Outlook of Climate Change Impact -Downscaling modeling-

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United Nations
Educational, Scientific and
Cultural Organization

Orientation Seminar on Climate Change Adaptation

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Introduction

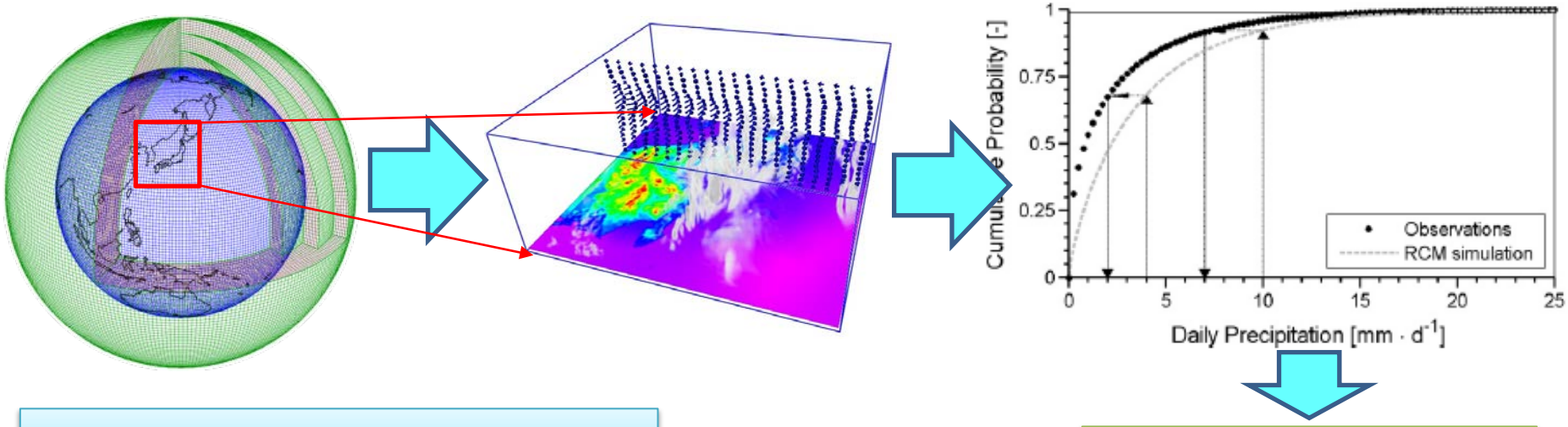
- ICHARM tackling with climate change effect on flood and draught risk for Solo River basin, Indonesia.
- To examine high resolution rainfall, dynamic downscaling are conducted with the boundary condition of MRI-AGCM3.2S Past (1979-2003) and future RCP8.5 scenario (2075-2099) climate (25 years each).
- Statistical downscaling is also used to estimate uncertainty of the results.
- Ground raingauges are used for bias correction (44 sites, 1981-2005)

What is dynamic downscaling?

General Circulation Model "Projection"

Simulation by a Regional Climate Model

Bias correction



Governing equations of Atmosphere

Momentum equation

$$\frac{du}{dt} - \left(f + \frac{\tan\phi}{a} u \right) v = -\frac{\partial p}{\rho a \cos\phi \partial\lambda} + F_\lambda$$

$$\frac{dv}{dt} + \left(f + \frac{\tan\phi}{a} u \right) u = -\frac{\partial p}{\rho a \partial\lambda} + F_\phi$$

$$\frac{dw}{dt} = -\frac{\partial p}{\rho \partial z} - g + F_z$$

Conservation equation

$$\frac{d\rho}{dt} + \rho \left[\frac{1}{a\cos\phi}\frac{du}{d\lambda} + \frac{1}{a\cos\phi}\frac{\partial(v\cos\phi)}{\partial\phi} + \frac{\partial w}{\partial z} \right] = 0$$

Thermodynamic equation

$$c_v \frac{dT}{dt} + p\frac{d\alpha}{dt} = Q$$

Equation of state

$$p = \rho RT$$

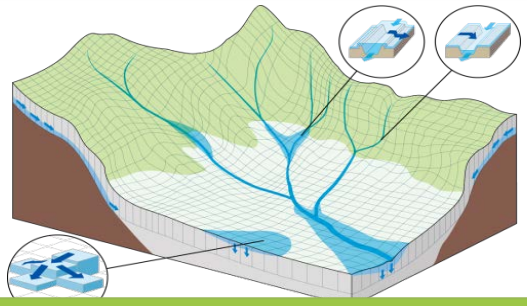
Total derivative on spherical coordinate

$$\frac{d}{dt} = \frac{\partial}{\partial t} + \frac{u}{a\cos\phi}\frac{\partial}{\partial\lambda} + \frac{v}{a}\frac{\partial}{\partial\phi} + w\frac{\partial}{\partial z}$$

$(\lambda, \phi, z : longitude, latitide, height), \alpha = 1/\rho, f = 2\Omega\sin\phi$

Climate Conditions of Past and Future; e.g. Greenhouse gas concentrations

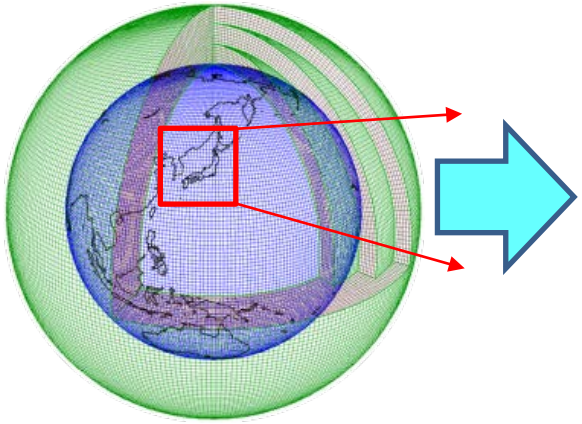
Hydrological simulation



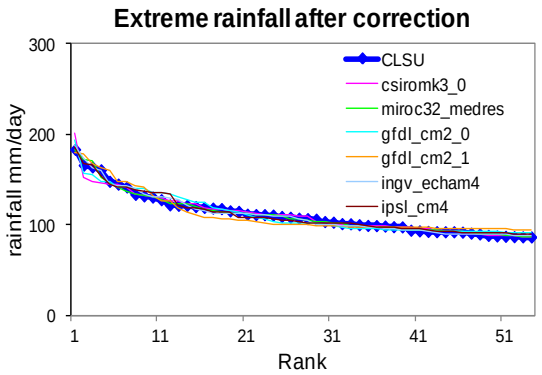
Dynamic downscaling is expensive at computational costs. We can compute only one GCM but with high resolution.

