DROUGHT

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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. extremely costly

- 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

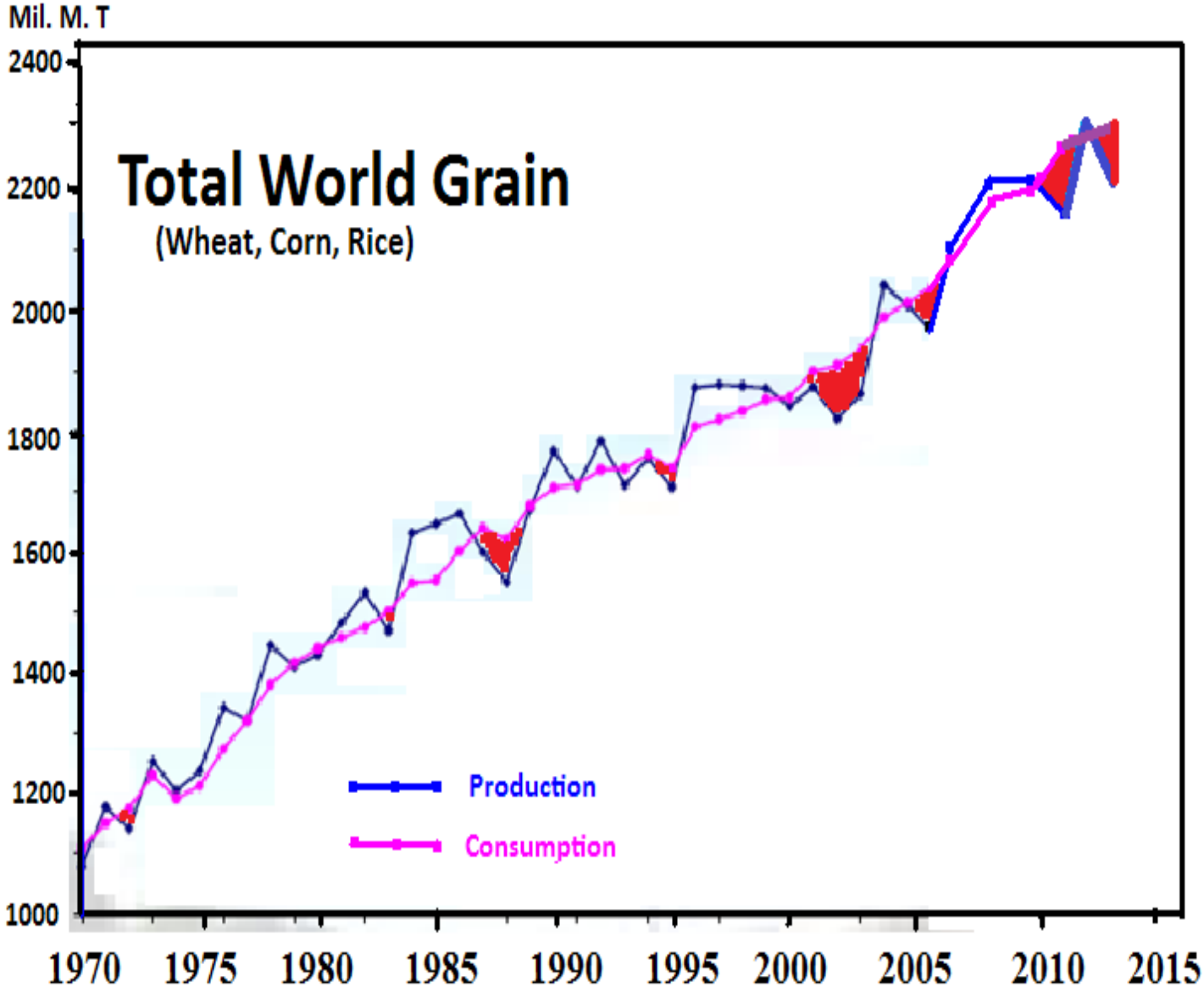
World Population Affected by Natural Disasters 1967-1991

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

Total People Affected: **2.8 billions**

Total People Killed: **3.5 millions**

World Grain Production-Consumption, 1970-2012



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
1996 – USA, Russia, Argentina, Kazakhstan Australia
1988 – USA

AFRICA: GTS (WMO-based) weather station network

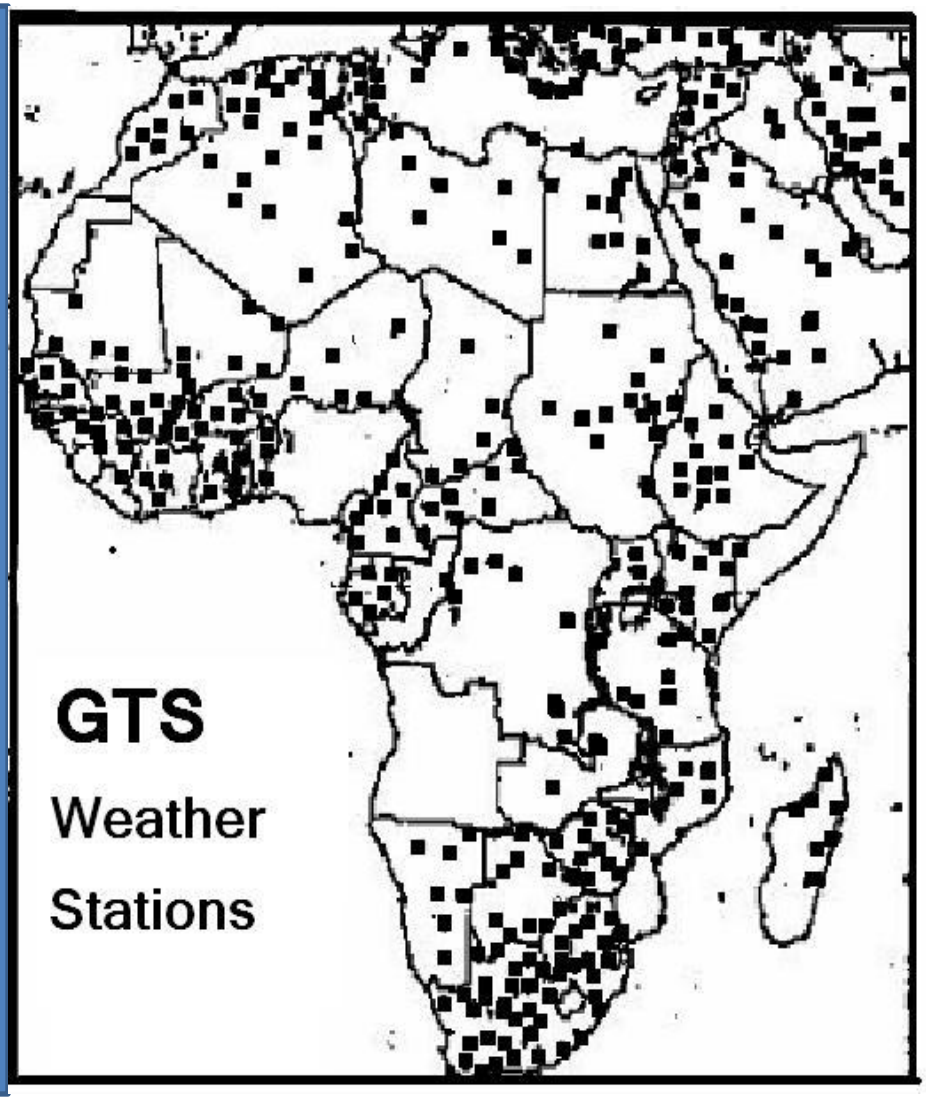
On the average

One weather station covers

31,000 sq. km

NOAA satellites cover

Current: 16 sq. km
S-NPP: 0.25 sq. km



Drought Data and Methods

- **Meteorological Data** (precipitation, temperature, humidity, soil moisture & their anomalies)
- **Meteorological Indices** *Hydrothermal Coefficient index (GTK); Palmer Drought Severity Index (PDSI); Standardized Precipitation Index (SPI); The Standardized Precipitation (P)-Evapotranspiration Index (SPEI); The Drought Monitor; The new Forest Drought-Stress Severity Index*
- **Satellite Indices** *Normalized Difference Vegetation Index; Wide dynamic range vegetation index- WDRVI; Enhanced vegetation index – EVI; Vegetation Health Indices (VH)*
- **Combination Indices**: Satellite & *In situ* *Vegetation Drought Response Index- VegDRI; Evaporative Drought Index (EDI);*

What to Measure?

- Start
- End
- Intensity
- Duration
- Magnitude
- Area
- Season
- Origination
- Impacts

CHALLENGERS

- Unreliable D. forecasts
- D. - Deficiency of water
- How to measure “Deficiency”?
- D. - Multidimensional disaster
- Contributors: Ecosystem, Weather, Climate, Soil
- Contributors: Space, Time
- D. Difficult to validate: Indices are not validated
- D. Representation - Too technical to understand
- Users need intensity, area, duration, start/end, impacts

Drought from Space: New Method

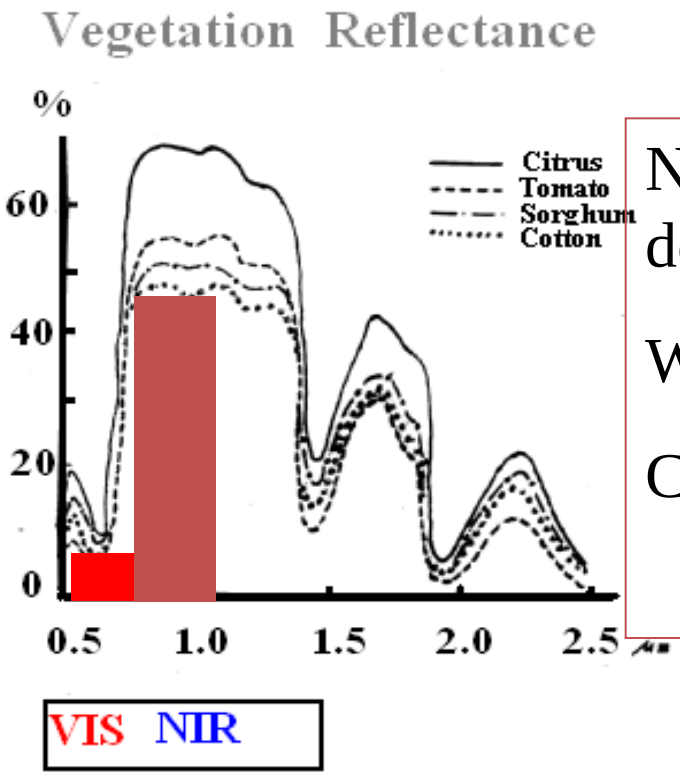
Sensors	***Advanced Very High Resolution Radiometer (AVHRR)***
	Visible Infrared Imaging Radiometer Suite (VIIRS)
Satellites	**NOAA:** ***NOAA-7, 9, 11, 14, 16, 18, 19***
	SNPP/JPSS
Data Resolution	***Spatial - 1, 4 (GAC), 8 & 16 km (GVI);***
	Temporal - 7-day composite
Period	**35-year (1981-2014)**
	3-year (2011-2014)
Coverage	**World** ***(75 N to 55 S)***
Channels	**VIS , NIR , Thermal**

Typical Vegetation Reflectance

VIS reflectance depends on

CHLOROPHYLL

CAROTENOID



NIR reflectance depends on

WATER CONTENT

CELL STRUCTURE

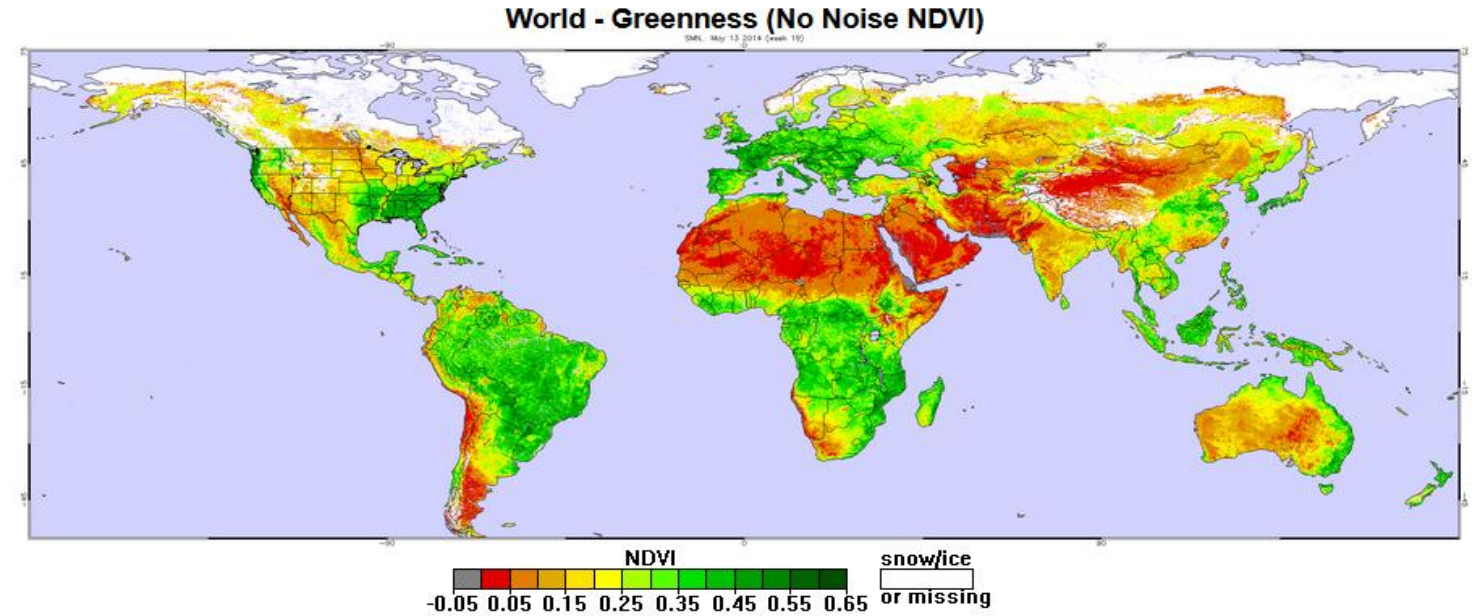
NDVI = (NIR-VIS)/(NIR+VIS)

