Land Surface Datasets Used in NCEP Modeling Systems: Current Status and Future Plans

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Environmental Modelling Center (EMC)
College Park, MD, USA

...and a large number of collaborators!
# Land-Surface Datasets Currently Used

## Land surface data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation type</td>
<td>IGBP-MODIS 1 km</td>
</tr>
<tr>
<td>Soil type</td>
<td>STATSGO-FAO type 1 km</td>
</tr>
<tr>
<td>Green vegetation fraction (GVF)</td>
<td>NESDIS AVHRR, 5-yrs monthly 1/8 deg</td>
</tr>
<tr>
<td>Leaf area index (LAI)</td>
<td>Constant (3 or 4)</td>
</tr>
<tr>
<td>Albedo</td>
<td>BU-MODIS/UAz-MODIS, monthly, 1km</td>
</tr>
<tr>
<td>Emissivity</td>
<td>Climatology</td>
</tr>
<tr>
<td>Phenology</td>
<td>Look-up table</td>
</tr>
</tbody>
</table>

## Land data assimilation:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow depth</td>
<td>AFWA SNODEP; ~23km</td>
</tr>
<tr>
<td>Snow cover</td>
<td>NESDIS-IMS</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>SMOPS; top 1-5cm, 0.25 x 0.25 deg grids</td>
</tr>
<tr>
<td>GVF/LAI</td>
<td></td>
</tr>
</tbody>
</table>

## Land data evaluation:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface radiation flux</td>
<td>SURFRAD radiation/ARMCART/ NESDIS GSIP</td>
</tr>
<tr>
<td>Sensible heat flux</td>
<td>Ameriflux/FLuxnet/ARMCART</td>
</tr>
<tr>
<td>Latent heat flux (evaporation)</td>
<td>Ameriflux/FLuxnet/ARMCART</td>
</tr>
<tr>
<td>Soil moisture (station obs)</td>
<td>NASMD (NA) &amp; ISMN (global)</td>
</tr>
<tr>
<td>Soil temperature (station obs)</td>
<td>Oklohama/USCRN/SCAN/U.S. cooperative stations</td>
</tr>
<tr>
<td>Surface skin temperature</td>
<td>GOES, GOES-R</td>
</tr>
</tbody>
</table>
Terrestrial Hydrometeorological Observations

- Land surface temperature (MODIS, AVHRR, GOES, ...)
- Surface soil moisture (SMMR, TRMM, AMSR-E, SMOS, Aquarius, SMAP)
- Snow water equivalent (AMSR-E, SSM/I, SCLP)
- Snow cover fraction (MODIS, VIIRS, MIS)
- Water surface elevation (SWOT)
- Terrestrial water storage (GRACE)
- Precipitation (TRMM, GPM)
- Radiation (CERES, CLARREO)
- Vegetation/Carbon (AVHRR, MODIS, DESDynI, ICESat-II, HypsI, LIST, ASCENDS)
The issue of tiling or blockiness due to the coarse LSC data was solved first soil layer moisture 18h fcst 2015122200
Collaborations between NESDIS/STAR and NCEP/EMC

Soil Moisture Data Assimilation

Multi-year mean VIIRS GVF over CONUS

- Better AC score @500 hPa
- Better light precipitation
- Increase warm bias and RMSE
- Reduce wet bias and RMSE over ast CONUS
- Increase wet bias and RMSE over West CONUS

VIIRS GVF was tested in both GFS and NAM

Schematic representation of assimilating satellite soil moisture products from NESDIS/SMPOS into NCEP Global Forecast System (GFS)

Global Land Data Assimilation System (GLDAS), NASA Land Information System (LIS), Noah land-surface model
We are working on using LIS EnKF to assimilate AFWA snow depth. The successful EnKF applications require accurate error estimates both from satellite observations and from the land model.
Procedure to Implement the New Data into the UFS

Metrics for Evaluating the Impact on Forecasts

- Anomaly correlations, biases, RMSE (u,v,T,P,SLP,q,cloud)
- Hurricane track and intensity errors
- Biases and RMSE (surface fields: skin T, 2-m T and Td, 10-m wind, soil moisture, snow, precipitation, surface fluxes)

NESDIS GSIP for GFS/NAM
Surface Shortwave Flux Verification

The NESDIS Geostationary Surface and Insolation Product (GSIP) of surface shortwave flux is used for the EMC model verification.

