SNPP-J1/VIIRS Vegetation Health 1 km (VIIRS/VH-1)

Presenter Felix Kogan

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STAR/JPSS Enterprise Algorithm Workshop
NCWCP College Park, MD

Outline

- Introduction
- Team Members
- Users
- Requirements
- Current Operational Product
- Capabilities Assessment
- Architecture & Algorithm
- Testing & Validation
- Lessons Learned
- Plan of Operations
- Risk

Introduction

- Vegetation health (VH) is a method derivation of global vegetation condition from VIS and IR channels of afternoon operational polar-orbiting satellites;
- The method is based on three bio-physical and ecosystem laws;
- The global VH (GVH) output is produced every week;
- Briefly, algorithm includes retrieval of orbital VIS and IR, calculation of NDVI and BT, their daily and weekly mapping & development of time series, comprehensive NDVI & BT massaging and calculation of three VH indices
- The developed products include 16 & 4 km AVHRR/GVH and 4 km VIIRS/GVH;
- We also put these data on our WEB for validation purposes

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

from 2015, nearly 6,000 users entered this page every month;

- Currently, 1 km SNPP/VIIRS is developing

VH-1Team & Users

- **Lead: Felix Kogan, NOAA/NESDIS/STAR**
- **NESDIS Team:**
  - NDE/OSPO: Dylan Powell, Wei Yu, Ricky Irving
  - OSPO: Hanjun Ding
  - OSD: Tom Schott
  - JPSS: Lihang Zhou
  - STAR: Walter Wolf
  - Data Center: CPC, NCDC
  - Contractor: Wei Guo
- **Main Requestors & Users**

  - Lead at NOAA: Matthew Rosencrans, **NWS/NCEP/CPC**

  - Lead at USDA: Mark Linderman, **USDA/FAS**, Eric Luebehusen, **USDA/WAOB**

Requirement(s)

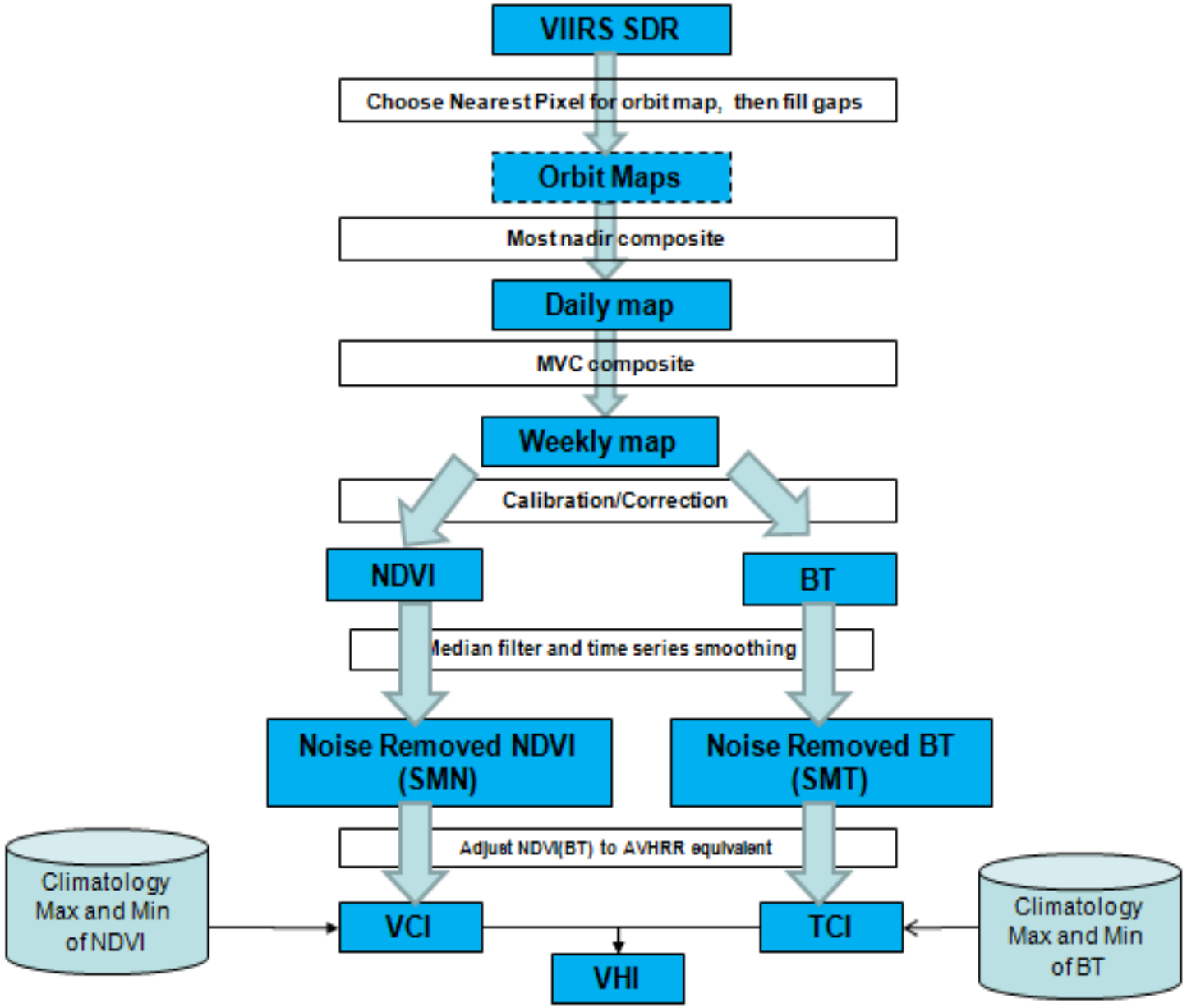
- **Requirement(s)**
  - **NWS/NCEP/CPC Request number 1312-0008 from Matthew Rosencrans,**
    Summary: Develop 1-km resolution Vegetation Health (VH-1) product from SNPP/VIIRS for
    (a) Operational monitoring
    (b) Climate services

  Explanation: SNPP-J1/VIIRS VH-1 product will replace SNPP/VIIRS VH-4 and NOA/AVHRR VH-4 product. It will be used in 1. NWS/CPC operational practice for (a) global and USA drought monitoring, (b) analysis of climate impacts on food security in Africa; 2. in USDA modeling global crop production and projecting the global commodity market; 3. Global community.
- **NOAA Mission Goal supported:**
  - Serve society's needs for weather and water information;
  - Enhance society's ability to plan and respond;
  - Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation;
  - Provide Climate Services.
- **User community**
  - NOAA/NWS's Climate Prediction Center needs 1 km drought information for North America Drought Monitor, Africa's food security assessment and global climate impact assessments
  - NOAA/NESDIS/OSPO VH product distributor
  - USDA/FAS & WAOB requested 1 km S-NPP-based VH products to predict global crop production and market performance
- **Benefit to user**
  - NOAA/NWS/CPC & OAR will predict Drought, Fire Risk, Flood/Standing water, Food security, Mosquito-born diseases;
  - USDA will predict global crop/pasture production & assess commodity market;
  - NOAA/NESDIS will provide Global drought watch; Biomass burning emission, Fire risk, Soil wetness.

