NASA's Goals for GOFC

Martha E. Maiden
Information System Specialist
Office of Earth Science, Research Division
mmaiden@hq.nasa.gov

Why GOFC Is Important to NASA

1) GOFC questions mirror questions posed by the NASA Earth Science Enterprise Research Strategy for 2000-2010, which drives our program

2) NASA plays a major role in USGCRP Carbon Initiative.

3) NASA has increased its emphasis on demonstrating societal relevance of its space-borne assets: we have an applications division, and multiple programs joint programs with such agencies as USGS, USDA (Forest Service) DoT.

4) The importance of forests in the world today, the post-Kyoto era.

5) The desire by NASA to contribute to the Integrated Global Observing Strategy. NASA is a member of CEOS, which is an IGOS Partner.

ESE Research Strategy for 2000-2010

The key research topics studied by NASA's Earth Science Enterprise fall largely into three categories: forcings, responses, and the processes that link the two and provide feedback mechanisms. This conceptual approach applies in essence to all research areas of NASA's Earth science program, although it is particularly relevant to the problem of climate change, a major Earth science-related issue facing the countries of the world. The scientific strategy to address this immensely complex problem can be laid out in five steps or fundamental questions, each raising a wide range of cross-disciplinary science problems.

- ***How is the global Earth system changing?***
- ***What are the primary forcings of the Earth system?***
- ***How does the Earth system respond to natural and human-induced changes?***
- ***What are the consequences of change in the Earth system for human civilization?***
- ***How well can we predict the changes to the Earth system that will take place in the future?***

How are global ecosystems changing?

Variations and trends in the productivity, composition, and health of terrestrial and marine ecosystems are a significant aspect of Earth system variability. In addition to the production of food and fiber, ecosystems govern the changes in the Earth's biogeochemical cycles, especially the carbon cycle, and modulate the cycling of water over land through changes in storage capacity and evapotranspiration. Peaks in marine primary productivity (blooms) usually occur when oceanic motions bring nutrient-rich waters into the well-lit upper oceans. Such events often dominate the downward flux of organic carbon. Terrestrial primary productivity varies more predictably with the seasons over much of the Earth's land surface, initiating photosynthesis and growth after the thawing of frozen soils or with the onset of a rainy season, peaking when environmental conditions are optimal, and declining when temperatures drop below freezing or with the onset of seasonal drought. Annual primary productivity does vary significantly from one year to the next in response to a variety of environmental factors, such as changes in nutrient supply and extreme or variable weather events. ***Satellite observations provide the only means to obtain a global view of the Earth's ecosystems, their spatial distribution, extent, and temporal dynamics, and to estimate changes in primary productivity. This information is needed globally, at moderate spatial resolution (hundreds of meters to a kilometer) and high frequency (daily or near-daily), and can be derived from the analysis of moderate-resolution multispectral image data obtained by operational and research satellites.***

ESE Research Strategy for 2000-2010

What are the changes in global land cover and land use, and what are their causes?

Biophysical phenomena and human activities that drive changes in land cover and land use include changes in agricultural practices, natural and human-triggered fires, drought and flooding, forest exploitation and clearing, grazing by domestic animals, and urbanization. Each of these phenomena can cause considerable disturbance or stress in natural and managed ecosystems, and consequently the whole Earth system. In combination, these changes in land cover and land use have grown to become a major factor of landscape modification, affecting ecosystem productivity and biogeochemical cycles; regional climates and hydrologic regimes; soil erosion and sediment transport. Documenting these changes and investigating their causes requires observations at the spatial scales of the disturbance or stress factors themselves, often on the order of tens of meters. ***The observational requirements are for periodic global inventories of land cover and land use, derived from observations repeated once or a few times per year. This information is obtained from systematic global multispectral mapping of the land cover at spatial resolution of a few meters. The potential of meter-class resolution ("hyperspatial") mapping is being investigated for sharper diagnosis of causal factors and likely future trends.***

How do ecosystems respond to environmental change and affect the global carbon cycle?

