GSL - Forecast Systems that Provide Solutions

Organizational Excellence and Information Technology
GSL Organizational Structure

- Decision Support
- Earth System Prediction
- Advanced Technologies
- IT Foundation

Organizational Excellence

- Efficient Administration
- Empowered Workforce
- Diversity and Inclusion
- Strategic Investments
- Science Driven

B6.1, B6.8
Evaluation Criteria: Quality

Indicators ensuring that GSL is performing high-quality work now and into the future and progressing toward OAR’s goal to conduct preeminent research.
GSL DELIVERS SCIENCE BY THE NUMBERS

42 Average publications/yr
69 Research Projects
7755 Citations of publications by GSL since 2008
155 Research to Operations Transitions
3992 BUC, BAP, and HSSR citations since 2002
550 Science On a Sphere® datasets
71M Weather observations processed each day
2.9M Weather observations processed each hour
750,000 Automated commercial aircraft observations processed each day

Delivering Science
Transitions, Consumers, and Impacts

Assessments
- Supports informed decisions
- Makes models more accurate

Physics Packages
Accelerates model development

Weather and Air Chemistry Models
- Air quality
- Severe weather
- Flooding

Model Evaluation Tools
Accelerates model development
Transitions, Consumers, and Impacts

Data Processing
- MADIS
- AQP1

Science Literacy
Reaching millions
- Science On a Sphere®
- Science on a Sphere Explorer
- Science On a Sphere Explorer Mobile

Software Infrastructure
Efficient processing and computation
Optimize compute power
Major Awards

International
- Haagen-Smit Outstanding Paper Prize
- Certificate of Appreciation
- Certificate of Appreciation

National
- Charles L. Mitchell Weather Analysis and Forecasting Committee Early Career
- 490C Bronze Medals Given by NOAA
- Distinguished Career 2 Employee of the Year Employee of the Month
- NOAA Research Outstanding Scientific Paper
- Technology Transfer
GSL Service

National and International Societies
Collaborations

<table>
<thead>
<tr>
<th>Primary Collaborations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA Research Laboratories</td>
</tr>
<tr>
<td>National Weather Service</td>
</tr>
<tr>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>Department of Energy</td>
</tr>
<tr>
<td>Joint Center for Satellite Data Assimilation</td>
</tr>
<tr>
<td>NOAA’s Office of Education</td>
</tr>
<tr>
<td>Earth Prediction Innovation Center (EPIC)</td>
</tr>
<tr>
<td>Interagency Council for Advancing Meteorological Services (ICAMS)</td>
</tr>
<tr>
<td>Developmental Testbed Center (DTC)</td>
</tr>
<tr>
<td>Cooperative Institutes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Collaborations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA Line Offices and Programs</td>
</tr>
<tr>
<td>13 International Government Agencies</td>
</tr>
<tr>
<td>13 International Private Companies</td>
</tr>
<tr>
<td>3 International Non-Profit Organizations</td>
</tr>
<tr>
<td>18 U.S. Government Organizations</td>
</tr>
<tr>
<td>40 State Government Organizations</td>
</tr>
<tr>
<td>18 Universities</td>
</tr>
<tr>
<td>18 U.S. Private Companies</td>
</tr>
<tr>
<td>472 MADIS Data Providers</td>
</tr>
<tr>
<td>3 U.S. Non-Profit Organizations</td>
</tr>
<tr>
<td>215 Science On a Sphere® Installations</td>
</tr>
</tbody>
</table>
Recognition from Customers

Jeff McQueen, Air Quality Modeling Team leader for the NWS “It was kind of revolutionary the first time we saw smoke forecasts at that resolution”

NWS Charleston, SC: "Software developed by GSL is always nothing short of outstanding. Having been a NWS forecaster for 18 years and dealing with the software side of things for more than 12 years, I can say unequivocally that GSL software is the gold standard.”