Current & Required Capabilities: Vegetation Health Product

	Current Operational Capabilities	Requested Capabilities	Proposed Operational Capabilities
Satellite Source (s)	**SNPP/VIIRS-4 km** **NOAA/AVHRR-4 km**	**SNPP/VIIRS 1 km**	**Same as requested**
Product Name	**VCI-4** **TCI-4** **VHI-4**	**VCI-1 from VIIRS** **TCI-1 from VIIRS** **VHI-1 from VIIRS**	**Same as requested**
Accuracy	**VCI , TCI, VHI – 4%**	**No change**	**No change**
Latency	**6 hours after the end of each 7-day period**	**4 hours after the end of each 7-day period**	**Same as requested**
Timeliness	**Weekly**	**No change**	**No change**
Coverage	**Global land surface (75degN-55degS)**	**No change**	**No change**
Resolution	**0.036 degree (4 km)**	**0.009 degree (1 km)**	**Same as requested**
Other attributes	**Mapped SNPP/VIIRS counts, observed angles, channels' values with calibration parameters.**	**VHI, VCI, TCI** **Formats: NetCDF/HDF & Geo-TIFF**	**Same as requested**

GVH Algorithm Block-Scheme



Algorithm Summary

- VH algorithm requires retrieval of I1, I2 & I5 from VIIRS
- Mapping I1, I2 & I5 to a standard global grid
- Development of global daily and weekly maps
- Calculation of NDVI & BT:

  (a) Real time (from VIIRS)

  (b) Climatology (from AVHRR)
- Noise removal from SMN and SMT
- Adjustment of VIIRS SMN and SMT to standard climatology
- Checking stability of adjustments
- Calculation of VIIRS/VH (VCI, TCI, VHI)
- VIIRS/VH indices (VHI, VCI & TCI) are validated against AVHRR/VH, other satellites and in situ data
- **FURTHER: New climatology from JPSS will improve the results**

VH Validation Concept

- **Algorithm improvement** (VIIRS climatology**)**
- **Collect *In situ* data**

  Meteo. Parameters & indices (P, T, SPI, ET, PSDI, USDM)
  Crop indices (USDA, FAO, Countries)
  Diseases indices
  Satellites data
  Economic indicators
  Environmental assessments

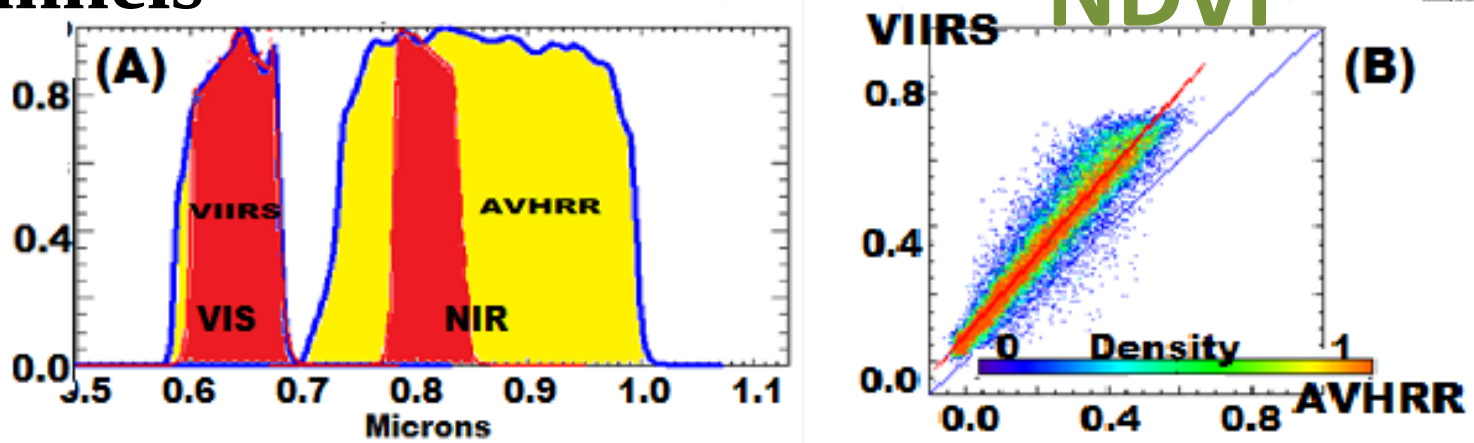
- **Comparison with other satellites**
- **Checking stability of dynamics**
- **Correlation and regression analysis for data matching**
- **WEB usage** (World, Countries, Regions)

