Restructuring of U.S. Federal Coordination to Advance Meteorological Services

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ABSTRACT: For the first time in over 50 years, the United States has, at the direction of Congress, restructured the way in which federal departments and agencies coordinate to advance meteorological services. The new framework, known as the Interagency Council for Advancing Meteorological Services (ICAMS), encompasses activities spanning local weather to global climate using an Earth system approach. Compared to the previous structure, ICAMS provides a simplified, streamlined framework for coordination across all stakeholders in implementing policies and practices associated with the broad set of services needed by the United States now and into the future. ICAMS also provides improved pathways for research and services integration, as well as mechanisms to more effectively engage the broader community, including academia, industry, nonprofit organizations, and particularly the next generation of educators, researchers, and operational practitioners.

KEYWORDS: Operational forecasting; Policy

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The development and provision of meteorological services is a critical function of a multisector enterprise in the United States, the foundation of which is an array of federal agencies which fund and perform research, create and field instruments and computational forecast models, train professionals, and provide an array of products and services for use by nearly every sector of society. Such services not only are important for the protection of life and property, but also for ensuring public health, economic prosperity, and national security. Although the National Weather Service (NWS) mission is to provide weather, water, and climate data, forecasts and warnings for the protection of life and property and enhancement of the national economy, many other federal agencies have mission requirements related to meteorology.

Coordination and collaboration across relevant federal departments and agencies is a requisite for ensuring U.S. leadership in the meteorological services enterprise. Other key participants include higher education, which performs research and educates students, as well as the private sector, which develops and fields new technologies and adds value to government products and services, including via media communication of information to the public.

The importance of meteorological services to the United States cannot be overstated. Several hundred fatalities occur each year from lightning strikes, tornadoes, flash floods, hurricanes, winter storms, rip currents, wild fires, avalanches, and extreme heatwaves.¹

Additionally, a tremendous economic impact is associated with both ordinary weather fluctuations as well as extreme events.

Lazo et al. (2011) estimate that roughly 3.4% of U.S. gross domestic product (GDP) across every sector of the economy is sensitive to general weather variability. When it comes to major weather events, combined with increasing financial risk exposure, direct and indirect economic impacts can easily rise into the trillions of dollars (Schulten et al. 2019; Oustry et al. 2020; Svartzman et al. 2021).

¹ www.weather.gov/hazstat/

Although much of the focus of meteorological services tends to be on direct impacts to life and property, there exists a significant indirect influence on health as well, such as air quality effects on respiratory health, severity and duration of the cold and flu seasons, general food safety, water-related and vector-borne diseases, and overall mental health (Greenough et al. 2001; Bell et al. 2018; Zhang et al. 2020). Extreme weather also can have national security implications, not just from an economic stability and energy security perspective, but also from potential direct impacts on facilities and assets at home and abroad (Feith 2017; GAO 2019; Briggs 2020; VanDervort 2020).

For the first time since creation of the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) in 1964, the United States has restructured the way in which federal agencies and departments coordinate to advance meteorological services. Compared to the previous structure, the Interagency Council for Advancing Meteorological Services (ICAMS) utilizes an Earth system approach and provides a more streamlined framework to align weather-related research and services integration.

The creation of ICAMS fulfills a congressional mandate to improve coordination across all federal weather² services. Its elevation to the highest levels of U.S. Government leadership across all relevant departments and agencies, including The White House, reflects the importance of such services to the nation and allows for more effective engagement not only across all relevant departments and agencies, but also with the broader community, including academia, industry, and nonprofit organizations.

² Use of the term meteorological in ICAMS, rather than weather, is addressed in the section “Creating ICAMS.”

In this article, we discuss the importance of meteorological services to the United States, key drivers from a historical context for administrative restructuring into ICAMS, and overview the motivation and mandate of Congress in requiring it. We then describe the process by which ICAMS was established and overview its structure, goals, and differences from and advantages relative to the previous framework. We conclude with a summary of next steps and ways in which all sectors of the community can be involved as ICAMS moves forward.

