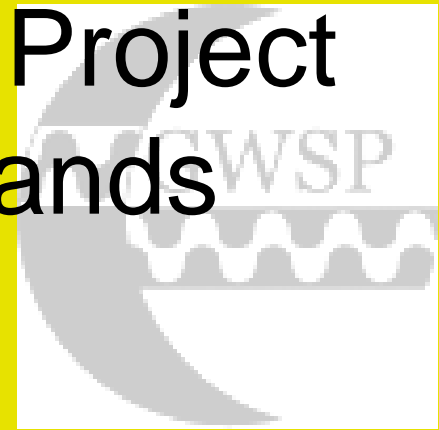


The Global Water System Project (GWSP): Focus on Drylands



Alexander I. Shiklomanov,
Charles J. Vörösmarty
Co-Chair of GWSP SSC
www.gwsp.org



A Collaboration of the *Global Environmental Change Programmes*

A joint project w/ financial support from:



The NEESPI / LCLUC Drylands Meeting
Urumqi, China, Sept 16-20th 2007



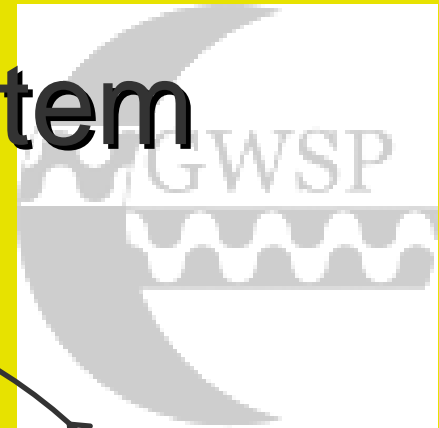
CENTRAL TENET OF THE GWSP

Humans are changing the global water system in a globally-significant way, but without.....adequate knowledge of the system and thus its response to change

GWSP is Science-Driven but Policy-Informing and organized around 3 science themes:

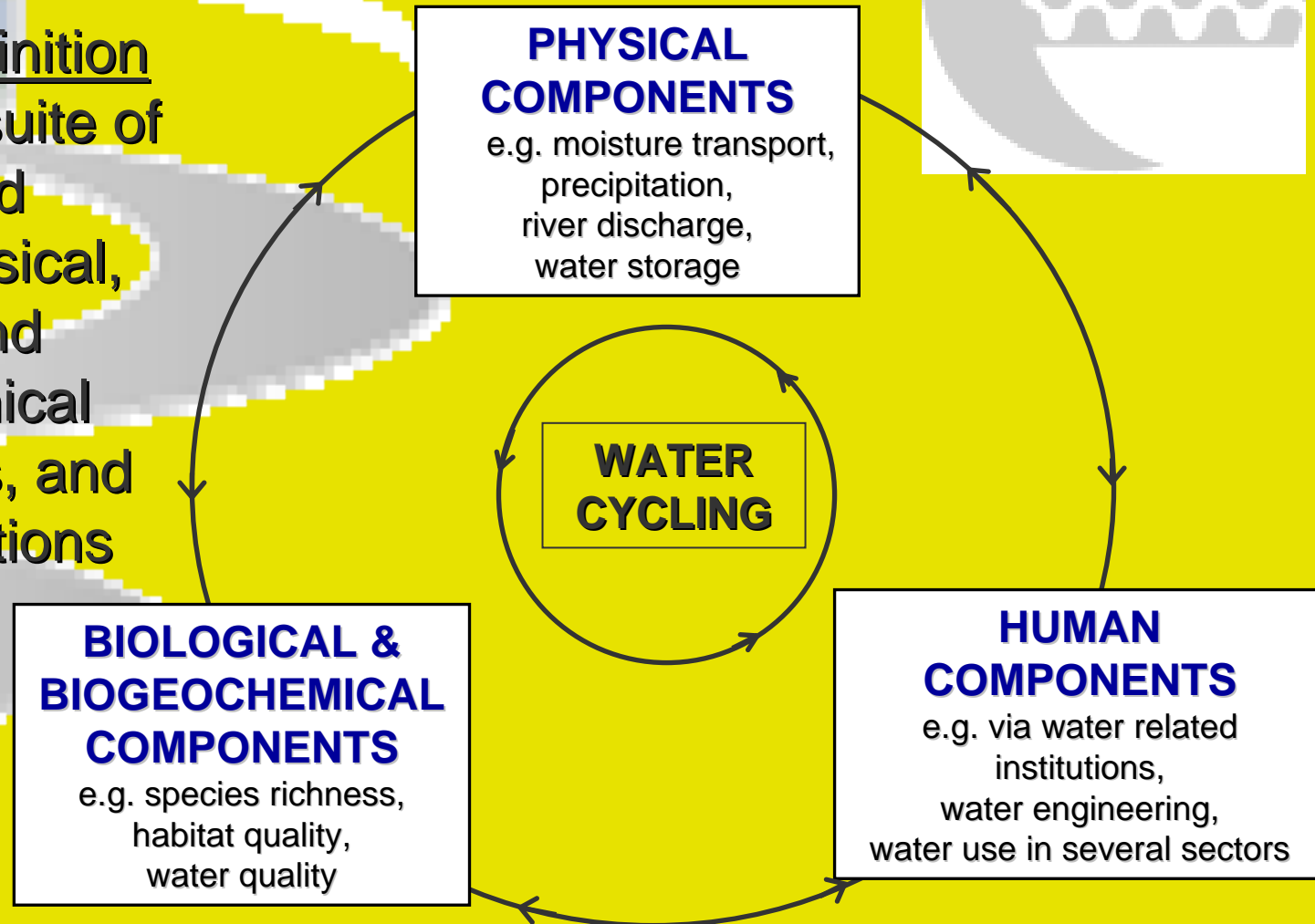
1. Quantify change and its sources
2. Uncover feedbacks in the global water system
3. Assess system adaptation and resilience

The Global Water System



Working definition

The global suite of water-related human, physical, biological and biogeochemical components, and their interactions



GWSP Implementation Strategy

The logo for the Global Water Sanitation Partnership (GWSP) is located in the top right corner. It features a stylized globe with a wavy line representing water, and the acronym 'GWSP' is written in a bold, sans-serif font across the middle of the globe.

➤ Programme definition and initiation (2 years)

- Finalize research plan
- First SSC meeting February '05
- Results: 1. First fast-track activities (n=10)
2. Regional offices established
3. Initial sponsorship