Model predicted diurnal cycles of surface shortwave fluxes at seven sites across US are compared with GSIP and surface observations on daily basis.

Istvan Laszlo (NESDIS)
Jesse Meng (EMC)
Some issues of Satellite Land Products

- Remote sensing in the thermal infrared is limited to clear sky conditions
- Snow contamination
- Coarse resolution (such as soil moisture)
- Errors from satellite images and uncertainties in the algorithms used to retrieve the data
  - **Validation and uncertainty assessment**: lack of documentation of satellite validation strategies and methods across the different communities
  - **Representativeness**
  - **Temporal stability**
  - **Uncertainty**: random, systematic
- **latency**
Updating land surface datasets is in our plan for GFS V17. We have done many works with NESDIS to test the impact of new data on the model before. We just need to resurrect this effort and make sure the high quality data can be implemented into the UFS.

### Project Information & Highlights

**FOC:** Jack Kain; backup: Vijay Tallapragada  
**Lead:** Helen Wei  
**Scope:** Improve land surface physics and upgrade land surface model  
**Expected benefits:** Improve land surface prediction for all NCEP operational systems.  
**Sub-projects:** redmine Summary  
**Targeted Ops system:** GLDAS, FV3GFS  
**Dependencies:** NASA LIS, NESDIS satellite retrieval land dataset.

### Schedule

<table>
<thead>
<tr>
<th>Milestones &amp; Deliverables</th>
<th>Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further optimize Noah MP options with other physics</td>
<td>Q4FY20</td>
<td>In progress</td>
</tr>
<tr>
<td>Integrate and test fresh lake model Flake in FV3GFS</td>
<td>Q4FY20</td>
<td>In progress</td>
</tr>
<tr>
<td>Unify veg/soil table among all NCEP operational systems</td>
<td>Q2FY20</td>
<td>In progress</td>
</tr>
<tr>
<td>Turning land surface physics with other physics</td>
<td>Q4FY20</td>
<td>In progress</td>
</tr>
<tr>
<td>Update Land Surface Characteristic datasets</td>
<td>Q1FY20</td>
<td>In progress</td>
</tr>
<tr>
<td>Compare different LSMS (Noah LSM, RUC, LM4) in FV3GFS</td>
<td>Q4FY21</td>
<td>Planned</td>
</tr>
</tbody>
</table>

### Issues/Risks

- Issue: Limitation of the improvement by the other physics components;  
- Resolution: close cooperation with the other projects and physics groups  
- Issue: different versions of Noah MP in NASA LIS, WRF, and NWM;  
- Resolution: create a repository for standalone Noah MP  
- Issue: proper cold-start FV3GFS Noah MP; Resolution: sufficient offline spinup using LIS/GLDAS  
- Issue: Noah MP performance in GFS:16 prototype not optimized  
- Resolution: postpone and further optimize Noah MP options with other physics

### Resources

- **Staff:** 0.1 Fed FTEs + 3.5 contractor FTEs, need additional 1 Fed FTE for Land Dev  
- **Funding Source:** STI & CPO  
- **Compute:** WCLOSS (dev and prod), RDHPS (GaaS)  
- **Archive:** Varies, TBD

**Legend:**  
- R Management Attention Required  
- Y Potential Management Attention Needed  
- G On Target
Vegetation Health Applications in USDA

Harlan D. Shannon
Meteorologist
USDA Office of the Chief Economist
World Agricultural Outlook Board

Presented at:
2020 JPSS/GOES Proving Ground/Risk Reduction (PGRR) Summit
College Park, MD
February 25, 2020
In 1972, a severe drought led to massive crop failure in the former Soviet Union.