“I personally, while on shift, have seen the HRRR performing head over heels better than other models most of the time.”

“The Global Systems Laboratory’s development of foundational and pragmatic state-of-the-science technologies to improve predictions of weather and its impacts on society has been one of the nation’s true success stories that is significantly under-appreciated given the enormous value it returns to the nation.”

Peter Neilley, The Weather Company
NOAA Global Systems Laboratory

Evaluation Criteria: Relevance

Indicators describing the degree to which GSL’s research and development is relevant to NOAA’s mission and of value to the Nation
### 2017: Weather Research and Forecasting Innovation Act

Prioritize weather research to improve weather data, modeling, computing, forecasts, and warnings for the protection of life and property and the enhancement of the national economy.

- Earth System Modeling
- High-Resolution Weather Modeling
- Decision Support Systems
- High-Performance Computing

### 2018: National Integrated Drought Information System Act

Carry out weather and air chemistry research programs, advance weather modeling skill, reclaim and maintain international leadership in the area of numerical weather prediction, and create a community global weather research modeling system that is accessible by the public.

- Earth System Innovation Center (EPIC)
- Air Chemistry Modeling
- Unified Forecast Systems

### 2020: Floods Act

Requires NOAA to evaluate and improve flood watches and warnings and communication of information to support preparation and responses to floods.

- High-Resolution Weather Modeling
- Automated Quantitative Precipitation Information System
- Decision Support Systems

### 2021: Clean Future Act

Improve public health, resilience, and environmental outcomes.

- Air Chemistry Modeling
- Atmospheric Science for Renewable Energy
### Alignment with DOC/NOAA/OAR Goals

#### DOC’s Strategic Objectives

<table>
<thead>
<tr>
<th>DOC’s Strategic Objectives</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Expand Commercial Space Activities</td>
<td><strong>Advance Innovation</strong></td>
</tr>
<tr>
<td>Increase Aquaculture Production</td>
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<tr>
<td>Reduce and Streamline Regulations</td>
<td>Reduce and Streamline Regulations</td>
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<tr>
<td>Strengthen Domestic Commerce</td>
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<tr>
<td>Enhance the Nations Cyber-security</td>
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<tr>
<td><strong>Reduce Extreme Weather Impacts</strong></td>
<td><strong>Reduce Extreme Weather Impacts</strong></td>
</tr>
<tr>
<td>Provide accurate Data to Support Economic Activity</td>
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</tr>
<tr>
<td>Engage Commerce Employees</td>
<td>Engage Commerce Employees</td>
</tr>
<tr>
<td>Accelerate Information Technology Modernization</td>
<td>Accelerate Information Technology Modernization</td>
</tr>
<tr>
<td>Consolidate Functions for Cost Savings</td>
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</tbody>
</table>

#### NOAA Research and Development Priorities (2020-2026)

<table>
<thead>
<tr>
<th>NOAA Research and Development Priorities (2020-2026)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Reducing societal impacts from hazardous weather and other environmental phenomena</td>
<td>Sustainable use and stewardship of ocean and coastal resources</td>
</tr>
<tr>
<td><strong>A robust and effective research, development, and transition enterprise</strong></td>
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</table>

#### OAR’s Strategic Goals

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Drive Innovative Science</td>
<td>Make forecasts better</td>
</tr>
<tr>
<td>Make forecasts better</td>
<td>Detect Changes in the Ocean and Atmosphere</td>
</tr>
<tr>
<td>Detect Changes in the Ocean and Atmosphere</td>
<td>Explore the Marine Environment</td>
</tr>
</tbody>
</table>

#### Global Systems Laboratory Strategic Goals

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<tr>
<th>Global Systems Laboratory Strategic Goals</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Develop state-of-the-art Earth-system prediction capabilities</td>
<td>Revolutionize the communication of weather information and impacts to consumers</td>
</tr>
<tr>
<td>Revolutionize the communication of weather information and impacts to consumers</td>
<td>Invest in people, partnerships, and organizational performance</td>
</tr>
</tbody>
</table>

| 14 | 14 |
NOAA Science and Technology Strategies
The Impacts of GSL’s Research

Advancing the tools in NWS Offices

GSL-developed technology helps the NOAA National Weather Service and emergency managers quickly respond to weather threats.

