USE OF THE MULTI-MODEL ENSEMBLE (MME) MEAN OF GLOBAL CLIMATE MODELS (GCMs) FOR HYDRO ELECTRICITY GENERATION PLANNING IN ZAMBIA

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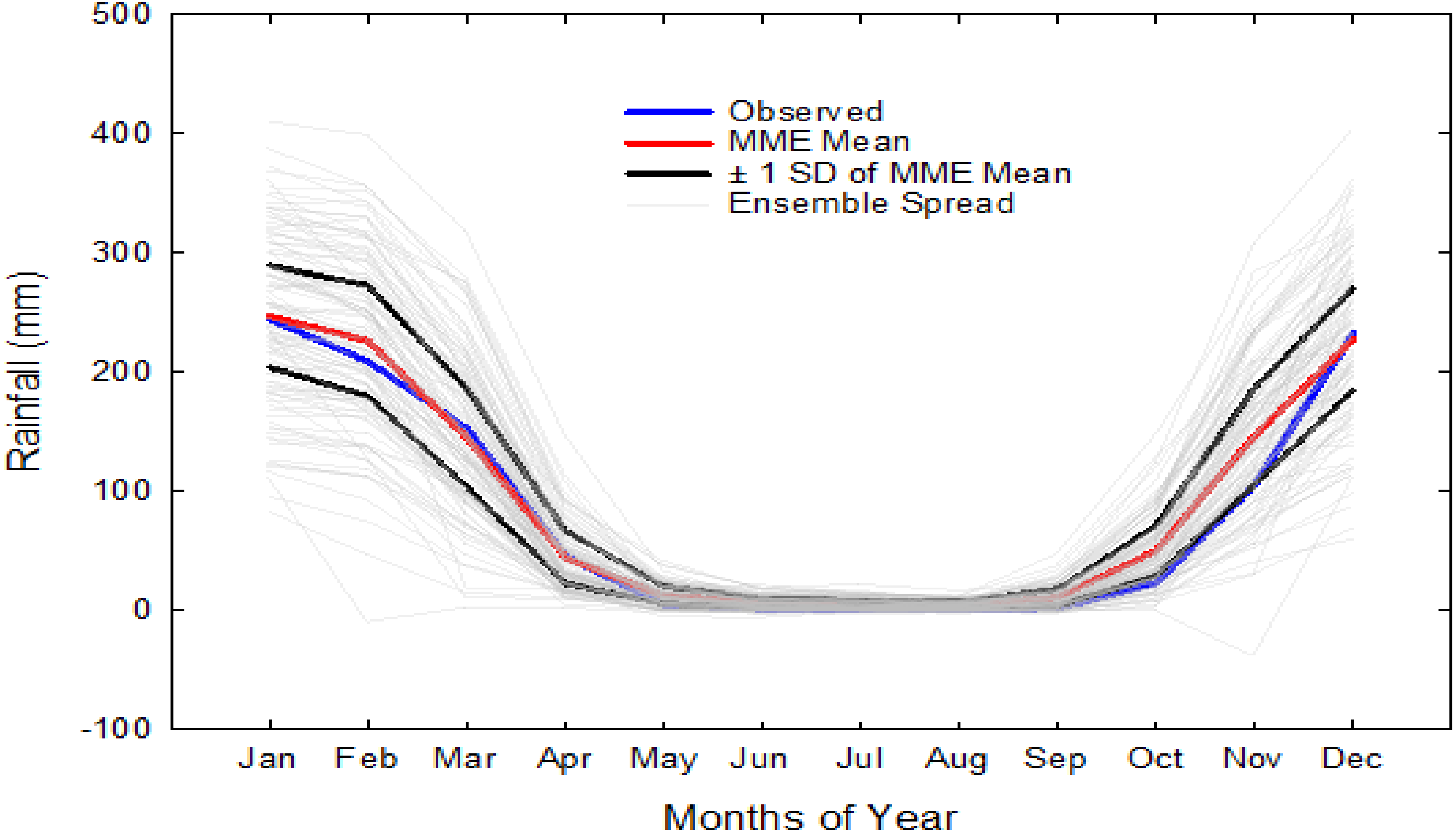
Hydroelectric Power and Climate Variability

- Largest source of renewable electricity globally
- Produces around 17% global electricity
- Climate variability effects on future hydroelectricity generation
- Vulnerability of Southern Africa to climate variability
- Global Climate Models (GCMs) and climate variability
- CMIP5 Representative Concentration Pathways
  - RCP2.6, RCP4.5, RCP6.0, RCP8.5
- Multi-Model Ensemble (MME) of GCMs

