Overview of Observing Systems and Associated Research to Assess Variability and Extremes in the Water Cycle.

Rick Lawford
November 18, 2010
Kyiv, Ukraine

Why worry about observations?

A Narrative of the Economic Imperative:

In January 2008, when a major hydroelectric corporation (not free to mention the name) was making its spring projection for power generation when it found that 9 remote climate stations in the Williston reservoir basin had failed in mid-November.

To "save money" this corporation used climate estimates to predict the snow accumulation rather than send a technician out to fix the stations. In February they did send out a technician and found that the basins were reporting much less snow on the ground than they had anticipated.

Result: There was a 6% drop in the Williston forecast amounting to 860 GWh then worth $50 million on the market.

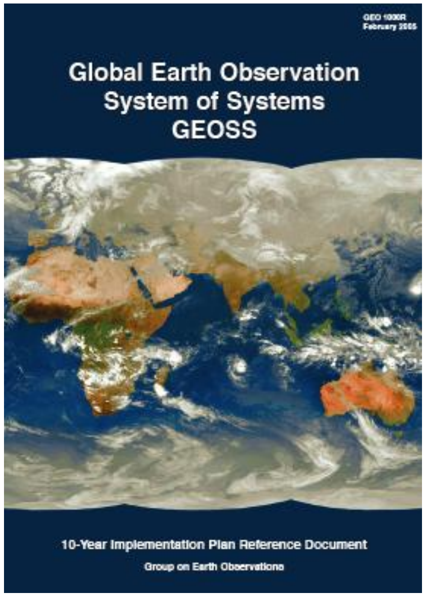
The cost of a trip to check the stations: < $10,000.

Benefit to Cost ratio: $50,000,000/ $10,000 = **5000 to 1**

Observations are important for:
-Allowing comparisons between present conditions and past conditions,
- provide a basis for explaining what has happened,
- provide a basis for prediction through initializing prediction systems.

Some of the issues encountered in data usage:
-Data quality,
-Interoperability of data systems,
-Availability of data in digital formats.

GEO is developing GEOSS: a Global, Coordinated, Comprehensive and Sustained System of Observing Systems



Relevant Facts:

- GEO involves 81 nations and 61 international organizations who have agreed to work together to build GEOSS.
- GEO coordinated this work by implementing 3 year work plans which are intended to lead to the achievement of the Targets outline in the GEOSS implementation plan.

Targets → Tasks → Sub Tasks

The Water Target

By 2015, produce comprehensive sets of data, information products and services to support decision-making for efficient management of the world's water resources, based on coordinated, sustained observations of the water cycle on multiple scales.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HURRICANES IN HAITI, EXTENSION OF CALL
On 11 September charter activation 220 was extended for a third time to cover the area hit successively by Hurricane Gustav, Hurricane Hanna, and Hurricane Ike, as the city of Gonaives remained under water and media reported about 500 dead.
More...
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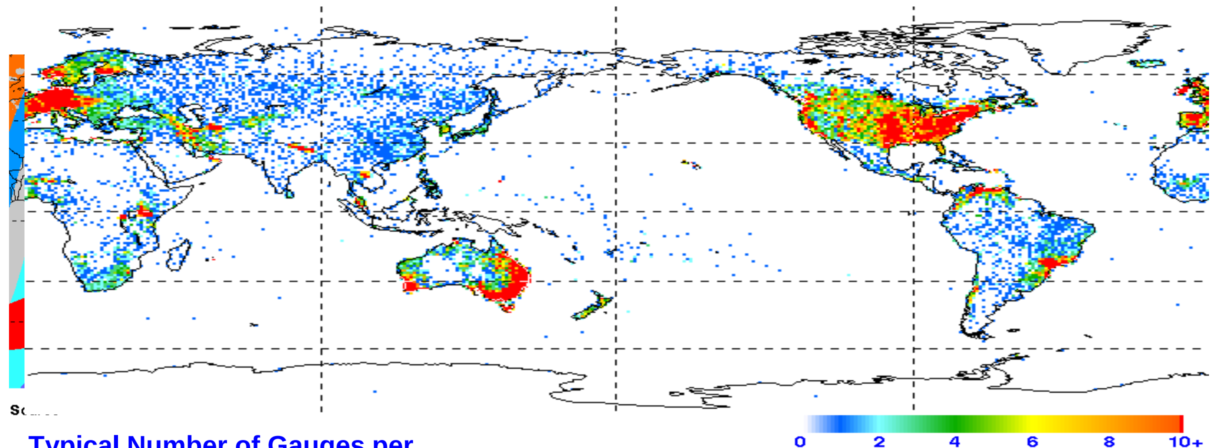
Recent Results of a cross-SBA Analysis of Users Needs for Data

Variable	Ranking in the Cross-SBA List in US-09-01a	Status of Observations	Possible Follow-on
Precipitation	#1	In good shape in most areas	GPM needs support IGWCO happy to help with US-09-01a follow-on
Soil Moisture	#2	SMOS & SMAP beneficial. Surface obsetvations need to be strengthened	
Surface Humidity U. Air Humidity	#6 #17	IGWCO has looked to GEWEX to lead	Intercomparison of products.
Vegetation Cover (Evapo-transpiration)	#7	ET is not included as an GCOS ECV	ET workshop planned
River flow Observations	#19	WMO has advanced HARON proposal	CNES has a mission proposal under development

Priority Measurements: Precipitation

Microwave sensors in low orbit (best estimates) provide one snapshot over ~ 80% of the Earth every three hours.

Gauges are confined to land areas, and provide the densest coverage only at the monthly scale. Gauge data are important for anchoring the satellite estimates.



Typical Number of Gauges per 2.5° Gridbox

Climate observations: coarse resolution, long-term records

Instantaneous records: combine satellite and gauge data in different ways to produce high-resolution data.

Dataset	Algorithm	Lead Institution
GPCP	Merger	NASA and NOAA/ GEWEX
CMORPH	Morphing	NOAA/NWS/CPC
GSMaP	Morphing	JAXA
NRL MW/IR	Microwave-calibrated infrared	U.S. Naval Research Lab
PERSIANN	Neural network	Univ. of California at Irvine
TMPA	Merger, with gauge	NASA/GSFC

