

NASA LCLUC Program: Land Cover and Land Use Change and Atmospheric Interactions

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Land Cover and Land Use Change (LCLUC):

“the other global change!”

- LCLUC is the most pervasive and visible form of environmental change - In most places more immediate than climate change ?
- In a rapidly changing world - all regions of the World are experiencing some aspect of LUC
- The impacts of LU Change on the Earth System are significant
 - Biomass burning is a land management practice in many parts of the World e.g. agricultural residue, forest/land clearing, pasture management
- All land use change is local but there are regional patterns, problems and necessary regional solutions
- LCLUC will continue to be important, driven by world population growth and economic development and the associated demands for land, the need for an increased food supply, wood products and natural resources

Definitions: Land Cover, Land Use, Change

- **Land Cover** – what we observe – vegetation/bare soil/buildings etc – (amenable to remote observations - land cover type, land cover parameterization, vegetation continuous fields, objects)
- **Land Use** – the use to which the land is put with the associated management practices (e.g. agriculture mechanized or subsistence, clear cutting, selective logging, biomass burning, afforestation, recreation, conservation)
 - A piece of land may have multiple uses at one time
- **Changes in Land Cover** - change in cover type (forest to pasture, cropland to woodland, agriculture to urban), change in characteristics (structure, field size, degradation, productivity, species composition)
- **Changes in Land Use** – change in management practices, intensification, extensification, mechanization, irrigation, abandonment, cropping system, protection
- **Important for Gas Emissions and Aerosols** - deforestation, land clearing, agricultural and urban expansion, crop residue burning



Land-Cover/Land-Use Change Program

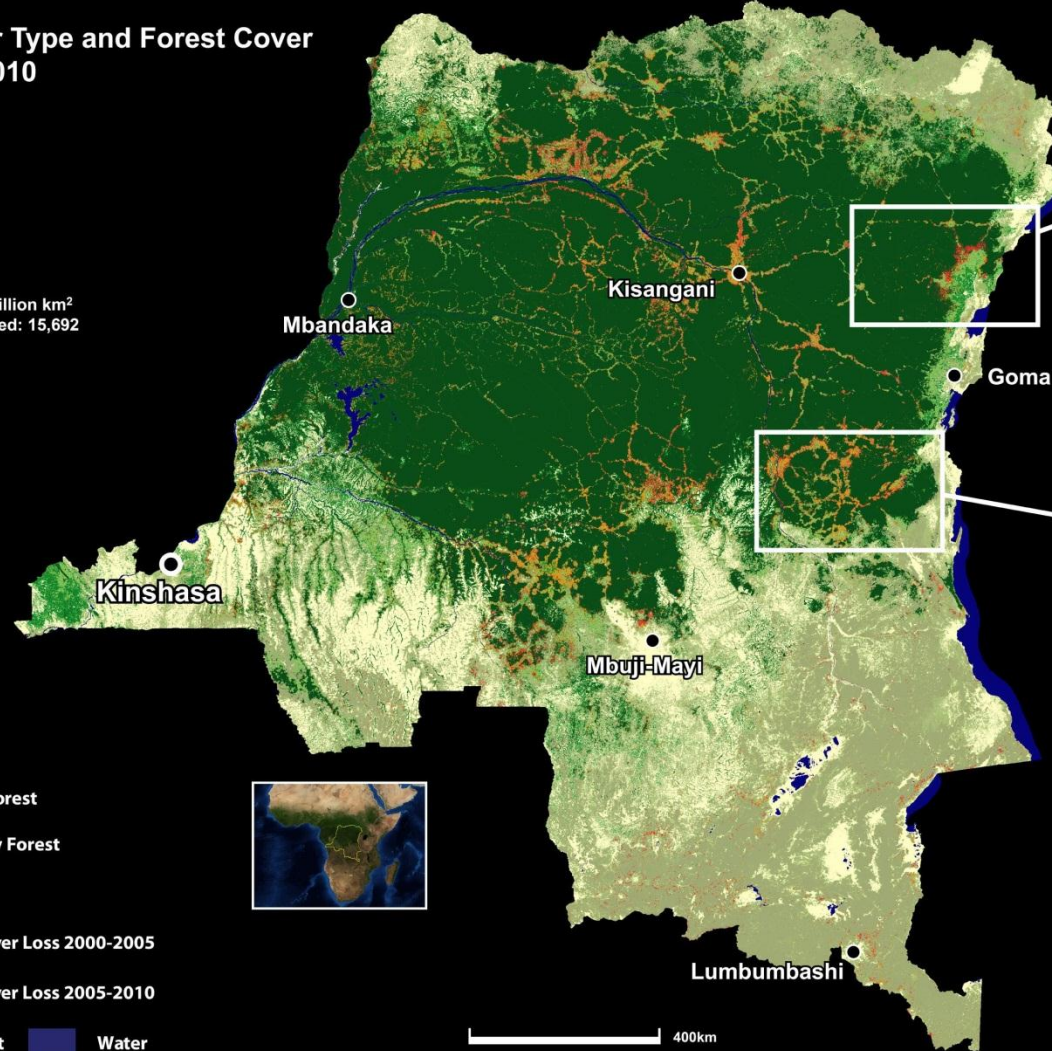
- LCLUC is an interdisciplinary scientific theme within NASA's Earth Science program combining physical and social science. The ultimate vision of this program is to:
 - **develop the capability for periodic global inventories of land use and land cover from space, and quantify the rates of change**
 - **to develop the scientific understanding and models necessary to simulate the processes taking place,**
 - **and to evaluate the consequences of observed and predicted changes**

<http://lcluc.hq.nasa.gov/>

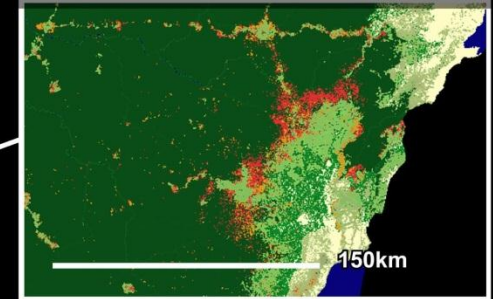
Democratic Republic of the Congo

Forest Cover Type and Forest Cover Loss 2000-2010

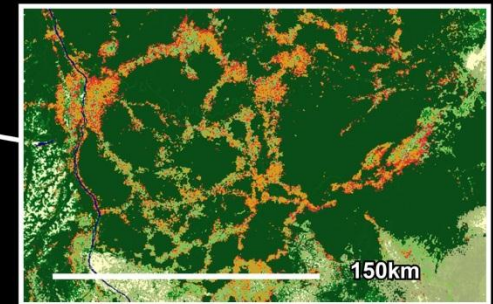
Area analyzed: 1.8 million km²
Total images processed: 15,692



Front of forest clearing in North Kivu province within a region of persistent conflict and internally displaced populations.



Lattice of trunk roads and associated agricultural clearings in Maniema and South Kivu



Reference:

Reference: Potapov P.V., Turubanova S.A., Hansen M.C., Adusei B., Broich M., Allstatt A., Mane L., and Justice C.O. (2011) Quantifying forest cover loss in Democratic Republic of the Congo, 2000-2010. Remote Sensing of Environment (accepted)

Data and images: <http://congo.iluci.org/carpemapper/>

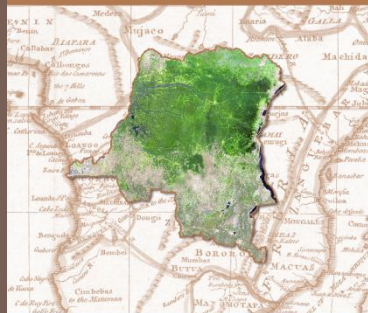


- The national year 2000 forest cover was estimated to be 1.59 million km², with gross forest cover loss for the last decade totaling 2.3% of forest area.

- Forest cover loss increased by 14% between the 2000-2005 to 2005-2010 intervals, with the greatest increase occurring within primary humid tropical forests.

