Vegetation Health Development and Applications Transition from AVHRR to JPSS

Presenters:
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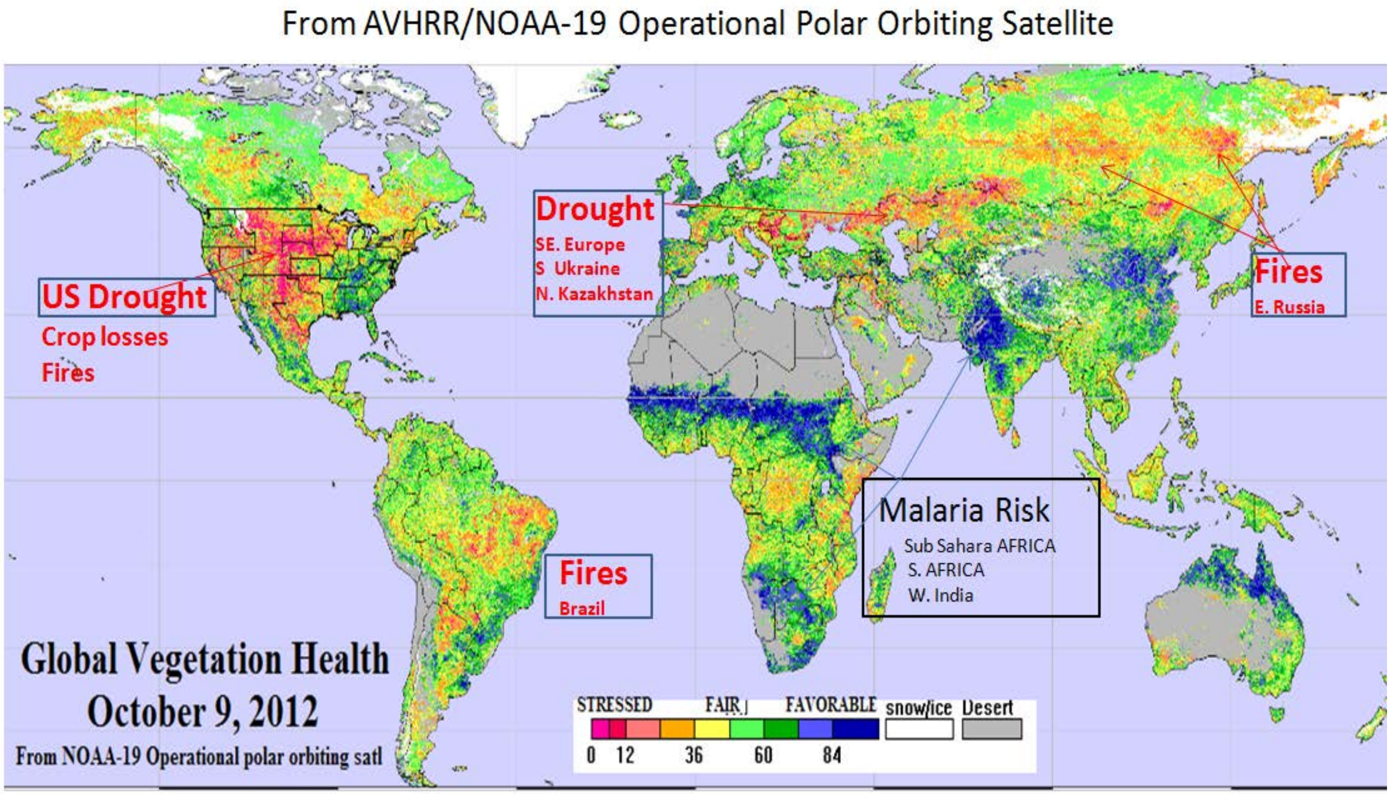
Vegetation Health Index & Applications, Aug, 2017

Vegetation Health (VH) is an indicator of satellite-based vegetation response to weather (mostly P and T)



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

- Vegetation Health
- Drought
  - Area
  - Intensity
  - Duration
  - Start/End
  - Impacts
- Moisture Stress
- Thermal Stress
- Healthy Vegetation
- Crop/pasture Prod.
- Fire Risk
- Soil Saturation
- Mosquitoes Diseases
- Land Greenness
- Landslides
- Food security
- Climate Change
- Land Change

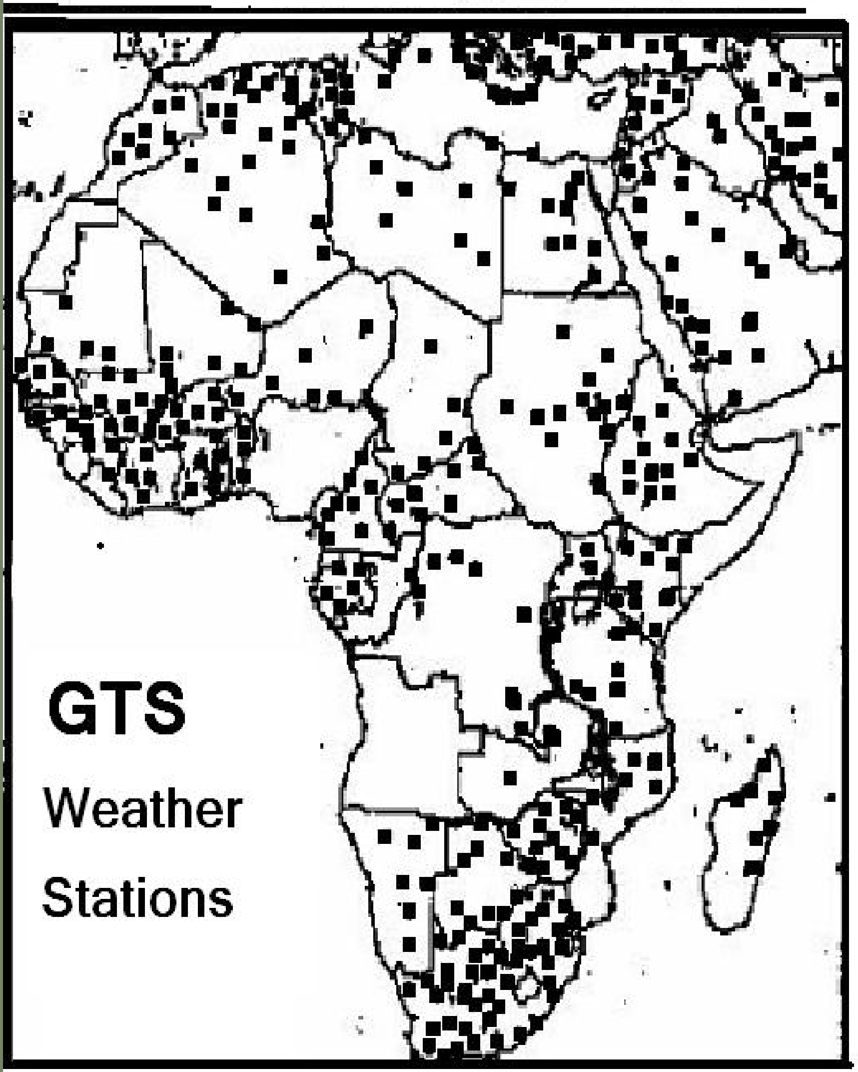
GTS (WMO-based) weather station network

One weather station covers

GLOBAL -10,000 sq. km
Africa - 31,000 sq. km

NOAA satellites cover

AVHRR: 4 & 16 km²
VIIRS: 0.5, 1 & 4 km²



Vegetation Health

(1) Normalized Difference Vegetation Index (NDVI)

VIS (Ch1) and NIR (CH2)

Brightness Temperature (BT)

IR (CH4)

(2) NDVI & BT Climatology

Vegetation Health (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

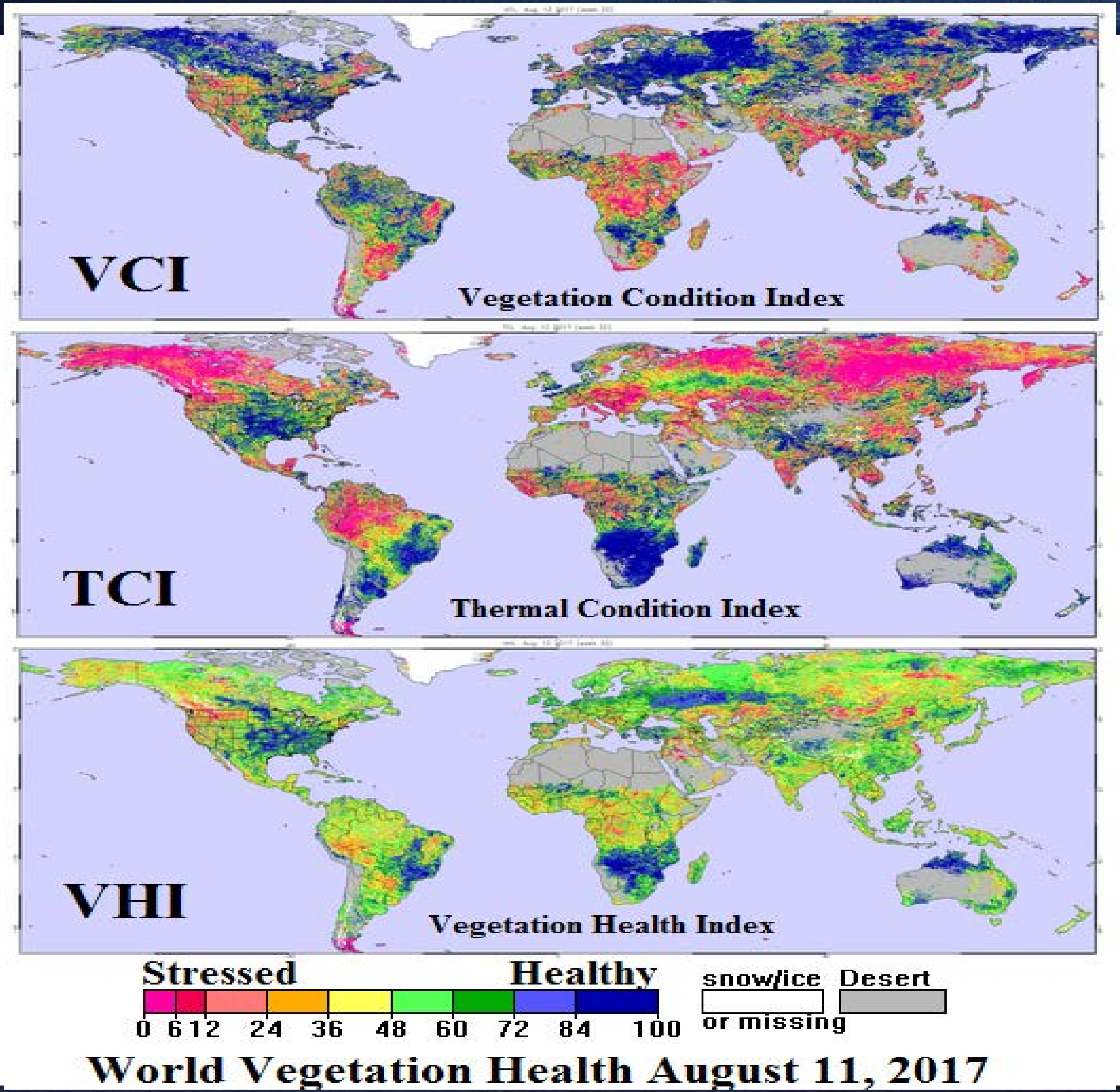
Vegetation Health Index (VHI), **values 0 – 100**

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

VEG. HEALTH

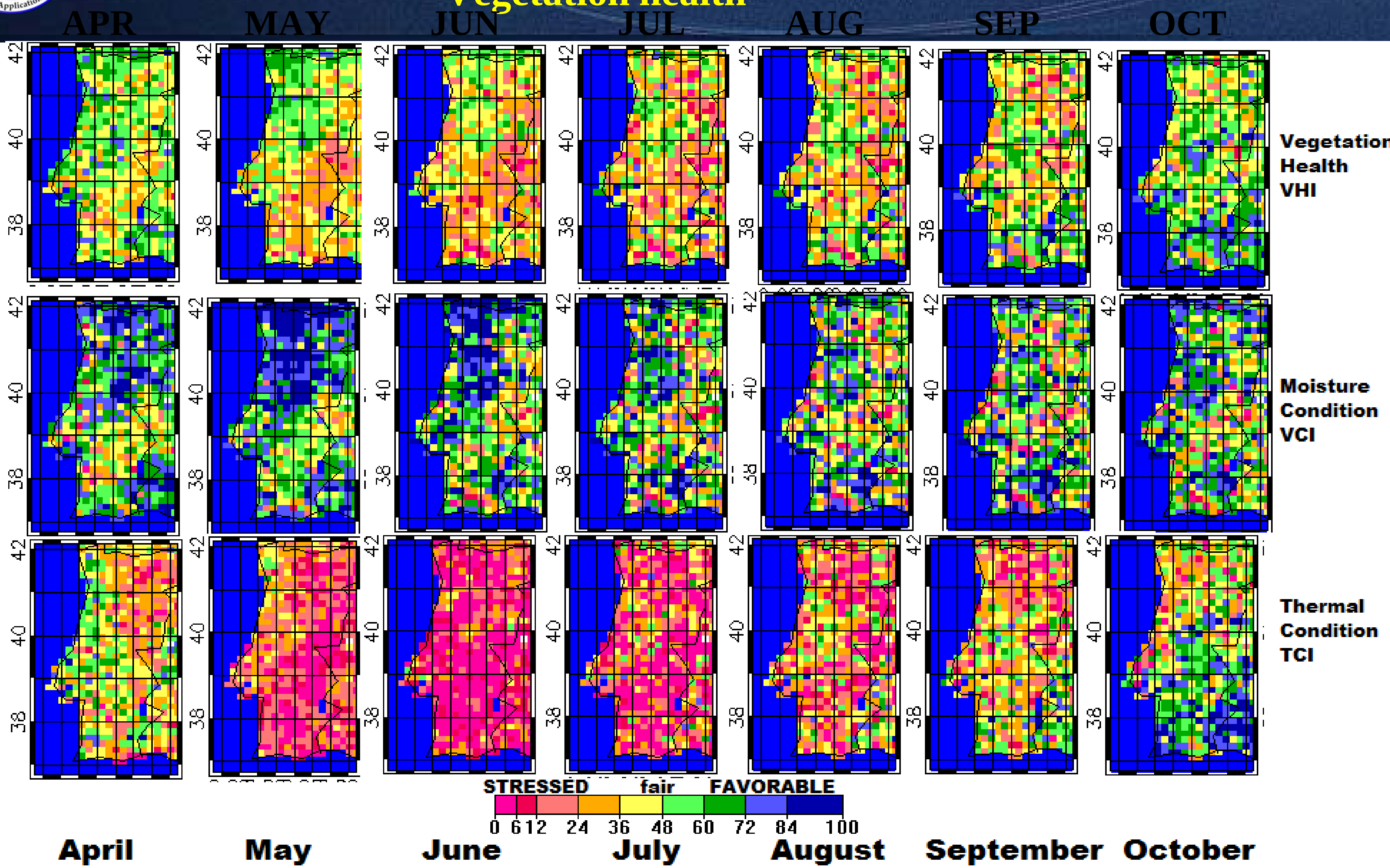
0 – indicates extreme stress; **100 – indicates favorable conditions**