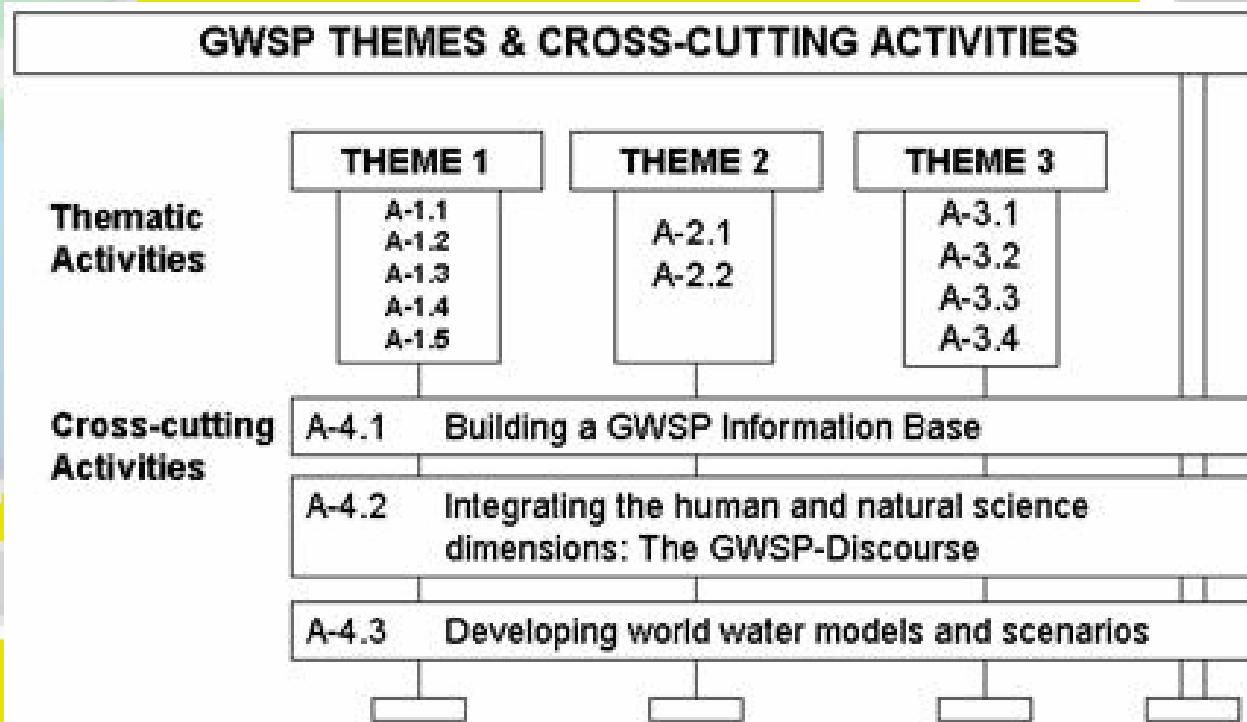
➤ Production phase (3 years)

- Three new prioritized activities: plan to be launched in the fall of 2007
- Broaden community participation
- Stakeholder involvement

➤ Data synthesis and application of results (5 years)

- Data synthesis, application and distribution of results

Scientific Framework



Theme 1 - Magnitudes and Mechanisms of Change

- A-1.1 Water Governance and the Global Water System
- A-1.2 Land Cover Changes and the Global Water System
- A-1.3 Climate Change and the Global Water System
- A-1.4 Water Diversions and the Global Water System
- A-1.5 Nutrient and Sediment Transport and the Global Water System

Theme 3 - Resilience and Adaptation

- A-3.1 Water Requirements for Nature and Humans
- A-3.2 The Nature of Adaptive Capacity of the Global Water System
- A-3.3 Approaches to Enhancing Adaptive Capacity (the role of institutions, governance, industrial transformation)
- A-3.4 The Provision of Ecosystem Goods and Services by the Global Water System

Theme 2 - Linkages and Feedbacks

- A-2.1 Linkages at Different Spatial Scales in the Global Water System
- A-2.2 Legacy of Human and Natural Interactions in the Global Water System

International Project Office Bonn

- Eric Craswell (Executive Director)
- Dr. Marcel Endejan (Deputy Executive Officer)
- Daniel Petry (Fast-Track Activity Co-ordinator)
- Lara Wever (Administrative & Finance Officer)

Liaison Activities w/ Affiliate Groups

- Other ESSP Joint Projects
- GECPS (WCRP/GEWEX, IHDP, IGBP, DIVERSITAS)
- IGWCO, GEOSS, IHP, WWAP
- NEESPI and Other Adopted Case Studies

*Facilitation, Coordination
& Communication*

10 Fast Track Activities

- Lexicon
- GWS Atlas
- Water Indicators
- Environmental Flows
- Governance Workshop
- GWSP-LOICZ Partnership
- Advanced Institute
- Case/Regional Studies
- Science Article
- WWDR-Review

*Formulate agenda
Oversight*

*Identify outputs
Execute activities*

Science Steering Committee

- Charles Vörösmarty (Co-Chair, Executive Committee)
- Joseph Alcamo (Co-Chair, Executive Committee)
- Dennis Lettenmaier (Executive Committee)
- Robert Naiman (Executive Committee)
- Claudia Pahl-Wostl (Executive Committee)
- Stuart Bunn
- Malin Falkenmark
- Joyeeta Gupta
- Felino Lansigan
- Changming Liu
- Jose Marengo
- Christer Nilsson
- Eric Odada
- Jay O'Keefe
- Taikan Oki

GWSP National/Regional Groups

- Japan, China, U.S., India (under discussion)
- GWSP-Asia w/ Southeast Asia (under discussion)
- European (neWater, Framework study teams)



Global-RIMS (Atlas, Indicators)

includes regional, continental and global datasets at resolutions from 6' to 30'

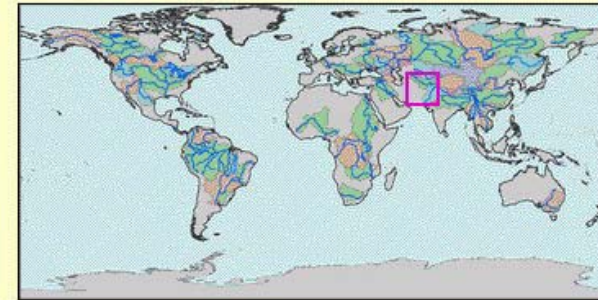
Functionality of system: Data mounting; Data preprocessing; Data navigation and display



A Global Rapid Integrated Monitoring System (**Global-RIMS**)



Home	Data	Navigation	Links	
	Elevation			
	Population			
	Population Dnsty	Population 1990		
	Precipitation	Population 1995		
	Runoff	Population 2000		
	Discharge	Population 2015		
	Fragmentation			
	Floodplain			
	Landuse			
	AirTemperature			
	Evapotranspir.			
	IrrigatedArea			
	Water Demand			
	WWDR World			
	WWDR Africa			
WWDR Tropics				
Masks				
Soils				
Crop Area				
Infant Mortality				
Underweight Chld				
Landcover- Afr.				



Instructions to navigate

Population Density 2000

Metadata Link

Basin Name	Amu-Darya
Pass mouse over map	
Longitude	
Latitude	
Basin	
Country	
Population Density 2000, per km ²	<input type="checkbox"/> Check Box to Load