Making Forecasts Better

Increasingly accurate wind and precipitation forecasts are improving agriculture production and managing wildfires.
The Impact of GSL’s Research

Supporting the U.S Economy
GSL provides weather prediction modeling systems that improve weather services and provide a benefit of $41B to the American public each year.

Improving Energy Forecasts
GSL provides increasingly accurate weather forecasts to improve the stability of our power grid.

Improving Aircraft Safety
The HRRR is the foundation for FAA weather products and is helping to reduce weather aviation flight delays that cost air travelers billions of dollars each year.
The Impacts of GSL’s Research

**Advancing HPC Science**
GSL researches and hosts efficient high-performance computing to support NOAA’s mission.

**Promoting a Scientifically Literate Society**
GSL technology encourages learning and discovery for a science-literate society.

**Improving Public Air Quality Forecasts**
Increasingly accurate wind, smoke, and precipitation forecasts are essential for managing wildfire operations and alerting the public to air quality hazards.
Community Engagement

GSL hosts:
- Forecaster Assessments
- Model training
- Model tutorials on YouTube
Community Engagement: Testbeds

Hazardous Weather Testbed
- Experimental Warning Program
- End Users Experiments
- Threats-in-Motion tests
- Probabilistic Hazard Information

Hazardous Weather Testbed
- Spring Experiment
  - GSL Ensemble Forecast Models
  - 3D Real-time Mesoscale Analysis
  - GSL FV3 Limited Area Model
  - GSL Rapid Refresh Forecast System

Hydrometeorology Testbed
- Annual Flash Flood and Intense Rainfall Experiment
- Annual Winter Weather Experiment

Aviation Weather Testbed
- HRRR 750m Nest for SFO fog
## Community Engagement: Collaborations

<table>
<thead>
<tr>
<th>International</th>
<th>National</th>
<th>NOAA</th>
<th>Academic</th>
<th>Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image" alt="NASA" /></td>
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<td><img src="image" alt="KIAPS" /></td>
<td><img src="image" alt="NOAA" /></td>
<td><img src="image" alt="CIRA" /></td>
<td><img src="image" alt="Amazon" /></td>
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<td><img src="image" alt="Environment Canada" /></td>
<td><img src="image" alt="NOAA" /></td>
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<td><img src="image" alt="ARM" /></td>
<td><img src="image" alt="Climate Research Facility" /></td>
<td><img src="image" alt="NOAA" /></td>
<td><img src="image" alt="Physical Sciences Laboratory" /></td>
<td><img src="image" alt="IBM" /></td>
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<td><img src="image" alt="NCAR" /></td>
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<td></td>
<td><img src="image" alt="Cray" /></td>
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</tbody>
</table>
Public Engagement

American Indian Science and Engineering Society Annual Meeting (Milwaukee upper, OKC lower)

University of Wyoming Girls in STEM

Government Career Day CU Denver, Metro State, Community College of Denver

Denver Museum of Nature and Science Girls and Science Day

8th Grade Science Days

Colorado Science Teachers Conference

NOAA Research: Top tweet of the year, 200K impressions, 38% engagement rate
Fostering an Environmentally Literate Society

Science On a Sphere®

Real-World Example #3: How to Sentence an Equation:

**Environmental Study:** Science on a Sphere (SOS®) demonstrates the effects of atmospheric science, climate change, and ocean temperature on the environment. The volume of a sphere is four-thirds of π multiplied by the radius $r$ to the third power.

1. Write an expression that represents the volume of a sphere.

*Variable:* Let $r$ = radius.

