Poster4-V58

ASSESSING CURRENT TRENDS AND DOWNSCALING OF MOIST HEATWAVES IN SOUTHERN VIETNAM AND CAMBODIA TO UNCOVER FORMATION MECHANISMS AND DYNAMICS

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1. INTRODUCTION

Moist heatwaves (HWs) are intensifying under the influence of global warming, posing severe risks to densely populated tropical regions such as the Indian subcontinent and Southeast Asia. These events have profound implications for public health, agriculture, and energy systems P. D. Howe (2019). While the role of temperature in heat stress is well recognized, the impact of relative humidity (RH) remains insufficiently explored. In addition, high-resolution datasets that adequately represent key variables such as air temperature (TAS), maximum air temperature (TASMAX), minimum air temperature (TASMIN), and RH are notably scarce across these regions. This study employs advanced statistical downscaling techniques to generate 9-km daily datasets and to model the dynamics of moist HW metrics, their formation mechanisms, and associated compound events. The findings aim to provide actionable insights for the development of urgent and effective regional climate adaptation strategies.

2. USED DATA & METHODOLOGY

Type	Name	Spatial Grid	Period, Interval	Variables
Observation	MSWX-GloH2o	0.1×0.1	1978−present, 3-hourly	tasmin
	VN-OBS	0.1×0.1	1980−2015, daily	tas
RCMs CORDEX Domain SEA22	RCA4-CNRM-CM5	0.22×0.22	Hist: 1981−2005, daily	tasmax
	EC-Earth3-Veg		RCPs 2.6, 8.5: 2015−2100	rh
GCMs (CMIP6)	EC-Earth3-Veg	0.7×0.7	Hist: 1981−2014, daily	precipitation
	EC-Earth3	0.7×0.7	SSP1.26, 5.85: 2051−2100	
	HadGEM3-GC31-MM	0.83×0.56		
NEX-GDDP variant: r1i1p1f1 Downscaled products from NASA via BCSD	ACCESS-CM2	0.25×0.25	Hist: 1981−2014, daily	
	ACCESS-ESM1-5			
	BCC-CSM2-MR			
	CanESM5			
	CMCC-CM2-SR5			
	CMCC-ESM2			
	EC-Earth3			
	EC-Earth3-Veg-LR			
	GFDL-CM4			
	GFDL-ESM4			

Table: Summary of used data. The blue text is used for downscaling purposes, while the black text is used for comparison or other calculations.

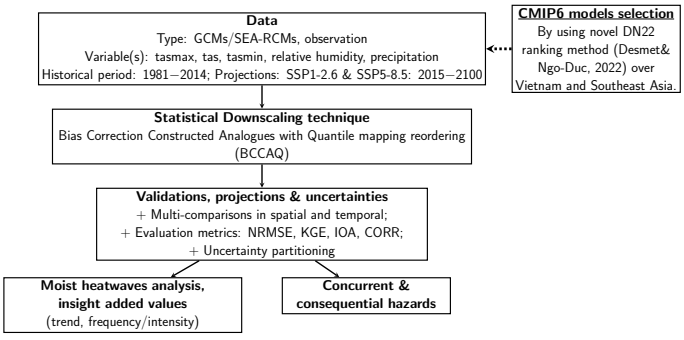


Figure 1: Conceptual workflow

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A heat wave event is a period during which daily mean temp exceeds the 90^{th} percentile for at least 3 consecutive days between May and October. And, moist HW is characterized by an RH of 66% or more K. J. Ha (2022). To further access moist HW metrics, let T_d be the maximum temperature on the day d, and n the total number of HW days. The 25^{th} and 75^{th} percentiles of maximum temperature for the reference period (1981−2000) are denoted as T_{ref25p} and T_{ref75p}, respectively. Tr90_d is the 90^{th} percentile threshold temperature S. E. Perkins-Kirkpatrick (2020).

○ HeatWave Magnitude Index daily

$$\text{HWMId}_{\text{hw}} = \sum_{d=1}^{n_{\text{hw}}} M_d(T_d);$$

$$\text{where} \quad \text{M}_d(T_d) = \begin{cases} \frac{T_d - T_{\text{ref25p}}}{T_{\text{ref75p}} - T_{\text{ref25p}}} & \text{if } T_d > T_{\text{ref25p}}, \\ 0 & \text{if } T_d \le T_{\text{ref25p}}. \end{cases}$$

○ Average Intensity AVI $= \frac{\sum_{d=1}^{n} T_d}{n}$

○ Average Anomalies AVA $= \frac{\sum_{d=1}^{n} (T_d - \text{Tr90}_d)}{n}$

3. RESULTS

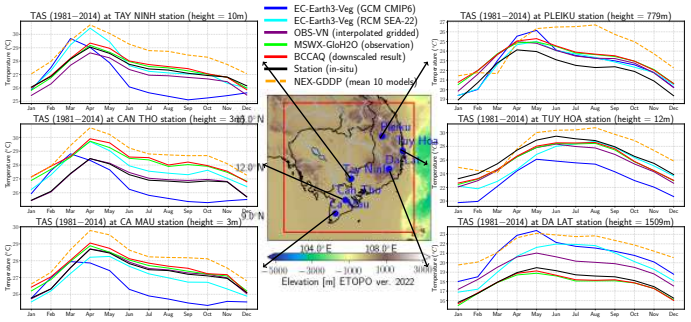


Figure 2: Seasonal TAS (outermost LHS and RHS) across 6 stations, shown as blue dots on the topography. Red rectangle is Region of interest (ROI) within the scopes of this study.

