UNIVERSITY OF COPENHAGEN

Department of Geography and Geology

Opportunities and challenges of application of satellite remotely-sensed data in Land System Science

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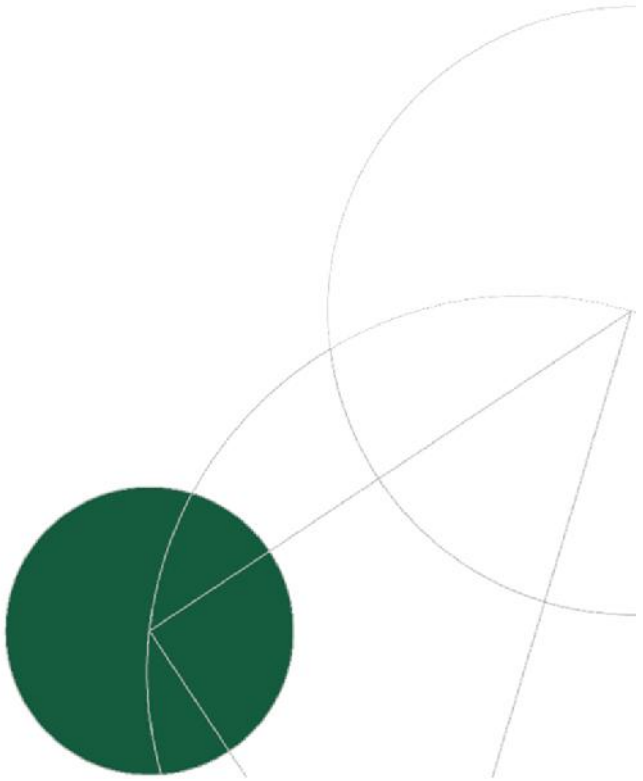
2nd EARSeL SIG LU/LC and NASA LCLUC joint Workshop “Advancing horizons for land cover services entering the big data era”, May6-7, 2016, Prague

Outline

- Data accessibility
- Quality of the products
- Matching community needs



Motivation for this talk

- Post-Doc 2010-2014 at IAMO
- 60 researchers with focus on agricultural economics and land system science
- Key research directions: structural development of farms and rural areas, agricultural markets, policies, theory of structural change
- Limited use of remote sensing products across IAMO

iamo
Leibniz Institute of Agricultural Development in Transition Economies

http://www.iamo.de/lsc

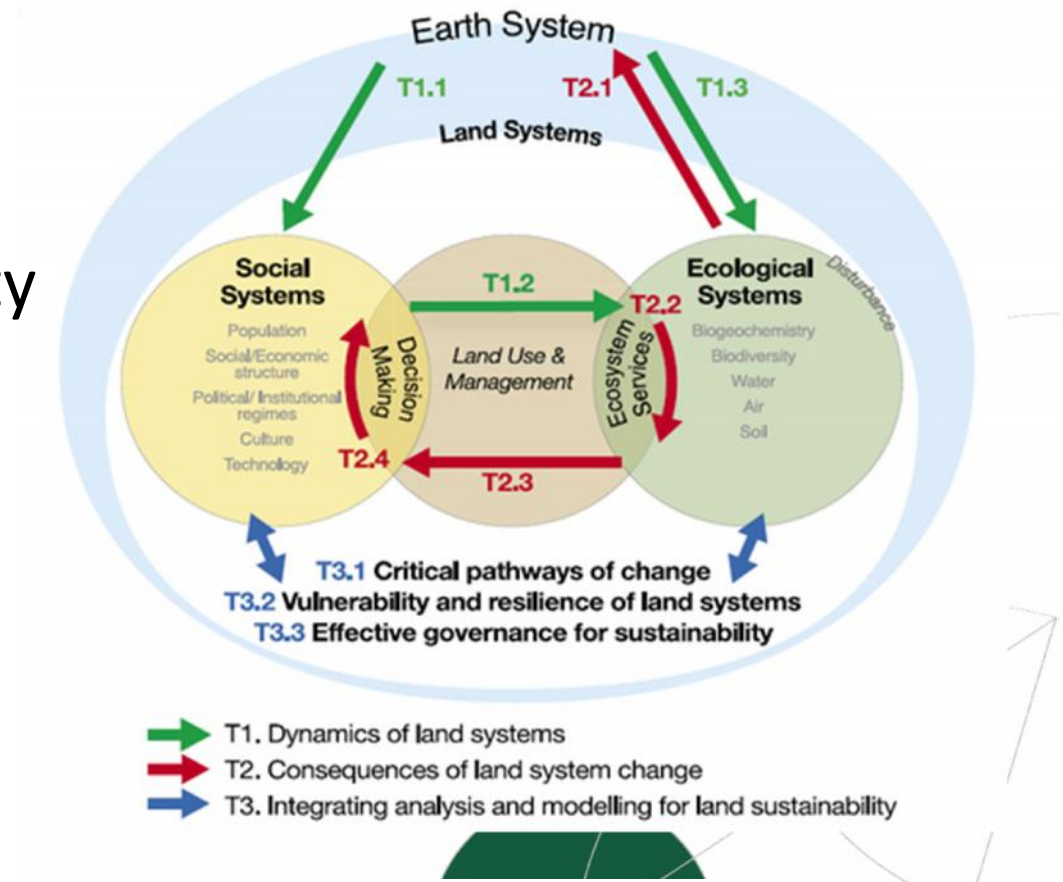
Emerging field of Land System Science

Human interactions with the natural environment

Necessity:

- to monitor land use dynamics and its intensity
- Understand the drivers
- Predict the change
- Assess feedback to the Earth System

Critical role of satellite remote Sensing is emphasized!



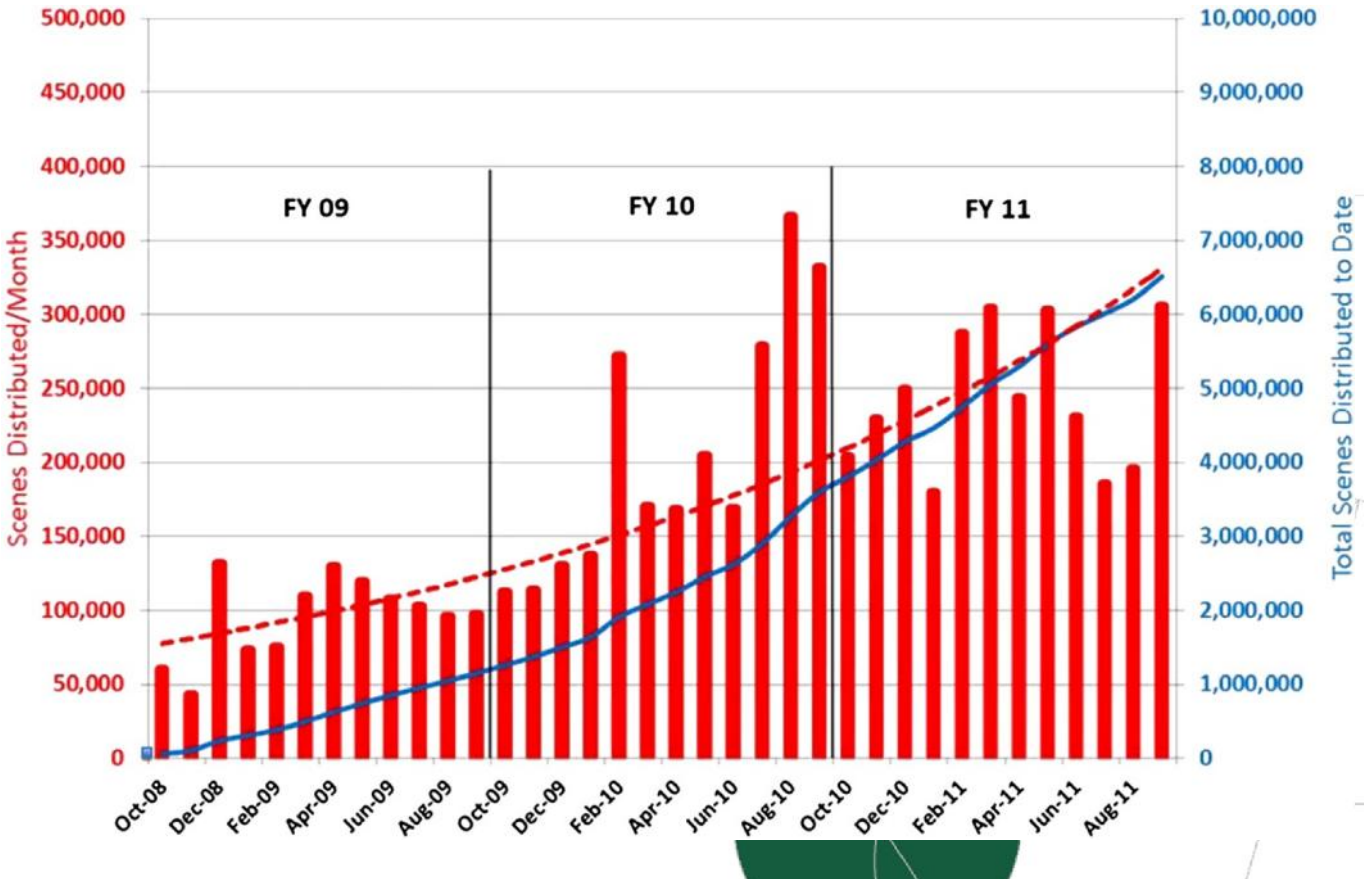
Source: Kuemmerle et al. 2013, COiES

Verburg et al. 2015, Anthropocene

Living in exciting time!

