

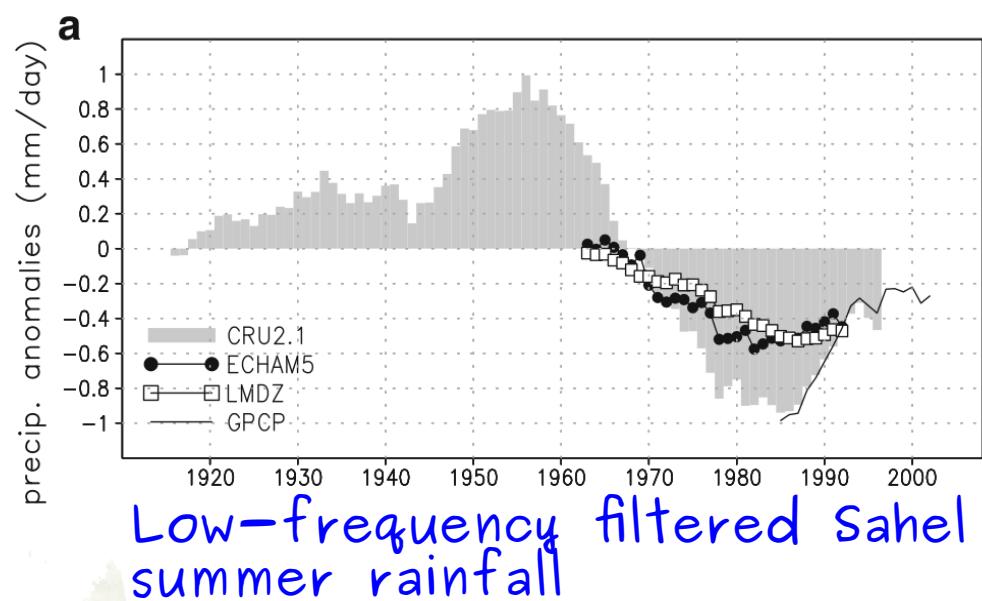
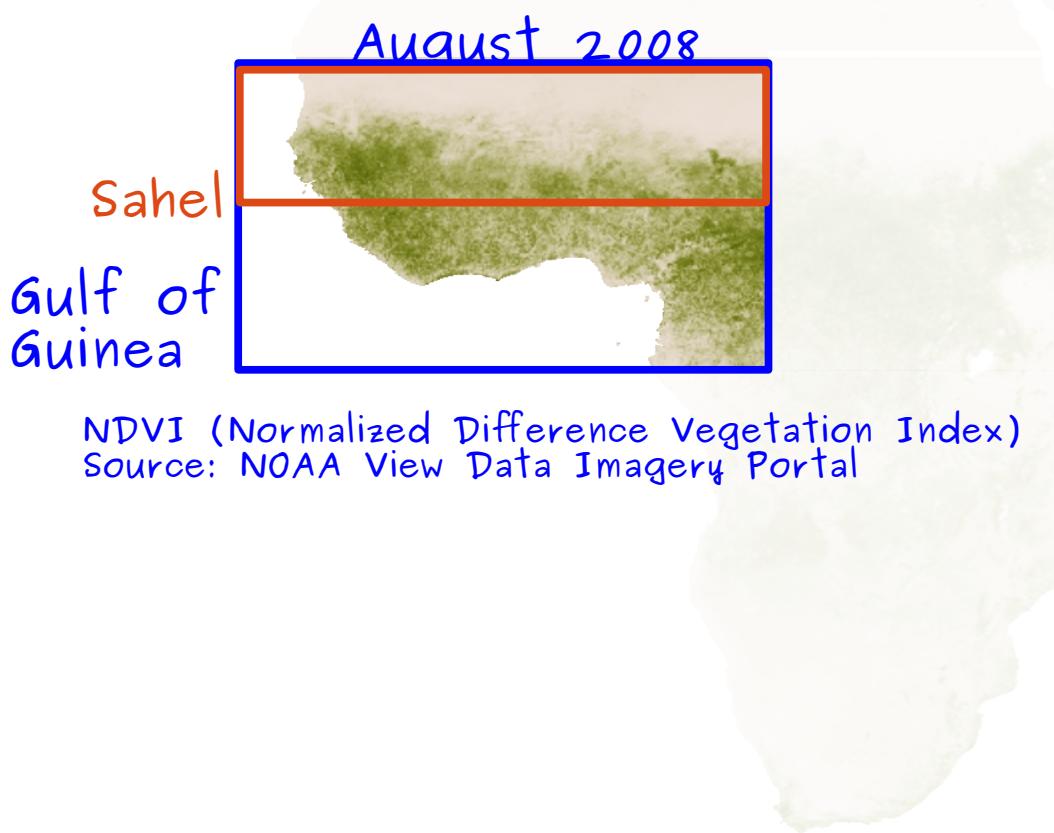
Decadal prediction of Sahel rainfall using dynamics-based indices

Noelia Otero, Elsa Mohino, Marco Gaetani

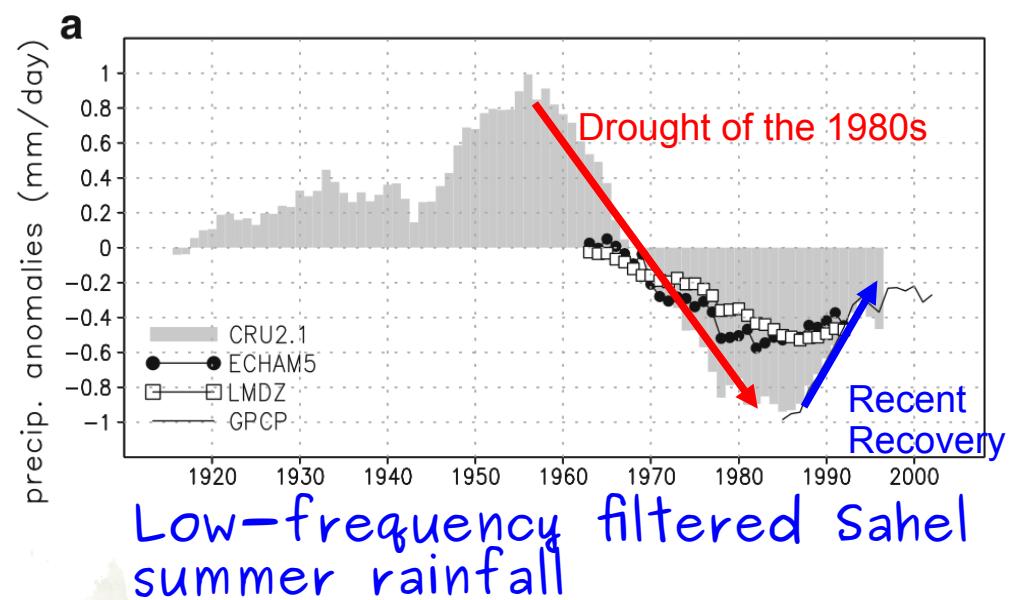
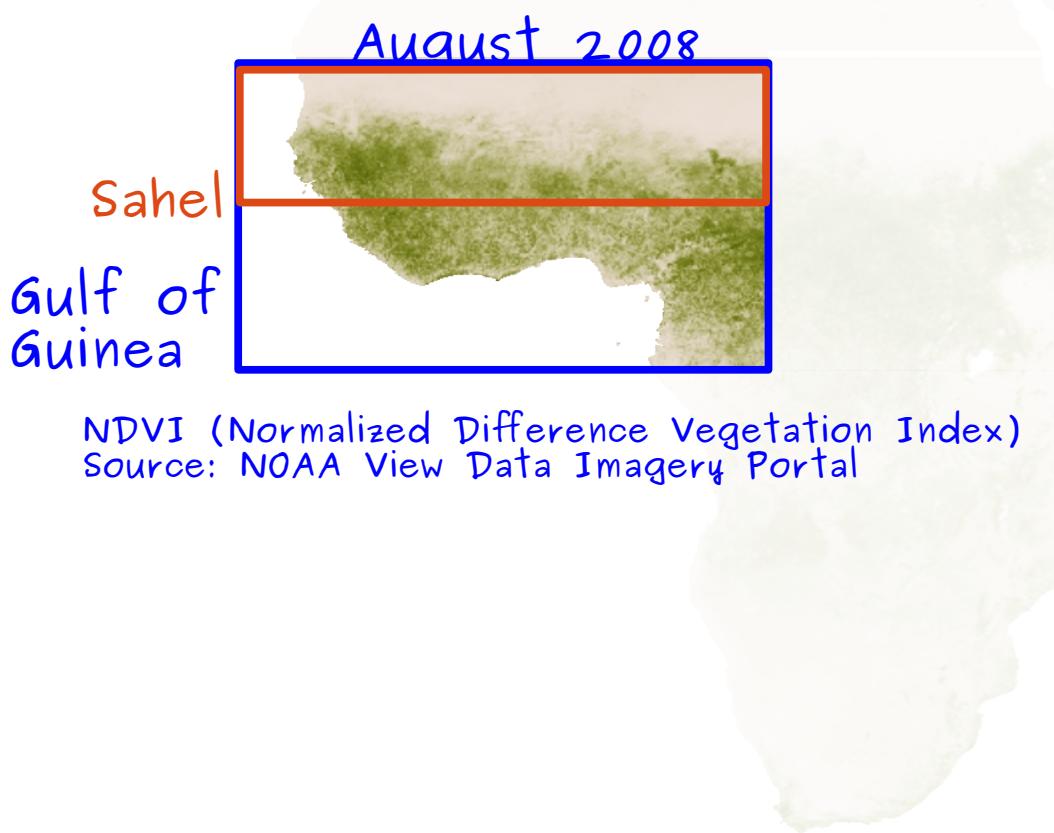


Otero, N., E. Mohino, M. Gaetani (2015) Decadal prediction of Sahel rainfall using dynamics-based indices. *Clim Dyn*, DOI 10.1007/s00382-015-2738-3

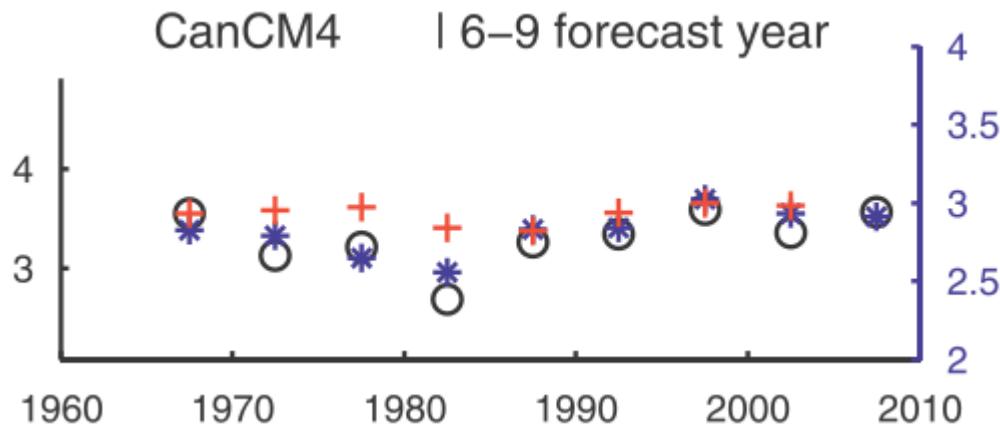
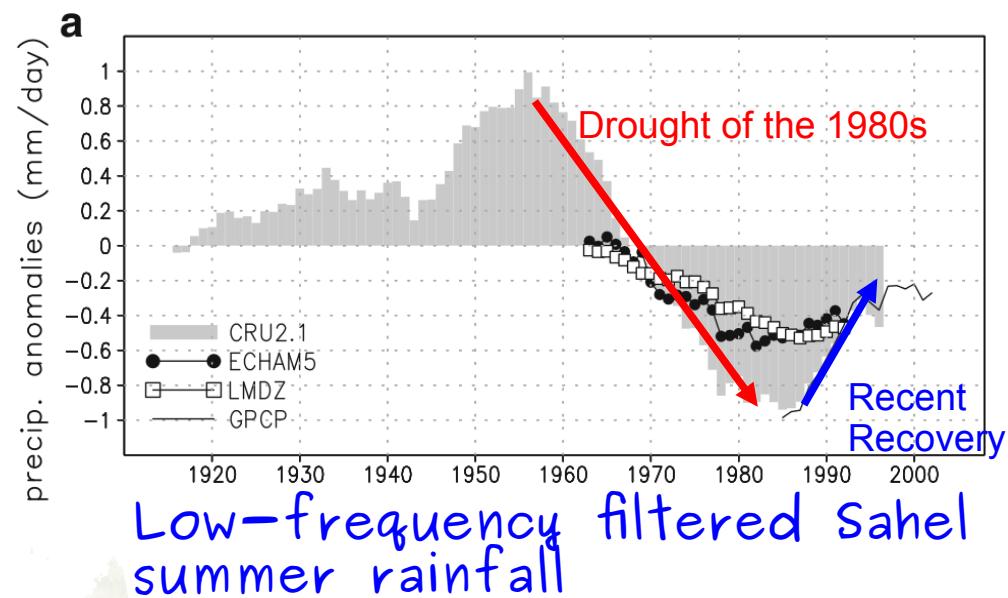
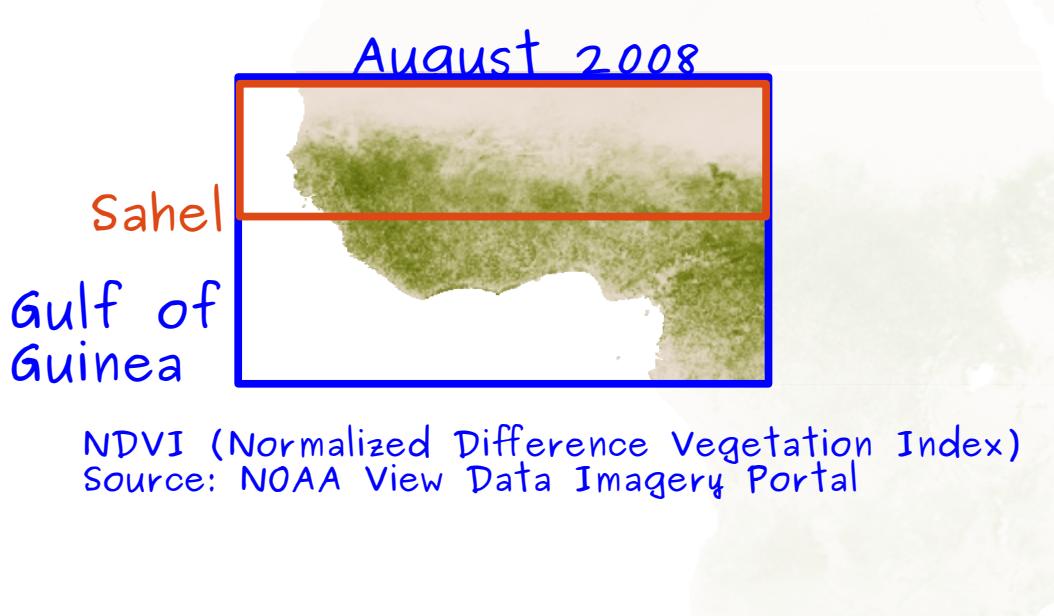
Sahel rainfall has shown marked decadal variability:



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Some models are skilful in predicting Sahel decadal rainfall variability
(Gaetani and Mohino 2013; Martin and Thorncroft 2014)

Averaged 4-year rainfall summer anomalies for observations (circles), and initialized (stars) and non-initialized (crosses) CanCM4 simulations

Gaetani and Mohino (2013)

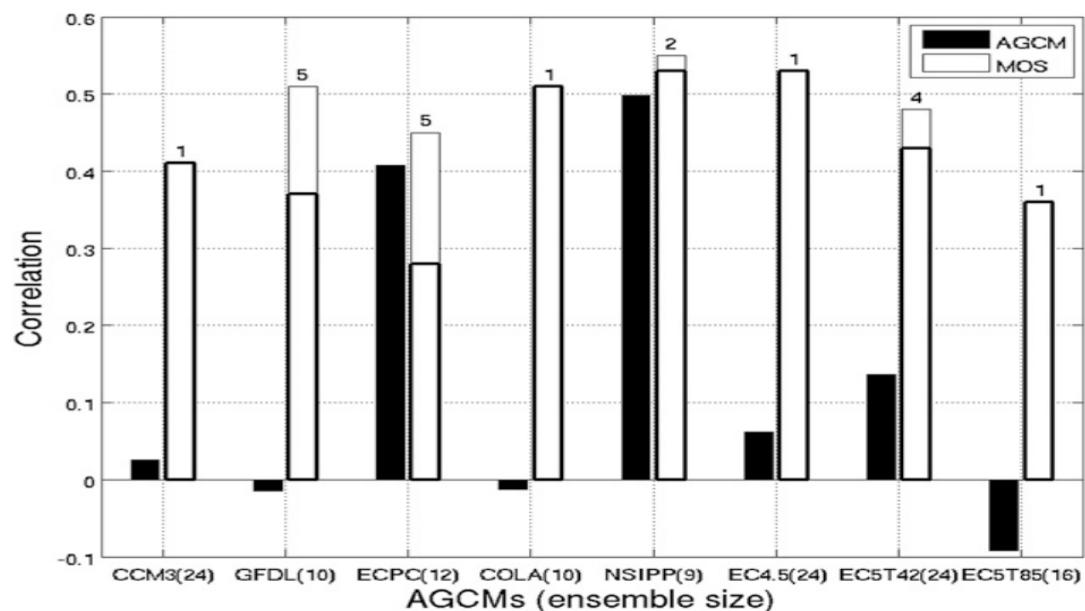
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However, GCMs are known to be typically more skilful in reproducing the variability of atmospheric dynamic variables rather than rainfall over West Africa.

