CAMBODIA LAO PDR THAILAND VIETNAM

THE JOINT RESEARCH ON HYDROLOGICAL IMPACTS OF THE LANCANG HYDROPOWER CASCADE ON DOWNSTREAM FLOOD AND DROUGHTS

KEY FINDINGS ON ANALYSIS OF EXTREME DROUGHT OF 2015-2016

THE 8TH MRC REGIONAL STAKEHOLDER FORUM

PREPARATION OF BASIN DEVELOPMENT STRATEGY 2021-2030 AND MRC STRATEGIC PLAN 2021-2025

05 NOVEMBER 2019, MRC SECRETARIAT, VIENTIANE, LAO PDR

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ANALYSIS OF EXTREME DROUGHT OF 2015-2016

The content of this chapter are the findings from the report "Joint Observation and Evaluation of the Emergency Water Supplement by China to Mekong River" (MRC, 2016)

Background

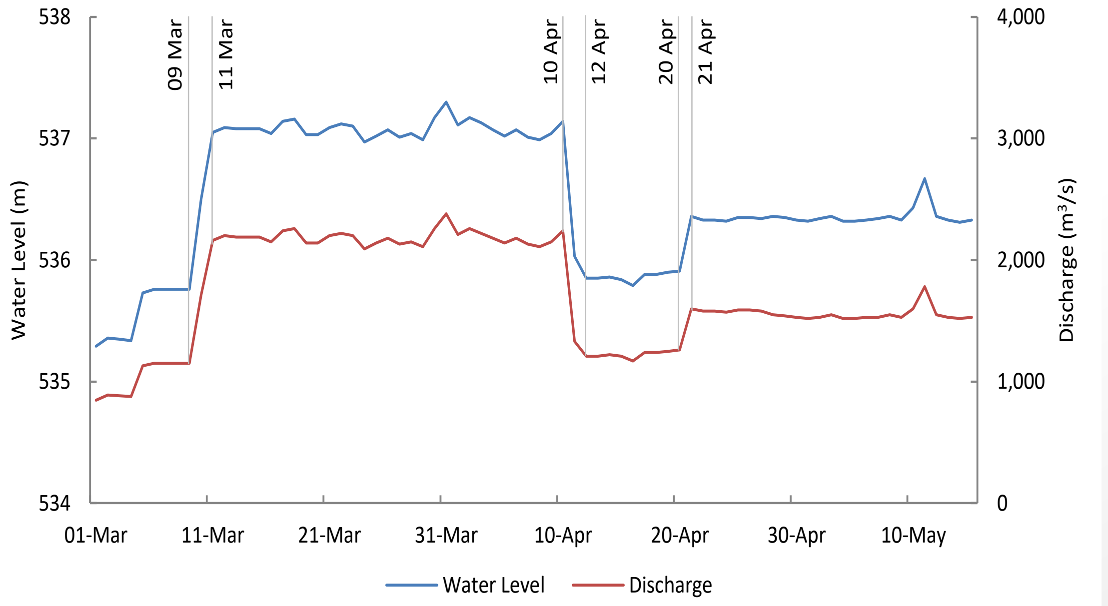
- Observation of global land and ocean temperature reveals that **Years 2015-2016** are the **warmest year** of record.
- The **El Niño 2015-2016** is recorded to be the **strongest** and has already created weather chaos around the world including the **Lancang-Mekong Basin**, which have been hit by **abnormally dry conditions**.
- The **recent drought conditions** over the Lower Mekong Basin have **worsened and triggered China** to **implement** its **emergency water supplement** from its cascade reservoirs in the Lancang River to the Mekong River by increasing the water discharge from Yunnan's Jinghong Reservoir from **9 March to 31 May 2016**.

Background

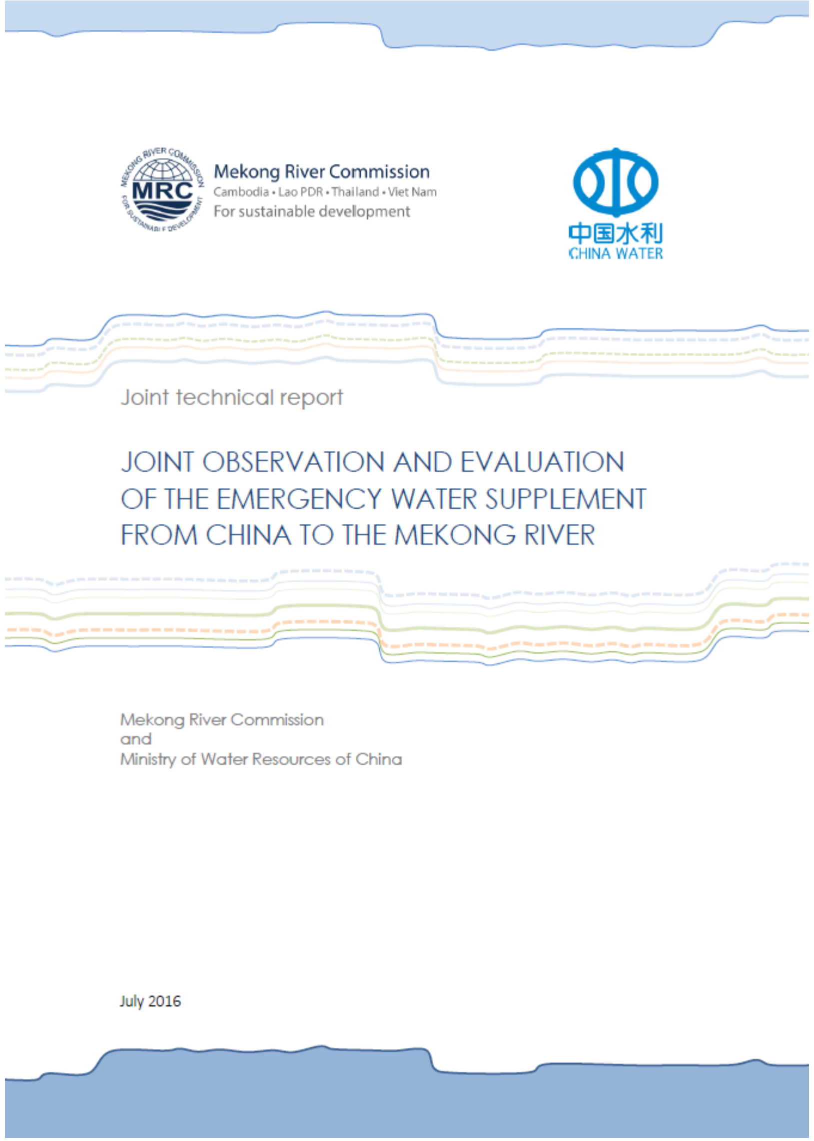
- The Government of China decided to implement its emergency water supplement in a '**three-phase plan**'.
    1) from 9 March to 10 April 2016, with an average daily discharge of no less than 2,000 m3/s;
    2) from 11 April to 20 April 2016 with the discharge of no less than 1,200 m3/s; and
    3) from 21 April to 31 May 2016 with the discharge of no less than 1,500 m3/s.

- The China's Ministry of Water Resources and MRC Secretariat then co-organised experts to conduct a **Joint Observation and Evaluation** (**JOE**).

- To **evaluate jointly** the **effect of the emergency water supplement** from China, to gather this important experience and to build a **good foundation** of further **Lancang-Mekong water resources cooperation**.



