Climate risk report for the Sahel region

Supplementary Document: Appendices

Authors: Sarah Holmes, Nick Brooks, Gabrielle Daoust, Rebecca Osborne, Hannah Griffith, Amy Waterson, Cathryn Fox, Erasmo Buonomo, and Richard Jones

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Image location: Chad

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Appendix A: Methods and Data

Climate in context methodological approach

The key stages in the methodology and division of responsibilities across the project team are presented in a schematic in Figure A1 and described in more detail below.

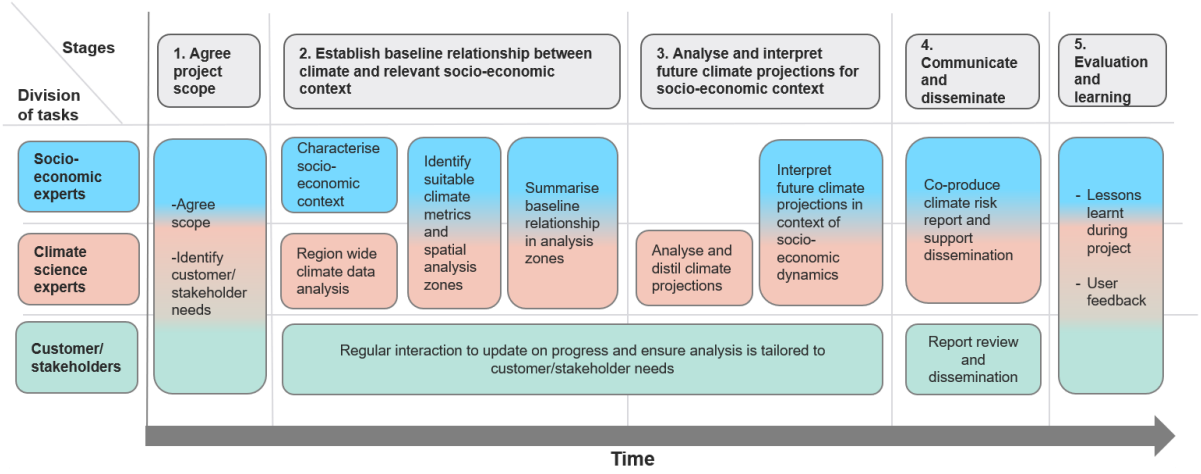

Figure A1 – Schematic diagram of the key stages of the methodology and division of tasks between the socio-economic experts (ODI), climate science experts (Met Office) and customer (FCDO) roles of the project team. This diagram is an initial draft of the Climate in Context methodology[1] currently being developed.

Stage 1 involves agreement on the scope of the work and the format of the outputs through iterative discussions across the project team. Consultations with the customer (FCDO) are conducted to identify the socio-economic themes relevant to their decision context.

Stage 2 involves establishing the baseline relationship between climate and the key socio-economic themes identified in Stage 1. This includes:

- Preliminary analysis is conducted to characterise the regional socio-economic context and regional climate through a combination of literature review and processing climate reanalysis data by the relevant experts.
- Identification of suitable climate metrics and spatial analysis zones via an iterative process between the experts, drawing on the outcomes of the preliminary analysis.
- Characterisation of the baseline climate, the key climate-related vulnerabilities and exposure to climate-related hazards in each of the spatial analysis zones.

Stage 3 involves analysis of future climate projections and interpretation in the context of the key vulnerabilities and baseline assessments developed in Stage 2. This includes:

- Selection of appropriate climate model simulations for the region and quantitative analysis of projected changes in relevant climate variables in each of the spatial analysis zones.

[1] A report documenting the Met Office Climate in Context methodology is in preparation and due to be published in 2021.

- Distillation of the future climate projections into narrative summaries for the relevant climate metrics in each spatial analysis zone.
- Translation of the future climate summaries into climate risk impacts with a focus on the key socio-economic themes.

Stage 4 involves the co-production of a report summarising the analysis and outcomes, tailored to the needs of the customer.

Finally, **Stage 5** involves evaluation and learning of the process to support future applications of the methodology.

Climate data and analysis methods

The climate projections in this report came from an ensemble of 30 CMIP5 global climate model simulations (see Table A1), 20 CMIP6 global climate model simulations and 20 regional climate model simulations (see from the CORDEX project (see Table A2). The models selected are those that were available to access at the time of analysis. Model simulations were assessed for their suitability in simulating the climate of the region by comparing the baseline periods from the model simulations with the reanalysis. The results from this assessment were taken into consideration when interpreting the future projections from the model simulations. More detail on evaluation of these model simulations and known biases is available in IPCC (2013), Ntoumos et al., (2020), Oztuek et al., (2018), Syed et al., (2019).

Table A1 – GCM simulations from CMIP5 used in the climate data analysis, from https://pcmdi.llnl.gov/mips/cmip5/availability.html.

Modelling Centre	Model	Institution
BCC	BCC-CSM1-1	Beijing Climate Center, China Meteorological Administration
	BCC-CSM1-1	
CSIRO-BOM	ACCESS1-0	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia), and BOM (Bureau of Meteorology, Australia)
	ACCESS1-3-m	
CCCma	CanESM2	Canadian Centre for Climate Modelling and Analysis
CMCC	CMCC-CM	Centro Euro-Mediterraneo per I Cambiamenti Climatici
	CMCC-CMS	
CNRM-CERFACS	CNRM-CM5	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique
CSIRO-QCCCE	CSIRO-Mk3-6-0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence
EC-EARTH	EC-EARTH	EC-EARTH consortium
GCESS	BNU-ESM	College of Global Change and Earth System Science, Beijing Normal University
INM	INMCM4	Institute for Numerical Mathematics
IPSL	IPSL-CM5A-LR	Institut Pierre-Simon Laplace
	IPSL-CM5A-MR	
	IPSL-CM5B-LR	

MIROC	MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
	MIROC-ESM	
	MIROC-ESM-CHEM	
MOHC	HadGEM2-CC	Met Office Hadley Centre
	HadGEM2-ES	
MPI-M	MPI-ESM-LR	Max Planck Institute for Meteorology
	MPI-ESM-MR	
MRI	MRI-CGCM3	Meteorological Research Institute
NCAR	CCSM4	National Center for Atmospheric Research
NCC	NorESM1-M	Norwegian Climate Centre
NIMR/KMA	HadGEM2-AO	National Institute of Meteorological Research/Korea Meteorological Administration
NOAA-GFDL	GFDL-CM3	NASA Goddard Institute for Space Studies
	GFDL-ESM2G	
	GFDL-ESM2M	
NSF-DOE-NCAR	CESM1-CAM5	National Science Foundation, Department of Energy, National Center for Atmospheric Research

Table A2 – GCM simulations from CMIP6 used in the climate data analysis, from https://pcmdi.llnl.gov/mips/cmip5/availability.html.

Modelling Centre	**Model**	**Institution**
BCC	BCC-CSM2-MR	Beijing Climate Center, China Meteorological Administration
CCCma	CanESM5	Canadian Centre for Climate Modelling and Analysis
CNRM-CERFACS	CNRM-CM6-1	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique
	CNRM-CM6-1-HR	
	CNRM-ESM2-1	
CSIRO	ACCESS-ESM1-5	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia)
EC-EARTH consortium	EC-Earth3	EC-EARTH consortium
	EC-Earth3-Veg	
INM	INM-CM4-8	Institute for Numerical Mathematics
	INM-CM5-0	
	INM-CM6A-LR	
MIROC	MIROC6	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MOHC	HadGEM3-GC31-LL	Met Office Hadley Centre
MOHC	UKESM1-0-LL	
MPI-M	MPI-ESM1-2-LR	Max Planck Institute for Meteorology
MRI	MRI-ESM2-0	Meteorological Research Institute
NCC	NorESM2-MM	Norwegian Climate Centre
NOAA-GFDL	GFDL-ESM4	NASA Goddard Institute for Space Studies
	GFDL-CM4	
NUIST	NESM3	Nanjing University of Information Science and Technology

Table A3 – RCM simulations from CORDEX AFR-44 used in the climate data analysis. These are downscaled simulations of a subset of the CMIP5 models in Table A1 at ~50km resolution.

