The tables in this document represent the complete set of findings and recommendations from the UCAR Review of the NCEP Environmental Modeling Center. The tables also include the EMC action plan in terms of specific actions, status and due dates. In June 2011, the Committee Chairs provided EMC management with a written evaluation of the action plan to date. The Committee evaluation of each recommendation and the EMC response is provided beneath each of the assessment categories. NOTE: yellow highlighted text represents updates since 14 March 2013.

Community Review NCEP Assessment and Recommendations (Last modified 13 January 2014 WML)

Environmental Modeling Center (EMC)

Mission and Vision: Findings

Finding MV1: *The present mission statement for EMC,* **"Maintain, enhance and transition-to-operations numerical forecast systems for weather, ocean, climate, land surface and hydrology, hurricanes, and air quality for the Nation and the global community and for the protection of life and property and the enhancement of the economy."** *although adequate, is uninspiring because it begins with the word "maintain." A more effective approach would be something along the lines of "Provide the most effective numerical forecast systems…". This suggested wording implicitly includes development, enhancement, translation, and maintenance but avoids the term "advanced" because something that is advanced isn't necessarily most effective. Additionally, because hurricanes represent a weather phenomenon, including them in the list is redundant. Rather than listing specific phenomena or processes, which will never be complete, EMC might consider saying its forecast systems are used for atmospheric, oceanic, and environmental prediction from local to global scales and from minutes to years/decades. Finally, it is unclear whether EMC's mission is to protect life and property and enhance the economy on a global scale. The current mission statement is ambiguous in this regard because it places Nation and global community together.*

The vision statement, "With **our partners, to be the world's best and most trusted provider of numerical forecast systems for weather, ocean, climate, land-surface and hydrology, hurricanes and air quality."** *is much more compelling but is problematic in again providing an incomplete listing of weather phenomena and processes. Ultimately, EMC must determine whether it can indeed achieve the vision put forth. In contrast to ECMWF, which operates a single model and is structured far differently, EMC operates numerous models having different frameworks and purposes. Although EMC is moving toward a common model framework (the NOAA Environmental Modeling System, or NEMS), the sheer number of models supported, in comparison to the number of staff, may never allow it to be the "best in everything."*

Assessment Recommendation	Planned Action	Status	Due Date
Recommendation MV1: although adequate, is uninspiring because it begins with the word "maintain." A more effective approach would be something along the lines of "Provide the most effective numerical forecast systems…". Rather than listing specific phenomena or processes, which will never be complete, EMC might consider saying its forecast systems are used for atmospheric, oceanic, and environmental prediction from local to global scales and from minutes to years/decades. Finally, it is unclear whether EMC's mission is to protect life and property and enhance the economy on a global scale. The current mission statement is ambiguous in this regard because it places Nation and global community together.	**MV1.1:** EMC will revisit mission and vision statements	**MV1.1:** Internal discussion with EMC staff has started. Have modified EMC overview slides to emphasize the development and implementation aspects of the mission. Maintenance is downplayed but not ignored since is a non-trivial level of effort. **MV1.1a:** EMC director transition dictates schedule.	**MV1.1:** Q2FY14 **MV1.1a:** Q2FY14

Customers and Partners: Findings

Finding CP1: *The EMC has insufficient and ineffective interaction with the research community and with other NCEP centers. Although many successful research collaborations exist involving EMC and the external community (e.g., satellite data assimilation work with the JCSDA and university collaborators, the development of storm-scale numerical weather prediction systems with the University of Oklahoma, National Severe Storms Laboratory (NSSL) and SPC), EMC acknowledges that a long-standing perception persists of its lack of receptivity to innovations from outside its walls. The review panel believes this perception is reality. Evidence for this is manifest in the research community's lack of understanding of EMC's necessarily highly-regimented production suite schedule, which favors fast, efficient code over what may be considered operationally incompatible, state-of-the-science capabilities. In addition, inadequate facilities for hosting meetings and workshops, an inadequately funded visiting scientist program, and an overworked staff that is unable to visit peer institutions and universities because of production deadlines contributes to a dulling of the intellectual environment so vital to EMC's success. Discussions with other NCEP service centers reveal a similar lack of connectivity with EMC.*

Finding CP2: *The EMC has too many customers, products, and services for its budget. Unlike its peer operational centers around the world, EMC has extensive mission requirements with a large number of differing model elements composing its production suite. EMC management views each component of the "jigsaw puzzle" (production suite) as sacrosanct. Even with expected (modest) increases in computing capability, the projected development and deployment of a suite of forecast models being run at increasingly finer resolution will further strain limited resources.*

Assessment Recommendation	Planned Action	Status	Due Date
Recommendation CP1: The EMC must be proactive in reaching out to the community, including its sister NCEP centers, to assess needs and priorities and foster more effective understanding of activities and stimulate working relationships. In order for EMC's achievements to match its vision, it must ensure that its work is addressing community needs and priorities and working effectively with its sister NCEP centers. Further, it must be more effective in engaging the research community so as to take full advantage of research developments that can enhance its operational capabilities. Although EMC conducts the annual NPSR, wherein customers and partners are invited to provide input into EMC's requirements setting process, greater engagement with the community – particularly the research community – is needed. The World Meteorological Organization (WMO) programs, including the World Weather Research Programme (WWRP), the World Climate Research Programme (WCRP; inclusive of the Global Energy and Water Cycle Experiment (GEWEX), Climate Variability and Predictability (CLIVAR),	**CP1.1**: Increase collaborations on key scientific development. **(1)** Atmospheric Data Assimilation - Hybrid system, partners with ESRL, U. Oklahoma, GMAO **(2)** Climate process team (CPT) physics development with U. Washington, JPL, UCLA to improve shallow convection and stratus in global forecast model **(3)** Hold international workshop on CFS V.2 **(4)** Enhance collaboration with DTC (4.1) HWRF (4.2) GSI (4.3) NEMS (4.4) mesoscale ensemble systems **(5)** Enhance collaboration with GMAO, Navy, GFDL on Ocean Data Assimilation	**CP1.1:** **(1)** plan signed, code development proceeding, global operational implementation slated for Q3FY12. **2)** Proposal accepted; coordinated project underway **(3)** Meeting held 8 March 2011. Meeting summary available on request. **(4.1)** HWRF tutorial and code repository **(4.2)** GSI tutorial and code repository **(4.3)** DTC placed software engineer at EMC to support NEMS development **(4.4a)** EMC supported DTC ensemble workshop (Sept 2009) and subsequent development of NOAA white paper on mesoscale ensembles **(4.4b)** EMC/DTC/DET collaborating on testing physics based component of SREF for FY12 operational implementation **(5)** Draft Ocean Data Assimilation plan developed (Dec 2010) joint between NCEP, GFDL, NASA and NAVY. NCEP considering adoption of NCODA for assimilation system for HYCOM and WWWIII.	**CP1.1:** **(1)** Plan completed and signed Feb 2010; development progressing well; pre-implementation results remain positive. Operational implementation on 22 May 2012. **(2)** First CPT meeting held at NCEP in November 2010. Roles and responsibilities clearly defined. Work has started. Results presented at CFSv3 planning workshop Aug 2011. **(3)** Completed (4.1) completed (4.2) completed (4.3) completed (4.4a) completed (4.4b) completed **(5)** NCEP now has access to NCODA—Tolman EMC lead

Stratospheric Processes and their Role in Climate (SPARC), and Climate and Cryosphere (CliC) programs), and the Working Group on Numerical Experimentation (WGNE) provide invaluable access to the international research community. The EMC has been historically underrepresented in these programs in comparison to its European, UK, Canadian, Australian, and Japanese counterparts. In order to be the world's leading environmental modeling center, EMC needs to foster a vibrant, intellectually stimulating research environment by increasing interactions with the national and international research communities. Although the move to a new building undoubtedly will provide the infrastructure and environment necessary to support meetings and workshops, especially with collaborators at the University of Maryland, a robust visiting scientist program and improved use of community test beds also is needed. Further, support for EMC staff members to visit peer operational centers, including all sister NCEP centers, for extended exchanges no doubt would enhance the intellectual vitality of all participating organizations. However, mechanistic changes such as visiting programs and new space are not sufficient; EMC needs to change its personality in working with the broader community and foster a culture of "EMC without walls" rather than the present framework in which activities are considered by all as either internal or external to EMC.	**(6)** Work with ESMF developers, Navy and AFWA to develop common model architecture	**(6)** EMC active in NUOPC CMA and TTP Committees. ESMF developers visited EMC 5/18/2010.	**(6)** Ongoing commitment. Y. Zhu EMC lead
	(7) Work with JCSDA partners to use NPP data	**(7)** FY10-11 work complete, including formatting CrIS and ATMS; JPSS IPO funding 2 FTE to support. EMC participating in interview process. EMC management now meets bi-weekly with NESDIS STAR management. JPSS pulled funding for staff shortly after interviews were held.	**(7)** ATMS implemented 22 May 2012. CrIS implementation Aug 2013 after WCOSS went live.
	(8) US-EUROSIP climate products	**(8)** Providing NCEP GEFS products. Working jointly with CPC (lead Center on EUROSIP)	**(8)** Ongoing commitment
	(9) Support EMC participation at professional meetings	**(9)** In 2010, EMC increased travel by 30% over FY09 budget. Staff attended 32 conferences in 15 countries. In 2011 there are plans to attend 39 conferences in 18 countries. See attached slide set listing international collaborations and participation in WMO/working groups. FY12 budget required a 25% reduction in travel. Travel in FY13 has been significantly reduced (down to 30% of FY 11 level) limiting EMC participation in professional meetings (i.e., only 4 federal employees approved to attend 2014 AMS annual meeting)	**(9)** Ongoing
	(10) Plan and execute CFSv3 planning workshop via CTB	**(10)** CTB hosted a community based workshop to begin the planning process for CFSv3 development. Presentations and summary can be found at: To view the presentations in the meeting, go to :http://www.cpc.ncep.noaa.gov/products/ctb/ctb-home.shtml and then click "*The CFSv3 Planning Meeting on August 25-26, 2011 <http://www.cpc.ncep.noaa.gov/products/ctb/meetings/2011/CFSv3/>".*	**(10)** Completed
	(11) Plan and execute joint DTC/EMC workshop on NWP physics	**(11)** A workshop organized by the DTC and NCEP/EMC was held at the World Weather Building in Camp Springs, Maryland on 26-28 July 2011. The goals of the two and a half day meeting were to find short-term opportunities for improving numerical weather prediction (NWP) models, and to establish a longer-term framework for closer collaboration between research and operations (R&O). **Please see meeting** web site for links to presentations: <http://www.dtcenter.org/events/workshops11/mm_phys_11/index.php> Plenary summaries and the final workshop summary <http://www.dtcenter.org/events/workshops11/mm_phys_11/Workshop_Summary_Final.pdf> under the "Agenda" tab.	(11) Completed. Briefing NWS OS&T Director 21 September on workshop summary and recommendations. BAMS article published.
	(12) Site visit to NRL MRY to identify joint collaborative projects	**(12)** EMC Acting Director was invited to visit NRL MRY Sept 12-13 to identify areas of alignment for enhancing EMC-NRL collaboration with intent to accelerate model development activities. Top two priority areas identified are development of semi-lagrangian advection capability within NAVGEM and GFS; (2) Land surface data assimilation; (3) application of ocean/wave data assimilation (NCODA) at NCEP. Note that EMC and NRL plan to have working meetings on the topics. Exact format TBD. EMC and NRL directors also agree to consider hosting visiting	**(12)** Ongoing.