Priority Observation – Soil Moisture Measurements

Soil Moisture Mapping

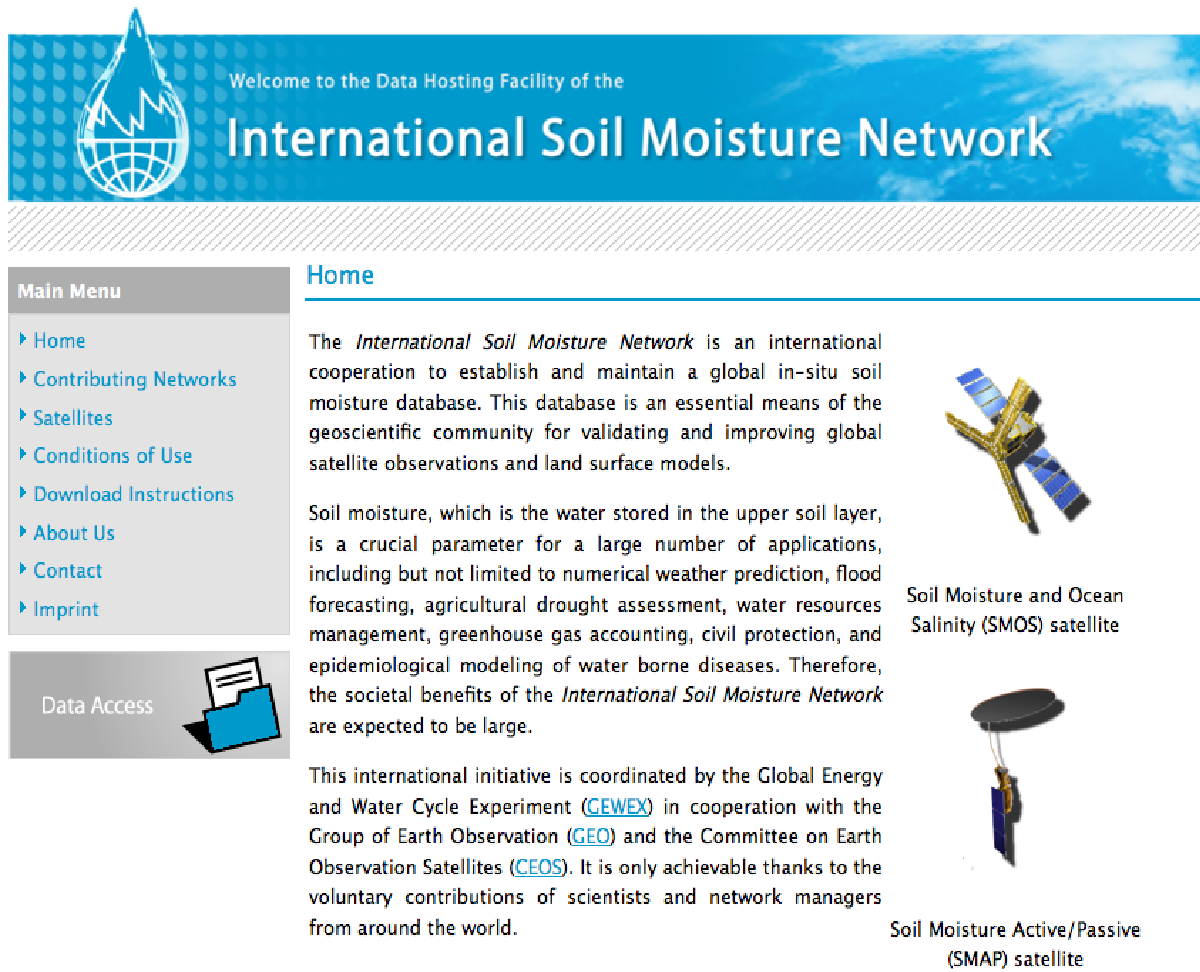
SMOS and SMAP are dedicated soil moisture missions.

ESA launched SMOS in 2009.

NASA fly an active / passive microwave soil moisture mission in 2012-2013.

SMAP extends soil moisture to deeper depths with improved spatial resolution

In-situ observations are needed to validate these new satellite products. Standards and coverage are major challenges.



Welcome to the Data Hosting Facility of the

International Soil Moisture Network

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Data Access

Home

The *International Soil Moisture Network* is an international cooperation to establish and maintain a global in-situ soil moisture database. This database is an essential means of the geoscientific community for validating and improving global satellite observations and land surface models.

Soil moisture, which is the water stored in the upper soil layer, is a crucial parameter for a large number of applications, including but not limited to numerical weather prediction, flood forecasting, agricultural drought assessment, water resources management, greenhouse gas accounting, civil protection, and epidemiological modeling of water borne diseases. Therefore, the societal benefits of the *International Soil Moisture Network* are expected to be large.

This international initiative is coordinated by the Global Energy and Water Cycle Experiment (GEWEX) in cooperation with the Group of Earth Observation (GEO) and the Committee on Earth Observation Satellites (CEOS). It is only achievable thanks to the voluntary contributions of scientists and network managers from around the world.

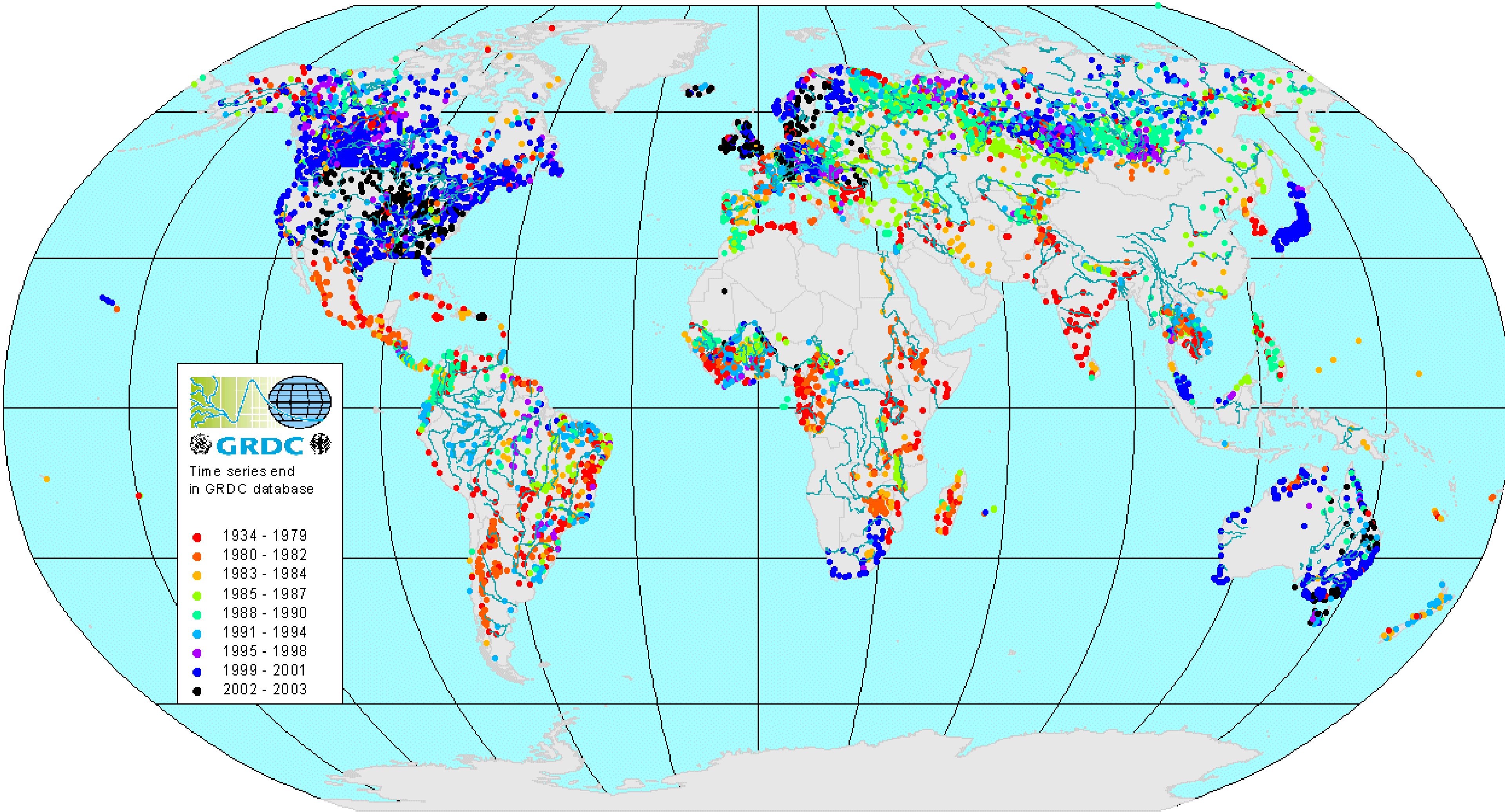
Soil Moisture and Ocean Salinity (SMOS) satellite