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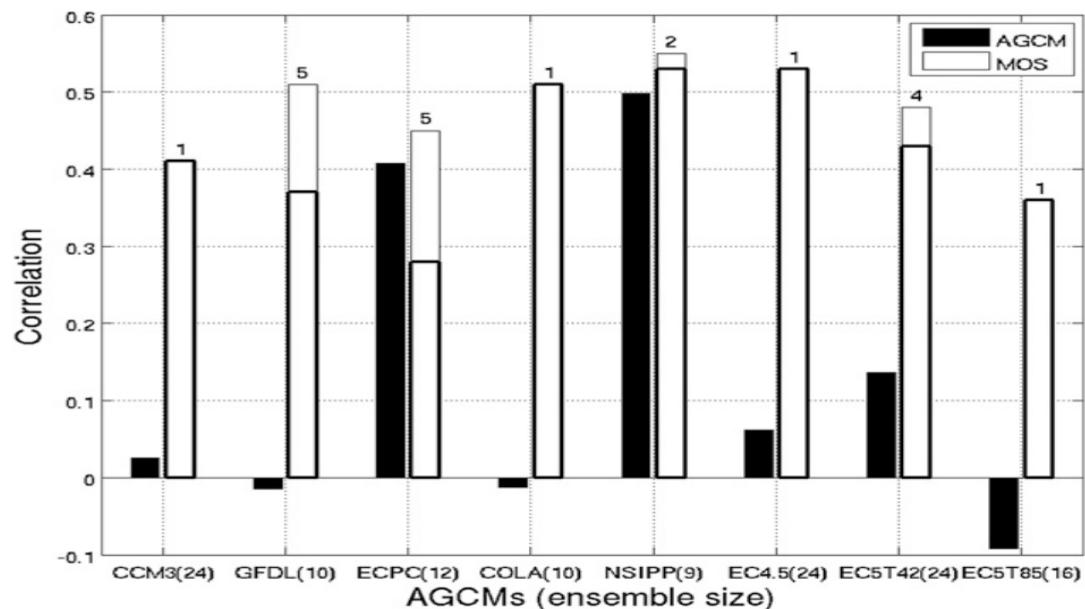


Correlation between observed Sahel rainfall (1968–2001) and simulated AGCM Sahel rainfall (filled bars) and after applying a MOS to u at 925 hPa

Ndiaye et al. (2011)

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Correlation between observed Sahel rainfall (1968–2001) and simulated AGCM Sahel rainfall (filled bars) and after applying a MOS to u at 925 hPa

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Could we predict Sahel rainfall trends some years ahead using dynamics-based indices?

Aim of the work:

- study the skill of CMIP5 decadal hindcasts in predicting Sahelian summer (JAS) rainfall USING dynamics-based indices
- Evaluate the additional skill coming from the initialization

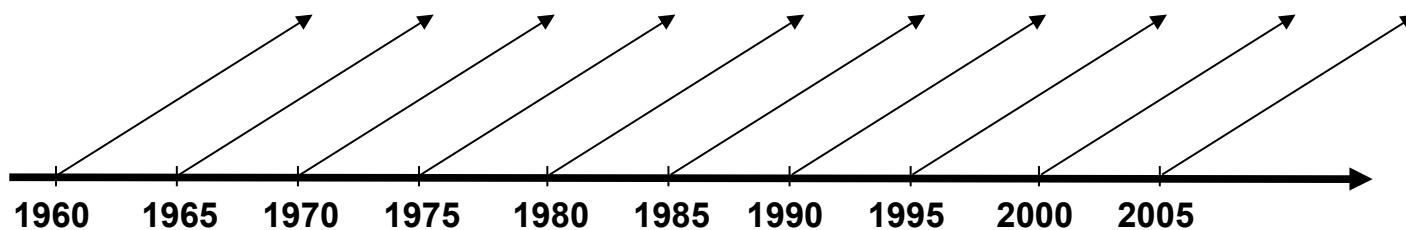
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CMIP5 simulations (14 models, range 3 to 10 ensemble members)

- **Decadal hindcasts (all forcings, including volcanoes, initialized)**



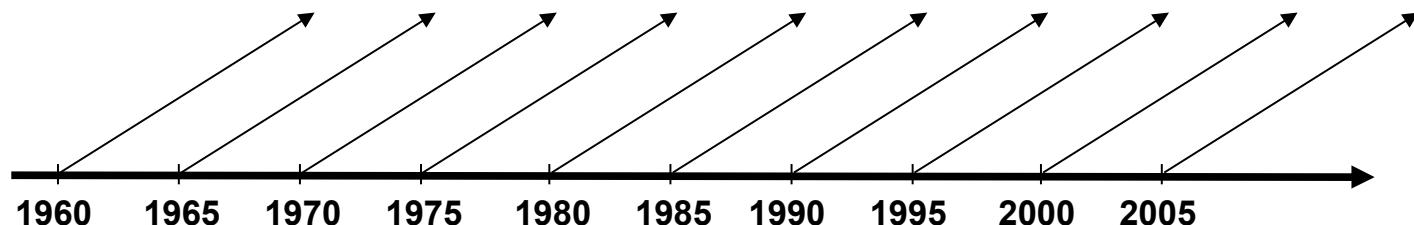
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- **Historical** (all forcings, including volcanoes, **no initialization**)



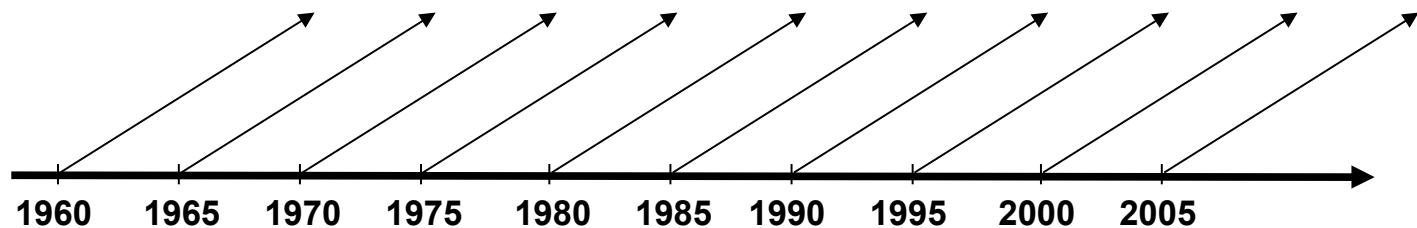
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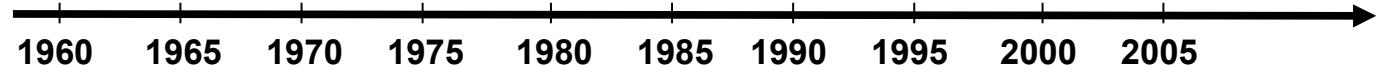
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Observations



- CRU-TS3.1 dataset 1901–2009 (Harris et al. 2014)
- GPCP dataset 1979–present (Adler et al. 2003)
- ERA40 (Uppala et al. 2005)
- NCEP/NCAR Reanalysis (Kalnay et al. 1996)

Methods

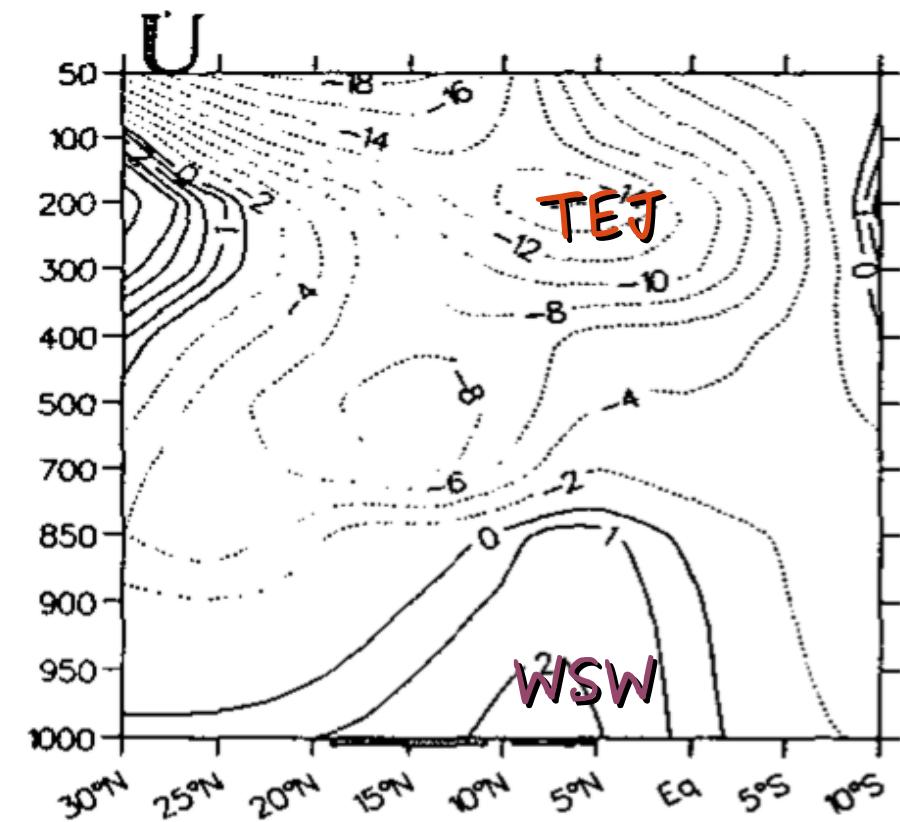
We tested the potential of using wind fields for decadal prediction of Sahel rainfall

Methods

We tested the potential of using wind fields for decadal prediction of Sahel rainfall

- Westerly surface winds (WSW)
- Tropical Easterly Jet (TEJ)

There is a strong link between winds at low and high levels

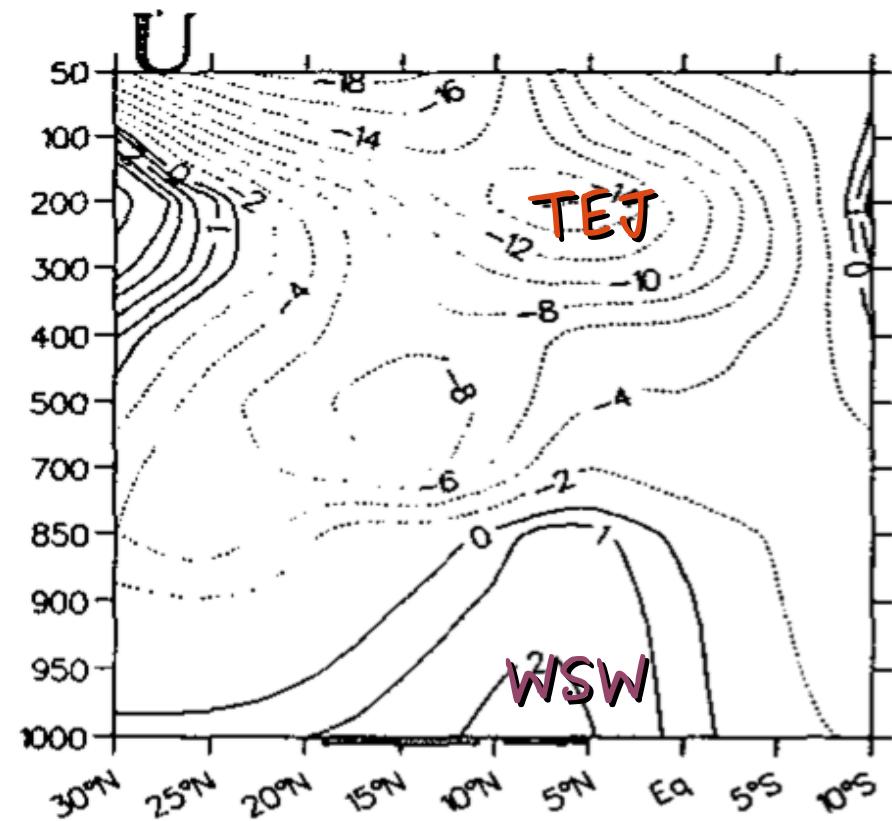


Fontaine et al. (1995): Latitude-Pressure profile of zonal winds (m/s) at 0° longitude in August

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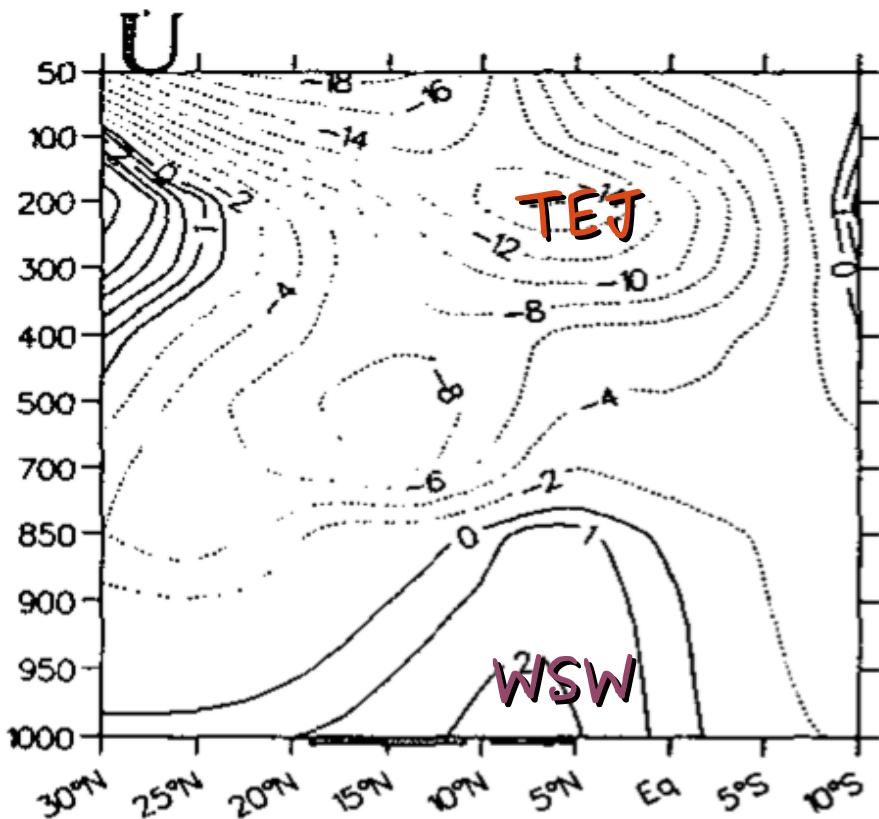
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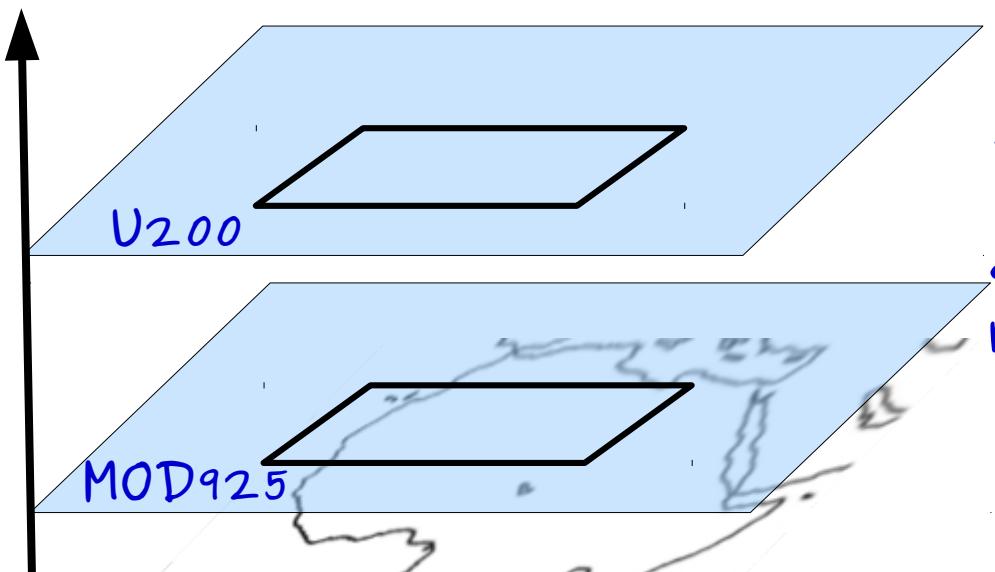
(standardized anomalies)

- WAMI definition independent from rainfall
- WAMI highly related to Sahel rainfall: +TEJ & +WSW → +Sahel rain

Methods

We tested the potential of using wind fields for decadal prediction of Sahel rainfall

To choose the appropriate region for the WAMI definition, we applied CEOF of MOD925 and U200 in reanalysis and historical sims.



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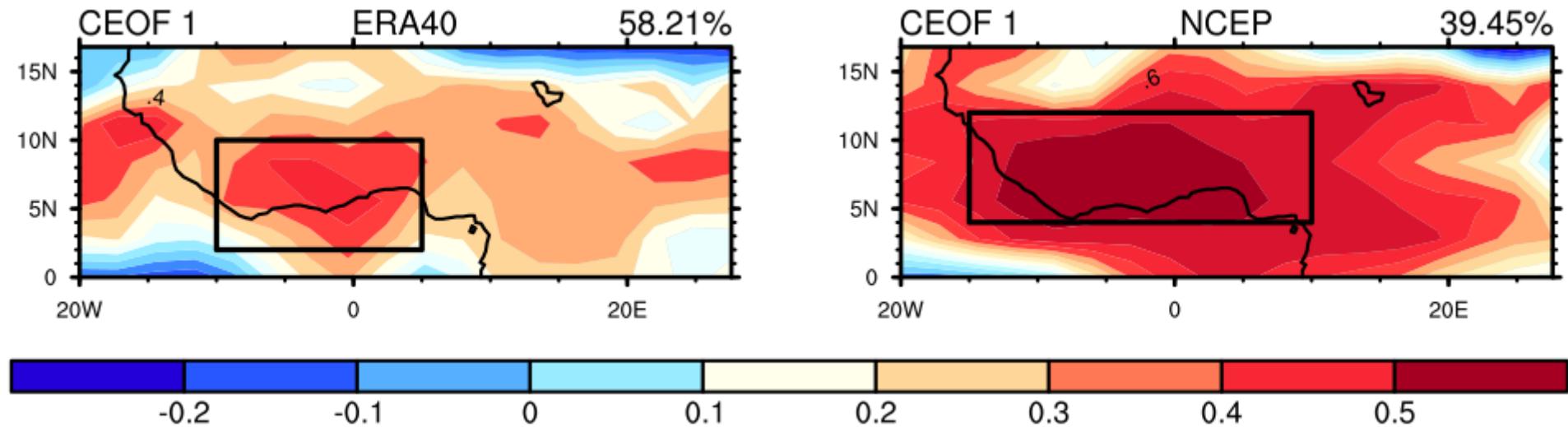
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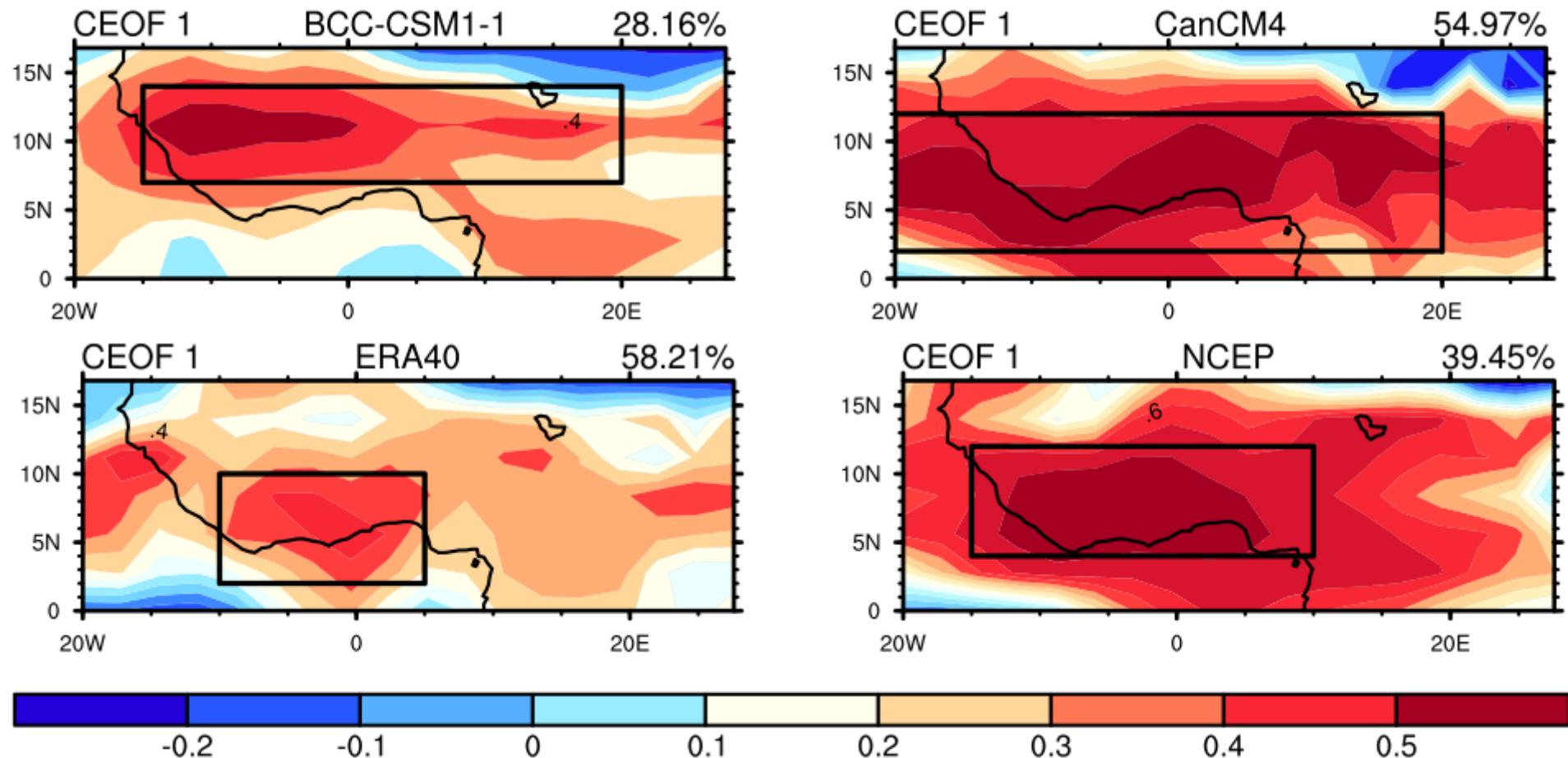
1st mode CEOF correlation patterns: MOD925 hPa



