



DEPARTMENT OF COMMERCE RESEARCH PERFORMANCE PROGRESS REPORT (RPPR)

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AWARD INFORMATION	
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RECIPIENT ORGANIZATION	
20. Recipient Name: REGENTS OF THE UNIVERSITY OF COLORADO, THE	
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22. Recipient DUNS: 007431505	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, more than 800 environmental scientists, engineers, developers, and others work to understand the dynamic Earth system, including people's relationship with the planet, by exploring a wide variety of research arenas 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 60 projects that fall under four key NOAA themes: Science and Technology Enterprise, Weather-Ready Nation, Climate Adaptation and Mitigation, and NOAA Engagement Enterprise.

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 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 Laboratory. CIRES also supports research conducted with other NOAA line offices: SWPC and other parts of the NWS, 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?

The reporting year 2018-2019 was an extraordinary one for CIRES. Our scientists accelerated NOAA 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; using innovative instruments and modeling techniques to reveal new developments in global air pollution; and much more.

CIRES' scientists published their findings in 800 peer-reviewed papers in hundreds of different journals, and 371 of those directly resulted from collaborations with NOAA research teams. Our researchers won and shared many prestigious awards, perhaps most importantly, the Presidential Early Career Award for Scientists and Engineers (PECASE). Brian McDonald, a CIRES researcher in the CSD, won a PECASE, as did his colleague Andrew Rollins, a newly minted federal scientist who worked for CIRES when nominated. Nine of our scientists were critical to NOAA's implementation of the OneStop data discovery system this year, an achievement that earned a Department of Commerce Bronze Medal for the federal employees and a CIRES Bronze Medal for their cooperative institute colleagues.

Like Rollins, six 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 dozens of 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.

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 to encourage media coverage of research results, to ensure NOAA leadership is aware of accomplishments, and to 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 Research Experience for Community College Students, Lens on Climate Change for middle and high school students, U.S. and international curriculum development, Girls On Rock, Community Natural Hazard Resilience Education, and more.

CIRES is committed to increasing diversity and inclusion in science: our Diversity & Inclusion Director led trainings on topics including gender bias and bystander intervention, and piloted a baseline culture survey for the University of Colorado Boulder, which provided actionable information to the CIRES Director and will be implemented university-wide this fall.

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

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 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 CGA provided several opportunities this year, including: networking training, use of social media for scientists, development of a professional web page, and engagement with visiting distinguished lecturers.
- Expanding analytic skills: CIRES' Earth Lab wrapped up the first official cycle 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.
- Technical training of new hires: In support of many projects, CIRES on-boarded new researchers with varying levels of experience, and our supervisors and colleagues taught them the skills and techniques needed to carry out important NOAA research.
- Collaborating internationally: CIRES researchers participated in many multi-agency field missions this year, collaborating with scientists from different institutions, fostering shared resources, and exchanging ideas and information.
- Developing leadership and other new skills: CIRES scientists working on projects with NOAA had many opportunities to provide leadership (e.g., in FIREX-AQ), and to experiment with new roles, including data collection, data analysis, blogging, and even media engagement.
- 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.
- Traveling: CIRES researchers attended dozens of conferences in the United States and around the world, and visited other research facilities and institutions to learn how to improve their own science.

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

Also see Q. 29 and App. 2 for publications.

CIRES is committed to communicating the institute's scientific discoveries to the scientific community, decision-makers, and the public. CIRES communicators collaborate closely with colleagues in NOAA, CU Boulder, the American Geophysical Union (AGU), our centers, and academic and government institutions around the globe.

During the 2019 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 highlighted frequently in the media, receiving coverage in, for example: BuzzFeed, the Denver Post, Mashable, IFL Science, National Geographic, NPR, Washington Post, Public Radio International, 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 125 CIRES scientists presented at the American Geophysical Union Fall meeting, 65 presented at the American Meteorological Society annual meeting, and many others attended or presented at the Geological Society of America, European Geophysical Union, Ozone Secretariat meetings of the United Nations Environment Programme, and others. CIRES Fellow Joost de Gouw also sat on a press conference panel with colleagues at the 2019 American Association for the Advancement of Science meeting to address indoor air pollution and our homes as a key source of chemical exposure.

Our scientists also spoke regularly and extensively with decision makers, including elected officials. In August 2018, CIRES hosted staffers from House and Senate authorization committees, working with government relations experts from NOAA and the University of Colorado to develop an agenda that fostered awareness and appreciation of our work in space weather, big data analytics, Extended Continental Shelf definition, and more. CIRES Director Waleed Abdalati responded to several Congressional requests and participated in calls and meetings with U.S. representative Joe Neguse (2nd district, Colorado) and Sen. Cory Gardner (Colorado). At Gardner's request, Director Abdalati spoke on climate research and forecasting during a hearing of the Commerce Subcommittee on Science.