Scope and Methodology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Joint technical report

JOINT OBSERVATION AND EVALUATION
OF THE EMERGENCY WATER SUPPLEMENT
FROM CHINA TO THE MEKONG RIVER

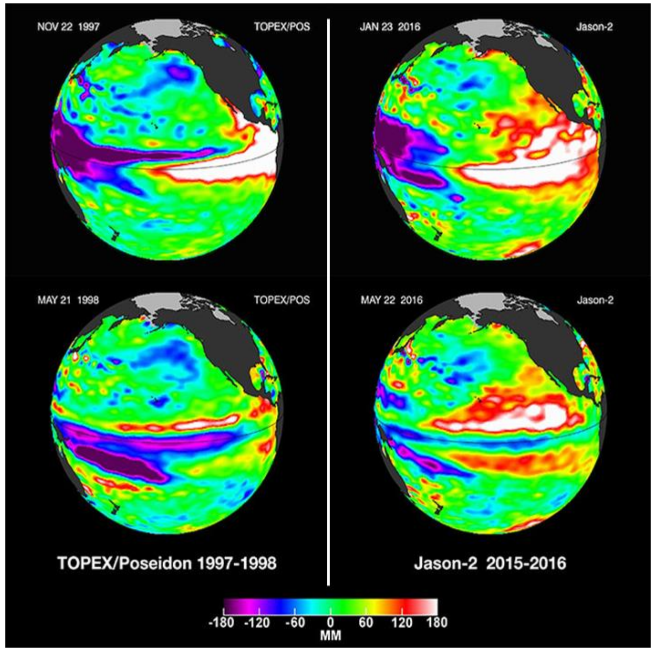
Mekong River Commission
and
Ministry of Water Resources of China

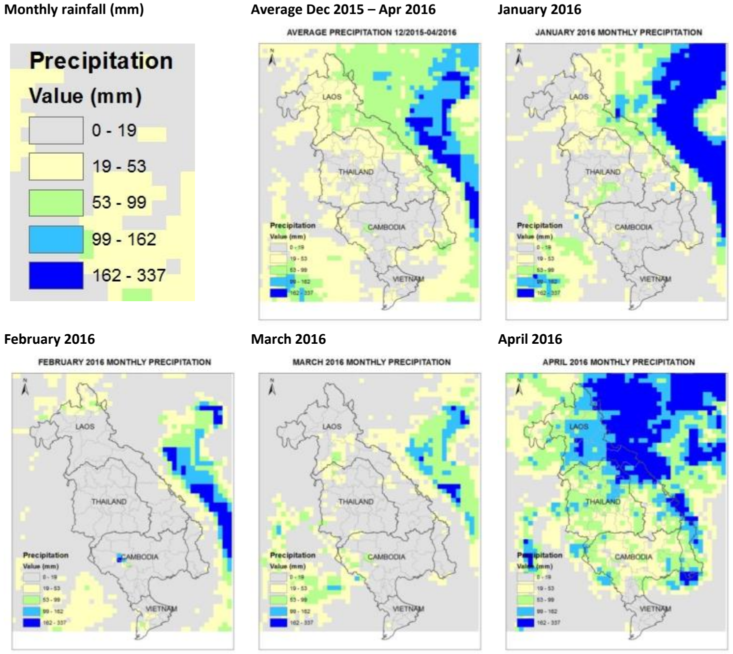
July 2016

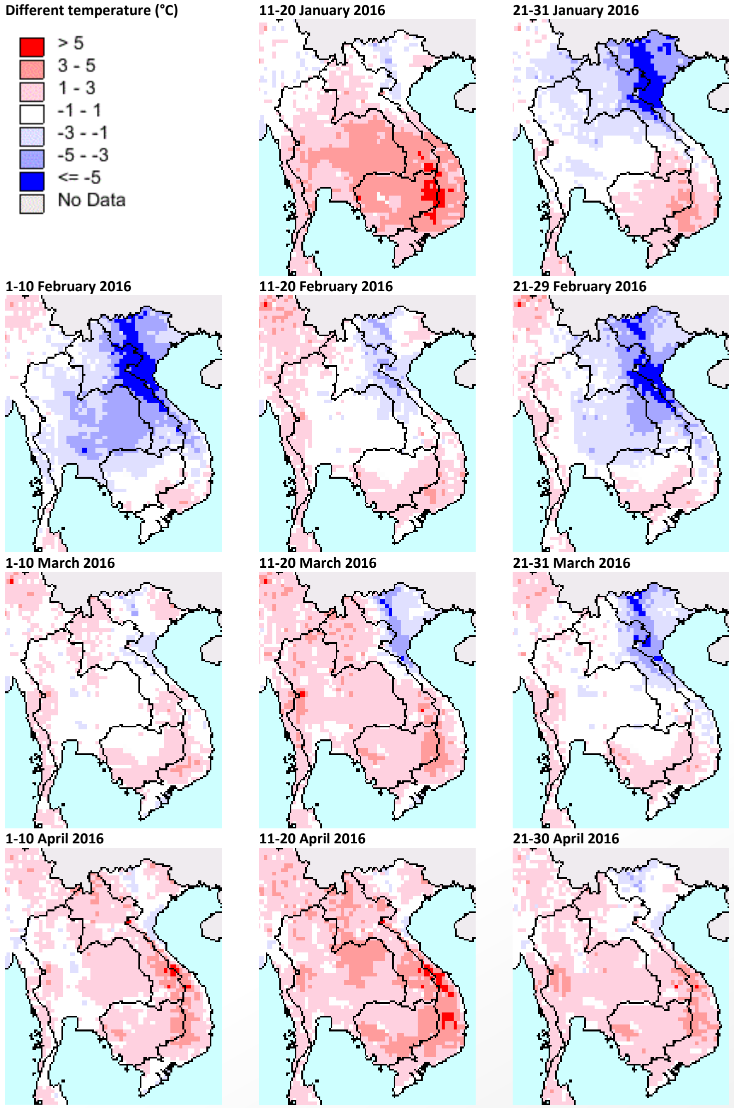
- **Cause of the drought** in the Lancang-Mekong Basin – temperature, rainfall, inflow, soil moisture and water stress
- **Influence of Lancang cascade reservoir** operation on dry season volume – long term average of 1960-2009 and 2010-2015
- **Hydrological influence of water supplement** on water level, discharge and volume – monthly values
- **Net contribution** of the water supplement to discharge – hydrograph separation and adjustment
- **Variation of water level** and **discharge** – daily value to long term average
- **Flow propagation** along the mainstream – sequence of events
- **Salinity variation** in the Mekong Delta – maximum/minimum values

Findings (1/8)

- **Reduced rainfall** amount and **inflow discharge** to the Lancang Basin have been observed in the dry season of 2016.
- The low river flow condition during the wet season 2016 was a factor to promote drought 2015/16.
- Likewise, the Mekong Basin has been experienced by **abnormally dry conditions** with **high temperature** and **less rainfall**. These meteorological and agricultural droughts are strongly believed to be impacted by the super **El Niño 2015-2016**.

