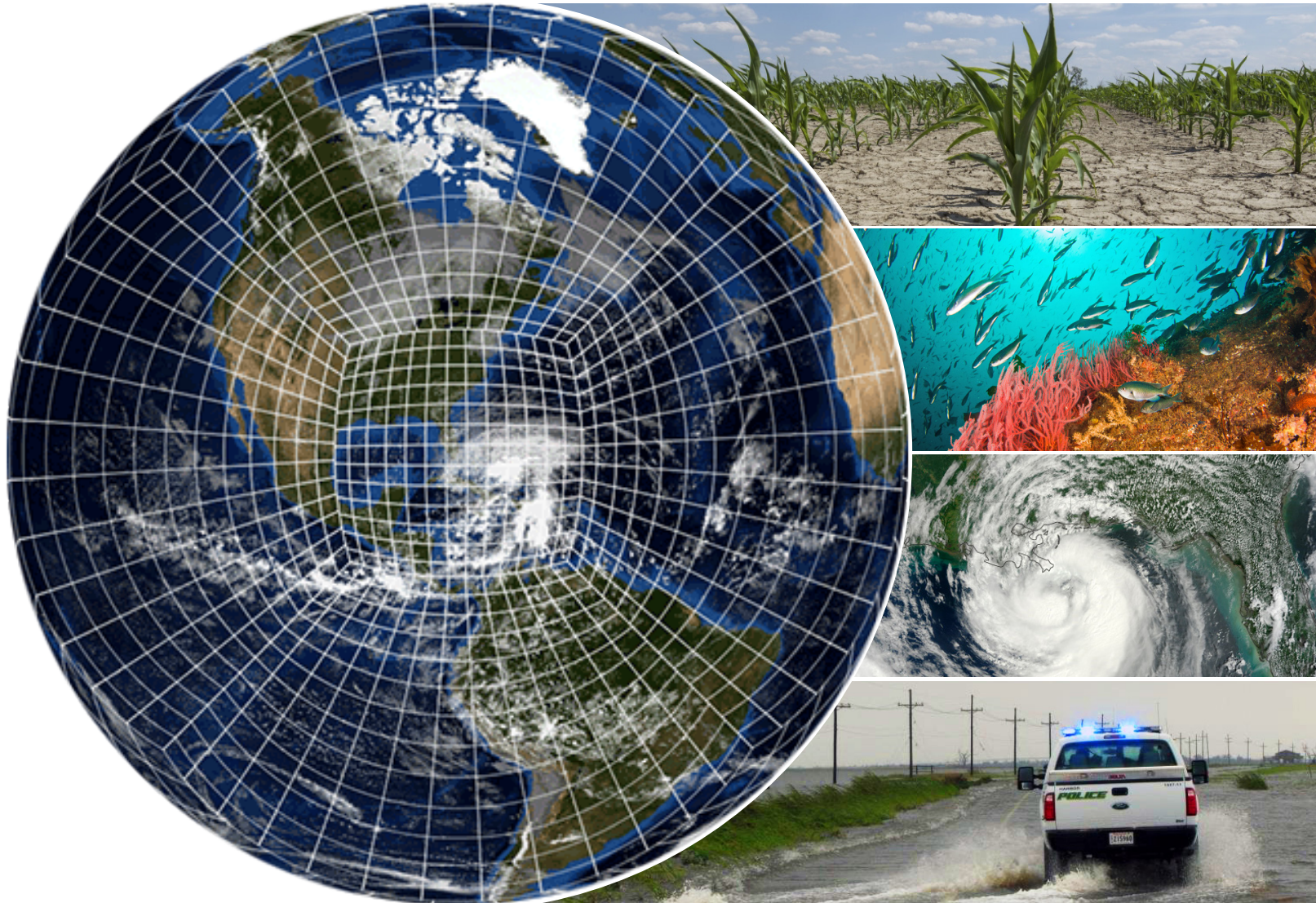


THE MODELING, ANALYSIS, PREDICTIONS, AND PROJECTIONS PROGRAM



OVERVIEW AND INVESTIGATOR FEEDBACK

THE MODELING, ANALYSIS, PREDICTIONS AND PROJECTIONS PROGRAM: OVERVIEW AND INVESTIGATOR FEEDBACK

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MAPP
Modeling, Analysis,
Predictions, and Projections

The Modeling, Analysis, Predictions and Projections (MAPP) program has advanced climate modeling and prediction capabilities, both within and beyond NOAA.

Two key MAPP program indicators: (i) 75% of MAPP-funded projects have contributed to improved modeling and prediction of climate, and (ii) 100% of MAPP's Climate Test Bed projects have transitioned from research to NOAA operations.

MAPP's current research and development (R&D) projects address four stakeholder-driven environmental application areas: drought and water resources, weather and climate extremes, fisheries and marine ecosystems, and coastal flooding. The program is based on a robust peer-review process and funds more than 100 researchers annually, with at least 80 different R&D projects in progress at any given time. About 85% of MAPP's roughly \$13 million in FY 2017 grant funds has been awarded competitively to 36 different research institutions, in 17 U.S. states.

From 2011 to 2018, MAPP's R&D projects have addressed NOAA's global coupled modeling, prediction and projection needs in support of NOAA's mission mandates and those of its stakeholders. MAPP has contributed to the Office of Oceanic and Atmospheric Research (OAR) portfolio of modeling R&D activities, bridging the weather and climate communities through MAPP's past subseasonal to seasonal prediction efforts, by extending NOAA's reach into a broader set of expertise/capabilities. Over several years, MAPP and its predecessor programs have served as funders and leading coordinators of modeling and prediction research activities, working with core partners at NOAA and in the external community. The MAPP program has supported R&D projects as well as activities to transition research into a broad set of applications, with emphasis on NOAA operations. The MAPP program is a recognized brand for NOAA's modeling and prediction research, both nationally and internationally.

MAPP investigators have contributed substantially to the advancement of NOAA's National Weather Service (NWS) suite of operational models and prediction tools, and those of the National Earth System Prediction Capability (ESPC), giving rise to several new products and tools that are described in this report. Specifically, they have assessed causes and predictability of U.S. drought and created new tools to monitor and predict drought as part of the National Integrated Drought Information System (NIDIS); provided new insights into long-term climate trends; and developed new evaluation tools to accelerate NOAA model development.

In a recent survey, both NOAA and non-NOAA MAPP investigators provided their views regarding the value of the MAPP program to the climate community. Collectively, they commented that MAPP's facilitated modeling community forums bring a "clarity of focus" and a "shared sense of purpose and community" to its internal and external PIs that is necessary to address challenges associated with improving accuracy and lead time of climate predictions. They also expressed value for the way in which MAPP blends fresh ideas from the external PI community with wisdom and guidance from NOAA PIs who have more experience in transitioning research to operations. MAPP's external research community brings fresh perspectives to NOAA, while also benefitting from collaboration with NOAA experts and internal R&D capabilities. This approach helps push NOAA to look beyond its immediate needs and make breakthroughs, and facilitate the transition of new, experimental tools and methodologies to NOAA's operational models. Albeit, some PIs expressed frustration in the rate of research uptake by NOAA operational entities, an issue beyond MAPP.

MAPP investigators agreed on the importance of the program's past engagement in sub-seasonal to seasonal (S2S) research, in coordination with the World Climate Research Program's international S2S Prediction Project, emphasizing the role of coupled processes with which MAPP's climate community has expertise. They highlight that MAPP has been a bridge between the weather and climate community and an effective conduit for transitioning their S2S research to NOAA's operational models. They also regard MAPP's peer-review process as rigorous and essential to selecting the best projects because it provides a stringent and fair vetting mechanism that opens the door to good ideas and it forces people to "push the envelope" in exploring and developing new capabilities for NOAA while receiving feedback from their peers.

2 MAPP PROGRAM OVERVIEW

Part 1: MAPP Program Overview

The MAPP program is a competitive grants program hosted by the Climate Program Office, which is located in the National Oceanic and Atmospheric Administration's (NOAA) Office of Oceanic and Atmospheric Research (OAR). From 2011 to 2018, MAPP has addressed NOAA's global coupled modeling, prediction and projection needs in support of NOAA's mission and those of its stakeholders. Over several years, MAPP and its predecessor programs have served as funders and leading coordinators of modeling and prediction research activities for NOAA, as part of the broader climate science community. MAPP's activities have been integrated with those of other CPO programs, bridging the weather and climate communities through MAPP's past subseasonal to seasonal prediction efforts and spanning from foundational Earth system science research to development of applications with socio-economic benefits. The MAPP program has provided NOAA broad connectivity and a holistic suite of activities for modeling and prediction across timescales, both nationally and internationally.

MAPP aims to benefit the NOAA Line Offices and their stakeholders by augmenting and complementing internal research capabilities. More broadly, MAPP also aims to address the needs of NOAA's stakeholders as part of third party organizations. MAPP benefits the institutions and scientists that are directly involved in climate modeling R&D at NOAA, academia, other agencies.

Through its annual Federal Funding Opportunity announcements, MAPP applies a rigorous peer review approach to competitively select the best ideas from the scientific community at large in support of NOAA's mission. This process ensures that NOAA benefits from the best, most rigorous science, and that funding decisions are well-motivated. On average, MAPP supports over 100 investigators annually, with about 80 ongoing projects at any given time. These projects involve scientists from academia; across NOAA's Line Offices, laboratories and centers; and other agencies. MAPP fills an important niche for NOAA, by engaging the best minds in the community in coordinated activities that address its modeling and prediction mission requirements.

In FY 2017, the overall MAPP budget was about \$13 million with about \$11 million allocated competitively (\$3.7 M for S2S research); funding was allocated for projects involving 28 U.S. academic institutions, with 36 total institutions, across 17 States (see Figure 1). The majority of MAPP program investigators were either early career or mid-career scientists, with most of the funding for all projects allocated to support the training of students and postdocs. This support, which enables early career scientists to work on NOAA's science problems, provides an "on-ramp" for the next generation of scientists to serve the Nation and support NOAA's mission.

