Applications of Machine Learning/ Deep Learning by NASA IMPACT

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2019 Spacecraft Flight Software Workshop

9 December 2019





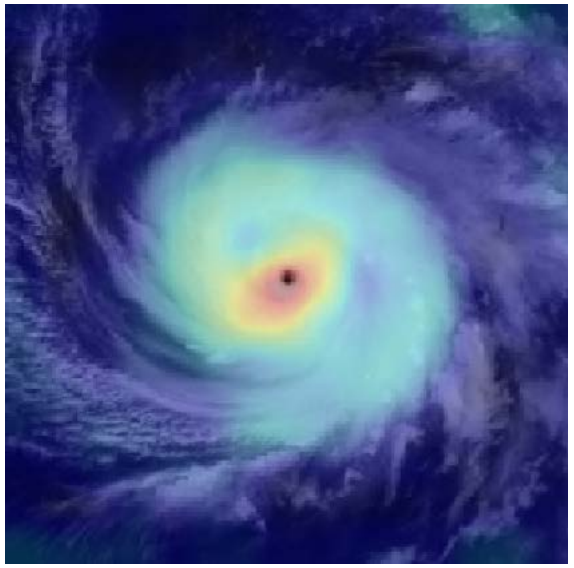
Background

What is IMPACT?

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How do we fit into NASA Earth Science?

How do we use machine learning and deep learning to answer Earth Science questions?



Earth Science – NASA's Strategic Goal

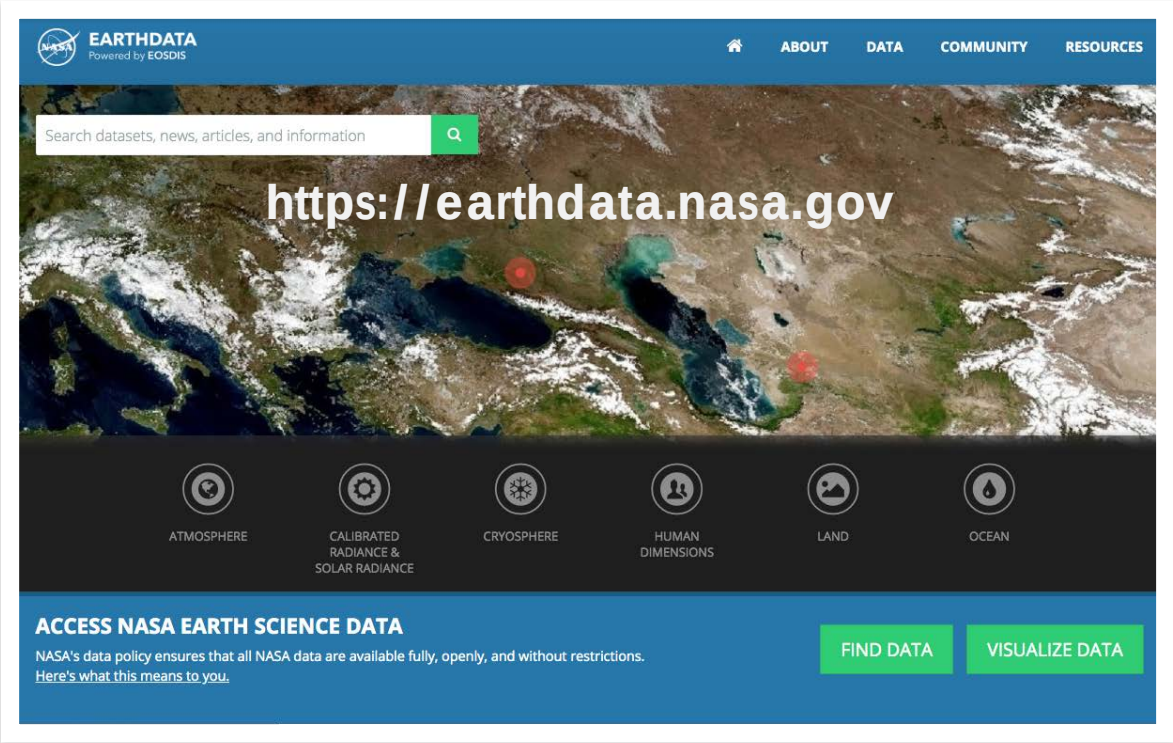
This ability to ***observe our planet comprehensively*** matters to each of us, on a daily level. Earth information - for use in Internet maps, daily weather forecasts, land use planning, transportation efficiency, and agricultural productivity, to name a few - is central to our lives, providing substantial contributions to our economies, our national security, and our personal safety. It helps ensure we are a thriving society. - NRC, 2018



NASA's Strategic Goal 1.1: "Understand The Sun, Earth, Solar System, And Universe."

Earth Science Data System Program

The Earth Science Data System (ESDS) Program is an essential component of the Earth Science Division (ESD) and is responsible for:

