# The Extreme Climate Index as an innovative instrument to stimulate climate adaptation efforts in Africa

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## 1. Introduction

- The Extreme Climate Facility (XCF) proposed by the African Risk Capacity (ARC) offers a practical example of a climate index insurance scheme, which bundles the components of sound climate adaptation.
- The XCF will provide countries, buying weather insurance from ARC, with additional funds for adaptation should extreme weather events in their region increase in magnitude and/or frequency, as reflected by the Extreme Climate Index (ECI).
- The ECI is an objective, multi-hazard index capable of tracking changes in the frequency or magnitude of extreme weather events. Changes in frequency and intensity of these events may indicate that a shift to a new climate regime is underway in a particular area.

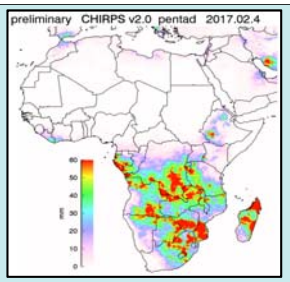
*A dust storm during an intense drought over the western maize production region of South Africa in summer 2015/16 (Photo by Christa Lombard, Agricultural Research Council).*

- The main hazards covered by ECI:
  - Extreme wet conditions (e.g. flooding),
  - Extreme dry conditions (e.g. droughts),
  - Extreme heat events,
  - Region-specific risk events.

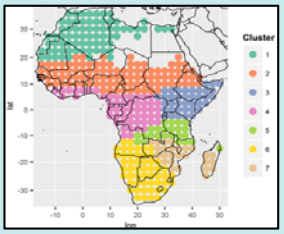
*Tropical Cyclone Dineo heading towards southern Africa on 14 February 2017 (MODIS imagery courtesy of NASA's Distributed Active Archive Centers (DAACs)).*

## 2. Calculation of the ECI

- The ECI is calculated from the following input datasets:
  - For temperature: NCEP/NCAR Reanalysis 1 dataset
    - Temperatures recorded 4 times per day at surface level sigma=0.995.
    - Spatial Resolution: 2.5° (lon) x 2.5° (lat).
    - Extent: Global.
    - Time range: 1948 - current.
  - For precipitation: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) dataset [1]
    - Accumulated rainfall for monthly periods.
    - Spatial resolution of 0.05° (lon) x 0.05°(lat).
    - Extent: 50°S-50°N (and all longitudes).
    - Time range: 1983 – present.




*Consisting of a blend of satellite and weather station data, the CHIRPS dataset is continually updated.*




*The ECI is standardized across broad geographical regions, so that extreme events occurring under different climatic regimes in Africa can be compared.*

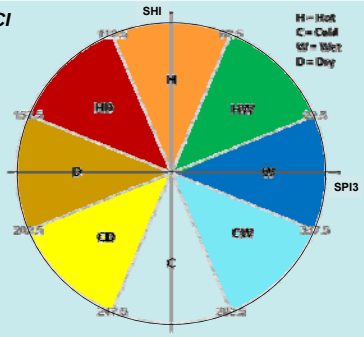
- Rainfall values per grid point are converted to Standardized Precipitation Index (SPI[2]) values for a range of periods (e.g. 3-month, 12-month time scale), to accentuate various climate-related hazards.
- Temperature values (daily maximums accumulated) are transformed to a Standardized Heat-wave Index (SHI) value accentuating hazards associated with extremely high maximum temperatures.
- The SPI and SHI are combined in a 2-component (SHI & 3-month SPI) and 3-component (SHI & 3-month SPI & 12-month SPI) prototype of the ECI.
- Extreme values of the combined index (ECI) are calculated and tested for robustness.
- Application of the ECI on historical data yields results that seem in accordance with some known historical extreme events, but further investigation and testing are needed.

***3-month SPI and SHI combined in a 2-component ECI***

$$\begin{cases} \rho = \sqrt{x^2 + y^2} \\ \varphi = \tan^{-1}\left(\frac{y}{x}\right) \end{cases}$$

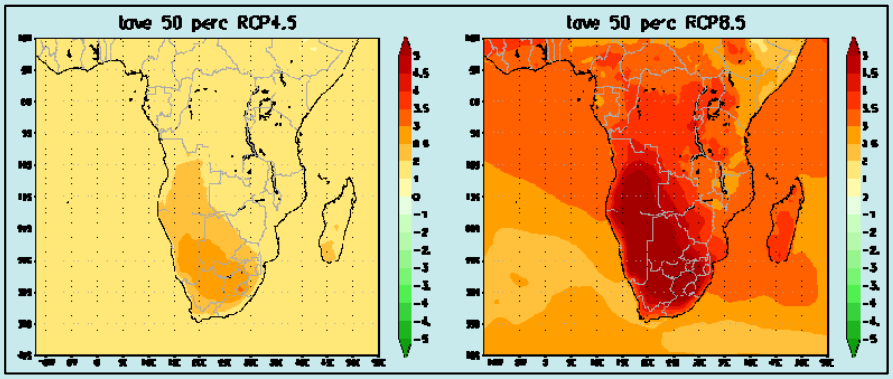
**Intensity:**
- **real positive number, chi-squared distributed;**
- **describes event's magnitude.**

**Angular component:**
- **0° ≤ j < 360°;**
- **relative contribution of the single-hazard indices.**




## 3. Future development of the ECI

- Research is now underway at the CSIR and SASSCAL, to verify and further develop the ECI for application in African countries, through a project initiated by ARC.
- The focus will be on:
  - Most appropriate definitions of extremely wet and dry conditions in Africa.
  - Verification of best available detests for ECI using amongst others the SASSCAL weather station network www.sasscalweathernet.org).
  - Projected trends in the ECI under climate change, using detailed regional projections generated by the CSIR and through the Coordinated Regional Downscaling Experiment (CORDEX).
- This work will be concluded by the development of a web-based climate service informing African Stakeholders on climate extremes.




***Conformal Cubic Atmospheric Model (CCAM) contributions to CORDEX: Projected changes in average temperatures (degrees C) over Africa for 2080-2099 relative to 1971-2000 for RCP4.5 (high mitigation -left) and RCP8.5 (low mitigation - right). The ECI will be calculated for these and other similar datasets.***

[1] Funk C., Peterson P., Landsfeld M., Pedreros D., Verdin J., Shukla S., Husak G., Rowland J., Harrison L., Hoell A., Michaelsen J., "The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes". *Scientific Data* 2, 150066. doi:10.1038/sdata.2015.66 2015.

[2] McKee T. B., Doesken N. J., Dosio A. Graversen, Kleist J., " The relationship of drought frequency and duration to time scales", *Proceeding at Eight Conference on Applied Climatology* (1993).