



Radiant Earth
Foundation

EARTH IMAGERY FOR IMPACT

Machine Learning on Earth Observations; Introduction and Applications

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Radiant Earth Foundation

*IndabaX Sudan 2021
September 11, 2021*



Mission

Empowering organizations and individuals globally with open Earth observation training data, standards and tools to cultivate a global community focused on machine learning and Earth observations to meet the world's most critical challenges.



Vision

Leveraging machine learning and Earth observation for positive global impact

Agenda

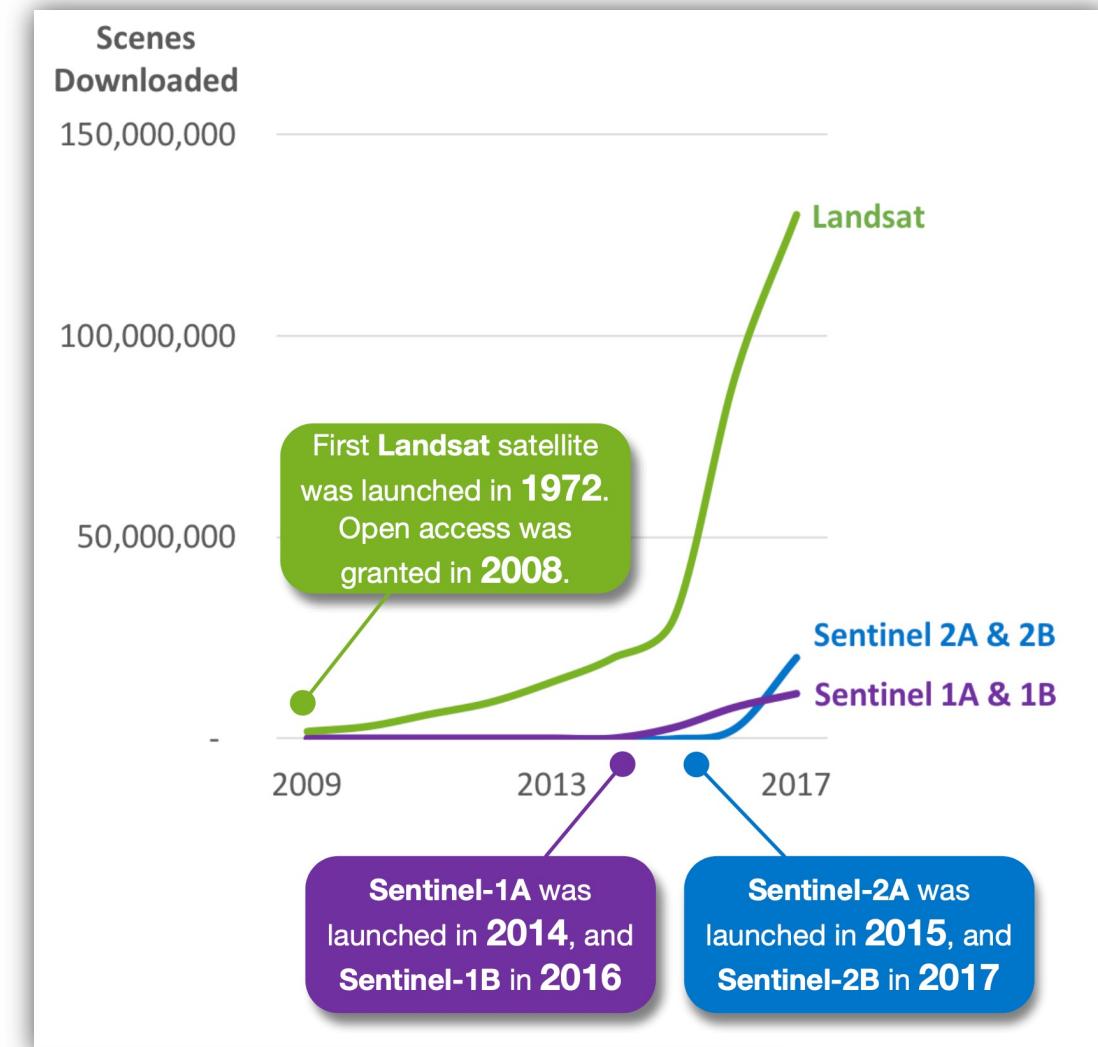


- Earth Observations 101
- Machine Learning Applications on Earth Observations
- Existing Challenges
- Radiant MLHub Training Data Repository
- LandCoverNet Benchmark
- Hands-on Jupyter Notebook Example