Key MAPP Program Partners (2011-2018)

- National Integrated Drought Information System (NIDIS)
- National Weather Service (NWS)/Office of Science Technology and Innovation and NWS/National Centers for Environmental Prediction (NCEP)
- NOAA Climate Test Bed and the interagency National Earth System Prediction Capability (ESPC), through which MAPP has supported research and development projects as well as activities to transition research into a broad set of applications, such as to NOAA's NWS operations
- National Marine Fisheries Service (NMFS)/Office of Science Technology and Innovation
- National Environmental Satellite, Data, and Information Service (NESDIS)/ Joint Polar Satellite System (JPSS) program
- Other U.S. agencies via the U.S. Global Change Research Program (USGCRP) and the US-CLIVAR program, including the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the Navy.
- International partners including the World Climate Research Program (WCRP) (e.g. CLIVAR and GEWEX programs) and joint WCRP/World Weather Research Program (WWRP) research, such as the Subseasonal to Seasonal (S2S) Prediction Project

3 MAPP PROGRAM OVERVIEW



Figure 1: FY 2017 snapshot of MAPP program budget distribution across U.S. states and universities. Specific budget distribution varies year to year but MAPP generally works with institutions across many U.S. states.

MAPP provides opportunities for exploratory research to advance NOAA’s mission, specifically targeted at NOAA’s prediction needs. A rigorous research-to-operations (R2O) transition activity complements this research, geared toward testing and evaluation of promising research advances for operational use. MAPP was among the earliest adopters of NOAA’s transition guidelines, often informing refinement of procedures in this area. Several important transitions to NWS operations have occurred annually because of MAPP’s work (see Figure 3 for examples).

MAPP’s portfolio of activities is inherently interrelated — foundational research funded by MAPP is conducive to the development of new applications, and, vice versa, user needs for new capabilities drive new research. Similarly, advances in foundational process modeling, data assimilation and model evaluation for climate applications are relevant for prediction across timescales. Applications of modeling in one discipline spurs advances in another. The integration and interconnectedness of MAPP’s activities is a key to how the program functions — each component strengthens the other. For example, the drought work MAPP funds is relevant to the model development work, the development work is relevant to the data assimilation work, the assimilation work is relevant to the prediction work, etc.

Over time, major MAPP research/transition thrusts have included the following:

- **Climate prediction from weeks to decades**
- **Drought research and other modeling applications**
- **Reanalysis and data assimilation**
- **Climate and Earth system modeling**
- **Long-term climate projections**



Program implementation from 2011–2018 included 2–3 annual Federal Funding Opportunity announcements for the broad scientific community (see Figure 2), which resulted annually in 15–20 new 2- to 3-year projects. A hallmark of MAPP’s program implementation is its sustained community engagement, for which program managers developed new cost-effective approaches. For example, MAPP pioneered the organization of Task Forces, involving MAPP-funded investigators, to coordinate activities and facilitate communication for specific research themes. Since 2011, MAPP has organized 8 Task Forces¹ (with 4 ongoing at any given time), each involving more than 30 scientists, meeting monthly and running for 3 years. The MAPP webinar series, open to the public, provides a regular linkage between NOAA PIs and the broader external PI community. The series is now in its 7th year and has been attended by thousands of individuals; recordings, available on the MAPP site² and YouTube, have been watched hundreds of times. The MAPP Quarterly Newsletter³ provides program news and highlights. MAPP has published 11 technical reports to synthesize research findings or recommendations, and all are publicly accessible. MAPP has directly organized 10 topical community workshops in key program areas and co-supported numerous other community workshops. In short, MAPP-sustained community engagement enables communication and coordination, which optimizes program outcomes.

Through these activities and targeted engagement within NOAA and other agency programs, MAPP also serves as an important organizer of U.S. modeling activities. Via MAPP’s engagement as part of the USGCRP Interagency Group for Integrated Modeling and US-CLIVAR, NOAA’s modeling, prediction and projection activities are better coordinated with those of other agency programs. Thus, MAPP is a leading force behind the annual organization of the U.S. Climate Modeling Summit, an annual gathering of the leadership from the leading domestic climate modeling institutions now in its 4th year. MAPP hosted the inaugural summit back in 2015. Within NOAA, MAPP is a founding participant of the Research Council Unified Modeling Task Force (now Committee) and a key contributor to NOAA’s ESPC activities. Overall, MAPP promotes coordination and optimization of modeling activities within NOAA and among U.S. agencies.

¹ MAPP’s 8 past and present task forces include the Subseasonal to Seasonal Task Force, the Model Diagnostics Task Force, the Drought Task Force, the Climate Model Development Task Force, the Marine Prediction Task Force, the Climate Reanalysis Task Force, the Climate Prediction Task Force, and the CMIP5 Task Force.

² Past MAPP webinars are available for viewing: cpo.noaa.gov/MAPP/webinar

³ Archived MAPP quarterly newsletters can be viewed here: cpo.noaa.gov/MAPP/newsletters

5 MAPP PROGRAM OVERVIEW

Two key MAPP program indicators: (i) 75% of MAPP-funded projects have contributed to improved modeling and predictions of climate, and (ii) 100% of MAPP's completed Climate Test Bed projects have successfully transitioned from research to NOAA operations. MAPP research has resulted in over 200 annual peer reviewed publications, the development of 6 journal special collections and tens of practical applications for NOAA and the broader stakeholder community (see Figure 3 for select examples). Practical applications and science outcomes of MAPP's research include:

- The advancement of NOAA's NWS suite of operational models and prediction tools as part of the Climate Model Development Task Force (2014-2017), the Climate Prediction Task Force (2012-2015) and the NOAA Climate Test Bed. For example, MAPP supported the testing and operational implementation of the North American Multi-Model Ensemble (NMME) seasonal prediction system in partnership with NWS as part of the NOAA Climate Test Bed, NMME Science Team and other agencies, and MAPP is now working on improving the NMME.
- MAPP also led the first set of NOAA initiatives to develop S2S predictions as part of the S2S Prediction Task Force (2016-2019). MAPP's S2S projects have resulted in several tools now contributing to the NWS Experimental Week 3-4 Outlook and the ongoing Subseasonal eXperiment (SubX, 2016-2018).
- MAPP's Climate Reanalysis Task Force (2013-2016) led the community evaluation of the Climate Forecast System Reanalysis (CFSR), which is informing ongoing planning for NOAA reanalysis.
- MAPP's CMIP5 Task Force led efforts to understand future long-term changes over North America (2011-2014), informing the USGCRP's Climate Science Special Report and the upcoming 4th National Climate Assessment.
- The Model Diagnostic Task Force (2015-present) developed several new evaluation tools in support of accelerated NOAA climate model improvement.
- The MAPP-NIDIS Drought Task Force (2011-present, three different investigator groups) led drought research activities in support of NIDIS. This resulted in an improved understanding of the causes of U.S. drought and its predictability as well as several new tools for drought monitoring and prediction, now contributing to the official U.S. Drought Monitor and U.S. Drought Outlook.
- Most recently MAPP spearheaded research on living marine resources and coastal flooding and climate in support of the NMFS and the NOS (Marine Prediction Task Force, 2017-2020); and is planning to explore best use of NESDIS JPSS data via assimilation into models for Earth system monitoring.

Overall, MAPP-supported has R&D leveraged science excellence and leadership in the broad U.S. community to address NOAA's modeling needs, coordinated with and expanding upon work done internally at NOAA. Thus, MAPP has substantially contributed to the U.S. climate science enterprise, with particularly positive impacts on NWS' operational models as well as the next generation of NOAA and non-NOAA scientists.



