Future projection of extreme PR over the Korean Peninsula under global warming levels, using a large ensemble of RCMs in CORDEX-East Asia Phase 2

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1. Introduction

- Recent global temperature (2011–2020) has increased by 1.09℃ (IPCC, 2021).
- Extreme precipitation (PR) events have occurred over the Korean Peninsula (KP).
- Under UNFCCC adopted in Paris in 2015, two targets were set:
- Global warming levels (GWL) at 1.5℃ and 2.0℃.
- For the projection, state-of-the-art RCMs in CORDEX-East Asia (EA) were used.
- In addition, a large ensemble was constructed
- Using RCMs downscaled from GCMs under future scenarios.

2. Data & Methodology

◆ Constructing a large ensemble

- Using a large ensemble could reduce uncertainty from small number of RCMs.
- RCMs in CORDEX-EA Phase 2, GCMs and scenarios in CMIP5 and CMIP6.

6 Future scenarios → **4 GCMs** → Downscaling → **6 RCMs** → **Large Ensemble Under GWL 1.5℃ GWL 2.0℃**
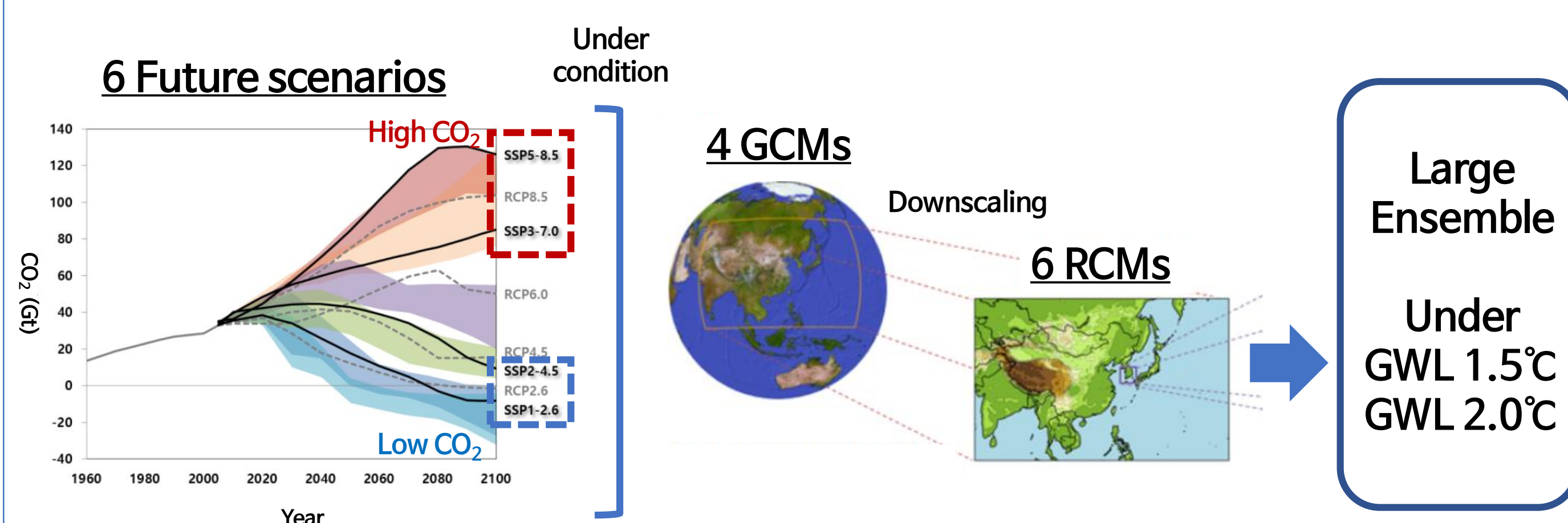
- Timing for reaching a GWL was calculated for each GCM and scenario.
(A year when 21 years running averaged global temperature change reach GWL)
- Future analysis was conducted using 21 years centered on the timing.

GCM	RCM	Scenario	GWL	
			1.5℃	2.0℃
UKESM1-0-LL	HadGEM3-RA CCLM WRF GRIMs RegCM	SSP1-2.6	2020	2031
		SSP2-4.5	2021	2030
		SSP3-7.0	2023	2032
		SSP5-8.5	2021	2029
HadGEM2-AO	HadGEM3-RA CCLM RegCM	RCP2.6	2045	–
		RCP8.5	2034	2045
MPI-ESM-LR	HadGEM3-RA SNU-MM5 CCLM WRF	RCP2.6	2022	–
		RCP8.5	2017	2036
GFDL-ESM2M	WRF RegCM	RCP2.6	–	–
		RCP8.5	2036	2052
RCM ensemble members			36	29

◆ Quantification of extreme PR

- For the intensity, a index of RX1day from ETCCDI was used.

