Regional Technical Workshop on Application of Modelling Tools for Climate Change Impact and Vulnerability Assessment

8 – 9 September 2009, Bangkok, Thailand

MEKONG RIVER COMMISSION
MRC
FOR SUSTAINABLE DEVELOPMENT

MRC-CSIRO Project on Climate Change Impacts in the Mekong River Basin

- Impacts of Climate Change on Mekong Hydrologic Regimes of Baseline and Development Scenarios -

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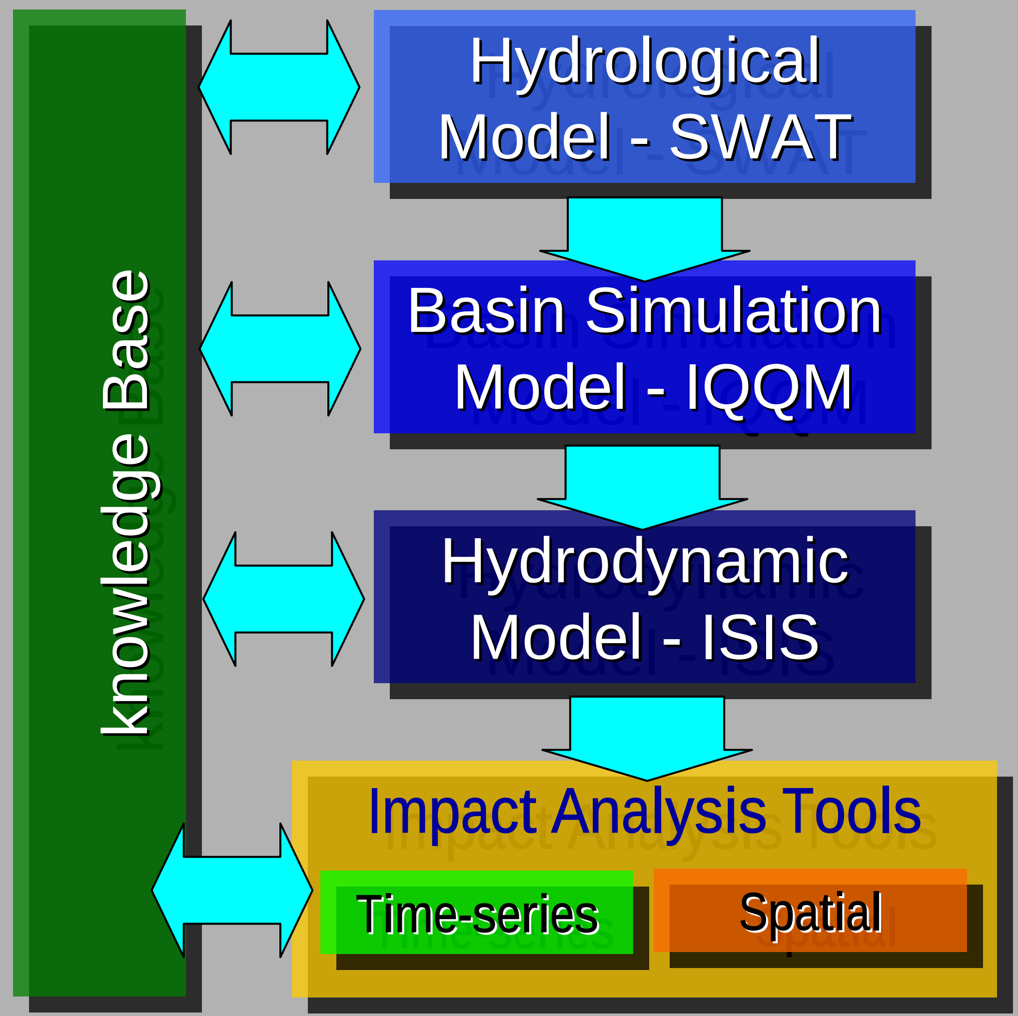
OUTLINE

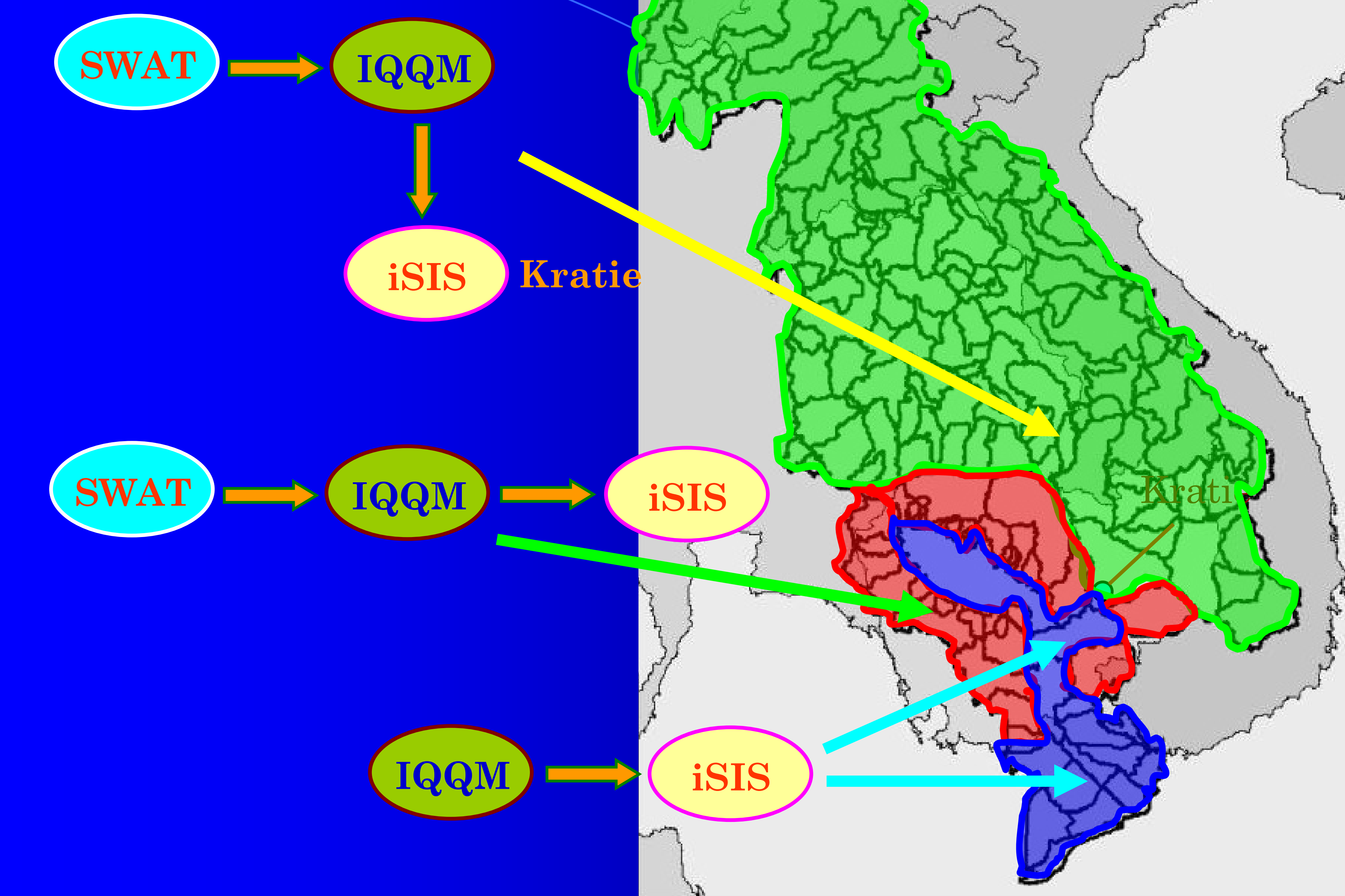
- Brief on MRC Decision Support Framework (DSF) and scenarios
- PRECIS RCM climate data processing and adjustment
- Verification of baseline scenario for climate change study
- Hydrologic regime and change under baseline scenario
- Hydrologic regime and change under development scenario
- Summary

Brief on MRC Decision Support Framework (DSF) and scenarios

Decision Support Framework

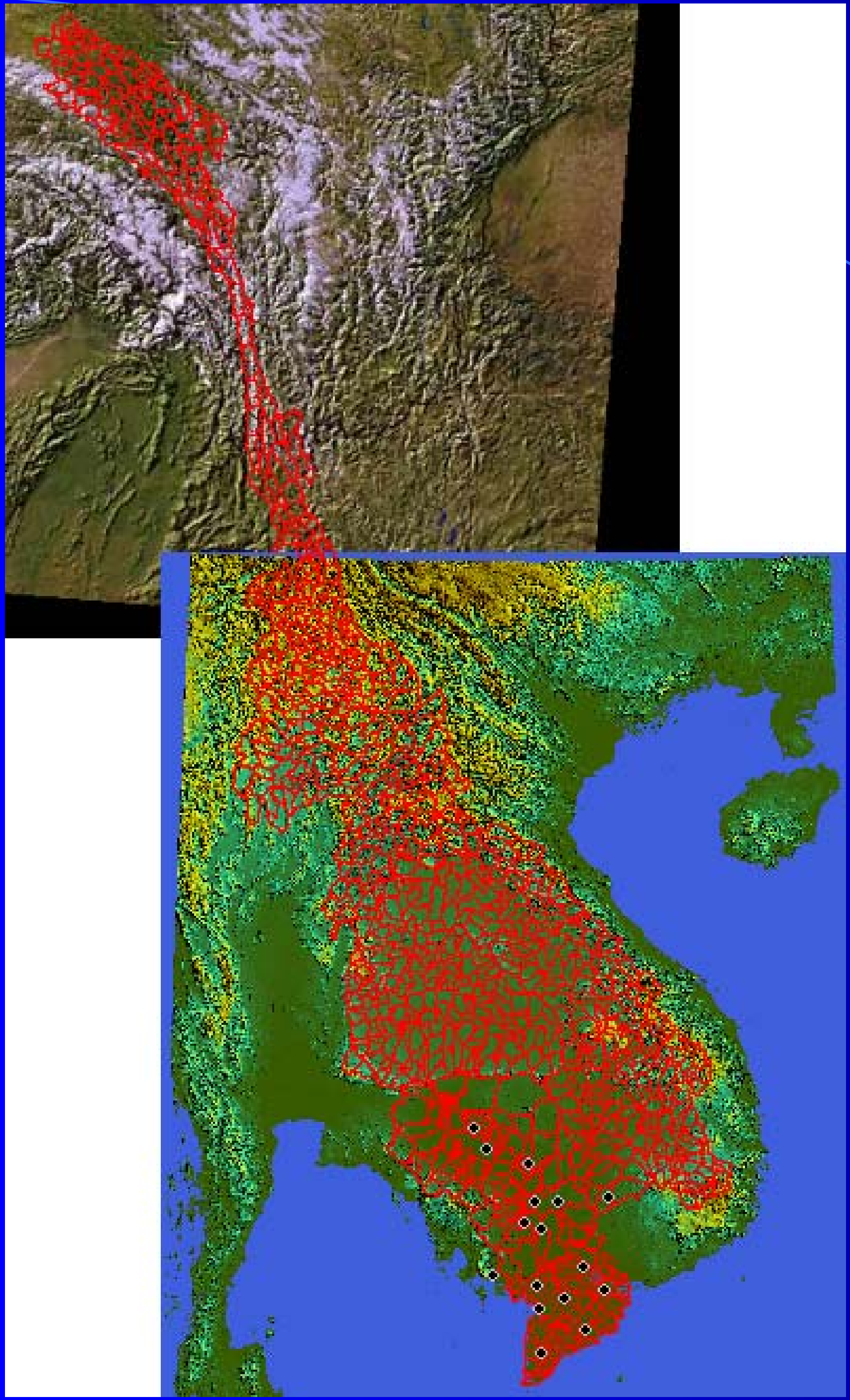


Scope of DSF



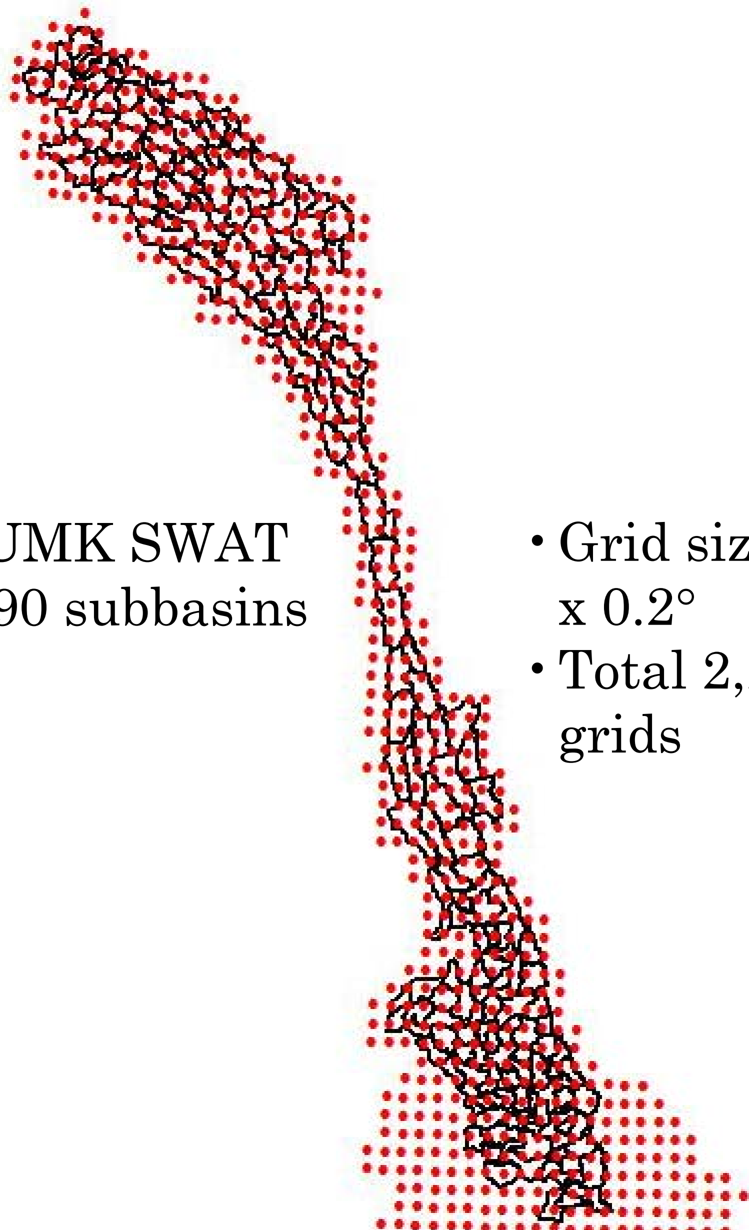
SWAT
IQQM
iSIS
Kratie
SWAT
IQQM
iSIS
IQQM
iSIS
Inflow at China-
Lao border

PRECIS RCM climate data processing and adjustment



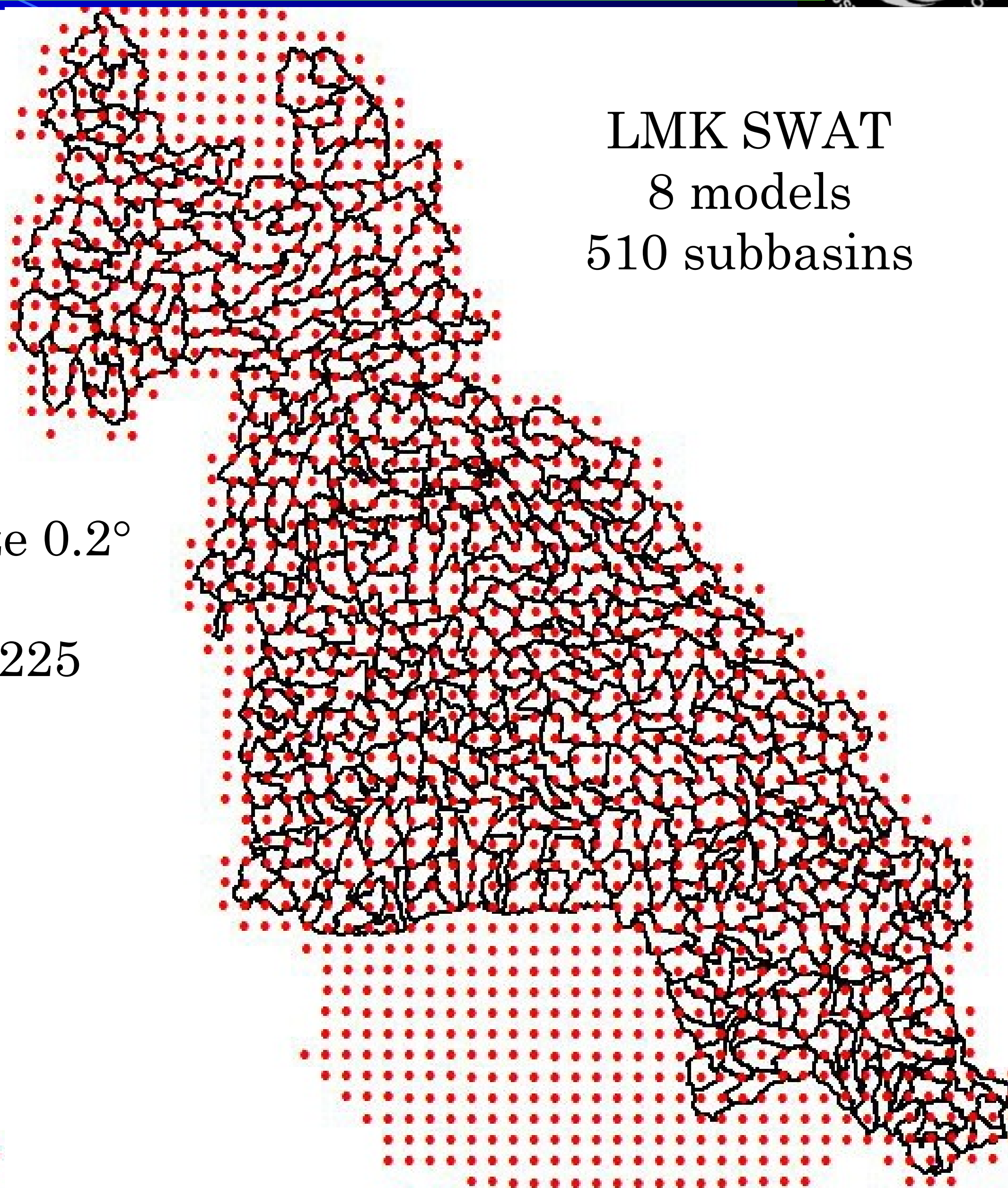
All subbasins and sub-areas covering the whole MRB

PRECIS climate data (1/2)



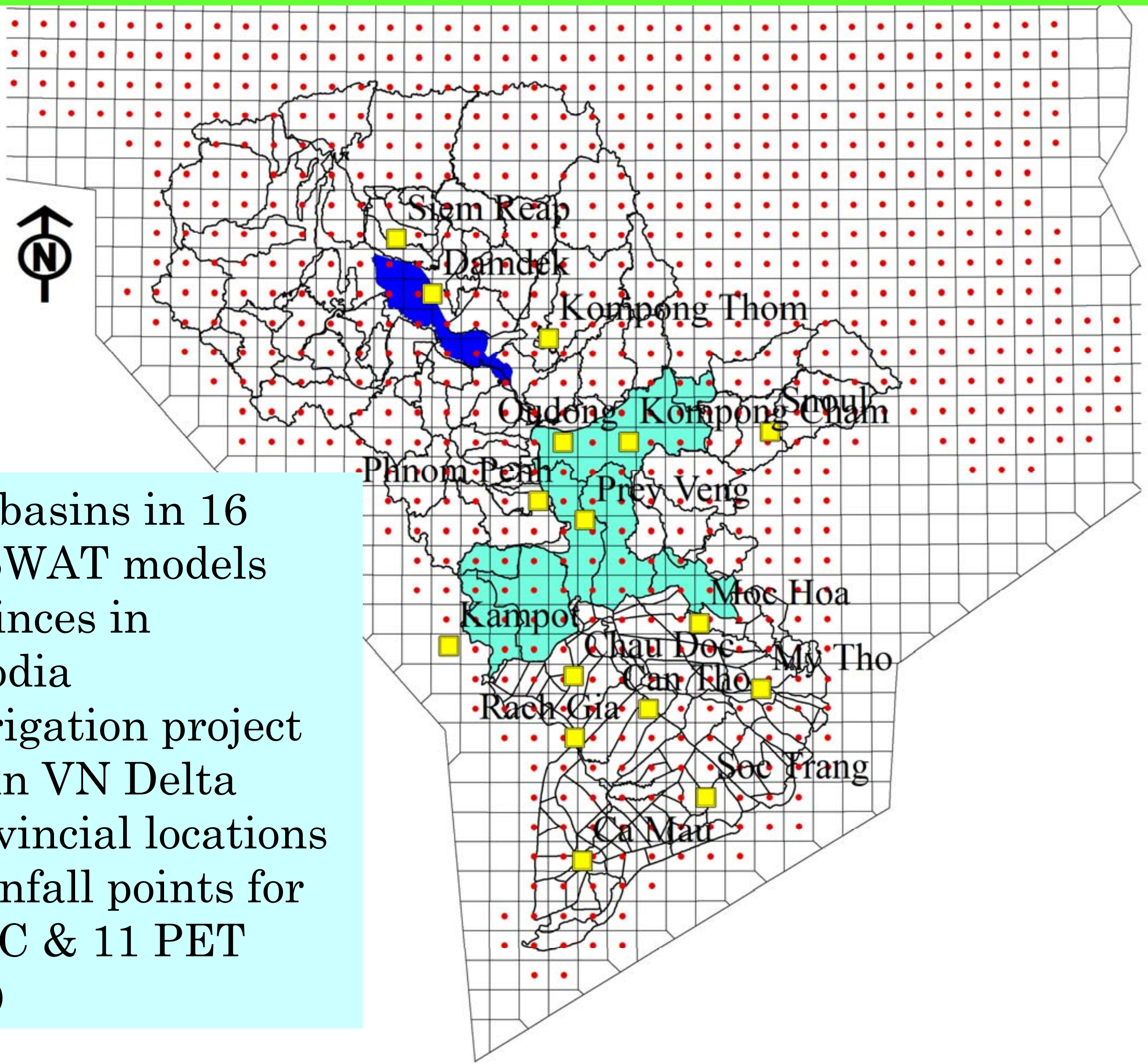
UMK SWAT
190 subbasins

- Grid size 0.2° x 0.2°
- Total 2,225 grids



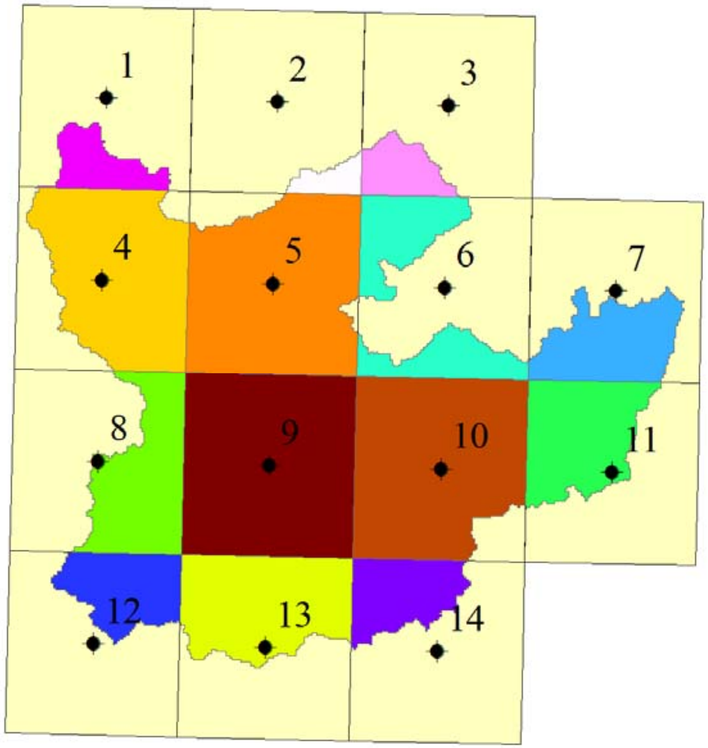
LMK SWAT
8 models
510 subbasins

PRECIS climate data (2/2)



- 63 subbasins in 16 GLK SWAT models
- 8 provinces in Cambodia
- 120 irrigation project areas in VN Delta
- 16 provincial locations (14 rainfall points for iSIS BC & 11 PET points)

Subbasin climate calculation

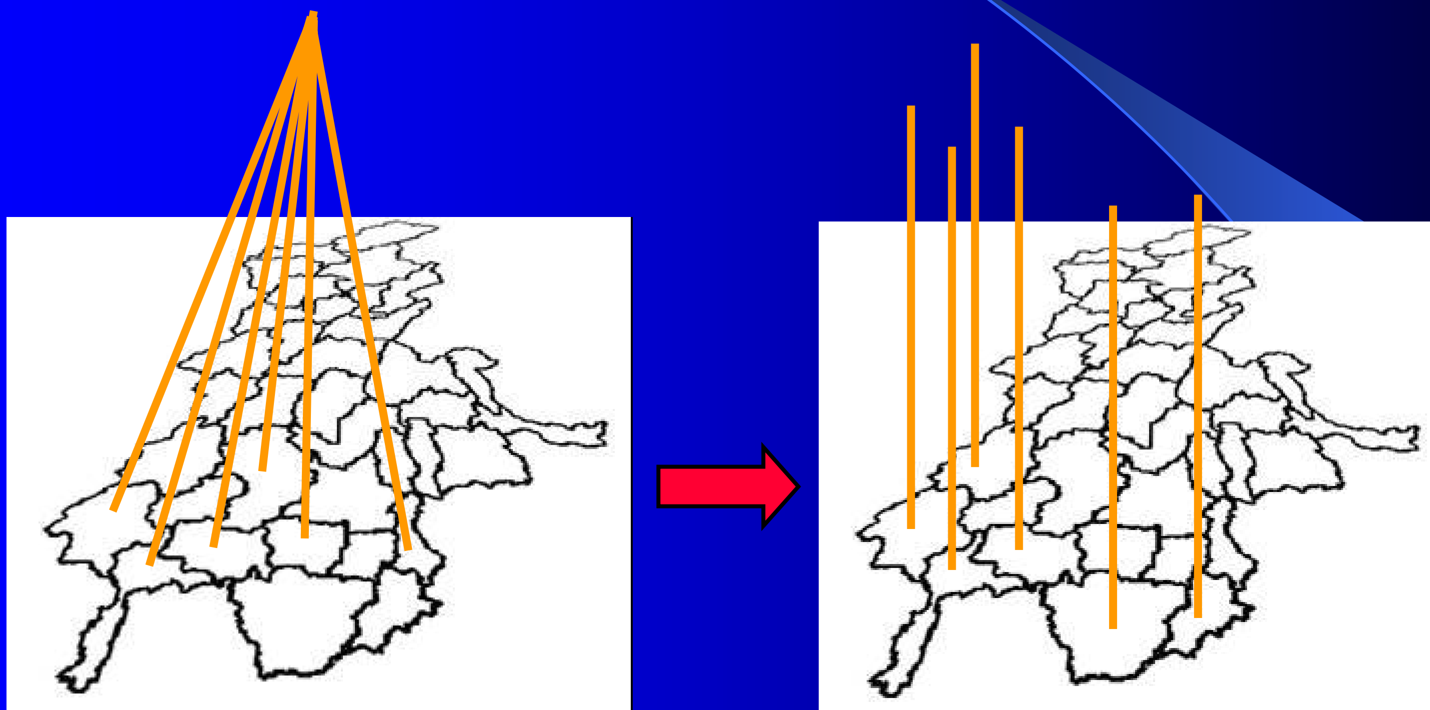


$$P_{sub} = \frac{\sum_{i=1}^{n} A_{itsc,i} P_i / A_i}{\sum_{i=1}^{n} A_{itsc,i} / A_i}$$

