



DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR	
6. Last Name and Suffix: Wiedinmyer , null	7. First and Middle Name: Christine ,
8. Title:	
9. Email: christine.wiedinmyer@colorado.edu	10. Phone Number: 303-735-5741
AUTHORIZING OFFICIAL	
11. Last Name and Suffix: Matteson , null	12. First and Middle Name: Ron ,
13. Title: Assistant Director, Grant Administration	
14. Email: ron.matteson@colorado.edu	15. Phone Number: 303-492-2693
REPORTING INFORMATION	
Signature of Submitting Official: Waleed Abdalati	
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20. Recipient Name: REGENTS OF THE UNIVERSITY OF COLORADO, THE	
21. Recipient Address: 3100 MARINE ST STE 481 572 UCB, BOULDER, CO 80309-0001 USA	
22. Recipient UEI: SPVKK1RC2MZ3	23. Recipient EIN: 846000555

ACCOMPLISHMENTS

24. What were the major goals and objectives of this project?

CIRES' mission is aligned with NOAA's and focuses on science in service to society: We conduct innovative research that advances our understanding of the global, regional, and local environments and the human relationship with those environments, for the benefit of society.

At CIRES, nearly 900 environmental scientists, engineers, developers, students and others work to understand the dynamic Earth system, including people's relationship with the planet, by exploring a wide variety of research areas including: weather and climate, changes at Earth's poles, air quality and atmospheric chemistry, water resources, solid Earth sciences, and more. Roughly half of our people work embedded in NOAA groups; the rest conduct their research at the University of Colorado Boulder. Our cooperative agreement work with NOAA is described by 66 projects that fall under two NOAA themes—Weather-Ready Nation, and Climate Adaptation and Mitigation—and two NOAA enterprise objectives—Engagement, and Science and Technology.

Each of these projects includes specific research activities and deliverables, and the work is conducted in NOAA laboratories in close collaboration with agency scientists and leaders. Our projects are described in detail in our 2012 proposal to NOAA, organized by nine CIRES themes. And of note: all aspects of our work include the dissemination of data and tools to professional users and to the general public and education communities.

CIRES' research efforts with OAR are centered in the NOAA Earth System Research Laboratories. CIRES also supports research conducted with other NOAA line offices: SWPC and other parts of the National Weather Service, and NCEI in the National Environmental Satellite, Data and Information Service. CIRES' Western Water Assessment is supported by NOAA's Climate Program Office, as is the National Integrated Drought Information System, which is staffed primarily with CIRES experts. Our Education and Outreach team is funded primarily through grants from agencies including the National Science Foundation, NASA, and others.

25. What was accomplished under these goals?

During the 2019-2020 reporting year, our scientists accelerated NOAA's mission work, improving scientific understanding of weather, climate, and humans' ability to adapt to a changing planet. CIRES research teams explored all aspects of the Earth system: developing technology to better forecast storms, from blizzards to hurricanes; harnessing satellite, aircraft, and in-situ data to ensure we understand the future of the Arctic in a changing climate; launching large-scale international efforts to explore all aspects of the Arctic system, using innovative instruments and modeling techniques to reveal new developments in global air pollution; and much more.

CIRES' scientists published their findings in about 690 peer-reviewed papers in hundreds of different journals, and 470 of those directly resulted from collaborations with NOAA research teams. Our researchers won or were part of teams that won many prestigious awards including: a NOAA 2020 Bronze Medal in Scientific/Engineering Achievement; a 2020 NOAA Silver Medal award; three 2019 CO-LABS Governor's Awards for High-Impact Research, Department of Commerce Silver Medal, a CU Distinguished Research Lecture, and more. This year, Clarivate Analytics also named four CIRES scientists "highly cited researchers," among the one percent most cited in their fields: Jose Jimenez, Noah Fierer, Julianne Stroeve, and former Ph.D. student Jonathan Leff.

Nine CIRES scientists achieved NOAA employment in this reporting year, forming the foundation of a pipeline that brings exemplary candidates to the agency. CIRES supported more than 100 graduate students and several postdoctoral researchers this year, including several who worked in NOAA teams. Our Visiting Fellows program, supported in part by the Cooperative Agreement, brought in a handful of postdoctoral and sabbatical colleagues for CIRES Fellows in NOAA and at the University of Colorado Boulder. These are impressive scientists: This year, two were lead authors on Nature and Nature Communications papers, for example.

