Using drought indicators for disaster risk management: A case study of dam infrastructure in the Pampanga River Basin, the Philippines

M. Gusyev[a,b], A. Hasegawa[a,b], P. Sanchez[a] and H. Sawano[a]

[a]International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO, Public Works Research Institute (PWRI), Tsukuba, Japan

[b]National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan

United Nations Educational, Scientific and Cultural Organization

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ICHARM

Outline

1) Introduction of ICHARM activities

2) Study Area of the Pampanga River basin

3) Standardized indices

4) Results

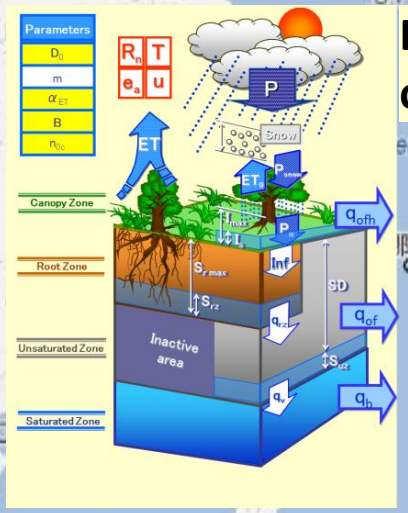
5) Summary

International Centre for Water Hazard and Risk Management (ICHARM)

1) ICHARM established in 2006 as
   UNESCO Category II Centre
2) Hosted by Public Works Research
   Institute (PWRI) in Tsukuba, Japan
3) Research, Networking and Training
   (Master and PhD Programs)
4) Additional information is at the web-site
   http://www.icharm.pwri.go.jp/

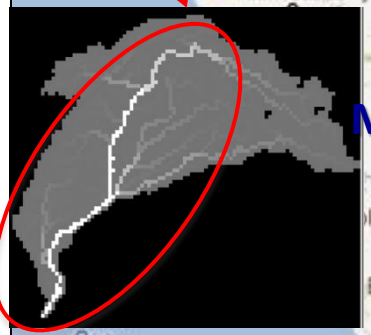
Five SOUSEI Program basins with BTOP

Chao Phraya River Basin, Thailand

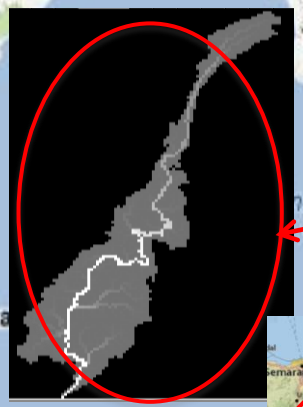


BTOP model components

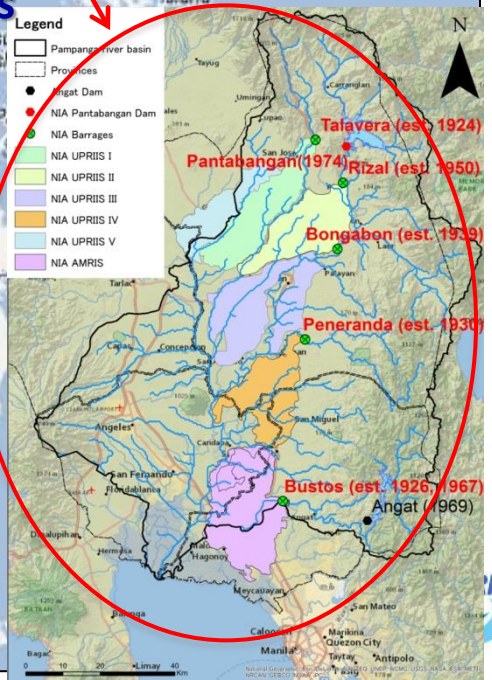
Indus River basin, Pakistan



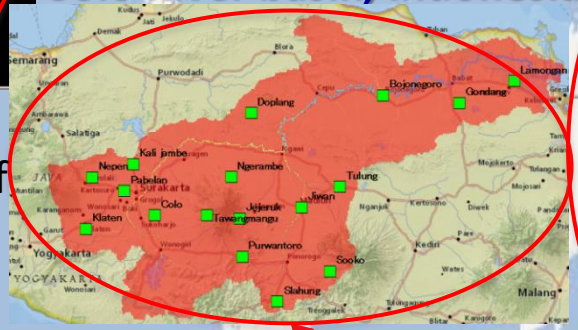
Mekong River basin



Pampanga River basin, the Philippines



Solo River basin, Indonesia



- Dam infrastructure is main source of irrigation and domestic water supply
- Agriculture is a main economic activity during dry/wet seasons
- Exposed to severe droughts in the past

Case study of the Pampanga River basin

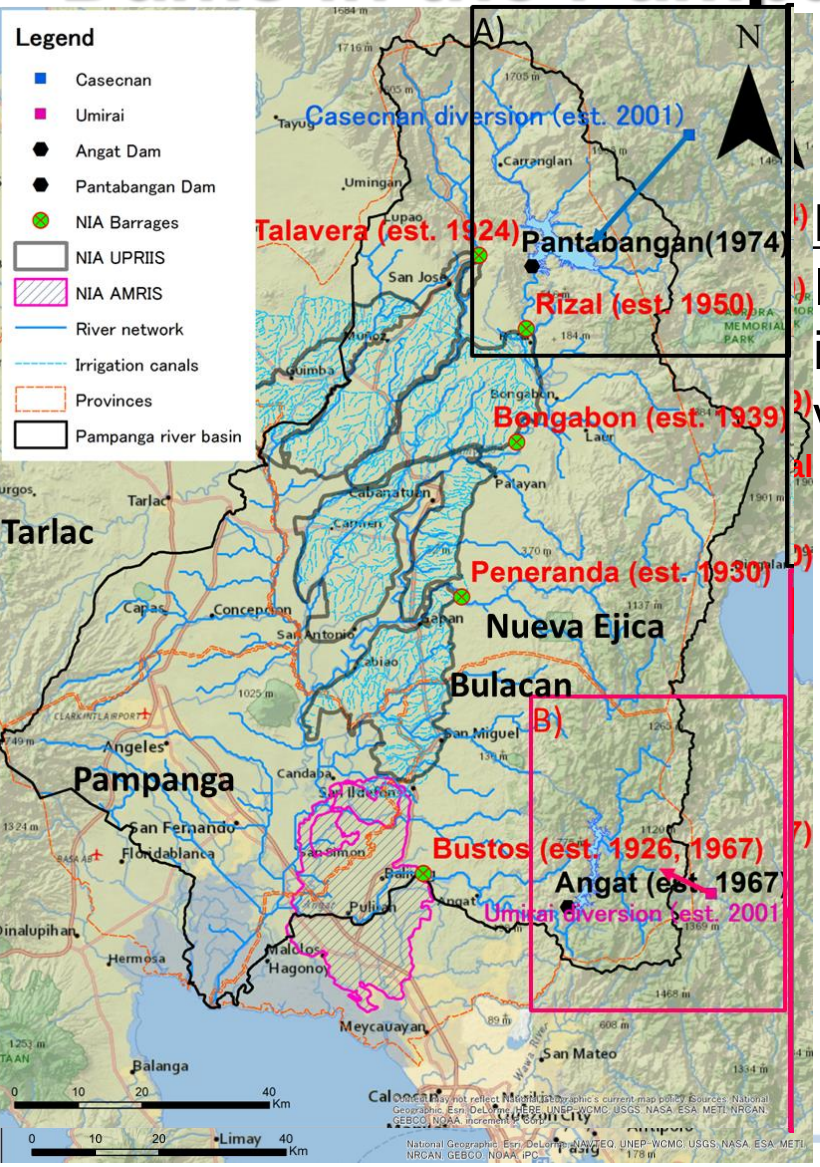
Area: ~ 10,000 km^2
Main Provinces: Bulacan, Nueva Ecija, Pampanga, and Tarlac
Annual Precipitation: 1500-3000 mm
Wet (May – Oct) and Dry (Nov – April) rice growing seasons.
Rice production is about 27% of the Philippines

