

## FINAL REPORT

### Office of Research and Applications (ORA)

### National Environmental Satellite, Data, and Information Service (NESDIS)

### National Oceanic and Atmospheric Administration (NOAA)

## External Science Review

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### I. Overview

On September 14-15, 2000, an external team conducted a science review of the Office of Research and Applications (ORA) within the National Environmental Satellite, Data, and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA). The review was convened at the request of the Associate Administrator of NESDIS, Dr. Greg Withee, in response to a NOAA Science Advisory Board (SAB) call for information regarding the quality and use of science in support of NOAA's mission. The SAB provided a suggested framework for science reviews. This framework includes the following eight (8) themes deemed to be important parameters relative to a strategic review of NOAA science projects and programs. These themes are (1) quality, creativity, and credibility, (2) timeliness and scale, (3) science connected to the application and operational implementation of policy, (4) capacity-building, (5) education, (6) efficiency, (7) social science integration, and (8) diversity. The ORA science review and the contents of this report are based on information provided by the ORA in the form of an overview document entitled, *Office of Research and Applications ... in the Year 2000*, and a series of presentations with supporting documentation provided by the management team of the ORA.

This report, recognizing the significant accomplishments within the ORA, will focus and comment on the plans of the ORA for its future and the adequacy of its defined roadmap to accomplish this prescribed future. Also provided in this report is a summary of the (1) goals, objectives and accomplishments of ORA, (2) status of strategic and operational planning initiatives and their implementation within ORA, and (3) existing and future challenges and opportunities for ORA as perceived by the External Science Team (EST). Provided, as an attachment, is a listing of EST members and their affiliations.

### **ORA Mission and Objectives**

Overviews of the mission, goals, objectives, planning and accomplishments of the ORA were provided by the Director of the ORA, Dr. James F. W. Purdom, the Deputy Director, Dr. Marie Colton, and the Chief Scientist, Dr. W. Paul Menzel. These overviews were then expanded upon in detail by each of the three Division Chiefs of the ORA. Provided are highlights of each.

The Office of Research and Applications supports the mission of NOAA and NESDIS by providing observations and information from environmental satellites to describe and predict changes in the Earth's environment, and conserve and manage wisely the Nation's coastal and marine resources to ensure sustainable economic opportunities. The ORA is the science arm of NESDIS and provides leadership, guidance, and direction for NESDIS research, development, and applications activities with respect to satellites and satellite data. Its primary objectives are to:

- Ensure that satellite remote sensing data and information products are of the highest quality possible;
- Enhance the utilization of satellite remote sensing data and information products so that the NOAA missions of environmental assessment, prediction, and stewardship are met both today, and in the future; and

- Conduct basic and applied oceanographic, land surface and atmospheric research on the use of satellite data for monitoring environmental characteristics and their change.

The ORA objectives, as delineated, support the implementation of the strategic vision and plan of NOAA. Activity within the ORA focuses on NOAA's strategic themes of (1) environmental assessment and prediction and (2) environmental stewardship. In the area of **environmental assessment and prediction**, ORA scientists focus on ensuring that current satellite data utilization is maximized as part of NOAA's integrated environmental observation, assessment, and forecast services. These services are directed toward enhancing public safety and the Nation's economic and environmental security. ORA scientists are actively engaged in three areas within that theme: (1a) Advance Short-Term Warning and Forecast Services where science is focused on achieving the goals of the U.S. Weather Research Program and on improving the utilization of satellite data for Numerical Weather Prediction (NWP); (1b) Implement Seasonal to Interannual Climate Forecasts, where atmospheric NWP models are coupled with ocean models to produce seasonal to inter-annual forecasts of weather and ocean variables; and (1c) Predict and Assess Decadal to Centennial Change where considerable energies are devoted to calibration and validation of long-term satellite data sets useful for studying climate trends and natural variability. In the **environmental stewardship** theme, which concentrates on maintaining U.S. ocean and coastal areas with healthy ecosystems and encouraging wise human use and development of ocean, coastal and living marine resources, ORA scientists are active in two of the main focus areas: (2a) Build Sustainable Fisheries; and (2b) Sustain Healthy Coasts.