Our scientists show off their science in tours of the NOAA and CIRES buildings, for students, retirees, and agency and university leaders. They support high school interns and Hollings Scholars, give talks in local schools, and participate in career days. Through the CIRES communications team, CIRES also works closely with federal colleagues, writing press releases and other communications products that encourage media coverage of research results, ensure NOAA leadership is aware of accomplishments, and respond to Congressional inquiries.

CIRES also hosts an Education and Outreach Program that runs several projects that regularly attract volunteers from CIRES, the CU Boulder community, and NOAA. These include, for example, Research Experience for Community College Students; Lens on Climate Change; U.S. and international curriculum development; launching Massive Open Online Courses; and collecting footage from the unprecedented MOSAiC Arctic expedition for a planetarium show and Google Expeditions experiences, teacher workshops, and more.

CIRES is committed to increasing diversity and inclusion in science. Led by our Diversity & Inclusion Director, efforts include:

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ACCOMPLISHMENTS (cont'd)

26. What opportunities for training and professional development has the project provided?

CIRES scientists have the opportunity to engage in all professional development programs that are part of the University of Colorado Boulder (eg, the Graduate Student Career Office, the Office of Postdoctoral Affairs, and central Human Resources) and CIRES, and some of NOAA's. For early career scientists who work at NOAA, training generally includes lab and field work with experienced NOAA scientists, conference and workshop attendance, and engagement with CIRES peers and mentors.

Professional development examples:

Encouraging diversity: CIRES Diversity & Inclusion developed and led a number of training programs aimed at supporting diversity and inclusion in our workforce, attracting broader participation in our organization, and improving inclusivity in the sciences.

Mentoring students and early career scientists: The CIRES Graduate Association supports CIRES graduate students and postdocs from various fields in a supportive, unified environment. The CIRES Members Council also launched the CIRES Mentoring Program in 2019, connecting early- and later-career scientists across the entire institute. The Mentoring Program won a 2020 CIRES Outstanding Performance Award.

Expanding analytic skills: CIRES' Earth Lab wrapped up its second year of a professional graduate certificate called Earth Data Analytics-Foundations. Through the program, recent college graduates and working professionals gained the skills needed to succeed in today's world of big data.

Training new hires: In support of many projects, CIRES on-boarded new researchers with varying levels of experience, and our supervisors and colleagues teach them the skills and techniques they need to carry out important NOAA research. CIRES scientists working on projects with NOAA had many opportunities to provide leadership, and to experiment with new roles, including data collection, data analysis, blogging, and even media engagement.

Leading field safety training: CIRES Fellow Kristy Tiampo and Education & Outreach director Anne Gold led an NSF-funded field safety training series in 2019.

Developing leadership and other new skills, including Interacting with government and industry partners: CIRES scientists worked with government and industry users of CIRES data products and technologies, learning how best to encourage productive partnerships between scientists and decision makers.

Collaborating internationally: CIRES researchers participated in many multi-agency field missions this year, most notably, the Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAIC) expedition and preceding Alaskan field training for the mission.

Engaging with collaborators: CIRES researchers attended dozens of conferences and meetings in the United States and around the world.

27. How were the results disseminated to communities of interest?

CIRES is committed to communicating the institute's scientific discoveries to researchers, decision-makers, and the public. CIRES communicators collaborate closely with NOAA colleagues; CU Boulder; the American Geophysical Union (AGU); American Meteorological Society (AMS); and other academic, professional, and government institutions around the globe.

During the reporting period, communications efforts included dozens of news releases, media relations, videos, animations, social media, blogs, promotion of CIRES research during conferences, and more. CIRES scientists and research were often highlighted in media, receiving coverage in, for example: The Atlantic, The Denver Post, Nature World News, National Geographic, NPR, The Washington Post, Smithsonian, USA Today, CNN, CBS, The Wall Street Journal, and many other local, national, and international media outlets.