VCI, TCI & VHI Aug 11, 2017



2015 PORTUGAL

Vegetation health



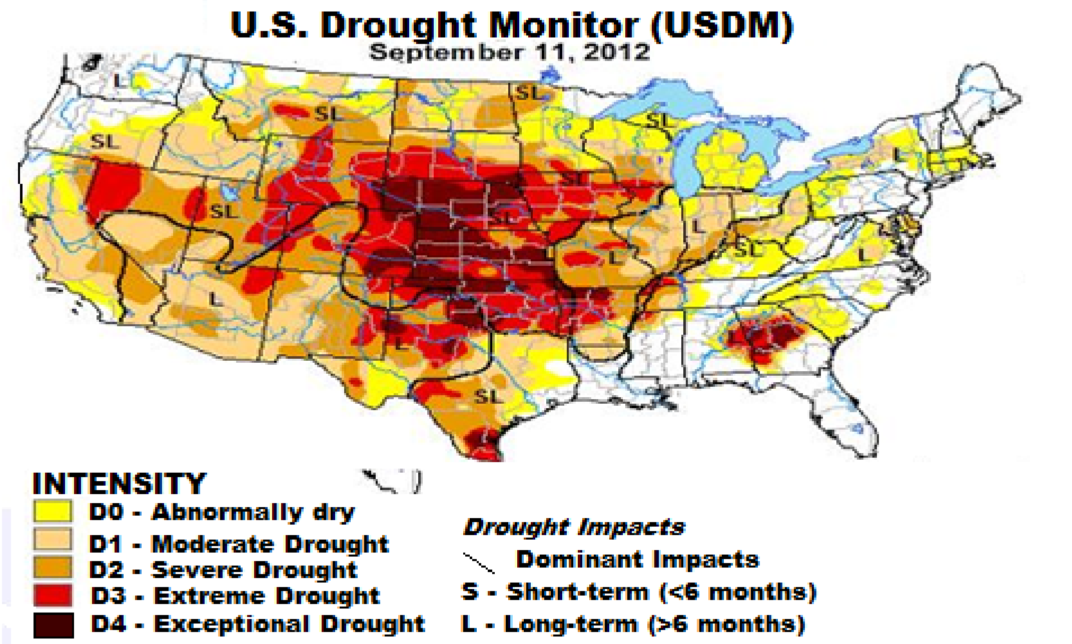
Vegetation Health 2015, PORTUGAL

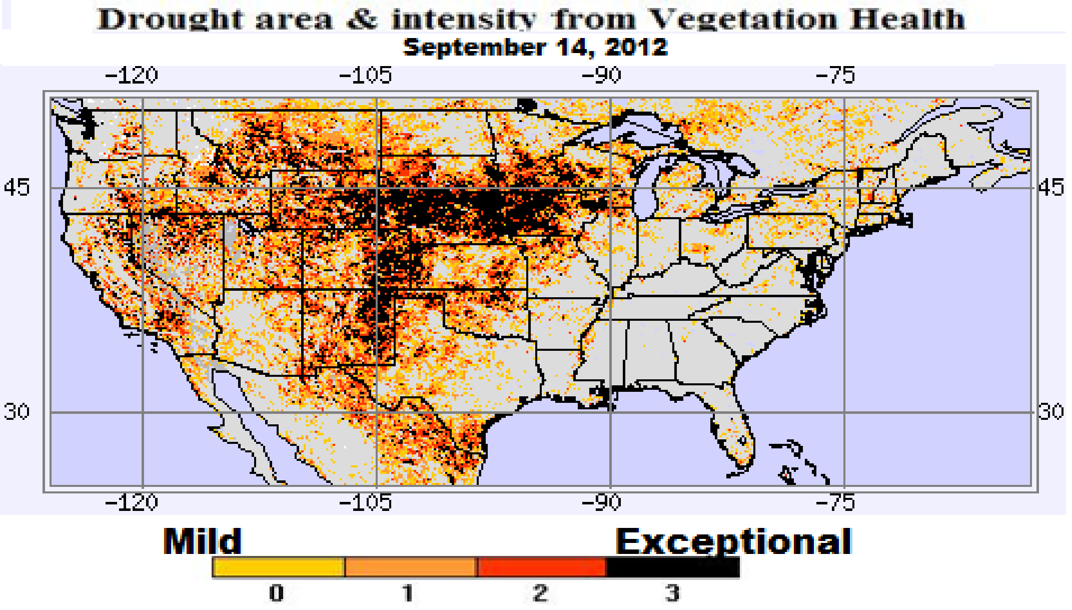
Vegetation Health (VH) Data

- NOAA/AVHRR (37y) 16 sq. km
  4 sq. km

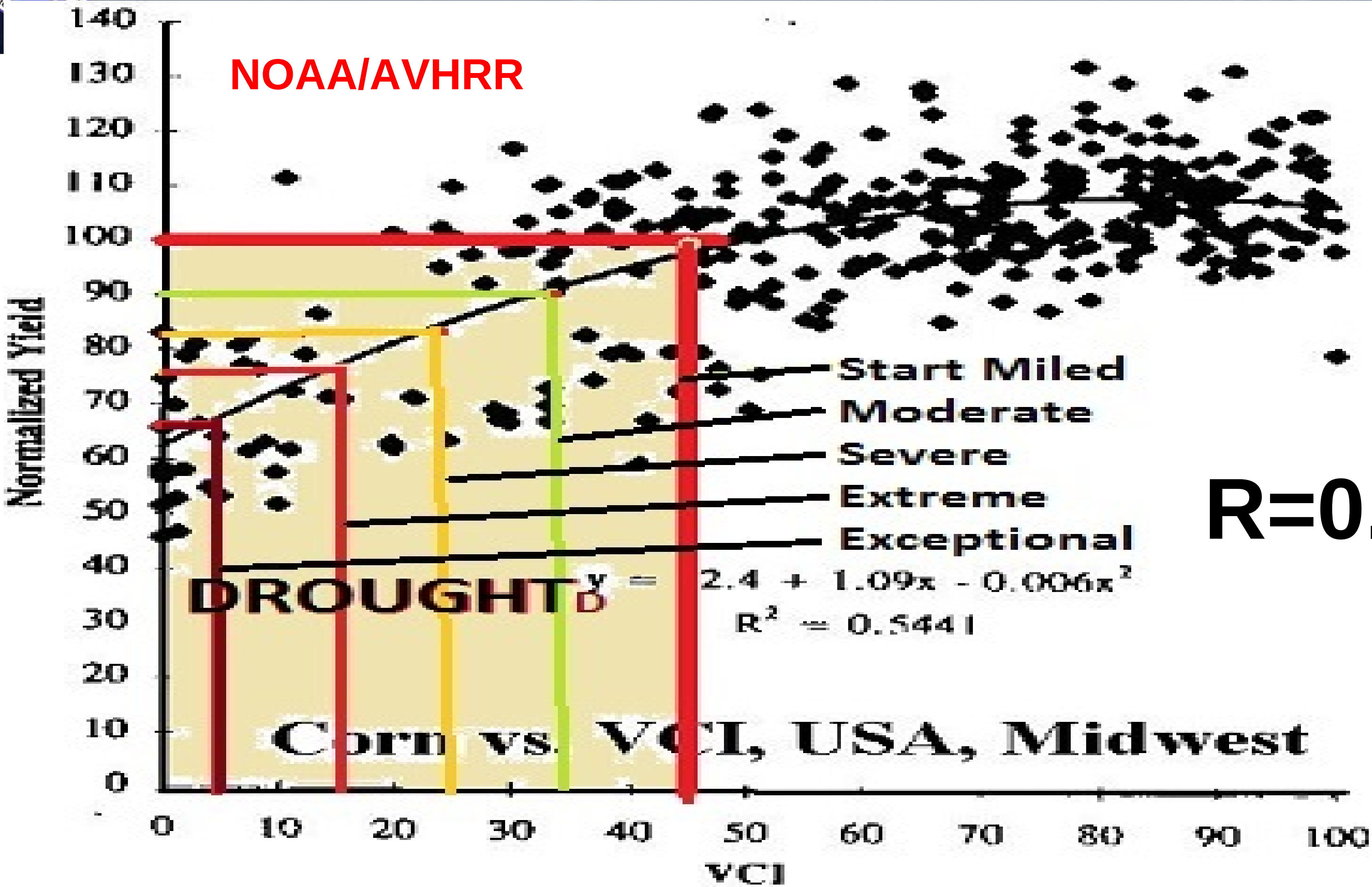
- SNPP/VIIRS (6 y) 4 sq. km
  1 sq. km
  0.5 sq. km

Drought USDM & VH





Corn Yield vs AVHRR-based Vegetation health indicator (VCI) Midwest, USA

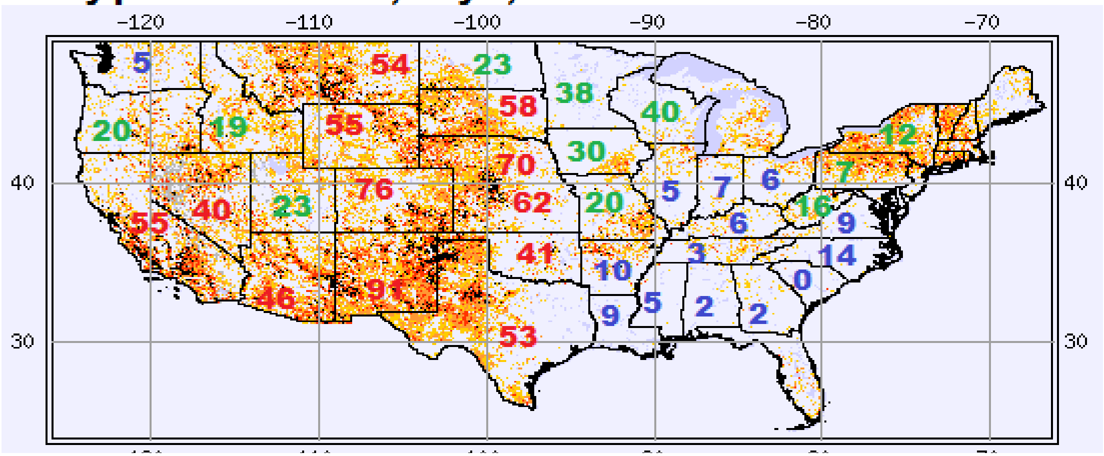


R=0.75

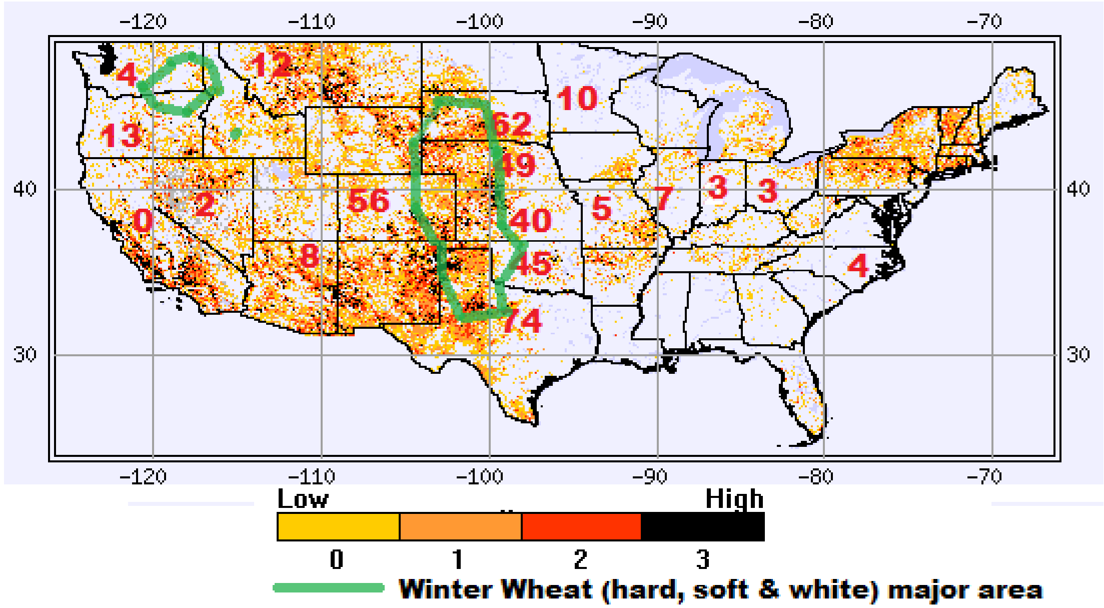
Correlation of Corn Yield Anomaly with VCI and Drought Classification

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

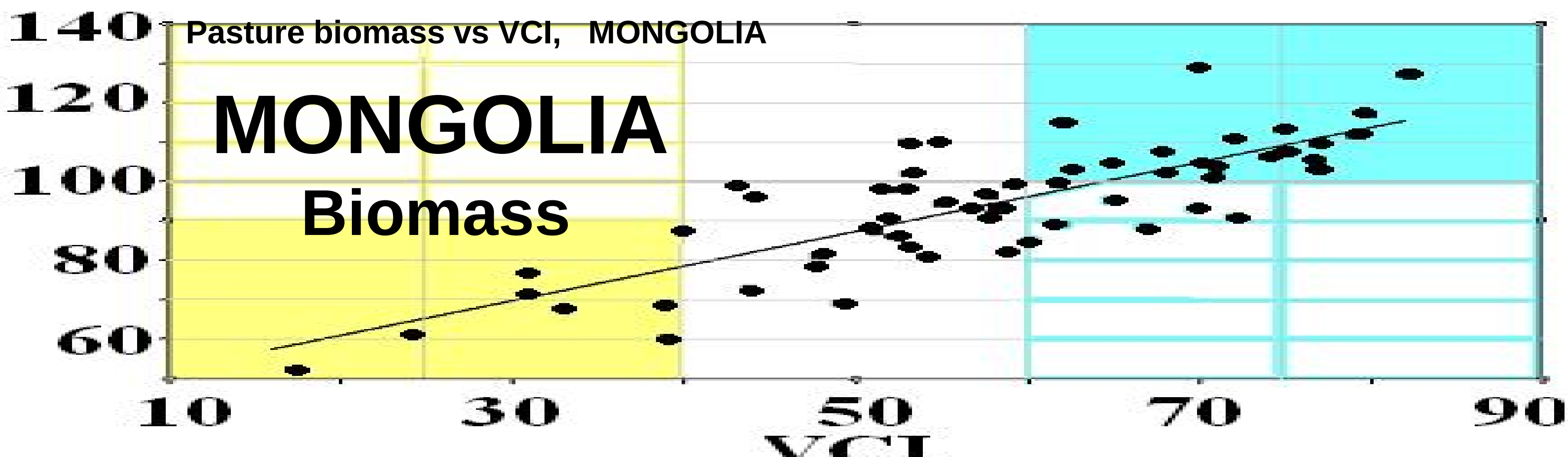
VH-based Drought Stress & % state with pasture & range land in poor & very poor coonditions, May 6, 2013



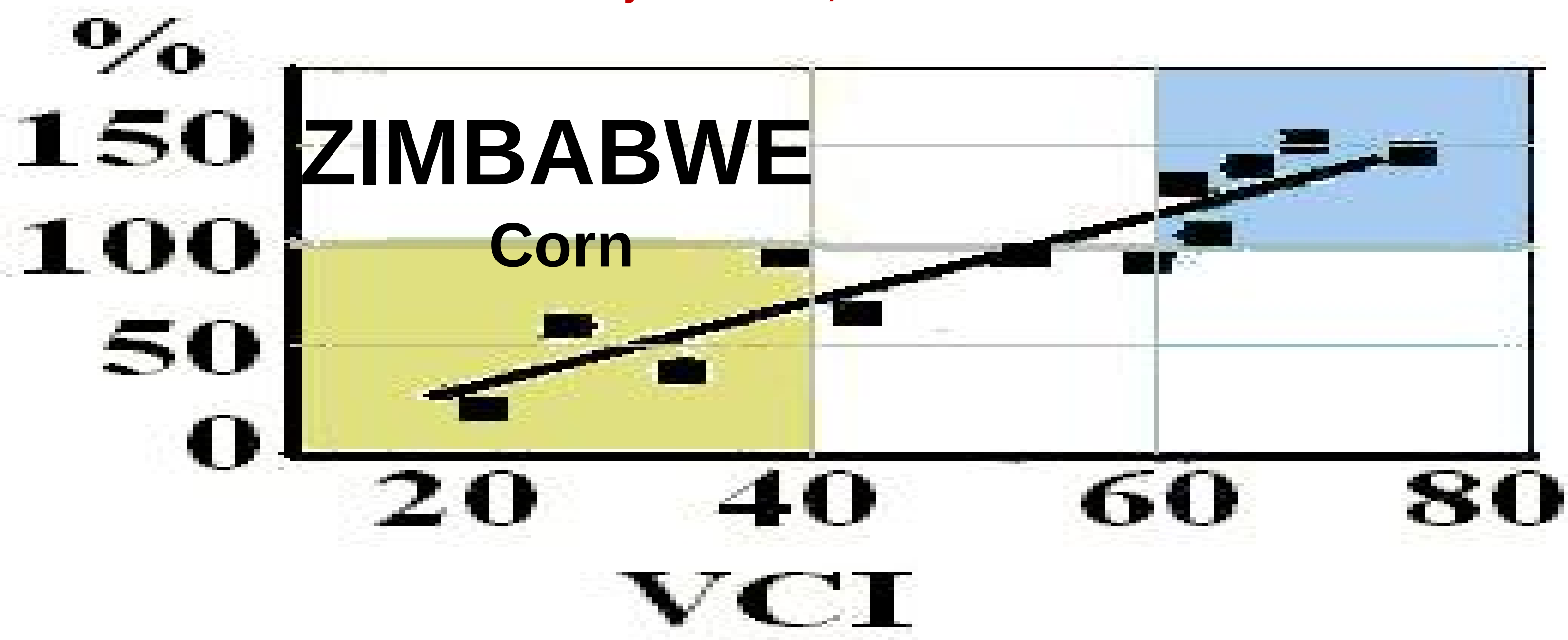
VH-based Drought Stress (NOAA), May 6, 2013 & Percent Whinter Wheat Area in Poor and Very Poor Conditions (USDA), May 5, 2013



VH-Biomass & Corn Yield Modeling & Prediction

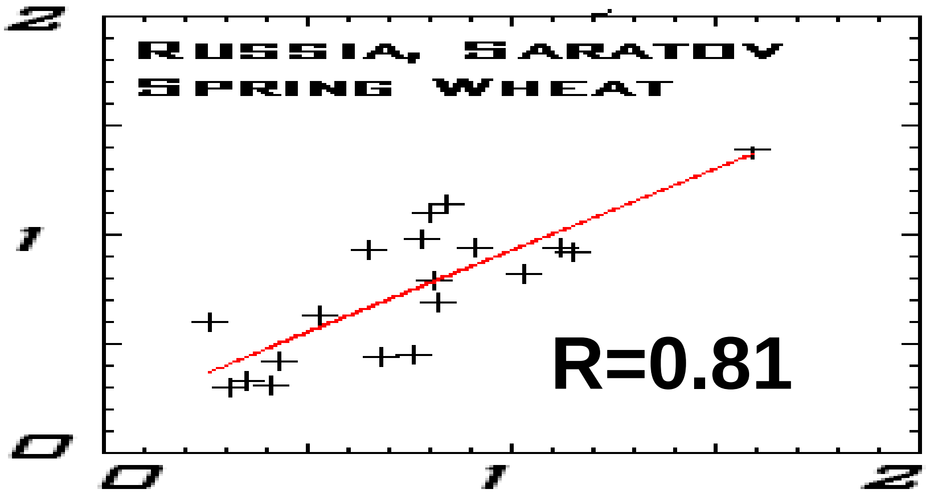


Corn yield vs VCI, ZIMBABWE

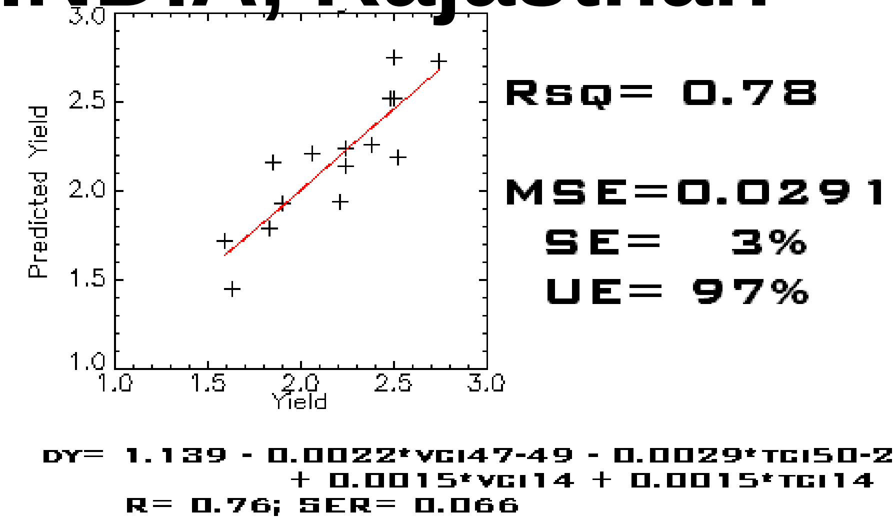


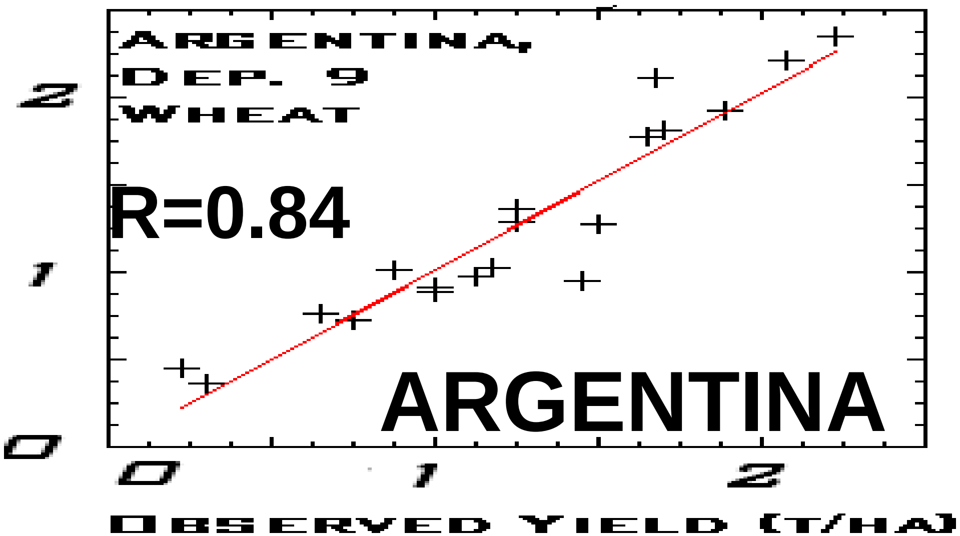
VH Predicted vs Observed Wheat Yield R=0.81

