Vegetation Health
NOAA-20/VIIRS CAL/VAL MATURITY REVIEW
March 21, 2019

Presented by Felix Kogan
Outline

• VH Product Team Members
• Product Overview
• VH Requirements
  – General
  – Specific
• General Direction: Continue Checking
  – Data/product quality
  – Adjustment
  – Verification
  – Consistency
  – Validation
  – Building Data Records
  – New products
• Users Feedback
• Work with NDE
• Knowledge distribution
• Conclusions and Path Forward
VH Product Team

• **Lead**: Felix Kogan (STAR)

• **Backup Lead**: Hanjun Ding (OSPO)

• **NESDIS team**:
  – STAR: Felix Kogan, Wei Guo (IMSG), Wenze Yang (IMSG)
  – OSGS: Geoffrey Goodrum, Brandon Bethune
  – JPSS: Arron Layns
  – OSAAP: Kathryn Shontz
  – OSPO: Hanjun Ding, Yufeng Zhu
  – NCEI: Phil Jones

• **User team**
  – NWS/NCEP CPC: Contact (Matthew Rosencrans, **Wasilla Thiaw**)
  – USDA WAOB: Contact (Eric Luebehusen, **Mark Brusberg, Harlan Shannon**)
  – **US Drought Monitor** (David Miskus, Brad Rippey)

• **Product Oversight Panel**: Land Surface POP (LSPOP)
Product Overview

– **Product Final:**
  - Vegetation Condition Index (VCI), - Moisture
  - Temperature Condition Index (TCI) - Thermal
  - Vegetation Health Index (VHI) –Moisture/Thermal
– **Product Intermediate:** SMN - Smoothed NDVI, SMT - Smoothed Brightness Temperature, NDVI, BT
– **Original Data**
  - Channels: I1, I2, and I5
– **Coverage:** Global Land Surface (75N-55S, 180W-180E)
– **Resolution**
  - Spatial: 0.009° (1 km)
  - Temporal: 7 days
REQUIREMENTS: General

• VH supports NOAA Mission:
  (1) Understand **climate variability and change**;
  (2) Serve society's needs for **weather and water** information;
  (3) **International Cooperation** and Collaboration;
  (4) Environmental **Literacy, Outreach, and Education**

• **Develop Unique NOAA Products**
  – Vegetation Health (VH)

• **Support Socioeconomic Activities**

• **Serve Users:** Weather & Climate, Agriculture, Forestry, Water, Health (WMO, FAO, UNESCO, USDA, USAID, Commerce), Drought, Moisture & Thermal stress, Healthy Condition, Weather impacts, Land surface change, Food security
# REQUIREMENTS: Specific

## Vegetation Health Products

<table>
<thead>
<tr>
<th>EDR Attributes</th>
<th>JPSS L1RD</th>
<th>Veg. Health Product System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Horizontal Cell Size</strong></td>
<td>Objective – 0.009° (1 km)</td>
<td>Objective – 0.009° (1 km)</td>
</tr>
<tr>
<td><strong>Vertical Reporting Interval</strong></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Mapping Uncertainty, 3 sigma</strong></td>
<td>Objective – &lt;0.009°</td>
<td>Objective – &lt;0.009°</td>
</tr>
<tr>
<td><strong>Measurement Precision</strong></td>
<td>Threshold – 2.0% (For the range 0-100%)</td>
<td>Threshold – 2.0% (For the range 0-100%)</td>
</tr>
<tr>
<td></td>
<td>Objective – NS</td>
<td>Objective – NS</td>
</tr>
<tr>
<td><strong>Measurement Accuracy</strong></td>
<td>Threshold – 1.0%</td>
<td>Threshold – 1.0%</td>
</tr>
<tr>
<td></td>
<td>Objective – NS</td>
<td>Objective – NS</td>
</tr>
<tr>
<td><strong>Refresh</strong></td>
<td>Threshold – Every 7 day period</td>
<td>Threshold – Every 7 day period</td>
</tr>
</tbody>
</table>
DIRECTION: Checking Data

Spectral Response Functions: NOAA-20 vs S-NPP

Relative Spectral Response Function

0.0 0.2 0.4 0.6 0.8 1.0
0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1

NOAA-20: I1, I2
S-NPP: I1, I2

Relative Spectral Response Function

0.0 0.2 0.4 0.6 0.8 1.0
10.0 10.5 11.0 11.5 12.0 12.5 13.0

NOAA-20: I5
S-NPP: I5
DIRECTION: Checking Data

**VIS** NOAA-20 vs S-NPP March 4, 2019

Normalized Histogram

- S-NPP (1)
  - samples = 468074
  - mean1 = 0.161467
  - mean2 = 0.159432
  - std1 = 0.0894418
  - std2 = 0.0891071
  - Diffmax = 0.353900
  - Diffmin = -0.354200
  - mean(diff) = -0.0020356
  - stddev(diff) = 0.0477194