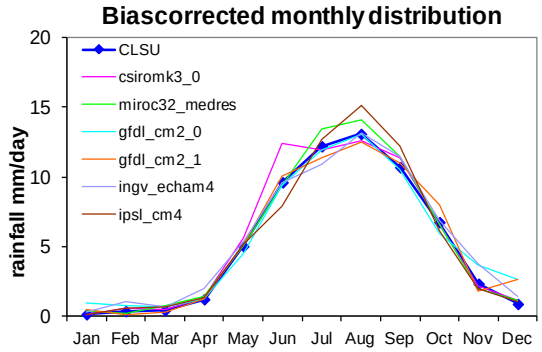
What is statistical downscaling?

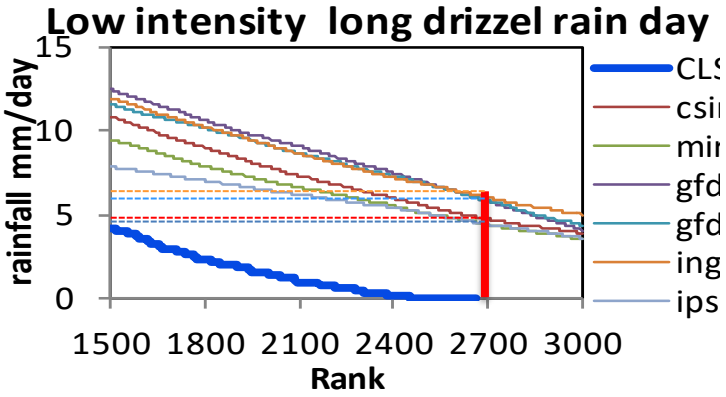
General Circulation Model "Projection"



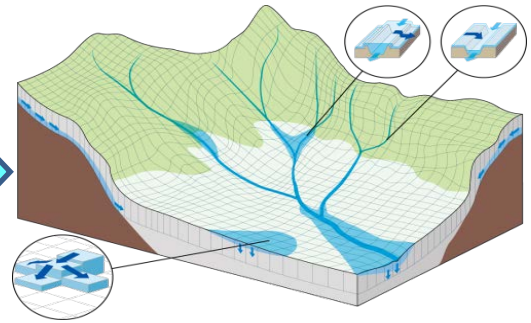
Bias correction







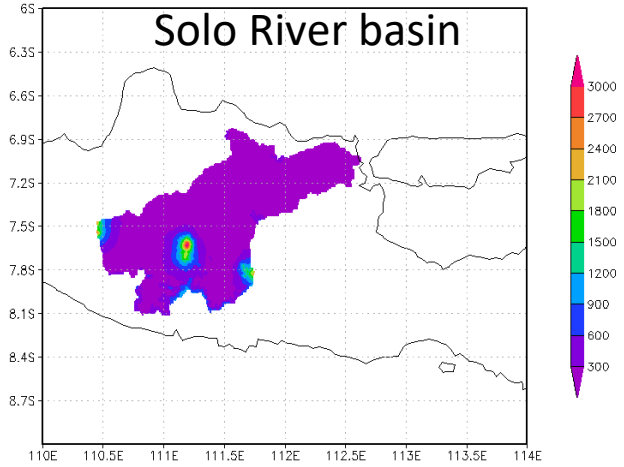
Hydrological simulation to discuss flood risk

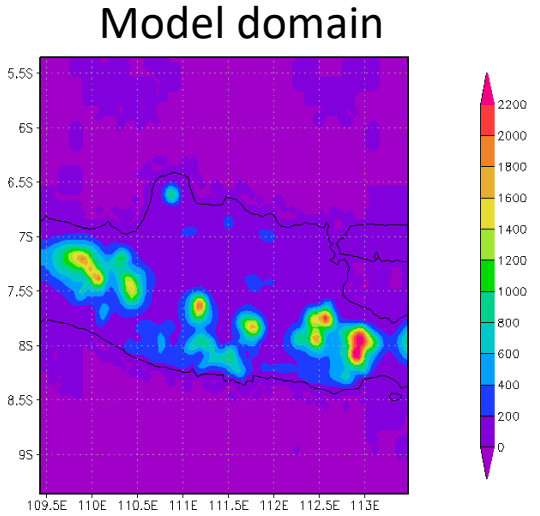


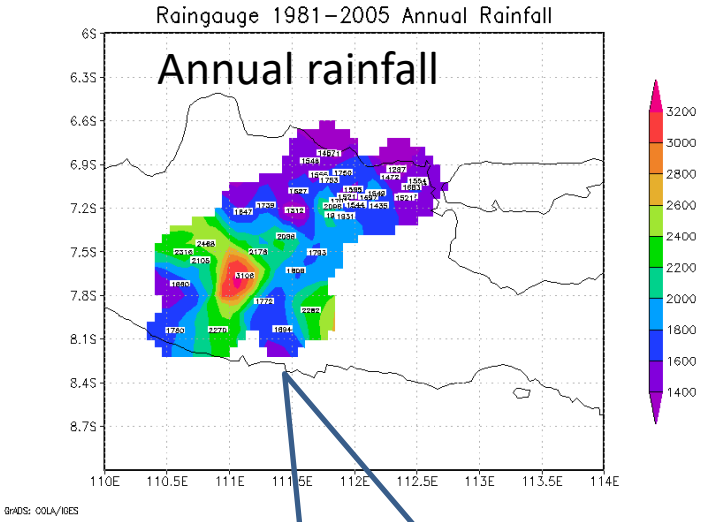
Extreme rainfall:
Generalized Pareto Distribution
Normal rainfall:
Gamma distribution fitting
No Rain Day:
Applied to the model

Statistical downscaling is cheap at computational costs. We can compute several GCMs to evaluate its uncertainty.