History of U.S. Meteorological Services Coordination

Origin of the Office of the Federal Coordinator for Meteorology (OFCM). The history of meteorological services in the United States traces its roots to atmospheric observations, which have been collected since the nation's founding. The U.S. Weather Bureau, which originally was established in 1870 to better coordinate various meteorological services, was transferred to the Department of Commerce in 1940 because of its growing involvement in aviation and air mail (Whitnah 1961; Komons 1978; Fuller 1990). Around this same time, the Army and Navy established separate weather operations. Coordination among federal agencies was managed through the Joint Meteorological Group (JMG), which later included the Joint Numerical Weather Prediction Unit, established in 1954, to formally coordinate numerical weather prediction (NWP) programs among the Weather Bureau, Air Force, and Navy (Shuman 1972).

Congress asked the Bureau of the Budget (BoB; later named Office of Management and Budget; OMB) in 1961 to examine the duplication of meteorological services within different agencies (Fuller 1990). This was later codified in Public Law 87-843, section 304 of the Department of Commerce Appropriations Act of 1963, and on 13 November 1963, BoB issued Circular A-62,³ which stated that despite successful operations, the development programs were not well coordinated (Moore 1964; NRC 1995). The report went on to clarify the various responsibilities among the Department of Commerce and other agencies with respect to both basic and specialized meteorological services and set up an adjudication process to resolve potential issues.

³ www.icams-portal.gov/publications/spacewx/fcm-i7.pdf

In response to Circular A-62, the Department of Commerce established in January 1964 the Office for the Federal Coordinator for Meteorology (OFCM), which was headed by the Director of the Weather Bureau (who served as Federal Coordinator) and oversaw the Interdepartmental Committee for Meteorological Services (ICMS) and the Interdepartmental Committee for Applied Meteorological Research (ICAMR; Kreitzberg 1969; Fuller 1979). OFCM was tasked with facilitating the coordination of meteorological activities across federal agencies to achieve a more cost-effective and streamlined process to efficiently utilize shared resources. FCMSSR was formed at the same time to provide policy guidance to the Federal Coordinator from senior officials representing each participating agency (Moore 1964; White 1964; Fuller 1990).

Meteorological services were rapidly expanding as advancements in radar, satellites, and computing became readily available. As a result, the Environmental Science Services Administration (ESSA), of which the Weather Bureau became a part, was created in 1965 within the Department of Commerce (Stanley 1965; United States Congress 1965; Hahn 1968). Two years later, the Office of Special Assistant for Environmental Services (SAES) was established to coordinate these environmental services within the Department of Defense (DoD; Markus et al. 1987). SAES assumed the role of JMG and served as the new interface between DoD and OFCM, replacing the Air Weather Service (AWS) as the primary participant on many interagency and international meteorological committees. In 1970, ESSA was renamed the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Weather Bureau became the NWS.⁴

⁴ www.govinfo.gov/content/pkg/FR-1970-10-06/pdf/FR-1970-10-06.pdf#page=1

Despite some progress in coordination, OFCM struggled because it was tasked with aligning efforts across multiple entities

without having authority over actual budgets and requirements. In a 1977 report to Congress, the U.S. Government Accountability Office (GAO) stated that unnecessary duplication existed in the nation's weather services (GAO 1977). In a follow-on report in 1979, titled "The Federal Weather Program Must Have Stronger Central Direction," GAO concluded the lack of cooperation between the various weather services was a result of BoB circular A-62 not providing OFCM with any type enforcement mechanism (GAO 1979). Despite some points in the report being refuted by DoD counterparts (Fuller 1990), OFCM underwent a substantial reorganization, forming the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) by merging ICMS and ICAMR, which had been part of the original 1964 formation of OFCM (Jensen 1975; Harrison 1988).

ICMSSR, which had been chaired by the Federal Coordinator, received guidance at the program-management level from participating agencies. The original nine participating departments and agencies were the Departments of Agriculture, Commerce, Defense, Treasury, and Health, Education and Welfare, as well as the Federal Aviation Agency,⁵ National Aeronautics and Space Administration, National Science Foundation, and Atomic Energy Commission. BoB was invited to have an observer in attendance at the FCMSSR meetings (Hallgren 1980; Fuller 1990).

⁵ The Federal Aviation Agency became the Federal Aviation Administration in 1967 (www.faa.gov/about/history/brief_history/#agency).

