Wrap-up
Final Remarks

Garik Gutman,
NASA Headquarters
Manager, LCLUC

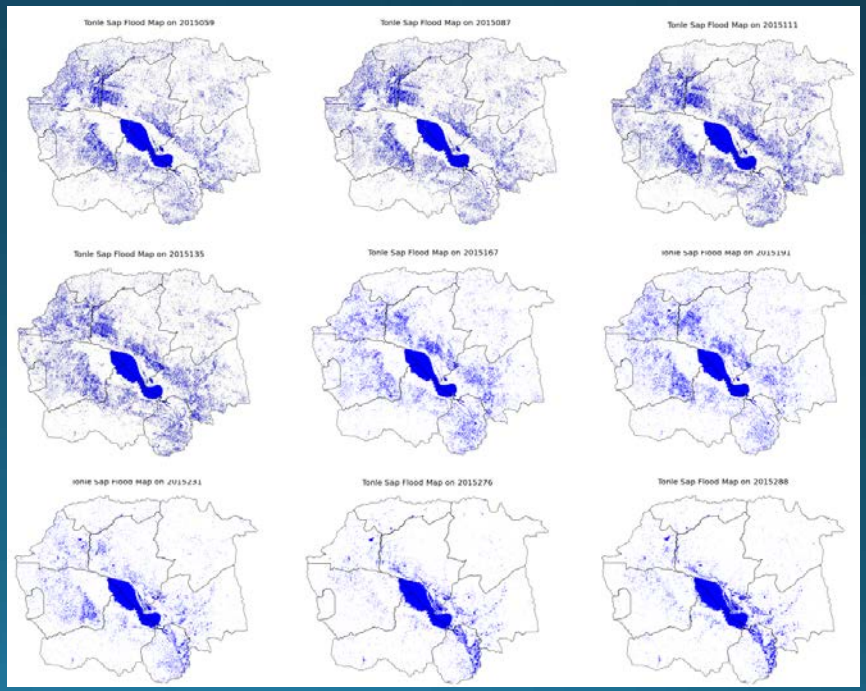
- LCLUC is a global program supported through regional partnerships to enhance
  - Regional scientists' access to NASA assets
  - NASA scientists access to national data and facilitate field data collection
- LCLUC is a catalyst for regional science initiatives through
  - Networks by leveraging national/local knowledge and resources and strengthening NASA research projects
  - Workshops focused on societal priorities and policy-relevant land-use science
- LCLUC is a promoter of regional capacity building through
  - NASA data-use training
  - International data sharing

Operational algorithms and products for near real time maps of rice extent and rice crop growth stage using multi-source remote sensing

PI: W. Salas, N. Torbick, AGS
Thuy Le Toan, CESBIO; Dirk Hoekman, Wageningen

- Fuse SAR-optical for mapping agricultural conditions; technology transfer with partners
- S. Asia
- Sentinel-1, PALSAR-2, Landsat-8, Sentinel-2, Radarsat-2
- Fusion provides more and better information; the approach strives to extract strengths of any / each satellite to complement another platform
- Pilot sites have beta products; begun cal / val coordination with ESA, regional partners (AsiaRice, IRRI, VAST, SERVIR, Ministries,…)

