The GEOSS Water Cycle Integrator

An Innovative Tool for Effective Collaboration in the Water Sector

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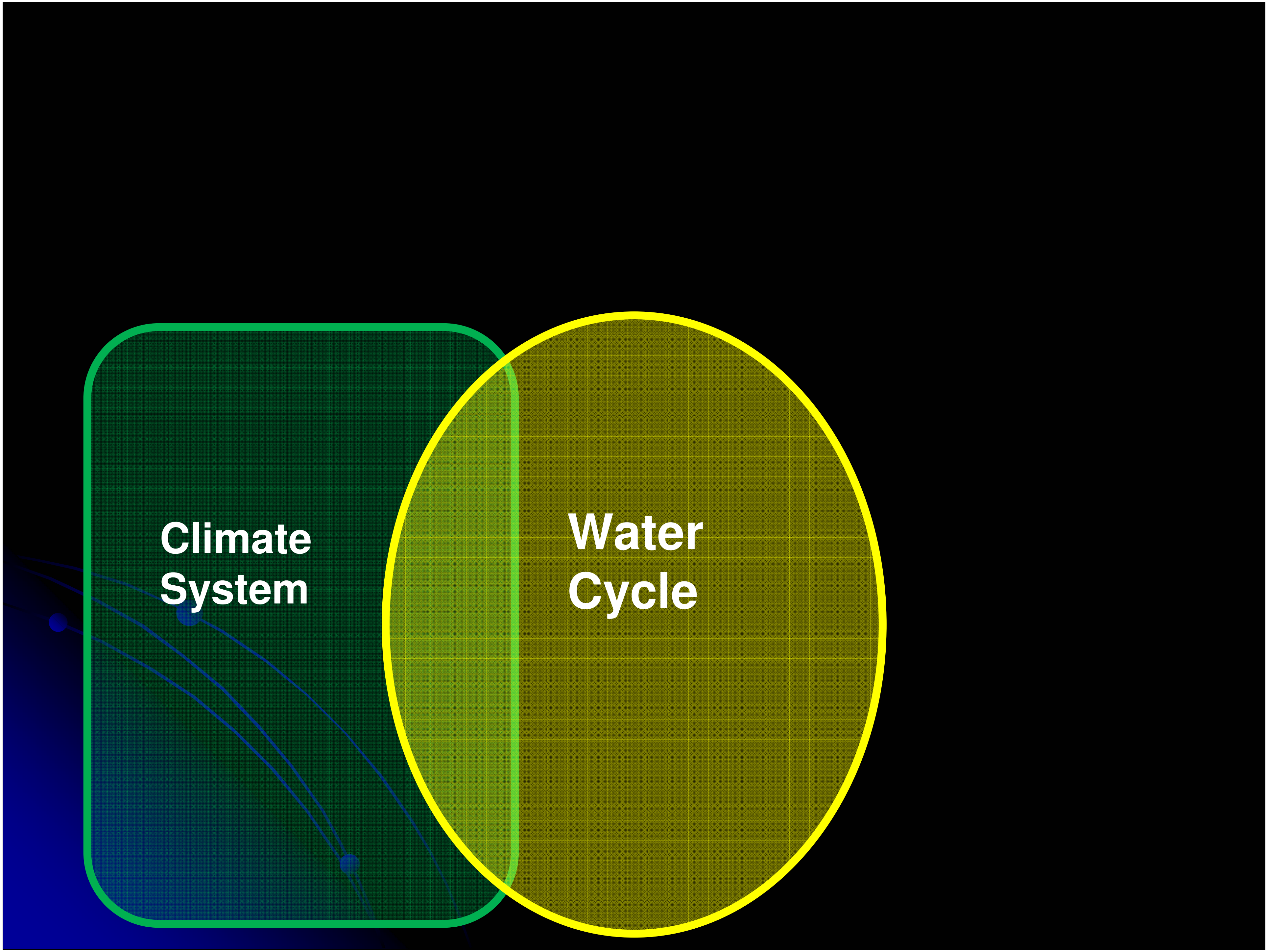
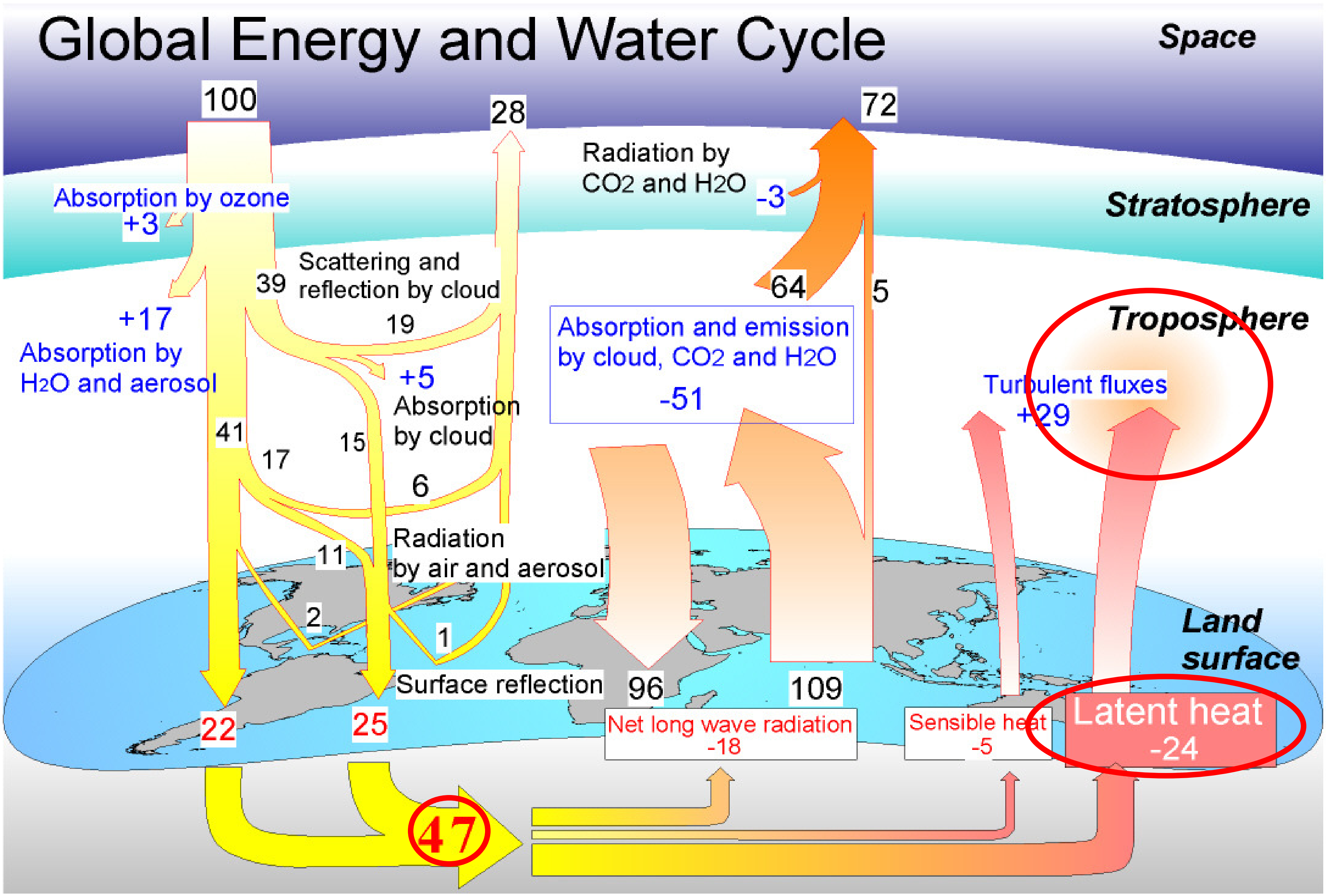
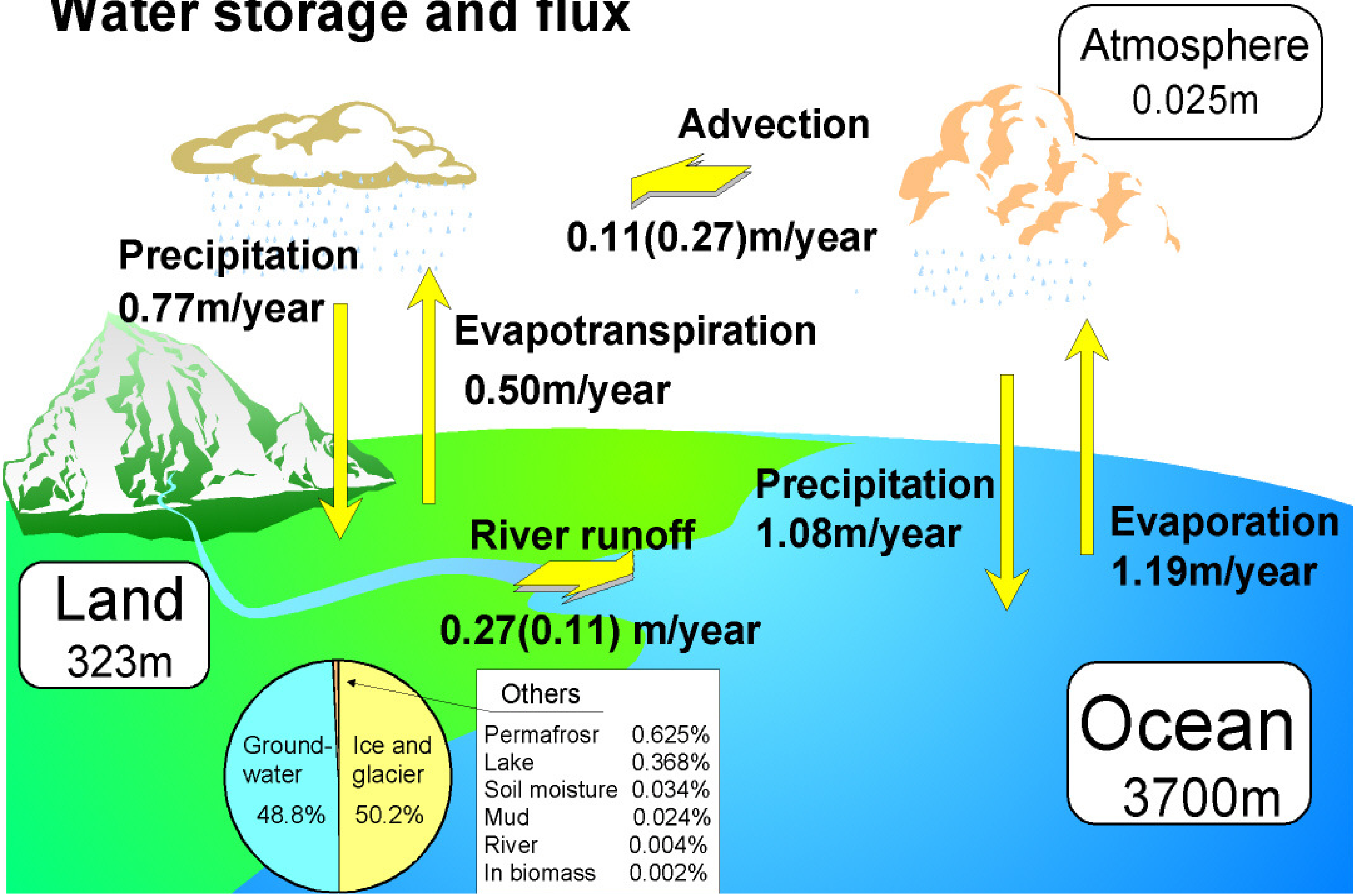
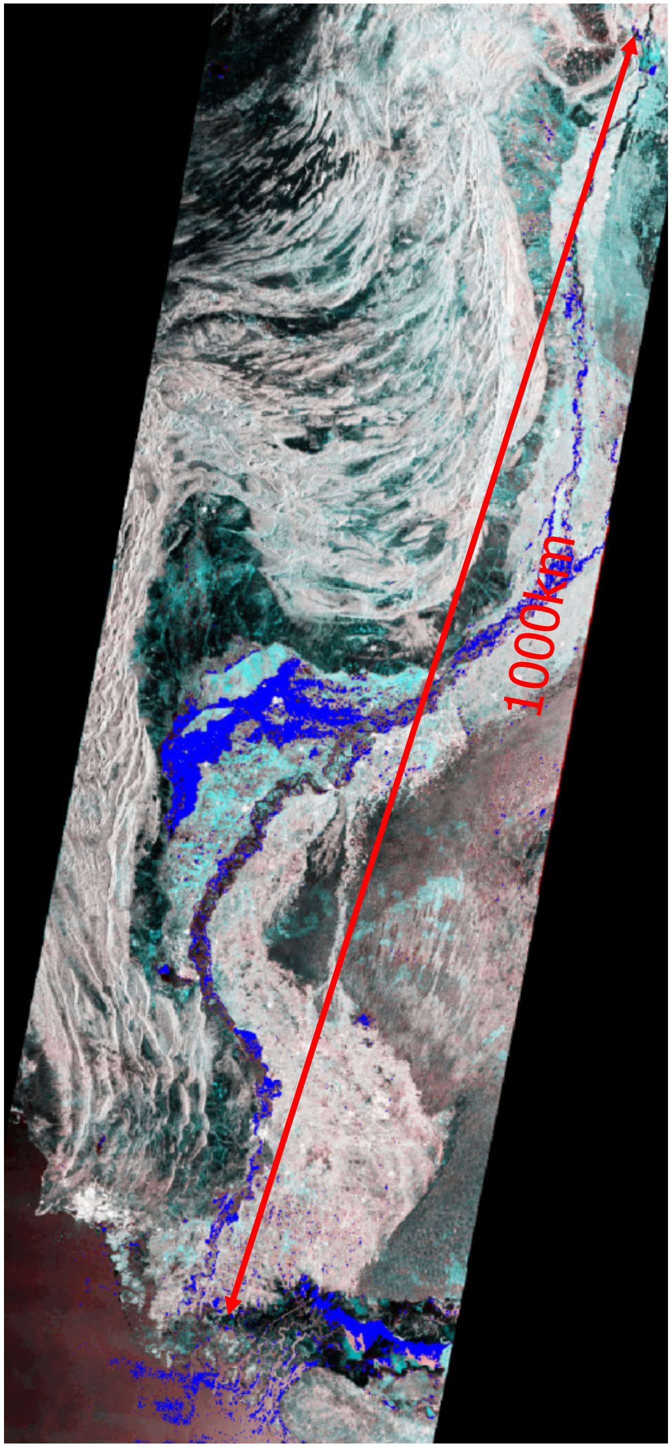

Climate
System
Water
Cycle

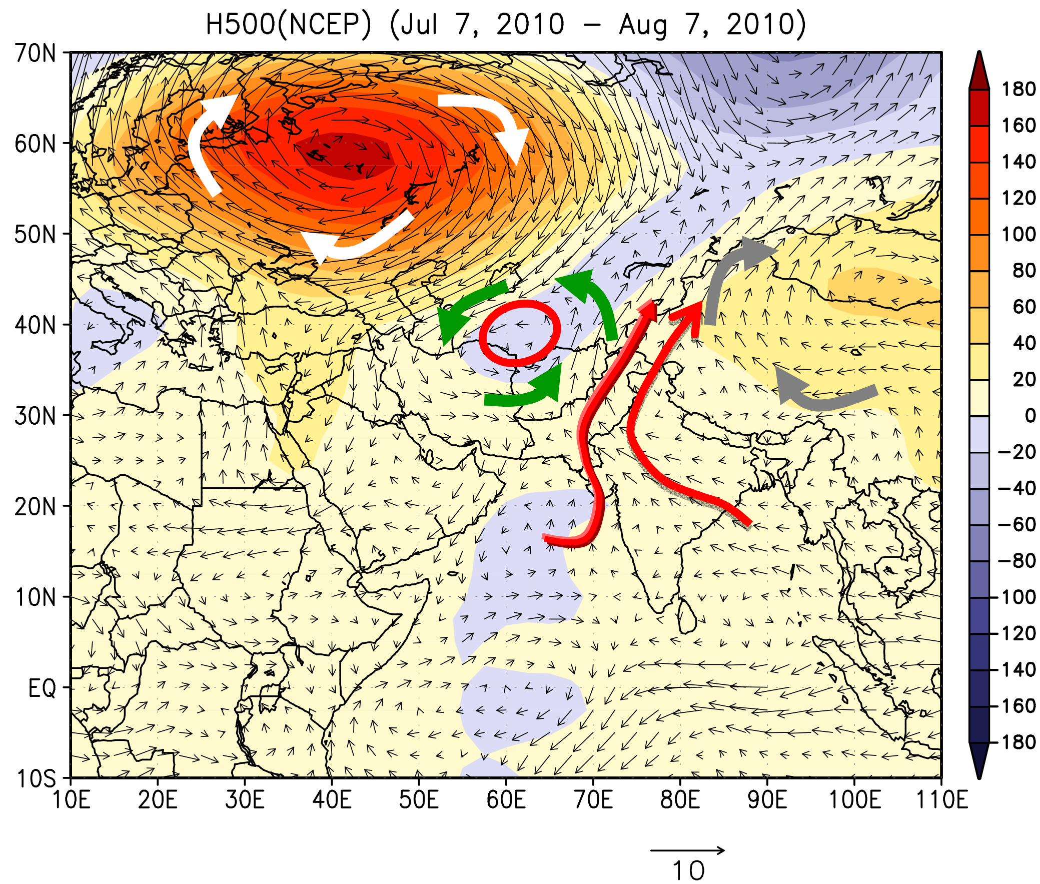
Variability of Climate and Water Cycle: Unique Roles of Water

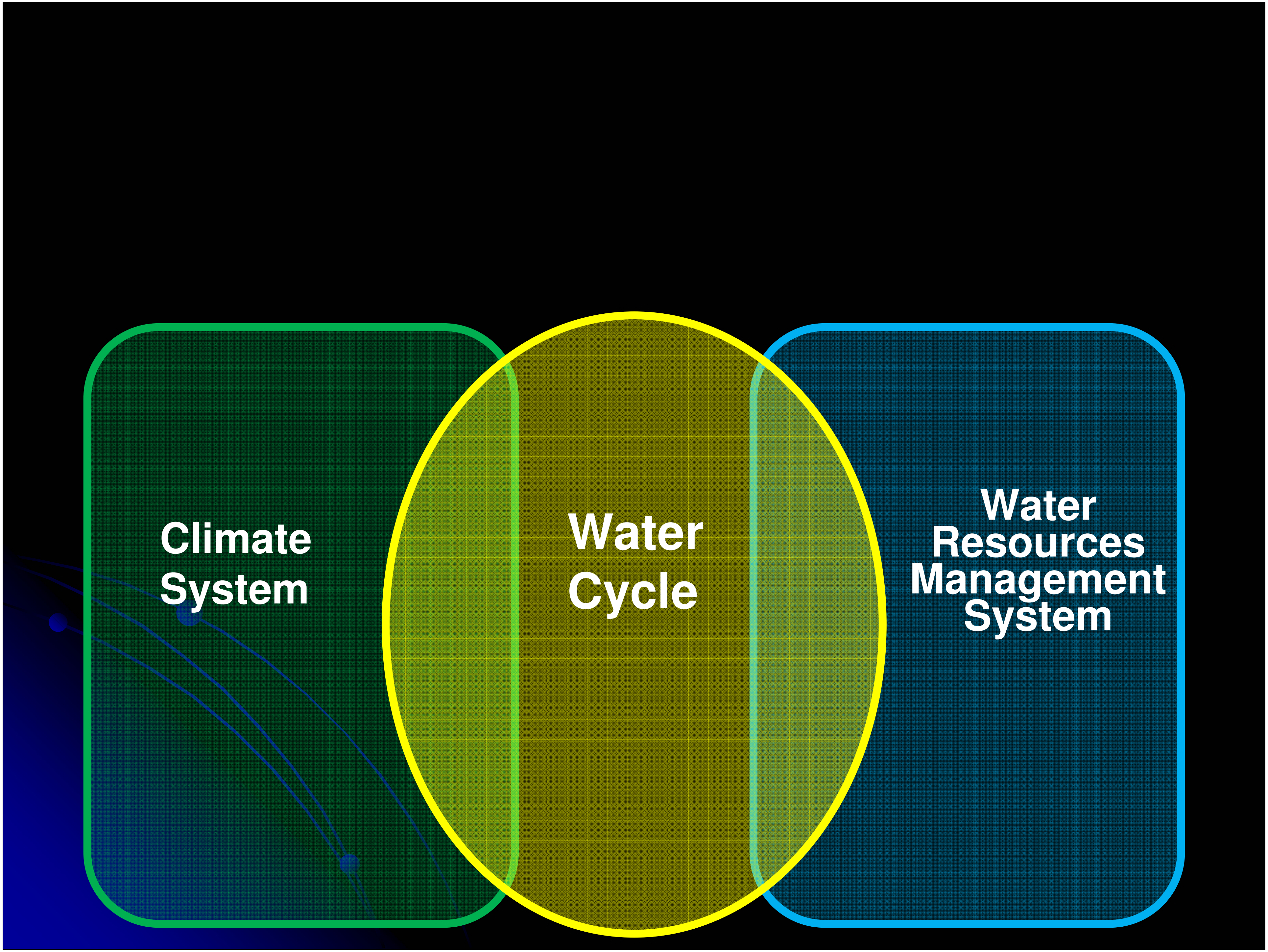


Water storage and flux

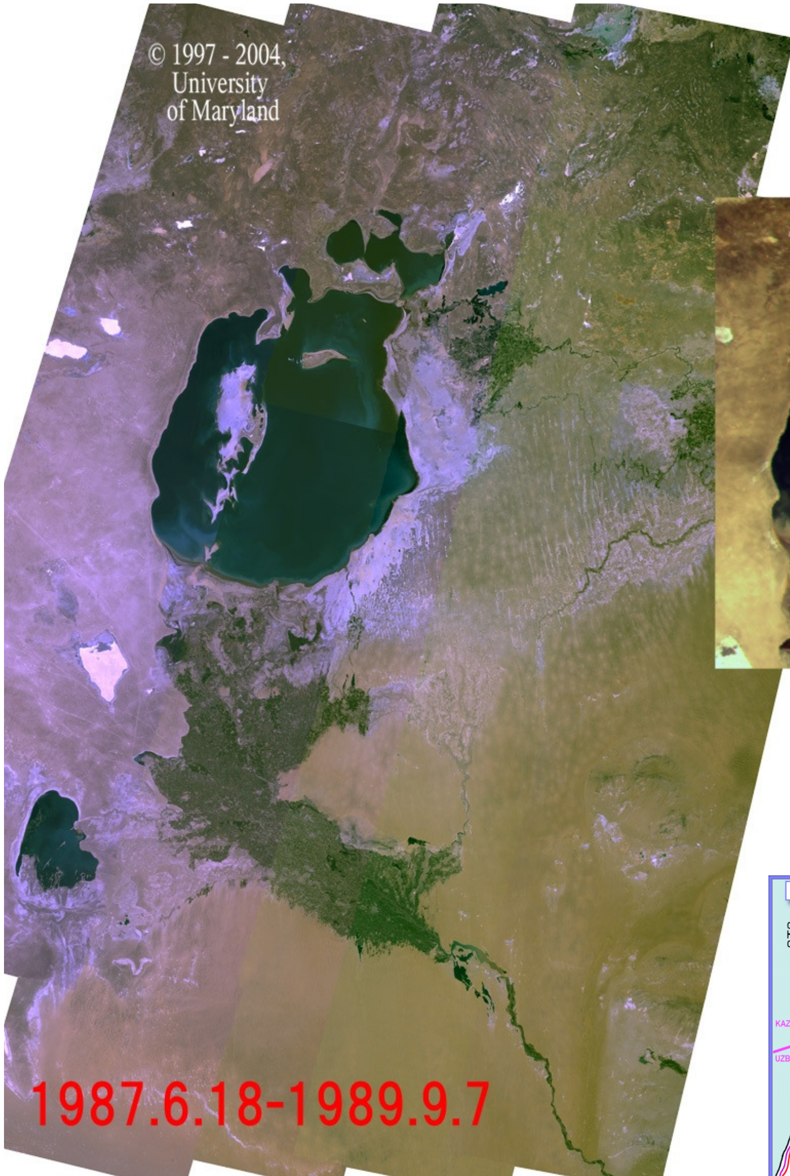



1000km


H500(NCEP) (Jul 7, 2010 – Aug 7, 2010)
70N
60N
50N
40N
30N
20N
10N
EQ
10S
10E
20E
30E
40E
50E
60E
70E
80E
90E
100E
110E
180
160
140
120
100
80
60
40
20
0
−20
−40
−60
−80
−100
−120
−140
−160
−180
10


Climate System
Water Cycle
Water Resources Management System

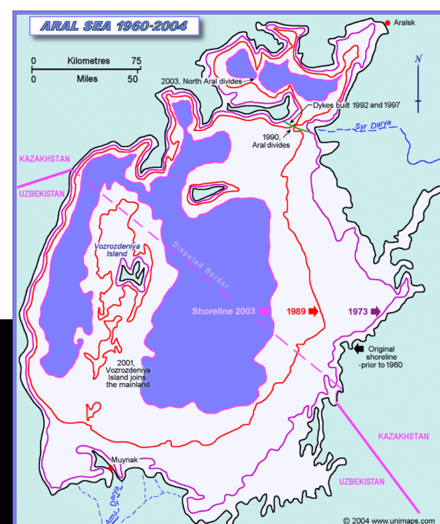
Shrinking Aral Sea



1996.11.16

2003.10.14

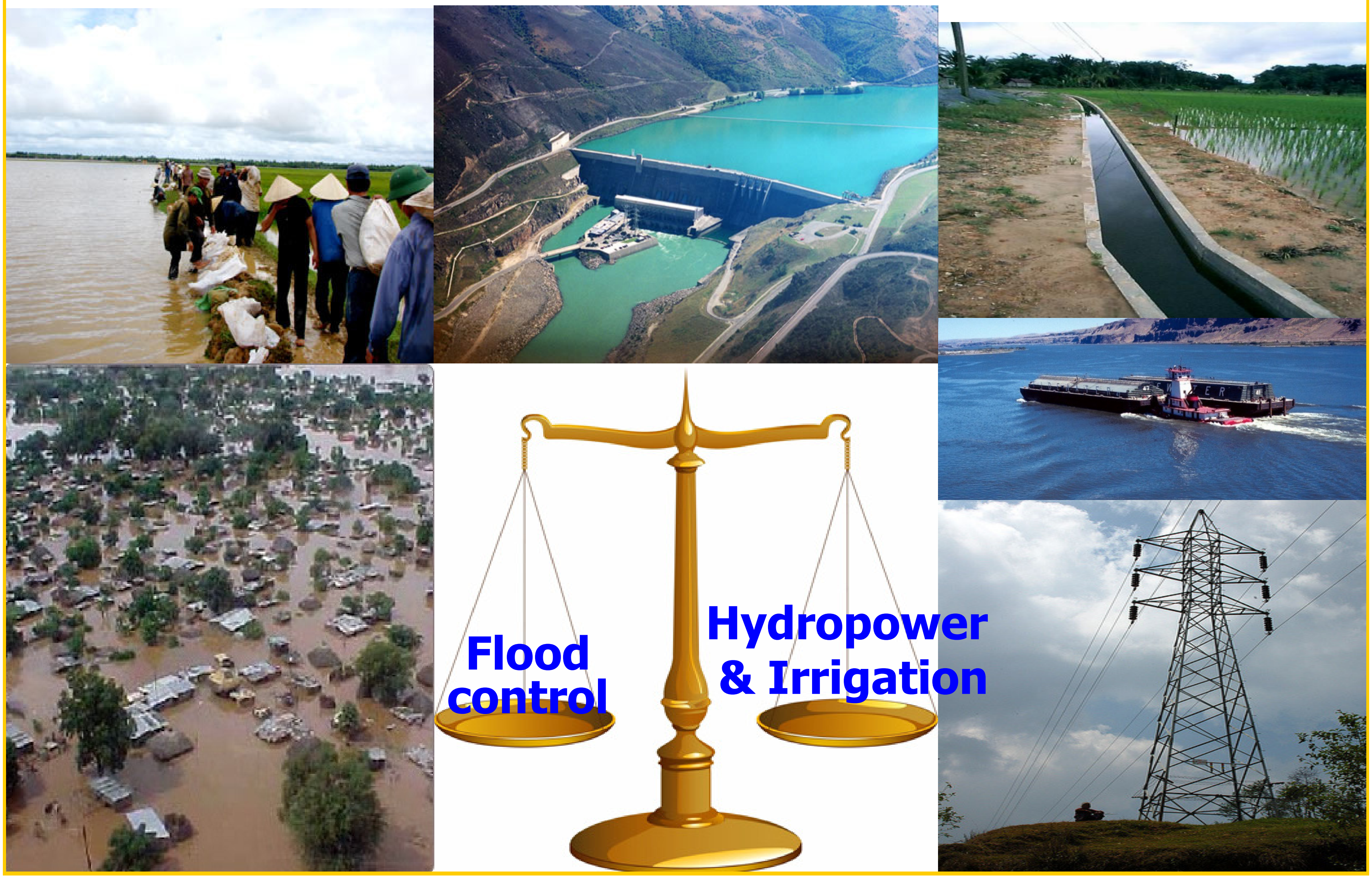
2006.9.23
-2007.10.30

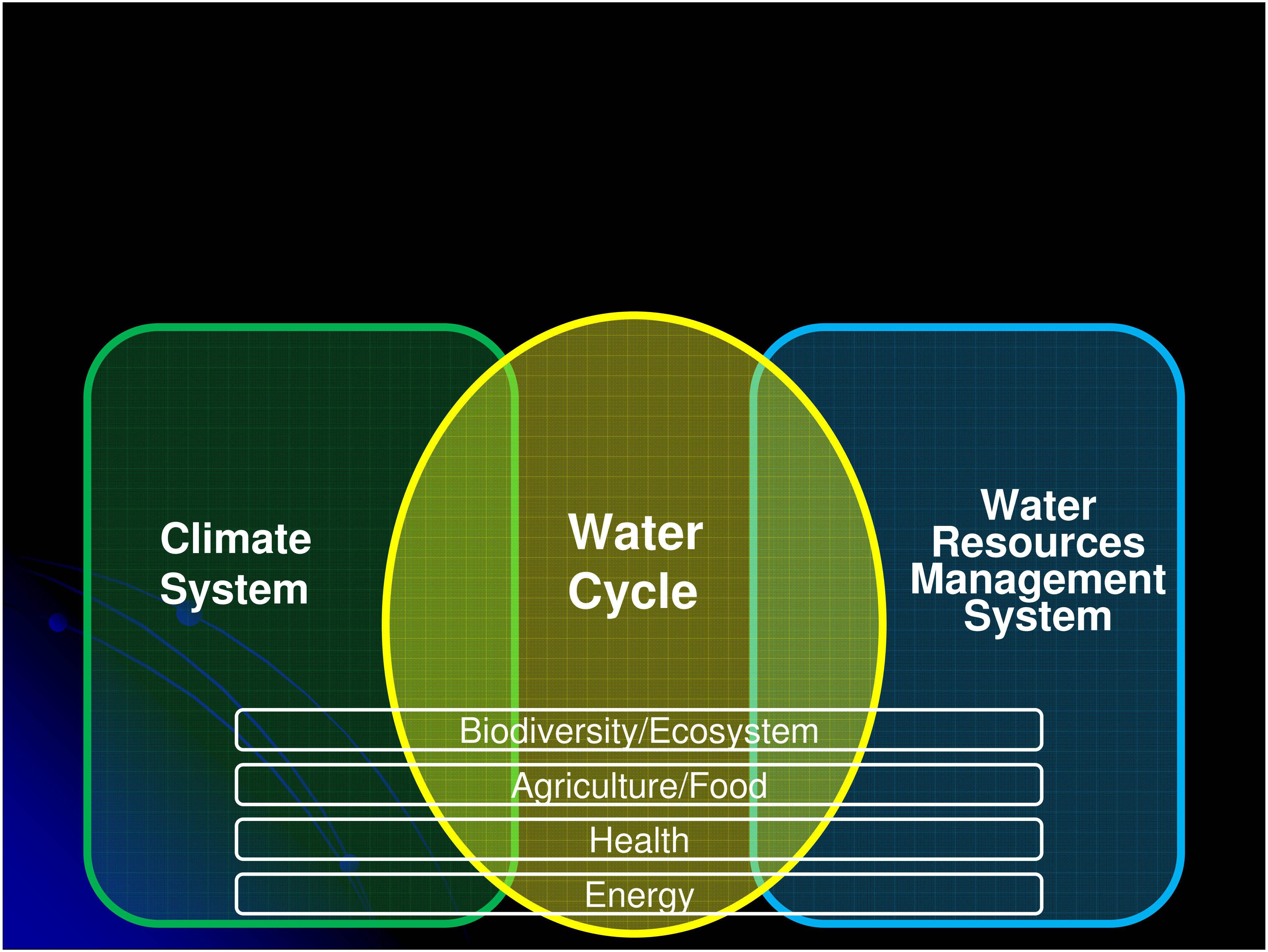


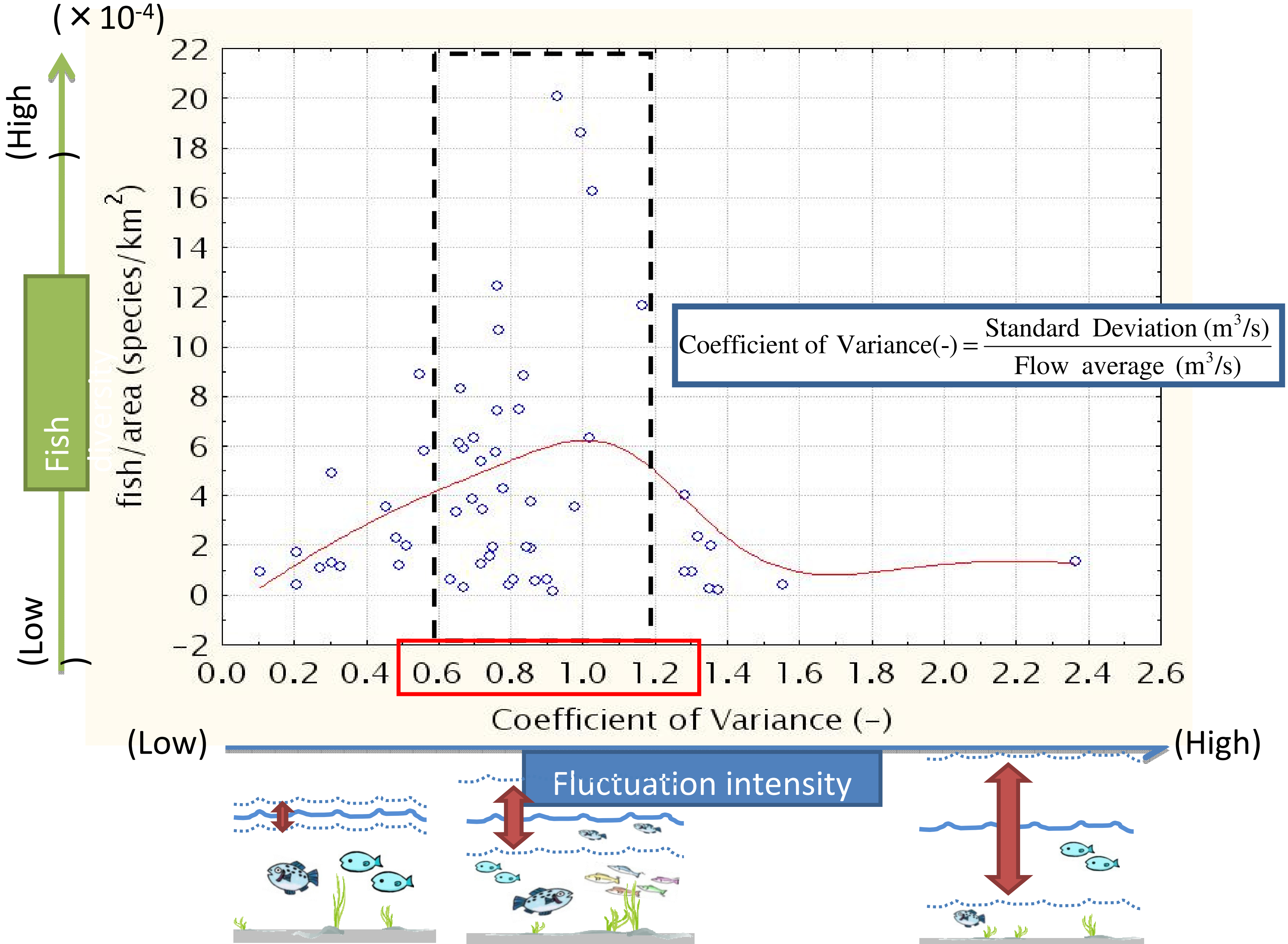
Km

0 500

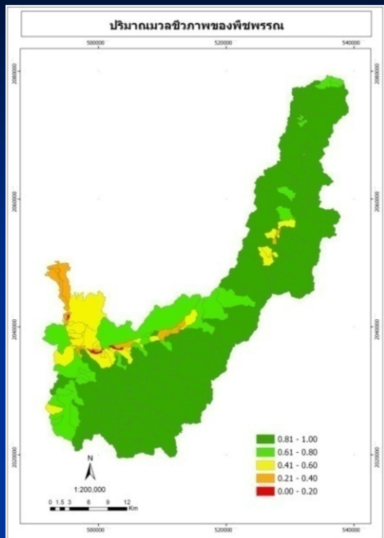
– operation of multi-purpose dam -



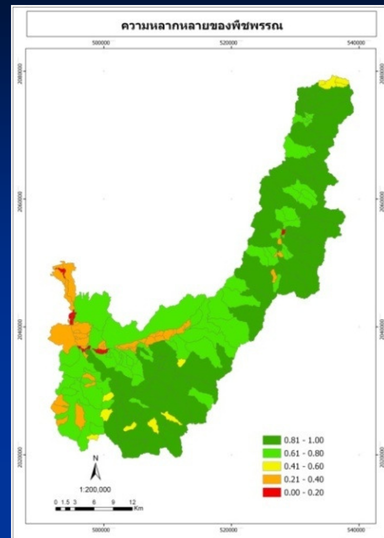

Climate System
Water Cycle
Water Resources Management System
Biodiversity/Ecosystem
Agriculture/Food
Health
Energy


