

**Integrating Ocean Observations:
A Strategic Vision to Benefit NOAA's Earth
System Modeling and Predictions**

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Executive Summary

The Need. The United States is facing a profound climate crisis. As a result, more severe and frequent extreme events are developing due to increased water vapor evaporating into the atmosphere; warmer oceans fueling greater wind speeds; and rising sea level causing enhanced erosive forces due to waves and currents. Actionable Earth system information is needed across a range of audiences and timescales to help all elements of society mitigate, prepare for, and adapt to challenges related to climate change that threaten lives, livelihoods, property, and ecosystems nationwide.

The Response. NOAA must embark on a new way of doing business by fully integrating the ocean observing communities with its weather, water, and climate programs in order to provide society with state-of-the-science actionable data, information, and services. Historically, the scientific communities studying and predicting the atmosphere, ocean, and terrestrial hydrology have been organized around their own disciplines and separated from one another and from the end-users. The insufficient integration of ocean observations in numerical models is a clear limiting factor for improving skill in Earth system prediction across timescales. An integrated climate-scale, phenomena-based ocean observing system will improve NOAA's Earth system prediction by better supporting model initialization that is vital for validating and improving system parameterizations and development.

The Approach. This Strategic Vision is an outcome from the 2020 Integrating Ocean Observations to Improve NOAA's Hurricane Intensity Forecasts Workshop, and is designed to bolster coordination across NOAA mission areas, programs, and service areas. Implementing the objectives and outcomes will also depend on strengthening and expanding partnerships with academic, private, and international groups, and Federal, State, regional, local, and Tribal governments.

Legislative and Executive Mandates. This Strategic Vision is in alignment with mandates from Congress and the Executive Office of the President, including the: Weather Research and Forecasting Innovation Act of 2017; National Integrated Drought Information System Reauthorization Act of 2006; Geospatial Data Act of 2018; Integrated Coastal and Ocean Observation System Act of 2009; Foundations for Evidence-Based Policymaking Act of 2019; 2020 Executive Order on Tackling the Climate Crisis at Home and Abroad; and Coordinated Ocean Observations and Research Act of 2020.

Strategies and Initiatives. This Strategic Vision is in alignment with several inter- and intra-agency efforts, including: Earth System Predictability Research And Development Strategic Framework And Roadmap; Interagency Council for Advancing Meteorological Services (ICAMS); NOAA's Earth Prediction Innovation Center Strategic Plan; NOAA's Precipitation Prediction Grand Challenge; NOAA's Climate and Fisheries Initiative; NOAA's Science Advisory Board's Climate Working Group White Paper on Advancing Earth System Prediction

Impact. Enhanced science-based information and services that address weather, water, oceanic, and climate vulnerabilities will improve our nation's security and environmental information by saving lives, protecting property, safeguarding natural resources, and supporting the economy.

Strategic Objectives and Outcomes

Objective 1.0 Strengthen and Sustain Coordination and Communication

Outcome 1.1 Communication and coordination across NOAA's value chain, disciplines and readiness levels, and with external partners is continuously sustained to align priorities, opportunities, and efforts.

Outcome 1.2 External partners have access to key data sets, models, metrics, and data assimilation systems.

Objective 2.0 Align, Enhance, and Maintain Ocean Observations

Outcome 2.1 Ocean observation systems are continuously coordinated and deployed using an evidence-based approach that supports the highest priority research and development (R&D) and operational needs, and results in a comprehensive ocean observing strategy.

Objective 3.0 Improve Ocean Data Management

Outcome 3.1 A cloud-based oceans data lake provides a central, easy to access location to store, share, archive, and quality control raw observing data, as well as provide the standardized, QA/QC'd ocean observations transmitted to Earth system models or disclaimers on experimental data.

Outcome 3.2 Data assimilation systems are enhanced using evidence-based criteria to improve the assimilation of data into numerical models and to demonstrate the impact of ocean observations.

Outcome 3.3 Ocean data and information services are useful, usable, and used.

Objective 4.0 Prioritize and Align End-to-End Funding

Outcome 4.1 End-to-end funding is prioritized in annual and multi-year budgets to enhance and accelerate improvements in Earth system science and prediction to save lives, protect property and increase coastal resilience.

Outcome 4.2 Funding opportunities are aligned to meet intra- and inter-Line Office and cross-agency goals and objectives and incentivize engagement, collaboration, and innovation.

Objective 5.0 Enhance Organizational Support

Outcome 5.1 Lessons learned are continuously documented, reviewed, and implemented across NOAA's value chain as they relate to integrating ocean observations to improve hurricane forecasting.

