

DECADAL PREDICTION OF SAHEL RAINFALL: WHERE DOES THE SKILL (OR LACK THEREOF) COME FROM?

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University Complutense of Madrid

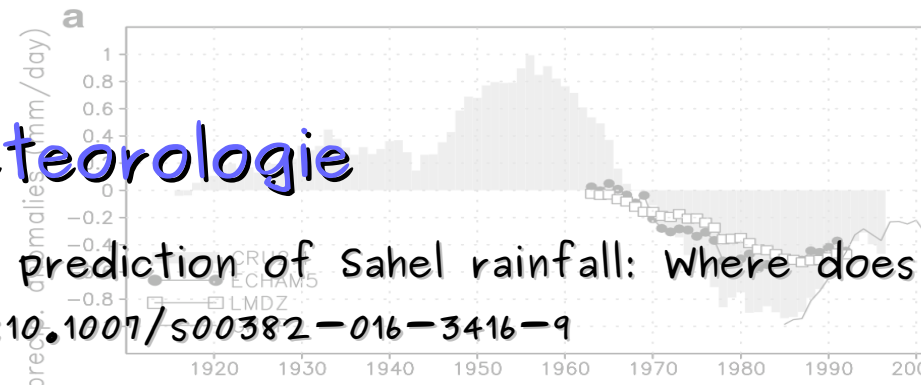
Noel Keenlyside

University of Bergen

Bjerknes Centre for Climate Research

Holger Pohlmann

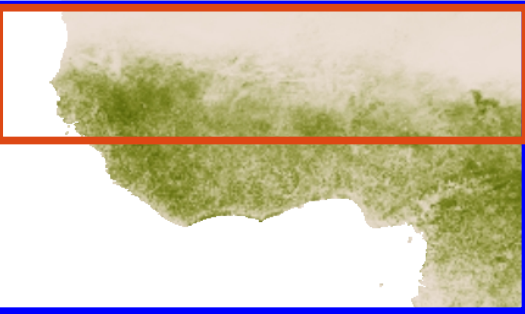
Max-Planck-Institut für Meteorologie



Mohino E, N Keenlyside, H Pohlmann (2016) Decadal prediction of Sahel rainfall: Where does skill (or lack thereof) come from? *Clim. Dyn.* DOI:10.1007/s00382-016-3416-9

DECADAL VARIABILITY OF SAHEL RAINFALL

Sahel rainfall has shown marked decadal variability:

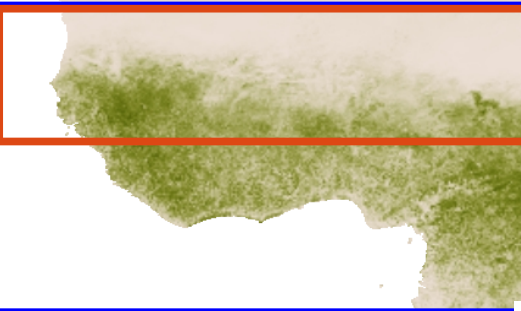


Sahel

Gulf of
Guinea

DECADAL VARIABILITY OF SAHEL RAINFALL

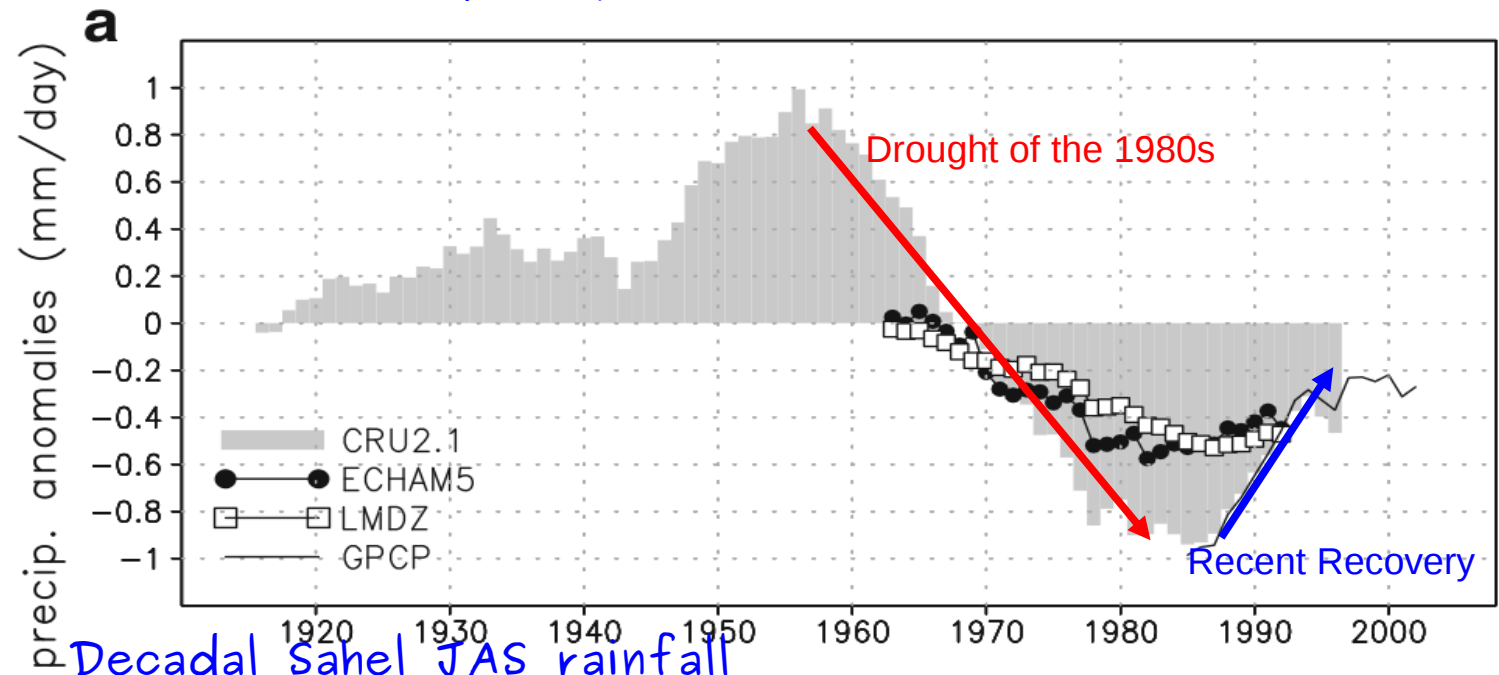
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Sahel

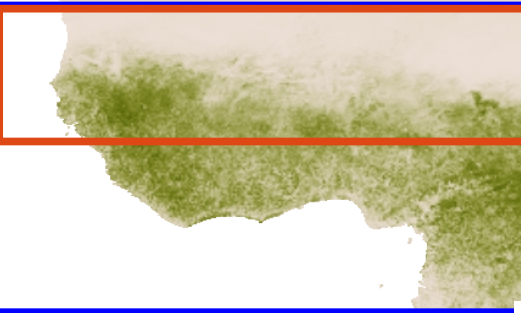
Gulf of Guinea

Decadal Sahel JAS rainfall



DECADAL VARIABILITY OF SAHEL RAINFALL

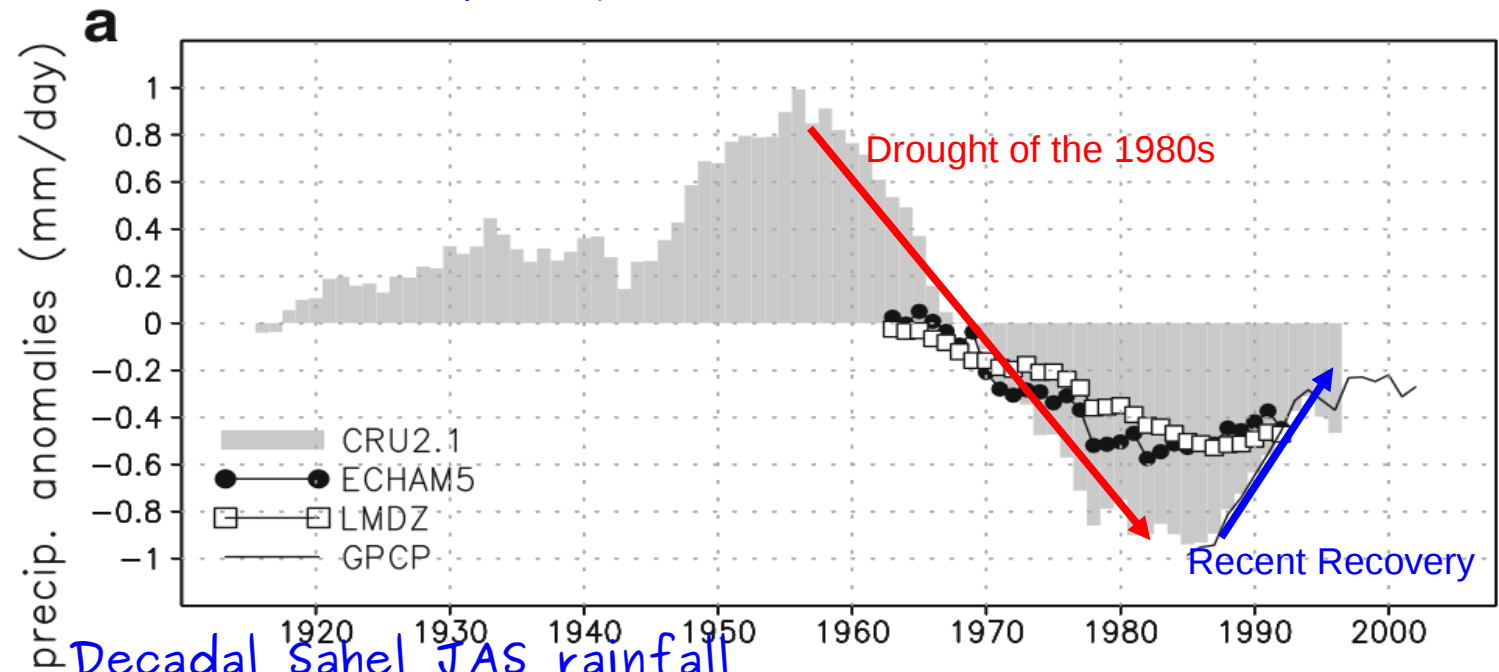
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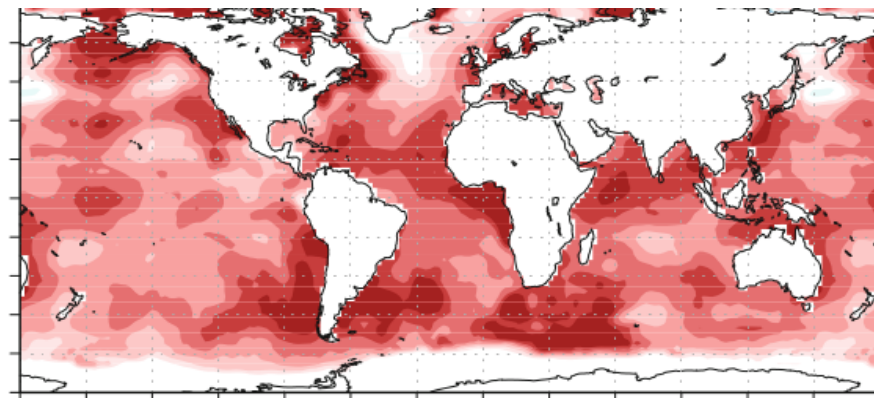
Decadal Sahel JAS rainfall



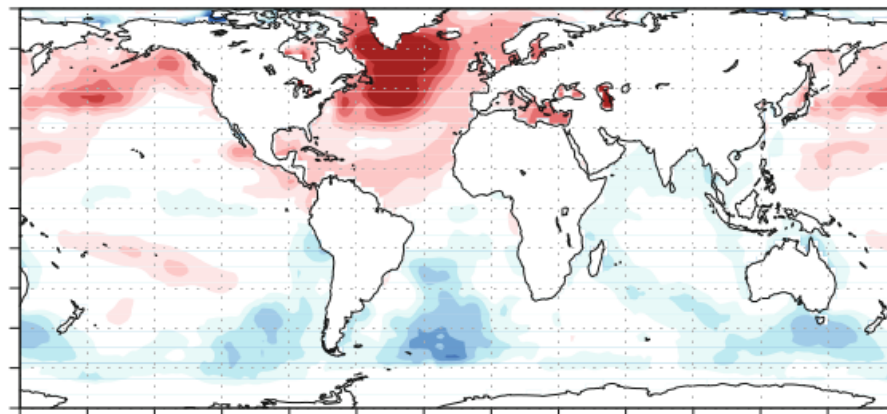
Main source of such variability SSTs (Rodríguez-Fonseca et al. 2015, and references therein)

DECADAL VARIABILITY OF SAHEL RAINFALL

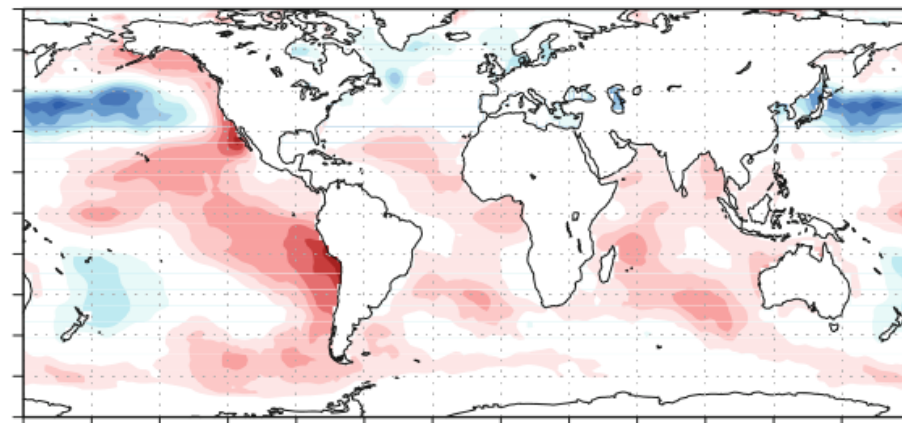
GW



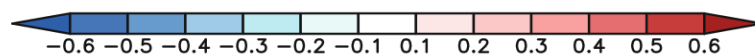
AMV



IPO



Regression of summer SSTs (K, left) onto GW (top), AMV (middle) and IPO (bottom) indices Mohino et al. (2011)



DECADAL VARIABILITY OF SAHEL RAINFALL

Tropical SST warming



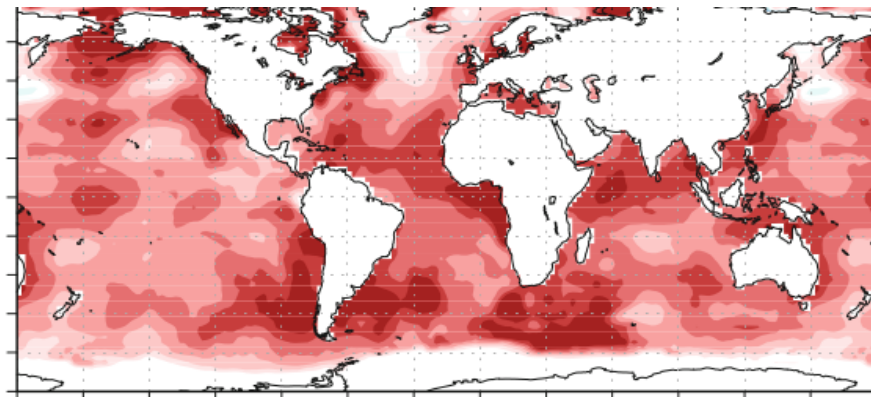
Subsidence over WA



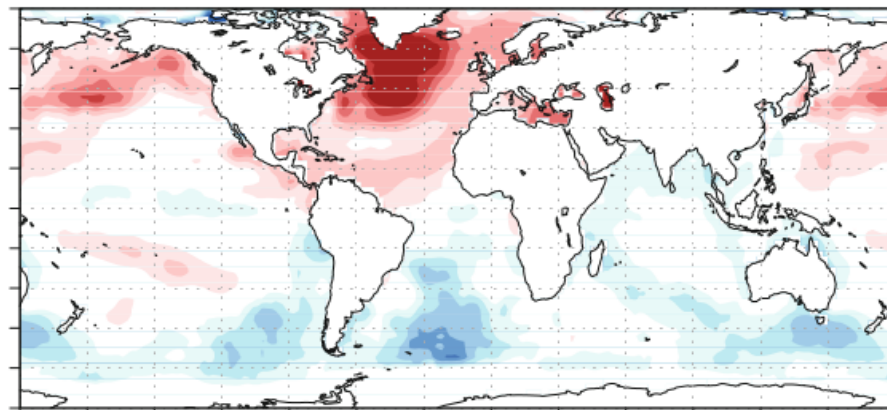
Sahel drought

e.g. Giannini et al. 2003, 2013; Lu and Delworth 2005, ...