CIRES researchers presented at conferences, workshops, and meetings in the United States and around the world, inspiring collaboration and further research. About 150 CIRES scientists presented at the 2019 AGU Fall meeting, 75 presented at the 2020 AMS annual meeting, and many others presented at the 2019 Geological Society of America, 2020 European Geophysical Union, Ozone Secretariat meetings of the United Nations Environment Programme, and others. Two dozen CIRES researchers were among 300 international scientists part of the MOSAIC expedition, co-coordinated/conceived by CIRES/NOAA scientist Matthew Shupe. Shupe called in from an icebreaker in the Central Arctic for a 2019 AGU Fall Meeting press event, giving a real-time update on the polar expedition.

Our scientists also spoke extensively with decision makers and elected officials. Twila Moon (NSIDC) testified before the House Science, Space and Technology Committee's 2019 hearing, Earth's Thermometers: Glacial and Ice Sheet Melt in a Changing Climate. CIRES Director Waleed Abdalati and other CIRES scientists hosted members of the House Select Committee on the Climate Crisis for a discussion in advance of the committee's field hearing on CU Boulder campus in August 2019. CIRES Director Waleed Abdalati met with NASA Administrator Jim Bridenstine during a CU Boulder tour, he participated in a stakeholder roundtable discussion on climate change and national security with Congressman Joe Neguse at CU Denver, and he joined other campus leaders to speak with U.S. Commerce Department Deputy Secretary Karen Dunn Kelley about the value of agency-academia partnerships. Abdalati also led the NOAA cooperative institute (CI) directors in sending a letter to House and Senate Appropriators in support of robust funding for CIs and NOAA's Office of Oceanic and Atmospheric Research (OAR).

CIRES' Western Water Assessment (WWA), a NOAA Regional Integrated Sciences and Assessments program funded primarily through the Climate Program Office, also engaged regularly with users of its research. WWA teamed up with leading hydrology experts to integrate 800 studies, agency reports, and other sources to assess the state of the science and water resources of the Colorado River Basin. Colorado River Basin Climate and Hydrology: State of the Science aimed to create a shared understanding of the physical setting and the latest research underpinning the management of Colorado River water resources.

Finally, CIRES scientists and staff were involved in many other events to educate, engage, and inspire the public. CIRES' Center for Technology and Policy Research held a series of seminars featuring politicians across the political spectrum discussing climate: CU

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ACCOMPLISHMENTS (cont'd)

28. What do you plan to do during the next reporting period to accomplish the goals and objectives?

During the next reporting period, CIRES scientists will continue to build on our past successes by collaborating with our NOAA colleagues to address the mission-critical science of each of our partner groups in the agency. Our work will continue to push the boundaries of research in Earth and environmental sciences, foster climate literacy, improve live-saving forecasts and technologies, and deliver critical information to decision makers. CIRES will keep training next-generation Earth and climate scientists, developing and improving new innovative techniques and products, and disseminating scientific findings to the public. And we will continue to keep up with changes in NOAA's strategic priorities, aligning our work and workforce with the agency's needs.

PRODUCTS

29. Publications, conference papers, and presentations

In June 2020, we submitted a batch of nearly 700 peer-reviewed publications to NOAA's Jennifer Fagan-Fry, NOAA's Institutional Repository Manager, who will determine if some are in the repository already or are open access. For the rest that are associated with our Cooperative Agreement, we will contact the CIRES authors and will ask them to submit the relevant paper version to the IR. Please see the list of publications in Appendix 2.

PRODUCTS (cont'd)

30. Technologies or techniques

See below for highlights of technologies/techniques developed/improved by CIRES researchers during the reporting period; this is not exhaustive.

