

Dynamical Downscaling of CAM4 over Southern Africa: Analysis of Trends in Precipitation Extremes

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Introduction

- Global models are often run in coarse resolution due to computational limitations
- Finer scale features of regional climate can not be understood from global model outputs
- Regional climate models can be used to dynamically downscale global model simulations over the area of interest
- 20 years of CAM4 simulation is downscaled over sub-equatorial Africa using WRF-ARW model
- Precipitation extremes over sub-equatorial Africa is analyzed in the downscaled data and compared with observations.

Data and Methodology

- NCAR Community Atmospheric Model version 4 (CAM4) is forced with observed monthly varying Hadley center Sea Surface Temperature and Sea Ice concentration data (HadISST) from 1989 to 2009 and yearly varying green house gas concentrations, ozone, and aerosol forcing. The CAM4 model is configured with a horizontal resolution of $0.9^\circ \times 1.25^\circ$ (lat x lon) and 26 vertical layers.
- The CAM4 fields are used to generate initial and lateral boundary conditions for Weather Research and Forecasting (WRF) model over sub-equatorial Africa.
- Tropical Rainfall Measuring Mission (TRMM) 3B42 daily data during 1998-2009 period are used to compare the model simulated (CAM4 and WRF) precipitation climatology during the same period.
- Extreme precipitation indices as defined in Table 1 are derived from CAM4 and WRF daily precipitation data during 1990-2009 period.
- Also the extreme precipitation indices are derived from TRMM 3B42 daily precipitation data during 1998-2009 period.
- The trends in extreme precipitation indices are computed using a Generalized Linear Model¹ (GLM). GLM is a flexible version of ordinary least square linear regression.

