

NOAA Center for AI (NCAI)

Objectives and Current Activities

Rob.Redmon@noaa.gov

Director, NCAI (noaa.gov/ai)

Senior scientist, NOAA NCEI (ncei.noaa.gov)

July 27, 2023

NOAA SAB AI Panel Session

Agenda

Motivation and Scene Setting

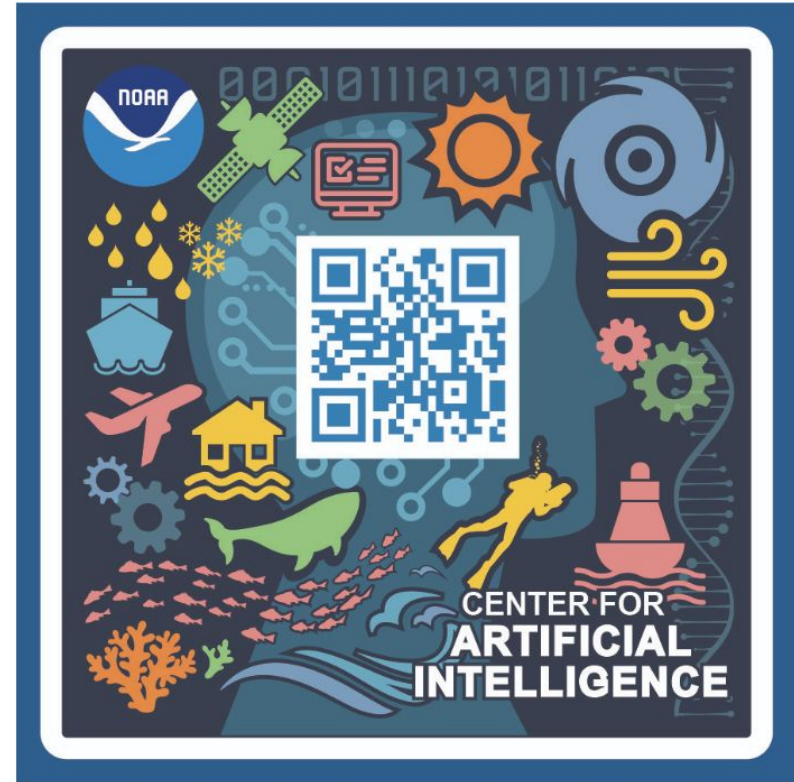
- NOAA's AI Activities to Advance our Mission
- Many Use Cases - Sun to Ocean
- NOAA's AI Strategic Approach

NOAA Center for Artificial Intelligence

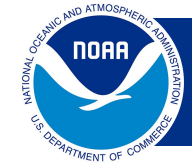
- Ethical AI Innovation
- AI-ready Data Standard
- Training the Workforce
- Community of Practice / Partnership Development

A place to publicly connect with NOAA's 800+ member Community of Practice around AI for Earth system science to develop synergies and partnerships

NCAI Mailing List: tinyurl.com/y2ehvhfg



noaa.gov/ai



Roles for AI in Advancing NOAA's Strategic Goals

Climate-Ready Nation

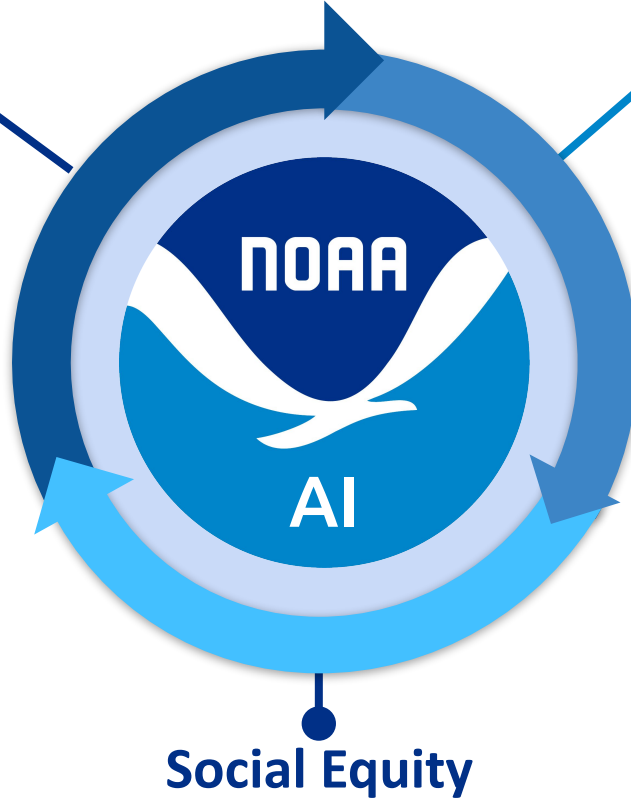
Existing baselines decreasingly relevant.