The **Climate Research and Applications Division (CRAD)** reviewed the satellite products developed for prediction and climate data sets for assessment. There is a laudable and significant effort overall to demonstrate the applications of satellite data. The Division is also quite active in performing and developing satellite calibration procedures and planning for new satellite instruments. The special challenges and opportunities seen by the CRAD include developing improved methodologies for

assimilating satellite data into global atmospheric models. In particular, the rate at which existing volumes of data are utilized by global models of the atmosphere does not keep pace with the generation of these volumes of data (i.e., a smaller fraction of data over time is being effectively utilized by global models of the atmosphere). The problem may grow given that much more data intensive, higher output multispectral/ hyperspectral instruments are being planned or developed for the near and far future.

The CRAD is encouraged and excited about the progress being made to develop a joint NOAA/NASA Center for data assimilation wherein ORA will play a major role. The thinking communicated suggests that the proposed Center should assist in meeting the challenges and goals delineated. The CRAD also recognizes the special challenges associated with the growing climate monitoring and trends assessment thrusts associated with NOAA including the opportunities and challenges associated with the National Polar Orbiting Environmental Satellite Series (NPOESS). Because NPOESS is a multi-agency (NOAA, DOD/Air Force/NASA) organization requiring new collaborations and interactions, organizational challenges are anticipated; however, the benefits to science of these partnerships are far-reaching.

**The Atmospheric Research and Applications Division (ARAD)** described how it focuses on the use of satellite data in support of the strategic goal of NOAA to perform environmental monitoring and prediction. The Division primarily targets applied research and technology transfer in support of this goal. This involves developing new techniques and products, transferring the technology to the user community through effective applications efforts, and from those efforts also assisting in the definition of improved future satellite instrumentation and operations. The priorities and requirements identified, given the existence of the Internet/World Wide Web, included performance of rapid prototyping and evaluation of products and developing new methodologies to perform technology transfer through web-based products. These efforts are directed toward maximum utilization of satellite data and products through better training and education of the User Community. The efforts of the ARAD also strive to

better utilize new data from non-NOAA (e.g., NASA and international satellite programs) satellite data sources.

The **Oceanic Research and Applications Division (ORAD)** described how its personnel seek to effectively develop and apply satellite data for coastal and ocean applications. Major activities include involvement in and support of the Coastwatch program and demonstrating the use of ocean surface winds, topography, sea surface temperature, rainfall, ice cover, ocean biology/chlorophyll estimates, etc. as determined from satellite data. The ORAD seeks to prepare for the future by assessing initiatives that include the NPOESS, an “Ocean Observer” satellite, an U. S. Synthetic Aperture Radar (SAR), and international efforts (e.g., EUMETSAT, ESA, Japan, China, India, etc.) for coastal and ocean monitoring and attendant applications. The ORAD is focused on nurturing the emerging coastal constituency and developing a leadership reputation for such efforts. The organizational goal is to be effective in facilitating the transfer of knowledge from a research status to an operational status of initiatives that include active microwave determination of ocean surface winds, satellite altimetry over oceans, observations of ocean color, synthetic aperture radar (SAR), sea surface temperature and the assimilation of satellite data for use in ocean models.

### **EST Review**

The Review of the ORA by the External Science Team (EST)) found an organization displaying considerable vitality and accomplishment. Overall the efforts within the divisions of the ORA appeared focused on the mission and its objectives and purposes which were aligned and cognizant of the goals and objectives of NESDIS and NOAA. These efforts were organized so as to create a complementary and mutually supportive atmosphere across ORA divisions. The ORA has developed what appears to be regarded by NESDIS and NOAA as a very valuable service to them and the external science community. Currently, formalized approaches are not in place within the ORA to obtain information regarding the

value-added from ORA science to the internal/external community. **Recommendation:** It is recommended that these approaches are defined and implemented.

The future of ORA is likely going to be somewhat different from the past in that convergence of intellectual and operational capital is taking place among producers of satellite data. **Recommendation:** The ORA will need to be much more sensitive to other interested customers and to form partnerships with other research and development laboratories. Clearly, senior management recognizes this imperative with respect to the use of satellite data in NWP, however, strong partnerships must be established with other domains.

The ORA has a vision of collaboration with others but it seemed to the EST that the vision was limited to the Cooperative Institutes that ORA has or will create. Currently, there are three existing cooperative institutes with a fourth proposed. **Recommendation:** It is recommended that a broader outreach is established to engage the inventiveness and energy and resources of other universities and other agencies that have interests similar to ORA. The use of Centers/Cooperative Institutes at various universities (e.g., Wisconsin and Colorado) provides valuable collaborations with academia. These collaborations foster new ideas and heighten the probability and success of educating and motivating scientists who can complement and extend the existing and future base of research and applied scientists within ORA.