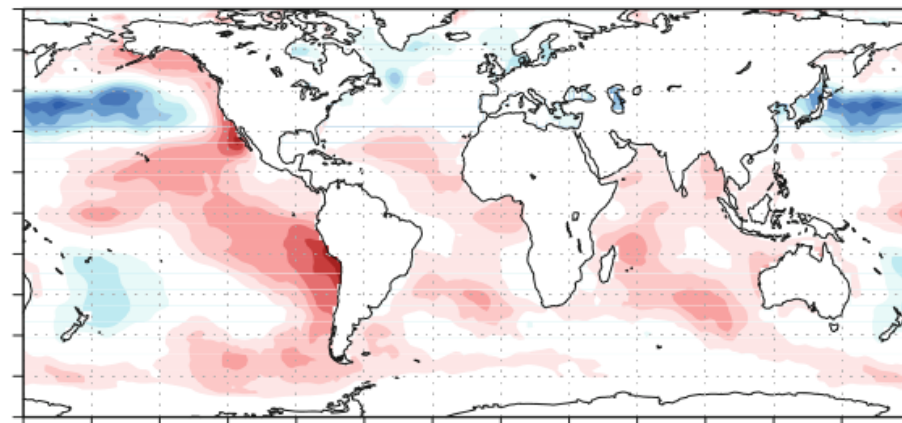
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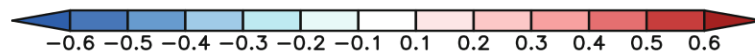
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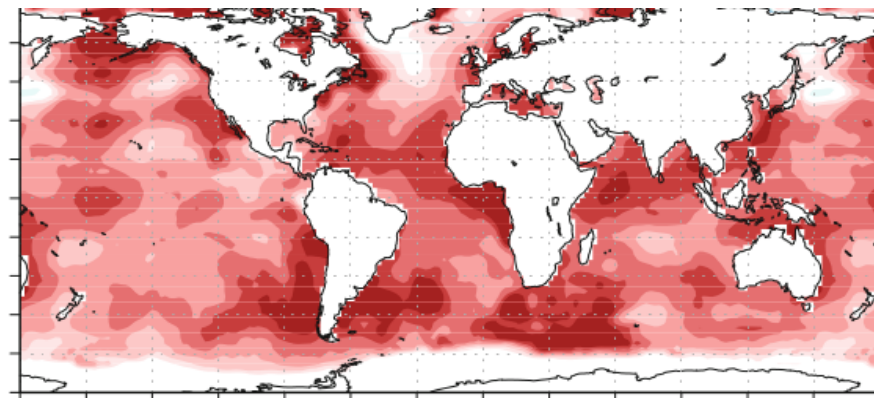
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SST northward gradient



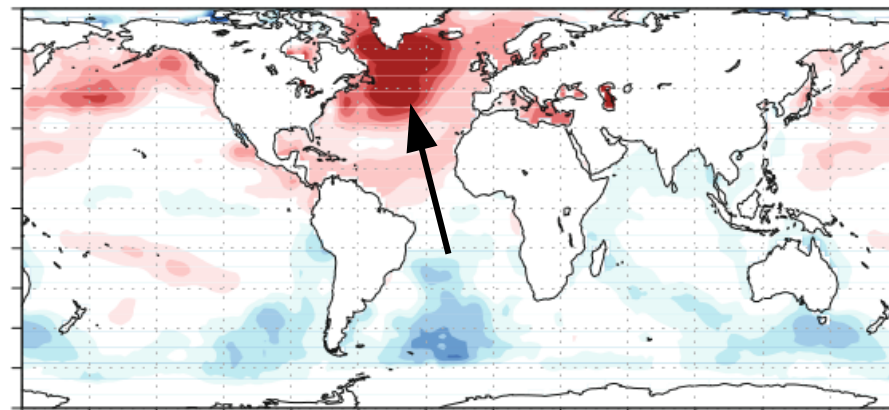
Northward shift of ITCZ

AMV

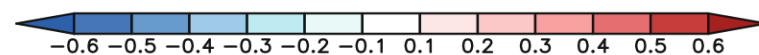
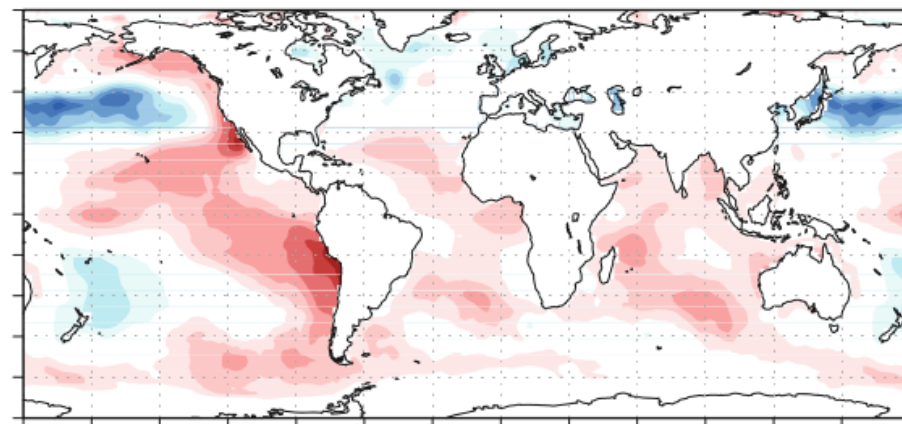
Increased Sahel rainfall



Folland et al. 1986; Palmer 1986; Hoerling et al. 2006; Knight et al. 2006; Ting et al. 2009, 2011...



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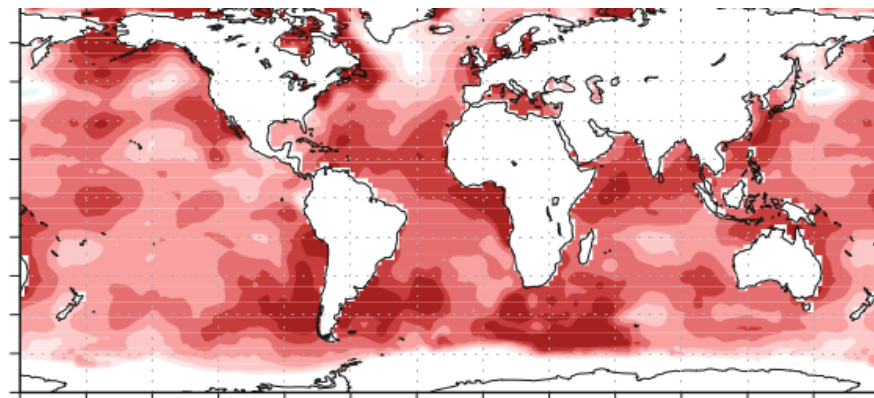
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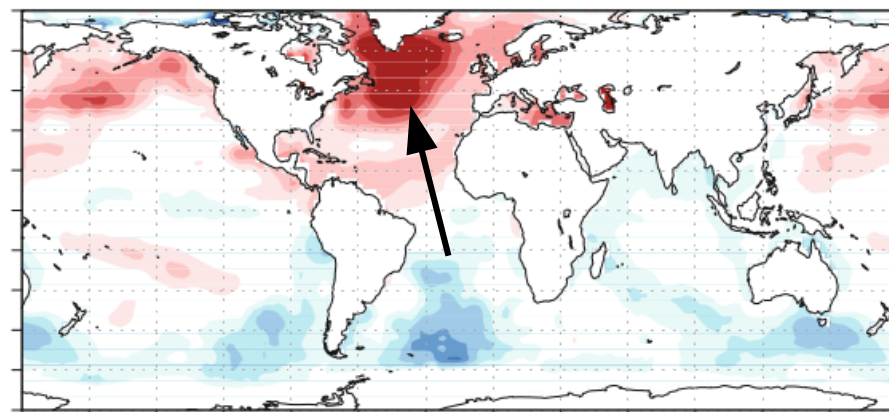
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Tropical Pacific SST warming

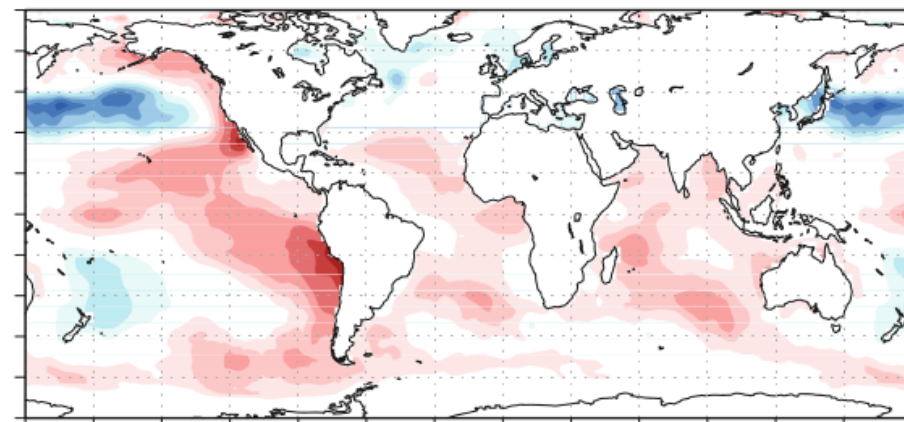


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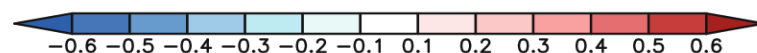


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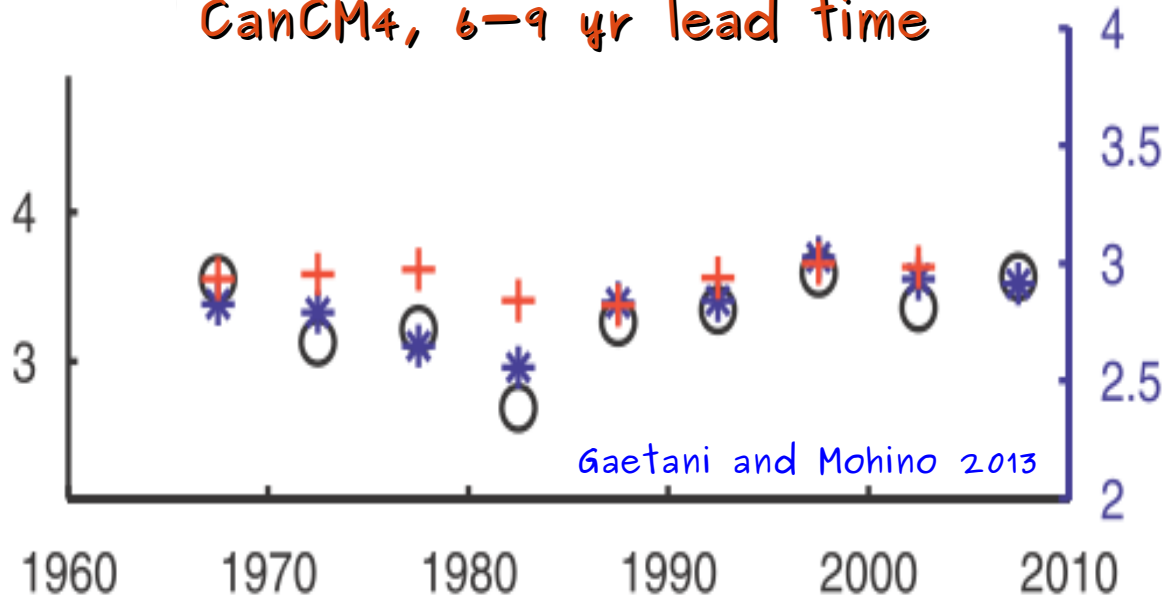


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DECADAL PREDICTION OF SAHEL RAINFALL