→ Increased low level wind jet

Results

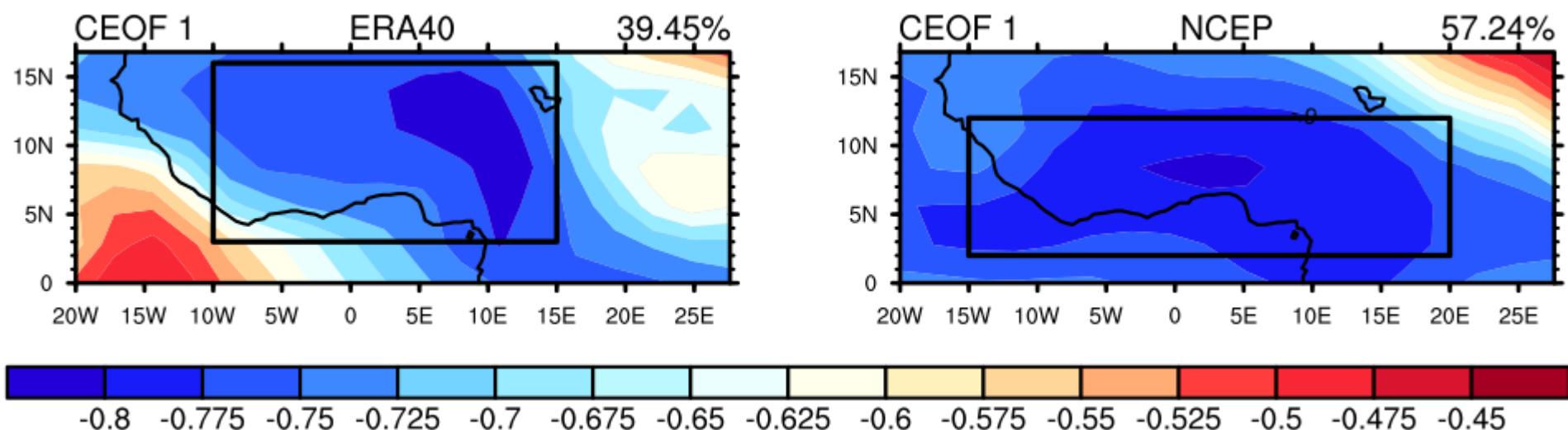
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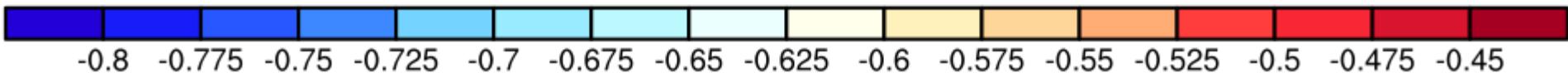
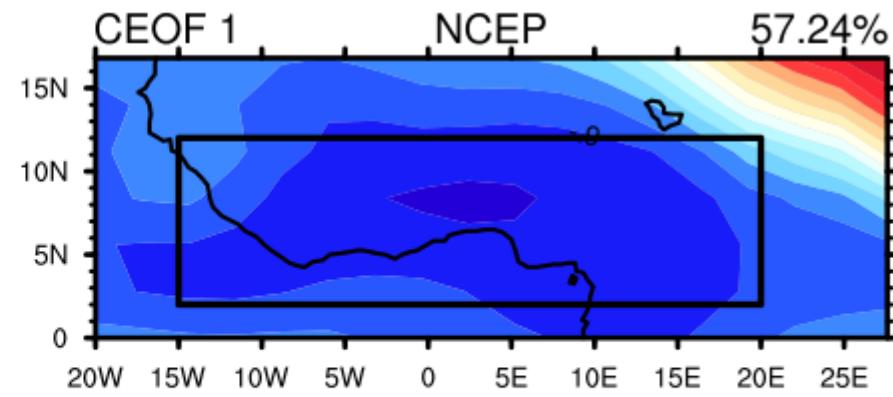
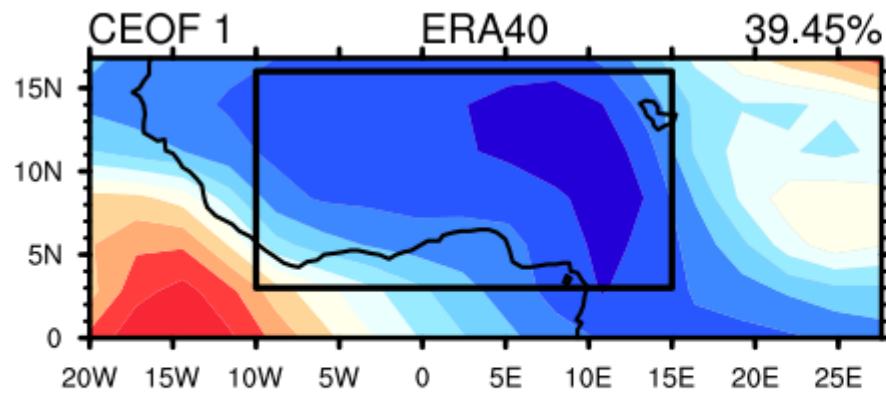
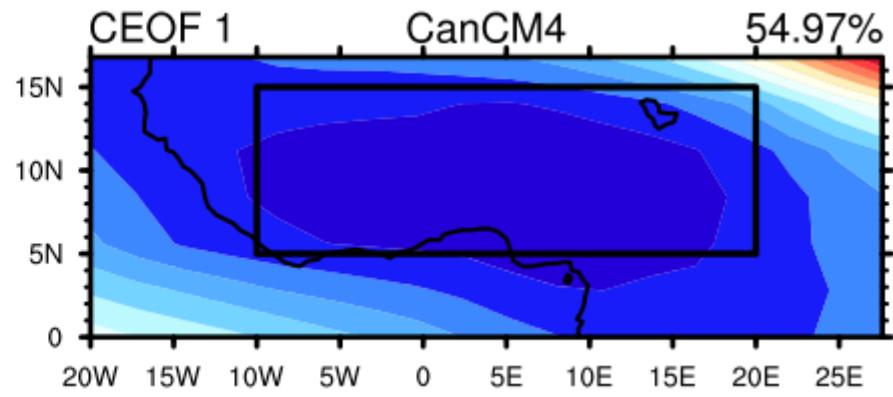
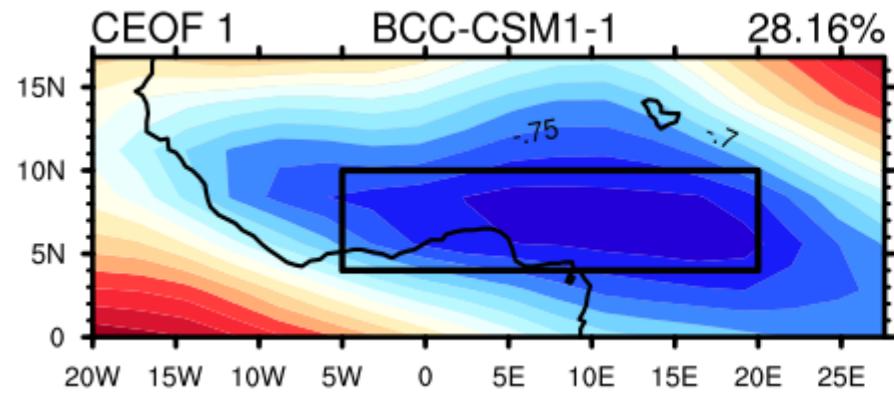
1st mode CEOF correlation patterns: U200 hPa



- Increased tropical easterly Jet
- Increased low level wind jet

Results

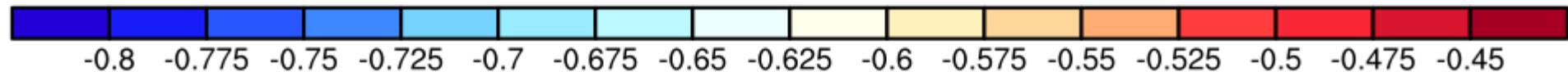
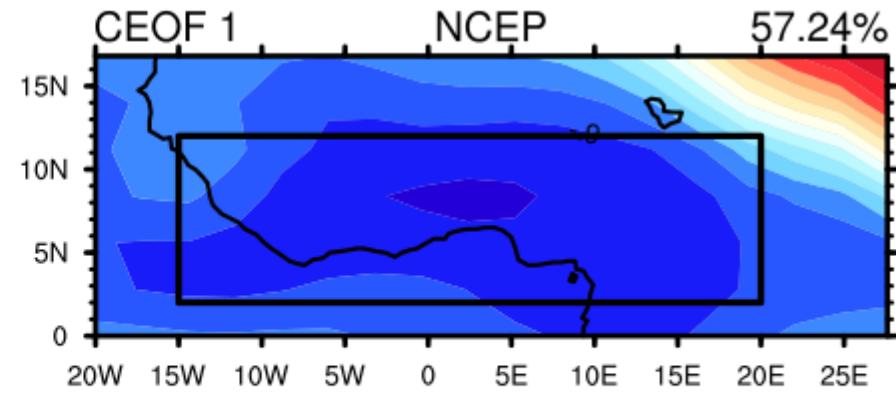
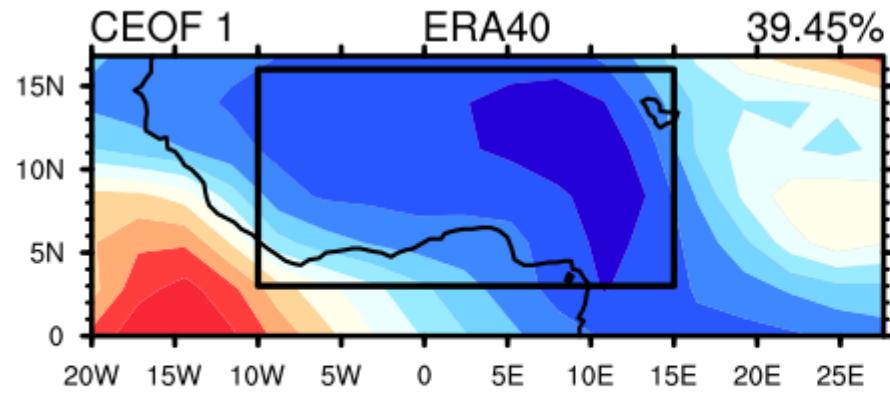
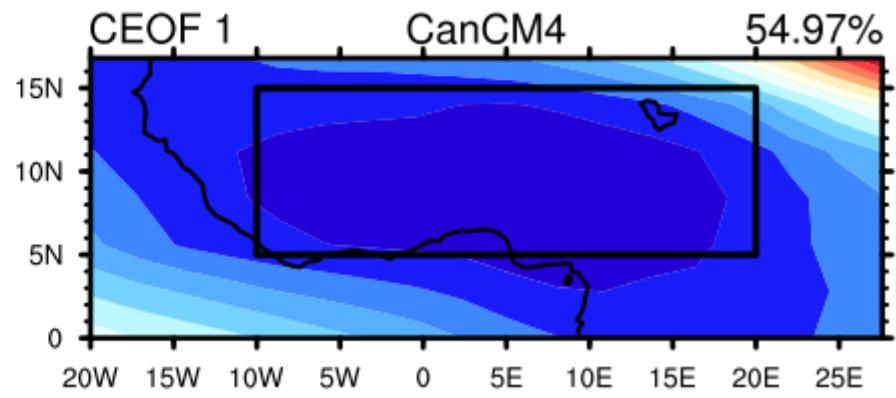
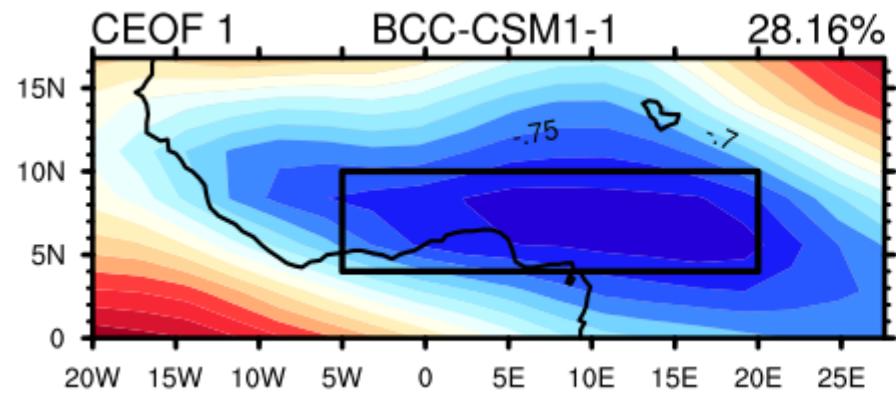
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1st mode CEOF correlation patterns: U200 hPa

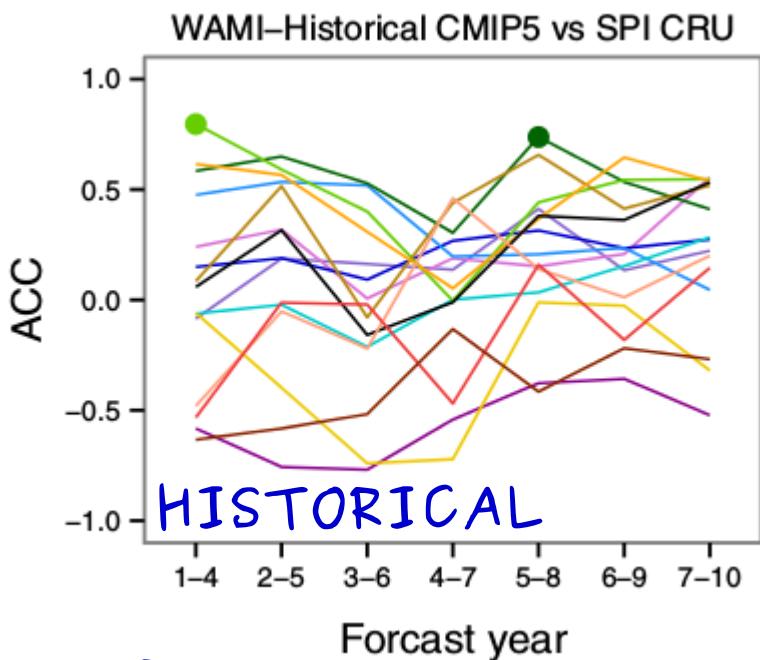
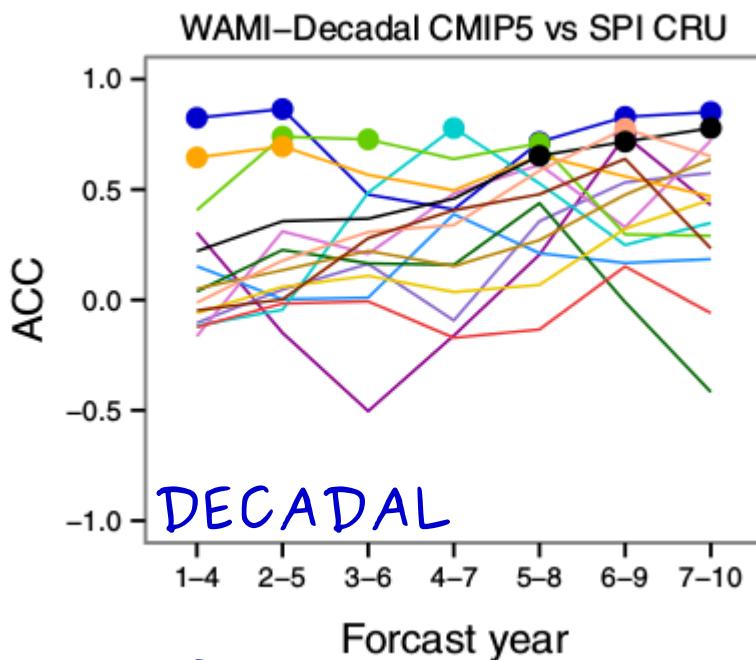