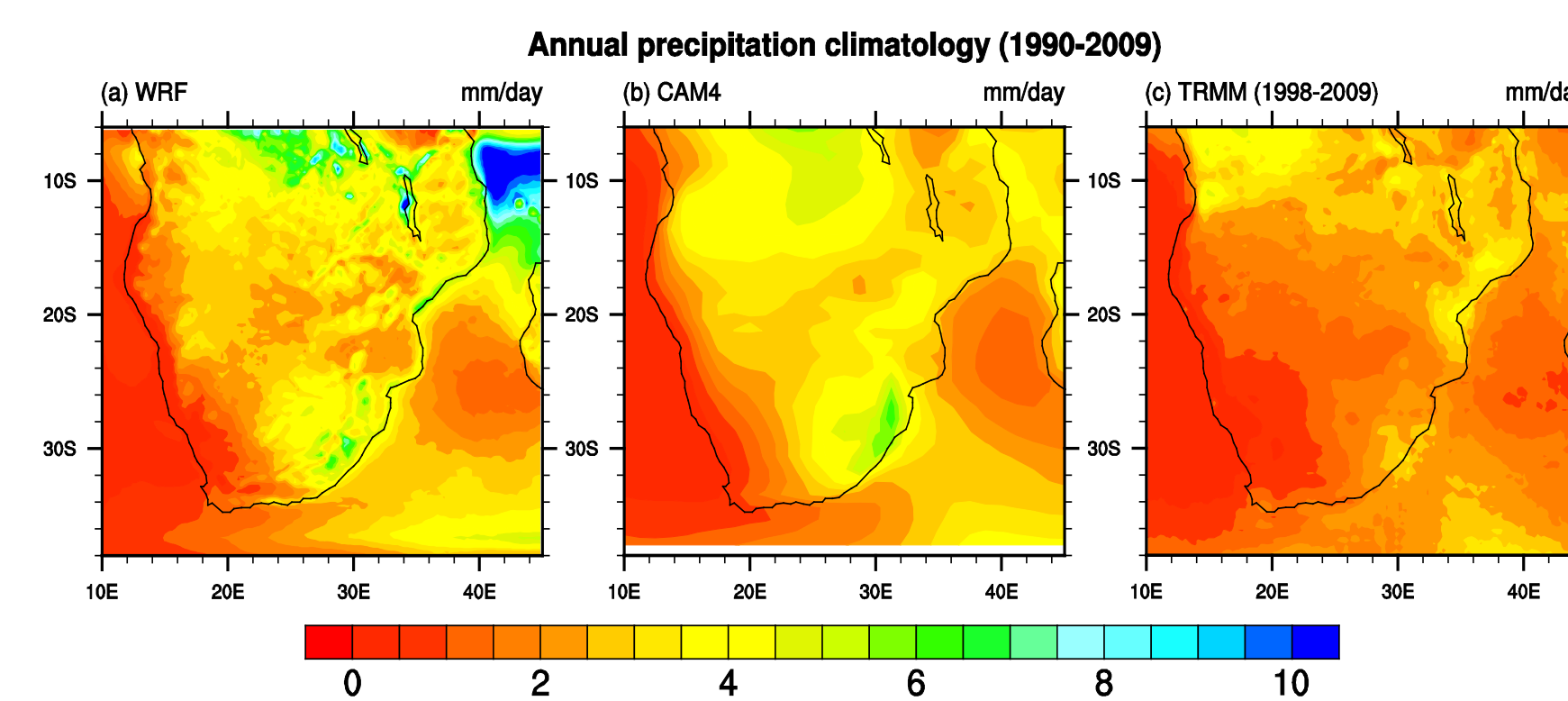


Figure 1: Annual precipitation climatology (mm/day) from (a) WRF downscaling, (b) CAM4 and (c) TRMM. WRF and CAM4 correspond to 1990-2009 period while TRMM 1998-2009 period.

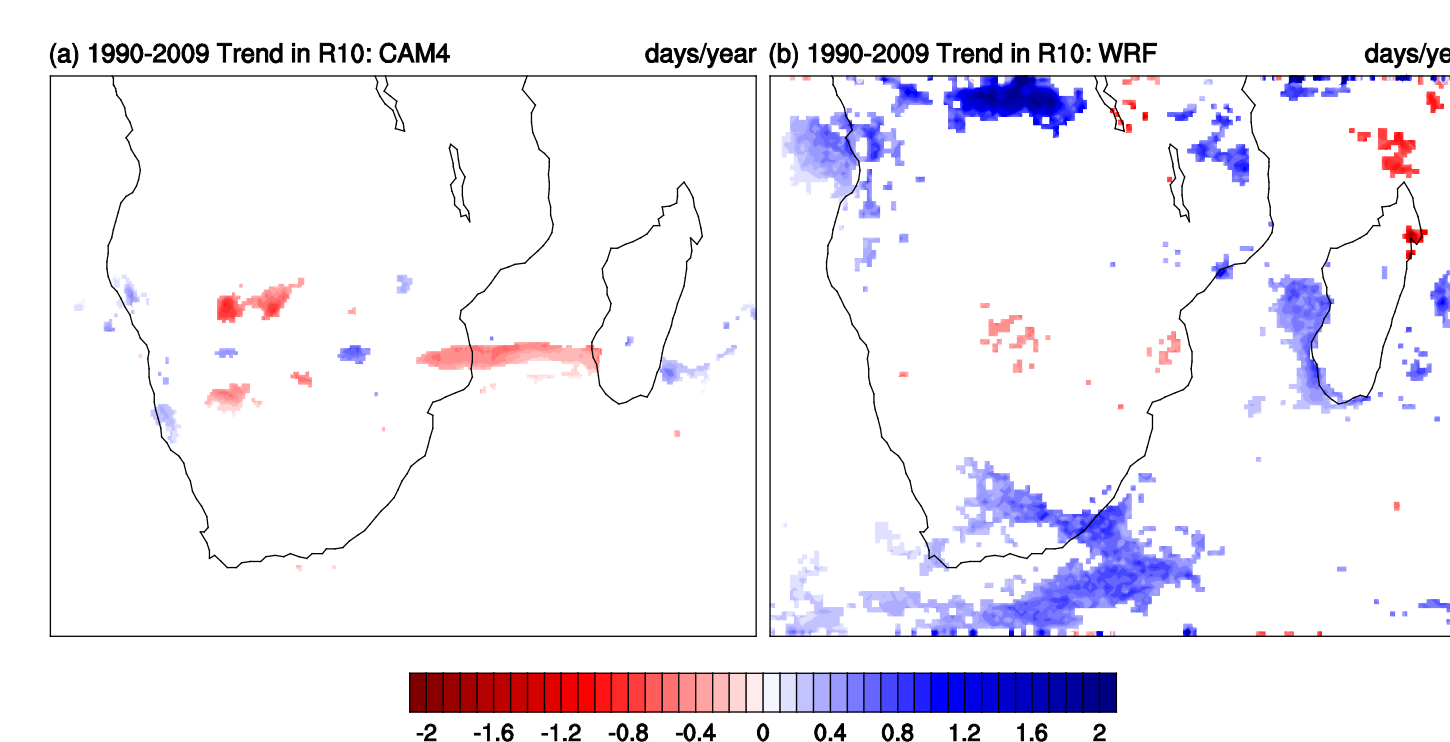


Figure 2: 1990-2009 trend (days/year) in R10 from (a) CAM4 and (b) WRF downscaling. Trends are statistically significant at 90% level.

