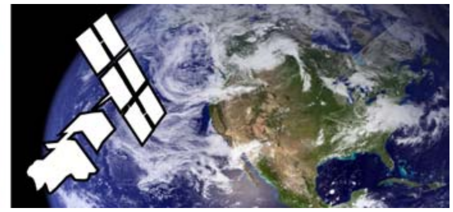

January 8, 2003

Drs. Ghassem Asrar, Jared Entin, and Jack Kaye
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Dear Drs. Asrar, Entin, and Kaye

The NASA Surface Water working group is funded through the Terrestrial Hydrology Program (THP) of NASA's Earth Science Enterprise (ESE). We are an outgrowth of the post-2002 mission planning process, and in particular our July, 1999 white paper [*Vörösmarty et al.,* 1999]. This letter is intended to summarize the goals and achievements of our working group to date. Our hope is that the comments contained herein will be useful in developing future ESE science and technology NRAs and more generally in ESE's long-term planning (e.g., the "Roadmap").

River discharge as well as lake and wetland storage of water are critical terms in the surface water balance, yet they are poorly observed globally and the prospects for improvement from *in-situ* networks are bleak [e.g., *Shiklomanov et al,* 2002; *IAHS,* 2001; *Stokstad,* 1999]. Considering this, and following some discussion and refinement of the 1999 white paper, our working group has decided to focus on the following science and applications questions:

(1) *What are the observational and data assimilation requirements for measuring natural and manmade surface storage and river discharge that will allow us to*
   a. *understand the land surface branch of the global hydrologic cycle,*
   b. *predict the consequences of global change, and*
   c. *make assessments for water resources management?*

(2) *What are the roles of wetlands, lakes, and rivers*
   a. *as regulators of biogeochemical cycles (e.g., carbon and nutrients) and*
   b. *in creating or ameliorating water-related hazards of relevance to society?*

Global models of weather and climate could be constrained spatially and temporally by stream discharge and surface storage measurements. Stream discharge, in particular, is an appealing component of the surface hydrologic cycle to measure because it represents a spatial integration of watershed processes. Yet this constraint is rarely applied, despite weather and climate modeling results showing that predicted precipitation is often inconsistent with observed discharge. For example, *Lenters et al* [2000], using NCEP/NCAR reanalysis data over the continental U.S., found that model predictions of runoff are often in error by 50%, and even 100% mismatches with observations were not uncommon. *Coe* [2000] found similar results for many of the world's large river basins. Hydrologists recognize the great potential of this constraint and such research is underway but is limited to historical periods, and where stream flow observations are readily available. So, although global earth system models continue to improve through incorporation of better soils, topography, and land use and cover maps, these models are now becoming limited as a consequence of the decline in observations of discharge and water storage. As current and proposed global observations of precipitation, snow, and soil moisture evolve, we believe there will be an increasing demand for constraining measurements of surface water storage and river discharge. Thus, as NASA develops missions for global observations of critical hydrologic parameters such as soil moisture (i.e., HYDROS) and precipitation (i.e., GPM), the lack of concomitant measurements of runoff and surface water storage at compatible spatial and temporal scales may well result in inconsistent parameterizations of global hydrologic, weather, and climate models.

Global observations of wetland, lake, and river hydrology also provide the scientific underpinnings for our comprehension of land surface hydrological processes. For the past ~100 years, our understanding of the hydraulic characteristics and hydrologic mass-balances of surface water runoff have largely been derived from discharge measurements at in-channel gauging stations. Measurement of in-channel discharge unfortunately does not provide the information necessary for understanding flow and storage in off-river-channel environments, such as wetlands, floodplains, and anabranches (e.g., braided channels). These environments are increasingly recognized for their important roles in biogeochemical cycling of waterborne constituents, and in trace gas exchange with the atmosphere. Wetlands and surface water cover ~4% of the earth's landmass [*Prigent et al.,* 2001], and these environments are disproportionately important in global budgets of atmospheric carbon dioxide and methane, and possibly other greenhouse gases that are presently unobserved [*Richey et al.,* 2002]. For example, the mean annual area of flooded wetlands in the tropical lowlands of South America has recently been estimated at 0.73 million km^2, or 14% of the total land lying below an elevation of 500 m [*Melack et al,* in review], and most of this area is floodplain that is hydrologically connected to the major rivers. Rather than fixed station measurements, remote sensing offers the only practical way to determine the spatial and temporal patterns of inundation and water storage of these areas, which in turn are required to estimate their role in gas exchange and in impacting riverine fluxes of water, sediments, and nutrients to the ocean.

In addition to the scientific interests and challenges that could be addressed by global remote sensing of surface water storage and discharge, there are important practical implications as well. For instance, *Vörösmarty et al.* [2000] describe the global societal effects from increasing demands for freshwater. These demands will place a premium on better management of water resources – especially in parts of the world where surface networks are sparse or nonexistent. There are related national security issues associated with the management of water in parts of the world where surface water information is unavailable. Furthermore, with population growth and economic expansion, society is increasingly at risk from potentially more severe water-related extremes in weather, which include not only flooding but drought as well [*van der Wink et al.,* 1998].

Thus, we are addressing several of ESE's science questions. Regarding *variability*, we are attempting to answer "How are global precipitation, evaporation, and the cycling of water changing?" and "How are global ecosystems changing?" With respect to *response*, we are focusing on "What are the effects of clouds and surface hydrologic processes on Earth's climate?" and "How do ecosystems respond to and affect global environmental change and the carbon cycle?" Resulting *consequences* that we are addressing include "How are variations in local weather, precipitation and water resources related to global climate variation?" Important *prediction* questions we are trying to answer include "How can weather forecast duration and reliability be improved by new space-based observations, data assimilation, and modeling?"

There are great opportunities on the horizon for answering these questions. For example, members of our working group have utilized various satellite data sets to derive braided river discharge [*Smith et al.,* 1996], river and lake water heights [*Birkett,* 1998], and floodplain storage changes [*Alsdorf et al.,* 2000]. Although none of these approaches is ideal, in part because they all rely on instruments and platforms designed for other purposes, we believe the advances based on this research provide direction for instrument improvements. For example, at our most recent meeting in November 2002, Ernesto Rodriguez and Yunjin Kim of JPL sketched-out a small, cost-effective interferometric SAR that may be able to provide measurements of water heights and flow velocities. Other instruments, such as lidar systems, also need investigation. A set of stream and lake targets at which ICESat observations will be collected during a test period in early 2003 will provide some information in this respect.

We hope that this summary of our working group's activities and perspectives will help in the development of ESE's long term vision, and in the shorter range facilitation of science and technology development efforts. To help facilitate these concepts, we will contact you to determine when we can present and discuss activities in person. In the meantime, more information about our working group can be found on our web site (www.swa.com/hydrawg), or feel free to contact any of us.

Sincerely,

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