VIIRS versus AVHRR

Climate data records problems

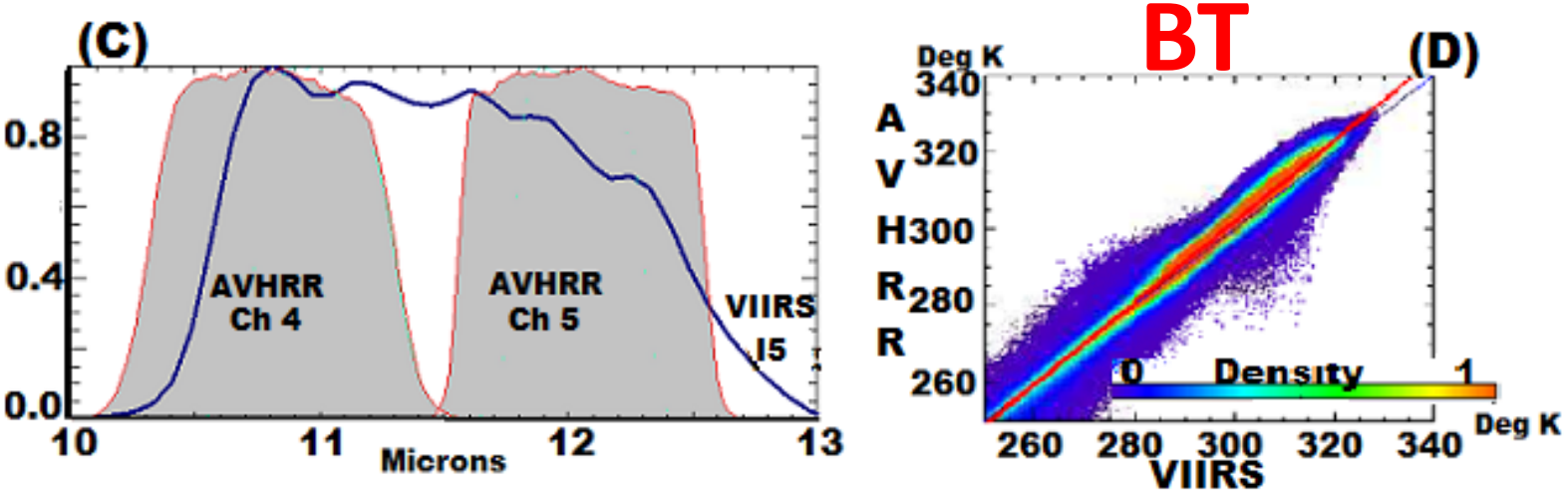
Channels

NDVI



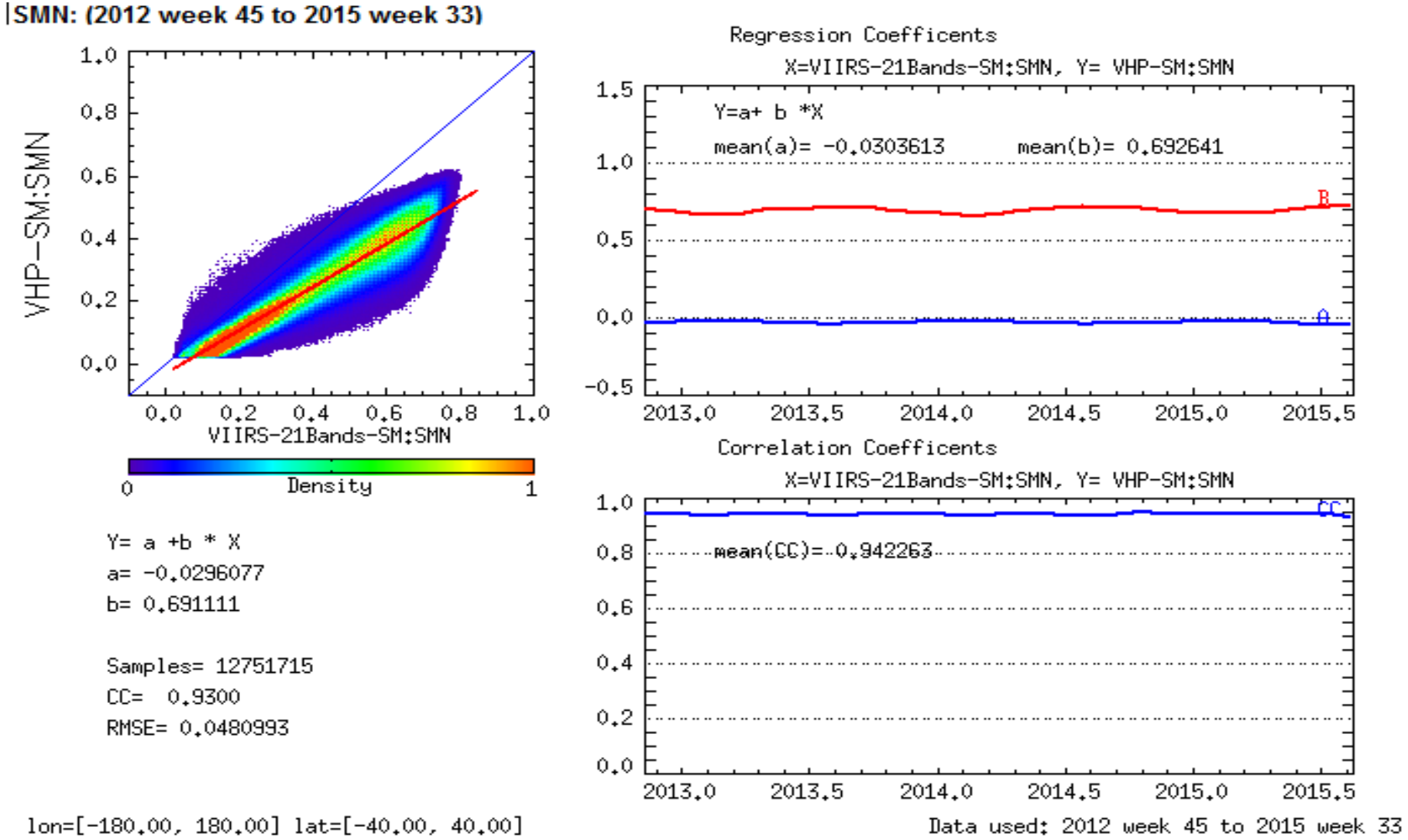
Normalized Difference Vegetation Index (NDVI)

BT



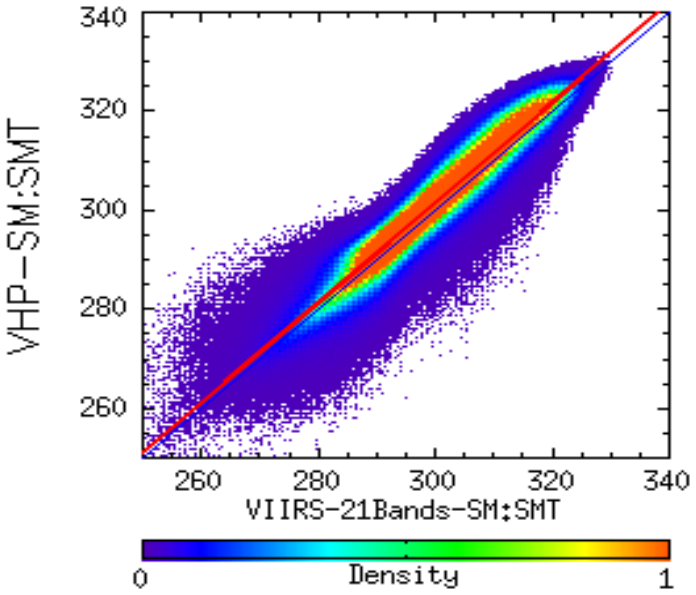
Brightness Teperature (BT)

