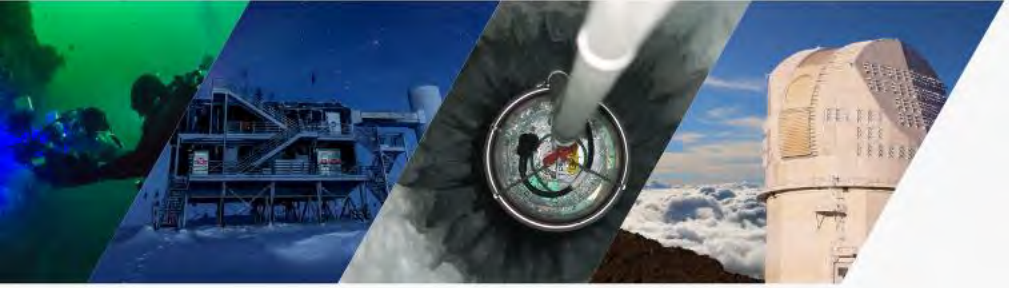
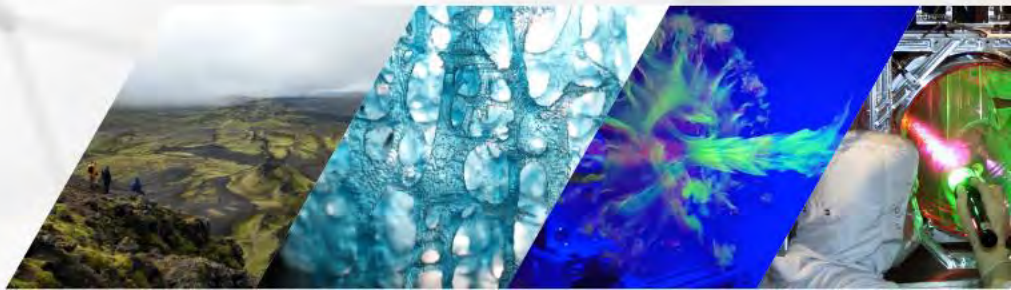


2022 NSF RESEARCH INFRASTRUCTURE WEBINAR SERIES

February Webinar Part 2:
Science Impact Metrics
2:00pm – 3:30pm



Afternoon Session: Science Impact Metrics
2:00pm – 3:30pm

Panel Discussion on Science Impact Metrics

- Panel Discussion on Best practices for collecting, calculating, and reporting science impact metrics. Can we develop a uniform approach across all Major and Mid-scale Research Infrastructure?
- Panelists will discuss how different Major and Mid-scale Research Infrastructure facilities define and measure science impacts and how our community might develop best practices
  - Panelists introduce themselves presenting slides briefly offering perspective on Science Impact Metrics (5 mins X7)
  - Moderator will ask predeveloped questions to the panelists (30 - 40 mins)
  - Moderator will ask panelists questions from attendees (10 mins)

Afternoon Session: Science Impact Metrics
2:00pm – 3:30pm

- **Panel includes**
  - **John Trowbridge**, Senior Scientist, Woods Hole Oceanographic Institution
  - **Wendy Bohon**, Senior Science Communication Specialist, Incorporated Research Institutions for Seismology
  - **Albert Lazzarini**, Deputy Director, Laser Interferometer Gravitational Wave Observatory Laboratory
  - **Daniela Loock,** Director, Corporate Services Ocean Networks Canada.
  - **Benoît Pirenne**, Director, User Engagement, Ocean Networks Canada
  - **Mitch Malone**, Director, *JOIDES Resolution* Science Operator for the International Ocean Discovery Program
  - **Kirsten Ruiz**, Director, Field Science, National Ecological Observatory Network
  - **Dennis Crabtree,** Director Emeritus, Dominion Astrophysical Observatory
  - **Matthew Mayernik**, Project Scientist & Research Data Services Specialist, NCAR Library

Moderator: John Trowbridge, Senior Scientist, Woods Hole Oceanographic Institution

Dr. Trowbridge serves as the principal investigator for the Ocean Observatories Initiative (OOI) and is responsible for the operation and management of this NSF Major Facility, which involves ~ 160 scientists, engineers, and data experts who maintain the infrastructure and deliver ~ four terabytes of data each month.

OOI Mission: Sustained Data for a Changing Ocean

Sponsored by NSF. Operated and managed by WHOI, UW, and OSU.

- Quality-controlled real-time interdisciplinary data from more than 800 instruments on five arrays at three scales
- Success = data use for research & education by the earth & ocean science communities

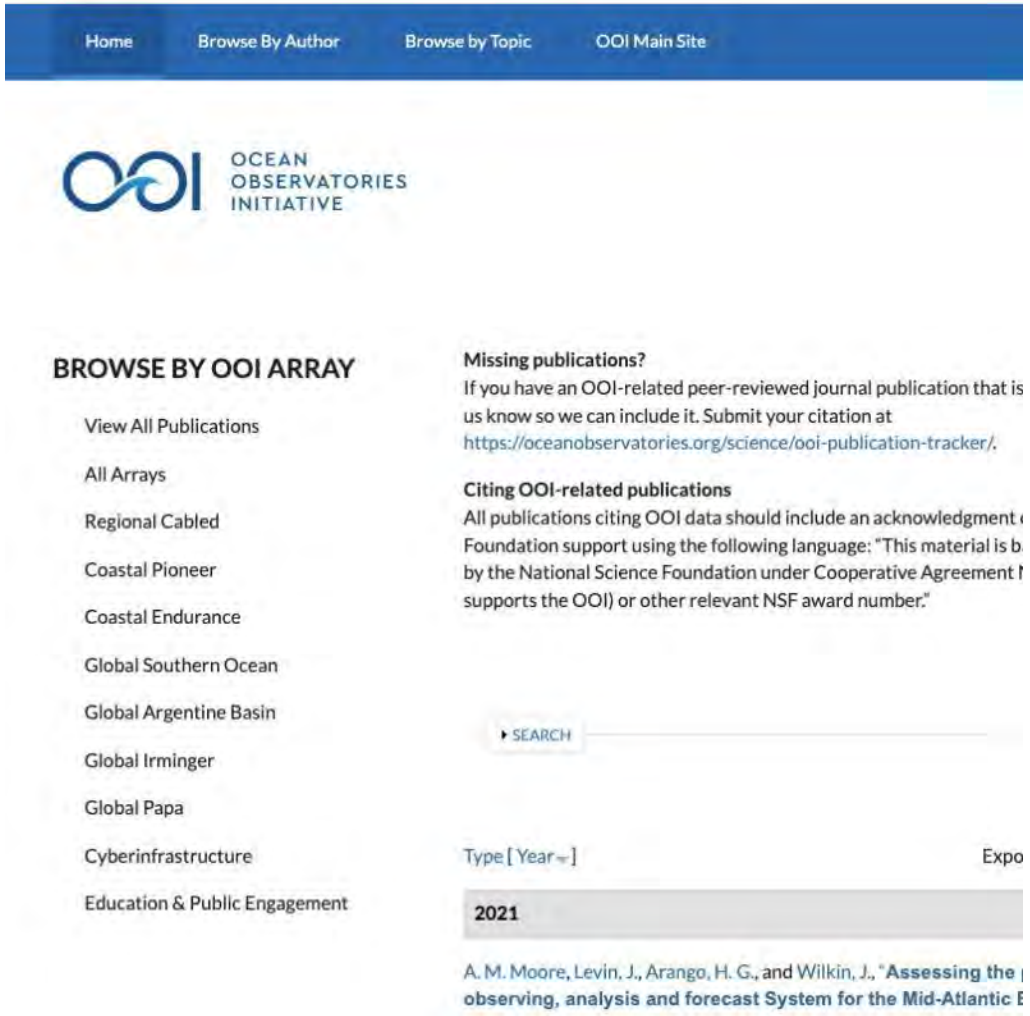
OOI Calendar 2021 Highlights

- Seven major deployment & recovery cruises
- Selection of new site for Coastal Pioneer Array
- New Data Center
- Expansion of data user community

Research Vessel *Nathaniel B. Palmer* services the OOI Array in the Southern Ocean. Photo credit: WHOI.

OOI Science Impacts thru 31 Dec 2021

- Track publications, citations, Altmetrics, and funding
- 231 OOI-related publications in refereed journals
  - 201 lead authors
  - 105 lead institutions
  - 22 countries
  - 5 continents
- 100 NSF awards using OOI data or infrastructure
  - $54.2m total
  - 75 lead PIs
  - 39 lead institutions



Why It Matters

Nature Climate Change: Increased risk of a shutdown of ocean convection

Nature Scientific Reports: Anomalous near-surface low-salinity pulses off the central Oregon coast

Nature Scientific Reports: Direct interaction between the Gulf Stream and the shelfbreak south of New England

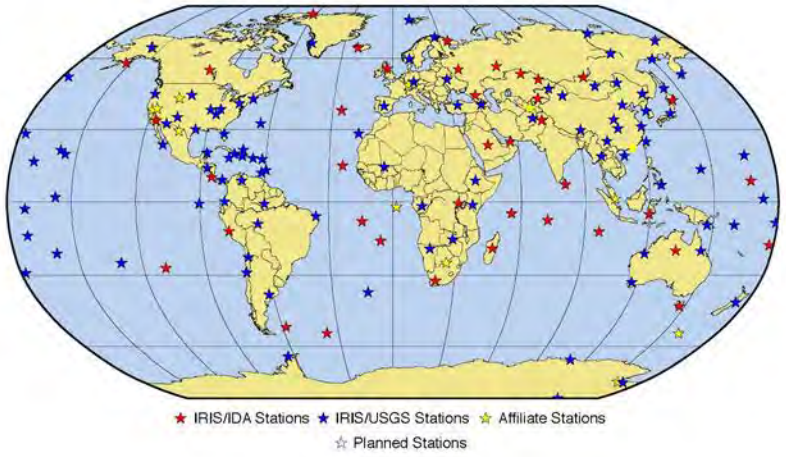
Science: Inflation-predictable behavior and co-eruption deformation at Axial Seamount

Nature Communications: The mechanism of tidal triggering of earthquakes at mid-ocean ridges

Wendy Bohon, Senior Science Communication Specialist, Incorporated Research Institutions for Seismology

- Wendy Bohon is a geologist who studies earthquakes and works to improve the communication of hazard and risk before, during and after rapid onset geologic hazards. She is currently the geologist and Senior Science Communication Specialist for the Incorporated Research Institutions for Seismology (IRIS).
- IRIS is a consortium of over 100 US universities dedicated to the operation of science facilities for seismological data, contributing to scholarly research, education, earthquake hazard mitigation, and verification of the Comprehensive Nuclear-Test-Ban Treaty.

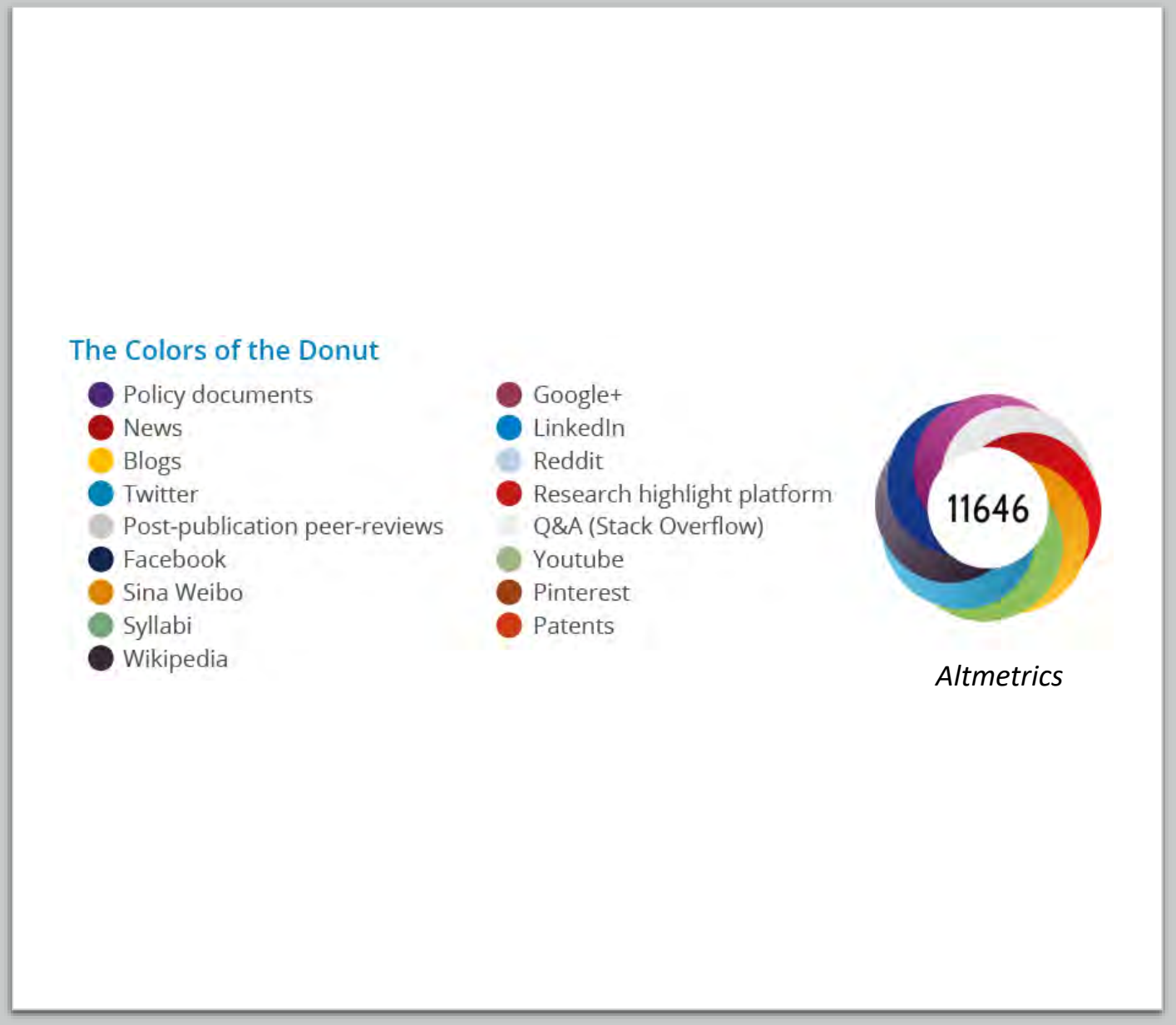
Global Seismographic Network



- IRIS operates Seismological Facilities for the Advancement of Geoscience (SAGE) facility on behalf of the NSF.