CanCM4, 6-9 yr lead time

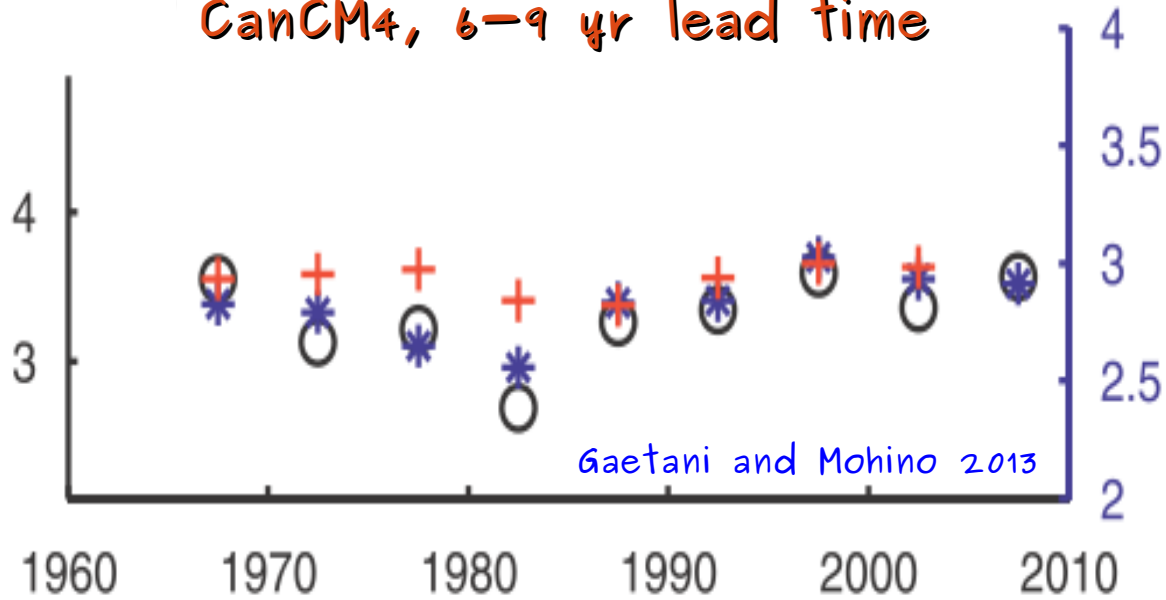


Some models are skilful in predicting Sahel decadal rainfall variability

- Observations
- * Decadal predictions
- + Historical

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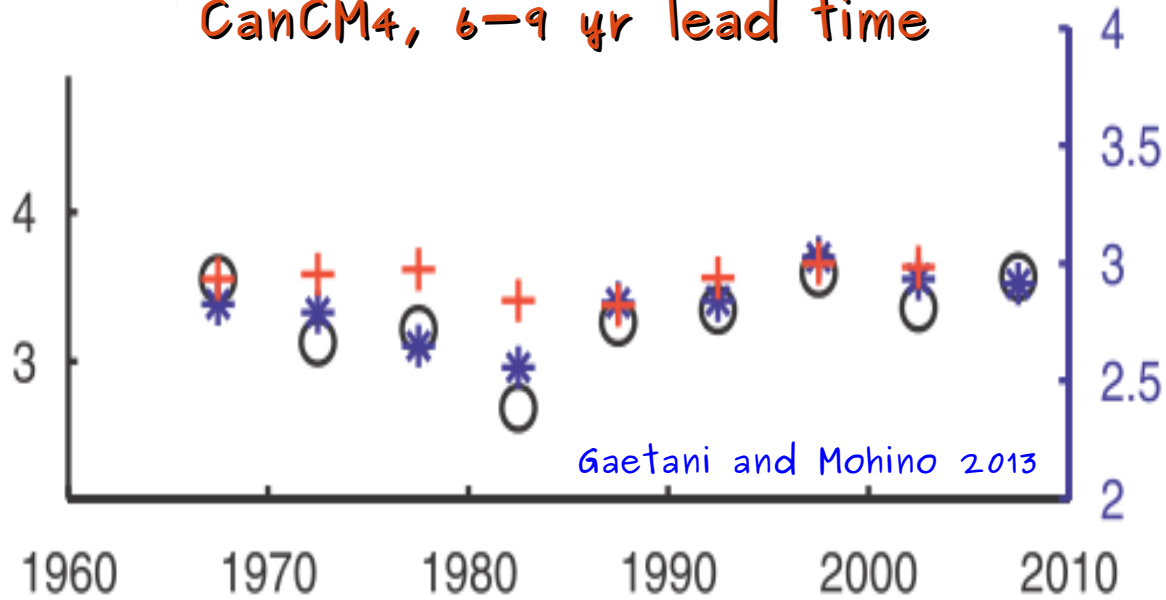
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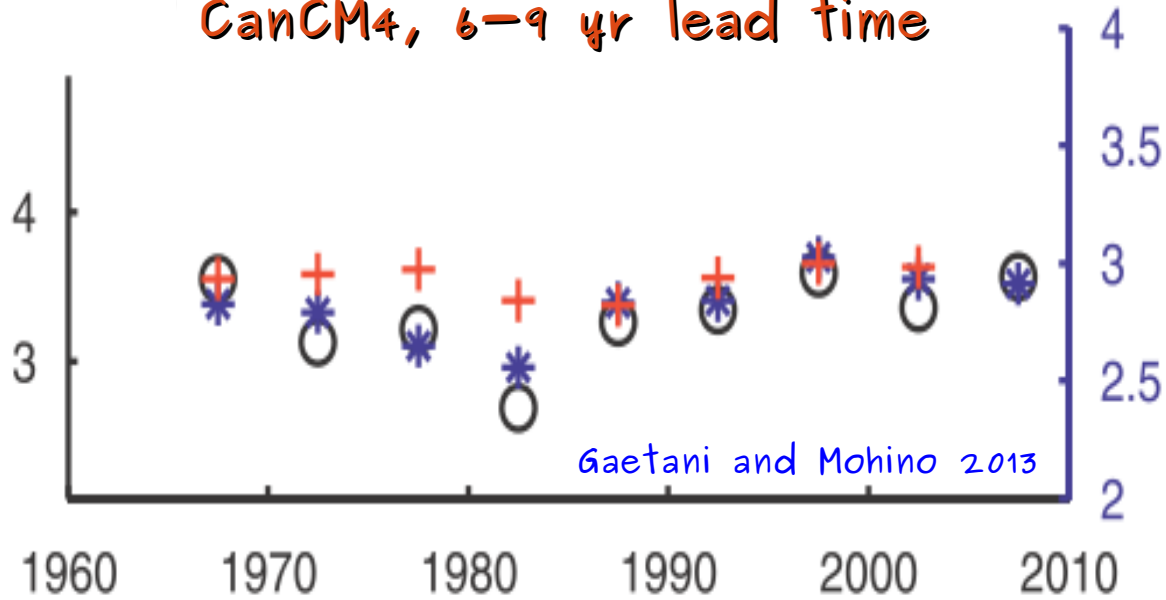
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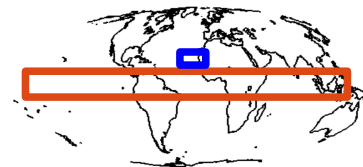
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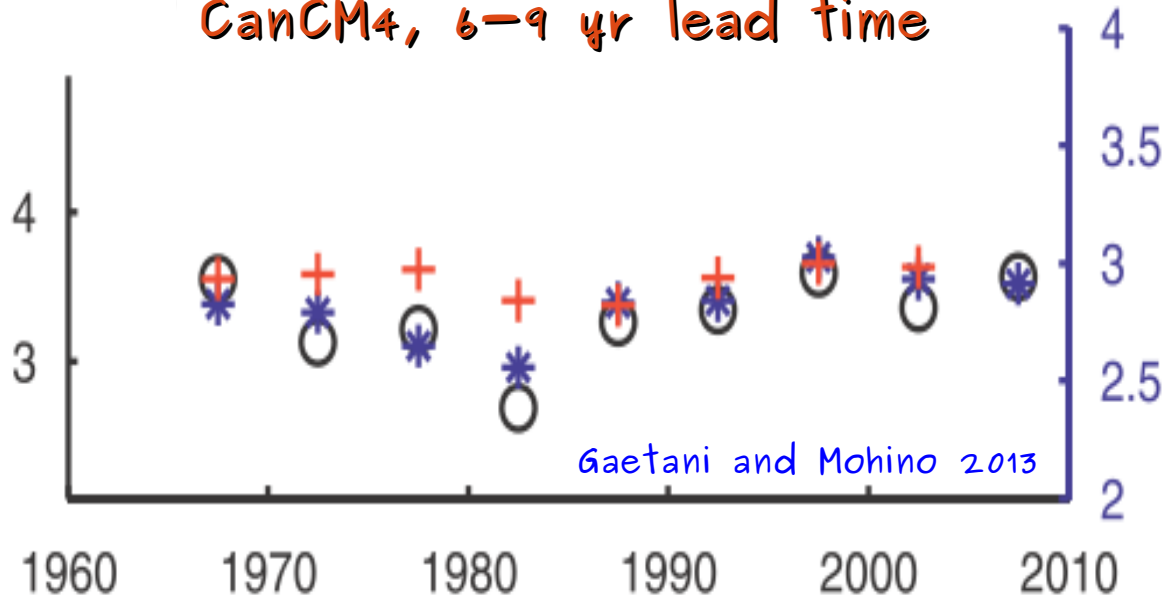
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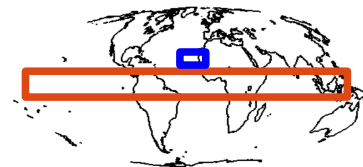


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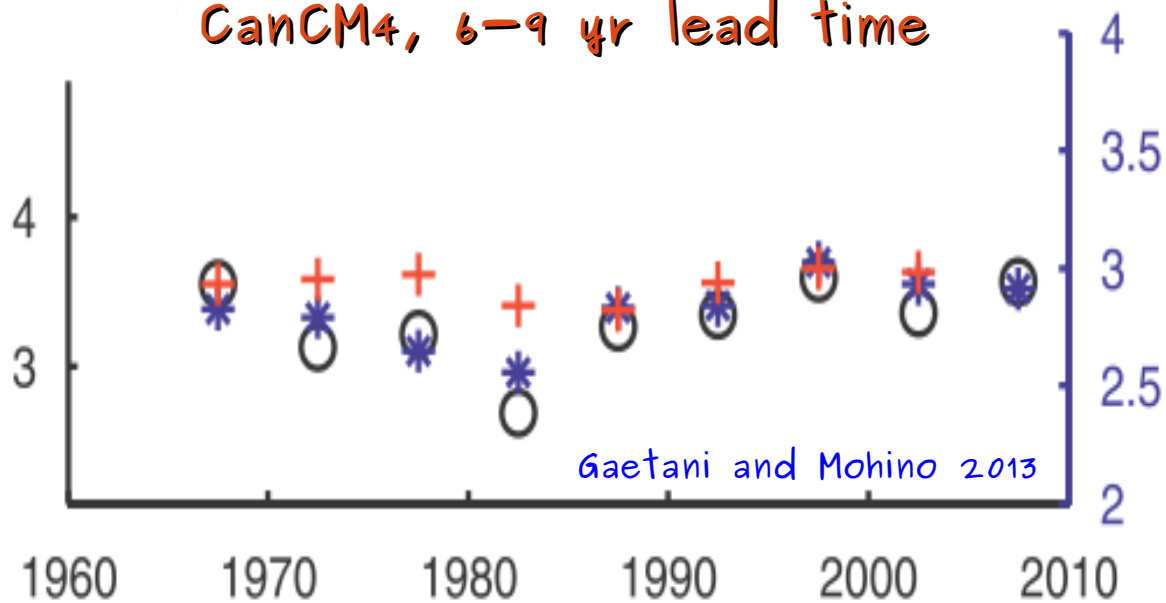
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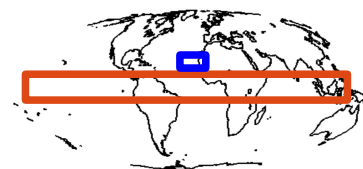


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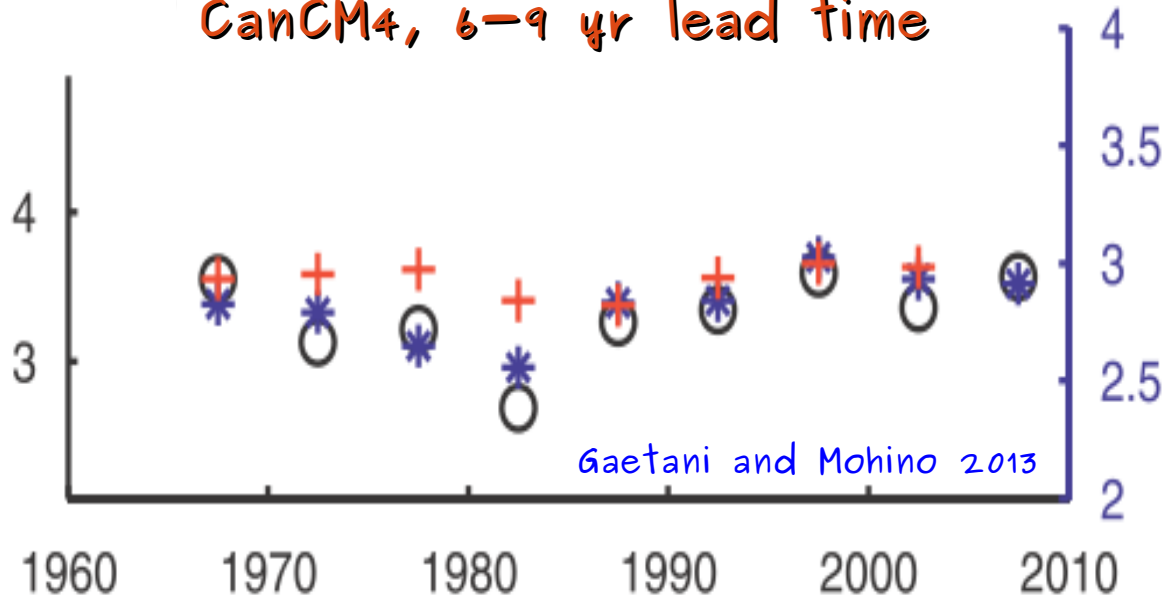
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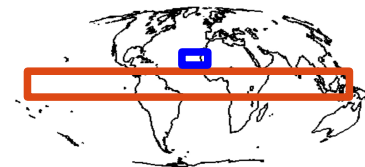


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Here we use:

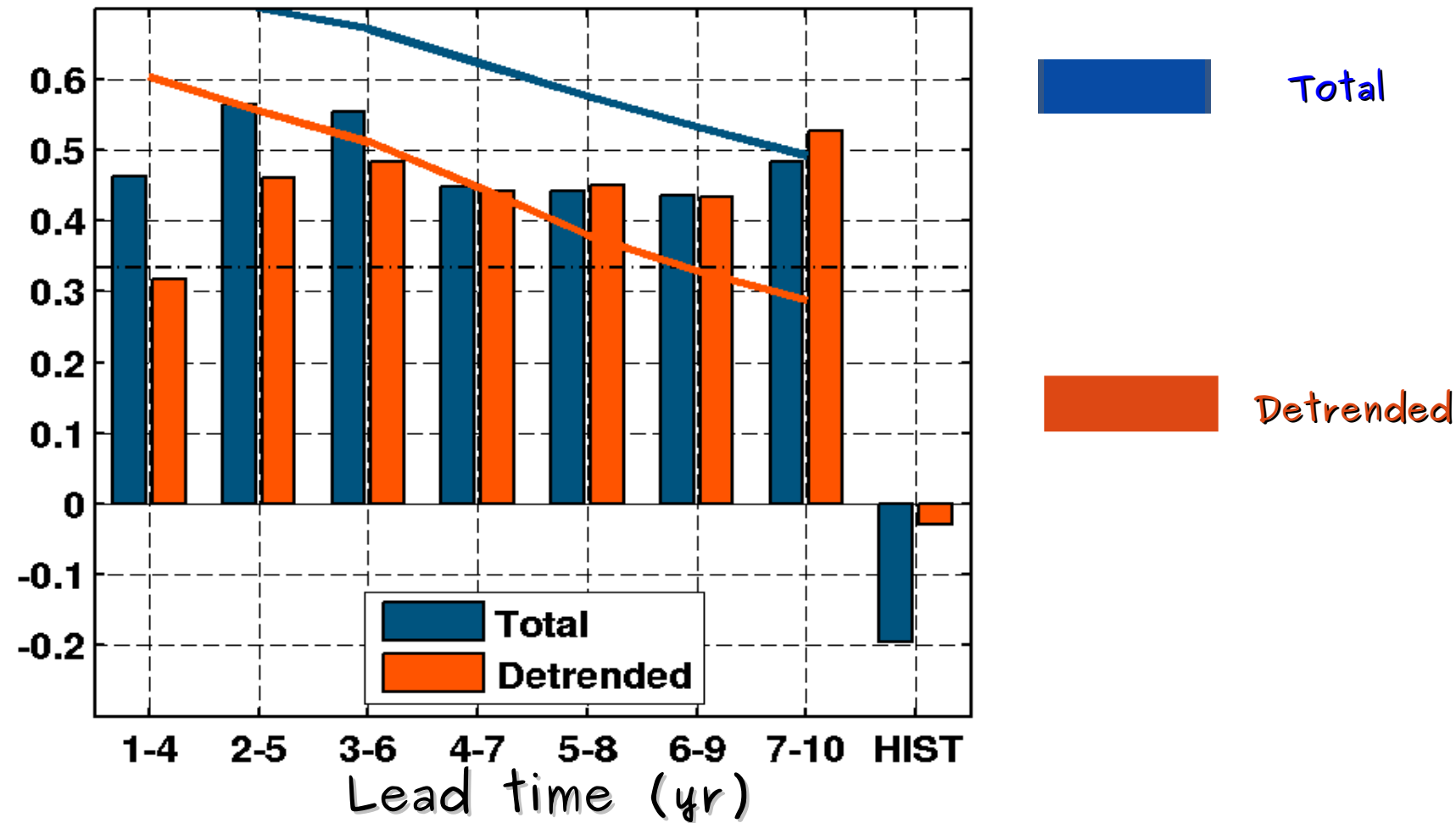
EXTENDED (1901-2010) MPI-ESM-LR decadal predictions
(Müller et al. 2014)