Earth Observations



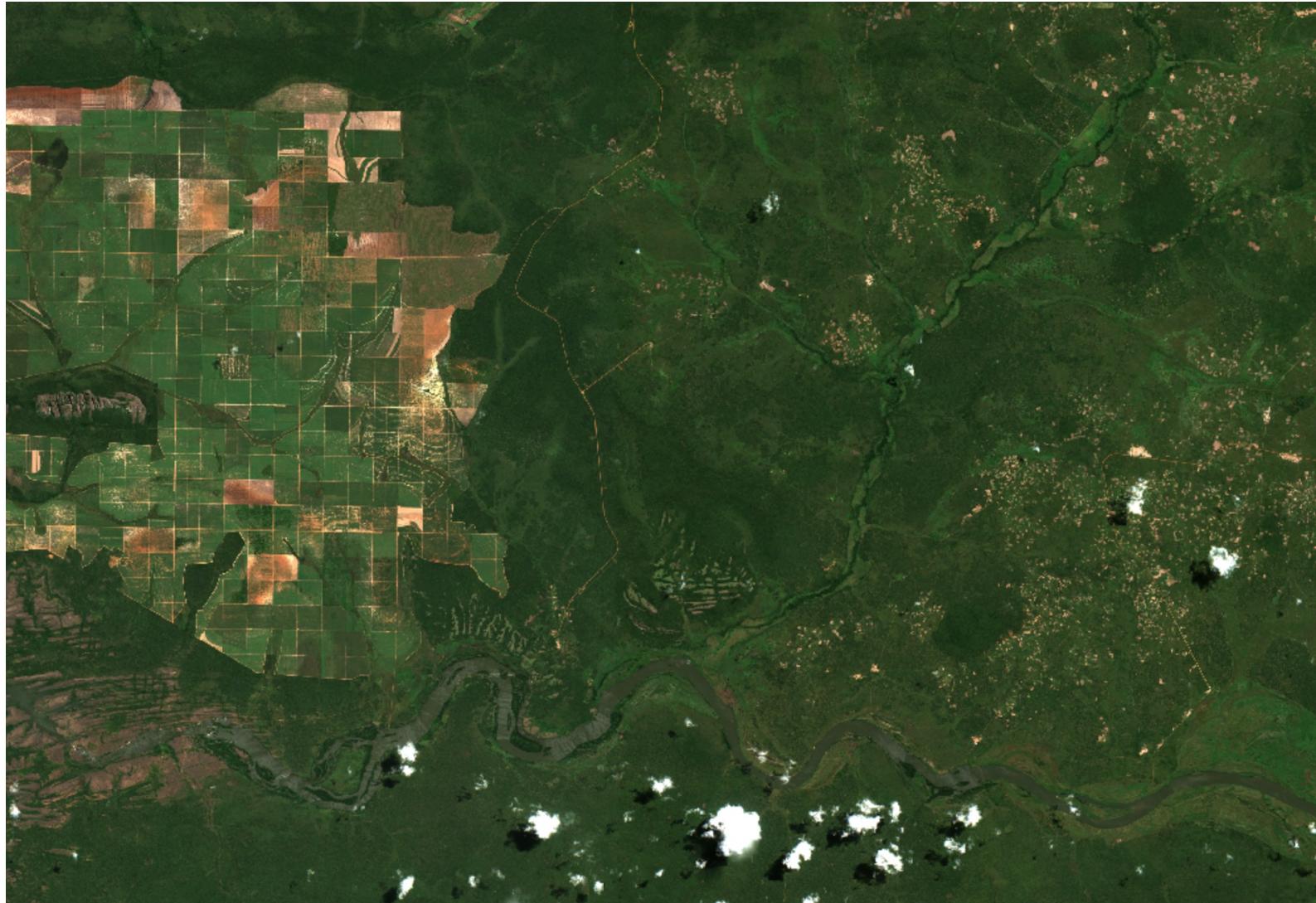
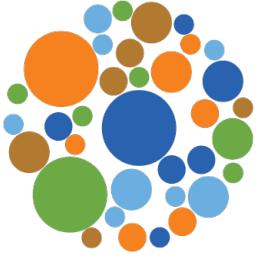
- Consistent spatio-temporal data at global scale
- Growing number of satellite platforms
 - Government
 - Commercial
- Increased temporal revisit
- Increased spatial resolution



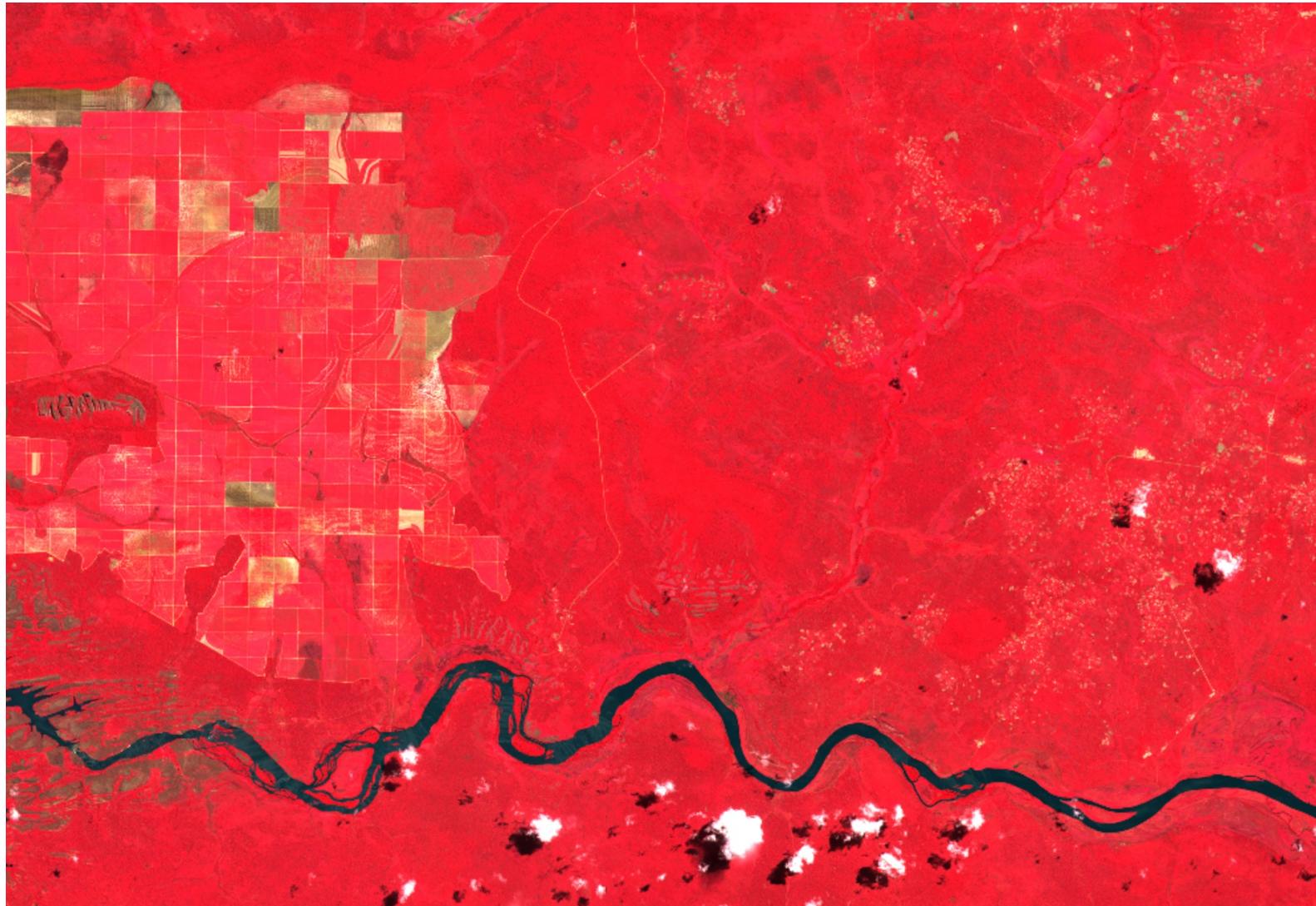
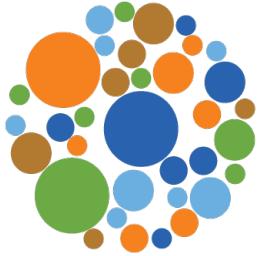


