2009 Community Review of

NCEP Central Operations

Carried out by the

University Corporation for Atmospheric Research

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Executive Summary

The University Corporation for Atmospheric Research (UCAR) was requested in November 2008 by the National Centers for Environmental Prediction (NCEP) to facilitate a thorough and thoughtful community review of the nine centers that comprise NCEP, as well as the NCEP Office of the Director. This report summarizes the review of NCEP Central Operations (NCO) that was conducted by the panel that also reviewed the Environmental Modeling Center (EMC).

For the National Oceanic and Atmospheric Administration (NOAA) numerical weather and climate prediction endeavor to serve the nation adequately and be comparable to those that are the best in the world, NOAA must ensure that NCO and EMC work to:

- Create a culture and work environment that attracts an extraordinary cadre of talented scientists skilled in various aspects of numerical weather prediction. This will require innovative personnel policies, a much greater fraction of civil service positions, opportunities for advancement based on scientific and technological contributions, and systematic mechanisms and commitments for ensuring cooperation and collaboration with the national and international modeling community.

- Deploy computer capabilities that are comparable or better than those of other major international centers. This will require a substantial increase in computer power and data management and storage facilities;

- Employ data assimilation capabilities that are significantly advanced beyond those now used. This will require a careful examination and comparison of next-generation possibilities, including Four-dimensional Variational Analysis (4D-Var) methods and ensemble Kalman filter approaches; and

- Embrace an entirely new approach to model development and implementation. This will require a substantial effort to focus on creating a single, powerful, flexible, multi-scale atmosphere,-ocean-land surface modeling approach that can be specialized to specific resolutions and time scales. It should be an effort that involves the entire national weather modeling community and engages partners from other agencies, academia, and the private sector. It will require a substantial commitment from NOAA and it is both urgent and absolutely essential to begin today in order to advance U.S. capability to an acceptable level in the decade to come.

1. Introduction

1.1 Purpose: Context and Summary of Charge

The University Corporation for Atmospheric Research (UCAR) was requested in November 2008 by the National Centers for Environmental Prediction (NCEP) to facilitate a thorough and thoughtful community review of the nine centers that comprise NCEP, as well as the NCEP Office of the Director. NCEP is organized under the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA). The nine centers include:

- Aviation Weather Center (AWC; Kansas City, MO)
- Climate Prediction Center (CPC; Camp Springs, MD)
- Environmental Modeling Center (EMC; Camp Springs, MD)
- Hydrometeorological Prediction Center (HPC; Camp Springs, MD)
- NCEP Central Operations (NCO; Camp Springs, MD)
- Ocean Prediction Center (OPC; Camp Springs, MD)
- Space Weather Prediction Center (SWPC; Boulder, CO)
- Storm Prediction Center (SPC; Norman, OK)
- Tropical Prediction Center (TPC; Miami, FL)

This report summarizes the review of NCOand was conducted by the panel that also reviewed EMC. The last such review of NCO was held in 1997.

The 2009 review of NCEP was undertaken because the centers of NCEP are viewed collectively as a critical national resource that delivers national and global weather, water, climate and space weather guidance, forecasts, warnings and analyses to its partners and external user communities. These products and services respond to user needs to protect life and property, enhance the Nation's economy and support the Nation's growing need for environmental information. As the centerpiece of the National Weather Service's science-based forecast enterprise, NCEP serves as the focal point for weather, climate and space weather modeling, analysis and dissemination of forecast products and services. As such, it is essential that NCEP be held to a set of high standards that define the quality, quantity, timeliness, impact and improvement over time of its products and services. An independent, external evaluation of the effectiveness with which NCEP is accomplishing its mission and realizing its vision was deemed necessary.

It has been over a decade since most centers have been assessed, as external reviews of each center occurred independently most recently during the period 1996 – 2001. In particular, the complementary roles and interactions among the centers were not comprehensively reviewed. The goal of the current review is to evaluate the entire range of NCEP activities, with particular emphasis on the way in which the various centers interact with each other, and in some cases rely upon each other, and with other NOAA, federal, academic and non-governmental entities.

This is a particularly appropriate time to conduct such a review insofar as many national and international challenges have arisen that require NCEP to operate at the highest possible level of scientific and technological excellence. Examples of challenges facing the Nation for which NCEP's products and services are essential include the following:

- The growing threat of hazardous weather reached a new and staggeringly high level of severity in the 2005 hurricane season during which 28 named storms threatened the U.S. Atlantic and Gulf of Mexico coastlines, including Hurricane Katrina that caused massive damage and loss of life in New Orleans and along the Gulf coast.

- The 2007 Intergovernmental Panel on Climate Change released its fourth assessment report, stating unequivocally that the Earth's climate is changing at an unprecedented rate as a result, in part, of human activities. This recognition, along with the growing predictive understanding of the influence of El Niño and the Southern Oscillation, and a host of other climate factors and conditions, on climate-sensitive sectors of the U.S. population and economy, has led NOAA to begin planning for a suite of National Climate Services.

- Adverse weather continues to strongly affect the aviation industry, and the NWS' pledge of support to satisfy the weather requirements of the Federal Aviation Administration's (FAA's) new Next Generation Air Transportation System (NextGen) will place increased demands on NCEP services.

- Solar activity, in the form of flares and coronal mass ejections, has a profound influence on the Earth's atmosphere (causing beautiful auroral displays) and can project fluxes of high energy particles that can disrupt communications, navigation, satellites, electric power grids, and human space flight. Solar activity has an approximately 11-year cycle and has been at a minimum for the past few years, and is expected to rise to its next maximum in 2013. Given the increasing dependence of the U.S. and world economies on aviation, telecommunications, and the Global Positioning System (GPS), the coming Solar Maximum has the potential to be highly disruptive.

Because the threat to life and property from weather, climate and space weather anomalies has never been higher and continues to rise, the products and services of NCEP must be of the highest quality, timeliness and impact.

In order to provide a review that could be most useful to NCEP, the UCAR review was organized into five panels, each of which was asked to review two NCEP centers both individually and as a complementary pair. The five panels were asked to review:

- AWC and SPC
- CPC and HPC
- EMC and NCO
- OPC and TPC
- SWPC

In each case, the pair of centers was chosen specifically because the two centers in each pair are expected to work more closely together, having affinities of mission and/or stakeholder communities.

Each panel was asked to review the centers' vision and mission to determine its relevance, appropriateness and alignment with NCEP's strategic plan. The review also assessed the productivity and quality of the scientific activities, and the quality, relevance and impact of operational products and services. Special emphasis was placed on the ability to gauge and meet customer demand and emerging requirements, the effectiveness of activities intended to support technology transfer based on research conducted either within or outside NOAA, and the effectiveness of collaboration with the academic research community or the private sector. The review evaluated the balance between operations and research and development and assessed the plans for evolving the suite of products and services. Finally, as indicated above, the interactions of each center with its "sister" center (except SWPC) and the outside communities were evaluated. The full charge to the review panels is provided in Appendix A.

1.2 Procedure

The review panel conducted its site visit to NCO on 9-10 July 2009. To prepare for the visit, a set of questions was provided to NCO leadership. In return, a comprehensive binder of material was provided to the review panel. This included NCO overview documents and other pertinent information. A web-based surveyalso was distributed to a variety of stakeholders.