Shift of the paradigm of agencies' behavior regarding data accessibility (freeing Landsat archives, LDCM & Sentinel-2 programs)

Monthly summary of scene downloads from the EROS Data Center



Source: Wulder et al. 2012, Remote Sensing of Environment

However..

- 39 satellites carry optical sensors that allow to record satellite images with finer than 100m spatial resolution

- However, only two programs so far allows free access for satellite images archive

…..there is room for improvement

Source: Wulder et al. 2012, ESA-ESRIN

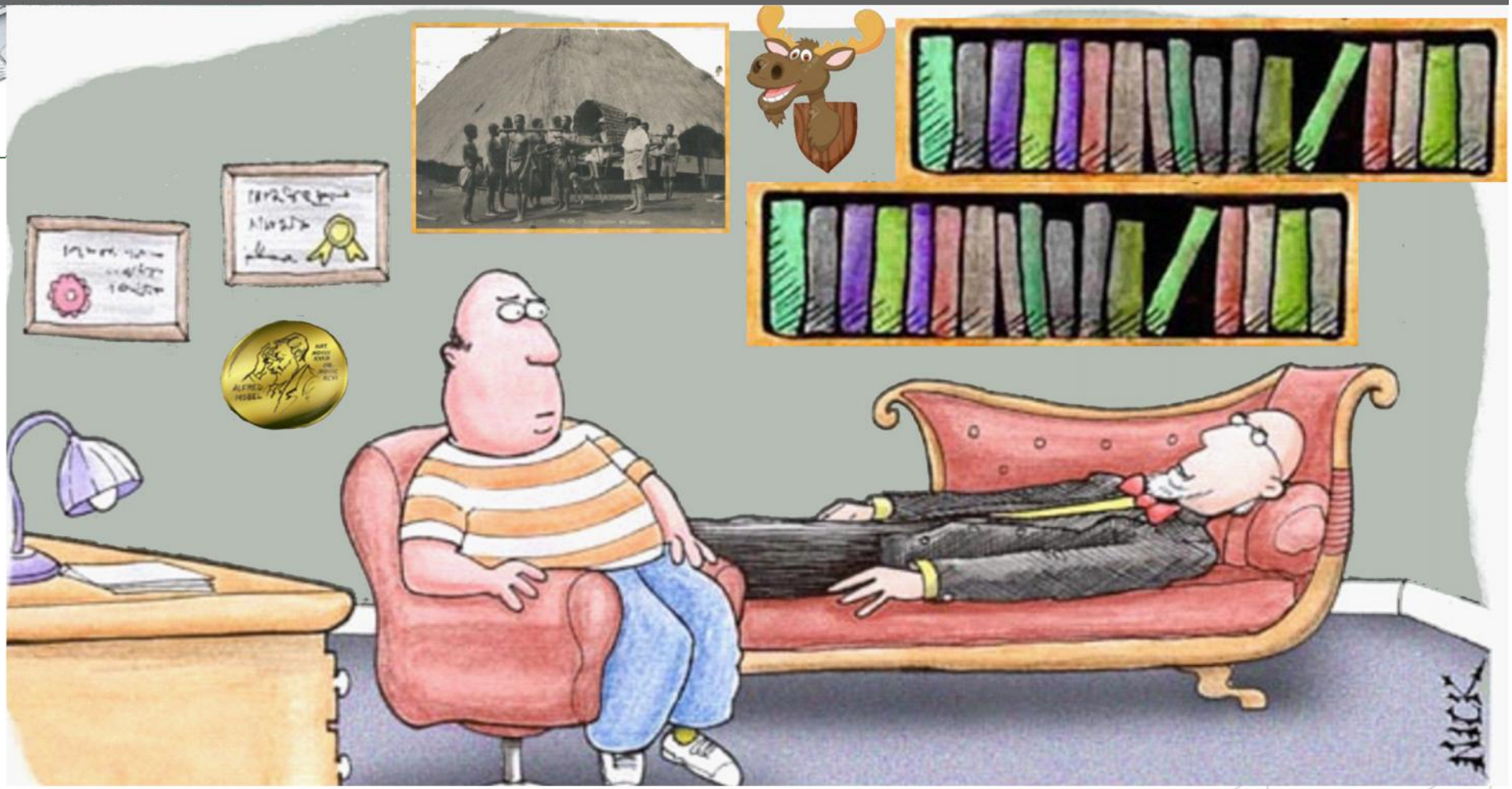
However…

-Preprocessing and classification of datasets requires computational facilities (big data)

- And skilled personal
- Not so many institutions can afford

Even worse…

Screening over 2,000 publications (2011-2015) in Remote Sensing of Environment showed only in few publications authors considered to place datasets as Supplementary or provide a link for data download

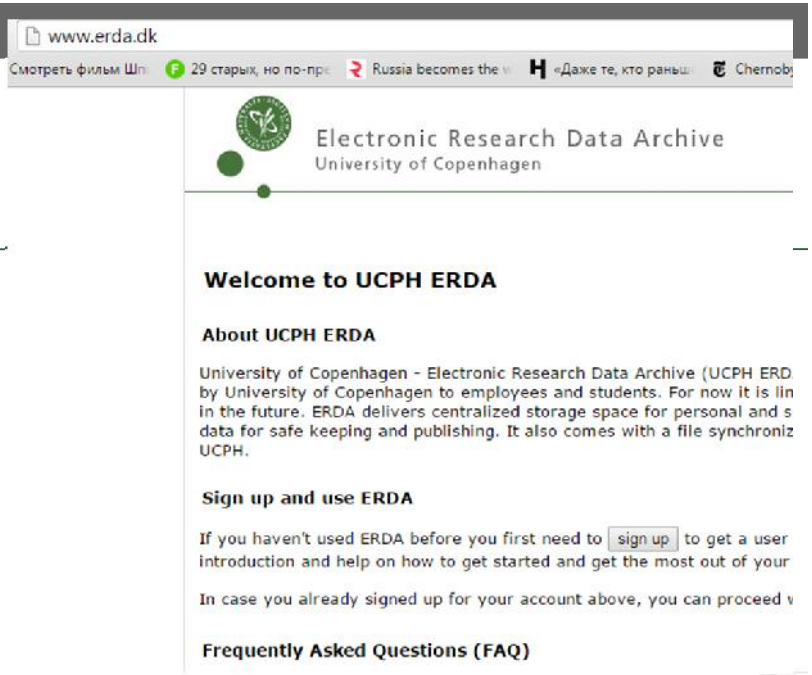


Son, it was a great time, so many publications, exotic field trips, and awards. Access to publications by subscription and my ignorance of opening collected data gives you a chance to write a thesis about their backwardness

What can we do about that

- Elsevier-like journals offer opportunity to upload datasets, appendix, supplementary
- Researchgate, Academia. Edu, other repositories, https://arxiv.org/, GEOSHARE
- Universities require and have facilities to store datasets, including freezing data options (i.e. UCPH M. Penkowa case)

- Funding agencies? Requirement to release the products after 3 year period following the official end of the project



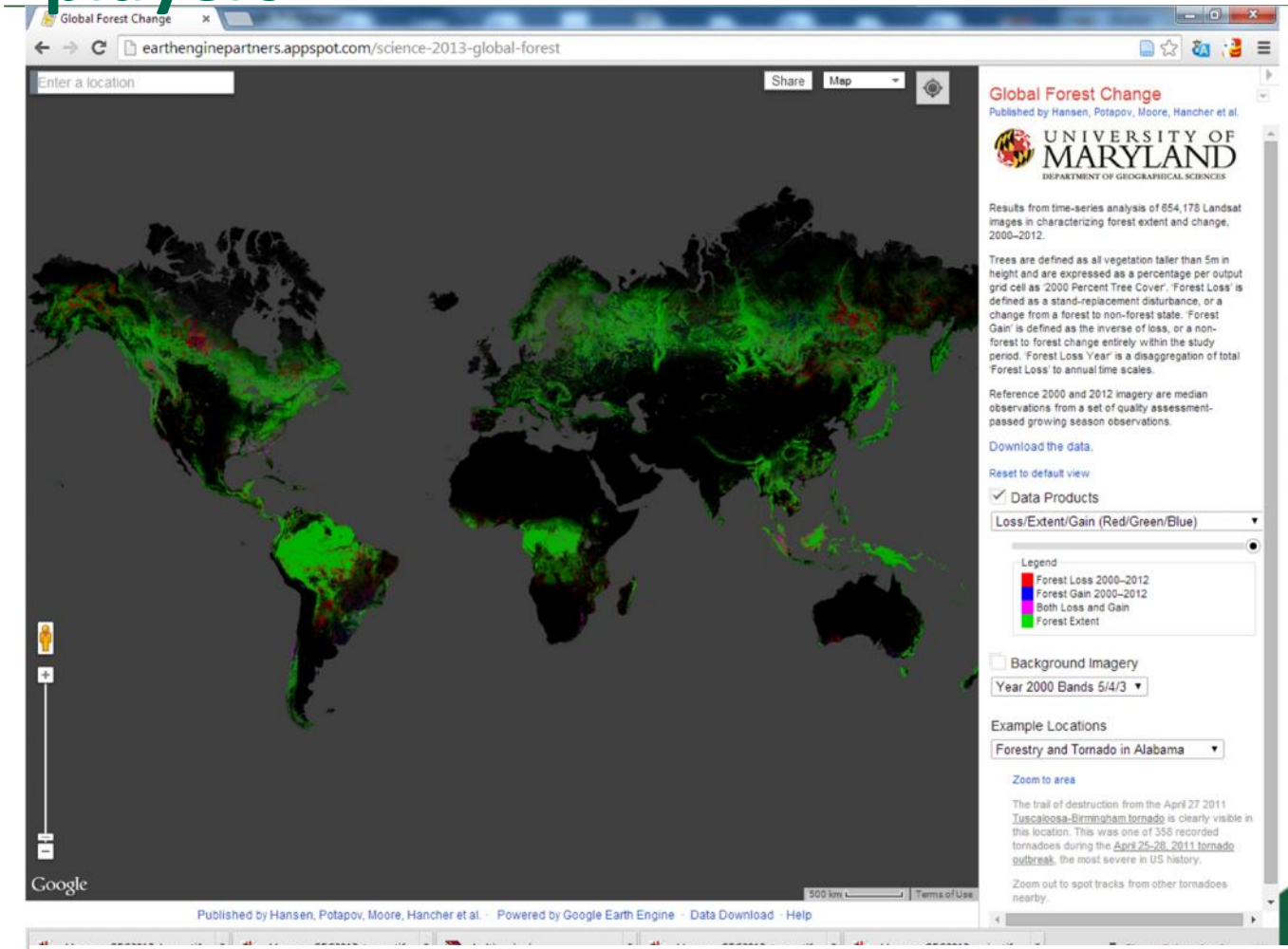
-Increase the awareness about existing LULCC products!