	CP1.2: Meet periodically with other NCEP Center Directors to discuss how EMC can improve their products	scientists to enhance collaboration. **CP1.2** Established meetings with NCO, HPC, SPC and CPC. Joint special projects with centers underway.	**CP1.2** Ongoing commitment
Recommendation CP2: The EMC must streamline its portfolio of products and services. Through greater engagement of the community, EMC must re-prioritize its products and services to ensure that planned increases in resolution, sophistication of data assimilation and physics parameterizations, and increasing number of model executions via ensembles can be achieved with the highest value possible. One consideration toward achieving this goal is the adoption of a single (unified) multi-scale modeling approach capable of global, regional, and local prediction. Although this concept has long been debated, the clear message from other prediction centers around the world is that such a framework appears to be essential for meeting tomorrow's challenges in light of unavoidable limitations in funding and staffing.	**CP2.1**: Continue developing NEMS for both operational and research applications **CP2.2:** Unify global weather and seasonal climate analyses by introducing coupled atmosphere-ocean-land surface-sea ice system into GDAS and GENS **CP2.3:** Consolidate regional ensemble system (SREF) **Cross References:** **PS1.1:** Participate in NOAA Modeling strategic planning and budgetary processes. **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidlines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the operational modeling systems.	**CP2.1:** NEMS development continues. First operational implementation of NEMS was FY12Q1 when the NNMB replaced the NMM in the NAM slot **CP2.2:** Testing GDAS with coupled system (GSI/GODAS). Results on weather prediction do not warrant operational implementation in FY12. Exploring coupled capability with HYCOM and/or GOLD ocean models. NCEP co-organizer of a WGNE meeting on coupled atm/ocean NWP meeting to be held in spring 2013 in DC area **CP2.3:** Four Eta model members replaced by WRF ARW members in Q1FY10 SREF upgrade. Q2FY12 SREF upgrade will eliminate all RSM and ETA members. Will be composed solely of NMM and ARW members.	**CP2.1:** completed **CP2.2:** GODAE OceanView - WGNE: Joint Workshop on Short to Medium-range coupled prediction, Washington DC, 19 - 22 March 2013 **CP2.3:** Completed

***Evaluation of CP1*:** We are very encouraged by the many activities that are in concert with our rather long recommendation. Success of the hybrid data assimilation team effort is vital if NCEP is to keep up with peers. The response is somewhat minimal on engagement in the international programs mentioned in CP1, but the planned CFS Workshop is a good start. No response was made on the suggested two-way scientific visiting program, and recent progress on the NCWCP building suggests that a multi-partner planning effort on this program should begin.

EMC Response to CP1: Engagement with international programs is significant (see appendix A). Hybrid EnKF-3DVar GDAS top priority for NCEP in FY12 and pre-implementation testing on schedule for Q3FY12 implementation (COMPLETED). EMC more proactive in developing and hosting targeted workshops with external community (see actions 10-13 for CP1 above). Visiting scientist program is very desirable and Acting Director working with NOAA leadership to find ways of funding it (Budget continues to decrease limiting opportunity to host US scientists). It must be understood that EMC has little discretionary funding to self-invest in visiting scientists. EMC Acting Director is willing to set aside portion of overhead funding (EMC no longer collects overhead to support additional staff) to fund post-doc positions within EMC. FY12 cuts in programmatic

funding (CPO—reanalysis and ocean DA; HFIP, NWS AQ will not allow Director to acquire funds for new visiting scientists. Budget constraints continue in FY12 and EMC has lost 15 contractor/visiting scientist positions in the last 6 months.

Evaluation of CP2: Some good first steps have been taken, as the Eta and RSM models will be retired. We realize that unifying regional and global models is a longer and much more complicated task, and there are also good arguments for multi-model ensembles. However, we still encourage efforts on a unified NEMS. It looks as if the use of NMMB for NAM has been decided, but the path to the next global system is unclear. The panel would like to see the plan for how this will proceed.

1. EMC Response to CP2: Strategy for a unified modeling capability for NCEP will take time to develop. EMC management is consulting with international centers which adopted such a strategy to determine pros and cons. The formation of a Scientific Advisory Board for EMC could be used to help develop such a plan. The NEMS is an infrastructure that provides flexibility for running multiple models and associated ensemble systems in an operational setting. It can be used for global and regional atmospheric models as well as ocean, land and ice. Moving nest capability has been developed and 2-way nesting as well. This development may allow the HWRF configuration to be integrated into the NEMS/NMMB system beyond FY12. Using portion of HFIP and Hurricane Sandy funding to integrate HWRF into NMMB. The global model to beat operationally is the GFS--spectral. Current plans for the global system include development of the Semi-Lagrangian advection formulation within GFS with first opportunity for operational implementation in Q4FY14. Preliminary testing is encouraging at T1534 (~13km). It's obvious that NCEP must consider non-hydrostatic dynamics for higher resolution global system. Candidates include NMMB, GFDL Finite Volume, and MPAS. OAR Sandy Supplemental project initiated to begin systematic testing of non-hydrostatic cores. EMC-NCAR MMM working a joint project to put have NCEP become a MPAS friendly user in the spring of 2012 and EMC will put GFS physics into MPAS—Fanglin Yang to visited NCAR for a 3 week period to get MPAS training in spring. NCAR has incorporated GFS physics into MPAS. Results pending.

Products and Services: Findings

Finding PS1: *The EMC is producing an enormous number of products and services that are viewed as valuable by the community. However, the growing model suite and diverging platforms of these implementations seem overbearing and potentially detrimental to future capabilities. The EMC has shown an ability to adapt and grow to fit user needs, and during the past decade, the EMC production suite has grown to include long-range and short-term ensemble products, increased resolution and forecast periods for short-range and long-range models, as 15 well as inclusion of high-resolution mesoscale, air quality and global ocean modeling. It is commendable that EMC provides the global community with reliable, daily products; however, it is equally apparent that the current approach to development and ongoing support of these products probably is unsustainable, thus threatening achievement of EMC's vision. The EMC leadership has recognized the lack of resources needed to sustain its approach to numerical model development, including adoption of NEMS. However, the review panel did not see evidence of a strategic plan to organize available resources, both internally and across the user community, to streamline its production suite in a broader sense.*

Finding PS2: *The EMC has created several valuable and noteworthy products that clearly demonstrate its ability to successfully cooperate and synthesize the community's needs into an operational product. Specifically, it has implemented a number of major new capabilities over the past five years that showcase its ability to serve a diverse user base. Some of these advances and implementations include:*

- *Data Assimilation Team: Unification of the Global, Regional, Real-time Mesoscale Analyses (RTMA) with the GSI system.*
- *Ensemble Team: Implementation of North American Ensemble Forecast System (NAEFS) with Canada.*
- *Climate Team: Implementation of the Climate Forecast System (2004) and its reforecast data base.*
- *Hurricane Team: Implementation of the Hurricane Weather Research and Forecast (WRF) system.*
- *Land Surface Team: Unification of the NOAA Land Surface Model (LSM) across Global Forecast System (GFS), WRF-NMM (Non-hydrostatic Mesoscale Model) and WRF-ARW (Advanced Research WRF model) applications.*
- *Global Branch: Implementations in 2005 that include use of the GSI analysis, addition of a hybrid sigma-pressure coordinate to improve representation of the stratosphere, and a rewritten and modernized radiation package.*
- *Mesoscale Branch: Implementation of explicit-convection High-Resolution Window Runs to support the SPC/NSSL Spring Program.*
- *Marine Branch: Adoption of the WAVEWATCH III wave model as the defacto community operational and research standard.*

The EMC leadership also recognizes they must increase the speed with which research outcomes are transitioned to operational implementation, using an improved approach that leverages resources within the external research and academic communities. EMC must take a leadership role in promoting its operational needs to foster a more effective, mutually beneficial relationships with the research community.

Finding PS3: *They understand the importance of meeting user requirements and providing high quality service.*

Assessment Recommendation	Planned Action	Status	Due Date
Recommendation PS1: The EMC must develop an approach to consolidate the vast number of numerical models currently being developed and supported. The EMC is to be commended for a 'can do' culture that seeks to meet expanding needs of internal and external user communities. However, EMC must find a balance between implementing new mandates, some of which are unfunded, and sustaining current mission needs. In order for EMC to push forward in what undoubtedly will be a resource-constrained environment for the foreseeable future, it must seek to eliminate the growing number of divergent numerical models currently under development or in production. It also is apparent that the diversity of models today has placed a strain on the ability of EMC to support and quickly	**PS1.1:** Participate in NOAA modeling strategic planning and budgetary processes. **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidlines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the	**PS1.1:** EMC has participated (is participating) in the following NOAA planning activities: (1) NOAA Environmental Modeling Program strategic plan (2) NOAA Science Workshop white paper entitled "Strengthening NOAA Science" (3) NWS OS&T Science and Technology roadmap (4) SEE budget planning for the Climate Service and Environmental Modeling Integration Program **PS1.2:** Committee formulation in the early stages. Must prepare a proposal for NCEP management.	**PS1.1:** Continuous commitment **PS1.2:** EMC must develop strategic plan before forming SAC—in progress

implement upgrades and enhancements to its production suite. In addition, inefficiencies inherently occur because some models produce similar, overlapping products, and this duplication consumes valuable staff time as well as computing resources. The EMC should develop a plan to migrate the current suite toward a more unified modeling approach that can leverage all resources currently available – from research and operations staff to computing capacity. This approach also will provide for a more suitable environment to effectively and efficiently transition visiting and on-site staff in and out of EMC.	operational modeling systems. **PS1.3**:Develop a strategy for a unified modeling prediction capability for global and regional applications. Must be developed with NOAA EME participation.	**PS1.3:** Under consideration. Must address scope and ramifications of a unified approach on multi model ensemble systems.	**PS1.3:** Plan to unify/simply production suite in progress. Unified modeling system may not be possible due to large and growing scope of NCEP mission.
Recommendation PS2: The EMC must adopt a formal approach for consistently delivering full-resolution products (operational or experimental – requires clarification) to the entire user community. The EMC's vast array of products has created an equally large user community that relies upon them. Unfortunately, many of the products disseminated from EMC models are substantially degraded in both temporal and spatial resolution relative to their native frameworks and are limited in other ways (e.g., representing only certain fields). As a result, EMC should take a leadership position within NCEP – working with NCO and others, given the considerable information technology (IT) issues involved – to formalize and implement an approach for disseminating full-resolution, comprehensive information from its models. Doing so will leverage the creative, developmental and computational capacity of the global community, thus providing valuable feedback for future model improvement.	**PS2.1:** Use NOMADS to provide all products on public server in full resolution format. **PS2.2:** Keep NWS HQ informed on model resolution upgrades through formal NWS established processes **PS2.3:** Ensure CFSRR data gets to NCDC for distribution to public **PS2.4**: NCEP contributing to CMIP5	**PS2.1:** EMC now supports NCO quarterly upgrades to NOMADS. EMC developers provide new products for distribution via NOMADS based on customer requests. **PS2.2:** **(1)** EMC and NCO corroborate to produce Technical Information Notices in accordance with NWS regulations prior to all implementations. **(2)** EMC is not responsible for establishment of AWIPS and SBN priorities. **(3)** NCEP operational model grids available via NCEP FTP server or NWS TOC/NOMADS—NCO responsible center for dissemination of NCEP production suite products **PS2.3:** CFSRR data dissemination responsibility of NCDC. Data delivery plan completed. **PS2.4:** Data contributed to archive	**PS2.1:** NOMADS quarterly upgrades now part of the EMC/NCO AOP **PS2.2:** Completed **PS2.3:** Complete **PS2.4**: Ongoing
Recommendation PS3: The EMC must work closely with NCO to ensure continuation of the current high standard of product reliability without becoming too risk averse, which could slow the progress of enhancements and upgrades to the production suite. The process of transition from research to operations (R2O) is inappropriately informal and needs a terms of reference document to improve its effectiveness. This should be jointly developed between EMC and NCO and could be one mechanism to help alleviate the organizational tensions noted elsewhere in this report.	**PS3.1:** EMC working with NCO to review and revise the NCEP Implementation Process (IP) **PS3.2:** EMC and NCO will revise the IP and execute prototypes to test procedure and demonstrate feasibility	**PS3.1:** (1) Chartered two projects designed to address issues and revise implementation process. (2) Team formed to execute project (3) EMC/NCO management provide NCEP Director with monthly updates on progress (4) Tolman and Magee leading team (5) First test implementation to be conducted in Q3FY11 using the WWIII upgrade (6) Expect to use new system during transition to new WCOSS in FY13 **PS3.2:** Project proceeding. Revised process for environmental equivalence developed and under testing with prototype implementation for wave	**PS3.1:** Ongoing **PS3.2:** Extend to other implementations in FY14 and beyond.

