

Laboratory Review

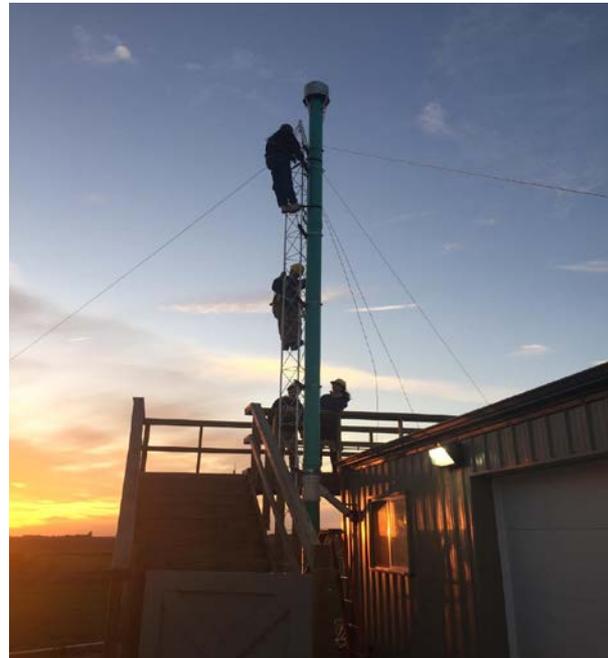
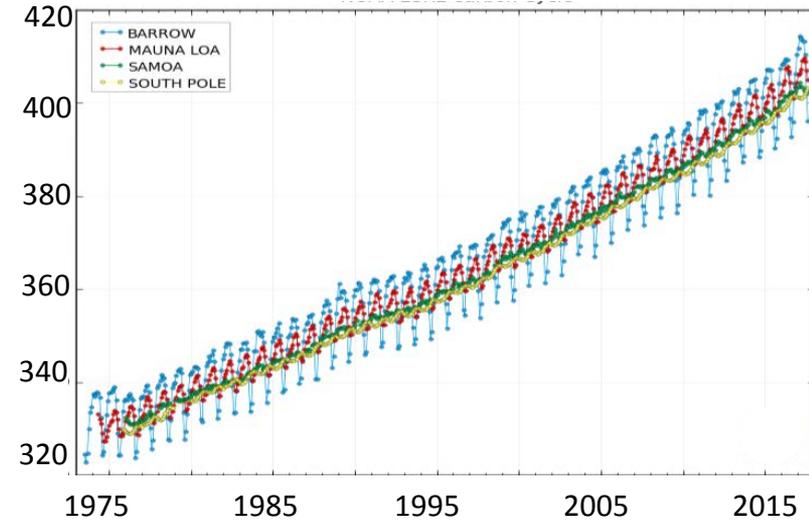
NOAA/ESRL Global Monitoring Division



Carbon Dioxide at Observatories



James Butler
Director
21-24 May 2018



Outline

- Summary of Previous (2013) Panel Report
- Mission of NOAA's Global Monitoring Division
- Organization and Management
- How We Plan, Ensure, and Measure Success
- Transformative Opportunities
- Upcoming Sessions



2009-2013 Review Panel Summary

- **Relevance:**
 - “**Environmental Security** of the nation”
 - “**Essential** to the NOAA mission”
- **Quality:**
 - “GMD has become a **NOAA/ESRL star**”
 - “**pushing the frontiers** in Climate, Greenhouse Gases, Ozone Depletion, and Air Quality”
 - “**will be used by the international community for decades to come**”
- **Performance:**
 - “The investments into GMD have been **well optimized** in an underfunded environment”
 - “The work ... is of the **highest caliber**”
 - “The **scientific community, nation, and beyond are reaping the benefits**, and are heavily dependent on GMD. Now is the time to strengthen the capacity of GMD even further to maintain its global lead in these activities”



2013-2018 Panel Recommendations

Recommendations:

- **Expand** the science that GMD does to support other science and regulatory agencies (state, national, and international)
- **Sustain** operations, scientific analysis, and technological development required for its mission.
- **Add** additional resources into all aspects of GMD operations, scientific analysis, and innovation.
- **Recruit** new talent and reinvigorate the both CIRES and NOAA positions
- **Ensure** continuity in observing network

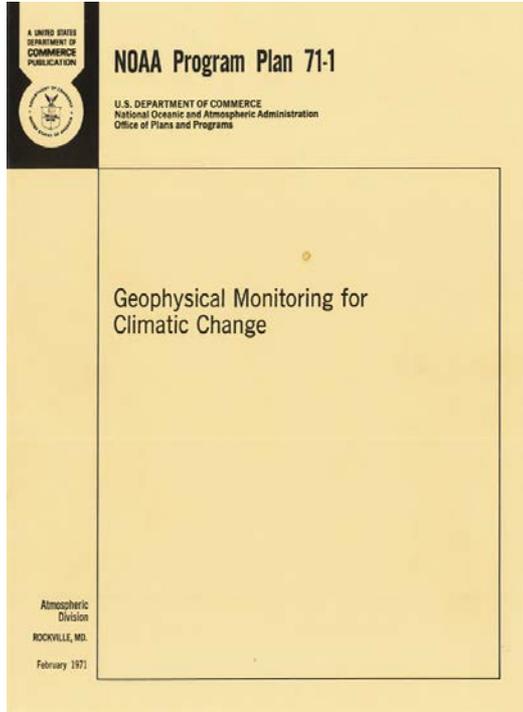


GMD Mission



NOAA Program Plan 71-1

“Geophysical Monitoring for Climatic Change”

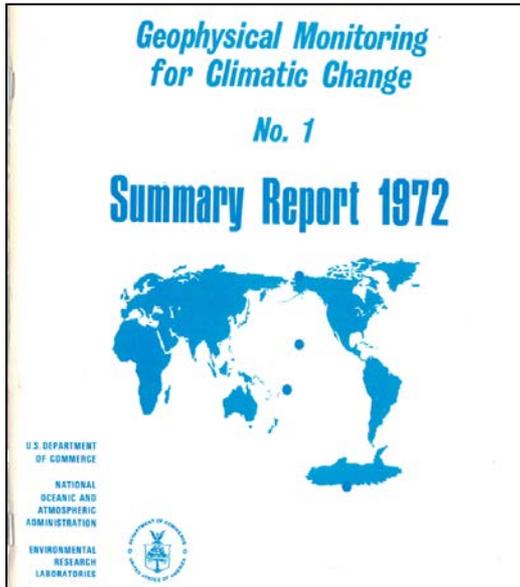


- “This plan, *Geophysical Monitoring for Climatic Change*, is NOAA’s program for global monitoring of man’s inadvertent modification of weather and climate.”
 - *Robert White, Acting Administrator, NOAA*
- “Determination of the **trends of the climatically important burden of atmospheric contaminants and resolution into natural vs. man-induced sources** is essential to the preservation of environmental quality.”

GMD Origins

“... We must achieve a new awareness of our dependence on our surroundings and on natural systems which support all life, but awareness must be coupled with a full realization of our enormous capability to alter these surroundings.”

Richard M. Nixon, 1970



*“It is the objective of the GMCC program to respond to the need for this new awareness **by providing a portion of the quantitative description and analysis needed.** Specifically, it is our objective to measure the necessary parameters **for establishing trends of trace constituents** important to climate change and of those elements that can assist in apportioning the source of changes to natural or anthropogenic sources, or both.”*

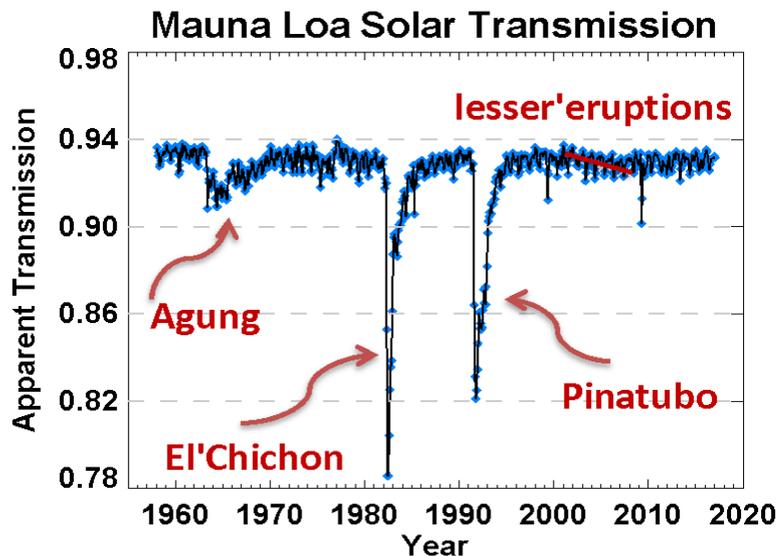
*“This program has its special focus in establishing a **long-term time series** from ground-based information.”*

