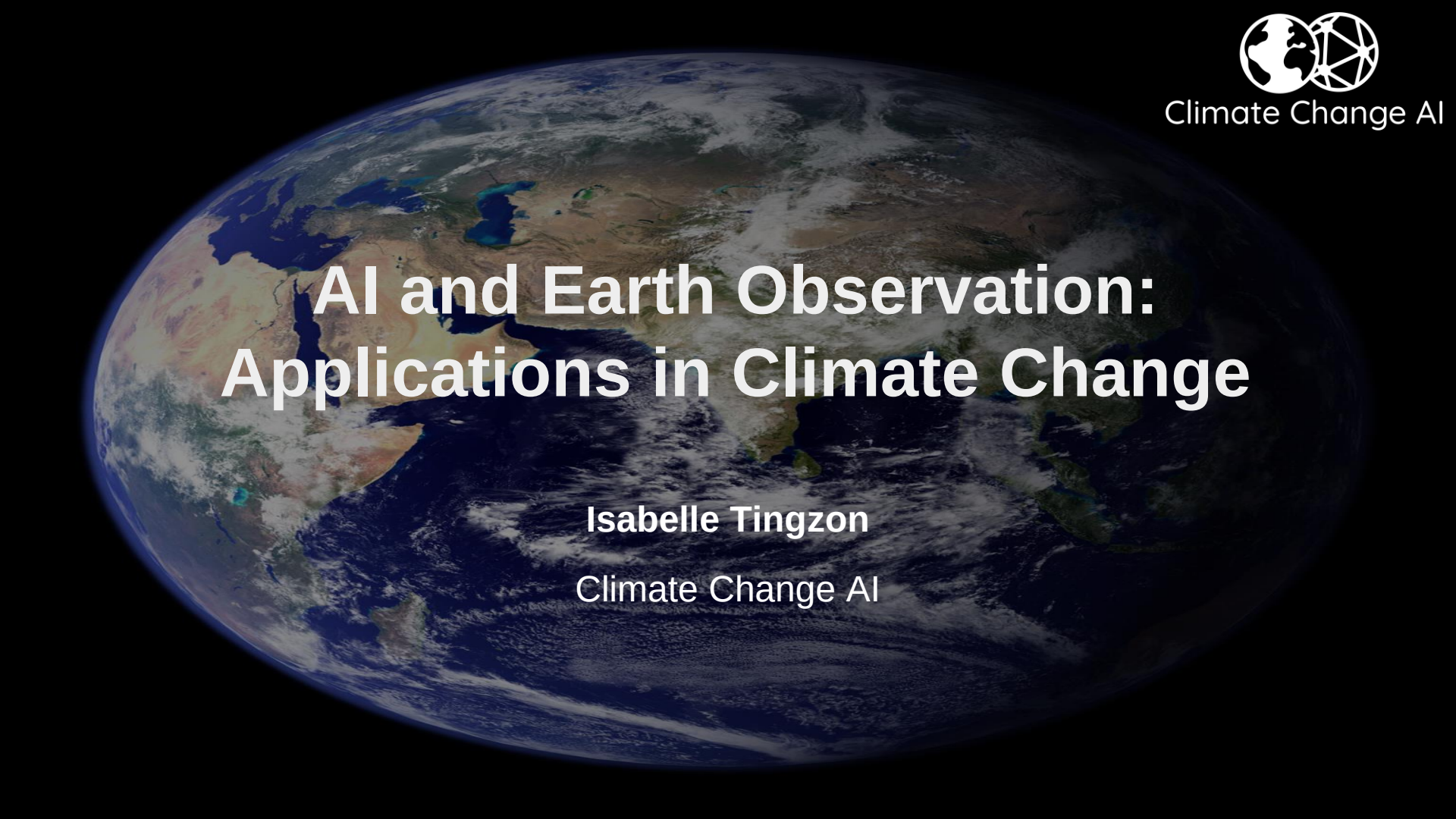


Climate Change AI

AI and Earth Observation: Applications in Climate Change

Isabelle Tingzon

Climate Change AI

Overview

1. Introduction to Climate Change & Machine Learning
2. Remote Sensing & Computer Vision
3. Hands-on Tutorial: Pytorch & Google Earth Engine
4. Final Thoughts and Next Steps

Part 1: Climate Change & Machine Learning

Climate Change

- One of the greatest challenges facing humanity
- Increasingly severe effects: rising sea levels, severe typhoons and floods, droughts and wildfires, extreme heat
- Mitigation and adaptation approaches need

Machine Learning: A Powerful Tool

Machine Learning (ML): Group of techniques that automatically extract patterns from large amounts of data

Capable of generating “new” (derived) data from unconventional data sources (e.g. satellite images)

Deep Learning (DL): A subset of ML based on artificial neural networks for deep representation learning; useful for large unstructured data like text and images

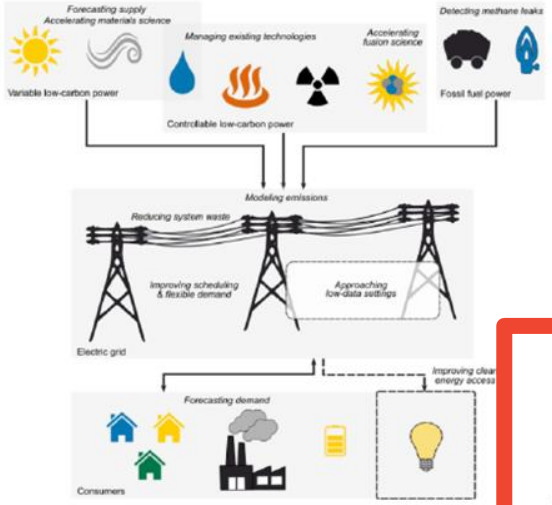
Computer Vision (CV): Field of AI that derived meaningful information from digital images (mimicking human visual system)