	Cross references: **POC8.1:** NCO and EMC Directors set up regular meetings **POC8.3:** NCO and EMC will define projects to address improvements to the NCEP Production Suite Implementation Process (IP)	model upgrade in Q1FY12.	

***Evaluation of PS1*:** The response indicates that moving to a unified system properly is a careful and deliberate process, and we encourage EMC to push forward. An UCAR Community Advisory Committee for NCEP has been created that will not require FACA guidelines. The UCACN will need to decide if it wants to take on this task or form a more specialized sub-committee to work with EMC and NCEP management on this issue.

EMC Response to PS1: Response to CP2 is repeated here: Strategy for a unified modeling capability for NCEP will take time to develop. EMC management is consulting with international centers which adopted such a strategy to determine pros and cons. The formation of a Scientific Advisory Board for EMC could be used to help develop such a plan. The NEMS is an infrastructure that provides flexibility for running multiple models and associated ensemble systems in an operational setting. It can be used for global and regional atmospheric models as well as ocean, land and ice. Moving nest capability has been developed and 2-way nesting as well. This development may allow the HWRF configuration to be integrated into the NEMS/NMMB system beyond FY12. Using portion of HFIP and Hurricane Sandy funding to integrate HWRF into NMMB. The global model to beat operationally is the GFS--spectral. Current plans for the global system include development of the Semi-Lagrangian advection formulation within GFS with first opportunity for operational implementation in Q4FY14. Preliminary testing is encouraging at T1534 (~13km). It's obvious that NCEP must consider non-hydrostatic dynamics for higher resolution global system. Candidates include NMMB, GFDL Finite Volume, and MPAS. OAR Sandy Supplemental project initiated to begin systematic testing of non-hydrostatic cores. EMC-NCAR MMM working a joint project to put have NCEP become a MPAS friendly user in the spring of 2012 and EMC will put GFS physics into MPAS—Fanglin Yang to visited NCAR for a 3 week period to get MPAS training in spring. NCAR has incorporated GFS physics into MPAS. Results pending.

***Evaluation to PS2*:** Response to provide full-resolution data via NOMADS is excellent; not sure if it will be possible. [NOTE: NCO also received this recommendation, but confusion ensued re "native" vs "full-resolution" grids, the latter being what is desired. We encourage EMC to work with NCO toward the full-resolution goal.] Information about the CFSRR data is appreciated but it is noted that the promised date for availability of the reforecast data is now long past.

EMC Response to PS2: EMC, CPC and NCDC developing proposal for upper level management documenting costs associated with providing community with access to CFSRR hindcast dataset. Decisional authority resides at the NCEP and NCDC Director level. NCEP is working with ESSIC to provide a subset of reforecast data to them for internal use and dissemination to public. On hold until ESSIC can identify funding source. CPO MAPP planning project with NCDC and NCEP to archive and disseminate data.

Evaluation of PS3: We appreciate EMC's response to accept a more structured implementation process. As of this past fall/winter, though, the implementation rate had become slower, not faster, which was blamed on some unfilled senior production analysts positions. Will need an update to learn if this bottleneck has been alleviated.

EMC Response to PS3: The NCO PMB SPA office is fully staffed (8 SPA's). EMC and NCO have developed a modified implementation process using code management principles that is more efficient than the current process. Details were provided at the UCACN meeting in October. NCO SPA staffing reduced by 2 due to FY12 budget cuts. I don't have an update on NCO SPA staffing levels.

Information Systems: Findings

Finding IS1: *High performance computing resources available at NCEP are far below 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 competitive position among world forecasting centers. Although computing power alone will not elevate NCEP to world leadership, failure to address this issue will continue to place NCEP at a notable disadvantage. The table below, provided by the EMC Director, demonstrates the notable advances that could be wrought with thoughtful investments in a much more capable HEC system.*

Finding IS2: *The EMC is severely lacking in non-HEC computing resources, particularly disk space, necessary to support its mission. A key limitation in the ability of EMC staff members 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 models 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 communication regarding EMC needs and resource provisioning decisions by NCO.*

Finding IS3: *The EMC lacks a structured management process, of the type used in many organizations – especially those having complex structures – to ensure effective planning and resource allocation. The complete lack of formal project management is exacerbating many of the issues raised in this report.*

Assessment Recommendation	Planned Action	Status	Due Date
Recommendation IS1: The EMC must be provided with adequate computational resources for both operations and research. The EMC must request sufficient resources for substantially enhanced HEC capability, at the very least through the NOAA Planning, Programming, Budgeting and Execution System (PPBES) process, and leverage opportunities for using external computing resources whenever practical (e.g., from nationally available supercomputing facilities supported by the National Science Foundation (NSF) or other agencies). The computing resources needed to support a broad range of activities, from research and development 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 research computing allocation decisions with the appropriate experts at EMC and NCO, but with shared goals in mind. Procurement of new systems must accommodate requirements across the NCEP family of centers.	**IS1.1**: Participate in NCEP HPC Resources Allocation Committee (HPCRAC) **IS1.2:** Convey EMC systems development plans to NCO and compare with available resources **IS1.3:** Plan resources allocation for NOAA R&D computer at Site A (ORNL) and Site B (West VA). **IS1.4:** Support NOAA Weather and Climate Operational Supercomputer Systems (WCOSS) acquisition plan development and execution	**IS1.1:** Ongoing. **IS1.2:** Provide computer resource requirements with emphasis on disk to NCO on a bi-yearly update cycle. **IS1.3:** Allocation process and definition agreed to by all NOAA line office representatives and DUS. Process executed to develop FY12 R&D compute allocations. Allocations approved by NOAA OCIO on 5 August 2011. EMC Acting Director is the committee chair. **IS1.4:** EMC supporting WCOSS acquisition plan development and acquisition in support of NCO and NOAA OCIO in the areas of requirements, benchmarks, evaluation factors, etc.	**IS1.1:** Continuous activity requiring EMC participation. **IS1.2** Provided monthly at HPCRAC **IS1.3:** NOAA OCIO has established an allocation committee active in FY12 and FY13. Lapenta acting Chair (2-years). **IS1.4:** Completed

Recommendation IS2: The EMC should work with NCO to implement IT solutions (e.g., desktop resources and connectivity, software) to increase flexibility and capability. This should include development of a written agreement between EMC and NCO to clearly define lines demarcating the roles and responsibilities of both organizations. As it is apparent that NCO provides many IT support services to EMC and the NCEP service centers, EMC also must have a written service agreement with NCO to clearly define the responsibilities and service levels NCO is to provide. Clear metrics should be established (e.g. time to establish an account, problem escalation) and clear definitions made of rules and procedures governing hardware and software utilization. These clarifications will help ensure effective understanding and the setting of appropriate expectations	**IS2.1:** merge EMC Helpdesk with NCEP Helpdesk function **IS2.2:** Work with NCO on IT software standards **IS2.3:** NOAA OCIO requested NCEP consolidate help desk services (i.e., EMC, CPC, NCO)—May 2012 memo	**IS2.1:** Merger accomplished **IS2.2:** Participate in NCEP IT Standards Process **IS2.3:** Plan developed Jan 2013	**IS2.1:** Completed **IS2.2:** Completed **IS2.3** Completed
Recommendation IS3: Many groups within EMC need to consider using external computing and other resources, e.g., at NSF or other centers. It is clear that considerable development and test work could be performed via access to external IS resources. Although the availability of resources identical to those used for the production suite is necessary for optimization and final implementation testing, much of the functional testing and impact analysis of model changes can be accomplished using external resources. Considerable resources are available to NOAA from the NSF TeraGrid, and access to them should be vigorously pursued. A side benefit of such utilization includes increased interaction with and visibility in the research community, particularly in the area of HEC, networking, and data stewardship.	**IS3.1:** Port model system benchmark to ORNL Cray **IS3.2:** Begin using ORNL Cray system **IS3.3:** Use NOAA R&D Site A computer for global modeling (S/I and ensemble emphasis) **IS3.4:** Conduct development of hybrid ensemble variational data assimilation system on HFIP computer resource in Boulder in concert with ESRL and University of Oklahoma investigators **IS3.5:** CFSv2 code provided to COLA in Q3FY11. **IS3.6:** Porting GDAS/GFS to NASA JCSDA	**IS3.1:** Benchmarks ported **IS3.2:** Plan and execute limited control runs **IS3.3:** Computer available Q1FY11. NCEP gained user access Q2FY11. Porting codes (GDAS/GFS) has been slow caused by black of documentation and slow comms. NCEP developing porting plan for GAEA and ZEUS. **IS3.4:** Primary development conducted at ESRL. Development progressing and nuances associated with ESRL computer environment are being documented. Code ported back to IBMP6 for pre-implementation testing. **IS3.5:** COLA has system running at NCAR (IBMP6) and NASA ARC (SGI). **IS3.6:** EMC hosted 2 NASA staff for a month to train them how to run GDAS/GFS on NCEP R&D system in support of transition to NASA JCSDA machine. EMC working with JCSDA to include JIBB in code porting strategy to reduce redundancies.	**IS3.1:** DoE never provided allocations despite constant NOAA requests. CLOSED **IS3.2:** See above. CLOSED **IS3.3:** EMC effectively using NOAA R&D HPC assets. **IS3.4:** Completed **IS3.5:** Completed: Q4FY10. CLOSED **IS3.6:** EMC completed Hybrid parallel to JCSDA JIBB and S4 machines as requested. CLOSED

Recommendation IS4: The EMC should institute formal project management practices, which will provide greater discipline and focus in planning, resource allocation, risk management and execution. Such practices will assist in balancing demands with available resources and in responding to unfunded mandates with well understood impacts and resource reallocation implications. Additionally, the planning phase of this structured process will produce clear requirements that also can feed into the planning processes of other NCEP centers	**IS4.1:** Plan EMC Scientific Project Office (ESPO) **IS4.2:** Institution of project management practices.	**IS4.1:** Established ESPO in revised EMC staffing plan **IS4.2:** Weekly meetings with NCO began; assigned EMC Executive Officer to manage. Application of project management practices to CCS disk and processor count allows for longer term planning associated with the NCEP production suite.	**IS4.1:** No funding to support plan **IS4.2:** Process established and executed

Evaluation of IS1: EMC is doing what is necessary to convey its computing needs "up the ladder", so most advice on this issue is for NCEP Director and higher. We believe that if the NOAA CIO (DoC CIO, OMB, etc.) requires a better "business case" for HPC investments, then NCEP should be very proactive in articulating this case. The external community, especially the private sector, should be provided with supporting data. In IS1.2, we are not sure what "emphasis on disk" means; while it is true that the research (backup) computer has insufficient disk space, emphasis needs to be on the proper balance between CPU power, storage and bandwidth.

EMC Response to IS1: Building the business case for NOAA operational compute capability is beyond the scope of EMC. We don't have the skill sets required to do the work and I'll argue that the business case must be developed at higher level in the agency. NOAA must build advocacy among the users of the operational products as stated in your evaluation of IS1. Recent publications have pointed to the need for more operational HPC. Outcome TBD. The Sandy Supplemental HPC increases for NOAA R&D will not be realized until FY15. As a result, the NOAA R&D requirements for all R&D (including Sandy Supplemental projects) exceeded FY14 HPC availability by a factor of 3. Therefore, some R&D projects will be forced to proceed at a slower pace than originally planned.

***Evaluation of IS2*:** The actions above are a good start. Would need to poll staff as to whether clear lines of responsibility have been articulated, with NCO providing the IT security and hardware/software maintenance EMC needs, while allowing EMC to manage its in-house software. A similar comment was made in the evaluation of the NCO response to this issue.