This study multi-compares seasonal between models and downscale TAS over 6 stations. BCCAQ M. Clark (2004); A. T. Werner (2016) outperforms the CMIP6 model and aligns closely with in-situ data, while NEX-GDDP products (achieved via Bias Correction and Spatial Downscaling) overestimate temperature by 1–3^{o}C at most stations (Figure 2). Results from several Mekong Delta stations accurately capture the pre-monsoon temperature peak during the dry season February-March-April-May (FMAM).

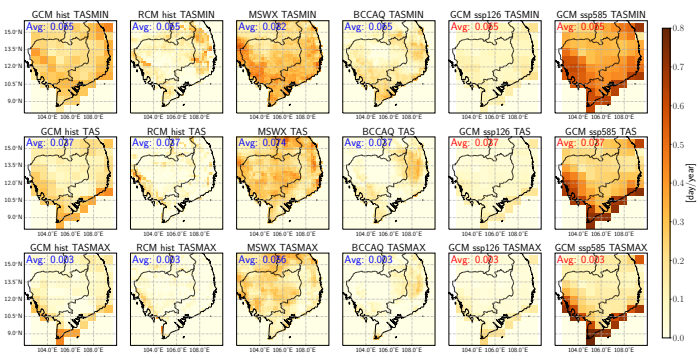


Figure 3: Moist HW day(s)/years. TASMIN tends to record higher values than TAS and TASMAX in historical period and scenarios.

Analysis of HWMId and AVI shows high values in urban areas like Ho Chi Minh City and Phnom Penh, with a projected increase of up to 0.8 HWs day(s)/year under the SSP-5.85 scenario, especially in coastal regions (Figure 3). TASMIN (night/early morning temperature) consistently records higher values than TAS and TASMAX, suggesting reduced heat release due to the greenhouse effect of high moisture. Verifying these assumptions with sub-daily or hourly data would help to better understand day/night temperature differences during moist HW. Furthermore, spatial performance is assessed using the Expert Team on Climate Change Detection and Indices (ETCCDI), GCM/RCM models, observations, and downscale results. The spatial BCCAQ performance accurately represents climate indices and climatologies at finer resolutions, improving predictions of extreme events like tropical nights and summer days in regional climates as well climatologies of long rain seasons June-July-August-September-October (JJASO) ad RH over ROI. (Figure 4).

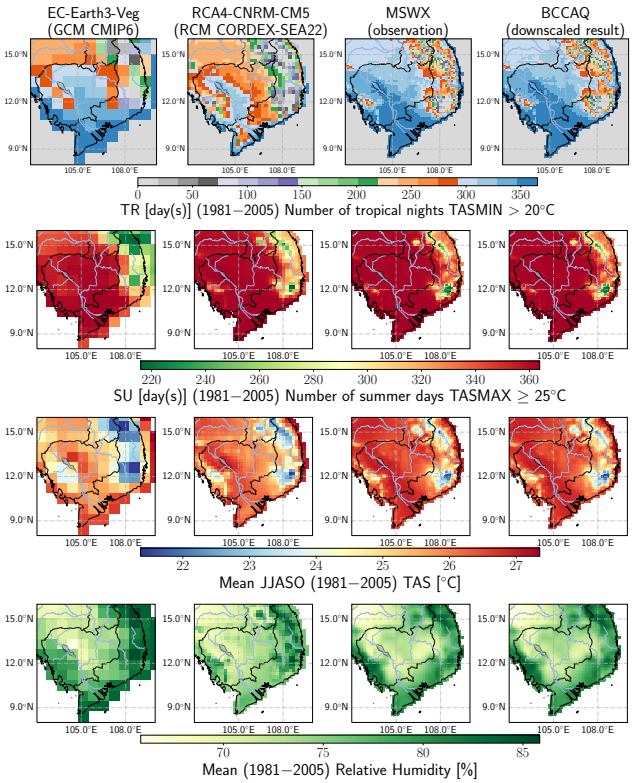


Figure 4: Columns (LHS to RHS) show GCM, RCM, observation, and downscale results.

4. CONCLUSIONS

Moist HWs are prominently represented by days per year with TASMIN, and for the first time, the advanced hybrid downscaling method BCCAQ is applied over Southeast Asia. Mountainous regions pose ongoing challenges for GCM/RCM, and higher resolution may not always improve understanding of the physical processes driving local climate patterns. Future research focuses on identifying the drivers of moist HWs and exploring compound events to further unravel these complex climate dynamics.

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