Tackling Climate Change with Machine Learning

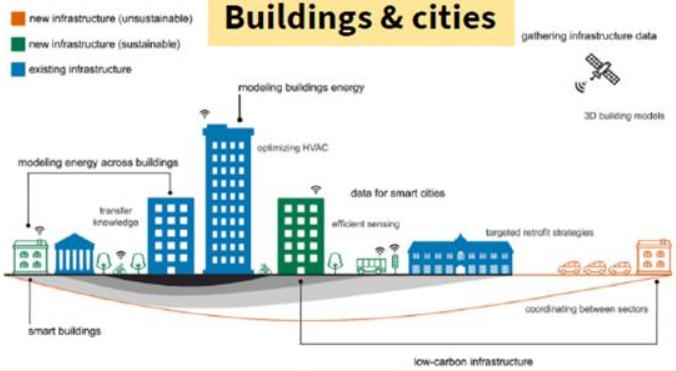
David Rolnick[1*], Priya L. Donti[2], Lynn H. Kaack[3], Kelly Kochanski[4], Alexandre Lacoste[5], Kris Sankaran[6,7], Andrew Slavin Ross[8], Nikola Milojevic-Dupont[9,10], Natasha Jaques[11], Anna Waldman-Brown[11], Alexandra Luccioni[6,7], Tegan Maharaj[6,7], Evan D. Sherwin[2], S. Karthik Mukkavilli[6,7], Konrad P. Kording[1], Carla Gomes[12], Andrew Y. Ng[13], Demis Hassabis[14], John C. Platt[15], Felix Creutzig[9,10], Jennifer Chayes[16], Yoshua Bengio[6,7]

[1]University of Pennsylvania, [2]Carnegie Mellon University, [3]ETH Zürich, [4]University of Colorado Boulder, [5]Element AI, [6]Mila, [7]Université de Montréal, [8]Harvard University, [9]Mercator Research Institute on Global Commons and Climate Change, [10]Technische Universität Berlin, [11]Massachusetts Institute of Technology, [12]Cornell University, [13]Stanford University, [14]DeepMind, [15]Google AI, [16]Microsoft Research

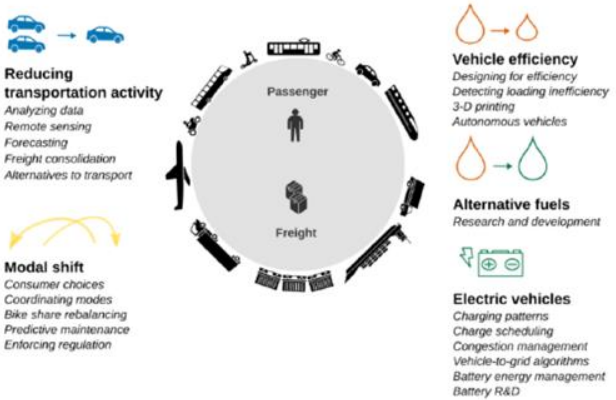
Electricity systems



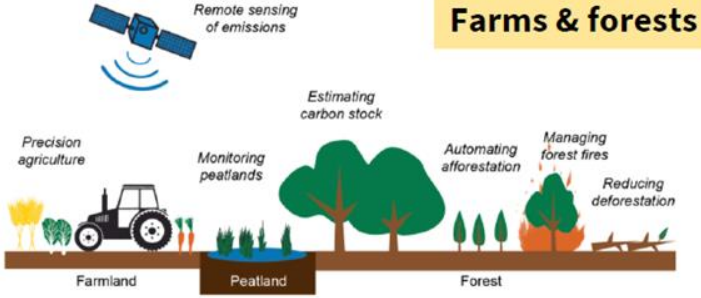
Buildings & cities



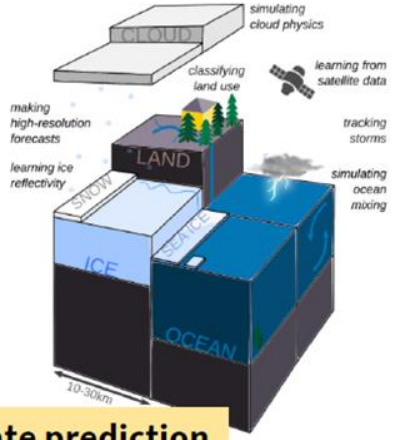
Transportation



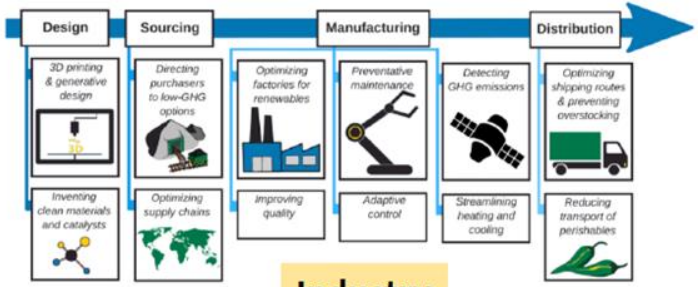
Farms & forests



Climate prediction



Industry



Societal adaptation

Recurring themes

Forecasting (solar power, extreme events, carbon prices)

Data mining & generation (disaster response, urban planning)

Remote sensing (agriculture, infrastructure data, deforestation)

Approximating time-intensive simulations (climate, energy)