NDVI (SMN): AVHRR-VIIRS time series 2012-2015.5



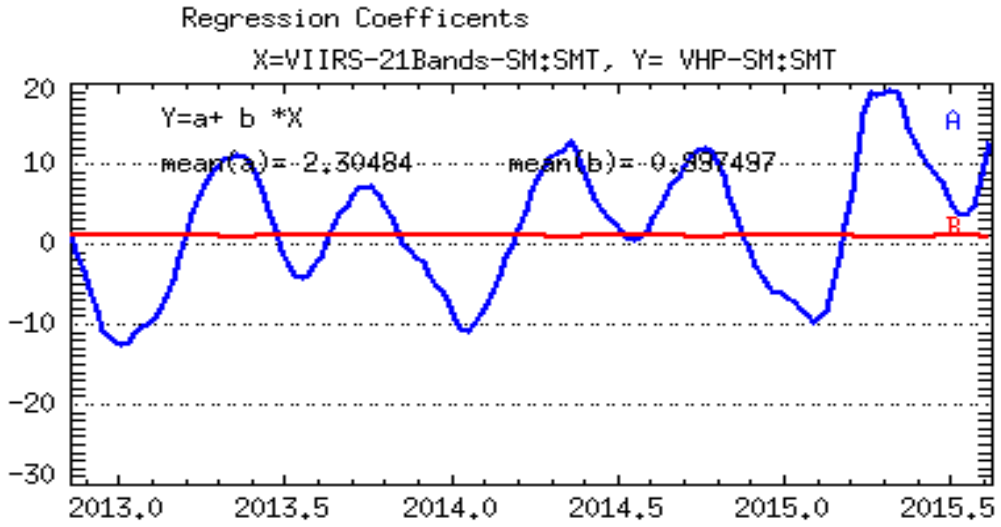
BT (SMT): AVHRR-VIIRS COR. and Regr. Tser 2012-2015.5

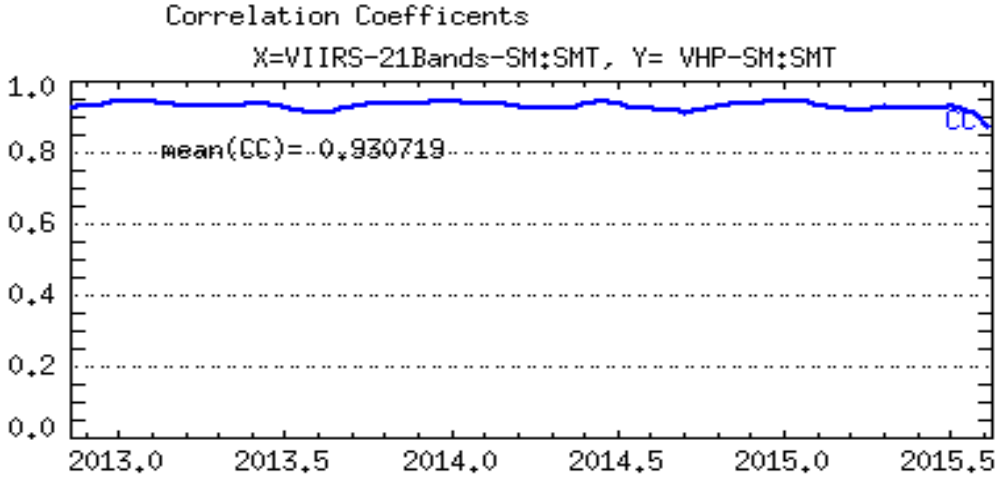
SMT: (2012 week 45 to 2015 week 33)



Y= a +b * X
a= -1.20120
b= 1.00928

Samples= 12913809
CC= 0.9156
RMSE= 3.97196

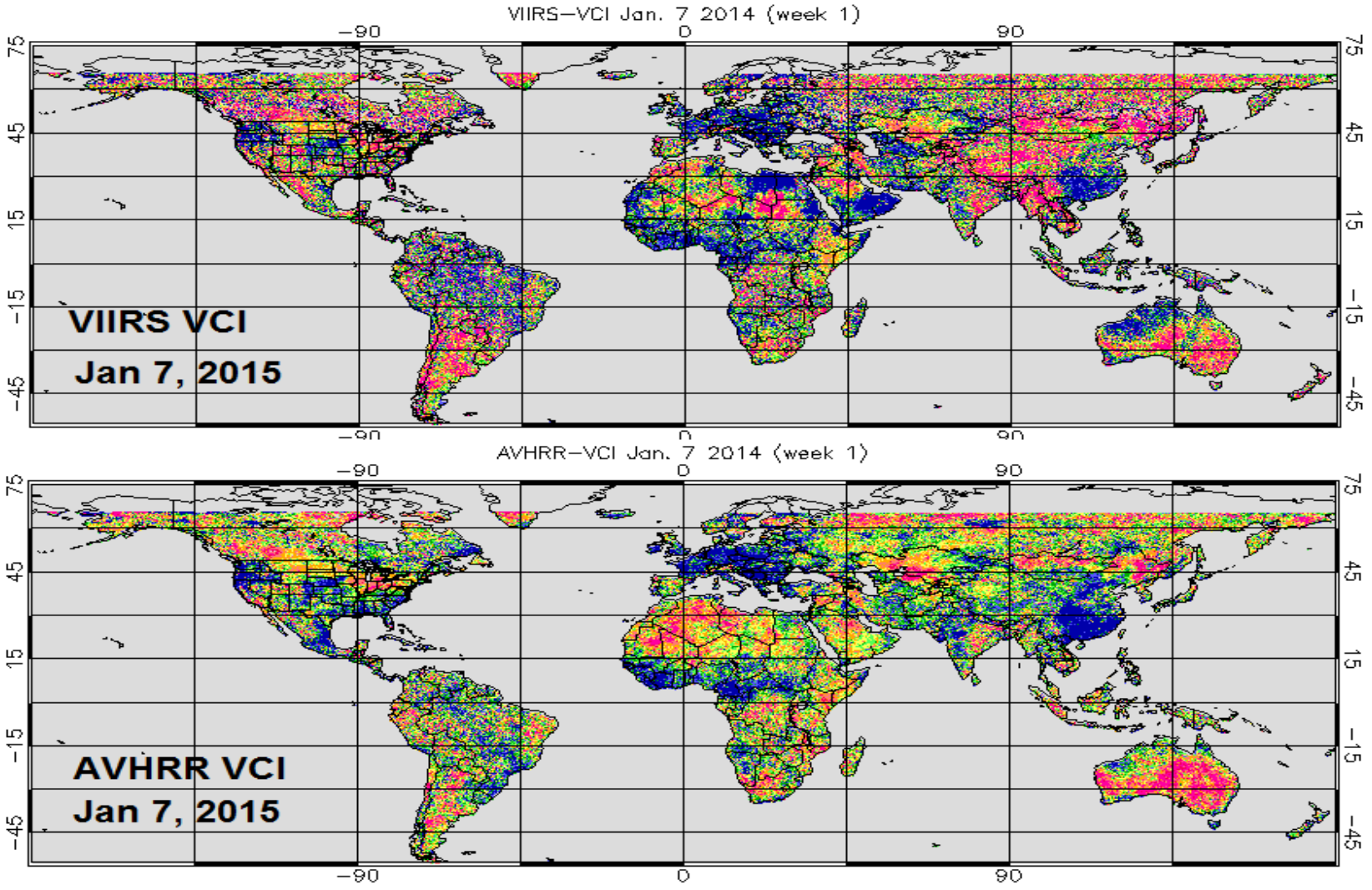




lon=[-180.00, 180.00] lat=[-40.00, 40.00]