Outcome 5.2 The appropriate, diverse, inclusive, and prepared capacity is available to coordinate observation efforts, assimilate data, analyze impacts, and implement best practices.

Introduction

The use of weather forecasts by individuals, businesses, and governments is ubiquitous: Should a school system be closed due to snowy conditions? How much power should an electric utility plan to produce in order to meet demand for air conditioning during a summer week? Is a weather-sensitive military engagement likely to be effective on a particular afternoon? Although short-term forecasts play a vital role in shaping societal decision-making, many critical decisions must be made several weeks to months in advance. For example, naval and commercial shipping planners designate shipping routes weeks in advance to take advantage of favorable conditions or avoid hazards; drought forecasts help inform farmers about which seed varieties are most likely to increase yields and reduce costs; and water resource managers face a multitude of decisions about reservoir levels in the weeks, months, and seasons ahead of eventual water consumption. The value and importance of forecasts across timescales will increase as our nation's economic activities, security concerns, and stewardship of natural resources become increasingly complex, globally interrelated, and affected by longer-term climate changes.

The crucial issues of extreme weather events, climate change, and subseasonal-to-decadal forecasting involve all the components of the earth system: atmosphere, oceans, land, biosphere, and cryosphere. The oceans serve as heat reservoirs that continuously exchange heat, moisture, and carbon with the atmosphere, drive weather patterns, and influence the slow, subtle changes in climate. However, the oceans are among the most poorly known and understood components because of the sparseness of data, often due to the difficulty of probing certain regions or oceanic layers.

Scientists are increasingly aware of the important role the ocean plays in weather and climate forecasting. Over the past decade, measurements from the climate-oriented ocean observing system have been key to advancing the understanding of extreme weather events that originate and intensify over the ocean, such as hurricanes. However, the frequency and density of ocean observations does not rival the amount of data available for atmospheric parameters. The paucity of observations, particularly in regions where they are strongly coupled to the atmosphere, is a clear limiting factor for improving NOAA's skill in Earth system predictions across all timescales.

Improving NOAA's Earth system prediction requires an integrated ocean observing system with an operational data stream to support prediction initialization and phenomena-based observations vital for validating and improving system parameterizations and development. Additionally, assessments of global change rates, and what is controlling the concentration of greenhouse gases in the atmosphere, requires quantifying the ocean heat and carbon budgets directly. Meeting this challenge will require bold, progressive action, a coordinated approach from planning to implementation, and substantive engagement with external partners.

STRATEGIC GOAL

Improve NOAA's Earth system prediction to provide more accurate, reliable, and timely forecasts across timescales by closing gaps in ocean observations and better integrating ocean observations into numerical models.

The Need

Improving NOAA's Earth system prediction will require an integrated ocean observing system with an operational data stream to better quantify exchanges between ocean and atmosphere, support prediction initialization, data assimilation (DA) and phenomena-based observations vital for validating and improving system parameterizations. Historically, the scientific communities studying and predicting the atmosphere, ocean, and terrestrial hydrology have been organized around their own disciplines and thus separated from one another and from the end-users. In addition to significant scientific advances in the areas of ocean science and data assimilation, enhancing and integrating NOAA's ocean observing system into the weather-water-climate systems presents a tremendous challenge. This effort will require cross-Line Office and cross-discipline coordination, and research-to-operations planning, to inform, prioritize, and shape NOAA's weather, water, climate, and Earth system prediction efforts.

The challenge ahead is for NOAA to review and consider its investments in observations and observational enhancements, model improvements, data assimilation, and research in light of the most pressing needs for improved forecast information from the end user community. NOAA must embark on a new way of doing business by fully integrating the ocean observing communities with its weather, water, and climate programs in order to provide society with state-of-the-science actionable data, information, and services.

Why Now?

2020 set the new annual record of 22 billion-dollar weather and climate disaster events - shattering the previous annual record of 16 events that occurred in 2011 and 2017.¹ 2020 was the sixth consecutive year (2015-2020) in which 10 or more billion-dollar disaster events have impacted the United States. Many extreme events and the impacts they cause (e.g., billion-dollar disasters; see Figure 1) are the result of the warming climate system causing increased water vapor evaporating into the atmosphere; warmer oceans that fuel greater wind speeds; and rising seas that cause greater erosive forces of waves and currents.

Reducing the impacts of climate change, protecting the nation's ecosystems and economy, and ensuring our National security will increasingly rely on improved skill in forecasting weather; extreme weather events; and long-term shifts in weather, ocean, and sea-ice patterns. The World Climate Research Programme's *Grand Challenge on Weather and Climate Extremes* echoes the need for reliable predictions of extremes on time scales from days to seasons and centuries, and the urgent need for improved observing data in order to better identify the factors and mechanisms that determine the location, intensity, and frequency of various climate extremes including droughts, floods, heavy precipitation events, heat waves, cold spells, tropical and extratropical storms, coastal sea level surges and ocean.