0 days 00 hours 00 minutes
Sentinel-2 constellation:
summer solstice

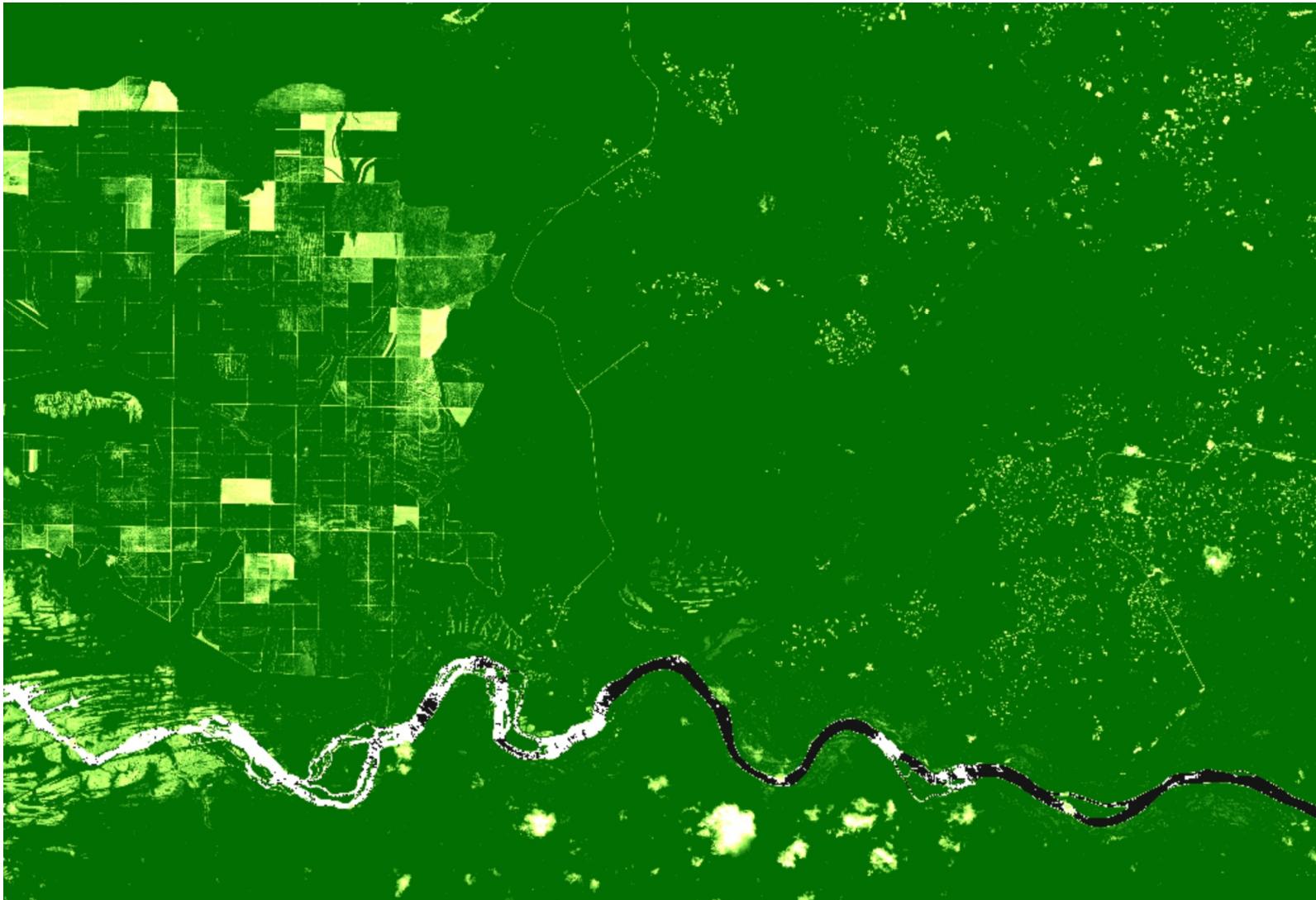
Multispectral (R,G,B)



Multispectral (NIR,R,G)



Multispectral (NDVI)

