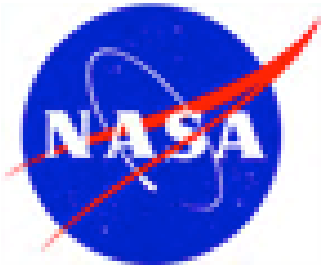
Advances in remote sensing for vegetation dynamics and agricultural management

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

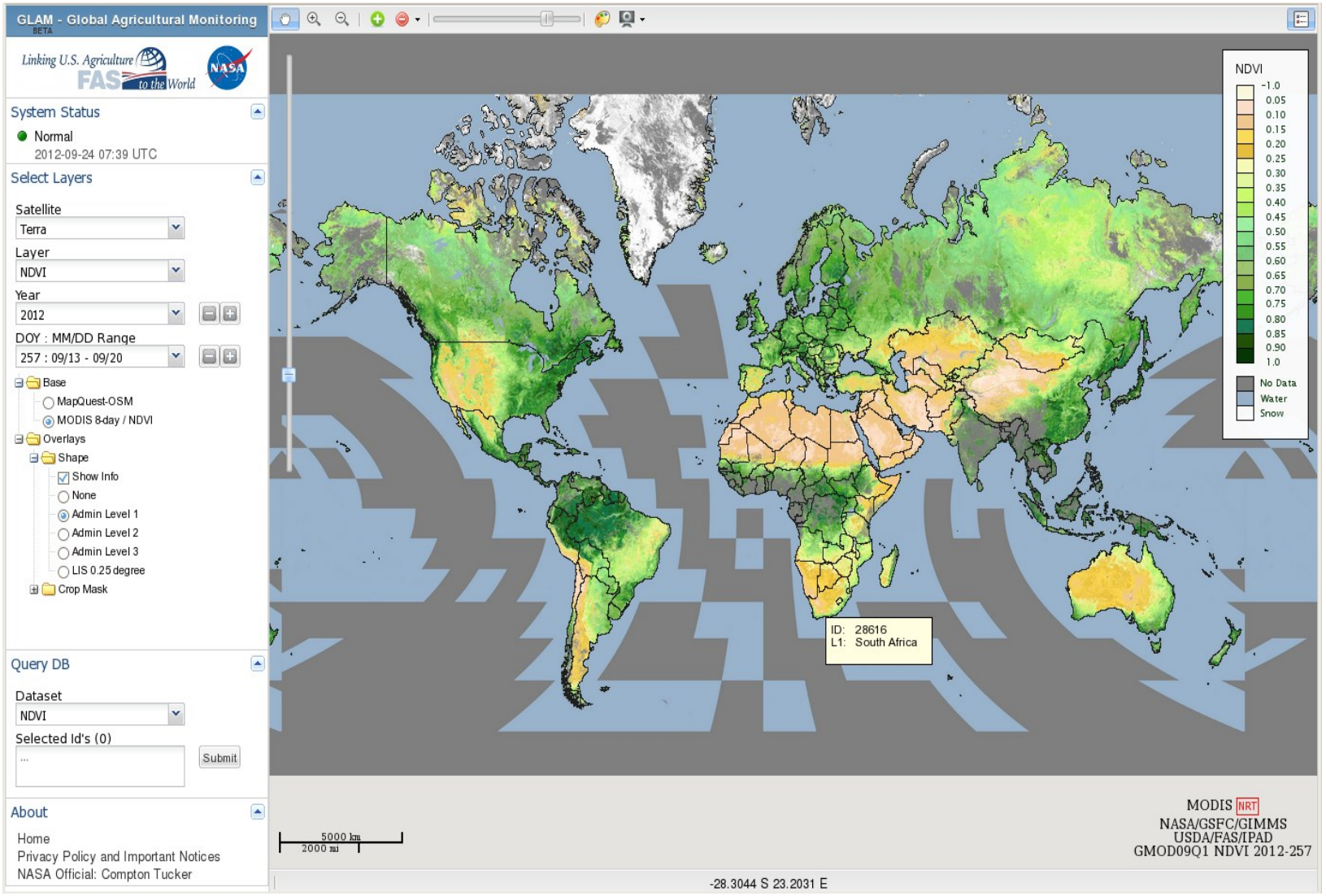
- Second generation MODIS-based agricultural system to support FAS monitoring activities
- Successor to the Pekko system (@ UMD) – proof of concept ...
- Improvements – wall to wall global coverage, rapid query, & simplicity

Includes:

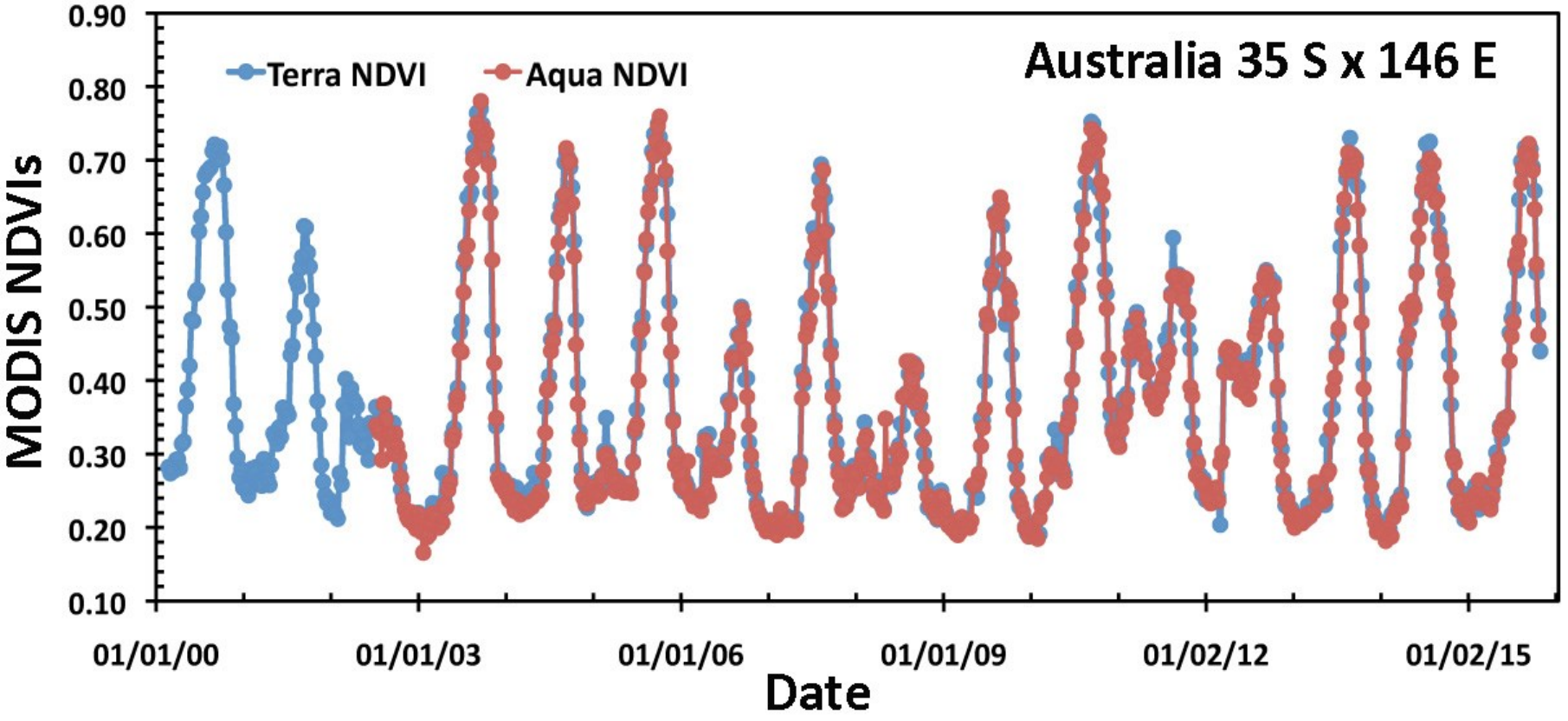
- NRT production - every 8-days – 2000-Present (TERRA), 2002-Present (AQUA)
- Two processing nodes set up (glam0 for USDA/FAS/IPAD, glam1 as fail-safe/other agency/public system).
- Data: provides Terra and Aqua data (NDVI + Anomalies, Color Composites).
- GUI Data query and plotting by Crop masks (10+), administrative regions (3) and LIS (0.25^{o})
- 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