(×10-4)
(High)
(Low)
Fish
diversity
fish/area (species/km2)
22
20
18
16
14
12
10
8
6
4
2
0
-2
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
Coefficient of Variance (-)
Coefficient of Variance(-) = Standard Deviation (m3/s) / Flow average (m3/s)
(Low)
(High)
Fluctuation intensity

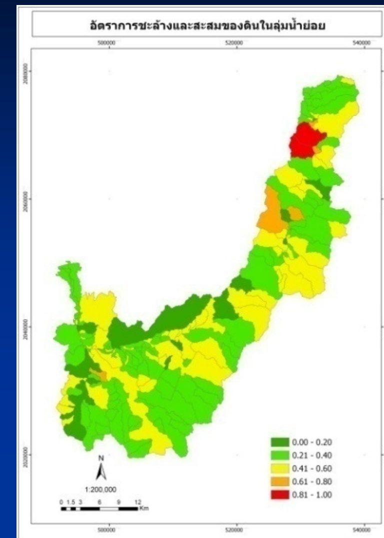
Criterion of Ecology



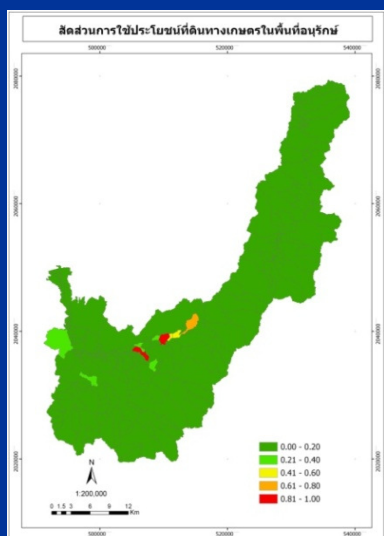
Biomass of Vegetation



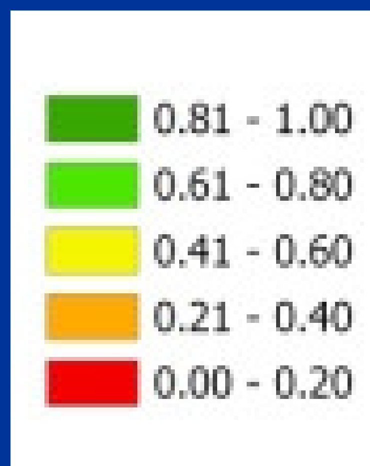
Diversity of Vegetation

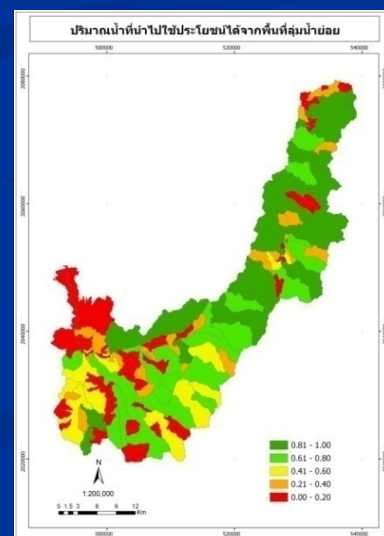


Ratio of Soil Loss & sediment in sub-watershed



Ratio of Agri. Land Uses in Conservative Areas



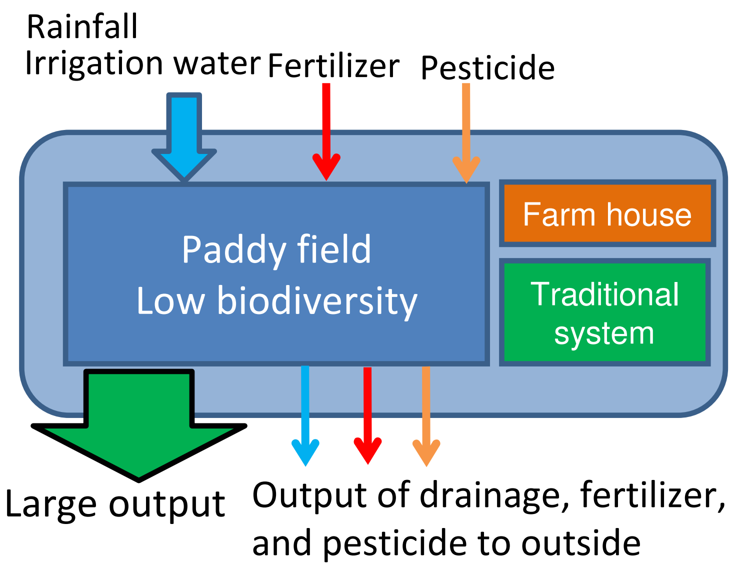


Available Water from Sub-watershed

Bio-production system in harmony with conservation of biodiversity

Modern crop production system

Large input from outside of the system

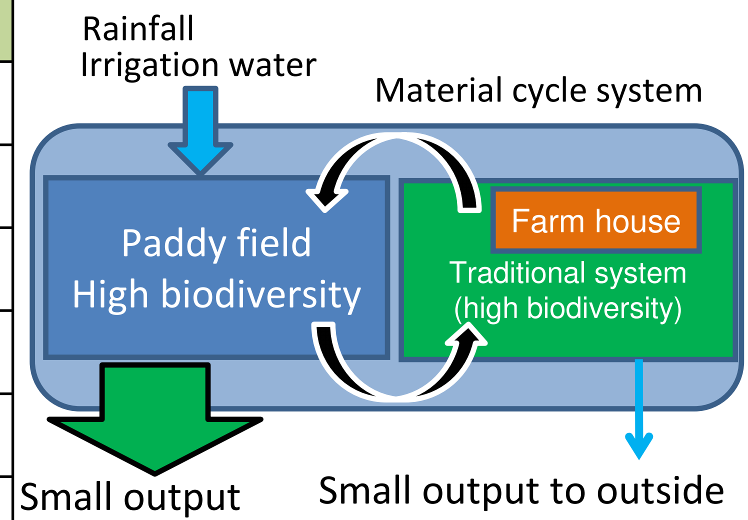


Ecosystem services inventory

Ecosystem service	Index	Flow/ Stock
Provision service	Rice	・・・
	Orchards	・・・
	Fishes	・・・
Adjust service	Water purification	・・・
Basement service	Material cycle	・・・
Bio-diversity service	Crops, Orchards, Birds, Fishes, Plants, ...etc	・・・

Traditional crop production system

Small input from outside of the system



Work together with sub theme 1

Development of technology and social system of low input sustainable production system which prevent catastrophic collapse

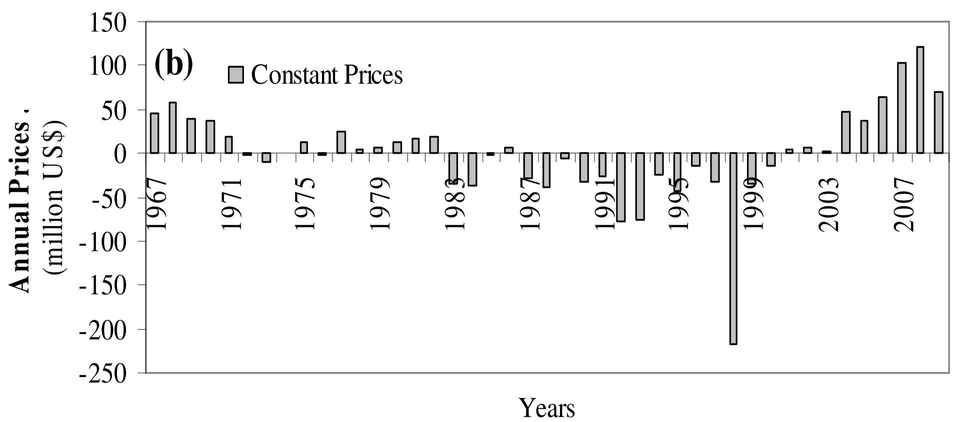
Synthesis between modern and traditional crop production systems

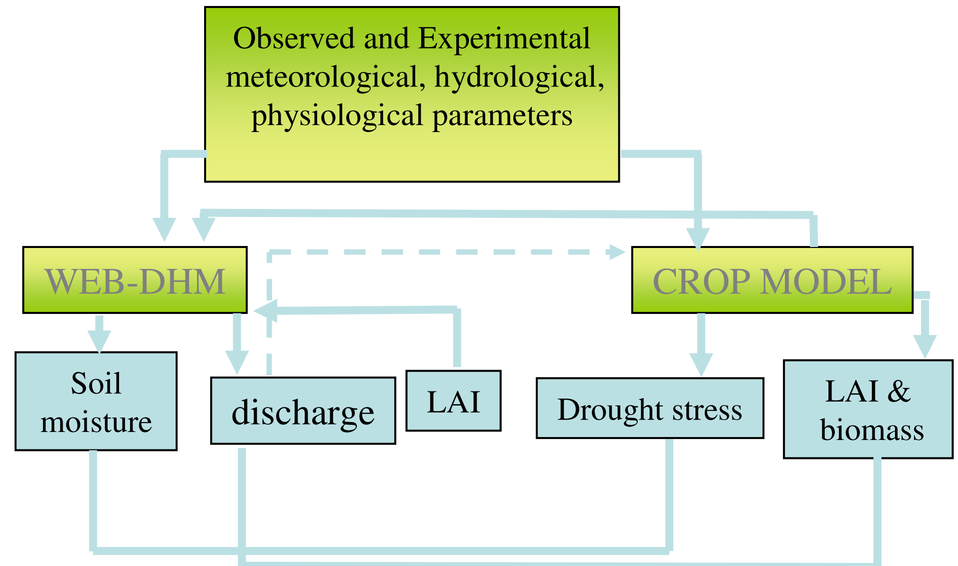
Work together with sub theme 2

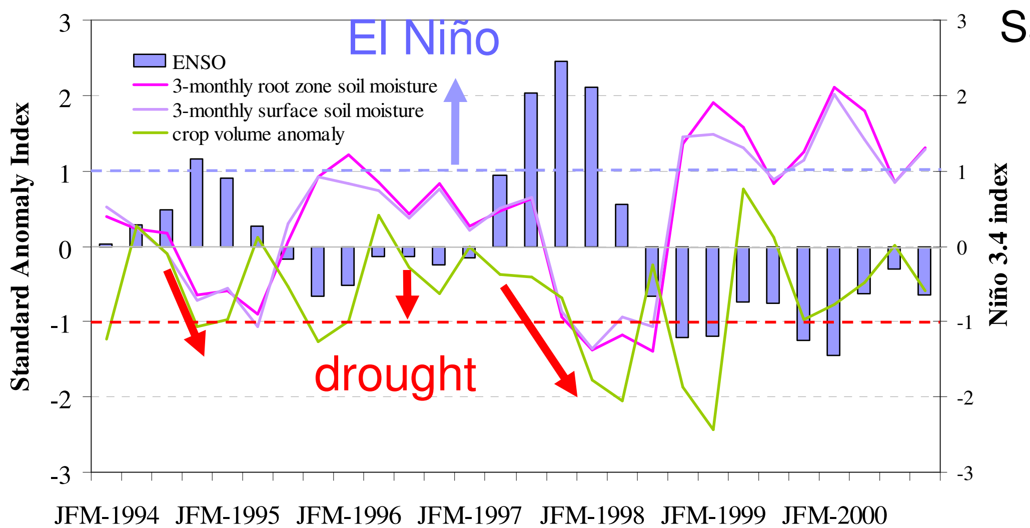
Presentation of policy options for the use of local resources through strengthening resilience with scientific evidence

Mosaic crop production system with strengthened resilience

Application: Agricultural Production and Drought Monitoring



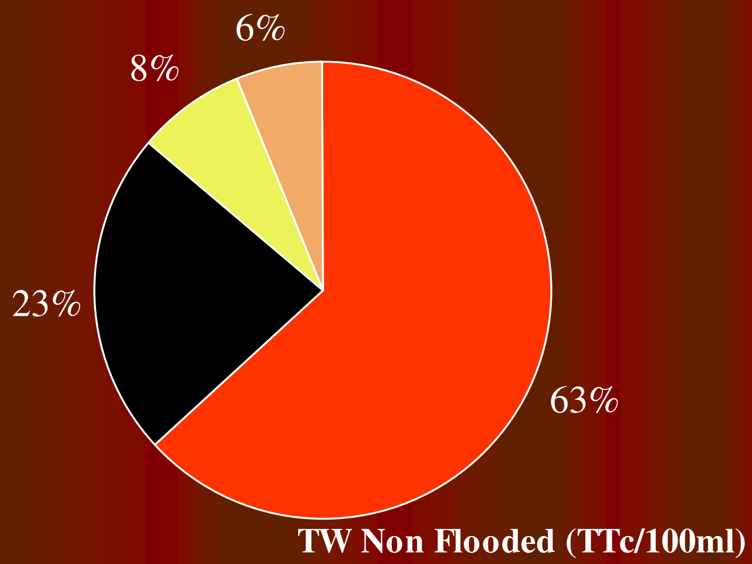


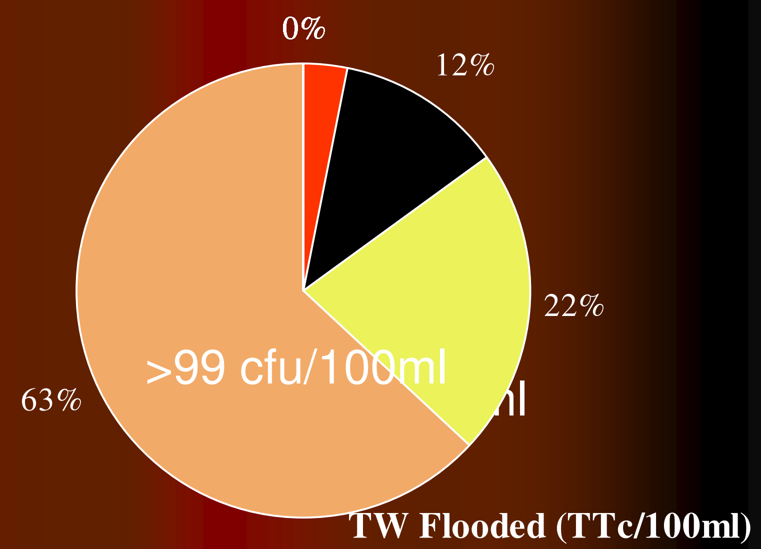


Sample output for rice production simulation:

year	Actual	simulated
1983	--	7012 kg/ha
1987	--	7247kg/ha
1991	--	6900kg/ha
1998	34164 metric tons (BAS, 2011)	6903kg/ha (34116 metric tons)

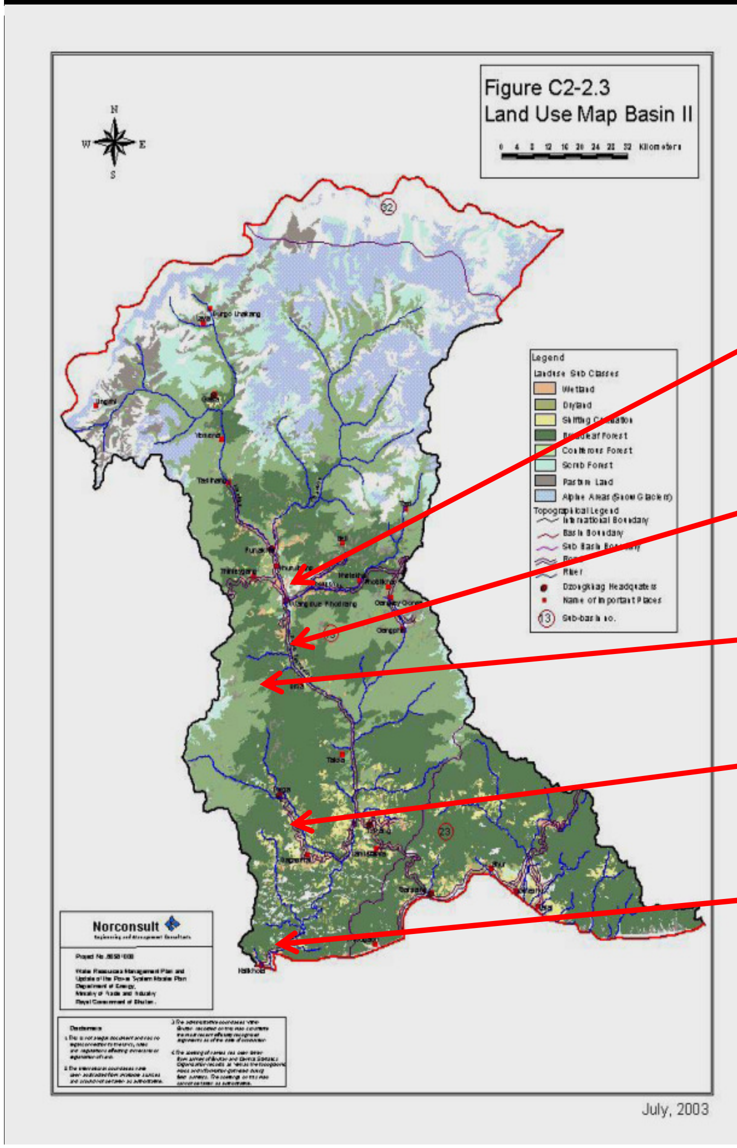
Bacteriological contamination of tube well during floods



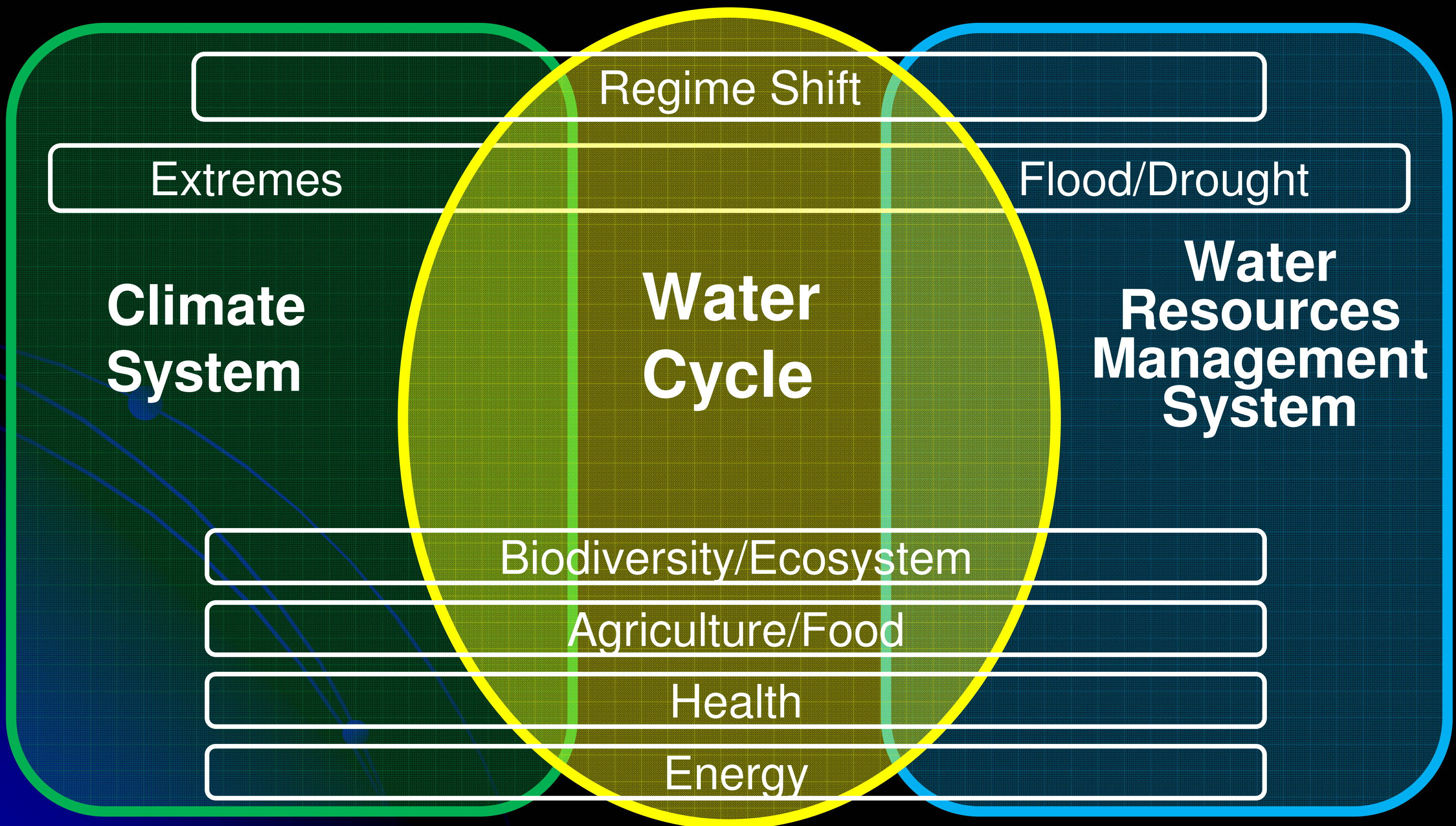


Bilqis et all. 2004

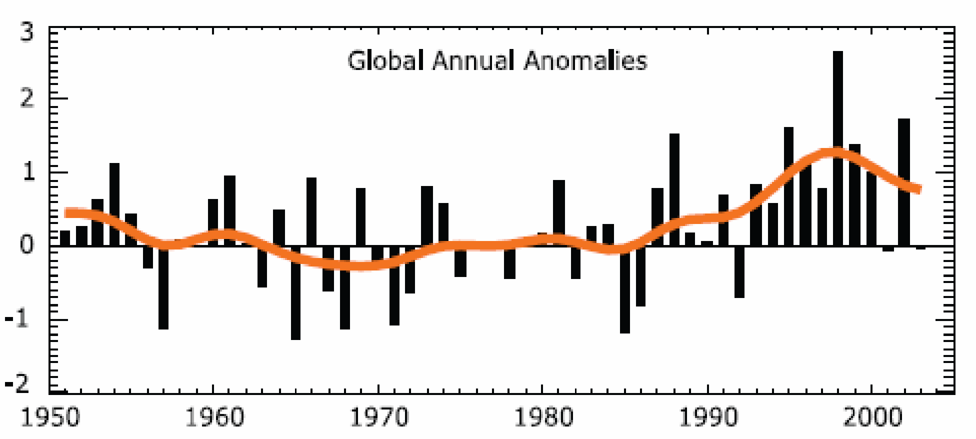
Hydropower Development in Punatsangchhu

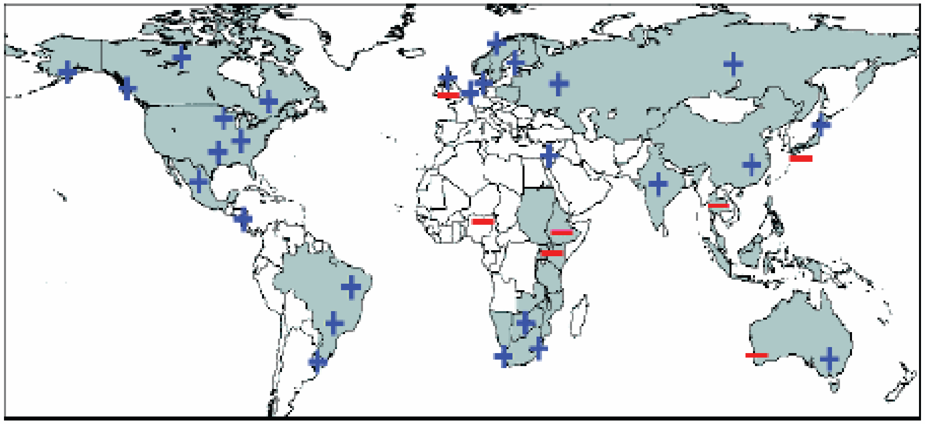


Project Name	Capacity (MW)	Status
Punatsangchhu-I	1200	Under construction
Punatsangchhu-II	900	Under construction
Basochhu – I&II	24 & 40	Completed
Dagachhu	114	Under construction


Regime Shift
Extremes
Flood/Drought
Climate System
Water Cycle
Water Resources Management System
Biodiversity/Ecosystem
Agriculture/Food
Health
Energy

Heavy Precipitation Events: Frequency increases over most areas





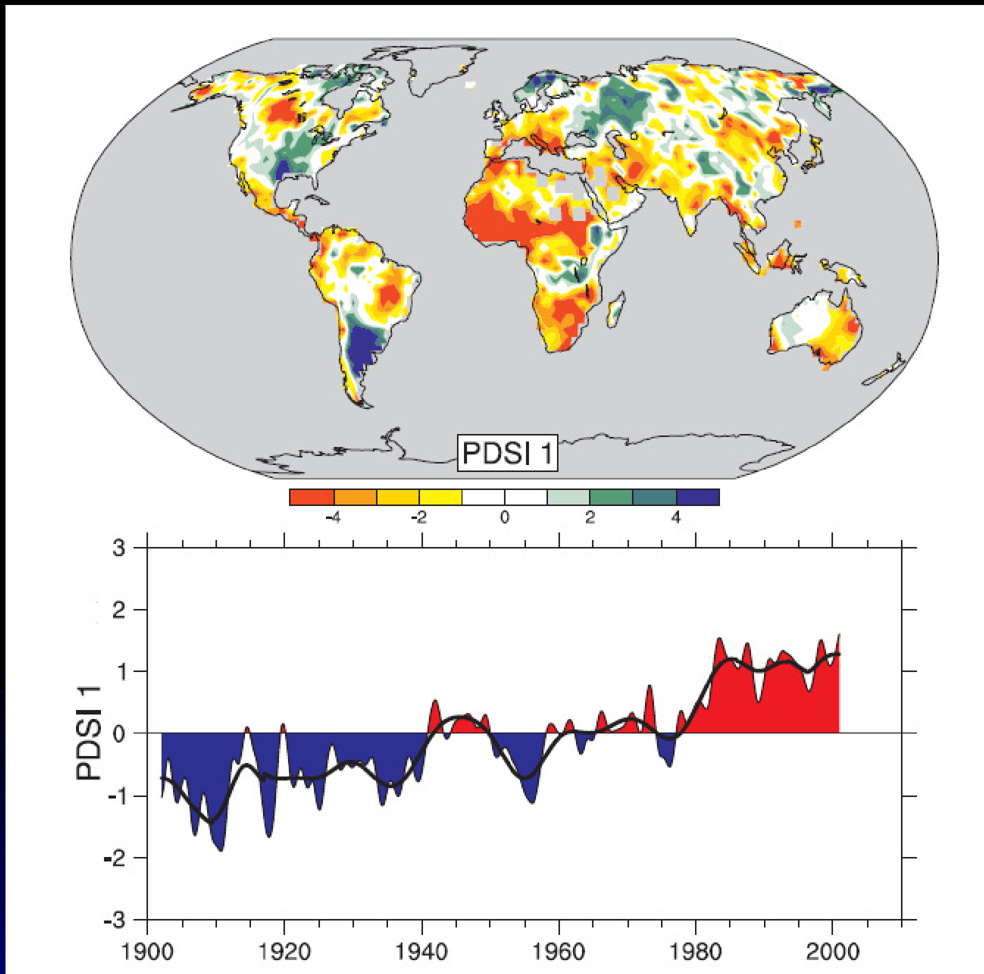
Anomalies (%) of the global annual time series defined as the percentage change of contributions of very wet days from the base period average .

Mozambique
Feb. 2000

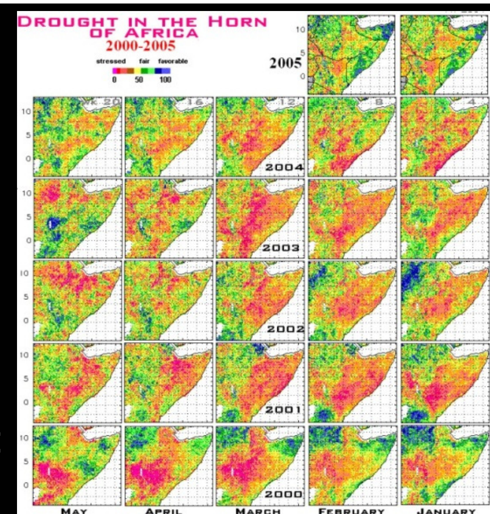
Europe
Aug. 2002

944mm/24h
Mumbai
India
2005

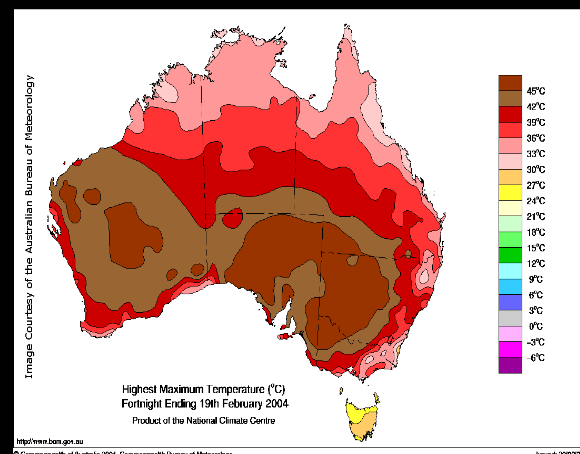
Area affected by droughts increases



Monthly Palmer Drought Severity Index (PDSI)



Long-term Drought in East Africa

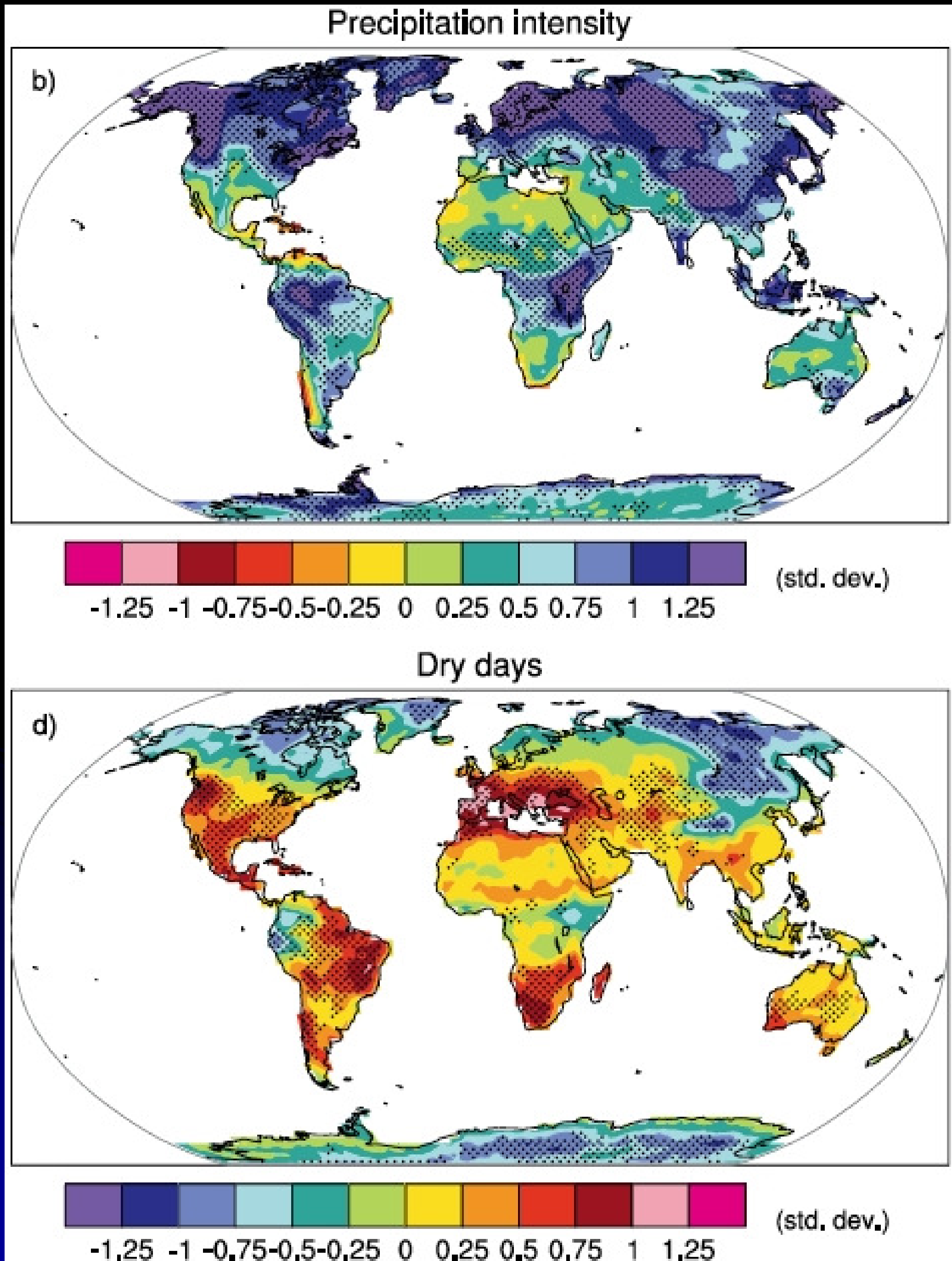


Australia 2002-2003 2006-2007

Mekong 2010

IPCC AR4

Projected changes in extremes



It is *very likely* that heavy precipitation events will continue to become more frequent.

> 90%

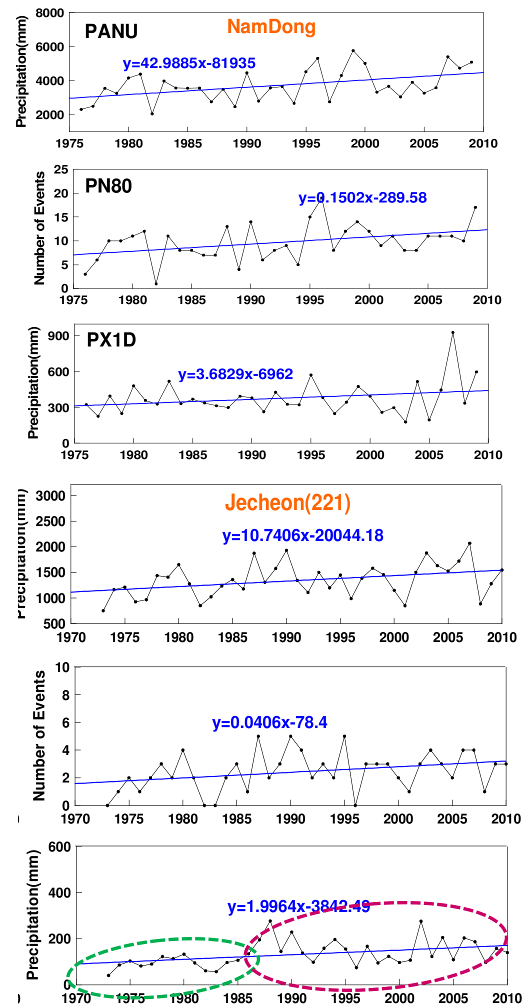
It is *likely* that area affected by drought increases.