RESULTS

EXTENDED (1901-2010) MPI-ESM-LR decadal predictions

RESULTS

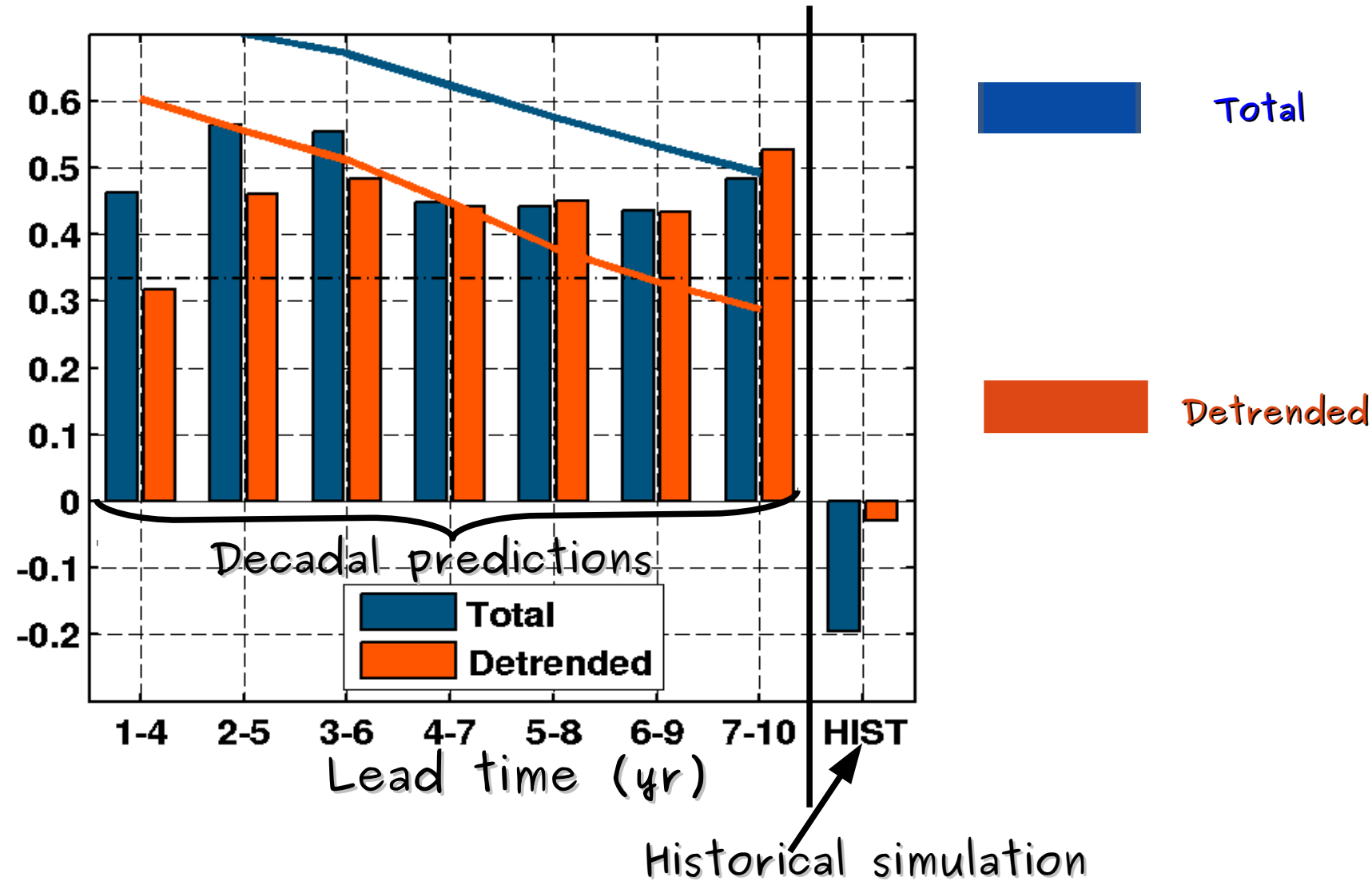
ACC skill scores for Sahel rainfall



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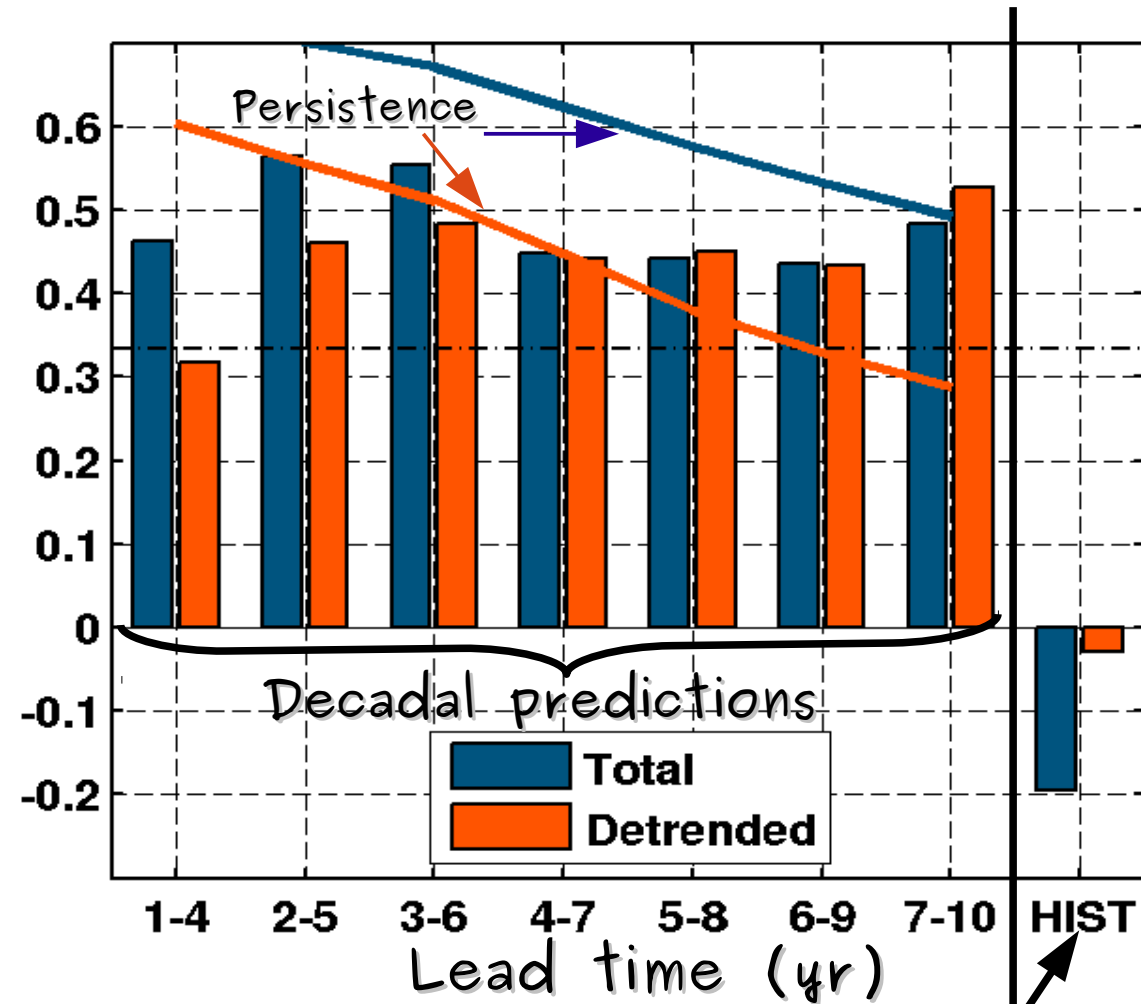
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ACC skill scores for Sahel rainfall



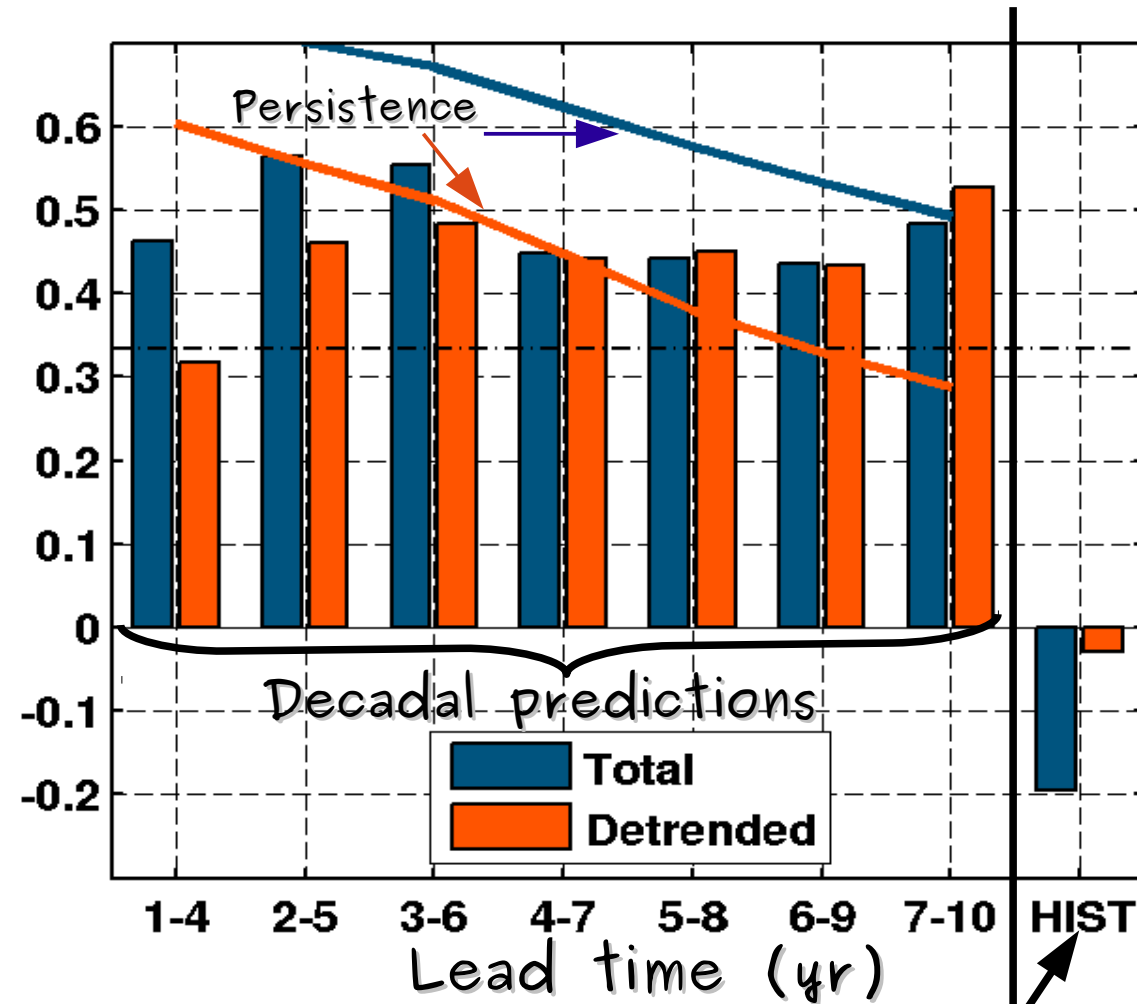
- Total
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- Better skill than for total at some lead times
- Decadal predictions beat persistence from 4-7 yr lead time onwards

Historical simulation

EXTENDED (1901-2010) MPI-ESM-LR decadal predictions

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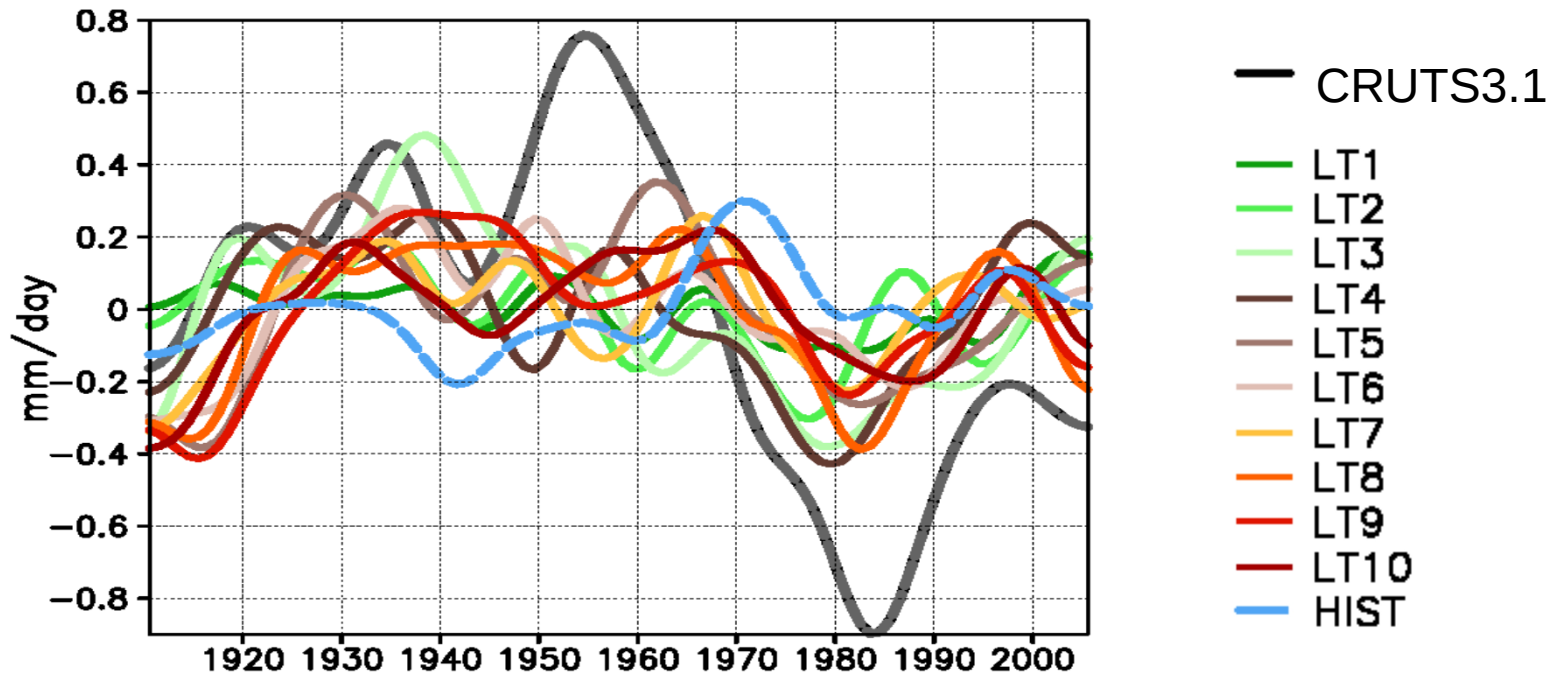
Historical simulation

Why??

