Multi-objective calibration of a hydrological model using satellite-based data and ground data for improved drought management in a poorly gauged Mekong River basin

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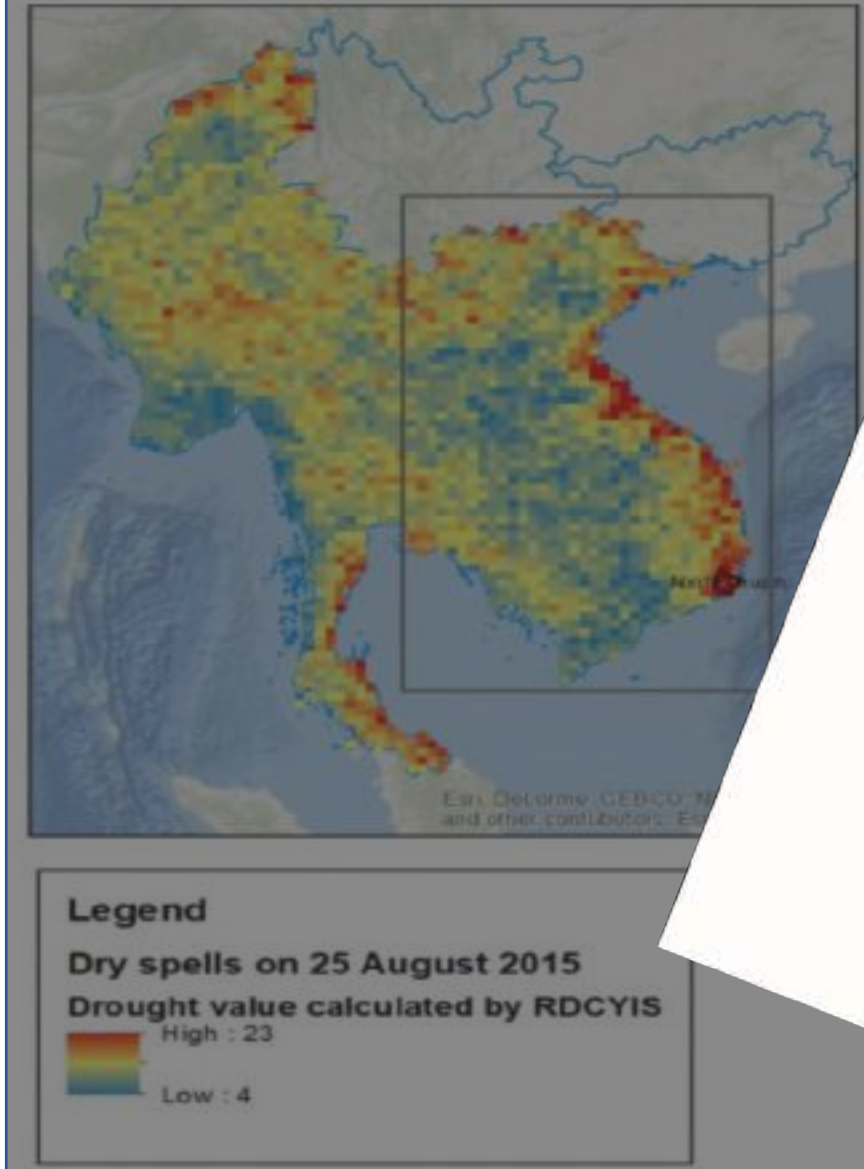

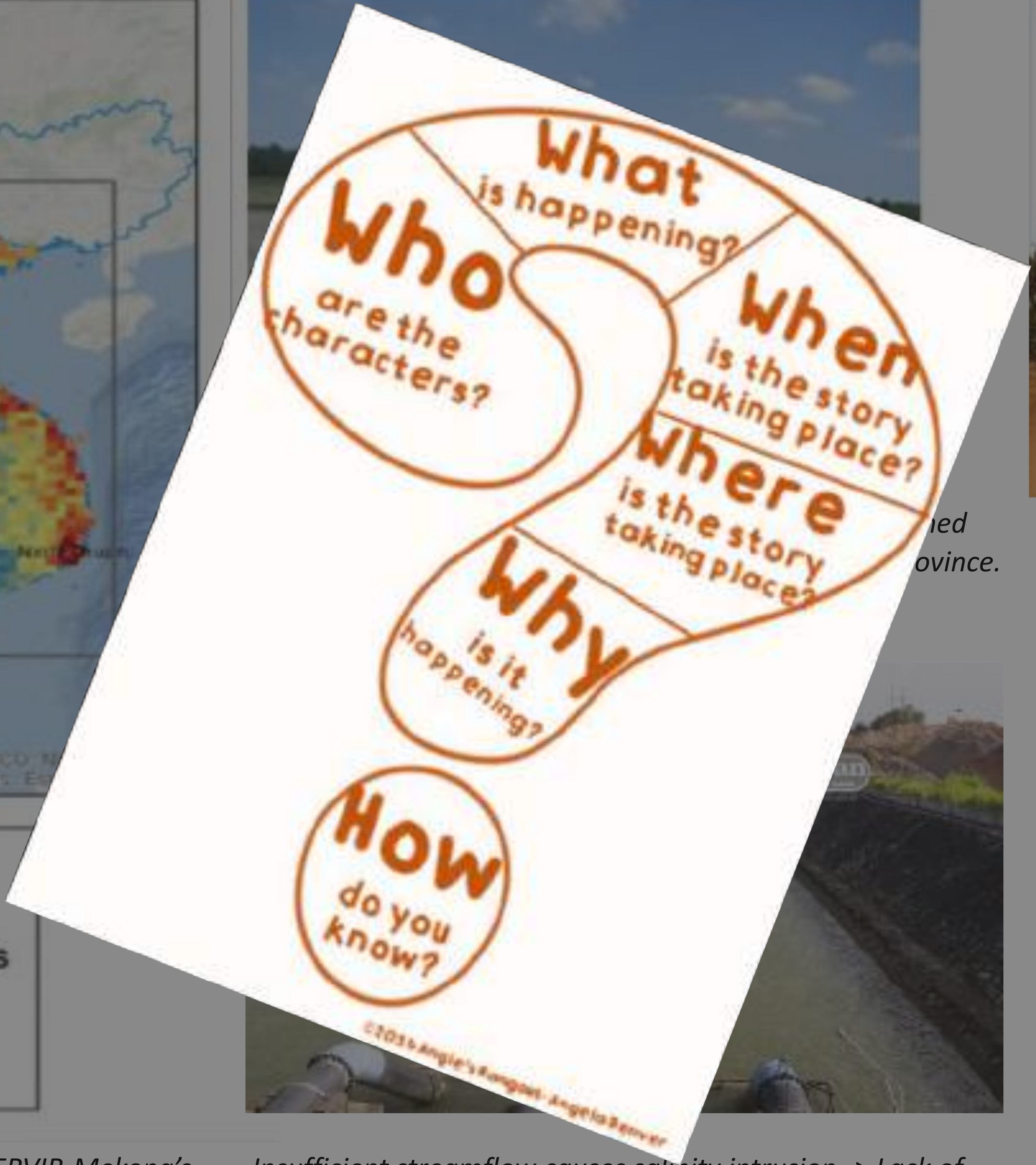

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Massive coffee fields have been abandoned because of water shortage for irrigation in Gia Lai in 2015.
Image Credit: Tintuc Media, 2015

