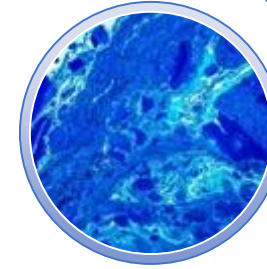




Radiant Earth
Foundation

EARTH IMAGERY FOR IMPACT

Open Data



Positive Impact



Innovative
Technologies

THE DRAMATIC PACE OF INNOVATION IN GEOSPATIAL ANALYTICS FOR LAND, SEA AND SPACE

ANNE HALE MIGLARESE

CEO & FOUNDER

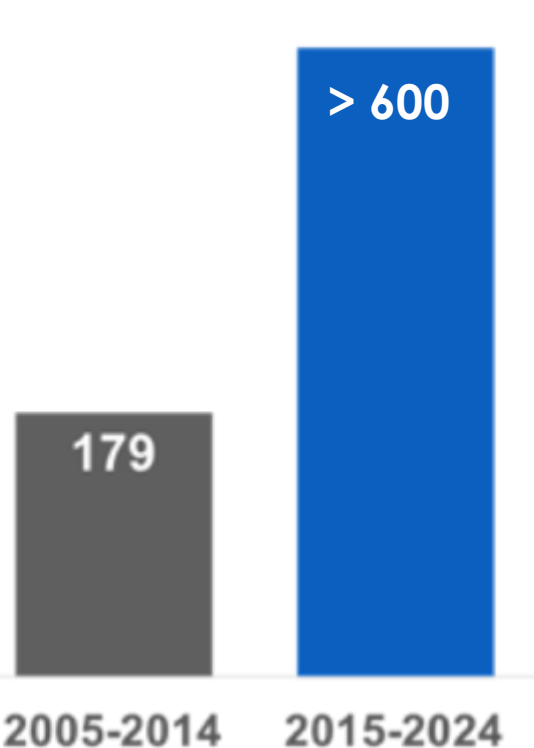


Outline

- ▶ Good to be back
- ▶ New sensors
- ▶ New hardware
- ▶ New analysis approaches
- ▶ Old problems
- ▶ New problems
- ▶ Conclusion



Earth Observation Satellites



Satellite



Aircraft



Drone

Dramatic
increase in
imagery supply



Cloud Computing



Machine Learning

IOT

Block Chain

Digital Twin

Rapid Innovation



New Solutions

CHALLENGE

OPPORTUNITY

SOLUTIONS

Commercial Visible EO Satellites



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The era of commercial EO satellites took off in the US after the passage of the Land Remote Sensing Policy Act in 1992 allowing the private sector to operate space systems.