- Pantabangan Dam (3,000 MCM)
Primary Purpose: Irrigation of 100,000 ha
Secondary: Electricity, Flood Control

- Angat Dam (600 MCM)
Primary Purpose: Water Supply to Manila City (about 12 million people)
Secondary: Irrigation of about 25,000 ha, Electricity, Flood Control.

Reference: Japanese International Cooperation Agency (2011); National Irrigation Administration (2014); National Power Corporation(2014).

Water Supply from Pantabangan and Angat Dams in the Pampanga River basin



Two rice growing seasons:
Wet (May – Oct) and Dry (Nov – April).

Pantabangan Dam is operated by National Irrigation Administration (NIA) and supplies 5 irrigation service areas of about 105,000 ha via super long diversion canals and barrages.

Angat Dam discharge is coordinated by National Water Resources Board (NWRB)

1) To the Metro Manila City
2) To downstream farmers in the NIA irrigation service area of about 26,000 ha.

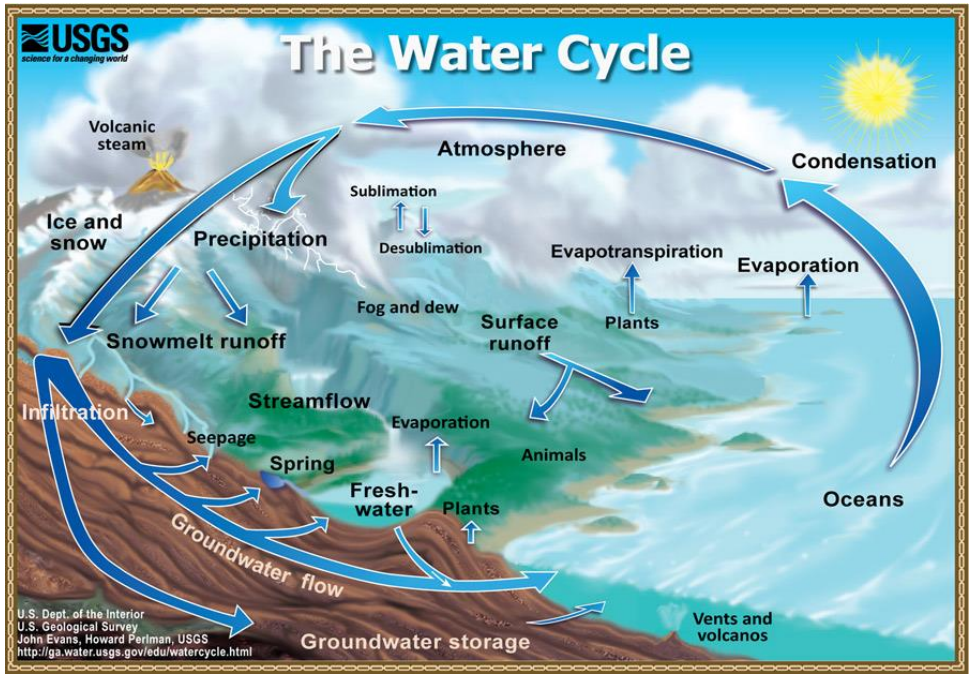
Several major natural and socio-economic droughts happened in 1982-1983, 1987, 1989-1990, 1991-1992, 1997-1998, 2004, 2010, and 2015.

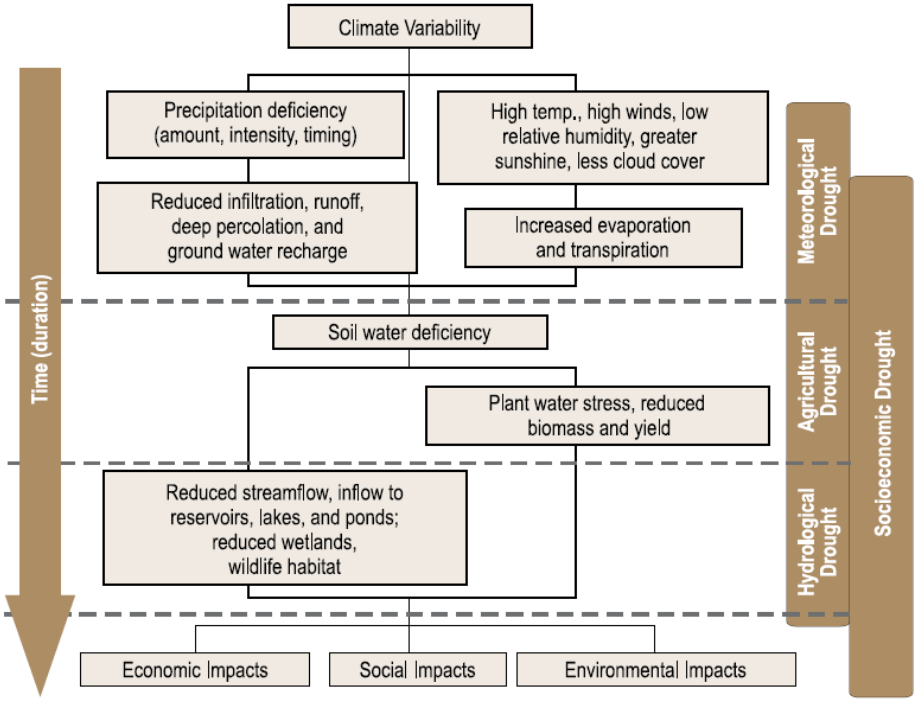
Reference: Japanese International Cooperation Agency (2011); National Irrigation Administration (2014); National Power Corporation(2014).