Example Tonle Sap, Cambodia Sentinel-1A Rice Inundation Dynamics Time Series

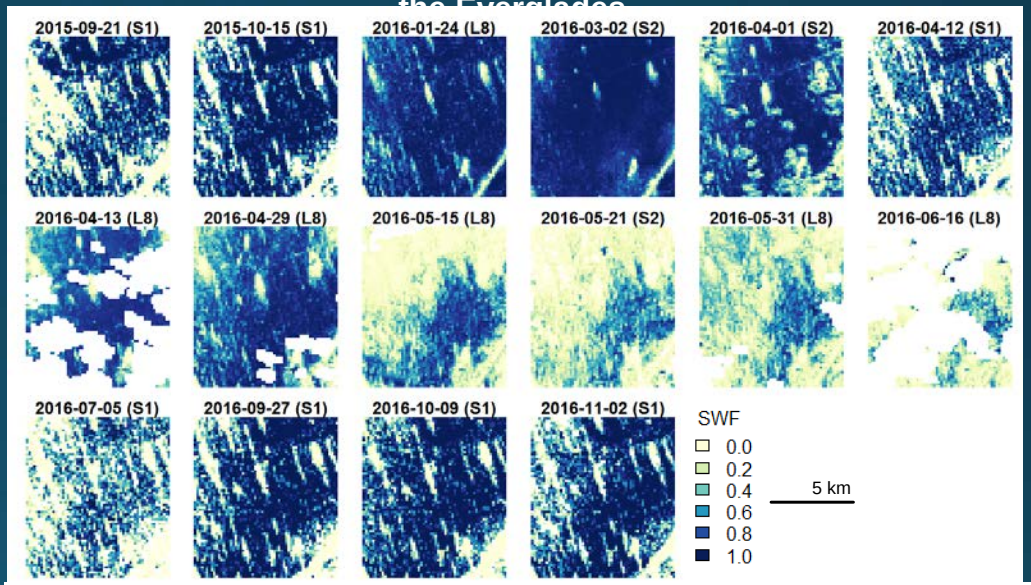


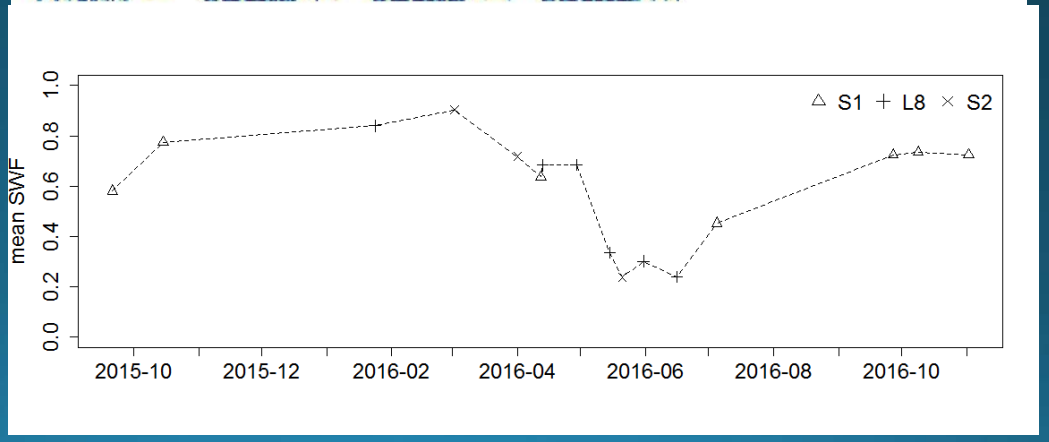
Towards Near Daily Monitoring of Inundated Areas over North America through Multi-Source Fusion of Optical and Radar Data

Chengquan Huang (PI), Ben DeVries, Wenli Huang, University of Maryland
Megan Lang (Co-I), US Fish and Wildlife Service National Wetland Inventory; **John Jones (Co-I),** USGS
Irena Creed (International Collaborator), University of Western Ontario, London, ON, Canada

- Goals:
  - Develop automated inundation mapping algorithms for Landsat, Sentinel-2 and Sentinel-1
  - Generate near daily inundation products over US and southern Canada
- Progress:
  - Algorithm for the automated quantification sub-pixel water fraction (SWF) developed for optical data streams (Landsat-5/7/8 and Sentinel-2) and tested over several sites
  - Algorithm for automated classification of water for Sentinel-1 developed and tested over several sites
- Benefits of MuSLI inundation approaches:
  - Provide needed spatial-temporal details: small water bodies, areas inundated for short periods, rapid inundation changes
  - Enable advances in understanding aquatic systems: connectivity, function, carbon, and biodiversity

Time series sub-pixel water fraction (SWF) maps derived using Sentinel-1 (S1), Sentinel-2A (S2) and Landsat-8 (L8) imagery over the Everglades



