Utilizing Global Earth Observing Systems to Improve Water Resource and Ecosystem Forecasting Capabilities

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UNIVERSITY of NEW HAMPSHIRE

Persistent Water Resource Challenges

Sanitation and access to clean water

Flood hazard/response

Water for development

Food security

Maintaining aquatic ecosystem services

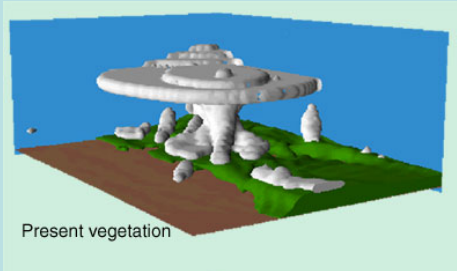
Pollution

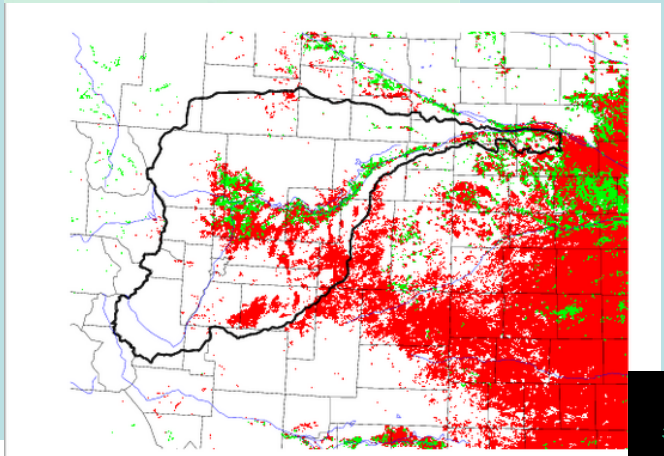
Contributions from Earth System Science

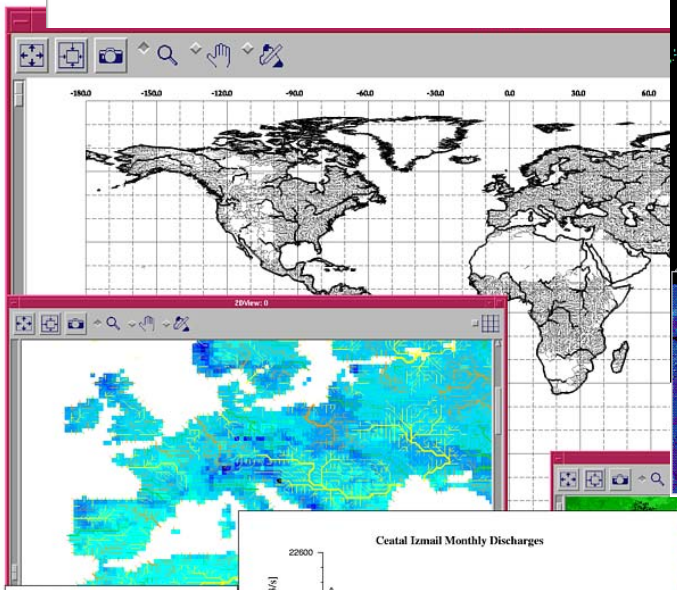
- *In situ* networks
- Operational satellite-based monitoring of the hydrosphere
- Simulation models and data analysis tools (NWP-4DDA, GCMs, RCMs, ESMs)

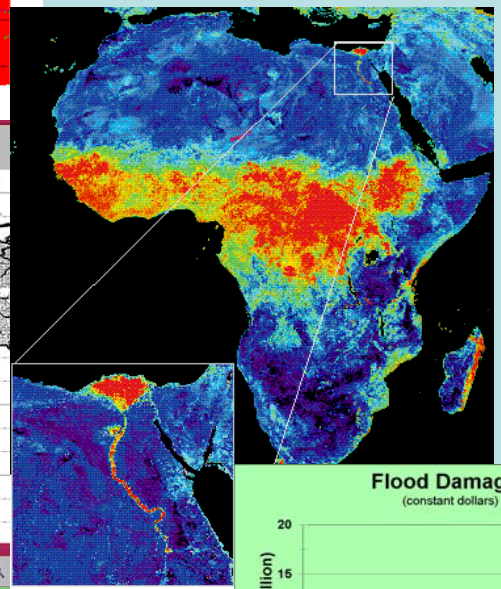
…are creating new ways to view the "global water crisis"

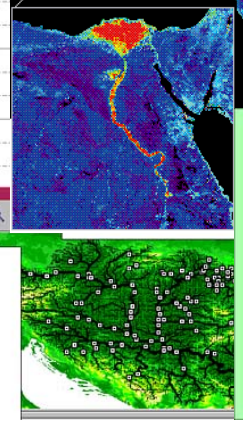
…to inform policy and improve management

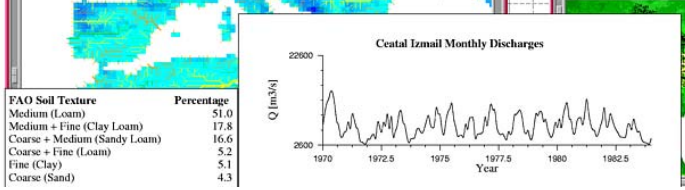


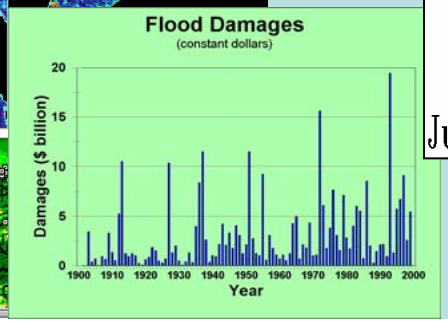


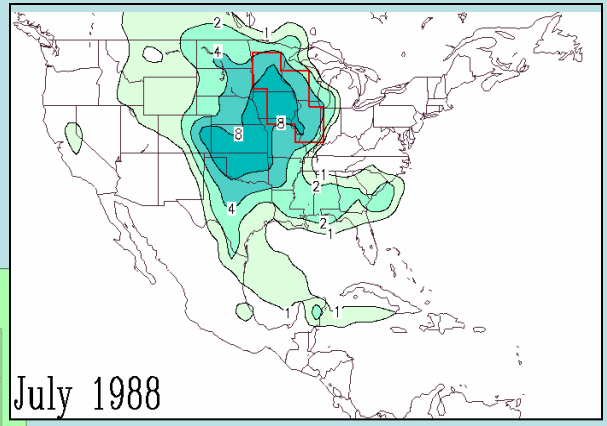






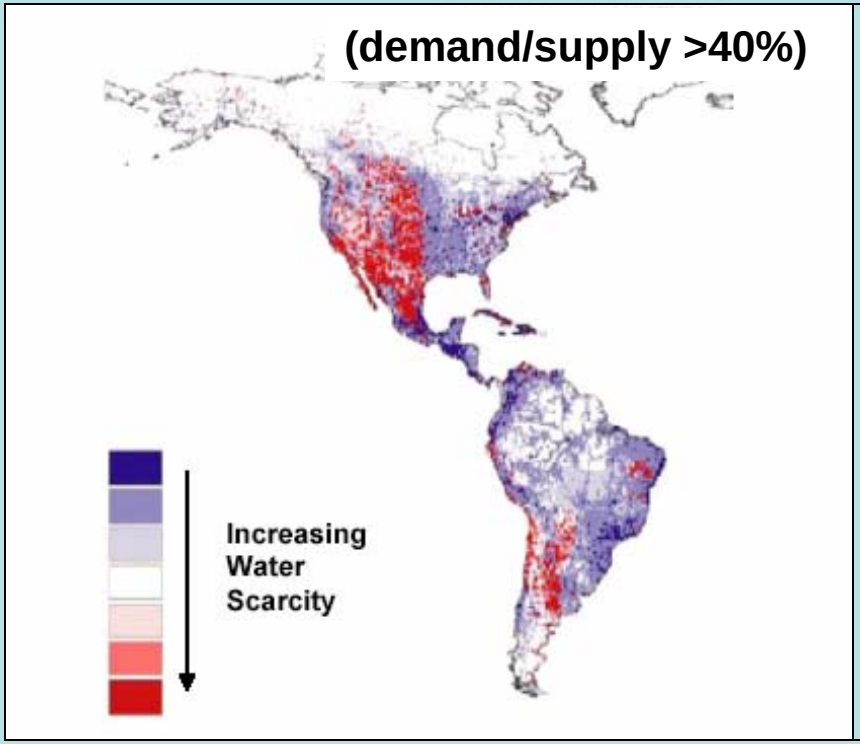






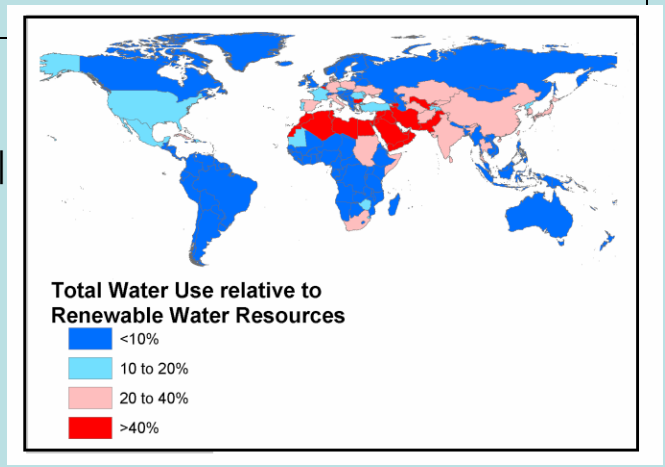
New Geospatial Approaches Merge Supply w/ Use