Why drought characterization is challenging?

Droughts are much more complex than floods:

1) Natural drought is a “water deficiency from normal conditions”
2) Slow propagation of water shortage in water cycle
3) Unclear start, duration and end (weeks – years) of droughts
4) Anthropogenic water use is needed to identify water scarcity (or socio-economic drought)





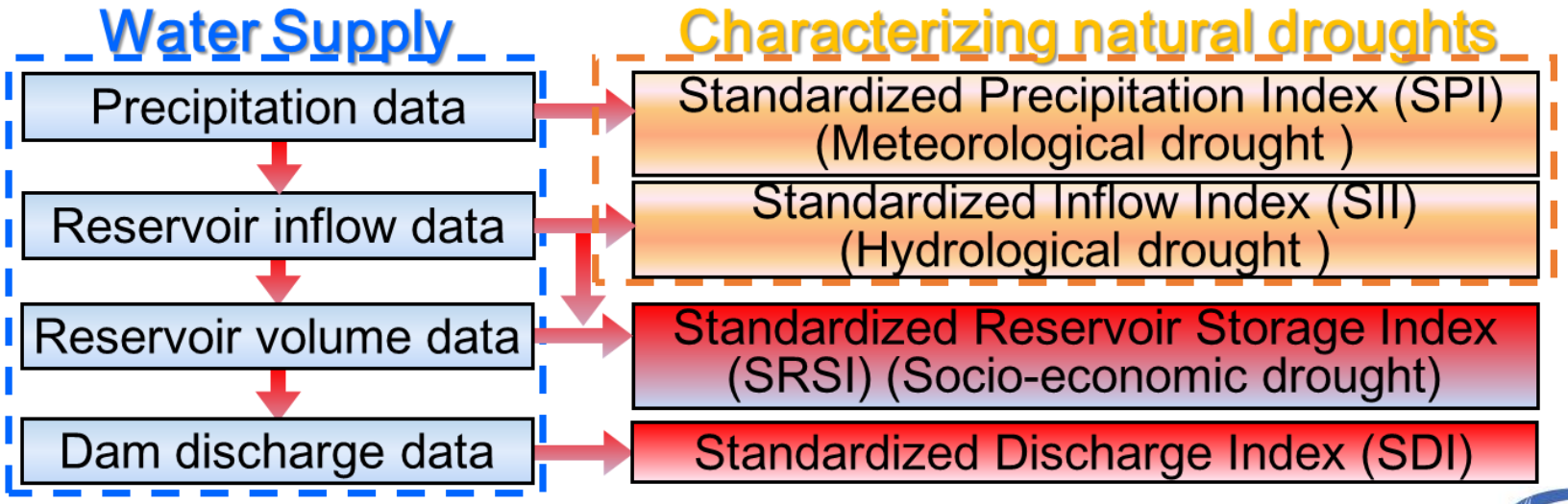
Reference: USGS (2015), UN ISDR (2009): Drought Risk Reduction Framework and Practices

Drought assessment with standardized indices

The goal is to characterize natural and socio-economic droughts with standardized indices by:

1) Using the same method of calculation introduced by McKee et al.(1993)
2) Having the same range of evaluation between -4 (dry) and +4 (wet)
3) Evaluating several time scales from 1-week to 36-month
4) Developing standardized indices with local dam inflows, water storage and discharge data.

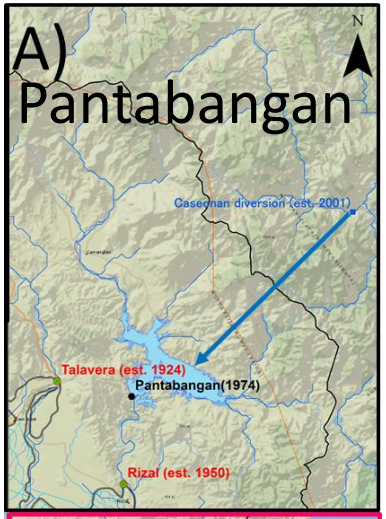
For example, Standardized Precipitation Index (SPI) is obtained with precipitation data and characterizes meteorological drought as adopted by WMO (2012).