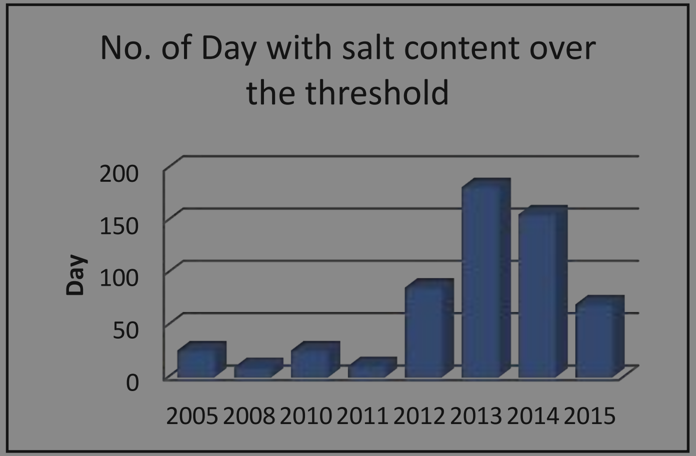
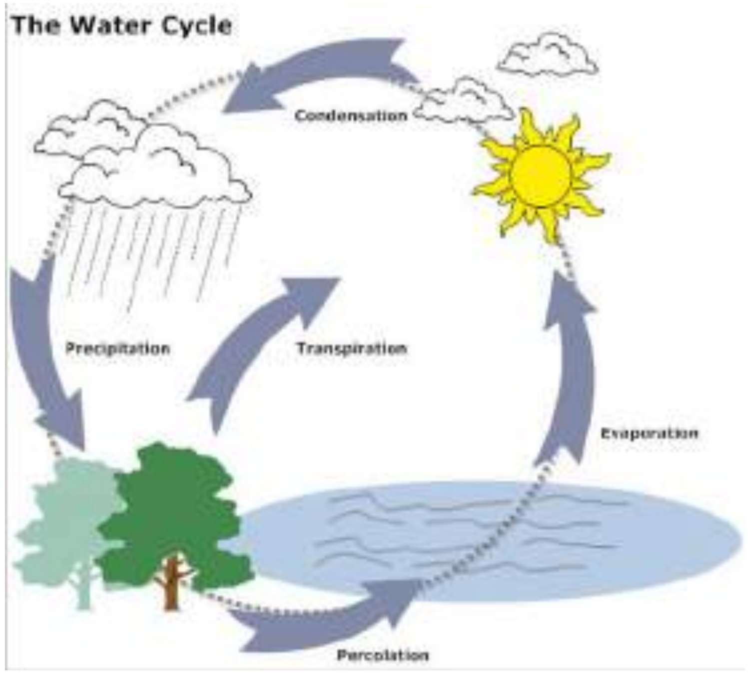


Image credit: ADPC/ This map generated from SERVIR-Mekong's Regional Drought and Crop Yield Information System shows dry spell areas throughout Vietnam during the drought of 2015.

Insufficient streamflow causes salinity intrusion -> Lack of surface water for water supply plant in Danang, 2018
Image Credit: CADN Media, 2018

Insufficient streamflow causes salinity intrusion -> Lack of surface water for water supply plant in Danang, 2018. Graph credit: DISED, 2016

Background



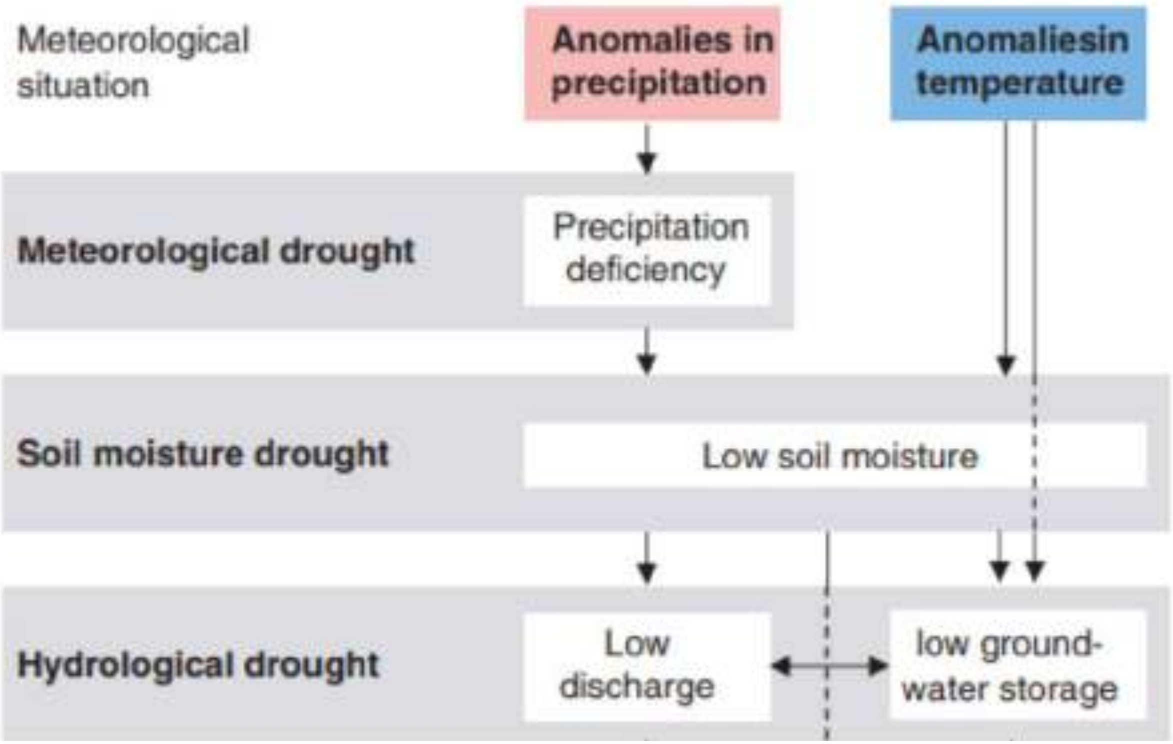


FIGURE 2 | Scheme representing different categories of drought and their development. (Derived from Peters,[53] Van Loon,[54] Stahl[55]).