*Geophysical Monitoring for
Climate Change
First Summary Report, 1972*

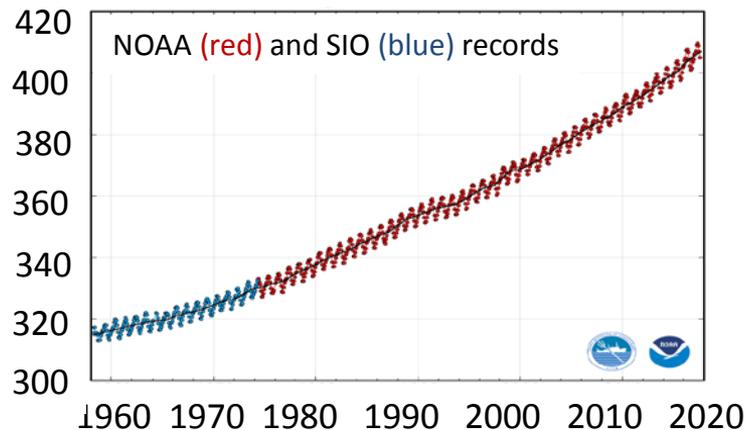
GMD Vision and Mission

Vision

GMD providing and society using the best possible information to inform climate change, weather variability, carbon cycle feedbacks, and ozone depletion



Mauna Loa Carbon Dioxide



Mission

To acquire, evaluate, and make available accurate, long-term records of atmospheric gases, aerosol particles, clouds, and surface radiation in a manner that allows the causes and consequences of change to be understood

How GMD sets priorities

- Legislative mandates
- Consistency with NOAA's and OAR's strategic plans and priorities
- Relevance to interagency and international plans
- Relevance to national and international assessments
- Within the framework of GMD's mission:
 - Align research along Grand Challenges
 - Identify key scientific questions
 - Determine role of long-term observations to answer those questions
 - Sustain quality and continuity of observations
 - Understand the observed distributions and trends
 - Expand networks as needed
 - Conduct periodic regional-scale studies



Key Legislative Drivers of GMD's Research



- GMD's research contributes to fulfilling requirements for over 25 laws
- Four pieces of US legislation stand out
 - National Climate Protection Act (1978)
 - Global Climate Change Program Act (1990)
 - Global Change Research Act (1990)
 - Clean Air Act (1990)

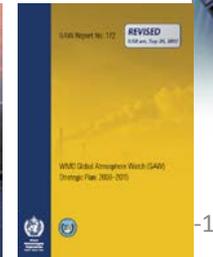
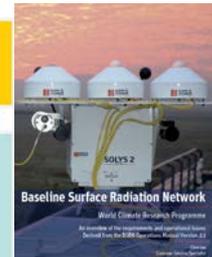
Plans and Agreements

- **United States**

- National Global Change Research Program Research Plan
- US Carbon Cycle Science Plan
- NOAA Next Generation Strategic Plan
- NOAA Research Plan & OAR Priorities
- NOAA/ESRL GMD Research Plan

- **International**

- WMO Global Atmosphere Watch Strategic Plan
- GCOS Implementation Plan
- GEOSS Strategic Plan
- GEO Carbon Strategy
- WCRP Strategic Plan



NOAA Plans

NOAA Next Generation Strategic Plan

- **Goal: Climate Adaptation and Mitigation**
 - **Primary Objective:** Improved Understanding of Climate Change and its Impacts
 - **Other Objectives:** Assessments, Mitigation and Adaptation, Climate-Literate Public, Partnerships
- **Goal: Weather Ready Nation**
 - **Objectives:** Reduced loss from high impact events, improved water management and air quality, healthy people and economy, and improved transportation

OAR Strategic Plan

- **Aim: Climate Adaptation and Mitigation**
 - What is the state of the climate system and how is it evolving?
 - What causes climate variability and change on global to regional scales?
 - What improvements in global and regional climate predictions are possible?
- **Aim: Weather Ready Nation**
 - How does climate affect seasonal weather and extreme weather events?
 - How can we improve forecasts for freshwater resource management?
 - How are atmospheric chemistry and composition related to each other and ecosystems, climate, and weather?



OAR Priorities

- Sustain the long-term observations of the Earth System
- Improve the accuracy of weather forecasting and climate predictions
- Provide the environmental information needed by decision makers
- Sustain and enhance ocean exploration and research infrastructure
- Provide the essential scientific understanding of ecosystem processes and change
- Enhance marine resources management
- Detect, and provide early warning information for ocean, weather and climate events



GLOBAL MONITORING DIVISION

2018-2022 Research Plan



Taking the pulse of the planet



GMD Research Plan

- Documents GMD's purpose
- Built around recognized Grand Challenges*
- Identifies key scientific questions
- Shows how GMD activities help answer those questions
- Provides a path forward
- **Includes milestones as measures of performance**

*Weatherhead et al 2017, Earth's Future, Nov 2: WCRP
<https://www.wcrp-climate.org/grand-challenges/grand-challenges-overview>



GMD Research Themes and Applications



GMD Research Themes and Applications



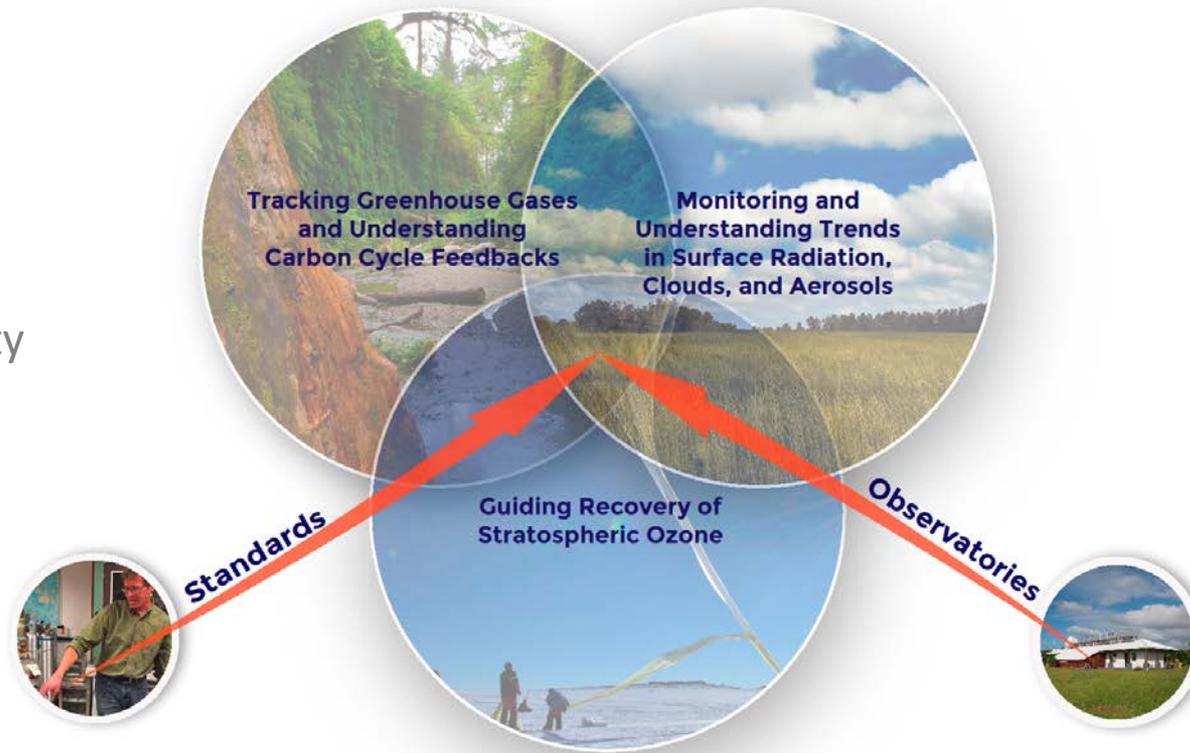
Radiative Forcing

Renewable
Energy Support

GMD Research Themes and Applications

Climate
Sensitivity

Climate
Intervention



Air Quality

Arctic Processes

Scientific Questions

(Details in Research Plan)



Greenhouse Gases and Carbon Cycle Feedbacks

- ✓ How do oceanic and terrestrial carbon fluxes vary in a changing climate?
- ✓ How spatially and temporally variable are anthropogenic inputs of greenhouse gases?
- ✓ How is upper tropospheric and lower stratospheric water vapor interacting with climate change?