Show cities on the map

Upstream search distance at click point -

0 1 2 grid cells

Deselect Basin

Calculations with DSS Data for this area

Data calculation and manipulation system

Calculations with RBIS-UNEP Data for Selected Area

Macro Calculator for Selected Area

Parameter	Unit	Symbol	Parameter	Unit	Symbol	Parameter	Unit	Symbol
Elevation	m	D1	Irrigated Area	km ²	D13	Population Density 1990	per km ²	D25
Precipitation 6'	mm/yr/grid	D2	N Load	T/grid/yr	D14	Population Density 1995	per km ²	D26
Runoff, CMP 6'	mm/yr/grid	D3	Air Temperature Calculated	Degrees Celsius/grid/yr*	D15	Population Density 2000	per km ²	D27
Actual Evapotranspiration	mm/yr*	D4	Infant Mortality Rate	deaths per 10,000	D16	Population Density 2050	per km ²	D28
Discharge	km ³ /grid/yr*	D5	Runoff	mm/yr*	D17	Population 1950, Total	per grid	D29
Discharge Corrected	km ³ /grid/yr	D6	Irrigated Area (402)	percent per gridcell	D18	Population 2000, Total	per grid	D30
Water Use 2000, Agricultural	km ³ /grid/yr	D7	Water Use 1960, Agricultural	km ³ /grid/yr	D19	Population 2030, Total	per grid	D31
Water Use 2000, Domestic	km ³ /grid/yr	D8	Water Use 1960, Domestic	km ³ /grid/yr	D20	Discharge Calculated	m ³ /grid/sec/yr*	D32
Water Use 2000, Industrial	km ³ /grid/yr	D9	Water Use 1960, Industrial	km ³ /grid/yr	D21	Discharge Composite	m ³ /grid/sec/yr*	D33
Cultivated Land Mask	fraction	D10	Precipitation Observed 1deg	mm/grid/yr*	D22	Runoff Modeled	mm/yr*	D34
Crop Area	fraction	D11	Flood Plain	value	D23	Discharge Variability	ratio	D35
Cell Area 6m	m ²	D12	Low Slope	value	D24	Active Streamorder	1-10 scale	D36

*Time Series default units - [See instructions](#).

Enter equation using dataset symbols from the above table. Example - $(D1 + D2)/2 + \text{sqrt}(D3)$

Equation - $(D6-D7-D8-D9)*1000000/D30$

Force range to: Min= Max=

Options - Equation for Cell Cumulative: CC = Number of grid cells: NC.

All arithmetic operators could be used, such as: + - * / ** (?:), as well as most of commonly used scalar functions ([help](#)), such as `sqrt()`, `abs()`, `exp()`, `log()`, `sin()`, `cos()`, `tan()`, etc. Parameters and functions are case insensitive, and spaces are allowed.

Use Log Scale

Use high resolution for data alignment

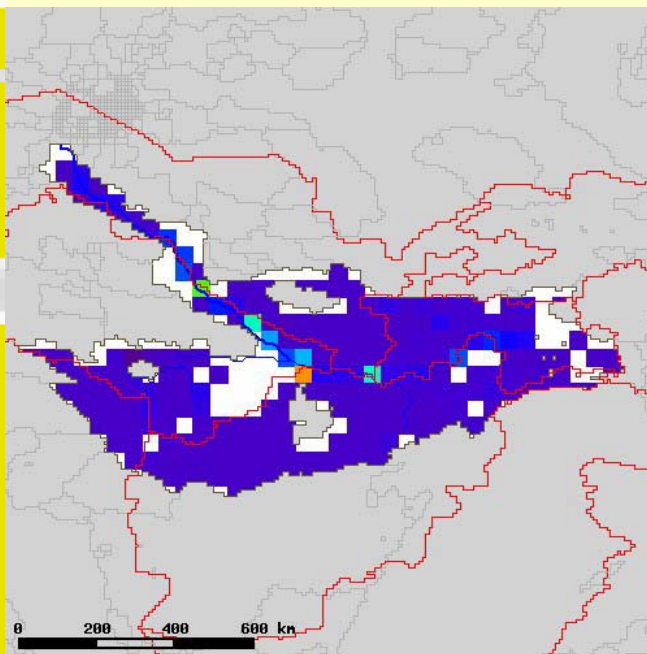
Replace Illegal Operation with "nodata"

Get Results as Data

Legend: B/W

Rainbow

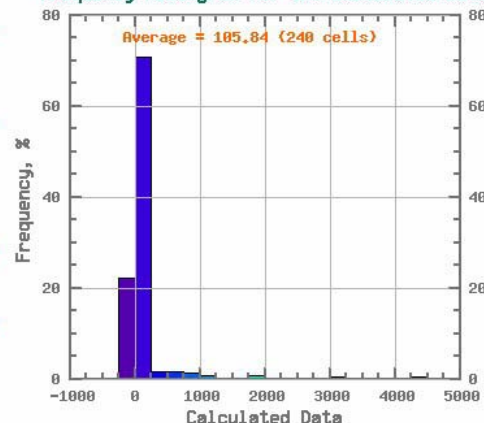
[Return to Data Explorer](#)



Calculation Results for Selected Area

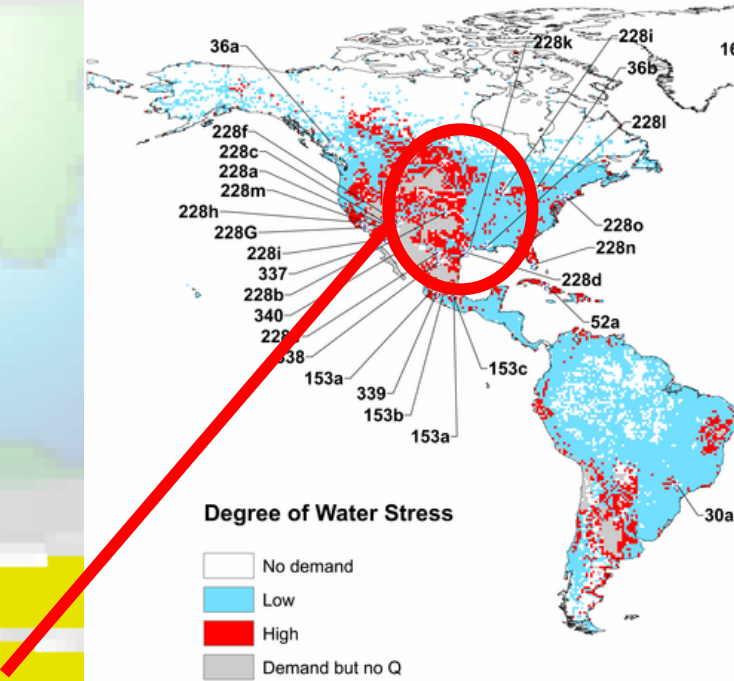
Equation used - $(D6-D7-D8-D9)*1000000/D30$

