iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 8 **Issue:** IX **Month of publication:** September 2020

**DOI:** https://doi.org/10.22214/ijraset.2020.31604

# Climate Change Assessment using Climate Indices Approach: A Brief Overview

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***Abstract: Climate of the world is increasingly becoming unpredictable in terms of the prevailing hydro-meteorological trends and the subsequent impact on the water resources of different regions by changing frequency, duration and magnitude. In order to better assess such climate impacts for the future, Global and Regional Climate Models are utilized to accurately simulate the most likely changes in the climate based on the current prevailing trends. World Climate Research Program (WCRP) approved Expert Team on Climate Change Detection Monitoring and Indices (ETCCDMI) Climate Indices technique is one of the widely used approach in assessing such trends in climate based on meteorological variables of the regions. Climate Indices approach utilizes daily temperature and precipitation variables on daily time steps to compute 27 core indices for assessing changing trends in the climate of the region. This study illustrates the use of climate indices approach for climate change assessment.***
***Keywords: Climate Change, Hydro-Meteorological Modelling, Climate Indices, Rclimdex Package, Impact Assessment***

## I. INTRODUCTION

On a global scale, the increased carbon emissions with the recent decades in particular accelerated the warming of the atmosphere with an increase in variation of meteorological trend in most parts of the world. The hap hazard use of fossil fuels for cheap energy generation for commercial and industrial requirements to meet the ever-increasing demography of population along with decreasing cultivable land and forest cover contributed to an overall increased concentration of carbon foot-print being trapped in the atmosphere has severely altered the global water cycle with some regions affected more severely in terms of hydro-meteorological trends resulting in severe droughts, famines, heat-waves, urban flooding, seasonal shifts and anomalies [1],[2],[3]. Extensive research is being conducted to assess the impact of such accelerated climate change variations on various fields most notably its impact on both global and local scale hydrological cycle, agriculture and food security, terrestrial and marine ecosystems etc. Climate change is fast becoming an existential threat to existing and future water supply balance with the need to effectively tackle water management strategies throughout the globe [4], [5].

## II. CLIMATE CHANGE ASSESSMENT USING CLIMATE MODELS:

In the recent past, most of the knowledge related to climate was based on the historical record of observed weather events, forecasts and regional topography to assess the fluctuations in climate of such regions for impact studies [6]. Extrapolation of such weather events along with an appropriate statistical technique was used to arrive at observations of likely future behaviour of climate anomalies [7]. Up until then, climate models were rarely incorporated into such impact studies due to the greater level of uncertainties in its outcomes. But in the recent advancements in cloud computing technology, researchers have been able to more accurately simulate or model the climate of the world. Presently, these climate models are the main source of predicting climate change assessments for the future [8], [9].

The uneven distribution of water resources coupled with accelerated anthropogenic activities such as population increase, urbanization and industrial growth, the global circulation patterns are going to be affected; aggravating climate of different regions [10]. This would in turn influence the global hydro-meteorological patterns both on a spatial as well as temporal level [11]. Changing precipitation patterns with uncertain temperatures in the future scenario would affect hydrological cycles on the regional and global scale depicting climate change [12]. For this purpose, artificial simulation software mimicking the global atmospheric and weather patterns under the aforementioned scenarios would project the future hydro-meteorological characteristics in order to arrive at most-likely picture of the climate with less uncertainties for better management of existing water resources of the world [10]. Global Circulation Models or Global Climate Models (GCM) contemplate the present climate and based on its algorithms, predict the future likely change in the climate [13], [14]. GCM data output resolution is coarse with each grid cell covering the climate of approximately 200 to 500 km of area which becomes a major hurdle in predicting regional/local climate with accuracy. GCM's, although do provide quantitative assessment of future climate change though with inherent biases since local topography and weather alterations are not accurately distinguished in GCM outputs [15]. With such uncertainties encompassing GCM datasets, accurate climate change projections become difficult for impact studies with different emission scenarios for the future. Dynamically downscaled Global Circulation Models at fine spatial resolutions of 25 to 50 km grid-size, known as Regional Circulation Models (RCM) are more suited for impact studies at regional scale encompassing sub-surface investigations, hydrological flow estimations, flood vulnerability and risk assessment, flora and fauna change etc.; since finer resolutions enable for better modelling of local climates i-e., weather and topography incorporation in climate change Impact studies [16], [17], [18].

