COMBINING GLOBAL WATER CYCLE OBSERVATIONS AND SCIENCE TO ADDRESS ISSUES RELATED TO THE PROTECTION AND DEVELOPMENT OF THE WORLD'S WATER RESOURCES

RICK LAWFORD
DIRECTOR, IGPO

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GRAZ, AUSTRIA

WHERE THIS TALK WILL LEAD US:

1. OVERVIEW OF THE GLOBAL WATER CYCLE AND ITS IMPORTANCE

2. REVIEW OF PROGRAMS AIMED AT ENHANCING EARTH OBSERVATIONS FOR WATER MANAGEMENT

3. REVIEW OF WHAT IS NEEDED TO ENABLE EARTH OBSERVATIONS TO MAKE A FULL CONTRIBUTION TO WATER RESOURCES MANAGEMENT.

THE GLOBAL WATER CYCLE

THE GLOBAL WATER CYCLE (GWC) ENCOMPASSES THE **MOVEMENTS, TRANSFORMATIONS AND RESERVOIRS** OF **WATER, ENERGY AND WATER-BORNE MATERIALS** THROUGHOUT THE EARTH SYSTEM AND THEIR **INTERACTIONS WITH ECOSYSTEMS AND THE GLOBAL WATER SYSTEM.** THE GWC OPERATES ON THE FULL CONTINUUM OF SPACE AND TIME SCALES AND INVOLVES PHASE CHANGES AND ENERGY EXCHANGES.

SOME STRESSES INFLUENCING THE USE AND DEVELOPMENT OF WATER

POPULATION: A UN MID-RANGE PROJECTION ESTIMATES AN INCREASE OF 2.8 BILLION BY 2050.

IRRIGATED AGRICULTURE: ACCOUNTS FOR >90% OF THE GLOBAL WATER CONSUMPTION.

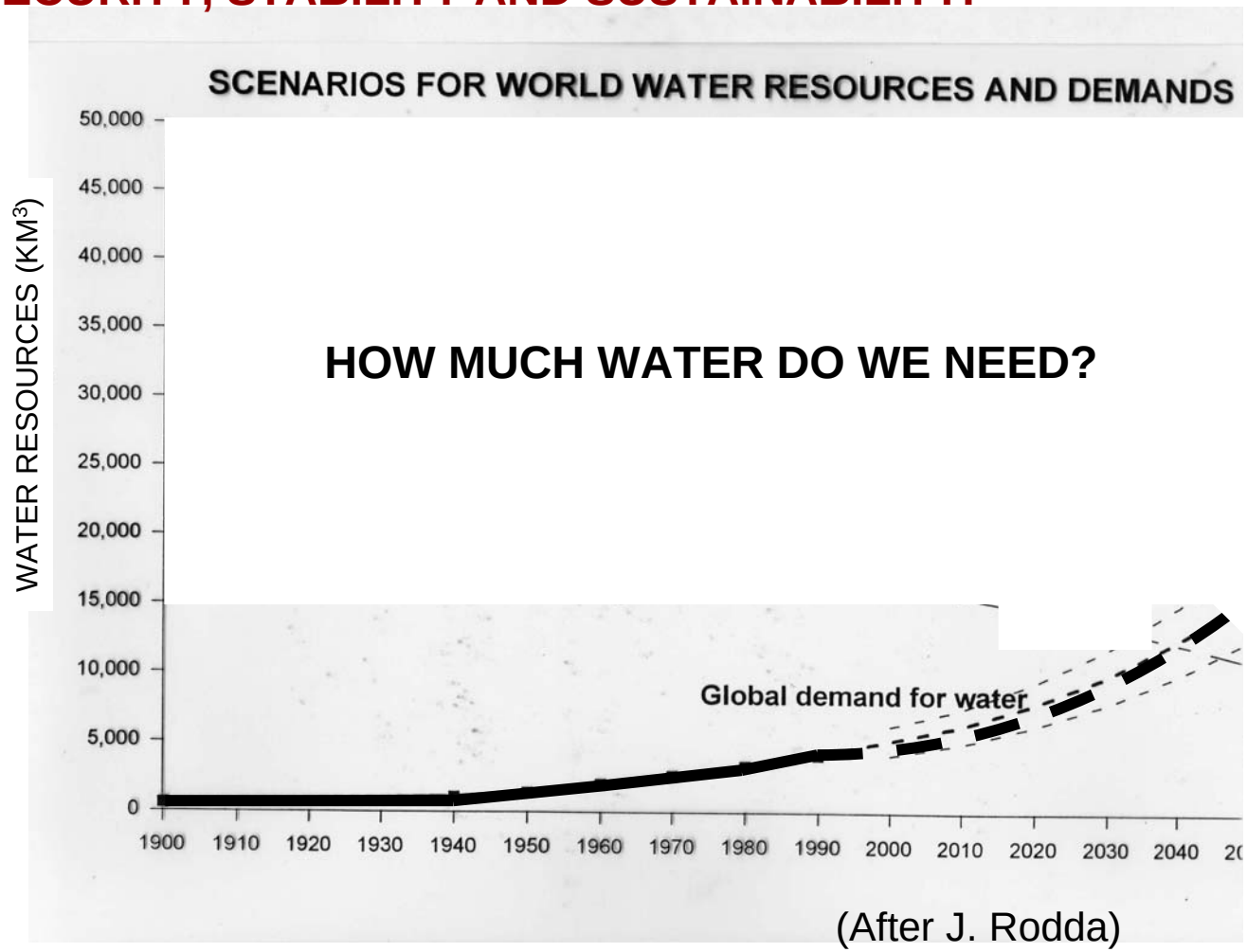
INDUSTRIALIZATION AND DEVELOPMENT: INDUSTRIAL WATER USE IS PROJECTED TO DOUBLE BY 2050.

URBANIZATION: POPULATION IN URBAN AREAS EXPECTED TO INCREASE FROM 36% (1995) TO 52% IN 2050.

LAND USE: CONVERSIONS OF FORESTS TO FARMLAND AND URBAN LANDSCAPES CONTINUE TO CHANGE STREAM FLOW PATTERNS.

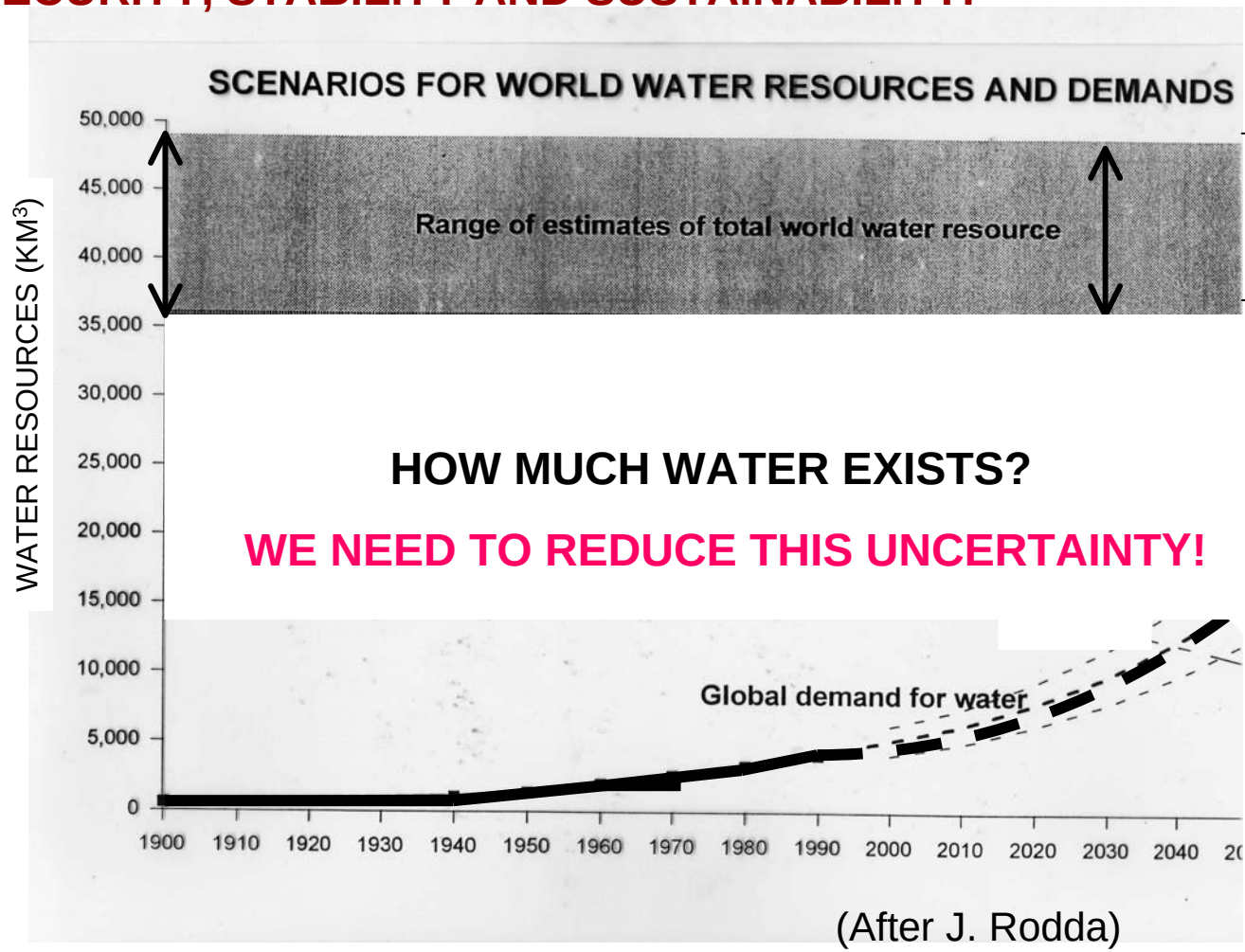
CLIMATE: CLIMATE CHANGE IS EXPECTED TO ADVERSELY AFFECT WATER AVAILABILITY AND DEMAND.

THE GLOBAL WATER CYCLE IS RESPONSIBLE FOR THE DISTRIBUTION OF PRECIPITATION AND WATER SUPPLIES. THESE SUPPLIES ARE DISTRIBUTED UNEVENLY AROUND THE WORLD, LEADING TO WATER-RICH AND WATER-POOR NATIONS. ON A REGIONAL (AND EVENTUALLY A GLOBAL BASIS) THIS DISPARITY LEADS TO PROBLEMS RELATED TO SECURITY, STABILITY AND SUSTAINABILITY.



(After J. Rodda)

THE GLOBAL WATER CYCLE IS RESPONSIBLE FOR THE DISTRIBUTION OF PRECIPITATION AND WATER SUPPLIES. THESE SUPPLIES ARE DISTRIBUTED UNEVENLY AROUND THE WORLD, LEADING TO WATER-RICH AND WATER-POOR NATIONS. ON A REGIONAL (AND EVENTUALLY A GLOBAL BASIS) THIS DISPARITY LEADS TO PROBLEMS RELATED TO SECURITY, STABILITY AND SUSTAINABILITY.



