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THE NASA LAND PROCESSES PROGRAM: STATUS AND FUTURE DIRECTIONS

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I. INTRODUCTION

The past decades have seen the development of powerful new observational capabilities for investing the Earth's surface. Beginning with simple cameras in the hands of the Mercury astronauts, NASA spacecraft have provided mankind with a dramatic new perspective from which to view its home. This perspective is both scientific and emotional. I do not think it a coincidence that the rapid increase in environmental awareness of the 1960's coincide that the rapid presentation of increase in environmental awareness of the 1960's coincided with the presentation of images of our finite planet.

This paper, however, deals with that new scientific perspective and how NASA is responding to the opportunities it presents. For most of the past decade, NASA focused its efforts on the immediate exploitation of space-based sensors in Earth-oriented programs which served the needs of commercial and governmental users. As with any new program, it met with mixed results; some activities were successful and others were not. Others succeeded but were not commercially viable. After nearly a decade of applied programs it was time for an assessment. In response to presidential and agency directives, NASA has restructured its Earth-oriented programs to concentrate on the scientific use of its satellites while other agencies and private enterprise have assumed responsibility for programs of interest to them.

NASA's new focus for the land program is on the study of the Earth's surface in the context of the emerging concept of "global habitabiity". We are seeking to understand the complex coupled system of the land surface, the atmosphere and the oceans. The emphasis is on global and continental scales and on the processes which take place at the boundaries (e.g., land-atmosphere interactions). There is a concentration on understanding processes which lead to changes in the "state variables", the basic physical and biological properties of the Earth's surface. From the perspective of mankind these changes may be either beneficial or harmful. Desertification is a prime example of a harmful change while the propsoed diversion of 5 majopr Siberian rivers is aimed at producing beneficial changes. Change begats change, and the impact of increased desert areas on atmospheric circulation and precipitation patterns might actually be beneficial elsewhere on the globe! It is the nature of mankind to be pesimistic about change, and no one to my knowledge has actually suggested that there are possible benefits to desertification. We are more prone to see the potential bad which might result from any change, and there is a growing litiny of environmental disasters which are likely to occur if the Siberian rivers are reversed. The point is, that we simply do not yet have the required scientific understanding to adequately predict or assess the consequences of natural or man-induced changes to our planet.

II. PLANNING ACTIVITIES

In making this change of direction NASA has conducted a series of studies, and the reports of these studies provide some insight into the new direction. The report of the Executive Committee of the 1982 summer study at Woods Hole (Goody, 1982) established the overall philosophy and pointed out the great importance and relative imaturity of the land programs. In the year following that study, a plan for Land Global Habitability was prepared (Witwer, 1983). A basic structure for the land program was developed and many science issues were identified. The program envisioned there greatly exceeds the likely available resources. A multiyear effort which began before the Woods Hole study led to a program plan for global biology (Rambler, 1983). Like the land global habitability report, it develops a good structure and identifies many key science issues but it requires a larger budget than is available. A further study on the role of biogeochemical cycles was conducted which presented a somewhat different philosophy (McElroy, 1983). Finally, the Committee on Earth Sciences of the Space Science Board is nearing completion of its independent study of NASA's Earth oriented programs, and other study efforts are underway, both internal and external to NASA.

Further planning is clearly necessary. During the coming year there will be some additional study efforts. Part of the task is to cull from the previous documents the basis for an affordable and vital program. More importantly, the past three years has seen the development of some new global data sources, an increased understanding of their meaning, and the entrainment of previously Earth-bound terrestrial scientists. New theoretical constructs are emerging, allowing us to propose a more soundly based program. The study efforts will be designed to bring the ideas to the fore.

III. PROGRAM THRUSTS 1985...

The land processes program can be viewed as having three major facets. In keeping with the interdisciplinary emphasis of NASA's program, two of the facets are interfaces to external programs or disciplines. Ultimately, each facet would have an approximately equal share of the funding resources.

The first facet is the interface between the land and the radiative-physical world as exemplified by the climate. Our understanding of climate is now limited by the lack of proper parameterization of land-air interactions. Physical and biological properties of the land surface such as albedo, surface roughness, and above ground biomass control the excahnge of latent and sensible heat and momentum. The global circulation models are now being modified to incorporate these interactions. Observational data are required for basic input parameters, and detailed process studies are needed to properly parameterize the interactions in the models. Characterization of the current state of the Earth's surface, identification of changes and illucidation of the most important change mechanisms are required.

