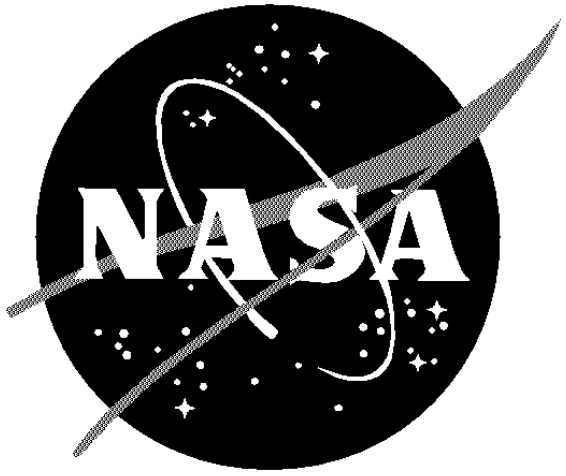

**National Aeronautics and Space Administration**

**July 27, 1998**

**NRA-98-OES-11**

# RESEARCH ANNOUNCEMENT

## OPPORTUNITIES TO PARTICIPATE IN THE LAND SURFACE HYDROLOGY PROGRAM

**Step 1 proposals due September 18, 1998**
**Step 2 proposals due November 24, 1998**

**OMB Approval No. 2700-0087**

# OPPORTUNITIES TO PARTICIPATE IN THE LAND SURFACE HYDROLOGY PROGRAM

**NRA-98-OES-11**

**Issued July 27, 1998**
**Step 1 proposals due September 18, 1998**
**Step 2 proposals due November 24, 1998**

**Office of Earth Sciences**
**National Aeronautics and Space Administration**
**Washington, DC 20546**

## I. Background and purpose of this NASA Research Announcement

NASA's Earth Sciences Enterprise endeavors to understand the total Earth system and the effects of natural and human-induced changes on the global environment. The Science Division of the Earth Sciences Enterprise (ESE) supports research and analysis that is designed to promote and increase the use of remotely sensed information for detecting and evaluating environmental status and change at both regional and global scales. The ESE has identified five interdisciplinary science questions that have reached sufficient maturity and hold the greatest promise of practical, near-term societal benefit for focused research in the context of longer-term goals of the Science Division. These questions are:

- Is the climate changing in ways we can understand and predict?
- Can we understand and predict how terrestrial and marine ecosystems are changing?
- Can we understand and predict how atmospheric composition is changing?
- Can we improve our understanding of the processes and dynamics of the Earth's surface and interior, and use this knowledge to assess and mitigate natural hazards?
- Can NASA assist in the development, implementation, testing, and evaluation of new, applications-oriented sensors that will help the public, other Agencies, State projects, or commercial interests to use the perspective and quantitative measurement capability of space-based observations for the public good?

Appendix A contains more details about ESE research priorities. There are important hydrologic aspects to all of the ESE research questions except atmospheric chemistry. The ESE Land Surface Hydrology Program, one of 17 disciplinary programs in the Science Division, has the goal of developing a predictive understanding of the role of water in land-atmosphere interactions, and to further the scientific basis of water resources management. The program currently consists of four elements:

a) Observational and modeling studies designed to understand large-scale soil moisture dynamics. Included are methods for describing the heterogeneity of soils, vegetation, and precipitation, as well as the role of topography, use of remote sensing techniques for surface soil moisture, and development and application of data assimilation techniques to incorporate soil moisture observations (in situ and remotely sensed) into coupled land-atmosphere models;
b) Support for development of regional coupled land-atmosphere models for water resources planning and management, and as tools for improving the performance of global models with respect to prediction of seasonal to interannual variability;
c) Development of techniques for monitoring changes in surface hydroclimatology due to changes in land cover and land use using remote sensing measurements and operational environmental data; and
d) Participation in field and numerical experiments designed to improve the coupling of physical, biological, and chemical process representations.

In addition to these research elements, NASA is in the process of developing a focus on global land surface hydrology. A brief synopsis which summarizes the expected nature of this initiative is enclosed as Appendix B.

This NASA Research Announcement (NRA) seeks to strengthen the Land Surface Hydrology Program as well as its contributions to the interdisciplinary science themes in the following four priority topics:

Priority Topic 1: Use of remote sensing and in situ data from intensive field campaigns to improve hydrologic prediction

Priority Topic 2: Hydrologic impacts of land use-land cover change.

Priority Topic 3: Development of data assimilation methods for hydrologic applications

Priority Topic 4: Other topics of interest to the NASA LSHP.

This NRA is the second of a planned series of annual announcements by the Land Surface Hydrology Program intended to strengthen the core science, and to enhance the contributions of the program to the interdisciplinary science questions. Proposals submitted in response to this announcement will be competing for approximately $3 million in Fiscal Year 1999. Typical awards are expected to be in the range of $50-150k per year, although some multi-investigator, multi-institution, or otherwise complex projects may be funded at slightly higher levels.

## II. Guidance for proposers

### A. Technical information and instructions for proposers

Appendix C provides technical information concerning the four priority topics for which proposals are sought under this NRA. Also included in Appendix C is the amendatory guidance for proposers that are specific to this solicitation. *Please note that this solicitation involves two stages: Step 1 requires brief, summary proposals and Step 2 requires full proposals. Also note that the amendatory guidance shall be used wherever conflicts exist with the general instructions for responding to NASA Research Announcements which are included in Appendix C.* Appendix D contains instructions for responding to NASA research announcements. Appendix E contains instructions for foreign participation in this NRA. The proposal cover page is provided in Appendix F.

### B. Eligibility

Participation in the Land Surface Hydrology Program is open to all categories of domestic and foreign organizations, including institutions of higher education, industry, non-profit organizations, NASA centers, and other government agencies. With respect to proposals from US government research laboratories, civil service salary costs are not reimbursable. Participation by non-US scientists is encouraged within the guidelines described in Appendix E, which include a no-exchange-of-funds provision.

C. Proposal submission and schedule

Proposals submitted in response to this NRA will be subjected to peer review utilizing either mail or panel evaluation, or both. A NASA management review of technical and logistical feasibility and cost analysis will also be conducted. Step 1 proposals should include a cover page (institutional authorizing signatures not required) and up to 5 pages of text, single-spaced, with type no smaller than 12-pt., including abstracts and references. Proposers will be notified by NASA regarding its review of Step 1 proposals, which will be assigned to one of four rating categories: *1) high priority, 2) medium priority, 3) low priority, and 4) non-responsive or inappropriate*. All Step 1 proposers are eligible to respond with full Step 2 proposals; however, full proposals from the Step 1 proposals rated in categories 3 or 4 are discouraged. Step 2 proposals require institutional authorizing signatures, and should adhere to the format and page limitations given in Appendix C. The schedule is:

Step 1 proposals due by 5 p.m., EDT, September 18, 1998
Notification of Step 1 recommendations: by September 30, 1998
Step 2 proposals due by 5 p.m., EDT, November 24, 1998
Announcement of selections: by March 1, 1999

Submit proposals to:

Identifier: NRA-98-OES-11
Land Surface Hydrology
Code Y
400 Virginia Avenue, SW, Suite 700
Washington, DC 20024
Telephone: 202/554-2775

Copies required: 10

Submit one additional copy of foreign proposals to:

NASA Headquarters
Office of External Relations
Earth Science Division

Mail Code IY
300 E Street, SW
Washington, DC 20546-0001

Selecting official: Director, Science Division
Office of Earth Science

Inquiries: Dr. Dennis Lettenmaier
Mail Code YS
NASA Headquarters
300 E Street, SW
Washington, DC 20546-0001
TEL: 202/358-1847
FAX: 202/358-2771
Email: dennis.lettenmaier@hq.nasa.gov

Your interest and cooperation in participating in this opportunity are appreciated.

Ghassem Asrar
Associate Administrator for the
Earth Sciences Enterprise

Enclosures:

Appendix A, New Vision of Earth Science and Applications Research Priorities at NASA
Appendix B, NASA Global Land Hydrology Strategy
Appendix C, Technical Information on Research Sought under NRA-98-OES-11 and Amendatory Guidance for Proposers
Appendix D, Instructions for Responding to NASA Research Announcements
Appendix E, Guidelines for Foreign Participation
Appendix F, Proposal Cover Page

# APPENDIX A: NEW VISION OF EARTH SCIENCE AND APPLICATIONS RESEARCH PRIORITIES AT NASA

## INTRODUCTION

The goals of the NASA Earth Science Enterprise are to use the global perspective of observations from space to understand the planet as a complex, coupled system (involving the atmosphere, oceans, land and ice surfaces and the living biosphere), and to enable an improved stewardship of our environment with sustained human progress through space observations and the assessment and mitigation of the effects of natural disasters.