Accelerated experimentation (batteries, perovskites, nuclear fusion)

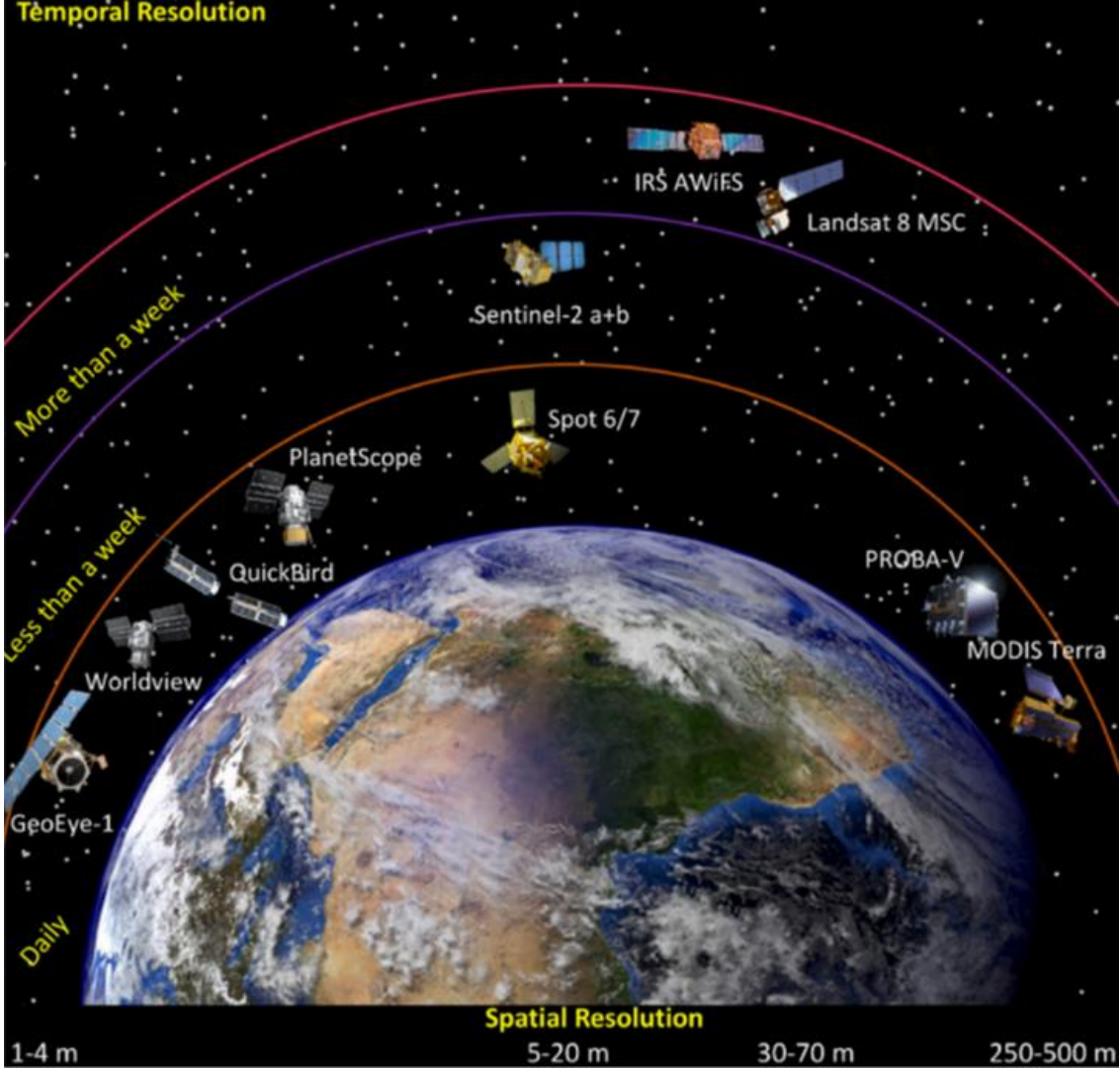
Optimizing systems (precision agriculture, heating and cooling)

Predictive maintenance (natural gas pipelines, resilient infrastructure)

Part 2: Remote Sensing & Computer Vision

Remote Sensing

Satellites observing the Earth provide us with a huge amount of **Earth Observation (EO)** data that help us better understand our changing world.



