LCLUC Program: Silver Jubilee Update

Garik Gutman,
NASA Headquarters
Manager, LCLUC Program

Fires

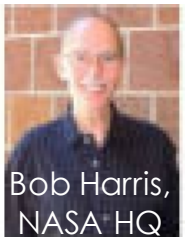
Deforestation

Urban changes

Agriculture

The Foundations of the LCLUC Program and its Inception

- Foundations
  - 1990 NASA Landsat Pathfinder initiated (U. New Hampshire, U. Maryland)
  - 1990 IGBP-DIS – global data sets (inc. 1km Land Cover)
  - 1994 IGBP/IHDP LUCC officially launched (Skole, Chair)
  - 1994 Global Land Cover Monitoring Proposal
- The LCLUC Inception
  - Discussions with Bob Harris, NASA Earth Science Director
  - May 1995 ESSAC review at NASA HQ
  - First funded LCLUC Budget Cycle: LCLUC-2016
  - First LCLUC Science Team Meeting 1997 Airlie House, Warrenton Va.

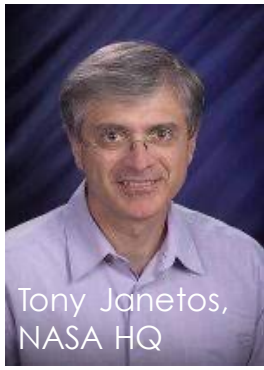

Bob Harris, NASA HQ

https://lcluc.umd.edu/sites/default/files/lcluc_documents/Justice%20LCLUC20.pdf

Tony Janetos, 1995 (white paper)

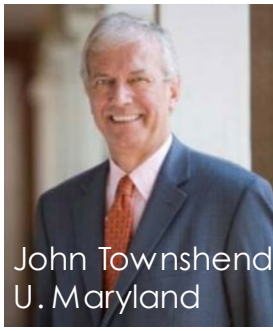
"Underlying philosophy… further the understanding of the consequences of land use change for continued provision of ecological goods and services" - Sustainable management, **human influences**, expanding human population

"Ultimate vision …to develop the capability to perform repeated inventories of LU LC from space and develop the scientific understanding and models necessary to evaluate the consequences of observed changes"


Tony Janetos, NASA HQ

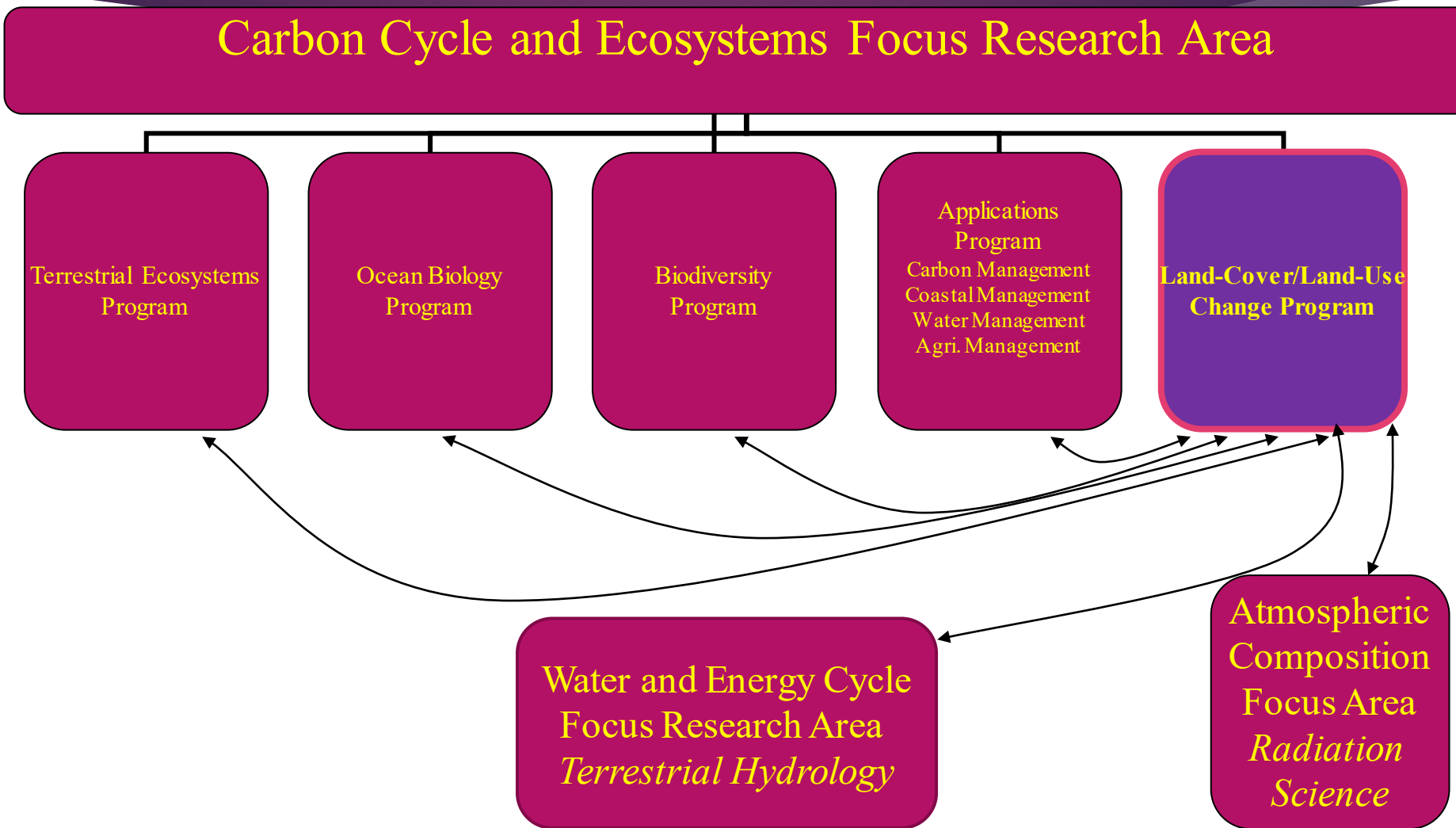
Recognizing leadership

- Established and led
  - IGBP-DIS
  - GOFC-GOLD Program
- Pioneer in satellite Land Cover work
- Established and led the Global Land Cover Facility (GLCF) @UMD, which helped build the case for the Open Landsat Archive
- Mentored many LCLUCers over 25 years


John Townshend U. Maryland

Thank you!

INTERNAL NASA LINKAGES

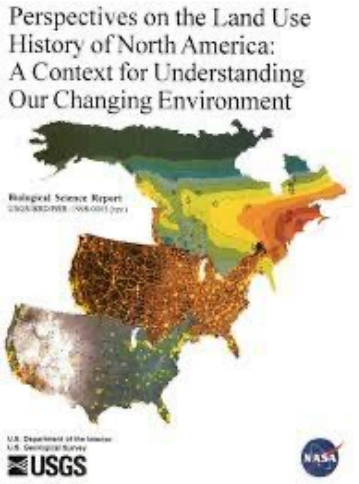


25 Years of External Interactions: National

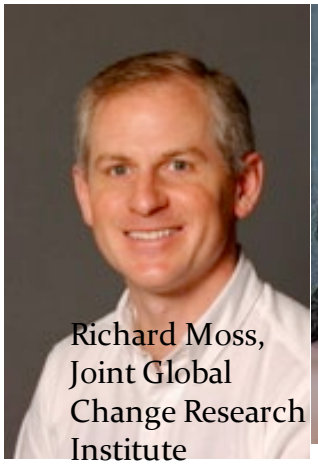
- U.S. Global Climate Research Program (USGCRP)
  - Participated in and supported the **LULCC** Interagency Working Group
  - Contributed to USGCRP's annual issues of **Our Changing Planet**
  - Supported **NRC review** of land-use models, co-sponsored with USGS
- U.S. Geological Survey (USGS)
  - Contributed to **Landsat** program
  - Supported USGS science projects
  - Contributed to National project on Land Use History of North America (LUHNA)
  - Co-Led and co-sponsored **Global Land Surveys** initiative and projects
- U.S. Department of Agriculture (USDA) and U.S. Forest Service (USFS)
  - Contributed to **HARVEST** program
  - Supported USDA and USFS science projects
- U.S. Agency for International Development
  - Supported **SERVIR** - coordination with two hubs in Asia
  - Participated in **PEER** (Partnerships for Enhanced Engagement in Research)

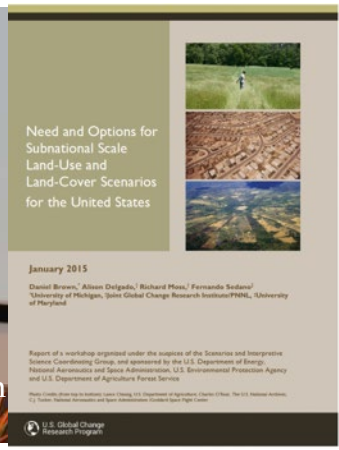
LCLUC Support of National Projects

- Multiagency national project on Land Use History of North America (LUHNA) 1996-1998
  - **Chapter 3** Assessing the Impact of Urban Sprawl on Soil Resources in the United States Using Nighttime "City Lights" Satellite Images and Digital Soils Maps, *Marc L. Imhoff, William T. Lawrence, David Stutzer, and Christopher Elvidge*



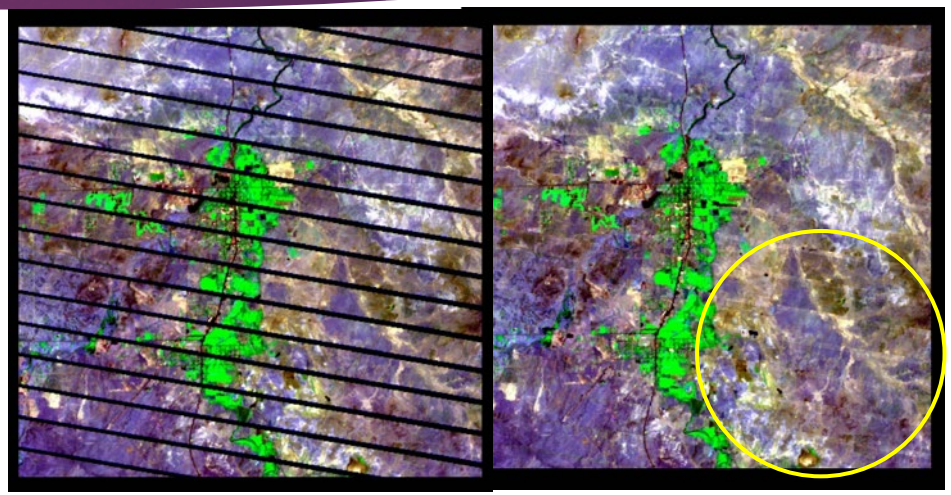
- NRC review of Land-Use Models, co-sponsored by NASA LCLUC and USGS
  - National Climate Assessment (land use scenarios)
  - Workshop on scenarios June 2014
  - Report Jan 2015





The Story Behind the Mid-Decadal Global Land Survey (GLS) 2005

- 2003 Memorial Day Scan Line Corrector failure → Striping on images
- Proposed interpolation methods
  - Reports on Investigations by a team of 30+ researchers from USG and Academia
  - data compositing using adjacent or multi-temporal coverage to fill in data gaps
- Most affected
  - areas with **infrequent temporal coverage**



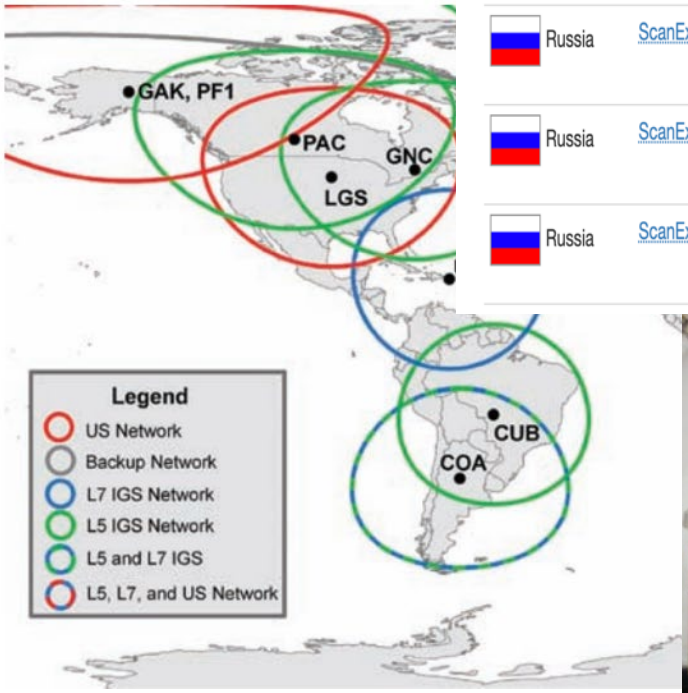
Composite Imagery Using Regression Tree
From Report by Vogelman et al. (USGS), 2003
http://www.ga.gov.au/webtemp/image_cache/GA3430.pdf

Compton Jim Tucker, NASA GSFC

Combine L-7 and L-5!

- working **less well when substantial seasonal differences** exist among the scenes
- appropriate for deforestation assessments, regional land cover mapping
- **Not so good** for assessments and mapping in areas **where rapid intra-seasonal changes** take place, such as in agricultural landscapes

Handling the Gaps in L-5 Acquisitions:
ScanEx to the Rescue!



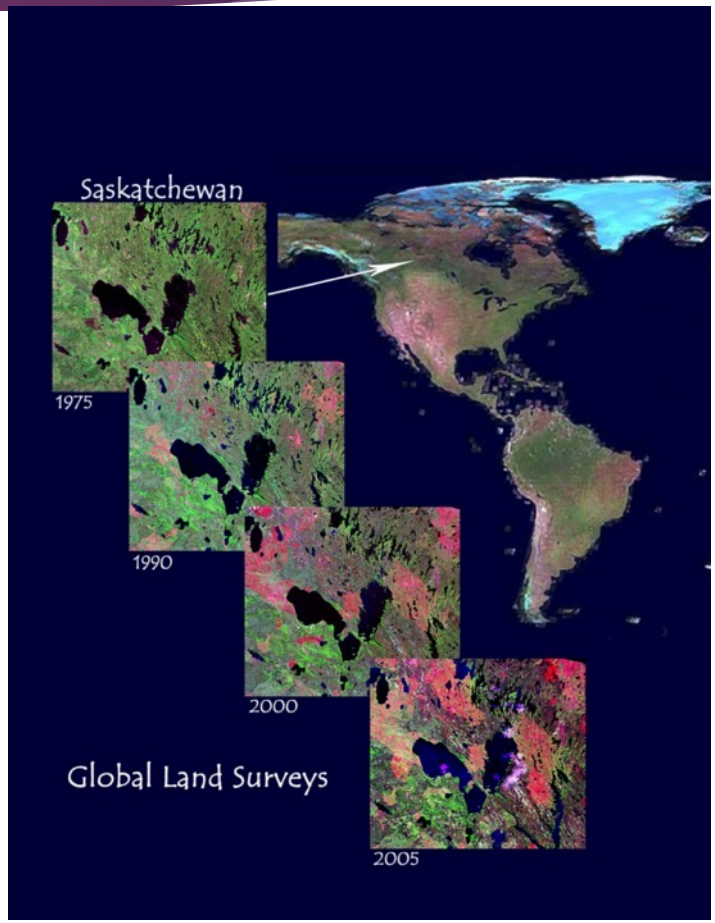
Russia	ScanEx	KML Irkutsk, Russia	IKR	Jun 2006 - Oct 2007; Jun 2009 - Oct 2011
Russia	ScanEx	KML Magadan, Russia	MGR	Jul 2007 - Oct 2007; Jun 2009 - Aug 2011
Russia	ScanEx	KML Moscow, Russia	MOR	May 2006 - Oct 2007; Jun 2009 - Oct 2011

Vlad Gershenzon
ScanEx, Russia

Steve Covington
USGS/NASA

NASA-USGS Global Land Survey Data Sets

- Global cloud-free, geocorrectedd Landsat (5+7)-based datasets centered on 1975, 1990, 2000, **2005, and 2010**
- EO-1 ALI data were used for mosaics over small islands
- 1 scene per epoch at the peak of vegetation → 30-m global mosaic
- For global assessments of land-cover change (e.g., FAO's FRA)
- Paper describing GLS-2005 published in P&RS Journal with a cover image
- Available for download via GLOVIS/EarthExplorer at USGS free of charge
- Remote Sensing of Environment, 2013, ***Assessment of the NASA–USGS Global Land Survey (GLS) datasets***, Gutman et al.

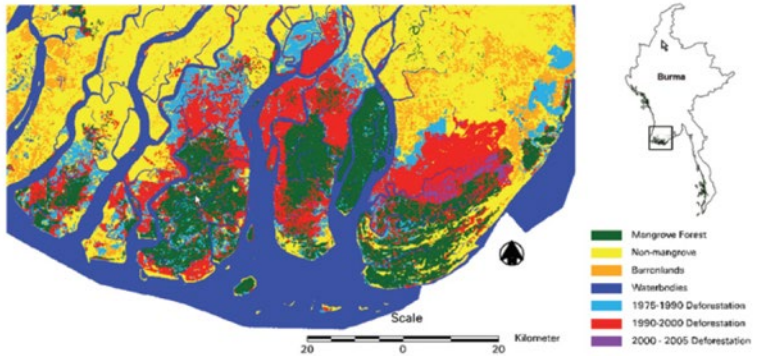


Progression of fires scars in central Canada

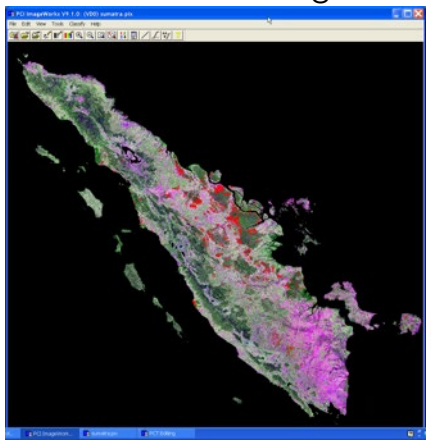
GLS LCLUC Science Projects

Reminder: Landsat data were not free yet!