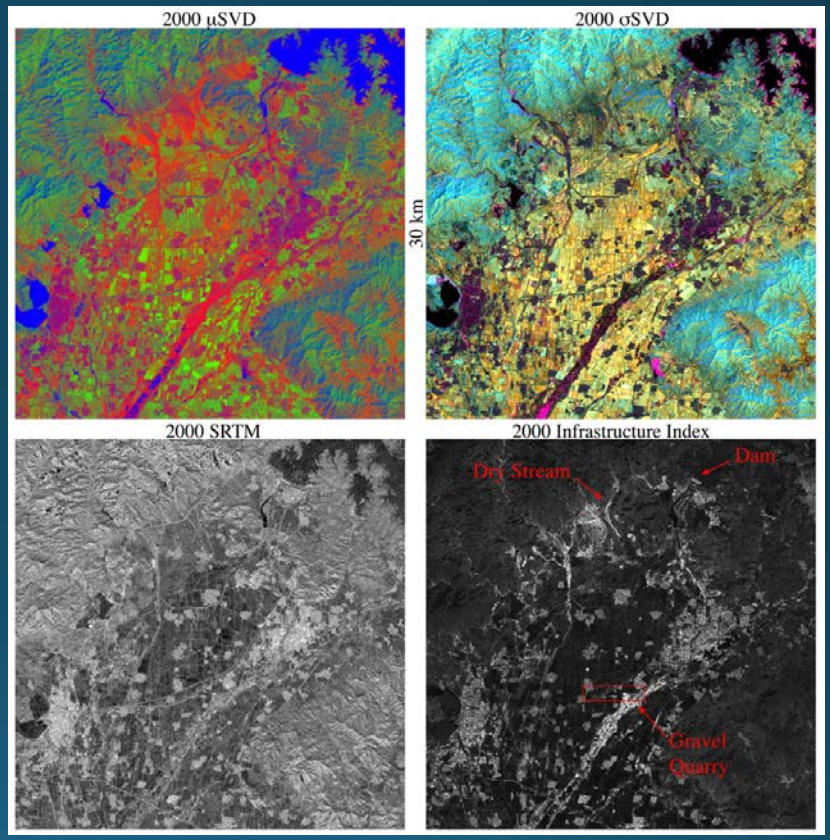


Multi-source imaging of infrastructure and urban growth using Landsat, Sentinel and SRTM

C. Small - Columbia Univ. USA *S. Nghiem – NASA/JPL USA*
T. Esch – DLR Germany

- *Develop continuous index to map built/impervious land cover*
- *Map changes in settlement extent between 2000 and 2015*
- Global Extent – 20 urban-rural gradients in different biomes
- *Optical: Landsat + Sentinel 2*
- *Radar: SRTM + Sentinel 1*
- Multi-season – Spectral Stability
- Multi-source – Reflectance + Backscatter
- Multi-decade – Robust WRT sensor & time

- *Developed spectral stability index*
- *Now characterizing reflectance-backscatter relations across biome*



Stable Reflectance = Impervious surfaces

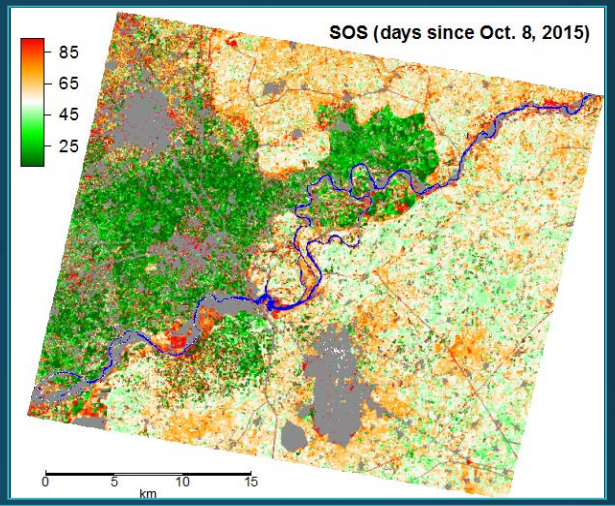
High Backscatter = Corner reflectors

Both together = High Infrastructure Density

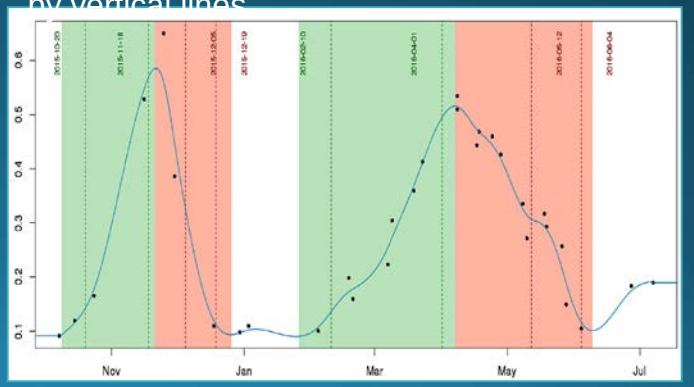
Multisource Imaging of Seasonal Dynamics in Land Surface Phenology: A Fusi Approach Using Landsat and Sentinel-2

Mark Friedl, PI; Josh Gray, Co-I; Boston University
Lars Eklundh, Lund University, Patrick Hostert, Humboldt University,

- **Goals:**
  - *To quantify the timing and magnitude of land surface phenology events ("phenometrics") at moderate spatial resolution, and*
  - *To generate gap-filled time series of spectral vegetation indices that characterize the entire seasonal cycle of land surface phenology at fixed time steps.*
- **Geographic area:** *Global (but focused on study sites)*
- **Data used:** *Landsat 8, S2 (supplemented by Landsat 5, 7 & MODIS)*
- **Advantage of MuSLI approach:** *Time series density*
- **Up-to-date progress:**
  - *Ongoing international collaboration with Lund University and Humboldt University, Berlin (BU Team visiting Berlin & Lund in Nov., 2016)*
  - *Manuscript in prep., AGU presentation, analyzing phenology algorithms*
  - *Data set development focused on Cal/Val data for core test sites.*
  - *Manuscript in prep describing Kalman Filter algorithm to fuse OLI and MSI.*
  - *Analysis of phenology algorithms based on HLS data (see figure at right)*