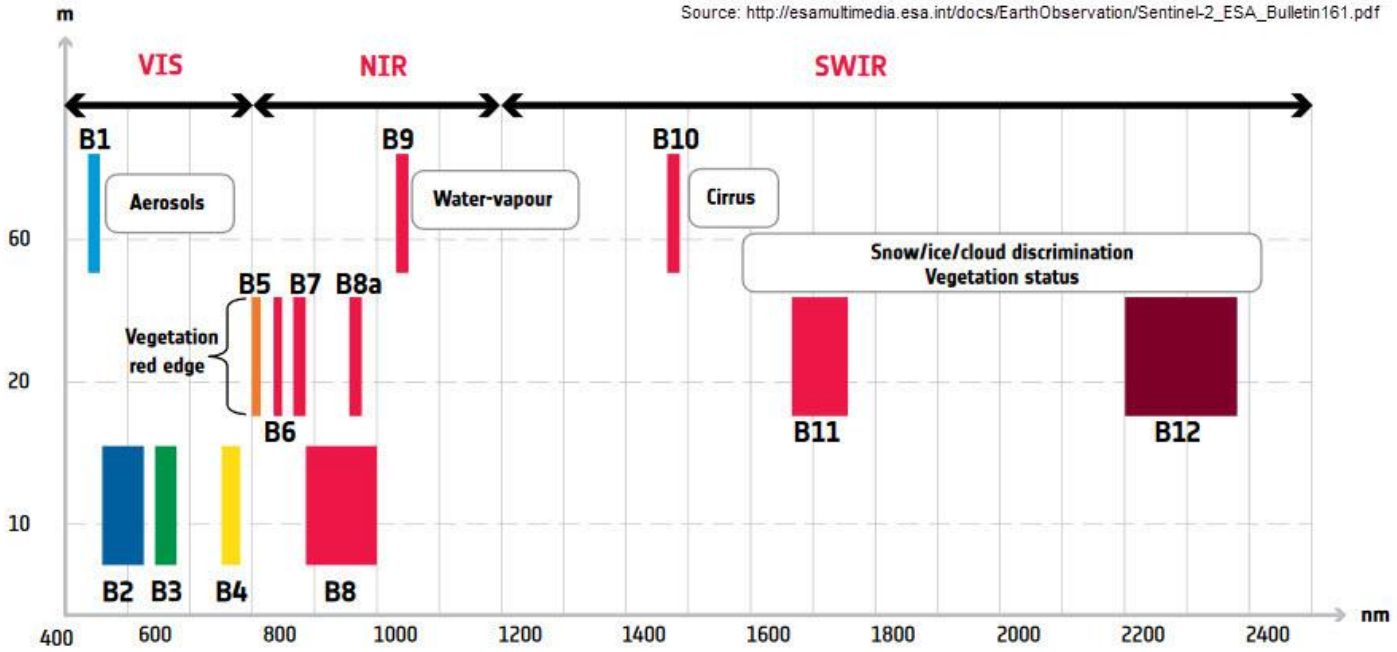
Sentinel-2

Launched in 2015, the first wide-swath, multispectral imaging missions under the Copernicus Program, with the ESA.

Global coverage, frequent revisit time (every 10 days), used in a wide array of applications.

Sentinel-2 data is free and publicly available with moderate resolution (10-60 m) and long time series (2015 - present).

Sentinel-2 Multispectral Bands



↑ Spatial resolution versus wavelength: Sentinel-2's span of 13 spectral bands, from the visible and the near-infrared to the shortwave infrared at different spatial resolutions ranging from 10 to 60 m on the ground, takes land monitoring to an unprecedented level

https://apps.sentinel-hub.com/sentinel-playground/

Google Earth Engine & Python GIS

Google Earth Engine

A geospatial processing service with a multi-petabyte catalog of satellite imagery and geospatial datasets.

Google Earth Engine

Python GIS:

QGIS

rasterio/**rasterio**

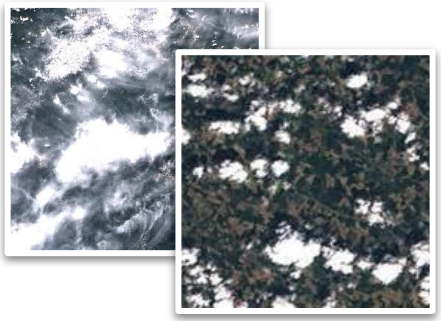
Rasterio reads and writes geospatial raster datasets