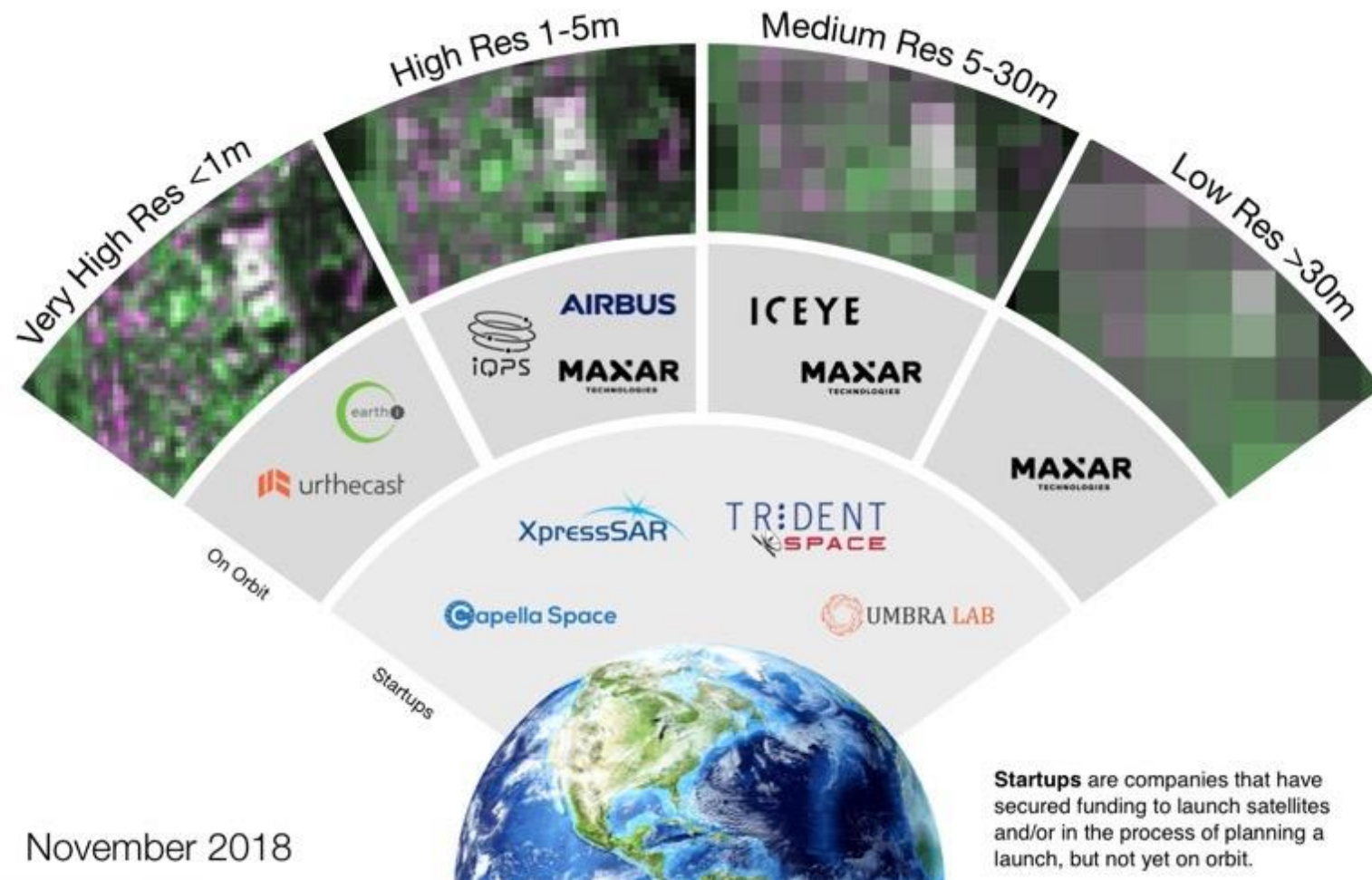


November 2018

Startups are companies that have secured funding to launch satellites and/or in the process of planning a launch, but not yet on orbit.

Commercial Radar Satellites

Synthetic Aperture Radar (SAR) satellites are active sensors that penetrate through clouds and darkness to monitor Earth surface physical properties.



November 2018

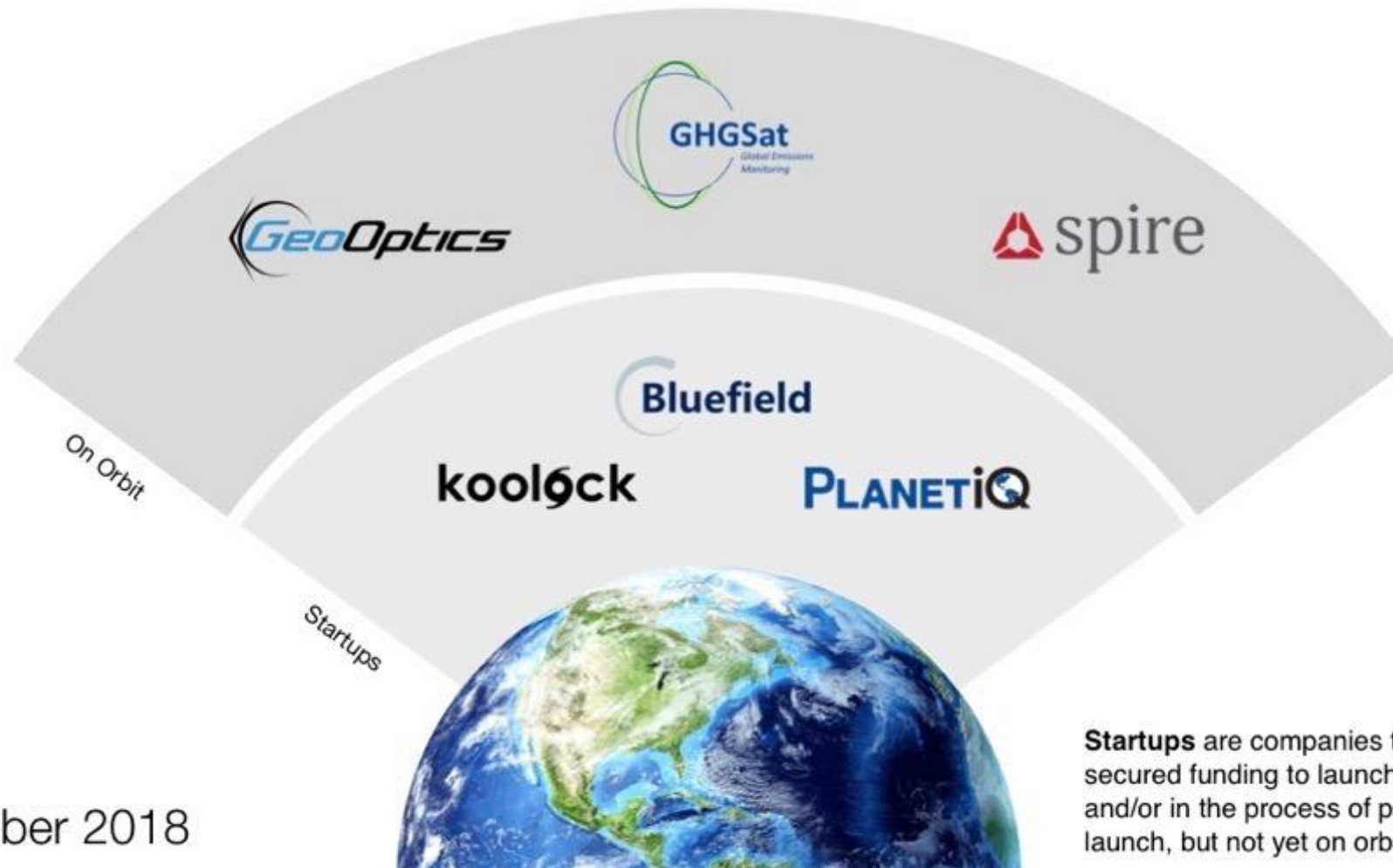
Startups are companies that have secured funding to launch satellites and/or in the process of planning a launch, but not yet on orbit.

