WECHO: A Water and Energy Cycle EOS Clearing House Client

NASA-ROSES 2006 A.19: Advancing Collaborative Connections for Earth System Science

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Center for Research on Environment and Water

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GEORGE MASON UNIVERSITY

Water Cycle Research Making a Difference

http://crew.iges.org

The Water and Energy Cycle

Water in the climate system functions on all time scales: From hours to centuries

The Energy and Water Cycles are *tightly intertwined* – Solar radiation drives and feedbacks with the water cycle, and energy is transferred through water movement and phase change.

Importance of global water and energy cycling

1.Water exists in all three phases in the climate system and the phase transitions are a significant factor in the regulation of the global and regional energy balances

2.Water vapor in the atmosphere is the principal greenhouse gas and clouds at various levels and composition in the atmosphere represent both positive and negative feedback in climate system response

3.Water is the ultimate solvent and global biogeochemical and element cycles are mediated by the dynamics of the water cycle

4.Water is the element of the Earth system that most directly impacts and constraint human society and its well-being.

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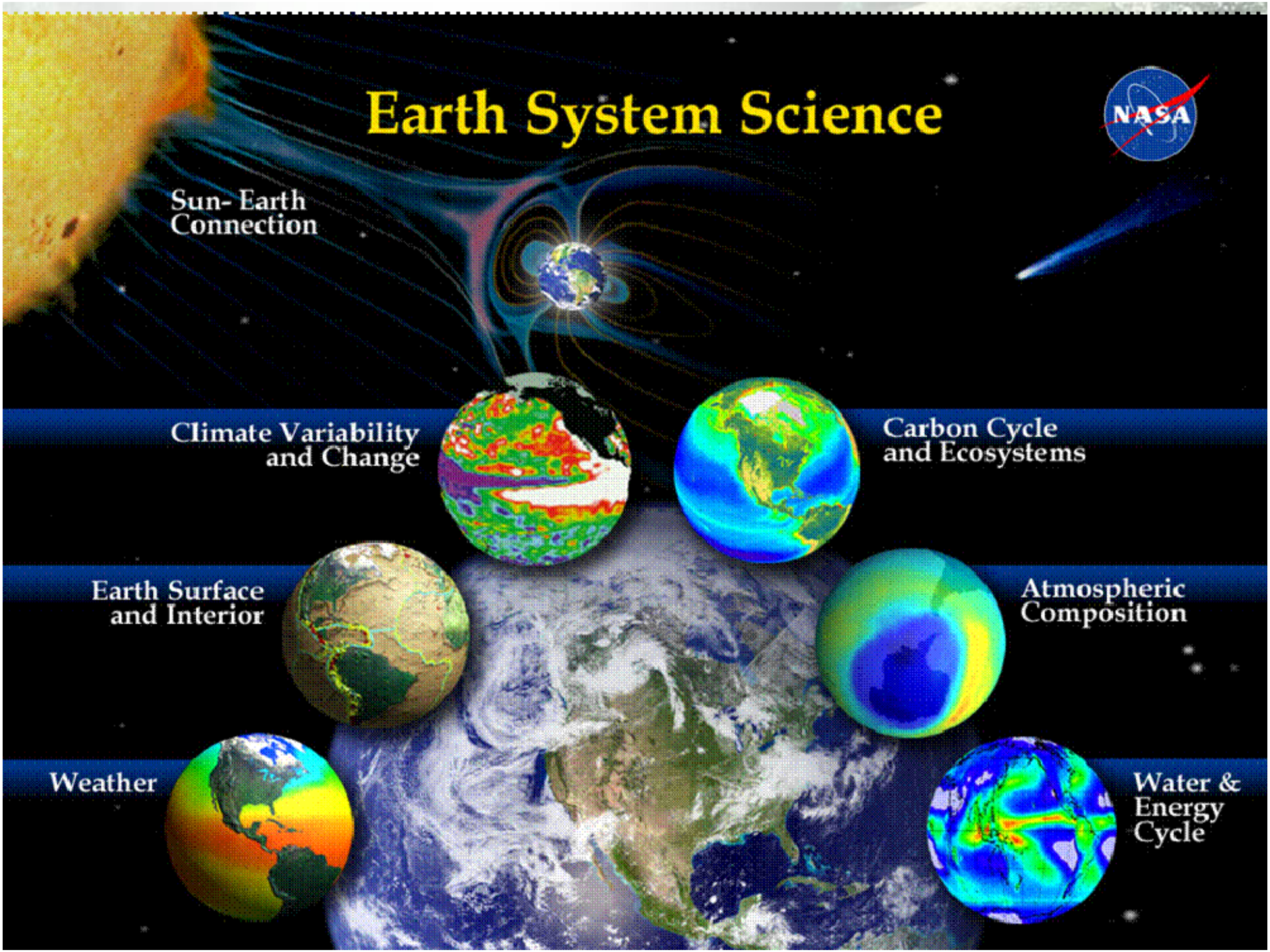
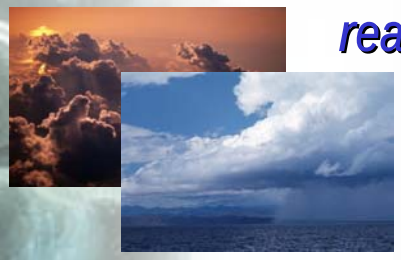

