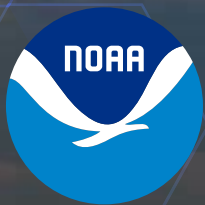# GLOBAL SYSTEMS LABORATORY

2021-2031 Strategic Plan

Jennifer Mahoney
Director
Global Systems Laboratory

Message from the GSL Director

As one of NOAA's premier research laboratories, the Global Systems Laboratory (GSL) has a history of successfully transitioning atmospheric research into advanced products and services for weather operations. GSL is part of the National Oceanic and Atmospheric Administration's (NOAA) Office of Oceanic and Atmospheric Research (OAR) within the U.S. Department of Commerce. GSL has five divisions that focus on advanced technologies, decision support services, model development, innovative data assimilation and verification techniques, and high-performance computing.

NOAA's long-term goal of a "Weather-Ready Nation" drives GSL's preeminent weather research and development portfolio. Our tagline is 'forecast systems that deliver solutions." GSL delivers innovative research to provide the NOAA National Weather Service (NWS) and the public with increasingly accurate, rapidly updating environmental models to save lives and property. GSL's work to develop state-of-the-art decision support and data-delivery tools helps inform the public so they are more resilient to high-impact weather. Finally, GSL's cutting-edge visualization systems and high-performance computing technology supports a vibrant economy and leads the environmental science community.

This 10-year strategic plan aims to maintain agility in a changing research landscape. GSL's core competencies, expertise, and mission align with DOC, NOAA, and OAR objectives and support Congress's Weather Research and Forecasting Innovation Act of 2017 and the National Integrated Drought Information System Reauthorization Act of 2018. GSL prizes its strong relationships with forecasters, the aviation community, university research partners, other NOAA organizations, the private sector, and its Cooperative Institute partners (CIRES and CIRA) in accomplishing its mission. This plan seeks to build upon these relationships and engage in new collaborations.

GSL's powerful team has a legacy of delivering ground-breaking research that has revolutionized weather operations. This plan aspires to develop and empower our future leaders by committing to diversity, inclusiveness, excellence, and integrity to transform NOAA's future in world-class science. This next generation of scientists will be critical in leveraging new technology to prioritize mission-relevant research to serve both local, national, and global communities.

Jennifer Mahoney
Director
Global Systems Laboratory

GSL is working to improve forecasts of how much precipitation will fall during a rain event. This photo was taken dby the Texas National Guard after flooding in Houston caused by Hurricane Harvey.

Introduction

Every year millions of Americans are in danger from extreme weather and water events. The Nation endures destructive and deadly hurricanes and tornadoes, devastating floods, droughts, wildfires, and powerful winter storms, causing billions in damage. In 2020, there were 22 weather/climate disaster events with losses exceeding $1 billion each, setting a new annual record for disasters affecting the United States. These events resulted in the deaths of 262 people with an overall cost of $95 billion, having significant economic effects on the areas impacted. NOAA must be prepared to respond to these extreme events with the world's best Earth-system models and the most robust observational systems. (NOAA Business Brief, April 2019).

As one of NOAA's premier research laboratories, the Global Systems Laboratory (GSL) enables operational weather forecasters to produce the best forecasts using state-of-the-art technology that incorporates the latest science. GSL has a history of successfully transitioning research into advanced products and services for operations. GSL values its strong relationships with the following organizations:
- National Weather Service (NWS) researchers and forecasters
- NOAA Research laboratories
- NOAA National Centers for Environmental Prediction
- Federal Aviation Administration (FAA)
- National Center for Atmospheric Research (NCAR)
- University of Colorado and the Cooperative Institute for Research in Environmental Sciences (CIRES)
- Colorado State University and the Cooperative Institute for Research in the Atmosphere (CIRA)
- Joint Center for Satellite Data Assimilation (JCSDA)
- NOAA testbeds: Developmental Testbed Center (DTC), Hazardous Weather Testbed (HWT), and Hydrometeorology Testbed (HMT)
- Private sector

Statutory Authority

GSL is aligned under Weather Research and Forecasting Innovation Act of 2017 15 U.S.C. § 8501, air chemistry and air quality research: Clean Air Act as amended, 42 U.S.C. §§ 7401-7431, Tsunami Warning, Education, and Research Act of 2017, Title V, 33 U.S.C. § 3201 note, NOAA's Weather-Ready Nation goal, and the NOAA Ocean and Atmospheric Science Education Program (33 USC 893a).