Improving NOAA's ocean observations efforts will enhance the quality and value of NOAA's Earth system prediction by including more sources of predictability and, thus, predictive skill for the development of a seamless forecast system to meet decision making needs across timescales.²

¹ [2020. U.S. Billion-Dollar Weather and Climate Disasters](#)

² [World Climate Research Programme. Weather and Climate Extremes](#)

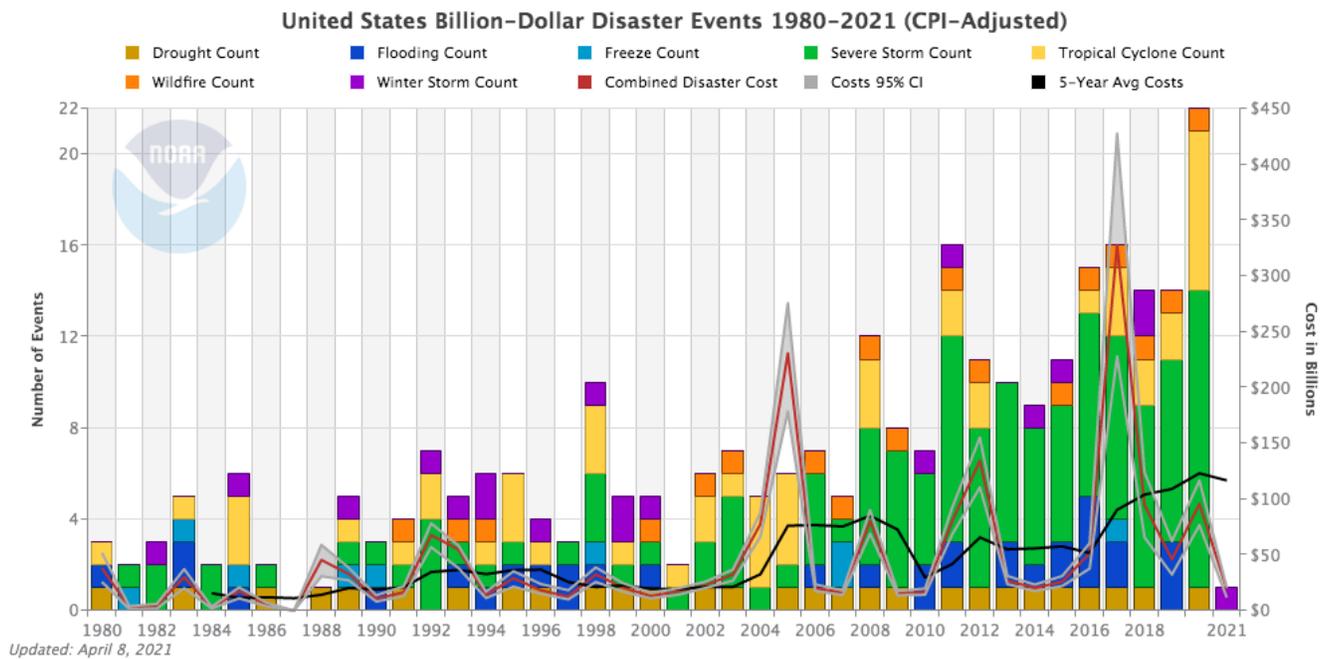


Figure 1. U.S. 2019 Billion-dollar Weather and Climate Disasters (1980-2021)³

Audience and purpose. This Strategic Vision should be co-developed with NOAA’s experts and leaders to create an overarching, integrated strategy for advancing critical weather, water, climate, and ocean science and services, which supports national climate adaptation and resilience. It is designed to bolster coordination across NOAA mission areas, programs, and service areas. It also acknowledges that, while budget realities and emerging needs are captured in Line Office annual guidance and operating plans, NOAA leaders should use this document to prioritize investments in improving ocean observations and integrating these data into numerical models to better address societal challenges related to Earth system prediction.

Legislative and Executive Mandates

This report is in alignment with the several mandates the Congress and the Executive Office of the President have established.

