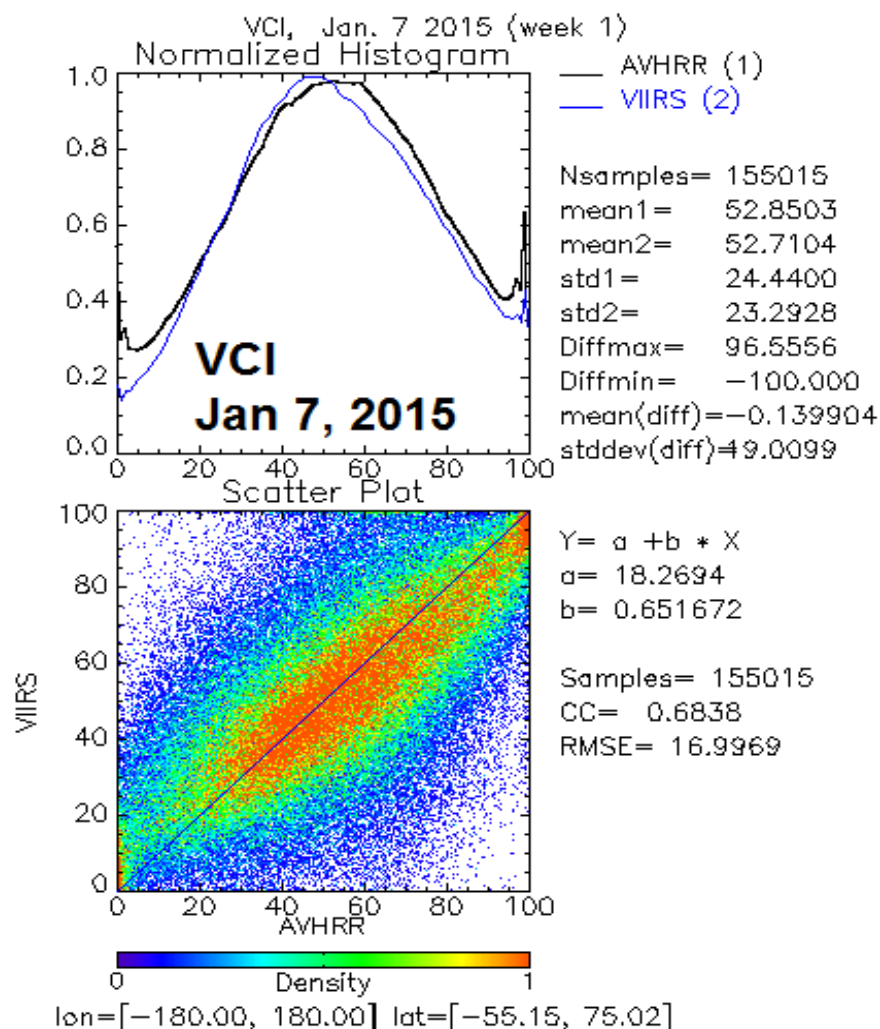
# AVHRR/VH-Crop Yield Correlation



# Validation: VCI

## Correlation of VIIRS & AVHRR

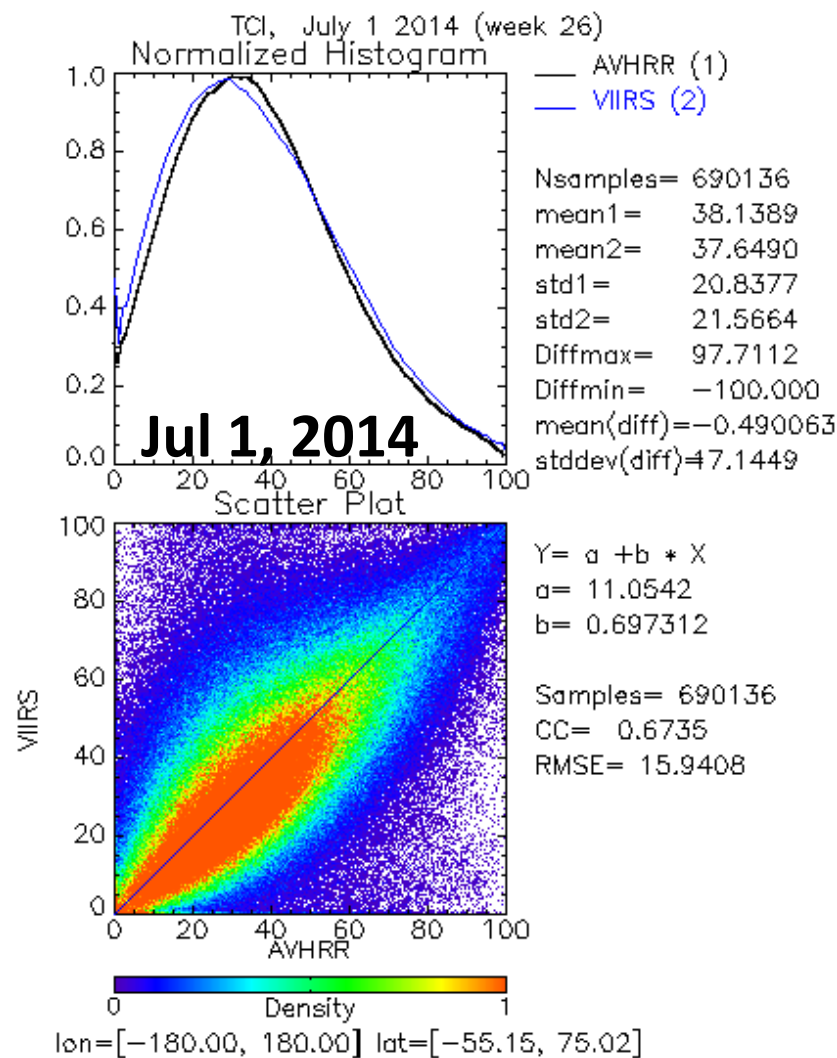
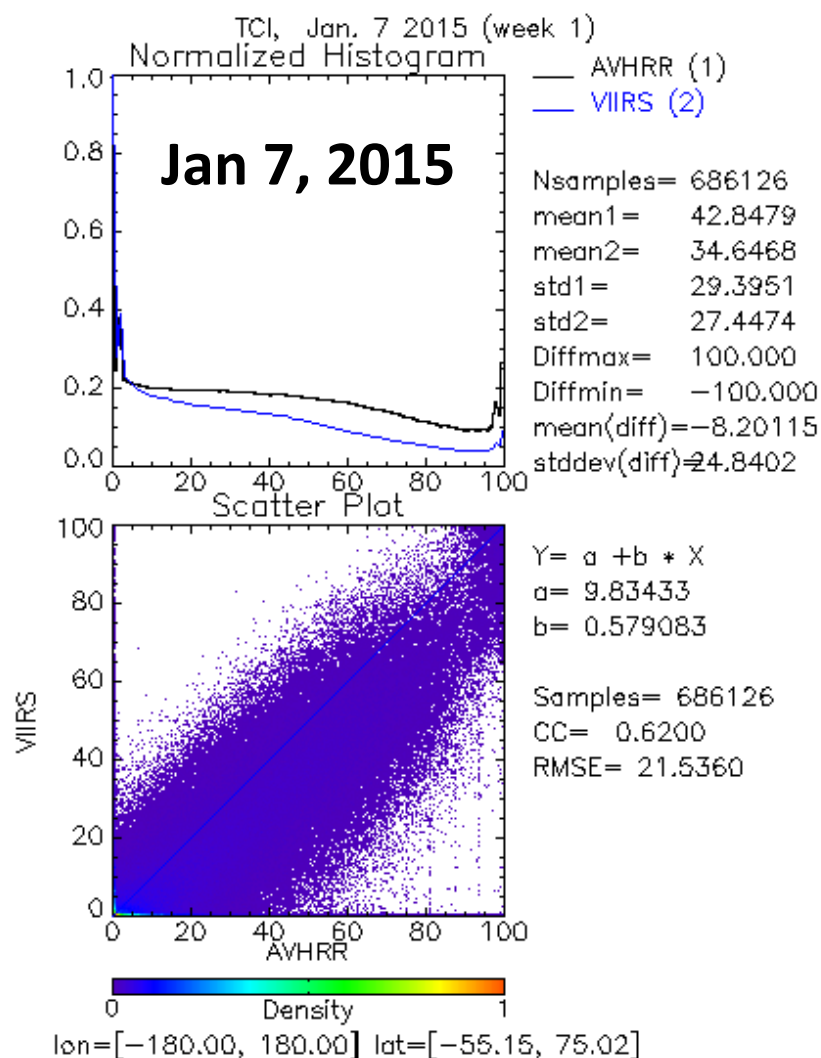
### Jan 7, 2015 & Sep 9, 2014