Above: Estimated day of year for SOS (start of season) based on HLS time series for scene near Lahore, Pakistan. **Below:** sample HLS time series for a multi-cropped pixel; estimated phenology dates identified by vertical lines

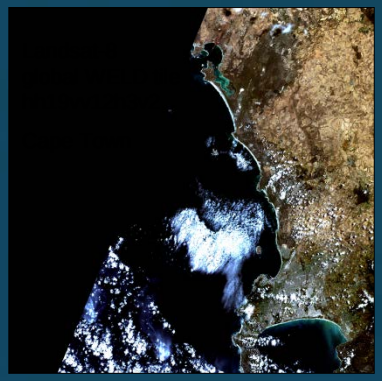


Prototyping a Landsat-8 Sentinel-2 Global Burned Area Product

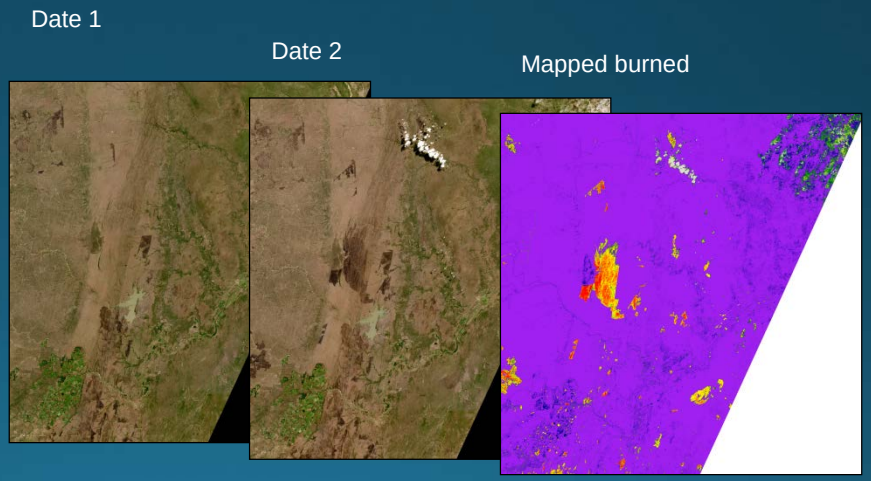
David Roy, Haiyan Huang, Lin Yan, Hankui Zhang, Jian Li, (GSCE, South Dakota State University, USA), Luigi Boschetti (Idaho, USA); International Collaborators: Jose Gómez-Dans & Philip Lewis (UCL, London, U.K), Emilio Chuvieco (Alcala, Spain), Kevin Tansey (Leicester, U.K)

- **Goal:** Prototype global 30m burned area product to meet user needs for
  - improved carbon budget accounting
  - greenhouse gas and aerosols emissions
  - environmental management
  - post-fire assessment and remediation
  - people - environment - climate - fire research
- **Geographic area**: Africa + global sample
- **Data used:** Landsat-8 and Sentinel-2A/B
- **MuSLI advantage:**
  - Landsat-8 and Sentinel-2A/B together provide needed temporal resolution for time series burn change detection
  - Landsat-8 has improved quantization, signal/noise characteristics, and acquisition coverage over heritage Landsat missions
  - Sentinel-2 has Landsat-8 like bands at 10m & 20m with higher acquisition coverage than Landsat

- **Progress:** Sentinel-2 processing under global WELD processing, and Landsat-8 to Sentinel-2 registration, developed and implemented



- **Progress:** Automated sensor-agnostic burned area algorithm for WELD processed time series prototyped



Integrating Landsat 7, 8 and Sentinel 2 data in improving crop type identification and area estimation