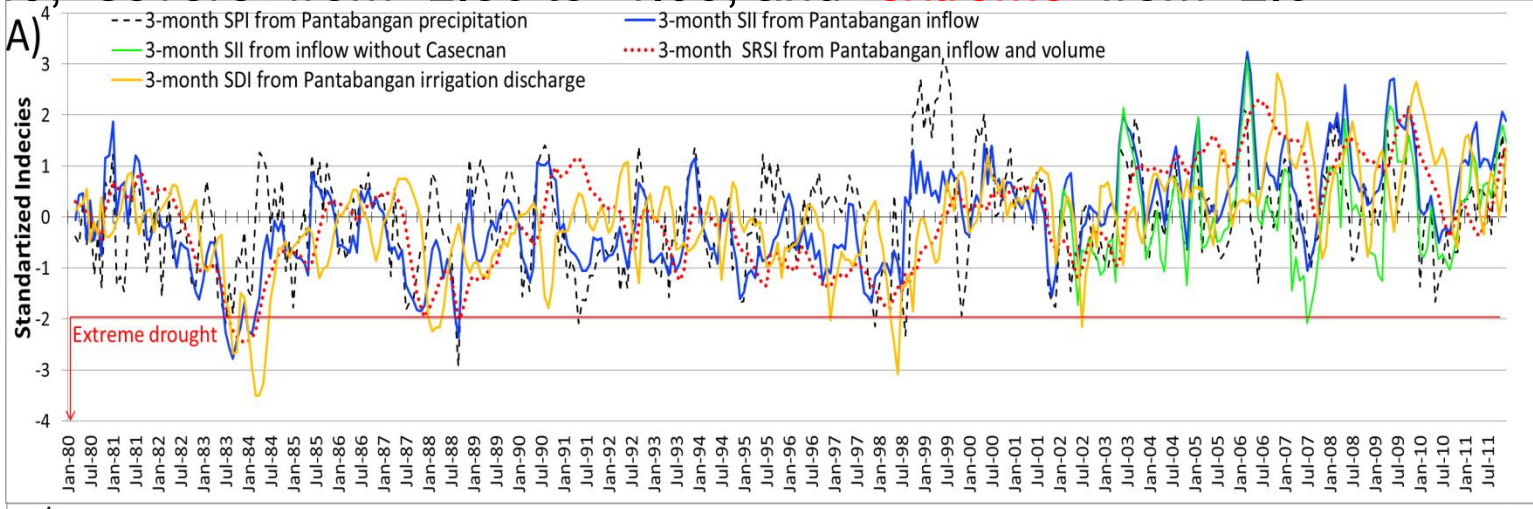


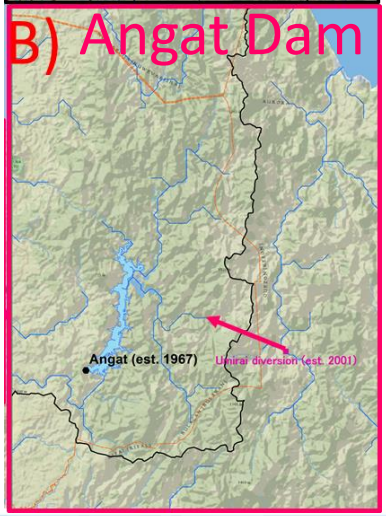
Reference: McKee et al. (1993); World Meteorological Organization (WMO) (2012); Gusyev et al. (2015).

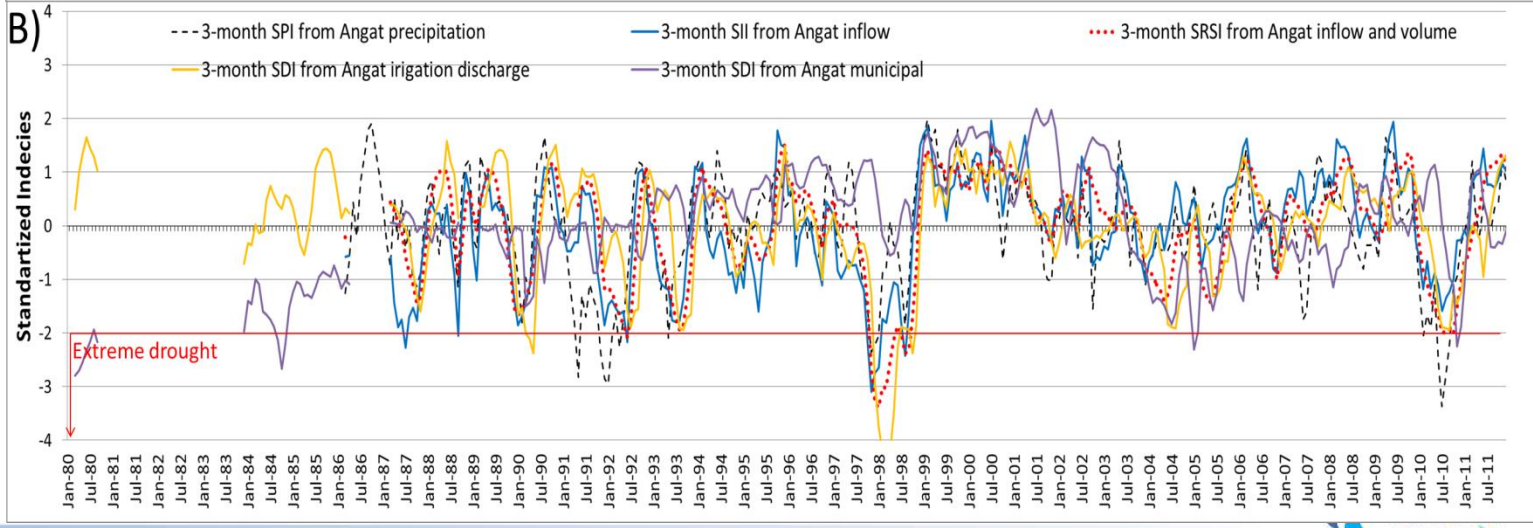
Standardized indices for the Pantabangan and Angat Dams from 1980 to 2012

The same scale of standardized indices: "near normal" up to -0.99, "moderate" from -1.0 to -1.49, "severe" from -1.50 to -1.99, and "extreme" from -2.0



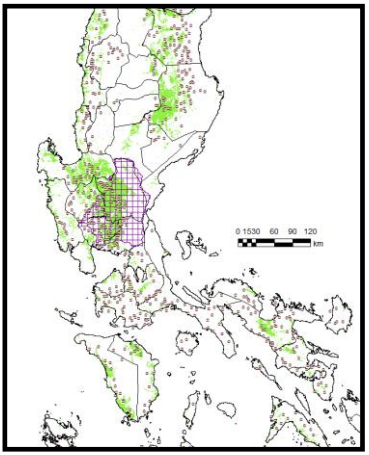






Reference: Gusyev et al. (2015). Drought assessment in the Pampanga River basin, the Philippines - Part 1: Characterizing a role of dams in historical droughts with standardized indices. The 21st International Congress on Modeling and Simulations (MODSIM) 2015, Brisbane, Nov 29-Dec 4, Australia.