Altmetrics

- Altmetrics are metrics and qualitative data that are complementary to traditional, citation-based metrics. – *Altmetric*
- ***Give insight into how often scholarly work is used and discussed.***



Altmetrics

Incorporated Research Institutions for Seismology (IRIS)

Dr .Wendy Bohon, Senior Science Communication Specialist

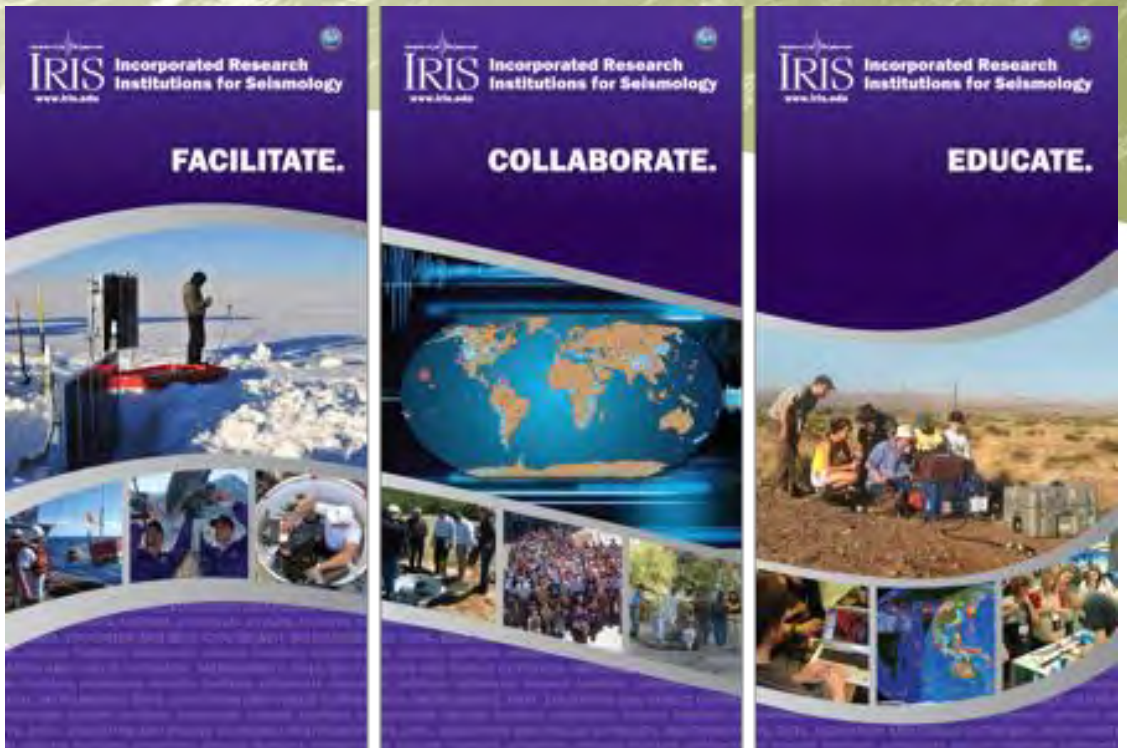
Seismic Facility for the Advancement of Geoscience

SAGE
National Science Foundation's
Seismological Facility for the Advancement of Geoscience

Operated by
IRIS

Directorates

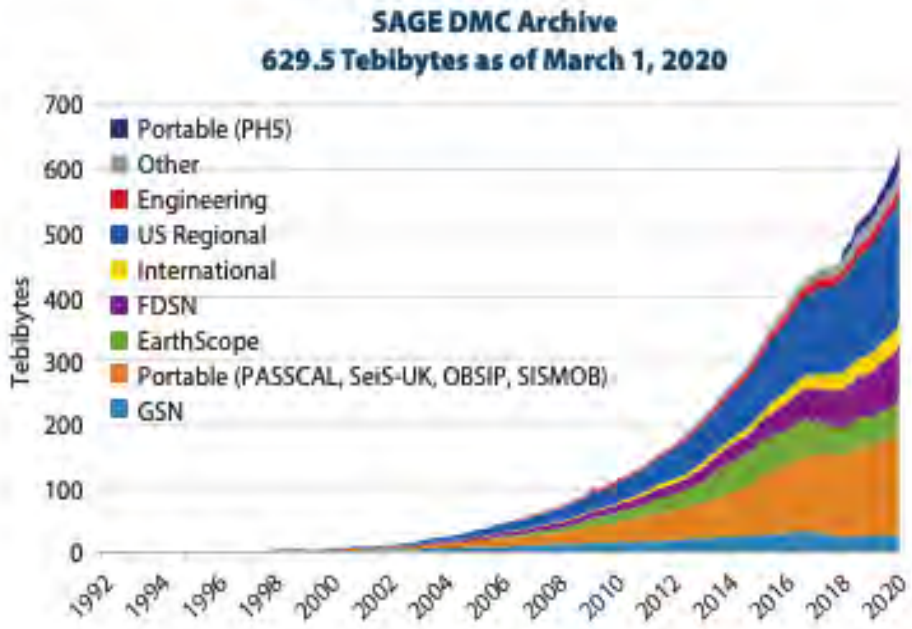
Data Services	• Data operations, information technology, databases, data quality control, data products, software engineering
Education and Public Outreach	• Education specialists, social media, outreach, communications (print, online, video)
Instrumentation Services	• Instrumentation, field engineering, instrument test and evaluation, communications, power systems, deployment technology, etc.

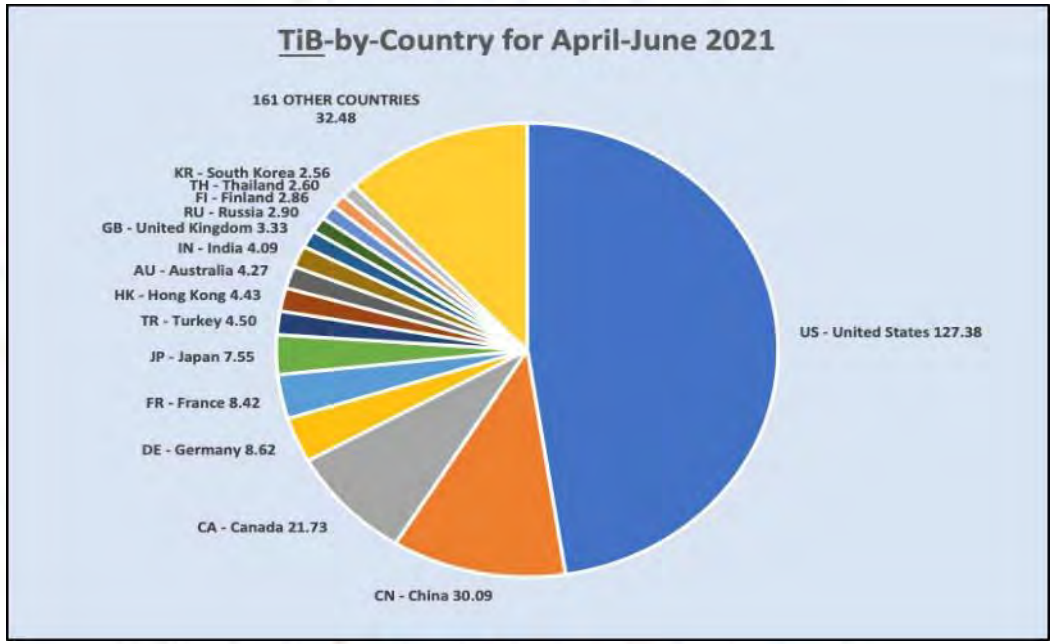


- Consortium of 125+ US universities dedicated to the operation of science facilities for the acquisition, management and distribution of seismic data.
- We manage the **NSF SAGE Facility** (*Seismological Facility for the Advancement of Geoscience*)

Data Services

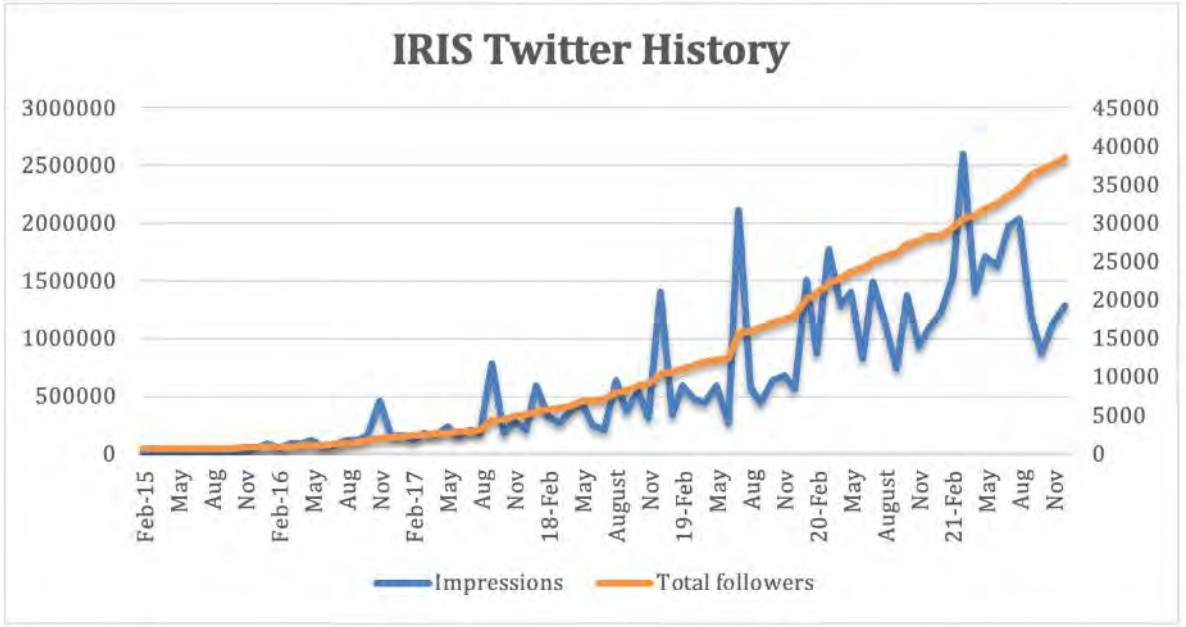
- Data Services offers services that Earth scientists rely on in 175+ countries.
- Data distribution is nearly one petabyte in volume annually