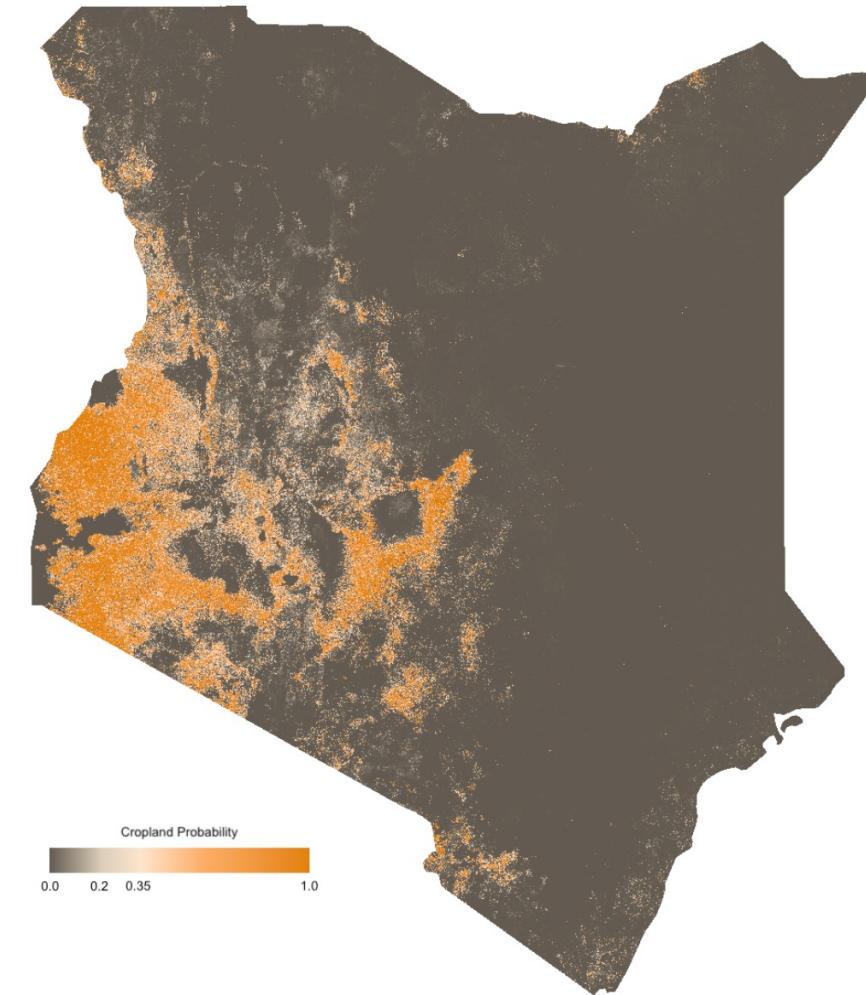


ML Applications on EO



Cropland Detection

- Segmentation task



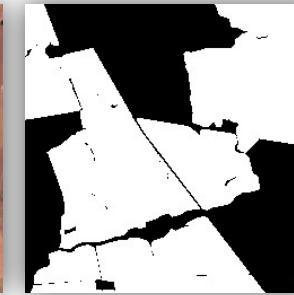
Cropland Probability Map, Kenya, Tseng et al., 2020, NASA Harvest

ML Applications on EO



Crop Type Detection

- Segmentation task



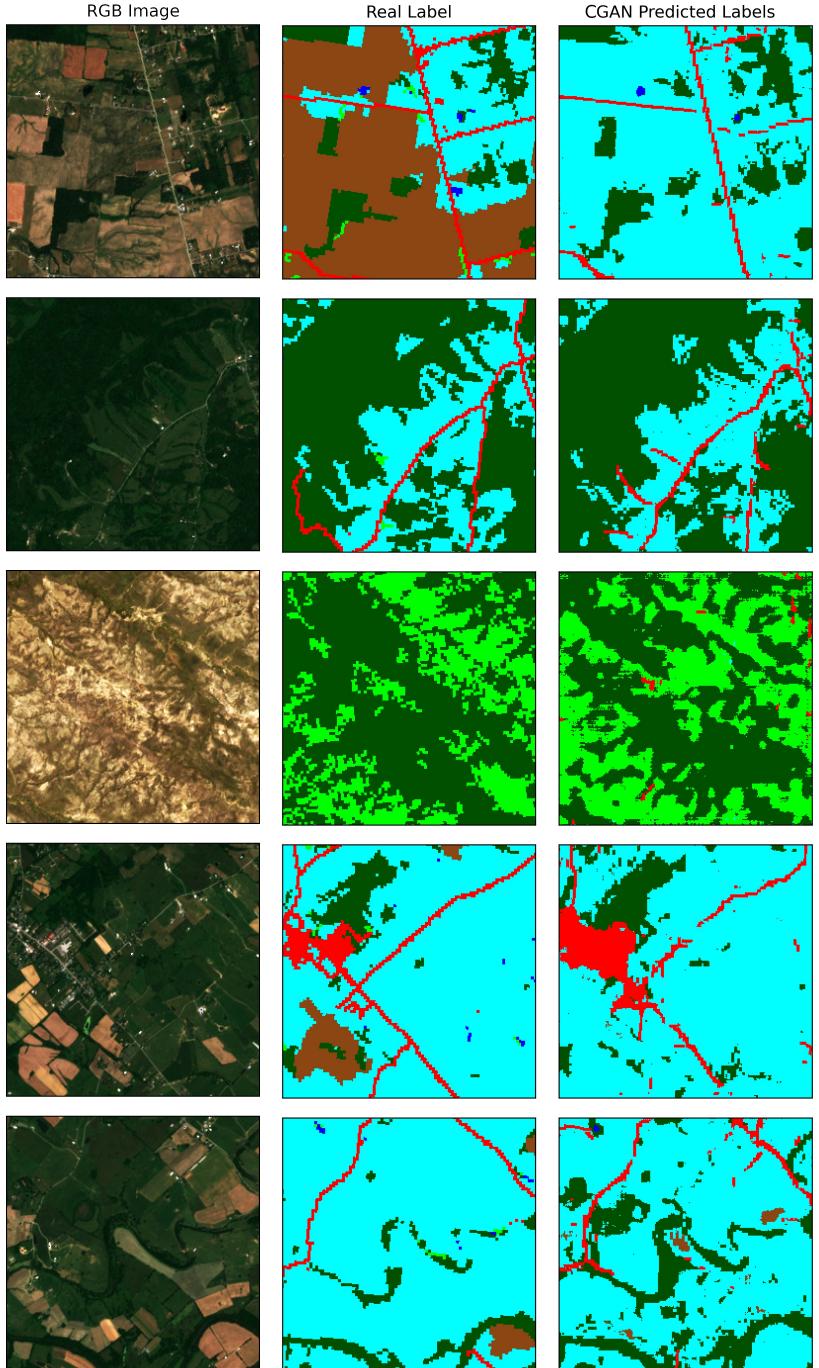
Wheat crops, South Africa, Radiant Earth Foundation

ML Applications on EO

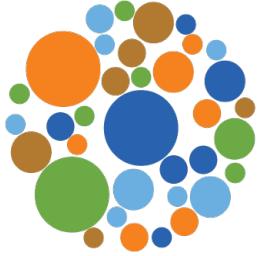
Land Cover Classification

- Segmentation task

red: developed
dark blue: open water
cyan: pasture
dark green: forest
light green: grass
brown: cultivated



ML Applications on EO



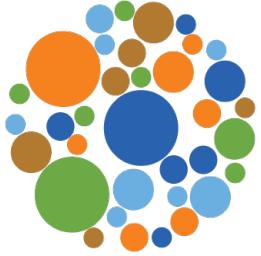
Surface Water Detection

- Segmentation task



Surface water, Zambia, Courtesy of Radiant Earth Foundation

ML Applications on EO



Building Footprint Detection

- Semantic segmentation task



Building Footprints, Monrovia, Liberia. Courtesy of Open Cities AI Challenge

ML Applications on EO



Road Detection

- Semantic segmentation task



Road labels, DeepGlobe Dataset

Opportunity for Global Development Problems



- **Increasing volume of data**
 - New satellites, in situ sensors, and models
 - Public and commercial sectors
 - **Advancements in Machine Learning techniques**
 - Data-driven and fast iterations
 - Capable of detecting complex and non-linear relationships
 - **Availability of cloud services**
 - Brining computation to data
 - Scaling resources on-demand
 - Serverless designs