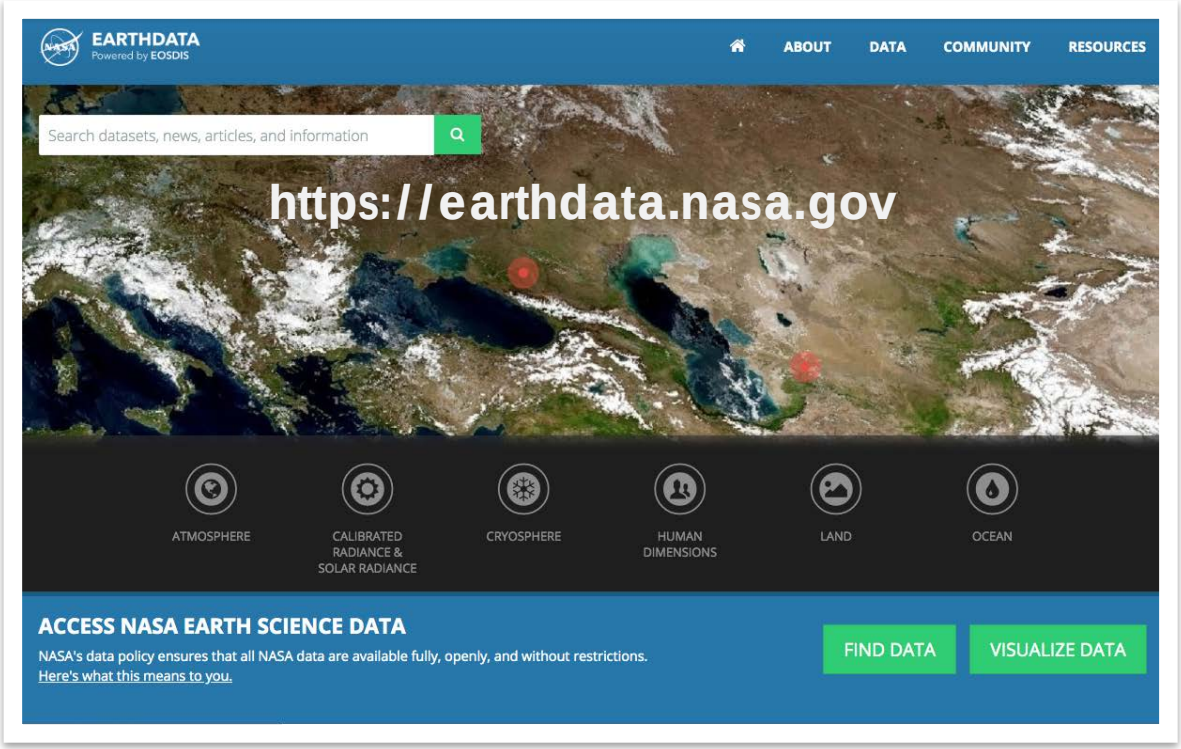


- Actively managing NASA's Earth science data (Satellite, Airborne, and Field).
- Developing unique data system capabilities optimized to support rigorous science investigations and interdisciplinary research.
- Processing (and reprocessing) instrument data to create high quality long-term Earth science data records.
- Upholding NASA's policy of full and open sharing of all data, tools, and ancillary information for all users.
- Engaging members of the Earth science community in the evolution of data systems.

The Earth Science Data and Information System (ESDIS) project at GSFC maintains and operates a data and information system for the Science Mission Directorate (SMD) and its ESD. IMPACT at MSFC supports the ESDS Program and collaborates with the ESDIS project.

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Maximize return on NASA data sets

IMPACT Mission

Empowering Science and Applications by Integrating Data, Technology and People Together

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Foster innovation



Build strategic connections



Enable early technology adoption

Icons from thenounproject.com By Chameleon Design, IN and Vectors Market

Early Technology Adoption



New technology assessment, roadmap and prototyping for Data System evolution

Success Stories:

- MAAP – new collaboration platform for open science
- Machine Learning – Road map and Deep Learning applications

Machine Learning Road Map

Need

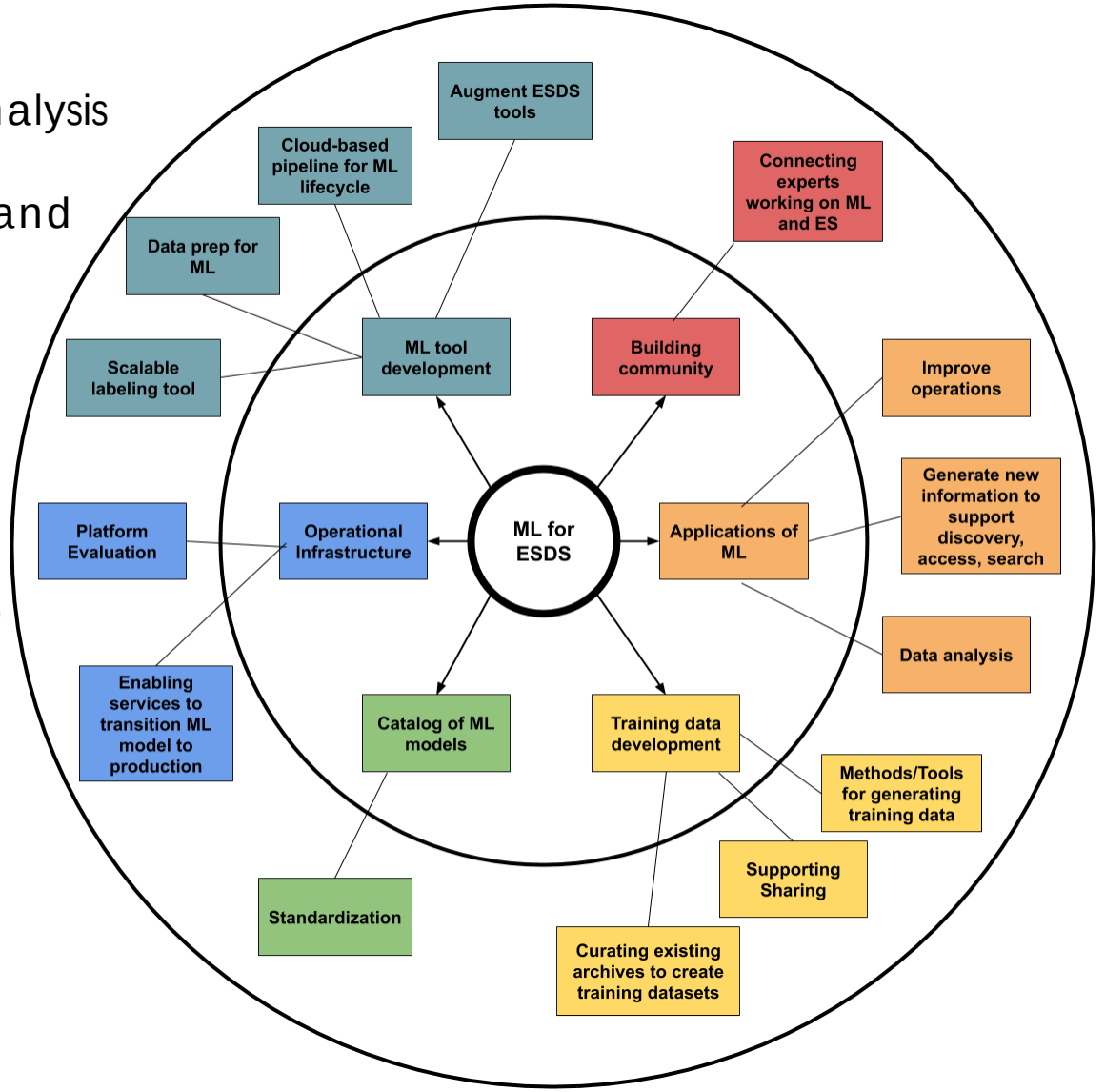
- Provide opportunities to innovate new ways of analysis and obtain valuable insights from EO data
- Utilize ML techniques to improve search, access, and usability as well as overall operations in EOSDIS