→ Increased tropical easterly Jet
→ Increased low level wind jet

→ Increased Sahel rainfall (obs)

Results

ACC scores between WAMI from models and observed Sahel precipitation index (SPI: 10N20N–15W15E)

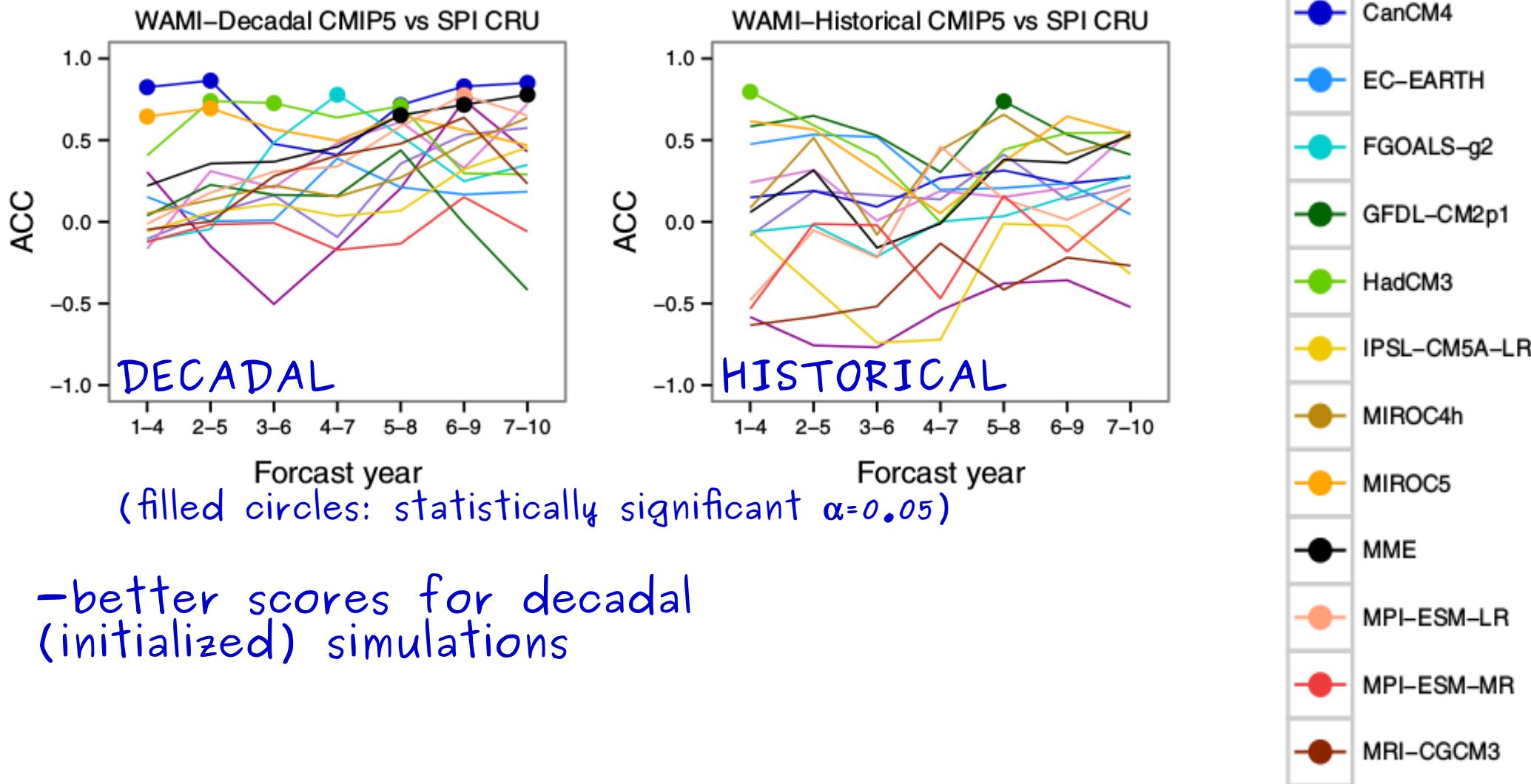


(filled circles: statistically significant $\alpha=0.05$)

- BCC-CSM1-1
- CCSM4
- CNRM-CM5
- CanCM4
- EC-EARTH
- FGOALS-g2
- GFDL-CM2p1
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- MIROC4h
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- MME
- MPI-ESM-LR
- MPI-ESM-MR
- MRI-CGCM3

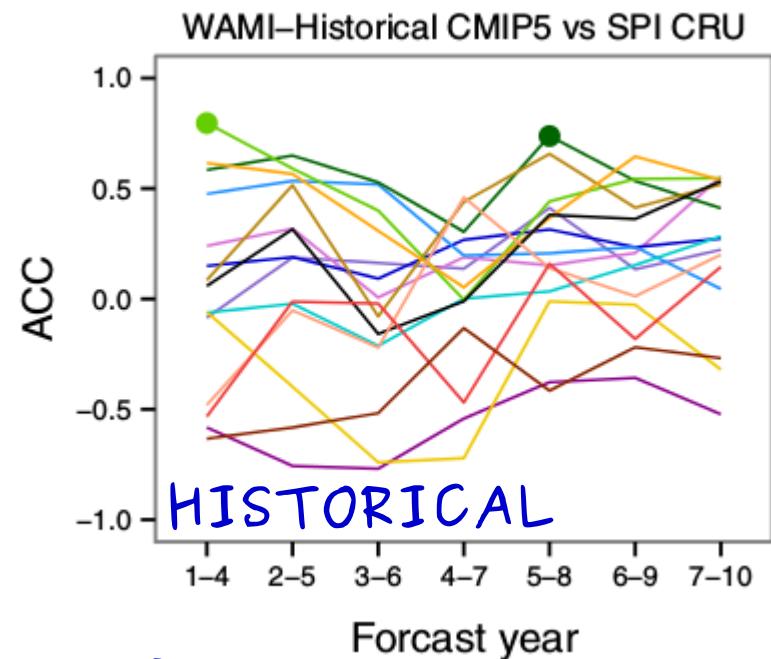
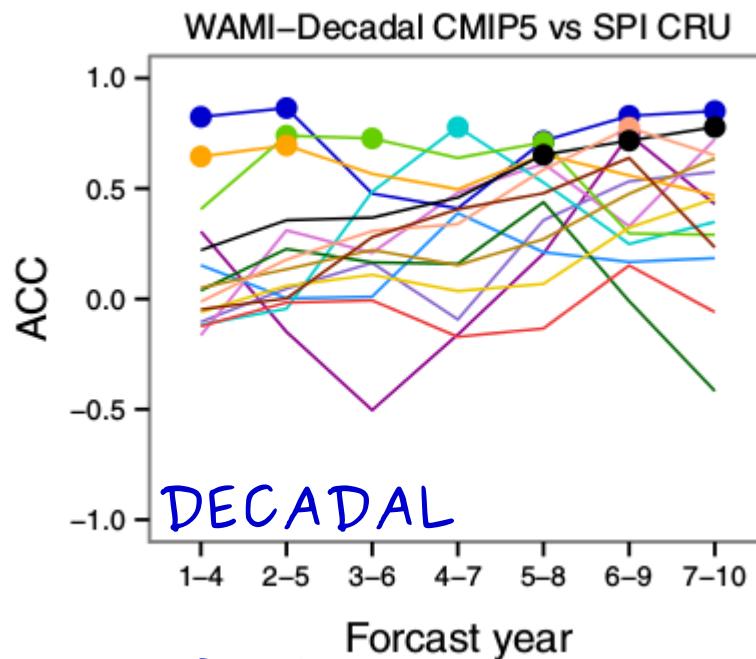
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-better scores for decadal
(initialized) simulations

-CanCAM4, HadCM3, MIROC5, FGOALS-g2,
MPI-ESM-LR, BCC-CSM1-1, MME

Results

Average skill for probabilistic forecasts of three categories
(above normal, below normal and normal) for WAMI models
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HR: hit rate (fraction of events for which an alarm was rightly issued)

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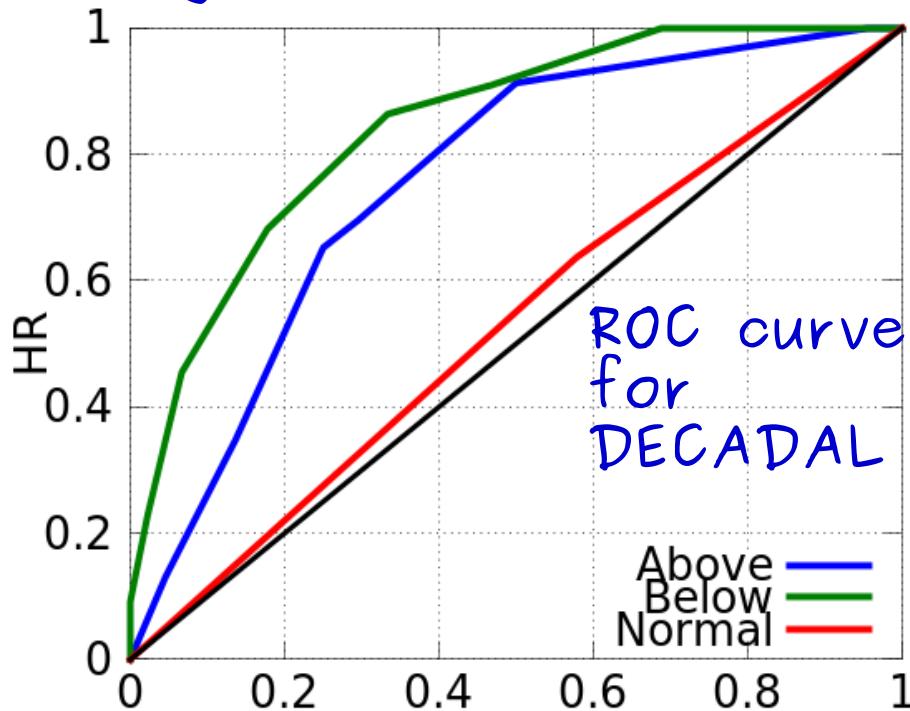
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ROC curve
for
DECADAL

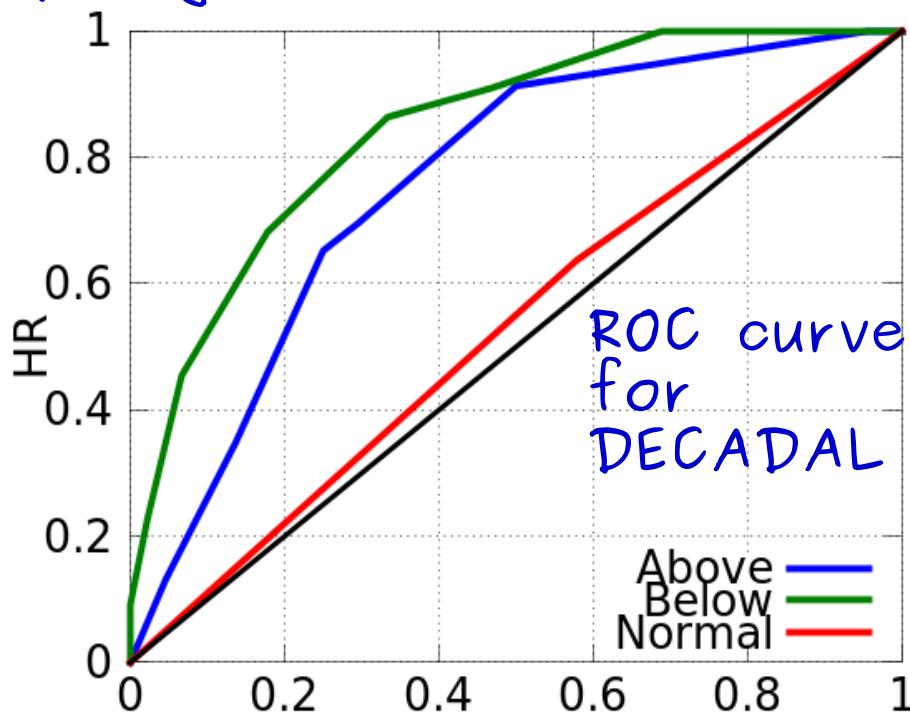
Above
Below
Normal

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	Decadal	Historical
Above (A)	0.51	0.14
Below (B)	0.69	0.33
Normal (N)	0.06	0.07

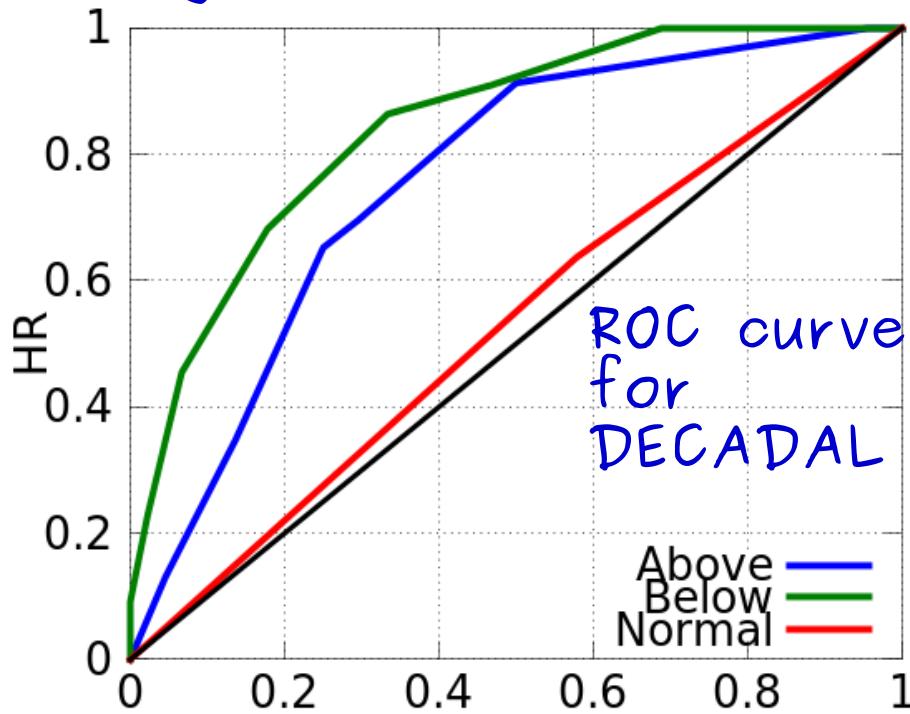
ROC scores for the three categories in the decadal and historical sims

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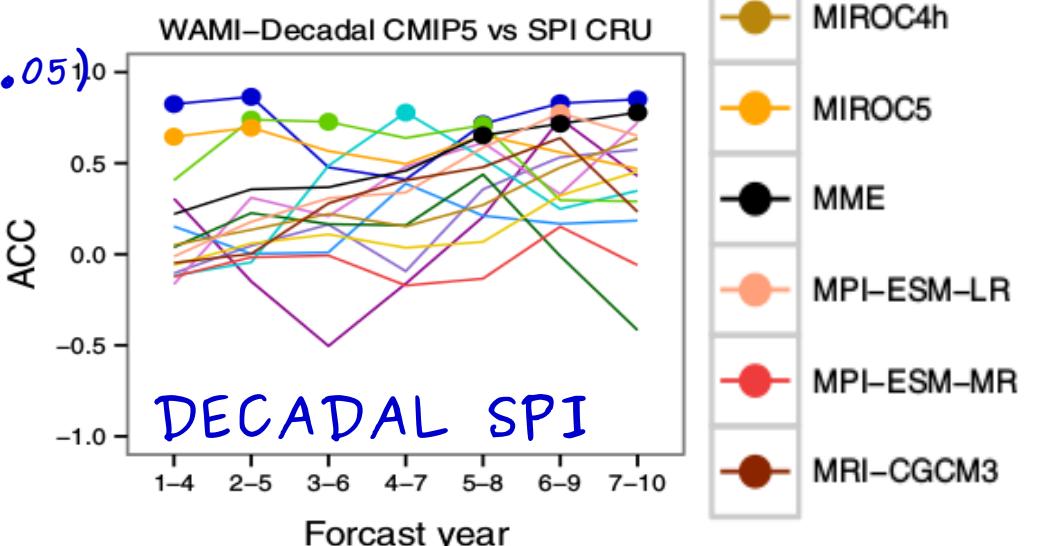
→ better skill for Below than Above
→ better skill for decadal than historical

FAR: false alarm rate (fraction of non-events for which an alarm was wrongly issued)