Monthly Normalized Difference Vegetation Index (NDVI) (0.25 degree grids) from AVHRR

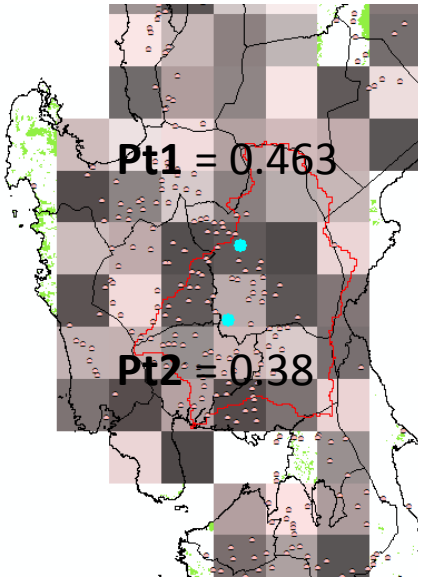


AVHRR is the Advanced Very High Resolution Radiometer

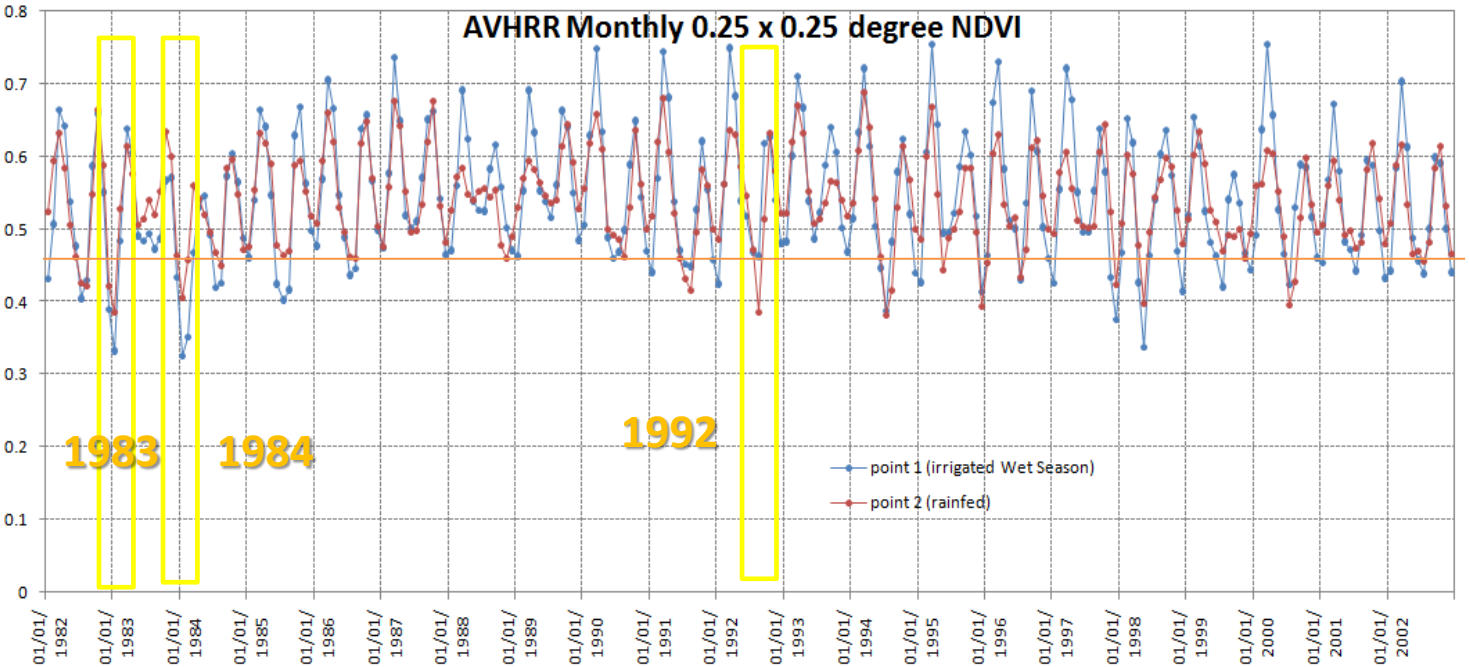
- **Point 1**: UPRIIS irrigated area (Lat. = 15.641° , Long. = 120.882°)
- **Point 2**: Downstream of UPRIIS in Nueva Ecija in shallow rainfed area (Lat. = 15.284° , Long. = 120.818°)

Pink dots: rice types (details) as collected by IRRI and mapped in 1982

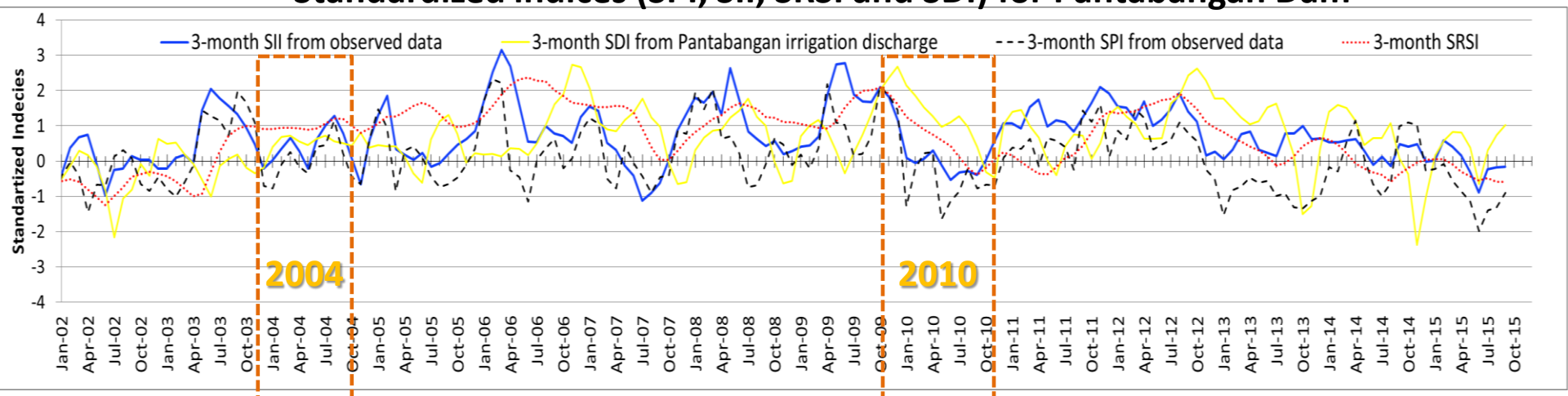
Green area: agriculture extent by PhilRICE and IRRI