The program of the Enterprise will be guided by the following over-arching questions:

- Is the climate changing in ways we can understand and predict?
- Can we understand and predict how terrestrial and marine ecosystems are changing?
- Can we understand and predict how atmospheric composition is changing?
- Can we improve our understanding of the processes and dynamics of the Earth's surface and interior, and use this knowledge to assess and mitigate natural hazards?
- Can NASA assist in the development, implementation, testing and evaluation of new, applications-oriented sensors that will help the public, other Agencies, State projects, or commercial interests to use the perspective and quantitative measurement capability of space-based observations for the public good?

In the post EOS AM-1, PM-1, and CHEM time period, we will have made significant advances in space observations of the Earth system, but we expect to need continuing measurements of specific components of the system as well as new measurements allowed by emerging technologies. We plan to conduct those measurements within a new NASA paradigm for space-borne projects that will emphasize small, focused missions to test hypotheses and address key questions. This new paradigm calls for a balanced program of space observations, airborne and ground-based measurements and modeling. Such a program will conceptually link and coordinate all aspects of the Earth Science Enterprise.

## FIVE QUESTIONS AND THEIR IMPLICATIONS FOR FUTURE SPACE OBSERVATIONS

1. Is the climate changing in ways we can understand and predict?

Climate is continually changing from one season to the next, one year to the next, one decade to the next. The real question is not whether we can measure climate change, but whether the changes we do observe correspond to mechanisms or processes we can understand, predict and, in general, attribute to a specific cause. Another aspect of the same problem is determining the effect changes in global climate may have on the frequency and intensity of severe weather events and the impact of transient climate variations, such as El Niño phenomena, on different regions of the world.

Climate is the integrated result of weather. Because these phenomena are manifestations of extremely complex interplay between a multiplicity of non-linear processes, there is no way we can unravel causes and effects on the basis of one or a small set of characteristic measurements - such as a record of global mean atmospheric temperature. We strive instead to acquire as complete a description of the atmosphere-ocean-land system as possible, leaving no loose end that allows alternative explanations and residual uncertainty. We depend heavily for this purpose on systematic observation and analysis carried out by operational environmental agencies for weather and climate forecasting purposes. Accordingly, the Office of Earth Science attributes high scientific value to the improvement of global operational environmental observing and data analysis systems, for example the National Polar Orbiting Environmental Satellite System (NPOESS), which will begin operations in the early part of the 21st century.

Many external factors that govern the earth climate - such as radiation received from the sun, aerosols from natural or anthropogenic origin, the concentration of greenhouse gases - or slowly evolving components of the earth climate system, especially the world ocean circulation, global terrestrial vegetation, snow/water storage on land, the mass balance of the Greenland and Antarctic ice-sheets, cannot be adequately determined from existing operational observations. An essential objective of the Office of Earth Science is to develop new observing techniques for measuring these factors or components from space and, in cooperation with partner agencies, define an international observing strategy to systematically sample relevant global properties.

A third, equally essential task is investigating the processes that play an important role in defining the earth climate. Foremost among these is the complex interplay of water vapor, liquid and ice with atmospheric radiation transfer. The accumulation of snow, the storage of water and subsequent evaporation of soil moisture control climate over large continental areas. Deep-water formation, the sinking of cold saline water in the North Atlantic Ocean, controls the transport of heat to high northern latitudes without which the climate of Europe would be similar to that of Alaska. The formation, transport and melting of sea-ice govern the energy budget of Polar Regions, heat transfer from the ocean to the atmosphere and the fresh water balance of the oceans, thus affecting global climate. The mechanics of glaciers and ice sheets determine the mass balance of land ice, future changes in the volume of the oceans and global mean sea level.

In addressing the above over-arching climate question, the Earth Science Enterprise will obtain data on climate diagnostics, forcings, and impacts. These data will be used to address the following crucial questions:

- Are global and regional-mean surface temperatures rising or falling?
- Will the frequency and intensity of the El Niño phenomena and of severe weather events change in response to environmental changes and can we achieve a better capability to predict them?
- Can we link changes in water vapor, cloud properties and the hydrological cycle to changes in the circulation of the global atmosphere?
- Do we understand the linkages between climatic changes, ocean circulation and ice sheets?
- Will an increase in atmospheric aerosols offset the heating caused by greenhouse gases?

2. Can we understand and predict how terrestrial and marine ecosystems are changing?

Terrestrial and marine ecosystems undergo changes that are the results of human activity, of their own intrinsic biological dynamics, and of climate variability and change. There are very few landscapes on Earth that have not been significantly altered or are not being altered by humans. Since nearly half the global population resides in coastal regions, the coastal biosphere is increasingly impacted through anthropogenic activities, both intentional and accidental. As the human population of the Earth continues to grow, there will be continuing pressure on the Earth's biological resources to provide food, fiber, and maintain ecosystem services in a sustainable, long-term fashion. As in the case of the climate, the challenge is to detect the changes and to sort out the contributing factors. Ecosystems also act as mediators of feedbacks to atmospheric chemistry and climate, both in terms of alterations of water and energy budgets and in terms of fluxes of greenhouse gases. Determining the sign and magnitude of the feedbacks is essential to assessing the interaction of biogeochemistry on atmospheric gas composition and its radiative forcing.

The effort to understand the observed changes in terrestrial and marine ecosystems, and to predict their capacity to sustain biological productivity and diversity requires a coordinated Earth system science program in which terrestrial, atmospheric and oceanic processes are examined, modeled, and monitored.

There are three broad objectives associated with such a coordinated program. The first is to document the current patterns of land-cover, terrestrial and ocean productivity, and their changes on interannual time

scales. The current pattern of land-cover most often reflects past and present land-use. The larger patterns of land-cover are observable and can be monitored from space. From historical archives, including the last twenty years of satellite data, one can build a quantitative assessment of landscape and land-use change, and associated changes in terrestrial productivity and processes. Subtler types of change which take place, for example, through intensification of human use, require additional in-situ information. The ability to document the spatial patterns of ocean productivity is relatively recent, and the ability to detect changes quantitatively is evolving rapidly, as new sensors such as SeaWiFS provide data. We must, therefore, improve and maintain the capability to perform repeated global inventories of land-cover and land-use and ocean productivity patterns from space, and to develop the scientific understanding and models necessary to evaluate the consequences of the observed changes.

The second major objective is to understand the processes that control patterns and changes in marine and terrestrial ecosystems. In both marine and terrestrial ecosystems, factors affecting primary production ultimately affect the abundance and diversity of life within the whole ecosystem. Using space-based measurements, we are able to observe and document changes in primary production. Primary productivity, or the process of photosynthetic carbon fixation, is a major sink for atmospheric $CO_2$ , whereas respiration and organic decay subsequently release carbon back into the atmosphere. Total fluxes due to these processes are on the order of 150-200 GtC/yr, but it is the net fluxes that we seek to understand. Contributions of the biosphere to net changes in atmospheric $CO_2$ are the most important carbon-related phenomenon to understand from a climatic perspective. These net fluxes, on the order of 1.5 to 2.0 GtC/yr, reflect a non-equilibrium state in the global carbon cycle. The role of the biosphere is complex. Carbon is being transferred from tropical ecosystems and sequestered in northern boreal ecosystems, and yet the specific location and processes involved in this sequestration are unknown. Furthermore there are important interannual variations in biologically mediated carbon fluxes that are poorly understood. It is critically important to understand the processes by which these fluxes are mediated, and the interactions with nitrogen fluxes, atmospheric $CO_2$ concentrations, soil condition, climate variability, and human activities. As the US government evaluates its policy options for responding to the Kyoto protocols, understanding these issues takes on a new level of international policy importance. Space observations and tracking of these processes as they are represented in surface reflectance, microwave backscatter, and in the distribution of biomass are very high in priority both for understanding terrestrial and marine ecosystems, and their impact on climate.

The third major objective is to develop predictive capabilities for ecosystem processes and patterns, both in terrestrial and marine environments. In both environments, the Earth Science Enterprise is already carrying out major model development and intercomparison programs that utilize remote sensing data. Current data are used either to derive critical model parameters, as for example in the use of NDVI data to derive the fraction of absorbed photosynthetically active radiation; or independently to validate model results, as in the use of phenological information derived from AVHRR data to query the reliability of ecosystem models in reproducing accurate seasonal cycles of primary productivity. As the observational base becomes richer, more complete, and better calibrated, the ability of the modeling community to explore the use of remotely sensed data will additionally grow.