Modelling centre	**Institution**	**RCM**	**Driving GCM**
CLMcom	Climate Limited-area Modelling Community (CLM-Community)	CCLM4-8-17	CNRM-CM5
			MPI-ESM-LR
			EC-EARTH
			HadGEM2-ES
DMI	Danish Meteorological Institute	HIRHAM5	EC-EARTH
GERICS	Helmholtz-Zentrum Geesthacht, Climate Service Center Germany	REMO2009	IPSL-CM5A-LR
			MIROC5
			HadGEM2-ES
MPI-CSC	Helmholtz-Zentrum Geesthacht, Climate Service Center, Max Planck Institute for Meteorology	REMO2009	EC-EARTH
			MPI-ESM-LR
SMHI	Swedish Meteorological and Hydrological Institute	RCA4	CNRM-CM5
			CSIRO-Mk3-6-0
			CanESM2
			HadGEM2-ES
			EC-EARTH
			MPI-ESM-LR
			IPSL-CM5A-MR
			NorESM1-M
			MIROC5
			GFDL-ESM2M

Appendix B: Climate plots

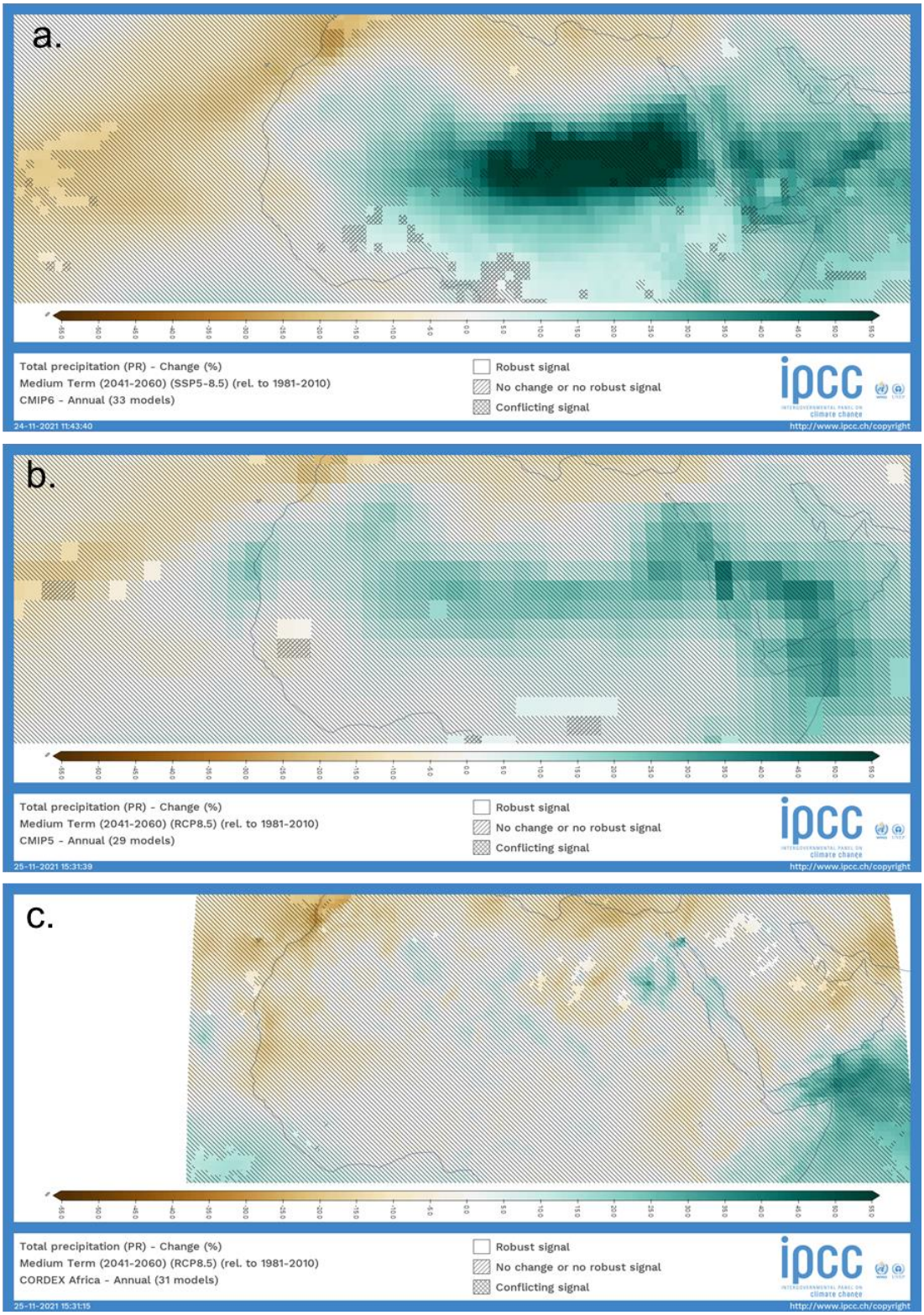

Figure B1: Maps of Sahel region showing change in total precipitation (%) for 2041-2060 from baseline period (1980-2010) under RCP8.5/ SSP585 for a. CMIP6, b. CMIP5 and c. CORDEX Africa. Maps show the differences between models in producing the projected Sahel precipitation gradient. CMIP6 shows this most clearly where as CMIP5 and CORDEX Africa are less clear. Signal is also very uncertain across all models. This indicates why the projected precipitation gradient is not visible in this report's zone analysis as analysis considers all models and only CMIP6 models show a strong signal. Maps created using IPCC Interactive Atlas (2021), uncertainty: advanced.

