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Supplement of

Quantifying projected changes in runoff variability and flow regimes of the Fraser River Basin, British Columbia

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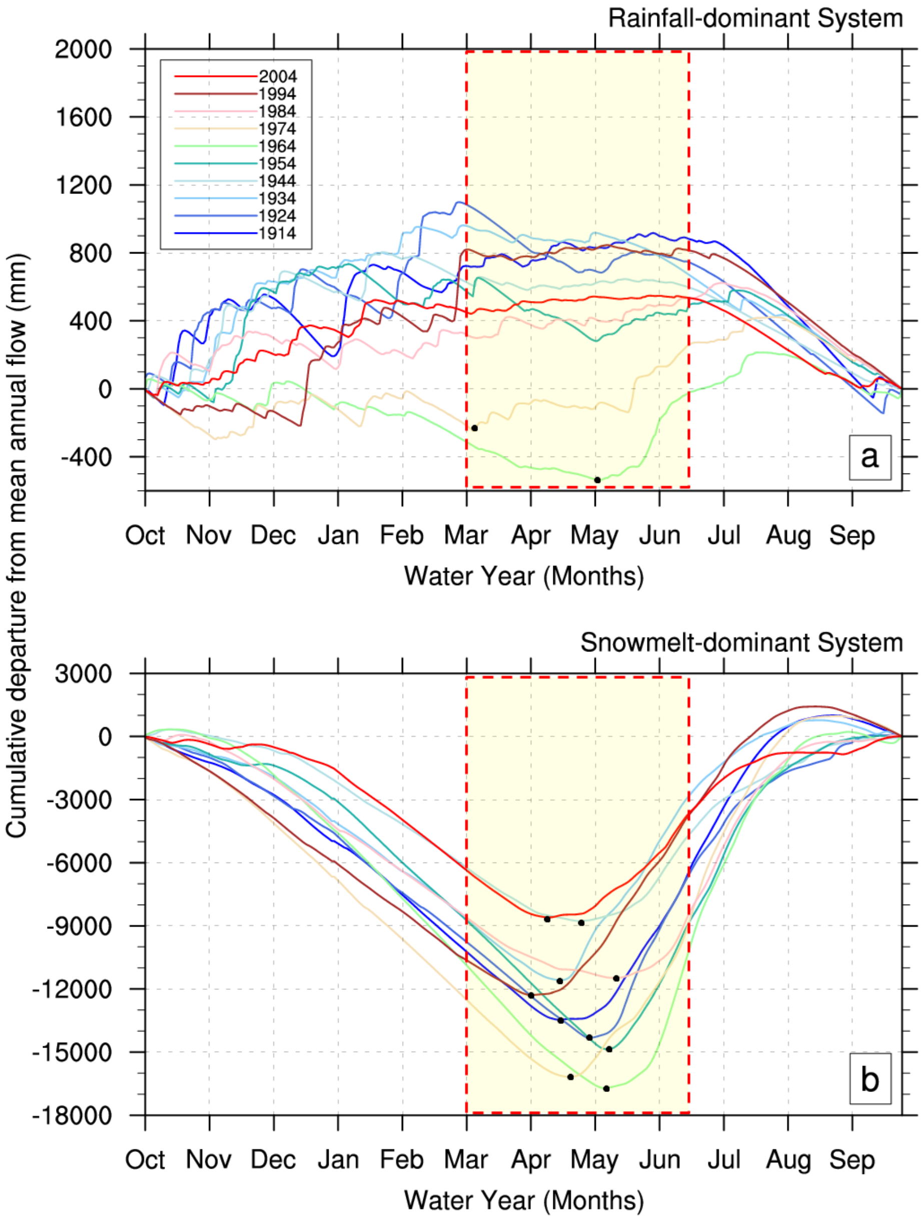
Supplementary Table 1: List of the 21 CMIP5 models used in the present study.