Dynamic Downscaling





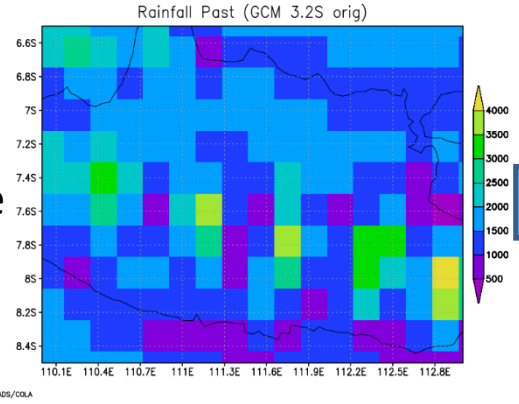


WRF-ARW ver.3.7.1
Inner : 96x96x40 5km
Cumulus : no
Cloud : Lin

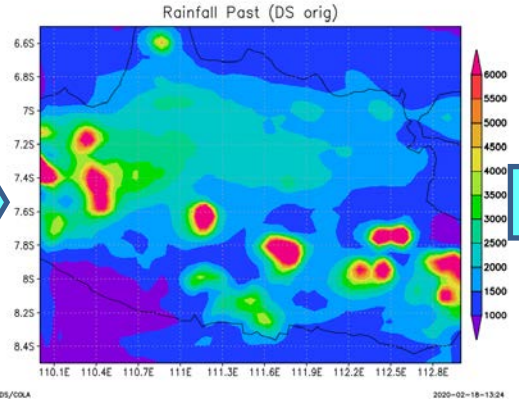
44 raingauges, 1981-2005 25 years

Past climate

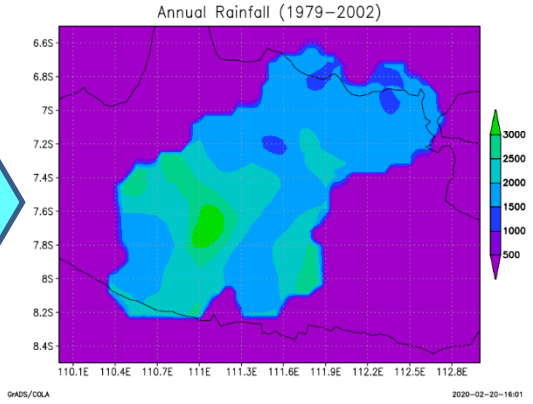
GCM original



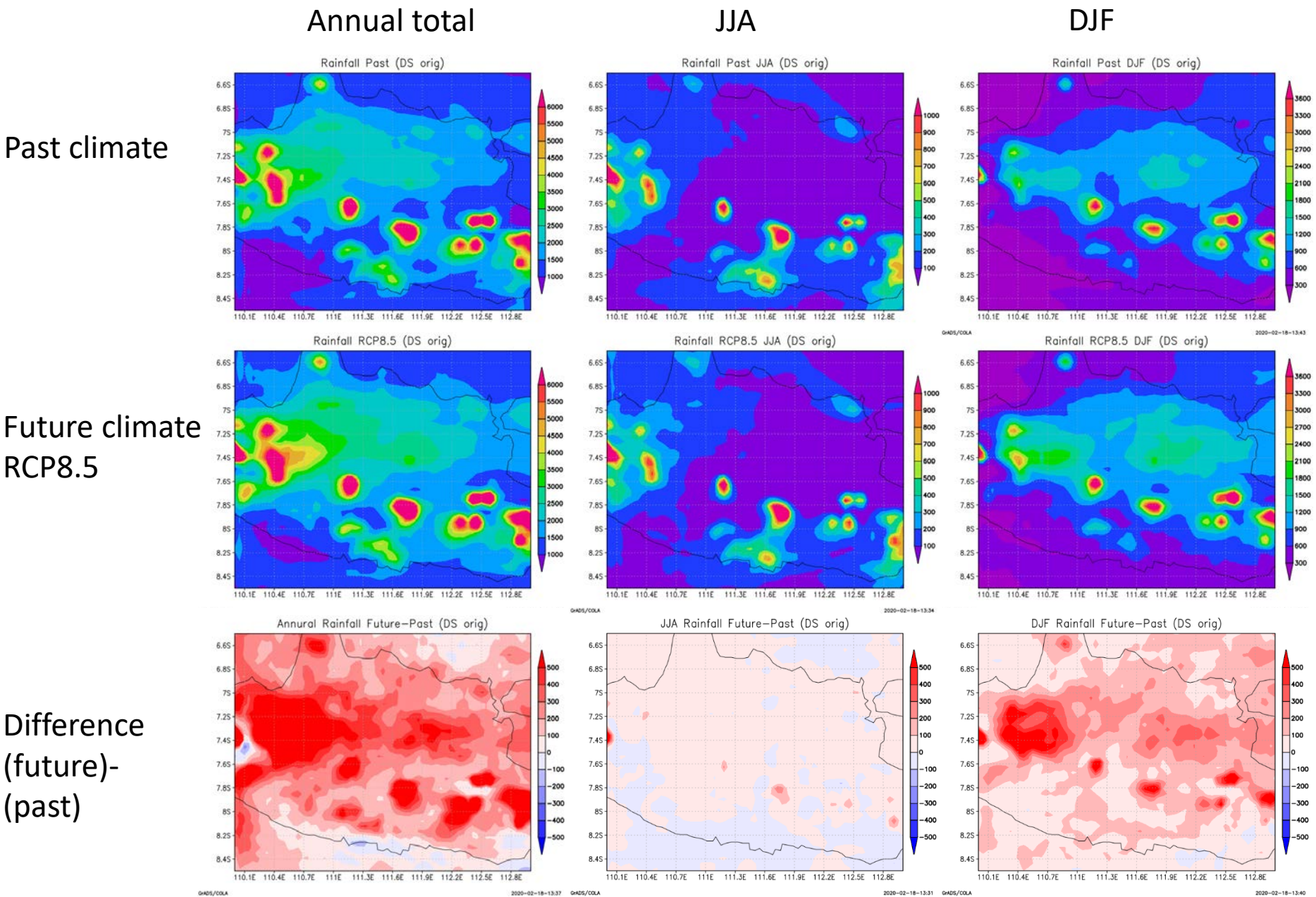
After downscaling



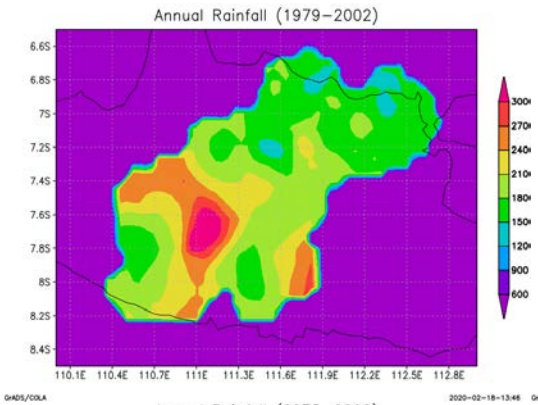
