Advances in remote sensing for vegetation dynamics and agricultural management

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Overview: Enhance the NASA- Foreign Agricultural Service’s Global Agricultural Monitoring System with Coincident NDVI, Soil Moisture, & Chlorophyll Fluorescence
GLAM OVERVIEW

- Second generation MODIS-based agricultural system to support FAS monitoring activities
- Successor to the Pekko system (@ UMD) – proof of concept ...
- Improvements – wall to wall global coverage, rapid query, & simplicity

Includes:
- NRT production - every 8-days – 2000-Present (TERRA), 2002-Present (AQUA)
- Two processing nodes set up (glam0 for USDA/FAS/IPAD, glam1 as fail-safe/other agency/public system).
- Data: provides Terra and Aqua data (NDVI + Anomalies, Color Composites).
- GUI Data query and plotting by Crop masks (10+), administrative regions (3) and LIS (0.25°)
- Capture AoI/current map view with visible crop and shape layers in PNG or JPEG formats.
- Keyboard shortcuts to improve data set navigation and querying
- Updated MODIS Collection 6 Near Real Time Products in progress…
- Soil Moisture data layer also in progress…
- Working toward possible chlorophyll fluorescence data layer
SYSTEM OVERVIEW

http://glam1.gsfc.nasa.gov/
Sample MODIS NDVI Output

AUSTRALIA 35 S X 146 E

Date

MODIS NDVI

Terra NDVI
Aqua NDVI
Sample MODIS NDVI Output

Australia 35 S x 146 E

Date

NDVI

NDVI Anomaly
Conclusion: Drought During Pollination Reduced So. African Corn Yield

Crop conditions change from above-average to below-average during the critical pollination stage in early February.

Differences from 10-year MODIS NDVI Average (2003-13)

Source: USDA/NASA MODIS Global Agriculture Monitoring (GLAM) Project
http://glam1.gsfc.nasa.gov/
USDA/FAS NDVI-based Estimate for French Corn

2014 Record Corn Crop -- 17 M tons

2003-13 Mean vs. 2014 NDVI values from April to September.

Aquitaine & Midi-Pyrenees Departments, France’s Primary Corn Region

MODIS Aqua NDVI 8-Day Anomaly; Corine Dryland Mask
Soil Moisture Objective

To enhance the USDA FAS global crop assessment decision support system via the integration of SMAP soil moisture products into the FAS 2 layer Palmer model. SMAP’s radar failed—SMOS radar data being used instead. Solar Induced fluorescence is also being investigated for an additional data layer.
PM-SMOS Soil Moisture, Methodology

Set up:

**Palmer Model**
- physically based model
- 2 layers, surface and subsurface
- 0.25°

**Forcing**
- former AFWA
  - Upcoming change: GPM
- Variables: Precipitation; Min and Max Temp.

**Satellite observations**
- SMOS ESA (SMOPS)
  - Upcoming change: SMAP and ASCAT (Passive and Active); Prototype developed (SMOS and ASCAT)

**Data Assimilation**
- EnKF
- 30 ensemble members
- Rescaling: Variance-based
- R: NDVI-based climatology
  - Upcoming change: Triple Collocation Analysis

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PM – Palmer Model  
SM – Soil Moisture  
SMOS – Soil Moisture Ocean Salinity  
SMAP – Soil Moisture Active Passive  
ASCAT – Advanced Scatterometer  
GPM – Global Precipitation Measurement  
AFWA – U.S. Air Force Weather Agency  
NDVI – Normalized Difference Vegetation Index  
DA – Data Assimilation  
EnKF – Ensemble Kalman Filter  
TCA – Triple Collocation Analysis
PM-SMOS Soil Moisture, Products

- All data products
  - 3-days composites
  - Near-real time (max 5 days latency)
- Products
  - L03 – SMOS assimilated soil moisture [mm]
    - Surface layer ‘as1.grib’
    - Sub-surface layer ‘as2.grib’
  - L04 – profile soil moisture [%]
    - Profile ‘smp.grib’
  - L05 – anomaly soil moisture [-]
    - Surface layer ‘anom1.grib’
    - Sub-surface layer ‘anom2.grib’
India Rapeseed

• Planting Sept. mid-Nov. monsoon dependent
• ~70% irrigated after monsoon ends
• Lowest area planted in 5 years due to weak 2015 monsoon in Rajasthan
• SMOS soil moisture critical input

• Bolten & Mladenova NASA/GSFC
Methodology: **Operational Implementation**


The benefit of assimilating satellite-based estimates.
Methodology: *Operational Implementation NDVI & Soil Moisture for the USDA/FAS*

Soil Moisture by Bolton & Mladenova NASA/GSFC
Solar-Induced Fluorescence (SIF) is currently produced using the Global Ozone Monitoring Experiment 2 (GOME-2) on the EUMETSAT MetOp-A platform.

SIF has been shown to be useful for estimating crop yields (Guanter et al., 2014, PNAS; Guan et al., 2015, Glob. Change Biol., in press)

SIF has been shown to follow the seasonal cycle of GPP derived from flux tower measurements (Joiner et al., 2014)
How do we retrieve fluorescence from GOME-2?

[Over cloudy ocean ($\rho_{670} > 0.7$) or over snow/ice or Sahara] and $\text{SZA} < 75^\circ$?

- START
  - Radiance and irradiance data; Level 1B

SZA < 70° and over land?

- yes
  - Principal component analysis (generate PCs)
  - Retrieve fluorescence, atmospheric absorption (coefficients of PCs), and surface reflectance using linear radiative transfer model with non-linear fitting

Data are publicly available (2007-present):
http://avdc.gsfc.nasa.gov/
Monthly (level 3 gridded) data are produced shortly after the end of a month.

- Quality assurance checks (residuals, cloud filter, etc.);
  - Level 2

- Gridded fluorescence data; Level 3

Yes
NDVI, Soil Moisture, & SIF

1 Stop Shopping: same grid & time step

SIF by Joiner & Yoshida NASA/GSFC

Australia
35 S x 146 E
NASA NDVI, Soil Moisture, & SIF
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