Recovery of Stratospheric Ozone

- ✓ How well is the Montreal Protocol working to reduce ozone depletion?
- ✓ Is stratospheric ozone recovering as expected?
- ✓ How is climate influencing Brewer-Dobson circulation and its feedbacks?
- ✓ How sensitive is the oxidative capacity of the atmosphere and how is it changing over time?

Surface Radiation, Clouds, and Aerosols

- ✓ How does surface radiation vary in space and time?
- ✓ How do climate change and variability work to redistribute clouds ?
- ✓ How do aerosol optical properties vary as a function of location, time, and atmospheric conditions?
- ✓ How does black carbon influence lower atmospheric heating and cloud prevalence?
- ✓ How do changing sky conditions affect ultraviolet radiation at the Earth's surface?
- ✓ How can information on surface radiation improve renewable energy predictions?



How We Plan, Ensure, and Measure Success



Path To Success



- **Rigor** – role as a world leader in measurements that we do
- **Excellence** – in the science that comes from the measurements
- **Pathfinder** – for new technology to enhance and sustain measurements
- **Transparency** – making measurements, methods, scientific findings accessible to the public
- **Leadership** – providing guidance to the rest of the scientific community to ensure compatibility of global measurements

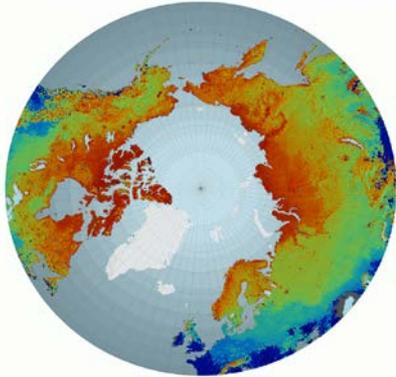


How We Measure Success

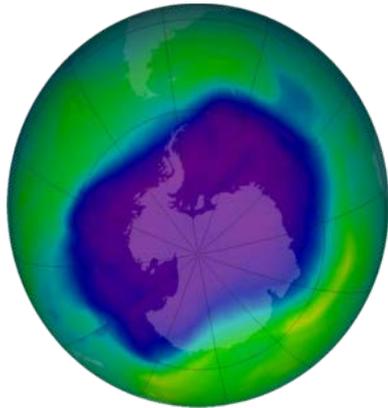
- **Sustained** high-quality long-term records of atmospheric composition
- **Preeminence** of our science as documented through the peer-review process
- **External recognition** of staff
- **Ability to update** products regularly
- **Use of products** by external partners
- **Leadership** on councils, advisory groups, and committees
- **Contributions** to assessments



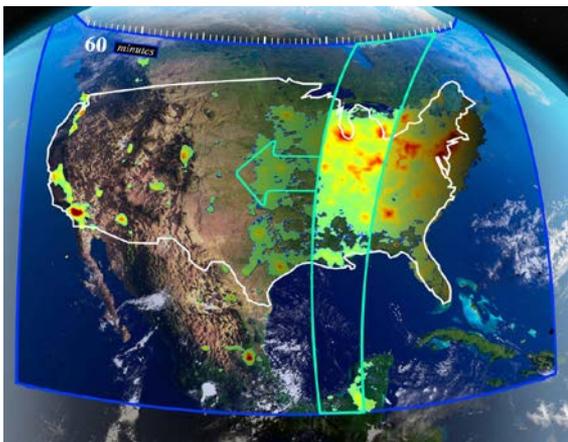
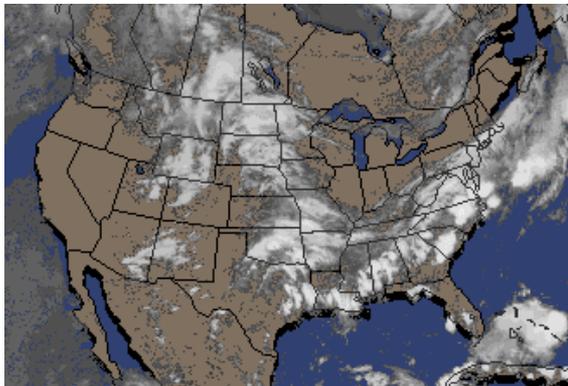
Some Substantive Accomplishments of GMD



- **Magnitude of the terrestrial, northern hemispheric sink** for atmospheric carbon dioxide
 - Continuing to provide on-going, solid evidence that half of the CO₂ emitted to the atmosphere is taken up by land and oceans
 - Continuing to investigate the reliability of sinks
- **Turnover of ozone-depleting gases** and the onset of ozone recovery
 - Annually quantifying the contributions of Montreal Protocol and other gases to potential ozone recovery
- **Stability of oxidizing capacity** of the troposphere largely derived from these ozone-depleting gases and their replacements
 - Affects lifetimes of many gases in the atmosphere

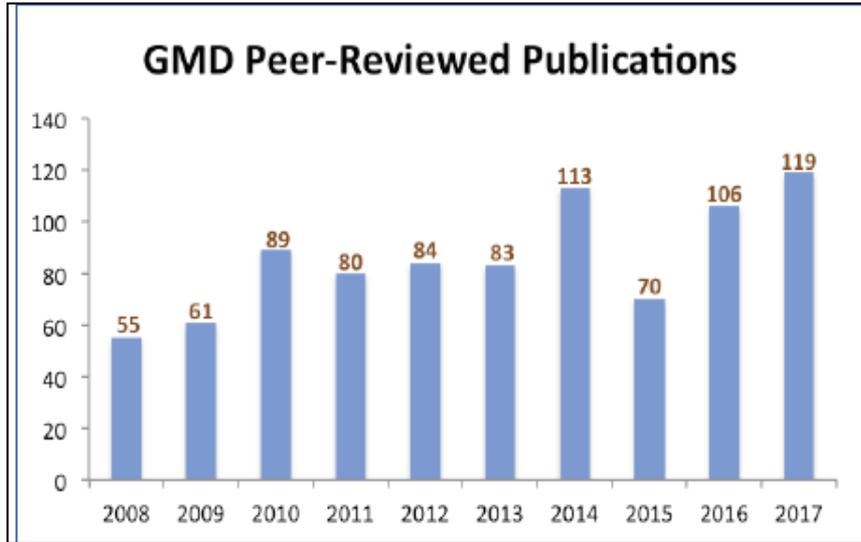


Some Substantive Accomplishments of GMD

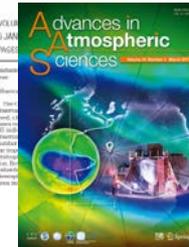
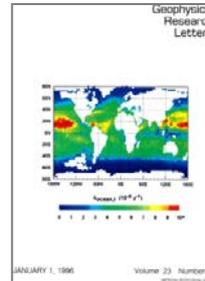


- **Large increase in radiative energy** at the surface across the United States over the past 15 years (equivalent to twice the forcing from a doubling of CO₂)
 - This, while noting a decrease in aerosol radiative forcing
 - Caused by variability of clouds on decadal scales
- **Improving satellite retrievals** through continuous evaluation of retrievals for O₃, UV, surface radiation, water vapor, and GHGs
- **Primary source for information and data** on hundreds of variables in the atmosphere
 - Virtually all of these are identified as GCOS Essential Climate Variables