During the on-site visit, NCO Director,Ben Kyger, presented highlights of the Center, including successes and challenges. A facility tour was followed by the review panel attending a daily operations status meeting and operations review. Other presentations were given on computational infrastructure, facilities, security, redundancy, the data ingest, analysis and forecast production suite, products and services, the Change Control Board, budget and management, and external engagement. Considerable time was spent conducting interviews with administrative staff, senior duty meteorologists, information technology and facilities staff, and staff in production suite management, products and services, and research and external engagement. The visit concluded with a briefing of initial findings and recommendations to NCOleadership and the NCEP Director, Dr. Louis Uccellini.

2. Overview of NCEP Central Operations

2.1 Mission and Vision

NCO is part of the NWS and one of two major NCEP support centers. According to documentation provided to the review panel, the mission of NCO is to:

> *Execute the NCEP operational model suite (create climate, weather, ocean, space and environmental hazard products); Manage improvements to the NCEP model suite (Support the research, development, and transition of new or enhanced models to operations); Develop meteorological software (Used by the NCEP Centers to create forecaster generated products); Manage the flow of data and products (To and from the NCEP Centers, partners, and customers).*

Likewise from the same document, the vision of NCO is to:

> *Set the standard for information technology excellence for the NWS. NCO will serve as a valued technical asset for the NWS and NOAA in defining and accomplishing mission goals. NCO will be as renowned for IT management as NCEP is for scientific excellence.*

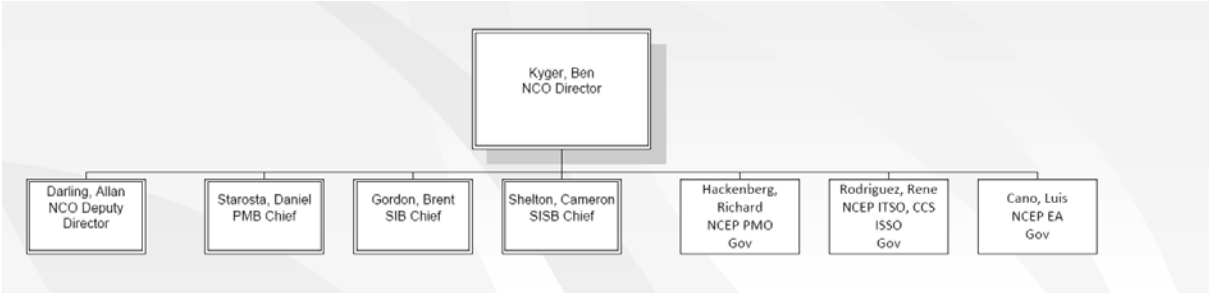
According to documentation provided to the review panel, the NCO vision and mission have not changed significantly during the past 10 years and no significant changes are anticipated during the next decade.

2.2 Brief History

Formerly the Automation and Meteorological Operations Divisions of the National Meteorological Center, NCO was created as part of a comprehensive modernization and restructuring of the NWS, the planning for which began in the 1980s. According to McPherson (1994), the guiding philosophy behind establishing NCO was a central support organization to coordinate and integrate the activities of other centers. A major change in NCO, compared to its predecessor organization, was the notion that supercomputing facilities would simply be another node or set of nodes on the NCEP network – driven by the fact that distributed and centralized computing had become mostly indistinguishable (McPherson 1994)[1]. Consequently, NCO was envisioned to have purview over all of NCEP's computing systems.

2.3 Organizational Structure

As shown in the figure below, NCO presently is organized into the Office of the Director as well as a Production Management Branch (PMB), Shared Infrastructure Services Branch (SISB), and Systems Integration Branch (SIB). At the time of the review, NCO staff comprised 96full time employees (FTEs) consisting of civil servants and contract employees.



The PMB supports implementation and monitoring of all modifications to the operational production suite to ensure the reliability of NCEP's real-time data processing, analysis, forecast, and product generation services. PMB serves as the technical transition between the research and

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1 McPherson, R.D., 1994: The National Centers for Environmental Prediction: Operational climate, ocean, and weather prediction for the 21st Century. *Bull. Amer. Meteor. Soc*., **75**, 363-373.

development of all aspects of the NCEP's computing algorithms and their operational implementation. The PMB also is responsible for final checkout of new applications software prior to operational implementation and its maintenance after implementation. Standards enforcement ensures that proper procedures are followed and standards are applied for any new or modified algorithm.

The SISB provides system administration and other user support services on a 24-hour basis for NCEP computing and communications systems. These systems include local and wide area networks, high-end computing (HEC) systems, servers and workstations, personal computers, NWS systems used within NCEP, ancillary devices such as graphics plotters, and the interfaces among all of the above. The SISB is responsible for overall planning, design, development, implementation, and assessment of NCEP computing and communications capabilities as well as for facilities and infrastructure that support the relevant technologies. This responsibility includes coordinating network and communications issues between NCEP and other parts of NOAA as well as between NCEP and other agencies.

The SIB is responsible the development and maintenance of the NCEP Advanced Weather Information Processing System (NAWIPS) and the Model Analysis and Guidance (MAG) system. These responsibilities include requirements definition across all NCEP centers, design, construction, testing, and deployment.

Other components of the organizational chart above include several non-management positions that report to the director, including the Project Management Officer (PMO), the Information Technology Security Officer (ITSO), the Information System Security Officer (ISSO), and the NCEP Enterprise Architect (EA).

3. Progress Since the Previous Review

In support of NCO's striving for international pre-eminence achieved through vision, careful planning, focused and collaborative science, communication with and commitment to the operational and user communities, the 1997review team articulated six principal recommendations for NCO. Below these recommendations are described and the progress to date on each presented.

1997 Recommendation #1: Acquire an advanced, high-end computing system.

Background: NCO manages computational infrastructure and contracts for NOAA's Operational Central Computer System (OCCS) and is the lead in high-end computing (HEC) acquisitions. At the time of the 1997review, concerns were raised that NCO was inadequatelyprepared for anew supercomputing system. Specifically, NCO had not at that time established appropriate benchmarks for evaluation of the proposed new system.

*Progress:*AMarch, 2001 NCEP Advisory Panel Report found that "NCEP had satisfactorily addressed issues related to the preparation of the request for proposal for the Class 8 High Performance Computer acquisition". Although NCO was successful in navigating the procurement process a decade ago, the current review panel finds that NCO leadership has inherited a 10-year HEC contract/procurement that was not based upon a thorough, systematic requirements analysis. Furthermore, NCO-managed HEC is not always responsive to user requirements, andcollaboration between EMC and NCO in an end-to-end process for HEC acquisition remains a challenge. The current OCCS contract expires in September, 2012, and the next generation OCCS contract award is scheduled for 2011.

1997 Recommendation #2: Automate the control and monitoring of the production suite with an enhanced capacity for event-driven operations in an advanced, high-performance computing system.

Background: The NCEP 1995 Strategic Plan called for the ability of operations to flexibly respond to emergency situations – like "Critical Weather Days" which require additional, high-resolution, regional forecast model runs.

Progress: NCO has developed flexibility in its production suite to allow for runs of the Hurricane Weather Research & Forecast Model (WRF) at the expense of higher resolution, regional Nonhydrostatic Mesoscale Model (NMM) forecast runs. The current review panel finds that additional capacity is being planned to allow for future event-driven model runs as the system grows over the next five to 10 years.