6 MAPP PROGRAM OVERVIEW

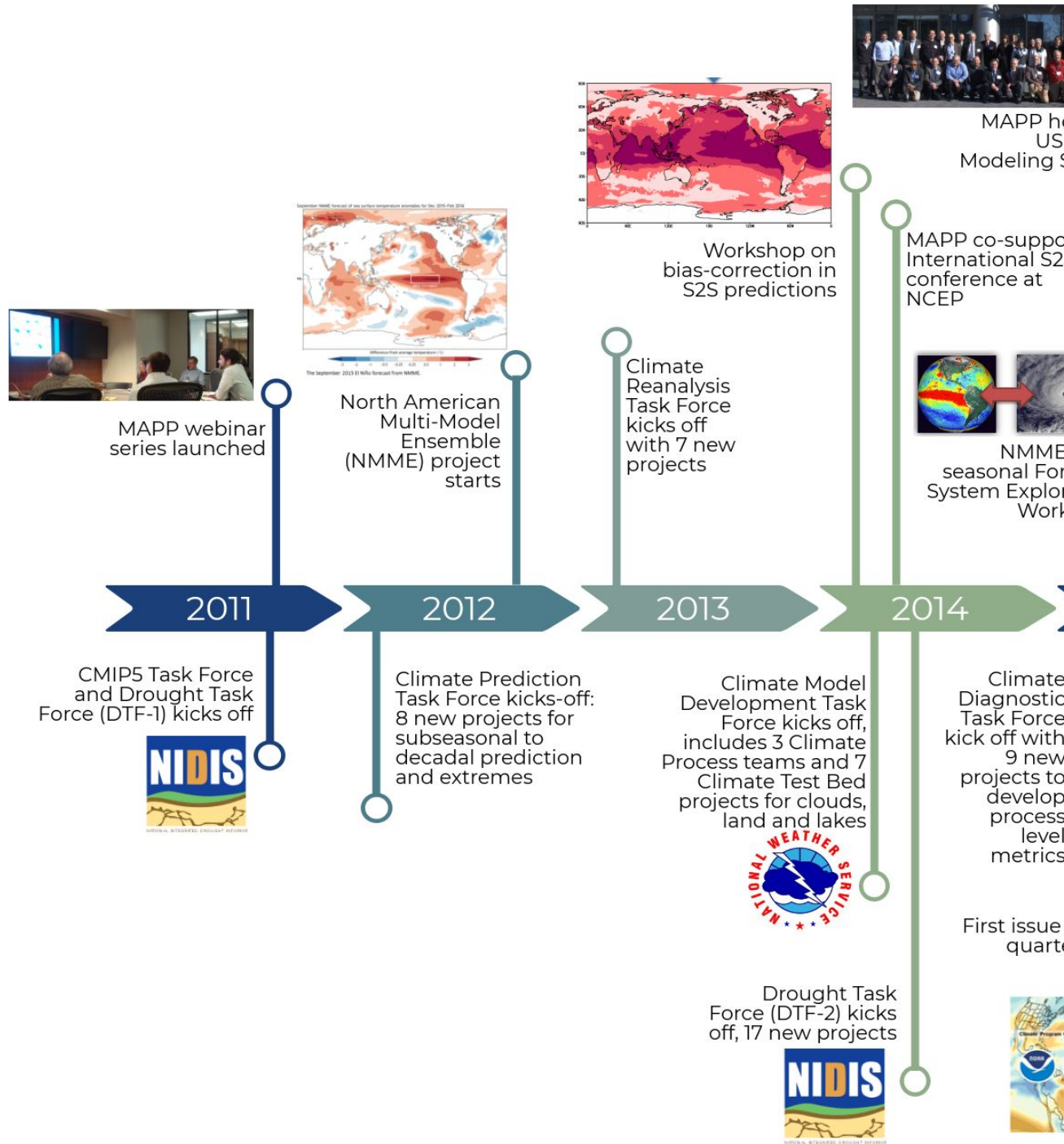
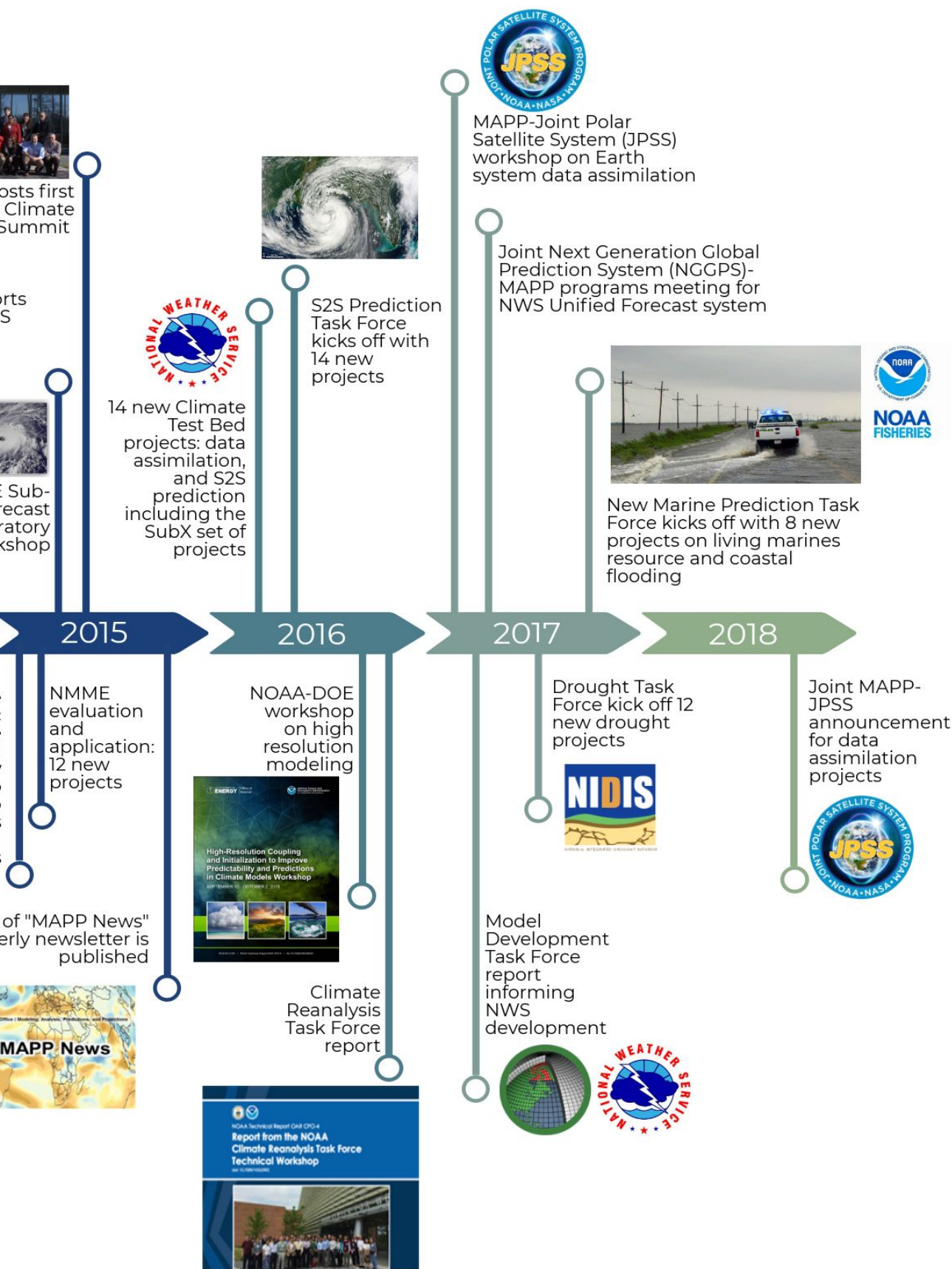


Figure 2: Main MAPP Program activity milestones during 2011-2018.

7 MAPP PROGRAM OVERVIEW



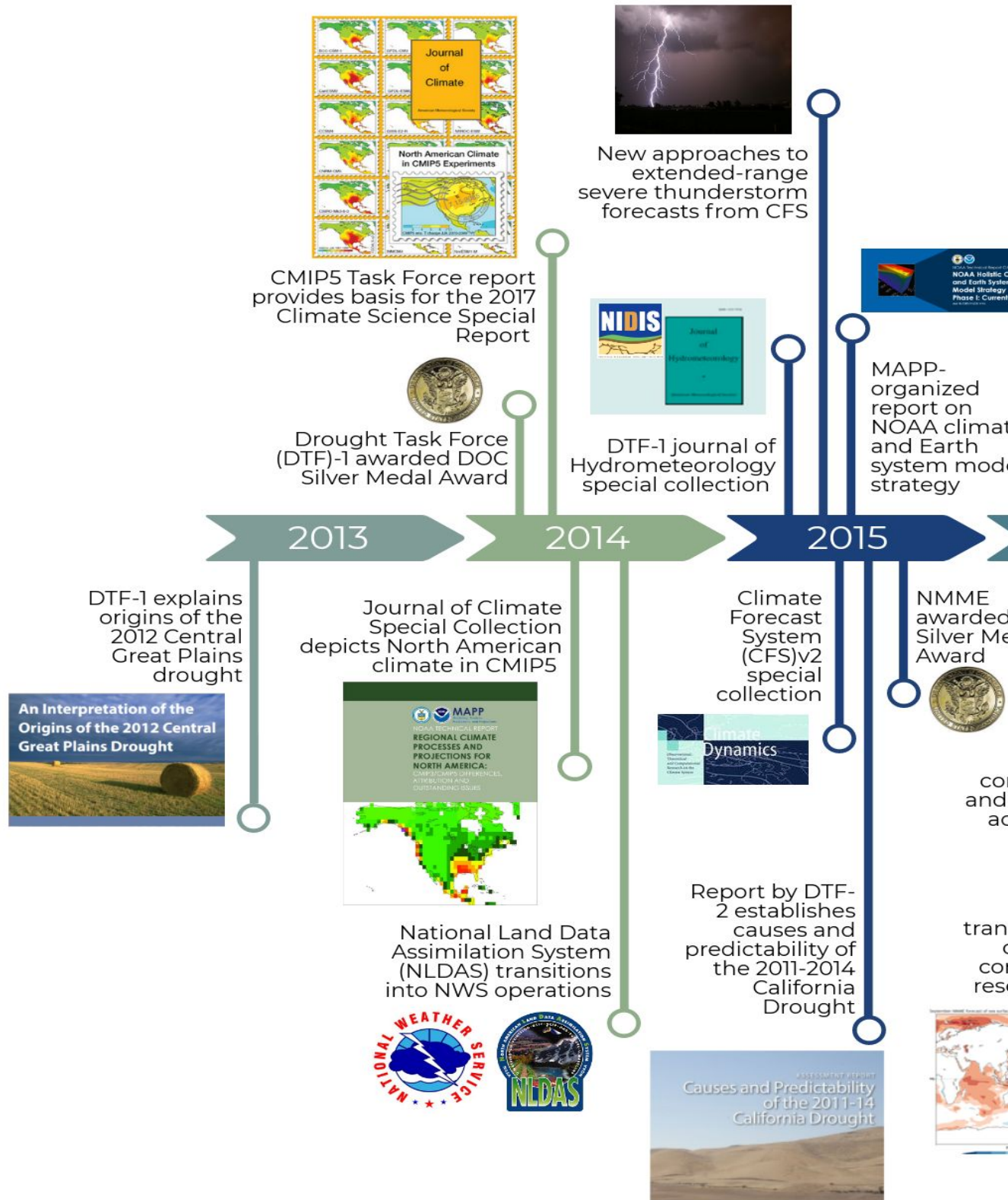
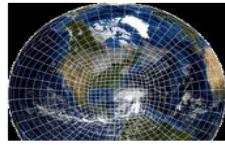


Figure 3: Examples of MAPP program achievements during 2011-2018.

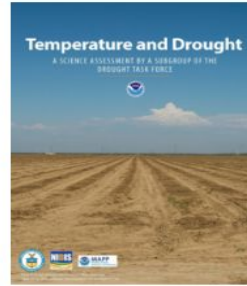
9 MAPP PROGRAM OVERVIEW



Synthesis of drought research accomplishments and needs in support of NIDIS



MAPP contributes to NOAA Unified Modeling strategy



Temperature-drought relationship for North America assessed



MAPP S2S research plays a substantial role in advancing subseasonal extreme weather and climate prediction



MAPP's newsletter enters its 3rd year and it is distributed to 291 people



NMME special collection published

2016

2017

2018

SubX data is publicly available

Climate Test Bed tested land and aerosol schemes ready for transition to NWS operational model

New week 3-4 forecast tools test by MAPP-CTB project transitions in operations

CMIP5 Task Force work applied to develop the Climate Science Special Report

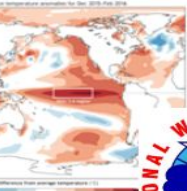


MAPP webinar series in its 7th year, to date thousands of attendees, hundreds of YouTube views



CFSv2 archive completed publicly accessible

The NMME transitions to NWS operations and continues to be a research platform



Part 2. Investigator Feedback

In January 2018, MAPP PIs were invited to provide feedback regarding their views of the program. The MAPP program team sought to understand why PIs elected to work with the program; the importance of the program to both NOAA and non-NOAA PIs; and PIs' opinions on specific aspects of program implementation, such as community engagement, project selection process, program areas, etc. Both NOAA and non-NOAA PIs were surveyed, with questions adapted slightly for each group. While participation in the questionnaire was voluntary, over 55 individual PIs responded — a 50% response rate, with 50% of respondents participating anonymously. This section summarizes the survey's questions and outcomes and includes a sample of survey responses from both NOAA and external PIs. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the investigators and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration and specifically MAPP program managers. Full responses are available online (see text box in the References on page 29).