To address the issues associated with the above over-arching question for terrestrial and marine ecosystems, the Earth Science Enterprise will therefore acquire data on the distribution and changes in terrestrial and ocean conditions and productivity, the processes that control or are altered by these changes, and will develop and validate predictive models to address the following critical questions:

- What are the magnitude and variability in net emissions from changes in tropical land-use?
- What are the magnitude and variability in terrestrial biological productivity, and what processes control it?
- Can we predict the ability of terrestrial and marine ecosystems to continue to provide food, fiber, and ecosystem services in the face of growing human populations and climate variability and change?
- What controls primary productivity in major ocean ecosystems on interannual and decadal time-scales, and thus the ability to predict how these ecosystems will respond to and influence climate change?

- How long can the biologically-mediated sinks of carbon continue to operate before other limiting factors come into play?

- What are the current fluxes of radiatively important trace gases from terrestrial and marine ecosystems, and how might they change?

3. Can we understand and predict how atmospheric composition is changing?

In the last two decades an integrated program of space, aircraft, balloon, and ground-based measurements has established that the chemical composition of the atmosphere is changing and that some of the changes, such as the buildup of chlorofluorocarbons and of carbon dioxide are the result of human activities. In the case of chlorofluorocarbons (CFCs) buildup, it has been further established that these long-lived compounds are lifted into the stratosphere, broken down by solar ultraviolet radiation, and become the sources of highly reactive chlorine atoms, which catalytically depletes the earth's protective layer of stratospheric ozone.

In response to these findings, the nations of the world have placed limits on the emissions of CFCs that are now beginning to decrease in the lower atmosphere. Within the next decade they will decrease in the stratosphere, which will result in less depletion of stratospheric ozone. A major challenge of atmospheric chemical research in the coming decade is to follow this process and to ensure that no unexpected problems with stratospheric ozone arise from the CFC substitutes and growing use of other halogen compounds or from climate changes that could affect stratospheric chemistry.

Buildup of stable, long-lived gases such as carbon dioxide, methane, and nitrous oxide underlies the "greenhouse gas" phenomenon and is a forcing factor in radiation balance. More reactive gases, such as carbon monoxide and ozone, also play an important role in this phenomenon. Understanding the chemistry of these gases, most of which occurs in the troposphere is another major focus of global atmospheric chemistry research.

Apart from the role of these reactive gases in global radiation balance, there is another important issue surrounding them. As the developing and emerging nations, particularly in Asia and Latin America grow in population and economic activity, emissions of pollutant gases, such as CO and the oxides of nitrogen that largely control tropospheric ozone concentration, will undoubtedly increase enormously. The effects of this growing atmospheric pollution on a global scale are not well predicted because natural processes that both emit gases into the atmosphere and remove human pollutants through photochemistry are not well characterized. Understanding and predicting these effects is a frontier area of atmospheric research for the next decade and beyond. It is a global scale problem that lends itself particularly well to the use of space observations and correlative and complementary in-situ measurements

Given the current status of knowledge of stratospheric and tropospheric chemistry and expected scientific return from current and planned space measurements (UARS, TOMS, SAGE, and the instruments on the planned CHEM satellite), a series of measurements with smaller instruments that will incorporate advanced technology can be identified for the post CHEM era with the new NASA paradigm of smaller, focused missions.

For stratospheric chemistry global measurements of total ozone and ozone vertical distributions will be the principal long-term requirement as the ozone layer recovers in response to the Montreal Protocol limitations on CFCs. To track cause and effect, measurements will be needed of several key chemical species that are involved in the chemistry of ozone depletion or that are chemical tracers of atmospheric transport. Measurements of aerosol content of the stratosphere will define volcanic influences on stratospheric chemistry. Direct measurements of source gases such as CFCs, hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs) will also be a long term need.

For tropospheric chemistry global scale measurements of ozone as a function of altitude are key requirements from both a climate impact and a global pollution perspective. The ozone concentration levels in the troposphere are controlled to a large extent by concentrations of oxides of nitrogen, which originate mostly in the lower troposphere. Long term measurements of the oxides of nitrogen will be needed to track

cause and effect relationships between tropospheric ozone and pollution growth. Measurements of carbon monoxide concentrations as a function of altitude and geographic location will be valuable as a pollution indicator and a tracer for tropical overturning. Natural fluxes of key tropospheric chemicals into the atmosphere from both land and water will be a key input to global chemical models. It will also be important to determine the extent to which changing atmospheric aerosol concentrations will modify tropospheric chemistry.

The studies undertaken to answer the above general question will provide answers to three important questions that are certain to be at the center of public environmental concerns in the first decade of the next century:

- Is the Montreal Protocol working as expected to stop ozone depletion in the stratosphere by manmade chemicals, and is there any threat that is not yet recognized which will require additional government action?

- How can space observations contribute to better detection and characterization of regional to super-regional air pollution and assist in dealing with control issues that transcend state and even national borders?

- To what extent is industrial and urban pollution distributed globally and what will be the global atmospheric consequences of large-scale pollution as emerging economies greatly increase their use of fossil fuels?

4. Can we improve our understanding of the processes and dynamics of the Earth's surface and interior, and use this knowledge to assess and mitigate natural hazards?

The Earth is a dynamic planet that is constantly changing, not only at its surface but within its interior as well. From direct and often catastrophic experience, we know that internal motions of the Earth crust can generate earthquakes and melting of rocks in the lithosphere is the origin of volcanism. The flow of the planetary core generates the Earth's magnetic field, which ultimately protects life on the planet from the harmful effect of energetic particles from the sun.

We already have considerable knowledge of the structure of the Earth interior, the metallic core, the mantle of dense minerals, and the lighter lithosphere and crust. Each of these components is in motion, although at greatly different velocities. Movements in the core generate the magnetic field; changes in the flow of the core result in sudden changes in the polarity of the Earth's magnetic field. The mantle drives the lithospheric plates causing them to collide, subduct into the mantle and melt, thus separating the lighter minerals that feed volcanoes. At the Earth's surface, anomalous weather and climate events, especially unusual rainfall, interact with the solid Earth and drive the landscape toward a new equilibrium, often through catastrophic landslides, flooding and beach erosion.

In order to understand these phenomena and interactions, scientific questions such as the following need to be addressed:

- Can we understand the forces that drive earth motions from the core to the surface?

- Can we determine the fundamental processes controlling earthquake generation?

- What are the processes by which landscapes are formed and modified?

5. Can new, observations from new applications-oriented sensors be applied for the public good?

NASA’s Applications and Outreach Program is very diverse in its scope and impacts. Some examples of its current capabilities range from assisting today's measurement-oriented precision agriculture to improve crop yield to developing tools that can interpret operational satellite and direct broadcast data in forms that help in real-time disaster loss prevention and mitigation efforts.

Observing the surface extent of flooding and the threats to life and property are paramount in national and state agency efforts to help people. Certain businesses can benefit by more precise mapping and automated integration of land/civilization features observable through high-resolution remote sensing.

NASA has an enabling role in helping people to gain greater benefits through the intelligent use of precise remote sensing from satellites and other platforms.

In certain cases, NASA might develop a new sensing technique or improved sensor for airborne testing and eventual use on a satellite of opportunity. In others, NASA might develop new computer techniques using advanced technology and possibly even on-board processing to save communications bandwidth and make real-time warnings from satellites a reality. In still other situations, NASA might team with industry to develop and test new methodologies that eventually might become an asset to commercial remote sensing.

The potential for new space observation-based applications is limitless, and many techniques already have been tested and proven successful. In responding to the challenge for development of new sensors in this area, one should consider the ultimate value to people as having high merit. Thus, a sensor/system for the detection of, say, fires from space would be beneficial in terms of preventing the loss of lives, property, and environmental resources or diversity. A system which could integrate satellite-derived rainfall, flooding potential, reservoir content, and model runoff in the traditional hydrological sense could help the many agencies concerned with water as a resource or as a threat.

There are many types of surface and/or vegetation mapping applications that would assist the responsible agencies in their missions of enabling sustainable development. Applications have new frontiers, as well. For instance, there is new hope in tracking the expansion of disease-generating environments, such as mosquito habitats, so that early warning of potential epidemics might be possible.

The concepts for new applications should not be limited to these alone. The purpose of this brief listing is to suggest that the scope of potential applications is large and the ways that remote sensing data from satellites might be used has just begun to be defined. There may be opportunities for additional commercial involvement, interagency demonstration projects, direct-to-the-public transmissions from satellites, and monitoring of new, life-saving data from space. NASA is open to the consideration of all forms of new and improved applications of satellite remote sensing data.