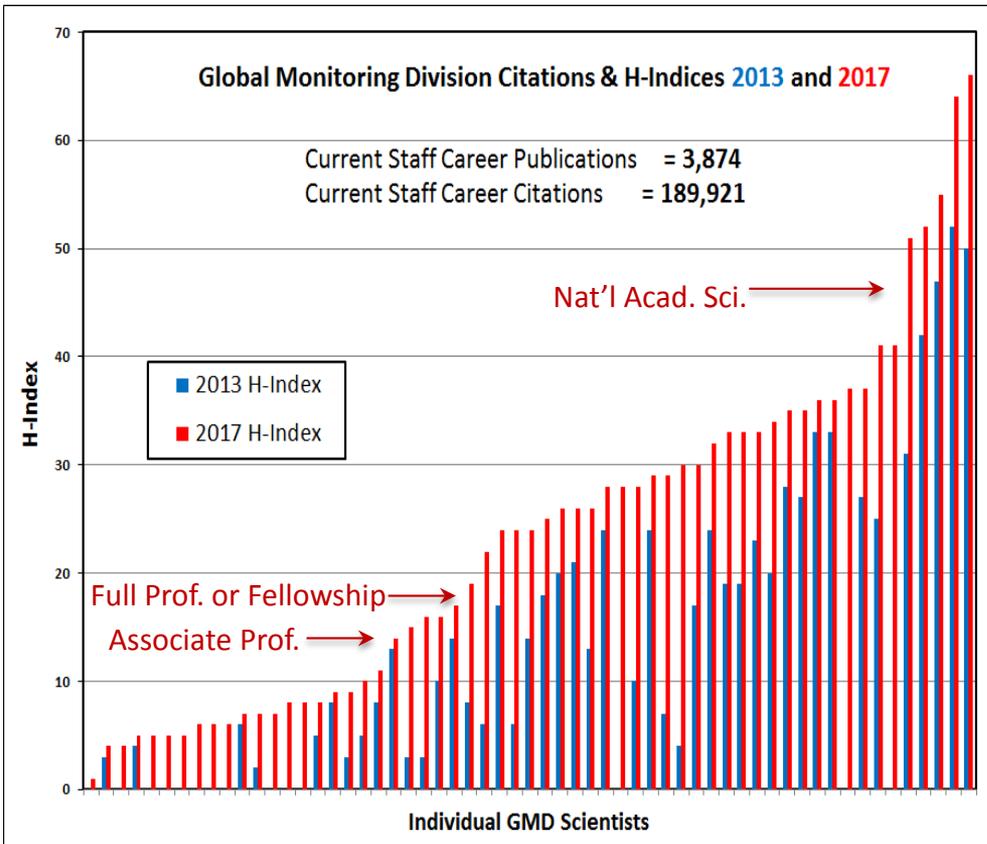
Publications Keep Increasing



- These are publications with GMD authorships.
- The number has **increased at ~7 per year** since 2013, our last review.
- That's the same rate of increase since 2008.



Staff Performance – Hirsch Index



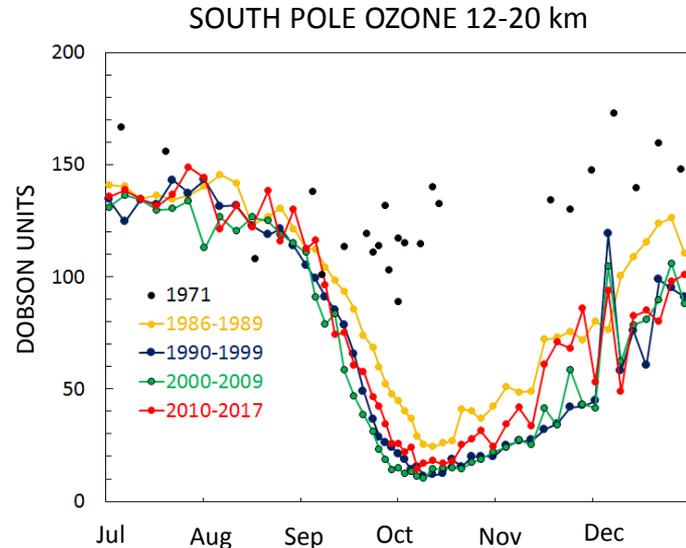
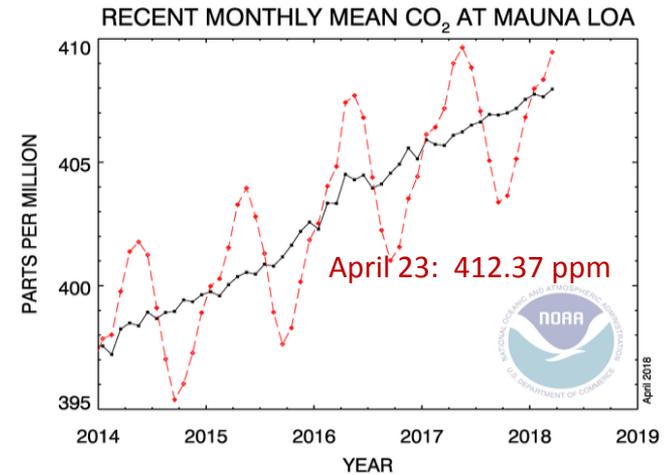
	H-Index*	# Pubs.	# Citations
Tans	66	227	17,195
Oltmans	64	234	13,015
Elkins	55	175	8,799
Ogren	52	159	8,264
Dlugokencky	51	144	8,282
Johnson	41	107	5,008
Sweeney	41	144	7,270
Long	37	94	6,574
Novelli	37	74	4,356
Hintsa	36	76	3,784
Montzka	36	147	7,812
Butler	35	59	3,804
Schnell	35	110	4,028
Bruhwyler	34	59	5,412
Andrews, A.	33	93	3,410
Conway	33	65	7,162
Miller, J.	33	89	4,257
Jefferson	32	65	3,307
Masarie	30	46	6,324
Miller, B.	30	70	4,140
Hurst	29	71	2,708
Moore	29	68	3,513
Michalsky	28	89	2,699
McComiskey	28	118	4111
Sheridan	28	63	3,502

*As of Dec 2017

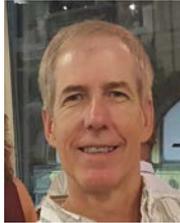


On-line Products

- Interactive Data Visualization
- Annual Greenhouse Gas Index
- Ozone-Depleting Gas Index
- South Pole Ozone
- GLOBALVIEW and ObsPak
- Mauna Loa and Global Trends
- GMD 3 Dimensional Maps of Composition
- Solar Calculator



Awards Summary 2013-2017



- DOC Bronze Medal Award (1)
- NOAA/CIRES Silver Medal Award (1)
- Yoram J. Kaufman Award (1)
- OAR Outstanding Paper (2)
- CIRES Outstanding Service Awards(6)
- Governor's Award for High Impact Research (2)
- AGU Excellence in Refereeing (3)
- Vaisala Award (1)
- Total of **28 External Awards** honoring **61 individuals** in GMD over past 5 years

Partners

- GMD operates instruments or collects samples at **78 locations in 35 states** in the US
- Nearly all of the **13 US agencies** participating in the USGCRP make use of GMD's data and products
- GMD operates similarly at **161 locations in 67 countries**
- Over **100 partnering scientists worldwide**, many in association with WMO Global Atmospheric Watch

- NOAA/ESRL Global Monitoring Annual Conference
 - Essentially GMD's annual meeting to engage with partners contributing to, sharing, or using GMD's data and data products routinely.

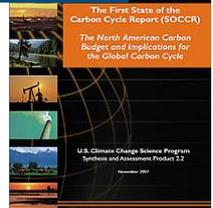
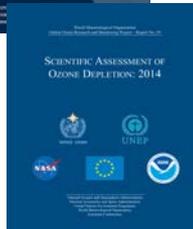
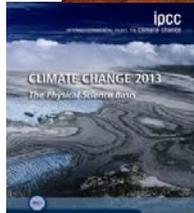
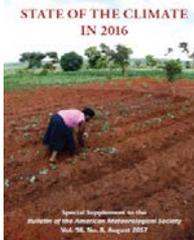


National and Global Leadership

- **WMO Commission for Atmospheric Science**
 - US Lead Delegate
 - WMO Global Atmosphere Watch (Four members of Scientific Advisory Groups (2 chairs))
 - Many members of GHG Measurement Techniques Group
- **European Research Infrastructures**
 - Advisory Boards for 3 EU Infrastructures



- **Global Climate Observing System (GCOS)**
 - Atmospheric Observation Panel for Climate
- **US Global Change Research Program**
 - Carbon Cycle Interagency Working Group
 - Carbon Cycle Scientific Steering Group
 - North American Carbon Program Scientific Steering Group
 - SOCCR Co authors (3 co-leads)
- **Group on Earth Observations**
 - GEO Carbon
- **WCRP Baseline Surface Radiation Network**