Index	Index Definition	Units
RX1day	The maximum PR in each year	mm

- For the distribution, generalized extreme value distribution (GEVD) was used.
- RX1day was fitted to the GEVD.
- 20 years return period were derived from the GEVD.

20 years return value (Rv20) — Long tale close to extreme value
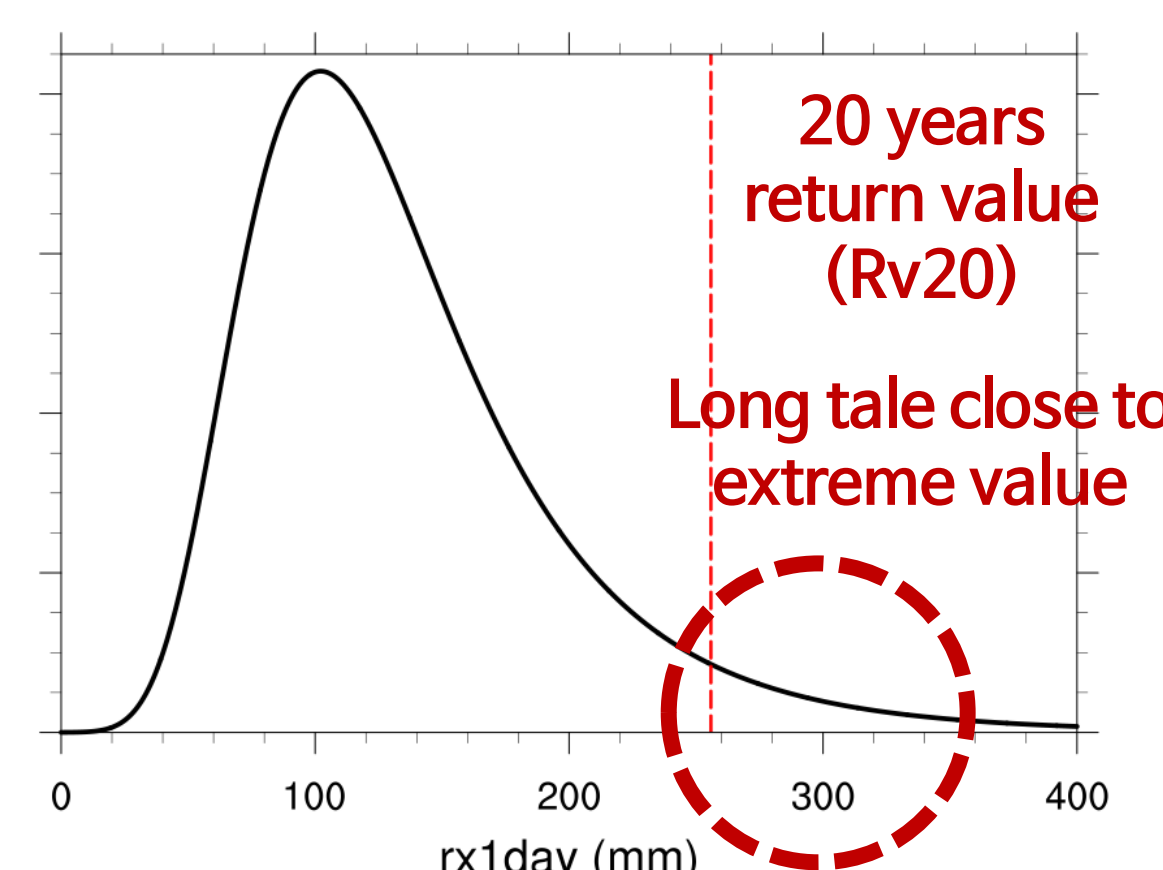
4. Discussion