Earth System Science
NASA
Sun- Earth Connection
Climate Variability and Change
Carbon Cycle and Ecosystems
Earth Surface and Interior
Atmospheric Composition
Weather
Water & Energy Cycle

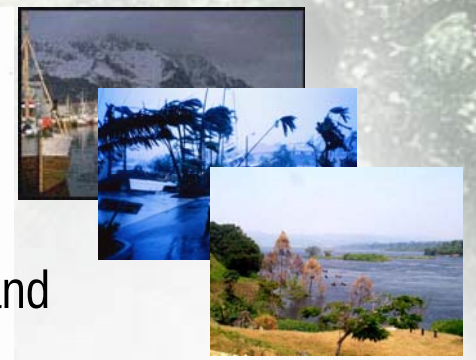
Why study the water and energy cycle?...

Variations in greenhouse gases, aerosols, and solar activity force changes in climate…

…but, consequences of climate change are realized through the water cycle.

Thus, we must *characterize*, *understand*, and *predict* variations in the global water cycle.





Water and Energy is linked to all 12 Science Application Themes.

Carbon Management

Water Management

Agricultural Competitiveness

Public Health

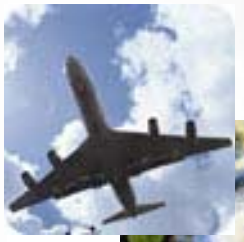
Homeland Security

Invasive Species

Energy Forecasting

Coastal Management

Ecological Forecasting



Aviation Safety

Disaster Preparedness

Air Quality

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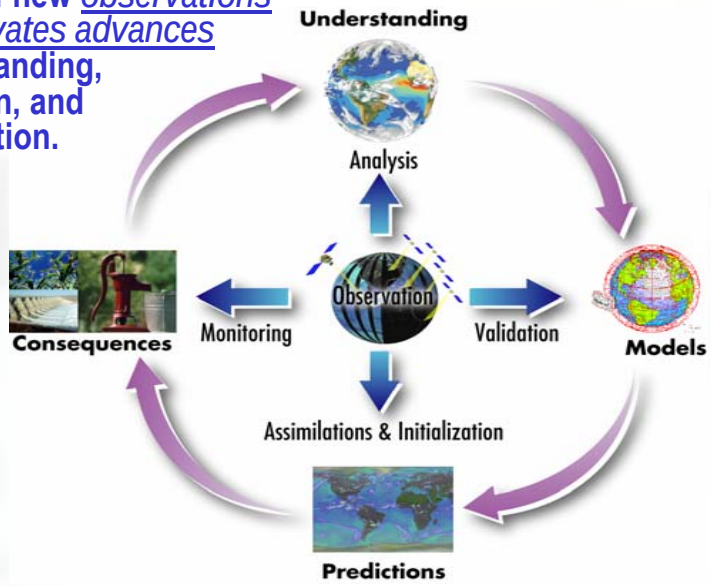
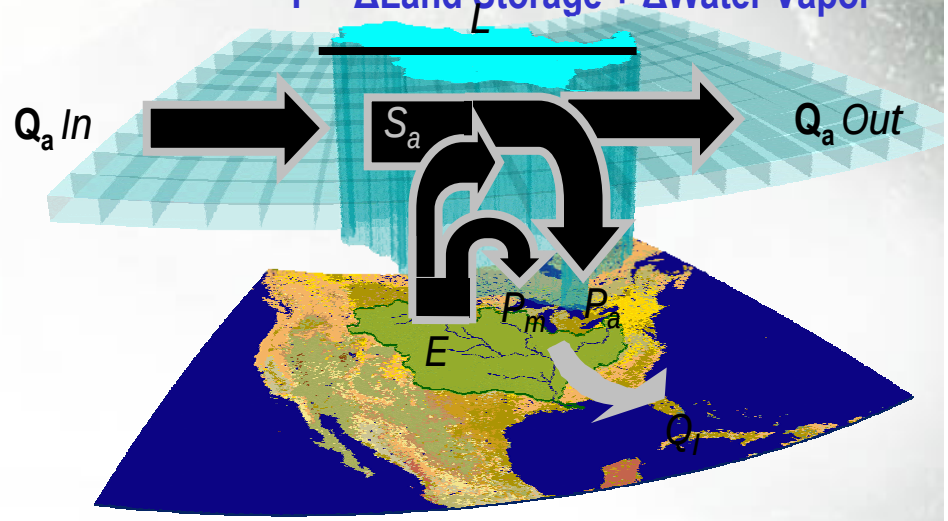
NASA WEC Observation Capabilities