> 67%

Trend analysis for daily precipitation index

- **Jecheon stations at summer and annual season show increasing trends.**
- **NamDong stations at annual precipitation show severe increasing trends**

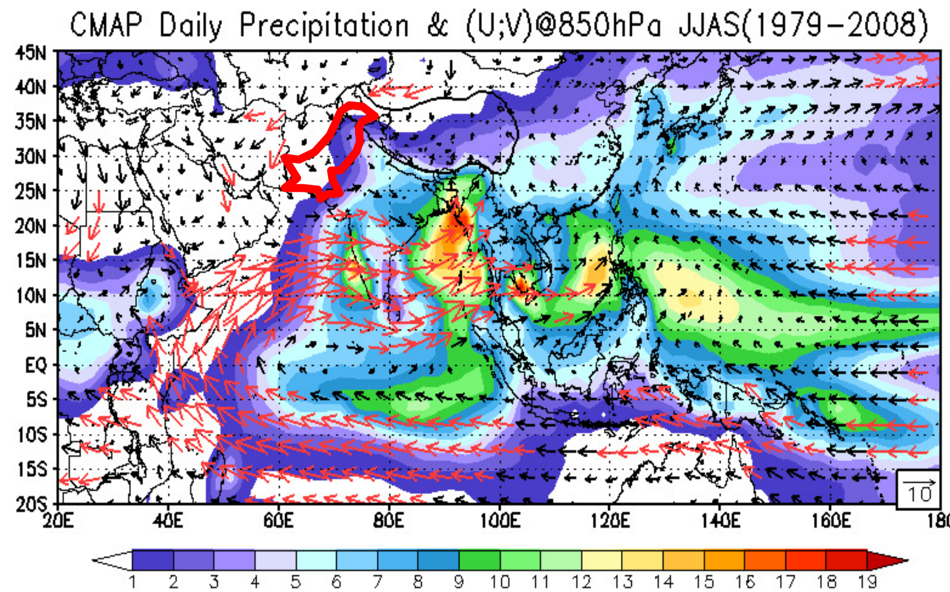
Station	Time	Linear regression		Mann-Kendall test	
		b(slope)	p-value	β	p-value
Jecheon (221)	Spring	-0.1963	0.8670	0.1760	0.8603
	Summer	9.1183	0.0185**	2.2629	0.0236**
	Fall	2.1614	0.2271	0.9808	0.3267
	Winter	-0.3427	0.4962	-0.7796	0.4356
	Annual	10.7406	0.0171**	2.5395	0.0111**
NamDong (Veitnam)	Spring	7.9989	0.0182**	6.6154	0.0083**
	Summer	-2.4933	0.4772	-1.696	0.5335
	Fall	26.3648	0.0767*	17.8737	0.1305
	Winter	11.1181	0.0053**	12.1917	0.0017**
	Annual	42.9885	0.0100**	28.0611	0.0083**
Matulid (Philippines)	Spring	-3.9561	0.727	-4.7692	0.8337
	Summer	6.6105	0.6932	-3.8182	1
	Fall	5.4175	0.8279	11.5	0.8887
	Winter	-8.0561	0.6222	-22.5	0.3273
	Annual	0.0158	0.9997	-25.375	1

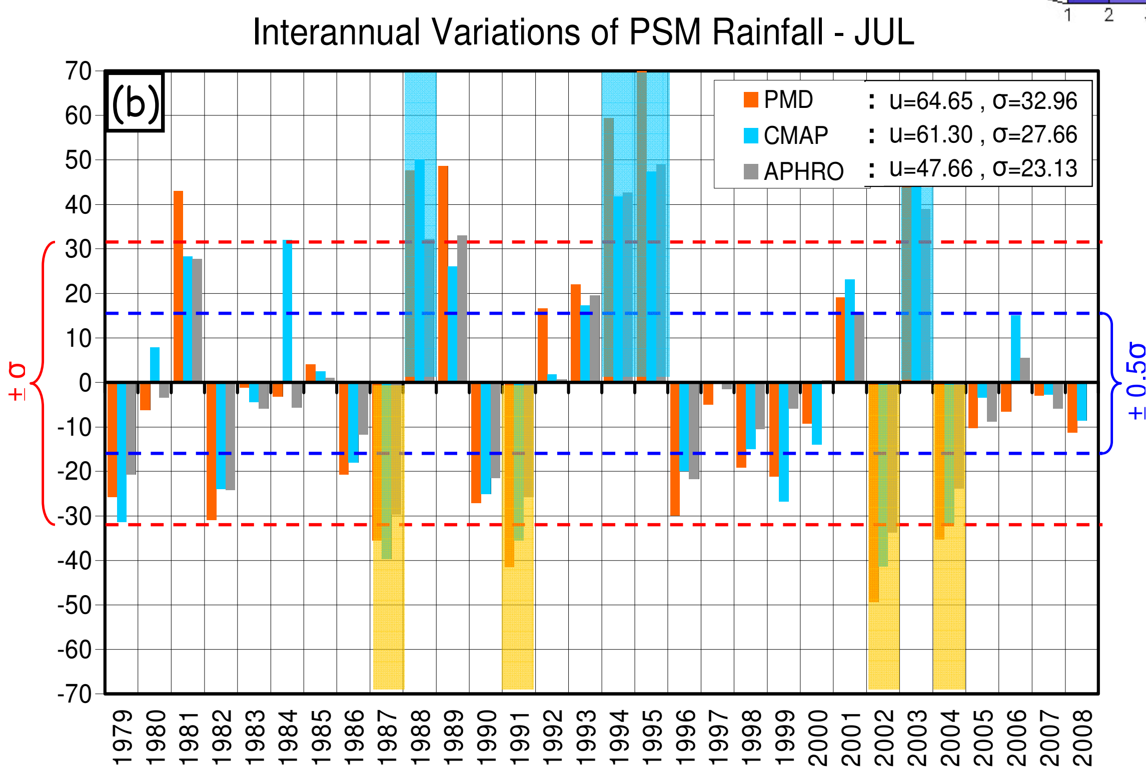


On-going and Future Plan to be taken

	Country	Basin Name	Temperature	Precipitation	Runoff
1	Bangladesh	Meghna	×	×	×
2	Bhutan	Punatsangchhu	×	×	×
3	Cambodia	Sangker	×	×	×
4	India	Seonath	×	×	×
5	Indonesia	mamberamo	×	×	×
6	Japan	Upper Tone River	×	×	×
7	Korea	Upper Chunju-dam	○	○	○
8	Lao PDR	Sebangfai River	×	×	×
9	Malaysia	Langat	×	×	×
10	Mongolia	Selbe	△	△	△
11	Myanmar	Shwegyin	×	×	×
12	Nepal	Bagmati	×	×	×
13	Pakistan	Swat	×	×	×
14	Philippines	Pampanga	×	○	×
15	Sri Lanka	Kalu Ganga	×	×	×
16	Thailand	Mae Wang	×	×	×
17	Uzbekistan	Chirchik-Okhangaran	×	×	×
18	Vietnam	Huong	○	○	○

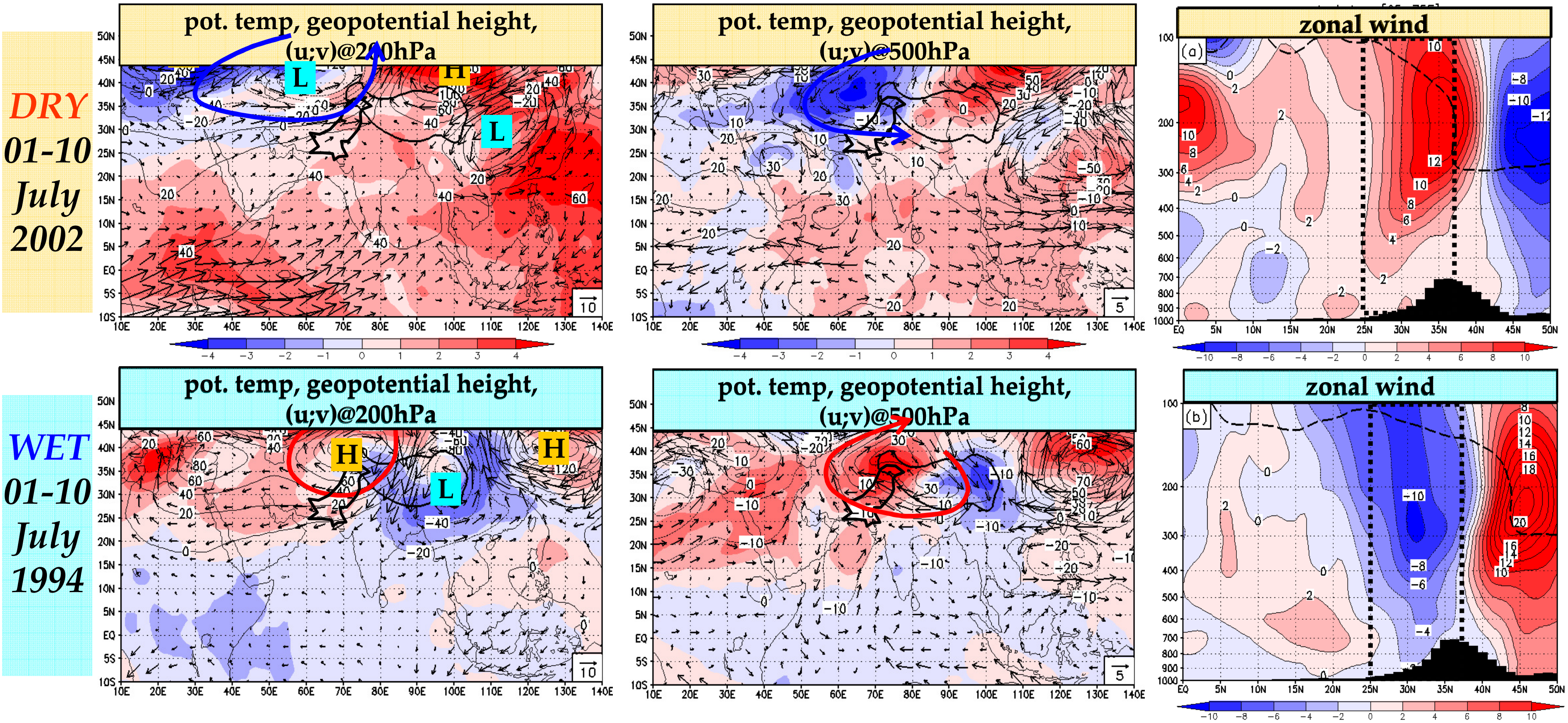
Pakistan Summer Monsoon (PSM)





Dry	Wet
1987	1988
1991	1994
2002	1995
2004	2003

4Basic Atmospheric Structure and Mechanism – PSM Dry & Wet Events



Dry Event: anomalous mid-upper troposphere : cyclonic circulation & cold temperature

➡ anomalous westerly i.e. strengthening of westerly jet around Pakistan

Wet Event: anomalous mid-upper troposphere : anticyclonic circulation & warm temperature

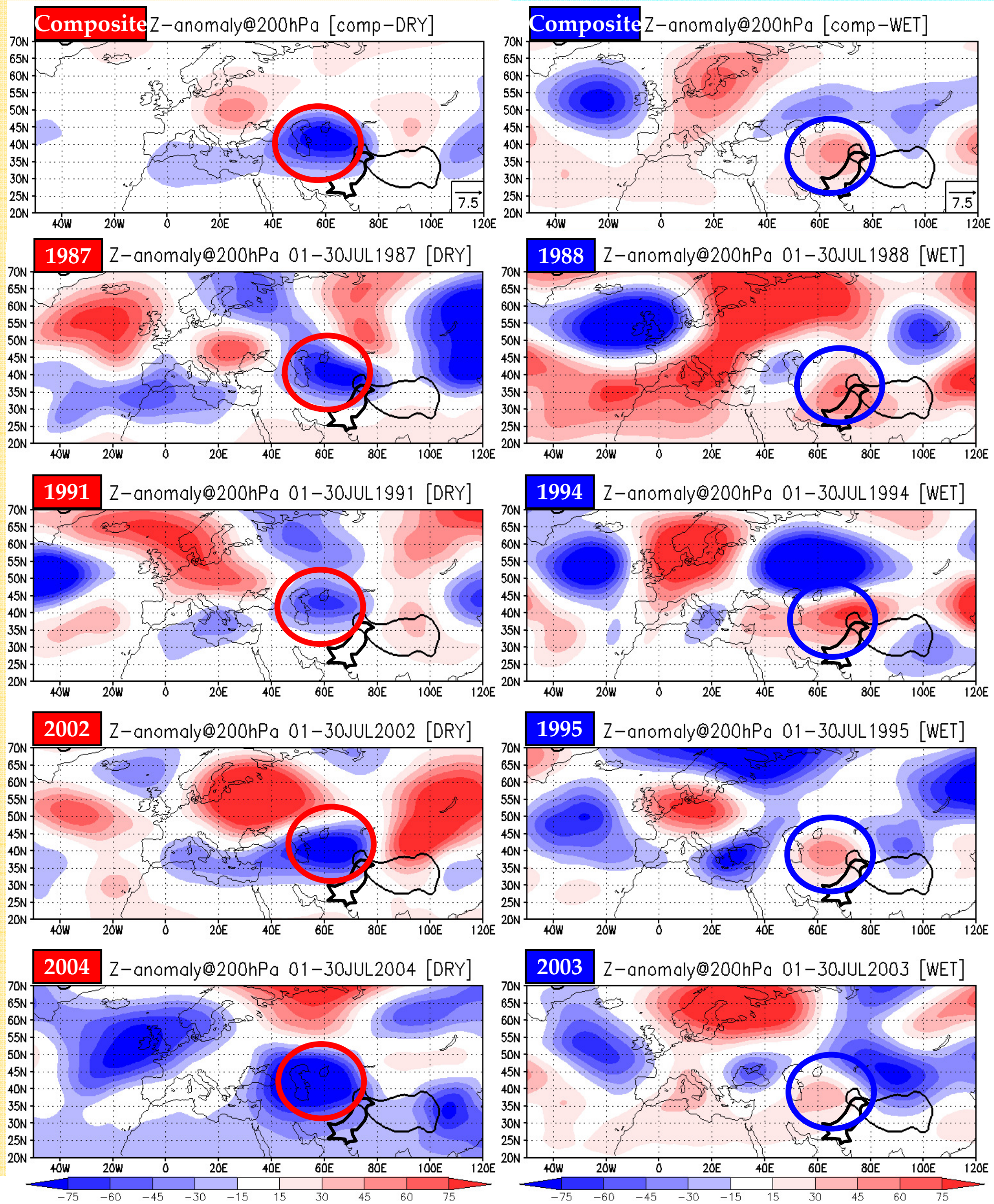
➡ anomalous easterly i.e. strengthening of easterly jet around Pakistan

4. Persistence of Anomalous Condition – PSM Dry & Wet Events

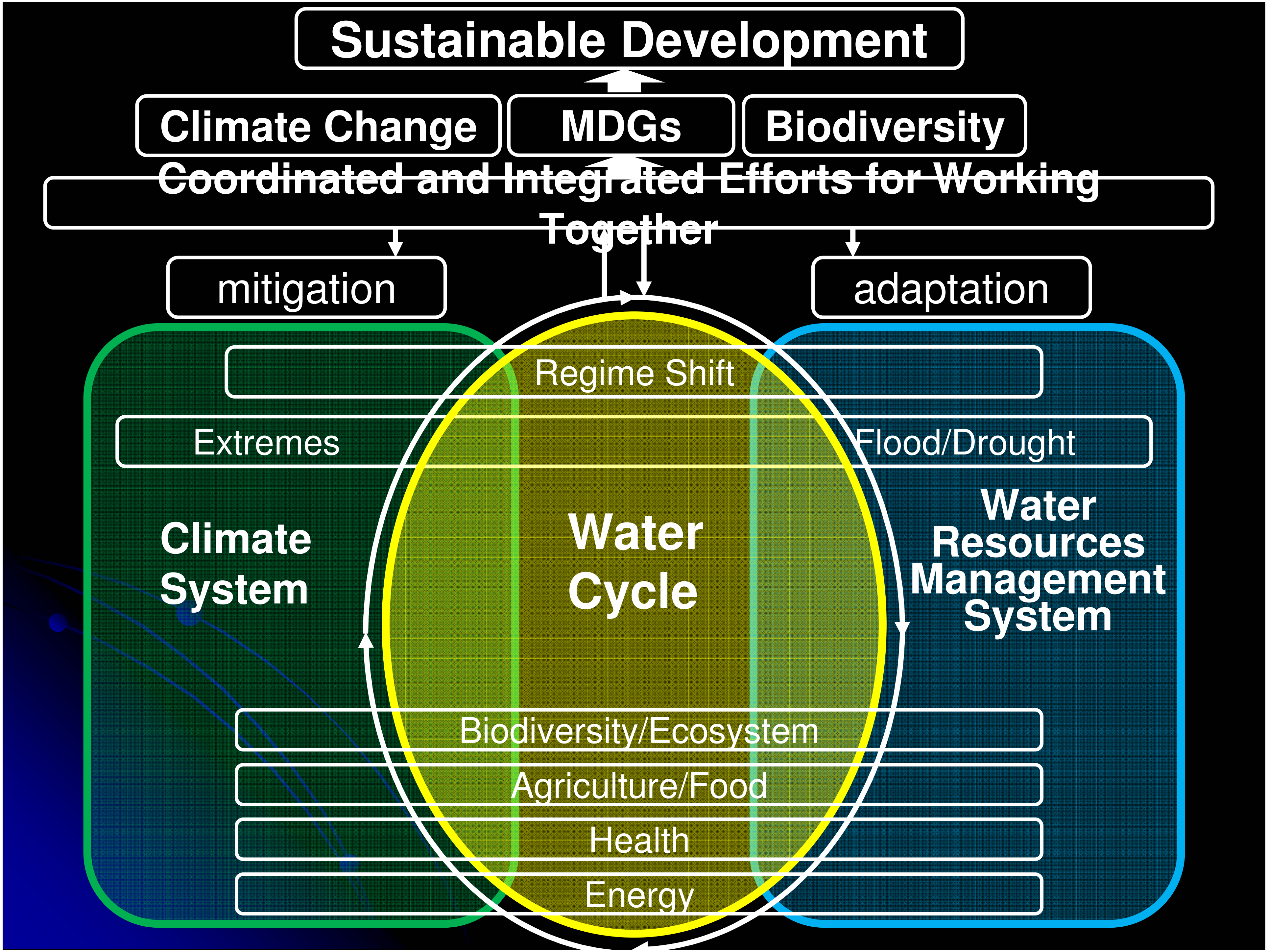
PSM DRY Events

PSM WET Events

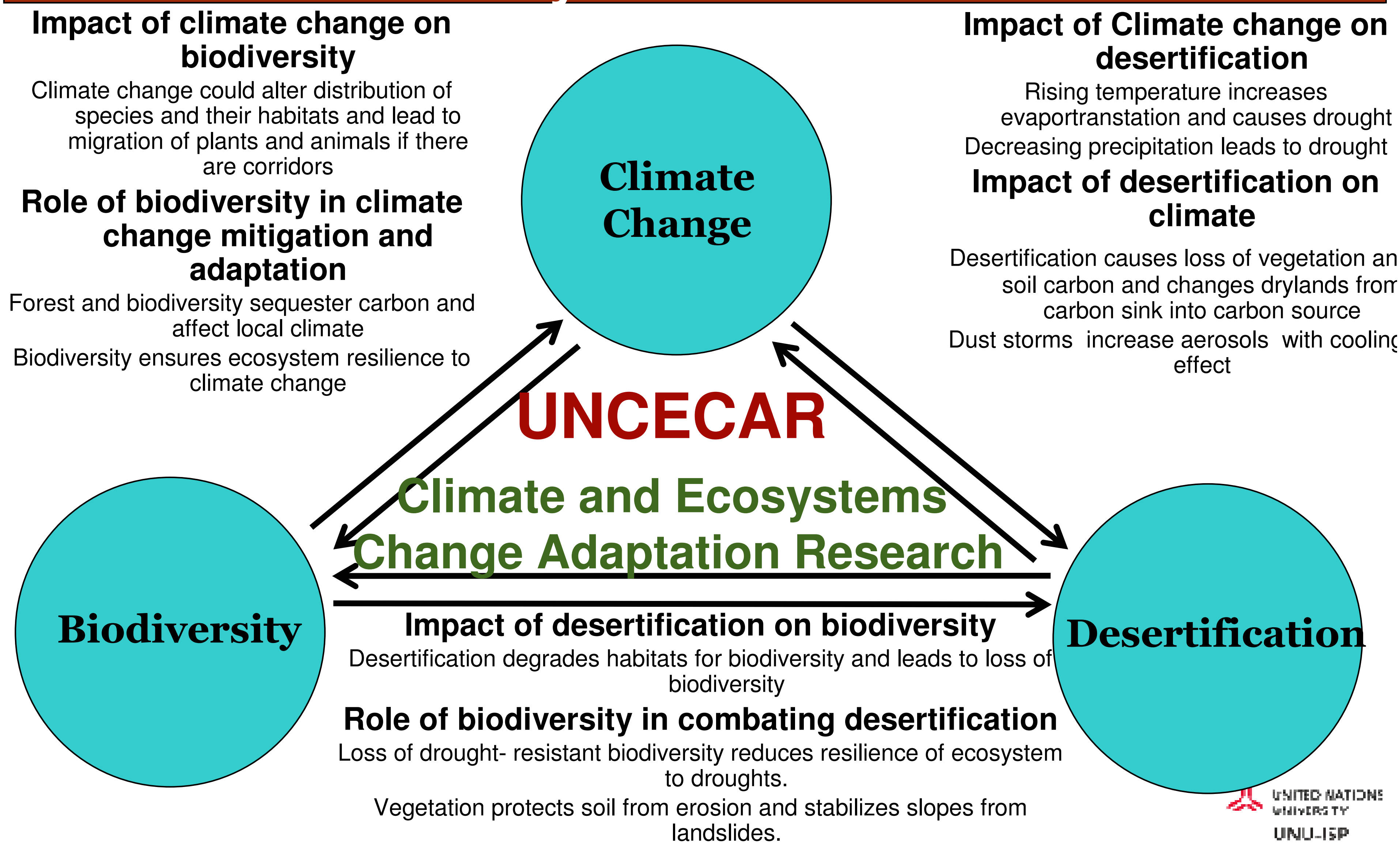
Persistence of cyclonic anomaly northwest of Pakistan



Persistence of anticyclonic anomaly northwest of Pakistan


Sustainable Development
Climate Change
MDGs
Biodiversity
Coordinated and Integrated Efforts for Working Together
mitigation
adaptation
Regime Shift
Extremes
Flood/Drought
Climate System
Water Cycle
Water Resources Management System
Biodiversity/Ecosystem
Agriculture/Food
Health
Energy

Interactions between climate change, biodiversity and desertification



12 Year History of GEOSS Water
6 Year History of GEOSS/AWCI

1992 Rio Summit

2000 – **Integrated Global Observing Strategy (IGOS) Water Theme** Proposal

2001 – Water Theme Approved

2002 –Team Report Writing Team

World Summit on Sustainable Development (WSSD) →Rio +10
Ad-hoc (GEO)

2003 – Preparation for "**Integrated Global Water Cycle Observation (IGWCO)**"

2004 – IGWCO Team Report — Preparation for 10-year Implementation Plan

2005 – 1st IGWCO in Tokyo → **GEO/GEOSS** **Asian Water Cycle Initiative (AWCI)**

2006 – 2nd IGWCO in Paris — 1st Sump. in Tokyo; 1st TTM in Bangkok

2007 – 3rd IGWCO in DC — 1st GEOSS AP in Tokyo — 2nd Simp. in Tokyo; 1st ICG in Bali

2008 – 4th IGWCO in Geneva — 2nd GEOSS AP in Tokyo — 3rd Simp. in Beppu; 2nd ICG in Tokyo

2009 – 5th IGWCO in Kyoto — 3rd GEOSS AP in Kyoto — 3rd ICG in Beijing; 4th ICG in Kyoto

2010 – 6th IGWCO in New York — 4th GEOSS AP in Bali — 5th ICG in Tokyo; 6th ICG in Bali

2011 – 7th IGWCO in Tokyo — 7th ICG in Tokyo; 1st CCAA/T in Tokyo

June 2012: Rio +20 — 5th GEOSS AP in Ahmedabad — **8th ICG in Seoul**

GROUP ON EARTH OBSERVATIONS

GEO, the Group on Earth Observations

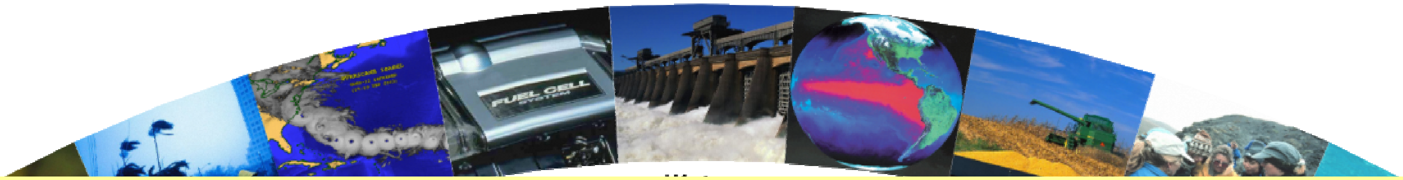
An Intergovernmental Body
with 86 Members & 61 Participating Organizations

- *Earth Observation Summit I (July 2003: Washington DC)*
- *EO Summit II (April 2004: Tokyo)*
- *EO Summit III (February 2005: Brussels)*
- *EO Summit IV (November 2007: Cape Town)*
- *EO Summit V (November 2010: Beijing)*

GROUP ON EARTH OBSERVATIONS

GEOSS

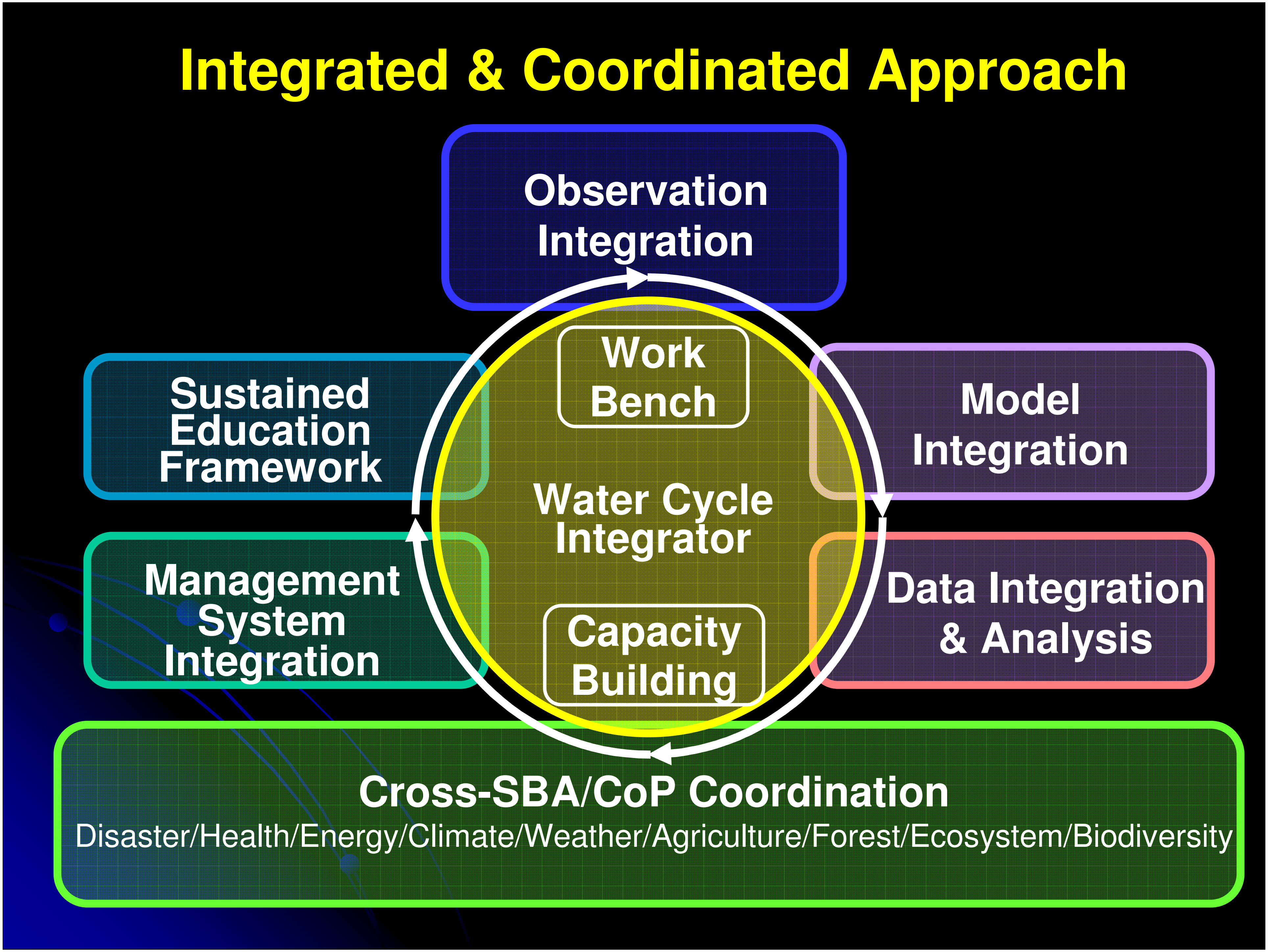
Global Earth Observation System of Systems



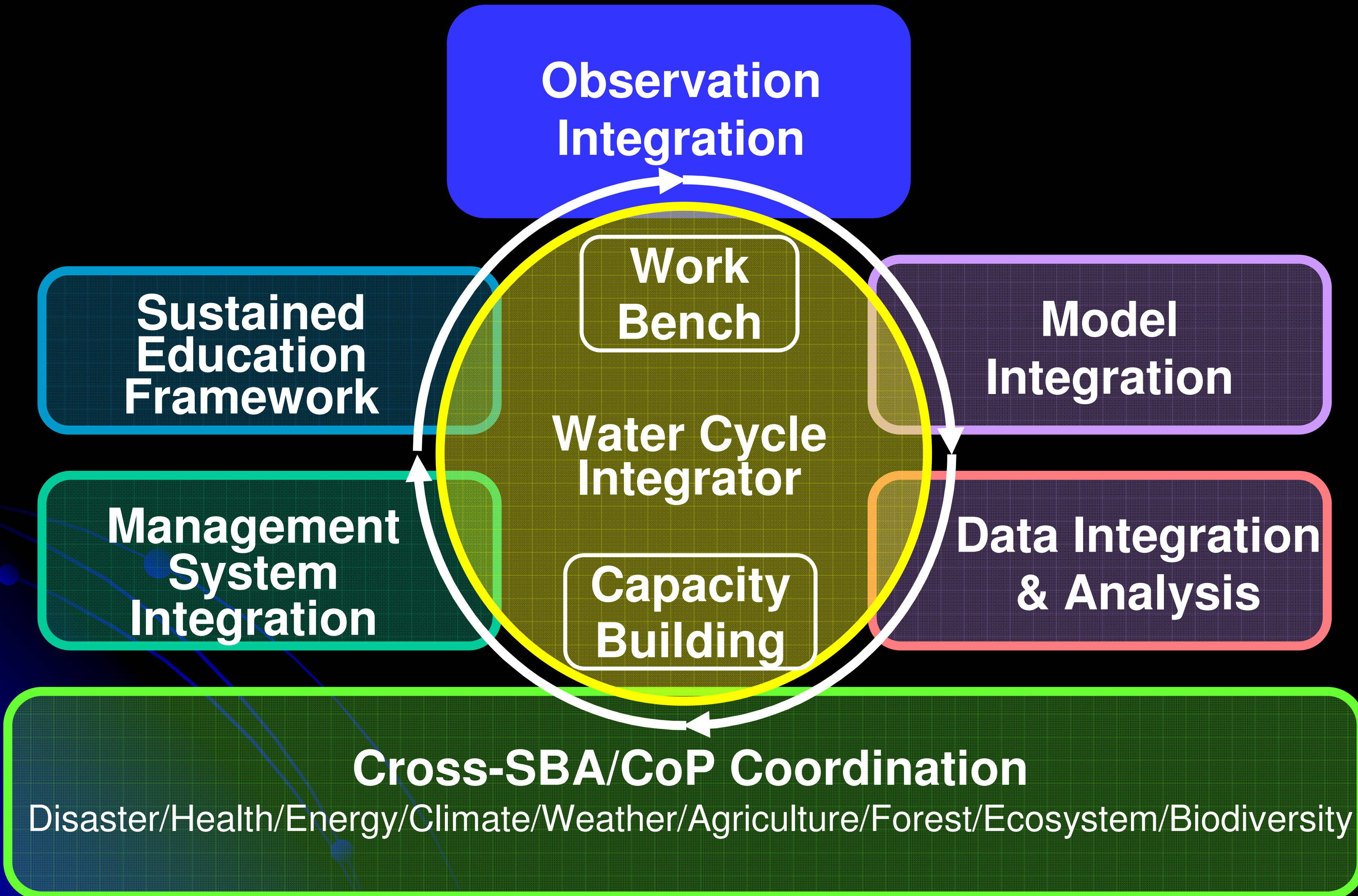
Vision for GEOSS

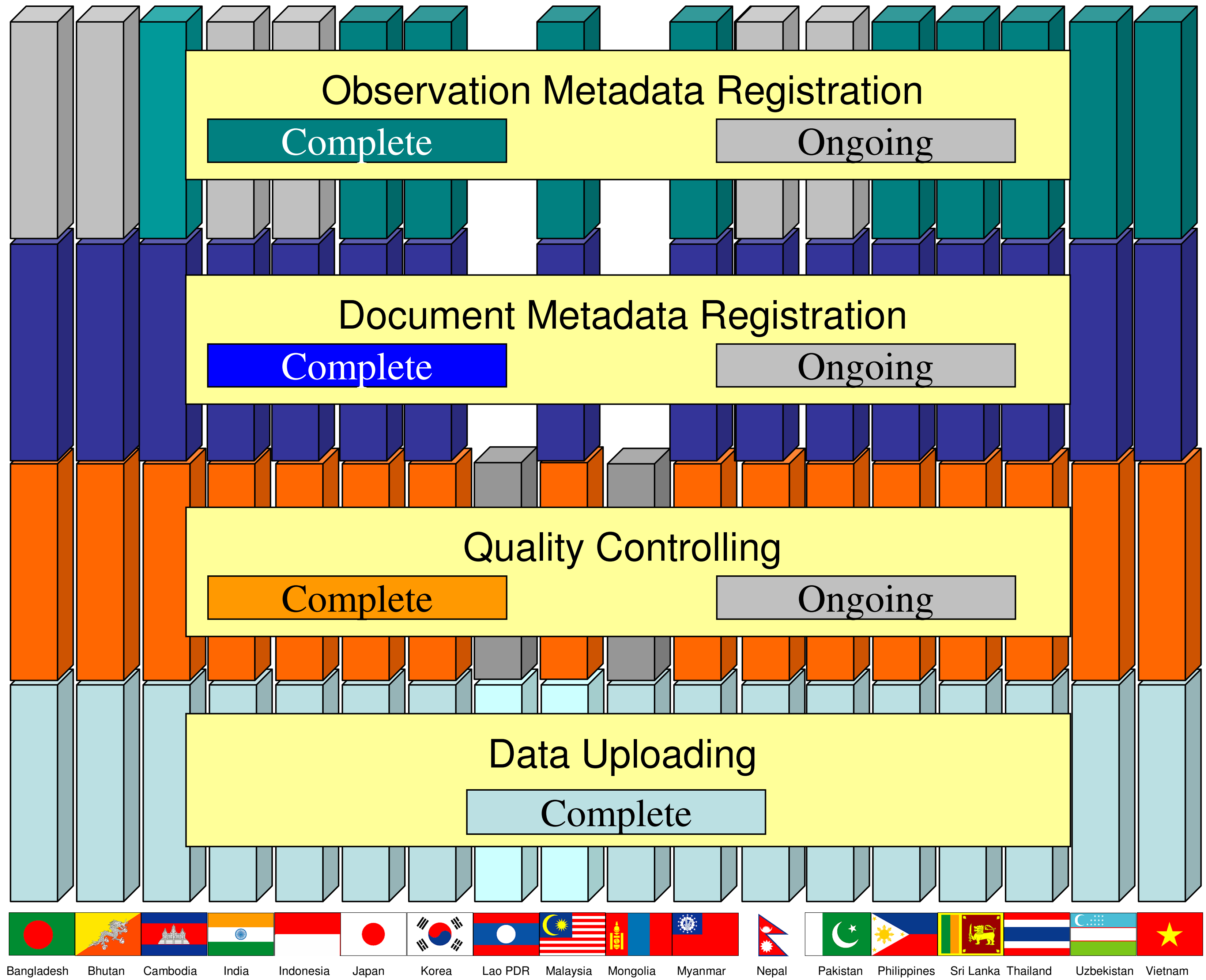
The vision for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.