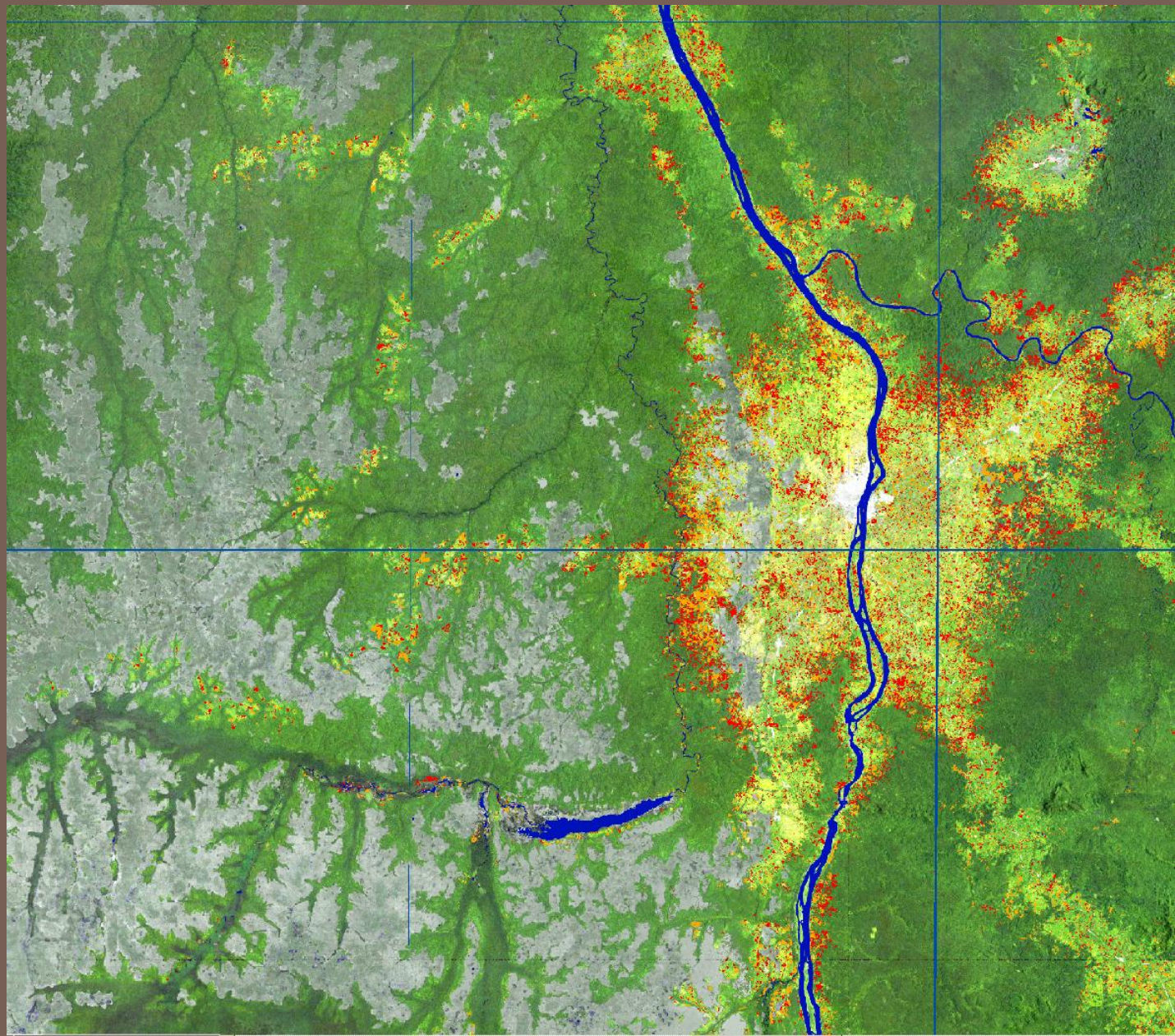
- Gross forest cover loss within protected areas increased by 64% between the two intervals.

- Results illustrate an accelerating rate of forest cover loss during the past 10 years.



Observatoire National des Forêts (ONFC) - OSFAC
Université Etienne de la Savie (UES)
Université du Maryland (UMD)

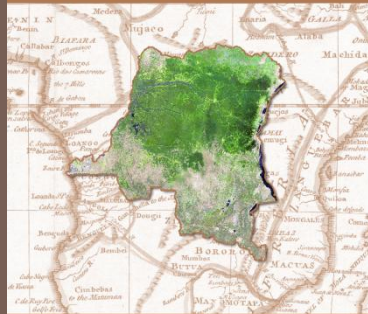
DRC forest type and change detection 2000-05-10



Perte de la couverture forestière

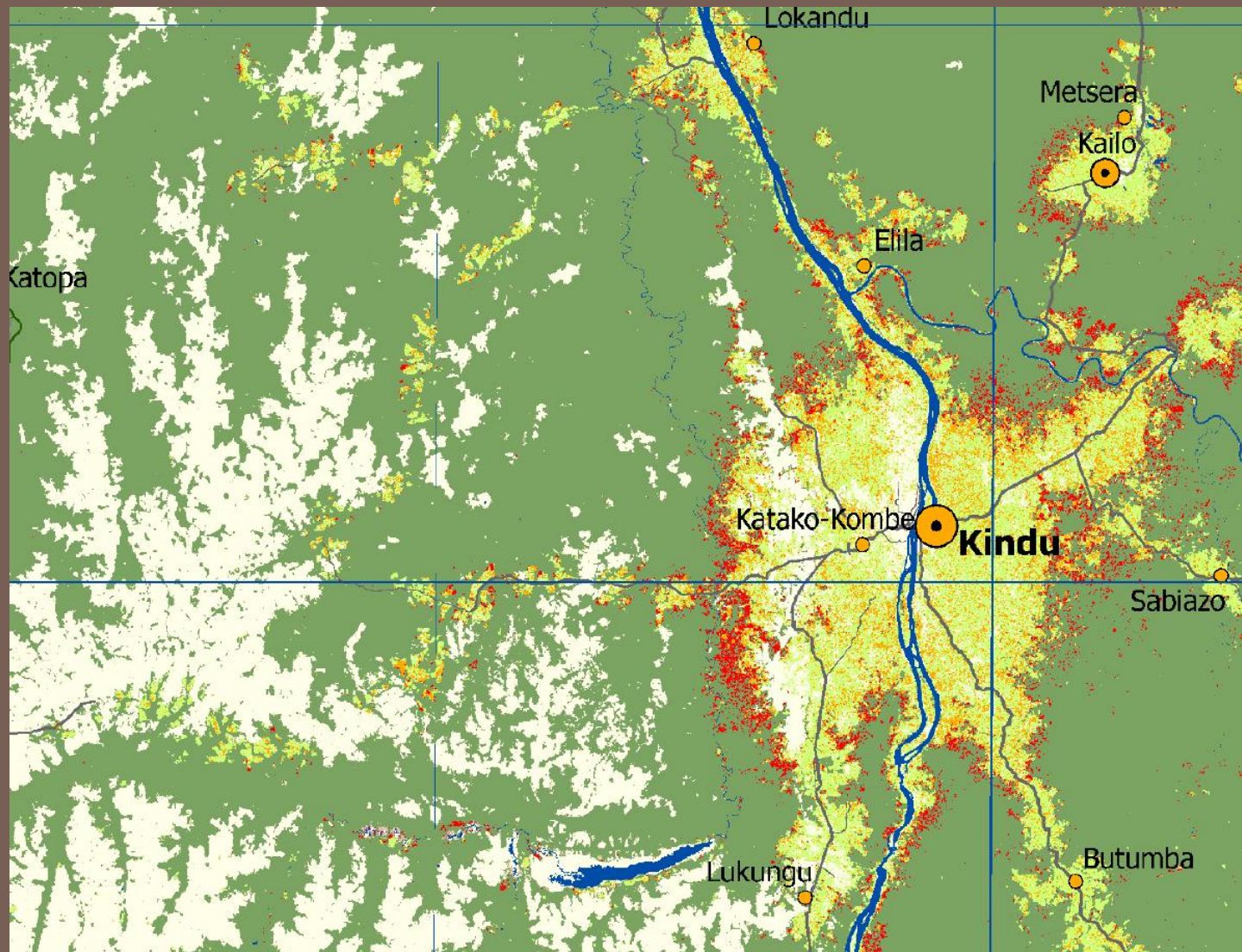
2000-2005

2005-2010



Observatoire National des Forêts (ONFC) - Observatoire National des Forêts (ONFC)
Université de Kinshasa (UNIKIN) - Université de Kinshasa (UNIKIN)
Université du Maryland (UMD) - Université du Maryland (UMD)