## III. CLIMATE INDICES

From climate indices for vulnerability assessments (climate indices can be defined as a set of relations between different hydro-meteorological parameters in a specific way so as to assess its impact on likely climate change and denominate its effect. It could be a parameter like the frequency, intensity or magnitude of precipitation or temperature extremes monthly, seasonally, annually; and how it could change in the future scenarios and impact climate change. Such indices are a manifestation of simplifying the impact of climate change in a more robust and quantifiable manner for the understanding of research communities of various sectors having a direct impact of such change [8].

## IV. HISTORICAL BACKGROUND OF CLIMATE INDICES DEVELOPMENT

The persistent problem that researchers faced while canvassing for evidence of changing climate was the lack and inadequate cache of observed historical weather data for consistent and homogenous portrayal of climate change and hence, thereof, the inability to detect high quality and consistent changes in climate variables. During the late end of the 20$^{th}$ century, world Meteorological Organization (WMO) created Inter Governmental Panel on Climate Change (IPCC) to effectively tackle scientific information at government level in order to disseminate knowledge for effective assessment, future risks; and its adaptation and mitigation strategies through Working Groups (WG) and publishing Assessment Reports on a regular basis. At first, indices at seasonal and annual scales were developed between the first and second assessment reports but a region wide approach for climate indices calculation was still missing.

## V. ETCCDMI BASED CLIMATE INDICES APPROACH

WMO Commission for Climatology through its World Climate Research Programme (WCRP) project on climate variability (CLIVAR) constituted an Expert Team on Climate Change, Detection, Monitoring and Indices (ETCCDMI) developed a core set of twenty-seven indices derived from daily maximum temperature, minimum temperature and precipitation through its published report in June, 009 where a detailed overview of its rationale, use, detection, quality control and assessment mechanism for improving understanding of climate change detection is outlined. Out of the twenty-seven indices, sixteen are temperature related and 11 are precipitation related indices. Such indices can be divided into absolute, threshold, duration, percentile and other indices that do not fit into any of the mentioned groups of indices. A List of the 27 ETCCDI core climate indices and their definitions are available online at http://etccdi.pacificclimate.org/list_27_indices.shtml [19], [20].

## VI. RCLIMDEX PACKAGE USING R-SOFTWARE

A powerful statistical software R (see http://www.r-project.org) is used to compute these 27 core indices for different regions under study by using various GCM and/or RCM datasets input for present and future periods with various IPCC emission scenarios. Xuebin Zhang and Yang Feng at Climate Research Division have developed and maintained a source code “RClimdex” that provides a friendly user interface to compute all 27 core indices in R-software [21], [22]. It is pertinent to mention that owing to the constraint of missing observed data, not all indices will be successfully calculated except for modelled data since it will have no such missing values. RClimdex package performs data quality control as a prerequisite for indices calculation. Once the indices are calculated, changes in temperature and precipitation patterns and trends can be assessed for likely impact of climate change. The quality control is maintained by the package includes an internal format that replaces missing values by #N/A which the software recognizes as values not present. Value that are deemed unreasonable like negative precipitation values and daily values when maximum temperature is less than the minimum temperature is all replaced as not available. Rclimdex package does not compute monthly indices if 3 day values are missing whereas for annual indices computation only 15 days missing values are tolerated. For threshold indices calculation, 70% of the data needs to be present. Quality control also removes user defined outliers i.e., those values that are deemed outside defined threshold of the user [23], [22].

## REFERENCES


[1] N. Hengade, T. I. Eldho, and S. Ghosh, "Climate change impact assessment of a river basin using CMIP5 climate models and the VIC hydrological model," *Hydrol. Sci. J.*, vol. 0, no. 0, 2018.