Contemporary Population under High Water Stress



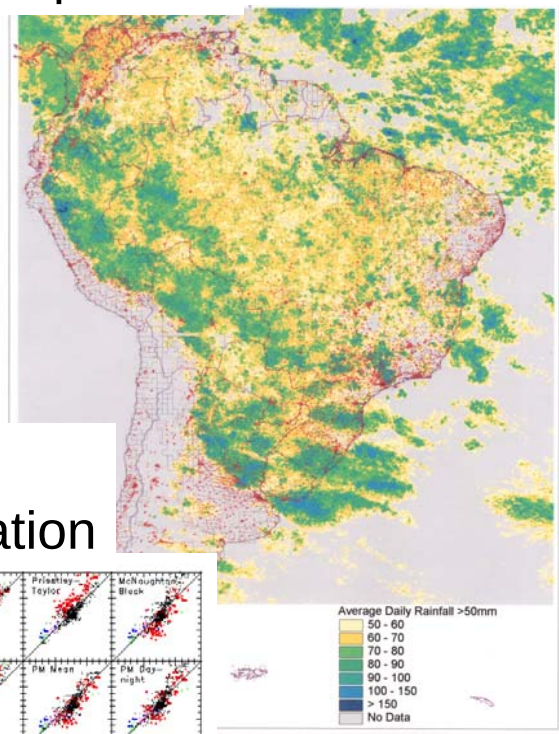
- Number highly sensitive to accounting unit
- Grid-based (30' lat/long) estimates (n > 60,000) capture spatial variability & show much higher numbers than country-level statistics (n ≈ 200)

		Total Population (billions)		
		Country-level		Grid-based
Water Stress	**DIA/Q (unitless)**	**U.N.**	**Grid Sum**	**Full Resolution**
Low	*<0.1*	**1.72**	**1.95**	**3.16**
Moderate	*0.1 to 0.2*	**2.08**	**1.73**	**0.38**
Med-high	*0.2 to 0.4*	**1.44**	**1.54**	**0.37**
High	*>0.4*	**0.46**	**0.45**	**1.76**