# Validation: TCI

## Correlation of VIIRS & AVHRR

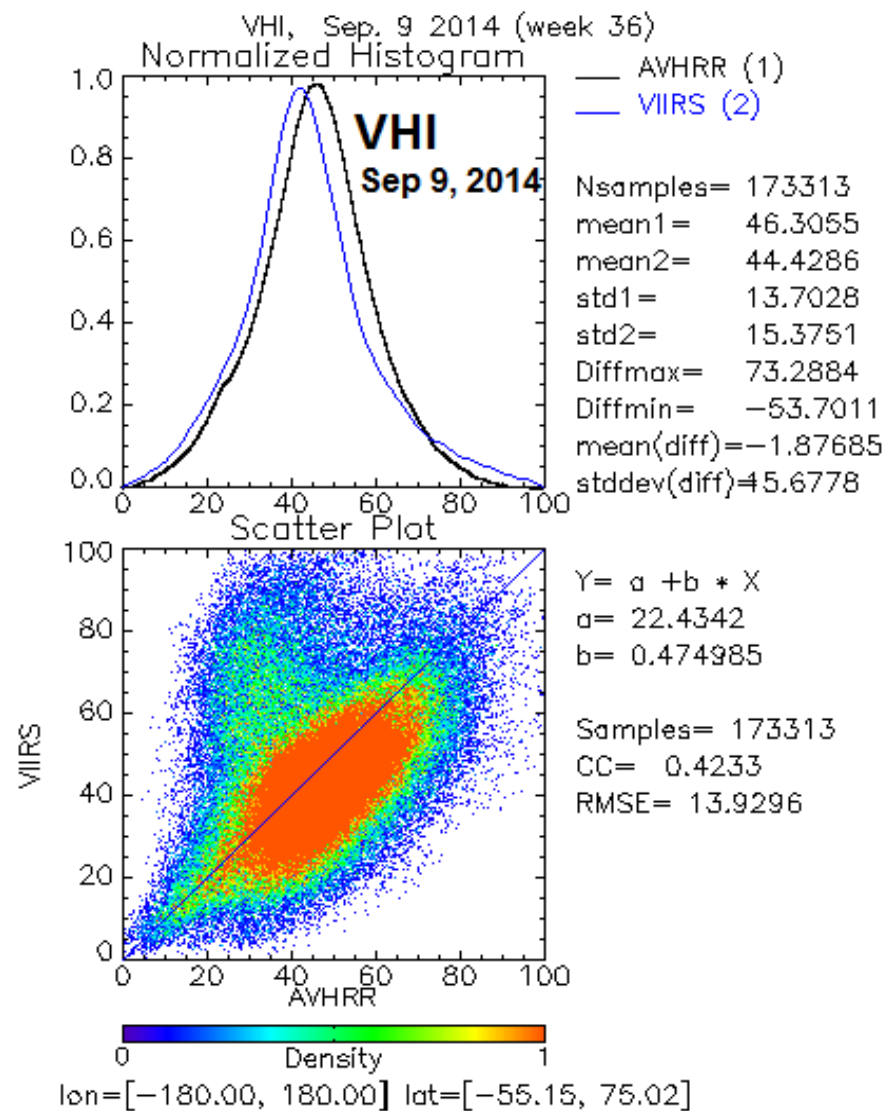
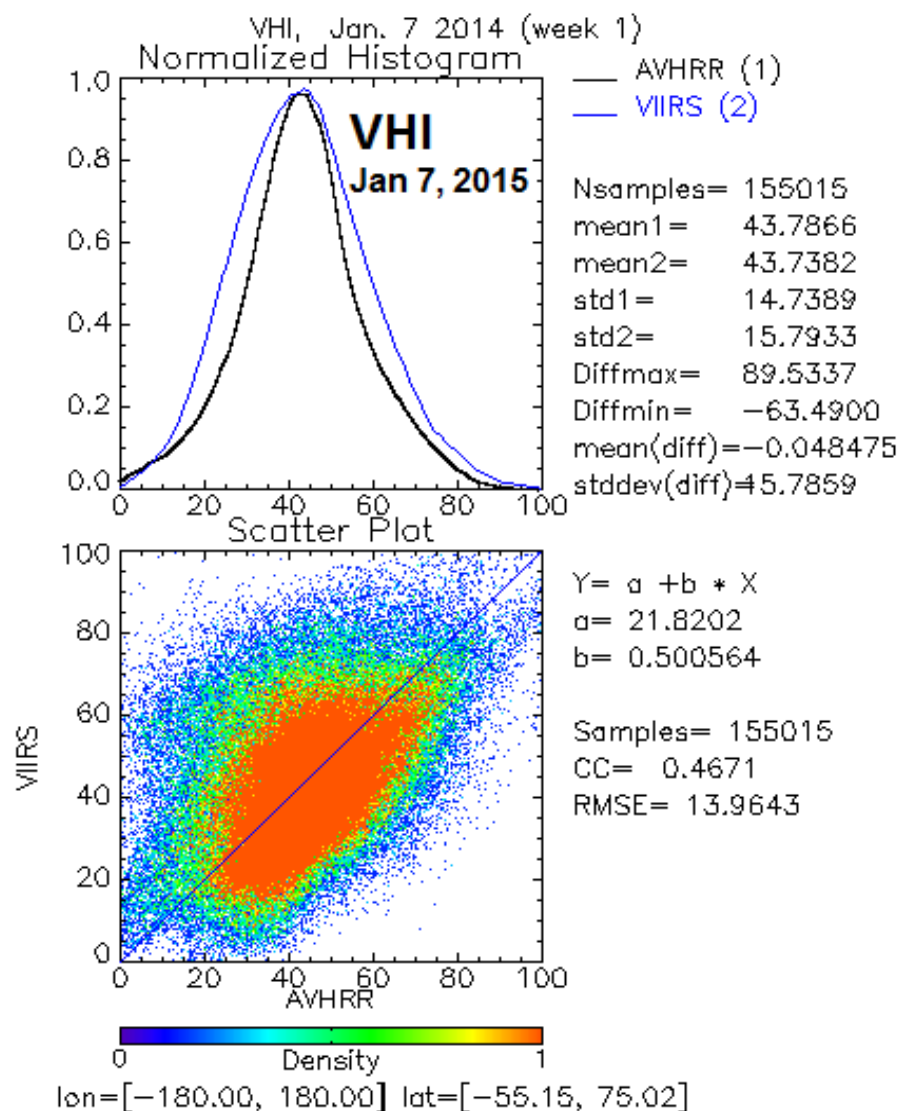
### Jan 7, 2015 & Jul 1, 2014