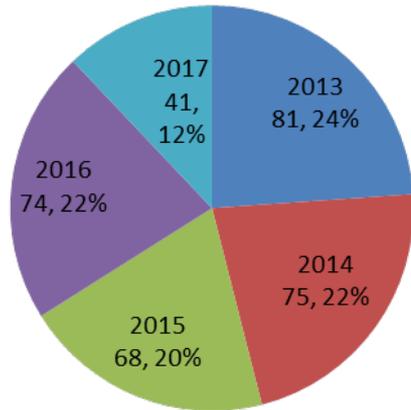
Assessments

- Our contributions to **Assessments are the highest level product** and ultimate transition for our research:
 - Provide evaluations and syntheses of the most recent research
 - Operate at the interface of science and policy, providing policy-relevant information
- **IPCC Assessments**
 - Inform nations through UNFCCC on climate and climate change mitigation
 - Significant vehicles for educating global society on climate change
- **Ozone Assessments**
 - Inform nations through the Vienna Convention on the Ozone layer
 - Resulted in significant amendments to the Montreal Protocol
 - Led to acceleration of production phaseouts, most recently HCFCs
- **National Assessments**
 - Provide US policy-makers with climate-relevant information



ESRL Student Program 2013-2017

- CIRES/CIRA
- Educational Partnership Program
- High Schools
- Hollings Scholars
- Research Experience for Undergraduates
- Science and Technology, Corp.
- Significant Opportunities in Atmospheric Research
- Tribal College Collaboration



339 Students
served in
2013 – 2017



GMD Outreach

Building Global Capacity

- **Coordinates** with scientists, universities, agencies around world to add sites to measurement networks
- **Trains** emerging scientists abroad and WMO partners

Public Outreach

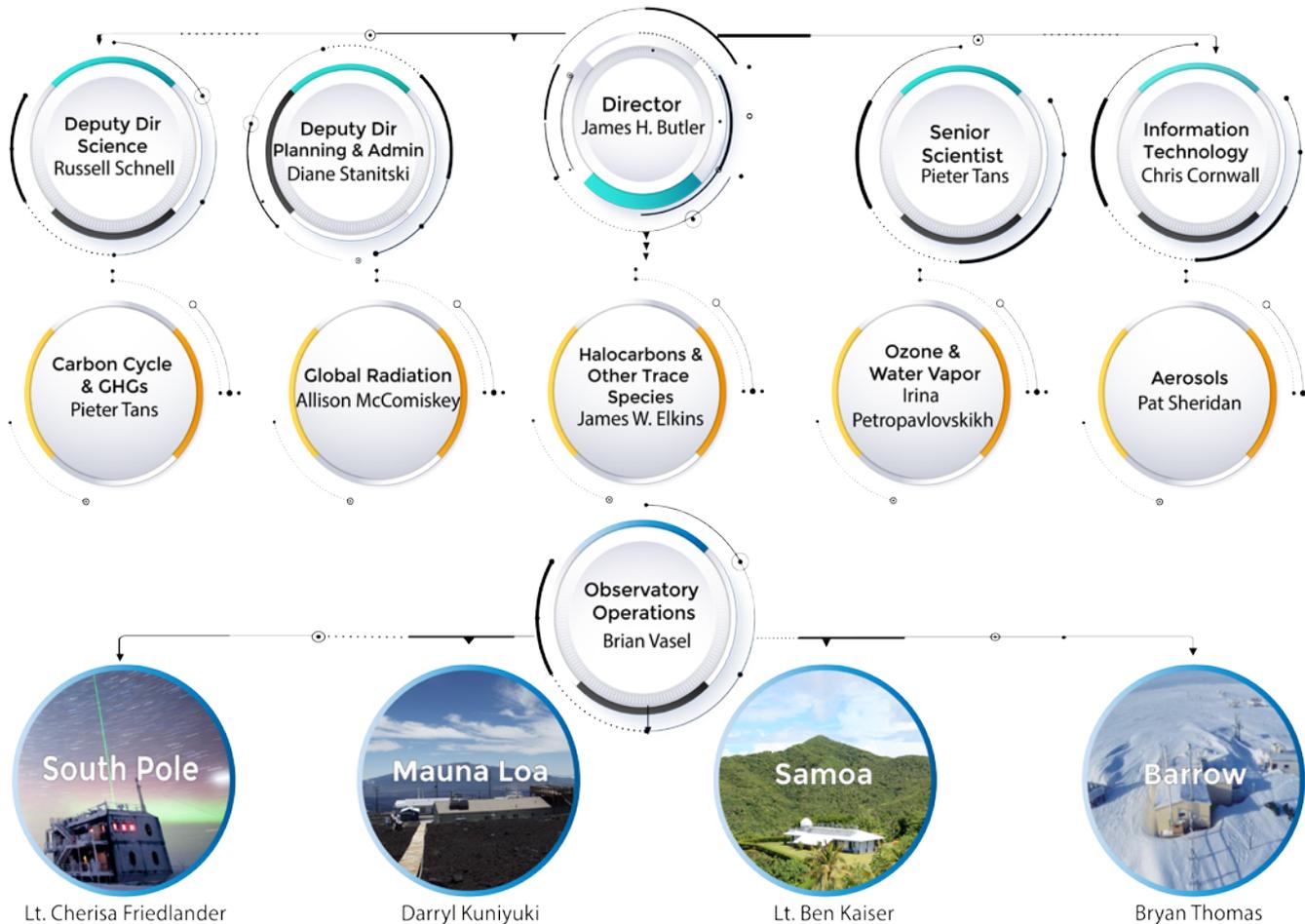
- **GMD Observatories** provide tours, community presentations, student field work
- **29,485 visitors** to our facility in 2013-2017 were shown SOS, the GMD “Wall”, and other activities
- **Organized** NOAA activities for Native American students and minority groups (e.g., **AISES, Howard**)
- **Served** as panelists and presenters in local high school science classes
- **Presented** GMD science at TEDx Boulder Salon
- **Hosted** anniversary events with Boulder media