Today's NASA has placed a greater emphasis on public outreach and specifically is expanding a programmatic effort in that direction; hence it would also seem appropriate to consider the potential uses of satellites in the role of enabling greater public outreach. This could take the form of transmissions of data products processed on-board a spacecraft directly to the public or, perhaps, the concepts surrounding the "data base in the sky" of using satellites to generate, accumulate, and retransmit requested environmental information to the public. This area has the potential for wide distribution of remotely sensed information when considered in conjunction with the expected expansion of Internet and communication capabilities that will be available to the public.

# Appendix B: NASA Global Land Hydrology Strategy
# DRAFT 6/1/98

Background:

Hydrology is the study of the movement of water at and near the land surface. Classical , scientific hydrology has focused on relatively small spatial scales (e.g., hillslopes with areas of the order of hectares to catchments with area of the order of a few square km) at which the processes that control the generation of runoff and streamflow can be observed directly. Under idealized assumptions regarding media properties, the processes of moisture movement in saturated media are well described by Darcy's Law, and its more general form, the Richards Equation, in unsaturated media. In principle, starting with such fundamental representations, it is possible to predict physically the fate of precipitation, infiltration, and the fast and slow processes by which streamflow is generated during and between storms. At the scale of an idealized hillslope, Freeze's pioneering work in the 70s demonstrated the feasibility of such an approach. Nonetheless, attempts to generalize this approach for larger watersheds generally have not been successful, mainly for two reasons: a) surface (and subsurface) topography, at scales of meters to tens of meters, exerts a strong control on the evolution of saturated areas, which in turn dominate the production of runoff in most humid and semi-humid environments. Therefore, the computational demands of extending approaches like Freeze's to generalized topography are immense, and would overwhelm even the fastest of the current generation of computers; b) spatial variations in the classical properties of the media (e.g., hydraulic conductivity, porosity, sorptivity) as well as soil structure (macropores; lenses and layering) likewise exert strong control on surface hydrologic processes. Furthermore, in the absence of intensive field observations, media properties cannot be known with the accuracy that would be required for hydrologic prediction based strictly on first principles, even at the scale of relatively small catchments.

Therefore, all hydrologic models, whether developed for operational or scientific purposes, of necessity must parameterize the key processes. At small scales, such parameterizations can be based more or less loosely on idealized physics, and observations (e.g., the topographic index used in Beven and Kirkby's Topmodel and its derivatives). At larger scales, the problem of developing suitable parameterizations is more challenging. Nonetheless, it is at the larger scale (arguably tens of square km and up) at which the atmosphere "sees" the land surface, and at which land-atmosphere transfer schemes (LATS) used in climate and numerical weather prediction models have focused. The genesis of LATS is somewhat different than that of hydrological models: while hydrological models have arisen from a heritage of predicting streamflow given precipitation, the motivation of LATS is to predict the partitioning of net radiation into latent, sensible, and ground heat fluxes, and to reflect the role of vegetation in so doing. Historically, these models have emphasized vertical complexity (i.e., representation of multiple layers in the above-surface vegetation canopy and soils) and sacrificed representation (or parameterization) of the spatial variability that controls runoff generation. Recently, this distinction has become somewhat blurred, as hydrologists have recognized the desirability of representing heat and radiation fluxes at the surface, and LATS developers have begun to acknowledge the role of spatial variability. Nonetheless, representation of the physical effects of spatial variability in the parameterization of surface fluxes remains very much an open question.

Given the recognition of the role of the land surface in weather and climate prediction, not to speak of the important socioeconomic implications of large rivers, NASA's Land Surface Hydrology Program intends to place more emphasis on global prediction. The NASA global land surface hydrology strategy will focus on representation of the fluxes of moisture (streamflow and evapotranspiration), storage of water at and near the land surface (soil moisture, and snow; lakes, streams, and surface impoundments,) and energy fluxes over the land areas of the globe. Two considerations motivate this strategy: First, NASA, by virtue of its satellite mission, produces global data; the optimal use of those data requires predictive tools that are applicable to the entire domain of the data. Second, remote sensing data, while often inferior to surface observations in terms of local accuracy, provide information about spatial texture, and a global extent, that cannot be matched by in situ observations. Exploitation of the information content of these data requires a focus on scales much larger than that of traditional hydrological modeling. In a sense, the strategy is intended to fulfill suggestions of Eagleson in the early 80s that a field of continental hydrology be established. Although NSF initiated a program in continental hydrology in the late 80s, it existed for only a few years before being subsumed by the current NSF Hydrological Sciences Program, after which the focus was lost. For the reasons mentioned above, NASA is arguably better situated in terms of its mission objectives to foster the development of the field. As a side note, any distinction between continental

hydrology, as envisaged by Eagleson, and global hydrology, as suggested here, is less conceptual than practical. Given the historical resistance of hydrologists to working at large scales, it is important to avoid the temptation to focus on areas (continents) with the best surface data (where the marginal value of remote sensing may be lowest); the ultimate goal must be to develop a global land surface hydrologic prediction capability.

Science Questions:

The science questions to be addressed by a global hydrology initiative are: a) "How does the land surface modulate or enhance variability in weather and climate variables at the surface, particularly runoff and precipitation over land? How can these interactions be predicted at continental and global scales?" ; b) "Can the capability of global weather and climate observing systems be utilized and/or enhanced to make meaningful predictions of river flow, and the transport of sediment and biochemical constituents, by major global rivers?"; c) "How can intensive in situ observations best be used to develop models applicable at continental and global scales?", and d) "What are the in situ and remote sensing observational requirements, and/or assimilated data products, needed to verifying the performance of hydrologic models at continental and global scales?".

Strategy:

The NASA global hydrology strategy will focus on development of a global hydrologic prediction capability, based on the following elements:

1) Strong ties to intensive field campaigns. Measurements of surface fluxes of moisture and energy exist for many of the major climatic and hydrologic regimes, from field campaigns such as FIFE, BOREAS, HAPEX-MOBILHY and SAHEL, the GEWEX GAME and LBA Continental Scale Experiments, and others. Although the particulars vary, the relevant spatial scale of these observations is usually of the order of "patches" surrounding flux towers, up to catchment areas in the case of streamflow observations. A key element of the strategy is to build up from these small scale observations to continental and global scales, essentially by variations of a mosaic approach;

2) Use of remote sensing data to the maximum extent possible, to a) represent surface forcings to the land surface system (currently most feasible for downward solar radiation); b) validate or update [land surface and/or coupled land-atmosphere] model state variables, such as skin temperature, snow extent, and perhaps near-surface soil moisture and snow water equivalent; and c) (using composites of remote sensing and in situ data) validate or update surface fluxes predicted by such models, such as net radiation and sensible heat flux;

3) A focus on the development of new sensors and sensor technology relevant to land surface hydrology. It must be recognized that current and expected data products from the first series of EOS sensors, while of some potential use for hydrology, fail to fulfill the potential of remote sensing with respect to global hydrologic prediction. Improvements in precipitation monitoring, and development of a capability to monitor discharge of major rivers, are key areas that will require both new sensors and scientific support;

4) Development of a capability to use data assimilation methods to combine observations with predictive modeling. This is a technique that has yet to be fully utilized in macroscale hydrology. Approaches that utilize both off-line surface forcings, and coupled land-atmosphere modeling, should be considered. In the case of coupled assimilation, development of protocols for interactions with atmospheric modeling centers with state-of-the-art global atmospheric modeling capability such as ECMWF and NCEP, and strengthening of the land surface capabilities at the Goddard DAO, will be essential;

5) Development of observations and predictive tools that represent the role of water in transporting biochemical constituents from the land surface, through rivers, and eventually to the oceans. The role of hydrology in biogeochemistry, and especially prediction of the movement and storage of carbon on and from the land surface, needs to be better addressed.

Future Directions:

Notwithstanding the importance of surface atmospheric forcings to terrestrial hydrology, the strategy as sketched out here focuses primarily on the storage and movement of water at and near the land surface. Clearly, water exists in a more comprehensive global context. The vast majority of the earth's water is stored in the oceans, but the atmosphere accounts for most of the dynamic transfer of fresh water globally, and essentially all of the transfer of water from the oceans to the land surface. Therefore, as a better understanding of global land surface hydrology is developed, there will become a need to broaden the strategy to study the global hydrological cycle, as opposed to the hydrology of the land surface. Most of the transport of moisture in the atmosphere occurs in the lower troposphere. Furthermore, precipitation is arguably the most important forcing of the land surface hydrologic system. Therefore, an obvious extension of the strategy developed here would be improved precipitation prediction, in which the contribution of remote sensing could be better profiling of moisture in the atmosphere and its transport.