PIs: M. Hansen, P. Potapov, University of Maryland

International collaborators: Pierre Defourny, UCL & Carlos Di Bella, INTA

Goals

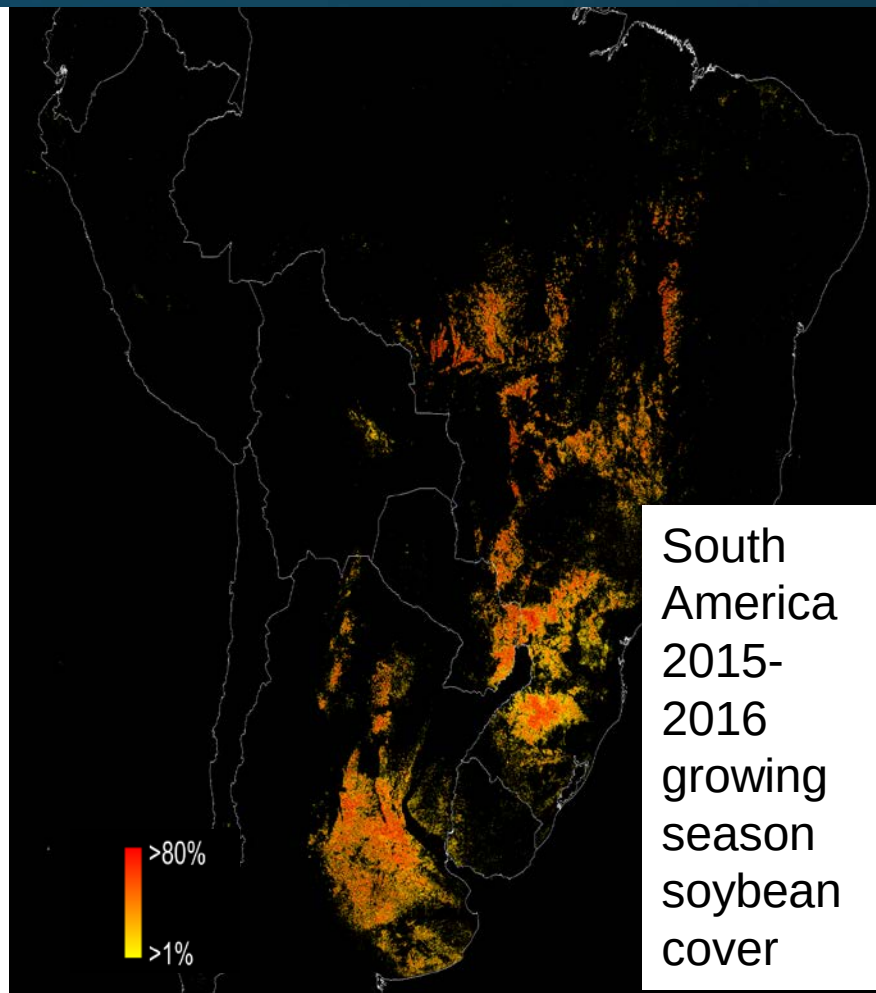
- Develop and implement a system for defining the required phenological sampling for mapping crop types.
- Determine if Landsat and/or Sentinel 2 acquisitions are sufficient in meeting required sampling frequencies for selected commodity crop type mapping (required best individual date image inputs).
- Compare the performance of single date images and seasonal metrics in mapping crop type at local (per sample block) and regional (all sample blocks at once) scales.
- Given sufficient temporal richness, validate area estimation of crop type for large scale industrial and fine scale smallholder cropping systems.

Scale - National

Data - Primarily Landsat 7 and 8 and Sentinel 2A

Advantage - Crops require more detailed phenologic profiles for characterization

Progress – Testing use of data in Tanzania for corn mapping, waiting for systematic acquisitions over large commodity crop landscapes

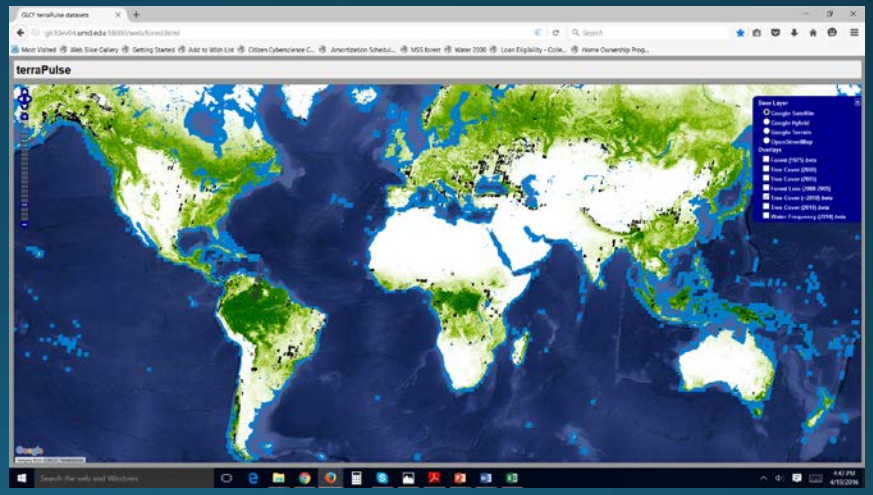


South America 2015-2016 growing season soybean cover

Multi-source imaging of time-serial tree and water cover at continental to global scales