Objectives

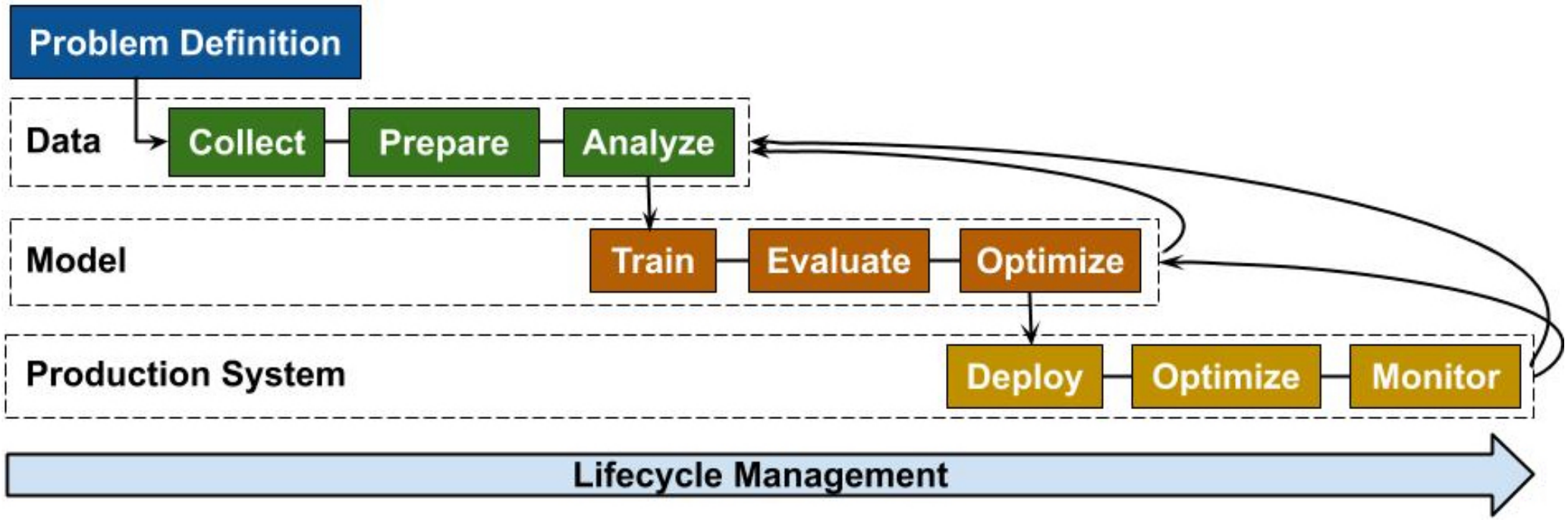
- Identify areas of strategic development
- Track new developments in the AI and ML community to inform the ESDS Program
- Develop and promote the concept of “OpenML”
- Evaluate new tools and platforms

Deliverables

- Workshops focused on areas of interest
- Develop use cases
- Strategic recommendations



