ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Assessing Dust Storm Frequency and Intensity in Egypt Under Climate Change Scenarios

Zeinab Salah

Egyptian Meteorological Authority

zeinabsalah@gmail.com

INTRODUCTION & AIM

- **Introduction**: Dust in the atmosphere poses significant risks to human health, the environment, and various socioeconomic sectors. Larger non-respirable particles (greater than 10 µm) can irritate the skin and eyes, while widespread sand and dust storm (SDS) events can disrupt transportation networks, damage infrastructure, reduce visibility, and in severe cases lead to injuries, fatalities, and property losses. Agriculture is particularly vulnerable: dust storms can bury seedlings, damage plant tissues, suppress photosynthesis, and accelerate soil erosion, collectively reducing crop productivity. In Egypt, dust storms are a recurrent phenomenon—especially during spring, when Khamaseen depressions dominate—often extending hundreds of kilometers and causing substantial environmental and economic impacts.
- **Aim**: This study aims to develop an index representing the frequency and intensity of dust events in Egypt under future climate conditions. A "dusty days indicator" is constructed using maximum daily dust concentrations simulated by the ICTP Regional Climate Model (RegCM4) (Giorgi et al., 2012) . The analysis evaluates how dust storm characteristics may evolve under two climate change scenarios—RCP4.5 and RCP8.5—in order to better understand potential future extremes and their implications.

METHOD

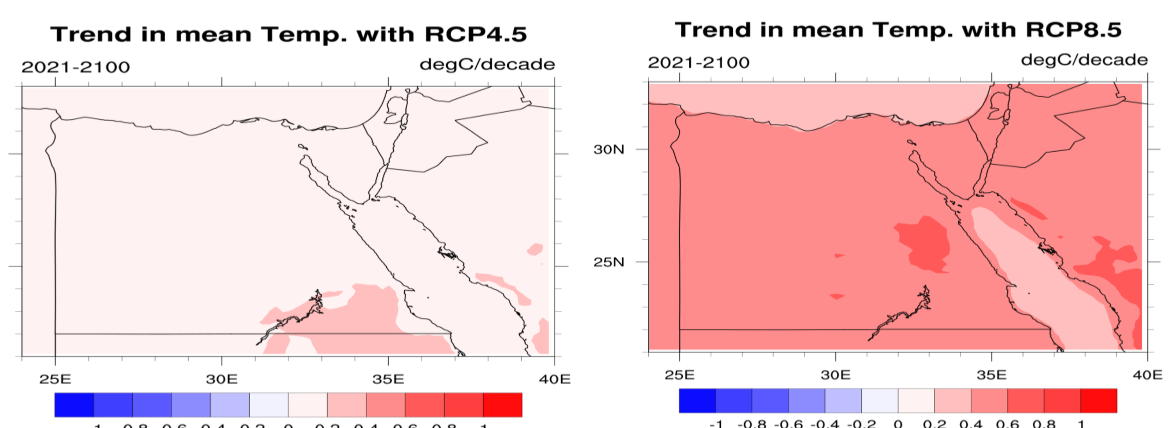
- **Model configuration**

Meteorological initial field	MPI-ESM-MR (with 1.8 degree resolution) Two RCPs during the period of 1978 to 2100, with considering two years as spin up.
Dynamics	MM5 Hydrostatic (Grell et al 1994)
Radiation	CCM3 (Kiehl 1996)
Large-Scale Clouds & Precipitation	SUBEX (Pal et al 2000)
Cumulus convection	Emanuel (1991) over Ocean & Grell over Land with Fritsch & Chappell (1980) cumulus closure scheme
Boundary Layer	Holtslag (1990)
Dust emissions	Saltation and sandblasting (Zakey, 2006; Marticorena and Bergametti, 1995; Alfaro and Gomes, 2001). (without feedback interactions)
Land Surface	BATS (Dickinson et al 1993)
Horizontal resolution	20kmx20 km : Egypt and parts of surrounding countries).