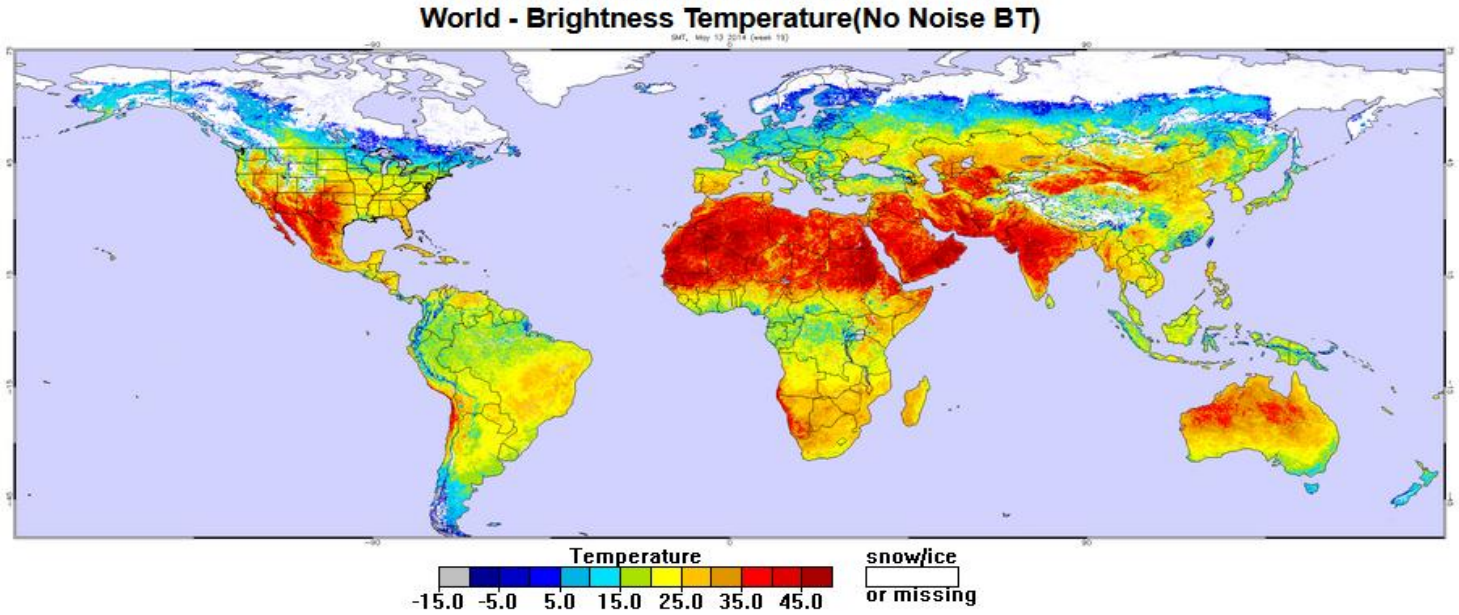
NDVI & Reflectance

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**

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

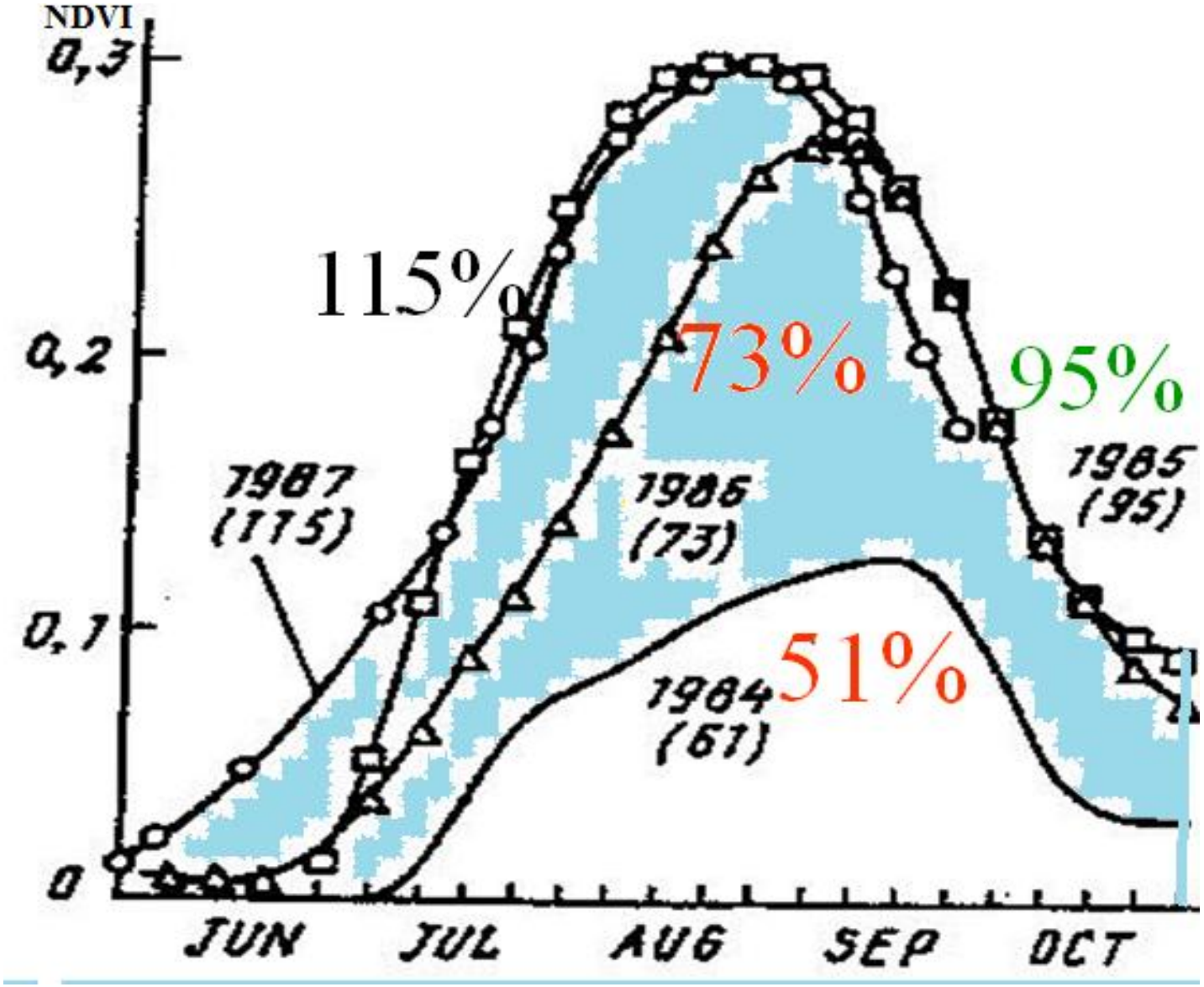
No noise NDVI and Brightness Temperature (BT)
May 13, 2014





- The 34-year S-LCDR includes AVHRR-based Normalized Difference Vegetation Index (NDVI) & Brightness temperature (BT)
- Data resolution: 4 km & 7-day
- Processing: Pre- & post-launch calibration, long- and short-term noise removal
- Data products: Vegetation health, Moisture and Thermal conditions, Drought, Fire risk. Soil saturation, Malaria & other
- The products were use by 56,000 users in 2013
- NDVI and BT data records will continue from the new generation of operational polar-orbiting satellites: S-NPP & JPSS VIIRS

NDVI & Rainfall (% of mean) SUDAN



NDVI-based Weather & Climate components, Ethiopia

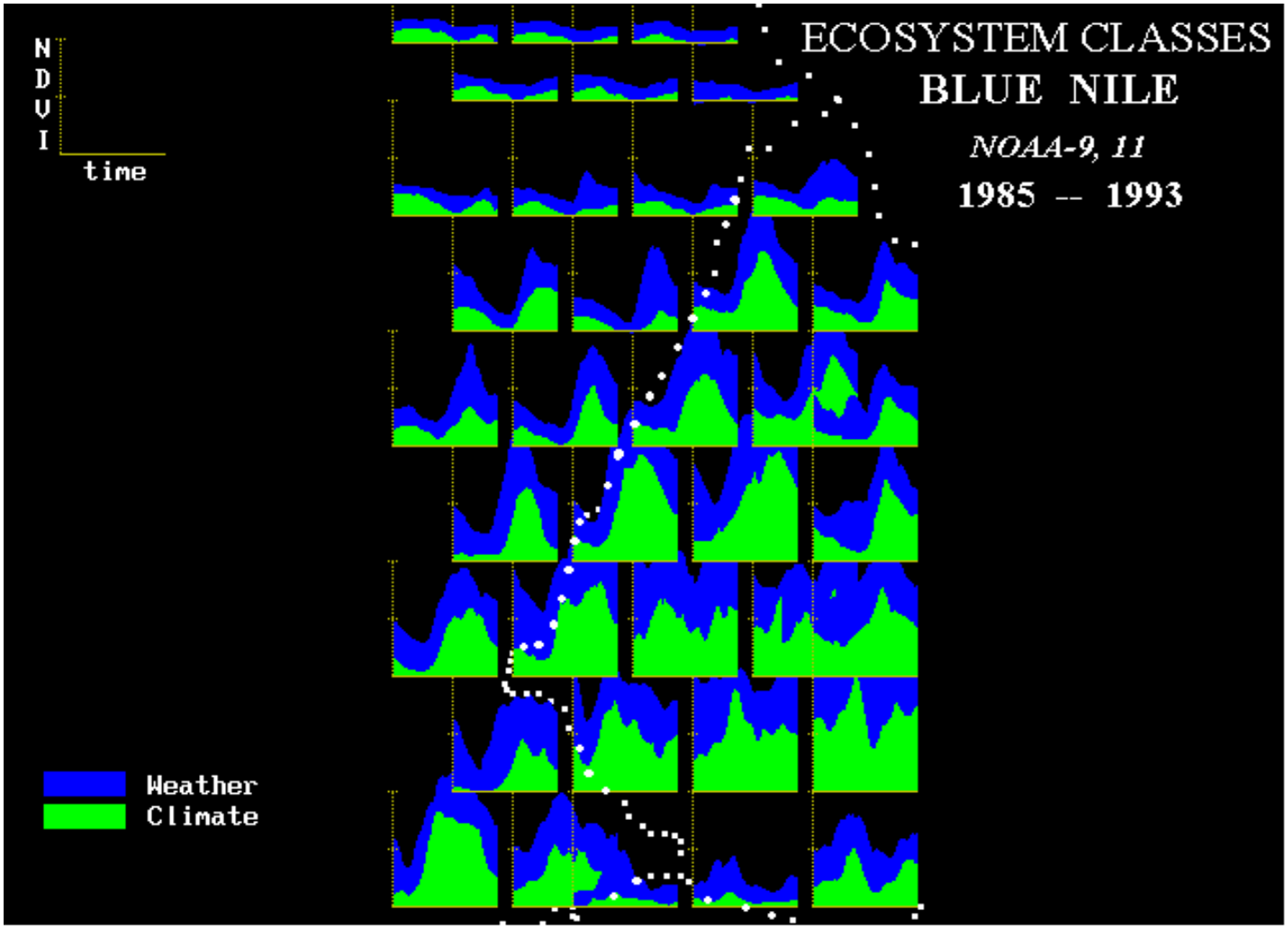


Fig. 6. Ecosystem classes from multi-year maximum and minimum NDVI in the Blue Nile basin

SATELLITE 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;