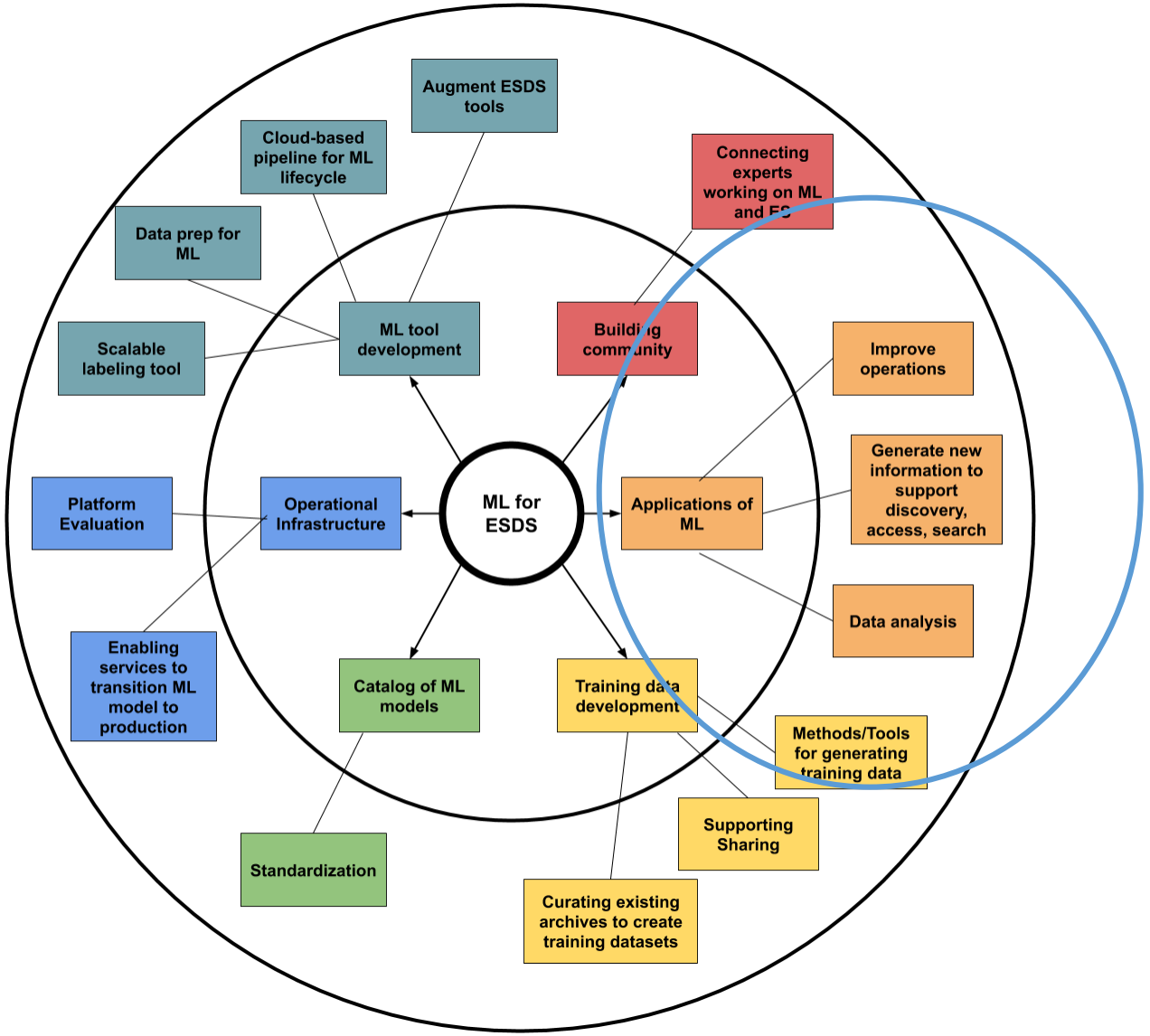
Research to Operation



ML Road Map

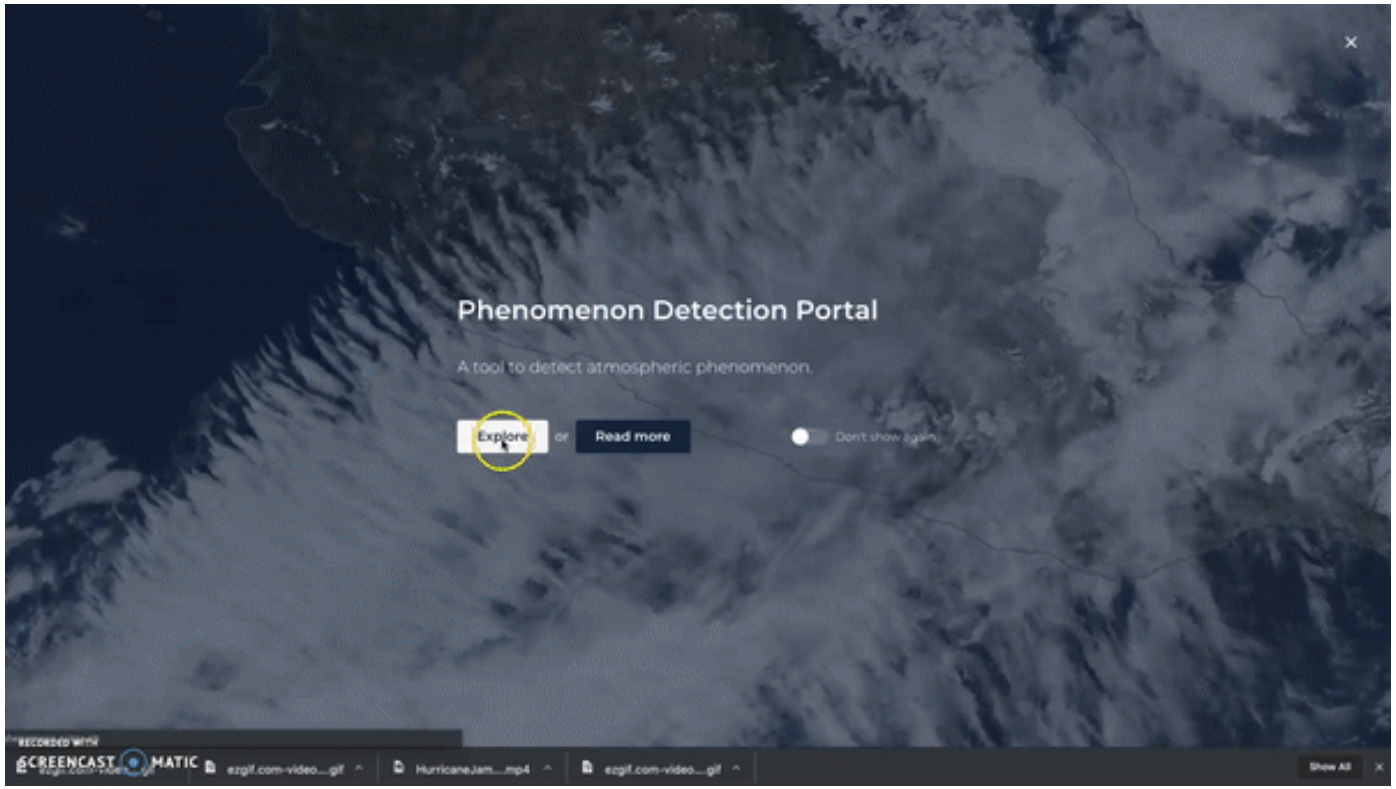
Phenomena Portal

A user interface designed to visualize and analyze a dynamic event catalog of atmospheric phenomena