PI: John Townshend, Global Land Cover Facility, Department of Geographical Sciences, University of Maryland
Co-Is: Joseph O. Sexton, Min Feng, Saurabh Channan, Global Land Cover Facility, Department of Geographical Sciences, University of Maryland
International collaborator: Christiane Schmullius, University of Jena, ESA GLOBBIOMASS Project

- **Goal**: Develop methodologies for fusing optical and radar imagery into data streams of tree- and water-cover estimates
- **Geographic area**: Global
- **Data used**: Landsat TM, ETM+ & OLI; Sentinel 1 & 2; PALSAR
- **Advantage**: long-term and globally consistent estimates without gaps due to clouds or sensor failure
- **Progress:**
  - Global estimates of tree cover based on Landsat (2010)
  - Development of online portal for collaborative data visualization and progress-reporting
  - Successful first test of incorporating Sentinel-2: filled cloud gaps
  - Unsuccessful first test of incorporating Sentinel-1: weak tree-cover signal

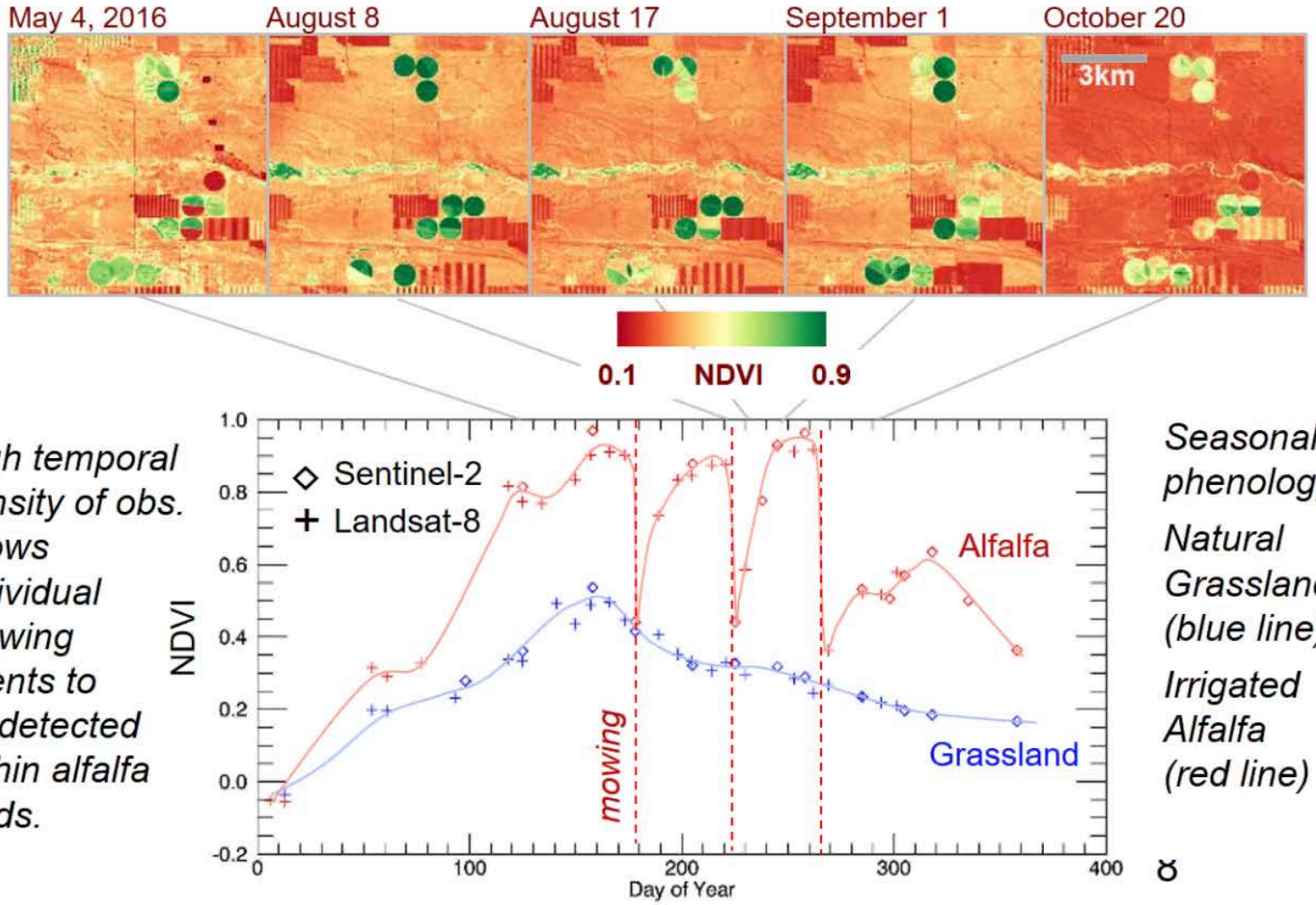


Global, Landsat-based tree-cover estimates for the 2010 GLS epoch visualized through an online portal for collaboration based on shared geospatial datasets.