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, to facilitate "co-production" of science that directly serves society's needs. WWA's guide, "Making Research More Useable," proved popular across the university, RISA, and other communities, as the broader researcher community comes to understand the value of front-end engagement with the users of science.

Finally, CIRES scientists and staff were involved in a handful of events to educate, engage, and inspire the public. In October 2018, CIRES organized a TEDxBoulderSalon event, "The Melting Arctic." In September 2018, NSIDC director Mark Serreze gave public book talks on his new book, *Brave New Arctic*, at CU Boulder and the Denver Museum of Nature and Science. In February 2019,

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

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.

PRODUCTS

29. Publications, conference papers, and presentations

At the end of June, 2019, we submitted a batch of about 800 peer-reviewed publications to NOAA's Jennifer Fagan-Fry, NOAA's Institutional Repository Manager, who determined that many of them are either in the repository already or are open access. She and her team returned to us a list of 244 publications that potentially require uploading to the IR; some are not directly related to our Cooperative Agreement. We will contact the CIRES authors of the relevant subset of those papers, and will ask them to submit to the IR. Please see a full list of publications in Appendix 2.

PRODUCTS (cont'd)

30. Technologies or techniques

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

CIRES scientists in PSD:

- Made two parameterizations operational in the new, upgraded NOAA/National Centers for Environmental Prediction Global Forecast System (GFS 15.1) using the Finite Volume Cubed Sphere (FV3GFS).
- Developed the miniFlux Unmanned Aircraft System instrument; Air-Deployable MicroBuoy; and the Coupled-Arctic Forecasting System.
- Led Evaporative Demand Drought Index (EDDI) development, for early warning and monitoring of agricultural and hydrologic drought and wildfire.
- Collaborated with NOAA to develop and evaluate an extended-range wind hazard forecast product for the contiguous United States and Alaska.

CIRES scientists in GSD:

- Added more than 1,000 mesonet (automated weather monitoring station) sites to feed data to NWS operations.
- Oversaw the development of and transition-to-operations of the Common Community Physics Package (CCPP), a library of physical parameterizations for use in numerical weather prediction models.
- Updated code in the Hurricane Weather Research and Forecasting (HWRF) model to correctly interpolate monthly ozone climatology, improving the 3-5-day hurricane track forecast from ~305 to ~270 nautical miles (error at 5 days).
- Tested new prototype configurations of NOAA's operational Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) forecast systems, demonstrating improvements of predecessor versions.

CIRES scientists in SWPC:

- Worked closely with NOAA colleagues to develop the Whole Atmosphere Model - Ionosphere Plasmasphere Electrodynamics (WAM-IPE) system, which will be transitioned into operations at NOAA as early as fall 2019.
- Improved the Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model (CTIPe) which is currently running operationally in support of space weather needs of the International Space Station and other NASA missions.

CIRES scientists in NWS:

- Revised two internal websites and produced images for a third that all supply timely images and data to Weather Prediction Center (WPC) forecasters.
- Developed installation packages for weather forecast offices in Alaska and Hawaii to install the NOAA Atlas-14 database (average recurrence intervals) to help forecasters identify when forecast models are predicting a climatologically extreme rainfall event.

~~Per request from forecasters and in collaboration with NOAA partners, developed a web-based, improved version of the Extreme~~

31. Inventions, patent applications, and/or licenses

CIRES researcher Caroline Alden is one of several who developed a process for determining the location and size of a methane gas source within a large area with a spectrometer gas monitor. Patent info: 3/26/2019, application #15/729,079, patent #10240998.

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 for Science Christine Wiedinmyer, Associate Director William M. Lewis Jr., and 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' 800+ 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 year, our HR Director moved to another state; Angela Knight now serves in that role.

35. What other organizations have been involved as partners?

Please see Appendix 3.

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

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 six 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 and climate forecasting. Within these disciplines and supported by the Cooperative Agreement, CIRES scientists improved and accelerated science. This year, Clarivate Analytics named five CIRES scientists "highly cited researchers," among the 1 percent most cited in their fields: Joost de Gouw (cross-field); Noah Fierer (environment/ecology); Jose Jimenez (geosciences); Julianne Stroeve (geosciences) and the late John Wahr (cross-field).