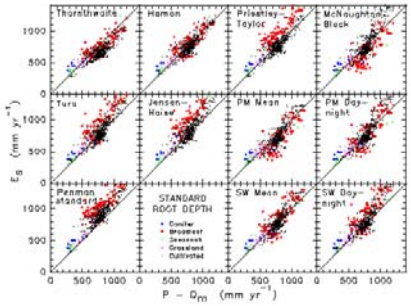


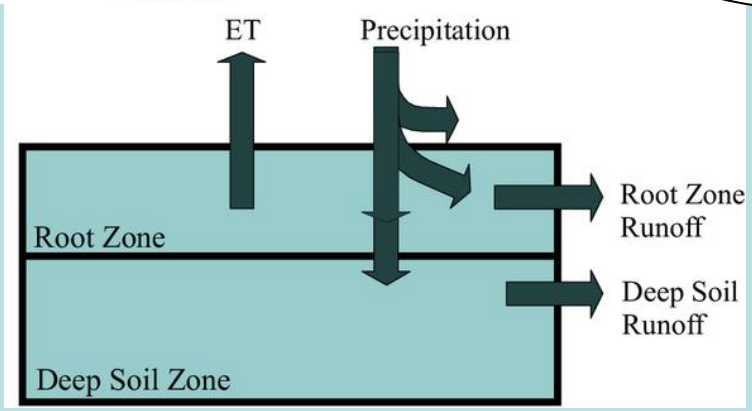
Vorosmarty et al. 2000

Precipitation

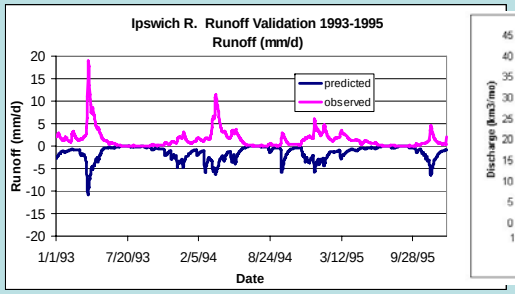


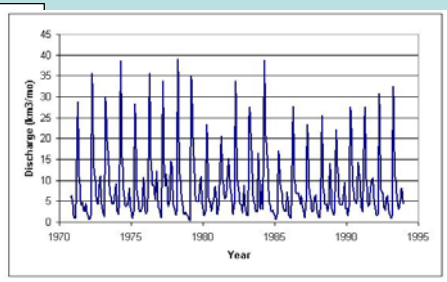
Evapo-transpiration





River Corridor Flows = Often Important Part of Regional Water Resource Base

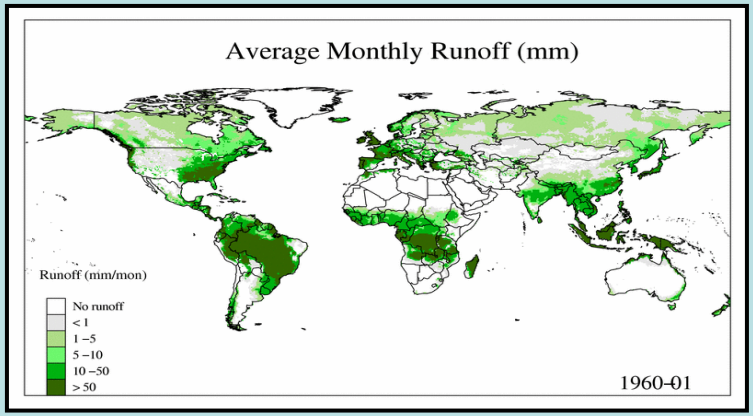




Lateral Transport

Channel Topology

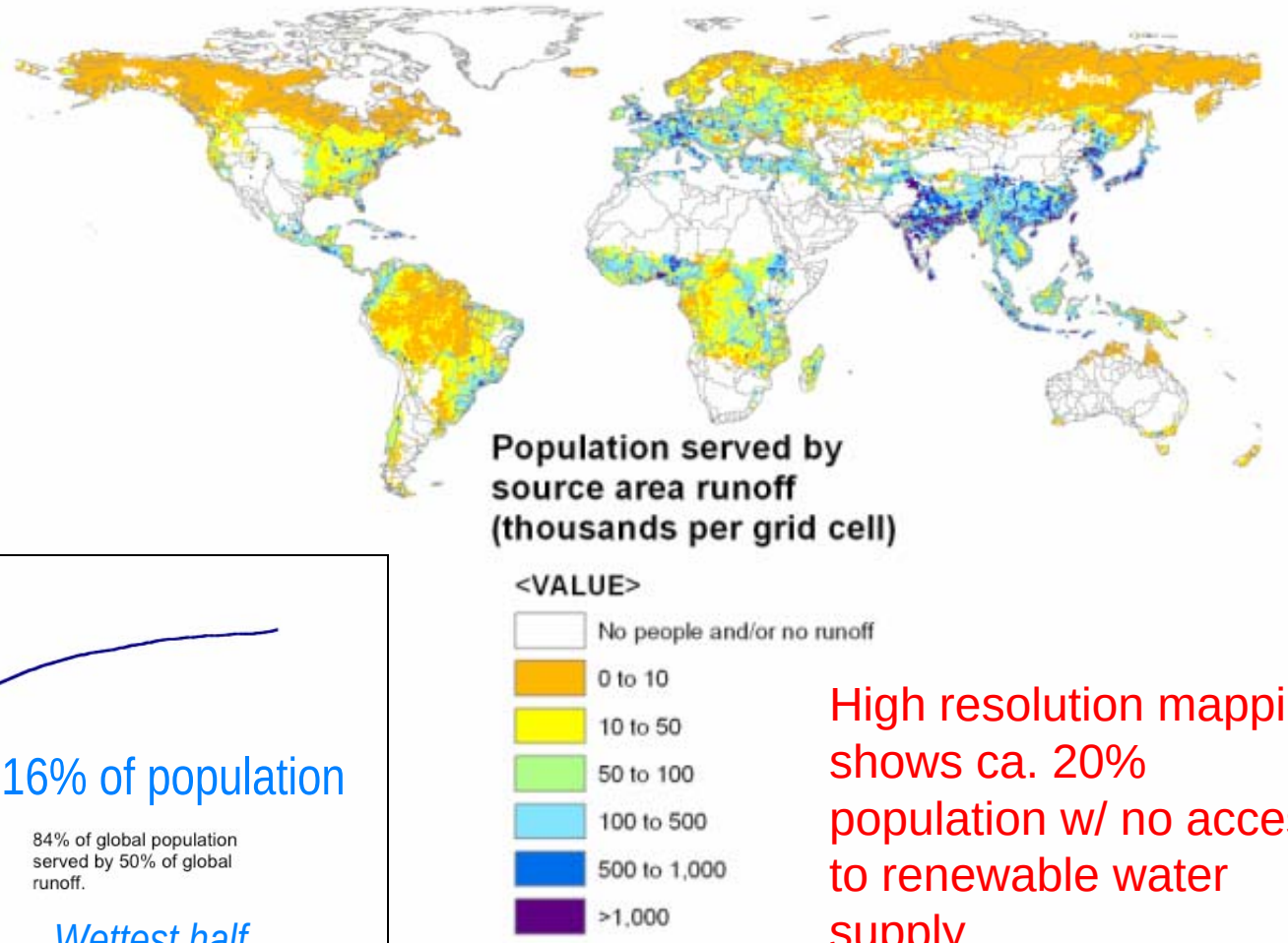
WBM/WTM

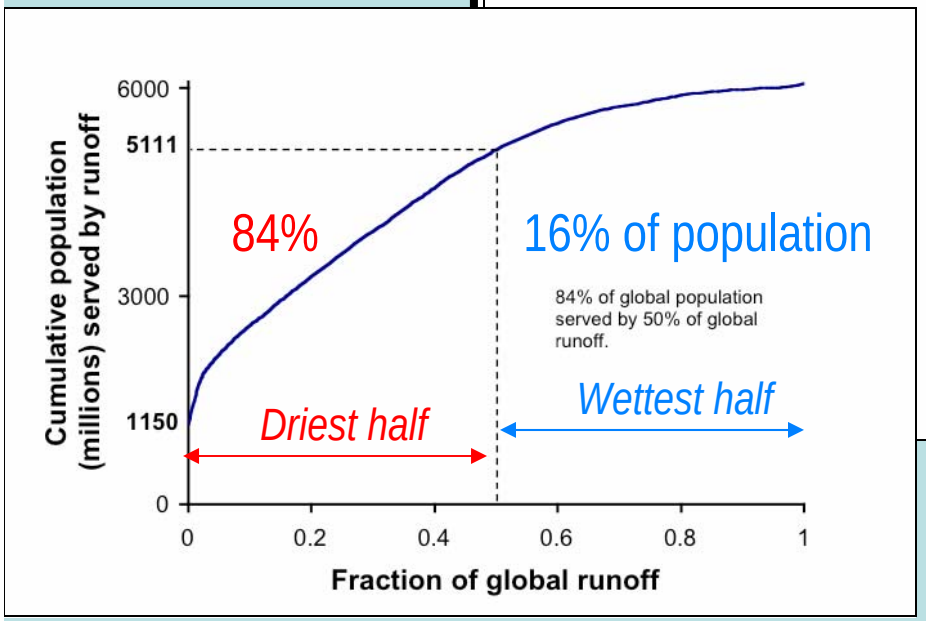


Runoff= Local Water Resource

Humans Interacting w/ the Global Water Cycle--

The Picture Today





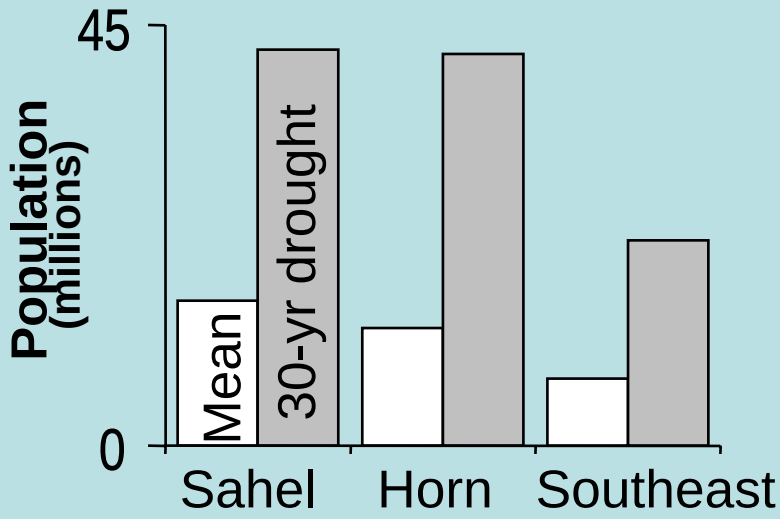
High resolution mapping shows ca. 20% population w/ no access to renewable water supply

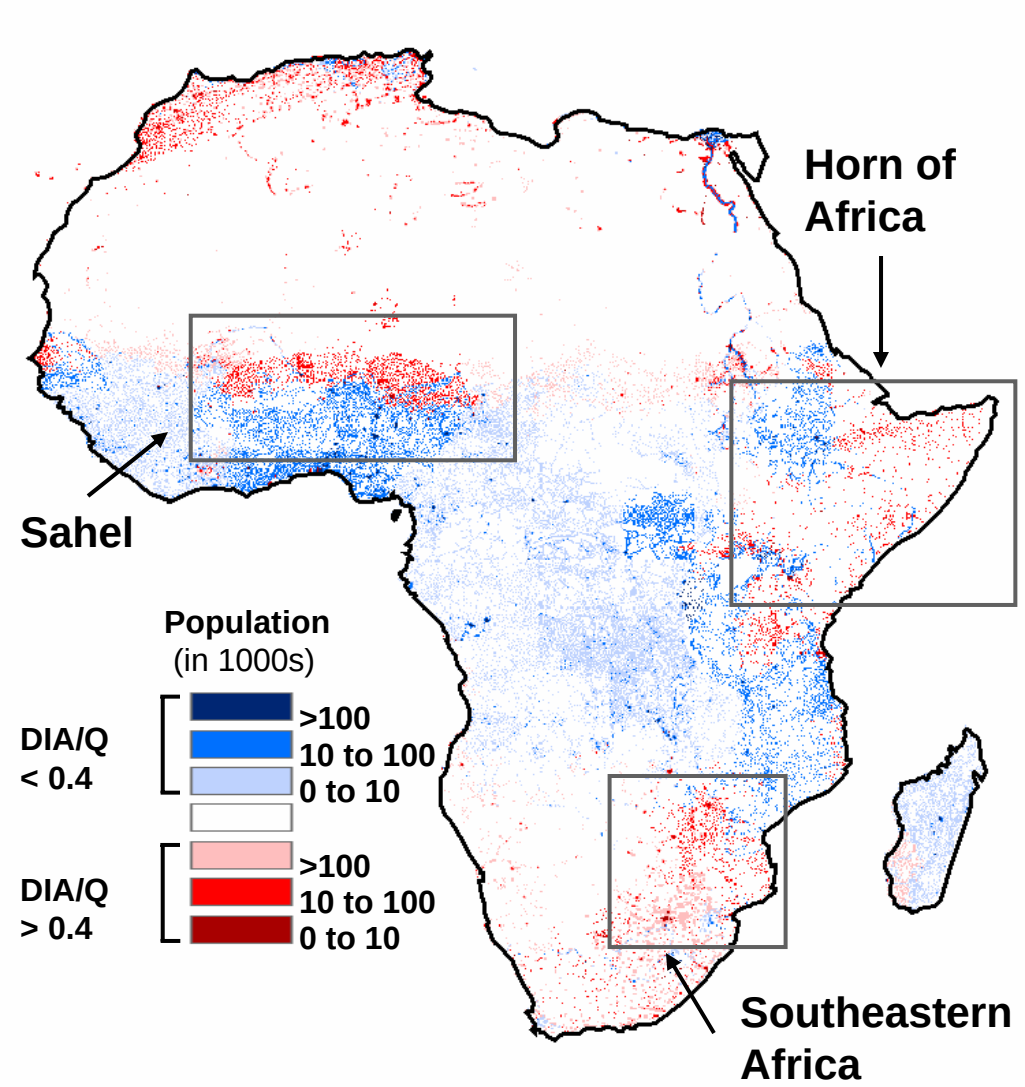
- Importance of upstream source areas: note Amazon/S. Asian contrast
- Notion of tradeoffs w/in basin

Vörösmarty et al. (2005), Millennium Assessment, Conditions & TrendsWorking Group