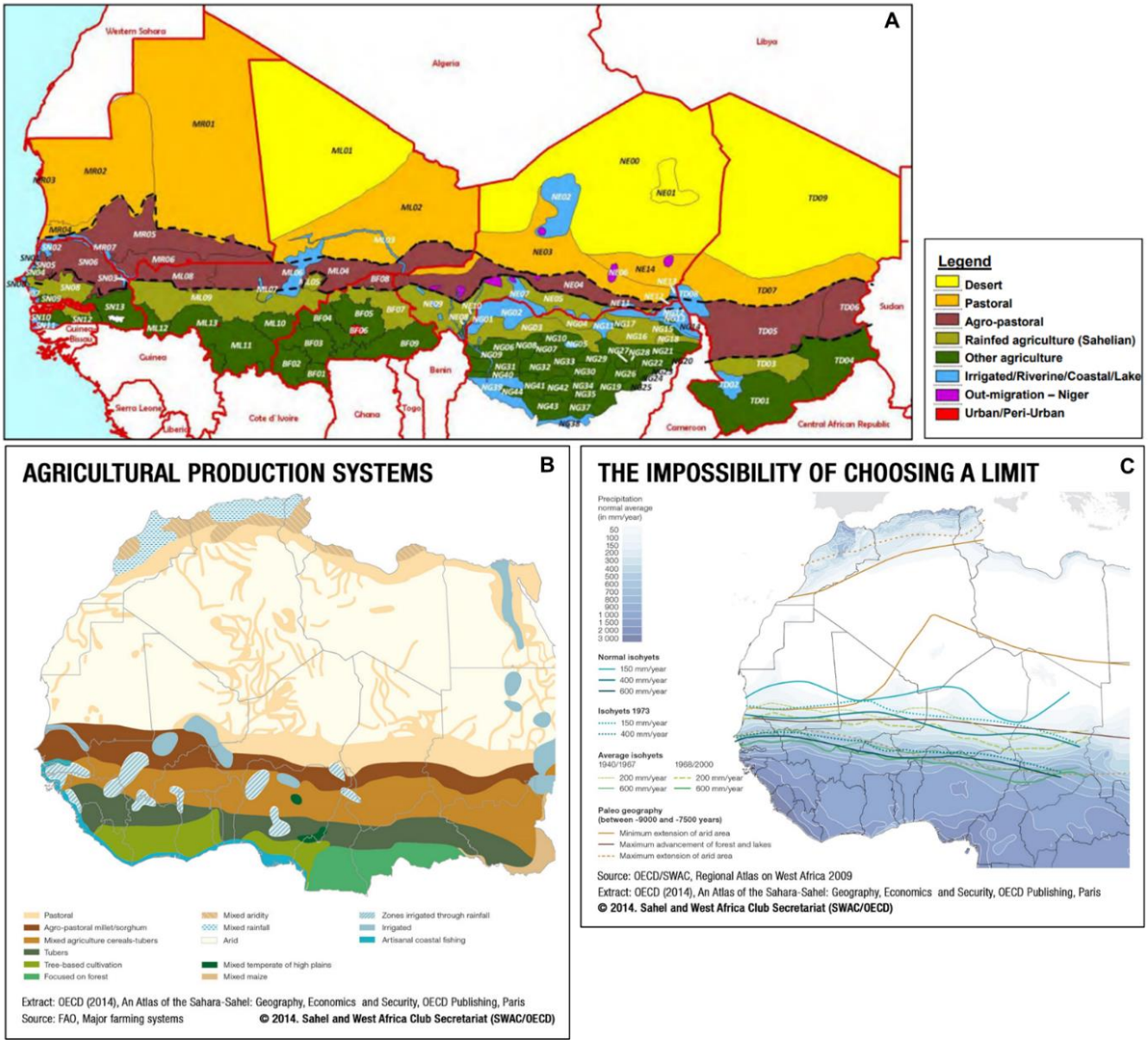

Figure B2: Maps used to create spatial analysis zones for Sahel region in addition to climate classification. Map A shows FEWS NET livelihoods zones overlayed with modes of agriculture including those based around major river systems (Holt & Lawrence, 2013). Map B shows simplified map of major agricultural production systems (OECD, 2014). Map C shows multiple isohyet lines for different historical periods, indicating the oversimplification of individual isohyet lines (OECD/SWAC; 2009.

Additional plots of the baseline climate and projected climate changes for annual and seasonal timescales, in each spatial analysis zone are included in the following sections.