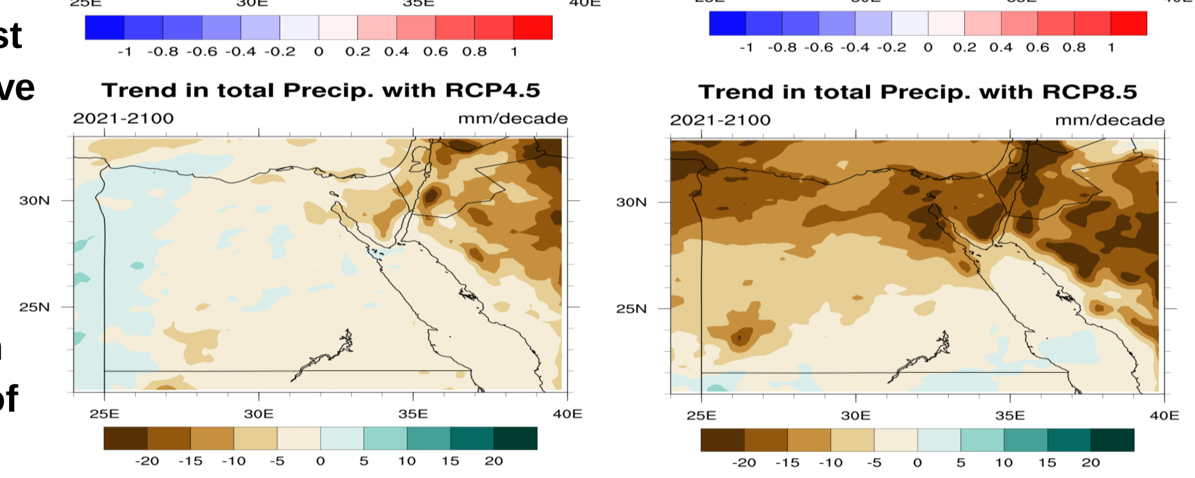
- **Dusty Days Indicator**
  - The maximum daily dust concentration was calculated from the output of RegCM4 model at every grid point within the region.
  - The time series of maximum daily concentrations were calculated during the reference period (1980-2005), which were used to define thresholds corresponding to the dust concentrations.
  - Dust intensity is classified by percentage as follows: normal (75th percentile), high (90th percentile), very high (95th percentile), and extreme (99th percentile).
  - Then the percentages of occurrence of the different categories of dusty days were calculated up to 2100 based on the reference period.
  - Climate Data Operator "CDO" was used to process the model output netCDF files and perform these calculations.

RESULTS & DISCUSSION

- Trend in mean air temperature (degC/decade) calculated from 2021 to 2100 using RCP4.5 (on the left) and RCP8.5 (on the right).
- **With RCP4.5:** Positive trend reaches 0.2 over whole Egypt and >0.2 over the southern parts.
- **With RCP8.5:** Trend increases to 0.4 over Egypt.