1997 Recommendation #3: Develop a more flexible, high-volume data management system.

*Background:*Although NCO identified that data storage requirements would grow by an order of magnitude in the post-review period, its plans for managing data and concomitant data storage systems did not address the requirements in a depth deemed adequate by the review panel. Given the anticipated increase in high-volume data storage and the complexity of systems required to manage such data, coupled with the unique needs of high-performance computing centers, the 1997 review panelbelieved that no single solution to data management existed. The panel suggested that NCO consult with peer installations to learn about looming implementation challenges.

Progress: The 2001 NCEP Advisory Review Team opined that the process for designing and scaling storage architecture requirements is not sufficiently well-defined. The proposals for the high volume data management system continued to lack sufficient specificity. The present review panel finds that EMC has insufficient computing resources, particularly disk space, to support its mission. The lack of disk space on development systems managed by NCO limits EMC staff from effectively accomplishing their work.

1997 Recommendation #4: Implement software for an integrated meteorological workstation.

*Background:*In 1997, NAWIPS and the Advanced Weather Interactive Processing System (AWIPS) had become completely independent programs, aside from financial support. AWIPS requirements were driven by NWS Weather Forecast Office (WFO) needs for quick display and processing of satellite and radar observations, while NAWIPS requirements were determined more by model inputs and the need for graphical display and processing at NCEP service centers. The NAWIPS was conceived to have a single development program for all NCEP service centers to promote communication among these centers and reduce duplication of effort in development. Although NAWIPS software was viewed as competently written and managed, concerns over the future direction of its development we noted by the 1997 review team. Specifically, a clear statement of program requirements and how those requirements linked back to NCEP centers was lacking. Further, dependence of the software on legacy code from GEMPAK (General Meteorological Package) that might become obsolete was a concern in NCEP centers. NCO recommended a plan to migrate from NAWIPS to commercial meteorological workstation software or develop a strategic plan to address continued development of NAWIPS.

*Progress:*The NWS initiated a project to update AWIPS, and following a review of the current NAWIPS and the proposed AWIPS-II (second generation AWIPS) system, NCO determined that the functionality currently resident in NAWIPS parameter calculations and graphical product creation would benefit the entire NWS, and that the proposed NAWIPS software architecture would benefit NCEP. NCO has begun working with the NWS Office of Science and Technology, and with the prime contractor for the project, Raytheon Technical Services, to achieve these goals.

NCO is in the process of transitioning its NAWIPS system into the AWIPS-II architecture. This transition will meet future forecaster needs and promote collaboration among NWS forecasters. As NCO accomplishes this transition, AWIPS-II will fully replace all existing software components with modernized service-oriented software applications. The transition will be informed by a close interaction with the NCEP service centers so that the final product will cause no changes to the forecasters' workflow or their capabilities. After completion of the transition to AWIPS-II, NCO will be supporting two goals (3.7 and 4.0) of the NCEP Strategic Plan for 2009-2013.

1997 Recommendation #5: Enhance the support infrastructure for a distributed computing environment[2].

Progress: The 1997 review team identified a major issue related to the support for distributed computing, namely, the definition of an appropriate balance between the use of models at NCEP servicecenters and WFOs as compared to the centralized running of models by NCO. The present review panelviews this issue as being resolved by NWS based on a cost/benefit analysis which considers meteorological forecast requirements, the availability of distributed, local

[2] As defined by the 1996 Review Team, "distributed computing environment" refers "to the geographically distributed nature of the NCEP organization throughout the U. S. and to the requirements for NCO to provide operational products and support to the other NCEP centers."

expertise to maintain and run the models, bandwidth requirements, and the cost of necessary computing capability.

1997 Recommendation #6: NCO should conduct an annual review of its disaster recovery and service continuity plans and should revise its arrangements in order to assure adequate coverage.

Progress: Although existing continuity of operations plans form a solid base upon which to build, current plans for maintaining operations in the event of outages or failures are not inclusive of all critical NCO functions. Further, NCO's interaction with peer institutions appears insufficient to advance NCO's ability to identify best practices that might aid in streamlining operations and assist the development of plans for continuity of operations in the event of catastrophic backup facility failures.

4. Summary of Stakeholder Survey

To gain better understanding of stakeholder perspectives regarding NCO, a survey was distributed to numerous individuals including representatives from NCEP service centers and other external organizations interested in NCO products; users of the NCO-operated high performance computing systems and High Performance Storage System (HPSS); and internal and external users interested in scheduled NCEP software/hardware changes. A total of 266 responses were received.

Nearly 80% of respondents use NCO data products. The panel analyzed respondents from another part of NCEP, another part of NOAA, the military, other Federal agencies, state/local government, non-profit/non-governmental (NGO) organizations, for profit/private enterprise, media/broadcasting, private consultant, educational/academic institutions, and other areas. A total of 54% of those responding were NOAA employees.

The strongest positive responses related to relevance and availability of NCO products. Over 80% of NCO stakeholders strongly agree or agree somewhat that NCO products and services are relevant to their organization, that NCO products and services are readily accessible in a timely manner, that NCO products and services are readily available in a timely fashion, and that the stakeholder organization would lose significant capability without NCO products and services. The strongest negative responses pertained to outreach, technology refresh, and quality of NCO products and services. Approximately 30% of those responding strongly disagree or disagree somewhat that NCO has effective mechanisms for requesting input from external stakeholders, that NCO is well positioned to handle a changing technology landscape in the next 5-10 years, and that NCO products and services represent state-of-the-art capability, although each of these questions also had substantial responses that either somewhat agreed or strongly agreed with these assertions.

The panel conducted this preliminary analysis of the survey results, with the expectation that NCO will conduct further analyses.

5. General Observations and Overarching Issues

The US generates a colossal amount of information about the present and future state of the atmosphere that flows in an unceasing stream from government centers to users throughout the public and private sectors. Decisions about public safety, national defense, corporate actions, and environmental management are all made on the basis of this information.

NCO is responsible for the flow of much of this information in the United States. Indeed, NCO and EMC are partners intertwined in the complex process of converting observations of the current state of the environment into forecasts of future conditions, and particularly of severe weather or climate anomalies, which may pose risk or provide economic opportunity.

A contemporary national weather and climate prediction center is a collection of talented and highly skilled individuals, a suite of computational and data systems, and an array of communications channels. EMC scientists develop computer programs that analyze observations and produce forecasts as a stream of digital information. NCO acquires, deploys, operates and supports the requisite computational and data resources and delivers digital products to users in NOAA, other agencies, and the private sector. Some usersfurther process these data and output steams with their own computing resources to generate data products thatmeet their own needs.

NCO has improved considerably under present leadership and users are pleased with the consistent on-time deliveryof the products on which they depend. But significant challenges lie ahead for both EMC and NCO as observation systems increase in capability and information density, as the conceptual and software frameworks of the computer forecast systems become more complex and powerful, and as users demand forecast products of increasing skill at increasing resolution.

Meeting these challenges will require improved interactions—and deep mutual respect—between EMC and NCO. Today's tensions over methods and responsibilities must be swept away with the recognition that the success of each depends upon the success of the other. The key here is that EMC designs computational engines while NCO runs the machinery and delivers the products. EMC and NCO must be partners – in the deepest sense of the word – that work together from the beginning to end of the entire prediction process.