Some USDA officials noted an increase in Soviet grain purchasing activity, but there was limited information sharing within USDA.

As a result, the former Soviet Union was able to orchestrate a large purchase of U.S. grain at below-market prices.

This incident, known as “The Great Grain Robbery”, significantly reduced U.S. stocks and dramatically increased consumer prices.

In 1977, the WAOB was established to coordinate official government forecasts of agricultural commodities monthly.

WASDE contributors include:

- Agricultural Marketing Service - information on existing prices
- Economic Research Service - market impacts on supply/demand fundamentals
- Farm Service Agency - policy impacts on producer behavior
- Foreign Agricultural Service - commodity conditions in international areas
Agricultural Weather Analyses

- WAOB meteorologists monitor weather and climate worldwide.
- Crop weather assessments are prepared weekly using a variety of data and products:
  - precipitation
  - soil moisture
  - temperature
  - climate indices
  - snow cover
  - crop progress
  - reservoir level
  - crop condition
  - stream flow
  - satellite imagery
- At a minimum, assessments inform economists qualitatively how crop prospects are changing.
- Ideally, these assessments provide quantitative yield estimates.
- Simple crop models and analytical techniques aid yield analyses.
- Historically, satellite data were used primarily to visually corroborate weather data.
- In recent years, satellite imagery have taken on a much more robust role in our assessments.
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 75% of total national production.
- Major and minor areas combined account for approximately 85% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

VHI of current year, Oct 7, 2010 (week 40)

Yield (vs. trend)

Vegetative

R² = 0.10
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 70% of total national production.
- Major and minor areas combined account for approximately 90% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

VHI of current year, Oct. 7, 2019 (week 40)

Yield (vs. trend)

$R^2 = 0.19$
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 75% of total national production.
- Major and minor areas combined account for approximately 80% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

VHI of current year, Oct. 7, 2010 (week 40)

Yield (vs. trend)

\[ R^2 = 0.35 \]
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 70% of total national production.
- Major and minor areas combined account for approximately 90% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

Data obtained from the Australian Bureau of Statistics.

VHI of current year, Oct. 7, 2010 (week 40)

Yield (vs. trend)

- Reproductive

$R^2 = 0.49$
Vegetation Health and Crop Yields

Australia: Wheat

Yield (vs. trend)

$R^2 = 0.61$

VHI of current year, Oct. 7, 2010 (week 40)
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 70% of total national production.
- Major and minor areas combined account for approximately 90% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

Yield (vs. trend)

$R^2 = 0.74$

Wheat crop calendar for most of Australia

VHI of current year, Oct. 7, 2010 (week 40)

reproductive
Vegetation Health and Crop Yields

**Yield (vs. trend)**

VHI

- Major areas combined account for approximately 70% of total national production.
- Major and minor areas combined account for approximately 80% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.*

* Data obtained from the Australian Bureau of Agricultural and Resource Economics and Sciences.

**Australia: Wheat**

* VHI of current year, Oct. 7, 2010 (week 40)

* Wheat crop calendar for most of Australia

- Plant
- Harvest

**Yield (vs. trend)**

$R^2 = 0.84$

reproductive
Vegetation Health and Crop Yields

**Australia: Wheat**

- Major areas combined account for approximately 75% of total national production.
- Major and minor areas combined account for approximately 95% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

**VHI of current year, Oct. 7, 2010 (week 40)**

- **Yield (vs. trend)**

  ![Graph showing Yield (vs. trend) with R² = 0.88](image)

  - R² = 0.88

  - Reproductive
Vegetation Health and Crop Yields

Australia: Wheat

- Major areas combined account for approximately 70% of total national production.
- Major and minor areas combined account for approximately 80% of total national production.
- Major and minor areas derived from 2015/16 Agricultural Census data.