# Validation: VHI

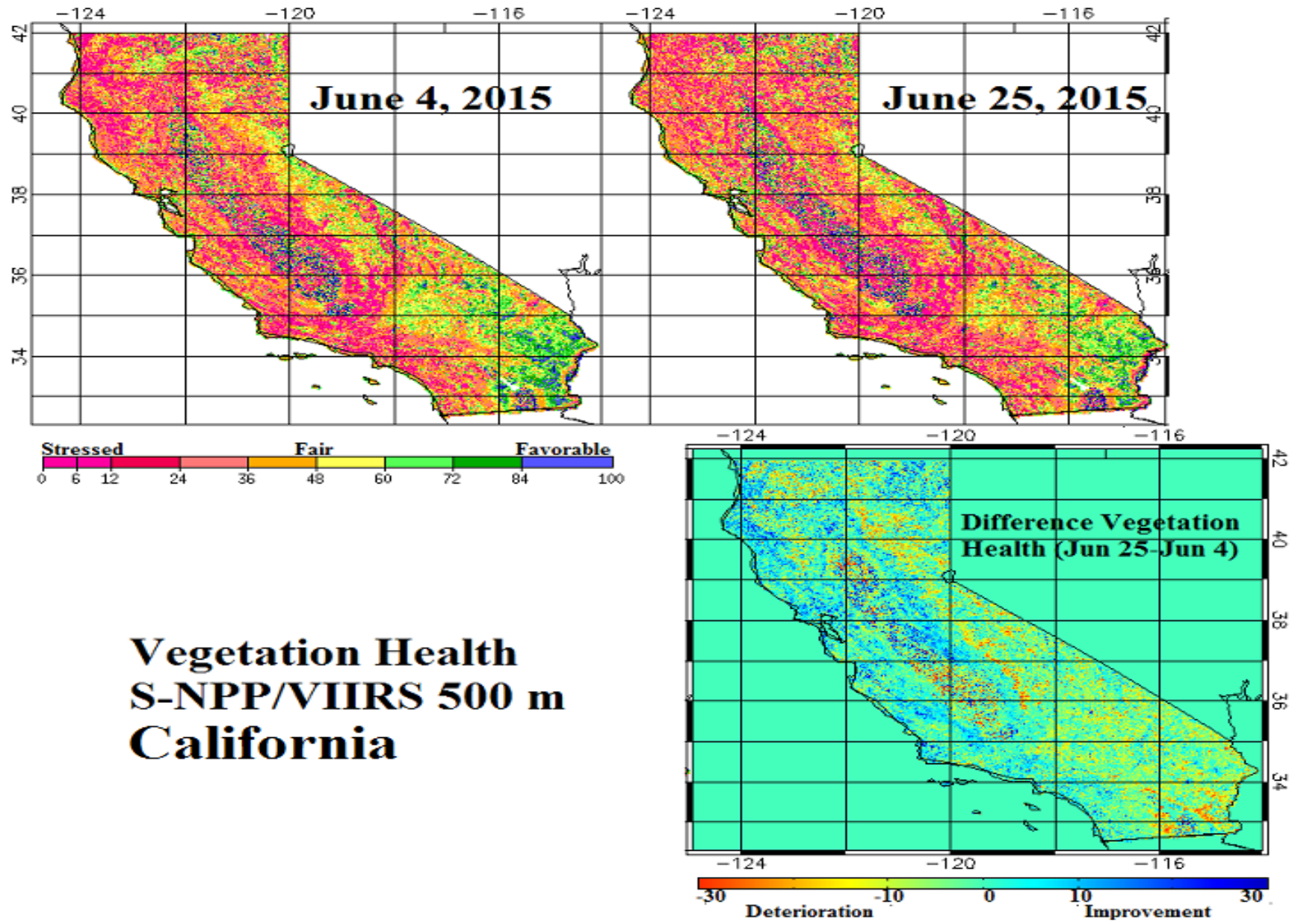
## Correlation of VIIRS & AVHRR

### Jan 7, 2015 & Sep 9, 2014



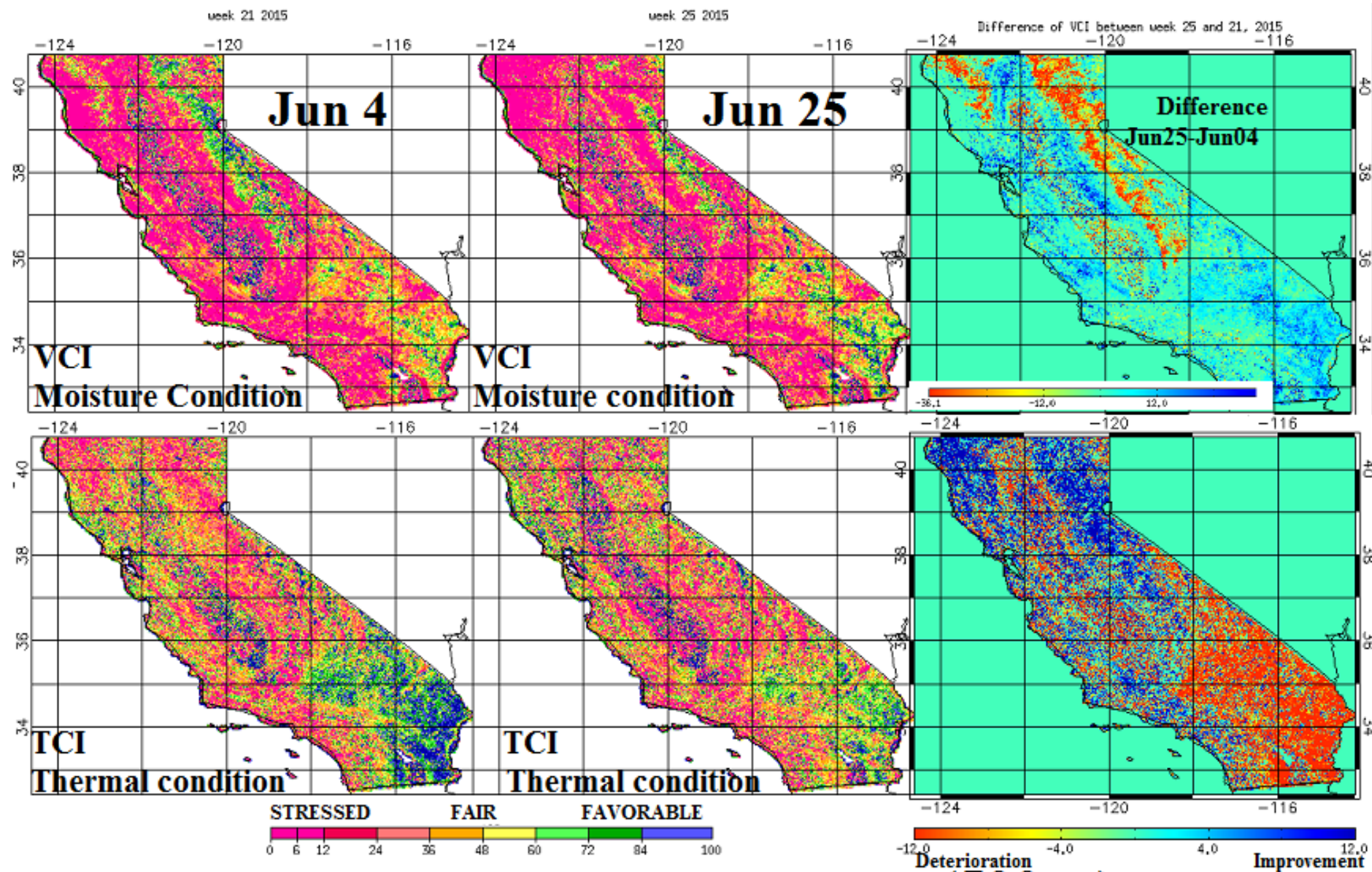


# Vegetation Health (VHI) California June 2015

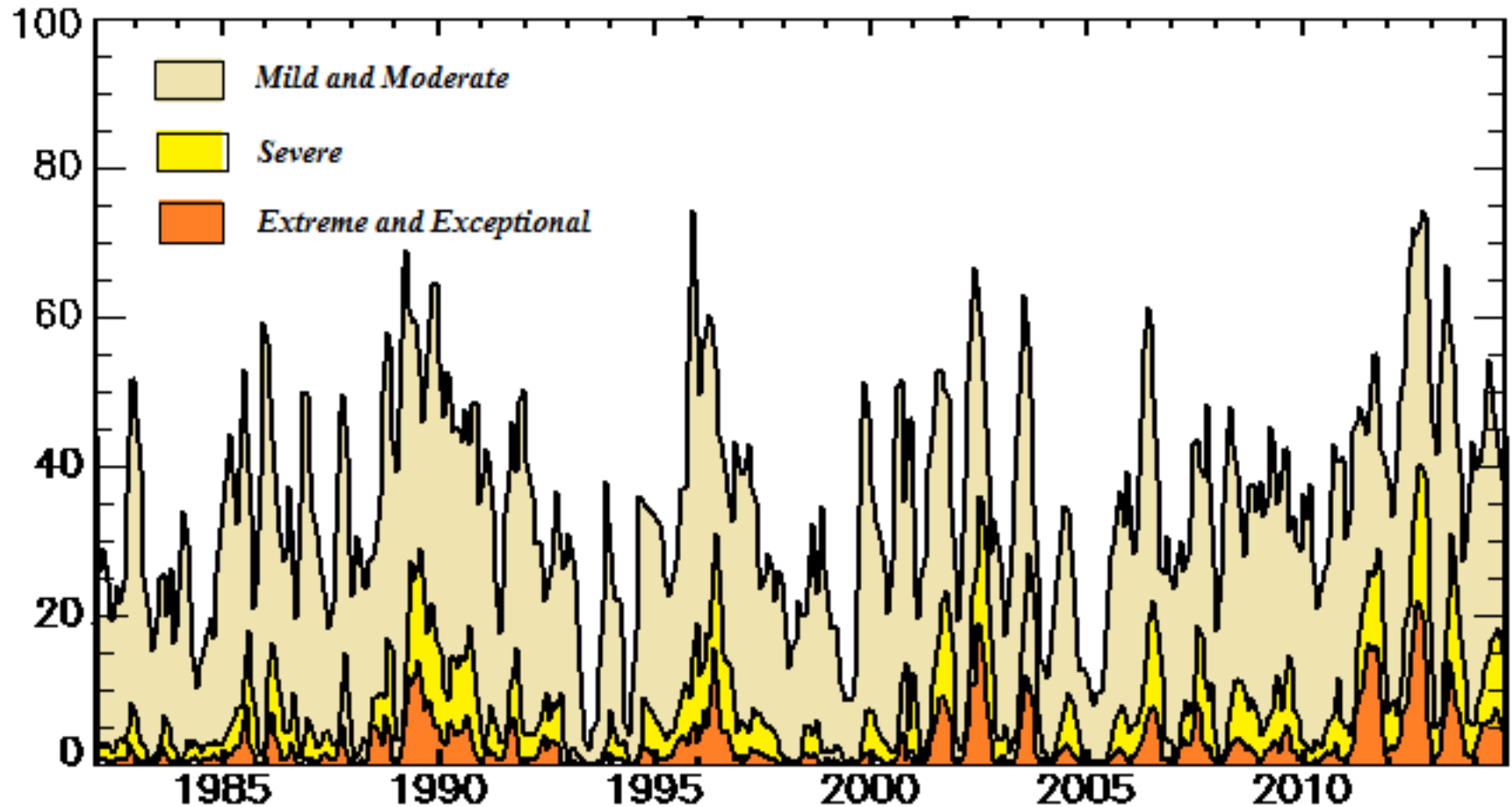




# Moisture & Thermal Condition

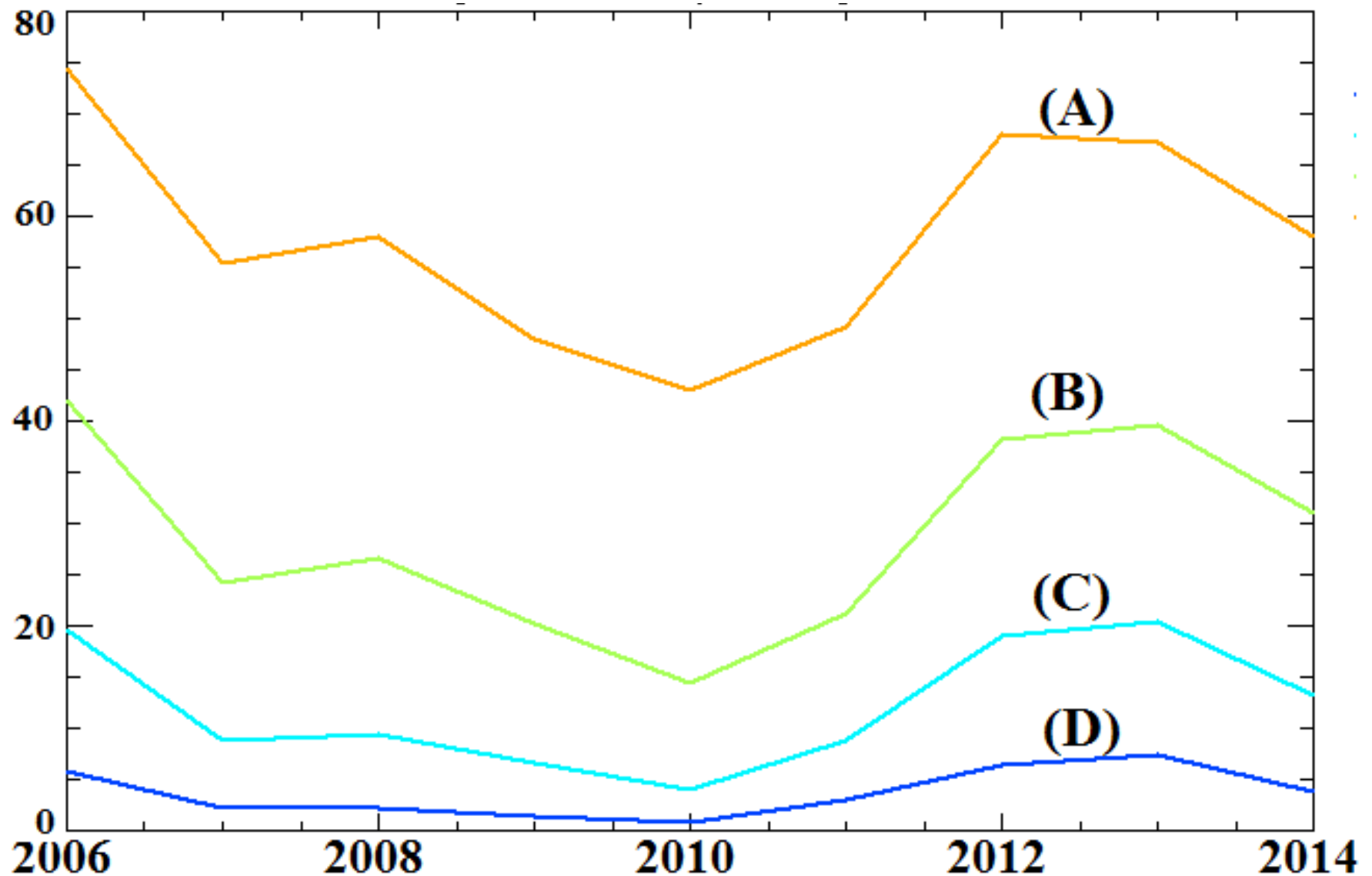


# Percent Western US under Drought

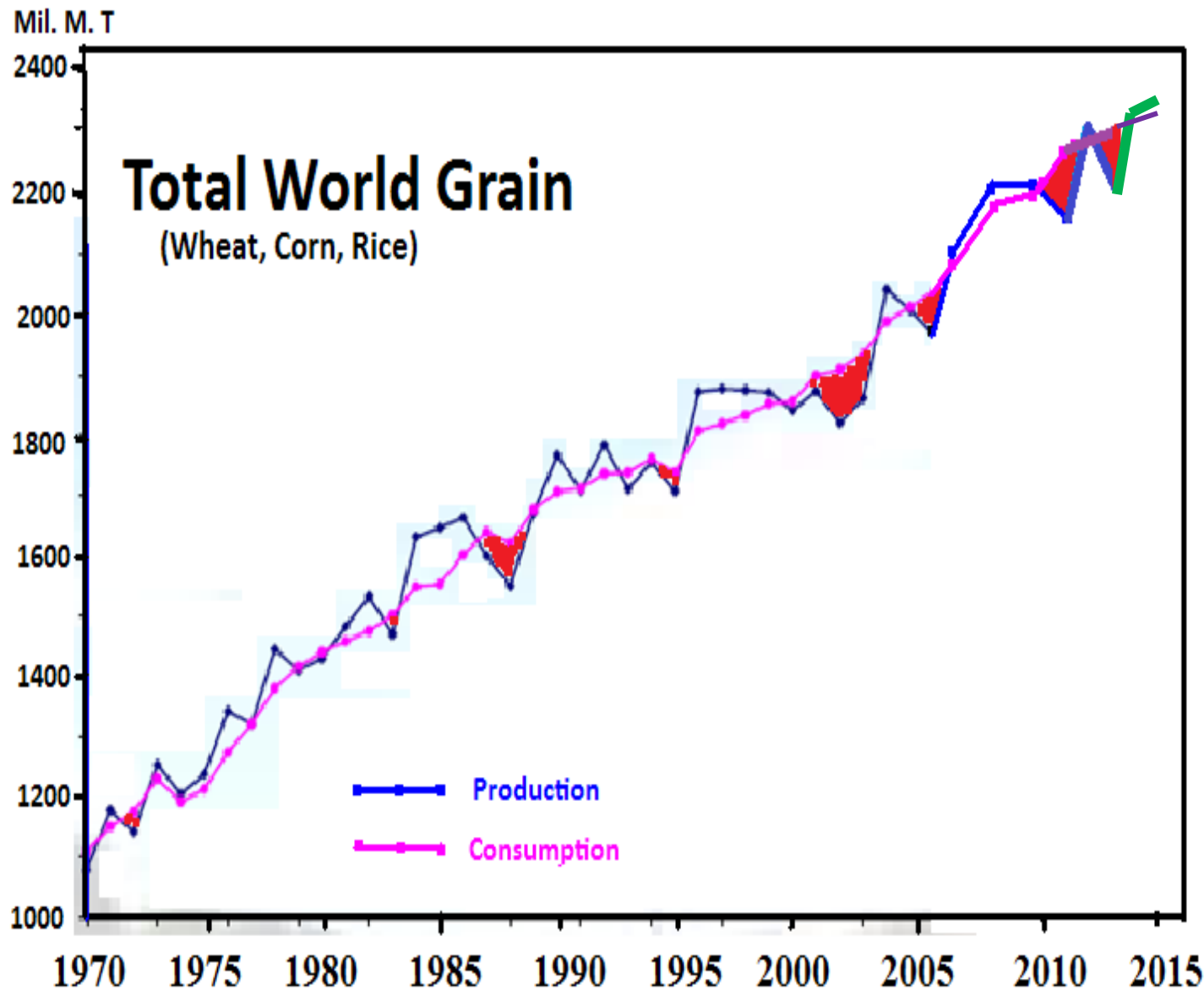


Drought Area & Intensity by weeks: Western United States, 1982-2014

# Days with Drought



# World Grain Production-Consumption, 1970-2013



## Droughts

**2013** - Argentina,  
Brazil, Australia, USA

**2012** – USA

**2011** – USA

**2010** – Russia,  
Ukraine, Kazakhstan,  
Argentina

**2007** – Australia,  
China, Argentina,  
Brazil

**2003** – USA, Europe,  
Australia, India,  
China

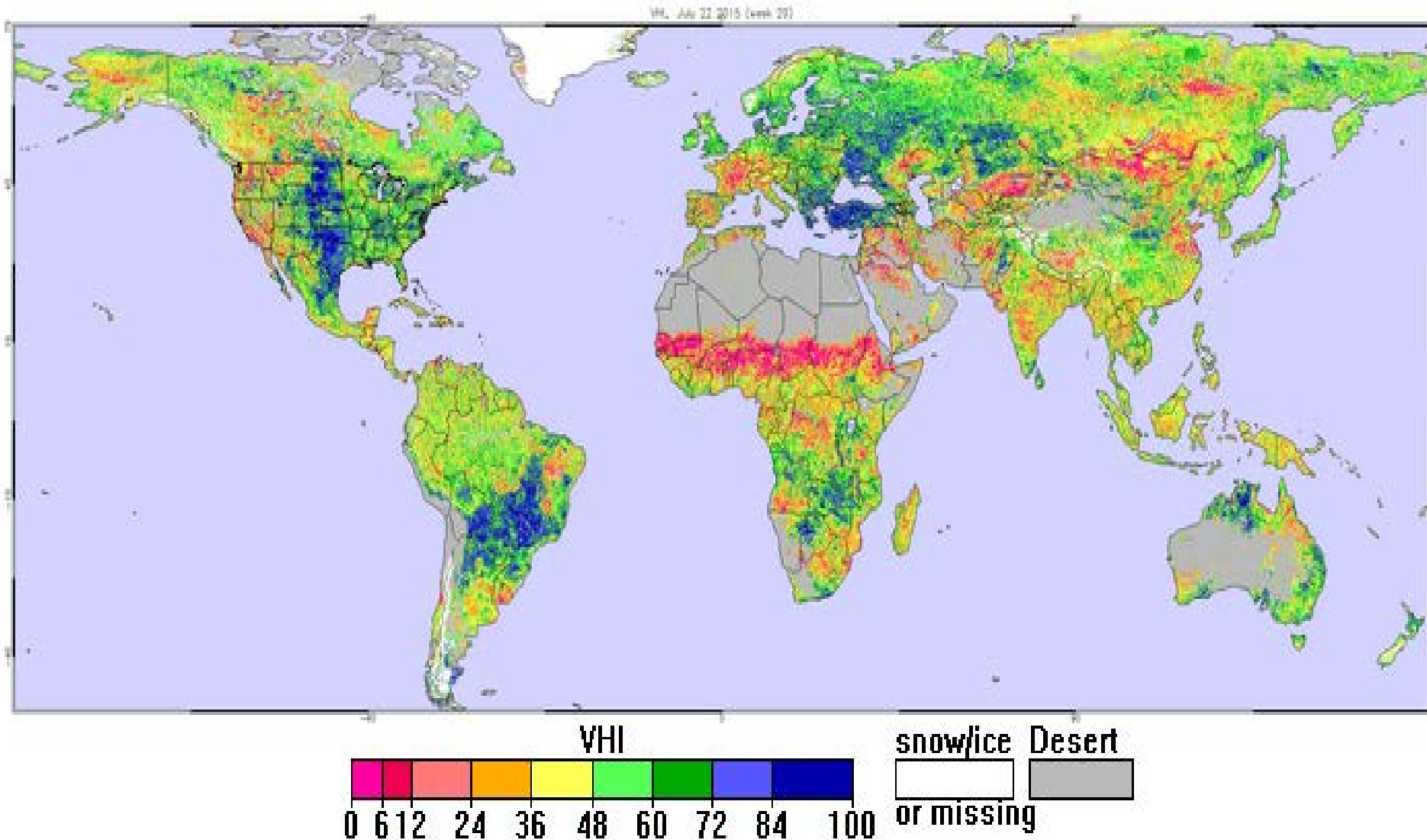
**2002** – USA, India,  
Australia, S. Africa

**2001** - China

**1996** – USA, Russia,  
Argentina,  
Kazakhstan Australia