NCO deserves considerable credit for the recent enthusiasm and passion it has brought to the process of meeting its responsibilities. It has been successful in creating a more rigorous process to manage computation and delivery of products. But the process-oriented management perspective of NCO has not been fully cognizant of the model development perspective of EMC, and thus a fully integrated set of processes composing the requirements of both EMC and NCO – critical to the future mutual success of these two organizations – is completely absent. This has led to tensions and associated efforts to protect perceived prerogatives. The two organizations must develop a better understanding of the requirements and advantages of creating a more formal and optimal approach to managing their collaboration.

Some of the tension arises because the present computational and data storage resources managed by NCO are woefully inadequate and adversely impact staff performance and morale. Collaboration between EMC and NCO in anticipating needs for new computer and server capabilities, and in developing the compelling case that will lead to the necessary resources being allocated, remains a challenge. NCO also has a responsibility for computer systems used by other NCEP organizations, including forecast and research centers at various locations around the country. This brings a notable challenge to NCO in understanding the interaction of scientific requirements and technological capabilities. Also, NCO staff members must be provided more opportunity for professional development across the range of their responsibilities.

NCO, like EMC, has become insular. It is not sufficiently engaged with other operational or research supercomputer centers on the national or international level to take advantage of community advances in development of concepts and implementation of processes for successful management of complex computer systems.

With new supercomputers coming to NCEP, with powerful new observation systems imminent, with computational frameworks emerging, and with new ideas certain to task them all, NCO and EMC must delineate their missions and responsibilities more precisely, integrate their cultures, and work toward the future.

As summarized in a recommendation in the next chapter, EMC is responsible for the development of numerical environmental prediction models and for their quality and skill in operations. NCO is responsible for the timely and reliable production of forecasts and concomitant products with those models and accessory software systems. Together they must create an effective forecast system scaled to the available resources. Together they must foresee future scientific and technological trends and opportunities and seek the computational and human resources to take advantage of them. Together they are partners in progress, partners in change, and partners in a key national endeavor. Together they bear an awesome responsibility and they will only succeed by working together.

6. Findings and Recommendations

6.1 Mission and Vision

The present mission and vision statements, though well intentioned, do not reflect the true service nature of NCO and are insufficiently bold. For example, should not NCO seek to set the IT standard of excellence for operational weather/climate prediction centers around the world, not just within NWS? Additionally, although NCO certainly should be renowned, the latter part of the vision statement struck the review panel as somewhat odd in that success for NCO is predicated on its service role of ensuring the success of EMC and all NCEP service centers. We suggest a careful reevaluation of the mission and vision statements with due consideration given to all findings and recommendations reported herein.

6.2 Customers and Partners

NCO sustains and executes the operational suite of NCEP numerical analyses and forecast models and prepares products for dissemination. In addition, NCO leads the meteorological software development effort for NCEP's service centers while also playing a key role in ensuring the timely delivery of essential data and products to NCEP's community of customers and partners. NCO supports the operational infrastructure requirements of NCEP's seven service centers, NWS field forecast organizations, and the broader user community which includes the private sector, other government agencies, the general public, and international partners.

In order for the US to maintain an effective environmental modeling capability that meets the needs of a broad user community, no partnership is more important than that between NCO and EMC. In order for NCO to continue delivering relevant and timely products in view of increasingly complex and demanding production schedules, it must effectively engage its partners and customers to better understand their requirements. NCO also must seek and establish meaningful collaborations with peer national and international environmental prediction centers and other Federally supported supercomputing centers.

6.2.1 Findings

Finding CP1: A commitment to on-time delivery and rigorous change management is important for NCEP.NCO has demonstrated a genuine commitment to on-time daily product delivery. As of mid-July, 2009, NCO's performance metric of 99% of products produced within 15 minutes of the expected time has been regularly achieved since the goal was established in September, 2006. Monitoring the generation of products arekey stepsin product dissemination via AWIPS and NOAAPort, and NCO has indicated that average product latency to the NOAAPort Satellite Broadcast Network as been significantly reduced since 2002. NCO's latency goal of 12 minutes has been met since 2006.

Because of a notably tight production suite schedule, both NCO and EMC are committed to ensuring that changes to production suite components are managed rigorously to ensure stability and predictable system behavior. Changes are tracked from testing to implementation,and NCO seeks to ensure that prior to implementation, stakeholders directly affected have an opportunity to review proposed changes.

Finding CP2: NCO lacks sufficient understanding of its customers and stakeholders and may not adequately appreciate that EMC is its first most important partner.NCO views its interactions with customers within NCEP centers and NWS regional offices as its greatest priority, while customers further removed from NCEP (e.g., NWS Family of Services users,universities) of lesser importance. NCO admits that it does not truly understand customer needs or the extent of its customer base, and attempted to remedy this circumstance by establishing an NWS-wide products, services, and customers tracking system. This tracking system was cancelled in 2008,because it had insufficient priority for funding.

NCO's vision statement is striking in that, as stated above, NCO does not appear to recognize that its interactions with EMC are of paramount importance in supporting the NWS/NCEP mission, particularly via furnishing products to support NWS field operations, the private sector,

and other government agencies. The lack of a true partnership between NCO and EMC is further reflected in problematic collaborations, particularly with respect to development of effective change management implementation strategies. The review panel found both EMC and NCO supportive of the need for rigorous testing procedures inproduction suite management, but in disagreement on how to implement these strategies.

Finding CP3: The user community's desire for products, especially output at the resolution of model execution, is not being met and only will increase with time. At present, major dissemination paths to public and private users of numerical weather prediction (NWP) model output are the NCEP file transfer protocol (FTP) server at the NOAA Web Operations Center (WOC) and the NCEP FTP server at the NWS Telecommunications Gateway (TOC). Products with World Meteorological Organization (WMO) headers are sent to TOC for worldwide dissemination. The CONDUIT (Cooperative Opportunity for NCEP Data Using Internet Data Delivery Technology) Local Data Manager (LDM) feed from WOC is a key source of model output to the university community. External users also can access NOAA real-time operational NWP model output through the NOAA Operational Model Archive Distribution System (NOMADS) server at WOC. These various systems are used by the private sector and academic communities to obtain analyses and forecasts as well as initial and boundary conditions for both products and experimental models run at higher resolution. Both communities have a requirement for NCEP model output at native resolution. At present, because of a combination of disk storage and bandwidth limitations, these products are not available.

Finding CP4: NCO has insufficient interaction with other operational or mission-critical IT processing centers (e.g., other national and international NWP centers, National Science Foundation (NSF) supercomputing centers, commercial data centers) to the degree that would be advantageous. Although NCO maintains close operational relationships with many meteorological agencies, these relationships appear to be primarily focused on data exchanges and data formats (e.g., NCEP/NCO being a member of the World Meteorological Organization's codes group). These interactions are, by NCO's admission, mostly reactive. Although such relationships are necessary for any global modeling center, they appear insufficient to advance NCO's ability to identify best practices that might aid in streamlining operations and assist the development of plans for continuity of operations in the event of catastrophic backup facility failures. NCO currently does not appear to be taking advantage of other supercomputing facilities and commercial data centers in ways that might alleviate data storage needs and computational resource limitationscaused by overburdened operational requirements. Additionally, NCO was not represented at the recent Computing in Atmospheric Sciences meeting despite a formal invitation to attend.