Soil Moisture Active/Passive (SMAP) satellite

[illegible]	[illegible]	[illegible]	[illegible]
Level 3	Daily Global Composite Radiometer-based Soil Moisture	36 km	36 hours
Level 3	Daily Global Composite Active-Passive Soil Moisture	9 km	36 hours
Level 4	Carbon Net Ecosystem Exchange	1 km	14 days
Level 4	Surface & Root Zone Soil Moisture	9 km	7 days

SMAP: http://smap.jpl.nasa.gov/science/applicWG/
In-situ: http://www.ipf.tuwien.ac.at/insitu

Runoff: Populating Global Data Bases remains a GRDC problem



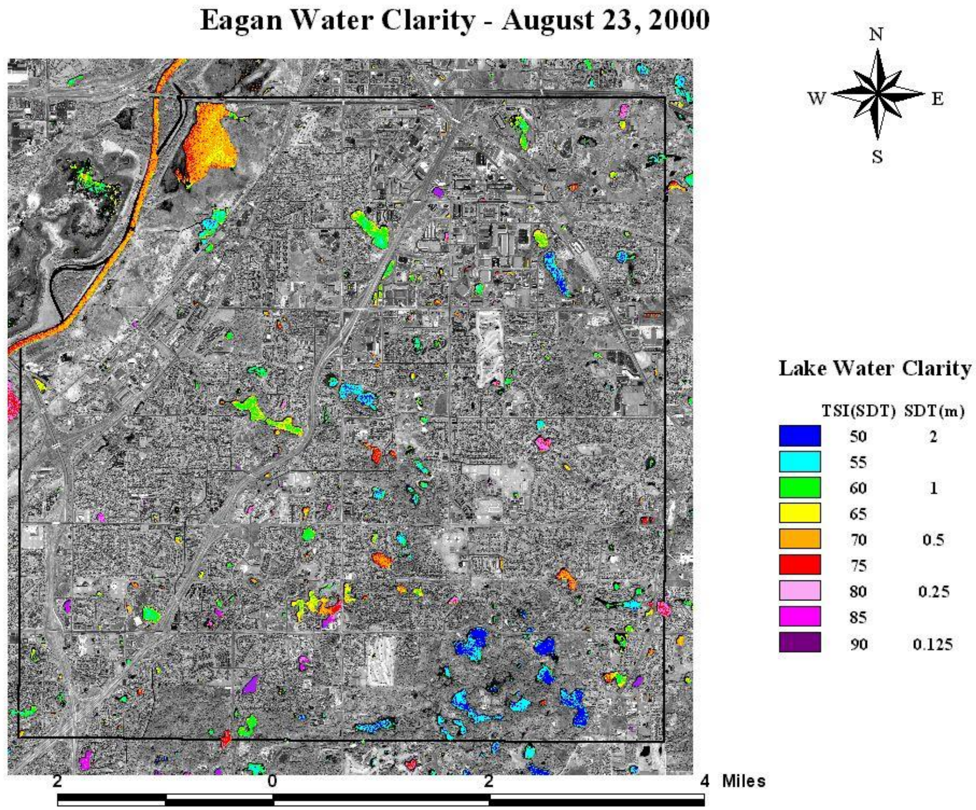
Anthropogenic Stressors

- Low and high flow volumes (minimum flow requirements)
- Eutrophication
- Thermal Discharges
- Diffuse pollution (Urban and Rural)
- Mining discharge (Hard rock gold mining/cyanide)
- Pathogens

CRISIS SPECIFIC MONITORING

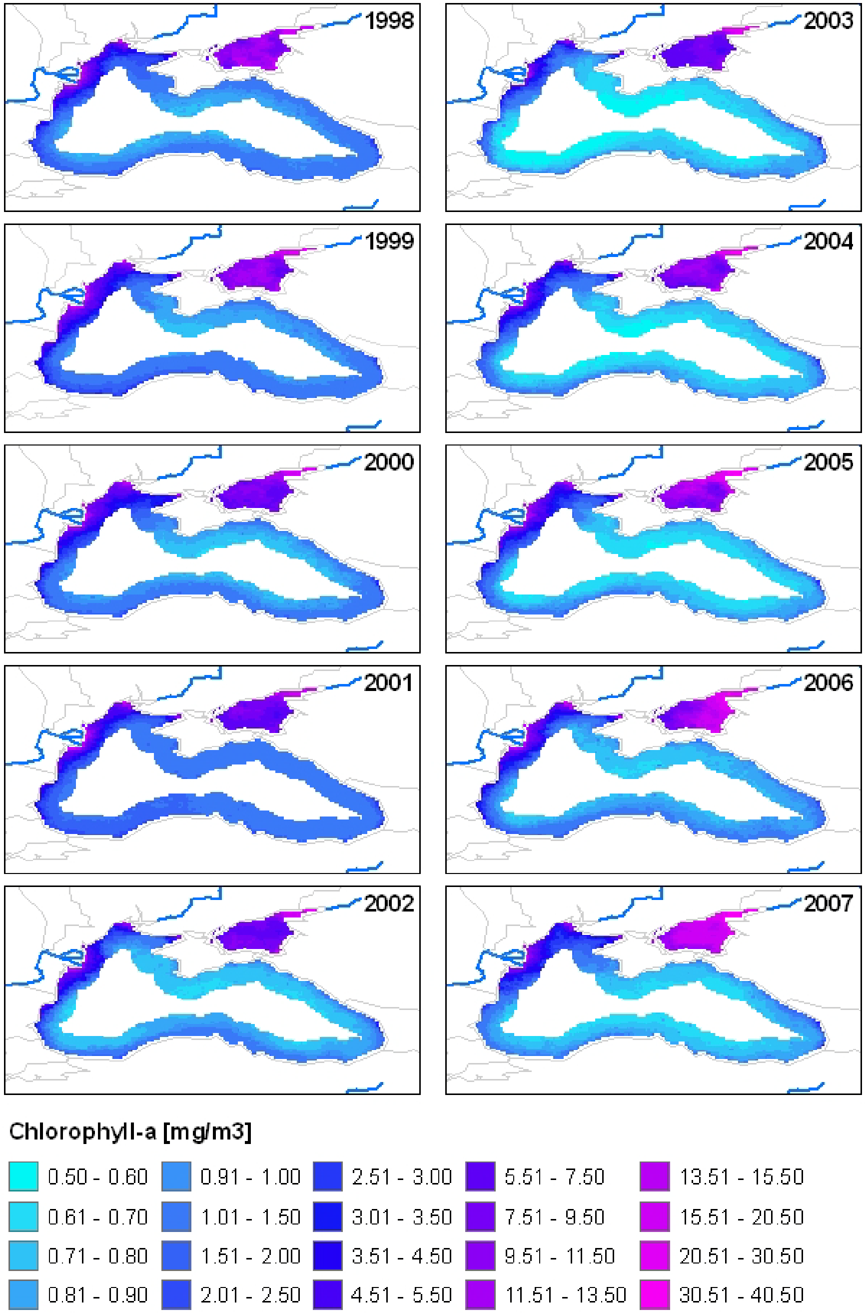
User Groups with Water Quality Concerns

- Municipal drinking and sanitation utilities
- Agriculture
- Recreation
- Industry
- Ecological needs biological integrity