Commercial Weather Satellites



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Weather satellites provide information on Earth's climate and atmospheric conditions.



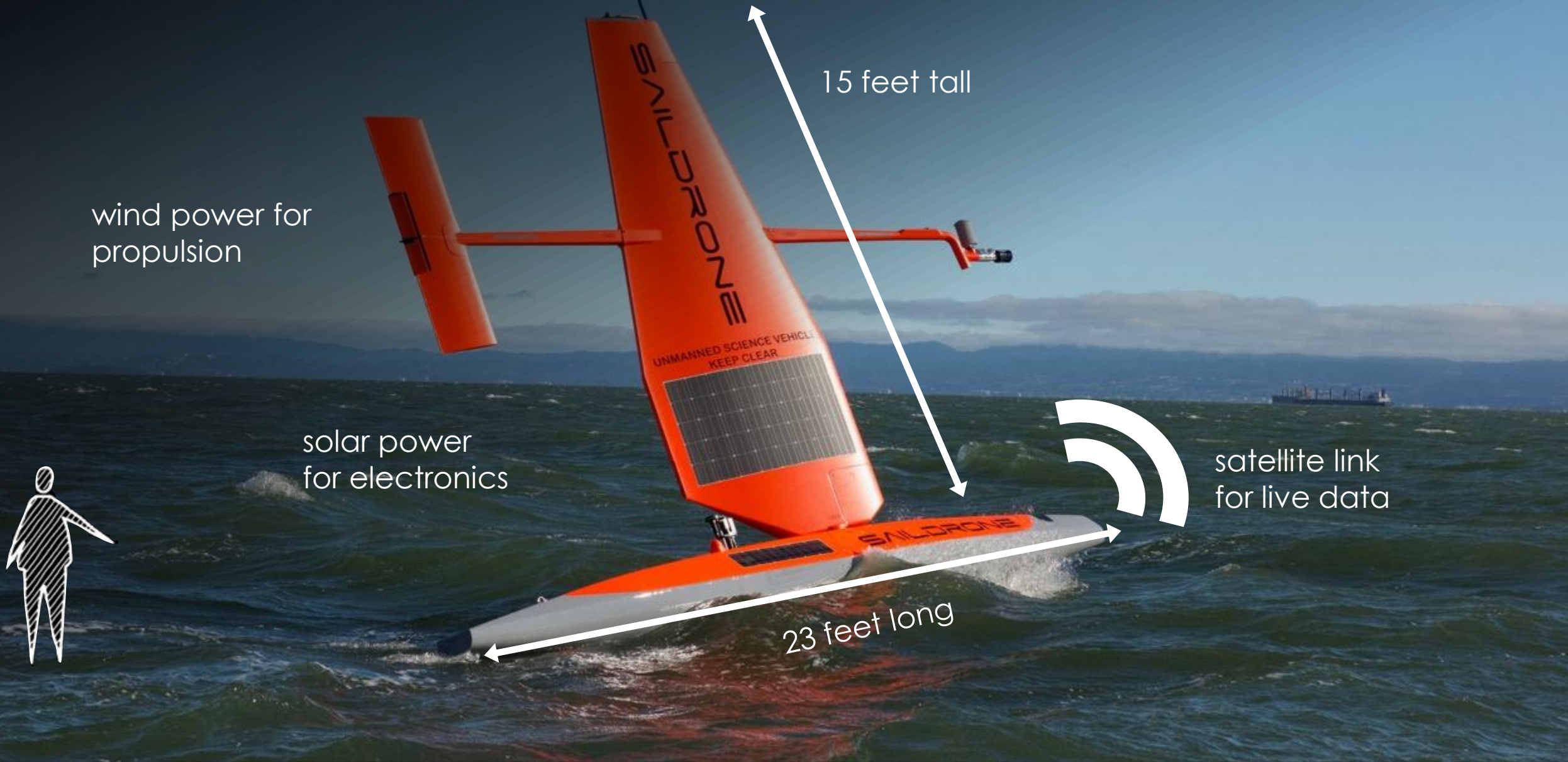
November 2018

Startups are companies that have secured funding to launch satellites and/or in the process of planning a launch, but not yet on orbit.