Frequency Histogram for the Calculated Data

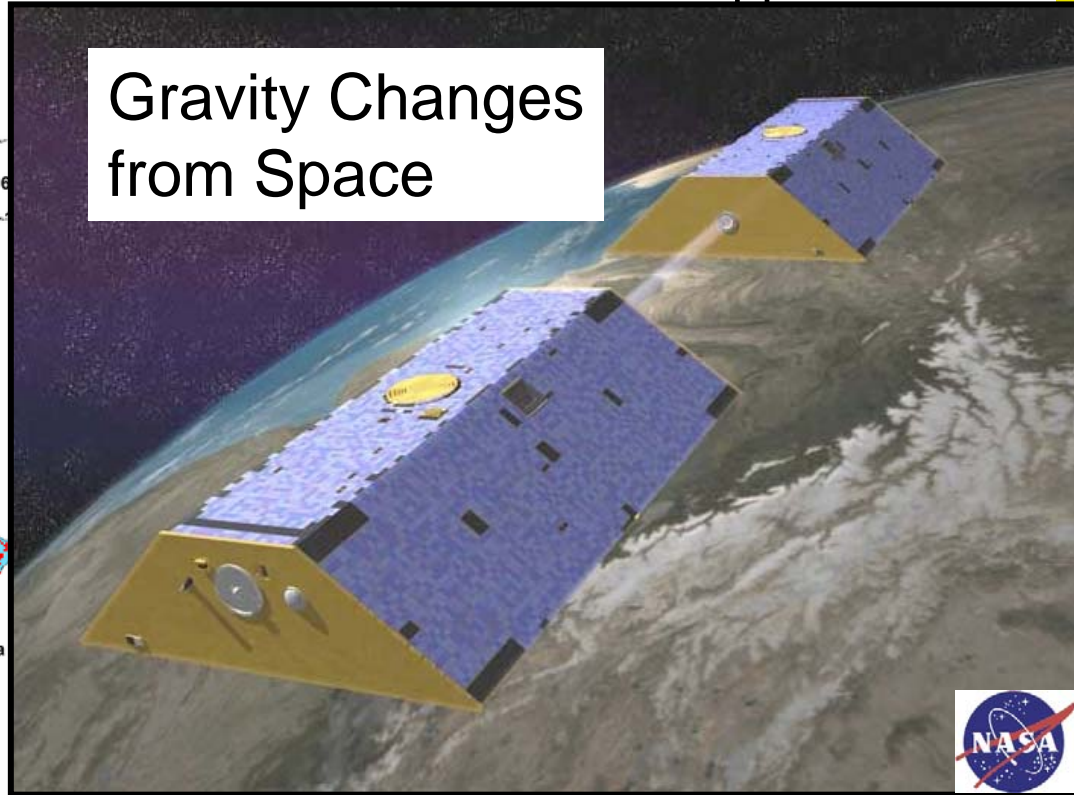


Currently water use exceeds water resources over ~ 20% of Amudarya drainage basin

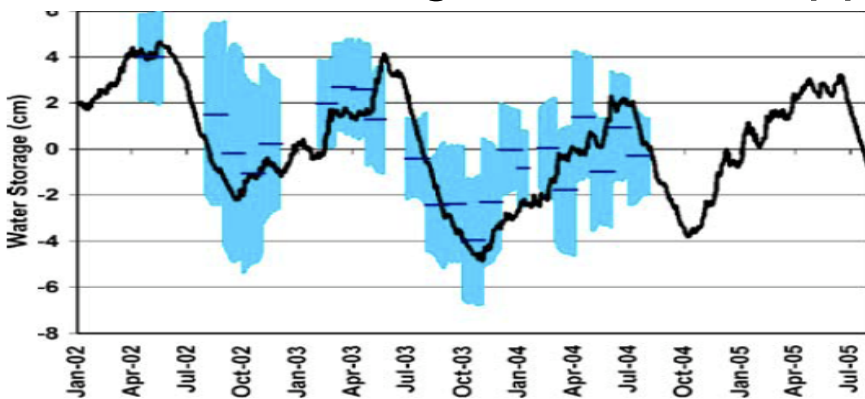
Irrigation & Urban Water Use in Excess of Sustainable Supplies



Gravity Changes from Space

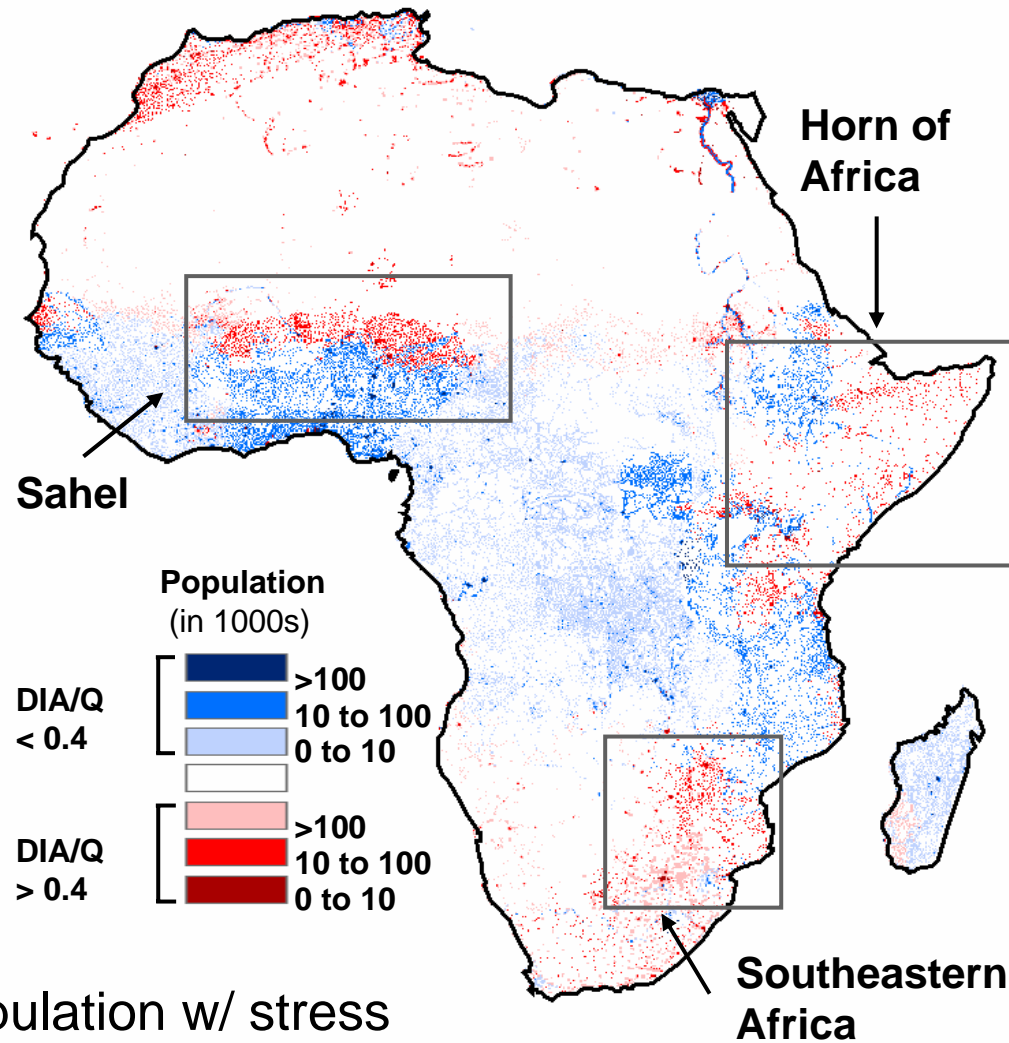
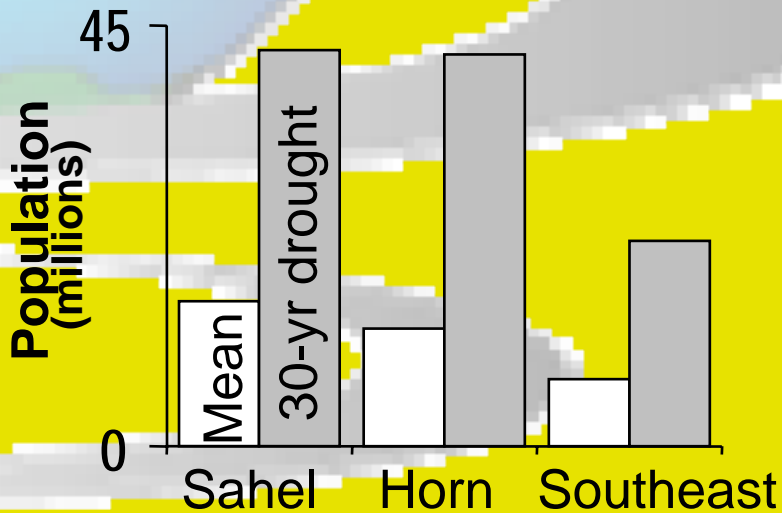