Institution	**Model Name**	**Resolution (Lon.° × Lat.°)**
Commonwealth Scientific and Industrial Research Organization (CSIRO) and Bureau of Meteorology (BOM), Australia	ACCESS1.0 ACCESS1.3	1.8 × 1.2
Beijing Climate Center, China Meteorological Administration	BCC-CSM1.1	2.8 ×2.8
College of Global Change and Earth System Science, Beijing Normal University, China	BNU-ESM	2.8 ×2.8
Canadian Centre for Climate Modelling and Analysis, Canada	CanESM2	2.8 × 2.8
National Center for Atmospheric Research, U.S.A.	CCSM4	1.2 × 0.9
Centre National de Recherches Météorologiques/Centre Européen de Recherche et Formation Avancée en Calcul Scientifique, France	CNRM-CM5	1.4 × 1.4
Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence, Australia	CSIRO-Mk3.6.0	1.8 ×1.8
LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; and CESS, Tsinghua University, China	FGOALS-g2	1.8 × 1.2
NOAA Geophysical Fluid Dynamics Laboratory, U.S.A.	GFDL-CM3 GFDL-ESM2G GFDL-ESM2M	2.5 × 2.0
Institute for Numerical Mathematics, Russia	INM-CM4	2.0 × 1.5
Institut Pierre-Simon Laplace, France	IPSL-CM5A-LR IPSL-CM5A-MR	3.7 × 1.9
Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute and National Institute for Environmental Studies, Japan	MIROC-ESM	2.8 × 2.8
	MIROC5	1.4 × 1.4
Meteorological Research Institute, Japan	MRI-CGCM3	1.1 × 1.1
Max Planck Institute for Meteorology, Germany	MPI-ESM-LR MPI-ESM-MR	1.8 × 1.8
Norwegian Climate Centre, Norway	NorESM1-M	2.5 × 1.9

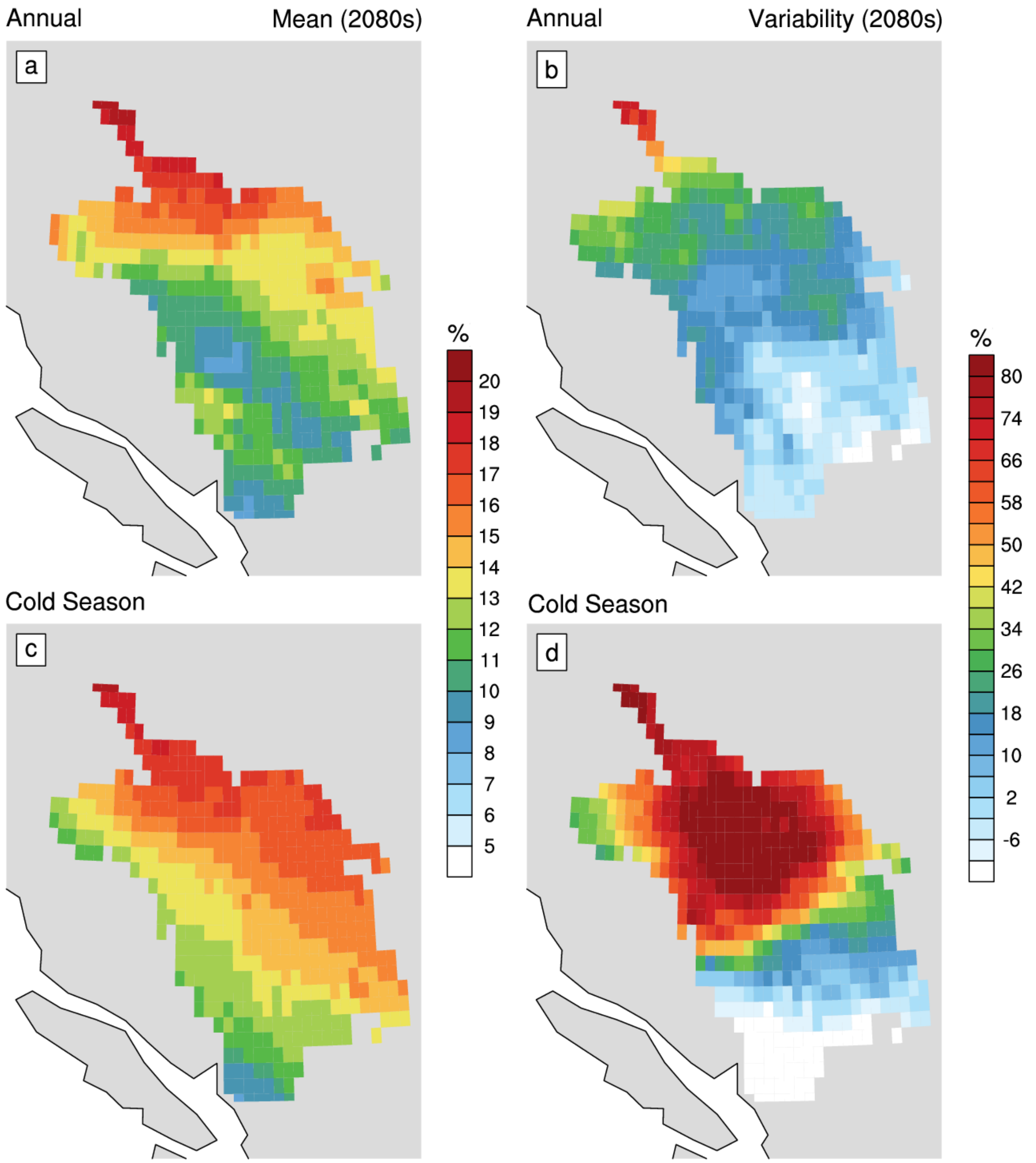
All model outputs are for RCP 8.5, are statistically downscaled and bias-corrected using BCCAQ2 (Sec. 2.2), and are regridded to a common horizontal resolution of 0.25° to facilitate the VIC model simulations.