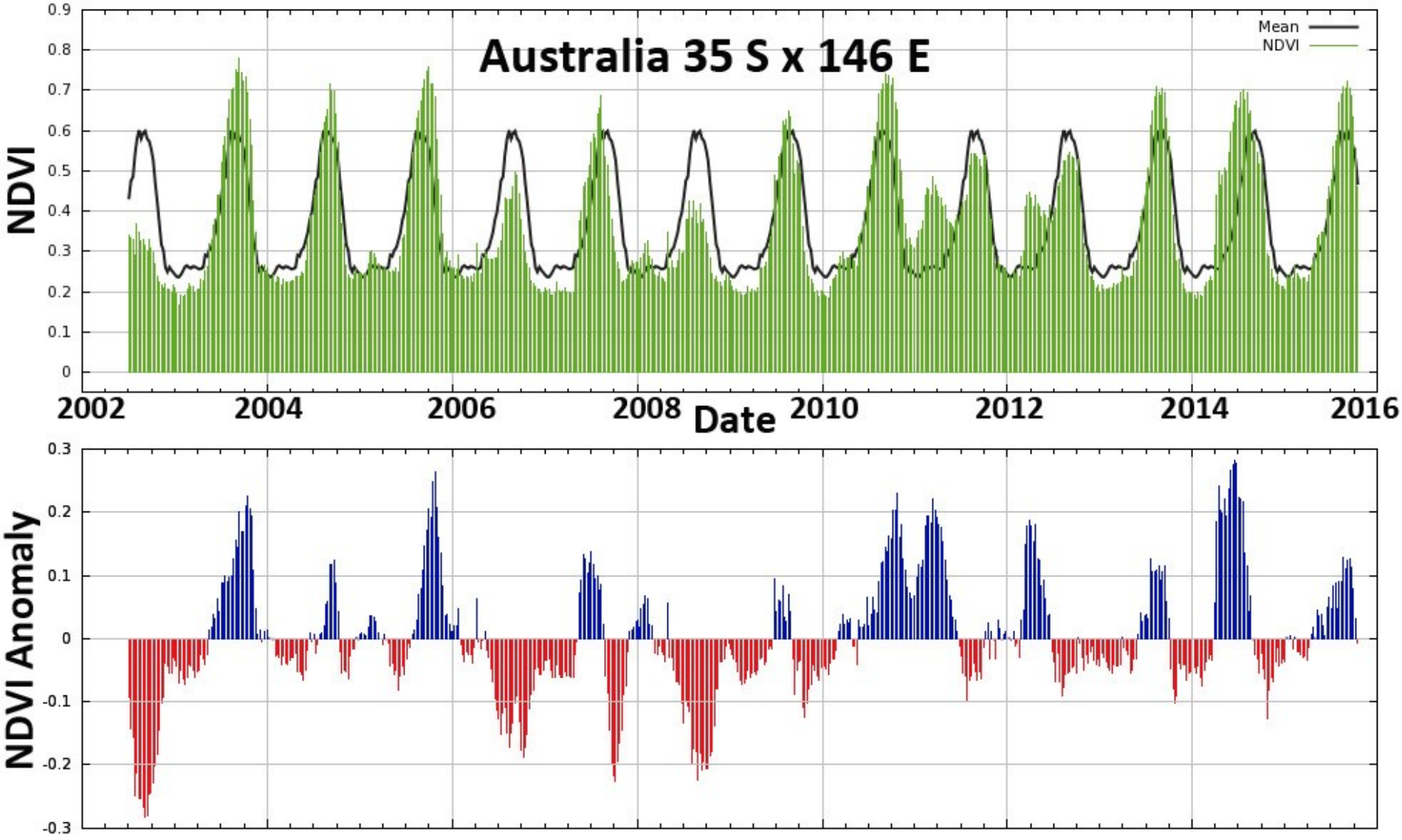
http://glam1.gsfc.nasa.gov/



Sample MODIS NDVI Output

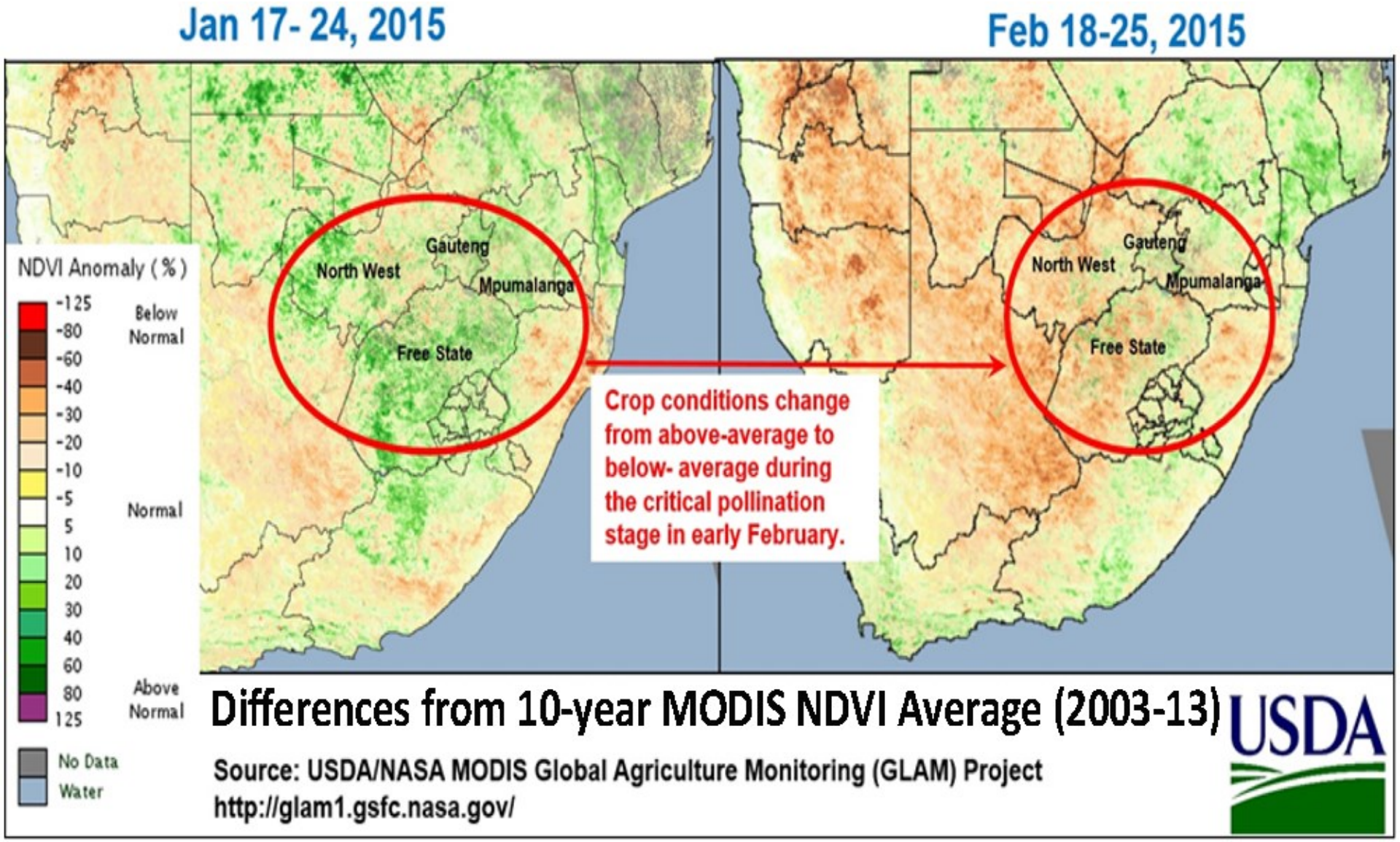


Sample MODIS NDVI Output



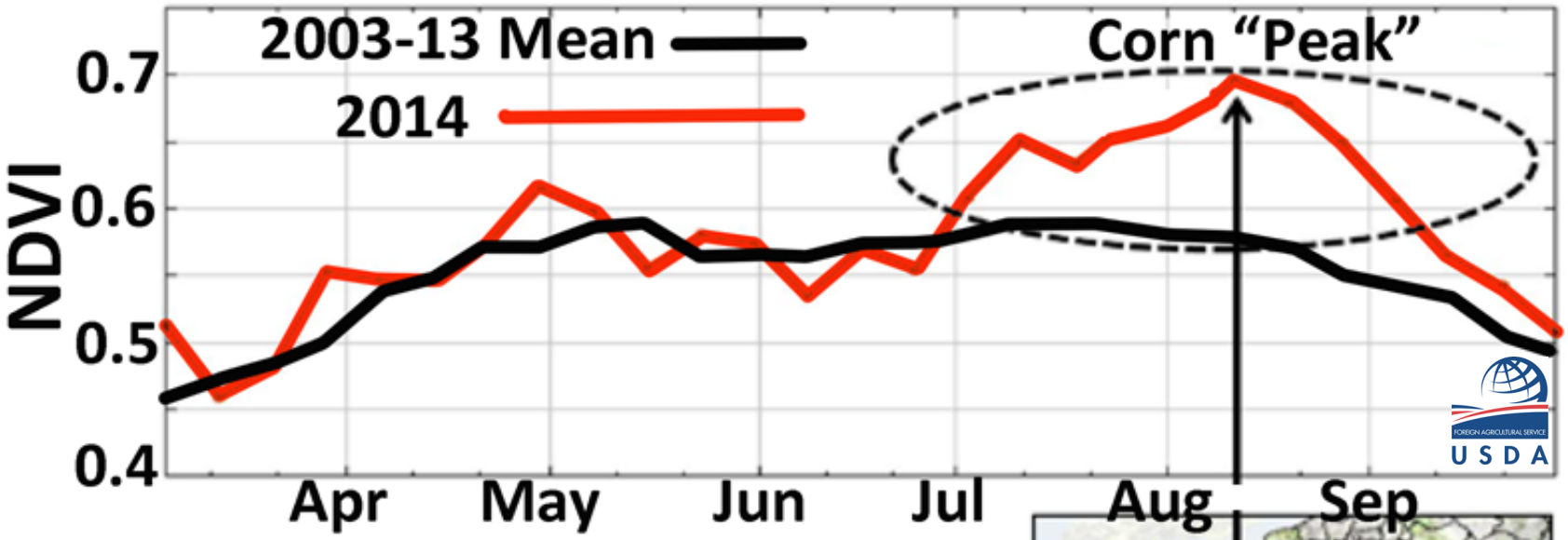
USDA/FAS NDVI Application

Conclusion: Drought During Pollination Reduced So. African Corn Yield



USDA/FAS NDVI-based Estimate for French Corn

2014 Record Corn Crop -- 17 M tons



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

MODIS Aqua NDVI 8-Day Anomaly; Corine Dryland Mask

NASA/GSFC/GIMMS/USDA/FAS/IPAD

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

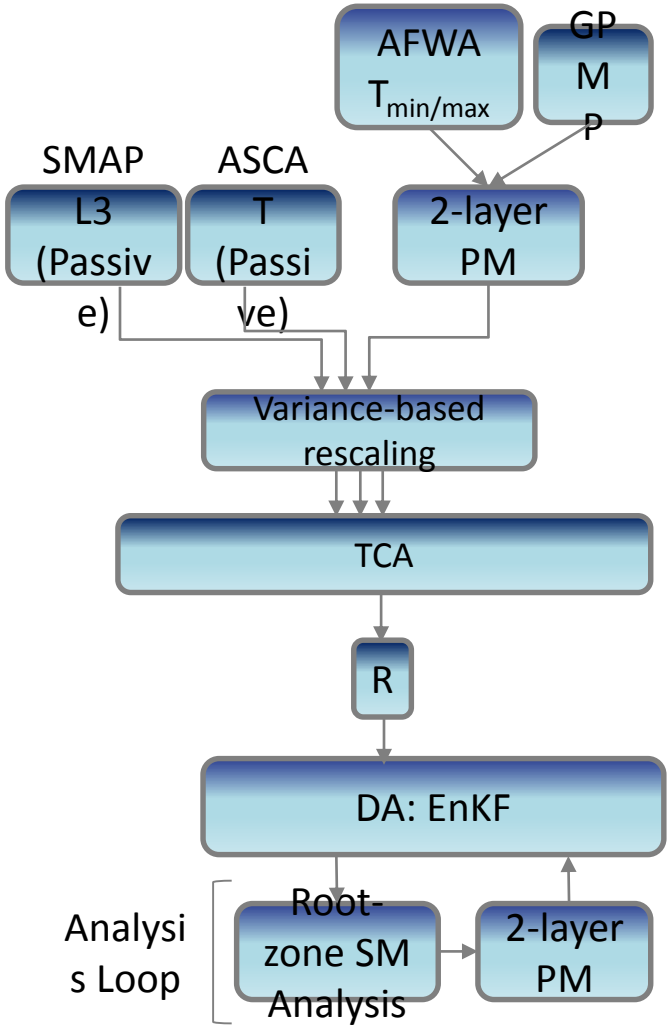
- former AFWA