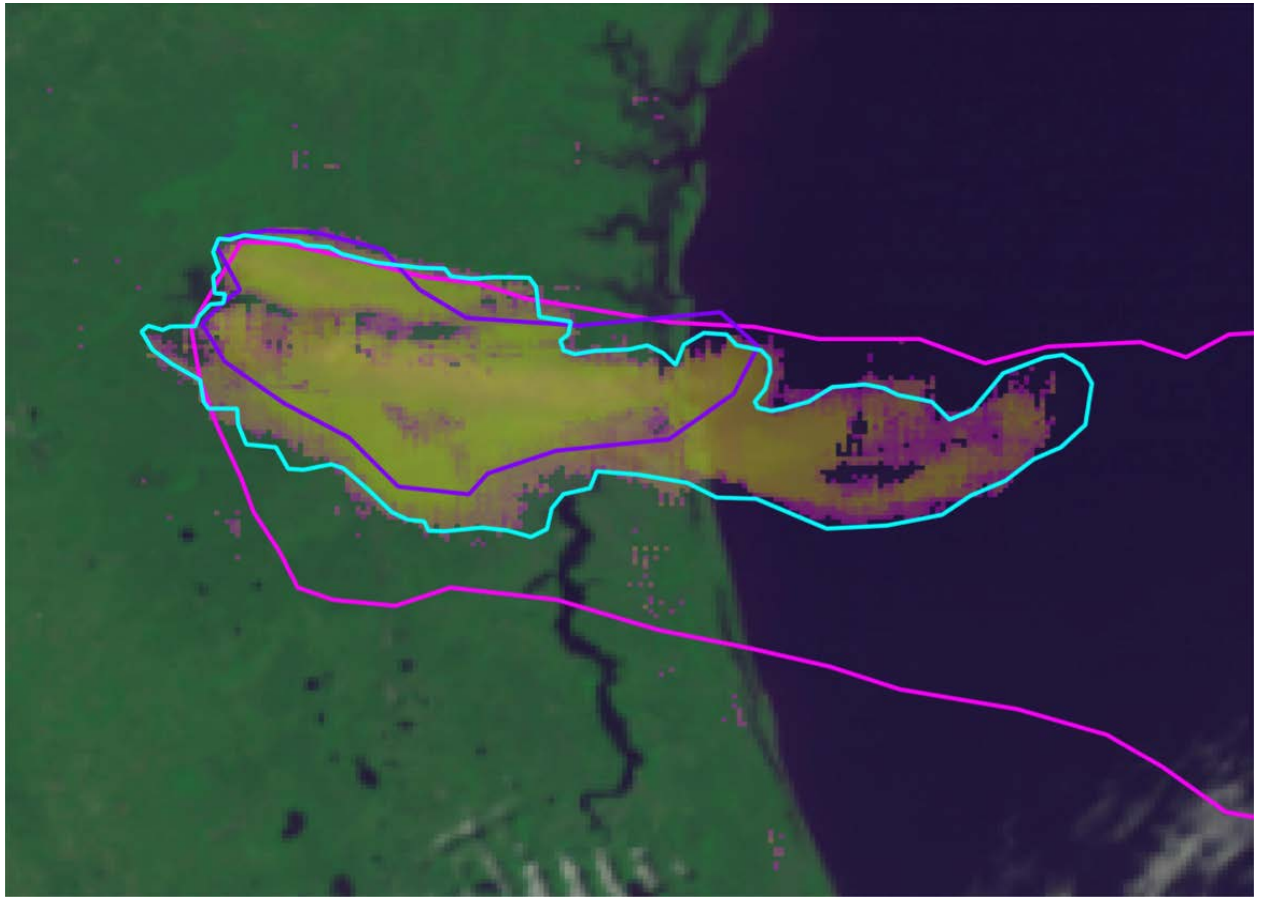
Phenomena Portal

- Incorporate ML models with manually labeled data
- ML models run daily to detect atmospheric phenomena
  - Smoke
  - High latitude dust
  - Transverse cirrus bands
- Detections stored in event database
  - Visualize model output
  - Analyze events in space and time
- API for accessing/parsing event database



Smoke Detection
2 May 2018 - Southern Florida

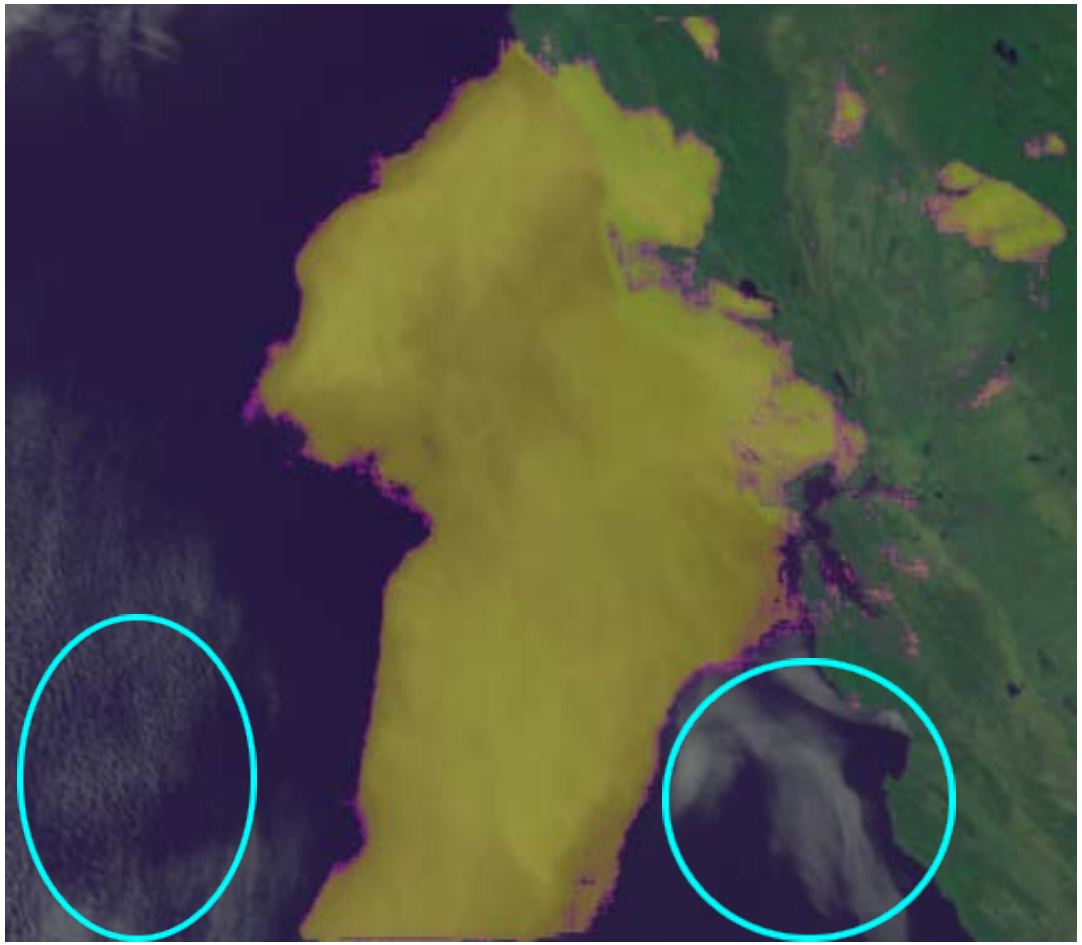
- Smoke identified over both land and ocean
  - Model identifies well defined plumes for scenes with absence of complex features
  - Probabilities resemble visually observed optical thickness
- Predictions resemble quality-controlled shapefiles