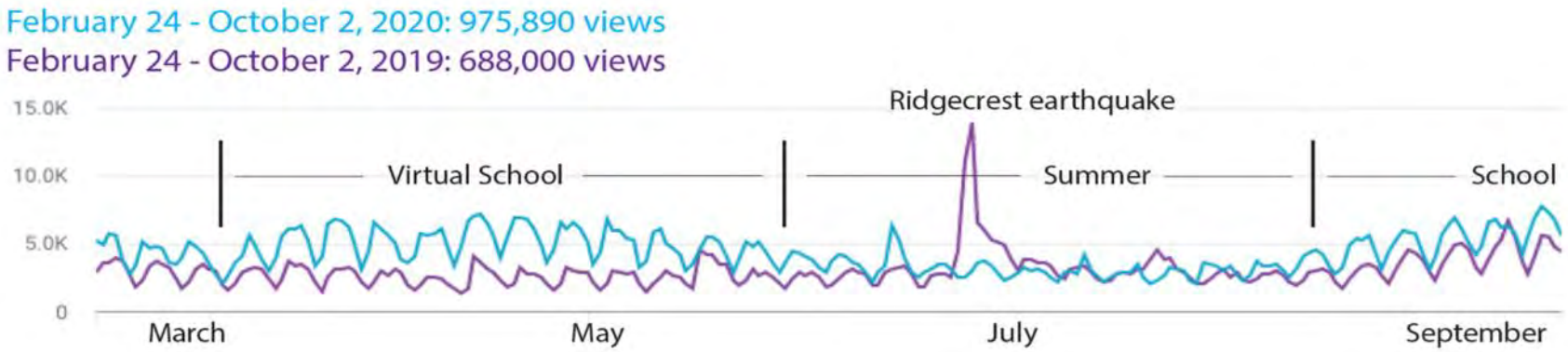




Education and Public Outreach

- Website and apps
  - 10.5 M views in 2021
  - 4k downloads
- Social Media
  - +25 M impressions
  - YouTube
    - 35.5k subscribers
    - 1.5+ million views
    - 63,000+ hours of watch time



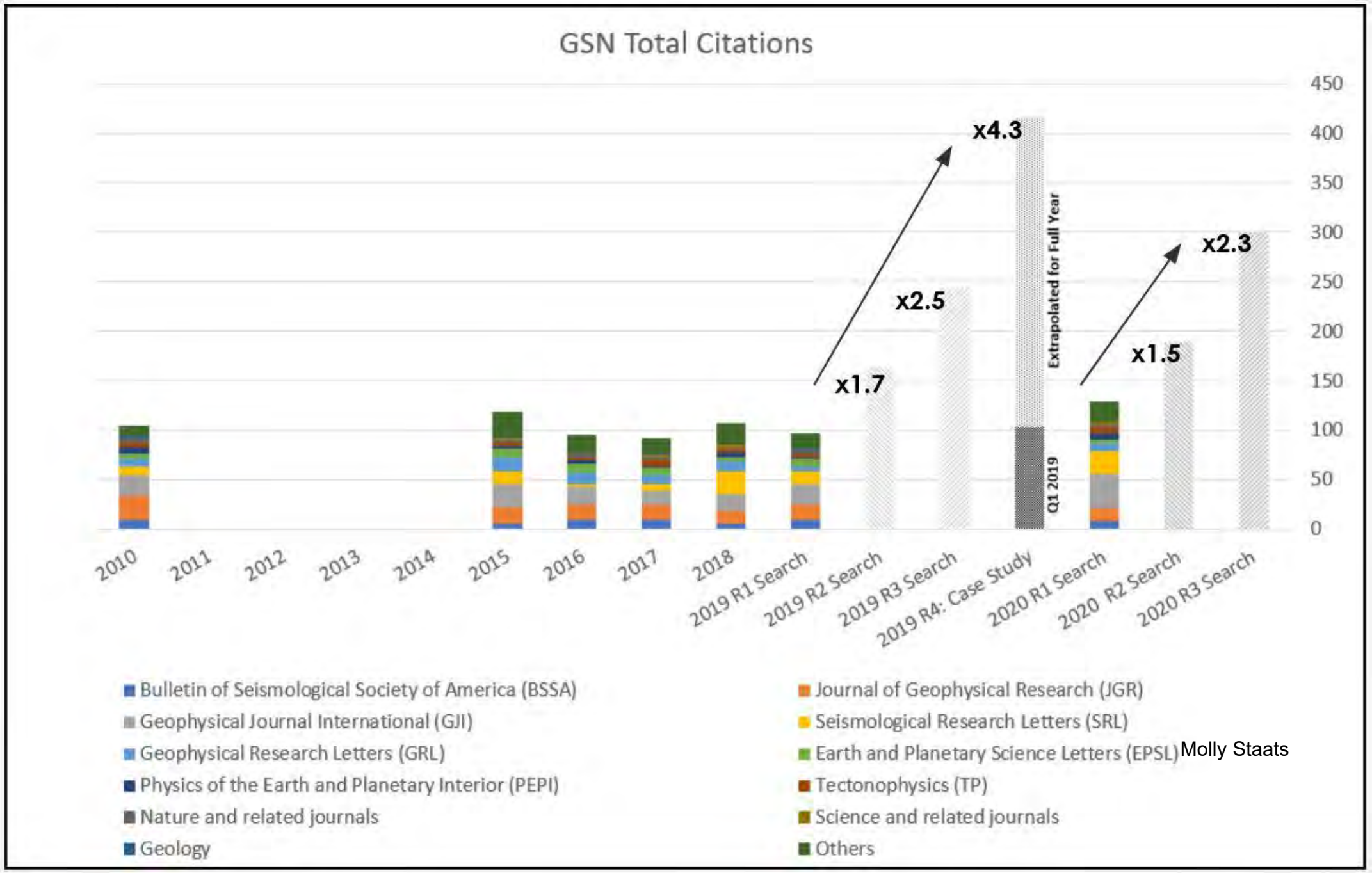


SAGE
National Science Foundation's
Seismological Facility for the Advancement of Geoscien

Instrumentation Services

- In an average quarter, ~30-40 new experiment starts, ~50 continuing
  - Experiment durations range from weeks to years
- 107 PI's and students were trained over the past year
- Current PASSCAL Instrumentation Inventory (roughly):
  - 1,000 Broadband Sensors
  - 310 Short period systems
  - 1,300 recording systems
  - 3,200 Nodal systems
  - 17 multi-channel systems
  - 1,500 geophones
  - 80 Polar rated Broadband sensors
  - 140 Polar rated Data Acquisition systems
  - 2 GPR systems
  - 6 MT systems and growing

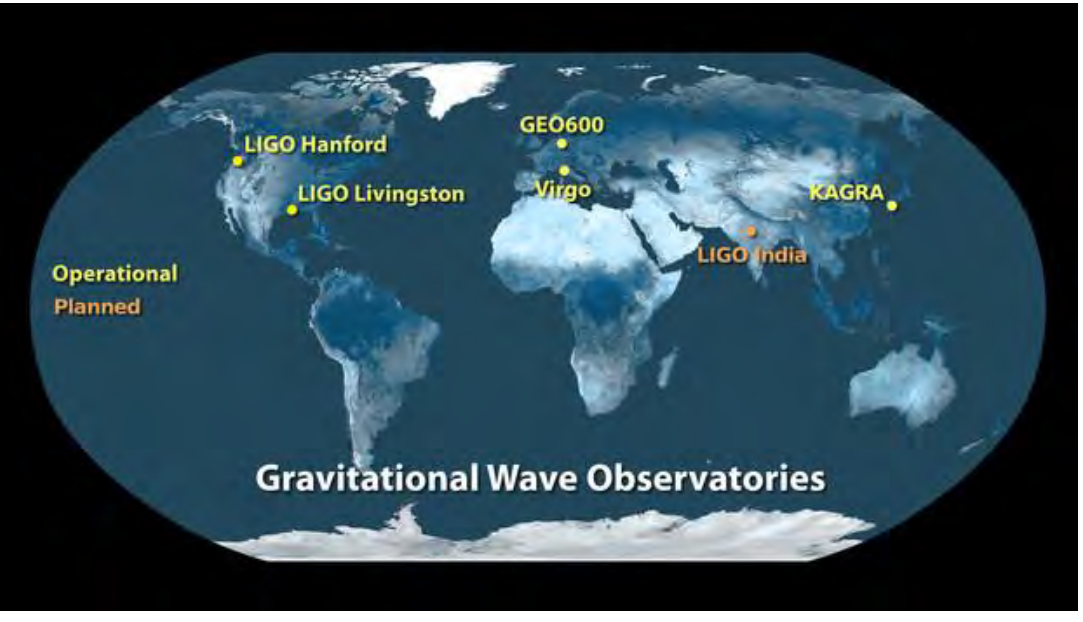
- Availability metrics roughly based on having ~75-80% of each of these either in use or ready to go
  - i.e. 20-25% are being revalidated/repaired after an experiment
- Most support science experiments, but significant portion of usage is for education (field classes)



Molly Staats

Albert Lazzarini, Deputy Director, Laser Interferometer Gravitational Wave Observatory Laboratory

- LIGO's mission is to open the field of gravitational-wave astrophysics through the direct detection of gravitational waves. LIGO detectors use laser interferometry to measure the distortions in space-time occurring between stationary, hanging masses (mirrors) caused by passing gravitational waves.
- LIGO is funded by the U.S. National Science Foundation and operated by the California Institute of Technology and MIT.



- LIGO's advanced detectors also received financial support for their construction from Australia, Germany, and the United Kingdom. LIGO detectors are available for use by members of the LIGO Scientific Collaboration (LSC), comprising researchers in partner institutions around the world.

Advanced LIGO: A Detection Machine

Science Metrics

Albert Lazzarini
Deputy Director, LIGO Laboratory
California Institute of Technology

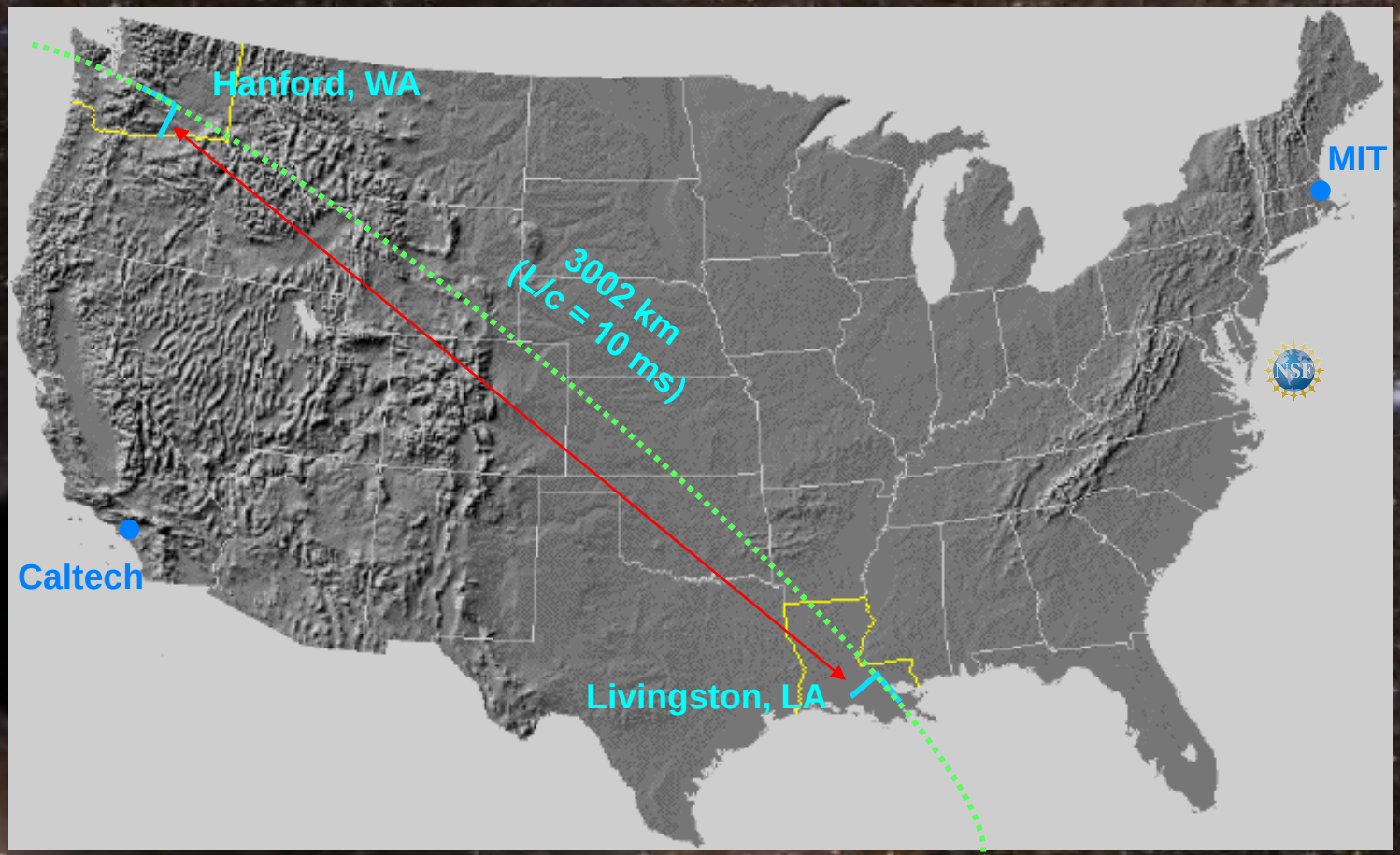
NSF Large Facilities Workshop: Science Metrics
16 February 2022 (remote meeting)

SXS Image: of Merger of GW150914

LIGO

LHO, LLO interferometer arms are parallel and are approximately aligned along the great circle connecting the sites

The LIGO Laboratory Sites

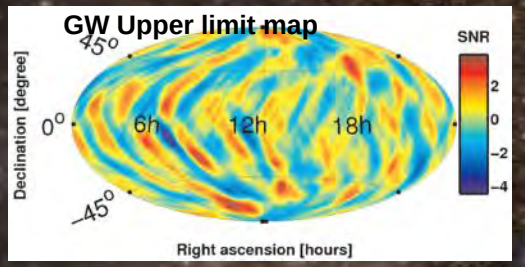


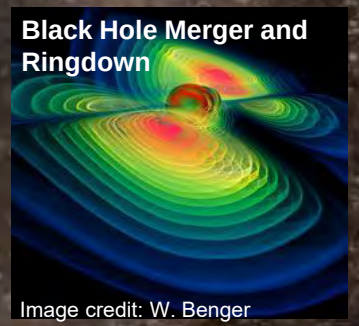
Jointly built and operated for the U.S. National Science Foundation by Caltech and MIT under a Cooperative Agreement

LIGO Addresses Fundamental Questions in Physics and Astronomy

LIGO is the world's leading facility for conducting gravitational-wave science.