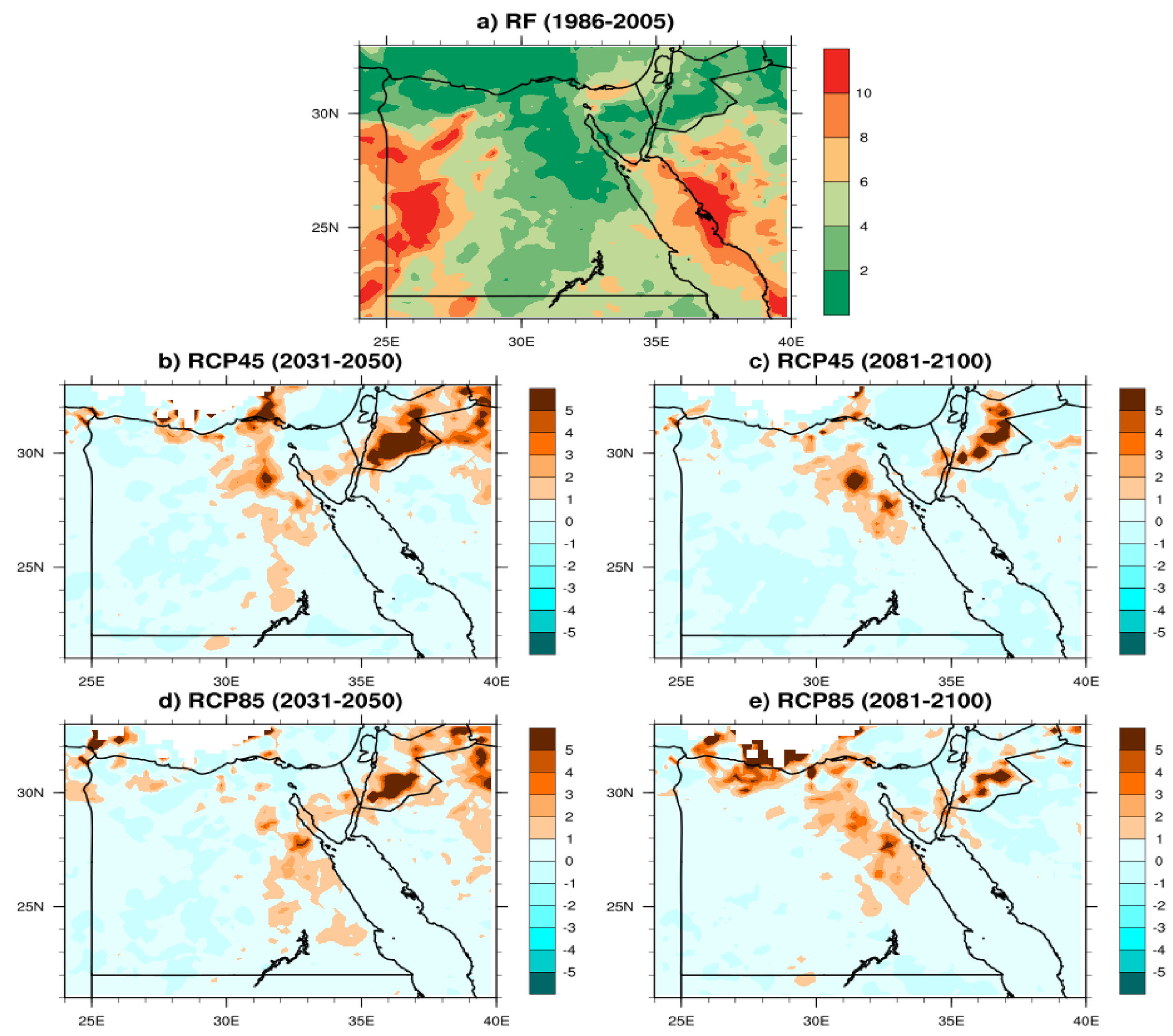


- Trend in total precipitation (mm/decade) calculated from 2021 to 2100 using RCP4.5 (on the left) and RCP8.5 (on the right).
- **With RCP4.5:** Negative trend reaches -5 over most of Egypt with small positive values on the western regions.
- **With RCP8.5:** Negative trend over whole Egypt reaches -15 over northern parts which are sources of dust storm.