-Interdisciplinary workshops,

Brown bag seminars,

-Special calls and issues of the journals

Increasing role of the commercial players

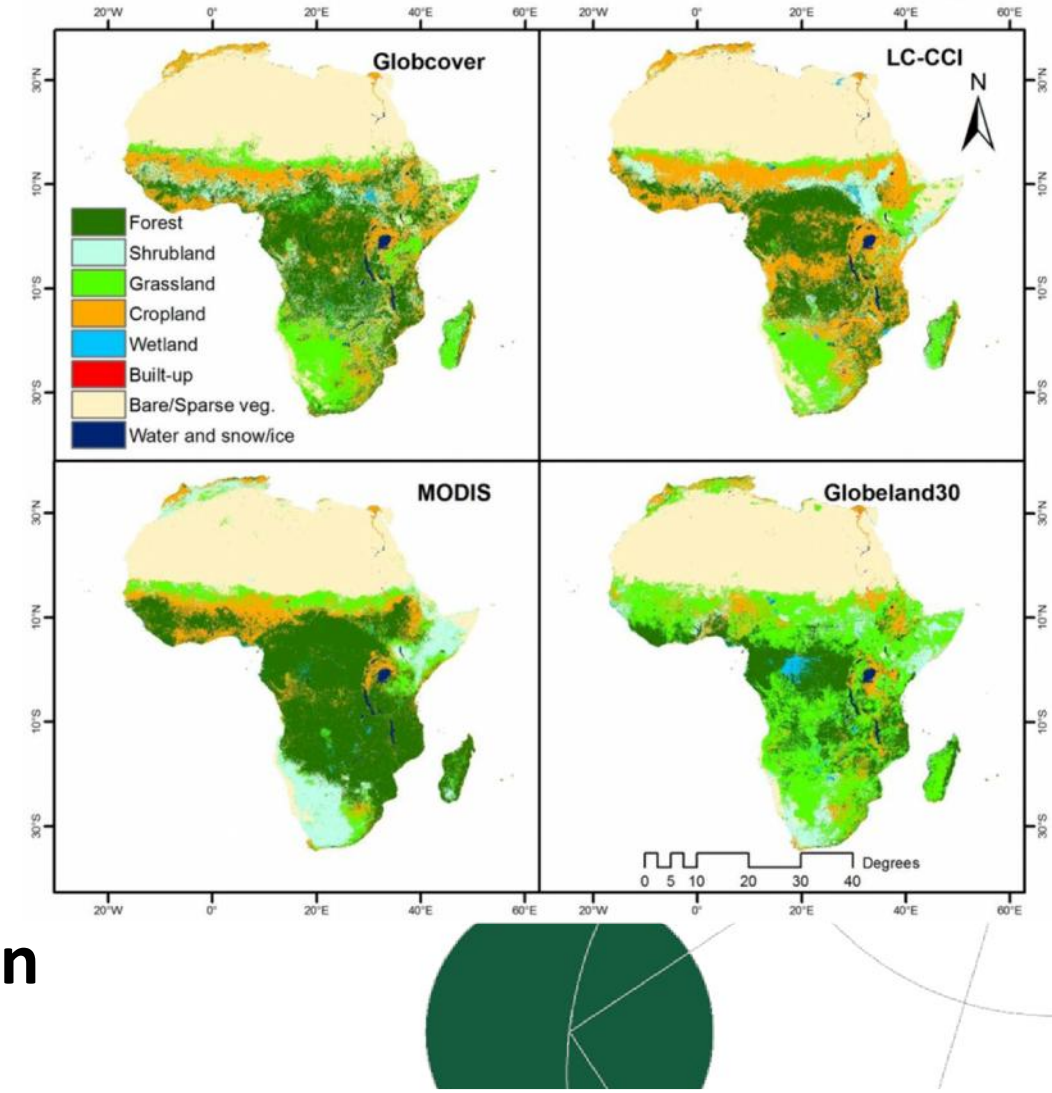


Source: Hansen et al. 2013, Science

http://earthenginepartners.appspot.com/science-2013-global-forest

Quality of LULCC products

- It is often believed remote sensing provides reliable and unbiased information about LULCC
- Products are used without account for induced errors
- What is the cut-off to decide, whether RS product is useful or not for LU models?

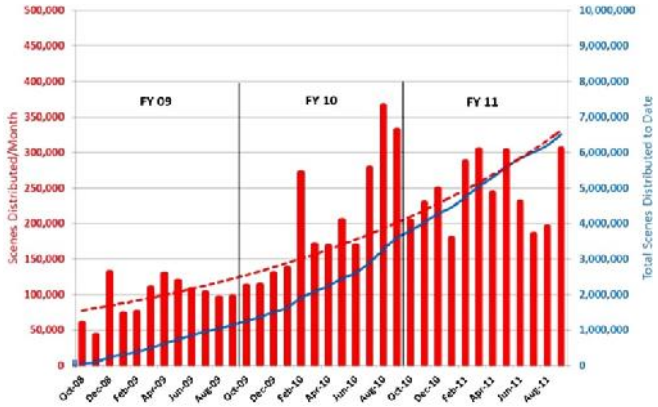


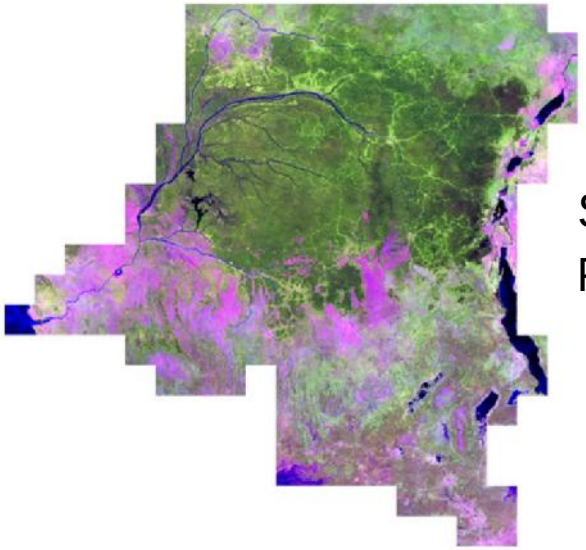
Potential false land cover change due to difference in quality of land cover products

Source: Tsendbazar et al. 2015 Remote Sensing

Growing number of works with massive processing of Landsat imagery- Exciting!