EXTENDED (1901-2010) MPI-ESM-LR decadal predictions

RESULTS

Analyse Sahel rainfall for each lead time separately ...

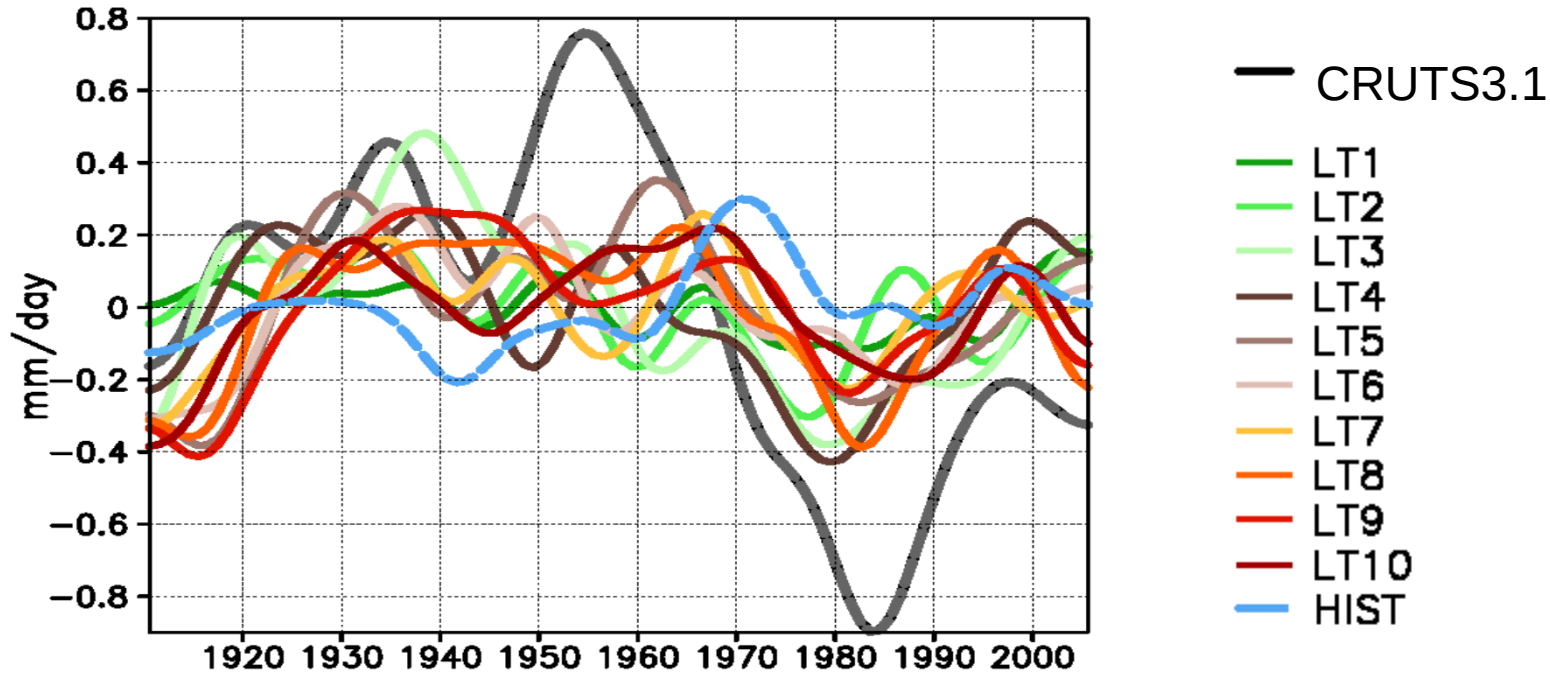


... and its relation to GW, AMV and IPO

$$y = ax_1 + bx_2 + cx_3 + \epsilon$$

RESULTS

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Sahel rainfall

GW

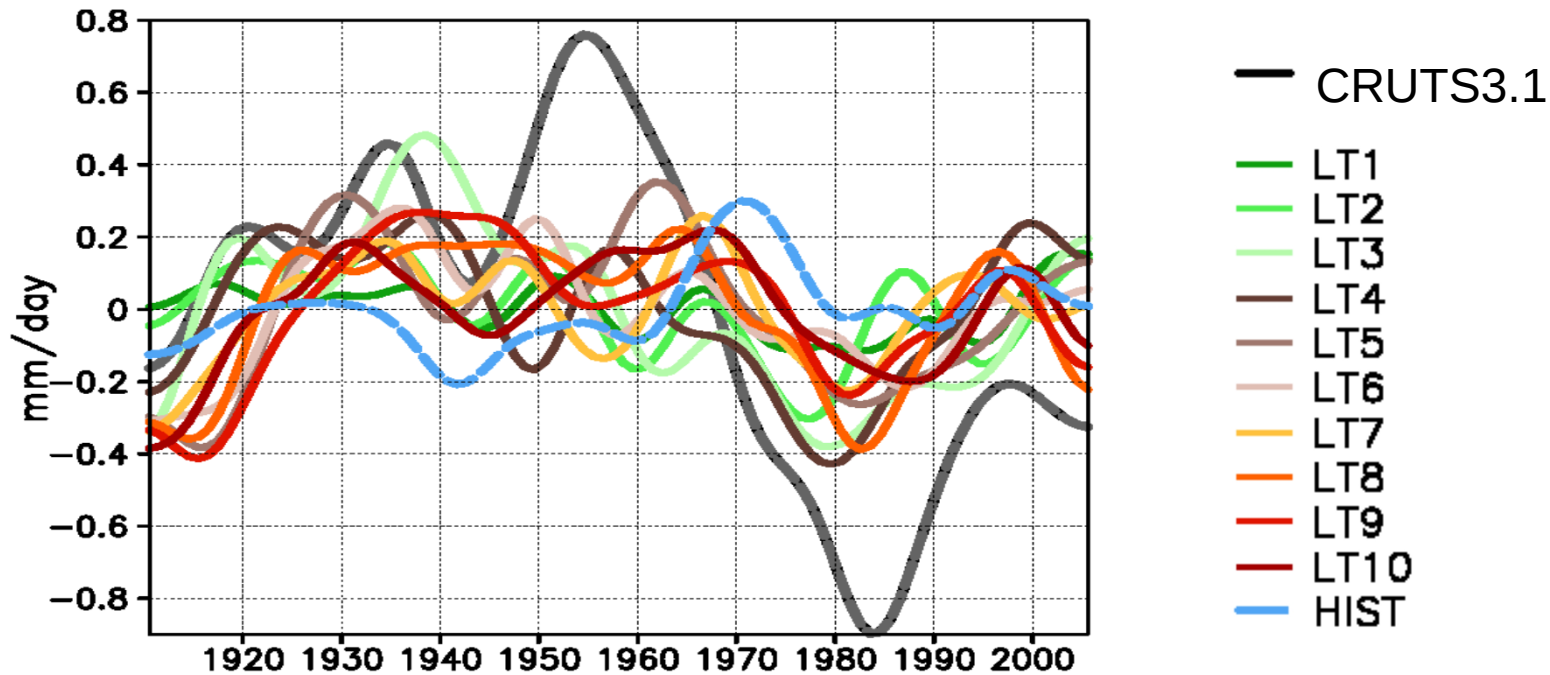
AMV

IPO

residual (unfitted)

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Coefficients (multilinear regression analysis)

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Sahel rainfall

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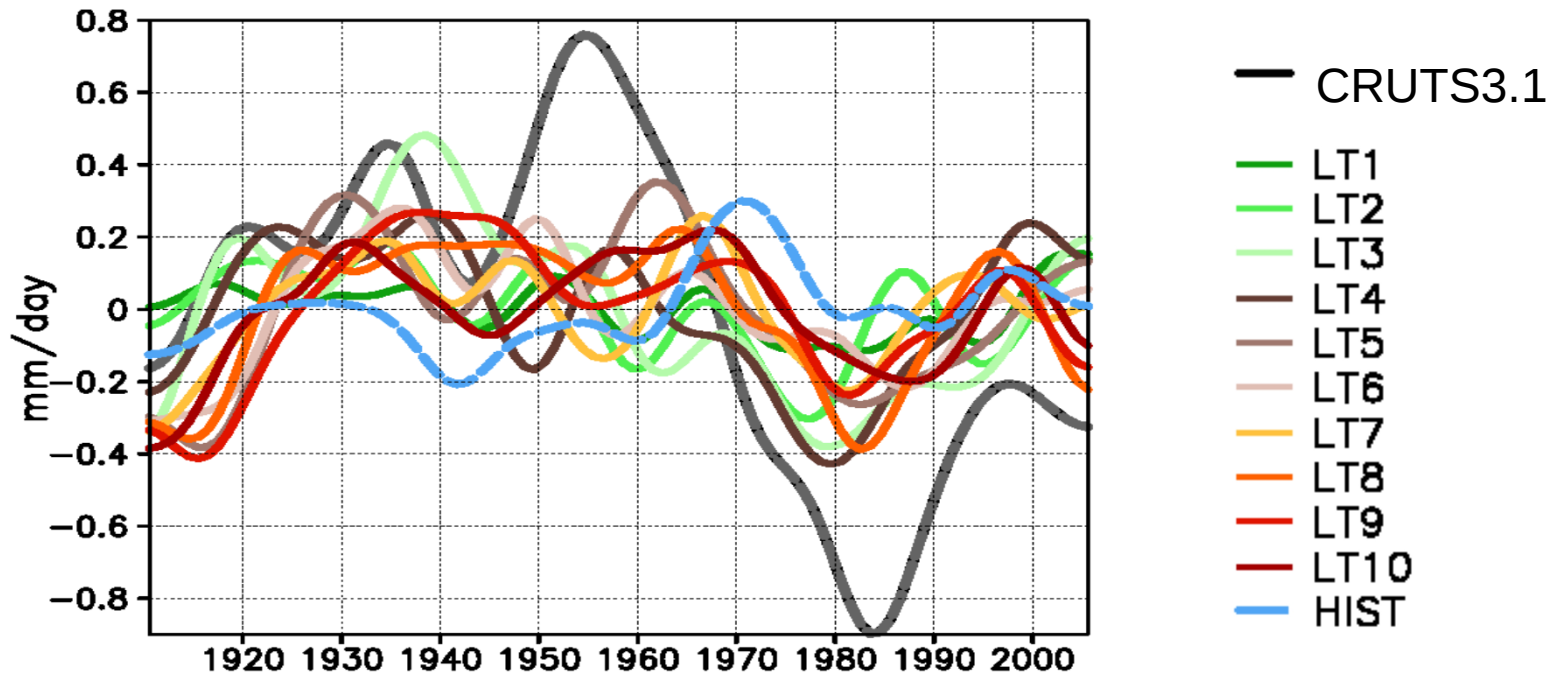
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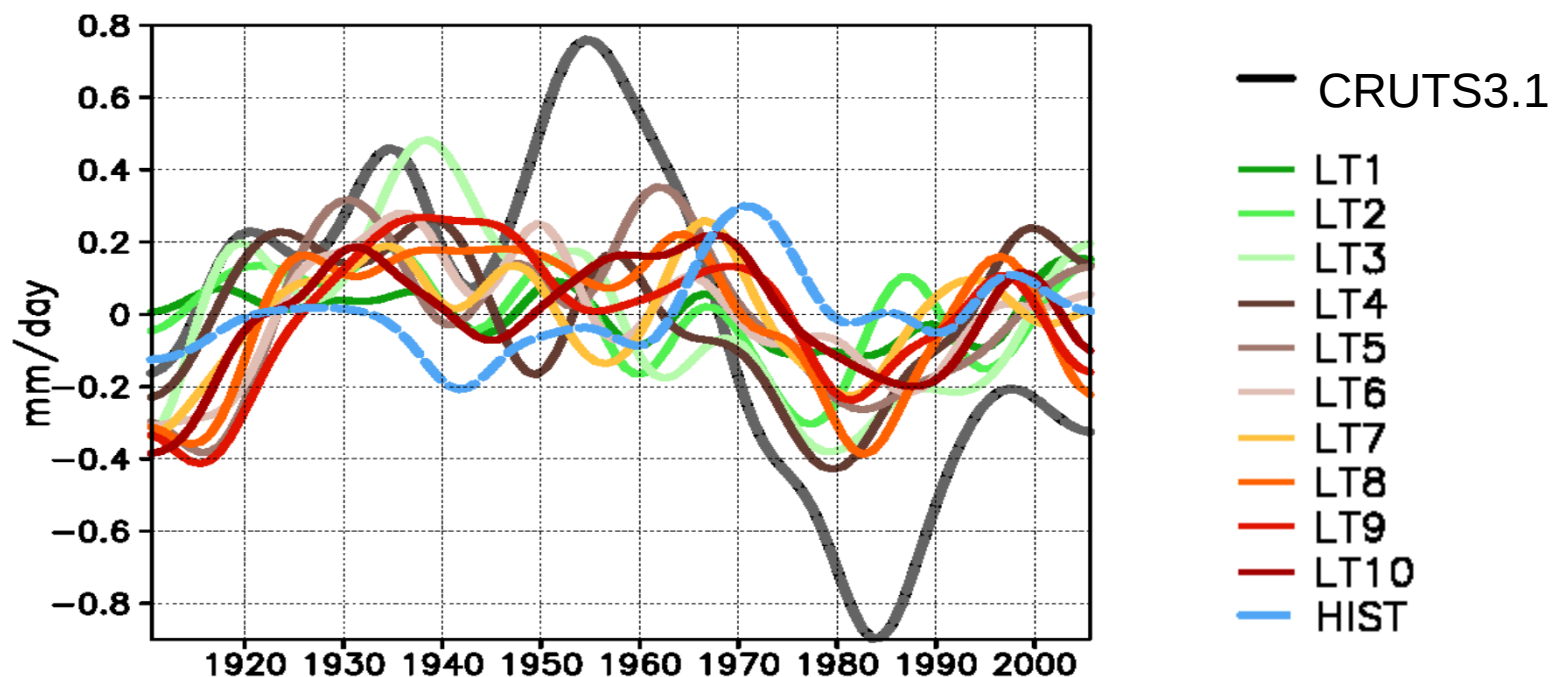
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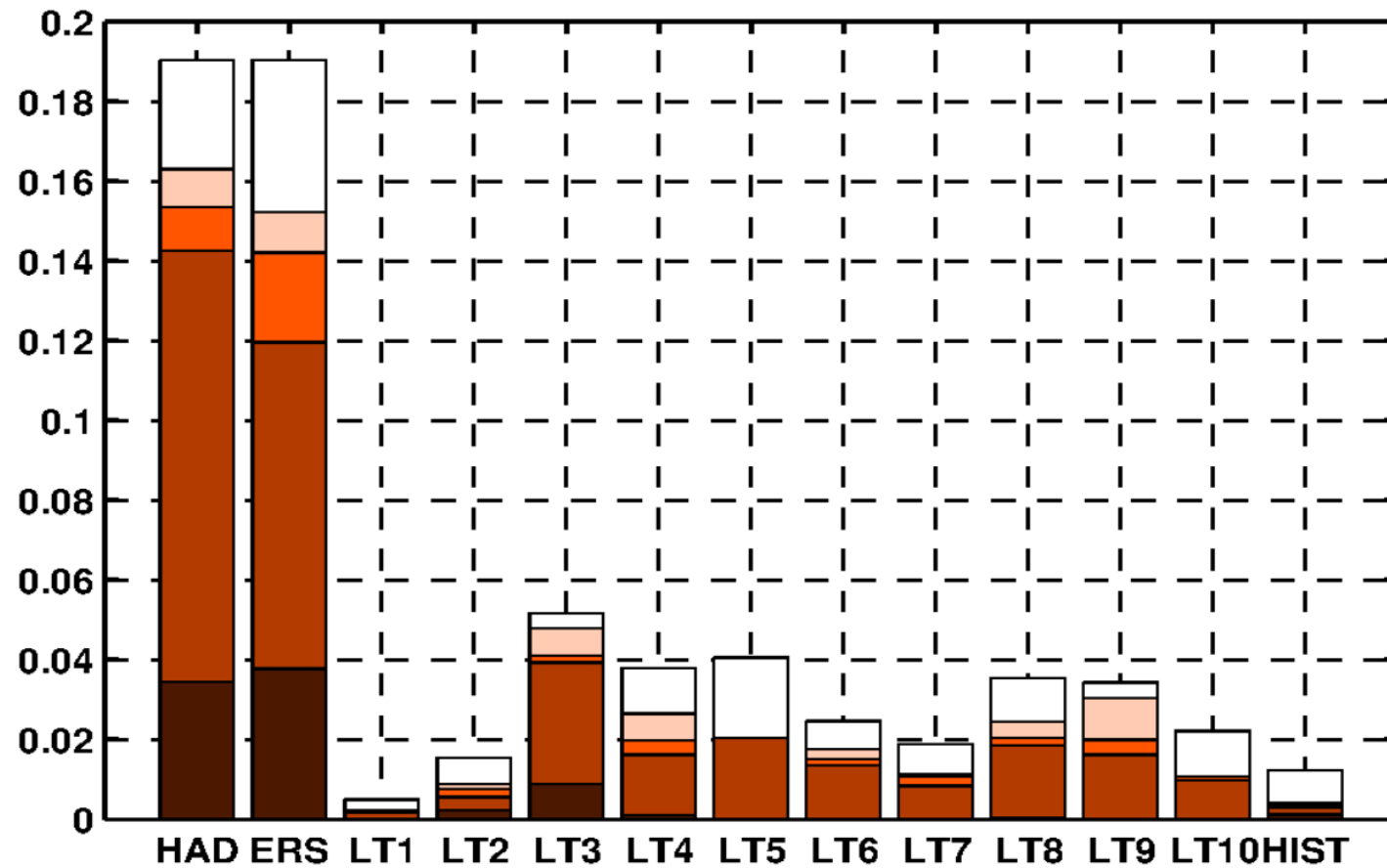
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(Indices defined as in Mohino et al. 2011)