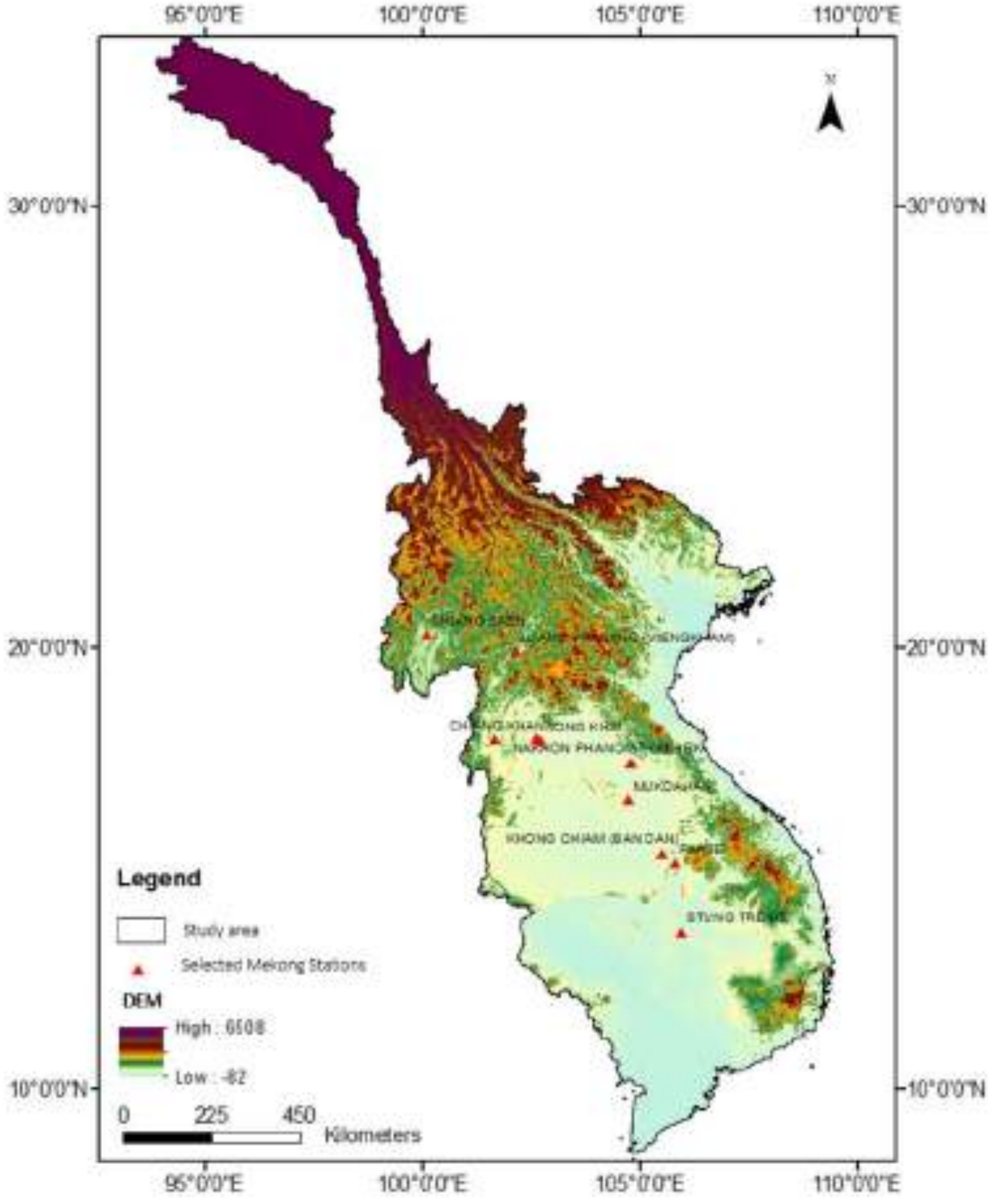
Loon, 2015

Research Questions

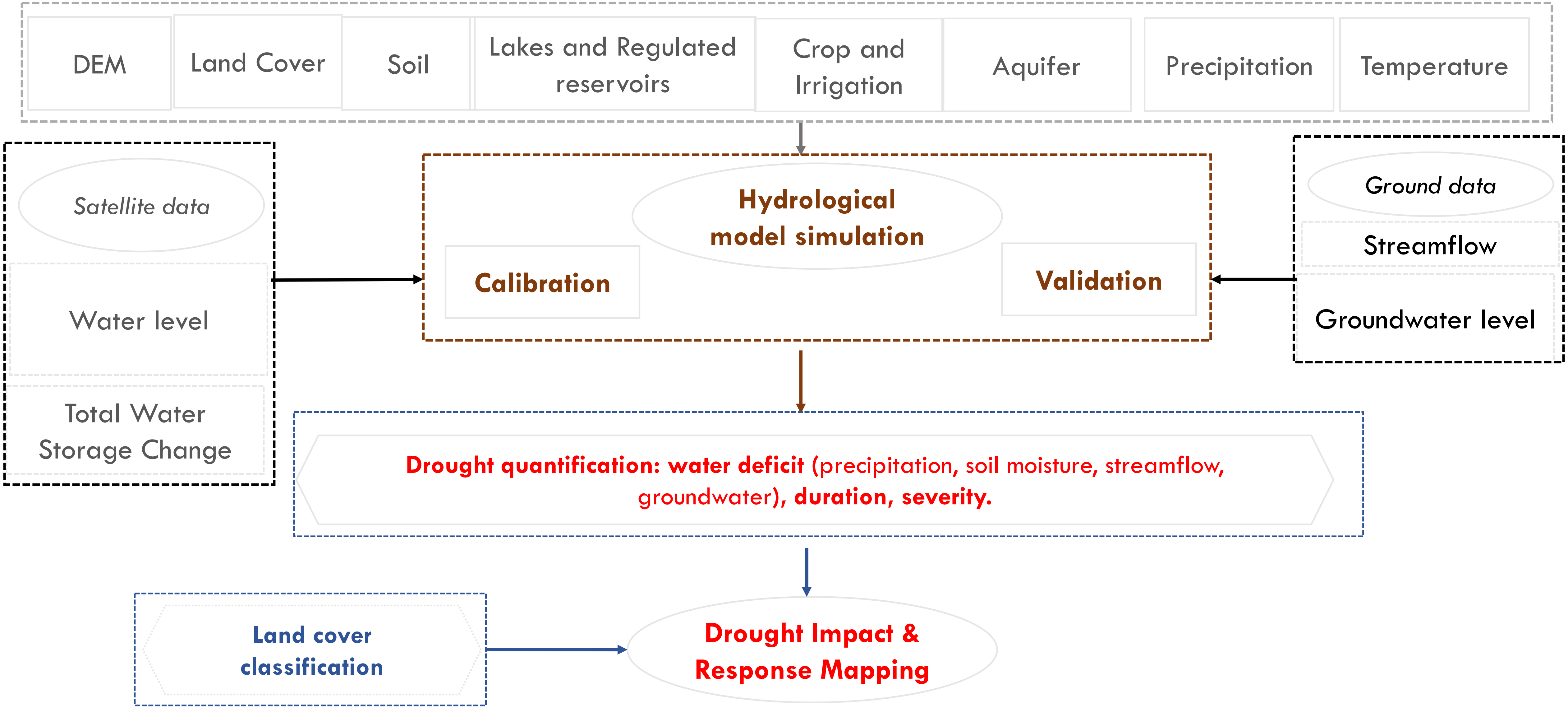
- Drought was a recurring disaster in the region, causing significantly high socio-economic cost to the local people.
- The area lacks a comprehensive and practical drought monitoring network.
- The study aims to answer

(1) What causes drought and how to quantify drought in the region?

(2) Is there an alternative water source in response to drought?