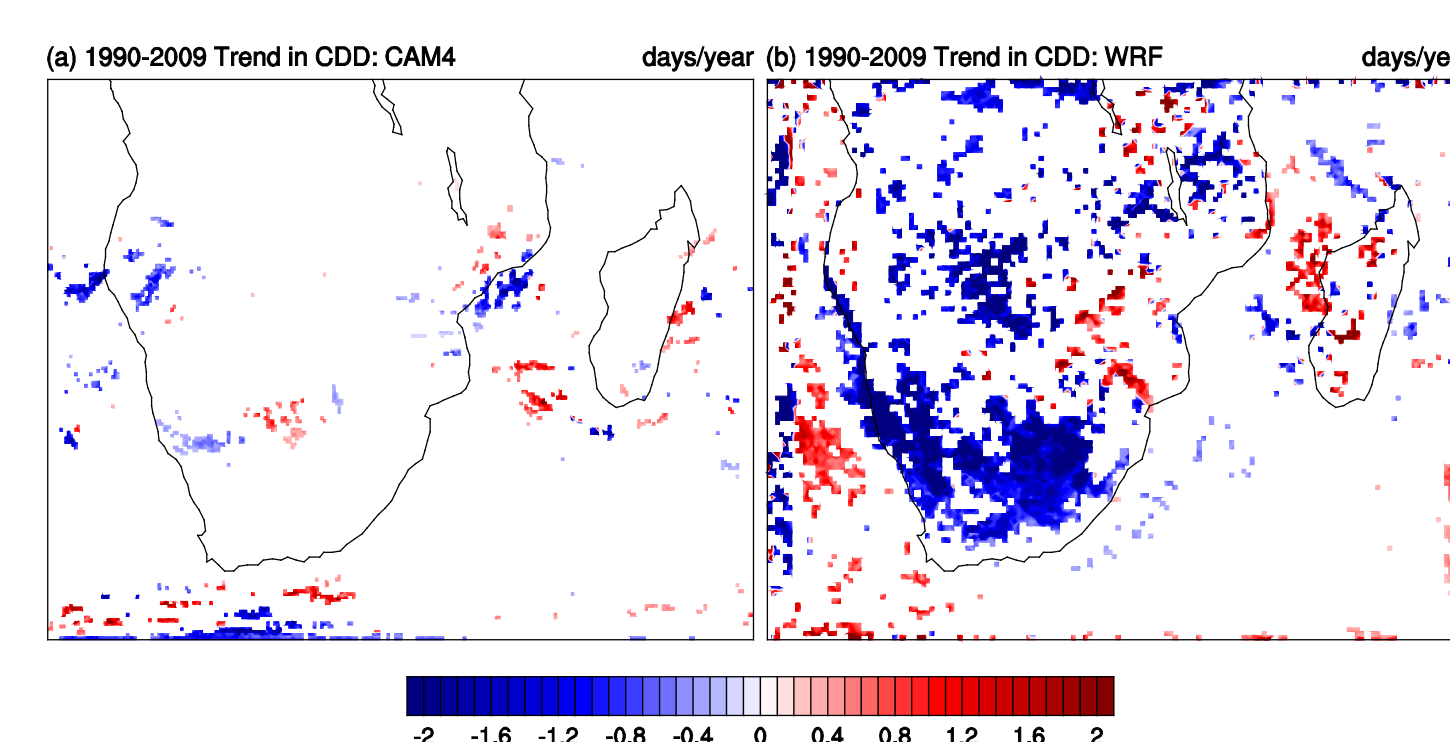


Figure 3: Same as figure 2 but for CDD

WRF model set up

- Domain: $5^\circ \text{ S} - 38^\circ \text{ S}$ and $8^\circ \text{ E} - 53^\circ \text{ E}$.
- Horizontal resolution: $27 \times 27 \text{ km}$ (175×139 grids in East-West and North-South directions and 36 vertical levels).
- PBL scheme: YSU
- Cumulus parameterization: Kain-Fritsch scheme
- Shortwave and Longwave radiation: CAM
- Land Surface scheme: Noah
- Microphysics: Lin et al