GeoPandas

Challenges in AI for Earth Observation

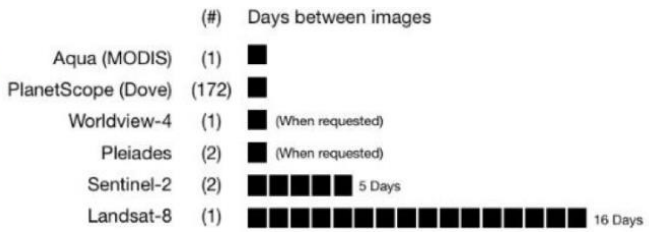
Sparse Labels

Cloud



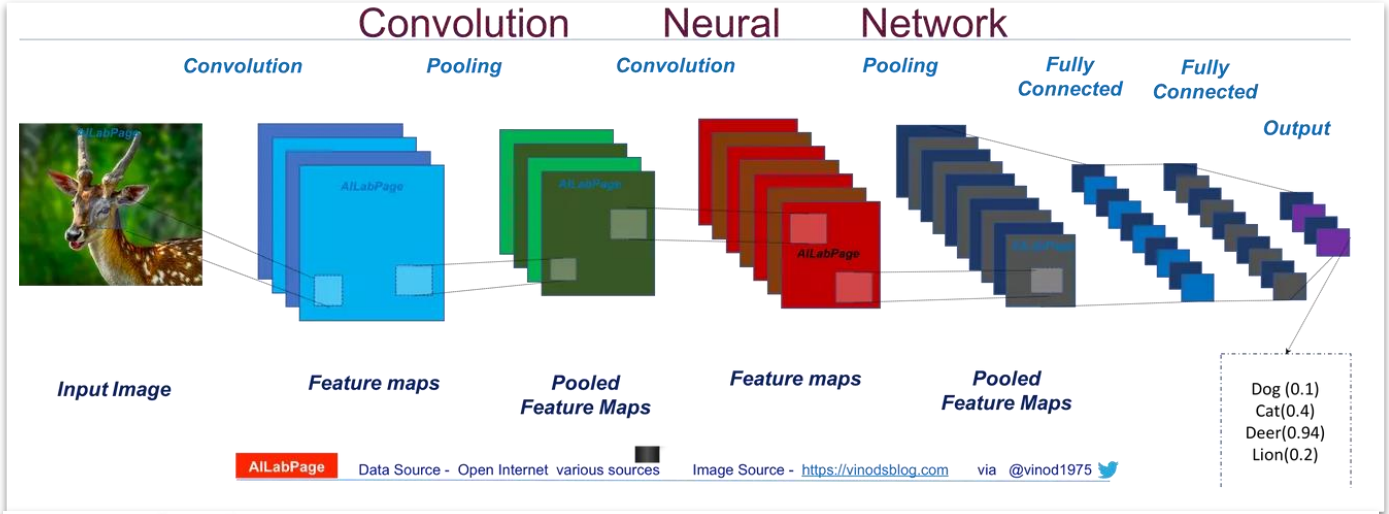
Spatial Resolution

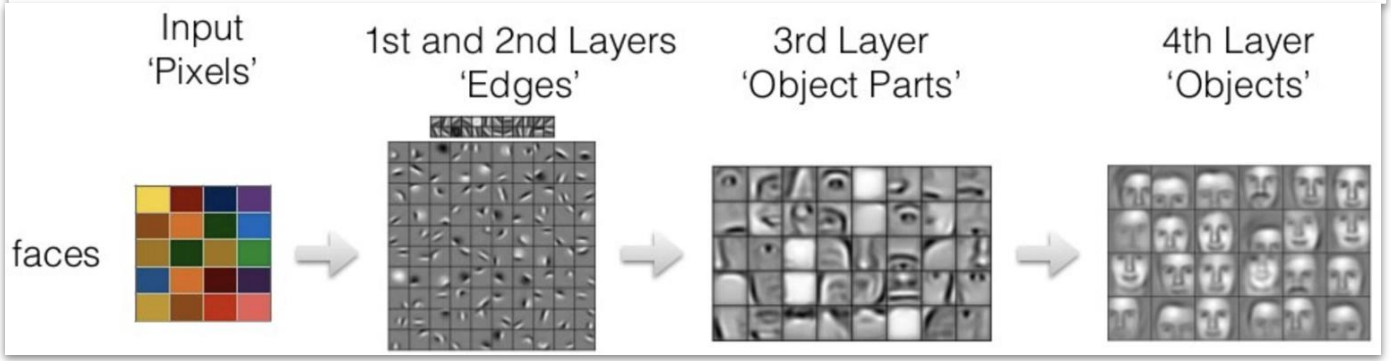
Temporal Resolution



Source: https://towardsdatascience.com/how-to-use-open-source-satellite-data-for-your-investigative-reporting-d662cb1f9f90

Computer Vision





Computer Vision

Four main computer vision tasks:

- Image classification
- Object detection
- Semantic Segmentation
- Instance segmentation

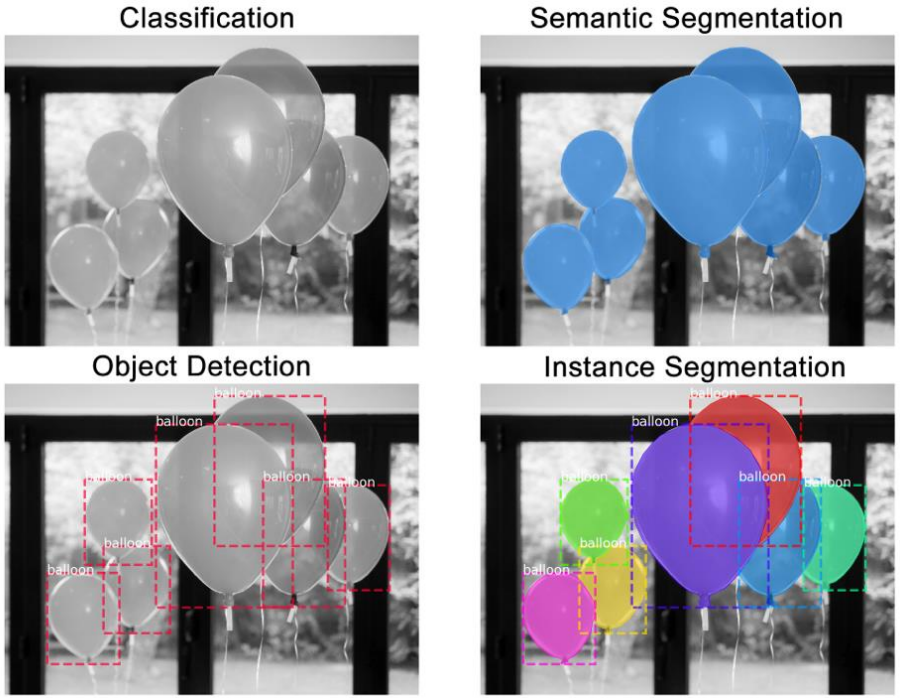


Image source: https://medium.com/@tibastar/mask-r-cnn-d69aa596761f

Image Classification

Determines the type or class label of an image.

Applications in EO:

- Crop type mapping
- Land use and land cover classification
- Local climate zone classification