EMC Response to IS2: The EMC IT system is now owned by NCO. The EMC IT helpdesk continues to support the 150+ staff and coordinates C&A and IT security with NCO. EMC Considers this recommendation response closed. See IS2.3: NOAA OCIO requested NCEP consolidate help desk services (i.e., EMC, CPC, NCO)—May 2012 memo.

***Evaluation of IS3*:** These are excellent first steps. The next stage is to explore use of the Teragrid with NSF and Teragrid centers, perhaps in collaboration with universities.

EMC response to IS3: We are aggressively porting codes to NOAA R&D systems (GAEA and ZEUS) and the JCSDA JIBB and have a transition plan in place. We are not ready to consider how to use the Teragrid at this point in time. EMC codes ported to Zeus and development work underway. All codes are now portable to Linux environment.

***Evaluation of IS4*:** In the "Due Date" column following the create ESPO action, it was written that "No funding to support plan", which we assume means that ESPO was not enacted. However, since "underfunded mandates" continue to be a problem, some process must be developed to assess the resources required for new and ongoing projects, even if it needs to be done out-of-hide. The institution of project management practices is applauded.

EMC Response to IS4: EMC is considered a major IT investment by DoC entitled "Data Assimilation and Modeling" and is now being managed using project management principles. The Acting Director is the project manager and will become certified later in FY12. DoC requires monthly reporting on project status including milestone schedule, costs and risks. Project was reviewed by DoC on 23 March 2012. Has received a "green" rating for the past 7 months. Project downgraded to "minor investment" in FY13 resulting in loss of visibility at DoC level.

***Evaluation of IS5*:** This recommendation is the same as IP1 in the NCO Review. The NCO provided a detailed response, on which we commented in their response document. In general, EMC and NCO collaboration is much better, but the systems engineering approach is still a work in progress.

EMC Response to IS5; EMC and NCO adopting more systematic approach to implementation process and scheduling. Implementations made in FY12 and FY13 into a full machine was an extraordinary accomplishment by EMC, NCO and associated partners. Required unprecedented coordination, planning and execution.

Science and Technology: Findings

Finding ST1: *The EMC global model suite ranks 4th or 5th in the world, based upon objective skill scores, a rank that has deteriorated since the last review. It is patently unacceptable for the United States – given its extraordinary need for accurate weather and climate information across all sectors of society – to operate a global forecast system that lags well behind those of other nations and has continued to lose ground over the past several years. The reasons for this ranking are many and complex, ranging from inadequate computing resources to insufficient staffing levels, the latter driven by the support of too many modeling systems. This report offers specific findings and recommendations along those lines, but the review panel wishes to note here, with a clear and unequivocal statement, that EMC global model skill cannot be allowed to remain in such an embarrassing position in the world.*

Finding ST2: *The EMC is effective in supporting a limited number of students (funding, hosting) and this effort should be expanded with the move to the new building. The review panel is pleased to note that EMC hosts students and has been effective guiding their work on important scientific and technical problems related to prediction science. These students will become next-generation scientists, and their involvement in operational research will help promote the continued growth and development of EMC. Through these students, EMC also develops strong interactions with university faculty and researchers, allowing new ideas to be tested for operational implementation. We strongly encourage expansion of this program with the move to the new building, which will offer greater flexibility in office space.*

Finding ST3: *The EMC has an inadequate research visitor program. Although EMC has a significant number of visiting scientist appointments (e.g., via the SAIC contract), these positions are not truly visitor positions. Many visiting scientists have worked at EMC for a long period of time (i.e., longer than 10 years).Effectively, these long-term positions become surrogates of EMC staff, though without formal NOAA appointments. A common definition of a visitor is an individual who stays at the visiting institution not more than two years, with an intention to go back to his/her home institution. Using this standard, it is clear EMC does not have an adequate visitor program. With the need for EMC to be positioned at the cutting edge of science and technology, it is very important that a continuous flow of new ideas be maintained via a broadly inclusive visiting researcher program.*

Finding ST4: *The 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.*

Assessment Recommendation	Planned Action	Status	Due Date
Recommendation ST1: NOAA, NWS, NCEP and EMC leadership must vigorously address recommendations in this report, and take other necessary actions, to propel US operational global model skill to a leadership position in the world. It is vitally important that the organizations noted above understand the importance of, and take strong action to implement, the recommendations made in this report. The many challenges described herein are substantial, yet the opportunities are equally great. Failure to act with vigorous determination and leadership – at a time when the need for effective weather and climate prediction guidance are at unprecedented levels and science and technology are advancing at record paces – would be a grave disservice to the nation.	**ST1.1:** GFS Q4FY10 implementation: • Modify GFS shallow/deep convection and PBL • Detrainment from all levels (deep convection) • PBL diffusion in inversion layers reduced (decrease erosion of marine stratus) • GSI/GFS Resolution from T382 (~35km) to T574 (~28km) & 64L	**ST1.1:** Resulted in significant reduction in high QPF bias for precip amounts exceeding > 1.0" in 24h. Reduced tropical cyclone track and intensity error s for 2008 and 2009 hurricane seasons in Atlantic and East Pacific. Increased skill of 5-day 500mb AC in northern and southern hemispheres.	**ST1.1:** Completed
	ST1.2: Develop and execute plan for advanced global Hybrid Ensemble-Variational Data Assimilation System (HEVDAS) with NOAA ESRL, NASA GMAO, Univ of Oklahoma.	**ST1.2:** Plan developed and signed Q2FY10. System under development with preliminary tests showing positive impact on analysis and GFS forecasts at reduced resolution. Expected global implementation Q3FY12.	**ST1.2:** Completed
	ST1.3: Semi-Lagrangian formulation of GFS under development	**ST1.3:** Preliminary tests being conducted at T1500 (~13km) 64L on WCOSS.	**ST1.3:** Operational implementation targeted for Q4FY14 at T1534L64

Recommendation ST2: NOAA, NWS, and NCEP leadership should assist EMC in developing a vibrant, intellectually stimulating research capability and strengthen interactions with the national and international research communities. With the constant demand of operating and maintaining a large number of prediction suites that consumes most of its resources, EMC has limited ability to develop and maintain a vibrant and intellectually stimulating research program. The lack of resources also prevents EMC from having strong interactions with the national and international research communities. The lack of such interaction directly limits the ability of EMC to translate the most effective science outcomes into practice, and also limits the ability of researchers outside EMC to engage challenging research problems directly beneficial to EMC. For example, an effective R2O transition requires investments in "operations to research" (O2R) by making the operational systems available to the research community. Doing so requires considerable resources beyond what the Developmental Test Bed Center (DTC) can provide. The review panel recommends that NOAA, NWS and NCEP leadership find ways of providing the resources and guidance necessary to transform EMC into an organization – recognized by the world – as the nexus of intellectually stimulating research and open interaction.	**ST2.1:** EMC participation in WMO activities **Cross References** CP1.1-4 (DTC) ST1.2 (HEVDAS) IS3.5 (COLA and CFSv2 porting) IS3.6: (GDAS/GFS porting to NASA JCSDA)	**ST2.1:** Participation includes: WGNE WWRP WCRP GEWEX CLIVAR GODAE GABLES	**ST2.1:** Ongoing
Recommendation ST3: NOAA, NWS, and NCEP leadership should assist EMC in developing a meaningful visiting scientist program, perhaps in conjunction with NSF, UCAR, and others. A robust visitor program would allow leading researchers from national and international research and operational institutions to visit and interact with EMC staff, resulting in promising new ideas to be tested for possible operational implementation. Such a visitor program would be an important component of achieving Recommendation ST1 above. We also recommend that 22 NOAA and NWS leadership work with NSF and UCAR to secure additional resources for such a program.	**ST3.1:** EMC transmit prototype VS program description to NWS/OST **ST3.2:** EMC recruiting campaign	**ST3.1:** Proposal submitted to NWS OS&T **ST3.2** EMC staff will now visit universities during government travel if they are within reasonable range of meeting.	**ST3.1:** No funding available. EMC Acting Director will continue to pursue opportunities for post-doc positions within the center. No change in funding situation. **ST3.2:** EMC Acting Dir visited University of Utah in Feb 2013—seminar and round table discussion with staff and students. EMC acting Dir visited Ohio Univ and speak at local AMS meeting on own time due to NMWS budget cuts. Hosted a Hollings Scholar student in the summer of 2013. Waiting for NSF VSP to begin.

Recommendation ST4: Accelerate the design of a flexible and adaptable modeling system that will lead to reductions in the number of individual models operated by EMC. As noted earlier in Recommendation PS1, EMC is operating and maintaining a large number of individual models, thus consuming a significant fraction of EMC resources and placing a strain on its ability to interact with the research community, pursue new initiatives, and meet unanticipated requirements. EMC must make a serious effort to reduce the number of individual models within its operational suite. A unified modeling approach, as that now being pursued with NEMS is needed to leverage available resources, both in terms of personnel as well as computational capacity. An excellent example of this recommendation in action is the GSI system, which is being used for global, regional and mesoscale data assimilation. No reason exists to continue the development of the Regional Spectral Model (RSM) and Eta models, knowing that the primary model framework to be used for regional and mesoscale prediction is WRF (NMM and ARW). We strongly encourage EMC to look seriously at all modeling systems and accelerate the design of NEMS that will lead to reductions in the number of individual models. In this context, EMC also should consider maintaining common physics suites for regional and global models. The recommended reduction in the number of individual models (and model components) would free existing EMC resources for other purposes, as noted above. This recommendation bears on issues such as the present capability and future plans of the Short Range Ensemble Forecast (SREF), which though valuable represents yet another arguably unnecessary challenge in managing a large portfolio of models. Finally, EMC should vigorously pursue a broad spectrum of approaches to data assimilation in the context of NEMS, especially hybrid ensemble-variational techniques as are now being developed jointly by EMC, the NOAA Earth System Research Laboratory (ESRL) and the National Aeronautics and Space Administration (NASA). The reasoning behind this recommendation is that, by the time a variational-only system would be implemented by EMC some 3 to 4 years from now – given	**Cross references:** **CP2.1**: Continue developing NEMS for both operational and research applications **CP2.2:** Unify global weather and seasonal climate analyses by introducing coupled atmosphere-ocean-land surface-sea ice system into GDAS and GENS **CP2.3:** Consolidate regional ensemble system (SREF)		

that ECMWF has been using this approach for many years – the gap between NCEP and ECMWF, and possibly other prediction centers, no doubt will have grown even wider.			
Recommendation ST5: The collaborative effort between NCO and EMC on 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.	**ST5.1:** Correct upper air station dictionary **ST5.2:** Test changes to surface data processing to remove redundant data	**ST5.1:** Corrections implemented **ST5.2**: Changes tested (neutral impact); implementation planning on track	**ST5.1:** Complete **ST5.2:** part of O&M

***Evaluation of ST1*:** We have noticed the improved GFS performance relative to its "competitors" during the past 9 months. On average, it appears that the GFS is at least 3rd best each month (to ECMWF and UKMET), with occasional "first place" finishes on some days. So, the gap has narrowed w.r.t. the ECMWF, but it is still significant. As noted above and earlier, improving the DA scheme is crucial. The new UCACN team will want to see the plan for how the new global model will be selected among the various competitors. Also, we noticed that the NAM appears to score last among the 6 models evaluated in precipitation skill in almost all categories (as shown on the STATS_vsdb web page). EMC should set a goal of producing the best QPF scores with its new regional model, at least over the CONUS area.