In other examples, CIRES scientists:

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

- CIRES scientists in CSD discovered unexpected sources of air pollution from personal and industrial products. Their work has brought together those who study indoor vs. outdoor air quality, and it has also inspired decision makers, including the California Air Resources Board, to learn more.
- CIRES scientists in the same group completed a global aerosol sampling study that is revealing new pathways for the formation and transport of natural and pollution aerosol. The results are redefining the way a global model treats aerosol removal. (CSD-04, CSD-06)
- With federal colleagues, CIRES scientists in GMD discovered substantial unreported emissions of CFC-11, an ozone-depleting substance restricted under the Montreal Protocol. Their work not only motivated new research, it also motivated an international investigation. (GMD-05)

Engaged scientists and scientific community around the world:

- The International Global Atmospheric Chemistry project, led by a CIRES scientist, is fostering a global community of diverse atmospheric scientists. (1555842)
- The Tropospheric Ozone Assessment Report (TOAR), led by a CIRES scientist, motivated tropospheric atmospheric scientists from around the world to collaborate and create the first comprehensive database of global ozone pollution. (CSD-03)
- CIRES scientists in NCEI helped make terabytes of marine geophysics and space weather data accessible to the world; the team won a Department of Commerce Bronze Medal in 2019 for the OneStop data discovery system. (NCEI-01, -02, -05)
- 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)

Improved models to better our understanding of earth systems:

- CIRES scientists in GSD updated a data-ingest system called MADIS to incorporate new observations, improving weather models used by the NWS, and the Hurricane Weather Research and Forecasting (HWRF) modeling system featured in the next task.

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 impacted other disciplines. Just a few examples include:

Making discoveries likely to spark new research in other areas:

- The launch of Aeolus, the first lidar deployed in space for global wind measurements, marks a new era in space-based remote sensing. Data from Aeolus is being used to assess performance of optical technology, investigate capability of laser-based instruments to provide usable wind measurements from space, and evaluate the impact of lidar-measured winds to improve weather prediction. (1557481)

- The groundbreaking work by Brian McDonald and his team in CSD identifying volatile chemical products as a major source of pollution in urban areas has sparked an explosion of new research in other fields—such as human health studies—investigating the impacts of those VCPs on outdoor and indoor environments. (CSD-04)

- CIRES scientists are on the forefront of stochastic physics development: the NWS depends on these contributions in stochastic physics and post-processing to advance the NGGPS model and downstream products. (PSD-26)

Impacting decision makers through science that serves society:

- 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 in GMD 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)

- 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)

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 (their research on wind behavior in complex terrain will improve forecasts for wind energy firms by 15-25 percent), which provide critical data to emergency managers and wind energy managers.

- CIRES scientists in NCEI produce coastal digital elevation models for the nation, serving the needs of diverse users including tsunami warning centers; these data are critical for coastal run-up models to forecast inundation. Also in NCEI, CIRES scientists ensure historical data on natural hazards are available to all; these data are used in risk management and planning. (NCEI-04)

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

In the past year, CIRES grew by a few dozen people, both to support NOAA's growing needs and because of successful grant writing by individual scientists who supported researchers, postdocs, and graduate students.

To highlight a few of the changes: We hired several additional scientists in CSD to work on projects that include the Tropospheric Ozone Assessment Report (TOAR), Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ), Portable Optical Particle Counter (POPS) aerosol experiments, and more. In GMD, we hired several new postdocs and graduate students to work on projects such as studying ozone depletion with ozonesonde balloon launches, and we hired a few scientists in PSD to work on sea ice forecasting and prediction of climate extremes. In GSD, 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 (including a veteran) 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, warnings, and other products 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.

-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 developed SOS® Mobile, the first free tool, to bring materials and support needed for data literacy to teachers and students. Note: A NOAA Environmental Literacy Grant awarded to CIRES' Education and Outreach Program helps fund work to bring hazards education, through SOS® 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 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.

*The Crowdsourced Bathymetry project brings in data collected by citizen scientists—people who operate commercial or recreational ships in places where nautical charts are poor—with two key results: increasing those citizens' scientific understanding of the seafloor, and improving NOAA's understanding of the sea floor structure.

-CIRES scientists gave dozens of public lectures and presentations over the last year, not only at conferences like the AGU Fall Meeting, but on CU Boulder's campus, NOAA's Boulder campus, and other local venues like the Denver Museum of Nature and Science.

-A CIRES scientist in CSD helped undergraduate students at the Colorado School of Mines develop their statistical skills in a semester-long course focused on analyzing the TOAR ozone database. (CSD-03)

-The Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III-ISS) validation project provided an opportunity to engage with a small rural school district in eastern Colorado and present information to junior and senior high school students about the role of the stratosphere in Earth's climate and climate change. (CSD-07)

-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.

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

When NOAA facilities were mostly closed during the 2018-2019 partial government shutdown, CIRES scientists who normally work at NOAA used office, meeting, and laboratory spaces in the CIRES building on CU Boulder's campus.

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

-Enhanced data storage requirements: Projects in GSD and PSD increasingly required large amounts of data, increasing computer cluster storage needs.