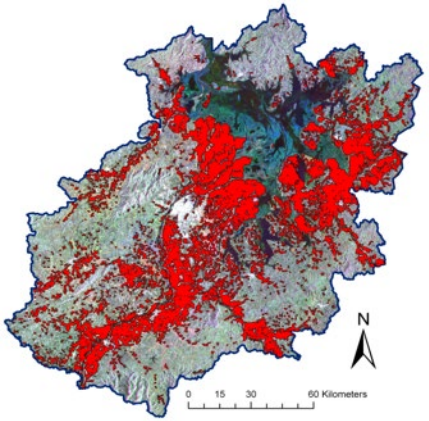
- Chander, G. (USGS EROS) - Sensor cross-calibration
- Davis, B. (NASA SSC) - Sensor intercomparison for land cover
- Giri, C. (USGS EROS) – Monitoring Tropical Mangrove Forests
- Masek, J. (GSFC) – North American Forest Disturbance
- Skole, D. (MSU) – Tropical Forest Cover Change
- Townshend, J. (UMD) –South America Forest Cover Change
- Xiao, X. (UNH) – Land Cover Products for Monsoon Asia
- Hansen, M. (SDSU) – Forest Cover in Humid Tropics



Giri: Mangrove Loss, 1975-2005



Hansen: Humid tropical forest cover and change, Sumatra, Indonesia 1999-2009

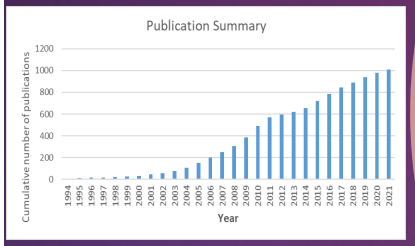


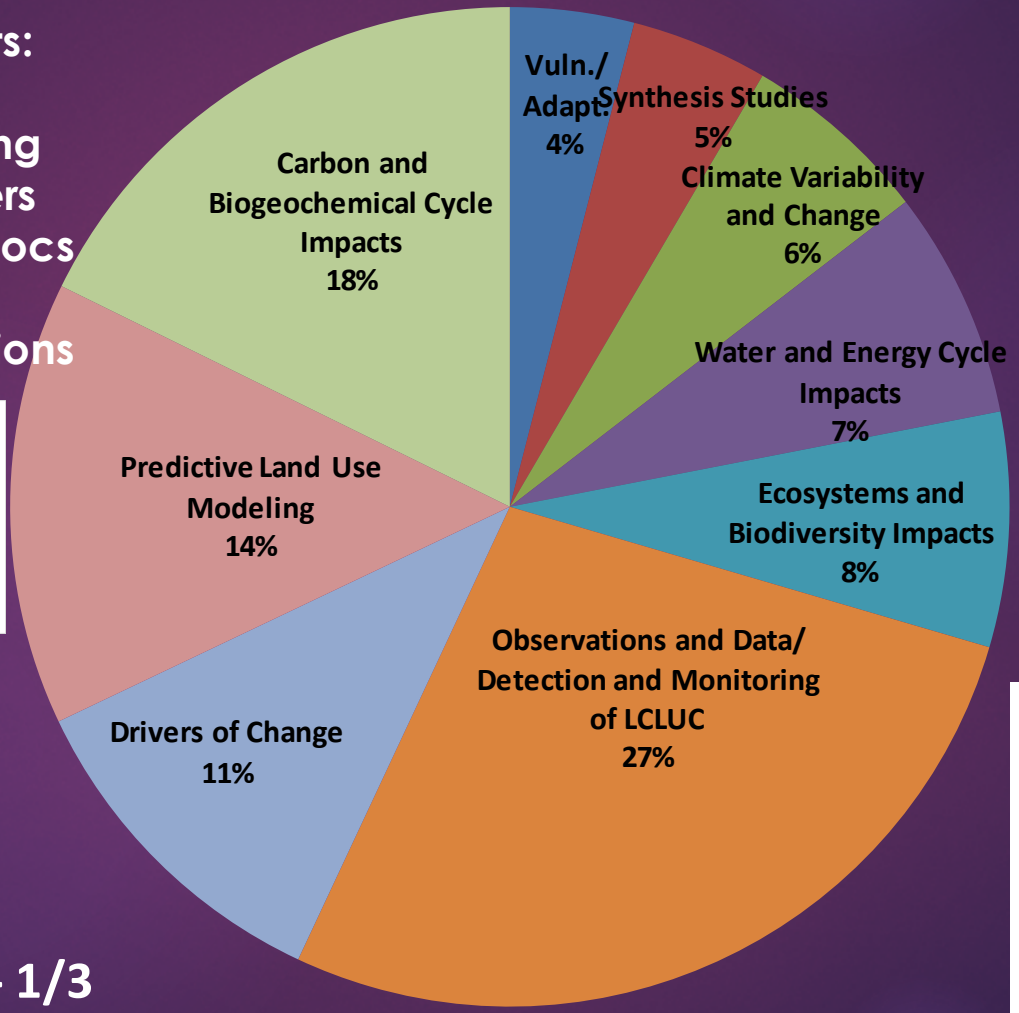
Xiao: Paddy rice, water and wetlands in Poyang Lake, China

LCLUC Program Content

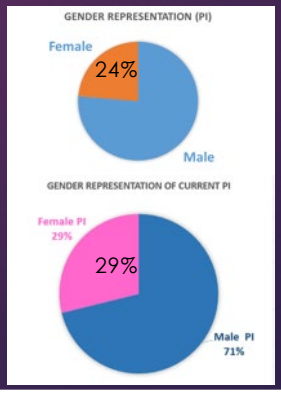
25-yr Program stats:

- >300 projects
  - ~50 ongoing
- >800 researchers
  - >20 post-docs
  - >50 grads
- >1000 publications





Impacts - 1/3
Monitoring - 1/3
Synthesis, other - 1/3



http://lcluc.hq.nasa.gov

Mass Growing by "Coalescence"

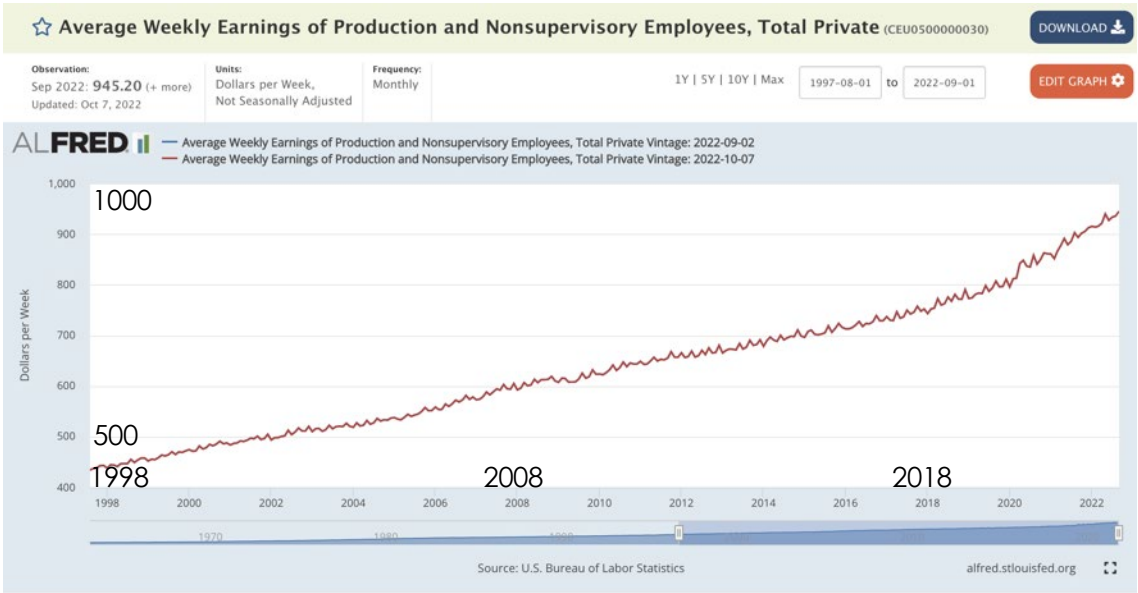
- Carbon Cycle program
- Inter-Disciplinary Science program (IDS)
- Instrument teams
  - Landsat
  - TERRA/AQUA/NPP
- ACCESS/MEASURES
- **Multi-Source Land Imaging (MuSLI)**

LCLUC Budget in Time

- **Inflation, sequestration, harvesting – I will get by - I will survive... (Jerry Garcia)**
- **Growing demand, growing community**
- **Balancing LCLUC processes and geography**

"The overall top-line 2022 budget for Science Mission Directorate is $7.9B, the **highest SMD budget in the history of NASA**, even accounting for inflationary increases"

...and we got by, we did survive...



The Role of Social Science

- **Human Dimensions have an important role in LCLUC**
- **Social and Economic science research includes**
  - **impacts of changes in human behavior and economy on LCLUC**
  - **impacts of LCLUC on society**
  - **adaption to climate change of land-use systems**
- **The Socio-Economic component has been a mandatory part of all LCLUC proposals, unless otherwise stated in the solicitation**

LCLUC Program
Science Team Meetings

In Greater Washington DC Area

Spring Blossom → Fall Colors

LCLUC-2020 virtual in October (Fall Colors)

LCLUC-2021 in-person in October (Fall Colors)

LCLUC-2022 (CC&E Focus Area Joint Meeting) May 2022 (back to Spring Blossom)

LCLUC Synthesis: the Early Years

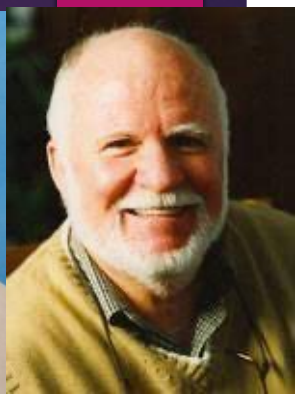

Jack Mustard


Ruth DeFries


Tom Fisher


Emilio Moran


Ron Rindfuss


Billy Turner

- Case studies over the world
- Synthesis
  - Patterns to processes
  - Disturbances and feedbacks
  - Trajectories and projections

The LCLUC milestone: 2004

Garik Gutman,
Anthony C. Janetos,
Christopher O. Justice,
Emilio F. Moran,
John F. Mustard,
Ronald R. Rindfuss,
David Skole,
Billy Lee Turner II and
Mark A. Cochrane

Trajectories of Economic and Land Use Development

LCLUC International Regional Initiatives

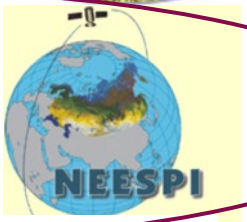
- **SAFARI (South Africa)**

- 3-year project, began in August 1999
- studied the environment of southern Africa
- LCLUC: burning of African forests & savanna
- Goal: to explore how emissions affect phenomena ranging from regional crop productivity to global climate change.

- **LBA (Amazon)**

- Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): 1998-2006
- LBA-Eco: Field campaign in several sites to help answering questions on forest conversion, re-growth, selective logging, and the sustainable land use in Amazonia

- **NEESPI (Northern Eurasia)**



- The Northern Eurasia Earth Partnership Initiative (NEESPI) 2006-2016.
- Currently, Northern Eurasian Future Initiative (NEFI) a regional component of Future Earth

- **MAIRS (Monsoon Asia)**

- The MAIRS programme (Monsoon Asia Integrated Regional Study) 2006-2016
- Currently, Monsoon Asia Integrated research for Sustainability - part of Future Earth

- **SARI (South/Southeast Asia)**

- South/Southeast Asia Research Initiative (SARI) 2014-2024
- LCLUC interactions on climate, water resources, biodiversity, atmosphere, vulnerability, impacts and adaptation issues

25 Years of External Linkages: International

- **Global Observations of Forest Cover and Land-use Dynamics (GOFC-GOLD) since 1997**
  - **Fire Implementation Team office at UMD funded by LCLUC**
  - **Regional Information Networks**
- **CEOS/GEO**
  - **International Working Group on Calibration and Validation**
  - **Land Surface Imaging (LSI) Constellation Working Group**
  - **Global Landcover Datasets (SB-02 C1)**
- **IGBP/IHDP → Future Earth**
  - **Global Land Program (GLP)**
  - **Some LCLUCers are**
    - **GLP fellows or Sci Steering Com members or GLP Nodal Coordinators**

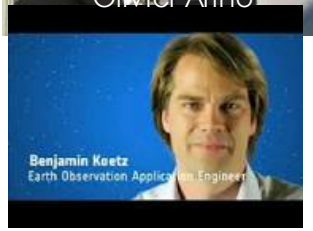
- **International Regional Initiatives**
  - **SAFARI (South Africa)**
  - **LBA (Amazon)**
  - **NEESPI (Northern Eurasia)**
  - **MAIRS (Monsoon Asia)**
- **EARSeL (EU Remote Sensing Labs)**
  - **LULC Special Interest Group**
    - **Joint biennial workshops**
- **Space Agencies**
  - **ESA and worldwide**


Ioannis Manakos

Olivier Arino


Ariane de Bremond Peter Verburg


Francesco Sarti



25 Years of International Regional Initiatives
LCLUC First 10 years

- NASA EOS **Southern African** Regional Science Initiative
  - **SAFARI** 2000


NASA SAFARI-2000 LCLUCers

Chris Justice, U. VA

David Roy, U. MD

- Large-Scale Biosphere-Atmopshere Experiment in **Amazonia** (**LBA**)
  - LBA ECO 1998-2006


Project Scientist, LBA-ECO
Michael Keller, USFS

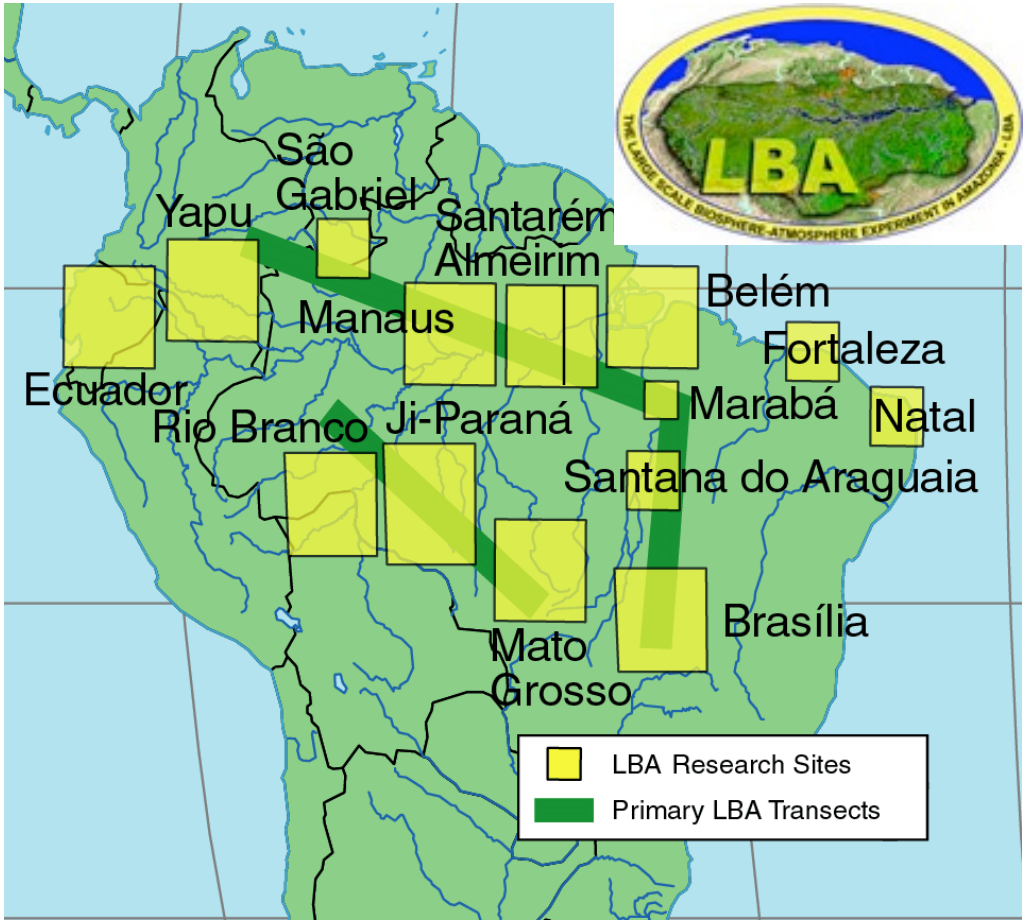
Project Manager. LBA-ECO
Don Deering, NASA GSFC

SAFARI 2000

Each ETM+ scene (185km*185km) had a local SAFNet collaborator

- 3-year project, began in August 1999
- studied the environment of southern Africa
- LCLUC component
  - the burning of African forests & savanna
- Goal: to explore how emissions affect phenomena ranging from regional crop productivity to global climate change.

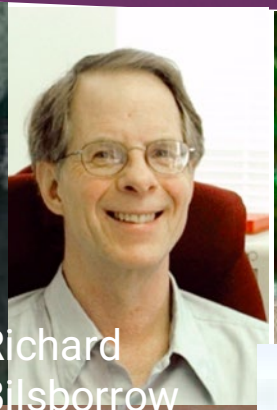
Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA): 1998-2006



LBA ECO LCLUCers

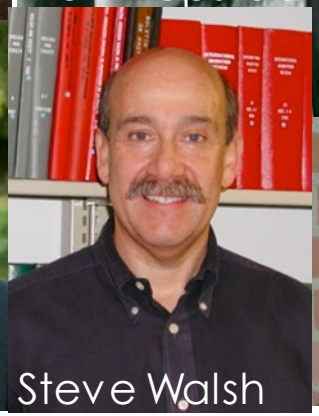

Greg Asner


Dan Nepstad

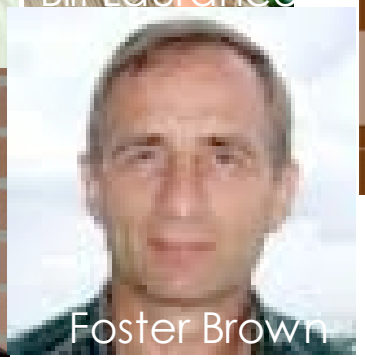

Richard Bilsborrow

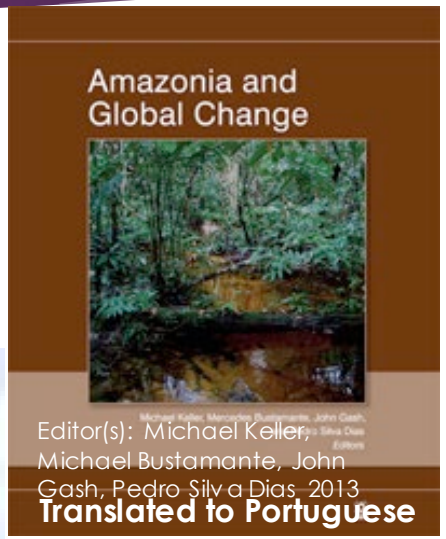

Bill Laurance


Emilio Moran


Steve Walsh


Bob Walker


Foster Brown



Editor(s): Michael Keller, Michael Bustamante, John Gash, Pedro Silva Dias, 2013

Translated to Portuguese

LBA Synthesis


Michael Keller, USFS

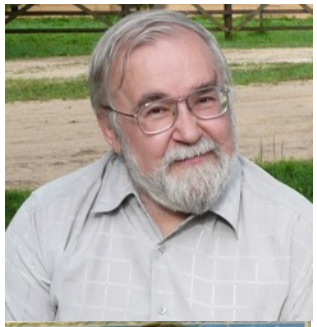
LBA ECO Project Scientist

Science Question: How do tropical forest conversion, re-growth, and selective logging, influence carbon storage, nutrient dynamics, trace gas fluxes, and the prospect for sustainable land use in Amazonia?

International Regional Initiatives

LCLUC Last 15 years

- **Northern Eurasia** Earth Science Partnership Initiative (**NEESPI**)
  - **NEFI** under Future Earth
- **Monsoon Asia** Integrated Regional Study (**MAIRS**)
  - under Future Earth/**Future Asia**
- **South/Southeast Asia** Research Initiative (**SARI**)



Project Scientst
NASA-NEESPI/NEFI
Pasha Groisman, NOAA

Project Scientist
NASA-MAIRS
Jiaguo Qi, MSU

Project Scientist
NASA-SARI
Krishna Vadrevu, NASA, MSFC

International Regional Science Team Meetings Last 15 years

Northern Eurasia Earth Science Partnership Initiative: 2006-2016

NASA-RAS Interactions in Early 90's
RAS: Russian Academy of Sciences

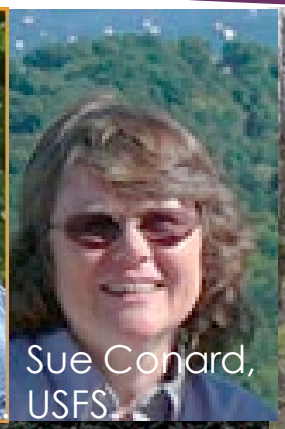
Gen. Korovin,
(Inter. Forest Inst.)
Deputy Dir.
Specialists on Fires

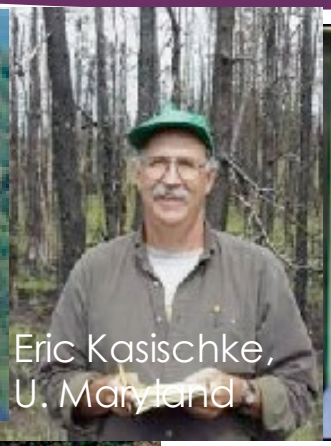
Acad. Aleks. Isaev
(Inter. Forest Inst.)
Led RAS-NASA
interactions before
& during NEESPI era

Bob Murphy (NASA HQ)
Facilitated installation of
AVHRR Receiving Stations
Prior to NEESPI in mid-90's

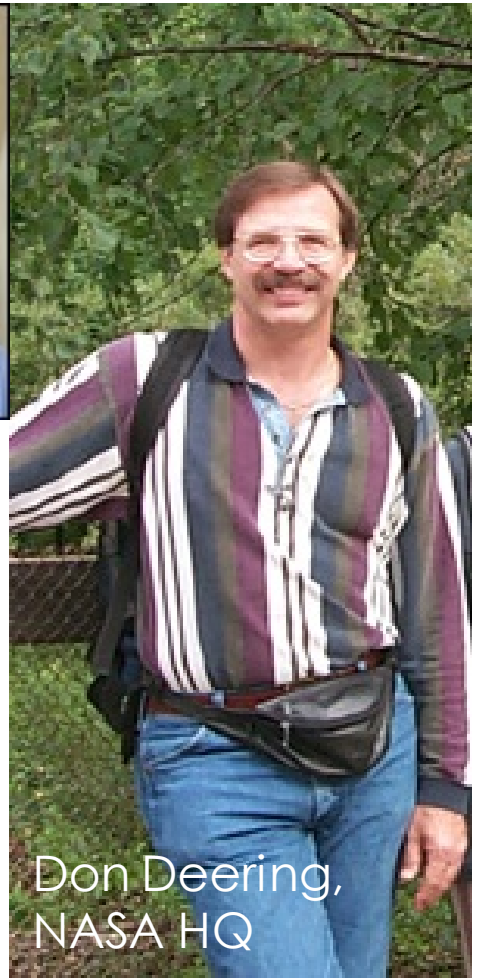
Pre-NEESPI Leads of Projects in Russia

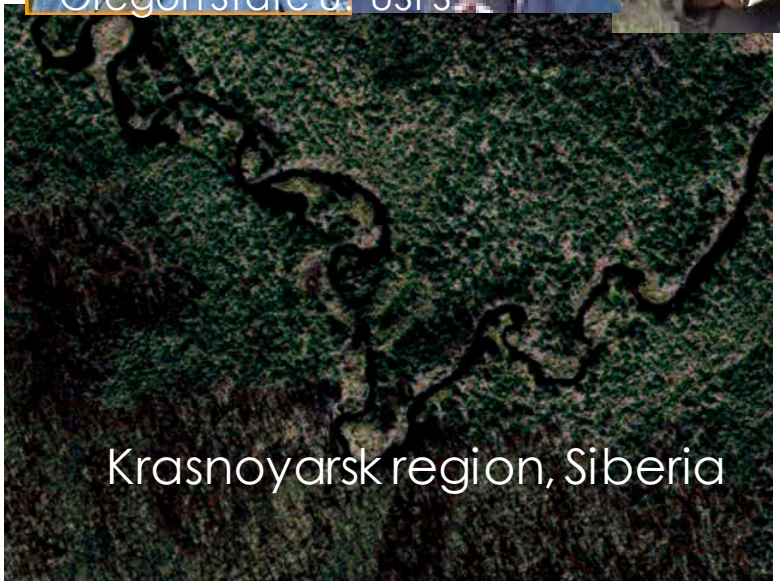

Olga Krankina, Oregon State U.