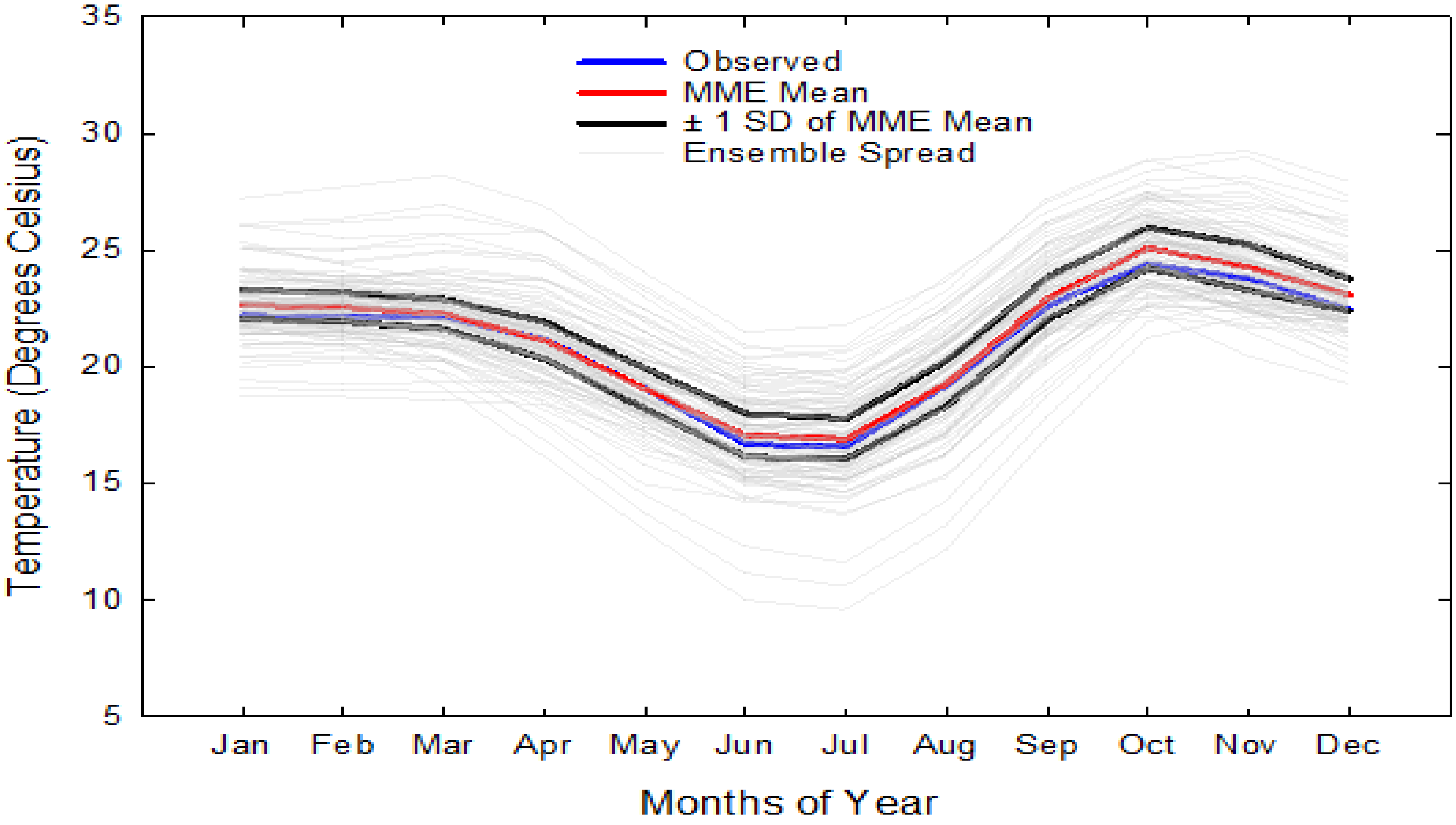
Climate Models – How accurate are they?

- 30 year historical climate evaluation (1970-2000) for Zambia
- 30 year mean monthly historical rainfall and temperature (Control)
- 30 year mean monthly historical rainfall and temperature (CMIP5 Modelled Data)
- Computing CMIP5 MME Mean for validation
- Validation of CMIP5 simulated climate against historical data
- Validation results