Supplementary Table 2: 30-year runoff mean and interannual variability (estimated by standard deviation). Values are calculated for each individual CMIP5-VIC simulation and are averaged to get the MME annual mean. The inter-model spread in runoff mean and its interannual variability are indicated as uncertainty ranges (±) estimated by a 5-95% models range.

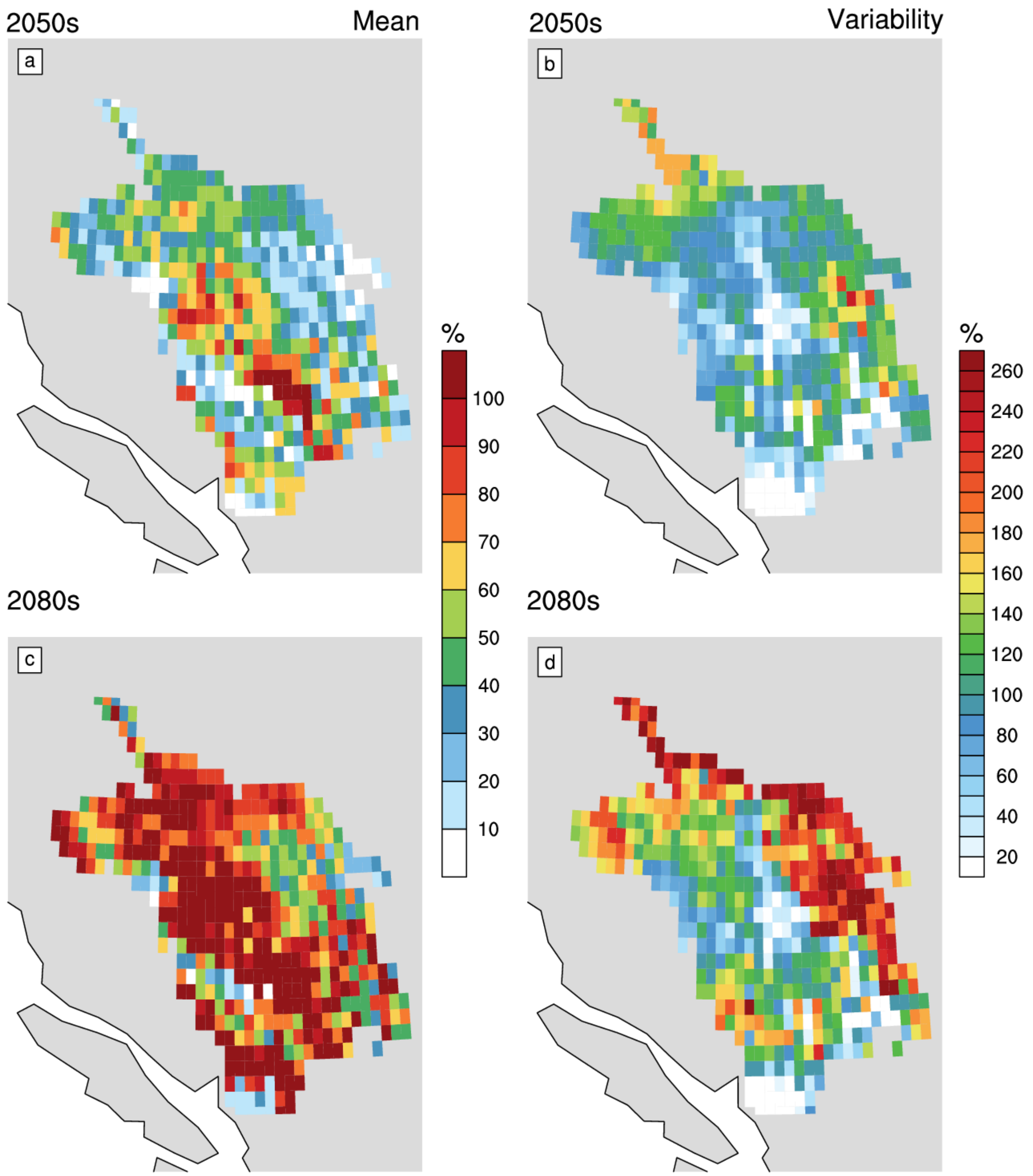
Basin	Mean and interannual variability of Runoff (mm yr^{-1})					
	1990s (1980-2009)		2050s (2040-2069)		2080s (2070-2099)	
	Mean	**Variability**	**Mean**	**Variability**	**Mean**	**Variability**
Rocky Mountains	790 ± 9	129 ± 10	798 ± 25	128 ± 9	796 ± 32	133 ± 7
Interior Plateau	220 ± 3	41 ± 3	228 ± 7	41 ± 3	236 ± 10	42 ± 3
Coast Mountains	1250 ± 10	158 ± 8	1364 ± 25	177 ± 12	1410 ± 33	206 ± 14
UF	554 ± 55	120 ± 15	548 ± 58	121 ± 15	535 ± 60	123 ± 14
QU	551 ± 7	110 ± 8	550 ± 19	109 ± 8	545 ± 23	112 ± 6