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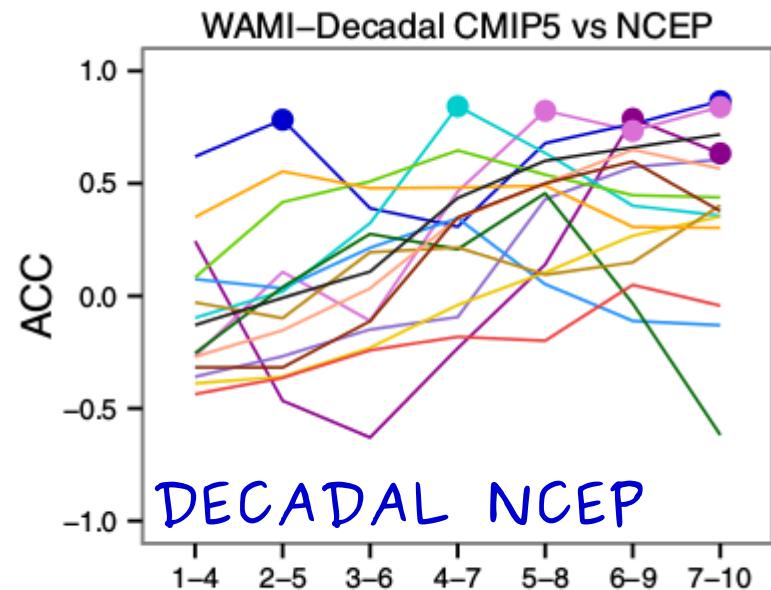
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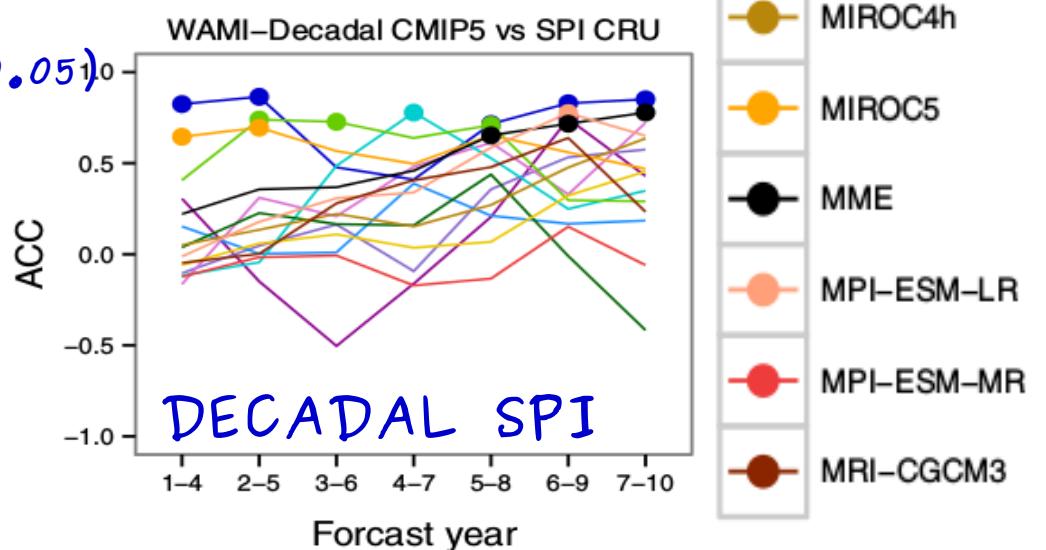
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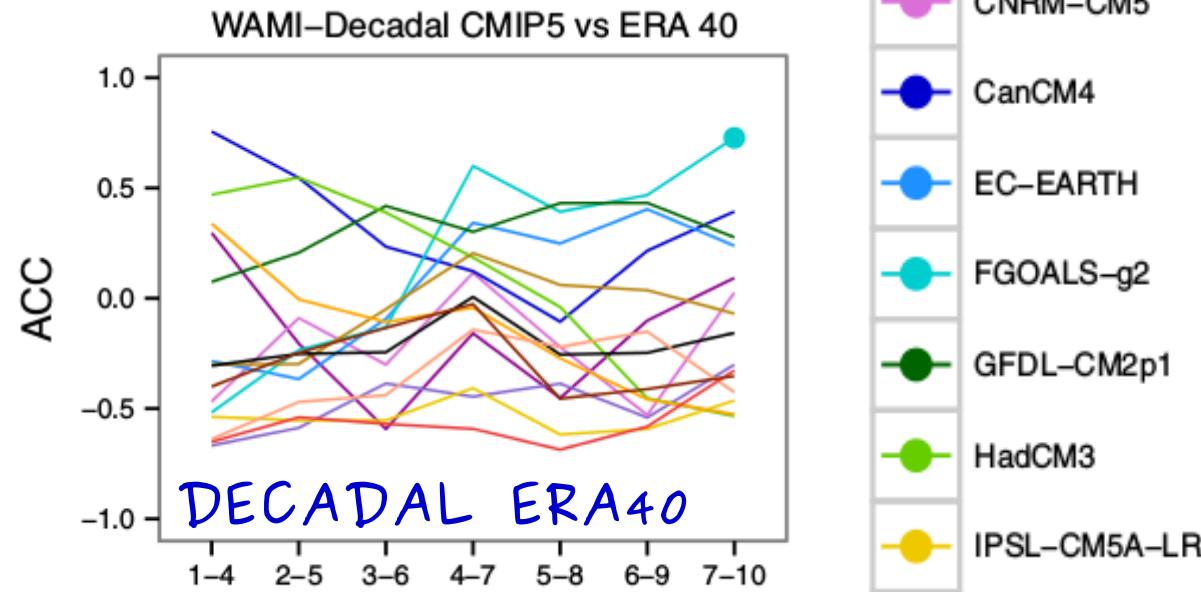
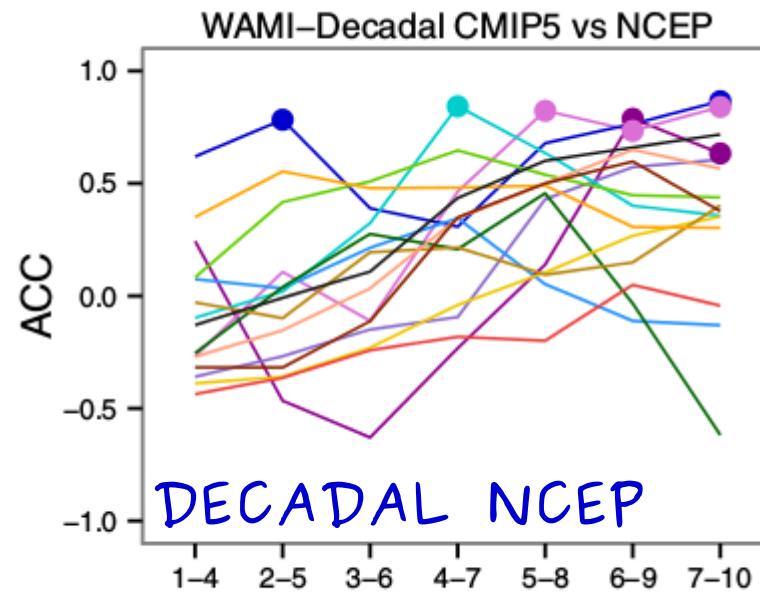
-general decrease in skill with
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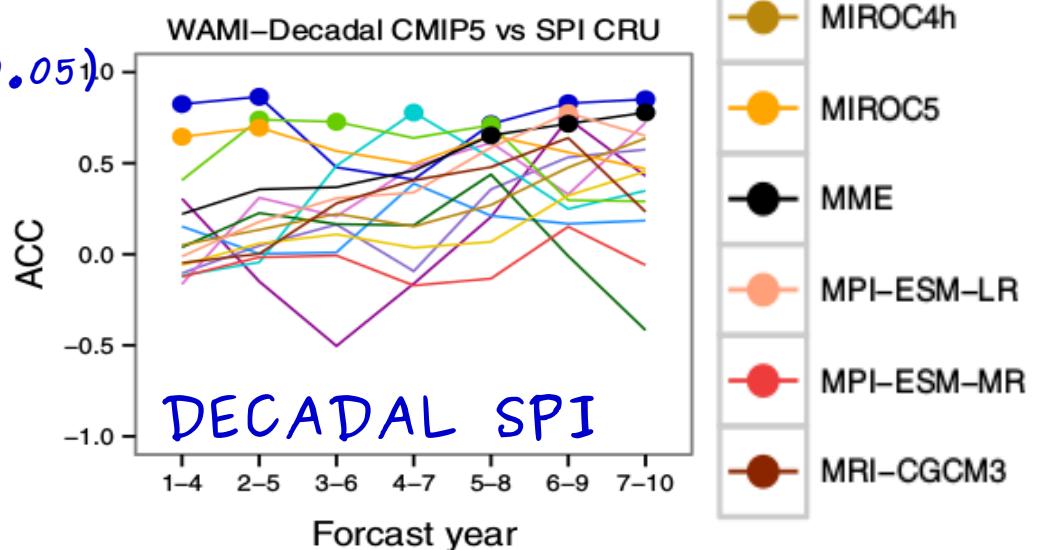
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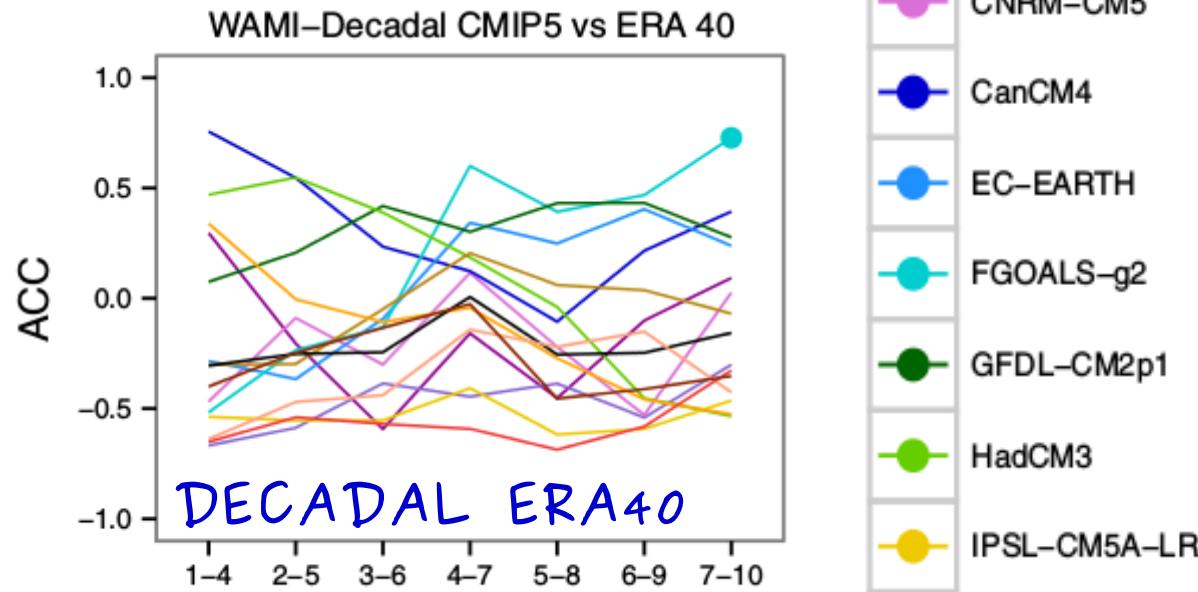
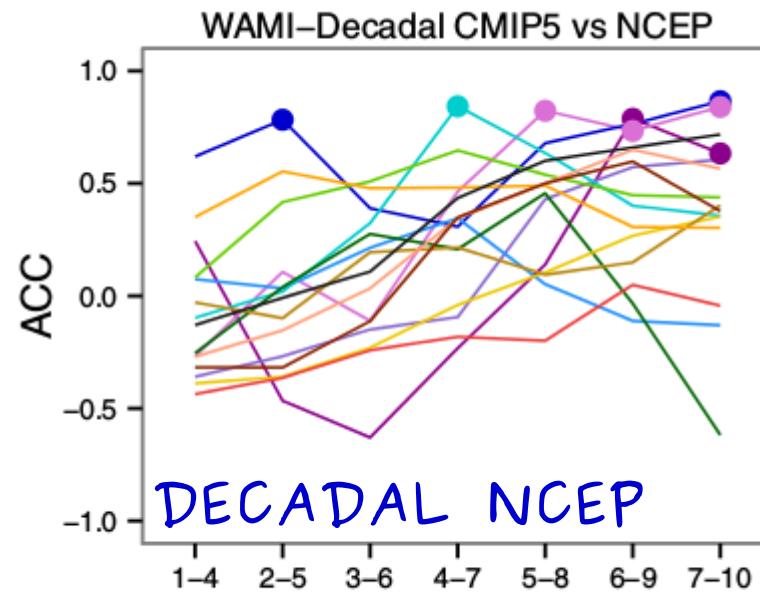
-complete loss of skill with ERA40



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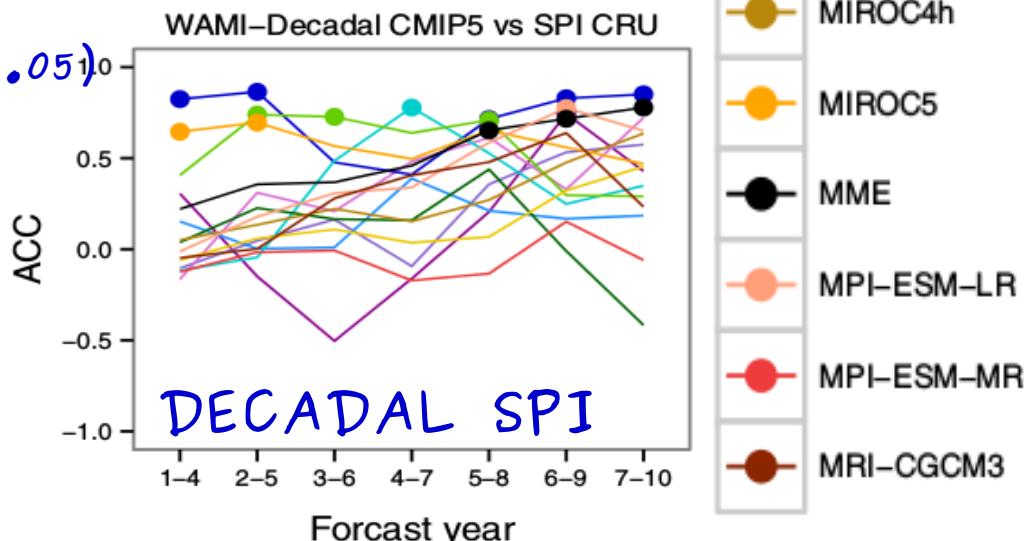
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-complete loss of skill with ERA40 **WHY?**



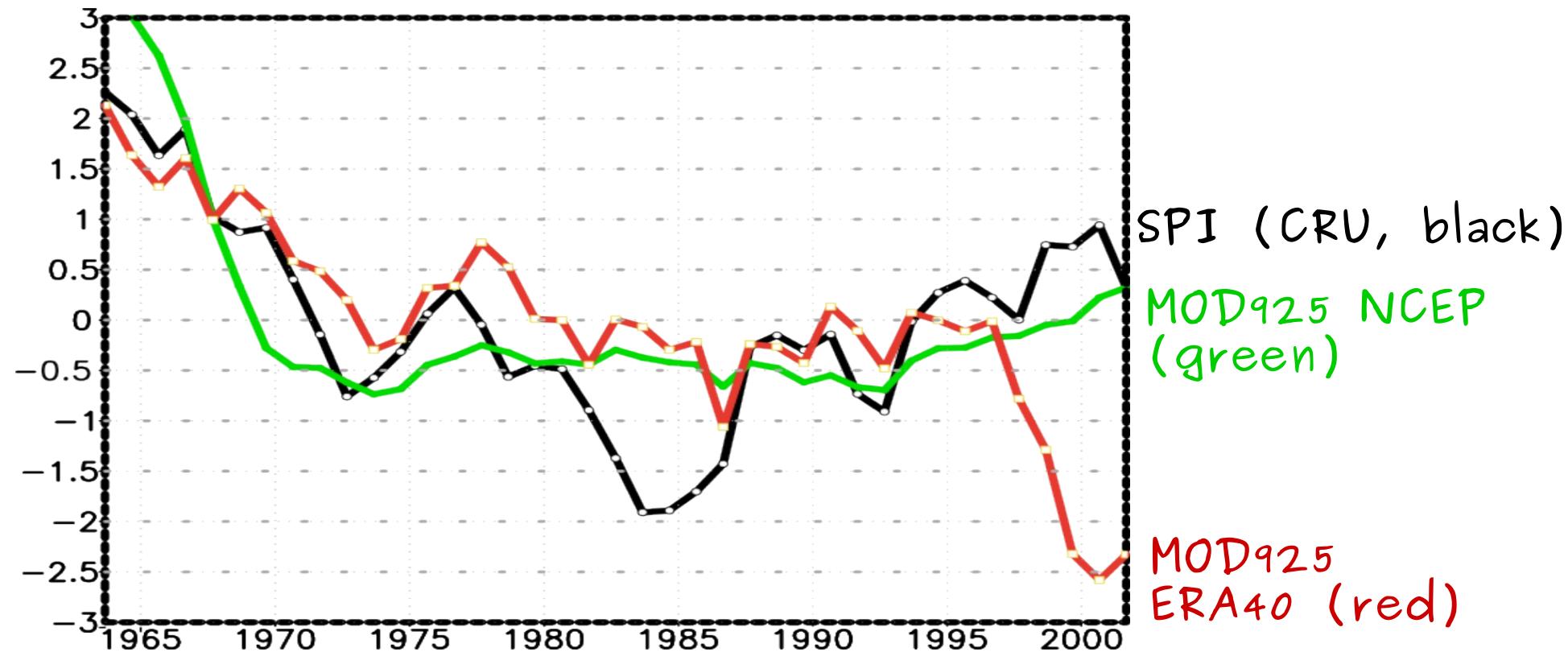
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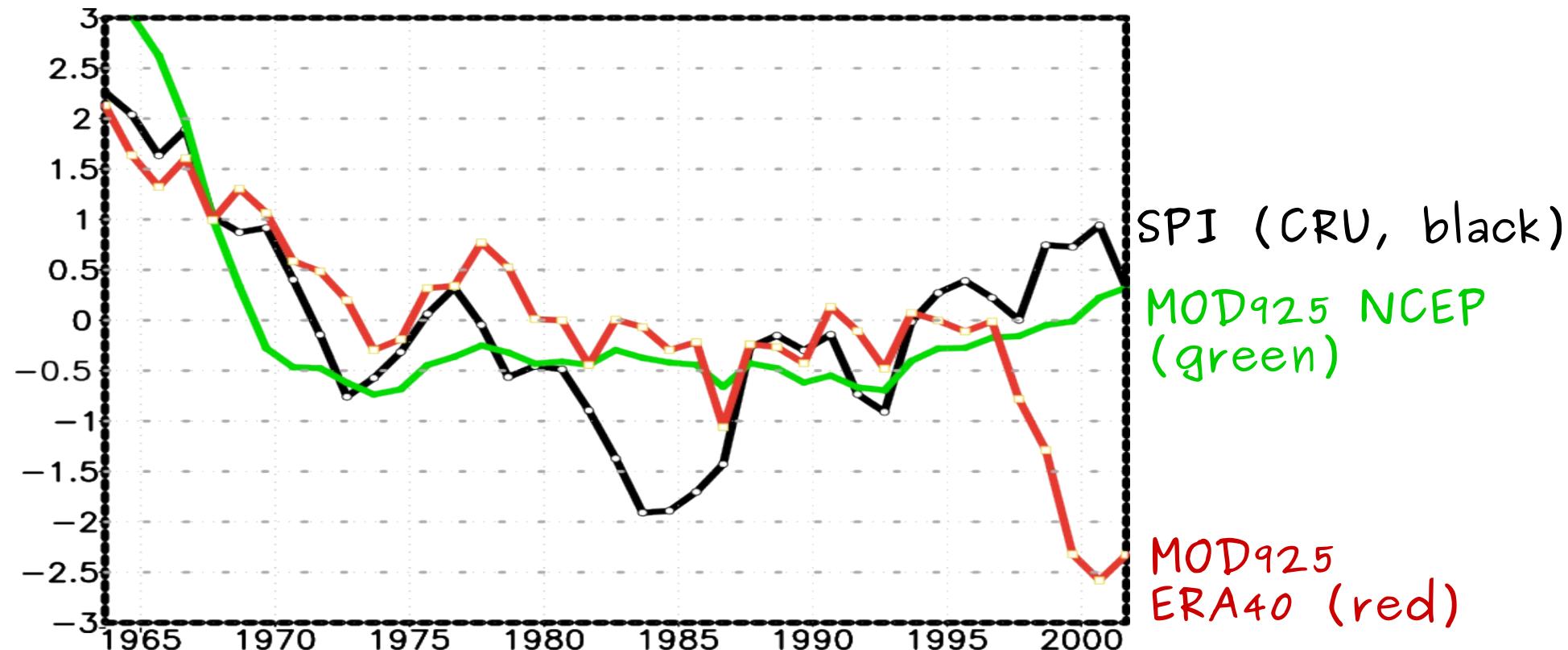