Terrestrial and marine ecosystems are affected by multiple environmental stresses and disturbances that can result in changes in primary productivity, continental and oceanic carbon sources and sinks, and the biogeochemical cycles of carbon and other important nutrients. Response processes in ecosystems need to be understood at the level of basic functional and structural changes. Ecosystem functional responses involve changes in physiology and biogeochemical cycling. Ecosystem structural responses involve changes in species composition, biomass density, canopy architecture, and distribution patterns across a landscape or within the ocean.

In order to estimate carbon sources and sinks on the land, ecosystem science needs to quantify the responses of terrestrial ecosystems to disturbance in terms of ***biomass changes***, and consequent carbon sequestration or emission. There is no direct method for estimating total biomass by remote measurements, but quantifying above-ground biomass appears feasible, based on experiments performed from the Space Shuttle. A fuller implementation of this concept is under development, and future exploratory projects have been proposed, to address biomass accumulation in ecosystems responding to disturbance.

The global ocean carbon cycle is dominated by the solubility pump (changes in the ability of the ocean take up CO_2), which is driven by changes in ocean temperature and circulation. The biological pump is another critical component of the ocean carbon cycle and involves sinking, diffusion, and active transport of biologically-produced carbon compounds. The CO_2 balance of the atmosphere and ocean can be affected by the biological pump through changes in limiting nutrient supplies. The observational requirements are long-term observations of the ocean circulation and temperature, ocean productivity, and estimates of the major phytoplankton groups in the upper ocean. Coastal ecosystems are highly productive and extremely variable, and human impacts on the ocean are greatest in coastal regions, as are the impacts of climate variability and sea-level rise. Thus, priority is given to quantifying variability in ***coastal primary productivity***. Coastal biological processes are constrained by geography and can be characterized by observations that resolve weather-induced changes (e. g. transient sediment transport events) and tidal fluxes. The principal observational requirement is quasi-continuous observation of ocean color in selected coastal regions, with appropriate spatial, temporal and spectral resolution (on order of hundred of meters, hours, and five spectral channels, respectively).

Quantifying regional ***carbon sources and sinks*** for both the ocean and land can be approached through the inversion of precise measurements of spatial and temporal variations in the total column amount of CO_2 in the atmosphere. The method, founded on the use of inverse atmospheric transport models for analyzing atmospheric concentration data, has the potential for independent direct determination of global CO_2 fluxes. Possible space-based measurement methods are at an early conceptual stage.

What are the consequences of land cover and land use change?

To understand the consequences of land cover and land use change for sustainability of ecological goods and services, both the biophysical and the human factors that drive land cover and land use changes must be addressed. Natural and human-induced disturbances such as fire, insect infestations, and logging may change large areas of the Earth's surface, but more subtle changes that result in habitat degradation and fragmentation (e. g., forest clearing and/or burning, land use change associated with urbanization) or the introduction of non-native species can lead to diminished ecosystem functionality, redistribution of species within an area, and/or loss of biodiversity. The impacts on agriculture, forestry, and water resources; biodiversity; carbon storage or release; and the geographic distribution and activities of human populations need to be quantified. ***Satellite observations, especially high-resolution multispectral image data acquired to estimate primary productivity, document land cover patterns, or assess change in ecosystem properties, also can contribute to assessing such consequences and identifying those regions most susceptible to changes in species distributions.*** The verification of these changes and the identification of the impacted species is best carried out through *in situ* studies that will typically be carried out by agencies other than NASA.

White House Press Release, Sept. 7

President Clinton is strongly committed to working with the United Nations and the United States' international partners to strengthen environmental protections worldwide and to meet the vision of a sustainable future outlined in the Secretary General's Millennium Report.