**1988** – USA

# Vegetation Health July 22, 2015



# Web

**[http://www.star.nesdis.noaa.gov/  
smcd/emb/vci/VH/index.php](http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/index.php)**

**Every week on Thursday**































































# 2.5-day VH WEB view (May 4-6, 2015)

Page Views May 1-6, 2015

	Today May 6	Yesterday May 5	This Month May 1-6
 <a href="#">STAR Vegetation Health Site</a>	132	206	806

## Countries used Vegetation Health WEB during May4-6, 2015

153 Hits		30.60%	United States		
81 Hits		16.20%	South Africa		
54 Hits		10.80%	Switzerland		
41 Hits		8.20%	Australia		
17 Hits		3.40%	Mexico		
16 Hits		3.20%	India		
16 Hits		3.20%	Armenia		
11 Hits		2.20%	France		
10 Hits		2.00%	Germany		
9 Hits		1.80%	Dominican Republic		
8 Hits		1.60%	United Kingdom		
7 Hits		1.40%	Myanmar		
7 Hits		1.40%	Korea, Republic Of		
7 Hits		1.40%	Spain		
6 Hits		1.20%	Ukraine		
6 Hits		1.20%	Iran, Islamic Republic		
5 Hits		1.00%	Kenya		
5 Hits		1.00%	Japan		
5 Hits		1.00%	China		
4 Hits		0.80%	Romania		