- Our study suggested that extreme PR over the KP would be intensified under both of GWL 1.5℃ and 2.0℃ condition.
- Atmospheric factors like increased moisture capability, vertical instability, moisture flux and convergence would affect to the change of extreme PR.
- However, none of the factors could fully explain the change, which implies other factors like typhoon, monsoon and so on over the EA (need for further study).
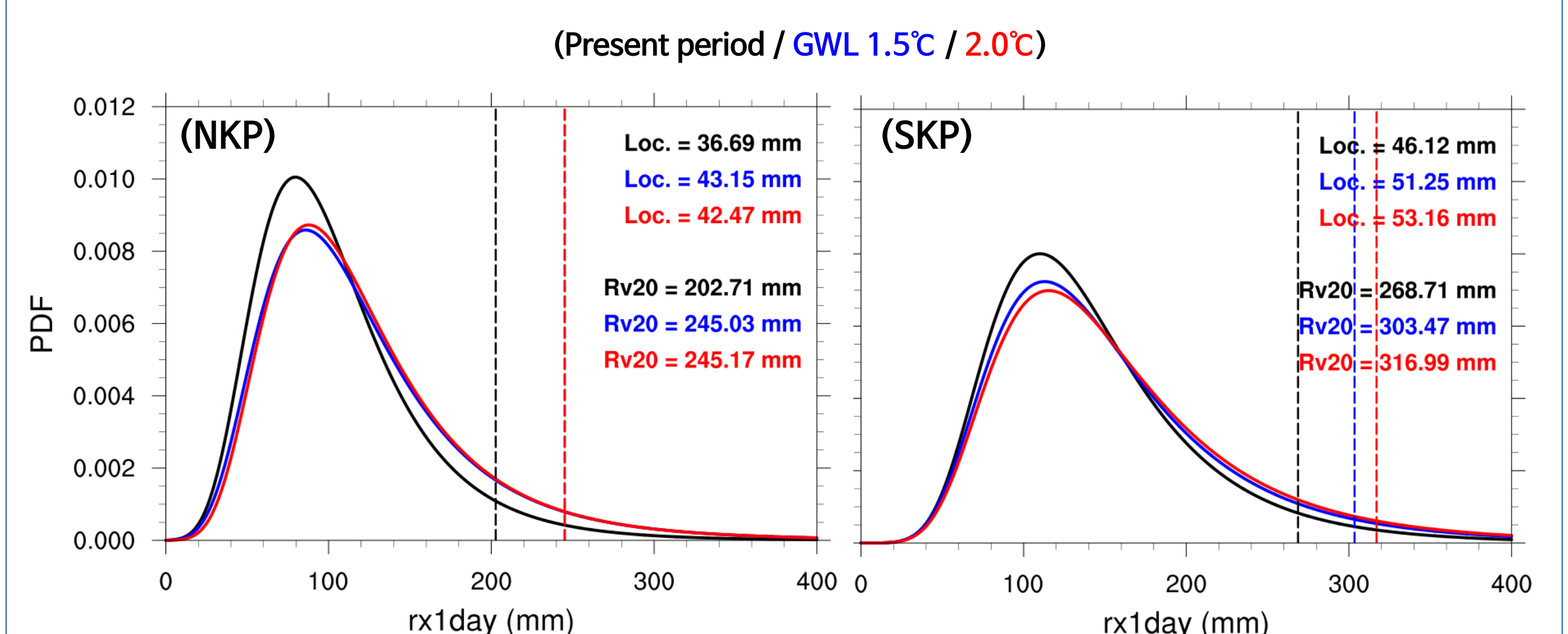- Meanwhile, our study suggests need for limiting GWL to 1.5℃, as other studies.

3. Results

◆ Change of the intensity (RX1day)

- RX1day would be intensified by 12.05% (GWL 2.0℃).
- Larger increase over northern / southern KP (NKP, SKP), not central KP (CKP)
- Additional warming (GWL 2.0℃–1.5℃) would make large increase over southern coast of SKP.