Challenges in Geospatial ML



Geospatial Training Data Catalogs:

- Lack of Geo-Diversity
- Scarce data sources
- Data Accessibility
- Inter-Operability
- Machine learning-readiness



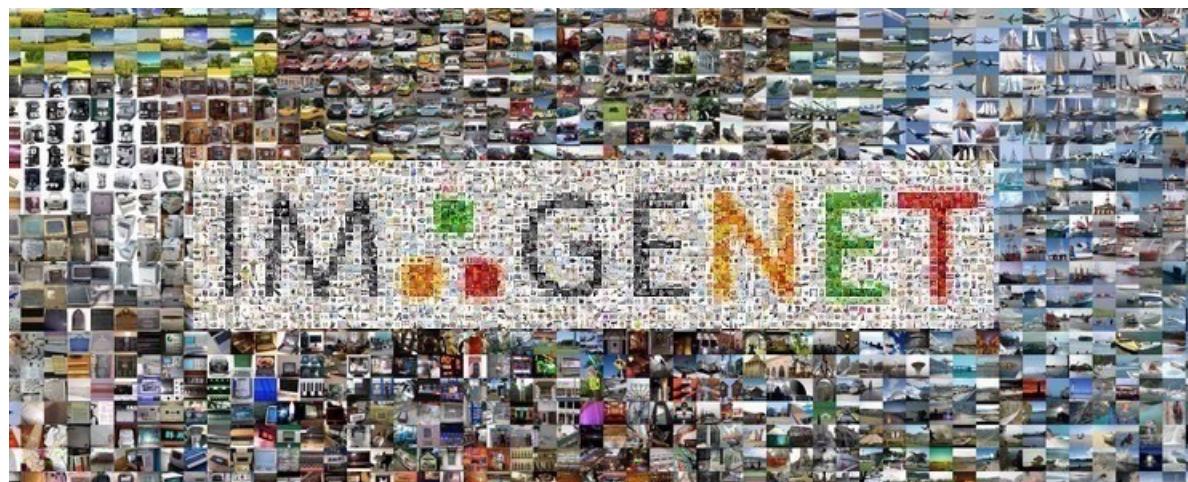
Result of Gaps in Training Data Catalogs:

- Biased or incorrect results
- Inability to capture wide range of possible outcomes in space and time

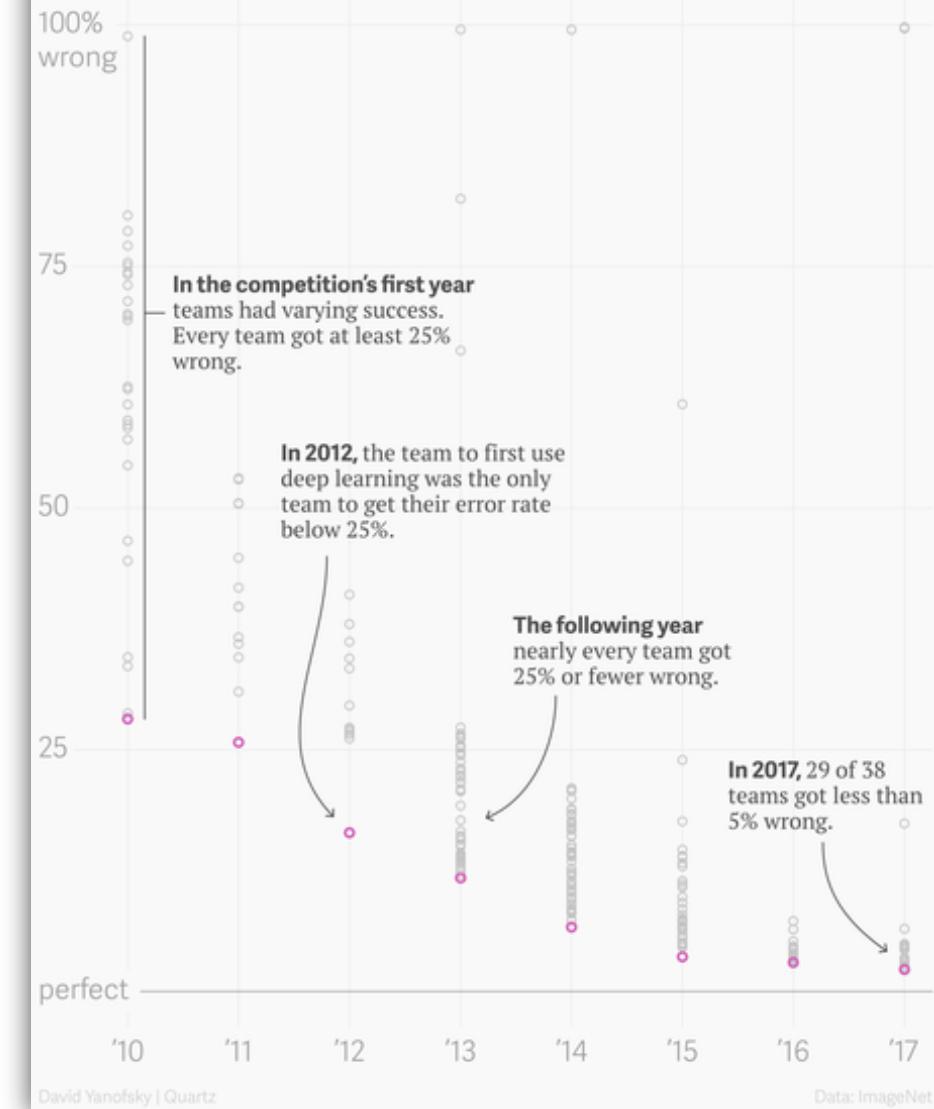
ImageNet



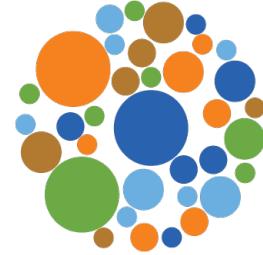
- 14 M annotated images including 1 M with object bounding boxes.
- 20 K categories of objects
- Open access
- Annual competition 2010-2017



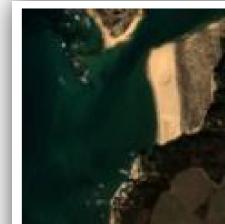
ImageNet Large Scale Visual Recognition Challenge results



BigEarthNet



- 590,326 Sentinel-2 image patches
- Each patch is a section of i) 120×120 pixels for 10m bands; ii) 60×60 pixels for 20m bands; and iii) 20×20 pixels for 60m bands.
- Each image patch is annotated by multiple land-cover classes
- Images are selected across 10 EU countries.