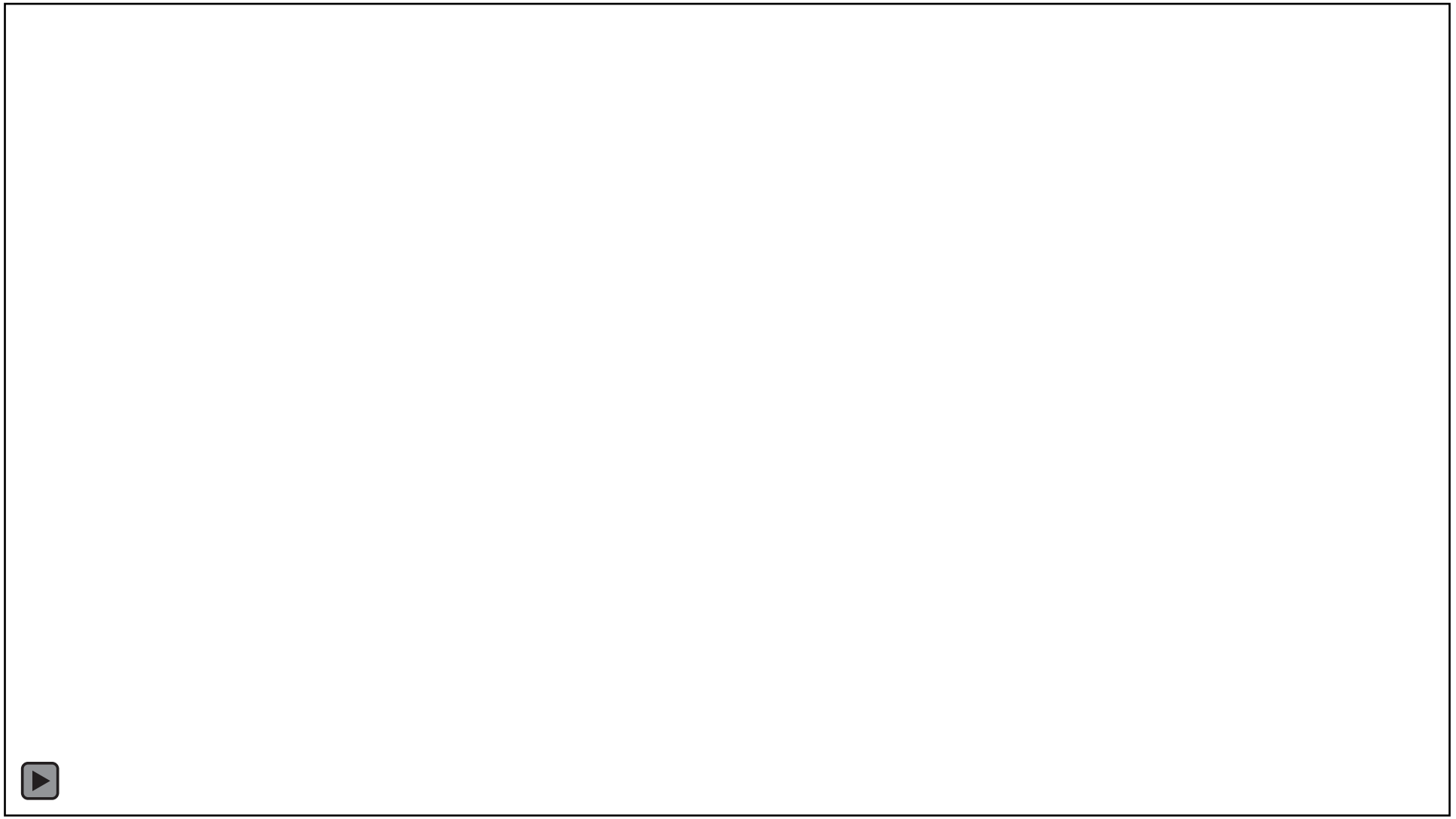
GOES 16 pseudo-RGB with contoured model predictions (shading), HMS shapefiles (magenta and purple), and subject matter quality controlled shapefile (blue).