SAILDRONE

EACH SAILDRONE IS CAPABLE OF LONG RANGE AUTONOMOUS MISSIONS OF UP TO 12 MONTHS



15 feet tall

wind power for propulsion

solar power for electronics

satellite link for live data

23 feet long



Atmospheric Measurements

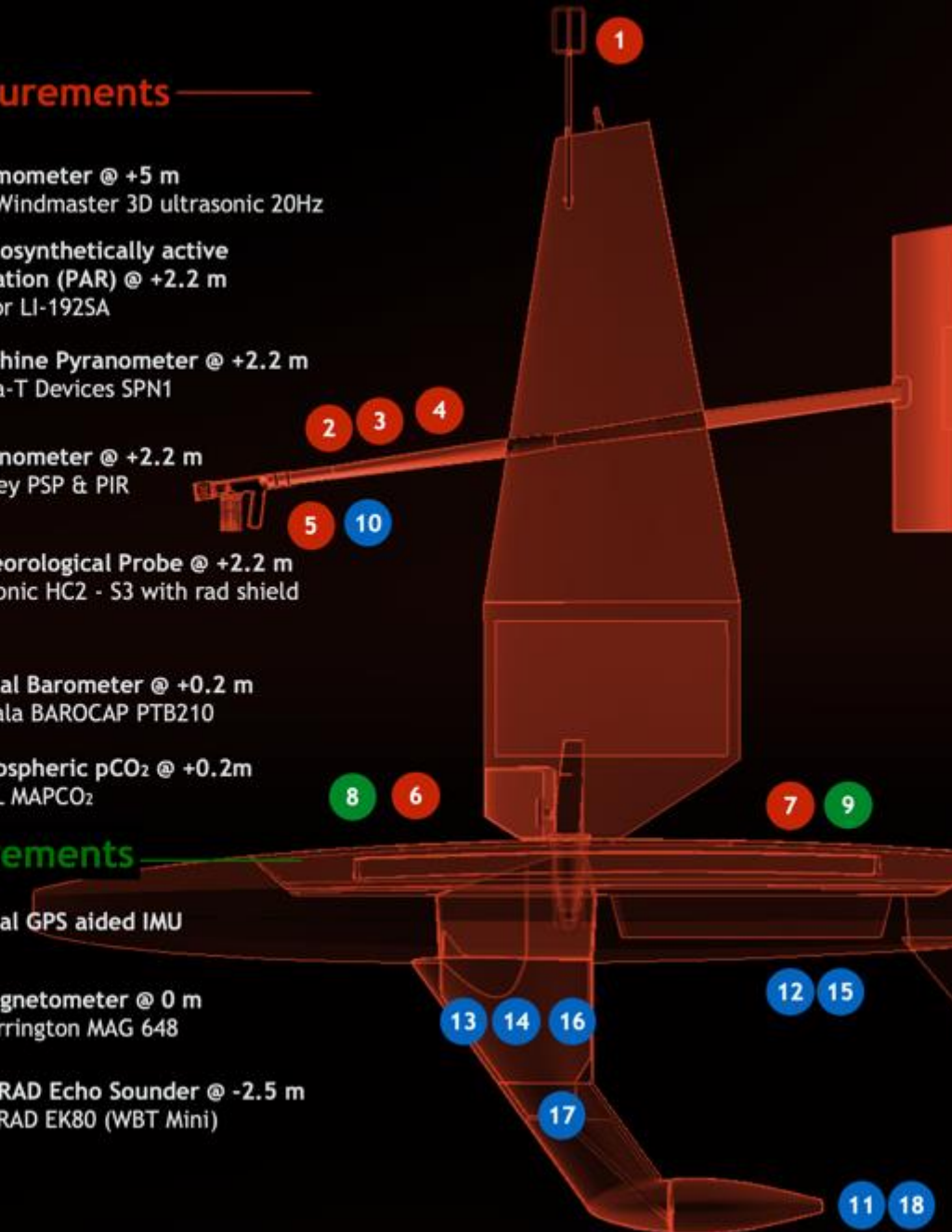
Wind Speed	1	Anemometer @ +5 m Gill Windmaster 3D ultrasonic 20Hz
Wind Direction	1	
Radiation	2	Photosynthetically active radiation (PAR) @ +2.2 m Li-Cor LI-192SA
	3	Sunshine Pyranometer @ +2.2 m Delta-T Devices SPN1
Air Temperature	4	Pyranometer @ +2.2 m Eppley PSP & PIR
	5	Meteorological Probe @ +2.2 m Rotronic HC2 - S3 with rad shield
Relative Humidity	5	
Pressure	6	Digital Barometer @ +0.2 m Vaisala BAROCAP PTB210
pCO ₂	7	Atmospheric pCO ₂ @ +0.2m PMEL MAPCO ₂

Physical Measurements

Wave Height & Period	8	Dual GPS aided IMU
Magnetic Field	9	Magnetometer @ 0 m Barrington MAG 648
Depth	17	SIMRAD Echo Sounder @ -2.5 m SIMRAD EK80 (WBT Mini)