What stage are you in your career?

80% of MAPP PIs from the external community are either early career or mid-career scientists, while only 20% said they are late career scientists. This contrasts with MAPP's NOAA PIs, who are either late career (53%) or mid-career (47%) (Figure 4). Thus, MAPP's inclusion of external PIs helps bring fresh ideas into the modeling and prediction field while NOAA's PIs help provide perspective and guidance to the relatively more junior extramural science community.



Figure 4: Responses to the question “What stage are you in your career?” LEFT: External PIs, RIGHT: NOAA PIs

Why did you respond to a CPO/MAPP solicitation?

Besides the general need for research funding, scientists both in the external community and NOAA respond to MAPP research solicitations because the program themes resonate with them. For external PIs, there is a specific interest in working with NOAA, for which the MAPP program provides opportunities. NOAA PIs respond to MAPP solicitations because of the benefit they get from working with the external community—they say they find a breadth and diversity of experience and expertise in the external community that doesn't always exist within NOAA. They are pleased when external investigators invite them to collaborate on new research ideas via MAPP program opportunities. In addition, both external and NOAA PIs see practical value of the R2O projects supported by MAPP as one key reason to engage.

PI Quotes: Why did you respond a CPO/MAPP solicitation?

“My research is oriented toward understanding the physical mechanisms and using the understanding to improve our operational forecast systems. The objectives of the CPO/MAPP solicitation provide a very good opportunity to connect both aspects efficiently.”-External PI

“The solicitation was very timely in terms of the type of research needed to support anticipated NOAA products.”-NOAA PI

“MAPP has had an increasing focus on weather and climate processes in the tropics and their teleconnections, including their implications for prediction on subseasonal and longer timescales, that I found societally important and also matched my research interests.”-External PI

“Our group was approached by several teams to provide forecasts from global models to be used in regional ocean forecast systems. I am interested in how weather and climate influence fish and other marine organisms by their influence on the ocean state.”-NOAA PI

“The fire managers had a need in Alaska and we have these NMME forecasts so we wanted to see if a product could be made to help them in their decision making. I am also interested in climate drivers of fire in Alaska and interannual climate variability.”-External PI

“Relevant to operational development, which is important to millions of people.”-NOAA PI

“Desire to help NCEP become a world leading climate forecast organization.” -External PI

How is MAPP funding making a difference to you? About how much of your total current funding (%) does MAPP provide?

Across the board, PIs say MAPP funding makes a significant difference to them (Figures 5 and 6). For early career scientists in the external community, MAPP provides a large fraction of their salary and often allows them to advance in their careers by providing opportunities for professional growth and experience they wouldn't have gotten otherwise, such as contributing to the enhancement of NOAA's operational forecast models. More senior scientists say MAPP provides critical funding they need to train students and postdocs who will be the next generation of experts in climate modeling and prediction, thus ensuring our nation's developmental pipeline is second to none. NOAA PIs say MAPP funding enables external PIs to work with them in ways that enhance their research and accelerate the transition of their research to operations. Specifically, because the MAPP program facilitates NOAA scientists' collaborations with external scientists, both communities benefit from professional development in terms of cross-pollination of ideas, participation in bigger teams, mentoring from senior scientists, constructive feedback from wider peer communities, and opportunities to apply their research to real-world problems.

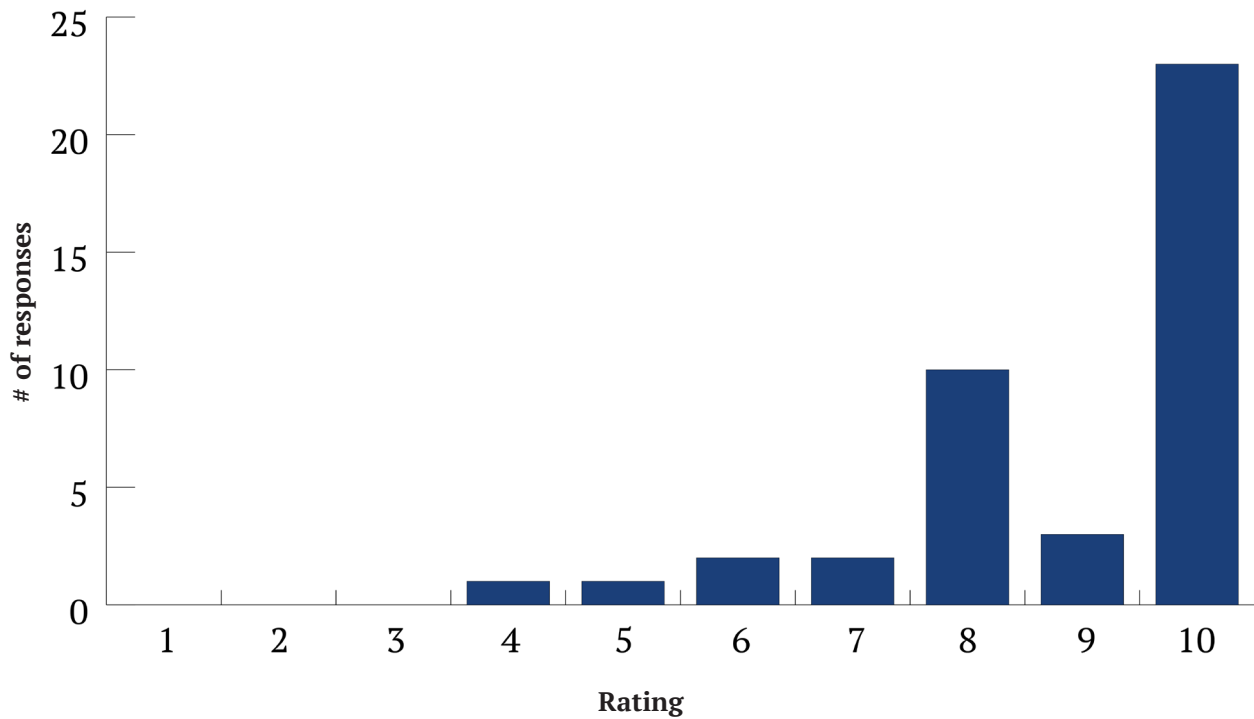


Figure 5. Responses to the question “On a scale from 1-10, how much of a difference is the MAPP funding making to you?” (External PIs)

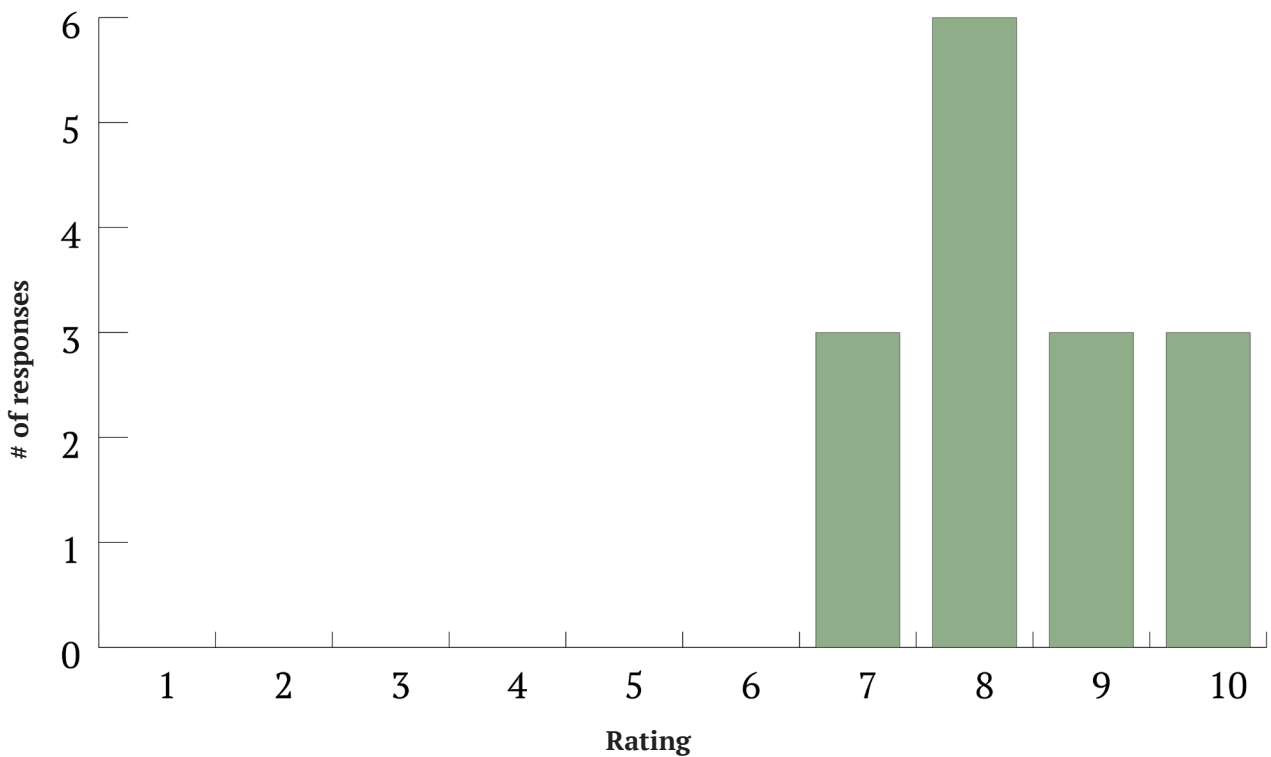


Figure 6. Responses to the question “On a scale from 1-10, how much of a difference is the MAPP funding making to you?” (NOAA PIs)

PI Quotes: How is the MAPP funding making a difference to you?