Image downloads after freeing Landsat archives

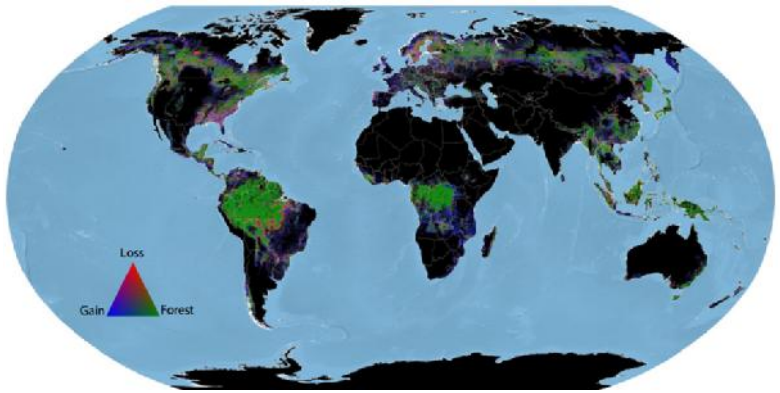




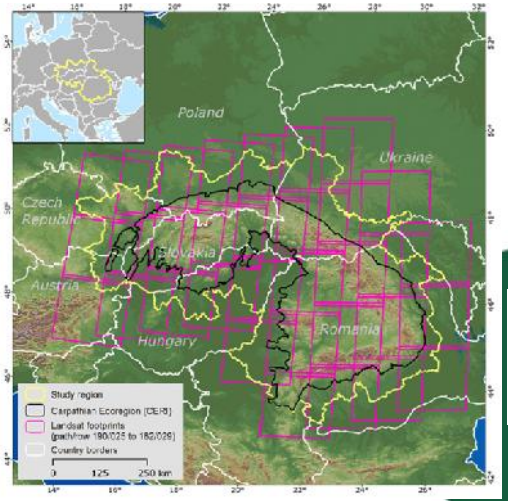
Forest-cover change in Congo

Source: Potapov et al. 2012

Another global forest-cover change product



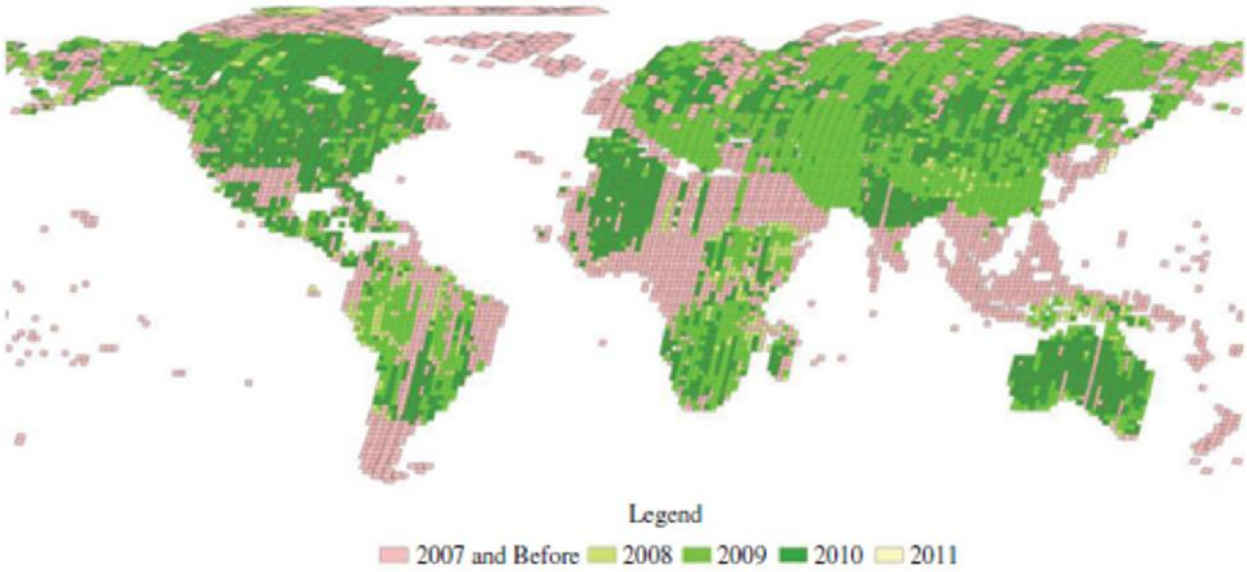
Source: Kim et al. 2014

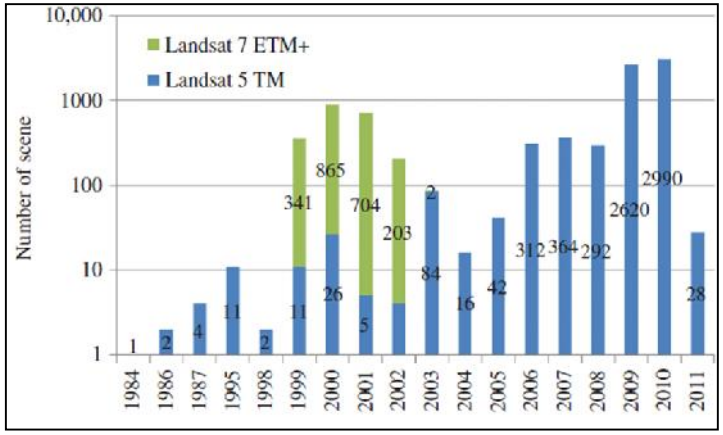


Agricultural land-cover change in the Carpathian region

Source: Griffiths et al. 2013

However, Landsat imagery availability is not equal across the globe

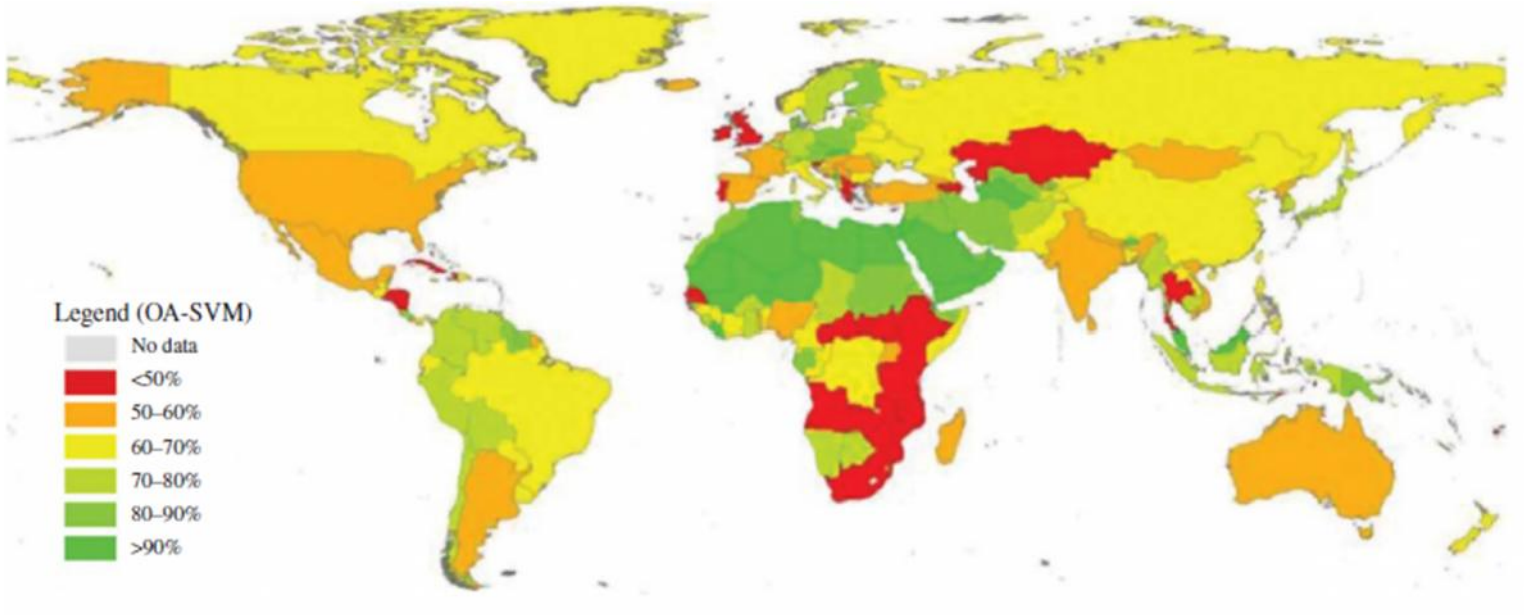




Source: Gong et al. 2012

Accuracy of global products varies

Accuracy is low for grasslands, savanna, but also in the tropics

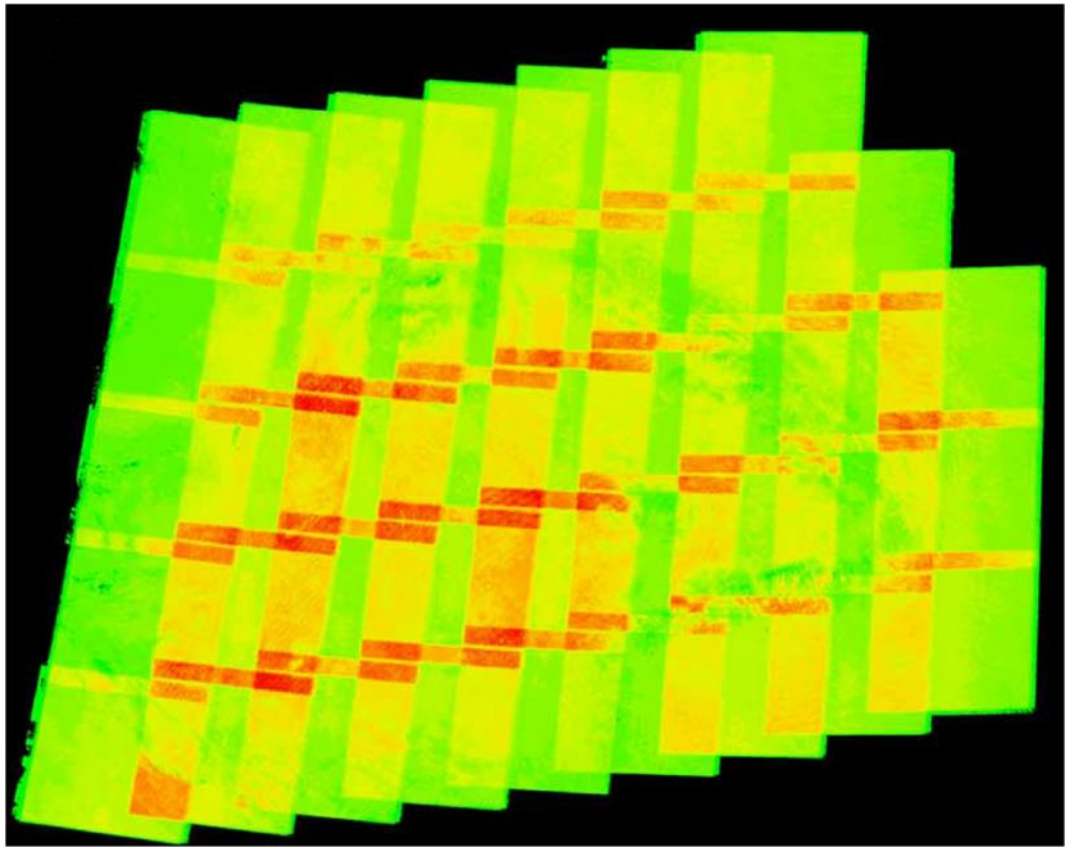


Source: Gong et al. 2012

Counts of clear observations in dense time stacks

Areas with overlapped imagery exhibit regions with higher pixel counts and likely higher accuracies

What about accuracies for green areas (lower pixel counts)?