Drought Is Key Feature of African Security Issues

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

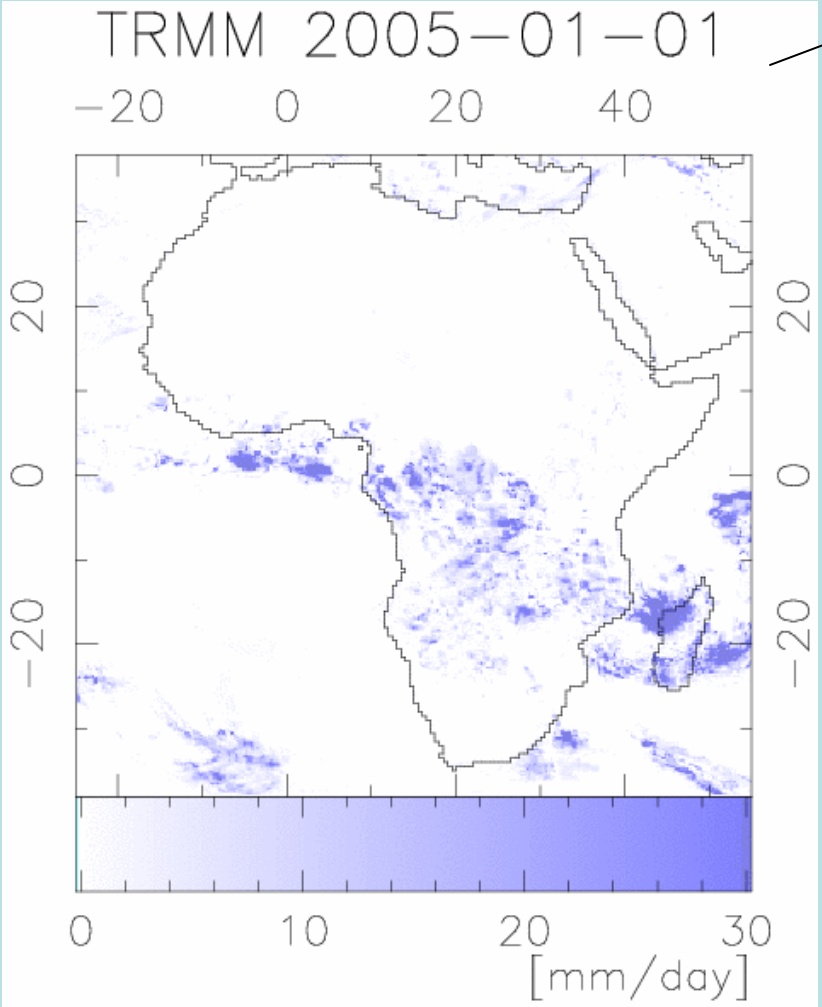




Continental total: Mean ---> 25% population w/ stress
30-yr drought ---> 40%

Vörösmarty et al. 2005

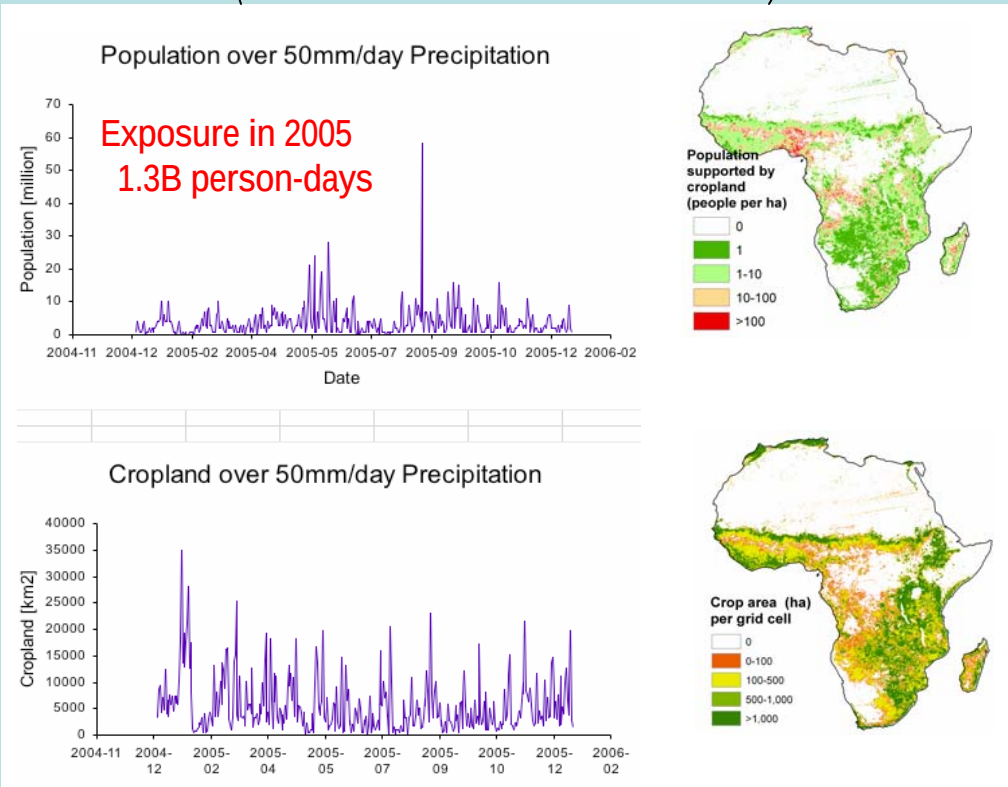
“Operationalizing” Water Stress Indicators: Merging Near Real-Time Data with Socio-economic Information



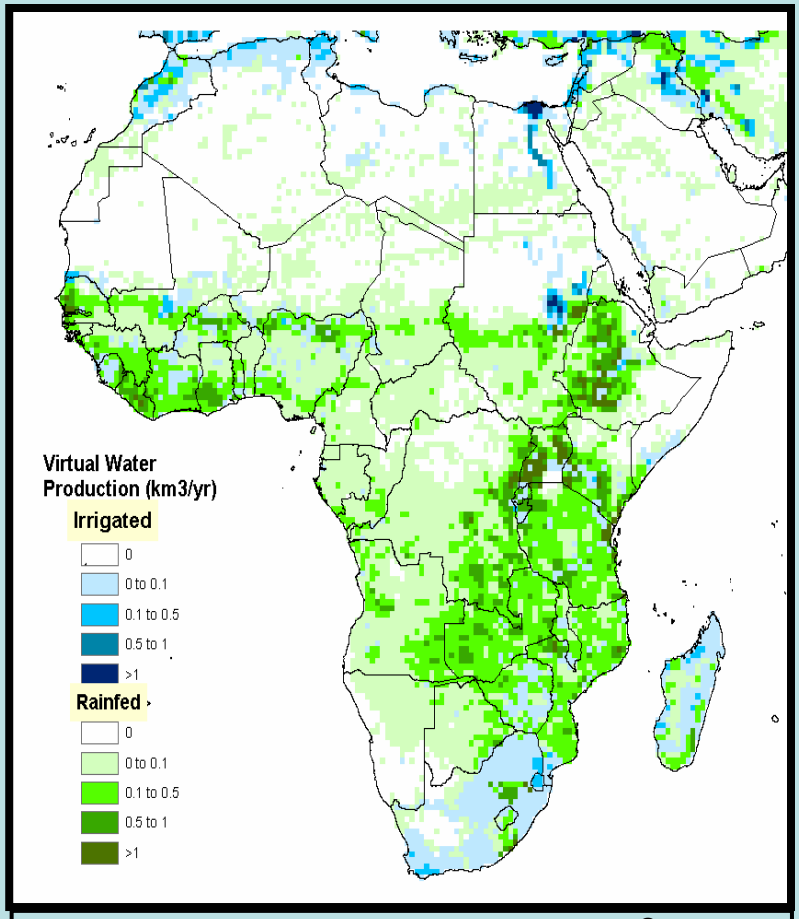
“GEOSS-class” Geophysical data

Derived Products (e.g. hazard exposure)

Geospatial Socio-economics



NATIONAL "WATER ACCOUNTS"



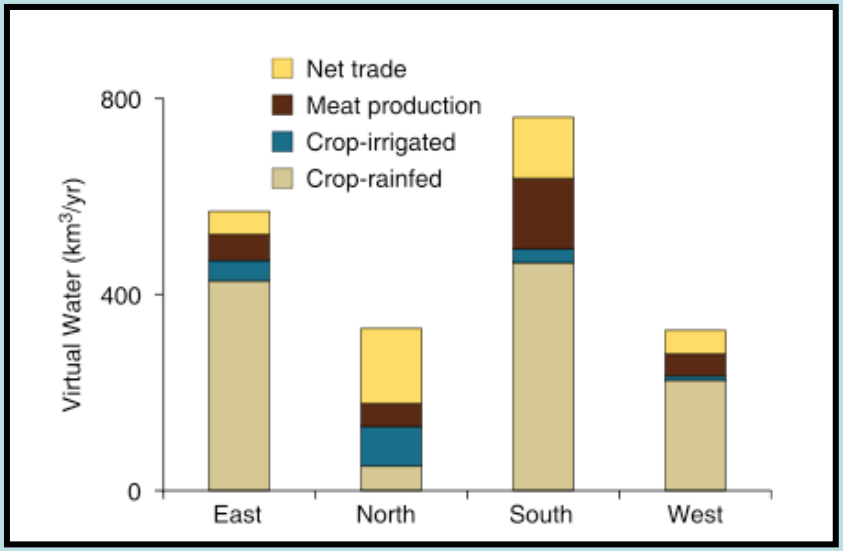
Virtual Water for the Africa (km^3/yr)