(Anomaly field)
(outlined circle: p-value < 0.05)
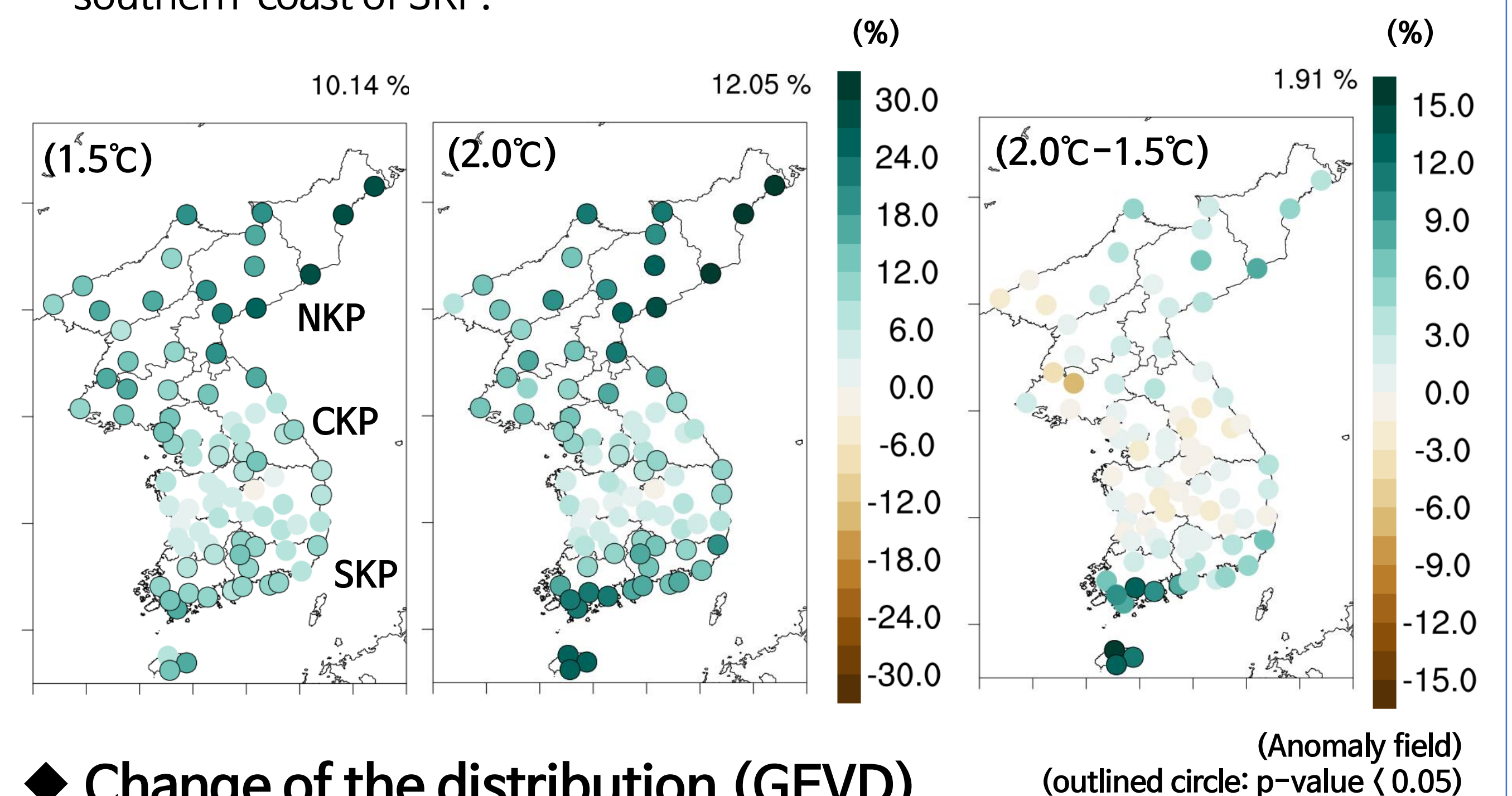
◆ Change of the distribution (GEVD)

- The distribution would shift to the right.
- Therefore, Extreme event (occur once every 20 years in present period)
→ NKP: every 9.96 years / SKP: every 10.88 years under GWL 2.0℃.
- The additional warming would make the distribution shift to the right for SKP.

(Present period / GWL 1.5℃ / 2.0℃)

(NKP) Loc. = 36.69 mm / Loc. = 43.15 mm / Loc. = 42.47 mm
Rv20 = 202.71 mm / Rv20 = 245.03 mm / Rv20 = 245.17 mm

(SKP) Loc. = 46.12 mm / Loc. = 51.25 mm / Loc. = 53.16 mm
Rv20 = 268.71 mm / Rv20 = 303.47 mm / Rv20 = 316.99 mm

◆ Mechanism for the change (C-C relationship)

(Analysis for June to September during days occur RX1day)

- Relationship between the warming and extreme PR over NKP and SKP close to Clausius-Clapeyron (7.7%/℃).
→ Increased moisture capability could intensify extreme PR.
- Regional difference for CKP (2.03%/℃) indicates other possible factors.