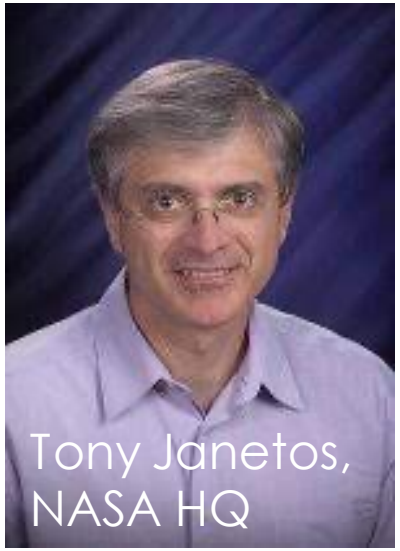

Sue Conard, USFS


Eric Kasischke, U. Maryland


Jon Ranson, NASA HQ

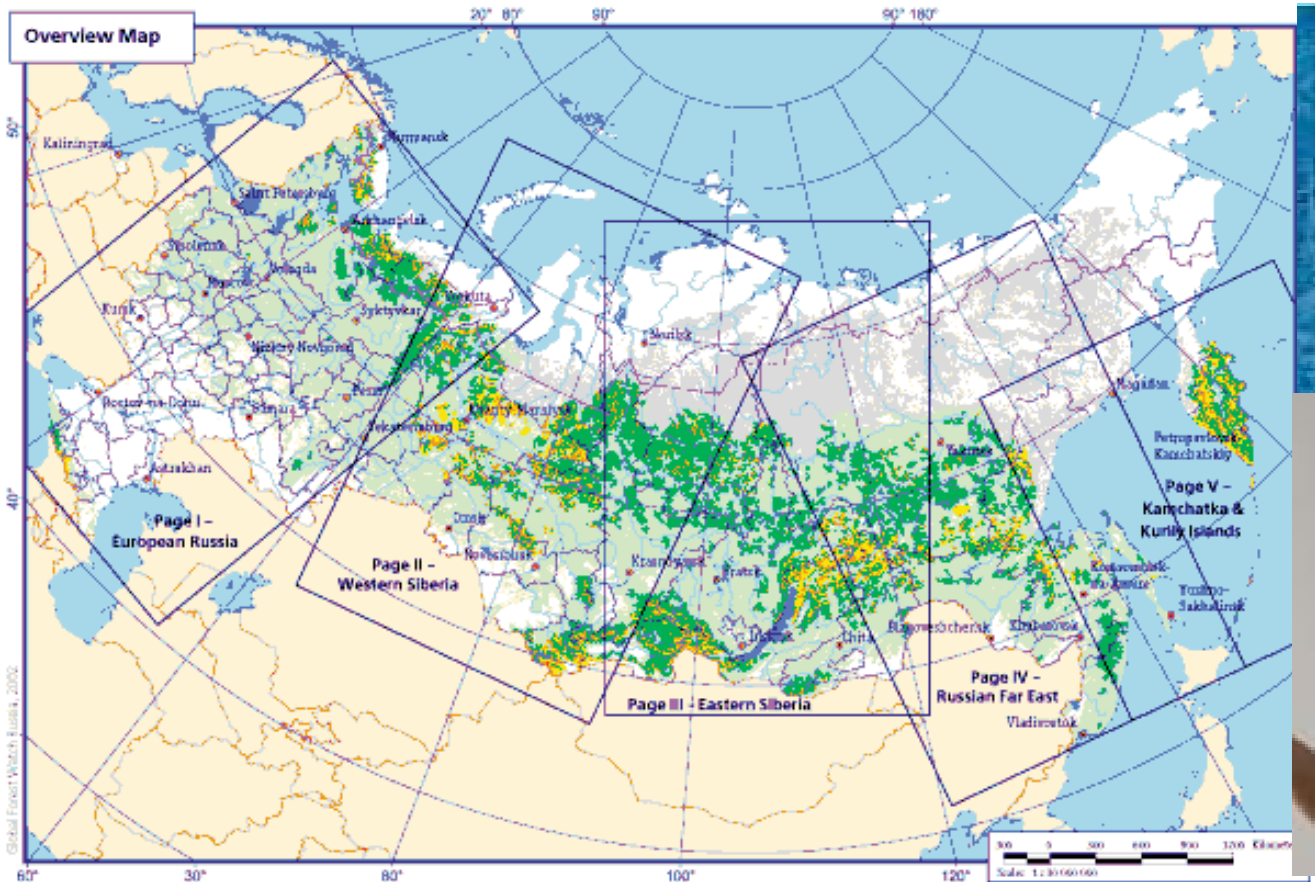

Don Deering, NASA HQ


Krasnoyarsk region, Siberia


Tony Janetos, NASA HQ

Pre-NEESPI Product: Intact Forest Landscapes of Northern Eurasia:

NASA + World Resource Institute + Green Peace Russia



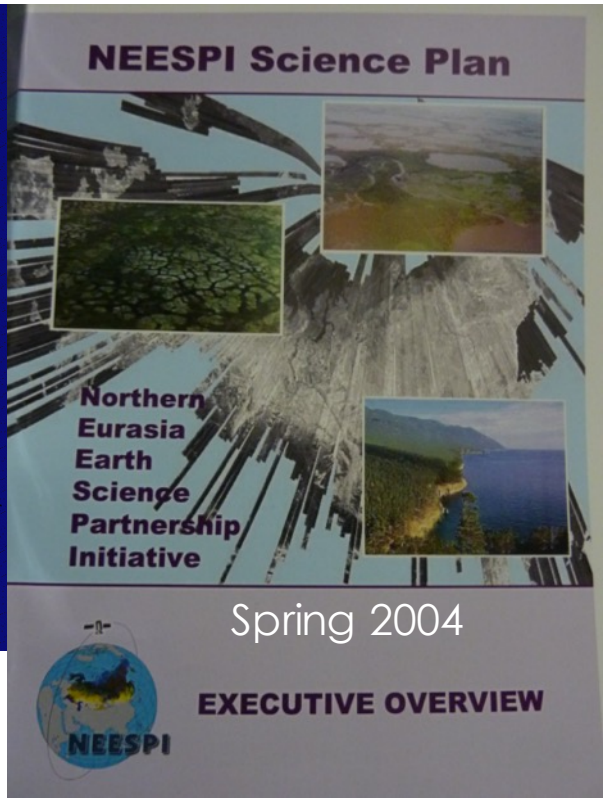
Peter V. Potapov, UMD

Svetlana Turubanova, UMD

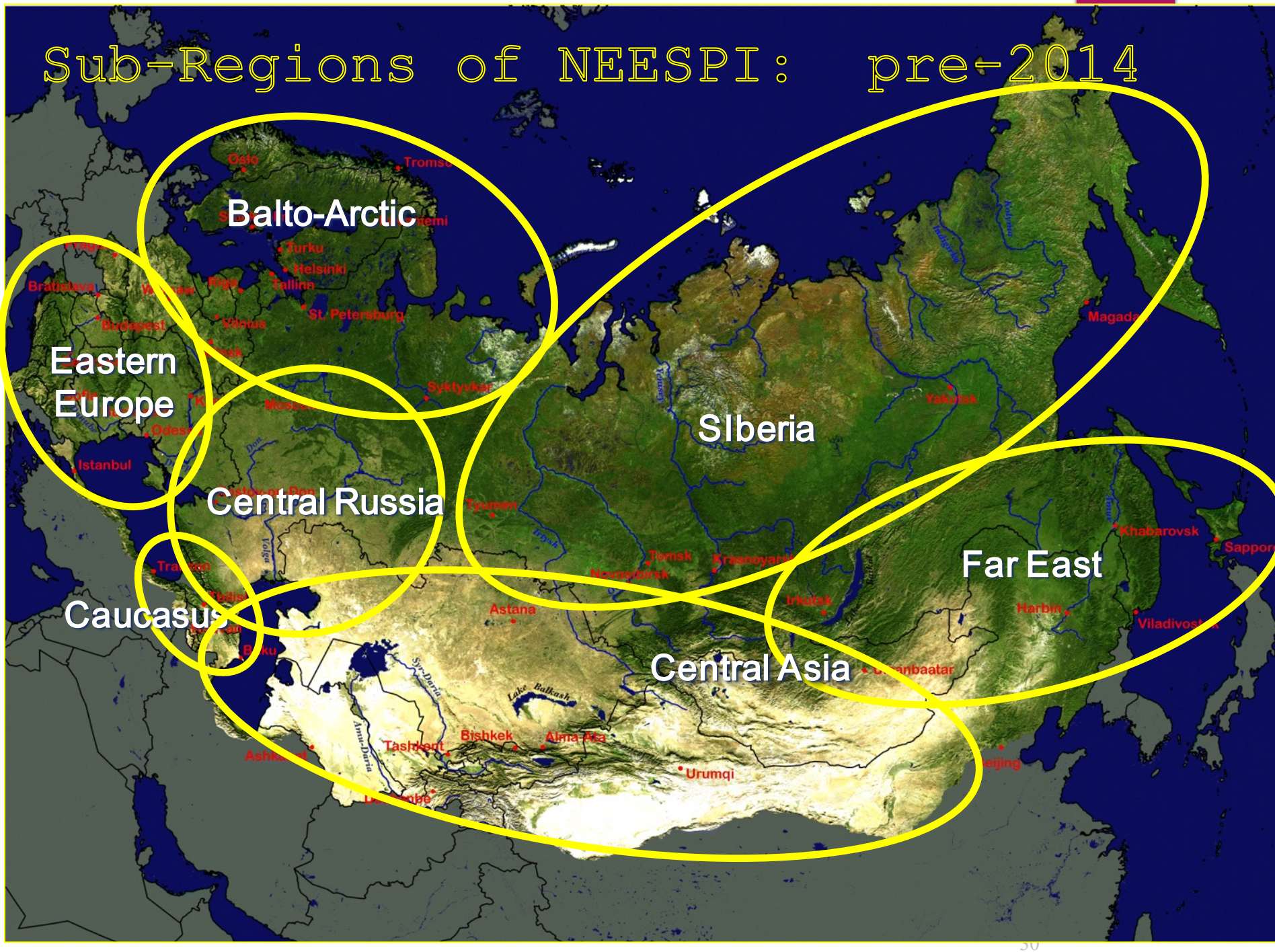
NEESPI Yalta Summit
Review of Science Plan: 2003

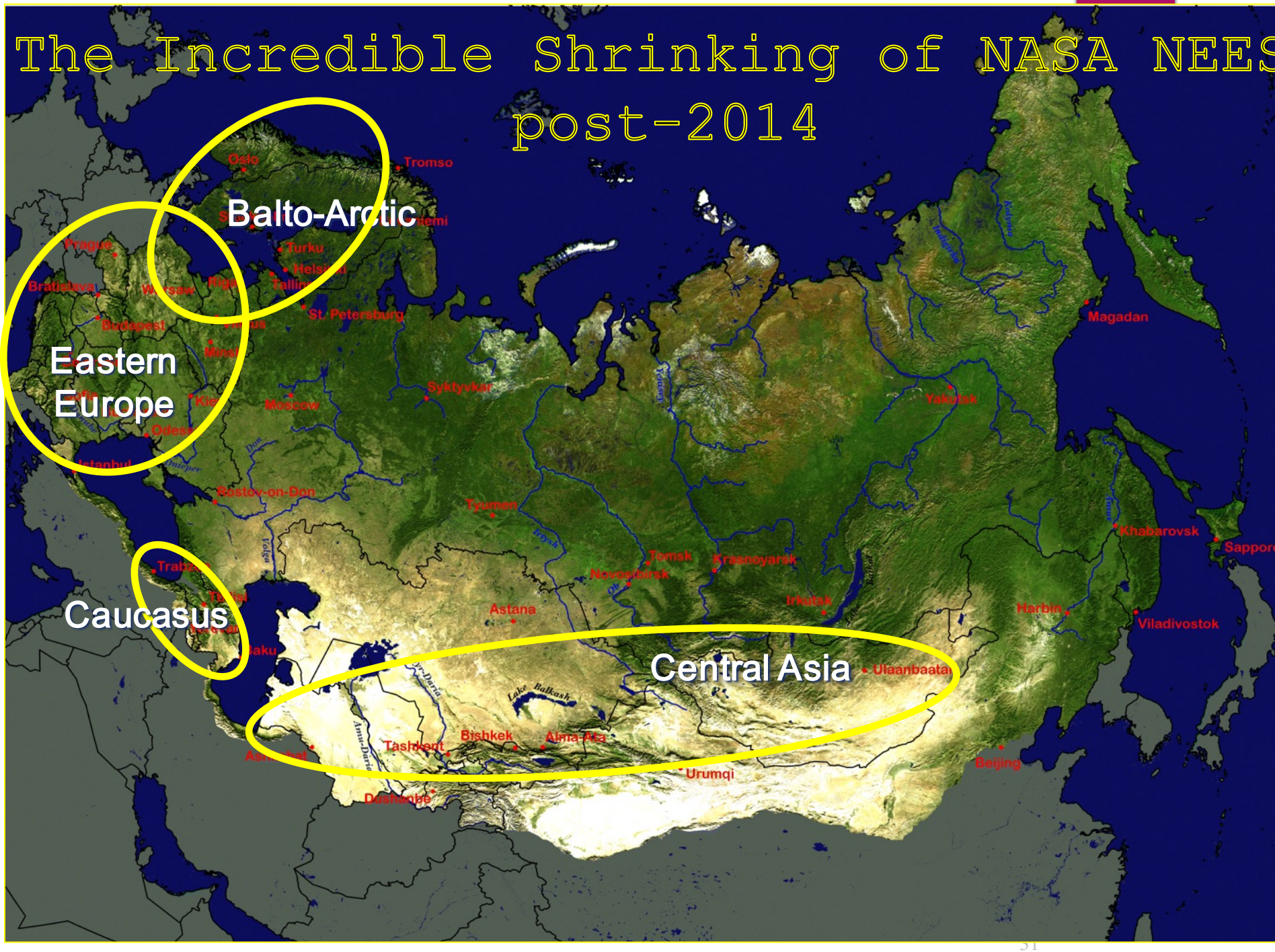
NEESPI Approved @ NASA HQ 2005

NEESPI MODIS RGB Composite
Used to hang on the wall @NASA HQ
Courtesy: Mutlu Ozdogan, U. Wisconsin

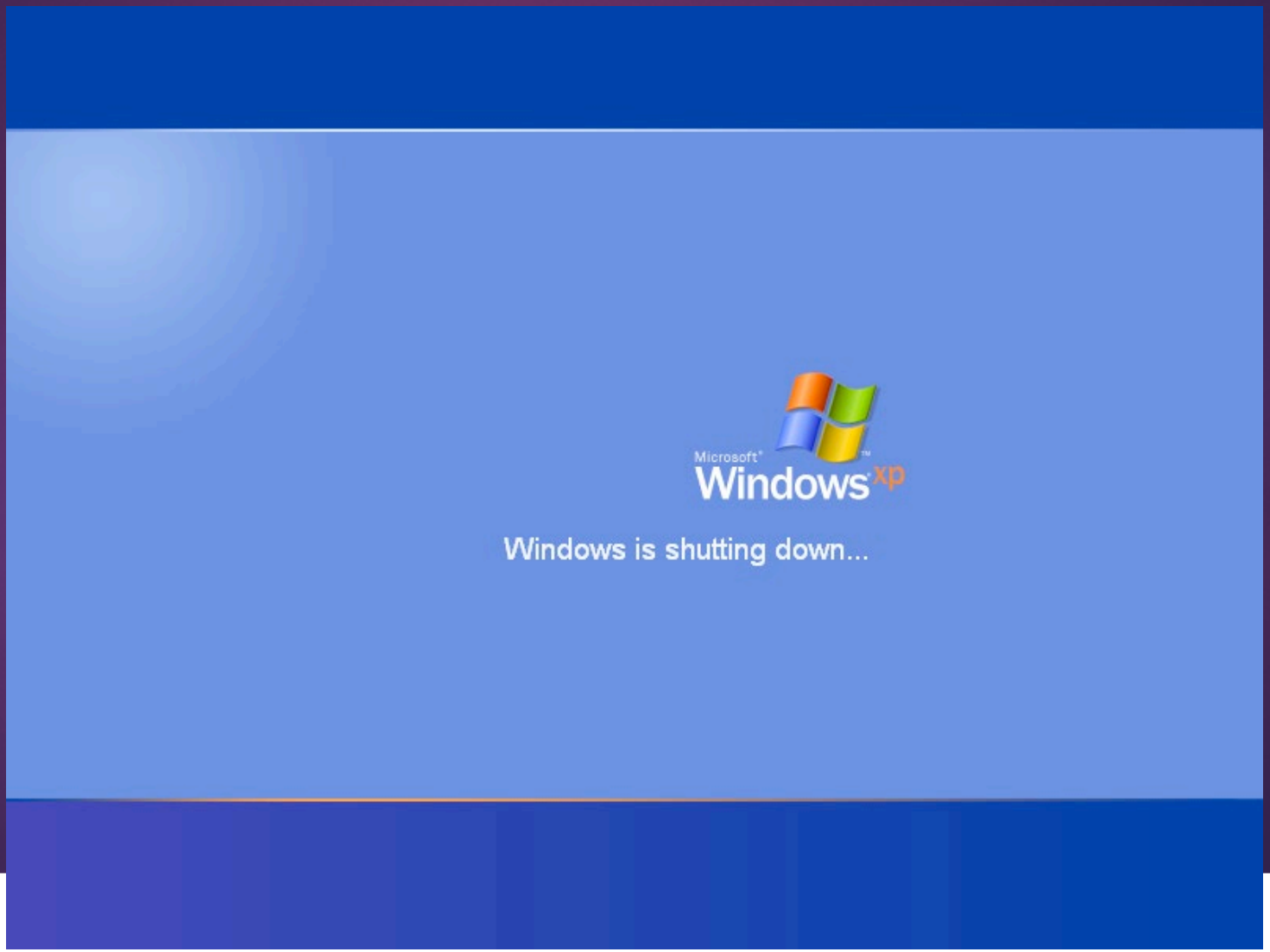


Ghassem Asrar,
Associate Administrator, Earth Science 1998-2005
NASA HQ
Senior Vice President, Science @USRA


Sub-Regions of NEESPI: pre-2014
Balto-Arctic
Eastern Europe
Central Russia
Caucasus
SIberia
Far East
Central Asia
Oslo
Tromso
Turku
Helsinki
Tallinn
Riga
St. Petersburg
Vilnius
Bratislava
Budapest
Istanbul
Odessa
Syktyvkar
Yakutsk
Magadan
Tyumen
Tomsk
Krasnoyarsk
Novosibirsk
Irkutsk
Khabarovsk
Harbin
Astana
Bishkek
Alma-Ata
Tashkent
Urumqi
Lake Balkash
Syr-Darya
Amu-Darya


The Incredible Shrinking of NASA NEES
post-2014
Balto-Arctic
Eastern Europe
Caucasus
Central Asia
Oslo
Tromso
Turku
Helsinki
Tallinn
Riga
Prague
Bratislava
Warsaw
Budapest
Minsk
Kiev
Odessa
Istanbul
St. Petersburg
Moscow
Syktyvkar
Rostov-on-Don
Tyumen
Magadan
Yakutsk
Khabarovsk
Tomsk
Novosibirsk
Krasnoyarsk
Irkutsk
Harbin
Viladivostok
Trabzon
Tbilisi
Baku
Astana
Ulaanbaatar
Lake Balkash
Bishkek
Alma-Ata
Tashkent
Urumqi
Beijing
Dushanbe
Dnieper
Don
Volga
Ural
Ob
Yenisey
Lena
Amur

