Advances in remote sensing for vegetation dynamics and agricultural management

Compton Tucker & Michael Puma

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 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
Sample MODIS NDVI Output

Australia 35 S x 146 E
USDA/FAS NDVI Application

Conclusion: Drought During Pollination Reduced So. African Corn Yield

Jan 17 - 24, 2015

Feb 18-25, 2015

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

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

---

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*


Model only  

The benefit of assimilating satellite-based estimates.

11-20 April, 2014
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?

- Radiance and irradiance data; Level 1B
  - [Over cloudy ocean ($\rho_{670} > 0.7$) or over snow/ice or Sahara] and SZA < 75°?
    - yes
      - Principal component analysis (generate PCs)
  - SZA < 70° and over land?
    - yes
      - Retrieve fluorescence, atmospheric absorption (coefficients of PCs), and surface reflectance using linear radiative transfer model with non-linear fitting
      - Quality assurance checks (residuals, cloud filter, etc.); Level 2
- Gridded fluorescence data; Level 3

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.
NDVI, Soil Moisture, & SIF

1 Stop Shopping: same grid & time step

Respective Scales

Date

Australia
35 S x 146 E

SIF by Joiner & Yoshida NASA/GSFC
NASA NDVI, Soil Moisture, & SIF

Food Security Team:

Compton Tucker, Michael Puma, John Bolton, Iliana Mladenova, Assaf Anyamba, Joanna Joiner, Yasuko Yoshida, Edwin Pak, & Jen Small