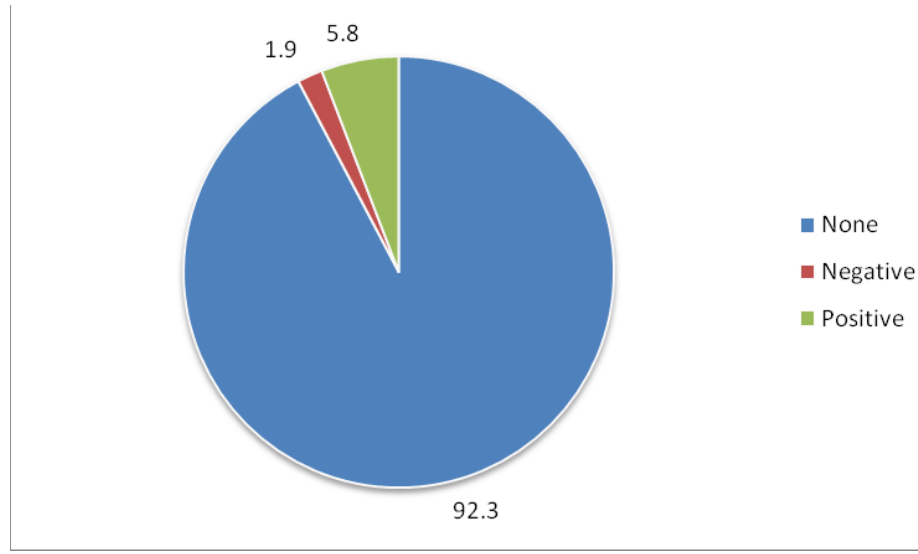


TROPHIC STATUS IMAGES FOR WATER BODIES NEAR EAGAN, MN FROM IKONOS DATA (FROM S. GREB)

Time series of chlorophyll-a concentration in the Black sea



Global Trends

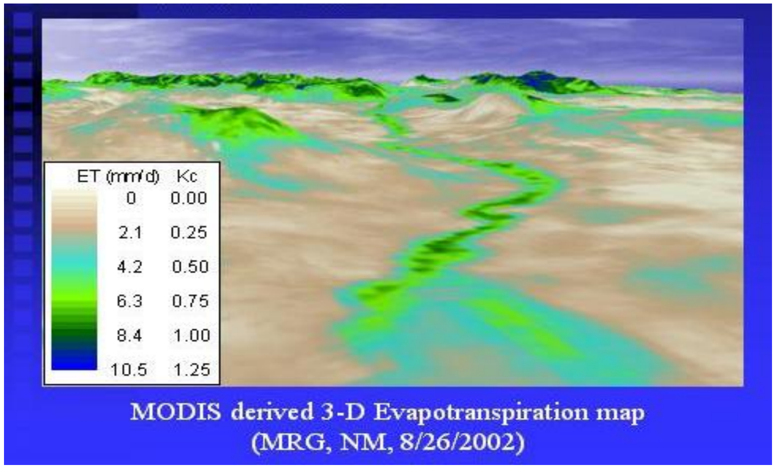


Percent of all grid cells covered by the global near-coastal-zone buffer (10-100 km off shore) where trends in chlorophyll concentrations between 1998 and 2007 were either absent, positive, or negative

(Courtesy of SEDIAC)

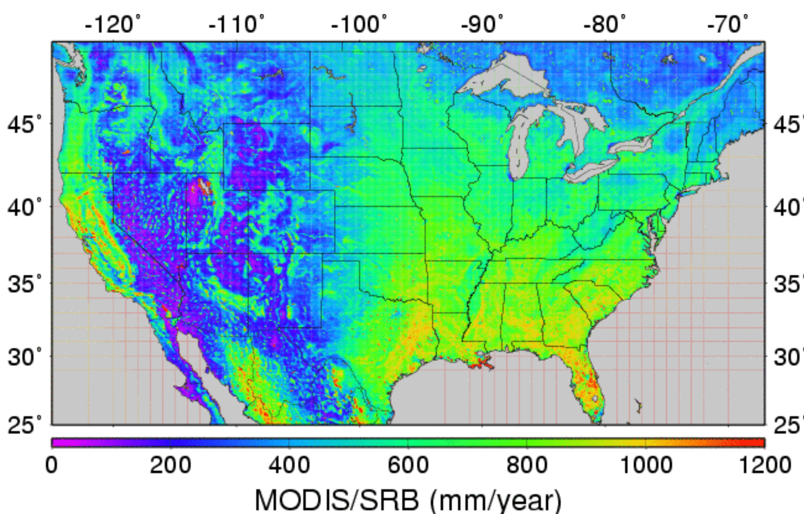
NASA ET Satellite Data w/ Real-Time with Local to Global & Applications

Translation of Landsat ET to MODIS ET for Local to Regional Applications (R. Allen)

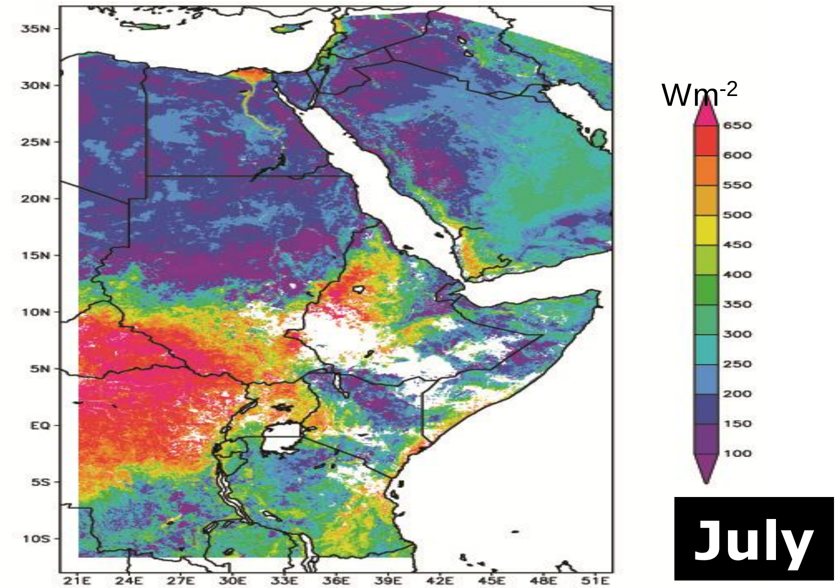


MODIS derived 3-D Evapotranspiration map (MRG, NM, 8/26/2002)

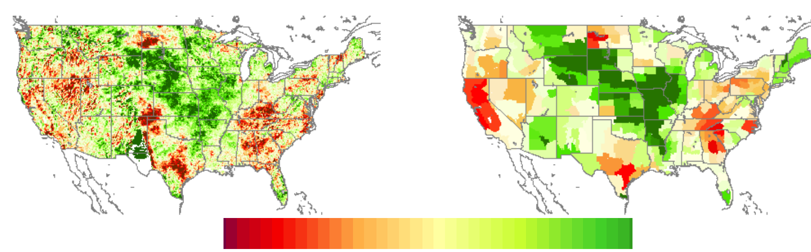
One of Two NASA MODIS & Related Products in Near Real Time towards a Global ET. U Wash. Continental US 2001-2009.(to 1-km)