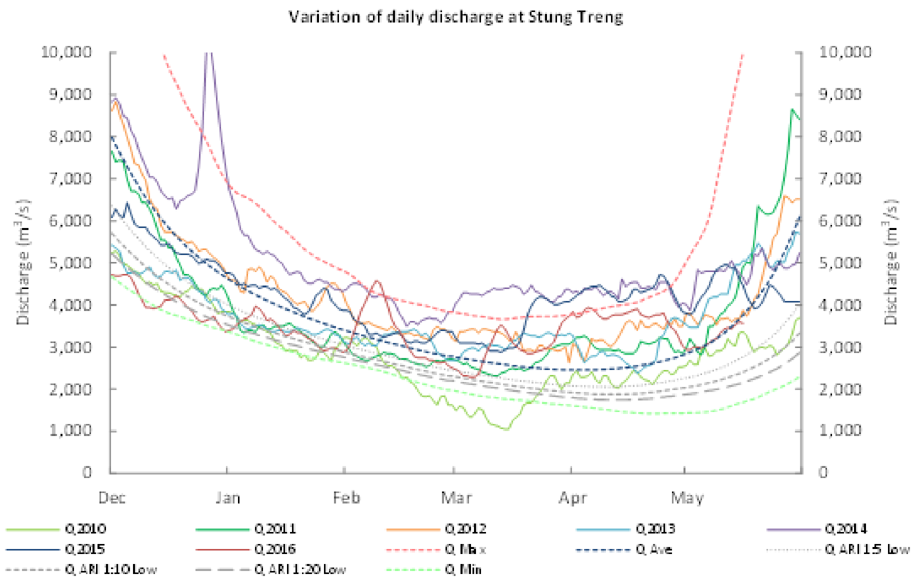


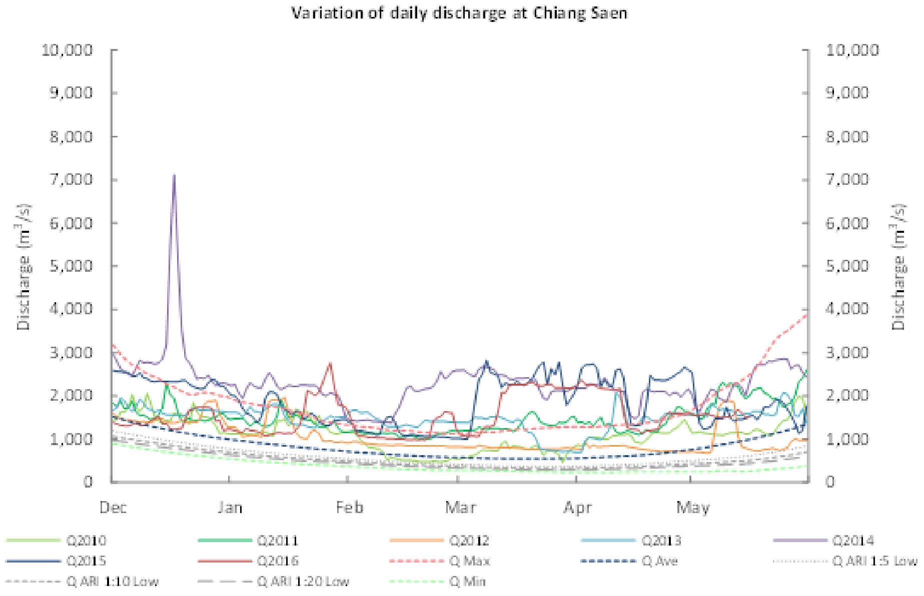




Findings (2/8)

- Monitoring of flow conditions on the mainstream suggests that water level and discharge in the dry season of 2015/2016 at Vientiane/Nong Khai and Stung Treng in December 2015 were few days below the long term minimum of 1960-2009.
- However, thanks to the emergency water supplement from China, <u>the water level and discharge at most stations along the Mekong mainstream were most of the time above the long term average and even higher than the long term maximum in March and April 2016</u>.

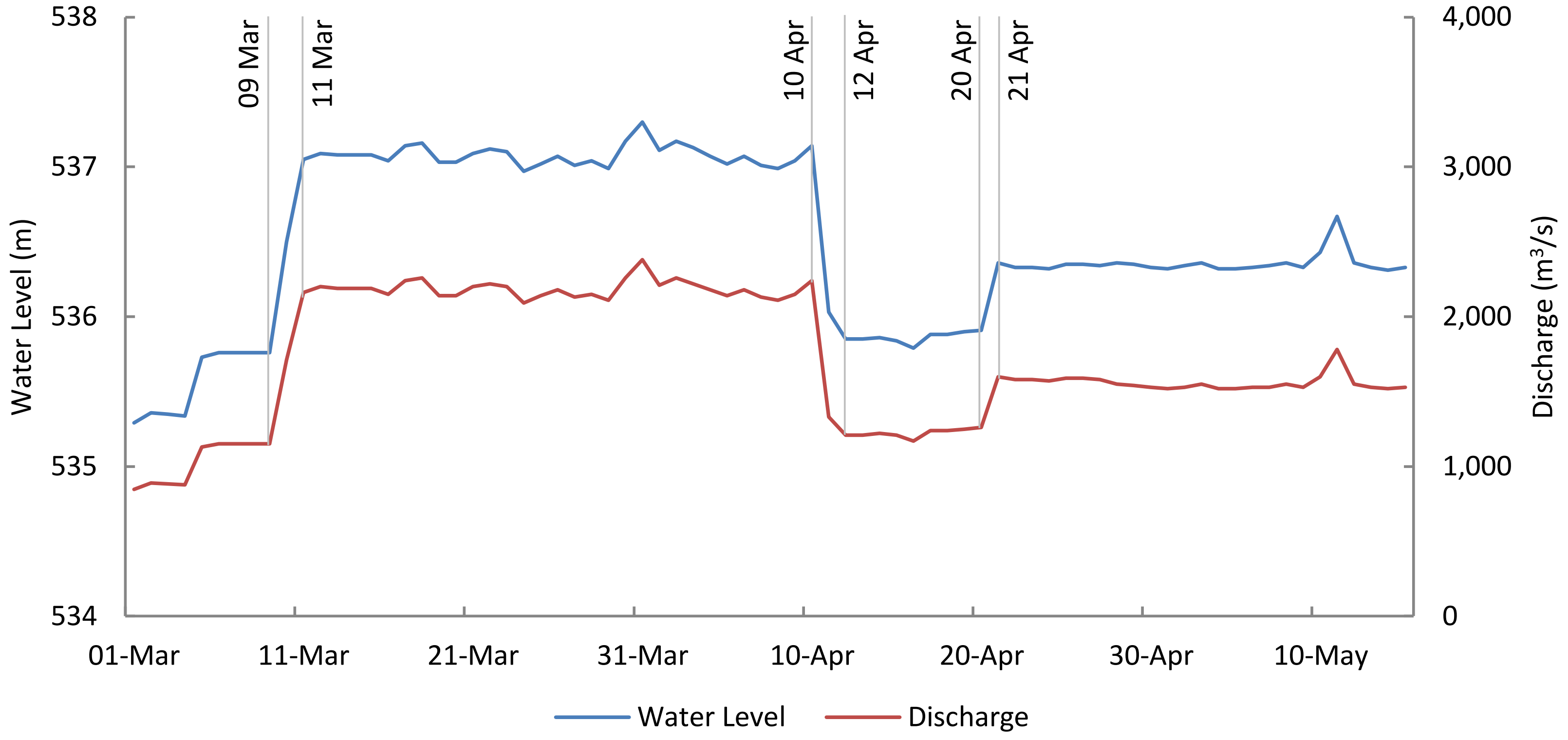




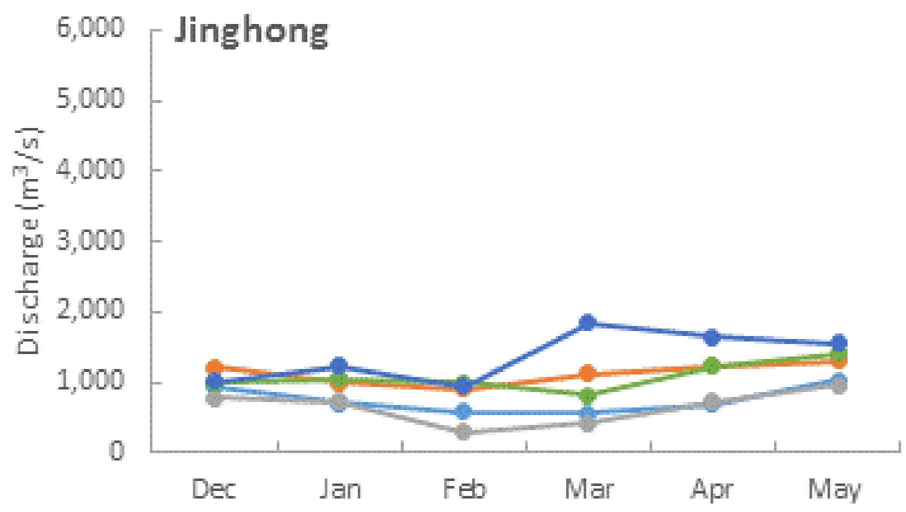
Findings (3/8)

