Projected Impacts of Climate Extremes over Selected African Coastal Cities under 1.5°C and 2.0°C Global Warming.

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Introduction

- African coastal cities are vulnerable to climate change due to their high exposure, low adaptive capacity and high population density.
- Discussions about setting goals to limit global warming by a predefined threshold have been actively ongoing since the mid-1990s. COP16 in 2010 set this threshold at 2°C while COP21 set an ambitious 1.5°C target.
- Whilst several studies have investigated future projections of extreme climate over several African regions based on CORDEX simulations (Giorgi and Gutowski 2015), most of them focused on:
  - Impacts at the end of the 21st century (Abiodun et al., 2017; Dosio, 2017).
  - Based on results of either a single or small set of CORDEX simulations*, mainly due to limited number of available simulations* (Endris et al., 2013; Dosio and Panitz, 2015; Pinto et al., 2015)
- In this study we:
  - utilized current and most complete CORDEX Africa ensemble consisting of 25 simulations under Representative Concentration Pathway (RCP) 8.5 – More robust than a single or small set of CORDEX simulations (McSweeney et al., 2015).
  - Analyzed the response to rainfall & temperature extremes over – Cape Town, Durban, Dar es Salaam, Maputo & Mombasa, when projected global temperatures reach 1.5°C and 2.0°C.

Data and Methods

Area of study:

- Spatially this study considers Southern Africa, defined as the region lying between 36°S to equator and 10° - 52°E, with focus on 5 coastal city regions.

Datasets:

- 25 CORDEX-Africa simulations driven by the **RCP8.5** - comprises the largest ensemble and may also be considered the most realistic business-as-usual scenario given the current trajectory of greenhouse gases emissions (Taylor et al. 2012).

Methods:

- Global Warming Levels (GWLs): - Although different definitions exist in the literature, all generally start with some pre-industrial baseline and use an averaged window period e.g. 15, 20 or 30 years to compute departure from the baseline and arrive at when the GWL of interest is reached.
- The timing for these levels is commonly defined as the centre year of a long enough period when global mean temperature reaches predefined anomalies (1.5, 2, 2.5°C etc.) relative to preindustrial levels (1861-1890 in this study) as it is available across all CMIP5 historical simulations.
- Given the RCM downscaled data begins at 1950 and that the RCP scenarios begin in 2006 we define our control period for the present/recent climate as 1971- 2000. The corresponding 30-year period is then extracted from the downscaling RCM for analysis.