To mitigate economic loss, large-scale datasets need to be (re)processed with increasing frequency and in near real-time, delivered as **AI-ready data** to Cloud environments with **democratized access**

BUILDING A **CLIMATE READY NATION**

NOAA FY22-26 STRATEGIC PLAN

EXECUTIVE SUMMARY



Blue Economy

For operational insights, NOAA data must be AI-ready and Cloud-accessible to a broad range of stakeholders

Social Equity

Standardizing trustworthy and responsible AI, Democratizing innovation with help from gAI tools



Authoritative Earth System Information & Services

“In the context of *authoritative products and services*, the notion of “authoritative” means...

... conferred by users

- Community / Partner Use and impact
- Proof is in their use
- Reliable, valuable

“service”

NCEI:
Aim here

... credibly represent earth system

- Accuracy, rigor
- Scientific credibility

“science”

... carefully sourced and transparent

- Discoverability
- Provenance
- Preservation

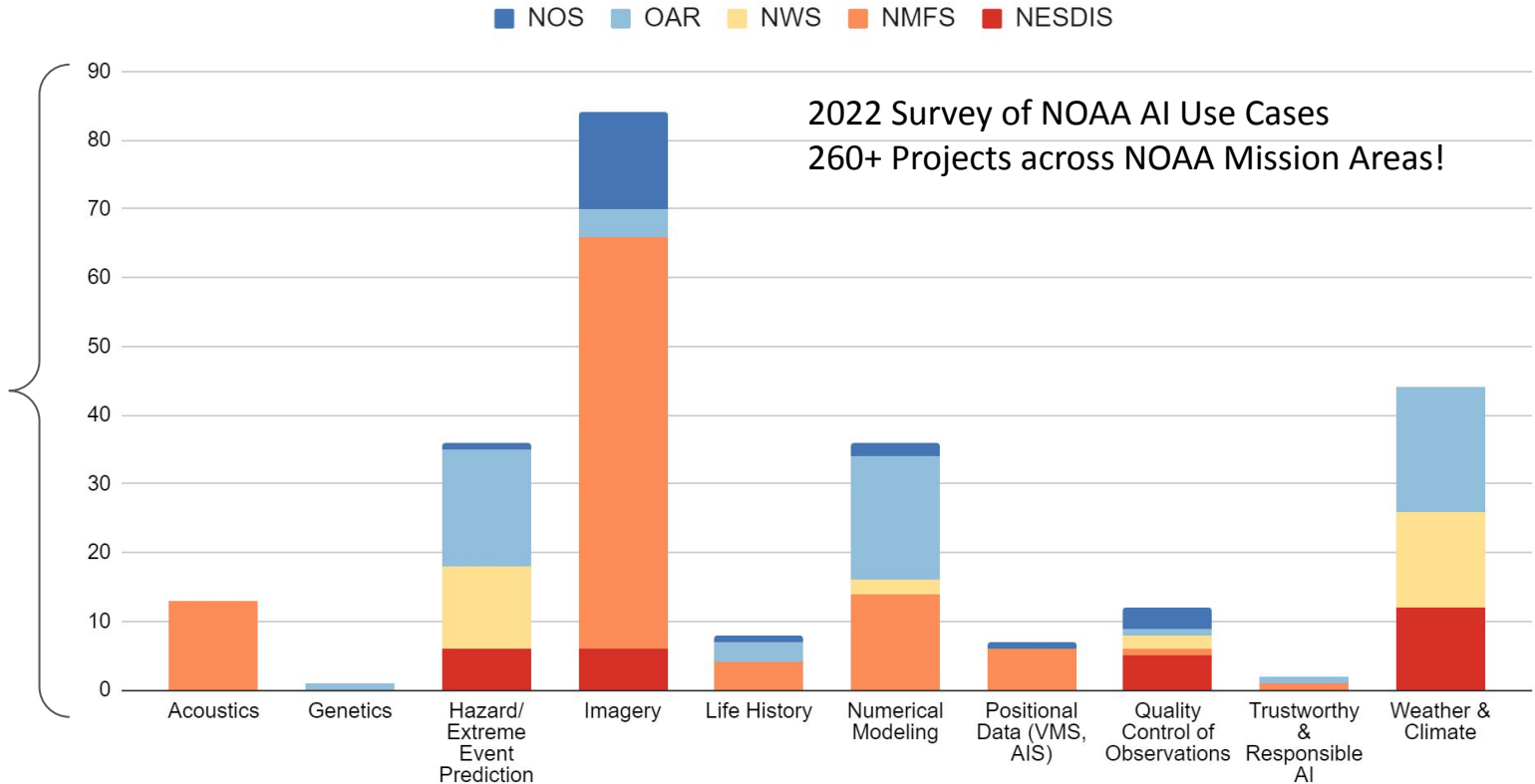
“stewardship”