The ORA recognizes that continuing to foster close alliances with academic/research/development groups will maximize future development. **Recommendation:** In particular, it is imperative that close relations be maintained between the NWP model development group of the National Center for Environmental Prediction (NCEP) and ORA if the goal of improving the use of satellite data in NWP models is to be realized. In addition, if both organizations were able to collocate with NASA and university associates then their synergy will most probably result in significant payoffs.

The leadership of the ORA by the Director, Dr. James F. W. Purdom, is commendable and deliberate in demonstrating a sense a vision and purpose to the organization. The EST found that quality research was being performed and significant effort aimed towards addressing the needs of a broad customer base. There is anecdotal evidence that the ORA has made continual, substantive efforts in strengthening its overall science output. Much less in evidence were new products designed to enhance the tangible outputs that can result from the use of satellite data. **Recommendation:** The EST wishes to re-emphasize the ORA's unique and important role as a transition laboratory and that it must be more deliberate in its work to maintain a healthy balance between development and transitions. Other NESDIS laboratories have budgetary lines that clearly define the relative effort between development and transitions, the ORA does not. **Recommendation:** The EST believes that it would be wise and prudent for the ORA to develop metrics that would permit management to have a more quantitative view of the relative effort in each of these areas, a view that can be communicated to others. Publications are a good measure of the scientific development activity but there did not seem to be any demonstrable measure of the value-added to other organizations by the transition and operational product activities.

**Recommendation:** It is recommended that ORA routinely survey organizations internal and external to NOAA to determine the value-added to the activities of their organizations by the ORA transition and operational product activities.

While the mission and objectives of the ORA are clearly stated, they are very broad. The reality of finite human, fiscal and operational resources necessitates that the ORA have a plan that aligns its research, development and applications activities with the constraints of the resources available. ORA is in a situation in which approximately 50% of its budget is base and the remainder derives from other internal and external programs. The existing match between base funding from NOAA and expenditure for salaries is an unhealthy situation as it gives managers very little flexibility, particularly in initiating new projects. Clearly this is a situation that is ripe for mission drift. The Director was adamant in his position that he controls mission drift and that this was not an issue. However, in discussions with some members

of the staff, work was being performed for non-NOAA agencies that did not connect at all with the NOAA strategic directions. **Recommendation:** The ORA must distinguish between work that is relevant and work that is a priority. Given that part of ORA's mission is the validation of satellite products, it is unfortunate that ORA scientists must seek external funding for instrumentation and to support field programs. Does NOAA/NESDIS/ORA consider the inherent, if not the immediately apparent costs of obtaining external funds? The constraints of inadequate base funds warrant vigilance by the ORA to avoid mission drift and to prioritize its objectives.

The description of the process of prioritization of product development by the ORA was sketchy and there seemed to be confusion as to who had control of the decision making in this regard. In addition, there were instances where product requests had been on "lists" for several years with no apparent action. **Recommendation:** The EST is of the view that a stronger effort needs to be made to ensure that product development is connected with the prime customers (who we expect to be within NOAA and in particular the NWS). It would have been useful to the EST if there were some evidence presented of customer input and customer satisfaction. **Recommendation:** To this end, a strategic plan for the ORA is needed which incorporates customer input. This plan will not only serve as an important element in the ORA roadmap to the future, it will further serve to integrate the vision, mission and objectives of the ORA with other divisions within NESDIS and NOAA. This integration is needed to maximize the contributions of the ORA to the broader community of internal and external stakeholders. An ORA operational planning process (OPTORA) has been initiated which has the promise of providing the guidance needed by the ORA to prioritize work and to ensure that this work is used by other areas within NESDIS and NOAA to make informed decisions regarding operational and data needs. **Recommendation:** The EST applauds this effort and recommends that it is aligned with the ORA and NESDIS budgets and that it is used to prioritize work internal and external to the ORA.

