*Supplement of*

Intensification characteristics of hydroclimatic extremes in the Asia monsoon region under 1.5 and 2.0 °C of global warming

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Table S2. Statistical results of the VIC model validation for the selected basins in this study.

Table S3. Statistical results of the VIC model validation for the maximum runoff in the selected basins in this study. Individual value of maximum runoff obtained from the time seriesdatasets (e.g., measured runoff, simulated runoff) used in Figure S4.

**Table S1. Results of the GCM evaluations based on the skill scores of 12 climate variables (pr: precipitation, tas: mean near-surface air temperature, tasmax: maximum near-surface air temperature, tasmin: minimum near-surface air temperature, rlut: outgoing longwave radiation, psl: sea level pressure, tos: sea surface temperature, ta: air temperature, zg: geopotential height, hus: specific humidity, ua: zonal wind, and va: meridional wind)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | GCMs | Score of each variable | | | | | | | | | | | | Total  score | Rank | Select  (O,X) |
| pr | tas | tas  max | tas  min | rlut | psl | tos | ta | zg | hus | ua | va |
| 1 | ACCESS1.0 | 1 | -1 | 1 | 0 | 1 | -1 | 0 | 1 | -1 | -1 | 1 | 1 | 2 | 8 | X |
| 2 | ACCESS1.3 | -1 | -1 | -1 | 1 | 0 | -1 | 0 | 1 | -1 | -1 | 1 | 1 | -2 | 13 | X |
| 3 | bcc-csm1-1 | -1 | 1 | -1 | -1 | -1 | 1 | 0 | -1 | 1 | 1 | 0 | 0 | -1 | 12 | X |
| 4 | bcc-csm1-1-m | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | -1 | 1 | 9 | 2 | O |
| 5 | BNU-ESM | 1 | 1 | -1 | -1 | 1 | 1 | 1 | -1 | 1 | 1 | -1 | 0 | 3 | 7 | X |
| 6 | CanESM2 | 1 | 1 | -1 | -1 | 1 | -1 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 5 | O |
| 7 | CMCC-CM | -1 | 1 | 1 | 1 | 0 | -1 | 0 | 1 | 1 | 1 | 1 | 1 | 6 | 6 | X |
| 8 | CMCC-CMS | 1 | 1 | 1 | 1 | 0 | -1 | 0 | 1 | 1 | 1 | 1 | 1 | 8 | 4 | O |
| 9 | CNRM-CM5 | 1 | 1 | 1 | -1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 9 | 3 | O |
| 10 | GFDL-CM3 | 1 | -1 | 1 | 1 | 1 | -1 | 0 | 1 | -1 | -1 | 1 | 0 | 2 | 9 | X |
| 11 | GFDL-ESM2G | 0 | -1 | 1 | -1 | 1 | -1 | 0 | -1 | -1 | -1 | 1 | 1 | -2 | 14 | X |
| 12 | HadGEM2-CC | 1 | -1 | 1 | 1 | 1 | -1 | 1 | -1 | -1 | -1 | -1 | 1 | 0 | 11 | X |
| 13 | IPSL-CM5A-LR | -1 | -1 | 0 | 1 | -1 | 0 | 0 | 1 | -1 | -1 | -1 | -1 | -5 | 16 | X |
| 14 | IPSL-CM5A-MR | -1 | -1 | 1 | 1 | -1 | 0 | 0 | 1 | -1 | -1 | 0 | -1 | -3 | 15 | X |
| 15 | IPSL-CM5B-LR | -1 | -1 | -1 | -1 | -1 | 0 | 0 | -1 | -1 | -1 | -1 | -1 | -10 | 19 | X |
| 16 | MIROC-ESM | -1 | -1 | -1 | -1 | 0 | 0 | 1 | -1 | -1 | -1 | -1 | -1 | -8 | 18 | X |
| 17 | MIROC-ESM-CHEM | -1 | -1 | -1 | -1 | 1 | 0 | 1 | -1 | -1 | -1 | -1 | -1 | -7 | 17 | X |
| 18 | MRI-CGCM3 | -1 | -1 | 0 | 1 | -1 | 1 | 1 | 1 | -1 | -1 | 1 | 1 | 1 | 10 | X |
| 19 | NorESM1-M | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 10 | 1 | O |

**Table S2. Statistical results of the VIC model validation for the selected basins in this study.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Basin | GRDC station | Area  (km2) | Statistics | | | |
| CC | ME | RMSE (mm/month) | VE (%) |
| 1 | Tone | Fukawa | 12,458 | 0.91 | 0.68 | 24.6 | 33.62 |
| 2 | Yodo | Hirakata | 7,281 | 0.87 | 0.75 | 28.6 | -8.31 |
| 3 | Gan Jiang | Jian | 56,200 | 0.93 | 0.84 | 26.8 | -12.5 |
| 4 | Han Shui | Ankang | 41,400 | 0.95 | 0.84 | 17.7 | 15.8 |
| 5 | Muar | Buluh Kasap | 3,130 | 0.58 | 0.33 | 62.0 | 9.2 |
| 6 | Ganges | Hardinge Bridge | 846,300 | 0.86 | 0.59 | 29.3 | -32.2 |

**Table S3. Statistical results of the VIC model validation for the maximum runoff in the selected basins in this study. Individual value of maximum runoff obtained from the time seriesdatasets (e.g., measured runoff, simulated runoff) used in Figure S4.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Basin | Maximum runoff (mm) | | Relative error (%) |
| Measured value | Simulated value |
| 1 | Tone | 302.4 | 249.0 | -17.7 |
| 2 | Yodo | 333.9 | 299.8 | -10.2 |
| 3 | Gan Jiang | 314.5 | 268.1 | -14.8 |
| 4 | Han Shui | 283.0 | 282.4 | -0.2 |
| 5 | Muar | 405.3 | 271.3 | -33.1 |
| 6 | Ganges | 173.5 | 209.6 | 20.8 |

**Figure Captions**

Figure S1: Six river basins (denoted by No. 1-No. 6, which correspond to the numbers in Table S2) used for validating the VIC model in this study. The countries within the study area are delineated by black lines and white shading, and each basin is outlined by a blue line with various colors. Green circles denote the Global Runoff Data Centre (GRDC) stations located in the outlets of the six individual river basins.