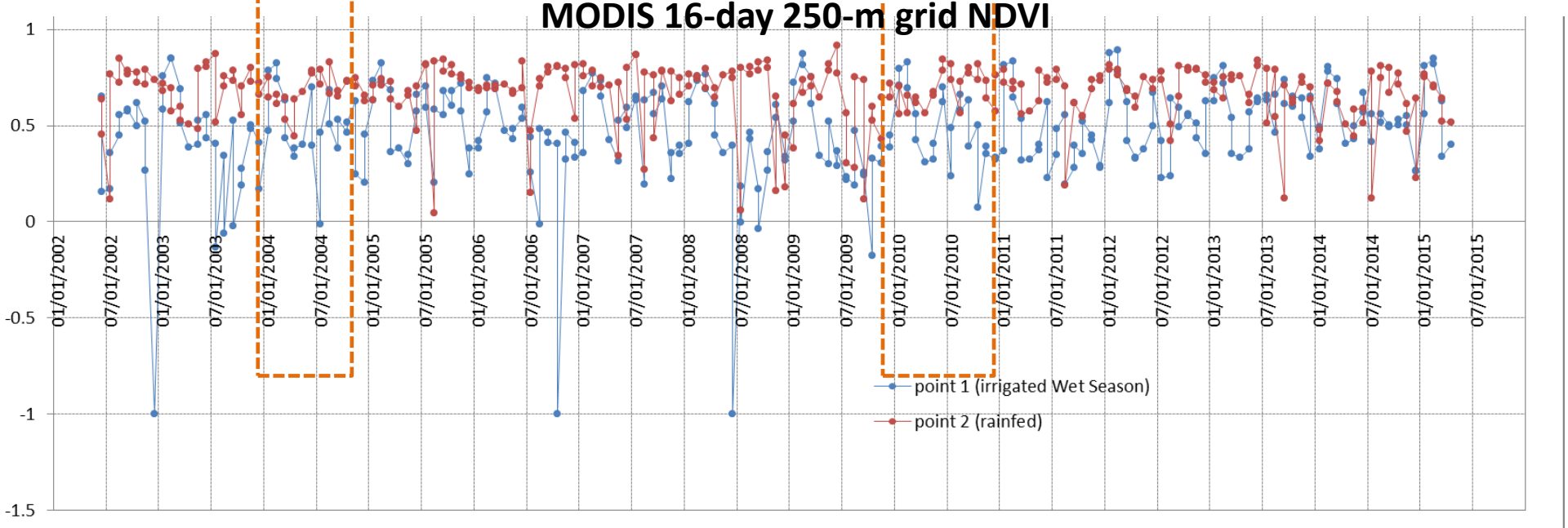


AUGUST 1992



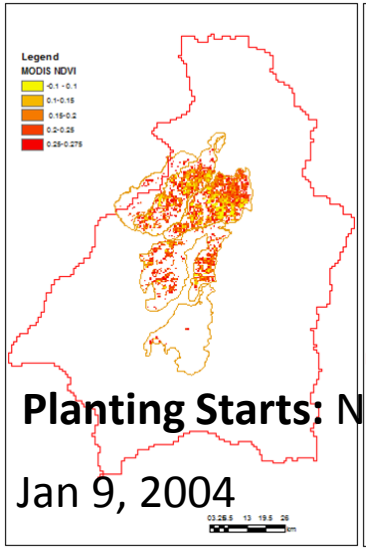
Combining standardized indices with MODIS 16-day NDVI (250-m grids) from 2002 to 2015





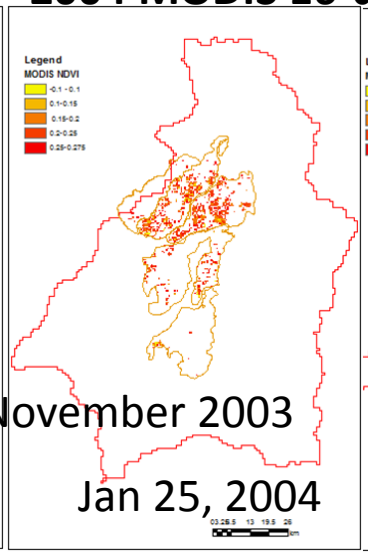
Spatial distribution of 2004 and 2010 drought in the Pantabangan Dam irrigated area

2004 MODIS 16-day NDVI (250-m)

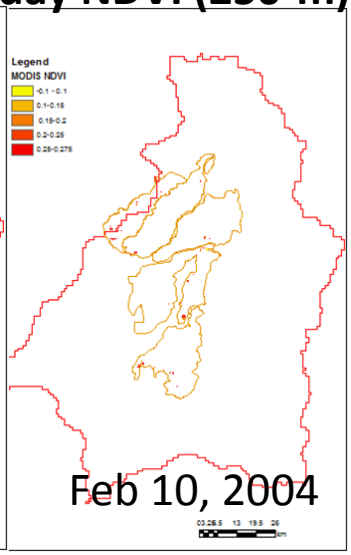


Planting Starts: November 2003

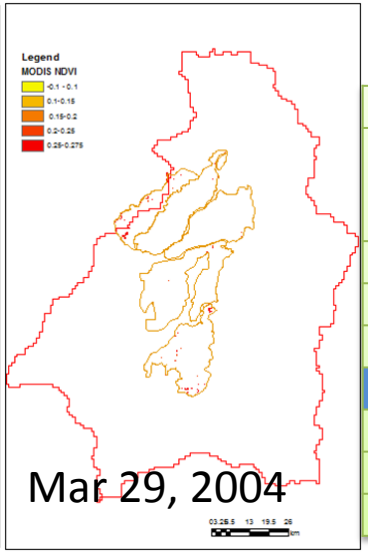
Jan 9, 2004



Jan 25, 2004



Feb 10, 2004

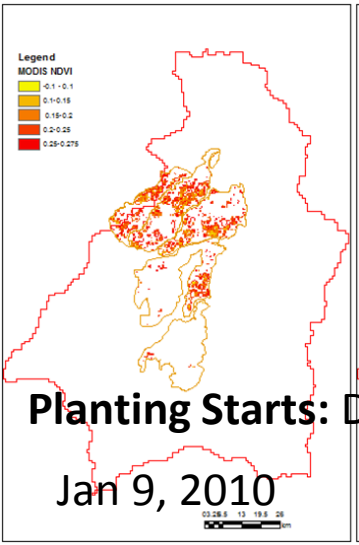


Mar 29, 2004

Damaged Area in 2004:
1623 ha (*Source: NIA*)