Priorities for this activity are well controlled in terms of the relatively mature climate theories.

The work in this portion of the program will be conducted, in part, under the auspicies of the International Satellite Land Surface Climatology Project (ISLSCP) an activity organized under the auscpicies of COSPAR and IAMAP. Several workshops have been conducted over the past year. Reports from these workshops provide further details (Rasool and Bolle, 1984; Murphy and Nicholson, 1984; Ohring and Sellers, 1984).

The second facet of the program addresses the interface between the land and the biogeochemical world. Here the situation is less well defined in that there is not yet a true global science in place which is ready to incorporate the land processes. This activity will be more in the exploratory stage, with few guidelines to provide an overall sense of priorities. The measurements required of the land observing system may not be possible. The theories to interpret those observations which are possible are not well developed nor are they adequately tied to physical principles. Work should proceed, as should additional planning activities.

The third facet of the program addresses the study of crustal conditions and processes from a geological perspective. One of the principal objectives of geological investigators in recent years has been to evalaute the combined utility of visible, infrared, and microwave techniques for mapping the occurrence and distribution of geological materials on a global basis. Much of the geological research sponsored by NASA in the past has been concerned with studies of arid and semi-arid lands. These projects have provided insight into the ecology of arid environments which has important implications for the other facets of the overall program described above. In addition, the members of the geological community have become increasingly interested in natural associations between vegetation and underlying geological materials. Their studies of mineral-induced stress in vegetation canopies may eventually contribute to long-term studies vegetation condition and vigor in regional systems. In addition to the topics mentioned above, geological investigators are employing space acquired remote sensing data to study processes that mold and shape the Earth's surface on geological time scales. These studies afford us a unique opportunity to expand our thinking regarding the factors that govern the habitability of the Earth.

IV. EXAMPLES OF CURRENT WORK

The current program contains a number of activities which, by example, may provide a better insight to the evolving program than can any list of programmatic studies. One example of a research effort which supports both the interface with the radiative and physical world and the biogeochemical world is that of C. J. Tucker and his colleagues at Goddard Space Flight Center and the University of Maryland and the University of Redding. They are using the low spatial resolution (1-4 km) imagery of the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA operational satellites to map the temporal variation of natural vegetation. Much of the work has concentrated on arid regions (see for example Tucker, 1983), but more recent work has examined a variety of biomes (e.g., Justice et al 1984). These exploratory studies are of relevance to biogeochemical cycling, especially the carbon cycle, and to climate through the periodic variation in surface albedo and evapotranspiration.

Another example is the work of D. Peterson and his colleagues at the Ames Research Center and the Universities of Wisconsin, Montana, and Florida State. They are tackling the difficult problem of measuring forest biomass from remotely sensed data. Using a series of transects over closed canopy forests in the Pacific Northwest they have demonstrated the ability to distinguish biomass classes which are governed by various environmental factors.

The prusuit of the direct science use of remote sensing data requires constant attention to the underpinnings of the measurement science. A program in remote sensing science per se is required. The work of J. Norman of the University of Nebraska typifies that aspect of the program. Norman is working on the 3-D canopy model to accruarely describe the bidirectional reflectance distribution of a variety of plant canopies. The model carefully treats the physical and biological properties of the canopy as input parameters, allowing insights as to the dominate mechanisms for directional reflectance, and ultimately to the inversion of observed properties to determine the biophysical state properties (Norman and Wells, 1983). Another investigator, Narenda Goel of SUNY Binghampton has developed a viable approach for model inversion and applied it to agricultural data (Goel et al 1984).

These few examples served to show the evolving trend within the program. Many other activities are underway which are equally important to the new global science. In particular, I should note that there is work going on in the thermal region, in the use of high spectral resolution in the visible and near infrared, and using both active and passive microwave systems.

V. CONCLUSION

The NASA program in land sciences is in the early stages of transition from an applications oriented program to a synergistic program in Earth sciences. The financial outlook is good in the long run, but the severe cutbacks over the past several years have left the program in a dollar limited mode. The next few years will see some further refinement of the ideas associated with the new program thrust as the full power of the available data becomes apparent and as the theoretical basis for interpreting global scale data is developed. Although the continuity of Landsat operations is in doubt, there exists a powerful continuing source of information in the operational NOAA satellites and several promising research sensors are being developed for use from the Shuttle begining in 1987.

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