EMC Response to ST1: Response to CP2 is repeated here: Strategy for a unified modeling capability for NCEP will take time to develop. EMC management is consulting with international centers which adopted such a strategy to determine pros and cons. The formation of a Scientific Advisory Board for EMC could be used to help develop such a plan. The NEMS is a infrastructure that provides flexibility for running multiple models and associated ensemble systems in an operational setting. It can be used for global and regional atmospheric models as well as ocean, land and ice. Moving nest capability has been developed and 2-way nesting as well. This development may allow the HWRF configuration to be integrated into the NEMS/NMMB system beyond FY14. The global model to beat operationally is the GFS--spectral. Current plans for the global

system include development of the Semi-Lagrangian advection formulation within GFS with first opportunity for operational implementation in Q2-Q3 FY14. Preliminary testing is encouraging at T1500 (~13km). It's obvious that NCEP must consider non-hydrostatic dynamics for higher resolution global system. Candidates include NMMB, NIM, Finite Volume, and MPAS. OAR-NWS defining a program to identify an appropriate non-hydrostatic Dyn-core. A major challenge is to develop a high resolution NWP system that provides high quality QPF forecasts and mode of convection for severe weather applications. EMC working closely with SPC, HPC and HWT to address this challenge. Established bi-weekly EMC-SPC telecons to share results on NAM/RR operational performance and parallels

Evaluation of ST2**:** We are pleased with the ongoing and new international activities, and realize that this recommendation is redundant with earlier ones on U.S. collaborations. The over-arching goal is to improve the research culture and capabilities at EMC in order to attract top scientists to work or visit there.

EMC Response to ST2: Excerpt from response to CP1: " Engagement with international programs is significant (see appendix A)" Also linked with JCSDA and other NOAA testbeds. Working to build network with universities with programs in modeling to deal with work force succession planning (see ST3.2 task added in table). EMC culture is undergoing change. Working with operational deadlines requires a unique skill set not easily obtained. Working to recruit expertise.

Evaluation of ST3**:** We are glad to see that a VS plan was developed. Although NWS/OS&T said no funding was available, there are many other ways to develop a VS program. Thus we encourage EMC to work with the NCEP OD and the UCACN to continue to develop a plan that can be vetted both internally in NOAA and to the external community.

EMC Response to ST3: Excerpt from CP1: **"**Visiting scientist program is very desirable and Acting Director working with NOAA leadership to find ways of funding it. It must be understood that EMC has little discretionary funding to self-invest in visiting scientists. EMC Acting Director is willing to set aside portion of overhead funding to fund post-doc positions within EMC. See new ST3.2: EMC recruiting campaign. EMC Acting Dir visited University of Utah in Feb 2013—seminar and round table discussion with staff and students. The EMC acting Dir visited Ohio Univ and speak at local AMS meeting on own time due to NWS budget cuts. Waiting for NSF VSP to begin.

Evaluation of ST4**:** Agree that this recommendation is mostly repetitive, but certainly belongs in the S&T category. As noted above, actions so far have been excellent, with hopefully more to come.

EMC Response to ST4: EMC working to build a strategic plan and formation of a science advisory board. The strat plan must be coordinated across NOAA and this has been problematic in the past.

Evaluation of ST5**: W**e presume that the above are but two of many actions to address this issue. Recent AC scores appear to show less frequent dropouts since the P6 implementation, but having a vigilant team to investigate serious model errors is always a good idea.

EMC Response to ST5: NCEP has formed a team to recommend a more robust model assessment capability similar in nature to that implemented at ECMWF. The purpose of the group is to assess model performance and provide feedback into the model development process. The plan is reformulate the dropout team to accomplish this goal. NASA GMAO has also developed a similar capability and EMC will meet with them to observe the process to prepare its own plan. EMC has formed the Model Evaluation Group (MEG) that evaluates mode performance on a daily basis and reports out to EMC, CPC, HPC and SPC staff on a weekly basis. MEG has received accolades from participants and has greatly improved EMC situational awareness in terms of model performance. EMC plans to increase staffing in FY13.

People and Organizational Culture: Findings			
Finding POC1: *The EMC leadership and staff have created an organization that meets the day-to-day challenges of model development and numerical prediction and functions reasonably well. It was evident during the on-site review that the talented EMC staff members share a strong commitment to the EMC mission and enjoy a rewarding satisfaction in their accomplishments and contributions. The EMC Director has an impressive, detailed understanding of the tasks at hand and the challenges that must be met. The Director, Deputy Director, Branch Chiefs, and Team Leaders appear to work well together. The EMC staff members view the leadership team as strong advocates for employees and for the organization as a whole, although communication and guidance from the top of the organization to lower levels could be improved so that all employees understand both priorities and impediments to progress.* **Finding POC2:** *The EMC accomplishments mask a number of serious stresses and strains that are likely to prevent it from attaining its vision as "best in the world". Some of the problems are internal to EMC, some a consequence of NOAA and federal personnel policies. The most significant internal challenge concerns the apparent lack of willingness on the part of EMC leadership to recognize the reality of insularity, work collaboratively with NCO to resolve important differences that are impeding progress, and be disciplined in scaling back and consolidating the number of models and related systems so as to achieve the EMC vision. The EMC staff members are overwhelmed with many projects and cannot focus on achievements that will lead to preeminence. Senior staff is working at an overload pace that cannot be sustained, and NCEP leadership does not seem to appreciate the severity of, or be willing to address, these challenges.* **Finding POC3:** *The EMC organizational structures and workforce planning need attention. The EMC has responded to previous review recommendations by implementing a matrix management model. However, the main use of the model has been to staff projects funded with external resources and as a consequence, team leaders are drawn away from core responsibilities. The lack of a clear delineation of mission and responsibilities for EMC and NCO creates a difficult situation for both organizations and forces staff members into ad hoc arrangements in order to circumvent tension at higher levels. The longevity of the staff is an important advantage, though EMC is now facing considerable turnover and the loss of significant experience and knowledge. Although the federal Civil Service (CS) allows scientists to be promoted into senior ranks as scientists, NWS personnel policies seem to link promotion to acceptance of management responsibilities. Throughout EMC, ineffective and cumbersome government personnel practices work against the superior achievement evident in competing organizations that today are best in the world.* **Finding POC4:** *The dependence on, and commitment to, outside funds stresses the EMC staff and deflects attention from the core tasks of the organization. NOAA provides EMC (in 2009) with direct funding of about $12M for the core mission and for 65 civil service employees. Some 30 other funding sources, including other NOAA organizations and other federal agencies, provide another $11M for a wide variety of tasks, many of them performed largely by employees of EMC contractor companies. This portfolio requires considerable attention of EMC executives and senior scientists and distracts them from core mission.* **Finding POC5:** *The EMC seems to focus on day-to-day demands rather than on the bold and innovative advances required to achieve its vision. The EMC planning seems to be incremental and fails in setting clear and definitive priorities. The culture appears to be one of risk aversion and EMC seems to be a follower—at best—rather than a leader in the now global movement toward collaborative community numerical models and frameworks. The plethora of models EMC maintains consumes the strength of staff and requires duplication of scientific and programming effort.* **Finding POC6:** *Although NextGen represents a potentially transformative activity for NCEP, little evidence exists that EMC recognizes the importance of NextGen and is planning effectively for it. The meteorological services required to support higher density, trajectory-based operations and integrative decision support frameworks in NextGen could radically transform how NCEP in general and EMC in particular do business. The review team saw little evidence of a thoughtful strategic plan, developed in close coordination with FAA and other relevant organizations, regarding NextGen.*			
Assessment Recommendation	**Planned Action**	**Status**	**Due Date**

Recommendation POC1: The NCEP and EMC leadership need to create a new personality for the organization both internally and externally. Although a variety of technical or mechanistic solutions will be effective for addressing some of the recommendations made herein (e.g., implementation of a formal visiting scientist program, and more structured procedures for code changes), NCEP and EMC leadership must recognize that such changes alone will not solve some of the most important problems faced by EMC – problems relating to community perception regarding EMC values, EMC's willingness to consider alternative views and new ideas, and EMC's openness to collaboration. These factors are not mechanistic but rather reflect the personality of the organization, and the manner in which they are conveyed to the community rests with the EMC director. The director sets the tone for the organization, and as noted in Finding POC1, the present director does an exceptional job dealing with technical issues. However, an organization rises and falls based upon other dimensions of leadership as well, as noted above, and considerable attention needs to be given to them if EMC hopes to achieve both its technical vision and its role as international leader.	**POC1.1:** EMC management improve manner in which EMC's mission, work plans and values are communicated internally and externally **Cross References:** **CP1.1**: Increase collaborations on key scientific development.	**POC1.1:** (1) EMC management and staff will listen to all ideas with respect (2) EMC management and staff to communicate development plans to all interested parties (3) EMC management and staff will provide insight into decision making process (i.e., increase transparency) (4) Team Building training for all GS14-15 was held 4-5 May 2011 (5) Several EMC management team members participated in a 360 feedback exercise	**POC1.1:** Continuous
Recommendation POC2: The EMC must develop and implement a more formal process for defining core mission goals and setting priorities for those efforts required to achieve preeminence. The strategic planning necessary to streamline EMC activities and ensure success will be demanding, difficult work. It also must be collaborative and will require considerable dedication by the best minds in the organization. Some of EMC's goals and priorities will be dependent upon resources such as computer capability and staff talent and availability. EMC cannot continue to accept new tasks without new resources, expecting overloaded staff members to adapt to even more overload. The priorities developed must provide the resolve and motivation to say 'No!' to tasks that do not represent core mission goals, are not included in priorities, and are not supported with resources. Other core goals must be more cultural and long-lasting, including a dramatic	**Cross References:** **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidelines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the operational modeling systems. **IS4.1:** Plan EMC Scientific Project Office (ESPO) **IS4.2:** Institution of project management practices.		

revision in the posture of the organization toward change, toward community modeling initiatives, and toward acceptance of good ideas regardless of their source.			
Recommendation POC3: The EMC must be bold, must take a long view, must focus on goals instead of tasks, and must put tomorrow ahead of today. Scientific understanding, computing and communications technology, observational capabilities, and demands for reliable environmental information are increasing at an accelerating pace. If EMC, NCEP, NWS and NOAA are to be relevant tomorrow, they all must start thinking very seriously *today* about tomorrow. They must start thinking about demands and opportunity brought by acceleration of change. EMC needs to encourage bold, blue-sky thinking, it needs to stimulate ideas never before considered, and it must foster those outrageous ideas that reveal the key features of the future yet to come.	**Cross References:** **IS4.1:** Plan EMC Scientific Project Office (ESPO) **PS1.1:** Participate in NOAA modeling strategic planning and budgetary processes. **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidelines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the operational modeling systems.	**POC3.1:** ESPO part of IS4	**POC3.1:** July 2010
Recommendation POC4: The EMC must seek enlightened and challenging external advice from leaders in the field and from an EMC component of an NCEP external advisory board created under the aegis of the NOAA Scientific Advisory Board. The essential task of the external advisers and the external advisory board will be to drive EMC to embrace and implement Recommendation POC2. Then EMC can look forward to the years ahead with verve and vigor; then it can march toward its vision with both courage and confidence.	**Cross Reference:** **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidelines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the operational modeling systems.		
Recommendation POC5: All levels of NOAA must focus on ensuring that EMC has a sufficient number of sufficiently capable staff members to accomplish its core mission goals. Establishing adequate and flexible mechanisms for motivating, rewarding, and promoting talented scientists is essential to making EMC an attractive career choice. Success in developing and operating numerical models that give NCEP global preeminence requires financial, physical, computational, and human resources. Of these, human resources must be considered first and must be given highest priority. Computers cannot (yet) convert scientific principles into algorithms and convert	**POC5.1:** Create a staffing plan, differentiating between EMC Branches and Science Teams required to obtain adequate staffing level to support mission **POC5.2:** Brief EMC staffing plan to NCEP and NWS management **POC5.3:** Take a more proactive role in awarding EMC personnel when opportunities arise.	**POC5.1:** Staffing plan submitted to NCEP Leadership in Q4 FY10. **POC5.2:** Provided to NCEP OD **POC5.3:** Submitted numerous NOAA Employee of the Month, Dept of Commerce Gold, Silver and Bronze medal nominations in 2010. GFS 2010 upgrade awarded a gold medal. FY12 submissions were: CFSv2 (Gold); NAM (gold); HYCOM (Gold). NWSHQ Responses to nominations--NAM nomination was rejected, CFSv2 reduced to a silver nomination, and HYCOM accepted as Gold.	**POC5.1:** No action by NOAA leadership. EMC submitted base budget review and identified gaps in staffing require to sustain O&M and transition projects. **POC5.2:** 15 June 2010 **POC5.3:** Ongoing. Rational for NAM gold nomination rejection not known.