**Appendix C**
**Technical Information on Research Sought under NRA-98-OES-11 and Amendatory Guidance for Proposers**

This appendix provides background technical information regarding the research topics to be supported under this NRA. Section I describes the four priority topics. The content and evaluation of Step 1 proposals are discussed in Section II. The format and evaluation of full proposals for Step 2 are discussed in Section III. The guidelines below shall be used wherever conflicts exist with the general instructions for responding to NASA Research Announcements given in Appendix D.

## I. Priority topics

Proposers should identify the specific priority topic(s) to which they are responding. Proposals without this identification or without an identifiable connection to one of the priority topics may be judged non-responsive to this NRA.

### Priority Topic 1: Use of remote sensing and in situ data from intensive field campaigns to improve hydrologic prediction

Studies are sought that will to improve understanding of land-atmosphere interactions, and enhance hydrologic prediction capabilities at local to regional scales, through use of remote sensing and in situ data collected during intensive field campaigns. Proposals should address one of more of the following general issues:

1) Use of field data, and derived data products from field campaigns, to improve understanding of interactions between the land surface and atmosphere at local to regional spatial scales, and/or how better understanding of such interactions can be used to improve hydrologic prediction at these scales. Studies could focus either on one-way interactions (e.g.., use of remotely sensed soil moisture data to improve flood or drought forecasting; or evaluation of improvements in precipitation forecasting that could result from better understanding of land surface conditions) or two-way (e.g., better understanding of the role and significance of recycling of precipitation at local and regional scales). Among the field data sets that might form the basis for interpretive studies are:

a) SGP97: SGP97 (see http://hydrolab.arsusda.gov/sgp97 for details) was conducted during June and July, 1997, in central Oklahoma. The experiment focused primarily on a more or less rectangular portion of the DOE ARM/CART facility (see http://www.arm.gov/docs/sites/sgp/sgp.html for details) of north central Oklahoma and south central Kansas, with a focus on the Little Washita River basin and El Reno areas of central Oklahoma. The experiment was originally conceived as an airborne experiment for daily mapping of surface soil moisture, and the primary rectangular area represents the

bounds of flight lines for the NASA P3, on which the ESTAR L-band passive microwave radiometer was flown (more or less daily) for a period of about one month. The experiment was subsequently expanded in scope to meet interdisciplinary interests, such as boundary layer observations. The primary considerations in the experimental design were (1) maintaining as much spatial airborne coverage of soil moisture as possible on a daily basis; (2) nesting when- and wherever possible to allow observations at a hierarchy of scales; and (3) making maximum use of existing facilities in the area.

Proposals are sought that will make use of SGP97 data to better understand land-atmosphere interactions (and especially the role of soil moisture in controlling land-atmosphere interactions) at scales from local to regional, the range of which is represented in the SGP97 experimental design. Proposers are referred to the SGP97 experiment plan (available from the SGP97 home page at the URL noted above) and the SGP97 data archive (still under construction, accessible at http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/SGP97/sgp97.html) for details of the experiment and the data collected.

b) Other existing data sets from focused land surface and/or land-atmosphere field campaigns: A number of field experiments have been conducted over the last decade, for the general purpose of improving the understanding of land-atmosphere interactions. Among these experiments are CASES (Cooperative Atmosphere Surface Exchange Program); various GEWEX (Global Water and Energy Experiment) Continental Scale Experiments, HAPEX (Hydrology-Atmosphere Pilot Experiment), NOPEX (Northern Hemisphere Climate-Processes Land-Surface Experiment, FIFE (First ISLSCP Field Experiment) and many others. Information about the experiments mentioned above can be found at:

CASES: http://www.mmm.ucar.edu/cases/cases.html
GEWEX Continental Scale Experiments: http://www.tor.ec.gc.ca/GEWEX/GHP/ghp.html
HAPEX: http://www.orstom.fr/hapex/
NOPEX: http://hydserver.hyd.uu.se/nopex
FIFE: http://www-eosdis.ornl.gov/FIFE/FIFE_Home.html

Projects that are primarily involved with analysis and/or other use of BOREAS and LBA data will not be considered, as they are more appropriate to other recent NRAs (NRA-97-MTPE-08 and NRA-98-MTPE-01, respectively). However, projects that use BOREAS and/or LBA data in a broader context, for instance, in conjunction with field data collected at other intensive observation campaigns, may be appropriate.

The focus of this topic is use of data and derived products from previously conducted field campaigns. With the possible exception of very limited field activities that are carefully focused on enhancing previously collected data, it is not anticipated that new field programs will be funded.

Priority Topic 2: Hydrologic impacts of land use-land cover change.

One of the five major themes of the U.S. Global Change Research Program is to advance understanding of the causes, magnitude, and consequences of changes in land cover as they relate to the land surface hydrologic system, and terrestrial ecosystems. The LSHP has a particular interest in advancing understanding of land cover and land use changes as they relate to land surface hydrologic response over a range of space and time scales. For instance, appropriate topics could include changes in flood frequency, drought susceptibility, water yield, low flows, and groundwater-surface water interactions from local to regional and continental-scales caused by, or related to, land cover change. Identification of land cover change is an ideal application for satellite sensors. Under this NRA, the LSHP is interested not only in proposals that develop, or make use of, land cover data from remote sensing sources, but also in proposals that make unique and innovative use of remote sensing data to understand the functioning of the land surface hydrological system with respect to fluxes and storage of moisture at and near the land surface. Proposals are solicited that will:

- Utilize land-cover data from new remote sensing sources or algorithms over a range of scales from various remote sensing products (e.g., from Landsat, AVHRR, EOS-era sensors such as MODIS, and other remote sensing sources) to evaluate the effects of land use conversion (e.g., conversion of forest and other natural land cover to agricultural uses; logging, urbanization, and other land cover conversions) on the surface water balance and catchment hydrological response, including such issues as water yield, flooding, and constituent transport. Note that it is not intended to fund algorithm development activities under this NRA;

- Develop new regional, continental, and/or global land cover and related data sets in support of hydrological prediction activities. Again, it is not intended to fund algorithm development activities under this NRA. However, compilation of high quality data sources from remote sensing and other sources that could have widespread use in the hydrologic community is encouraged. Proposals responding to this item should include a description of provisions for distribution to, or accessibility of, the data to the scientific community;

- Utilize remote sensing data to interpret the hydrologic effects of land cover disturbance not related to land cover conversion. Included could be disturbances such as fire, drought, pestilence, and volcanoes. Proposals responding to this section are encouraged to make use of interpretive techniques, such as hydrological prediction models, statistical methods, and or other techniques in conjunction with remote sensing data.

Priority Topic 3: Development of data assimilation methods for hydrologic applications.

Data assimilation is widely used in numerical weather prediction to combine observations (especially of free atmosphere variables, such as humidity, temperature, and wind profiles) from different sources, and of differing quality, with model predictions. Data assimilation is identified as one of the elements of the NASA Global Land Hydrology Strategy (Appendix B). Although some investigations of the potential of data assimilation have been performed, particularly in conjunction with soil moisture, and surface temperature observations, the work to date has mostly been exploratory in nature. Proposals are encouraged that will develop the potential of data assimilation methods in conjunction with macroscale hydrologic prediction methods for application at continental to global scales. Approaches that utilize both off-line surface forcings, and coupled land-atmosphere modeling, will be considered. In either case, however, use of remote sensing data must be a central element. Proposals are especially encouraged that involve collaboration with global atmospheric modeling centers, such as ECMWF, NCEP, and/or the NASA/GSFC Data Assimilation Office.

Priority Topic 4: Other topics of interest to the NASA LSHP.

A limited number of studies may be funded that do not fit directly under Priority Topics 1-3, but are nonetheless of interest to the Land Surface Hydrology Program for scientific, strategic, or other reasons. It is expected that not more than 20 percent of the total funds awarded under this NRA will go to projects funded under this topic. Proposals appropriate to this Priority Topic could, for instance, include demonstrations and/or evaluations of the usefulness of remote sensing data for hydrologic prediction, preliminary scoping studies that might may lead to new or innovative remote sensing missions and/or sensors of particular interest to the hydrological sciences community, participation in international activities of particular relevance to the program, and other related activities.

Remote Sensing Relevance: All Step 2 proposals should contain a brief statement of the use of, and/or relevance of the project to, remote sensing or other aspects of the Earth Sciences Enterprise. Where the remote sensing relevance of a proposal is not apparent from the project description, Step 1 proposers are encouraged to include such a statement as well.