Total volume released at Jinghong was **12.65 billion m^3**:

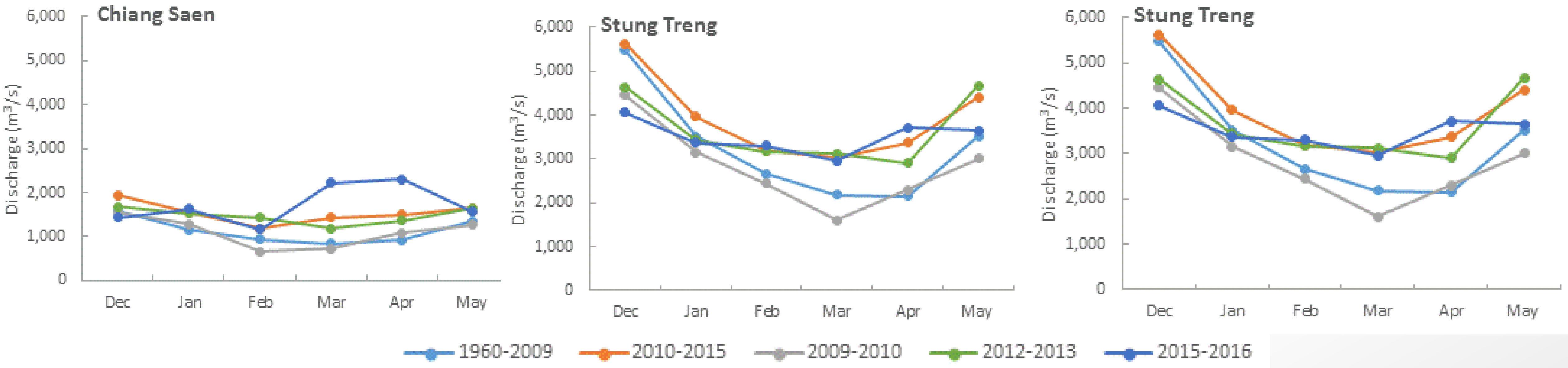
- 6.10 billion m^3 from 9 March to 10 April 2016,
- 1.07 billion m^3 from 11 April to 20 April 2016, and
- 5.48 billion m^3 from 21 April to 31 May 2016.



Findings (4/8)

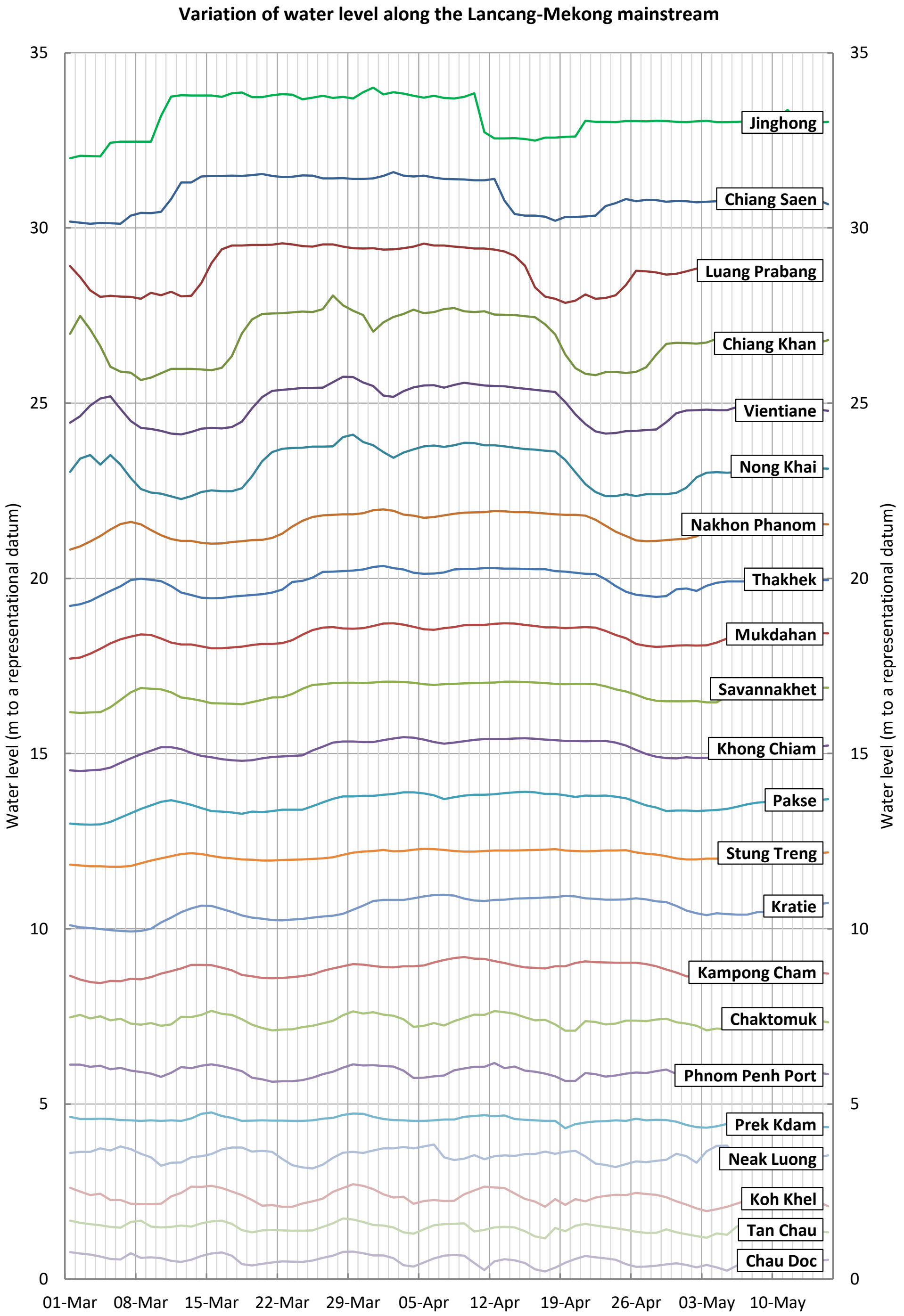


- During the period of the emergency water supplement in March and April 2016, the monthly discharges at Jinghong were 1,280 m^3/s and 985 m^3/s respectively, larger than the average of 1960-2009, and 704 m^3/s and 442 m^3/s respectively, higher than the average of 2010-2015.
- Discharges at key stations along the Mekong mainstream were also increased to a different extent.
- With a proper operation of the Lancang cascade dams, the discharge along the Mekong mainstream increased considerably in these two months of March-April.