Right – USDA-ARS 'Alexi-DisAlexi' for Regional to Loca ET. Applied to Nile. {30m – 25km}

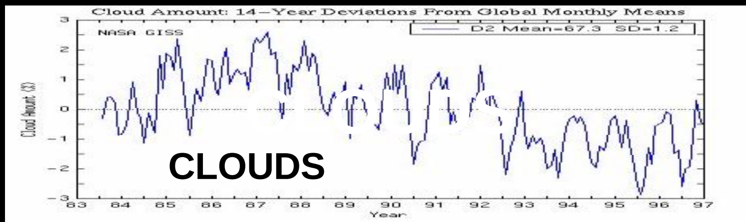


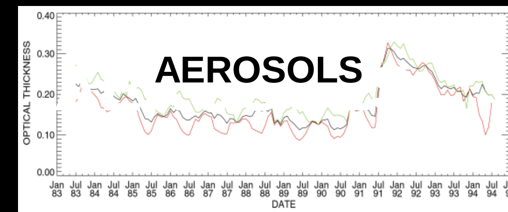
Normalized Evaporative Stress Index USDA/ARS

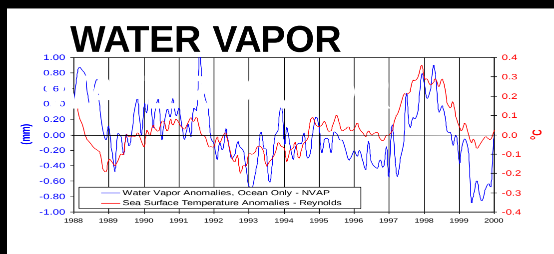


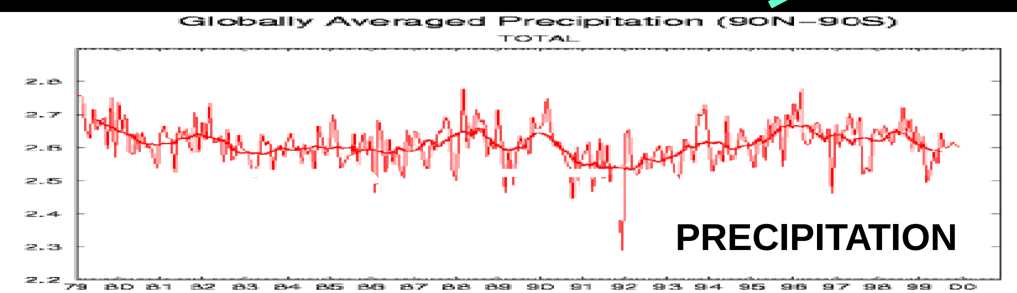
2009

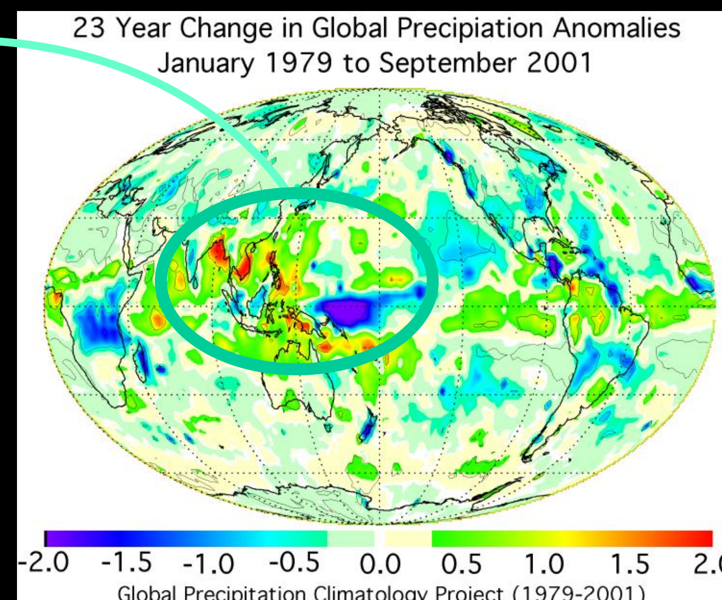
GEWEX HAS DEVELOPED GLOBAL PRODUCTS FROM OPERATIONAL SATELLITES FOR









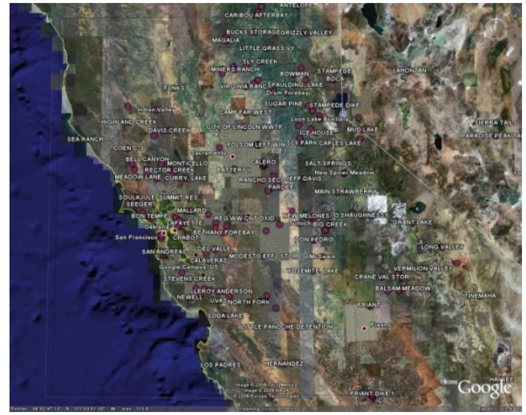


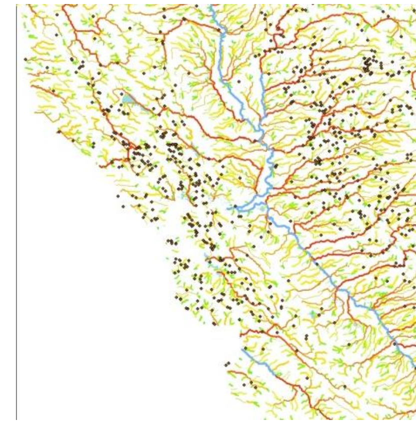
While global trends do not appear to exist for precipitation, GPCP products indicate that regional trends do occur.

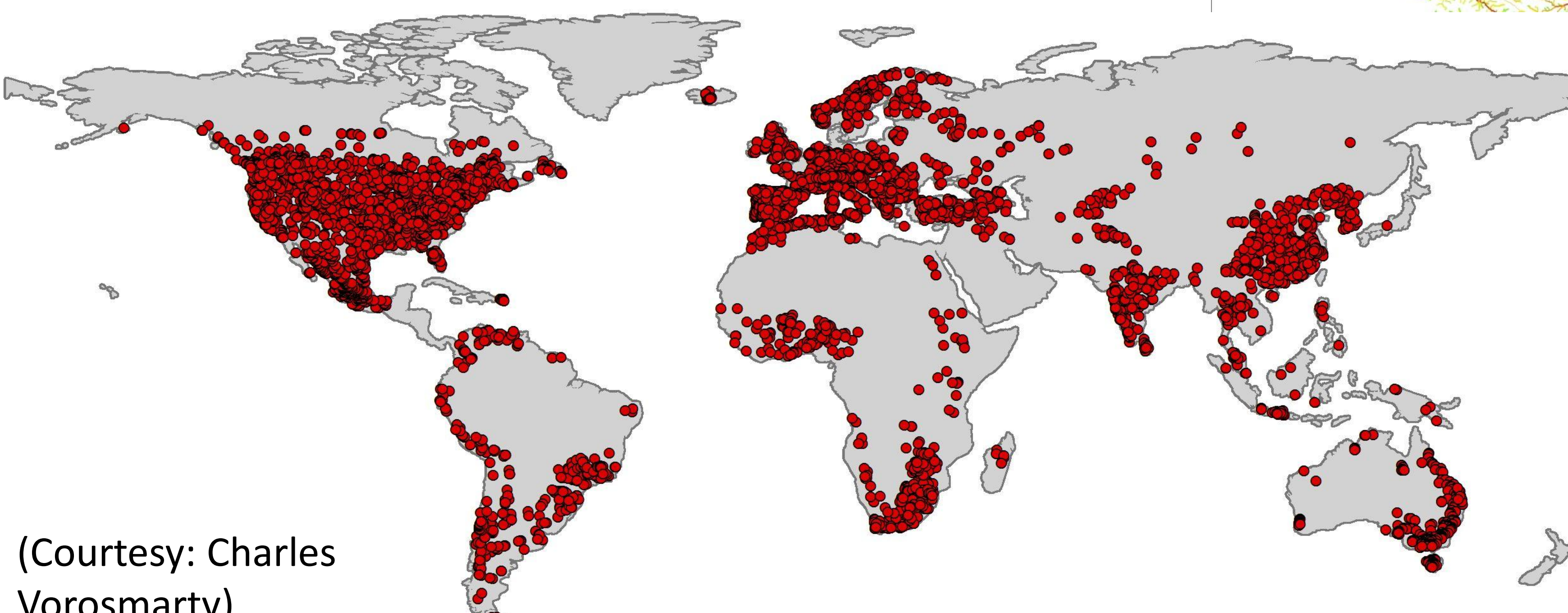
The GWSP (Global Water System Project) digital atlas provides water system information on water infrastructure, etc.