algorithms into computer code. Working at the very heart of the U.S. weather prediction enterprise should be attractive and rewarding for many atmospheric scientists. It could be made more attractive than it is now with more flexible and more enlightened approaches to career opportunity and advancement that strike an appropriate balance among scientific management, creativity, knowledge production, and service. As an important step to improving the work environment, NCEP and EMC should create a formal orientation and mentoring program for new employees and visitors that stresses the goals, procedures, and rewards of the enterprise.			
Recommendation POC6: NOAA must act to reduce the EMC dependence on, and commitment, to outside funds and projects. The first step is to increase the funding for civil service scientists who will contribute to the main mission. The second step should be to examine carefully whether the work supported by outside funds should be done by contract employees within EMC or whether it might be done by contract employees or private firms engaged by the agencies now transferring funds to EMC. The ratio of external to internal funds in EMC should be much smaller than it is now to ensure an adequate focus on being 'the world's best and most trusted provider' of numerical weather forecasts in the service of the nation.	**POC6.1:** Action required by NOAA Leadership to change programmatic funding model **Cross references:** **POC5.1:** Create a staffing plan, differentiating between EMC Branches and Science Teams required to obtain adequate staffing level to support mission	**POC6.1:** Funding for core mission remains unchanged. Development areas at risk include land surface modeling and climate due to uncertainty within NOAA Climate Program Office and the evolving Climate Service. Cuts in NOAA funding is pending in FY12—reanalysis, ocean DA, AQ, HFIP and HPCC at risk.	POC6.1: Ongoing issue
Recommendation POC7: NOAA, NWS and NCEP leaders must significantly increase their role in planning for NextGen, especially with regard to EMC. This includes but is not limited to issues related to product and service planning, provision of necessary resources, development of effective communication strategies, and adequate frameworks for testing and evaluation.	**POC7.1:** Work with NWS HQ to define requirements and define funding **POC7.2:** Develop meta data for use in Real-Time Mesoscale Analysis, funded by NEXTGEN **POC7.3:** Institute quarterly upgrades to NOMADS data sets and consider software upgrades to "harden" system	**POC7.1:** Off-site strategic planning meeting was held in October 2010 with NCEP Directors to map NCEP Strategic Plan to NWS Strategic Plan and NEXGEN. **POC7.2:** hire contractor to perform work **POC7.3:** Quarterly upgrades scheduled by NCO and EMC assists in setting requirements and preparing data sets	**POC7.1:** Completed October 2010, however, this activity is ongoing **POC7.2:** Completed August 2010. NEXTGEN funding zeroed out in FY12. **POC7.3:** Completed March 2010
Recommendation POC8: The NCEP Director should work with the Directors of EMC and NCO to address some of the cultural and other challenges responsible for creating stress between the two organizations.	**POC8.1:** NCO and EMC Directors set up regular meetings **POC8.2:** NCO and EMC create collaborative summary of the stresses and how they will be addressed	**POC8.1:** Weekly meetings have begun and are ongoing **POC8.2:** Create summary of NCO and EMC views and present to NCEP, NCO & EMC management	**POC8.1:** Complete March 2010; meetings ongoing and have shown to be extremely valuable in resolving short and long term issues. **POC8.2:** Completed April 2010

	POC8.3: NCO and EMC will define projects to address improvements to the NCEP Production Suite Implementation Process (IP)	**POC8.3:** The IP improvement project is being tracked at the NCEP Director level and being refined at the working level through a series of incremental projects. Thus far two projects have been completed (attempting to prototype improvements to job scheduling changes and instituting a strict version numbering protocol). (2) Weekly implementation meetings occur on Mondays at 10:30	**POC8.3:** Completed and activities ongoing

***Evaluation of POC1*:** We are gratified to see EMC leadership become more open to collaboration and improve internal transparency.

EMC Response to POC1: Lapenta still Acting Director. He has had three Acting Deputies in a 9 month period and needs a fourth in November. The extended uncertainty in leadership is being mitigated to the best of his ability. Lapenta has been Acting Director for the past 36 months. Expect EMC director vacancy to be advertised in March 2014 time frame. Ask UCACN to aggressively advertise and bring to the attention of potential candidates. Next EMC Director will have unique opportunity to select 4 GS15 positions—global chief, climate lead, deputy and technical modeler.

***Evaluation of POC2*:** These earlier responses are certainly relevant here, and have been commented on. It is perhaps the role of the NCEP OD to develop an institution-wide policy that will bring structure and discipline to the process of deciding what NCEP can and can not do.

EMC Response to POC2: EMC needs a strategic plan for the development of the operational production suite. However, it can't be developed in isolation and must represent a larger NOAA wide effort. EMC working with NOAA Environmental Modeling Program (EMP) planning process. The EMP has planning and programming responsibility but no execution authority.

***Evaluation of POC3*:** The panel agrees with this response. Obviously this needs to be a team effort up the chain.

EMC Response to POC3: Same as response to POC2

***Evaluation of POC4*:** Same as before. Role of new UCACN will be much broader than above.

EMC Response to POC4: Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidelines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary is it is responsible for the majority of the operational modeling systems.

***Evaluation of POC5*:** We support the response. We realize that OPM is not a paragon of flexibility, which often makes government employment unattractive. However, we encourage as much flexibility and creativity as is legal to hire, motivate and retain key employees. Strongly agree with nominating employees for awards.

EMC Response to POC5: EMC is working to expand recruiting network and aggressive workforce succession planning. See new ST3.2: EMC recruiting campaign. EMC Acting Dir visited University of Utah in Feb 2013—seminar and round table discussion with staff and students. EMC acting Dir visited Ohio Univ and speak at local AMS meeting on own time due to NWS budget cuts.

***Evaluation of POC6*:** Response adequate; problem needs NWS and NOAA attention.

EMC Response to POC6: No change since UCAR Review was held in July 2009.

***Evaluation of POC7*:** Response difficult to assess since don't know result of strategic planning meeting. Obtaining support for NEXGEN responsibilities will be important.

EMC Response to POC7: EMC participates in planning activities as much as possible.

***Evaluation of POC8*:** We view these actions as very good first steps, and hope they are having the desired result.

EMC Response to POC8: EMC/NCO relationship on a much more professional level—both at the management and worker levels. The best way for the review committee to determine progress would be independent verification by asking staff.

Business Processes: Findings

Finding BP1: *Linking science teams with branches in a matrix configuration responds to previous review recommendations .At the same time, most crosscutting projects appear to be externally (i.e., soft) funded, which may reduce their likelihood of completion. Some employees interviewed during the site visit recognized the pros (exposure to multiple projects) and cons (too little, too much, or conflicting direction) to matrix management. Some of the most productive staff members are diverted from core priorities by these efforts.*

Finding BP2: *The EMC planning lacks focus and prioritization. It is unclear how the next generation production suite will be developed. Although NPSR is the primary requirements process and is viewed favorably by NWS, EMC's role in its specification is vague, as is how NPSR integrates into NOAA's planning processes. Some concern was expressed during the site 27*
visit regarding EMC's isolation from prioritization of research in NOAA, and staff expressed a lack of clarity regarding the "right" level of research for EMC, vice development. In part because of the lack of focus and effective planning processes, EMC has accepted too many projects, diluting the talent required to complete core achievements that will lead to preeminence. Moreover, senior staff workload cannot be sustained. Some staff members have consistently long workweeks exceeding 55 hours, in addition to substantial travel commitments.

Finding BP3: *The EMC has serious stresses with NCO. It appears that lines demarcating the roles and responsibilities of EMC and NCO have blurred, with the perception that these two organizations compete for "turf", particularly in processes associated with approving and implementing production suite changes. Friction arises frequently because EMC and NCO do not share the same concerns or culture. Transition to the P6-based computing system, for example, 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 due to the HEC transition lasted far too long, and the HEC system managed by NCO lacks balance due to a shortage of disk space, further reducing the pace of EMC's research. Further, management of IT infrastructure is rather confused, and lines demarcating the roles and responsibilities of EMC and NCO have blurred also. NCO handles many or even most approvals for items such as system accounts, email addresses, etc., and NCO appears very slow in responding, often taking 6+ months to provide approvals. This seriously impacts the value offered by visitors. NCO also has control over the approval of software and hardware usage on the network, which often places detrimental restrictions on staff. Although EMC has an Information Technology Help Desk, its staff members admittedly are not at all qualified to perform their IT security duties. All of these circumstances are complicated by the fluid nature of NOAA security policy.*

Finding BP4: *The EMC R2O is hampered by inadequate support for test beds and less than effective utilization. Test beds are one of the key avenues through which innovation enters the production suite. However, EMC does not always manage the test beds. For example, CPC runs the Climate Test Bed and uses it to improve CPC products, not EMC climate models.*

Finding BP5: *Federal laws, rules, and regulations impose numerous obstacles to recruiting, retaining, and promoting EMC employees, contractors, and visitors. The number of CS employees at EMC essentially is fixed and at capacity, despite a strong desire expressed by contractors and visitors to achieve a CS position, as well as funding now available to convert at least some of them. This leads to considerable difficulty in succession planning. Although some progress has been made in the CS/non-CS (or soft funded) staff ratio, the problem still remains and the current practice is unsustainable. During on-site interviews, some contractors expressed a sense of distance from decision-making – that they are treated the same as CS employees, but with little value attached to their input. Most NOAA staff awards can go to CS employees only. Although CS pay is relatively low compared to industry and academia, flexibility promotes an acceptable work-life balance. Because physical access to and account authorization on NCEP's National Critical Systems is strictly limited due to export restrictions, contractors, especially those without US citizenship, 28*
face a lengthy and difficult process, beyond EMC's control, to gain access to the computing resources they need. Travel requests must be made abnormally early, thus limiting the ability of staff members to participate in useful activities that have relatively short announcement lead times.

Finding BP6: *Unattractive and unsafe facilities impede recruitment and retention. The current EMC facilities are embarrassingly inadequate, both in terms of working office space and space for conferences and meetings. This is a long-standing problem that is exacerbated by the delay in moving to the new National Center for Weather and Climate Prediction at the University of Maryland.*

