Web Service-based Vegetation Condition Monitoring System - VegScape

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Project Goals

- Improve the science, objectivity, robustness and defensibility of nationwide crop vegetation condition monitoring operation at NASS
- Develop an operational National Crop Condition Monitoring System (NCCMS) - VegScape
- Produce crop vegetation condition data products that are complementary to existing NASS crop condition products.
- Enhance data accessibility, interoperability, online analytics, and dissemination.
- =>Meet user’s requirements.
Why Do We Need A New Crop Vegetation Condition System?

- AVHRR sensor
  - AVHRR 17 – Dead;
  - AVHRR 18 – Aging, and not consistent with AVHRR 17.
  - Low spatial resolution (1km)
  - Low temporal resolution (biweekly)

- NASS weekly publishes NDVI low resolution static map; NASS needs:
  - better spatial and temporal resolutions;
  - data processing and web publishing automation;
  - better visualization and data dissemination;
  - vegetation condition analytics & assessment.
OLD VEGETATION MONITORING
Static Crop Condition Image (NDVI)
Yearly Comparison (Ratio to Previous Year)
Ratio Comparison to Previous Year in Percent

Vegetation Condition Percent Change: 2009 ÷ 2008
Period 12 (3/10 - 3/23)

Percent Change
- <= -25%
- <= -15%
- <= -5%
- +/-
- >= +5%
- >= +15%
- >= +25%
- Clouds/Snow

Agricultural Statistics Districts
1:15,000,000
Original Image: NASA GRAIL Radar1:1 Original
Composite Image: 2008 BASE Data Center
Contact email: nrcs-pro@usda.gov
For Additional Images: Please visit: http://www.nass.usda.gov/research
To download full image: http://www.nass.usda.gov/research/
Percent Change Ratio to Median

Period 12 (3/10 - 3/23)
User’s Major System Requirements

- Interactive vegetation condition mapping.
- Pixel-level level granularity.
- On-the-fly data processing and presentation.
- Online analytics within user defined region.
- Geospatial query capability.
- Crop specific vegetation condition information.
- Equal accession and dissemination via spatially enabled Web-based system to facilitate equal information access.
New Vegetation Condition Monitoring System - VegScape

- Different sensor - MODIS
  - Daily repeat => weekly composite
  - 250 meter spatial resolution;
  - Rich cloud pixel information and better preprocessing;

- GIS technology provides
  - Web-based interactive mapping
  - Various online capabilities: online navigation, zooming, panning, downloading, or on-the–fly processing, online statistics, data profiling, etc.

- VegScape provides
  - Data retrieving and processing automation
  - Web publishing and dissemination automation
  - Irregular, ad-hoc data retrieving and processing for emergency assessment or reporting
  - Objective historical data comparison for crop condition assessment
  - Various vegetation condition metrics;
  - Crop land focused, or even crop specific monitoring;

- VegScape reuses the same geo-information technology as CropScape
Considerations of Architecture Design and Technology

- Web Based Service Oriented Architecture
- OGC standard compliant web services:
  - Web Feature Service (WFS), Web Map Service (WMS), Web Processing Service (WPS), Sensor Observation Service (SOS), etc.
- Service Integration
  - Support of workflows: Business Process Execution Language (BPEL), BPEL execution engine
  - Re-use all algorithms published in WPS
- Re-use functions/algorithms already developed
Service-Oriented Architecture (SOA)

Application Layer
- Web Applications
- Crop Progress Applications
- Other Applications

Service Layer
- OGC WMS
- OGC WFS
- GeoLinking
- Process Services: Statistics Analysis, etc.
- GDAS

Data Layer
- Raster Data: Cropland Data Layers
- Vector Files: US States/Counties Layers
- Attribute Data: Crop Statistics Data

Web Services
- HTTP

Other Applications
- Crop Progress Applications
- GDAS
MODIS Surface Reflectance (MOD09GQ)
Resolution: 250m
Bands: Band 1 (620-670nm) and 2 (841-876nm)

NDVI: calculating, mosaicking, & clipping

NDVI weekly & biweekly: maximum value composite (MVC)

NDVI biweekly composite
NDVI weekly composite

MVCI: weekly or biweekly

NDVI biweekly composite
NDVI daily
NDVI weekly composite

WCS

NDVI (daily, weekly, or biweekly)

WPS

Legend

Data processing flow for vegetation index calculation.