P_{sub}	=	SWAT subbasin precipitation
$A_{itsc,i}$	=	Intersected area between grid i and subbasin
P_i	=	Precipitation data of grid i
A_i	=	Area of rectangular grid i
n	=	Number of overlaid grids, in this example n = 14

One set of climatic parameters (from one station) per multiple subbasins

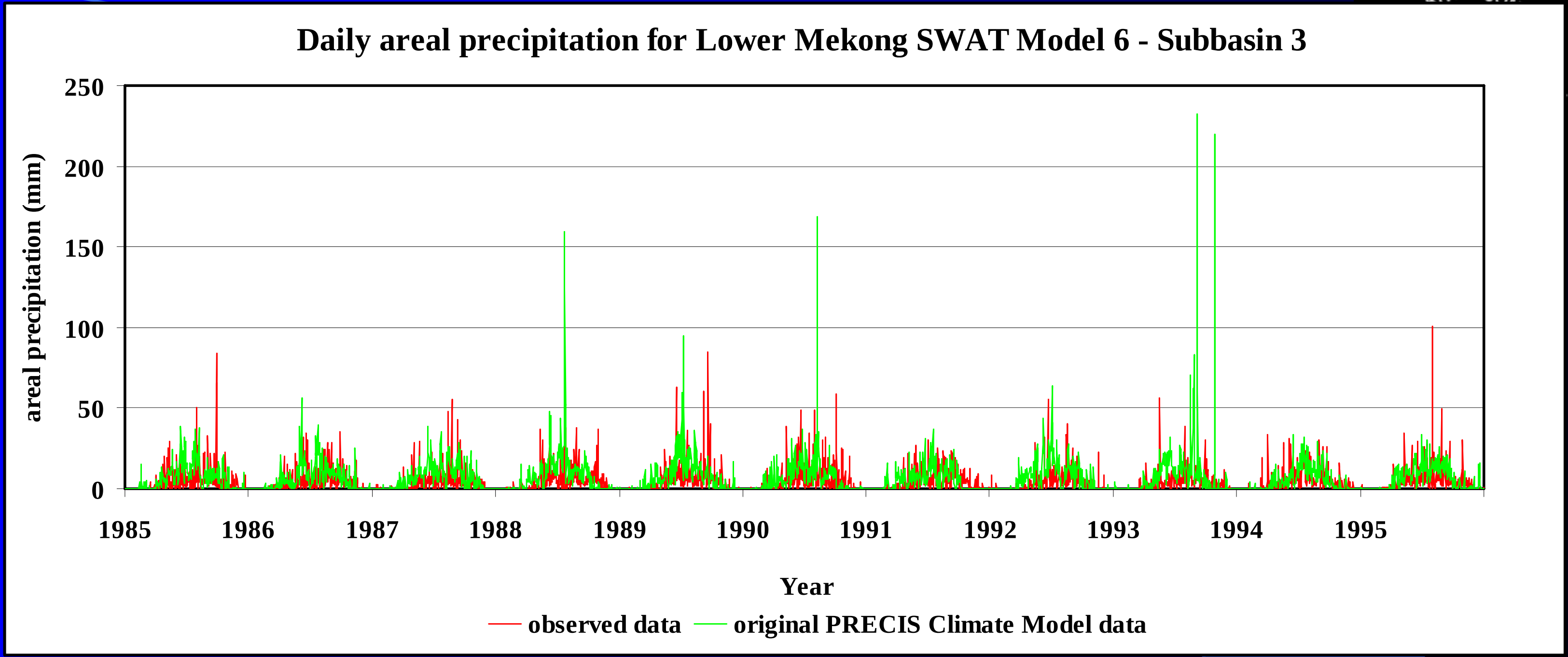
One set of climatic parameters per one subbasin

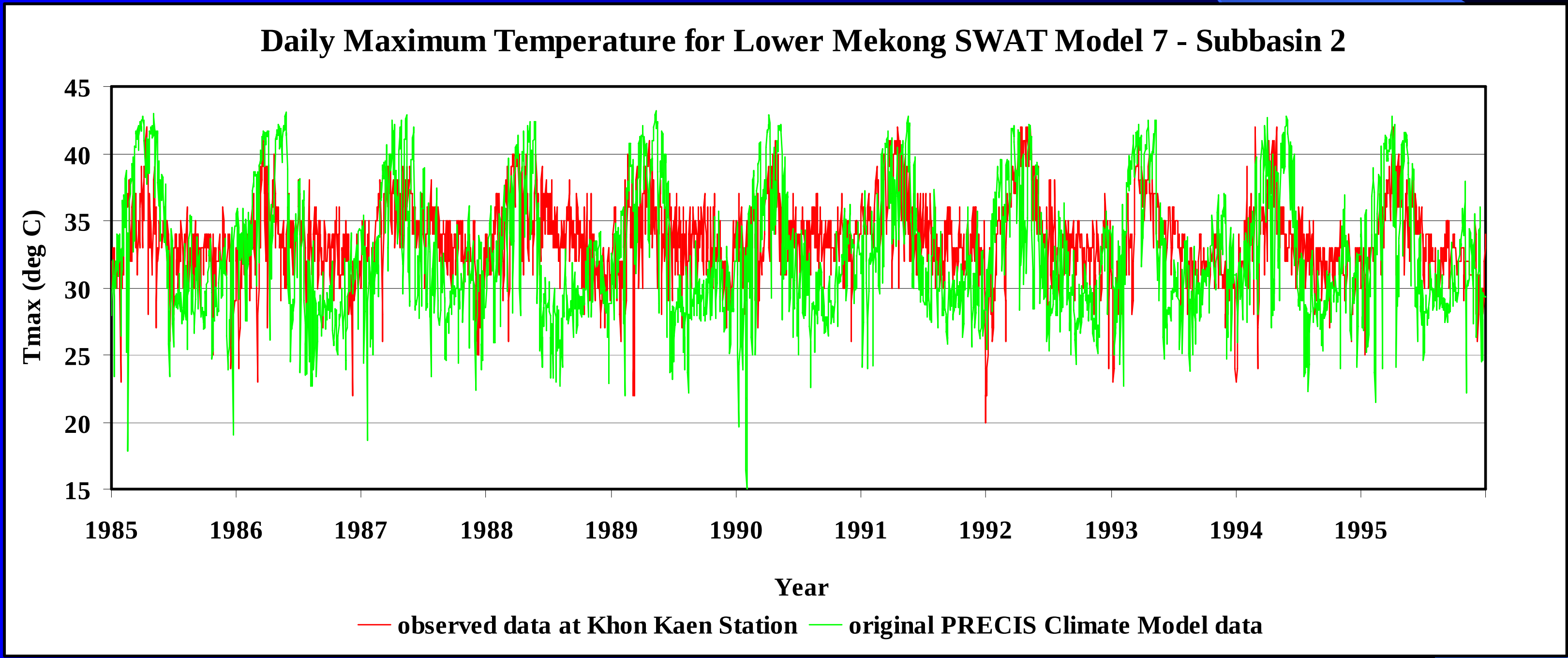


Current calibrated SWAT models

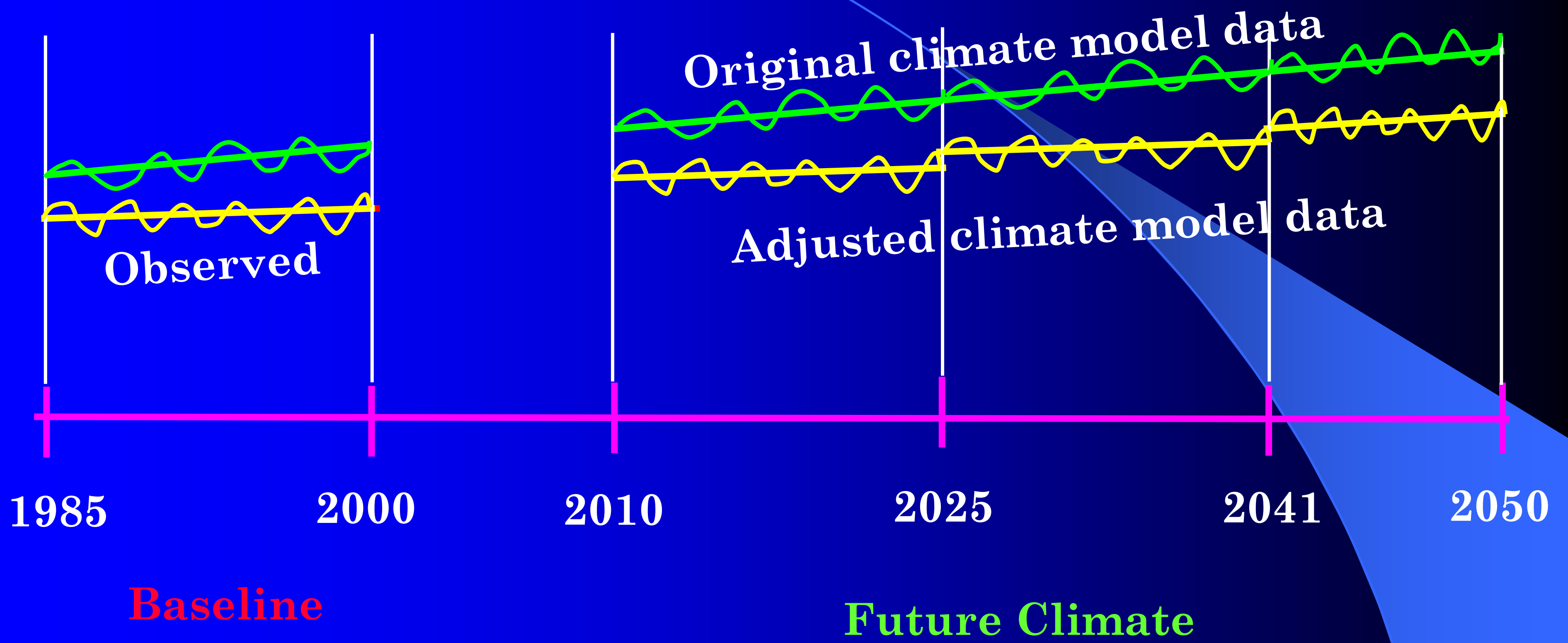
SWAT baseline model for climate change

Why need to adjust PRECIS climate data?





How can adjust PRECIS climate data?



Adjust subbasin precip

$$P_{adjCCM\,(sub\_i,month\_j)} = P_{CCM\,(sub\_i,month\_j)} - f \times \left(P_{CCM\,(sub\_i,month\_j)} - P_{calib(sub\_i,month\_j)}\right)$$

$$P_{adjCCM\,(sub\_i,month\_j,day\_k)} = P_{adjCCM\,(sub\_i,month\_j)} \times P_{pat(sub\_i,month\_j,day\_k)}$$

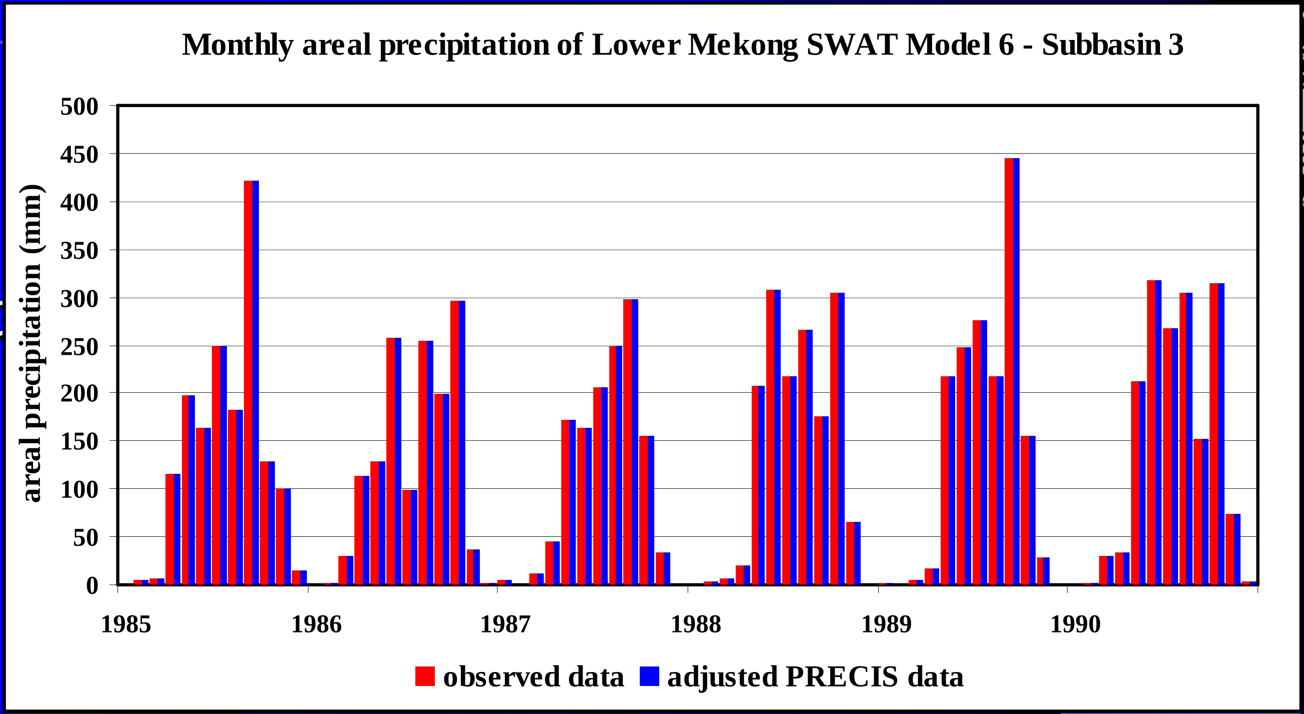
Adjust subbasin temp

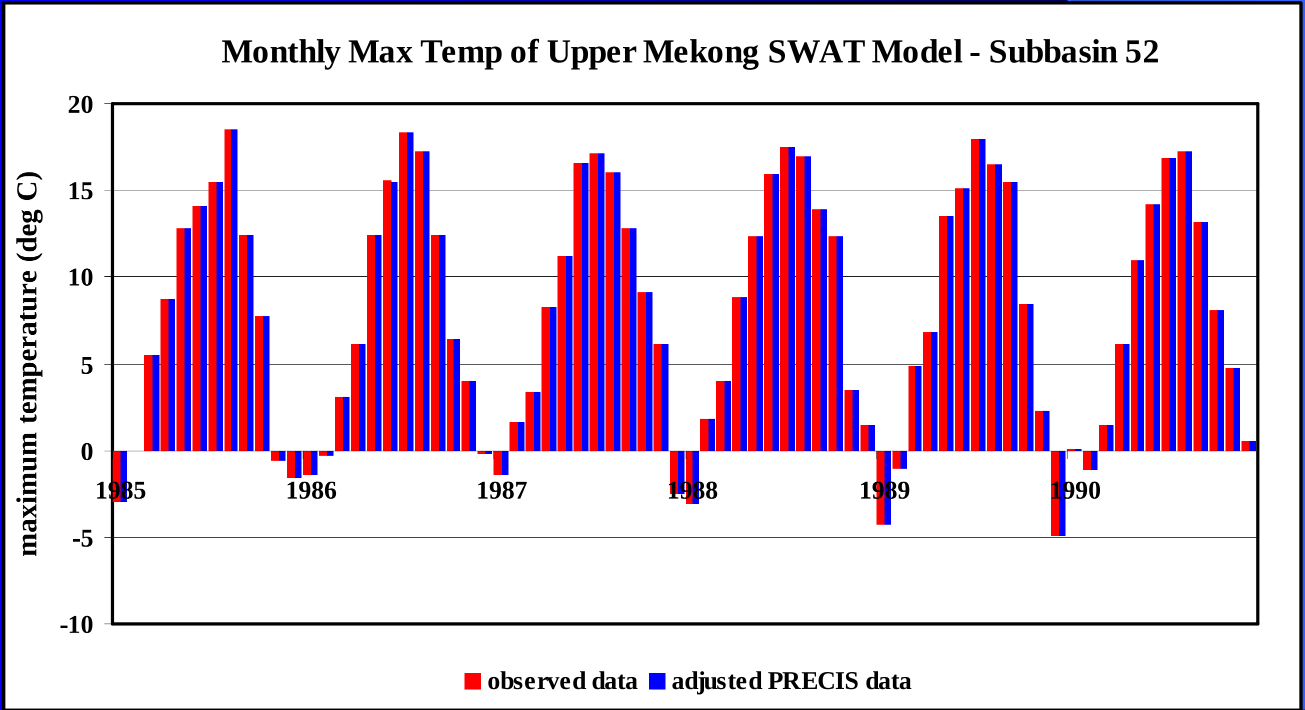
$$T_{diff\,(sub\_i,month\_j)} = \bar{T}_{CCM\,(sub\_i,month\_j)} - \bar{T}_{calib(sub\_i,month\_j)}$$

$$\bar{T}_{adjCCM\,(sub\_i,month\_j)} = \bar{T}_{CCM\,(sub\_i,month\_j)} - T_{diff\,(sub\_i,month\_j)}$$

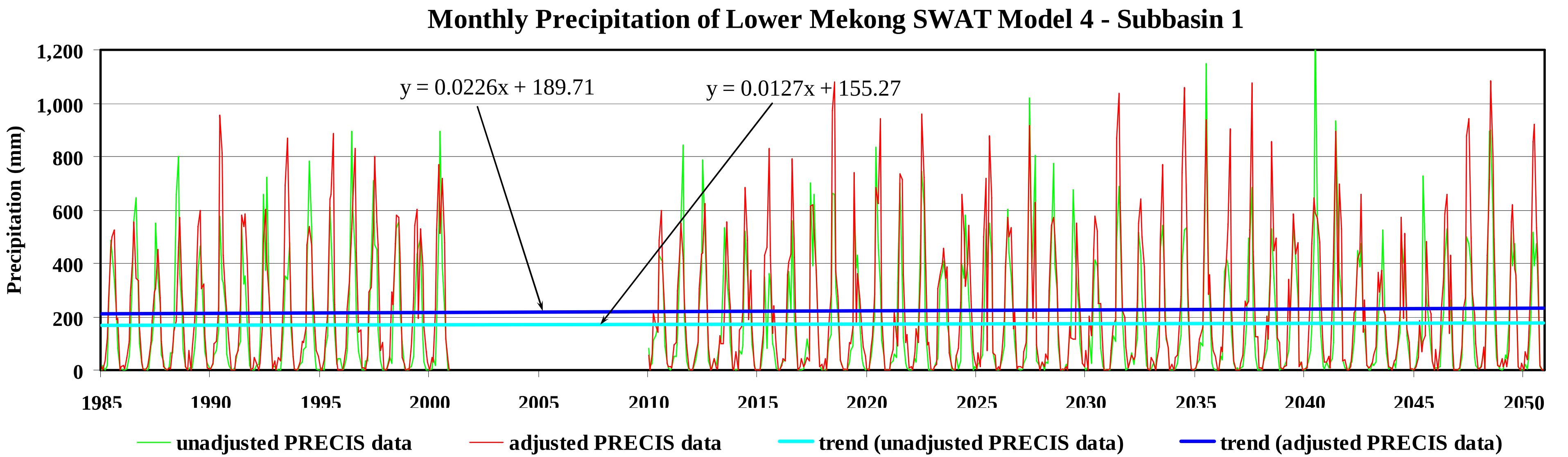
$$T_{adjCCM\,(sub\_i,month\_j,day\_k)} = T_{CCM\,(sub\_i,month\_j,day\_k)} - T_{diff\,(sub\_i,month\_j)}$$

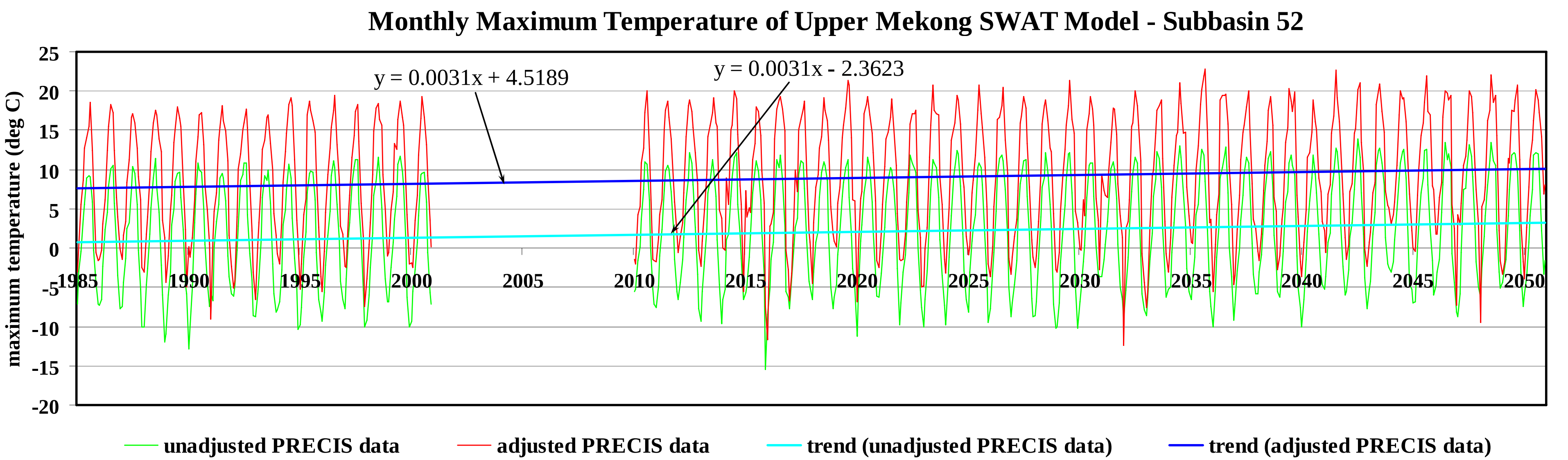
Results from adjustment of PRECIS climate data



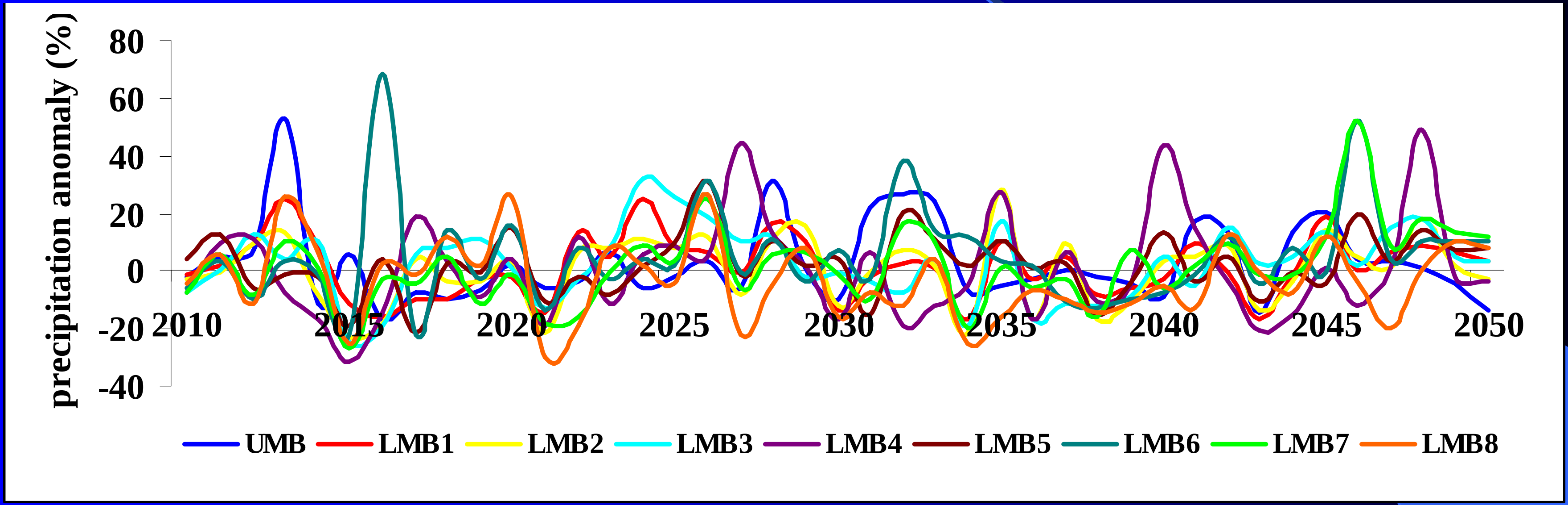


After adjustment, similar trends can be maintained

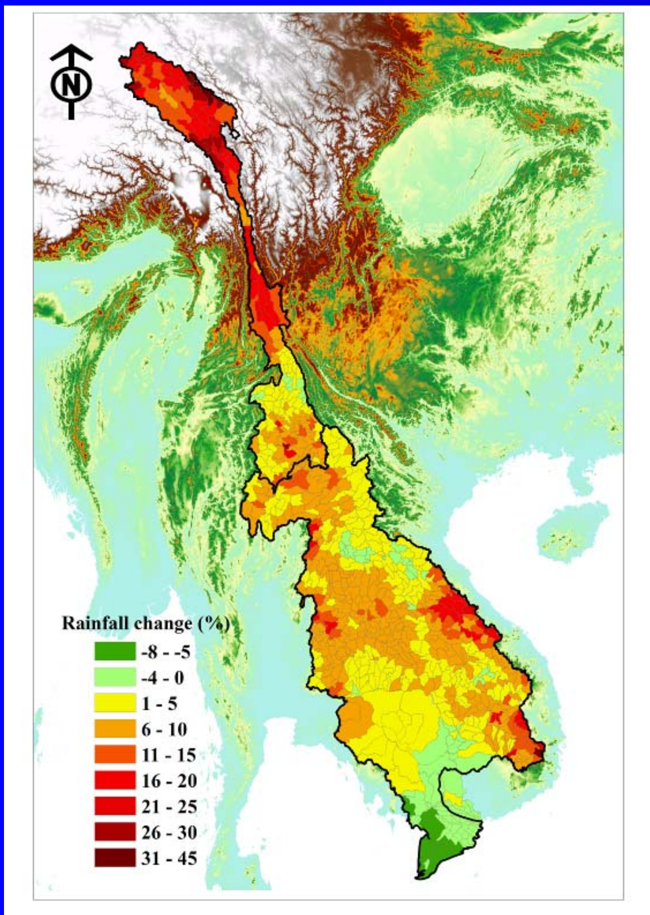




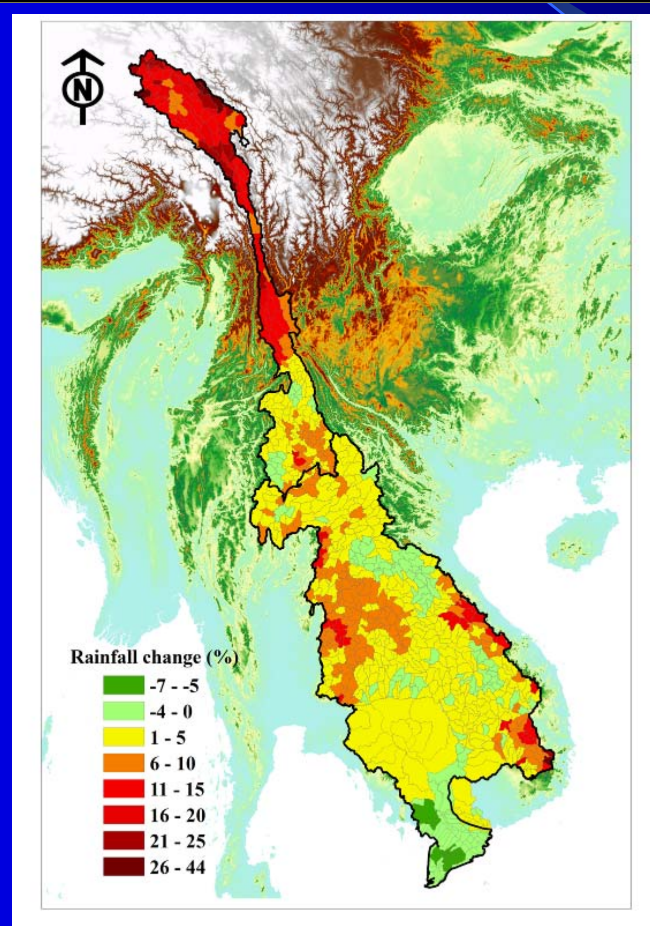
Percentage deviation of annual rainfall from the mean of baseline period (1985 – 2000) in Subbasin 1 for each SWAT model