  - Upcoming change: GPM
- Variables: Precipitation; Min and Max Temp.

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

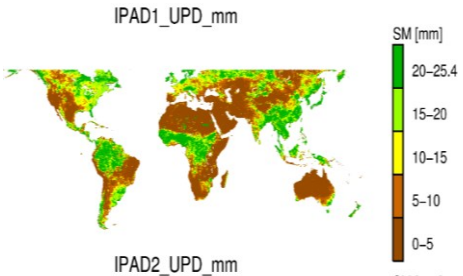


PM – Palmer Model
SM – Soil Moisture
SMOS – Soil Moisture Ocean Salinity
SMAP – Soil Moisture Active Passive
ASCAT – Advanced Scatterometer
GPM – Global Precipitation Measurement
AFWA – U.S. Air Force Weather Agency
NDVI – Normalized Difference Vegetation Index
DA – Data Assimilation
EnKF – Ensemble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

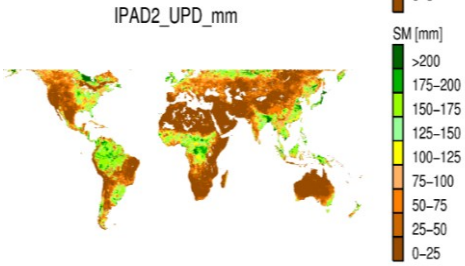
PM-SMOS Soil Moisture, Products

- 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’