- Fundamental Physics
  - Is General Relativity the correct theory of gravity?
    - Wave propagation speed (delays in arrival time of transients)
    - Spin character of the radiation field (polarization of radiation from CW sources)
    - Are black holes really characterized by only mass and spin?
  - How does matter behave under extreme conditions?
    - Determine the matter equation of state nuclear densities
- Astrophysics, Astronomy, Cosmology
  - Do compact binary mergers cause GRBs?
  - What is the supernova mechanism in core-collapse of massive stars?
  - How many low mass black holes are there in the universe?
  - Do intermediate mass black holes exist?
  - How bumpy are neutron stars?
  - Can we observe populations of weak gravitational wave sources?
  - Can binary inspirals be used as "standard sirens" to measure the local Hubble parameter?





LIGO Science Metrics

- Demographics
  - Building the future scientific workforce
  - Education and Public Outreach

- Scientific reach
  - When LIGO is observing
  - Space-time volume explored
    - Up time
    - Sensitivity
  - Number of detections
  - Open data

LIGO Science Metrics
Building the scientific workforce

- LIGO is embedded in the physics and astronomy departments of Caltech and MIT
  - 7 faculty are affiliated with LIGO Laboratory
  - Rich environment for students and postdoctoral scholars
  - The two observatories also mentor several Caltech or MIT postdoctoral scholars at any given time
- Since the 1990s:
  - 36 Graduate students; 33 went on to postdoctoral positions, 3 took jobs in industry
    - 20 students currently
  - 92 postdoctoral scholars
    - 31 now in faculty positions,
    - 35 staff scientists,
    - 20 in industry
- Summer REU/Undergraduate Research Fellowships (~ 20-30 per summer)
  - Historically has been a pipeline to graduate students and postdoctoral scholars

LIGO Science Metrics
Education and Public Outreach

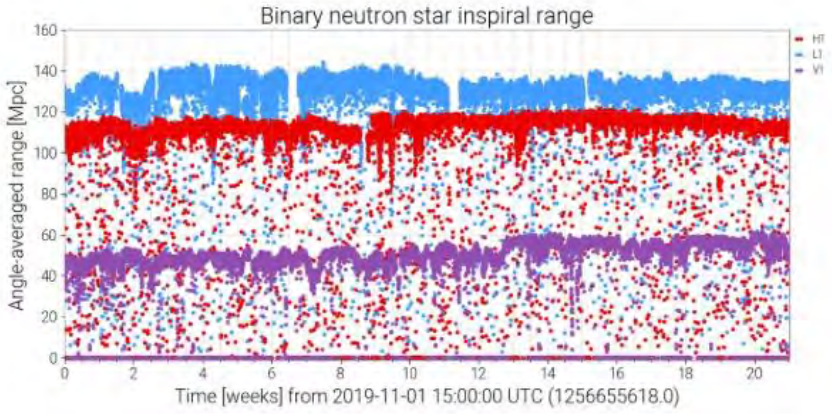
- LIGO in Louisiana has had a Science Education Center (SEC) for ~ 15 years
  - Partnerships with local HBCUs
- LIGO in Washington received funding for a LIGO Exploration Center (LExC)
  - Inauguration: May 2022
  - Working to formalize docent program with local minority-serving colleges
- Assess impact by tracking:
  - Number of visitors who come to the outreach center(s)
    - During pandemic: virtual tours and activities
  - Open-house events and activities/programs
  - Teacher professional development (PD) contacts
  - Conference presentations and/or publications on the LIGO EPO program
  - Teacher PD and Docent programs are evaluated using surveys and interviews

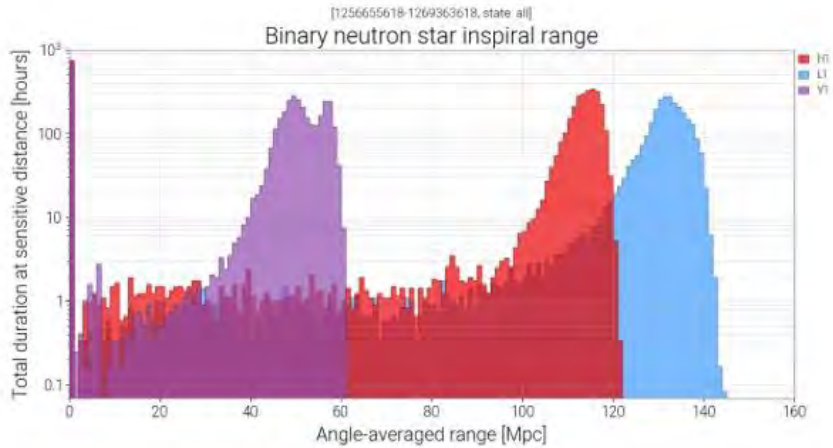
LIGO Science Metrics
Science Reach

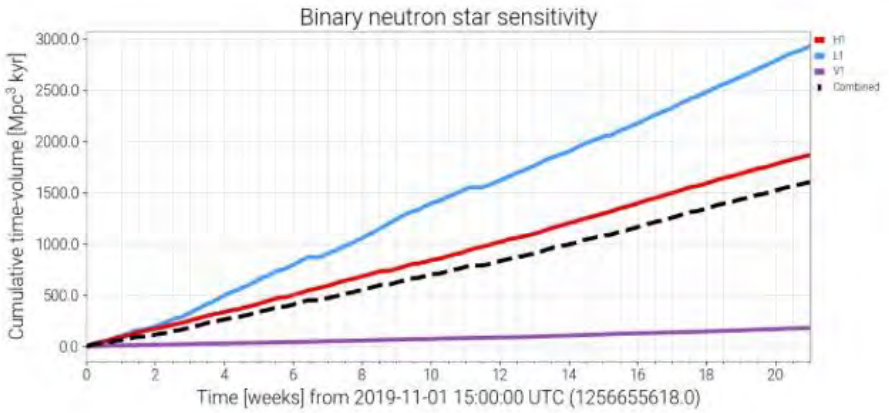
- Observing time – up time/duty cycle

LIGO Science Metrics
Science Reach

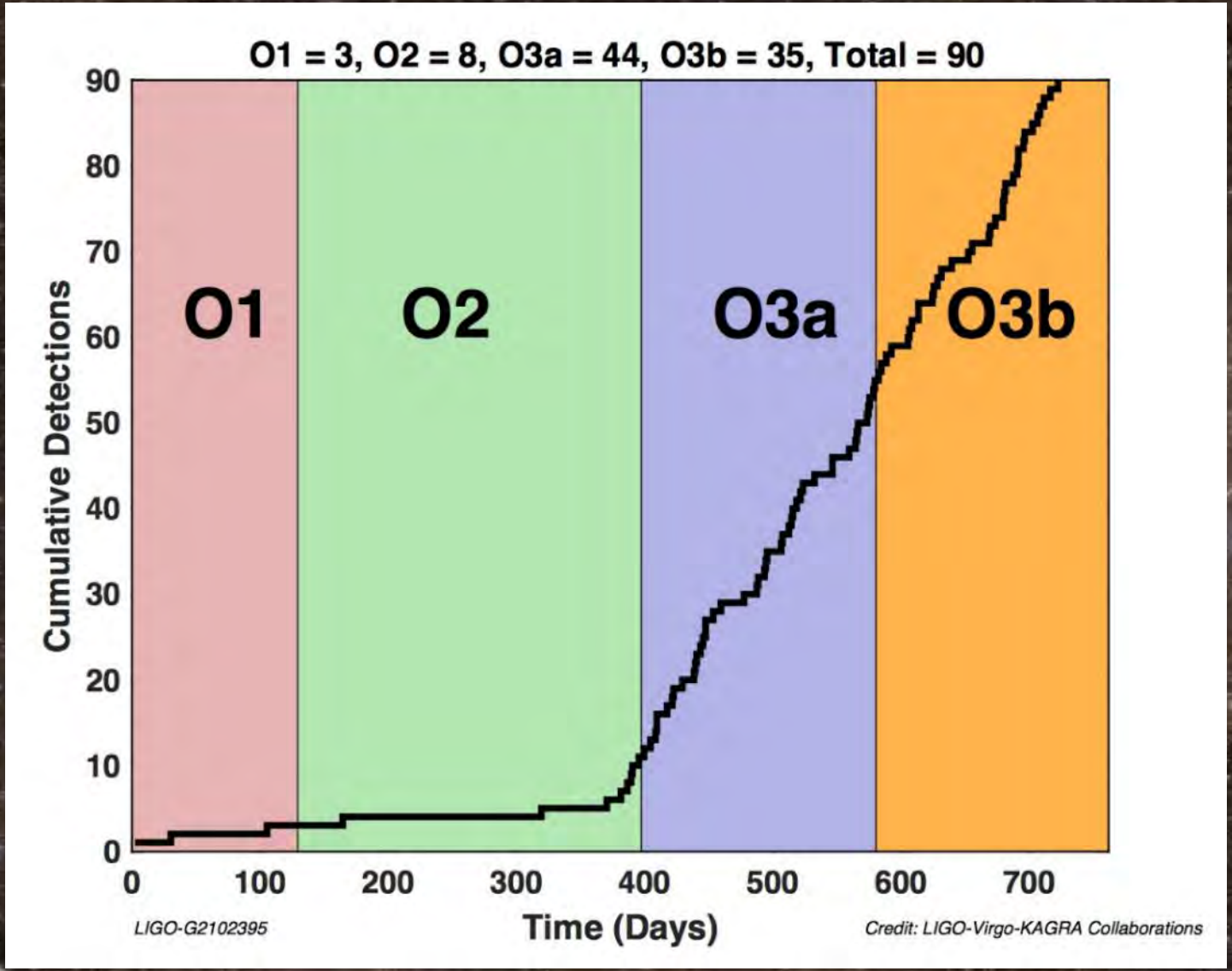
- Sensitivty => range
- Event rate ~ (Range)^3 X (Observing time)







Instrument improvements dramatically affect event rates



LIGO

Gravitational Wave Open Science Center

Data Software Online Tools About GWOSC

The Gravitational Wave Open Science Center provides data from gravitational-wave observatories, along with access to tutorials and software tools.