CIRES scientists in:

CSL:

Developed and implemented a number of new technologies and instruments to support the FIREX-AQ campaign:

A smaller and easier-to-operate instrument flying on the NASA DC-8 aircraft that measured nitrogen oxide. The new instrument has a higher sensitivity and faster time response than the standard instrument. (CSD-04)

A new instrument to measure aerosol angular scattering patterns was deployed for the first time. (CSD-06)

A solid state laser-induced fluorescence technique recently developed for sulfur dioxide measurement was adapted for measurement of nitric oxide, and a new instrument, NOAA LIF-NO, was constructed and deployed on the NASA DC-8. (CSD-07)

PSL:

Continued to improve parameterizations in the upgraded NOAA/National Centers for Environmental Prediction Global Forecast System using the Finite Volume Cubed Sphere, in support of improved weather forecasting. (PSD-20)

Developed a diagnostics package that will allow for validation of microphysical parameterizations, helping to develop products for model guidance and for aircraft guidance that will be made available to the public on the NOAA webpage. (PSD-21)

Installed an S-band snow-level radar in the San Francisco Bay for the Advanced Quantitative Precipitation Information project, which seeks to improve precipitation and hydrological modeling to help agencies in the Bay Area better manage water resources. (PSD-22)

GSL:

Contributed to several public releases of software packages to the broader scientific community: Unified Forecast System Medium-Range Weather application v1.0 for performing global weather forecasts in research and NOAA operations, and the Common Community Physics Package, a library of physical parameterizations for numerical weather prediction models that allows the research community to contribute to models. (GSD-07)

Updated the widely used community software infrastructure packages Earth System Modeling Framework, National Unified Operational Prediction Capability Layer, ESMF Python, and worked with scientists at NCAR, the U.S. Navy, NOAA, DOE, NASA and others to deliver updated versions of Earth system models and data services that incorporated these packages. (GSD-12)

Developed software and systems technology to integrate observations and forecasts to deliver improved forecast information in the San Francisco Bay region. (GSD-13)

CIRES scientists in NWS and SWPC:

Developed and launched a website hosted by the National Weather Service for the Winter Storm Severity Index project. (NWS-01)

~~Tuned an object tracker tool called the Method for Object-based Diagnostic Evaluation Time-Domain to track heavy precipitation~~

31. Inventions, patent applications, and/or licenses

Donald David in the CIRES Integrated Instrument Development Facility filed a patent application U.S. 2019 / 0267532 A1: "Enhanced Superconducting Transition Temperature in Electroplated Rhenium," published August 2019.

PRODUCTS (cont'd)**32. Other products**

No additional products to report. Please note that as per guidance, all information about technologies and techniques, etc. have been sent to NOAA sponsors.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS**33. What individuals have worked on this project?**

CIRES Director Waleed Abdalati is the PI on the CIRES-NOAA Cooperative Agreement. Abdalati is supported by Associate Director William Lewis, Associate Director for Science Christine Wiedinmyer, a senior management team of four other managers, and CIRES Fellows, including an executive committee of CIRES Fellows. About 40 administrative staff members support the director's agenda, serving the finance, human relations, information technology, communications, and other needs of CIRES' nearly 900 scientists, engineers, developers, and others.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (*cont'd*)

34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

This reporting year, our HR Director stepped down; Angela Knight has been the CIRES HR Director for most of the past year.

35. What other organizations have been involved as partners?

Please see Appendix 3.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS (cont'd)

36. Have other collaborators or contacts been involved?

No additional people to report beyond those listed in Appendix 3. Please note that Appendix 4, attached, contains the "CI Employee Support Table," which includes the fact that nine CIRES employees attained NOAA employment during this reporting period.

IMPACT

37. What was the impact on the development of the principal discipline(s) of the project?

CIRES supports scientists who are world leaders in several Earth science disciplines, including atmospheric chemistry and physics, space weather, cryospheric change, and weather/climate forecasting. Within these disciplines and supported by the CA, CIRES scientists improved and accelerated science.

CIRES scientists:

Made groundbreaking findings that redefined the direction of research within their fields:

CIRES scientists worked with NOAA and international research communities to assess the performance of the Aeolus space-based wind lidar. This work will have a profound impact on the design of future space-based wind observing systems. (project no. 1557481)
CIRES scientists in GML investigated stratospheric ozone recovery after last year's discovery of Montreal Protocol-violating CFC-11 emissions. They are also investigating air quality changes due to anthropogenic pollution (including COVID-19's impact on industrial pollution), fires, and stratospheric ozone intrusions. (GMD-02)