Mekong Region	ECHAM4 Scenario	Mean Annual Precipitation (mm)					Change of Mean Annual Precipitation (%)				Rate (mm/yr)
		1985 - 00	2010 - 25	2026 - 41	2042 - 50	2010 - 50	2010 - 25	2026 - 41	2042 - 50	2010 - 50	
Upper Mekong	A2	901	979	1,008	1,019	999	8.7	12.0	13.2	10.9	+2.56
Lower Mekong	A2	1,598	1,647	1,671	1,707	1,670	3.0	4.6	6.8	4.5	+1.86
Entire Mekong	A2	1,458	1,512	1,538	1,568	1,535	3.7	5.5	7.6	5.3	+2.00
Upper Mekong	B2	901	965	1,000	982	982	7.2	11.1	9.0	9.1	+2.12
Lower Mekong	B2	1,598	1,628	1,680	1,573	1,636	1.8	5.1	-1.6	2.4	+0.98
Entire Mekong	B2	1,458	1,494	1,543	1,454	1,504	2.5	5.8	-0.3	3.2	+1.21



ECHAM4 A2



ECHAM4 B2

Change (%) of mean annual subbasin rainfall during 2010-50 relative to 1985-2000

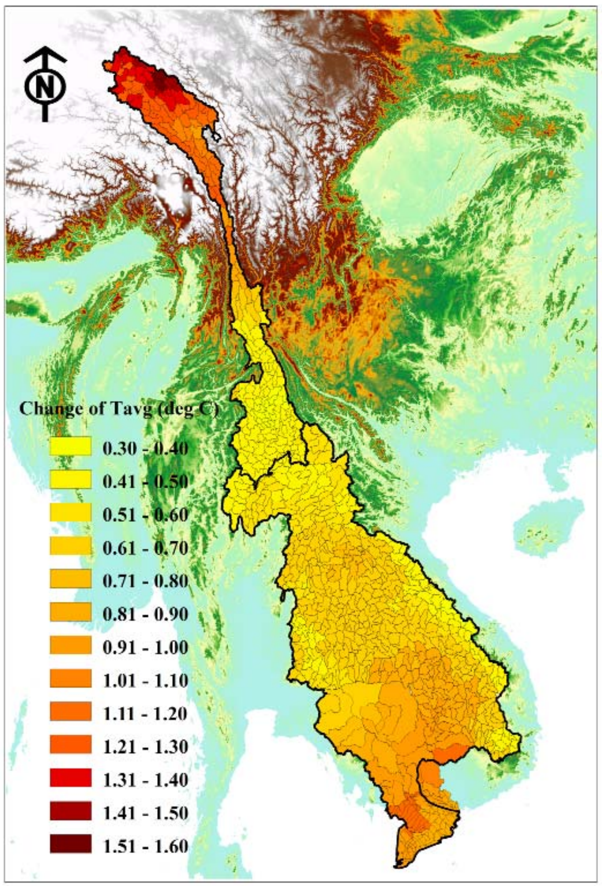
A2: trend 1985 - 2050

Areal Precipitation		Trend (mm/year)	
Scale	Number	Min	Max
subbasin	846	-3.55	+13.74
model	36	-1.90	+3.40

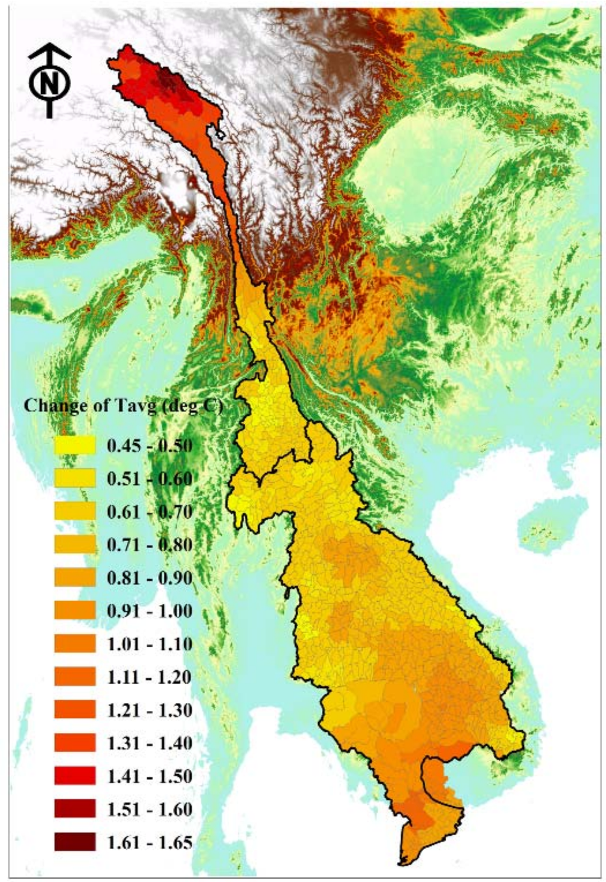
B2: trend 1985 - 2050

Areal Precipitation		Trend (mm/year)	
Scale	Number	Min	Max
subbasin	846	-3.17	+11.30
model	36	-1.92	+2.12

Mekong Region	ECHAM4 Scenario	Mean Annual Average Temperature (°C)					Change of Mean Annual Average Temperature (°C)				Rate (°C/year)
		1985 - 00	2010 - 25	2026 - 41	2042 - 50	2010 - 50	2010 - 25	2026 - 41	2042 - 50	2010 - 50	
Upper Mekong	A2	11.9	12.4	12.7	13.6	12.8	0.5	0.8	1.8	0.9	+0.023
Lower Mekong	A2	26.2	26.4	26.9	27.5	26.8	0.3	0.7	1.3	0.7	+0.018
Entire Mekong	A2	23.3	23.6	24.0	24.7	24.0	0.3	0.8	1.4	0.7	+0.019
Upper Mekong	B2	11.9	12.5	12.9	13.8	12.9	0.6	1.0	1.9	1.0	+0.026
Lower Mekong	B2	26.2	26.6	26.9	27.8	27.0	0.4	0.7	1.6	0.8	+0.020
Entire Mekong	B2	23.3	23.7	24.1	25.0	24.1	0.4	0.8	1.7	0.8	+0.021



ECHAM4 A2



ECHAM4 B2

Change (°C) of mean annual subbasin daily average temperature during 2010-50 relative to 1985-2000

A2: trend 1985 - 2050

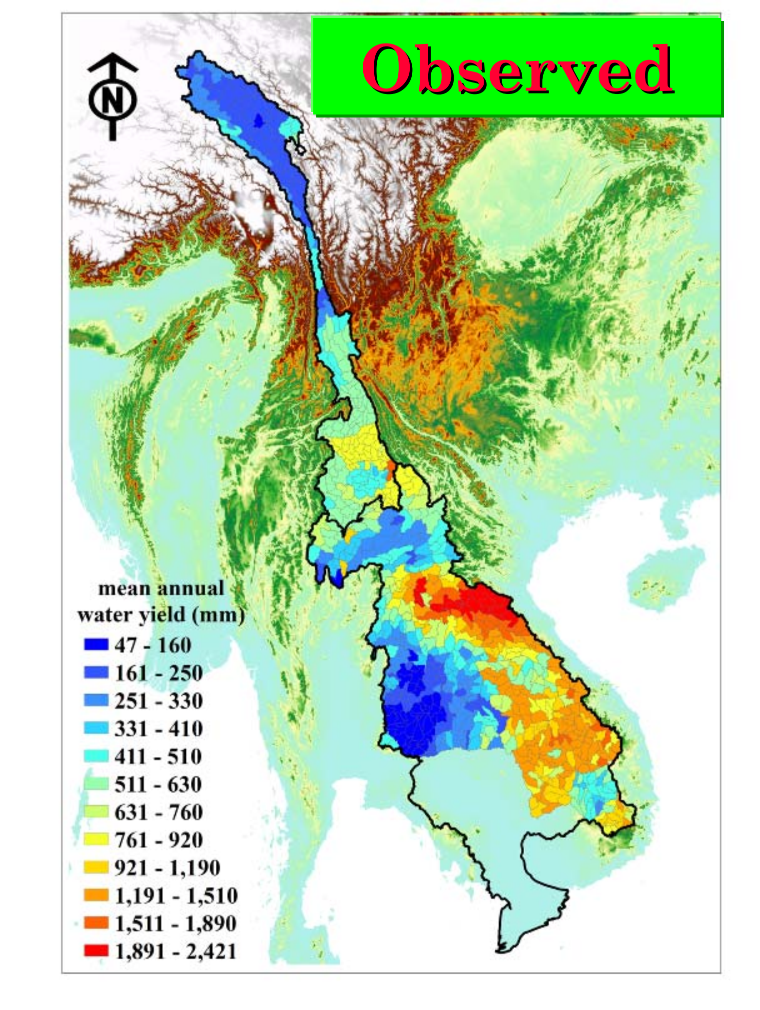
Mean Temperature		Trend (°C/year)	
Scale	Number	Min	Max
subbasin	846	+0.008	+0.040
model	36	+0.012	+0.029

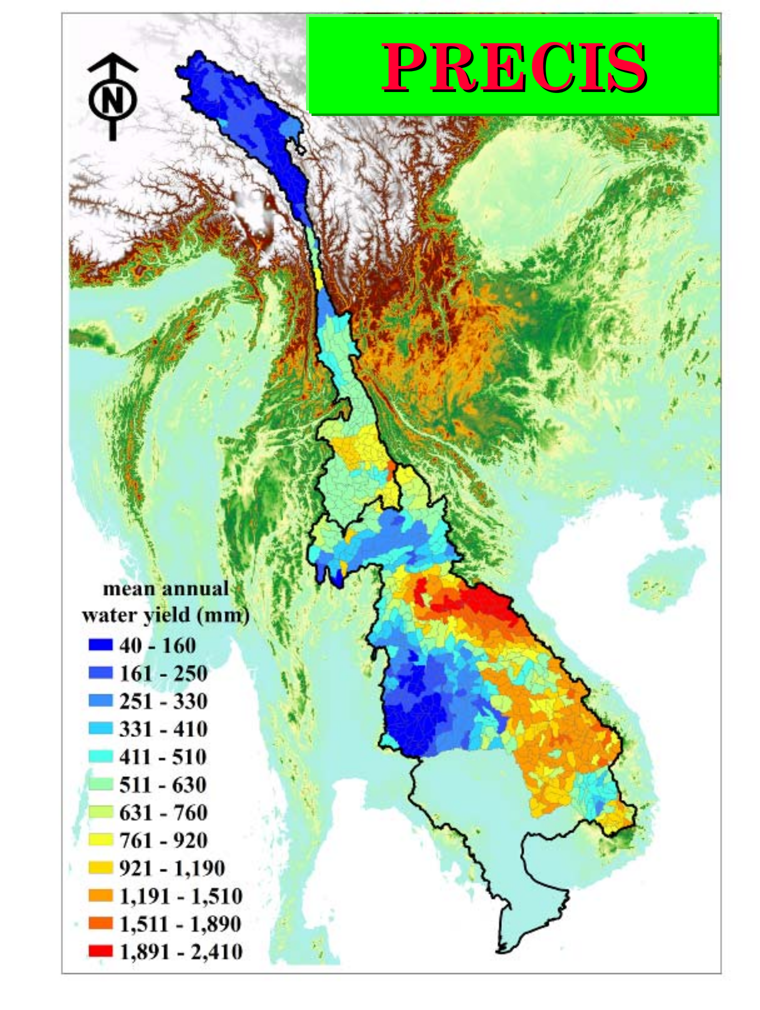
B2: trend 1985 - 2050

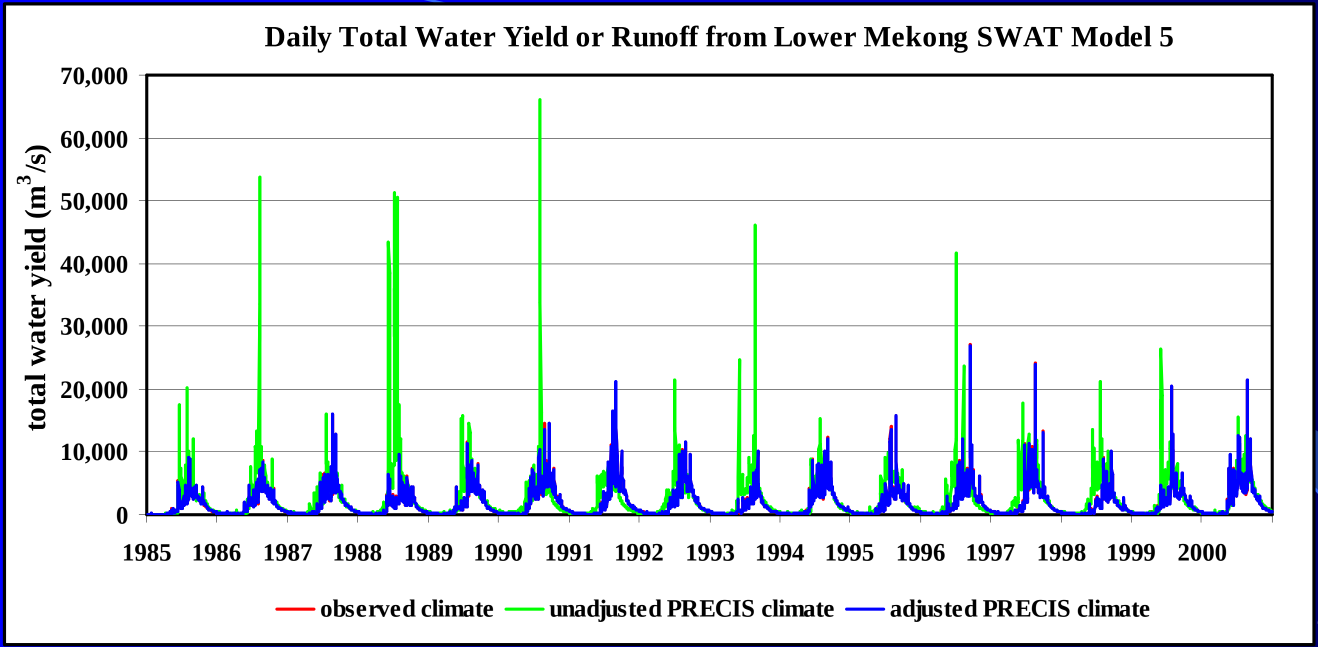
Mean Temperature		Trend (°C/year)	
Scale	Number	Min	Max
subbasin	846	+0.012	+0.043
model	36	+0.016	+0.029

Verification of baseline scenario for climate change study

Differences of mean annual SWAT water yields (runoff) in LMB using observed and PRECIS climate data as inputs are in the range of ±10% for subbasin and +0.8% for entire LMB.



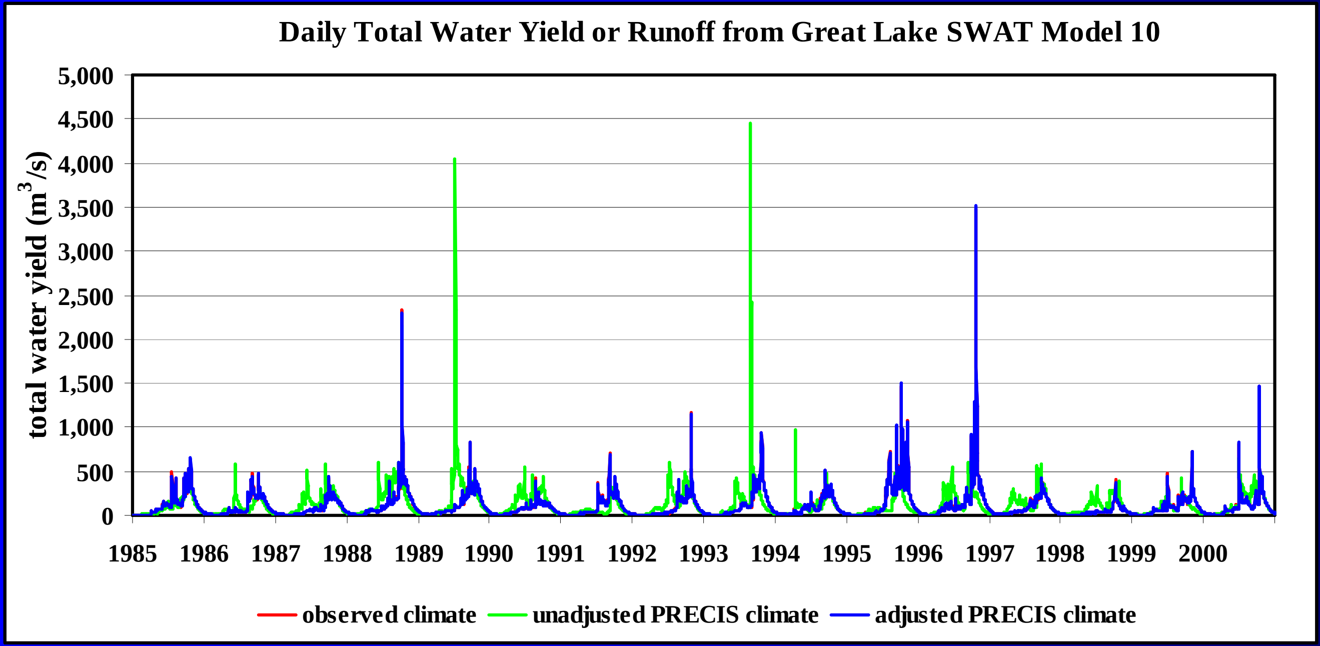




CE ≈ 0.98 – 1.00
VR ≈ 96.9 – 100.3%

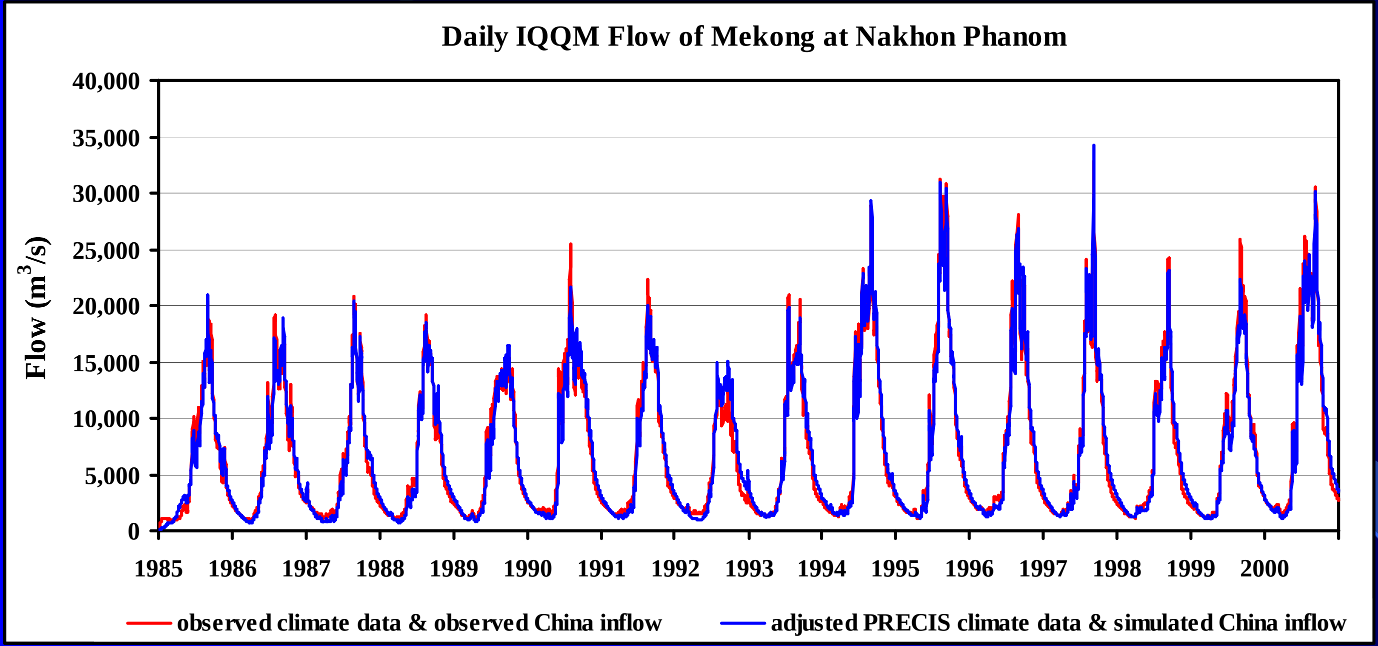
CE = Coefficient of Efficiency

VR = Volume Ratio of simulated to observed



CE ≈ 0.92 – 1.00
VR ≈ 90.7 – 101.5%

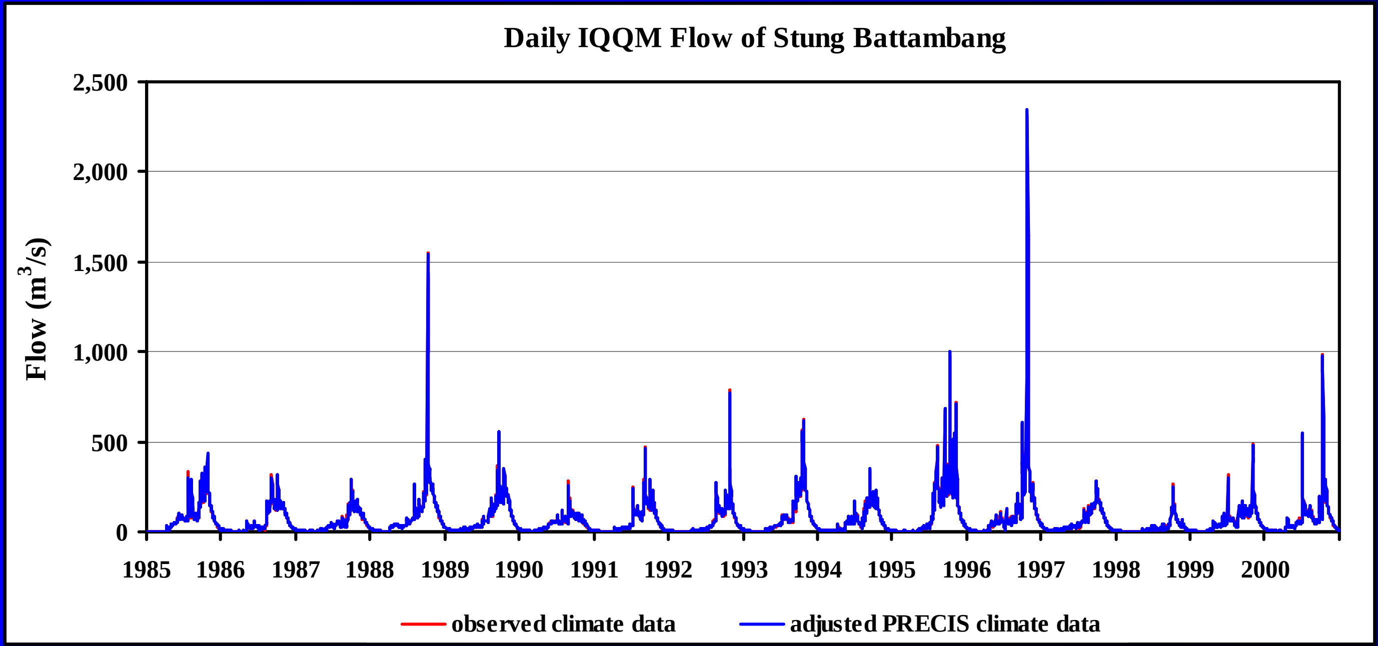
Key hydrological stations in the Lower Mekong Mainstream



CE ≈ 0.90 (0.73) – 1.00
VR ≈ 91.4 – 101.6%

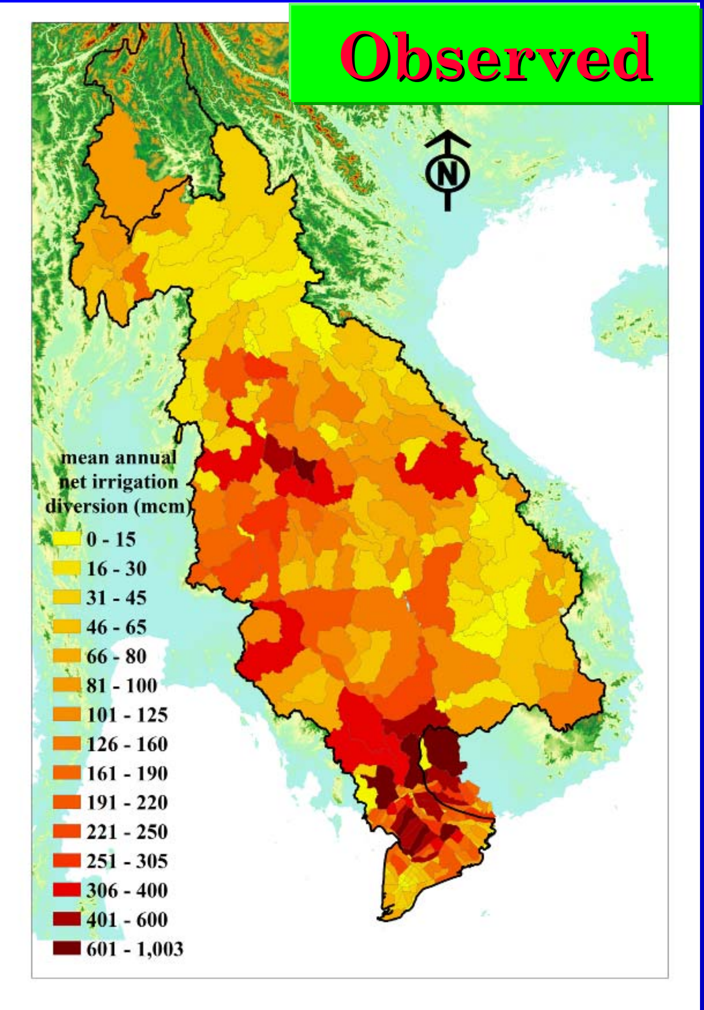
CE = Coefficient of Efficiency

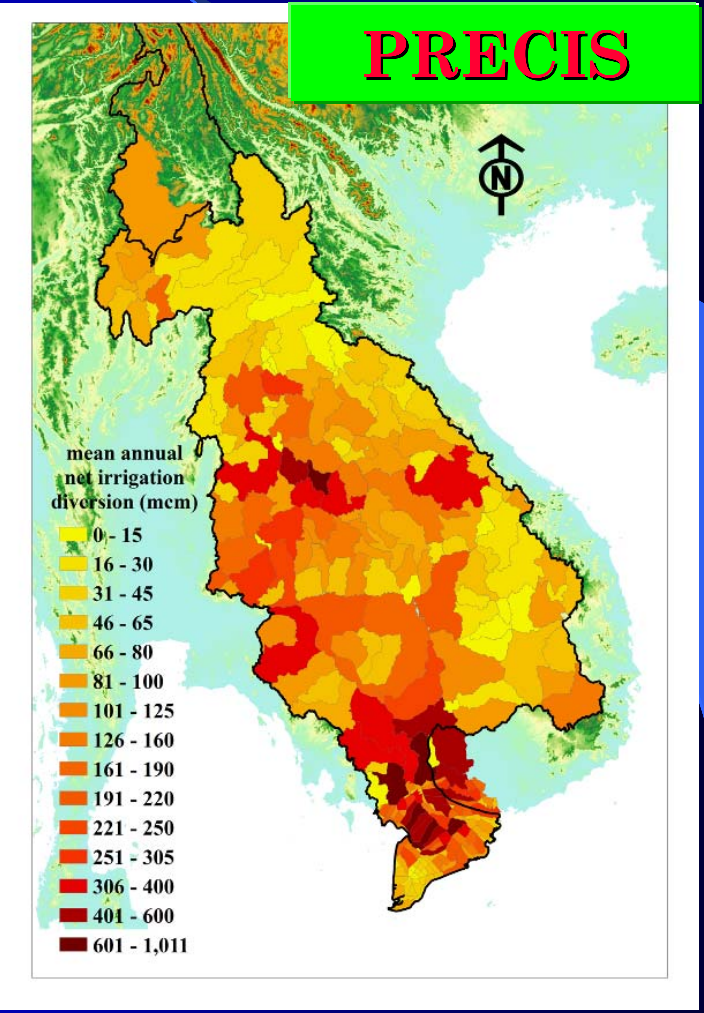
VR = Volume Ratio of simulated to observed



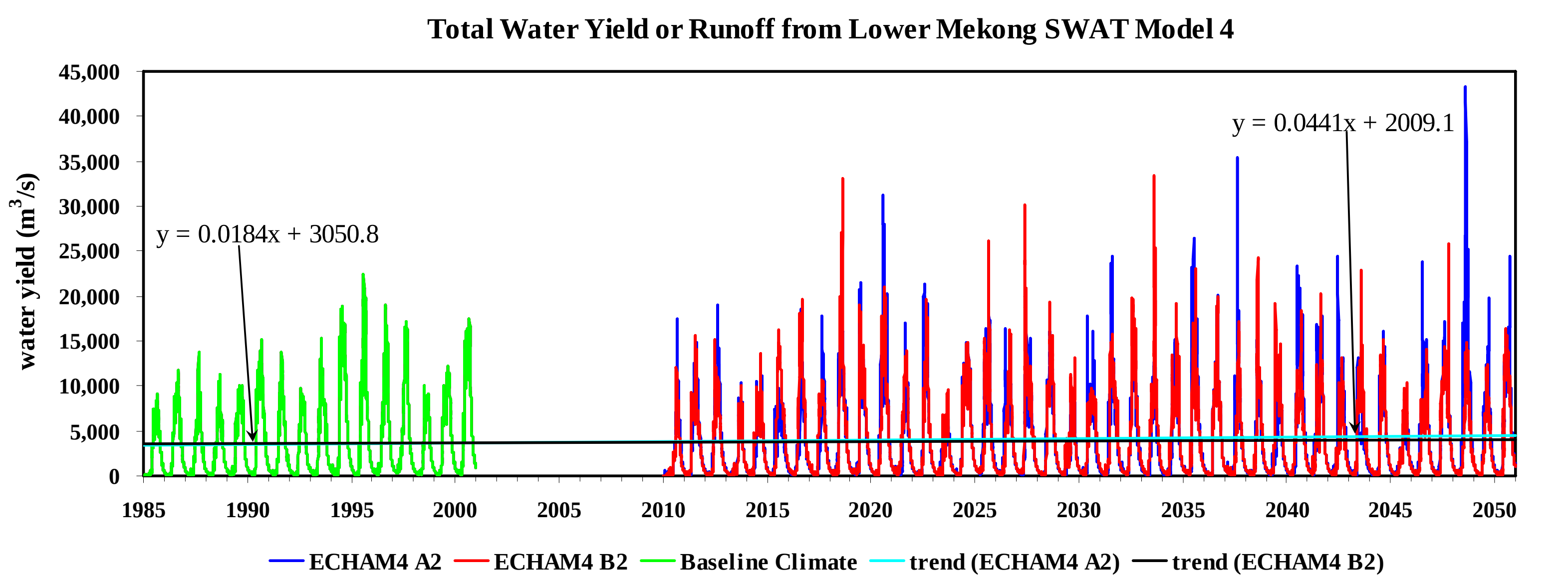
CE ≈ 0.92 – 1.00
VR ≈ 90.7 – 101.4%

Differences of mean annual (IQQM) irrigation diversions using observed and PRECIS climate data as inputs are in the range of ±10% for subbasin and -0.004% for entire LMB.