VHI of current year, Oct. 7, 2010 (week 40)

Yield (vs. trend)

\[ R^2 = 0.91 \]
An analysis of vegetation health and crop yields revealed a strong correlation.
In August, VHI-based corn yield estimates suggested record yields were likely in Russia...

...and in the months following, official USDA estimates were steadily adjusted upward, partially in response to the VHI analyses.

When used together, weather and vegetation health data often provide an accurate yield forecast well before the harvest is complete.
Several key aspects have facilitated success:

- **VHI data have a long track record** – support development of crop yield relationships
- **Data are available in a GeoTiff format** – user friendly and GIS compatible
- **Data are updated weekly** – when issues do arise, they are often addressed very quickly
- **Recalculated data incorporated in updates** – removes noise, improving yield forecasts
- **Well designed web site** – easy to navigate and promotes automated downloads
- **Development of cropland specific data sets** – significantly reduces USDA processing time and greatly increases operational value

*You know a data set has value when the ICEC chairs request to see it!*
Land Data Assimilation Capabilities and Opportunities

Dr. Christa D. Peters-Lidard
Deputy Director for Hydrosphere, Biosphere, and Geophysics
Earth Sciences Division
NASA Goddard Space Flight Center
The Evolution of Land Data Assimilation

- **T,q-based soil moisture nudging concept**
  - Mahfouf, 1991

- **T,q-based soil moisture OI at Météo-France and ECMWF**
  - Giard and Bazille, 2000

- **Precipitation-based LDAS (e.g., NLDAS, GLDAS, MERRA-Land)**
  - Drusch and Viterbo, 2007

- **EKF/EnKF Soil Moisture DA**
  - Dunne and Entekhabi, 2005

- **EKF/EnKF Snow Cover and Snow Water Equivalent (SWE) DA**
  - Sun et al., 2004

- **EKF/EnKF Skin Temperature DA**
  - Bosilovich et al., 2007

- **EnKS Terrestrial Water Storage (GRACE) DA**
  - Zaitchik et al., 2008

- **EnKF Vegetation/Albedo/Leaf Area Index (LAI) DA**
  - Paiva et al., 2013

- **EnKF Water Level DA**
  - Kumar et al., 2019

- **EnKF Multivariate DA**
  - Jasinski et al., 2019

Additional methods:
- **EKF/EnKF**
- **EnKS**

Methods covered include:
- Soil Moisture
- Snow Cover
- Snow Water Equivalent
- Skin Temperature
- Terrestrial Water Storage
- Vegetation/Albedo/Leaf Area Index
- Water Level
Current Land Data Assimilation Capabilities
50 years of soil moisture: from concept to operations

- Improved soil moisture algorithms
- Spaceborne demonstration

- Ground and aircraft development and verification of theory (1-10m resolution)
- SMAP DA at Air Force
- SMOS DA at ECMWF
- SMAP Level-4 Product at GMAO

Soil Moisture Assimilation Improves Evaporation

Latent heat flux RMSE and BIAS before (OL) and after AMSR-E soil moisture assimilation

NASA-DA is the ‘official’ NASA product, while LPRM-DA is an alternate retrieval algorithm.

Soil Moisture Forecast Impacts at ECMWF

Figure 8: Sensitivity of 24 h screen level temperature forecast to the soil moisture analyses of a) SLV, b) ASCAT, and to SMOS soil moisture analyses at c) 12 h and d) 24 h forecast. The blue colour bar indicates cooling of 2 m temperature, and red colour bar warming of 2 m temperature. The reference experiment is the OL. Units are K.

Snow Assimilation Improves Streamflow

Improvement in streamflow due to snow depth assimilation

Albedo Assimilation Improves Snow Depth

 Improvement in snow depth RMSE (mm)

The Role of Land in Earth System Prediction

- Land states (soil moisture, groundwater, snow) can provide predictability in the window from deterministic (weather) to climate (O-A) time scales, peaking at S2S.
- Vegetation states, related to soil moisture anomalies, give predictability at/beyond S2S time scales.
- L-A coupling is active where there is sensitivity, variability and memory.
- “Good” models and analyses (of atmosphere and land) needed to exploit this source of skill.