Findings (5/8)

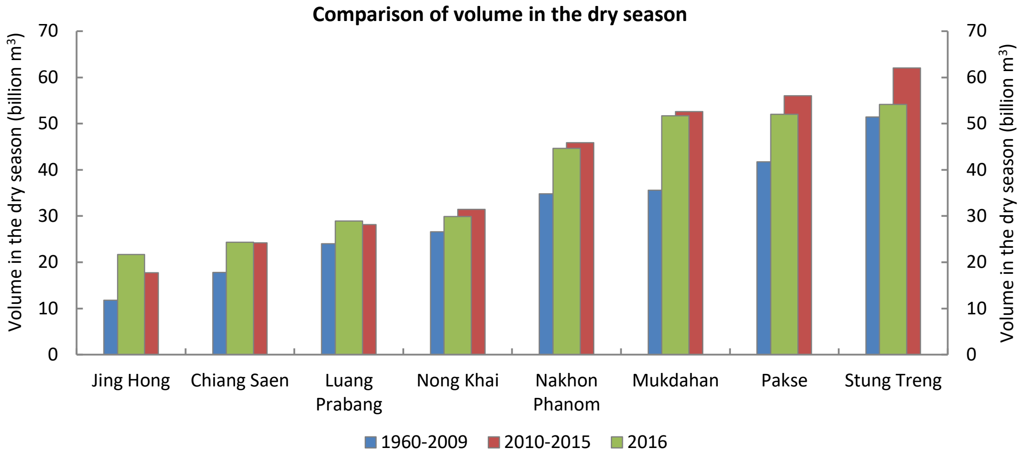
- The emergency water supplement from China arrived at Chiang Saen on 11 March and increased till 14 March 2016.
- This pattern reached Luang Prabang on 14 March, Chiang Khan on 17 March, Nong Khai on 19 March, Nakhon Phanom on 22 March, Mukdahan on 23 March, Pakse on 25 March, Stung Treng on 27 March, Kratie on 28 March and Tan Chau on 1 April 2016.
- <u>The emergency water supplement increased water level or discharge along the Mekong mainstream to an overall extent of 0.18-1.53 m or 602- 1,010 m^3/s</u>.
- <u>Equally, the maximum salinity in the Mekong Delta decreased by 15% and 74%, and the minimum salinity decreased by 9% and 78% according to observation stations</u>.

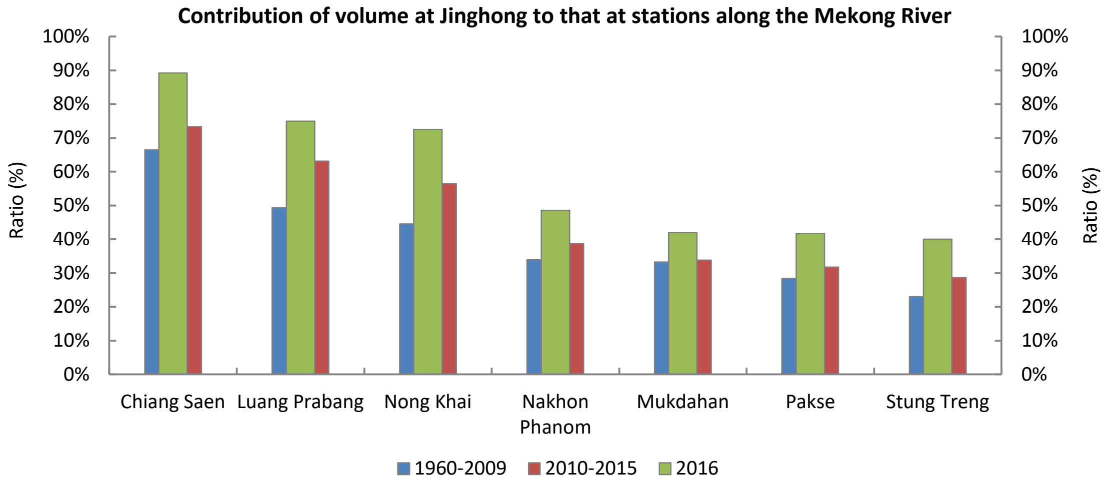


Findings (6/8)

- **Total volume in the dry season of 2016** (December 2015 to May 2016) at Jinghong presented huge portion **(40%-89%)** of the total volume at different stations along the Mekong mainstream.
- It is considered that the increase in volume in the Mekong River was 20% and 10%, compared to average accumulated volume of 1960-2009 and 2010-2015, respectively.

Station	Volume of the dry season (billion m³)			Deviation of volume between (billion m³)		
	1960-2009 (% Jinghong)	2010-2015 (% Jinghong)	2016 (% Jinghong)	2016 and 1960-2009	2016 and 2010-2015	2010-2015 and 1960-2009
Jinghong	11.82 (100%)	17.77 (100%)	21.69 (100%)	9.87	3.92	5.95
Chiang Saen	17.79 (66%)	24.22 (73%)	24.33 (89%)	6.54	0.11	6.43
Luang Prabang	23.99 (49%)	28.15 (63%)	28.94 (75%)	4.95	0.79	4.17
Nong Khai	26.57 (44%)	31.48 (56%)	29.90 (73%)	3.33	-1.57	4.90
Nakhon Phanom	34.85 (34%)	45.90 (39%)	44.66 (49%)	9.81	-1.25	11.06
Mukdahan	35.59 (33%)	52.59 (34%)	51.69 (42%)	16.10	-0.90	17.00
Pakse	41.74 (28%)	56.02 (32%)	52.01 (42%)	10.28	-4.01	14.28
Stung Treng	51.41 (23%)	62.06 (29%)	54.19 (40%)	2.78	-7.88	10.65





Findings (7/8)

- Additionally, the volume from 10 March to 10 April 2016, which was first period of the emergency water supplement, claimed significant portion, specifically 99% at Chiang Saen, 92% at Nong Khai and 58% at Stung Treng.

Station	Travelling time	Moving band of 32 days	Discharge (m^3/s)	Volume (billion m^3)	Ratio of Jinghong
Jinghong	+0 day	10 Mar to 10 Apr	2,170	6.00	100%
Chiang Saen	+1 day	11 Mar to 11 Apr	2,199	6.08	99%
Luang Prabang	+4 days	14 Mar to 14 Apr	2,237	6.18	97%
Nong Khai	+9 days	19 Mar to 19 Apr	2,361	6.53	92%
Nakhon Phanom	+12 days	22 Mar to 22 Apr	3,262	9.02	67%
Mukdahan	+13 days	23 Mar to 23 Apr	3,748	10.36	58%
Pakse	+15 days	25 Mar to 25 Apr	3,781	10.45	57%
Stung Treng	+17 days	27 Mar to 27 Apr	3,726	10.30	58%

Findings (8/8)

- Similarly, net contribution of the water supplement in term of discharge to total discharge was 47% at Jinghong, 44% at Chiang Saen, 38% at Nong Khai and 22% at Stung Treng.
- The water supplement from the Lancang reservoirs reached the Mekong Delta in early April 2016. There was a 4-day low salinity at early April at 4 selected stations, though it was in rising tide period. The maximum salinity in April was between 2.2‰ and 6.4% less than that in March.
- This contribution also alleviated salinity intrusion in the Mekong Delta.

Salinity (‰)	Tran De		Long Phu		Dai Ngai		An Lac Tay		Soc Trang City	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Salinity in March	27.4	5.6	23.1	4.1	13.8	0.9	8.0	0	9.0	3.0
Salinity in April	23.4	5.1	17.2	1.4	7.4	0.2	2.1	0	6.8	1.2
Salinity reduction	-4	-0.5	-5.9	-2.7	-6.4	-0.7	-5.9	0	-2.2	-1.8
Reduction ratio	-15%	-9%	-26%	-66%	-46%	-78%	-74%	-	-24%	-60%

Hydrograph separation for 'regular discharges' at	Discharge (m^3/s)
Jinghong (5 days: 5-9 Mar)	1,146
Chiang Saen (5 days: 6-10 Mar)	1,237
Nong Khai (5 days: 13-17 Mar)	1,455
Stung Treng (5 days: 21-25 Mar)	2,908
Difference of 'regular discharge' between	
Jinghong and Chiang Saen	91
Jinghong and Nong Khai	309
Jinghong and Stung Treng	1,762
Contribution of catchment area between	
Jinghong and Chiang Saen	91
Chiang Saen and Nong Khai	218
Nong Khai and Stung Treng	1,453
Hydrograph adjustment between	
Jinghong and Chiang Saen (travelling time: +1 day)	50
Jinghong and Nong Khai (travelling time: +9 days)	250
Jinghong and Stung Treng (travelling time: +17 days)	1,650
Average discharge of the moving band of the emergency water supplement at	
Jinghong (32 days: 10 Mar to 10 Apr)	2,170
Chiang Saen (32 days: 11 Mar to 11 Apr)	2,199
Nong Khai (32 days: 19 Mar to 19 Apr)	2,361
Stung Treng (32 days: 27 Mar to 27 Apr)	3,726
Net contribution and ratio to total discharges during the water supplement at	
Jinghong	1,024 (47%)
Chiang Saen	962 (44%)
Nong Khai	906 (38%)
Stung Treng	818 (22%)