A Global, Coordinated, Comprehensive and Sustained System of Observing Systems


Integrated & Coordinated Approach
Observation Integration
Sustained Education Framework
Work Bench
Model Integration
Water Cycle Integrator
Management System Integration
Data Integration & Analysis
Capacity Building
Cross-SBA/CoP Coordination
Disaster/Health/Energy/Climate/Weather/Agriculture/Forest/Ecosystem/Biodiversity

Integrated & Coordinated Approach

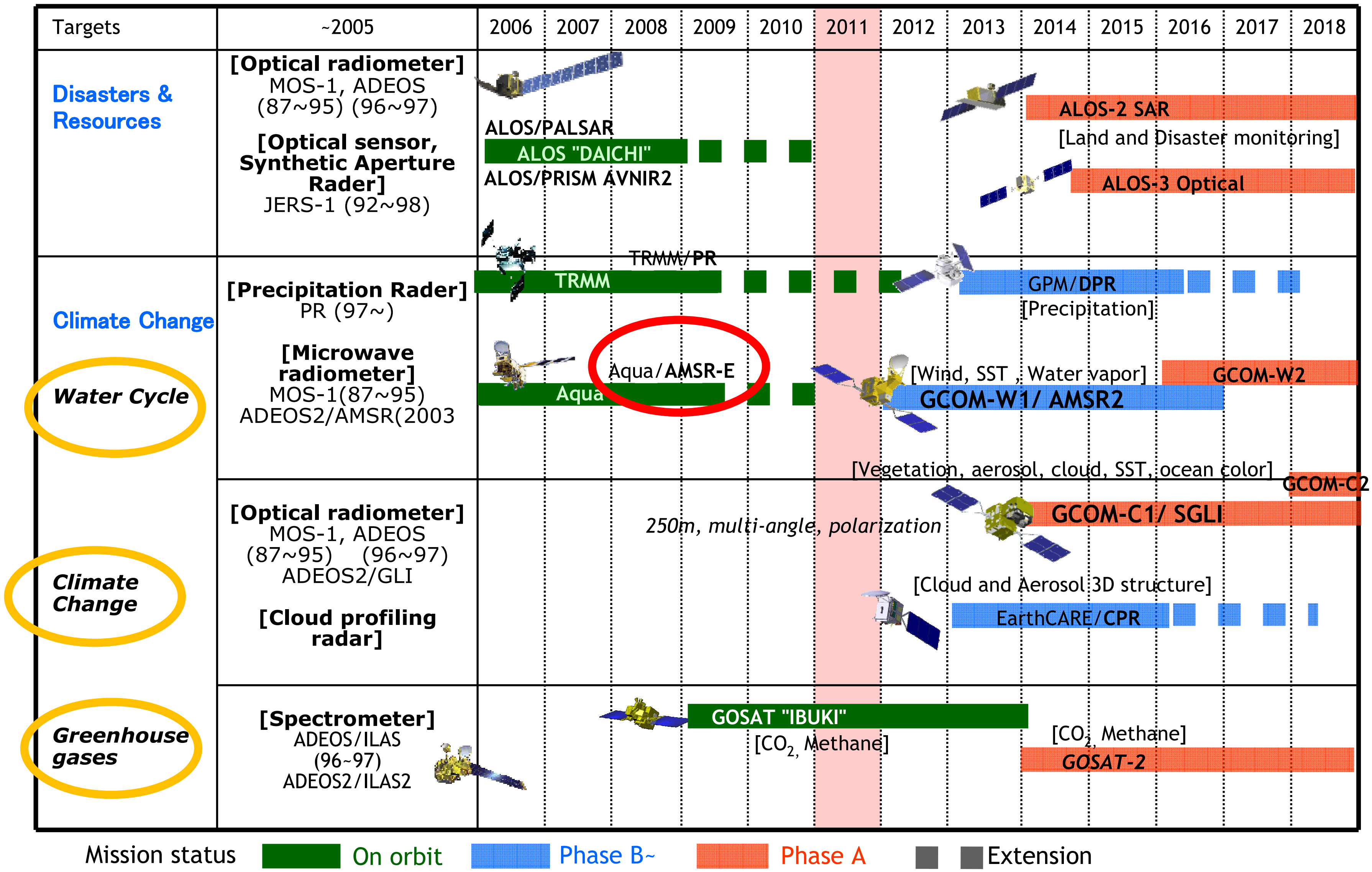




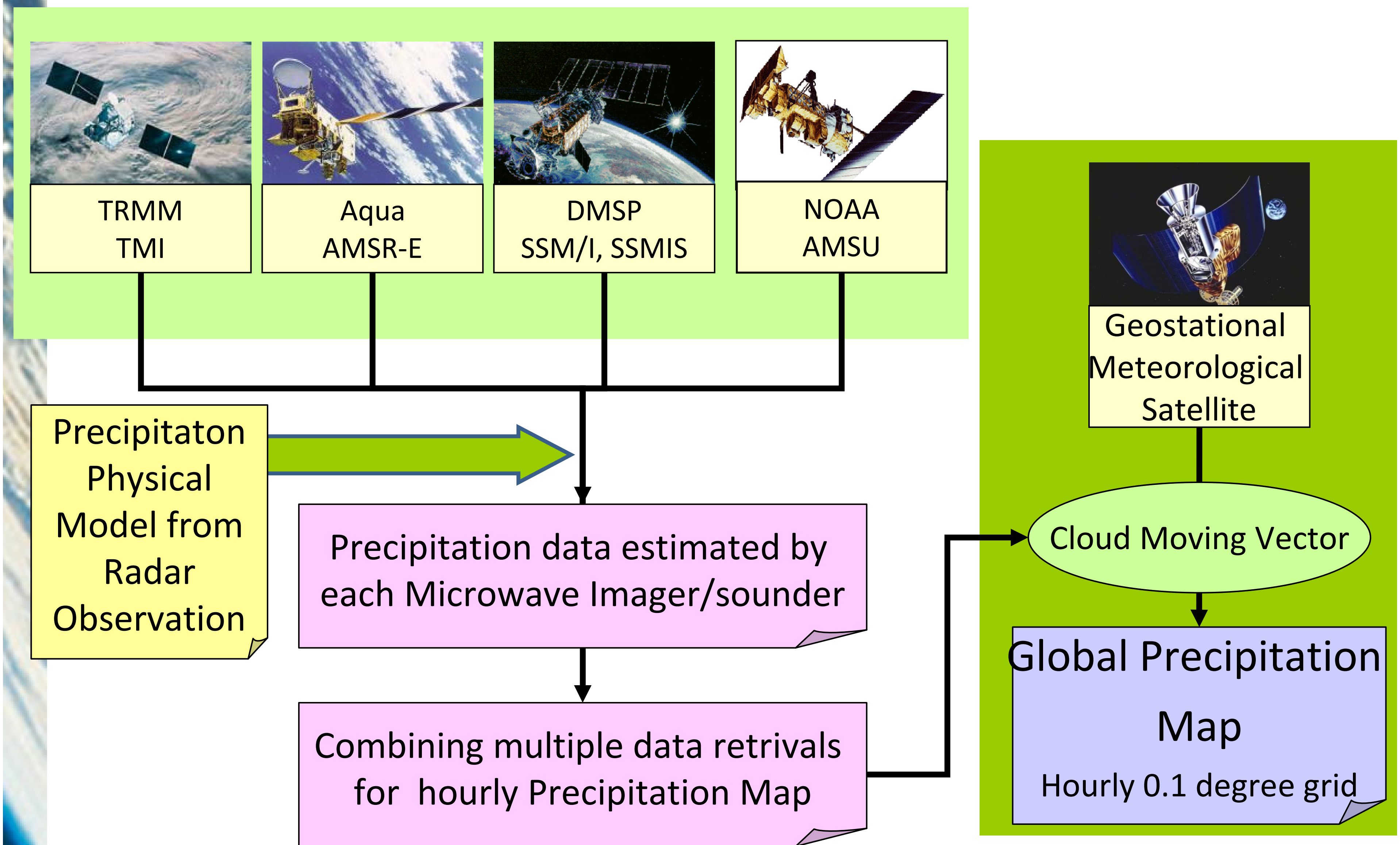
Observation Metadata Registration
Complete
Ongoing
Document Metadata Registration
Complete
Ongoing
Quality Controlling
Complete
Ongoing
Data Uploading
Complete
Bangladesh
Bhutan
Cambodia
India
Indonesia
Japan
Korea
Lao PDR
Malaysia
Mongolia
Myanmar
Nepal
Pakistan
Philippines
Sri Lanka
Thailand
Uzbekistan
Vietnam

Satellite Observation Integration

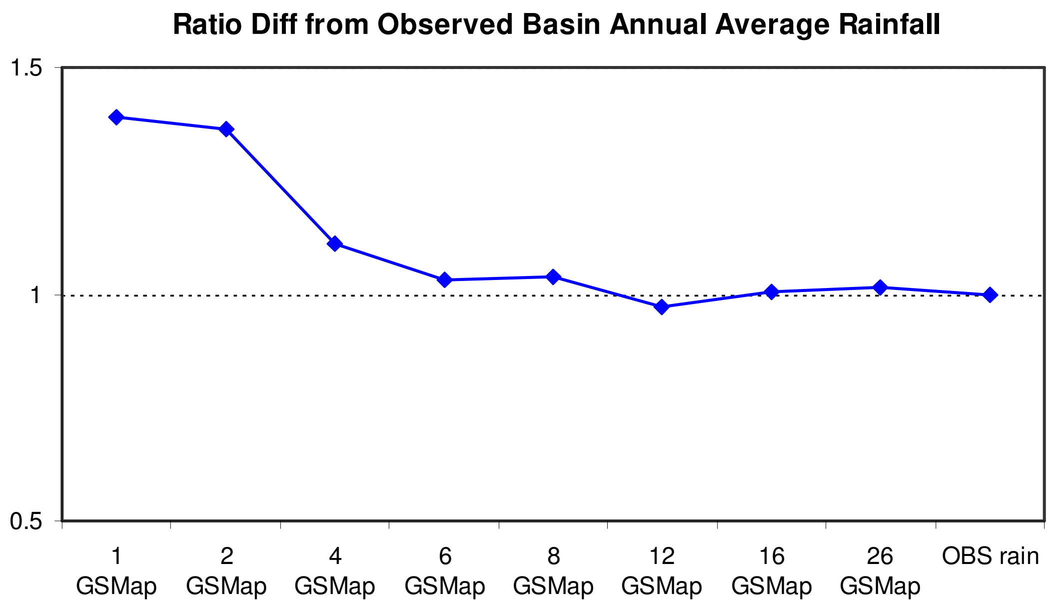
Long-Term Plan of Earth Observation by JAXA

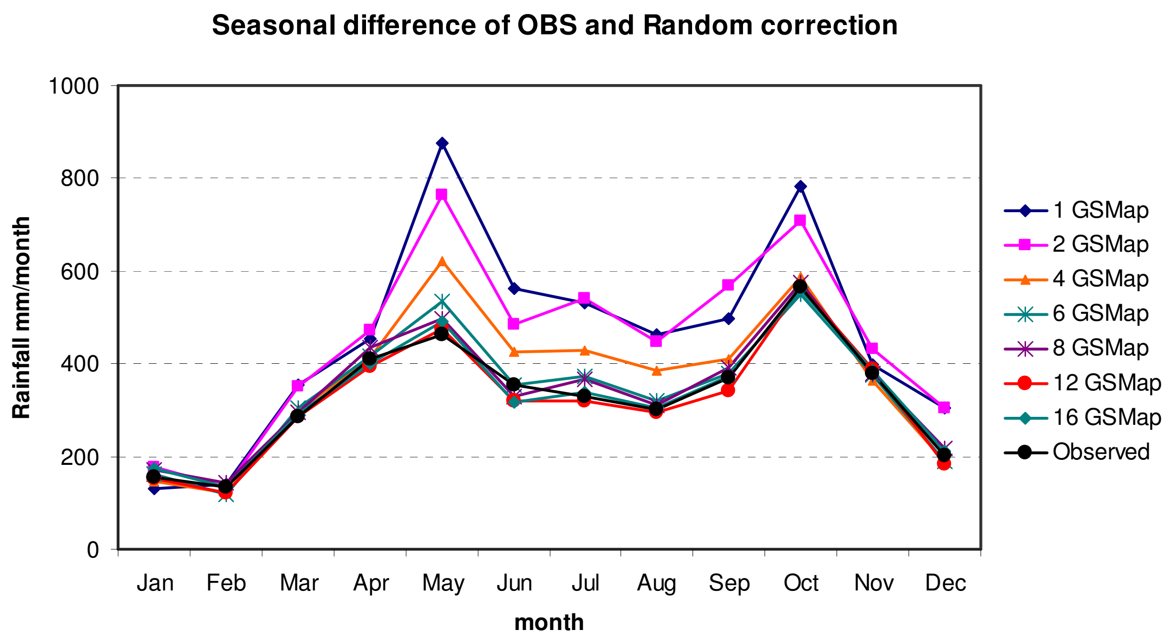


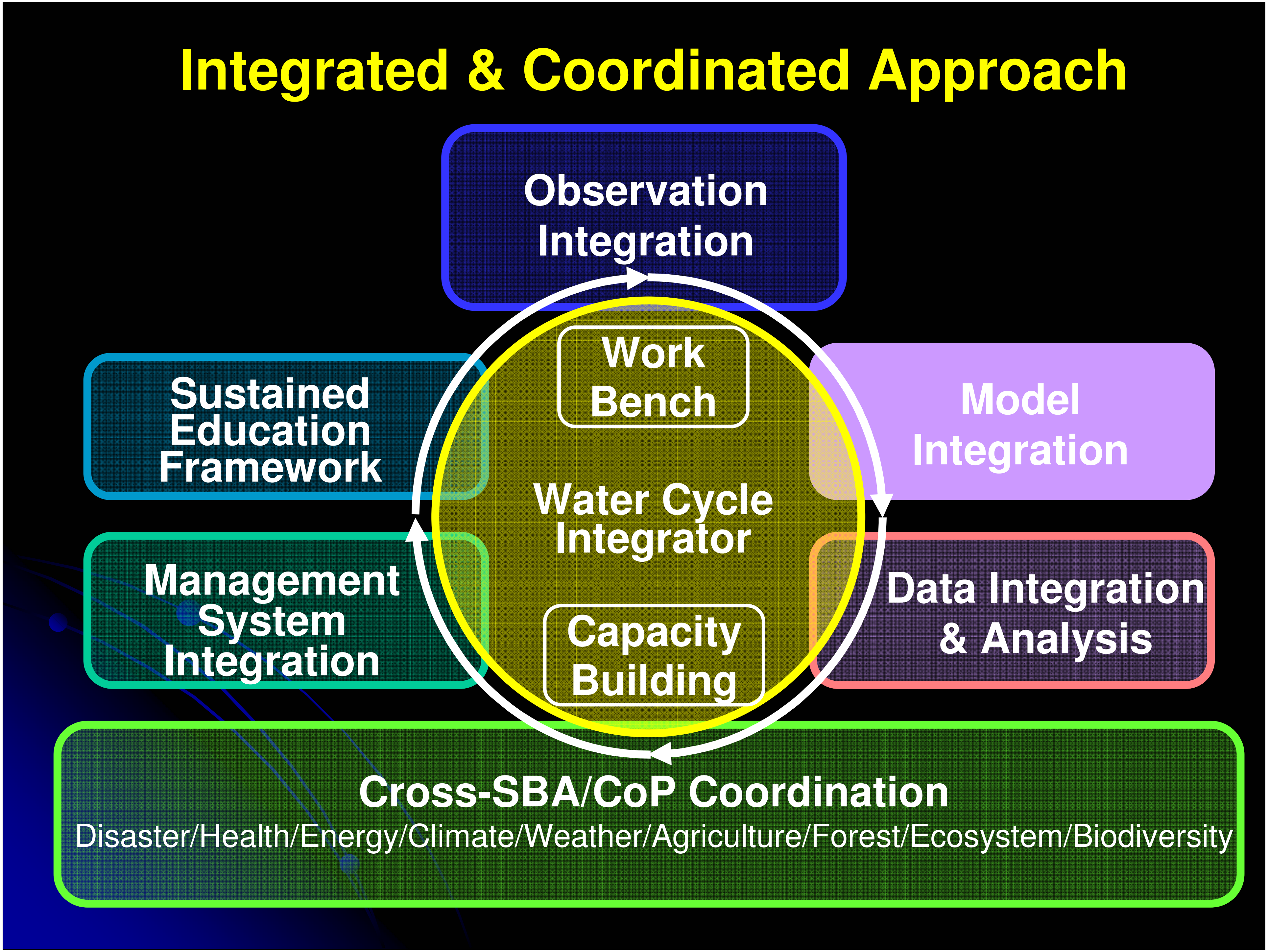
Satellite Combined Product
Global Precipitation Map



Checking Sensitivity of Numbers of Rain gauges





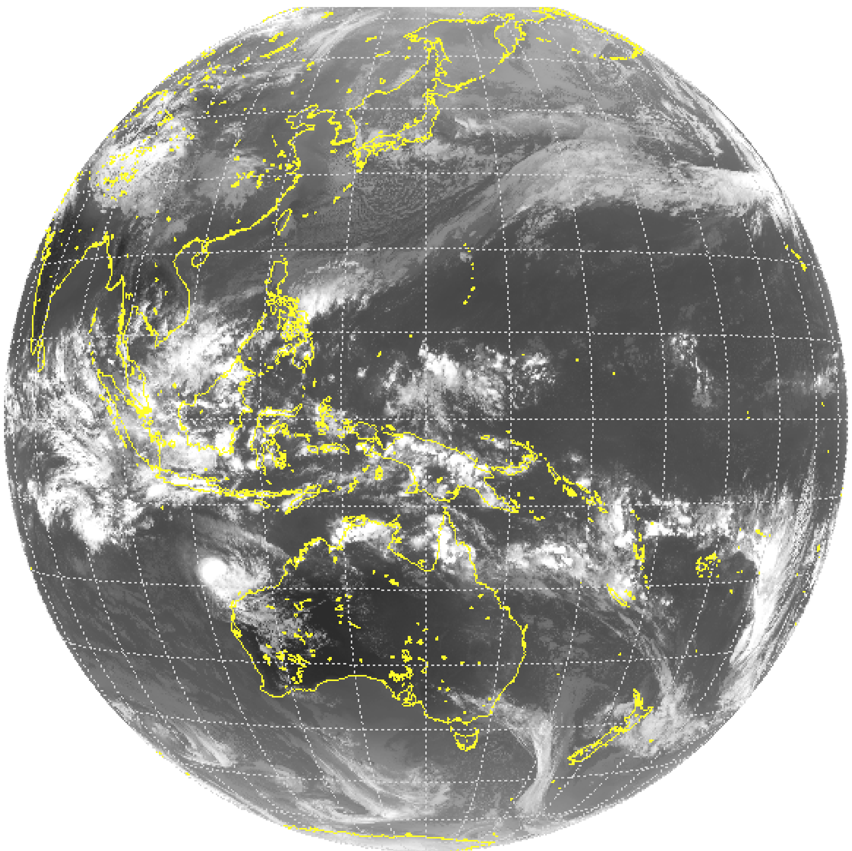

Integrated & Coordinated Approach
Observation Integration
Sustained Education Framework
Model Integration
Work Bench
Water Cycle Integrator
Capacity Building
Management System Integration
Data Integration & Analysis
Cross-SBA/CoP Coordination
Disaster/Health/Energy/Climate/Weather/Agriculture/Forest/Ecosystem/Biodiversity

Improvement from JRA-25

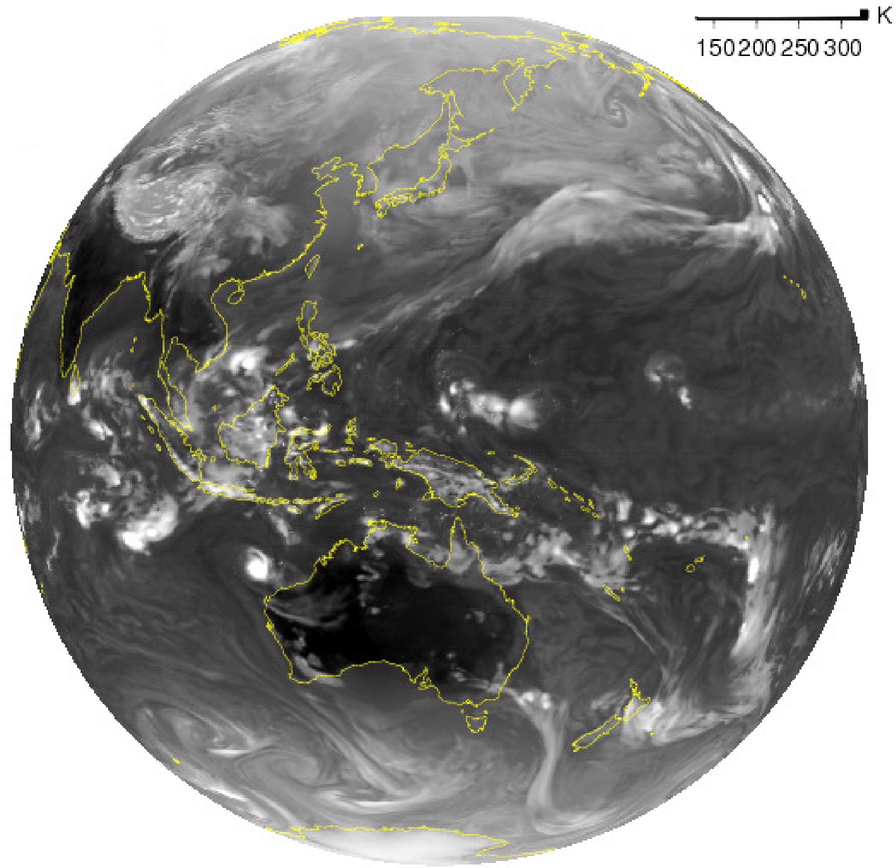
		JRA-25	JRA-55
Target period		1979 – 2004 (26yr)	1958 - 2012 (55yr)
Model	Resolution	T106L40 Top:0.4hPa Horizontal：120km	TL319L60 Top：0.1hPa Horizontal ：60km
	Time integration	Euler	Semi-Lagrangean
	Physics	As of Mar.2004	New radiation
	Green House Gas	CO_2：375ppm(Const)	CMIP5 or other CO_2、CH_4、N_2O、CFC-11、CFC-12、HCFC-22
Assimilation		3D-VAR	4D-VAR
Bias Correction		[Upper Air] RAOB(Andrae et al.,2004)	[Upper Air] RAOBCORE Satellite Variational bias correction

Observation vs. Model

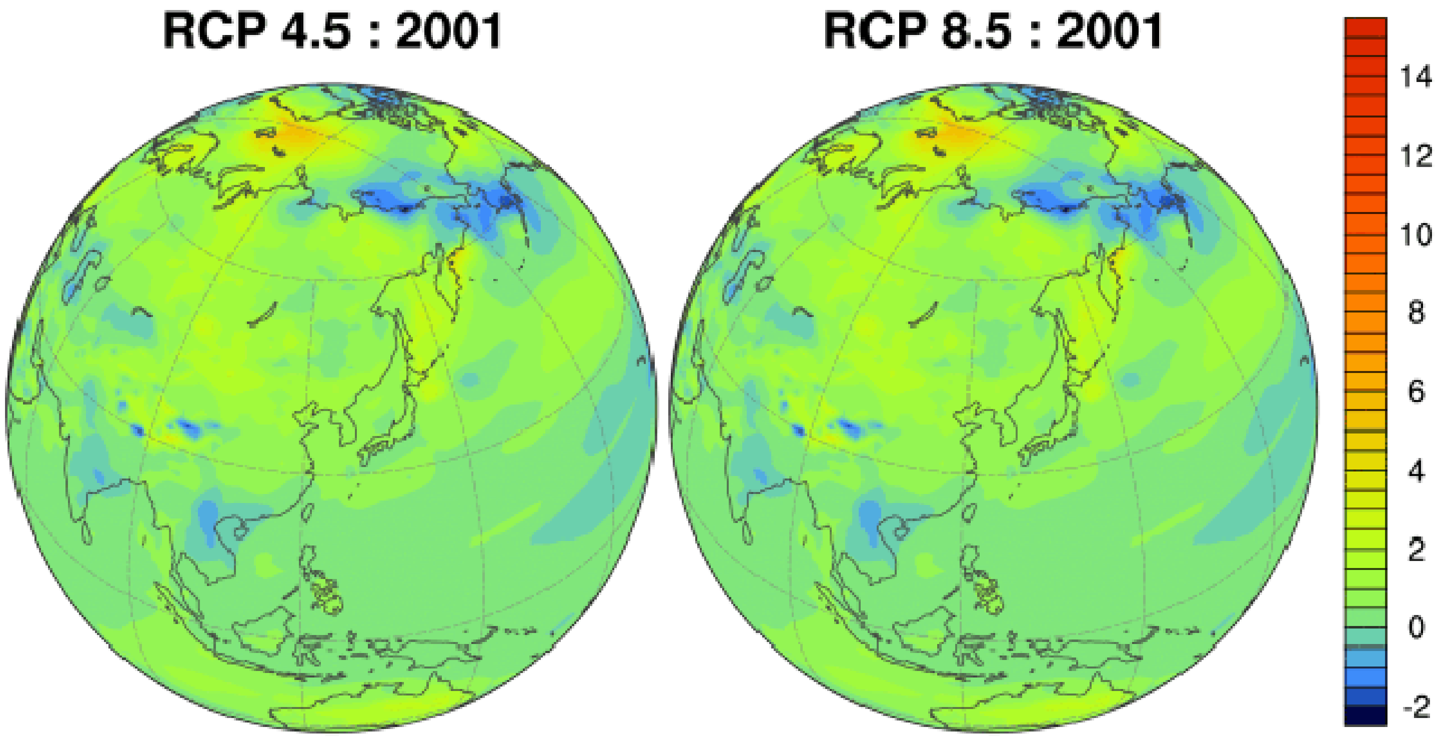
Satellite Observation (IR)

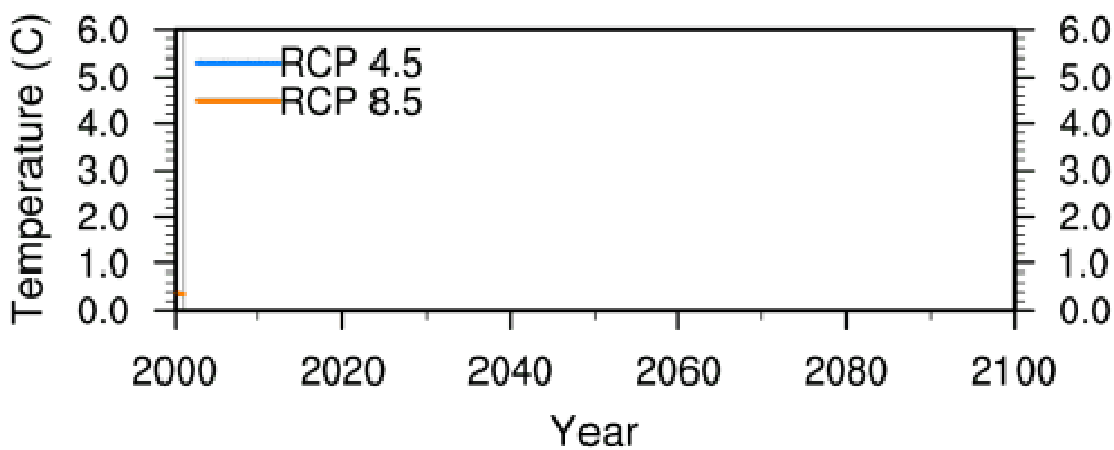


20km GSM Simulation



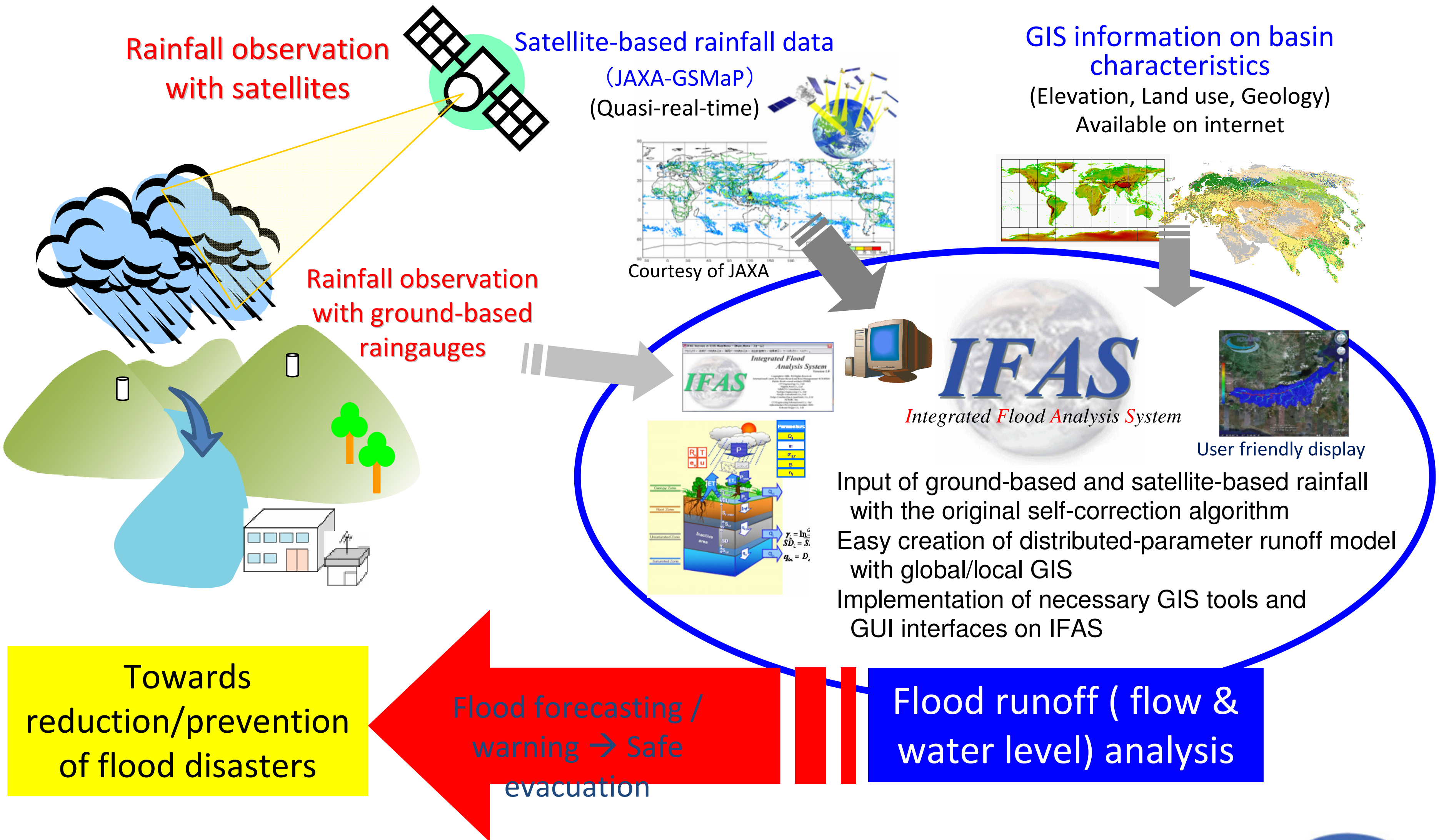
GLOBAL TEMPERATURE CHANGE (2001-2099)





Integrated Flood Analysis System (IFAS)

Flood runoff analysis system with satellite-based rainfall & global GIS information

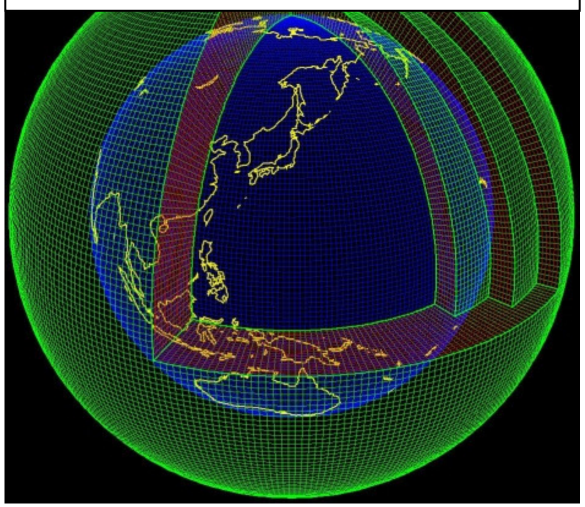


ICHARM

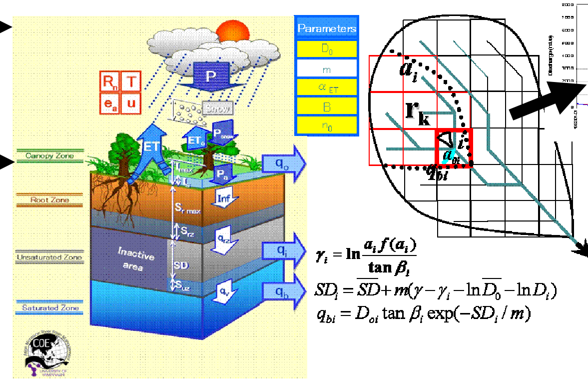
Assessment of the impact of climate change on flood disaster risk and its reduction measures over the globe and specific vulnerable areas

10-40 km mesh
global stream path

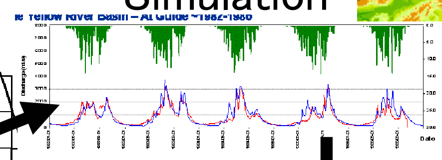
MRI-AM20km global meteorological simulation

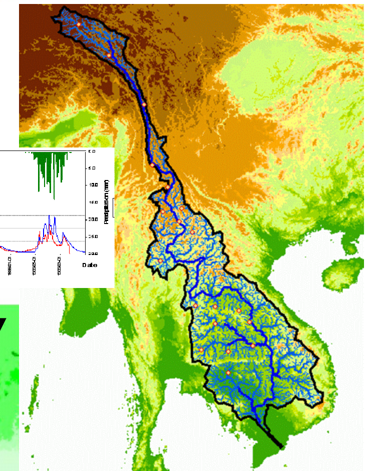


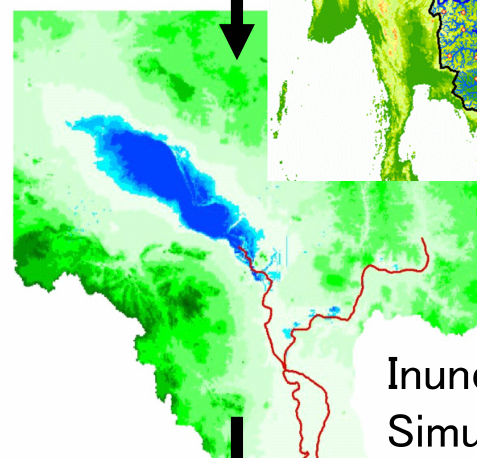
Block-wise use of TOPMODEL with Muskingum-Cunge method (BTOPMC)



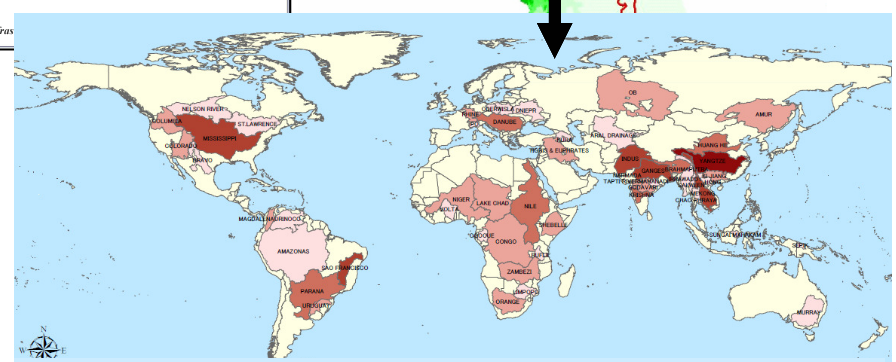
Hydrological Simulation







Inundation Simulation



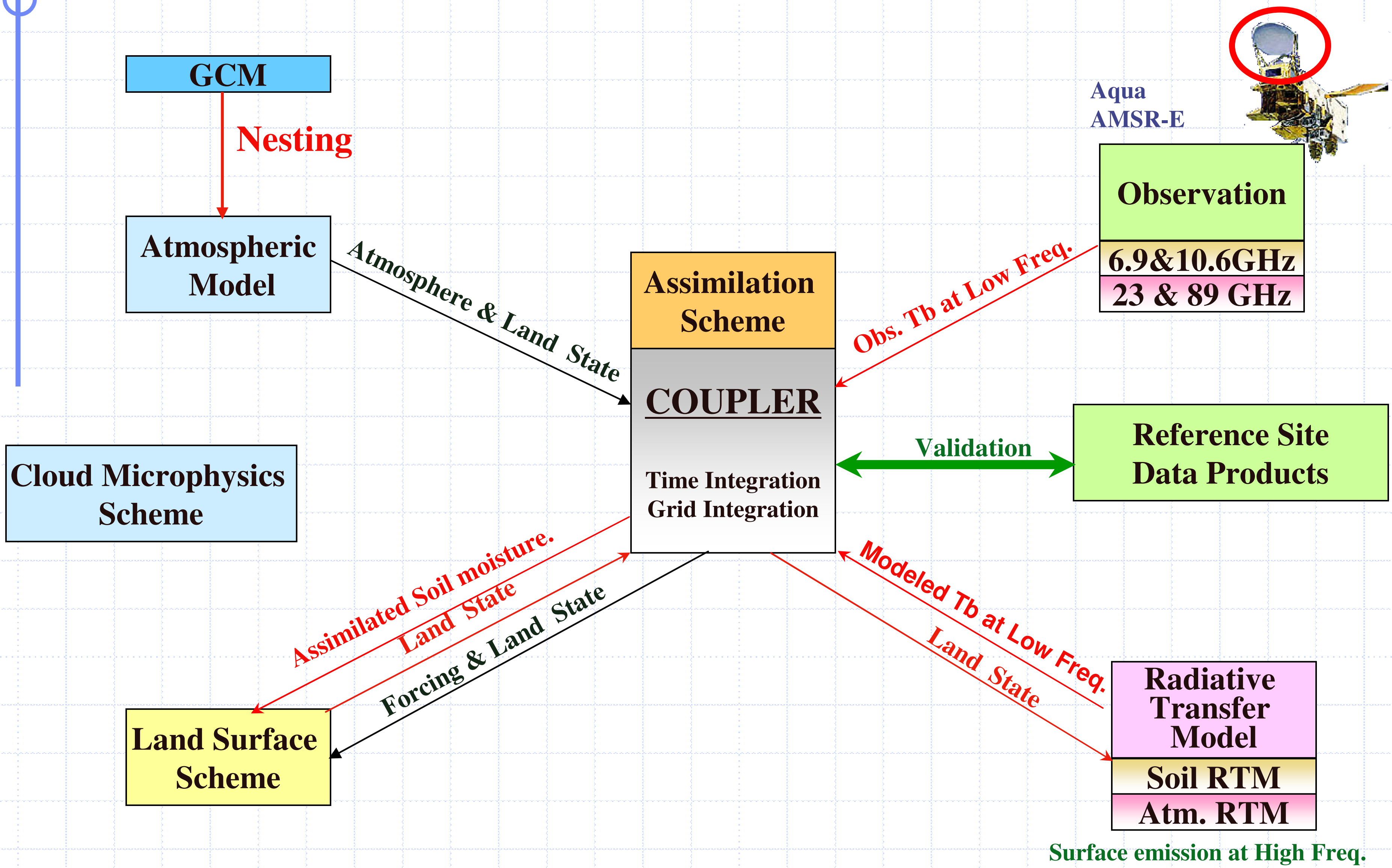
Global Flood Vulnerable Risk Map

KAKUSHIN

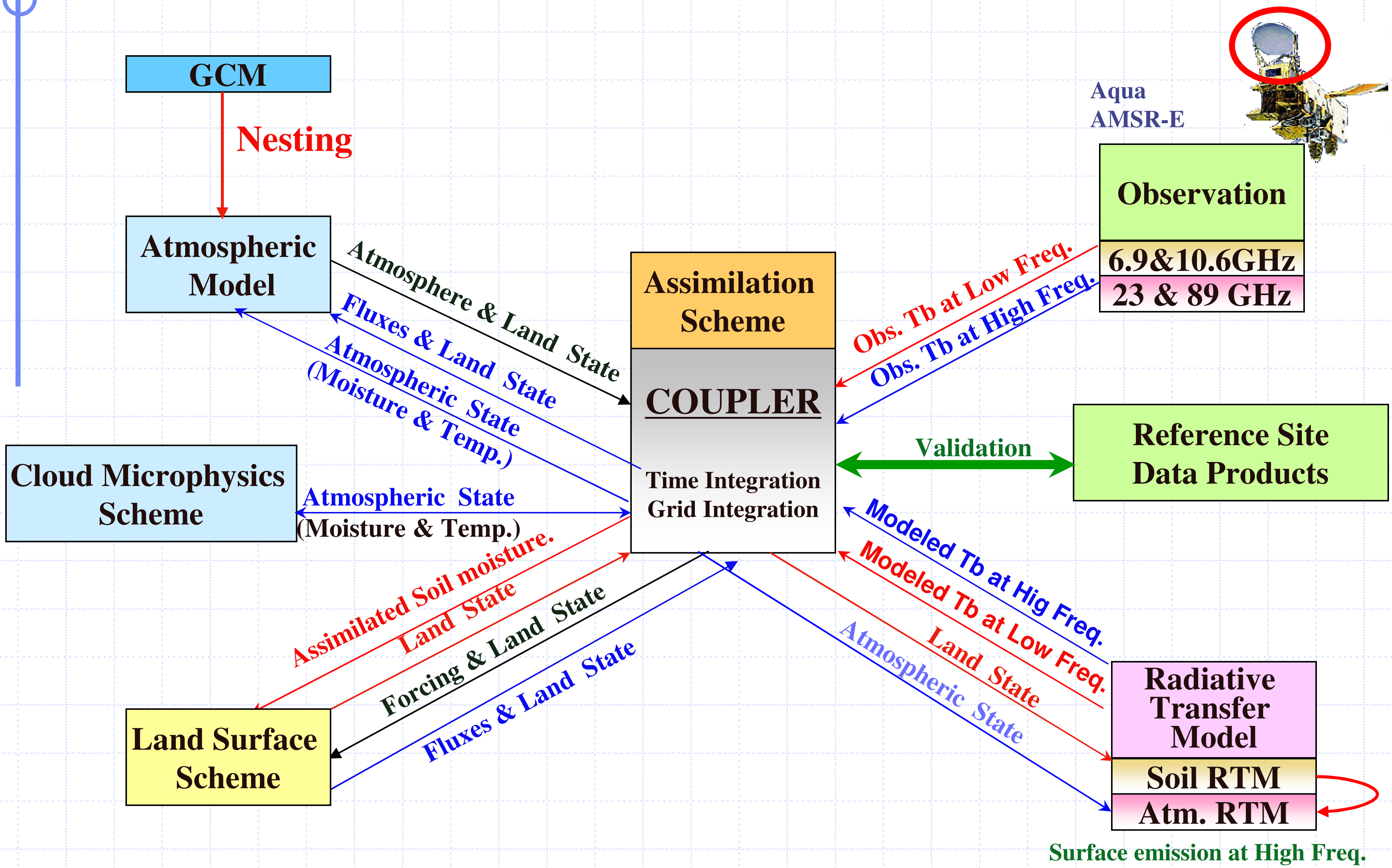
Innovative Program of Climate Change Projection for the 21st Century

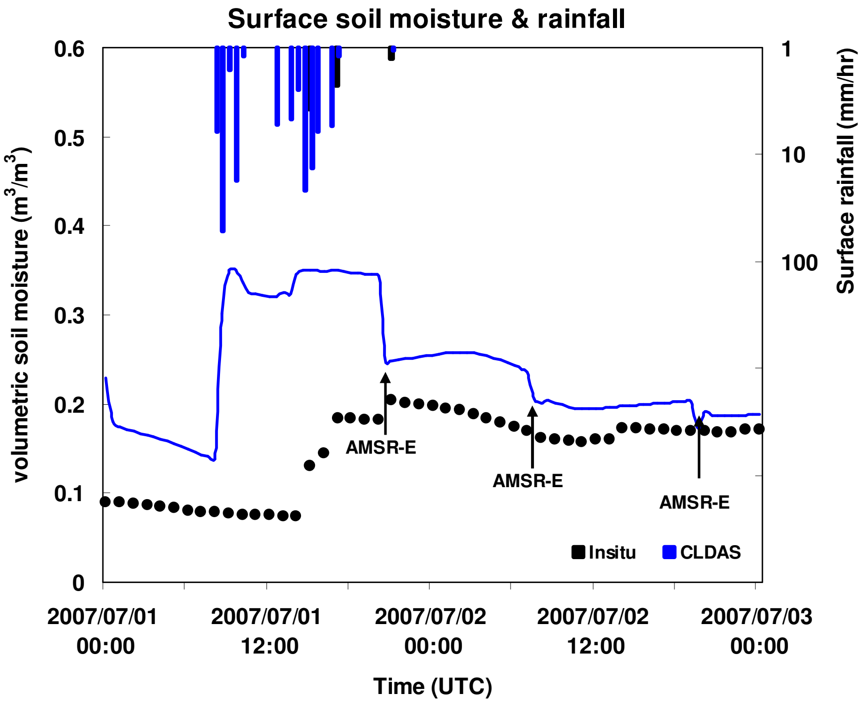
Project Period: 2007 Apr. – 2012 Mar.