TN	347 ± 4	72 ± 5	349 ± 11	69 ± 5	347 ± 14	74 ± 4
CH	417 ± 5	65 ± 4	461 ± 10	70 ± 5	493 ± 12	74 ± 5
LF	358 ± 4	58 ± 4	369 ± 11	58 ± 4	376 ± 13	61 ± 3



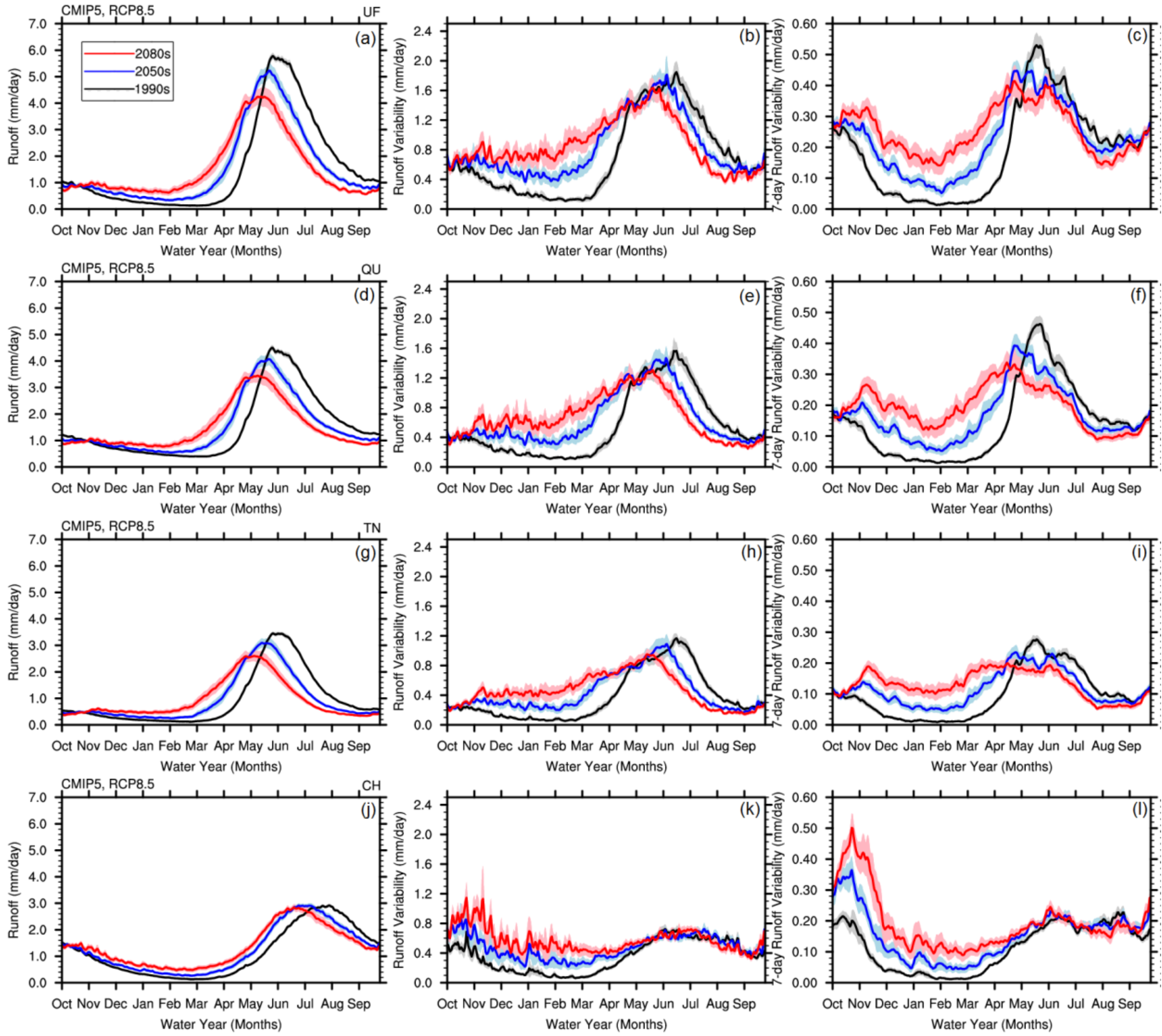
Supplementary Figure 1: Cumulative departure from the water year's mean observed flow for the Capilano River Above Intake (WSC ID 08GA010) (a) and Fraser River at Hope (WSC ID 08MF005) (b), for 10 years within the 1914-2010 time period. Panel (a) demonstrates a rainfall-dominant system where snowmelt pulses (SPs) are detected in only two of the 10 years whereas panel (b) illustrates a river where there are clear SPs in all the selected years. Black dots represent the day of water year (i.e. SP) when cumulative departure from the mean flow is a water year maximum. The discharge data are acquired from the Water Survey of Canada's Hydrometric Dataset (HYDAT; Water Survey of Canada, 2018).