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

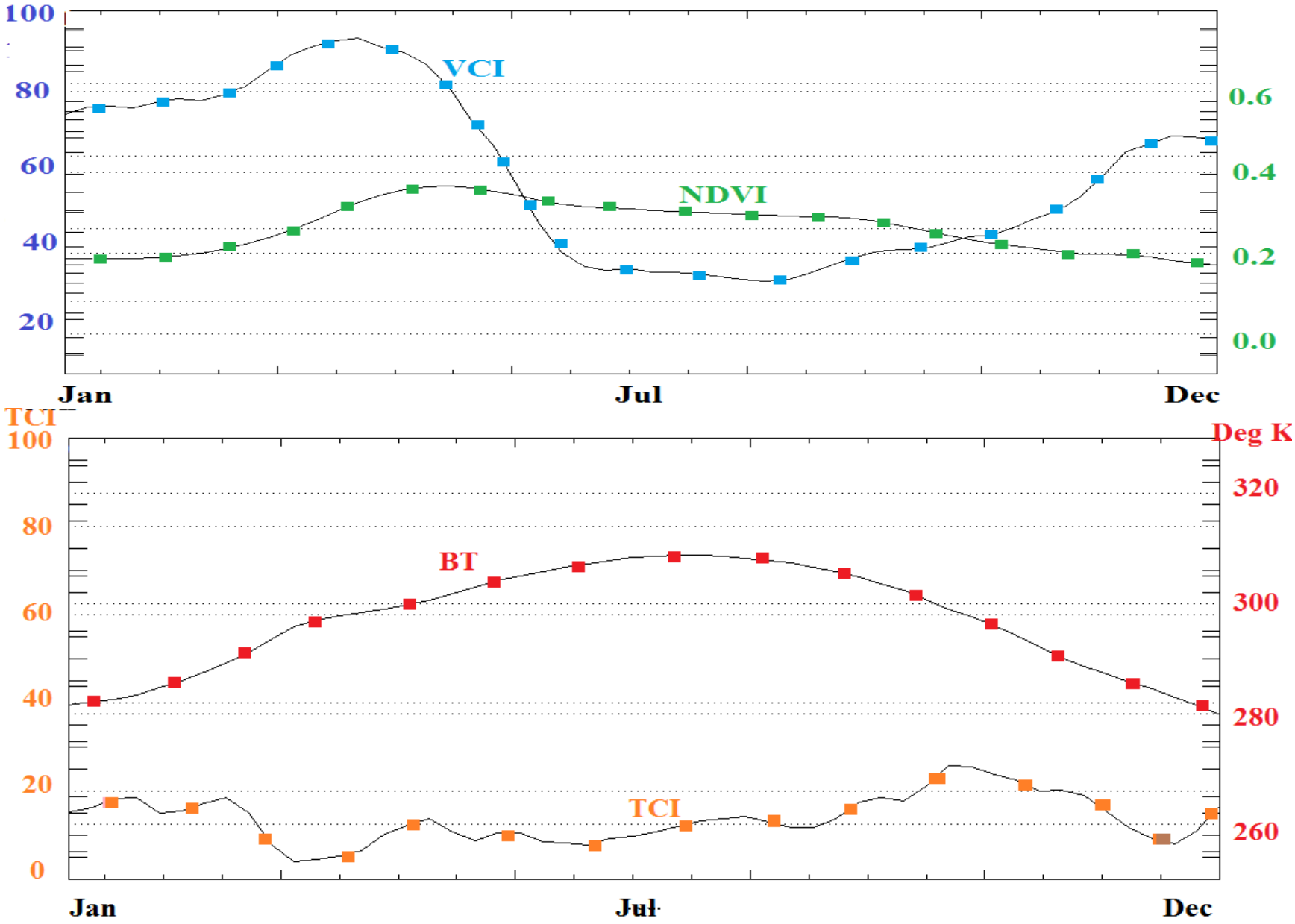
VHI=a*VCI+(1-a)*TCI

VEG. HEALTH

0 – indicates extreme stress

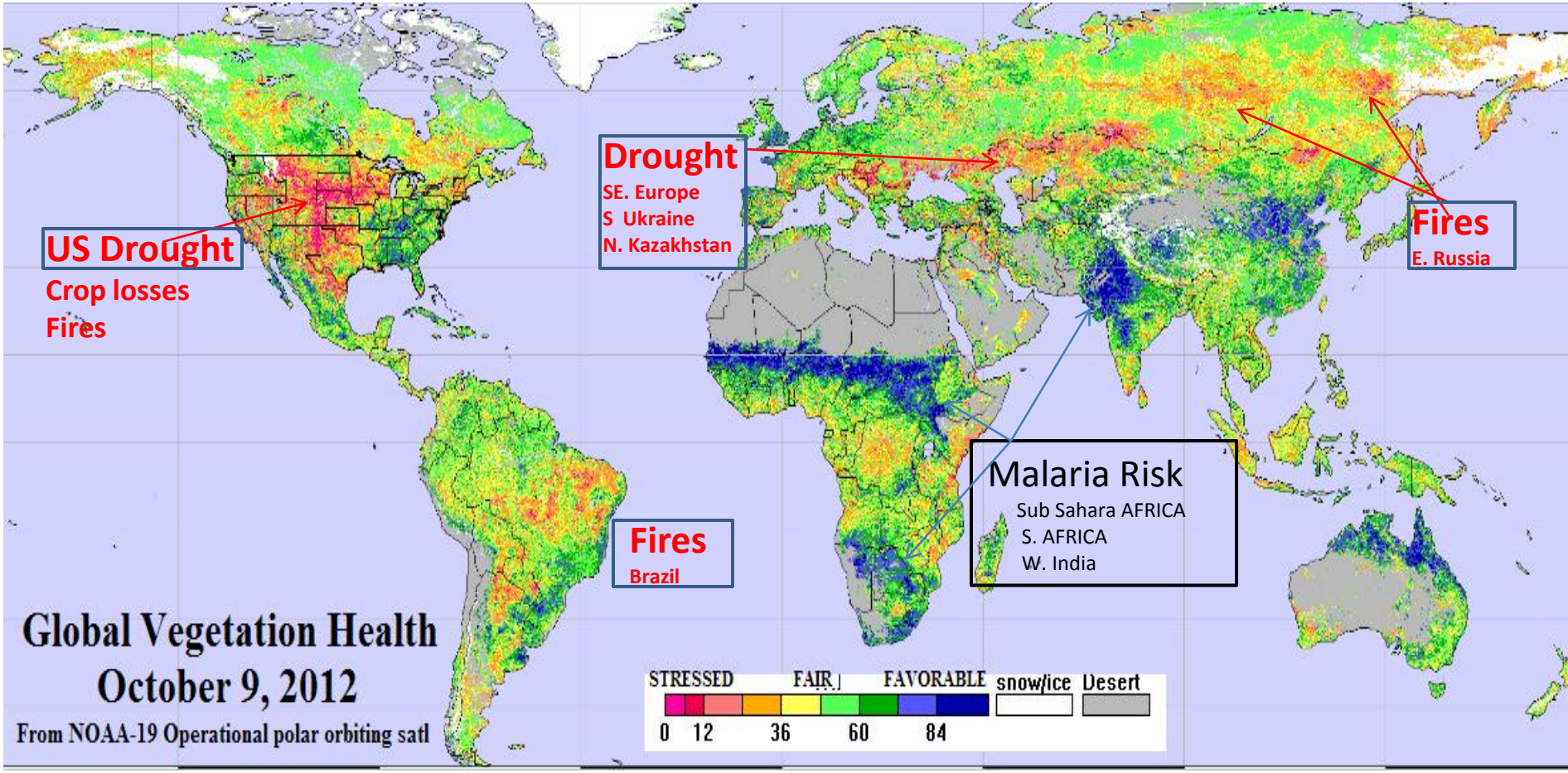
100 – indicates favorable conditions

VCI vs NDVI & TCI vs BT, 2012, Kansas



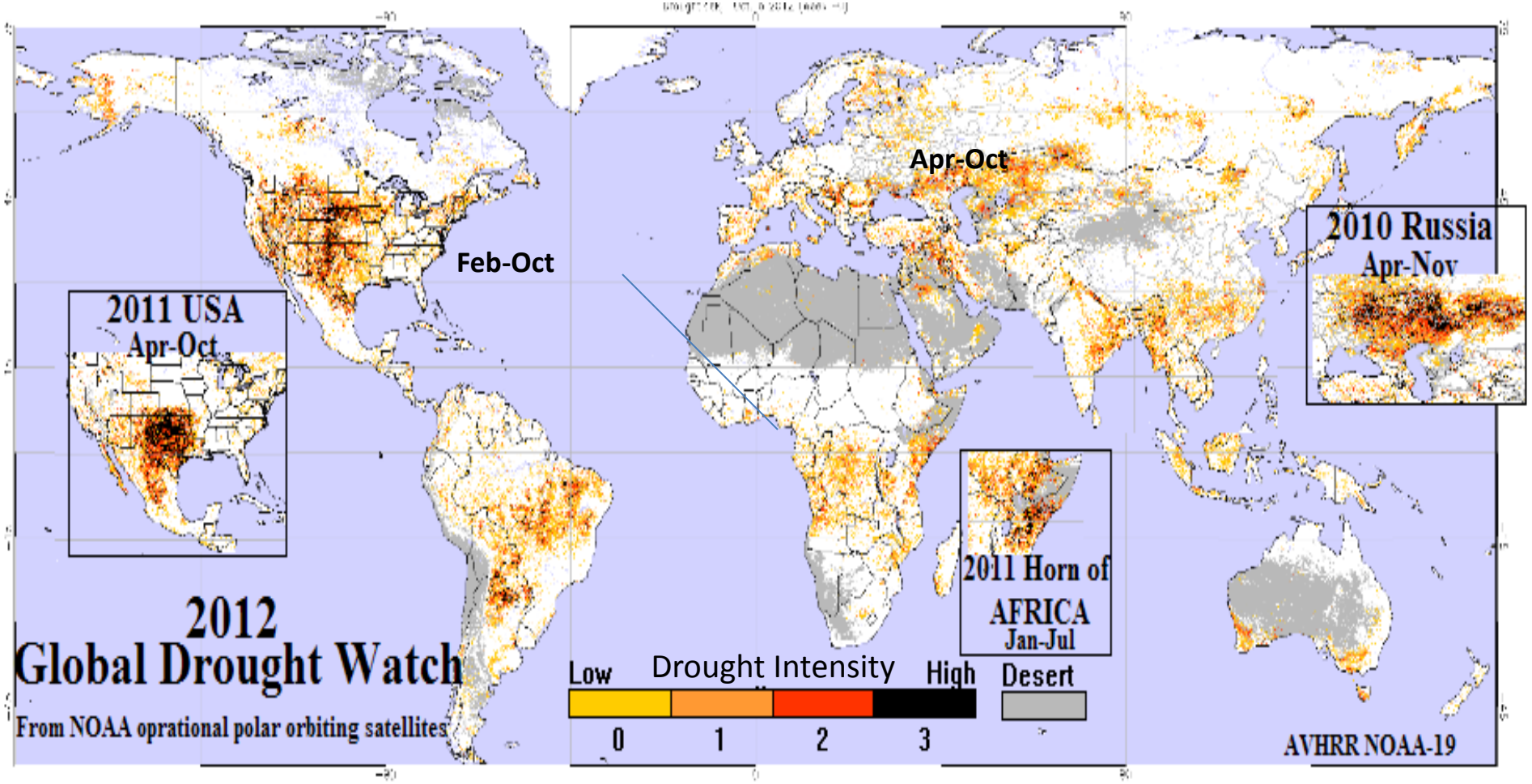
2012 Global Vegetation Health (VH)

From AVHRR/NOAA-19 Operational Polar Orbiting Satellite



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

Drought-related Vegetation Stress: 2010-2012



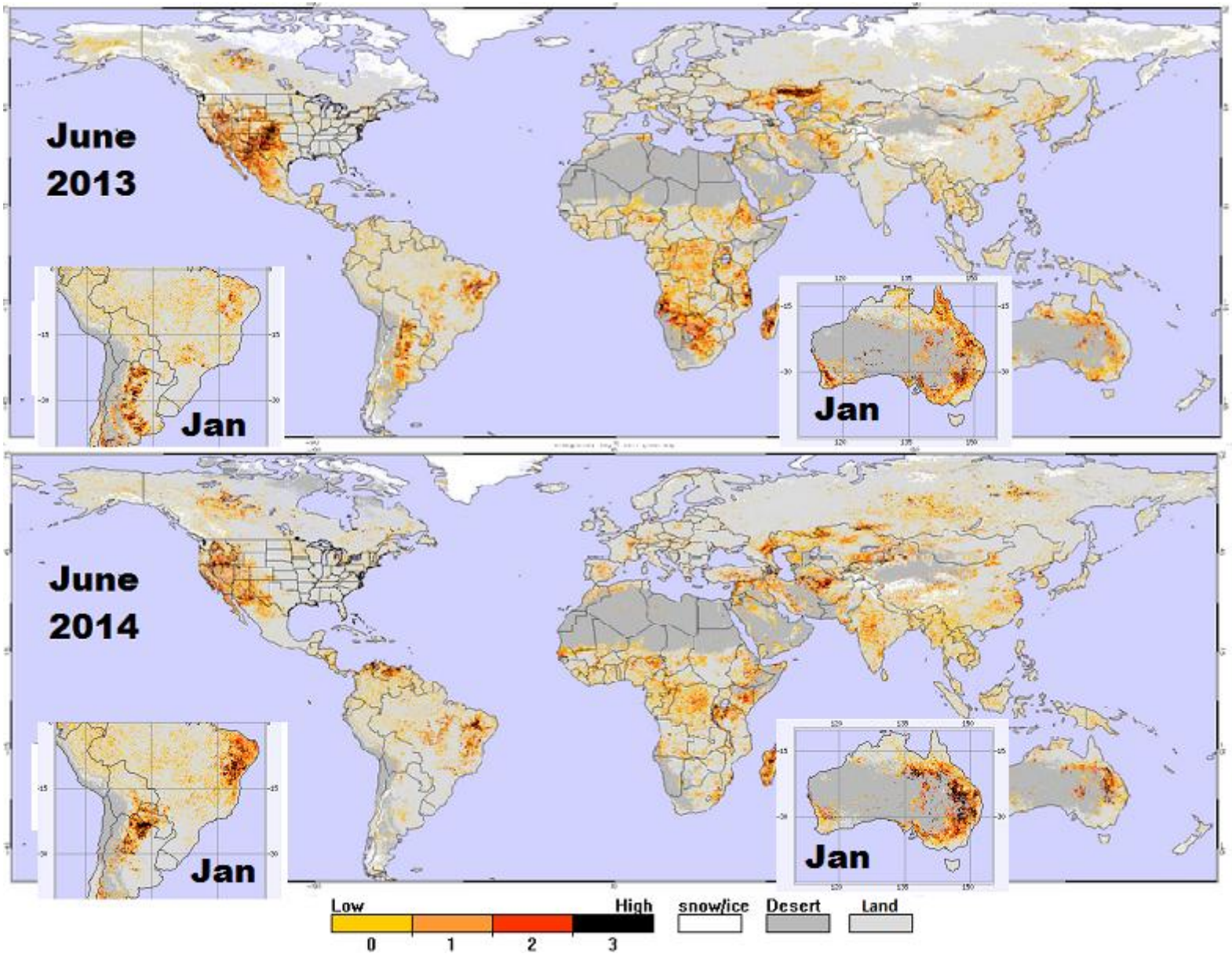
2012- Extreme drought in the USA, southern UKRAINE, northern KAZAKHSTAN,
- Severe drought in eastern INDIA & southern China, Kenya & South America

2011 – Exceptional drought in Texas (USA) and the Horn of AFRICA

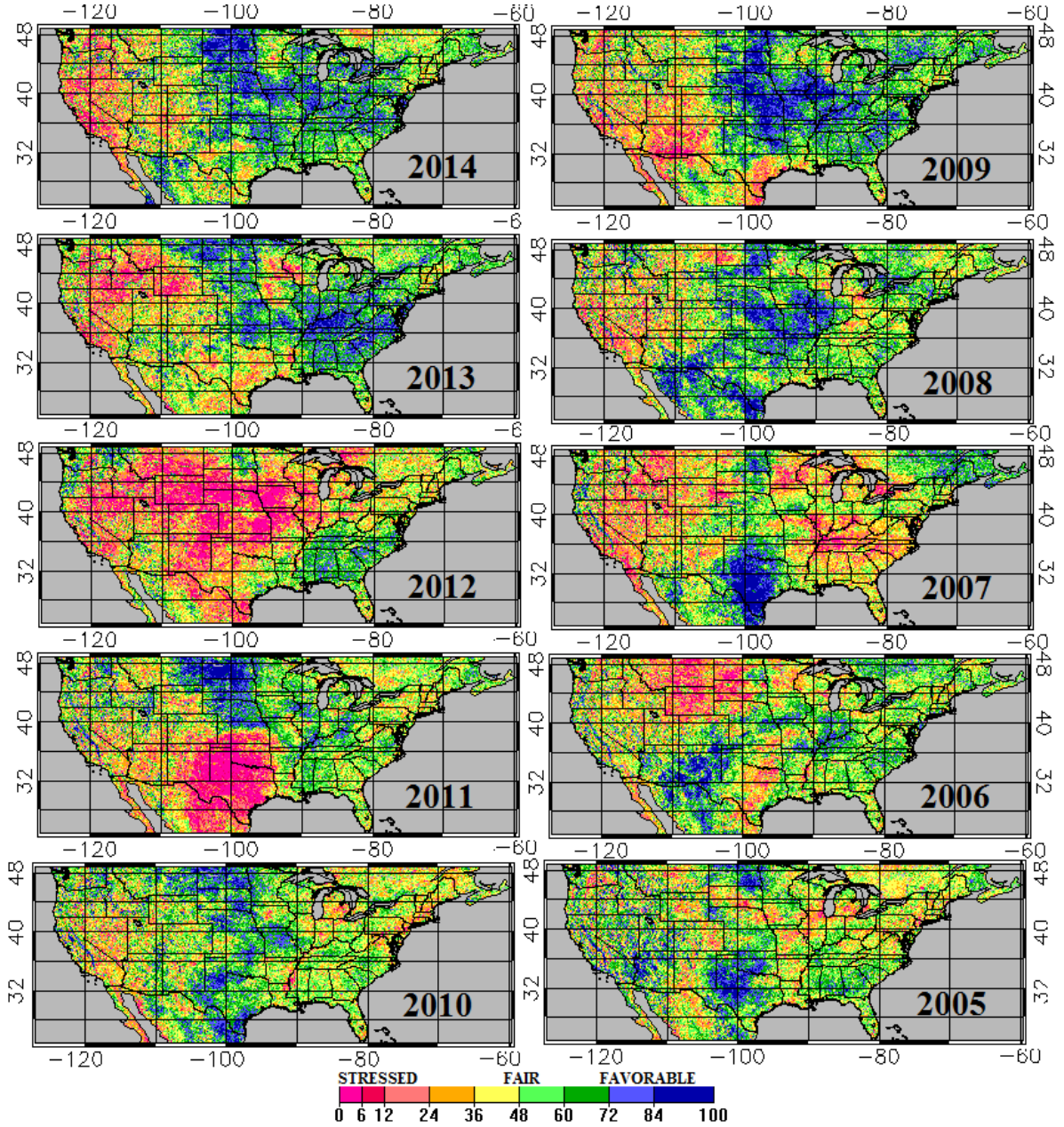
2010 - Exceptional drought in RUSSIA and UKRAINE