Zone 1 - West desert: Northern Mauritania and Mali

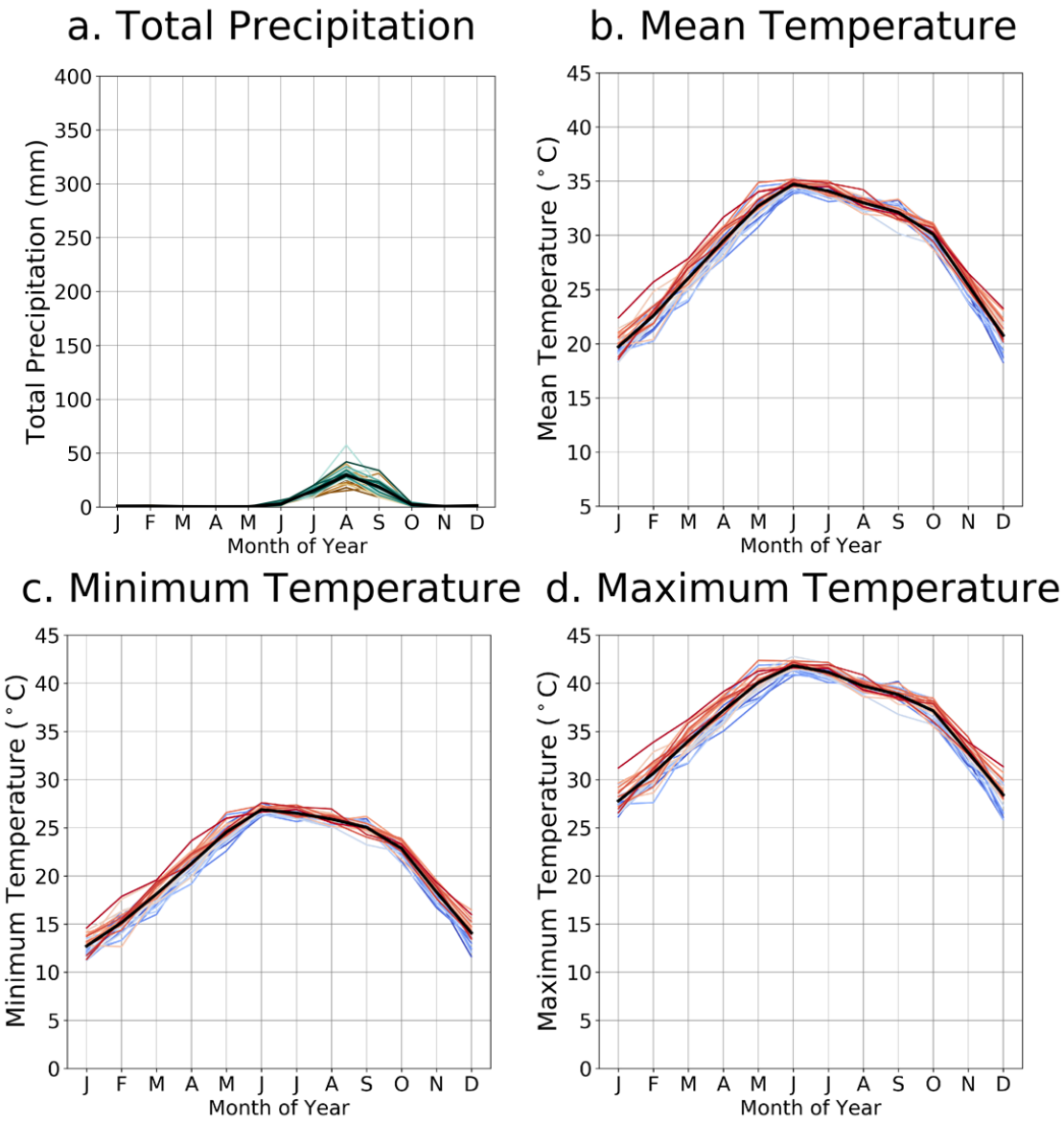

Figure B3: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

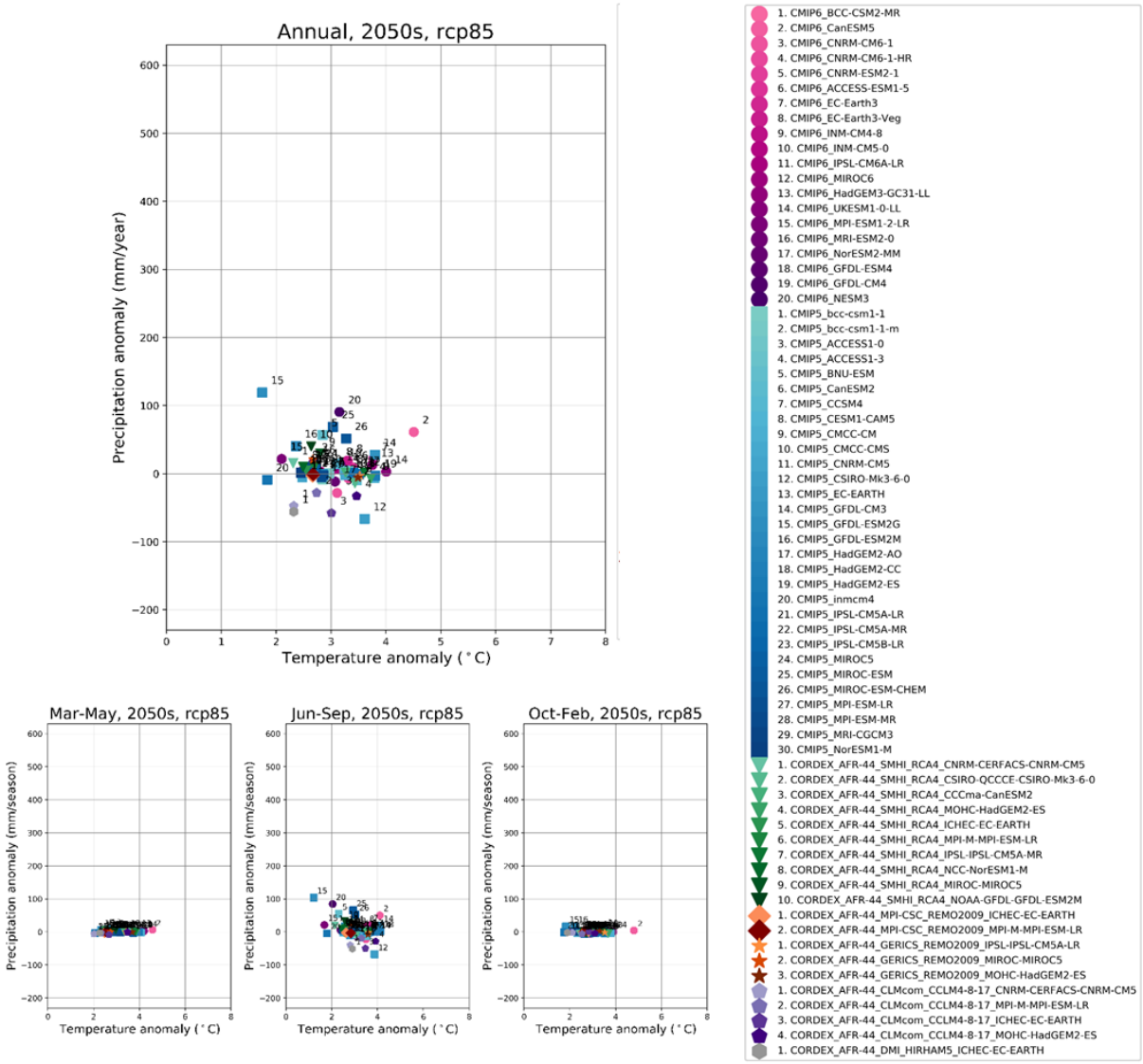

Figure B4: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

Zone 2 – Desert East: Northern Niger and Chad