GRACE Δ storage for Mississippi



Drought Is Key Feature of African Security Issues

Population Above and Below Water Stress Threshold During Drought
 -- 30-year duration statistics



Continental total: Mean --> 25% population w/ stress
 30-yr drought --> 40%

WBM/WTM ... WBMPlus



- **WBM/WTM**
 - 1-D physically based macroscale hydrological model (Vörösmarty, 1998)
 - WTM Routing based on river network (STN)
- **WBMPlus**
 - WBM + irrigation + reservoirs; daily time step (real time routing, irrigation, reservoirs)

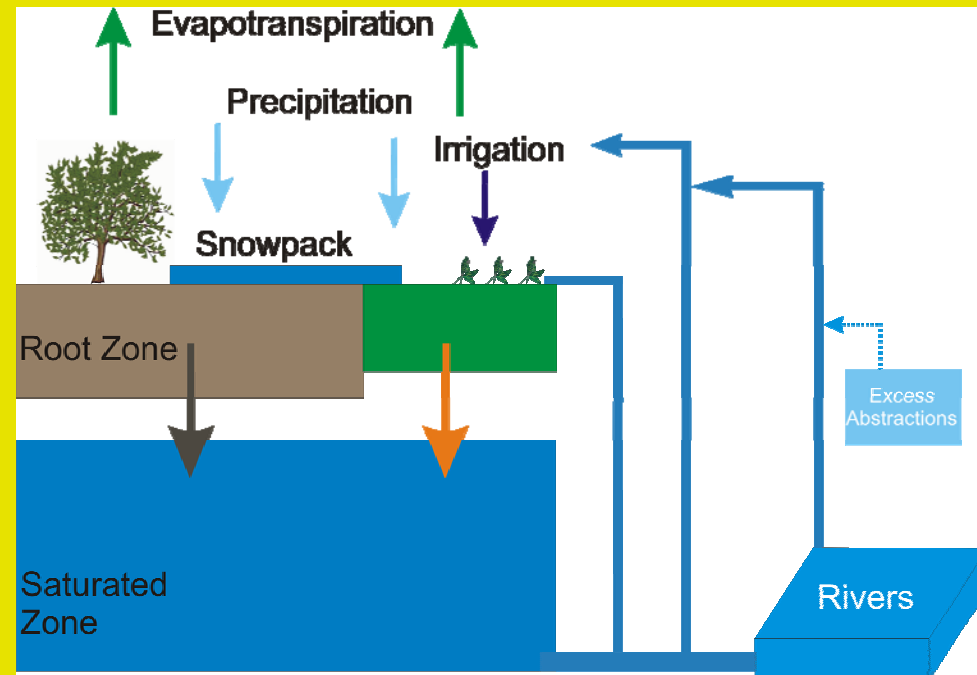
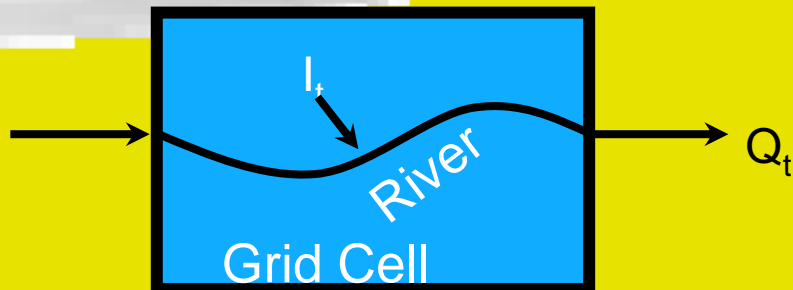
Flow routing model

$$Q_{t+1} = C_0 I_{t+1} + C_1 I_t + C_2 Q_t$$

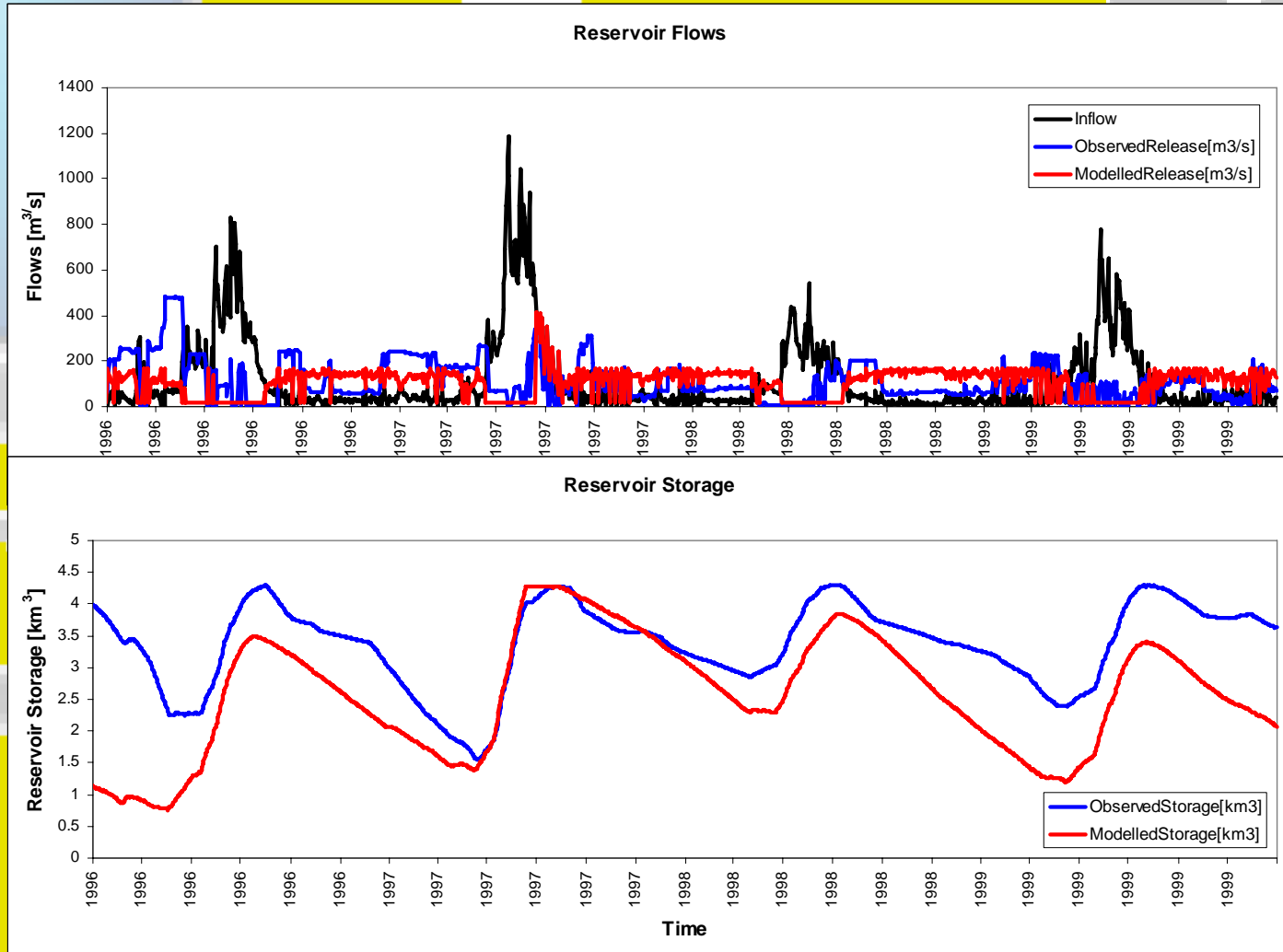
Coefficients $C_0, C_1, C_2, = f(\text{River Geometry})$