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THE JOINT RESEARCH ON HYDROLOGICAL IMPACTS OF THE LANCANG HYDROPOWER CASCADE ON DOWNSTREAM FLOOD AND DROUGHTS

KEY FINDINGS ON OF THE RESPECTIVE HYDROLOGICAL IMPACTS OF CLIMATE VARIABILITY AND HYDROPOWER OPERATION

THE 8TH MRC REGIONAL STAKEHOLDER FORUM

PREPARATION OF BASIN DEVELOPMENT STRATEGY 2021-2030 AND MRC STRATEGIC PLAN 2021-2025

05 NOVEMBER 2019, MRC SECRETARIAT, VIENTIANE, LAO PDR

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ANALYSIS OF THE RESPECTIVE HYDROLOGICAL IMPACTS OF CLIMATE VARIABILITY AND HYDROPOWER OPERATION

Scope and Methodology

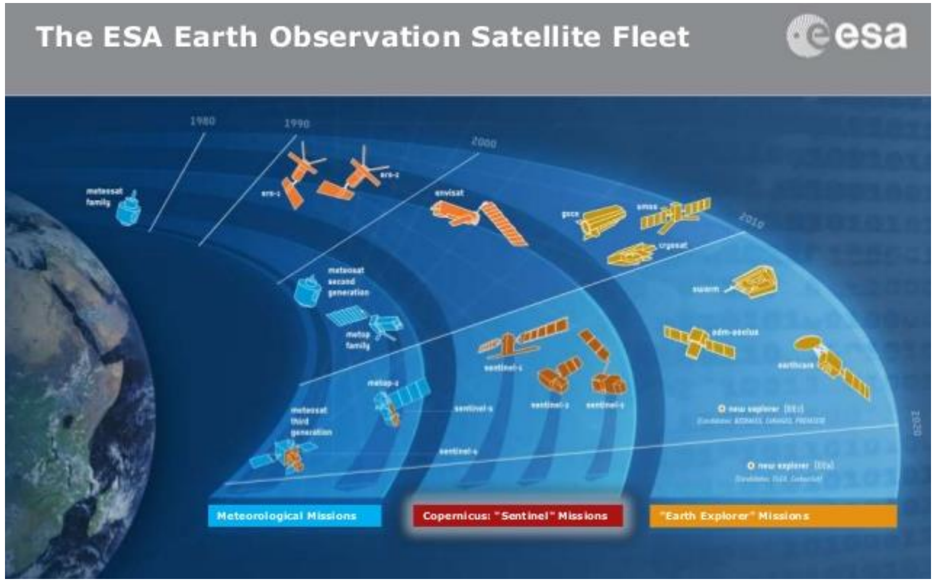
- This study sought to differentiate **the effects of actual hydropower dam operation and climate variability** on streamflow for two sub-basins of the Lancang-Mekong basin, namely Chiang Saen and Luang Prabang.
- Discharge data was analyzed before **dam development (before 2009)** and compared it to **post dam development (after 2009).**
- Using a **hydrological model (GR4J)** calibrated over the pre-dam period (1998-2008), streamflow was simulated using rainfall from the second period (2009-2016) and compared with flow observed over the same period.
- **Any difference between observed and simulated flow would then be attributed to non-climatic drivers of hydrologic change** such as hydropower operation. This analysis was particularly focused on the dry season (October-May) of hydrologic years 2009/2010, 2012/2013 and 2015/2016.

How ?

- Data scarcity

not much is known about hydropower operations especially on the Chinese side of the basin.

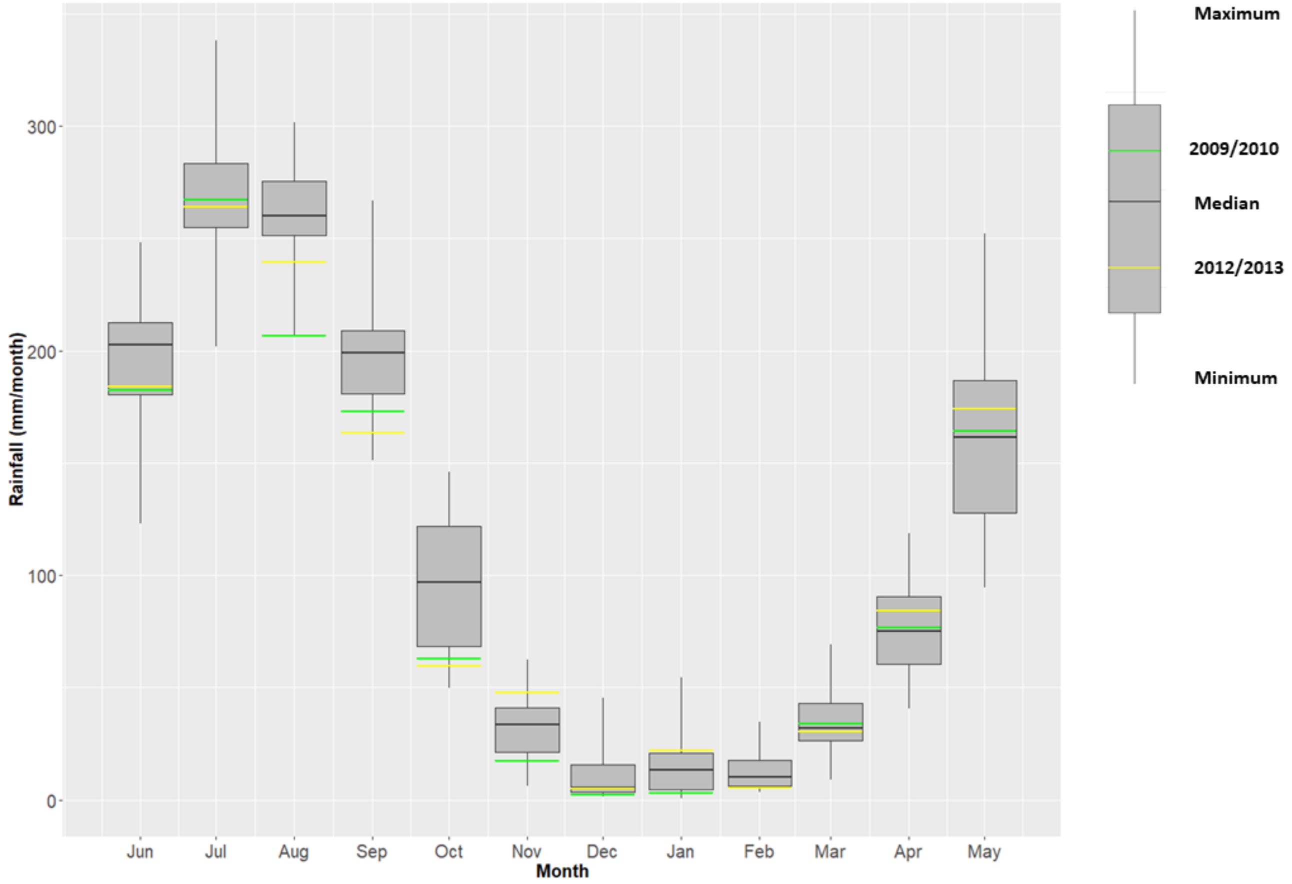
- We overcome this challenge by combining Remote Sensing and hydrological modeling



Recent advances in Earth observation (EO) satellites have made improved global observations of several key parameters governing the global water cycle possible

Findings (1/3)

- Long term (19 year) rainfall analysis in the basin shows that for both the 2009/2010 and 2012/2013 dry seasons, **the basin experienced low rainfall** over most of the period with most monthly values below the 19-year median.
- The November 2012 and January 2012 rainfall were above the long-term median whereas both the 2009/2010 and 2012/2013 rainfall were above the long-term median during the months of April and May.