Ocean Measurements

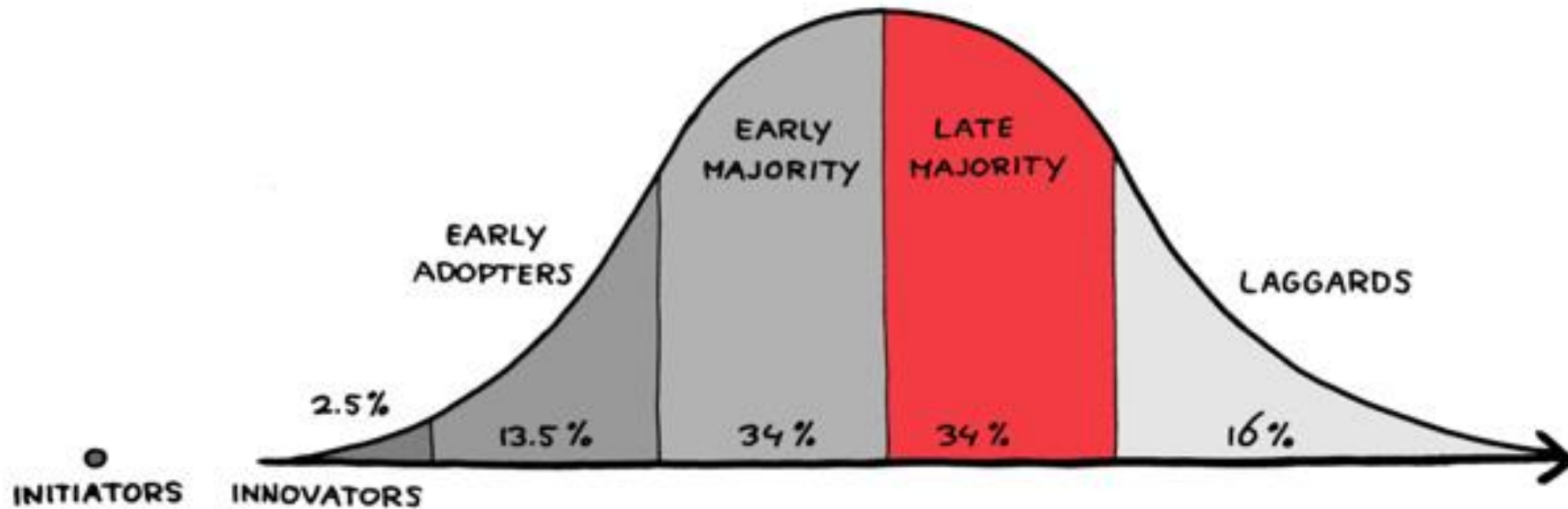
Skin Temperature	10	SST IR Pyrometer @ +2.2 m Heitronics CT15.2
Ocean Currents	11	ADCP @ -0.2 m Teledyne RDI Workhorse 300 kHz
pH	12	pH Sensor @ -0.5m Honeywell Durafet
Chl - a	13	Fluorometer @ -0.2 m RBR Chl-a Fluorometer or Seabird Scientific WET labs Eco Triplet
CDOM Concentration		
Red Backscatter		
Dissolved Oxygen	14	Oxygen Optode @ -0.5 m Aanderaa 4831 or RBR DO
pCO ₂	15	Dissolved pCO ₂ @ -0.5 m PMEL MAPCO ₂
Water Temperature	16	Thermosalinograph @ -0.5 m RBR CTD or Teledyne RDI Citadel TS-NH or Sea-Bird Scientific CTD
Salinity		
Marine Mammal Acoustics	17	Passive Acoustic Recorder Acousonde
Fish Biomass	18	SIMRAD Echo Sounder @ -2.5 m SIMRAD EK80 (WBT Mini)