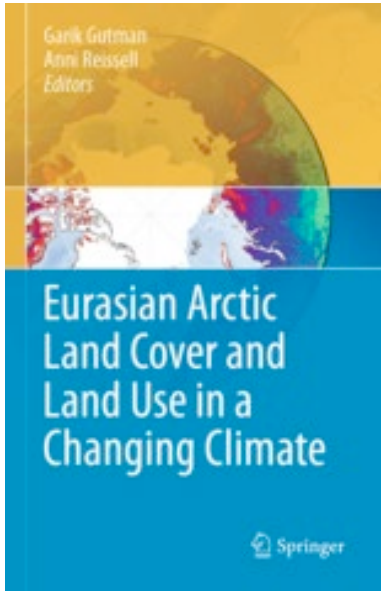
Window of Opportunity in NASA-Russia Relations: 2004 -2014



NEESPI-LCLUC Science

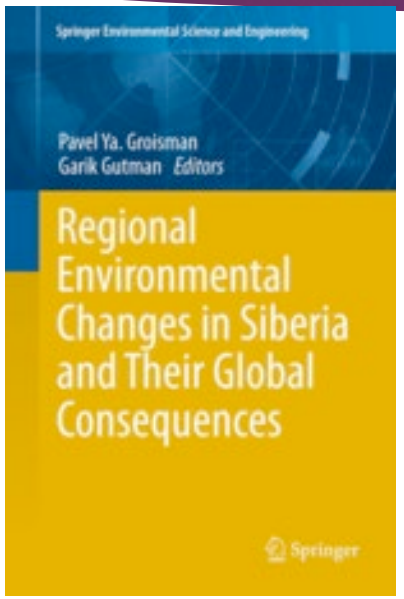
NEESPI: Northern Eurasia Earth Science Partnership Initiative

NEESPI → NEFI (Northern Eurasia Future Initiative)



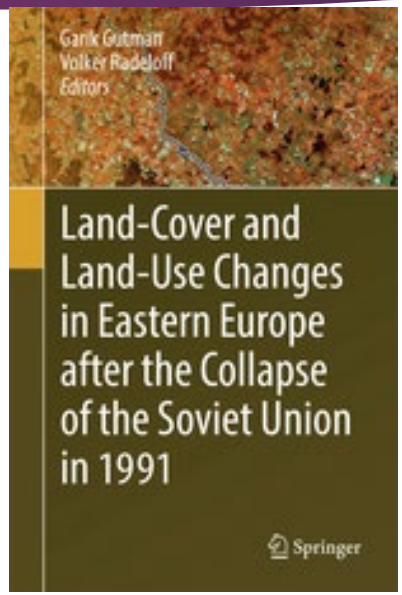
Springer 2010

Arctic



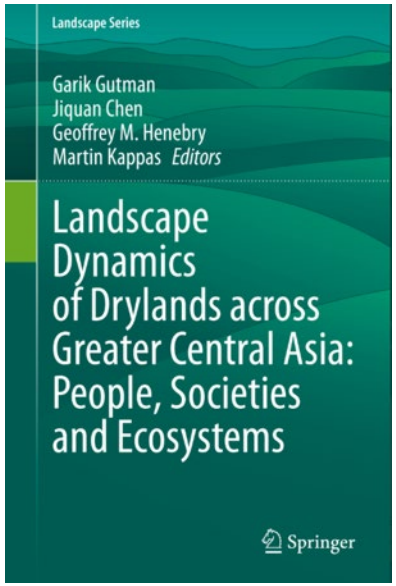
Springer 2012

Siberia



Springer 2017

Eastern Europe



Springer 2020

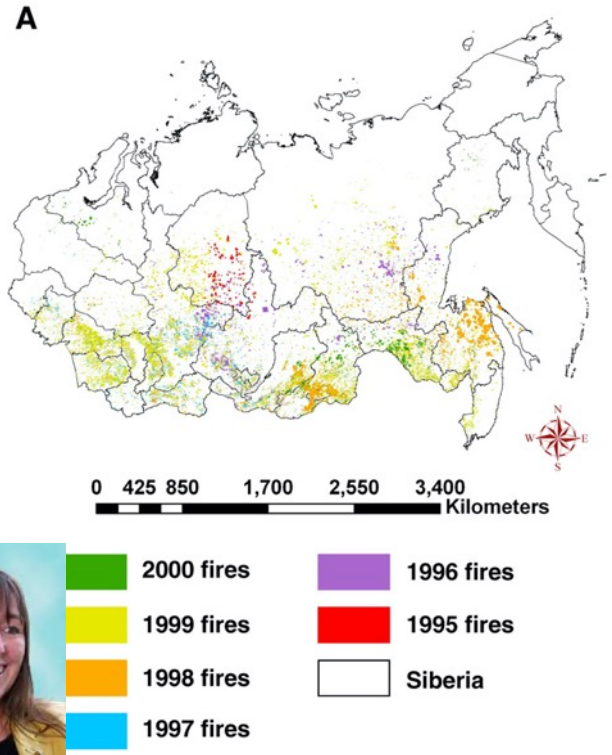
Central Asia

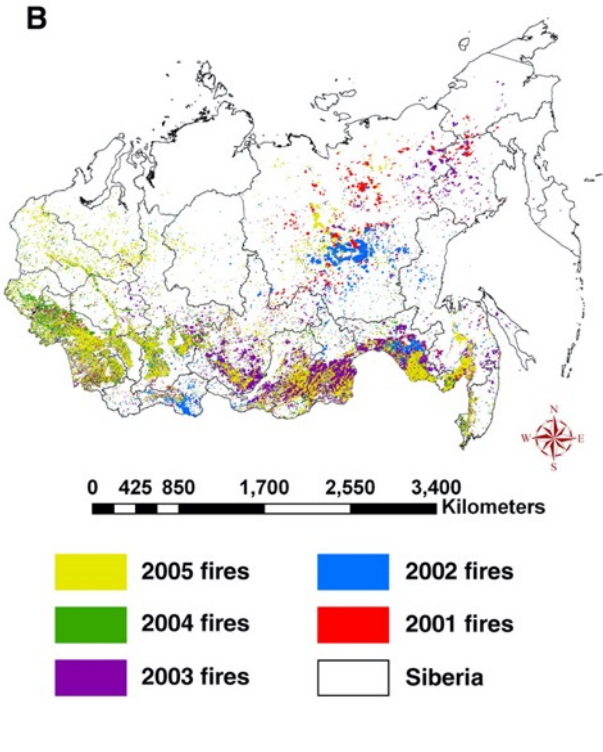
> 750 scientists from 200 institutions in 30 countries with > 170 projects
80 Ph.D. students

>1500 papers

Source or sink?

- Shift in terrestrial ecosystem C balance from a sink to a source may be occurring in the boreal forests of northern Eurasia as a result of changes in climate and an increase in fire activity in recent years
- Visible increase in the number of fires in Siberia during this decade





Amber Soja, NASA Langley

LCLUC in the Arctic

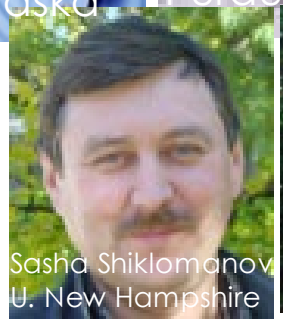
- Nancy Maynard,.,*et al*. (2011). Impacts of Arctic Climate and Land Use Changes on Reindeer Pastoralism: Indigenous Knowledge and Remote Sensing
- International Polar Year (IPY) project EALÁT (www.ealat.org)
- The EALÁT story has been selected for inclusion in Science for Environment Policy, http://ec.europa.eu/environment/integration/research/research_alert_en.htm

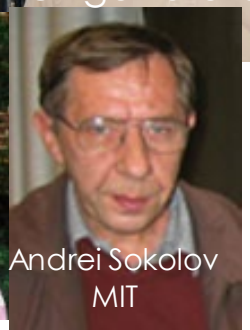
Nancy Maynard

Reindeer herding

Industrial pollution
In the Arctic

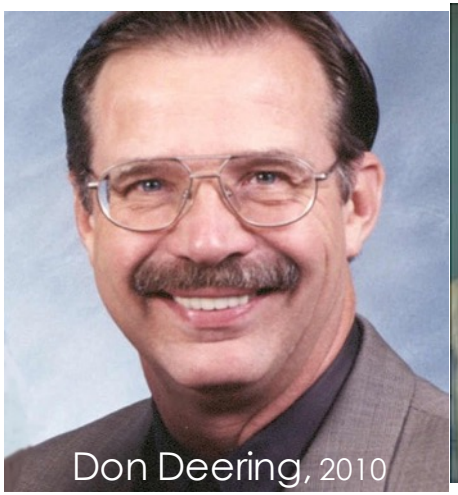
NEESPI Synthesis





NEESPI-LCLUC: In Memoriam

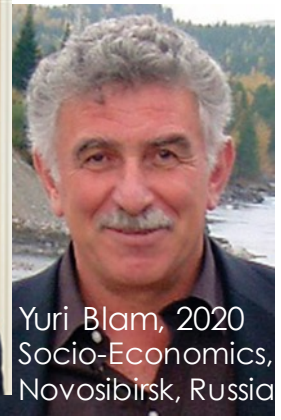
As times go by…



NEESPI Project Manager
@NASA GSFC

Creator of NEESPI GIOVANNI Interface @NASA GSFC

NEESPI Chief Scientist, RAS



Supporter of Pre-NEESPI
NASA-RAS projects,
LCLUC 1st Program Manager

The organizer of the NEESPI Science Plan Review in Yalta, Ukraine 2003

The China Issue

Karen Seto	Multi-Scale and Multi-Sensor Analysis of Urban Cluster Development and Agricultural Land Loss in China and India	04/01/2011	03/31/2014
Shunlin Liang	Accessing Chinese Satellite Data Products for Land Applications	01/01/2010	01/01/2013
Daniel Brown	Grassland Ecosystems and Societal Adaptations Under Changing Grazing Intensity and Climate on the Mongolian Plateau	07/01/2009	06/30/2012
Jiquan Chen	Interactive Changes of Ecosystems and Societies on the Mongolian Plateau: From Coupled Regulations of Land Use and Changing Climate to Adaptation	05/20/2009	05/19/2012
Peilei Fan	China's Urbanization and Its Sustainability Under Future Climate Change	04/21/2009	04/20/2012
Gregory Leptoukh	NASA Data and Services Supporting Monsoon Asia Integrated Regional Study in Eastern Asia	04/01/2009	08/31/2012
Annemarie Schneider	Monitoring and Modeling Urbanization in China: A Mixed Methods and Multi-Scale Approach	04/01/2008	03/12/2012

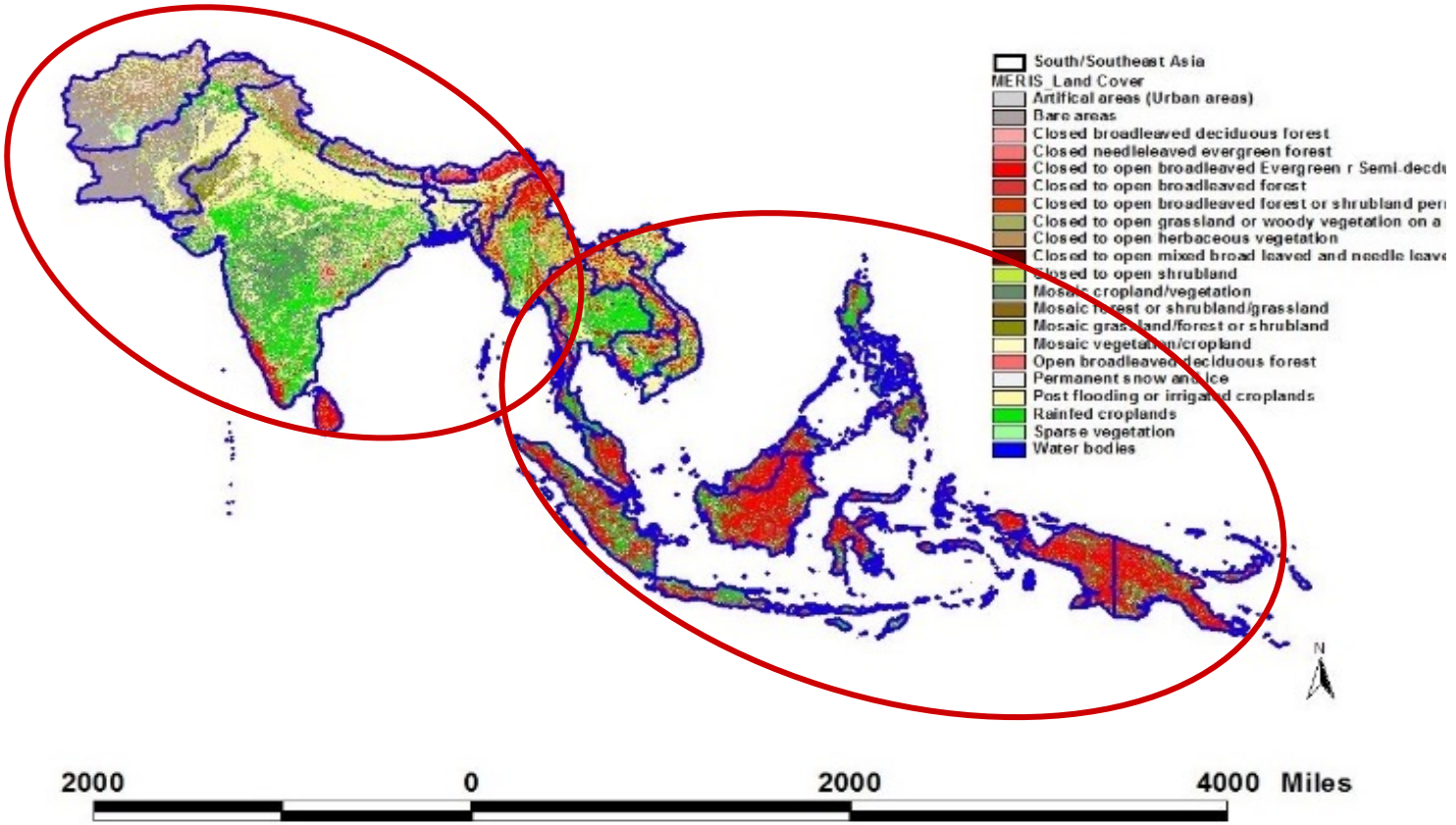
The **Wolf Amendment** - the law passed by the United States Congress in 2011 that prohibits NASA from using government funds to engage in direct, bilateral cooperation with China-affiliated organizations from its activities without explicit authorization from FBI and the U.S. Congress.

Frank Wolf, Rep. Virginia

Last 10 years: Projects on China without collaborations in China... --- not easy!

Last 7 years: Projects on Russia without collaborations in Russia ... --- not easy!

South/Southeast Asia Research Initiative: SARI



NASA-MAIRS Pre-SARI Studies: <2015

Pre-SARI Synthesis Projects 2012-2014

LCLUC-2012

- Atul Jain, U. of Illinois
  - Land Cover and Land Use Changes and Their Effects on Carbon Dynamics in South and Southeast Asia: A Synthesis Study

- Jeff Fox, East-West Center, Hawaii
  - Forest, Agricultural, and Urban Transitions in Mainland Southeast Asia: Synthesizing Knowledge and Developing Theory

LCLUC-2013

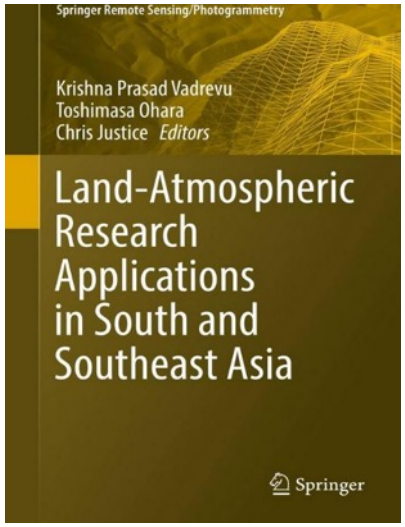
- Peilei Fan, Michigan State
  - Urbanization and Sustainability Under Global Change and Transitional Economies: Synthesis from Southeast, East and North Asia

- Seto, Karen , Yale U.
  - Synthesis of LCLUC studies on Urbanization: State of the Art, Gaps in Knowledge, and New Directions for Remote Sensing Science

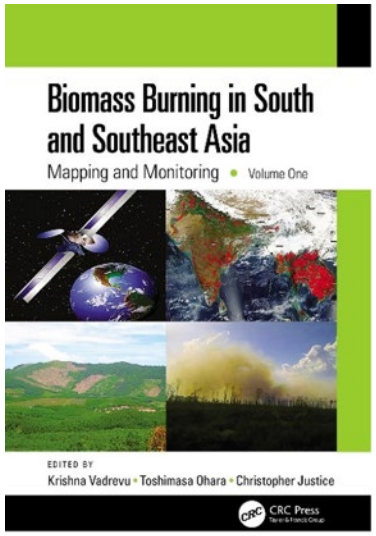
NASA-SARI Science

- pre-SARI studies and synthesis projects
- LCLUC-2015: South Asia
- LCLUC-2016: Southeast Asia
- LCLUC-2018: All Asia

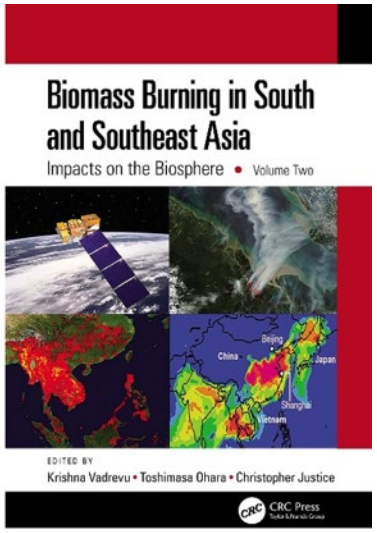
- > 250 scientists
- >150 institutions
- 15 countries
- > 25 projects
- >250 papers
- 12 special issues