Finding CP5: Working relationships and links between NCO and the NOAA National Climatic Data Center (NCDC) are not apparent.In none of the review panel's discussion of partnerships or collaborations did the relationship between NCO and NCDC emerge. In light of NCEP's involvement in NOAA's NOMADS project, which provides archived access to high volume NWP model output and other information, the review panel believes that NCO's role in facilitating the exchange of data between NCEP and NCDC for this purpose would have been highlighted.

6.2.2 Recommendations

Recommendation CP1: NCO should actively engage with other similar centers around the world and participate, to the extent possible, in international forums on numerical prediction, high performance computing, and related topics. A key mechanism for both understanding and impacting directions in the international prediction and computing communities is active engagement in professional meetings, exchange visits, and sharing of best practices and tools. NCO should thoughtfully pursue these goals as part of its broader strategy to become the world leader in weather and climate prediction IT.

Recommendation CP2: NCO should continue to explore and implement strategies for delivering model output at native model resolution for university and private sector uses.NCO should work with its partners in the NOMADS data delivery system to work toward the goal of delivering all NCEP model output at native resolution, including all members of the NCEP's ensemble systems.

Recommendation CP3: NCO should re-evaluate its chosen performance metrics and add to them with a view toward enhancing its overall performance measures.NCO's demonstrated ability to reach its own established metrics for on-time product generation and product dissemination is laudable. It is recommended, however, that NCO re-evaluate these metrics by either "setting the bar higher" regarding reliability or determining whether the metrics they have chosen are consistent with customer or partner needs. New metrics might include measures of the delivery of increasingly higher resolution model output, the breadth of the spectrum of products delivered, measures of collaboration between EMC and NCO as well as between or among other organizations, and customer satisfaction.

6.3 Products and Services

NCO is positioned within NCEP as a critical support center that ultimately enables global user community access to the wide variety of products and services created by the various NCEP centers. NCO also provides a software development service to various NCEP centers to be used in operational forecast product creation. As a result, NCO provides services focused heavily on its information technology (IT) capability and change management processes designed toensure on-time and highly reliable production of the NCEP model suite and other products.

NCO has shown an ability to adapt and implement new technologies to help achieve its mission. However, it must also look to expand its current set of metrics to create an integrative process, especially with EMC, that demonstrates a valuable, rapid change process to help NCEP meet its mission within NWS.

6.3.1 Findings

Finding PS1: NCO demonstrates a commitment to on-time delivery of the products and services produced throughout NCEP.NCO leadership and staff possess an understanding of the critical importance of on-time delivery and stability of the products and services they disseminate. On-time delivery metrics have been established and are continually referenced throughout the

organization as a means for measuring success. This culture and approach is commended and should continue. Additional metrics to expand the breadth and impact of NCO should also be developed as described in Recommendation CP1.

Finding PS2: NCO has worked to embrace the adaptation of new technologies to achieve its mission and vision.NCO leadership recognizes its role as 'the standard for information technology excellence for the NWS'. To achieve this portion of its vision statement, NCO has evaluated and implemented new technologies aimed at increasing the number and value of services it provides to NCEP. For example, NCO recently implemented a 'server virtualization' capability aimed at increasing computing power in a controlled resource environment. Continuing to foster and implement new technologies while sharing this capability with other NCEP centers is a core responsibility of NCO. However, as noted elsewhere (see, for example, Recommendation IS4), NCO could be even more effective implementing new technologies and management practices, including those designed to support service center capabilities.

Finding PS3: NCO software development teams need additional and enhanced communication channels to the NCEP centers they serve.Although NCO leadership believesit has a direct understanding of NCEP service center requirements, this feeling was not shared by those assigned to various projects within NCO. NCO must assume a leadership position in creating communication channels between users of their products and services and NCO project teams charged with their development. This enhanced communication will lead to better project specification and a feeling of inclusion by the NCO development teams in the entire NCEP production process.

6.3.2 Recommendations

Recommendation PS1: NCO should work closely with EMC to deliver NWP products at native resolution and forecast output frequency. NCO must work closely with EMC to insure that IT capacity and capability exist to disseminate to the entire global user community all NWP products, at native temporal and spatial resolution, created within the NCEP model suite. This recommendation will require careful planning between NCO and EMC as data sets and product suites change and develop in the future. It is imperative for NCO to ensure appropriate budget allocation, planning and information technology (IT) infrastructure innovation to help EMC in meeting this requirement.

Recommendation PS2: NCO and EMC should develop metrics that measure the impact and rate of implementation of forecast models and use them to manage the pace of meaningful innovation. NCO has demonstrated the ability to adhere to an on-time metric that is required throughout the weather and climate enterprise. To further the missions of NCO, EMC and ultimately NCEP, it is imperative that additional metrics be developed jointly by NCO and EMC. These metrics should evaluate the rate of implementation matched with the value of the change being implemented within the EMC model suite. Additionally, the metrics should be created and adhered to jointly by EMC and NCO to ensure that both organizations show the same level of commitment to these new guiding metrics as is given to the extant on-time metric.

6.4 Information Systems

The NCO vision statement includes "set[ting] the standard for information technology excellence for the NWS…" and that"NCO will be as renowned for IT management as NCEP is for scientific excellence." Unfortunately, nothing in the NCO mission speaks directly to the management of information systems or information technology. In fact, the mission statement indicates that NCO should be doing something beyond IT management, and this fact exposes a serious deficiency in defining and executing its purpose.

6.4.1 Findings

Finding IS1: High performance computing resources available at NCEP are significantly far behind those needed to achieve its goal of being the world's foremost weather and climate prediction enterprise.It has long been recognized that the lack of adequate high performance computing capability is a major factor in NCEP's less than desirable position amongworld forecasting centers. Although computing power alone will not elevate NCEP to world leadership, the existence of these resources is a necessary condition for NCEP to achieve the stated goal.

Finding IS2: Collaboration between EMC and NCO in an end-to-end process for HEC acquisition remains a challenge.The review panelnoted that challenges continue to exist in an HEC acquisition requirements collection process that is inclusive of both NCO and EMC staff. Further, the analysis of identified needs and the specification and selection of resources fails to involve NCO's major customers.

Finding IS3: The delineation of IT responsibilities between NCO and NCEP service centers is unclear.The management of IT infrastructure is rather confused, and the lines demarcating roles and responsibilities of NCO and NCEP service centers are poorly defined. This is particularly true in responses to security incidents.

Finding IS4: No formal continuity of operations plan exists for the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) or regional forecasts in the event of a complete Central Computing System (CCS) outage.Should a complete outage occur at CCS (e.g. a wide-spread power outage on the U.S. eastern seaboard), HYSPLIT and regional forecasts will cease until repairs can be made. Although NCO is to be commended for its ability to switch operations from the primary to the backup system in a timely manner, significant exposure remains in the event both facilities become unavailable. Although such an occurrence may have seemed remote a decade ago, such is not the case in today's post 9/11 environment.

Finding IS5: EMC is severely lacking in computing resources, particularly disk space, to support its mission.A key limitation in the ability of EMC staff to effectively accomplish their work is a severe lack of disk space on development systems managed by NCO. The imposed

disk quotas limit not only the scale and scope of experiments that might be run, but they also limit the ability for developers to implement new models. Several EMC teams are experiencing this problem and it suggests a lack of effective communicationregarding EMC needs and resource provisioning decisions by NCO.