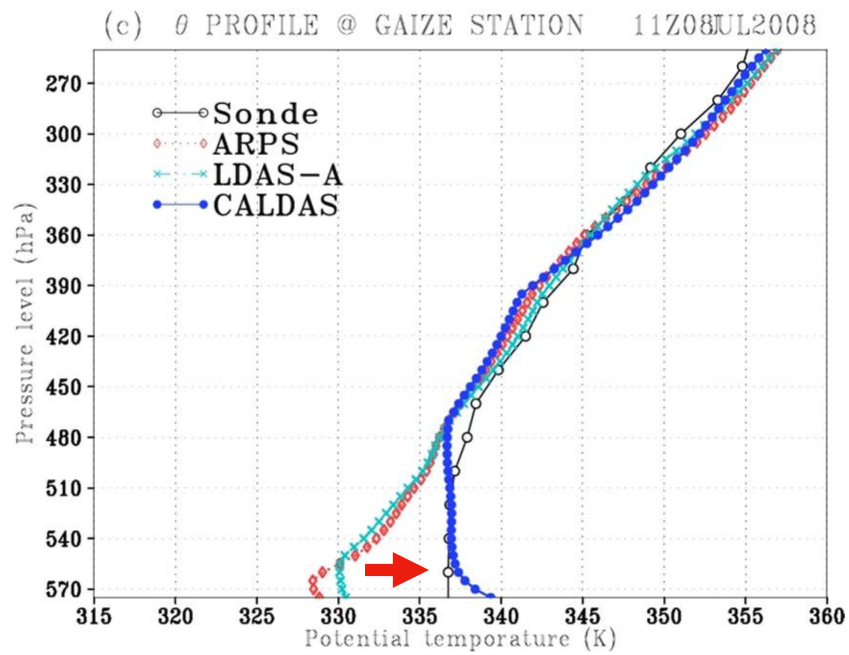
Data Integration by LDAS-COUPLER

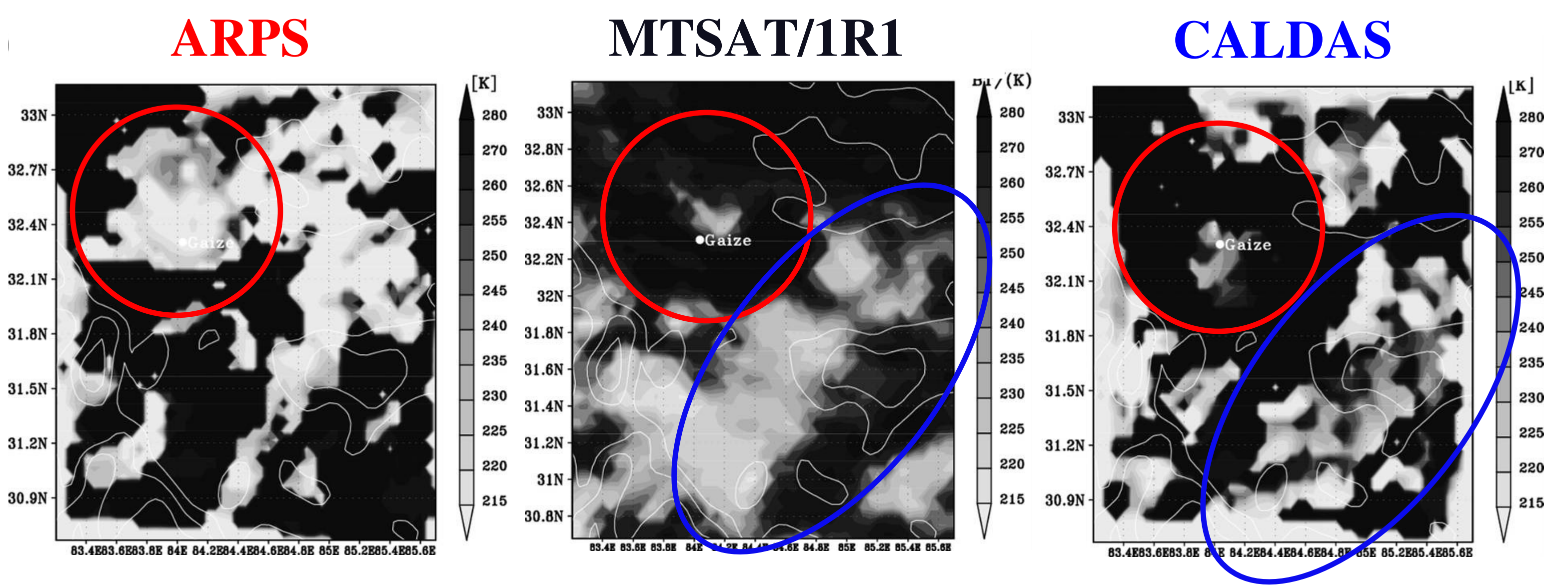


Coupled A-L DAS (CALDAS)-COUPLER



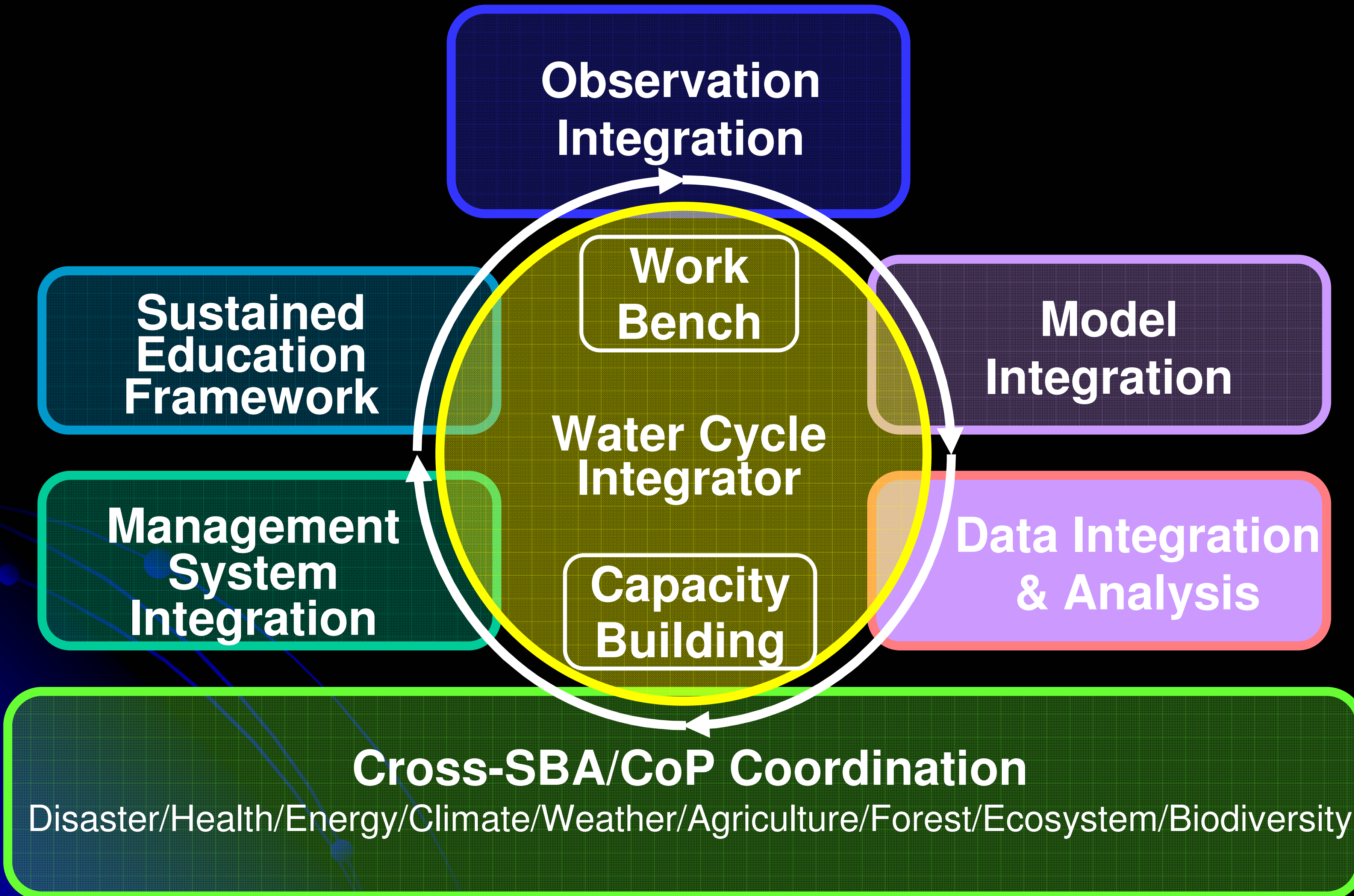






0900 UTC 08th July 2008

Integrated & Coordinated Approach

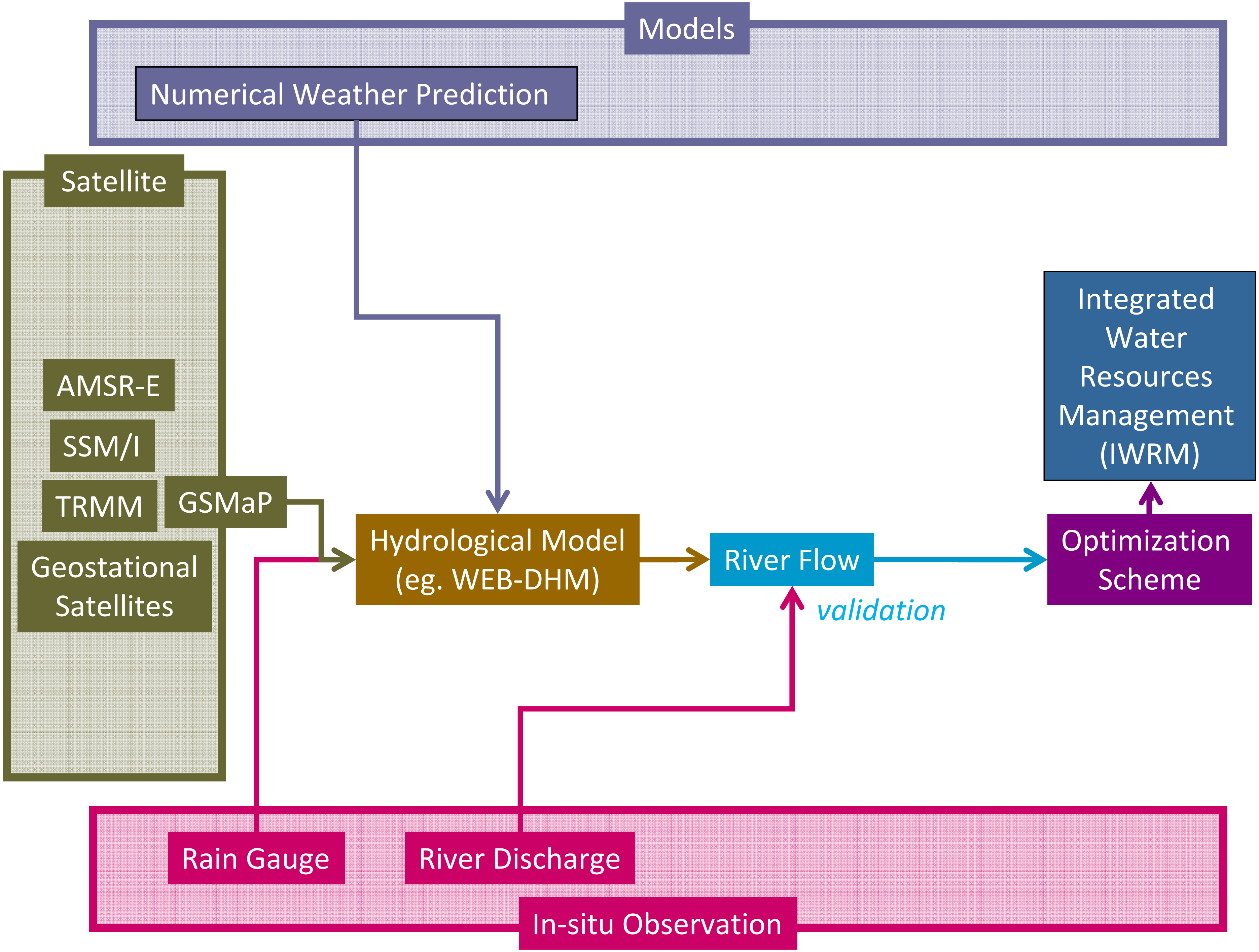


Models

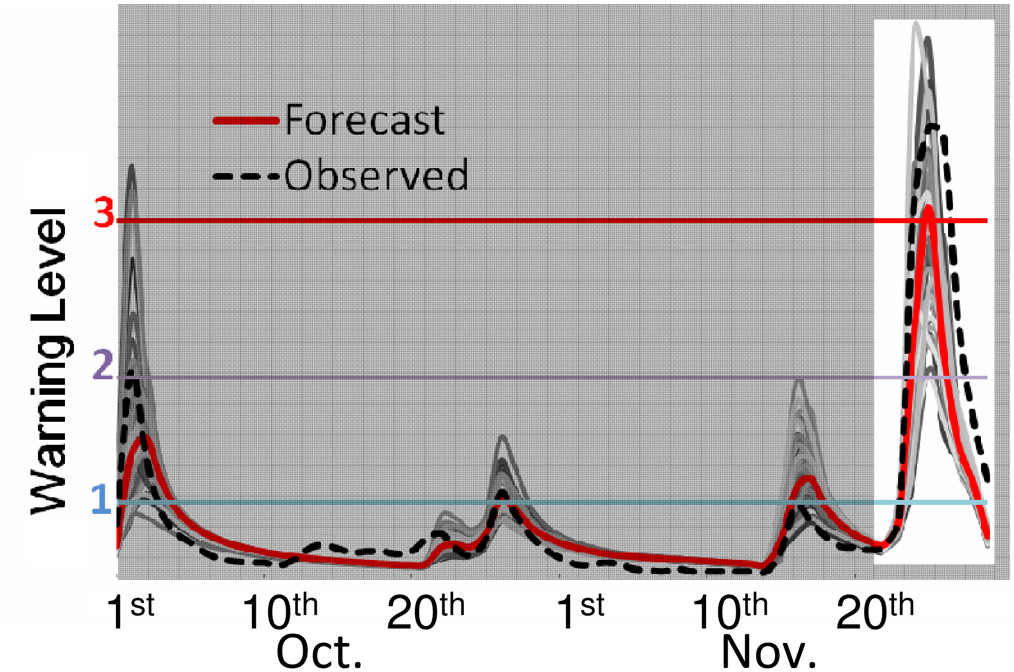
Satellite

Data Integration

In-situ Observation

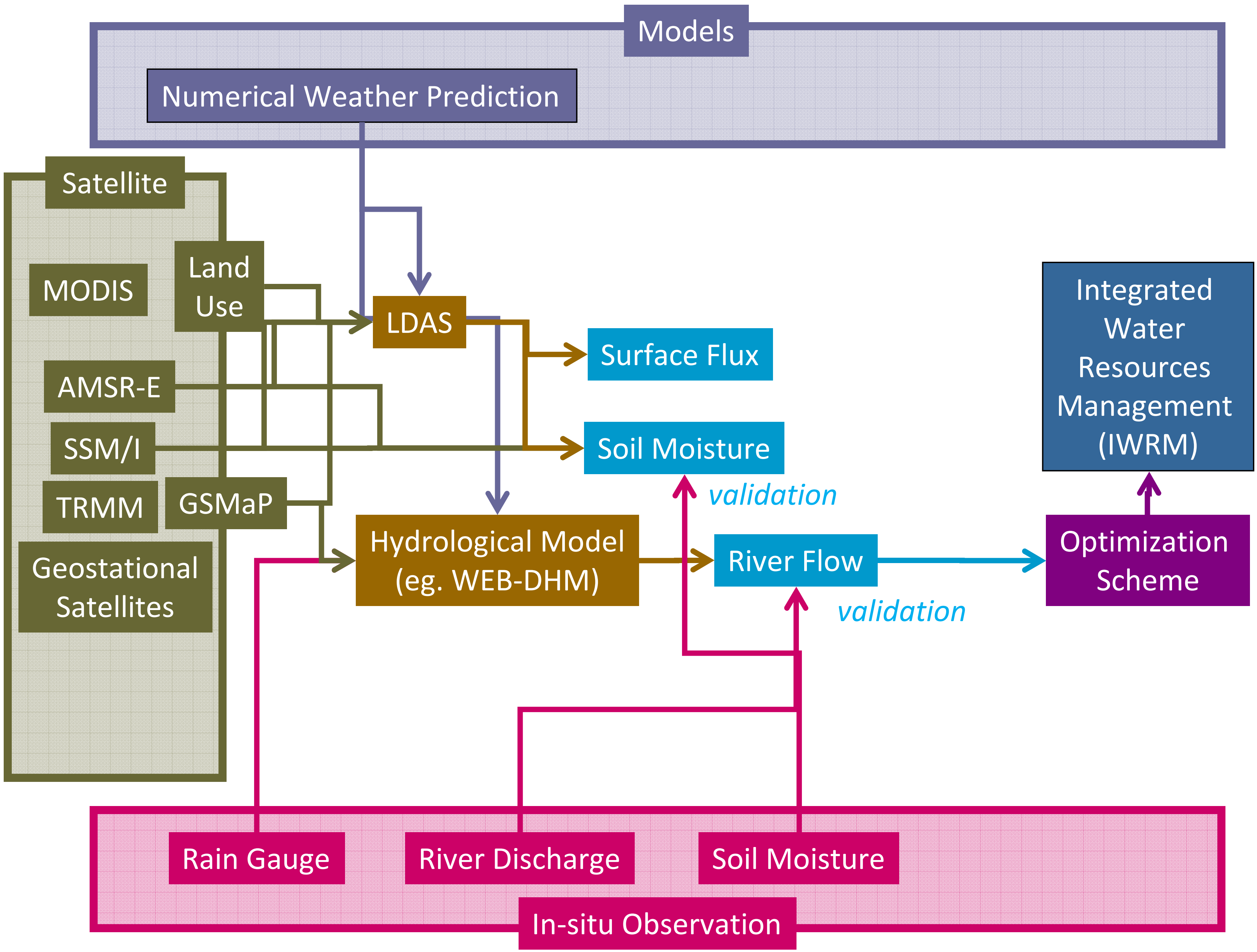


Models
Numerical Weather Prediction
Satellite
AMSR-E
SSM/I
TRMM
GSMaP
Geostational Satellites
Hydrological Model (eg. WEB-DHM)
River Flow
validation
Optimization Scheme
Integrated Water Resources Management (IWRM)
Rain Gauge
River Discharge
In-situ Observation



2004

Date		Nov.					
		24	**25**	**26**	**27**	**28**	29
Predicted exceedance probability (%)	**W.L.3**		**8**	**52**			
	W.L.2		**74**	**96**	**72**		
	W.L.1	6	**96**	**96**	**96**	**96**	96
Observed	**W.L.**	0.9	**3.1**	**3.5**	**3.5**	**2.4**	**1.7**


Models
Numerical Weather Prediction
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MODIS
Land Use
AMSR-E
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TRMM
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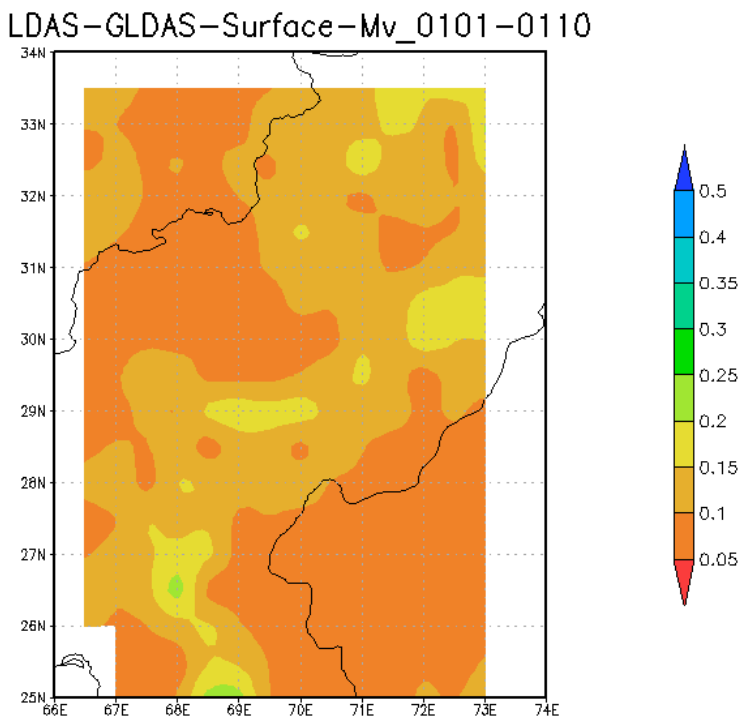
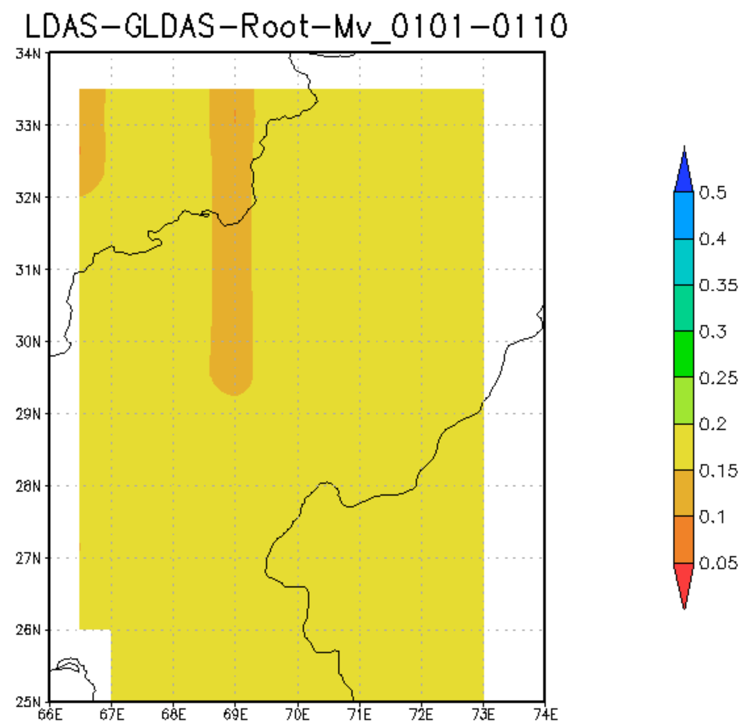
Results: 10days averaged soil moisture in the middle of the Indus River

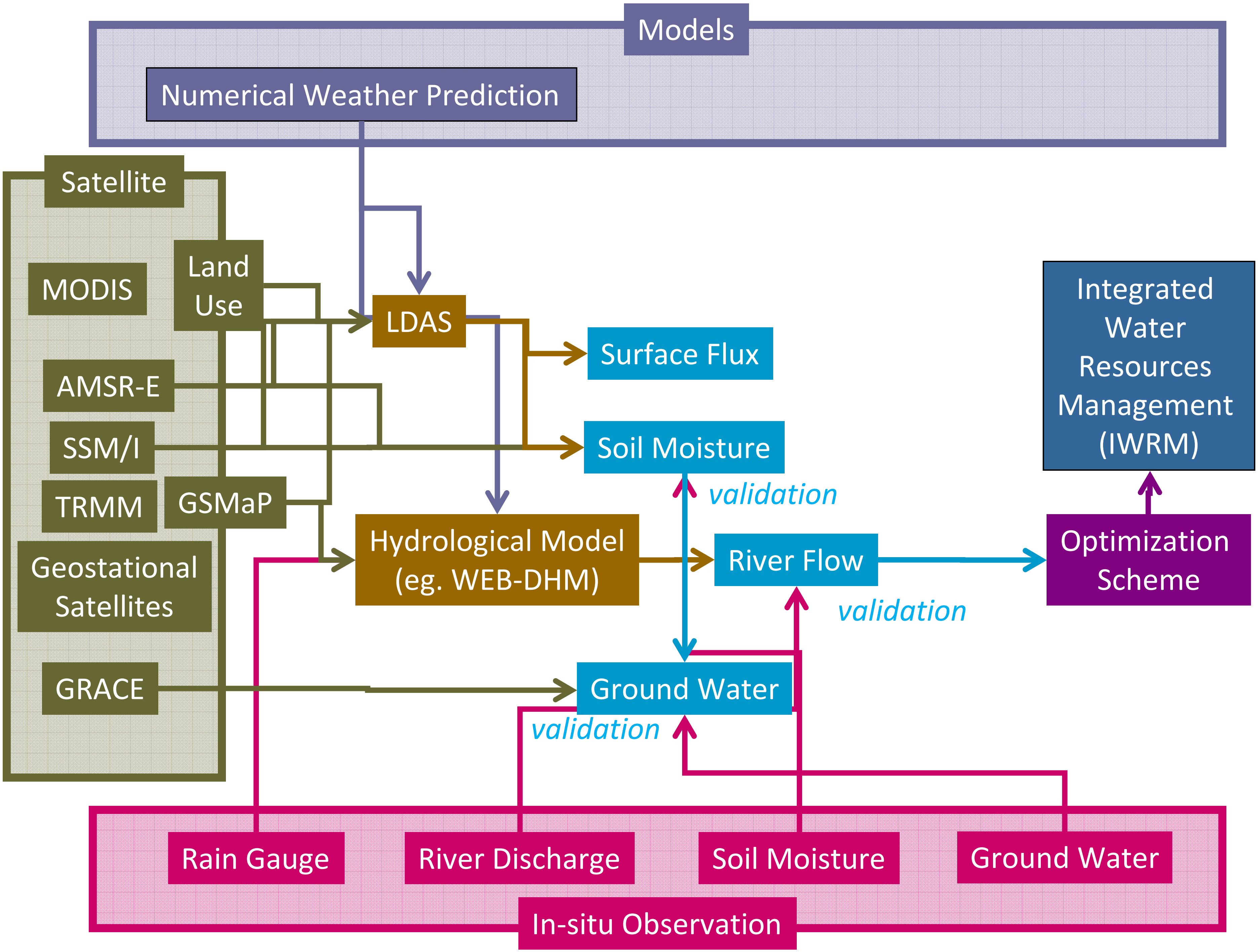
Surface soil moisture



Root zone soil moisture



GrADS: COLA/IGES 2010-11-20-09:16 2010-11-20-11:51


Models
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Land Use
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GSMaP
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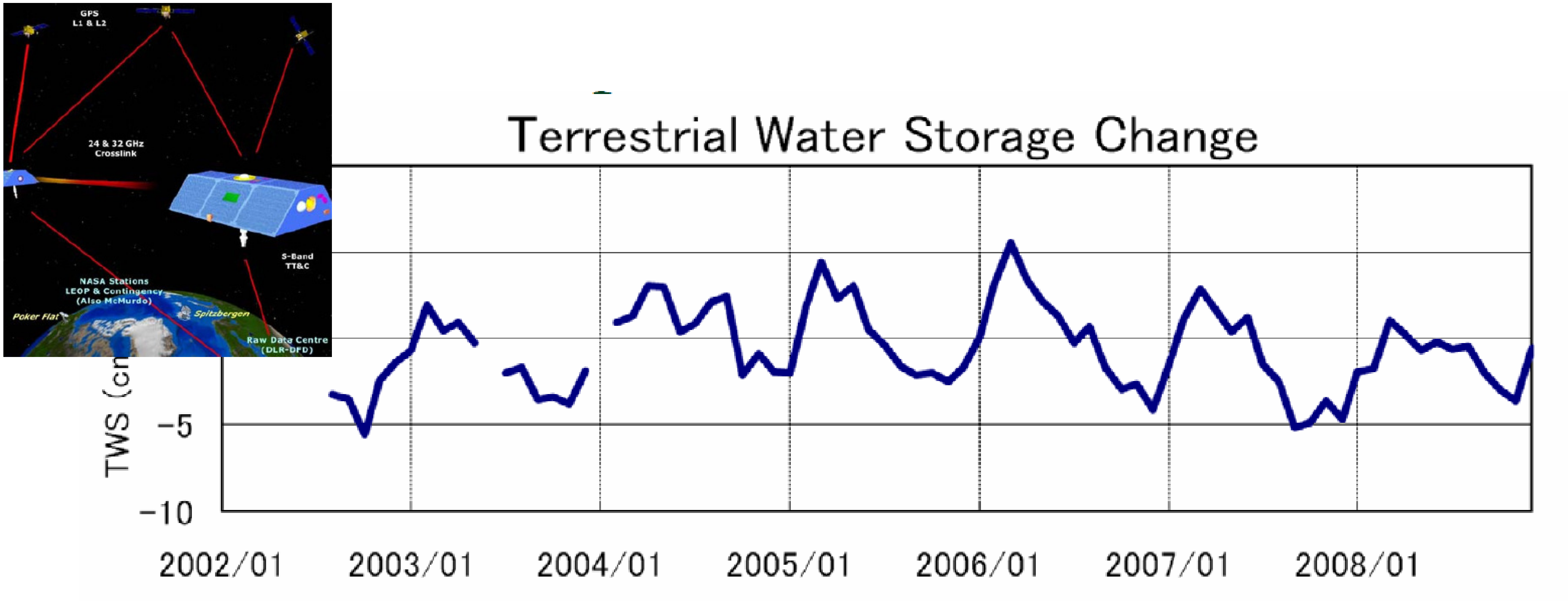
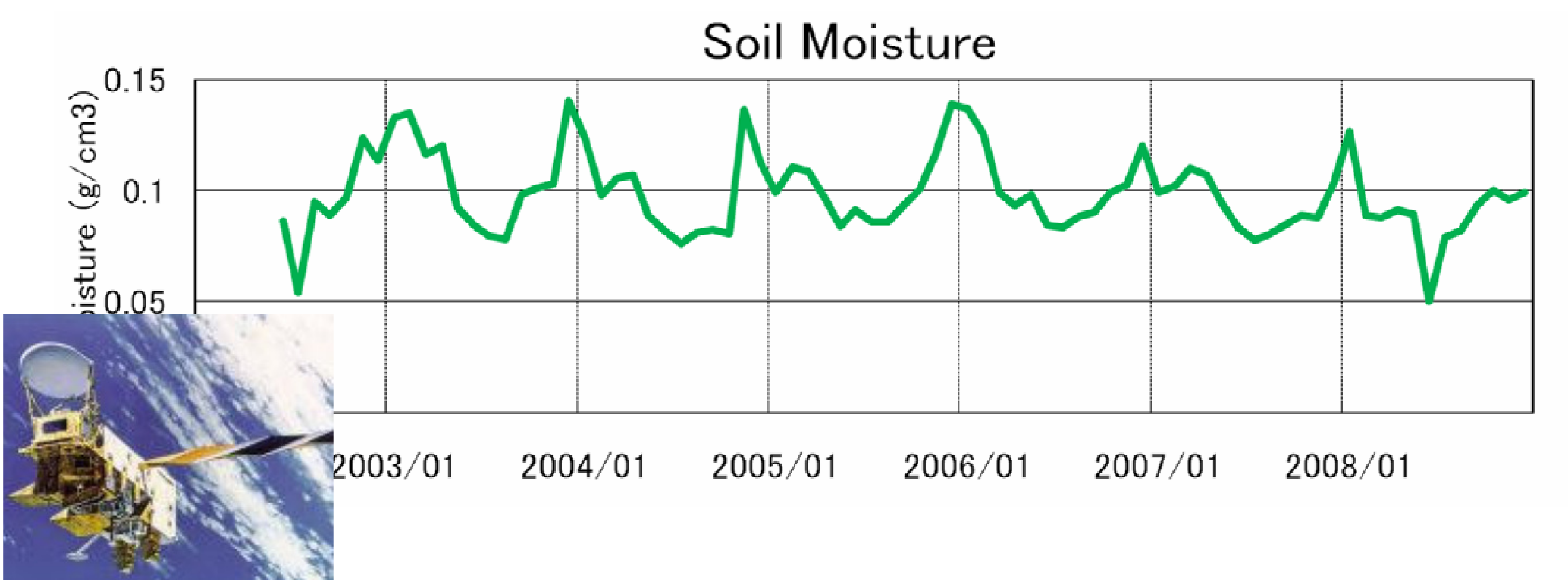
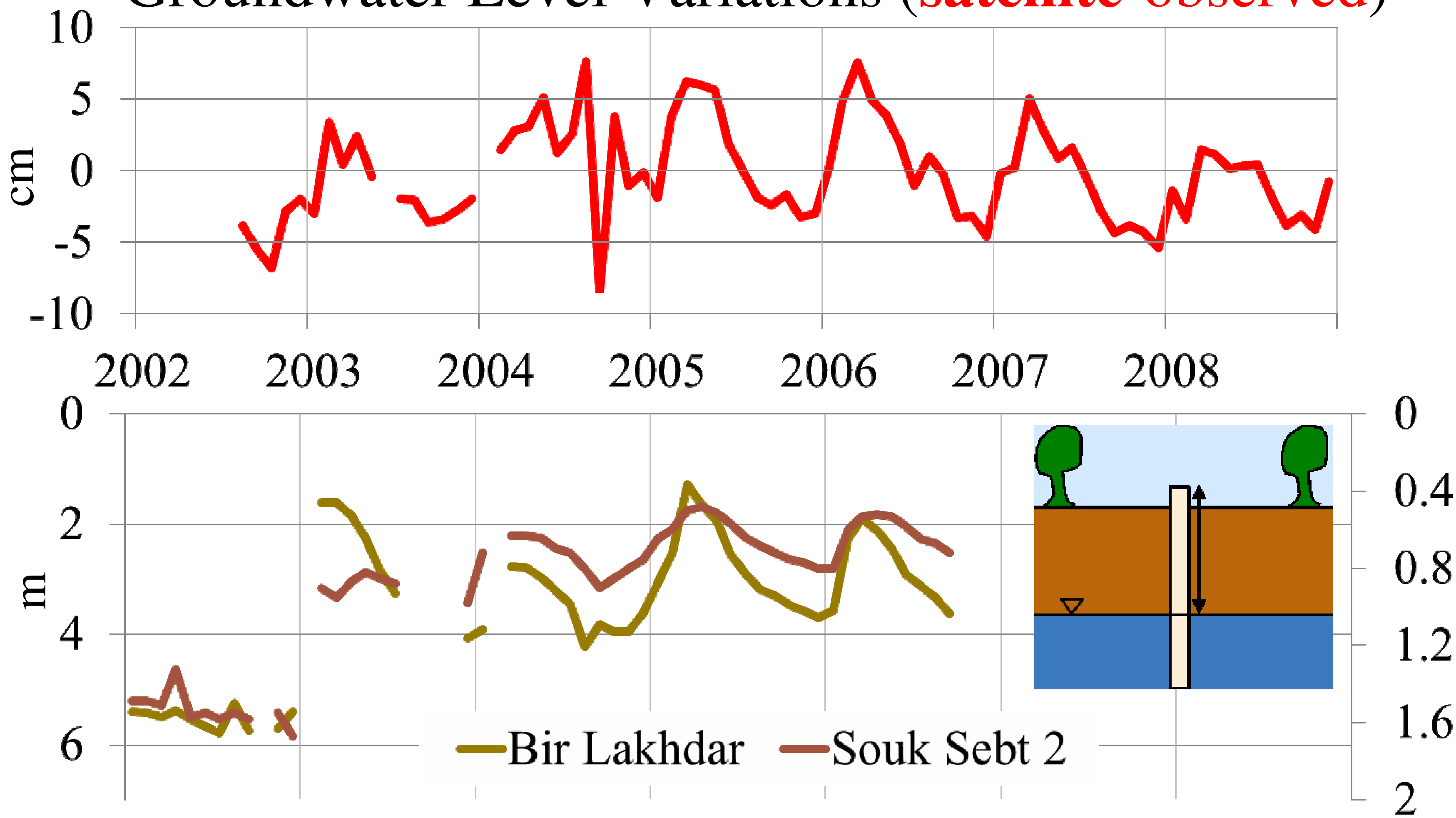
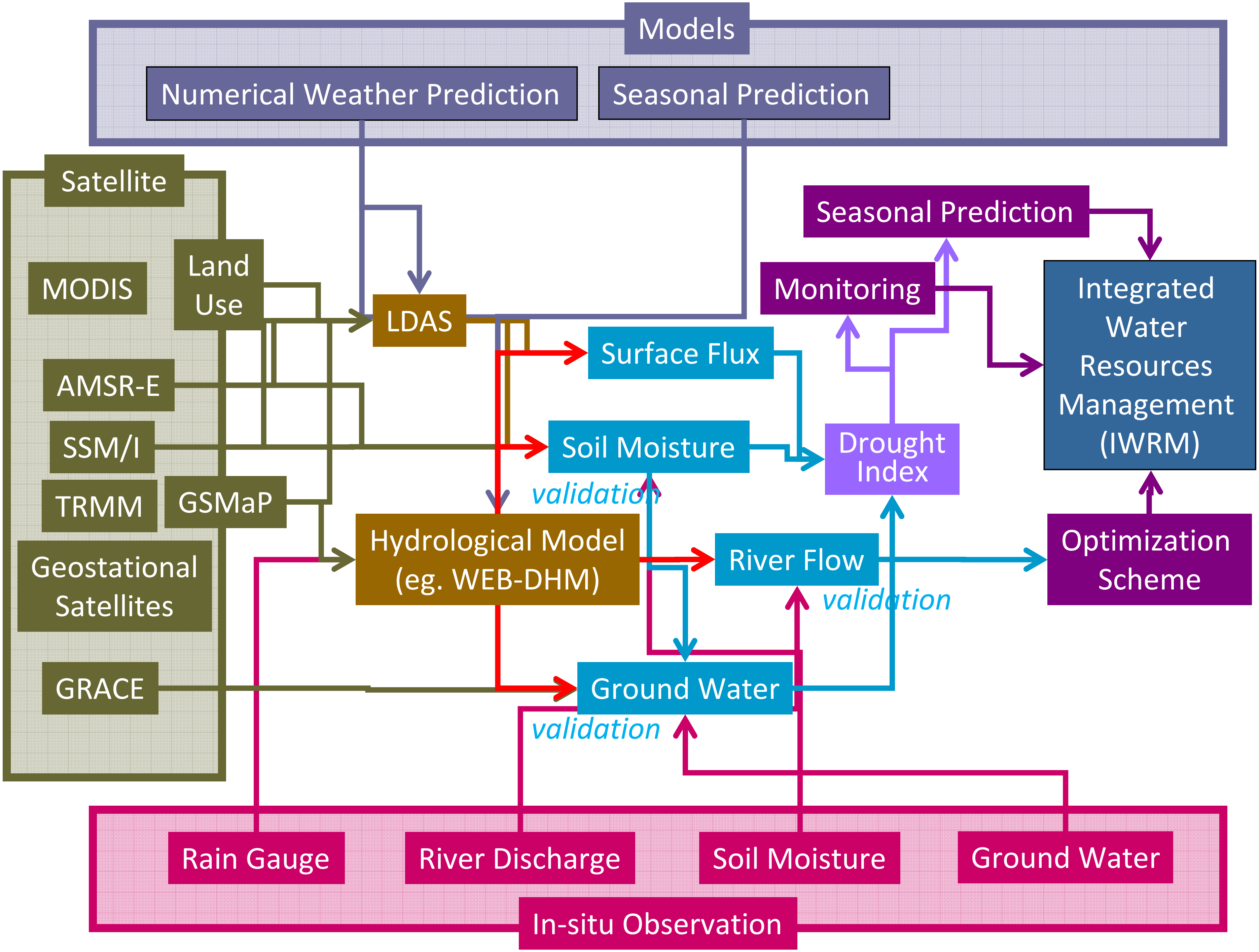