Global Reservoir and Dam (GRanD) Database

Currently ~ 7000 dam locations referenced to SWBD polygons and HydroSHEDS river network





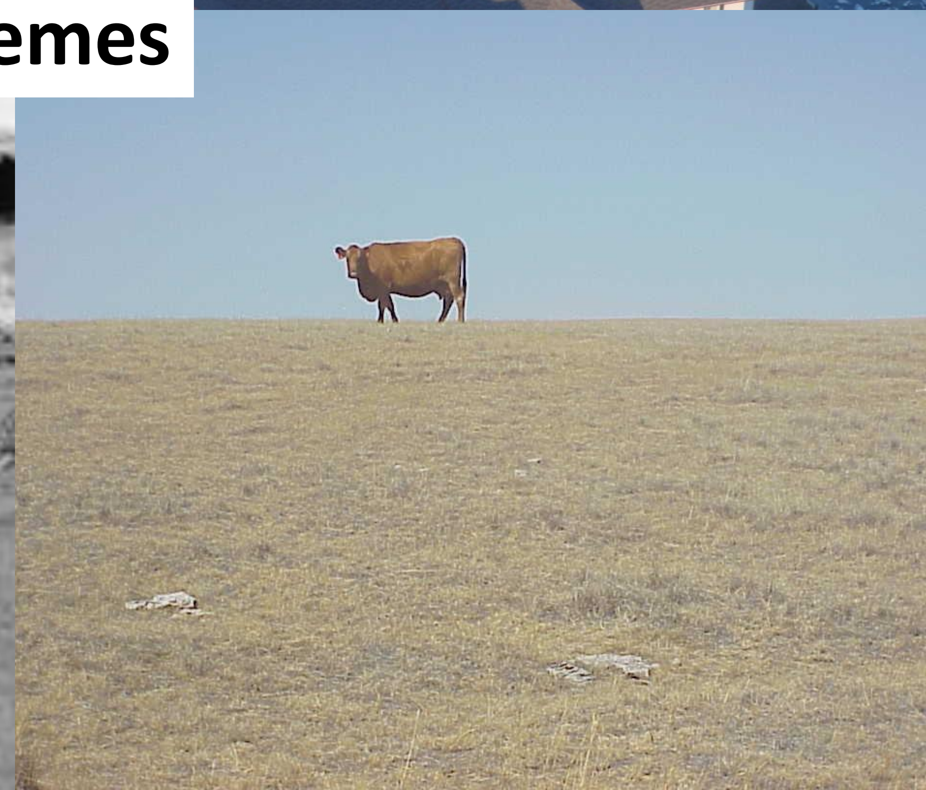


(Courtesy: Charles Vorosmarty)

~ 2600 reservoirs ≥ 100 Mio. m^3

Total storage capacity ~ 6000 km^3 (>80% of world total)

Extremes



Special requirements for Observations in support of Extreme Events (Floods and Droughts)

1. Data need to be **homogeneous** over long periods of time for the development of design statistics.
2. The assumption that the future is the same as the past when using **return period values** as design values needs to be modified. There is a view that statistics should be adjusted to account for trends and projected changes from models. However, scale mismatches must be addressed in such approaches.
3. Our perceptions of **key variables** needs to be enlarged and not just based on which observations are convenient.
4. The development of monitoring systems must combine our **global** monitoring capabilities and the **local** knowledge of the criteria for extreme events.