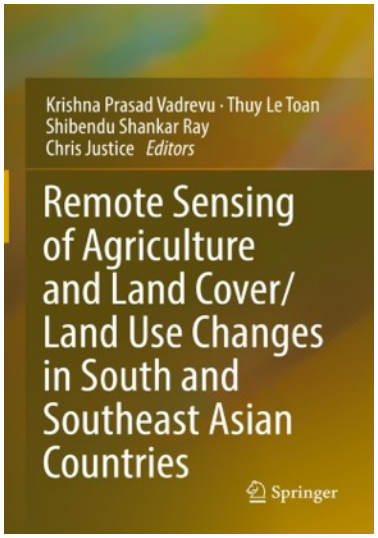
Springer 2018



CRC Press, 2021



CRC Press, 2021

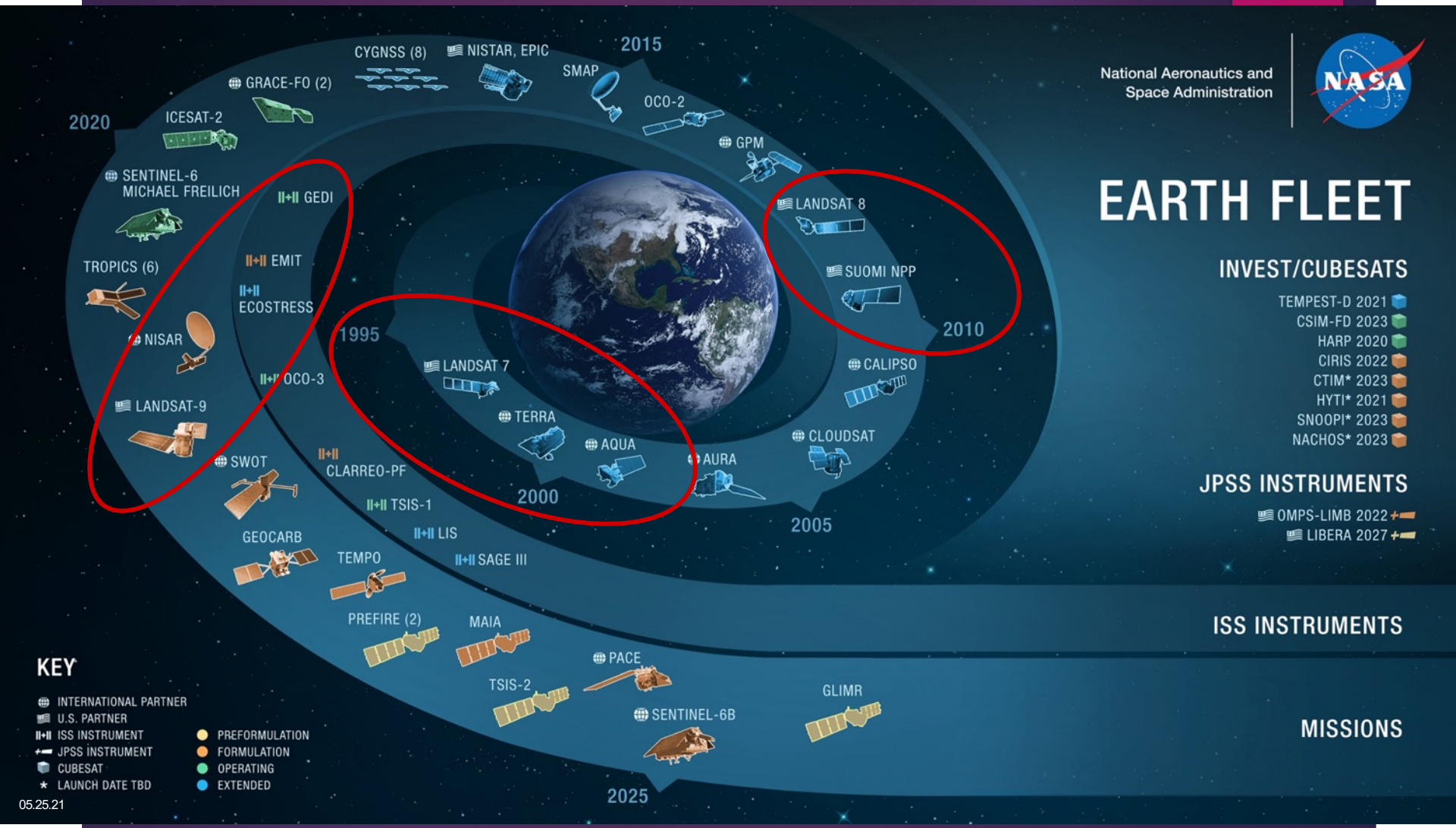


Springer 2022

25 Years of Regional Programs: Summary of Accomplishments

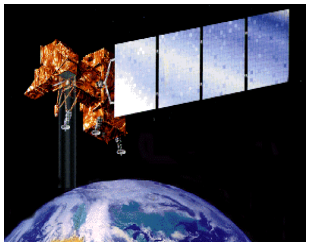
The program has

- **advanced scientific analysis** to areas of the globe where LCLUC is taking place and provided insight into the various impacts of these changes
- **examined the underlying drivers** of land-use change including socio- economic, political, institutional aspects in diverse regions of the globe
- **evaluated the role of satellite data** in initiating projections of future regional land-use change
- **built broad networks** of international scientists that routinely utilize NASA data to monitor regional land-use change


National Aeronautics and Space Administration
NASA
EARTH FLEET
INVEST/CUBESATS
TEMPEST-D 2021
CSIM-FD 2023
HARP 2020
CIRIS 2022
CTIM* 2023
HYTI* 2021
SNOOPI* 2023
NACHOS* 2023
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
2015
2020
1995
2010
2000
2005
2025
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GPM
GRACE-FO (2)
ICESAT-2
SENTINEL-6 MICHAEL FREILICH
GEDI
LANDSAT 8
SUOMI NPP
TROPICS (6)
EMIT
ECOSTRESS
NISAR
OCO-3
LANDSAT 7
CALIPSO
LANDSAT-9
TERRA
AQUA
AURA
CLOUDSAT
SWOT
CLARREO-PF
TSIS-1
LIS
GEOCARB
TEMPO
SAGE III
PREFIRE (2)
MAIA
PACE
TSIS-2
SENTINEL-6B
GLIMR
KEY
INTERNATIONAL PARTNER
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
PREFORMULATION
FORMULATION
OPERATING
EXTENDED
05.25.21

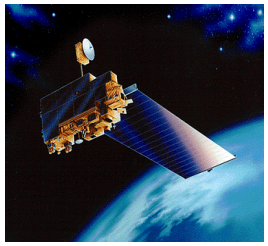
NASA LCLUC-Relevant Missions: 25 years of Remote Sensing

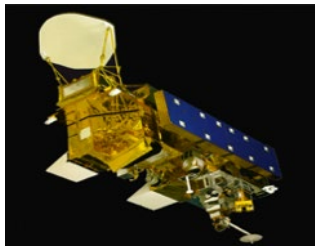
Systematic Missions - Observation of Key Earth System Interactions



Landsat 5 & 7

3/1/84 & 4/15/99





Terra

12/18/99

ASTER MODIS

Aqua

5/3/02

Suomi-NPP

10/28/11

VIIRS

Landsat 8

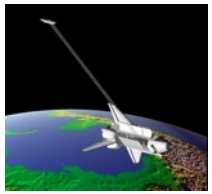
2/11/13

Landsat 9

Sep 2021

Exploratory Missions –

Exploration of Specific Earth System Processes and Demonstration of Technologies

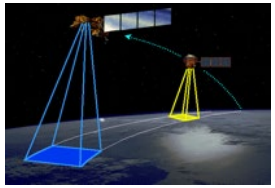


ShuttleRadar Topography Mission

SRTM active

2/11/02-2/22/02

Space Shuttle Endeavour



Earth Observing EO-1

ALI (predecessor of Landsat-8)

Hyperion – first hyperspectral in space

11/21/00-3/30/2017

International Space Station (ISS)

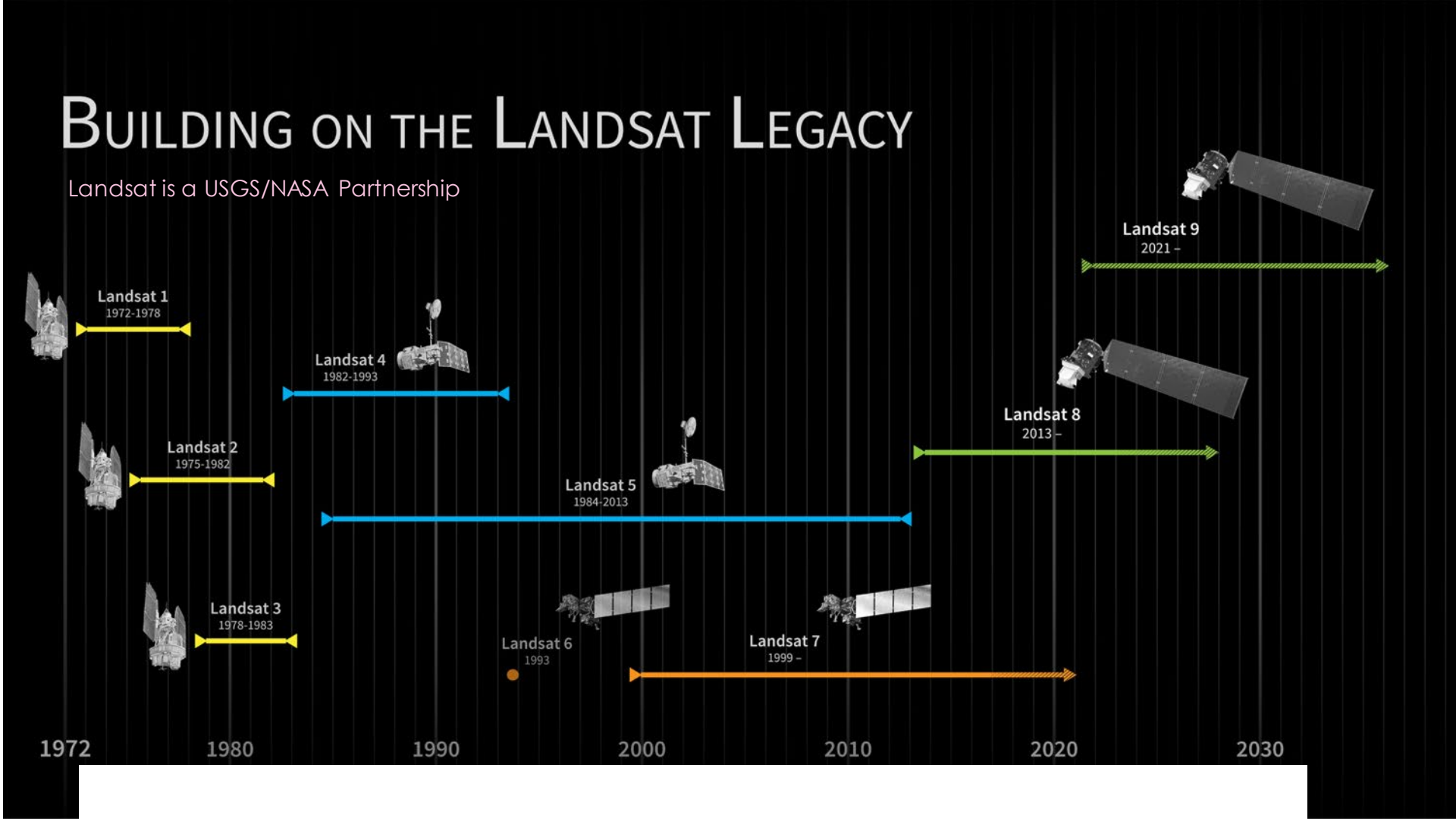
ECOSTRESS (thermal IR)

GEDI (Lidar)**active**

DESIS (Hyperspectral)

Building on the Landsat Legacy

Landsat is a USGS/NASA Partnership



- The Landsat program: Earth Resources Technology Satellites Program 1966, Landsat 1 (ERTS) launched in July 1972
- Thermal band added for Landsat 3 and beyond
- After launch, Landsat operations are transferred from NASA to USGS to collect, archive, process, and distribute the image data
- Until 2010 expensive, FREE NOW!
- Two-Landsat system frequency revisit time: 8 days -- in some areas may not provide enough observations for monitoring rapid changes (e.g., Ag) but sufficient for slow changes (e.g., Urban)

Data Aspects

- NASA LCLUC program expects its PIs to make their data and products available to the community for free and open access

LCLUC PIs must provide metadata on data products generated under NASA-funded projects

- LCLUC metadata page
- Very High-Resolution (VHR) data for NASA-affiliated scientists

Metadata

Displaying 1 - 35 of 35

Search by Keywords

Apply Reset

Metadata Title	Project name	Team	Institution	Project Start Date	Project End Date
Land-Use Status, Change and Impacts in Vietnam/Cambodia/Laos	Land Use Status, Change and Impacts in Vietnam, Cambodia and Laos	Son Nghiem, Andrea Gaughan Forrest Stevens	Jet Propulsion Laboratory	05/01/2018	12/31/2021
Understanding the Role of Land Cover/Land Use Nexus in Malaria Transmission Under Changing Socio-Economic Climate in Myanmar	Understanding the Role of Land Cover/Land Use Nexus in Malaria Transmission Under Changing Socio-Economic Climate in Myanmar	Tatiana Loboda, Mark Carroll Julie Silva Myaing Nyunt Christopher Plowe Kathleen Stewart	University of Maryland	05/01/2017	03/01/2020
Complex Forest Landscapes and Sociopolitical Drivers of Deforestation - The Interplay of Land-use Policies, Armed Conflict, and Human Displacement in Myanmar	Complex Forest Landscapes and Sociopolitical Drivers of Deforestation - The Interplay of Land-use Policies, Armed Conflict, and Human Displacement in Myanmar	Peter Leimgruber, Qiongyu Huang Melissa Songer Joseph Sexton Min Feng Saurabh Channan Enze Han Kevin Woods	Smithsonian Institution	05/01/2017	05/01/2020

Commercial Smallsat Data Acquisition (CSDA) Program Update

The commercial data currently distributed by NASA are available under different scientific use licenses and various access portals. The Commercial Smallsat Data Acquisition (CSDA) program evaluates and procures data from commercial vendors that advance NASA's Earth science research and applications activities. Currently, data acquired during the evaluations of Planet, Maxar (formerly DigitalGlobe, Inc.), and Spire Global are available. Data from the Teledyne Brown Engineering, Inc., DLR Earth Sensing Imaging Spectrometer (DESIS) also are available through a separate collaboration with the International Space Station (ISS).

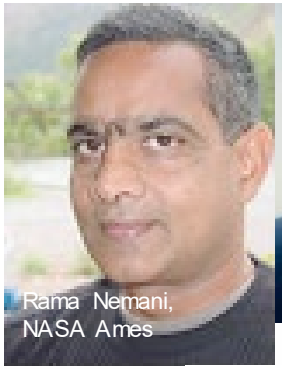
More Info: https://earthdata.nasa.gov/esds/csdap/commercial-datasets

PDF file:

CSDA_ROSES_data_access_overview[1].pdf

NASA Earth Exchange (NEX)
NASA Ames Center Portal

- **Provides resources** (core data sets, software/workflows, and computing) for data- and compute-intensive, NASA-supported Earth science grand challenges
- **Engages and enables the Earth science community** to address global environmental challenges
- **Improves efficiency** and expands the scope of NASA Earth science technology, research and applications programs
- **Shares community-generated datasets and results** to promote cross-collaboration and reduce the overall burden for teams to execute on future work
  - MODIS, Landsat, VIIRS, GOES, Sentinel-2 and other project-relevant data on high-throughput POSIX-based file systems
  - All data can be accessed from the NEX datapool directories


Rama Nemani, NASA Ames


Jennifer Dungan, NASA Ames

https://nex.nasa.gov
https://www.nasa.gov/nex/access

25-Year of Global LCLUC Products: Summary of Achievements

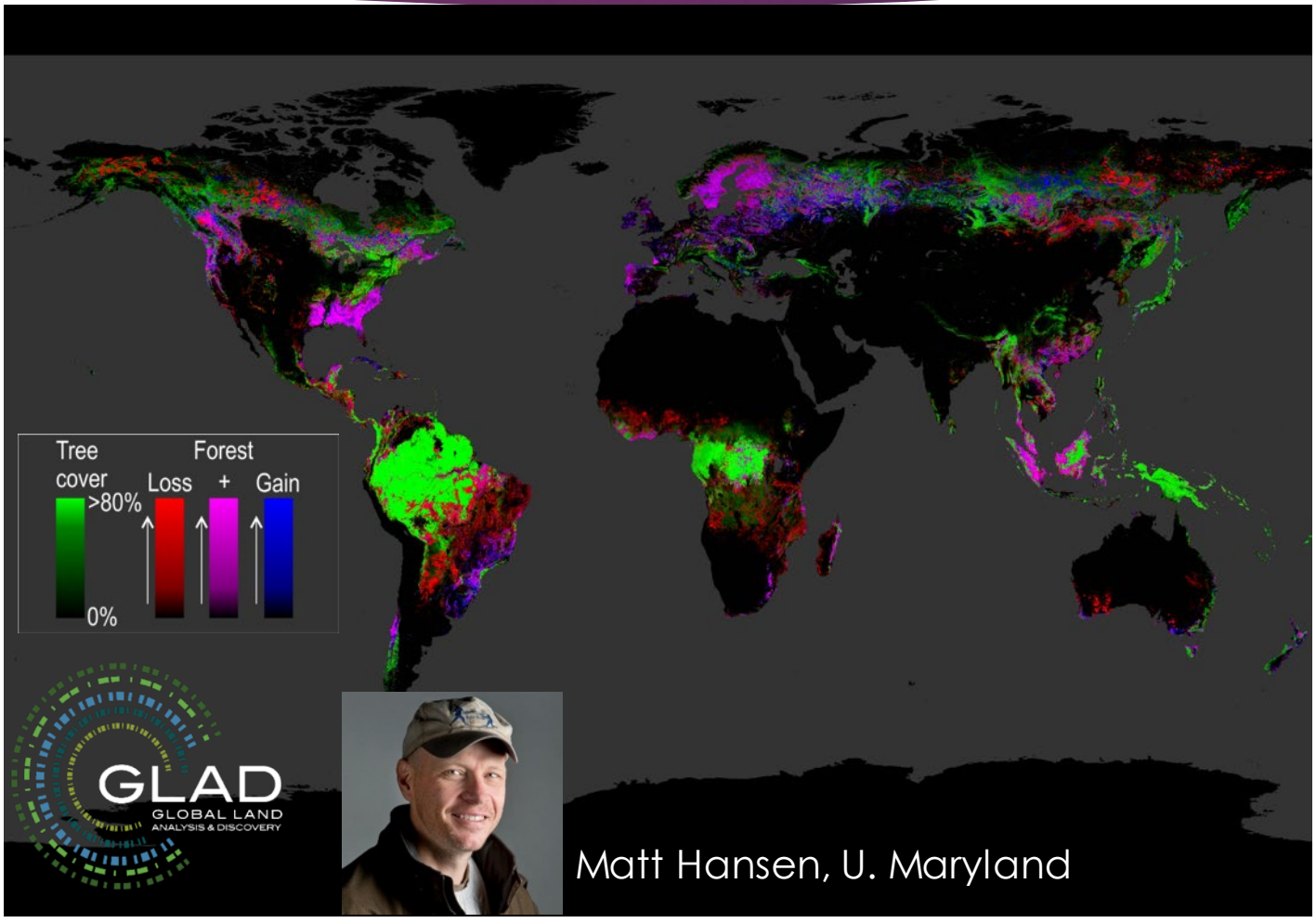
The program has

- **provided the basis for monitoring**, reporting and verification of urban-, forest-, and agricultural cover change in the context of the implementation of Carbon Treaties
- **created the means to undertake periodic, continuous global assessments** of Land-Cover and Land-Use Change
- **quantified rapid changes** in the urban built environment, forest cover and agriculture around the globe
- **provided the primary science rationale** for the Landsat Mission and, more general, Sustainable Land Imaging
- **developed** global Landsat-based products

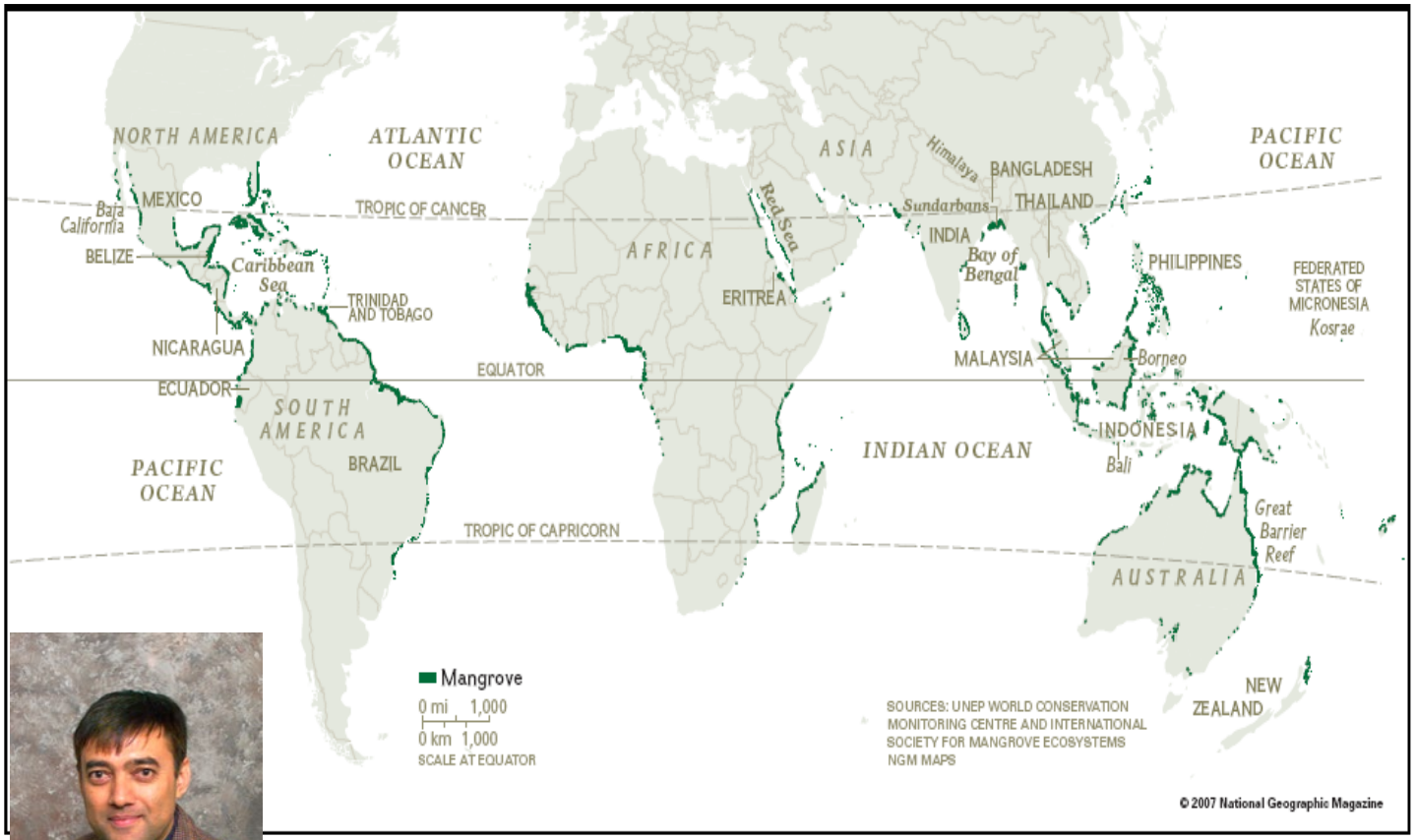
Global Mosaic Using Landsat-7 and -5

David Roy, State Dakota State U. → Michigan State U.