Popular Models: ResNet, VGG

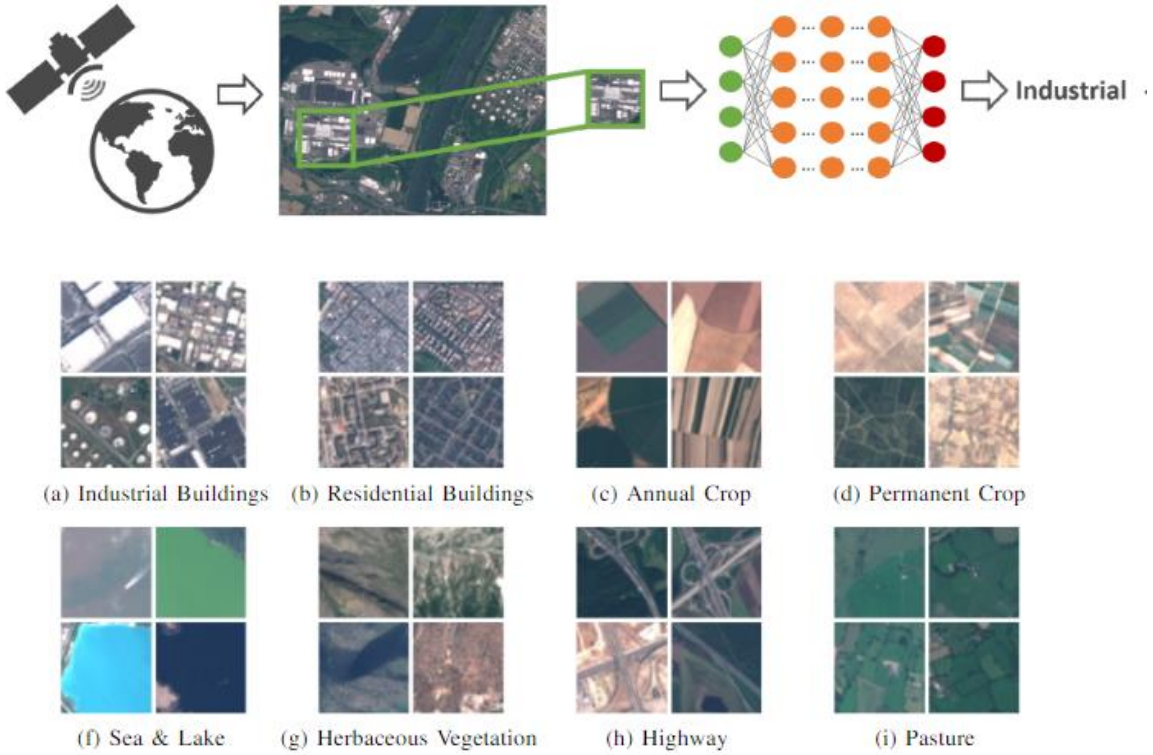


Image source: Helber, Patrick, et al. "Eurosat: A novel dataset and deep learning benchmark for land use and land cover classification." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 12.7 (2019): 2217-2226.

Object Detection

Locates the presence of objects in an image, with bounding box and class labels.

Applications in EO:
Detection and location of aerial and land vehicles, oil tanks, power plants, etc.

Popular Models: Faster R-CNN, YOLO

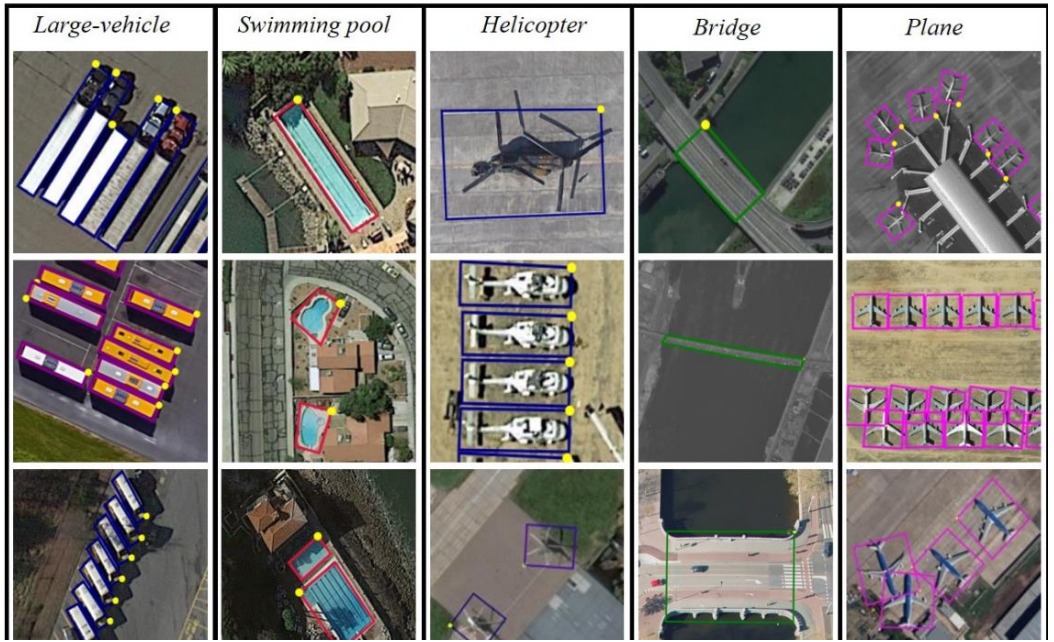


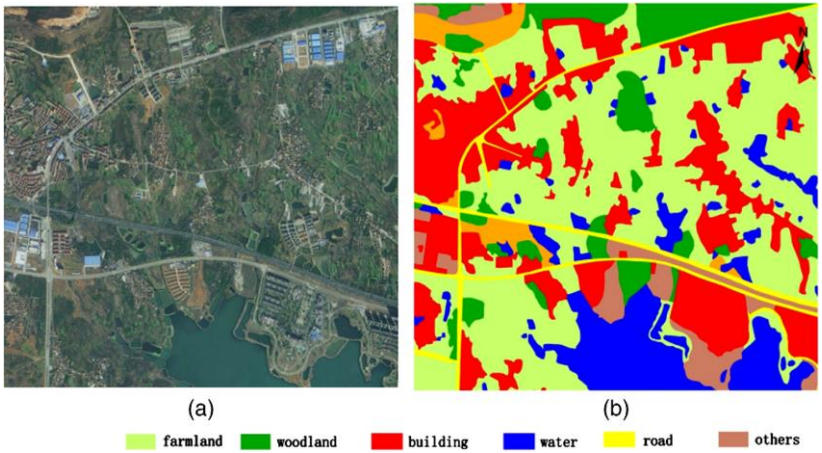
Image source: Xia, Gui-Song, et al. "DOTA: A large-scale dataset for object detection in aerial images." *Proceedings of the IEEE conference on computer vision and pattern recognition*. 2018.