GPS
L1 & L2
24 & 32 GHz
Crosslink
S-Band
TT&C
NASA Stations
LEOP & Contingency
(Also McMurdo)
Poker Flat
Spitzbergen
Raw Data Centre
(DLR-DFD)
Terrestrial Water Storage Change
TWS (cm
−5
−10
2002/01
2003/01
2004/01
2005/01
2006/01
2007/01
2008/01


Soil Moisture
oisture (g/cm3)
0.15
0.1
0.05
2003/01
2004/01
2005/01
2006/01
2007/01
2008/01

Groundwater Level Variations (**satellite**-observed)



Groundwater Level Variations (**ground**-observed)


Models
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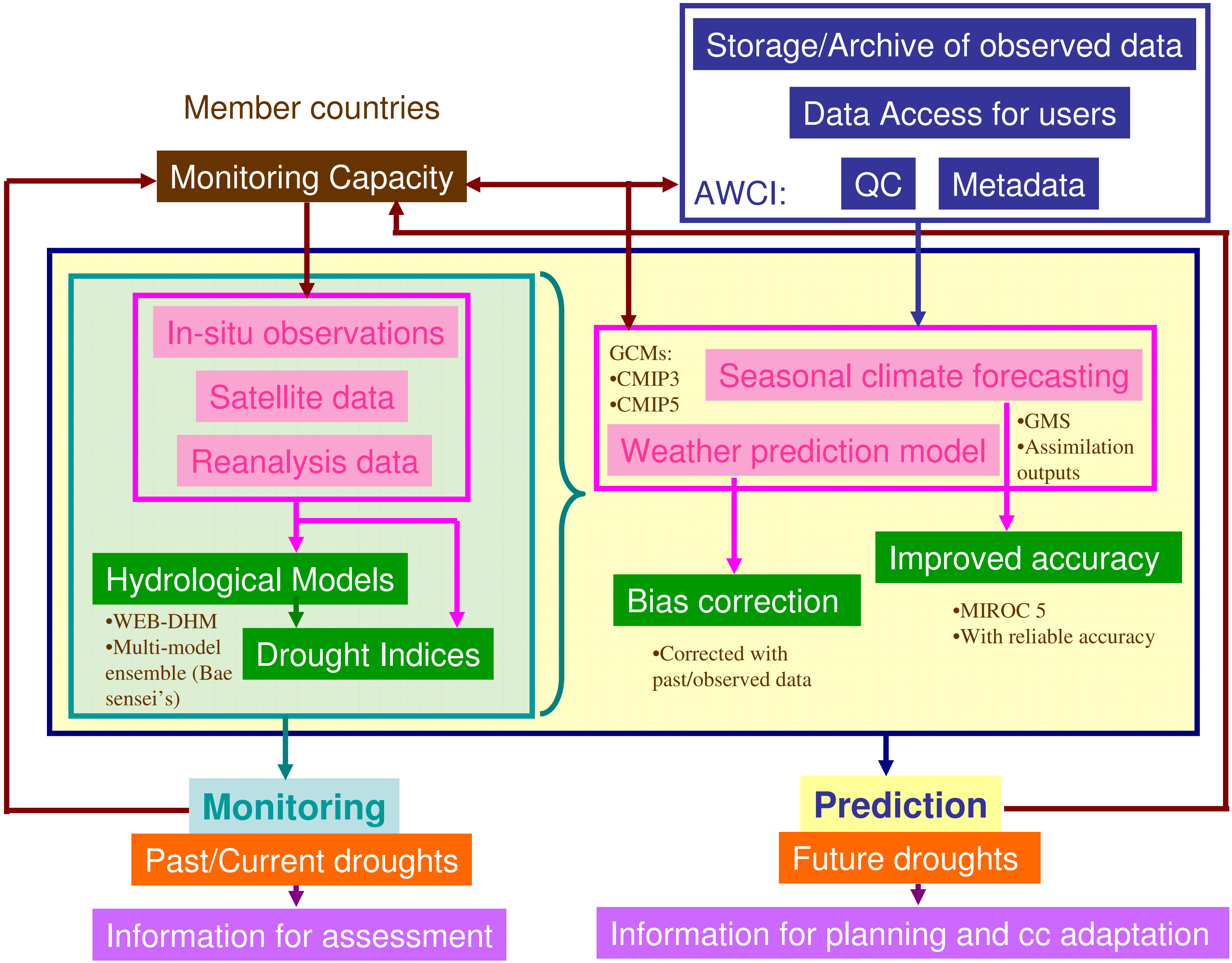
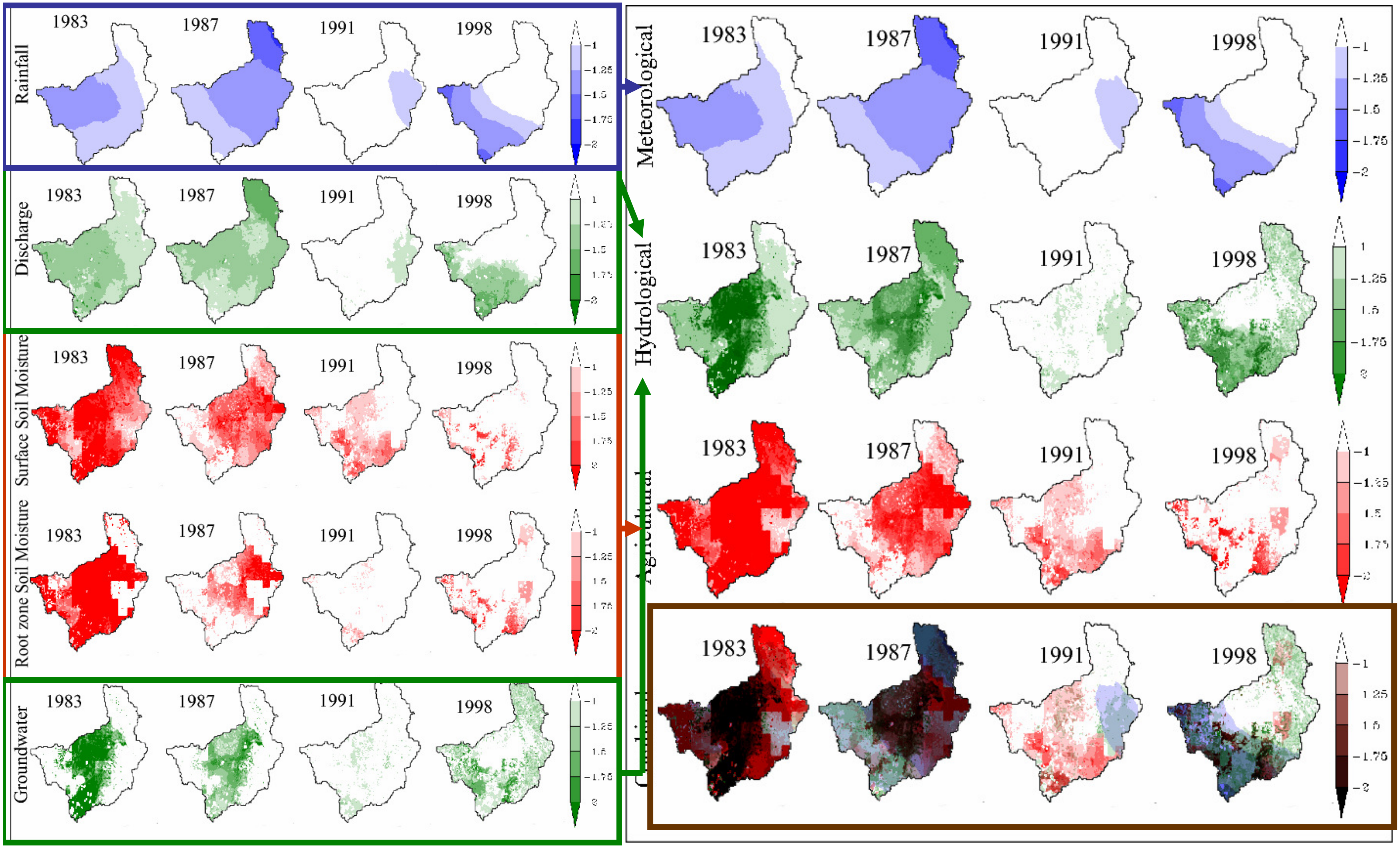


Storage/Archive of observed data
Data Access for users
AWCI:
QC
Metadata
Member countries
Monitoring Capacity
In-situ observations
Satellite data
Reanalysis data
Hydrological Models
•WEB-DHM
•Multi-model ensemble (Bae sensei's)
Drought Indices
GCMs:
•CMIP3
•CMIP5
Seasonal climate forecasting
Weather prediction model
•GMS
•Assimilation outputs
Improved accuracy
•MIROC 5
•With reliable accuracy
Bias correction
•Corrected with past/observed data
Monitoring
Past/Current droughts
Information for assessment
Prediction
Future droughts
Information for planning and cc adaptation

Spatial SA: Philippines

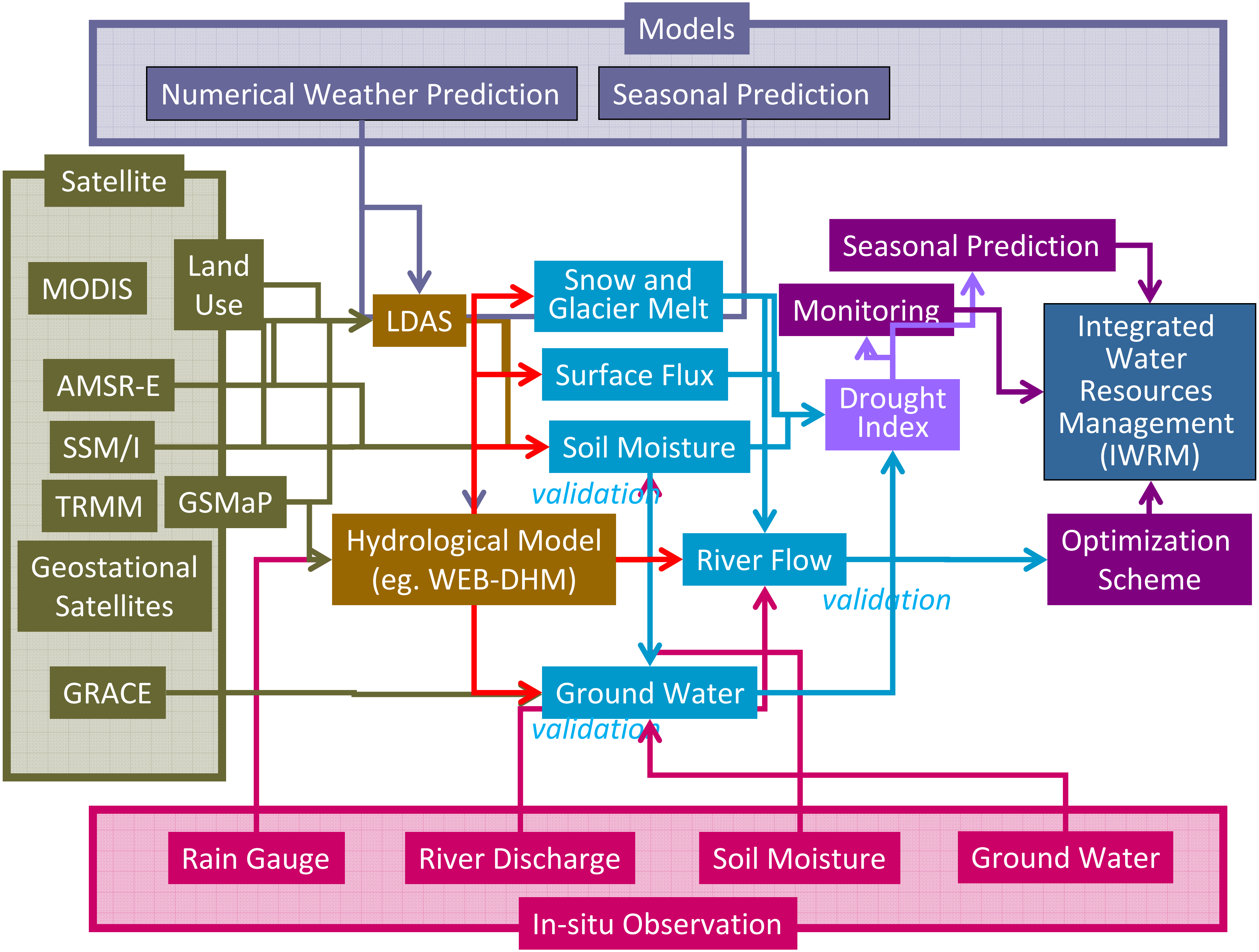


Seasonal Drought Prediction

Months	1st		2nd		3rd	
Year	Observed	SFC	Observed	SCF	Observed	SCF
1983	↗ red	↗ red	↘ red	↘ red	↗ green	↘ red
1991	↘ green	↘ green	↗ green	↗ green	↘ green	↘ green
1997	↘ green	↘ red	↘ green	↘ red	↘ red	↘ red
1999-2000	↗ green	↘ green	↗ green	↗ green	↗ blue	↗ blue

ARROW Legends: **red**= drought; **green**=normal; **blue**=wet

e.g. increase towards drought conditions ↗ red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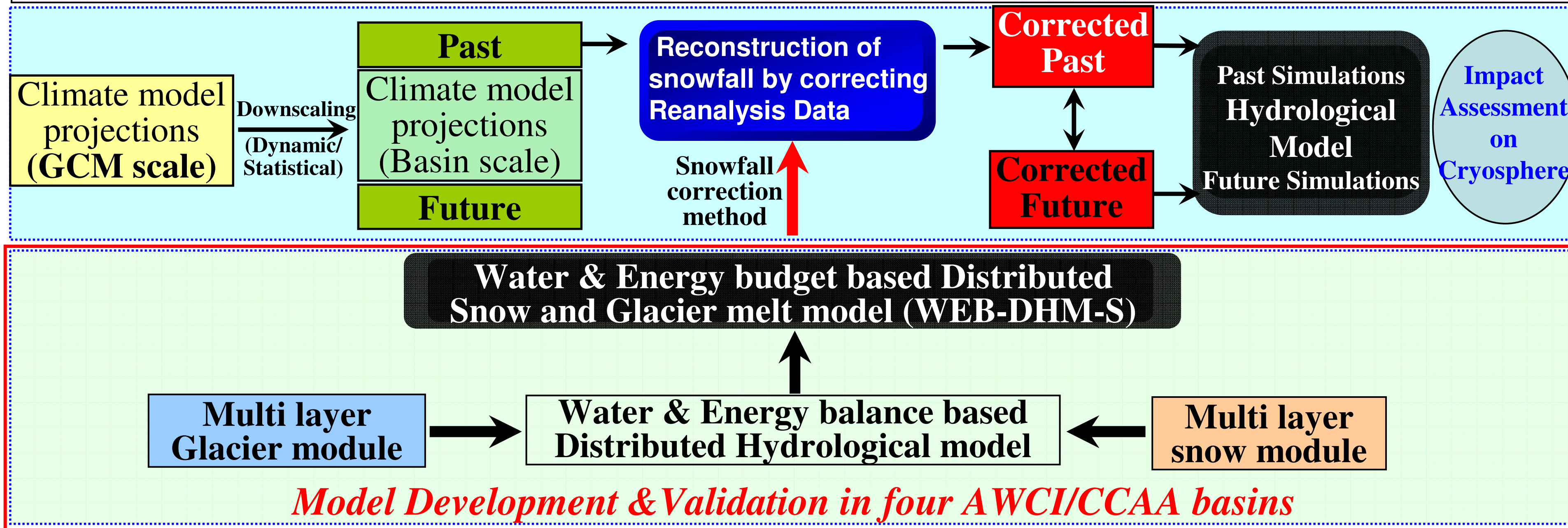
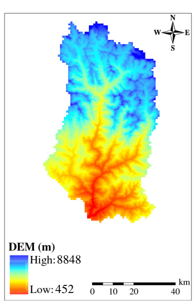
Motivation for AWCI/CCAA Study-Snow & Glacier

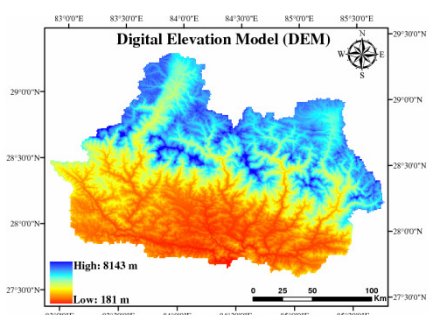
- *Long term snowfall dataset is needed for bias correction of climate projections, which is currently unavailable in many poorly gauged/ungauged basins.*
- *Reanalysis dataset can be used as baseline data but they should be corrected in prior to application.*
- *A method has to be established for snowfall correction, based on analysis of simulated discharge with observed one and simulated snow cover with satellite snow cover, through physically based hydrological modeling. Thus, firstly, we need to develop "the physically based snow & glacier-melt model"*



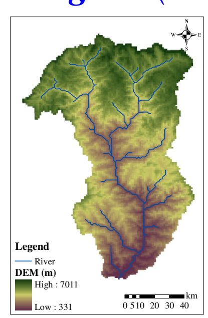
Dudhkoshi (Nepal)



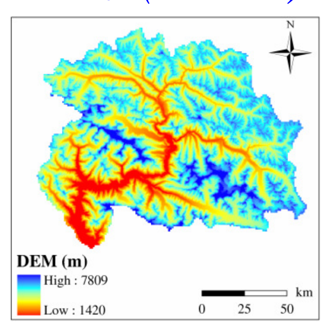
Narayani (Nepal)



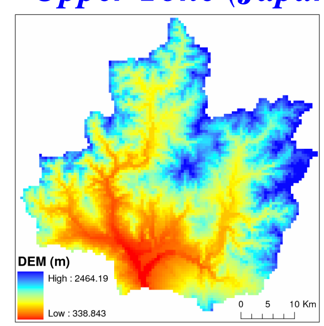
Punatsangchu (Bhutan)

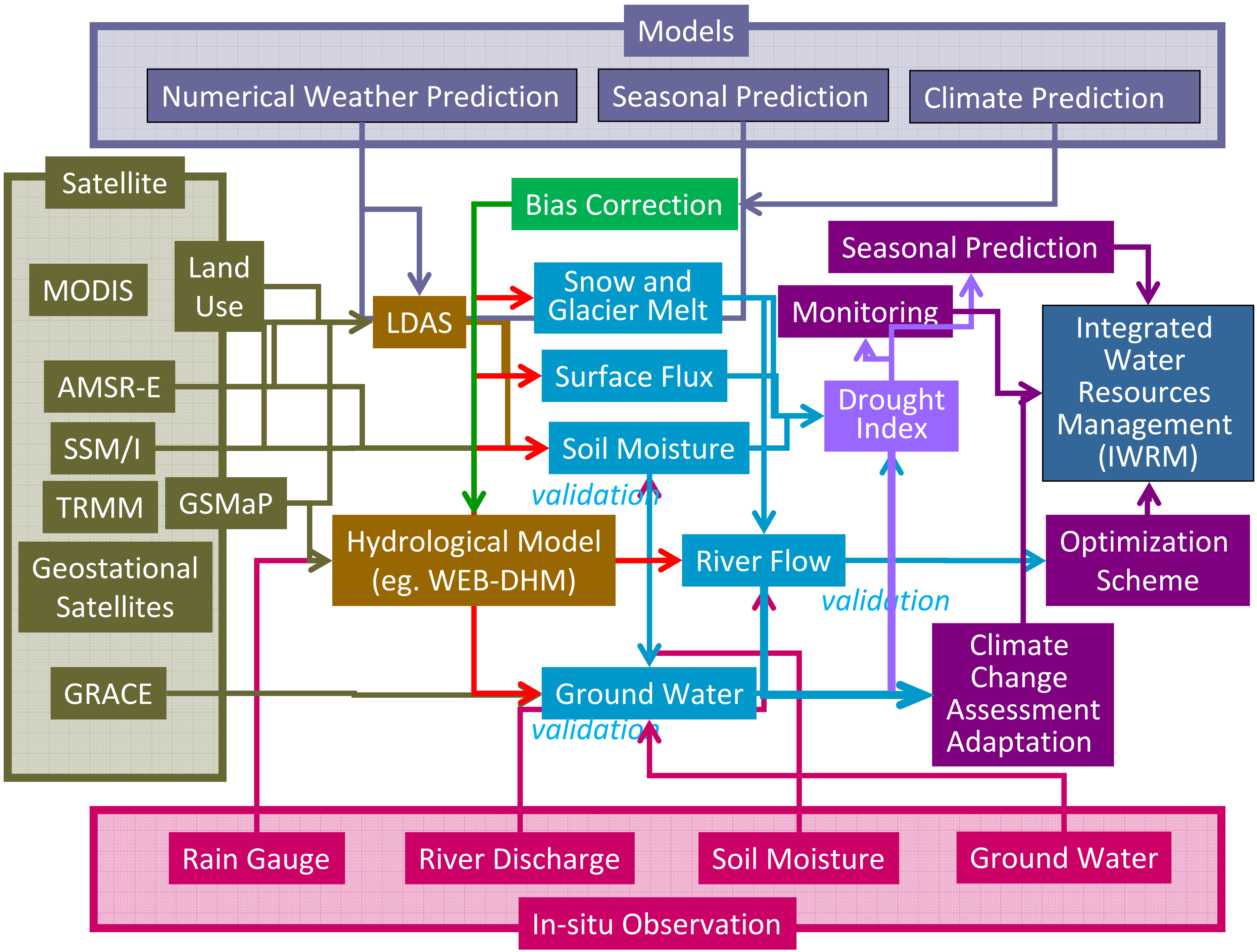


Hunza (Pakistan)



Upper Tone (Japan)




Models
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Seasonal Prediction
Climate Prediction
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Ground Water
In-situ Observation

Climate Change Assessment & Adaptation Framework

Climate Change Assessment & Adaptation

Observed Rain(1981−2000)
CMIP3 20C3M(1981−2000)
A1Bscenario(2046−2065)

Removing Improper Global Climate Models

Bias Correction (Normal rain, Annual maximum, no rain days)

Downscaling
GSMaP Spatial Distribution Map

Observed Rain(2003−2008)
GSMaP Rain(2003−2008)
Monthly correction

Area Average Spatial Weight Distribution Map

Check Applicability
Poor−gauged Basin

Check Sensitivity
− Number of Rain gauges
Evaluation
−Annual basin average rainfall
−seasonal climatology rainfall

WEB−DHM

DEM
Soil
Land Use
Vegetation

Rainfall
Temperature
Relative Humidity
Wind Speed
Solar Radiation

Calibration
Validation
Basin Parameter

WEB−DHM

Application to AWCI Demonstration Basin

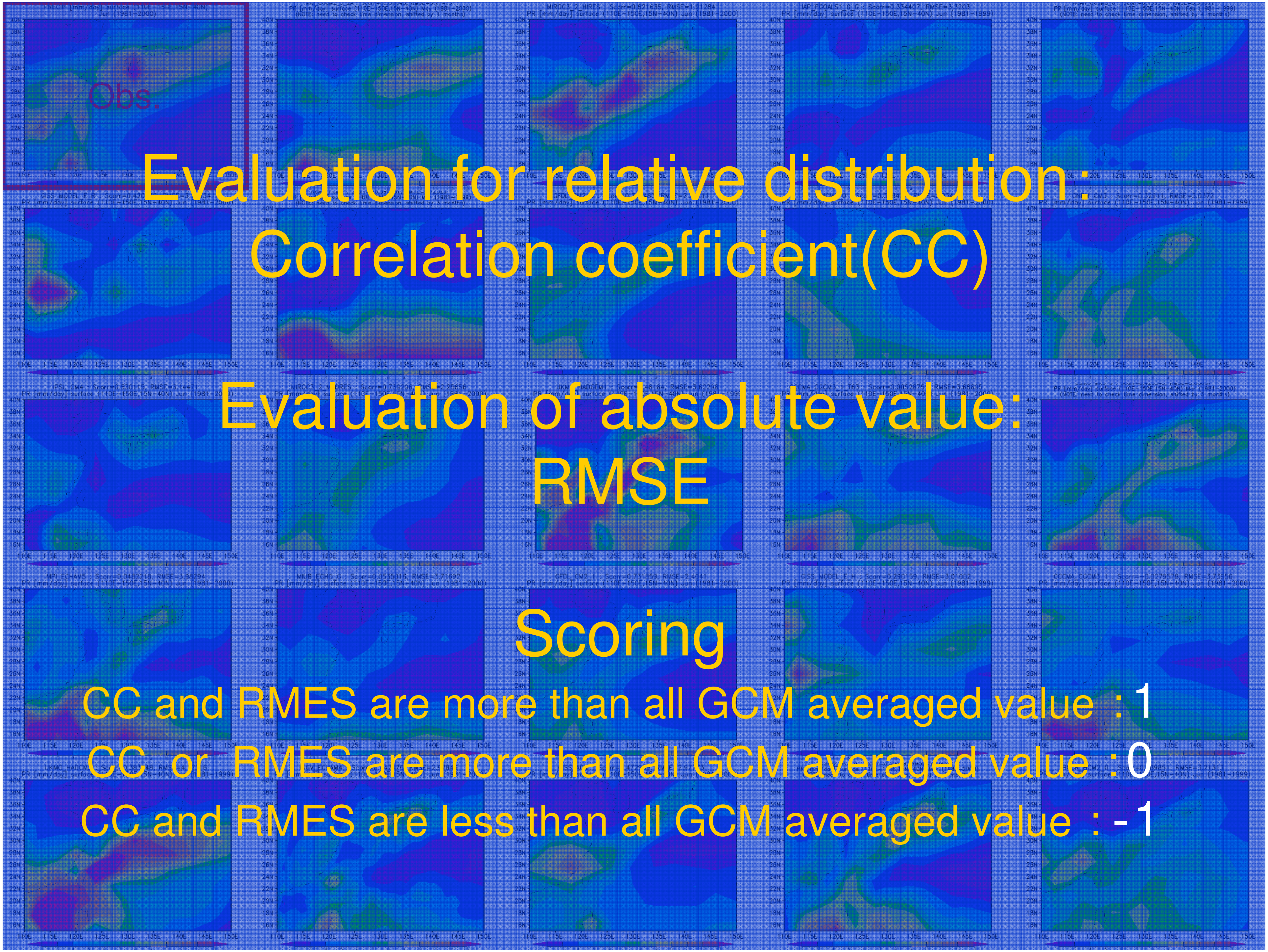
Analysis of Flood

Flood Alert & Evacuation
Inundation Area (Land Use Map & topography)
Inundation depth (River cross section)
Hazard Mapping (Socio Economic data)

Provide Usable Knowledge & Adaptation Measures

CMIP3 : Coupled Modeled Intercomparison Project Phase-3

20C3M : 20th Century Numerical Reproductive Experiment



Evaluation for relative distribution : Correlation coefficient(CC)

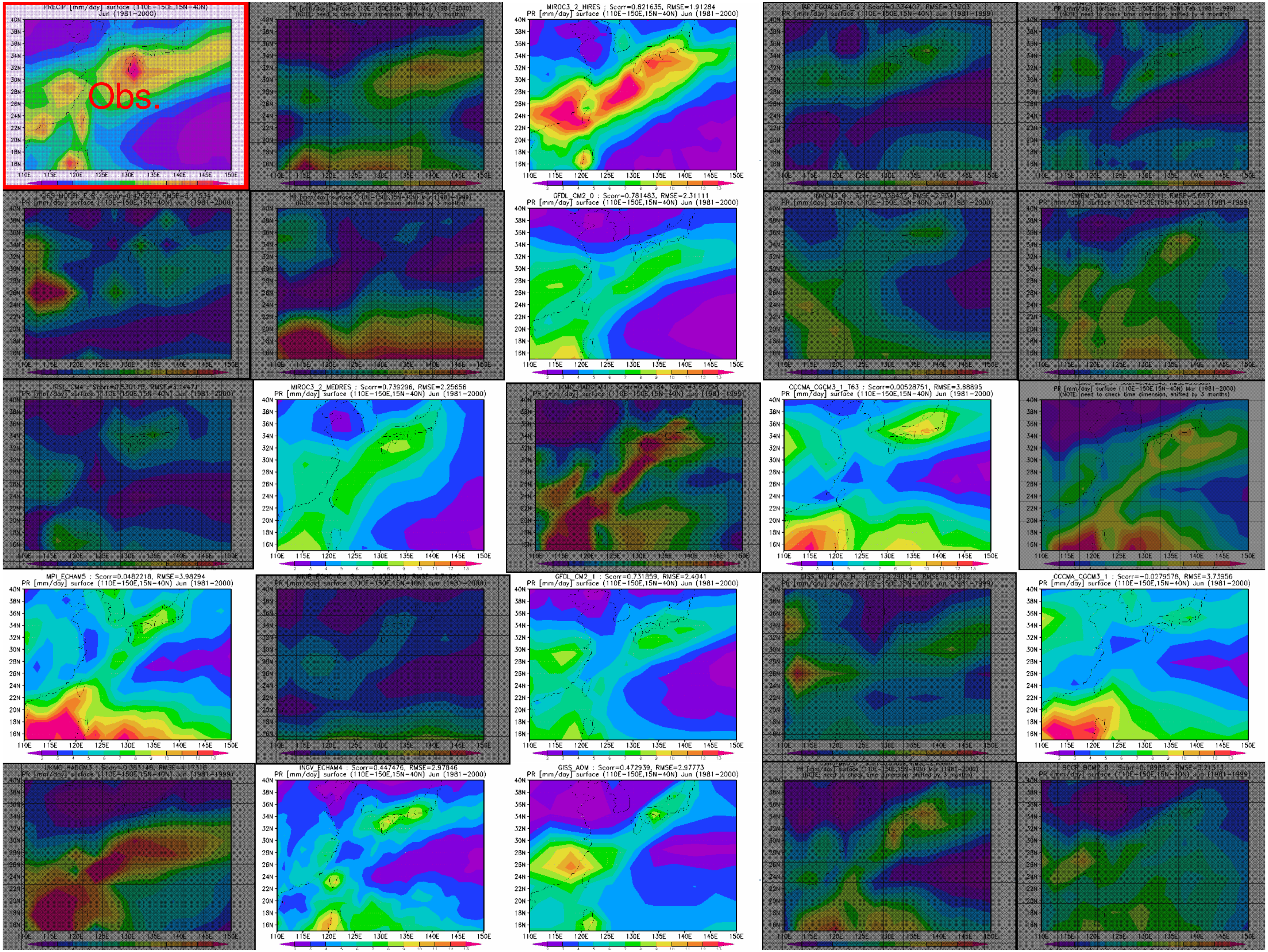
Evaluation of absolute value: RMSE

Scoring

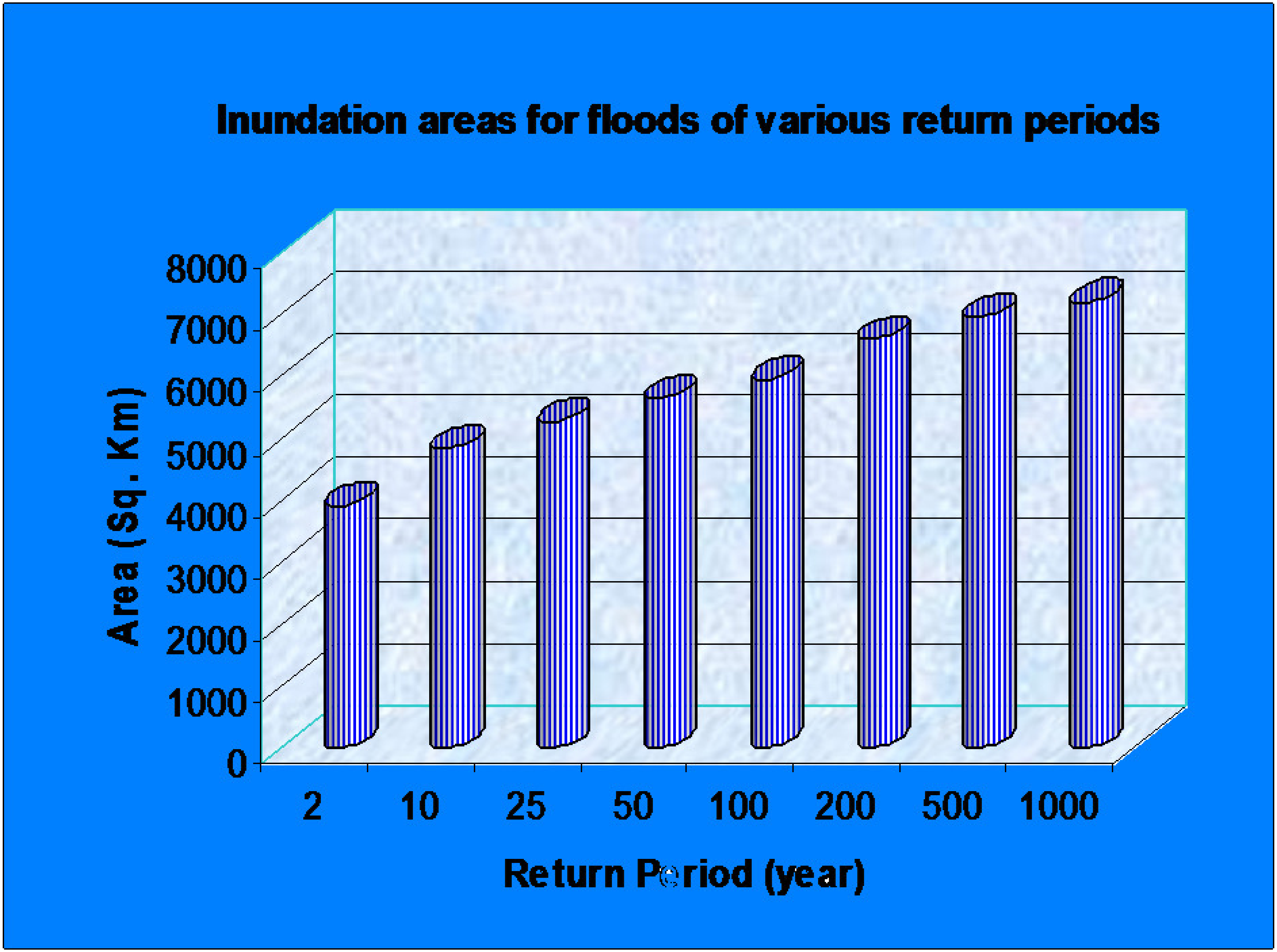
CC and RMES are more than all GCM averaged value : 1