Tree Cover Extent and Forest Loss and Gain: 2000-2014

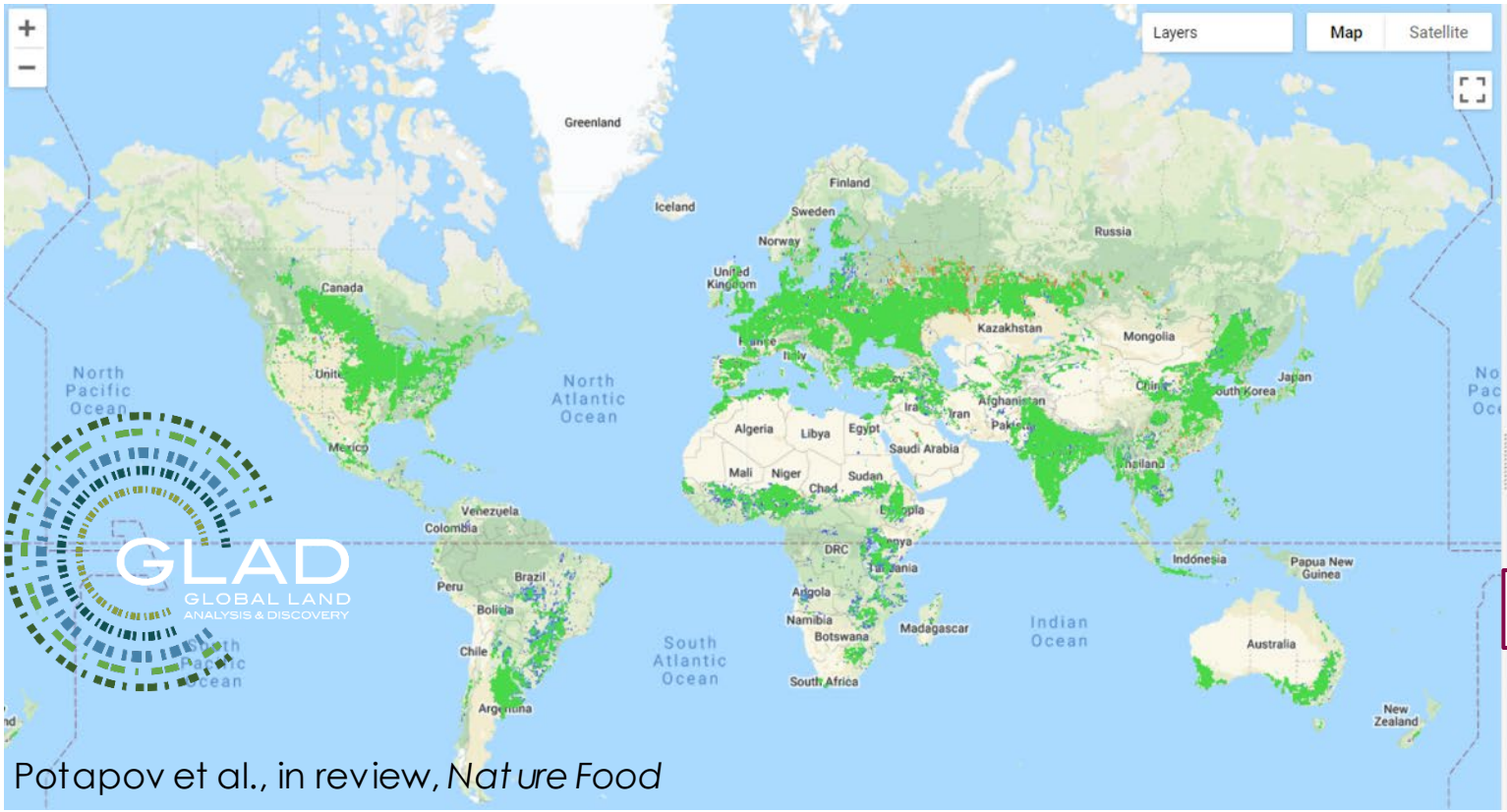


Mangroves Extent



Chandra Giri, USGS → EPA

Global cropland extent and change 2000-2020



Global cropland expansion in the 21st century

Global cropland dynamics 2000-2019

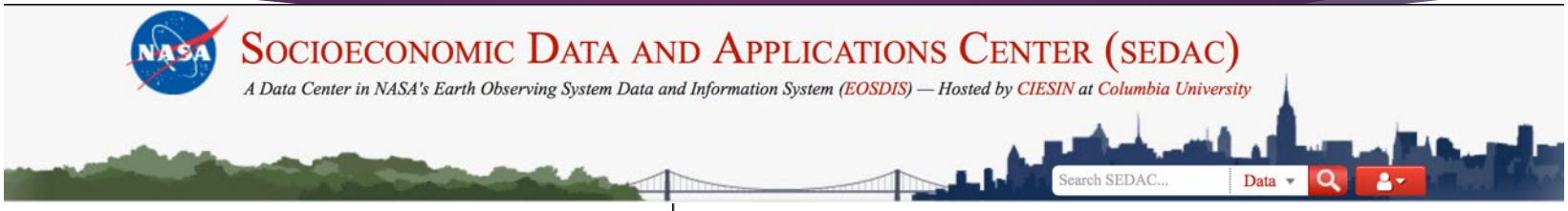
Global cropland dynamics 2000-2019:

- Stable cropland
- Intermittent cropland: 4/5 intervals
- Intermittent cropland: 3/5 intervals
- Intermittent cropland: 2/5 intervals
- Cropland gain in 2004-2007
- Cropland gain in 2008-2011
- Cropland gain in 2012-2015
- Cropland gain in 2016-2019
- Cropland loss in 2004-2007
- Cropland loss in 2008-2011
- Cropland loss in 2012-2015
- Cropland loss in 2016-2019

Potapov et al., in review, *Nature Food*

UNIVERSITY OF MARYLAND 18 56

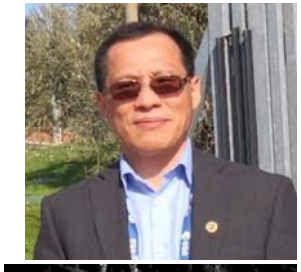
Impervious Surfaces and Settlements Extent

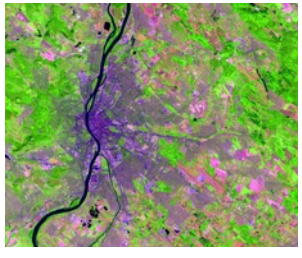


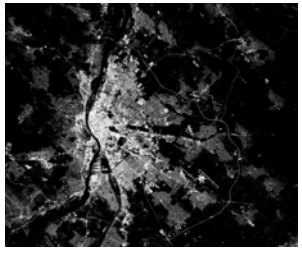
"The Global High Resolution Urban Data from Landsat data collection contains the two companion data sets produced by

Eric Brown de Colstoun, NASA GSFC

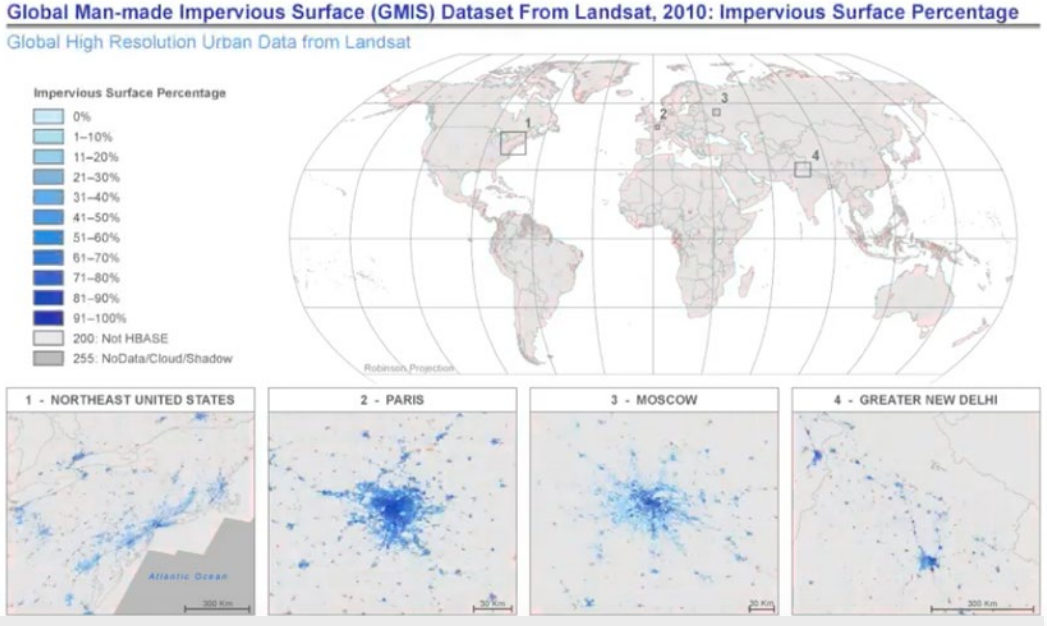
Cheng Huang U. Maryland





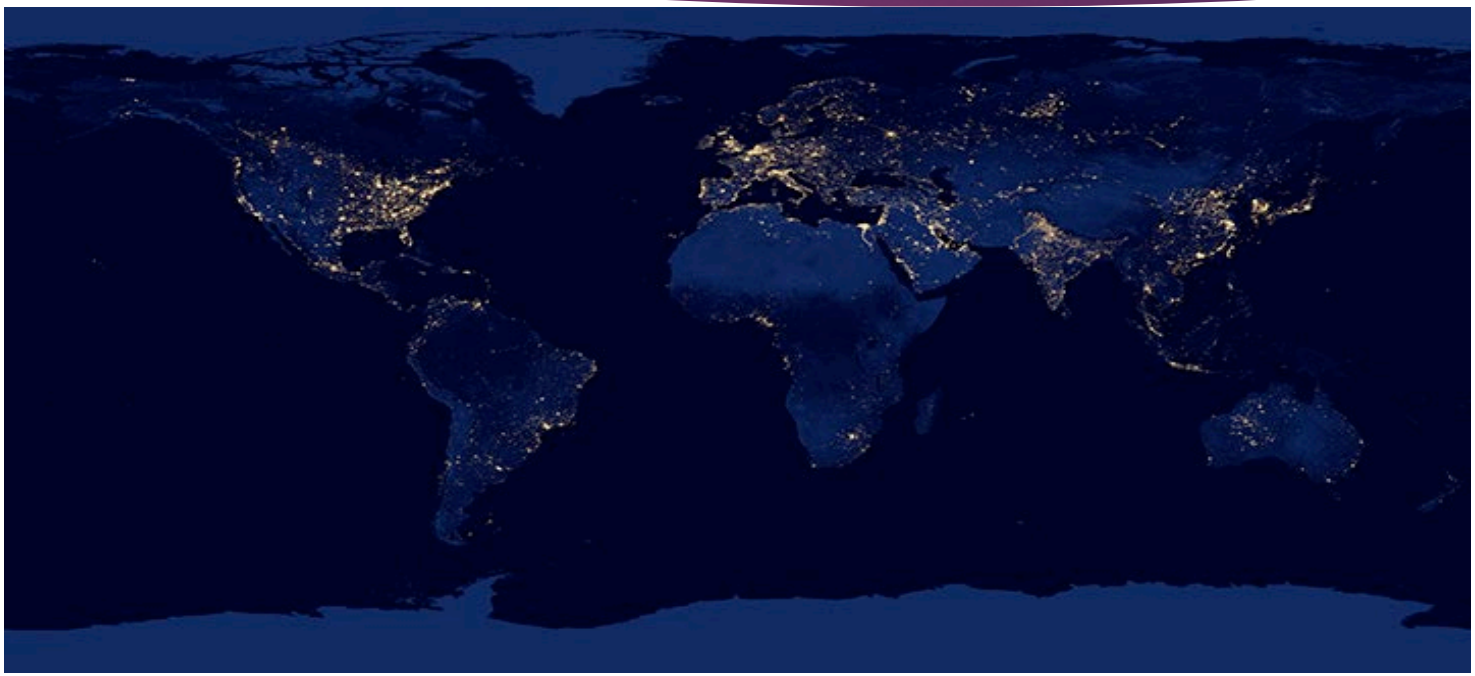


Budapest from Landsat (2010)



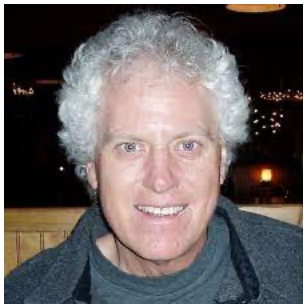
- LCLUC Global Products (available since 2015)
  - Global Man-made Impervious Surfaces
  - Global Human Built-up And Settlement Extent

Global Night Lights: DMSP/OLS→ VIIRS/S-NPP



From OLS (5km^2/ 6 bits) to VIIRS(742 m^2 /14 bit)

The Night Lights composite assembled from data acquired by the Suomi National Polar-orbiting Partnership (Suomi NPP) satellite over nine days in April 2012 and thirteen days in October 2012.



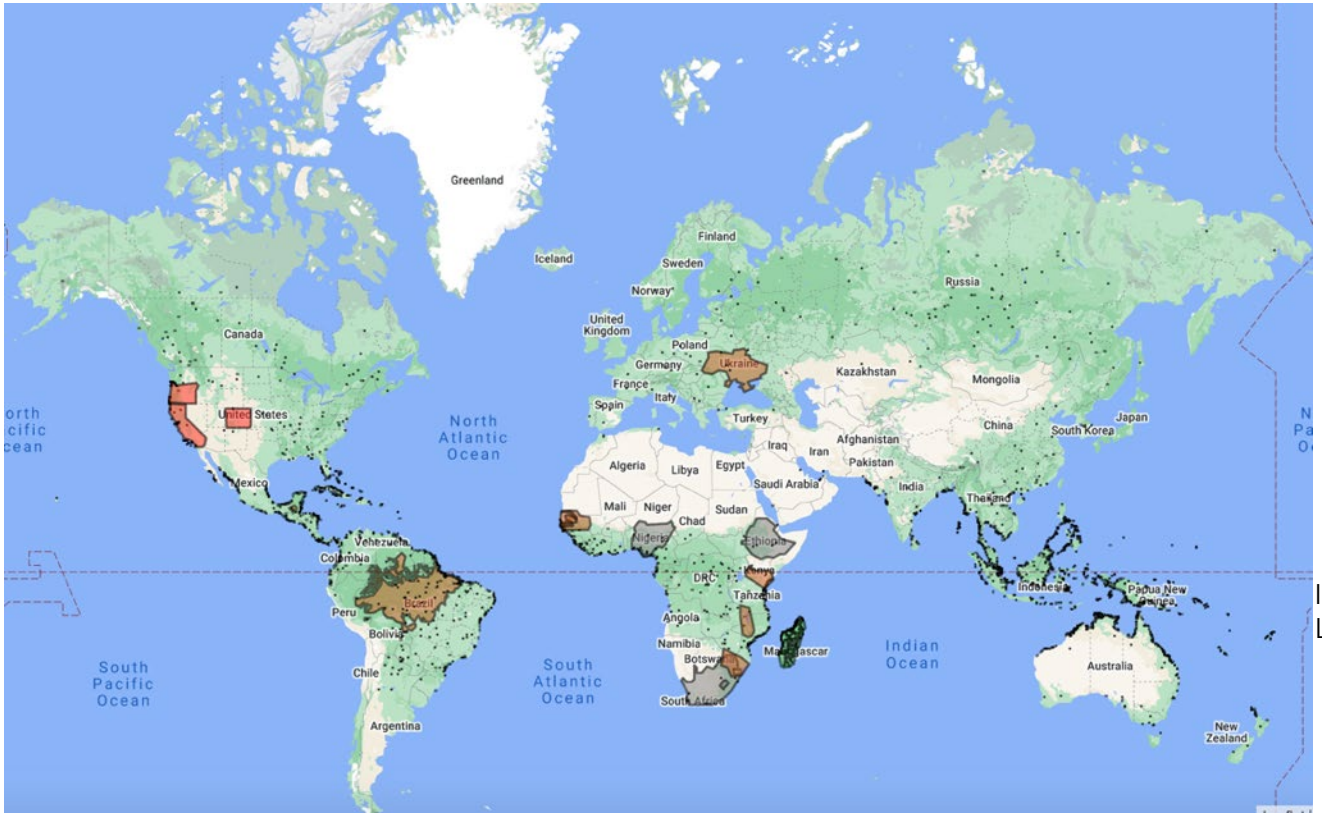
Chris Elvidge
NOAA → Colorado School of Mines

Miguel Román,
NASA GSFC

Towards a Global LCLUC Hotspots Map

Agriculture

Mining

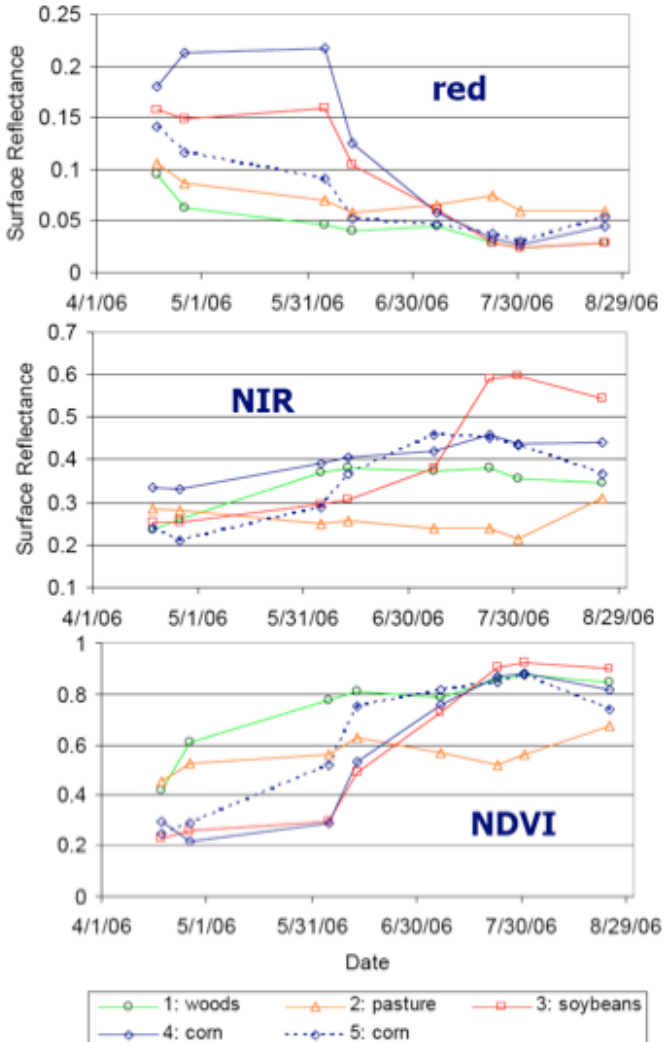


Indrani Kommareddy
LCLUC Program

LCLUC-20 Selections

Will be complemented by SARI hotspots and LCLUC-21 selections

Merging Data From Landsat-like Mid-Resolution Sensors Prior to ESA Sentinel Program



Land-cover phenology at 30 m

- Red reflectance, near-infrared (NIR) reflectance, and NDVI values for individual fields from central Illinois during the first half of the 2006 growing season

- Data are combined from **Landsat-5, -7, ASTER, and IRS**

Courtesy: Feng Gao, USDA

Multi-Source Land Imaging (MuSLI)

Combining optical and microwave data: Landsat + Sentinel2 + Sentinel1

- Sentinel-2a: launched in Jun 2015
- Sentinel-2b: launched in Mar 2017
- Sentinel-1a: launched in Apr 2014
- Sentinel-1b: launched in Apr 2016
- Sentinel-1b: set for launch in 2023
- Landsat-7: launched in Apr 1999
- Landsat-8: launched in Feb 2013
- Landsat-9: launched in Sep 2021