“I think MAPP funding is essential to convince others to work with us to improve NOAA products and services.”-NOAA PI

“The MAPP program provided the support that funded my transition from a postdoc to an assistant research professor position, and the projects have facilitated collaborations not only with NOAA/NCEP, but also with NASA, the U.S. Navy, and the European Centre for Medium Range Weather Forecasts (ECMWF).”-External PI

“Supports important collaborations with university scientists, focused on key research areas that have direct relevance to NOAA missions.”-NOAA PI

“MAPP has allowed me to further my research program on subseasonal to seasonal timescales, which has led us to make breakthroughs in subseasonal prediction of mid-latitude weather that would not have otherwise occurred.”-External PI

“MAPP funding has affected my career in multiple ways: (a) it has allowed to collaborate with my peers either via joint proposals or via several MAPP-sponsored task forces; (b) MAPP has challenged me to develop methodologies to better understand atmospheric variability and predictability, (c) peer-reviewed papers published as result of MAPP-sponsored research has been instrumental in advancing my career, and (d) it has allowed me to mentor several scientists that have been successful in their own careers.”-NOAA PI

“MAPP funding is critical to enabling the NOAA/EMC and NASA/GSFC partnership to transition NASA-developed modeling and data assimilation capabilities into operations at NOAA.”-External PI

“It has helped our center (NCEP/EMC) in model development and related activities, and in our interactions and leveraging with the research community; e.g. other NOAA labs, NASA, international projects and programs (e.g. GEWEX).”-NOAA PI

How many early scientists, students or other staff have been involved over the course of your current project(s)?

MAPP funding supports many early career scientists and students, thus helping to train students and postdocs who will be the next generation of experts in climate modeling and prediction, from whom NOAA can draw benefits in the future. Early career scientists are involved in about a quarter of MAPP's funded projects. For other projects, MAPP awards funds to mid-career or late-career scientists who, in turn, support students and postdocs. Thus, MAPP funding is critical to the next generation of climate scientists at NOAA and in the external community.

PI Quotes: How many early scientists, students or other staff have been involved over the course of your current project(s)?

“MAPP has provided some funding for 3 early scientists, an early career faculty member, a postdoc, and a graduate student. The rest of the team is comprised of senior members but the bulk of the funding goes to the early scientists.”-External PI

“We are involved in 3 MAPP projects with about 20 other scientists, 7 of which are early career scientists.”-NOAA PI

“8 students; 7 early career scientists.”-External PI

“Could be as many as 10 if you consider the broad umbrella of collaborative projects.”-NOAA PI

How would you characterize differences in MAPP project funding versus other kinds of NOAA funding (e.g., via a new NOAA budget initiative)? (NOAA PIs only)

NOAA PIs comment that MAPP program opportunities, targeting specific applied research issues, provide focus and, therefore, its projects are more efficient and tend to produce quicker results in terms of advancing predictive skill and capacity, and in terms of evolving NOAA’s operational models. NOAA PIs appreciate that MAPP provides more opportunities to explore new research areas than other funding mechanisms, such as work supported by Service Level Agreements (SLA). These views reflect the breadth of the MAPP program, spanning a large fraction of the NOAA R&D Funnel from Readiness Level (RL) 2-3 to RL 9, with lower levels typically being Test Bed work. NOAA PIs also find that MAPP’s open calls for funding provide a level playing field and help select the best ideas.



NOAA PI Quotes: How would you characterize differences in MAPP project funding versus other kinds of NOAA funding?

“I think MAPP encourages working across different branches of NOAA, with Universities and fishery managers. I think it also has very practical outcomes that can benefit managers and stakeholders.”

“MAPP is more flexible and allows us to explore new ways to do research. Some other NOAA funding, such as SLA, is very specific.”

“MAPP funding is more open minded to new ideas and innovation. I find other NOAA programs to be much more restrictive in what you can investigate.”

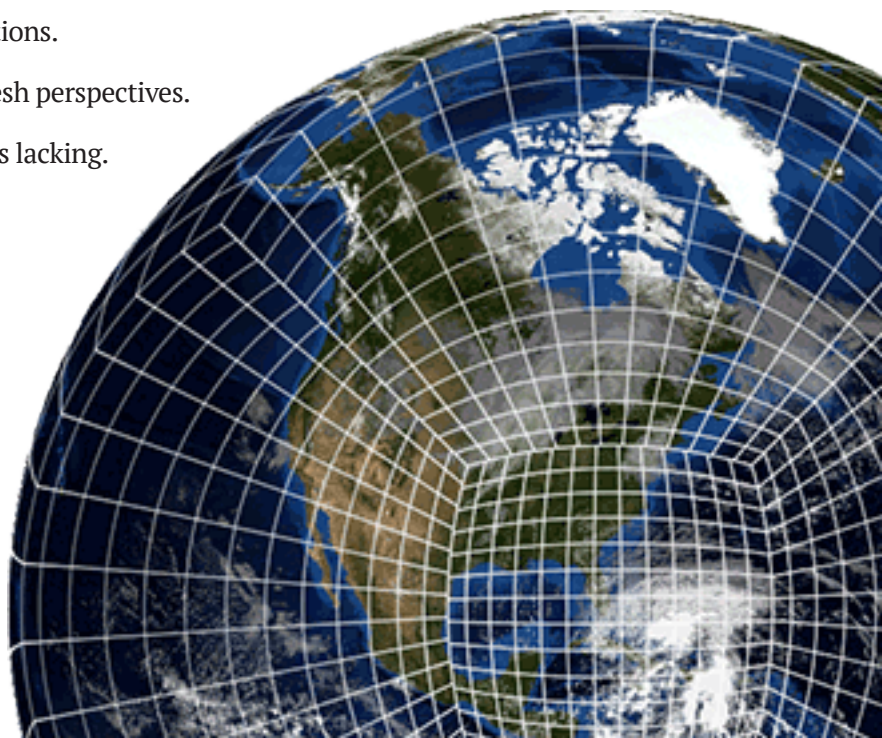
“MAPP enables targeted research with timely and actionable results; NOAA initiatives don’t always ensure that the necessary applied research is performed.”

“MAPP calls for funding are an open competition and level playing field. This aspect is important and unique to MAPP and encourages the best ideas to get funded.”

Why or why not is the collaboration with the external community that underpins a MAPP project important to you? (NOAA PIs only)

The general sense from NOAA PIs is that NOAA’s exposure to a wider range of viable ideas, as part of external community collaborations, is essential to the evolution of NOAA’s operational models. Without this exposure to so many new ideas, they say, NOAA’s progress would be slower and less cost effective. Specifically, NOAA PIs involved with MAPP say their collaborations with the external community via MAPP projects have the following benefits:

- Accelerates progress on difficult research questions.
- Enables external collaborations which bring fresh perspectives.
- Brings expertise and research skill that NOAA is lacking.
- Enables interdisciplinary teams.
- Reinvigorates NOAA’s internal talent.



NOAA PI Quotes: Why or why not is the collaboration with the external community that underpins a MAPP project important to you?

“It allows us to make more significant advances in difficult research questions.”

“MAPP allows collaboration between government and academic science, allowing the work to focus on real problems but with broad expertise.”

“Brings in unique research skills not currently in NOAA itself.”

“The topics that MAPP tackles are very interdisciplinary and require a broad spectrum of participants to tackle the topics being addressed.”

“Collaboration with the external community is an important aspect to advance research and accomplish the goals of NOAA. It allows NOAA to draw on a much bigger talent pool, and also invigorates the science talent within NOAA.”

Why or why not do you think MAPP program community engagement via Task Forces, webinars, workshops, etc., is beneficial?

A large majority of external PIs say that the MAPP program community engagement efforts have been very beneficial to them (Figure 7):

- Webinars are a cost-effective way for early-career scientists and students to share new ideas and to receive professional development and training.
- Task Forces are mechanisms for sharing experiences and early results, and provide a means to forge collaborations and enhance collegiality.
- Engagement provides a useful connection between the researchers and the operational and broader stakeholder community, hence helping to close the R2O/R2A gap.
- MAPP’s facilitated engagements create a shared sense of purpose and community among its internal and external PIs, which all agree is necessary to tackle the hard tasks associated with improving the accuracy and lead time of climate predictions.
- A few PIs said they feel there is an additional overhead time associated with MAPP’s engagements and they find it hard to participate.

Somewhat Beneficial 7.1%

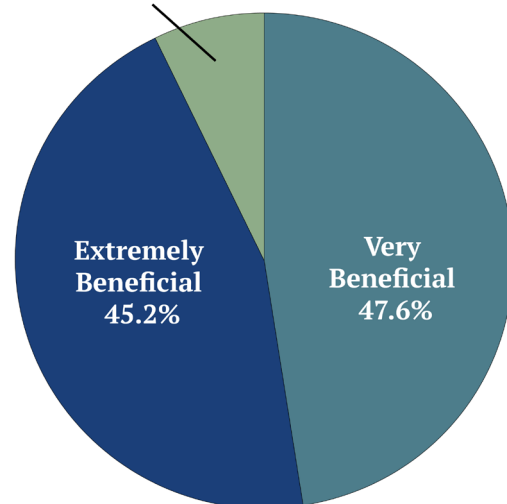


Figure 7. Responses to the question “How beneficial do you think MAPP’s community engagement is?” (External PIs)

PI Quotes: Why or why not do you think MAPP program community engagement via Task Forces, webinars, workshops etc. is beneficial?