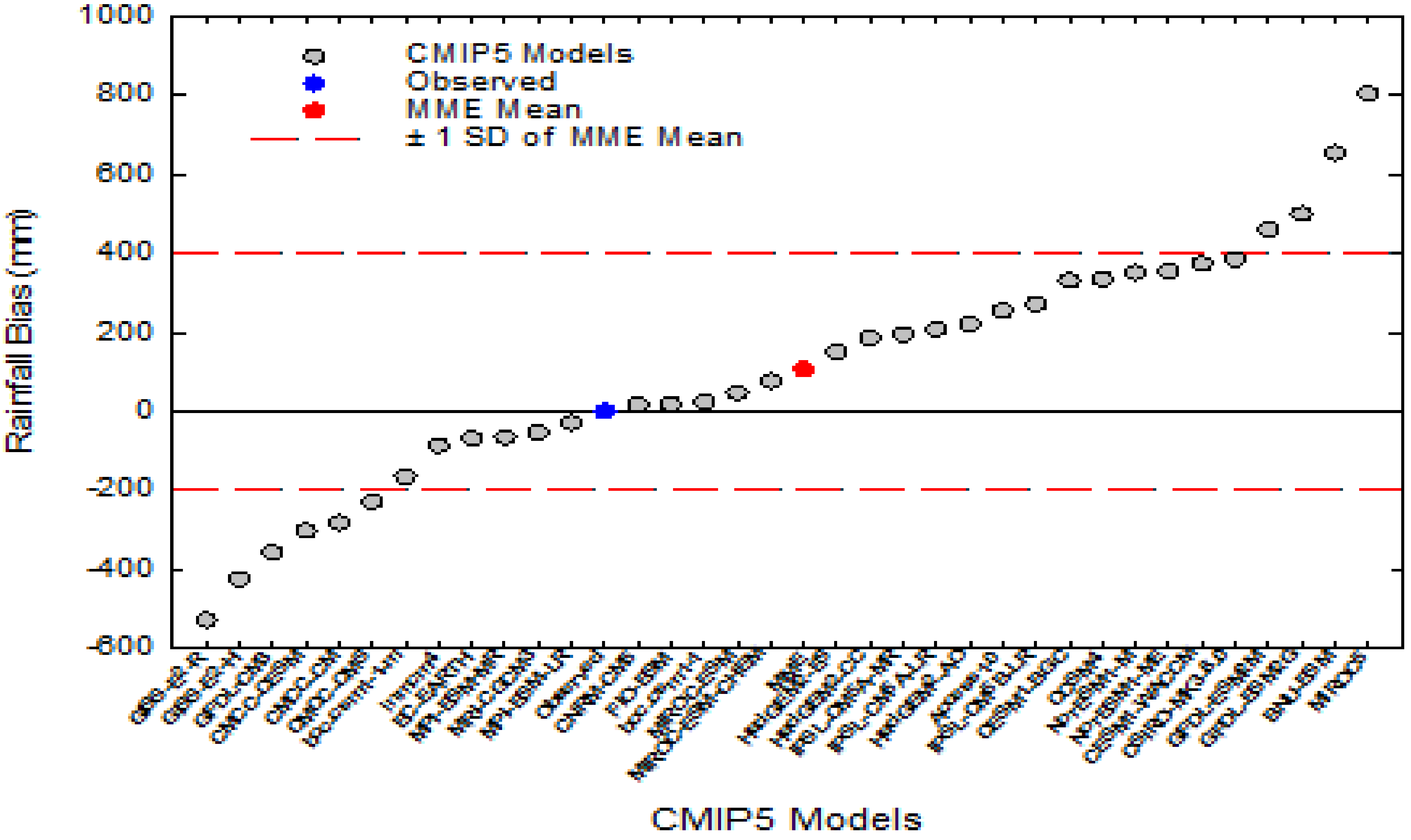
- Results of validation - Rainfall



- Results of validation - Temperature



- Bias Assessment - Rainfall



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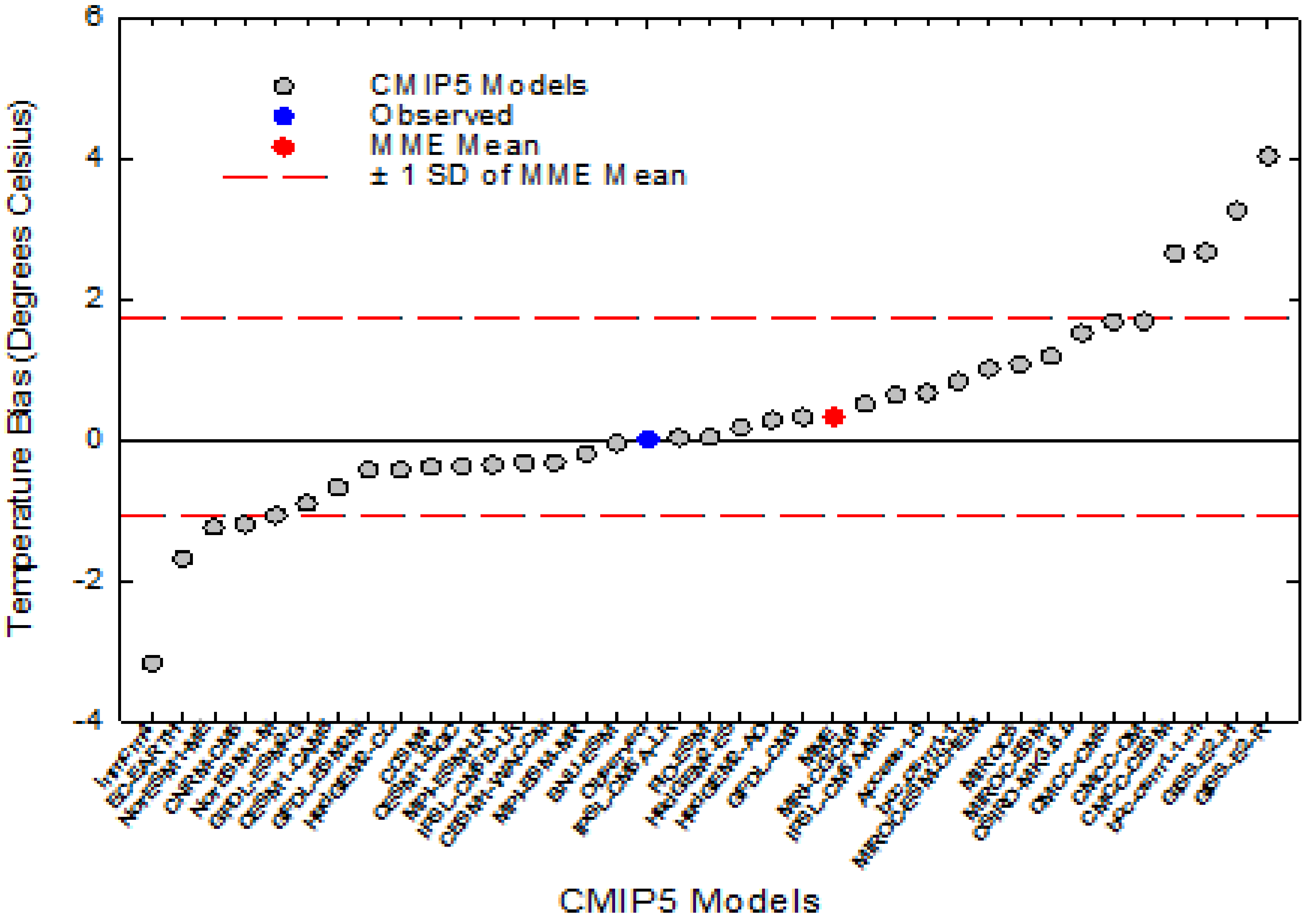