Five standing committees originally were created within ICMSSR to address basic services, systems development, aviation services, operational environmental satellites, and space environmental forecasting. The Committee for Systems Development was later changed to focus on automated weather-information systems, and a sixth committee was added to address operational processing centers (Harrison 1988). The most recent OFCM organizational structure, prior to ICAMS, is shown in Fig. 1, where four standing committees existed under ICMSSR to address operational environmental satellites, operational processing centers, climate services, and interagency weather research. The remaining programs within the previous committees were either absorbed into one of the remaining four or reconstituted in the ICMSSR Working Groups and Joint Action Groups (Fig. 1).

Evolution of the U.S. Weather Enterprise. With help from the American Meteorological Society (AMS) and U.S. Weather Bureau, courses in meteorology slowly emerged throughout higher education, and by the early 1940s, meteorology was broadly recognized as a unique discipline within the university sciences (Harper 2012; Fleming 2016).

The focus on air power during WWII played a dominant role in advancing weather forecasting because of the sensitivity of aviation to meteorological conditions. These developments also drove the expansion of the upper-air radiosonde network, as well as observations from ships and aircraft (Benjamin et al. 2019). As the need for meteorologists grew, the field of weather prediction expanded into the broader area of atmospheric sciences. In the late 1940s and early 1950s, access to the newly invented electronic digital computer led to the first numerical models developed by university scientists. Subsequent support was provided through the JNWPU to further the development of this effort for both civilian and military use (e.g., Smagorinsky 1983; Harper et al. 2007; Benjamin et al. 2019).

Related research and education continued advancing through the late 1950s and 60s with the formation of the National Science Foundation (NSF) followed by the University Corporation for Atmospheric Research (UCAR) and the National Center for Atmospheric Research (NCAR; Houghton 1996). This led to a transition to the more encompassing Earth system science approach, as scientists and university researchers began to explore complex interactions, feedbacks, and cycles of the various spheres.

Evolution of private sector meteorology has accelerated at an exceptionally rapid rate as well. Less than 20 years ago, the majority of companies in the commercial weather space

Fig. 1. Administrative structure for coordinating meteorological services and supporting research in the United States immediately prior to the creation of ICAMS. Adapted from Fig. 1 in “The Federal Weather Enterprise: Fiscal Year 2019 Budget and Coordination Report,” available at www.icams-portal.gov/resources/icams/fedrep/2019_fedrep.pdf.

were known as “value-add” service providers (NRC 2003). These industries relied largely on government-produced data they would repackage into products and services to support various market sectors.

Today, private industry spans the entire value chain of organizations both involved in producing or delivering meteorological services as well as those reliant upon them. Commercial data providers offer both in situ and satellite observations; some companies specialize in forecast model development and improvement; cloud service providers offer high-performance computing (HPC) resources; and the original value-add industry is now using sophisticated artificial intelligence (AI) and machine learning (ML) to support its customers.

The weather enterprise has arrived at a point where both the public and private sectors are reliant upon each other. Understanding of the respective roles and strengths of the various sectors of the enterprise was addressed in a National Research Council report (NRC 2003), which contributed to the American Meteorological Society creating the Commission on the Weather, Water and Climate Enterprise.

Other activities have contributed as well, such as the NWS’s Weather Ready Nation (WRN) Ambassadors (Uccellini and Ten Hoeve 2019) and the World Meteorological Organization’s (WMO) Global Weather Enterprise Forum (GWEF; Thorpe and Rogers 2018).

With development of the Earth Prediction Innovation Center (EPIC; Jacobs 2021) and release of Short-Range, Medium-Range, and Subseasonal-to-Seasonal Applications⁶—the latter of which are the entire workflows based on the U.S. Unified Forecast System (UFS) community model—engagement of the nation’s entire weather enterprise in the forecast process has never been greater (Tallapragada 2020).

⁶ <https://github.com/ufs-community/ufs-weather-model>

Motivation for a new approach

Prior to 2017, the last comprehensive weather-related legislation passed by the U.S. Congress was the NOAA Authorization Act of 1992. Its successor, the Weather Research and Forecasting Innovation Act of 2017 (hereafter Weather Act; Public Law 115-25), was signed into law in April 2017, with the primary goal of improving the prediction of high-impact weather through investments and partnerships focused on observational, computing, and modeling capabilities.⁷ Although the Weather Act covers a broad range of meteorological topics, the motivation for administrative restructuring was driven largely by the need for better coordination of relevant weather research and forecast innovation activities through elevated visibility and engagement among principal-level policymakers.