# VH-Web Visitors

August 24, 2015, by 10 am

Countries during Aug 20-24



United States	United States Flag
Germany	Germany Flag
Mexico	Mexico Flag
United Kingdom	United Kingdom Flag
India	India Flag
South Africa	South Africa Flag
Brazil	Brazil Flag
Singapore	Singapore Flag
Japan	Japan Flag
China	China Flag
Australia	Australia Flag
Kenya	Kenya Flag
Vietnam	Vietnam Flag
Ukraine	Ukraine Flag

# Conclusions

2014 World Population 7.3 bil. Increases with **Accelerating** Rate;

World Grain Production Increases with **Decelerating** Rate

Grain supply drops below demands (in the 21<sup>st</sup> century 8 years out of 15)

Severe Droughts - Reduces Global Grain Production 4-7% every 4-6 years; Moderate Drought – Reduces Grain 1-3% every 2-3 years

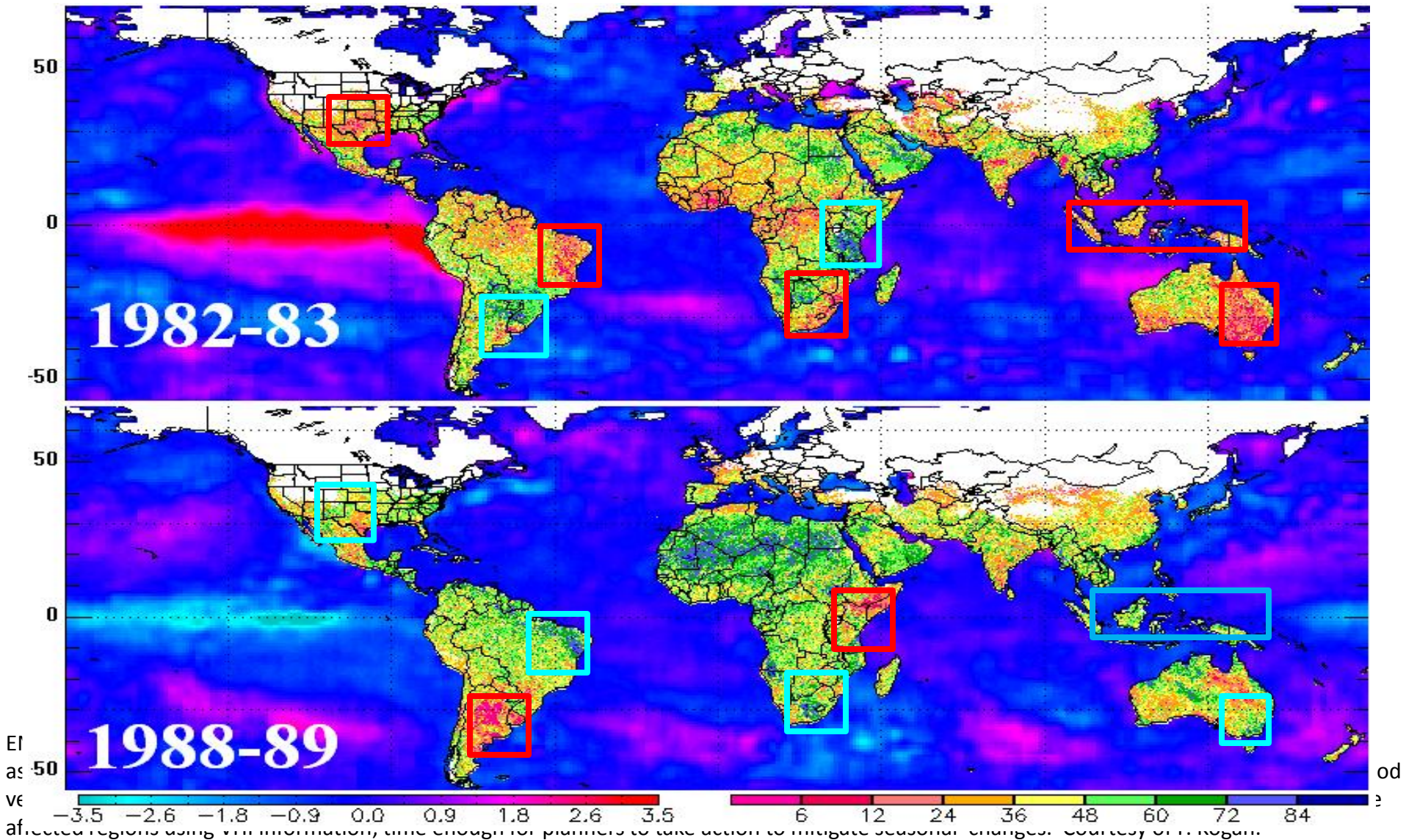
Satellite-based Vegetation Health (VH) Technology Provide Tools for Drought Monitoring & 1-2 Month Advanced Prediction of its Start/End, Area, Intensity, Duration and Impacts

VH Provide Prediction of Drought-related Crop & Pasture Losses:  
(a) 1-2 Months in Advance of Harvest, (b) During ENSO years 3-4 months prediction

Drought Area & Intensity has not Changed during the Period of Strong Global Warming



# VH-Drought Prediction from ENSO (3-6 months)



El  
as  
ve  
1988-89

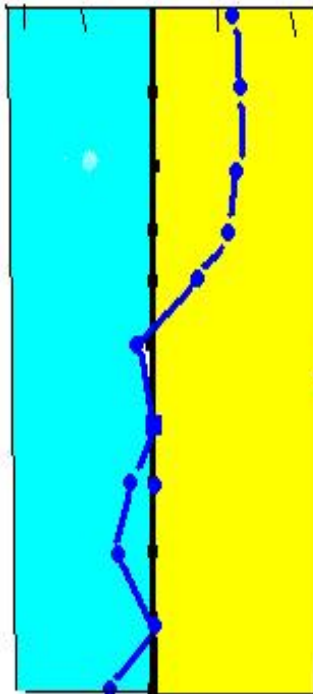
affected regions using VHI information, time enough for planners to take action to mitigate seasonal changes. Courtesy of M. Regan.



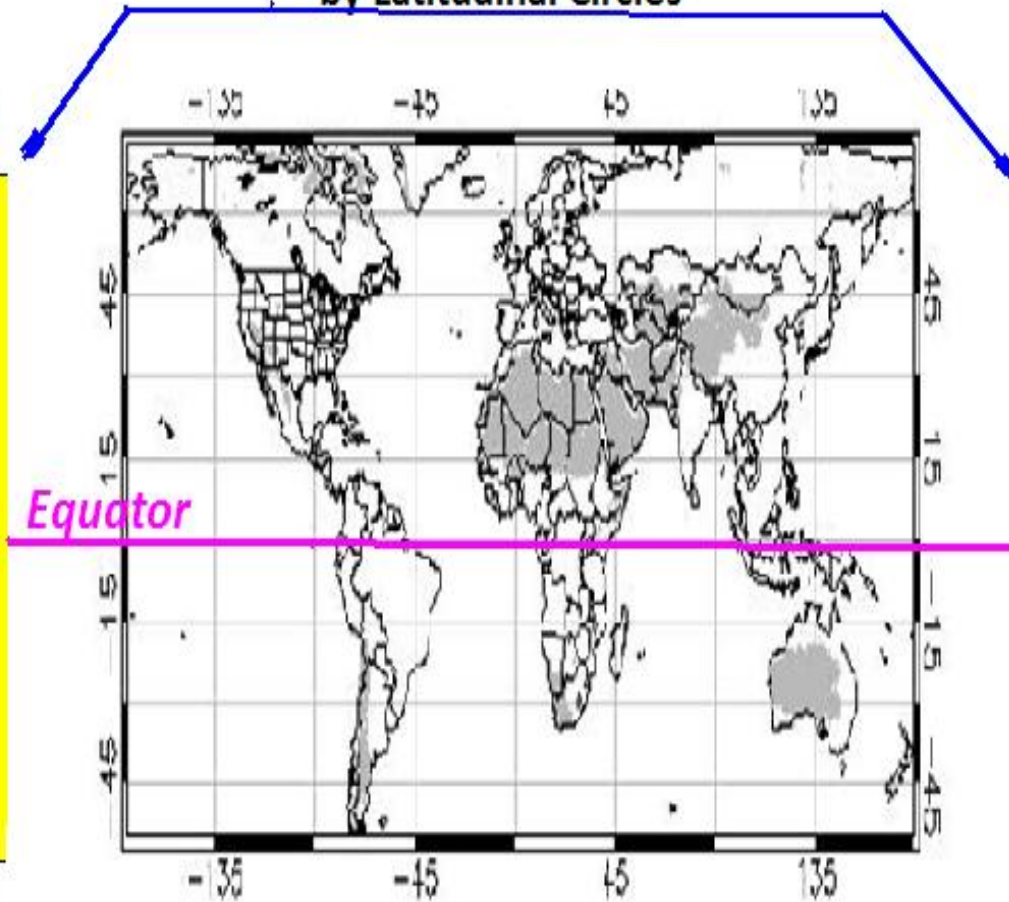
# NDVI-based Land Cover Change trend, 1982-2007