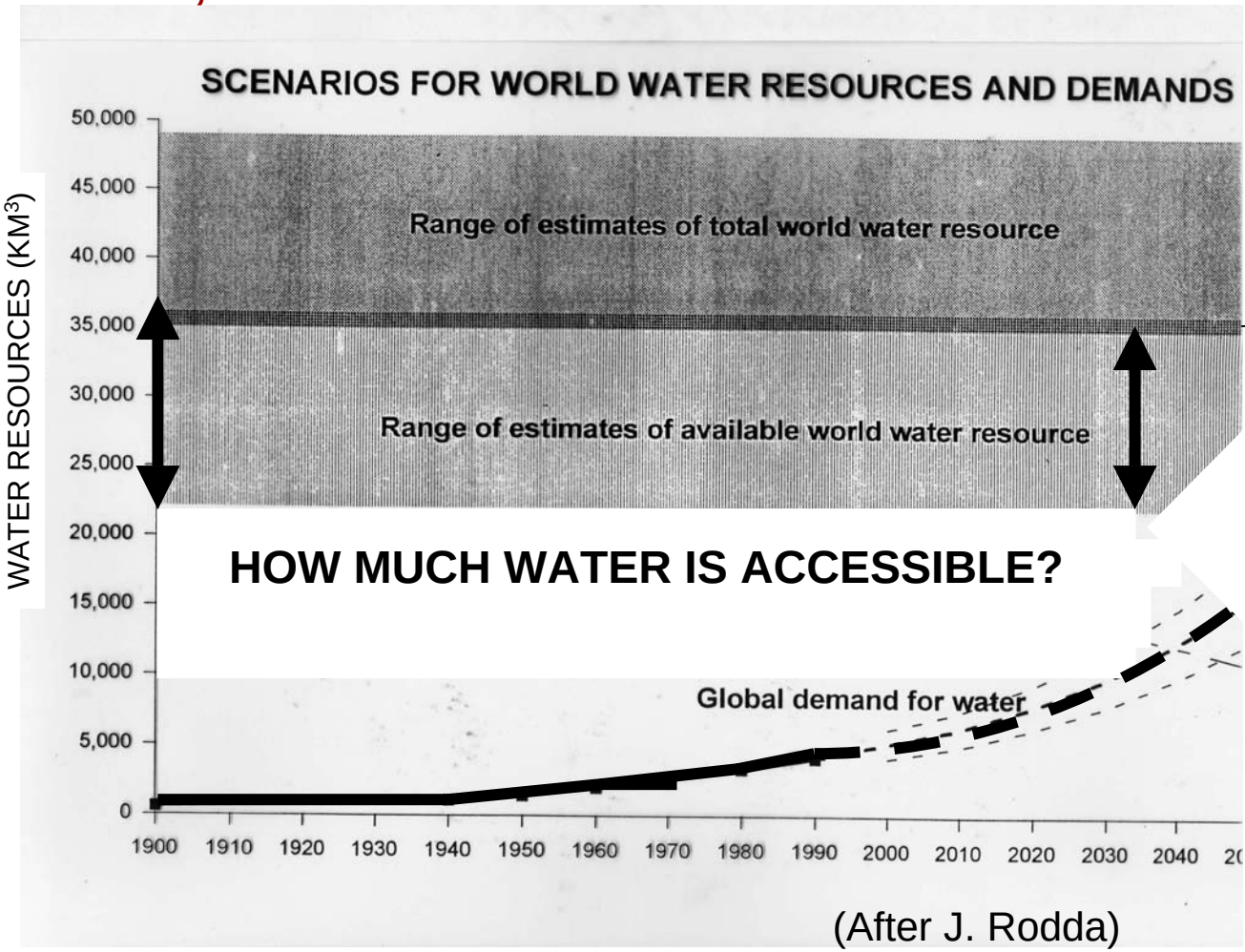
MAJOR PROBLEM BY 2090?

HOW MUCH WATER EXISTS?

WE NEED TO REDUCE THIS UNCERTAINTY!

(After J. Rodda)

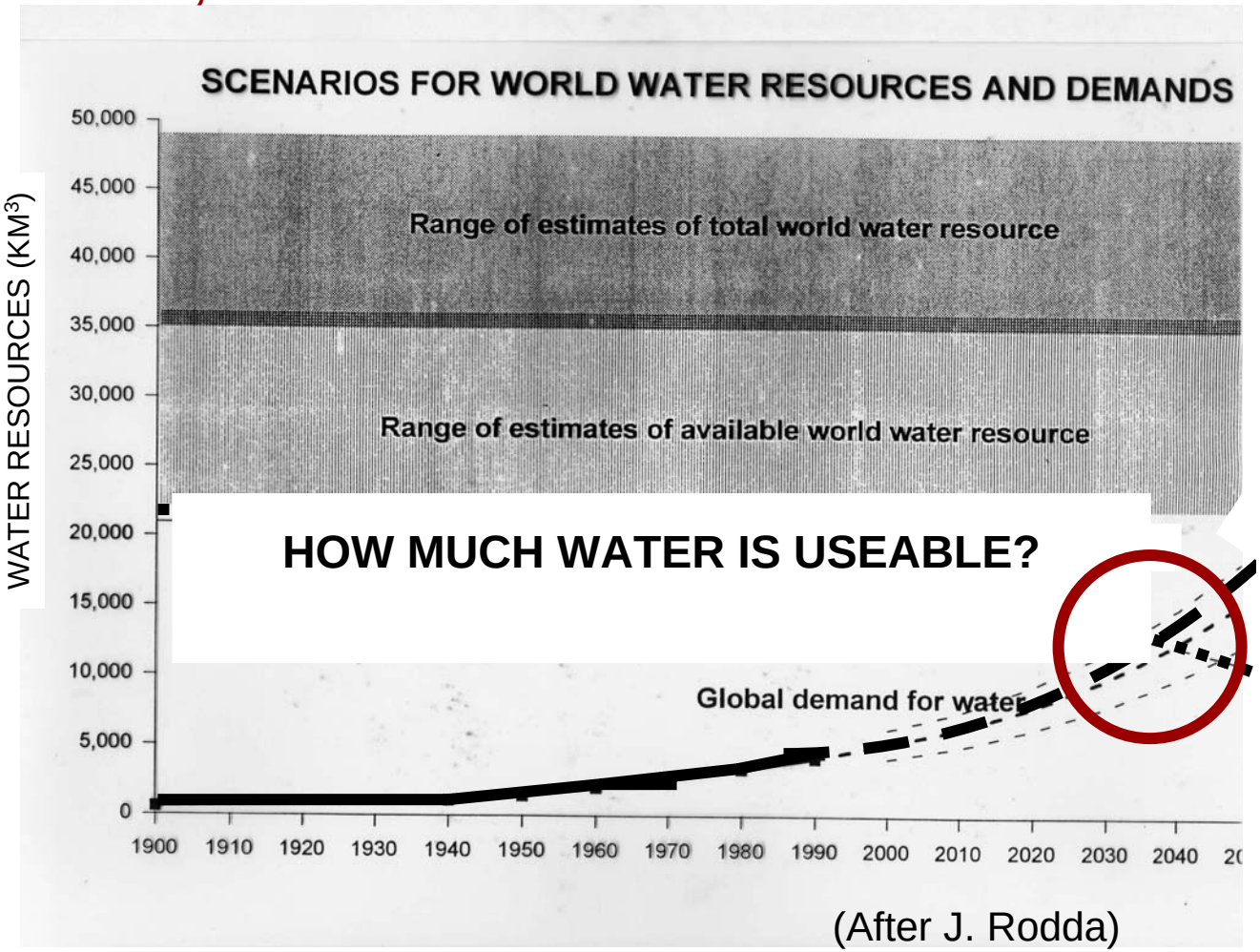
THE GLOBAL WATER CYCLE IS RESPONSIBLE FOR THE DISTRIBUTION OF PRECIPITATION AND WATER SUPPLIES. THESE SUPPLIES ARE DISTRIBUTED UNEVENLY AROUND THE WORLD, LEADING TO WATER-RICH AND WATER-POOR NATIONS. ON A REGIONAL (AND EVENTUALLY A GLOBAL BASIS) THIS DISPARITY LEADS TO PROBLEMS RELATED TO SECURITY, STABILITY AND SUSTAINABILITY.



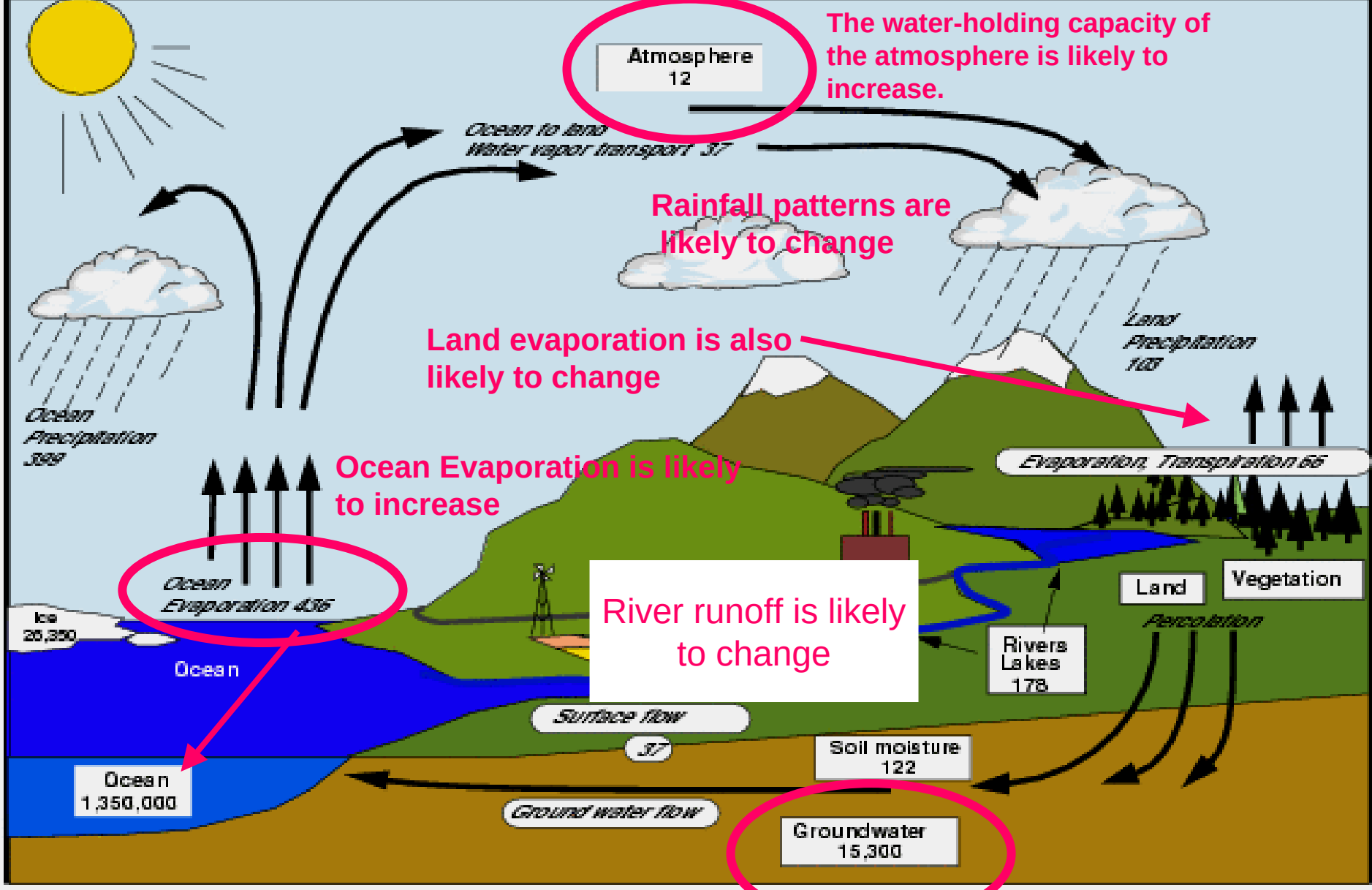
(After J. Rodda)

MAJOR PROBLEM BY 2070?

THE GLOBAL WATER CYCLE IS RESPONSIBLE FOR THE DISTRIBUTION OF PRECIPITATION AND WATER SUPPLIES. THESE SUPPLIES ARE DISTRIBUTED UNEVENLY AROUND THE WORLD, LEADING TO WATER-RICH AND WATER-POOR NATIONS. ON A REGIONAL (AND EVENTUALLY A GLOBAL BASIS) THIS DISPARITY LEADS TO PROBLEMS RELATED TO SECURITY, STABILITY AND SUSTAINABILITY.