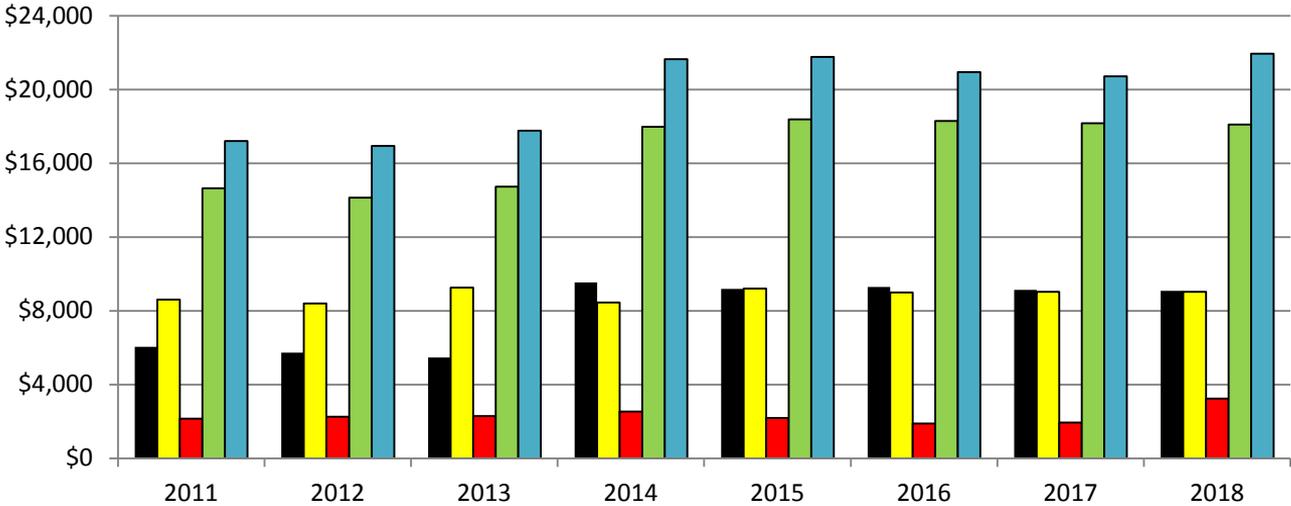
Organization and Management



GMD Organization

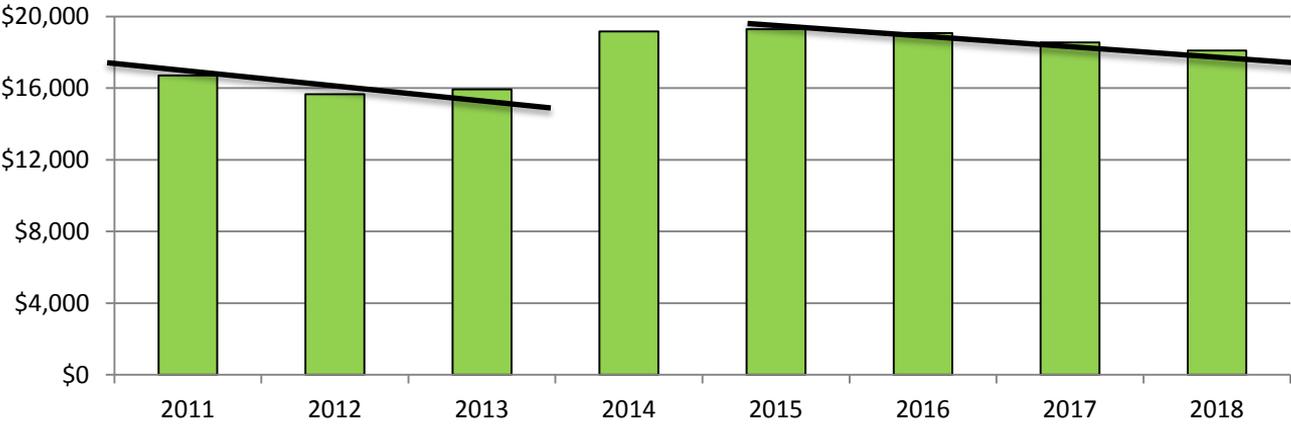


GMD Income



- OAR Base
- Clim. Prog. (also OAR)
- Reimbursable
- Total NOAA Funding
- Total Funding

\$2018 Basis



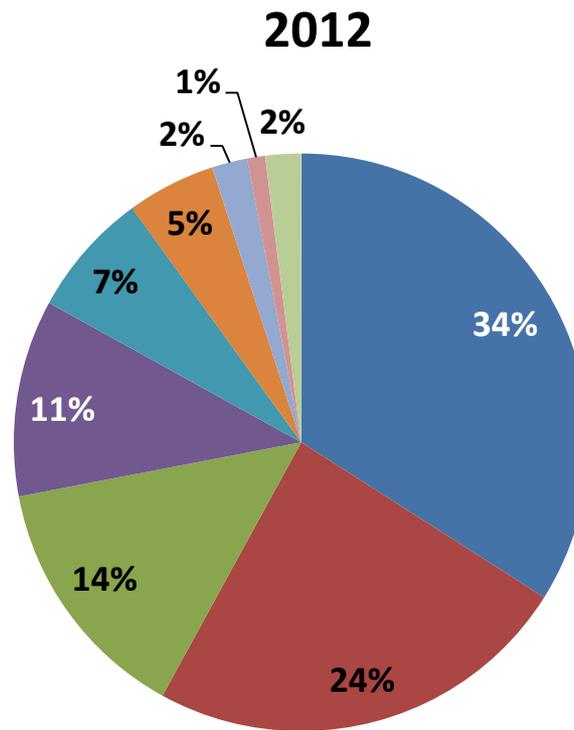
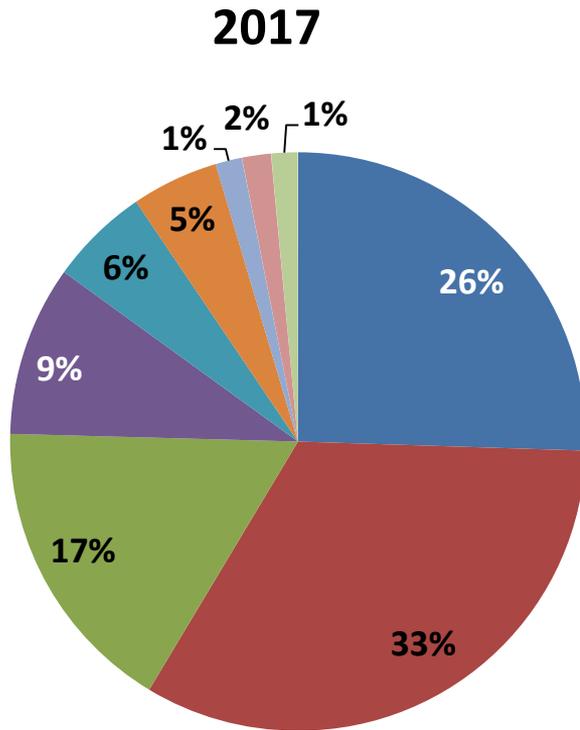
~\$1.5M drop in spending power since 2015

■ \$2018 Basis (NOAA)

*NOAA funds only. External funding adds another 15-20 %



Expenditures by Function

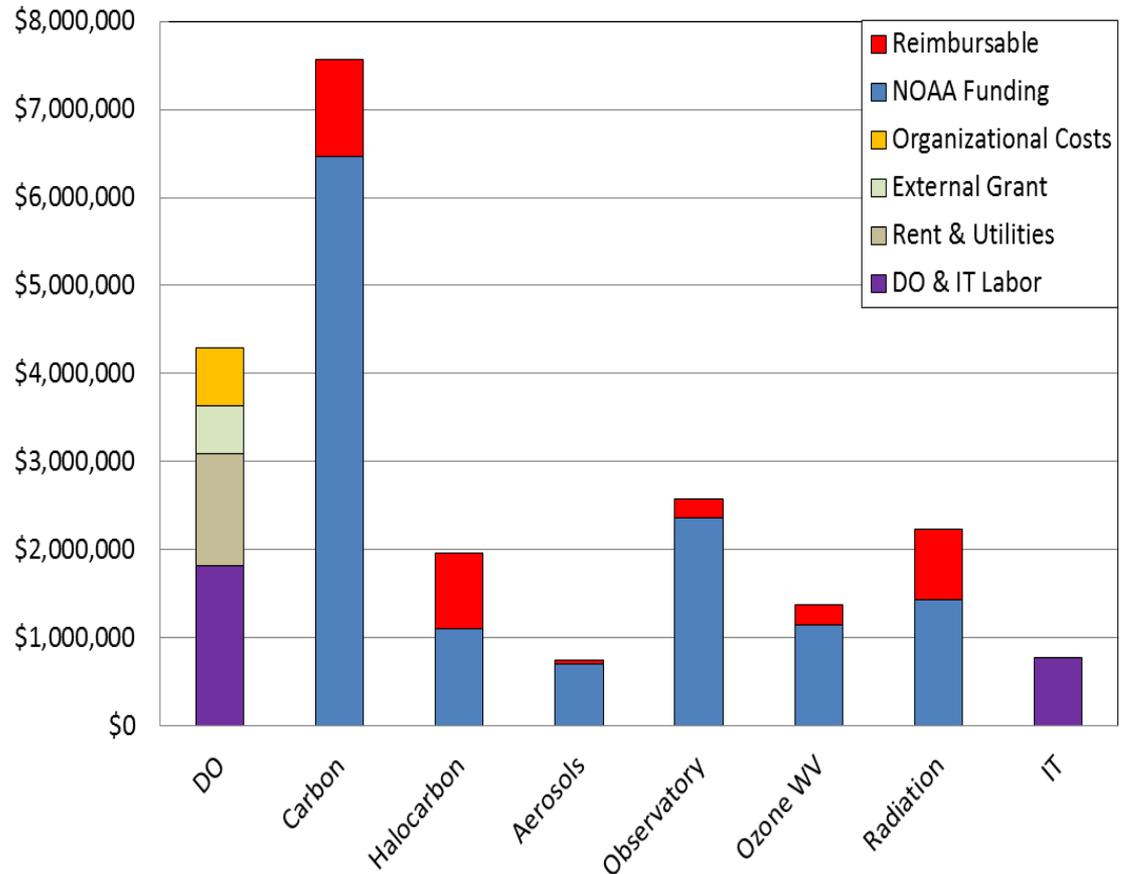


- Fed Salaries/Benefits
- CIRES
- Contract/Services
- Facilities / Rent
- NOAA Overhead
- Supplies
- Equipment
- Shipping
- Travel



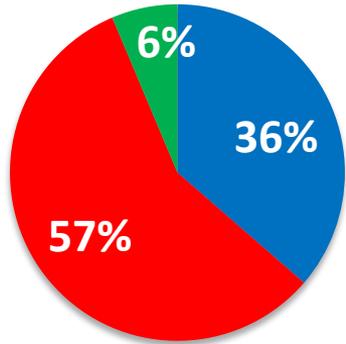
Budget distribution in GMD (2018)