DRC forest type and change detection 2000-05-10



Forêts primaires



Forêts secondaires



Savanes arborées



Type de couvert forestier

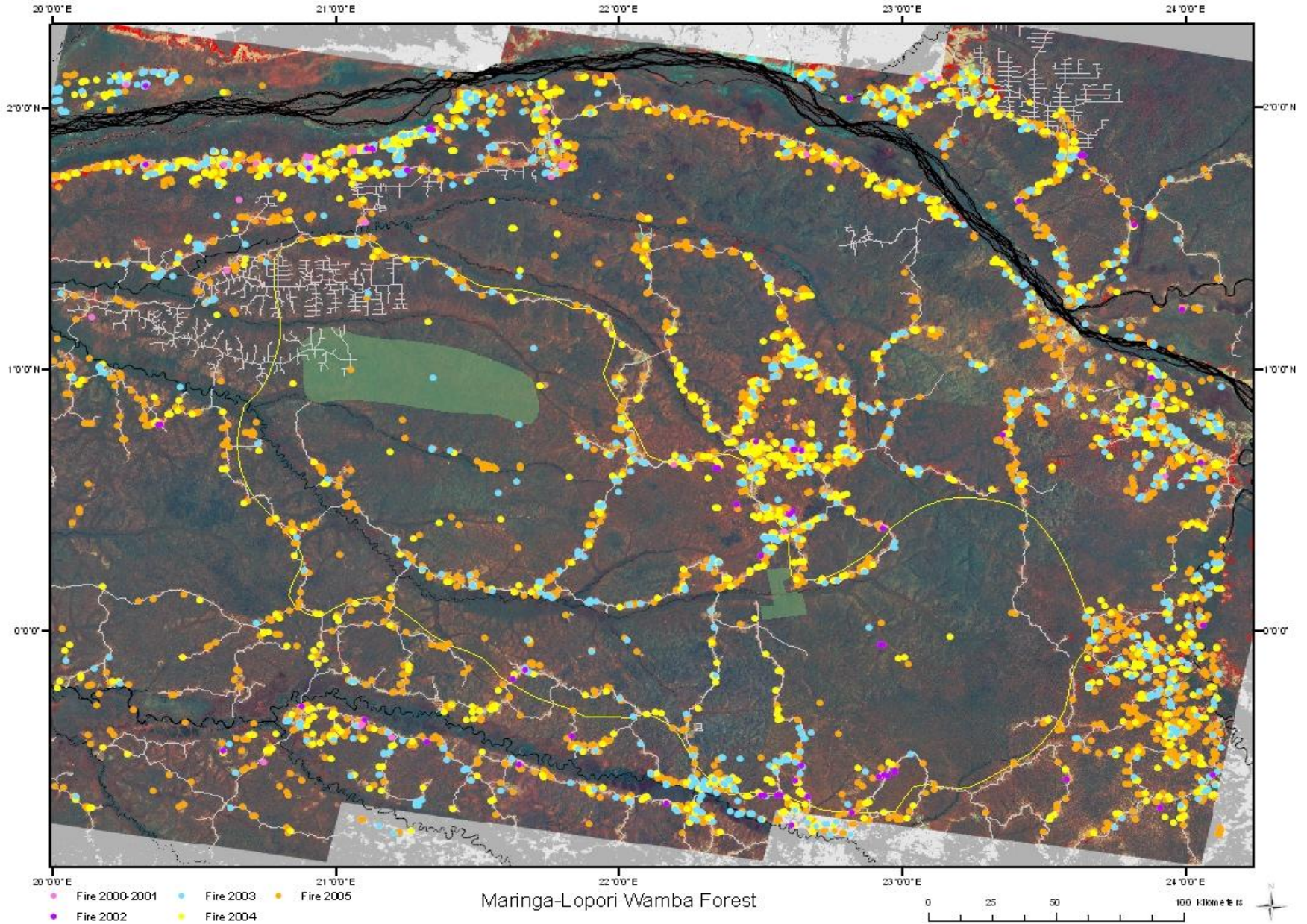
Perte de la couverture forestière

Forest cover extent and loss in the DRC 2000 to 2010

Forest cover for year 2000 and forest cover loss for 2000–2010 (thousand ha) per DRC province. HT – Humid tropical forests.

Region	Percent of region area analyzed	Forest area, 2000				Forest cover loss, 2000–2005				Forest cover loss, 2005–2010			
		Total forest	HT primary	HT secondary	Woodlands	Total forest	HT primary	HT secondary	Woodlands	Total forest	HT primary	HT secondary	Woodlands
Bandundu	100.0	15,887.3	10,019.0	2858.8	3009.5	199.2	33.8	150.4	15.0	183.2	67.6	82.7	32.9
Bas-Congo	82.0	892.4	78.8	579.7	234.0	13.6	1.3	10.2	2.1	10.7	2.3	6.0	2.4
Equateur	100.0	35,453.4	31,225.7	3574.5	653.2	379.0	90.1	284.8	4.1	421.9	162.2	254.3	5.4
Kasai-Occidental	100.0	9570.5	6802.9	1823.5	944.1	223.9	52.8	161.3	9.8	234.8	110.4	105.2	19.2
Kasai-Oriental	100.0	9845.2	7881.0	1202.9	761.3	148.1	36.6	105.6	5.9	165.9	62.4	94.8	8.6
Katanga	100.0	25,725.5	621.7	273.6	24,830.2	140.6	3.5	6.7	130.4	232.2	5.3	6.4	220.5
Kinshasa	98.4	97.4	14.9	54.9	27.6	4.7	0.4	3.6	0.6	6.5	1.0	4.2	1.2
Maniema	100.0	9983.3	7720.9	1604.0	658.4	142.9	30.1	109.8	3.0	141.4	54.0	82.2	5.1
Nord-Kivu	99.8	4590.9	3595.6	784.5	210.9	38.0	10.0	23.5	4.5	48.3	26.4	19.9	2.0
Orientale	100.0	43,064.0	33,232.9	4850.1	4981.0	373.2	91.7	258.8	22.8	450.1	180.4	241.8	27.9
Sud-Kivu	99.9	4419.3	3261.7	686.6	471.0	72.6	16.3	53.4	2.9	81.0	28.5	49.2	3.3
DRC total	99.6	159,529.2	104,455.0	18,293.1	36,781.1	1735.8	366.6	1168.1	201.2	1975.9	700.7	946.8	328.5