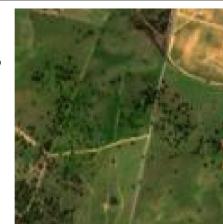
permanently irrigated land,
sclerophyllous vegetation,
beaches, dunes, sands,
estuaries, sea and ocean



permanently irrigated land,
vineyards, beaches, dunes,
sands, water courses



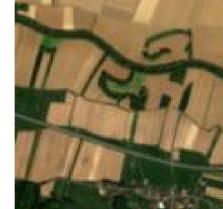
coniferous forest, mixed
forest, water bodies



non-irrigated arable land,
fruit trees and berry
plantations, agro-forestry
areas, transitional
woodland/shrub



non-irrigated arable land



discontinuous urban fabric,
non-irrigated arable land,
land principally occupied
by agriculture,
broad-leaved forest

SpaceNet



- 7 benchmarks
 - Roads
 - Buildings
 - Change Detection
- Imagery
 - World-View from Maxar (high-res)
 - SAR from Capella Space
- Evaluation metrics and baseline models



ML Commons for Earth Observation



Hub

- EO Training Datasets
- ML Models
- Competitions
- Image annotation + ground-referencing

Community

- Convenings to develop standards for ML on EO
- Interoperability of datasets
- Technical Working Groups
- White Papers

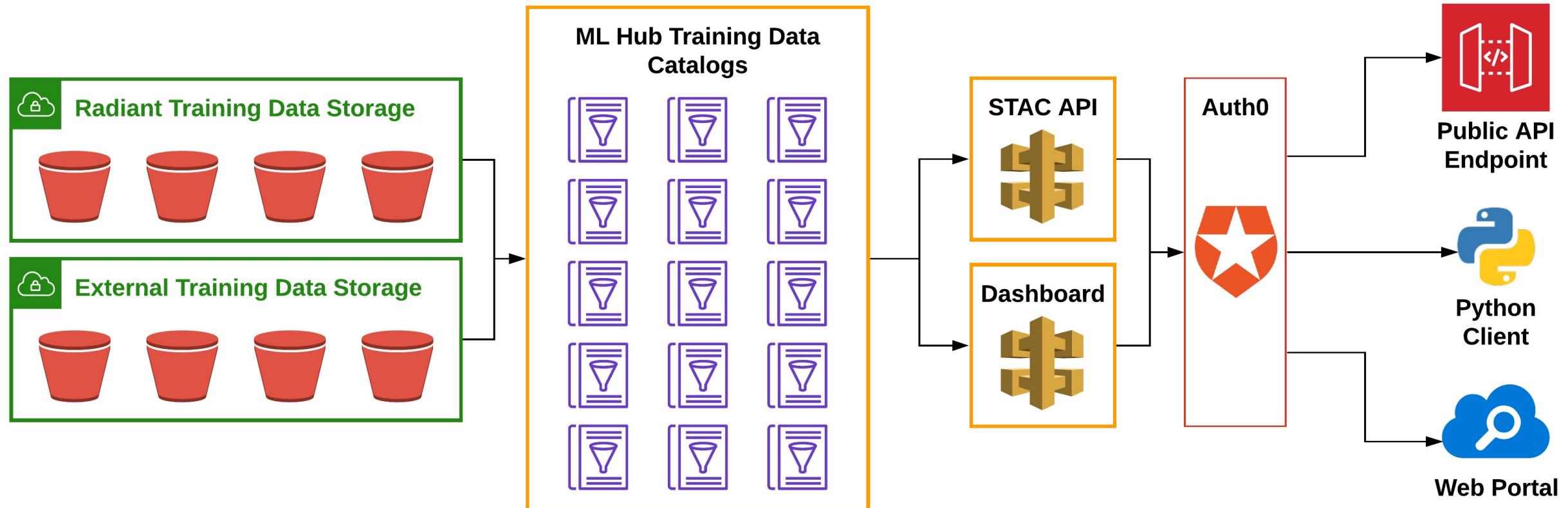
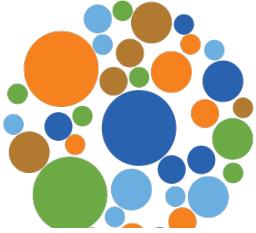
Education

- EO market information
- Best practices on use of ML and EO
- Speaking engagements
- Media outreach



Radiant MLHub
Earth Imagery for Impact

Radiant ML Hub



Sign up on mlhub.earth

Radiant MLHub Repository



- Each dataset has a DOI with version and citation
- FAIR data principles
 - Findable
 - Accessible
 - Interoperable
 - Reusable

Radiant MLHub Training Data Registry



Radiant MLHub
EARTH IMAGERY FOR IMPACT

Great African Food Company Crop Type Tanzania

<https://doi.org/10.34911/rdnt.5vx40r>

[crop type](#) [segmentation](#) [sentinel-2](#)

Description

This dataset contains field boundaries and crop types from farms in Tanzania. Great African Food Company used Farmforce app to collect a point within each field, and recorded other properties including area of the field.