Proposed research Framework



Research steps

Step 1

- Review existing drought indices
- Examine **which drought indices** can be used for a typical coastal river basin

Step 2

- Setup hydrological model in Indochina region
- Examine **drought impact mapping methodology** in one small river basin

Step 3

- Examine **multi-objective calibration** in **Mekong river basin**
- Apply drought impact and response mapping the basin

Step 4

- Calibrate and validate hydrological model in **Indochina region**
- Apply the drought impact and response mapping in the region

Step 1 Research Results

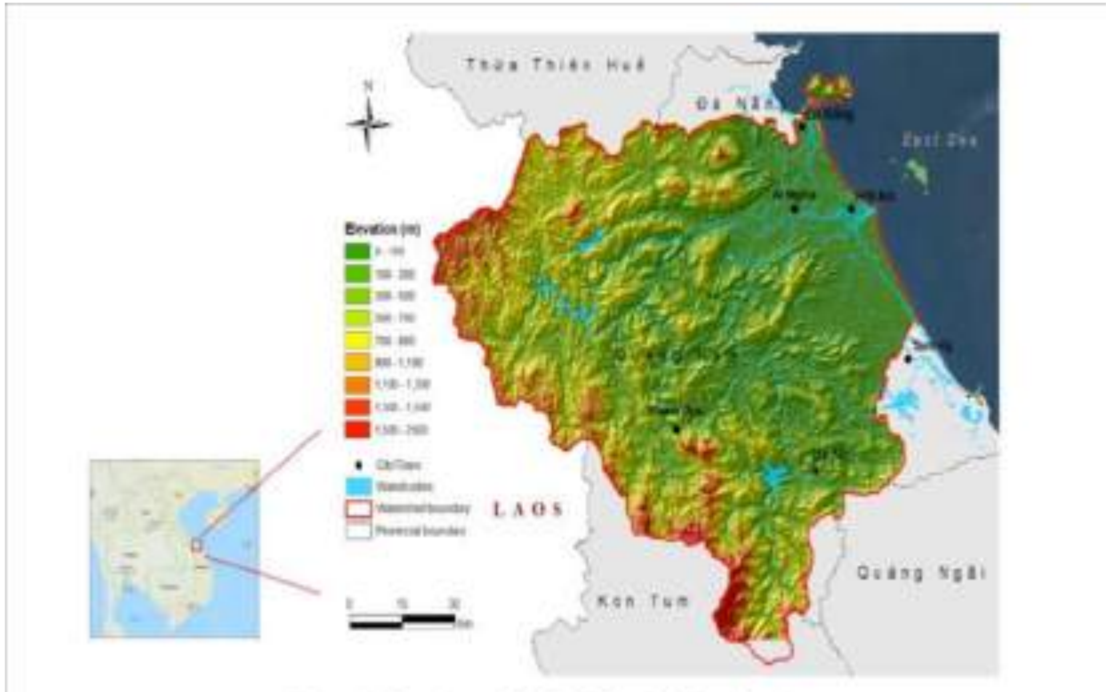


Figure 1. Overview of the Vu Gia—Thu Bon basin.


Figure 8. Number of drought months identified by six VIs at different locations.

Figure 9. Maximum duration of droughts identified by six VIs at different locations.

Du et al., 2018

Finding:

- **No consistent index and method** for all drought types
- Less studies **linking different drought types** in real cases.

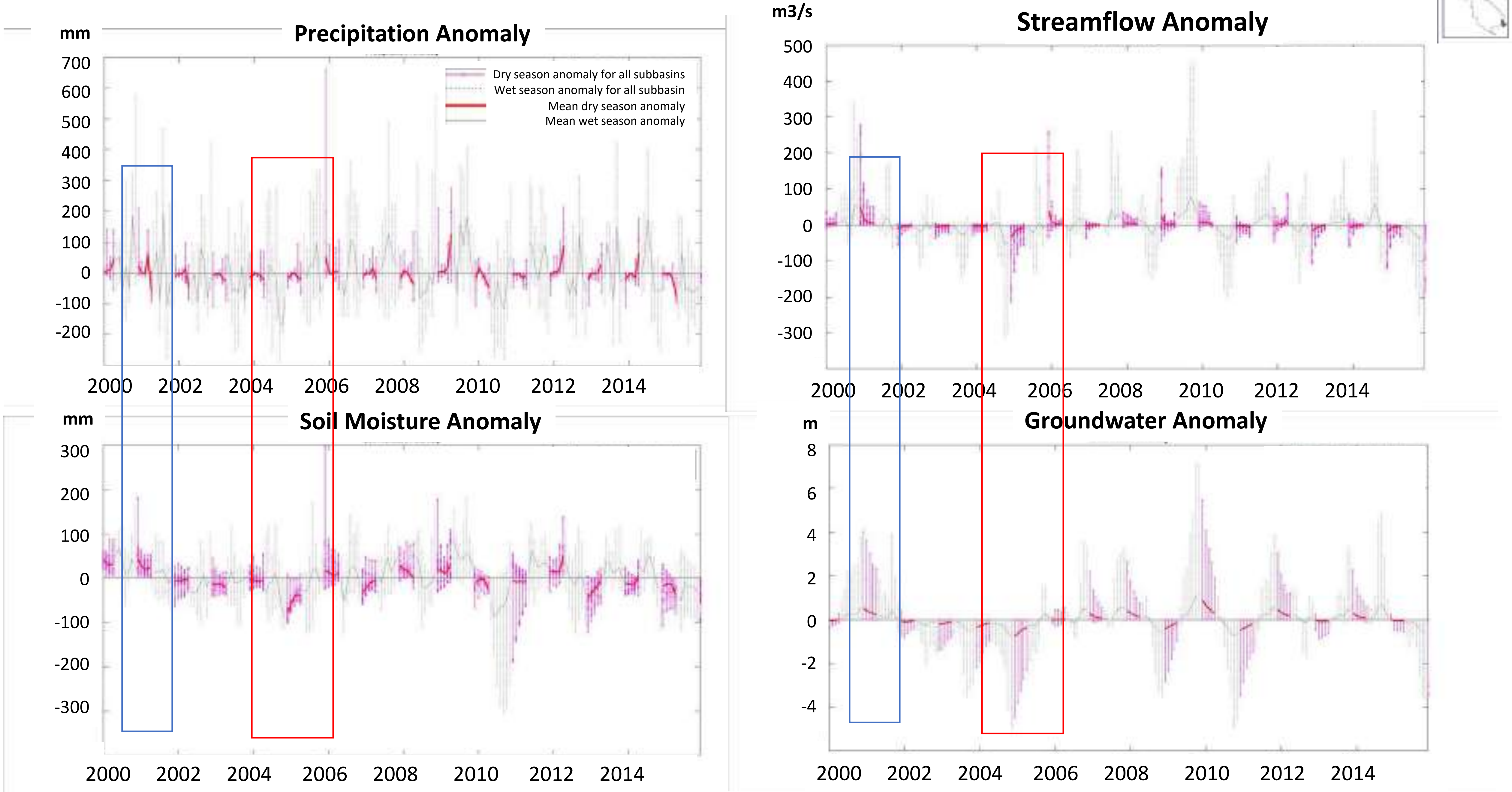
	SPHY	TOPKAPI-ETH	SWAT	VIC	LIS-FLOOD	SWIM	HYPE	mHM	MIKE-SHE	PCRGLOB-WB	GEO-top
Processes integrated											
Rainfall–runoff	+	+	+	+	+	+	+	+	+	+	+
Evapotranspiration	+	+	+	+	+	+	+	+	+	+	+
Dynamic vegetation growth	+	–	+	+	+	+	a	NA	+	+	–
Unsaturated zone	+	+	+	+	+	+	+	+	+	+	+
Groundwater	+	–	+	+	+	+	+	+	+	+	+
Glaciers	+	+	–	–	–	+	+	–	–	–	+
Snow	+	+	+	+	+	+	+	+	+	+	+
Routing	+	+	+	+	+	+	+	+	+	+	+
Lakes incorporated into routing scheme	+	–	+	+	+	+	+	NA	+	+	–
Reservoir management	–	–	+	–	–	+	+	NA	–	+	–
Field of application											
Climate change impacts	+	+	+	+	+	+	+	+	+	+	+
Land use change impacts	+	+	+	+	+	+	+	+	+	+	+
Irrigation planning	+	–	+	+	–	+	+	–	+	–	+
Floods	–	–	–	–	c	–	+	–	+	+	+
Droughts	+	+	+	+	+	+	+	+	+	+	+
Water supply and demand	–	–	+	–	–	–	+	NA	–	–	–