Q = river discharge from grid cell

I = locally generated inflow to river (less irrigation)



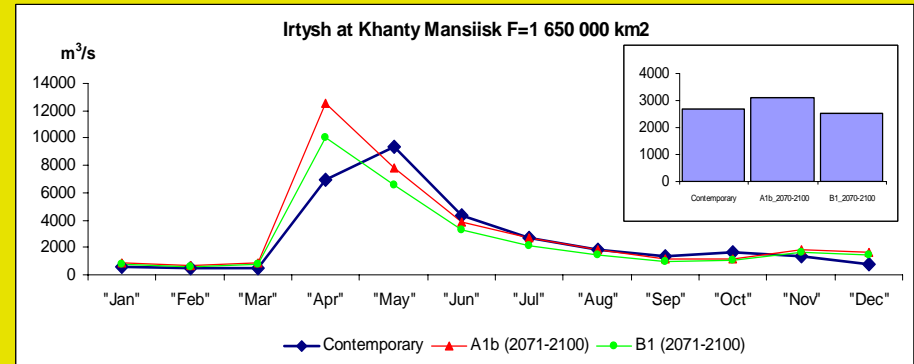
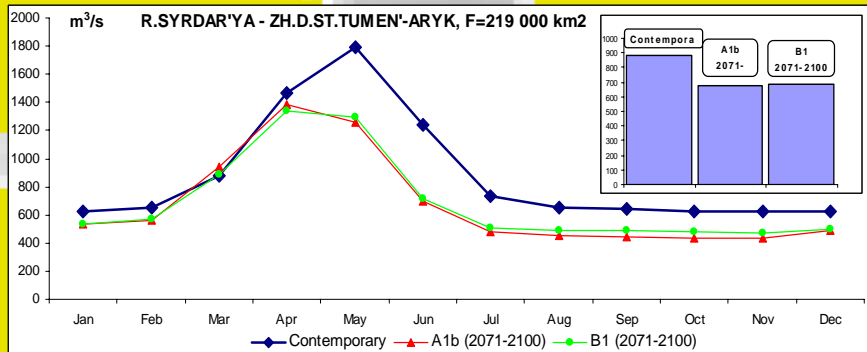
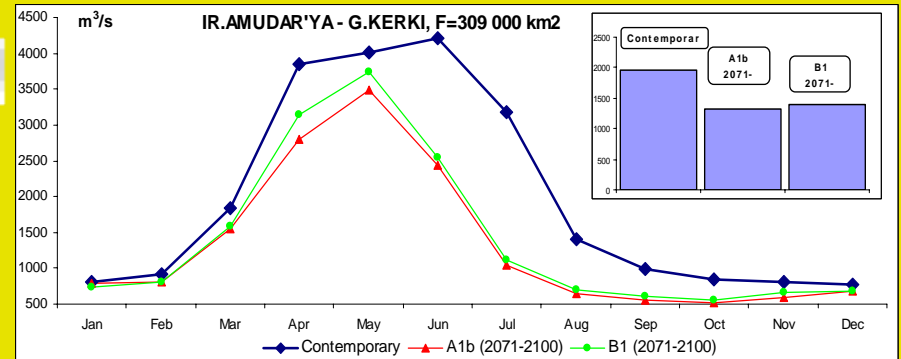
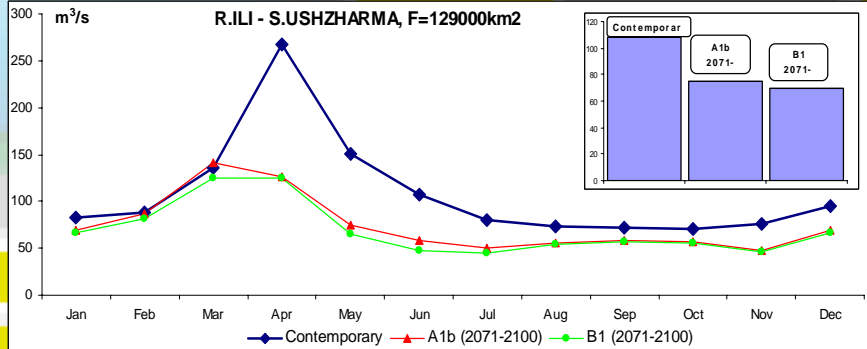
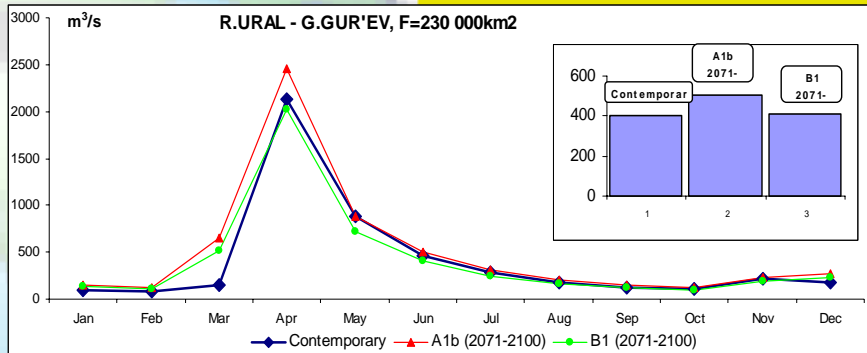
Reservoir Routing



Simulations of WBMPlus with ECHAM-5 A1b and B1 scenarios

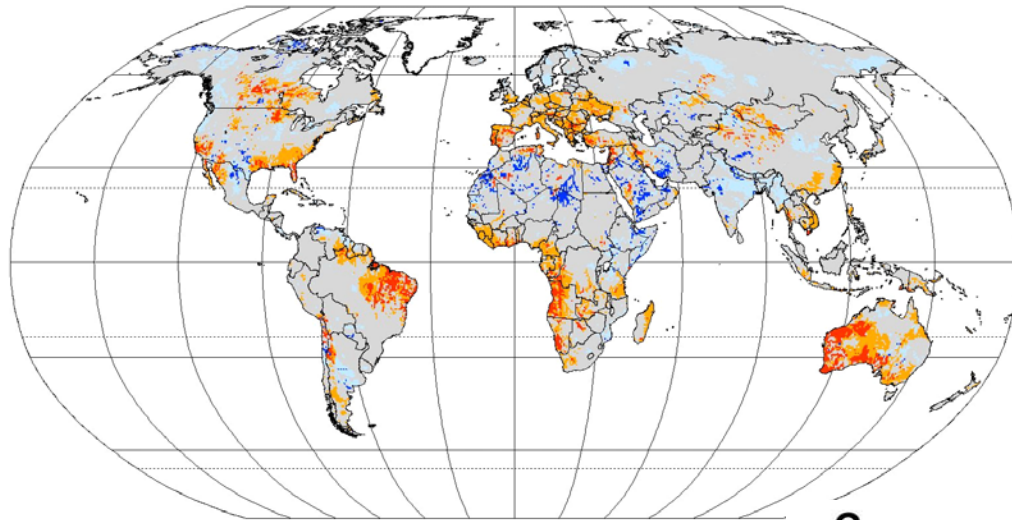


Large river basins in Central Asia



New Integrated Study Area GLOBAL-SCALE INITIATIVE (GSI)