Scatter Plot

Y = a + b * X

- a = 0.021548598
- b = 0.85393775

Samples = 468074

- CC = 0.8571
- RMSE = 0.045896814

Density

lon = [-179.60, 179.80]
lat = [-54.00, 74.00]
DIRECTION: Checking Data

NIR NOAA-20 vs S-NPP March 4, 2019

Normalized Histogram

Scatter Plot

Y = a + b * X
a = 0.096982287
b = 0.61768610

Samples = 364365
CC = 0.6254
RMSE = 0.051783338

lion=[-179.60, 179.80] lat=[-54.00, 74.00]
DIRECTION: Checking Data

BT NOAA-20 vs S-NPP March 4, 2019

Normalized Histogram

- S-NPP (1)
- NOAA-20 (2)

samples= 7352575
mean1= 292.248
mean2= 292.178
std1= 15.3077
std2= 15.5021
Diffmax= 56.2000
Diffmin= -59.8000
mean(diff)= -0.046686
stddiff= 5.34452

Scatter Plot

Y = a + b * X
a = 14.023096
b = 0.95185203

Samples= 7352575
CC= 0.9399
RMSE= 5.2935887

[Graphs showing temperature data for NOAA-20 and S-NPP]
DIRECTION: Checking Data

Mapping

Indonesia, 12: Jawa Timur, Vegetation Condition Index and Temperature Condition Index (VCI)

VCI, July 29, 2018 (week 30)

VIIRS-VH, Zoom Level=7 (1.2 km), tiles=8

Stressed VCI Favorable

0 6 12 24 36 48 60 72 84 100

NOAA-20 VIIRS Vegetation Health Beta Maturity Review
**DIRECTION**

**Adjustment**

**In Beta Review**

**NOAA-20**  
**S-NPP**

**Presently**

**NOAA-20**  
**S-NPP**
DIRECTION: Verification

SMN NOAA-20 vs S-NPP, Jan 21, 2019

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/j01_browseCompareVH.php
DIRECTION: Verification

SMT NOAA-20 vs S-NPP, January 21, 2019

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/j01_browseCompareVH.php
DIRECTION: Verification

VCI  NOAA-20 vs S-NPP, January 21, 2019

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/j01_browseCompareVH.php
DIRECTION: Verification

TCI NOAA-20 vs S-NPP, January 21, 2019

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/j01_browseCompareVH.php
DIRECTION: Verification

VHI NOAA-20 vs S-NPP, January 21, 2019

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/j01_browseCompareVH.php
DIRECTION: Checking Consistency 2018-2019
DIRECTION: Validation

Vegetation Health & USDA Top Soil Short & V. Short, % Pasture in Good & V. Good Condition: June 3, 2018
DIRECTION: Validation

Vegetation Health Index vs. Wheat Yields

Yield (vs. trend)

\[ R^2 = 0.92 \]

VHI data – Week 41
(7 day period ending Oct 14)

Note – Prelim data available Oct 15
Final data available Nov 25

He has demonstrated a high degree of success using the VHI data for Australia wheat yields, particularly later in the growing season.
While most winter crop areas of northern Europe bake, Spain has been the exception with wet, cool weather; this is reflected in the VHI.

* Yield data from PSD Online, 2018 yield is from last month
DIRECTION

Data Records: SMN (from NDVI) 1980-2019

(a) East Sahara
(b) Saratov
(c) Illinois
(d) South Queensland
(e) Maine
(f) Amazon

NDVI: AVHRR, GIMMS, VIIRS
DIRECTION:
NEW Product VH for Crops

Crop Area (colores) vs the entire land (blue) 2017

SMN

Crops

All Province

SMT

VCI

TCI
User Feedback

- **USDA-WAOB** have developed crop condition forecast tools using the VHI
  - **Harlan** - is using VHI for *Australia crop yields* with amazing success
  - **Brad** - uses the VHI for *discussing on USDA Radio and TV current crop conditions in the U.S*
  - **Mark** - I have just *released to the USDA Chief Economist* my new methodology for using VHI
  - **Eric** - VHI ascii data continues to be a *huge help* in my crop-yield modeling forecast
  - **Eric** - Is there a way to get country-averaged VHI — in addition to the admin-level VHI
  - **Eric** - has been very successful in assessing crops by the Department.