	Crops	Meat [1]	Total
Production	226	681	907
Imports	35	82	117
Exports	3	4	7
Balance	258	759	1017

[1] Includes grazing

AFRICAN VIRTUAL WATER ANALYSIS

- ~10% of supply "co-opted" for food production
- Green water: 83% of use
- Blue water: 17% of use
- Meat is important-->75% of all water



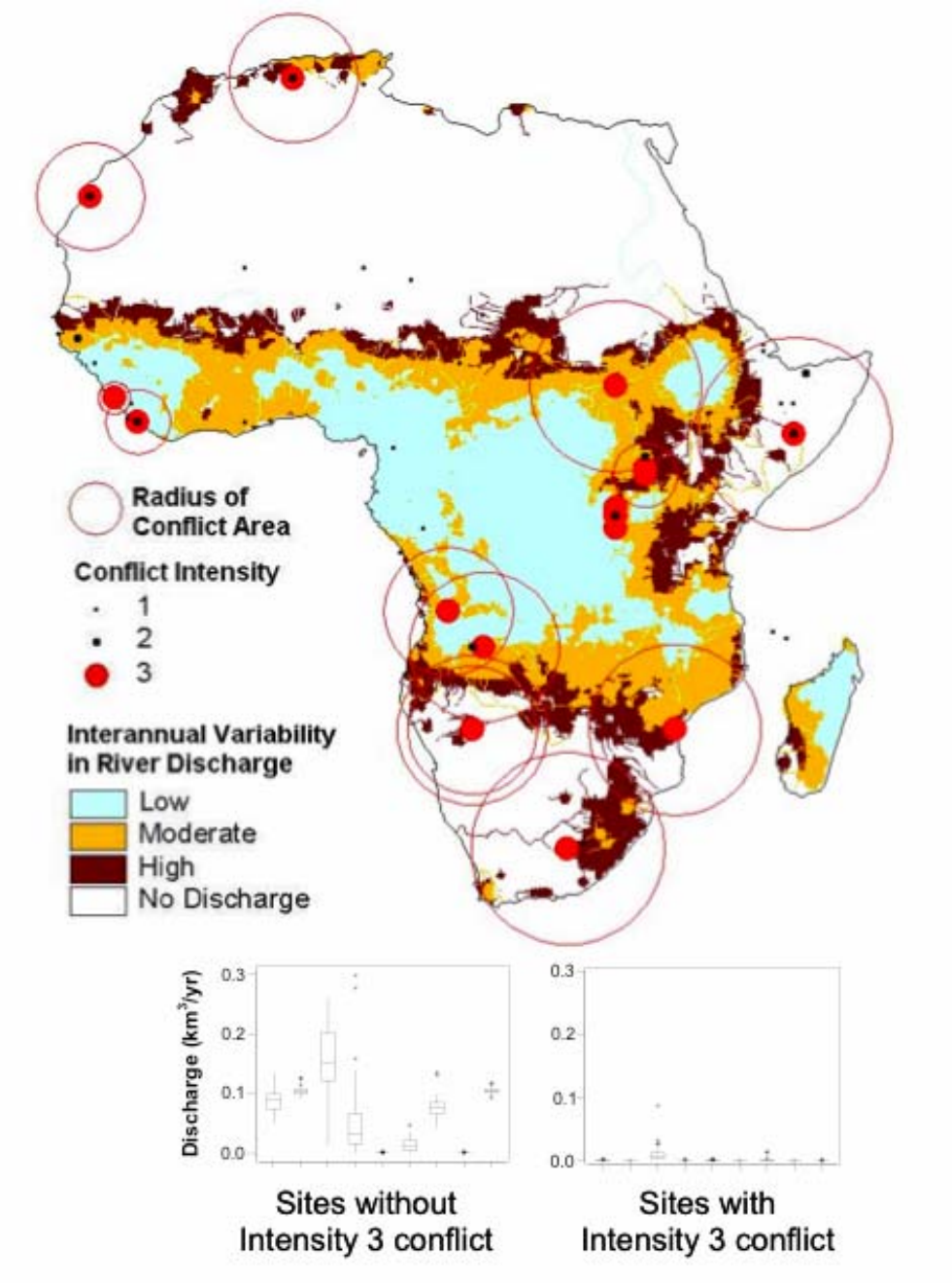
Millennium Assessment; Vörösmarty et al. 2005

Merging Geophysical and Social Science Information

Preliminary Analysis of River Corridor Flow as a Determinant of Civil Conflict

- UNH geophysical data
- PRIO/Uppsala Conflict Database

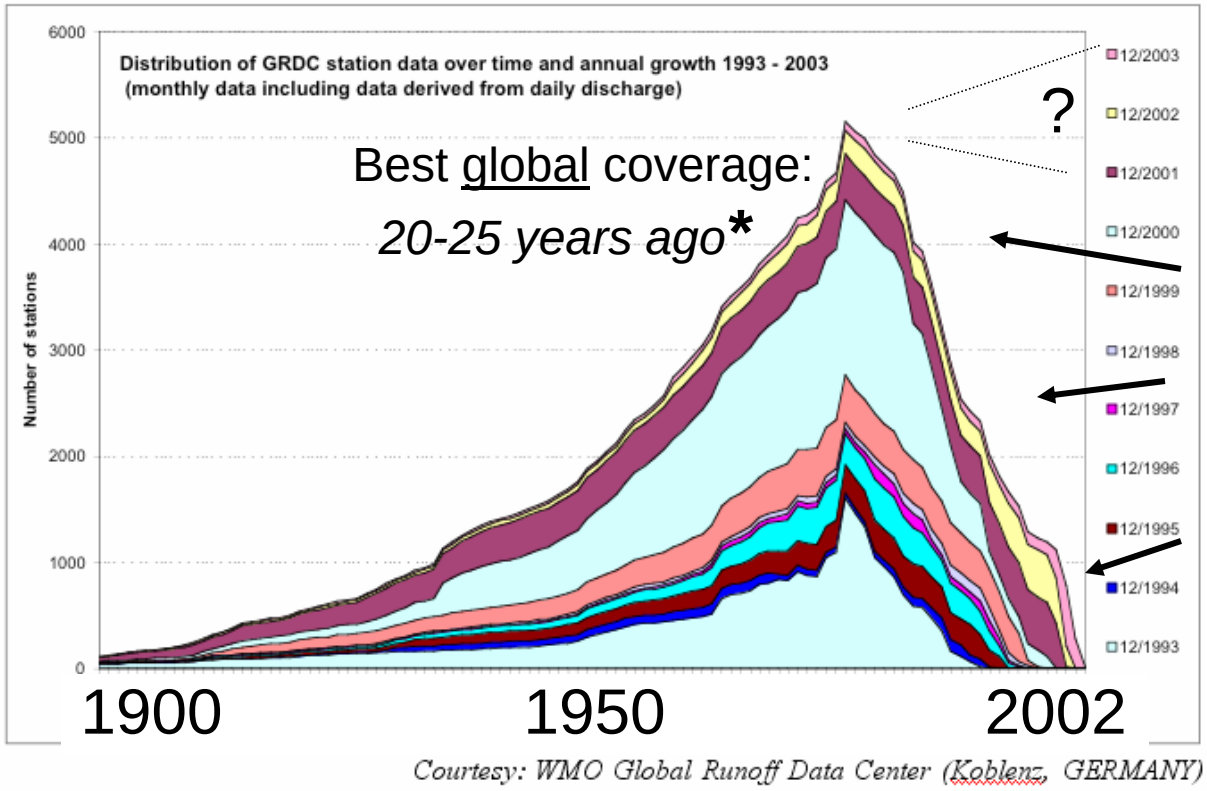
(www.prio.no/cwp/armedconflict)



Levy et al. (2005)

HISTORY OF OUR "Ground Truth" INFORMATION BASE

- WMO Global Runoff Data Center Archives



Courtesy: WMO Global Runoff Data Center (Koblenz, GERMANY)

Colors refer to archive "date stamp"