*Equation:* $V = \frac{4}{3} \pi r^3$

2. Find the volume of the 3-foot radius sphere used for SOS.

*Words:* Volume of a sphere.

*$4/3 \pi r^3$ Replace $r$ with $3$.

*Evaluate:* $3^3 = 27$.

*Multiply:* $\frac{4}{3} \pi \cdot 27$. 

The volume of the sphere is 36π cubic feet.

- 177 installations
- 23 countries & 33 states
- +67 million visitors
- +250 network members
- +330,000 Facebook® followers

- 38 SOSx® installations
- 25,000 SOSx downloads
Evaluation Criteria: Performance

The effectiveness and efficiency with which research and development activities are organized, directed and executed. Overall effectiveness with which the Laboratory plans and conducts its research and development given the resources provided, to meet NOAA’s Research mission and the needs of the Nation.
Measures of Performance

• Leadership and strategic planning
• Budget
• Workforce
• Information Technology
GSL Organizational Leadership

• Senior Leadership Team
  ◦ Deputy Director and Associate Director
  ◦ Division Deputy Chiefs

• Mid-career empowerment
  ◦ Evergreen Group
  ◦ IT Enterprise Team
  ◦ Mentoring team
  ◦ Peer Coaching

• Scientific strategic decisions
  ◦ Science Board - to begin this year
  ◦ Strategic Plan
  ◦ Scientific Grand Challenge

• Resource alignment toward Grand Challenge
  ◦ Director Directed Funding Opportunities
  ◦ Base funding

Team Member of the Month
Strategic Planning

• Annual all staff retreats.
• Stakeholder meetings (NWS, FAA, NCAR, GFDL)
• Writing team composed of GSL Division Deputies
• GSL staff review
• Senior Leadership review
• Release draft for Science Review Panel

2019

2020 – Virtual participation nearly exceeded 100
Scientific Grand Challenge

Provide actionable environmental information through the research and development of global storm-scale prediction and innovative decision support capabilities to serve society.

<table>
<thead>
<tr>
<th>GOAL 1</th>
<th>GOAL 2</th>
<th>GOAL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop state-of-the-art Earth-system prediction capabilities</td>
<td>Revolutionize the understanding and communication of weather-affected impacts</td>
<td>Achieve excellence through investment in people, partnerships, and organizational performance</td>
</tr>
</tbody>
</table>
Effective Tracking and Managing Projects and Program

- NOAA Research and Development Database (NRDD)
- Program management table
Leveraging Partnerships to Increase Efficiency

- Modeling and observations - Unified Forecast System
- Aerosols and air chemistry - OAR Labs and NCAR
- Boundary layer - OAR Labs
- Atmospheric Science for Renewable Energy Program - Broadening to OAR Labs
- Decision support - NWS and user community
- Data assimilation - Joint Center for Satellite Data Assimilation (JCSDA)
- Community based tools (e.g. CCPP)
- International partnerships (e.g. Taiwan, UKMet)
Involvement in NOAA and OAR Budget Planning

- Fire weather
- Clean Energy
- Modeling
- Artificial Intelligence
- HPC
- NOAA Cloud
### Scientific Leadership in the Weather Community

<table>
<thead>
<tr>
<th><strong>NOAA</strong></th>
<th><strong>OAR</strong></th>
<th><strong>DTC</strong></th>
<th><strong>External</strong></th>
</tr>
</thead>
</table>
| ● Co-Chair for NOAA’s HPC Allocation Committee  
● Co-Chair for NOAA Research Council’s Unified Modeling Committee (UMC)  
● Management Oversight Board and Executive Team for JCSDA  
● NOAA AI Executive Committee  
● NOAA Modeling Board Member  
● NOAA Central Region Team | ● OAR Cloud Tiger Team  
● OAR Representative for OMB Federal Data Center Optimization Initiative  
● Chair of the FACETs Working Group  
● OAR Awards Committee  
● OAR/NWS Bilateral Steering Committee | ● Deputy Director  
● Management Board  
● Executive Committee  
● Science Advisory Board | ● Unified Forecast System  
● Interagency Council for Advancing Meteorological Services (ICAMS)  
● NASA PBL Incubation Team |
GSL 10-Year Funding Profile