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

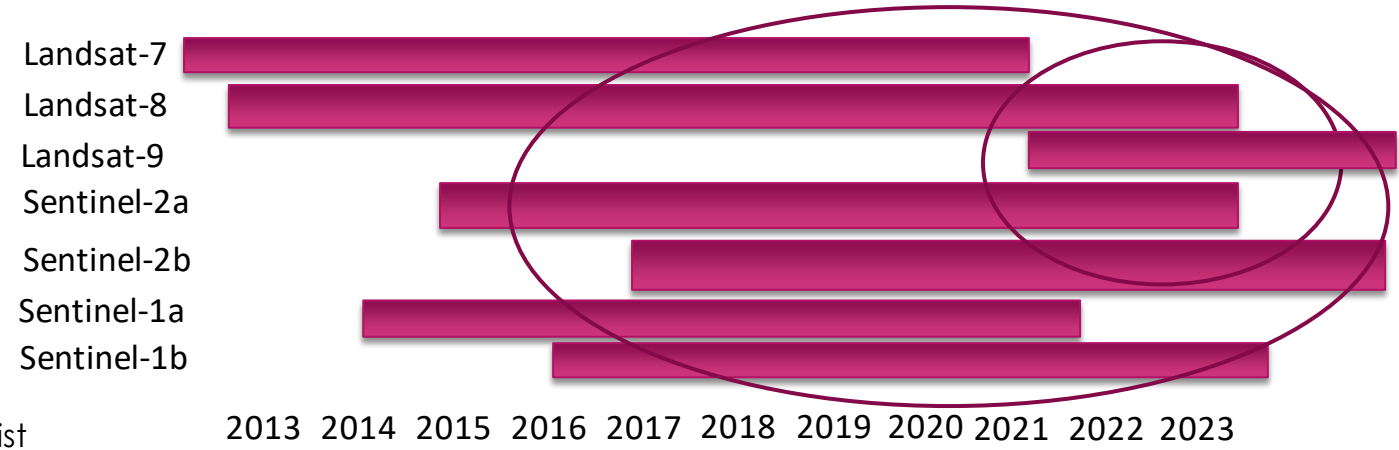
- Both sensors have 10-30m coverage in VNIR-SWIR
- Satellite orbits complementary
  - Landsat-8 & -9 8 days
  - Sentinel-2a & 2b 5 days
- Global ~3 day
- Merging in Sentinel-1 radar data provides all-weather microwave observations

Jeff Masek, NASA GSFC

MuSLI Project Scientist

Landsat-9 Project Scientist

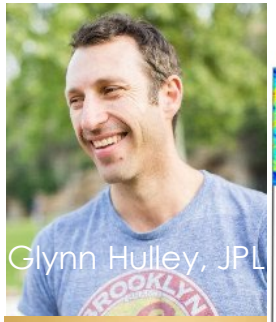
MuSLI ESA Project Scientist Benjamin Koetz,

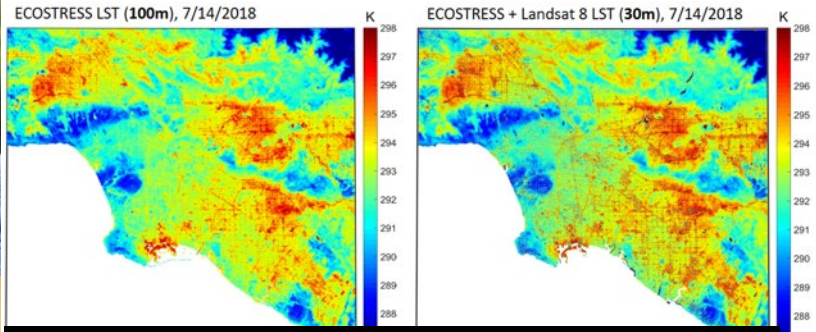


MuSLI Solicitations: LCLUC-2014 (merging Landsat and Sentinel-2); LCLUC-2017 (incl. Radar data); LCLUC-2020 (incl. VHR data); LCLUC-2023 (incl. IR data and all of the above)

Thermal IR in LCLUC
ASTER, Landsat, ECOSTRESS

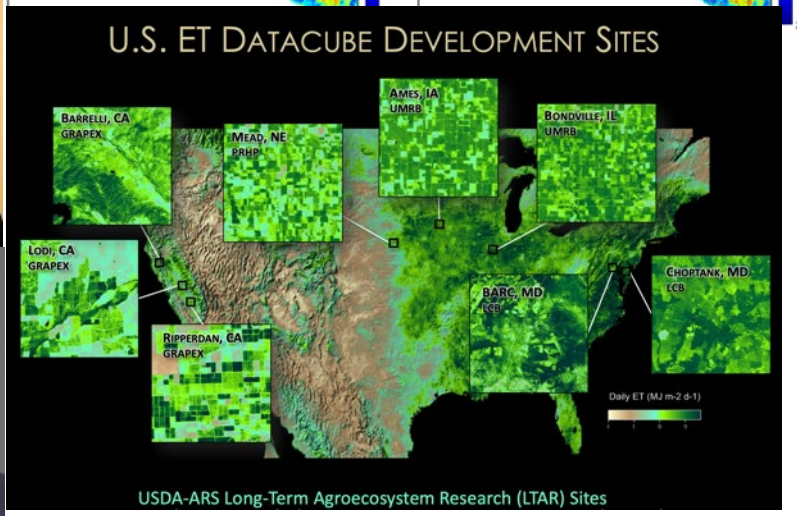
A High Spatio-Temporal Resolution Land Surface Temperature (LST) Product for Urban Environments


Glynn Hulley, JPL

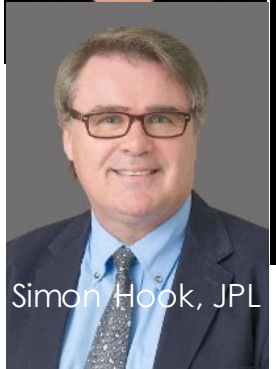


Water Use in Agricultural and Modeling


Martha Anderson, USDA



Coordination, Calibration and Algorithm Development of the Thermal Infrared Activities for the ESA Land Surface Temperature Monitoring (LSTM) Mission and NASA Surface Biology and Geology (SBG) Designated Observable


Simon Hook, JPL

* ECOSTRESS will not be decommissioned in 2022 !!
* The 2nd most requested product in the LP DAAC AppEEARS data access tool (among120+ products)

ECOSTRESS: NASA Instrument on ISS

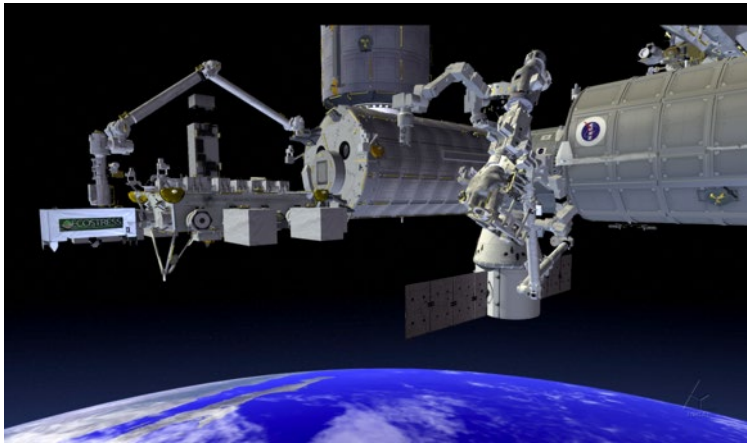
ECOsystem Spaceborne Thermal Radiometer Experiment on the International Space Station (ISS)

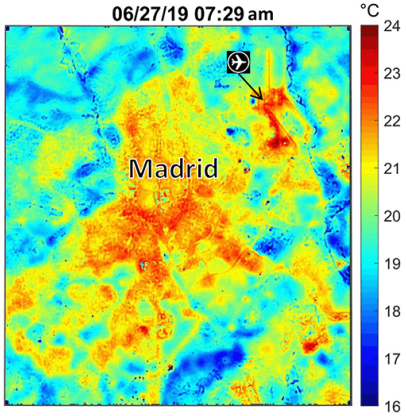
- Prototype HyspIRI **Thermal Infrared** Radiometer

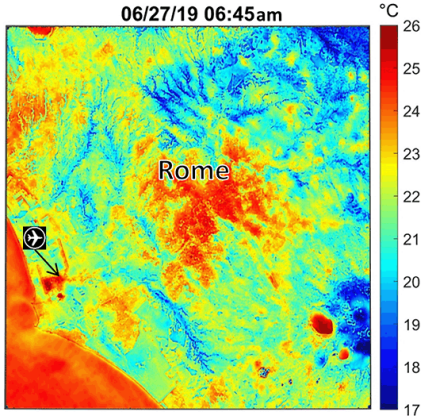
  5 spectral bands in the 8-12.5 µm range +1.6 µm

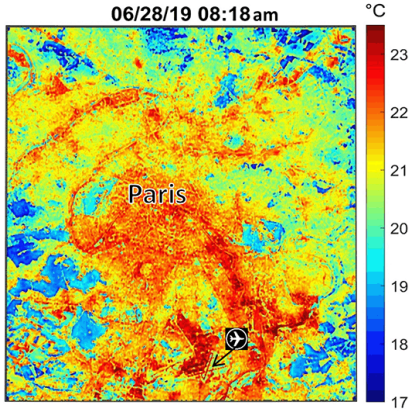
  - Spatial resolution ~70 m
  - **Advantage** over ASTER (on TERRA) – more frequent revisiit

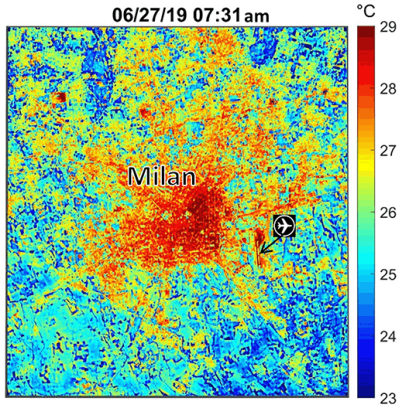
- Science objectives
  - Identify critical thresholds of water use and water stress in key biomes (e.g., tropical/dry transition forests, boreal forests)
  - Detect the timing, location, and predictive factors leading to plant water uptake decline and cessation over the diurnal cycle
  - Measure agricultural water consumptive use over CONUS at spatiotemporal scales applicable to improving drought estimation accuracy











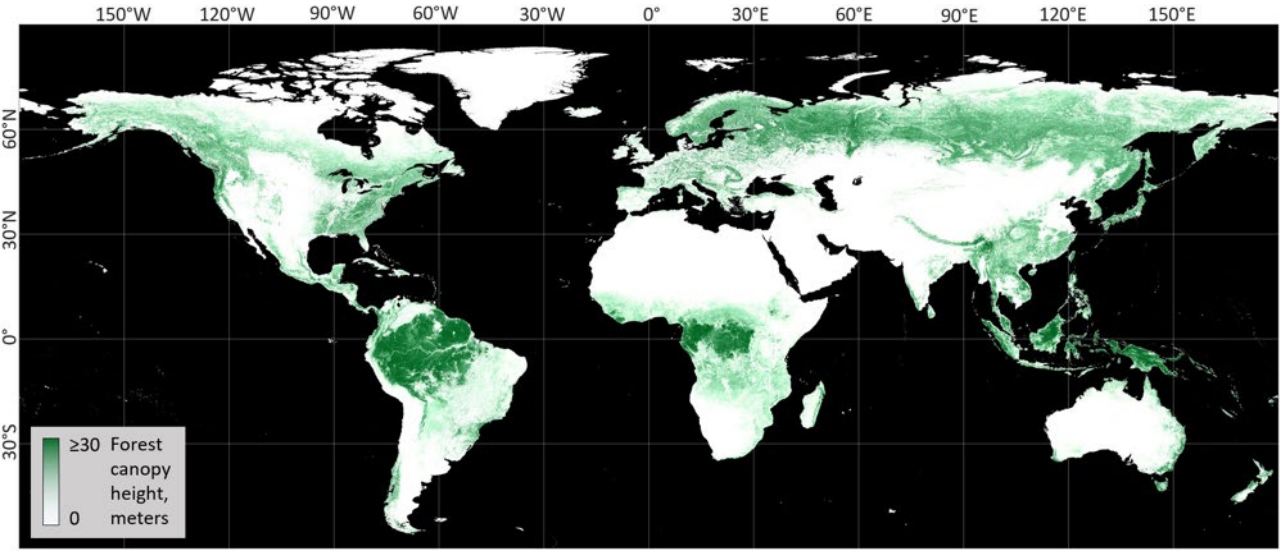
Global Ecosystem Dynamics Investigation
NASA GEDI mission

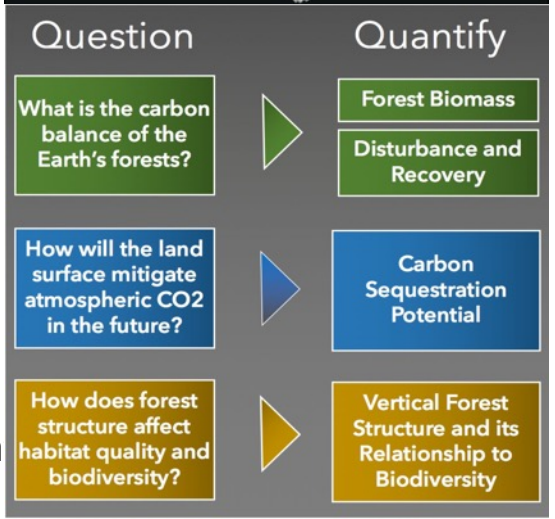
High resolution laser ranging observations

- three lasers produce eight parallel tracks of observations
- each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface

Global Land Analysis & Discovery

Global Forest Canopy Height: 2019

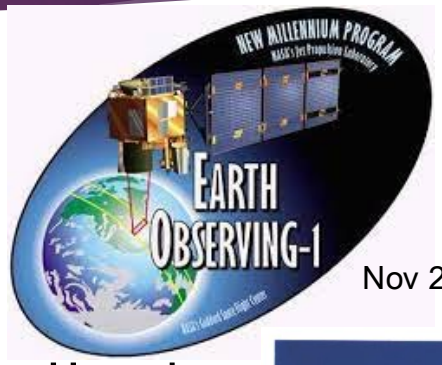




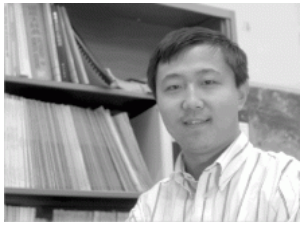
Integration of the GEDI lidar forest structure measurements and Landsa analysis-ready data time-series Potapov et al. 2020, RSE

Hyperspectral Data in LCLUC

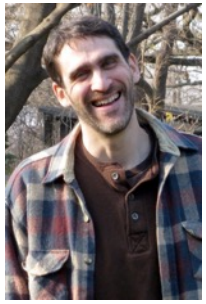
- Program Scientist for EO-1
- Early LCLUC years EO-1 projects
- Supported EO-1 projects



Nov 2000-Mar 2017



Peng Gong,
UC Berkely
→ China



Phil Townsend,
Appalachian Lab,
UMD → U. Wisconsin

Petya Cambpell,
NASA/UMBC

Fred Huemmrich,
NASA/UMBC

Hyperion

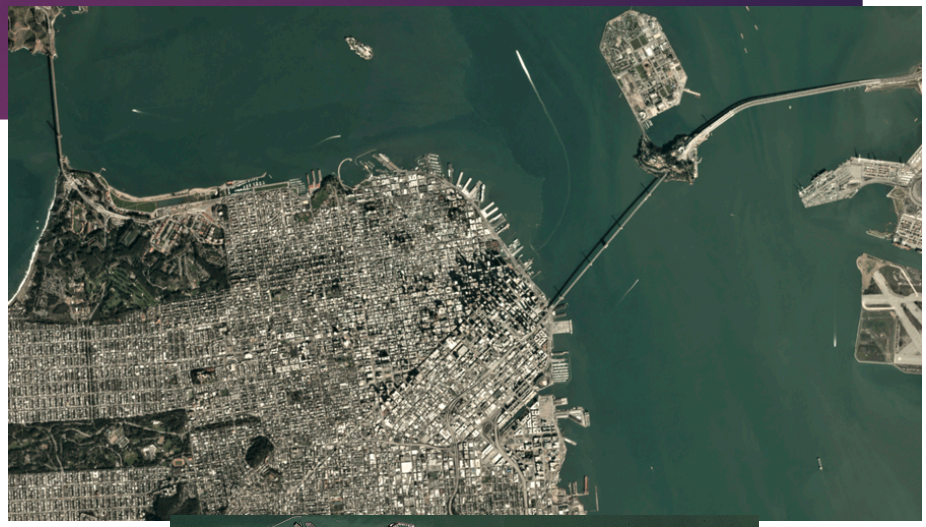
Greg Asner, ASU

Alex Goetz,
U. Colorado

Steve Ungar, NASA

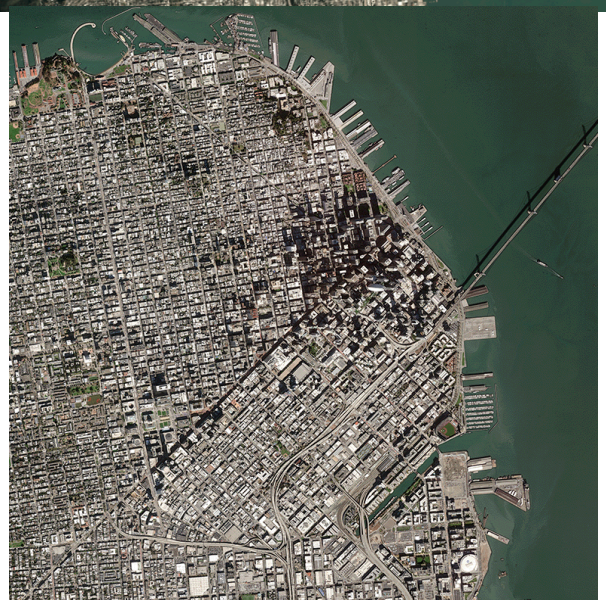
Betsy Middleton, NASA

Zooming-in



Commercial satellites offer images at fine spatial scale and high temporal resolution

- The first NASA Data Buy 2003 – Ikonos
- Planet Labs constellation (>200 sats) acquire daily images of the Earth with 3-m resolution
- Maxar (Digital Globe, WorldView) with 1m resolution



- NASA Commercial Smallsat Data Acquisition (CSDA)
- Limited Planet datasets are available for free at Universities
- Wall-to-wall VHR data over tropics purchased by the government of Norway (to tackle tropical deforestation)
- **Special Issue in Remote Sensing (2020) on applications of VHR data in LCLUC studies**

25 Years of Peer Reviewing With a Little Help from our Friends Overseas

Arnon Karnieli, Israel

Alex Prishchepov, Denmark

Levente Ronczyk, Hungary

Thui LeToan, France

Chris Schmullius, Germany

Andreas Heinimann, Switzerland

Derya Maktav, Turkey

Manfred Ehlers, Germany

Ioannis Manakos, Greece

Premek Stych,Czech Rep.

Pierre Defourny, Belgium

Benjamin Koetz, Italy

Zoltan Santos, Italy

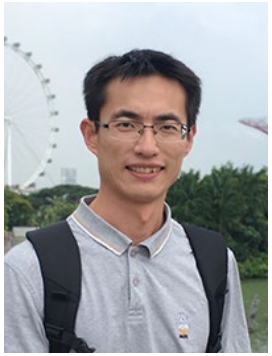
LCLUC Solicitations (Last 3 Years)

- LCLUC-19
  - For Early Career Scientists
  - Open to all LCLUC-related topics (Forests, Ag, Urban, etc.)
  - Regions of interest (Latin America, Mediterranean, Central and Western Asia)
- LCLUC-20
  - MuSLI (incl. VHR), Socio-Economic component NOT mandatory
  - Hot spots
- LCLUC-21
  - For Early Career Scientists; to complement the LCLUC-20 hotspot map
  - Focus on specific GOFC-GOLD networks regions
  - Amendment: SARI synthesis
    - Only one selection – for South Asia
- LCLUC-22
  - Hotspots
  - Land-use adaptation to climate change
    - 11 selections recommended (out of 23), will be announced next month
  - Amendment: SARI Southeast Asia synthesis
    - Will be announced within a couple of weeks
- LCLUC-23
  - MuSLI (incl. IR), Socio-Economic component NOT mandatory
  - Will be announced in Feb 2023

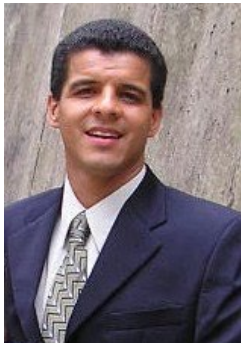
Rejuvenation of LCLUC: LCLUC-19 Selectees

Nick Cuba,
Auburn U.

