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DESIGN FLOOD ESTIMATION IN THE CONTEXT OF CLIMATE CHANGE – A CASE STUDY IN THE SOUTH CENTRAL AND HIGHLAND PROVINCES

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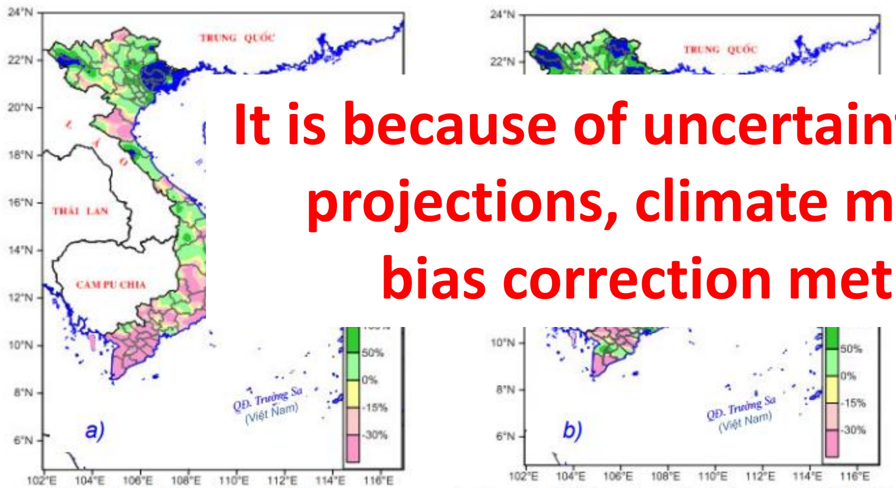
1. Introduction

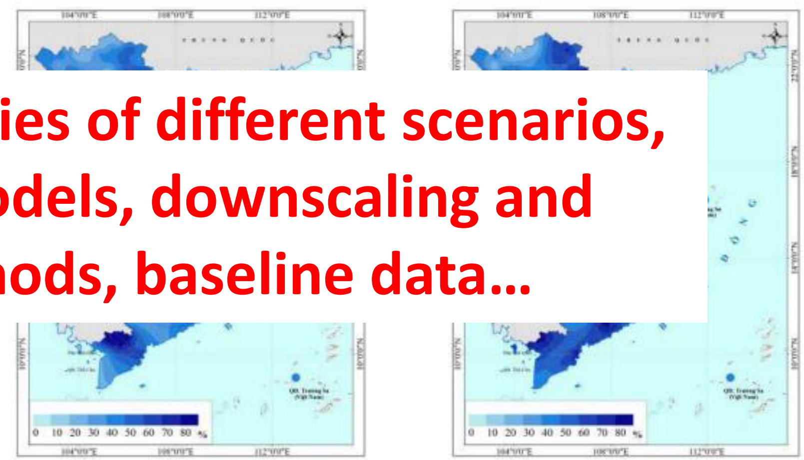
- The needs of design flood estimation in context of climate change in Vietnam:
  - Extreme events occur more frequent and intense due to climate change.
  - Many reservoirs have been operating which need more safety criteria for flood prevention.
  - *Very few studies have combined the design flood estimation and climate change in Vietnam.*

1. Introduction

- ***Climate change and sea level rise scenarios for Viet Nam*** were released by MONRE in 2009, 2012 (AR4) and 2016 (AR5).
- Different outcomes for *maximum daily precipitation changing* between the reports.



Hình 3.48. Mức thay đổi lượng mưa ngày lớn nhất (%) vào giữa (a) và cuối thế kỷ 21 (b) theo kịch bản phát thải trung bình



(a) vào giữa thế kỷ (b) vào cuối thế kỷ

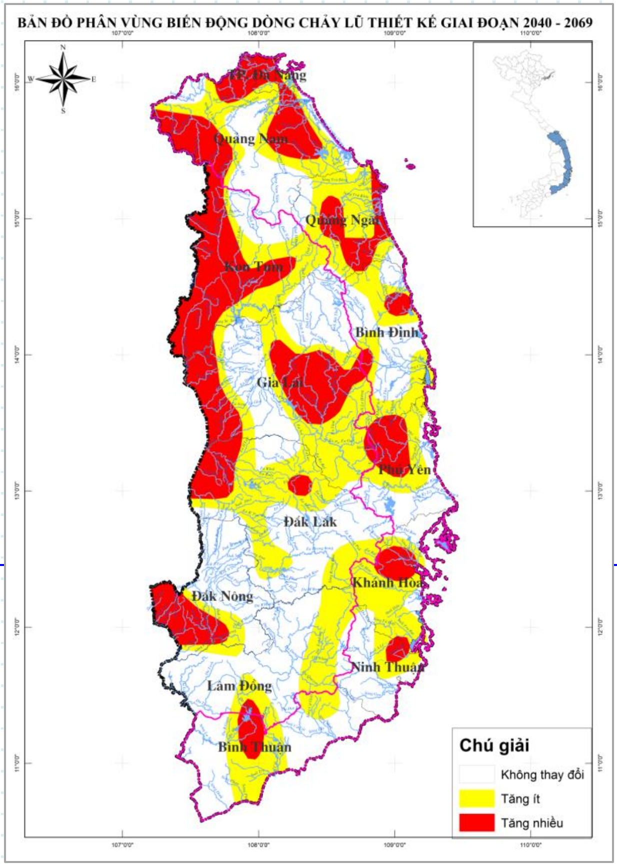
Hình 5.11. Biến đổi của lượng mưa 1 ngày lớn nhất trung bình theo kịch bản RCP4.5

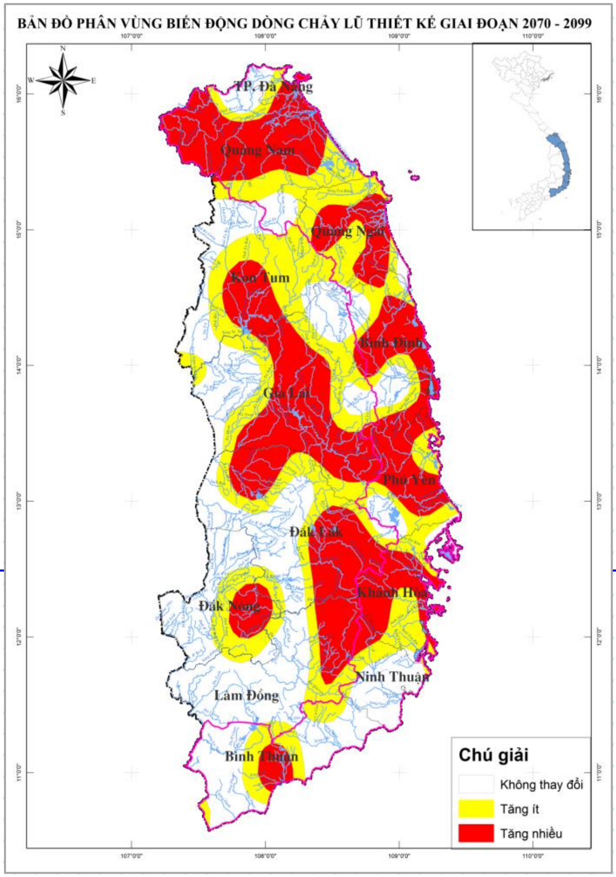
It is because of uncertainties of different scenarios, projections, climate models, downscaling and bias correction methods, baseline data...