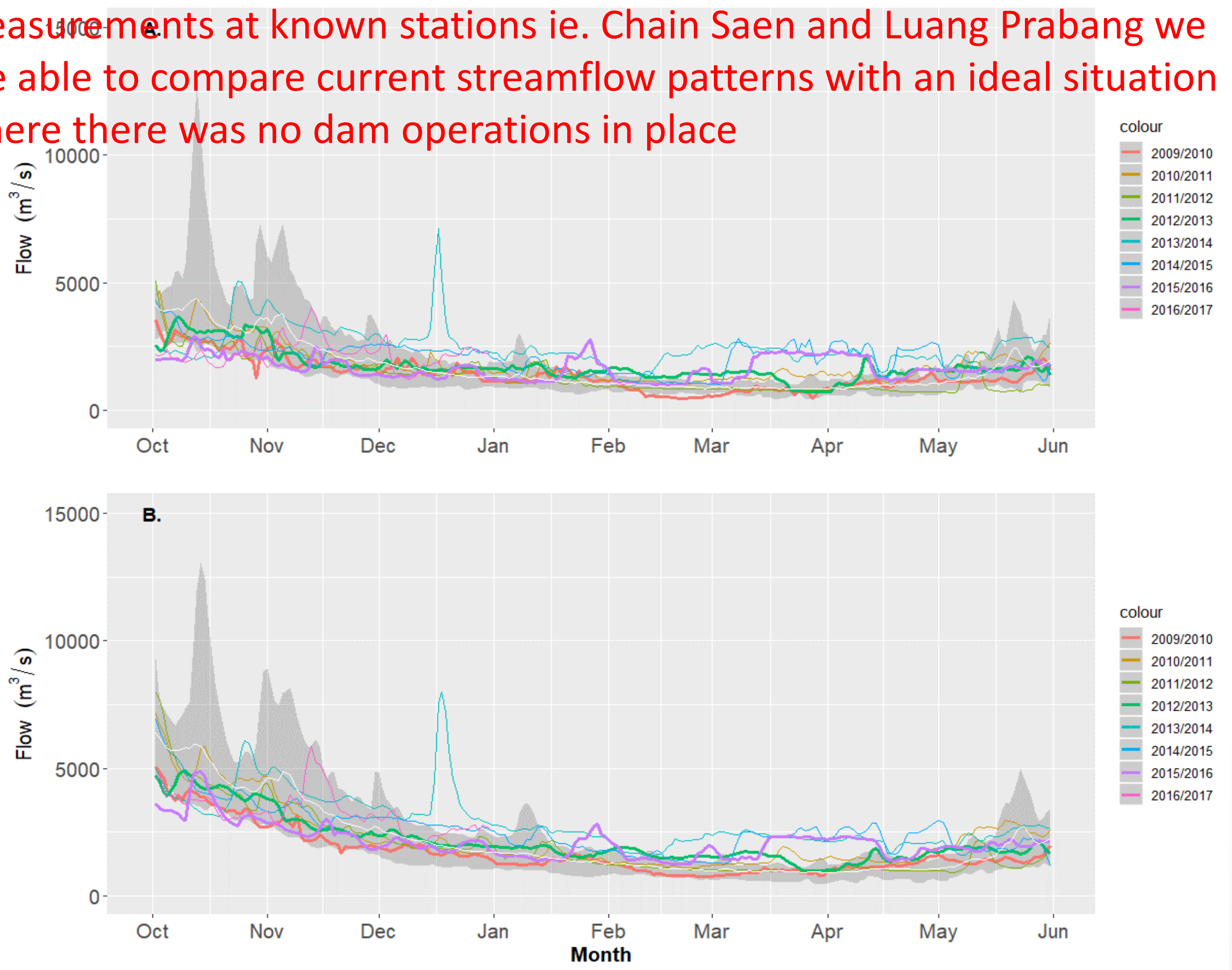


Long term (1998-2016) monthly rainfall distribution in the Lancang-Mekong River Basin compared to rainfall for hydrologic years 2009/2010 and 2012/2013

Findings (2/3)

- In 2009/2010 dry season, flows were below or at average flows of the pre-dam period.
- The 2012/2013 dry season flows were lower than average from October-November 2012 and then remained higher than average for the rest of the period (December 2012– May 2013).
- The 2015/2016 dry season showed extreme lows in October 2015 and higher flows with extreme highs in January 2016, February 2016 and from March through May 2016.

Combining Remote sensing data with the observed streamflow measurements at known stations ie. Chain Saen and Luang Prabang we are able to compare current streamflow patterns with an ideal situation where there was no dam operations in place



Observed streamflow from pre-dam period 1998-2008 (minimum and maximum in grey) compared to post-dam period 2009-2016 for A. Chiang Saen and B. Luang Prabang

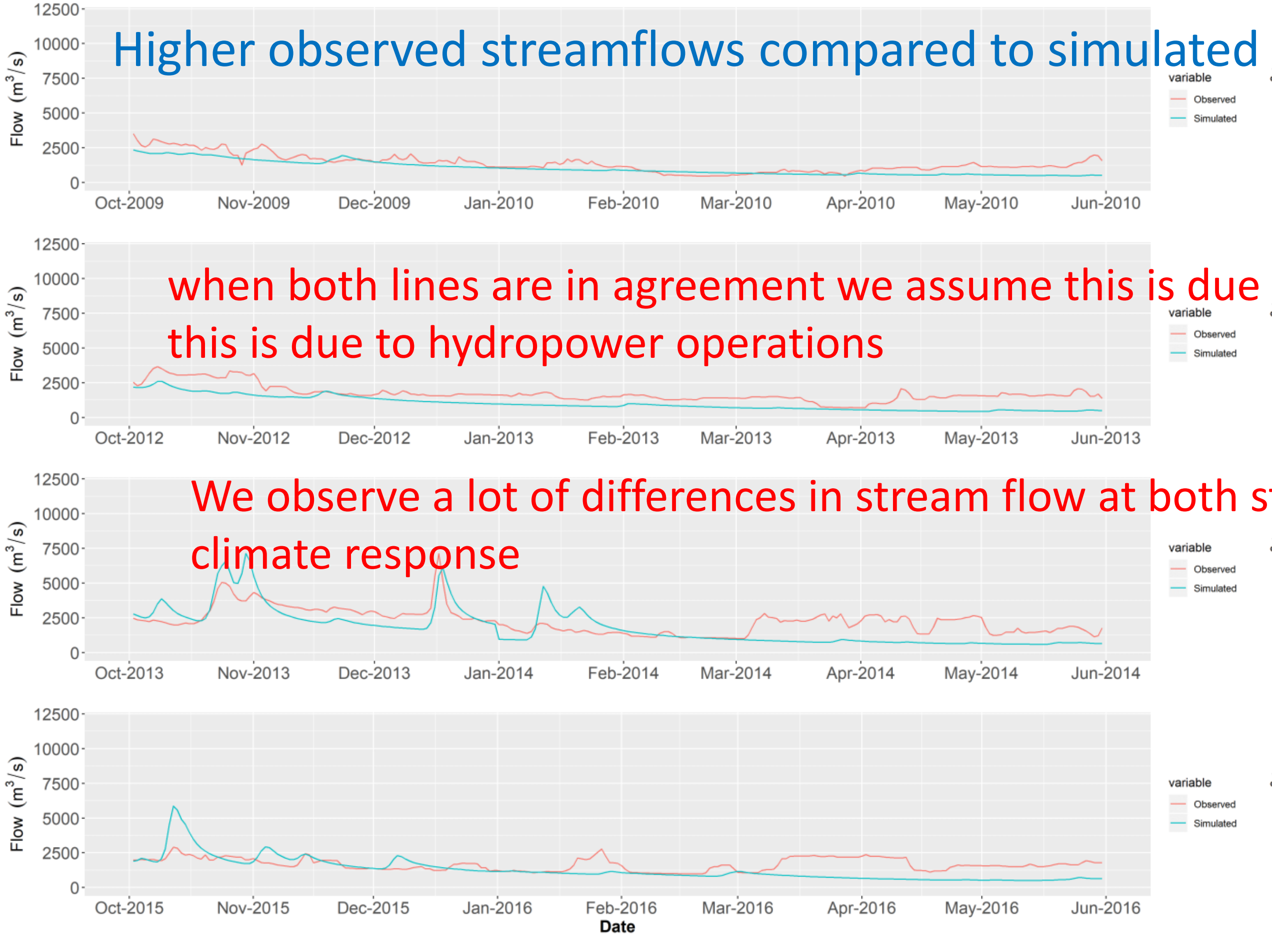
Findings (3/3)