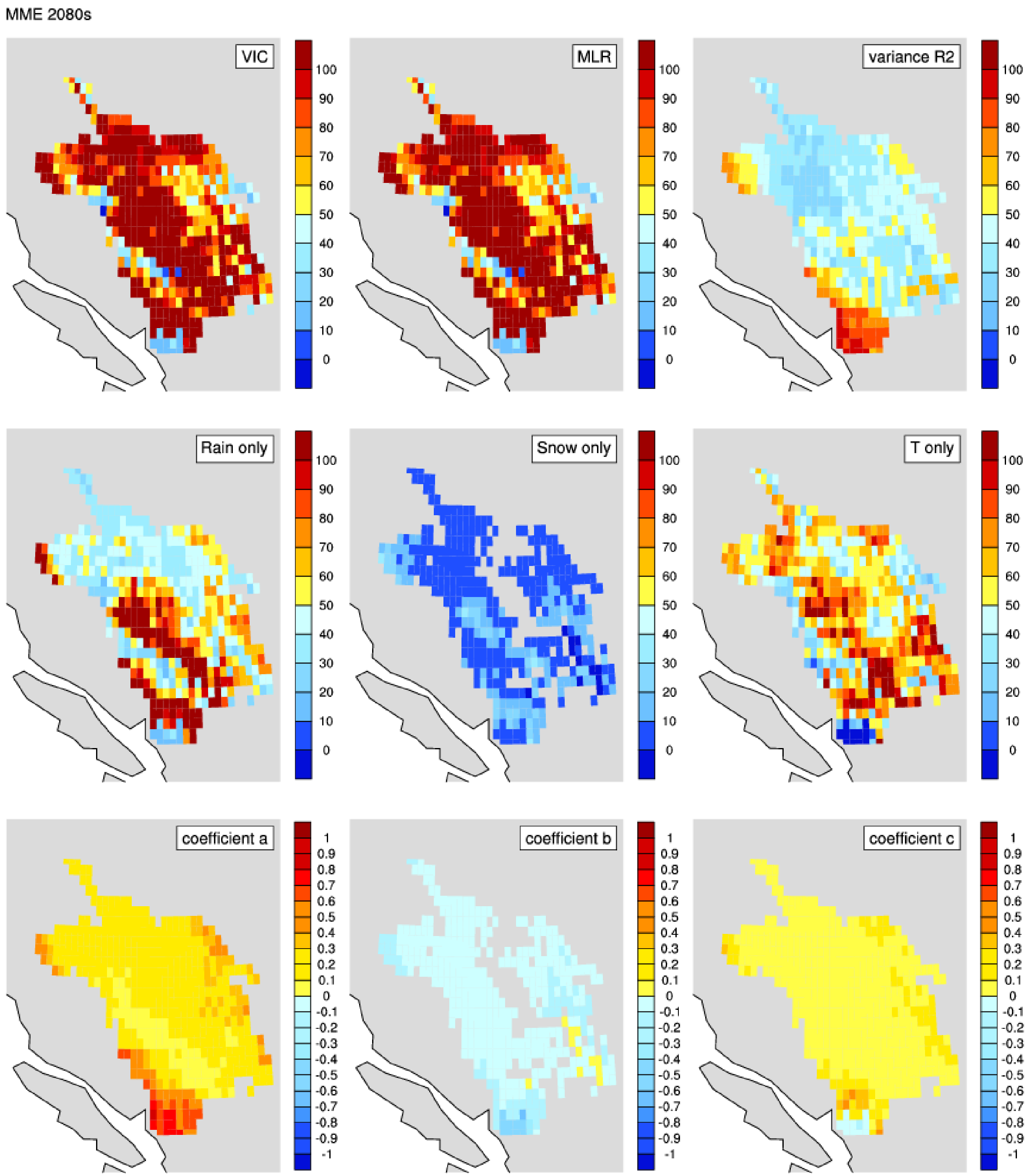
Supplementary Figure 2: Spatial patterns of change in MME mean (a, c) and interannual variability (b, d) of CMIP5 models precipitation in the 2080s relative to the 1990s. Panels (a-b) shows annual changes and panels (c-d) are for the cold season only. Units are in %.