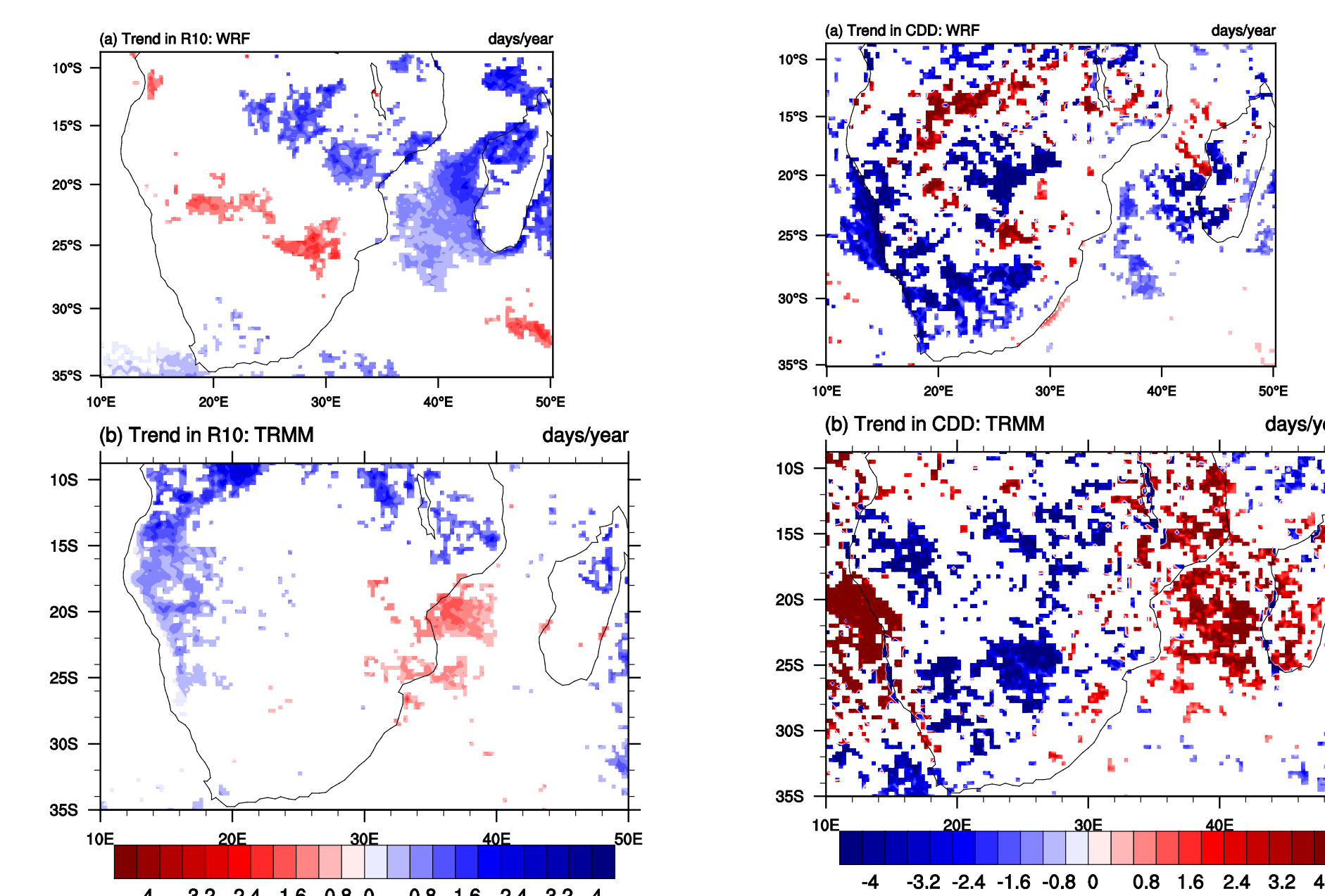


Figure 6: 1998-2009 trend (days/year) in R10 from (a) WRF and (b) TRMM. Trends are statistically significant at 90% level