RUSSIA



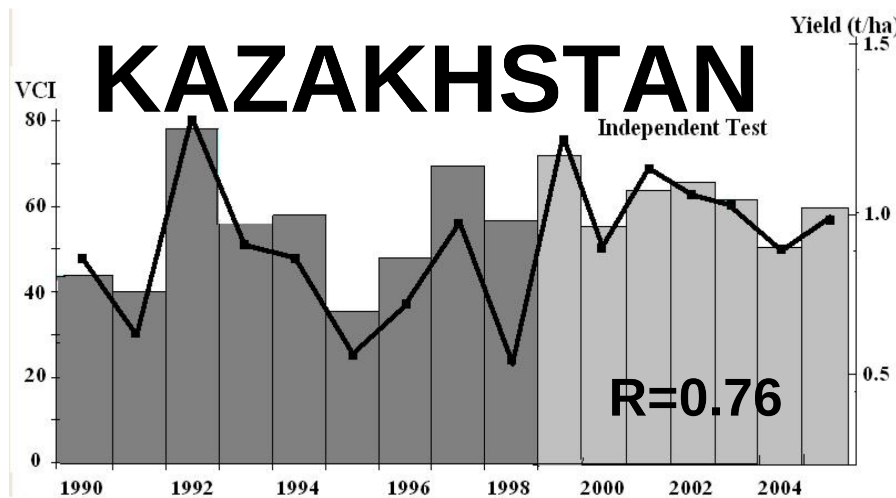
INDIA, Rajasthan





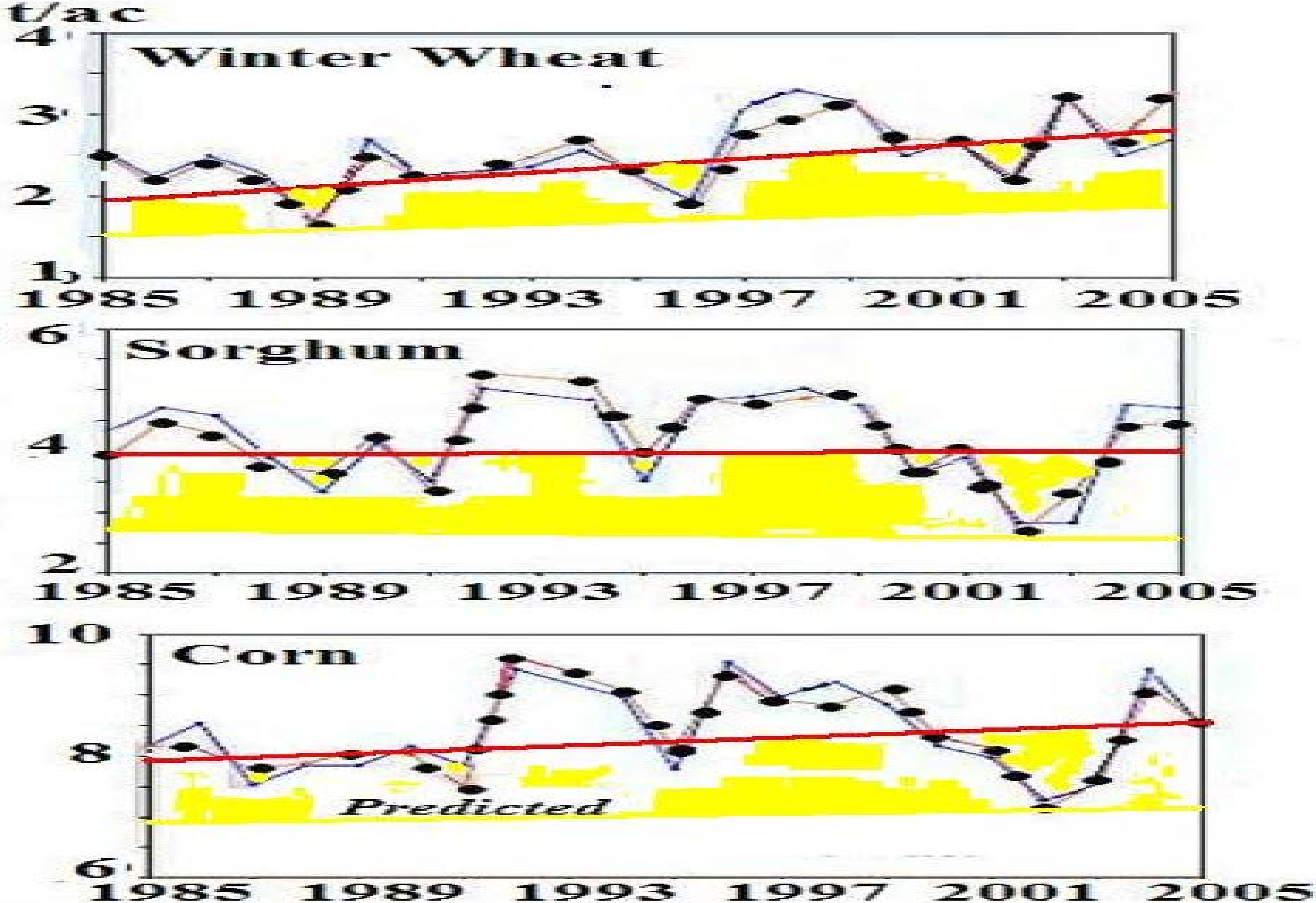
ARGENTINA

KAZAKHSTAN



Mean Yield (bars) and VCI, Kazakhstan, Spring Wheat

VH-Crop Losses Prediction: USA, Kansas



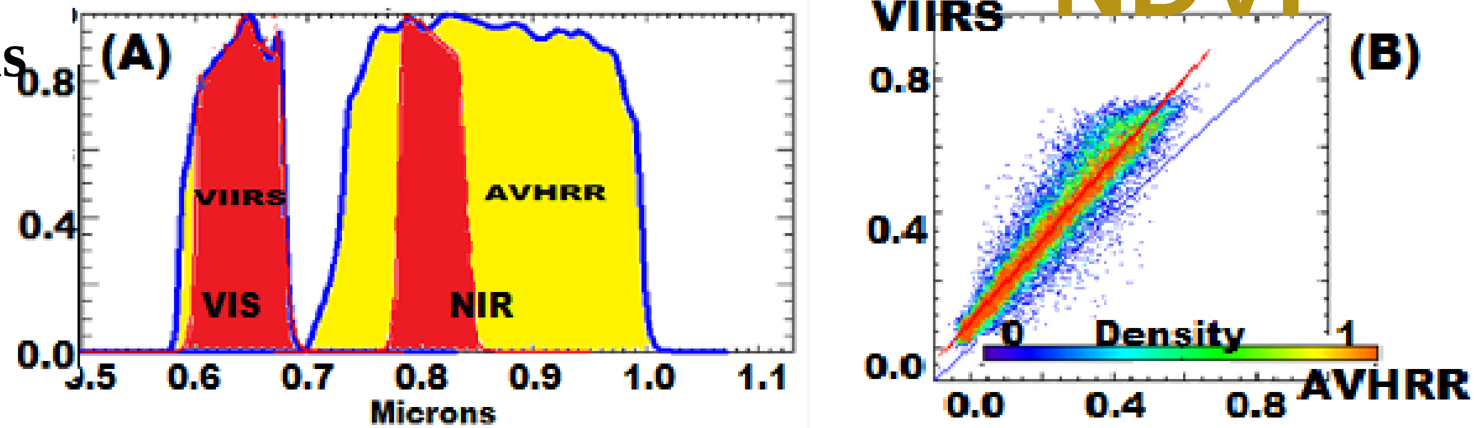
Observed & Predicted Yield, USA, Kansas

Channels:VIIRS versus AVHRR

Climate data records problems

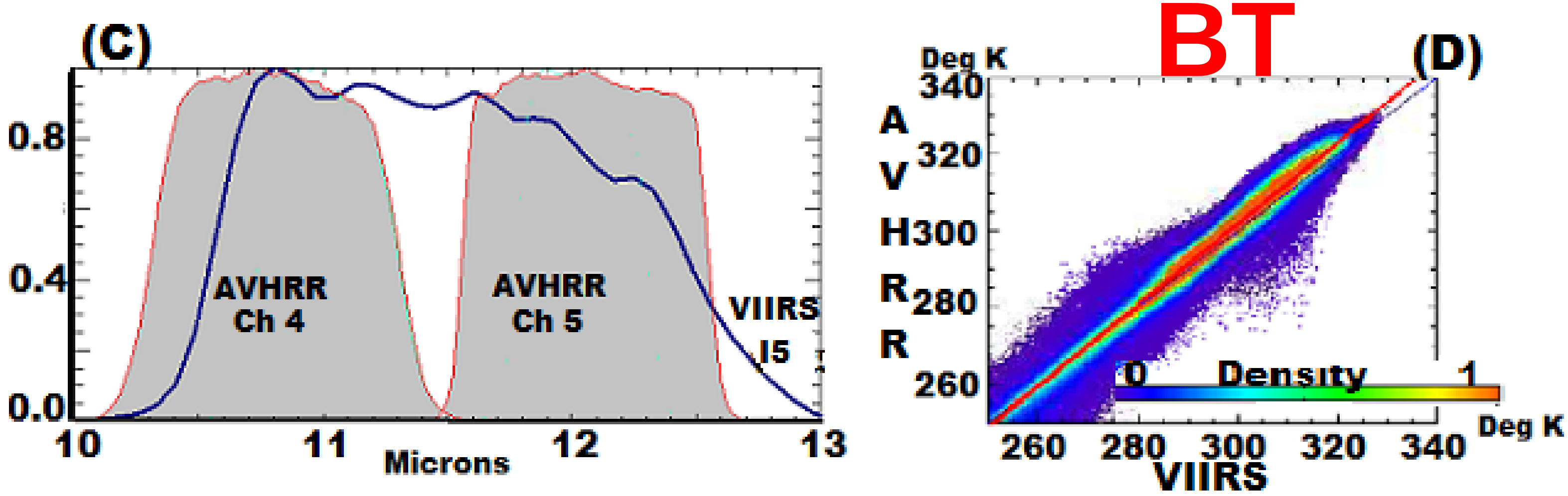
NDVI

Channels



Normalized Difference Vegetation Index (NDVI)

BT



Brightness Teperature (BT)

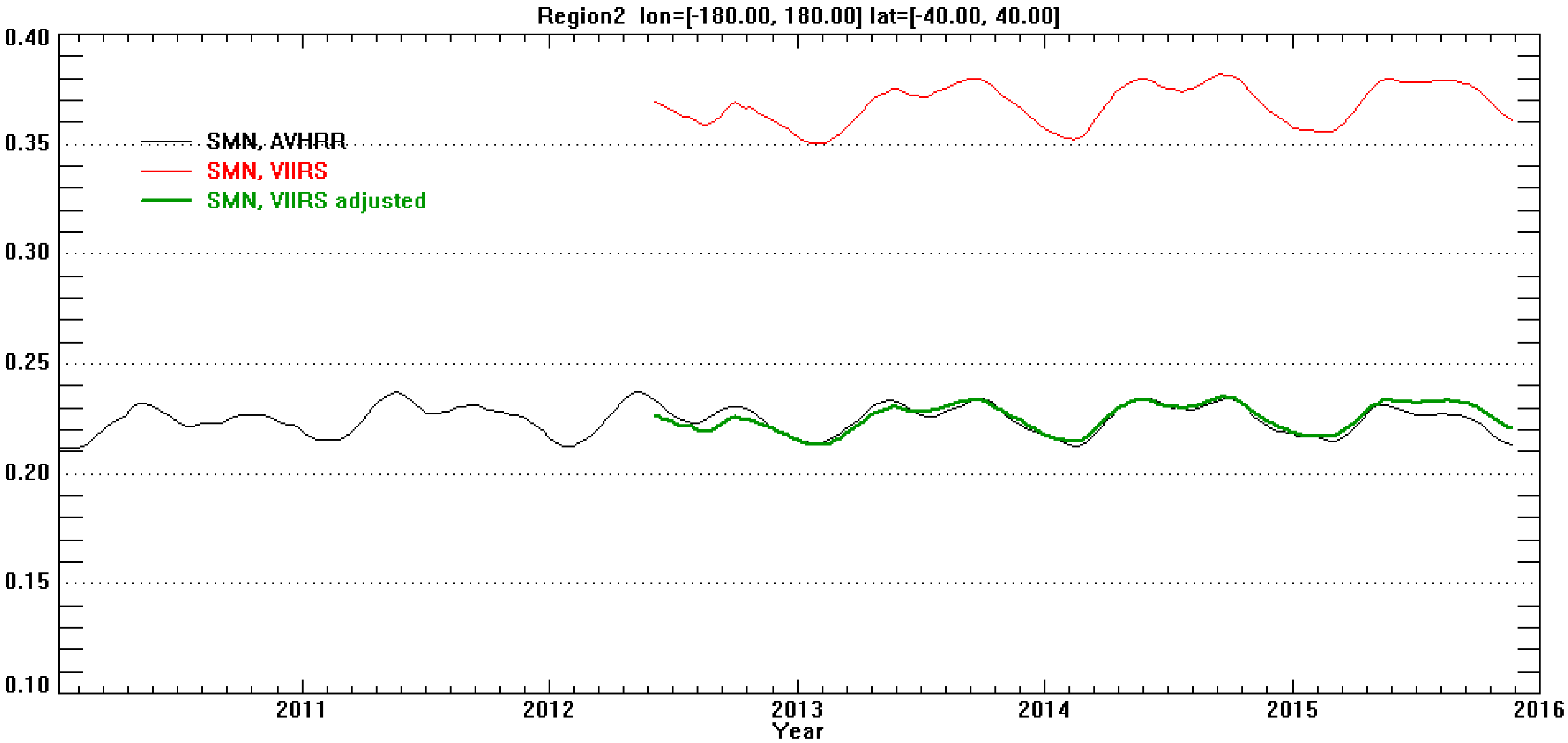
Transition to SNPP/VIIRS & J-1

- TWO methods:

1. Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR

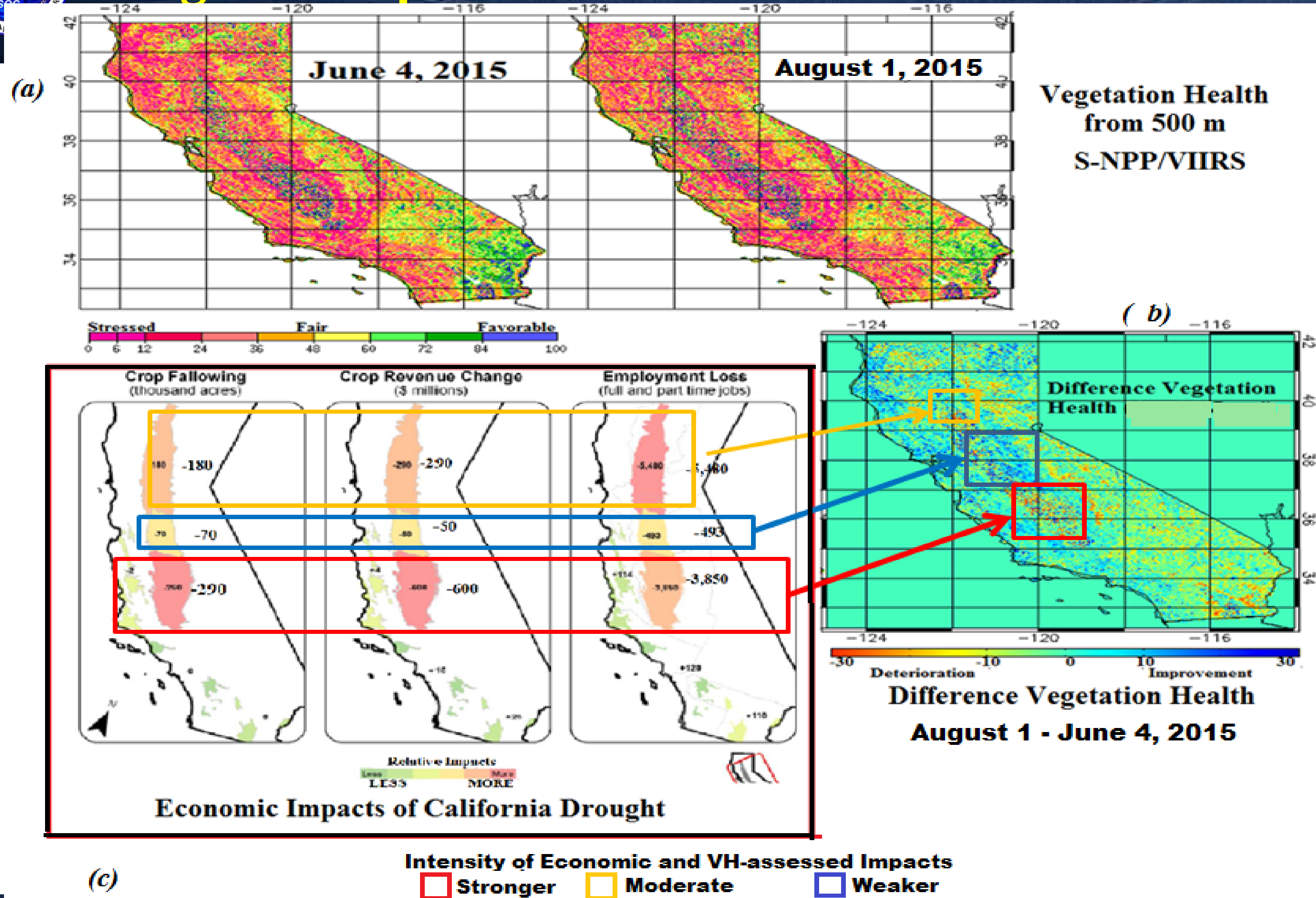
2. Adjust SNPP/VIIRS **5-year** weekly NDVI & BT **climatology** to NOAA/AVHRR **36-year** **climatology**