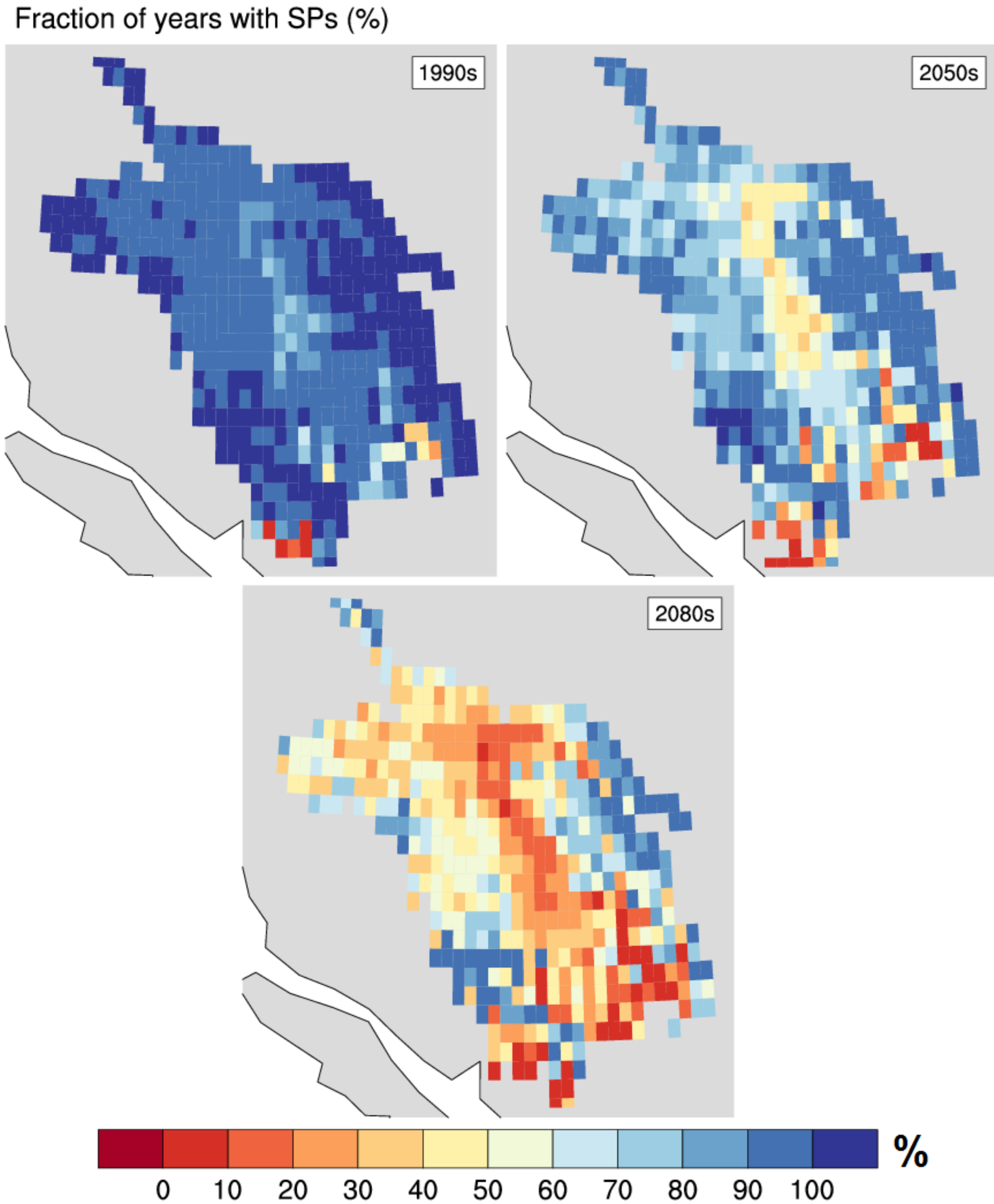
Supplementary Figure 3: Spatial patterns of change in MME mean (a, c) and interannual variability (b, d) of CMIP5-VIC simulated cold season runoff in the 2050s and 2080s relative to the 1990s. Units are in %.