Figure 7: Same as figure 6 but for CDD

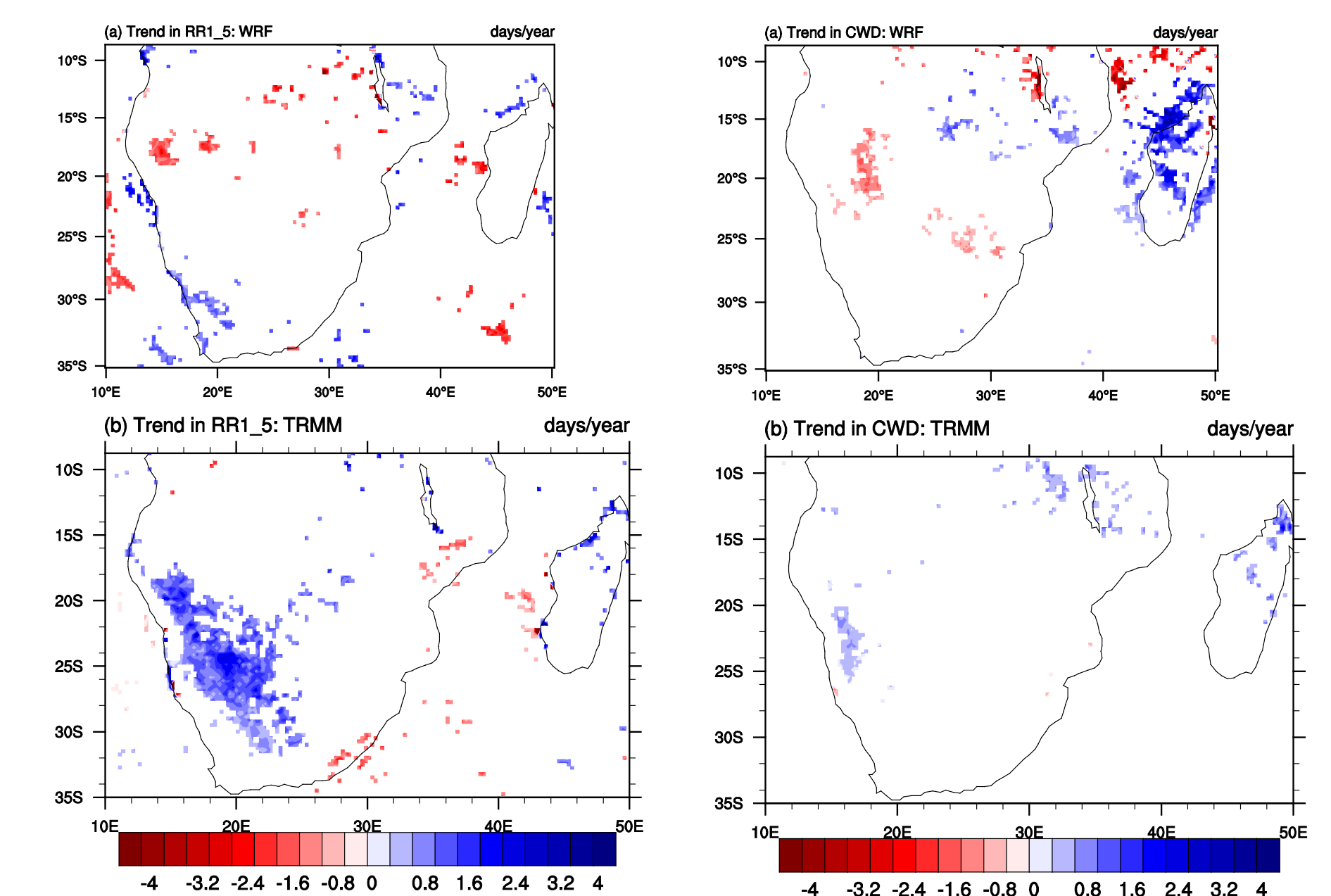


Figure 8: Same as figure 6 but for RR1_5

Figure 9: Same as figure 6 but for CWD

Results

- Overestimation of precipitation by WRF model is a major issue.
- WRF downscaling could resolve the finer-scale features of precipitation trends when compared to CAM4.
- 1998-2009 trends in daily precipitation based climate indices computed from WRF downscaling experiment and TRMM 3B42 daily precipitation are compared.
- An increasing trend in R10 over north-western part of sub-equatorial Africa in TRMM is not captured by WRF downscaling experiment. The increasing trend in R10 over Madagascar in TRMM is overestimated in WRF.
- The 1990-2009 trend in CDD computed from TRMM and WRF daily precipitation are qualitatively comparable over southern part of Africa, while over western and eastern regions they are not in agreement.
- Trends in RR1_5 during 1990-2009 period computed from WRF and TRMM are in agreement over Madagascar region.

References

1. Nelder, J. A. & Wedderburn, R.W (1972): Generalized Linear Models. *J R Stat Soc -A* **135**, 370-384.
2. Frich, P. et al (2002): Observed coherent changes in climatic extremes during the second half of the twentieth century, *Clim Res*, **19**, 193-212.

Table 1: Description of indices

Index	Description
RR1_5	Number of days with precipitation between 1 and 5 mm
R10	Number of days with precipitation 10 mm and above ²
CWD	Maximum number of consecutive wet days (Wet day is defined as the number of days with precipitation at least 1 mm)
CDD	Maximum number of consecutive dry days ² (Dry day is defined as the number of days with precipitation less than 1 mm)