Hydrologic regime and change
under baseline scenario



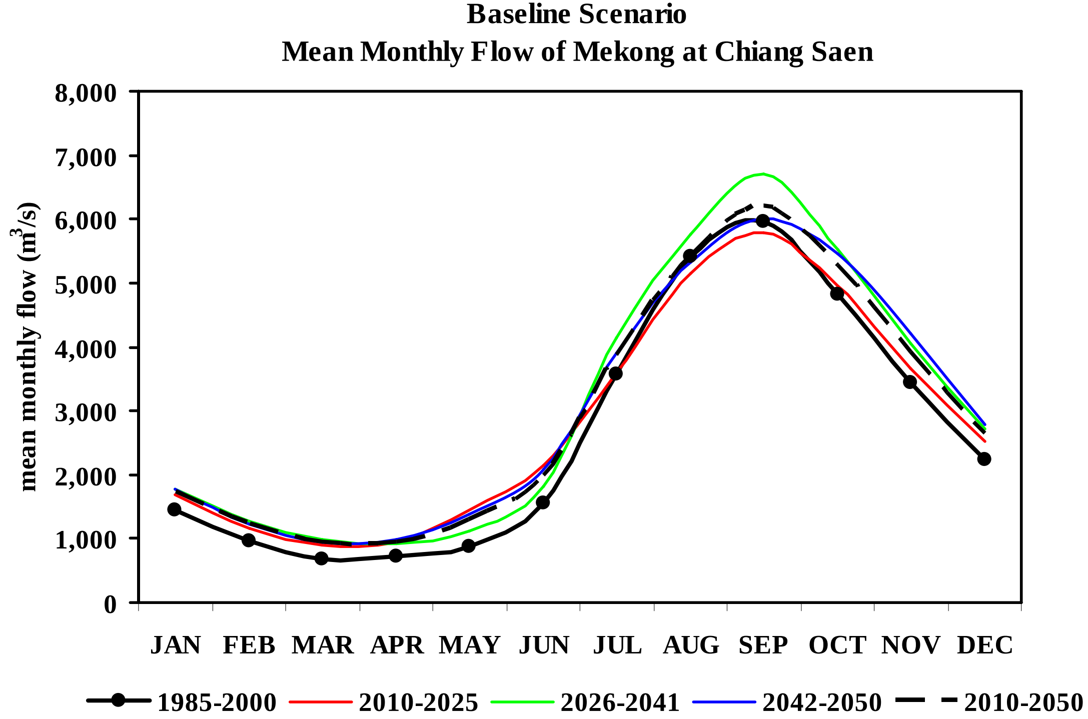
ECHAM4 A2

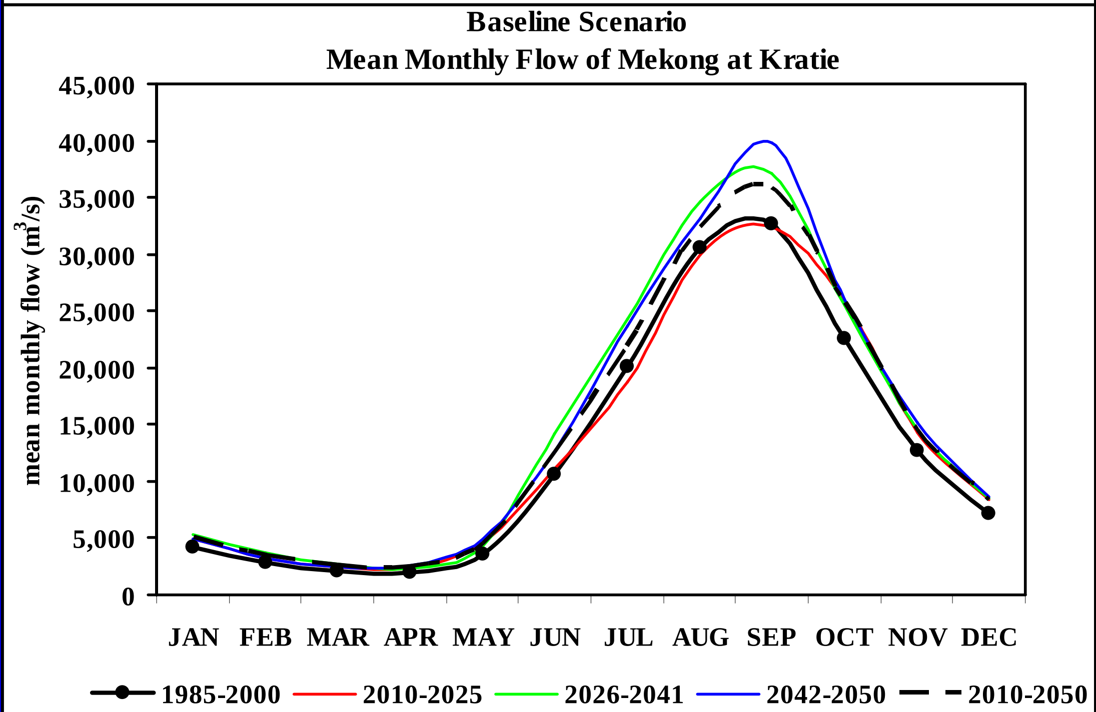
Mekong Sub-region	ECHAM4 Scenario	Mean Annual Water Yield or Runoff (mm)					Change of Mean Annual Runoff (mm)				Change of Mean Annual Runoff (%)			
		1985-00	2010-25	2026-41	2042-50	2010-50	2010-25	2026-41	2042-50	2010-50	2010-25	2026-41	2042-50	2010-50
Upper Mekong	A2	417.8	443.6	487.6	483.6	469.5	25.8	69.8	65.8	51.8	6.2	16.7	15.7	12.4
Lower Mekong (upstream Kratie)	A2	756.8	784.2	863.3	872.7	834.5	27.5	106.5	115.9	77.7	3.6	14.1	15.3	10.3
Great Lake and Vicinities	A2	496.2	509.9	490.7	554.7	512.3	13.7	-5.5	58.5	16.0	2.8	-1.1	11.8	3.2

ECHAM4 B2

Mekong Sub-region	ECHAM4 Scenario	Mean Annual Water Yield or Runoff (mm)					Change of Mean Annual Runoff (mm)				Change of Mean Annual Runoff (%)			
		1985-00	2010-25	2026-41	2042-50	2010-50	2010-25	2026-41	2042-50	2010-50	2010-25	2026-41	2042-50	2010-50
Upper Mekong	B2	417.8	432.1	473.5	446.5	451.4	14.3	55.7	28.7	33.6	3.4	13.3	6.9	8.0
Lower Mekong (upstream Kratie)	B2	756.8	773.9	855.0	744.0	799.0	17.1	98.2	-12.8	42.2	2.3	13.0	-1.7	5.6
Great Lake and Vicinities	B2	496.2	517.7	531.3	496.8	518.4	21.5	35.0	0.6	22.2	4.3	7.1	0.1	4.5

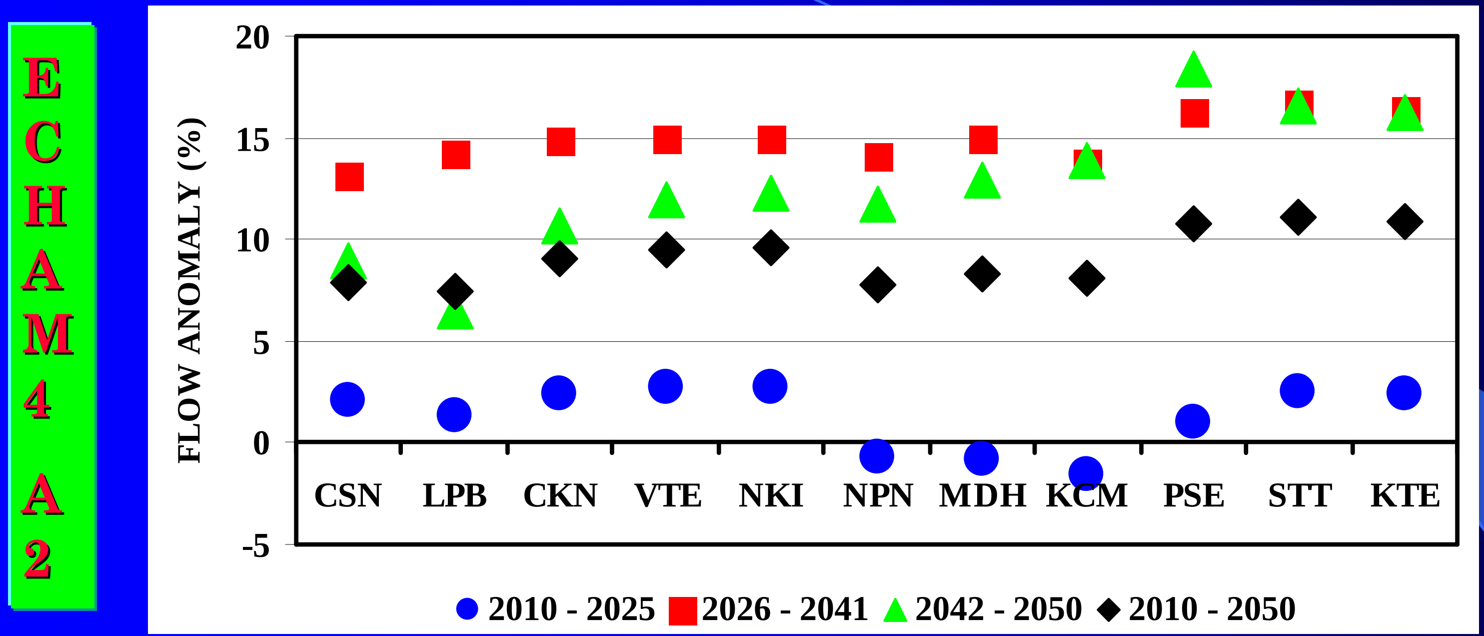
BDP Baseline Scenario

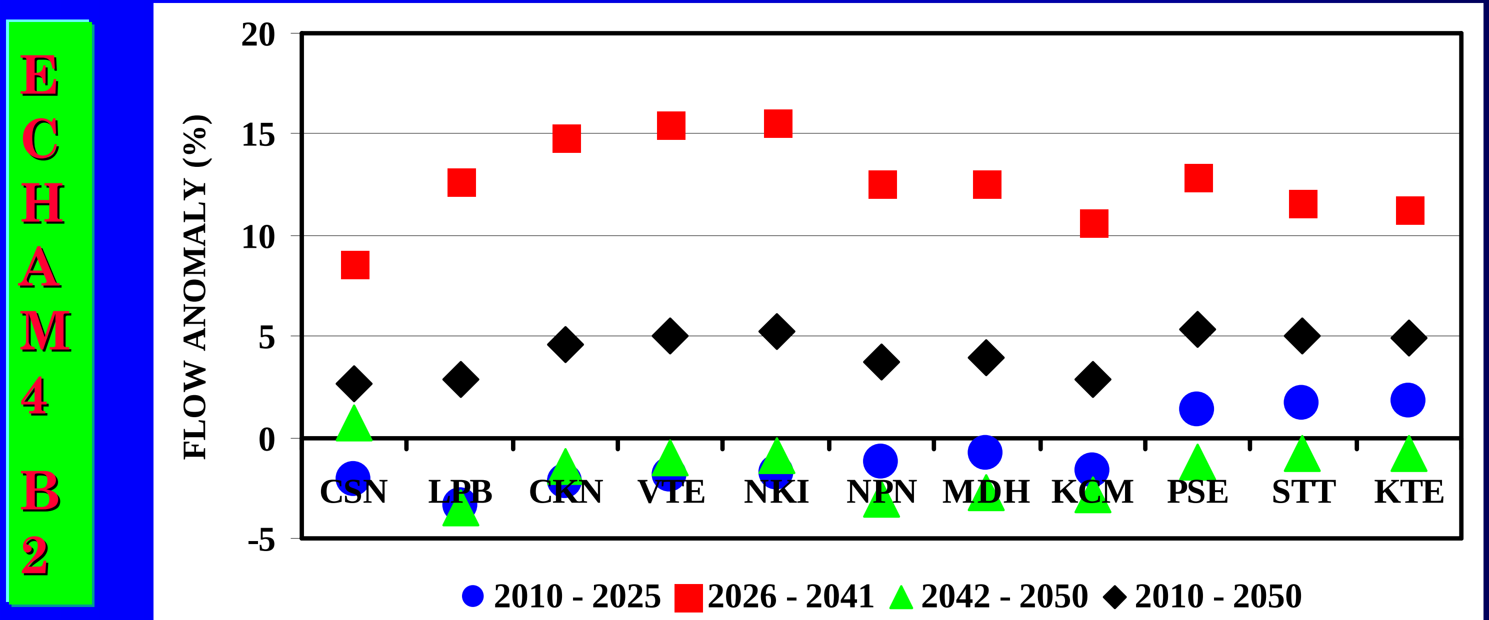




ECHAM4 A2

Change of wet seasonal flow

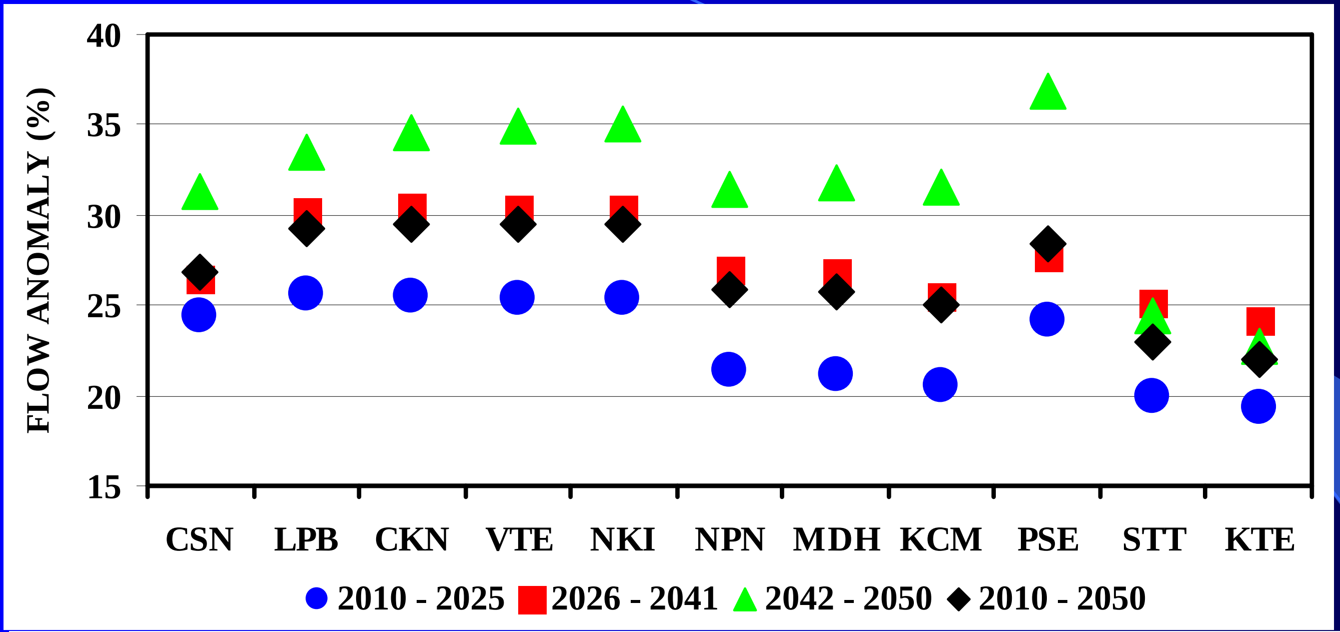




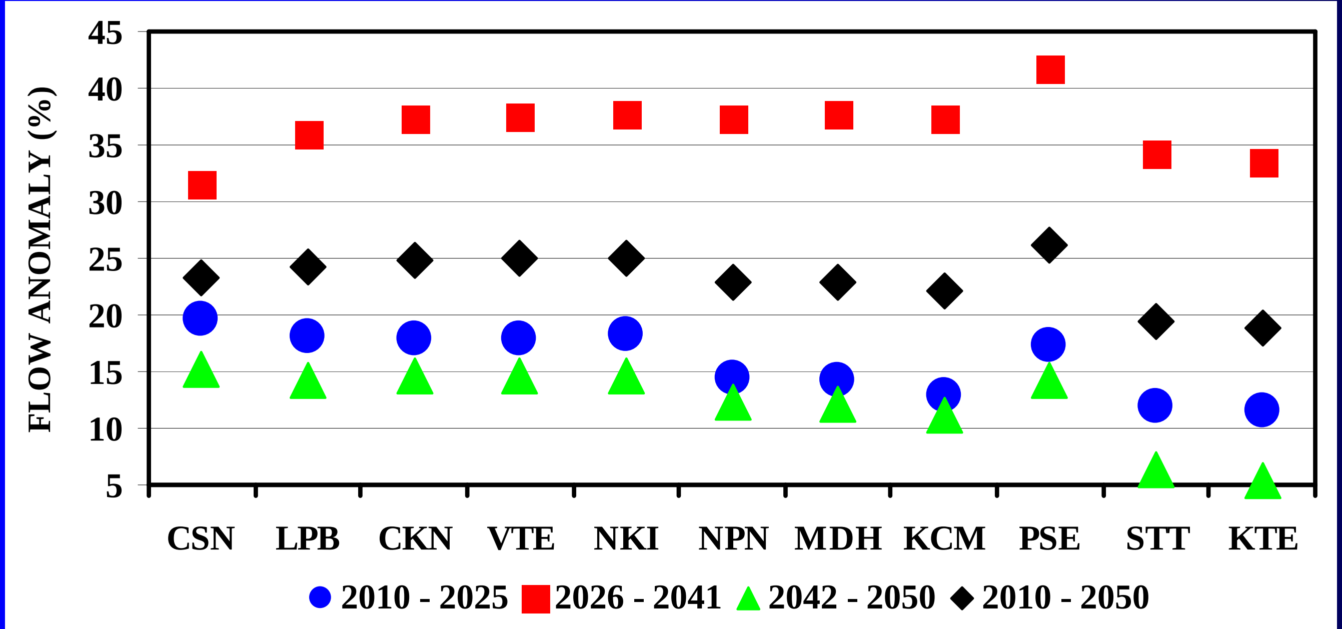
Impact from Future Climate Change

Change of dry seasonal flow

ECHAM4 A2



ECHAM4 B2

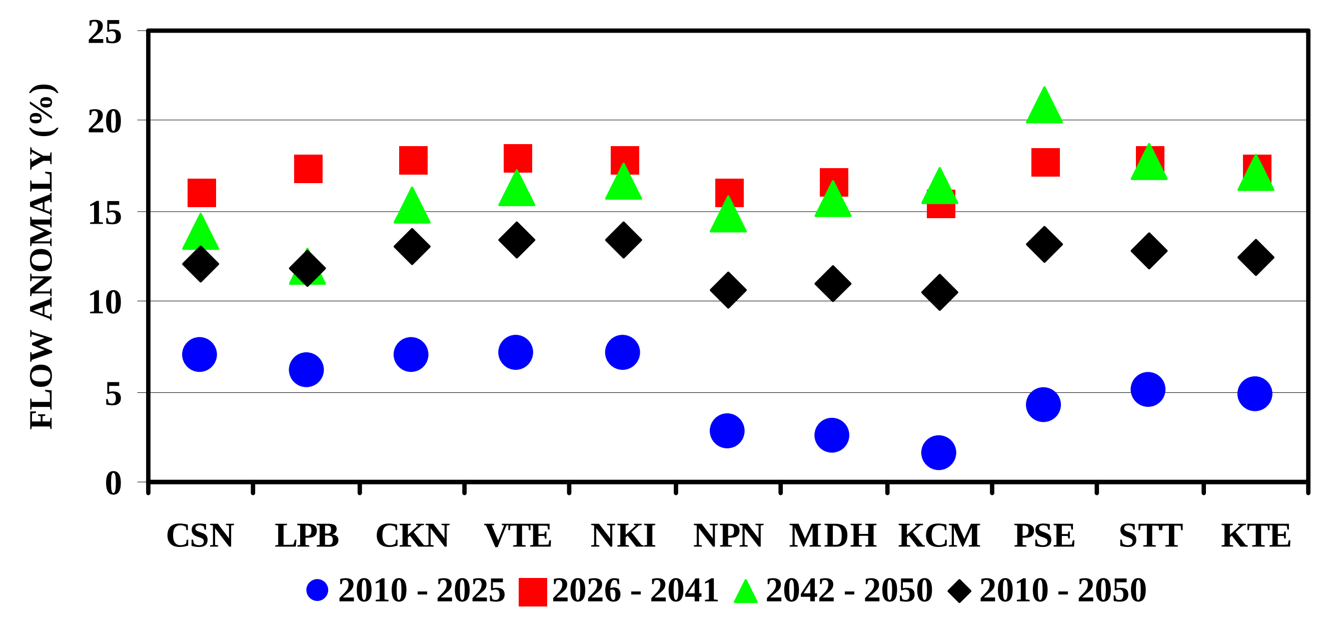


Impact from Future Climate Change

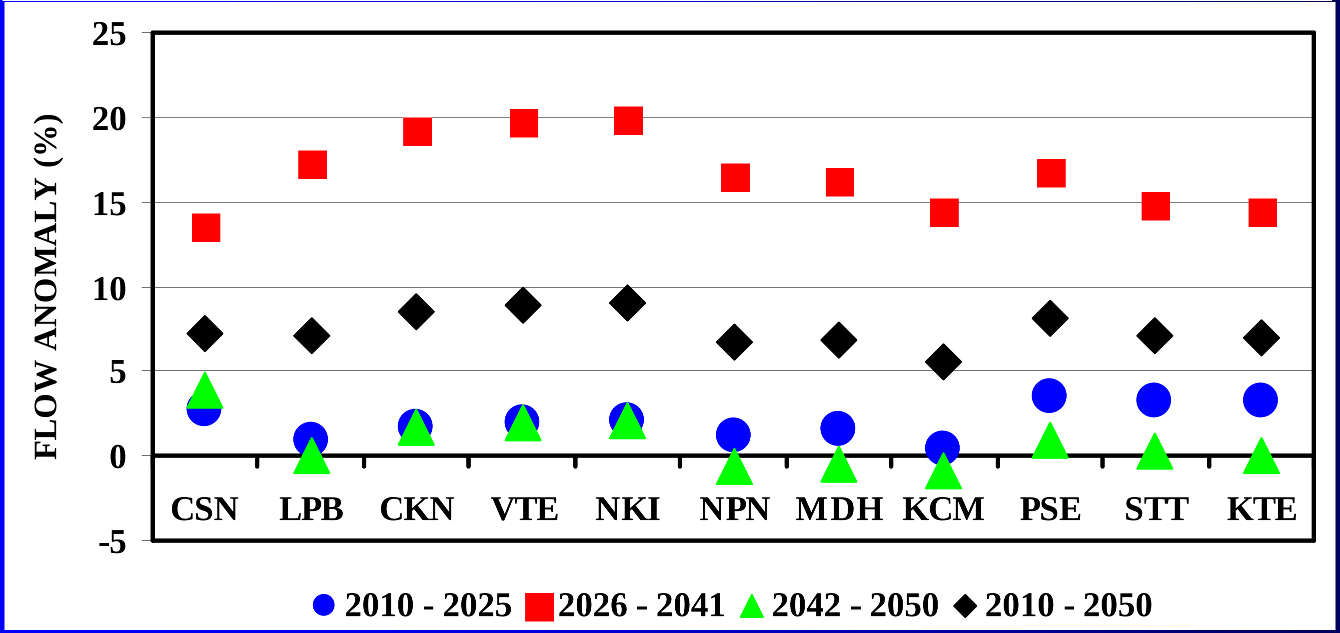
Change of mean annual flow

Impact from Future Climate Change

ECHAM4 A2



ECHAM4 B2



Mean Flow Downstream of Kratie: ECHAM4 A2

Station	Baseline Scenario: Mean Annual Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	12,292	12,855	14,312	14,228	13,726	4.6	16.4	15.7	11.7
Phnom Penh	11,967	12,426	13,639	13,345	13,102	3.8	14.0	11.5	9.5
Tan Chau	9,743	10,051	10,815	10,657	10,483	3.2	11.0	9.4	7.6
Chau Doc *	1,595	1,643	1,719	1,724	1,690	3.0	7.7	8.1	6.0