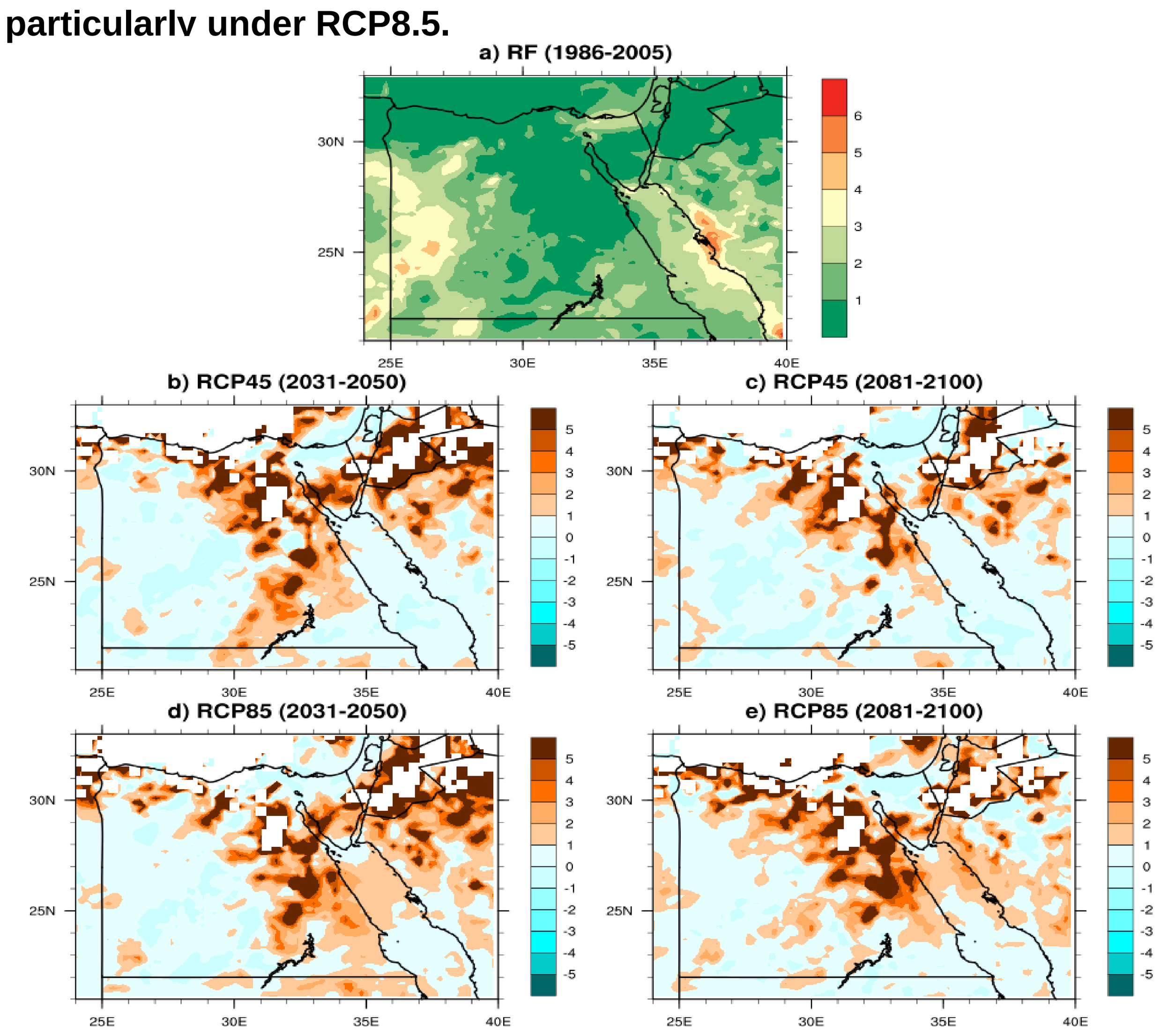
- **Moderate Dusty Days (>75pth):**

The figure shows the spatial distribution of moderate dusty days over Egypt for the historical period (1986–2005) and the projected changes under RCP4.5 and RCP8.5 scenarios. Future periods (2031–2050 and 2081–2100) exhibit varying increases or decreases in moderate dusty days relative to the historical baseline, with stronger changes generally appearing toward the end of the century and under the higher-emission scenario (RCP8.5).



- **High Dusty Days (>90 pth):**

The figure illustrates historical levels of high dusty days over Egypt and projected changes under RCP4.5 and RCP8.5. Both scenarios show varying shifts in the frequency of high dust events across the country, with more pronounced changes appearing toward the end of the century, particularly under RCP8.5.



CONCLUSION

- An indicator for the dust events can be calculated using the dust concentration from a regional climate model coupled with dust.
- The results of this study show that there is a positive trend in air temperature over Egypt accompanied by a negative trend in precipitation with RCP4.5, increased with RCP8.5, which may lead to increased dust emissions.
- Future projections show a general increase in moderate dusty days across Egypt, especially under the RCP8.5 scenario and toward the end of the century. These changes highlight growing environmental and health challenges as dust activity intensifies with climate change.

FUTURE WORK/REFERENCES

- **Future Work:** This study can be extended to cover the entire MENA region and validated through comparison with reanalysis data.
- **References:**

Alfaro SC, Gomes L (2001) Modeling mineral aerosol production by wind erosion: Emission intensities and aerosol size distributions in source areas. J. Geophysical Research, 106, d16.

Giorgi F, and Co-authors, 2012: RegCM4: Model description and preliminary tests over multiple CORDEX domains. Climate Research, 52, 7-29, https://doi.org/10.3354/cr01018.

Marticorena B, Bergametti G (1995) Modelling the atmospheric dust cycle: 1. Design of a soil derived dust production scheme, J. Geophys. Res., 100, 16,415– 16,430.

Zakey AS, Solmon F, Giorgi F (2006) Implementation and testing of a desert dust module in a regional climate model, Atmos. Chem. Phys., 6, 4687–4704, doi:10.5194/acp-6-4687-2006.