LIGO Hanford Observatory, Washington
(Credits: C. Gray)

LIGO Livingston Observatory, Louisiana
(Credits: J. Giaime)

Virgo detector, Italy
(Credits: Virgo Collaboration)

- **O3b Bulk Data Now Available**
- **GWTC-3 Catalog Data Now Available**
- **Start with a Learning Path**
- **Browse the Event Portal**
- **Download data**
- **Join the email list**
- **Open Data Workshops**
- **Attend Office Hours**

Ultimate scientific impact …

The conceptualization and construction of LIGO and its achievements were recognized in December 2017 by the Nobel Prize in Physics being awarded to the 3 scientists who led the effort to realize the dream. They were young men when they embarked on their life's adventure to make LIGO a reality

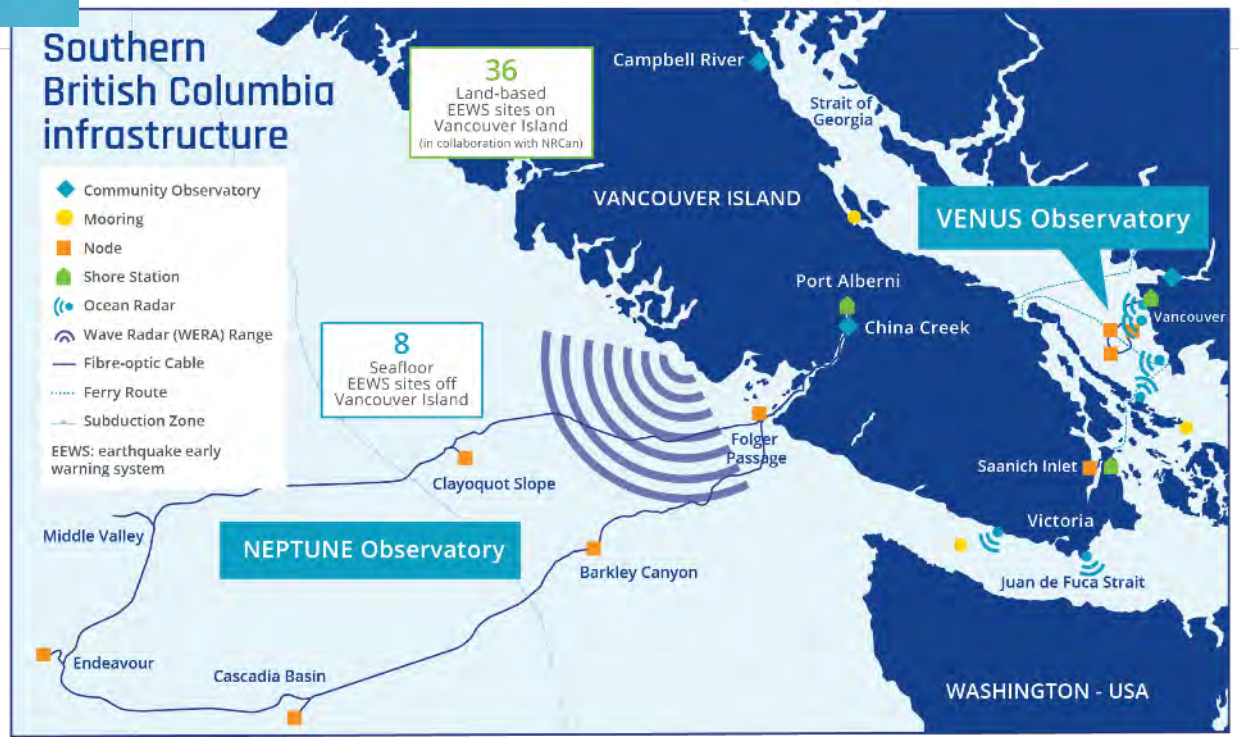
Daniela Loock, Director, Corporate Services & **Benoît Pirenne**, Director, User Engagement, Ocean Networks Canada

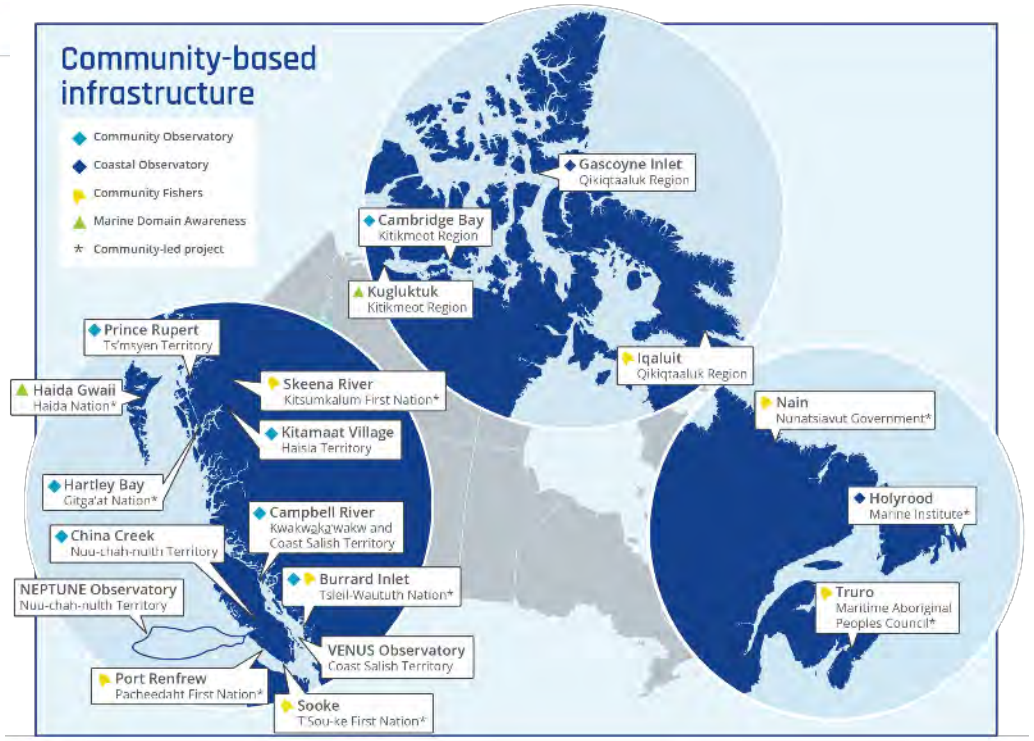
- Dr. Loock is responsible for ONC's strategic and operational framework and organizational policies. She leads Corporate Services, Learning & Community Engagement and Communications.

- Benoît Pirenne is Ocean Networks Canada Director, User Engagement, in charge of delivering services to scientists, society and industry and reporting to our funders.

- ONC's subsea observatories collect data via cabled, mobile and community networks. Our infrastructure supplies Internet connectivity to thousands of instruments up to 300 kilometres offshore, to depths of 2,660 metres.
- ONC's national coastal community observatory program, developed in collaboration with Indigenous communities and other partners, supports coastal monitoring, ocean citizen science, and youth training.

Ocean Intelligence for Science, Society and Industry

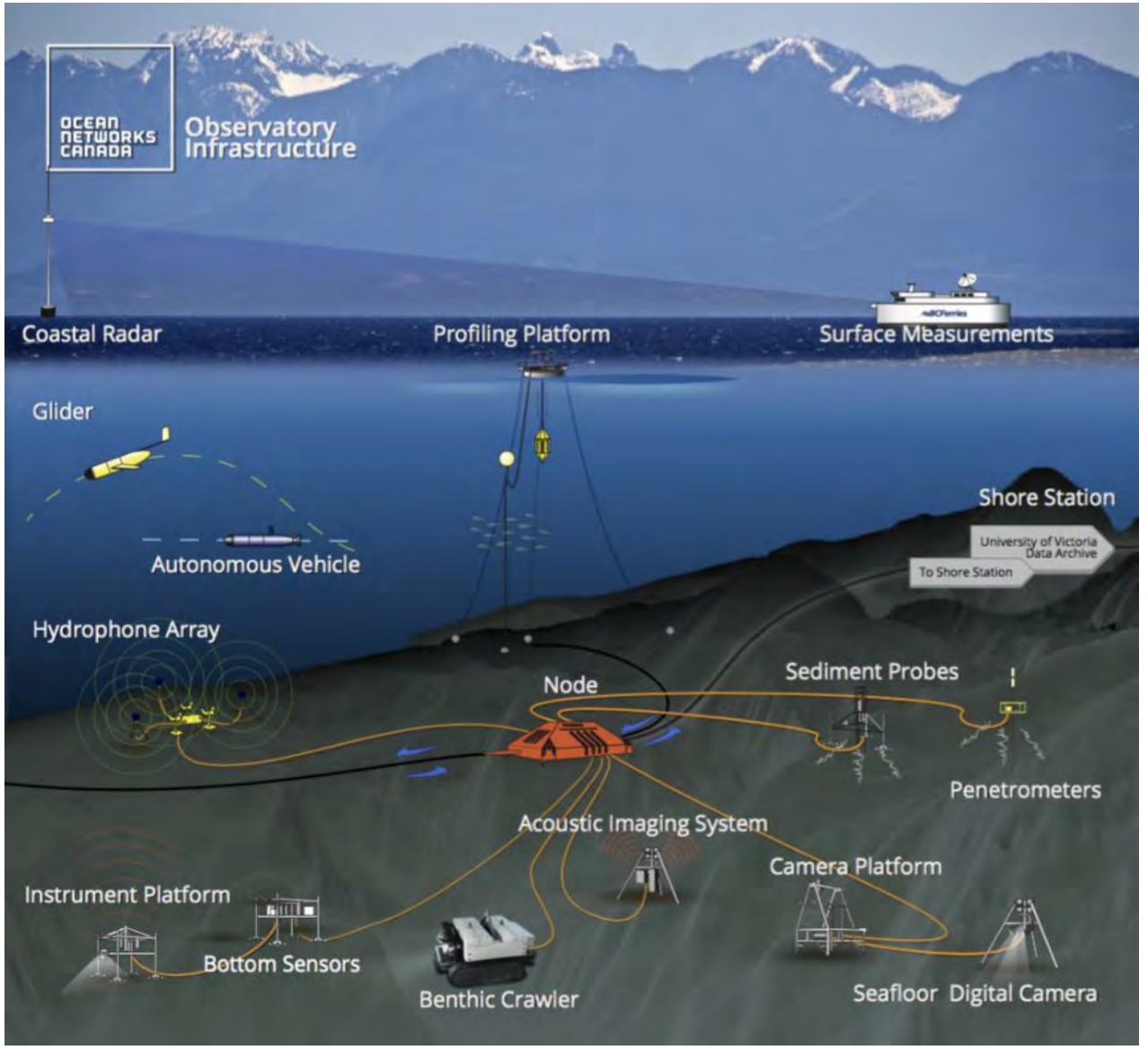




- ONC's is a Major Science Initiative funded at 60% by the Canada Foundation for Innovation
- Match funding is primarily provided by the Government of Canada, the Government of British Columbia and the University of Victoria
- Three key 2030 Strategic Objectives: Advance ocean observing; Develop and deliver data and ocean intelligence products and services; Enable ocean-based solutions for climate mitigation

Ocean Intelligence for Science, Society and Industry

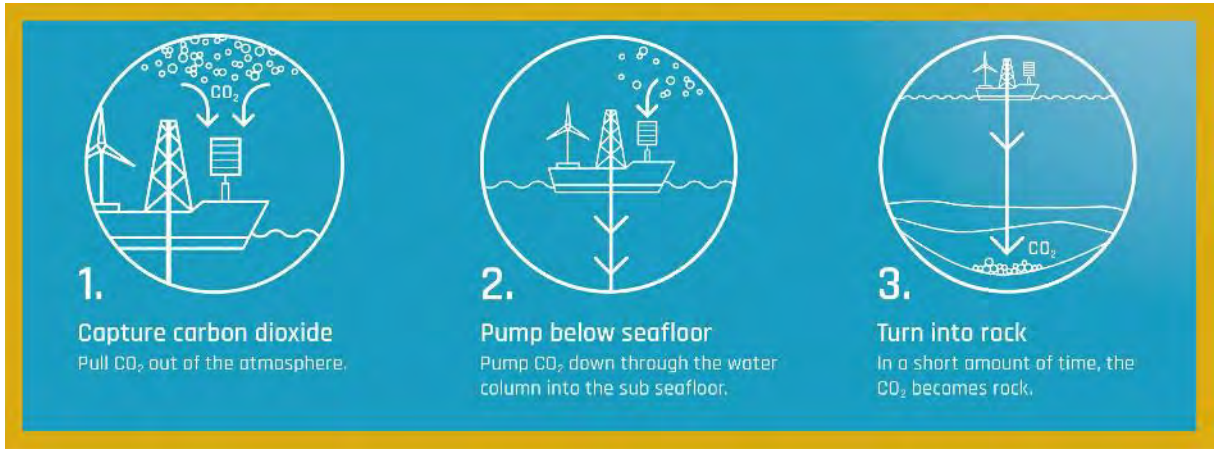
- Understanding human-induced change in the Ocean
- Life in the Ocean
- Interconnections among the seafloor, ocean, atmosphere and universe
- Seafloor and sediment in motion
- Marine Natural Hazards
- Ocean Big Data
- Pairing Indigenous approaches and scientific methods for ocean research