- **The Weather Research and Forecasting Innovation Act of 2017³** requires NOAA to collect and utilize information in order to make more usable, reliable, and timely foundational forecasts of subseasonal and seasonal temperature and precipitation.
- **National Integrated Drought Information System Reauthorization Act of 2006 (Reauth. 2018)**
 - The Earth Prediction Innovation Center (EPIC)⁴ will improve the global weather element of the Unified Forecast System (UFS) by extending infrastructure and user support for the UFS to a fully coupled Earth system prediction system to transform the operational suite of models critical to improving forecast skill beyond three weeks and addressing the full range of NOAA’s mission applications.
 - The Google Artificial Intelligence Prototyping Initiative resulted in a signed agreement with Google to explore the benefits of Artificial Intelligence and Machine Learning with the

³ [Weather Research and Forecasting Innovation Act of 2017](#)

⁴ [National Integrated Drought Information System Reauthorization Act of 2018 \(Public Law 115-423\)](#)

end goal to address large and diverse environmental data sets that advance capabilities in both weather prediction, environmental monitoring, research, and innovation.

- **The Geospatial Data Act (GDA) of 2018**⁵ promotes the organization, management, and coordinated use, sharing, and dissemination of geospatial data nationwide from the local, county, and state level to the national level, and supports the goal of creating a National Spatial Data Infrastructure to promote geospatial data sharing throughout the Federal Government, State, tribal, and local governments, and the private sector.
- **The Integrated Coastal and Ocean Observation System Act of 2009 (Reauth. 2020)** mandates the establishment of a national integrated system of ocean and coastal observing systems coordinated at the federal level.
- **Foundations for Evidence-Based Policymaking Act of 2019** directs NOAA to manage data (environmental, programmatic, financial, and administrative data, as well as documentation, code, and QA/QC information) as an asset, with the result being that all NOAA data default to open for use or reuse by the public without restriction, unless such sharing is expressly prohibited by other law and regulation.
- **The 2020 Executive Order on Tackling the Climate Crisis at Home and Abroad**⁶ mandates NOAA to tackle the climate crises, and resulting impacts, by prioritizing the mitigation of climate-related risks to make the Nation more resilient.
- **Coordinated Ocean Observations and Research Act of 2020**⁷ mandates NOAA conduct scientific assessments related to storms, including to: 1) seek public input before a Named Storm Event Model takes effect, and (2) allow NOAA to deploy sensors to areas in coastal states that are at the highest risk of experiencing geophysical events that would cause indeterminate losses.

Strategies and Initiatives

Several existing plans and strategies will be supported by implementing the objectives and outcomes listed in the Strategic Vision, including:

- Inter-agency
 - **Earth System Predictability Research And Development Strategic Framework And Roadmap**⁸ includes specific goals and objectives for improving Earth system prediction, including, but not limited to: 1) Reducing gaps in the observations-based characterization of conditions, processes, and phenomena crucial for understanding and using Earth system predictability; 2) integrating new observations, process understanding and emerging technologies to reduce model biases; and 3) accelerating the exploration and effective use of inherent Earth system predictability through advanced modeling; 4) expanding partnerships across disciplines and with external entities to accelerate progress; and training the next generation of interdisciplinary scientists.
 - **Interagency Council for Advancing Meteorological Services (ICAMS)**⁹ is the formal mechanism for Federal departments and agencies to coordinate implementation of policy and practices in meteorological services via an Earth system approach, including coordinating meteorological services encompassing weather, climate, hydrological,

⁵ [Geospatial Data Act of 2018](#)

⁶ [Executive Order on Tackling the Climate Crisis at Home and Abroad](#)

⁷ [Coordinated Ocean Observations and Research Act of 2020](#)

⁸ [Earth System Predictability Research And Development Strategic Framework And Roadmap](#)

⁹ [Interagency Council for Advancing Meteorological Services](#)

ocean, and related environmental services as well as coordinating all relevant land/air/ocean/space-based observation systems and associated data capabilities for meteorological research and services.

- Intra-agency
 - **NOAA's Earth Prediction Innovation Center Strategic Plan (EPIC)**¹⁰ The Integrating Ocean Observations Strategic Vision will support EPIC by: 1) Leveraging new environmental observational data that could contribute to existing and future weather models; 2) Increasing the accuracy of the initial state estimations and identify and quantify the uncertainties; 3) Incorporating JEDI tools; 4) Helping to extend useful forecast lead time & clarify uncertainties; 5) support fully-coupled modeling systems; 6) support community engagement; and 7) Aligning programs and funding opportunities.
 - **NOAA Precipitation Prediction Grand Challenge (PPGC)**¹¹ The Integrating Ocean Observations Strategic Vision will support the PPGC by: 1) improving Unified Forecast System (UFS) Precipitation Forecasts by addressing errors from initialization and model biases; 2) improving physics in coupled air-sea-land-ice models; 3) sustaining, enhancing, and exploiting observations; 4) improving process-level understanding and modeling; and 5) advancing the understanding of precipitation predictability.
 - **NOAA Climate and Fisheries Initiative (CFI)**¹² The Integrating Ocean Observations Strategic Vision will support the CFI by enhancing the observations needed to improve information on past, current, and future climate and ocean conditions to better prepare for, and respond to, climate impacts on marine and coastal resources
 - **NOAA's Science Advisory Board's Climate Working Group White Paper on Advancing Earth Systems Prediction.**¹³ The Integrating Ocean Observations Strategic Vision will address the recommendations to: 1) Target major gaps in the ocean observing system; 2) Ensure capability through robust observing system design projects and implement experiments to design networks of integrated observations and platforms; and 3) Work towards using an ensemble of predictions from a global model for stakeholder products.
 - **NOAA's Hurricane Forecast Improvement Program.** The Integrating Ocean Observations Strategic Vision will support this effort by closing gaps in ocean observations and co-located ocean-atmosphere observations; improving the assimilation of these observations into numerical models; improve model initialization; and improve coordination across NOAA's ocean and atmospheric communities.