Standardized indices of low-frequency filtered SPI (CRU, black), and MOD 925hPa for NCEP (green) and ERA40 (red)

-complete loss of skill with
ERA40 **WHY?**

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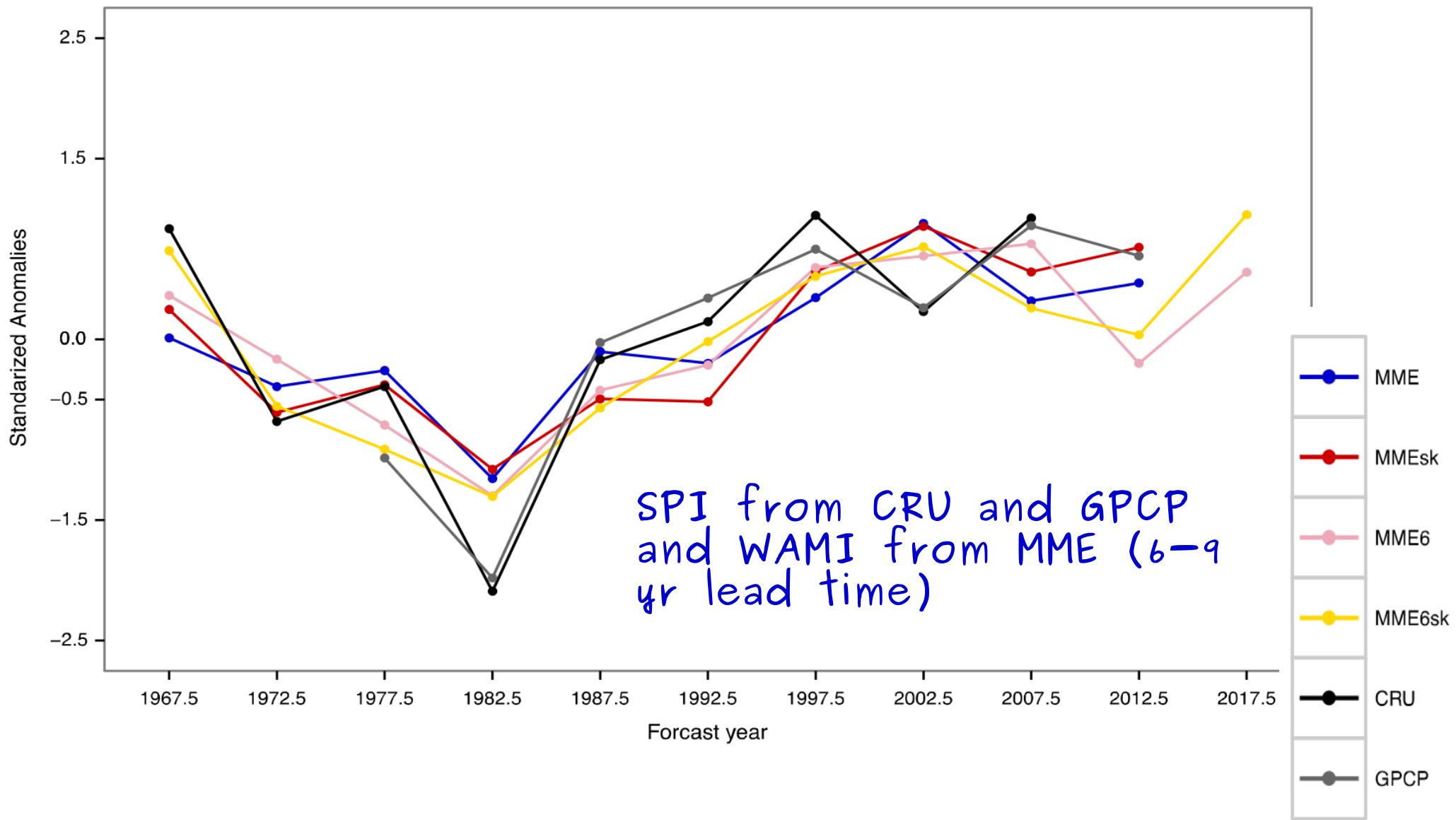
Due to the ERA40 representation of low-level winds from 1997 onwards

Results

Sahel rainfall perspectives for 2016–2019

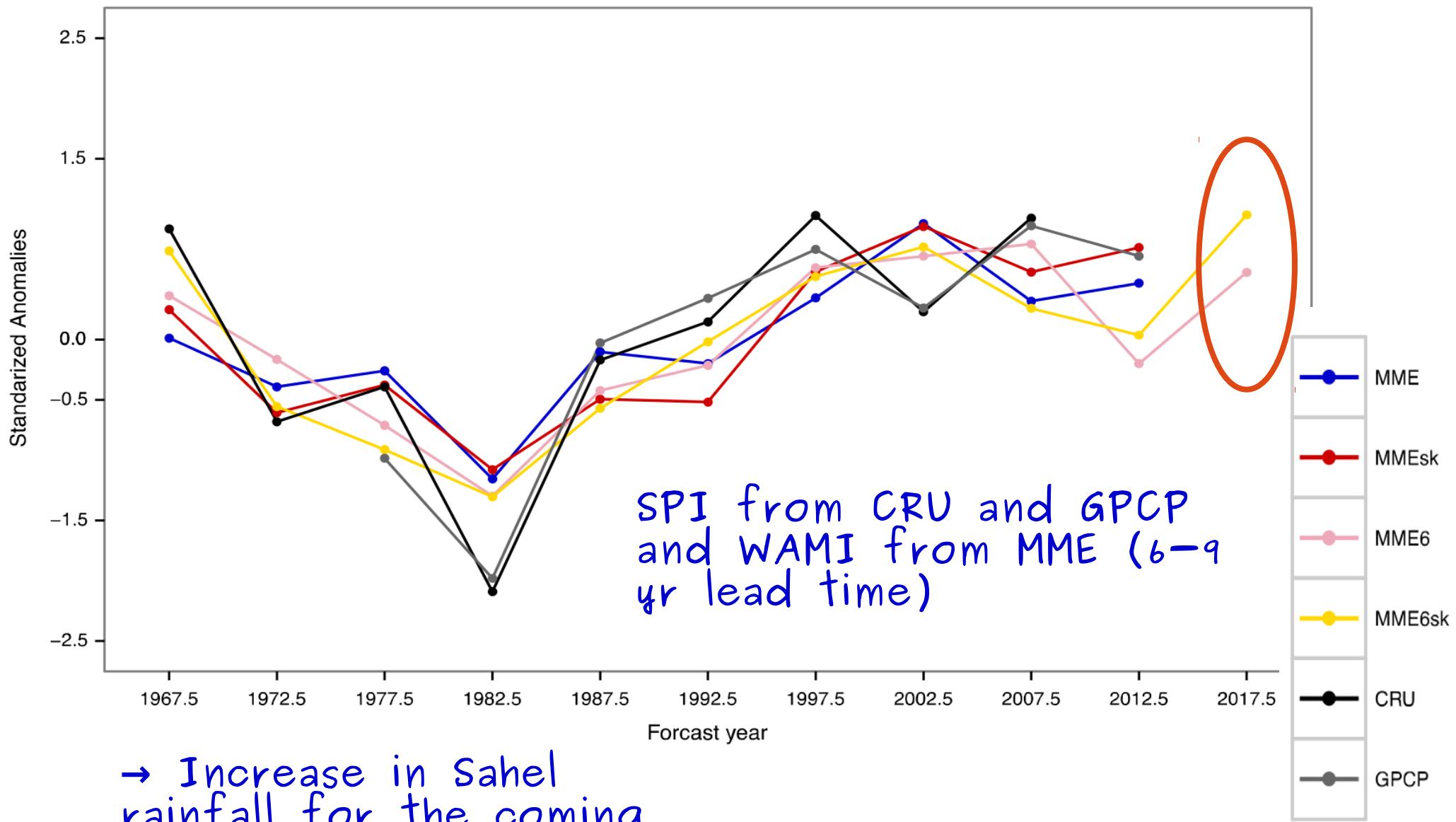
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Results

Sahel rainfall perspectives for 2016–2019



Conclusions

Otero, N., E. Mohino, M. Gaetani (2015) Decadal prediction of Sahel rainfall using dynamics-based indices. *Clim Dyn*, DOI
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Conclusions

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Otero, N., E. Mohino, M. Gaetani (2015) Decadal prediction of Sahel rainfall using dynamics-based indices. *Clim Dyn*, DOI
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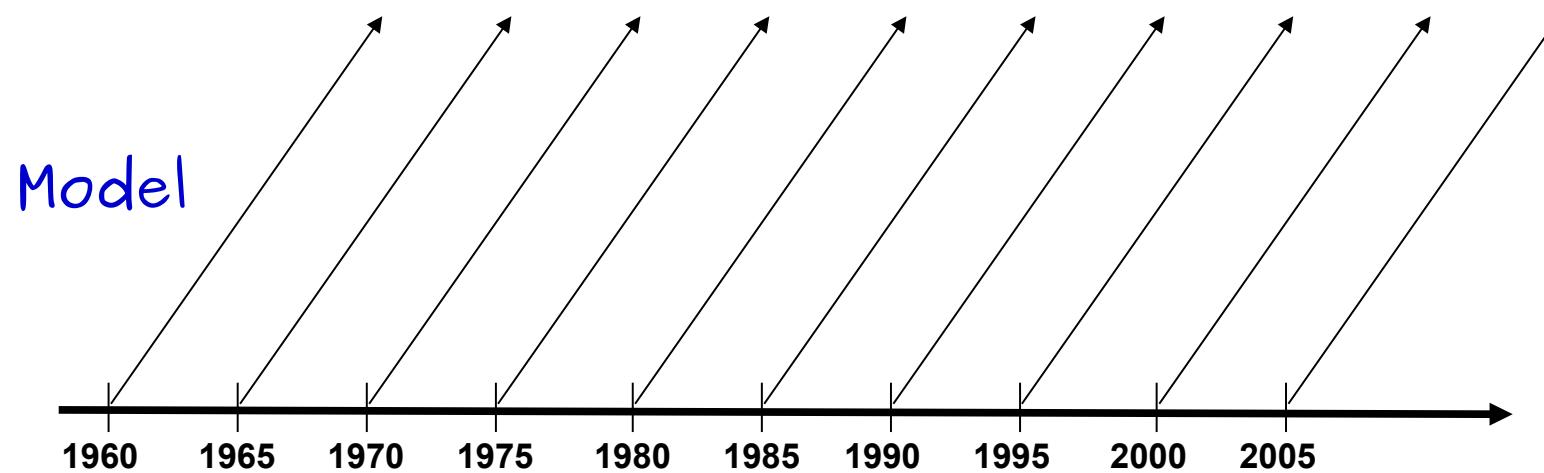
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Data 14 Models

Model name	Res.	Decadal	Historical	Initialization
BCC-CSM-1	T42 ($\sim 2.8^\circ$)	4	3	Full field
CanCM4	T42 ($\sim 2.8^\circ$)	10	10	Full field
CCSM4	$1.25^\circ \times 0.9^\circ$	10	6	Full field
CNRM-CM5	T127 ($\sim 1.4^\circ$)	10	10	Full field
EC-EARTH	T159 ($\sim 1.125^\circ$)	5	4	Full field
FGOALS-g2	$2.8^\circ \times 3.0^\circ$	3	5	Full field
GFDL-CM2.1	$2.5^\circ \times 2.0^\circ$	10	10	Full field
HadCM3	$3.75^\circ \times 2.5^\circ$	10	10	Full field
IPSL-CM5A-LR	$3.75^\circ \times 1.875^\circ$	6	6	Anomaly
MIROC4h	T213 ($\sim 0.6^\circ$)	3	3	Anomaly
MIROC5	T127 ($\sim 1.4^\circ$)	6	5	Anomaly
MPI-ESM-LR	T63 ($\sim 1.9^\circ$)	10	3	Anomaly
MPI-ESM-MR	T63 ($\sim 1.9^\circ$)	3	3	Anomaly
MRI-CGCM3	T159 ($\sim 1.125^\circ$)	9	3	Anomaly