“The connections I make through the Task Force and the information provided during webinars have absolutely sharpened the focus of my research and helped me communicate the results to a larger audience than I would otherwise.”-External PI

“The Task Force concept pioneered by the MAPP program has been beneficial in bringing together different Principal Scientists (PI) on proposals together. As part of our interactions in the Task Force, we are able to draw on the research effort of others, e.g., the data sets, expertise and knowledge others have. I have really enjoyed participating in different MAPP-led task forces to broaden the horizon of my understanding. The very concept of a Task Force is that ‘the sum is greater than the parts’.”-NOAA PI

“Engagement in the task forces allow collaboration and better communication by researchers working on similar tasks within a somewhat narrow field. It allows limited MAPP and NOAA resources to be pooled and used more effectively to accomplish the program and researchers’ objectives.”-External PI

“MAPP provides a link to the external community to bridge applied research directly to NOAA products” -NOAA PI

“Collaboration and building on others’ ideas and suggestions is crucial for systematic yet reasonably rapid scientific advances. Specifically for the MAPP program, this community engagement is vital towards ensuring that these advances meet the needs of water managers, stakeholders, and other users of our products.” -External PI

“It’s beneficial as it provides a funding/organizing mechanism for people to work together.”-NOAA PI

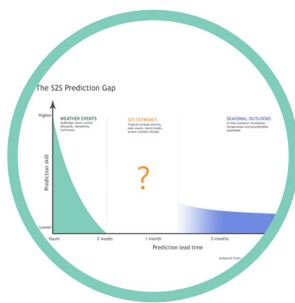
“It is truly a great idea to hear about other people’s work in the general area of the project. It builds collaborations across universities and government labs, and exposes us to new perspectives.”-External PI



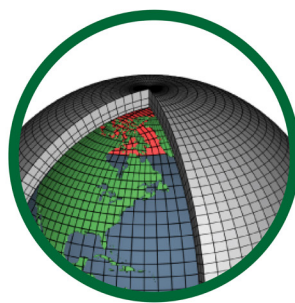
Marine Prediction Task Force
2017-2020



Drought Task Force
2017-2020
2014-2017
2011-2014



Subseasonal to Seasonal Task Force
2016-2019



Model Diagnostics Task Force
2015-2018

Figure 8. MAPP Task Forces active in 2018. (Note this is not a complete list of previous Task Forces).

Across the board, NOAA PI’s have very positive views of the MAPP program’s engagement efforts. They made the following points (Figure 9):

- MAPP program engagement allows communication, networking, broadens views, enables coordination and the initiation of new ideas, and helps to eliminate redundancies and avoid mistakes.
- They value MAPP’s cost effective ways of bringing the NOAA and non-NOAA PIs together.
- They perceive the engagements create an R2O “bridge.”
- They recognize that the MAPP Task Force concept produces new wholes that are greater than the sum of the parts.

Overall, NOAA PIs seem to particularly appreciate MAPP’s community engagement efforts even more than the external PIs.

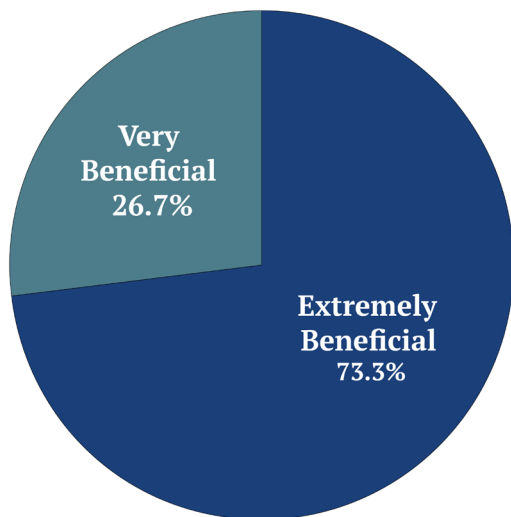


Figure 9. Responses to the question “How beneficial do you think MAPP’s community engagement is?” (NOAA PIs)

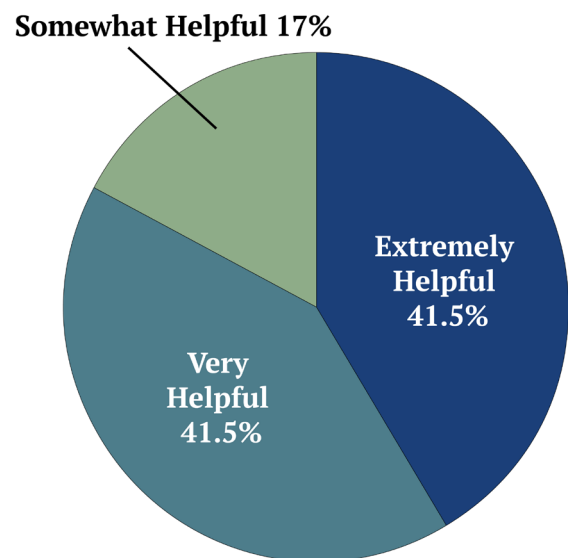


Figure 10. Responses to the question “How would you rate the helpfulness of this collaboration with NOAA to your work?” (External PIs)

How does this funding better enable you to work with NOAA and how does this collaboration benefit your work? (External PIs only)

Most people feel that their MAPP projects enable them to have a closer collaboration with NOAA and increase their awareness of societal needs/real-world problems relevant to NOAA’s mission (Figure 10). Productive external PI collaborations with NOAA include those with NCEP, the Geophysical Fluid Dynamics Laboratory, and NMFS (among many others); work via the Climate Test Bed; and region-specific collaborations with NOAA in Alaska and Hawaii. While most PIs have positive experiences working with NOAA, some also mention some of the challenges they have faced while working with NOAA personnel, (outside of the MAPP program), such as when accessing model data or engaging with operational center staff who are sometimes not interested in discussing research ideas.

External PI Quotes: How does this funding better enable you to work with NOAA and how does this collaboration benefit your work?

“This collaboration is essential for my research team since we can help provide the climate expertise while NOAA colleagues have a much greater appreciation for the stakeholders that depend upon the research. Without this connection it would be much more difficult for our work to be impactful.”

“My project involves collaborators at NOAA labs, and this has helped strengthen my connection with them. This has led to an increase in the amount of research my group conducts that is aimed at improving NOAA products.”

“One of the MAPP projects is associated with the Climate Test Bed, which has led to closer interactions with operational groups (CPC, CBRFC, NWC) as well as other research labs (ESRL).”

“Our forecasting depends on collaboration between academic scientists with ocean modeling expertise and NOAA scientists with climate modeling and fisheries habitat modeling expertise. This funding has enabled that collaboration to move forward in a concrete way.”

“This funding has allowed us to collaborate with NOAA scientists, making us more aware of the operational needs, and see how our research can eventually be applied to operational use. The collaboration has provided us with better understanding about the strengths and weaknesses of the diagnostic tools that we have developed.”

How is it helpful for NOAA to support external investigators? Which specific skills have you brought to NOAA? (External PIs only)

External PIs give many reasons for why it is good for NOAA to support external investigators, including which specific skills they bring to NOAA (Figure 11). Among those cited:

- Bringing specific expertise and fresh perspectives; extending NOAA’s limited internal R&D capabilities.
- Drive NOAA to look beyond immediate needs and support exploratory research that will result in breakthroughs bringing significant new capabilities rather than incremental progress.
- Facilitating transition of expertise and methods to NOAA is a key reason; however, some have been frustrated by NOAA not being receptive to their research.
- NWS is seen as particularly needy of this infusion, but NOAA labs are also cited as benefiting.
- Only a NOAA program would specifically support some of the work that’s needed for NOAA, not NSF or other agency programs.

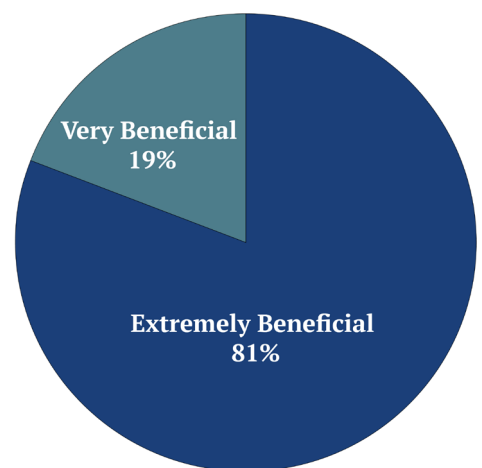


Figure 11. Responses to the question “How would you rate the benefit to NOAA of supporting external investigators?” (External PIs)

External PI Quotes: How is it helpful for NOAA to support external investigators? Which specific skills have you brought to NOAA?

“..with a relatively static and even shrinking workforce, NOAA cannot evolve and progress without the ability to support external investigators with a range of talents and perspectives to bolster NOAA efforts in new and pressing areas that need advancement.”

“External investigators can provide new ideas to assess and improve the models and tools that NOAA currently employs for forecasting and warning purposes. We have brought our expertise on model evaluations and understanding model biases to help motivate model improvements.”

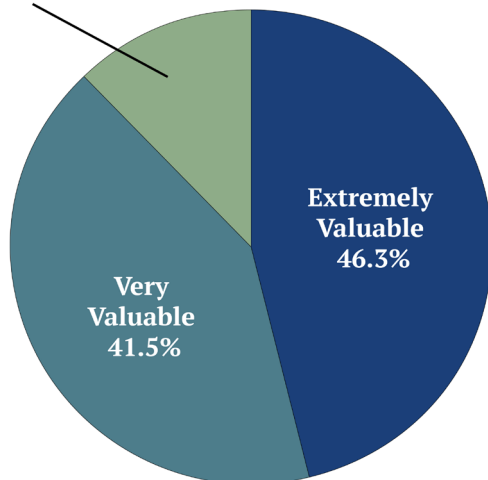
“NOAA personnel cannot possibly work on all the problems of interest to NOAA. The external investigators provide NOAA with access to skilled personnel and highly motivated young students, postdocs and researchers with new ideas and perspectives and, in collaboration with NOAA, allow important advances to be made and problems solved. It advances the science much more than a purely internal NOAA effort could do.”

“It is vital for NOAA to support external investigators but it is still necessary for NOAA and NCEP to make sure that the internal institutions are as receptive to making these collaborations productive. No fault of CPO, of course. But right now NOAA is still doing a very poor job of turning its external and internal research investment in developing better operational weather and climate models into actual improvements in these models. Bureaucracy, inertia, poorly managed internal rivalries and list-making still are rampant.”

What do you see as the value of a competitive peer-review process to select projects?

The MAPP program applies a rigorous peer-review process to select projects for funding. Overall, external PIs and NOAA PIs think this peer-review process is essential to selecting the best projects (Figures 12 and 13). External PIs said MAPP’s peer-review process...

Somewhat Valuable 12.2%



- Is a stringent vetting mechanism for good ideas and one that forces people to push the envelope.
- Is a fair process — none of the responses included complaints of being treated unfairly.
- Appropriately involves external experts in the selection process because NOAA does not have the internal knowledge to select the best, most cutting-edge projects.
- Opens the door to newcomers who bring important new ideas to the fields of modeling and prediction.
- The careful review process provides good feedback to proposers.
- Applies stringent rules to the Climate Test Bed process, which some PIs lament.