-Instrumentation and software improvements: CIRES' work in NCEI on ionospheric sounding capability required improvements in instrumentation at four sites, including Table Mountain Observatory. In PSD, CIRES' work to enhance predictability of weather and climate extremes required increased use of NOAA and Department of Energy high-performance computing systems in Boulder and elsewhere. Enhanced data management by CIRES scientists in NCEI required use of federal IT computing and storage infrastructure in Asheville, North Carolina. And CIRES staff in SWPC upgraded critical infrastructure for space weather data storage.

-Process infrastructure: CIRES' work in NWS on quantitative precipitation forecasting helped NOAA understand the technical requirements for other similar system transitions. CIRES work in SWPC resulted in development of processes and systems to provide real-time data from the NOAA Deep Space Climate Observatory satellite and the imminent transition of a coupled space weather model into full operations on NWS supercomputers.

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:

- CIRES scientists in NCEI worked to transfer and deploy the OneStop data search product to NOAA's IT infrastructure: it served approximately 10,000 users over the last 12-month period. In addition, NASA began using OneStop to power an integrated catalog of earth science data. (NCEI-01)
- CIRES researchers in GSD included their model improvements in the code transfer to the National Centers for Environmental Prediction for the next generation operational versions of the RAP and HRRR, planned for implementation in July 2020. (GSD-11)
- CIRES scientists with NWS helped develop the NOAA Atlas-14 installation package and transferred it to Weather Forecast Offices in Alaska and Hawaii and the Alaska-Pacific River Forecast Center. (NWS-02)
- A CIRES team in several NOAA groups (CSD and GSD) earned a CO-LABS Sustainability Award in 2018, for improving wind forecasts from the HRRR weather model to increase the usage of renewable power by industry. (CSD-08)
- CIRES researchers in GMD work with NOAA colleagues to develop NOAA's Skysonde software, which is shared with the public for prediction of ozone balloon trajectories. (GMD-02)
- Coupled Arctic model forecasts produced by CIRES scientists in PSD are used by NWS, the National Ice Center, the Office of Naval Research, the University of Colorado, the National Centers for Environmental Prediction, and more. (PSD-21)
- Ongoing work by CIRES scientists in CSD on the Portable Optical Particle Counter instrument has led to improvements in the design and operation that were carried over into the commercialized (Handix Scientific) version of the instrument. (CSD-07)
- CIRES scientists in GSD made improvements to modeling interactions of clouds and radiation, which they transitioned to the operational Hurricane Weather Research and Forecasting model. (GSD-07)

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. Some examples from this year:

Developing and improving forecasting to protect lives and property:

- NCEI's GOES-R Level 2 algorithms support SWPC's real-time space weather alerts for the safety of lives and property. (NCEI-08)
- CIRES scientists working in NWS improved life- and property-saving forecasts for a variety of extreme weather events including winter storms and heavy rainfall. (NWS-01-04)
- CIRES scientists in PSD improved models that guide warnings for critical wind and extreme precipitation as well as climate extremes. (PSD-19/20)
- GSD-based CIRES scientists supported efforts to improve forecasts of hazards to air and ground transportation. (GSD-03)
- SWPC scientists improved space weather forecasts that inform decision makers, global forecasting partners, and the general public about potentially damaging geomagnetic storms. (SWPC-01/05)
- GMD scientists collected ceilometer data that can improve weather forecasts and enhance confidence in climate change projections. (GMD-01)

Bettering our understanding of our environment and human health:

- CIRES scientists in CSD and GSD improved predictions of smoke transport from wildfires and worked to clarify our understanding of sources of VOCs and other air pollutants. This kind of information serves decision making by regulators as well as the general public. (CSD-02, -04, GSD-04)
- CIRES scientists in CSD and GMD worked to understand the dynamics of stratospheric ozone depletion, from levels of chemical emissions that can erode the ozone layer to weather conditions that affect chemistry. Stratospheric ozone loss can increase the risk of UV-related skin cancer and damage to crops and vegetation. (GMD-02, CSD-04)

Impacting decision making:

- CIRES researchers in GMD discovered unreported CFC-11 emissions in violation of the Montreal Protocol on Substances that Deplete the Ozone Layer. (GMD-05)
- CIRES researchers in PSD dissected the causes of extreme weather events like heat waves, droughts, and floods, helping policy makers and the general public make informed decisions about infrastructure investments in risk-prone areas. (PSD-24)

Improving navigation:

- CIRES scientists in GSD improved aviation forecasts, helping aviation managers assess weather-related threats including icing, turbulence, and convection. (GSD-06)
- CIRES scientists in NCEI completed an unexpected, out-of-cycle World Magnetic Model release in record time, ensuring the

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 , Less than 0.5% 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; university accounting practices cannot support a precise assessment.

CHANGES/PROBLEMS

45. Changes in approach and reasons for change

N/A

CHANGES/PROBLEMS (cont'd)

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

N/A

47. Changes that had a significant impact on expenditures

N/A

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

CHANGES/PROBLEMS (cont'd)

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

N/A

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

N/A

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.