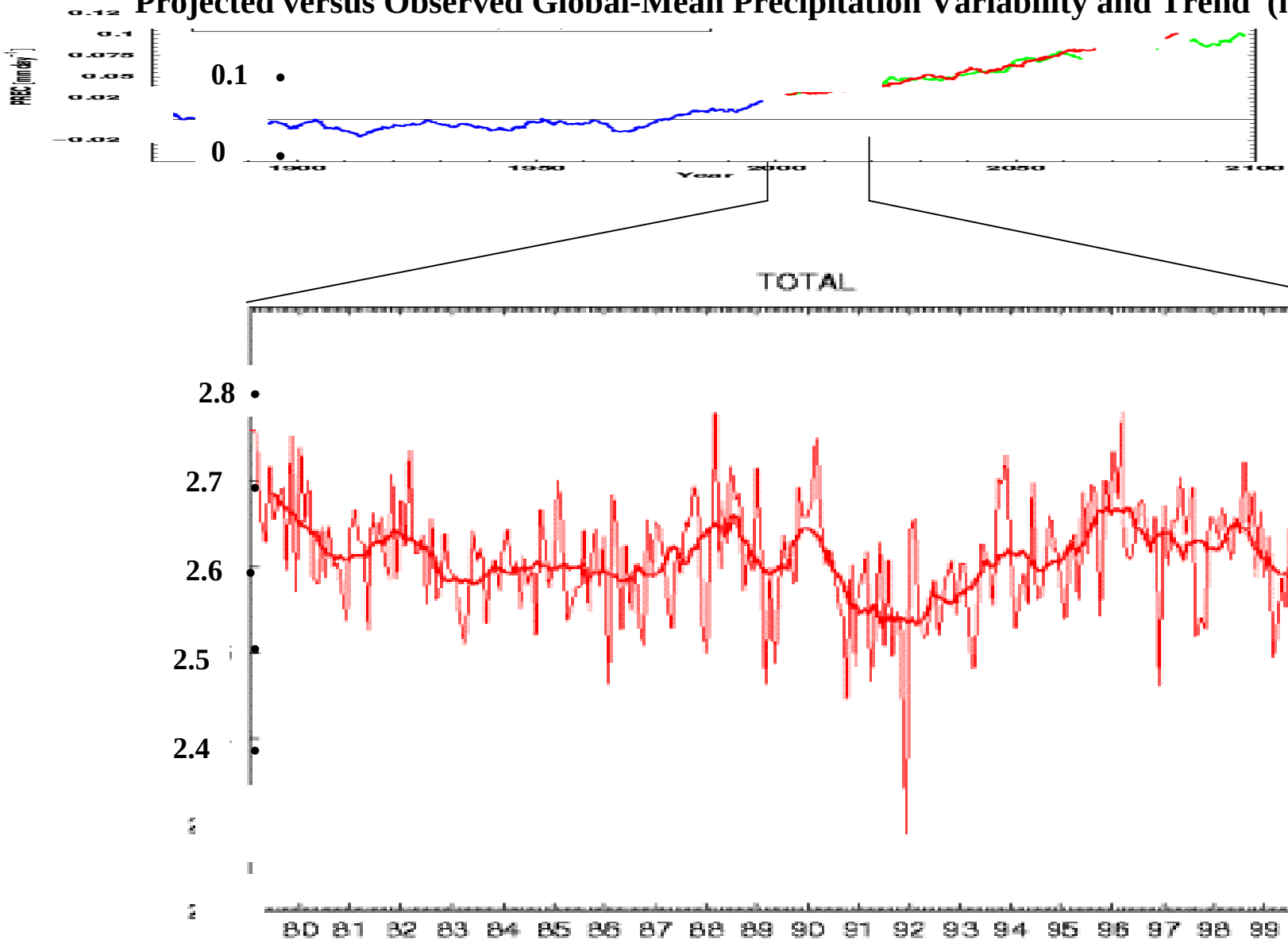
DEMAND WILL EXCEED SUPPLY OVER MANY AREAS BY 2030 – 2050.



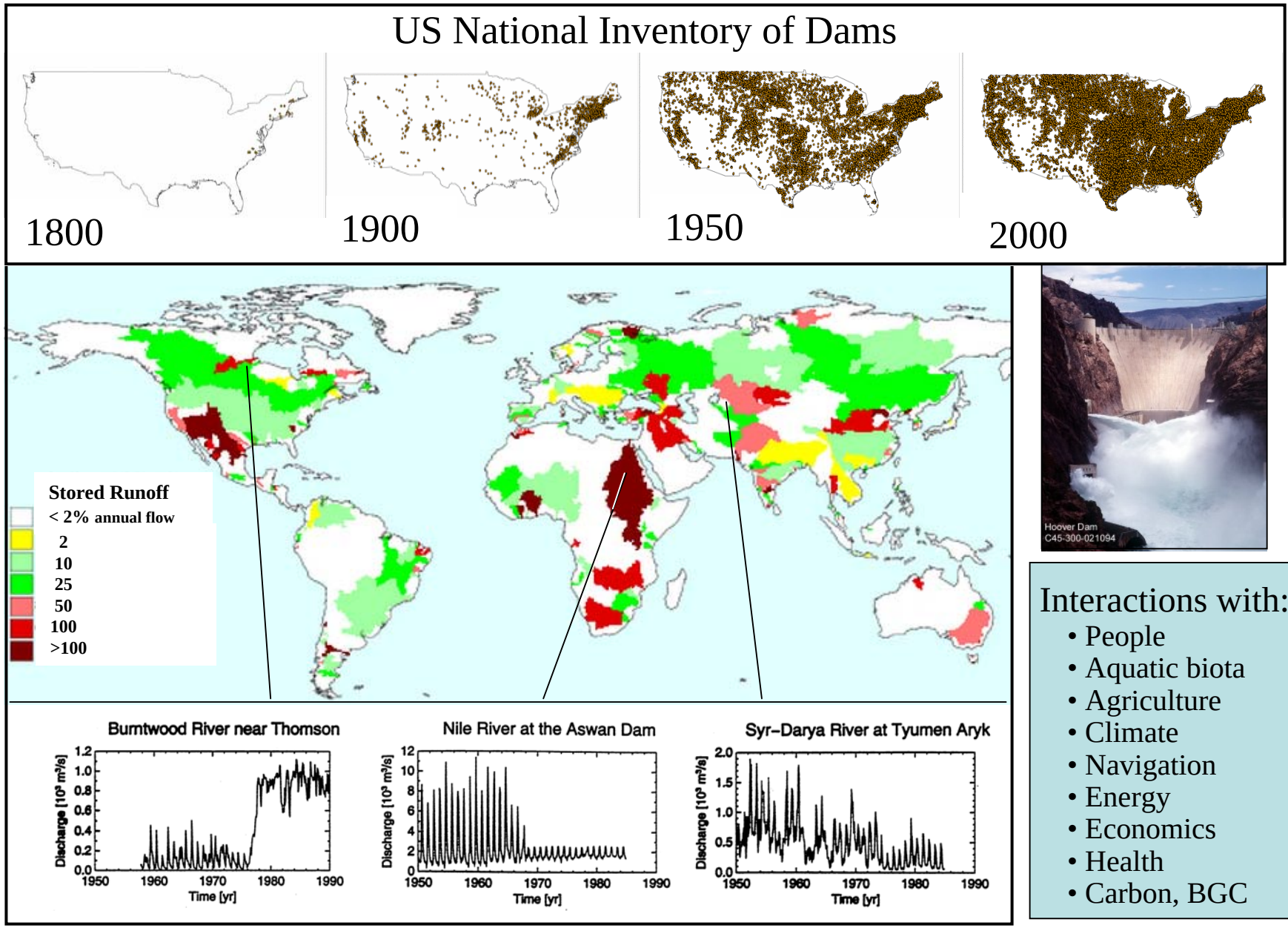
Hydrological cycle.

Units are thousand cubic km for storage and thousand cubic km/year for exchanges

Projected versus Observed Global-Mean Precipitation Variability and Trend (mm/day)



Engineering of Inland Waterways: A Fundamental Feature of Hydrosphere



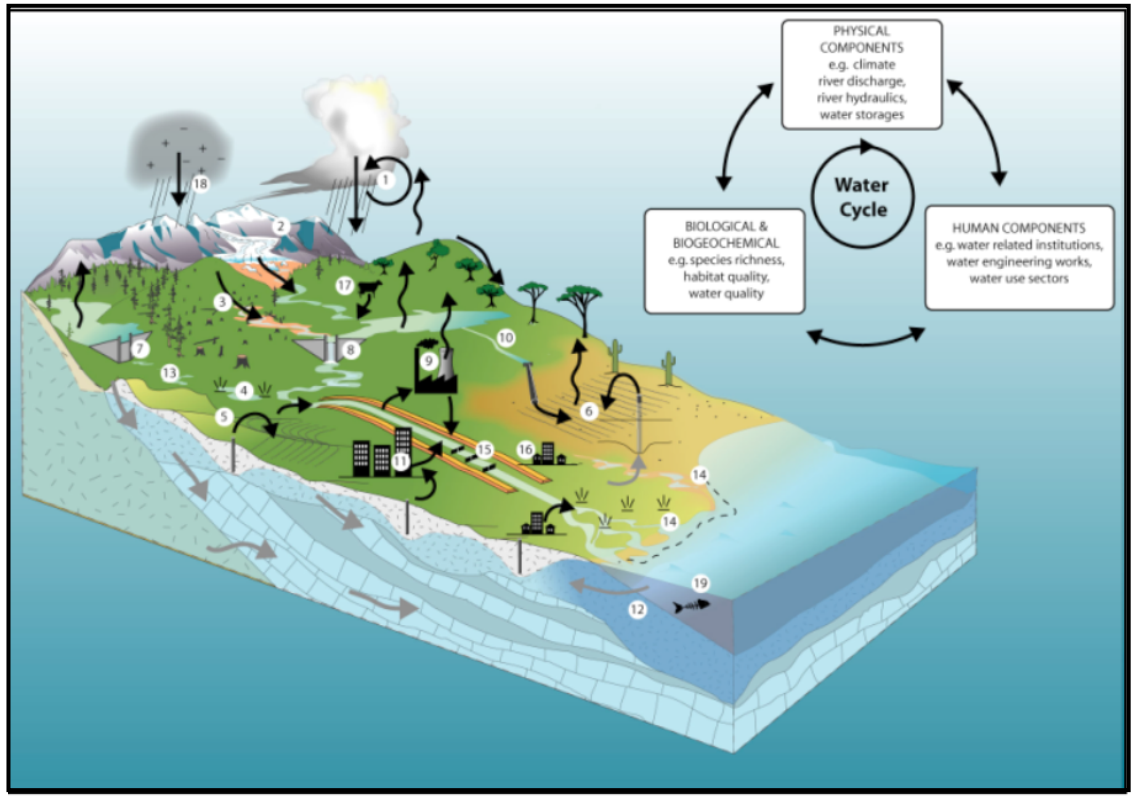
Interactions with:

- People
- Aquatic biota
- Agriculture
- Climate
- Navigation
- Energy
- Economics
- Health
- Carbon, BGC

Earth System Science Partnership

The Notion of a Global Water System

We are moving rapidly toward a fully global-scale picture of a changing hydrosphere, the anthropogenic contributions to this change, and its consequences

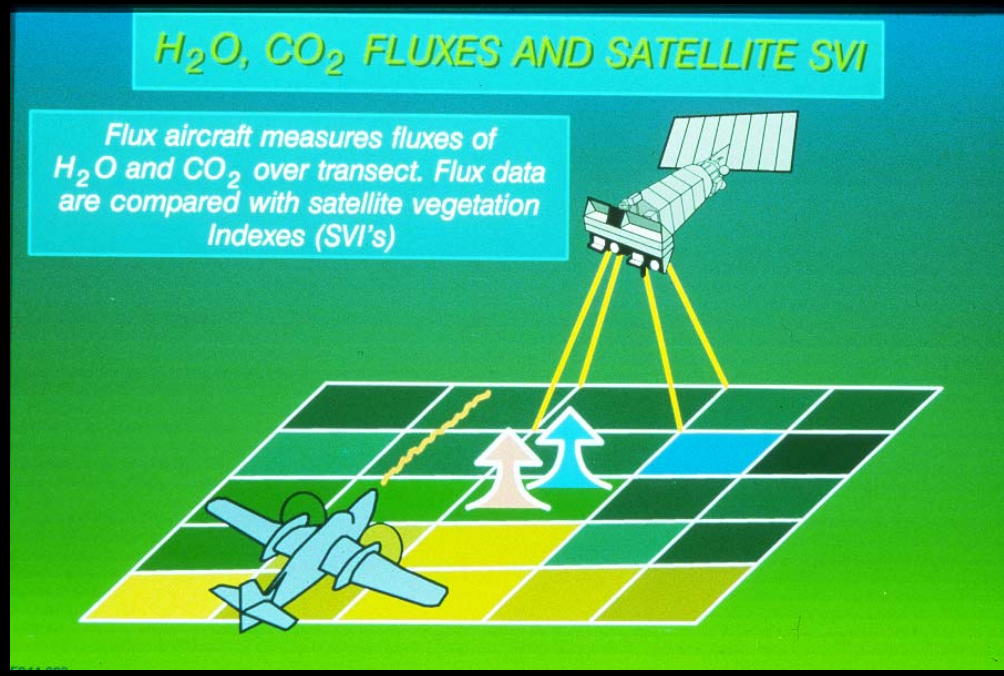


Integration across elements is a central GWSP Focus

GWSP Global Water System Project

ISSUE: HYDROLOGIC PREDICTION HAS MANY ERRORS INCLUDING THOSE ARISING FROM INADEQUATE SPECIFICATION OF THE INITIAL CONDITIONS