HLS: Harmonized Landsat/Sentinel-2 Products

https://hls.gsfc.nasa.gov

Laramie County, WY

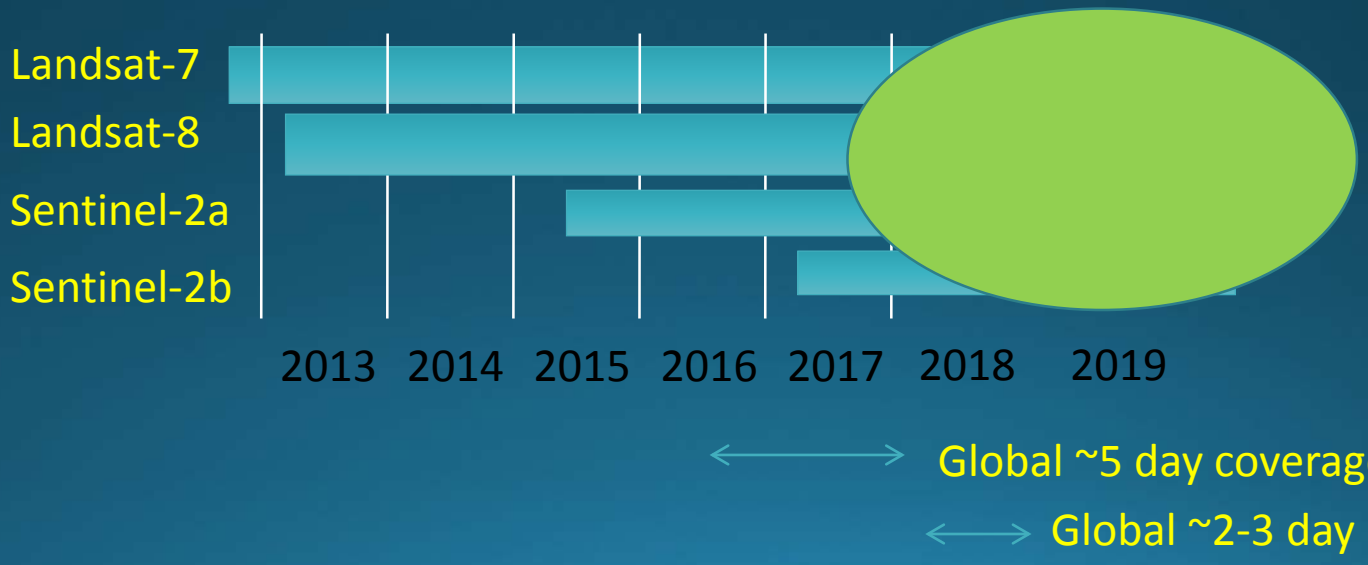


Courtesy: Jeff Masek, NASA GSFC

Sentinel-2 - Landsat Fusion

Merging Sentinel-2 and Landsat data streams could provide < 5-day coverage required for Ag monitoring

- Both sensors have 10-30m coverage in VNIR-SWIR
- Satellite orbits complementary
  - Landsat-7 & -8 8 days out of phase
  - Sentinel-2a & 2b 5 days out of phase
  - Landsat and Sentinel sun synch orbits precess relative to each other



LCLUC-2017 MuSLI Recent Selections

Roy, David Type 1	South Dakota State U.		Africa burned area product generation, quality assessment and validation â€“ demonstrating a Multi-Source Land Imaging (MuSLI) Landsat-8 Sentinel-2 capability
Shaaf, Chrystal Type 1	U. Massachusetts		Circumpolar Albedo of Northern Lands from Landsat-8 and Sentinel-2
Friedl, Marc Type 1	Boston U.		An Operational Multisource Land Surface Phenology Product from Landsat and Sentinel 2
Anderson, Martha Type 2	USDA		Characterizing Field-Scale Water Use, Phenology and Productivity in Agricultural Landscapes using Multi-Sensor Data Fusion
Campbell, Petya Type 2	UMBC/NASA		Prototyping MuSLI canopy chlorophyll content for assessment of vegetation function and productivity
Skakun, Sergi Type 2	UMD		Crop yield assessment and mapping by a combined use of Landsat-8, Sentinel-2 and Sentinel-1 images
Radeloff, Volker Type 2	U. Wisconsin		Monitoring abandoned agriculture, fallow fields, and grasslands with Landsat and Sentinel-2
Hulley Type 2 Thermal IR	NASA/JPL		A high spatio-temporal resolution Land Surface Temperature (LST) product for urban environments