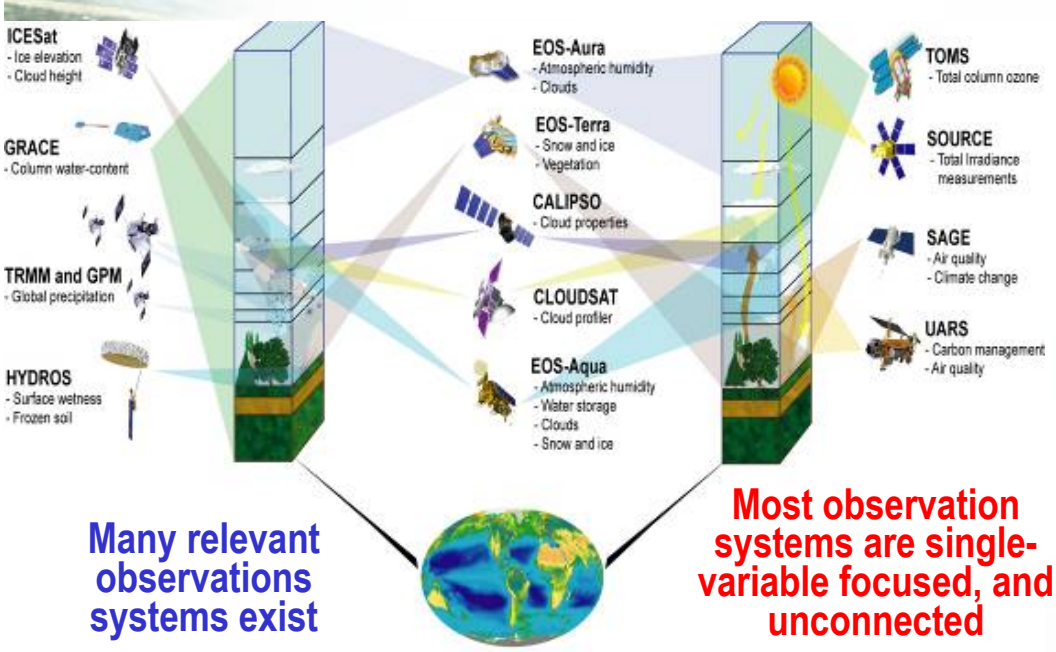
The availability of new *observations strongly motivates advances* in understanding, prediction, and application.



Input - Output = Storage Change

Transport + Evaporation - Precipitation – Runoff - P = ΔLand Storage + ΔWater Vapor





Many relevant observations systems exist

Most observation systems are single-variable focused, and unconnected

We must define and develop an integrated user-focused water observation system that can not only detect climate trends but also local variation of extremes

We must preserve critical *in-situ* benchmark observations that enable us to detect trends & extremes.