Drought-related Vegetation Stress 2013- 2014

from satellite-based Vegetation Health

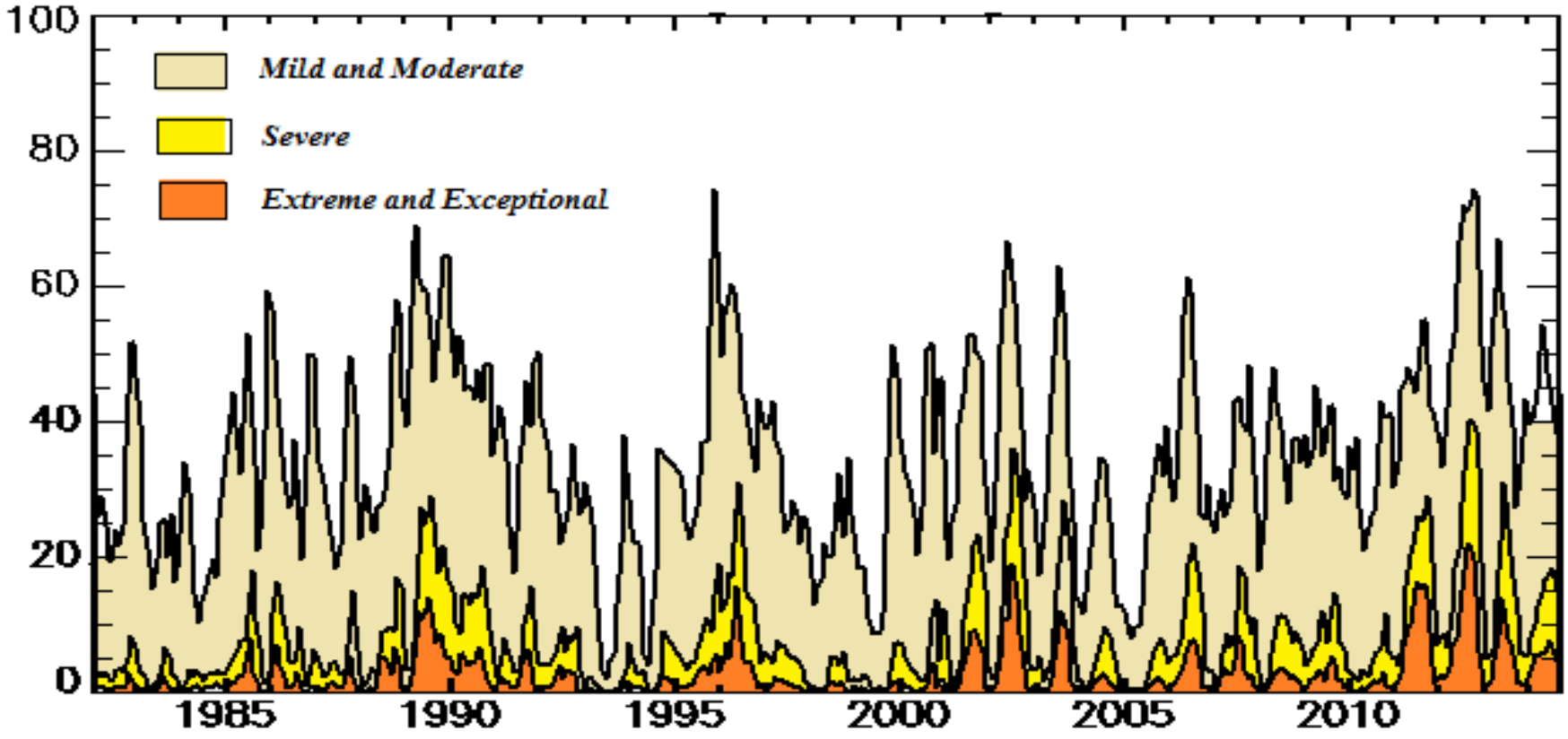


9-year Drought in Western USA from Vegetation health (VH)



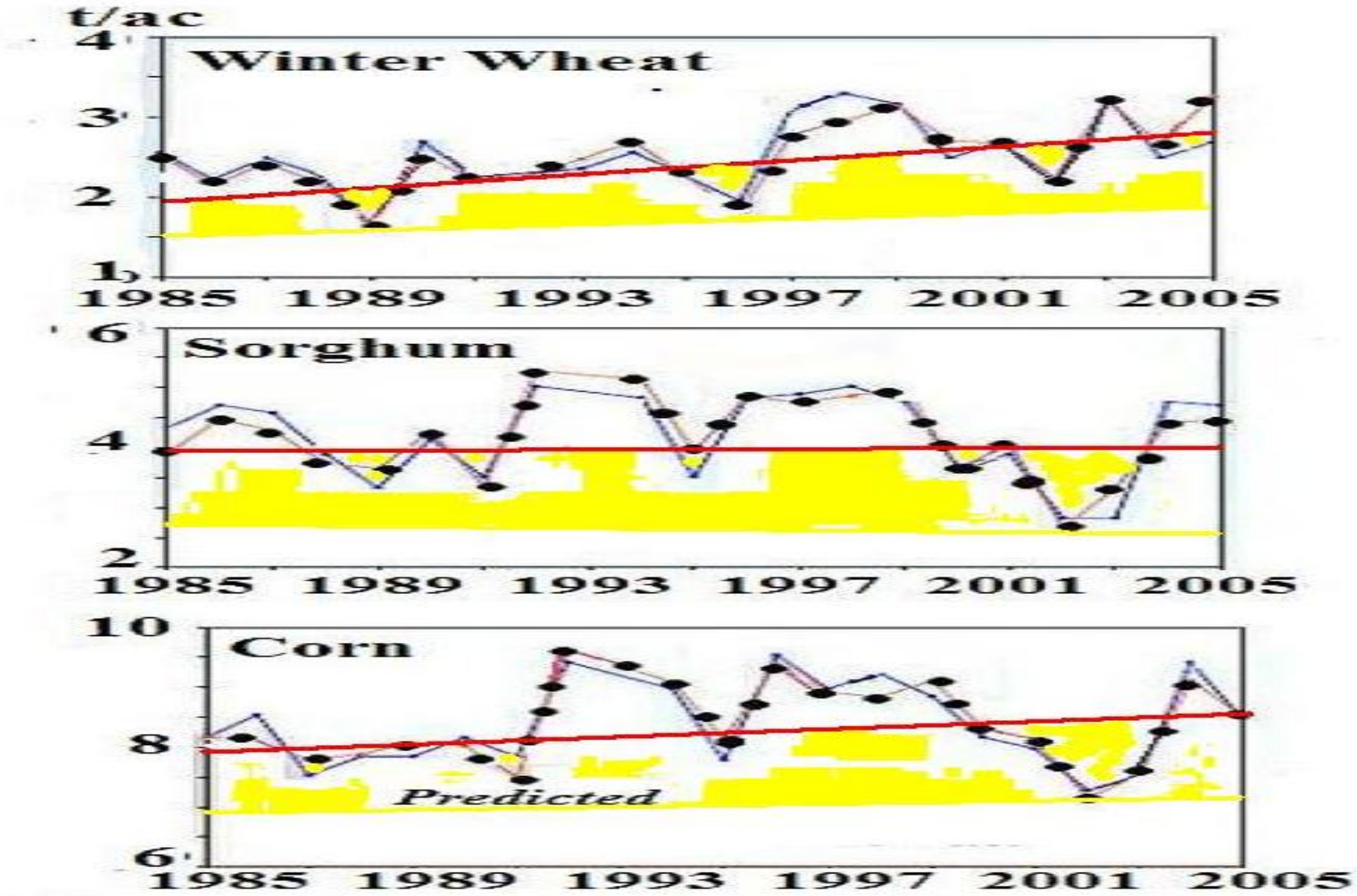
VH estimates vegetation health (condition) from extreme stress (dark red) to favorable conditions(dark blue)

Drought area for three intensities, 1982-2014 Western USA



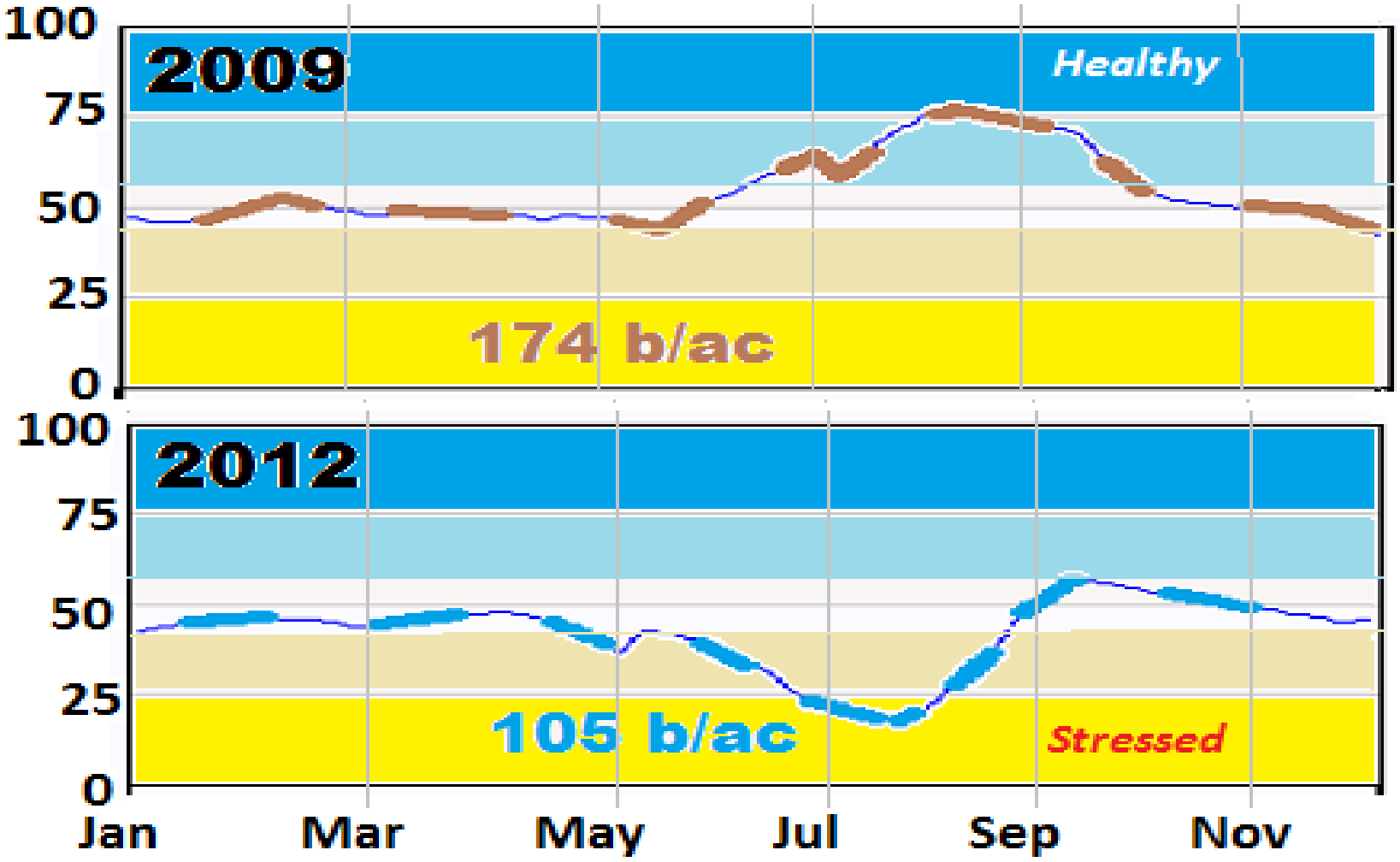
Drought Area & Intensity by weeks: Western United States, 1982-2014