Terink et al., 2015

Step 2 Research Results: *Setting up the model*

No	Variables	Detail/resolution	Data source
1	Topography and routing	15 arc-second	Hydrosheds (Lehner et al., 2008) and Hydro 1K (USGS)
2	Land cover	300 m	ESA Clmate Change Initiative – Land Cover project (ESA, 2017)
3	Soil	30 arc second	Harmonized World Soil Database
3	Lakes		Global Lake and Wetland Database 1.1 (GLWD) (Lehner and Döll, 2004)
4	Reservoirs and dams		Global Reservoir and Dam database v 1.1 (GRanD) (Lehner et al., 2011)
5	Temperature	0.5 degree, daily	HydroGFD (from Climate prediction Center, CPCtemp, 2018) (Berg et al., 2018)
6	Precipitation	0.5 degree, daily	HydroGFD (from GPCCv7 and CPC) (Berg et al., 2018)
7	River discharge (in-situ)	30 stations	Mekong River Commission (MRC) and National Centre for Hydro-Meteorological Forecasting (NCHMF)
8	Total Water Storage change	>150,000 km^2	NASA's Gravity Recovery and Climate Experiment (GRACE)
9	Water level		Envisat, Jason 2, Jason 3, Sentinel 3A
10	Aquifer		National Center for Water Planning and Investigation (NAWAPI) and International Groundwater Resources Assessment Centre (IGRAC)

Step 2 Research Results: *Testing drought impact mapping concept*



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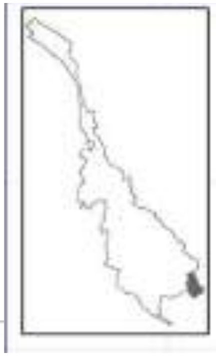