Land Use Fires – Congo Basin



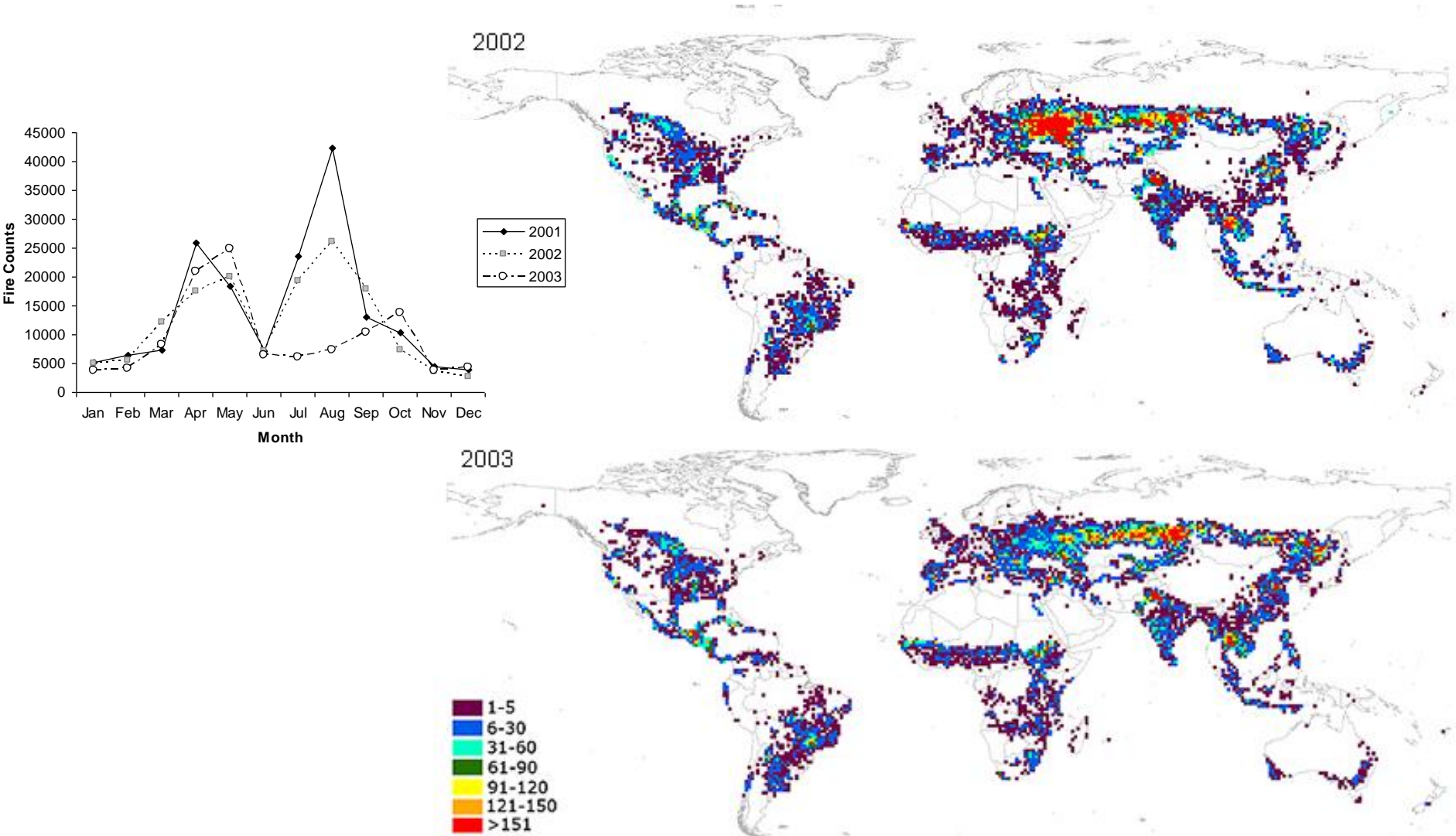
Land Use Fires: DRC



Shifting Agricultural Clearing and Pasture Maintenance



Land Use Fires: Global Agriculture



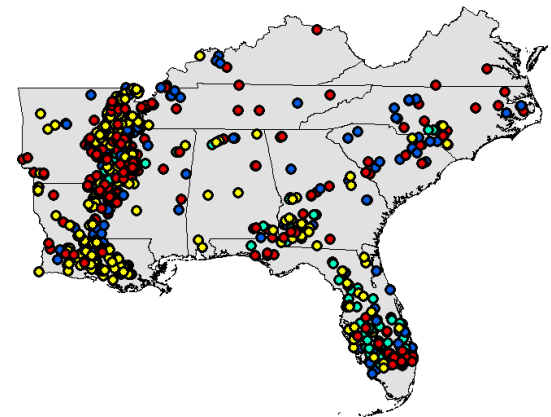
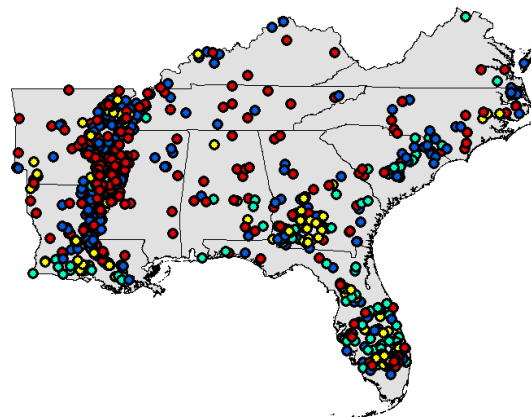
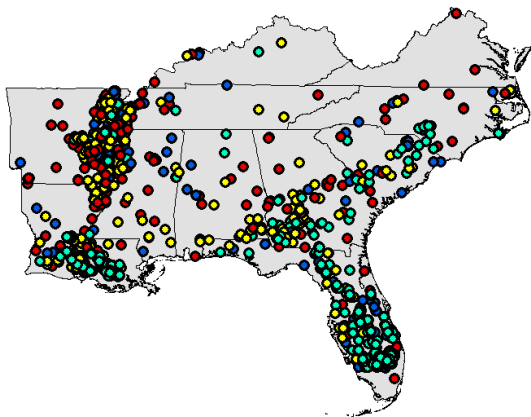
Land Use and Fire, Residue Burning SE. USA



2001

2002

2003



● January - March

● April - June

● July - September

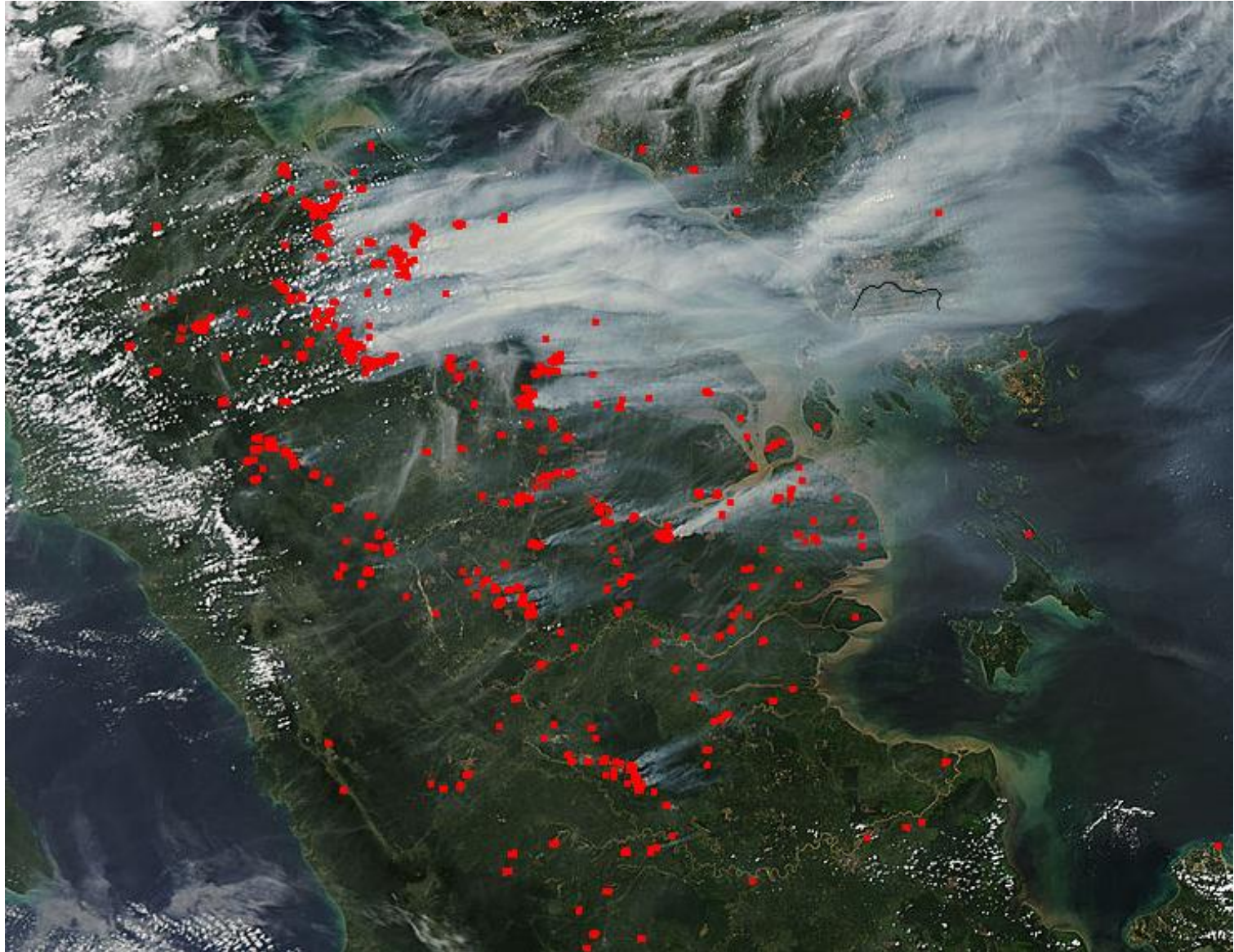
● October - December

Land Use and Fire: Agricultural Fires, USA

Sugarcane Burning, Louisiana 2004
Fires and Air Quality



What is going on here and what can be done that could reduce the burning ?