VH-Crop Losses Prediction: USA, Kansas



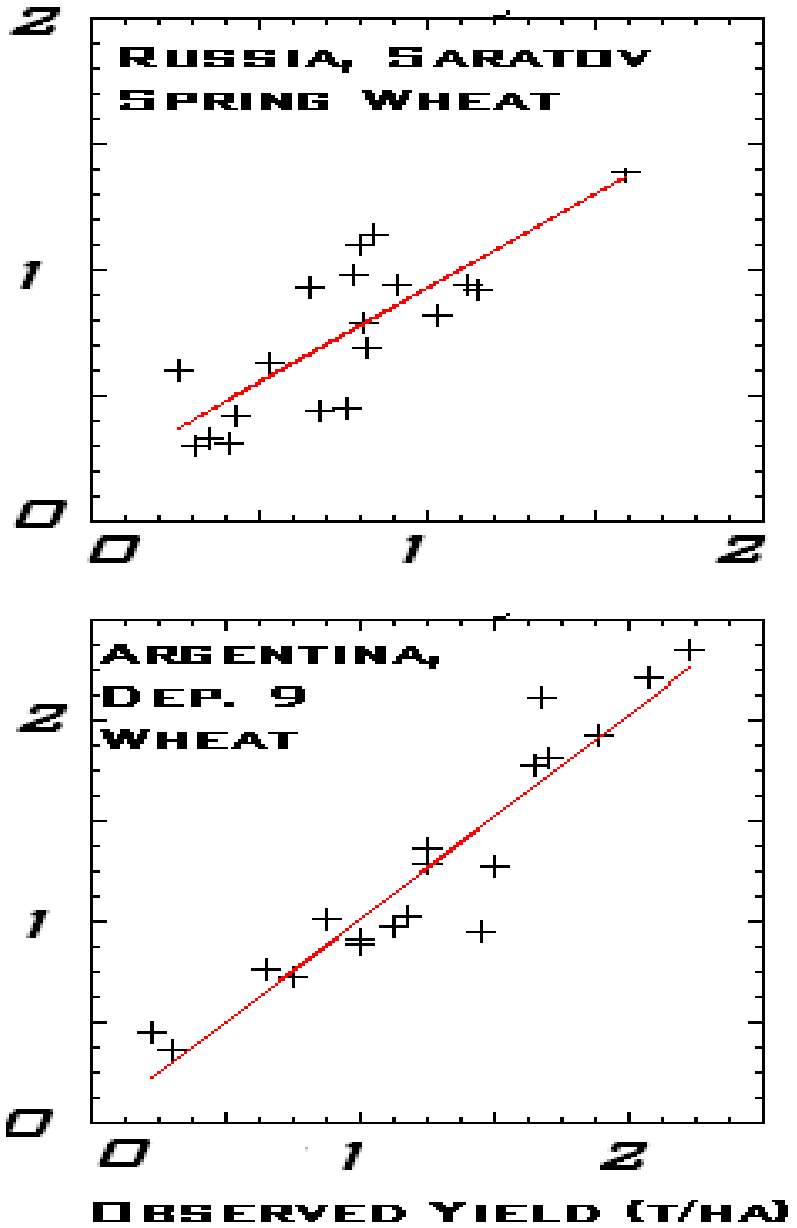
Observed & Predicted Yield, USA, Kansas

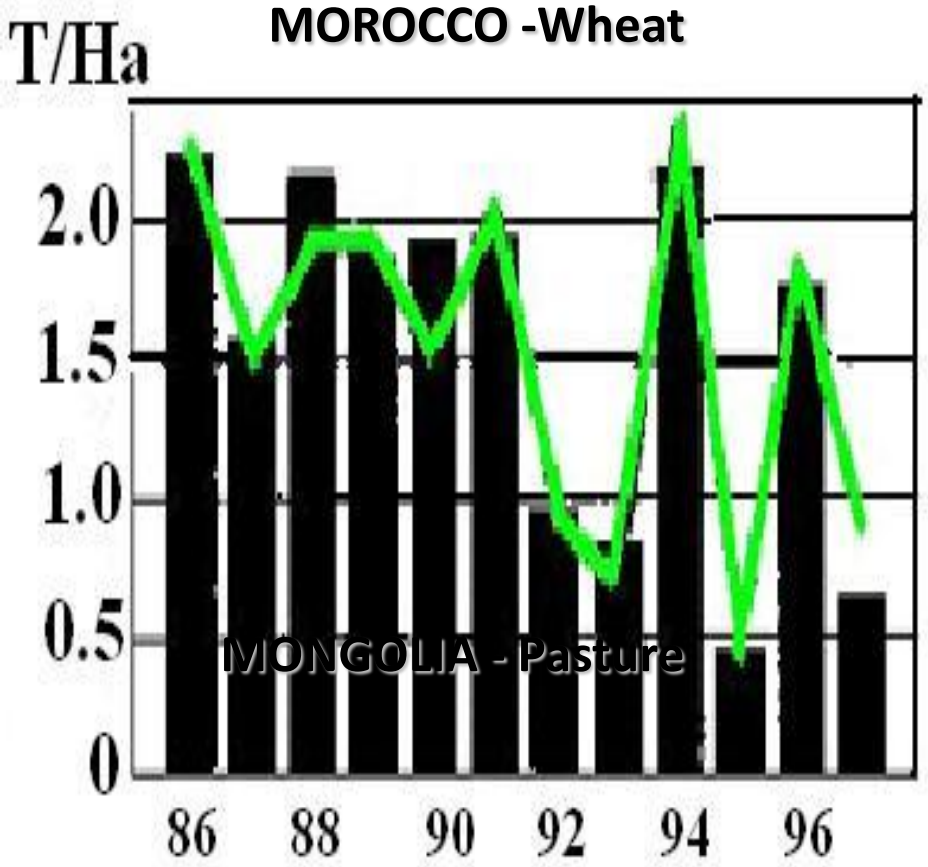
VH & Corn Yield, Illinois, USA



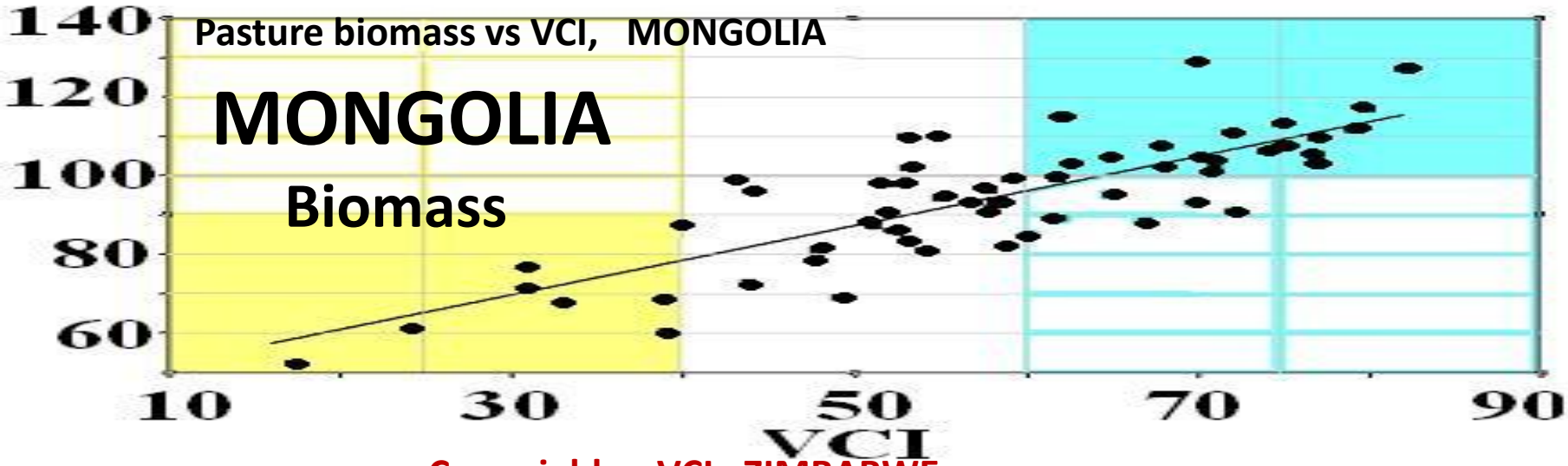
Vegetation health & corn yield. Illinois. USA

VH and Crop Yield

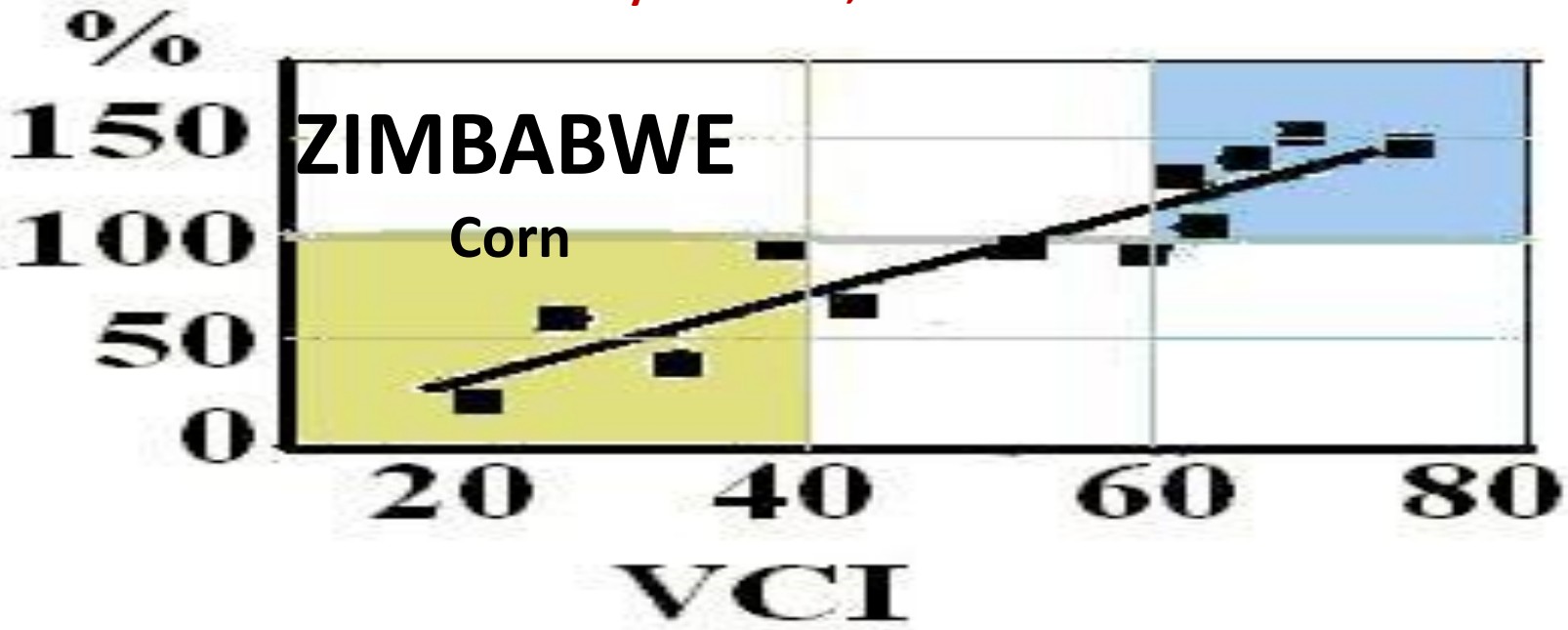




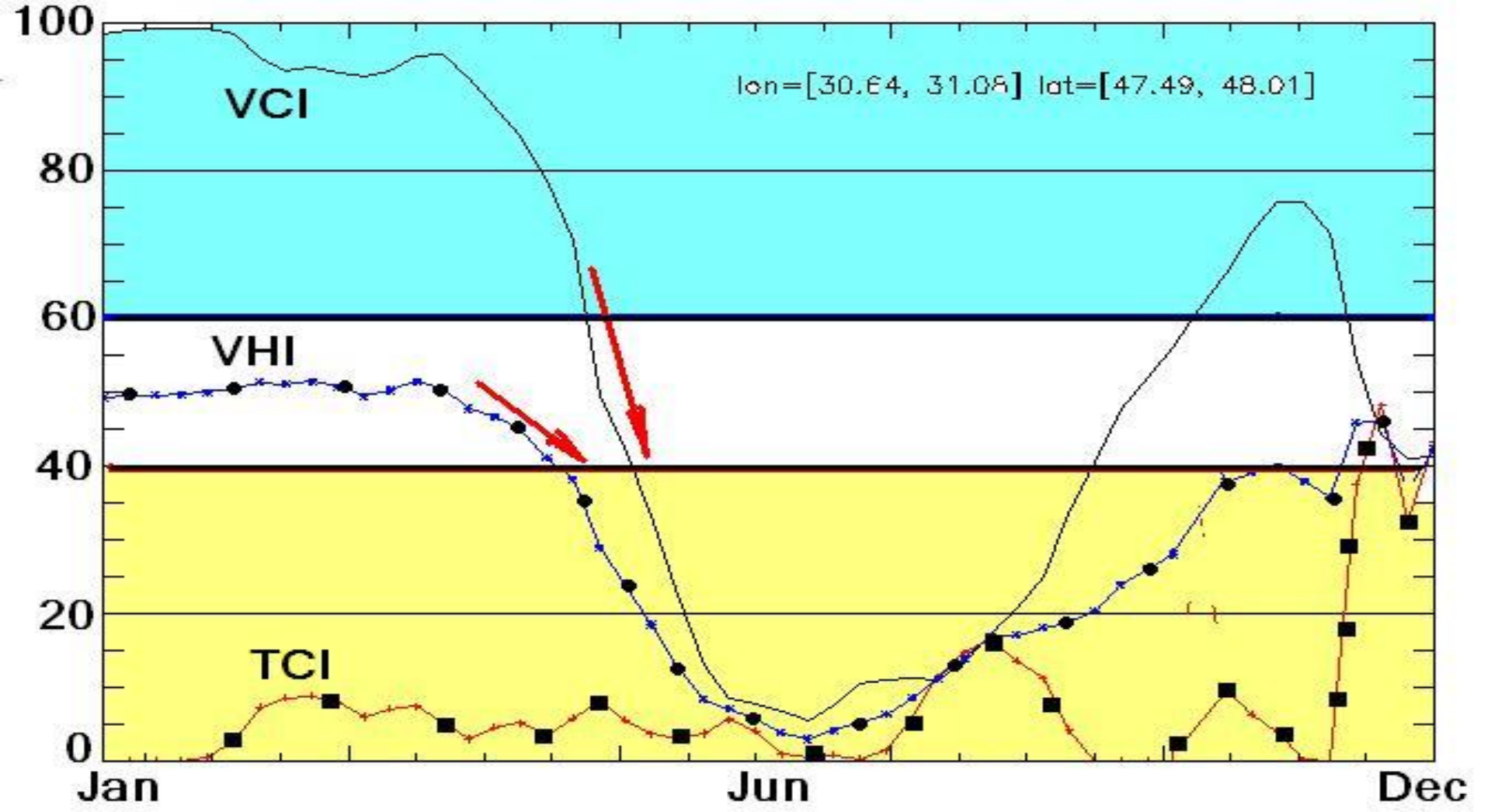
VH-Biomass & Corn Yield Modeling & Prediction