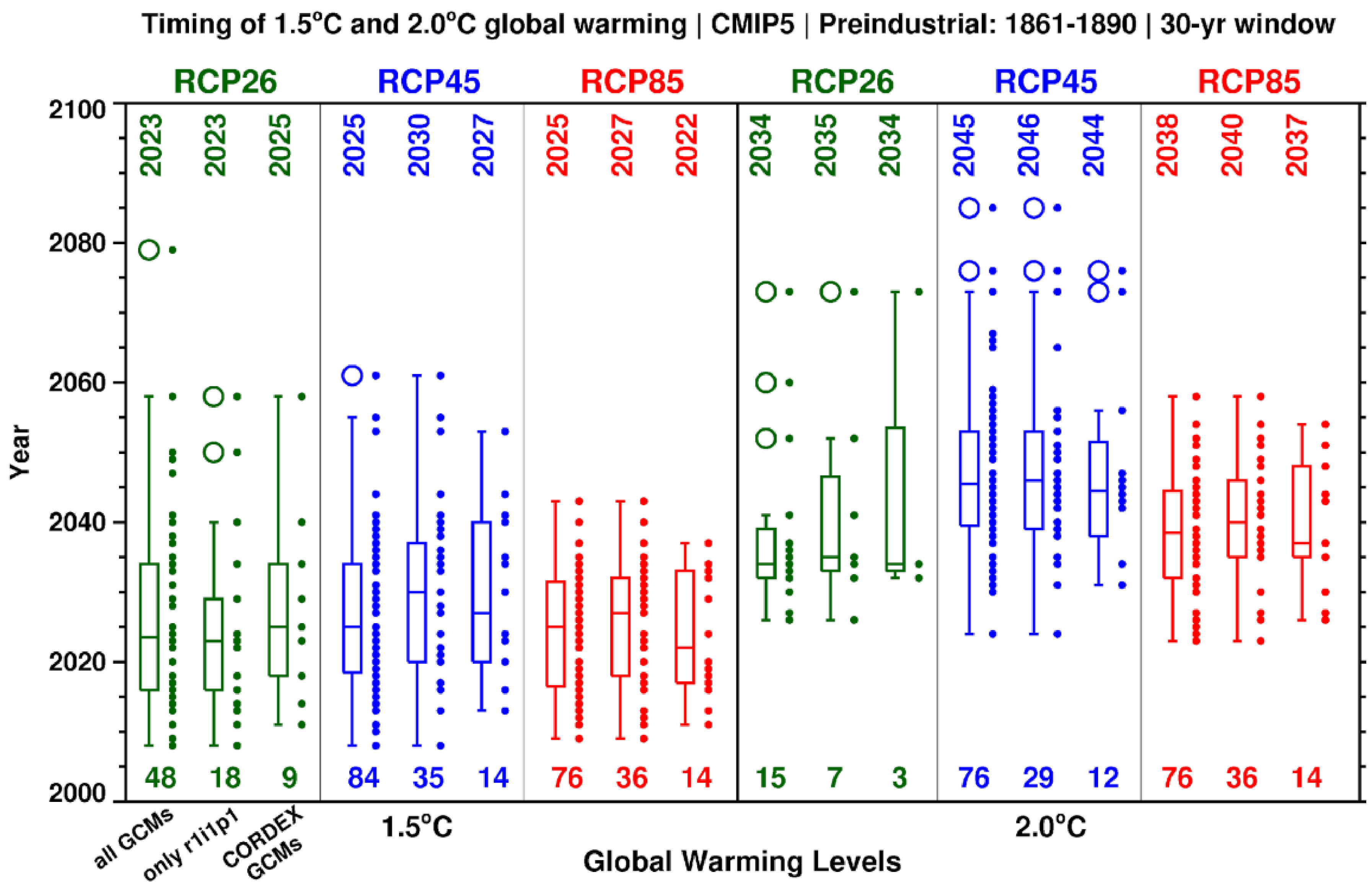

Fig 1: Timing of 1.5 and 2ºC GWLs under 3 RCPs for the grand CMIP5 ensemble (left), only the first member for each GCM if there was an ensemble available (centre) and the GCM subset that used in CORDEX Africa (right). Numbers at the bottom show the number of GCM simulations reaching the 1.5 and 2ºC GWLs and numbers at the top show the median year of GWL timing. Individual GCMs are represented by dots while ensemble statistics by whisker boxes.

Results

- There are several methodologies used to determine the robustness of climate change signal (Collins 2013). We consider a climate change signal robust if the following two conditions are fulfilled:
  - More than 80% of model simulations agree on the sign of the change.
  - The signal to noise ratio (SNR) ≥ 1.
- We analyzed mean precipitation and temperature fields as well as two extreme indices from the Expert Team on Climate Change Detection and Indices (ETCCDI):
  - Consecutive Dry Days (CDD) and Consecutive Wet Days (CWD).
- Analysis done both on annual and seasonal time scales.