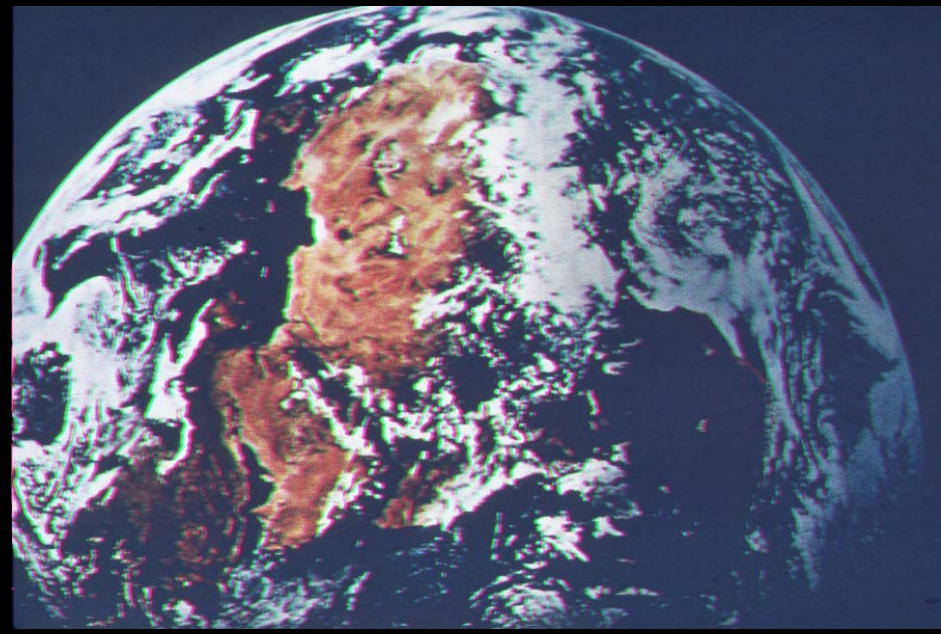
HYDROLOGIC PROCESSES AND HETEORGENEITY EFFECTS ARE NOT WELL UNDERSTOOD. CONSEQUENTLY, HYDROLOGIC MODELING SYSTEMS TEND TO BE VERY DEPENDANT ON BASIN AND MODEL SPECIFIC CALIBRATIONS.



MORE COMPREHENSIVE EARTH OBSERVATIONS ARE NEEDED TO ACCURATELY DEFINE INITIAL CONDITIONS.

ISSUE: THE WATER CYCLE PLAYS A ROLE IN MAINTAINING A CLIMATE EQUILIBRIUM

HISTORICALLY, SOME PROCESSES (VEGETATION, WATER CYCLE??) HAVE MAINTAINED THE EARTH'S CLIMATE IN EQUILIBRIUM. THE ROLE OF THE WATER CYCLE IN THE CONTEXT OF FUTURE NATURAL AND ANTHROPOGENIC CLIMATE CHANGE IS NOT WELL UNDERSTOOD.



CRITICAL EARTH OBSERVATIONS ARE NEEDED TO ADDRESS THE ROLE OF THE WATER CYCLE WITHIN THE CLIMAE SYSTEM.

ISSUE: THE USE OF SCIENCE AND SATELLITE OBSERVATIONS TO IMPROVE THE MANAGEMENT OF WATER RESOURCES IS NOT WELL DEVELOPED

ALTHOUGH STATE-OF-THE-ART DATA AND PREDICTION SYSTEMS ARE BEING DEVELOPED, THEIR OVERALL CONTRIBUTION TO THE MANAGEMENT OF WATER RESOURCES IS NOT BEING FULLY REALIZED.

NEW CAPABILTITIES AVAILABLE THROUGH BETTER EARTH OBSERVATIONS ARE NOT READILY ADOPTED INTO OPERATIONAL MANAGEMENT PROCEDURES.

MANY UNCERTAINTIES EXIST IN THE UNDERSTANDING OF THE GLOBAL WATER CYCLE AND THE CONSEQUENCES OF ITS CHANGES. COMMITMENTS EXIST AT THE HIGHEST LEVELS FOR ADDRESSING THESE ISSUES.

Plan of Implementation

World Summit on Sustainable Development (WSSD)

Paragraph 28

Improve water resource management and scientific understanding of the water cycle through cooperation in joint observation and research, and encourage and promote knowledge sharing, and provide capacity-building and the transfer of technology, as mutually agreed, including remote-sensing and satellite technologies, particularly to developing countries as well as countries with economies in transition, for this purpose.

Paragraph 115

Promote the development and wider use of earth observation technologies, including satellite remote sensing, global mapping and geographic information systems to collect quality data on environmental impacts, land use and land-use changes, including through actions at all levels to

(a) Strengthen cooperation and coordination among global observing systems and research programmes for integrated global observations, taking into account the need for building capacity and sharing of data from ground-based observations, satellite remote sensing and other sources among all countries;

(b) Develop information systems that make the sharing of valuable data possible, including the active exchange of Earth observation data.

2003 G8 Summit in Evian

Water

…in order to achieve the goals of the Millennium Declaration and the Plan of Implementation of the World Summit on Sustainable Development (WSSD)….. We are committed to playing a more active role in the international efforts towards achieving these goals, on the basis of the Monterrey consensus and building upon the outcomes of the Third World Water Forum and the Ministerial Conference held in Japan in March 2003.

4 Strengthening monitoring, assessment and research

4.1 In collaboration with all stakeholders, we will promote co-ordination of mechanisms for information sharing and monitoring by utilising existing UN and other systems and the network of websites established at the Third World Water Forum Ministerial Conference, and will encourage relevant international organisations to operate them.

4.2 We will support strengthening water monitoring capacity in partner countries to complement existing monitoring efforts.

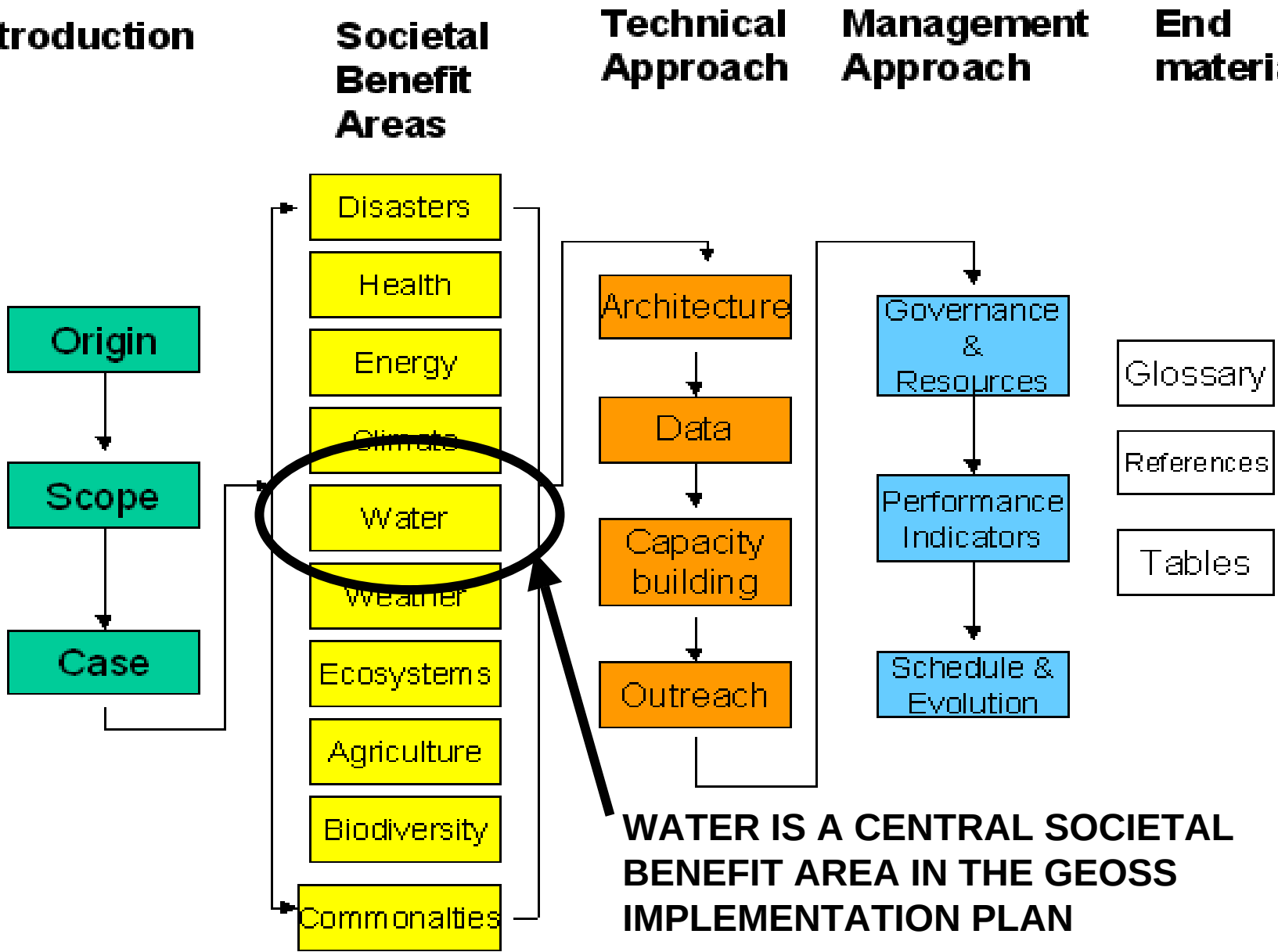
4.3 We will support the development of mechanisms for collaboration in water-cycle related research, and enhance research efforts in this area.

GROUP ON EARTH OBSERVATIONS

Declaration of the 1st Earth Observation Summit

- **Recalling the World Summit on Sustainable Development held in Johannesburg and the G-8 Summit held in Evian**
- **Affirmed need for timely, quality, long-term, global information as a basis for sound decision making.**
- **Recognized need to support:**
  1) Comprehensive, coordinated, sustained Earth observation system or systems;
  2) Coordinated effort to address capacity-building needs related to Earth observation;
  3) Exchange of observations in a full and open manner with minimum time delay and minimum cost; and
  4) Preparation of a 10-year Implementation Plan, building on existing systems and initiatives
- **Established *ad hoc* Group on Earth Observations (GEO) to develop Plan**

THE PLAN TO DEVELOP THE GLOBAL EARTH OBSERVING SYSTEM OF SYSTEMS (GEOSS) WAS ADOPTED IN 2005.



GEOSS WILL PROMOTE THE DEVELOPMENT OF DATA BASES NEEDED TO ADDRESS CRITICAL WATER SCIENCE ISSUES

DATA SETS ON THE DISTRIBUTION OF DAMS AND RESERVOIRS WILL BE CONSOLIDATED

DATA BASES ON THE USE OF WATER FOR IRRIGATION AND OTHER DEVELOPMENTAL ACTIVITIES

WATER REQUIREMENTS FOR DIFFERENT ECOSYSTEMS AND BIODIVERSITY REGIMES

GEOSS ALSO PRODUCE DATA BASES TO ASSIST IN THE ANALYSIS OF THE ROLE OF WATER IN HUMAN HEALTH ISSUES ON A PRIORITY BASIS.