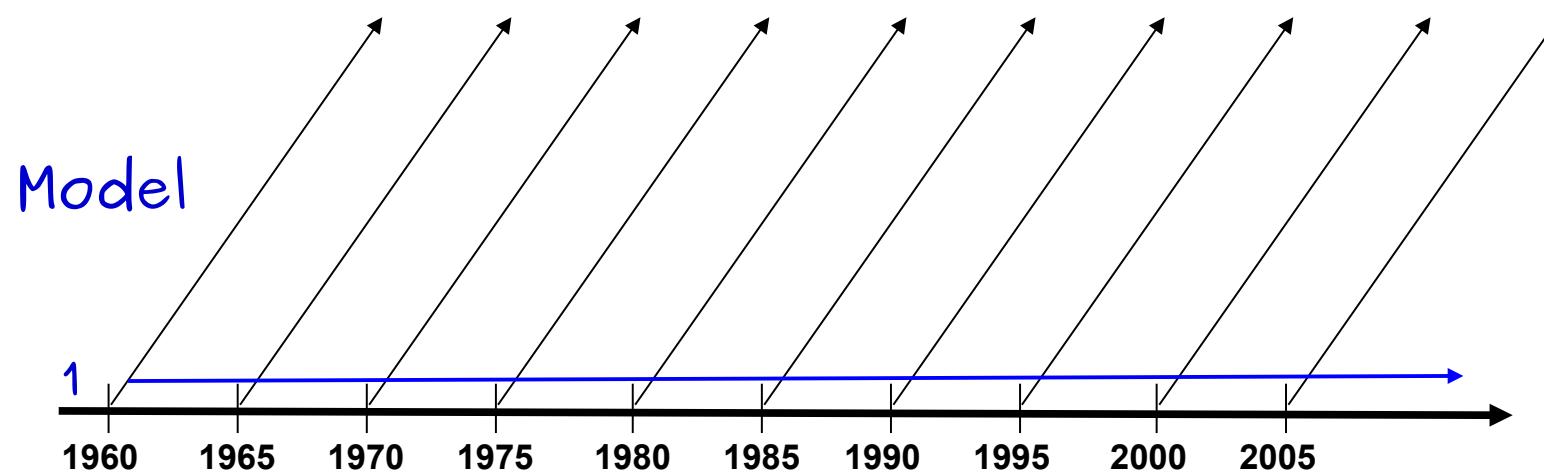
Methods

To focus on decadal time scales we average outputs using a 4-year running mean



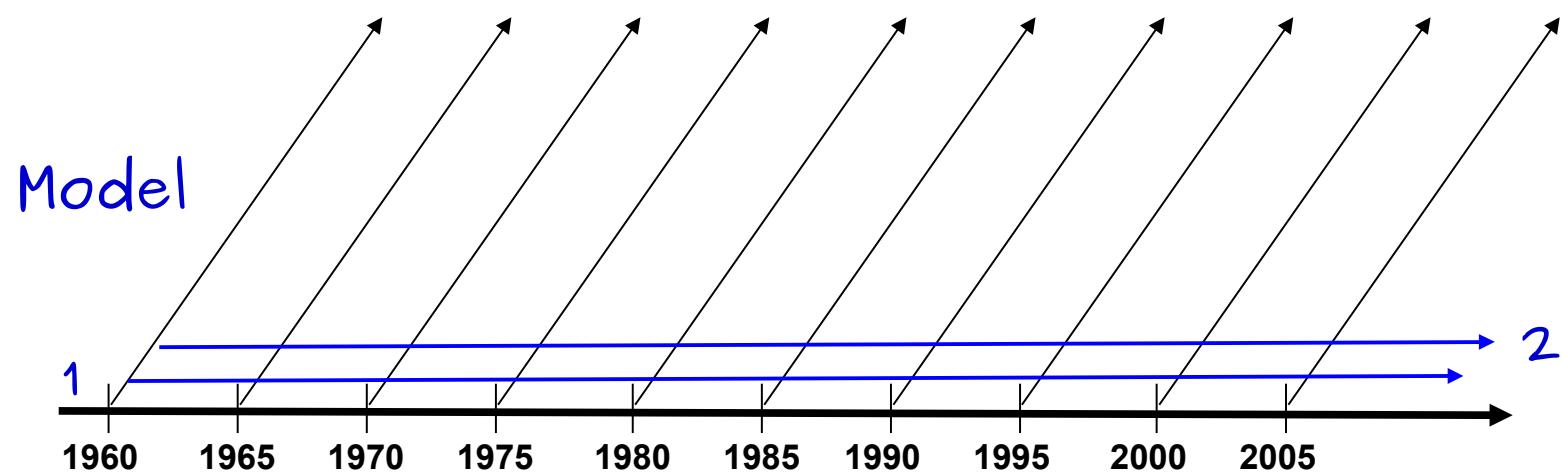
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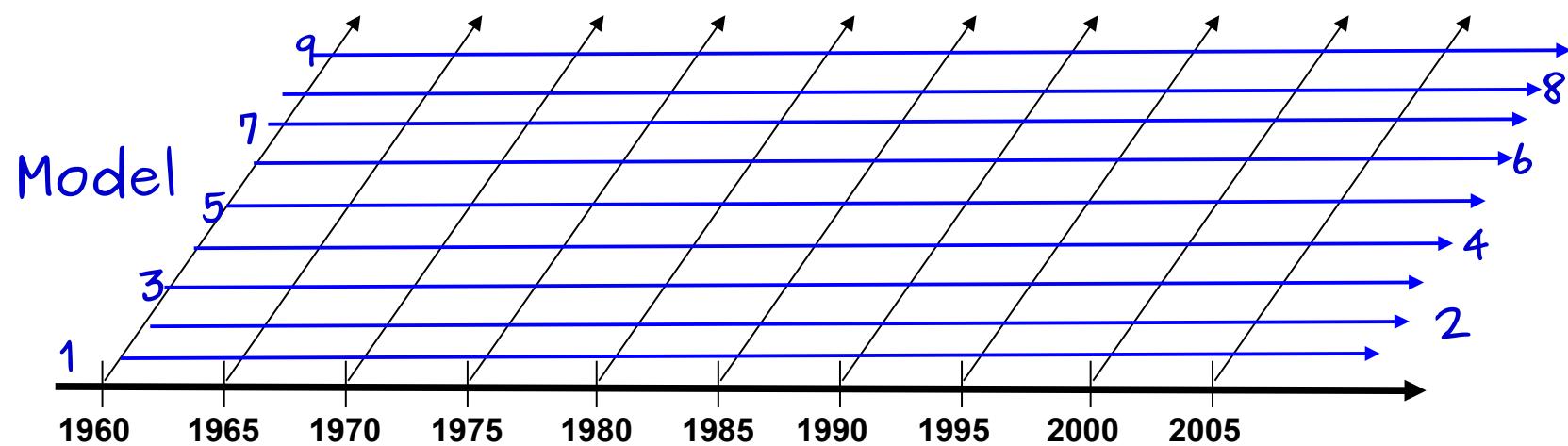
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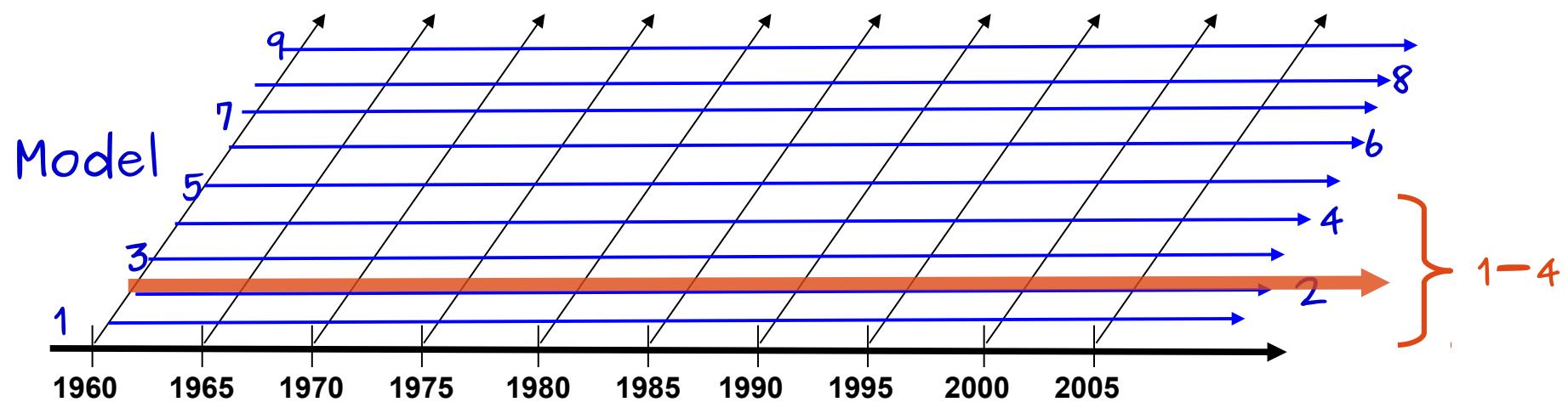
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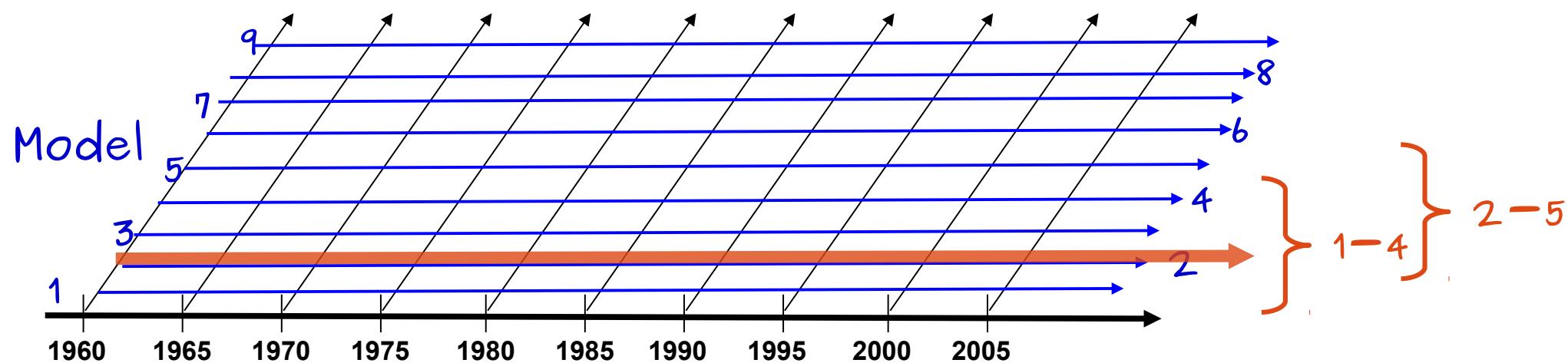
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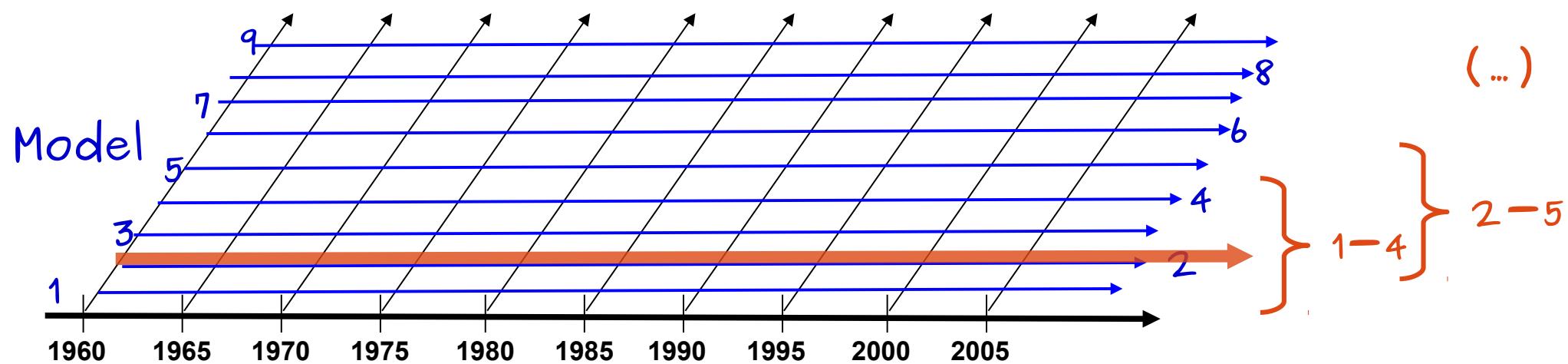
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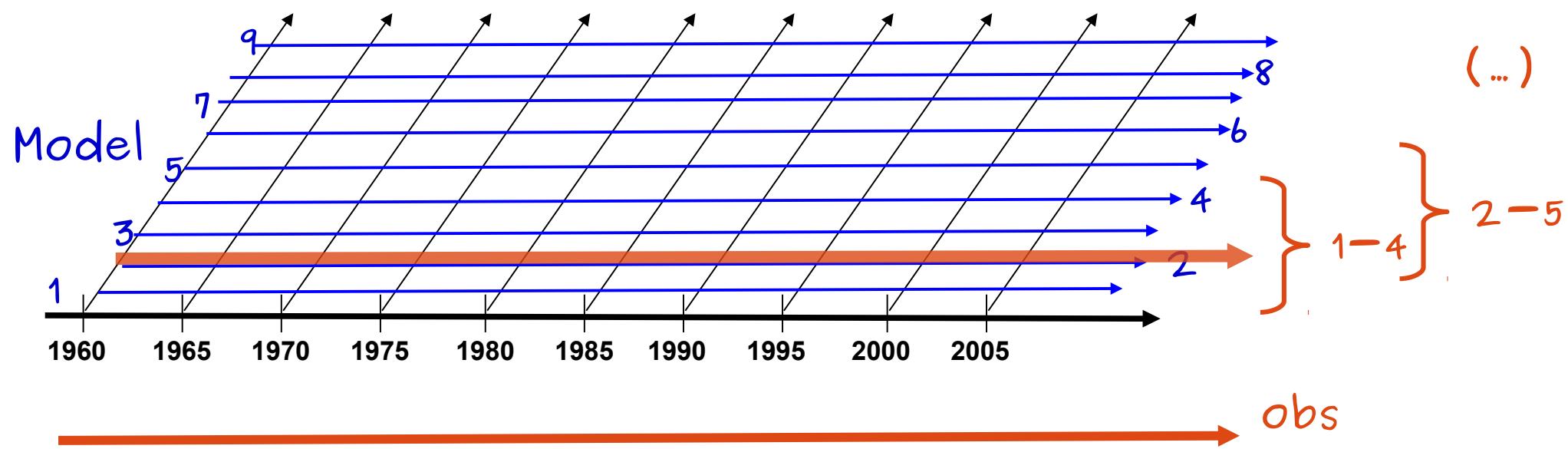
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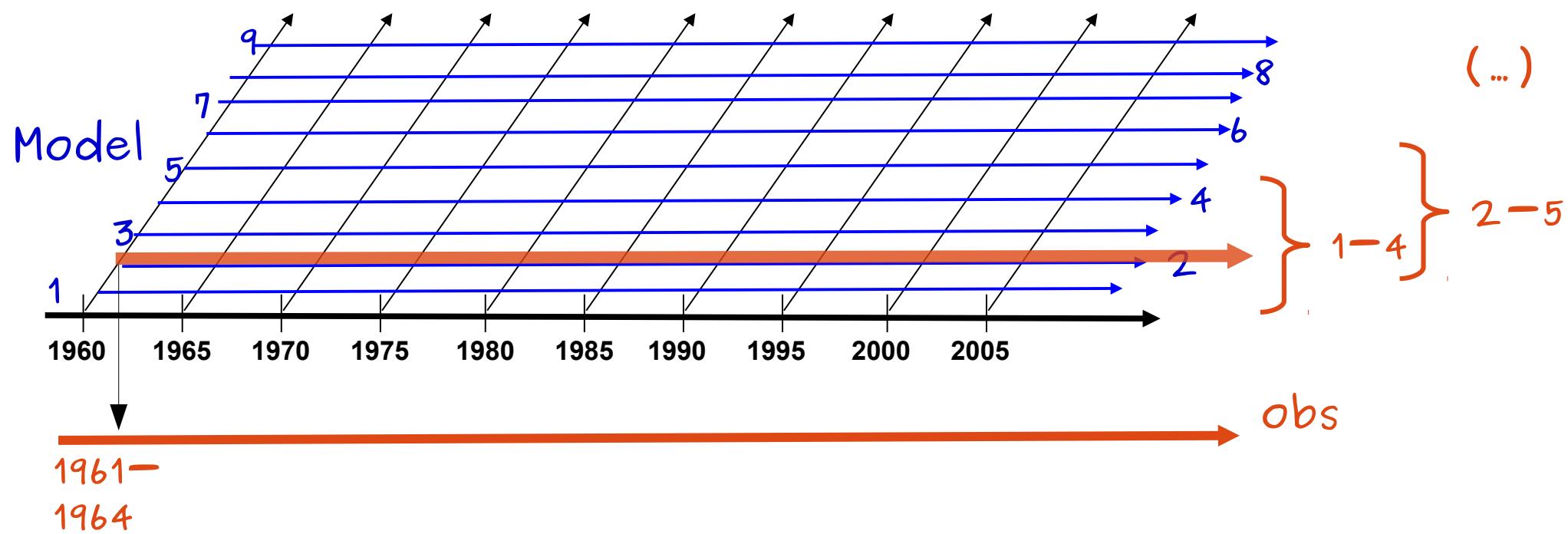
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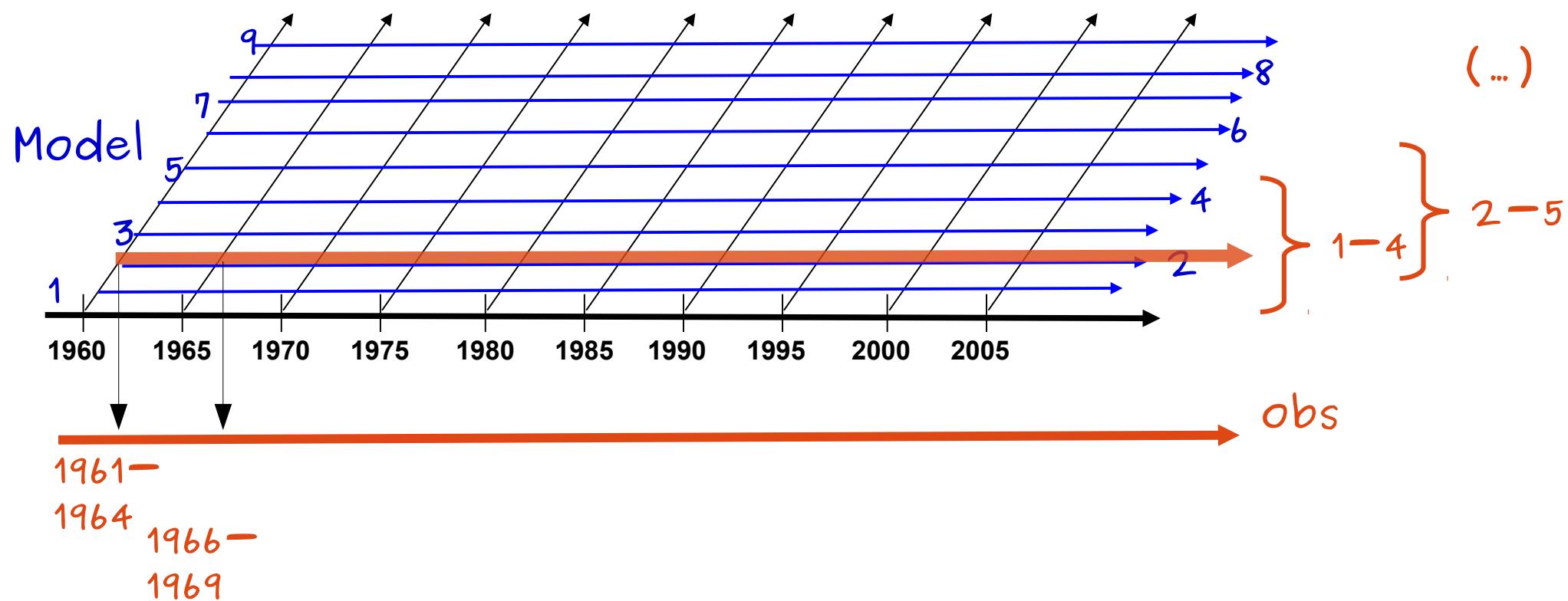
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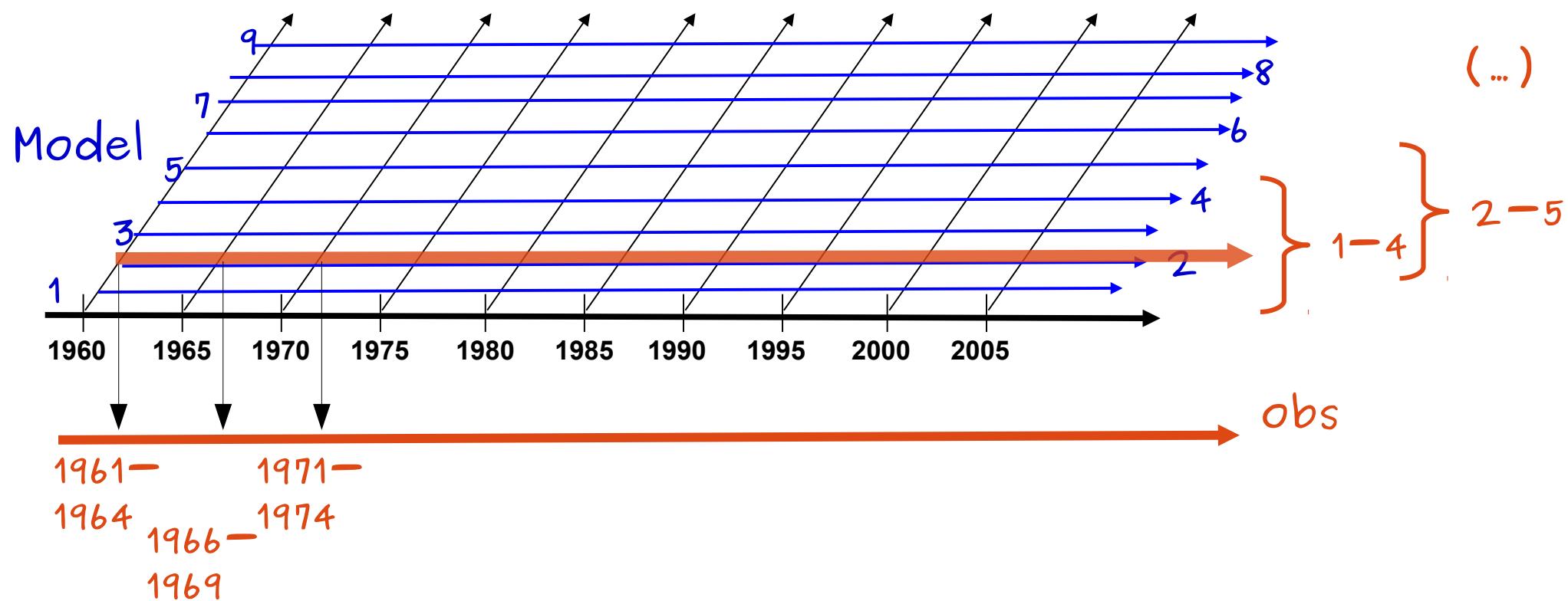
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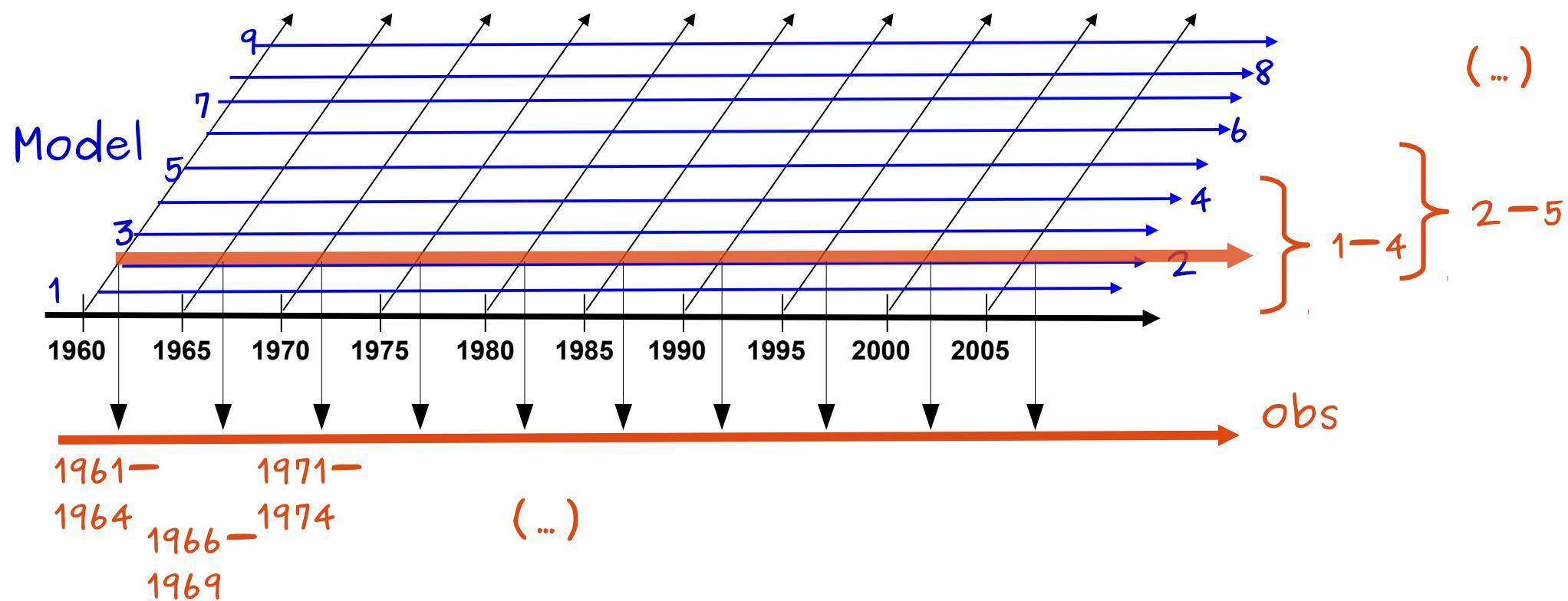
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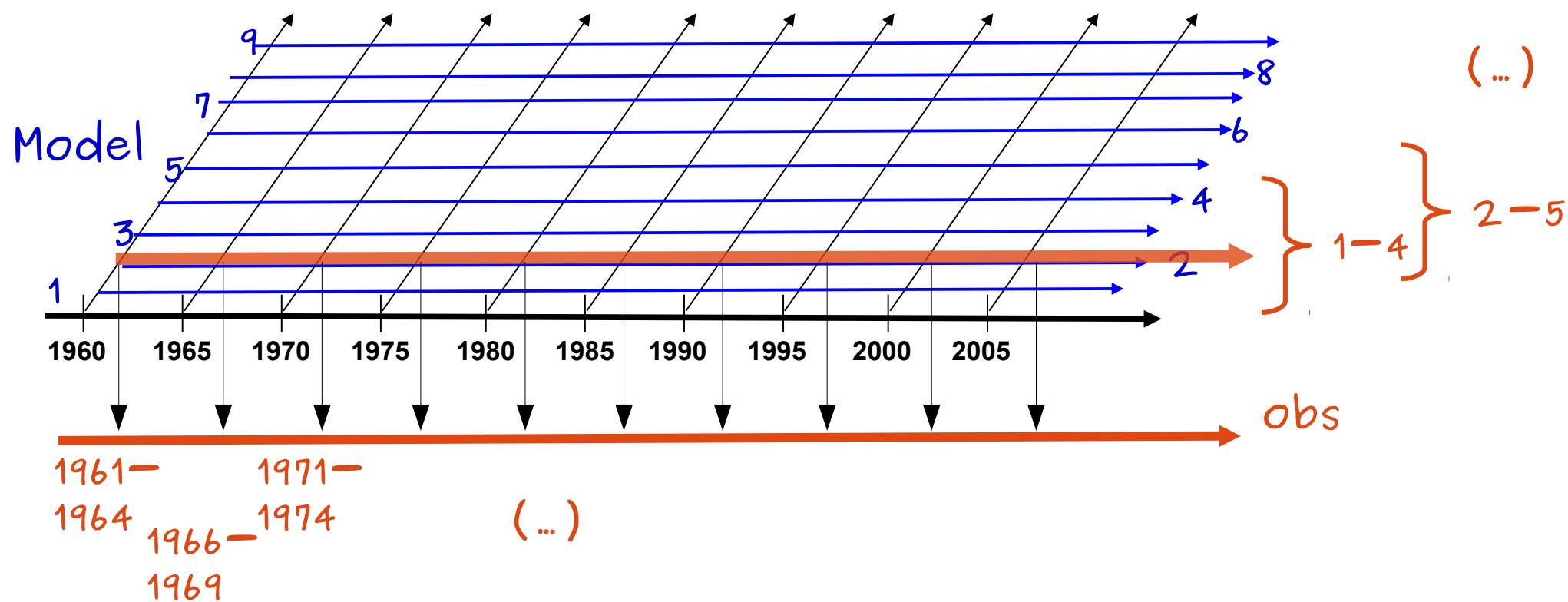
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To focus on decadal time scales we average outputs using a 4-year running mean