⁷ www.congress.gov/115/plaws/publ25/PLAW-115publ25.pdf

Congress sought to address this issue through section 402 of the Weather Act, which requires the Director of The White House Office of Science and Technology Policy (OSTP) to establish an Interagency Committee for Advancing Weather Services (ICAWS) with participation from agencies involved in weather forecasting and research, as determined by the President. It further requires the interagency committee to share information regarding forecasting improvements, as well as identify, prioritize, and map critical operational needs against future budget requests. Additionally, it directs the OSTP Director to take additional steps as needed to coordinate federal activities with those across the broader weather enterprise, including the private sector, State and local governments and emergency managers, and the academic research community.

Creating ICAMS

As a first step in meeting the 2017 congressional directive, then OSTP Director (first author) initiated preliminary discussions in early fall, 2019 with several OSTP staff and NOAA senior leaders (because the new organization, per the Weather Act, is chaired by the OSTP Director and Federal Coordinator⁸). Two important issues were addressed: possible administrative structures for and the remit of the new organization. Having a preliminary concept for both from a small group of senior leaders would improve the focus and efficiency of subsequent meetings, which ultimately involved dozens of career professionals and political appointees across relevant federal departments and agencies, including those from OMB.

⁸ In creating ICAMS, the NOAA Administrator was made the Federal Coordinator for Meteorological Services (a precedent set in 1970) to fulfill the requirement of the Weather Act.

The overall planning process, which took place from fall 2019 through late July 2020, was built upon a foundation of diversity and inclusivity, continuous communication, open and frank exchange of ideas and concerns, and consensus agreement on all key issues. These elements are reflected in the ICAMS principles shown below. Although input was obtained informally from external stakeholders, the federal government deliberative process prevented updates from being shared beyond government personnel as the planning proceeded.

Scope, mission, and principles. As noted previously, the intent of Congress in writing the Weather Act was to improve coordination of “relevant *weather* (emphasis added) research and forecast innovation across the Federal government.” However, because the term “weather” has a relatively narrow definition (American Meteorological Society 2020), encompassing

only the state of and impacts associated with the atmosphere, and in light of the fact that international organizations (e.g., WMO) already have broadened their scope beyond weather, early discussions regarding ICAMS focused on creating a broader remit for it as well. Several possibilities were considered, ranging from meteorology (encompassing the atmosphere, cryosphere, and hydrosphere) to the Earth system (encompassing the aforementioned elements plus lithosphere and biosphere). After considerable debate, creating a committee on Earth system services was viewed as going well beyond the intent of Congress, particularly with regard to including earthquakes and other geophysical phenomena, biological and ecological systems, and human health.

Ultimately, the need to encompass Earth system elements—consistent with today’s emphasis on Earth system science research and education—led to focusing ICAMS on meteorological services via an Earth system approach. As noted in the ICAMS charter (OSTP and NOAA 2020), this approach considers the planet as a whole, linking the atmosphere, oceans and hydrosphere, terrestrial realm, cryosphere, and biosphere and encompassing weather, climate, hydrological, ocean, and related environmental services. Here “services” broadly includes “all relevant activities that provide value to society whether over land, at sea or in the air, including for the protection of life and property, personal and public health, quality of life, sustainability of the natural world, and economic and national security.”

Additionally, instead of creating a committee, as directed in the Weather Act, OSTP chartered a council, under the authority of the OSTP Director, to fulfill the requirements of the Act. The ICAMS mission is to serve as the “formal mechanism by which all relevant federal departments and agencies coordinate implementation of policy and practices to ensure U.S. global leadership in the meteorological services enterprise. ICAMS also informs the development of relevant federal policies via the National Science and Technology Council (NSTC; see below) and within individual departments and agencies.”

The following set of principles not only guides the work of ICAMS going forward, but also was important in the collaborative effort undertaken to create it.

- The meteorological enterprise is a national asset for ensuring personal and community safety, economic success, national security, and education;
- individuals, and their creativity and dedication, are the greatest asset of the U.S. meteorological enterprise;
- effective cross-agency coordination and external engagement are critical to success;
- success for individuals and organizations is achieved via success of the enterprise as a whole;
- efficiency is foundational to the stewardship of taxpayer dollars;
- research, operations, and applications are mutually beneficial, mutually reinforcing, and equally important for realizing ICAMS goals;
- open debate and a diversity of opinions promote excellence and teamwork; and
- excellence results in quality and promotes public trust.