2012 **2016**

Research objectives

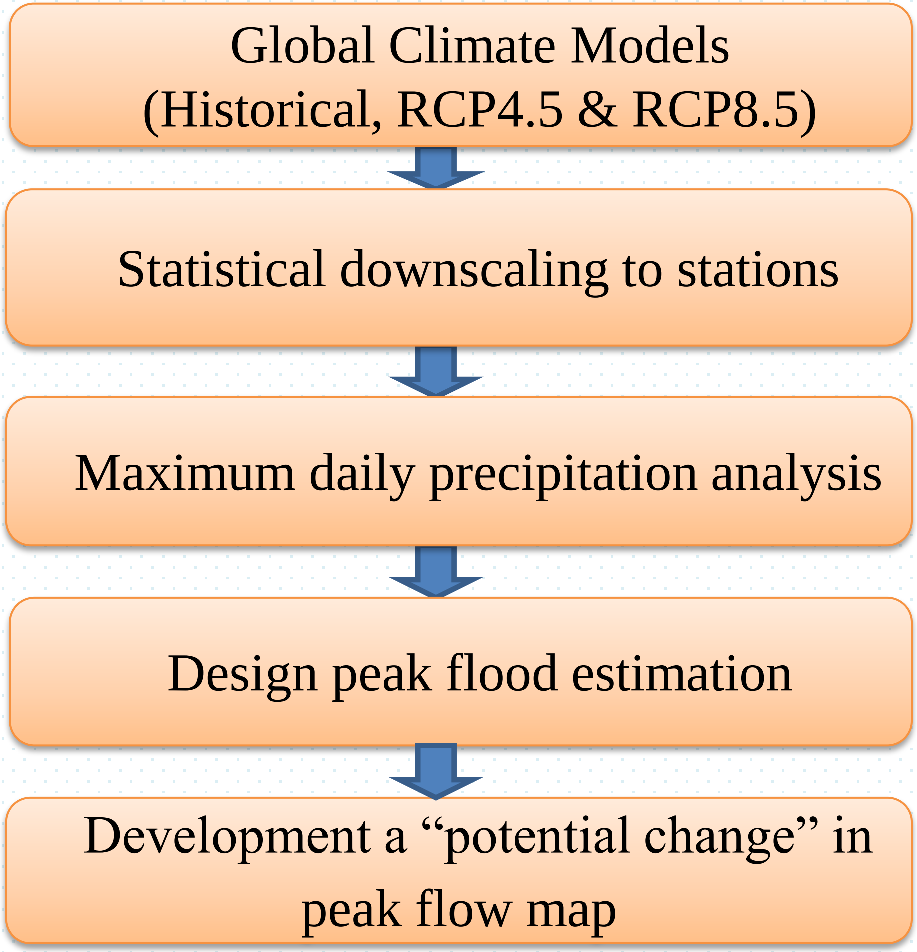
- Developing a «potential change» in peak flow map for Highland and South Central region taking into account the differences of scenarios, climate models...





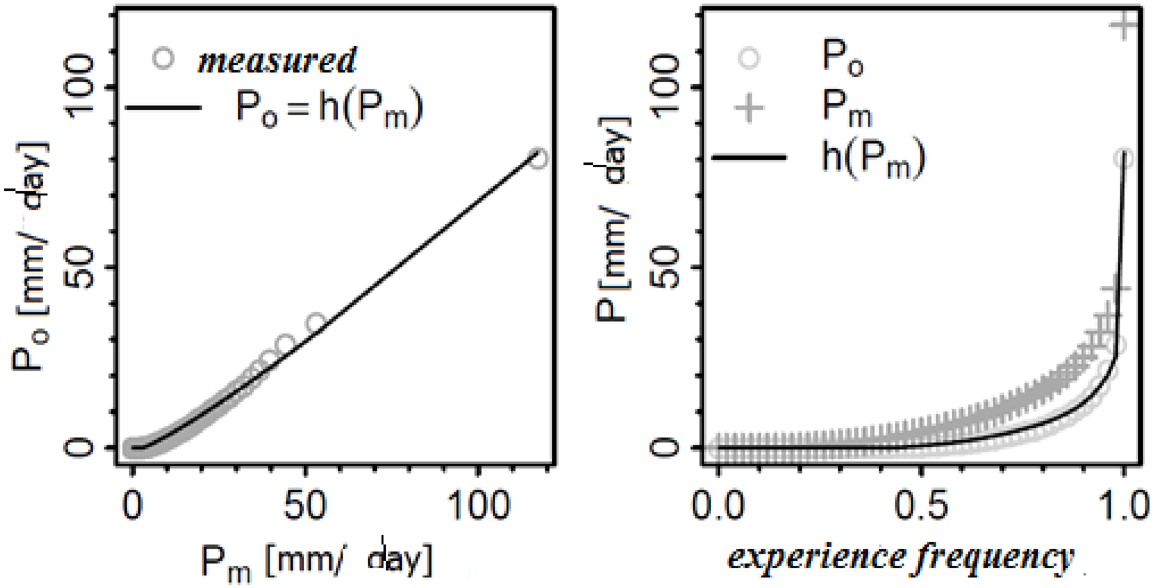
Methodology

- Statistical analysis: frequency analysis
- Statistical downscaling: bias correction
- Hydrological models: flow simulation from rainfall
- GIS: Map development



Steps of the research

Methodology



$$P_o = F_o^{-1}(F_m(P_m))$$

Where F_m is the cumulative probability distribution of P_m and F_o^{-1} is the cumulative inverse function corresponding to P_o.