CIRES scientists in GML seek to understand atmospheric transport, emissions of greenhouse gases, and atmospheric ozone distributions. Measurements from the ATom mission were important in understanding the influence of atmospheric dynamics on trace-gas concentrations measured at Earth's surface, and are being used to study the budgets and transport of greenhouse gases, pollutants, and reactive chemicals in the remote atmosphere. (GMD-05)

Engaged scientists and scientific community around the world:

The Tropospheric Ozone Assessment Report (TOAR), led by CIRES scientists, motivated tropospheric atmospheric scientists from around the world to collaborate and create the first comprehensive database of global ozone pollution. (CSD-03)

CIRES' NSIDC is the world authority on cryospheric change. NSIDC continually updates the Sea Ice Index for both poles and supports NOAA's annual State of the Climate report and Arctic Report Card. (NSIDC-01)

CIRES scientists in CSL were integral to the FIREX-AQ campaign, which brought together scientists sampling fuels on the ground, others investigating smoke via aircraft, remote satellite measurements, and modellers focused on air quality and climate. (CSD-04)

CIRES scientists in GSL ensure the research community has free access to and support for NOAA operational models and software packages, including GSI/EnKF, HWRF, CAPP, and multiple Unified Forecast System applications, all critical for state-of-the-art weather forecasting. This project also provides resources to help scientists test research innovations in operational systems, and assists in transitioning into operations. (GSD-07)

Terabytes of data collected throughout the field of marine geophysics were archived and made accessible to the world. (NCEI-02)

Scientists in NCEI also disseminate GOES-R-series space weather data sets to the space science community (NCEI-05), provide operational support for space weather monitoring and prediction at SWPC (NCEI-08), and develop the WDS-Paleo archive which

Attach a separate document if more space is needed for #6-10, or #24-50.

IMPACT (*cont'd*)

38. What was the impact on other disciplines?

CIRES' research in the past year significantly impacted other disciplines. Just a few examples include:

Impacting decision makers through science that serves society:

NSIDC, part of CIRES, produces short-term sea ice forecasts, indices, and other products used by diverse entities (e.g., the U.S. government, commercial shippers, energy companies). (NSIDC-01)

The U.S. Extended Continental Shelf project determines and documents the extent of the seafloor to which the United States has sovereign rights for the purpose of exploring, managing, conserving and/or exploiting the natural resources of the seabed and subsoil. (NCEI-13)

CIRES scientists from Western Water Assessment, PSL, and GSL were part of a NOAA team that received a CO-LABS award for their work on a multi-agency, public-private collaboration to estimate probable maximum precipitation and frequency of extreme events above dams in Colorado and New Mexico, to enhance safety and community resilience efforts and inform the Colorado State Engineer and Army Corp of Engineers' priorities and urgent projects.

CIRES scientists in GML collect and analyze data that help determine the efficacy of national and international agreements such as the Clear Air Act and the Montreal Protocol. (GMD-02) Some of this work also won a CO-LABS award: A 2019 CIRES study published in Nature confirmed the findings of CIRES-led 2018 work that discovered an unexpected global increase in emissions of CFC-11. The team presented strong evidence that China was violating the Montreal Protocol. In response to this team's work, the international body that oversees the Montreal Protocol has been working to better understand the problem, formulating an effective global response, and the Chinese government has presented a national-scale plan to reinvigorate their efforts to comply with the Protocol.

Supporting public safety by providing critical information to resource managers, emergency managers, government partners, etc.: CIRES scientists increased the NWS' ability to quickly and efficiently communicate hazardous winter weather threats to partners and the public through information decision support services such as flood preparation and mitigation. (NWS-02, -04)

CIRES scientists in GSD worked with the U.S. Department of Energy to improve HRRR wind and solar forecasts, which provide critical data to emergency managers and wind energy managers. The numerical weather forecasts produced by RAP/HRRR are used as the primary short-range guidance for critical weather elements including severe local storms, as well as low ceiling and visibility, icing conditions, and turbulence.

CIRES scientists in SWPC developed a new international advisory system to keep aircraft crew and passengers safe from space weather impacts.