Goals. ICAMS has the following goals that focus principally on domestic activities and reflect the missions of all participating agencies (see appendix):

- Coordinate, help prioritize, and execute activities for U.S. global leadership in meteorological services;
- streamline/consolidate activities, eliminate unnecessary duplication, and create greater efficiencies;
- improve participation of agency leaders in strategic planning and program execution;
- enhance communication and coordination, and promote sharing, within agencies and across the interagency;

- facilitate the expansion and strengthening of partnerships with non-government sectors;
- improve prioritization and promotion of high-impact and innovative initiatives;
- enhance research and operational interactions and feedback loops to accelerate advancement;
- enhance to all stakeholders messaging about the American meteorological enterprise; and
- develop, recruit and sustain a professional and diverse workforce engaged in meteorological science and services.

ICAMS also has the following “stretch” goal that places its work in an international context: *The United States will lead the world in meteorological services via an Earth system approach, providing societal benefits with information spanning local weather to global climate.*

Notably, this stretch goal covers a broad range of spatial and temporal scales and associated threats, and encompasses phenomena which today can be predicted quite skillfully (e.g., synoptic-scale weather) as well as those less so (e.g., local spring and winter precipitation, seasonal to subseasonal events).

Structure and leadership. The desire by Congress for a simplified and streamlined administrative framework inspired adoption of a structure for ICAMS similar to that of NSTC (Fig. 2; compare with Fig. 1). NSTC resides in the Executive Office of the President (EOP), is chaired by the President,⁹ and coordinates science and technology policy across some two dozen federal research and development agencies.

NSTC is structurally simple, stewarded by high-level government officials, engages hundreds of agency staff, and is extraordinarily effective in coordinating complex priority and planning involving annual federal research and development budgets in excess of \$150 billion.

The ICAMS structure (Fig. 3) reflects the NSTC model (Fig. 2) and consists of leadership (top box in Fig. 3) comprising two co-chairs (OSTP Director and NOAA Administrator) and senior federal officials, known as voting Principals. All are presidentially appointed, Senate-confirmed (PAS) federal employees¹⁰ representing the interests of their agency (see appendix). Because some departments and agencies have multiple subunits relevant to ICAMS, voting Principals may designate a nonvoting Principal as well. Meeting at least once per year, ICAMS voting Principals focus primarily on high-level topics of strategic importance to the nation. They also resolve issues brought to them by ICAMS senior staff.

⁹ Typically, the President delegates the chairperson role to the OSTP Director, which was the case in the Trump Administration.

¹⁰ Some agencies are not led by a PAS and thus designate an official to represent them in ICAMS.

Fig. 2. Structure of the National Science and Technology Council (NSTC) at the time ICAMS was established. Figure adapted from The White House Office of Science and Technology Policy (OSTP).

Fig. 3. Structure of the Interagency Council for Advancing Meteorological Services (ICAMS). Adapted from images made available from The White House Office of Science and Technology Policy (OSTP).

ICAMS is administered by the Interagency Meteorological Coordination Office (IMCO; Fig. 3). It consists of an Executive Director, from the Federal Senior Executive Service who is detailed to OSTP, along with a Deputy Director, who is detailed to NOAA. These individuals, along with the ICAMS co-chairs and Principals, have overall responsibility for success of the ICAMS mission. Both the Executive Director and Deputy Director positions rotate among participating agencies at intervals deemed appropriate by ICAMS leadership. This structure ensures IMCO leadership has direct and continuous access to The White House and senior NOAA leadership, and that all participating agencies have an equal voice in ICAMS. IMCO is staffed by career professionals, as well as detailees from participating agencies.

Given that NSTC, which is entirely separate from ICAMS, supports numerous activities relevant to ICAMS (e.g., the U.S. Global Change Research Program, the U.S. Group on Earth Observations, the Interagency Arctic Research Policy Committee, and the Networking and Information Technology Research and Development Program), effective coordination between NSTC and ICAMS is essential. This takes place in multiple ways, including via interaction between the NSTC and ICAMS Principals (upper-right dashed line to cyan box in Fig. 3), and between IMCO and NSTC leadership (middle-right dashed line to cyan box in Fig. 3). Additionally, numerous other activities appropriately take place within federal agencies and will remain there. However, strong coordination with ICAMS (center of Fig. 3) is essential if the United States is to succeed in achieving its aforementioned stretch goal.