Station	Baseline Scenario: Mean Wet Season Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	20,935	21,382	24,123	24,009	23,028	2.1	15.2	14.7	10.0
Phnom Penh	20,217	20,460	22,702	22,175	21,711	1.2	12.3	9.7	7.4
Tan Chau	14,435	14,511	15,823	15,618	15,266	0.5	9.6	8.2	5.8
Chau Doc *	2,207	2,207	2,317	2,343	2,280	0.0	5.0	6.1	3.3

Station	Baseline Scenario: Mean Dry Season Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	3,650	4,328	4,501	4,447	4,423	18.6	23.3	21.8	21.2
Phnom Penh	3,718	4,391	4,577	4,514	4,492	18.1	23.1	21.4	20.8
Tan Chau	5,052	5,591	5,807	5,696	5,700	10.7	14.9	12.7	12.8
Chau Doc *	983	1,078	1,120	1,105	1,101	9.7	13.9	12.4	12.0

* **Bassac River**

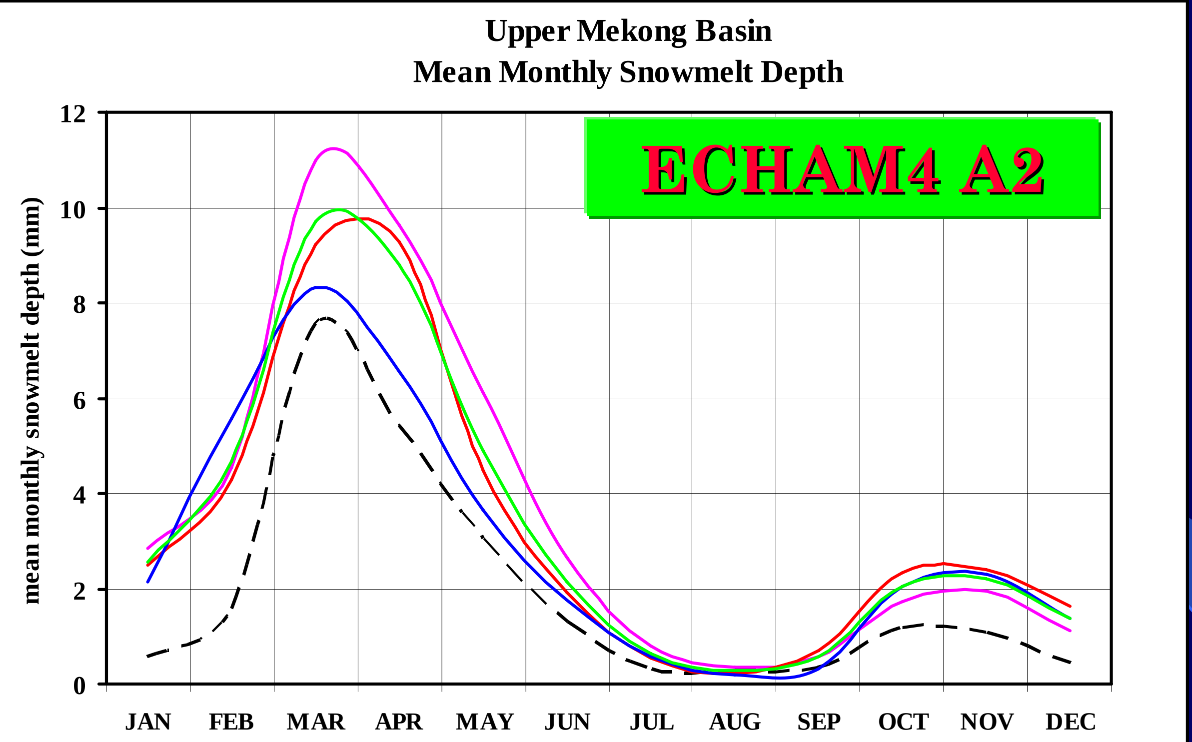
Mean Flow Downstream of Kratie: ECHAM4 B2

Station	Baseline Scenario: Mean Annual Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	12,292	12,661	13,979	12,265	13,089	3.0	13.7	-0.2	6.5
Phnom Penh	11,967	12,172	13,376	11,856	12,573	1.7	11.8	-0.9	5.1
Tan Chau	9,743	9,897	10,681	9,636	10,146	1.6	9.6	-1.1	4.1
Chau Doc *	1,595	1,608	1,708	1,576	1,640	0.8	7.1	-1.2	2.8

Station	Baseline Scenario: Mean Wet Season Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	20,935	21,248	23,161	20,712	21,877	1.5	10.6	-1.1	4.5
Phnom Penh	20,217	20,195	21,920	19,824	20,787	-0.1	8.4	-1.9	2.8
Tan Chau	14,435	14,392	15,391	14,047	14,706	-0.3	6.6	-2.7	1.9
Chau Doc *	2,207	2,184	2,277	2,150	2,213	-1.0	3.2	-2.6	0.3

Station	Baseline Scenario: Mean Dry Season Flow (m^3/s)					Flow Change (+/- %)			
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	3,650	4,073	4,797	3,818	4,300	11.6	31.4	4.6	17.8
Phnom Penh	3,718	4,148	4,833	3,889	4,359	11.6	30.0	4.6	17.3
Tan Chau	5,052	5,401	5,970	5,225	5,586	6.9	18.2	3.4	10.6
Chau Doc *	983	1,031	1,139	1,001	1,067	4.9	15.9	1.9	8.5

* **Bassac River**



MRC MEKONG RIVER COMMISSION FOR SUSTAINABLE DEVELOPMENT

A2

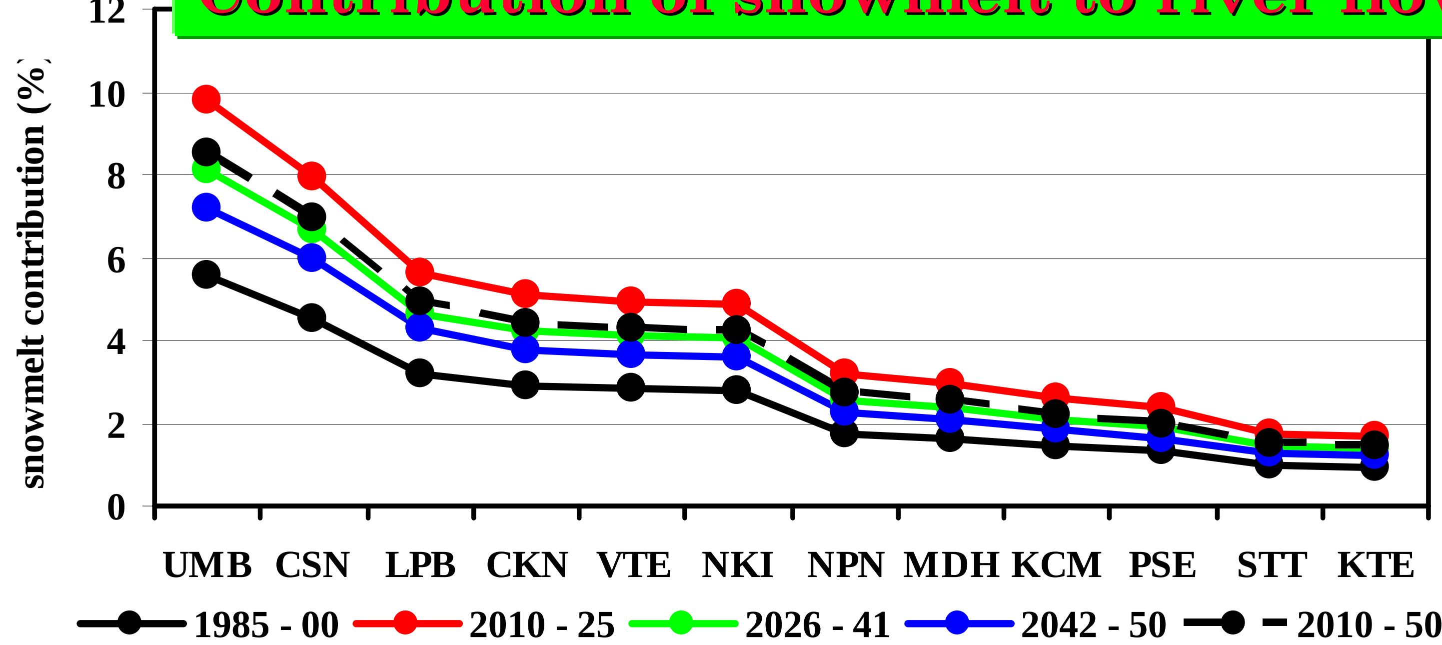
Period	Mean Annual Water Yield or Runoff (mm)	Mean Annual Snowmelt (mm)	Snowmelt Contribution to Water Yield (%)	Snowmelt Increase Relative to 1985 - 2000		Average Snowmelt Rate (m^3/s)
				(mm)	(%)	
1985 - 2000	417.8	23.2	5.5			120.0
2010 - 2025	443.6	43.4	9.8	20.2	87.3	224.7
2026 - 2041	487.6	39.5	8.1	16.4	70.6	204.7
2042 - 2050	483.6	34.8	7.2	11.7	50.3	180.4
2010 - 2050	469.5	39.9	8.5	16.7	72.3	206.7

B2

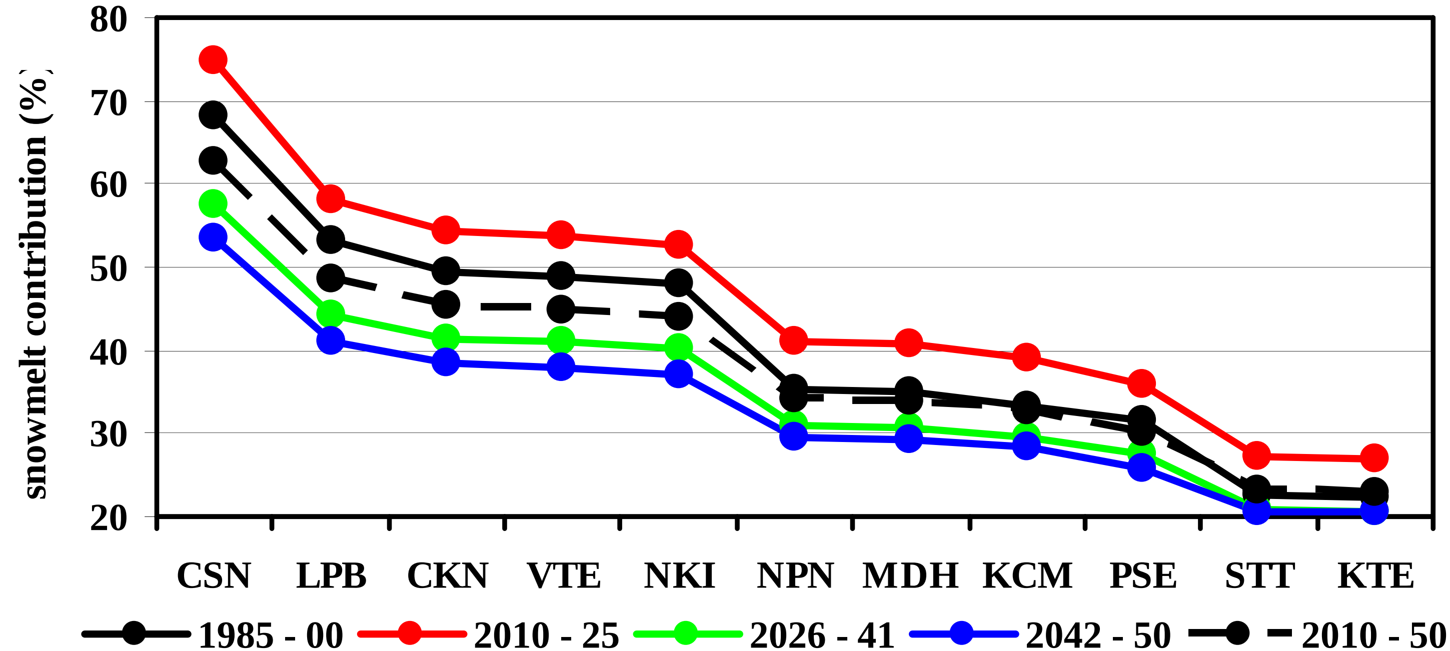
Period	Mean Annual Water Yield or Runoff (mm)	Mean Annual Snowmelt (mm)	Snowmelt Contribution to Water Yield (%)	Snowmelt Increase Relative to 1985 - 2000		Average Snowmelt Rate (m^3/s)
				(mm)	(%)	
1985 - 2000	417.8	23.2	5.5			120.0
2010 - 2025	432.1	41.1	9.5	17.9	77.2	212.6
2026 - 2041	473.5	36.6	7.7	13.5	58.2	189.8
2042 - 2050	446.5	33.0	7.4	9.8	42.4	170.9
2010 - 2050	451.4	37.5	8.3	14.3	61.8	194.1

Contribution of snowmelt to river flow

Annual



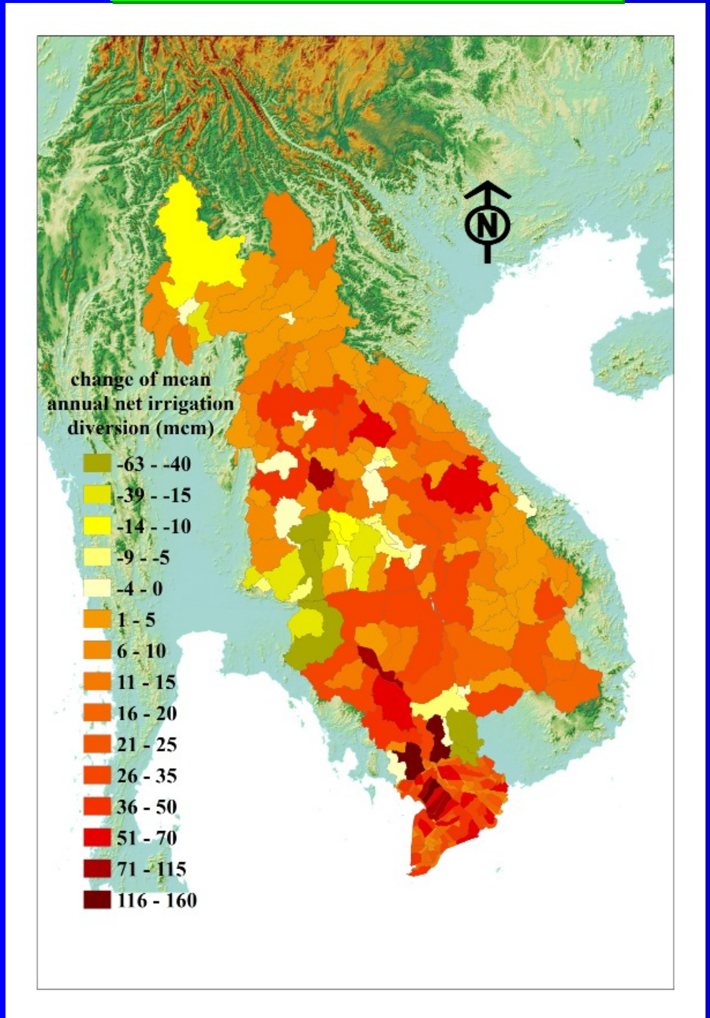
March



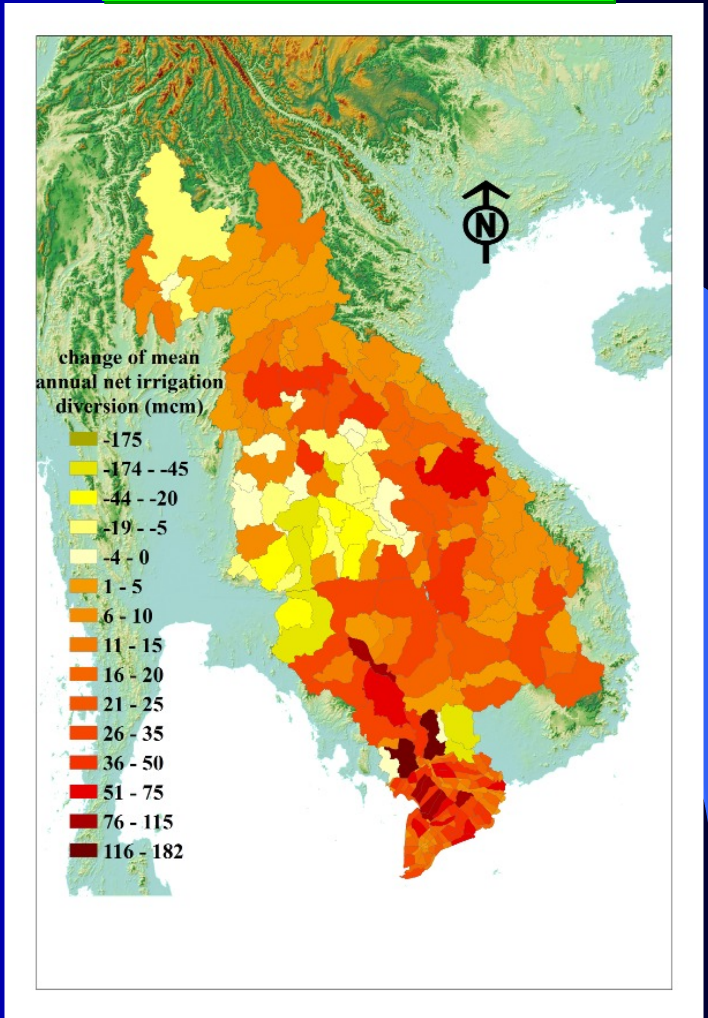
ECHAM4 A2

Period	Total Irrigation Diversion - ECHAM4 A2 Scenario			Total Irrigation Diversion - ECHAM4 B2 Scenario		
	Mean Annual Amount (10^6 m^3)	Change Relative to 1985 - 2000		Mean Annual Amount (10^6 m^3)	Change Relative to 1985 - 2000	
		+/- (10^6 m^3)	+/- (%)		+/- (10^6 m^3)	+/- (%)
1985 - 2000	36,097			36,097		
2010 - 2050	40,558	4,461	12.4	40,011	3,914	10.8

ECHAM4 A2

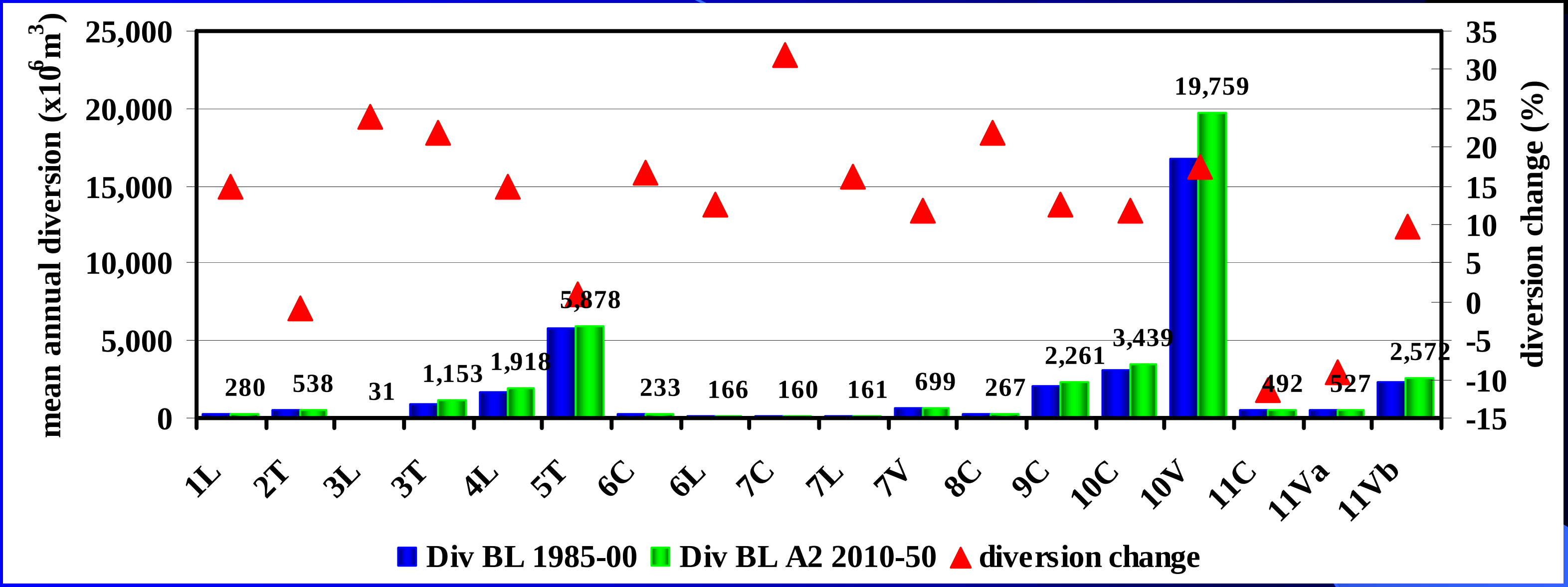


ECHAM4 B2

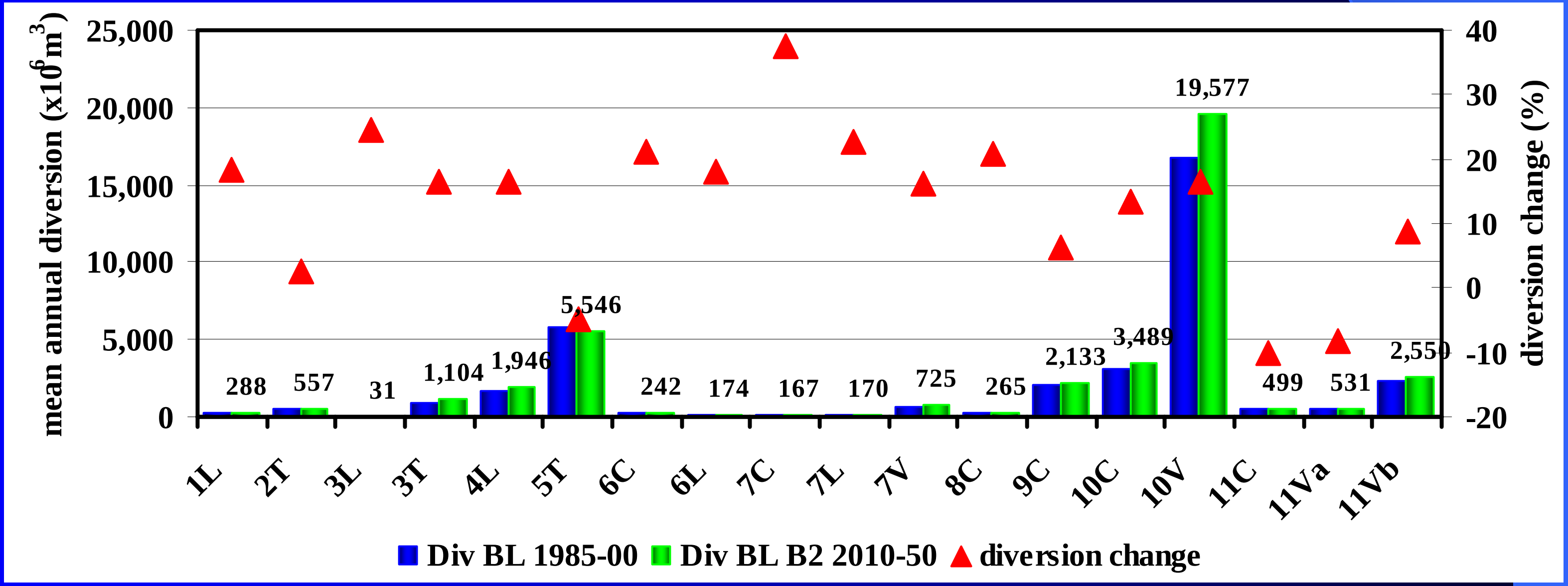


Impact from future climate change on irrigation diversion

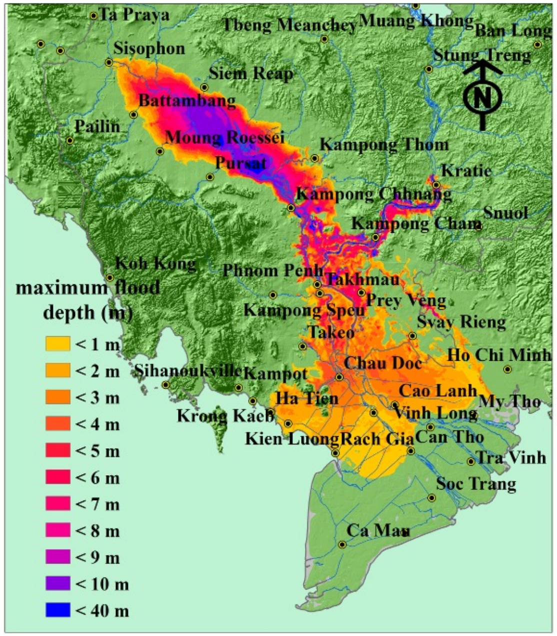
ECHAM4 A2



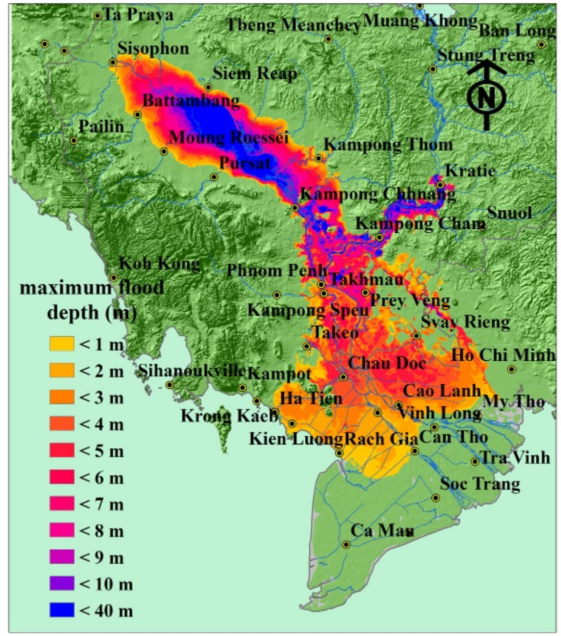
ECHAM4 B2



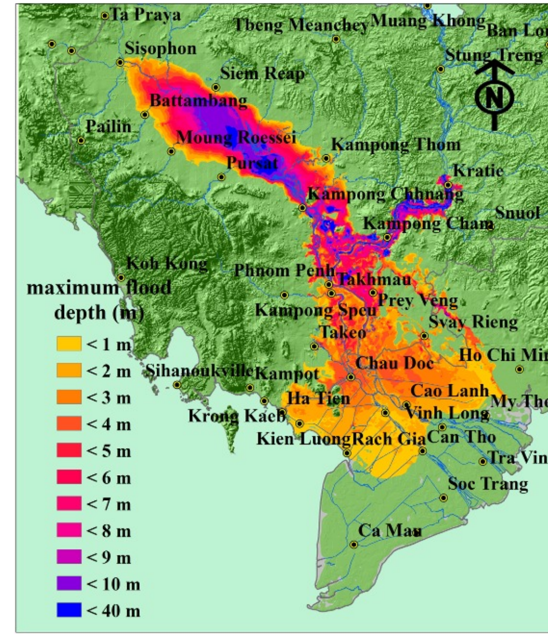
Flood Area from Maximum Flood Depth



BL-2000



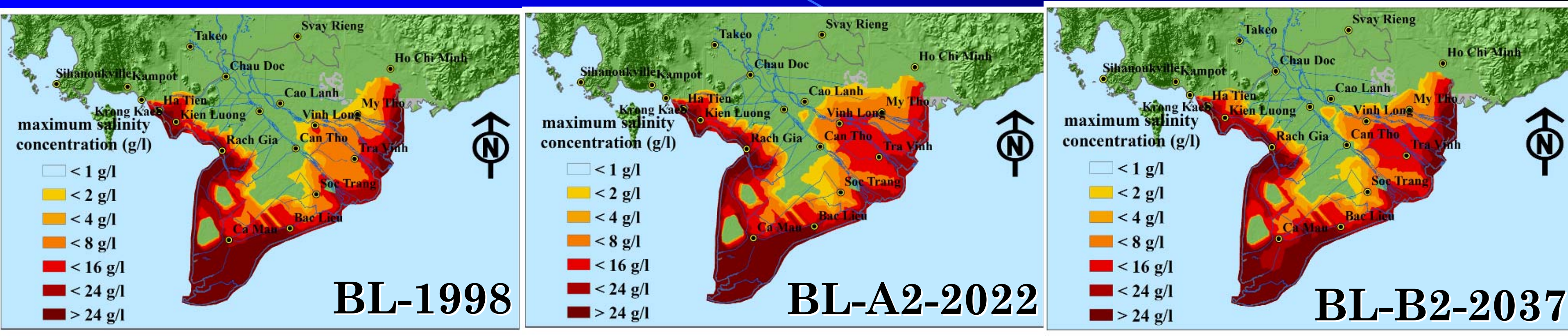
BL-A2-2048



BL-B2-2047

Maximum Flood Depth (m)	Flood Area based on Maximum Flood Depth (km^2)			Difference in Flood Area (+/- km^2)		Difference in Flood Area (+/- %)	
	[1]BL-2000	[2]BL-A2-2048	[3]BL-B2-2047	[1] vs [2]	[1] vs [3]	[1] vs [2]	[1] vs [3]
> 0.0 m	44,654	48,579	46,037	3,925	1,383	8.8	3.1
> 0.5 m	41,317	46,915	42,657	5,598	1,340	13.5	3.2
> 1.0 m	36,393	43,917	38,311	7,524	1,918	20.7	5.3
> 1.5 m	30,923	40,563	33,061	9,641	2,138	31.2	6.9
> 2.0 m	26,347	36,459	28,993	10,112	2,645	38.4	10.0
> 2.5 m	21,971	32,783	24,924	10,812	2,953	49.2	13.4
> 3.0 m	17,977	29,006	20,934	11,028	2,957	61.3	16.4
> 3.5 m	15,198	25,501	17,439	10,302	2,241	67.8	14.7
> 4.0 m	13,570	21,422	15,656	7,852	2,086	57.9	15.4