<table>
<thead>
<tr>
<th>Year</th>
<th>Non-NOAA</th>
<th>HPCC</th>
<th>Other NOAA</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY11</td>
<td>$10,322</td>
<td>$2,191</td>
<td>$10,495</td>
<td>$9,868</td>
</tr>
<tr>
<td>FY12</td>
<td>$10,091</td>
<td>$1,629</td>
<td>$10,426</td>
<td>$9,626</td>
</tr>
<tr>
<td>FY13</td>
<td>$6,216</td>
<td>$2,275</td>
<td>$8,281</td>
<td>$9,290</td>
</tr>
<tr>
<td>FY14</td>
<td>$8,244</td>
<td>$2,448</td>
<td>$20,466</td>
<td>$10,409</td>
</tr>
<tr>
<td>FY15</td>
<td>$6,123</td>
<td>$2,381</td>
<td>$13,348</td>
<td>$10,476</td>
</tr>
<tr>
<td>FY16</td>
<td>$5,679</td>
<td>$4,208</td>
<td>$11,763</td>
<td>$14,744</td>
</tr>
<tr>
<td>FY17</td>
<td>$6,417</td>
<td>$2,375</td>
<td>$13,824</td>
<td>$11,591</td>
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<tr>
<td>FY18</td>
<td>$8,170</td>
<td>$2,187</td>
<td>$11,812</td>
<td>$14,459</td>
</tr>
<tr>
<td>FY19</td>
<td>$6,144</td>
<td>$2,182</td>
<td>$13,260</td>
<td>$14,051</td>
</tr>
<tr>
<td>FY20</td>
<td>$7,650</td>
<td>$2,184</td>
<td>$12,138</td>
<td>$15,532</td>
</tr>
</tbody>
</table>

Total 2020: $37.5M
GSL Expenditures FY20
GSL Funding by Project FY20
## Investments: Now and into the future

<table>
<thead>
<tr>
<th>Organizational Excellence</th>
<th>Revolutionize communication of weather information to customers</th>
<th>Earth System Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Balance funding portfolio long-term research and short-term development</td>
<td>- Improve access to environmental data and deliver information for diverse uses</td>
<td>- Advance data assimilation concepts</td>
</tr>
<tr>
<td>- Build collaboration across the Lab Divisions</td>
<td>- Develop client applications and decision support capabilities</td>
<td>- Accurately represent physical and atmospheric composition processes in models</td>
</tr>
<tr>
<td>- Champion a healthy organizational environment</td>
<td>- Develop techniques to effectively communicate weather impacts and educate society</td>
<td>- Further seamless short-range to subseasonal prediction capabilities</td>
</tr>
<tr>
<td>- Develop plans for career growth and succession</td>
<td></td>
<td>- Develop leading-edge forecast verification techniques and tools</td>
</tr>
<tr>
<td>- Modernize IT infrastructure</td>
<td></td>
<td>- Create next-generation models that run efficiently on diverse exascale computing systems</td>
</tr>
<tr>
<td>- Nurture and expand collaborations</td>
<td></td>
<td>UFS, EPIC, JCSDA</td>
</tr>
</tbody>
</table>

### Notes:
- 16%
- 34%
- 50%

Note: Does not include contribution from OH
Funding Distributions

![Graph showing funding distributions over three years (2018, 2019, 2020). The graph includes categories for Research, Development, Demonstration, and Deployment. Each year shows a different percentage distribution.]
Generations by Organization
Federal Staff by Age Range