Griffiths et al. 2013 IEEE journal of selected topics in applied Earth observations and remote sensing

Over- and underestimation of LUC acreage.

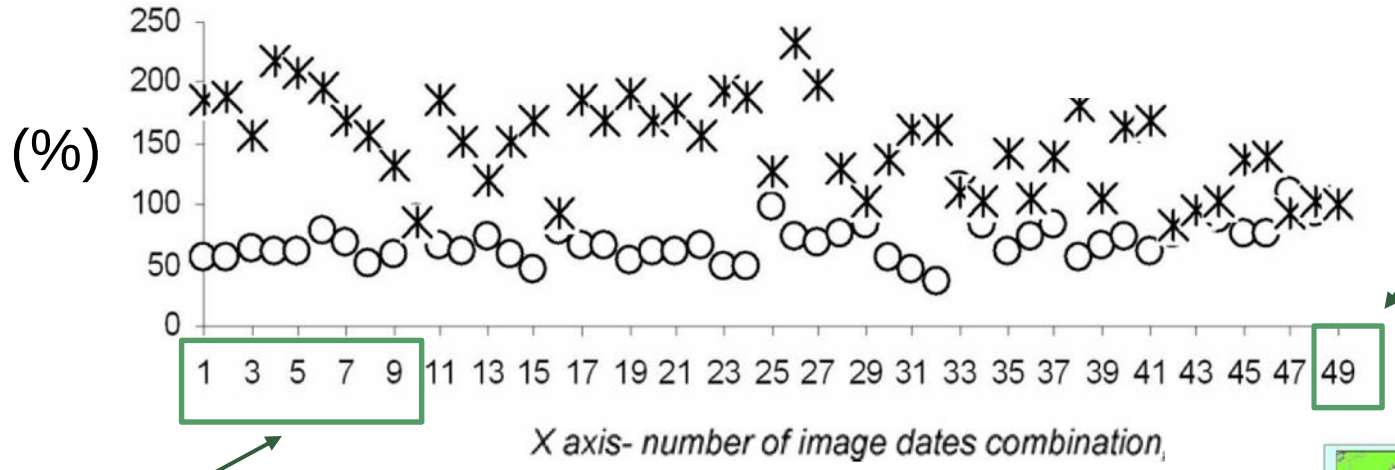
Assessing classifications of sub-optimal image dates

Optimal Combination

Spring Summer Fall

1989
1999/ 2000

Overestimation of "stable arable land" and underestimation of "abandoned arable land" compared to best classified map



Spring Summer Fall

1989
1999/ 2000

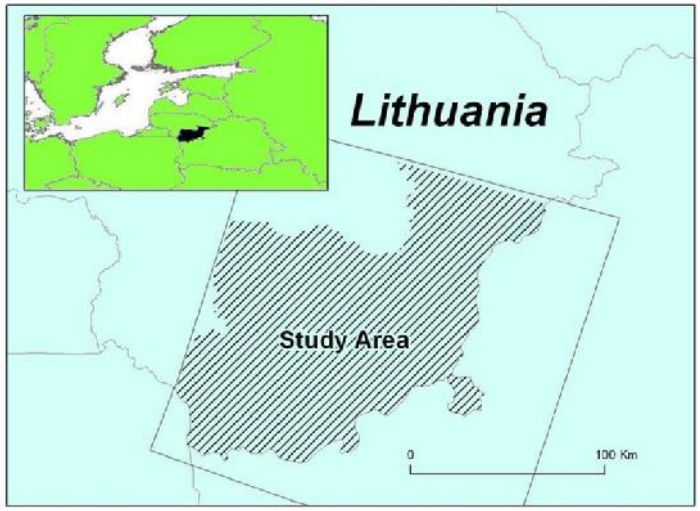
Suboptimal combinations

○ Percent of mapped abandoned arable land compared to the best map

✳ Percent of mapped stable arable land compared to the best map

Source: Prishchepov et al. 2012 Remote Sensing of Environment

Impact of classification accuracies on stability of LU models



Variables *(units)*	Spatial resolution/ Source
Soil pH *(units)*	Rasterized vector dataset/ SOVEUR/ SOTER 1:2,0000,000 digital maps [www.isric.org]
Elevation *(meters)*, slope *(degrees)*	Resampled raster 90 m dataset/ Shuttle Radar Terrain Mission (SRTM) [www.landcover.org]
Accumulated annual precipitation*(millimeters)*	Resampled raster 10 km dataset/ [www.agroatlas.ru]
Distance from nearest forest edge *(100 meters)*	Pixel level calculations/ 30 m Landsat TM/ETM+ classifications
Distance from nearest river *(100 meters)*	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Interpolated population counts from settlements in the late 1980s (the proxy for population density)	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Distance from provincial capital *(km)*, distance from nearest district center *(kilometers)*	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Distance from nearest settlement with over 500 people *(km)*	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Distance from nearest village *(km)*	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Distance from nearest road with hard coverage *(100)*	Pixel level calculations/ 1:100,000 declassified Soviet topographic maps
Night-time intensity for the year 1992 (proxy for GDP)	10*10km observations/ Defense Meteorological Satellite Program [www.oso.noaa.gov/dmsp/]

Source: Prishchepov et al. 2012 iEMSs

Results

- For “abandoned arable land” only three predictors were statistically significant for the best overall classified map (#49) (“ distance from nearest forest edge”, “distance from nearest road”, “distance from nearest village”) 9 times out of 10 models.
- With decrease of image-dates models became unstable, particularly, with “one-and-one” image dates combinations
- Suggested cut-off to use classifications, at least of 80% of UA, PA and individual class Kappa for classes of interest

Solutions

Boosting accuracies of classifications:

- Image fusion (Landsat archives+Sentinel-2, MODIS, other sensors)
- Emerging role of SAR imagery and LiDAR
- Ancillary data (DEM, texture, phenology metrics)
- Better understanding the sensitivity of LULCC models to error-induced LULCC maps (studying error propagation and uncertainties related to produced LULCC products is essential)

Summary and test results of input data enhancement categories

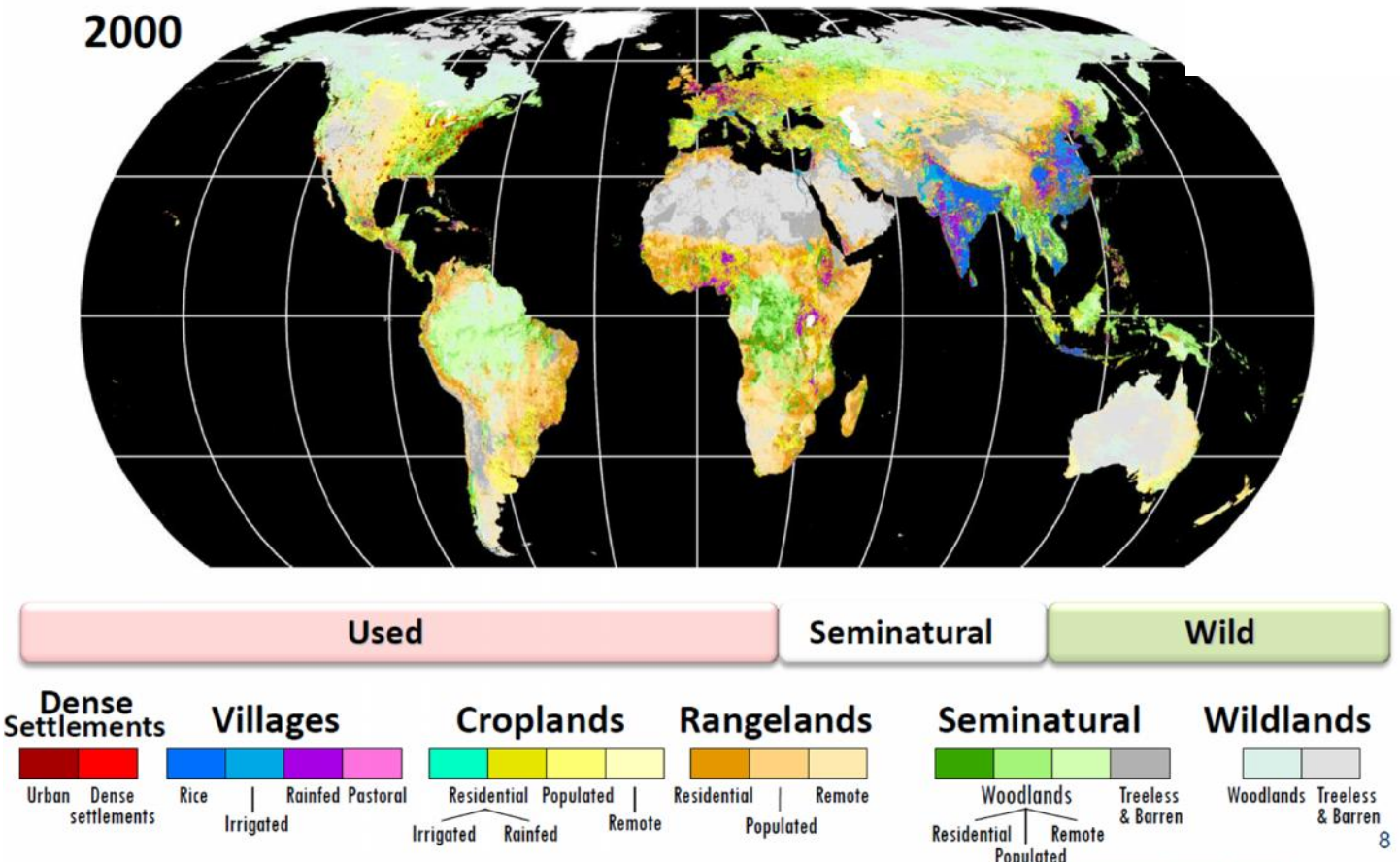
Input data enhancement category	Number of articles or sample size (number of articles with Second OA > First OA)	Mean OA of first classification (%)	Effect size (%) (Second OA − First OA)				P-value of median test
			Mean (standard error)	First quartile	Median	Third quartile	
Texture	31 (31)	71.2	12.1 (1.8)	4.2	8.5	19.8	<0.01
Ancillary data	57 (52)	71.4	8.5 (1.1)	3.3	6.0	13.3	<0.01
Multi-angle imagery	5 (5)	66.7	8.0 (2.6)	3.6	6.0	13.1	0.03
Multi-time imagery	16 (14)	73.3	6.9 (1.3)	4.1	7.0	10.4	<0.01
Image pre-processing	28 (24)	74.0	4.8 (1.0)	0.9	3.9	7.5	<0.01
Spectral indices	8 (6)	73.5	2.4 (1.3)	0.0	0.8	4.7	0.04
Feature extraction	47 (28)	79.5	−0.2 (1.5)	−2.4	0.8	3.3	0.21