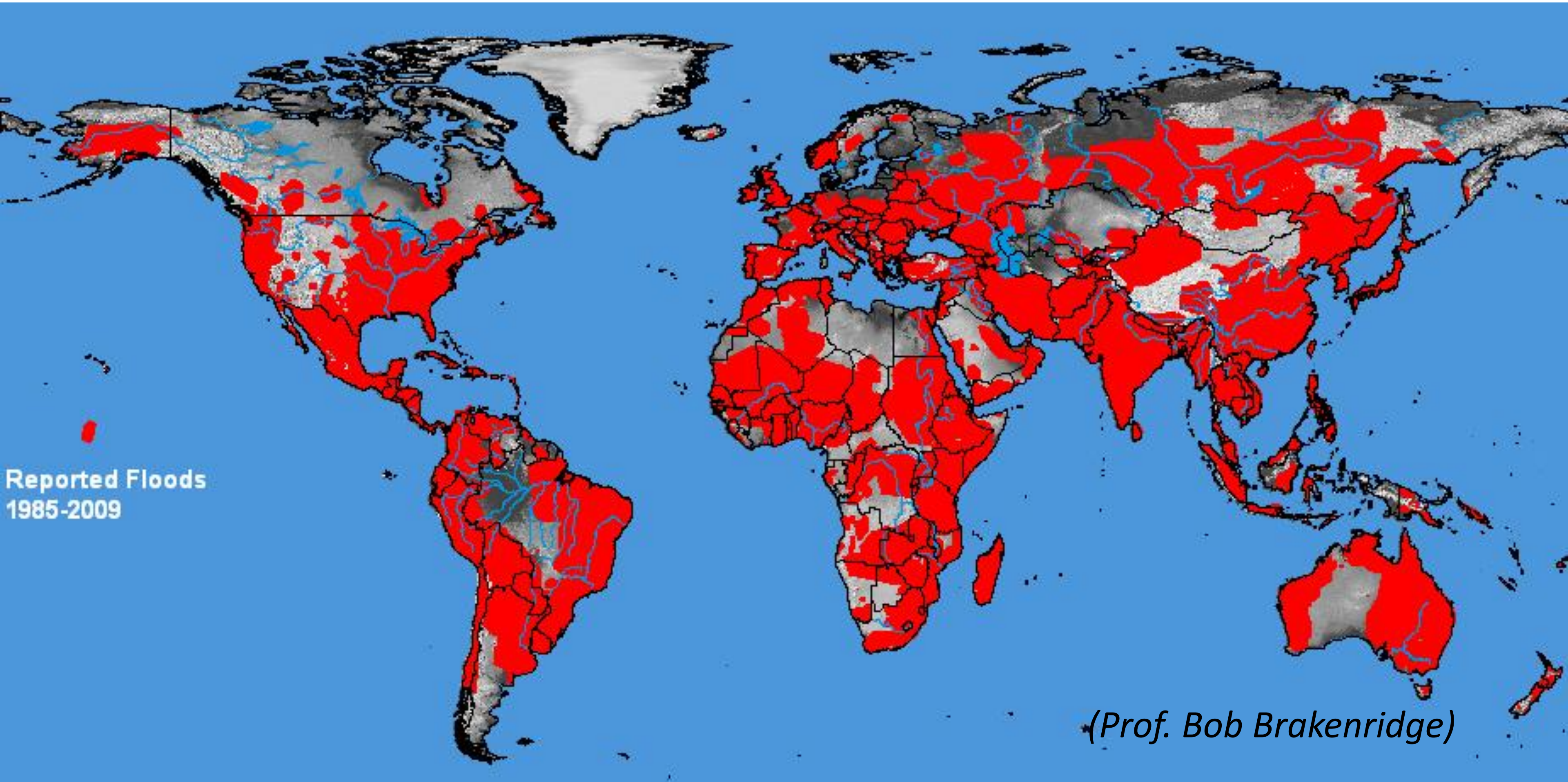
Dartmouth Flood Observatory

Flood Magnitude =LOG(Duration, days x Severity x Affected Area, sq km)

Severity 1: large flood events: significant damage to structures or agriculture; fatalities; and/or 10 -20 yr reported interval since the last similar event.

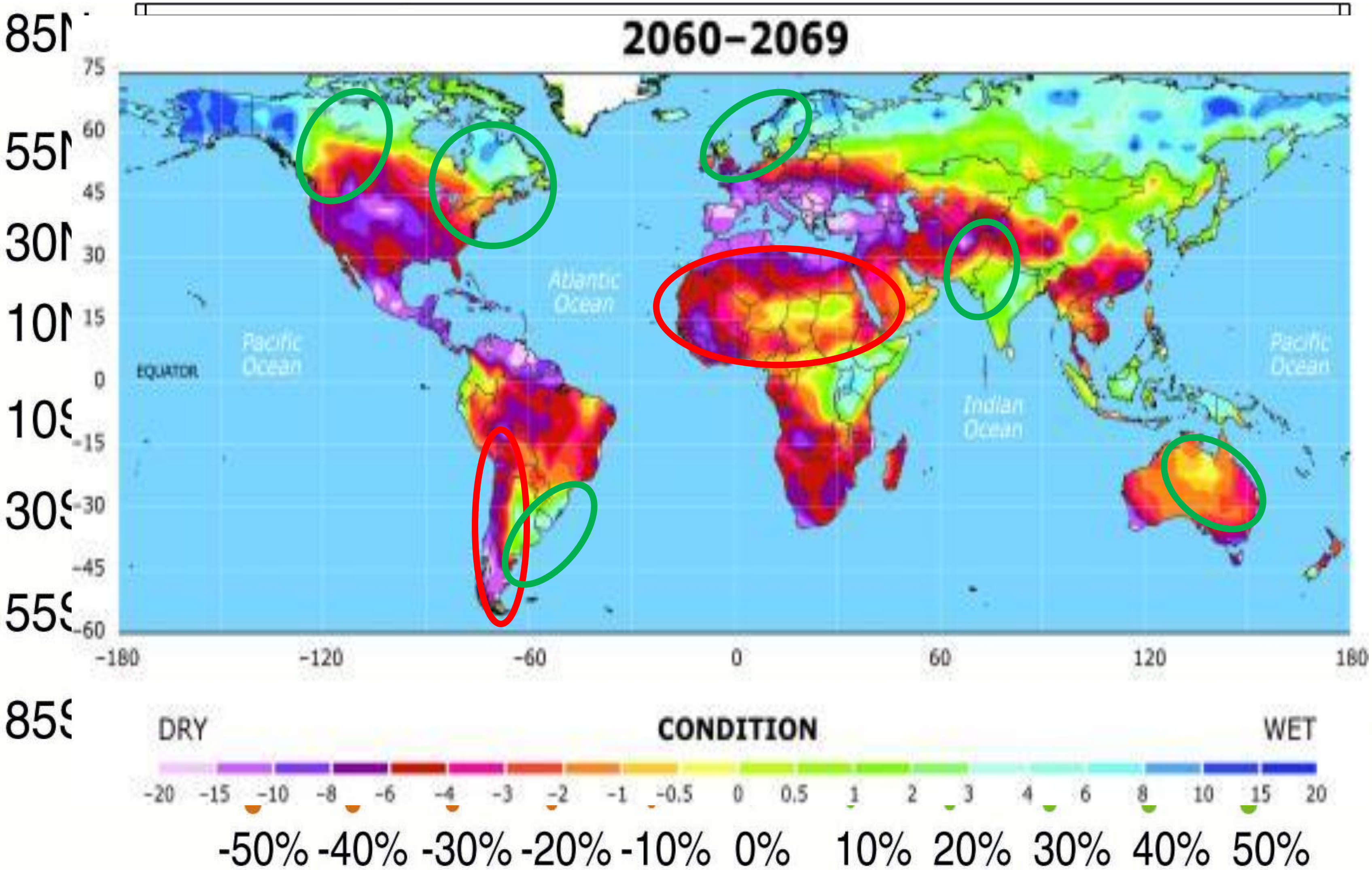
Severity 1.5: very large events: greater than 20 yr but less than 100 year recurrence interval,

Severity 2: extreme events: with an estimated recurrence interval greater than 100 years



(Prof. Bob Brakenridge)

Trends of Annual Precipitation 1900 until 1999



Source: IPCC Report 2001 - Originator: NCDC, USA

Regional drought impact studies have indicated the need to monitor a broader range of variables.

Statistically significant Drought Index correlations with wheat protein by category

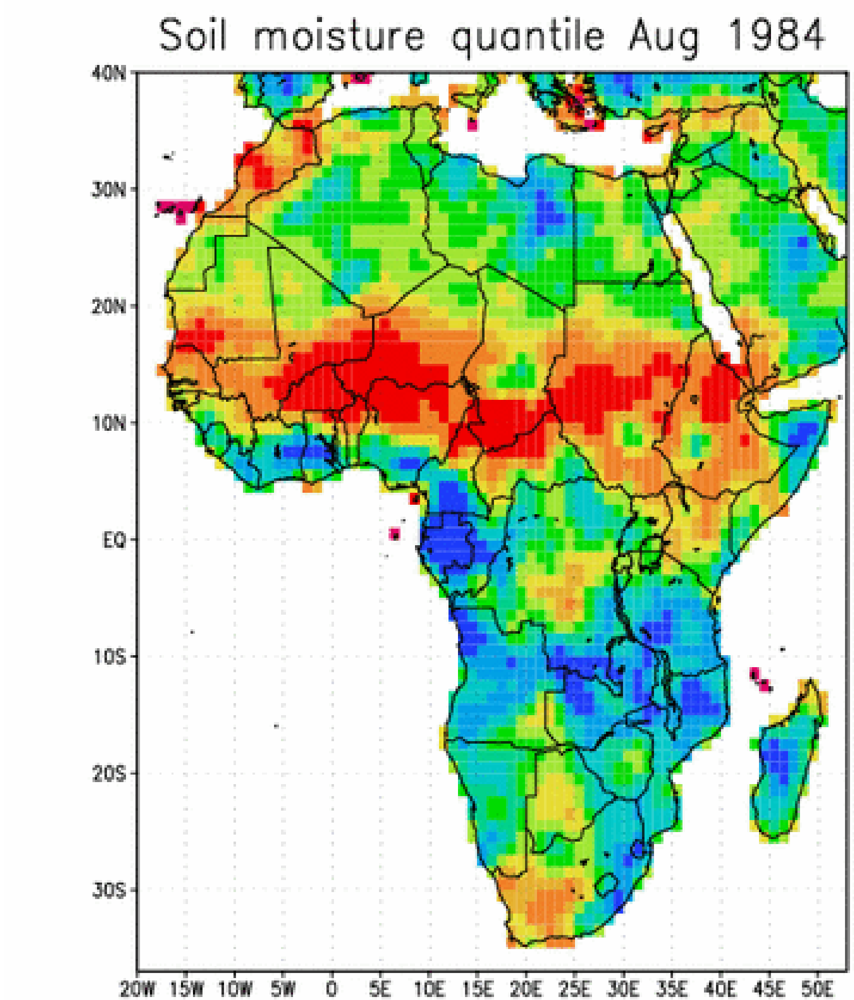
(from Paul Bullock)

