The AWCI training for the Climate Change Assessment and Adaptation study (AWCI/CCAA), 18-20 June 2013, Tokyo, Japan

Department of Civil Engineering, The University of Tokyo: 9:30-18:00, 10 June 19, 2013

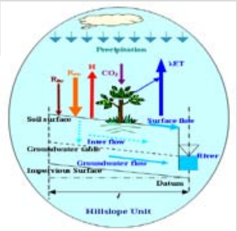
Hydrological Modeling (WEB-DHM) for the AWCI/CCAA Climate Change Impact Assessment studies

Focus: Floods and Droughts

THE UNIVERSITY OF TOKYO

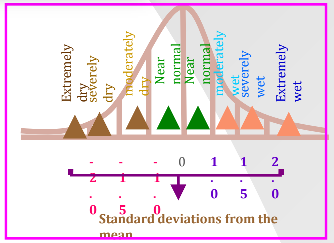
For more information contact: patricia@hydra.t.u-tokyo.ac.jp

June 19, 2013



1. Introduction of the WEB-DHM hydrological model

2. How to run the hydrological model with long-term forcing data (past and future)



3. Drought Indices Training

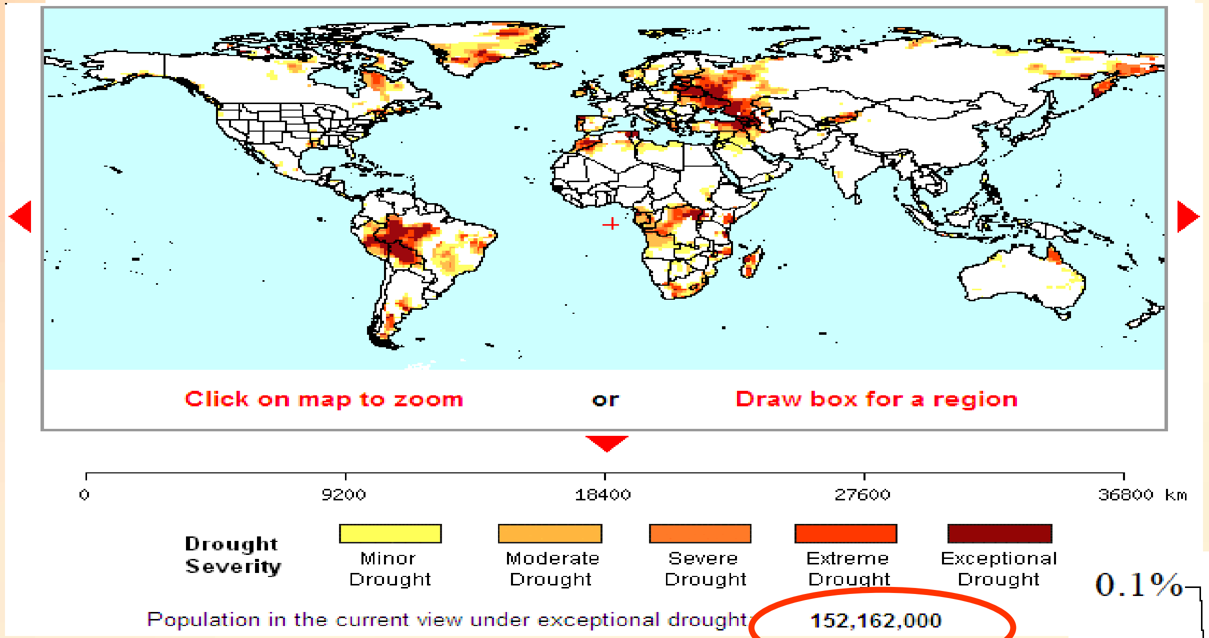
4. Interactive discussions between the CCAA participants with our UT team (*Patricia, Shrestha, Thanda, Asif, Peter*)

June 20, 2013

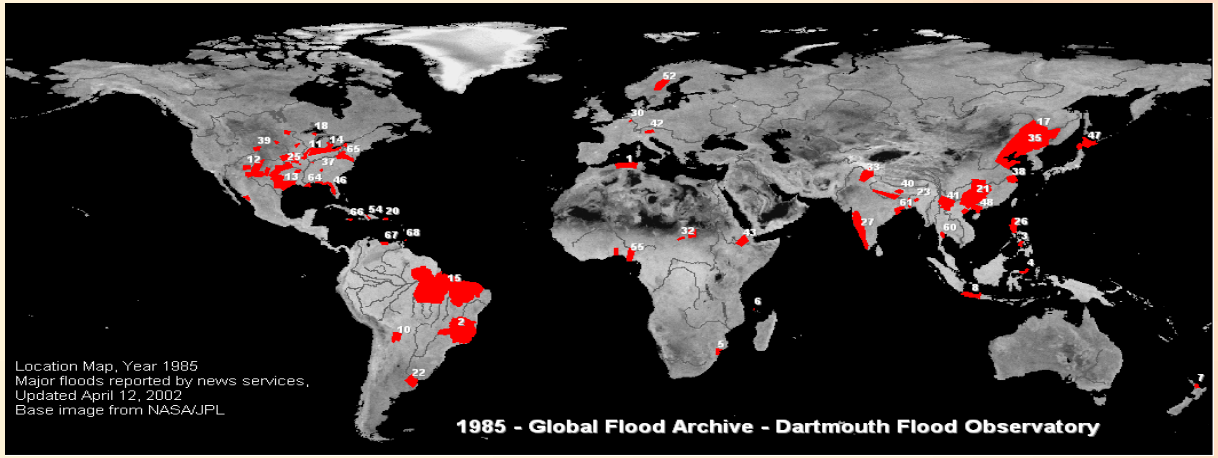
- ❑ How to analyze the simulated long-term discharge: by identifying the occurrence of floods and droughts.

Past

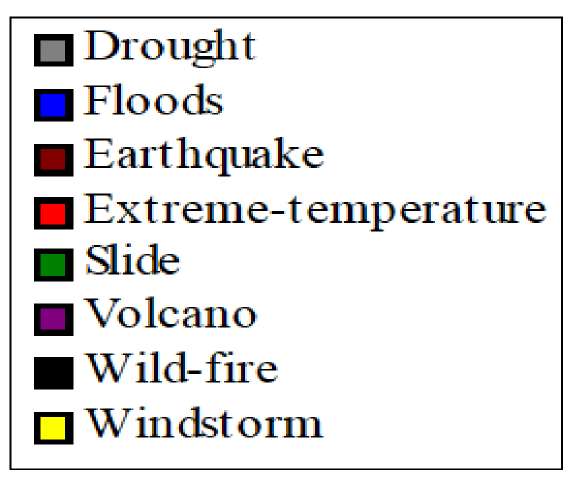
Global Drought (September 2010)

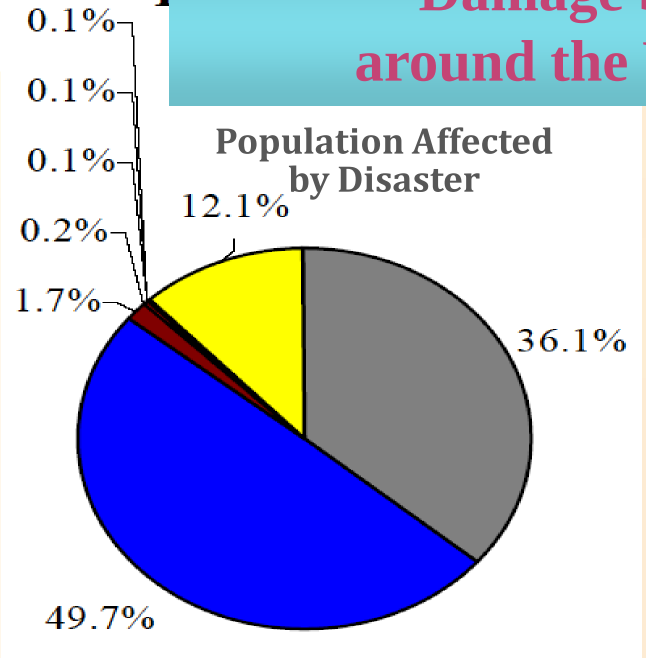


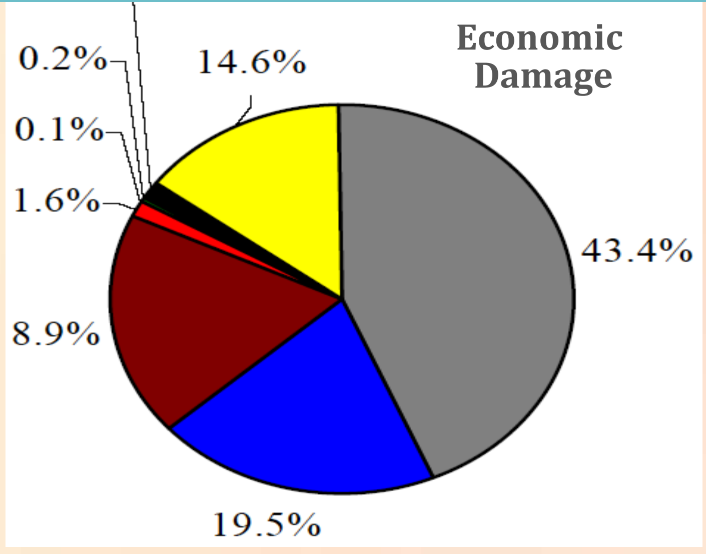
Global Flood Events (1985-2006)



Damage by Natural Disasters around the World in Last 28 Years

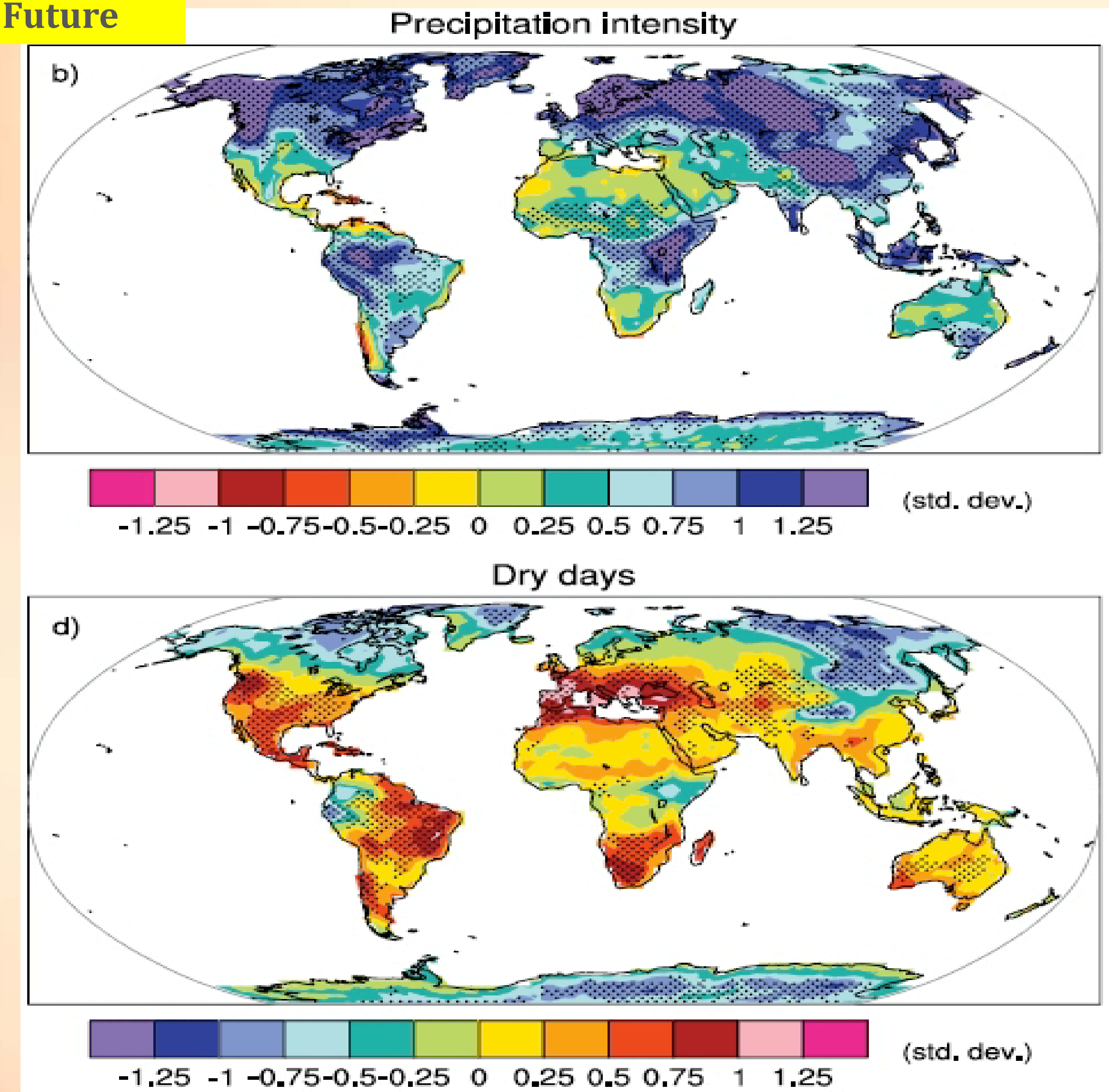






Future

IPCC AR4



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

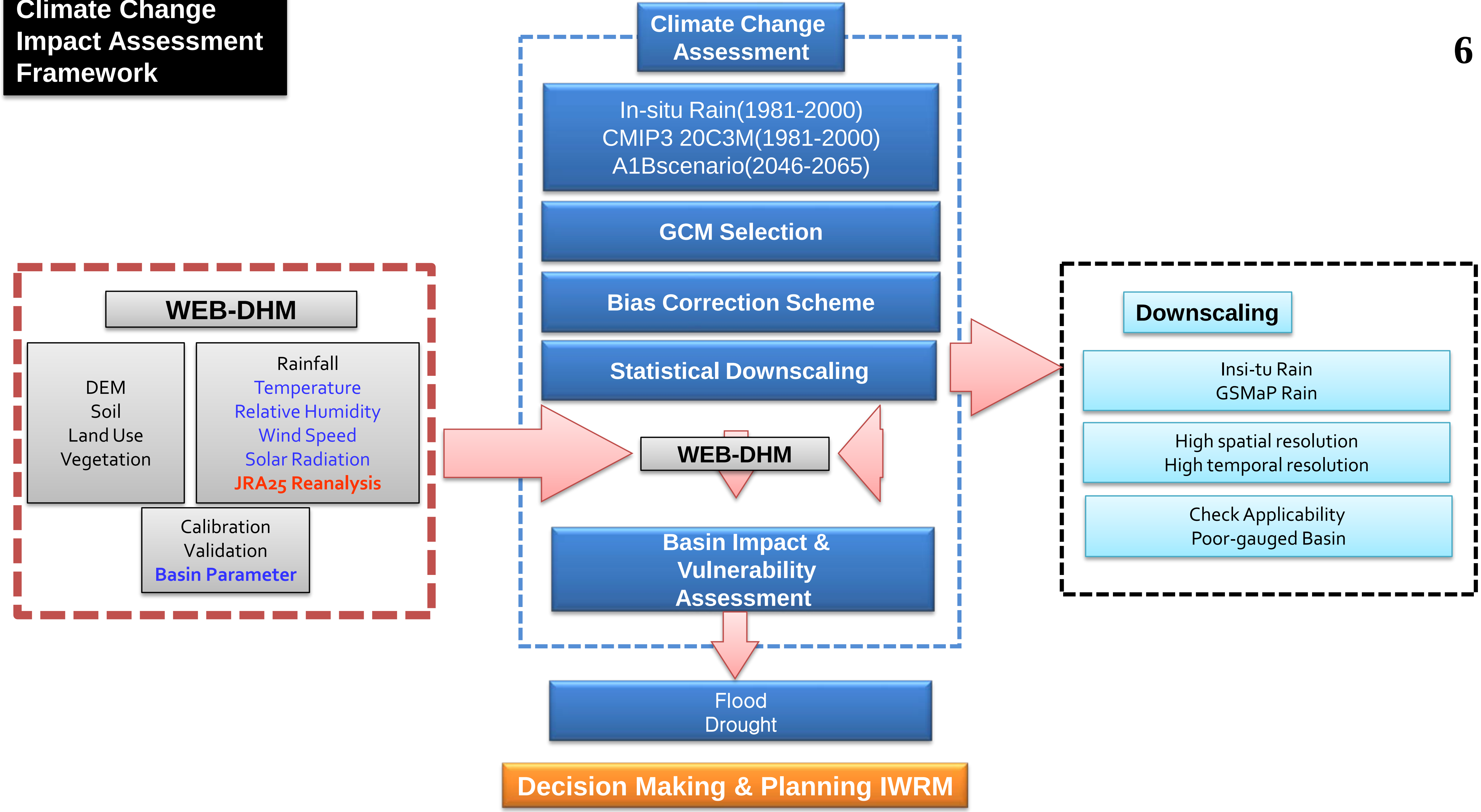
> 90 %

Projected changes in extremes

It is *likely* that area affected by drought will increase.