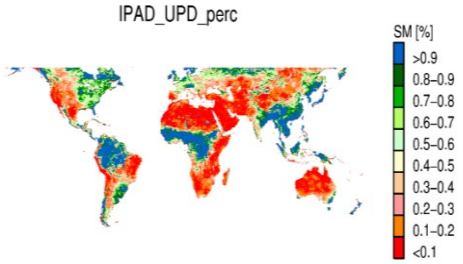
L03: as1 [mm]
Surface



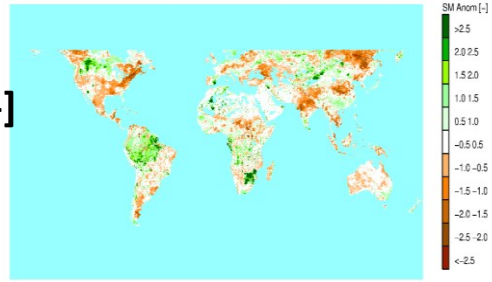
L03: as2 [mm]
Sub-surface



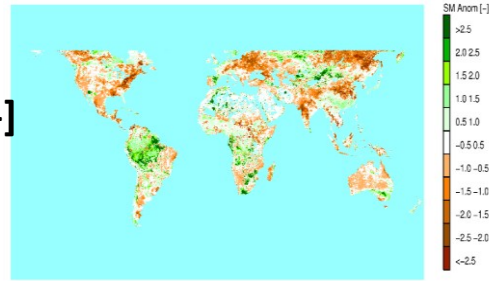
L04: smp [%]
Profile



L05: anom1 [-]
Surface



L05: anom2 [-]
Sub-surface

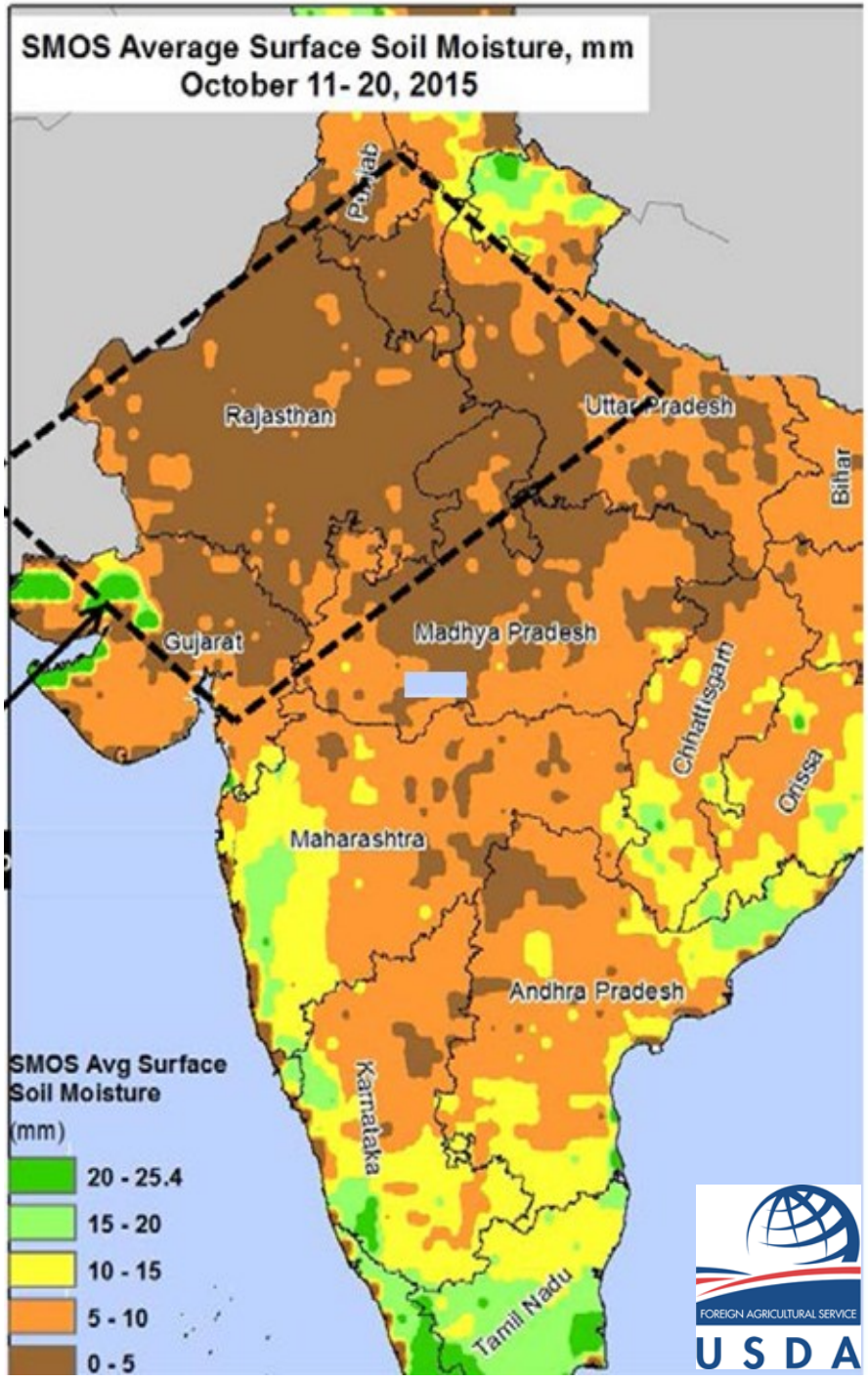


NASA/GSFC-SMOS Soil Moisture for USDA/FAS

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