NOAA Current AI Application Areas

AI Areas

- Imagery
- Wx / Climate
- Modeling
- Hazards
- Acoustics
- Quality Control
- ...
- Responsible AI



Applying AI to NOAA's Mission

Applying Artificial Intelligence to NOAA's Mission



Providing more accurate weather forecasts by improving models



Operating uncrewed systems for bathymetric mapping and geographic surveys



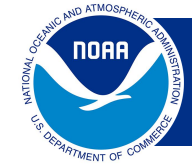
Predicting space weather by identifying solar events in real time



Reviewing aerial and underwater surveys to assess fish populations



Studying protected species with images and acoustic recordings



NOAA's AI Strategic Approach



National AI Initiative Act of 2020:

“The Administrator of NOAA [...] shall establish, a Center for Artificial Intelligence”

“There are authorized to be appropriated to the Administrator to carry out this section \$10,000,000 for fiscal year 2021”

Several Executive Orders, including:

- “Maintaining American Leadership in Artificial Intelligence”
- “Tackling the Climate Crisis at Home and Abroad”
- “Protecting Public Health and the Environment and Restoring Science To Tackle the Climate Crisis”



sciencecouncil.noaa.gov

Related NOAA Strategic Plan Goals & Objectives

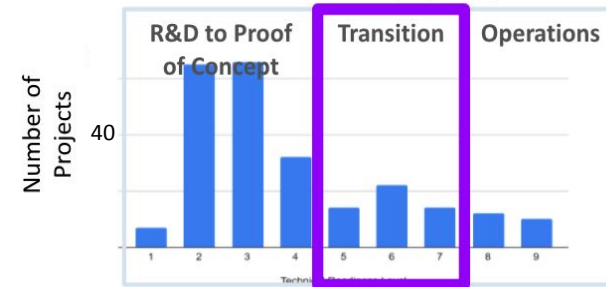
Foster an Information-Based Blue Economy:

NOAA will introduce innovation to data collection through various methods for species detection and explore AI/ML and data visualization technologies...

Ensure accessibility and enable an enterprise climate information framework to meet the needs of NOAA's users:

NOAA will leverage the lasting value of its observational holdings to create robust, sustainable and scientifically sound analysis and AI-ready climate records with the longevity, consistency and continuity needed to understand climate variability and change.