Ongoing Solicitations

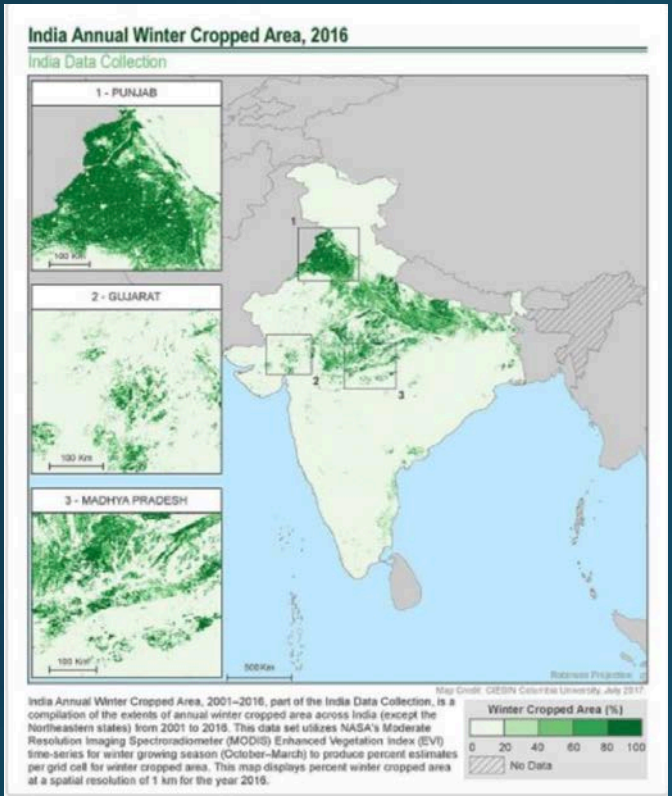
- **ROSES-2018**
  - **Land-Use Transitions in Asia (due date Aug 1 step-1, Mar 1 step-2)**

Programmatic Future

- **Keep social science component as an integral part of the LCLUC proposals**
- **Analyse multi-source land imaging (MUSLI) results**
- **Continue the support of SARI and NEFI through solicitations and meetings**
- **Revive research on Latin America**
- **Balance the program thematically and geographically**
- **Promote our products internally and externally: FB page, webinars, newsletters**
- **Enhance LCLUC-EARSeL and LCLUC-ESA collaboration**

Metadata Page on LCLUC website

Multi-sensor Fusion to Determine Climate Sensitivity of Agricultural Intensification in South Asia



- India Annual Winter Cropped Area, 2001 – 2016
- consists of annual winter cropped areas for most of India (except the Northeastern states)
- from 2000-2001 to 2015-2016.
- NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) Enhanced Vegetation Index (EVI; spatial resolution: 250m) for the winter growing season (October-March).
- Automated algorithm identifies the EVI peak in each pixel for each year and linearly scales the EVI value between 0% and 100% cropped area within that particular pixel.
- Maps were then resampled to 1 km and were validated using high-resolution QuickBird, RapidEye, SkySat, and WorldView-2 images spanning 2008 to 2016 across 11 different agricultural regions of India.
- The spatial resolution of the data set is 1 km, resampled from 250m.
- The data are distributed as GeoTIFF and NetCDF files and are in WGS 84 projection.

Meha Jain
Pinki Mondal
Gillian Galford
Ruth DeFries

Download Link:
http://sedac.ciesin.columbia.edu/data/set/india-india-annual-winter-crop...

Annually-available dataset in Geotiff or netCDF format with 1km spatial resolution in WGS84 projection. For more details please view the product documentation
at http://sedac.ciesin.columbia.edu/downloads/docs/india/india-india-annual

LCLUC in the News: Wards, Media

- Randolph H. Wynne, professor of forest remote sensing in Virginia Tech's College of Natural Resources and Environment, received a Society of American Foresters award recognizing his research in remote sensing applications that have resulted in significant advances in forestry.

08/15/2017: Dr. Jessica McCarty discuss
wildfires and smoke in Greenland on NPR

Near Future LCLUC-Related Meetings

- **SARI events**
  - **LCLUC regional science workshop: 27-30 May, Manila, Philippines**
  - **LCLUC Water-Energy-Food Nexus workshop: mid-August, Laos**
- **ERSeL-LCLUC 3d Joint Workshop: 11-12 July, Greece**
- **GOFC-GOLD workshop/training events**
- **PEEX Sep 17-20 Boreal forests**
- **WHISPERS (Hyperspectral...) Sep 24-26**
- **ESA Urban conference (ESRIN, Frascati) Oct 30-31**
- **GLP Open Conference April 24-26**

Thanks again to
the LCLUC Project Office support and our sponsors