Protecting the world's sensitive ecosystems. The United States is actively supporting the Millennium Ecosystem Assessment (an international study on the status of the world's ecosystems that is currently getting underway). Today, in his speech to the Security Council, the President announced *that the United States would contribute the first complete set of detailed, up-to-date satellite images of the world's forest ecosystems to the Assessment. The National Aeronautics and Space Administration will work with other U. S. agencies to assemble and provide these images from its TERRA and Landsat satellites over the next six months, with subsequent updates. This data will help researchers to understand better the status of forests and provide policymakers with new tools to help control illegal logging, conserve threatened forest areas, and promote sustainable economic growth. This effort builds on previous U.S. contributions of scientific data to international assessments of ozone depletion and climate change, and the data will be shared with the public and other interested parties.*

NASA's Relevance to GOFC

Missions

Landsat-7

Terra - MODIS, ASTER (with MITI, Japan), MISR

Aqua - MODIS

* SeaWiFS

* SRTM Shuttle Radar Topography Mission

* NPP >>>> Bridge mission to NPOESS

Research

Land Cover Land Use Change Program

-NASA NRA-99 had two elements:

1) Human and natural disturbance and the implications for carbon dynamics, and

2) Development of remote sensing techniques and data sets that could lead to operational forest monitoring systems

LBA Project houses the Brazilian component of LCLUC Program

Modeling and Data Analysis Program houses the Pathfinder Data Set component

NASA's Relevance to GOFC, 2

<u>Data and Information Systems and Services</u>

EOSDIS makes standard products available to all users, nondiscriminatory basis

Earth Science Information Partners - science and technology for targeted users

- Tropical Rainforest Information Center - MSU
- Global Land Cover Facility - UMD

  * both ESIPs: provision of data for FRA2000

NASA GOFC-DISS

- NASA-affiliated earth scientists, information scientists, engineers building infrastructure to expose NASA-related products and services to GOFC
- NASA participation in WGISS Test Facility

Cal/Val

- EOS Cal/val provides Jeff Privette chair of CEOS Cal/Val's Validation of Land Surface Parameter Subgroup

<u>GOFC Project</u>

Co-Chair from origin of GOFC, participation in design phase

Provides Liaison to GOFC Project Office

Supporting Regional Networks through IGBP/START

GOFC Goals/ CEOS WGISS Contributions

GOFC Project Implementation – test of IGOS

- **Goals: Global Change, Forests and Carbon, Forest Resource Management via the following implementation activities:**
  - **Forest Cover**
  - **Fire**
  - **Forest Biophysical Parameters**
- **Two scales of activity**
  - **Regional – sustained operational use – regionalization of GC, regional science/user networks as a means to engage and support national and local studies and use**
  - **Global - consistent coverage, global statistics, global modeling**

WGISS Contributions to GOFC Goals

- **Data availability - acquisition and operational continuity**
- **Ease of getting and using data**
  - **Determining availability, accessing multiple sources, data quality, using multiple formats**
- **Linking EO data to users' data and in-situ data**