Smoke Detection
9 October 2017 - Central California

- Large and small plumes detected
- Smoke identification over both land and ocean
- Coastal stratus clouds



Smoke Detection
27 October 2019 - Kincade Fire



Tropical Cyclone Intensity Estimation

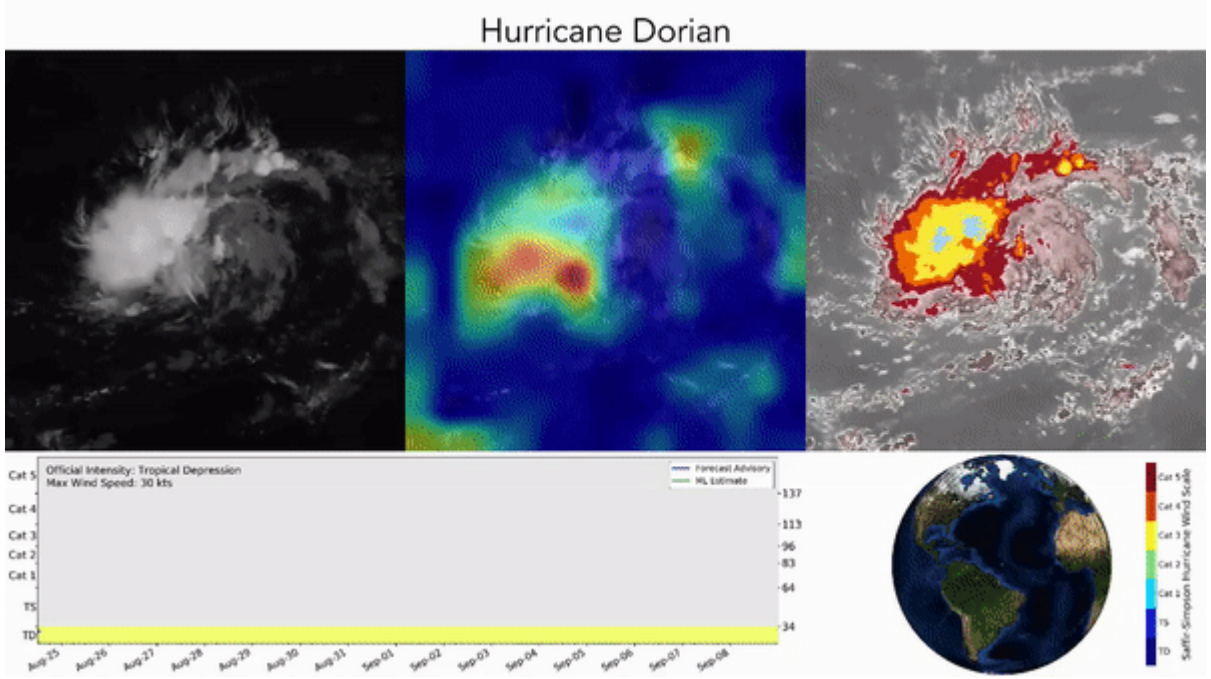


Need: Fast, objective estimates of hurricane intensity

Objectives

- Use a Deep Learning (DL) method to estimate intensity
- Create a situational awareness tool to display estimation and other information in real-time
- Use cloud infrastructure (Cumulus) to build a real-time system triggered by event notification

Tropical Cyclone Intensity Estimation Hurricane Dorian (2019)



- Hourly estimation of wind speed
- Get intensity estimates much faster than the current subjective methods (<1 minute vs. hours)
- Class activation maps show that DL model is identifying classic signatures of intense hurricanes

Tropical Cyclone Intensity Estimation
Hurricane Florence (2018)

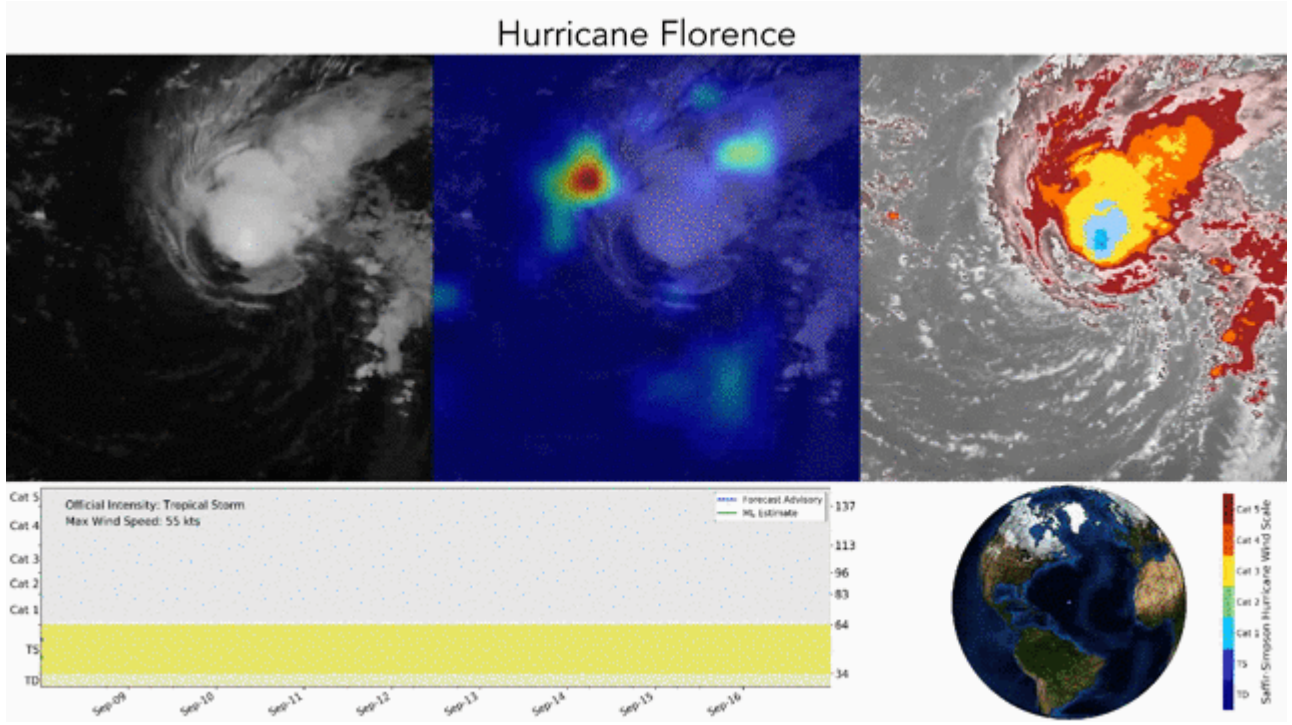
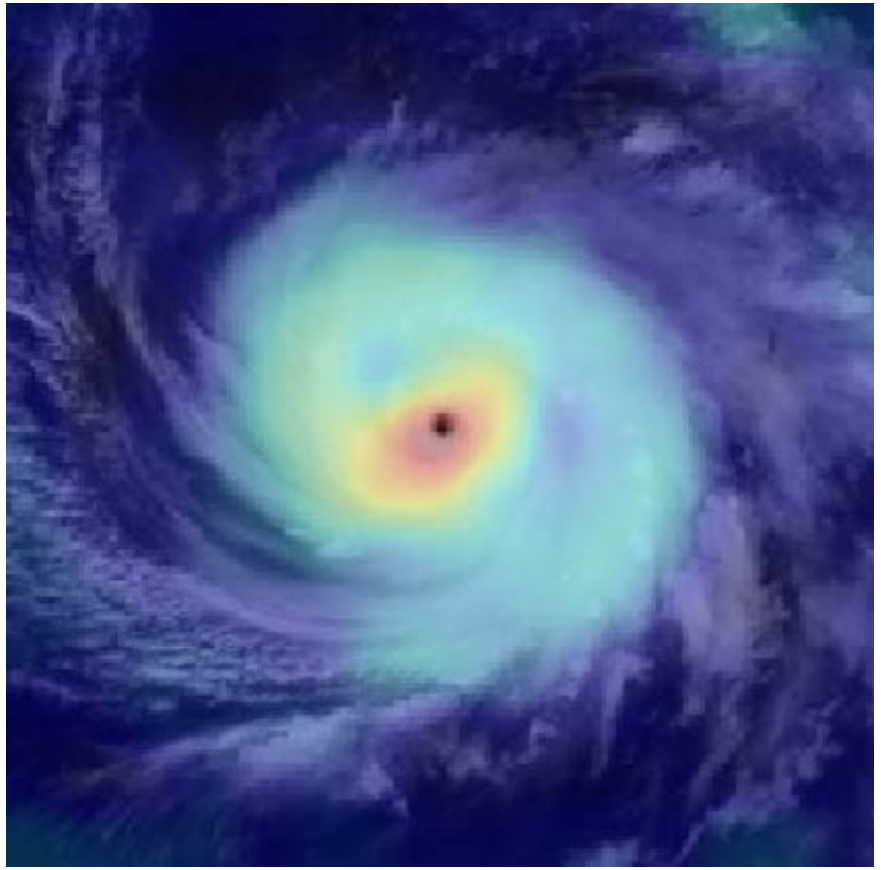