> 67 %

Climate Change Impact Assessment Framework



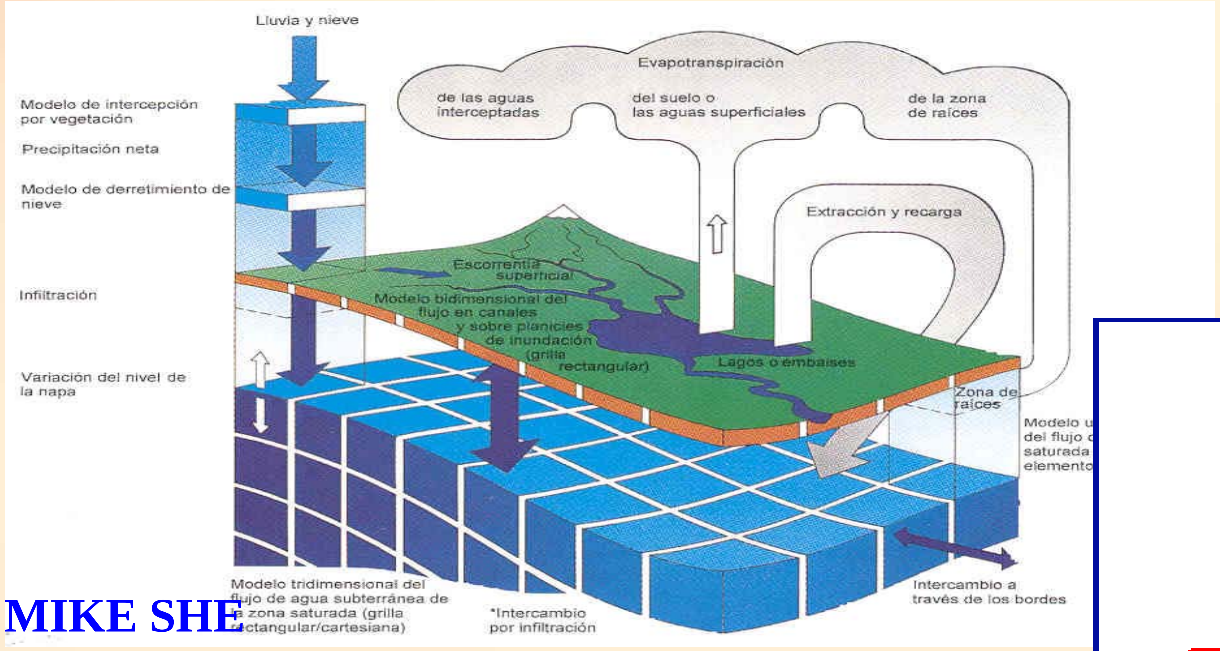
CMIP3 : Coupled Modeled Intercomparison Project Phase-3

20C3M : 20th Century Numerical Reproductive Experiment

Distributed Hydrological Models (DHMs)

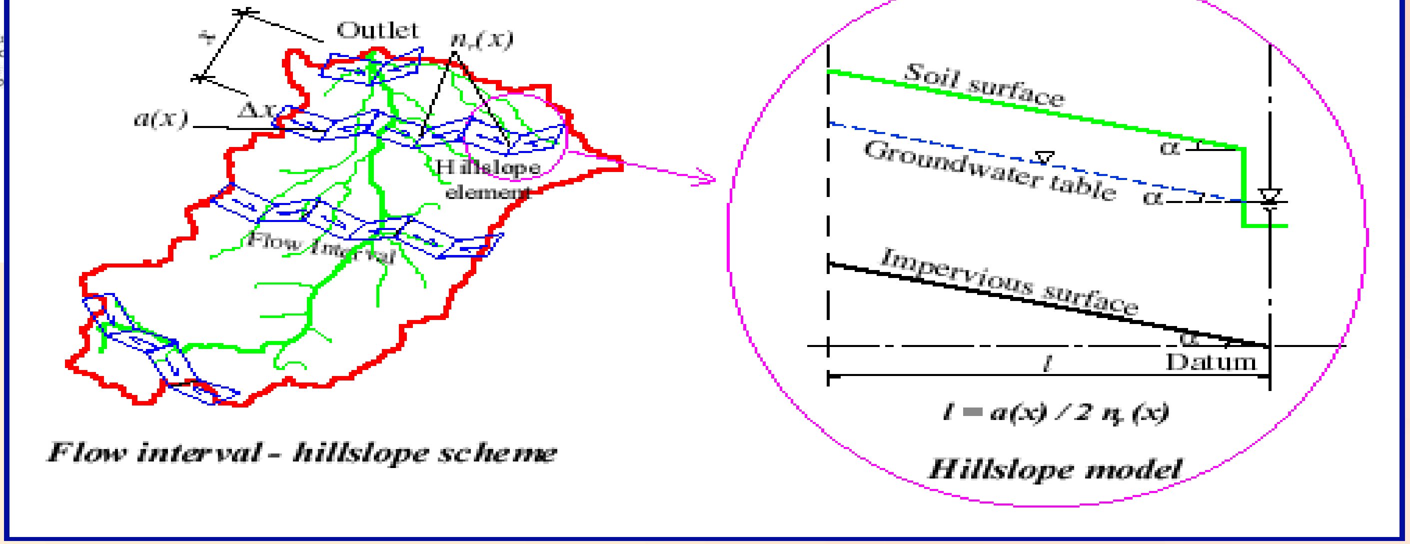
❖Distributed representation of spatial variation and physical descriptions of hydrological processes.

❑ Effective in water resources estimation.



MIKE SHE

GBHM

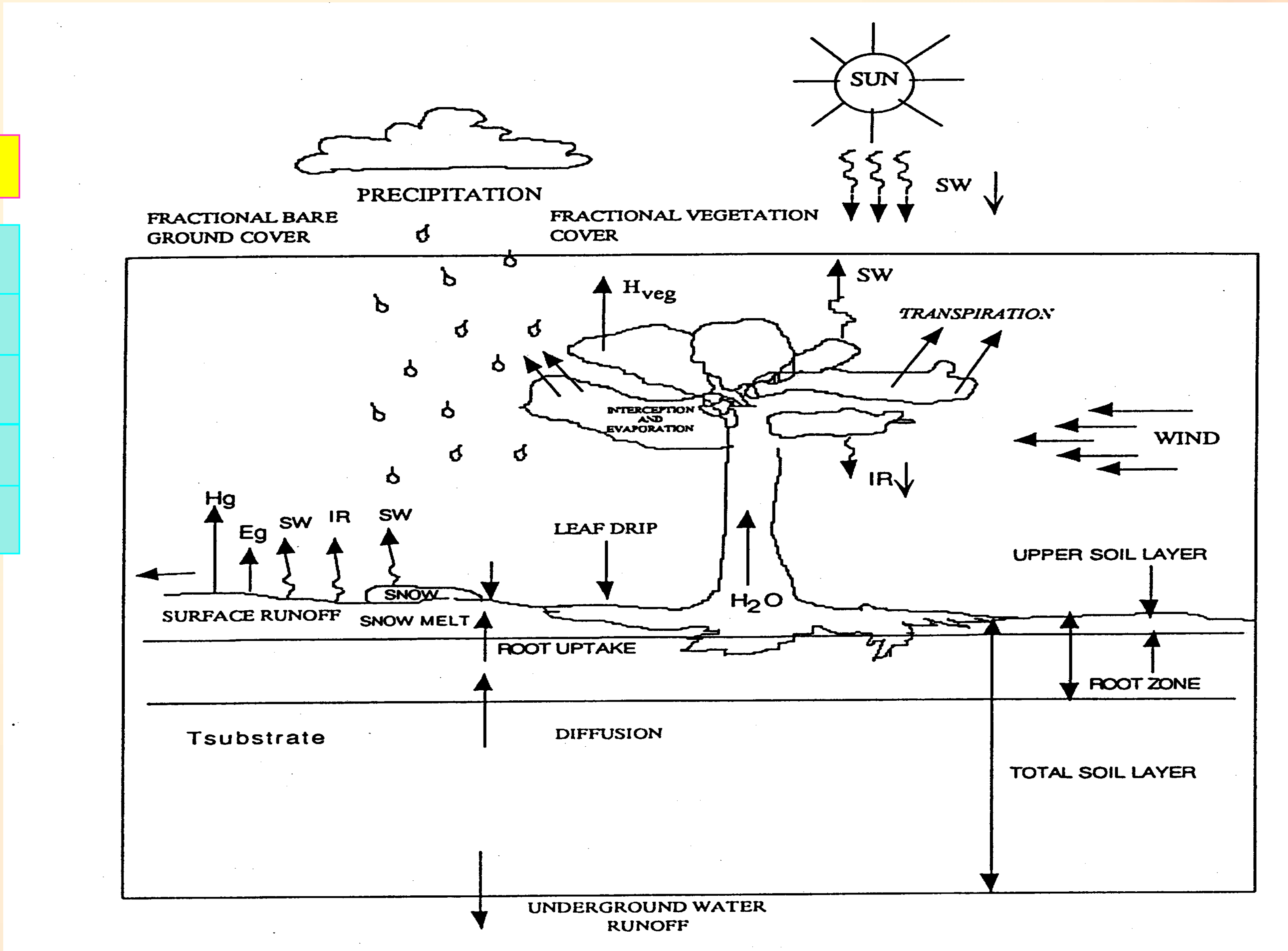


Weakness of Traditional DHMs (no energy balance):

Lack of credible descriptions for land-atmosphere interactions

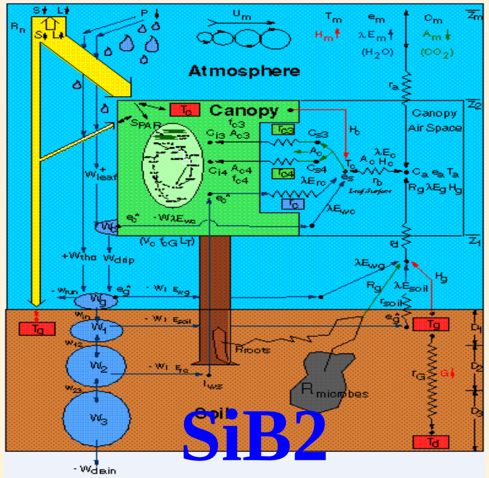
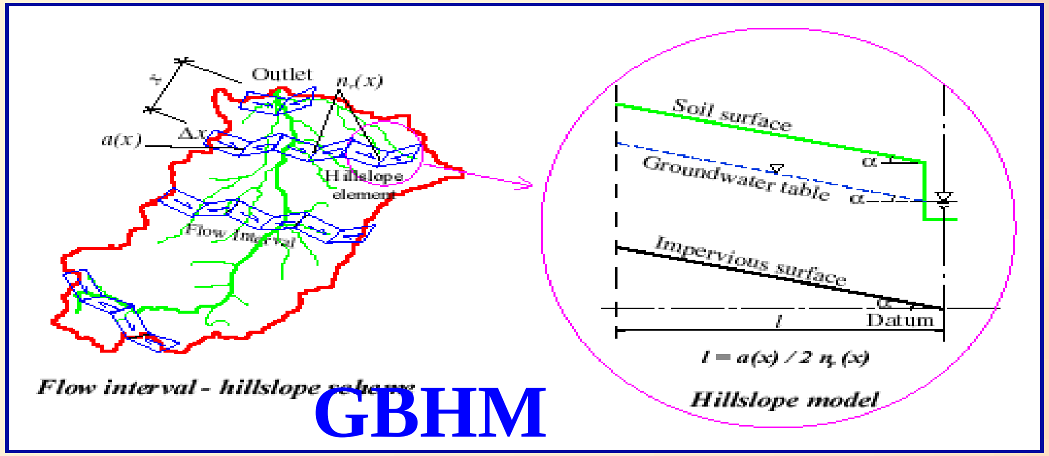
❑Flux:

- ➢Radiation
- ➢Heat
- ➢Water vapor
- ➢Momentum
- ➢Carbon Exchange



SiB2

With advanced physics

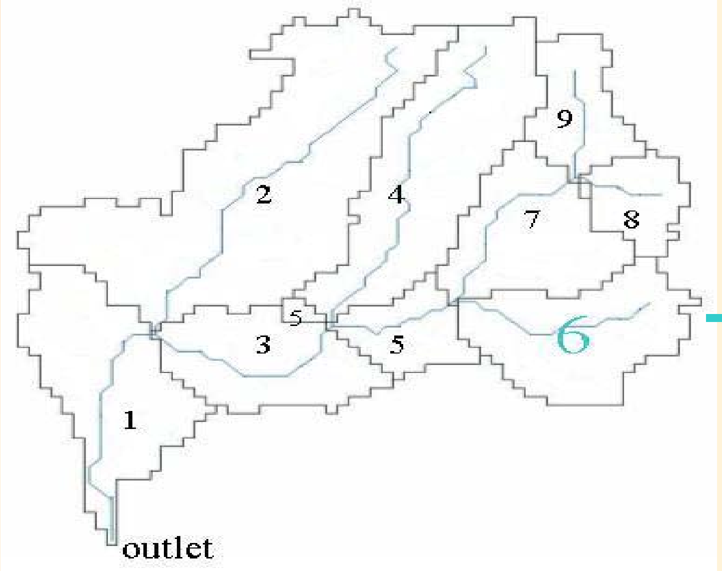
	Land Surface Models		Distributed Hydrological Models
Representative			
Merit	➢Good representation of water and energy fluxes in SVAT system; ➢Prediction of photosynthesis and respiration. SVAT=soil vegetation atmosphere transfer	Couple ⟷	➢Distributed representation of the spatial variation; ➢Slope-driven runoff generation and River Routing; ➢Groundwater dynamics.
Demerit	**1-D scheme, not consider:** ➢Sub-grid topography; ➢Lateral Runoff; ➢Groundwater dynamics.	**Remove** ✕	**Have large uncertainties in simulating** ➢Evapotranspiration (ET); ➢Evolution of soil moisture.

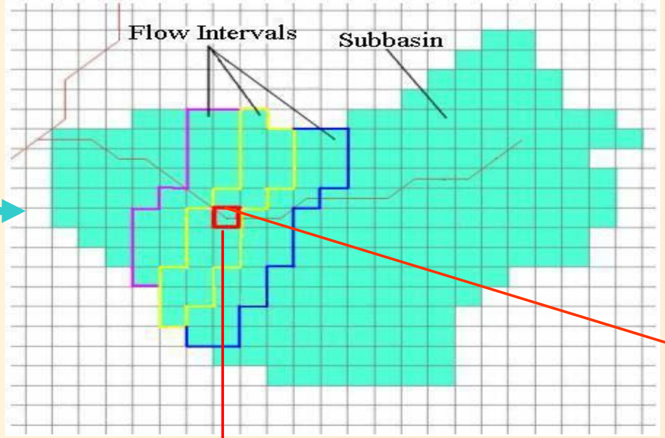
Wang, 2007, PhD thesis

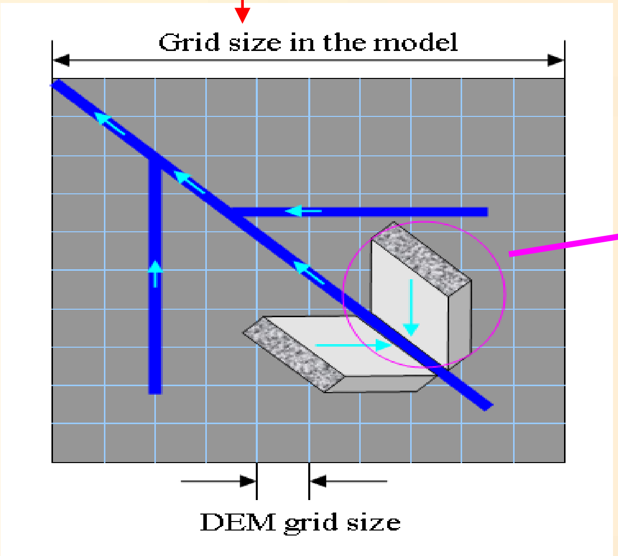
Wang, Koike et al., JGR, 2009

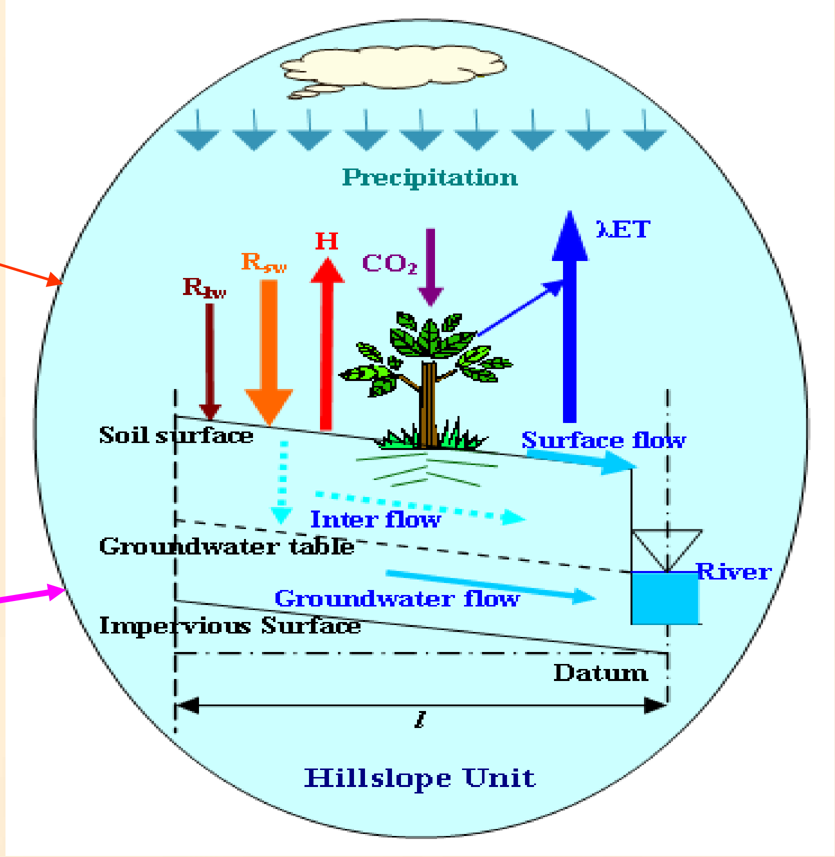
WEB-DHM

(Water and Energy Budget-based Distributed Hydrological Model)