The EST, in evaluating the presentations, recognizes that the ORA has a special set of challenges associated with the new instruments being planned for the future and the attendant complexity and volume of these observations. The data will be complex albeit the clear advantage and utility of the data are assured, therefore, the challenges of developing the applications and performing the technology transfer to the NOAA, other agencies, and the science community are very real and large. In particular, the challenges inherent in the acquisition and exploitation of new information technologies (computers, data storage, communications and networks, the use of the internet, etc.) and the staging of transitions from old to new technology are large. It was clear that the entire staff of the ORA recognized these challenges and was planning to use collaborations and partnerships to move in these directions. The pathway to allocating or obtaining the resources to do this, however, remains worrisome and a bit "murky". **Suggestion:** Given the very necessity and worthiness of performing these tasks and adequately obtaining the necessary resources and recruiting, retaining, and rewarding the requisite personnel, the EST suggests that NESDIS and NOAA management should be cognizant of this need and support the ORA insofar as possible.

The ORA and the ORAD are correctly planning and vectoring their efforts to include more emphasis on oceanography. Given the important role of the oceans in weather and climate this is a necessary and laudable direction for the future and the EST supports that. However, again the specifics of how that will be developed were not displayed in detail and, perhaps, it is premature or not possible. Nevertheless, the EST supports the ORA in doing this and suggests that NESDIS and NOAA subsequently encourage and support this as appropriate and possible. The approach of ORAD in attempting to identify the needs of the "customer base" as guidance to selecting tasks within the NOAA guidelines is appropriate.

The ORA suggests or even explicitly indicates that one of the keys to their future effectiveness is the use of the Cooperative Institutes. **Suggestion:** The EST also sees this as an effective strategy and supports

the addition of more oceanographic efforts in these Institutes and even the addition of a new institute in the future at an appropriate university as proposed by ORAD during this review.

To accomplish the objectives described above would suggest strongly that the budget for the ORA needs to be increased. The EST would support such an augmentation given the importance and logic of the directions noted above. However, in the face of budget constraints throughout NOAA, and even the entire federal government, at minimal, sustaining the existing budget is mandatory. Given the possibility of flat or declining budgets, and even in the case of an increased budget, the importance of partnering, working and collaboration with other agencies (e.g., NASA, DOE, etc.) cannot be overemphasized.

The recruitment of personnel through Cooperative Institutes and other vehicles is also very important to obtain the scientific talent needed to cope with and exploit the new data sources coming in the near future, and assimilating these data into coupled numerical models of the atmosphere, ocean and land processes. **Recommendations:** The ORA, NESDIS, and NOAA should look to new approaches to attract, educate, retain, and reward personnel that have the talents and potential needed. Special emphasis within that broad objective should be placed on identifying, encouraging, and recruiting underrepresented minorities. The programs and needs of the ORA should be described and directed toward universities with sizable minority populations. Programs should exist within the ORA to educate, encourage and promote minorities and women into management. The statistics provided to the EST by the ORA management on the status of women and minorities within the organization were not representative of an organization that encourages diversity. These statistics should be reviewed by NESDIS which in turn should formulate a plan to address the situation. The importance and attractiveness of the NOAA mission and the attendant contributions that a properly trained individual can provide for the benefit of mankind should be emphasized within this plan.

The ORA has clearly adopted internet-based communications, which can, and do, lead to greater efficiencies both in the delivery and assimilation of data. However, there is the risk that focusing on the immediacy of web-based demands will compromise the longer-term organizational vision.

**Recommendation:** It is important that management foster a view to distant research horizons and not allow pre-occupation with instant results for the web pages to dominate the agenda.

The management of ORA recognizes the need to increase the visibility of its research as a strategy to achieve increases in funding from NESDIS and NOAA. **Recommendation:** The EST applauds the recognition given to ORA researchers for their outstanding achievements. The EST believes that the ORA should continue to promote and encourage individuals and groups to seek NOAA-wide and other special awards in recognition of their outstanding achievements. This is a sound approach to increasing NESDIS/ORA visibility to the internal and external community.

### **III. Special Challenges and Priorities**

There are some special challenges that the EST would like to highlight in this section. **Suggestion:** One includes the ORA working with the management of NOAA, other elements of NOAA (e.g. the National Weather Service), and NASA to give more emphasis to the development of improved systems and observations from geostationary orbit. Collaboration with and encouragement of NASA to participate in such efforts is encouraged.

The wide range of scientific activities described throughout the review suggests that each division is spread thinly, i.e., too much breadth without adequate depth. This means that the continuity of research efforts is dependent upon staff turnover. **Recommendation:** It is recommended that the ORA determine an optimal breadth of research as part of its strategic planning process.