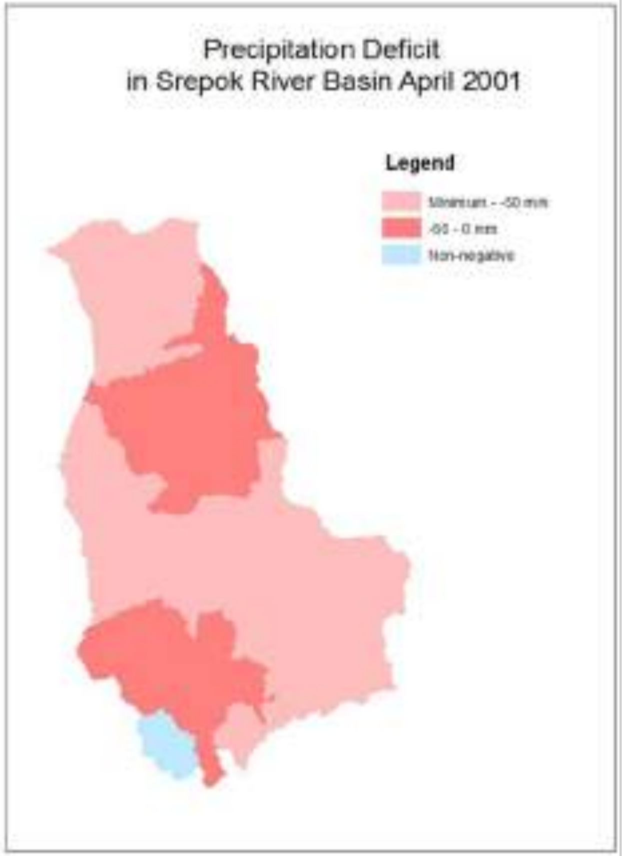

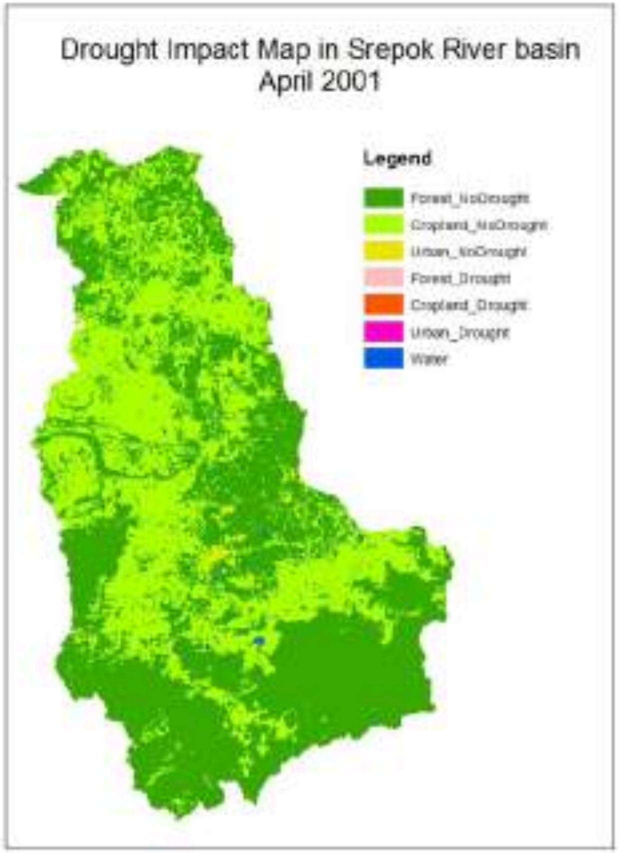

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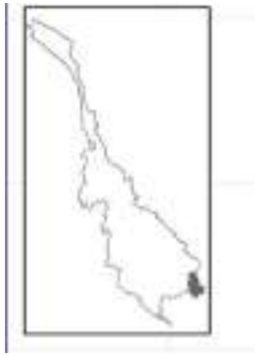
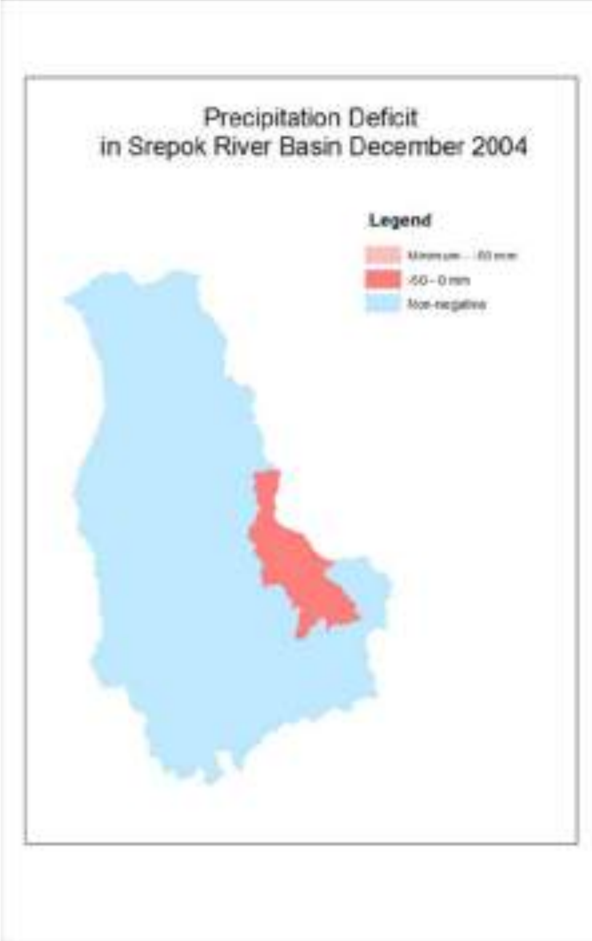
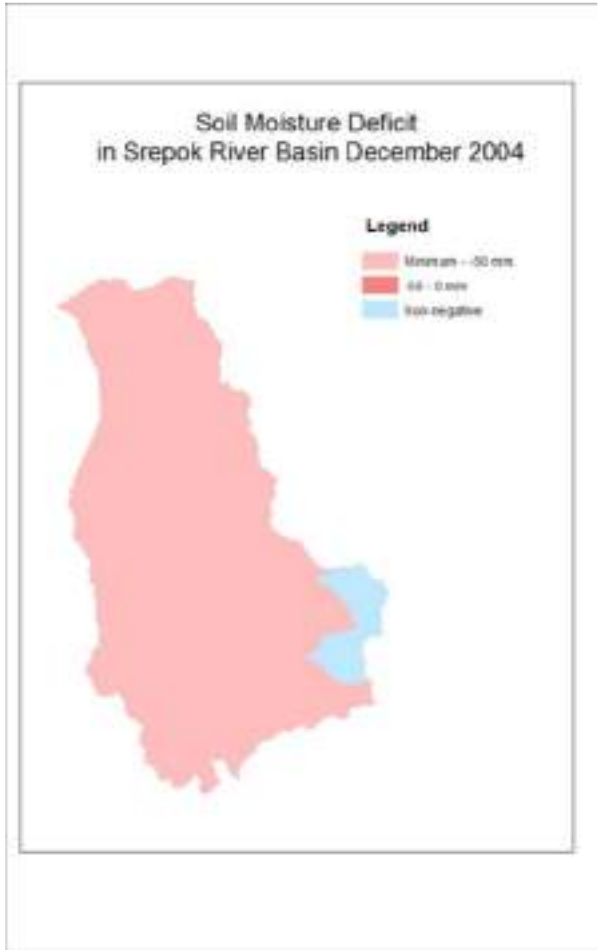
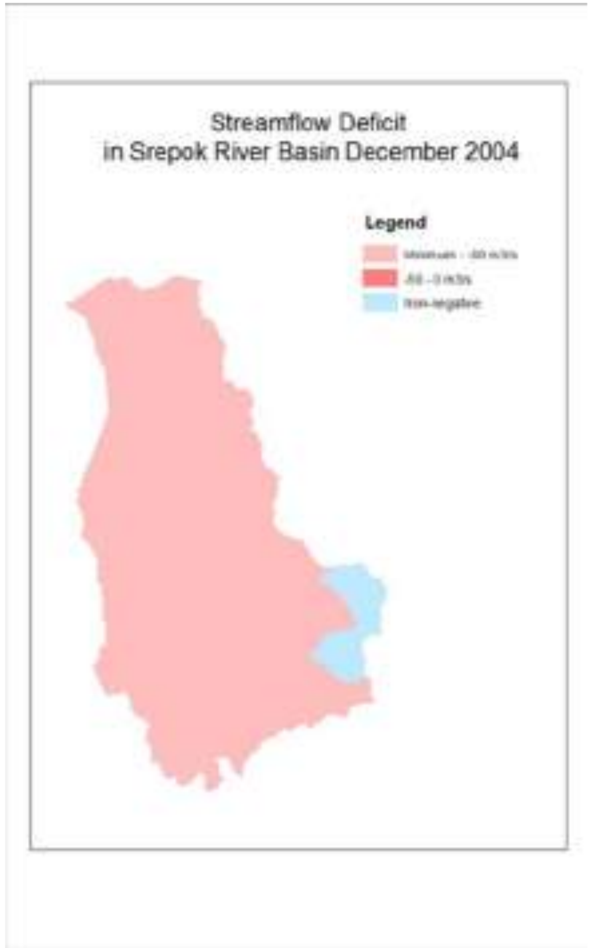
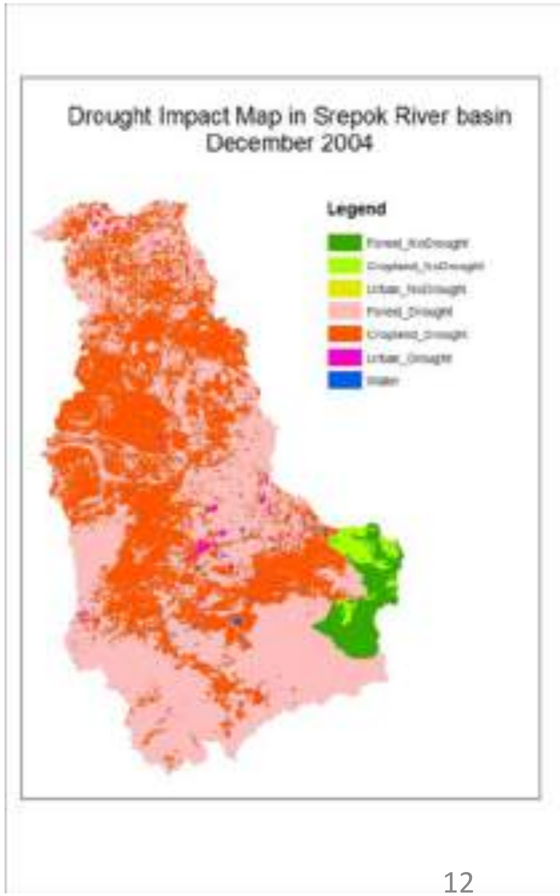