6.4.2 Recommendations

Recommendation IS1: NCO and EMC should collaborate to implement a formal systems engineering approach to NCO-EMC processes, which allows for coordination and, especially, planned evolution.Systems engineering focuses on how complex engineering projects should be designed and managed. It provides a structured approach not only forrequirements-gathering, prioritization, assessment of technological capabilities, design, task planning, optimization, and testing and implementation, but also the orderly evolution of a design and its implementation. Though many elements of systems engineering are present in current NCO processes, a proper systems engineering implementation would provide structure and coordination of these processes and assist in better focusingof resources.

Recommendation IS2: NCO and EMC should design and implement a formal, collaborative process to document scientific and computational validity before implementing a new model or model change.This process should be implemented as part of a full systems engineering approach to evolving the production suite (see Recommendation IS4). The document describing the process should establish the need for implementation, assess impacts on other system components (data, models, products, IT operations), and articulate expected benefits.

Finding IS3: Working with stakeholders and partners including, but not limited to, NCEP service centers, the Office of the Federal Coordinator of Meteorology (OFCM) and NWS and NOAA leadership, NCO and EMC must develop a comprehensive strategic plan for an enhanced NCEP computing portfolio consisting of a balance of HEC, storage, bandwidth and processing tools.In achieving this goal, other partners such as NCAR, the NSF supercomputing centers and Terascale Grid Based System (TeraGrid), and academic computing centers and informatics groups should be included.

Recommendation IS4: NCO should collaboratively identify and mitigate unnecessary duplication between NCO and NCEP organizations that it supports, e.g., IT support functions, forecast verification, customer surveys.In reviewing both NCO and EMC, it became evident that several activities are unnecessarily duplicated between them. Given the somewhat overlapping missions of these centers this is neither surprising nor negative. However, it is incumbent upon EMC and NCO to work effectively to identify unnecessary duplication and delineate responsibility to avoid loss of effort. Likewise, those activities for which both NCO and EMC believe duplication is necessary should be clearly justified and documented.

Recommendation IS5: A comprehensive formal plan should be developed and implemented that provides for continuity of operations across key products and services.Current plans for maintaining operationsin the event of outages or failures is not inclusive of all critical NCO functions. A formal plan that addresses a complete outage of CCS and ensures continuity of all

critical services and products must be developed. The existing plans form asolid base upon which to build.

Recommendation IS6: A commitment to on-time delivery and rigorous change management is important for NCEP and should be continued. NCO's commitment to on-time delivery is exemplary and the formal change management process is to be commended. The latter should be properly incorporated into a full instantiation of project management practice. However, a key point here is that these practices must be conducted in support of advancing the NCEP mission, i.e. on-time delivery of products cannot lead to lack of progress in delivering important improved or new products.

Recommendation IS7: NCO should clearly delineate its responsibilities and those of the NCEP service centers to clarify roles and responsibilities. This is particularly important in the context of responses to security incidents.

6.5 Science and Technology

In order to keep NCEP at the leading edge of prediction science and technology, continued improvements and enhancements to the modeling suite are needed. However, on-time delivery requires that changes be managed with great care to ensure stability. These conflicting demands require NCO and EMC to have a deep understanding not only of their own processes and requirements, but those of the other organization, as well as effective collaboration mechanisms on all facets of their synergistic mission.

6.5.1 Findings

Finding ST1: The review panel endorses the proposed suite-based concept for testing model system changes on the backup HEC system.Because NCEP modeling systems are closely coupled, changes made to one component frequently influence the performance of others, especially downstream in the prediction cycle. For example, a seemingly benign change in the Gridpoint Statistical Interpolation (GSI) data assimilation system could impact the performance of the Global Forecast System (GFS) forecast, subsequently impacting HWRF (which uses a GFS forecast for its initial and lateral boundary conditions). Therefore, before a specific model system change is implemented, the entire modeling suite must be tested to avoid undesirable results. The review panel commends NCO for making the backup HEC system available for suite-based testing of model system changes.

Finding ST2: Uncertainty regarding the proposed NOAA National Climate Service (NCS) and Next Generation National Airspace System (NextGen) are adversely impacting NCO and EMC planning, e.g., the location of operational seasonal forecasting.The proposed NCS and NextGen will require, respectively, operational seasonal prediction and high-resolution ensemble forecasting. The creation of these products will require computing resources far beyond NCO's current or even planned capability and thus will affect not only operations but also research. We

strongly recommend that NOAA and NWS leadership provide assistance to NCO and EMC in dealing with these uncertainties and in developing effective plans for the future.

Finding ST3: GFS performance "dropouts" represent a significant problem that must be addressed.It has been found that the NCEP GFS model experiences significant reductions in performance from time to time. A dropout is defined to occur when the five-day forecast 500 HPa anomaly correlation falls below 0.7. These occurrences are an important factor in explaining why NCEP global model forecast skill is not as high as that of ECMWF and UKMO, and thus eliminating dropouts is an important issue to help close the gap.

6.5.2 Recommendations

Recommendation ST1: The proposed suite-based concept for testing model system changes on the backup HEC system is good and should be developed and implemented in close collaboration with EMC.Although the concept of suite-based model testing is good, it requires a significant amount of computing and human resources. In order to optimize the use of resources for testing model system changes, it is important that NCO work closely with EMC to develop appropriate test procedures, and implement such procedures on the backup HEC system.

Recommendation ST2: The collaborative effort between NCO and EMC on Global Forecast System (GFS) performance "dropouts" should be continued and strengthened.Solving the dropout problem requires close collaboration between NCO and EMC staff, and the review panel notes with satisfaction that a joint NCO-EMC team has been established to address dropouts and is making good progress. We strongly support continued emphasis on the dropout problem and encourage NCEP leadership to direct adequate resources to it, perhaps by engaging external researchers on a temporary basis. Specifically, because the monitoring and quality control processing of observations rests with NCO and could be contributing to dropouts, NCO should redouble its efforts to identify potential problems that might be associated with dropouts.

6.6 People and Organizational Culture

NCO has the critical responsibility of running the suite of EMC numerical models on NCEP supercomputers, thereby converting scientific principles and observations into forecasts of weather and climate variability over periods ranging from days to months. It is demanding, highly technical work and together NCO and EMC have achieved a remarkable on-time performance for a suite ofmodels tightly scheduled day and night.

New leadership at NCO has generated an aggressive view of the Center's mission and an enthusiastic and confident organizational culture that places high value on fostering a systematic, process-driven approach to meeting NCEP goals and responsibilities. Although a rigorous and vigorous approach to managing the NCEP information technology challenges is essential to success, the new NCO approach has created significant tension and has yet to be adequately integrated with the missions and aims of other NCEP organizations.

6.6.1 Findings

Finding POC1: NCO leadership and staff are passionately committed to bringing the best and most effective contemporary principles and processes for managing complex computer production systems to the NCEP numerical forecast suite.The management of complex computer systems for research and production has evolved into an exacting and demanding discipline through the experiences gained at a wide variety of public and private supercomputer operations. Certainly, NCO must take advantage of this accumulated experience to ensure that its own operations are as controlled and as effective as possible. The commitment to a demanding mission and effective operations is shared by NCO staff members, who are dedicated, understand their role, and are aligned with leadership. Although collegiality and esprit de corps were evident and refreshing, notable problems came to light during the site visit.