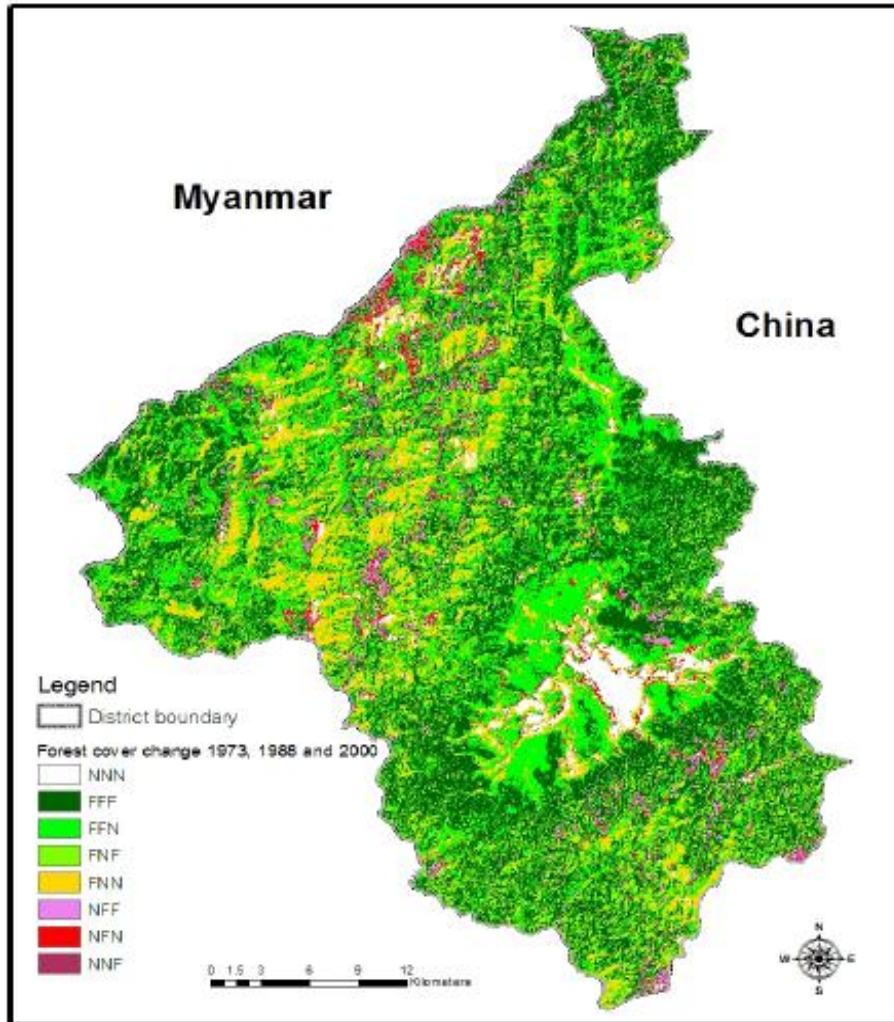
Land-Cover/Land-Use Change Program

Research Components

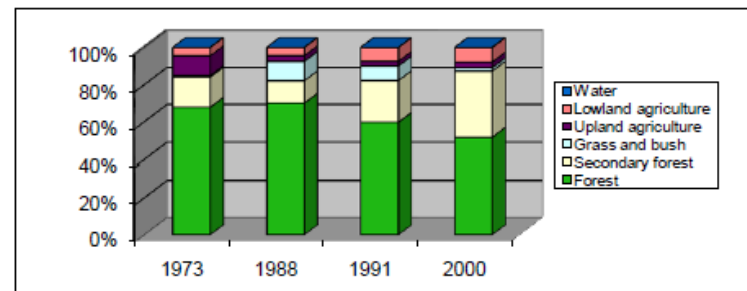
- **Quantifying the extent and rates of Land Cover and Land Use Change**
- **Understanding the Drivers/Causes of Land Use Change**
- **Understanding the impacts of LCLUC – for example on Atmospheric Composition, Terrestrial Ecology/Biodiversity, Terrestrial Hydrology, Climate**
- **Modeling future scenarios of Land Use Change and their impacts**
- **Communicate the scientific findings that can inform land use policy**

Forest Cover Change and Rubber Expansion in Lao PDR

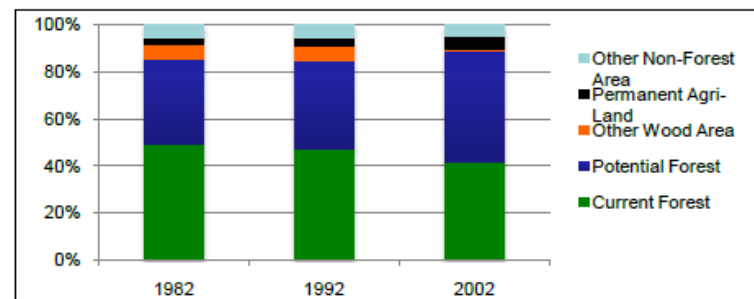
- Forest destruction and fragmentation
- Expansion of rubber plantation on shifting cultivation and fallow forest area



Sing District

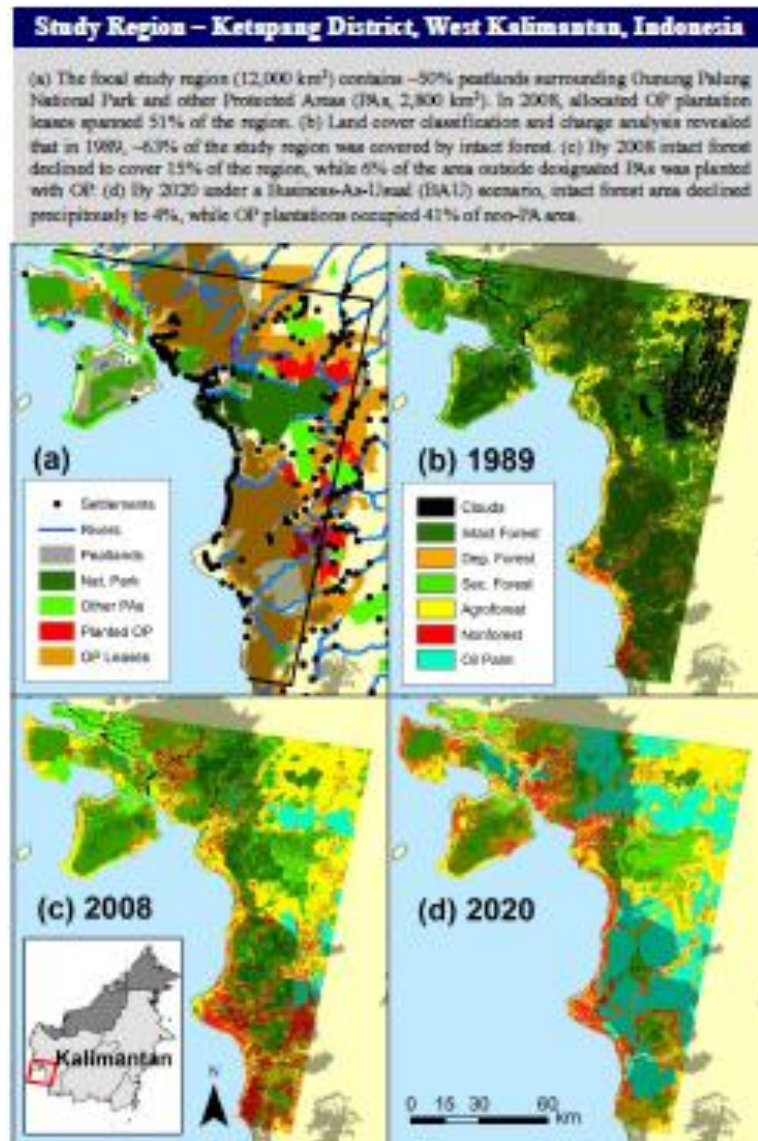


National level



Source: DOF 2007

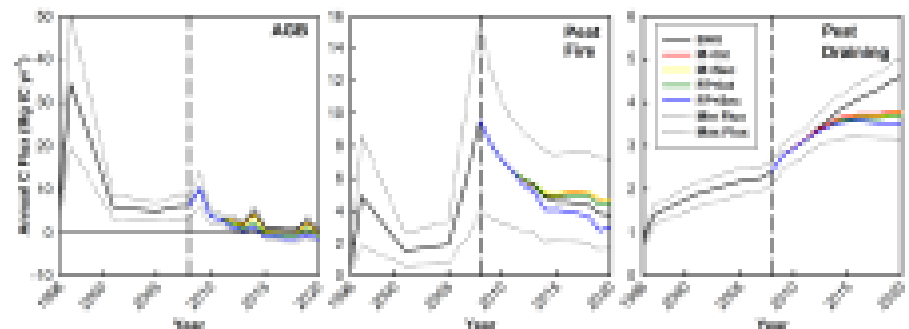
Effects of oil palm plantation expansion on Carbon Fluxes, West Kalimantan 1989-2020