Percent Greenness Change during 1982-2007  
by Latitudinal Circles

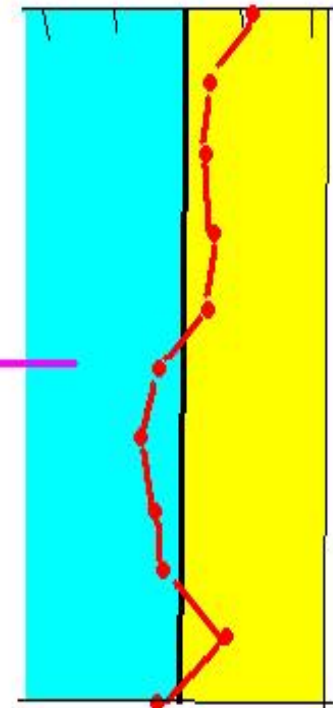
ANNUAL  
-20 -10 0 10 20



Decrease Increase

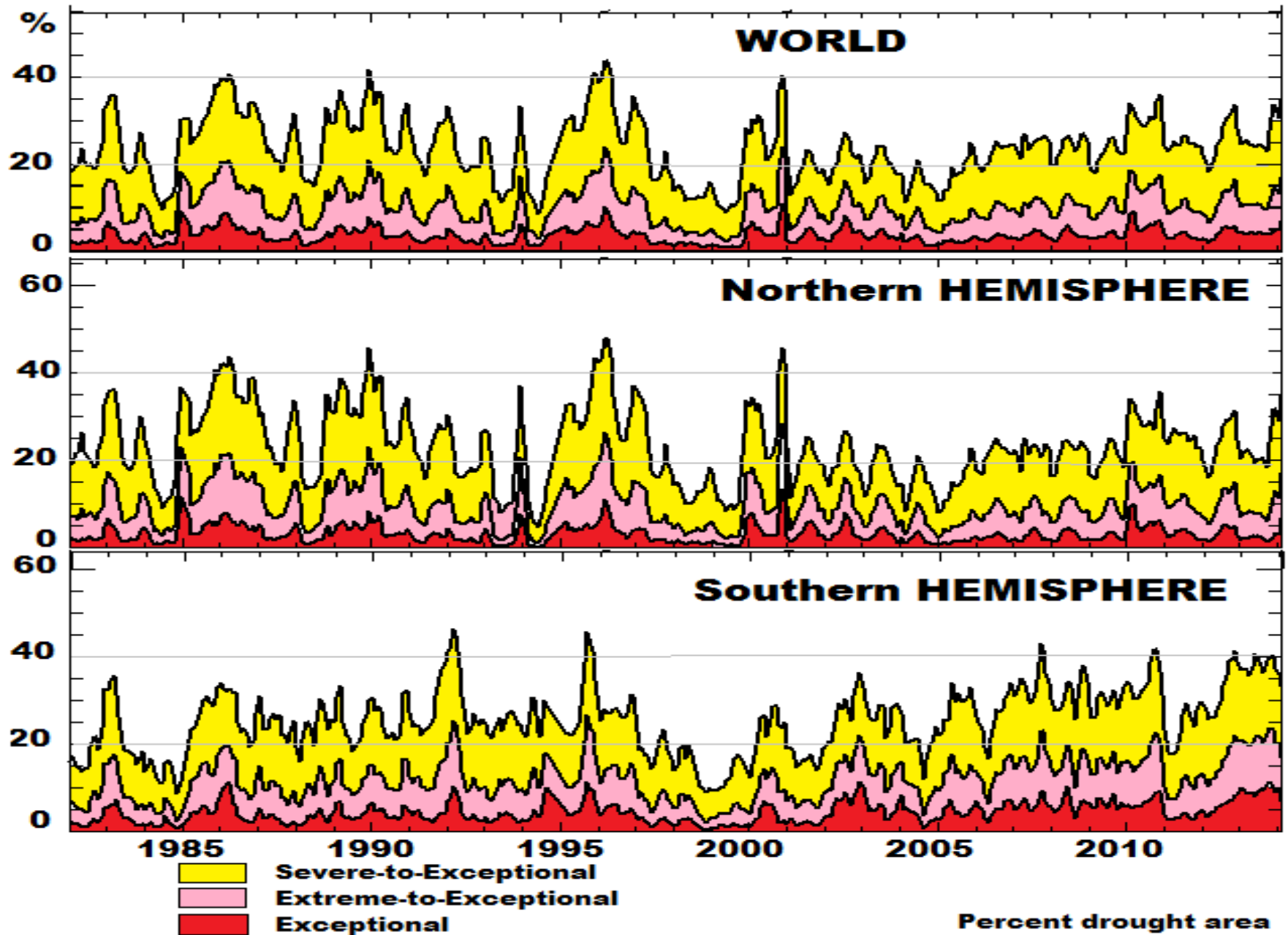


SUMMER  
-20 -10 0 10 20

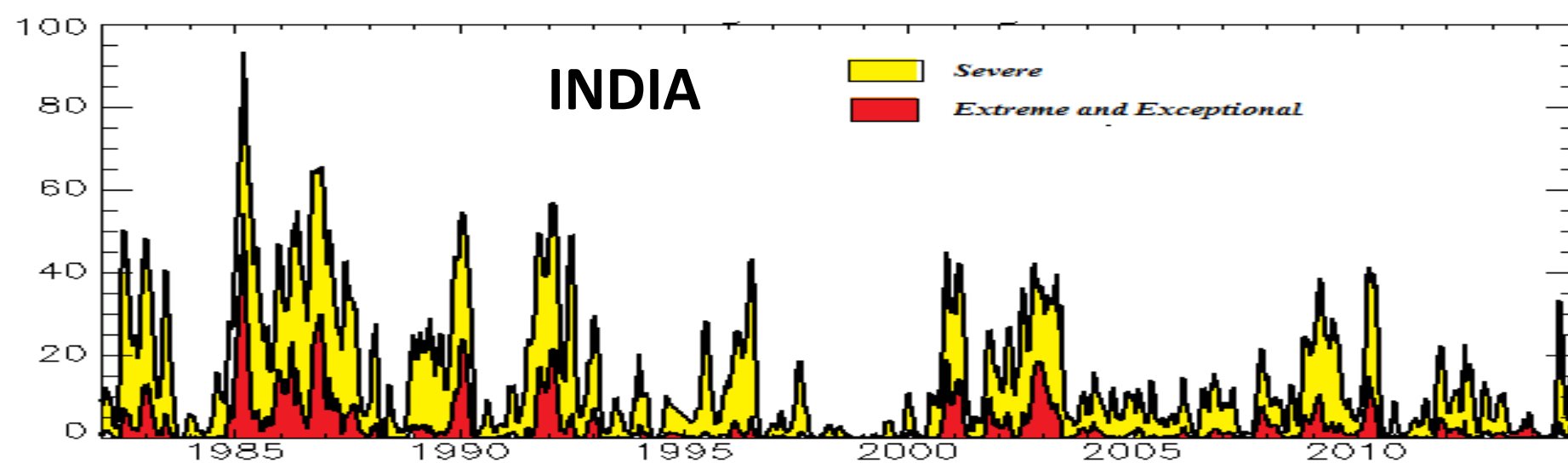
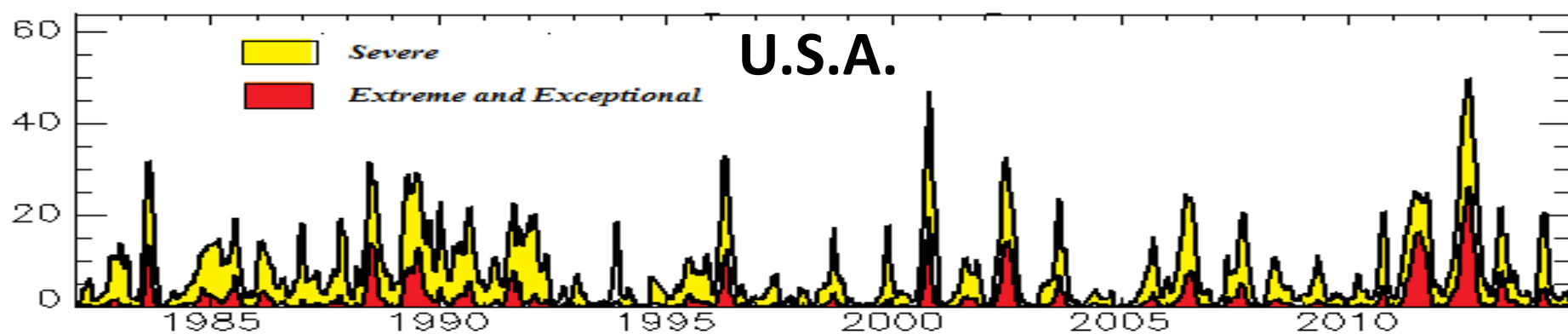
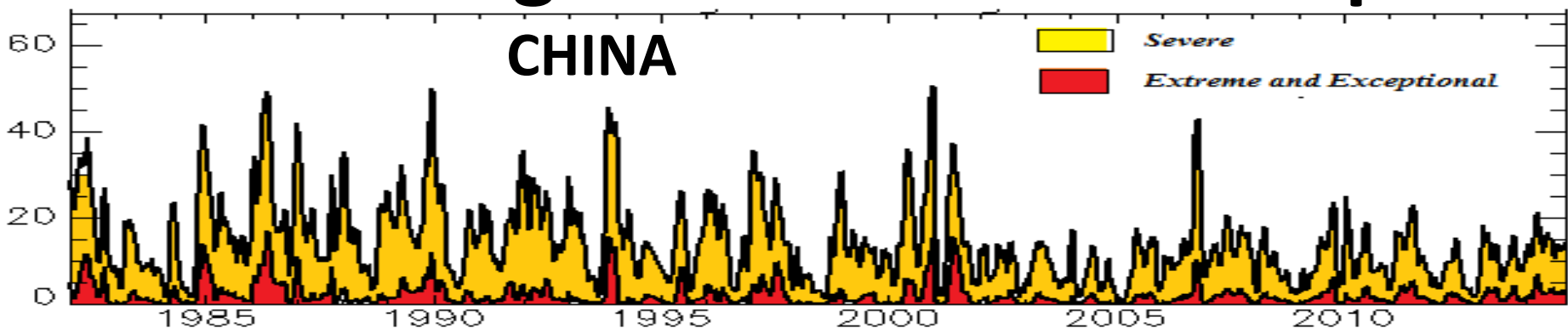


Decrease Increase

# Climate: Percent Land under Drought



# Percent Drought-affected Grain Crop Area



# AVHRR Data for Land Use

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**Sensors**      *Advanced Very High Resolution Radiometer (AVHRR)*