Finding POC2: The process and quality management perspective of NCO has not been adequately integrated with the research and numerical model development perspective of EMC, leading to seriously strained relations between NCO and EMC leadership. The leaders of the two organizations are fairly zealous in protecting what they see as their prerogatives – to the point of imperiling the collaboration necessary for success. In some cases, new NCO procedures were implemented unilaterally and more rapidly than could be accommodated in the EMC research-oriented culture. Too much time is being spent in what one executive described as "fighting".Fortunately, NCO staff and EMC scientists are bypassing some of the tension by learning to work together through ad hoc approaches to implement new models and manage their operation over a complex life cycle of change and improvement.

Finding POC3: NCO senior duty meteorologists (SDMs) are a key component of the NCEP operation and meet demanding responsibilities effectively.Acting as the daily weather-eye for NCEP, SDMs ensure that NCEP operations are focused to meet the challenge of critical weather events occurring anywhere in the US. As a group, SDMs are highly engaged, dedicated, and effective. They have demanding responsibilities and meet them well, earning them respect throughout NCEP and NWS.

Finding POC4: Some members of the NCO team have the difficult challenge of working at the complex interface among contemporary supercomputer operations, information technology, and advancing atmospheric science. They are not now adequately supported in meeting this challenge.Whatever their talents and accomplishments in the world of computing, NCO staff members must have some appreciation of the imperatives and aspirations of other worlds, including those of EMC, NCEP servicecenters, and the diverse private and public entities that depend upon NCEP products for managing weather and climate risk and opportunity.

6.6.2 Recommendations

Recommendation POC1: NCEP, EMC, and NCO leaders must ensure that the EMC and NCO missions are appropriately defined and that the cultures are sufficiently integrated and adequately collaborative.It is axiomatic that NCO and EMC must cooperate. Their substantially different cultures must complement each other, not clash. Achieving this goal will require a more careful delineation of vision and mission. EMC is responsible for the development of numerical environmental prediction models and for their quality and skill in operations. NCO is

responsible for the timely and reliable production of forecasts and concomitant products with those models and accessory software systems. Together they must create an effective forecast system scaled to available resources. Together they must foresee future scientific and technological trends and opportunities and seek the computational and human resources needed to take advantage of them. Together they are partners in progress, partners in change, and partners in a key national endeavor. Together they bear an awesome responsibility and they will only succeed by working together.

Recommendation POC2: NCO staff members who work at the interfaces of technology and atmospheric science should be given more opportunity for professional development.NCO staff thus should attend a variety of relevant professional conferences, workshops, and short courses. They should visit NCEP servicecenters, NWS forecast offices, and the weather and climate operations of other agencies and private firms for face-to-face conversations about present and future needs and requirements. Like successful salesmen, NCO staff members must know the territory.

Recommendation POC3: Senior Duty Meteorologists should be involved in data selection and denial experiments. One role of the SDM is to make decisions regarding the inclusion or denial of data in forecasts. To assist in this function, quantitative information about SDM decision impacts should be made available to SDMs, and they also should be involved in observing system experiments designed to better understand data impacts.

6.7 Business Processes

The focus on execution of a complex production suite and the delivery of resulting products makes essential NCO'sadherence to a set of documented business processes so that the strict time constraints on its activities are met without fail – while at the same time enabling innovation in a timely manner. NCO's business processes must include a rigorous approach to procuring and operating sufficient HEC assets that meet developmental and operational requirements, as well as a method for working with EMC to effectively translate model changes into the production suite. These important tasks must align with NOAA, NWS, and NCEP strategic goals, adhere to NOAA business processes, particularly those for planning, budgeting, and executing its programs, and make effective use of NCO's human resources.

6.7.1 Findings

Finding BP1: NCO leadership is passionate about bringing a more systematic, process-oriented approach to achieving the NCEP mission and also is open to suggestions for improvement.It has been noted elsewhere in this reportthat no formal software development process exists for NCEP models, a consequence of which is increased time required to move model and coding changes into the production suite. NCO is seeking to develop a joint process with EMC to improve the efficiency of thechange process with emphasis on the development of plans for repeatable testing. Effective, although ad hoc, interaction appears to be occurring at the staff level between EMC and NCO in code development, testing, and operational implementation. However, some

NCO procedural changes were implemented more rapidly than could be accommodated by the traditional research culture in EMC, and without sufficient engagement of EMC as a partner.

Finding BP2: NCO-managed high performance computing is not always responsive to requirements.Current NCO leadership inherited a 10-year HEC contract/procurement that was not based upon a rigorous, systematic requirements analysis, further complicated by budget constraints. Uncertainty regarding the proposed NCS and NextGen are adversely impacting NCO and EMC planning (see Finding ST2), e.g., location of operational seasonal forecasting and its backup. Collaboration between EMC and NCO in an end-to-end process for HEC acquisition remains a challenge. Funding for operational HEC has not increased. Despite documenting the gap between current capability and need in the Planning, Programming, Budgeting and Execution System (PPBES) process, support from the broader NOAA community is lacking.

Finding BP3: Serious stresses and strains exist between NCO and EMC. It appears that lines demarcating the roles and responsibilities of EMC and NCO are poorly defined, with the perception that these two organizations compete for "turf", particularly in processes associated with approving and implementing changes to the production suite. Friction can arise because EMC and NCO do not share the same concerns or culture. Transition to the P6-based computing system has not been a smooth one, and the unavailability of systems has prevented progress in EMC's development activities. The "moratorium" on production suite upgrades resulting from an overly lengthy HEC transition process has been deleterious. Further, theHEC system managed by NCO lacks balance due to a shortage of disk space, thus reducing the pace of EMC's research.

Additionally, the management of IT infrastructure within NCEP is rather confused, and lines demarcating the roles and responsibilities of EMC and NCO also are poorly defined. NCO handles many or even most approvals for items such as accounts on systems, email addresses, etc., and based upon interviews with EMC and NCO staff, NCO is often very slow in responding, often taking 6+ months to provide approvals. This seriously impacts the value offered by visitors, for example, for whom six months can be a large fraction of their visit. NCO also has control over the approval of use of software and hardware on the network,which often places detrimental restrictions on staff. Although EMC has a Security Office, its staff members admittedly are not at all qualified to perform their duties. All of these circumstancesare complicated by the fluid nature of NOAA security policy.

6.7.2 Recommendations

Recommendation BP1: NCO and EMC should align their processes so that the pathway from research to operational execution is visible to everyone.NCO and EMC should design and implement a formal, collaborative, documented process to establish scientific and computational validity before implementing a new model or model change. The document should establish the need for the implementation, assess impacts on other system components (data, models, products, IT operations), and articulate expected benefits. NCO and EMC also should collaborate in a broader, systems-engineering approach to shared processes (requirements-gathering, prioritization, assessing technological capabilities, defining tasking, optimization, testing, implementation, tempo control) that allows for coordination and, especially, planned evolution. Sharing standard project management practices should help in adopting this approach. Aligning

standard project management practices will help in many areas: planning, execution, coordination and reporting. It also will help address the requirement of balancing demands with available resources and responding to unfunded requests with well understood impacts and resource re-allocation.