Ines and Hansen, (2006)
Piani et al, (2010)

DATA

No	Models	Center	Country	Resolution
1	ACCESS 1.3	Bureau of Meteorology	Australia	$1{,}875^o$ x $1{,}25^o$
2	CanESM2	Canadian Centre for Climate Modelling and Analysis	Canada	$2{,}81^o$ x $2{,}79^o$
3	CMCC-CMS	Centro Euro-Mediterraneo sui Cambiamenti Climatici	Italia	$1{,}875^o$ x $1{,}865^o$
4	CNRM-CM5	Centre National de Recherches Météorologiques	France	$1{,}40^o$ x $1{,}40^o$
5	CSIRO-MK3.6	Commonwealth Scientific and Industrial Research Organization	Australia	$1{,}875^o$ x $1{,}865^o$
6	FGOALS-g2	Institute of Atmospheric Physics	China	$2{,}81^o$ x $2{,}79^o$
7	GFDL-ESM2G	Geophysical Fluid Dynamics Laboratory	USA	$2{,}50^o$ x $2{,}00^o$
8	HadGEM2-CC	Met Office Hadley Centre	UK	$1{,}875^o$ x $1{,}25^o$
9	IPSL-CM5A-MR	Institut Pierre Simon Laplace	France	$2{,}50^o$ x $1{,}268^o$
10	MIROC5	Atmosphere and Ocean Research Institute	Japan	$1{,}40^o$ x $1{,}40^o$
11	MPI-ESM	Max Planck Institute for Meteorology	Germany	$1{,}875^o$ x $1{,}865^o$

2 scenarios: RCP4.5 and RCP8.5

DATA

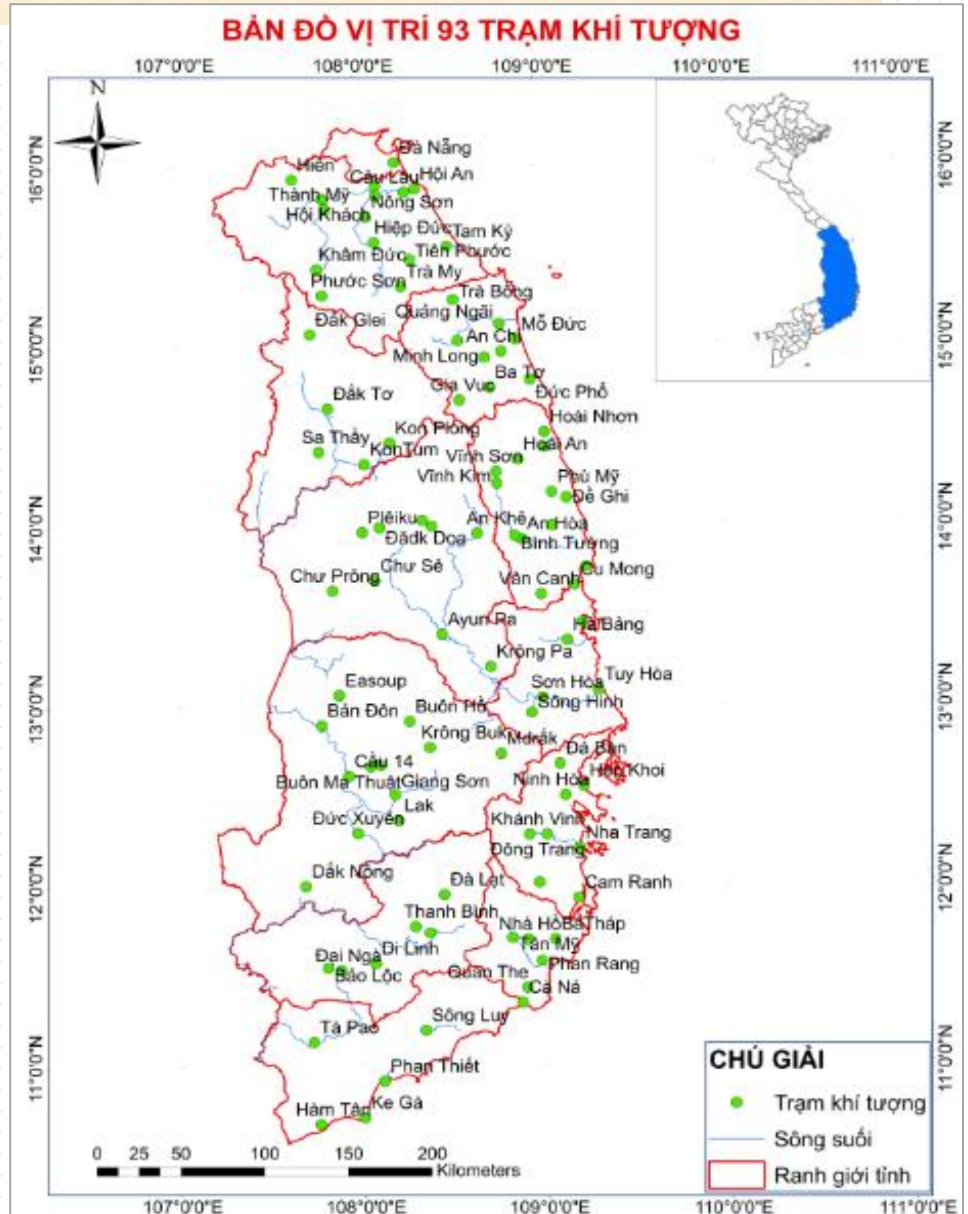
- 93 raingauge stations

- Baseline period:

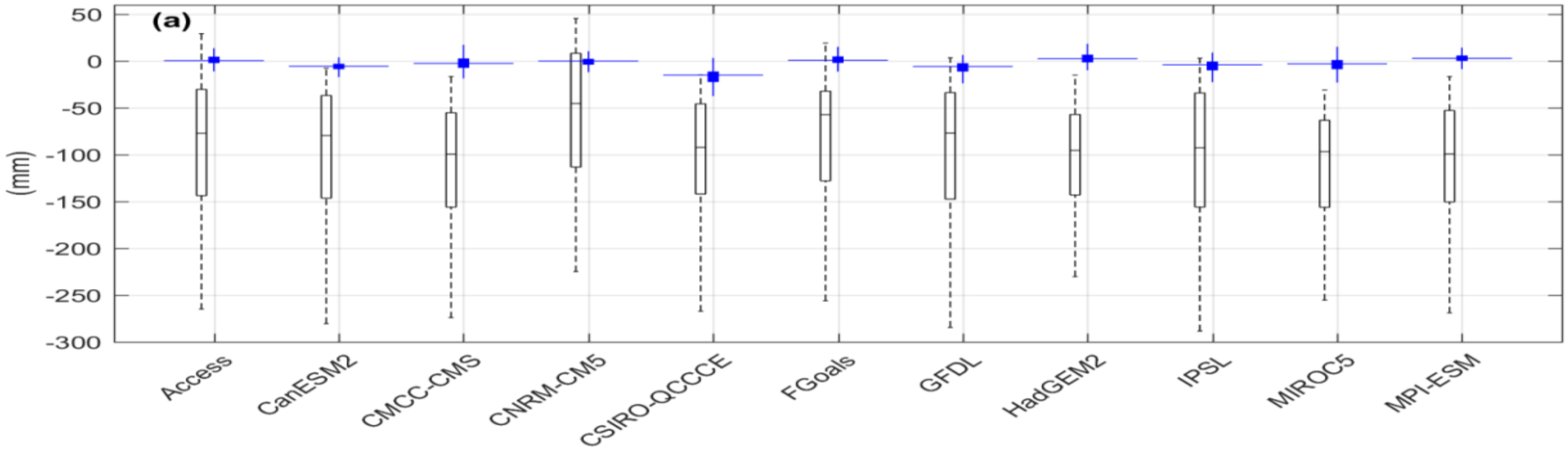
beginning of observation to 2005.