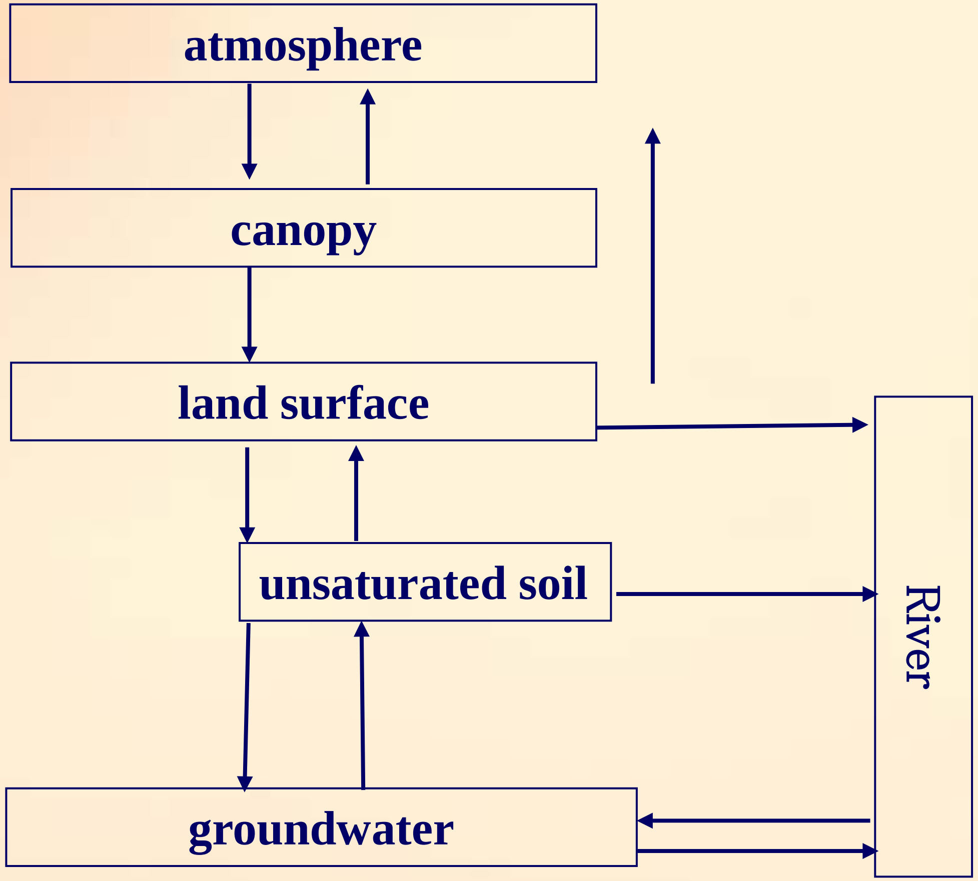


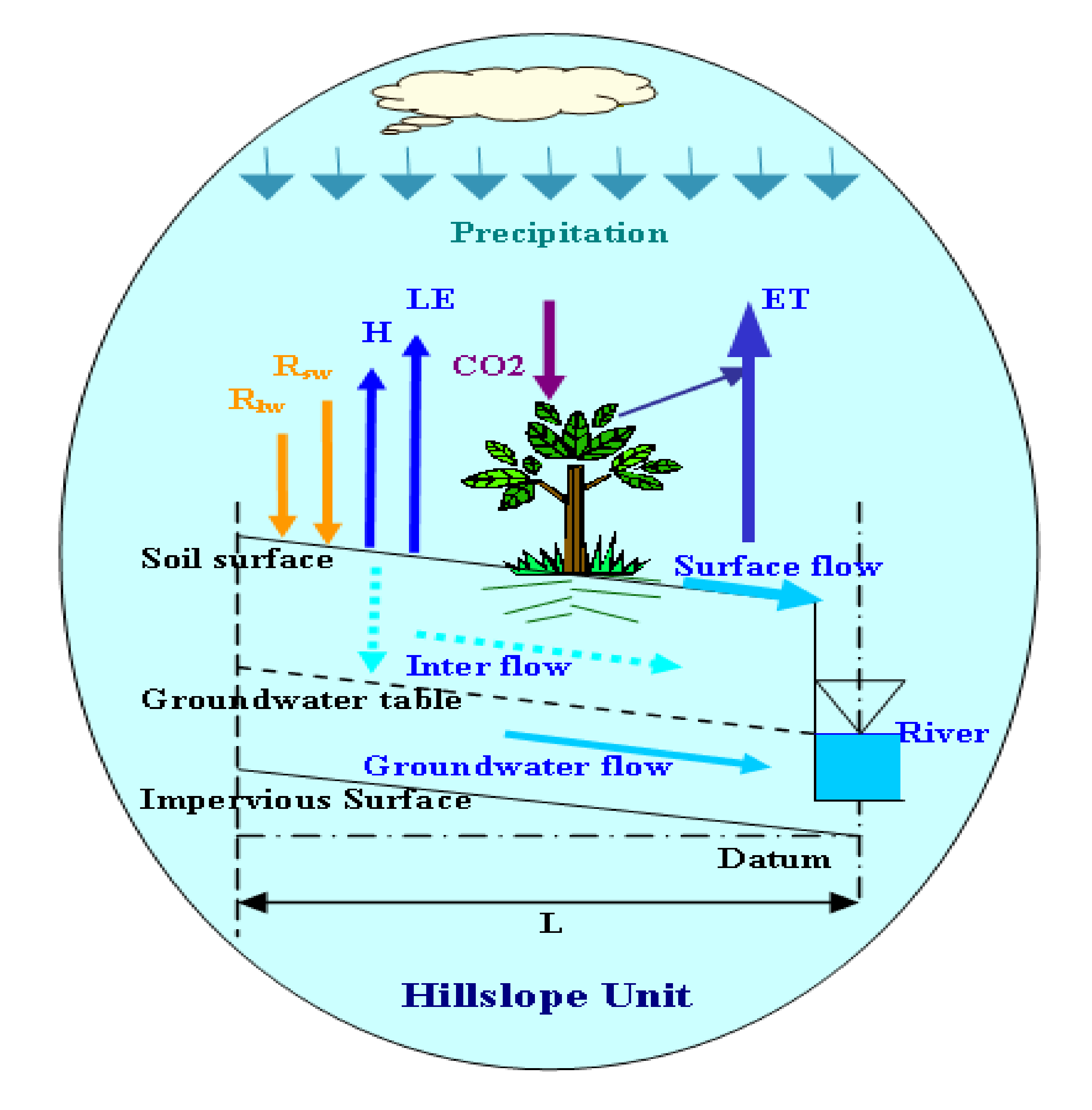




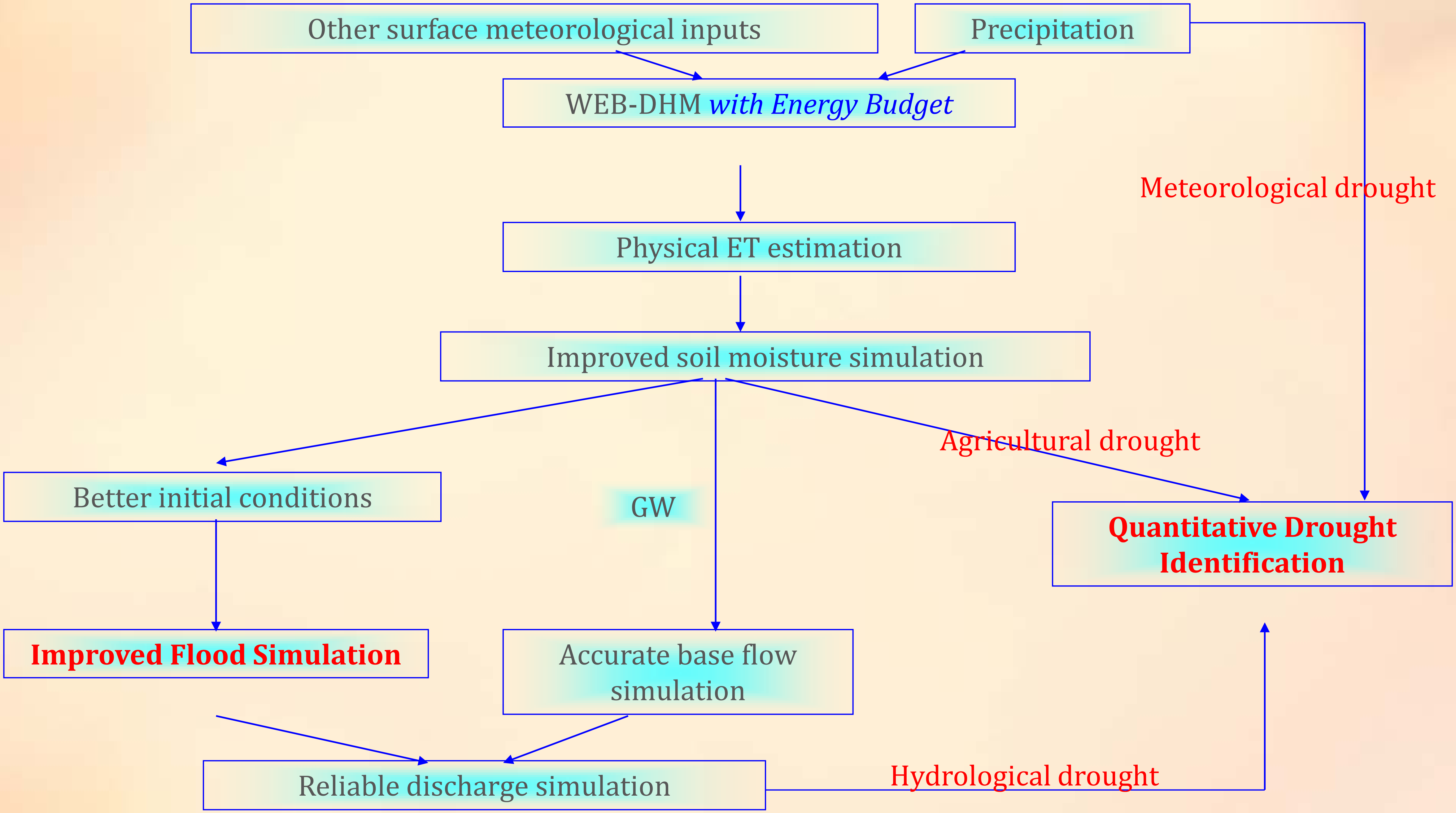
Slope length and angle are preprocessed from fine DEM

Processes Description





WEB-DHM is a solution for flood and drought

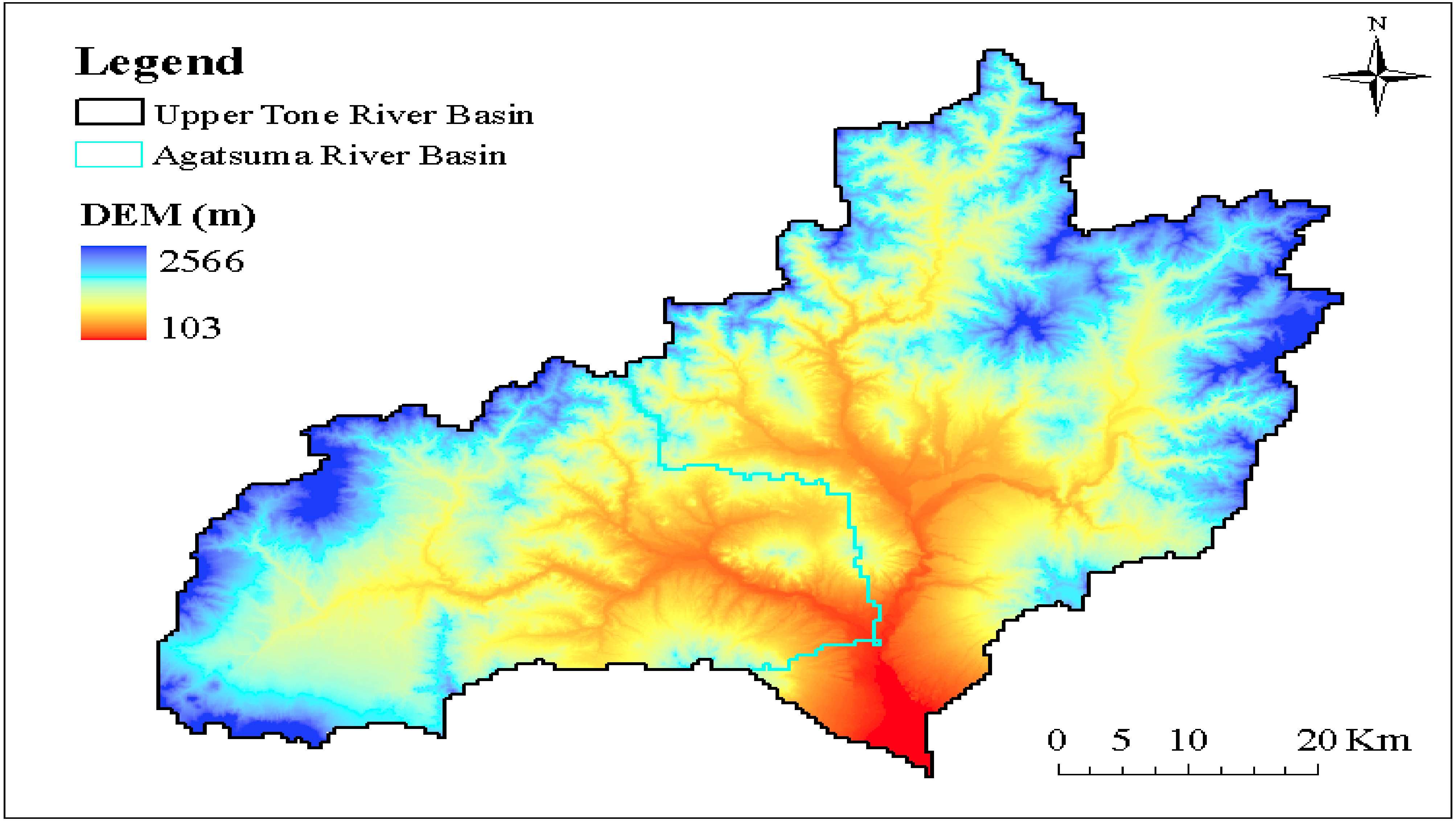


Model Inputs

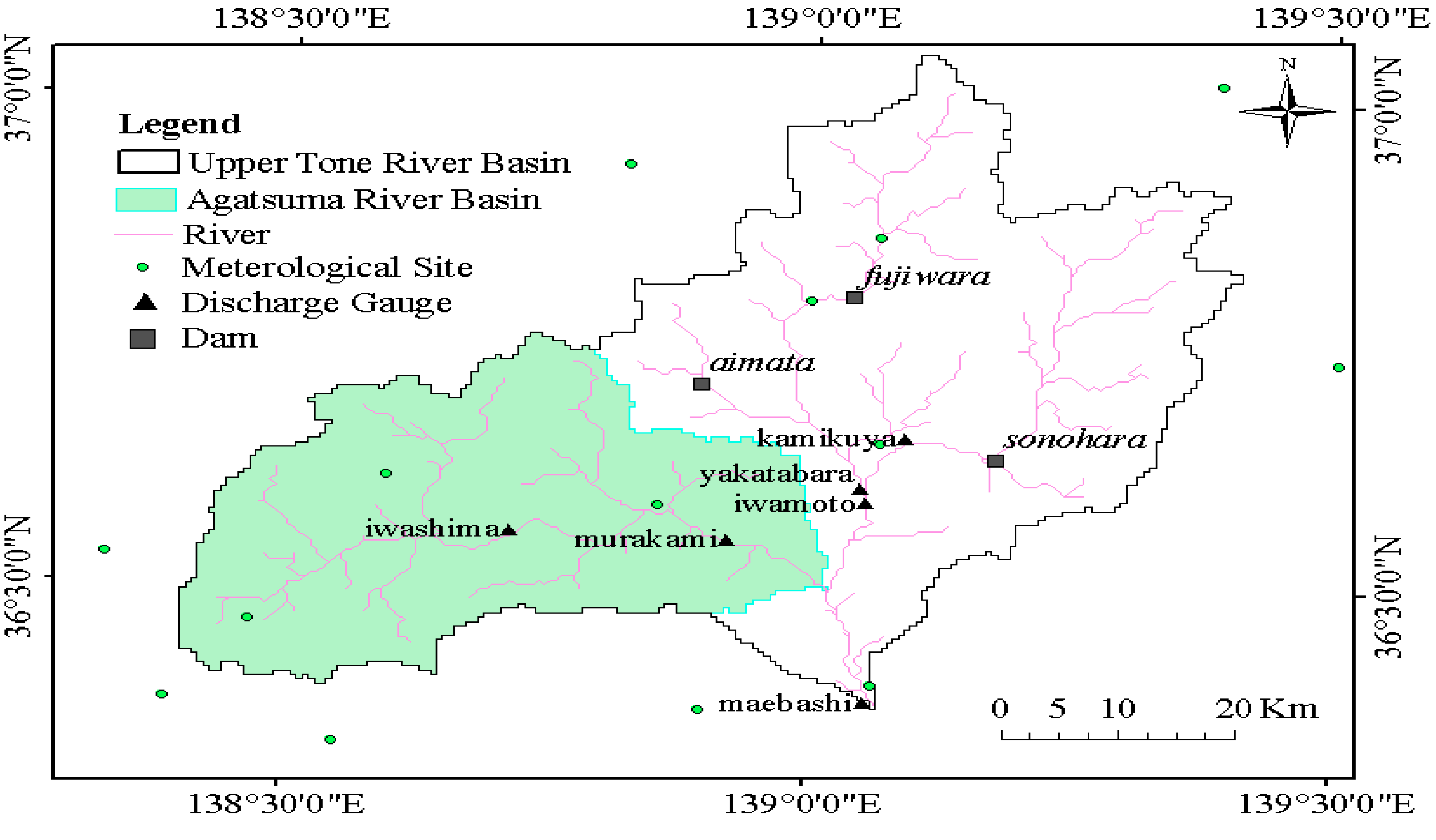
- DEM, river networks, sub-catchments with geomorphology,
- Soil map
- Land use map
- Precipitation
- Other Surface Meteorological data