ariable ↓ / Sphere →	Ocean	Land	Atmosphere
Internal or State Variable	sea level/surface topography (I/S) surface salinity (I/S) subsurface salinity structure (I) upper ocean currents (I/S) mid- and deep-ocean currents (I) sea ice (I/S) wave characteristics (I/S) sea surface temperature (I/S) subsurface thermal structure (I)	topography/elevation (I/S) land cover characteristics (I/S) permafrost (I) water runoff (I/S) snow/ice cover (I/S) glacier ice (I/S) subsurface moisture (I/S) surface temperature (I/S) subsurface temperature (I/S)	Wind profile (I/S) pressure profile (I) water vapor profile (I/S) precipitation (I/S) clouds (I/S) liquid water content (I/S) air temperature profile (I/S)
Forcing or Feedback Variable	ocean surface wind & stress (I/S) surface air humidity (I/S) precipitation (I/S) fresh water flux (I/S) sublimation & evaporation (I/S) geothermal heat flux (I) incoming SW radiation (I/S) incoming LW radiation (I/S) surface air temperature (I/S)	albedo (I/S) land use (I/S) surface winds (I) surface humidity (I/S) precipitation (I/S) sublimation & evapotranspiration (I/S) incoming SW radiation (I/S) incoming LW radiation (I/S) sensible heat flux (I/S)	surface topography (I/S) land surface vegetation (I/S) snow/ice cover (I/S) surface soil moisture (I/S) evapotranspiration (I/S) sea surface temperature (I/S) surface soil temperature (I/S) surface radiation budget (I/S) solar irradiance (S)

LUE=Water Cycle Variable; RED=Energy Cycle Variable; BLACK=Boundary condition

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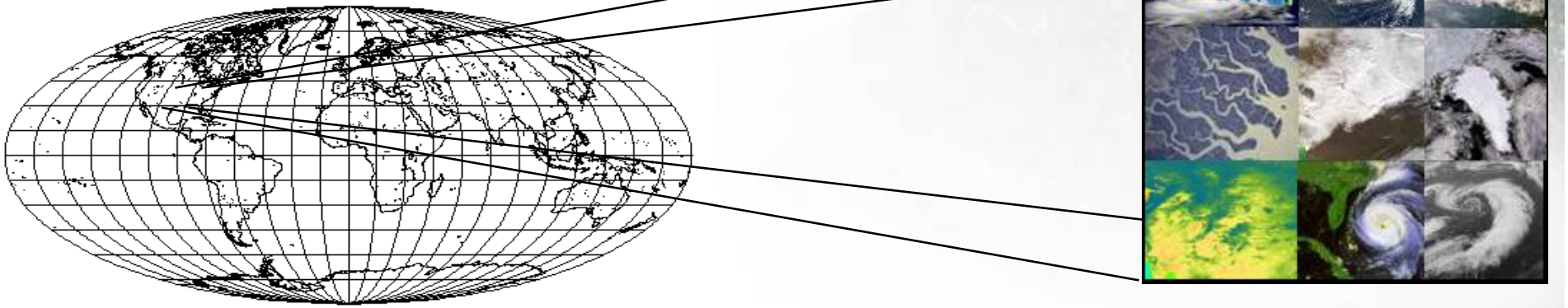
NASA WEC Modeling & Prediction Capacities

Climate models' grid-box representation of Earth's processes...



Each grid-box can only represent the "average" conditions of its area.

However, controlling processes of the water cycle (e.g. precipitation) vary over much smaller areas.

Developing Advanced Process-Resolving Models

- Useful prediction is critical – it is the link to stakeholders.
- We must move towards a new paradigm of climate models that produce useful weather-scale, process-scale, and application-scale prediction of local extremes (not just mean states).
- We must more fully constrain climate models with observations, to improve their realism and believability.

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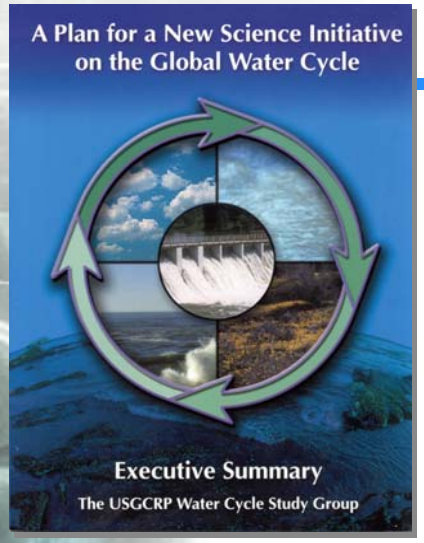


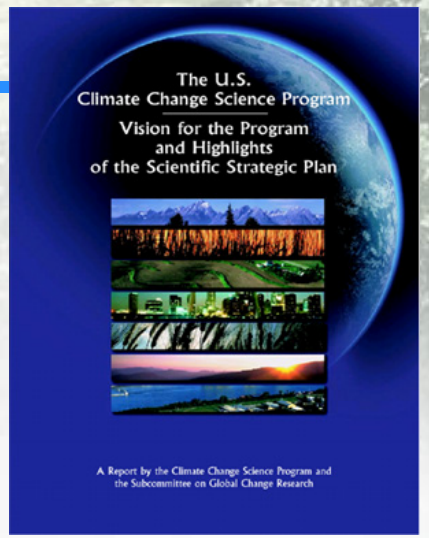
NASA ENERGY AND WATER CYCLE STUDY

NEWS

What are the causes of water cycle variations?