Corn yield vs VCI, ZIMBABWE



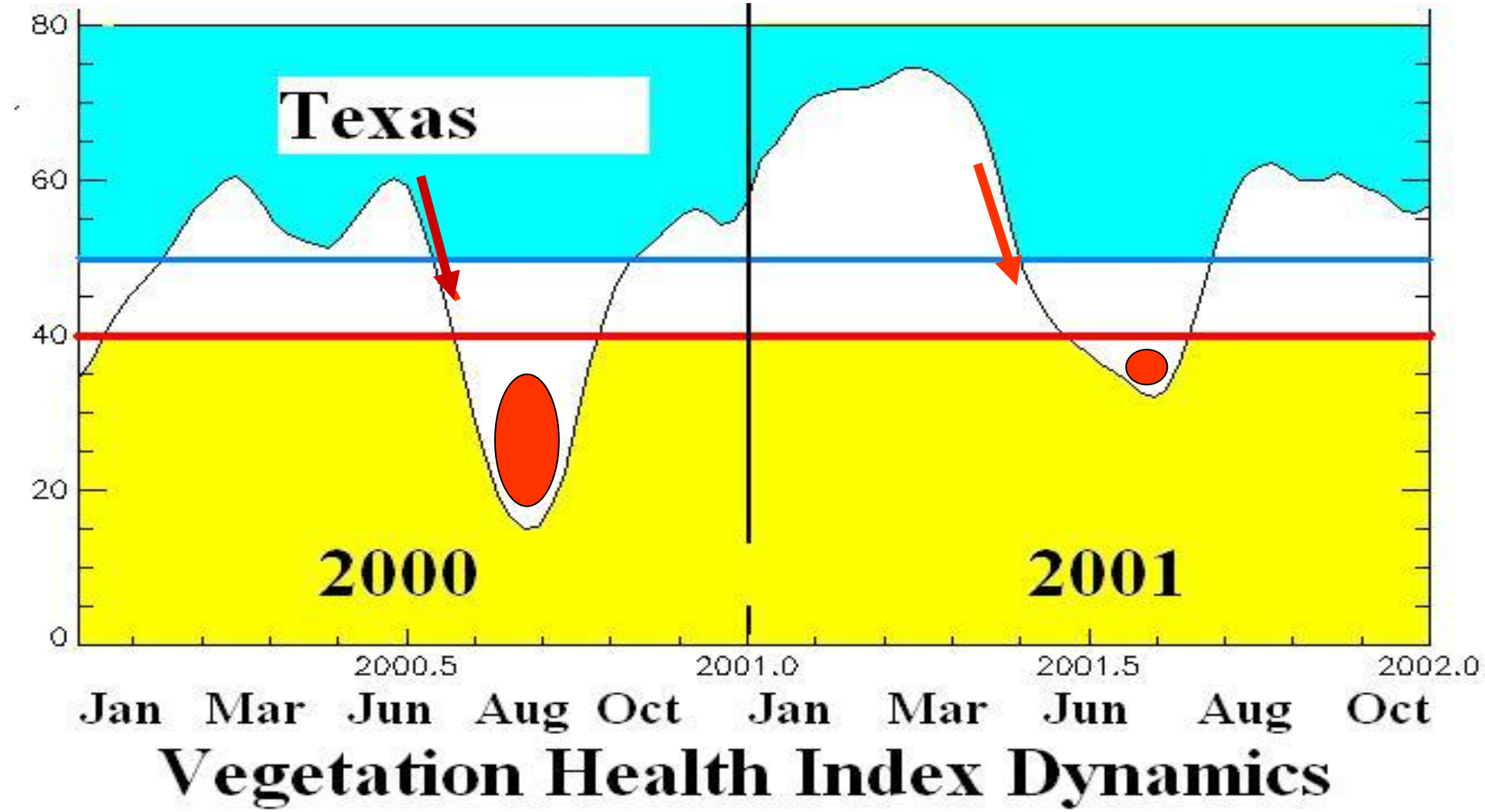
2007 Vegetation Health, UKRAINE



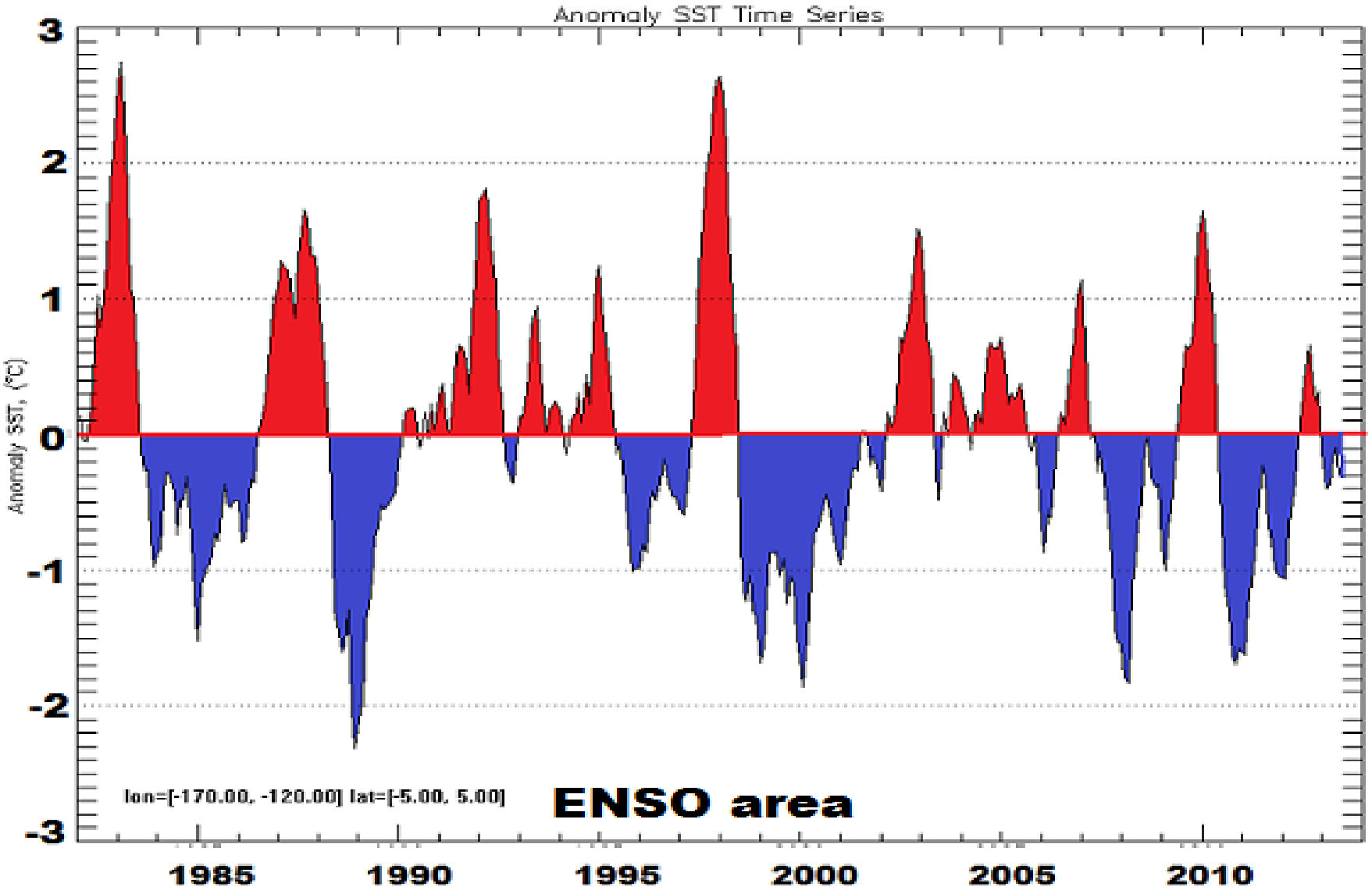
Vegetation health indices, 2007, UKRAINE

AVHRR from NOAA-18

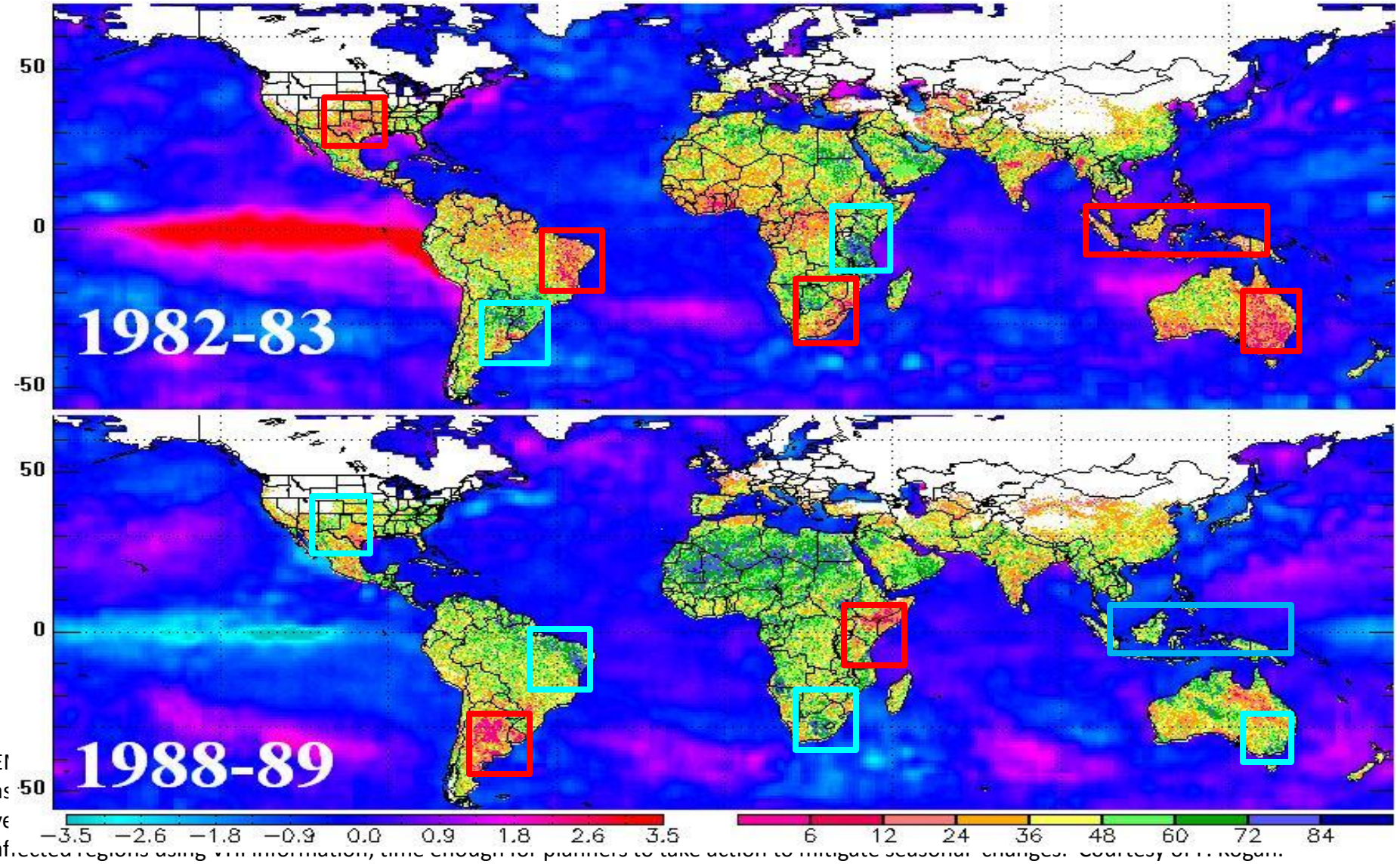
VH-Drought Prediction (1-2 months)



SST Anomaly in 3.4 ENSO



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



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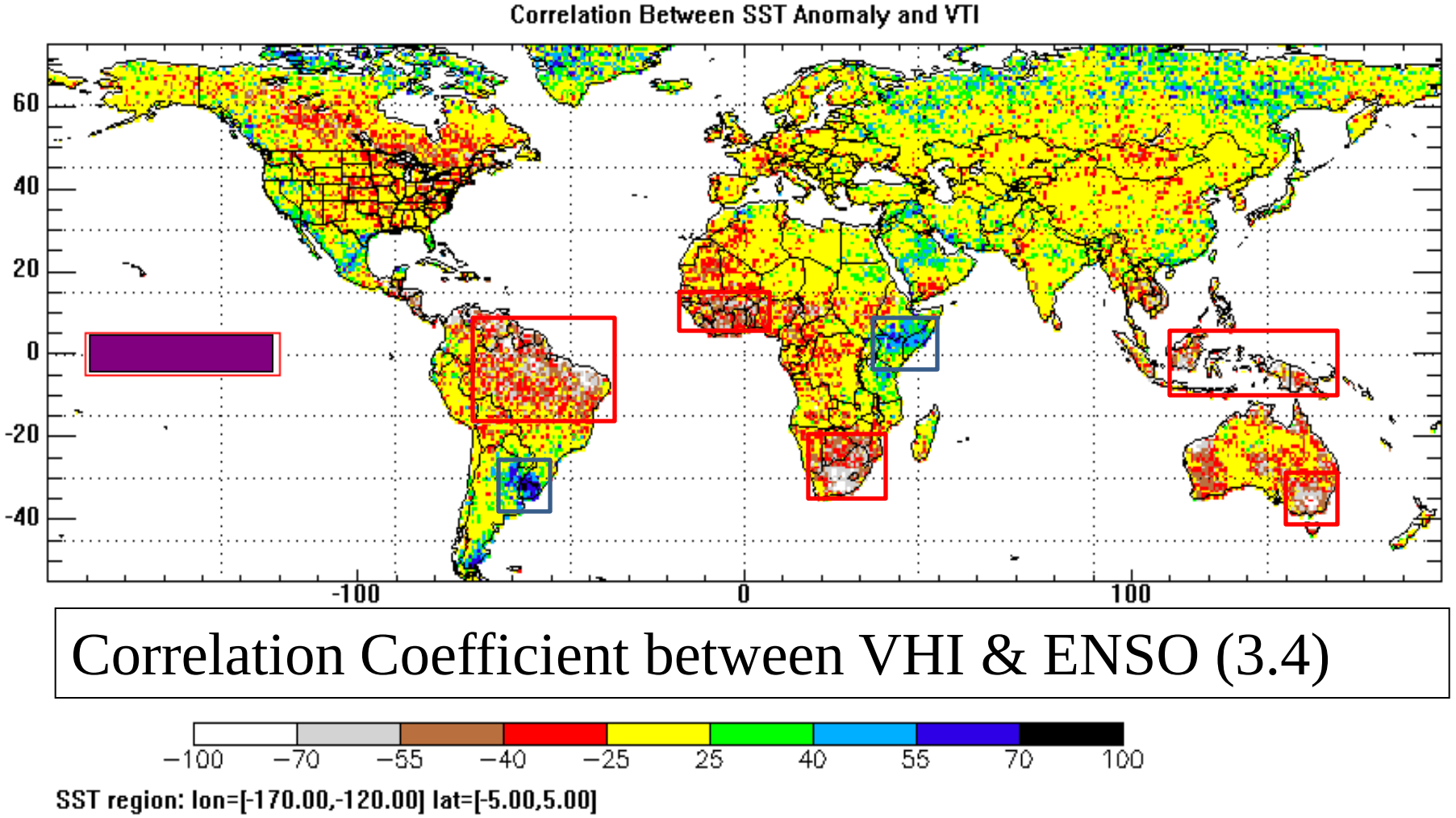
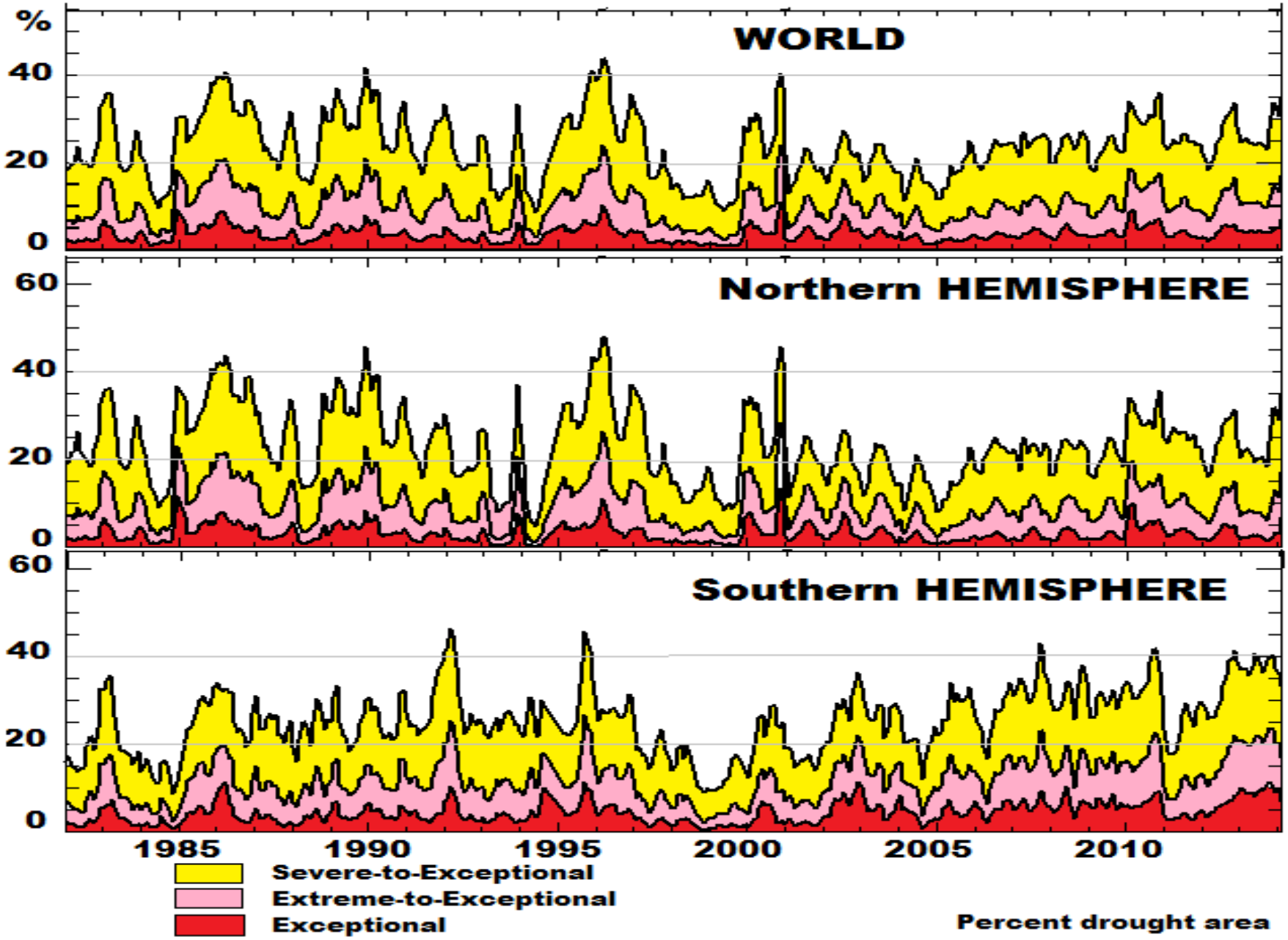
Sensitivity of Ecosystems to ENSO

Correlation of VH with SST anomaly in Tropical Pacific



Correlation Coefficient between VHI & ENSO (3.4)

Climate: Percent Land under Drought



Drought portal on NOAA-Web

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

Every week on Tuesday

VH Products

DISASTERS (droughts, soil saturation)