Estimates of Global Morbidity and Mortality of Water-Related Diseases (early 1990s)

	episodes/year or people infected	deaths/year
Diarrheal Diseases	1,000,000,000	3,300,000
Intestinal Helminths	1,500,000,000 (people infected)	100,000
Schistosomiasis	200,000,000 (people infected)	200,000
Dracunculiasis	150,000 (in 1996)	
Trachoma	150,000,000 (active cases)	
Malaria	400,000,000	1,500,000
Dengue Fever	1,750,000	20,000
Poliomyelitis	114,000	
Trypanosomiasis	275,000	130,000
Bancroftian Filariasis	72,800,000 (people infected)	
Onchocerciasis	17,700,000 (people infected; 270,000 blind)	40,000 (mortality caused by blindness)

Source: Table 2.2 from "The World's Water." Data from World Health Organization, 1995, "Community Water Supply and Sanitation: Needs, Challenges and Health Objectives." 48th World Health Assembly, A48/INF.DOC./2,28 April, Geneva, Switzerland.

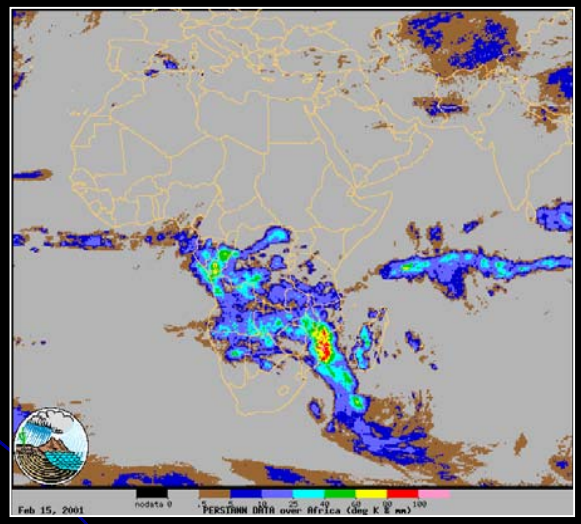
Mosquitos are transmitters of malaria, West Nile, Encephalitis.

Culex tarsalis: key carrier
Of encephalitis and West Nile virus

REMOTE SENSING CAN BE USED TO MONITOR WETLANDS AND PONDS, THE BREEDING GROUNDS FOR MOSQUITOS.

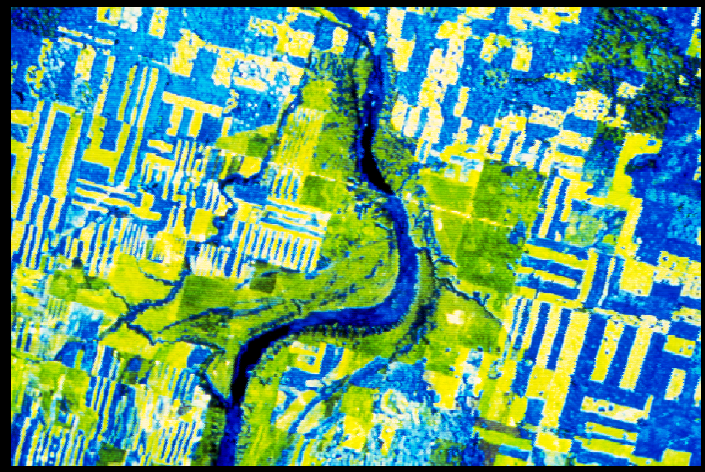
GOESS WILL PROMOTE THE USE OF EARTH OBSERVATIONS IN COPING WITH WATER CYCLE HAZARDS (E.G., FLOODS)

BEFORE THE EVENT, EARTH OBSERVATIONS CAN BE USED TO ASSESS THE VULNERABILITY TO FLOODING (SATURATED SOILS, FULL RESERVOIRS)



DURING THE EVENT, EARTH OBSERVATIONS PROVIDE INFORMATION ON THE PRECIPITATION PATTERNS.

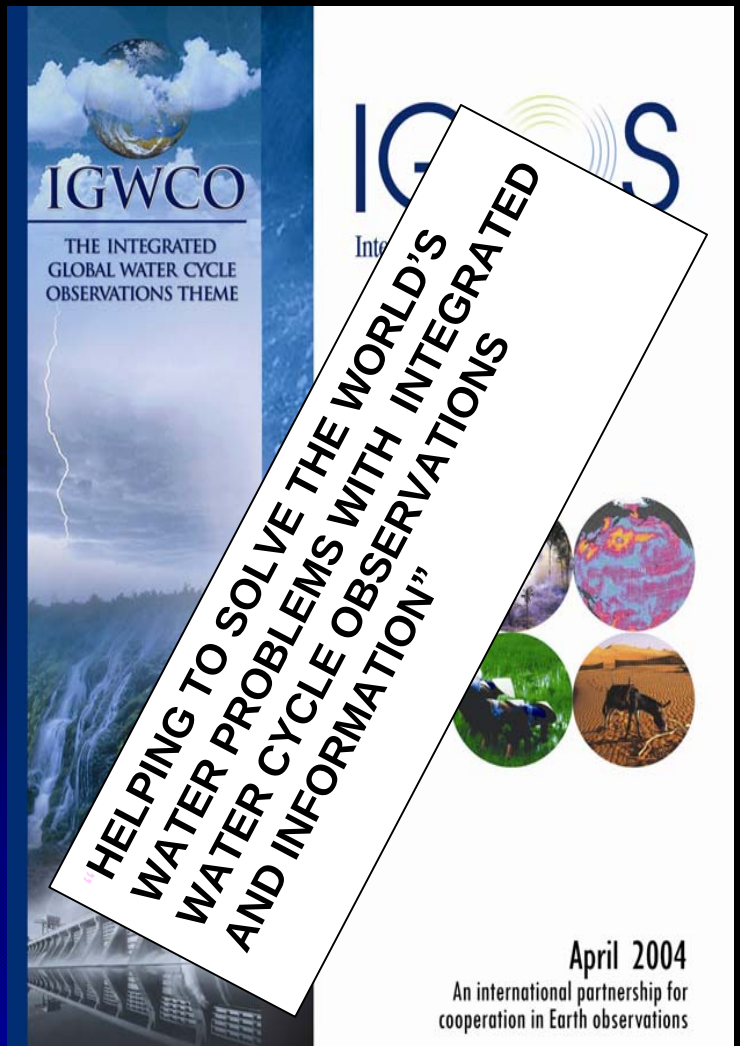
AFTER THE EVENT SATELLITE DATA CAN MAP THE INNUNDATED AREA



ISSUES BEING DEALT WITH BY THE GEOSS WATER SOCIETAL BENEFIT AREA

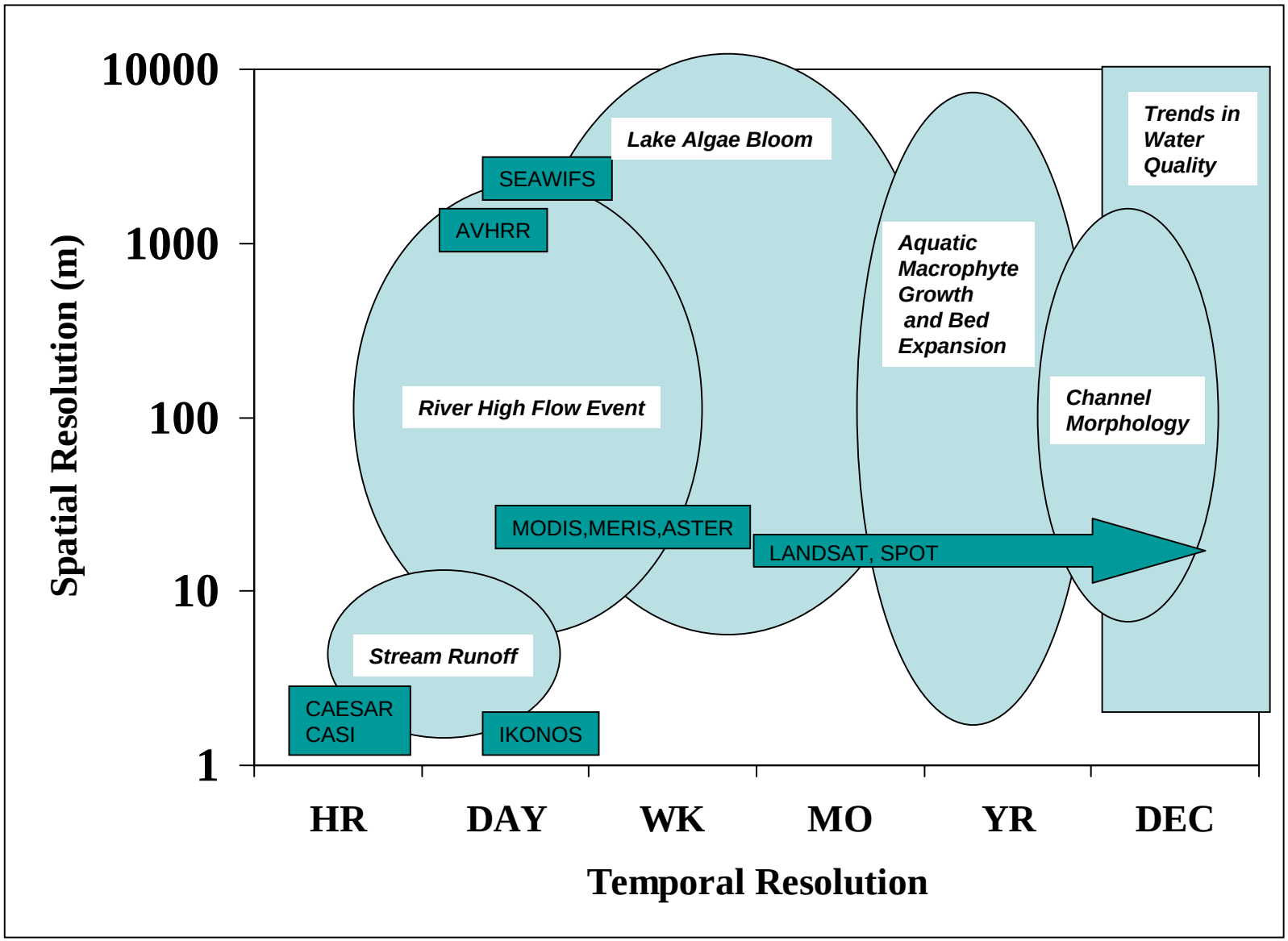
1. ENHANCEMENTS OF EXISTING IN-SITU WATER CYCLE NETWORKS.
2. DEVELOPMENT OF A NETWORK OF “SUPERSITES.”
3. DEVELOPMENT OF A WATER CYCLE DATA INTEGRATION SYSTEM
4. DEVELOPMENT OF INTEGRATED PRECIPITATION AND SOIL MOISTURE PRODUCTS.
5. EVALUATION OF THE INFORMATION NEEDS TO APPLY SATELLITE ALTIMETRY TO STREAMFLOW AND SURFACE STORAGE MEASUREMENTS,
6. COORDINATION OF IN-SITU AND SATELLITE DATA INTEGRATION AND DISSEMINATION.
7. DEVELOPMENT OF ENSEMBLE BASED HYDROLOGIC PREDICTIONS
8. PROMOTION OF THE USE OF EARTH OBSERVATIONS IN SUSTAINABLE DEVELOPMENT.
9. FREE AND OPEN DATA EXCHANGE
10. CAPACITY BUILDING ACTIVITIES AND THE EVALUATION OF BARRIERS TO CAPACITY BUILDING.