Are variations in the global and regional water cycle predictable?

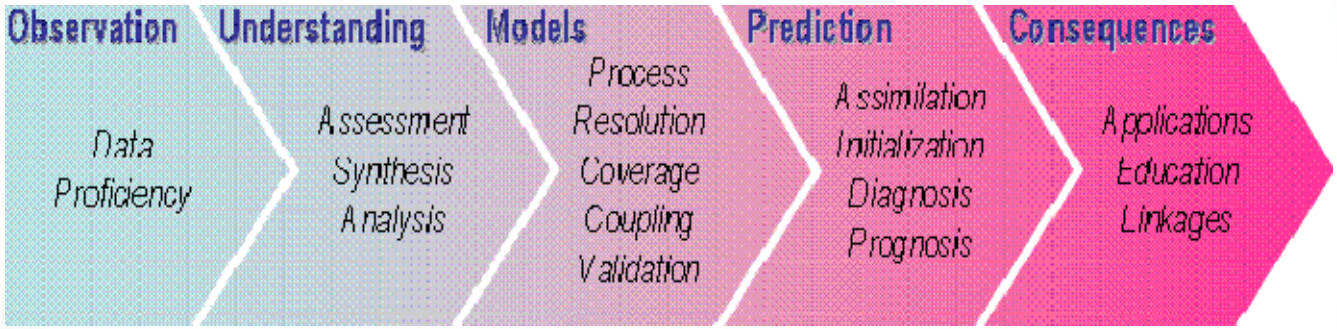
How are water and nutrient cycles linked?



NEWS Integrated Water and Energy Cycle Research Challenge:

Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.

The NEWS challenge is **global** in scale and requires the integration of NASA **system components** to **make decisive progress toward the NEWS challenge** in an **end-to-end program**