- Future period:

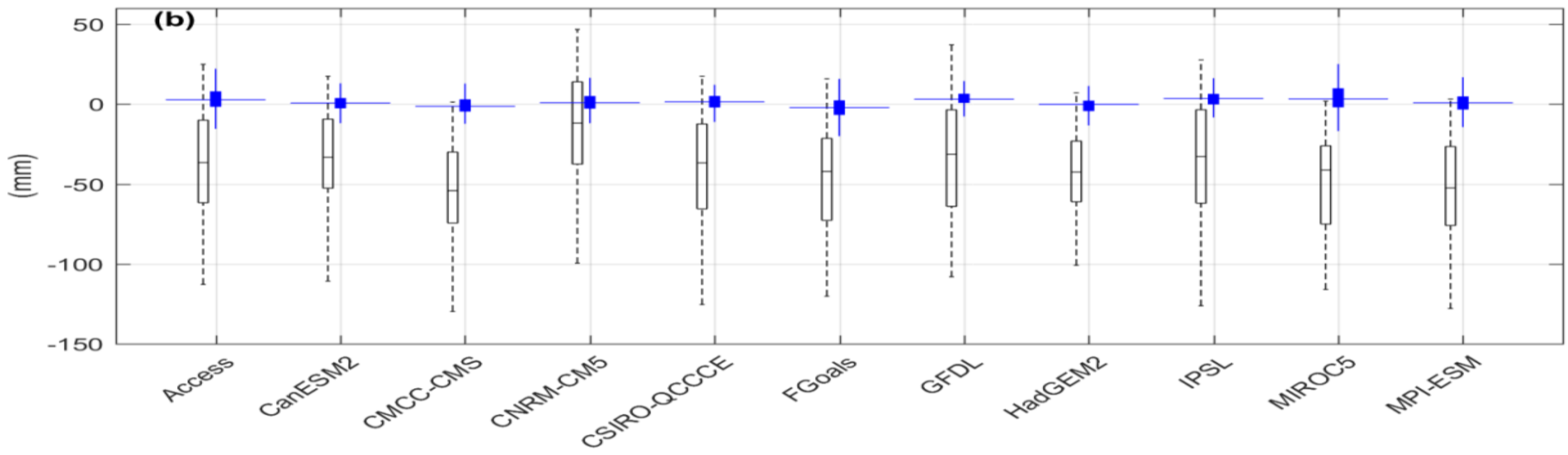
2040-2069, 2070-2099



RESULTS

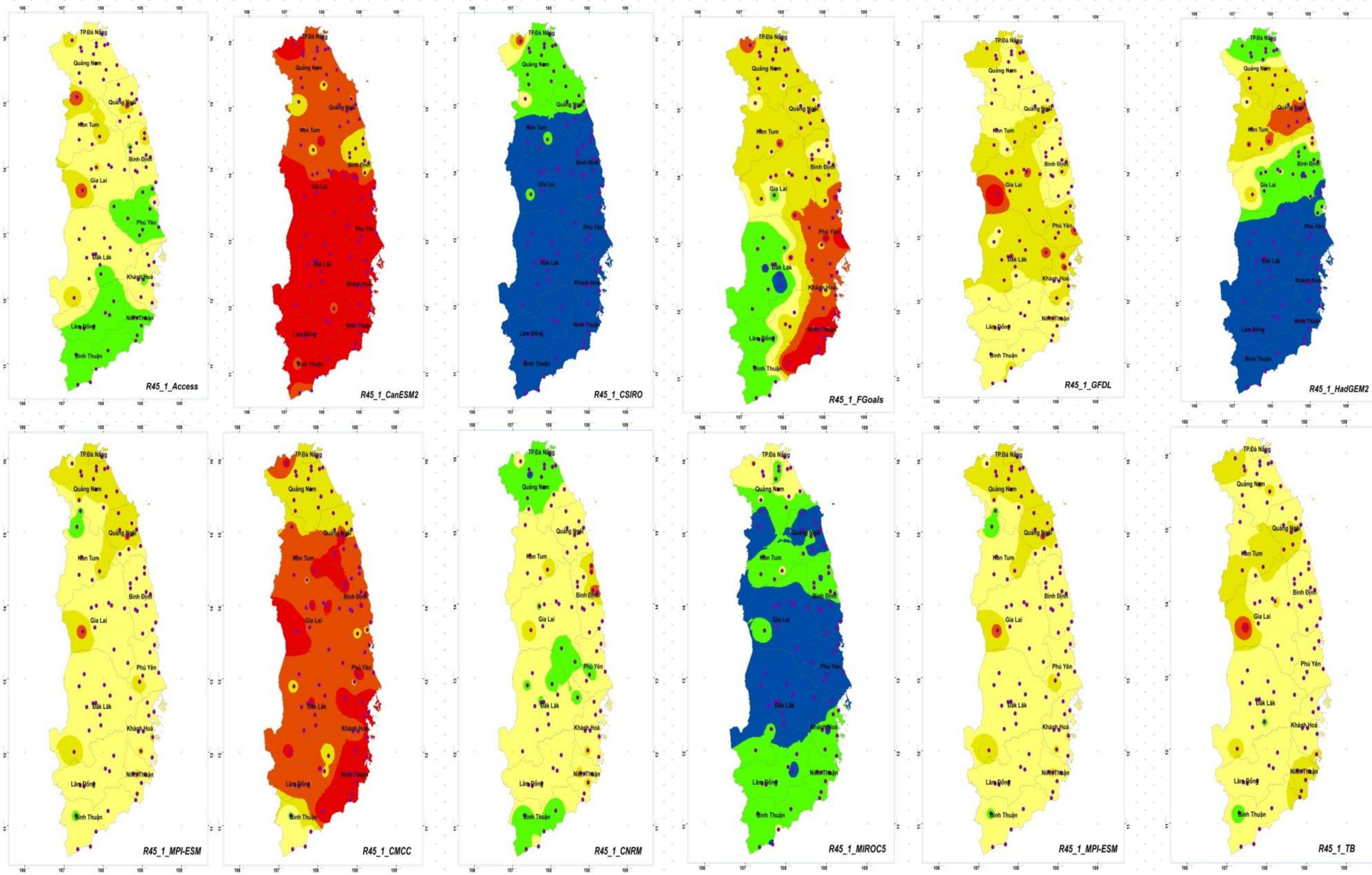


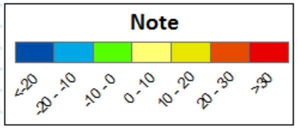
Average of maximum daily precipitation error