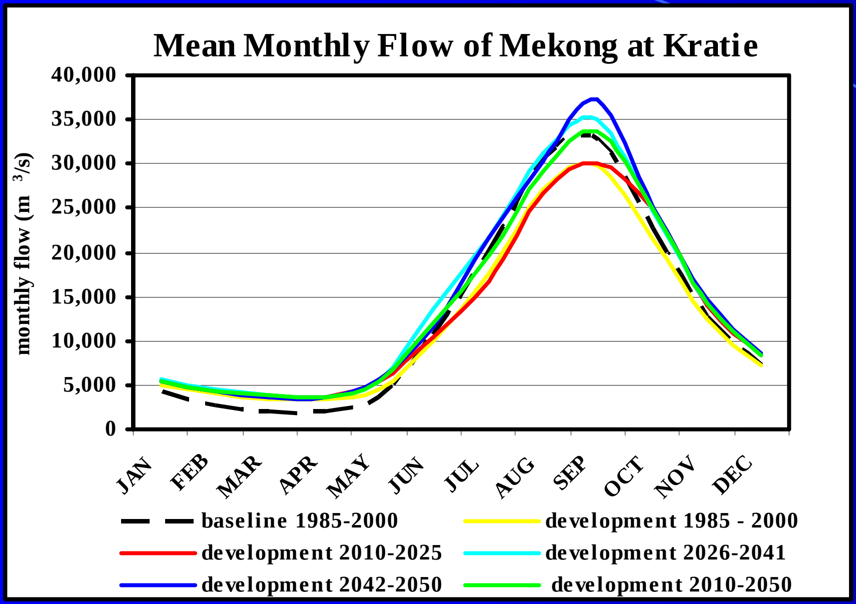
Area based on Max Salinity



Maximum Concentration (g/l)	Salinity Area for Maximum Concentration (km^2) - Baseline Scenario					Difference in Salinity Area (km^2)				Difference in Salinity Area (%)			
	[1]BL-1998	[2]BL-A2-2021	[3]BL-A2-2022	[4]BL-B2-2022	[5]BL-B2-2037	[1] vs [2]	[1] vs [3]	[1] vs [4]	[1] vs [5]	[1] vs [2]	[1] vs [3]	[1] vs [4]	[1] vs [5]
> 0 g/l	38,224	40,850	40,068	40,121	40,847	2,627	1,844	1,897	2,624	6.9	4.8	5.0	6.9
> 4 g/l	20,744	24,152	23,471	24,270	22,118	3,409	2,727	3,526	1,374	16.4	13.1	17.0	6.6
> 8 g/l	15,451	17,555	17,997	18,231	16,796	2,104	2,545	2,780	1,345	13.6	16.5	18.0	8.7
> 12 g/l	12,944	13,668	13,555	13,755	12,825	724	611	811	-119	5.6	4.7	6.3	-0.9
> 16 g/l	10,953	11,258	10,629	11,075	11,030	305	-324	122	77	2.8	-3.0	1.1	0.7
> 20 g/l	9,378	9,206	8,771	9,164	9,315	-172	-607	-214	-63	-1.8	-6.5	-2.3	-0.7
> 24 g/l	7,064	6,735	6,328	6,597	6,477	-329	-736	-468	-587	-4.7	-10.4	-6.6	-8.3
> 28 g/l	4,923	4,406	5,173	5,006	4,439	-517	250	83	-484	-10.5	5.1	1.7	-9.8
> 32 g/l	2,852	2,633	3,069	2,967	2,624	-219	216	115	-228	-7.7	7.6	4.0	-8.0

Hydrologic regime and change under development scenario

ECHAM4 A2



Mean Monthly Flow of Mekong at Kratie
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
monthly flow (m 3/s)
JAN
FEB
MAR
APR
MAY
JUN
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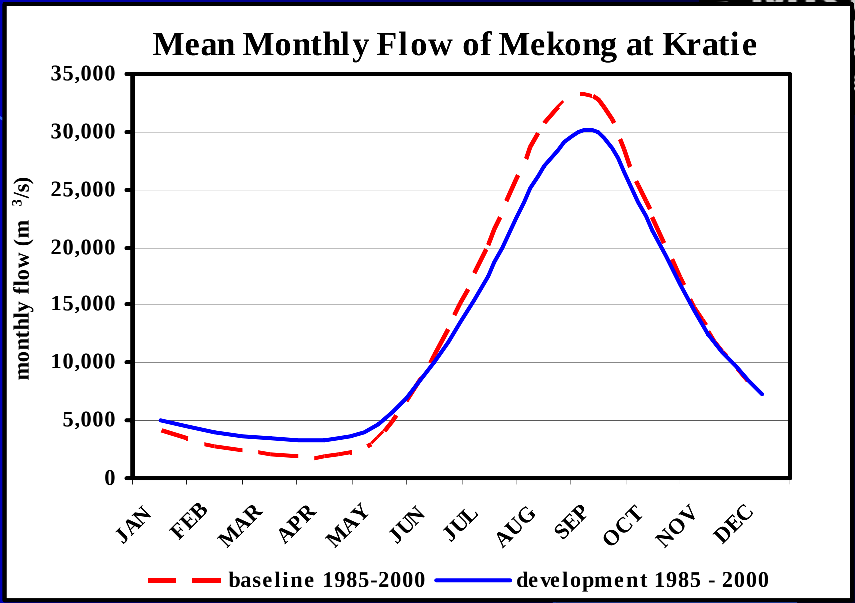
baseline 1985-2000
development 1985 - 2000
development 2010-2025
development 2026-2041
development 2042-2050
development 2010-2050



Mean Monthly Flow of Mekong at Kratie
35,000
30,000
25,000
20,000
15,000
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0
monthly flow (m 3/s)
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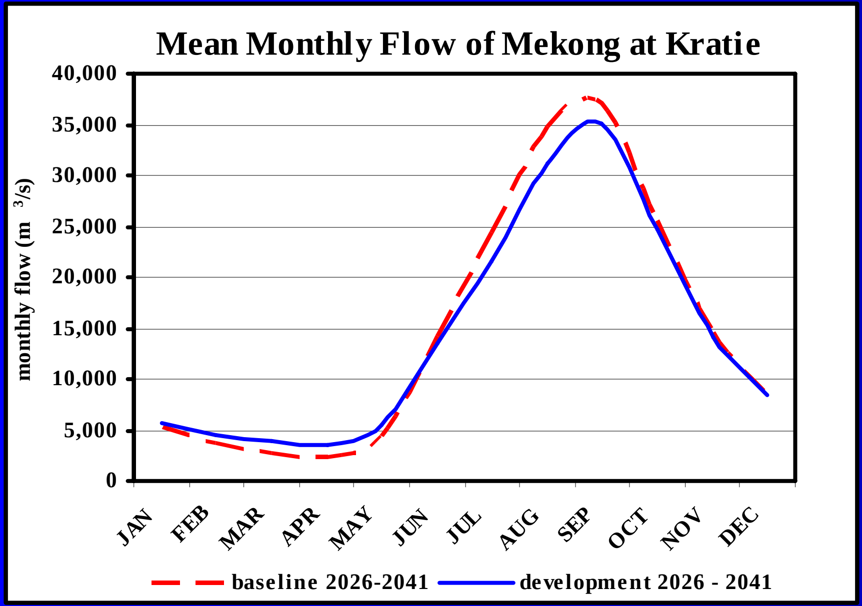
baseline 1985-2000
development 1985 - 2000



Mean Monthly Flow of Mekong at Kratie
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
monthly flow (m 3/s)
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MAY
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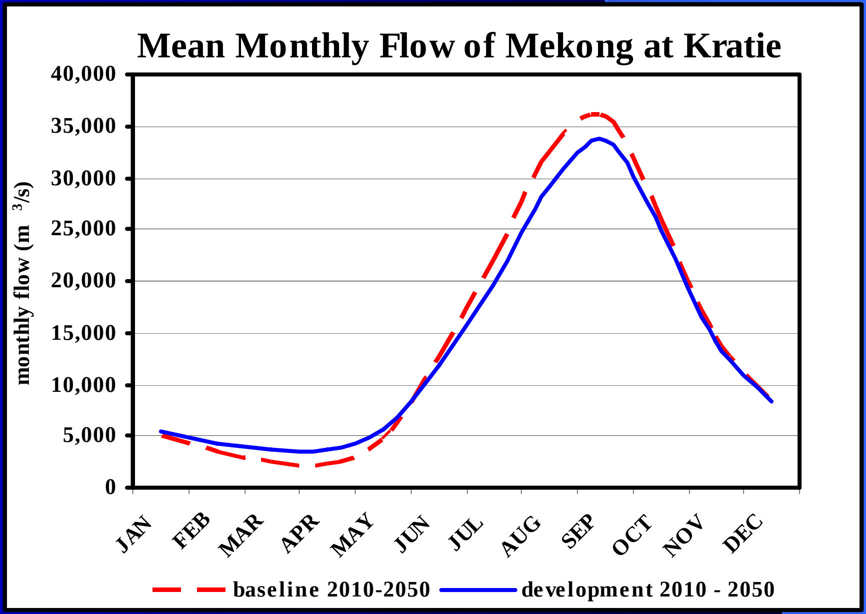
OCT
NOV
DEC
baseline 2026-2041
development 2026 - 2041



Mean Monthly Flow of Mekong at Kratie
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
monthly flow (m 3/s)
JAN
FEB
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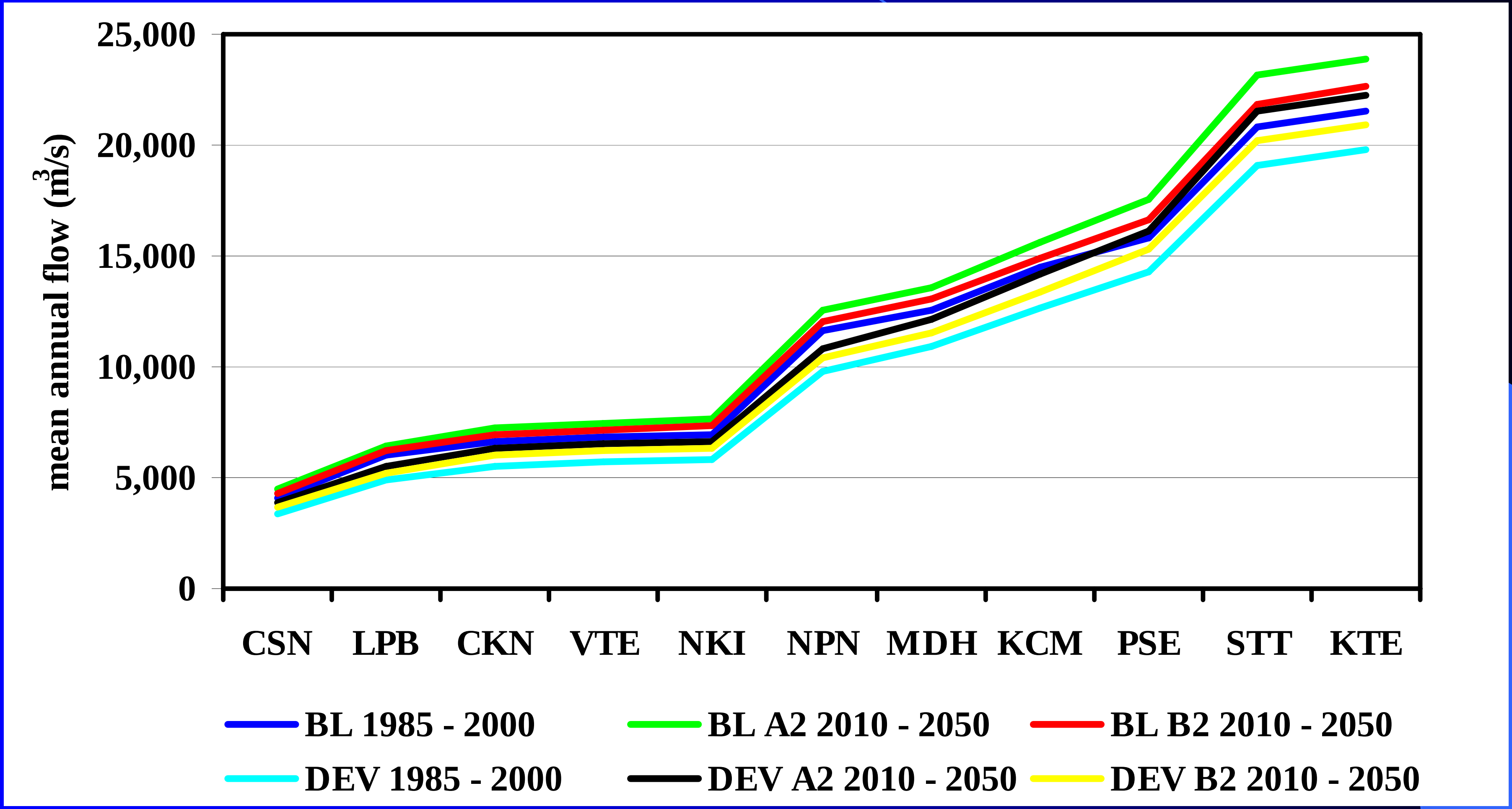
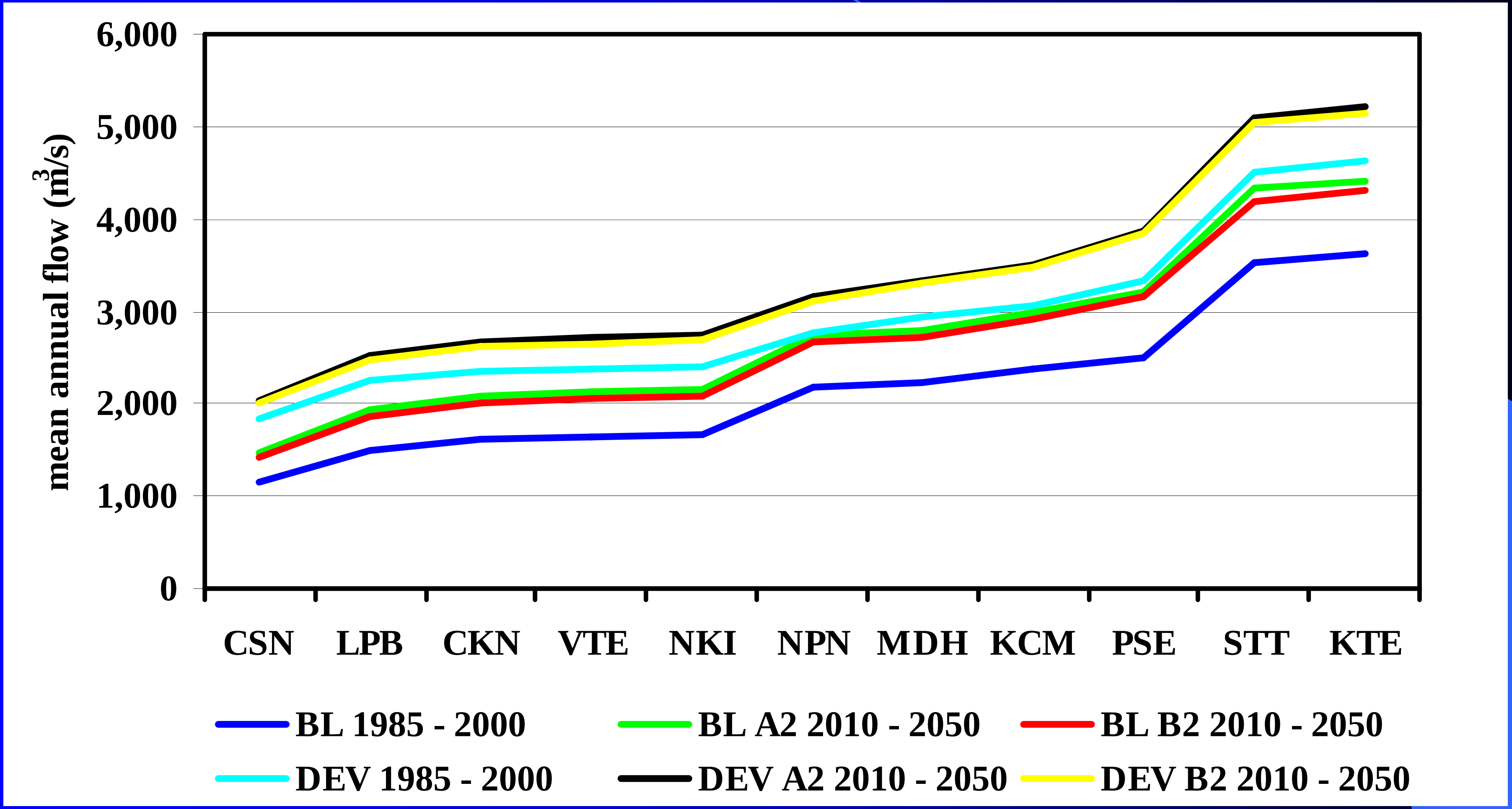
NOV
DEC
baseline 2010-2050
development 2010 - 2050

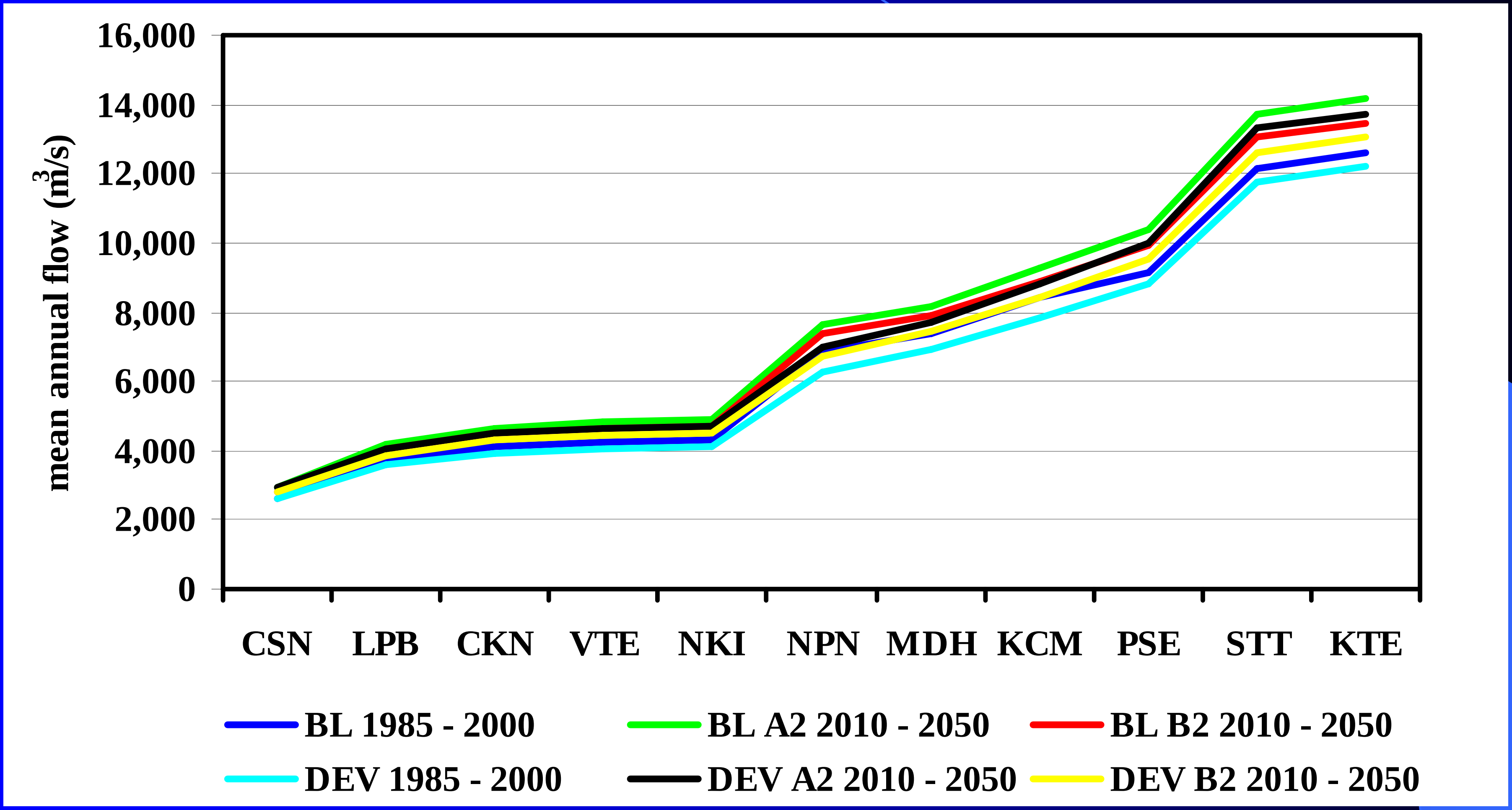
Mean Wet Seasonal Flow 1985 – 2000 & 2010 -2050



Mean Dry Seasonal Flow 1985 – 2000 & 2010 -2050

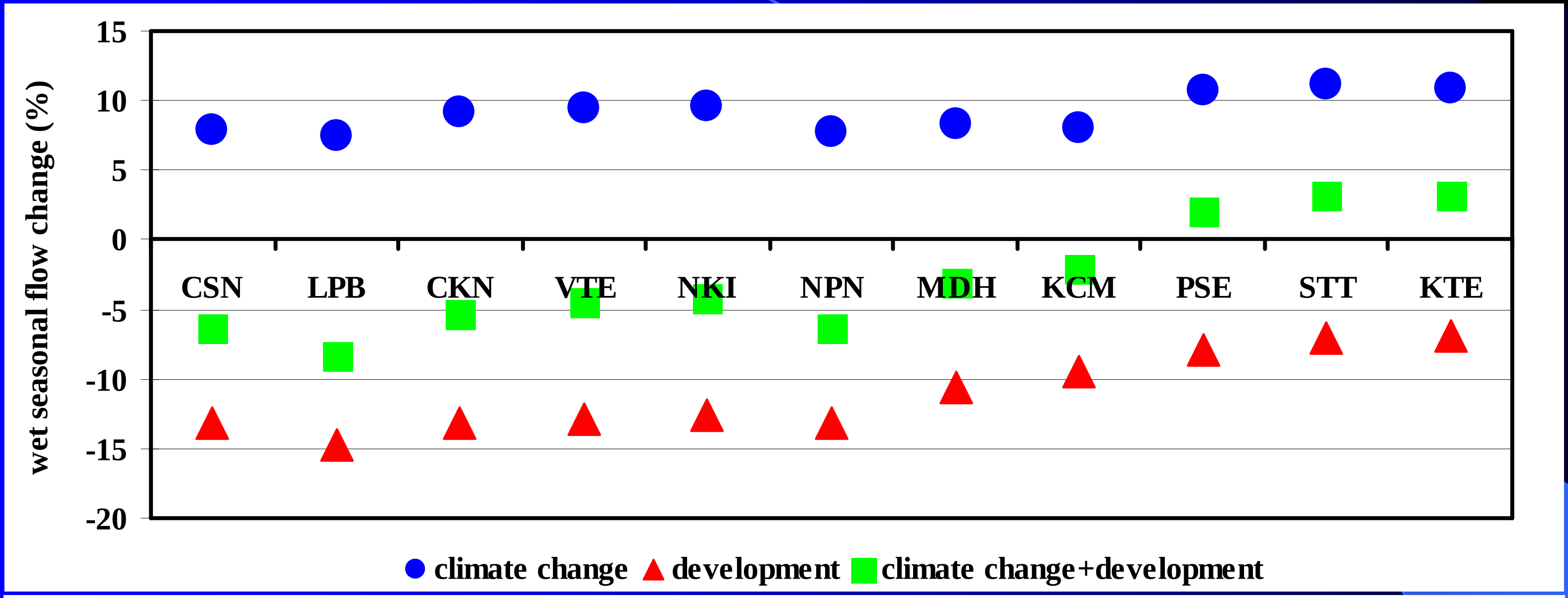


Mean Annual Flow 1985 – 2000 & 2010 -2050

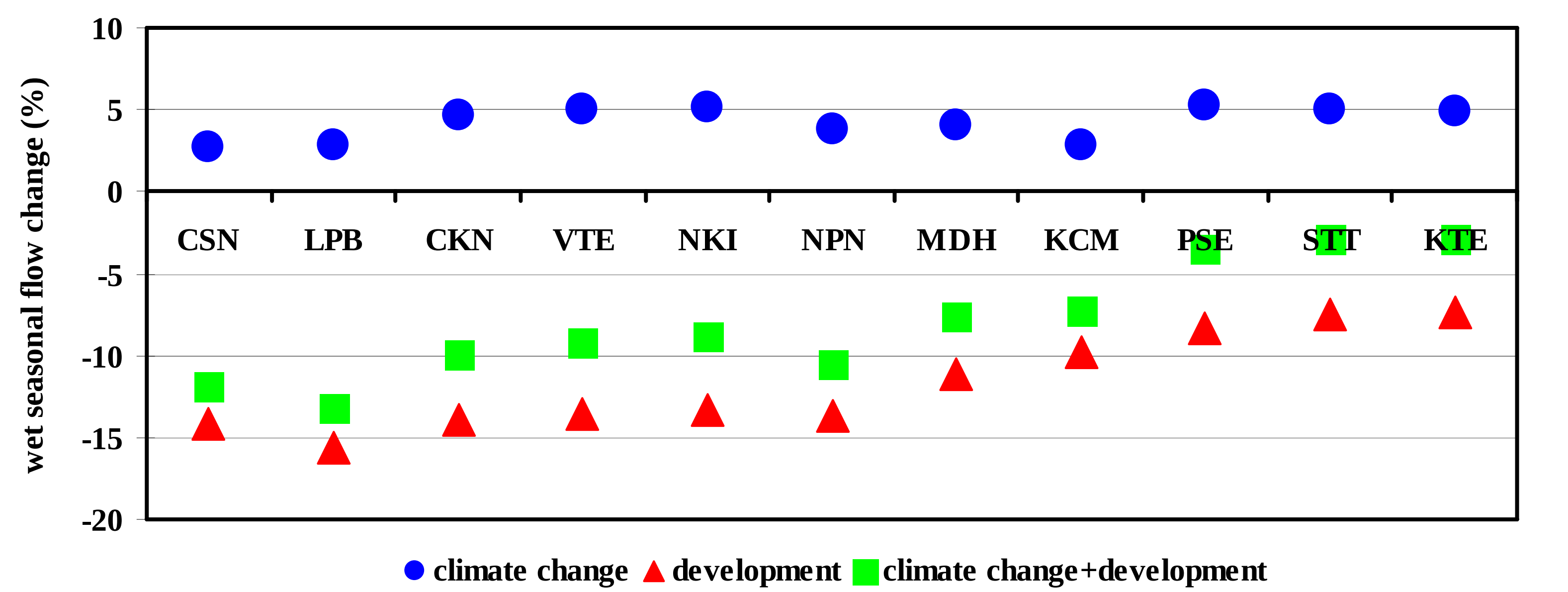


Flow changes (2010-2050) due to the impacts of future climate change and development - Wet Season