Slide courtesy Paul Dirmeyer
# STAR Land Product Development Science Team

## Science Team Information and Highlights

<table>
<thead>
<tr>
<th><strong>Science Team Lead</strong></th>
<th>Yunyue (Bob) Yu</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science Team Membership</strong></td>
<td>LST team members, Albedo team members, VI/GVF team members, SR team</td>
</tr>
</tbody>
</table>
| **Expected Benefits** | List of users  
  **LST:** NCEP/EMC, Land Hydrology Model; USDA, STAR Soil Moisture  
  **Albedo:** NCEP/EMC, Land Hydrology Model; STAR Cryosphere team  
  **VI/GVF:** NCEP/EMC, HRRR Model |
| **Operational Products** | JPSS (SNPP and NOAA-20) Operational: LST, Albedo, VI, GVF  
  GOES-R (G-16, G-17) operational: LST, Albedo |
| **Experimental Products** | Himawari AHI LST, Sentinel – 3 LST, |
| **Group Monitoring site** | [https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php](https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php) |
Operational JPSS LST Products

Orbit overpass time: 13:30/01:30;
Two granule products (750 m resolution)
  - Single 1.5 min granule data; combined 4 x 1.5 min granule data
One gridded product (1 km resolution)
  - Two grids a day: daytime and nighttime
Format: NetCDF, HDF5
Validated Maturity: Yes
Routine monitoring: Yes
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LST/single/JPSS1_VIIRS/
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/LST/single/SNPP_VIIRS
STAR LST Homepage: https://www.star.nesdis.noaa.gov/jpss/lst.php
Archive https://www.class.noaa.gov (*search – VIIRS_EDR)

Applications Performed:
- RTMA/URMA system data assimilation adjust T2M in Alaska region
- Input for high resolution SMAP data
- EMC forecasting model LST verification
- NASA DISCOVER-AQ field campaign for aircraft data verification
**Operational GOES-R LST Products**

**Current** satellites: GOES-16, GOES-17

**Observation modes:**
- FullDisk, hourly; CONUS, mins; Mesoscale, mins
- 2 km resolution

**Format:** NetCDF, HDF5

**Validated Maturity:** Yes (G-16)

**Data access:**
https://www.avl.class.noaa.gov/saa/products/search?sub_id=0&datatype_family=GRABIPRD

**Monitoring:**
https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php
ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/

**Applications performed:**
- ALEXI model exploits the mid-morning rise in LST from GOES to deduce the land surface fluxes, including evapotranspiration ET
- Diurnal temperatures for daily T range
- Urban air temperature model using G-16 LST

**ET (mm/day) from GET-D using GOES-16 LST**

**Month of July 2017**
Operational **JPSS Albedo** Products

**Orbit overpass time**: 13:30/01:30;

**Two granule products** (750 m resolution)
- Single 1.5 min granule data; combined 4 x 1.5 min granule data

**One gridded product** (1 km resolution)

**Format**: NetCDF, HDF5

**Validated Maturity**: Yes

**Routine monitoring**: Yes


STAR Albedo Homepage: [https://www.star.nesdis.noaa.gov/jpss/albedo.php](https://www.star.nesdis.noaa.gov/jpss/albedo.php)

Archive: [https://www.class.noaa.gov (*search – VIIRS_EDR)](https://www.class.noaa.gov)

**Applications Performed**:
- **EMC Model Albedo** abnormal 7/2017
- **EMC North American Land Data Assimilation System**
- **USDA DisALEXI** model for ET estimation
Operational \textit{VI/GVF} Products

**Vegetation Index:** TOA NDVI, TOC NDVI and EVI; daily, weekly, and 16-day composite.

**Green Vegetation Fraction:** daily rolling weekly

**Resolution:** global 4 km; regional 1 km

**Format:** NetCDF

**Validated Maturity:** Due in Mar 2020

Routine monitoring: draft developed

STAR LST Homepage: https://www.star.nesdis.noaa.gov/jpss/EDRs/products_VegIndex.php