## II. Content and evaluation of Step 1 proposals

Step 1 proposals are required of all who are interested in responding to this NRA. Step 1 proposals should include 1) a cover page (Appendix F), 2) up to 5 pages of text, single-

spaced, with type no smaller than 12-pt., including abstract and references, and 3) curriculum vitae, less than 2 pages in length, for each investigator. The main text should describe concisely the research to be conducted, motivation and expected consequences, technical approach, and an estimate of cost *(what, why, how, and how much*). Signatures of authorizing officials from submitting institutions are not required for Step 1 proposals.

Step 1 proposals will be reviewed on the basis of intrinsic merit, relevance to NASA mission and objectives, and the estimated cost. The evaluation criteria, in order of decreasing importance, are:

1. Relevance and responsiveness of proposed research to this NRA
2. Scientific and technical merit
3. Estimated cost

Following the Step 1 review, NASA will place each proposal in one of the following categories:

1) *high priority* (well-conceived and innovative proposals of high programmatic relevance and high scientific and technical merit)
2) *medium priority* (relevant proposals of sound scientific and technical merit)
3) *low priority* (proposals of less relevance, and/or containing major scientific or technical deficiencies, and/or projecting high costs relative to the expected scientific returns)
4) *non-responsive/inappropriate* (proposals not relevant to this NRA, and/or with scientific or technical flaws, and/or with cost estimates exceeding resources appropriate under this NRA)

Proposers will be notified as soon as possible, but no later than September 30, 1998, of the categorization of their respective proposals. Proposers of *high-priority* Step 1 proposals will be specifically encouraged to submit full proposals for Step 2. Full proposals from *medium-priority* Step 1 proposals will be accepted as well. Full proposals from *low-priority* Step 1 proposals will be considered, but are discouraged. Proposers of *non-responsive or inappropriate* Step 1 proposals are strongly discouraged from submitting a full proposal to this NRA. Step 2 proposals are due November 24, 1998.

III. Format and evaluation of Step 2 proposals

Only those proposals whose objectives and methodologies have been evaluated in Step 1 will be considered. Proposals whose objectives and methodologies have changed from Step 1 will not be evaluated in Step 2.

The content of Step 2 proposals should provide sufficient detail to allow the reviewers to assess the value of the proposed research, its contribution to NASA, and the likelihood that the investigators will accomplish the stated objectives within the requested resources and schedule. Proposals that do not adhere to the format below or the stated page limitations will not be reviewed.

1. Cover Page (See Appendix F)
2. Table of contents (Paginated)
3. Project Summary (Maximum length, 1 page)
4. Technical Plan (Maximum length, 15 pages, including all figures and charts, reference cited, and schedule and data plan if applicable)
5. Management Plan (Maximum length, 1 page, especially important for large or complex efforts involving interactions of numerous individuals or organizations)
6. Cost Plan (applicable to proposals from US institutions only; annual and cumulative budgets for no more than 3 years accompanied by justifications and explanatory notes)
7. Current and Pending Support (listing title, source, amount, and period of performance of the support received by each investigator)
8. Biographical Sketches (short vitae, listing only biographical, academic or professional essentials, and publications most relevant to the proposed research within the last 5 years)

Additional materials may be appended only when an informed review is not possible without them; these may include accepted manuscript yet to appear in print, background on new measurements or instrumentation, or letters on collaboration by scientists or organizations from other countries.

The evaluation criteria for Step 2 proposals are described below. Criterion 1 is the most important; Criteria 2 and 3 are approximately of equal weight.

1. Intrinsic merit, including scientific innovation and technical soundness in concepts and approaches, capability of the investigator(s), and the likelihood of leading to fundamental advances in knowledge and field practice.
2. Relevance and responsiveness of proposed research to this NRA
3. Realism and reasonableness of proposed cost, including its relation to resources available under this NRA

NASA may elect to support only a portion of the proposed investigation, pending successful negotiation. In cases of meritorious proposals of similar content or scope, NASA may recommend joint participation as a single project. In cases of partial or full duplication in content of an existing project or a proposal pending with another source, NASA will confer with the responsible source before a final disposition of the proposal.

## Appendix D
## INSTRUCTIONS FOR RESPONDING TO NASA RESEARCH ANNOUNCEMENTS (JANUARY 1997)[a]

(a) **General**.

(1) Proposals received in response to a NASA Research Announcement (NRA) will be used only for evaluation purposes. NASA does not allow a proposal, the contents of which are not available without restriction from another source, or any unique ideas submitted in response to an NRA to be used as the basis of a solicitation or in negotiation with other organizations, nor is a pre-award synopsis published for individual proposals.

(2) A solicited proposal that results in a NASA award becomes part of the record of that transaction and may be available to the public on specific request; however, information or material that NASA and the awardee mutually agree to be of a privileged nature will be held in confidence to the extent permitted by law, including the Freedom of Information Act.

(3) NRAs contain programmatic information and certain requirements which apply only to proposals prepared in response to that particular announcement. These instructions contain the general proposal preparation information which applies to responses to all NRAs.

(4) A contract, grant, cooperative agreement, or other agreement may be used to accomplish an effort funded in response to an NRA. NASA will determine the appropriate instrument. Contracts resulting from NRAs are subject to the Federal Acquisition Regulation and the NASA FAR Supplement. Any resultant grants or cooperative agreements will be awarded and administered in accordance with the NASA Grant and Cooperative Agreement Handbook (NPG 5800.1).

(5) NASA does not have mandatory forms or formats for responses to NRAs; however, it is requested that proposals conform to the guidelines in these instructions. NASA may accept proposals without discussion; hence, proposals should initially be as complete as possible and be submitted on the proposers' most favorable terms.

(6) To be considered for award, a submission must, at a minimum, present a specific project within the areas delineated by the NRA; contain sufficient technical and cost information to permit a meaningful evaluation; be signed by an official authorized to legally bind the submitting organization; not merely offer to perform standard services or to just provide computer facilities or services; and not significantly duplicate a more specific current or pending NASA solicitation.

(b) **NRA-Specific Items**. Several proposal submission items appear in the NRA itself: the unique NRA identifier; when to submit proposals; where to send proposals; number of copies required; and sources for more information. Items included in these instructions may be supplemented by the NRA.

(c) The following information is needed to permit consideration in an objective manner. NRAs will generally specify topics for which additional information or greater detail is desirable. Each proposal copy shall contain all submitted material, including a copy of the transmittal letter if it contains substantive information.

(1) **Transmittal Letter or Prefatory Material**.

(i) The legal name and address of the organization and specific division or campus identification if part of a larger organization;

(ii) A brief, scientifically valid project title intelligible to a scientifically literate reader and suitable for use in the public press;

(iii) Type of organization: e.g., profit, nonprofit, educational, small business, minority, women-owned, etc.;

(iv) Name and telephone number of the principal investigator and business personnel who may be contacted during evaluation or negotiation;

(v) Identification of other organizations that are currently evaluating a proposal for the same efforts;

(vi) Identification of the NRA, by number and title, to which the proposal is responding;

(vii) Dollar amount requested, desired starting date, and duration of project;

(viii) Date of submission; and

(ix) Signature of a responsible official or authorized representative of the organization, or any other person authorized to legally bind the organization (unless the signature appears on the proposal itself).

(2) **Restriction on Use and Disclosure of Proposal Information**. Information contained in proposals is used for evaluation purposes only. Offerors or quoters should, in order to maximize protection of trade secrets or other information that is confidential or privileged, place the following notice on the title page of the proposal and specify the information subject to the notice by inserting an appropriate identification in the notice. In any event, information contained in proposals will be protected to the extent permitted

by law, but NASA assumes no liability for use and disclosure of information not made subject to the notice.

Notice
Restriction on Use and Disclosure of Proposal Information

The information (data) contained in [insert page numbers or other identification] of this proposal constitutes a trade secret and/or information that is commercial or financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal the Government shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement). This restriction does not limit the Government's right to use or disclose this information (data) if obtained from another source without restriction.

(3) **Abstract**. Include a concise (200-300 word if not otherwise specified in the NRA) abstract describing the objective and the method of approach.

(4) **Project Description**.

(i) The main body of the proposal shall be a detailed statement of the work to be undertaken and should include objectives and expected significance; relation to the present state of knowledge; and relation to previous work done on the project and to related work in progress elsewhere. The statement should outline the plan of work, including the broad design of experiments to be undertaken and a description of experimental methods and procedures. The project description should address the evaluation factors in these instructions and any specific factors in the NRA. Any substantial collaboration with individuals not referred to in the budget or use of consultants should be described. Subcontracting significant portions of a research project is discouraged.

(ii) When it is expected that the effort will require more than one year, the proposal should cover the complete project to the extent that it can be reasonably anticipated. Principal emphasis should be on the first year of work, and the description should distinguish clearly between the first year's work and work planned for subsequent years.