  (Shortwave and longwave radiation, wind speed, humidity, air pressure, air temperature, cloud fraction)
- FPAR & LAI (satellite data)

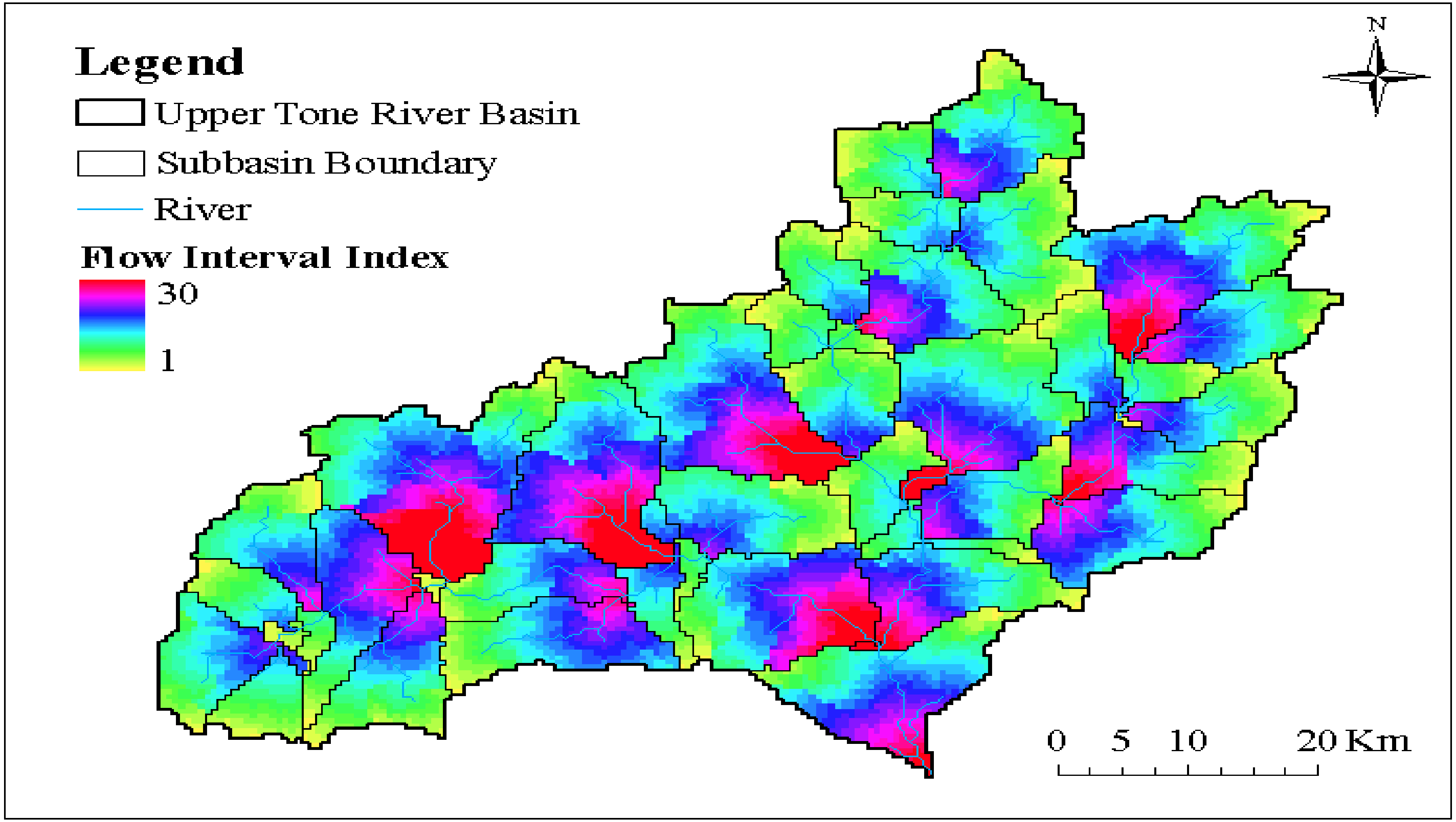
DEM (Digital Elevation Model)



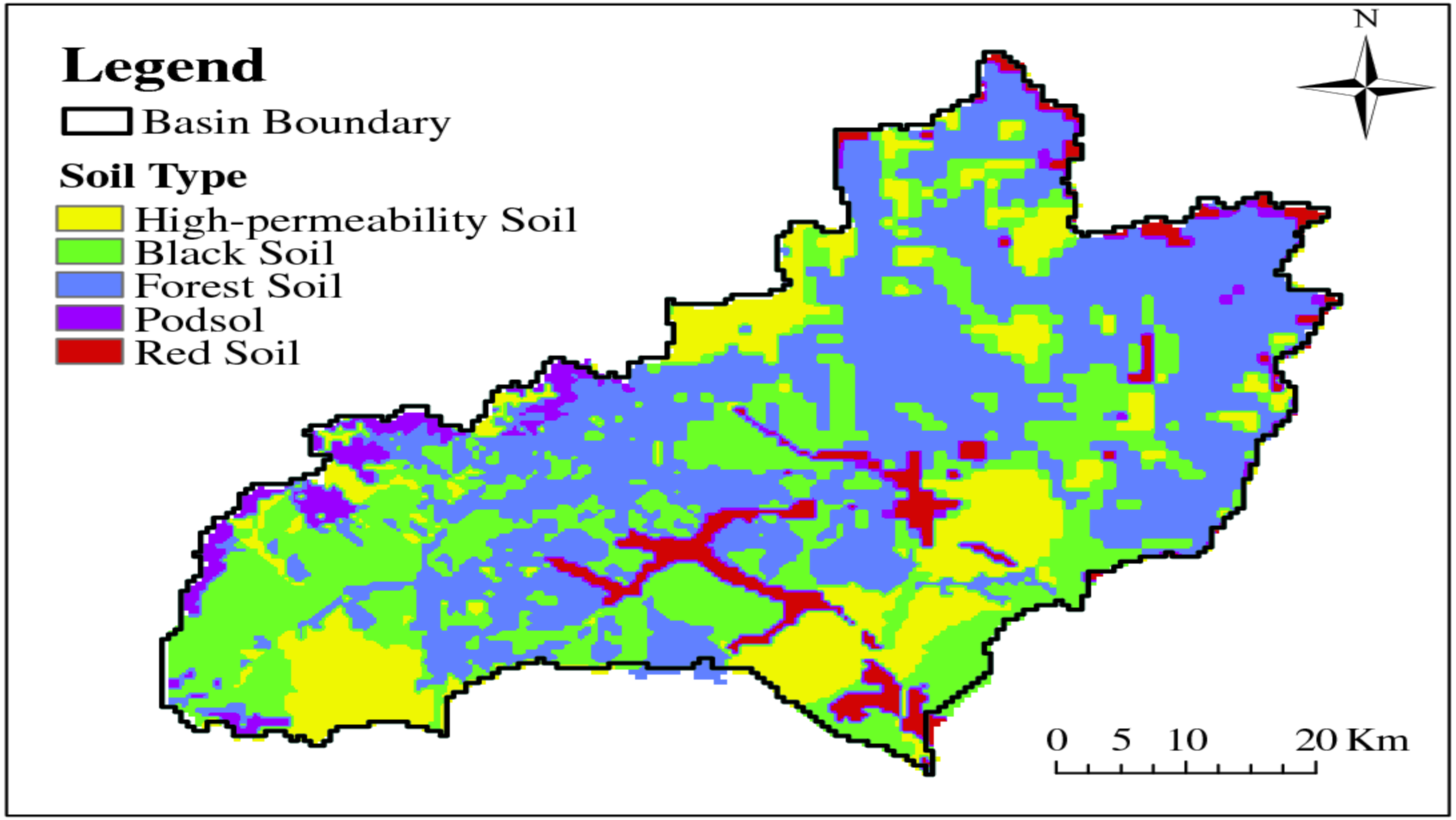
River Basin


138°30'0"E
139°0'0"E
139°30'0"E
37°0'0"N
36°30'0"N
N
Legend
Upper Tone River Basin
Agatsuma River Basin
River
Meterological Site
Discharge Gauge
Dam
fujiwara
aimata
kamikuya
sonohara
yakatabara
iwamoto
iwashima
murakami
maebashi
0 5 10 20 Km

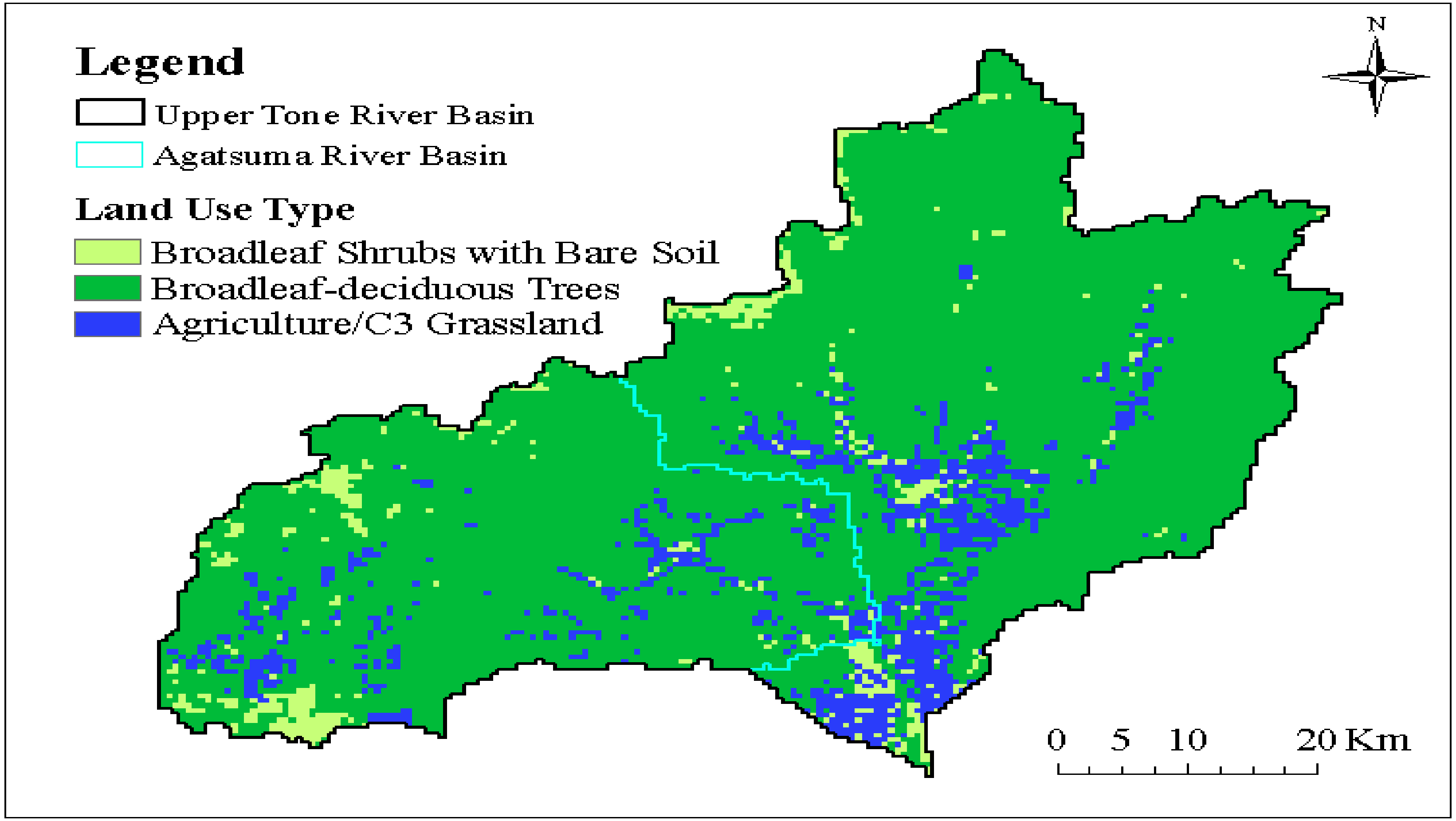
Spatial Discretization
Basin-> Subbasin-> Flow intervals



Soil Type

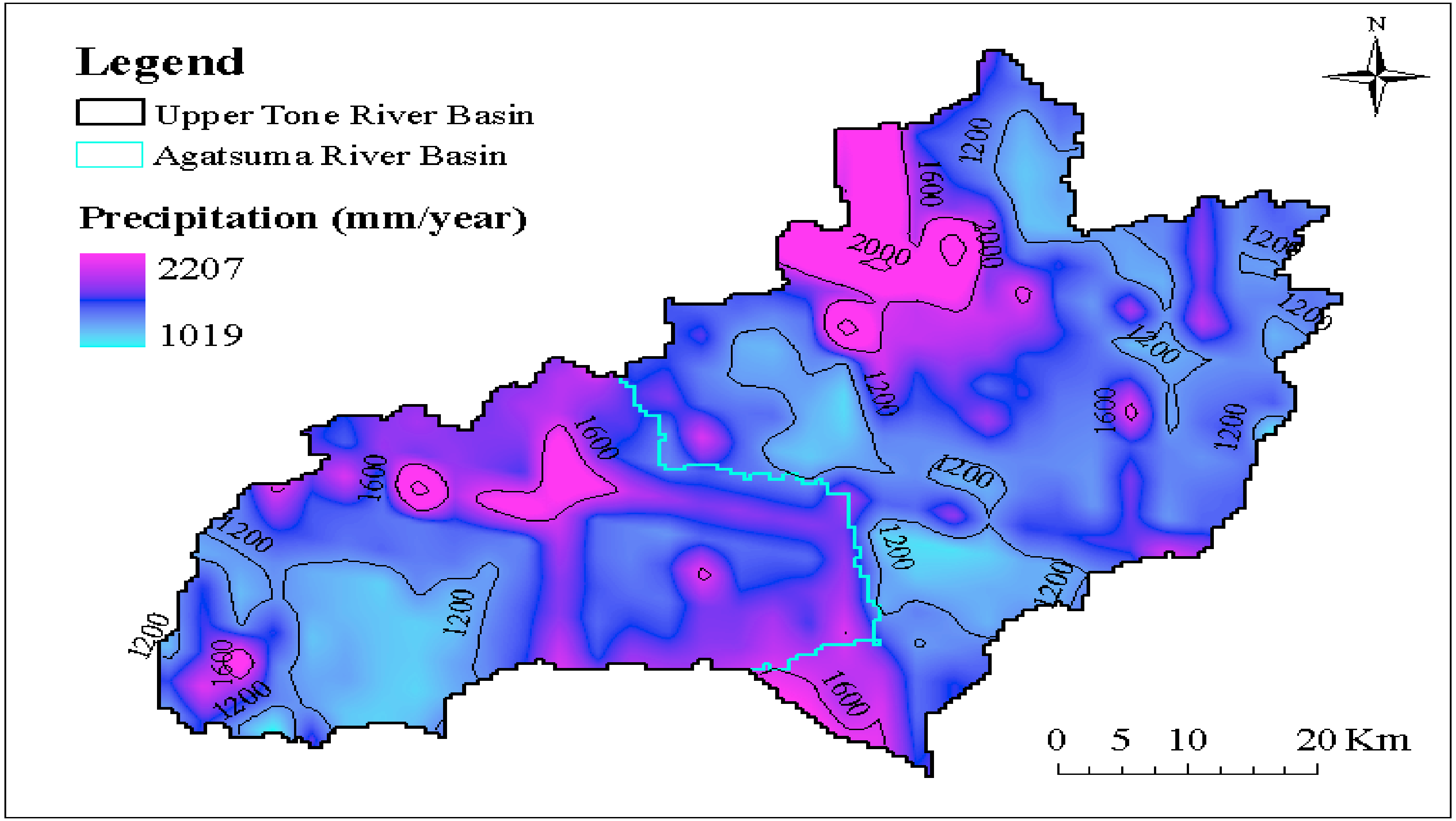

Legend
Basin Boundary
Soil Type
High-permeability Soil
Black Soil
Forest Soil
Podsol
Red Soil
N
0 5 10 20 Km

Land Use



Legend
Upper Tone River Basin
Agatsuma River Basin
Land Use Type
Broadleaf Shrubs with Bare Soil
Broadleaf-deciduous Trees
Agriculture/C3 Grassland
N
0 5 10 20 Km

An example of forcing data



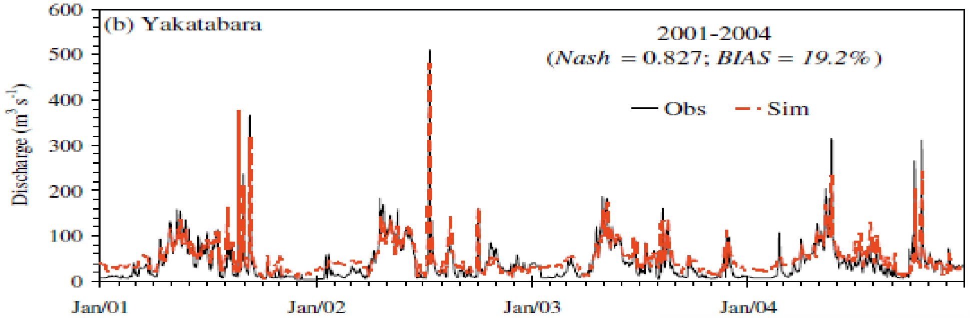
Mean precipitation for 2001 and 2002

Model outputs

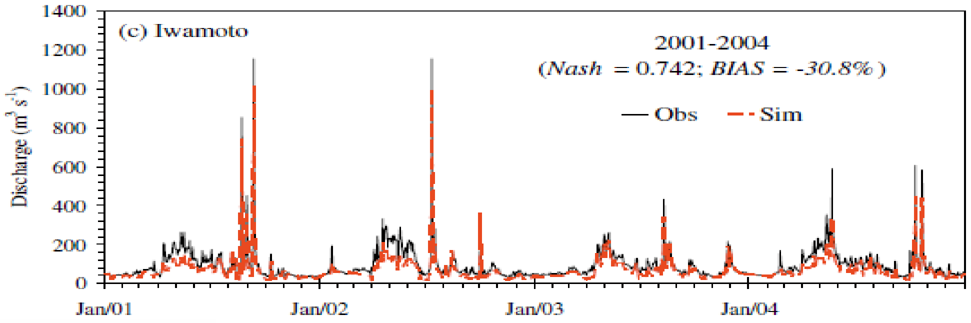
- Discharge
- Land Surface Temperature (LST)
- Evapotranspiration
- Soil moisture—(surface, root zone and deep soil zone)
- Soil temperature
- Ground water
- Energy and CO_2 flux