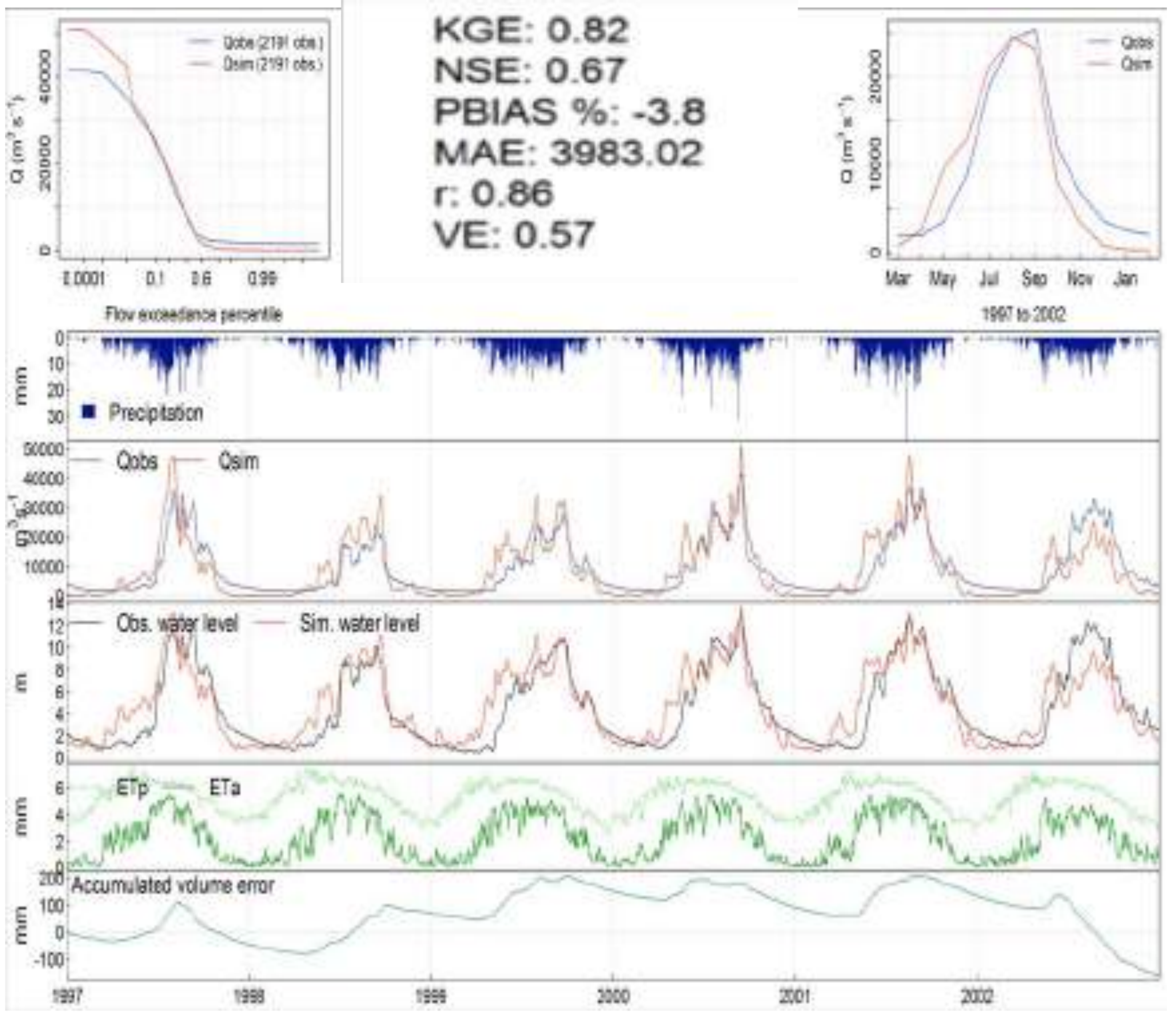


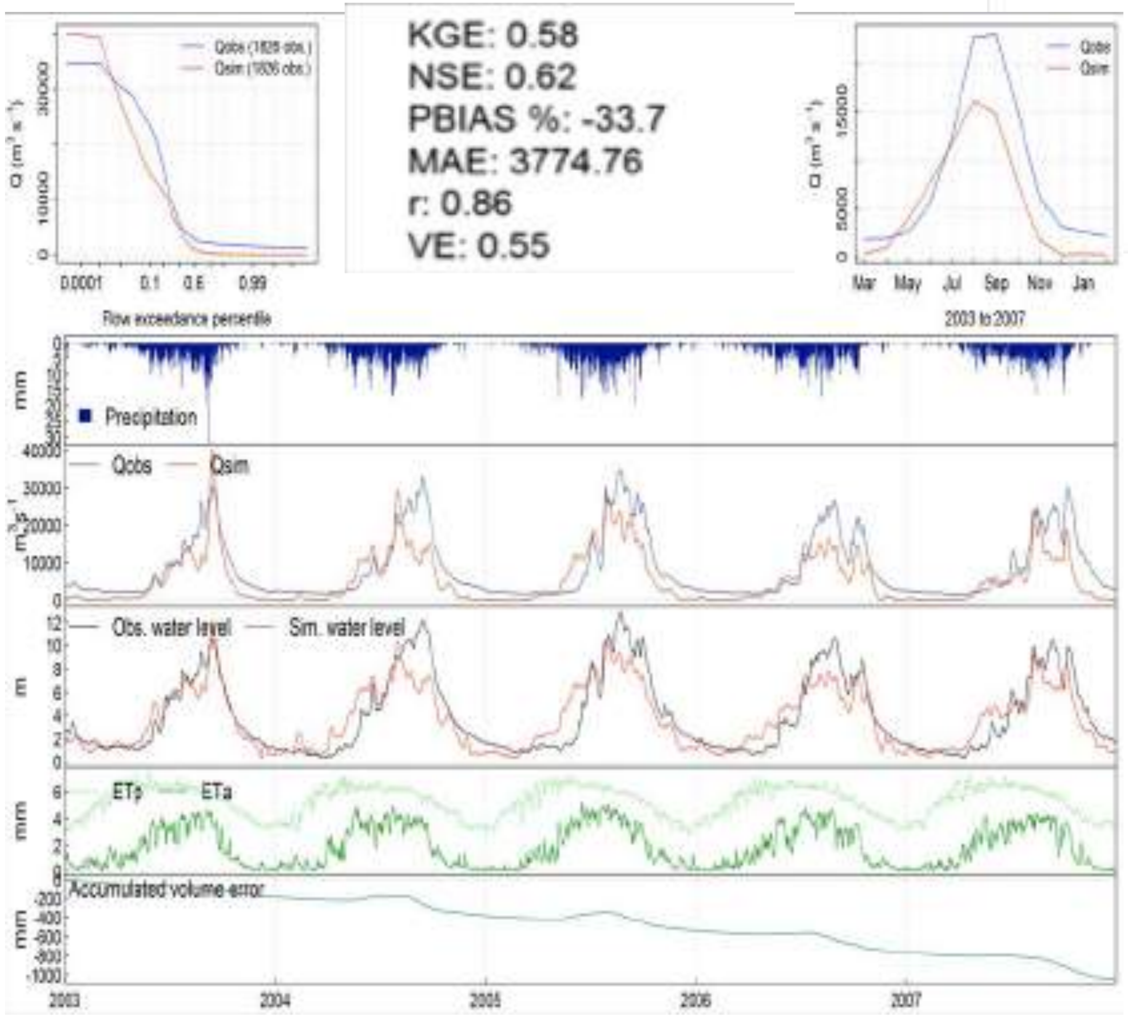
Step 3 Preliminary research results: *Calibrating model in Mekong river basin*

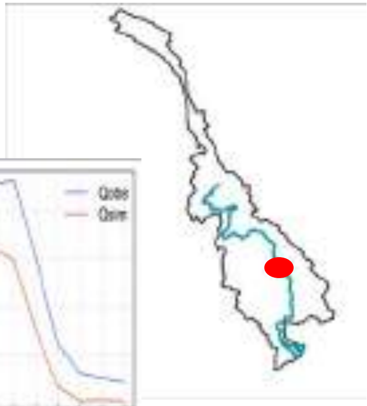
Station Name	NSE value for discharge Calibration period 1997 – 2002	NSE value for discharge Validation period 2003 – 2007
Chiang Saen	0.407	0.405
Luang Prabang	0.561	0.573
Chiang Khan	0.557	0.626
Vientiane	0.519	0.64
Nong Khai	0.585	0.686
Nakhon Phanom	0.704	0.507
Thakhek	0.691	0.503
Mukdahan	0.719	0.608
Khong Chiam	0.74	0.66
Pakse	0.716	0.744