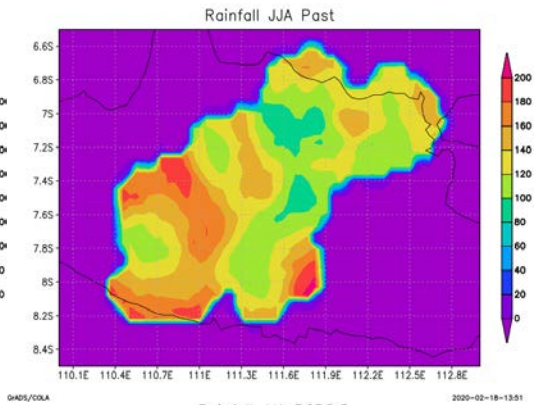
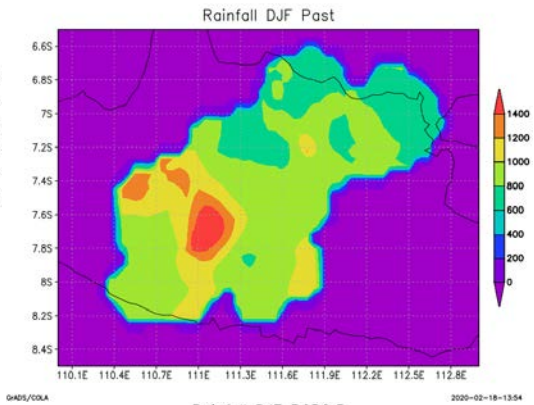
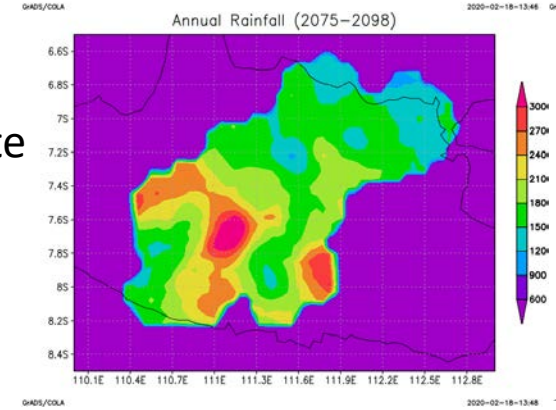
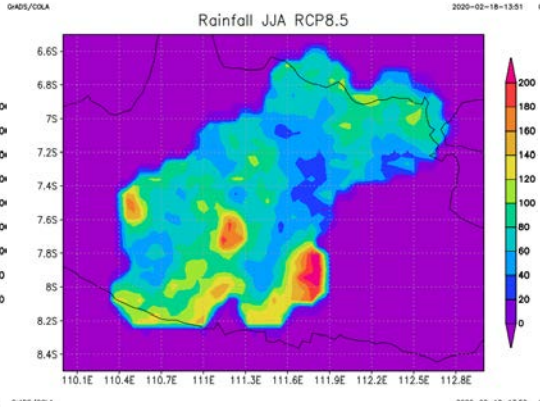
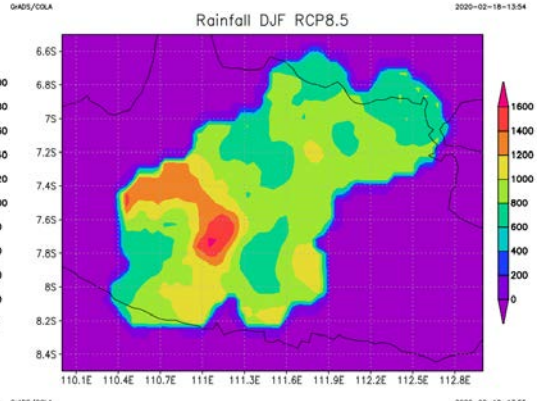
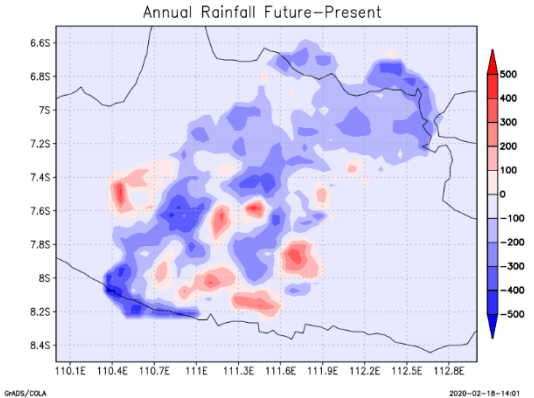
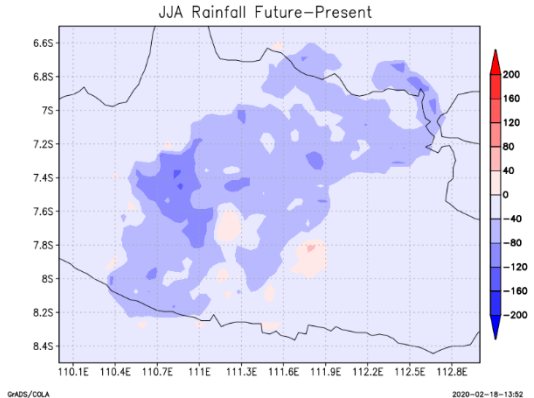
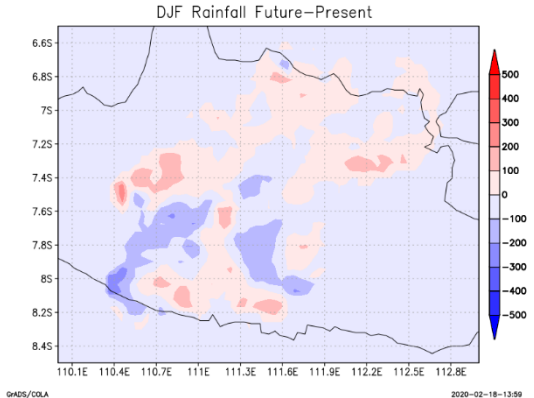
After bias correction