2022 Data Call included 261 projects (188 in 2020)



NOAA Center for AI as a Tech Hub

NCAI Program Office & Tech Hub

Ethical AI Innovation
Why, What, How

**Training
Responsible AI**

**AI-Ready Data
Standards**

**Partnership
&
Engagement**

**Communities of
Practice
Coordination**

Communities of Practice



Powered by
dynamic
workspaces

Savvy AI Trained Workforce

Fisheries Research Surveys

Digital Twins for Fire Wx

Multi-lingual Climate / Wx

Rule Making for Bycatch Limits

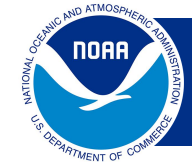
Optimizing Workflows



Sharing Knowledge

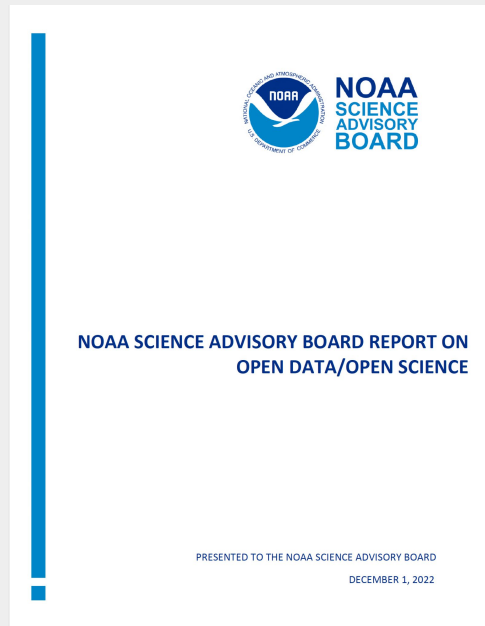
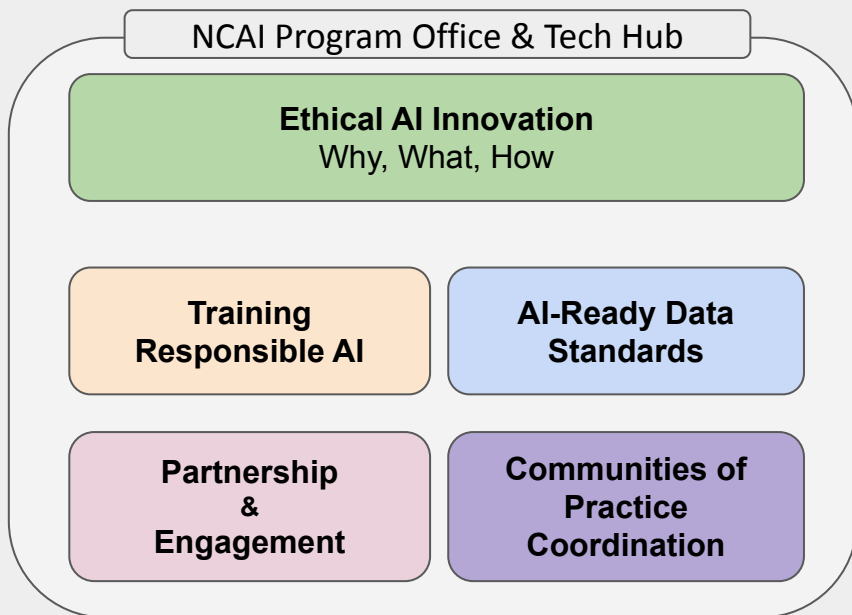


Obtaining Results



Connections to SAB Activities

<https://sab.noaa.gov/>



Climate WG

Ecosystem Sciences
and Management WG

Tsunami Science and
Technology Advisory Panel

Environmental Information
Service WG

Data Archiving and
Access Requirement WG

NCAI Initiatives and Pilots

Initiatives:

- AI-Ready Data
- Responsible AI Training
- Workshops / Partnerships

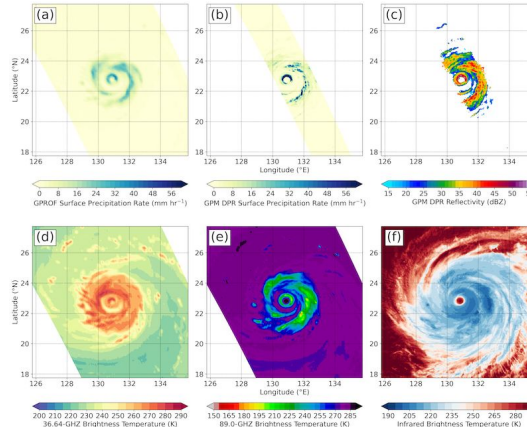
Pilots:

- *Current:* Humidity, Tropical Cyclone, Ocean Acoustics, UxS QC, Data Value via NLP
- *Upcoming:* Offshore wind, World Ocean Database, Arctic Sea Ice, others



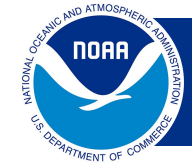
Working towards the creation of a spatially complete surface humidity dataset by blending remotely-sensed and in-situ surface humidity data using AI methods.

Goal: a dataset beta version that meets requirements with public health data and associated socioeconomic metrics, along with a heat health application demonstration.



This project evaluated and improved a dataset's AI-readiness. The new dataset, *Tropical Cyclone PReipitation, Infrared, Microwave, and Environmental Dataset (TC PRIMED)*, collocates and subsets LEO/GEO satellite imagery with ancillary model information to create a 22-yr dataset of TC-centric scenes.