CIRES scientists in PSL developed an Arctic forecast system being used as a testbed to develop the new NOAA coupled forecast system. Forecast products are uploaded on the RV Polarstern during the MOSAiC Arctic campaign to support scientific operations. Drift forecasts are contributed to the international SIDFEx project to assess forecast skill and develop consensus forecasts for operations. (PSD-21)

39. What was the impact on the development of human resources?

As of June 2020, CIRES remains over 800 people strong. Although CU Boulder imposed a hiring freeze because of fiscal losses associated with COVID-19 disruptions, we were exempted because we continued to bring in strong funding that required new hires to get the research done.

To highlight a few of the changes: We hired several additional scientists in CSL to work on projects that include the Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) campaign, Atlantic Tradewind Ocean–Atmosphere Mesoscale Interaction Campaign (ATOMIC), and more. In GML, we hired several new postdocs and graduate students to work on projects such as studying greenhouse gas trends and analyzing flask data and we hired a few scientists in PSL to work on improving wind forecasting. In GSL, we hired several scientists to work on data assimilation, modeling, and software development, and transitioning verification tools to NWS. In NCEI, we onboarded several full-time and part-time researchers to work on data management, software development, and more. In SWPC, a few new CIRES researchers are working to develop technology that provides forecasts, alerts, and warnings that characterize the arrival and magnitude of solar, radiation, and geomagnetic storms.

For more detailed information, please see Appendix 4, which contains the CI Employee Support Table and a list of recent CIRES hires in support of our cooperative agreement.

IMPACT (cont'd)

40. What was the impact on teaching and educational experiences?

CIRES works hard to provide professional development, including educational experiences, for our researchers and for the broader community, including students of all ages. Much of this work is not directly funded through the Cooperative Agreement; rather, it consists of volunteer work by individual researchers or work that is externally funded and supported by the CIRES Education and Outreach Program. A few examples follow.

CIRES scientists gave dozens of public lectures and presentations over the last year, not only at conferences but on CU Boulder's campus, NOAA's Boulder campus, Rotary clubs, Fiske Planetarium, Science on Tap, etc.

NCEI data products are used widely by younger students in K-12: In a recent survey of World Data Service-Paleoclimatology users, about 22 percent of respondents were K-12 or university educators or students seeking data for their courses. NSIDC products including The Sea Ice Index data and NOAA@NSIDC data also are used in classroom activities.

CIRES scientists Owen Cooper and Audrey Gaudel worked with Dr. Kathryn Goldfarb in CU Boulder's Department of Anthropology to develop a research project for her undergraduate course on Teaching Ethnography; the students used the data and findings from TOAR to engage with members of society regarding their perceptions of air pollution.

CIRES scientists in NCEI led or contributed to citizen science projects:

People around the world with smartphones have become citizen scientists by using NCEI's CrowdMag app to send magnetometer data to the CIRES/NOAA geomagnetic team. The team uses this data to create models of Earth's changing magnetic field by combining the crowdsourced data with that collected by ships, aircraft, and satellites—improving the accuracy of navigation systems. HamSCI, the Ham Radio Science Citizen Investigation, is a platform to advance scientific research and understanding through amateur radio activities; encourage the development of new radio technologies; and provide educational opportunities for the amateur community and the general public.

Many of the experts supporting NOAA's Science On a Sphere® (SOS) are CIRES researchers. SOS is rooted in teaching and education: each year, an estimated 66 million people visited facilities with SOS installed. This year, the SOS team launched the free app SOS® Mobile, which has now been downloaded thousands of times. (GSD-02) Note: A NOAA Environmental Literacy Grant awarded to CIRES' Education and Outreach Program helps fund work to bring hazards education, through SOSx Mobile, to Colorado students and beyond.

CIRES scientists served as mentors and consultants to programs run by our Education & Outreach group, for example: Research Experiences for Community College Students, the Trout Bowl and National Ocean Sciences bowl for high schoolers, and more. CIRES E&O also hosted a biweekly science webinar series for kids and families to view from home during the global pandemic.

41. What was the impact on physical, institutional, and information resources that form infrastructure?

When NOAA facilities were mostly closed during the 2020 remote work period resulting from the global pandemic, CIRES scientists who normally work at NOAA used home offices.