(5) **Management Approach**. For large or complex efforts involving interactions among numerous individuals or other organizations, plans for distribution of responsibilities and arrangements for ensuring a coordinated effort should be described.

(6) **Personnel**. The principal investigator is responsible for supervision of the work and participates in the conduct of the research regardless of whether or not compensated under the award. A short biographical sketch of the principal investigator, a list of principal publications and any exceptional qualifications should be included. Omit social security number and other personal items which do not merit consideration in evaluation of the proposal. Give similar biographical information on other senior professional personnel who will be directly associated with the project. Give the names and titles of

any other scientists and technical personnel associated substantially with the project in an advisory capacity. Universities should list the approximate number of students or other assistants, together with information as to their level of academic attainment. Any special industry-university cooperative arrangements should be described.

(7) **Facilities and Equipment**.

(i) Describe available facilities and major items of equipment especially adapted or suited to the proposed project, and any additional major equipment that will be required. Identify any Government-owned facilities, industrial plant equipment, or special tooling that are proposed for use. Include evidence of its availability and the cognizant Government points of contact.

(ii) Before requesting a major item of capital equipment, the proposer should determine if sharing or loan of equipment already within the organization is a feasible alternative. Where such arrangements cannot be made, the proposal should so state. The need for items that typically can be used for research and non-research purposes should be explained.

(8) **Proposed Costs**.

(i) Proposals should contain cost and technical parts in one volume: do not use separate "confidential" salary pages. As applicable, include separate cost estimates for salaries and wages; fringe benefits; equipment; expendable materials and supplies; services; domestic and foreign travel; ADP expenses; publication or page charges; consultants; subcontracts; other miscellaneous identifiable direct costs; and indirect costs. List salaries and wages in appropriate organizational categories (e.g., principal investigator, other scientific and engineering professionals, graduate students, research assistants, and technicians and other non-professional personnel). Estimate all staffing data in terms of staff-months or fractions of full-time.

(ii) Explanatory notes should accompany the cost proposal to provide identification and estimated cost of major capital equipment items to be acquired; purpose and estimated number and lengths of trips planned; basis for indirect cost computation (including date of most recent negotiation and cognizant agency); and clarification of other items in the cost proposal that are not self-evident. List estimated expenses as yearly requirements by major work phases.

(iii) Allowable costs are governed by FAR Part 31 and the NASA FAR Supplement Part 1831 (and OMB Circulars A-21 for educational institutions and A-122 for nonprofit organizations).

(9) **Security**. Proposals should not contain security classified material. If the research requires access to or may generate security classified information, the submitter will be required to comply with Government security regulations.

(10) **Current Support**. For other current projects being conducted by the principal investigator, provide title of project, sponsoring agency, and ending date.

(11) **Special Matters**.

(i) Include any required statements of environmental impact of the research, human subject or animal care provisions, conflict of interest, or on such other topics as may be required by the nature of the effort and current statutes, executive orders, or other current Government-wide guidelines.

(ii) Proposers should include a brief description of the organization, its facilities, and previous work experience in the field of the proposal. Identify the cognizant Government audit agency, inspection agency, and administrative contracting officer, when applicable.

(d) **Renewal Proposals**

(1) Renewal proposals for existing awards will be considered in the same manner as proposals for new endeavors. A renewal proposal should not repeat all of the information that was in the original proposal. The renewal proposal should refer to its predecessor, update the parts that are no longer current, and indicate what elements of the research are expected to be covered during the period for which support is desired. A description of any significant findings since the most recent progress report should be included. The renewal proposal should treat, in reasonable detail, the plans for the next period, contain a cost estimate, and otherwise adhere to these instructions.

(2) NASA may renew an effort either through amendment of an existing contract or by a new award.

(e) **Length**. Unless otherwise specified in the NRA, effort should be made to keep proposals as brief as possible, concentrating on substantive material. Few proposals need exceed 15-20 pages. Necessary detailed information, such as reprints, should be included as attachments. A complete set of attachments is necessary for each copy of the proposal. As proposals are not returned, avoid use of "one-of-a-kind" attachments.

(f) **Joint Proposals**.

(1) Where multiple organizations are involved, the proposal may be submitted by only one of them. It should clearly describe the role to be played by the other organizations and indicate the legal and managerial arrangements contemplated. In other instances,

simultaneous submission of related proposals from each organization might be appropriate, in which case parallel awards would be made.

(2) Where a project of a cooperative nature with NASA is contemplated, describe the contributions expected from any participating NASA investigator and agency facilities or equipment which may be required. The proposal must be confined only to that which the proposing organization can commit itself. "Joint" proposals which specify the internal arrangements NASA will actually make are not acceptable as a means of establishing an agency commitment.

(g) **Late Proposals**. A proposal or modification received after the date or dates specified in an NRA may be considered if doing so is in the best interests of the Government.

(h) **Withdrawal**. Proposals may be withdrawn by the proposer at any time before award. Offerors are requested to notify NASA if the proposal is funded by another organization or of other changed circumstances which dictate termination of evaluation.

(i) **Evaluation Factors**

(1) Unless otherwise specified in the NRA, the principal elements (of approximately equal weight) considered in evaluating a proposal are its relevance to NASA's objectives, intrinsic merit, and cost.

(2) Evaluation of a proposal's relevance to NASA's objectives includes the consideration of the potential contribution of the effort to NASA's mission.

(3) Evaluation of its intrinsic merit includes the consideration of the following factors of equal importance:

(i) Overall scientific or technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal.

(ii) Offeror's capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives.

(iii) The qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel critical in achieving the proposal objectives.

(iv) Overall standing among similar proposals and/or evaluation against the state-of-the-art.

(4) Evaluation of the cost of a proposed effort may include the realism and reasonableness of the proposed cost and available funds.

(j) **Evaluation Techniques**. Selection decisions will be made following peer and/or scientific review of the proposals. Several evaluation techniques are regularly used within NASA. In all cases proposals are subject to scientific review by discipline specialists in the area of the proposal. Some proposals are reviewed entirely in-house, others are evaluated by a combination of in-house and selected external reviewers, while yet others are subject to the full external peer review technique (with due regard for conflict-of-interest and protection of proposal information), such as by mail or through assembled panels. The final decisions are made by a NASA selecting official. A proposal which is scientifically and programmatically meritorious, but not selected for award during its initial review, may be included in subsequent reviews unless the proposer requests otherwise.

(k) **Selection for Award**.

(1) When a proposal is not selected for award, the proposer will be notified. NASA will explain generally why the proposal was not selected. Proposers desiring additional information may contact the selecting official who will arrange a debriefing.

(2) When a proposal is selected for award, negotiation and award will be handled by the procurement office in the funding installation. The proposal is used as the basis for negotiation. The contracting officer may request certain business data and may forward a model award instrument and other information pertinent to negotiation.

(l) **Cancellation of NRA**. NASA reserves the right to make no awards under this NRA and to cancel this NRA. NASA assumes no liability for canceling the NRA or for anyone's failure to receive actual notice of cancellation.

[a]note: in the event of conflicts between provisions of Appendix C and Appendix D, the provisions of Appendix C will govern

## Appendix E

## GUIDELINES FOR FOREIGN PARTICIPATION

NASA accepts proposals from entities located outside the U.S. in response to this NRA. Proposals from non-U.S. entities should not include a cost plan as they are make on a no-exchange-of-funds basis. Non-U.S. proposals, and U.S. Proposals that include non-U.S. participation, must be endorsed by the respective government agency or funding/sponsoring institution in the country from which the non-U.S. participant is proposing. Such endorsement should indicate the following points: (1) The proposal merits careful consideration by NASA; and (2) If the proposal is selected, sufficient funds will be made available by the sponsoring foreign agency to undertake the activity as proposed.

Proposals, along with the requested number of copies and Letter of Endorsement must be forwarded to NASA in time to arrive before the deadline established for this NRA. In addition, one copy of each of these documents should be sent to:

NASA Headquarters
Office of External Relations
Earth Science Division, Code IY
Washington, DC 20546
USA

Any materials sent by courier or express mail should include the street address 300 E Street, S. W., and substitute 20024 for the indicated ZIP code.

All proposals must be typewritten in English. All non-U.S. proposals will undergo the same evaluation and selection process as those originating in the U.S. Non-U.S. proposals and U. S. Proposals that include non-U.S. participation, must follow all other guidelines and requirements described in this NRA. Sponsoring non-U.S. agencies may, in exceptional situations, forward a proposal without endorsement to the above address, if review and endorsement are not possible before the announced closing date. In such cases, however, NASA's Earth Science Division of the Office of External Relations should be advised when a decision on the endorsement is to be expected.

