NOAA
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OMD OFFICE NOTE 1

https://doi.org/10.25923/0mxd-0362

Office of Modeling and Development (OMD) AI/ML Modeling Strategy (2026-2031)

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This manuscript was produced with the assistance Generative AI. All AI contributions have been subject to human review, including full quality assurance and extensive editing

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Office of Modelling and Development
Riverdale Park, MD
June 2026

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June 2026

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Introduction

This document presents the **Office of Modeling and Development's (OMD) Artificial Intelligence (AI/ML) Strategy (2026-2031).** It represents a high-level plan for integrating AI technology into its operations over the next three to five years to enhance environmental predictions. Artificial Intelligence serves as the umbrella term for machines capable of mimicking human intelligence, within which **Machine Learning (ML) exists as a core subset** dedicated to algorithms that improve automatically through experience. This strategy is centered around three core goals, aligning with broader NOAA and NWS initiatives:

- **Goal 1**: Build and support a technical and human infrastructure that enables a powerful end-to-end AI/ML Framework.
- **Goal 2:** Leverage AI/ML tools, models, and techniques to explore, develop, test, and implement an Advanced AI Environmental Prediction System.
- **Goal 3**: Leverage AI/ML in the day-to-day workflow at OMD.

This strategy document focuses on the high-level vision and objectives for integrating AI/ML into OMD's mission. Detailed implementation plans, specific timelines, and resource allocation are outside of the scope of this strategy.

Goals and objectives

This section identifies top level objectives for the three goals identified in the introduction

Goal 1: Build and support a technical and human infrastructure that enables a powerful end-to-end AI/ML Framework

This goal focuses on capacity building in OMD from both a technical and human resource perspective, through the following objectives.

Objective 1.1: Build the human infrastructure needed to effectively implement AI/ML at OMD

Success depends on building in-house expertise by (i) providing AI/ML training, (ii) reassigning the current workforce, and (iii) attracting experienced talent through strategic partnerships with NOAA teams, other government agencies, academic institutions, and the private sector.

Objective 1.2: Build and support a technical infrastructure that enables a powerful End-to-End AI/ML Framework

A viable and efficient technical framework requires (i) GPU and other up and coming hardware solutions in the context of High Performance Computing (HPC) and Cloud Computing, (ii) software libraries and packages such as PyTorch, TensorFlow, and SciTransformer on all

development and production hardware, (iii) AI tools, such as Copilot and Jules, to increase code efficiency, testing, and reviews, and (iv) A DevOps development workflow leveraging existing AI/ML pipelines from the weather prediction community.1

Objective 1.3: Generate AI-Ready Data

Adopt the Earth Science Information Partners (ESIP) AI-Ready Data Checklist.1to ensure that all relevant data produced by and for the present Production Suite of operational models can be used as input for AI/ML projects by NOAA and all of its partners.

Goal 2: Leverage AI/ML tools, models, and techniques to explore, develop, test, and implement an Advanced Environmental Prediction System

OMD aims to rapidly integrate AI/ML capabilities and benefits into our flagship products through the following objectives. Note that the objectives are closely aligned with the major components of the end-to-end business model of OMD starting with observations and ending with supporting Impact-based Decision Support Services (IDSS).

Objective 2.1: Data Assimilation (DA)

AI/ML provides opportunities to advance DA. OMD will focus on: (i) Processing observations, including data selection and superobservation approaches, enhancing use of observations, monitoring, quality control, observation operators, and bias correction, (ii) Improving algorithms, including applying AI/ML to emulate background error and balance operators, and evaluating AI/ML emulators for tangent linear and adjoint codes used in complex DA algorithms, and (iii) Optimizing the overall efficiency of the cycled DA system by strategically inserting AI/ML techniques, such as using AI/ML forecast models to quickly generate the background for the next analysis cycle.