IN 2003 IGOS-P APPROVED AN INTEGRATED GLOBAL WATER CYCLE OBSERVING THEME (IGWCO) WITH THE FOLLOWING OBJECTIVES



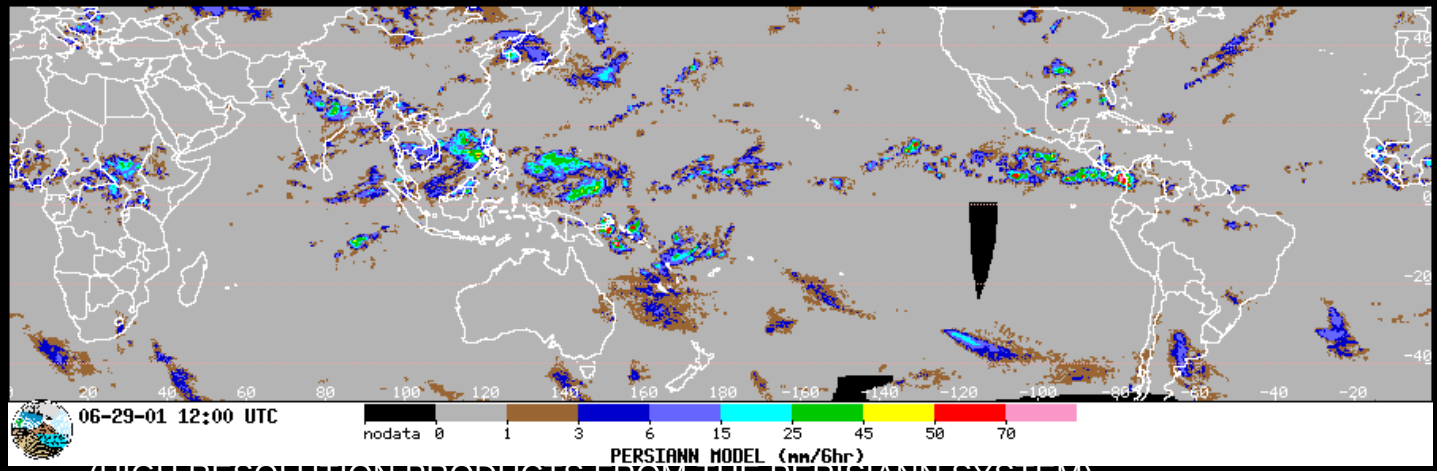
1. Provide a framework for guiding decisions on priorities and strategies regarding water cycle observations for:
   - Monitoring climate variability and change,
   - Effective water management and sustainable development of the world's water resources,
   - Societal applications for resource development and environmental management,
   - Specification of initial conditions for weather and climate forecasts,
   - Research directed at priority water cycle questions
2. Promote strategies that facilitate the processing, archiving and distribution of water cycle data products

SPACE AND TIME REQUIREMENTS FOR DIFFERENT APPLICATIONS NEED TO BE UNDERSTOOD.

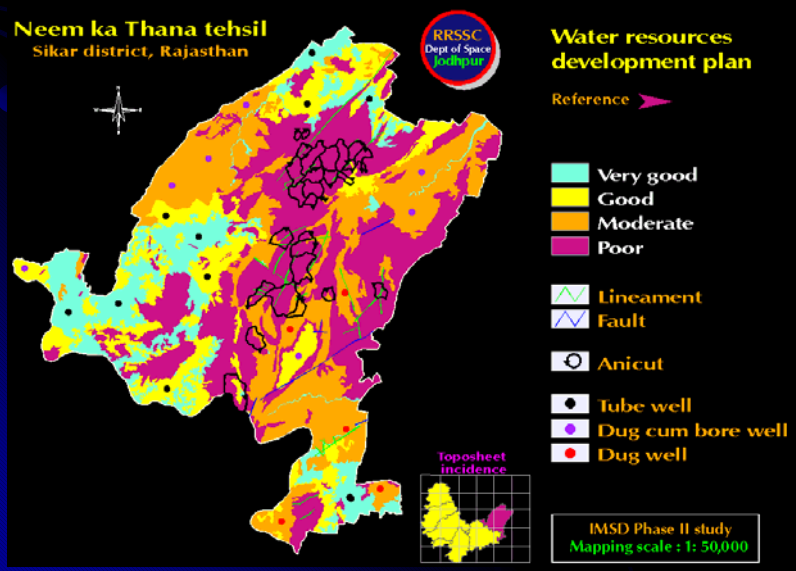


INTEGRATION IN THE IGWCO THEME

WORK IS DIRECTED AT INTEGRATED PRODUCTS FOR SPCIFIC WATER CYCLE VARIABLES INCLUDING PRECIPITATION AND SOIL MOISTURE.



(HIGH RESOLUTION PRODUCTS FROM THE PERISIANN SYSTEM)



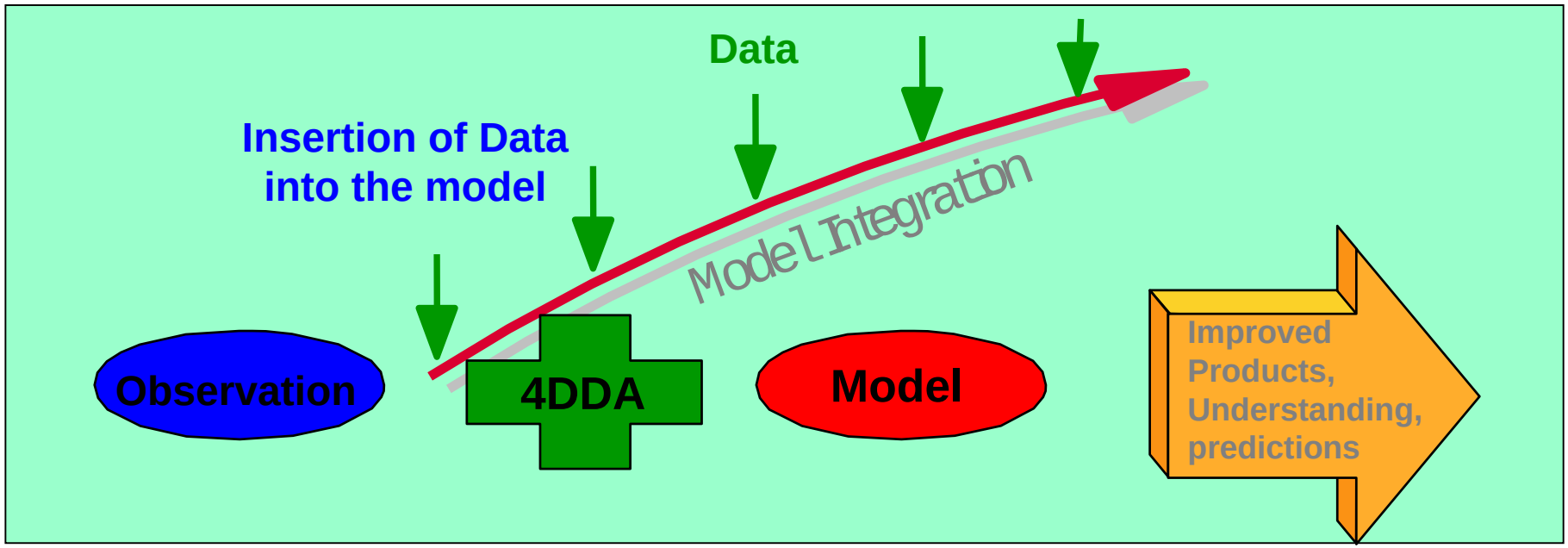
INTEGRATION IS ALSO DIRECTED AT THE DEVELOPMENT OF SYSTEMS FOR COMBINING DIFFERENT TYPES OF DATA. THIS INCLUDES DATA ASSIMILATION AND GEOGRAPHICAL INFORMATION SYSTEMS.

Paul R. Houser, NASA/GSFC Hydrological Sci
Paul.Houser@gsfc.nasa.gov

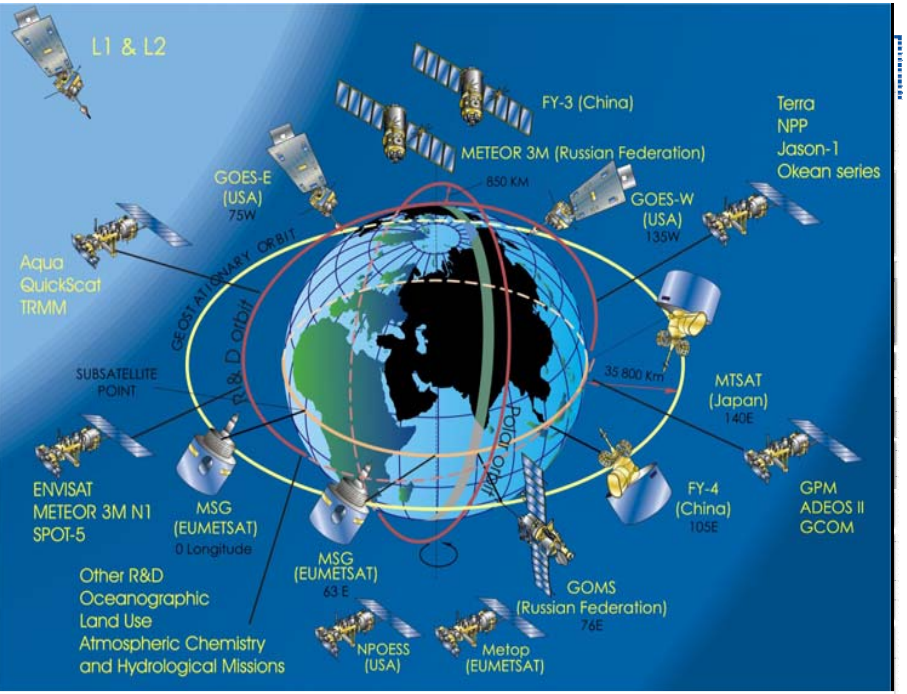
Global Land Data Assimilation System

Objective: **A 1/8 degree global land modeling and assimilation system that uses all relevant observed forcing, storages, and validation. Expand the current N. American LDAS to the globe. 1km global resolution goal**

Benefits: **Enable improved land-atmosphere understanding, hydrological and climate prediction, transfer research to application, and enable consistent inter-site comparison (I.e. GEWEX).**



HAS PROVIDED IGWCO WITH EXPERIENCE USING A RESEARCH-OPERATIONS PARADIGM AND IN INTEGRATED DATA SET DEVELOPMENT



CEOP, THE FIRST ELEMENT OF IGWCO, BRINGS TOGETHER THE EXPERTISE AND CAPABILITIES OF:

-5 MAJOR SPACE AGENCIES THAT PROVIDE DATA (JAXA, ESA, EUMETSAT, NASA, NOAA)

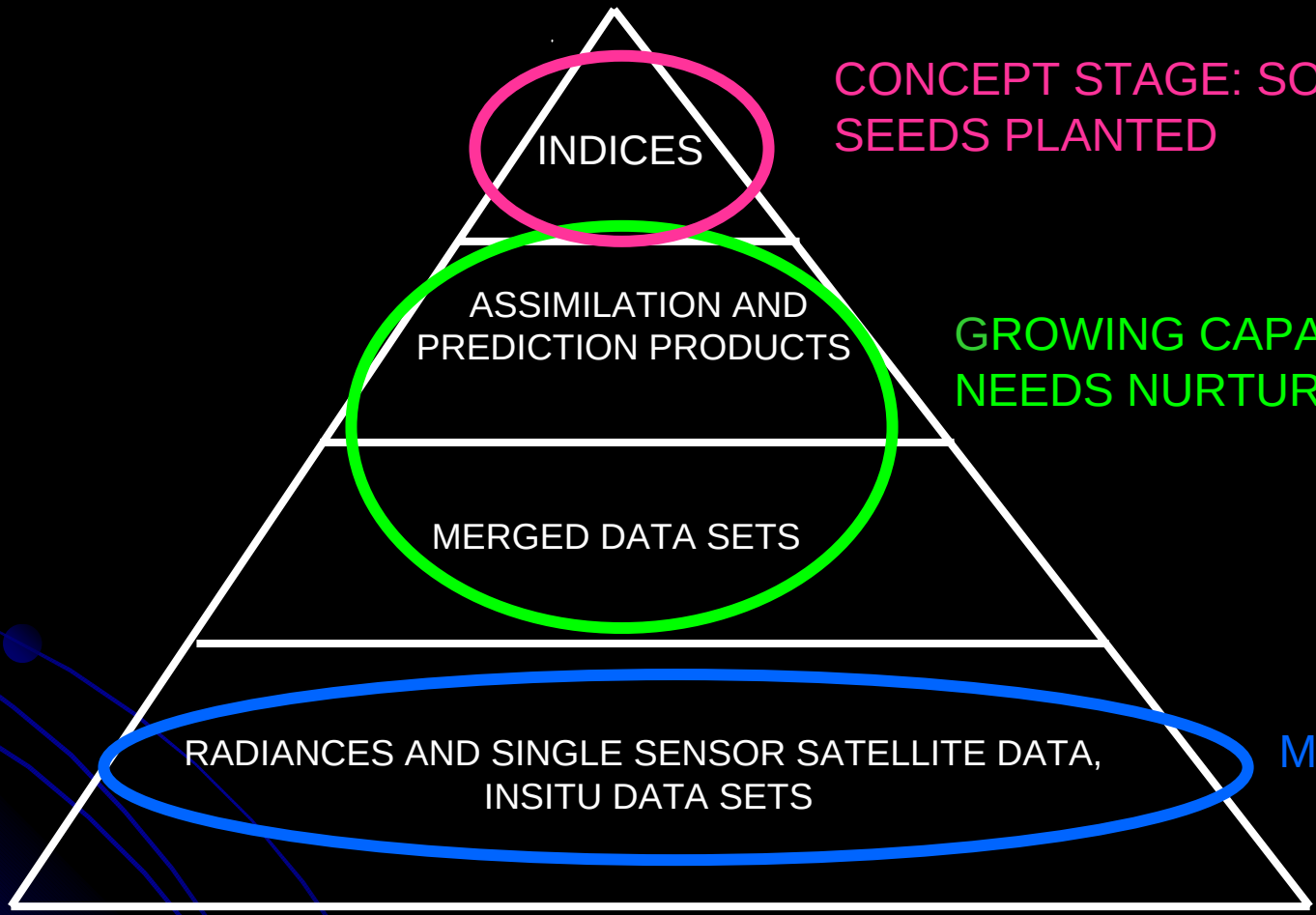
-11 MAJOR NUMERICAL WEATHER PREDICTION CENTERS IN PROVIDING MODEL OUTPUTS (ECMWF, NCEP, GMAO, JMA, ECPC, ETC)

-18 NATIONS IN PROVIDING REFERENCE SITE DATA (MANY OF WHICH HAVE RESTRICTIVE DATA POLICIES).