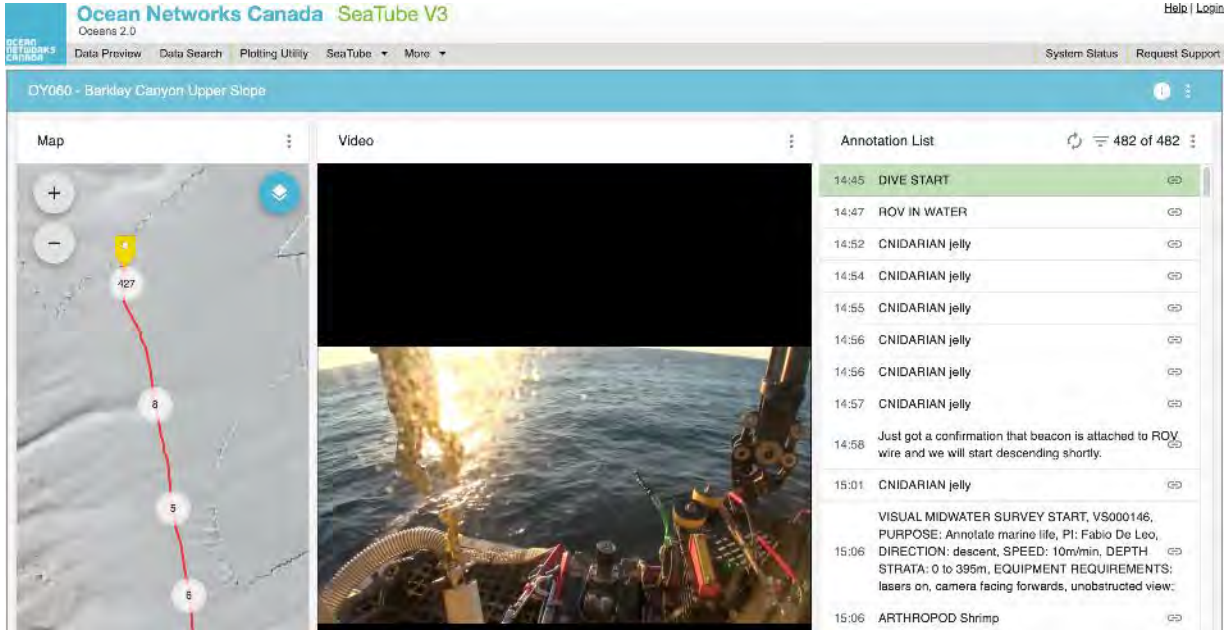


Ocean Intelligence for Science, Society and Industry

For Society and Industry:

- Public safety products
- Marine safety
- Value-added data management
- Technology acceleration



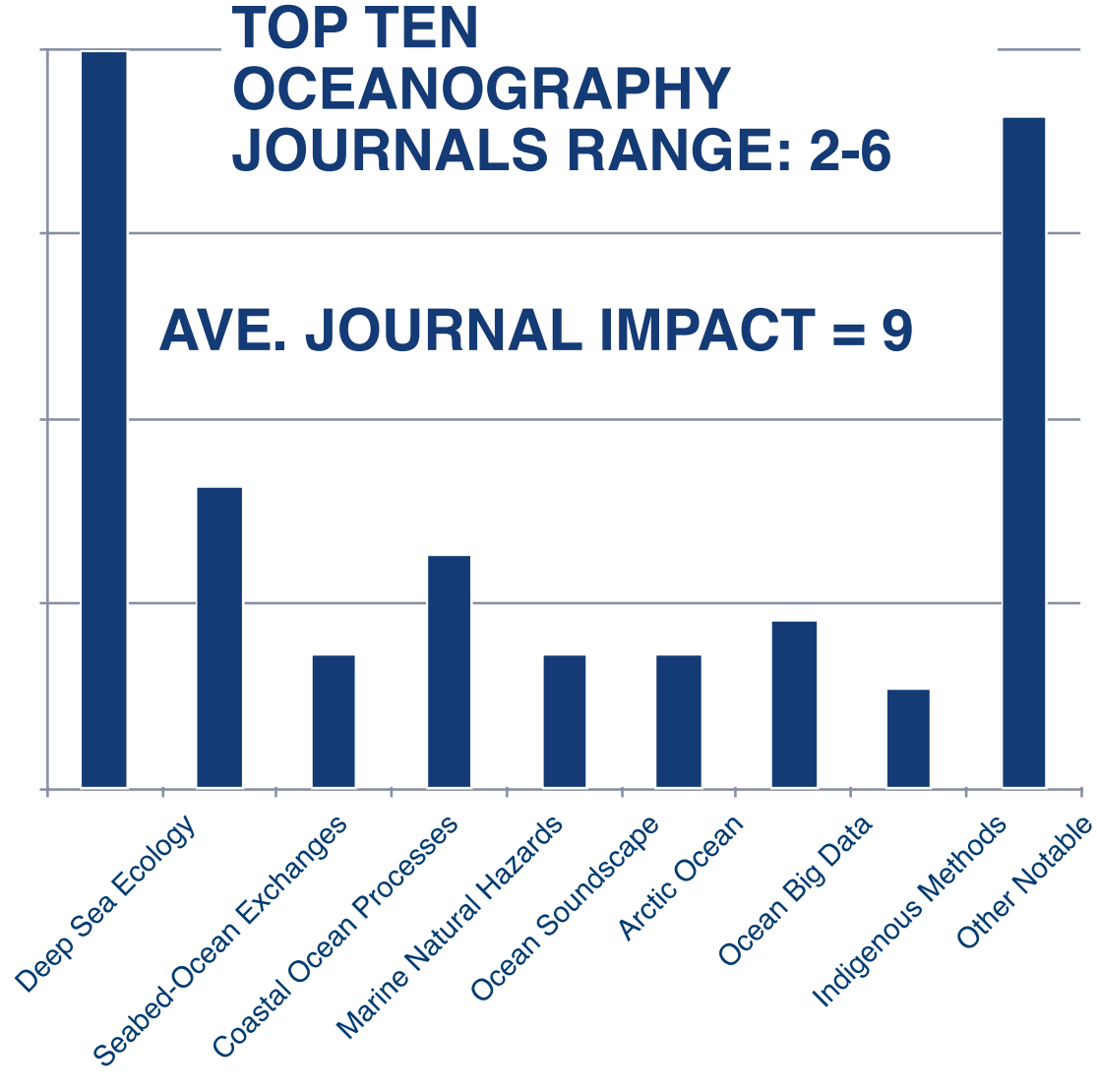


Standard Indicators

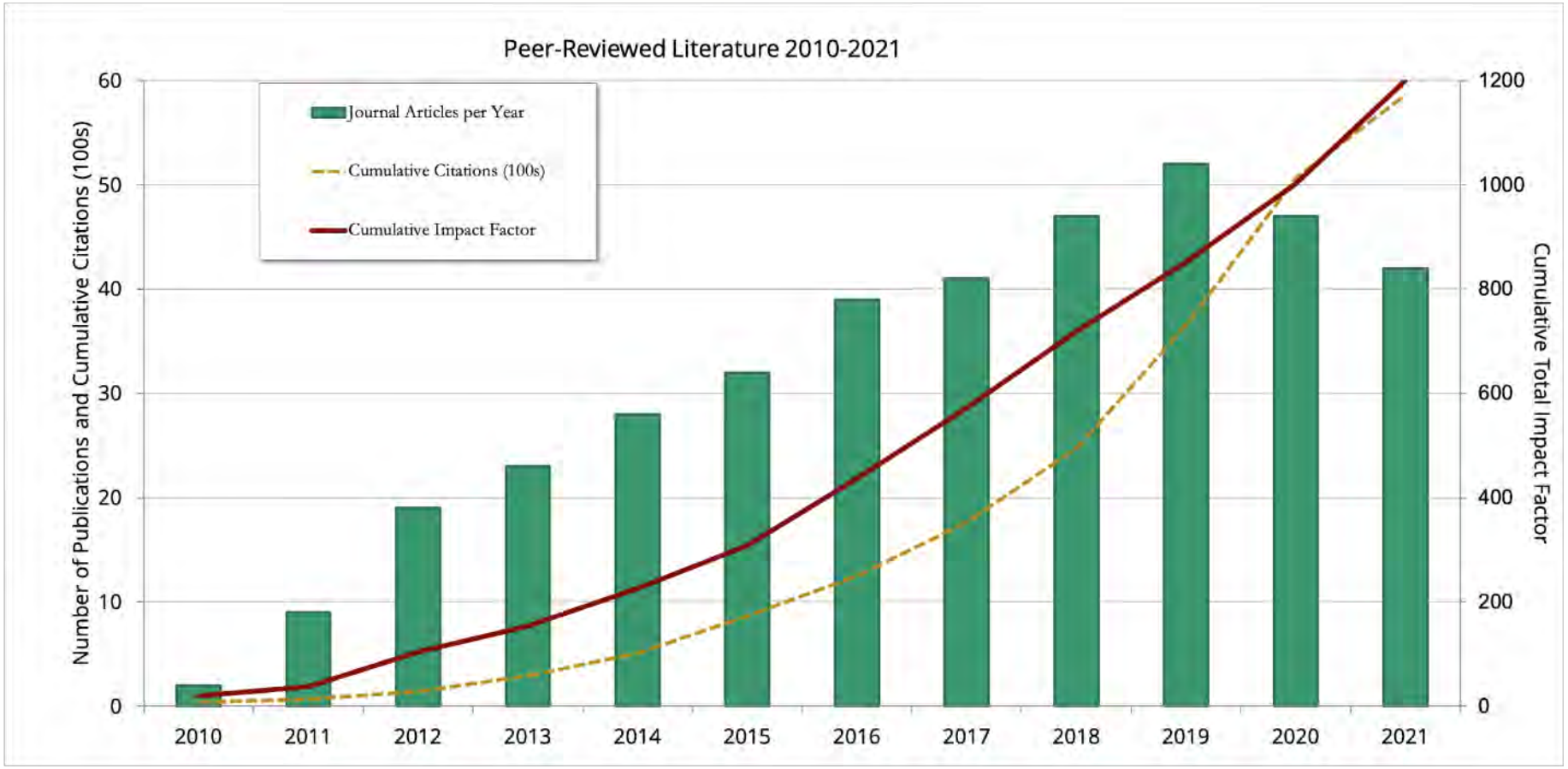
Standard Indicator Common	FY 20/21
Advancement of Research & Knowledge Transfer	130
Highly Qualified Personnel	3,152
Technology Transfer	42
User Access to the Facility	19,524
Optimal Use	56
Level of User Satisfaction	91%

Standard Indicator Facility-specific	FY20/21
Facility Reliability	86%
Active Collaborations	99
Informing Policy Development in Canada	300
Indigenous Community Engagement	36

Scientific Excellence



Science Metrics



- Publications referring to Ocean Networks Canada are collected using a combination of tools
- Distinguished between peer-reviewed, conference contribution, thesis, etc.

Ocean Networks Canada

ONC BY THE NUMBERS*

50+
instrumented sites

9,000+
ocean observing sensors

900+
km of seafloor backbone cables

105
earthquake early warning sensors

7
mobile instrument platforms

350+ GB
data collected per day

19,524
Oceans 2.0 total users

305+
data product formats

9
cabled community observatories

19
community-based monitoring programs

37
active Indigenous partnerships

$500M
total investment in infrastructure

3,152+
highly qualified personnel trained

160
high-tech jobs

172
scientific contributions

125
schools (K-12) engaged

Continuous open data **24/7/365**
15 years of data (and growing)

*For fiscal year 2020/2021

Mitch Malone, Director, JOIDES Resolution Science Operator, Texas A&M University

- The *JOIDES Resolution* (JR) is a research drilling vessel that collects sediment and rock cores, makes measurements below the seafloor, and installs long-term subseafloor observatories, providing scientists access to arguably the best and most continuous records of the last ~150 million years of Earth history. The IODP science plan addresses four broad themes: climate, deep life, planetary dynamics, and geohazards.
- The JR's complement can consist of 50 scientists and technicians and 65 crew members. The JR's science party is specific to each mission, with skills and science disciplines chosen especially to best achieve the mission's goals, sourced from the 22 nations in the IODP collaborative.

The *JOIDES Resolution* departing Honolulu, Hawaii

- *JOIDES Resolution*: JOIDES is an acronym for the Joint Oceanographic Institutions for Deep Earth Sampling, which was the original partnership of universities that sought to explore the geology beneath the ocean floor. "Resolution" is named after the *HMS Resolution,* one of the exploration vessels used by Capt. James Cook. The JR has been dedicated to its science mission since 1985.