Data used: 2012 week 45 to 2015 week 33

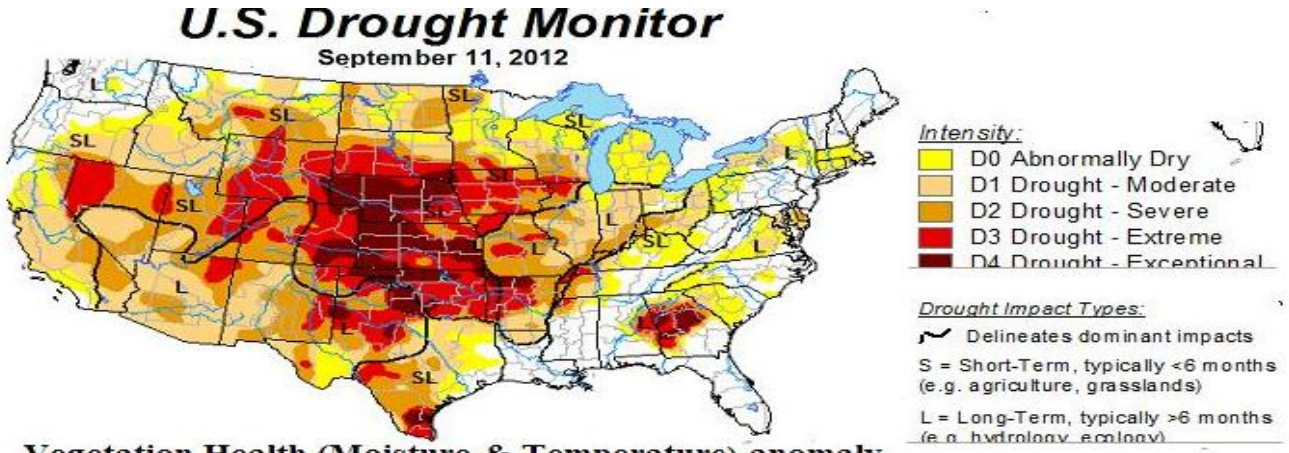
Comparison with Other Satellites: VALIDATION: VCI/VIIRS vs VCI/AVHRR



Comparison with Other Products USDM, VH vs GVH Drought

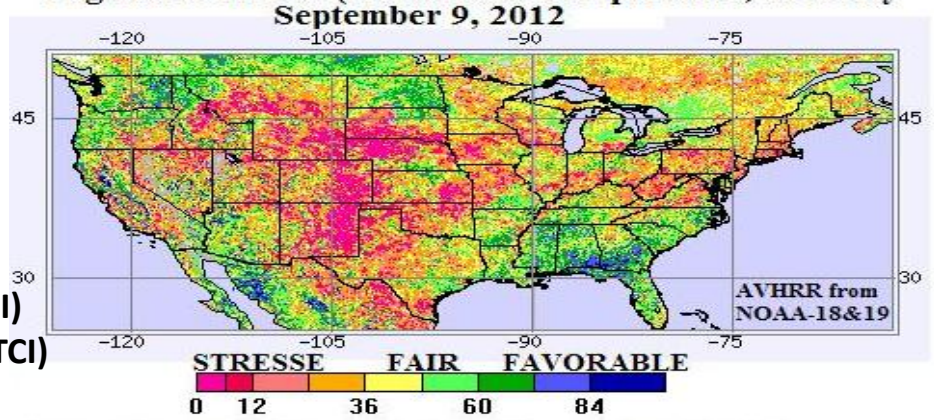
Drought Monitor

Palmer (PSDI)
Standardized Precip. Index (SPI)
Precipitation anomaly
Modeled soil moisture
Expert opinion

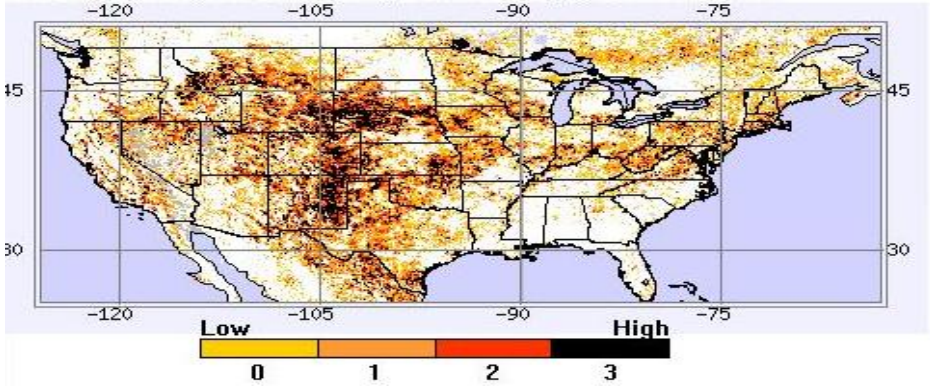


Vegetation Health Index

Vegetation Condition Index (VCI)
Temperature Condition Index (TCI)
Vegetation Health Index (VHI)