Figure 12. Responses to the question “How would you rate the value of the MAPP competitive peer-review process?” (External PIs)

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NOAA PIs echoed many of those same points, plus some important additional ones:

- They value MAPP’s competitive process because it provides a strict and rigorous evaluation of ideas.
- MAPP’s peer-review process encourages and rewards excellence in science, while avoiding internal biases.
- PIs value the feedback they get in the review process.
- The process allows scientists space to investigate important new ideas beyond the top-down internal NOAA approach.
- Some lament that the CTB process, requiring the participation of NOAA PIs, is “baking in” some choices; others think that, for this type of project, the competitive process is less important.

Somewhat Valuable 14.3%

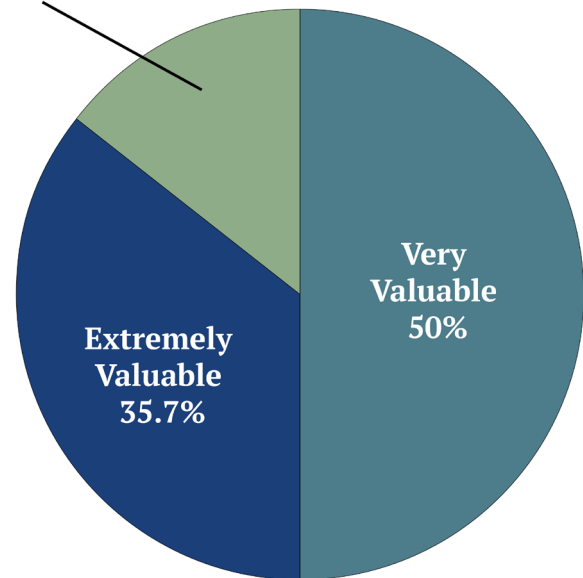


Figure 13. Responses to the question “How would you rate the value of the MAPP competitive peer-review process?” (NOAA PIs)

PI Quotes: What do you see as the value of a competitive peer-review process to select projects?

“Projects selected for funding are highly likely to advance our understanding of key processes and improve model forecast skill. I feel this is true because of the enormous effort required to write a successful proposal, the collective wisdom of the review panel in identifying high-value projects, and the inherent drive of PIs to successfully complete the work.” -**External PI**

“I am always interested to see what others think about my proposal, what do I miss and how to improve.” -**NOAA PI**

“It’s the only logical way to select projects -- the removal of peer review and placing those decisions in the hands of program managers would be a severe mistake.” -**External PI**

“The competitive peer-review process allows scientists the freedom to propose ideas of their own which is often not the case within NOAA.” -**NOAA PI**

“Peer-review mines the rich depths of community expertise to help identify imaginative but realistic ideas.” -**External PI**

“Peer review accomplishes three important things: (1) ensures a fair process, (2) best science and (3) external community buy-in in supporting the process.” -**External PI**

What outcomes from your project will have practical applications for NOAA and its stakeholders? Could you provide a brief summary of these practical applications, including which Line Office(s) and other stakeholders will benefit and in what approximate timeframe?

External PIs provided a long list of practical applications for NOAA from their MAPP projects include improving the outlooks for extremes (such as heat waves and fires), extending ENSO predictions, developing new drought monitoring and prediction, improving NOAA modeling and data assimilation capabilities, developing new tools for fisheries management, and developing new coastal sea level outlooks. Their work directly benefits the work of several NOAA Line Offices, including NWS/NCEP, OAR, NOS, NMFS. Examples of some stakeholders who benefit from their work include state water authorities and farmers in the West, fisheries managers, managers who need to deal with fire hazards in Alaska, and urban authorities in the Southeast who are concerned with coastal flooding risks.

PI Quotes: What outcomes from your project will have practical applications for NOAA and its stakeholders?

“My project will help improve confidence in subseasonal forecasts of tropical weather systems that are known to affect North American severe weather events.”-External PI

“Better cloud and boundary-layer parameterizations in NCEP operational weather and climate forecast models.”-External PI

*“ [My work] gives insight about how much predictability can be obtained from the stratosphere and therefore informs NOAA how valuable the inclusion of a well-resolved stratosphere is in NOAA’s S2S models.”
-External PI*

“Our work showing that atmospheric rivers are predictable along the U.S. West Coast multiple weeks in advance given knowledge of the MJO would be of direct benefit to National Weather Service forecast offices and water managers in the West.”-External PI

“Real-time climate monitoring and reanalysis. This information allows stakeholders to place the evolution of current climate in a historical perspective.”-NOAA PI

“ We can have a bias-corrected code to calculate a widely-used measure of fire danger (Build up Index) in Boreal Alaska (and Canada) which can be used with forecasts by NOAA to create products for Alaska managers in the time frame they need.”-External PI

“We develop model evaluation metrics that will help model developers to improve modeling and prediction of the MJO using climate models. As the MJO has great impacts on global climate / weather events, such hurricane, flooding, drought, wildfires, etc.”-External PI

“..improved soil moisture and drought depiction through advances made to NLDAS, including new model physics and data assimilation. These improvements are expected to lead to weekly USDM maps that better reflect real-world conditions.”-External PI

“NLDAS products are widely used. Each year there are over 5,000 distinct users, including US drought monitor, various governmental agencies, universities, research institutes and private enterprises.”-NOAA PI

“demonstrate the potential for improved management of the west coast Swordfish fishery (i.e., through more informed spatial/temporal closures of the fishery), with the key stakeholders being the Pacific Fishery Management Council, the NMFS West Coast Regional Office, and the fishers in the California Drift Gillnet fishery.”-External PI

“enhance multi-temporal sea level outlook components and other coastal flood indicators (e.g. flood frequency, wind and ocean circulation metrics) under consideration for the National Integrated Coastal Flooding Information System (NICFIS) Southeast pilot area.”-External PI

“NOS and NWS will be able to provide guidance about the changing nature of coastal flood risk, which is rapidly increasing as sea levels increase.”-NOAA PI

How does CPO/MAPP funding help advance the priorities of your NOAA lab/operational center? Could you provide an example of a tangible way in which this funding is advancing NOAA priorities and capabilities? (NOAA PIs only)

NOAA PIs funded by MAPP say that their research has improved Climate Prediction Center’s (CPC) subseasonal to seasonal forecasts (e.g. for drought); has resulted in an operational National Land Data Assimilation System (NLDAS) to monitor land hydrology that is now used for the National Water Center; is developing model diagnostics tools that accelerate the work of developers to improve NOAA models; and is enabling development of new environmental forecasts for fisheries and new sea level outlooks. NOAA MAPP PIs say that, in addition to helping generally advance the field of modeling and prediction, MAPP’s support is also helping their center make progress toward their own priorities (Figure 14).

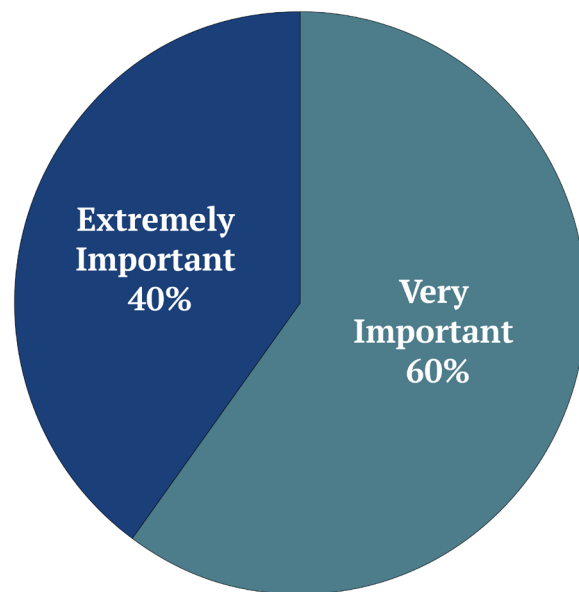


Figure 14. Responses to the question “How would you rate the importance of CPO/MAPP funding for advancing the priorities of your lab/operational center?” (NOAA PIs)

NOAA PI Quotes: How does CPO/MAPP funding help advance the priorities of your NOAA lab/operational center?

“MAPP funding has been responsible for improving several prediction products at NOAA CPC.”

“..diagnostic activities are feeding into development of models for NOAA mission.”

“.. improve stock assessments in the Northeast.”

“MAPP involvement in Marine seasonal Prediction is extremely important for NOAA fisheries.”

“We are helping develop coastal ocean forecast systems for the US east coast, California, Washington/Oregon and the Bering Sea.”

Is it possible for you to state, or estimate, the value of your research for particular stakeholders/sectors in economic terms (\$\$)? If so, please do.

Most investigators haven't specifically evaluated the economic value of their work, but all agree that their work produces value for the economy that is many times greater than MAPP's initial investment — ranging from millions to billions of dollars. Some PIs used the economic value of meteorological disasters to assess value while others made educated guesses.

PI Quotes: Is it possible for you to state, or estimate, the value of your research for particular stakeholders/sectors in economic terms?

“Possibly in the billions (due to loss from extreme/severe weather).”-External PI

“The value of my scientific research is an order of magnitude bigger than the grant amount, judging from the long-term impact on NOAA performance.”-External PI

“Multi-year droughts have tremendous socioeconomic impacts. The early warnings would help set the strategy for water conservation and agricultural planning to minimize the economic losses.”-External PI

“We do know that the NMME forecasts are used by a number of private sector businesses and by a number on non-federal government agencies.”-External PI

“It has been estimated that droughts cause roughly \$9 billion in damages per year in the United States. Through improved drought depiction by the U.S. Drought Monitor, damage payments and assistance would

be better targeted to those in extreme droughts, while saving assistance/payments to those not actually in severe conditions.”-External PI

“If one considers the value of water and water-related industry each year in the US (order ~\$100B), and that forecasts play an essential role in the management of that water, then the value of the research if successful is surely 10-100 times the cost of the research. A recent study at ECWMF/Reading put the ROI of weather/climate forecasting at 400:1.” -External PI

Why or why not do you think subseasonal to seasonal (S2S) modeling, prediction, and predictability is something that the MAPP Program should be engaged in?