H_0: Median OA effect size = 0, H_a: Median OA effect size > 0.

Source: Khatami et al. 2016 Remote Sensing of Environment

Shifting the paradigm of mapping land use versus land cover

We live in Anthropocene!



Source: Ellis et al. 2010, Global Ecology and Biogeography

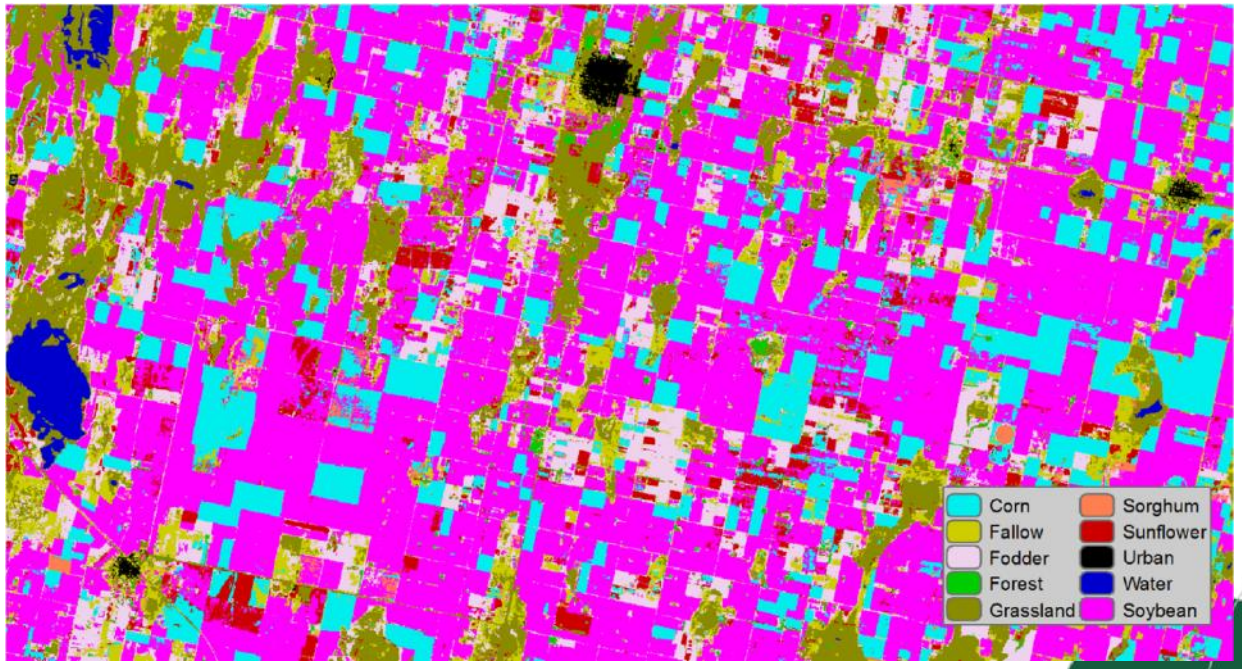
What society really needs

Agricultural economics perspective

- Structural characteristics of farms (size of farms, productivity, profits and losses, efficiency of production)
- Land use intensity (how often fields are cultivated, inputs, timing of sowing, harvesting, utilization of irrigated areas)
- Different crop types rather cropland vs. other classes
- Grazing intensity, grassland productivity
- Bioenergy production vs. traditional crops
- There is strong need in wall-to-wall systematic observations of above mentioned parameters, while case-studies also bring incredible asset!

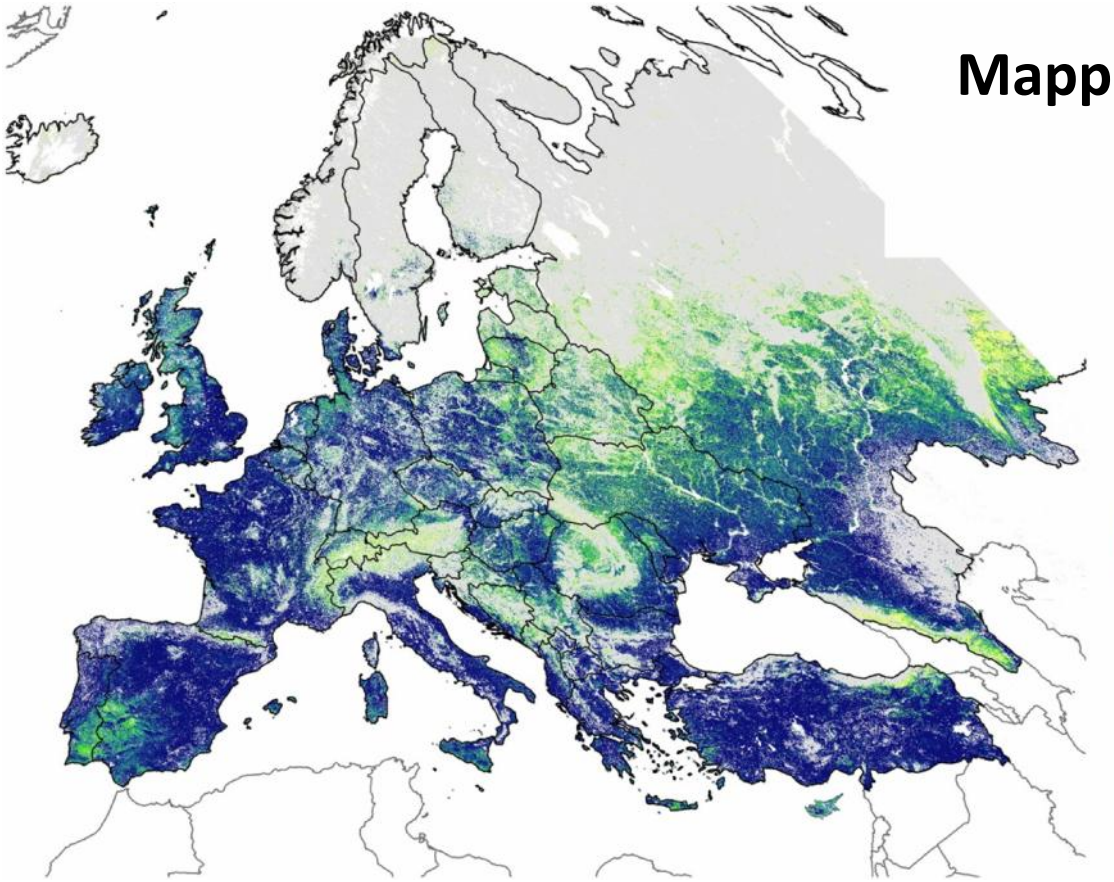
Moving from mapping land cover toward land use and land-use intensity

Mapping the conversion of grasslands into croplands in Pampas, Argentina with dense stacks of Landsat imagery