¹⁰ [NOAA's Earth Prediction Innovation Center Strategic Plan \(2020-2025\)](#)

¹¹ [NOAA Precipitation Prediction Grand Challenge](#)

¹² [NOAA Climate and Fisheries Initiative](#)

¹³ [Advancing Earth Systems Prediction White Paper](#)

Objectives and Outcomes

By leveraging major progress in observations, understanding, and models from the last several decades, and by learning lessons from the past, NOAA must concurrently pursue five interdependent strategic objectives, which are equal in priority, and will result in a specific set of outcomes: 1) Strengthen and Sustain Coordination and Communication; 2) Align, Enhance, and Maintain Ocean Observations; 3) Centralize and Enhance Ocean Data Management; 4) Prioritize and Align End-to-End Funding; 5) Enhance Organizational Support. When implemented, these objectives will close gaps in ocean and co-located observations, advance understanding of predictability, improve process level understanding, and improve prediction systems to address the oceanic variability associated with predictability limits and prediction skill (see Figure 2).

These strategic objectives will be pursued in partnership with NOAA's external partners to ensure that every person and business in our Nation will benefit from enhanced Earth system prediction through improved and more accurate weather-water-climate-ocean data, tools, and information.



Figure 2. Integrating Ocean Observations Strategic Objectives

Objective 1.0 Strengthen and Sustain Coordination and Communication

Generating key ocean observations will not alone improve NOAA's Earth System Prediction; this challenge also requires improved data assimilation, modeling efforts, forecasting analysis, and delivery of services. Improved integration of ocean observations into numerical models confronts complex

challenges that require interdisciplinary approaches with coordinated and tailored solutions. NOAA's canonical weather, climate, and Earth system communities must be expanded to include NOAA's greater ocean observing community. Doing so will enhance engagement and communication efforts; better align priorities, efforts, and resources; reduce the duplication of effort; and deliver critical ocean data in a way that the weather, climate, and Earth system communities expect to utilize them.

Outcome 1.1 Communication and coordination across NOAA's value chain, scientific disciplines, readiness levels, and with external partners is continuously sustained to align priorities, opportunities, and efforts.

Outcome 1.2 External partners have access to key data sets, models, metrics, and data assimilation systems.

Objective 2.0 Align, Enhance, and Maintain Ocean Observations

Ocean observations have been increasingly acknowledged by the forecast community as a critical piece to improve Earth system prediction¹⁴ and their importance will continue to increase as extreme weather events increase with our changing climate². Closing gaps in NOAA's ocean observing system that captures sustained and targeted ocean observations, and coordinates co-located ocean-atmosphere observations, is key to correctly represent the ocean component in ocean-atmosphere coupled intensity models and improving forecasts across all timescales.

Maintaining, developing, and deploying observing systems to generate sustained and targeted, regionally-tailored ocean observations across the complex and rapidly changing ocean environments is not an easy task; doing so requires coordinated efforts that result in high-quality, timely, accurate, and authoritative observations. Aligning and coordinating observing strategies across NOAA's Line Offices and with external partners can work to systematically fill gaps in ocean observations that will improve Earth system prediction, the understanding of ocean processes, and address multiple cross-Line Office agency initiatives.

Outcome 2.1 Ocean observation systems are continuously coordinated and deployed using an evidence-based approach that supports the highest priority research and development (R&D) and operational needs, and results in a comprehensive ocean observing strategy.

Objective 3.0 Improve Ocean Data Management

Better managing current and future ocean observing data requires a unified approach for ocean data governance that will deliver greater benefits to the agency, our partners, and the Nation. Efficient data management is important to ensure observations that are: 1) encompassed from various platforms; 2) easily accessible; 3) available in real-time or near-real-time; 4) checked for quality assurance and quality control (QA/QC); and 5) compatible with standards and metrics.