Change in extremes
2050s, ECAHM4/OPYC3, A2 scenario



Combined changes in coefficient of variation (runoff) and mean water availability



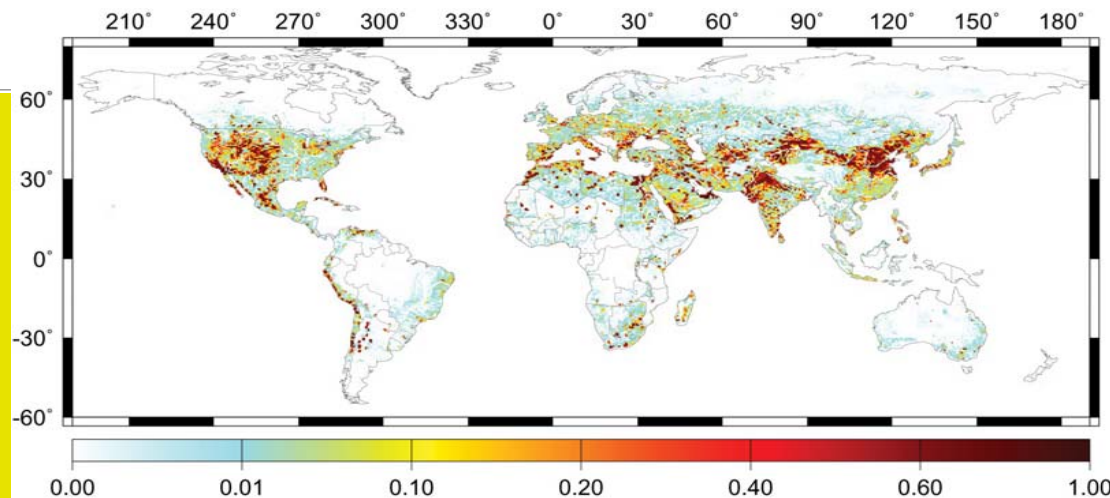
Alcamo et al.
(submitted)

Oki & Kanae
(2006)

Modelling
the impact
of climate change
on the GWS

C

Water Scarcity Index

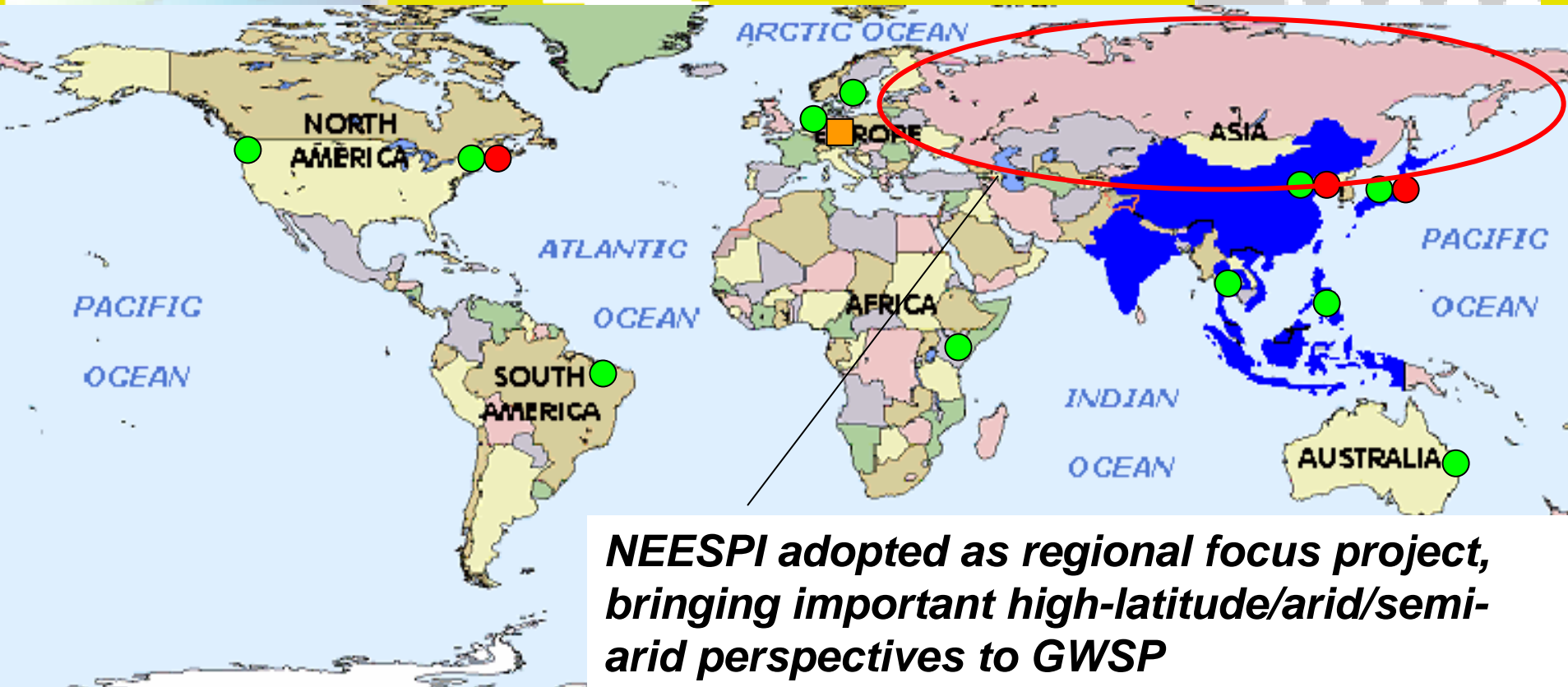


GWSP Regional Case-study Criteria





...or the way we choose our regional studies to support the "G" in GWSP

- *driven by continental-to-global perspectives*
- *link to highest degree possible biogeophysical, biology, biogeochemistry, human dimension perspectives*
- *focus on change-detection, attribution, feedbacks, and/or impacts*
- *achievable, trackable, product-driven*
- *targetted to engage other groups*
- *help answer key question of pandemic local or systematic GWS change*
- *help in comparative studies*

GWSP – A Growing World-Wide Network



Legend

-  GWSP Asia Network
-  Member of Scientific Steering Committee
-  National GWSP Committee
-  GWSP International Project Office



NEESPI Has a Broad Portfolio of Water System Studies



- Of 84 funded proposals, ~30 water-themed:

6 Water and Land Use/Cover Change	5 Cryosphere/Permafrost
3 Hydrological Extremes	6 Snow
3 Water Use and Engineering	2 Data Support
3 Integrative	1 Inland Water Quality
1 Coastal/Shelf Systems	

- Several Approaches

- Broad-scale *in situ* and remote sensing
- Modeling and geospatial analysis
- Integrated data systems
- Field studies

NEESPI Themes Meet These Criteria



- Multi-dimensional change over broad continental area (LUCC, Climate, Population Growth, Water Engineering, Emerging Economies)
- Region critical to Earth System (planetary heat balance, trace gases, fw fluxes to ocean)
- Impacts transcend disciplinary realms and affect water, energy, C, constituents, & human systems

What Can NEESPI & GWSP Do for Each Other?