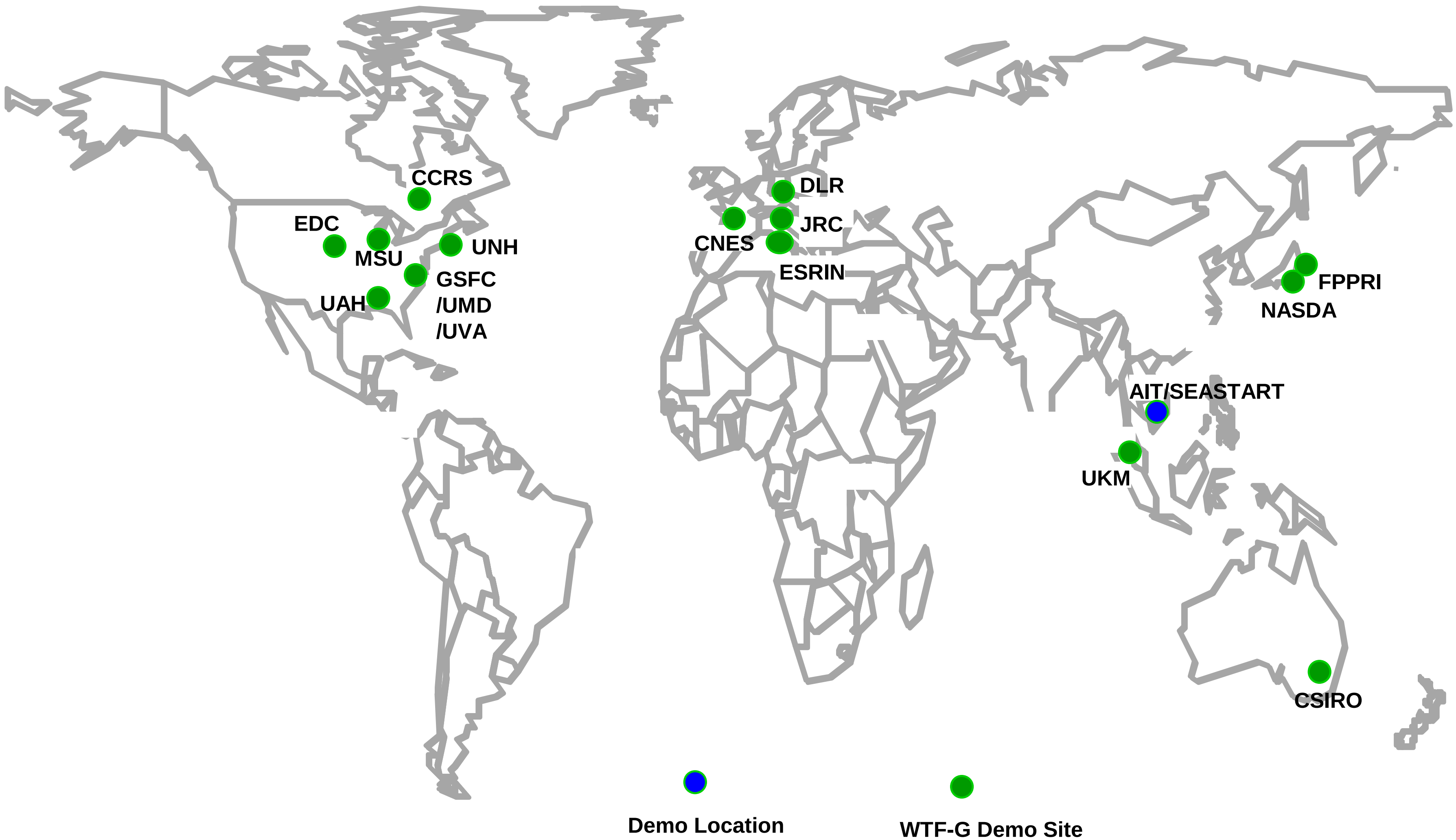
WGISS Test Facility: September 2000

WGISS Subgroups meeting hosted by NASDA and the National Research Council of Thailand (NRCT)

Here is a preliminary list of the WTF-G demos planned:

- World Fire Web (European Commission Joint Research Center)
- Earth Explorer (USGS EDC)
- Data Warehouse/CEONet (CCRS/USGS EDC)
- Tropical Rainforest Information System (Michigan State University, University of Kuala Lumpur, Maylasia)
- EOLI/MUIS (ESA ESRIN)
- Space-Time-Toolkit (University of Alabama Huntsville)
- MOCHA (University of Maryland)
- MODIS Fire (University of Virginia)
- DIAL OGC/WMT Demo (Raytheon ITSS, NASDA, Saga University, SEA START RC, NASA/GSFC, ACORS/AIT/Bangkok)
- GOFC International Directory Network Portal (NASA/GSFC)
- SPOT VEGETATION Data Access (SPOT Image, CNES)

Bangkok Demo Sites as of July 2000



Bangkok WTF-G Demos: Sept. 2000
Network Configuration