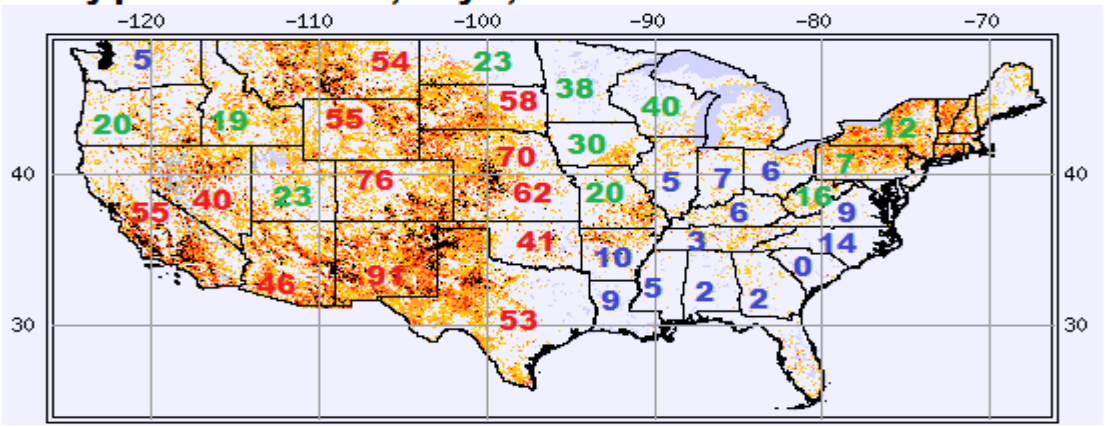


GVH-Drought

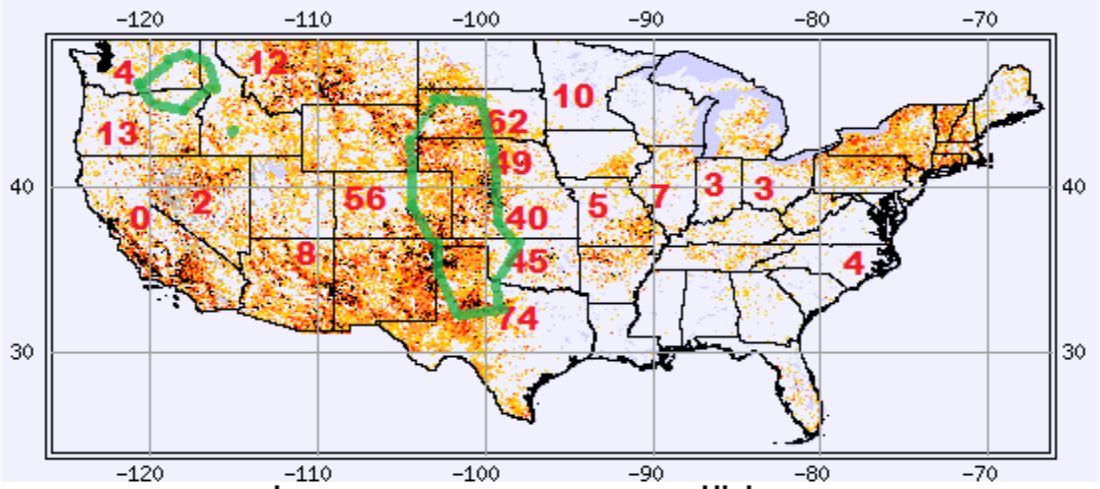


Comparison with Assessments GVH-drought stress & USDA pasture & winter wheat condition, May 6, 2013

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



WEB communication with USERS: 2.5-day GVH WEB view (May 4-6, 2015)

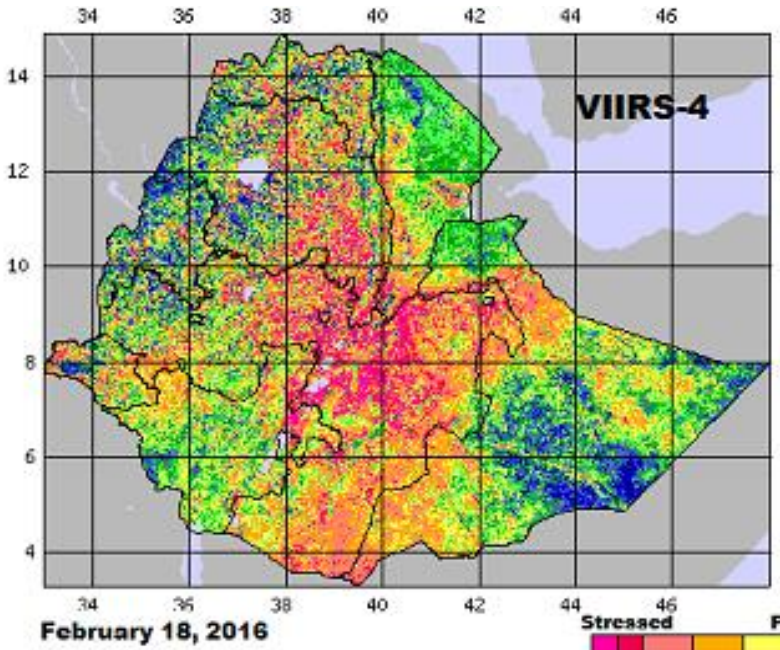
Page Views May 1-6, 2015

	Today May 6	Yesterday May 5	This Month May 1-6
STAR Vegetation Health Site	132	206	806

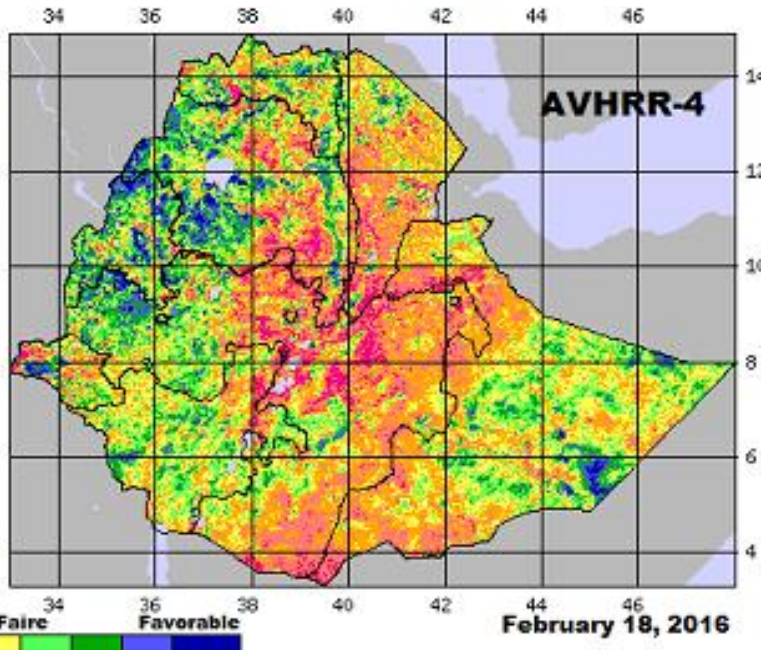
Countries used Vegetation Health WEB during May4-6, 2015

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 VIIRS vs AVHRR & Precipitation ETHIOPIA 2016