Wang, Koike et al., 2009, Journal of Hydrology

The upper Tone River Basin, Japan



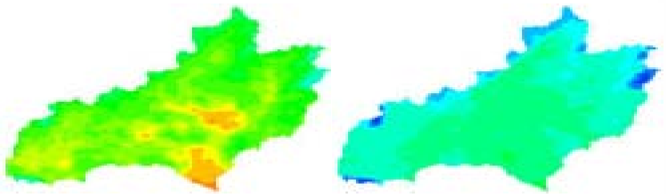
2001-2004

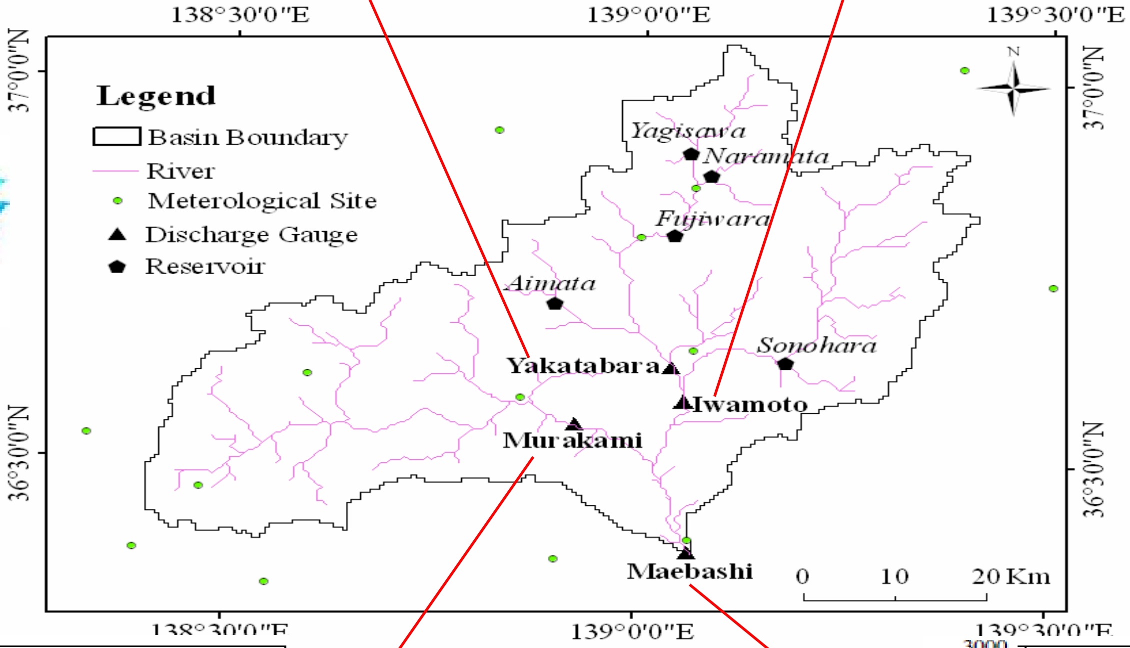


Simulated LST

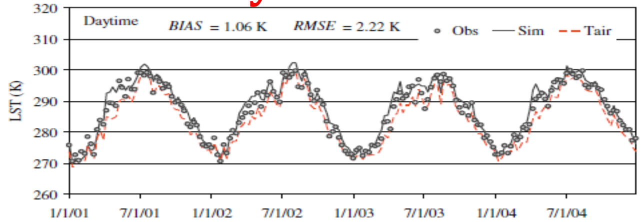
Daytime nighttime

MODIS LST

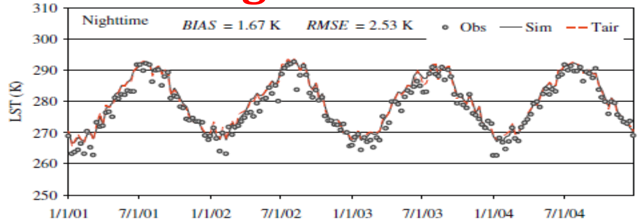


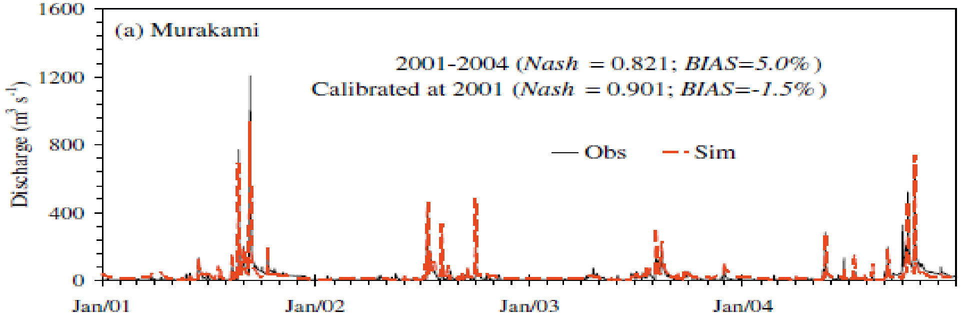


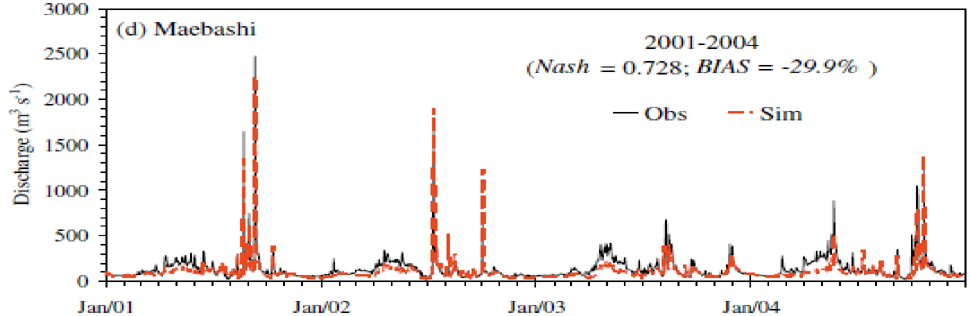
Daytime LST



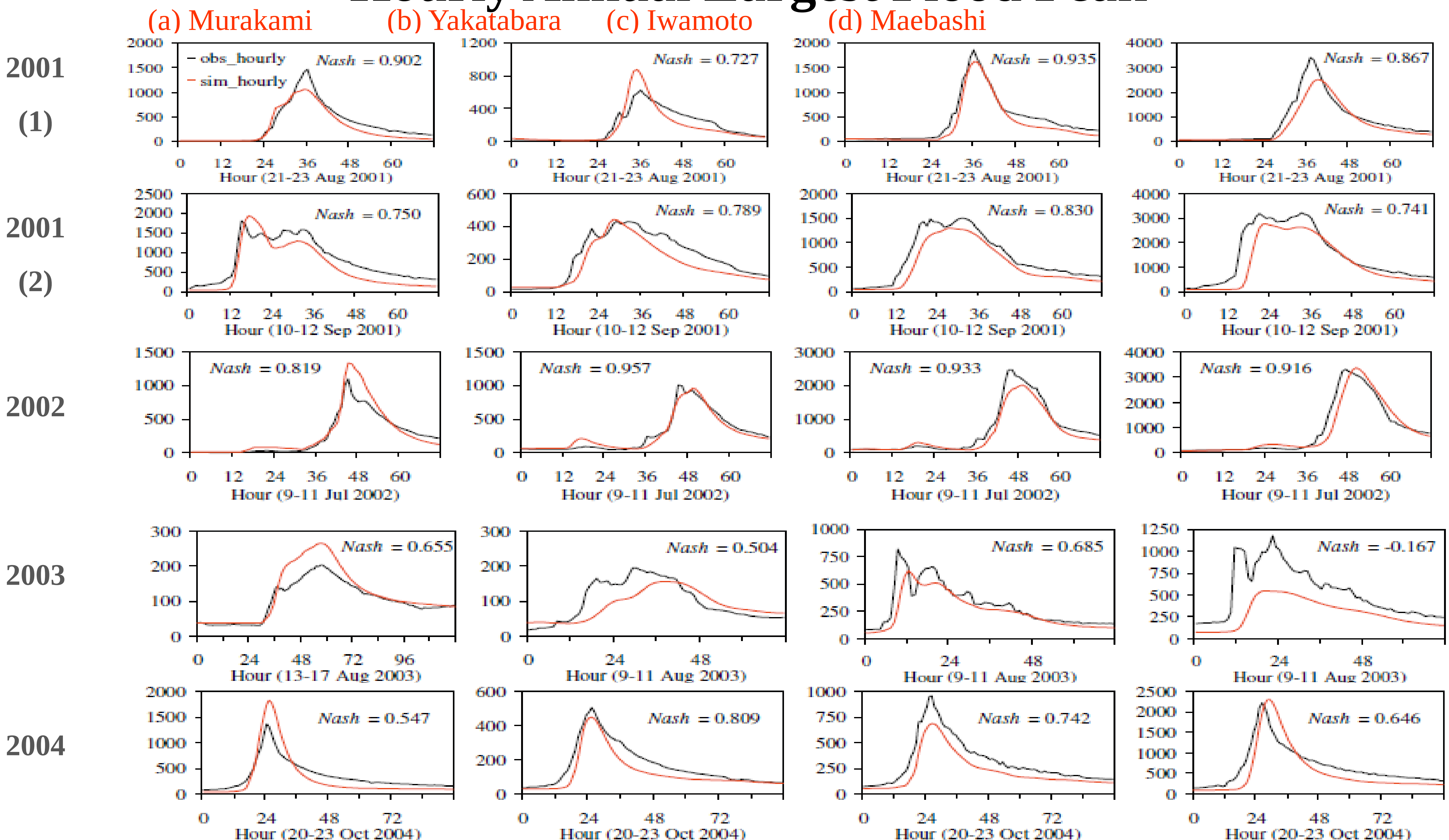
Nighttime LST





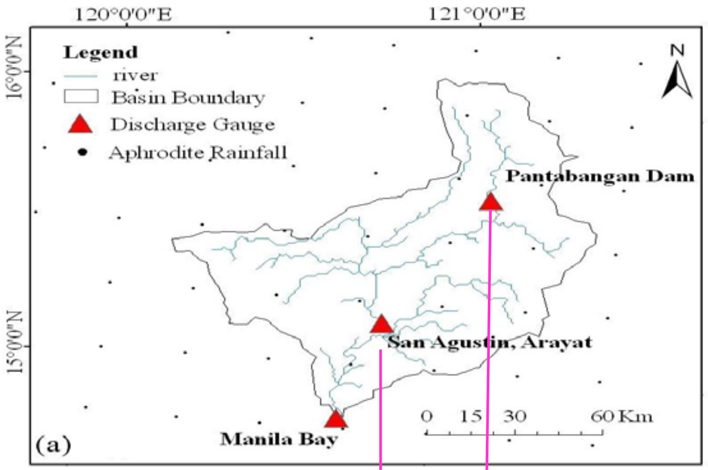


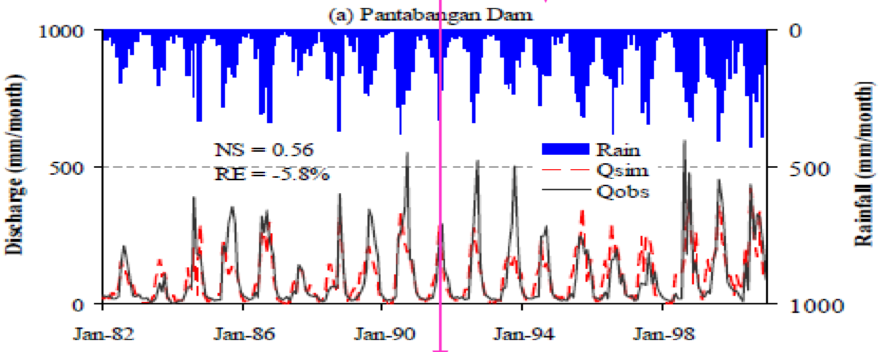
Hourly Annual Largest Flood Peak

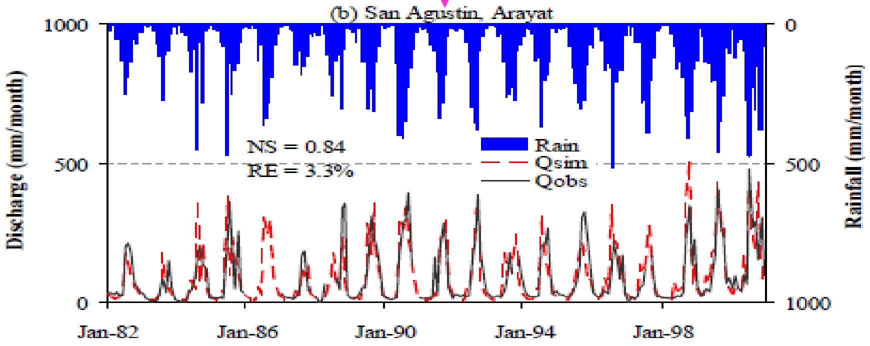


Jaranilla-Sanchez, Wang, and Koike, 2011, Water Resources Research

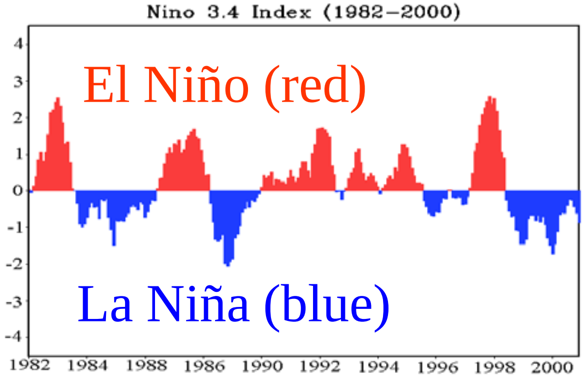
Drought study in Pampanga River Basin, Philippines