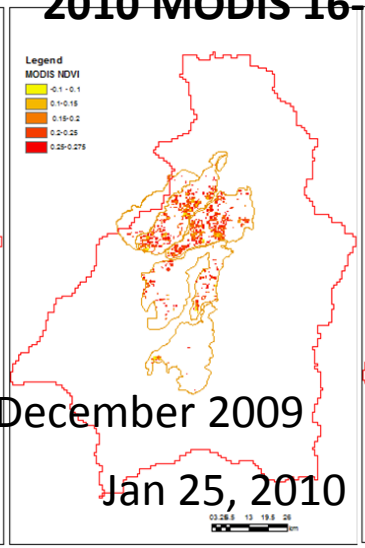
Threshold value	0.275
Total service area (paddy rice inside UPRIIS), ha	163733.800
Date	**Area, ha**
01/09/2004	55057.550
01/25/2004	23931.620
02/10/2004	1354.221
02/26/2004	2391.046
03/13/2004	2052.491
03/29/2004	1904.373

2010 MODIS 16-day NDVI (250-m)

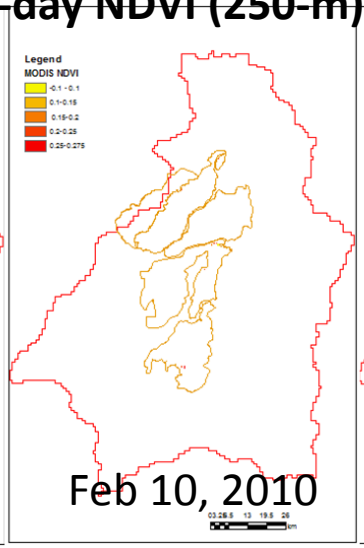


Planting Starts: December 2009

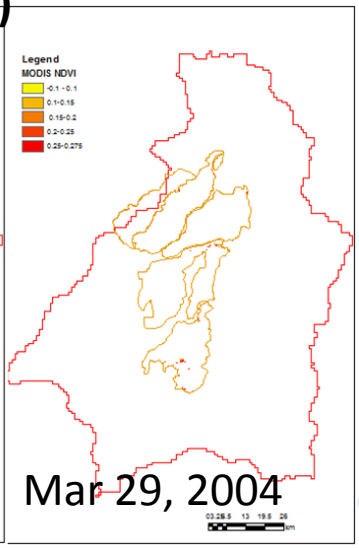
Jan 9, 2010



Jan 25, 2010



Feb 10, 2010



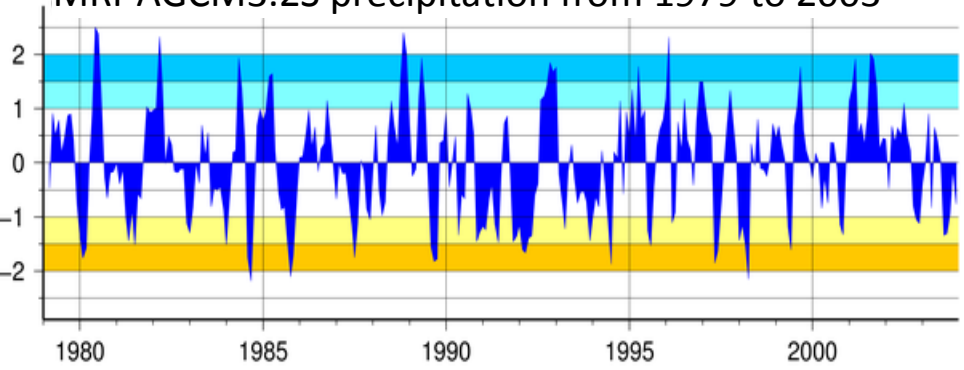
Mar 29, 2004

Damaged Area in 2010:
5691 ha (*Source: NIA*)

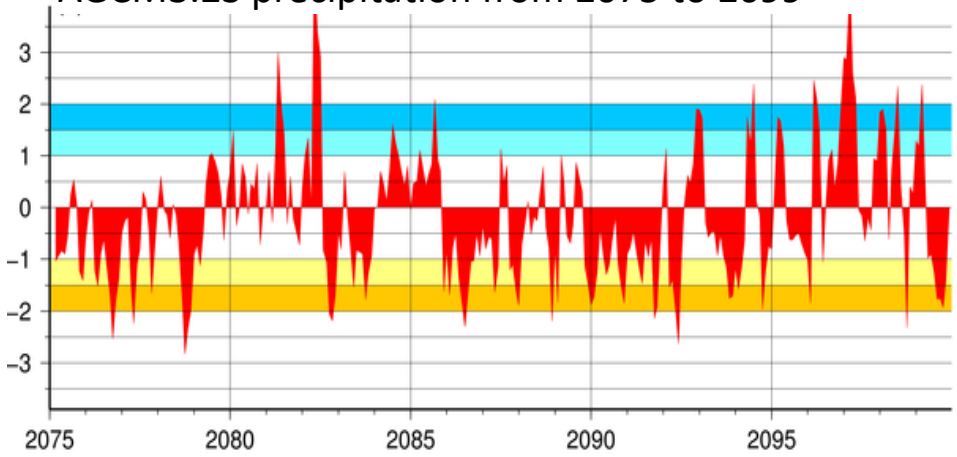
Threshold value	0.275
Total service area (paddy rice inside UPRIIS), ha	163733.800
Date	**Area, ha**
01/09/2010	35146.270
01/25/2010	6220.953
02/10/2010	275.076
02/26/2010	190.437
03/13/2010	402.034
03/29/2010	782.909

Standardized precipitation indices at Angat Dam under climate change

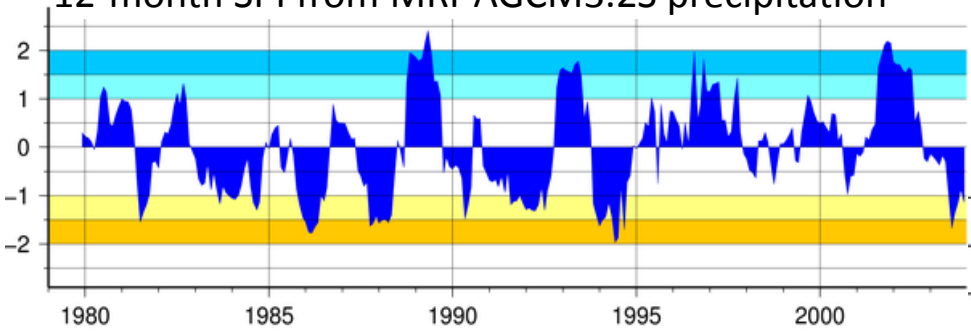
3-month standardized precipitation index (SPI) from MRI-AGCM3.2S precipitation from 1979 to 2003