Rainfall (Downscaling)

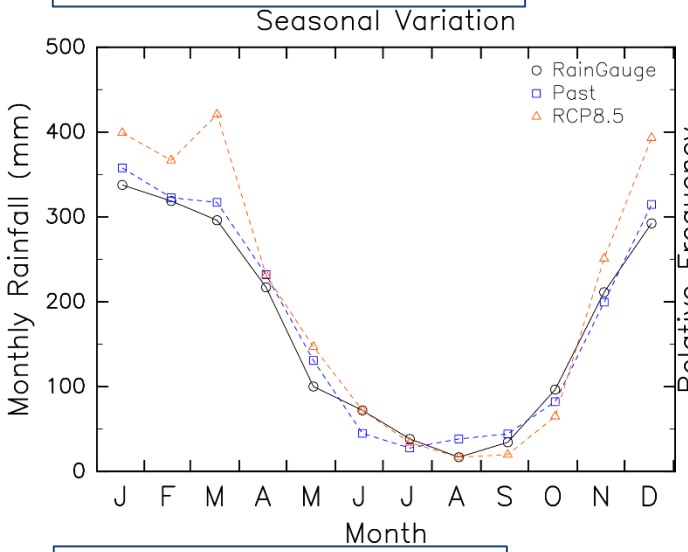


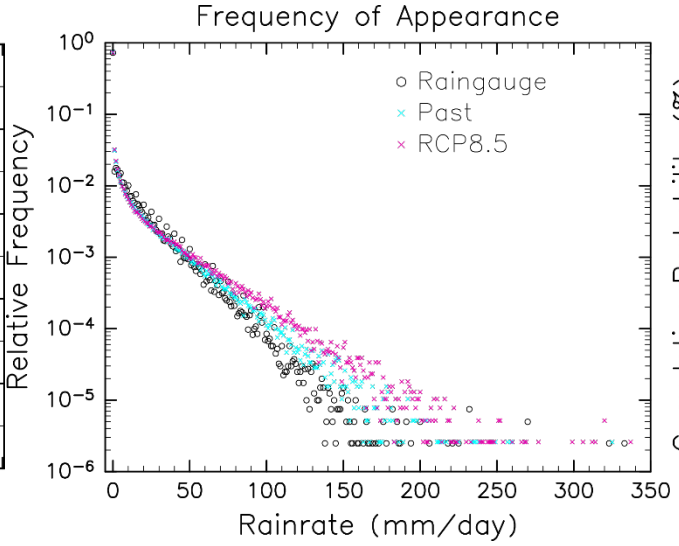
Rainfall (Bias corrected)

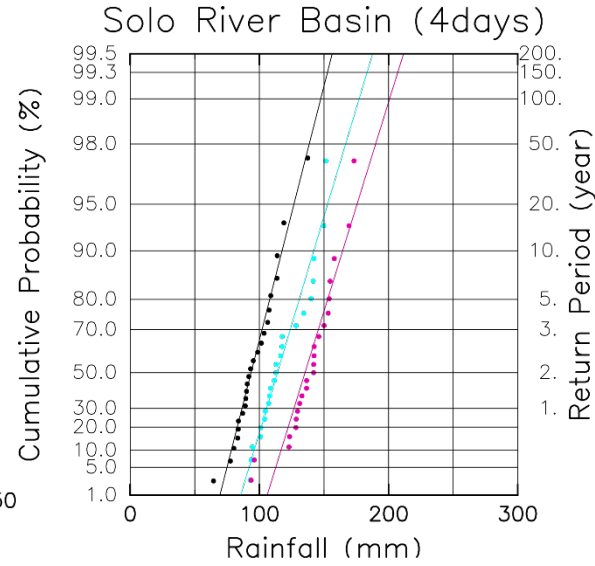
	Annual total	JJA	DJF
Past climate			
Future climate RCP8.5			
Difference (future)-(past)			