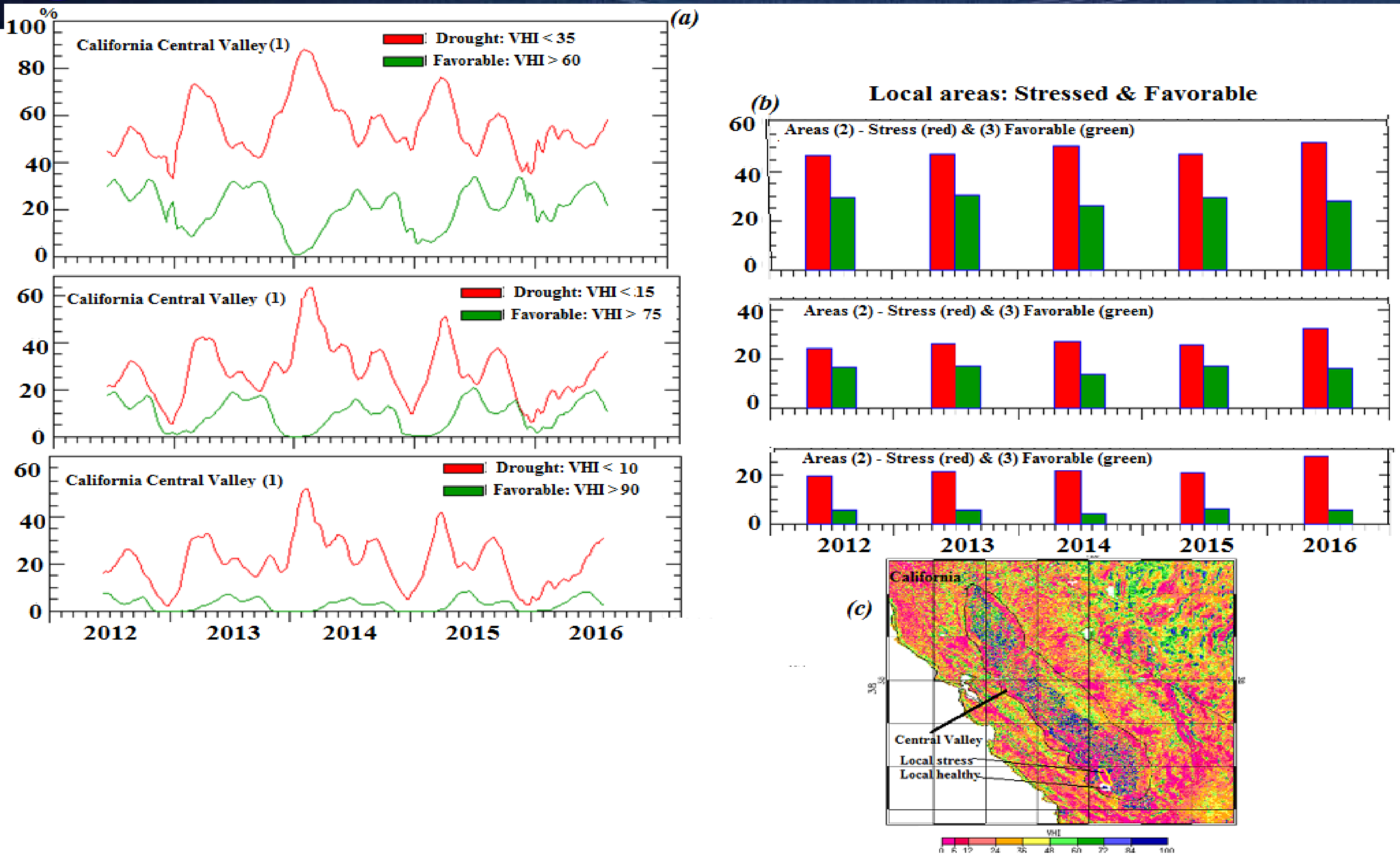
Time series of SMN from VIIRS and AVHRR



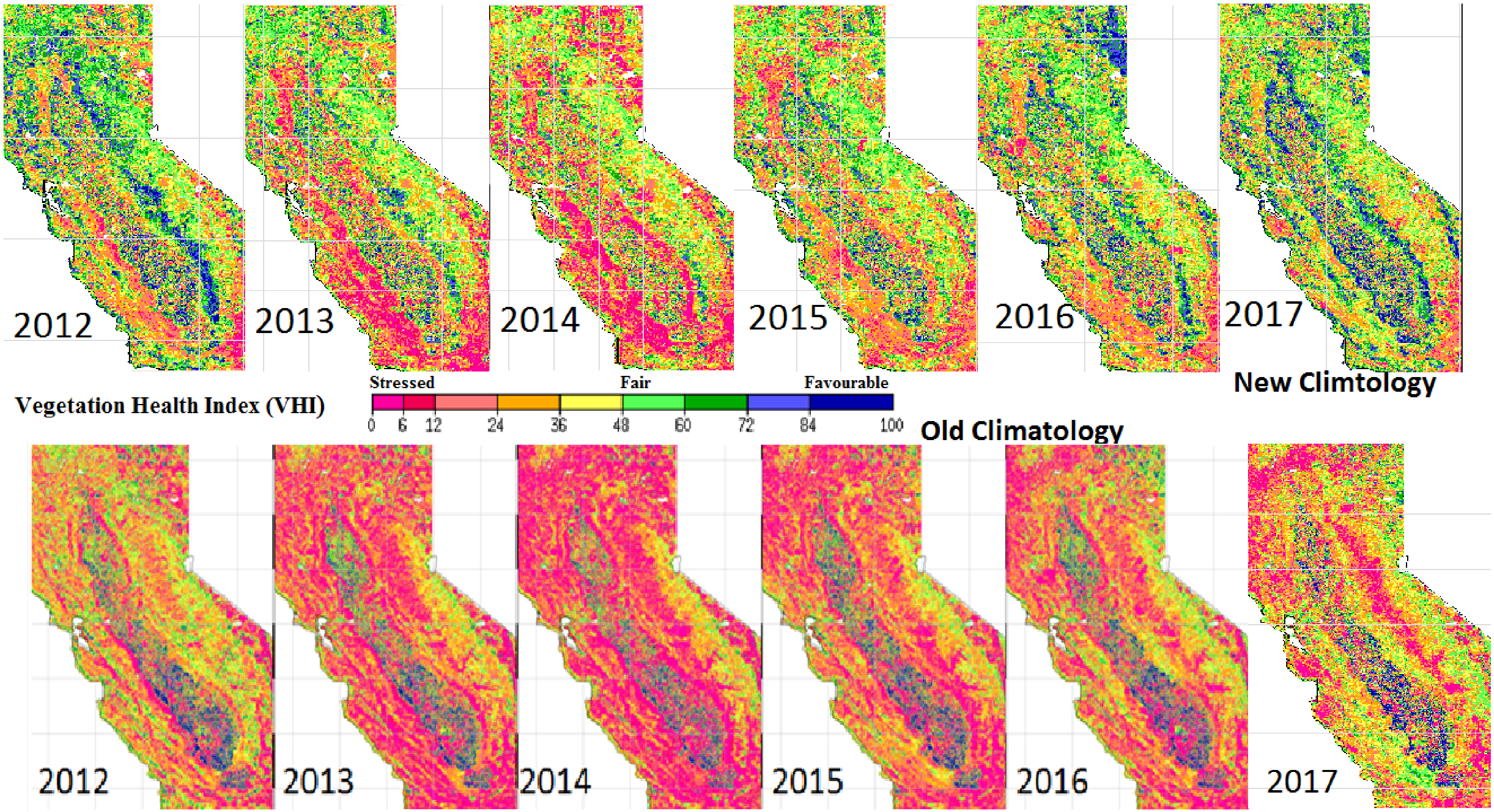
The SMN from VIIRS and AVHRR are not on the same level. Adjustment is required to make the long term time series aligned.

Drought & Impacts from VIIRS 0.5 km California



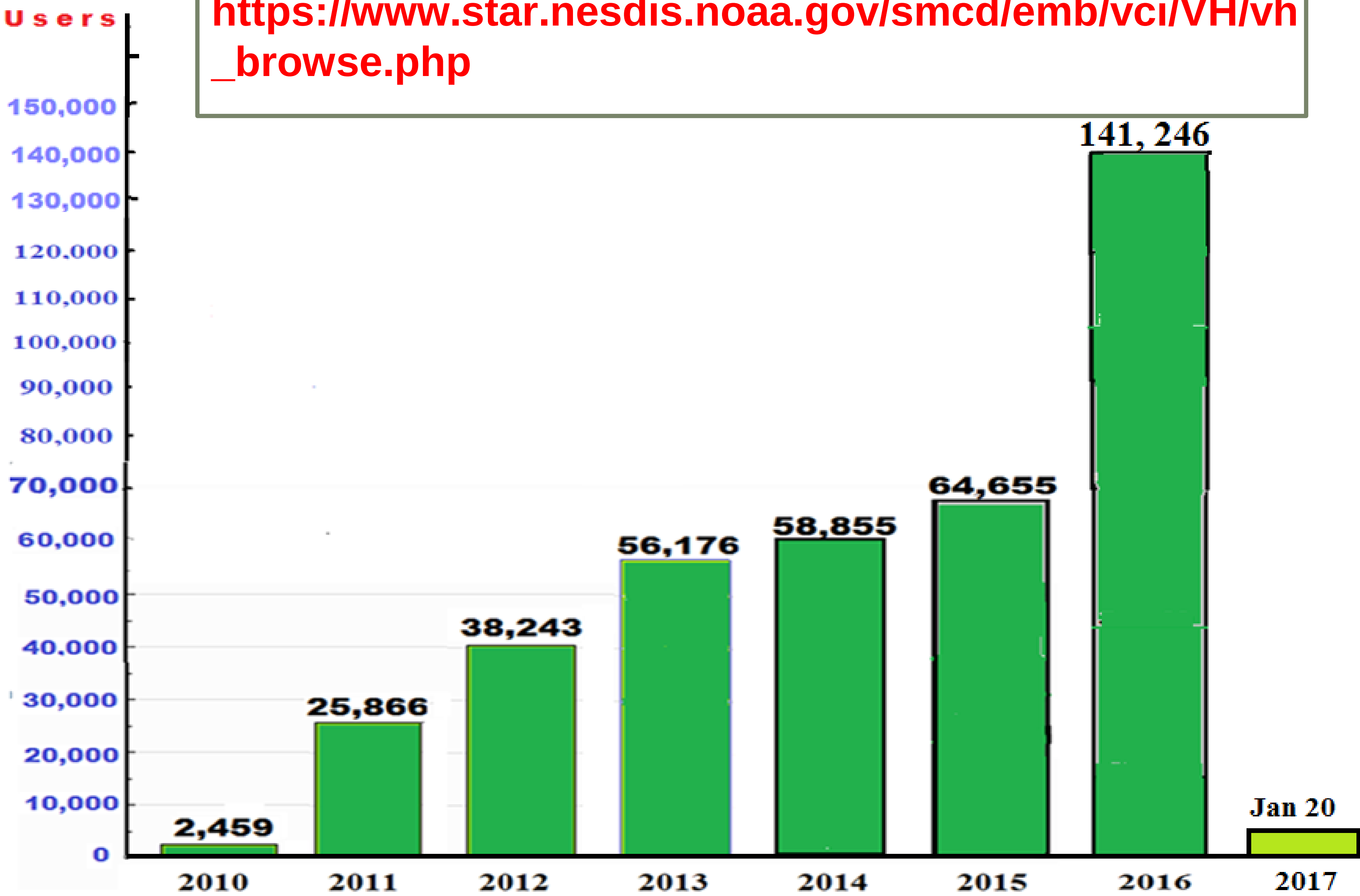

(a)
%
California Central Valley (1)
Drought: VHI < 35
Favorable: VHI > 60
California Central Valley (1)
Drought: VHI < 15
Favorable: VHI > 75
California Central Valley (1)
Drought: VHI < 10
Favorable: VHI > 90
2012
2013
2014
2015
2016
Local areas: Stressed & Favorable
(b)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
Areas (2) - Stress (red) & (3) Favorable (green)
2012
2013
2014
2015
2016
(c)
California
Central Valley
Local stress
Local healthy
VHI

Vegetation Health 0.5 sq.km: New & old Climatology



Users attending Vegetation Health WEB

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browse.php



Publication since the early 1980s

- **Camara N.E. and F.N. Kogan 2017. Monitoring landslides conditions in Madeira Island from NOAA operational satellites.**
- **Kogan F, W. Guo & W. Ysang 2017. SNPP/VIIRS vegetation health to assess 500 California drought, Geomatics, Natural Hazards and Risk, DOI:10.1080/19475705.2017.1337654 (http://dx.doi.org/10.1080/19475705.2017.1337654)**
- **C. Bhuiyan, A. K. Saha, N. Bandyopadhyay & F. N. Kogan 2017. Analyzing the impact of thermal stress on vegetation health and agricultural drought – a case study from Gujarat, India. *GIScience & Remote Sensing,* http://dx.doi.org/10.1080/15481603.2017.1309737**
- **Kogan F & W. Guo 2016. Strong 2015–2016 El Niño and implication to global ecosystems from space data. *International Journal of Remote Sensing,* 38:1, 161-178, DOI: 10.1080/01431161.2016.1259679**
- **Kogan F., Z. Popova and P. Alexandrov 2016. Early forecasting corn yield using field experiment dataset and Vegetation health indices in Pleven region, north Bulgaria. *Ecologia i Industria (Ecology and Industry)* Vol. 9, No 1, 76-80.**
- **Kogan F. and Guo W. 2015. 2006-2015 mega-drought in the western USA and its monitoring from space data. *Geomatic, Natural Hazards and Risk*, DOI:10/1080/19475705.2015.1079265. http://dx.doi.org/10/1080/19475705.2015.1079265.**
- **Kogan F., M.Goldberg, T.Schott and W.Guo 2015. SUOMI NPP/VIIRS: improve drought watch, crop losses prediction and food security. *International Journal Remote Sensing*, DOI: 10.1080/01431161.2015.1095370. http://dx.doi.org/10.1080/01431161.2015.1095370.**
- **Kogan F., W. Guo, A. Strashnaia, A. Kleshenko, O. Chub and O. Virchenko 2015. Modelling and prediction of crop losses from NOAA polar-orbiting operational satellites. *Geomatics, Natural Hazards and Risk.* http://dx.doi.org/10.1080/19475705.2015.1009178**
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- Kogan FN. 2001. Operational space technology for global vegetation assessment. *Bulletin of the American Meteorological Society* 82: 1949-1964.
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Publication since the early 1980s

- Kogan F.N. 1998. A typical pattern of vegetation condition in southern Africa during El Nino years detected from AVHRR data using three-channel numerical index. *International Journal Remote Sensing,* Vol. 19, No. 18, 3689-3695.
- Kogan FN. 1997. Global drought watch from space. *Bulletin of the American Meteorological Society* **78**: 621-636.
- *Kogan, F.N.J.T. Sullivan and Pu Bu Ciren, 1996.Testing post-launch calibration for the AVHRR sensor on world desert targets during 1985-1993. *Advancement in Space Research.* Vol.17, No. 1, 47-50.
- Kogan F.N. 1995a. Droughts of the late 1980s in the United States as derived from NOAA polar-orbiting satellite data. *Bulletin of the American Meteorological Society,* **76** (5), 655-667.
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- Kogan F. 1993c. Drought monitoring from NOAA polar orbiting satellites: Principles, development and verification. *Issledovaniya Zemli is Kosmosa (Land Studies from Space)*, No 4 (535.243.1:632.2), 12-22.
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- Kogan F. 1986, *Impact of Climate and Technology on Soviet Grain Production,* DELPHIC Inc., Falls Church, VA, USA, 178 p.
- Kogan F. 1985a. Sun Won't Keep Shine on Soviet Agriculture. *The Wall Street Journal.* August 29, p12.
- Kogan F. 1985b. Look for Soviet buying of grain to drop this year. *The Des Moines Register.* August 13.
- Kogan F. 1983a. Perspectives for grain production in the USSR. *Agricultural Meteorology,* 28, 213-227.
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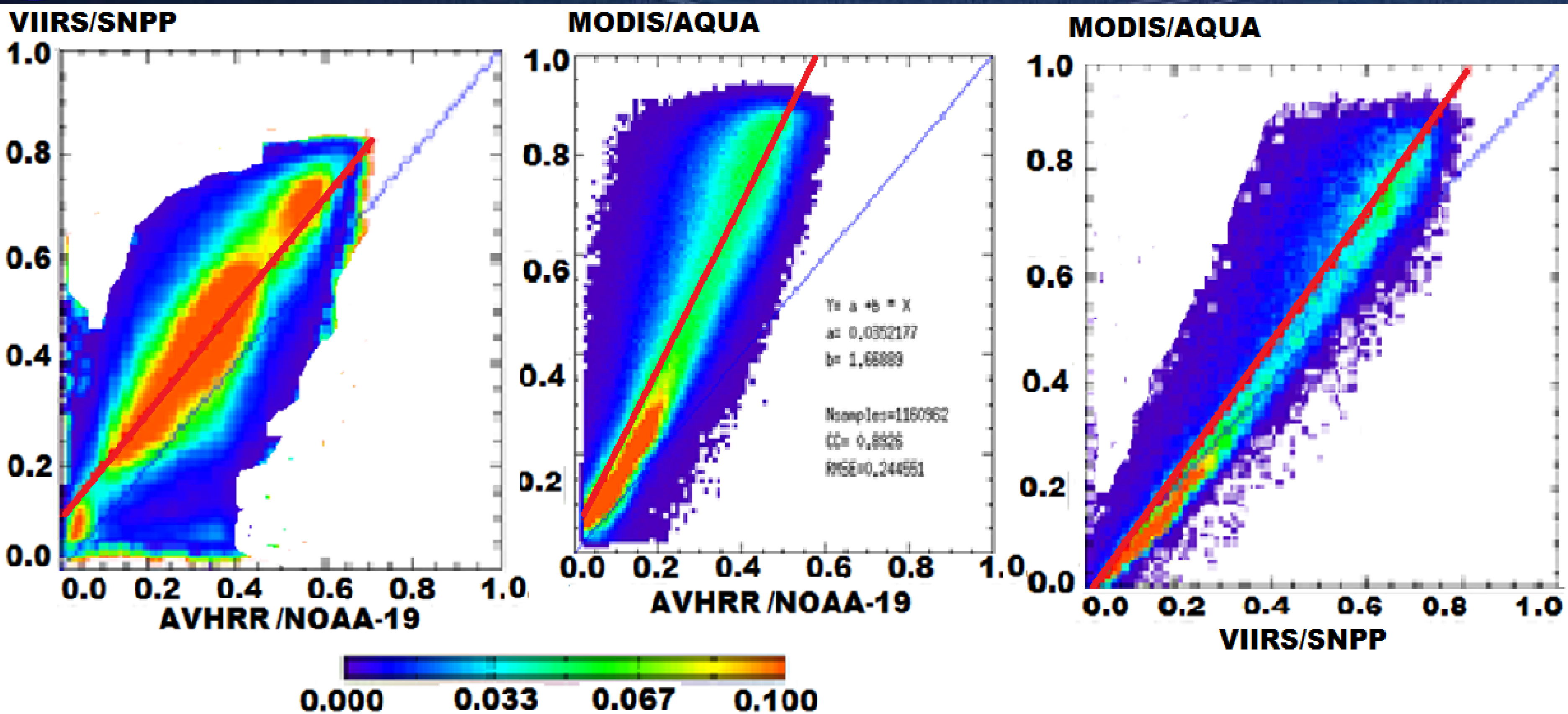
- **BACK UP**

Mean NDVI (40N-40S)
VIIRS vs MODIS vs AVHRR: 2012 July



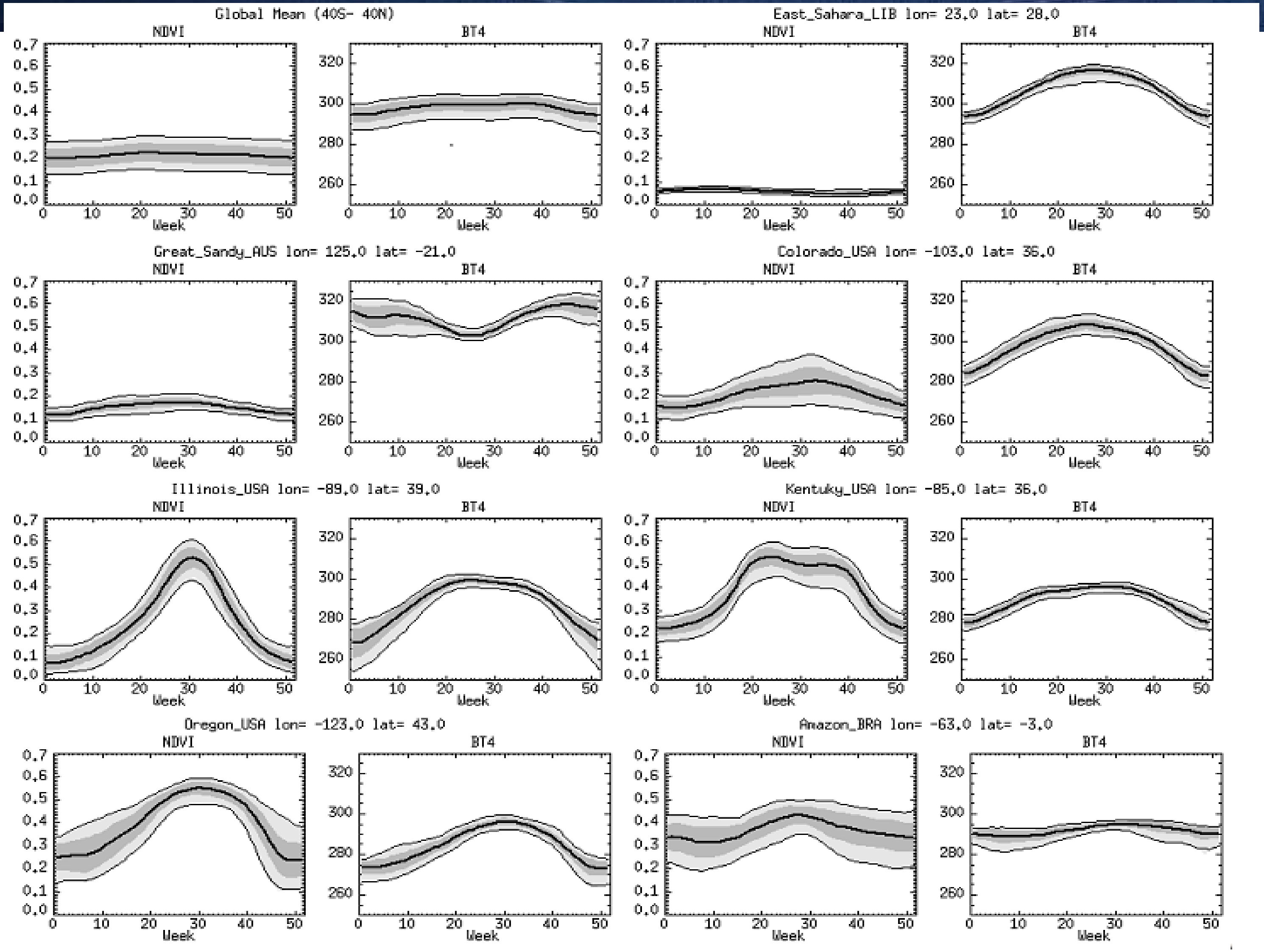
ACCOMPLISHMENTS

- Data collection from SNPP/VIIRS, AVHRR/NOAA-18 & 19, MODIS/AQUA
- Algorithm Development (data sampling, gap filling, reflectance calculation, noise removal)
- Data processing (NDVI, BT, no noise NDVI & BT)
- Data Stability tests