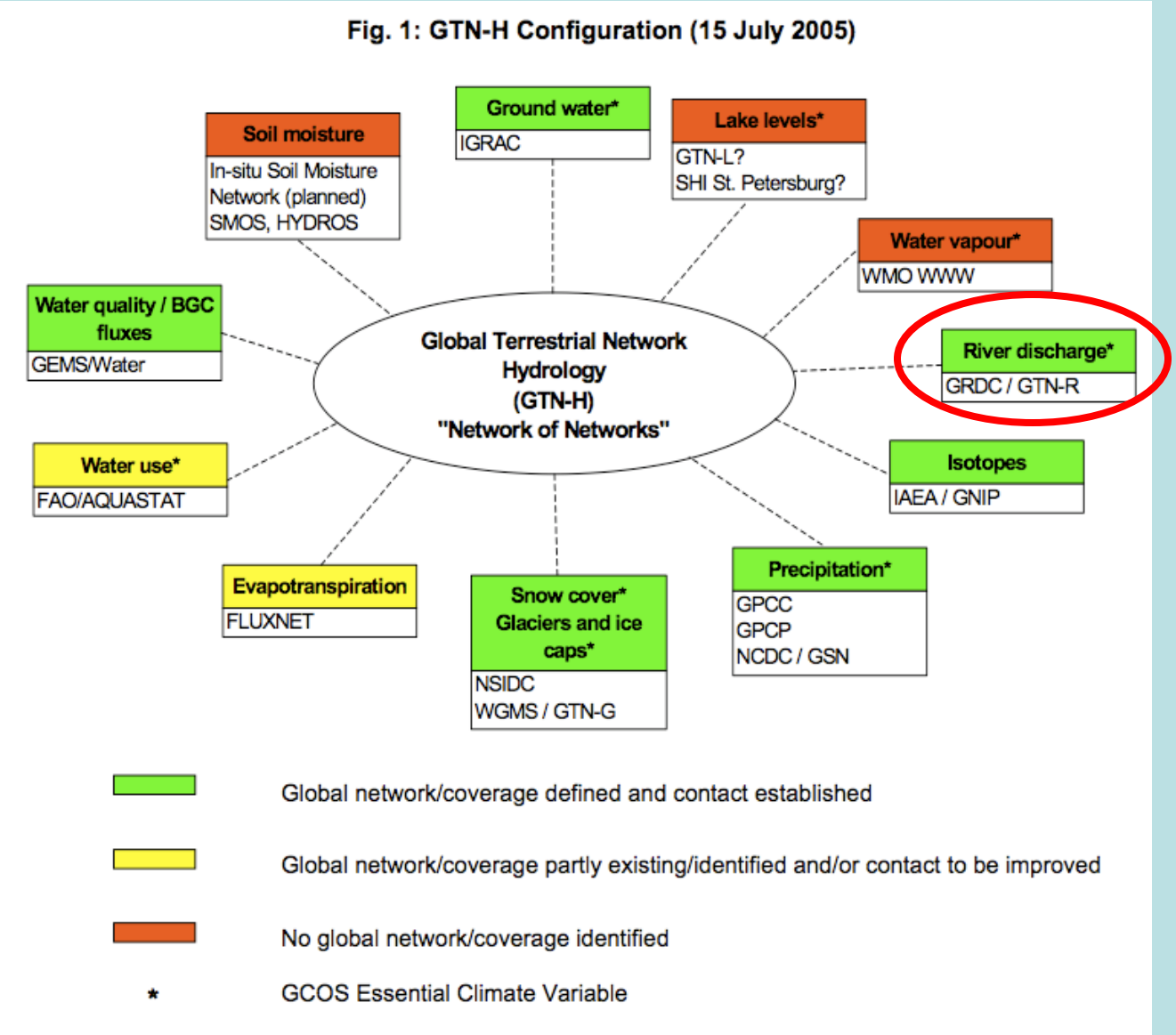
Future data availability highly uncertain

- Data Bank Closure
  - -- Commercialization of data
  - -- Legislative challenges/IP rights
- Station network losses
- Delays in data reduction & reporting
- Fragmentation across NHMSs

*Additional records certainly exist (e.g. national collections) --but currently unconsolidated & often in difficult-to-use, non-digital formats; dedicated global archive is in decline

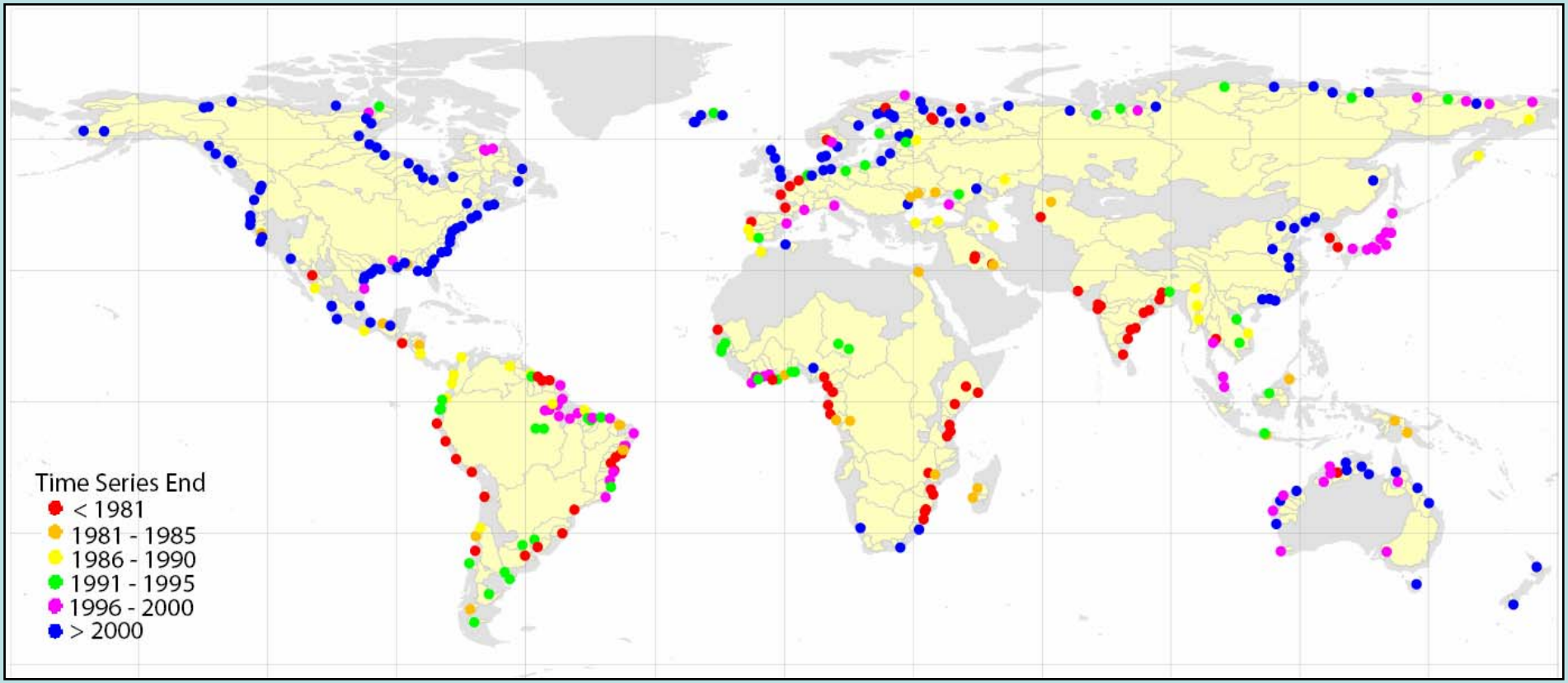
Global Terrestrial Network for Hydrology (GTN-H)

- "Network of networks" for water cycle elements
- 11 variables
- Near Real Time (NRT)



Slide courtesy of
W. Grabs (WMO)
T. Mauser (GRDC)

Global Terrestrial Network for River Discharge (GTN-R) http://gtn-r.bafg.de



The 380 river discharge stations along the continental coastlines lie in 355 of the 391 basins depicted here (status Nov 2006). The colour code indicates the latest data available in the GRDC database. (It well may be that many of the stations listed feature more up-to-date data which, however, are currently only available at the National Hydrological Service (NHS) maintaining the station, but not (yet) in the GRDC database.)

GLOBAL CLIMATE OBSERVING SYSTEM

WMO of UNESCO UNEP ICSU

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

Action T4 (TF2) *(agreed-to in 2004)*

Action: Confirm locations of GTN-R sites, determine operational status of gauges at all GTN-R sites, ensure that the GRDC receive daily river discharge data from all 380 sites within one year of their observation (including measurement and data transmission technology used).
Who: National Hydrological Services, through WMO CHy in cooperation with TOPC, GTOS and the GRDC.
Time-Frame: 2006 for finalization of network and reporting of any historical records, complete compliance, i.e., one-year time lag by 2009.
Performance Indicator: Reports to WMO CHy on the completeness of the GTN-R record held in the GRDC including the number of stations and nations submitting data to the GRDC, National Communication to UNFCCC.
Cost Implications: Category II increasing to III.

REALITY: Of 82 countries contacted….