Projected changes

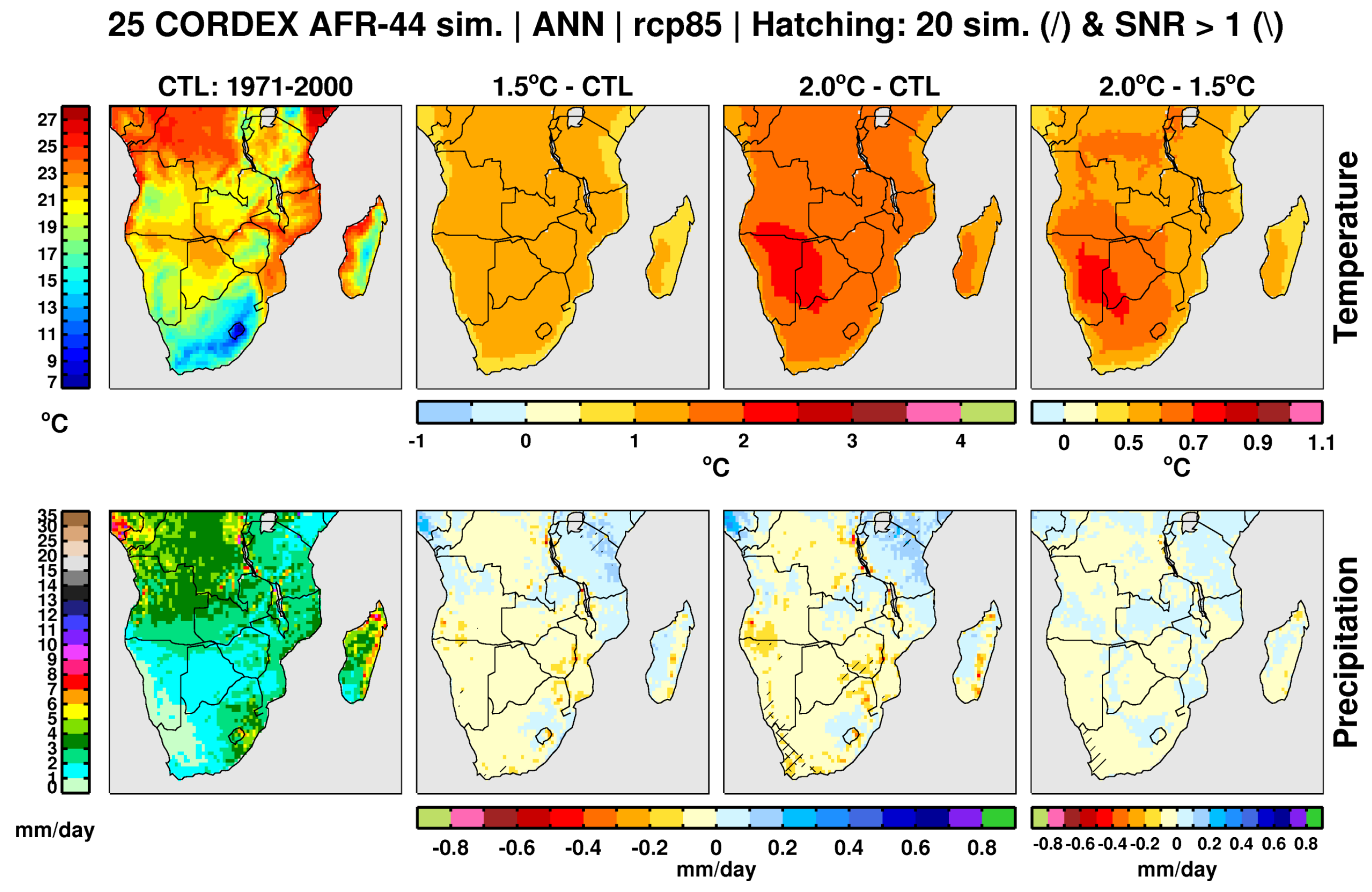

Fig 2: Annual changes in temperature (first row) and rainfall (second row) under 1.5 and 2.0 ˚C global warming. First column shows annual mean temperature and rainfall for control period , second and third columns show differences in annual mean temperature and rainfall between future and CTL during 1.5 and 2 ˚C GWLs, respectively and fourth column shows differences between 2 and 1.5˚C. Hatching shows areas where at least 80% of the simulations agree on the sign of the change and SNR > 1. For temperature all grid boxes satisfy the two criteria and the hatching is not shown.