GSL's research specifically addresses several objectives of this guidance:
- Reduce loss of life, property, and disruption from high-impact events
- Improve transportation efficiency and safety

GSL researchers work with NWS forecasters to test new technologies that will help streamline the forecast process and get the right information to decision-makers. Photo Credit: James Murnan.

- Improve freshwater resource management
- Create a more productive and efficient economy through environmental information relevant to key sectors of the U.S. economy
- Advance air and water quality services to the public
- Improve public literacy in Science, Technology, Engineering, and Math (STEM)

GSL is also excited to partner with the upcoming Earth Prediction Innovation Center (EPIC) to fulfill the authorization in the National Integrated Drought Information System Reauthorization Act of 2018 (Public Law (P.L.) 115-423) to improve the transition of research into operations by creating a community global weather research modeling system.

GSL is aligned with the following organizational goals:
- DOC: Evolve the NWS to deliver better weather forecasts
- NOAA: Implement the Weather Act and Accelerate Research to Operations (R2O)
- OAR: Make Forecasts Better

GSL Vision, Mission, and Values
The vision and mission of GSL encapsulates the transition of its research and development into operations, applications, and commercialization reducing societal impacts from hazardous weather and other environmental phenomena.
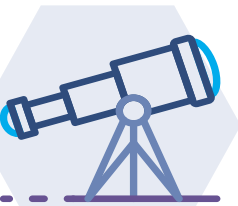
Vision:
Forecast systems that deliver solutions

Mission: Lead research and directed development through the transition of environmental data, models, products, tools, and services to support commerce, protect life and property and promote a scientifically literate public.

Science Driven

Public Service

Diversity & Inclusion

Excellence

Innovation

Integrity

Agility

Our Values

GSL Core Values:
- Science-Driven - stewards of science
- Diversity - committed to creating a diverse workforce
- Innovation - encouraging new ideas, creativity, and future vision
- Inclusion - interacting and collaborating with others to achieve our shared goals
- Public Service - responsive to the public and society for the greater good
- Agility - ability, and willingness to change as conditions and requirements change
- Excellence - striving to be the best at what we do in our research and public service
- Integrity - Adhering to moral and ethical principles

GSL Grand Scientific Challenge
A common scientific challenge has been established to align priorities and funding and accelerate scientific progress toward NOAA and OAR's strategic goals.

Provide actionable environmental information through the research and development of rapidly-updating global storm-scale prediction and innovative decision support capabilities to reduce so hazardous weather and other environmental phenomena.

GSL staff in front of the David Skaggs Research Center in Boulder, Colorado.

GSL Strategic Goals

Three primary goals form the foundational elements required to achieve the scientific challenge and will be used to guide GSL's decisions, priorities, and actions. Many of these goals and objectives directly align with NOAA's Research and Development Strategic Plan 2020-2026 and NOAA's Strategic Plan for Diversity, Equality, and Inclusion (2020).

Goal 1. Invest in people, partnerships, and organizational performance.

Objective 1.1. Balance portfolio funding toward long-term research and short-term development.
- Align funding to the GSL mission-relevant priorities.
- Increase investment in long-term research while maintaining our reputation as the leader for short-term applied research and development.
- Foster risk tolerance and agility by accepting failure as part of the scientific innovation process.