Objective 2.2: Forecast models

Through the Experimental AI Global and Limited-area Ensemble (EAGLE) project, we have already implemented operational Machine-Learning Weather Prediction models (MLWP), including a deterministic model, an ML ensemble, and a hybrid ensemble system. Building upon this success, OMD will: (i) Expand MLWP model development to include hurricane, air quality, and coupled earth modeling systems (atmosphere, ocean, ice, wave, aerosol/chemistry) with both global and limited-area applications, (ii) Develop models trained on observations to make forecasts at specific sites and train data-driven models with observations mapped to the regular model grid, and (iii) Integrate AI/ML technology into individual physics parameterizations to improve accuracy and speed up computationally expensive processes. This approach can also be applied to more holistic parts of models (e.g., emulate all physics in environmental component models, and address model biases or coupling).

Objective 2.3: Post-processing and calibration

Post-processing and calibration will leverage AI/ML for several key tasks, including more accurate data mining from physical model output, downscaling to increase the spatial resolution of model output and analyses, bias and error correction of deterministic and ensemble forecasts, quantifying uncertainty. Expanding traditional physical model approaches with AI/ML models, in particular the development of hybrid super-ensembles, requires development of hybrid physical-AL/ML approaches to all these topics.

Objective 2.4: Verification and Validation

Verification and Validation (including visualization) will explore Agentic AI systems[1] to fundamentally shift verification from basic reporting to active, conversational diagnosis, focusing on contextualized and actionable conclusions. On a more incremental level, validation and verification will focus on Object-Oriented (OO) methods to enable spatial and temporal pattern recognition of errors, AI/ML will be used to make error assessment more actionable for instance by using Support Vector Machines (SVM), Explainable AI (XAI) techniques, Layer-wise Relevance Propagation (LRP) error propagation, and AI/ML attribution to guide Process-Oriented (PO) evaluation of error origins in model subroutines.

Objective 2.5: Supporting IDSS

The ultimate end point of OMD's end-to-end business model is to support the Impact-Based Decision Support Services (IDSS) mission of the NWS. Here, AI/ML methods are considered more efficient and accurate at searching analogs from climatology to create products that highlight high-impact or anomalous weather events. The establishment of special training datasets of high-impact events are needed to support the development of AI/ML models and techniques to inform global and regional anomaly products, and the identification of rare events from, for instance, the National Blend of Models (NBM).

***Goal 3**: Leverage AI/ML in the day-to-day workflow at OMD*

Goal 3 augments the business model focus of AI/ML use with some cross-cutting AI/ML efforts and principles.

Objective 3.1: Use of Agentic AI

Agentic AI[1] has already been highlighted above in Objective 2.4, and is used in NWS operations, for instance, to support language translation of our products. This objective addresses Agentic AI as a productivity tool on the workfloor of OMD. In the latter context, Agentic AI will be used as a general productivity tool, similar to the more traditional use of Large Language AI models like Gemini, which is available throughout NOAA as part of our Google

[1] Agentic AI refers to proactive and autonomous AI systems that can plan, execute, and verify complex tasks, often serving as productivity agents for streamlined workflows.

tools suite. Agentic AI tools to help write or re-factor software such as Copilot or Jules are powerful force-multipliers in OMD. Note that NOAA rules of engagement with such AI tools require that they be used as tools to help develop text and software, with required human oversight and final approval.

Objective 3.2: Code Modernization

OMD will be working towards the modeling moonshot, which envisions a 3km resolution hourly cycling global DA and modeling system. Many of the code bases used by OMD show their age, and will require continuous and systematic modernization to enable the moonshot. In particular the Agentic AI mentioned in the previous Objective will assist it (i) refactoring old code (including moving away from Fortran), (ii) porting code to new platforms / hardware architectures, (iii) increasing operational efficiency and performance portability, (iv) generating documentation and unit tests, and (v) assisting with code integration and deployment.

Objective 3.3: DevOps

The EAGLE project mentioned above has allowed us to create a much more agile transition of research to operations (R2O) than the process we use for traditional physical models. OMD will make all R2O processes more agile by implementing a DevOps development workflow. This DevOps process will be assisted by AI/ML using approaches similar to those outlined in Objective 3.2