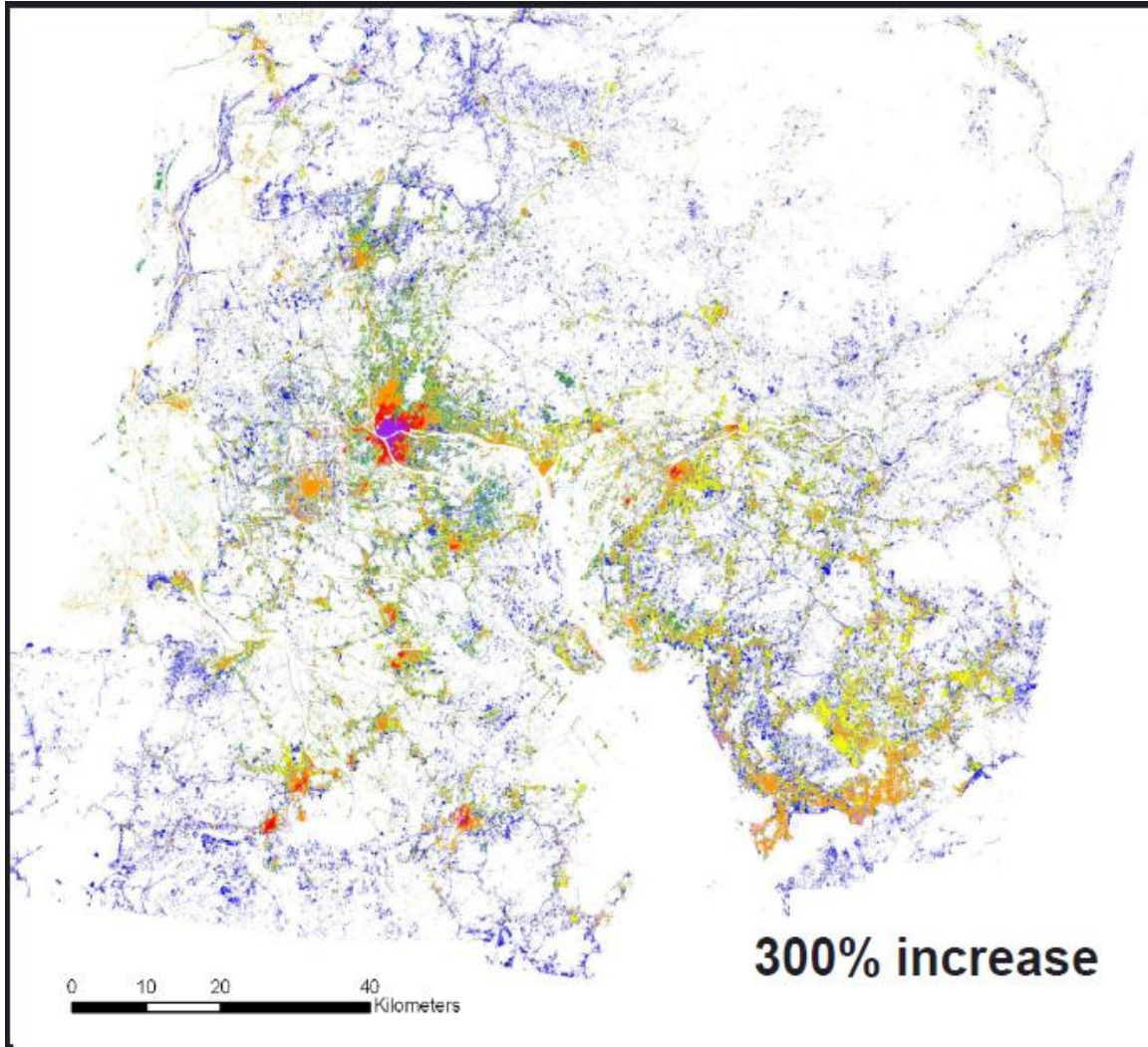
- Plantation expansion driven by commodity prices
- Plantations converted from agroforests (39%), intact forest (28%), 2ndry Forest (13%)....
- Reducing proximate C emissions requires protecting existing forests

Annual C flux under five future scenarios of OP expansion

Total C emissions (positive values) peaked in 1977-1998 when widespread fires during the ENSO-associated drought burned AGB and peatlands. Under a BAU scenario of oil palm expansion from 2009-2020, drained peatlands become the primary source of C emissions by 2020. Solid lines represent means of twenty model runs for each scenario from 2009-2020. Dotted lines indicate minimum and maximum C flux derived by applying low and high C input values.



Urban Land Use Expansion in the Pearl River Valley China



- In 25 years 1370 sq km of cropland and 520 sq km of natural vegetation converted to urban

Mechanisms

- Shenzhen Special Econ Zone – Guangzhou Open City
- Foreign direct investment (Hong Kong)
- Overseas investment
- Minor role of formal planning

NASA Land Cover and Land Use Change

- **The LCLUC Program aims to strengthen LCLUC research by**
 - **Connecting NASA/US researchers to regional scientists with a better understanding regional land use issues**
 - **Promoting and fostering LCLUC research in the international community**
 - **Encouraging the establishment of regional networks of LCLUC scientists to strengthen regional LCLUC research (working with international programs START, GOFC-GOLD, GEO)**
 - **To promote the use of satellite data for LCLUC related research and strengthen international cooperation on Earth Observations**

NASA LCLUC Supports Regional Science Campaigns and Initiatives

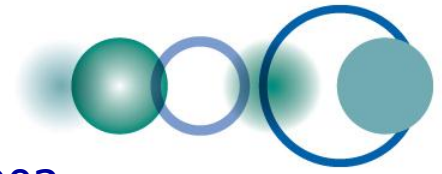
- LBA: Regional Field Campaign in Amazon
- SAFARI: Southern Africa Fire and Atmosphere
- CARPE: Central African Regional Project on the Environment in Congo Basin (with US AID)
- NEESPI: Northern Eurasia program
- MAIRS: Monsoon Area program
- *Emerging Initiative in South Asia Regional Initiative (SARI)*

LCLUC Research in South Asia and Relevant Global Scale Projects

Agriculture	Forests	Urban	Atmosphere	Sensors
<p>Quantifying Changes in Agricultural Intensification and Expansion in Monsoon Asia during 2000-2010.</p> <p>Xiao, Xiaming Oklahoma University</p>	<p>Mapping Three Decades of Global Forest Cover Change using the Global Land Survey Landsat Datasets</p> <p>Townshend, John University of Maryland College Park, USA</p>	<p>Using Landsat Global Land Survey Data to Measure and Monitor Worldwide Urbanization</p> <p>Brown de Colstoun, Eric NASA Goddard Space Flight Center</p>	<p>Land Use–Ecosystem–Climate Interactions in Monsoon Asia: Evaluating the Impacts of Current and Projected LCLUC on Climate, Water and Carbon Cycling in the First Half of 21st Century</p> <p>Tian, Hanquin Auburn University</p>	<p>Cross Calibration of Current LANDSAT Sensors with Foreign Landsat-Class Sensors for Long-Term Monitoring and Land-Surface Processes</p> <p>Chander, Gyanesh EROS data Center, USA</p>
<p>Multi-sensor Fusion to Determine Climate Sensitivity of Agriculture Intensification in South Asia</p> <p>DeFries, Ruth Columbia University</p>	<p>Enhancing Global Scale Observations and Information on Tropical Forest Change Using Landsat Global Data Remote Sensing</p> <p>Skole, David Michigan State University, USA</p>	<p>Multi-Scale and multi-sensor analysis of Urban cluster development and Agricultural land loss in China and India</p> <p>Seto, Karen Yale University</p>	<p>Land Cover And Land Use Change And Its Effects On Carbon Dynamics In Monsoon Asian Region</p>	<p>Sentinel-3 Science Products: A US contribution</p>
<p>Advancing methods for Global Crop Area Estimation</p> <p>Matthew, Hansen University of Maryland College Park</p>	<p>Global Tropical Mangrove Mapping</p> <p>Giri, Chandra, USGS EROS Data Center, USA</p>	<p>Understanding and Simulating Global Urban Expansion in the Context of Climate Change</p> <p>Zhou, Yuyu Joint Global Change Research Institute</p>	<p>Land Cover And Land Use Change And Its Effects On Carbon Dynamics In Monsoon Asian Region</p> <p>Jain, Atul University of Illinois at Urbana Champaign</p>	<p>Products: A US contribution</p> <p>Masek, Jeff NASA GSFC</p> <p>Justice, Chris University of Maryland College Park</p>