Radiant Earth Foundation team used the point measurements from the ground data collection and the area of each field overlaid on satellite imagery (multiple Sentinel-2 scenes during the growing season, and Google basemap) to draw the polygons for each field. These polygons do not cover the entirety of the field, and are always enclosed within the field. Therefore, they should not be used for field boundary detection, rather as reference polygons for crop type classification. Data points that were not clear if they belong to a neighboring farm

STAC Collections

Description
Crop Type Labels

Resource type
Labels

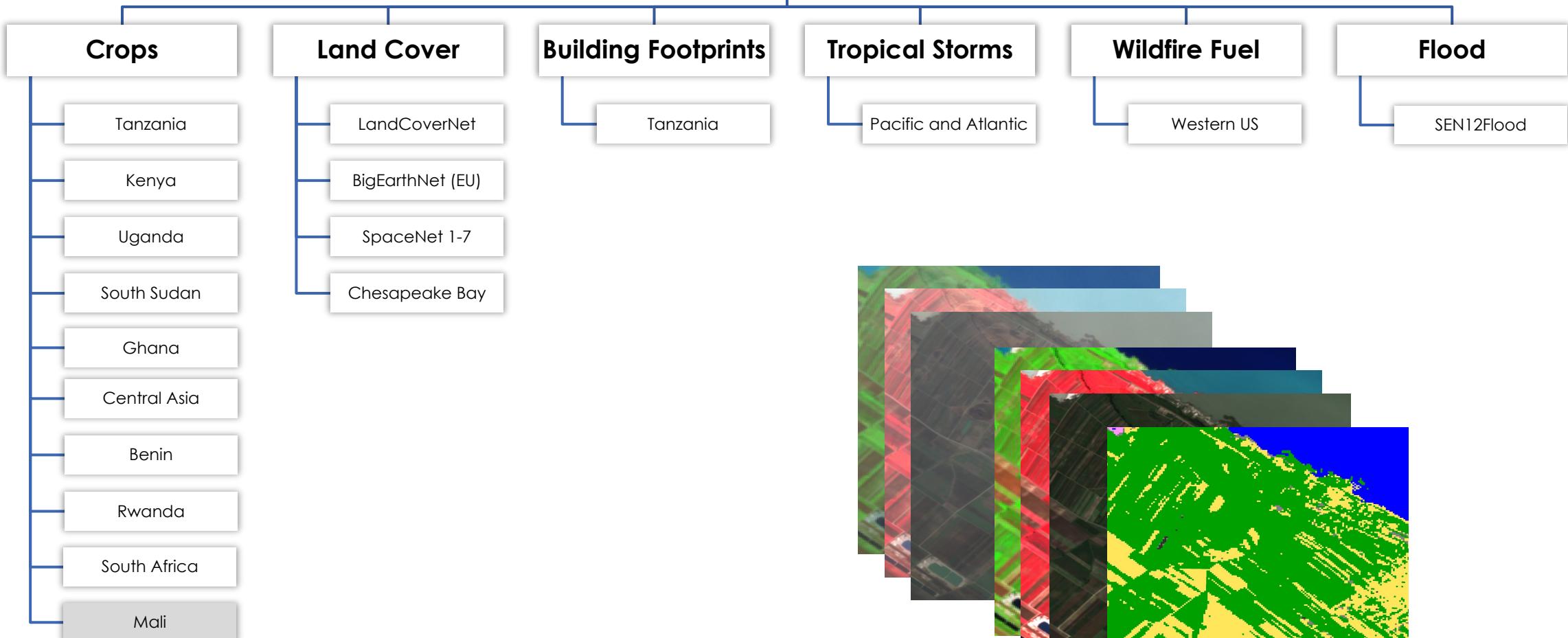
Collection ID
[ref_african_crops_tanzania_01_labels](#)

License
CC-BY-4.0

Download (Requires Radiant MLHub Account)
[ref_african_crops_tanzania_01_labels.tar.gz \(193.9 KB\)](#)



Radiant MLHub Data Catalog



LandCoverNet

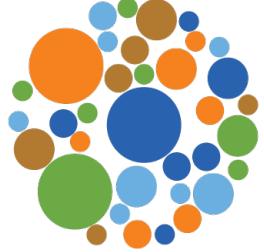


- Regularly updated Land Cover (LC) maps are needed for many applications.
- 14 of the 17 SDGs need an accurate LC map
- Sentinel-2 satellite imagery available globally
 - 10m spatial resolution (best open-access)
 - 5-day revisit
 - Multispectral (13 bands)
- Geographical diversity is key



Sample Sentinel-2 image, Nigeria

LandCoverNet V1.0



- African continent
- ~130M labeled pixels + consensus score
- 384K tasks were validated by users
- Available on Radiant MLHub repository
- Annual time-series
- CC BY 4.0 License

landcover.net

[Submitted on 5 Dec 2020]

LandCoverNet: A global benchmark land cover classification training dataset

Hamed Alemohammad, Kevin Booth

Regularly updated and accurate land cover maps are essential for monitoring 14 of the 17 Sustainable Development Goals. Multispectral satellite imagery provide high-quality and valuable information at global scale that can be used to develop land cover classification models. However, such a global application requires a geographically diverse training dataset. Here, we present LandCoverNet, a global training dataset for land cover classification based on Sentinel-2 observations at 10m spatial resolution. Land cover class labels are defined based on annual time-series of Sentinel-2, and verified by consensus among three human annotators.

Comments: Presented at the AI for Earth Sciences Workshop at NeurIPS 2020

Subjects: Computer Vision and Pattern Recognition (cs.CV); Machine Learning (cs.LG)

Cite as: arXiv:2012.03111 [cs.CV]

(or arXiv:2012.03111v1 [cs.CV] for this version)