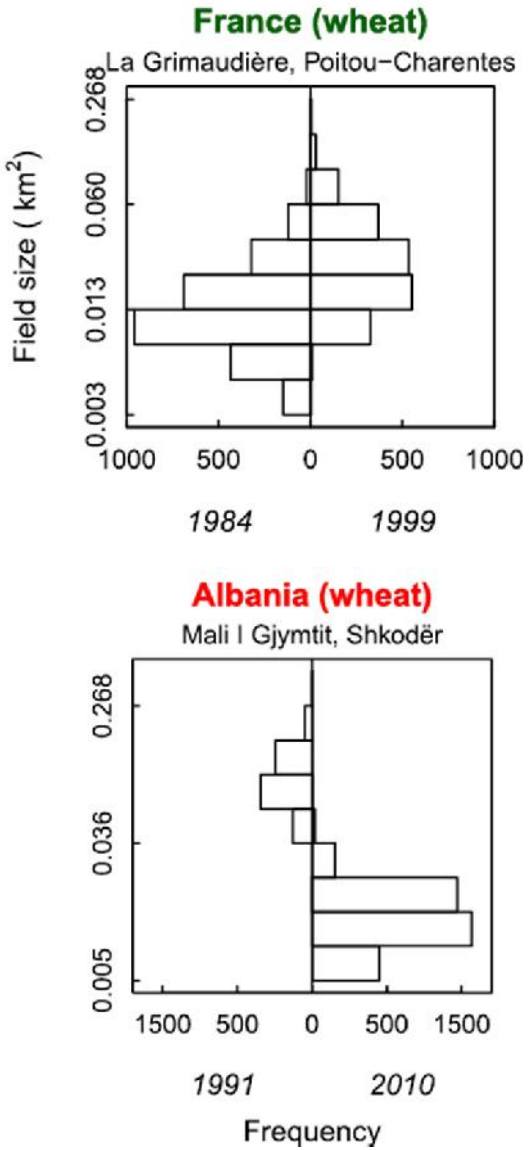
Source: Griffiths, Baumann, Humboldt University in Berlin

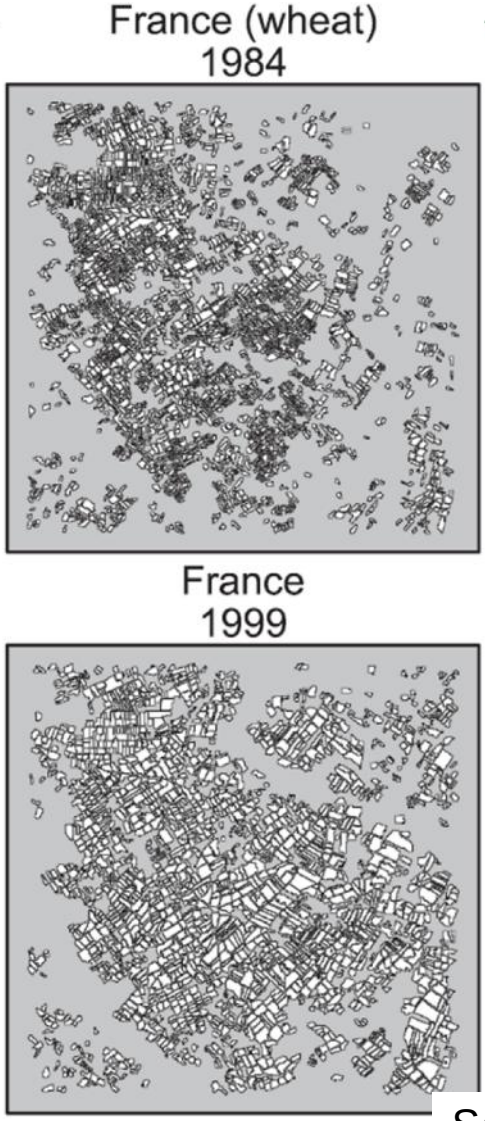
Cropping and fallowing frequency in Europe

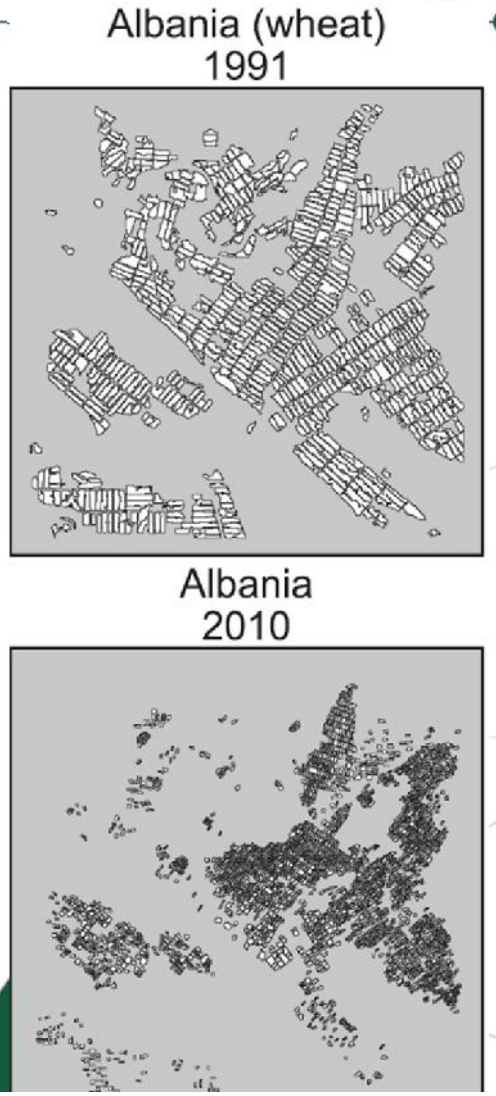


Source: Estel et al. 2016, Remote Sensing of Environment

Mapping the field sizes

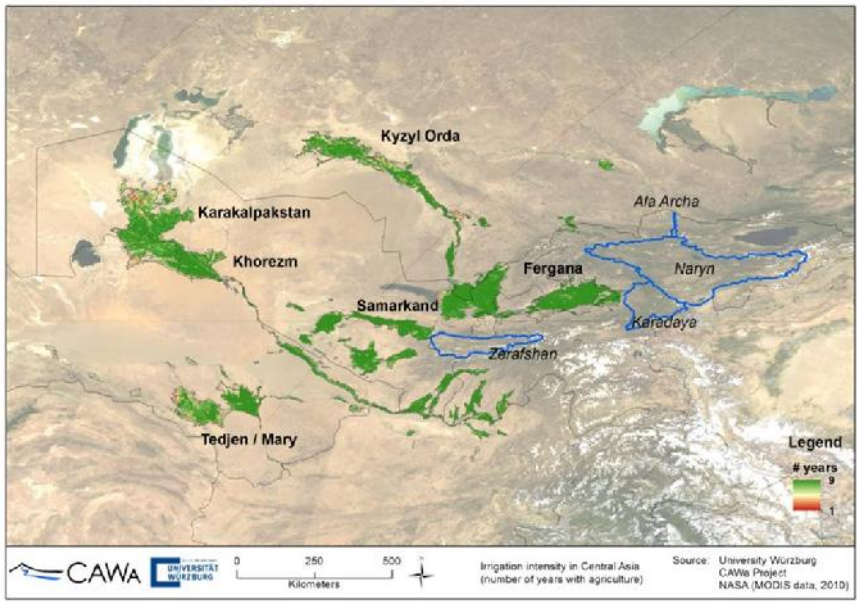






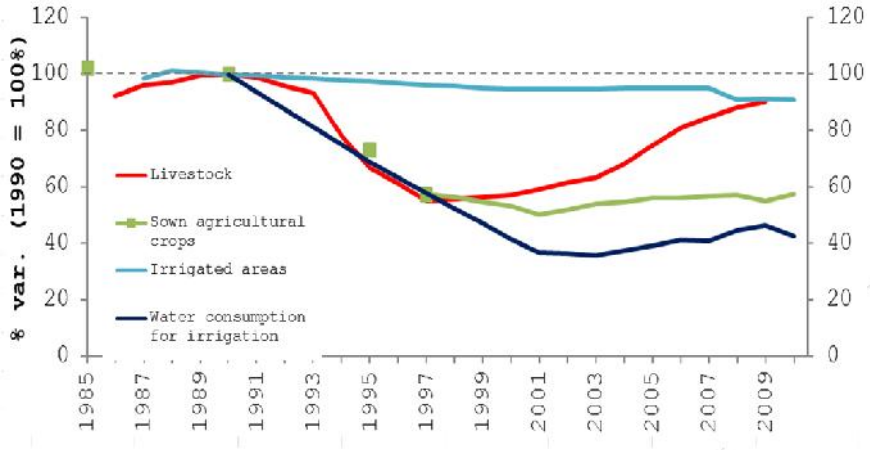
Source: White and Roy 2015, Geography and Environment

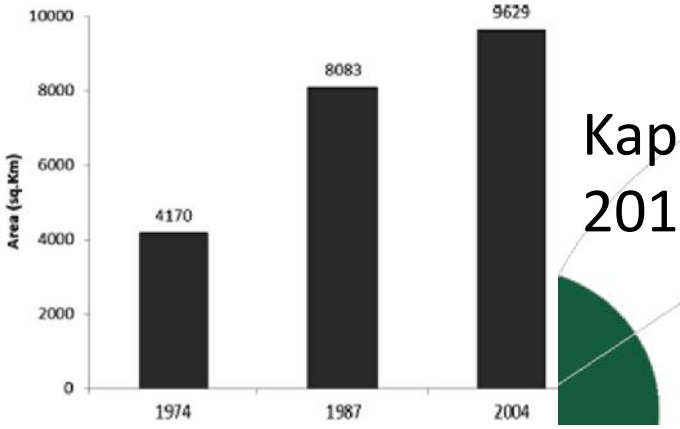
Mapping irrigated areas in Central Asia



Utilization of irrigated lands, Almaty region, Kazakhstan

Horion et al. 2016





Kaplan et al. 2013

The extent of the irrigated oasis area in Dashoguz province of Turkmenistan

Utilization of NDVI as an insurance index

Alternative insurance indexes for drought risk in developing countries

Ihtiyor Bobojonov[1], Rolf Sommer[2]