JR-IODP Science Impact Metrics

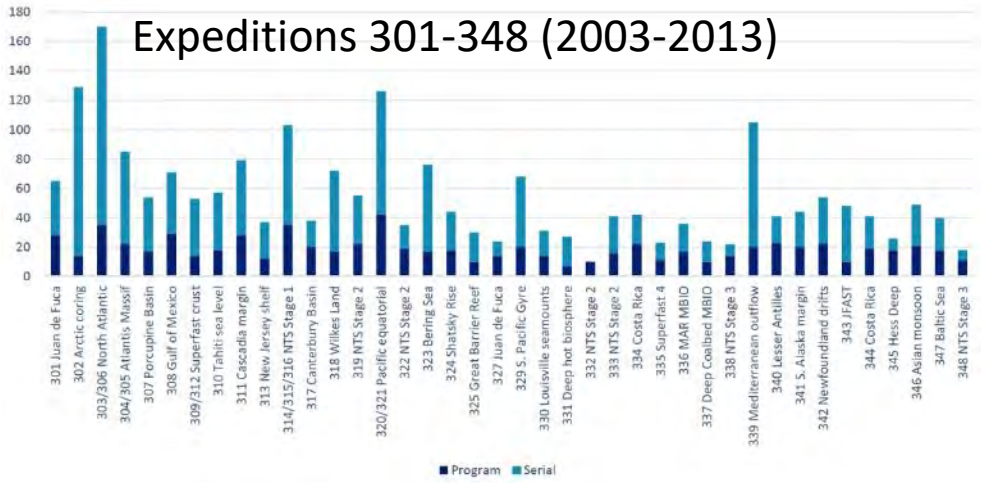
- Science impact metrics: Expeditions and Facility/Program
  - Produce a Scientific Ocean Drilling Bibliographic Database via a subscription with American Geosciences Institute (link available our web site)

  - Number of publications/expedition
  - Number of citations/expedition publications
  - Program or Facility publications in high impact journals
  - Altmetrics: more recently added to provide a measure of impact in news and social media

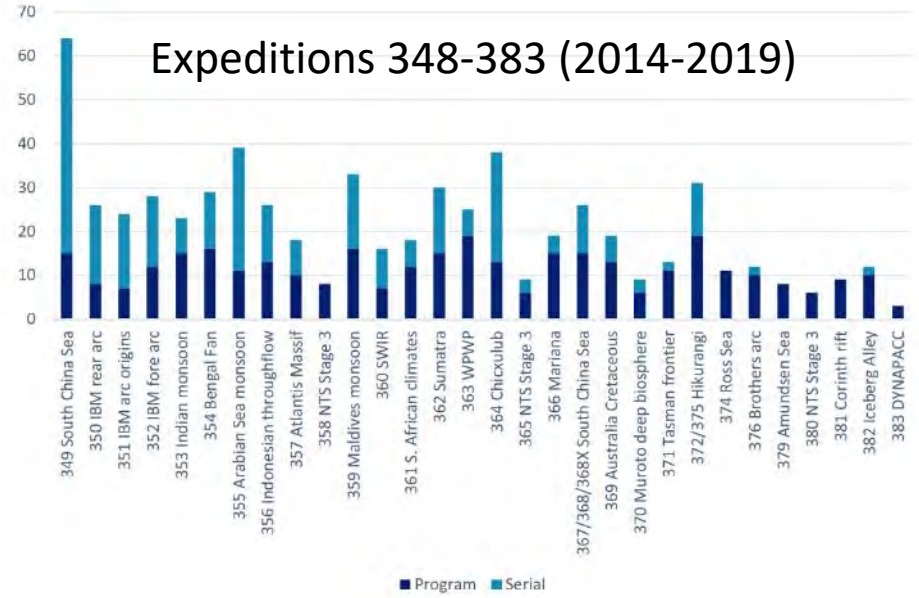
- Annual Report
  - Scientific Ocean Drilling Bibliographic Database and Publication Impact Report http://iodp.tamu.edu/publications/reports.html

JR-IODP Science Impact Metrics

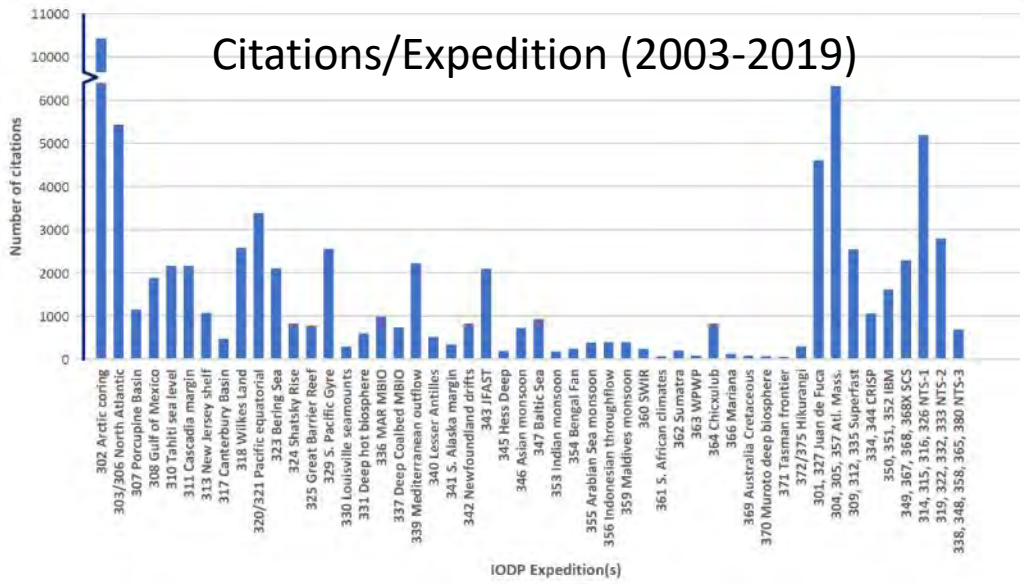
Expeditions 301-348 (2003-2013)

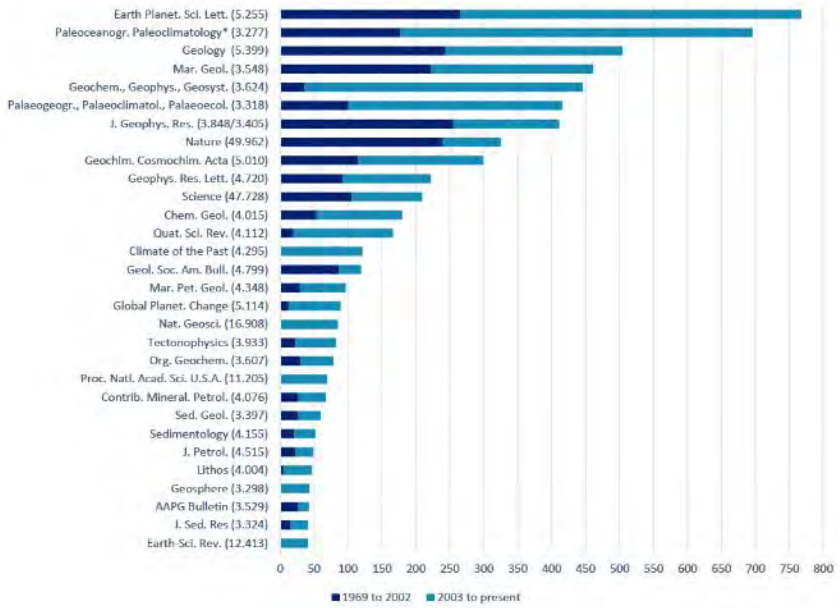


Expeditions 348-383 (2014-2019)



Citations/Expedition (2003-2019)





Kirsten Ruiz, Director, Field Science for the National Ecological Observatory Network

- As Director of Field Operations, Kirsten Ruiz is responsible for managing the instrument maintenance, execution of field sampling, and laboratory operations in each of the National Ecological Observatory Network's (NEON) twenty domains.
- NEON is a continental-scale observation facility operated by Battelle and designed to collect long-term open access ecological data to better understand how U.S. ecosystems are changing. NEON monitors ecosystems across the United States. Freshwater ecosystems include streams, rivers, and lakes while terrestrial ecosystems span from deserts to tropical forests.
- NEON operates 81 field sites strategically located across 20 ecoclimatic Domains across the United States, including 47 terrestrial field sites and 34 freshwater aquatic field sites. When logistically possible, aquatic and terrestrial sites are colocated to support understanding of linkages across terrestrial and aquatic ecosystems and their interactions with the atmosphere.

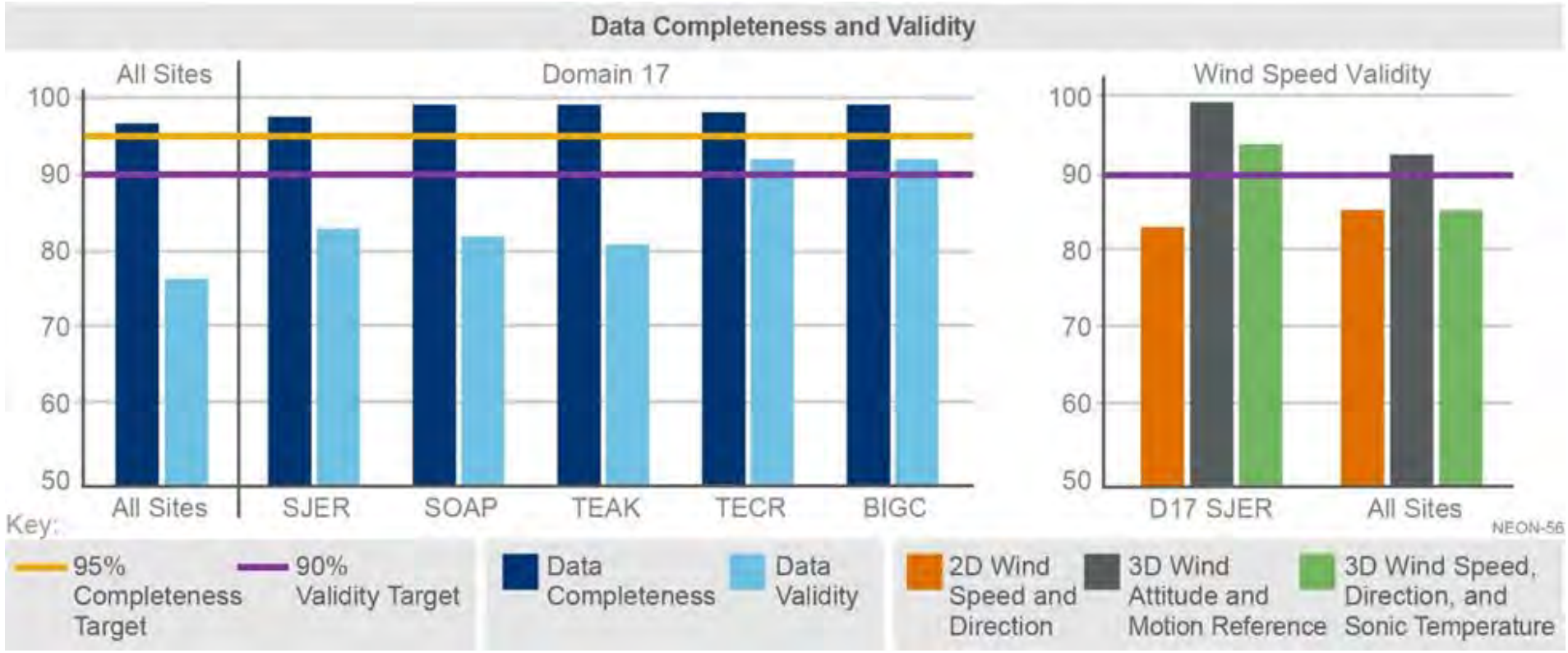
NEON field sites and ecoclimatic Domains

NEON and Science Metrics

NEON field sites and ecoclimatic Domains

- Outcomes from use of NEON data (and samples)
- Outcomes of NEON-supported interactions
  - On NEON data use
  - On participants science and data skills
- Supported by measures of
  - Data quality (validity, completeness) and latency
  - Diversity of users
  - Community satisfaction

NEON and Science Metrics



Herzberg Astrophysics

Dennis Crabtree, Director Emeritus, Dominion Astrophysical Observatory

- Dennis Crabtree is Director Emeritus at the Dominion Astrophysical Observatory. He uses bibliometrics as a tool for evaluating the performance of astronomical observatories and maintains a database of refereed publications from almost 30 telescopes.
- He has worked at the Gemini Observatory and the Canada-France-Hawaii Telescope (twice!)
- The Dominion Astrophysical Observatory (DAO) offers capabilities in optical imaging, spectroscopy and spectropolarimetry, and currently operates two research telescopes: the 1.8-metre Plaskett Telescope and the 1.2-metre telescope, which features the high-resolution McKellar spectrograph.