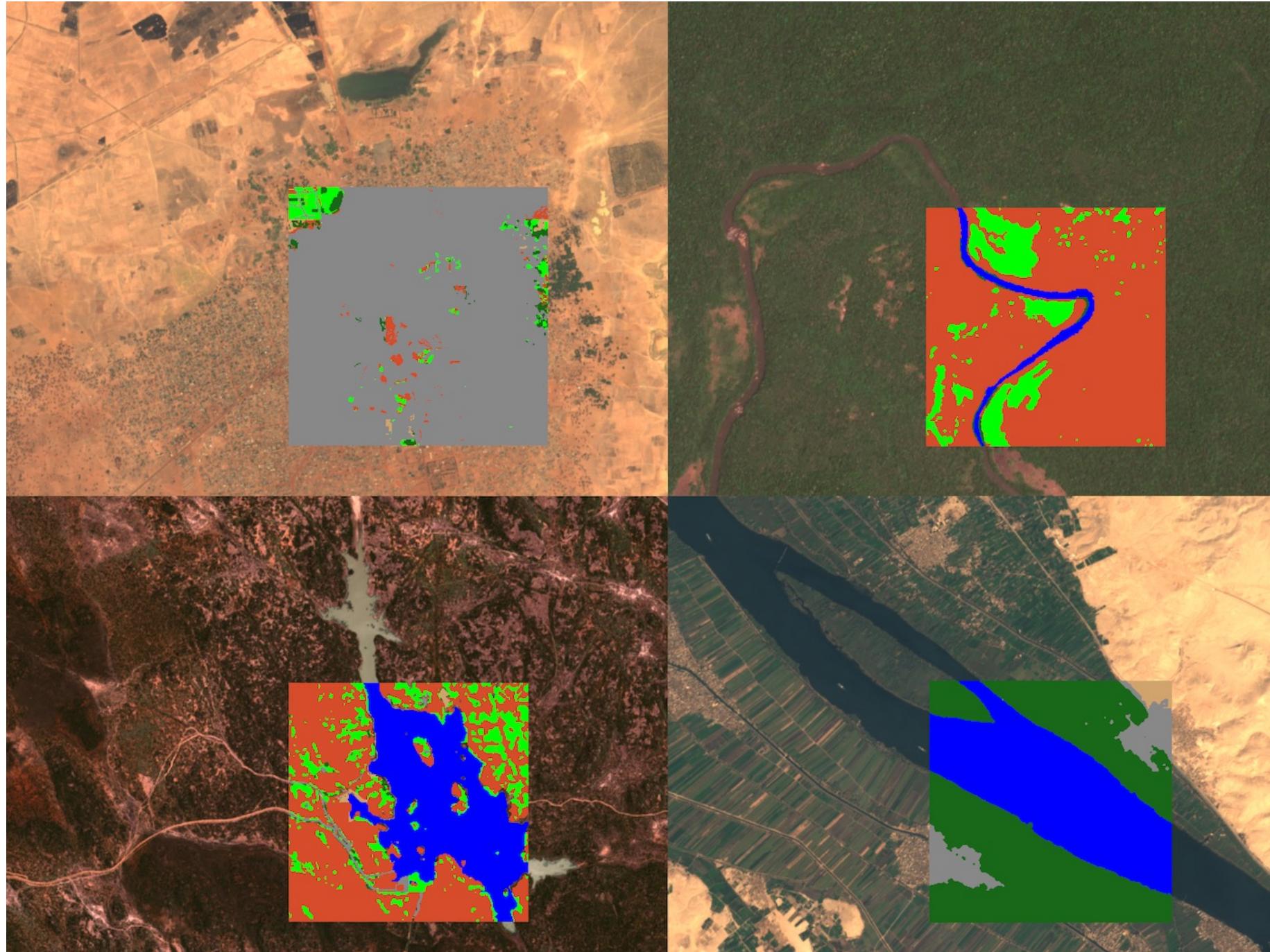
Taxonomy



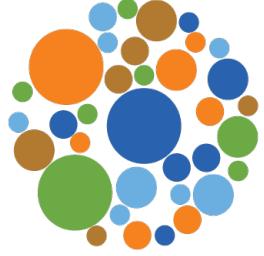
- Expert workshop to define the taxonomy based on community needs
- Annual LC definitions, and hierarchical

Level 1	Level 2	Level 3
Bare max veg/yr \leq 10%	Snow/Ice	Snow/Ice
	Water	Water
	Bare Ground	Artificial
		Natural
Vegetation max veg/yr \geq 10%	Woody	Woody
	Non-Woody	Cultivated
		(Semi) Natural

Sample Chips



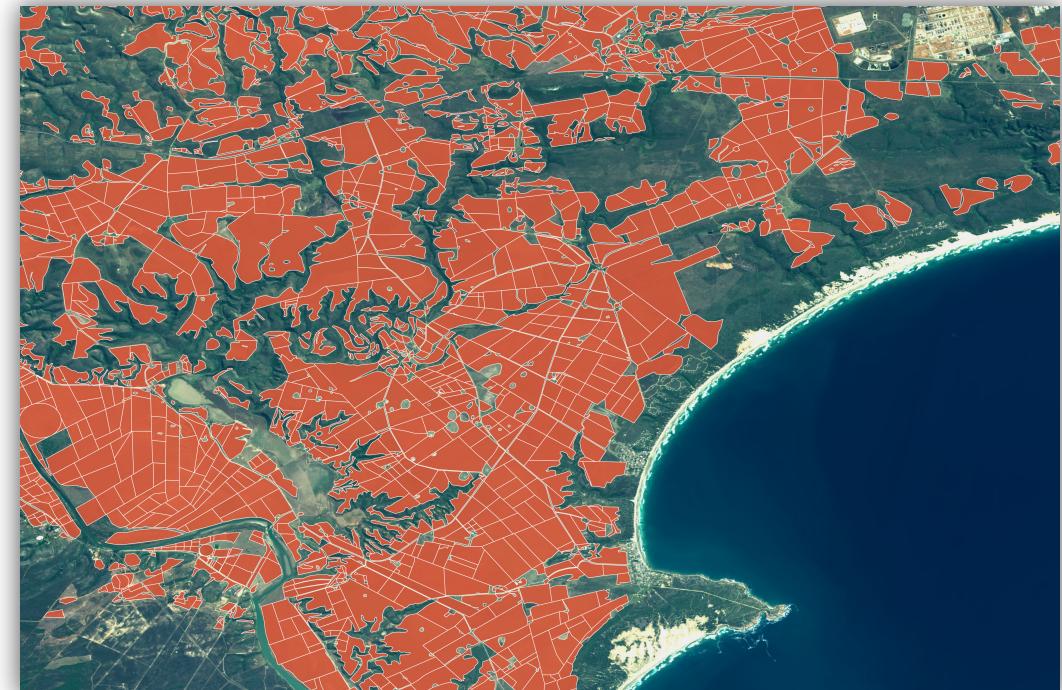
Ongoing Competition



Radiant Earth Spot the Crop Challenge

- Data from Western Cape, South Africa
- Two tracks for using multispectral and radar data
- Zindi Africa Platform
- Prizes for top three winners of each track

Deadline is Oct. 3rd



Partners and Collaborators



Dalberg
Data
Insights



BILL & MELINDA
GATES foundation

giz

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

FAIR FORWARD

Artificial Intelligence for all.

BigEarth



Chesapeake
Conservancy
EXPLORE. CONSERVE. INNOVATE.



SINERGISE



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RESOURCES
INSTITUTE



WORLD BANK GROUP

ZIND!



Platform for
Big Data
in Agriculture

GEO GROUP ON
EARTH OBSERVATIONS

Thanks!

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 **MLHub Slack Channel:**
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