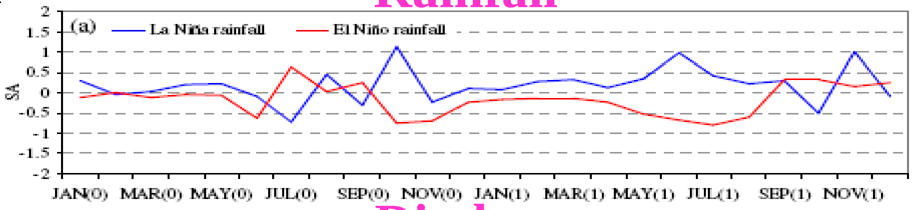


ENSO influence

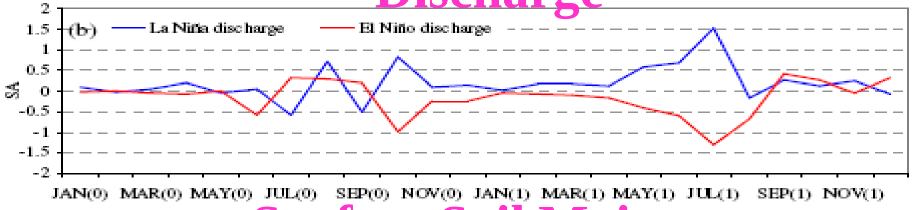


Standardized Anomaly Index

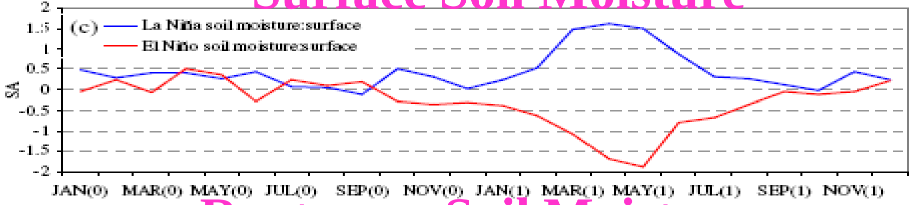
Rainfall



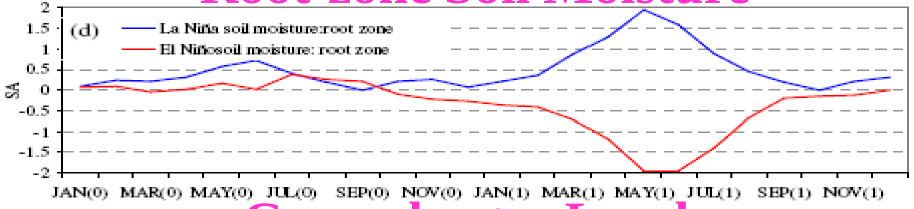
Discharge



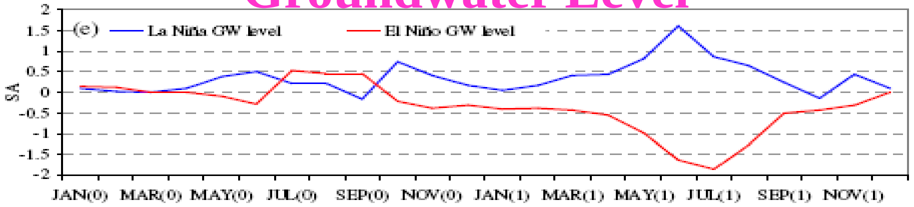
Surface Soil Moisture



Root-zone Soil Moisture

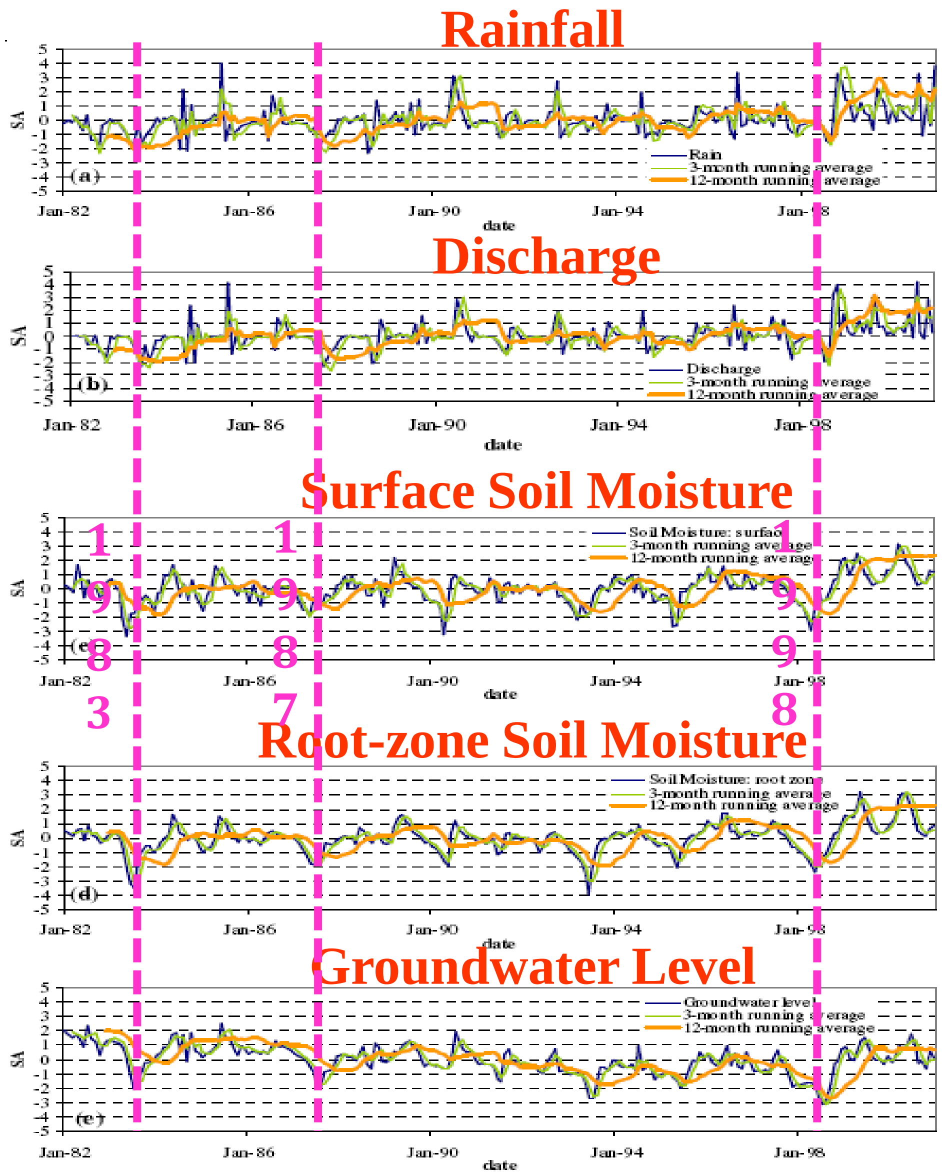


Groundwater Level



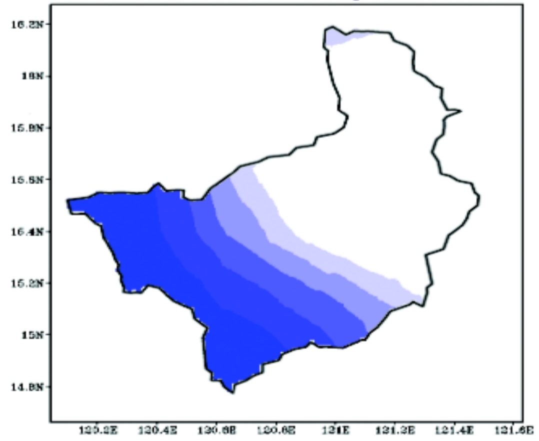
Drought identification, Pampangga River Basin, Philippines

Standardized Anomaly Index (SA)

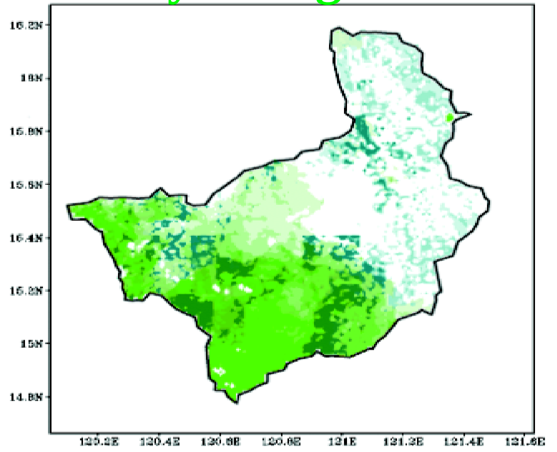


Drought-prone areas (*Aug 1998*)

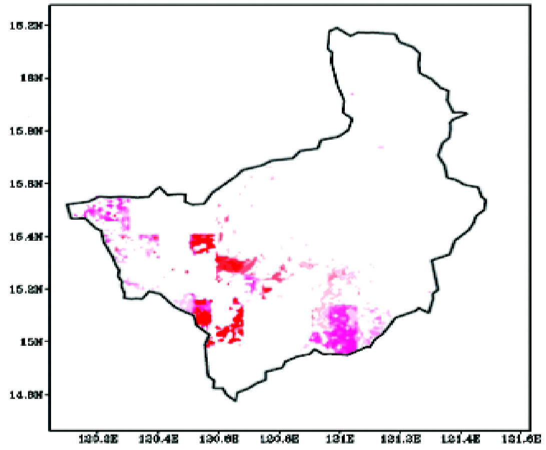
Meteorological



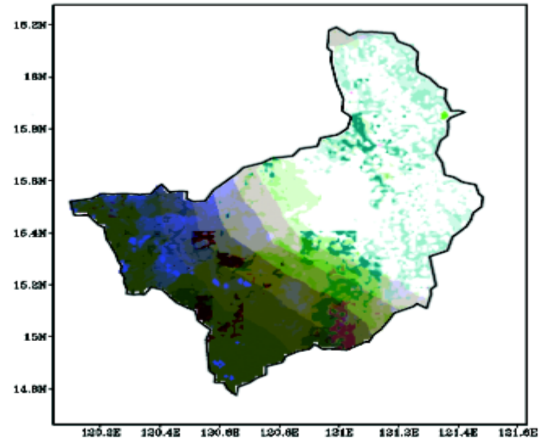
Hydrological

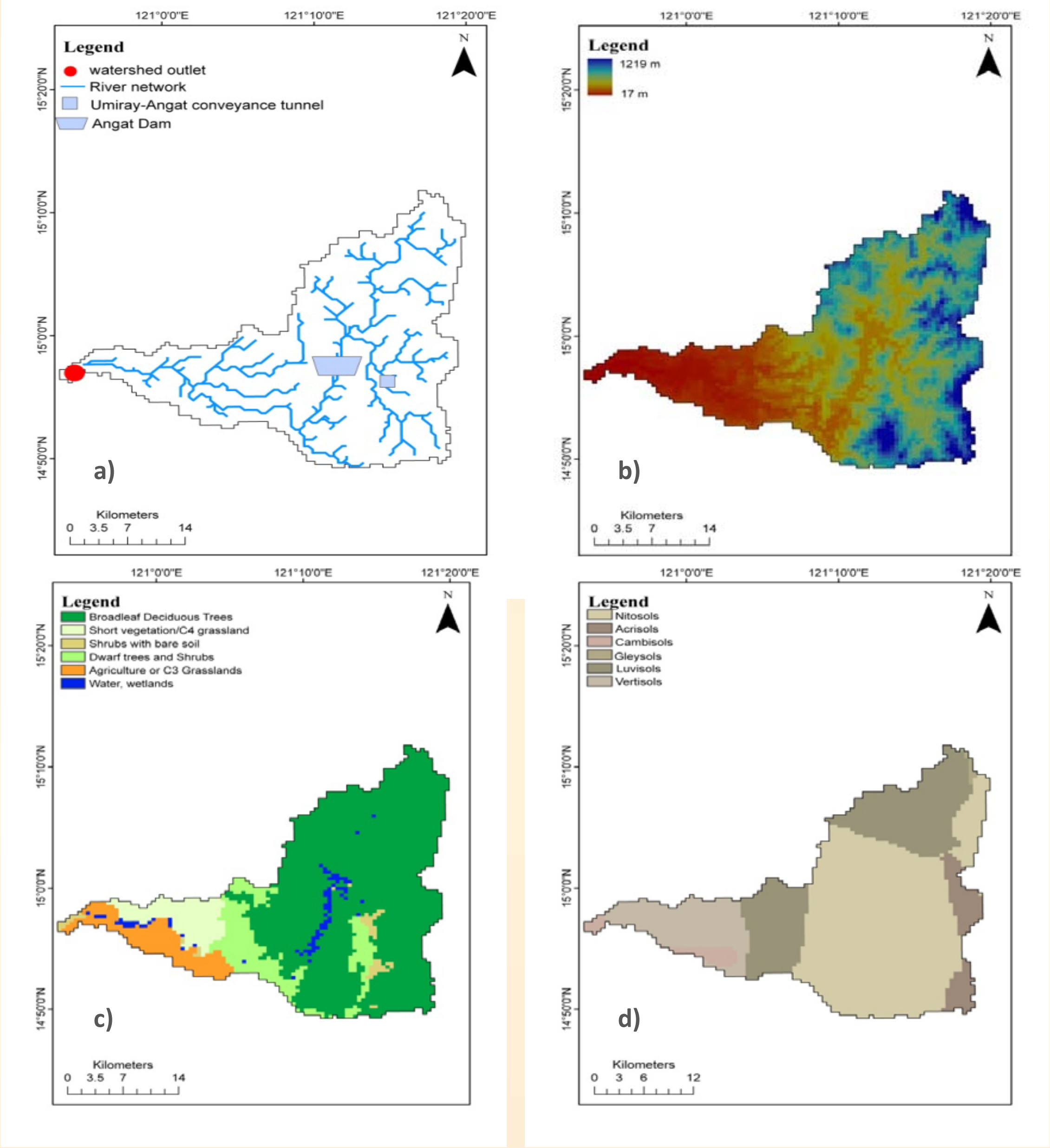


Agricultural

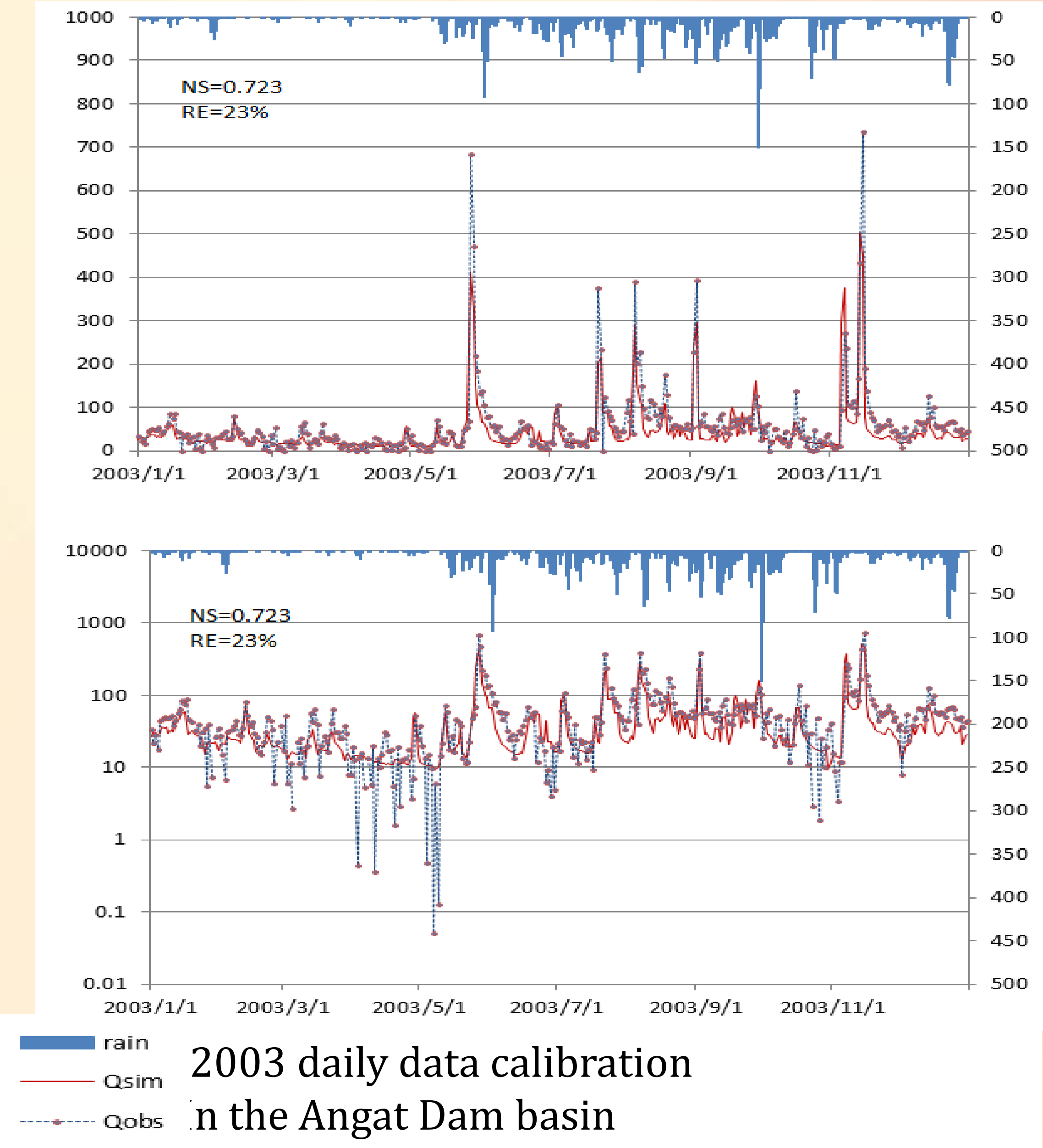


Combined





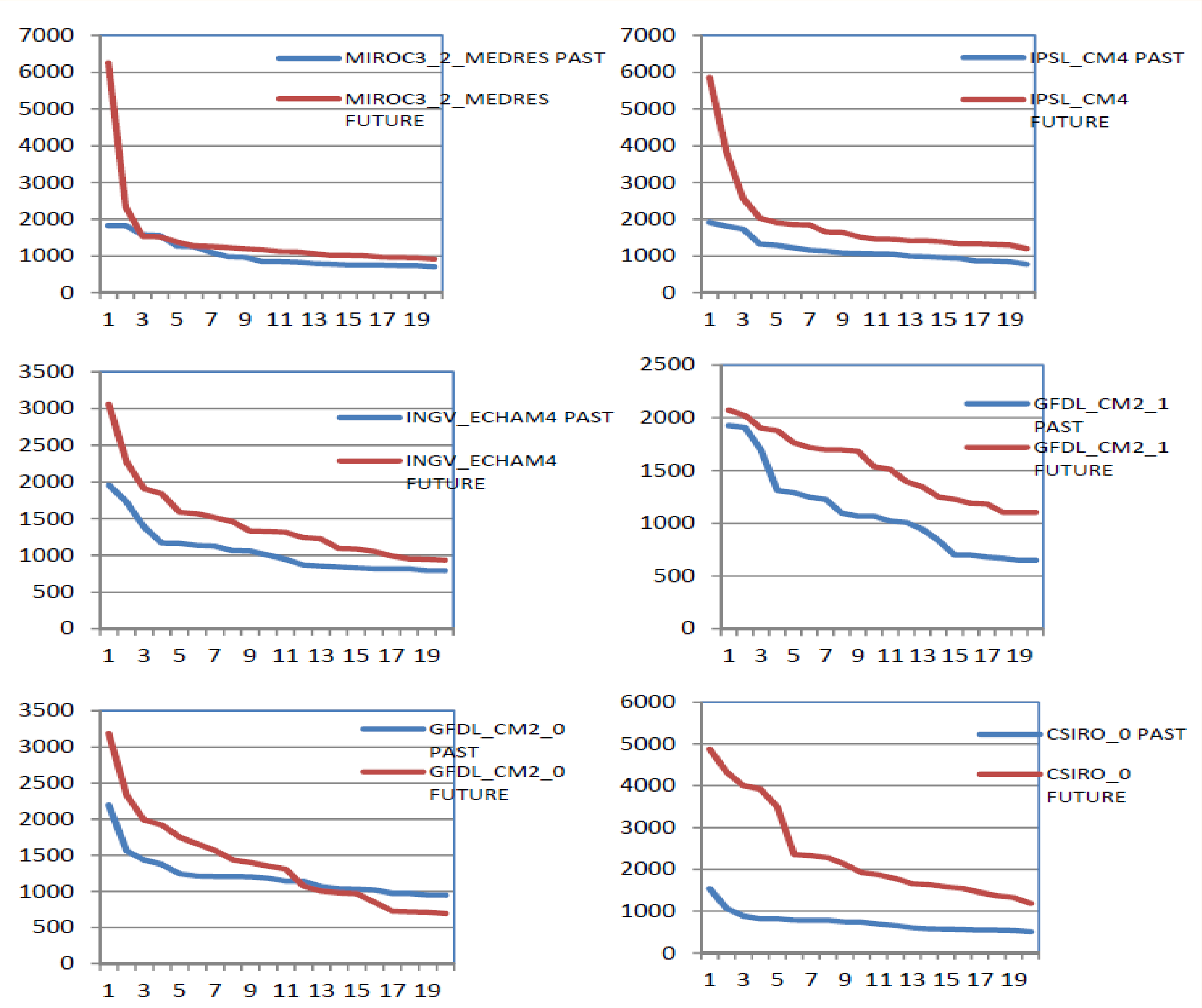
a) River Network, **b)** Digital Elevation, **c)** Local land use and **d)** Local soil.