Objective 1.2. Build collaboration across the laboratory.
- Leverage the talent, innovation, and collaborative nature of our scientists, engineers, and administrators.
- Establish and maintain transparent processes.
- Improve efficiency in all functions to effectively perform the scientific, information technology, and administrative duties.

Objective 1.3. Champion a healthy organizational environment.
- Pursue gender and racial diversity in our hiring and business practices internally and with our partners.
- Promote belonging and inclusion in all aspects and levels of the organization.
- Foster anti-racist practices including opposing racism and promoting racial tolerance.
- Increase communications to diverse audiences.

GSL's Evergreen Group works to strengthen GSL and support the Senior Leadership Team through coordination, communication, and activities that nurture current and future leaders, and promote a transparent, collaborative, and inclusive environment.

Objective 1.4. Develop plans for career growth and succession of employees.
- Identify and develop future leaders to ensure long-term success of the laboratory.
- Offer opportunities to grow at the early career level
- Balance our federal and non-federal staff for sustained development and long-term growth.
- Invest time and resources to provide more educational experiences to undergraduate, graduate, and postdoctoral associates.

Objective 1.5. Modernize the Information Technology infrastructure.
- Improve and maintain reliable and resilient IT services for traditional and high-performance computing architectures.
- Focus on energy-efficient, reliable, cost-effective, and sustainable data center services.
- Investigate cutting-edge technologies leading to future IT improvements that accelerate the development and transition of technologies.

Objective 1.6. Nurture, develop and expand strategic partnerships.
- Intentionally evaluate current partnerships and foster new partnership that align with GSL strategic goals.
- Facilitate new relationships and fortify existing partnerships to deliver and transition research.
- Partner with the broader weather research community (i.e., DTC, HWT, JCSDA, UFS, and EPIC) to deliver excellent science, services, and tools.

Goal 2. Develop state-of-the-art Earth-system prediction capabilities.

Objective 2.1. Advance data assimilation concepts and techniques.
- Advance the understanding of data assimilation methods and concepts aimed at improving the representation of convective scales.
- Develop and incorporate advanced data assimilation techniques and increase the exploitation of new observation datasets (e.g. satellite data) to improve predictive capabilities.
- Apply artificial intelligence to identify and correct model and observation errors and increase computational efficiencies.
- Contribute to community-based data assimilation systems (i.e., Joint Effort for Data assimilation Integration (JEDI).
- Explore how exascale computing systems could efficiently assimilate vast amounts of observations into coupled data assimilation systems.

Incident command meteorologists use GSL-developed weather and smoke models to direct fire-fighting operations. This photo of a Wyoming wildfire was taken by Liam Trooien Smith, a wildland fire fighter.

Objective 2.2. Advance research of physical and atmospheric composition processes in Earth-system models that affect such things as air quality, human health, and weather systems.

- Research, develop, and validate algorithms that best represent physical and atmospheric composition processes.
- Develop parameterizations and physics-dynamics interfaces.
- Represent uncertainty in parameterizations.
- Advance common community capabilities enabling the advancement of new physics and atmospheric composition schemes within the Unified Forecast System (UFS).

Objective 2.3. Research and develop short-range to subseasonal prediction capabilities.

- Advance the UFS to enable rapidly-updating forecasts of weather at storm-scale resolutions from regional to global domains.
- Research and advance techniques that couple the atmosphere, land surface, hydrology, ocean, and sea ice predictions.
- Research and develop stochastic methods and ensemble techniques to better represent forecast uncertainty.
- Integrate dynamical and data-driven approaches exploiting artificial intelligence and machine learning techniques.

Objective 2.4. Develop leading-edge forecast verification and validation techniques and tools.

- Develop and advance verification techniques and metrics for impact-based and meteorological assessments and other applications.
- Assess the quality of forecasts to identify strengths and weaknesses.
- Develop verification tools and technologies using the latest database and web-based technologies for assessing forecast quality and accuracy.

