# CMIP6 historical MMM (24 models) comparison with 21-model AMIP MMM (no INM-CM4-8) and observations

June 13, 2023

**Time period: 1979 - 2014 ( 36 years), AMIP MMM: 21 models**

List of AMIP models used

| | Model | Ensemble | Period |
|---|---|---|---|
| 1 | ACCESS-CM2 | 3 | 1979-2014 |
| 2 | ACCESS-ESM1-5 | 3 | 1979-2014 |
| 3 | BCC-CSM2-MR | 3 | 1979-2014 |
| 4 | CESM2 | 10 | 1950-2014 |
| 5 | CNRM-CM6-1 | 1 | 1979-2014 |
| 6 | CanESM5 | 2 | 1950-2014 |
| 7 | FGOALS-f3-L | 3 | 1979-2014 |
| 8 | FIO-ESM-2-0 | 3 | 1979-2014 |
| 9 | GFDL-CM4 | 1 | 1979-2014 |
| 10 | GFDL-ESM4 | 1 | 1975-2014 |
| 11 | GISS-E2-1-G | 5 | 1850-2014 |
| 12 | GISS-E2-2-G | 5 | 1979-2014 |
| 13 | HadGEM3-GC31-LL | 5 | 1979-2014 |
| 14 | HadGEM3-GC31-MM | 4 | 1979-2014 |
| 15 | IPSL-CM6A-LR | 20 | 1958-2014 |
| 16 | MIROC6 | 10 | 1979-2014 |
| 17 | MPI-ESM1-2-HR | 3 | 1979-2014 |
| 18 | MRI-ESM2-0 | 3 | 1979-2014 |
| 19 | NorCPM1 | 9 | 1950-2014 |
| 20 | NorESM2-LM | 1 | 1979-2014 |
| 21 | TaiESM1 | 1 | 1979-2014 |