The principal activities of ICAMS are executed within four committees (Fig. 3), each of which is co-chaired by multiple senior officials from participating agencies—thereby ensuring diversity of viewpoints and inclusion of all agency mission needs and priorities. Each committee has 15–20 formal members, drawn from across participating agencies, with other agency experts participating as well. The committee thematic titles and associated areas of responsibility (see the ICAMS charter for details) were carefully chosen to encompass top-line meteorological services activities, and as discussed below, several mechanisms exist to ensure cross-committee engagement (horizontal arrows in Fig. 3). Committee co-chairs, who

rotate among all participating agencies¹¹ at intervals deemed appropriate by ICAMS leadership, work closely with ICAMS and IMCO leadership to ensure the success of ICAMS and thus of its participating agencies. Additionally, ICAMS committees interact with their NSTC counterparts as needed.

¹¹ For a list of current co-chairs and their associated agency affiliations, visit <https://icams-portal.gov>.

Within each of the four ICAMS committees are subordinate units which address successfully finer-grained topics. These units include but are not limited to subcommittees, task forces, fast track action committees, and working groups—all of which may draw members from across all four committees and include external federal and non-federal participants as well. Additionally, given the highly integrative nature of meteorological services, joint action groups (JAGs) are used to address topics that cut across multiple committees and likewise involve participants within and external to federal agencies.

The aforementioned structure was crafted with two additional and very important goals in mind, the combined effects of which are indicated by the series of small vertical arrows at the bottom of Fig. 3. The first is to substantially enhance the effectiveness of research and operational services engagement (often referred to as research to operations, or R2O, operations to research, or O2R, and research to applications, or R2X). This takes place in a variety of ways, both within agencies and via programs funded by them, including but not limited to NOAA and other agency test beds, field programs, individual grants, and EPIC (Lapenta and Carlis 2020; Jacobs 2021).

The second goal is to ensure broad and diverse participation in ICAMS by non-federal agency stakeholders, especially the next generation of researchers and operational practitioners (e.g., those currently pursuing undergraduate and graduate degrees, holding postdoctoral appointments, or early career professionals in academia, industry and nonprofit organizations). This engagement takes the form of town hall meetings, webinars, special meetings convened by the National Academies of Science, Engineering and Medicine and AMS (especially local chapters), and agency meetings and workshops, to name a few.

Finally, it is important to note ICAMS was created during the unique circumstance of meteorologists holding both the NOAA Administrator and OSTP Director positions. Consequently, considerable effort was devoted to ensuring ICAMS would be successful when individuals from other disciplines held these positions. Steps taken include, in the charter, requiring both the OSTP Director and NOAA Administrator to serve as ICAMS co-chairs rather than delegating that authority. Additionally, having the voting Principals be PAS appointees, and the IMCO Executive Director detailed to OSTP and Deputy Director detailed to NOAA (though both working in IMCO), helps ensure visibility and engagement of ICAMS at the highest levels of agencies.

Transition from the previous structure into ICAMS and associated advantages

Context. Having described the rationale for and structure of ICAMS (Fig. 3), we now discuss the transition to it from the previous administrative framework (Fig. 1).

The ICAMS charter was signed on 31 July 2020 (Fig. 4) and the first meeting of voting Principals held on 27 August 2020. Thus, considerable work was needed in the months following to transition from the previous to the new structure. Because the IMCO leadership team was not yet in place, OSTP created the ICAMS Transition Team (ITT). Consisting of individuals from OSTP, NOAA and participating agencies, ITT is a temporary construct that oversees a wide array of activities, including managing early meetings of the ICAMS voting Principals, helping recruit and inform committee co-chairs, and working on legal and other aspects of the transition. Although the IMCO Deputy Director was hired in January 2021, the ITT continues, as of this writing, to assist with the transition.