NASA LCLUC support for International Observation Coordination

- CEOS Cal/Val Working Group
- **GOFC-GOLD Program and Regional Network Support**
 - **Developing Country Participation through START**
 - **GOFC-GOLD Fire Project Office at UMD**
- Interaction with relevant GEO activities
 - GEO Agricultural Land Use Change-GEOGLAM
 - GEO Global Forest Observation Initiative- GFOI
 - GEO Land Surface Imaging Constellation – LSI



An Intergovernmental Organization Established in 2003

THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS



GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics



- Use and refinement of land cover data and information products
- Coarse resolution earth observations for land cover mapping
- Fine-scale land cover change
- Integration with in-situ observations

Land Cover Characteristics and Change



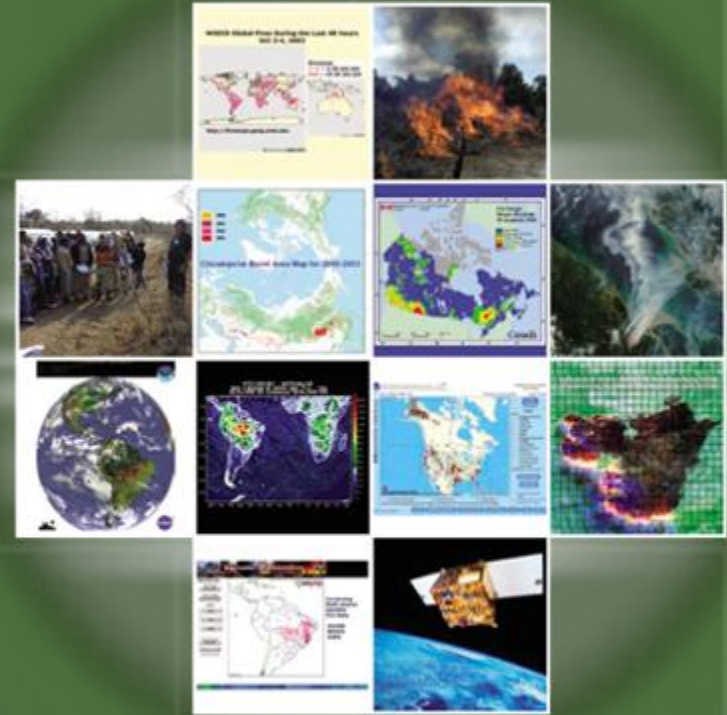
GOFC-GOLD

Global Observation of Forest and Land Cover Dynamics



- Refining international requirements for fire-related observations
- Best possible use of fire products from existing and future satellite observing systems
- Support fire management, policy decision-making, and global change research

Fire Mapping and Monitoring



Regional Networks

a critical component of the implementation of GOFC-GOLD

Providing the interface between the Implementation Teams and data users in the regions

NERIN – Northern Eurasia

SEARIN - South East Asia

OSFAC - Central Africa

Miombo - Southern Africa

SAFNET – Southern Africa

RedLatiF – South America

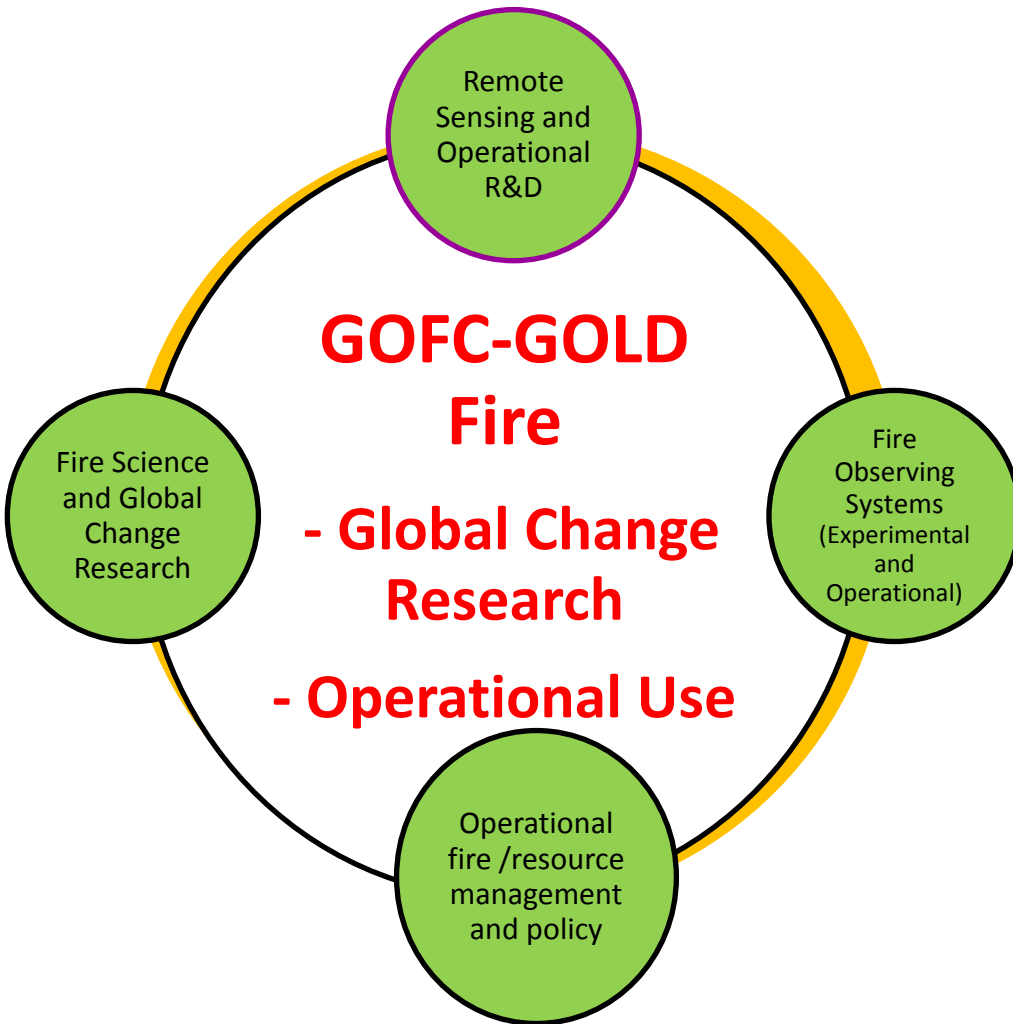
WARN – West Africa

CARIN – Central Asia

SCERIN – South/Central Eastern Europe

SARIN for Southern Asia?

The GOFC-GOLD Fire Community



GOFC-GOLD Fire Monitoring & Mapping Implementation Team

Global Observation of Forest and Land Cover Dynamics

HOME PARTICIPANTS PROJECTS RESOURCES REGIONAL NETWORKS MEETINGS CONTACT

Site Map

- Background
- Implementation Goals
- Objectives
- Documents and Publications
- Related Programs

Welcome To GOFC/GOLD-Fire

GOFC/GOLD (Global Observations of Forest and Land Cover Dynamics) is a project of the Global Terrestrial Observing System (GTOS) program, which is sponsored by the Integrated Global Observing Strategy (IGOS). The main goal of GOFC/GOLD is to provide a forum for international information exchange, observation and data coordination, and a framework for establishing the necessary long-term monitoring systems.

Fire Radiative Power products

The GOFC/GOLD-Fire Mapping and Monitoring Theme is aimed at refining and articulating the international observation requirements and making the best possible use of fire products from the existing and future satellite observing systems, for fire management, policy decision-making and global change research.

GOFC/GOLD is promoting a self-organized regional networks of data users, data brokers and providers, where closer linkages and collaborations are established with emphasis on an improved understanding of user requirements and product quality. GOFC/GOLD-Fire is pursuing, in a joint effort with the Committee on Earth Observing Satellites (CEOS) Working Group on Calibration and Validation (WGCV) Land Product Validation (LPV) subgroup, the coordinated validation of fire products by standardized protocols.