FORESTRY (fire risk)

AGRICULTURE (production, losses)

LAND CONDITION (moisture, thermal)

CLIMATE FORCING (ENSO)

HUMAN HEALTH (epidemics)

WATER (irrigation)

NWS MODELS (vegetation fraction)

ECOSYSTEMS (distribution & change)

CLIMATE CHANGE

DATA RECORDS

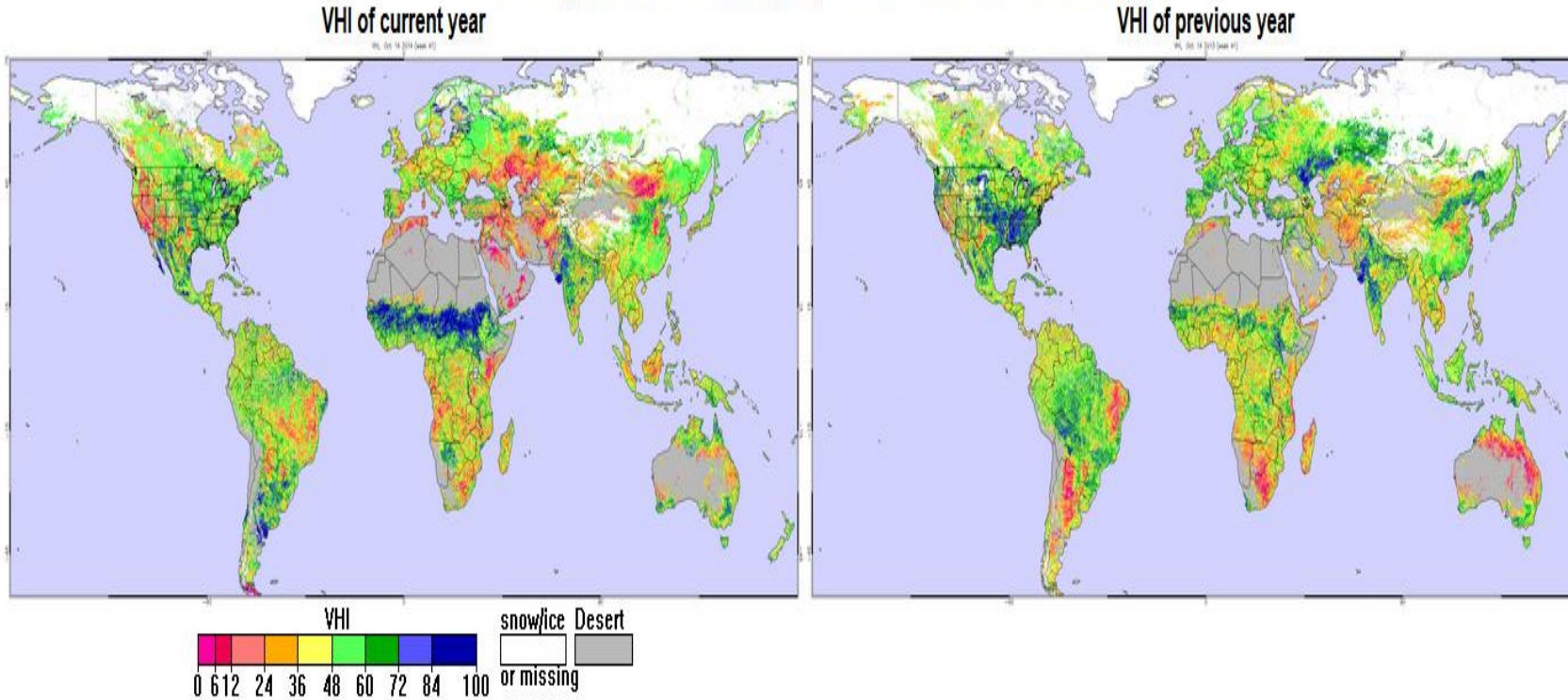
Drought & Vegetation Health Portal-1
NOAA/NESDIS/STAR

- Vegetation Health Home
- VH Images (16km) >>
- Image Animation (16km)
- Time Series for USA
- High Resolution VH (4km)
  - Image by Google-Map
  - Images By Country
  - VH Info By Province
  - Animation By Country
- Background and Explanation
- Example NDVI Image in Various projections
- Unusual Events
  - 2006: Horn Of Africa
  - El Nino
- Download Data
- Publications
  - Documentation
  - Presentations
  - Technique Background
- Resource Information
  - HE Rain Rate Hourly
  - HE Rain Rate Daily
  - HE Rain Rate Weekly
  - CMORPH Rain Rate Hourly
  - CMORPH Rain Rate Daily
  - CMORPH Rain Rate Weekly
  - Snow Map Weekly
  - Equatorial Crossing Time

Browse Archived Images: Please select an **Image Type**, **Region**, **Year** and **Week**.

Data type	Region	Year	Week
Vegetation Health (VHI)	World	< 2014 >	< 41 >

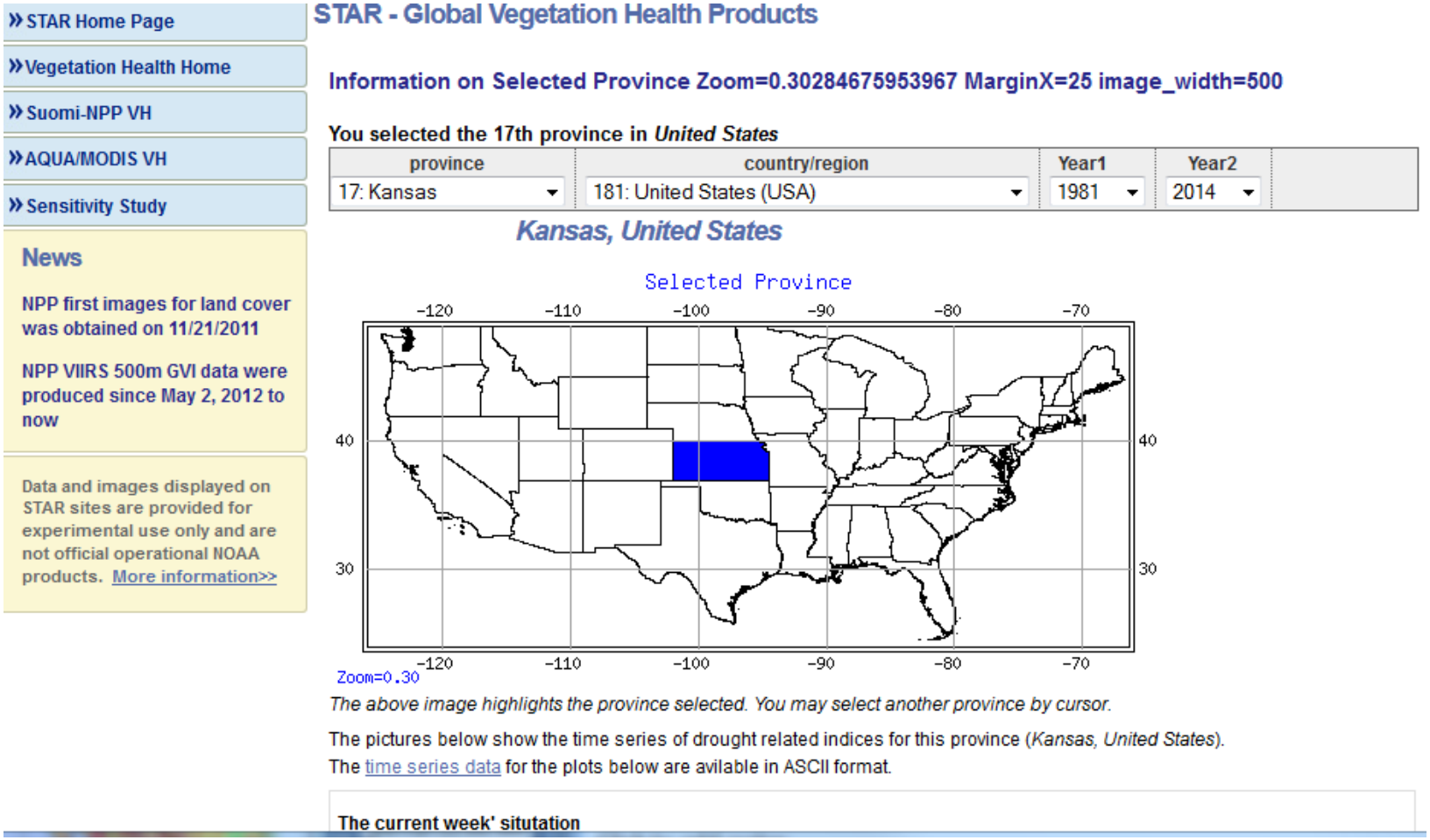
World - Vegetation Health Index (VHI): Current Week and One Year Ago



Click this image see gloabl image; Click on the expand image to review maximum resolution.

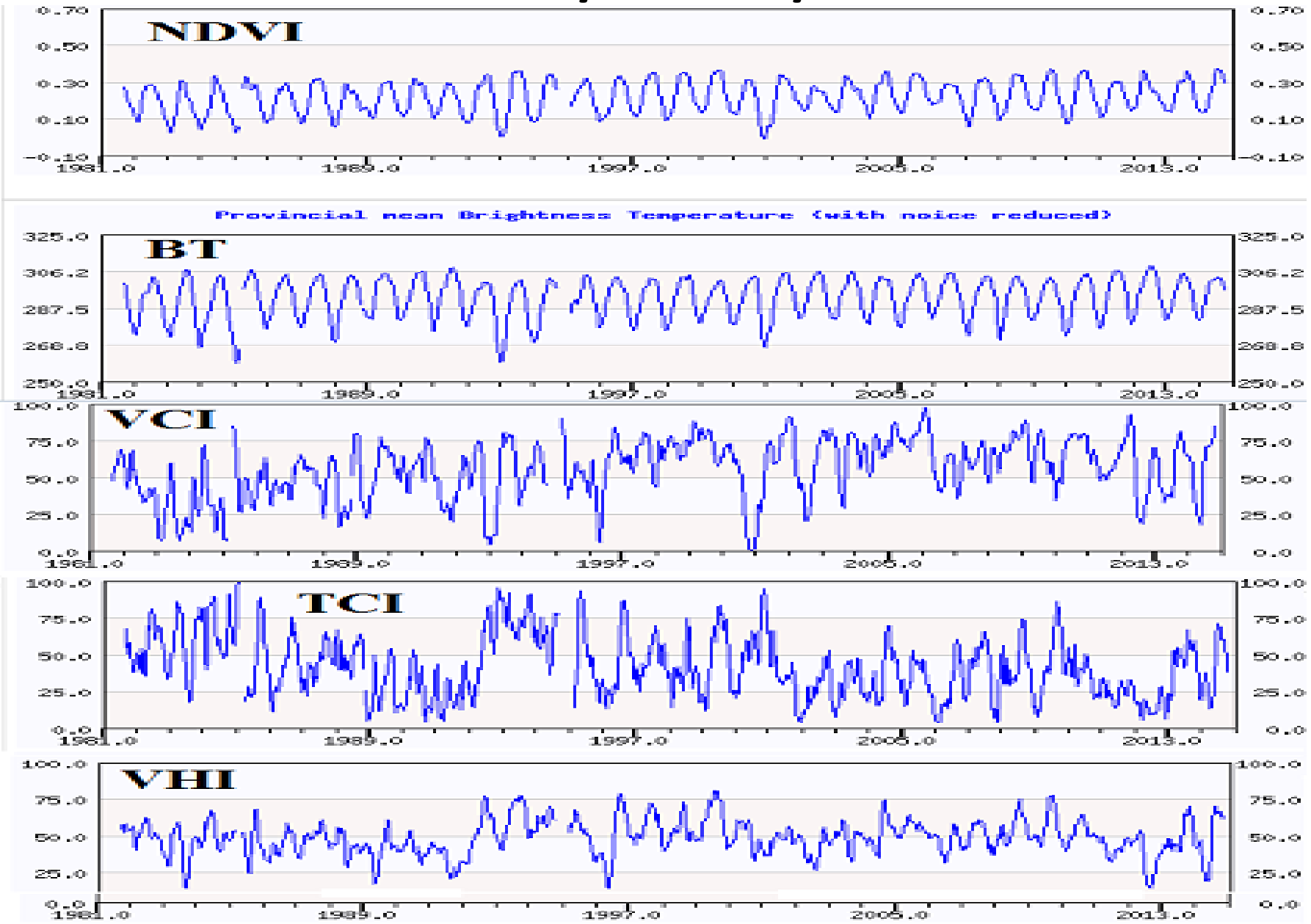
.star.nesdis.noaa.gov/smcd/emb/vci/gvix_webImages/2014/WorldBig_VHI_201441.png

Drought & Vegetation Health Portal-2 NOAA/NESDIS/STAR



http://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browseByCountry_province.php?country=USA&x=249&y=123

Drought & Vegetation Health Portal-3
NOAA/NESDIS/STAR

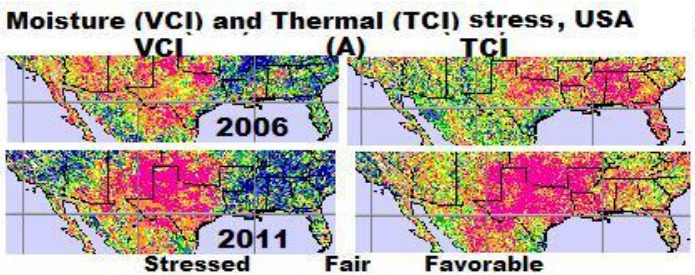


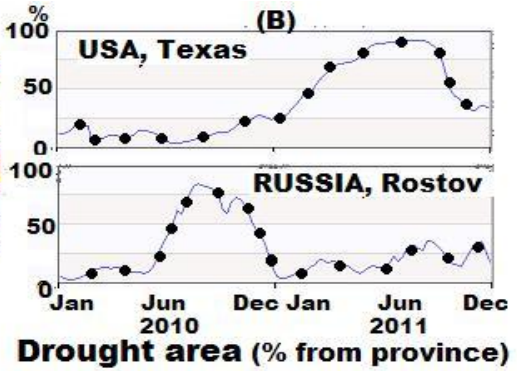
VH Applications

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

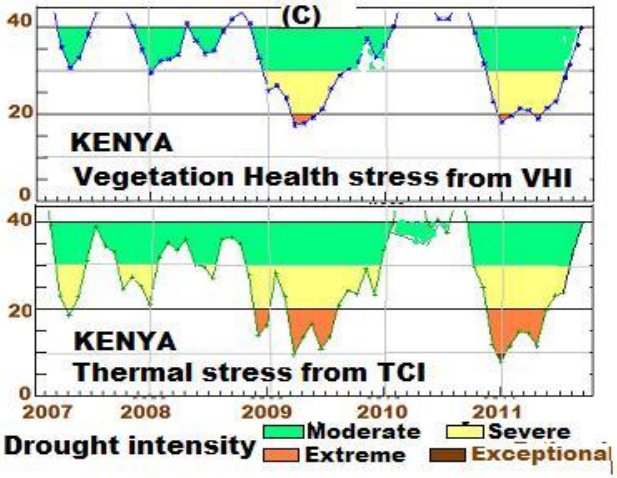
APPLICATIONS

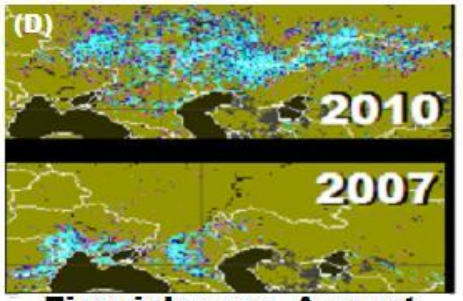
- (A) Moisture & Thermal stress
- (B) Drought area
- (C) Intensity of vegetation stress
- (D) Fire risk
- (E) Drought duration
- (F) Drought detection/prediction