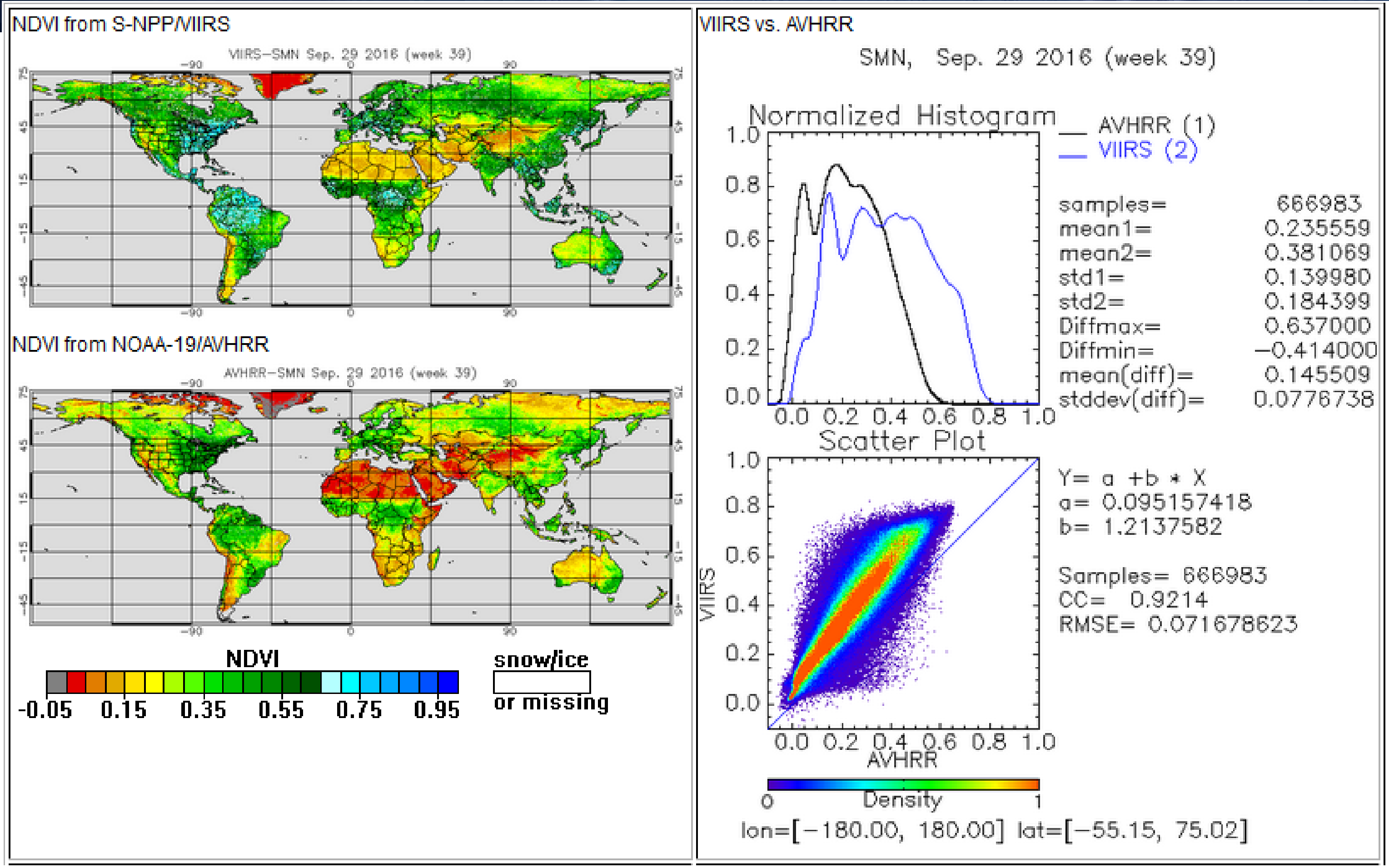
Algorithm Background

- **The SNPP & J1/VIIRS Vegetation Health (VH) Indices from EDR**
- **VIIRS/VH-1 is global weekly composite products with 1 km^2 resolution**
- **The VH-EDR consists of three indices, Vegetation Condition Index (VCI), Thermal Condition Index (TCI) and Vegetation Health Index (VHI)**
- **The algorithm is based on three bio-physical laws: Liebig's Law-of-Minimum, Shelford's Law-of-Tolerance & Carrying Capacity**
- Daily **SNPP/VIIRS-1** is derived from the TOA radiances: VIS, NIR - image bands: & Thermal bands
- The radiances are pre-launch & post-launch calibrated, checked for accuracy
- Weekly composite raw Normalized Difference Vegetation Index (NDVI) and raw Brightness temperature (BT) are calculated after adjustment for sun angle, observation time & atmospheric effects
- Noise removal from weekly raw NDVI & BT and converting them to no noise NDVI (SMN) and BT (SMT)
- Climatology derivation from multi-year SMN and SMT weekly data, using three Bio-physical Laws
- Two SNPP/VIIRS & J1/VIIRS climatology conversions to longer data sets & tests:
  - NDVI & BT real-time weekly from 5-year SNPP/VIIRS to 36-year NOAA/AVHRR
  - NDVI & BT climatology weekly from 5-year SNPP/VIIRS to 36-year NOAA/AVHRR
- Modeling SNPP/VIIRS-1 Vegetation condition index (VCI), Temperature condition index (TCI) & Vegetation health index (VHI)
- Derivation of VH-EDR's per-pixel quality flags (e.g., land/water snow, desert, cloud mask and random noise)
- Test SNPP VIIRS/VH-1 performance with in situ data

36-year Climatology: Max, Min, Mean



Expl: NDVI/SMN – VIIRS vs AVHRR



The SMN from VIIRS and AVHRR are not on the same level. Adjustment is required to make the long term time series aligned.

Vegetation Health Milestones Update
June 10, 2017

- Calculate 5 year climatology (max and min) from S-NPP VIIRS (Apr, 2017)
- Calculate same 5 year climatology from AVHRR (Apr 2017)
- Similar/dissimilar for the two climatology (May, 2017)
- Similar/dissimilar for 5-year & 36-year climatology
- Calculate VIIRS/VH (VCI, TCI, VHI) (Jun, 2017)
- Compare VIIRS/VH to AVHRR/VH for 2012-2017 (Jan, 2018)
  - If there are issues with the VIIRS climatology re-calculate it each year with J1 data.

Algorithm Improvements

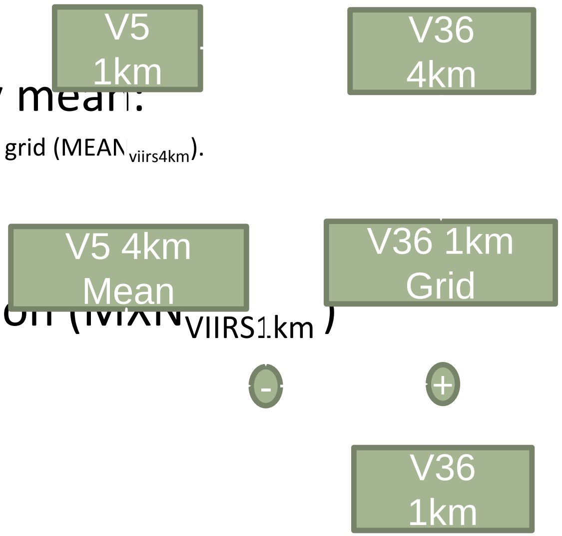
Algorithm Improvements

- 4 km Climatology from AVHRR
- 4 and 1 km Climatology from VIIRS
- Cal/Val Climatology for evaluating algorithm performance
    a. Comparison with AVHRR algorithms
    b. Comparison with *in situ* data

SNPP/VIIRS-1 Climatology

- Directly generate 5-year VIIRS 1km climatology (V5);

- Generate pseudo 36-year VIIRS 1km climatology (V36) based on VIIRS 4km V36 climatology and 1km V5 climatology:



- Get mean value over 4km grid cell for climatology mean:

  From V5 1km MEAN at specific week ($MEAN_{virrs1km}$), calculate mean values over 4km grid ($MEAN_{viirs4km}$).

- Calculate adjustment:

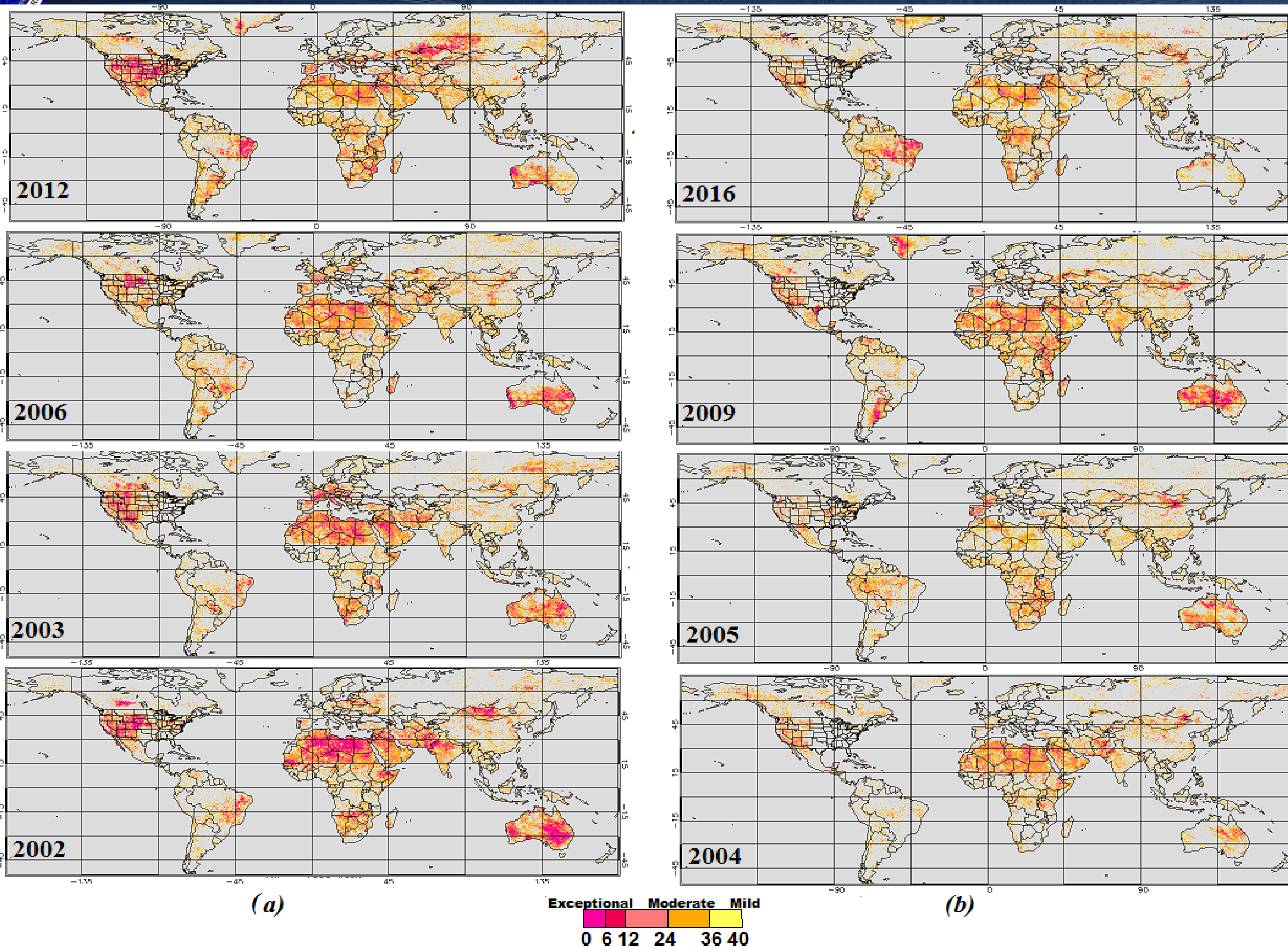
  $Adjustment = MEAN_{viirs1km} - MEAN_{viirs4km}$

- Interpolate 4km VIIRS climatology to 1km resolution ($MXN_{VIIRS1km}$)

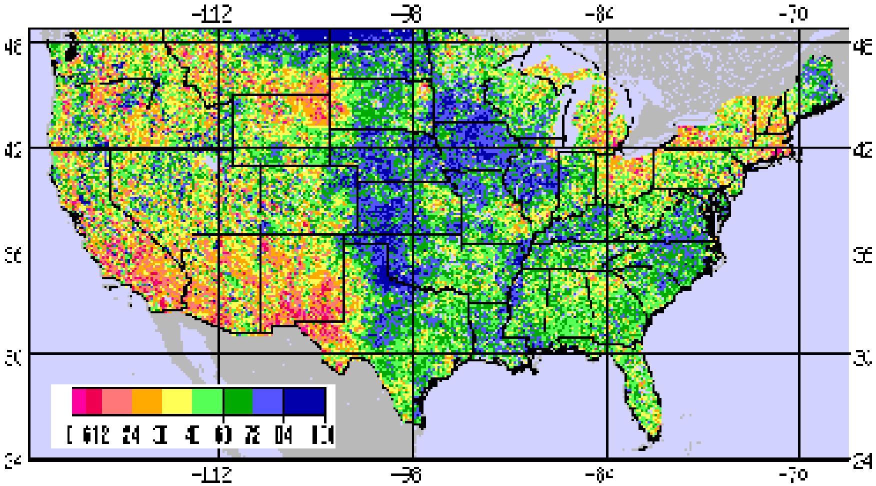
  $MXN_{viirs4km} \rightarrow MXN_{viirs1km}$

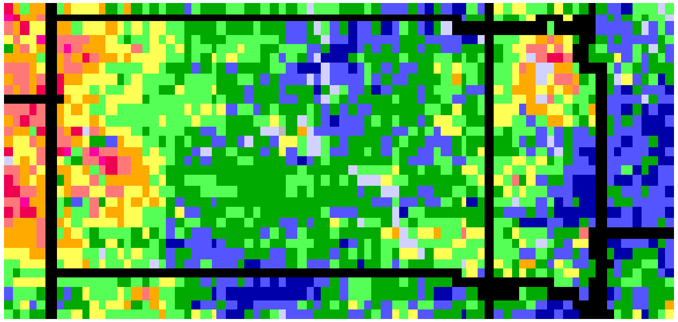
- $MXN_{new} = MXN_{viirs1km} + Adjustment$

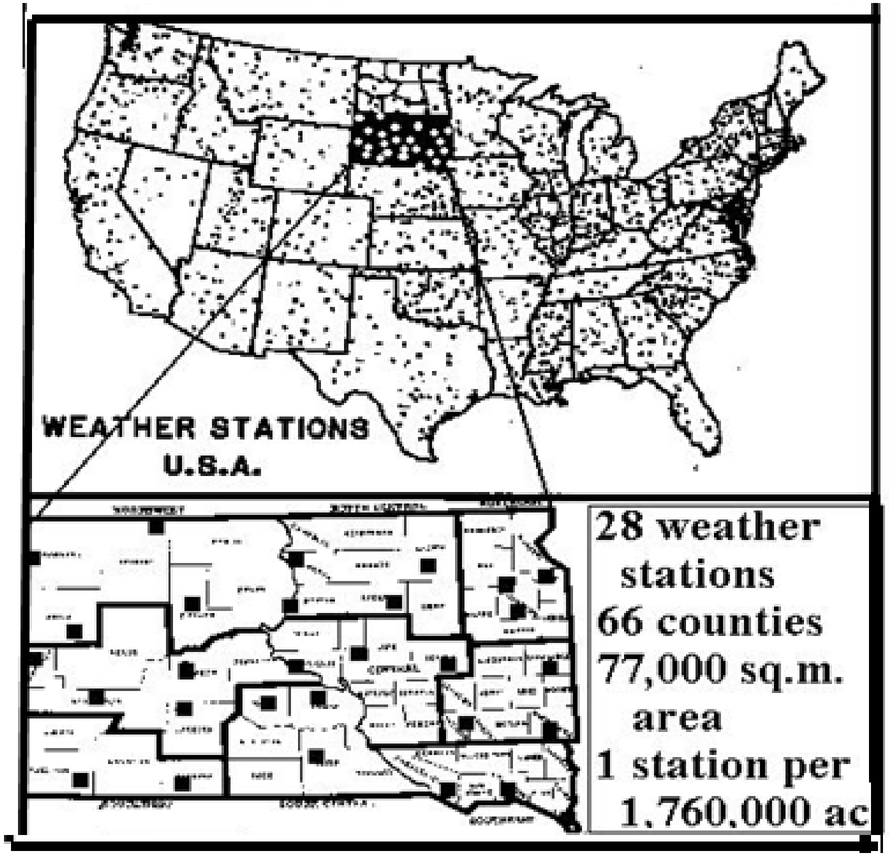
Back Up


2012
2006
2003
2002
2016
2009
2005
2004
(a)
(b)
Exceptional Moderate Mild
0 6 12 24 36 40

Weather Stations & Satellite Data Coverage







LAND COVERAGE

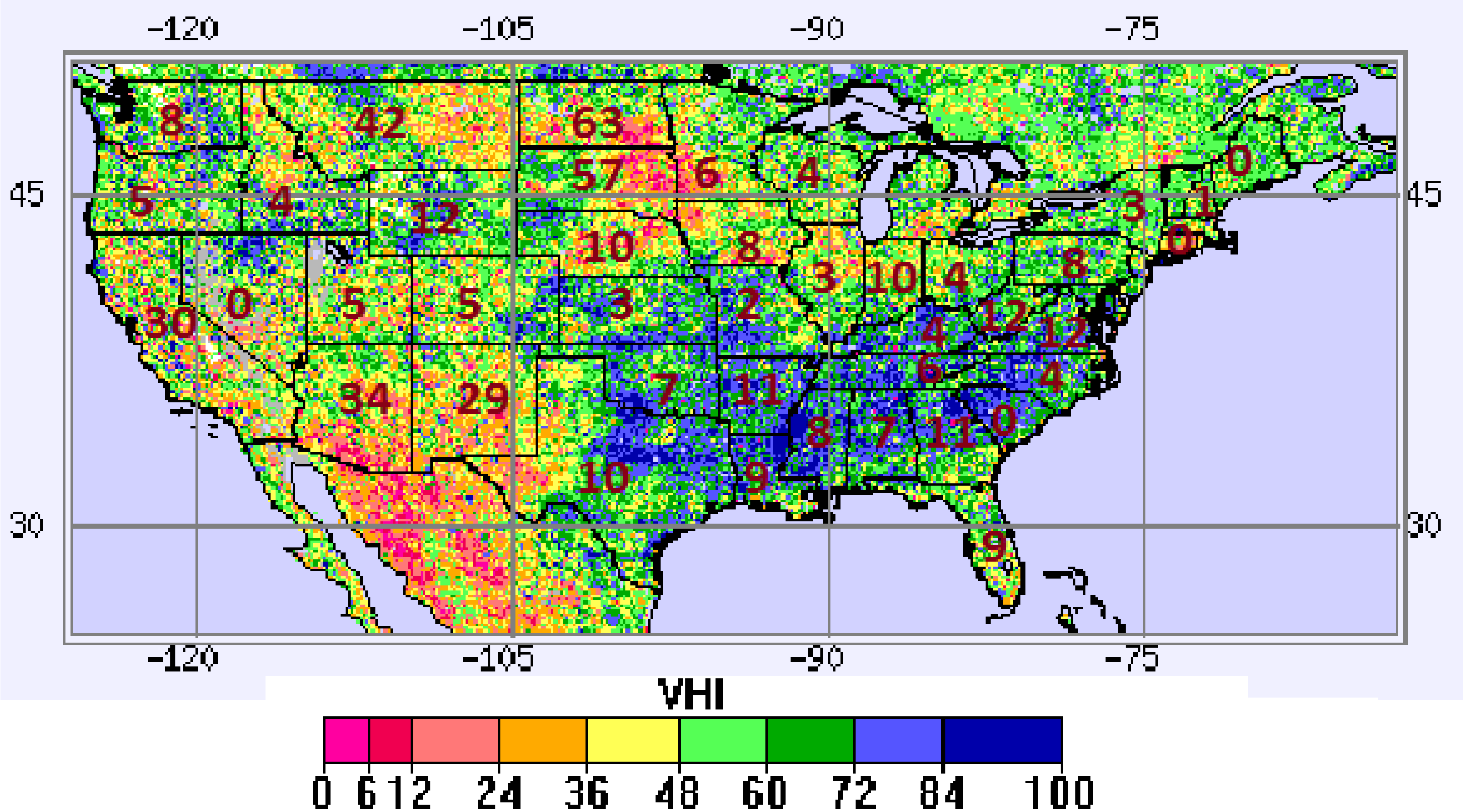
Satellite:

Every 4, 1 and 0.25 sq.km

Weather: One Station

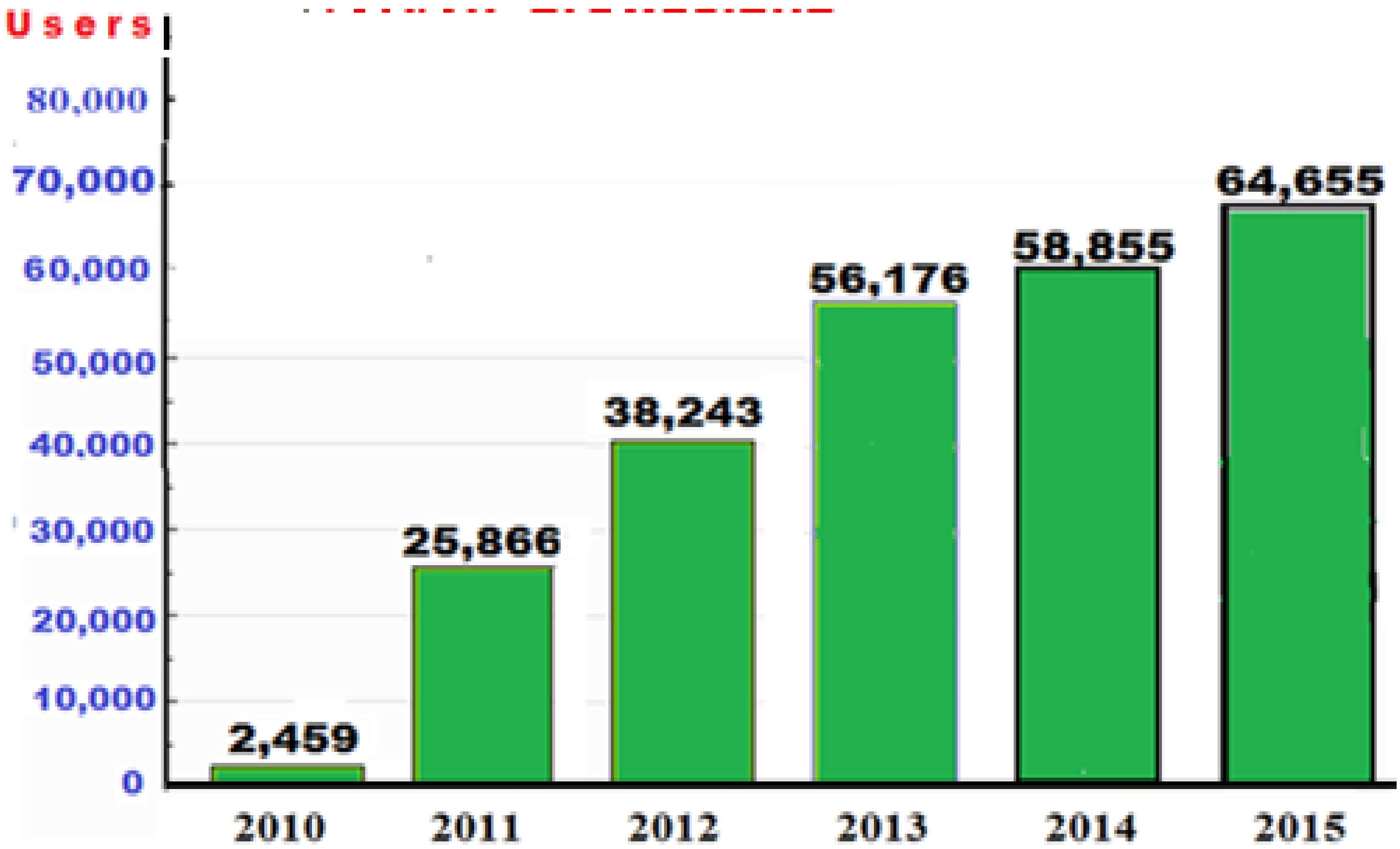
Every 7,140 sq.km (1,760,000 acres)

2017 Jul 8 VH & Jul 2, Pasture Conditions



Vegetation Health Jul 8, 2017 and % Pasture/Range Land in POOR & Very POOR Conditions, Jul 2, 2017 (USDA)

Number of VH Users per Year



Vegetation Health data sources

Sensors *Advanced Very High Resolution Radiometer (AVHRR)*

Visible Infrared Imaging Radiometer Suite (VIIRS)

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

S-NPP/VIIRS, J-1 (JPSS)/VIIRS

Data Resolution *Spatial* *0.5, 1, 4 (GAC), 8 & 16 (GVI) km;*

Temporal *7-day composite*

Period **37-year (1981-2017), future?**

5-year (2012-2016) currently

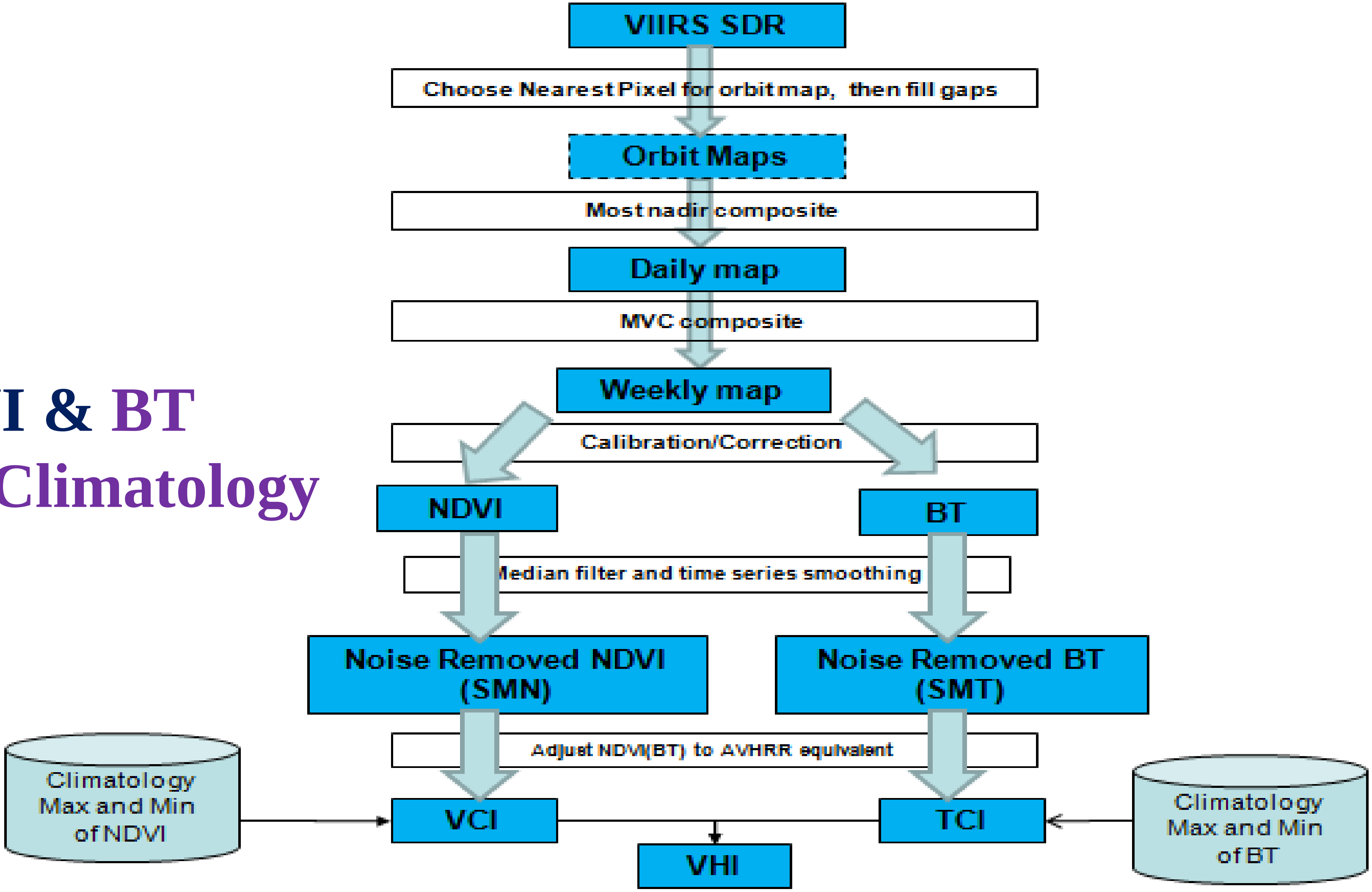
(2017 – 2030) future

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

Channels: VIS , NIR , IR ; *Indices:* NDVI & BT

AVHRR Algorithm Architecture (SA)

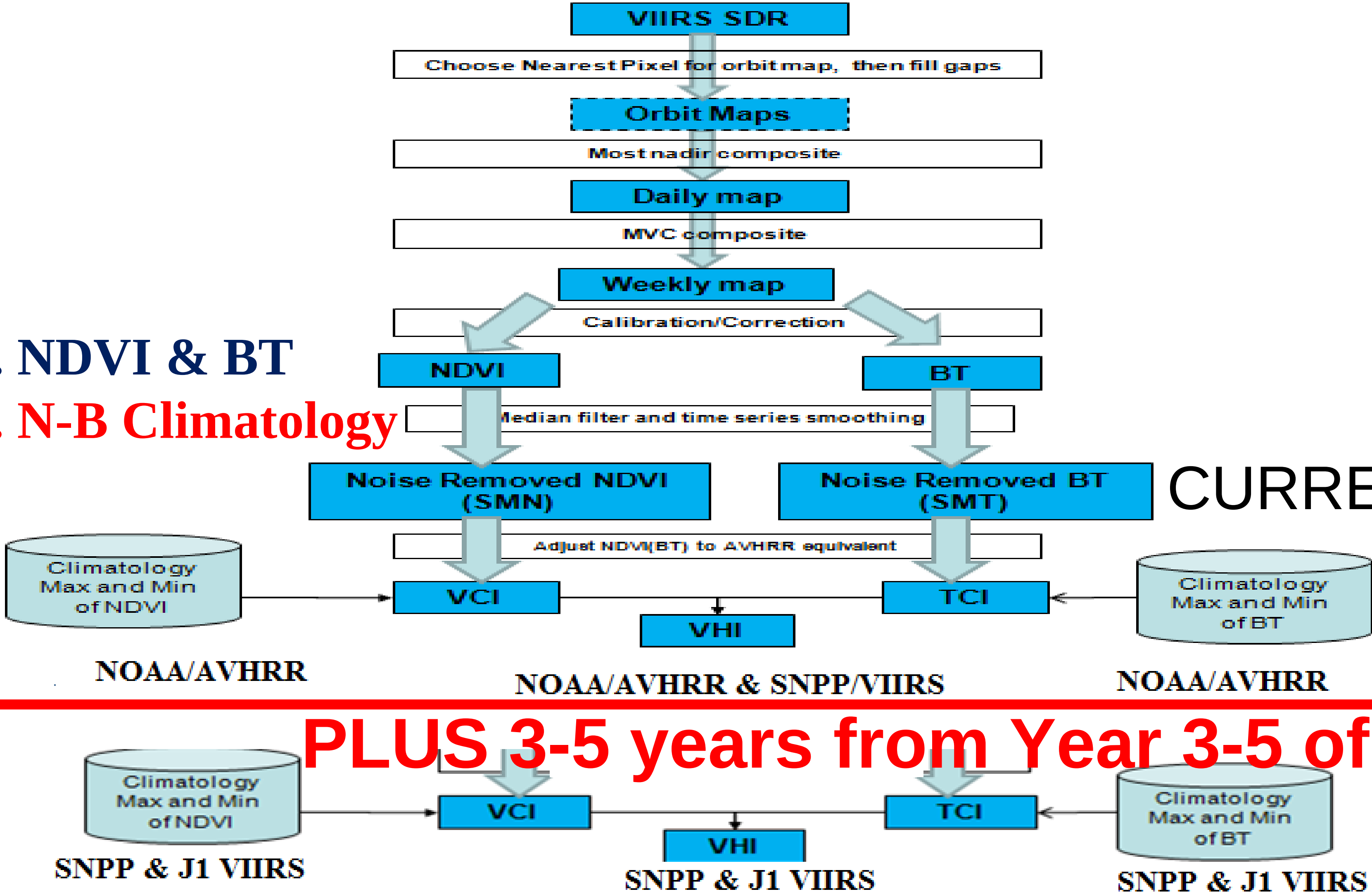
1. NDVI & BT
2. N-B Climatology



Transition to SNPP/VIIRS & J1/VIIRS

1. NDVI & BT
2. N-B Climatology

CURRENT



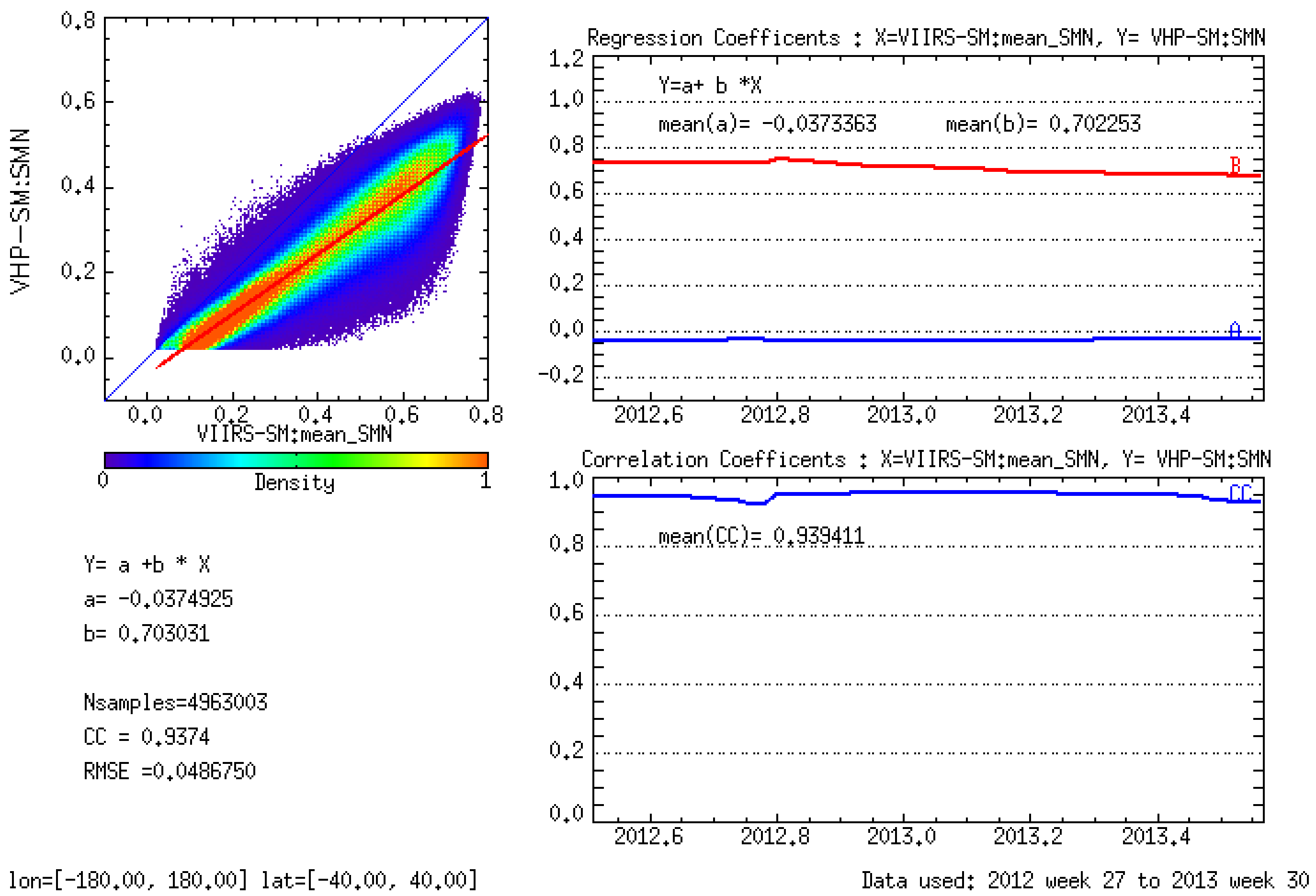
PLUS 3-5 years from Year 3-5 of J1

Transition to SNPP/VIIRS & J-1

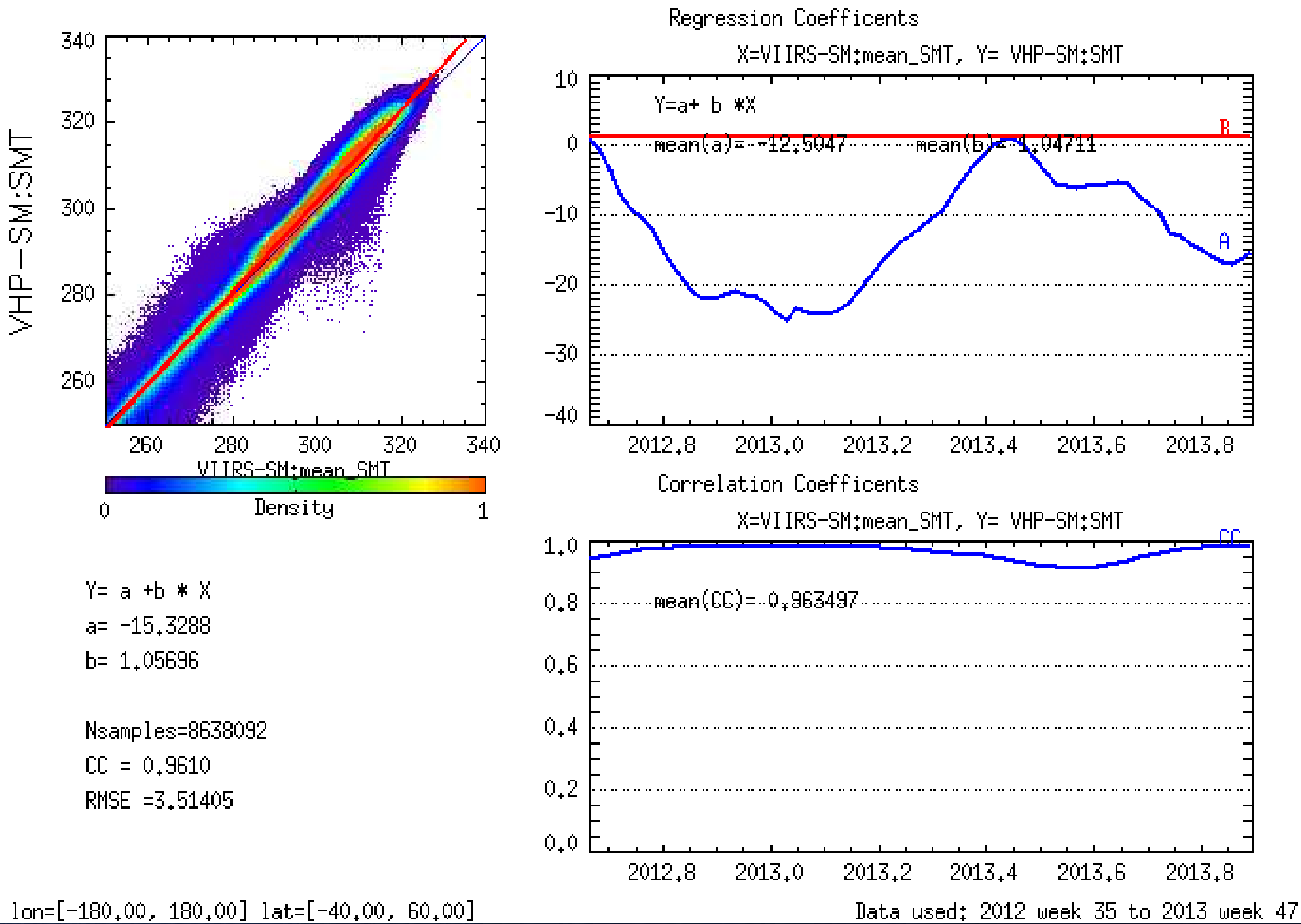
- From the TWO methods the **first** one is used:

1. Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR

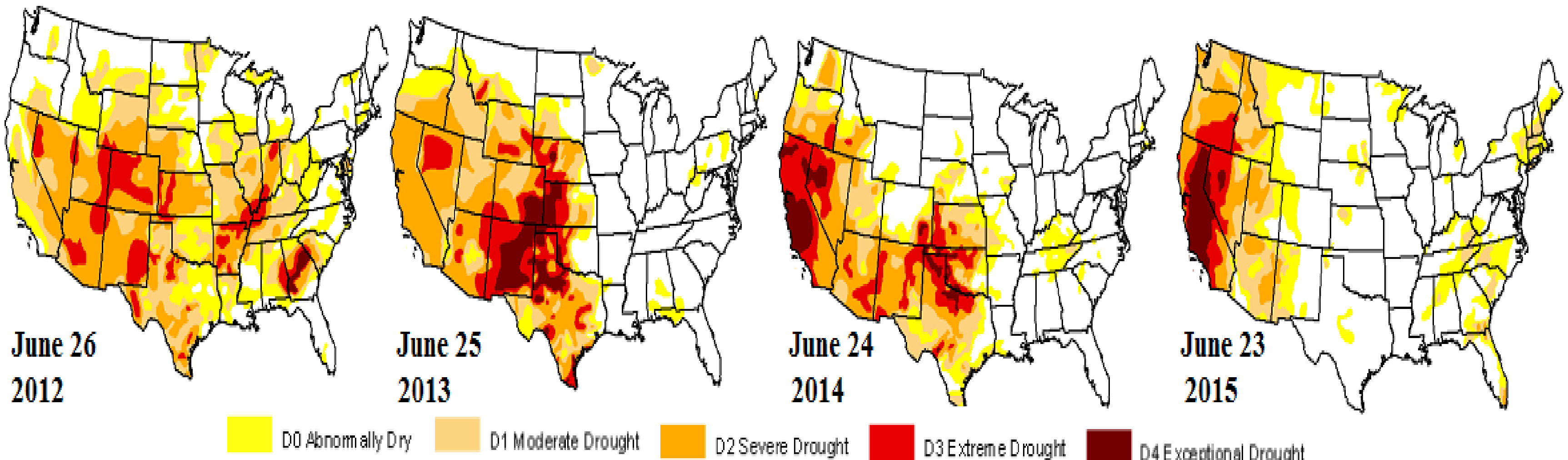
Expl: NDVI (SMN): AVHRR-VIIRS time series



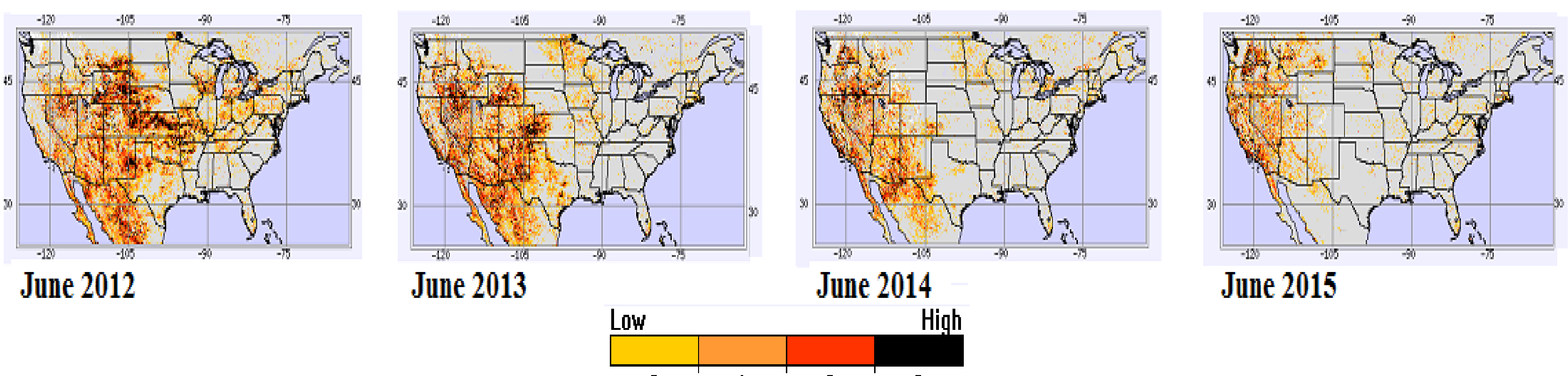
Expl: BT (SMT) AVHRR-VIIRS COR



USA Drought from USDM & VHI



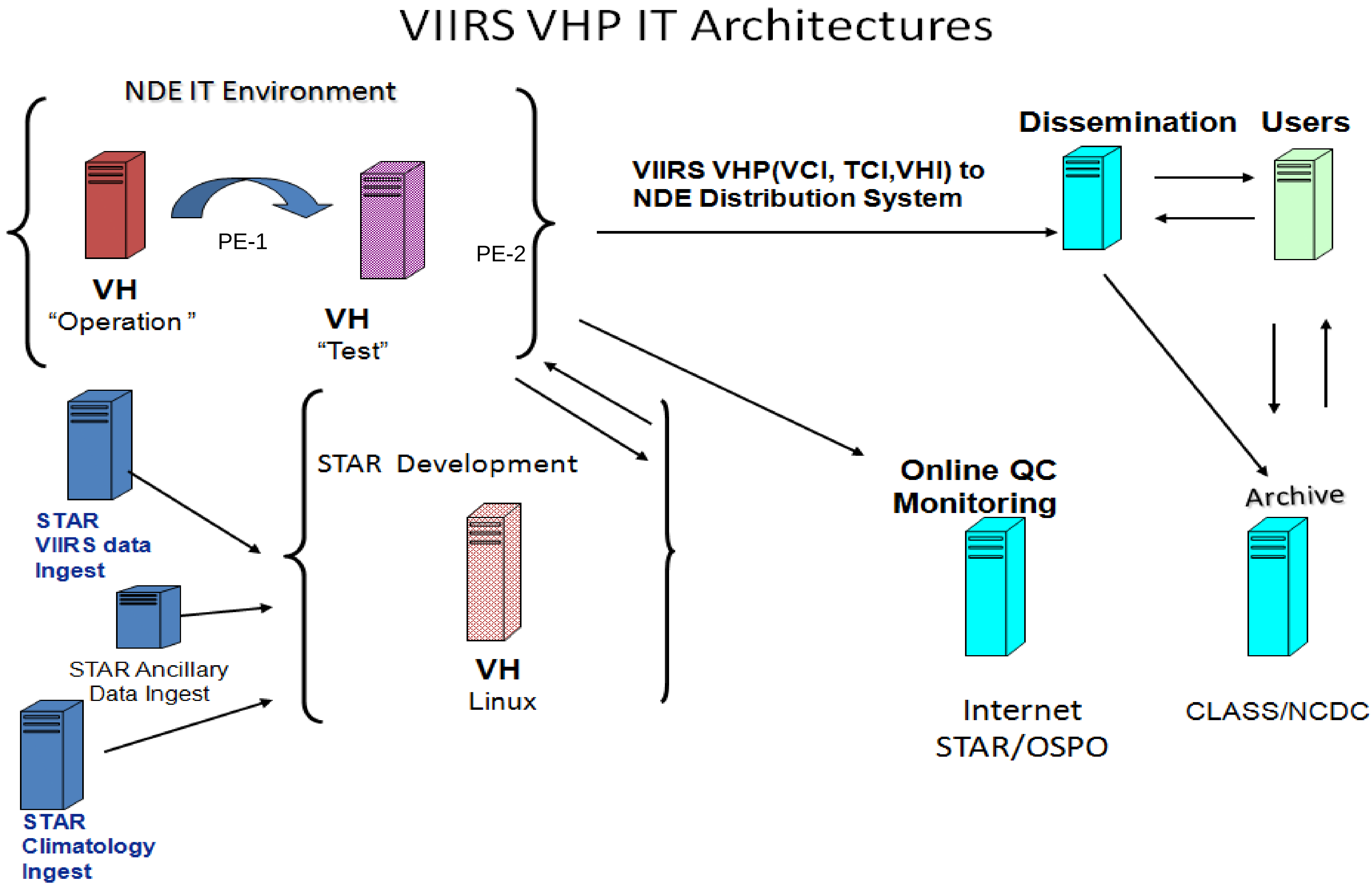
Drought from US Drought Monitor (USDM)



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

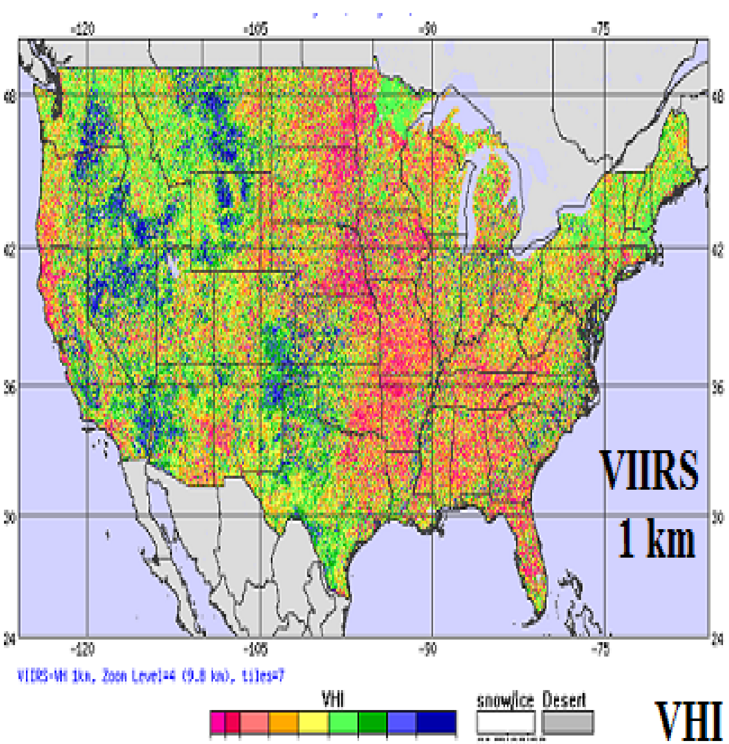
VIIRS VHP IT Architectures: Apply #1

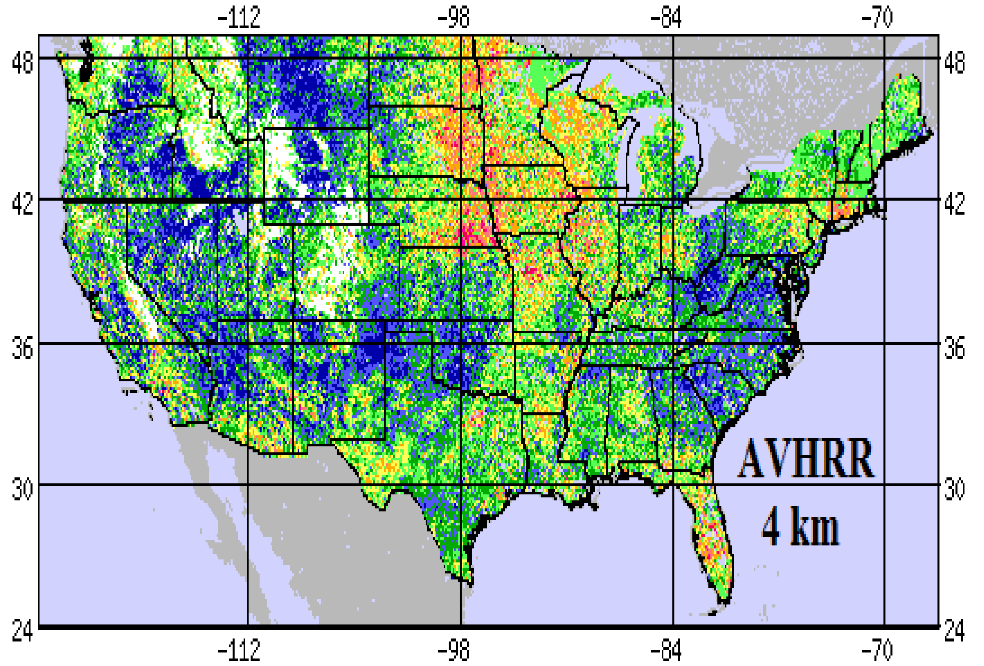
Adjust SNPP/VIIRS weekly NDVI & BT to weekly NOAA/AVHRR



VHI: VIIRS-1km vs AVHRR-4 km May 20, 2017

- SNPP/VIIRS-1   NOAA/AVHRR-4

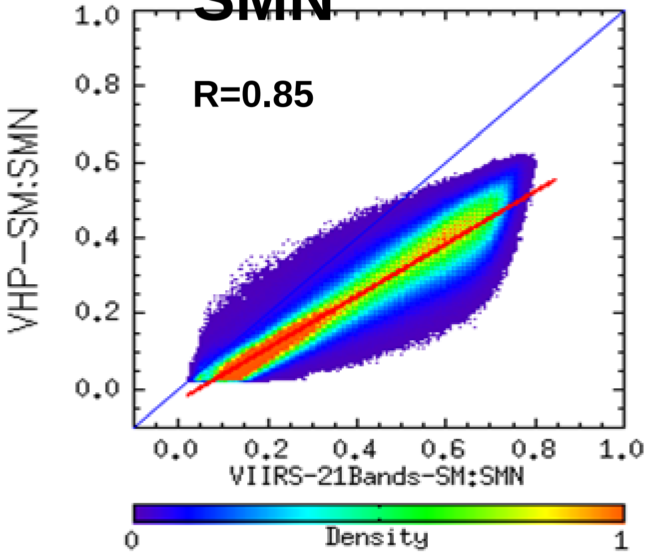




VHI for May 20 2017

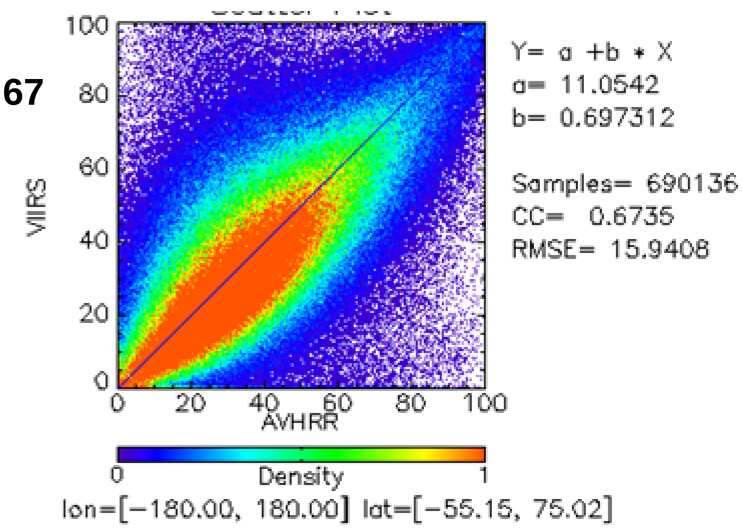
Expl: Error reduction is required

SMN



VCI

R=0.67



1. Raw data collection	**problem**
2. VIS, NIR & IR	**problem**
3. Climatology	**problem**

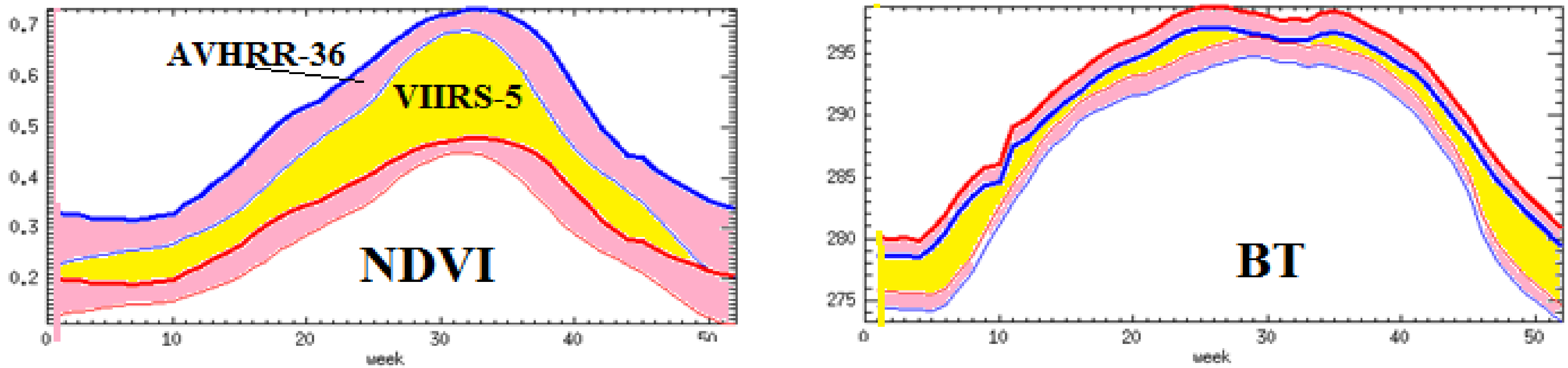
TRUE ????

Transition to SNPP/VIIRS & J-1

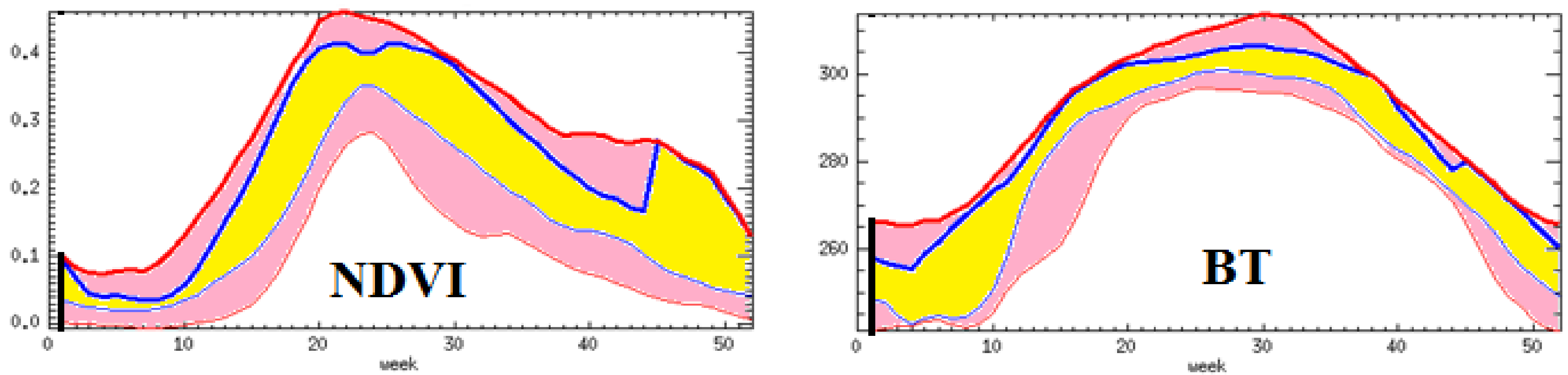
- From the TWO methods the **second** one is used:

Adjust SNPP/VIIRS **5-year** weekly NDVI & BT **climatology** to NOAA/AVHRR **36-year** **climatology**

Climatology A-36 vs V-5



ILLINOIS, USA (89W, 39N) Grassland



Saratov, RUSSIA (43E, 50N) Steppe

NDVI Min Max

BT Min Max

Climatology AVHRR-36 (1981-2016) & VIIRS-5 (2012-2016)