[2] L. Berga, "The Role of Hydropower in Climate Change Mitigation and Adaptation: A Review," *Engineering*, vol. 2, no. 3, pp. 313–318, 2016.

[3] B. Tarroja, A. Aghakouchak, and S. Samuelsen, "Quantifying climate change impacts on hydropower generation and implications on electric grid greenhouse gas emissions and operation," *Energy*, vol. 111, pp. 295–305, 2016.

[4] J. Joo, A. Zhang, X. Li, and C. Zheng, "Hydrological Responses to Climate Shifts for a Minimally Disturbed Mountainous Watershed in Northwest China," vol. 6667, no. June, 2017.

[5] C. Data, "Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation," no. 72.

[6] N. Nicholls and L. Alexander, "Has the climate become more variable or extreme? Progress 1992 – 2006," vol. 31, no. 1, pp. 77–87, 2015.

[7] S.-W. Folland, Chris & Karl, T.R. & Christy, J.R. & Clarke, R.A. & Gruza, G.V. & Jouzel, J. & Mann, Michael & Oerlemans, J. & Salinger, M. & Wang, *Observed Climate Variability and Change*. 2001.

[8] R. Meteorology, G. Persson, G. Strandberg, and M. Rummukainen, "Climate indices for vulnerability assessments," no. 111, 2007.

[9] K. Randall, D.A. & Wood, R.A. & Bony, Sandrine & Colman, R. & Fichefet, T. & Fyfe, J. & Kattsov, V. & Pitman, A. & Shukla, Jayashri & Srinivasan, Jayaraman & Ronald, Stouffer & Sumi, Akimasa & Taylor, *Climate Models and Their Evaluation*. 2007.

[10] N. Chokkavarapu and V. Ravibabu, "Comparative study of GCMs, RCMs, downscaling and hydrological models: a review toward future climate change impact estimation," *SN Appl. Sci.*, no. May, 2019.

[11] S. Kim, B. Sik, and K. Hwandon, "Assessment of future water resources and water scarcity considering the factors of climate change and social – environmental change in Han River basin, Korea," 2014.

[12] S. Kusangaya, M. L. Warburton, E. Archer, V. Garderen, and G. P. W. Jewitt, "Impacts of climate change on water resources in southern Africa : A review," *J. Phys. Chem. EAR*, 2013.

[13] F. Medicine and S. Paulo, "schistosomiasis," *Lancet Infect. Dis.*, vol. 14, no. 7, pp. 553–554, 2014.

[14] T. I. Panel *et al.*, *C l i m a t e Ch a n g e 2 0 0 7: I m p a c t s, Adaptation and Vulnerabilit y*.

[15] Impacts, Adaptation, and Vulnerability, "C LIMATE C HANGE 2001".

[16] D. P. Van Vuuren *et al.*, "The representative concentration pathways: an overview," pp. 5–31, 2011.

[17] C. Dyn, C. Park, S. Ki, M. Donghyun, L. Dong, and H. Cha, "Evaluation of multiple regional climate models for summer climate extremes over East Asia," *Clim. Dyn.*, 2015.

[18] S. By, "Assessment of climate change impact on water resources in the Pungwe river basin," pp. 138–157, 2011.