Objective 2.5. Develop next-generation Earth-system models in concert with advances in high-performance computing technologies.

- Design and develop modeling systems that incorporate high-fidelity numerics and physics, high-performance accelerated computing, and modern software engineering practices.
- Advance the science and utilization of cloud computing, GPUs and other computing technologies to accelerate scientific advances and innovations.
- Advance and integrate artificial intelligence analytics to accelerate the development of Earth-system predictions.
- Evaluate new algorithms and techniques based on numerical accuracy and computational efficiency, incorporating well-defined software processes.

Weather is the most common reason for air traffic delays. GSL is working to provide accurate and meaningful weather information to pinpoint conditions that may impact air traffic flow. Photo Credit: Susan Cobb.

Goal 3. Revolutionize communications, products, and services to enable informed decision-making.

Objective 3.1. Improve ways to discover, distill, store, and provide access to diverse, high-volume environmental data and observations.
- Explore emerging technologies that provide quality observations with more efficiency and timeliness.
- Advance Big Data concepts and develop methods to improve interoperability and synchronization of data and information across large datasets to promote innovation, utility and accessibility.
- Develop cost-effective and efficient ways to process and analyze large datasets.
- Develop techniques that translate data into meaningful information.

Objective 3.2. Develop applications with improved analysis, visualization, verification, and decision support capabilities for the NWS and other entities.
- Develop innovative visualization and information systems to advance decision and education tools.
- Advance the technologies of NWS forecast systems.
- Improve and enhance the utility of weather products and services (e.g. aviation and space weather, fire weather, convective weather, clean energy products etc.).
- Develop new tools that translate weather parameters into user-specific information and impacts.
- Explore platforms that allow community collaboration, involvement, and testing.

Objective 3.3. Research and develop techniques to improve understanding and effectively communicate weather impacts to educate society.
- Research the relationships between the state of the global climate and how changes are affecting local weather extremes (i.e. fires), environmental hazards (i.e. space weather), renewable energy, water availability, etc and associated societal impacts.
- Advance understanding of decision-making needs, capacity, and use of weather, water, climate, and space weather information.
- Advance understanding of forecaster operational decision environment to optimize usability of new modeling tools and technologies.
- Incorporate predictive analytics, social science technologies, and automation to combine forecast information with impact information.
- Research and develop new tools, technologies, and communication approaches and evaluate technologies in community-based testbed experiments.
- Continue to partner with educational institutions to increase understanding of NOAA-related science.

GSL evaluated the performance of winter weather forecast ensembles for snow at Denver International Airport and similar Mountain West airports. Photo Credit: Susan Cobb, NOAA GSL

Objective 3.4. Ensure that investments improve the skill, efficiency, and delivery of products, tools, and applications to operations

- Establish a set of metrics that measure the skill of models and products delivered to operations.
- Establish a process for tracking, prioritizing, and supporting the R2O process utilizing transition plans and the NOAA Research and Development Database (NRDD).
- Develop metrics to measure GSL's progress toward its Grand Scientific Challenge.
- Measure the economic benefits of GSL products and services.
- Insure investments are informed by social, behavioral, and user experience research to provide the best and most relevant environmental data, information, and displays.

Evaluation of GSL's progress toward its goals

The logic model to the right will provide a framework for evaluating GSL's progress toward its goals.

GSL will leverage the existing mechanisms to track progress toward its scientific goals and strategic objectives.

Planning
- Strategic Plan
- Implementation Plan
- Annual Operating Plan
- Budget plan
- Staff plan

Monitoring
- GSL project status summary
- NOAA R&D Database
- User feedback

Evaluating
- 5-Year Laboratory Review
- Economic benefit studies and forecast evaluations
- GSL-specific metrics

Reporting
- GSL Annual Science Report
- GSL Transitioned Projects table
- Economic benefit and forecast evaluation studies
- NOAA bibliometrics reports