A unified approach will dramatically accelerate the coordination and use of ocean observing data across Line Offices and with external partners; maximize openness and transparency; deliver the mission; and

¹⁴ <https://www.frontiersin.org/articles/10.3389/fmars.2019.00446/full#B38>

steward resources while protecting quality, integrity, security, privacy, and confidentiality. This approach requires open data management, which refers to providing authoritative, standardized data and metrics that are easily discoverable, accessible, usable, assimilated, and interoperable across different systems. Aligning capabilities across systems and platforms will require sustained communication and collaboration to deliver data in a way that users expect to utilize them.

This approach will also work to achieve better assimilation of key data into the models. Data assimilation is necessary to produce a high-resolution analysis using all available observations, to provide more realistic initial oceanic conditions that would lead to improvement of TC intensity forecast and tools to evaluate model guidance. A unified approach for data governance that includes a central repository for ocean observations will work to achieve better assimilation of key data into the models.

A unified approach for ocean data governance is aligned with the World Meteorological Organization's (WMO) data management efforts¹⁵; and NOAA's data management and governance efforts, including the NOAA Big Data Project¹⁶ and Earth Prediction Innovation Center (EPIC).

Outcome 3.1 A cloud-based oceans data lake provides a central, easy to access location to store, share, archive, and quality control raw observing data, as well as provide the standardized, QA/QC'd ocean observations transmitted to Earth system models or disclaimers on experimental data.

Outcome 3.2 Data assimilation systems are enhanced using evidence-based criteria to improve the assimilation of data into numerical models and to demonstrate the impact of ocean observations.

Outcome 3.3 Ocean data and information services are useful, usable, and used.

Objective 4.0 Prioritize and Align End-to-End Funding

Developing, improving, maintaining, and deploying observing platforms; building capacity; and assimilating and analyzing ocean data all require a strategic approach to efficiently leverage, fund, and align resources and efforts. Funding for improving forecast skill and/or ocean observations needs to move from being focused on research or operations to an aligned process that details the complete end-to-end process and value chain, including service delivery, decision support, observations, modeling, and research and development. Aligning funding opportunities between Line Offices and leveraging the expertise of external partners allows multiple research, observations, and stakeholder needs to be addressed.

This holistic approach is a required step toward defining the priorities and resources needed to lead NOAA into a future wherein a comprehensive suite of ocean and atmospheric observations are delivered and assimilated into cutting-edge numerical models to deliver state-of-the-art Earth system prediction and operational oceanography forecasts. This approach is crucial to rapidly address and respond to the changing ocean conditions and climate resulting in increasingly frequent and intense tropical cyclones to better save lives and property.

¹⁵ [WMO Data Sources for Lakes](#)

¹⁶ [NOAA Big Data Project](#)

Outcome 4.1 End-to-end funding is prioritized in annual and multi-year budgets to enhance and accelerate improvements in Earth system science and prediction to save lives, protect property and increase coastal resilience.

Outcome 4.2 Funding opportunities are aligned to meet intra- and inter-Line Office and cross-agency goals and objectives and incentivize engagement, collaboration, and innovation.

Objective 5.0 Enhance Organizational Support

As the need for deployed observing systems and enhanced data assimilation has increased, so too has the need for the support and capacity required to maintain coordination efforts across the ocean observation and hurricane communities. Sufficient organizational support is required to facilitate cross-Line Office and cross-organization coordination efforts, including maintaining interactive and sustained communication and engagement efforts; informing place-based, sector-based decisions; capturing and implementing best practices; defining the approaches for how and when different observational systems are applied; enhancing data assimilation; and analyzing the impacts of ocean observations on hurricane forecasts. Enhancing organization support allows for the wider adoption of new collaborations, improved data standardization, increased efficiency for the transitions of emerging technologies, and improved reproducibility of data collection for the increased utility of observations to a diversifying set of stakeholders.

Beyond the organizational support needed to facilitate and maintain coordinated and collaborative efforts across Line Offices and with external partners, a workforce that is ready to engage now as well as replace researchers and operators in the future is needed. In order for the ocean observation and hurricane communities to grow, training efforts are needed to integrate individuals at all levels of experience and expertise.

Outcome 5.1 Lessons learned are continuously documented, reviewed, and implemented across NOAA's value chain as they relate to integrating ocean observations to improve hurricane forecasting.

Outcome 5.2 The appropriate, diverse, inclusive, and prepared capacity is available to coordinate observation efforts, assimilate data, analyze impacts, and implement best practice.