- NEESPI science issues strongly water-related
- NEESPI an ideal regional focus study of GWSP
- Attribution studies (*GWSP Question 1*) & resilience / adaptability / governance issues (*GWSP Q3*) are clear avenues of collaboration w/ NEESPI
- Jointly developing hydrometeorological data integration & indicators of N. Eurasian water system state would be mutually beneficial (*GWSP Indicators and Atlas Cross-cutting Themes*)

NetScape
http://www.gwsp.org/

New Tab GWSP Home page

ESSP DIVERSITAS IGBP IHDP WCRP

GWSP
GLOBAL WATER SYSTEM PROJECT

Home
About Us
Activities
National Committees
Meetings
Who's Who in GWSP
What's New
Publications
Contact
Links
Login

ABOUT GWSP

The Global Water System Challenge

Water is essential to life on earth, plays a key role in the development and functioning of society and is recognised as a high priority resource for sustainable development. Over the past few decades, environmental science has produced insights into the linkages, interconnections and interdependencies in the global water cycle. The various human and physical, biochemical, and biological facets of the cycle make up the global water system.

The global water system is being transformed by major syndromes including climate change, erosion, pollution and salinisation. We know more about the physical aspects of the global water system and much less about the nutrient flows, biodiversity loss and human dimensions.

The Project

The Global Water System Project (GWSP) is a newly established joint project of DIVERSITAS, an international programme of biodiversity science, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP). These four global change programmes form the Earth System Science Partnership (ESSP).

For further information:

- Download [GWSP Science Framework Document](#) (approx. 2MB)
- Download [Powerpoint Presentation](#) (approx. 3MB)
- Download [GWSP brochure](#) (700KB)
- Download [GWSP Factsheet](#) (130KB)

**Global Water System Project
International Project Office
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Email: gwsp.ipo@uni-bonn.de
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EOS, Vol. 85, No. 48, 30 November 2004

EOS

WILEY-INTERSCIENCE AN IMPRINT OF JOHN WILEY & SONS

Humans Transforming the Global Water System

PROCES 509, 513-514

As water wages precariously in the machinery of the Earth system and as key to understanding the full scope of global change, greenhouse warming with a potentially accelerated hydrologic cycle is already a well-entrenched science issue, with strong policy implications. A broad array of other anthropogenic factors—widespread land cover change, engineering of river channels, irrigation and other consumptive losses, aquatic habitat degradation, and pollutants—also influence the water system in direct and important ways. A rich history of scientific research demonstrates the clear impact of such factors on local environments. Evidence now shows that humans are rapidly transforming the basic character of the water cycle on a reach broader than the collective significance of these many transformations on both the Earth system and human society remains fundamentally unknown (Planning Committee of the GWSP, 2004).

As aquatic systems, domestic, municipal, hydropower, and recreational water use is critical to a large and growing population that aspires to long-term improvements in well-being. Providing basic sanitation and clean drinking water services remains a major public health challenge. More than 1 billion people are without access to clean drinking water; 2.5 billion are without sanitation, and over 5000 people, mostly children, die each day from water-related diarrheal disease (World Water Assessment Programme, 2003).

Key manifestations of variability in the terrestrial water cycle continue to shape human history and as a costly source of vulnerability. In the United States, annual drought damage averages \$6 billion, with the 1986 drought alone costing over \$60 billion in 2002 (Bioscience 2003). Annual damage from flooding and other extreme weather (including the global water cycle) are even more costly, with billions in piece reports put losses from the 2002, hurricane season in the United States at

greenhouse warming to extreme weather and reduced availability of water resources. But several other factors, still poorly largely ignored, are proving to be globally significant as well (Table 1). These involve a great variety of direct anthropogenic activities, many operating at highly local scales. Initiatives made in remote sensing, land synthesis show that detectable river control is well planned (2004), about 10% annually, leading that the global intervention in the through land cover deforestation and water is likely to represent climate change at scales.

Effort provides a good rapid transformation (many more has been 5), with the aim of efforts to optimize water manipulation includes future and greenhouse (10% of global use (2003), improvement of water conservation and reducing their "footprint" in dramatically more nearly complex less to the ocean (eg, the in 1980s), global manufacturing of the total runoff in other's 600-700% increase change, and a 30% in total sediment delivery of 2003) resulted in a worldwide erosion that threatens 6, and fraction of water of 2000). Only of such changes but indicate by change these are track and substantial.

and World Climate Research Programme (WCRP) has been launched to study these complex issues. The primary aim of the Global Water System Project (GWSP) is to promote improved understanding of fresh water in the Earth system through integrated study of its interactions, biotic and abiotic. The GWSP science agenda emerged from a broad consensus of the water science and assessment community, with more than 200 contributors to interdisciplinary planning meetings starting in 2002, scientific planning documents, and a recent Open Science Conference (October 2003, Portsmouth, New Hampshire). A peer-reviewed framework and implementation plan consolidate these deliberations (Planning Committee of the GWSP, 2004). This article presents the scientific rationale for the GWSP, the project's key research questions, and an emerging agenda for the decade-long effort.

In the crowded landscapes of acronyms representing projects, programs, and institutions that deal with water, a strong justification must accompany any new international effort. Several characteristics distinguish the GWSP from other international watershed programs. The GWSP is designed to be the following:

- (1) Science-driven but policy-oriented. GWSP considers fundamental questions about water

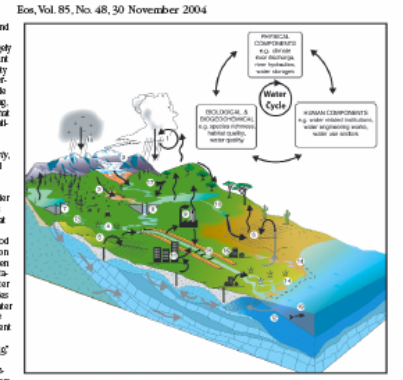


Fig. 1. The Global Water System under natural conditions is a complex amalgam of pools and dynamics, driven through complex, nonlinear forces defined by the physics, biogeochemistry and biology of the planet. In populated regions of the world, these systems have been reshaped and chemically through direct and indirect human interventions in the water cycle. Understanding these complex interactions requires an integrated, interdisciplinary perspective that considers humans as an important and interactive part of the Global Water System. See Table 1 for description of numerical entities.

are now global in extent, yet we lack an adequate understanding of how the overall system works, how it responds to change, and how society can best adapt to rapidly evolving and potentially new system states. The GWSP is organized to address the scientific in a systematic and unified manner. A special issue of *Aquatic Sciences* (Pillay-Reddy et al., 2002) highlights our collective capacity for pursuing this broad objective, which must

and surprises, such as a potential shutdown of North Atlantic deep water formation and ocean circulation arising from changes in human river discharge, or the emergence of toxic dead zones near the mouths of rivers heavily polluted by upstream agriculture and urbanization (Planning Committee of the GWSP, 2004). The GWSP is supported by three leading questions, which form its thematic structure: Question 1: What are the magnitudes of

Mapping the Links between Water, Poverty and Food Security

Summary Report on the Water Indicators workshop held at the Center for Ecology and Hydrology, Wallingford, 16th to 19th May, 2005

Report authors¹:
Caroline Sullivan, Charles Vörösmarty, Eric Craswell, Stuart Bunn, Sarah Cline, Claudia Heidecke, Adam Storygard, Alex Prousevitich, Ellen Douglas, Deborah Bossio, Dirk Günther, Anna Maria Giacomello, Dermot O'Regan and Jeremy Meigh

December 2005

The Global Water System Project

ESSP Report No. 3
GWSP Report No. 1

Science Framework and Implementation Activities

www.gwsp.org