Image courtesy Reuters

Lessons Learned

- Need consistent large-scale training data
- Open the AI black box
- Training data/input data becomes part of the code
- Versioning training data, model, algorithm becomes difficult
- DevOps, Continuous Integration/ Continuous Deployment (CI/CD) - new meaning
- Complexity with evolving platforms and infrastructure

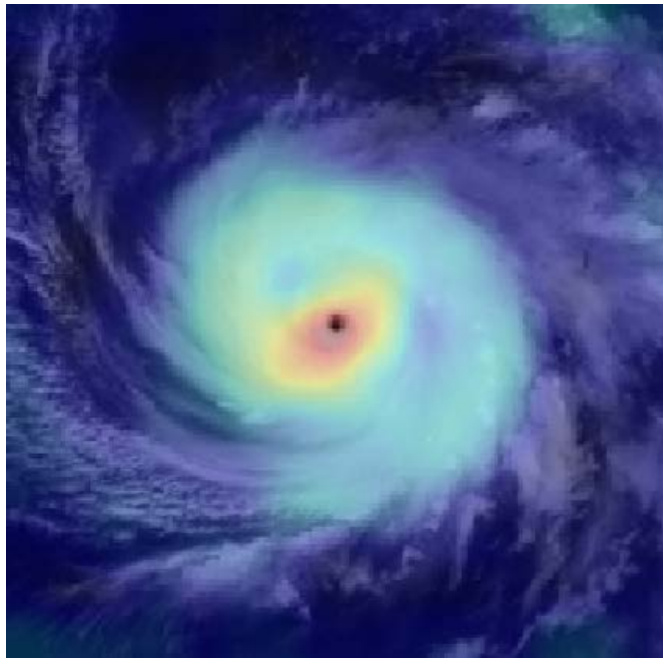


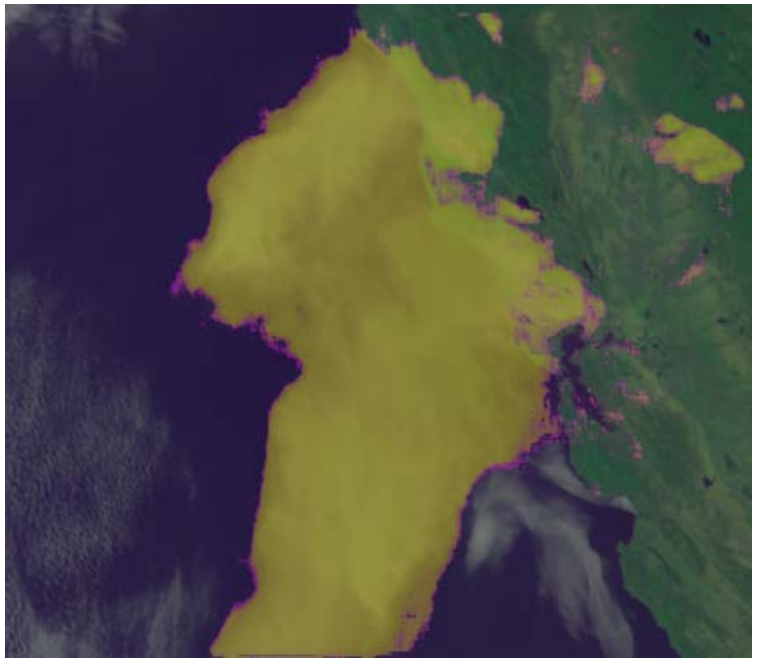
Conclusions

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Empowering Science and Applications by Integrating Data, Technology and People Together

Leveraging machine learning algorithms to analyze and increase usage of Earth system data





Thank you!

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