The congressional mandate for a new, simplified and streamlined structure described previously afforded an opportunity to carefully evaluate existing activities and structures

that may have outlived their useful purpose or were sufficiently similar in scope so as to gain greater effectiveness by being merged or modified. It also allowed for a gap analysis, initiation of new activities—particularly with regard to ICAMS encompassing meteorological services in an Earth system context—and identification of weak or missing linkages with activities beyond the ICAMS framework. Finally, the mandate facilitated greater emphasis and improved visibility and coordination on community participation as well as research/operations engagement.

Transition. Consider first the transition of foundational elements from the previous structure (Fig. 1) to ICAMS. Figure 5 depicts this transition, with the role of FCMSSR being assumed by the ICAMS co-chairs and voting Principals. The major difference between the old and new structures, as noted previously, is that ICAMS leadership consists of presidentially appointed, Senate-confirmed agency heads. Additionally, one co-chair (OSTP Director) is a White House senior staff member,¹² thus bringing meteorological services to the highest levels of the Executive Branch.

In the new structure, OFCM has been transitioned to IMCO (Fig. 5), where it will continue to perform most of the same functions as before, though with additional responsibilities. These include but are not limited to stewarding the four committees, playing a greater role engaging both federal and non-federal stakeholders, collaborating with White House components (especially OMB), and coordinating international activities in meteorological services in collaboration with participating agencies. As noted previously, the NOAA Administrator also is now the Federal Coordinator for Meteorology, and IMCO is led by an Executive Director from the Federal Senior Executive Service, along with a Deputy Director.

Topical activities from the previous structure within ICMSSR (Fig. 1), including working groups, subcommittees, task forces, and ESPC (Earth System Prediction Capability), have been transitioned into the four ICAMS committees (Fig. 5; ESPC no longer exists as a stand-alone activity). Work continues on consolidation, streamlining, and creating new activities, and additional details may be found on the ICAMS website.¹³

Advantages relative to the previous structure. ICAMS provides several advantages relative to the previous structure. First, as noted above, ICAMS elevates meteorological services to the highest levels of Government, especially The White House. It engages PAS appointees to represent their agency interests and broadens the scope to an Earth system context. This will allow the United States to do something it has never done before, namely, develop a true national roadmap for meteorological services that engages all relevant federal agencies as well as the broader community of stakeholders.

Second, the ICAMS framework is more straightforward and more intuitive than its predecessor (Fig. 1), with the four committees each addressing key topics in meteorological services (Fig. 3). For example, rather than having the coordination of satellites, Doppler weather radar,

Fig. 4. Signing of the ICAMS Charter on 31 July 2020 by Acting Under Secretary of Commerce for Oceans and Atmosphere, Dr. Neil A. Jacobs (left), and OSTP Director, Dr. Kelvin K. Droegemeier (right). Photo courtesy The White House Office of Science and Technology Policy (OSTP).

¹² The OSTP Director is a member of the President's Cabinet in the Biden Administration.

¹³ <https://icams-portal.gov>

Fig. 5. Transition from the previous administrative structure for coordinating meteorological services and supporting research in the United States (see Fig. 1) to ICAMS.

and other observations reporting to different parts of the administrative framework (Fig. 1), ICAMS places all observing systems within a single committee (Fig. 3). In combination, these factors reduce unnecessary duplication and ensure coordination across all platforms and agencies while promoting effective diversity of ideas and competition. They further improve agency collaboration in areas such as data security (via the Committee on Cyber, Facilities and Infrastructure) and enhance the provision of resources to the research community (via the Committee on Research and Innovation).

Third, ICAMS is structured to improve agency engagement not only at the level of Principals, but also via committee co-chairs, committee members, and IMCO leadership. As of the date of this publication, the four committees have a total of 13 co-chairs representing 8 different agencies. Cross-agency engagement is enhanced via the use of rotating leadership positions and joint action groups, the latter of which cut across committee topical areas.

Finally, one of most important roles of IMCO is engaging the broader community (i.e., academia, industry, nonprofits) in both planning and executing the meteorological services agenda. This especially includes participation of the next generation of researchers and operational practitioners in all sectors for which such services are relevant. Additionally, updates to the ICAMS charter itself (e.g., participating agencies, specifics of the U.S. leadership role globally) should be considered—with full community engagement—to ensure ICAMS is meeting its objectives in the most effective manner possible. Work along these lines already has begun as described previously, and additional mechanisms are expected to be created, particularly those which bring next generation voices to the table, as in the President’s Council of Advisors on Science and Technology during the Trump Administration (PCAST 2020).