- Both the Chiang Saen and Luang Prabang stations have experienced significant hydrological change from 2009-2016 compared to 1998-2008.

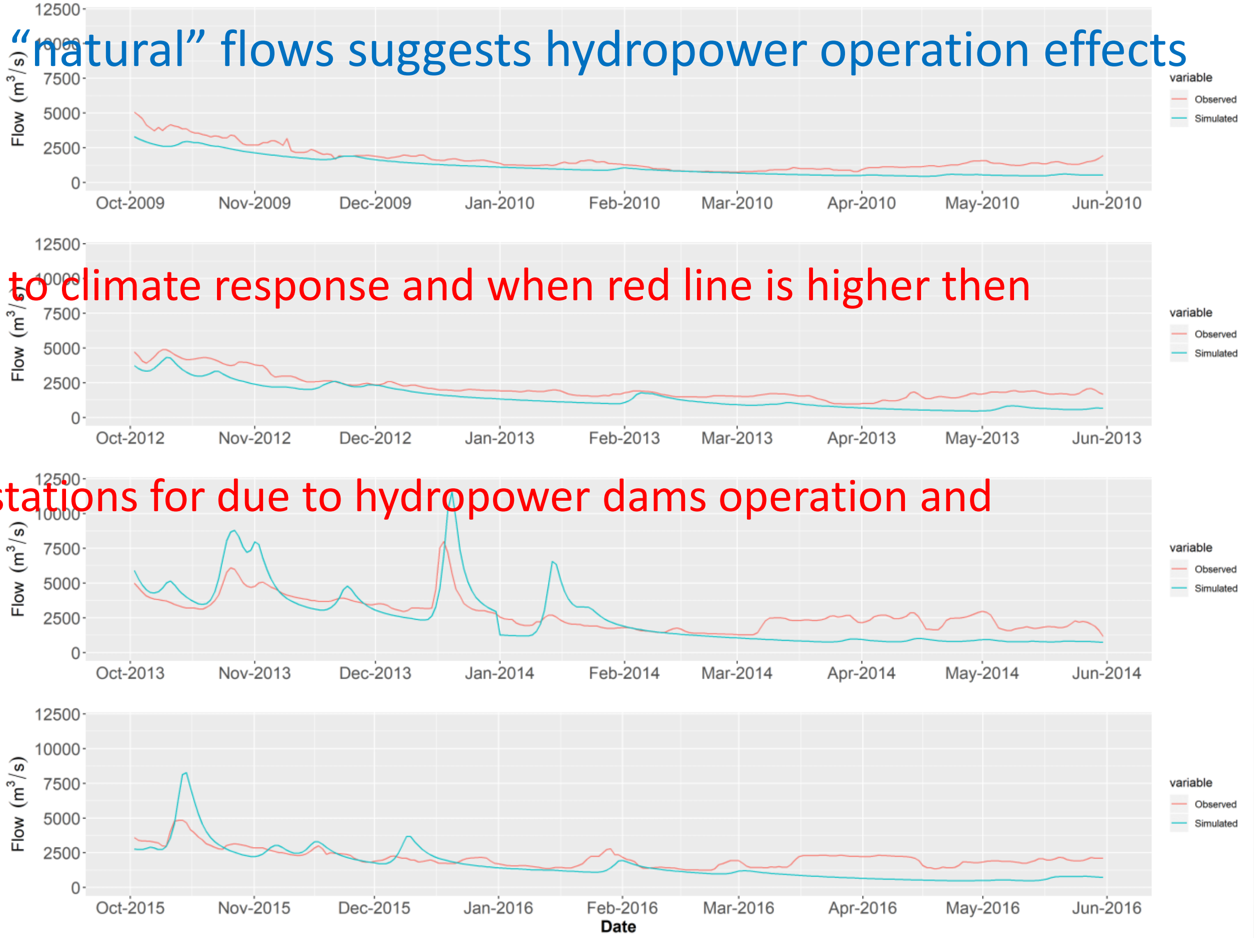
Higher observed streamflows compared to simulated “natural” flows suggests hydropower operation effects

when both lines are in agreement we assume this is due to climate response and when red line is higher then this is due to hydropower operations

We observe a lot of differences in stream flow at both stations for due to hydropower dams operation and climate response



Observed versus simulated flows at Chiang Saen for hydrological years 2009-2010, 2012-2013 and 2015-2016.



Observed versus simulated flows at Luang Prabang for hydrological years 2009-2010, 2012-2013 and 2015-2016.

Discussion

- Both the Chiang Saen and Luang Prabang stations have experienced significant hydrological change from 2009-2016 compared to 1998-2008.
- There has been increased streamflows during the dry seasons of 2009/2010, 2012/2013 and 2015/2016 which can be attributed mainly to hydropower influences.
  - At Chiang Saen observed streamflows exceeded simulated streamflows considerably for each of the dry seasons (44% in 2009/2010, 97% in 2012/2013 and 70% in 2015/2016) suggesting that these changes may be due to hydropower operation.
  - At Luang Prabang, there was a noticeable increase in dry season flows with higher average dry season increases during the 2009/2019 and 2015/2016 period compared to Chiang Saen. Our assessment of hydropower impacts at Luang Prabang show a 75-109% increase for the period December to May of the dry season.
- There is increased water availability during the dry seasons as a result of the hydropower dam operations.
- At both Chiang Saen and Luang Prabang, concurrent flow peaks of observed and simulated flows during December 13-17, 2013 suggests that this may be due to rainfall rather than hydropower operation.
- A visual examination of the observed rainfall in China and upper parts of LMB as well as the daily rainfall maps during the period further confirmed that these high flows were mainly due to localized rainfall.
- Thus, the flash flood of December 2013 is attributed to rainfall.

RECOMMENDATIONS

Recommendations

1) Key findings should be disseminated widely to stakeholders and the public which would increase and clarify their perceptions and understanding about the actual impacts of dam operation on some selected past extreme events in public memory.
2) Based on the river monitoring and forecasting of the MRCS and with support of the MRCS and LMWRCC, the MRC Joint Committee and the LMC Joint Working Group on Water Resources should convene a special joint meeting as needed on situations of unusual/extreme flood and/or drought and how dam cascade operation could address the issue.
3) Further joint studies are needed to further increase our knowledge base, enhance data and information sharing, improve or establish better coordination mechanisms and formulate specific basin-wide strategies and policies.

THANK YOU

One Mekong. One Spirit.

MEKONG RIVER COMMISSION FOR SUSTAINABLE DEVELOPMENT