Our PIs unanimously affirmed the importance of MAPP program engagement in S2S research and provided many specific examples of past work and future needs (Figures 15 and 16).

- Some PIs emphasize the importance of coupled processes for these predictions, which MAPP’s climate community has expertise in. These PIs are concerned about the traditional NWS focus on atmospheric dynamics and its lack of robust coupled modeling activities. They see MAPP as bringing that necessary scientific expertise to address the S2S problem.
- MAPP provides an R2O conduit for S2S research that is crucial to advancing near-term prediction capabilities.
- They credit MAPP’s leadership and vision, and successful past S2S research activities.
- Some think MAPP needs to keep a balance between different research areas, and also engage in prediction research for longer timescales.

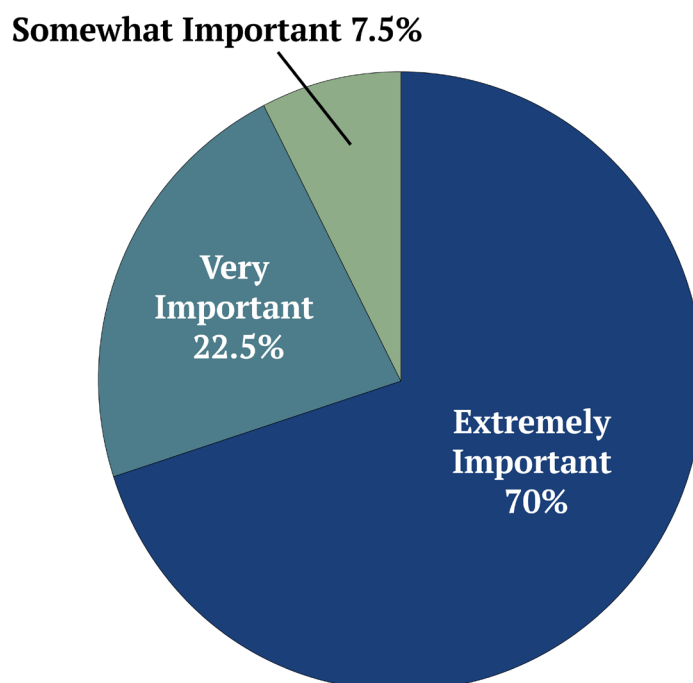


Figure 15. Responses to the question “How would you rate the importance of the MAPP program’s engagement in S2S?” (External PIs)

NOAA PIs specifically think that:

- S2S is a critical MAPP research area with important applications.
- MAPP has been one of the few programs that have targeted this area.
- They stress the seamless nature of the modeling and prediction problem

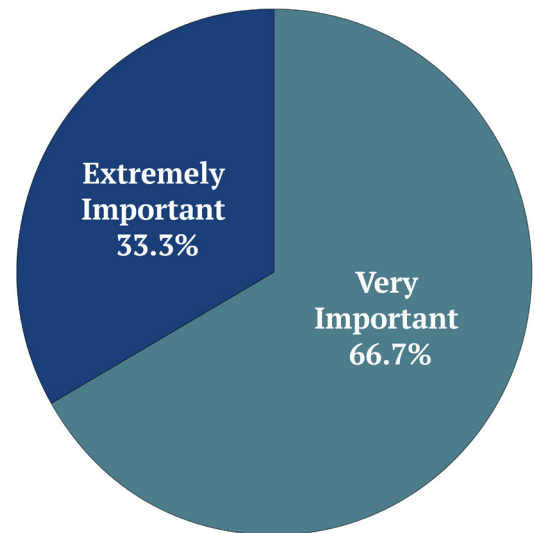


Figure 16. Responses to the question “How would you rate the importance of the MAPP program’s engagement in S2S?” (NOAA PIs)

PI Quotes: Why or why not do you think subseasonal to seasonal (S2S) modeling, prediction, and predictability is something that the MAPP Program should be engaged in?

“Improving S2S forecasts will yield enormous benefits to financial, energy, agricultural, and public safety sectors...MAPP’s support of S2S forecast activities directly support the US Department of Commerce mission objectives of promoting ‘job creation, economic growth, sustainable development, and improved living standards for all Americans by working in partnership with businesses, universities, communities, and workers.’”-External PI

“The S2S timescale provides a challenging environment for prediction, including both modeling and data assimilation, and seems an appropriate target for drawing expertise and experience from outside of NOAA.”-External PI

“S2S modeling work has demonstrated regional predictability in various ways - most of which can be harnessed at the spatial scales that managers need to make decisions. It connects climate and weather to managers in a very direct way.”-External PI

“MAPP program should be engaged in S2S activities to understand, model and predict the near-time extremes including persistence of seasonal droughts/floods, and short-period intense rainfall events that are punctuated by the phase of sub seasonal variations. The MAPP program has a clear vision, well poised to lead and address these pressing socioeconomic high-end events.”-External PI

“The research/development on the subject is very limited in the operational centers. A better understanding of physical reasons behind these phenomenons is essential to make any improvements. As such, the MAPP program should engage this kind of activity.”-NOAA PI

This report summarizes NOAA's MAPP program activities and outcomes over the last 7 years as they relate to advancing climate modeling, prediction, and projection capabilities, both within and beyond NOAA. The MAPP program has extended NOAA's reach into a broader set of expertise/capabilities; it has bridged the weather and climate communities through its S2S prediction efforts; and it is based on a robust peer-review process and PI engagement strategy. Two key indicators, include: (i) 75% of MAPP-funded projects have contributed to improved modeling and predictions of climate, and (ii) 100% of MAPP's completed Climate Test Bed projects have successfully transitioned from research to NOAA operations. Because of its sustained activities and outcomes, the MAPP program is now a recognized brand for NOAA's modeling and prediction research, both nationally and internationally.

The PI feedback summarized here provides a testimonial to the important R&D work the MAPP program conducts for the advancement of NOAA's mission, relevant science areas and for the professional development of NOAA and external PIs engaged in the program.

Overall, MAPP-supported research leverages scientific excellence and leadership in the broad U.S. community to address NOAA's mission modeling needs, coordinated with and expanding upon work done internally at NOAA. This support contributes substantially to the U.S. climate science enterprise to address NOAA stakeholder needs and positively impacts the next generation of scientists.

Acknowledgements

The MAPP program team is grateful for its resource partners, MAPP PIs dedicated engagement, and NOAA Senior Leadership support over the course of several years which have made past achievements possible. In addition, MAPP would like to thank David Herring and Rachel Gaal from the Climate Program Office for assistance and guidance on report preparation, as well as Wayne Higgins, Ben DeAngelo, and Jin Huang from the Climate Program Office for their thorough review comments and feedback.

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Mariotti et al., 2018. Progress in subseasonal to seasonal prediction through a joint weather and climate community effort. *NPJ Climate and Atmospheric Science* 1 (4) doi:10.1038/s41612-018-0014-z.

Zhang et al., 2018: Coordination to understand and reduce global model biases by U.S. and Chinese Institutions. *Bull. Amer. Meteor. Soc.* doi:10.1175/BAMS-D-17-0301.1.

Link et al., 2017: High-level NOAA Unified Modeling Overview. NOAA Technical Report, 20 p. doi:10.7289/V5GB2248.

Zhou et al., 2017: Exploring JPSS Data Application for Earth System Data Assimilation <https://doi.org/10.7289/V5XK8CM0>.

Kinter et al., 2017: Climate Model Development Task Force Final Report. doi: 10.7289/V5/TR-OAR-CPO-6.

Kinter et al., 2016: High-Resolution Coupling and Initialization to Improve Predictability and Predictions in Climate Models Workshop. DOE/SC-0183; NOAA Technical Report OAR CPO-5. doi:10.7289/V5K35RNX.

Schubert et al., 2016: Global Meteorological Drought: A Synthesis of Current Understanding with a Focus on SST Drivers of Precipitation Deficits. *Journal of Climate*, 29(11), 3989-4019.

Huang et al., 2016: Research to advance national drought monitoring and prediction capabilities doi: 10.7289/V5V122S3.

Compo et al., 2016: Report from the NOAA Climate Reanalysis Task Force Technical Workshop. NOAA Technical Report OAR CPO-4. doi: 10.7289/V53J39ZZ.

DeWitt et al., 2015: NOAA Holistic Climate and Earth System Model Strategy Phase I: Current State. NOAA Technical Report OAR CPO-3. Climate Program Office Silver Spring, Maryland. doi:10.7289/V5Z31WKK.

Wood et al., 2015: Prospects for Advancing Drought Understanding, Monitoring and Prediction *Journal of Hydrometeorology*, 16(4), 1636-1657.

Seager et al., 2015: Causes and Predictability of the 2011-14 California Drought.

Hoerling et al., 2014: Causes and Predictability of the 2012 Great Plains Drought, BAMS, 95, 2, pages: 269-282 doi: 10.1175/BAMS-D-13-00055.1.

Huang, J., Mariotti, A., Kinter, J., Kumar, A, and Schneider, E., Eds., 2013-2015: Topical Collection on Climate Forecast System Version 2 (CFSv2). Special Collection, Amer. Meteor. Soc. Climate Dynamics.

Schubert, S., Mo, K., and Mariotti, A., Eds., 2013-2015: Advancing Drought Monitoring and Prediction. Special Collection, Amer. Meteor. Soc. Journal of Hydrometeorology.

Maloney, E. D., Kinter, J., Sheffield, J., and Mariotti, A., Eds., 2013-2014: North American Climate in CMIP5 Experiments. Special Collection, Amer. Meteor. Soc. Journal of Climate.

Sheffield et al., 2014: Regional Climate Processes and Projections for North America: CMIP3/CMIP5 differences, attribution and outstanding issues. NOAA Technical Report OAR CPO-2, doi:10.7289/V5DB7ZRC.

Mariotti et al., 2013: Advancing drought understanding, monitoring and prediction, Bull. Amer. Met. Soc. doi:10.1175/BAMS-D-12-00248.1.

MAPP Program Investigator Feedback

Full responses are available via the links below:

External PI responses:

cpo.noaa.gov/Meet-the-Divisions/Earth-System-Science-and-Modeling/MAPP/Survey-Results-External

NOAA PI responses:

cpo.noaa.gov/Meet-the-Divisions/Earth-System-Science-and-Modeling/MAPP/Survey-Results-Internal