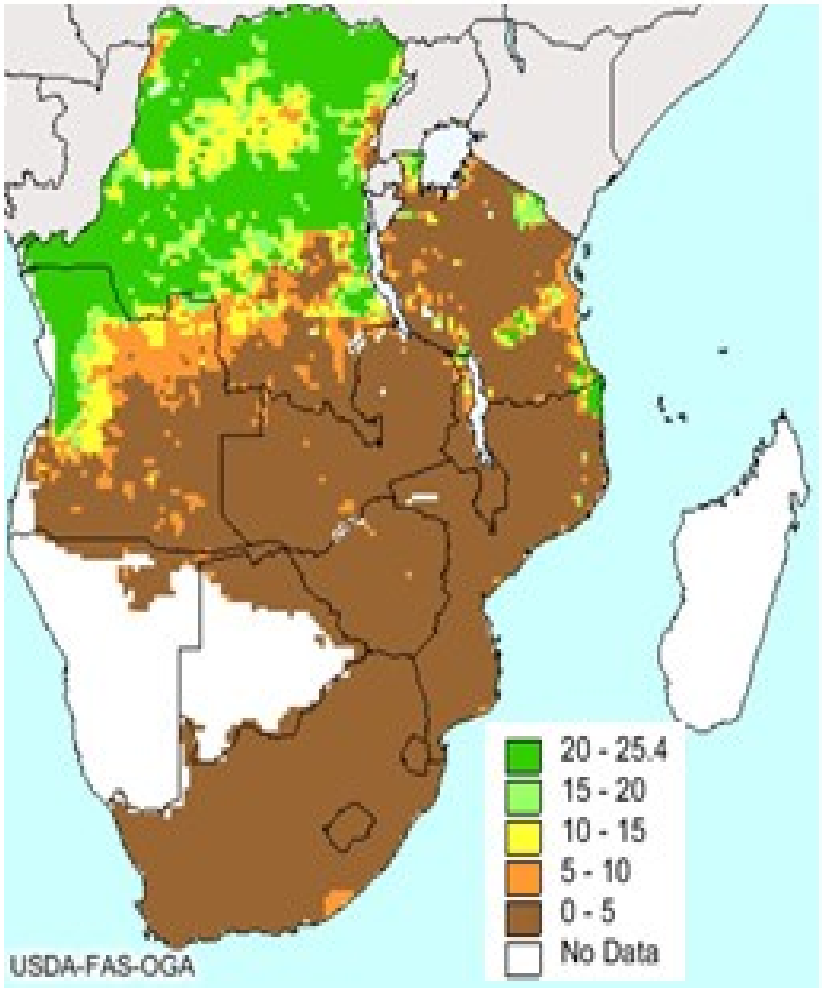
- Bolten & Mladenova NASA/GSFC



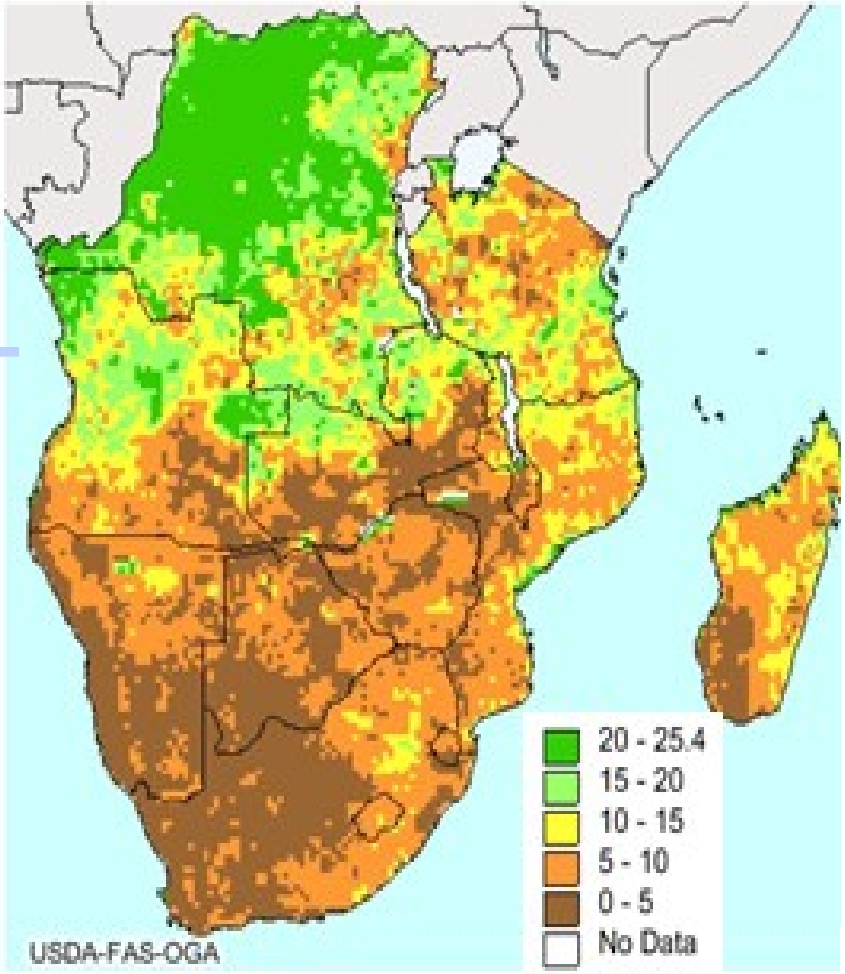
Methodology: *Operational Implementation*

- **Crop Explorer**: April 2014 http://www.pecad.fas.usda.gov/cropexplorer/

Model only



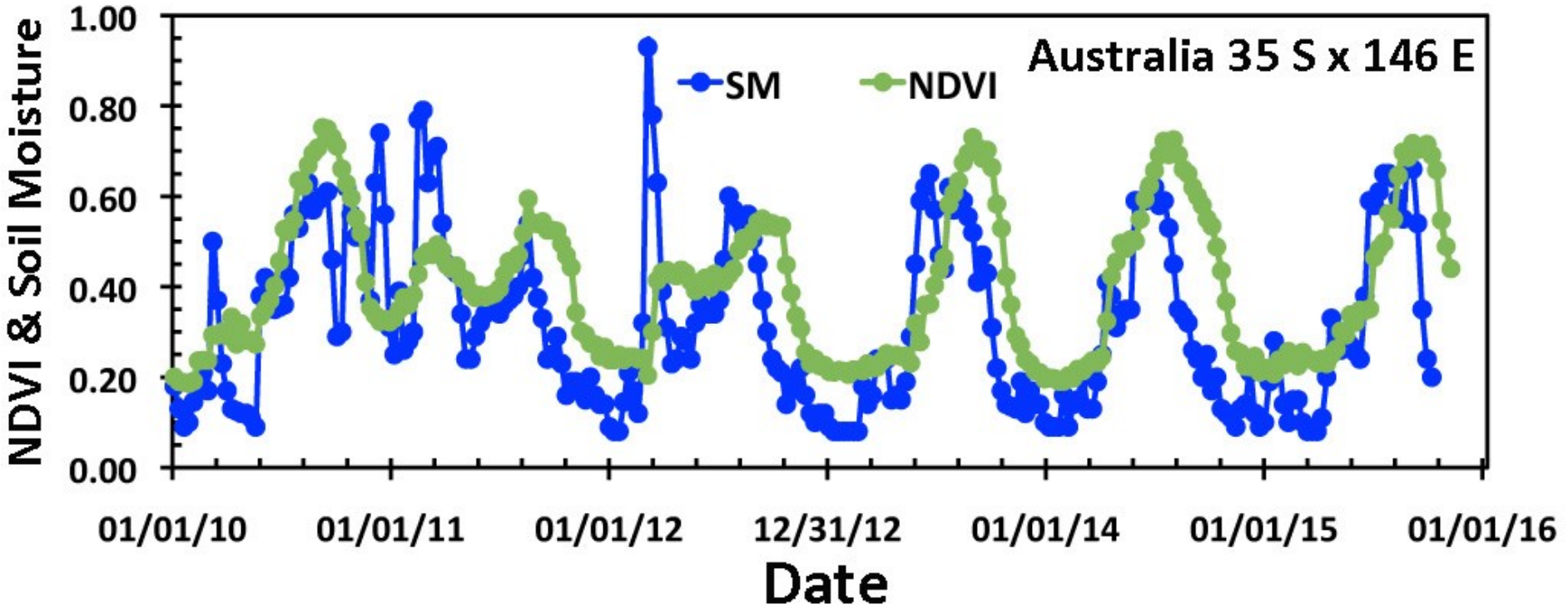
The benefit of assimilating satellite-based estimates.