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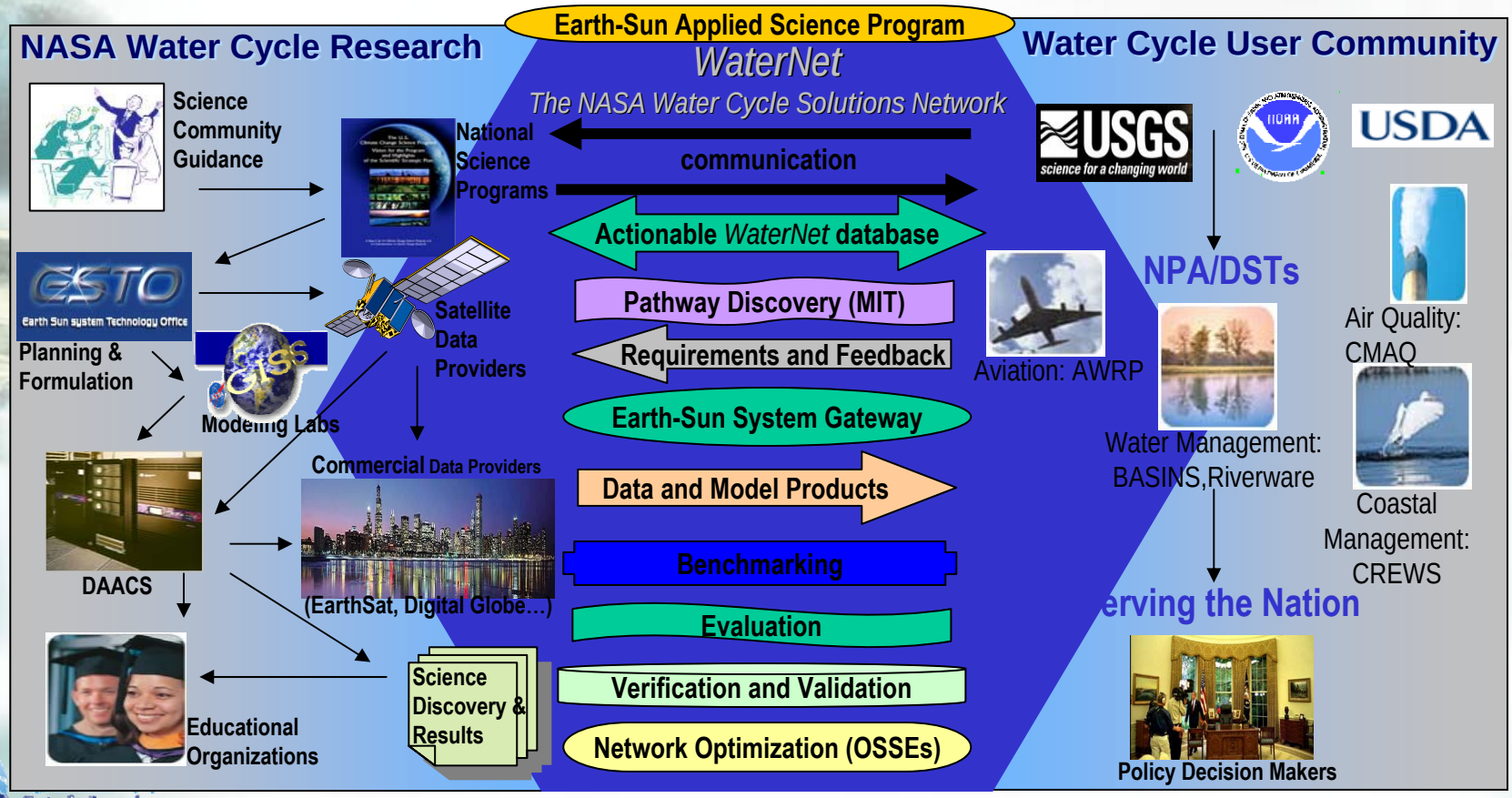
WaterNet: Concept

Improve and optimize the sustained ability of water cycle researchers, stakeholders, organizations and networks to interact, identify, harness, and extend NASA research results to augment decision support tools.

1. *Evolve a network of partners:* identify and analyze partner organizations to define collaboration pathways.
2. *Routinely identify, prioritize, mine and communicate relevant research products and results.*
3. *Optimize water cycle partner access* to research results and products to create a self-sustaining network.
4. *Analyze and document* the network effectiveness through metrics, resource estimates and documentation.
5. *Education and outreach* is important to help society understand and use the research in every-day application.

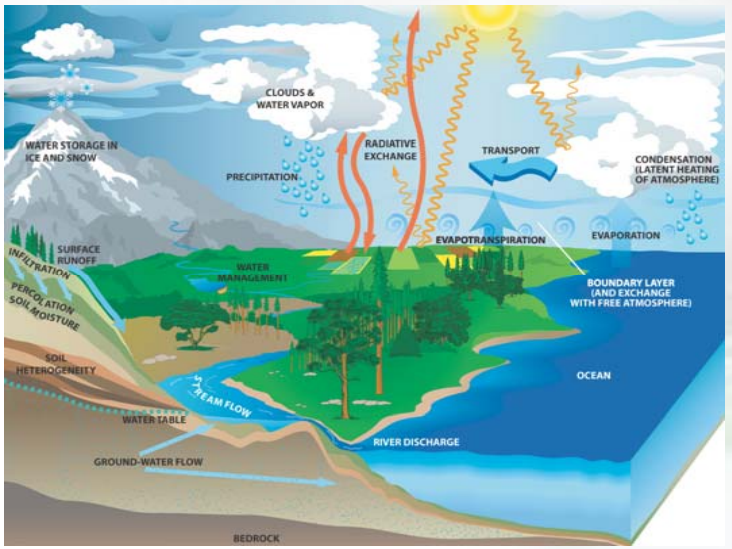


Project Motivation and Goal

Project Goal: develop a new Water and Energy Cycle (WEC) EOS Clearing House (ECHO) client (WECHO) that will use ECHO middleware technology to provide access to and discovery of data resources related to the NASA Global Water and Energy Cycle Focus Area (WECFA).