Standard deviation of maximum daily precipitation error

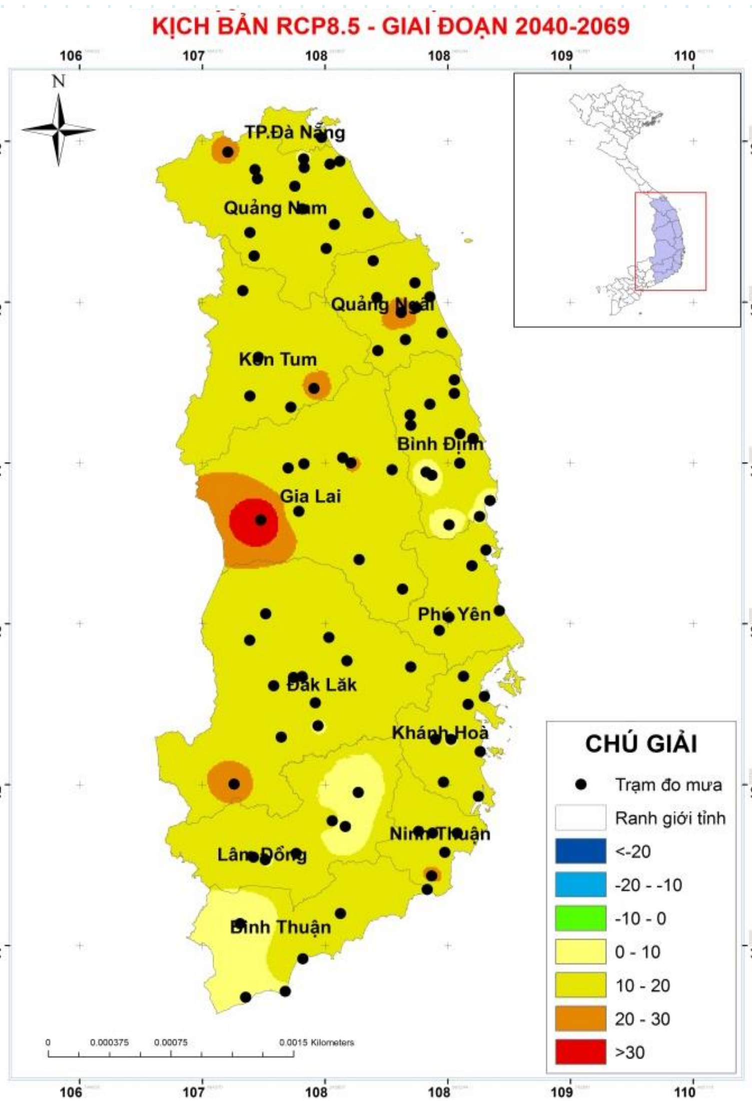
Change in maximum daily prepitation maps (%)