ECHAM4 A2

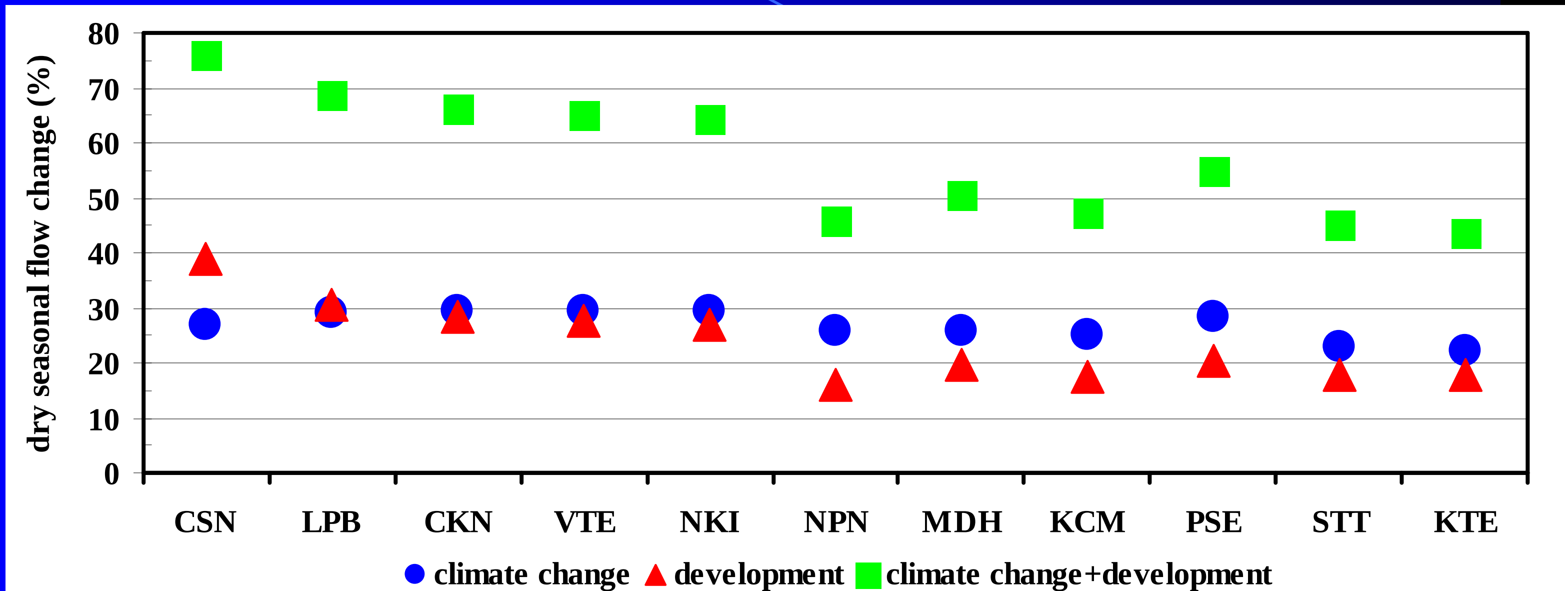


ECHAM4 B2

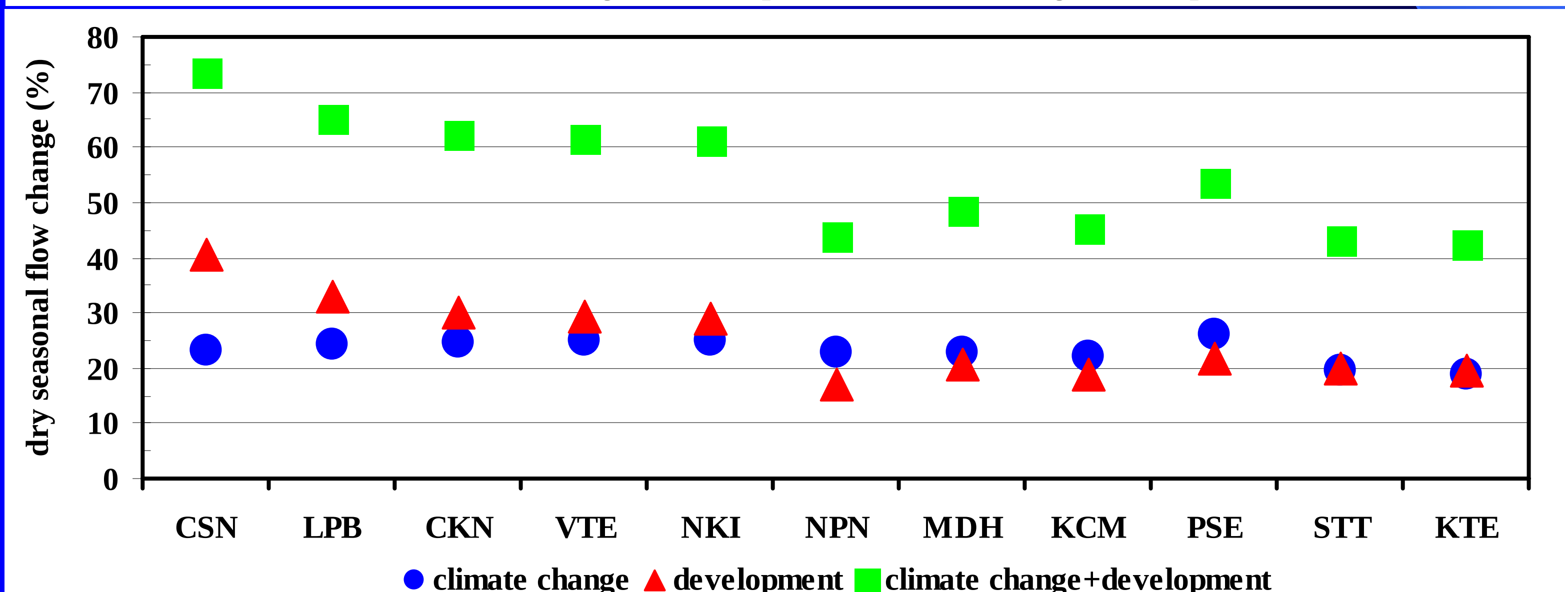


Flow changes (2010-2050) due to the impacts of future climate change and development - Dry Season

ECHAM4 A2

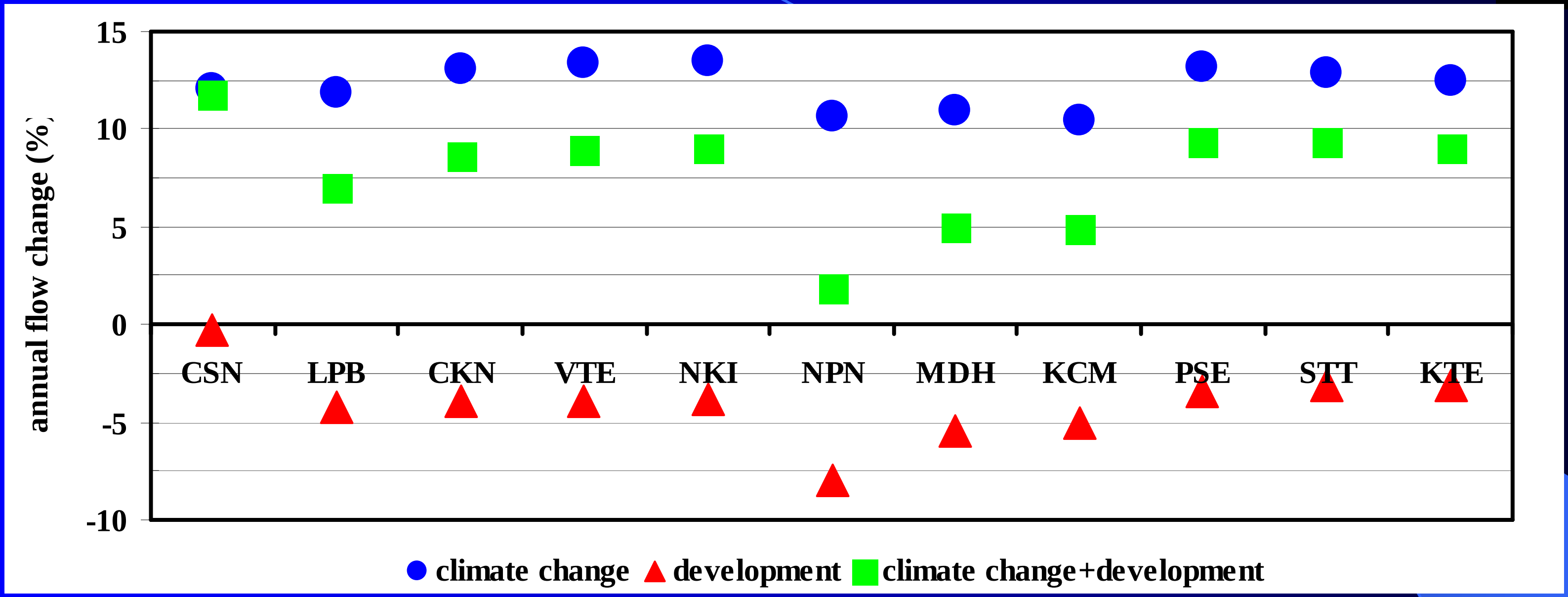


ECHAM4 B2

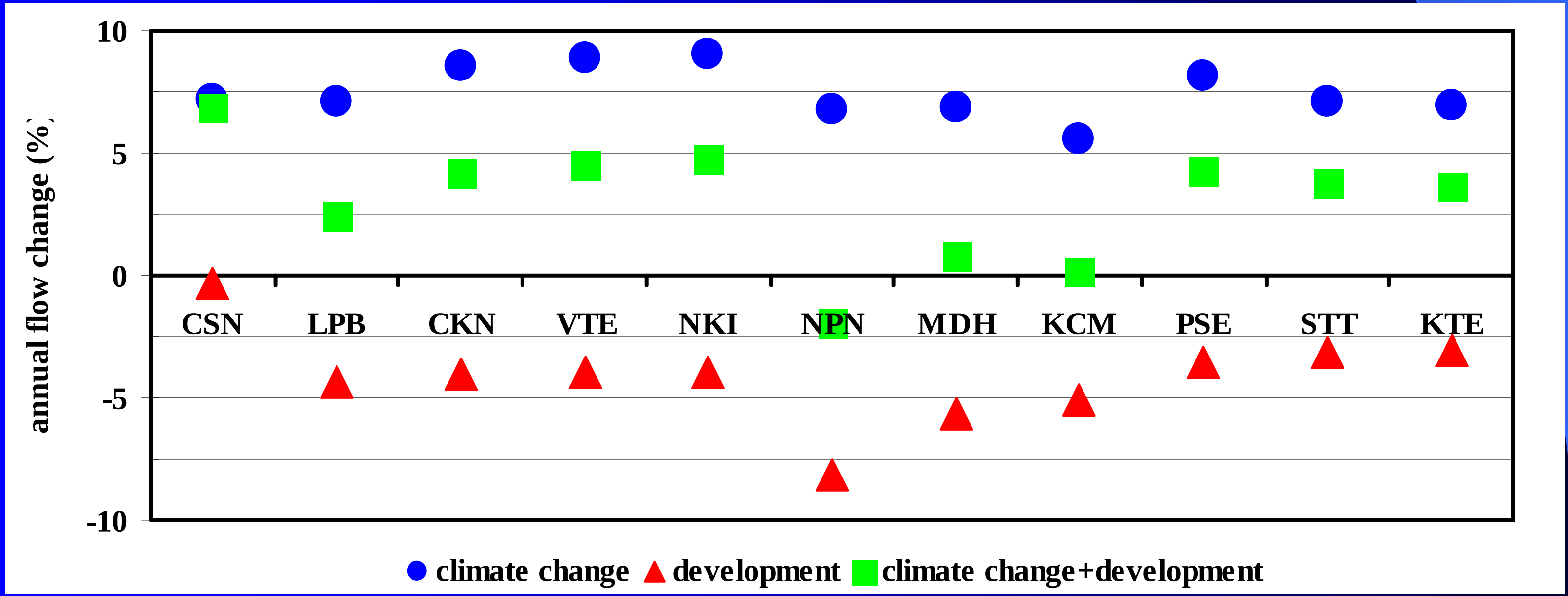


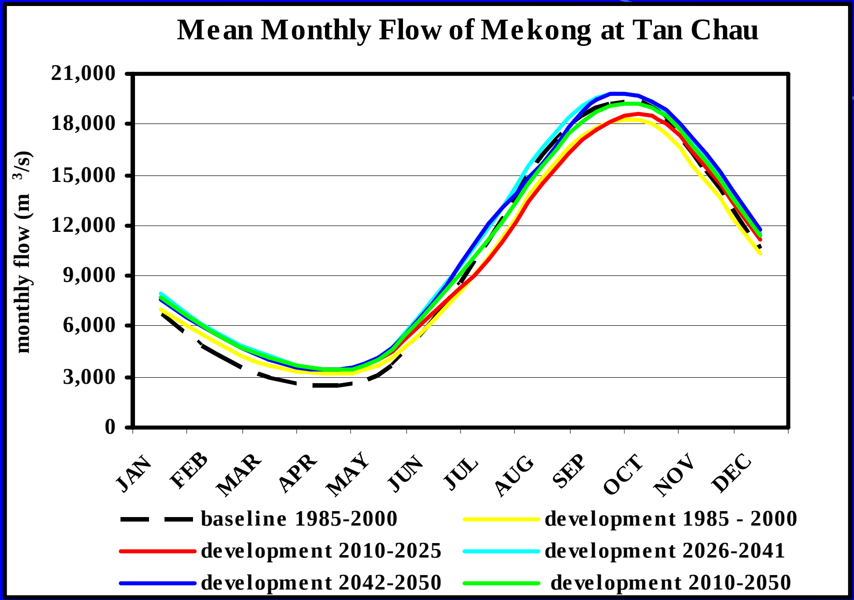
Flow changes (2010-2050) due to the impacts of future climate change and development - Annual

ECHAM4 A2



ECHAM4 B2




Mean Monthly Flow of Mekong at Tan Chau
21,000
18,000
15,000
12,000
9,000
6,000
3,000
0
monthly flow (m 3/s)
JAN
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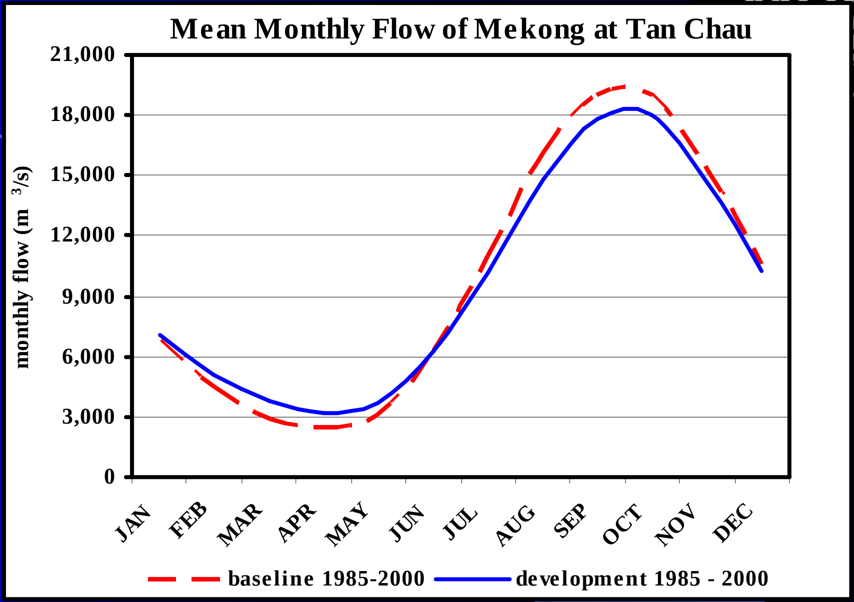
baseline 1985-2000
development 1985 - 2000
development 2010-2025
development 2026-2041
development 2042-2050
development 2010-2050


Mean Monthly Flow of Mekong at Tan Chau
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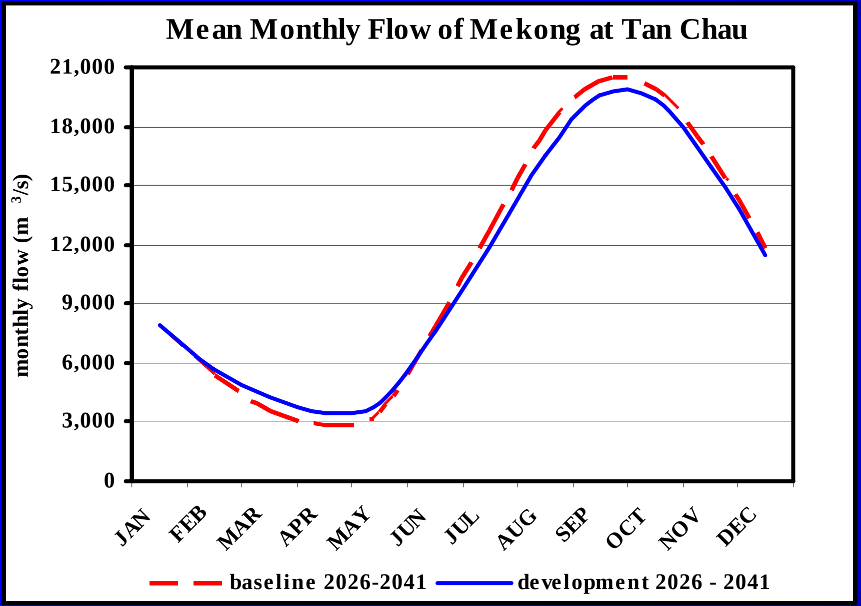
baseline 1985-2000
development 1985 - 2000


Mean Monthly Flow of Mekong at Tan Chau
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18,000
15,000
12,000
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monthly flow (m 3/s)
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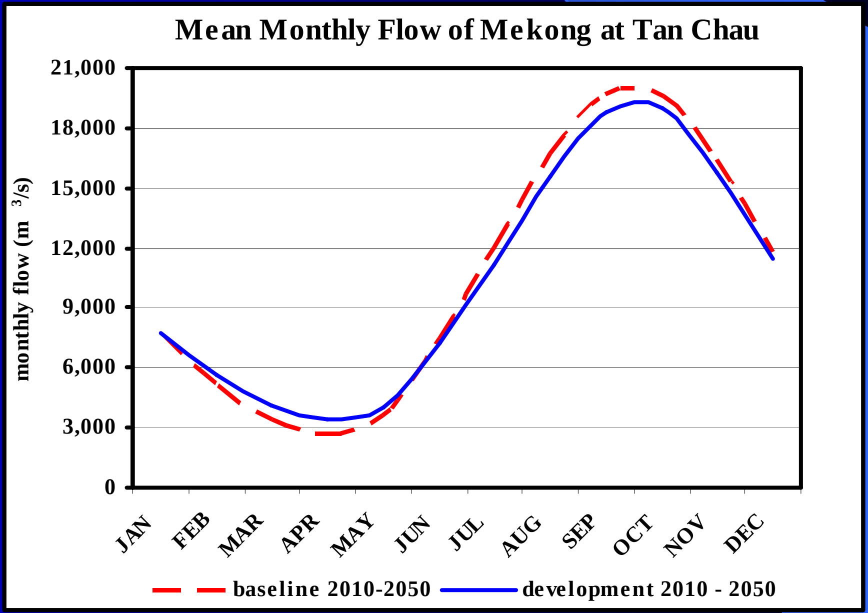
baseline 2026-2041
development 2026 - 2041


Mean Monthly Flow of Mekong at Tan Chau
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OCT
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baseline 2010-2050
development 2010 - 2050

Change of Mean Wet Season Flow (DEV vs BL)

A2

Station	Flow Change (+/- %) - DEV vs BL 1985 - 2000					Flow Change (+/- %) - DEV vs BL (same period)				
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	-7.8	-5.0	7.9	7.8	2.8	-7.8	-7.0	-6.4	-6.0	-6.5
Phnom Penh	-7.0	-5.1	6.3	4.1	1.4	-7.0	-6.2	-5.4	-5.1	-5.6
Tan Chau	-5.7	-4.4	5.0	3.9	1.1	-5.7	-4.9	-4.2	-4.0	-4.4
Chau Doc*	-2.8	-2.3	3.0	4.0	1.1	-2.8	-2.3	-1.9	-2.0	-2.1

B2

Station	Flow Change (+/- %) - DEV vs BL 1985 - 2000					Flow Change (+/- %) - DEV vs BL (same period)				
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	-7.8	-5.7	3.6	-8.7	-2.7	-7.8	-7.1	-6.4	-7.7	-6.9
Phnom Penh	-7.0	-6.3	2.6	-8.6	-3.3	-7.0	-6.2	-5.4	-6.8	-6.0
Tan Chau	-5.7	-5.1	1.7	-7.8	-3.0	-5.7	-4.8	-4.6	-5.2	-4.8
Chau Doc*	-2.8	-3.2	1.0	-4.8	-1.9	-2.8	-2.2	-2.1	-2.3	-2.2

Change of Mean Dry Season Flow (DEV vs BL)

A2

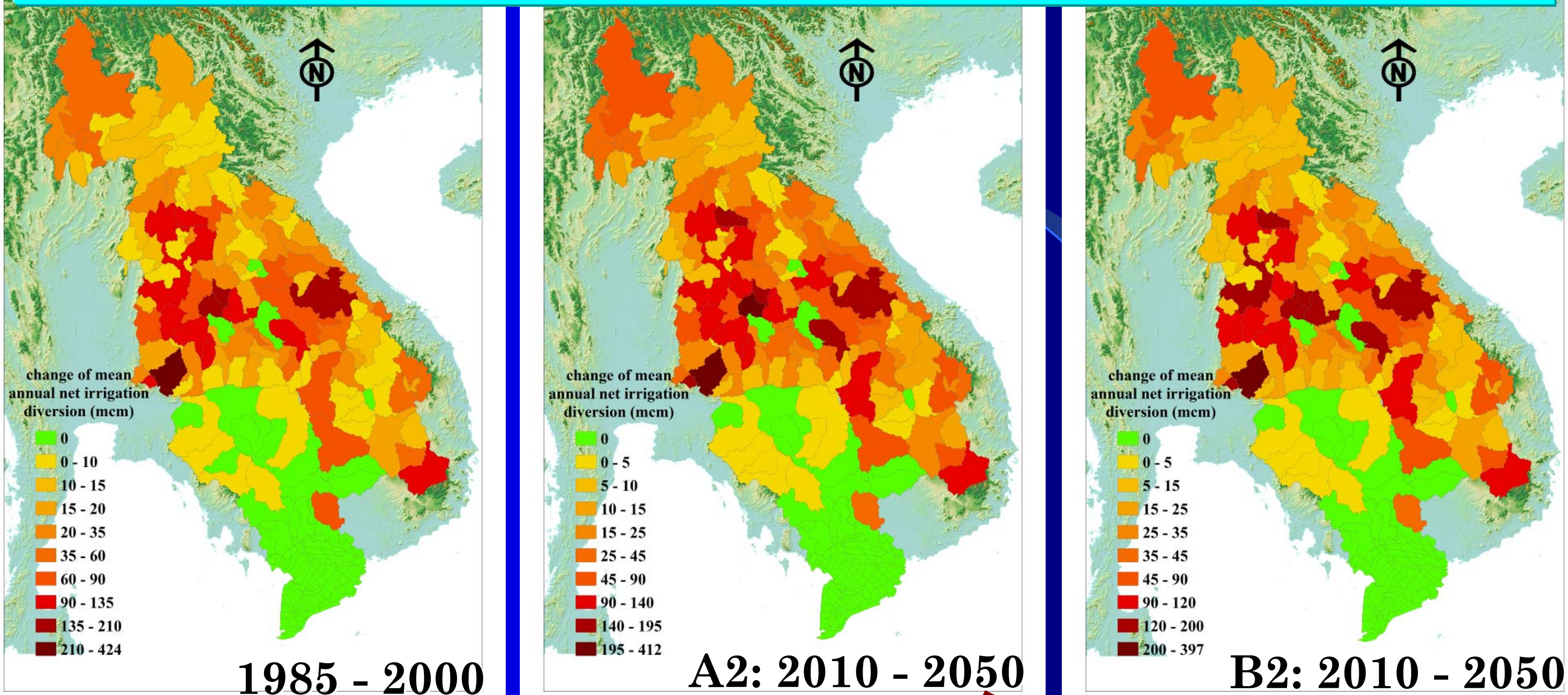
Station	Flow Change (+/- %) - DEV vs BL 1985 - 2000					Flow Change (+/- %) - DEV vs BL (same period)				
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	27.2	41.3	44.2	42.3	42.7	27.2	19.2	16.9	16.8	17.7
Phnom Penh	26.6	40.6	43.5	41.7	42.0	26.6	19.0	16.6	16.7	17.5
Tan Chau	8.9	18.4	21.4	20.6	20.1	8.9	7.0	5.6	7.0	6.4
Chau Doc*	12.8	21.4	23.9	22.7	22.7	12.8	10.7	8.8	9.1	9.6

B2

Station	Flow Change (+/- %) - DEV vs BL 1985 - 2000					Flow Change (+/- %) - DEV vs BL (same period)				
	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050	1985-2000	2010-2025	2026-2041	2042-2050	2010-2050
Kompong Cham	27.2	34.9	52.9	30.1	40.9	27.2	20.9	16.3	24.4	19.6
Phnom Penh	26.6	34.3	51.2	29.3	39.8	26.6	20.3	16.3	23.6	19.2
Tan Chau	8.9	13.3	25.4	8.8	17.1	8.9	6.0	6.1	5.2	5.9
Chau Doc*	12.8	16.2	26.6	13.9	19.8	12.8	10.8	9.2	11.8	10.3