Objectives:

- provide a web portal customized to the needs of NASA's WECFA user community.
- maximize NASA investments by facilitating the integration of WECFA research results;
- optimize the use of research satellites and revolutions in modeling capability;
- provide physical linkages to NASA data (WEC balances)
- allow users to integrate disparate WEC information;
- promote an improved understanding of WEC processes;
- allow evaluation of WEC predictions;
- facilitate portal usability by researchers, stakeholders, educators and the general public.



WECHO Flow Chart

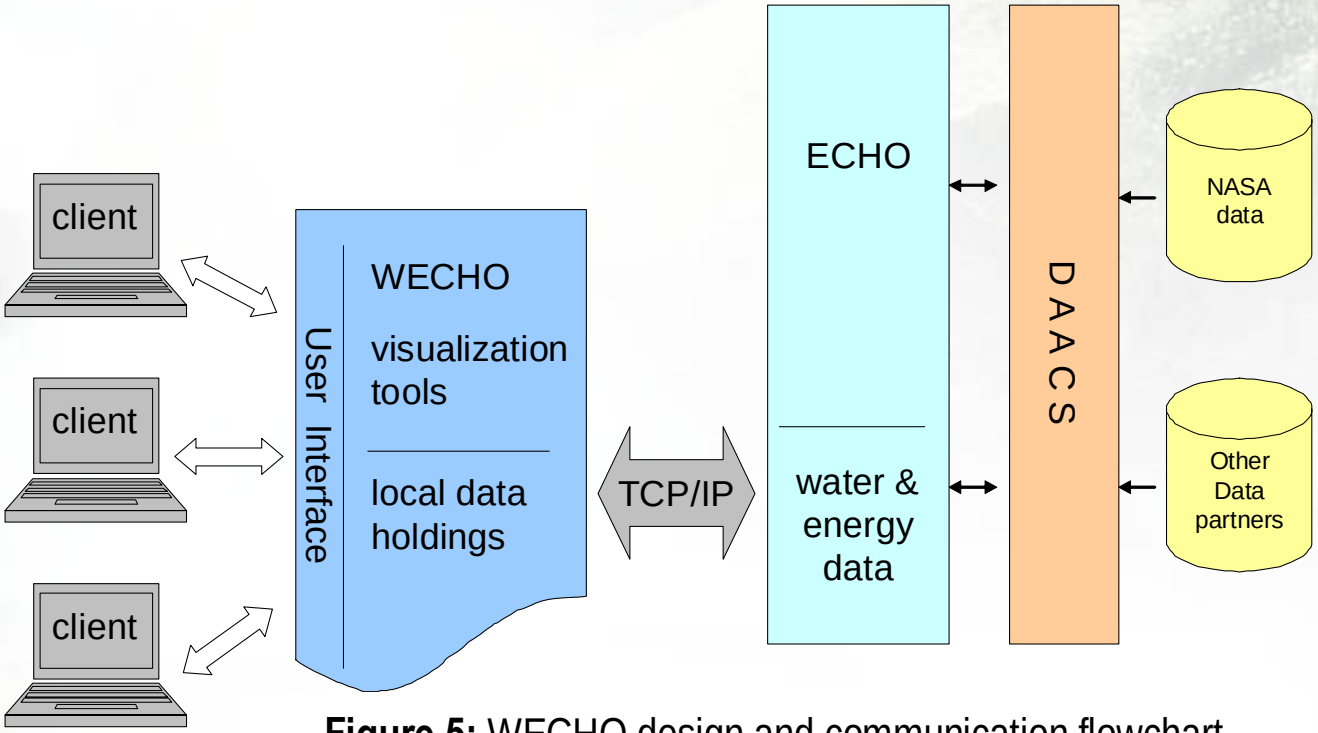


Figure 5: WECHO design and communication flowchart.

Work Plan Steps

- **Establish the WECHO portal design and functionality.**
- **Implement the portal design, including the required software engineering and visualization extensions.**
- **Enable some education and outreach components in WECHO, making it useful to a broader audience.**
- **Document and disseminate the WECHO for easy user access and future adaptation.**