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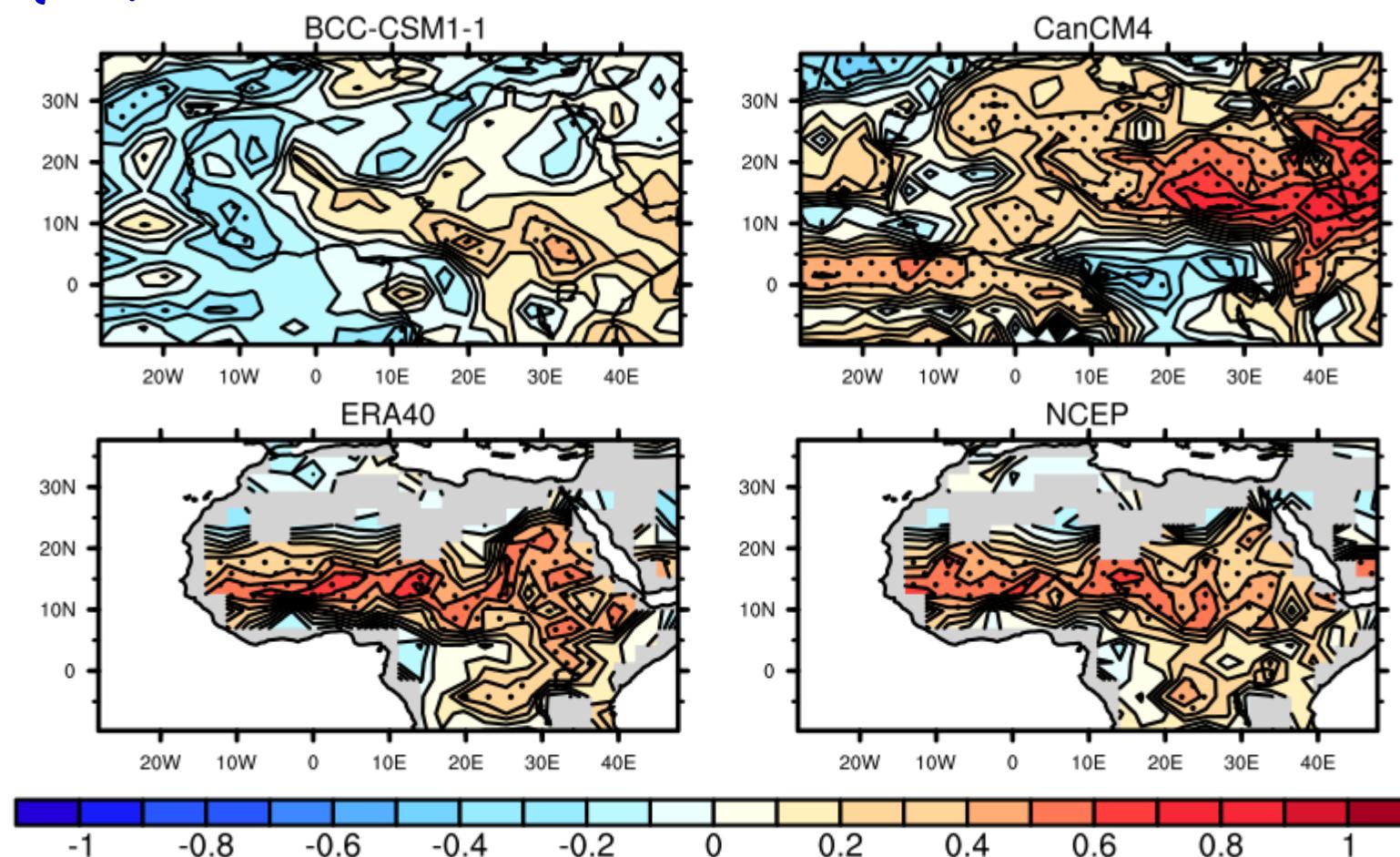
We apply predictive skill metrics to anomalies defined in the forecast dimension (removing stationary drifts) ACC (Anomaly Correlation Coefficient) and RMSE (Root Mean Square Error). We also test probabilistic forecasts.

Results

1st mode CEOF correlation with rainfall (not used in CEOF analysis)

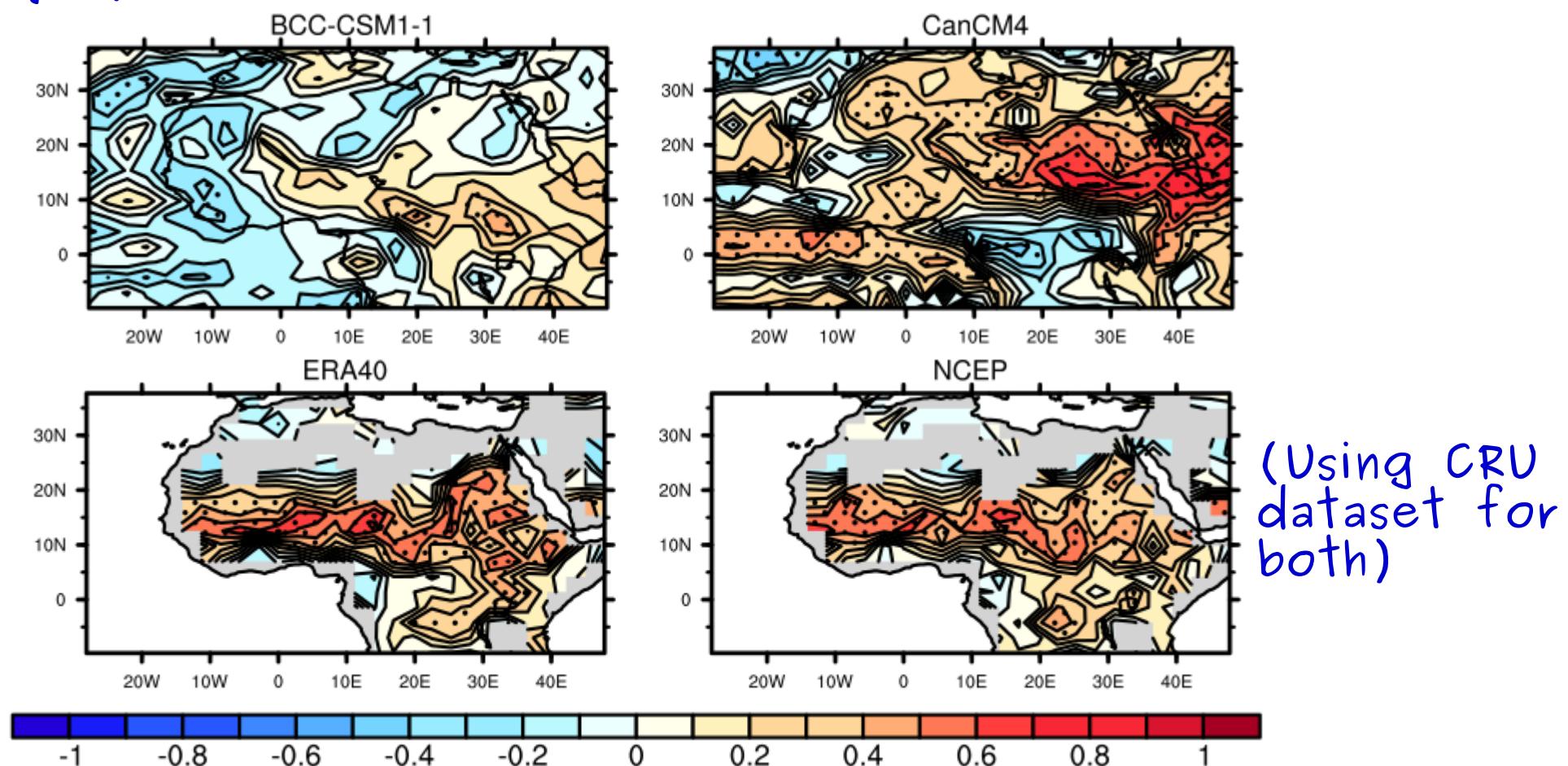
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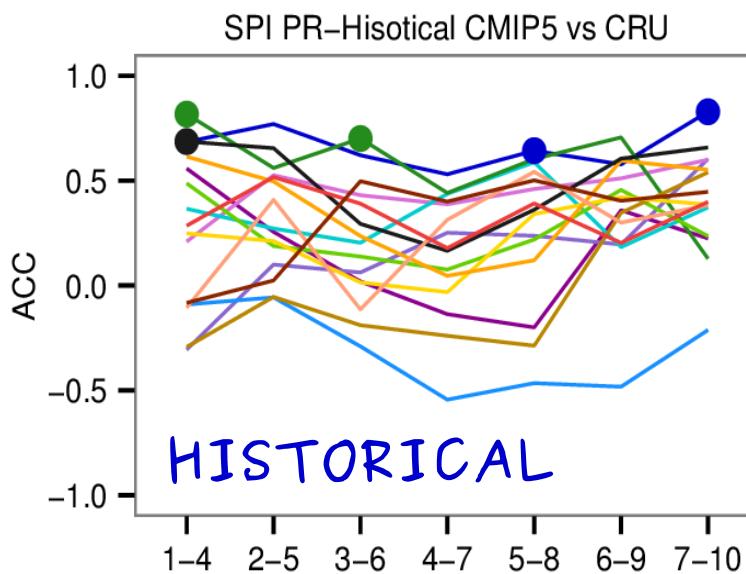
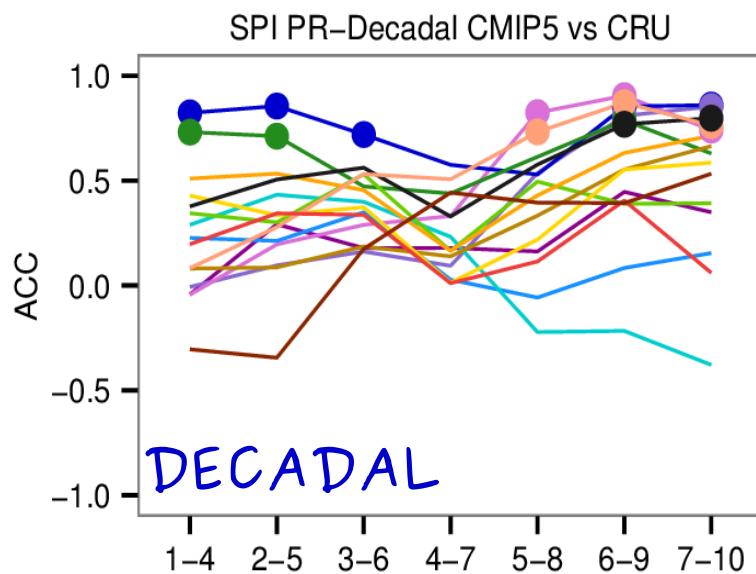
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→ PC of first CEOF mode is related to positive Sahel rainfall anomalies

Results

ACC scores for Sahel precipitation index (SPI: 10N-20N-15W-15E) between model and observations

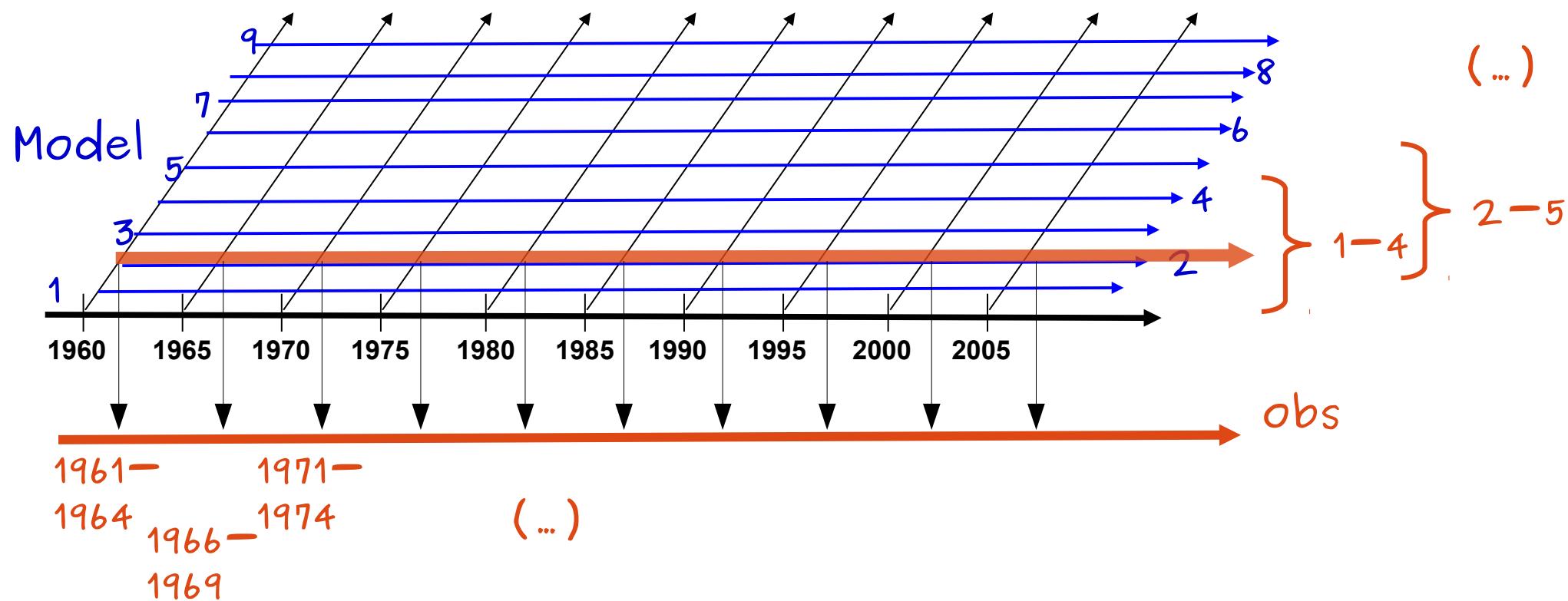


- BCC-CSM1-1
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- IPSL-CM5A-LR
- MIROC4h
- MIROC5
- MME
- MPI-ESM-LR
- MPI-ESM-MR
- MRI-CGCM3

- better scores for decadal (initialized) simulations
- CanCM4, CNRM-CM5, GFDL-CM2p1, MPI-ESM-LR, MME
Otero et al. (2015)
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