2003 daily data calibration in the Angat Dam basin

Angat River basin

It is virtually certain that floods will increase in the future (100%)



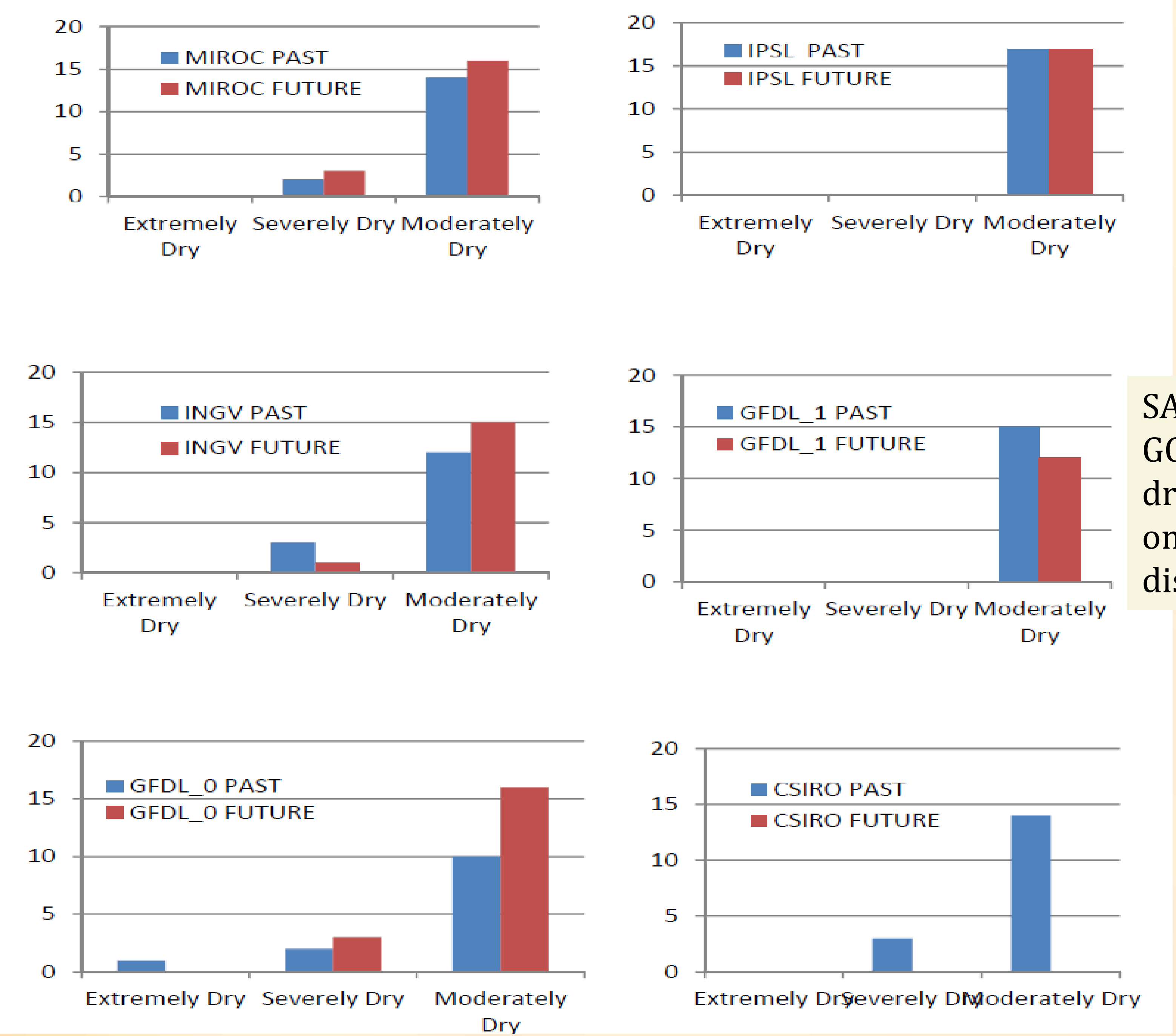
Changes of Flood in Angat Dam Basin

Changes of Drought in Angat Dam Basin

GCM Model	Drought Discharge (m^3/s) *(average 355th rank)*		**# of days/year** that **baseflow < past drought discharge** *(average of 355th rank)*		**Upper Limit of Drought Discharge(m^3/s)** *(10th percentile of 355th rank)*		**# of days/year** that **baseflow < past drought discharge** *(10th percentile of 355th rank)*		**Longest # of days for each year below average drought discharge**	
	Past	**Future**	**Past**	**Future**	**Past**	**Future**	**Past**	**future**	**Past**	**Future**
MIROC	0.144	0.151	27	34	0.123	0.107	2	13	100	135
IPSL	1.85	6.46	22	0	1.6	5.939	2	0	59	0
INGV	0.17	0.194	30	11	0.138	0.156	3	0	104	76
GFDL_1	0.156	0.173	39	28	0.123	0.131	1	0	134	88
GFDL_0	0.174	0.175	44	64	0.122	0.116	3	13	167	255
CSIRO	0.15	0.154	37	34	0.13	0.11	5	15	193	191

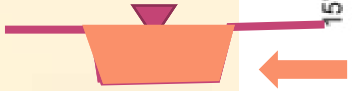
red = drier in future; more frequent below drought discharge
blue = wetter in future; less frequently below drought discharge

It is likely as not that droughts will increase in the future (50%-50%)



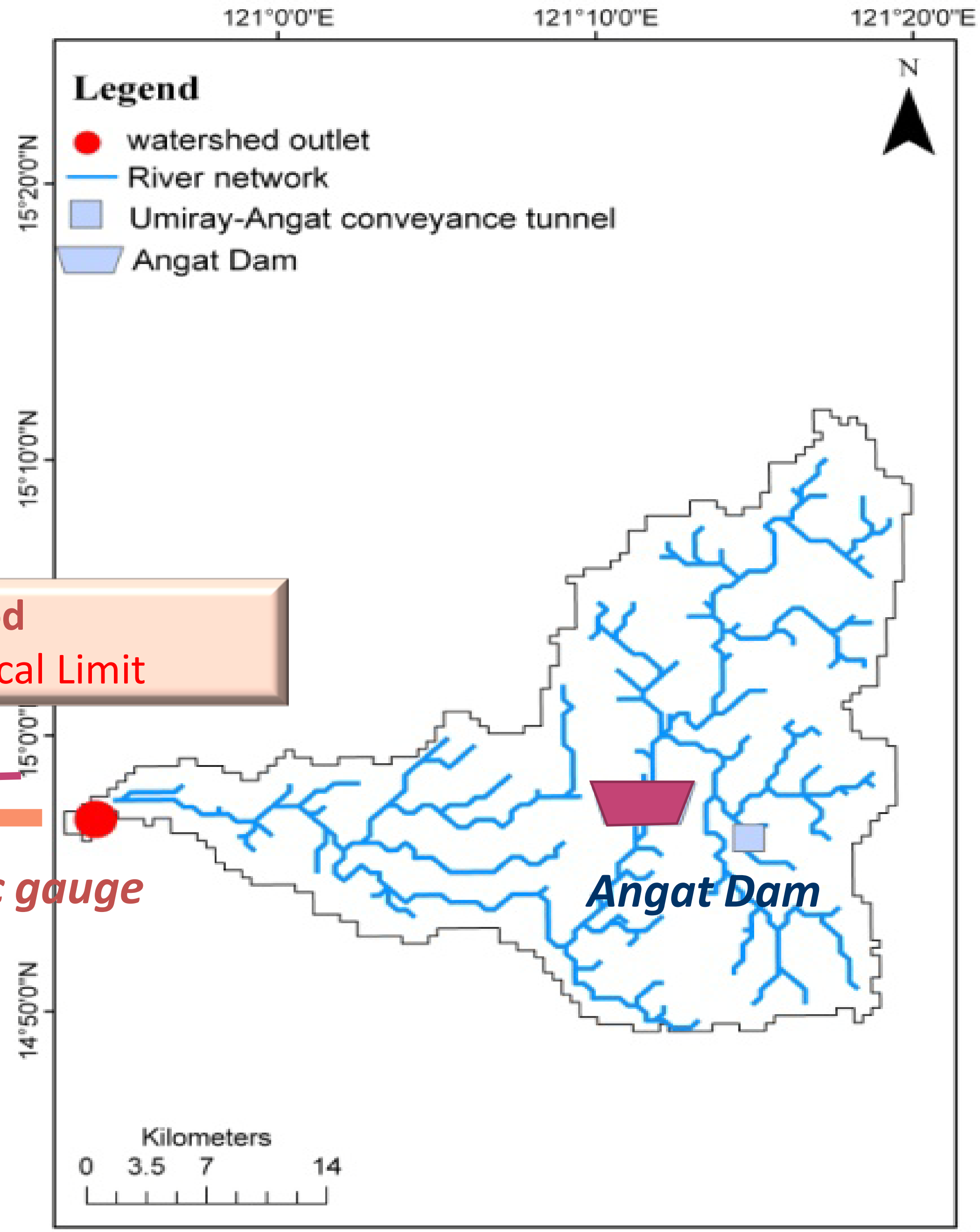
SA indices for the 6 selected GCM models for Hydrological drought in Angat Dam (based on simulated monthly discharge)

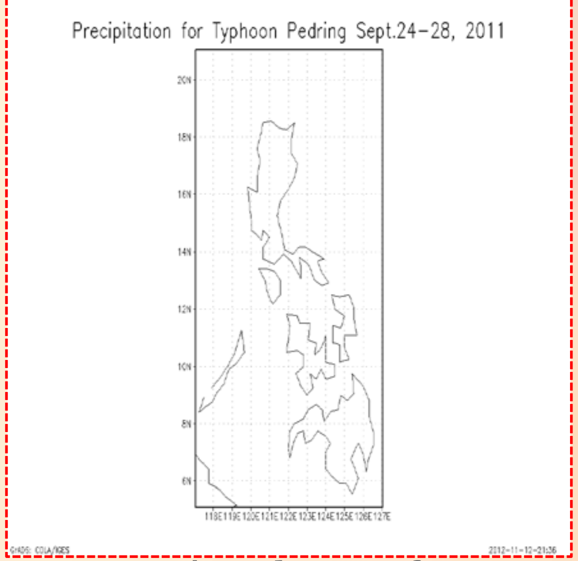
Minimize Flood
→WL below the Critical Limit



Matictic gauge

Example: Water level at Matictic Gauge should not exceed 33m amsl.





PAGASA's 6-hours forecast information

Maximize Water Use

- Water Supply to Metro Manila
- Hydropower Generation
- Irrigation

→ WL as high as possible

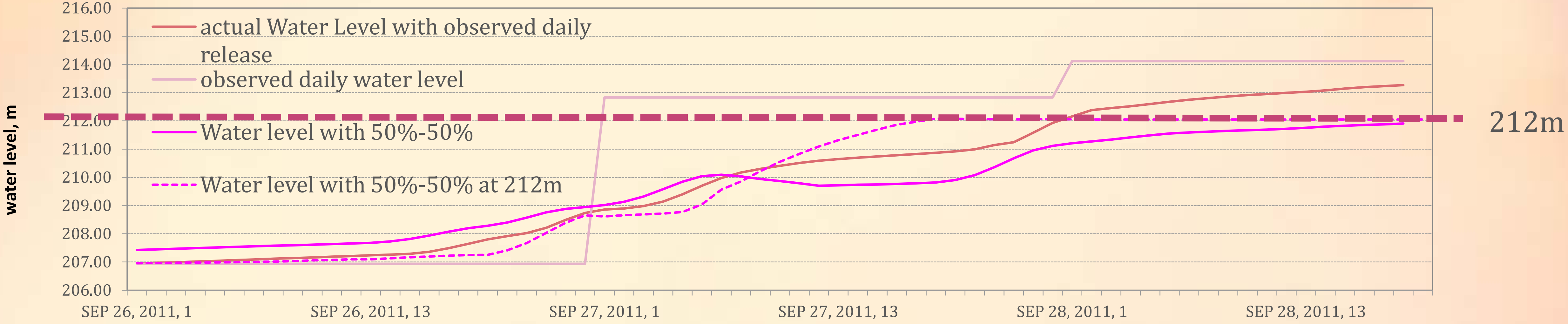
Example: Water level in the dam reservoir should be 212m

Case 5: Typhoon Pedring

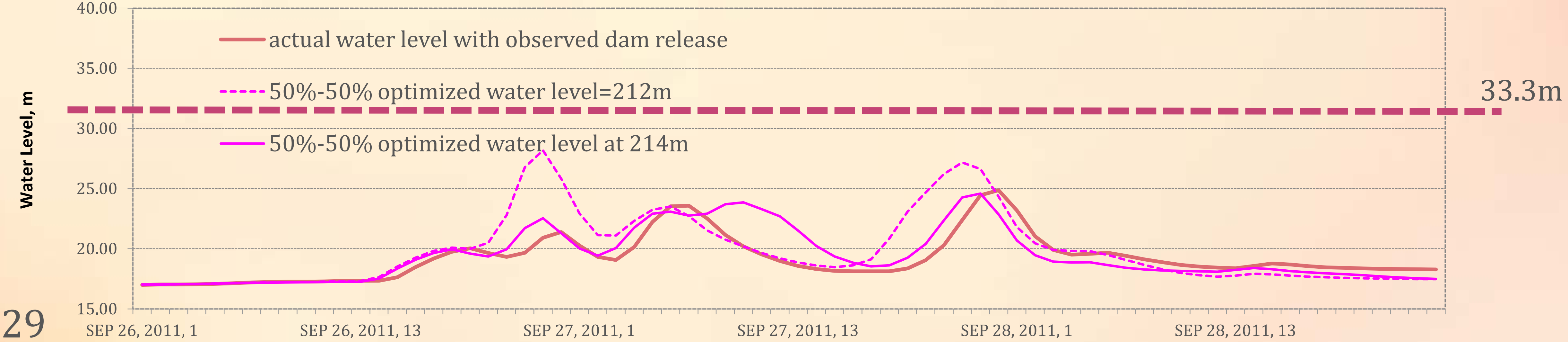
Water levels in the reservoir and at Matictic

(Water Level limit is changed from 214m to 212m at 50% Priority on Flood and 50% Priority on Water Storage)

Water level from Angat dam:



Water level at Matictic gauge:



Advantages of WEB-DHM

- A distributed biosphere hydrological model, which can give continuous, spatially-distributed descriptions of water and energy balance, as well as CO_2 flux for river basins.
- More reliable estimation of ET.

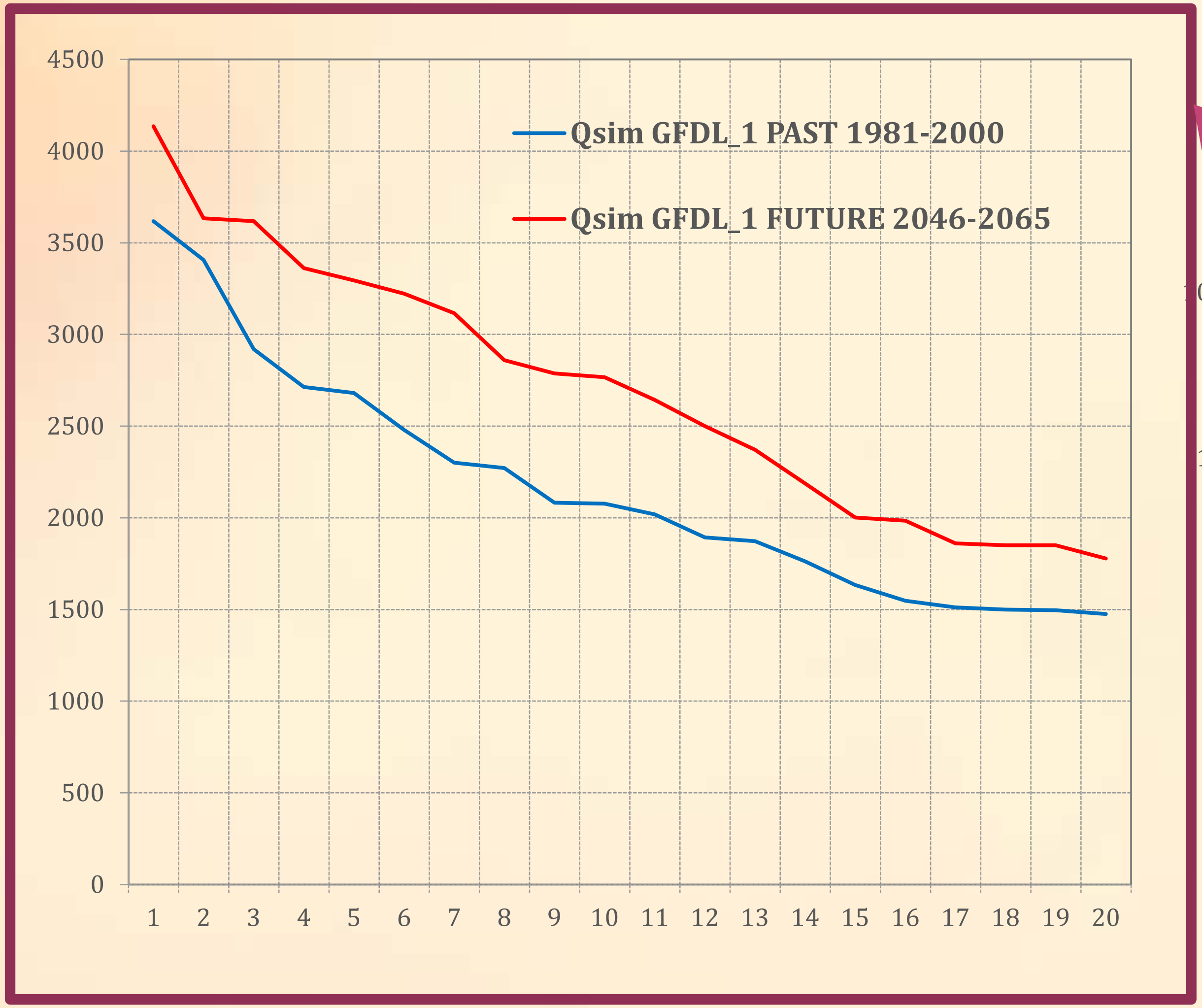
  (by using a biophysical land surface scheme for simulation of heat and moisture fluxes in the SVAT processes)
- Satellite data *is used to describe the vegetation state and phenology.*
- **Couple with GCM for flood and drought prediction**
- Applicability to large river basins.