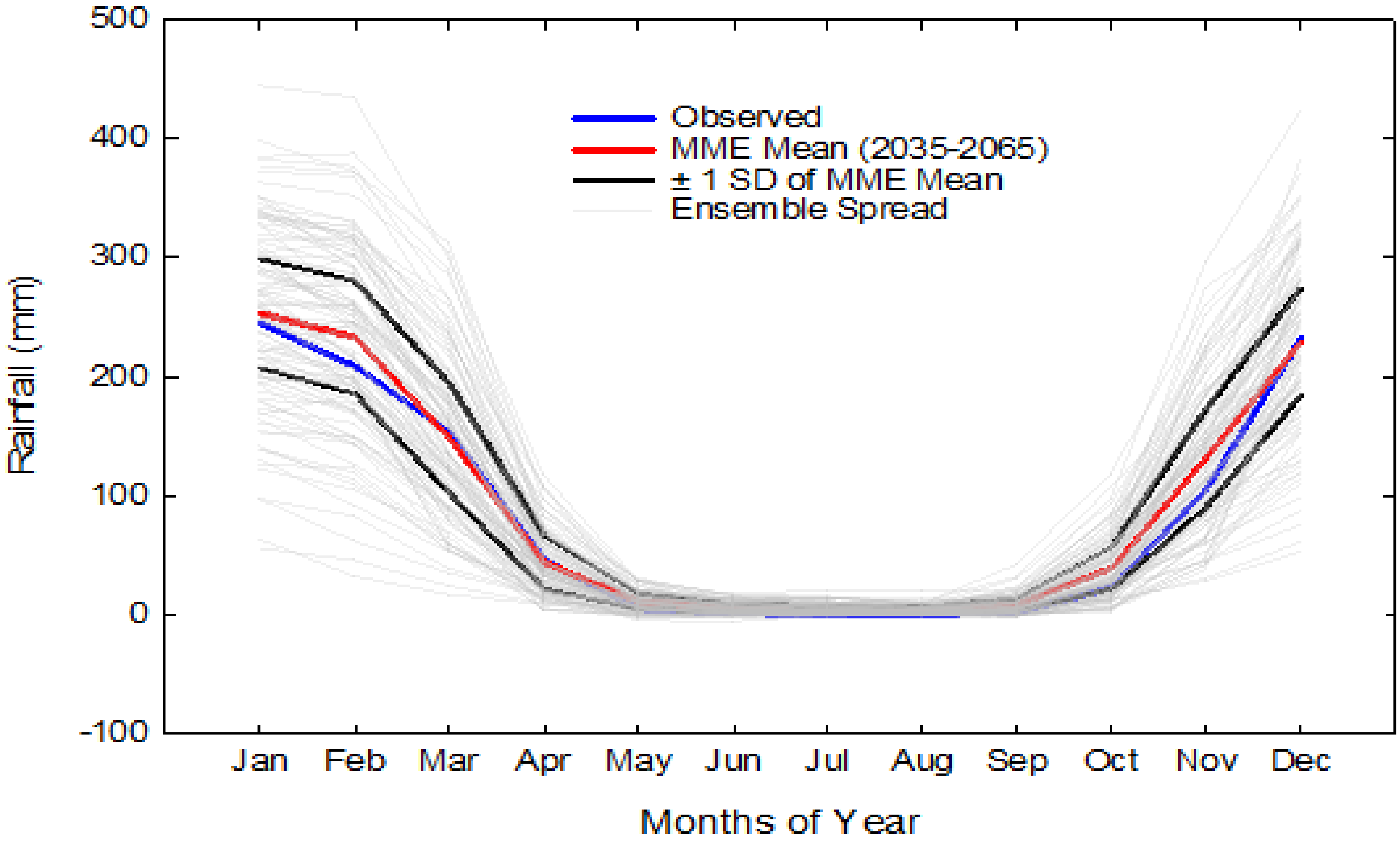
Projected Changes in Rainfall and Temperature for Zambia

- Future Period (2035-2065); Control Period (1970-2000)
- Representative Concentration Pathway (RCP) 8.5
- Modelled rainfall and temperature data (2035-2065)
- Computation of MME mean for modelled data (2035-2065)
- Percentage changes in mean annual rainfall and temperature (control and future period)