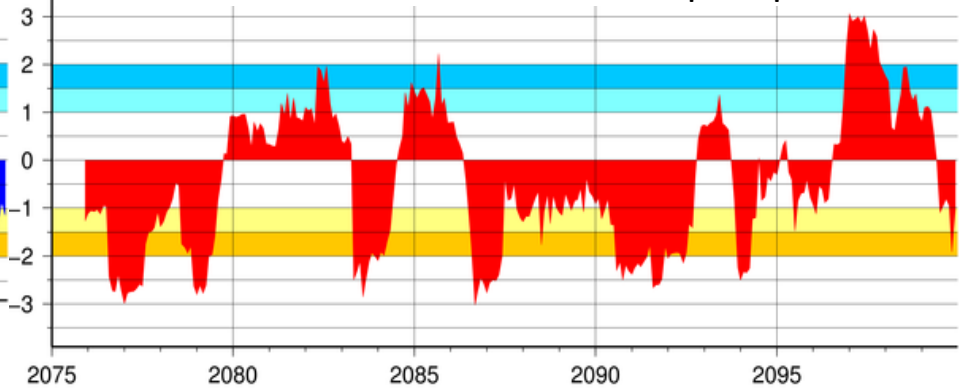
3-month comparative SPI (cSPI) from MRI-AGCM3.2S precipitation from 2075 to 2099



12-month SPI from MRI-AGCM3.2S precipitation



12-month cSPI from MRI-AGCM3.2S precipitation



The scale of standardized indices: “near normal” |cSPI| < 1.0, “moderate” 1.0 ≤ |cSPI| < 1.5, “severe” 1.50 ≤ |cSPI| < 2.0, and “extreme” |cSPI| => 2.0

Reference: Hasegawa et al. (2015). Drought assessment in the Pampanga River basin, the Philippines - Part 2: A comparative SPI approach for quantifying climate change hazard. The 21st International Congress on Modeling and Simulations (MODSIM) 2015, Brisbane, Nov 29-Dec 4, Australia.

Summary

1) We introduced a full-set of the standardized indices on 3-month time scale to provide useful information about natural and socio-economic drought development.

2) A combined use of standardized indices with NDVI can provide a spatial distribution of drought affected areas, but more field verification is needed.

3) The introduced standardized indices of 3-month time scale are applicable for drought monitoring with daily time step using one reference period.

4) This full-set of standardized indices can be computed from simulation results of local and Global BTOP models to provide drought forecast and climate change information for drought disaster risk management.

Acknowledgement

We express our sincere gratitude to

Ms. Rosalie Pagulayan and Mr. Hilton Hernando from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA),

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Mr. Russel Rigor of National Power Corporation,

and many others for their contribution of our drought research activities.

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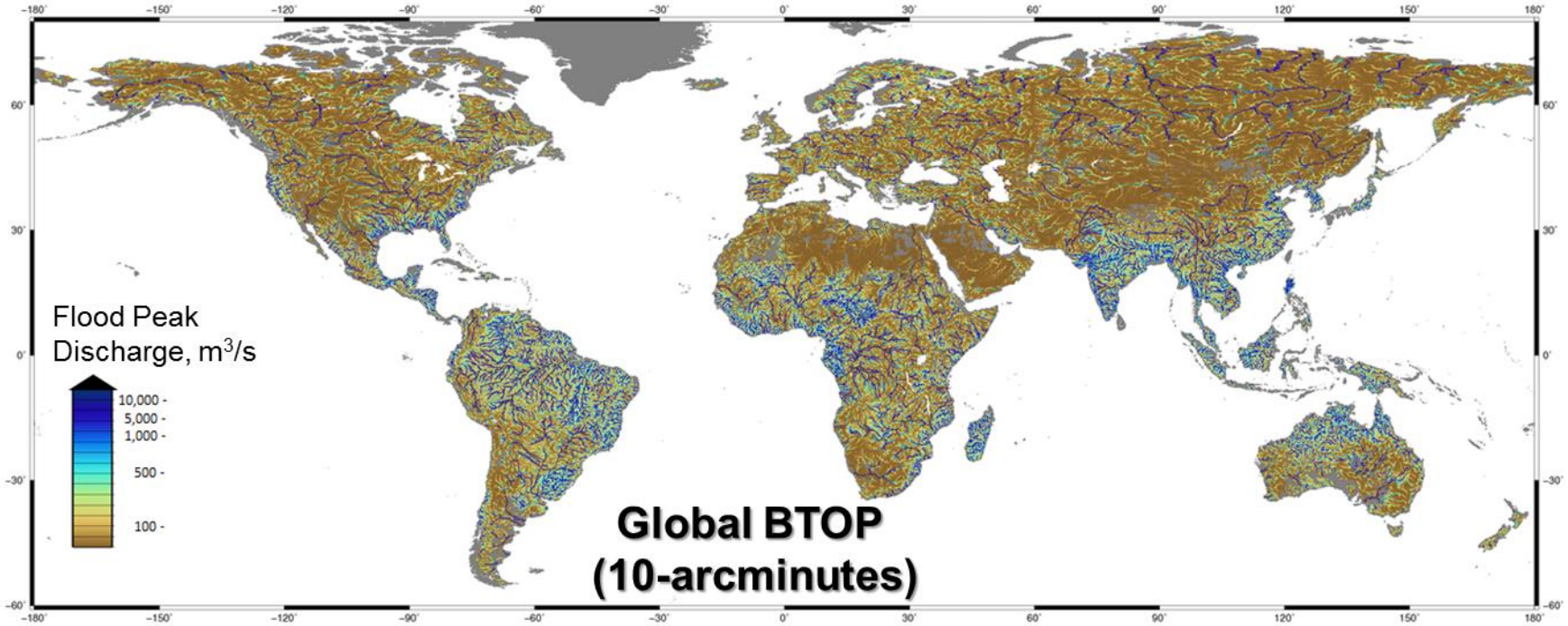
Thank you!

Please contact me by e-mail

gusyev55@pwri.go.jp



Reference: Magome J., Gusyev M.A., Hasegawa A. and K. Takeuchi (2015). River discharge simulation of a distributed hydrological model on global scale for the hazard quantification. MODSIM 2015, Brisbane, Nov 29-Dec 4, Australia