	AC Barrie	Superb
Water Supply Indices	0	3
Water Demand Indices	19	24
Water Balance Indices	14	18
Water Use Indices	7	7

Evapotranspiration provides a more accurate estimate of wheat yield and quality than precipitation indicies and should be utilized for assessment of agricultural drought.

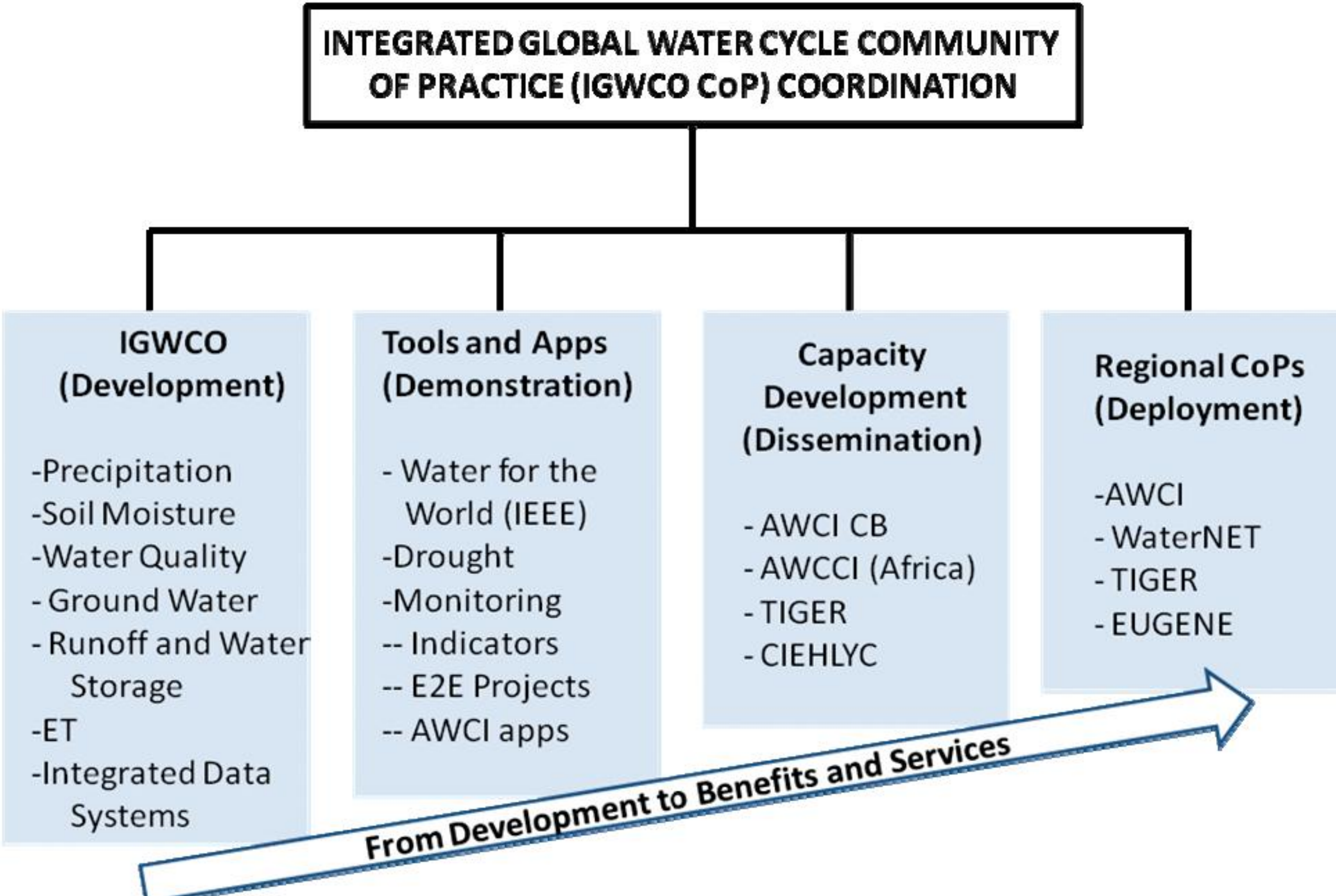
Plan #1: Integration of regional drought monitoring products into a global framework.

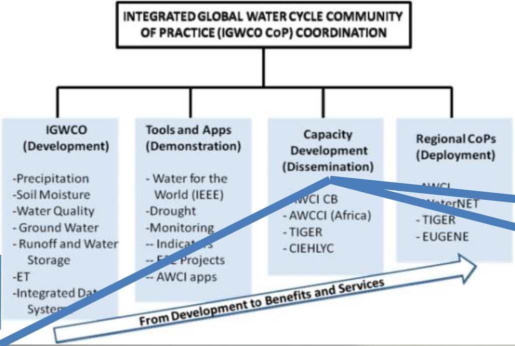
Plan #2: Expanding regional drought monitors to a global monitor.



Sheffield and Wood, *Journal of Climate*, 2008

In 2008, GEO adopted the IGWCO Community of Practice within the GEO framework as a means of outreach to the water community.




INTEGRATED GLOBAL WATER CYCLE COMMUNITY OF PRACTICE (IGWCO CoP) COORDINATION
IGWCO (Development)
-Precipitation
-Soil Moisture
-Water Quality
- Ground Water
- Runoff and Water Storage
-ET
Tools and Apps (Demonstration)
- Water for the World (IEEE)
-Drought
-Monitoring
-- AWCI apps
Capacity Development (Dissemination)
- AWCCI (Africa)
- TIGER
- CIEHLYC
Regional CoPs (Deployment)
- TIGER
- EUGENE
From Development to Benefits and Services


Tunisia (01/09)


Peru (12/09)


Japan (02/09)

Relevance of Observational Considerations for Ukraine Climate Science

Ukraine could benefit from hosting a GEOSS Capacity Building Workshop related to regional water cycle observations.

The programmatic infrastructure of GEO, GEWEX and GWSP could provide a basis for structuring water-related observations and research. Ukraine could consider the implications of playing a more active role in these international programmes.

A new initiative for a large drainage basin that exercises the capabilities of the Ukraine and US data and analysis systems and builds links with international programmes could have major benefits for the Ukraine.