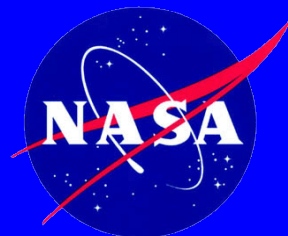
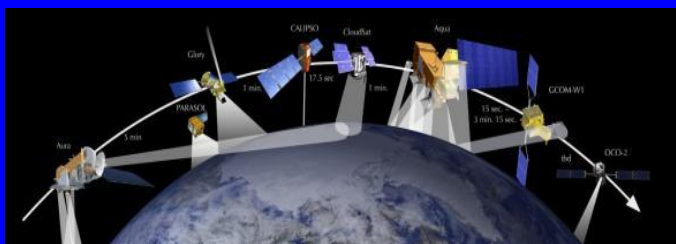
GOFC/GOLD-Fire is partnering with the Global Fire Monitoring Center (GFMC), and the United Nations International Strategy for Disaster Reduction (UNISDR) Wildland Fire Advisory Group / Global Wildland Fire Network.

GOFC-GOLD
GLOBAL OBSERVATION OF FOREST AND LAND COVER DYNAMICS

Site Maintained by Krishna Vadrevu
Website Developed by Jon Nordling

<http://gofc-fire.umd.edu/>

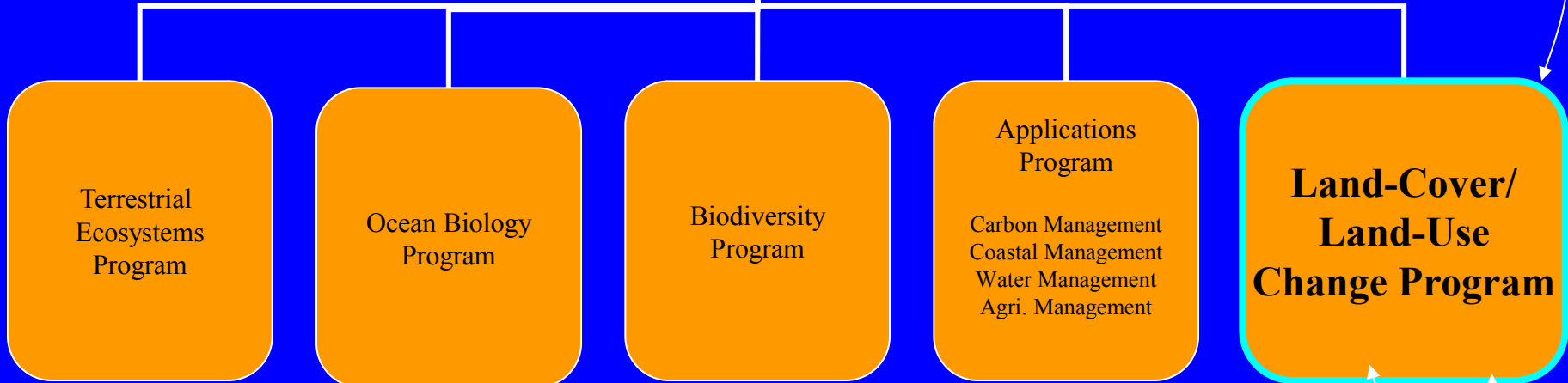
Linkages between LCLUC and other related NASA Programs



Internal NASA Programmatic Linkages

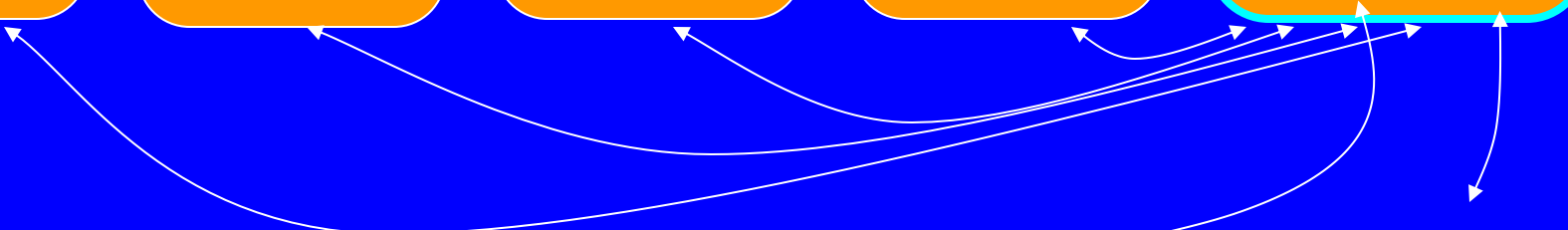
**Carbon Cycle
and Ecosystems
Focus Research
Area**

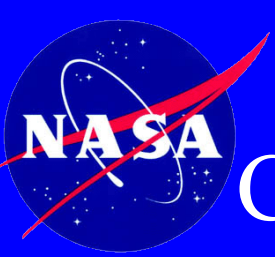
**Interdisciplinary
Science
Program**



**Water and Energy Cycle
Focus Research Area**
Terrestrial Hydrology

**Atmospheric Composition
Focus Research Area**
Radiation Science

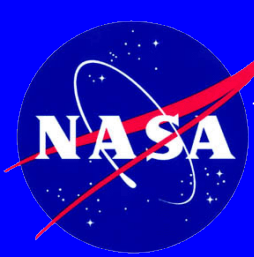




Atmospheric Composition Campaigns, Data Analysis and Modeling

Science Questions:

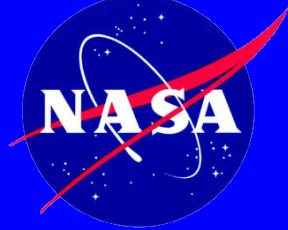
- How is atmospheric composition changing?
- What trends in atmospheric constituents and solar radiation are driving global climate?
- How do atmospheric trace constituents respond to and affect global environmental change?
- What are the effects of global atmospheric chemical and climate changes on regional air quality?
- How will future changes in atmospheric composition affect ozone, climate, and global air quality?



Atmospheric Composition Modeling and Analysis Program (ACMAP)

ACMAP addresses the issues of tropospheric air quality and oxidation efficiency, pollution sourced aerosol and its impact on cloud properties, stratospheric chemistry and ozone depletion, and chemistry/climate interactions.

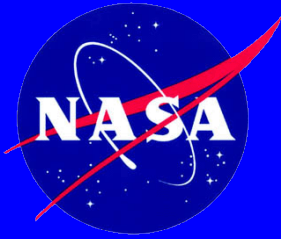
ACMAP is particularly interested in studies that integrate observations from multiple instruments with models to address attribution and predictions. The use of satellite and suborbital data sets and ground-based measurements are encouraged for modeling constraints and verification.



Interdisciplinary Research in Earth Science

Research investigations that meet the following criteria:

- a) offer a fundamental advance to our understanding of the Earth system;
- b) be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate;
- c) go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved;
- d) be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences

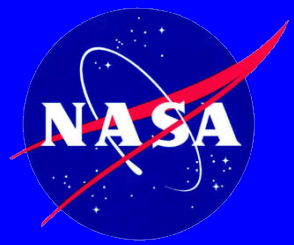


Interdisciplinary Research in Earth Science

Focus of Recent Calls for Proposals:

- Understanding Earth System Vulnerabilities to Climate Extremes
- Impacts of Changing Polar Ice Cover
- *Water and Energy Cycle Impacts of Biomass Burning*
- Impacts of Population growth on watersheds and coastal ecology
- Role of Permafrost in a Changing Climate

NASA Proposals can include international partners and can support the provision of goods and services (not salaries)

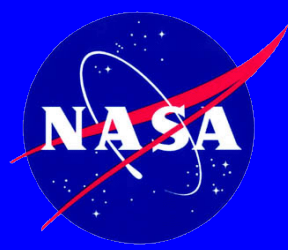


Carbon Cycle Science

Managed by the Terrestrial Ecology Program

Major Science Questions:

- How do natural processes and human actions affect the carbon cycle on land, in the atmosphere, and in the ocean?
- How do policy and management decisions affect the levels of the primary carbon-containing gases, carbon dioxide and methane, in the atmosphere?
- How are ecosystems, species, and natural resources impacted by increasing greenhouse gas concentrations, the associated changes in climate, and by carbon management decisions?



Earth Science Applications: Health and Air Quality

Projects address the use and application of Earth science observations and models in decision making associated with Health and Air Quality.

The projects can include all relevant NASA satellite mission observations and data products from non-NASA satellites, including foreign satellites and commercial products, if used in conjunction with some NASA capabilities.

Projects are encouraged to include modeling capabilities and predictions, data fusion and interoperability techniques, visualizations, or other Earth science products and capabilities to complement use of an array of Earth observations.