Assessment Recommendation	Planned Action	Status	Due Date

Recommendation BP1: The EMC should focus on core mission goals, including products and services, to prevent overextension, dilution and unnecessary activity. The EMC should assess its core competencies vis-à-vis its mission, and focus its human and computing resources on maximizing the use of those competencies toward meeting mission goals. The EMC also should integrate NOAA, NWS, and NCEP business processes, particularly PPBES planning activities, to streamline planning efforts and more effectively leverage the experience of EMC personnel. NCEP and/or EMC should have the ability to say "No!" to unfunded mandates and to the continuance of existing activities if they are not justified and core to the EMC mission. The complete lack of formal project management exacerbates many of the issues mentioned here. Implementing 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.	**BP1.1:** organize FY12 AOP around mission goals **Cross References:** **IS4.1:** Plan EMC Scientific Project Office (ESPO) **CP1.1**: Increase collaborations on key scientific development. **CP1.2:** Meet periodically with other NCEP Center Directors to discuss how EMC can improve their products **PS1.1:** Participate in NOAA Modeling strategic planning and budgetary processes. **PS1.2:** Establish a Scientific Advisory Committee to provide scientific assessment of operational modeling systems and future plans within FICA guidelines. Organizations that have operational systems running at NCEP will be subject to review (EMC, GSD, ARL, SWPC, PMEL, NOS). EMC will be primary beneficiary as it is responsible for the majority of the operational modeling systems. **IS1.1**: Participate in NCEP HPC Resources Allocation Committee (HPCRAC) **IS1.2:** Convey EMC systems development plans to NCO and compare with available resources **IS1.3:** Plan resources allocation for NOAA R&D computer at Site A (ORNL) and Site B (West VA). **IS1.4:** Support NOAA Weather and Climate Operational Supercomputer Systems (WCOSS) acquisition plan development and execution	**BP1.1:** FY12 AOP accepted by OD.	**BP1.1:** September 2011
Recommendation BP2: The EMC must be provided with adequate computational resources for both operations and research, along with a set of governance rules for these resources. EMC must request sufficient resources for substantially enhanced HEC capability, at the very least through the NOAA PPBES process, and leverage opportunities for using external computing resources whenever practical. The computing needed to support the broad range of EMC activities – from research and development 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 research computing	**Cross References:** **IS1.1**: Participate in NCEP HPC Resources Allocation Committee (HPCRAC) **IS1.2:** Convey EMC systems development plans to NCO and compare with available resources **IS1.3:** Plan resources allocation for NOAA R&D computer at Site A (ORNL) and Site B (West VA). **IS1.4:** Support NOAA Weather and Climate Operational Supercomputer Systems (WCOSS) acquisition plan development and execution. **IS3.1:** Port model system benchmark to ORNL Cray		

decisions with the appropriate experts at EMC and NCO, but with shared goals in mind. Procurement of new systems must accommodate requirements across the NCEP family of centers. Often, considerable functional testing and impact analysis of model changes can be accomplished with the use of external resources. Such a strategy should be pursued to allow more focused use of limited NCEP resources.	**IS3.2:** Begin using ORNL Cray system **IS3.3:** Use NOAA R&D Site A computer for global modeling (S/I and ensemble emphasis) **IS3.4:** Conduct development of hybrid ensemble variational data assimilation system on HFIP computer resource in Boulder in concert with ESRL and University of Oklahoma investigators **IS3.5:** CFSv2 code provided to COLA in Q3FY11. **IS3.6:** Porting GDAS/GFS to NASA JCSDA		
Recommendation BP3: The EMC must be provided with adequate base funding consistent with its mission and vision, and adequate personnel and mechanisms for promoting, rewarding and motivating them. The ratio of CSto non-CS employees, which has long been an issue, needs to be addressed. Adequate base funding, with allowances for labor cost-of-living adjustments, will permit EMC to attack the key prediction problems that are keeping it from preeminence (e.g., drop-outs). Additional CS positions must be obtained so that qualified visitors and contractors can move into them and thereby provide EMC with capable future leadership. It is not practicable for EMC to continue with such a small ratio of CS to non-CS or soft money employees. When feasible, EMC should remove distinctions among CS, contract, and visiting staff to promote a single team approach to meeting EMC's mission. Streamlining processes for travel authorization and computer accounts also is essential.	BP3.1: see POC5 for Staffing plan	BP3.1: see POC5 for Staffing plan	BP3.1: see POC5 for Staffing plan
Recommendation BP4: Expeditious completion of the new building and NCEP's move to it are vital to the future of EMC. The NOAA, NWS and NCEP leadership should work collaboratively to ensure this move is completed in the most expeditious manner possible.	BP4.1: no EMC action required	BP4.1: no EMC action required	BP4.1: no EMC action required
Recommendation BP5: The NCEP Director should work with the Directors of EMC and NCO to address some of the cultural and other challenges responsible for creating stress between the two organizations.	See POC8 above	See POC8 above	See POC8 above

***Evaluation of BP1*:** Haven't seen 2010 AOP, so not sure if EMC was able to make any headway on right-sizing their mission. Other cross-referenced activities should all help. This obviously is an ongoing annual concern.

EMC Response to BP1: See cross references in table. FY12 AOP is reduced in scope to reflect risks associated with transition to new operational machine and near full capacity of current P6 system.

***Evaluation of BP2*:** As before, these responses are all appropriate. A larger effort is needed on making the business case for more computer resources.

EMC Response to BP2: Replicate response to IS1: Building the business case for NOAA operational compute capability is beyond the scope of EMC. We don't have the skill sets required to do the work and I'll argue that the business case must be developed at higher level in the agency. NOAA must build advocacy among the users of the operational products as stated in your evaluation of IS1.

***Evaluation of BP3*:** Response in POC5 good for hiring, motivating, retaining top employees. There are several other aspects to BP3 not addressed (teambuilding among all employees; streamlining, etc.)

EMC Response to BP3: EMC management aggressively promoting training. EMC Acting Director added training requirement to all management team staff in FY11. He conducted a professionally facilitated team building off-site training for all GS14-15's (26 people) in May 2011. He increased training budget from $8K to $50K. Proposed FY12 group training will be focused on conflict management (may be at risk due to budget cuts) . EMC management is empowering staff by assigning small team projects. Response has been very positive and staff receiving internal and public recognition for stepping up. Training budget eliminated in FY12 and FY13 due to budget cuts.

***Evaluation of BP4*:** Recent news on the NCWCP is good. We hope it facilitates progress on other topics mentioned in the review.

EMC Response to BP4: EMC expects move to be complete in late FY12. However, the building space requirements were developed in the 2007-2008 time period. Growth between 2009-2011 will result in limited seating for visiting scientists. Current telework policy may need to be extended to NCWCP era making room for more visiting scientists. Seating limitation for new visiting scientists may be mitigated by lack of funding for visiting scientists. EMC management hopes this is not the case. FY12 budget cuts have resulted in the loss of 15 contractor/visiting scientist staff opening up seating in NCWPC. EMC successful in acquisition of project funds from NESDIS to support 2 visiting scientists. COLA also contributing a visiting scientist in land surface modeling.

***Evaluation of BP5*:** Same as for POC8.

EMC Response to BP5: EMC management responsive to meeting with other center leadership.

Comment: We note that the EMC review did not make any specific recommendations related to work being done in the Marine Modeling and Analysis Branch. However, both the OPC and TPC/NHC review reports had a significant number of recommendations that are relevant to this branch, primarily in the modernization of its ocean, coastal and surge (inundation) modeling suite. We encourage EMC leadership to also consider these recommendations as it moves forward.

Final Comment: While many of our evaluations to the responses pointed out missing or not yet completed aspects, we want to emphasis that we are very pleased overall with the proactive and positive response to the review recommendations, many of which are not easily addressed. We encourage these efforts to continue, even in this bleak funding environment, so as to be well prepared for specific opportunities.

EMC Final Comment—The comments provided by the co-chairs are much appreciated. Many of the recommendations require a change in culture within the center and this has been the top priority of the Acting Director in the past 36 months. The next major challenge for EMC and NOAA is the development of a strategic plan for NOAA operational modeling. EMC alone can not implement change without the support of the other NOAA line offices where modeling expertise resides. Doing so will require NOAA leadership to put trust in the modeling labs and centers to work towards such a plan.

Annual Report of the
UCAR Community Advisory Committee for NCEP
December 19, 2011

Managed by the
University Corporation for Atmospheric Research

UCACN
Frederick Carr, co-chair
James Kinter, co-chair
Lance Bosart
Gilbert Brunet
John Dutton
Maura Hagan
Bill Kuo
Gary Lackmann
Ronald McPherson
Leonard Pietrafesa
Warren Qualley
Steven Smith
Eric Wood

Environmental Modeling Center

5.1 Introduction

Bill Lapenta, EMC Director (acting), provided the initial briefing. Also present for this and the ensuing breakout discussions were Louis Uccellini from NCEP, and Fred Carr, John Dutton, Jim Kinter, Ron McPherson and Len Pietrafesa from UCACN.

5.2 Overarching Issues/Recommendations

Overall, the committee is pleased with the progress EMC has made since the 2009 Community review. The committee is particularly pleased to note that EMC has significantly improved the coordination and cooperation with NCEP Central Operations (NCO), and has developed a new and more efficient implementation process in collaboration with NCO. The working relationship between EMC and NCO is much improved. EMC has also made significant progress in the development of the next-generation data assimilation system, in collaboration with external developers. It is noteworthy that EMC is improving the transparency of its decision making process and its outreach to the modeling community.

The review committee encourages EMC to focus on a few key areas over the next 12 months:

a. EMC and NCO must collaborate to prepare a plan to move to a unified model and code base. The current process maintained by EMC and NCO is not sustainable in the future and steps need to be taken now to ensure that NCEP is a world leader in numerical modeling and prediction. [Same recommendation to NCO.]

EMC Response 5.2a: Development of a unified modeling strategy that can meet the operational requirements of the NOAA production suite will require the time and attention of the entire NOAA modeling enterprise through the NOAA Environmental Modeling Program lead by John Cortinas.

b. EMC should continue to improve transparency in its decision-making about future modeling systems and its outreach to the modeling community.

EMC Response 5.2b: We continue to communicate modeling progress and plans through professional meetings and workshops (CFSv2, NMME, NAEFS, AMS NWP/WAF, DTC WRF, WMO, etc.).

c. EMC should establish a Science Advisory Board, possibly as a sub-committee of the UCACN, to provide advice on strategic planning, development, and implementation of modeling systems for the next decade.

EMC Response 5.2c: The EMC management team supports the establishment of a EMC Scientific Advisory Committee (SAC). The purpose of the SAC is to: 1) Provide an independent assessment of the quality and relevance of the EMC scientific development and associated strategy which underpins NOAA's operational weather, climate and oceanographic services; and 2) Foster productive links with the global meteorological and climate community. The composition of the SAC will contain the following attributes: 1) Subject matter experts in model development and operational applications; 2) Experts from national and international major modeling development centers and academia; and 3) approximately 12 members appointed by NOAA/NWS leadership.

5.3 Comments on the Response to the 2009 Review

EMC has completed 8 out of 29 recommendations and has made significant progress on all other recommendations in responding to the 2009 review. The committee is pleased overall with the proactive and positive response to the review recommendations, many of which are not easy to address because they require a change in culture within EMC. The committee applauds EMC management's effort in encouraging the staff to be open and collaborative. Feedback from the community indicates that this transformation is working and has already produced positive results. 22

The opening up of the CFSv3 development process is considered a refreshing and welcoming change by the research community.
The outstanding items from the last review and the new challenges that have arisen since then that need to be addressed include:

a. Strategic plan for modeling. The committee urges EMC to continue the development of an executable strategic plan for modeling for the next decade, in coordination with NCO and EMC partners in the modeling community. The committee encourages EMC to establish a Science Advisory Board, in close coordination with the UCACN.

EMC Response 5.3a: Please see responses 5.2a and 5.2c.

b. Recruiting**.** The committee encourages NCEP to develop an expanded Visiting Scientist Program, especially for EMC and NCO, but also for the benefit of other NCEP Centers. The new building near the University of Maryland campus in Riverdale Park, with its 40 spaces set aside for visitors, affords a rare opportunity particularly for EMC. Emphasis should be given to attract graduate students as well as post-doctoral scientists and senior scientists. The committee urges EMC to work with the OD to develop a plan for an expanded and attractive Visiting Scientist Program.

EMC Response 5.3b: EMC strongly supports the establishment of a visiting scientist program and management has encouraged staff to begin searching/communicating with potential candidates (including post docs). The major obstacle associated with establishment of such a program is funding.

c. Community outreach. The committee recommends that NCEP, and especially EMC and NCO, encourage the use of operational models by research modelers in universities and laboratories. This will require coordination between EMC and NCO, support for visitors, and some cost and investments for community outreach activities (including tutorials, and community user support in partnership with the Development Test Center or DTC). The committee understands that not all ideas arising in the research community will be of equal merit or suitable for incorporation in operations, and is willing to advise on procedures to identify the most meritorious proposals. The committee also encourages NWS to establish a grant program, which would encourage the research community to work on problems that have the potential to lead to improvement of NCEP operational models.