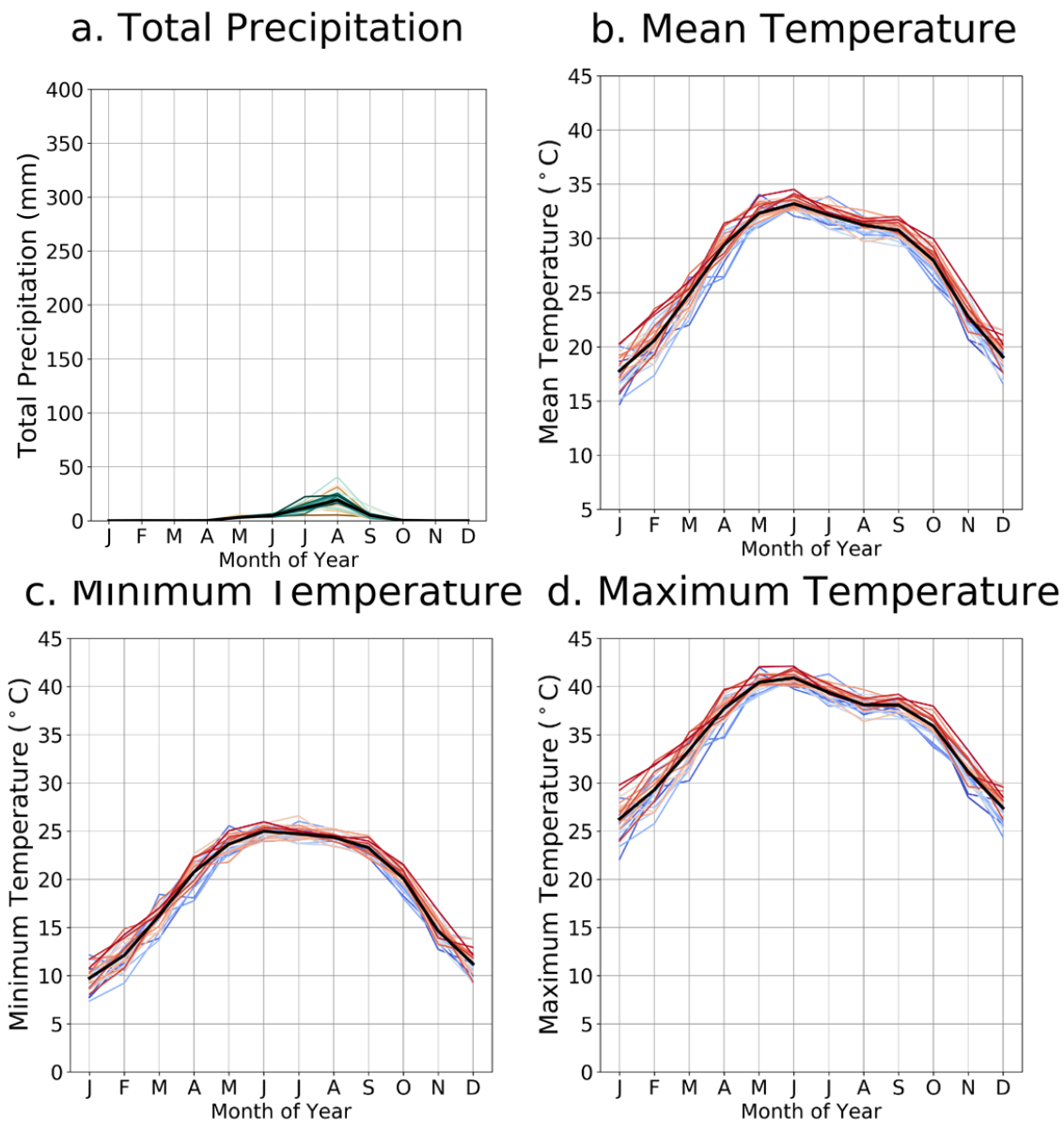

Figure B5: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

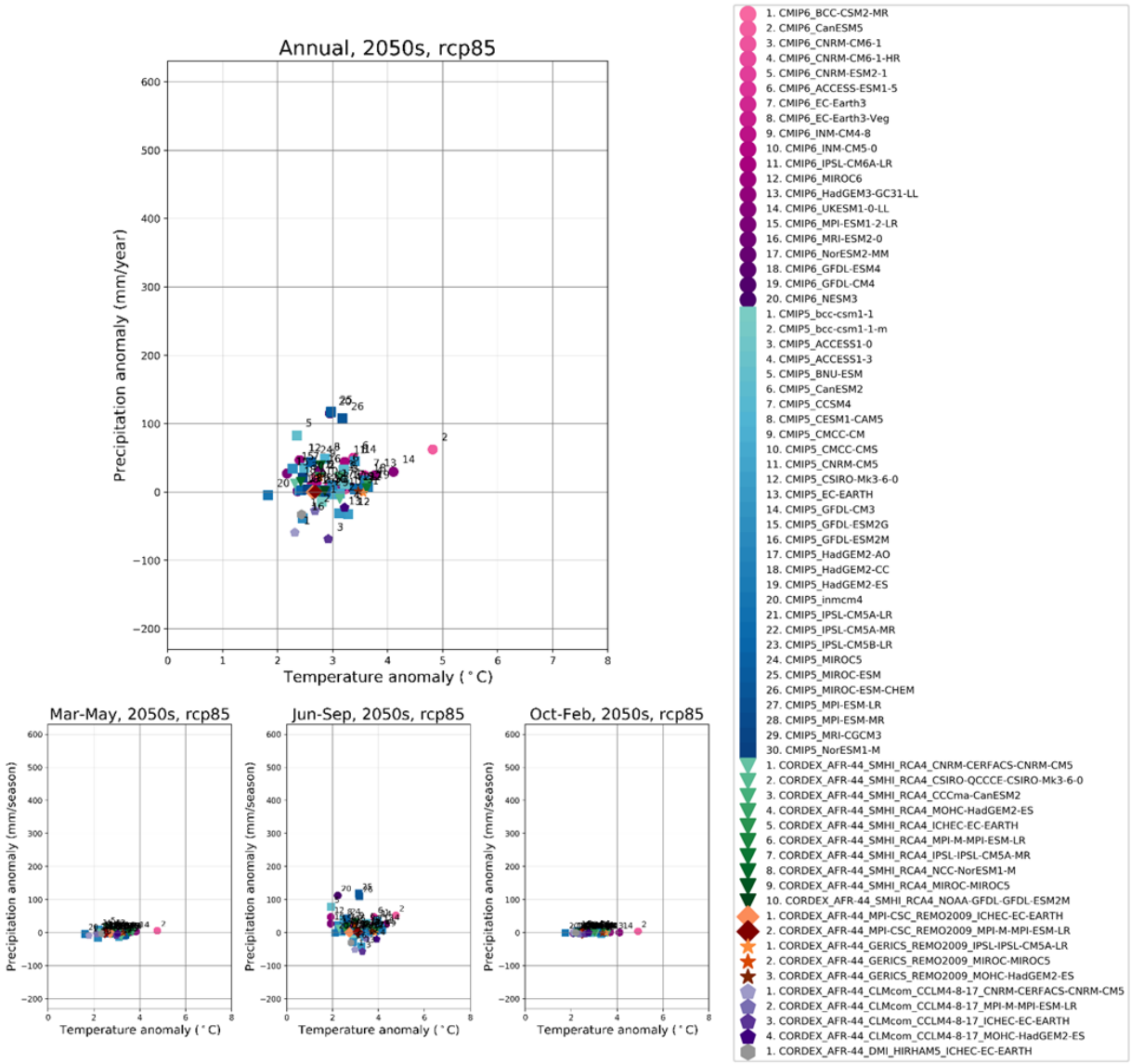

Figure B6: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

Zone 3 – Mixed rainfall west: Southern Mauritania, Mali, southwest Niger, northern Burkina Faso