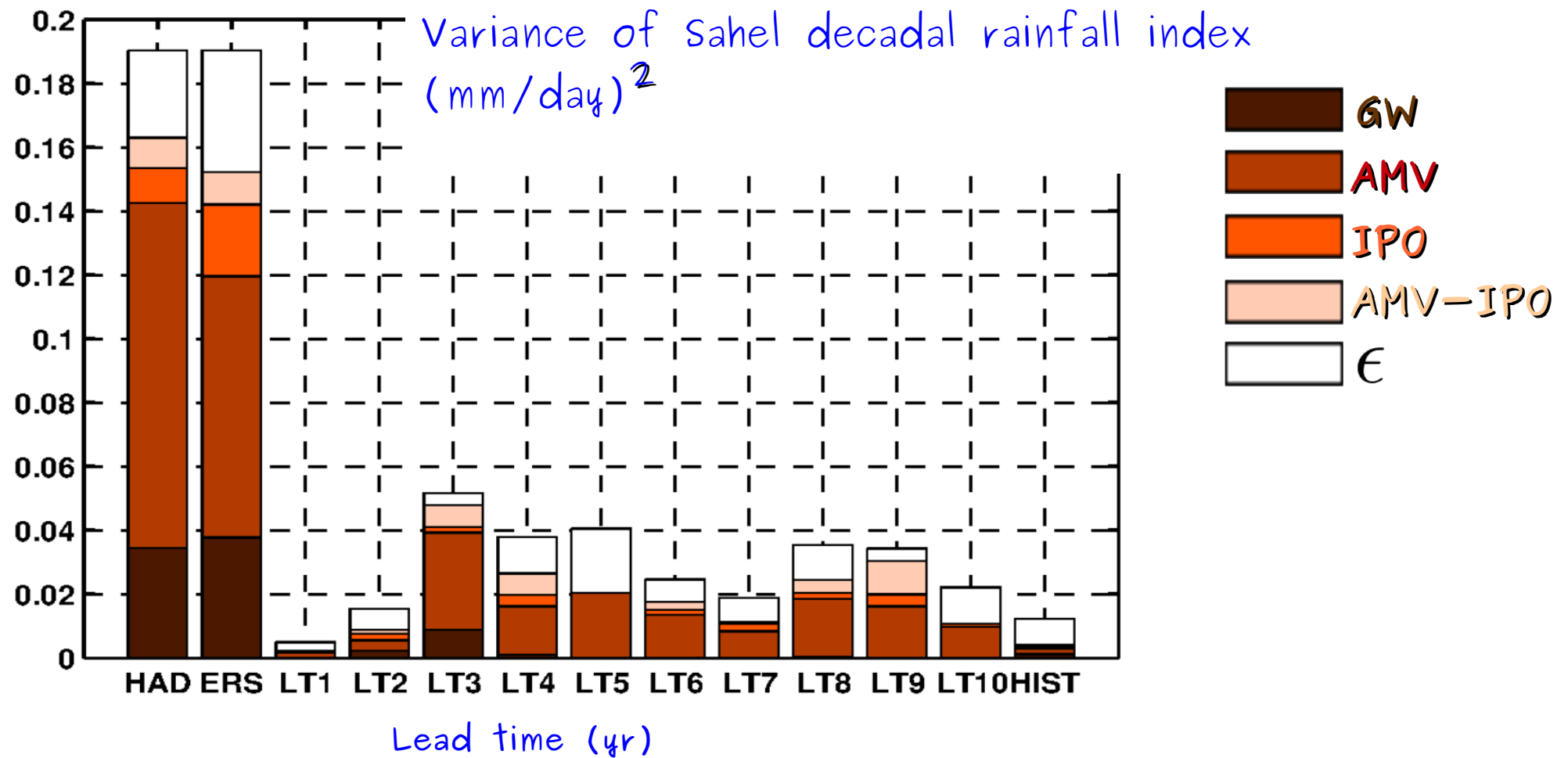
RESULTS

Partition of total variance of Sahel decadal rainfall



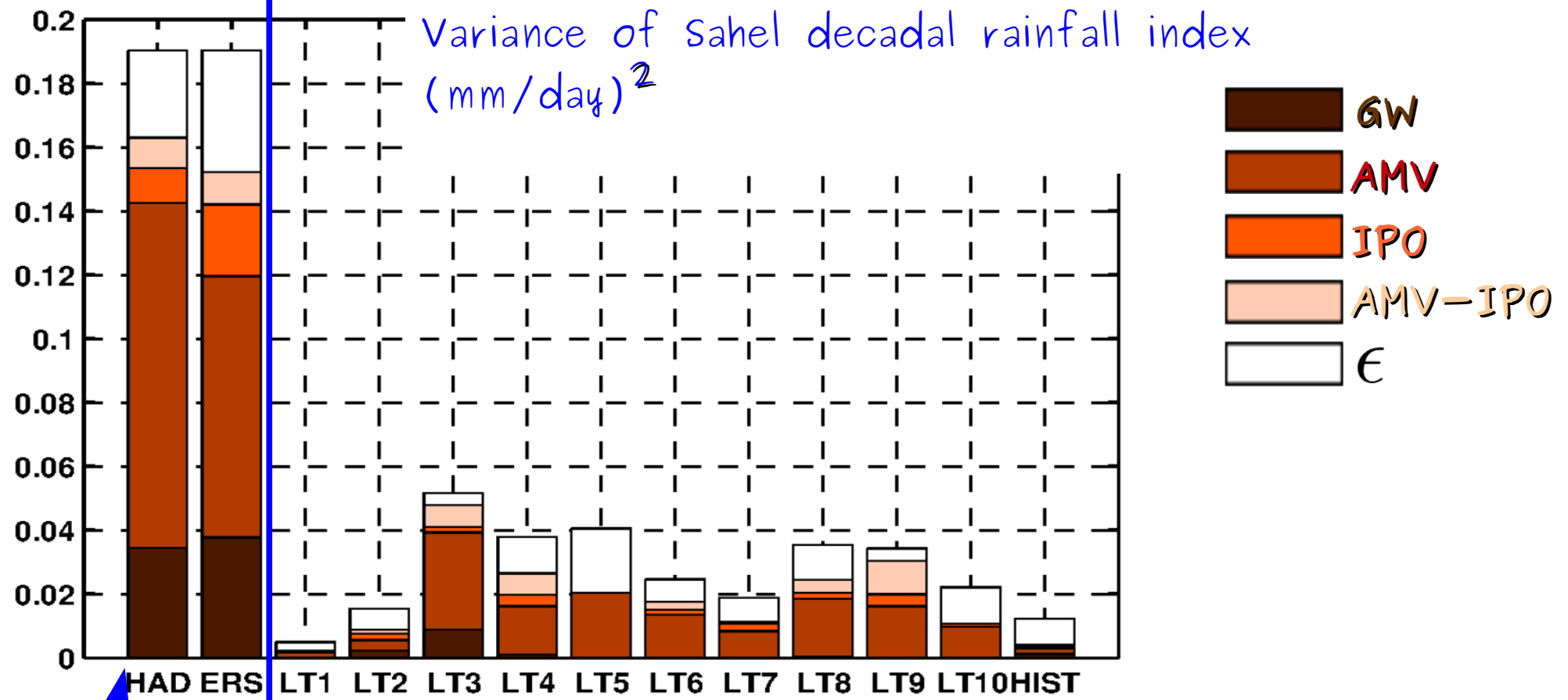
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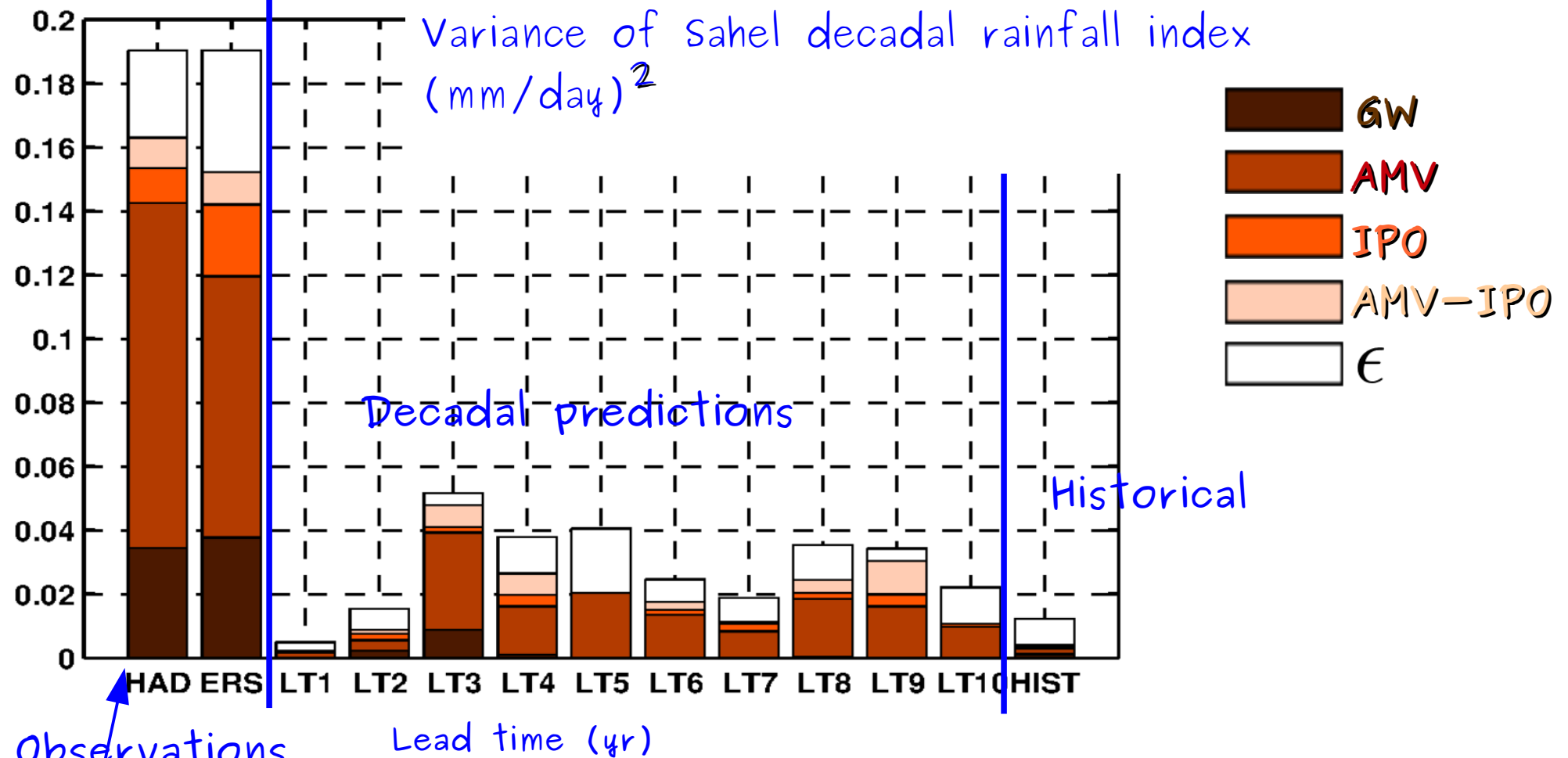
Observations

Lead time (yr)