~20 have responded (positively),

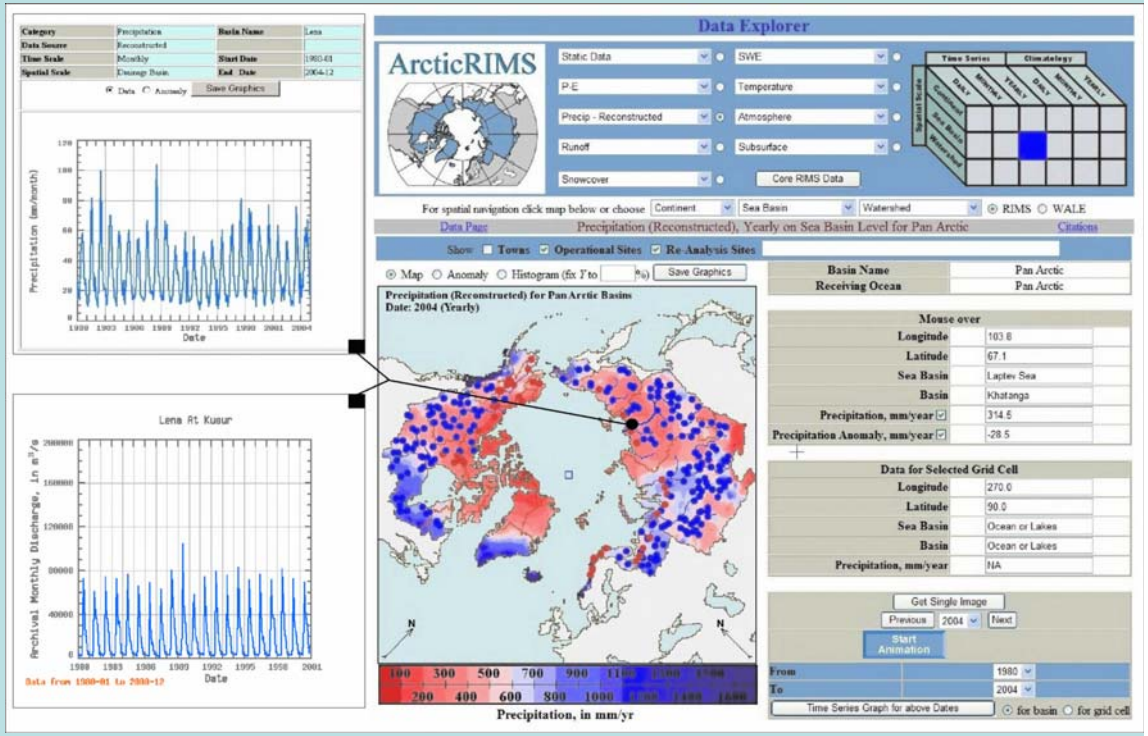
~6 have sent some information

0 has yet provided everything requested.

Regional Cooperation: Operational & Archival Hydrographic Data

Arctic-RIMS Data Compendium:

- Builds on R-ArcticNet (n>5700 stations)
- 62 operational gauges
- Near real time now: 7-10 day turnaround



R-ArcticNet Version 4.0: http://www.R-ArcticNet.sr.unh.edu/v4.0

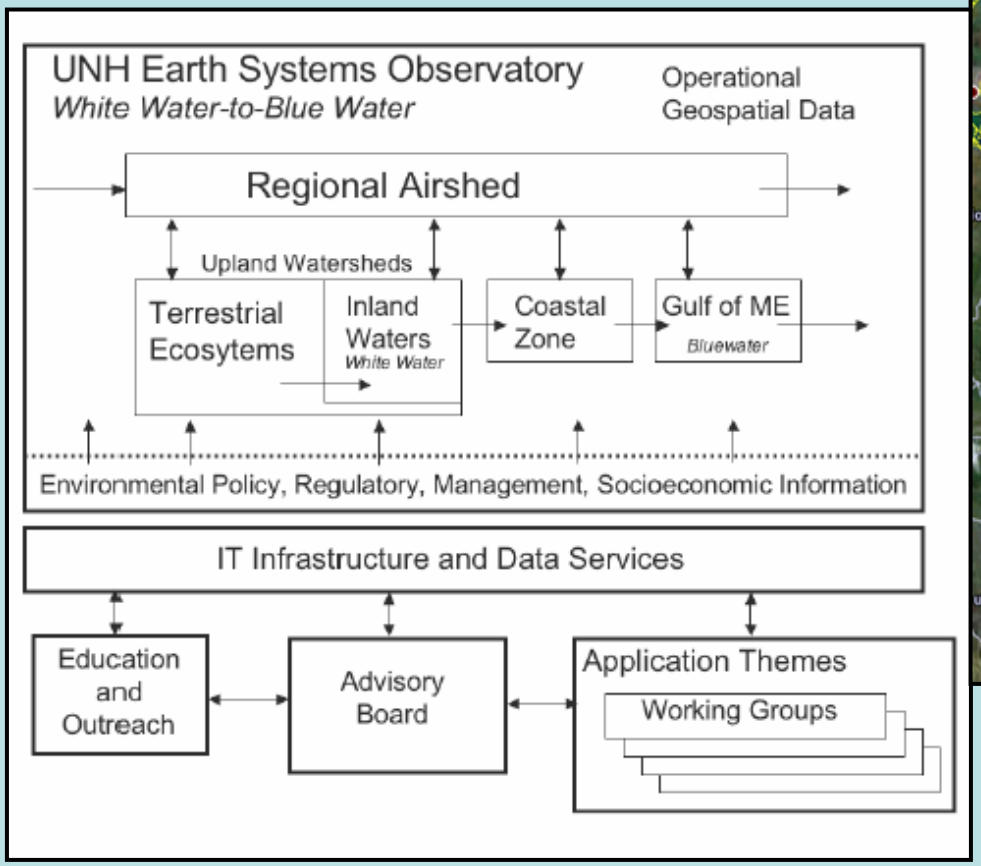
Arctic-RIMS http://RIMS.unh.edu

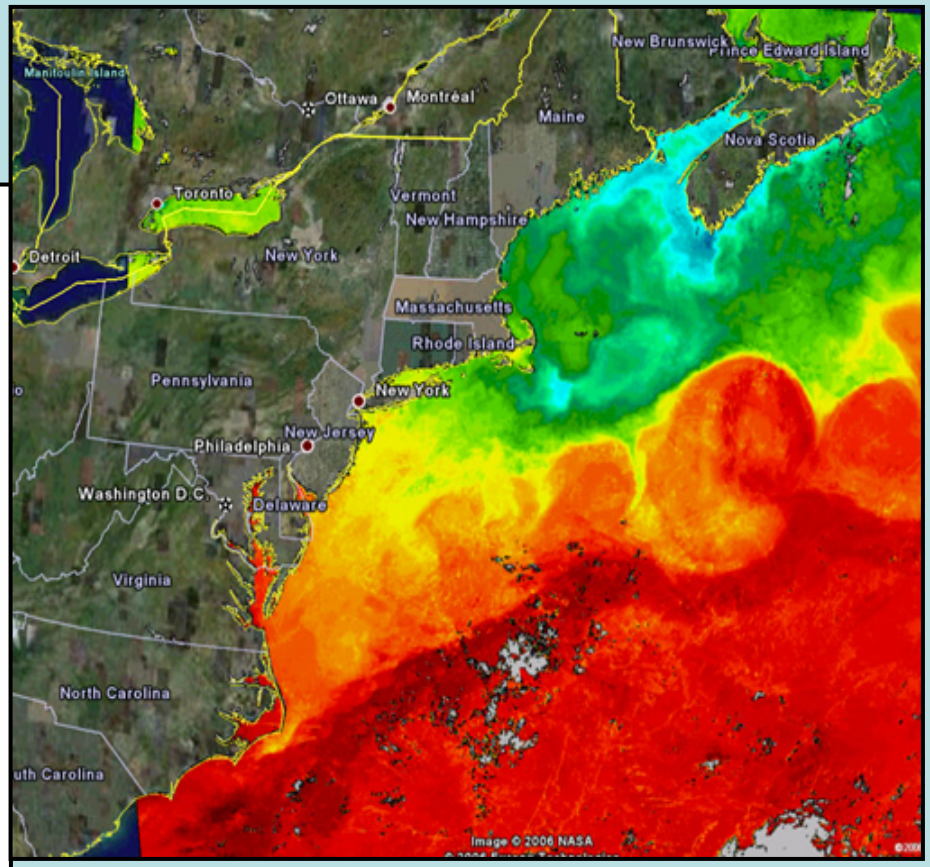
Water Systems Analysis Group http://www.watsys.sr.unh.edu

Distributed Geospatial Data Serving

The “Ecosystem Channel”