* Bassac River

Increases of irrigation diversions of climate change and development

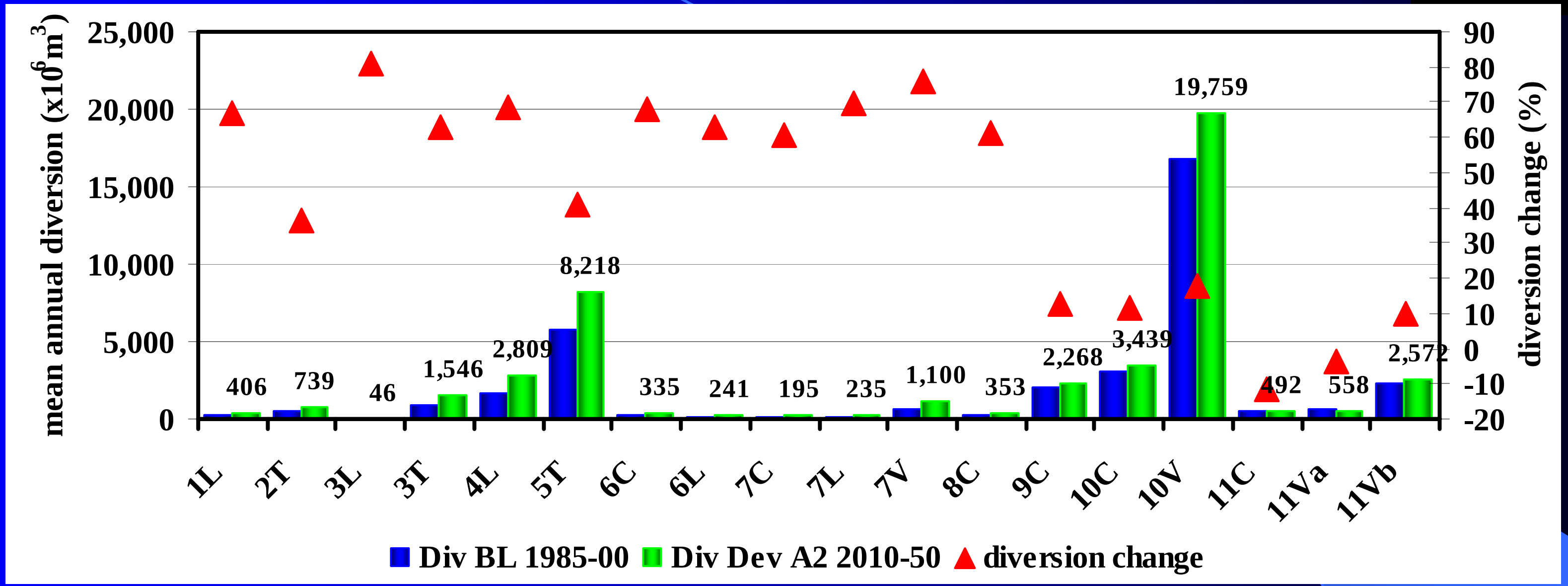


Scenario & Period	Mean Annual Total Irrigation Diversion		
	Mean Annual Amount ($x10^6$ m^3)	Change Relative to BL 1985 - 00	
		+/- ($x10^6$ m^3)	+/- (%)
BL 1985 - 00	36,097		
DEV 1985 - 00	40,539	4,442	12.3
DEV A2 2010 - 50	45,327	9,230	25.6
DEV B2 2010 - 50	44,795	8,698	24.1

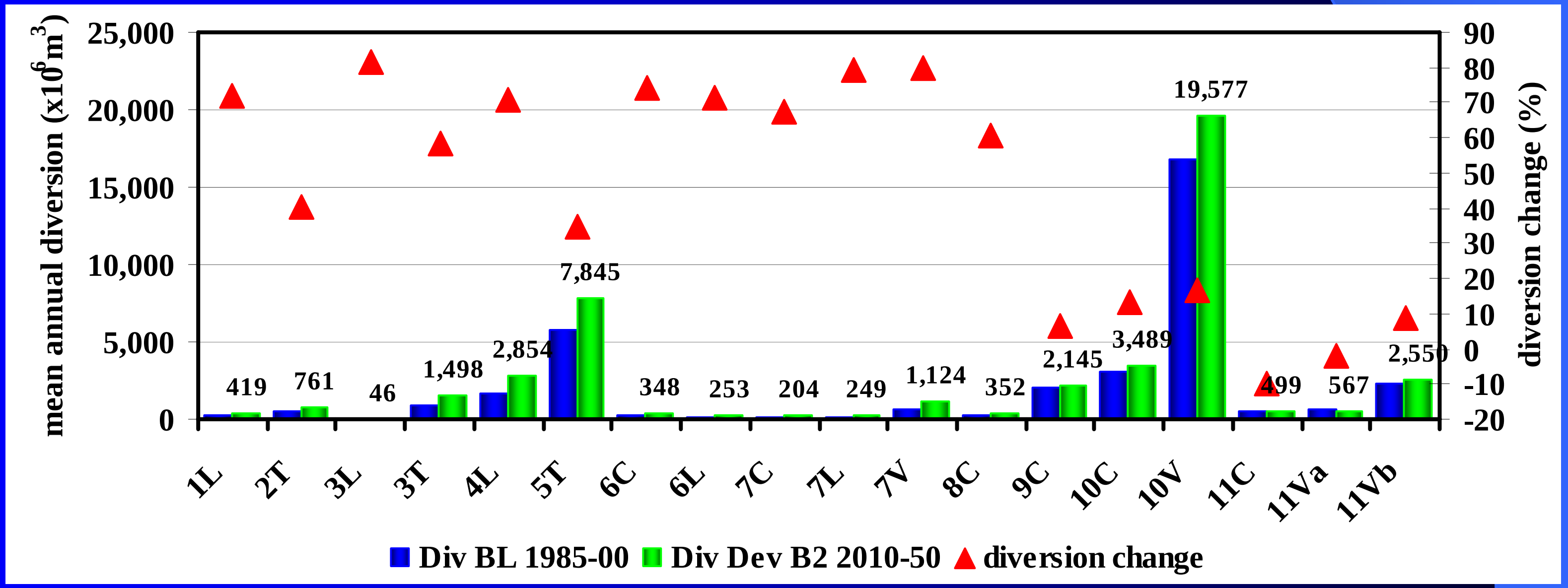
Scenario & Period	Mean Annual Total Irrigation Diversion		
	Mean Annual Amount ($x10^6$ m^3)	Change Relative to BL same period	
		+/- ($x10^6$ m^3)	+/- (%)
BL A2 2010 - 50	40,558		
DEV A2 2010 - 50	45,327	4,769	11.8
BL B2 2010 - 50	40,011		
DEV B2 2010 - 50	44,795	4,784	12.0

Combined impact from future climate change and development on irrigation diversion

ECHAM4 A2

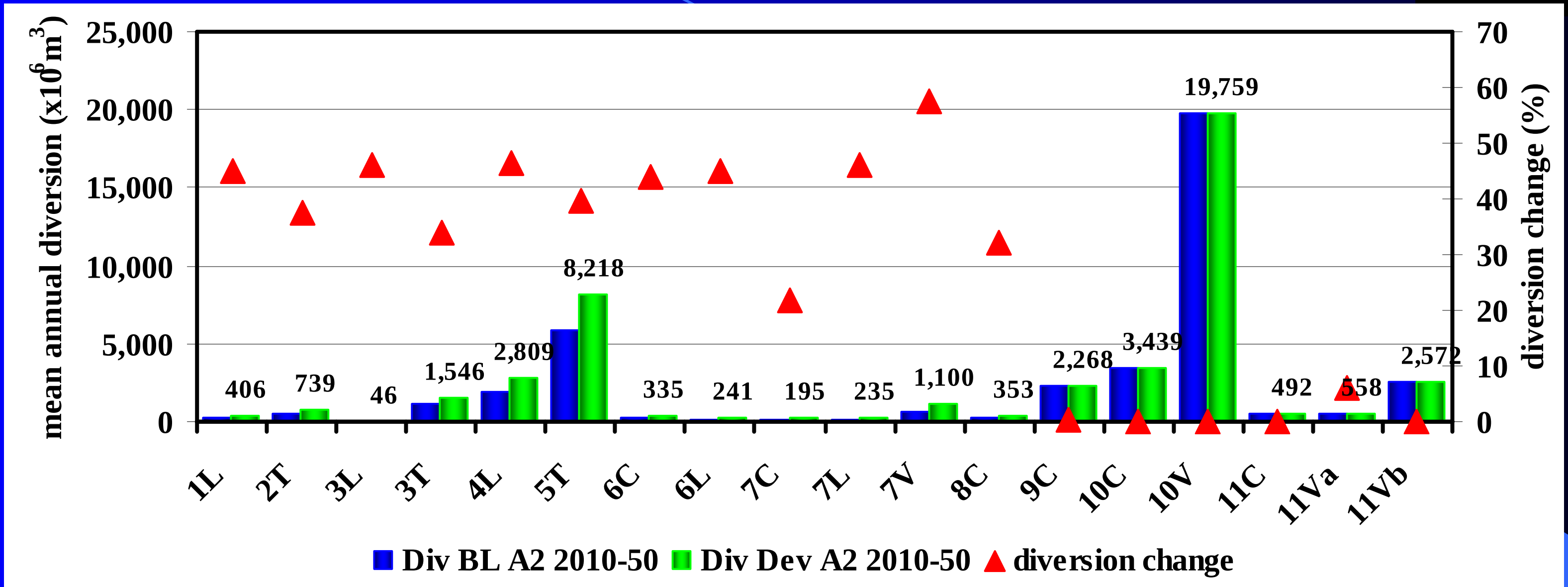


ECHAM4 B2

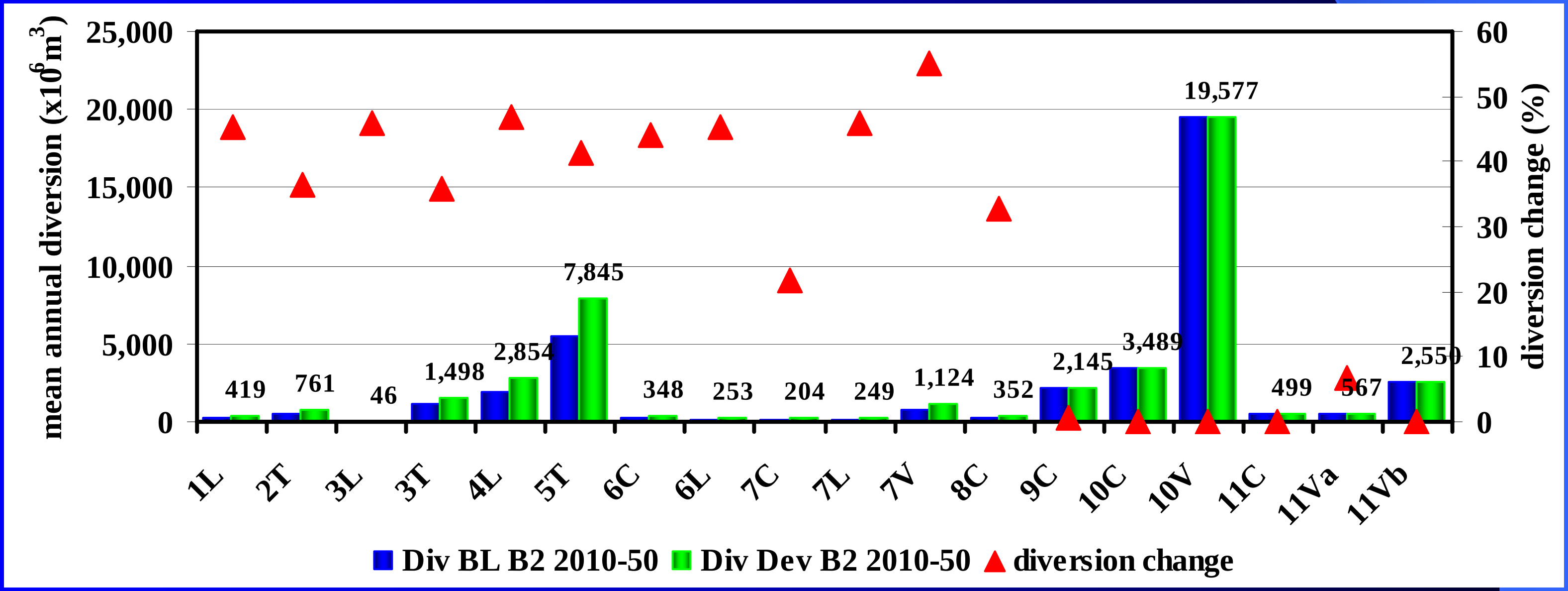


Impact from future development on irrigation diversion under climate change

ECHAM4 A2

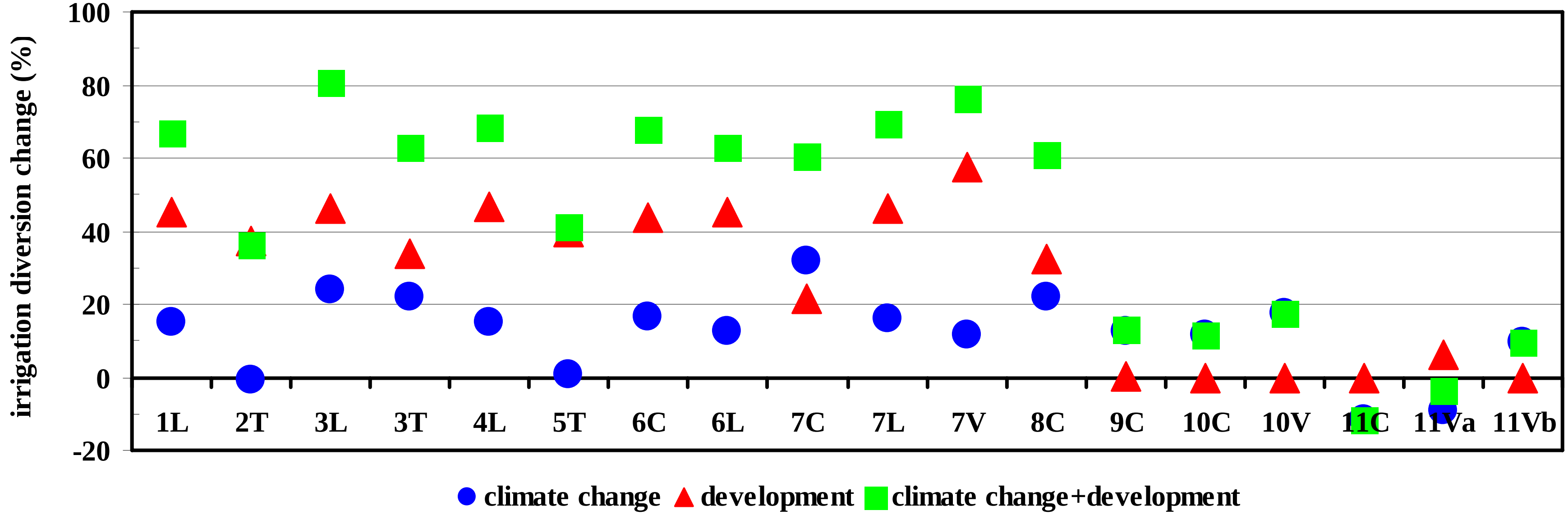


ECHAM4 B2

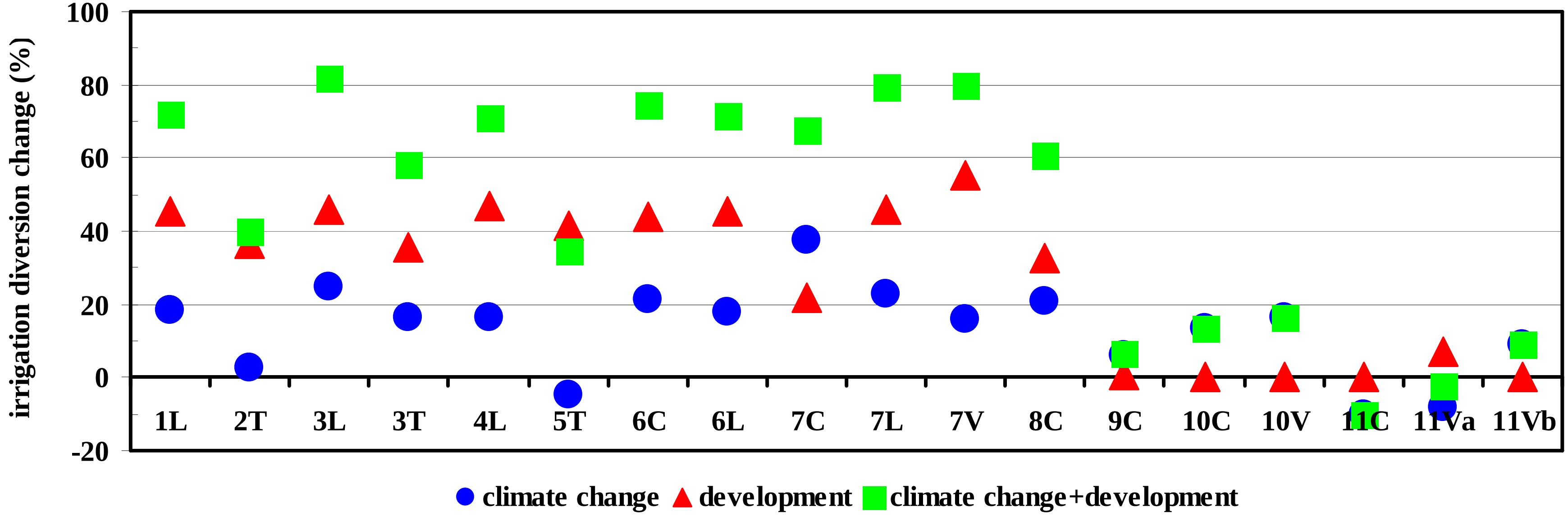


Impacts of future climate change and development on irrigation diversion 2010 - 2050

ECHAM4 A2

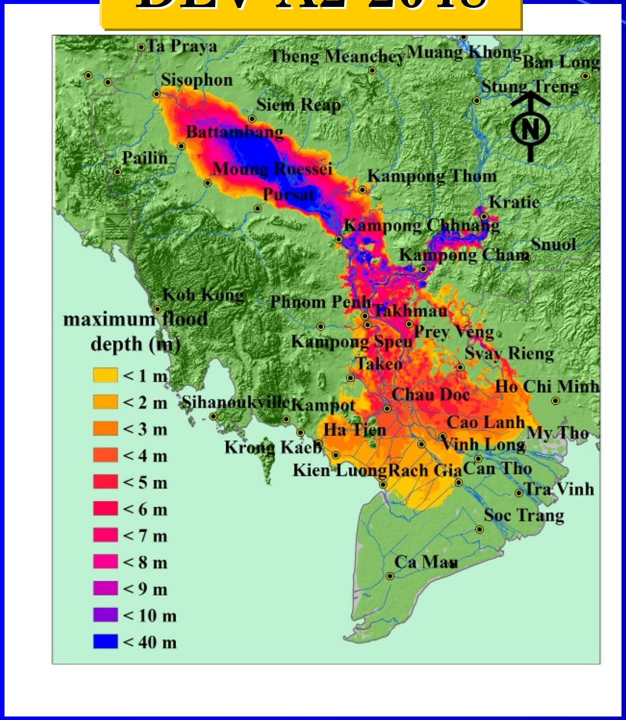


ECHAM4 B2

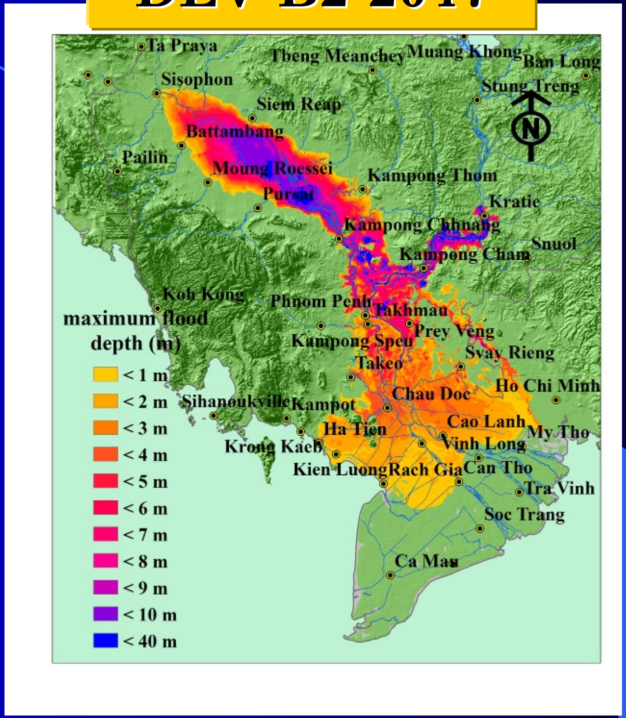


Flood Area based on Maximum Flood Depth

DEV-A2-2048



DEV-B2-2047

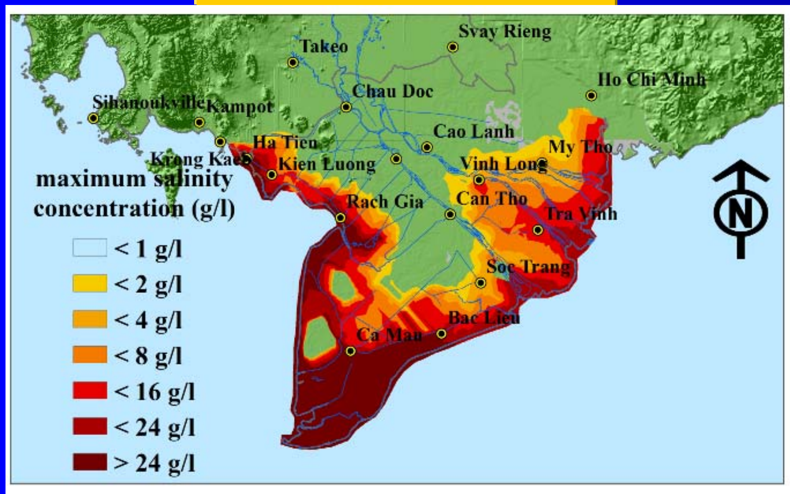


Impacts from future climate change (CC) and development (DEV) on flood areas (%) compared to flood area in 2000

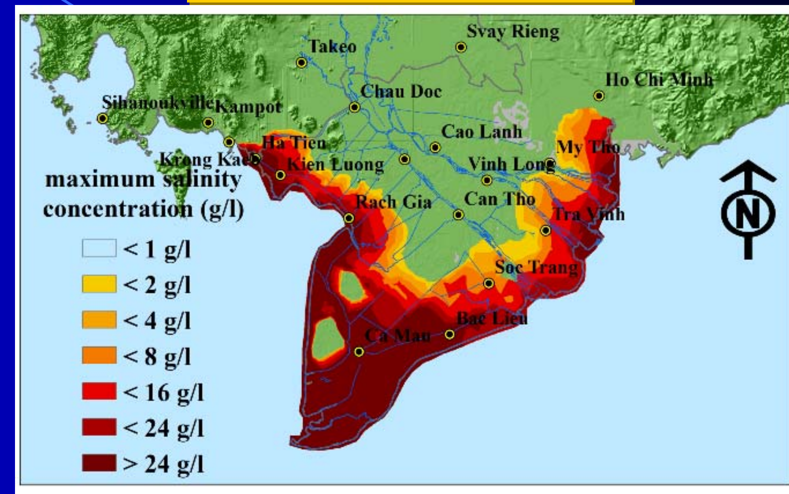
Maximum Flood Depth	ECHAM4 A2 Year 2048			ECHAM4 B2 Year 2047		
	CC	CC + DEV	DEV	CC	CC + DEV	DEV
> 0.0 m	+8.8	+8.2	-0.6	+3.1	+2.5	-0.6
> 0.5 m	+13.5	+12.8	-0.7	+3.2	+2.3	-0.9

Saline Area based on Maximum Salinity

DEV-A2-2022



DEV-B2-2037



Impacts from future climate change (CC) and future development (DEV) on the changes of saline areas (%) compared to saline area year 1998 of baseline scenario

Maximum Saline Concentration	ECHAM4 A2 Year 2022			ECHAM4 B2 Year 2037		
	CC	CC + DEV	DEV	CC	CC + DEV	DEV
≥ 0 g/l	+4.8	+0.4	-4.3	+6.9	-1.0	-7.3
≥ 4 g/l	+13.1	-3.8	-14.9	+6.6	-1.4	-7.5

Summary (1/4)

- Ranges of precipitation and temperature trends depend on the areal scale considered;

ECHAM4 A2

Areal Scale	Precip Trend (mm/year)		
	Min	Max	Mean
DSF Subbasin	-3.55	+13.74	
DSF Model	-1.90	+3.40	
Upper Mekong			+2.56
Lower Mekong			+1.86
Entire Mekong			+2.00

Areal Scale	Temp Trend (°C/year)		
	Min	Max	Mean
DSF Subbasin	+0.008	+0.040	
DSF Model	+0.012	+0.029	
Upper Mekong			+0.023
Lower Mekong			+0.018
Entire Mekong			+0.019

- Mean annual precipitation (ECHAM4 A2) during 2010 - 2050 might increase, compared to 1985 - 2000, 10.9% and 4.5% for Upper and Lower Mekong;
- Mean annual temperature (ECHAM4 A2) during 2010 - 2050 might increase, compared to 1985 - 2000, 0.9°C and 0.7°C for Upper and Lower Mekong;

Summary (2/4)

- Climate model data adjustment is crucial to maintain the DSF modelling outputs close to the existing outputs using observed climate data;
- Snowmelt in the Upper Mekong might increase 60-70% during 2010 - 2050, compared to 1985 - 2000, snowmelt in dry season plays significant role to river flows with contributions up to 68% at Chiang Saen down to 22% at Kratie;
- Changes of river flows during 2010 – 2050:

Wet Seasonal Flow

Impact	Flow Change - ECHAM4 A2			Flow Change - ECHAM4 B2		
	Chiang Saen	Kratie	Tan Chau	Chiang Saen	Kratie	Tan Chau
CC	+7.9	+10.9	+5.8	+2.7	+4.9	+1.9
CC+DEV	-6.3	+3.2	+1.1	-11.8	-2.8	-3.0
DEV	-13.2	-6.9	-4.4	-14.1	-7.4	-4.8

Summary (3/4)

Dry Seasonal Flow

Impact	Flow Change - ECHAM4 A2			Flow Change - ECHAM4 B2		
	Chiang Saen	Kratie	Tan Chau	Chiang Saen	Kratie	Tan Chau
CC	+26.8	+22.0	+12.8	+23.3	+18.8	+10.6
CC+DEV	+76.0	+43.7	+20.1	+73.5	+42.2	+17.1
DEV	+38.8	+17.8	+6.4	+40.7	+19.7	+5.9

Annual Flow

Impact	Flow Change - ECHAM4 A2			Flow Change - ECHAM4 B2		
	Chiang Saen	Kratie	Tan Chau	Chiang Saen	Kratie	Tan Chau
CC	+12.0	+12.5	+7.6	+7.2	+6.9	+4.1
CC+DEV	+11.7	+9.0	+6.0	+6.9	+3.6	+2.2
DEV	-0.3	-3.1	-1.5	-0.3	-3.1	-1.9

- **Increase of LMB total irrigation diversion during 2010 – 2050:**

Impact	Increase of Irrigation Diversion (%)	
	ECHAM4 A2	ECHAM4 B2
CC	+12.4	+10.8
CC+DEV	+25.6	+24.1
DEV	+11.8	+12.0

Summary (4/4)

- **Flood area changes in Mekong Delta for particular wet years during 2010 – 2050:**

Maximum Flood Depth	ECHAM4 A2 Year 2048			ECHAM4 B2 Year 2047		
	CC	CC + DEV	DEV	CC	CC + DEV	DEV
> 0.0 m	+8.8	+8.2	-0.6	+3.1	+2.5	-0.6
> 0.5 m	+13.5	+12.8	-0.7	+3.2	+2.3	-0.9

- **Saline area changes in Mekong Delta for particular dry years during 2010 – 2050:**

Maximum Saline Concentration	ECHAM4 A2 Year 2022			ECHAM4 B2 Year 2037		
	CC	CC + DEV	DEV	CC	CC + DEV	DEV
≥ 0 g/l	+4.8	+0.4	-4.3	+6.9	-1.0	-7.3
≥ 4 g/l	+13.1	-3.8	-14.9	+6.6	-1.4	-7.5


THANK YOU FOR YOUR ATTENTION