- CRUTS3.1
- HadISST1
- ERSSTv3b

RESULTS

Partition of total variance of Sahel decadal rainfall

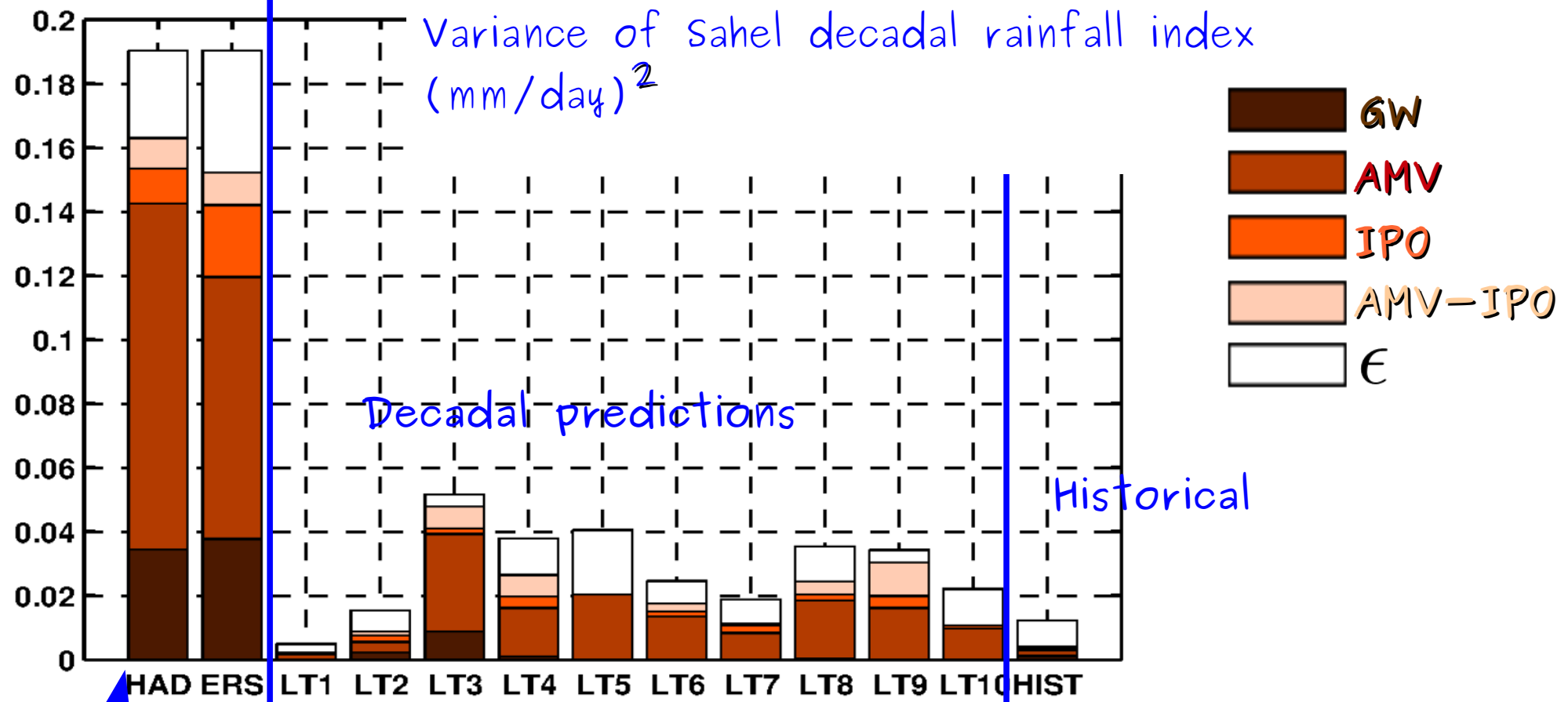


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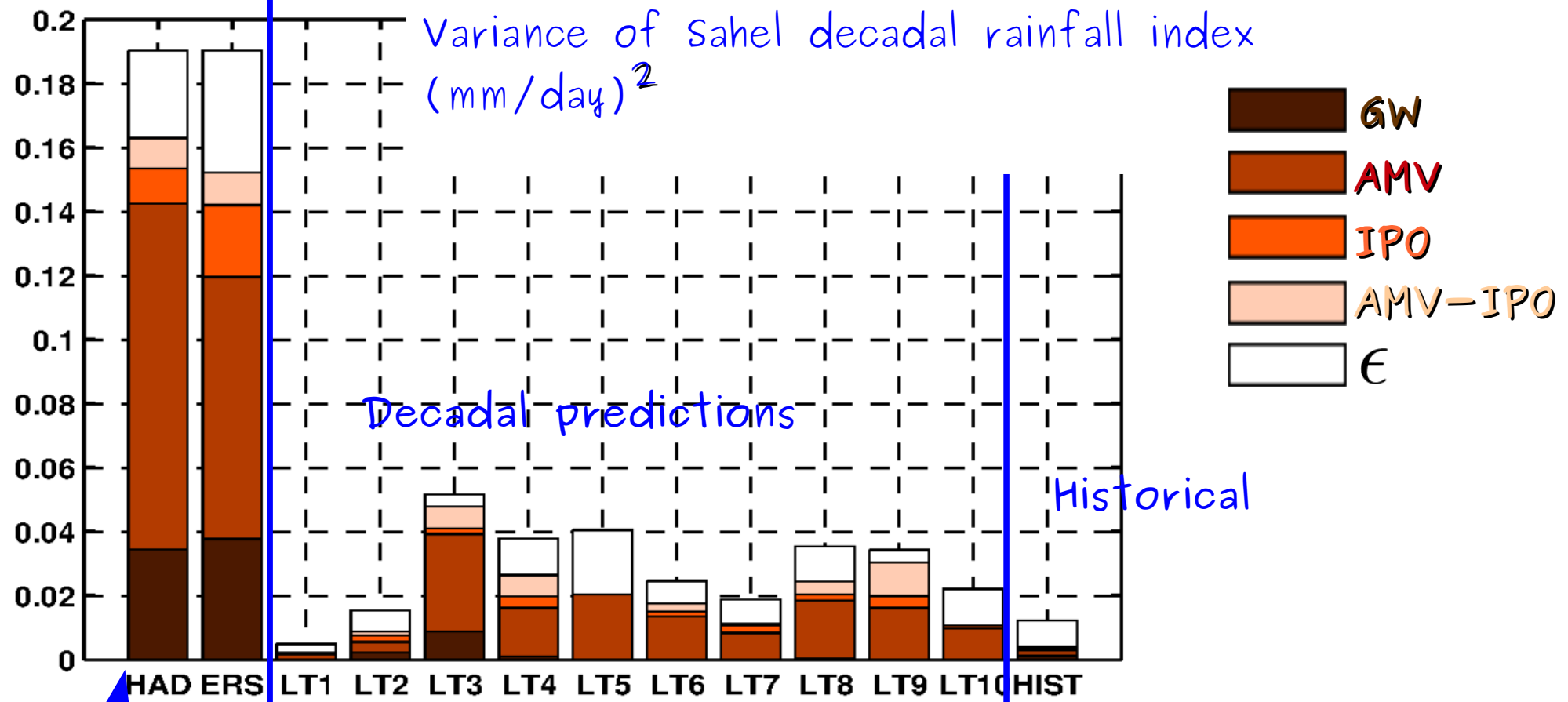
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Lead time (yr) - AMV explains most variance in obs & in dec. prediction

RESULTS

Partition of total variance of Sahel decadal rainfall



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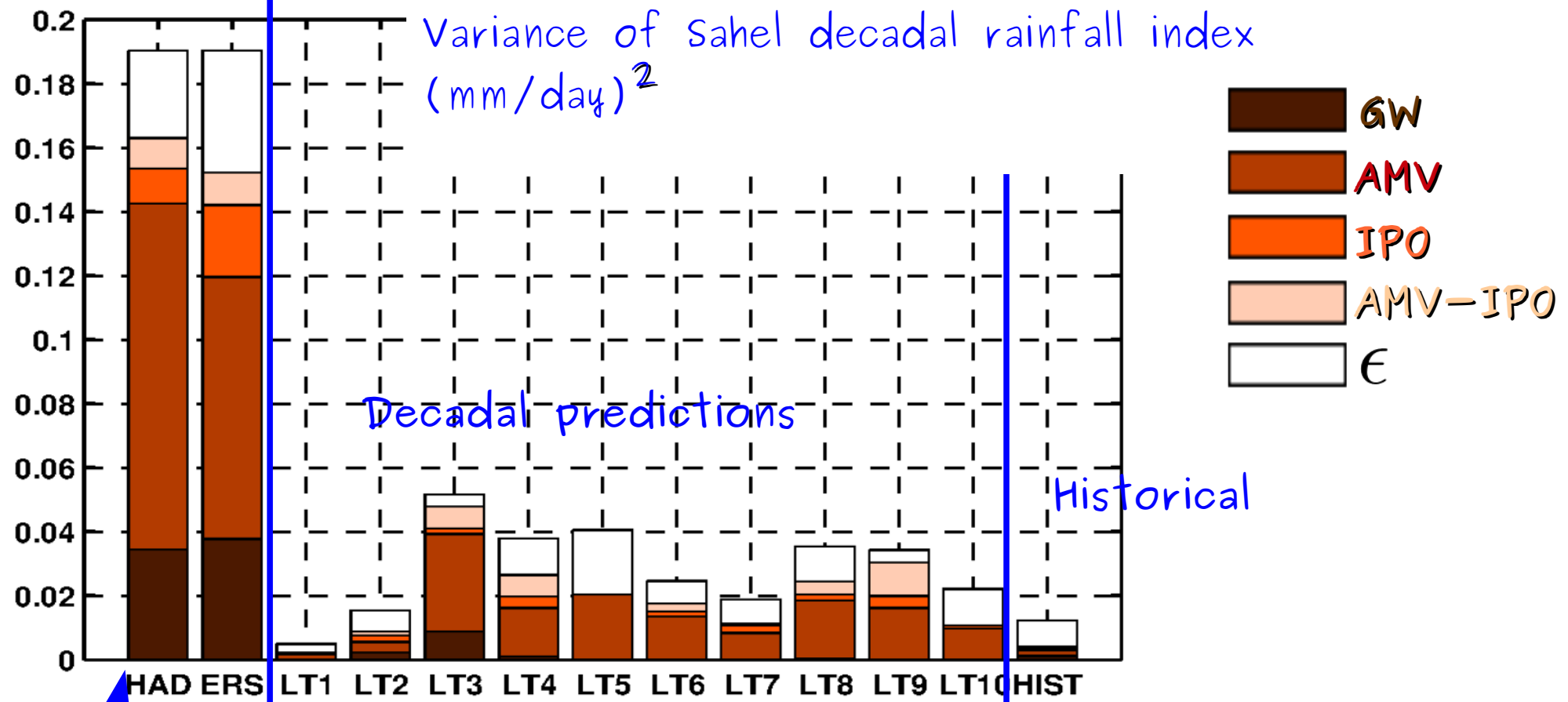
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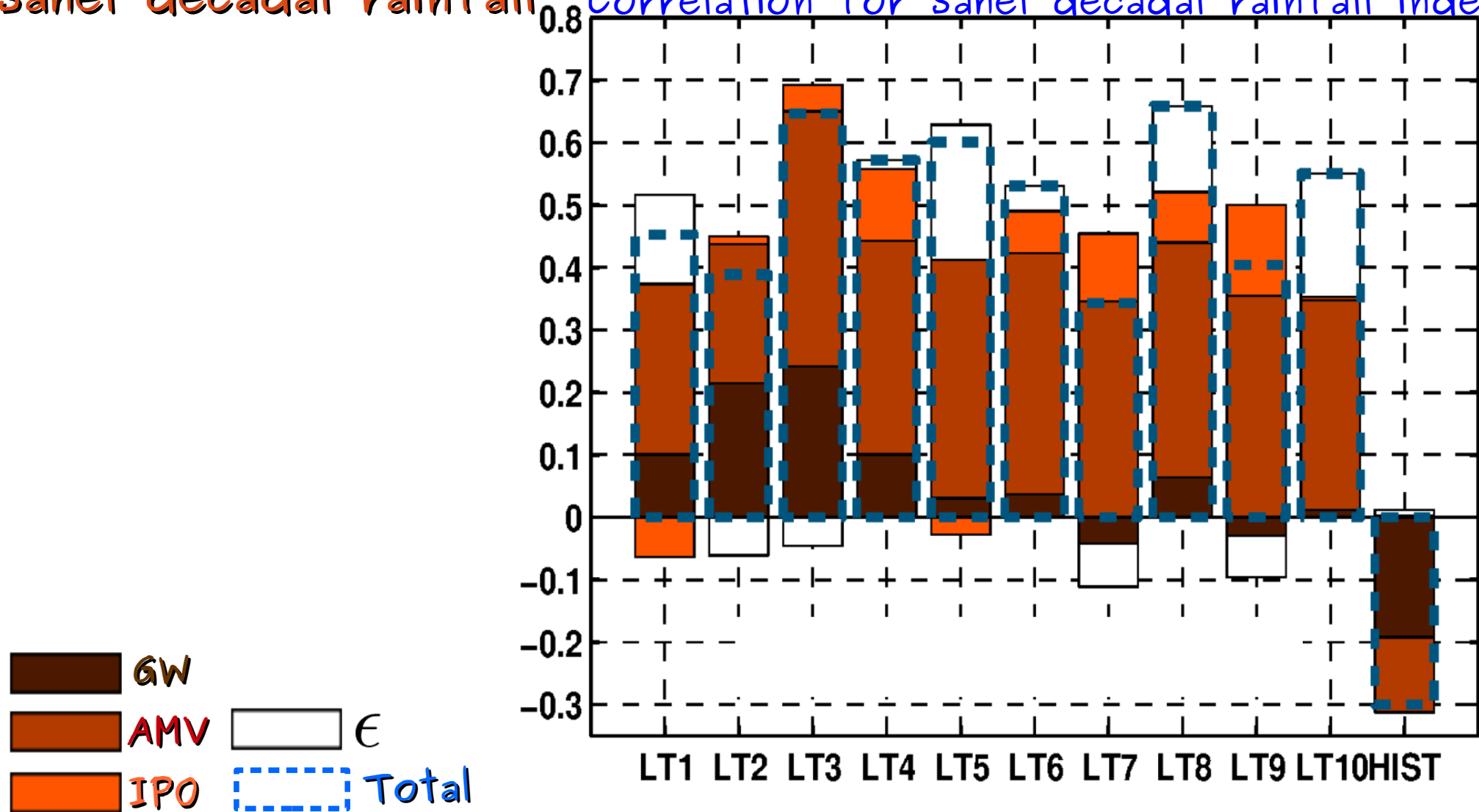
Lead time (yr)

- AMV explains most variance in obs & in dec. prediction
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- causes large RMSE