Archive: https://www.class.noaa.gov (*search – VIIRS_EDR)

**Applications Performed:**

- Test of using GVF in Noah land surface model in EMC
- Test of using GVF in NCEP GFS, positive impact of reducing error
- ESRL HRRR model used GVF to replace MODIS climatology.
- NASA SpoRT used VIIRS GVF over CONUS for anomaly response analysis; also the data are available now within WRF NWP model and UEMS/WRF modeling framework
- VIIRS VI data are used for Burned Area Emergency Response, and post fire, flash flood and debris flow assessment
NOAA Land Surface Emissivity Product

- Based on vegetation cover method (VCM)
- Bare ground emissivity is derived from multi-year averaged ASTER & MODIS LSE product.
- Use VIIRS green vegetation fraction (GVF) and snow fraction to account for the LSE dynamic change.
- Daily product at 1km resolution, including VIIRS and ABI split channels LSE and a broadband emissivity (BBE).
- Pixel based uncertainty is provided, with overall uncertainty of 1.5%.

LSE Status in NOAA

- Locally produced
- Operationally used in S-NPP and NOAA20 VIIRS LST product.
- Will be applied in GOES16/17 LST product.
- Broad band emissivity is under test in NOAA GFS and NAM model.
RTMA/URMA system data assimilation using VIIRS LST

(Top left) The analysis increment shows the difference between the adjusted T2M after/before LST assimilation. Red color indicates an increased model T2M, blue color indicates a decreased T2M.

(Top right) quality control results: red dot for pixels fail the quality control; blue dots for pixels selected for assimilation

(Bottom left) Model T2M before data assimilation

(Bottom right) Model T2M after LST assimilation

The bottom two surface weather map show the adjust of T2M field looks reasonable.
Fig. 2 Sample maps for (a) SMAPV5 25 km and (b) the downloaded 1 km SMAP SM retrievals on August 3, 2018.

Fig. 3 With respect to the quality controlled in situ observations, ubRMSE (Unit: m$^3$/m$^3$) for (a) SMAPV5 25 km and (b) UCLA_DTR 1 km SM estimations over the 3 May 2017 to 30 April 2019 period.
ALEXI model exploits the mid-morning rise in LST from GOES to deduce the land surface fluxes, including evapotranspiration ET.

A simple evaporative stress index (ESI), the ratio of actual-to-potential ET ($f_{PET}$), can then be computed from ALEXI ET estimates to represent surface soil moisture status; Negative ESI anomaly may indicate drought occurrence.
**User Application Example**

**Urban Air Temperature Model Using GOES-16 LST**

**Methodology and flow diagram**

Air temperature performance at a station in Washington DC

\[ T_{air} \approx T_{LST} + y_0 - Ae^{\frac{(x-x_0)^2}{2\sigma^2}} \]

**Nationwide Statistics**

WRF model air temperature compared to GOES-R air temperature prediction and in-situ observations

- **Model Performance**
  - \( R^2: 0.91 \)
  - RMSE: 2.91K

- **GOES-16 Landcover**
  - Water: 0%
  - Urban: 92%
  - Forest: 7%
  - Cultivated: 0%
  - Other: 1%

- **Station Elevation**: 86m

- **GOES-R Model Against Ground Station Air Temperature**

- **WRF Comparison with Station: KNYC**

  - Air Prediction Temp (RMSE: 1.87K)
  - WRF Model Temp (RMSE: 1.88K)
  - Station Temp
Satellite Land Data Products for NWP and NWM

Xiwu Zhan, NESDIS STAR Land Applications Science Team Lead

- JPSS VIIRS Annual Surface Type
- Soil Moisture Operational Product System (SMOPS)
- GOES Evapotranspiration and Drought (GET-D)
- High-resolution Soil Moisture
- Soil Moisture Data Assimilation
VIIRS Annual Surface Type 2018