TC PRIMED updates NCEI's *HURSAT*, and is available via both NCEI's archive and NOAA's Open Data Dissemination (NODD) program: Access: [NODD](#); NCEI [OneStop](#), [Geoportal](#)



AI-Ready Data Community Roadmap (Proposed)

ESIP Data Readiness Cluster

01

Develop and maintain AI-ready data standards

- **Short term:** Review of common domain data standard
- **Mid term:** Develop proposed AI-ready data standard for publishing process
- **Long term:** Publish and maintain AI-ready data standard

02

Develop automatic tools for AI-readiness assessment

- **Short term:** Update assessment form based on user feedback
- **Mid term:** Develop metrics to display & synthesize AI-readiness assessment results
- **Long term:** Develop automatic AI-readiness assessment tool

03

Develop and improve AI-ready open environmental data

- **Short term:** Uplift a pilot set of thematic AI-ready data
- **Mid term:** Develop tools and leading practices to improve data readiness at scale for community adoption
- **Long term:** Provide AI-ready data discovery tools and services

04

Sustain the engagement with user and capacity building

- **Short term:** Increase engagement with private sectors
- **Mid term:** Develop primers for AI-ready data checklist / standards for different user personas
- **Long term:** Develop and maintain training materials on AI-ready data and tools for different user personas

Learning Journeys for Responsible AI

Funded Future Project

Overview

- Tropical cyclone rapid intensification

Conventional Rapid Intensification Index Model

Random-Forest-Based Rapid Intensification Index Model

Description

- What is TC PRIMED?

Overview

- TC PRIMED file format

Data Exploration

- TC PRIMED overpass file
 - TC PRIMED environmental file
 - Simple analysis of Hurricane Florence (2018)

AI Example

- Using a Neural Network model to obtain precipitation rate in a pixel

Feature Engineering

- Pre-processing TC PRIMED data for more complex AI approaches

1 Exploring TC PRIMED, Chapter 3: Pixel-Based Neural Network Application

- Creators: Nafsal Razvi, Kathy Haynes, and Chris Stocum
- Affiliation: CIRA and NESDIS/STAR

1.1 Overview

TC PRIMED contains passive microwave observations in their original swath structure. One of the ways in which users can apply a machine learning method to TC PRIMED swath data is by training a machine learning model for individual pixels. In this notebook, we will explore one way to pre-process TC PRIMED passive microwave data and apply a pixel-based machine learning method.

1.2 Prerequisites

To successfully navigate and use this notebook, you should be familiar with:

- the basics of Python programming such as loading modules, assigning variables, and list/array indexing
- NetCDF files and NetCDF groups
- plotting data using matplotlib
- TC PRIMED overpass file data structure
- basic performance metrics like mean squared error and mean absolute error

1.3 Learning Outcomes

By working through this notebook, you will learn how to:

- pre-process TC PRIMED passive microwave data for a pixel-based machine learning application
- apply a pixel-based machine learning method to TC PRIMED passive microwave data

1.4 Background

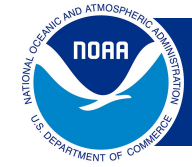
The Tropical Cyclone Precipitation, Infrared, Microwave, and Environmental Dataset (TC PRIMED) is a dataset centered around satellite passive microwave observations of tropical cyclones. TC PRIMED contains data from consistent sources, making it suitable for machine learning applications. For example, the passive microwave brightness temperature data in TC PRIMED has been corrected for any instrument drift and bias such that the observed brightness temperatures are consistent throughout the multiple years each satellite has been in orbit (Berg et al. 2016). Therefore, the differences in observed brightness temperatures are mainly due to differences in the characteristics of the different sensors in TC PRIMED.

TC PRIMED stores passive microwave brightness temperature data in its original swath format. To apply a machine learning model to swath data, users can take one of two approaches:

- process the swath data into a more uniform data structure to predict a storm-scale phenomenon (e.g., is there a hurricane eye in the passive microwave image?)
- make pixel-based predictions (e.g., is there convective or stratiform precipitation in the passive microwave pixel?)