-WCRP/ CEOS CEOP COMMITTEES BRING ALL THESE GROUPS TOGETHER

CEOP DEMONSTRATES THAT RESEARCH PROGRAMS CAN DEVELOP NEW APPROACHES TO PROBLEMS. A RESEARCH-OPERATIONS PARTNERSHIP IS VIEWED AS ESSENTIAL TO ACHIEVE THE GOALS OF IGWCO.

TURNING DATA INTO KNOWLEDGE THROUGH INDICATORS STEPS TO GROWING A CAPABILITY TO ADVISE POLICY MAKERS



CONCEPT STAGE: SOME SEEDS PLANTED

GROWING CAPABILILTY: NEEDS NURTURING

MATURE

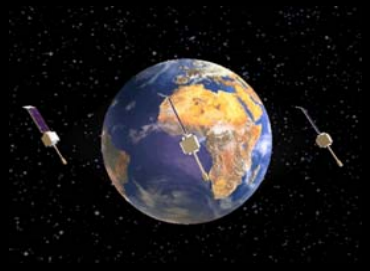
WATER CYCLE MEASUREMENTS WILL HAVE GLOBAL BENEFITS IF DEVELOPING COUNTRIES GAIN THE CAPABILITY OF USING THESE DATA

(Capacity Development– Technology, Education/Training and Field Applications)

- Developing nations should be provided with the hardware and software to access all IGWCO data products and forecasts.
- Training materials should be developed and sessions carried out in developing countries.

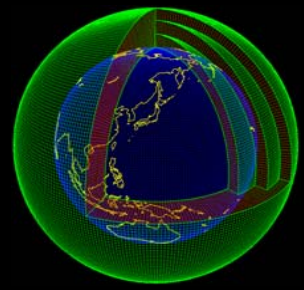
IGWCO WILL WORK ACTIVELY TO SUPPORT THE TRANSFER OF ADVANCED TECHNOLOGIES TO DEVELOPING COUNTRIES. IGWCO ENVISIONS WORKING CLOSELY WITH UNESCO AND SPACE AGENCIES (CEOS) TO ACHIEVE THIS GOAL.

ONE PERSPECTIVE OF THE GEWEX MISSION: GEWEX IS "THE DEVELOPMENT AND APPLICATION OF PLANETARY EARTH SCIENCE, OBSERVATIONS AND MODELS TO THE PROBLEMS OF CLIMATE AND WATER RESOURCES"



GEWEX

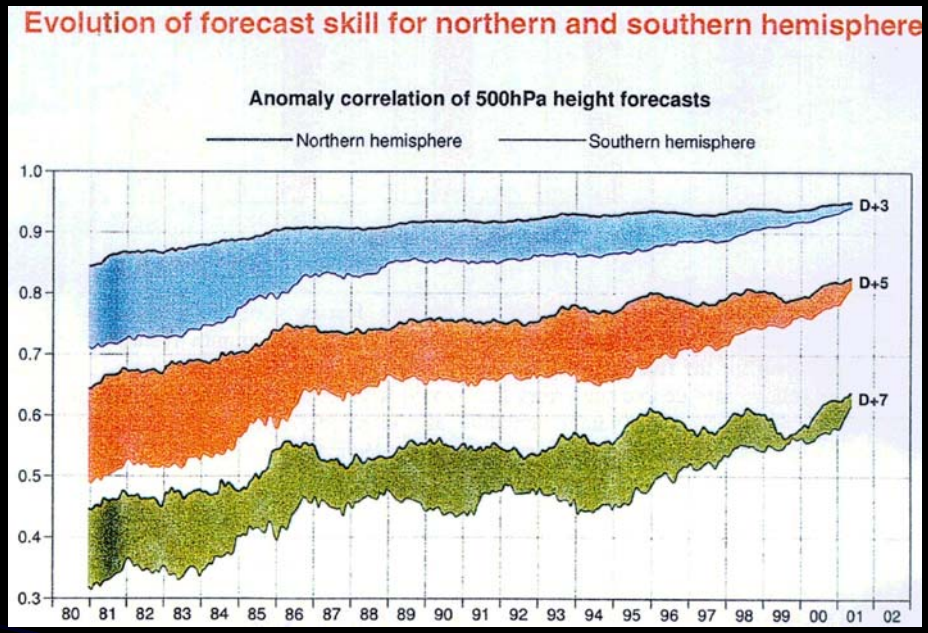
WCRP



THE PROGRAM ENTAILS:

- GLOBAL DATA SETS DERIVED FROM SATELLITE DATA, *IN SITU* DATA AND DATA ASSIMILATION CAPABILITIES,
- MODEL DEVELOPMENT AND PREDICTABILITY STUDIES
- FIELD AND PROCESS STUDIES
- APPLICATIONS

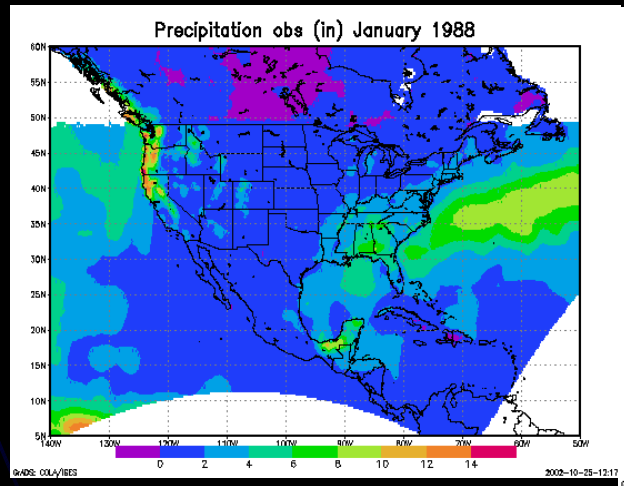
TOGETHER WITH OTHER GROUPS GEWEX HAS HELPED TO DEMONSTRATE THE VALUE OF SATELLITE DATA

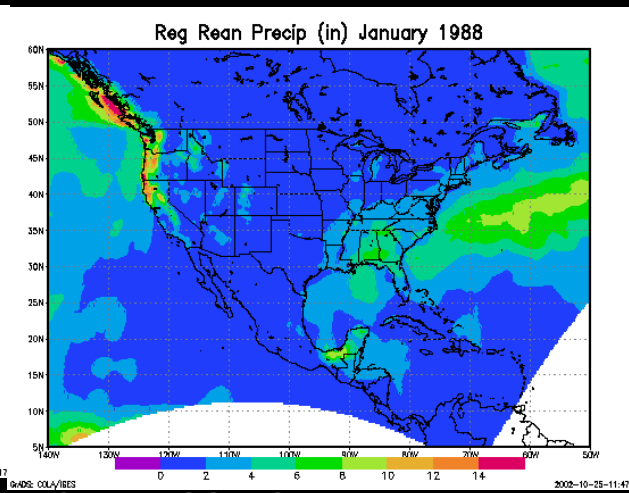


FROM ECMWF

ECMWF FORECAST SKILLS HAVE BENEFITED FROM THE INGEST OF SATELLITE DATA. WITH SATELLITE DATA FORECASTS FOR THE SOUTHERN HEMISPHERE ARE NEARLY AS ACCURATE AS THOSE FOR THE NORTHERN HEMISPHERE.

REGIONAL REANALYSIS PRODUCTS BENEFITED FROM TOVS DATA AND THE ASSIMILATION OF PRECIPITATION



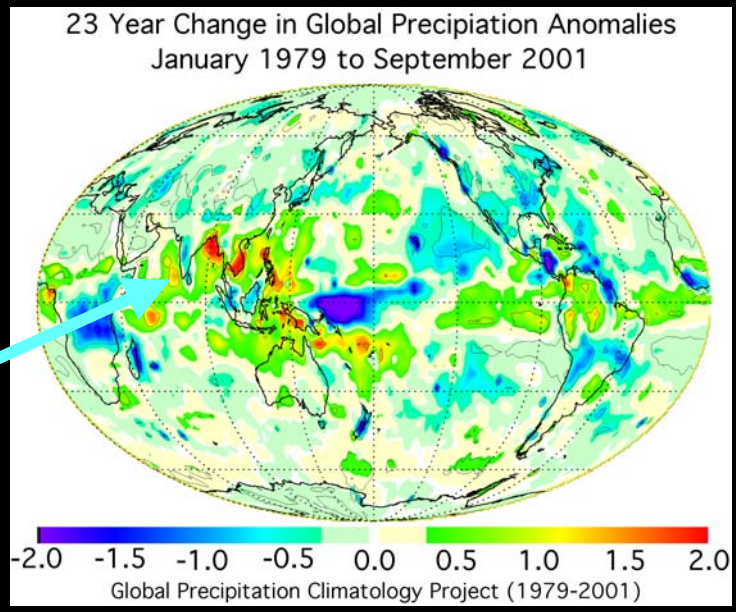


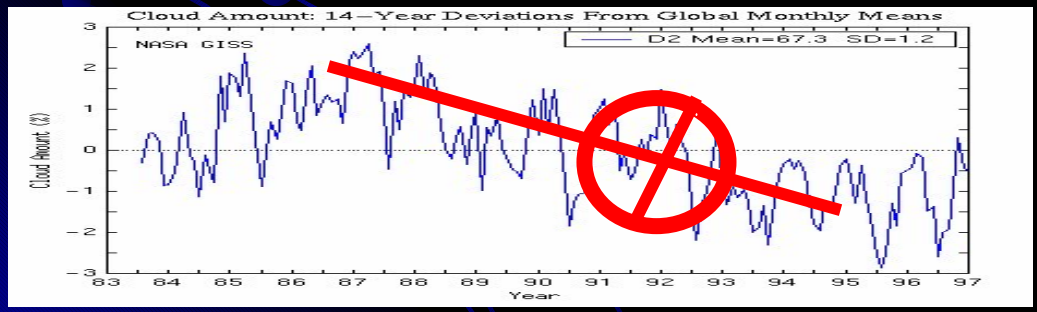
JANUARY 1998 – FROM MESSINGER

GEWEX HAS HELPED TO DEFINE THE LIMITATIONS IN THE USE OF CURRENT SATELLITE DATA

APPROPRIATE USE: DETERMINING WHERE DIFFERENT PROCESSES ARE OCCURING AND UNDERSTANDING THE PROCESSES AT WORK

REGIONAL PROCESSES AT WORK THAT AFFECT PRECIPITATION DISTRIBUTIONS





INAPPROPRIATE USE: BLINDLY APPLYING APPARENT TRENDS IN THE DATA TO INFER TRENDS IN CLIMATE WITHOUT EXAMINING THE PROCEDURES USED TO PROCESS THE DATA.