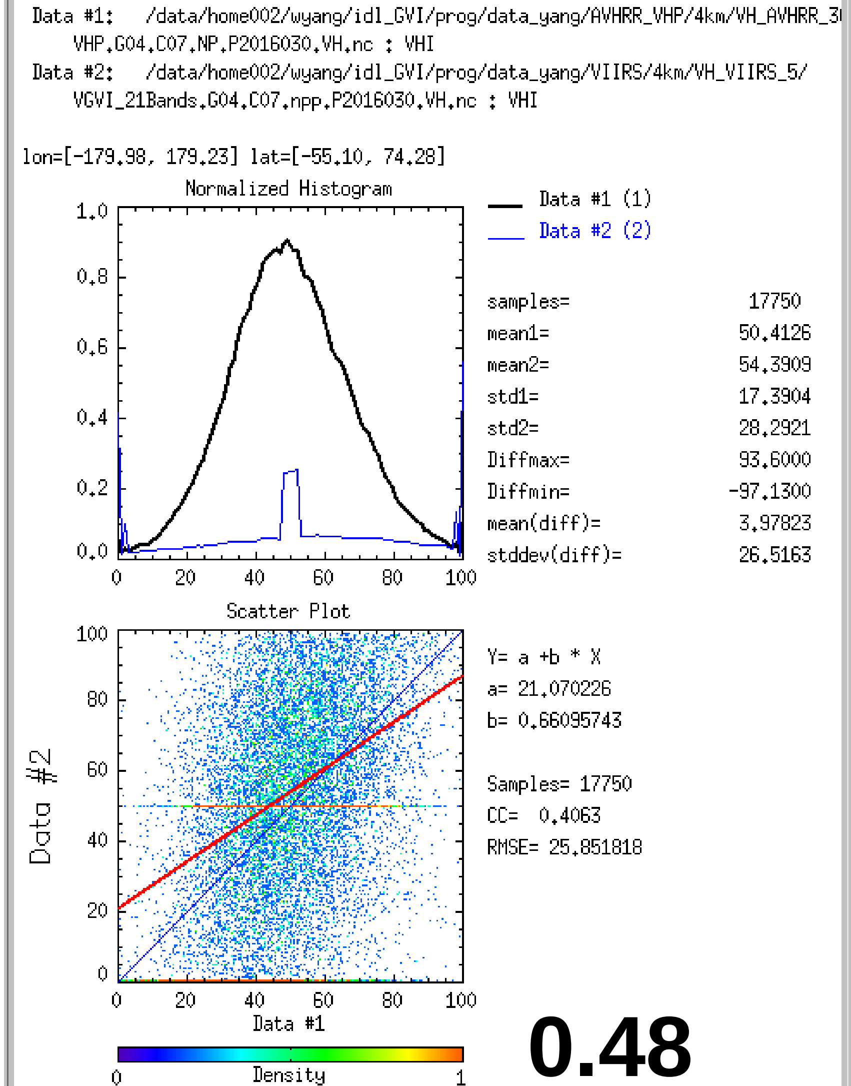
SNPP/VIIRS & NOAA/AVHRR 4km Climatology (Wz)

- Directly generate 5-year VIIRS 4km climatology (V5);
- Directly generate 5-year AVHRR 4km climatology (A5) at the same period with V5;
- Directly generate 36-year AVHRR 4km climatology (A36);
- Generate pseudo 36-year VIIRS 4km climatology (V36) based on the calculation from V5, A5 and A36 climatology:

$$V36 = V5 \times \frac{A36}{A5}$$

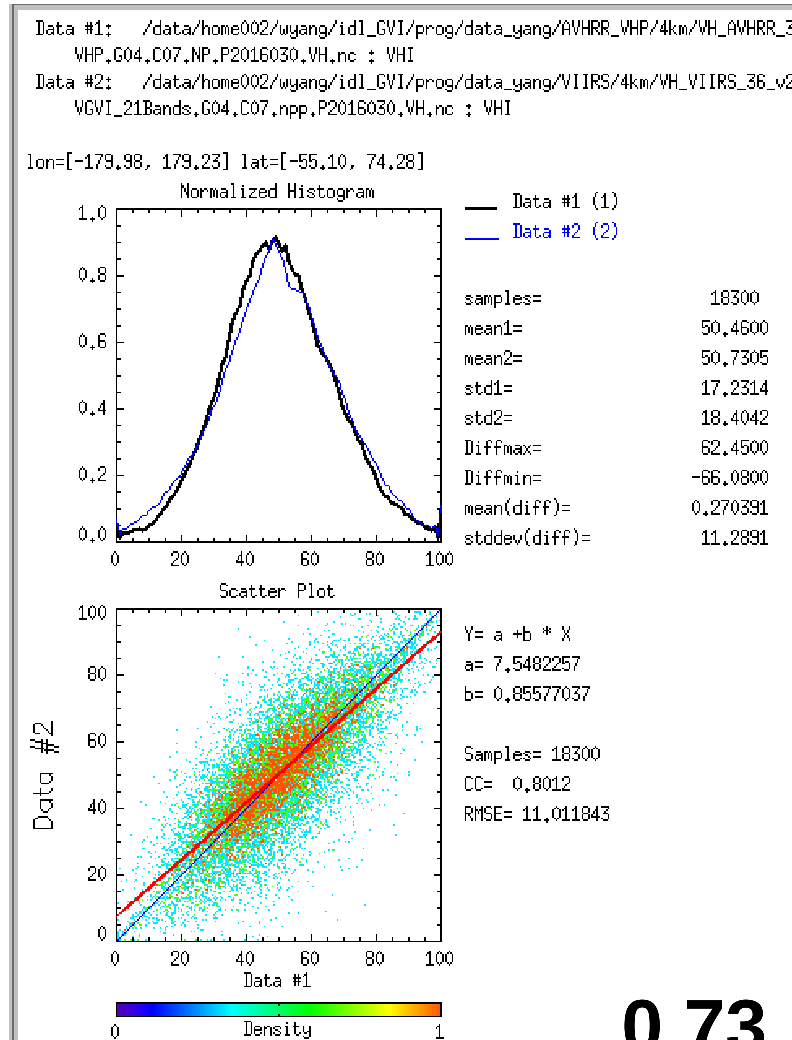
Test: VHI 4 km Product (Wz)

A36 vs. V5



0.48

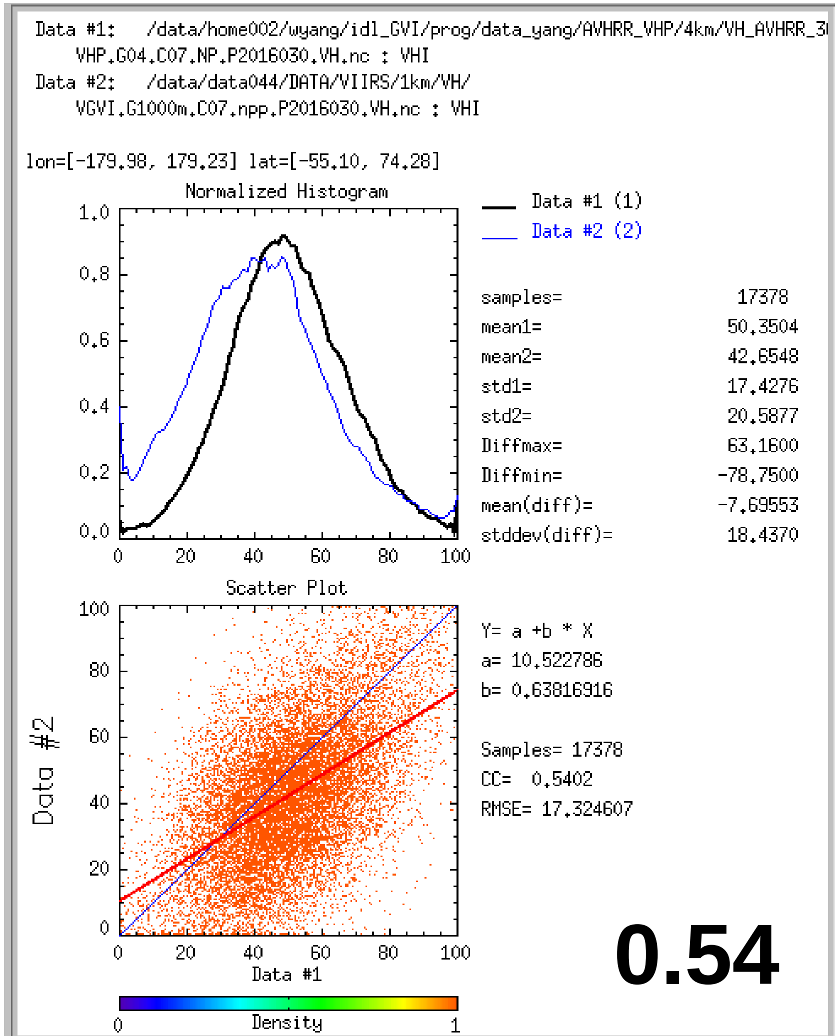
A36 vs. V36



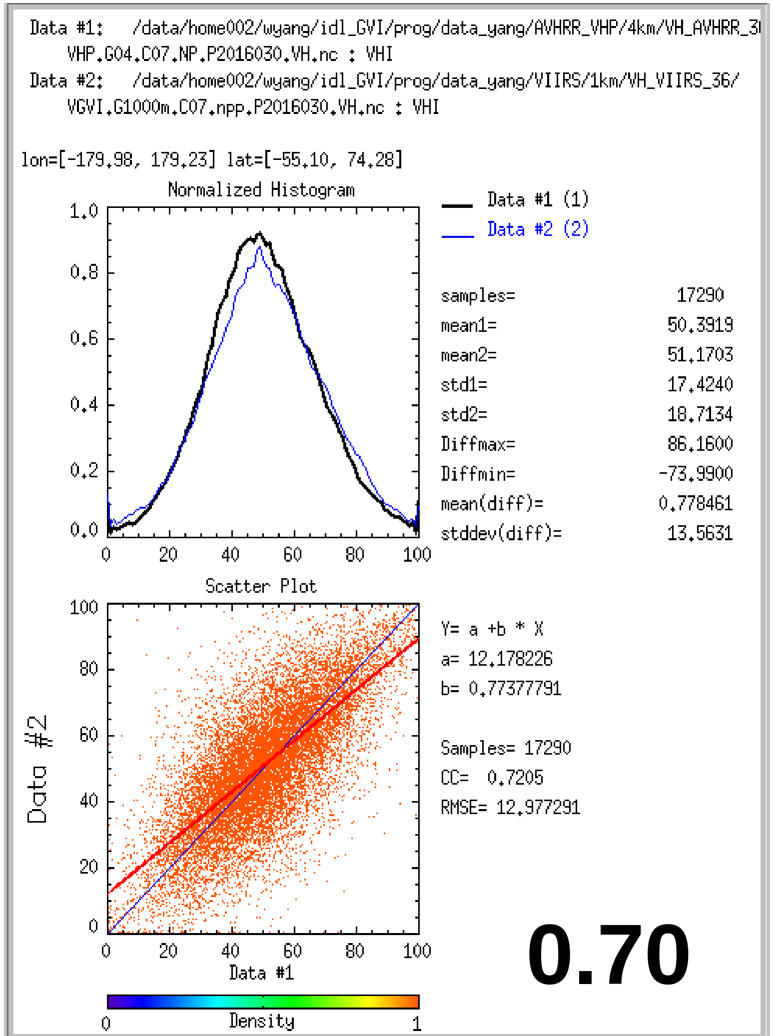
0.73

Test: VHI 1km Product

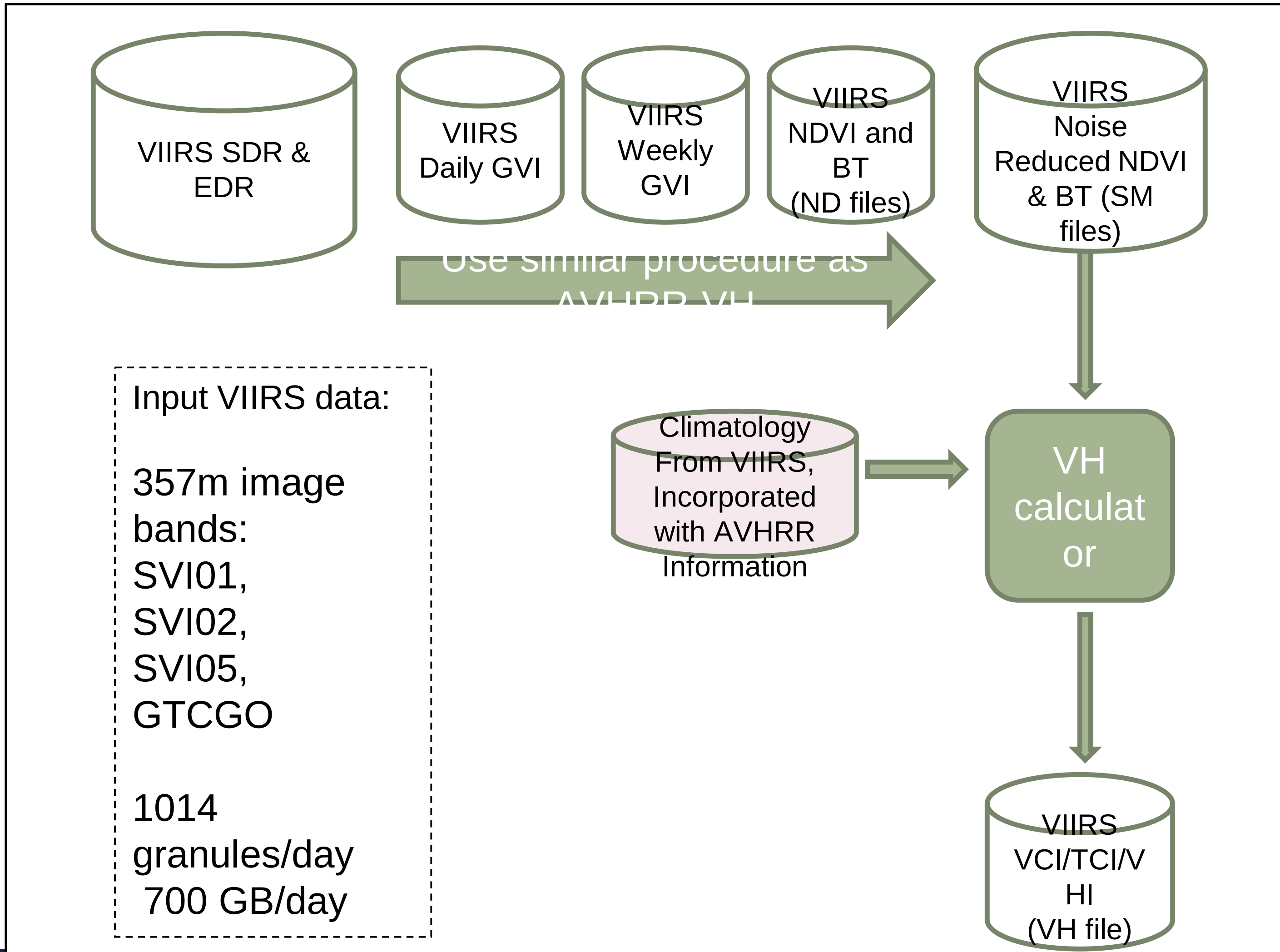
A36 vs. Former Scheme



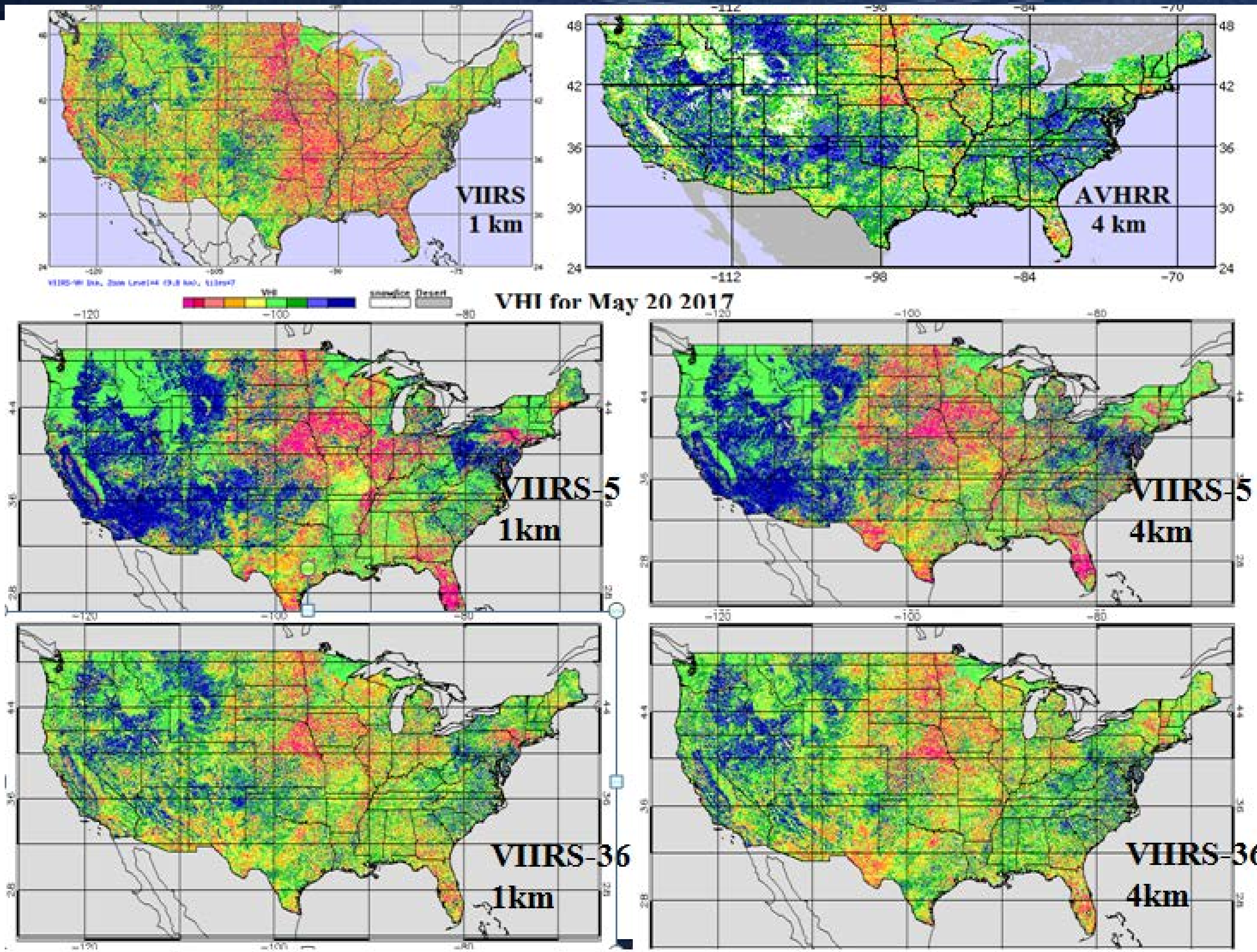
A36 vs. V36



New VIIRS-VH system: Data Flow (Wz)



VHI from V-36, V-5 & A-36 climatology



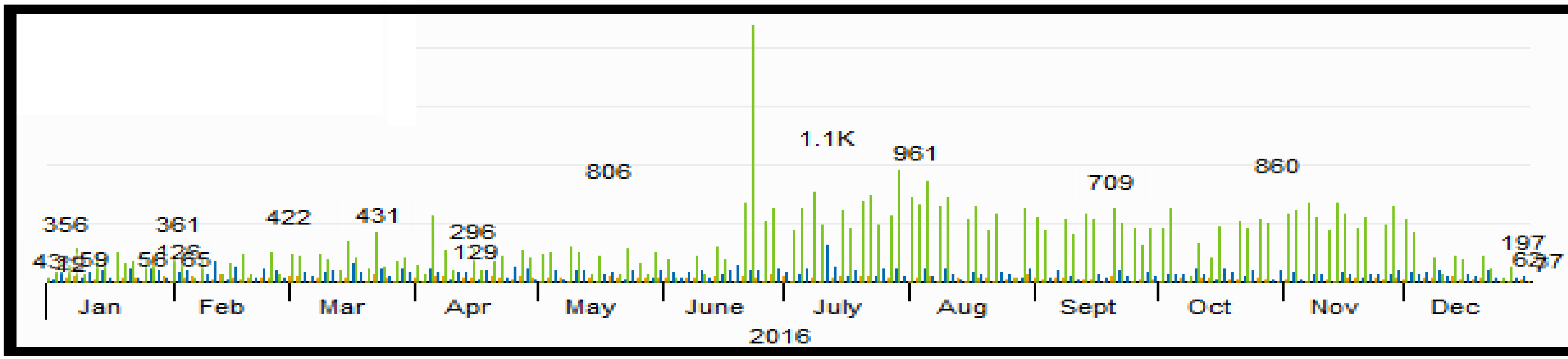
VHI calculated with the V-36 climatology

VH-WEB Users in 2016

Daily | Weekly | Monthly | Quarterly | Yearly

Page Views
Unique Visits
Returning Visits

Labels on Chart



Date Range: Last Year or 1 Jan 2016 - 31 Dec 2016

Chart Type: Line Chart Area Chart Bar Chart Save As Default

	Page Views	Unique Visits	First Time Visits	Returning Visits
Total	140,163	30,868	17,849	13,019
Daily Average	383	85	49	36

Vegetation Health (VH) Total Users in 2016 and Daily