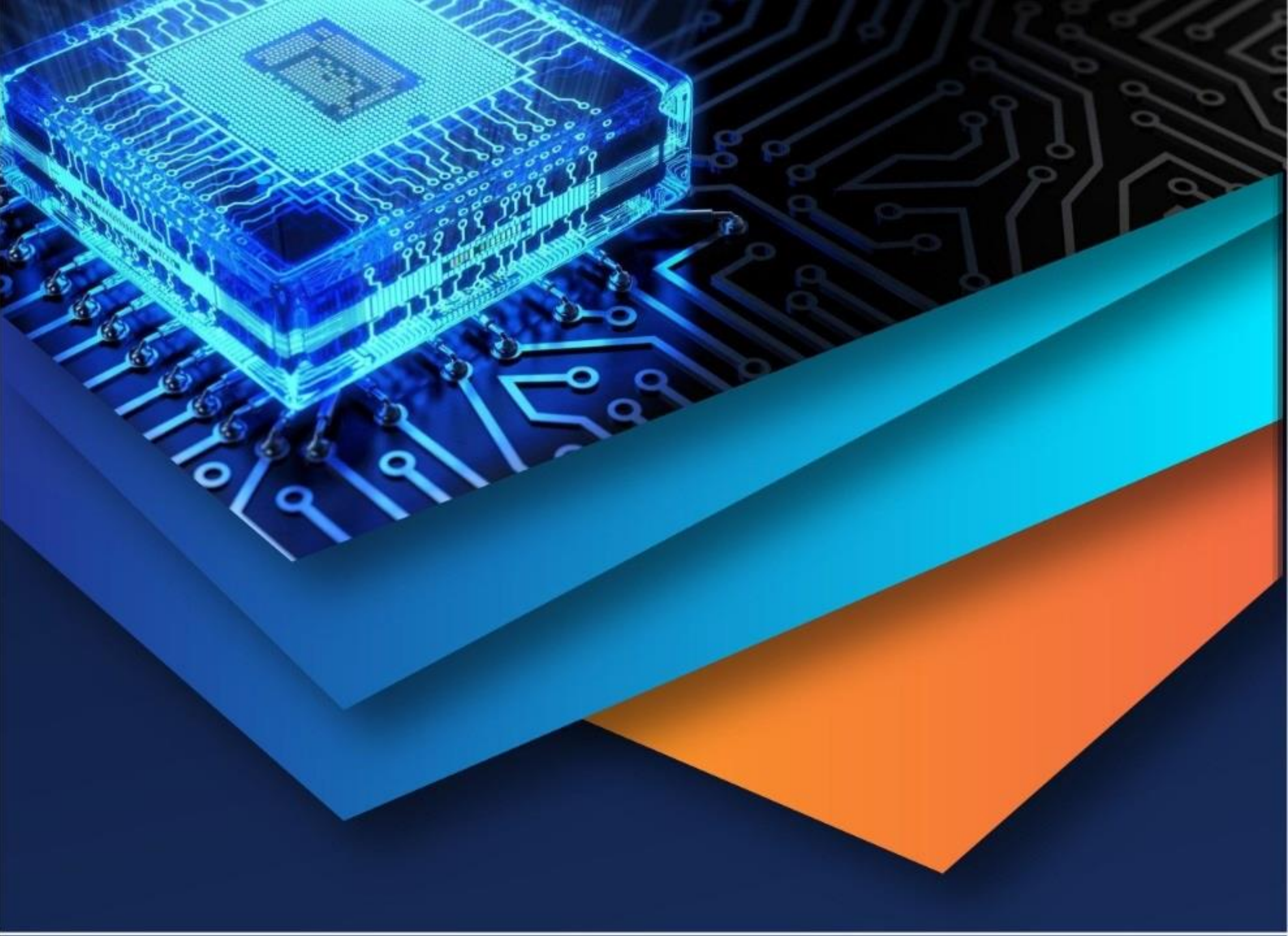
[19] A. G. Karl, T.R., N. Nicholls, "CLIVAR/GCOS/WMO workshop on indices and indicators for climate extremes: Workshop summary," vol. 42, pp. 3–7, 1999.

[20] C. Peterson, T.C., "Report on the Activities of the Working Group on Climate Change Detection and Related Rapporteurs 1998-2001. WMO, Rep. WCDMP-47, WMO-TD 1071, Geneve, Switzerland," p. 143pp.

[21] W. Climate, "change," vol. 54, no. 2, pp. 83–86, 2005.

[22] I. Ernmenta and L. P. A. Nel, *Climate Change 2014 Synthesis Report*.

[23] Xuebin Zhang and Feng Yang, "RClimDexUserManual." p. 23, 2004.

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