Successful and unsuccessful proposers will be contacted directly by the NASA Program Office coordinating the NRA. Copies of these letters will be sent to the sponsoring government agency.

**Appendix F**

**Proposal Cover Page**
**Land Surface Hydrology Program**
**NASA Research Announcement 98-OES-11**

Proposal No. _____ (Leave Blank for NASA Use)

Title: _____

Principal Investigator::_____

Department:_____

Institution: _____

Street/PO Box: _____

City: _____ State: _____ Zip: _____

Country: _____ E-mail: _____

Telephone: _____ Fax: _____

Co-Investigators:

| Name | Institution | Telephone |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

**Priority topics**

____ 1. Use of remote sensing and in situ data from intensive field campaigns to improve hydrologic prediction
____ 2. Hydrologic impacts of land use-land cover change.
____ 3. Development of data assimilation methods for hydrologic applications.
____ 4. Other topics of interest to the NASA LSHP

Budget:
1st Year: _____ 2nd Year: _____ 3rd Year: _____ Total: _____

Certification of Compliance with Applicable Executive Orders and U.S. Code **(not required for Step 1 proposals)

By submitting the proposal identified in this *Cover Sheet/Proposal Summary* in response to this Research Announcement, the Authorizing Official of the proposing institution (or the individual proposer if there is no proposing institution) as identified below:

- certifies that the statements made in this proposal are true and complete to the best of his/her knowledge;
- agrees to accept the obligations to comply with NASA award terms and conditions if an award is made as a result of this proposal; and
- confirms compliance with all provisions, rules, and stipulations set forth in the two Certifications contained in this NRA [namely, (i*) Certification of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs*, *and (ii) Certifications, Disclosures, And Assurances Regarding Lobbying and Debarment & Suspension*].

Willful provision of false information in this proposal and/or its supporting documents, or in reports required under an ensuing award, is a criminal offense (U.S. Code, Title 18, Section 1001).

Title of Authorizing Institutional Official: _____

Signature: _____ Date: _____

Name of Proposing Institution: _____

Telephone: _____ E-mail:_____ Facsimile: _____

**Certification of Compliance with the NASA Regulations Pursuant to Nondiscrimination in Federally Assisted Programs **(not required for Step 1 proposals)**

The *(Institution, corporation, firm, or other organization on whose behalf this assurance is signed, hereinafter called "Applicant ")* hereby agrees that it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), Title IX of the Education Amendments of 1962 (20 U.S.C. 1680 et seq.), Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and the Age Discrimination Act of 1975 (42 U.S.C. 16101 et seq.), and all requirements imposed by or pursuant to the Regulation of the National Aeronautics and Space Administration (14 CFR Part 1250) (hereinafter called "NASA") issued pursuant to these laws, to the end that in accordance with these laws and regulations, no person in the United States shall, on the basis of race, color, national origin, sex, handicapped condition, or age be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant receives federal financial assistance from NASA; and hereby give assurance that it will immediately take any measure necessary to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of federal financial assistance extended to the Applicant by NASA, this assurance shall obligate the Applicant, or in the case of any transfer of such property, any transferee, for the period during which the real property or structure is used for a purpose for which the federal financial assistance is extended or for another purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance shall obligate the Applicant for the period during which the federal financial assistance is extended to it by NASA.

this assurance is given in consideration of and for the purpose of obtaining any and all federal grants, loans, contracts, property, discounts, or other federal financial assistance extended after the date hereof to the Applicant by NASA, including installment payments after such date on account of applications for federal financial assistance which were approved before such date. The Applicant recognized and agrees that such federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign on behalf of the Applicant.

NASA FORM 1206

**CERTIFICATIONS, DISCLOSURES, AND ASSURANCES**
**REGARDING LOBBYING AND DEBARMENT & SUSPENSION**
****(not required for Step 1 proposals)**

## 1. LOBBYING

As required by Section 1352, Title 31 of the U.S. Code, and implemented at 14 CFR Part 1271, as defined at 14 CFR Subparts 1271.110 and 1260.117, with each submission that initiates agency consideration of such applicant for award of a Federal contract, grant, or cooperative agreement exceeding $ 100,000, the applicant must **certify** that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit a Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

## 2. GOVERNMENTWIDE DEBARMENT AND SUSPENSION

As required by Executive Order 12549, and implemented at 14 CFR 1260.510, for prospective participants in primary covered transactions, as defined at 14 CFR Subparts 1265.510 and 1260.117—

(1) The prospective primary participant **certifies** to the best of its knowledge and belief, that it and its principals:

(a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded by any Federal department or agency.

(b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, or receiving stolen property;

(c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (l)(b) of this certification; and

(d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.

(2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

BUDGET SUMMARY **(not required for Step 1 proposals)

For period from _____ to _____

- Provide a complete Budget Summary for year one and separate estimated for each subsequent year.
- Enter the proposed estimated costs in Column A (Columns B & C for NASA use only).
- Provide as attachments detailed computations of all estimates in each cost category with narratives as required to fully explain each proposed cost. See *Instructions For Budget Summary* on following page for details.

| | | | NASA USE ONLY | |
|---|---|---|---|---|
| | | **A** | **B** | **C** |
| 1. | Direct Labor (salaries, wages, and fringe benefits) | _____ | _____ | _____ |
| 2. | Other Direct Costs: | | | |
| | a. Subcontracts | _____ | _____ | _____ |
| | b. Consultants | _____ | _____ | _____ |
| | c. Equipment | _____ | _____ | _____ |
| | d. Supplies | _____ | _____ | _____ |
| | e. Travel | _____ | _____ | _____ |
| | f. Other | _____ | _____ | _____ |
| 3. | Facilities and Administrative Costs | _____ | _____ | _____ |
| 4. | Other Applicable Costs: | _____ | _____ | _____ |
| 5. | SUBTOTAL--Estimated Costs | _____ | _____ | _____ |
| 6. | Less Proposed Cost Sharing (if any) | _____ | _____ | _____ |
| 7. | Carryover Funds (if any) | | | |
| | a. Anticipated amount : | _____ | | |
| | b. Amount used to reduce budget | _____ | _____ | _____ |
| 8. | Total Estimated Costs | _____ | _____ | XXXXXXX |
| 9. | APPROVED BUDGET | XXXXXX | XXXXXXX | _____ |

# INSTRUCTIONS FOR BUDGET SUMMARY

1. Direct Labor (salaries, wages, and fringe benefits): Attachments should list the number and titles of personnel, amounts of time to be devoted to the grant, and rates of pay.

2. Other Direct Costs:
    a. Subcontracts: Attachments should describe the work to be subcontracted, estimated amount, recipient (if known), and the reason for subcontracting.
    b. Consultants: Identify consultants to be used, why they are necessary, the time they will spend on the project, and rates of pay (not to exceed the equivalent of the daily rate for Level IV of the Executive Schedule, exclusive of expenses and indirect costs).
    c. Equipment: List separately. Explain the need for items costing more than $5,000. Describe basis for estimated cost. General purpose equipment is not allowable as a direct cost unless specifically approved by the NASA Grant Officer. Any equipment purchase requested to be made as a direct charge under this award must include the equipment description, how it will be used in the conduct of the basic research proposed and why it cannot be purchased with indirect funds.
    d. Supplies: Provide general categories of needed supplies, the method of acquisition, and the estimated cost.
    e. Travel: Describe the purpose of the proposed travel in relation to the grant and provide the basis of estimate, including information on destination and number of travelers where known.
    f. Other: Enter the total of direct costs not covered by 2a through 2e. Attach an itemized list explaining the need for each item and the basis for the estimate.

3. Facilities and Administrative (F&A) Costs: Identify F&A cost rate(s) and base(s) as approved by the cognizant Federal agency, including the effective period of the rate. Provide the name, address, and telephone number of the Federal agency official having cognizance. If unapproved rates are used, explain why, and include the computational basis for the indirect expense pool and corresponding allocation base for each rate.

4. Other Applicable Costs: Enter total explaining the need for each item.

5. Subtotal-Estimated Costs: Enter the sum of items 1 through 4.

6. Less Proposed Cost Sharing (if any): Enter any amount proposed. If cost sharing is based on specific cost items, identify each item and amount in an attachment.

7. Carryover Funds (if any): Enter the dollar amount of any funds expected to be available for carryover from the prior budget period Identify how the funds will be used if they are not used to reduce the budget. NASA officials will decide whether to use all or part of the anticipated carryover to reduce the budget (not applicable to 2nd-year and subsequent-year budgets submitted for award of a multiple year award).

8. Total Estimated Costs: Enter the total after subtracting items 6 and 7b from item 5.