EMC Response 5.3c: EMC continues to interact with the DTC, CTB, HWT and the JCSDA providing in-kind support to promote a community modeling approach. Codes currently available to the community include WRF (NMM and ARW), WWW III, CFSv2, HYCOM, HYSPLIT (ARL), HWRF and GSI. In addition, EMC plans to host a modeling workshop at the NCWCP in the summer of 2013 supported in part by the NOAA Global Interoperability Program where qualified graduate students will be trained on how to run the GFS/NEMS system. The establishment of a program in NOAA focused on the NWP problem has been discussed for the past year without action. The need for such a program was a major finding from the NCEP/DTC Physics Workshop last summer. Past experience indicates that external advocacy for such a program from the academic community is the best pathway for success. The majority of NOAA grants programs are currently focused on climate research.

d. **Use of non-NOAA observing assets.** The committee urges NCEP, especially EMC, to take advantage of non-NOAA observing assets, via the MADIS (Meteorological Assimilation Data Ingest System) expanded archives, to expand and enhance assimilation of data into NCEP's suite of operational numerical forecast models.

EMC Response 5.3d: EMC makes full use of all available observations meeting data assimilation cutoff deadlines independent of delivery system.

5.4 Comments on Aspects of the 2020 Roadmap

Significant advance in the numerical guidance provided by EMC is essential for NWS to achieve the transformations identified in the Weather Ready National Service Plan. To meet future service requirements, EMC needs to expand its predictive capability in fine-scale modeling, Earth system modeling, and ensemble prediction. EMC's 2020 Roadmap in these areas is scientifically sound and reasonable. The committee encourages EMC to continue to consolidate and simplify its operational modeling suites, migrating toward a unified modeling approach. Advances in nonhydrostatic, unstructured grid methods for global models offer new possibilities. The committee also encourages EMC to continue to improve its transparency in decision-making about development and implementation of next generation systems. In particular, it must actively solicit community advice about the development and implementation of future generation modeling and data assimilation systems. EMC should also pay attention to advances in computing technologies, such as graphical processing units (GPU), which may potentially offer significant increases in modeling capability at relatively low cost.

EMC Response 5.4: EMC subject matter experts have participated in the development of all major NOAA and where appropriate interagency strategic planning documents. Please see responses 5.2a - c that specifically address a unified modeling approach, planning transparency, and scientific oversight. EMC and NCO are proactive in participating in exploring the use of advanced computer architectures such as GPU through white paper development in concert with the NOAA OCIO ensuring that the operational perspective is adequately represented in the discussion.

5.5 SWOT/C Analysis

Strengths

- The EMC has a talented staff with significant expertise and knowledge in model development and implementation processes
- EMC leadership is actively committed to in changing the culture of EMC and transforming it into an open and collaborative organization.

Weaknesses

- A reputation within the NCEP community of being insular and obstructive
- Difficulty in attracting new talent from outside the organization
- Lack of transparency in decision making with regards to future generational modeling systems

Opportunities

- Focused collaboration with other US modeling centers in common areas of model development
- Use of community models may provide mechanism for non-NOAA funding to improve operations
- Improved work environment with move to the NCWCP

Threats/Challenges

- Inadequate NOAA operational computing capacity
- Inadequate NOAA support for civil service science positions
- Lack of community inputs on the development of future generation modeling systems in the next decade

Annual Report of the
UCAR Community Advisory Committee for NCEP
31 January 2013

Managed by the
University Corporation for Atmospheric Research

Report on Environmental Modeling Center (EMC)

1. Preface/Introduction

The University Corporation for Atmospheric Research (UCAR) Community Advisory Committee for the National Centers for Environmental Prediction (NCEP) held its annual meeting on 25---26 October 2012 at the National Center for Weather and Climate Prediction (NCWCP), a beautiful new facility operated by the National Oceanic and Atmospheric Administration (NOAA) in Riverdale Park, MD.

The UCACN meeting included separate breakout sessions for each of the NCEP centers, including the Environmental Modeling Center. A summary of the discussion, findings and recommendations from that session is given below.

2. Overarching issues/recommendations

EMC has faced significant budget cuts in recent years. In 2012, EMC lost 15 contractors/visiting scientists, which accounted for approximately 10% of its work force. With the challenging fiscal environment, it is important for EMC to find ways to streamline its operation, and to consolidate components of its production suite (some of which are developed by its partners). We are pleased to see that EMC has phased out the ETA, RSM models over the past few years, and is planning to phase out the NMM-E. This plan will have implications for the HWRF (which is based on NMM-E) as well as the SREF (Short-Range Ensemble Forecast) system. We recommend EMC accelerate the migration of HWRF to another model framework (e.g., NMM-B/NEMS, or other alternatives) to reduce the time table for consolidating modeling systems and to minimize the impact on operational hurricane prediction. It is important to take into consideration the role of regional models in future hurricane prediction in this transition, given the increasing resolution of NCEP global forecast system (GFS) and its superior performance in hurricane track forecasting.

EMC Comment: we are porting HWRF capabilities into the NMMB as a part of a consolidation project.

It is recognized that the requirements for high-resolution numerical products by NCEP forecast centers (e.g., SPC, HPC, AWC and NHC) continue to grow with time. EMC has been doing its best to meet these requirements, given its computational and budget constraints. Forecast centers indicated that the communication between EMC and forecast centers with regards to forecast products requirements and development has been very good in general. On occasion, EMC has done post-processing in some very specific areas without involving the relevant centers. Such communication breakdowns are being addressed, and improving. The key challenge for EMC is the development and

operation of ensemble prediction system at cloud-resolving resolution, which would require a significant increase of computing resources beyond what is currently planned. The planned migration to a North American Rapid Refresh Ensemble (NARRE) system, using both the NMM-B and ARW dynamic cores, is a move in the right direction. However, this transition will not be possible before 2016 due to high-performance computing limitation. We recommend EMC explore ways to accelerate the development and transition to NARRE, and to identify alternative computing resources to achieve this goal.

EMC Comment: We are improving coordination and planning with remote centers. Bi-weekly meeting take place with SPC on high resolution modeling. EMC also involved in WoF project at NSSL.

Inspired by monitoring activities at ECMWF, Met Office and GMAO, EMC has established a Model Evaluation Group (MEG) project, which is designed to focus on product quality on a daily basis with feedback into the model development cycle. The MEG project has been very successful, and has brought significant benefits to the center, including enhancing communications and situation awareness among different modeling teams, providing critical feedback to modelers and managers, and providing streamlined feedback to outside users with model concerns. The MEG project can potentially serve as a point-of-contact for all model concerns outside of EMC. We complement EMC's effort on this project, and strongly encourage EMC to continue this project. Building on this success, we recommend EMC seek community's participation and support for the evaluation of EMC modeling systems. We recommend EMC present results from MEG projects at major NWP workshops (including the WRF workshop) or meetings, and to solicit community participation in the diagnosis of model problems and testing of alternative approaches. EMC should take advantage of its partnership with the Developmental Testbed Center (DTC) to pursue community participation in MEG project. DTC has close collaboration with EMC on several modeling systems, including WRF, NMM-B, HWRF, and GSI. With its strong linkage to the broader community, DTC can serve as a conduit for the EMC.

The recent development and operational implementation of GSI-EnKF Hybrid (through a collaboration between EMC and ESRL) is a resounding success. The improved global analysis from GSI-Hybrid led to improved global forecasts that benefitted all downstream models. This work is a great example of effective collaboration between a research laboratory and an operational center. We strongly encourage EMC to continue close collaboration with NOAA laboratories and the broader research community on the development of next-generation operational modeling and data assimilation systems.

EMC Comment: We continue to work closely with PSD on 4D-EnVAR development and MEG continues to grow in popularity.

3. Comments on Center's continuing response to 2009 Review

Significant progress has been made over the past two years on all issues identified in the 2009 Review. We are particularly pleased to see that the EMC-NCO relationship is amicable and conducive to effective collaboration. We also take note that the implementation process has greatly improved since 2009. EMC and NCO are encouraged to continue the collaboration on instituting an implementation process that is efficient and effective. We also note that significant progress has been made in unifying modeling codes and libraries for EMC and NCO.

One recommendation from the 2009 Review that EMC continues to work on is CP2. In particular, EMC must lead the development of a 10-year strategic plan for NOAA operational modeling. We realize that such effort would require commitment across NOAA and engagement of the national and international modeling center, and is challenging, as EMC must still deliver improved systems in the near term. We recommend EMC to take steps in formulating its vision for a 10-year strategic plan. The first step can be an EMC internal retreat to develop a draft 10-year modeling plan, with sufficient details on the goals, requirements, and approaches for future modeling systems. Once such a draft plan is developed, EMC should seek broader engagement from NOAA laboratories (e.g., GFDL, ESRL). This will allow the EMC's planning effort to be aligned with the broader NOAA Environmental Modeling Planning effort. Once the strategic plan is sufficiently mature, EMC should engage the broader science community for comments and participation.

4. Comments on FY13 Annual Operating Plan

EMC has developed a solid Annual Operating Plan (AOP) for 2013. The key activities include: (1) joint EMC-NCEP center projects, (2) hosting WGNE-GODAE workshop, (3) NCEP climate modeling team (NCMT), (4) Earth System Prediction Capability (ESPC) Demo Projects, (5) Model Evaluation Group (MEG), and (6) Development Cycle for various modeling systems: (a) Real-time Ocean Forecast System, (b) Wave Systems, (c) GDAS/GFS, (d) GEFS, (e) NAEFS, (f) NAM, and (g) HWRF. These activities are important and appropriate for EMC. The proposed efforts are feasible and scientifically worthwhile. As mentioned earlier, we recommend EMC to seek community participation in the MEG project. Engaging the community in the evaluation, diagnosis and testing of operational models will strengthen R2O and bring significant benefits to EMC.

As part of AOP 2013, EMC has proposed to establish a Scientific Steering Committee (SSC), with the purpose of providing an independent assessment of the quality and relevance of EMC scientific development and associated strategy. The proposed SSC can also help foster productive links with the global meteorological and climate community. We support the proposed concept of a SSC and its charge. However, we recommend that the SSC be formed after EMC has developed its draft 10-year strategic modeling plan (as suggested in section 2). SSC can be called upon to provide an assessment of the strategic plan and provide recommendations to EMC and NCEP management. Also, we would like to recommend that the SSC be incorporated as a sub-committee of the UCACN (instead of an independent body) to ensure close coordination between UCACN and SSC.

EMC comment: the inability of NOAA to hire a permanent EMC director has severely hampered this activity. It makes little sense to develop a strategic plan and form a scientific advisory committee with a acting director in place.

5. Comments on Strategic Planning

(a) Unified Modeling: The possible transition to a unified modeling strategy will have a significant positive impact on EMC. NOAA is facing significant budget challenges. In order to continue to provide quality service in a challenging fiscal environment, EMC needs to consolidate components of its production suite, yet continue to provide an operational numerical guidance system that meets NOAA operational requirements. The migration toward a unified modeling system will enhance collaboration and synergies among different modeling teams within EMC, and may result in significant saving in resources.

(b) Visiting Scientist Program: The Visiting Scientist Program (VPS) will have a significant positive impact on EMC. To accelerate the development and improvement of NCEP operational models, it is highly desirable for EMC to engage the broad science community in the testing and evaluation of its modeling systems. We strongly endorse the VSP program. We are pleased that NSF is interested in conducting a pilot program to support university PIs' to collaborate with NCEP as part of their funded proposals.

EMC is interested in establishing an "ECMWF-like" model testing facility (inspired by EMCWF's practice), where a researcher can visit EMC and perform experiments using EMC's modeling systems. This is an interesting concept, and deserves serious consideration. The development and operation of such a facility would require considerable resources and support from EMC and NCEP. We recommend EMC seek partnership with the DTC to explore the feasibility of establishing such a facility.

(c) High-Performance Computing: We are pleased to see that EMC is working closely with NCO to make full use of its high-performance computing resources, this progress was indicated by the raising of the 'high-water mark" in its computer usage. As noted earlier, the current plan for high-performance computing does not provide adequate computing for EMC. As a result, EMC cannot implement NARRE ensemble prediction at cloud-resolving resolution until 2016, which is necessary for EMC to support product developments required by NCEP forecast centers. The lack of computing resources also limits EMC's ability to perform global data assimilation, global forecast, and global ensemble prediction at resolutions competitive with ECMWF. NOAA management needs to continue to find ways to enhance high-performance computing resources for EMC. EMC should also explore other computing technology for its modeling systems.