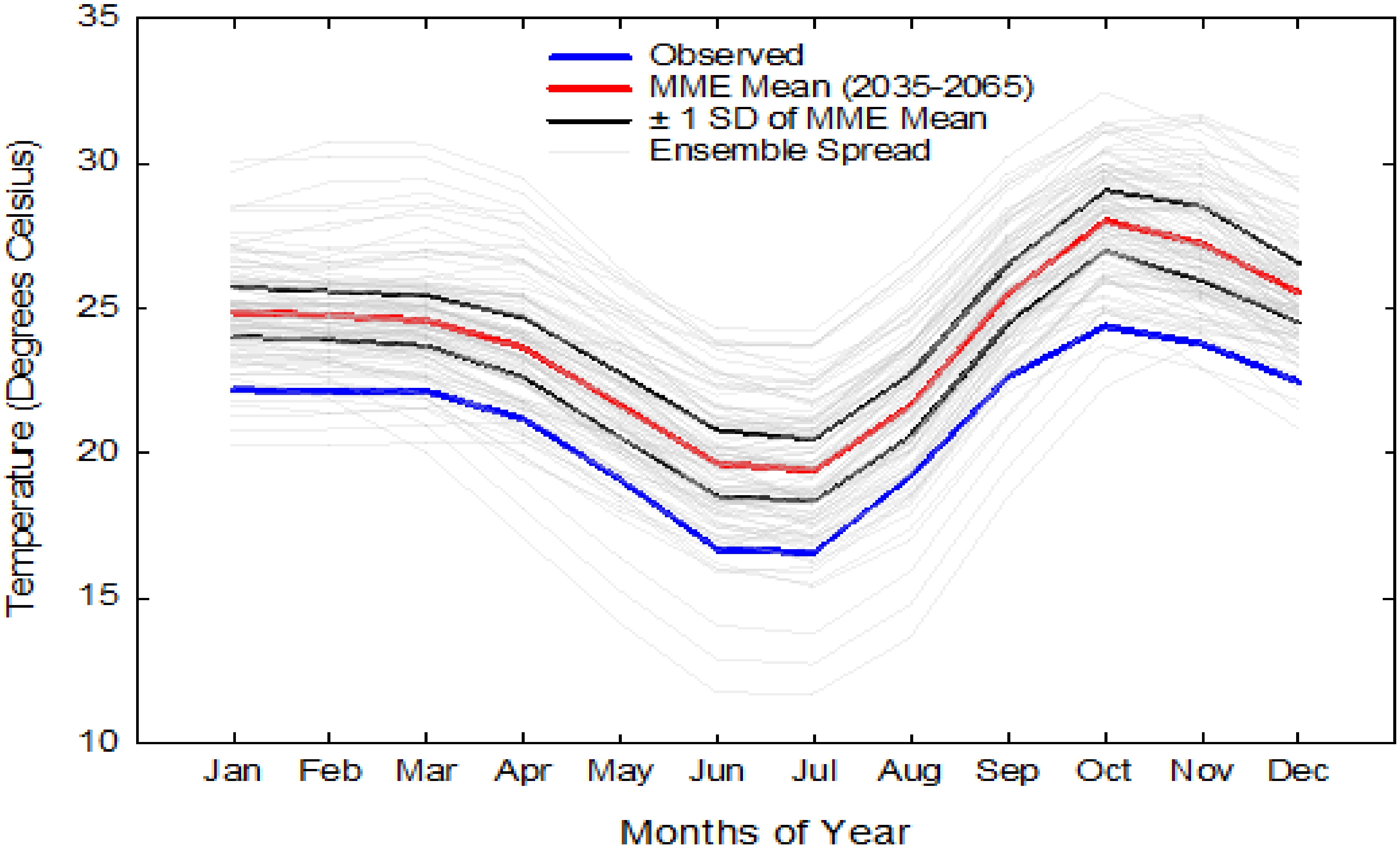
  - % Change in R = $\mathbf{(}(R_P - R_O) / R_O\mathbf{)*}100$ (1)

  - % Change in T = $\mathbf{(}(T_P - T_O) / T_O\mathbf{)*}100$ (2)