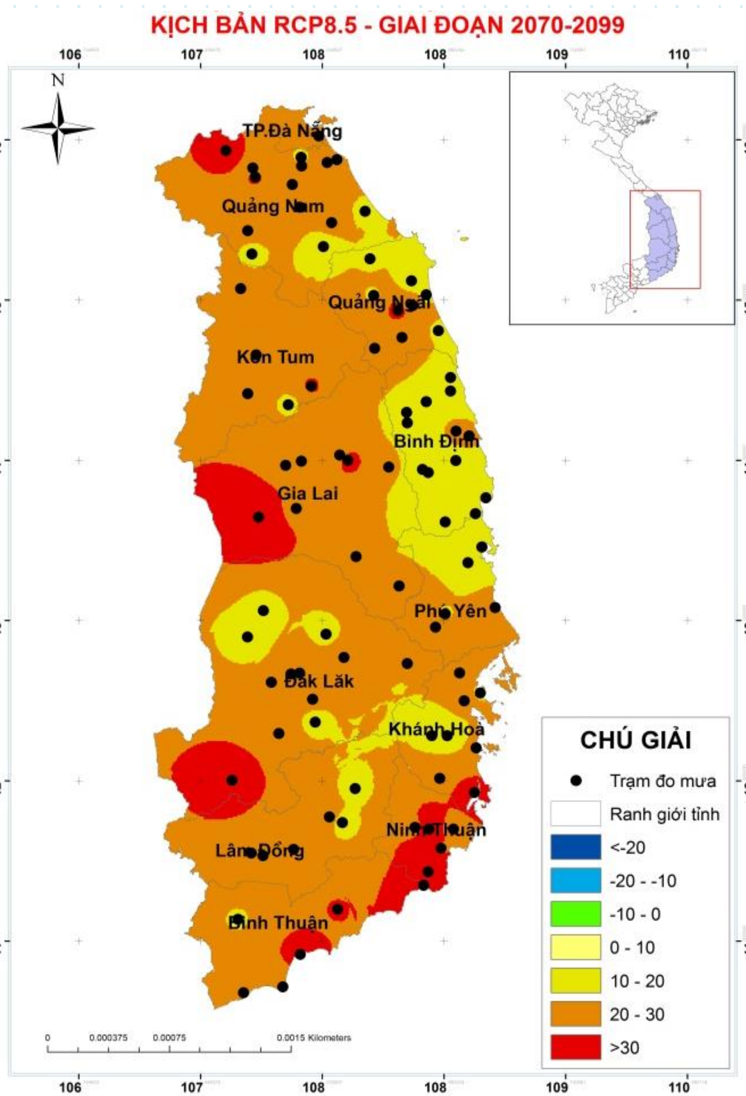




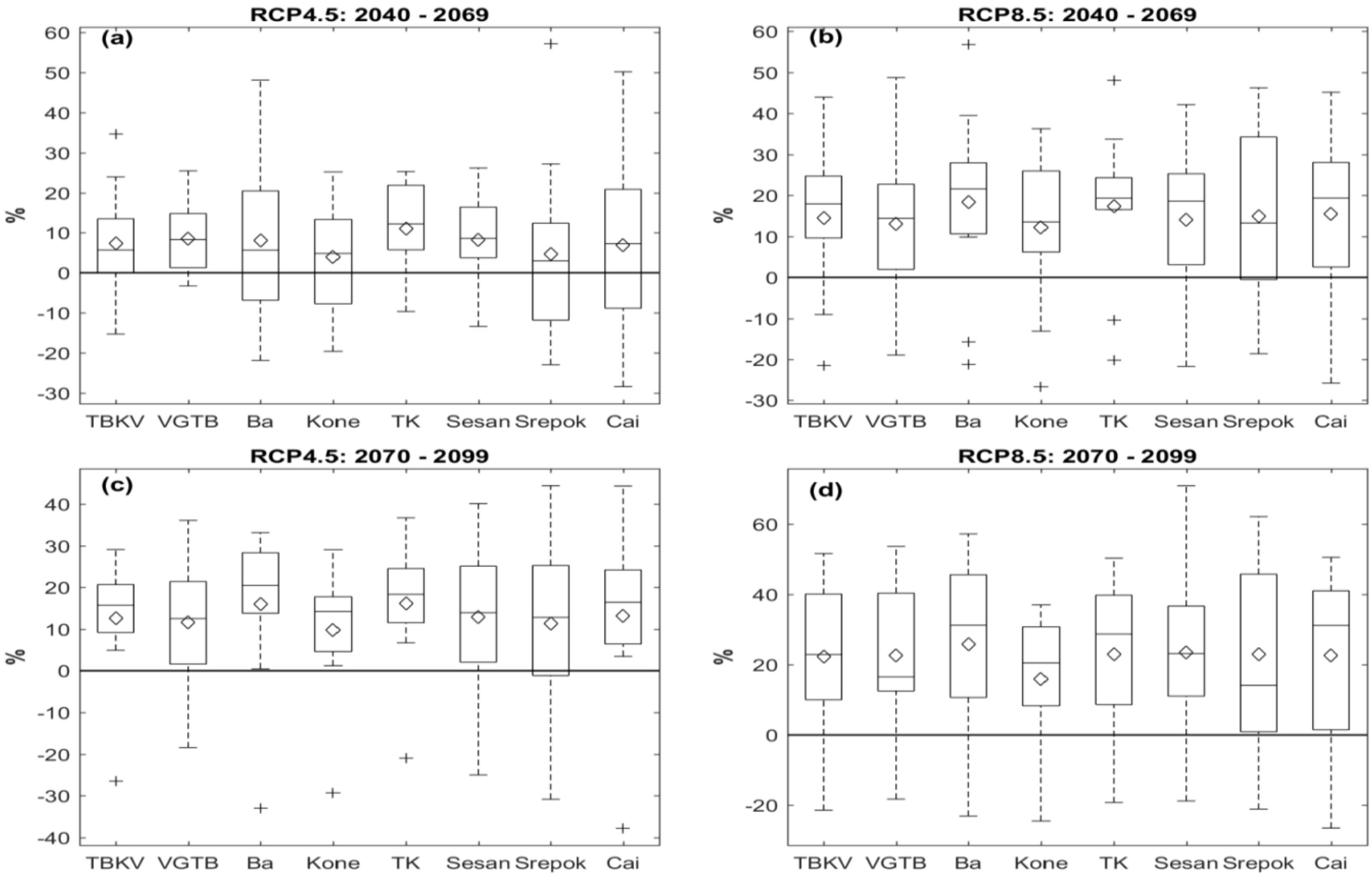
RCP4.5 – (2040-2069)

Change in maximum daily prepitation maps (%)