Linked Domains
& Observatory Systems





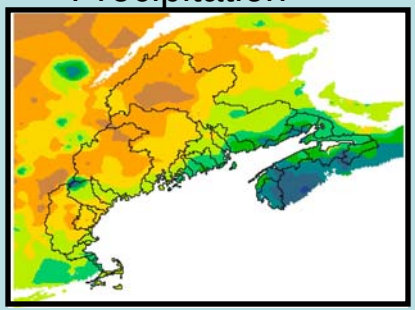
UNH EARTH SYSTEMS OBSERVATORY

UNIVERSITY OF NEW HAMPSHIRE

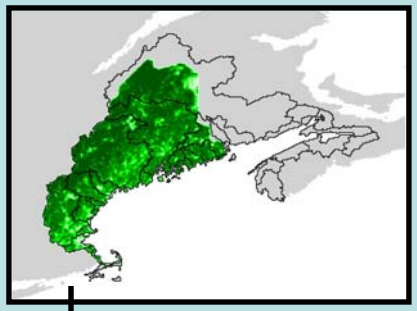
A Regional Prototype GEOSS System of Systems for Environmental Surveillance and Ecosystem Forecasts

e.g. INPUTS

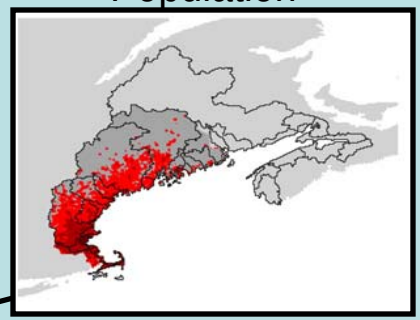
Precipitation



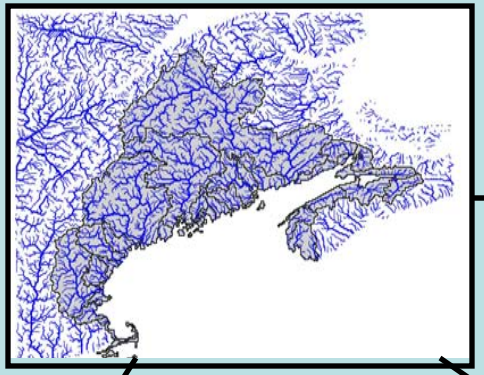
Land Cover

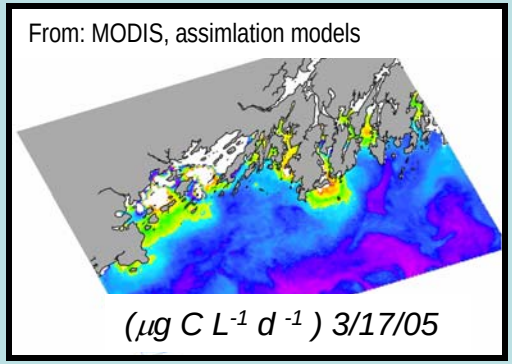


Population



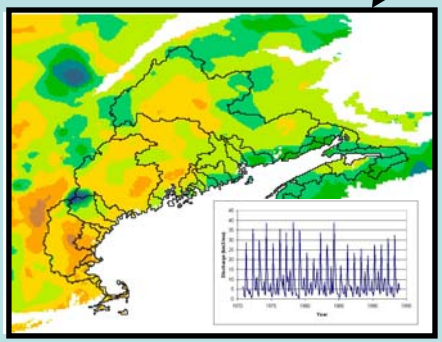
High Resolution River Networks (GM-WICS)



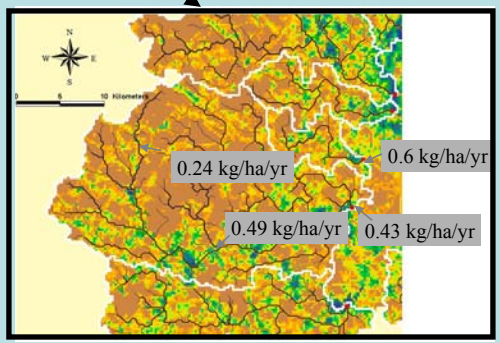


River Plumes & Coastal Zone Metabolism

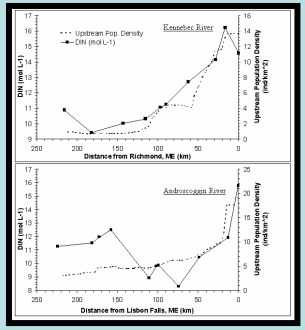
e.g. OUTPUTS



Runoff, Streamflow, Habitat Mapping

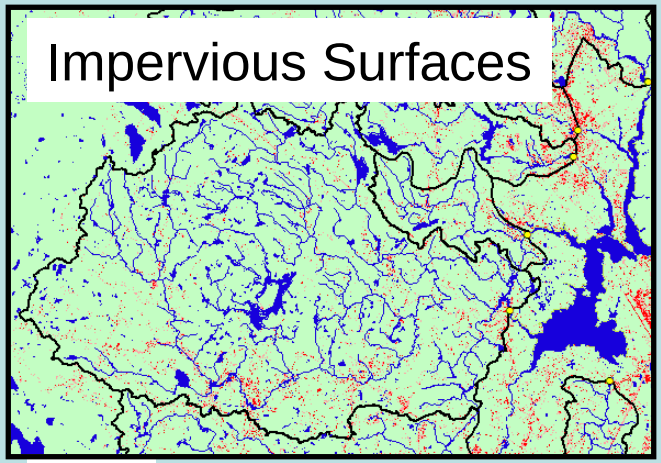


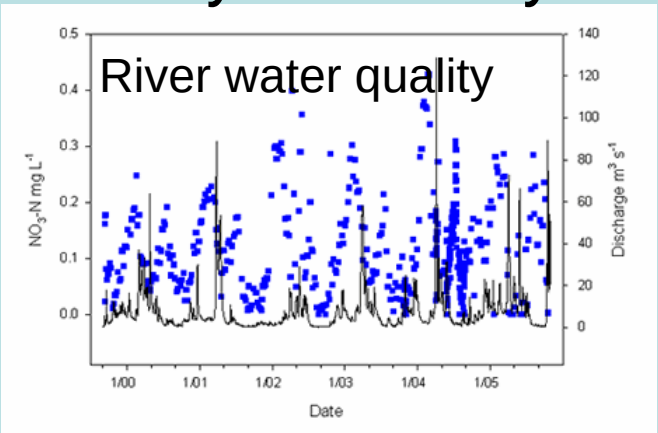
N Fluxes

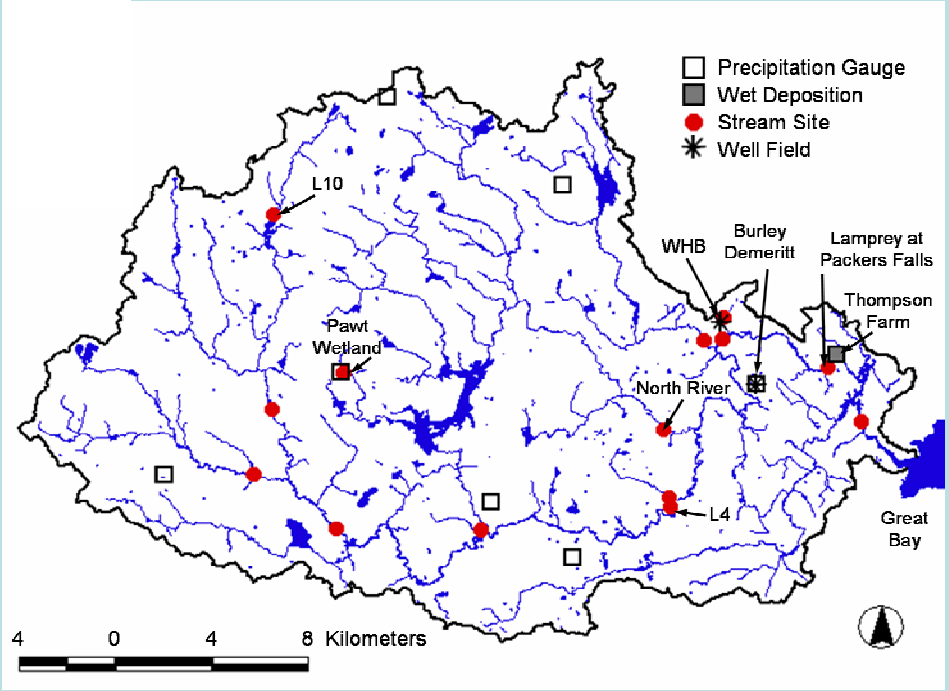


Regional Summaries, Report Cards, Alerts, & Indicaors

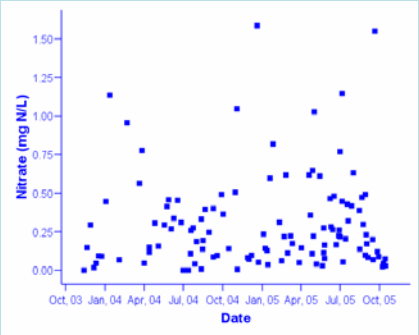
The Lamprey River (NH) as an Example of an Integrated Biogeophysical Observatory: Part of a System-of-Systems



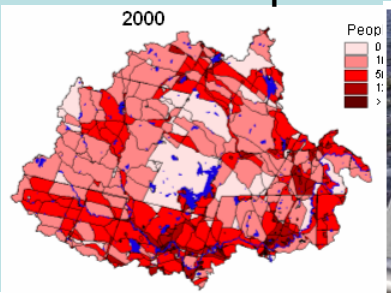




Wet Deposition



Population dynamics



Conclusions and Recommendations

- Many pressing fresh water resource problems -- transcend state & national boundaries
- Many new water science & assessment capabilities emerging from Earth System sciences
- **All** require *in situ* hydrographic network data--but widespread availability in severe decline
- Willingness of NHMSs to provide consistent, high quality data for common good--- essential for clear vision of emerging problems
- Recommendation: Capitalize on existing agreements (*i.e. Resolution #25, WMO Cg-XIII, 1999*) & consensus-based frameworks (*e.g. GCOS, IGOS-IGWCO, GTN-R & GTN-H, WMO-WHYCOS, GEOSS*)