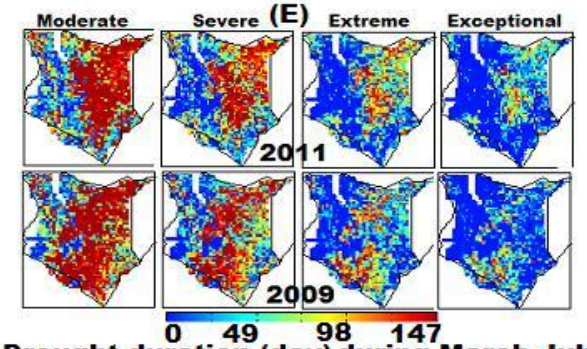


Drought area (% from province)

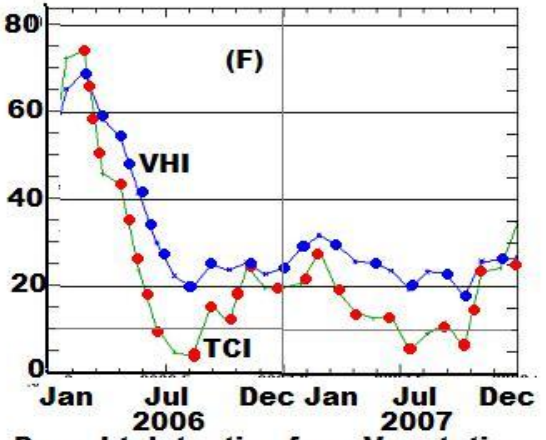




Fire risk area, August
RUSSIA & UKRAINE

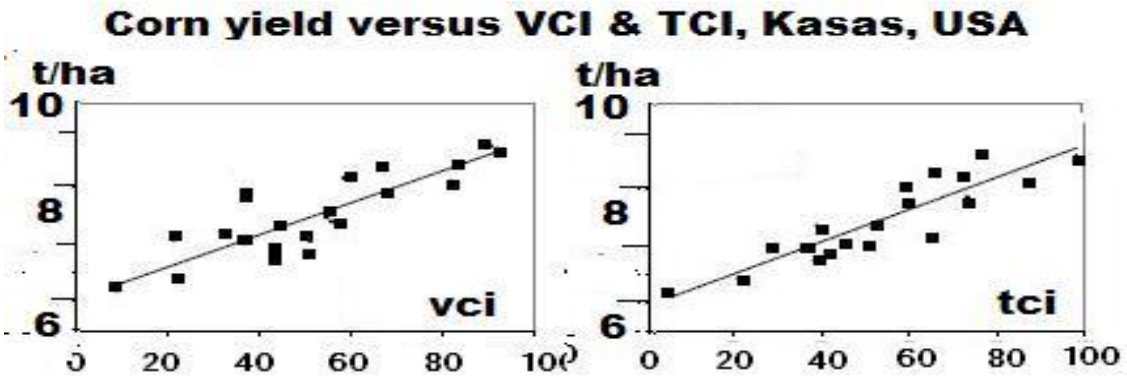


Drought duration (day) during March-July
KENYA



Drought detection from Vegetation Health (VHI) & Thermal (TCI) indices
Wheat belt, AUTRALIA (southwest)

VH Applications

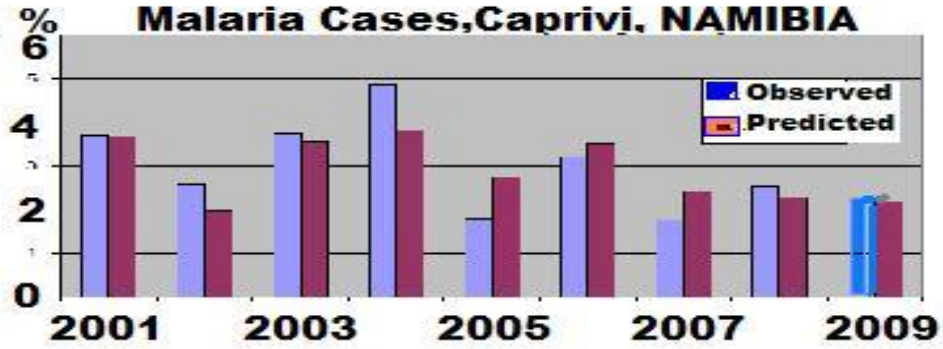


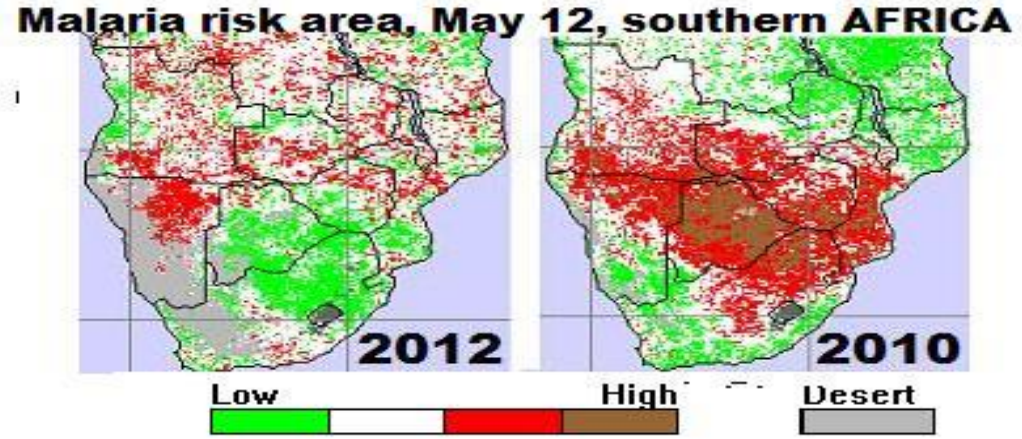
APPLICATIONS

Crop/Pasture Production

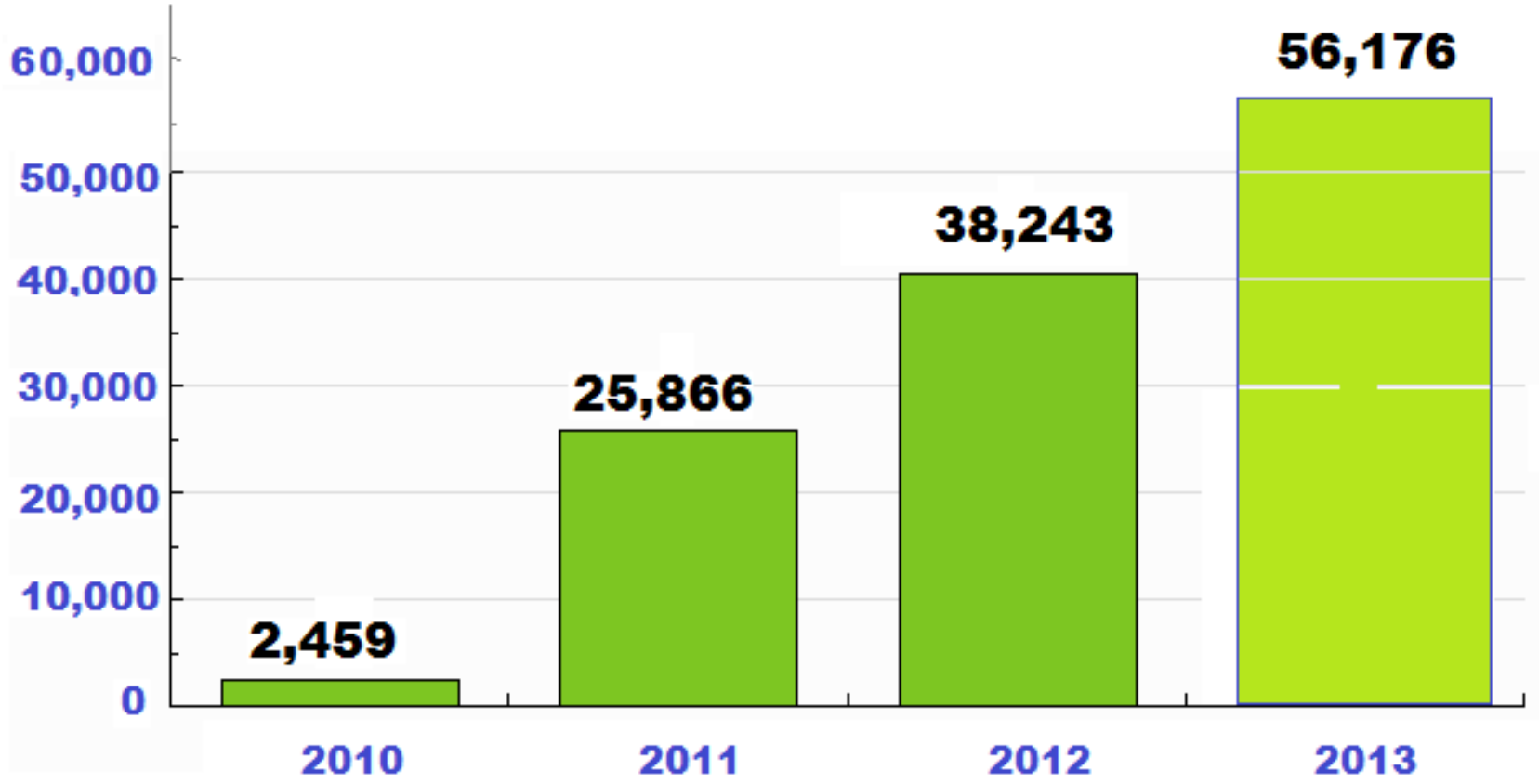
Malaria:

- **Number of affected people**
- **Affected area**
- **Intensity**





VH WEB Users' number



WEB page total users from a day of calculation started in Nov 2010

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

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 21st century 8 years out of 13)

Severe Droughts - Reduces Global Grain Production 4-7% every 4-6 years
Moderate Drought – Reduces Grain Yield up to 3% every 2-3 years

Satellite-based Vegetation Health (VH) Technology Provide Tools for Drought Monitoring & 1-2 Month Advanced Prediction of its Start

VH Provide Prediction of Drought-related Crop & Pasture Losses: (a) 3-6 Months in Advance of Harvest, (b) During ENSO years 8-12 months

VH can be used for predictions & assessments

- **Prediction of Drought start**
- **Assessment of Drought Area & Intensity**
- **Crop and pasture production prediction**
- **Land cover change**
- **Global & Regional climate warming dynamics**
- **Provide assessment of Regional Food Security**

Principal Publications since 2010

- **2015 - Felix Kogan and Wei Guo, 2015:** Agricultural Drought monitoring using space-derived biophisical products: a global perspective. ***Advances in Land Remote Sensing: Last 50 Year*** (chapter 13 of the Book)
- **2014 - Kogan, F. and W.Guo 2014,** Early twenty-first-century droughts during the warmest climate. *Geomatics, Natural Hazards and Risk.* http://dx.doi.org/10.1080/19475705.2013.878399
- **2013 - Nizamuddin, M., F. Kogan, R. Dihman, W. Guo, L. Roytman, 2013:** Modeling and Forecasting Malaria in Tripura, India using NOAA/AVHRR-Based Vegetation Health Indices. *Int. J. Rem. Sens. Applications*, Vol .3, Issue 3, 108-116.
- **2013 - Kogan, F., N. Kussul, T. Adamenko, S. Skakun, O. Kravchenko, O. Kryvobok, A. Shelestov, A. Kolotii, O. Kussul, A. Lavrenyuk, 2013**: Winter wheat yield forecasting in Ukraine based on Earth observation, meteorological data and biophysical models. *International Journal of Applied Earth Observation and Geoinformation* 23 (2013) 192–203
- **2013 - Kogan, F., T. Adamenko and W. Guo, 2013.** Global and Regional Drought Dynamics in the Climate Warming Era. *Rem. Sens.Letters.* Vol 4, Issue 4, 364-372
- **2012 - Kogan, F., L. Salazar and L. Roytman, 2012**: Forecasting crop production using satellite-based vegetation health indices in Kansas, USA**.** *J. Rem. Sens.* **33(9**), 2798-2819.
- **2012 - Rahman, A., K. Khan, N. Y Krakauer, L. Roytman, F. Kogan, 2012:** Use of Remote Sensing Data for Estimation of Aman Rice Yield. *International Journal of Agriculture and Forestry*, 2(1): 101-107 (DOI10.5923/j.iaf.20120201.16).
- **2011 - Rahman, A., F. Kogan, L. Roytman, M. Goldberg and W. Guo, 2011.** Modeling and prediction of malaria vector distribution in Bangladesh from remote sensing data. *Int. J. Rem. Sens.*. Vol 32, No. 5, 1233-1251.
- **2011 - Atiqur Rahman, Leonid Roytman, Mitch Goldberg, and Felix Kogan, 2011**: Comparative Analysis on Applicability of Satellite and Meteorological Data for Prediction of Malaria in Endemic Area in Bangladesh. *Am. J. Trop. Med. Hyg.,* 82(6), pp. 1004–1009.
- **2011 - Felix Kogan, Alfred Powell and Oleg Fedorov (Editors), 2011: *Use of Satellite and In-Situ Data to Improve Sustainability.*** Springer, 314 pp.
- **2010 - Bhuyan C. and F. Kogan, 2010**: Monsoon Variations and Vegetative Drought Patterns in the Luni Basin under Rain-shadow Zone. *Int. J. Rem. Sens.*. **Vol 31, No 12,** pp. 3223-3242
- **2010 - Atiqur Rahman, Nir Krakauer, Leonid Roytman, Mitch Goldberg and Felix Kogan 2010:** Application of Advanced Very High Resolution Radiometer (AVHRR)-based Vegetation Health Indices for Estimation of Malaria Cases. *Am. J. Trop. Med. Hyg.,* 82(6), pp. 1004–1009
- **2010 - Xiaoyang Zhang, Mitchell Goldberg, Dan Tarpley, Mark Friedl, Jeffrey Morisette, Felix Kogan, Yunyue Yu 2010:** Drought-induced Vegetation Reduction in Southwestern North America. *Env Res. Let.* **Vol. 5,** 11 p.
- **2010 - Felix Kogan 2010**: ENSO impact on vegetation. ***Use of Satellite and In-Situ Data to Improve Sustainability.*** Springer, pp. 165-174.
- **2010 - Kushnir, V., F. Kogan G. Korotaev, and A. Powel 2010**: Predicting natural disasters in the coastal zone based on links between land and marine ecosystems. *Geomatics, Natural Hazards and risk.* Vol. 1, No. 3, September. pp 185-198, (ISSN: 1947-5705)
- **2010 - Felix Kogan, Wei Guo, and Aleksandar Jelenak 2010:** Global Vegetation Health: Long-Term Data Records. ***Use of Satellite and In-Situ Datato Improve Sustainability.*** pp. 247-256.