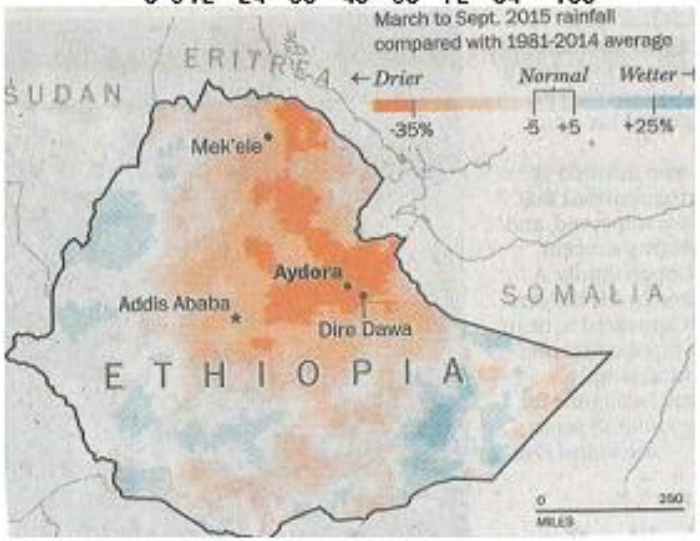
February 18, 2016



February 18, 2016

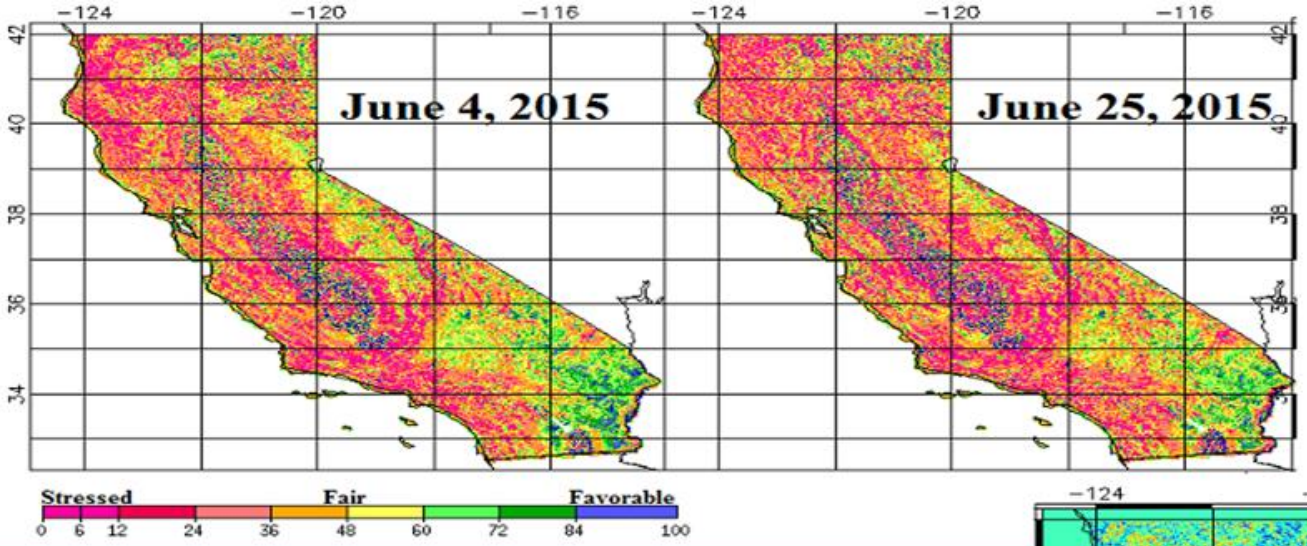
Stressed Faire Favorable

0 6 12 24 36 48 60 72 84 100



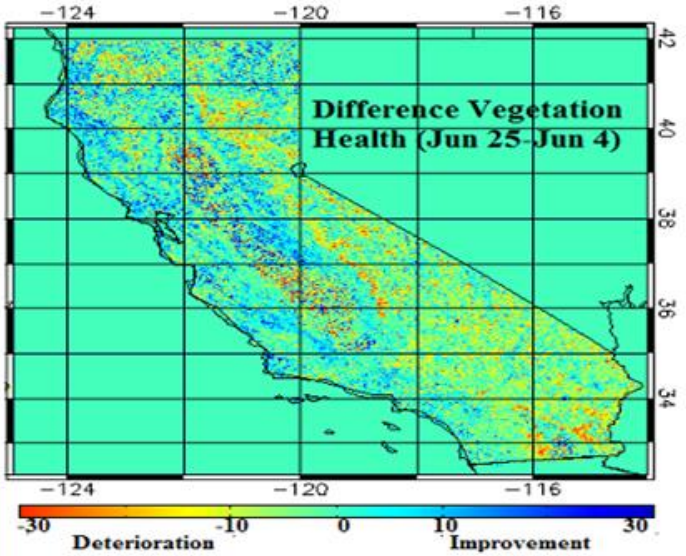
March-September 2015 precipitation anomaly
(deviation from 1981-2014 average)

California Drought Dynamics & Economic Impacts in 2015



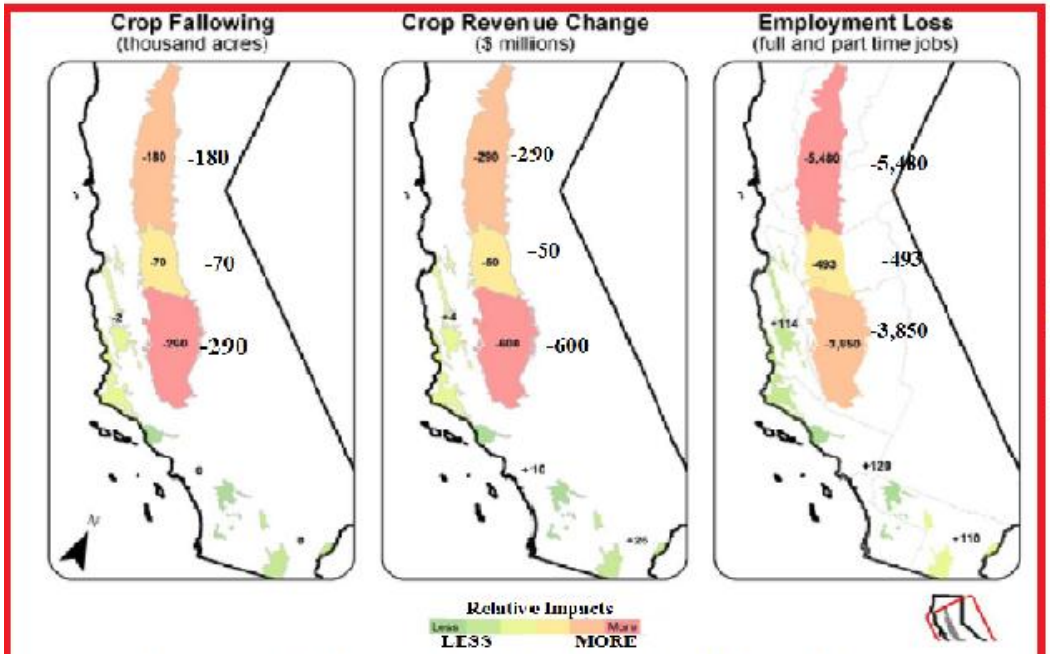
Vegetation Health from 500 m

S-NPP/VIIRS



Difference Vegetation Health

June 25 - June 4



SUMMARY

1. **Development:** VIIRS 1 km Global Vegetation health (GVH-1) for **detection and monitoring** disasters (a) drought, (b) moisture & thermal stress, (c) mosquito-born diseases, (d) fire risk, (e) landslides;
2. **Development:** SNPP-J1/VIIRS no noise NDVI and BT 1 km time series for **deriving climatology**;
3. **Development:** 35+ years 4 km GVH climate records (combine VIIRS & AVHRR) for detection **climate and land cover trend** from 4 decades 4 km GVH records.
4. **Validation**