Dynamic Downscaling

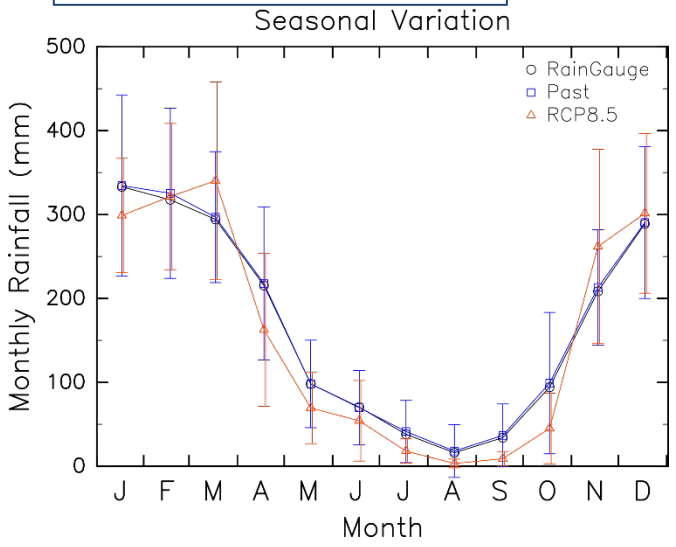
Before Bias correction

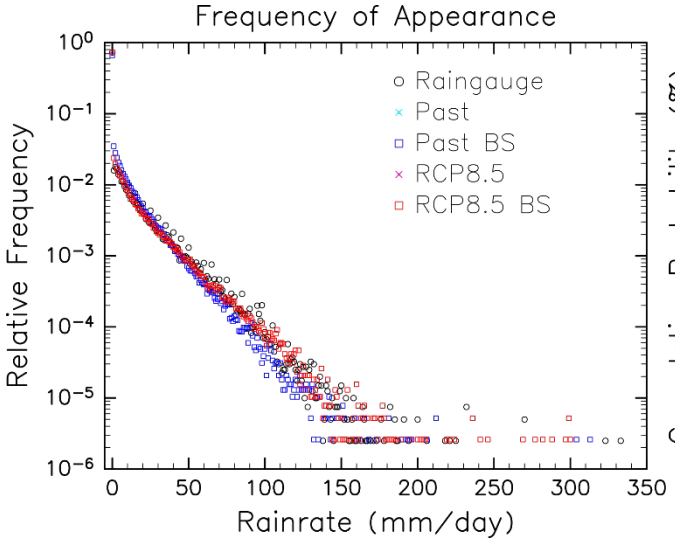


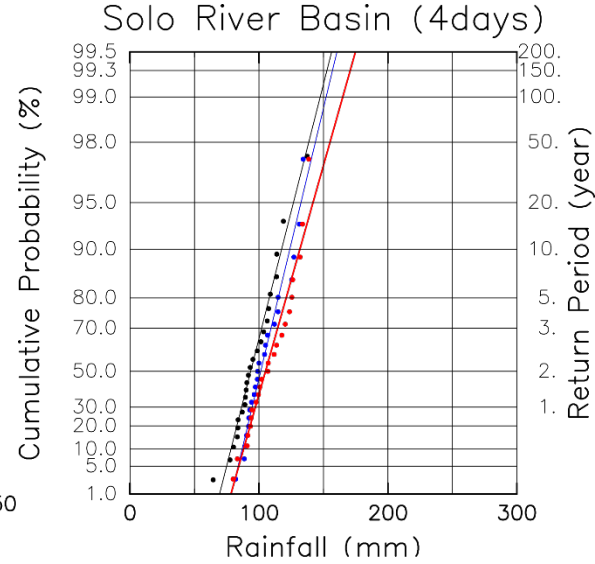




After Bias correction

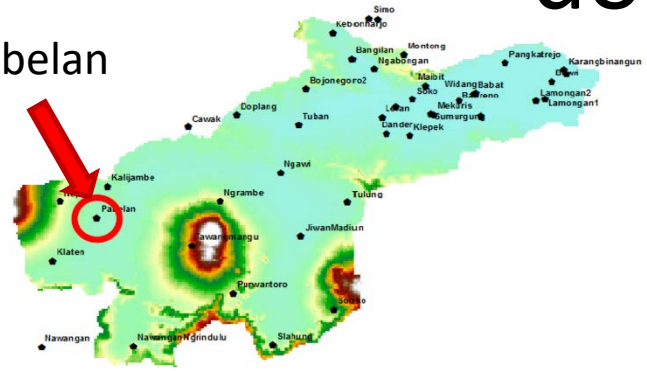