CC or RMES are more than all GCM averaged value : 0

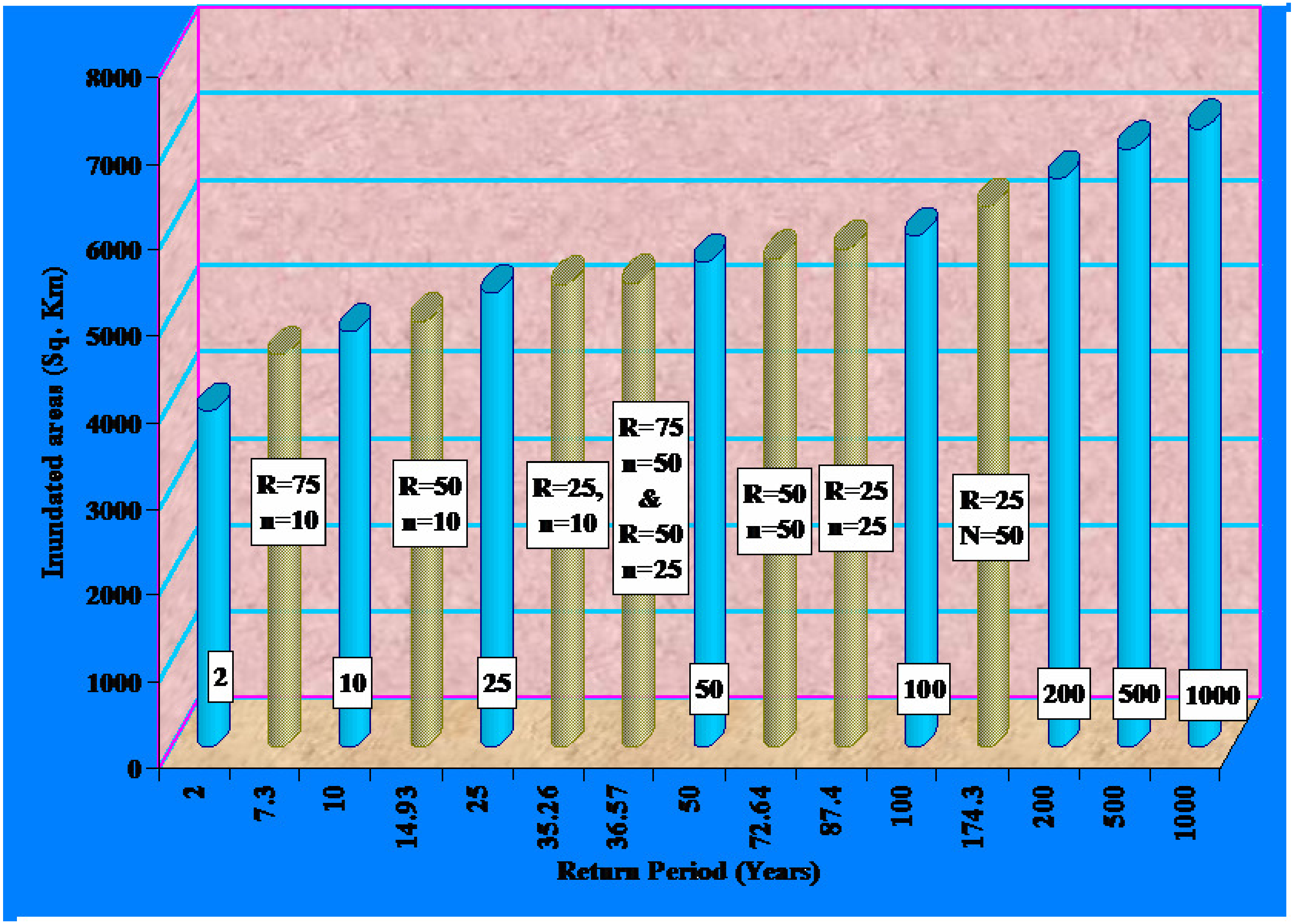
CC and RMES are less than all GCM averaged value : -1



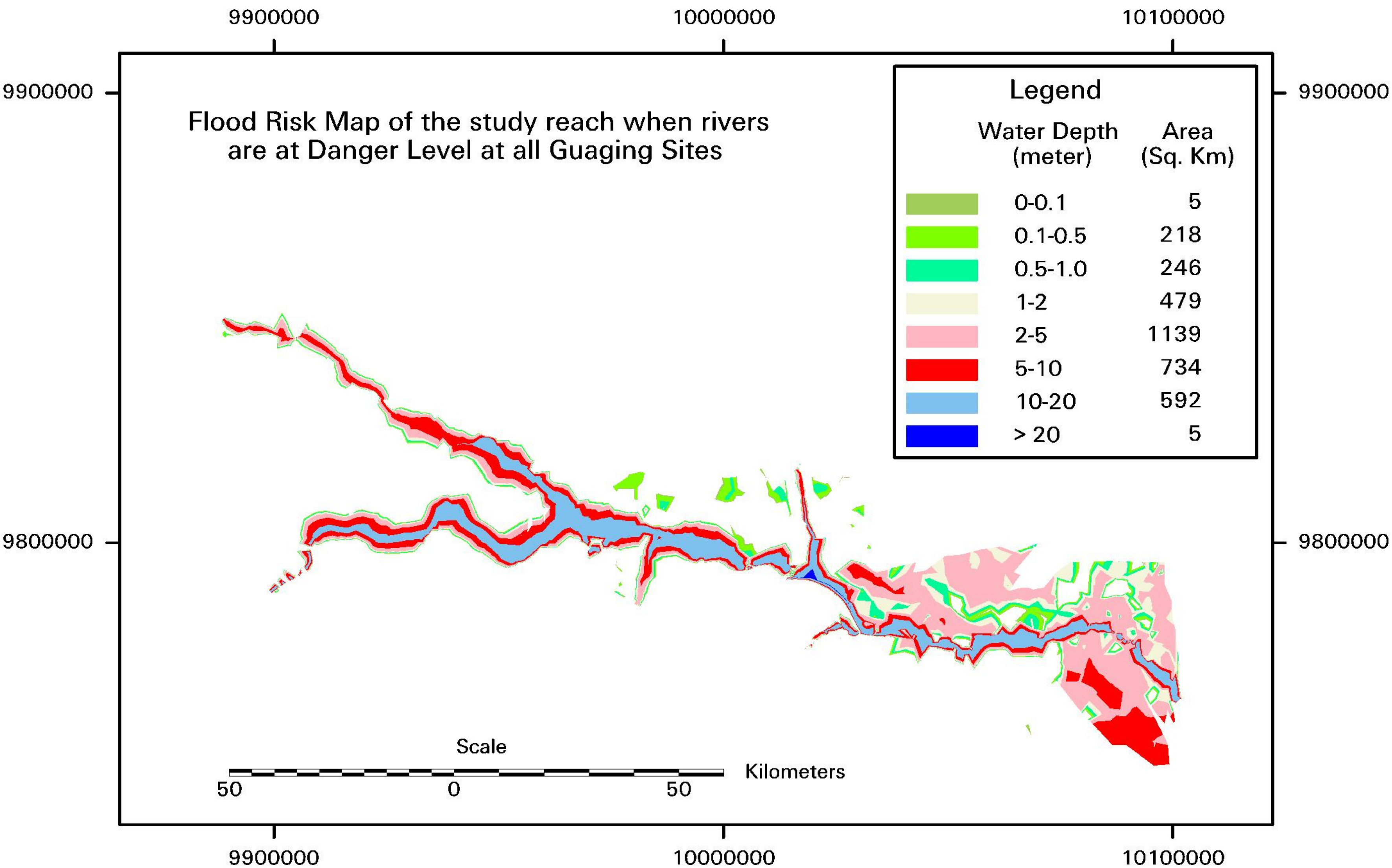
Obs.
PRECIP [mm/day] surface (110E-150E,15N-40N) Jun (1981-2000)
MIROC3_2_HIRES
GISS_MODEL_E_R
GFDL_CM2_0
INMCM3_0
CNRM_CM3
IPSL_CM4
MIROC3_2_MEDRES
UKMO_HADGEM1
CCCMA_CGCM3_1_T63
MPI_ECHAM5
GFDL_CM2_1
GISS_MODEL_E_H
CCCMA_CGCM3_1
UKMO_HADCM3
INGV_ECHAM4
GISS_AOM
BCCR_BCM2_0



Inundation areas for floods of various return periods
8000
7000
6000
5000
4000
3000
2000
1000
0
Area (Sq. Km)
2
10
25
50
100
200
500
1000
Return Period (year)

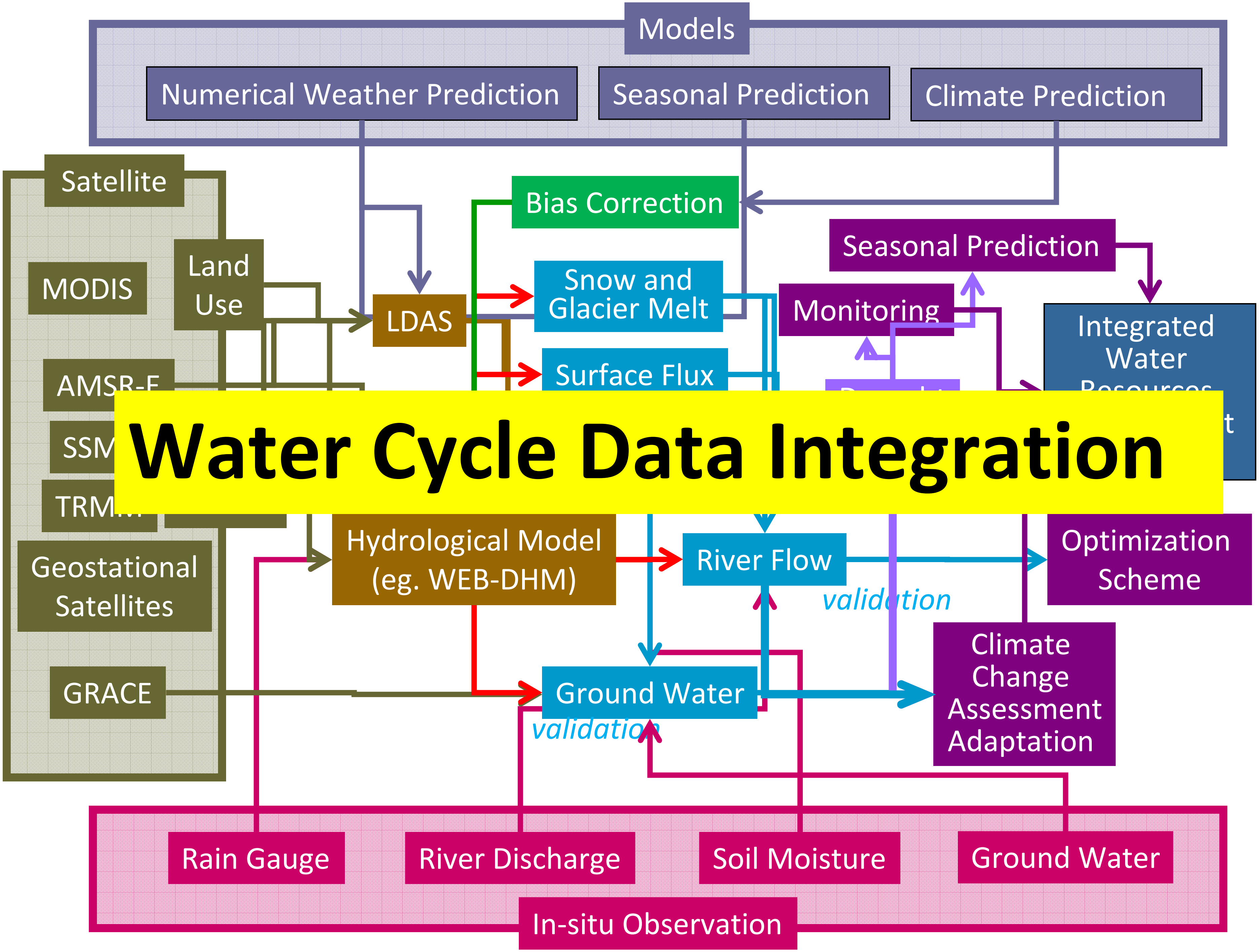


Inundated area for floods of various return periods and hydrological risk

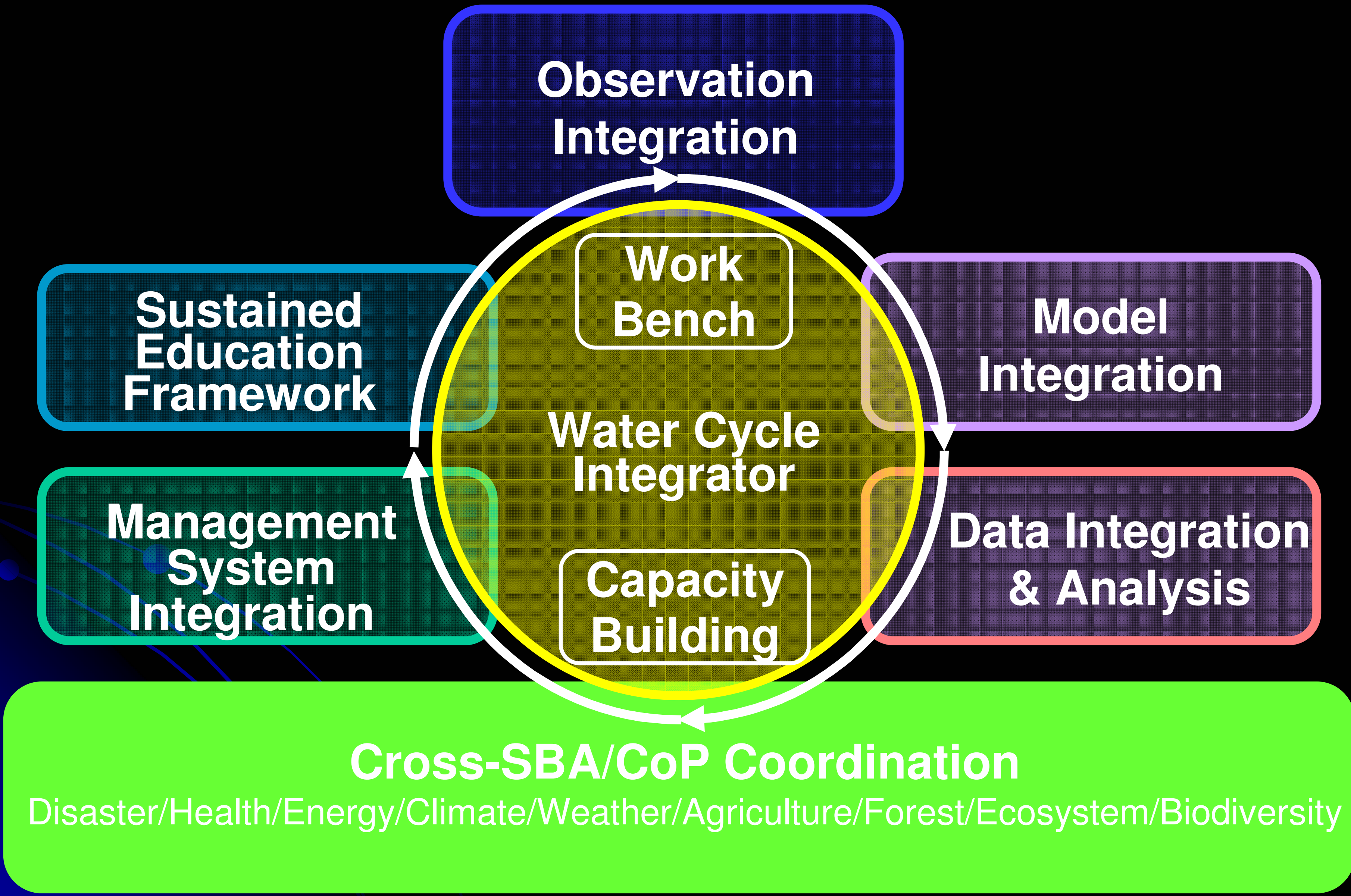


Flood Inundation map when the water level is at danger level at all the gauging sites

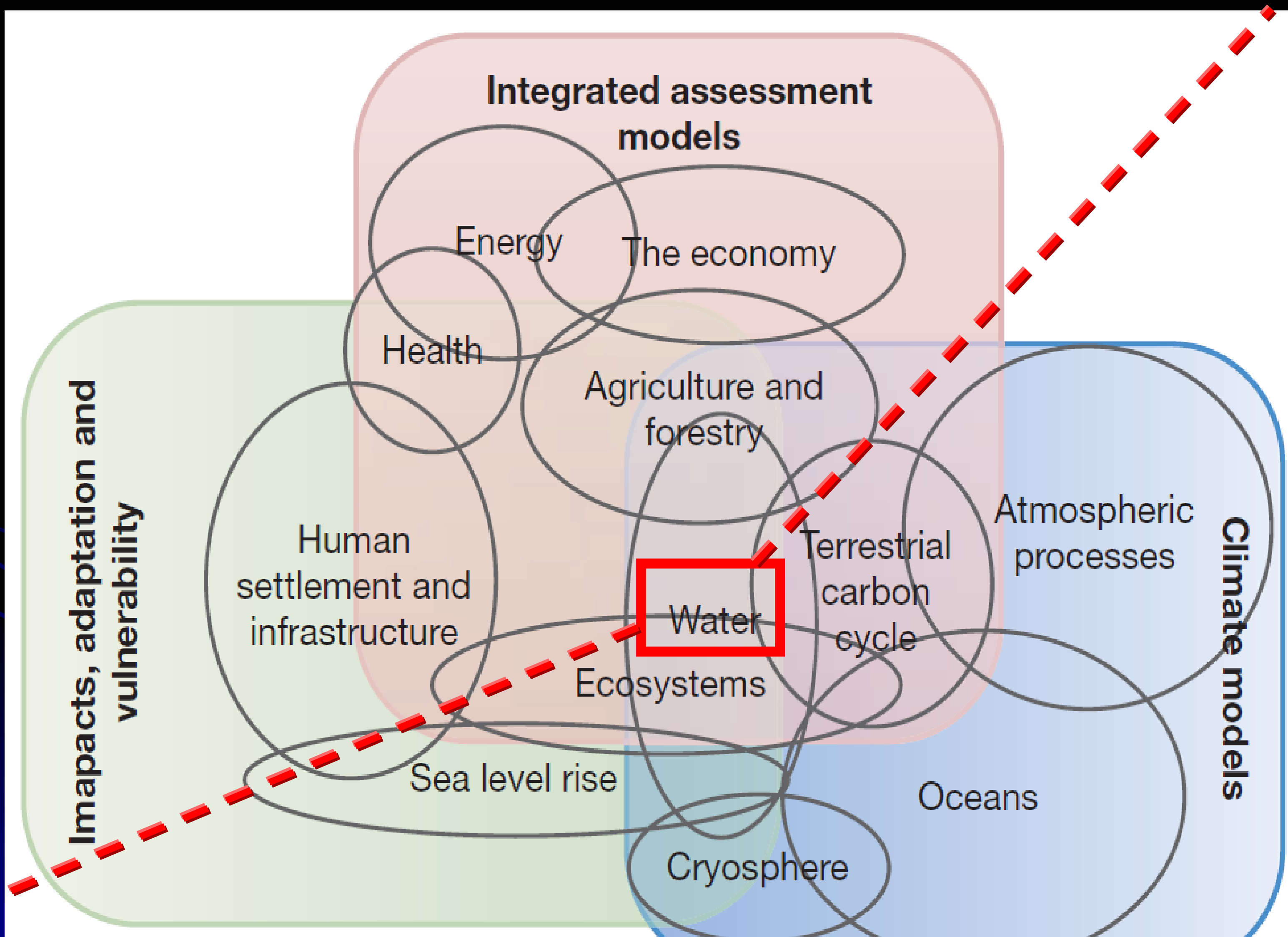
Water Cycle Data Integration



Integrated & Coordinated Approach

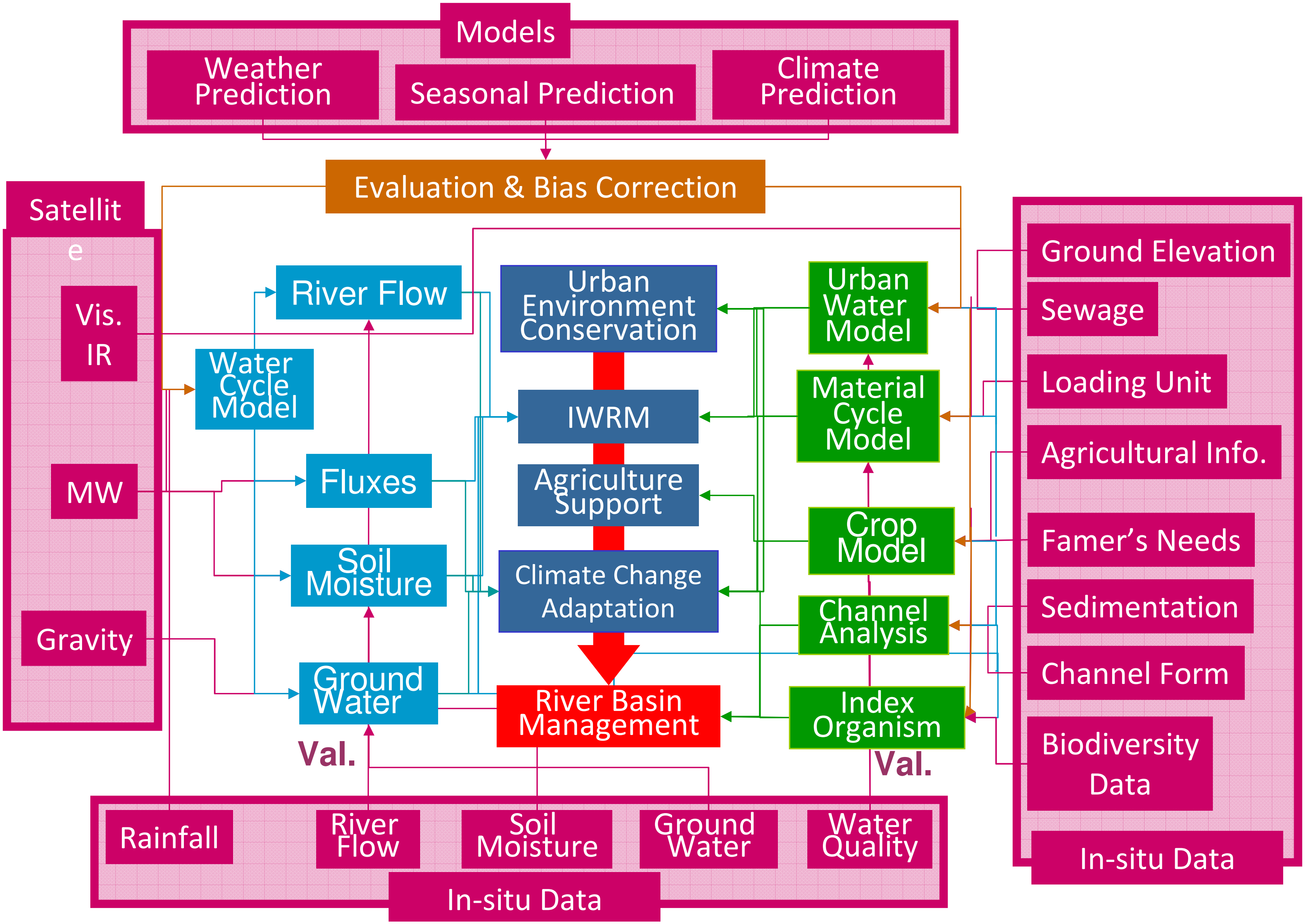


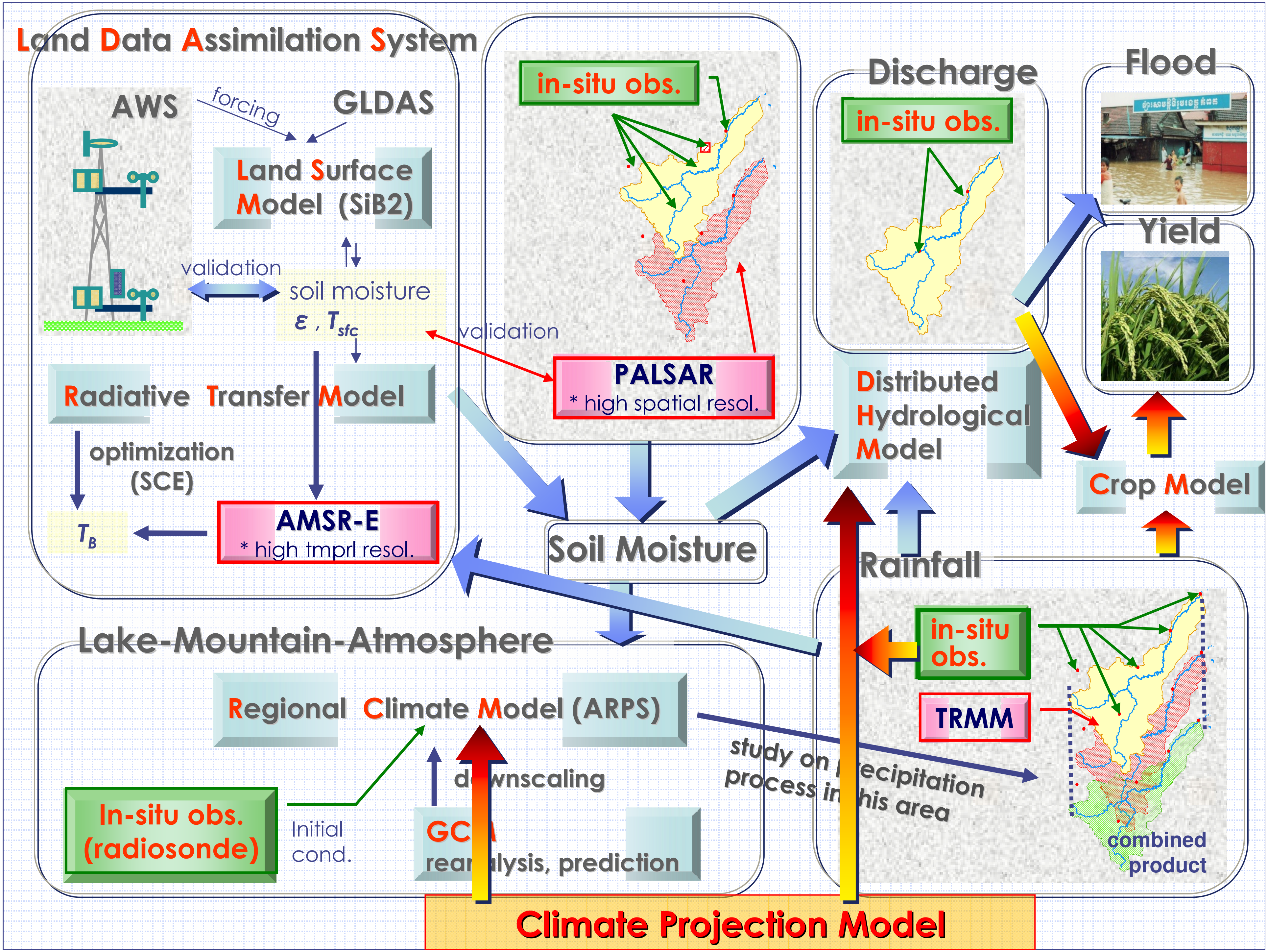
Water is a Key bridging between climate processes and societal benefits.



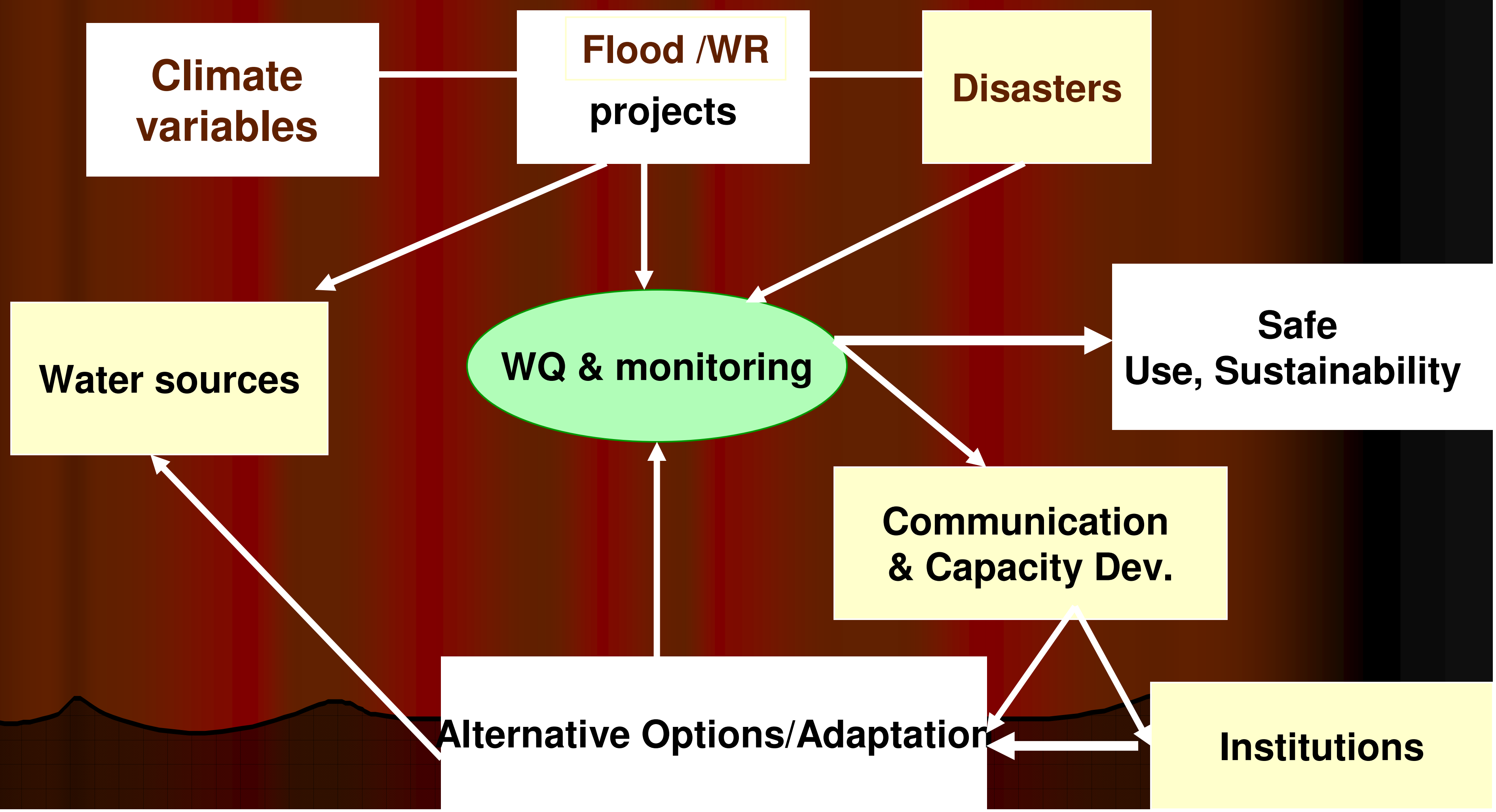
(Richard H. Moss, et al., *Nature*, 2010)

Data Integration & Information Fusion

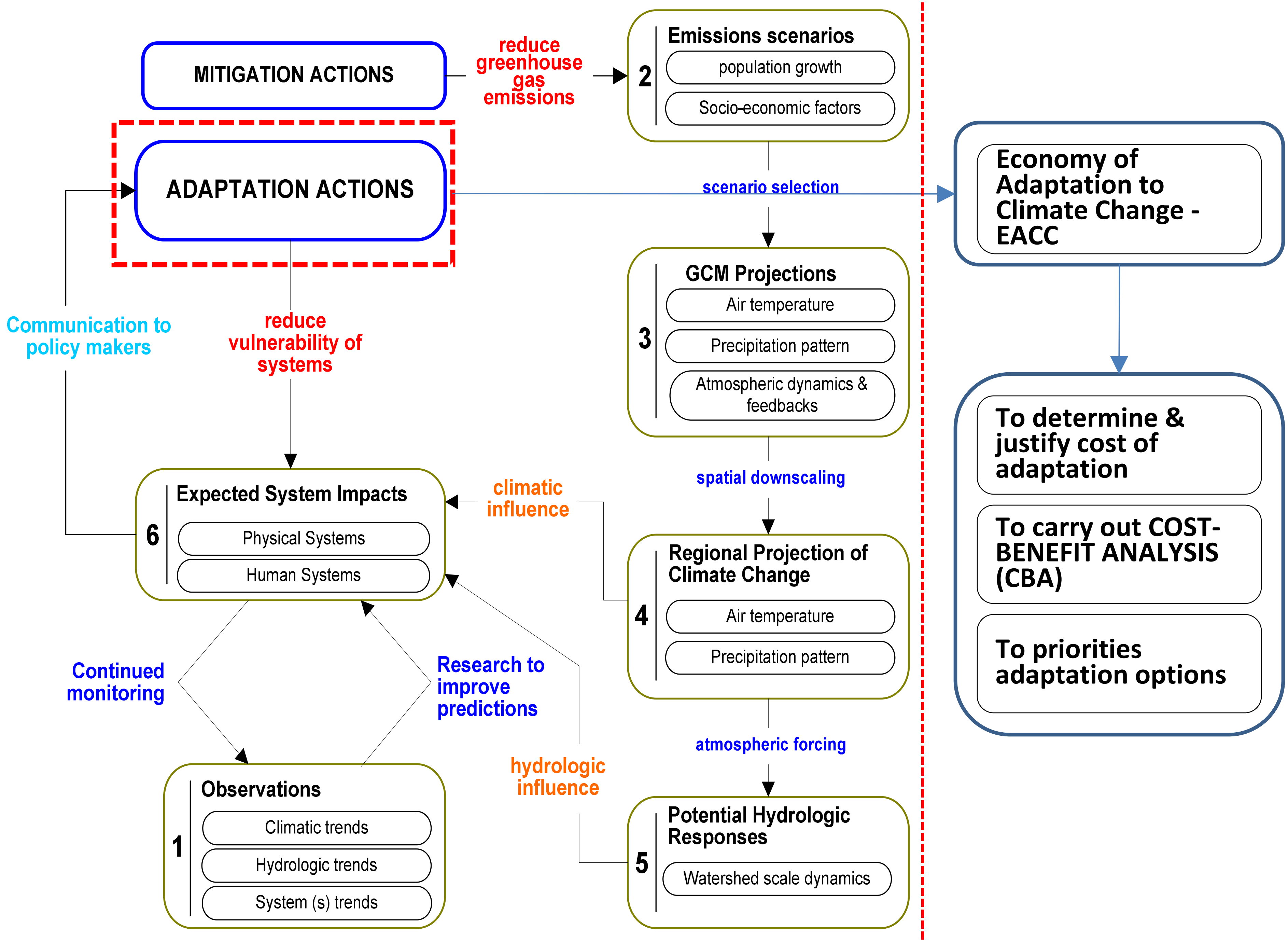



Land Data Assimilation System
AWS
forcing
GLDAS
Land Surface Model (SiB2)
validation
soil moisture
ε , T_{sfc}
Radiative Transfer Model
optimization (SCE)
T_B
AMSR-E
* high tmprl resol.
in-situ obs.
PALSAR
* high spatial resol.
validation
Soil Moisture
Discharge
in-situ obs.
Distributed Hydrological Model
Flood
Yield
Crop Model
Rainfall
in-situ obs.
TRMM
combined product
study on precipitation process in this area
Lake-Mountain-Atmosphere
Regional Climate Model (ARPS)
In-situ obs. (radiosonde)
Initial cond.
downscaling
GCM
reanalysis, prediction
Climate Projection Model