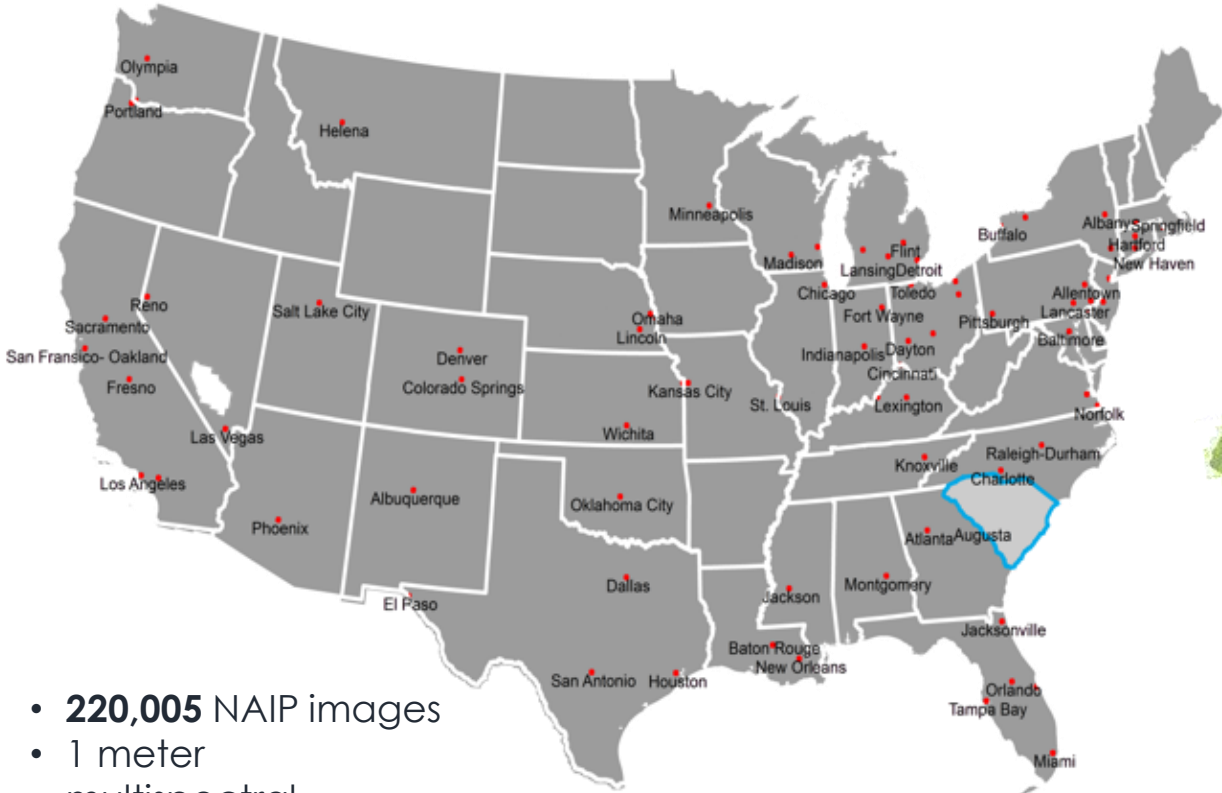


Machine Learning and Earth Observation Data

Technology Adoption Cycle



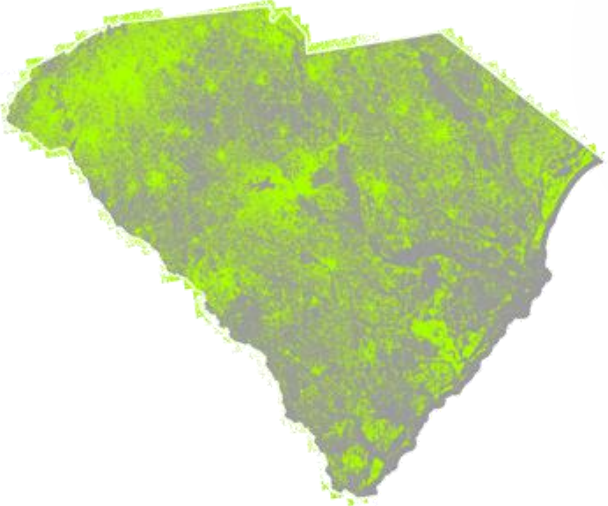
Mapping Buildings for CONUS using DCNN



- **220,005** NAIP images
- 1 meter multispectral 2012-2014
- ~5.8 TB compressed
- 9.8 trillion pixels

DOE Oak Ridge National Lab

Benchmarked contiguous U.S. on TITAN



Portland, OR (25,393 m²)
Imagery: June – July 2012
Lidar: September 2010



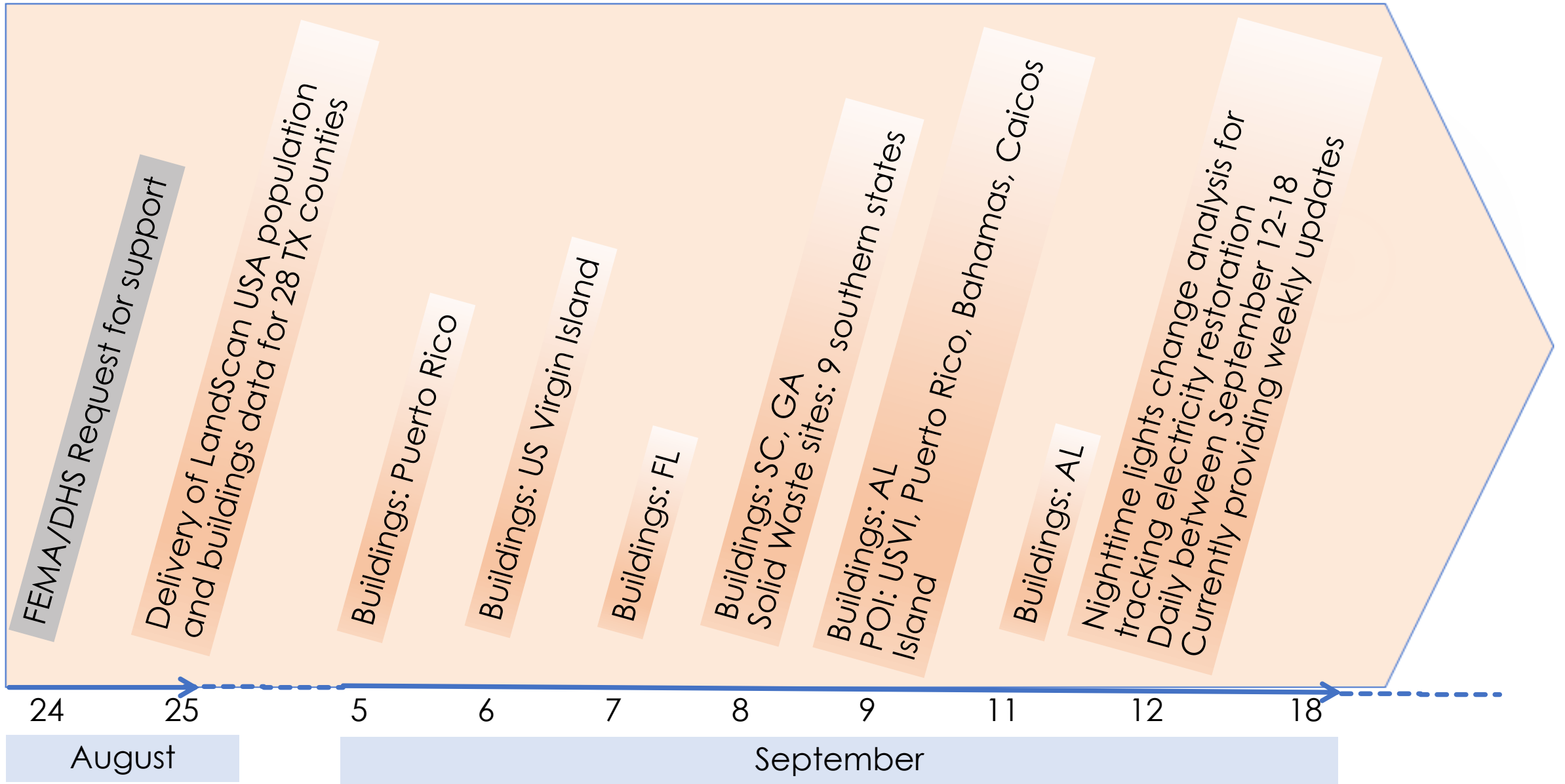
Frankfort, KY (14,801 m²)
Imagery: June 2012
Lidar: June 2011