*Visible Infrared Imaging Radiometer Suite (VIIRS)*

**Satellites**      NOAA: NOAA-7, 9, 11, 14, 16, 18, 19

*S-NPP → JPSS*

**Data Resolution** *Spatial - 1, 4 (GAC), 8 & 16 km (GVI);*  
*Temporal - 7-day composite*

**Period**      **35-year      (1981-2015)**

**3.5-year      (2011-2015)**

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

**Channels**      **VIS , NIR , Thermal**



# Mega-Drought in Western USA

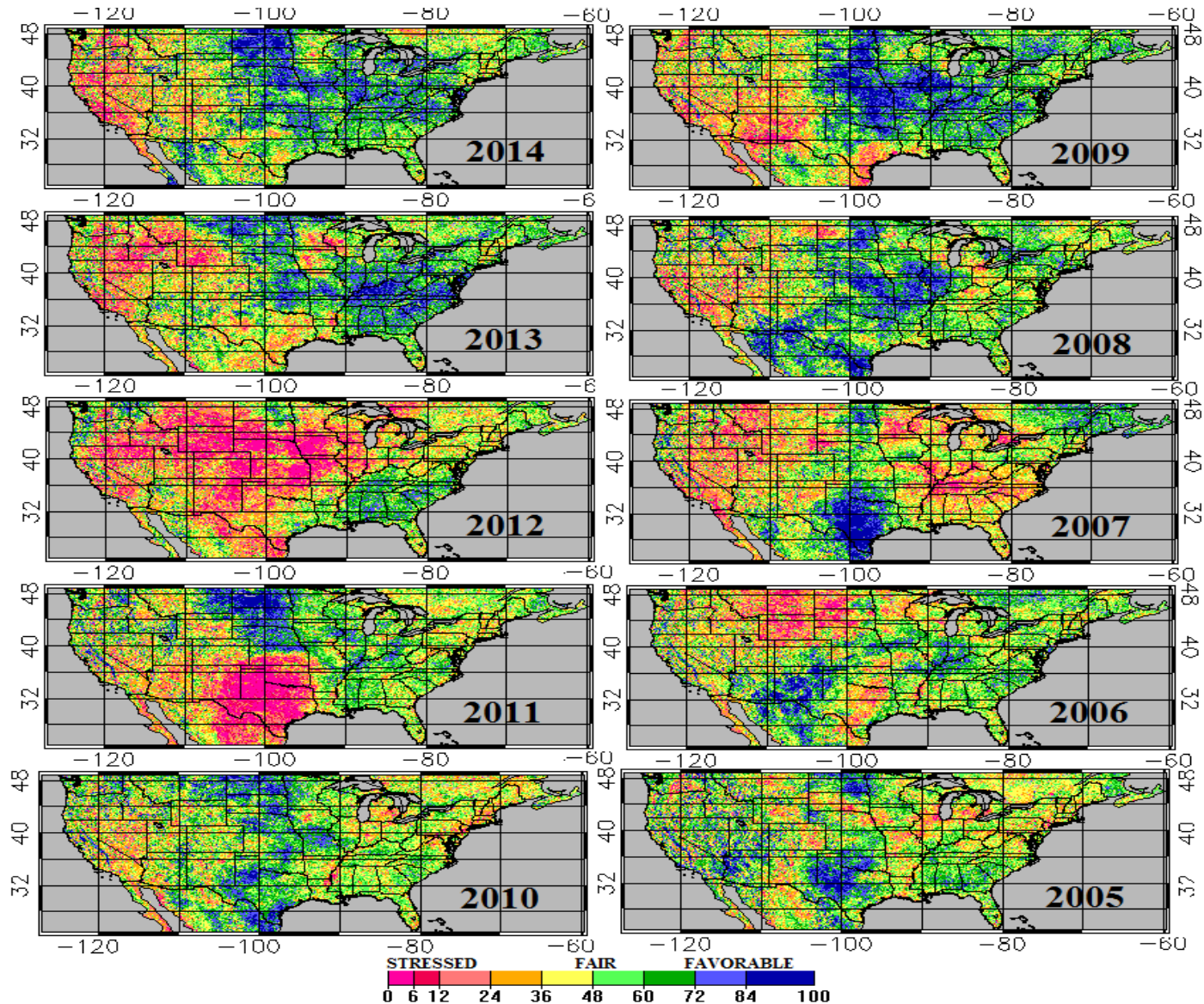
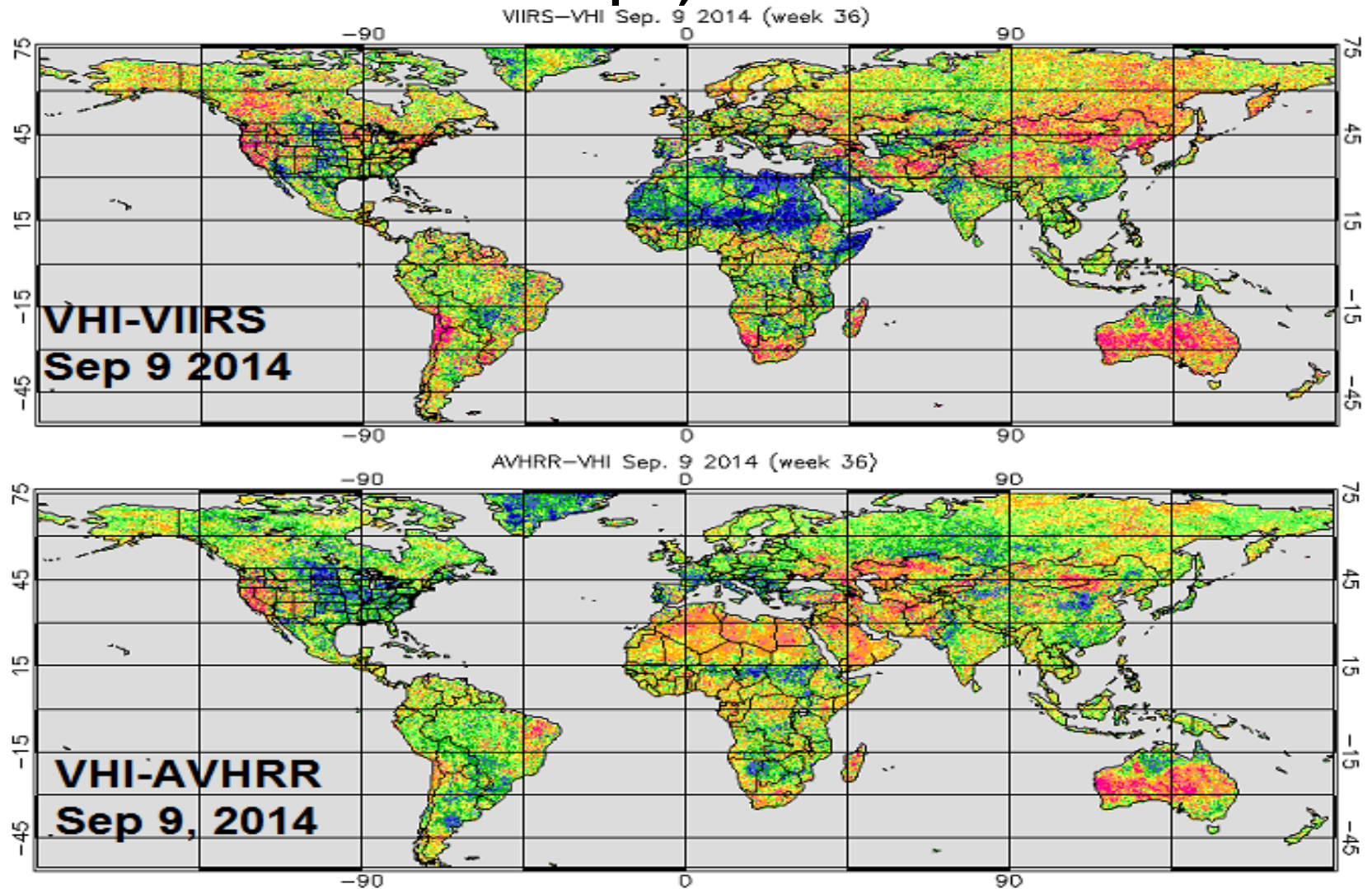
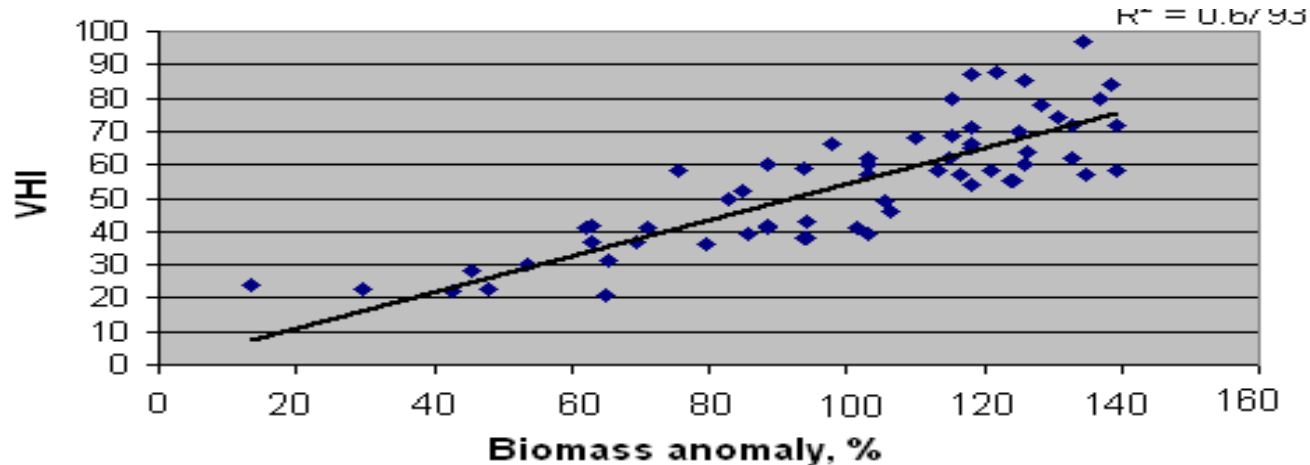


Figure 1. Vegetation health (from VHI) in August 2005 through 2014.