In this notebook, we will go through an example of the second approach. And, in contrast to the classification examples provided above, we will employ a machine learning regression. In particular, we will use passive microwave observations from the Global Precipitation Measurement mission (GPM) satellite to predict/regress the surface precipitation rate at each pixel. Using GPM observations simplifies our example since:

- it makes observations using a conical-scanning sensor, which ensures a constant resolution across the swath
- its observations in the 10.65 GHz through 89.0 GHz frequencies are located on the same swath



Opportunities to Advance NOAA's Mission using AI

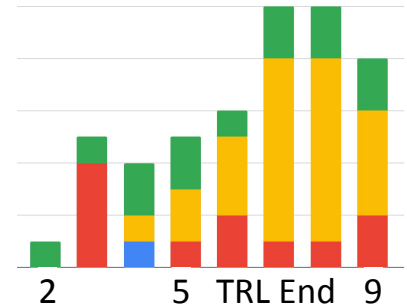
AI Innovation to Support NOAA's Mission

- Accelerating Climate Information Partnerships
- Advancing ESP and future Digital Twins
- *etc ...*

NCAI Collection vs. TRL Endpoint

- AI-ready data
- Advance AI
- R2X

TRL Advancement



Representative Themes

(Not a complete list.)

- Improving precipitation forecasts
- Anomaly detection and QC toolkits
- Image classification / species detection
- AI-ready data to accelerate cross-domain insights

Representative Transformative Examples

(Not a complete list.)

Expedite Downscaling of Global Climate Projections to Regional Scales

Clustering water masses of the World Ocean

Hybrid AI + 'Omics approach for forecasting reef coral susceptibility to climate change

Centralizing AI algorithms into a common framework for migration to cloud computing - benefiting marine mammal identification

Marshalling of Fleet Scientific Computing System data into an AI ready format

Improve predictions from the GFS/GEFS through reduction in systematic bias



Expanding NOAA AI Community of Practice through Partnerships

(Powered by Workshop Engagement (today) and sustained Community Workspaces (future))

IMPACT

Advance NOAA's mission through the proliferation of Responsible AI by building Communities of Practice for effective information exchange within NOAA and with external cross-sectoral Partners.

BENEFITS

We need to engage in conversations outside of the Agency in order to maximize the benefits of integrating responsible AI and other emerging technologies to realize NOAA and National objectives.

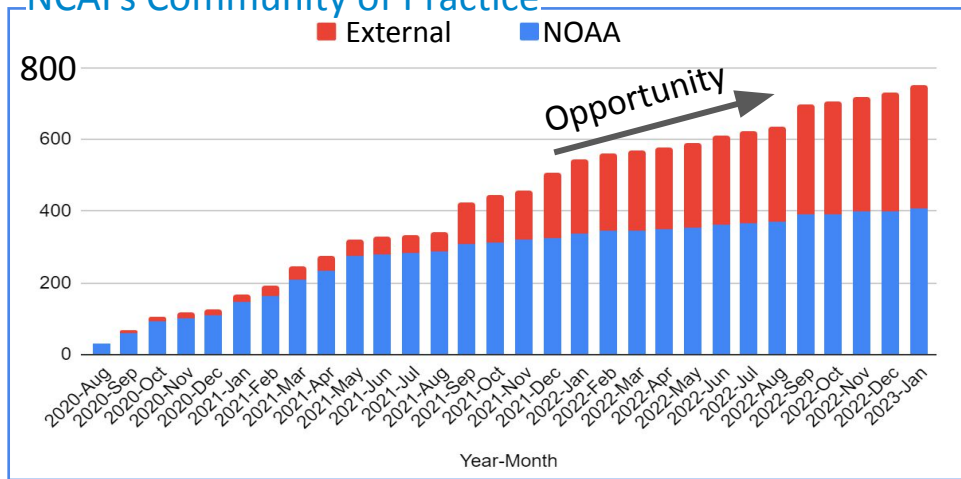
5th NOAA AI Workshop - September 19-21

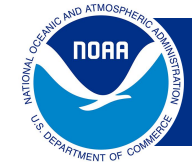
- Benchmarking Framework in AI R&D
- Research-to-Operations-to-Research (R2O2R)

Registration coming soon, express interest:

noaa.gov/ai/events/5th-noaa-ai-workshop-2023

NCAI's Community of Practice





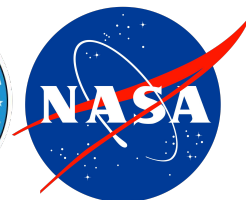
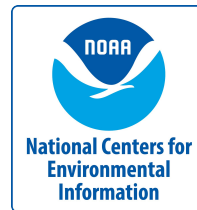
NOAA Center for Artificial Intelligence

Our Vision

Benefiting NOAA's mission by proliferating the use of Responsible AI at NOAA.

How?

We'll do this by lowering the cost of engaging curiosity for our Community of Practice.



noaa.gov/AI



Met Office