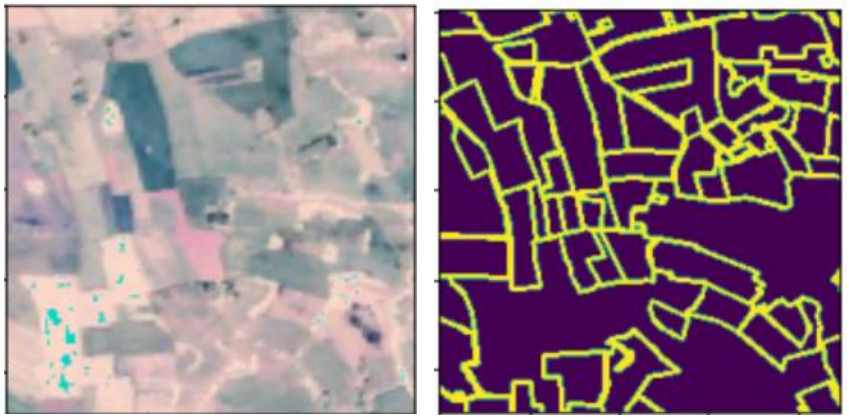
Semantic Segmentation

Classifies each pixel in an image as belonging to a certain class label.

Applications in EO: Pixelwise land cover classification, road segmentation, crop field delineation

Popular Models: FCN, U-net, DeepLabv3





Instance Segmentation

Combines both object detection and semantic segmentation.

Identifies the location of the object as well as the pixel mask of each particular object.

Applications in EO:

- Building instance segmentation
- Ship instance segmentation

Popular Models: Mask R-CNN

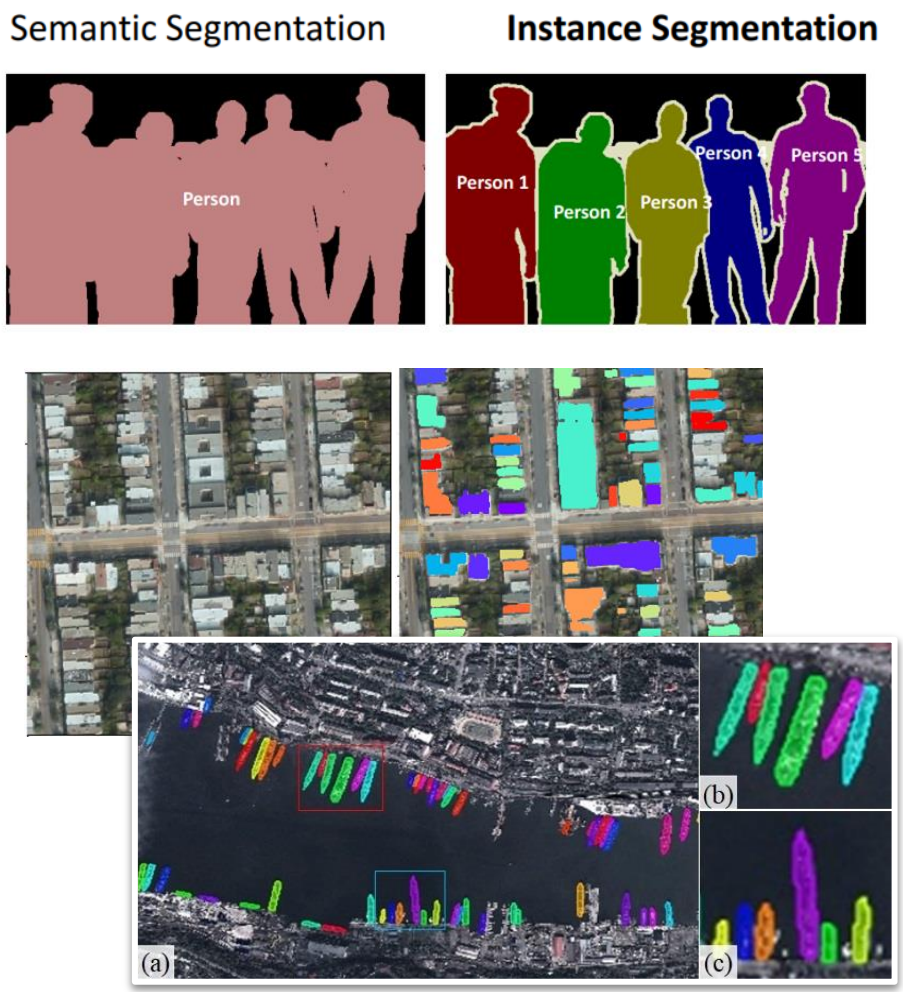


Image source: Feng, Yingchao, et al. "Ship instance segmentation from remote sensing images using sequence local context module." *IGARSS 2019-2019 IEEE International Geoscience and Remote Sensing Symposium*. IEEE, 2019.