Age Range
- < 21: 0 FY15, 0 FY21
- 21-30: 0 FY15, 0 FY21
- 31-40: 6 FY15, 6 FY21
- 41-50: 7 FY15, 15 FY21
- 51-60: 24 FY15, 13 FY21
- > 60: 9 FY15, 12 FY21

Count
Education by Organization

[Bar chart showing the percentage of education by organization in different degrees: Doctorate, Master's Degree, Bachelor's Degree, and Other.]
GSL Workforce by Function

2015:
- 70% Science
- 18% IT Support
- 14% Admin & Mgmt

2020:
- 39% Science
- 28% IT Support
- 15% Admin & Mgmt
- 18% Software Dev. or Eng.
Diversity, Equity, and Inclusion

NOAA’s Vision for Diversity and Inclusion

An inclusive environment in which NOAA leverages diversity to achieve mission goals and business objectives and maximizes the potential of individuals and the organization.

**DIVERSITY** is the mixture of the unique attributes that shape an individual’s identity which they bring into the workplace to help NOAA accomplish its goals. Diversity refers to demographic diversity (e.g., race, gender, sexual orientation), experiential diversity (e.g., affinities, hobbies, and abilities), and cognitive diversity (e.g., sensory processing and problem solving).

**INCLUSION** is a culture that values the unique attributes of all team members. It is an environment which is respectful, collaborative, supportive, and one that allows for equal access. Inclusion requires active and intentional engagement on the part of everyone and provides a feeling of belonging.
Workforce Diversity

Includes: Federal, CI and Contract staff
FY20 Race/Ethnicity by Organization
Working to Accelerate Diversity Objectives

• Recruiting by participating in public events
  ◦ AISES, student career days, local science days
• Strengthening partnerships with NOAA Cooperative Science Centers
  ◦ Recent re-engagement meetings with CSCs with tangible outcomes
• Utilizing NOAA hiring authorities to infuse early career underrepresented students into GSL
  ◦ NOAA Experimental Research and Training Opportunities (NERTO) - 1 summer intern
  ◦ SOARs - Significant Opportunities in Atmospheric Research and Science - 3 new summer interns
  ◦ William M Lapenta Student Scholarship - 2 new summer interns
Working to Accelerate Diversity Objectives

- Leading and participating in D&I working groups
  - OAR EEO Advisory Committee
  - ESRL Diversity and Inclusion Team
  - Boulder Laboratories Diversity Council
Staff Inclusion

Staff involvement

- Review and input to strategic plan
- Annual retreats - staff interaction, professional development, and strategic planning (B6.12, 6.14)
- Evergreen group -
  - Leadership opportunities
  - Contribution to Lab beyond technical projects
  - Training
- Employee satisfaction surveys
- Check-in surveys

Communication and transparency

- GSL Weekly Briefs
- GSL Notes (weekly) internal newsletter
- GSL Social ½ hour
- Holiday parties
- GSL Talks
- GSL Weather Briefings

B6.12, 6.14
Staff Recognition

- Team Member of the Month
- Shout-outs (from anyone to anyone)
- Numerous NOAA, OAR, CIRA, CIRES awards
NOAA Global Systems Laboratory

Information Technology
ITS Excellence

**Data Center - provides data to researchers in and outside of GSL**

- Facility that supports HPC systems
  - Monitored 24x7x365
  - State-of-the-art cooling and fire systems
  - Technician expertise

**Excelling in HPC Science**

- JET was one of the fastest computers in the world in 2002
- File systems adopted by other NOAA systems
- Manage Jet (Boulder) and Orion (MSU) systems

**Virtual Computing Infrastructure**

- Implemented a GPU cluster (proof of concept)
- Only cluster to run NOAA’s experimental models in real-time
- GSL’s computing resources converted to virtual machines saving resources

**Enable Research to Operations**

- Supports GSL and the wider NOAA community
- Data, ingest, decoding, reformatting, and monitoring
- Real-time ‘operations’ for research development and testing before delivery

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Leadership across NOAA