- 5 Research Groups
- Observatory Operations
- Director's Office and IT
 - Includes Admin & Budget
 - Largely non-scalable



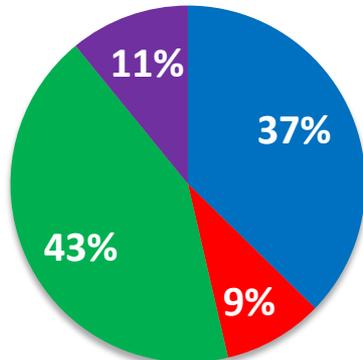
Workforce Profile

2017



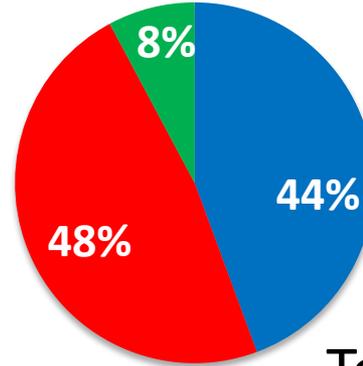
- Federal (with NOAA Corps x2)
- CI (CIRES & JIMAR)
- Contractor (STC)

Total "FTE" = 107



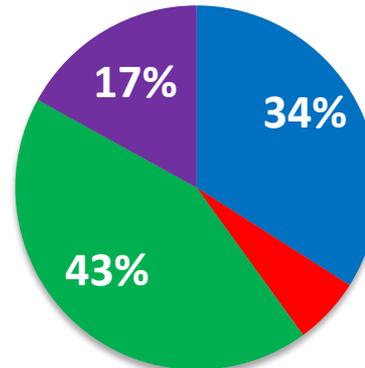
- PhD
- Masters
- Bachelors
- Other

2012



- Federal (with NOAA Corps x2)
- CI (CIRES & JIMAR)
- Contractor (STC)

Total "FTE" = 115

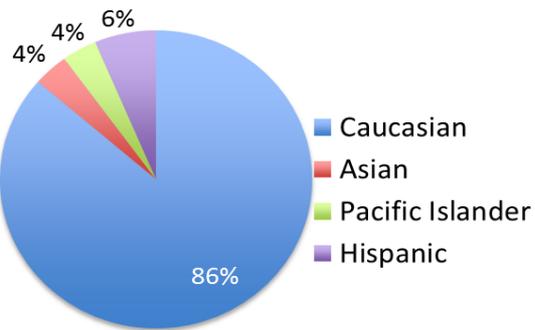
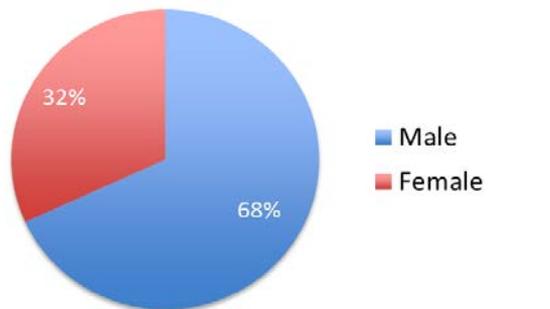


- PhD
- Masters
- Bachelors
- Other

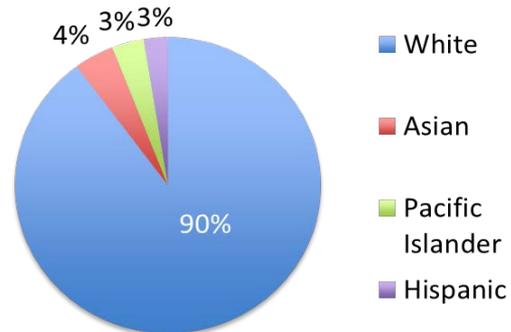
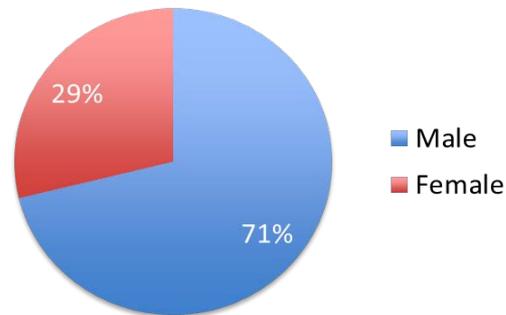


Workforce Demographics

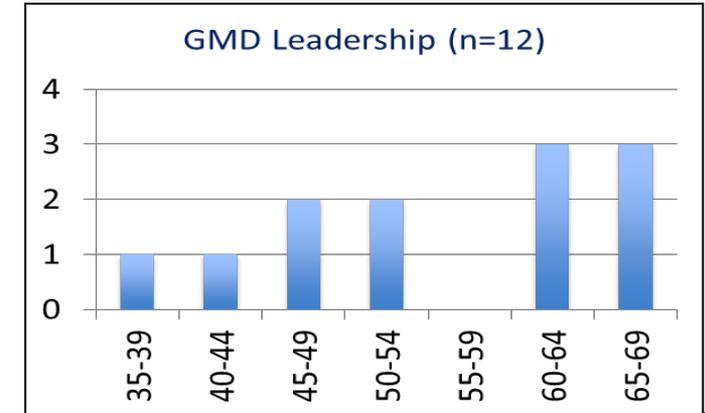
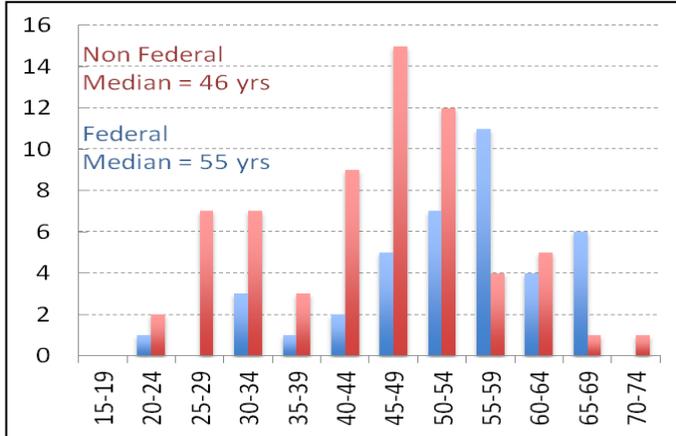
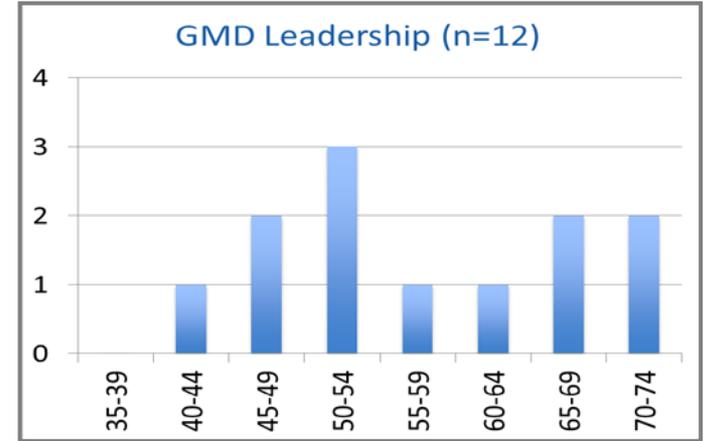
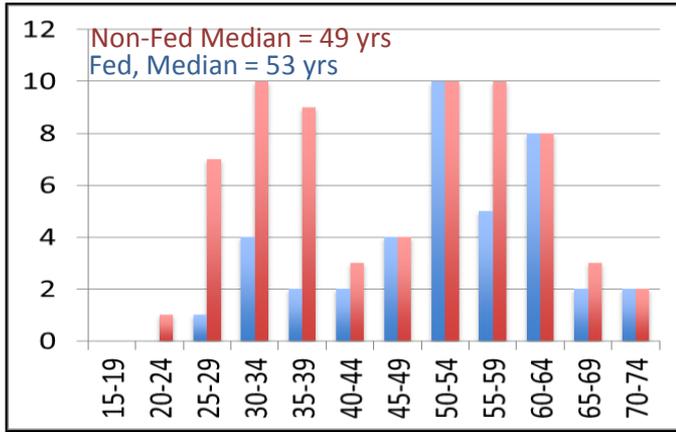
2017