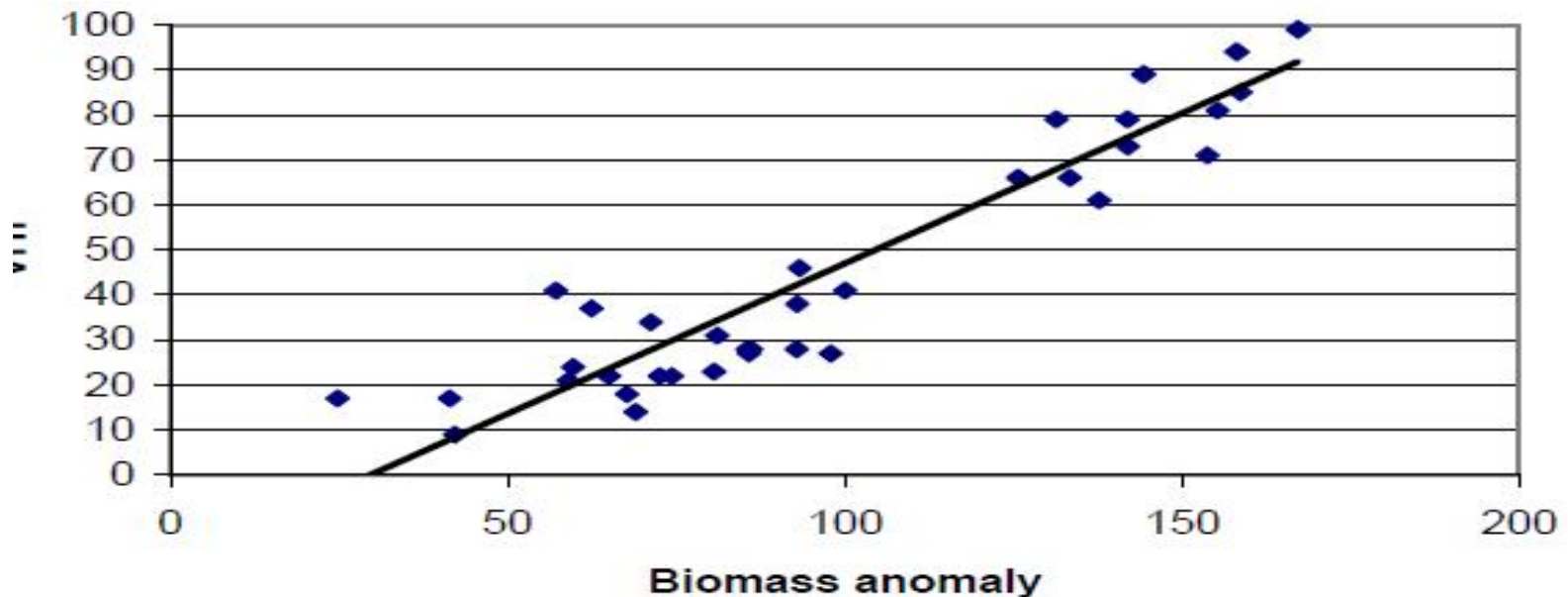
# VALIDATION: VHI VIIRS vs AVHRR Sep 9, 2014



# Biomass vs VHI, Turkmenistan



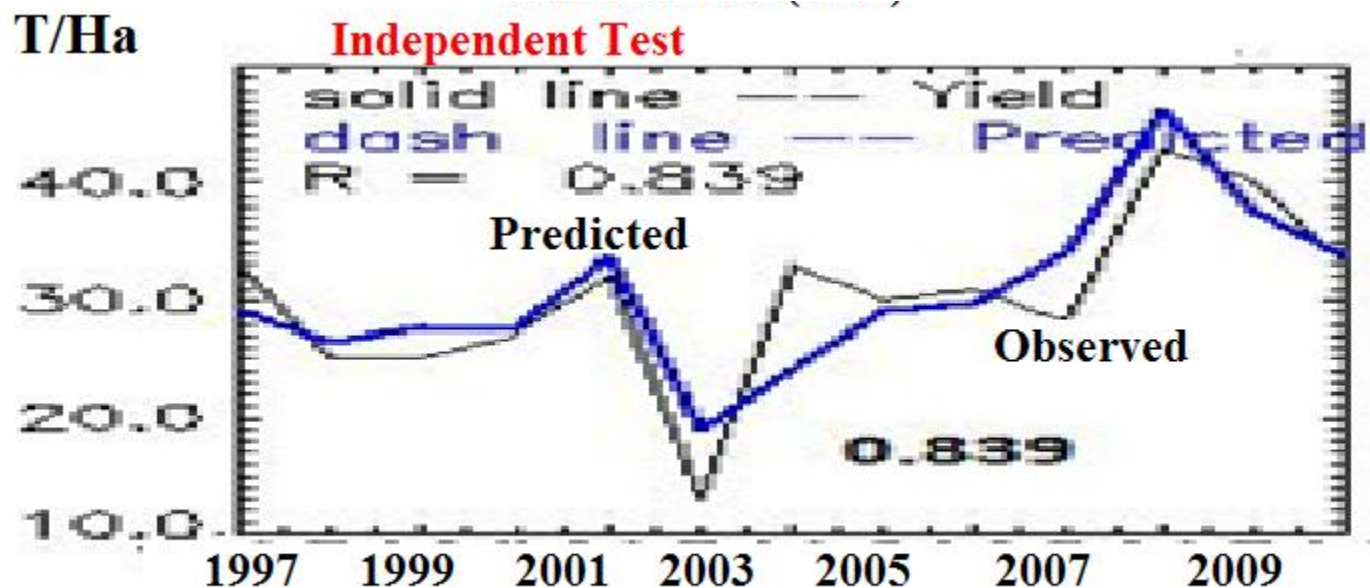
**Erbent, Turkmenistan, 1982-2009 ( $R^2=0.67$ )**



Lekker monitoring site ( $36^{\circ}16' N$ ,  $63^{\circ}42' E$ )  $R^2=0.885$ ,  $n=35$ , 1982-2005  
Southeastern Turkmenistan.



# Winter Wheat Yield Vinnitsa Obl. UKRAINE



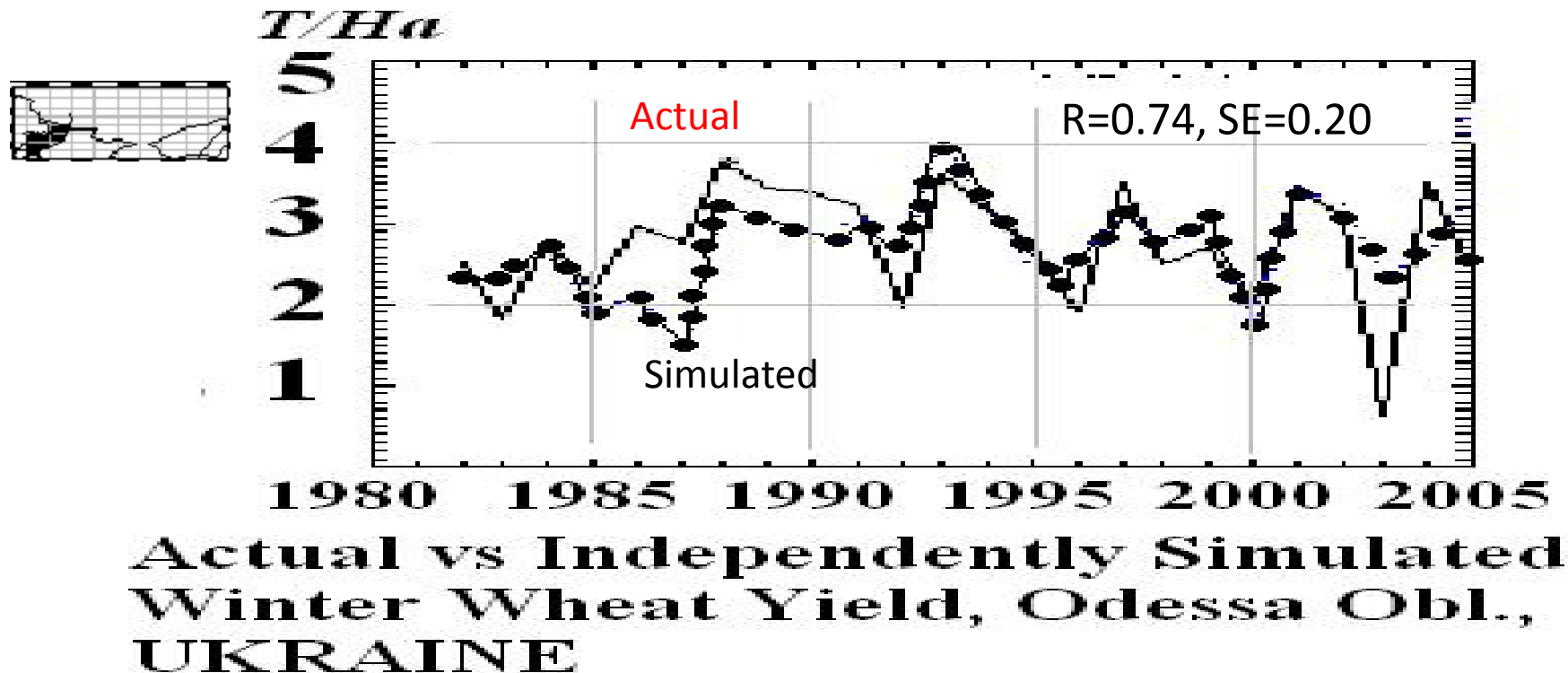
Winter Wheat yield Observed and VH-Predicted VINNITSA



# Winter Wheat Yield Odessa Obl. UKRAINE

Partial CC      **-0.57**      **0.58**      **-0.33**      **0.38**  
 $dY = 0.286 - 0.057VH_5 + 0.067VH_6 - 0.041VH_{18} + 0.044VH_{19}$

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# Vegetation Health data sources

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**Sensors**      *Advanced Very High Resolution Radiometer (AVHRR)*

*Visible Infrared Imaging Radiometer Suite (VIIRS)*

**Satellites**      NOAA: NOAA-7, 9, 11, 14, 16, 18, 19

*S-NPP → JPSS*

**Data Resolution** *Spatial - 1, 4 (GAC), 8 & 16 km (GVI);*

*Temporal - 7-day composite*

**Period**      **35-year      (1981-2015)**

**3.5-year      (2011-2015)**

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

**Channels**      VIS , NIR , IR

**Indices**      NDVI & BT