- Generated using 2018 VIIRS data acquired between:  
  - 1/1/2018 – 12/31/2018
- Available in two projections:
  - Sinusoidal and Lat/lon
- **VIIRS Global Annual Surface Type (AST):** The new VIIRS Annual Surface Type 2018 product (AST-2018, spatial resolution: 1km) based on 2018 whole year surface reflectance data is ready for users to download at the following FTP sites:
  
  - GST-2018: sinusoidal projection - [FTP site](#)
  - GST-2018: lat/lon projection - [FTP site](#)
  - GST-2018: 20Types for NCEP-EMC NWP models - [FTP site](#)

Legend:
- Evergreen Needleleaf Forest
- Evergreen Broadleaf Forest
- Deciduous Needleleaf Forest
- Deciduous Broadleaf Forest
- Mixed Forest
- Closed Shrublands
- Open Shrublands
- Woody Savannas
- Savannas
- Grasslands
- Permanent Wetlands
- Croplands
- Urban and Built-Up
- Cropland/Natural Vegetation Mosaic
- Snow and Ice
- Barren or Sparsely Vegetated
- Water Bodies
Why Surface Type

Surface Type Plays Important Roles in NWP models
VIIRS Daily Surface Type

- Annual surface type covers long term changes
- Short term changes include snow, burn scar, flooded area, etc
- An integrated daily surface type product is being tested

See Poster 12 by Chengquan Huang: Global Surface Type Products from VIIRS
SMOPS Product Versions

(a) r for V1.0

(b) r for V2.0

(c) r for V3.0

(d) PDF

V1.0 from 01 June 2007 to 03 Nov. 2010
V2.0 from 16 Nov. 2010 to 20 Sept. 2016
V3.0 from 1 April 2015 to most recent
NOAA Soil Moisture Operational Product System (SMOPS)

http://www.ospo.noaa.gov/Products/land/smops/index.html

- Developed by NOAA/NESDIS/STAR
- In operation at NOAA/NESDIS/OSPO

Operational data access contact: Limin.Zhao@noaa.gov

Science and historical data contact: xiwu.zhan@noaa.gov, yanjuan.guo@noaa.gov
Regional daily ET at 8km has been generated from GOES-13 and GOES-15 thermal infrared (TIR) data via GET-D using the Atmosphere-Land Exchange Inversion (ALEXI) model.

Daily ET is converted to Evaporative Stress Index (ESI) that represents soil moisture status.

Negative ESI is used to monitor drought early warning and occurrence.

GET-D is being updated to generate ET and ESI from GOES-16/17 ABI 2km observations.

See Poster 13 by Li Fang: An Evapotranspiration Product at 2-km resolution from NOAA GOES-16.
Downscaled High Resolution Soil Moisture

Figure 1. Comparison of SMAP SM data sets to be validated, over Oklahoma region (100.15W–94.53W, 34.2N–37.06N), on April 30th, 2015, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

Figure 2. Comparison of SMAP SM data sets to be validated, over Texas region (98W–92.5W, 31N–35N), on April 2nd, 2016, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

See Poster 9 by Jifu Yin: Near Rear Time 1 km SMAP Soil Moisture Data Product for Potential Use in National Water Model
Soil Moisture Data Assimilation with Noah LSM

RMSE differences of Noah LSM top-10cm soil moisture simulations after assimilating satellite products evaluated against SCAN measurements during 1 April 2015 -30 June 2017 period. More blue indicates improvement.