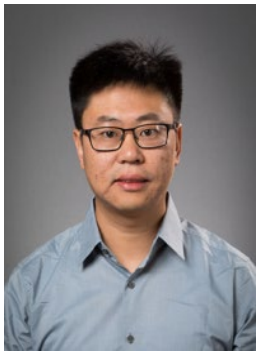
MEHA JAIN,
U. MICHIGAN



Zhenong Jin,
U. Minnesota



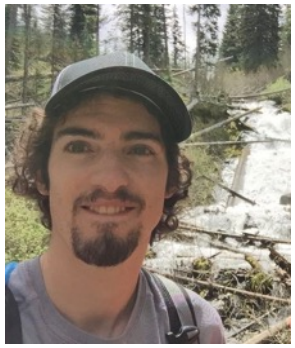
Carlos Munoz
Brenes, Conserv. Int.



Xiaopeng Song,
Texas Tech U

Robert Heilmayr,
UC Santa Barbara

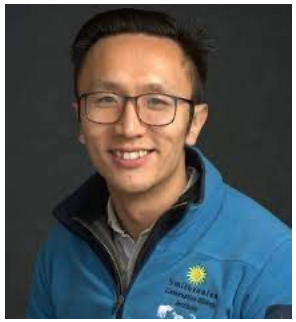
Xin Xi,
MICHIGAN TECH. U



Aaron Sparks,
U. Idaho

Chris Nolte
Boston U.

Rejuvenation of LCLUC: LCLUC-21 Selectees



Qiongyu Huang,
Smithsonian Inst.

McKenzie Johnson,
U. Illinois

Nimrod Carmon,
JPL

Sean Woznicki,
Grand Valley State U.

Eleanor Stokes,
Universities Space
Research Association

Alexey Shiklomanov,
NASA GSFC

Nina Brooks,
U. Connecticut

Latha Baskaran,
JPL

25 Years of GOFC-GOLD Program Support

St. Petersburg, Russia, 2001

Former GOFC-GOLD Chair
John Townshend, U. Maryland

"GOFC-GOLD Fellowships for **Data Training** and the Advanced Training Institute on Key GOFC-GOLD Themes", April-May 2012, July-August 2014 Sioux Falls , SD and Boston, MA

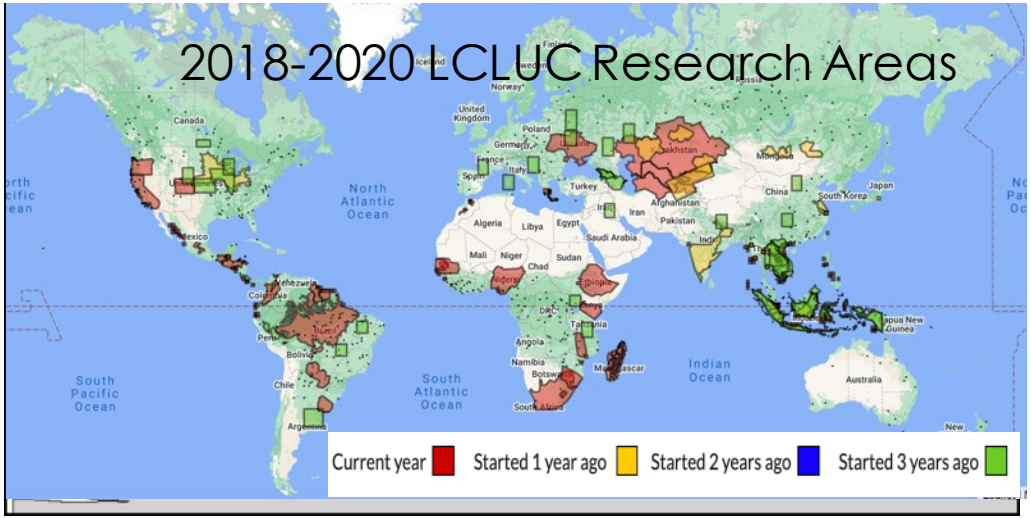
Curtis Woodcock
Boston U.

Former GOFC-GOLD Networks Coordinator, Olga Krankina, Oregon State U.

LCLUC Support of Chairs

- John Townshend
- Tony Janetos
- Chris Justice

- LCLUC Support of the Fire IT Office@UMD; @MSU and the Land Cover office @MSU
- LCLUC Support of Regional Networks via START



Current GOFC Networks Coordinator, Krishna Vadrevu, NASA MSFC

25 Years of Community Outreach

- **Quarterly e-Newsletter**
  - E-Newsletters: 11
- **PR, media**
- **Facebook, twitter, linkedin**
- **Website**
  - **Mapper**

LCLUC Webinars

- presentations: 92
- Started in 2014
- Total: 17 series
- Intensified in 2020
- Topical or regional

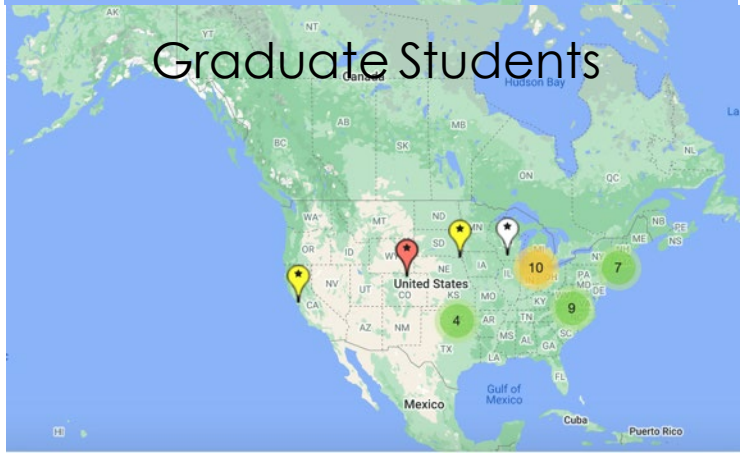
- **Total 21 SARI Webinars.**
- **Total 1845 individual participants from 117 countries**

LCLUC Urban and Agriculture Hotspots Webinar Series - 2022

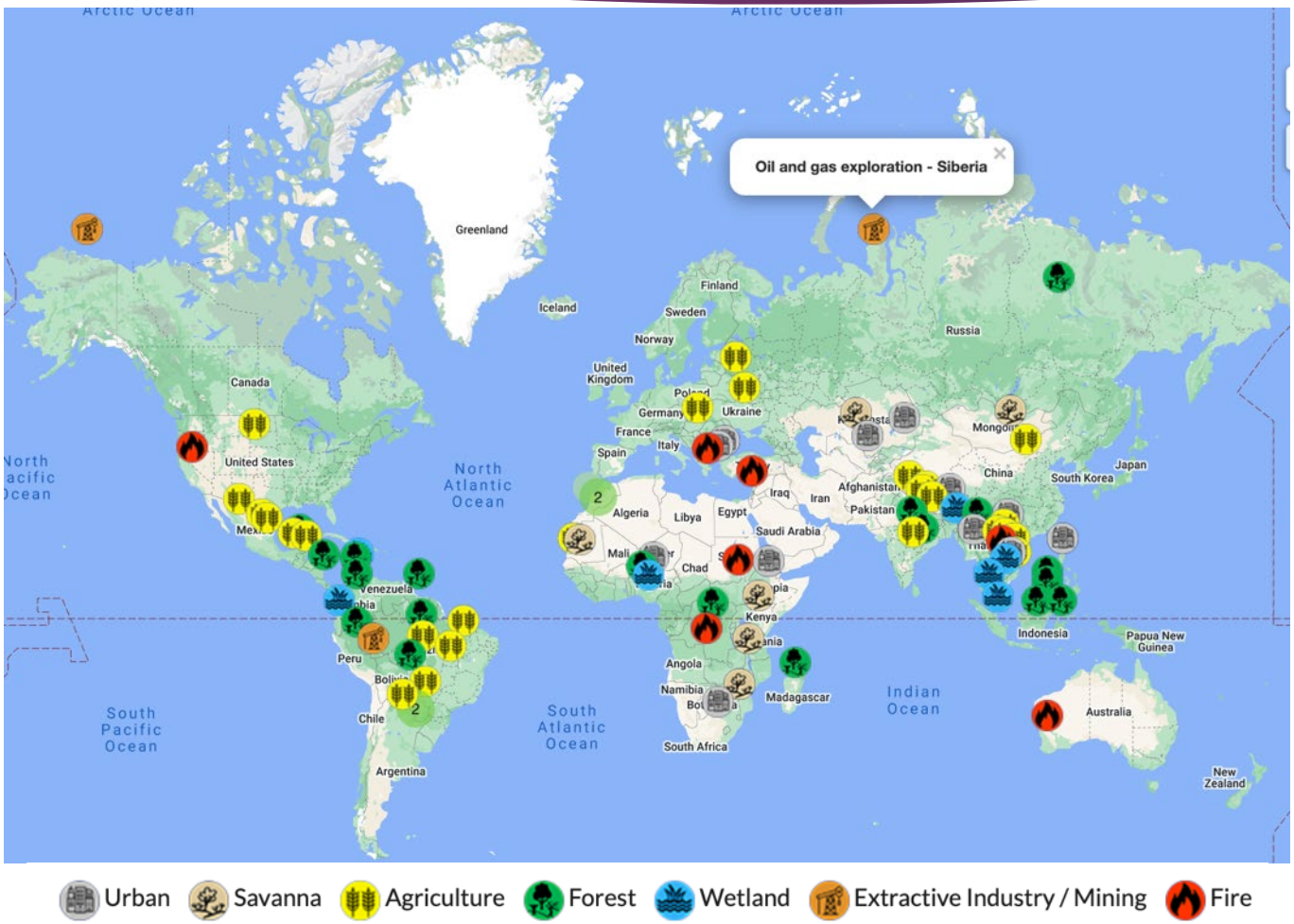
LCLUC Forest Hotspots Webinar Series - 2022

LCLUC Mapper Options

Indrani Kommareddy
LCLUC Program



Hotspots of Land Use



Indrani Kommareddy
LCLUC Program

Meghavi Prashnani
LCLUC Program

LCLUCers in Media: Sep 2020-Sep 2021

Albedo, Its Importance, and How It Can Affect Climate : Eyes on Earth – EROS Center Podcast on Remote Sensing, Earth observation, land change and science
Crystal Schaaf, Jan 2021

BBC Future Planet reports on research conducted by LCLUC PI Alexandra Tyukavina in the Congo Basin Rainforest.
Sasha Tyukavina, June 2021

How the world's northernmost forests are also under threat from climate change - Inquirer.Net Earth & Environment
Marc Friedl, May 2021

Solving Ecological Mysteries using Satellite data - New York Times
Volker Radeloff, Jan 2021

Commercial Satellites Shed Light on Small-Scale Agriculture - NASA Earth Data
Chris Neigh, Dec 2020

India's groundwater crisis threatens food security - A study covered by CNN and AAAS
Meha Jain, Feb 2021

BBC News reported on agricultural research in Africa by Catherine Nakalembe, Dec 2020
Also. Uganda's highest civilian award, the Golden Jubilee Medal Feb 2022

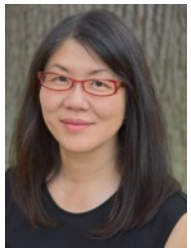
"Amazon degradation has become more destructive than deforestation." highlighted in Science Bulletin, Eureka alerts, AAAS, MSUToday, Folha de Sao Paulo, The Conversation, Earth.com
Dave Skole, Sep 2020

Talking Climate Change with Smithsonian Conservation Commons' Earth Optimism Initiative
Jeff Masek Oct 2020

Interview on NETVIET TV, Vietnam
Garik Gutman Feb 2020

Reference in the Washington Post on irrigated lawns
Garik Gutman Aug 2022

Radiant Earth Foundation featured **Catherine N.** and **Karen Seto** in an article "Celebrating Women in the ML4EO Community."
Mar 8, 2021 (Int. Women Day)

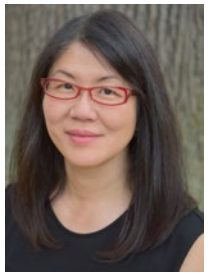


BBC world news interviewed Dr. Inbal Becker Reshef on how satellite information can be used to improve food security and agricultural decisions. Feb 2022

https://lcluc.umd.edu/content/archive-announcements. Only last 5 years out of 25 **– needs backtracking**

LCLUC Awardees: 2018-2022

Throw a tomato at me (and keep me informed) if I missed someone



Karen Seto (Yale U.)
2019 AAG Awardee for Outstanding Contributions to Remote Sensing

Catherine Nakalembe (UMD)
- **2020** Africa Food Prize Laureate
- **2019** GEO Individual Excellence Award

Jiquan Chen (Michigan State U.)
- OutstandingFaculty Award (**2020**)
- Fulbright Global Scholar Award (**2021-2022**)

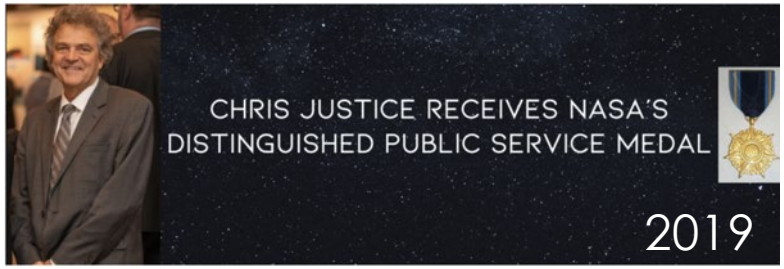
2020 UMD Research Excellence Award

Son Nghiem (JPL) elected AGU Fellow **2019**

2018 SERVIR Excellence Award

Jianguo "Jack" Liu, Michigan State U.
- World Sustainability Award (2021)
- Gunnerus Award in Sustainability Science (2021)

Feng Gao (USDA)
2018 Arthur S. Flemming Award



...and the **2021 Distinguished University Professor** award - the highest honor that UMD bestows on faculty members for their contributions to their fields of research.

25 Years of Early Career Scientists Support

- Students through Student Fellowships → FINESST calls
- New Investigator Program (NIP) calls
- LCLUC special calls to bring in young talents to the Program
  - LCLUC-11 (10 selections)
  - LCLUC-19 (9 selections)
  - LCLUC-21 (8 selections)
- NASA-Michigan State U. project to support students' participation in IALE conferences

Allison Leidner, NASA HQ

- International Association for Landscape Ecology (IALE) is the worldwide organization for landscape ecologists
- Primary mission is to promote global collaborations

Jack Liu,
Michigan State U.

25 years of International LCLUC Capacity Building

- Trainings in conjunction with regional LCLUC meetings since 2009

Promoting NASA data, data products and RS methods

In collaboration with NASA-USAID SERVIR
Nancy Searby, NASA HQ

  - NEESPI
    - NASA-ESA Trans-Atlantic Training (TAT) for students in Eastern Europe

Francesco Sarti, ESA

Pre-TAT LCLUC Training in Latvia - 2010 Czech trainees
Premek Stych, Charles U., Prague

8 TATs since 2013

  - SARI

Krishna Vadrevu, NASA MSFC

Trainings in South/SE Asia

  - In collaboration with SERVIR Hubs in Asia
  - In collaboration with JAXA, GISTDA

Students, 2008
Bangkok, Thailand

Hands-on Training

Involving Very Young in LCLUC

GLOBE Observer

Holli Kohl,
NASA GSFC

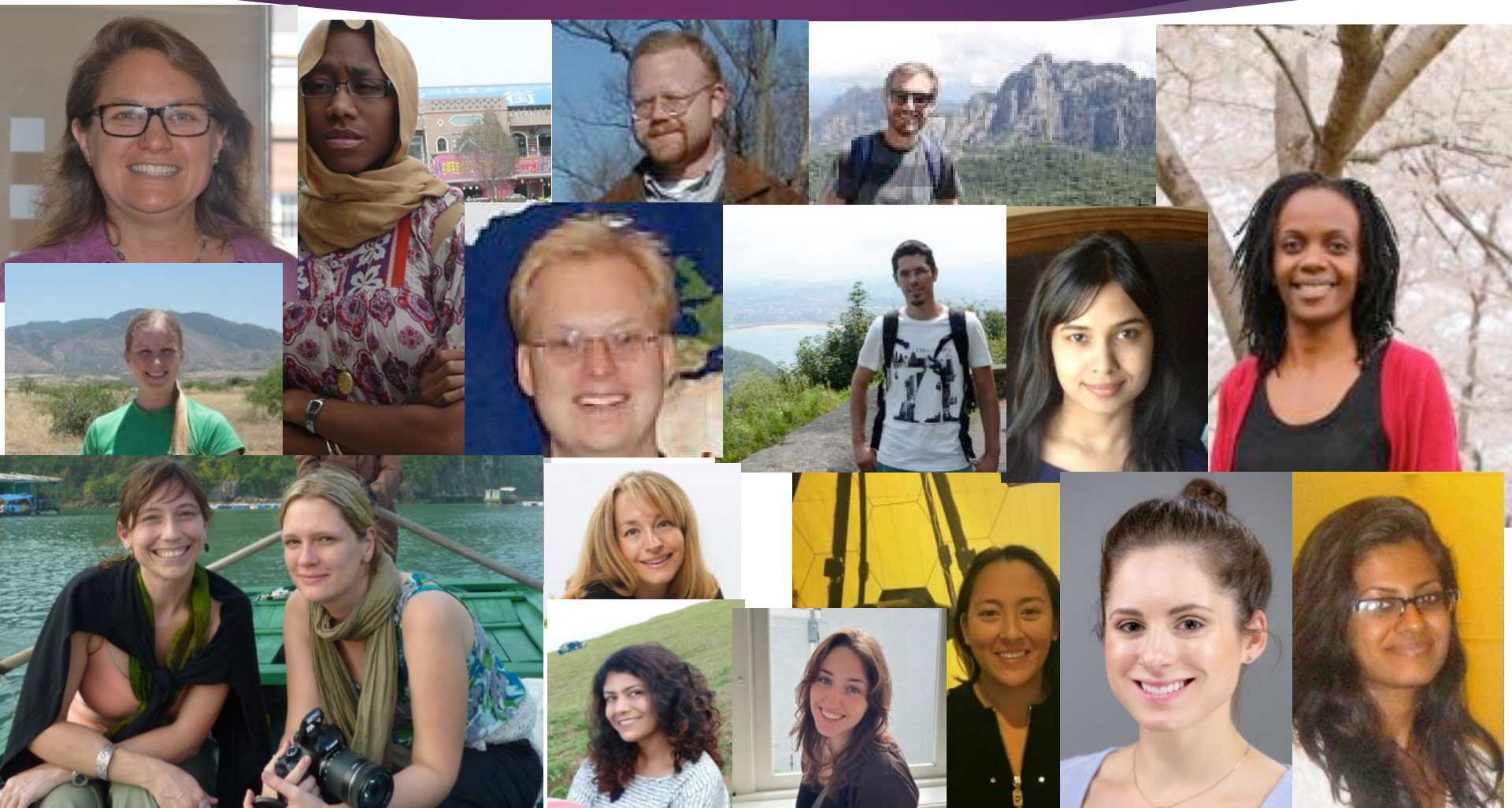
- LCLUC-GLOBE partnership
- Getting school students interested in LCLUC science
  - To help inclusion/diversity issues
  - To uncover the LCLUC world for kids
- Volunteering
  - I gave 5 lectures to GLOBE Estonia students and teachers: **Introduction to Land Remote Sensing**
  - A talk to school kids in Paphos, Cyprus

Global Geo-Referenced Field Photo Library @U. Oklahoma

Dr. Xiaming Xiao,
U. Oklahoma

Crowdsourcing and citizen science (including kids) to help LCLUC science:
Taking pictures, learning to comply with protocols, enjoying impact of their work

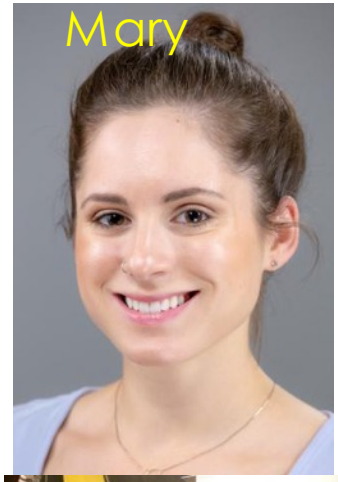
LCLUC Essentials for the 25 Years



Thanks go to

- Organizers: C. J. and Co.
- Sponsor: KBR

Doug Jaton, Calli Jenkerson, Mary Armstrong



- **TRISHNA** MISSION: FRANCO-INDIAN MISSION TO MONITOR THE WATER STATUS OF CONTINENTAL ECOSYSTEMS
  - 4 THERMAL + 6 OPTICAL BANDS
  - launch planned in 2025
- **KRISHNA** MISSION: SERVE LCLUC COMMUNITY BY HELPING WITH THE LCLUC PROGRAM

Deputy LCLUC Program Manager
Krishna Vadrevu, NASA MSFC

Happy Anniversary, LCLUC!

22 Years Together