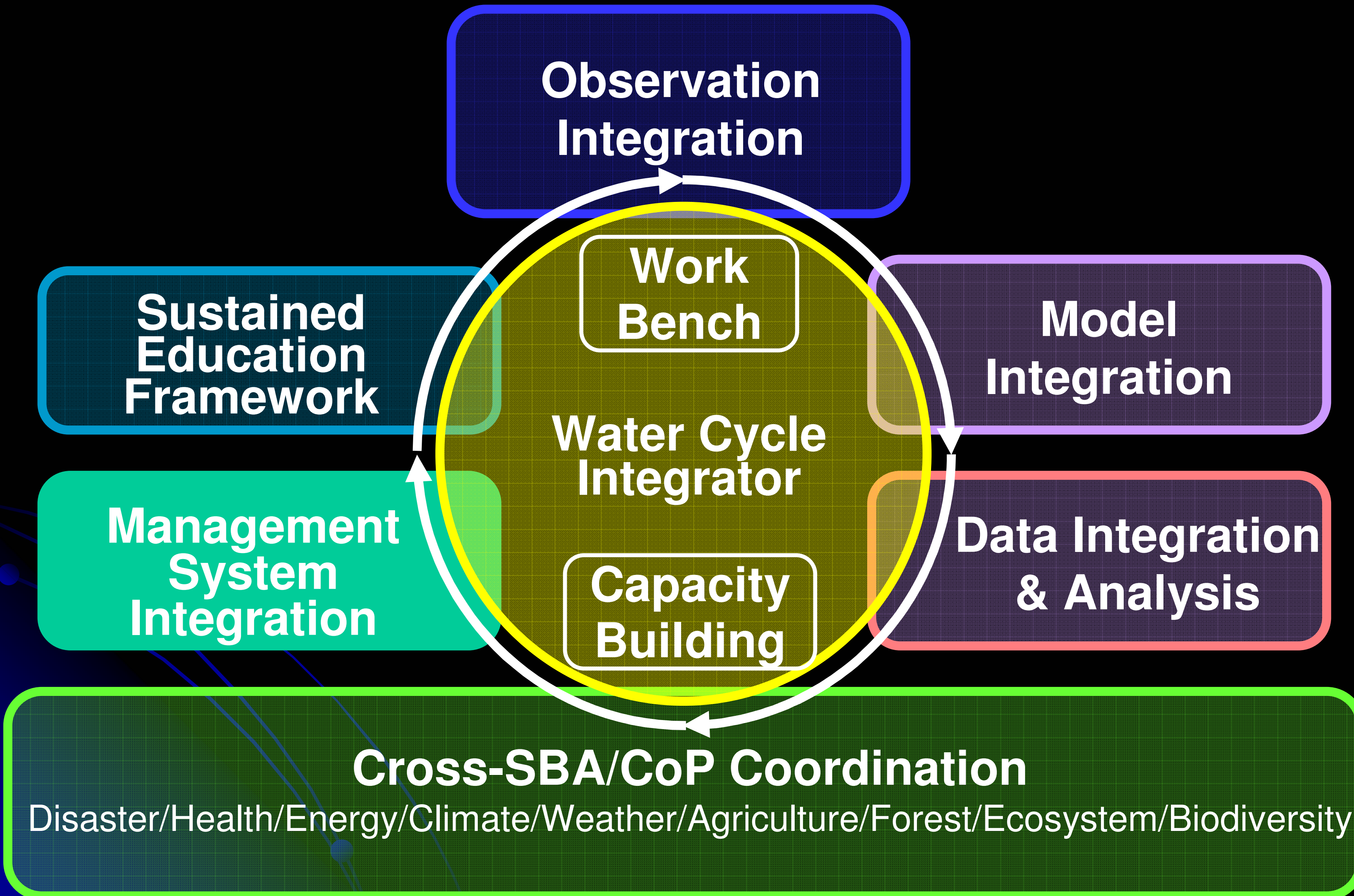
A Way Forward for sustainable IWRM in Bangladesh (A DW based project agreed upon by GOB, ADB and us/EPRC)



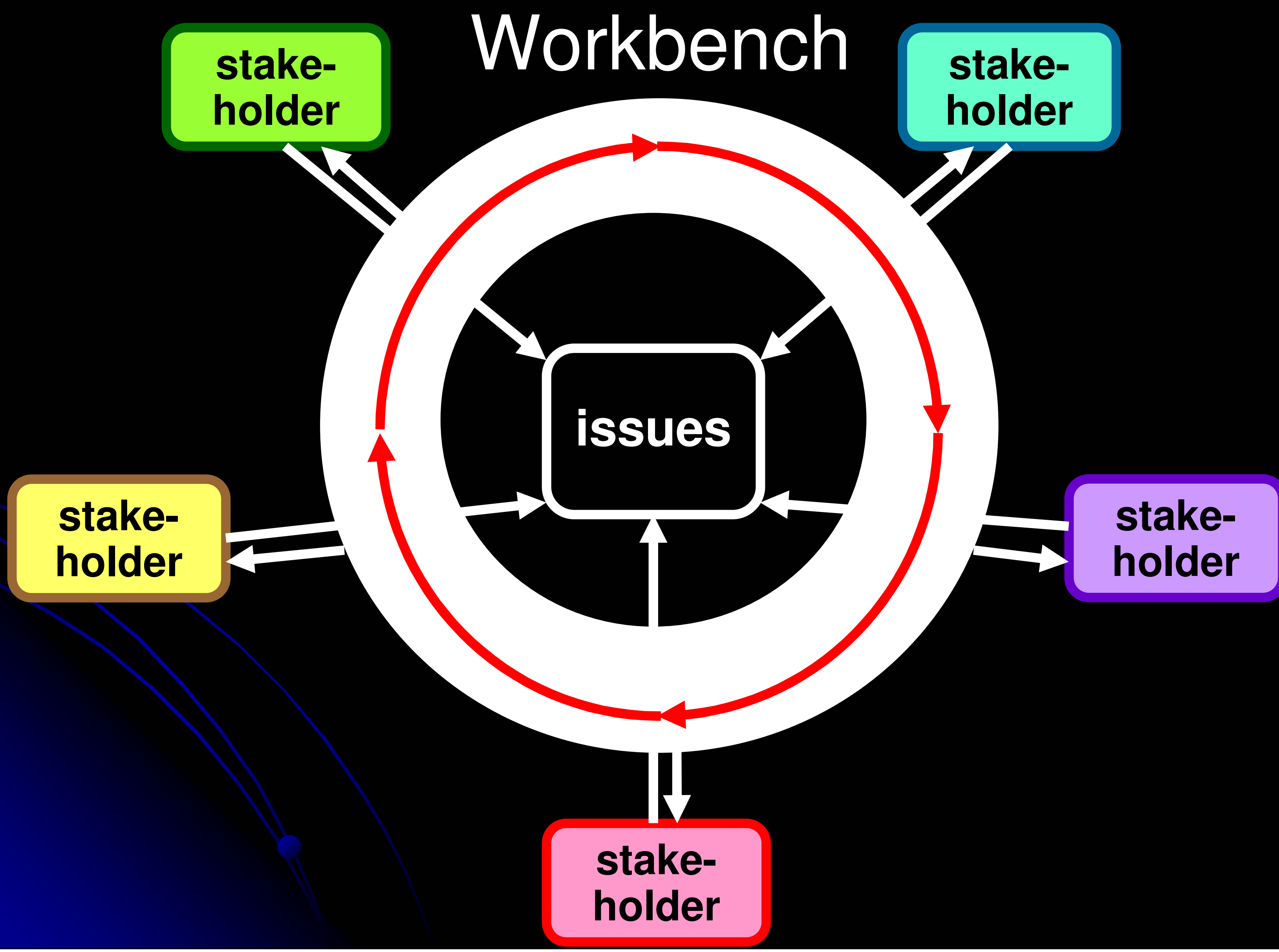
HOW TO TRANSLATE RESEARCH FINDING?

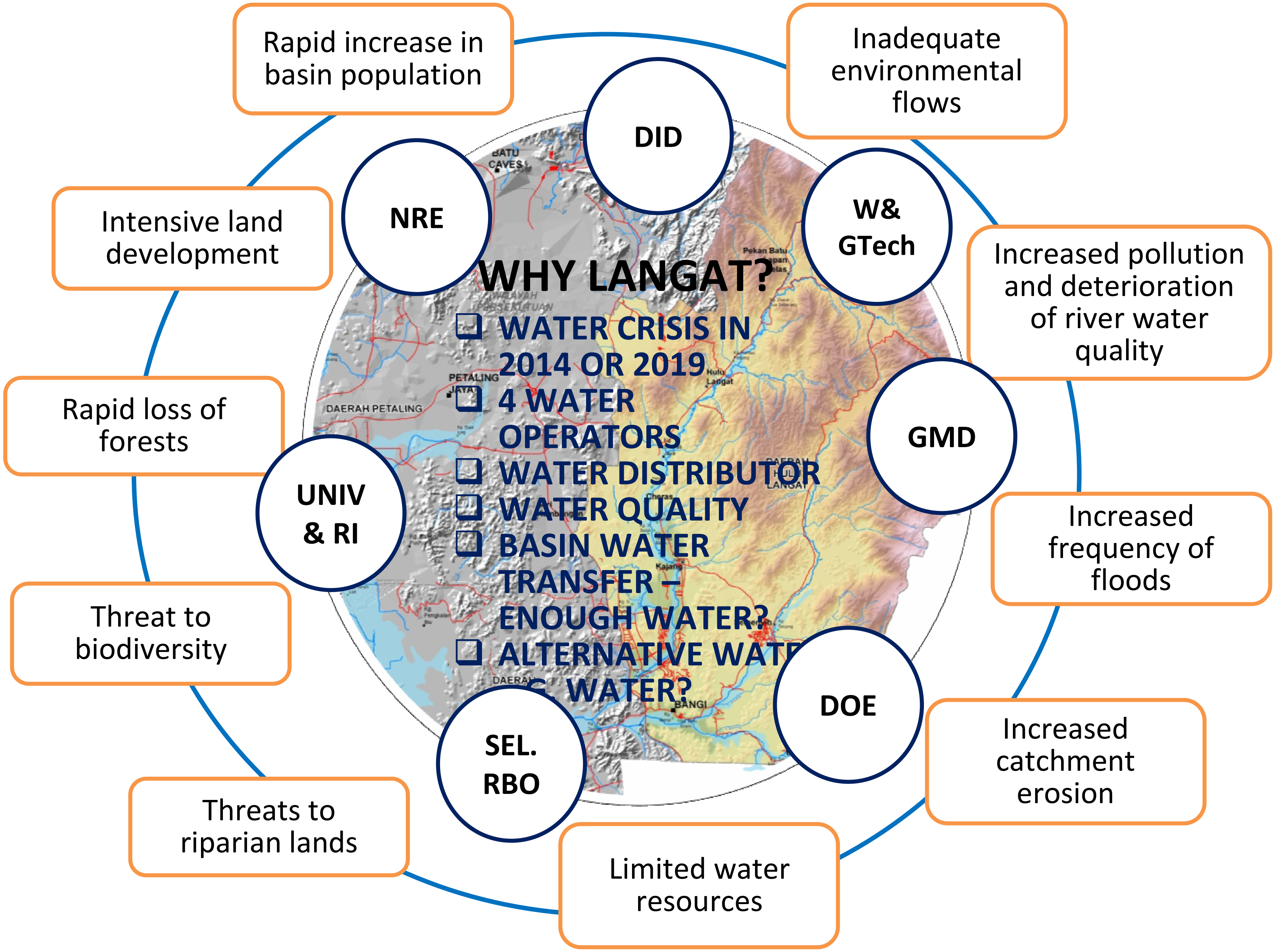


Integrated & Coordinated Approach



Sharing data & information, and working together





GEOSS – WCI WORK BENCH : INTEGRATED & COORDINATED APPROACH

Criterion Weighting by Academics, Farmers, and Local Administrators

Ecological Academics

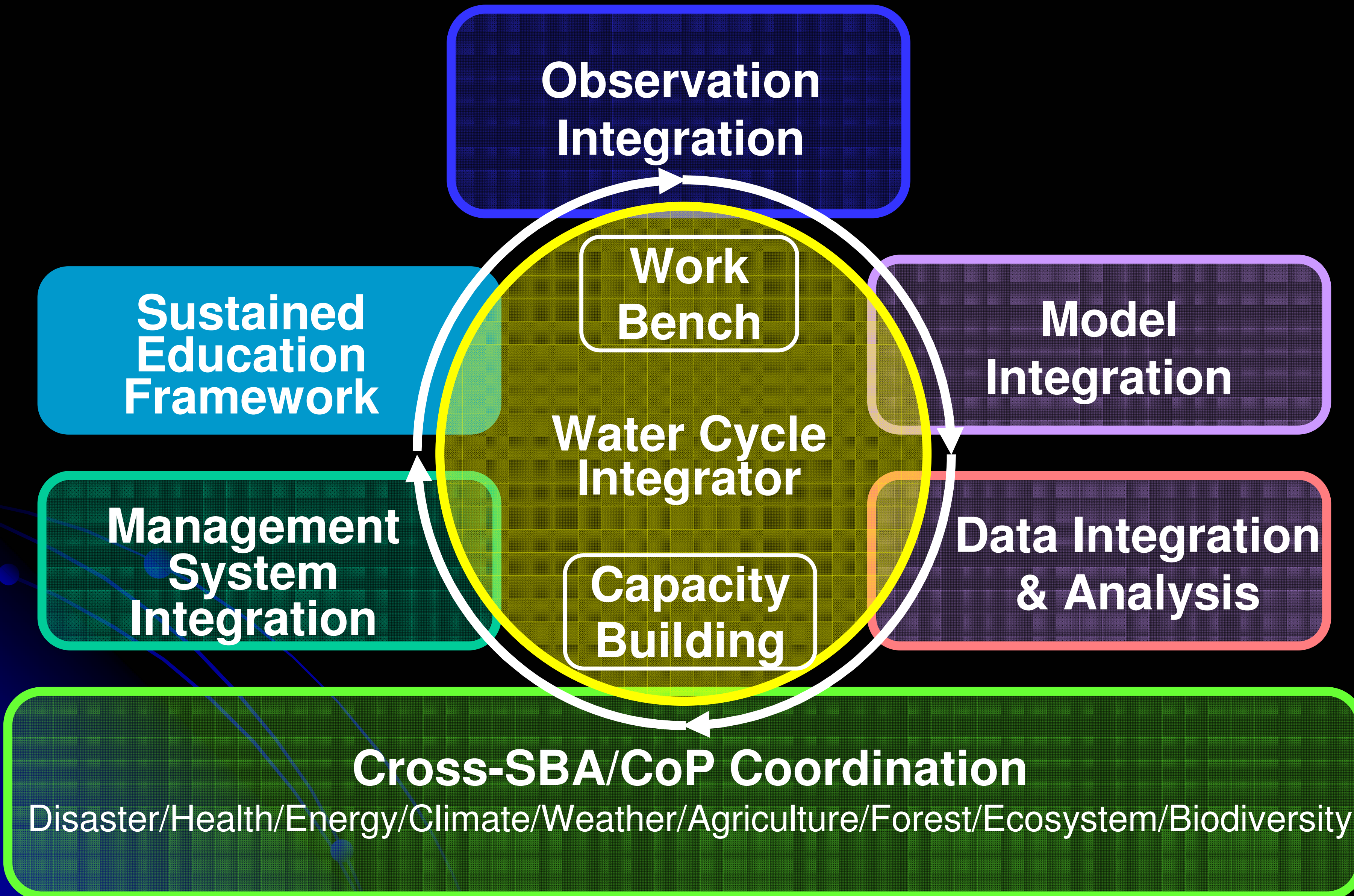
Local Administrators & Officers

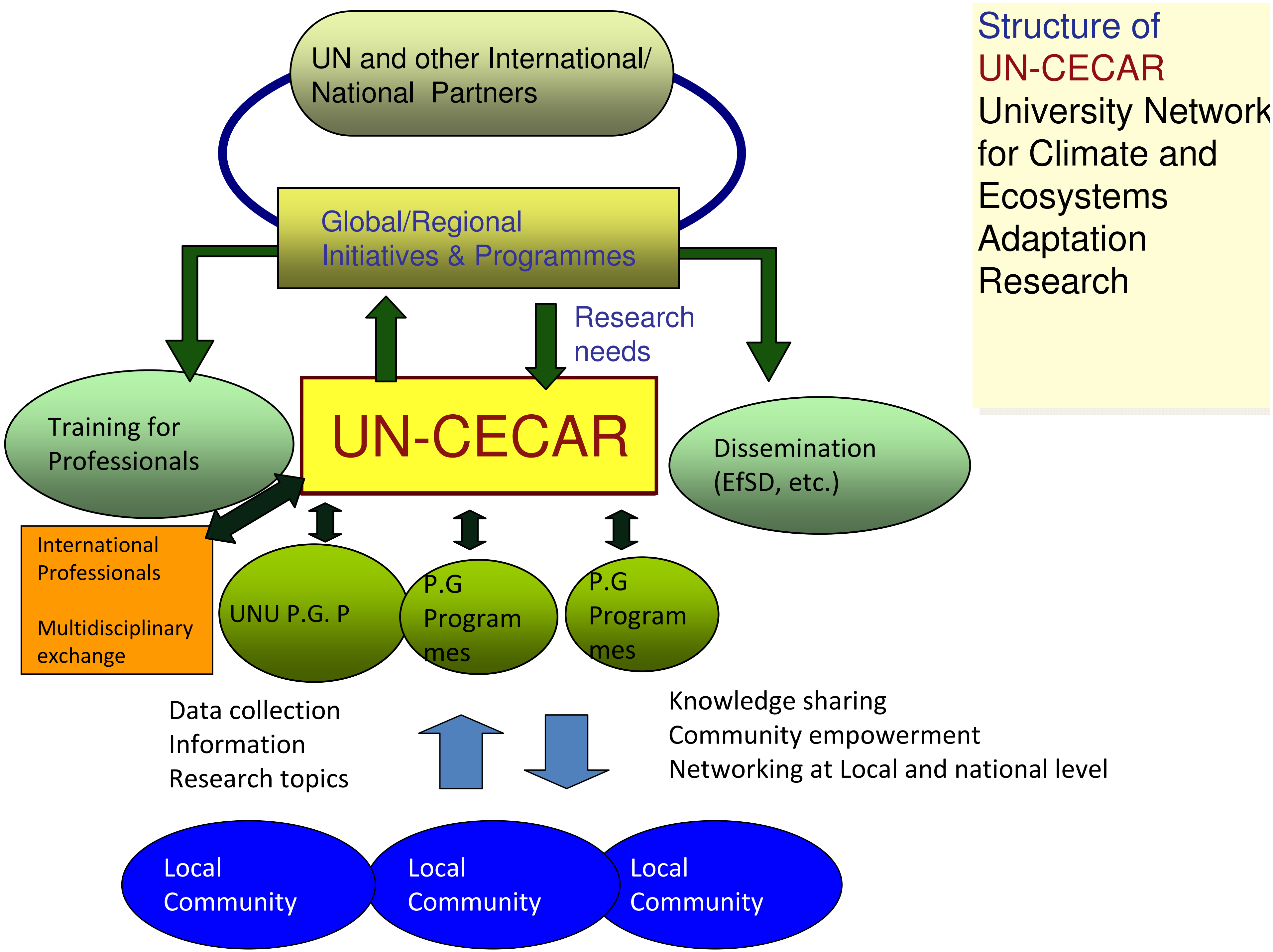
Community Leaders & Farmers

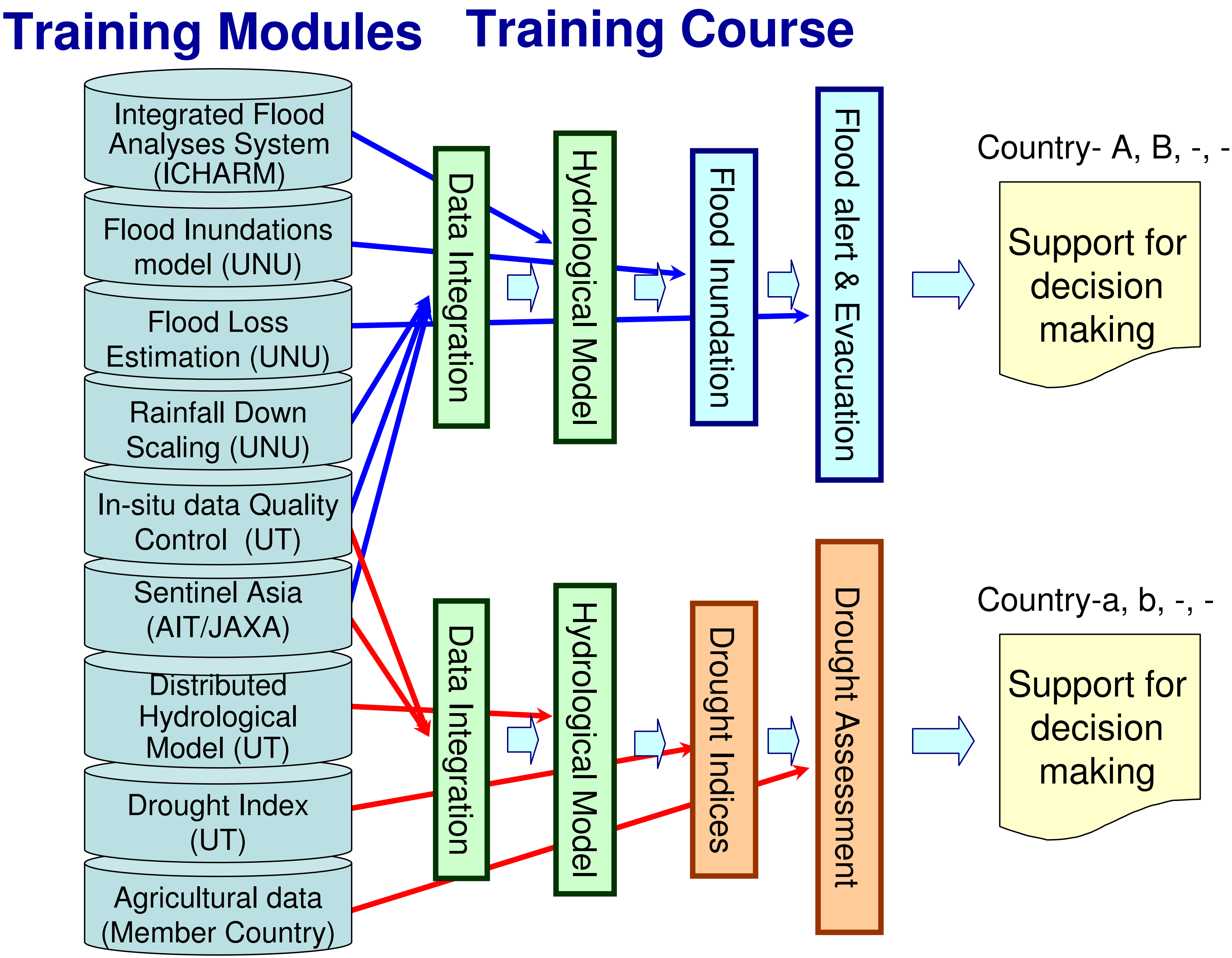
Expectations

- Resolving water shortage and flood issues fundamentally
- Developing a healthy water eco-system through water quality improvement and river restoration project
- Enhancing the standards of community leisure and quality life
- Boosting local economics through the green new deal project

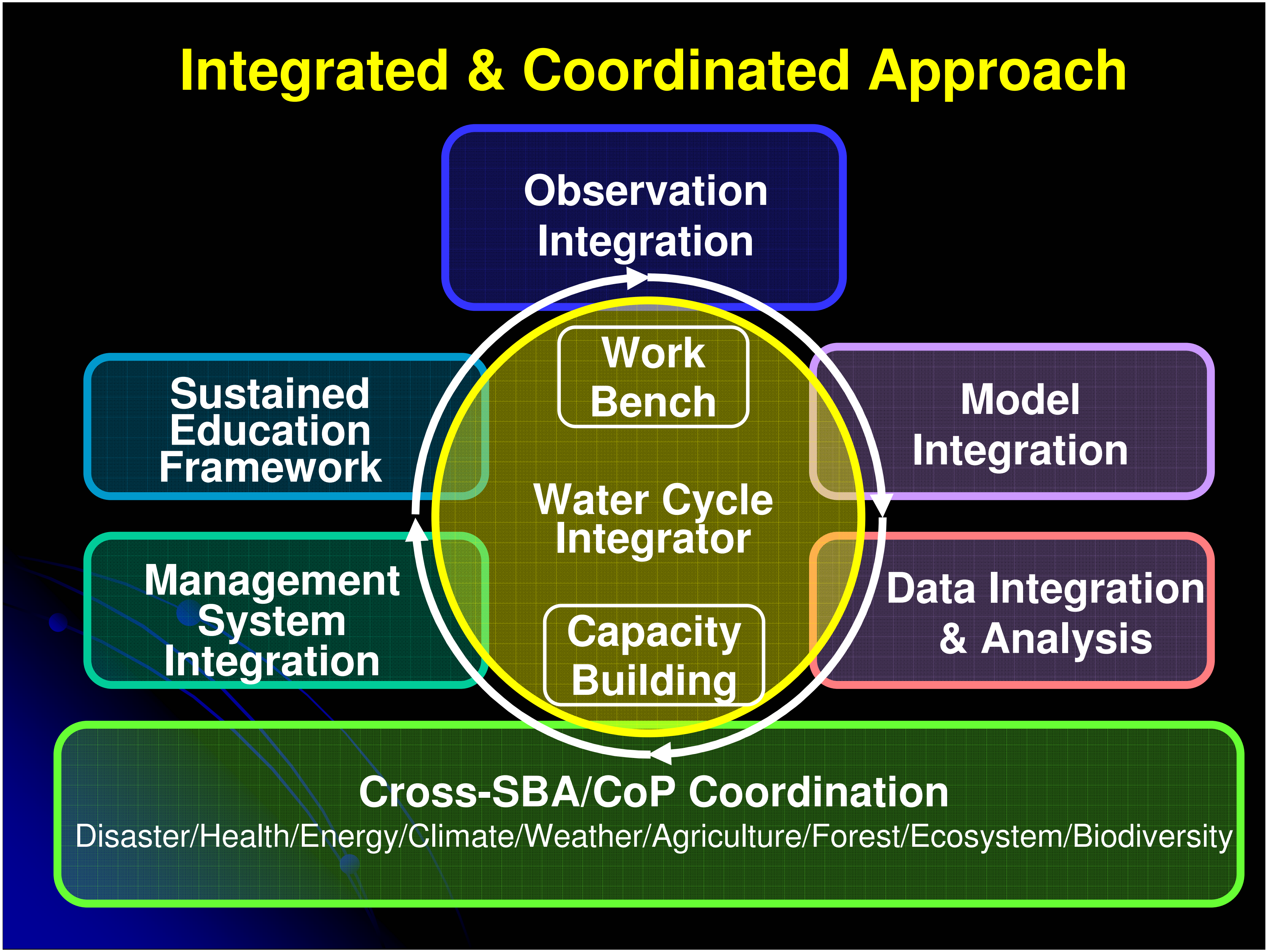
Integrated & Coordinated Approach



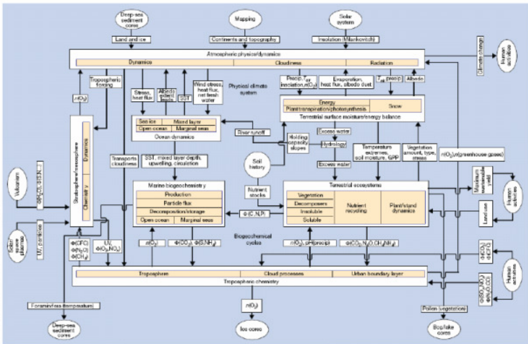

Structure of
UN-CECAR
University Network
for Climate and
Ecosystems
Adaptation
Research
UN and other International/
National Partners
Global/Regional
Initiatives & Programmes
Research
needs
UN-CECAR
Training for
Professionals
Dissemination
(EfSD, etc.)
International
Professionals
Multidisciplinary
exchange
UNU P.G. P
P.G
Program
mes
P.G
Program
mes
Data collection
Information
Research topics
Knowledge sharing
Community empowerment
Networking at Local and national level
Local
Community
Local
Community
Local
Community



Training Modules
Training Course
Integrated Flood Analyses System (ICHARM)
Flood Inundations model (UNU)
Flood Loss Estimation (UNU)
Rainfall Down Scaling (UNU)
In-situ data Quality Control (UT)
Sentinel Asia (AIT/JAXA)
Distributed Hydrological Model (UT)
Drought Index (UT)
Agricultural data (Member Country)
Data Integration
Hydrological Model
Flood Inundation
Flood alert & Evacuation
Country- A, B, -, -
Support for decision making
Data Integration
Hydrological Model
Drought Indices
Drought Assessment
Country-a, b, -, -
Support for decision making

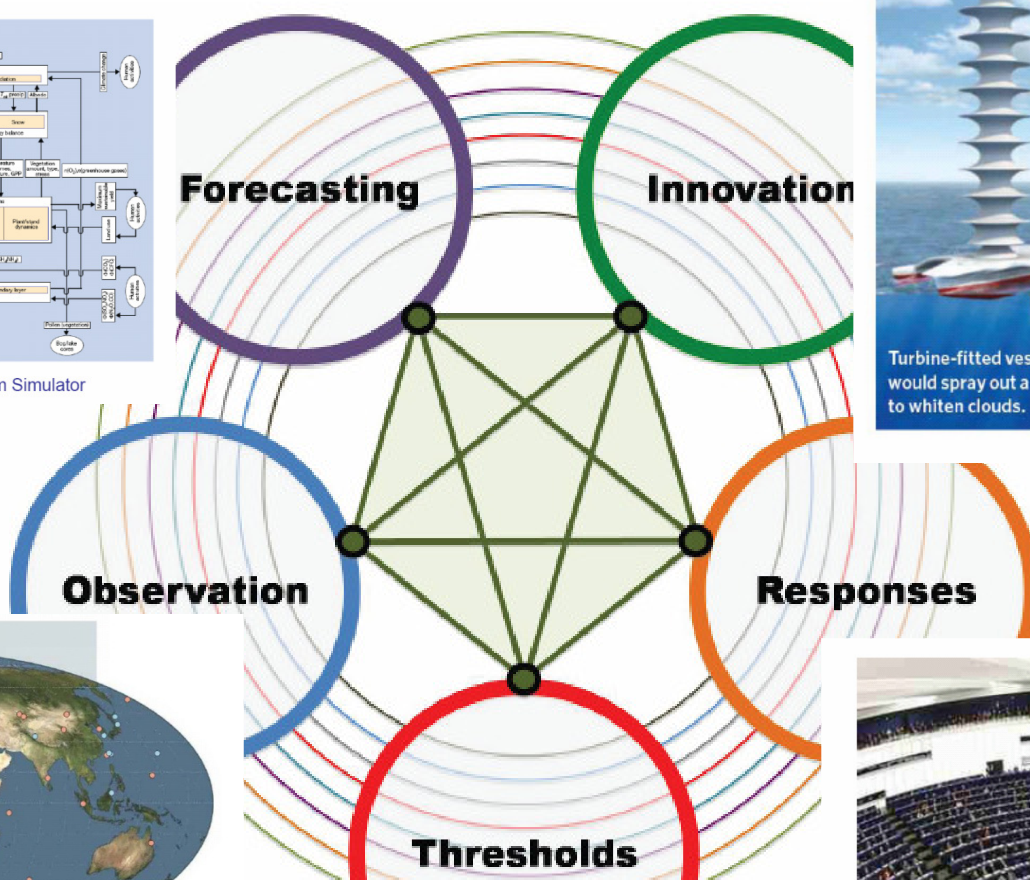

Integrated & Coordinated Approach
Observation Integration
Sustained Education Framework
Model Integration
Work Bench
Water Cycle Integrator
Capacity Building
Management System Integration
Data Integration & Analysis
Cross-SBA/CoP Coordination
Disaster/Health/Energy/Climate/Weather/Agriculture/Forest/Ecosystem/Biodiversity

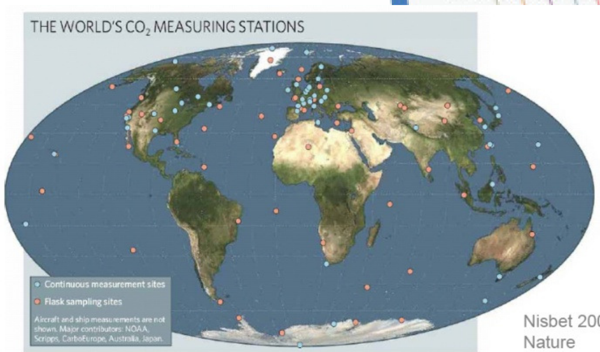
Grand Challenges



Schellnhuber 1999 Nature

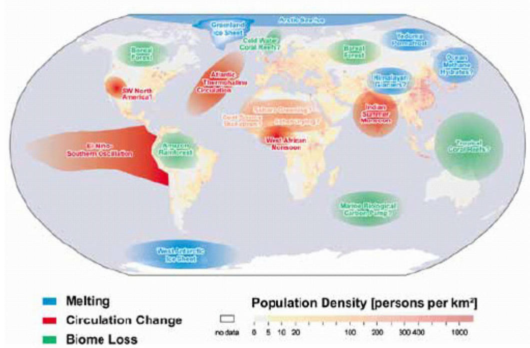
"Wiring diagram" (1985) → Earth System Simulator





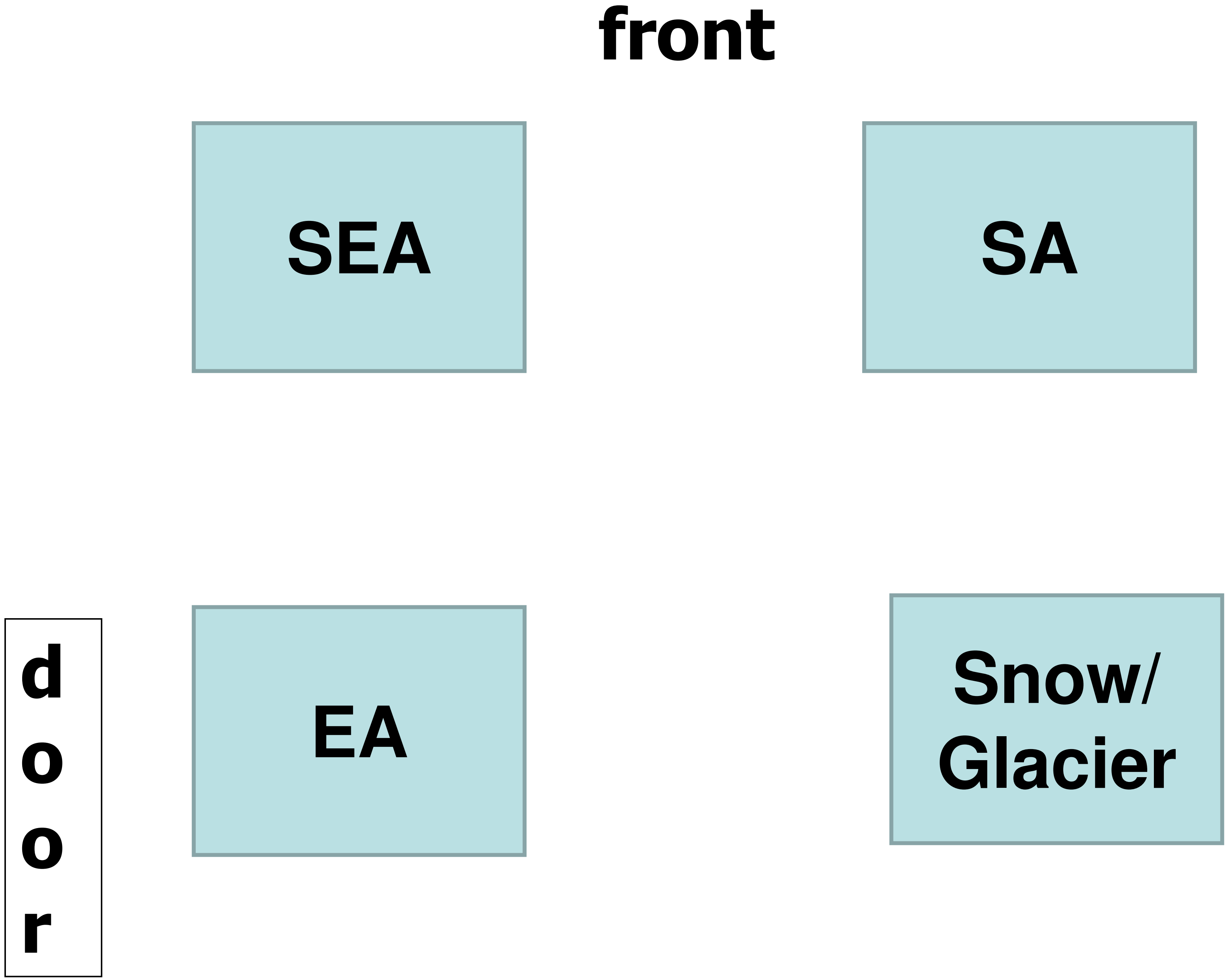
Nisbet 2007 Nature

G



after Lenton et al. 2008

Earth Governance


front
SEA
SA
door
EA
Snow/
Glacier