2012

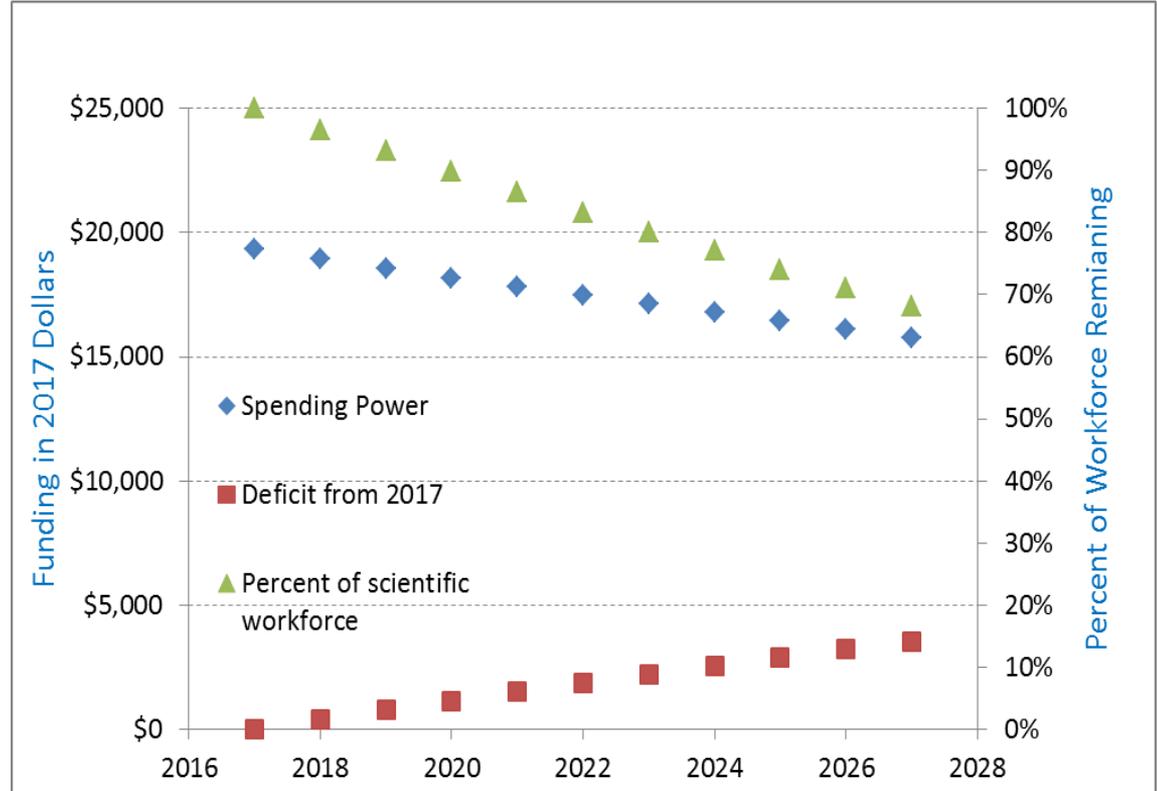


Workforce Age Distribution

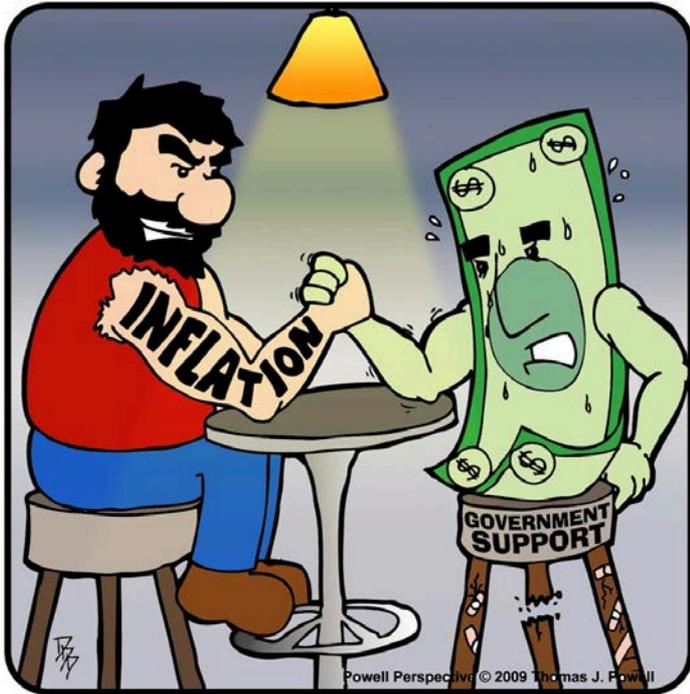


Our Challenge Ahead

- Inflationary erosion (2%/yr) impinges heavily on GMD
 - Extent of observations
 - Quality of observations
 - Number of personnel
- Steady funding means \$2M loss in 5 years, \$4M in 10 years.
- Steady funding puts GMD on a path to lose 1/3 of current scientific personnel in 10 years

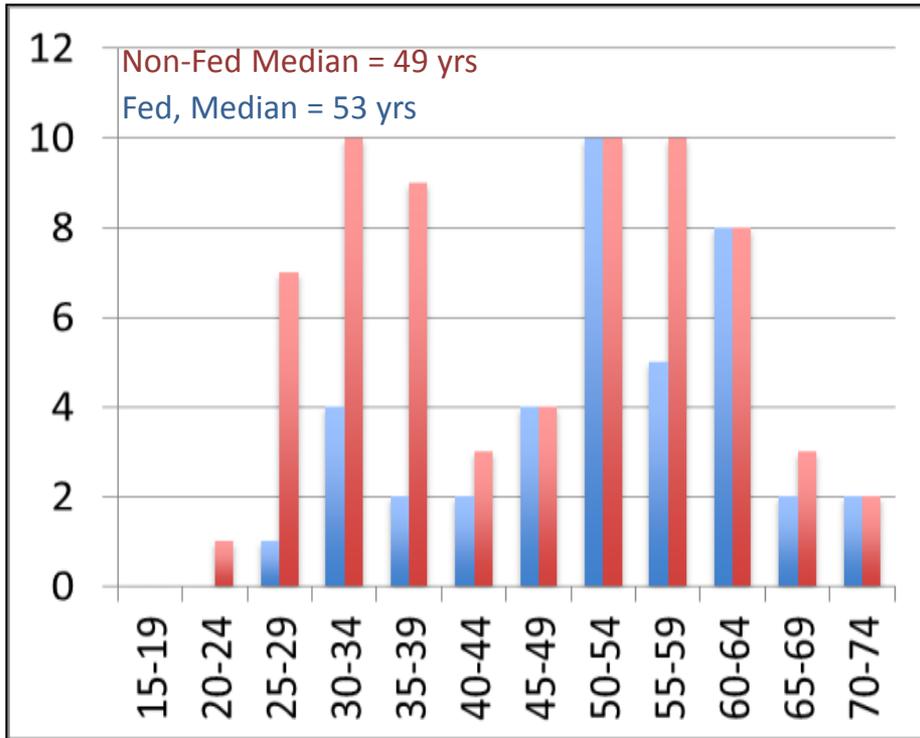


How are we addressing decreasing resources?



- Reimbursable projects
- Increasing efficiency
- Reducing redundancy
- Collaborating with other labs
- Cutting back on sites
- Renewing aging workforce?

Renewing the workforce



- Why
 - New ideas
 - New technology
 - New energy
 - Training leaders for future
 - Protecting a 50 year investment that NOAA has made
- How
 - Postdoc programs
 - Outside grants
 - Collaborations with universities



The Future

Operational Challenges

- Sustaining long-term observations in global networks
- Ensuring a world-class research workforce
- Addressing succession



Transformative Opportunities

- **Build** commercial aircraft capability
- **Expand** C-14 efforts
- **Augment** Surface Radiation Network to improve predictions
- **Enhance** upper atmospheric research
- **Support** renewable energy evaluation
- **Advance** US tall tower network for boundary layer composition studies



Upcoming Presentations





NOAA Global Monitoring Division

- . . . *providing the best possible information to inform climate change, weather variability, carbon cycle feedbacks, and ozone depletion.*

GMD Mission

- *To acquire, evaluate, and make available accurate, long-term records of atmospheric gases, aerosol particles, clouds, and solar radiation in a manner that allows the causes and consequences of change to be understood.*