- **WMO**: Vegetation Health products *demonstrated great values in the monitoring of drought* and its evolution in the WMO project
NOAA-20 Codes and Data Provided to NDE

- **DAP production code**
  - Code Suite on Aug 28, 2018
  - Updated code on Sep 24, 2018

- **Weekly ND data for generating smoothed data**
  - Week 16 – Week 34, 2018 on Aug 28, 2018
  - Week 46, 2018 - Week 7, 2019 on Feb 20, 2019

- **Daily input/output data for verification**
  - Input daily data Aug 26 & Aug 30, 2018
  - Output daily data Aug 26 & Aug 31, 2018
Paper Published


<table>
<thead>
<tr>
<th>Documentations (Check List)</th>
<th>Yes ?</th>
</tr>
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<tbody>
<tr>
<td><strong>Science Maturity Check List</strong></td>
<td></td>
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<tr>
<td>ReadMe for Data Product Users</td>
<td>Yes</td>
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<tr>
<td>Algorithm Theoretical Basis Document (ATBD)</td>
<td>Yes</td>
</tr>
<tr>
<td>Algorithm Calibration/Validation Plan</td>
<td>Yes</td>
</tr>
<tr>
<td>(External/Internal) Users Manual</td>
<td>Yes (S-NPP)</td>
</tr>
<tr>
<td>System Maintenance Manual (for ESPC products)</td>
<td>Yes (S-NPP)</td>
</tr>
<tr>
<td>Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)</td>
<td>Yes</td>
</tr>
<tr>
<td>Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)</td>
<td>Yes</td>
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</table>
Conclusion and Path Forward

**Conclusion**

1. RESULTS
   - No spurious histogram for raw data, indices & products
   - Strong correlation with other satellites

2. Mapping is appropriate

3. Adjustments are done

4. Verification: Good correlation with agricultural data

5. Created data records: match with other satellites

6. Developed new product (USDA request)

7. Good Users’ Feedback

8. Distributing Knowledge (paper published)

**Path Forward**

1. Evaluation of the SDR and EDR quality flags

2. Continue matching records and products (32 ecosystems)

3. Continue Validation

4. Work with OSPO

5. Preparation for new climatology and NOAA-21
• BACK UP
The VHI for flowering wheat in northeastern Germany was the lowest value since the VHI's inception in 1988.

* Yield data from PSD Online, 2018 yield is from last month
Principle

1. Matching Data & Products with Other Satellites (SNPP/VIIRS, NOAA/AVHRR, MODIS)
2. Matching Products with *in situ* data (P, T, SST, Soil moisture, Crop/pasture, Forest)
3. Preparation for NOAA-21
4. Continuity of VH Data Records
5. Advanced Products
6. New Development (climatology)
Evaluation methodology

For Beta evaluation the operational Suomi NPP product is used as reference

• **Comparison** between Suomi NPP and NOAA-20 vegetation health *original data, products on a tile basis*
  – Daily RGB from I1, I2 and I5
  – Daily NDVI (from I1, I2) and BT (from I5)

• **Comparison** of *global maps of Suomi NPP and NOAA-20* vegetation health products
  – Daily RGB from I1, I2 and I5
  – Daily NDVI and BT

• **Comparison** of global *vegetation health statistics* from Suomi NPP and NOAA-20
  – Weekly *Reflectance, NDVI/BT, processed SMN/SMT, VH indices VCI/TCI/VHI*

• **Time series** comparison at site level
Over the past month, drought has continued to afflict filling to maturing wheat and rapeseed in **northern Europe** outside of Poland, where much-needed rain fell.
1. **Beta**
   - Product is minimally validated, and may still contain significant identified and unidentified errors.
   - Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
   - Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. **Provisional**
   - Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
   - Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
   - Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
   - Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. **Validated**
   - Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
   - Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
   - Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
   - Product is ready for operational use based on documented validation findings and user feedback.
   - Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.
Your Stress product is telling a MAJOR VEGETATION STRESS which is not correct as we have very good rainfall this year and agriculture growth is great this year.
VALIDATION

Vegetation Health & USDA Top Soil Short & V. Short, % Pasture in Good & V. Good Condition:

June 3, 2018
Validation: S-NPP/VIIRS vs. Ground Data

S-NPP/VIIRS In Situ Validation (USDA, USDM)