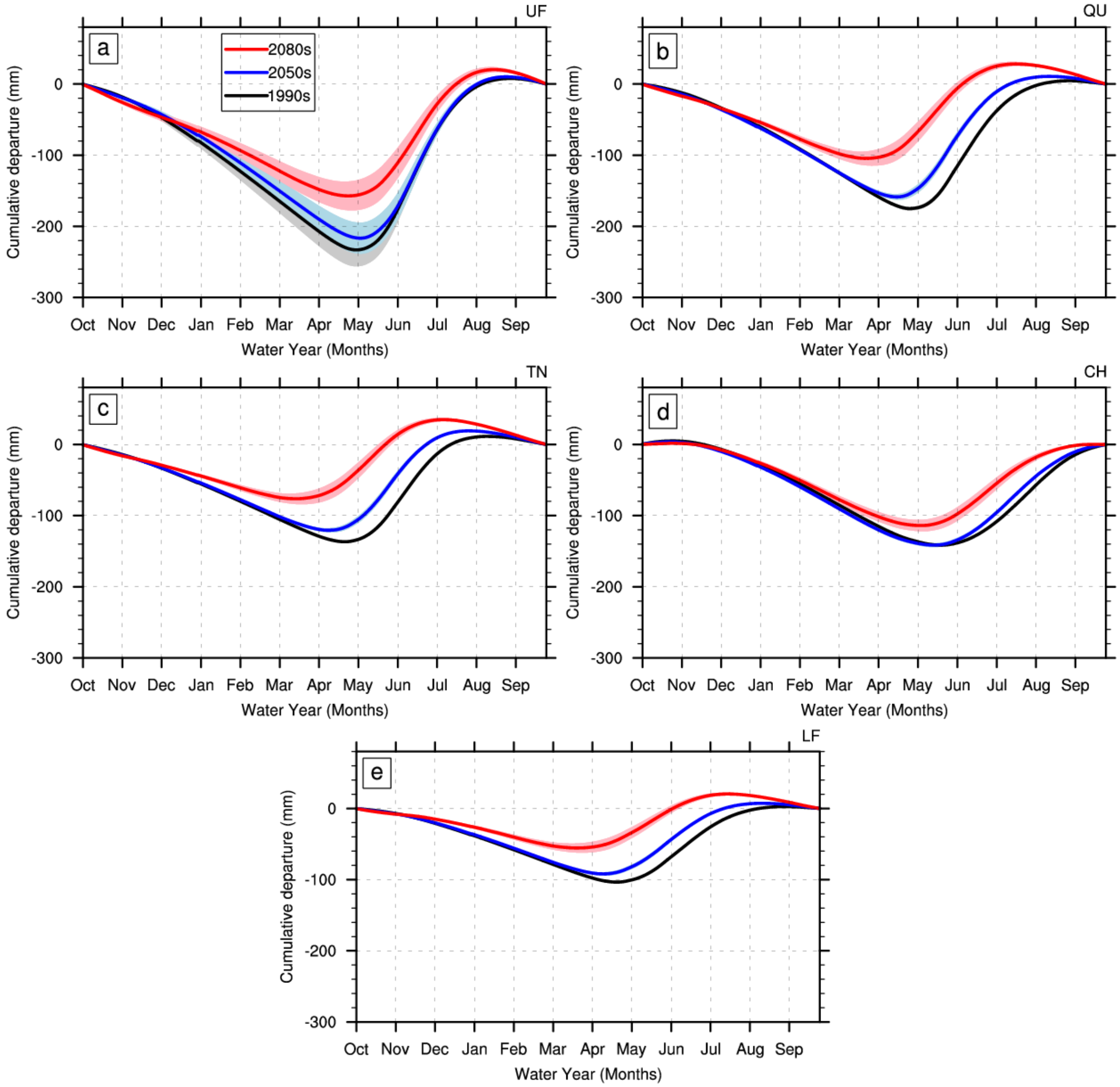
Supplementary Figure 4: CMIP5-VIC simulated daily runoff mean (a, d, g, j), variability (b, e, h, k) and 7-day moving average variability (c, f, i, l) for the UF, QU, TN and CH sub-basins. Black, blue and red curves represent the MME mean for the 1990s, 2050s and 2080s respectively. Shading represents inter-model spread as represented by 5-95% models range.



Supplementary Figure 5: Decomposition of key drivers affecting cold season runoff changes in the 2080s. Contributions are in % estimated using the multivariate linear regression (MLR, described in section 2.4.2) model forced with time series from 21 CMIP5 simulations. R^2 provides the variance explained by all three variables. Gridcells are shown only with values significant at p-value < 0.05.



Supplementary Figure 6: CMIP5-VIC simulated MME mean fraction of years with snowmelt pulses (SP, %) in the 1990s (a), 2050s (b), and 2080s (c). Zero values are assigned to gridcells where no snowmelt pulses are detected. Units are in %.



Supplementary Figure 7: CMIP5-VIC simulated cumulative flow departures for the 1990s, 2050s and 2080s for all sub-basins. Thick lines are for the MME mean and shading indicates the 5-95% models range. Units are in mm.