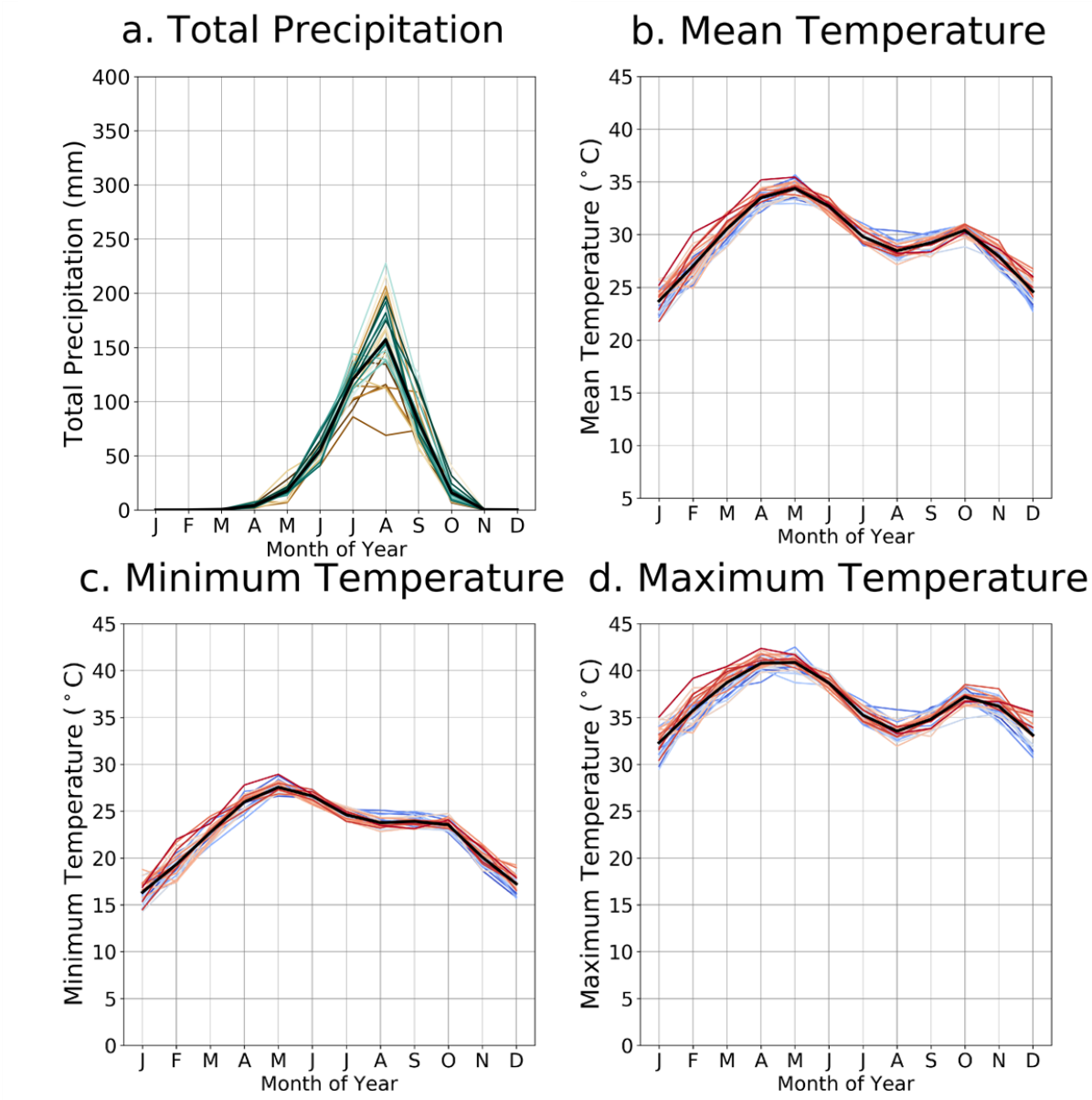

Figure B7: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

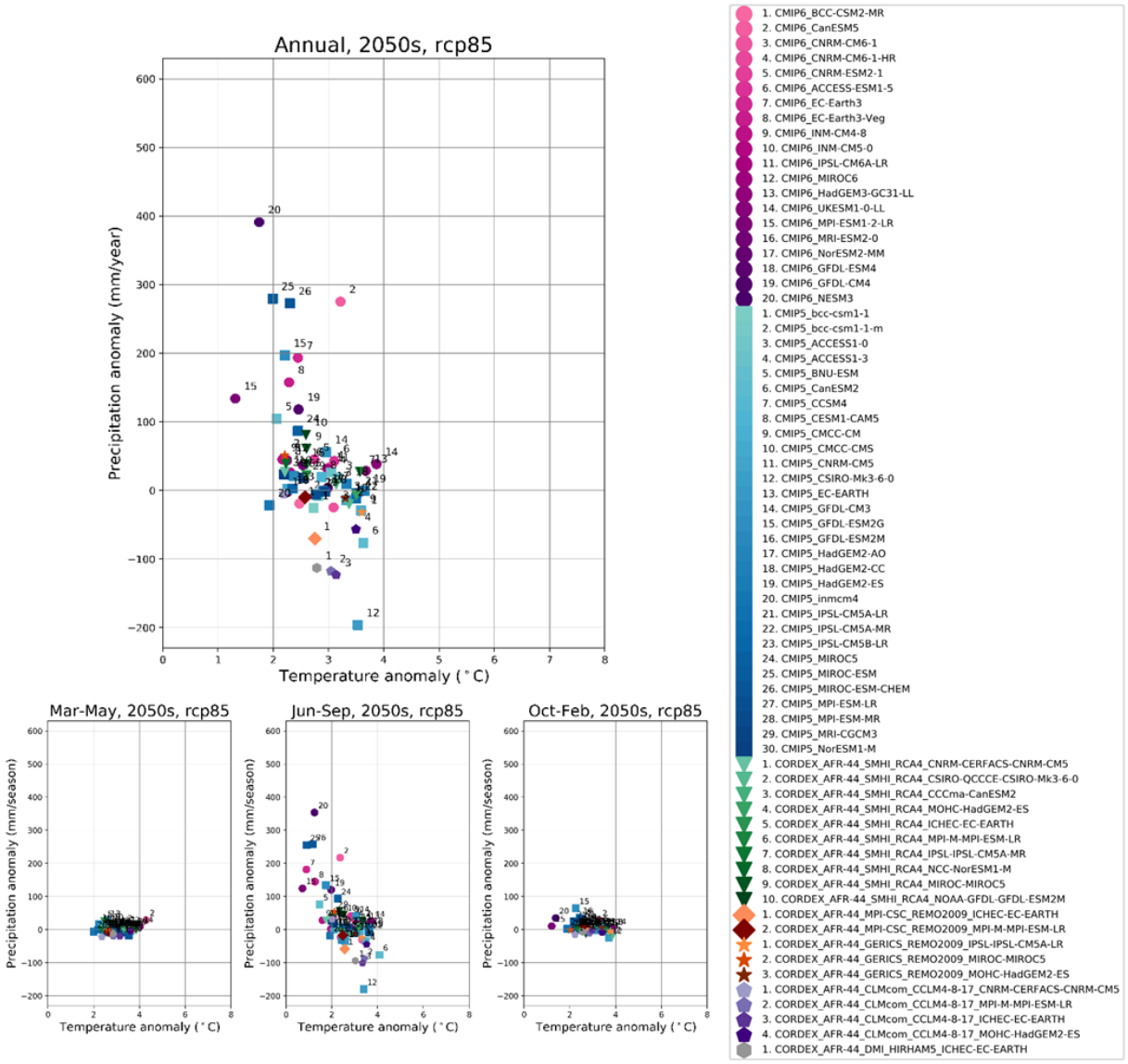

Figure B8: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

Zone 4 – Mixed rainfall east: South-eastern Niger and central Chad

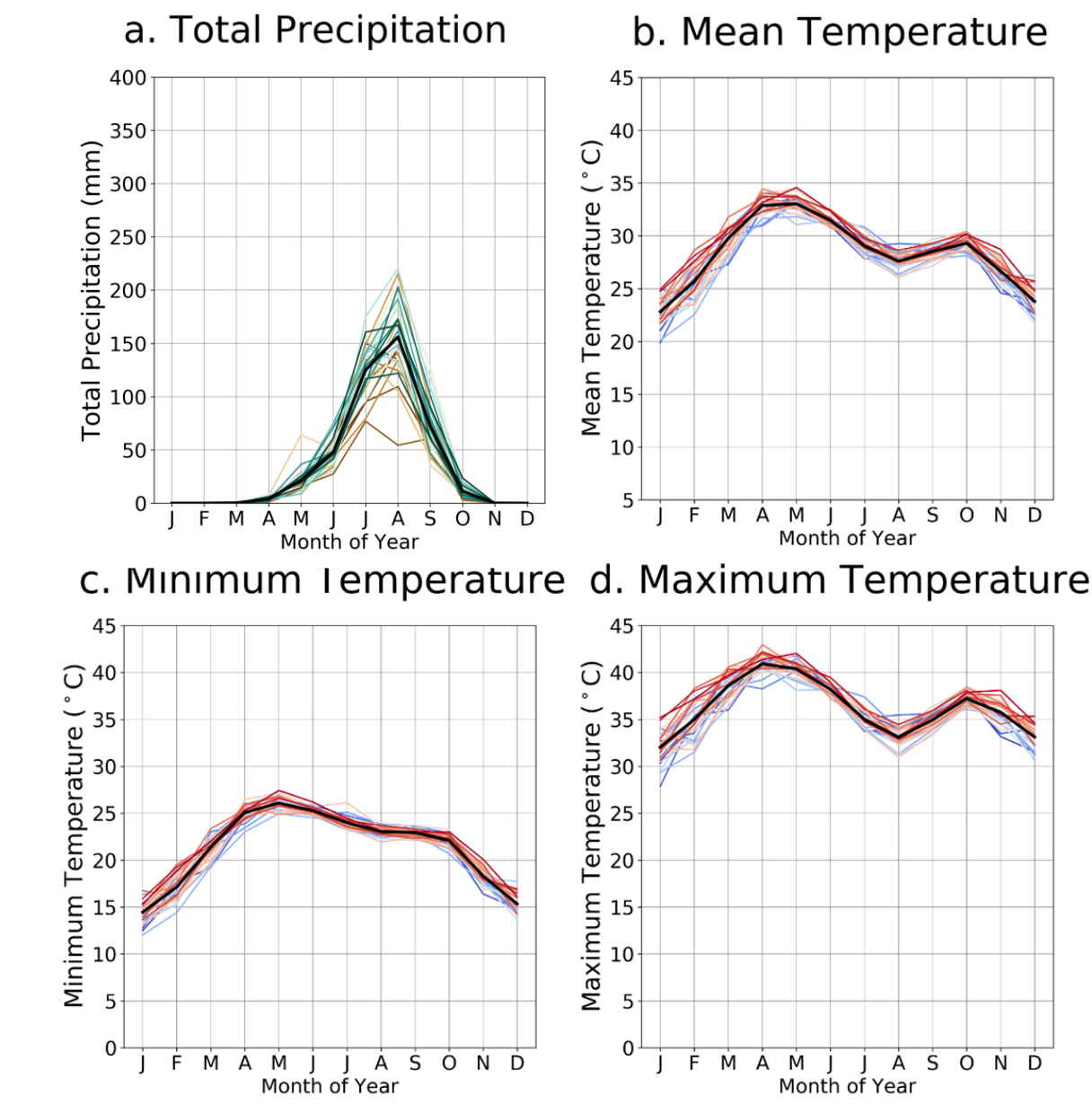

Figure B9: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

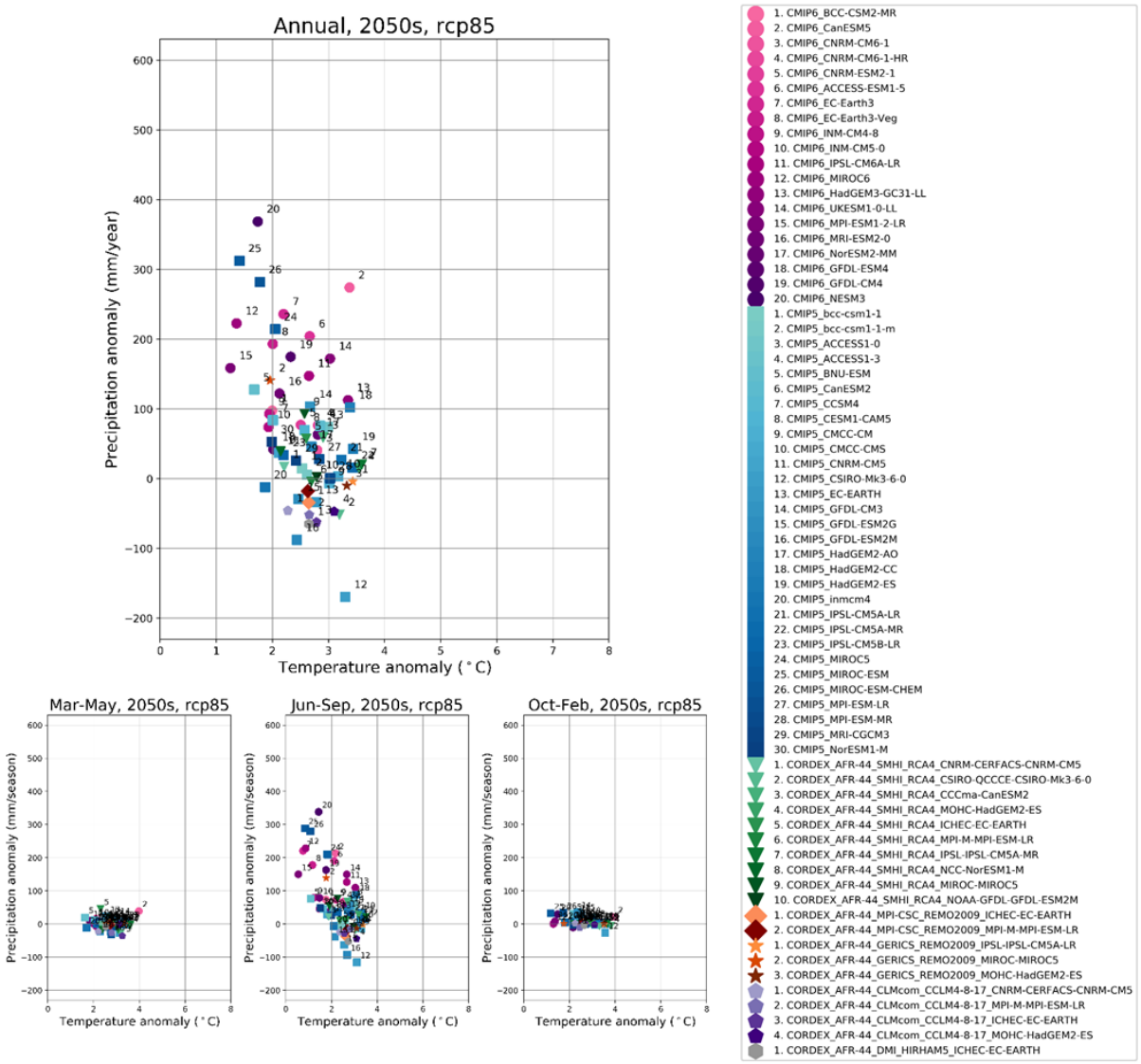

Figure B10: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

Zone 5 – Tropical east: Southern Mali and Burkina Faso

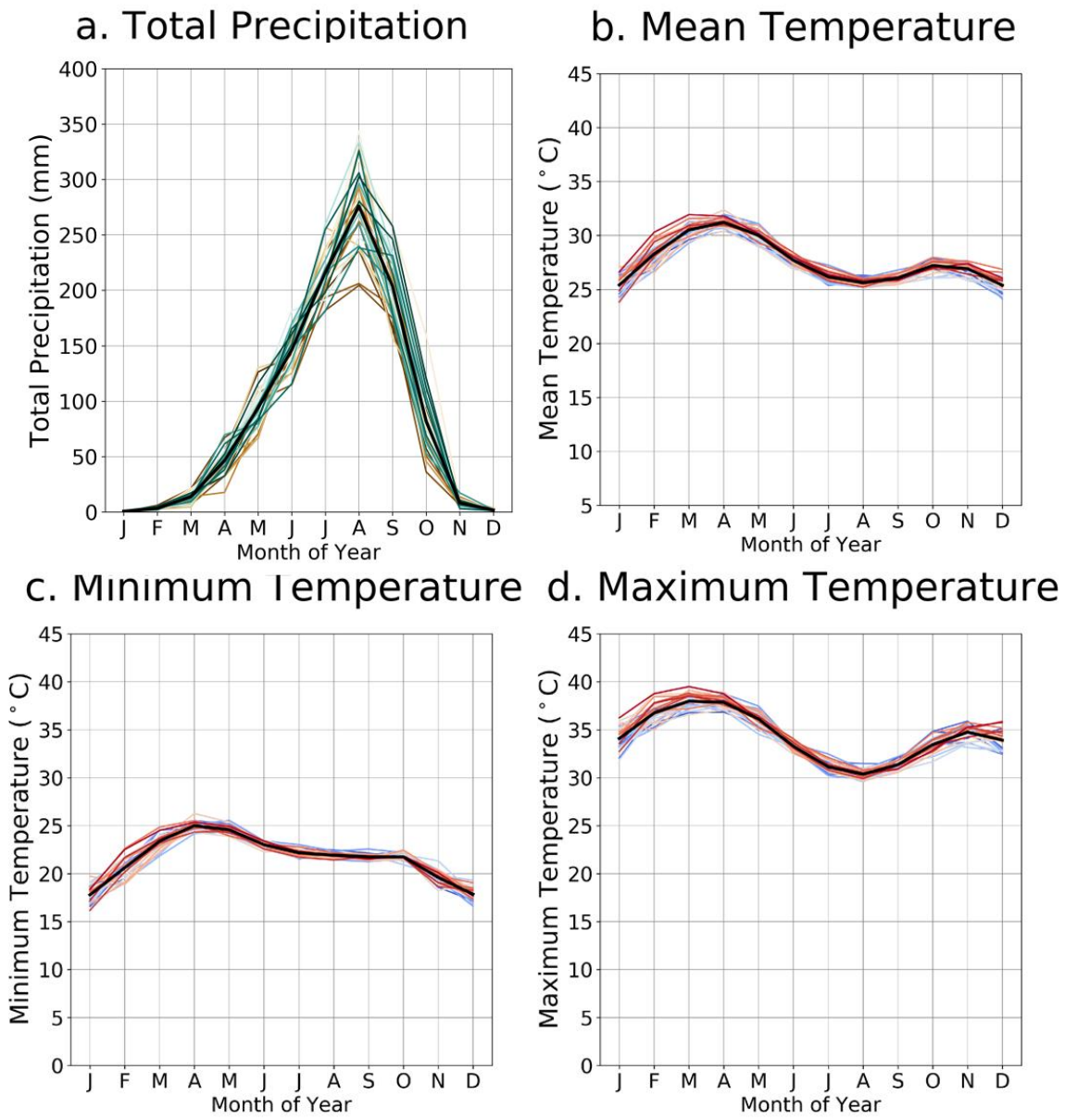