Other direct impacts to NOAA's infrastructure this year included (but are not limited to):

The TOAR Surface Ozone Database is a new and permanent addition at the Forschungszentrum Juelich Supercomputing Center and is available to scientists and policymakers worldwide. (CSD-03)

CIRES scientists in CSL acquired a GPU workstation to use convolutional neural networks for satellite data analysis. (CSD-06)

Six CIRES and NOAA colleagues spent a week outside of State College, Pennsylvania, for a ground-up refurbishment of the SURFRAD measurement station originally installed in 1998. (GMD-01)

Projects in GSL and PSL required larger amounts of data, increasing computer cluster storage needs.

Data management software was installed and is now running on federal IT infrastructure located in Asheville, North Carolina, and in cloud sandboxes supported by the NESDIS ACIO office. (NCEI-01)

NOAA's Weather Prediction Center's successful transition to the Advanced Weather Interactive Processing System (AWIPS) set an example for all other NCEP offices that are starting their transition to AWIPS. These centers include the Ocean Prediction Center, National Hurricane Center, and Storm Prediction Center. (NWS-04)

An NWS team completed an HMT Flash Flood and Intense Rainfall experiment that was entirely virtual due to COVID-19. (NWS-06)

CIRES scientists in SWPC replaced a monolithic central database with a microservices architecture for several key operational products and integrated Docker containerization to many SWPC operational processing and product systems. (SWPC-01)

IMPACT (*cont'd*)

42. What was the impact on technology transfer?

During the reporting period, dozens of technologies developed by CIRES scientists were transferred to other sectors, benefiting collaborating institutes, industry partners, decision makers, and the public.

For example:

The global air quality forecast model (FV3-Chem, or FV3-GOCART) developed by NOAA/ESRL/GSL was made operational at NCEP in March 2020. Information from the 2016-2018 ATom field campaign was instrumental in the development and initial verification of this model. (CSD-02)

Ongoing work on the POPS instrument has led to further improvements that have been carried over into the commercialized (Handix Scientific) version of the instrument. (CSD-07)

The Tropospheric Ozone Lidar Network (TOLNet) team in CSL/ARS received a NASA Group Achievement Award for the "development and implementation of a network of tropospheric ozone lidars to measure time series of vertical profiles of atmospheric ozone for air quality studies." (CSD-08)

Aerodyne Research, located in Billerica, Massachusetts, transferred to GML two Three-Waveband Spectrally-agile Technique (TWST) instruments originally developed for the U.S. Air Force to measure cloud optical depth for broken clouds. (GMD-01)

Several air quality models developed by CIRES researchers have been tested and delivered to NOAA NCEP for operational implementation: GEFS-Aerosols, RAP-Smoke, and HRRR-Smoke for CONUS and Alaska. (GSD-04)

New aviation forecast products were transferred to Federal Aviation Administration operations. (GSD-06)

CIRES scientists contributed to a Next Generation Global Prediction System model upgrade that allowed this new weather forecasting system to go operational in July 2019. (PSD-26)

NOAA OneStop's online interface serves both public users, scientists, and agencies such as NASA and the U.S. Geological Survey. (NCEI-01)

Coupled Arctic model forecasts produced by CIRES and other scientists are used by the MOSAiC campaign, the NWS, the National Ice Center, the NOAA Ocean Prediction Center, Sea Ice Drift Forecast Experiment and Sea Ice Prediction Network-Phase 2, the University of Alaska Fairbanks, the Office of Naval Research, National Centers for Environmental Prediction, and many others. (PSD-21)

The CIRES-developed WAM-IPE coupled model will be transitioned to NOAA operations in 2020, to provide specification and forecast of the near-Earth space plasma and neutral environment. (SWPC-03)

Because of a CIRES team in NWS, NOAA granted experimental status for the Winter Storm Severity Index, a tool that communicates potential winter weather impacts 72 hours into the future, and the agency recommended funding for two Joint Technology Transfer Initiative grant proposals on WSSI. (NWS-01)

43. What was the impact on society beyond science and technology?

CIRES researchers conduct science in service to society, reflecting NOAA's science, service, and stewardship missions. Examples from this year:

To better our understanding of our environment and human health, CIRES scientists:

Improved predictions of wildfire smoke transport and worked to clarify our understanding of sources of VOCs and other pollutants, serving decision making by regulators and the general public. (CSD-02, -04, GSD-04)