  (by simplification of a model grid to a hillslope element, and simplification of river routing process)

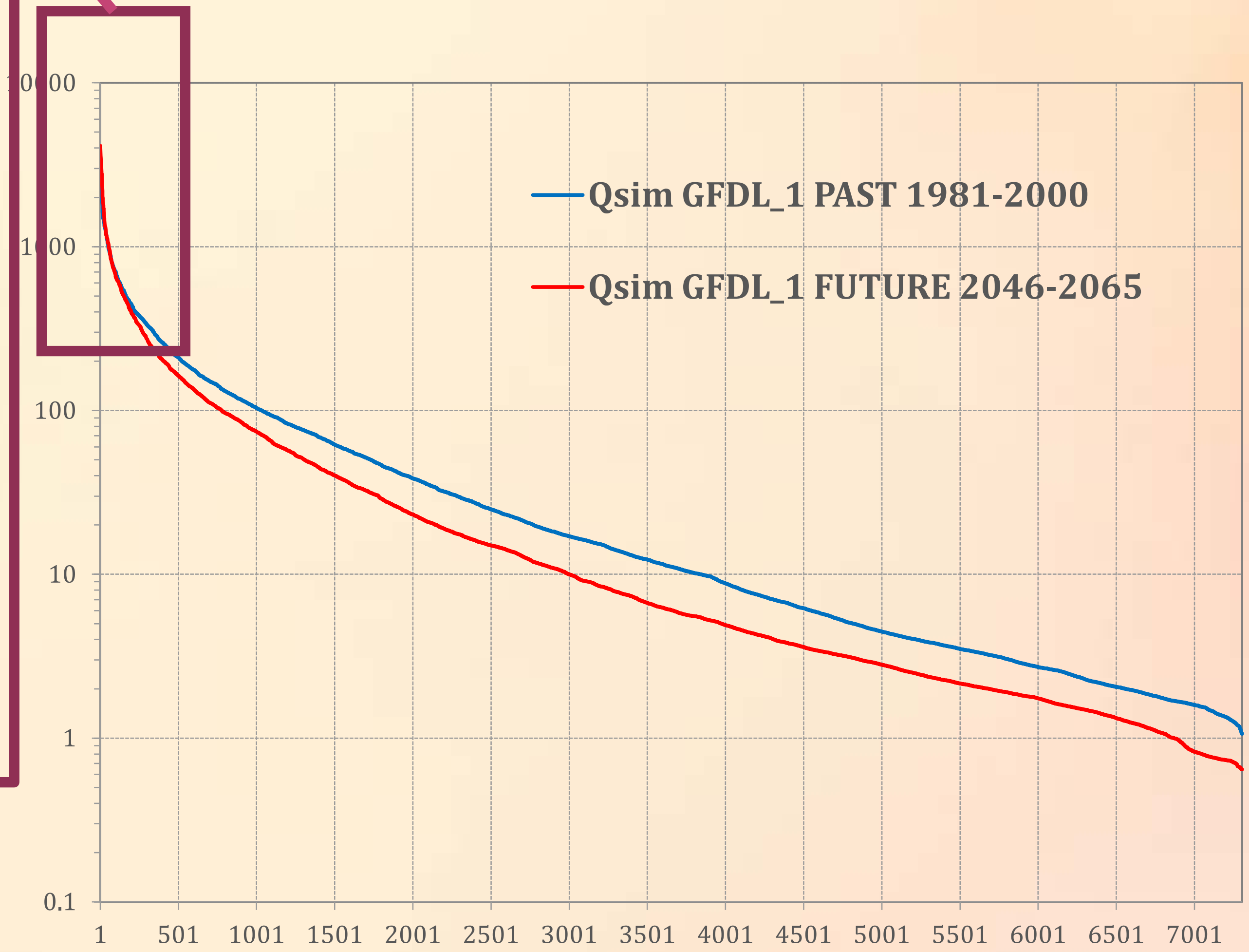
Main objectives of the WEB-DHM and Drought Indices training

- Get familiar with the basics of hydrological modeling and the theory/processes involved in basin-scale simulations
- Using minimal observation data parameters, be able to accurately and effectively simulate floods and drought at the watershed scale
- Analyze hydrological parameters (spatially and temporally) using a combination of tools : statistical software, templates, and visualization tools

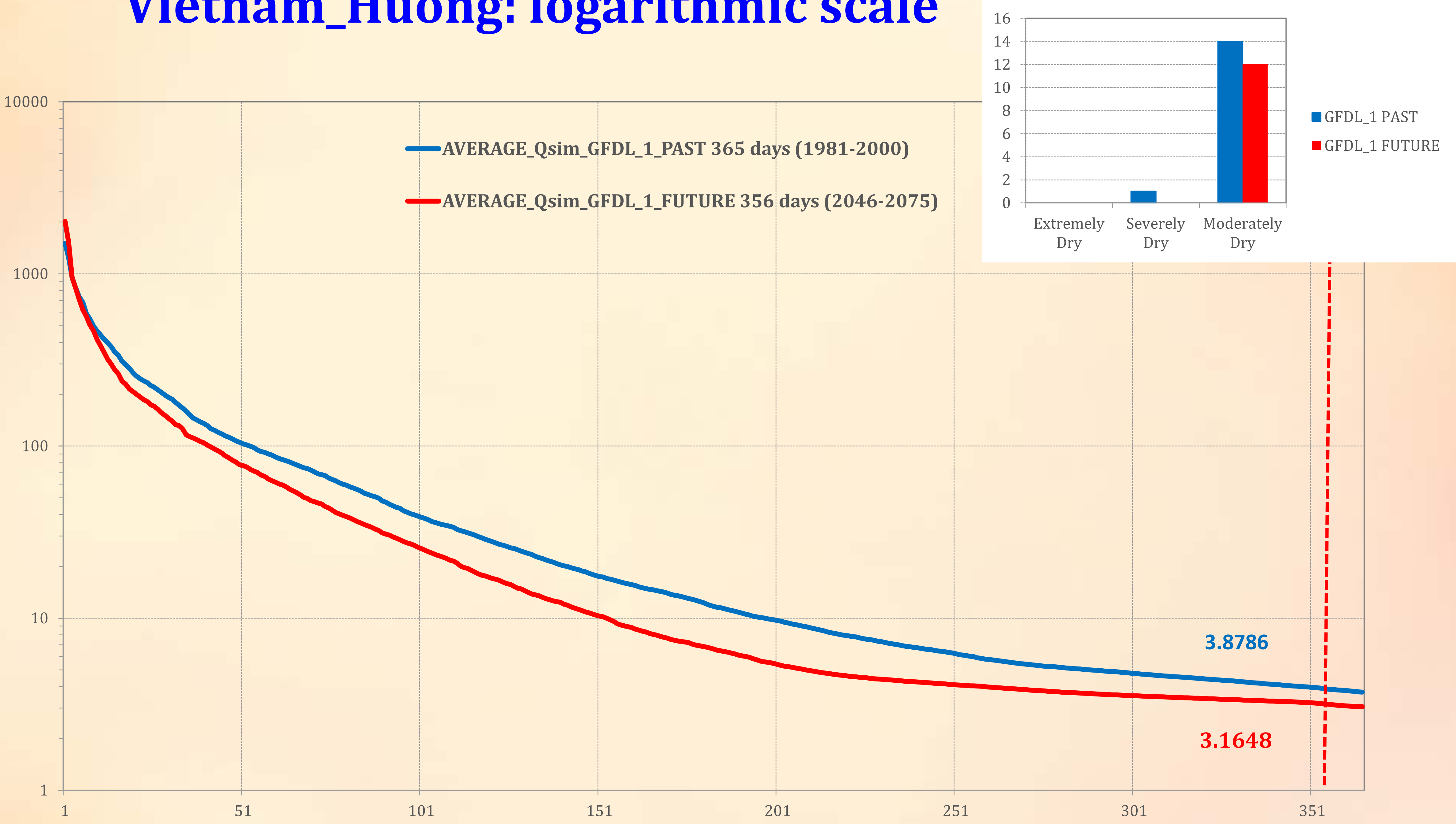
Vietnam_Huong: linear scale

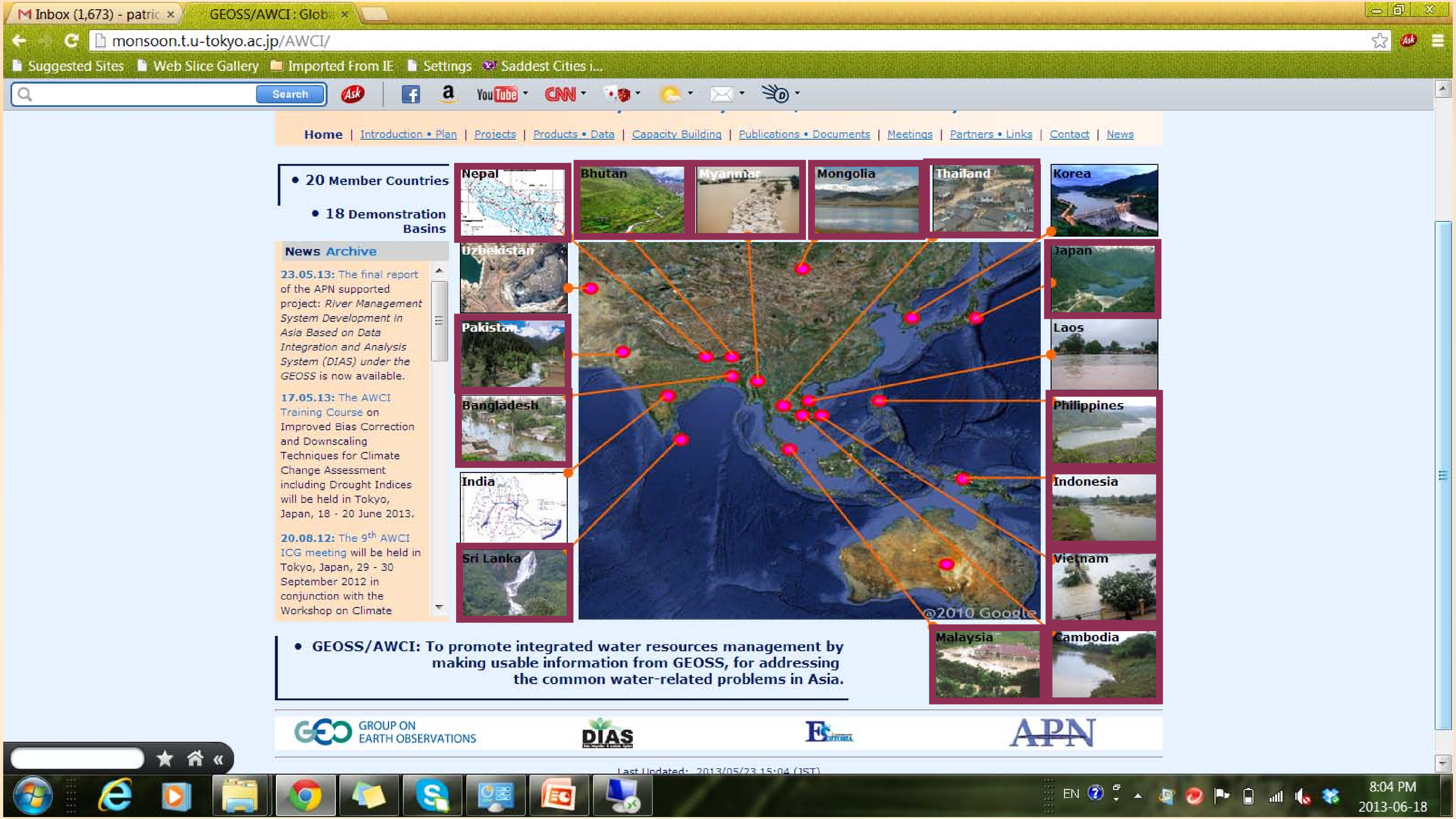


Top 20 peak discharge



Vietnam_Huong: logarithmic scale

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News Archive
23.05.13: The final report of the APN supported project: River Management System Development in Asia Based on Data Integration and Analysis System (DIAS) under the GEOSS is now available.
17.05.13: The AWCI Training Course on Improved Bias Correction and Downscaling Techniques for Climate Change Assessment including Drought Indices will be held in Tokyo, Japan, 18 - 20 June 2013.
20.08.12: The 9th AWCI ICG meeting will be held in Tokyo, Japan, 29 - 30 September 2012 in conjunction with the Workshop on Climate
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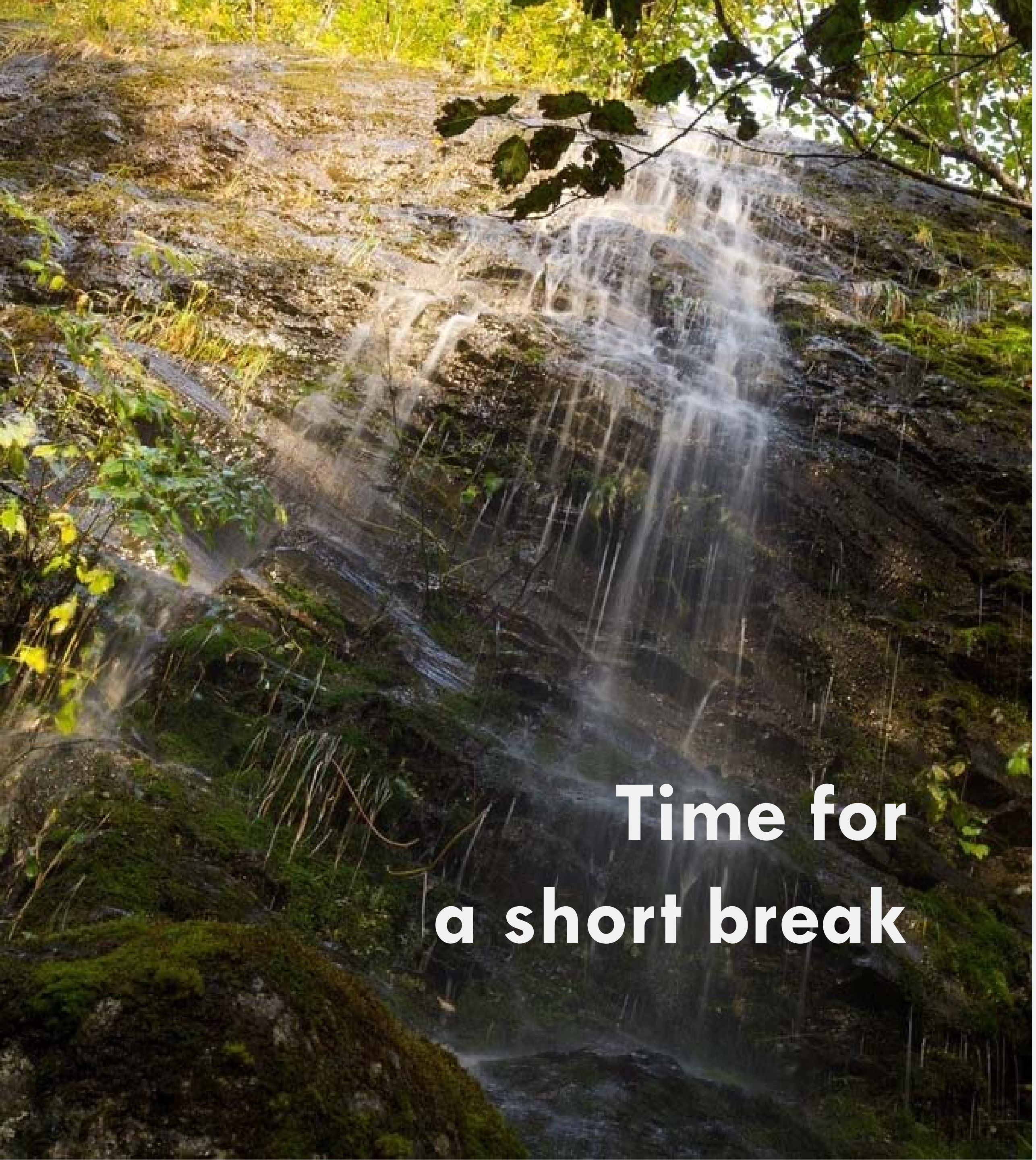
Thanda	Cambodia
Thanda	Indonesia
Shrestha	Japan
Asif	Malaysia
Asif	Mongolia
Asif	Myanmar
Shrestha	Nepal
Asif	Pakistan
Thanda	Philippines
Asif	Srilanka
Thanda	Thailand
Thanda	Vietnam



Time for a short break

: 0[illegible]