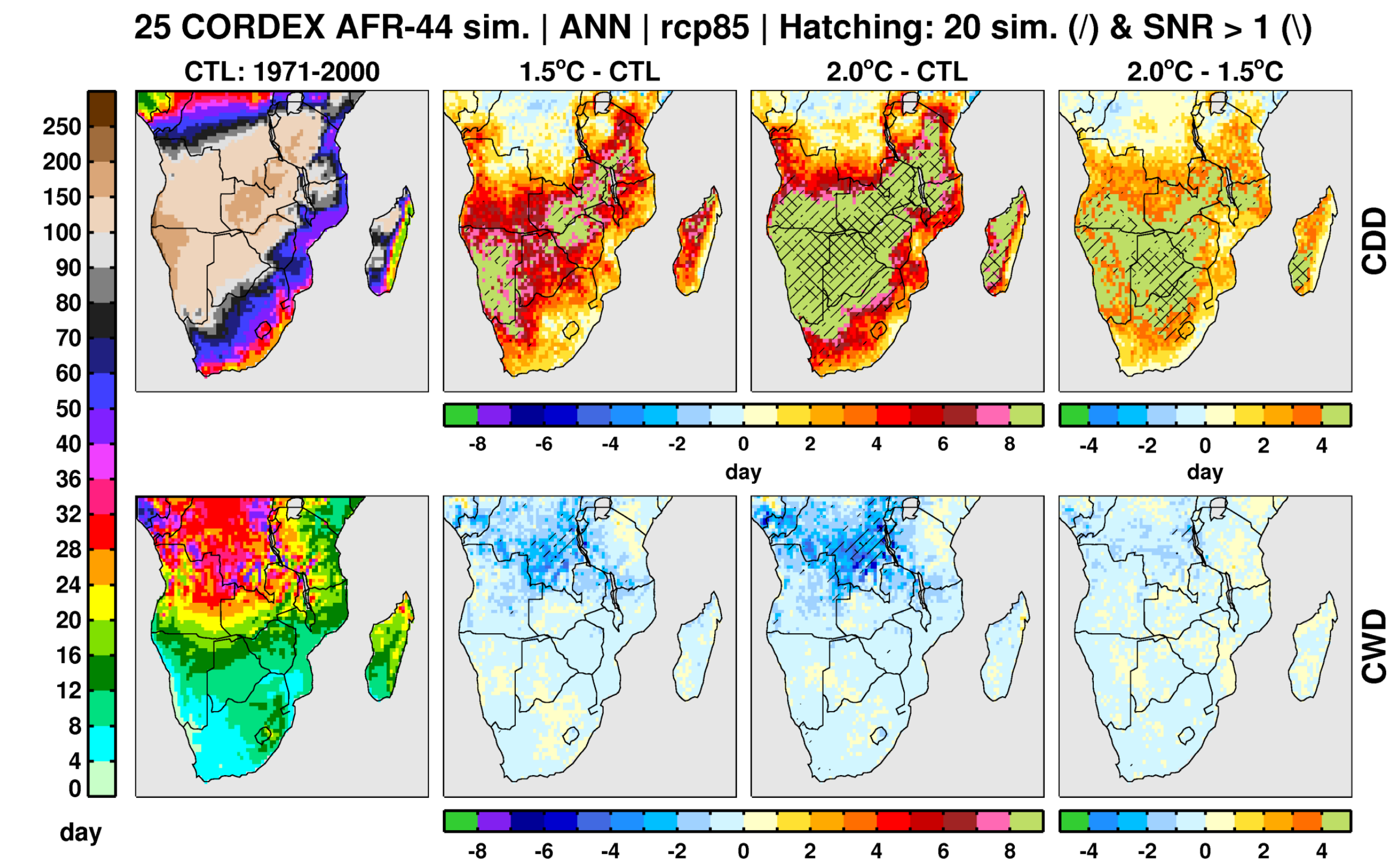

Fig 3 : Annual changes in CDD (first row) and CWD (second row) under 1.5 and 2.0 ˚C global warming based. First column shows number of CDD and CWD for control period. Second and third columns show projected changes in CDD and CWD between future and present under 1.5 and 2˚C global warming periods, respectively. Fourth column shows differences in CDD and CWD between 2 and 1.5˚C. Hatching shows areas where at least 80% of the simulations agree on the sign of the change and SNR > 1.

Discussion

Table 1 : Projected Annual (A) and seasonal (S{dominant season at each city}) changes in temperature (Temp), precipitation (Precip), CDD and CWD together with broad implications on **Water sector** (directly impacts other sectors: - Agriculture, Health etc). Double pointed arrow show that the change signal is NOT robust.

City	Temp A	Temp S	Precip A	Precip S	CDD A	CDD S	CWD A	CWD S	Broad Implications
Cape Town	↑	↑	↓	↓	↕	↕	↕	↕	Experienced its worst drought on record. Temp, Precip, CDD & CWD projections, suggests a possibility of frequent drought events in the future. Resilient water supply systems are required – desalination, management strategy (R&D) - taking advantage of years of sufficient precip to prepare for dry years etc.
Durban	↑	↑	↕	↕	↕	↕	↕	↕	Projected increase in temperature and increase in precip for Durban. Further studies required to ascertain whether temperature increases will offset any benefit from increased rainfall.
Maputo	↑	↑	↕	↕	↕	↕	↕	↕	Received below normal precip during 2017/2018 summer season. projected increase in temperatures and decrease in rainfall, suggests a possibility of diminishing summer rainfall . Calls for resilient water supply management.
Dar es Salaam Mombasa	↑	↑	↕	↕	↕	↕	↕	↕	Received normal to above normal precipitation. Projected increase in temperature, annual and seasonal (MAM) rainfall and decrease in seasonal CDD for Dar es Salaam and Mombasa. Further studies required to ascertain whether the temperature increases will offset any benefit from increased rainfall.

Conclusion

- Study region warms faster than the global mean, up to more than 1˚C under the 1.5˚C and ≥ 1.5 ˚C under 2 ˚C GWL compared to the control period.
- There is a general statistically insignificant decrease in the number of CWDs and increase in the average duration of CDD at the five cities.
- Further investigation required to ascertain whether the temperature increases will offset any benefit from increased rainfall at Durban, Dar es Salaam and Mombasa.
- These results suggest that actionable policies geared towards adaptive strategies to alleviate the impacts of global warming are needed.

Key References

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