Figure S2: Spatial distributions of the (a) annual minimum temperature (unit: °C) and (b) annual maximum temperature (unit: °C) for the historical period (1976-2005) in the Asian monsoon region. OBS and MME denote the values obtained from the observational temperature dataset and the MME of bias-corrected outputs from the five GCMs, respectively.

Figure S3: Spatial distributions of the (a) annual mean runoff (unit: mm) and (b) daily maximum runoff (unit: mm/day) for the historical period (1976-2005) in the Asian monsoon region. OBS denotes the simulated runoff from the VIC model fed by observational precipitation data (i.e., APHRODITE). MME denotes the simulated runoff from the VIC model fed by the MME of the bias-corrected outputs from the five GCMs.

Figure S4: (a-e) Time series of measured runoff (gray dashed line) and simulated runoff (black solid line) on a monthly basis averaged at each grid in the six river basins (denoted by Basin No. 1-Basin No. 6) corresponding to the labels in Figure S1. The simulated runoff is obtained from the VIC model fed by observational meteorological inputs (unit: mm). The blue bars along the upper x-axis indicate the mean area-averaged precipitation in each grid within the six individual river basins.

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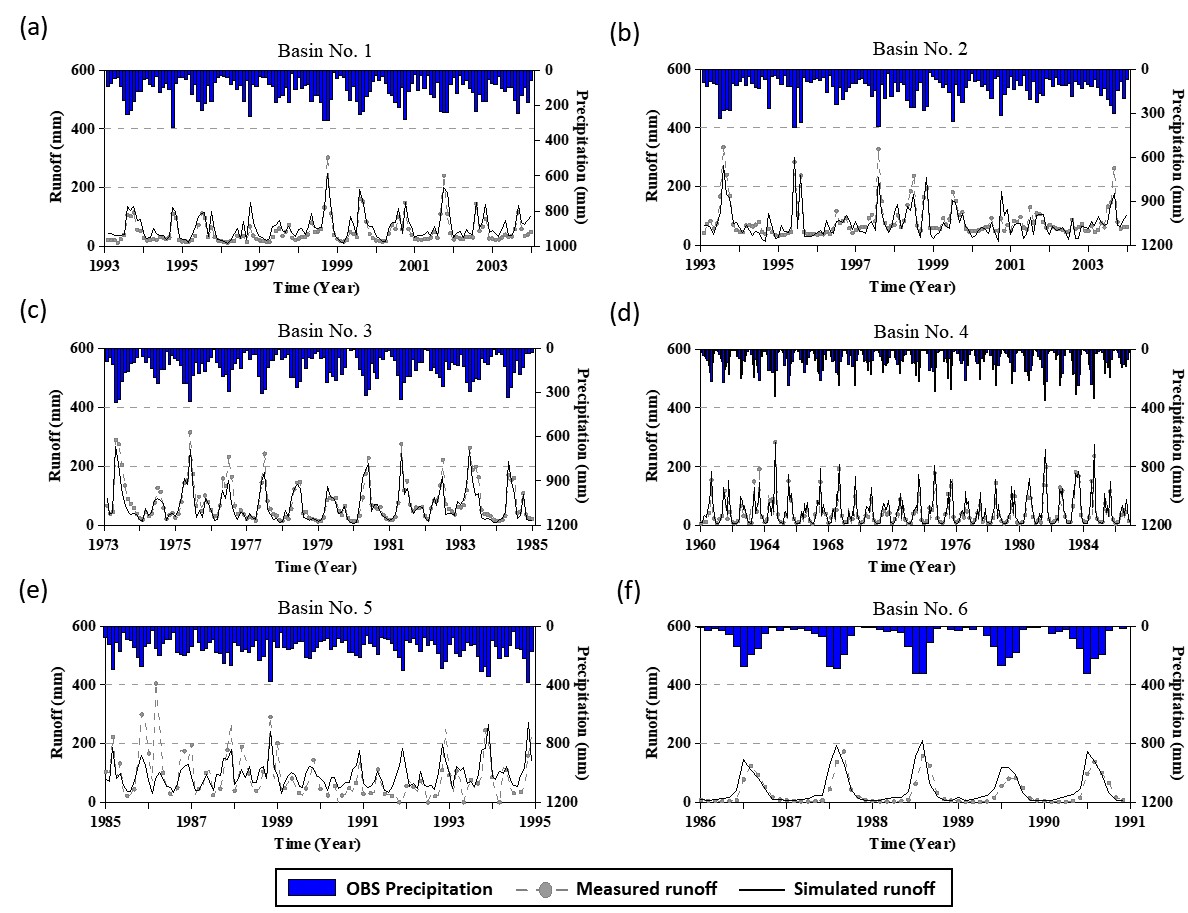
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