Appendix A. Acronyms

ACRONYM	DEFINITION
AOML	Atlantic Oceanographic and Meteorological Laboratory
DA	Data Assimilation
DAC	Data Assembly Center
EEOOTT	Extreme Events-Ocean Observations Task Team
EPIC	Earth Prediction Innovation Center
FAIR	Find, Access, Interoperate, and Reuse
GOMO	Global Ocean Monitoring and Observing
HFIP	Hurricane Forecast Improvement Program
IFC	Integrated Field Campaign
IOOS	Integrated Ocean Observing System
JEDI	Joint Effort for Data Assimilation Integration
NOAA	National Oceanic and Atmospheric Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NOS	National Ocean Service
NWS	National Weather Service
OAR	Oceanic and Atmospheric Research
OMAO	Office of Marine and Aviation Operations
OSE	Observing System Experiments
OSSE	Observing System Simulation Experiments
PPGC	Precipitation Prediction Grand Challenge
QA/QC	Quality assurance and quality control
RTOFS	Real Time Ocean Forecast System
TC	Tropical Cyclone
UFS	Unified Forecast System
WMO	World Meteorological Organization

Appendix B. Supporting Materials

Internal NOAA Materials

- B1. [NOAA Hurricane Forecast Improvement Program \(HFIP\) Strategic Plan](#)
- B2. [National Weather Service Weather Ready Nation Strategic Plan 2019-2022](#)
- B3. [NOAA Administrative Order 212-15: Management Of Environmental Data and Information](#)
- B4. [The FAIR Guiding Principles for Scientific Data Management and Stewardship](#)
- B5. [NOAA's Economic Valuation Guide 2021](#)
- B6. [NOAA Hurricane Forecast Improvement Program Five-Year Plan \(2019-2024\)](#)
- B7. [NOAA's Earth Prediction Innovation Center Strategic Plan \(2020-2025\)](#)
- B8. [NOAA Precipitation Prediction Grand Challenge](#)
- B9. [NOAA Climate and Fisheries Initiative Strategy](#)
- B10. [FY2022 OSTP R&D Priorities Memo](#)
- B11. [OSTP Earth System Predictability Strategic Framework and Roadmap](#)
- B12. [Service Delivery Framework and Implementation Plan](#)
- B13. [NOAA's Policy on Partnerships in the Provision of Environmental Information](#)
- B14. [NOAA's Ocean Acidification Research Plan](#)
- B15. [Workshop Crosswalk with NOAA Line Offices and Programs](#)

External Materials

- B16. [Geospatial Data Act of 2018](#)
- B17. [The Weather Research and Forecasting Innovation Act of 2017](#)
- B18. [National Integrated Drought Information System Reauthorization Act of 2018 \(Public Law 115-423\)](#)
- B19. [Coordinated Ocean Observations and Research Act of 2020](#)
- B20. [Executive Order on Tackling the Climate Crisis at Home and Abroad](#)
- B21. [Coordinated Ocean Observations and Research Act of 2020](#)
- B22. [Foundations for Evidence-Based Policymaking Act of 2018](#)

Appendix C. Crosswalk of Line Office Priorities

	Integrating Ocean Observations: A Strategic Vision to Benefit NOAA's Earth System Modeling and Predictions									
	Objective 1. Strengthen and Sustain Coordination and Communication		Objective 2. Align, Enhance, and Maintain Ocean Observations	Objective 3. Improve Data Management			Objective 4. Prioritize and Align End-to-End Funding		Objective 5. Enhance Organizational Support	
	Outcome 1.1 Communication and coordination across NOAA's value chain, disciplines and readiness levels, and with external partners is continuously sustained to align priorities, opportunities, and efforts	Outcome 1.2 External partners have access to key data sets, models, metrics, and data assimilation systems	Outcome 2.1 Ocean observation systems are continuously coordinated and deployed using an evidence-based approach that supports the highest priority research and development (R&D) and operational needs, and results in a comprehensive ocean observing strategy	Outcome 3.1 A cloud-based oceans data lake provides a central, easy to access location to store, share, archive, and quality control raw observing data, as well as provide the standardized, QA/QC'd ocean observations transmitted to Earth system models or disclaimers on experimental data	Outcome 3.2 Data assimilation systems are enhanced using evidence-based criteria to improve the assimilation of data into numerical models and to demonstrate the impact of ocean observations	Outcome 3.3 Ocean data and information services are useful, usable, and used.	Outcome 4.1 End-to-end funding is prioritized in annual and multi-year budgets to enhance and accelerate improvements in Earth system science and prediction to save lives, protect property and increase coastal resilience	Outcome 4.2 Funding opportunities are aligned to meet intra- and inter-Line Office and cross-agency goals and objectives and incentivize engagement, collaboration, and innovation	Outcome 5.1 Lessons learned are continuously documented, reviewed, and implemented across NOAA's value chain as they relate to integrating ocean observations to improve hurricane forecasting.	Outcome 5.2 The appropriate, diverse, inclusive, and prepared capacity is available to coordinate observation efforts, assimilate data, analyze impacts, and implement best practices.
NOS										
IOOS	X	X	X	X	X	X	X	X	X	X
COMT		X			X	X				
OAR										
GOMO	X	X	X	X	X	X	X	X	X	X
AOML	X	X	X	X	X	X	X	X	X	X
GFDL	X				X	X		X	X	
PSL					X	X			X	X
PMEL		X	X	X					X	X
WPO										
NWS										
NHC	X							X	X	
EMC	X		X		X	X		X	X	
OPC	X		X			X			X	
STI	X		X	X		X	X	X		
Dissemination	X			X		X	X	X		
NWS Observations Portfolio	X		X	X		X	X	X		
Cooperative Institutes										
CIMES										
CIMAS	X	X	X	X	X					
CINAR		X	X		X					
CIMEAS	X		X	X						
OMAO										
	X		X		X	X				
NESDIS										
						X				