Worked to understand the dynamics of stratospheric ozone depletion, from chemical emissions that can erode the ozone layer to weather conditions that affect chemistry. Stratospheric ozone loss increases the risk of UV-related skin cancer and damages crops. (GMD-02, CSD-04)

Collected high-res measurements of chemicals in the atmosphere using state-of-the-art lidar technology to help improve national weather prediction, climate models, and forecasts. This may enable faster development of renewable energy and help mitigate the impact of wildfire smoke on air quality. (CSD-08)

Developing and improving forecasting to protect lives and property, CIRES scientists:

Developed GOES-R Level 2 algorithms that support SWPC's real-time space weather alerts (NCEI-08) and improved the accuracy of space weather forecasts that inform decision makers and forecasting partners about damaging geomagnetic storms. (SWPC-01/05)

Improved forecasts for a variety of extreme weather events including winter storms and heavy rainfall. (NWS-01, -02, -03, -04)

Improved models that guide warnings for wind and extreme precipitation. (PSD-19/20)

Supported work to improve forecasts of hazards to transportation, reducing the damage from life-threatening weather. (GSD-03)

Produced key datasets that improve weather models for forecasting solar and wind energy, critical for the renewable energy industry. (GMD-01)

Impacting decision making, CIRES researchers:

Continued to investigate the impacts of, and solutions to mitigate, unreported CFC-11 emissions in violation of the Montreal Protocol on Substances that Deplete the Ozone Layer. (GMD-05)

Dissected the causes of extreme weather events such as heat waves, droughts, and floods, including conducting citizen science efforts such as Old Weather, Southern Weather Discovery, and Weather Rescue. These efforts help policy makers make informed decisions about infrastructure in risk-prone areas. (PSD-24)

In support of improved navigation, CIRES scientists:

Completed documentation for much of the U.S. extended continental shelf (ECS) and conducted ECS analyses for several island regions to establish U.S. sovereign rights (NCEI-13)

Attach a separate document if more space is needed for #6-10, or #24-50.

IMPACT (cont'd)

44. What percentage of the award's budget was spent in foreign country(ies)?

0 , About 0.4% of our award money was spent in other countries for expenses such as housing and per diem during field work. Note that this is a conservative estimate and the actual percentage is likely much smaller.

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

Nothing to Report

CHANGES/PROBLEMS (cont'd)

46. Actual or anticipated problems or delays and actions or plans to resolve them

Between mid-March 2020 and the end of our reporting period (May 31, 2020), some projects experienced slowdowns or delays related to coronavirus restrictions, e.g., limited or no access to labs or travel to field sites. Overall, all projects are making progress despite challenges. Project leads are working on highly relevant work: evaluating data already collected and writing papers, for example.

47. Changes that had a significant impact on expenditures

Nothing to Report

CHANGES/PROBLEMS (cont'd)

48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Nothing to Report

49. Change of primary performance site location from that originally proposed

When NOAA facilities were mostly closed during the 2020 remote work period resulting from the global pandemic, many CIRES scientists who normally work at NOAA used home offices; a few dozen were exempted and continued to work in NOAA labs.

PROJECT OUTCOMES

50. What were the outcomes of the award?

See attached PDF. "RPPR Question 50"

DEMOGRAPHIC INFORMATION FOR SIGNIFICANT CONTRIBUTORS (VOLUNTARY)

Gender:

- ☐ Male
☐ Female
☐ Do not wish to provide

Ethnicity:

- ☐ Hispanic or Latina/o Not
☐ Hispanic or Latina/o Do not
☐ wish to provide

Race:

- ☐ American Indian or Alaska Native Asian
☐ Black or African American
☐ Native Hawaiian or other Pacific Islander
☐ White
☐ Do not wish to provide

Disability Status:

- ☐ Yes
[] Deaf or serious difficulty hearing
[] Blind or serious difficulty seeing even
when wearing glasses
[] Serious difficulty walking or climbing
stairs
[] Other serious disability related to a
physical, mental, or emotional condition
☐ No
☐ Do not wish to provide

Attach a separate document if more space is needed for #6-10, or #24-50.