Noah LSM simulation evaluations with or without assimilating SMOPS soil moisture evaluated against SCAN measurements: (a) RMSE of Noah LSM OLP run, (b) RMSE of DUL DA case, (c) RMSE differences between CDF DA case and OPL run, and (d) RMSE differences between DUL and CDF DA cases over the 1 April 2015 - 31 March 2018 period. More blue indicates improvement.
SUMMARY:

- Several land products from JPSS and other satellites have been generated for NWP and NWM users.
- Surface type and soil moisture products are consistently available with good quality.
- High-resolution soil moisture is being tested.
- ET and drought products from GET-D is being tested.
- Land data assimilation algorithms and implementation at NCEP and NWC needs further investigation and transition efforts.
THANKS!
Vegetation Health
1981-2020
APLICATIONS

Felix Kogan, Wei Guo, Wenze Yang

Feb 25, 2020
Vegetation Health

COVERAGE

40-year (1981-2018) – Blended AVHRR-VIIRS (4, 16 km)
32-Year (1981-2012) – AVHRR noaa7-19 (4, 16 km)
8-year (2013-2018) – VIIRS s-npp (1, 4 km)
*Next 25-year (2022-2043) – VIIRS noaa21-24

Coverage World

Indices NDVI, BT, VCI, TCI, VHI
Vegetation Health is an indicator of Applications

**Applications**
- Vegetation Health
- Drought
  - Area
  - Intensity
  - Duration
  - Start/End
  - Impacts
- Moisture Stress
- Thermal Stress
- Healthy veg.
- Crop/pasture pr.
- Fire Risk
- Soil Saturation
- Malaria
- Land greenness
- Landslides
- Food security
- Climate change

a. World Grain Production-Consumption, 1970-2013

Droughts
2012 – USA
2011 – USA
2010 – Russia, Ukraine, Kazakhstan, Argentina
2007 – Australia, China, Argentina, Brazil, Ukraine
2003 – USA, Europe, Australia, India, China, Ukraine
1996 – USA, Russia, Argentina, Australia
1988 – USA
Drought Crop Losses in 2014

AUGUST

VCI

Moisture Conditions

TCI

Thermal Conditions
VH-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
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
Nov 25, 2017 Moisture (VCI) and **Thermal** (TCI) Vegetation Stress

![Portugal](image1.png)

![Spain](image2.png)

![Drought Stress](image3.png)

Legend:
- Low: Light
- Moderate
- Severe
- Extreme
- Exceptional
- High

Color Scale:
- 0
- 1
- 2
- 3
- 4

**VCI**

**TCI**
Crop Yield Actual and VH-Model Predicted in Kansas

Winter Wheat

Sorghum

Corn

Observed & Predicted Yield, USA, Kansas
VH Predicted vs Observed Wheat Yield

RUSSIA

Russia, Saratov
Spring Wheat

INDIA, Rajasthan

RsQ = 0.78
MSE = 0.0291
SE = 3%
UE = 97%

Argentina, Dep. 9
Wheat

KAZAKHSTAN

Mean Yield (bars) and VCI, Kazakhstan, Spring Wheat
VH-Biomass & Corn Yield Modeling & Prediction

Pasture biomass vs VCI, MONGOLIA

MONGOLIA Biomass

Corn yield vs VCI, ZIMBABWE

ZIMBABWE Corn
WEB Usage

- Web usage data for April 18, 2018 (4 hours)

- Bar chart showing average daily page view and unique visitors from April 17-24, 2018 (7 days)

- Bar chart showing user numbers from 2010 to 2020

URL: https://www.star.nesdis.noaa.gov/smd/emb/vci/VH/vh_browse.php
0.5 km
Vegetation Health WEB

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

Every week start counting from January 1
BACK UP
Conclusions

2018 World Population 7.6 bil. Increases with **Accelerating** Rate; World Grain Production Increases with **Decelerating** Rate

Grain Supply dropped below Demands (in 2001-2017 - 8 years)

**Severe Droughts** - Reduces Global Grain Production 4-7% every 3-5 years; **Moderate Drought** – Reduces Grain 1-3% every 1-3 years

**Satellite-based Vegetation Health (VH) Technology** Provide Tools for Drought Monitoring & 2-5 Weeks Advance Prediction of its Start/End, Area, Intensity, Duration and Impacts

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

**VH** Predicts Food Security Problem 3-5 Months in Advance the Developing Nations Need Assistance

**Drought Area & Intensity** has not Changed Globally & in USA’s Grain Area during Global Warming since 1981