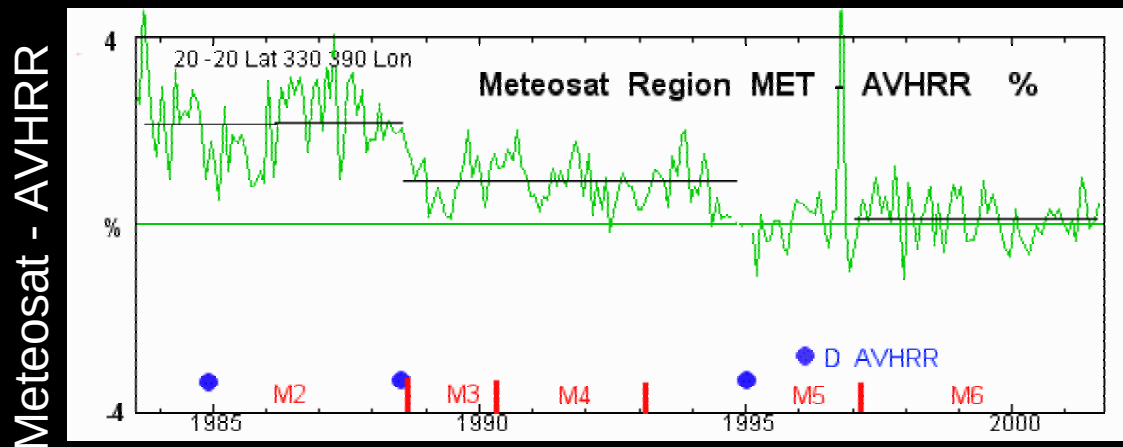
DEVELOPING LONG-TERM HOMOGENEOUS DATA SETS

FACTORS WORKING AGAINST HOMOGENEITY INCLUDE:

-CHANGES IN SATELLITE PLATFORM

-DETERIORATION OF SATELLITE FUNCTION OVER TIME (ORBIT DRIFT, SENSOR DEGRADATION, ETC)

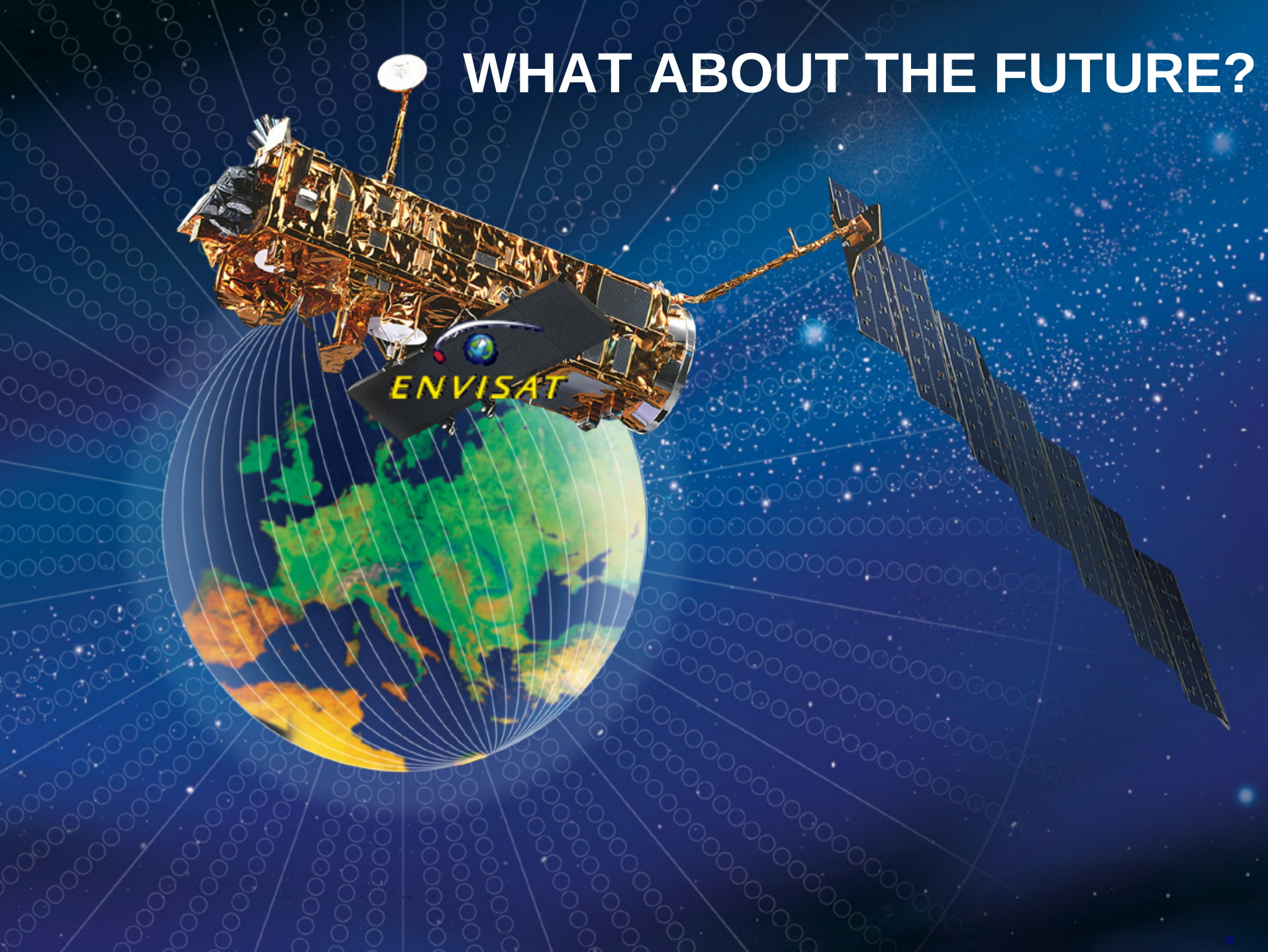
-CHANGES IN THE POSITION OF A GEOSTATIONARY SATELLITE.



Cloud anomalies (METEOSAT – GEO) over the equatorial region show a “stair-step” when GEO sensors changed. (Campbell and von der Haar)

GEWEX IS DEVELOPING PLANS FOR PRODUCT REPROCESSING THAT WILL LEAD TO BETTER TECHNIQUES FOR THE DEVELOPMENT OF HOMOGENEOUS DATA SETS FROM SATELLITE DATA.

WHAT ABOUT THE FUTURE?



THE HISTORY OF MEASUREMENT HAS STRONG LINKS TO SOCIETY'S DEVELOPMENTS IN WATER USE

EPOCH #1: WATER NATURE'S GIFT TO MANKIND (DAWN OF CIVILIZATION TO LAST CENTURY)

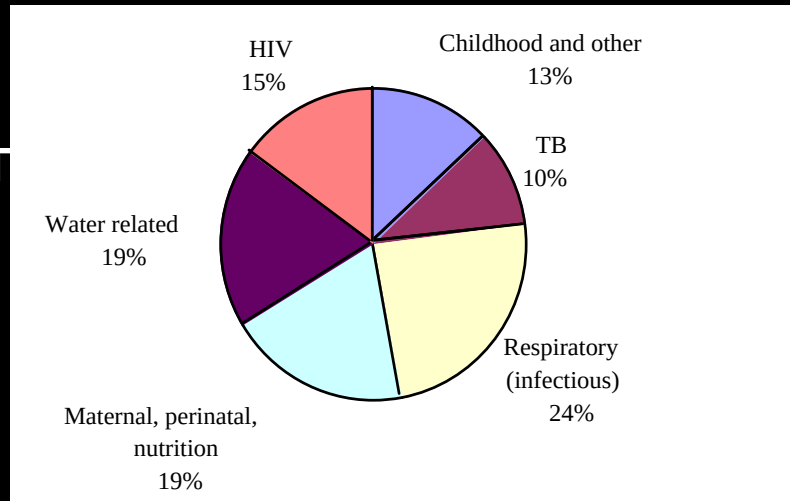
WATER IS ESSENTIAL FOR LIFE

EPOCH #2: WATER AND DEVELOPMENT (LATE 1800'S TO PRESENT)

WATER IS ESSENTIAL FOR PROSPERITY

EPOCH #3: WATER AND THE ENVIRONMENT (APPROX. MID-1960'S TO THE PRESENT)

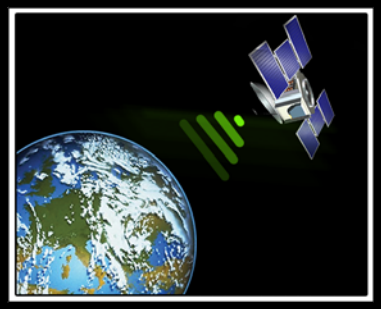
WATER IS ESSENTIAL FOR HEALTH (FOR HUMANS AND ECOSYSTEMS)



ARE WE ABOUT TO ENTER A NEW EPOCH IN WATER MANAGEMENT?

CAN WE IMPLEMENT A NEW EPOCH OF WATER MANAGEMENT IN OUR LIFETIMES THAT IS FACILITATED BY OBSERVATIONS AND IMPROVED PREDICTION SYSTEMS.

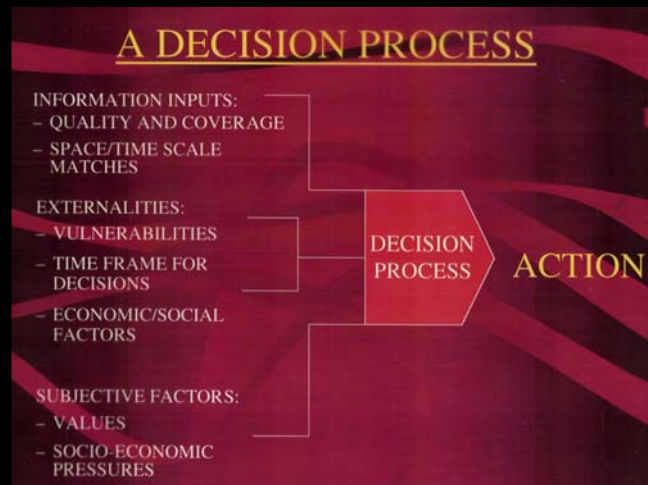
OBSERVATIONS



IMPROVED CAPABILITY TO ASSIMILATE AND PREDICT

cf. Sorooshian

INTEGRATED DECISION SUPPORT SYSTEMS



ONE PERSPECTIVE ON THE FUTURE

1. WATER RESOURCE AVAILABILITY VARIES AROUND THE WORLD LEAVING SOME COUNTRIES AS WATER-RICH AND OTHERS AS WATER-POOR.

2, BUILDING CAPACITY IN DEVELOPING COUNTRIES BY PROVIDING HARDWARE, SOFTWARE AND TRAINING TO FULLY UTILIZE SATELLITE DATA IN RESOURCE DECISIONS PROVIDES A STRONG RATIONALE FOR GLOBAL INFRASTRUCTURE.

3. PROGRAMS SUCH AS GEOSS HOLD A GREAT DEAL OF PROMISE THAT A GLOBAL SYSTEM COULD BE IMPLEMENTED DURING THE FEW DECADES.

4. THE LACK OF COMMITMENT TO COHERENT GLOBAL OBSERVING NETWORKS AND FREE AND OPEN DATA EXCHANGE POLICY COULD LIMIT PROGRESS IN DEVELOPING A GLOBAL EARTH OBSERVATIONS SYSTEM.

5. TECHNOLOGY ALONE CANNOT ADDRESS ALL OF THE FACTORS CAUSING DIFFERENCES BETWEEN PRECIPITATION RICH AND PRECIPITATION POOR COUNTRIES.

PLEASE ACCEPT AN INVITATION TO PARTICIPATE IN A VIRTUAL CONFERENCE ON SCIENCE AND TECHNOLOGY BEING HELD AS PART OF THE PREPARATIONS FOR WORLD WATER FORUM IV. INFORMATION CAN BE FOUND AT:

WWW.WORLDWATERFORUM4.ORG.MX.

LOOK FOR THE SCIENCE AND TECHNOLOGY VIRTUAL CONFERENCES CONVENED BY SUSANNA EDEN AND RICK LAWFORD.