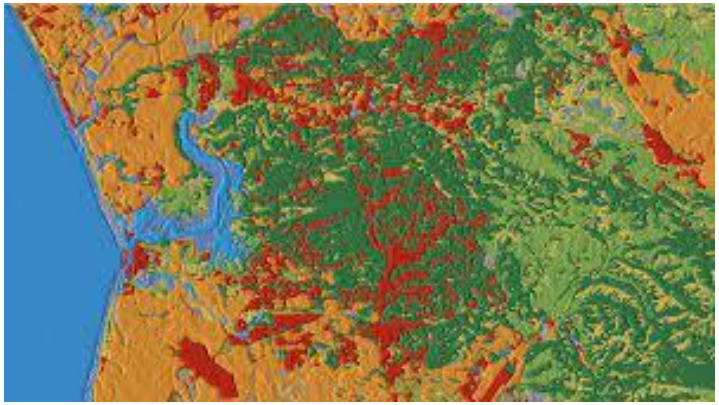
Part 3: Hands-on Tutorial: Land Use and Land Cover Classification using Pytorch and Google Earth Engine

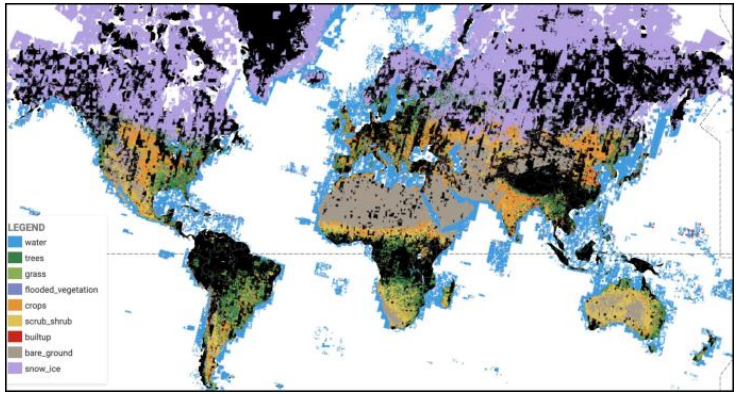
Land Use and Land Cover Mapping

- Critical for applications such as food security, urban planning, natural resource management, disaster risk planning, and many more.
- Examples:
  - Monitoring forest cover and identifying drivers of forest loss for conservation and restoration efforts
  - Vulnerability assessment of settlements and agricultural land for disaster risk reduction planning and long-term climate adaptation efforts

Land Use and Land Cover Mapping

- Traditionally done through on-screen manual digitization, visual interpretation, and field validation. However, this is often time-consuming, labor-intensive, and expensive.
- AI & EO provide opportunities to map land use and land cover in ways that are cheap and efficient while providing finer resolution and greater scale.





Colab Notebook Links

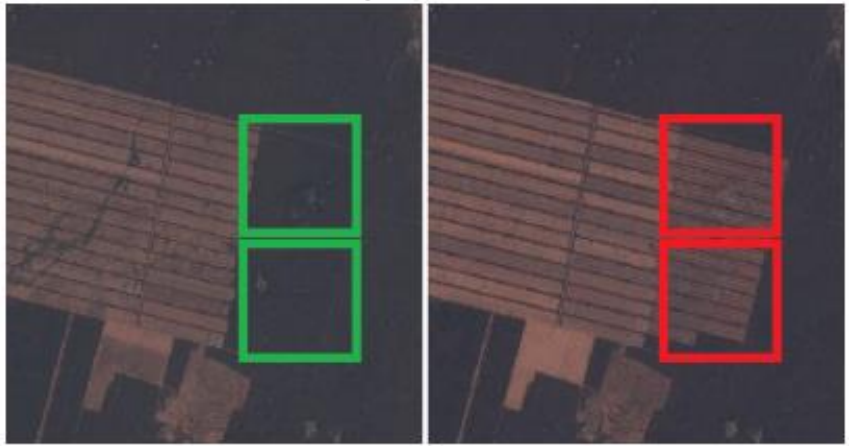
Part 1: Training a Resnet-50 Classifier in Pytorch for Land Use and Land Cover Classification (30 min)

Part 2: Automating Land Use and Land Cover Mapping using Python GIS and Google Earth Engine (30 min)

Part 4: Final Thoughts and Next Steps

Applications of LULC Mapping

Detecting deforestation



2015 2016

Detecting urban expansion

2015 2017

Source: Helber, Patrick, et al. "Eurosat: A novel dataset and deep learning benchmark for land use and land cover classification." IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 12.7 (2019): 2217-2226.

Annotated Satellite Image Datasets & Other Resources

Radiant MLHub

Radiant MLHub is the world's first cloud-based open library dedicated to Earth observation training data for use with machine learning algorithms. Designed to encourage widespread data collaboration, Radiant MLHub allows anyone to access, store, register, and share open training datasets for high-quality Earth observations.

GET STARTED

Roadmap for action

Learn about different ways to get involved (AI/ML or not)

Collaborate with others with different perspectives

Listen to what collaborators/stakeholders (be humble!)

Deploy and/or ensure a path to deployment

- Always keep the end goal in mind in problem formation and collaboration

Climate Change AI

Catalyzing impactful work at the intersection of climate change and AI

Digital resources

Foundational report on climate change and AI (plus summaries and tutorials)

Resource Wiki w/ datasets and additional resources

Conferences & events

Workshop series

- Submit and/or attend
- Mentorship programs

Summer school (multiple tracks)

Funding programs

Global research funding for impactful projects

Community, newsletter, & blog

Calls for Submissions

Funding

Projects & Courses

Readings

Jobs

Webinars & happy hours

Webinar series (monthly)

Virtual happy hours (biweekly)

Learn more & join in:

www.climatechange.ai

@ClimateChangeAI