BACK UP

Algorithm and Operation 1 km Vegetation Health

- **Current status of VH product**
  - Vegetation Health (VH) products at 4 km resolution have been developed, produced & applied at STAR & operationally at OSPO. **There is no equivalent products in the world.**
  - STAR place this product at the STAR's Web to receive users response.
  - **During 2015, nearly 6,000 world users requested the products every month.**
  - The result of VH application has been published in 4 papers and previously in a Book ("Use of Satellite & In situ Data to Improve Sustainability") explaining VH products and their multiple applications.
- **Overview of technical approach of the algorithm and its implementation**
  - The processing includes:
  - (a) **375 m granules** data retrieval (channels I1, I2, I5);
  - (b) **storing** 375 m granule data
  - (c) processing **overlapping granules**;
  - (d) **mapping 375 m** channels to1 km standard GVI map (orbit map);
  - (e) development of **daily map**;
  - (f) calculating intermediate indices (raw **NVI and BT**);
  - (g) compositing **weekly map**;
  - (h) Producing NVI & BT **time series**;
  - (i) NVI & BT **noise removal** (SMN & SMT);
  - (j) Conversion of VIIRS's SMN & SMT to AVHRR
  - (k) calculating new **climatology** for SMN & SMT;
  - (l) 1 km **VCI, TCI and VHI**;
  - (m) Meeting NDE requirements. SNPP-VIIRS system will produce a **weekly Vegetation Condition (VCI), Temperature Condition (TCI) & Vegetation Health (VHI).** The VH will be presented on a global gridded composite map in Lat-Lon projection with **0.009 degree horizontal resolution**. The system will be established on STAR Linux server using C++ & adapted to operation's IBM AIX OS with C++ compiler.
  - Ancillary data requirements: Static files containing **30 arc second** resolution **land sea mask** converted to HDF format, Land **cover type from IGBP** converted to HDF, **Calibration parameters** for visible channels

Concept of operations: The operation consists of eleven units: (1) Reading daily orbit VIIRS L1b radiances in the visible (I1), near infrared (I2) and thermal (I5) by granules; (2) Development of daily map; (3) Calibration of I bands; (4) Calculation of NVI & BT; (5) Development of NVI & BT time series; (6) Removing high frequency noise from NVI & BT & deriving SMN & SMT; (7) Development of SMN & SMT climatology; (8) Calculation of VCI, TCI & VHI products ;(9) Output of products to HDF/NetCDF & GeeoTiff formats; (10) Write meta data; (11) Real time QC

Vegetation Health (VH) 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

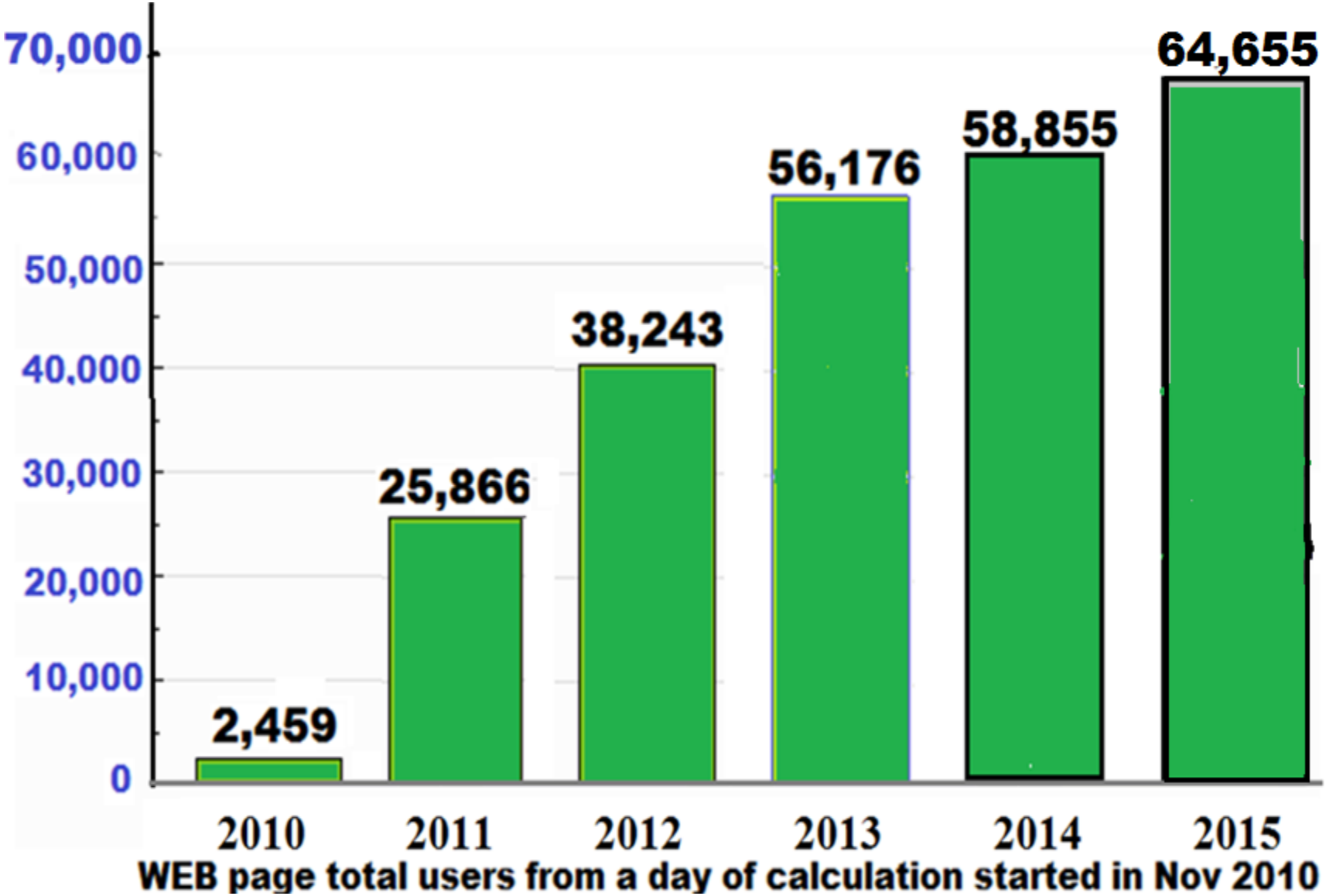
VHI=a*VCI+(1-a)*TCI

VEG. HEALTH

0 – indicates extreme stress

100 – indicates favorable conditions

Users attending Vegetation Health WEB



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

Weekly NDVI raw & smoothed
Sub-Sahara AFRICA