[1]Farm Management Group. Faculty of Agriculture and Horticulture. Humboldt-Universitaet zu Berlin, Germany. Email: ihtiyor.bobojonov@agrar.hu-berlin.de

[2]International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

Applicability of the Normalized Difference Vegetation Index (NDVI) in Index-Based Crop Insurance Design

CALUM G. TURVEY AND MEGAN K. MCLAURIN

Charles H. Dyson School of Applied Economics and Management, Cornell University, Ithaca, New York

(Manuscript received 8 November 2011, in final form 25 August 2012)

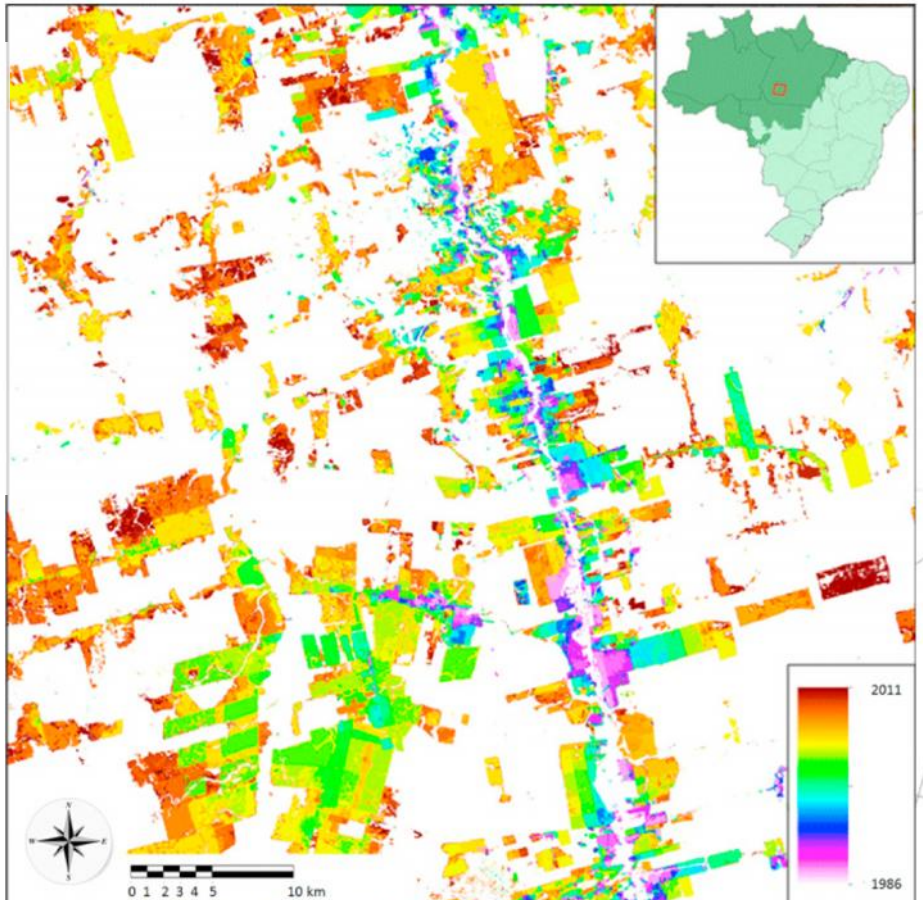
ABSTRACT

Index insurance is becoming increasingly popular because of its ability to provide low-cost, relatively easy to implement agricultural insurance for vegetation types whose productivity has been notoriously difficult to measure and to farmers in less-developed nations where traditional crop insurance schemes are not reasonable to implement. This study examines if the remotely sensed normalized difference vegetation index (NDVI) can be an effective basis for index-based crop insurance over a diverse set of locations. To do this the authors compare Advanced Very High Resolution Radiometer (AVHRR) values to cumulative precipitation, extreme heat, and crop yields for 60 locations across the United States for the years 1982–2003. Quadratic regression equations are used to explore these relationships. The findings suggest that the relationship between NDVI, precipitation, extreme heat, and crop yields is highly variable and dependent on location-specific characteristics. Without site-specific calibration, NDVI should not be widely applied to index-based insurance product design. However, NDVI may still be a useful tool in insurance design under certain circumstances. This may be disappointing to proponents of NDVI as a risk transfer mechanism but the authors believe it important to report negative results as a caveat, and to give researchers and practitioners pause before investing time and money into the proposition.

Detailed track of timing of LULCC is critical

- Carbon balance
- Assessing spillover effects
- "Blaming" the victims

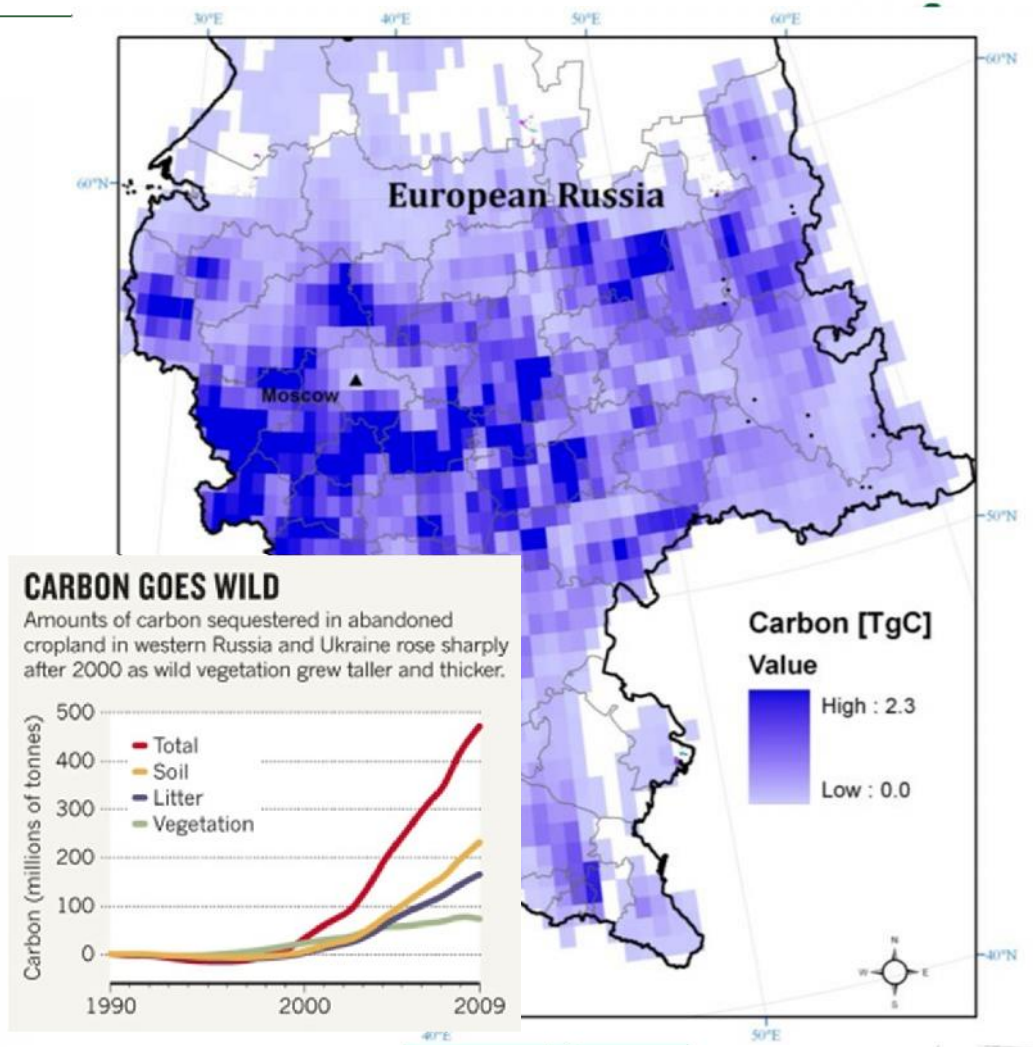
Mapping conversion of forest to rangeland in Amazon with Landsat imagery



Source: Verburg et al. 2015, Anthropocene

Detailed track of timing of LULCC is critical

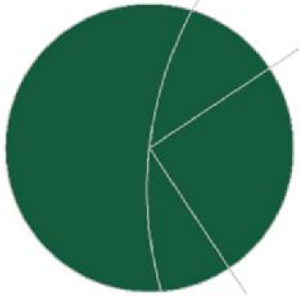
- Carbon uptake substantially increases after 10 years of abandonment
- Cropland abandonment resulted in a net carbon sink of **470 TgC** for 1990 to 2009
- Only in Russia alone one third of CO2 industry and fossil fuels emissions are offset by abandonment



Schierhorn et al. 2013, Global Biogeochemical Cycles

What can we do about that?

- Systematic mapping of land-use intensity
- Development of the new techniques (i.e., time-series analysis of Landsat-like archives, data fusion)
- Freeing the archives and the datasets
- Targeting the societal needs via collaboration with potential end-users
- Making the products understandable and user-friendly for broad-scale audience



Thank You!

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