Data processing

NDVI2010.04.30

NDVI2010.04.29

MVC

NDVI (daily, weekly & biweekly)

MVCI (weekly or biweekly)

WFS

WMS

Administrative boundaries
(Geographic coordinates, shapefile format)

Legend

- Process
- Data store
- Interface
- Data
Vegetation Condition Indices

\[ NDVI = \frac{(IR-R)}{(IR+R)} \]

\[ MVCI = \frac{NDVI(x,y) - NDVI_m(x,y)}{NDVI_m(x,y)} \times 100 \%

\[ RMNDVI = \frac{NDVI_i(x,y) - NDVI_{med}(x,y)}{NDVI_{med}(x,y)} \times 100\%

\[ RPNDVI = \frac{NDVI_i(x,y) - NDVI_{i-1}(x,y)}{NDVI_{i-1}(x,y)} \times 100\%

\[ VCI = \frac{NDVI(x,y) - NDVI_{min}(x,y)}{NDVI_{max}(x,y) - NDVI_{min}(x,y)} \times 100\% \]
VegScape – Layers, Products and Legends

Data Layers

- Basic Layers
  - Global Cover
  - CDL
  - Crop Mask
- Boundaries
  - Counties
  - States
  - ASG
- Water Layers
  - Rivers
  - Lakes
- Road Layers
  - Freeway System (National)
  - Major Highways (Regional)
- NDVI Layers
  - Weekly_NDVI_11_2013.03

Product Selection

- Type: NDVI
- Period: Weekly
- Year: 2013
- Date: 11(03.12_03.18)_2013

Legends

- NDVI Data Layer:
  - > 0.89
  - 0.79 - 0.89
  - 0.69 - 0.79
  - 0.59 - 0.69
  - 0.49 - 0.59
  - 0.39 - 0.49
  - 0.29 - 0.39
  - 0.19 - 0.29
  - 0.10 - 0.19
  - 0.05 - 0.10
  - < 0.05
  - No Data

- VCI Data Layer:
  - 0.82 - 1.00
  - 0.74 - 0.82
  - 0.59 - 0.74
  - 0.47 - 0.59
Weekly Vegetation Indices 07/24/12 – 07/30/12

NDVI

NDVI Ratio to Previous Year

NDVI Ratio to Median

NDVI Ratio to mean
Weekly Vegetation Indices 07/24/12 – 07/30/12

Crop Mask Applied

NDVI
Ratio Median NDVI or RMVCI

NDVI Ratio to Previous Year

Mean NDVI or MVCI
2011 Flood Missouri Bootheel NDVI Ratio to Median (Median of 10 years NDVI)

Cropland Data Layer

RMVCI Legend
- <= -25%
- <= -15%
- <= -5%
- +/-
- >= +5%
- >= +15%
- >= +25%
AOI Statistics - Ratio to Median VCI

04/19-04/25/11
Quantify vegetative area condition
VegScape Serves 2012 CDL by Using CropScape Web Service

2012 Cropland Data Layer
The 2012 Cropland Data Layer (CDL) product depicts land cover

7/24/12 – 7/30/12 NDVI
Vegetative condition indicates crops under stress from the 2012 drought
Data Mashup with Google Earth

Export any selected index data directly into **Google Earth**
Conclusions

- MODIS offers high spatial/temporal resolution & data continuity
- Web-based dynamic interactive mapping
  - Dynamic maps of Multi vegetation condition indices
  - Online navigation, zooming, panning, downloading, on-the-fly processing
  - Online analytics: Statistical analysis and change comparison
  - Automatic data retrieval, processing, publishing, and dissemination
- Irregular, ad-hoc data retrieval and processing for emergency assessment/reporting
- Assessing crop condition and identifying the areal extent of floods, drought, major weather anomalies, and vulnerabilities of early/late season crops
- Consider VegScape operational upon start of 2013 growing season!
- Unfinished business:
  - Further refine data processing algorithms to improve performance and quality;
  - Finish implementing and deploying web services.
  - Further enhancing and adding more functionalities
Questions & Comments?

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