Appendix D. Crosswalk of Intra-Agency Efforts

	Integrating Ocean Observations: A Strategic Vision to Benefit NOAA's Earth System Modeling and Predictions									
	Objective 1. Strengthen and Sustain Coordination and Communication		Objective 2. Align, Enhance, and Maintain Ocean Observations	Objective 3. Improve Data Management			Objective 4. Prioritize and Align End-to-End Funding		Objective 5. Enhance Organizational Support	
	Outcome 1.1 Communication and coordination across NOAA's value chain, disciplines and readiness levels, and with external partners is continuously sustained to align priorities, opportunities, and efforts	Outcome 1.2 External partners have access to key data sets, models, metrics, and data assimilation systems	Outcome 2.1 Ocean observation systems are continuously coordinated and deployed using an evidence-based approach that supports the highest priority research and development (R&D) and operational needs, and results in a comprehensive ocean observing strategy	Outcome 3.1 A cloud-based oceans data lake provides a central, easy to access location to store, share, archive, and quality control raw observing data, as well as provide the standardized, QA/QC'd ocean observations transmitted to Earth system models or disclaimers on experimental data	Outcome 3.2 Data assimilation systems are enhanced using evidence-based criteria to improve the assimilation of data into numerical models and to demonstrate the impact of ocean observations	Outcome 3.3 Ocean data and information services are useful, usable, and used.	Outcome 4.1 End-to-end funding is prioritized in annual and multi-year budgets to enhance and accelerate improvements in Earth system science and prediction to save lives, protect property and increase coastal resilience	Outcome 4.2 Funding opportunities are aligned to meet intra- and inter-Line Office and cross-agency goals and objectives and incentivize engagement, collaboration, and innovation	Outcome 5.1 Lessons learned are continuously documented, reviewed, and implemented across NOAA's value chain as they relate to integrating ocean observations to improve hurricane forecasting.	Outcome 5.2 The appropriate, diverse, inclusive, and prepared capacity is available to coordinate observation efforts, assimilate data, analyze impacts, and implement best practices.
Precipitation Prediction Grand Challenge										
Objective 1. Enhance and sustain user engagement										
Objective 2. Improve precipitation prediction products and applications										
Objective 3. Improve prediction systems for precipitation		x	x		x					x
Objective 4. Sustain, enhance, and exploit observations	x		x	x	x					x
Objective 5. Improve process-level understanding and modeling			x							
Objective 6. Advance understanding of precipitation predictability			x							
IOOS-OAR Workshops										
Hurricanes	x	x	x	x	x					
Cloud Computing				x						x
Technology Development and Transitions			x	x						
Climate Fisheries Initiative										
Action // Enhance the utility of existing climate information	x		x	x						
Action // Advance NOAA's regional modeling system										
Action // Establish regional teams and a national community of practice										
Action // Fuel innovation and applications through targeted research										
WWC Strategy (2022-2026)										
4.1 Service delivery										x
4.2 Decision support	x									x
4.3 Modeling and prediction	x		x	x	x			x		x
4.4 Research and development	x		x	x	x			x		x
4.5 Observations	x		x	x	x			x		x
EPIC Strategic Plan										
3.1 Accurate and reliable operational models	x	x	x	x	x			x		
3.2 Community contributions to operational modeling systems	x	x		x	x					
3.3 Community engagement	x	x						x	x	x