Figure B11: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

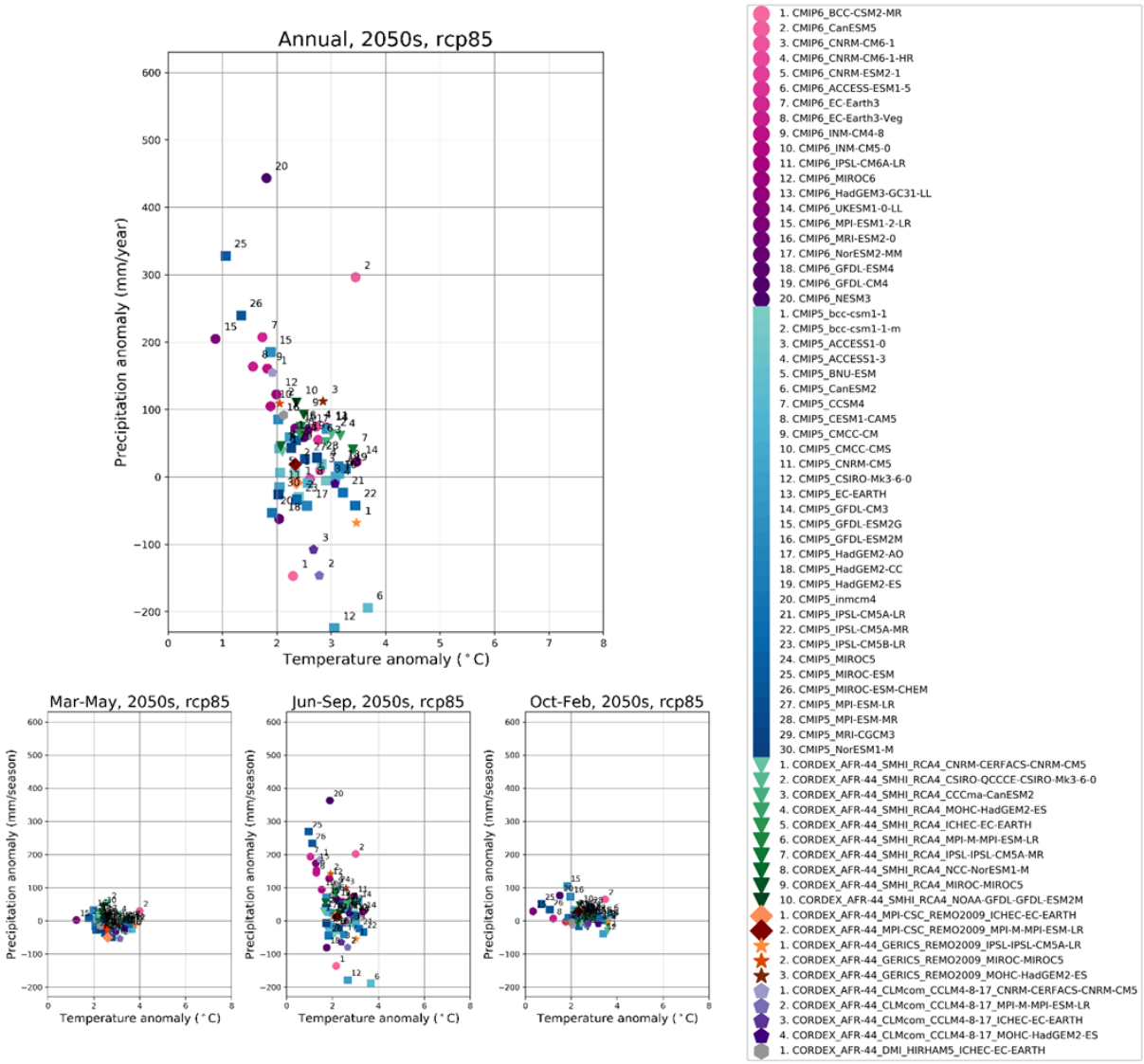

Figure B12: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

Zone 6 – Tropical west: Southern Chad

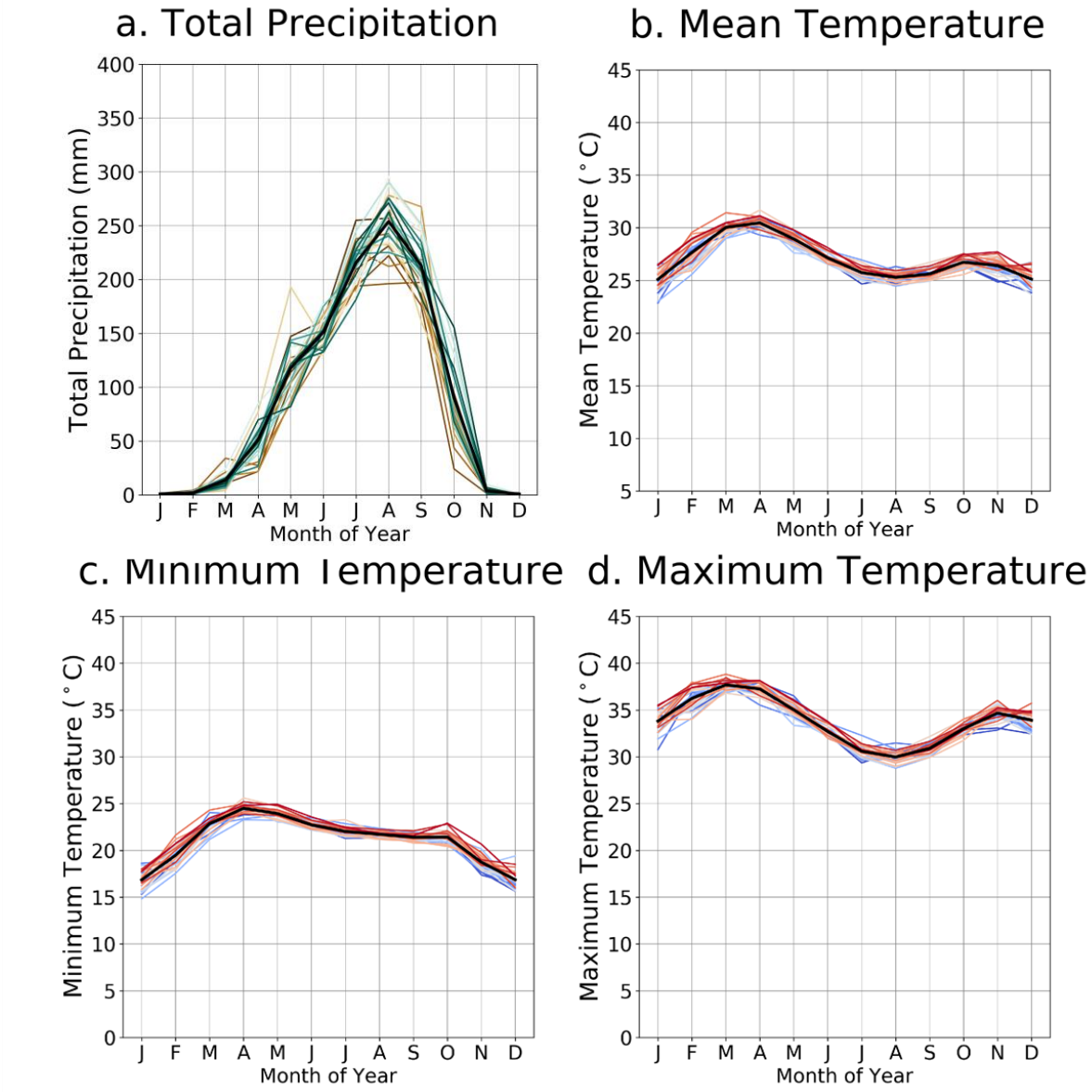

Figure B13: Observations of total monthly precipitation (a) and average daily mean (b), minimum (c) and maximum (d) temperature over the baseline period (1981-2010) for Zone 1. Each line is one individual year. Colours show the ordering of years from brown-blue (total precipitation) and blue-red (mean temperature) – this highlights the presence, or lack of, a trend over the