Part of Knox County, TN (18,527 m²)
Imagery: June 2012
Lidar: October 2014

Need to identify a systematic method for analyzing the accuracy of various model outputs across the U.S.

Timeline of DOE ORNL Support: 2017 Hurricane Season



Digital Globe Examples – Mozambique





Sanitation Team at Bill & Melinda Gates Foundation

- ▶ Independent estimates of sewage processing operations in developing countries are needed to monitor and verify SDG 6.
- ▶ We built and tested two models using Sentinel 1 (3 locations) and Sentinel 2 (2 locations) open source satellite imagery with a machine learning technique.
- ▶ We concluded that the spatial and temporal resolution of available open imagery demands a larger amount of training data to improve the model fit. Alternate locations offering less cloud cover and more training data is recommended.



DRONE

Original
Drone
Image


The World Bank





COMBINING DRONE AND STREET VIEW

Soft-story predictions

Drone images


 Single Story.


 Two Story.

 >Two Stories.

Street view images

 Logos/Sings.

 Garage.

 Large Window.

The World Bank



THE RESULTS

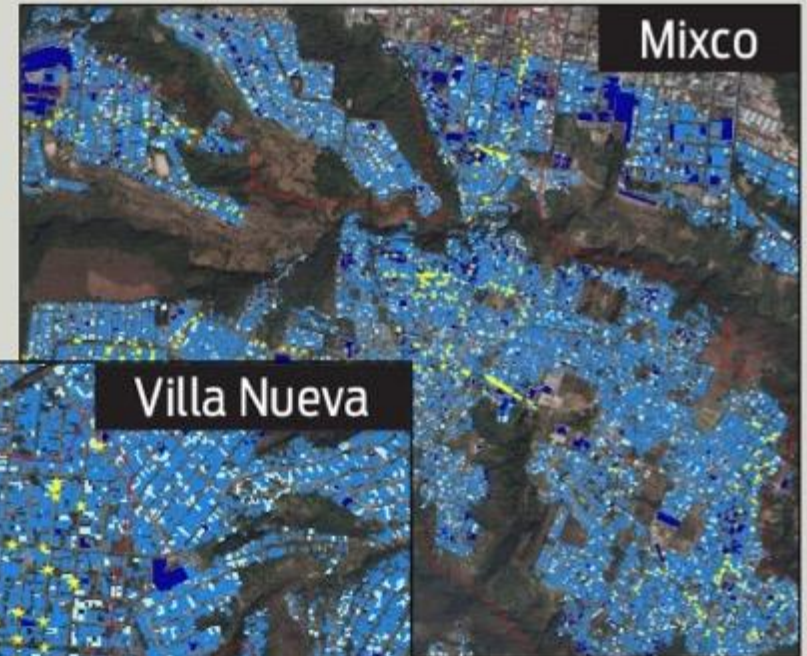
Of the 560 structures identified by the structural engineers as being soft-story.

The accuracy of our method to match the experts' eyes was 89%.

The World Bank



Satellite derived footprint is calling this building 7.32 meters high, 3.4 meters wide and 20 meters deep.



- Single Story.
- Two Story.
- >Two Stories.
- Logos/Sings.



Establish community focused on advancing the application of EO data to solve challenges in the Global South using ML techniques

← **Goal**

Open Source ML “Hub” for Earth observation

Educate & Inform

← **Services**

Training Data, Open Models & Standards

Crowdsourced Ground-Truth Image Labels

Technical Groups, Fellowships, Convenings

Market Analytics, Trends and Thought Leadership



MLHUB
MACHINE LEARNING
FOR IMPACT

Current ML Hub Training Datasets

Major
African
Crop
Type

Global
Land
Cover

- Built on ESA Sentinel-2
- 10 m resolution
- Crowdsourcing and citizen science to validate labels
- Hosted on AWS
- Available via API to public with Creative Commons license