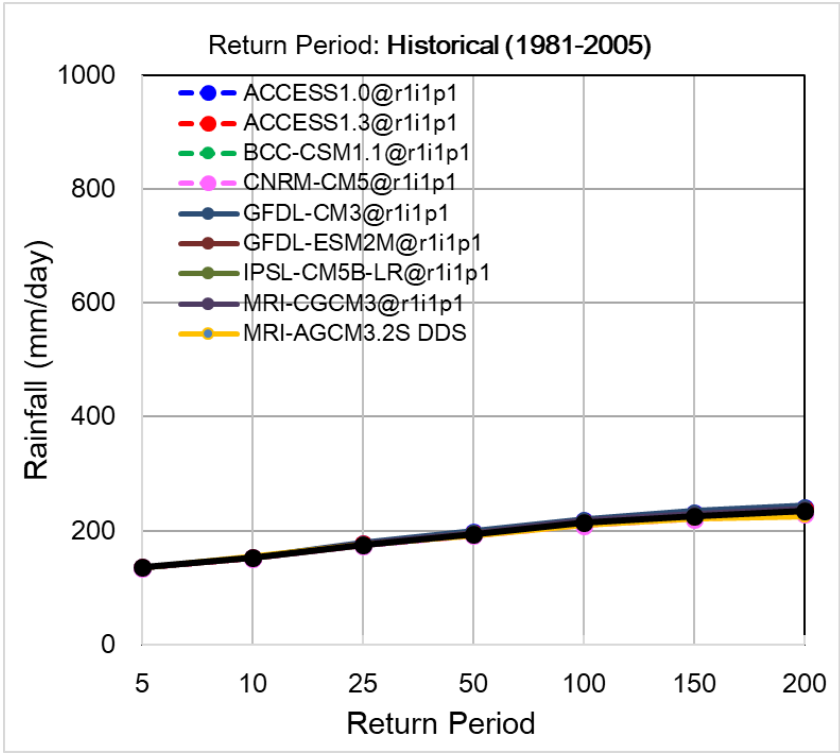


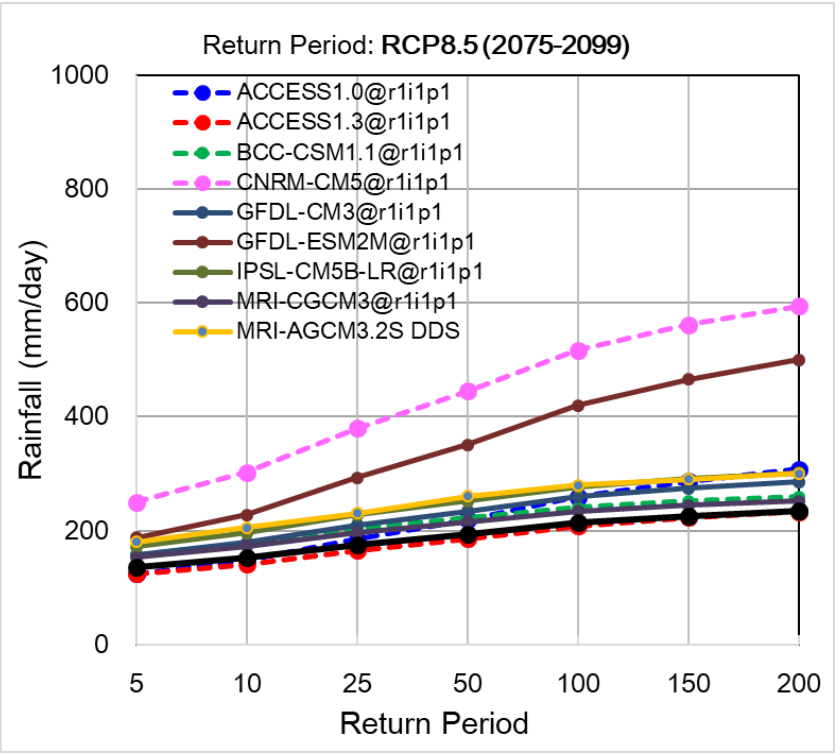


Combination of Statistical & Dynamical downscaling

Pabelan

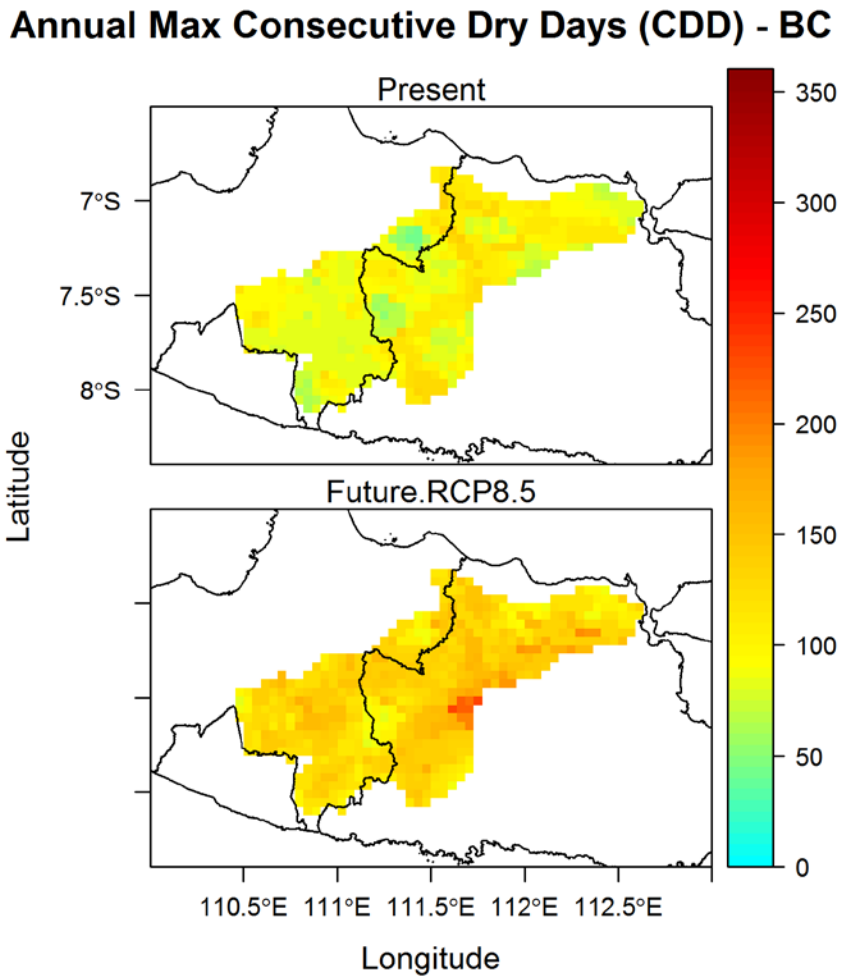




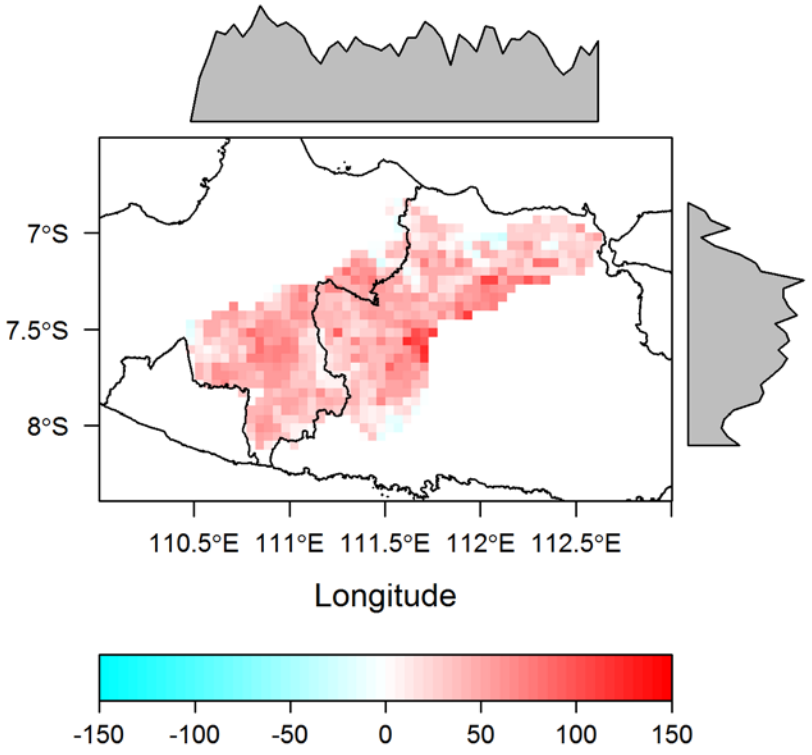


Consecutive Dry Days (CDD)