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Observatory Bibliometrics

- Papers in refereed journals are *the key product* modern observatories produce
  - Papers represent their contributions to knowledge (and justifies their operating budgets)
- Increased demand for accountability
  - Significant budgets required to construct and operate modern observatories
  - Number and impact of scientific results used to justify the budgets
- Publication statistics are of interest to Boards, funding agencies/foundations, …
- The # of publications is a measure of the productivity of an observatory
  - But how relevant/important is the work?
- Citation counts are a standard measure of the impact of paper, i.e., the more citations the more relevant the work
- The # of citations is a measure of the impact of an individual paper
  - Aggregated citation counts are a measure of an observatory's impact

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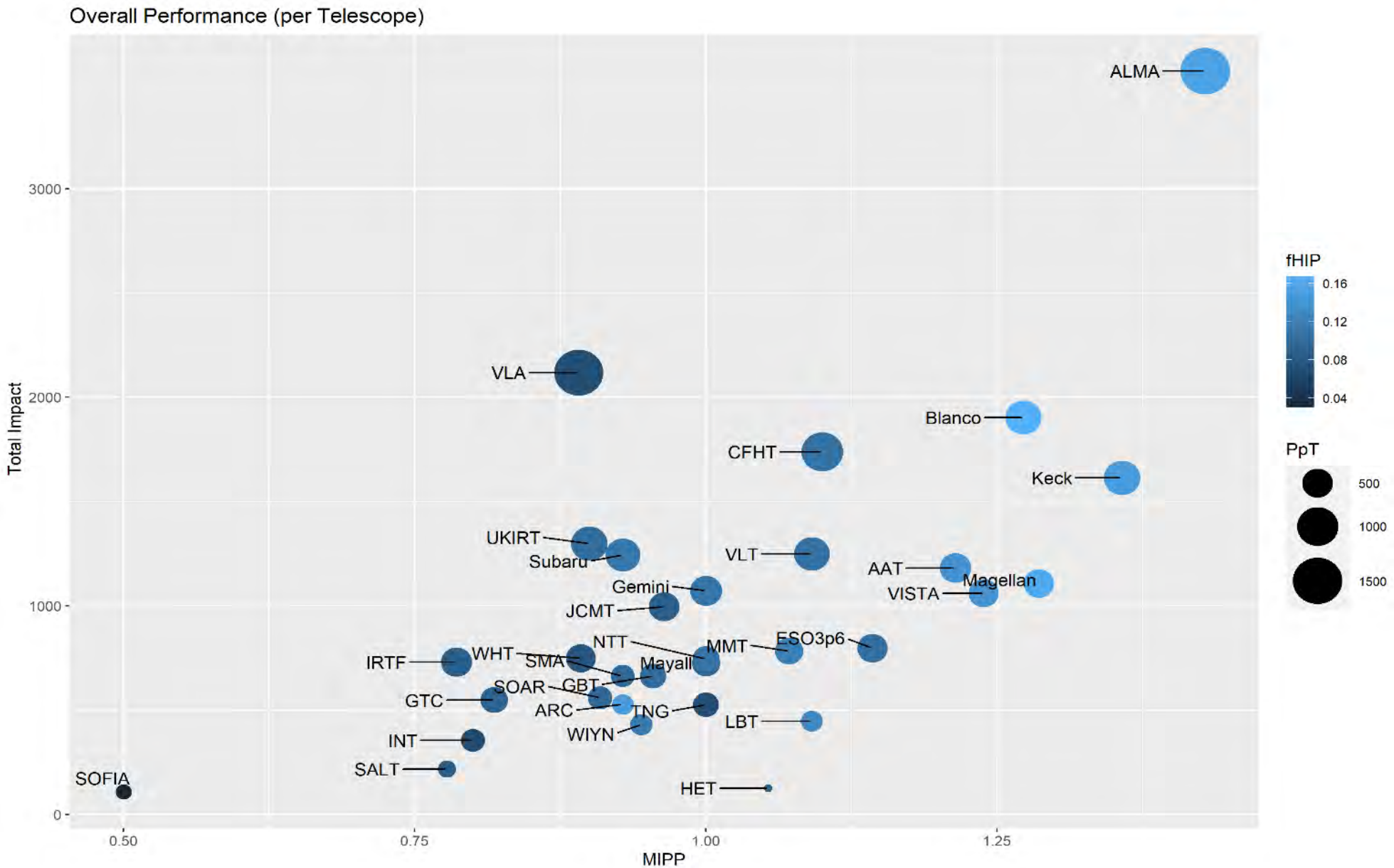
Observatory Science Performance



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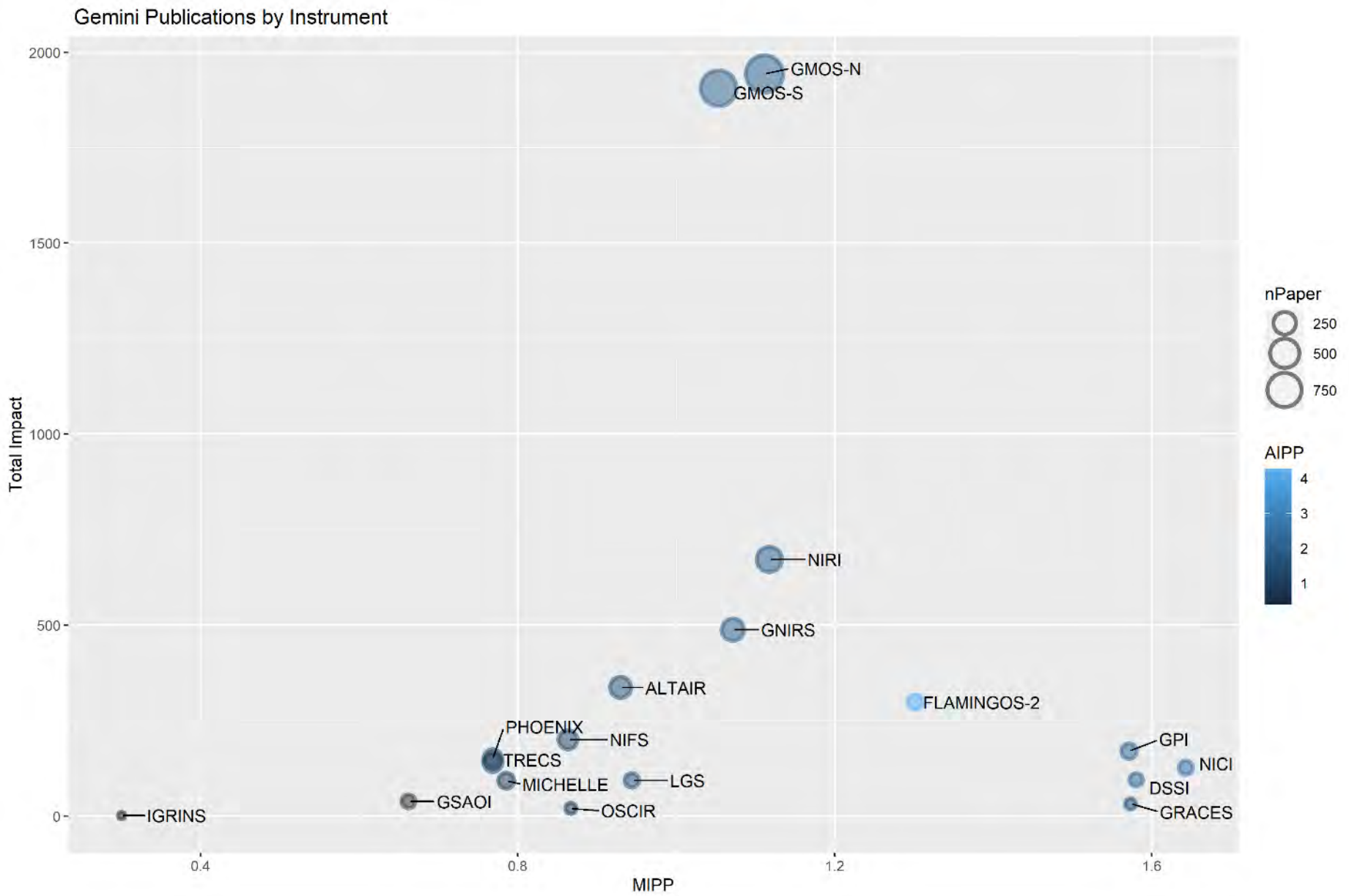
Gemini – Instrument Performance



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Matthew Mayernik, Project Scientist & Research Data Services Specialist, NCAR|UCAR Library

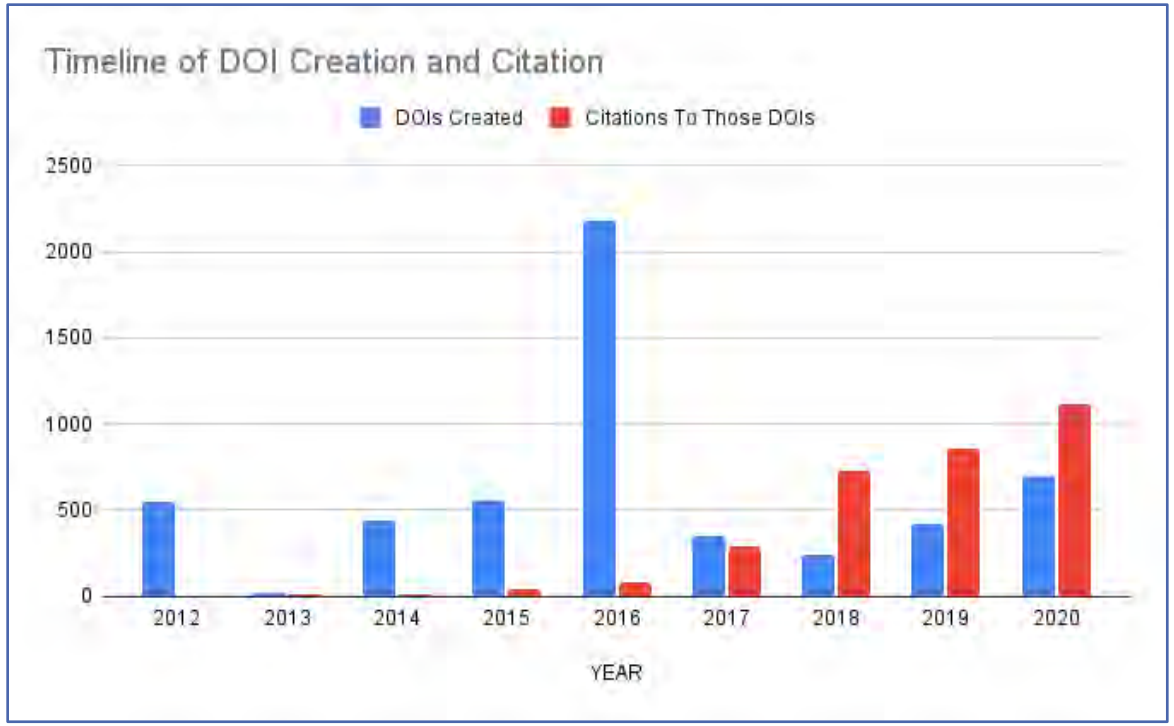
- Matt Mayernik is a Project Scientist and Research Data Services Specialist in the NCAR|UCAR Library (National Center for Atmospheric Research, University Corporation for Atmospheric Research).
  His work is focused on research and service development related to research data curation. His research interests include metadata practices and standards, data curation education, data citation and identity, and social and institutional aspects of research data.
- NCAR provides a variety of resources for the university community and broader Earth system science fields:
  - Computing facilities
  - Observational facilities
  - Data facilities
  - Computational models (weather, climate, hydrology, solar)

Use of Science Impact Metrics

- Reporting to funders/stakeholders
  - Annual reports
  - Reviews, special inquiries, etc.
- Assessing outcomes
  - What was highly cited?
  - Demonstrating reach of resources (e.g. computing systems, data sets, models)
- Internal operations / decision making
  - What services are used the most?
  - Identify potential problems with services (e.g. unexpected drop-offs in data access)
  - For data repositories: Inform future decisions about data set retention or deaccession

Science Impact Metrics Considerations

- Many sources of metrics, no one source is sufficient or complete
- What metrics are meaningful – e.g. usage vs citation?
- Automation vs. Manual effort - Trade-offs between getting metrics of questionable validity for many resources or high quality metrics for smaller / single resources
- Comparability of metrics for different facilities or different kinds of resources is challenging



End of Panelists Introduction and Presentations

It’s Time for Questions

Afternoon Session: Science Impact Metrics
2:00pm – 3:30pm

Bank of Questions for Science Impact Metrics panelists

1. **How and by whom, are Science Impact Metrics defined and used at your organization?**
2. **How and by whom are altMetrics defined and used at your organization ?**
3. **What are the Science Impact Metrics reporting mechanisms, i.e. internally, or to external funding agency or stakeholders?**

Afternoon Session: Science Impact Metrics
2:00pm – 3:30pm

Bank of Questions for Science Impact Metrics panelists

4. **How are Science Impact Metrics used to inform decision making?**
5. **What are the unique challenges related to Science Impact Metrics at your organization?**
6. **How do you tell if your Science Impact metrics are useful and meaningful?**

Afternoon Session: Science Impact Metrics
2:00pm – 3:30pm

Panel Discussion on Best practices for collecting, calculating, and reporting science impact metrics. Can we develop a uniform approach across all Major and Mid-scale Research Infrastructure?

Many thanks to all of today's participants

If you have a question that cannot be answered during this panel discussion, please email it to RIOutreach@nsf.gov.