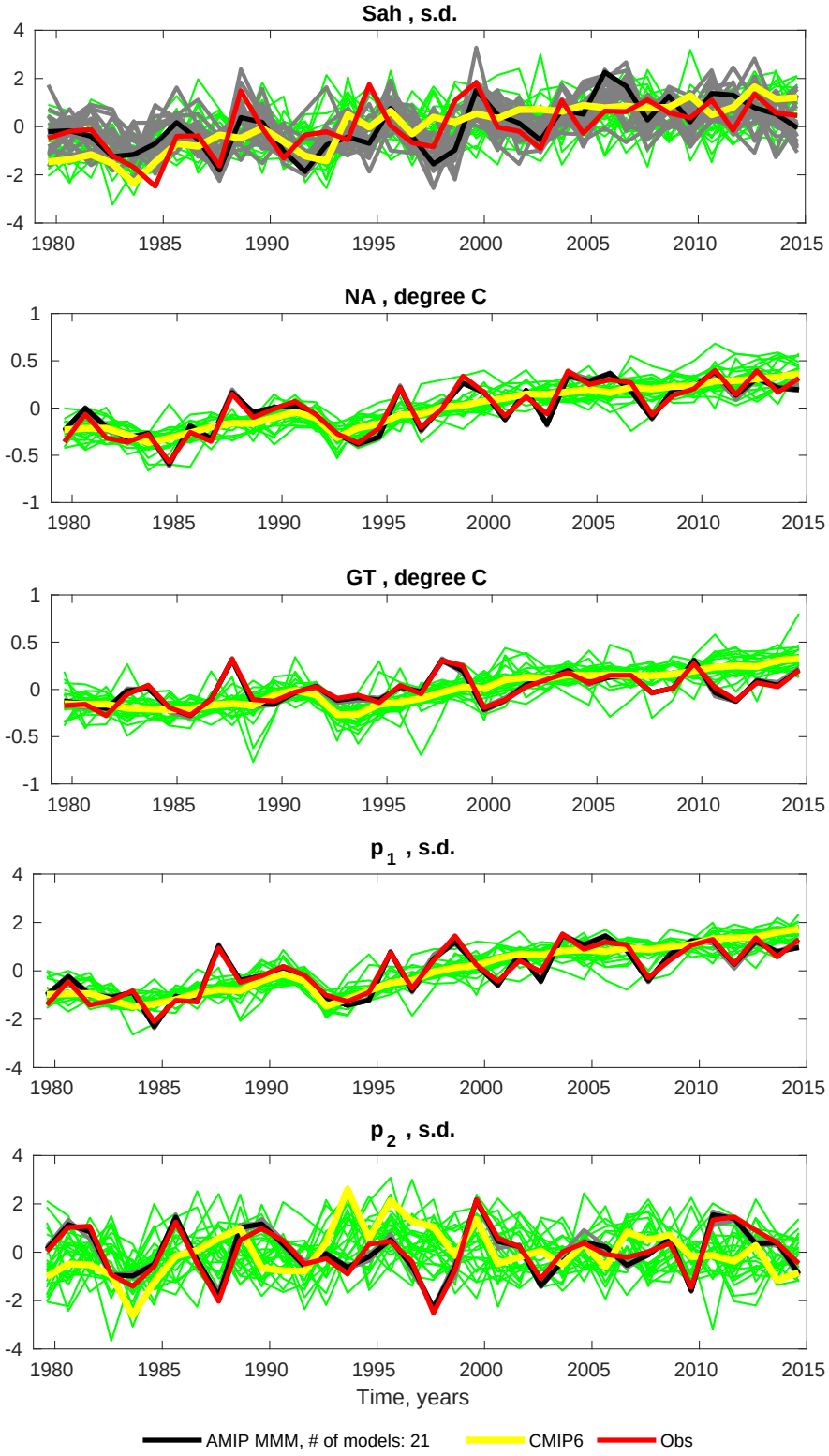


Figure 1: Top to bottom: time series of standardized Sahel rainfall, SST indices NA and GT, and of the dominant and trailing SVD modes of the predictors' space $p_1$ and $p_2$ for the single-model ensemble means of 24 CMIP6 models from historical simulations (*thin green lines*) and their multi-model ensemble means (*thick yellow lines*); the same for available AMIP simulations (*thin grey and thick black lines*). The *red lines* represent observations (rainfall from CRU TS4.05, SST from Kaplan et al. (1998,2003) extended version).

Table 1: Predictors space characteristics for the multi-model means from AMIP and CMIP6 historical simulations, as well as from observations. The time period of analysis is 1979 - 2014 ( 36 years) and the number of AMIP models is 21. Normalized eigenvalues $\lambda_i^* = \lambda_i(\lambda_1+\lambda_2)^{-1}100\%,\ i = 1, 2$ express percentages of the variance explained by factors $p_1$ and $p_2$. Hereinafter rainfall observations used are from CRU TS4.05 data set, SST from Kaplan et al. (1998), extended version 3.

| Product | $\sigma_1$,$^o$C GT | $\sigma_2$,$^o$C NA | $\rho$ | $k$ | $\phi$, arc $^o$ | $\lambda_1$, $(^o\mathrm{C})^2$ | $\lambda_2$, $(^o\mathrm{C})^2$ | $\lambda_1^*$, % | $\lambda_2^*$, % |
|---|---|---|---|---|---|---|---|---|---|
| AMIP | 0.15543 | 0.25115 | 0.550 | 0.619 | 66.08 | 0.0726 | 0.0146 | 83.23 | 16.77 |
| CMIP6 | 0.17875 | 0.21877 | 0.981 | 0.817 | 50.86 | 0.0791 | 0.0007 | 99.07 | 0.93 |
| Observations | 0.15668 | 0.26267 | 0.633 | 0.596 | 65.24 | 0.0810 | 0.0125 | 86.60 | 13.40 |

Table 2: Regression coefficients and skill for Sahel rainfall in the multi-model means from AMIP and CMIP6 historical simulations, as well as in observations. The time period of analysis is 1979 - 2014 ( 36 years) and the number of AMIP models is 21.

| Product | $a$ | $b$ | Correlation coefficient of $y$, $\hat{y}$ |
|---|---|---|---|
| AMIP | 0.455 | 0.603 | 0.756 |
| CMIP6 | 0.862 | 0.410 | 0.954 |
| Observations | 0.468 | 0.495 | 0.681 |

Table 3: Correlation coefficients between indices for AMIP (A), CMIP6 (C), and observations (O), calculated for the period: 1979 - 2014 ( 36 years) and 21 AMIP models.

| Index | r(A,C) | r(A,O) | r(C,O) |
|---|---|---|---|
| SR | 0.595 | 0.595 | 0.562 |
| NA | 0.771 | 0.973 | 0.815 |
| GT | 0.468 | 0.985 | 0.459 |
| $p_1$ | 0.764 | 0.979 | 0.786 |
| $p_2$ | 0.031 | 0.967 | 0.027 |