Consecutive Dry Days (CDD)



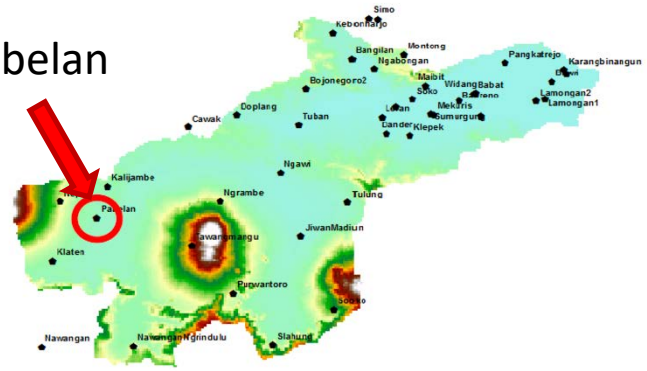
CDD Future-Past



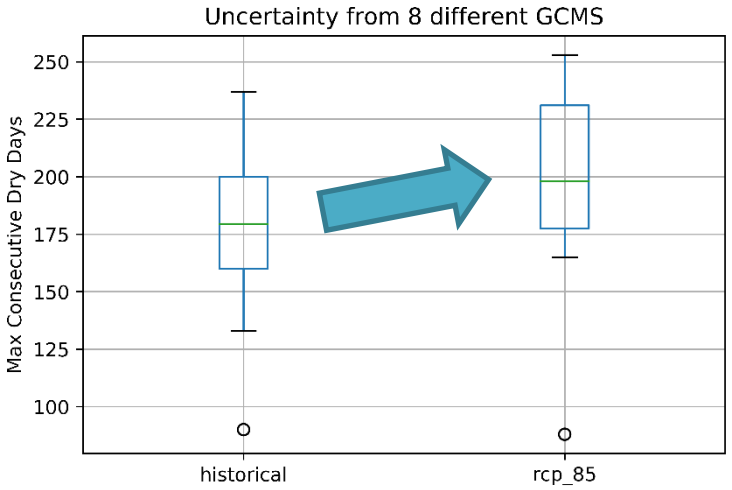
Maximum annual Consecutive Dry Day (CDD) increases in all the basin.

Consecutive Dry Days (CDD)

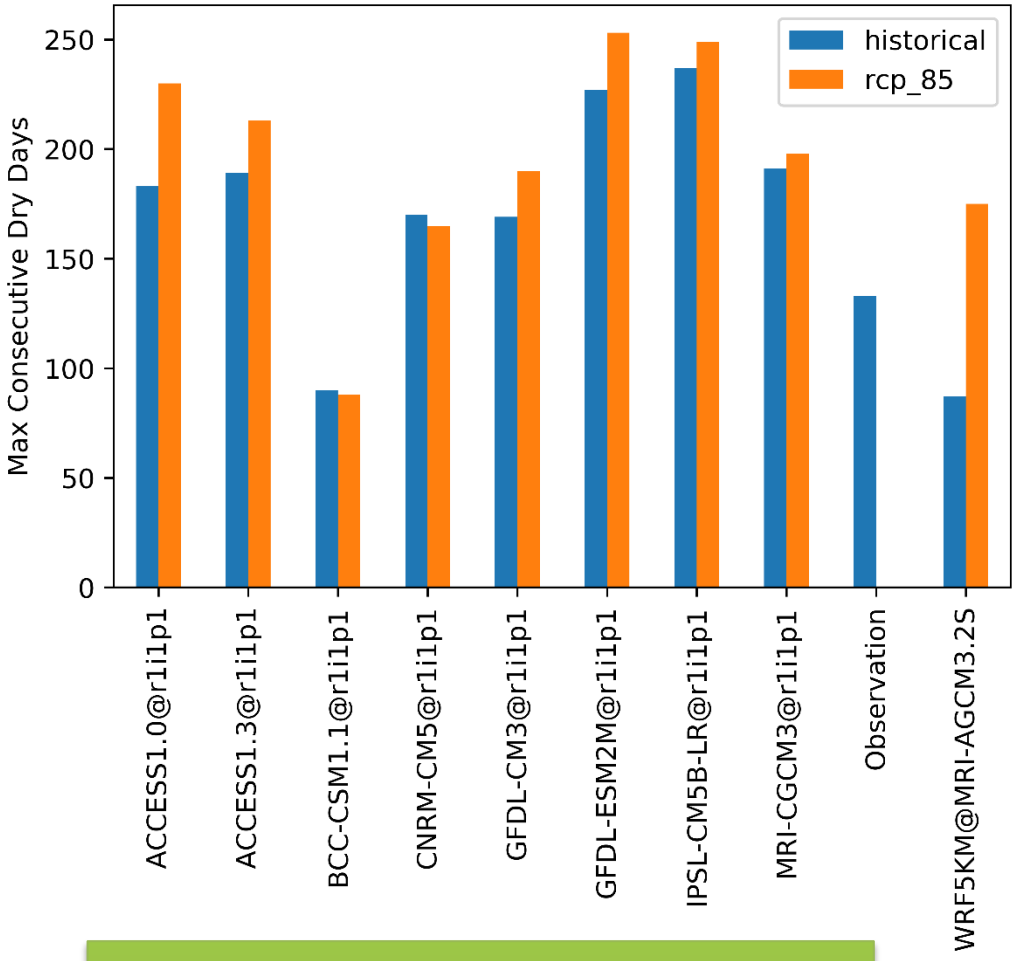
Pabelan



Box plot



8 GCM (statistical DS) and DDS



6/8 GCMs showed increase of CDD.
The results of DDS is relatively larger increase of CDD.

Summary

- Dynamic downscaling and Statistical downscaling provide climate change effects on flood and drought risks.
- We further compute another GCM with different scenarios (MRI-AGCM3.2H (60km) RCP8.5, RCP2.6).