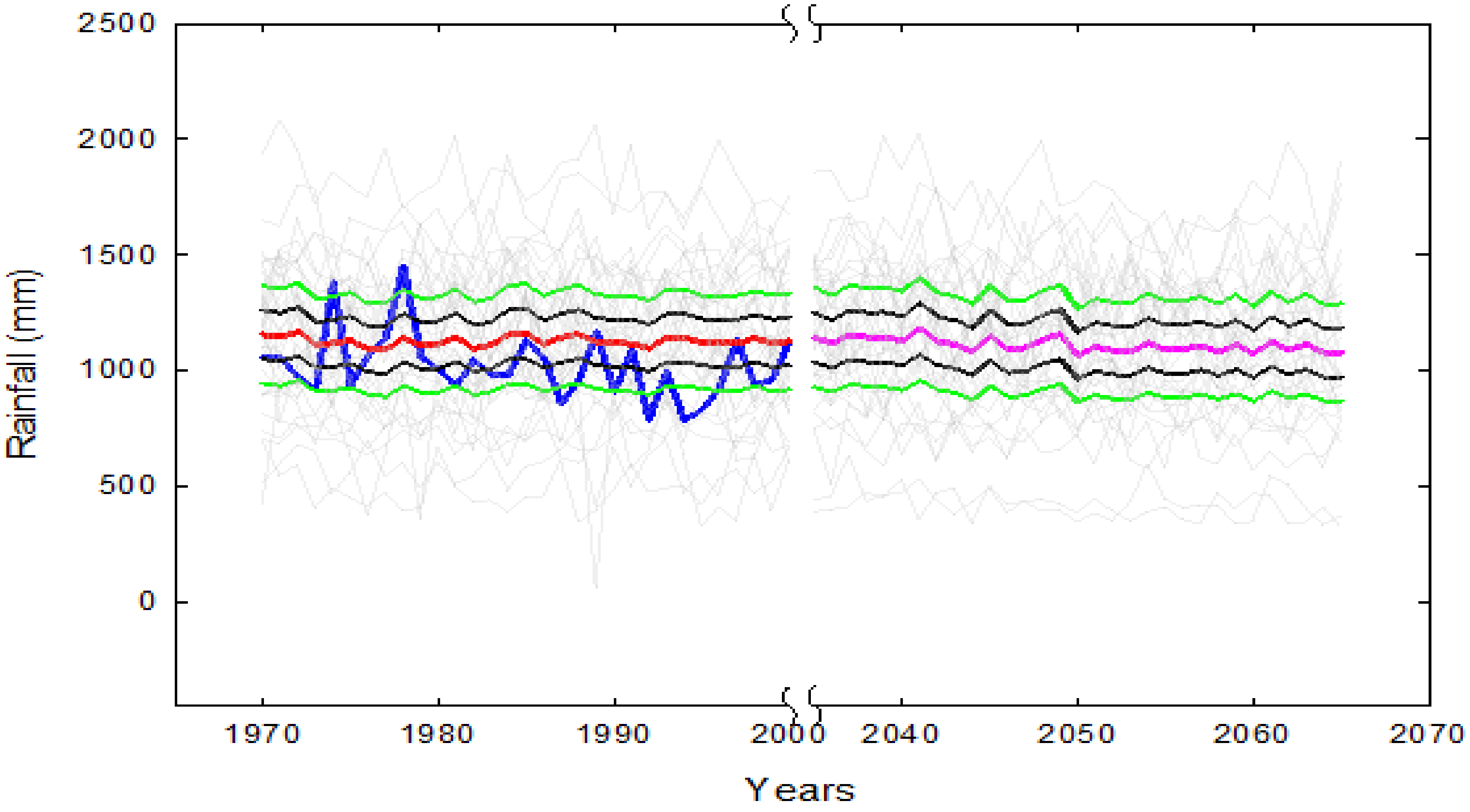
- Projected Monthly Rainfall Changes (2035-2065)



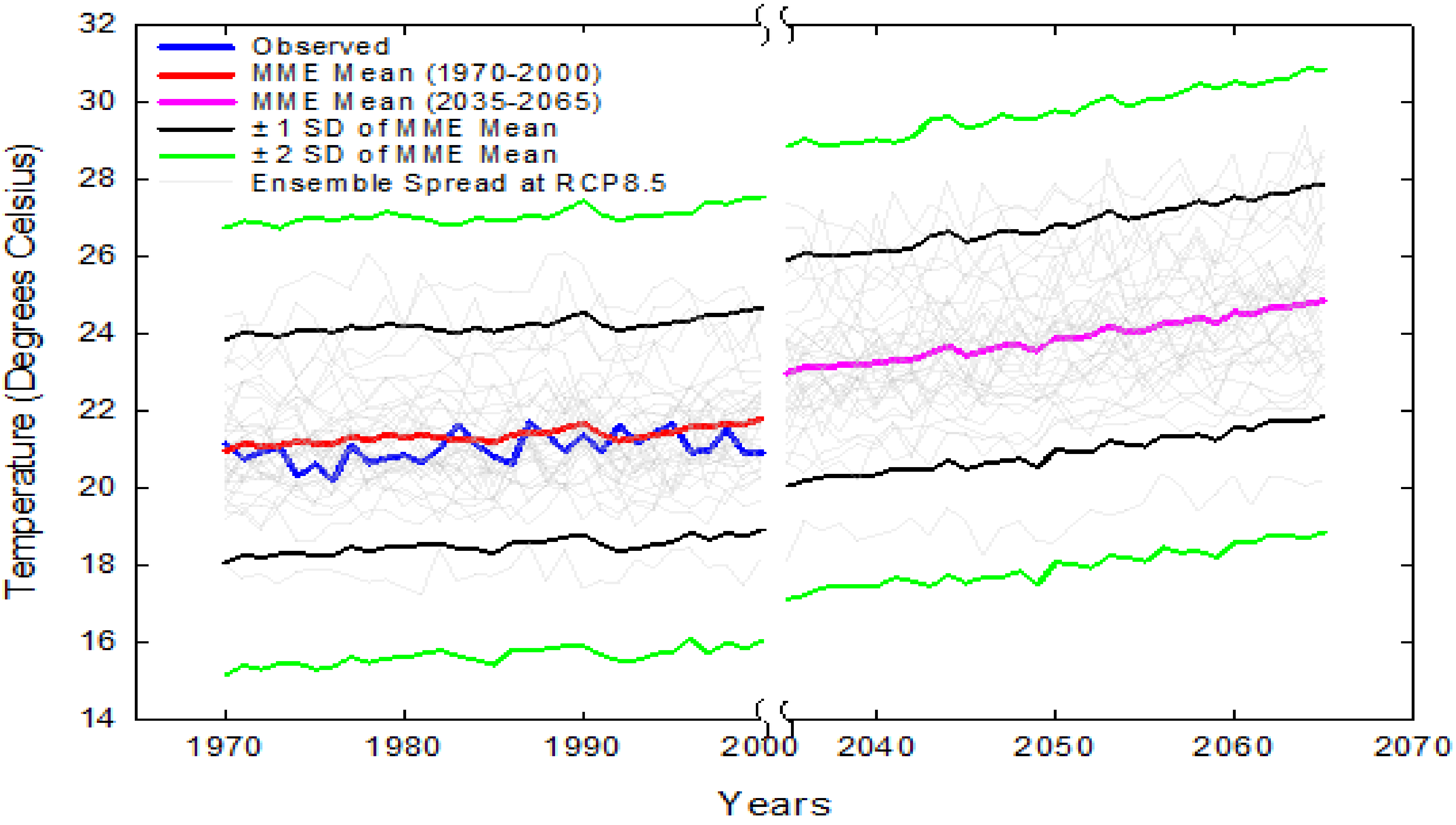
- Projected Monthly Temperature Changes (2035-2065)