Recommendation BP2: NCO should establish and document a process for collecting relevant requirements from all users of NCO-managed HEC systems and procure and manage systems that meet or exceed those requirements.NCO must work periodically with its HEC customers to establish requirements for current systems, system upgrades, and for the next procurement. NOAA's PPBES process can be used to document those requirements and request funding for HEC, but other NOAA programs must be engaged in supporting NCO's requests. Opportunities for using external computing resources should be leveraged whenever practical, e.g., from NSF-sponsored centers or other agencies' facilities. The computing required to support a range of activities, from R&D to test beds to operations, must be balanced so that today's research can be implemented in tomorrow's production suite. An objective set of guidelines must be instituted to align science and computing decisions with the appropriate experts at EMC and NCO, but with shared goals in mind.

Appendix A

National Centers for Environmental Prediction Review
Charge to the Review Panels

Charge

The University Corporation for Atmospheric Research (UCAR) will carry out a review of the National Centers for Environmental Prediction (NCEP) in 2009 through a series of panels that will assess the individual Centers, their interaction with each other and with other NOAA, federal, academic and non-governmental entities to determine how effectively NCEP is accomplishing its mission and realizing its vision. In particular, for each Center and NCEP as a whole, the Review will assess:

- Statements of mission, vision and five-year plans.

- Productivity and quality of scientific activities and/or operational products and services with an emphasis on the progress since the most recent review.

- Relevance and impact of the researchand/or products. Ability to meet customer demand and emerging requirements.

- Effectiveness of activities or specific plans for transition of research to operations (R2O), including research conducted outside NCEP within NOAA, within the federal research enterprise, and in academia or the private sector.

- Effectiveness of activities or specific plans for support of research by and/or joint efforts with program elements within NOAA that provide support for or conduct research as their primary mission and also with outside entities (academia; research laboratories) via the provision of operational products, services and in-house support (operations to research - O2R).

- Balance between operational responsibilities and research and development initiatives.

- Programmatic plans for new scientific activities and operational products and services, including plans for continuations and terminations.

In addition, the Review will address any specific other issues or questions raised in the course of the review.

Procedure

1. The Review will be organized under the leadership of an Executive Committee composed of two co-chairpersons, representatives of the operational environmental prediction and NCEP user communities, and each of the chairpersons of the individual Center Review Panels. Each Center Review Panel will have 5-6 members with diverse representation from academia, federal labs and users. The Executive Committee will develop a slate of panel members in consultation with the Director of NCEP. The Executive Committee will recommend a panel review slate to the President of UCAR, who will appoint the Review Panels.

2. The following documentation will be requested from each Center and NCEP:
   - Vision and mission statement (strategic plan, if extant)
   - Organization chart and list of present staff and visitors (staff turnover since last review)
   - Summary narrative of recent highlights and accomplishments
   - Summary narrative of R2O and O2R activities
   - Summary narrative of collaborative work
   - List of publications and/or reports since last review (with sample of reprints)
   - List of products and services, along with selected samples
   - Summary of budget, sources of support and expenditures
   - The NCEP and/or individual Center responses to the reviews conducted between 1996 and 2001.

3. Each Center will be asked to submit documentation, at least one month before the on-site visit, to UCAR for distribution to Review Panel members before the on-site visit.

4. An on-site review (typically 1.5-2 days) will be conducted at each Center. The date for each review will be fixed in consultation with the Center Director and the Director of NCEP.

5. Each Review Panel will provide a preliminary briefing to the Director of NCEP at the conclusion of each on-site review.

6. Each Review Panel will write a report of its findings. A draft of the review report for each Center will be shared with the Center Director to correct any factual errors.

7. The Executive Committee will write a final report, directed to the President of UCAR, that summarizes the findings of the reviews of the individual Center as well as NCEP as a whole, and will make recommendations for improvements.

UCAR will provide administrative help for the preparation of the individual Center Review Panel reports and the final report of the NCEP Review.

Appendix B

NCO Review Panel Membership

Kelvin Droegemeier (Chair)
University of Oklahoma

Antonio Busalacchi
University of Maryland

John Dutton
Prescient Weather Ltd
The Pennsylvania State University (Emeritus)

Brian Gross
NOAA Geophysical Fluid Dynamics Laboratory

Ying-Hwa (Bill) Kuo
National Center for Atmospheric Research

Michael Morgan
University of Wisconsin – Madison

Steven Smith
AccuWeather, Inc.

John Towns
National Center for Supercomputing Applications
University of Illinois at Urbana-Champaign

NCEP Review Executive Committee Members

Frederick Carr (Co-chair)
University of Oklahoma

James Kinter (Co-chair)
Center for Ocean-Land-Atmosphere Studies

Gilbert Brunet
Environment Canada

Kelvin Droegemeier
University of Oklahoma

Genene Fisher, Panel Chair
American Meteorological Society

Ronald McPherson
American Meteorological Society (Emeritus)

Leonard Pietrafesa
North Carolina State University

Eric Wood
Princeton University

Appendix C

List of Acronyms and Terms

4D-Var	Four-dimensional Variational Analysis
AWC	Aviation Weather Center
AWIPS	Advanced Weather Interactive Processing System
AWIPS-II	Second Generation Advanced Weather Interactive Processing System
BP	Business Practices
CCS	Central Computing System
CONDUIT	Cooperative Opportunity for NCEP Data Using Internet Data Delivery Technology
CP	Customers and Partners
CPC	Climate Prediction Center
CS	Federal Civil Service
ECMWF	European Center for Medium Range Weather Forecasts
EMC	Environmental Modeling Center
FAA	Federal Aviation Administration
FTE	Full Time Employees
FTP	File Transfer Protocol
GEMPAK	General Meteorological Package
GEWEX	Global Energy and Water Cycle Experiment
GFS	Global Forecast System
GPS	Global Positioning System
GSI	Gridpoint Statistical Interpolation
HEC	High-End Computing
HPC	Hydrometeorological Prediction Center
HPSS	High Performance Storage System
HWRF	Hurricane Weather Research and Forecast (WRF) Model
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory Model
IS	Information Systems
IT	Information Technology
LDM	Local Data Manager
MAG	Model Analysis and Guidance System
MV	Mission and Vision
NAWIPS	NCEP Advanced Weather Interactive Processing System
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NCO	NCEP Central Operations
NextGen	Next Generation Air Transportation System
NGO	Non-governmental Organization
NMM	Nonhydrostatic Mesoscale Model

NOAA	National Oceanic and Atmospheric Administration
NOMADS	NOAA Operational Model Archive Distribution System
NPSR	NCEP Production Suite Review
NSF	National Science Foundation
NTOP	NCEP Technical Operating Plan
NWP	Numerical Weather Prediction
NWS	National Weather Service
O2R	Operations-to-Research
OCCS	Operational Center Computer System
OFCM	Office of the Federal Coordinator of Meteorology
OPC	Ocean Prediction Center
PPBES	Planning, Programming, Budgeting, and Execution System
PMB	Production Management Branch
POC	People and Organizational Culture
PS	Products and Services
R2O	Research-to-Operations
SDM	Senior Duty Meteorologist
SIB	Systems Integration Branch
SISB	Shared Infrastructure Services Branch
SPC	Storm Prediction Center
ST	Science and Technology
SWPC	Space Weather Prediction Center
TeraGrid	Terascale Grid-Based System sponsored by the National Science Foundation
TOC	NWS Telecommunications Gateway
TPC	Tropical Prediction Center
UCAR	University Corporation for Atmospheric Research
UKMO	United Kingdom Meteorological Office
WFO	Weather Forecast Office
WMO	World Meteorological Organization
WOC	NOAA Web Operations Center
WRF	Weather Research and Forecast Model