baseline period. The bold black line indicates the average of the 30-year period. Observational dataset: CHIRPS and WFDEI for precipitation and temperature respectively.

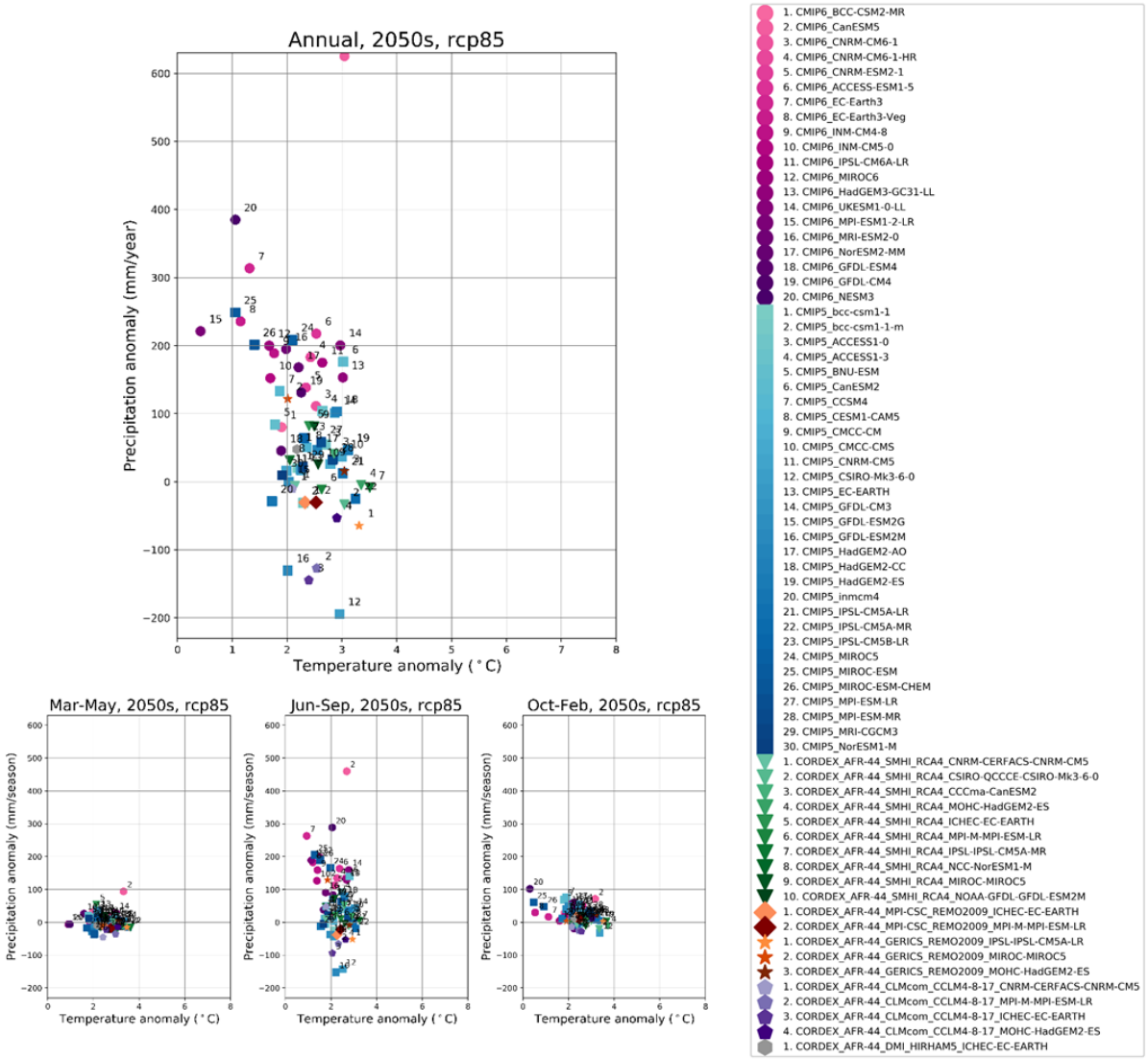

Figure B14: Projected change in average annual (top panel) and seasonal (bottom panels) precipitation and temperature in Zone 1. Each dot shows the difference between the average projected values in the 2050s and the average values in the current climate, for each climate model. Individual models are identified by the icon and number in the legend.

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