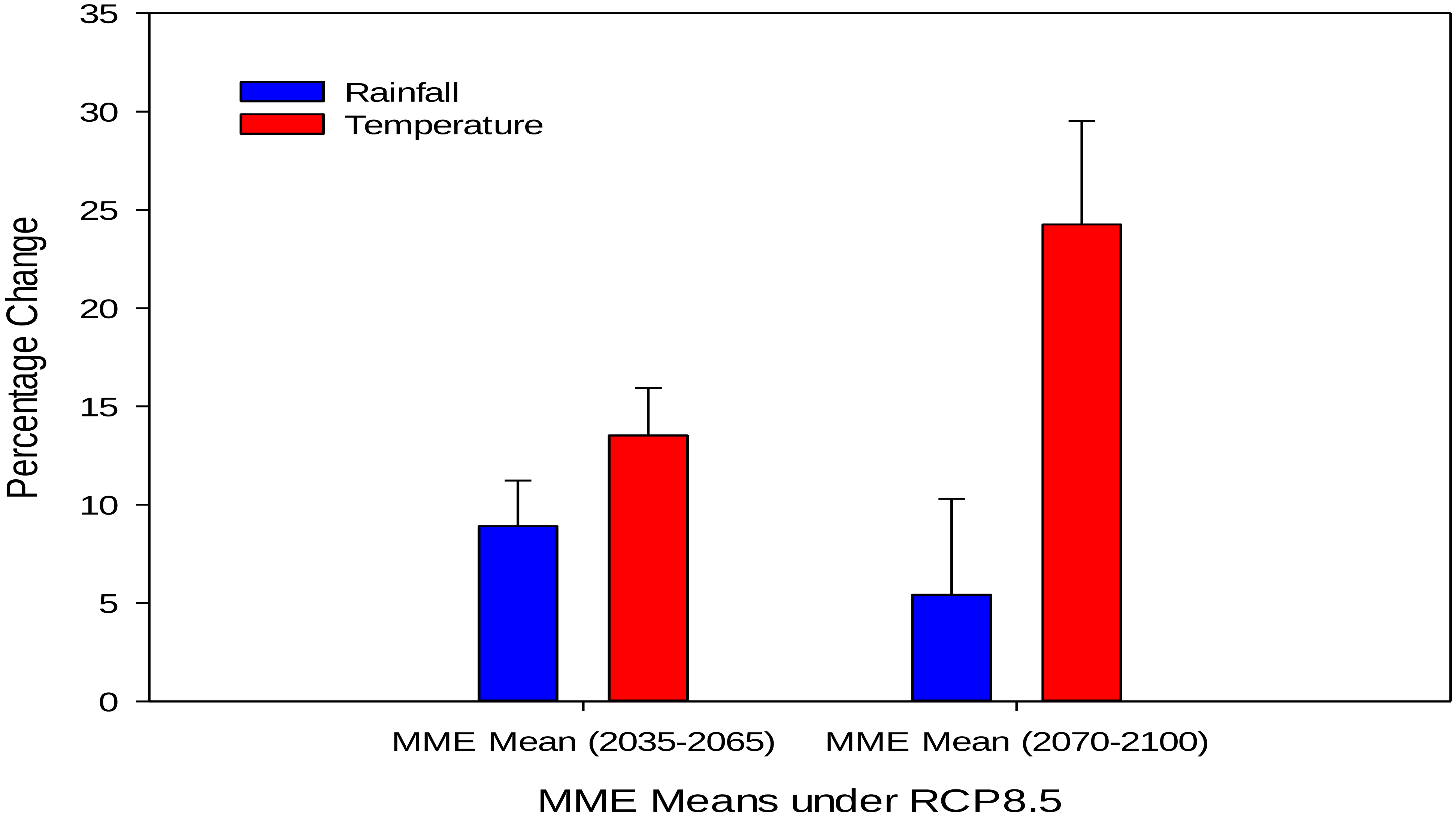
- Projected Annual Rainfall Changes (2035-2065)



- Projected Annual Temperature Changes (2035-2065)