(2.0℃) (NKP CKP SKP) — 6.54%/℃, 5.52%/℃, 2.03%/℃
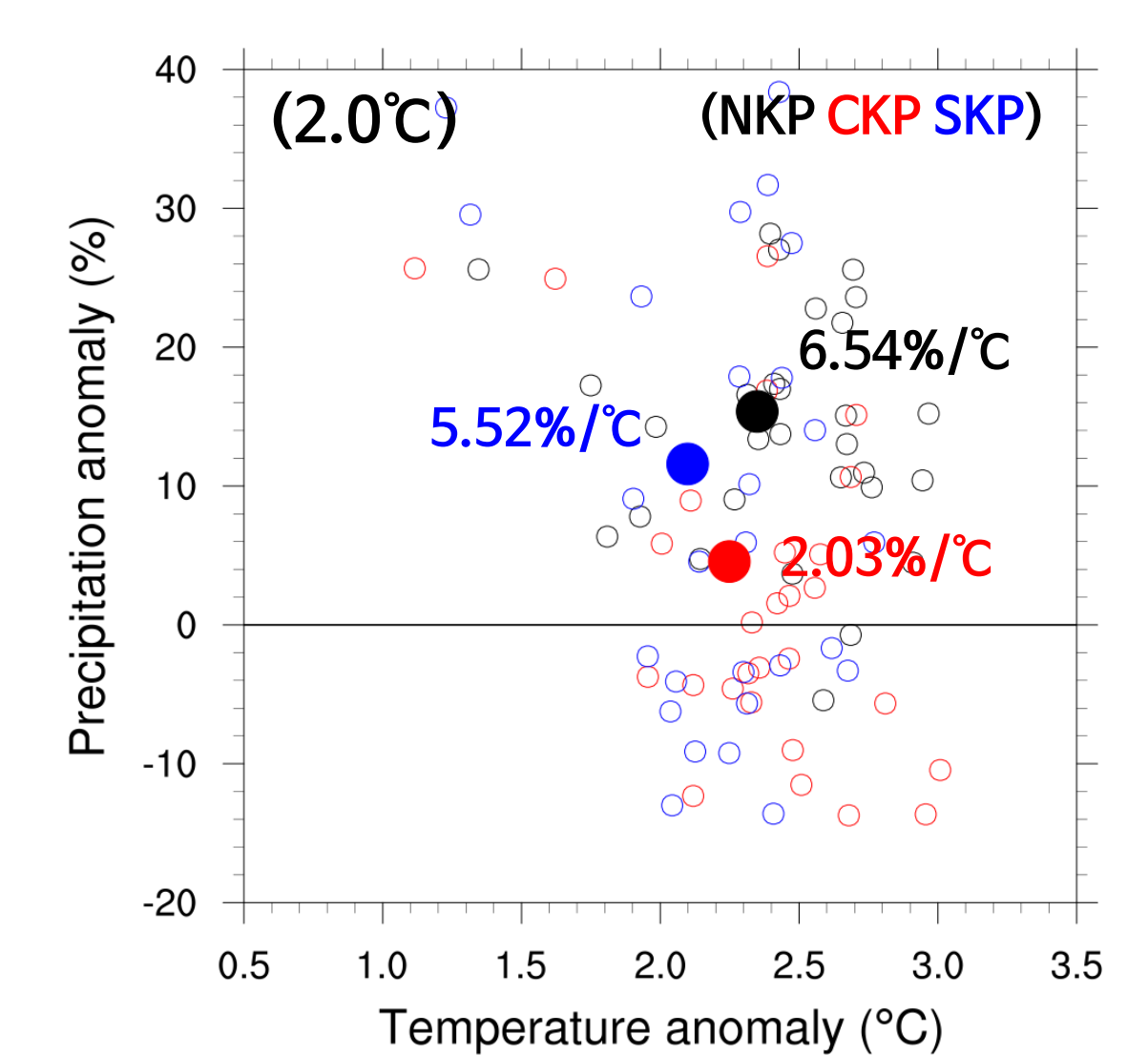
◆ Mechanism for the change (other possible factors)

(2.0℃: 500hPa zg) KP (contour: 5780 gpm) (present, future)

- 500hPa geopotential height (zg)
- Meandering shape (contour).
- Vertical instability condition
→ Would continue under the warming (contour and shading).

- 850hPa moisture flux (MF)
- Low-pressure anomaly over west of KP.
→ Significant increase of MF
- 850hPa MF convergence
→ Also increase around the KP.
→ (orography effect; not shown)

(2.0℃: 850hPa MF) Low

(Anomaly field; cross hatched: p-value < 0.05)