The way forward

The transition from the previous administrative structure to ICAMS is largely complete, with remaining tasks including hiring the IMCO Executive Director, finalizing subordinate units within each committee, and developing additional mechanisms to engage stakeholders beyond the federal government, both domestically and internationally. The ITT is expected to continue operating until its services are no longer needed.

Additionally, ICAMS and IMCO leadership are expected to begin developing a long-range, whole-of-nation plan for meteorological services that puts the United States on the path toward achieving the stretch goal described previously. Finally, consistent with a responsibility previously held by OFCM and now included in the ICAMS charter, IMCO will be developing and reporting annually to Congress a comprehensive budget for its operation, an interagency budget review of programs supporting meteorological services and related research, and associated annual implementation plans.

Summary and conclusions

We described the first major administrative restructuring of the United States' meteorological services enterprise in over five decades, initiated at the direction of Congress via the 2017 Weather Research and Forecasting Innovation Act. The new Interagency Council for Advancing Meteorological Services (ICAMS) serves as the formal mechanism by which all relevant federal departments and agencies coordinate implementation of policy and practices to ensure U.S. global leadership in the meteorological services enterprise. The structure of ICAMS is notably more straightforward and more streamlined than its predecessor, and its remit extends beyond weather to encompass other relevant services in an Earth system context.

Functionally, ICAMS comprises two co-chairs (Director of The White House Office of Science and Technology Policy and the Administrator of the National Oceanic and Atmospheric Administration) and presidentially appointed and Senate-confirmed agency heads as voting Principals. This structure elevates ICAMS to the highest levels of Government, giving it increased visibility and relevance in topics ranging from the environment to the economy and national security.

The Interagency Meteorological Coordination Office (IMCO) serves as the administrative home of ICAMS, and the principal work of ICAMS occurs within four committees (Observations, Services, Research and Innovation, and Cyber/Facilities/Infrastructure). IMCO and committee leadership rotate regularly among participating federal agencies to ensure broad representation, and subordinate activities within the committees ensure strong cross-committee and cross-agency engagement. External stakeholder involvement, especially that of next-generation researchers and practitioners, is foundational to ICAMS, as is international engagement.

ICAMS is viewed as enabling a stretch goal for the United States of leading the world in meteorological services via an Earth system approach, providing societal benefits with information spanning local weather to global climate. Key to achieving this goal is the development of a first ever multi-stakeholder, whole-of-nation strategic plan.

The new ICAMS framework essentially is in place, with the IMCO Deputy Director now on board and the ICAMS Transition Team continuing to assist. We expect ICAMS to be fully functional by the end of calendar year 2021.

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Appendix: United States Federal Departments and Agencies Participating in ICAMS

Executive Office of the President (EOP)

- Office of Science and Technology Policy (OSTP)
- Office of Management and Budget (OMB)

Department of Agriculture (USDA)

- Office of the Chief Scientist (OCS)

Department of Commerce (DOC)

- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)
 - National Weather Service (NWS)
 - National Environmental Satellite, Data, and Information Service (NESDIS)
 - National Ocean Service (NOS)
 - Office of Oceanic and Atmospheric Research (OAR)

Department of Defense (DOD)

- United States Army (USA)
- United States Air Force (USAF)
- United States Marine Corps (USMC)
- United States Navy (USN)
- United States Space Force (USSF)

Department of Energy (DOE)

Department of Health and Human Services (HHS)

- National Institutes of Health (NIH)
- Centers for Disease Control and Prevention (CDC)

Department of Homeland Security (DHS)

- Federal Emergency Management (FEMA)
- United States Coast Guard (USCG)

Department of the Interior (DOI)

- United States Geological Survey (USGS)
- Bureau of Land Management (BLM)
- National Park Service (NPS)
- Bureau of Ocean Energy Management (BOEM)
- U.S. Fish and Wildlife Service (FWS)

Department of State (DOS)

- Bureau of Oceans and International Environmental and Scientific Affairs (OES)

Department of Transportation (DOT)

- Federal Aviation Administration (FAA)
- Federal Highway Administration (FHWA)

Environmental Protection Agency (EPA)

National Aeronautics and Space Administration (NASA)

Nuclear Regulatory Commission (NRC)

National Science Foundation (NSF)

National Transportation Safety Board (NTSB)

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