- Percentage Change in Rainfall and Temperature



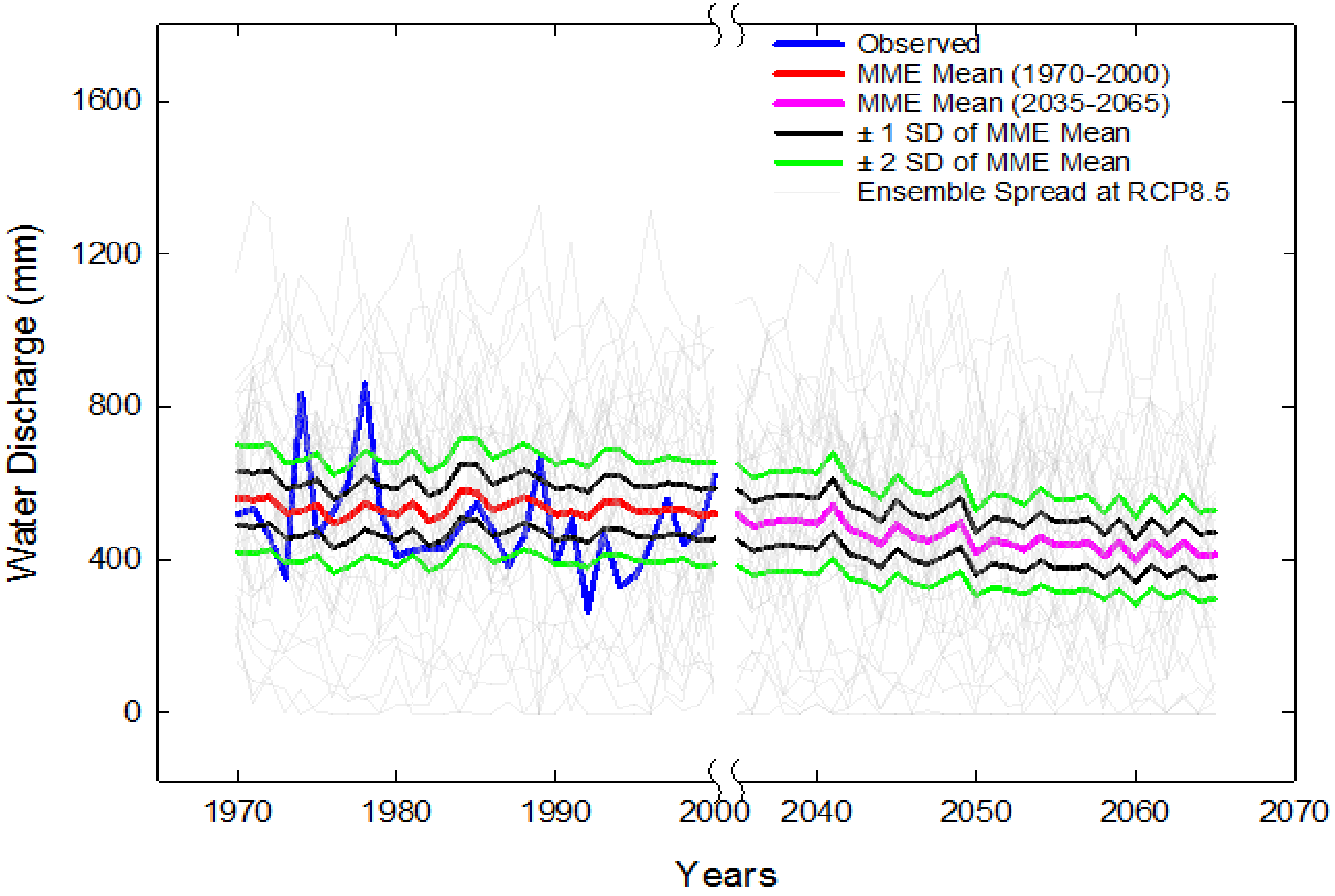
Change in Mean Annual Water Discharge

- Projected change (2035-2065) based on control period (1970-2000)
- Mean monthly water discharge (water balance equation)

  - $Q_m = P - E \pm \Delta S$ (3)
- 30 year monthly and annual mean water discharge and yearly water discharge (control and future period)
- Mean annual water discharge computation – Q_A
- Percentage change in mean annual water discharge

  - % Change in Q = $\mathbf{(}(Q_{Ap} - Q_{Ao}) / Q_{Ao}\mathbf{)}$*****100 (4)
- Key Assumptions considered

- Projected changes in mean annual water discharge



- Percentage variation in key climatic parameters

Parameter	MME Mean (1970 to 2000)	*MME Mean (2035 to 2065)*	MME Mean (2070 to 2100)
Rainfall	10.4 ± 2.3	*8.9 ± 2.3*	5.4 ± 2.4
Temperature	1.5 ± 3.8	*13.5 ± 4.9*	24.3 ± 5.3
PET	4.3 ± 0.7	*33.2 ± 1.3*	77.9 ± 2.4
Water Discharge	8.7 ± 3.6	*-7.1 ± 3.6*	-28.5 ± 3.5

Effects on Future Hydro Electricity Generation

- Key resource for hydroelectricity generation is runoff
- Projected decrease in mean annual water discharge
- Zambezi River Basin highly vulnerable
- Negative effect on hydroelectricity generation under RCP8.5 scenario
- Similar findings in previous research within Zambezi Basin

Conclusions

- Expected percentage reduction in hydroelectricity generation not quantified
- Different spatial resolutions of GCMs
- Equal weighting of models
- Different Representative Concentration Pathways
- Climate model uncertainty
- Overall, Climate Models can be used for planning