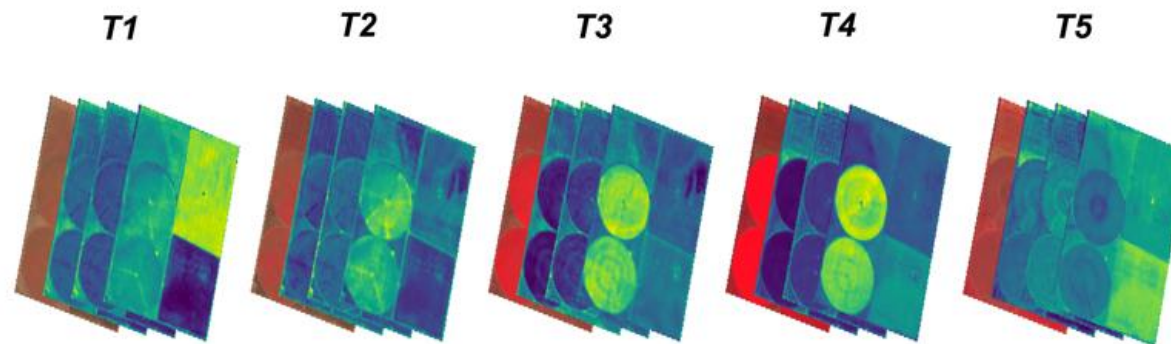
Sponsored by:

SCHMIDT FUTURES



Patrick J.
McGovern
FOUNDATION

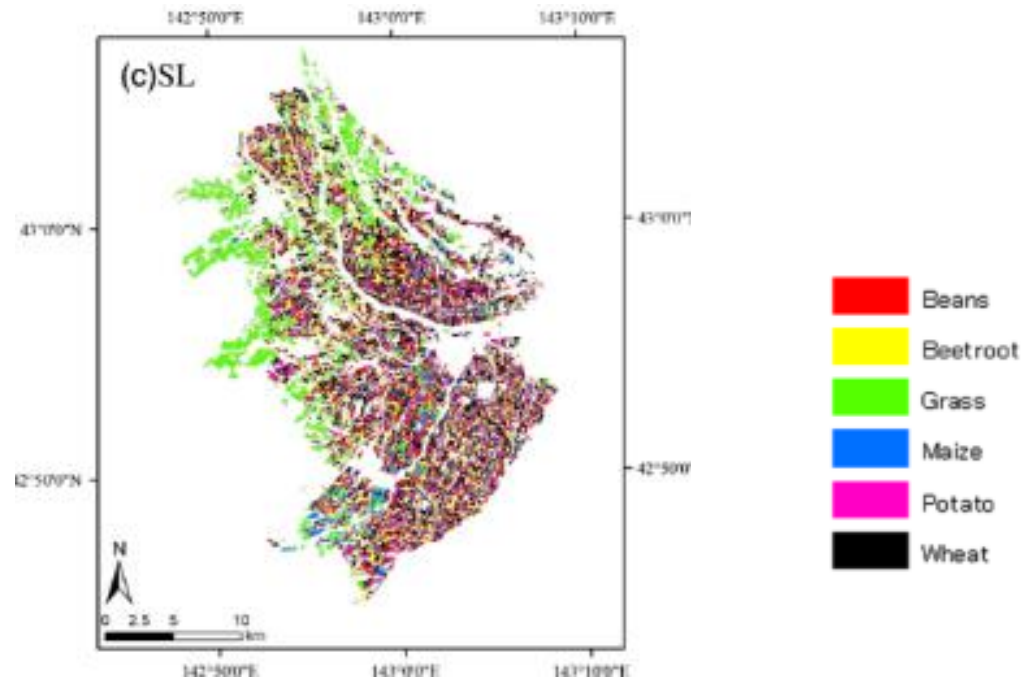
Sample training
data for crop type



**Crop Type
Labels**



Open Training Library of African Crops Using Sentinel-2



Using Convolutional Neural Networks and crowdsourcing to label imagery of major crops

- ▶ Phase I: Define the appropriate region-specific crop classes through community engagement
- ▶ Phase II: Generate a set of labeled images for each crop class based on Sentinel-2 and Landsat 8
- ▶ Phase III: Develop an online crowdsourcing platform to verify the Phase II-generated labels
- ▶ Collaborate w/ local partners to organize events, marketing and maximize partner networks
- ▶ Coordinating w/ African Regional Data Cube

Old Problems Persist

- ▶ Connectivity
- ▶ Collaboration and data sharing from an institutional perspective not a technical perspective
- ▶ Capacity Development
- ▶ Messaging on the solution and not the technology
- ▶ Funding

New Problems Emerge

- ▶ Privacy and Ethics in Geolocation and Machine Learning
- ▶ Training data standards & access
- ▶ COG, STAC & ARD adoption
- ▶ ML Accuracy Assessment
- ▶ Staying abreast of a rapidly changing landscape from a technical and market perspective.

Conclusions

- ▶ Never been a more exciting and innovative period in the geospatial sciences
- ▶ This is a global phenomena and markets across the globe are responding.
- ▶ The profession is rapidly diversifying
- ▶ There are serious issues of privacy and ethics that need to be addressed by this community that have largely been ignored
- ▶ Commercial Data Suppliers are rapidly changing their business model and moving from selling data to selling services off of their platforms
- ▶ The European Union is leading the way for supplying and supporting Open Data Innovation