The growing climate emphasis in NOAA, which the EST supports strongly, indicates that the ORA should also plan and encourage stronger and deeper efforts in calibration and validation of satellite data for climate purposes. As new sensors become operational their attendant data require careful characterization of the sensor performance including the calibration of the instruments and attendant error budget analyses relative to requirements, etc. **Recommendation:** This effort not only should involve joint efforts with NASA and the Department of Defense (DOD), but also with academia and the inclusion of graduate students and faculty. These types of efforts are very good for the training of students and the acquisition of an appropriate depth of understanding of how satellite instruments perform and how their measurements can be applied.

The primary mission of NOAA/NESDIS/ORA is one of stewardship of the environment; however, only anecdotal information was provided to the EST throughout the review regarding the societal impact/benefits of the ORA research underway. **Recommendation:** The EST encourages the ORA and its divisions to include in its planning and programs explicit social science objectives and associated research. Social science research is needed to clearly demonstrate the value-added of satellite data and products to the public-at-large. Congressional budgets are increased and decreased because of the strength of such arguments.

The ORA is presently housed in a building that is not compatible with, nor constructed to be efficient or effective for use in a high technology, data intensive, networked environment as required by the strategic vision of the ORA. **Recommendation:** The EST clearly notes this as a major challenge for the effectiveness of the ORA and encourages the ORA, working with the management of the NESDIS and NOAA, to be alert to opportunities to obtain housing facilities that adequately allow the mission, intents, and purposes of the ORA to be sustained as described in previous sections. **Suggestions:** The EST, in particular, believes that adequate facilities are highly important from a strategic planning point-of-view. The need to have highly trained and motivated personnel is aided by a venue that affords the ORA an

opportunity to identify future employees. Positioning such facilities near or on a university campus may represent the more cost-effective mechanism to ensure the availability of the needed workforce of the future. It is true that communications technologies can facilitate more distant connections than in the past, but because of the importance of student involvement and training, it is suggested that the ORA would be significantly more effective in meeting its needs, goals, and priorities if the close associations attendant with being near or on a college campus were captured.

#### **IV. Summary**

The EST has found the ORA to be a vital and productive organization that contributes well and is a valuable source of accomplishments and contributions to the NOAA/NESDIS and the entire Earth science and applications communities. The staff is motivated, productive, and responsive to the mission and goals of NOAA and NESDIS. The endeavors reflect good efforts responding to customer needs and substantial amounts of planning for the future are ongoing. The management is to be praised for fostering an environment where vigorous activity is clearly taking place.

There are challenges and needs for the future including responding to opportunities such as the data-rich, highly multispectral or hyperspectral instruments being developed or planned for the future. These efforts require careful planning and allocation of resources (dollars, personnel, infrastructure, and equipment). The EST sees explicit recognition of these challenges by the ORA personnel, but more definition of the roadmap to that future needs to be developed. The ORA collaborations with academia in the form of existing and planned (e.g., an institute devoted to or increasingly emphasizing oceanography) is key to the future and should be encouraged. The cooperative institutes also provide a venue of training of new personnel that will contribute to the NOAA/NESDIS/ORA missions and goals and the identification, recruitment and promotion of properly trained individuals for the future including underrepresented

minorities and women. The budget of the ORA ideally should be increased given the essential and leveraging role that the ORA provides in the NOAA/NESDIS organization.

Special challenges have been identified by the EST including the advocacy and development of increased observational capabilities from geosynchronous orbit that may involve a better “balance” between the scope of geosynchronous (GEO) activities and development versus low, earth-orbit (LEO) activities in NOAA; the need for a strategy to ensure the existence of a more diverse workforce; and, increased efforts in examining the social science implications of ORA research. The correct and important emphasis on climate monitoring and assessment in NOAA indicates careful attention and allocations of resources should be directed towards the characterization, calibration and error budget analysis relative to requirements and applications. The infrastructure needs of the ORA includes obtaining information technologies and a facility that is compatible with the information technology environment. The EST strongly suggests building facilities that engender strong collaboration with academia by being located on or near a university campus.

The future of the ORA looks bright; the challenges stimulating though formidable. The EST is pleased to have had the opportunity to review the ORA efforts and considers it an opportunity that has benefited all the participants of the EST.