11-20 April, 2014

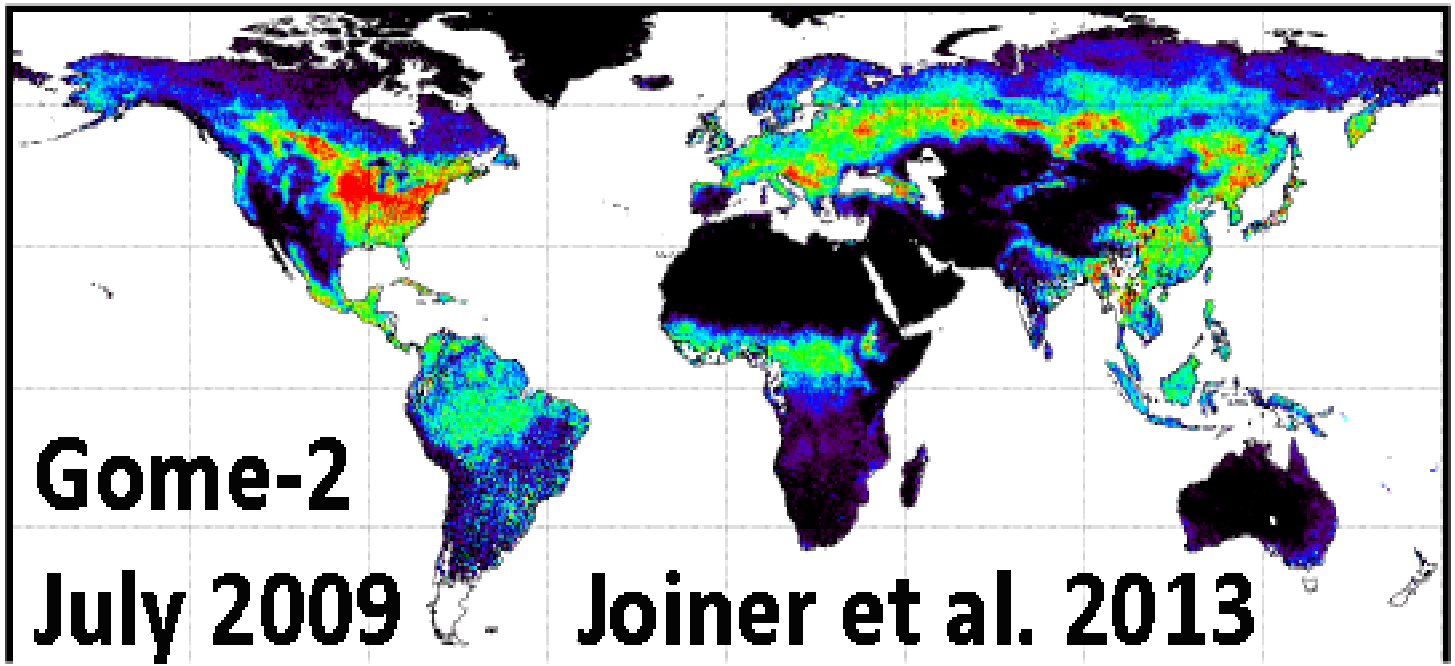
USDA FOREIGN AGRICULTURAL SERVICE

Methodology: *Operational Implementation NDVI & Soil Moisture for the USDA/FAS*



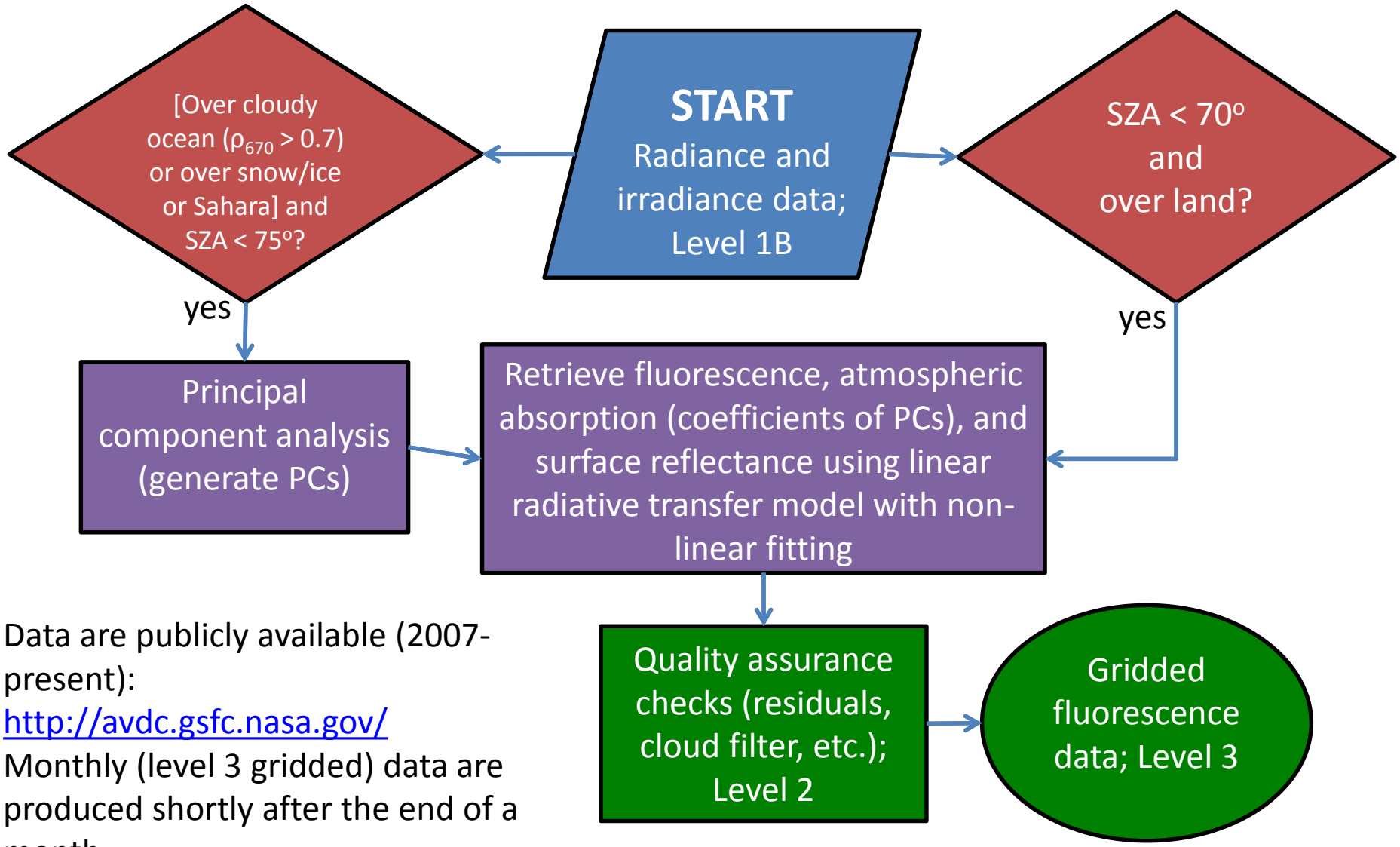
Soil Moisture by Bolton & Mladenova NASA/GSFC

- **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)**



GOME-2:
- **09:30 local time, 40x80 km pixels**
- **large swath (global coverage in 1.5 days)**
- **high SNR (>1000)**
- **FWHM = ~0.5 nm**
- **Use wavelengths 715-783 nm**

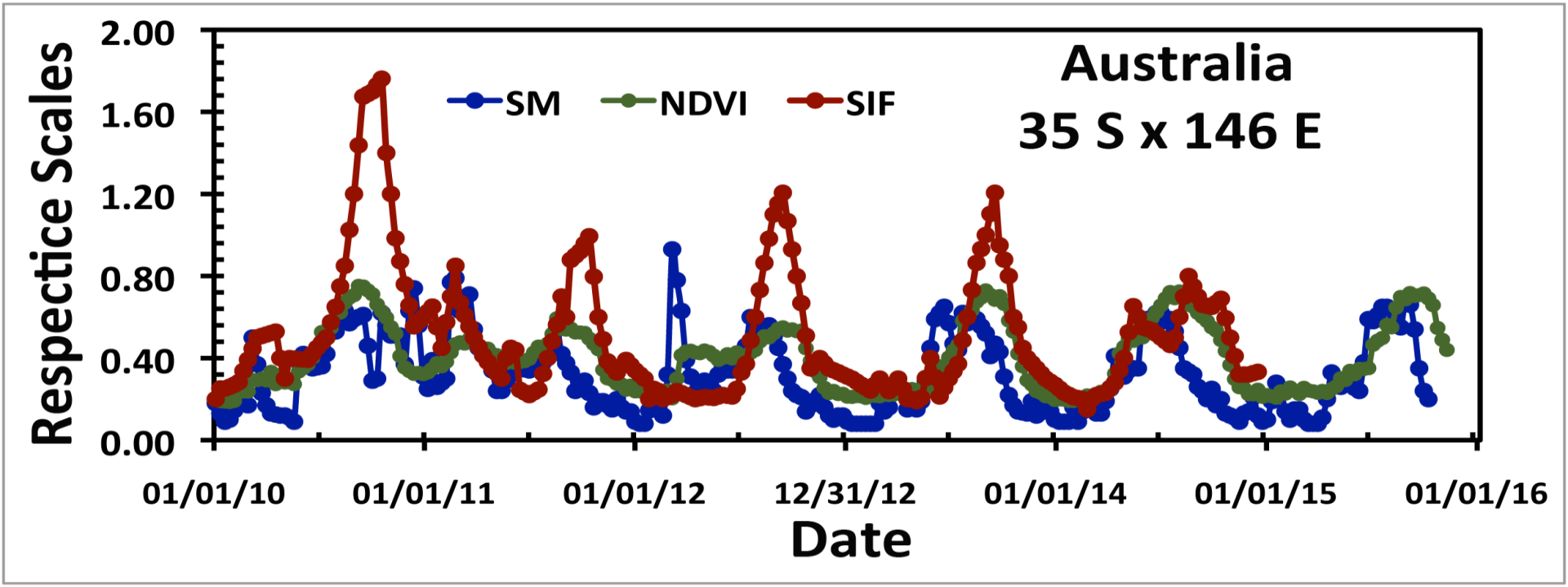
How do we retrieve fluorescence from GOME-2?



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



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