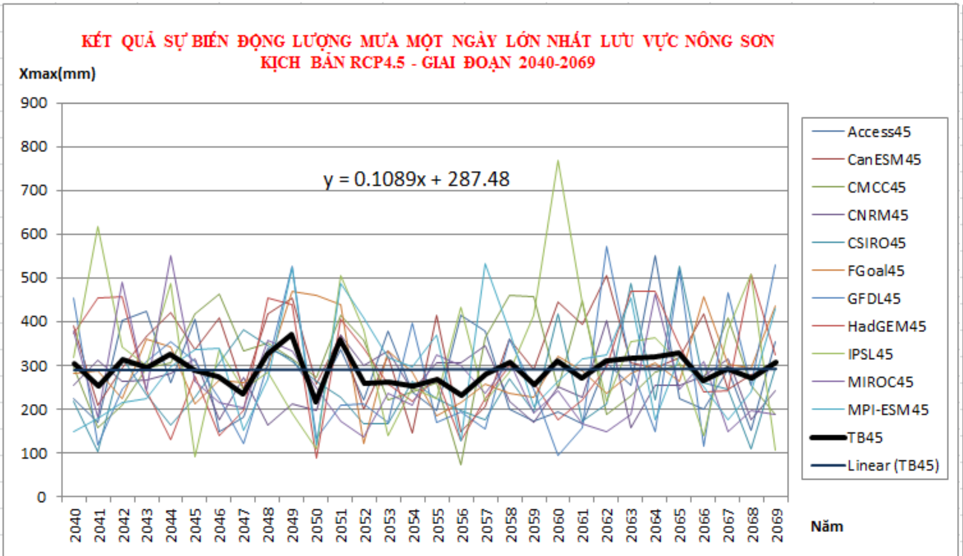


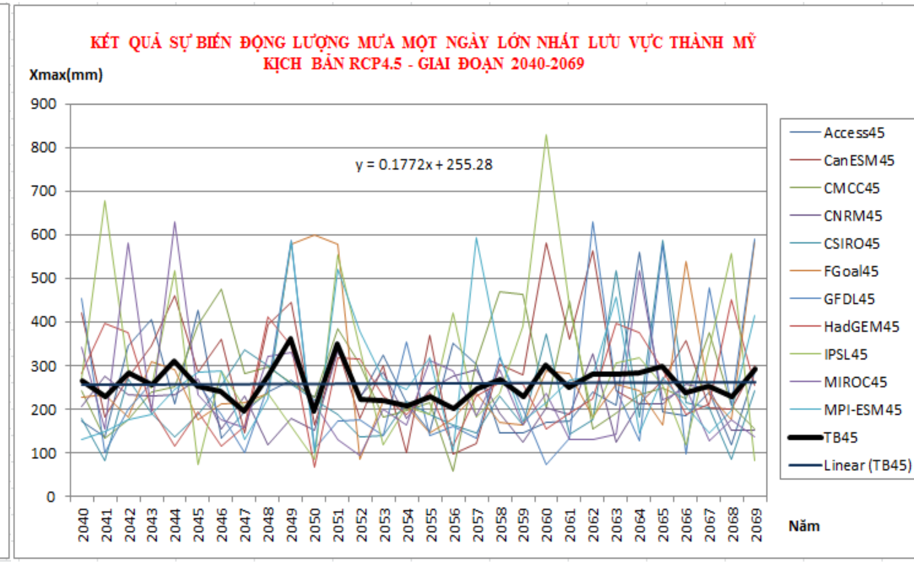


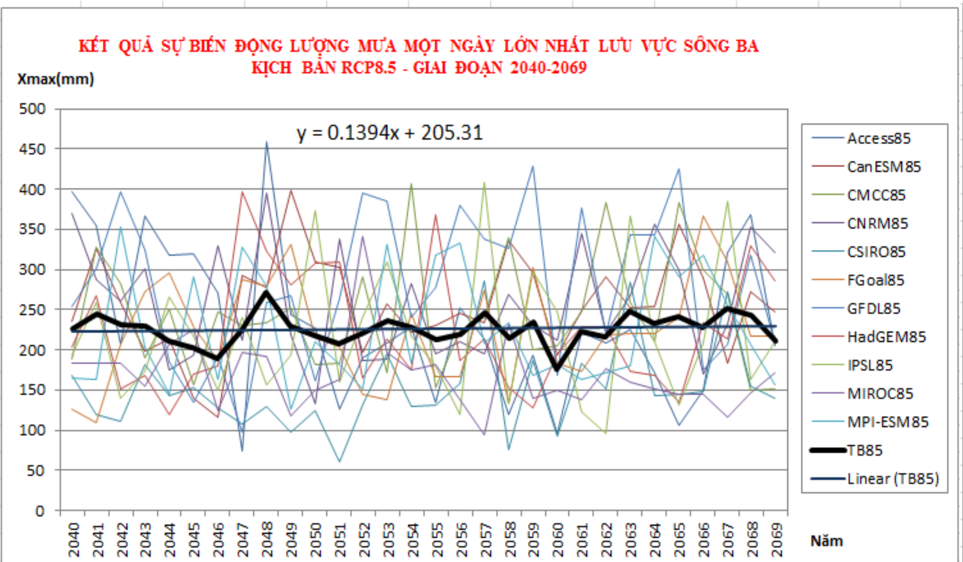
Maximum daily precipitation changing in some basins

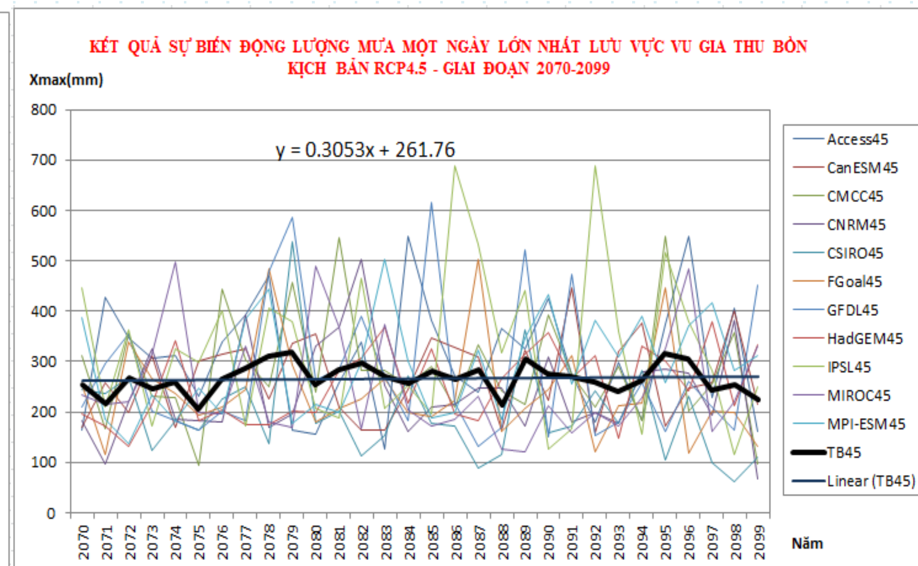


Maximum daily precipitation changing in some basins









Maximum daily precipitation changing

- Extreme rainfall tends to increase in future in most of basins (except RCP4.5 in the period 2040-2069).

- There is a significant difference in outcomes between models.

- Some models show the high reduction in average maximum daily rainfall in the Ba, Kone, Srepok and Cai Nha river basins, although they increase on average (all models).

Design peak flood estimation

Criteria of design peak flood estimation for ungauged basin in Vietnam(depends on area of basin):

- Less than 100 km^2: empirical G.A. Alexeyev's formula.

$$Q_p = A_p.\alpha.X_{1maxp}.F$$

- Between 100 km^2 to 1000 km^2: Sokolovsky's formula.

$$Q_P = 0{,}278\frac{\alpha\left(X_{1\max P} - H_0\right)}{T_l}F.f$$

- > 1000km^2: Estimated from similar basins.