WECHO Data Browsing

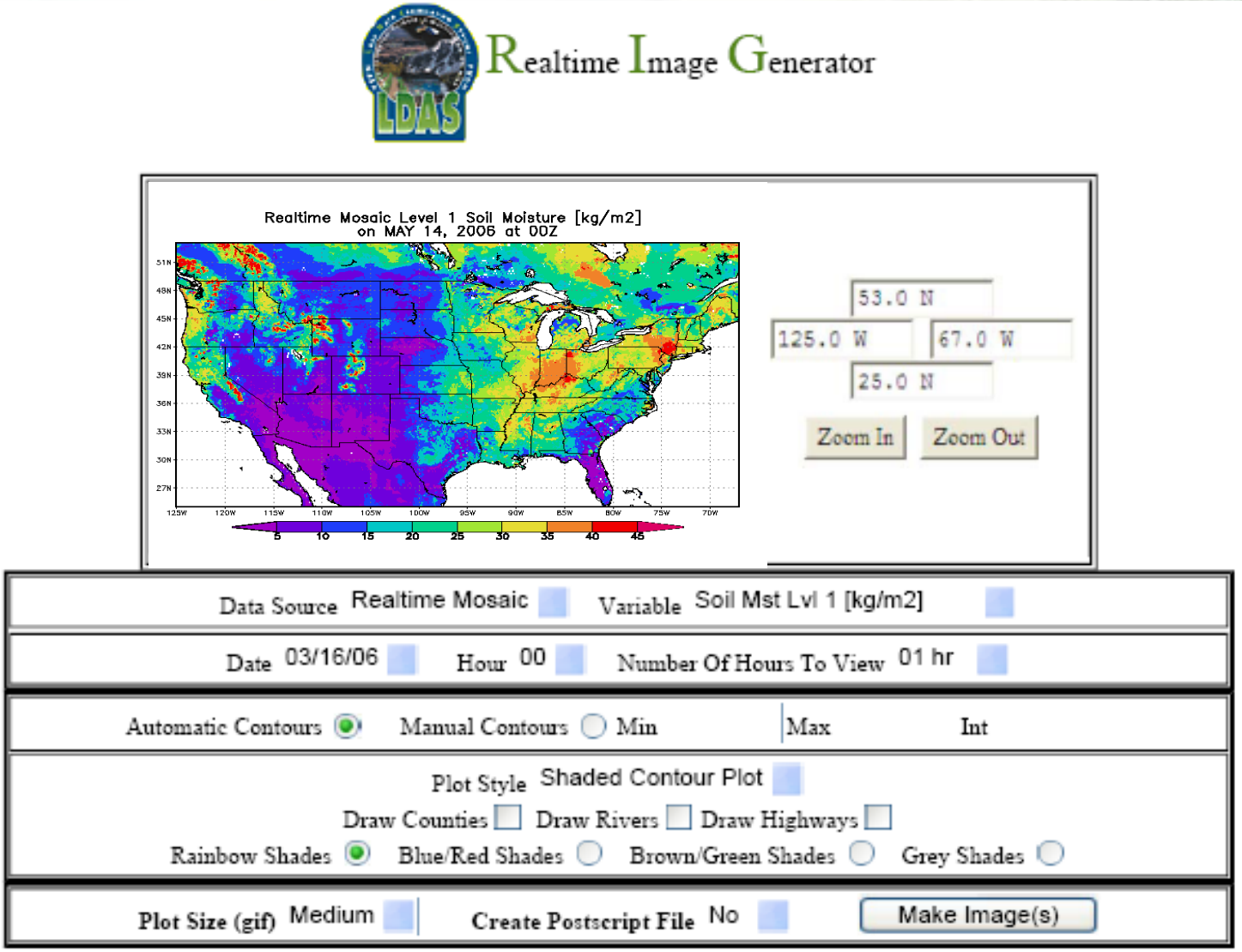


Figure 6: Example of the NLDAS Real-Time Image Generator.

WECHO Work Plan

WECHO: Water & Energy Cycle EOS Clearing House	*1 year: January - December 2007*		
Task	**Jan Feb Mar Apr**	**May Jun Jul Aug**	**Sep Oct Nov Dec**
Portal design formulation			
-design backend software interface			
-design user interface and functionality			
Portal implementation			
- backend software implementation			
- user interface implementation			
Portal extensions			
- develop water and energy cycle data alias and lookup functions			
- develop a local ECHO metadata cache & WEC data holdings			
- develop a visualization capability			
Portal documentation & dissemination			
- develop on-line user guide			
- develop links to/from other web water & energy cycle resources			
- web registration & negotiation links			
- interact with users to optimize WECHO functionality			
Education and outreach			
- Links to GMU students			
- Worked examples and scenarios			
Portal sustainability			
- maintenance plan			
- extension plan			
Note that degree of shading indicates effort level, with darker shading indicating more intensive effort.			

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