Station Name	NSE value for water level Calibration period 1997 – 2002	NSE value for water level Validation period 2003 – 2007
Nong Khai	0.749	0.712
Nakhon Phanom	0.706	0.718
Thakhek	0.697	0.736
Khong Chiam	0.79	0.79
Pakse	0.73	0.772

Step 3 Preliminary research results: *Calibrating model in Mekong river basin*

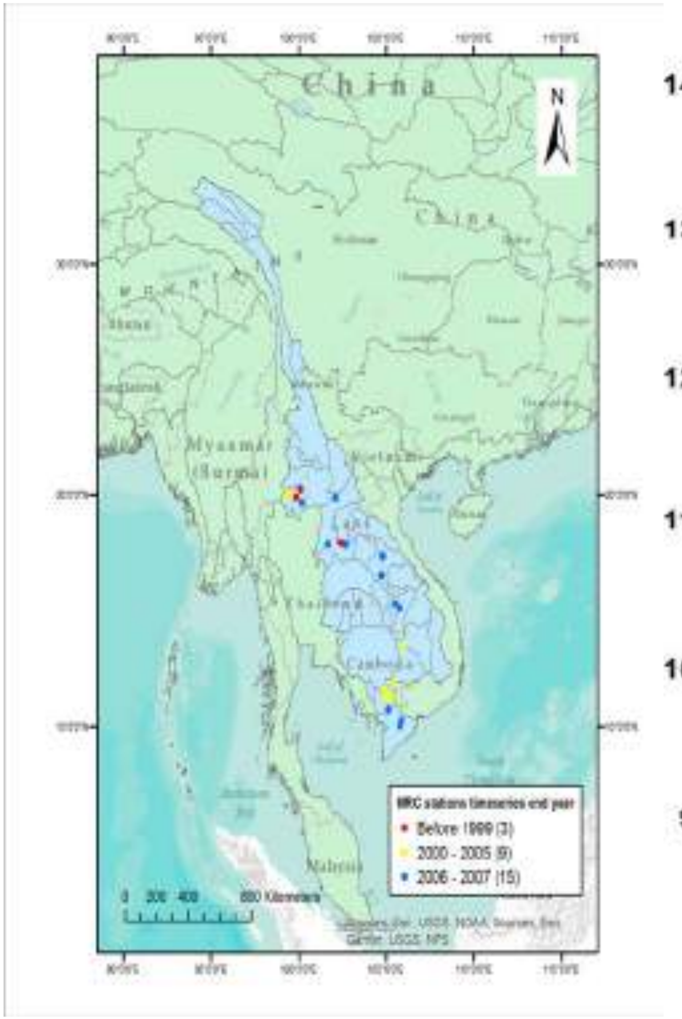


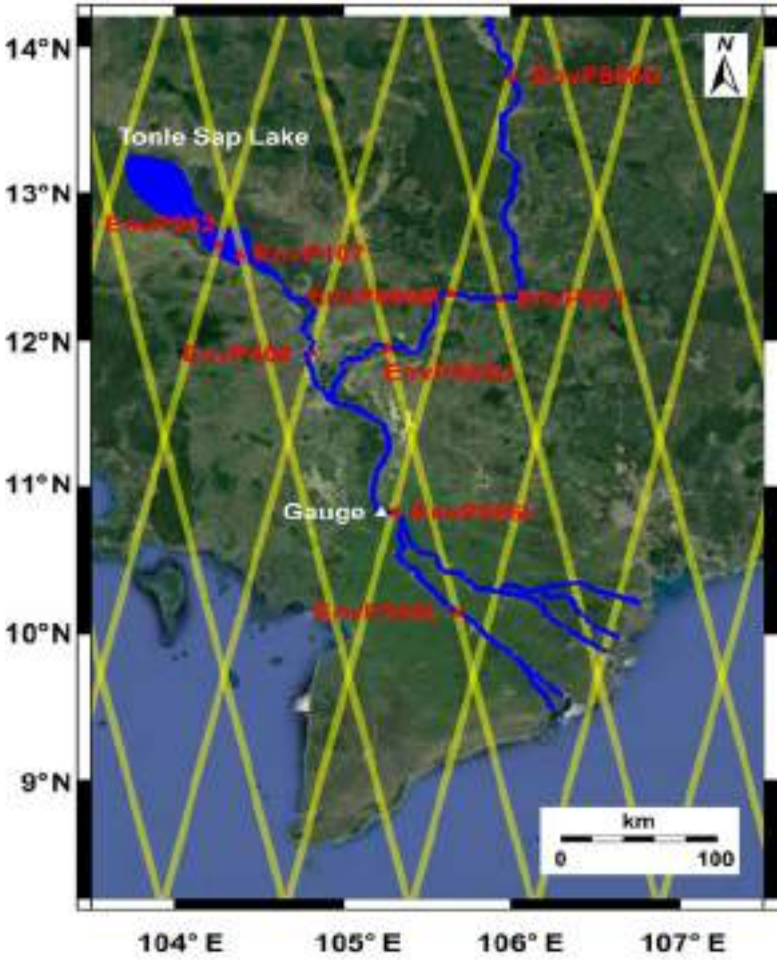


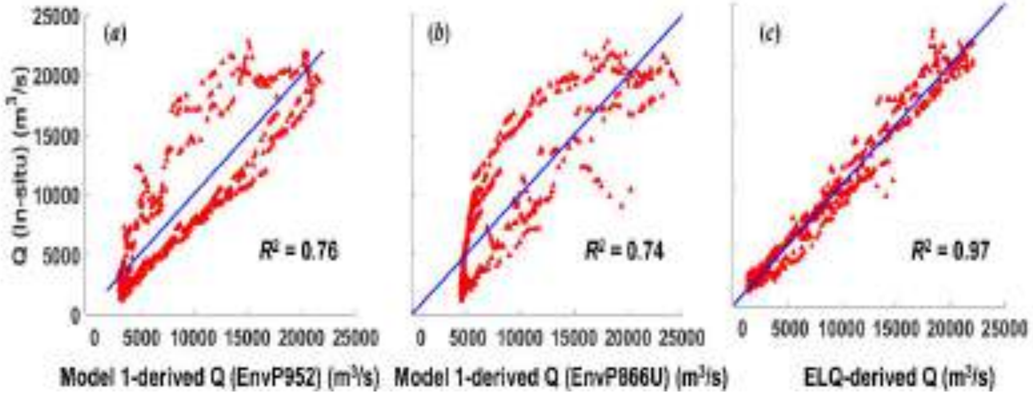


Khong Chiam Station

Step 3 Next research steps: *Using Altimetry-based water level and reconstructed discharge for supporting existing observation data*







GC31K-1384: Deriving Daily Discharges from Satellite Radar Altimetry and Ensemble Learning Regression in Poorly Gauged River Basins
12th December, 2018 (8-12.20 AM) , Poster Hall. Presented by Donghwan Kim

Conclusion and outlook

- It is essential to understand and address drought problems in this important drought-prone region.
- The selected hydrological tool is applicable for multi-basin and multi-objective calibration, thus better simulation of all water components.
- Drought impact mapping method is successful to understand what drought, how, when and where drought happened in selected river basin.
- Remote sensing and open source data will be very useful for this poorly gauged river basin to supplement scarce ground data.
- Continue to calibrate model using remote sensing data (altimetry and GRACE) and map drought impact and responses in the region.

Thank you for your attention

For more information, please contact

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