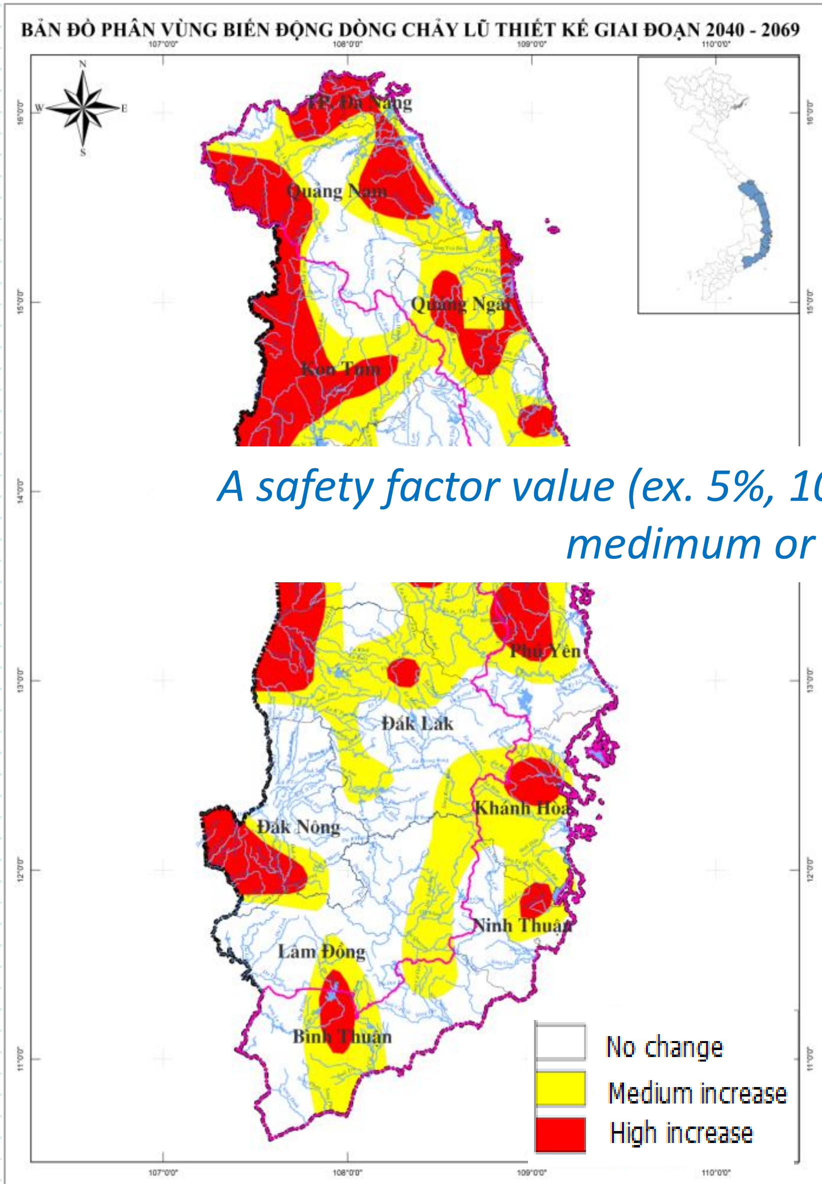
The changing of peak discharge is the same with the changing of maximum daily precipitation due to empirical formulas!!!

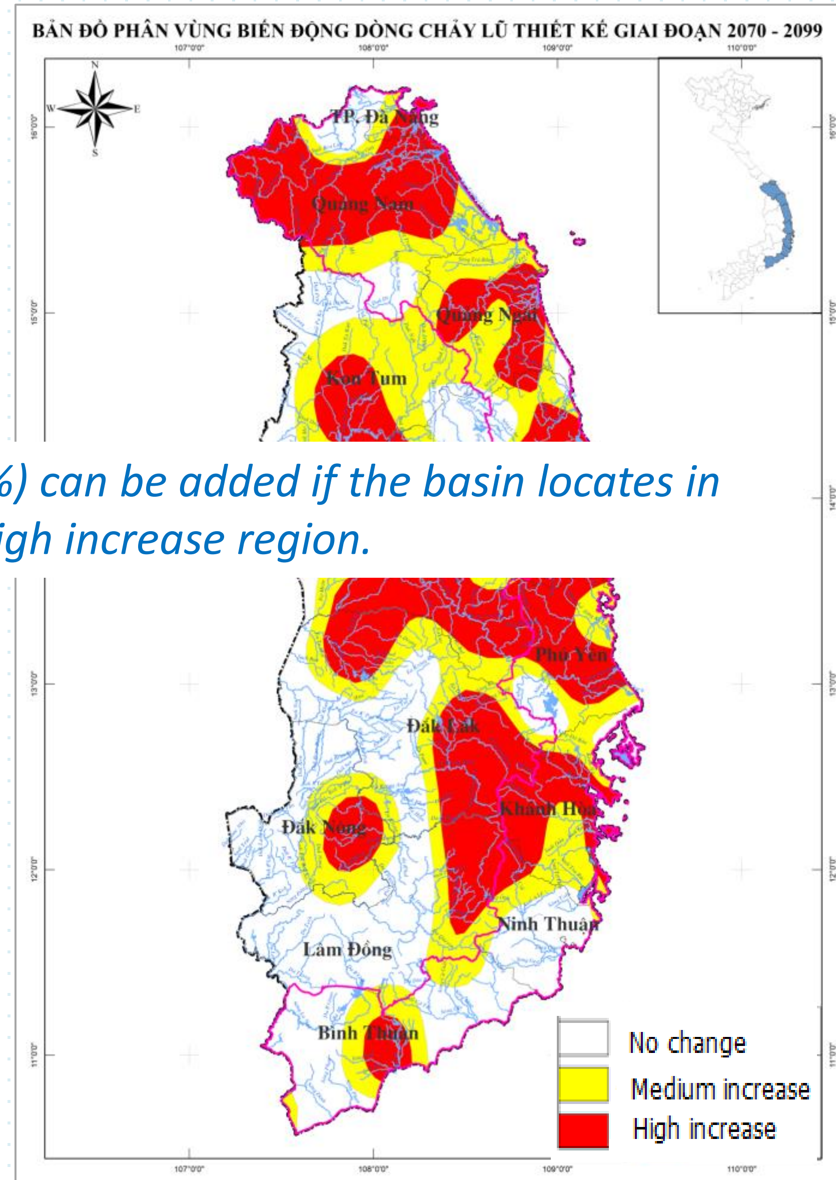
Criteria for classification

11 GCMs x 2 scenarios = 22 Outcomes

Groups	Number of outcomes show the increasing trend of peak discharge	Change on average of all models	The average change of coefficient of variation
3 (High Increasing)	> 2/3	> +10%	>=0
2 (Medium Increasing)	> 2/3	> +10%	<0
	> 1/2	> 0	>=0
1 (No change)	< 1/2		

“Potential change” in peak flood map





A safety factor value (ex. 5%, 10%) can be added if the basin locates in medimum or high increase region.

Summary

- Observation data from 93 raingauge station and 11 GCMs are used in this study. The bias correction procedure is applied in order to downscale the GCMs output to stations.

- On average, the extreme precipitation tends to increase in the region with 10-20% for the period 2040-2069 and 20-30% for the period 2070-2099 in both scenarios RCP4.5 and RCP8.5,

- There is a significant different outcomes between the GCMs showing the high uncertainty of climate expectation.

- A "potential change" map is generated for design flood estimation taking into account the impacts of climate change.

References

[1]: Ines AVM, Hansen JW, "Bias correction of daily GCM rainfall for crop simulation studies," Agric For Meteorol 138 44-53, 2006.

[2]: Piani, G.P. Weedon and others, "Statistical bias correction of global simulated daily precipitation and temperature for the application of hydrological models," Journal of Hydrology, Vol. 396 199-215, 2010.

[3]: Gudmundsson, L., Bremnes, J. B., Haugen, J. E., and Engen-Skaugen, T., "Technical Note: Downscaling RCM precipitation to the station scale using statistical transformations – a comparison of methods," Hydrol. Earth Syst. Sci., no. 16, pp. 3383-3390, September 2012.

Thank you for your attention