RESULTS

Partition of correlation of predicted and observed Sahel decadal rainfall

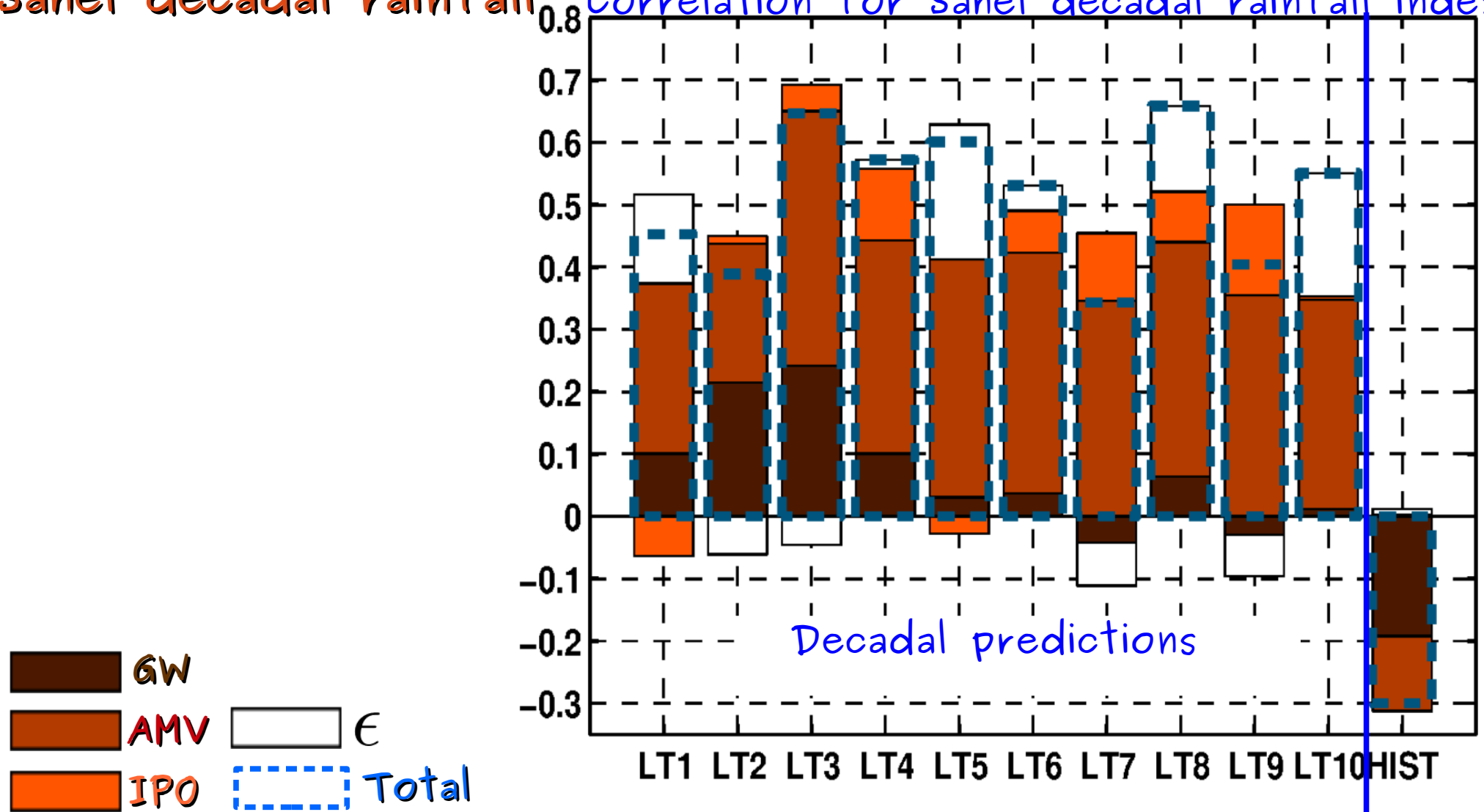
Correlation for Sahel decadal rainfall index



RESULTS

Partition of correlation of predicted and observed Sahel decadal rainfall

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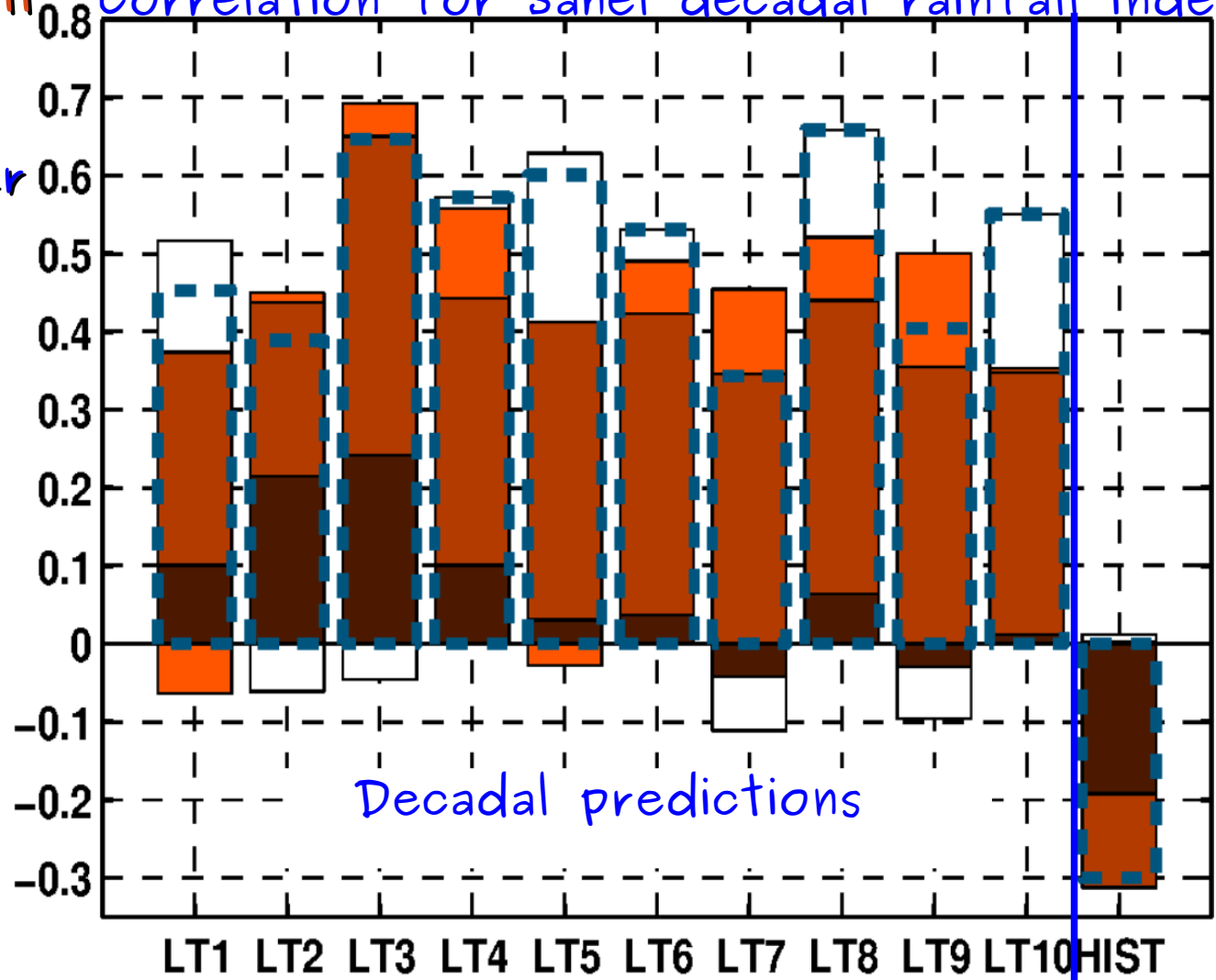
Historical

RESULTS

Partition of correlation of predicted and observed Sahel decadal rainfall

-GW weak and even negative contrib. LT > 5yr

Correlation for Sahel decadal rainfall index

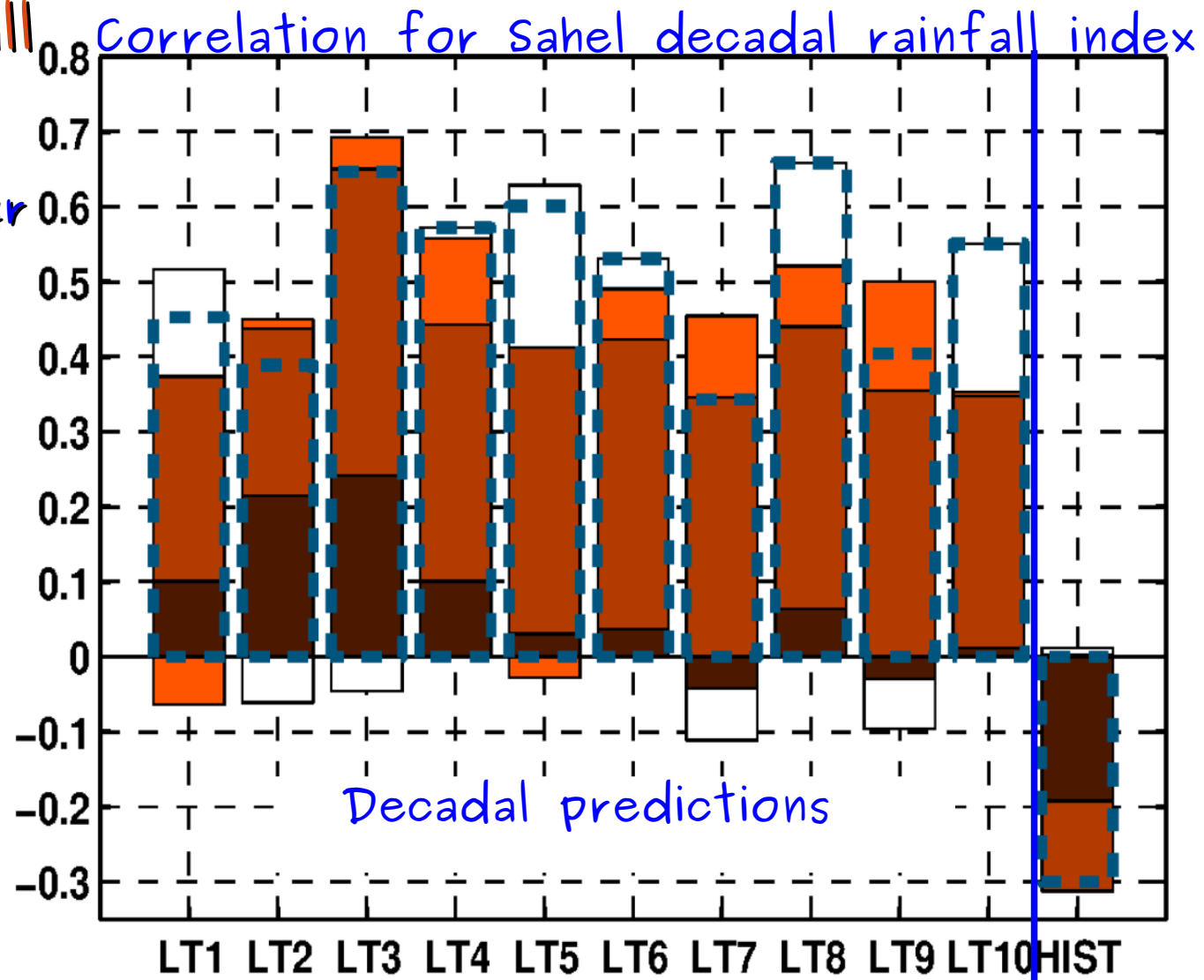


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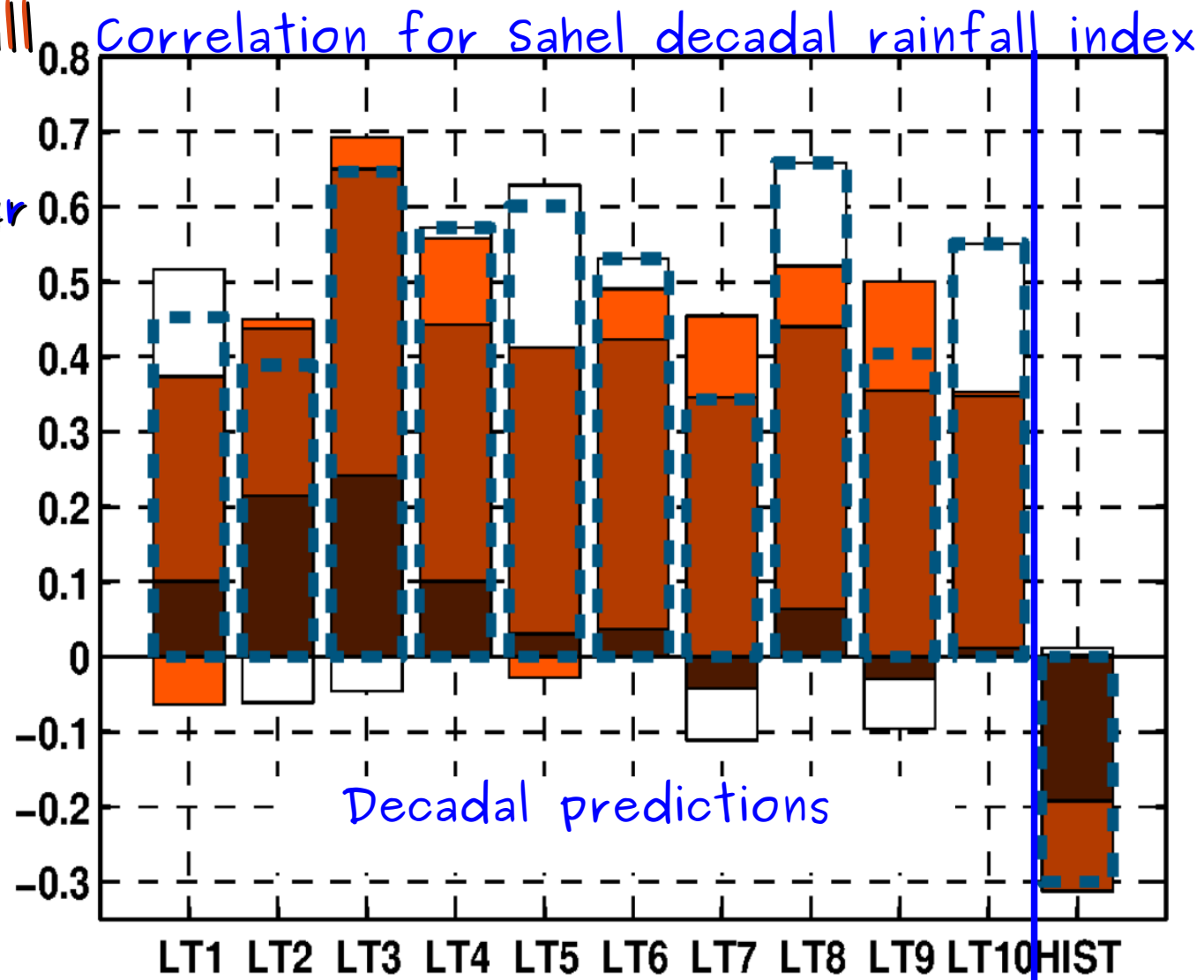
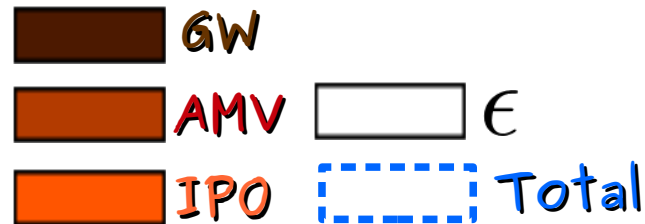


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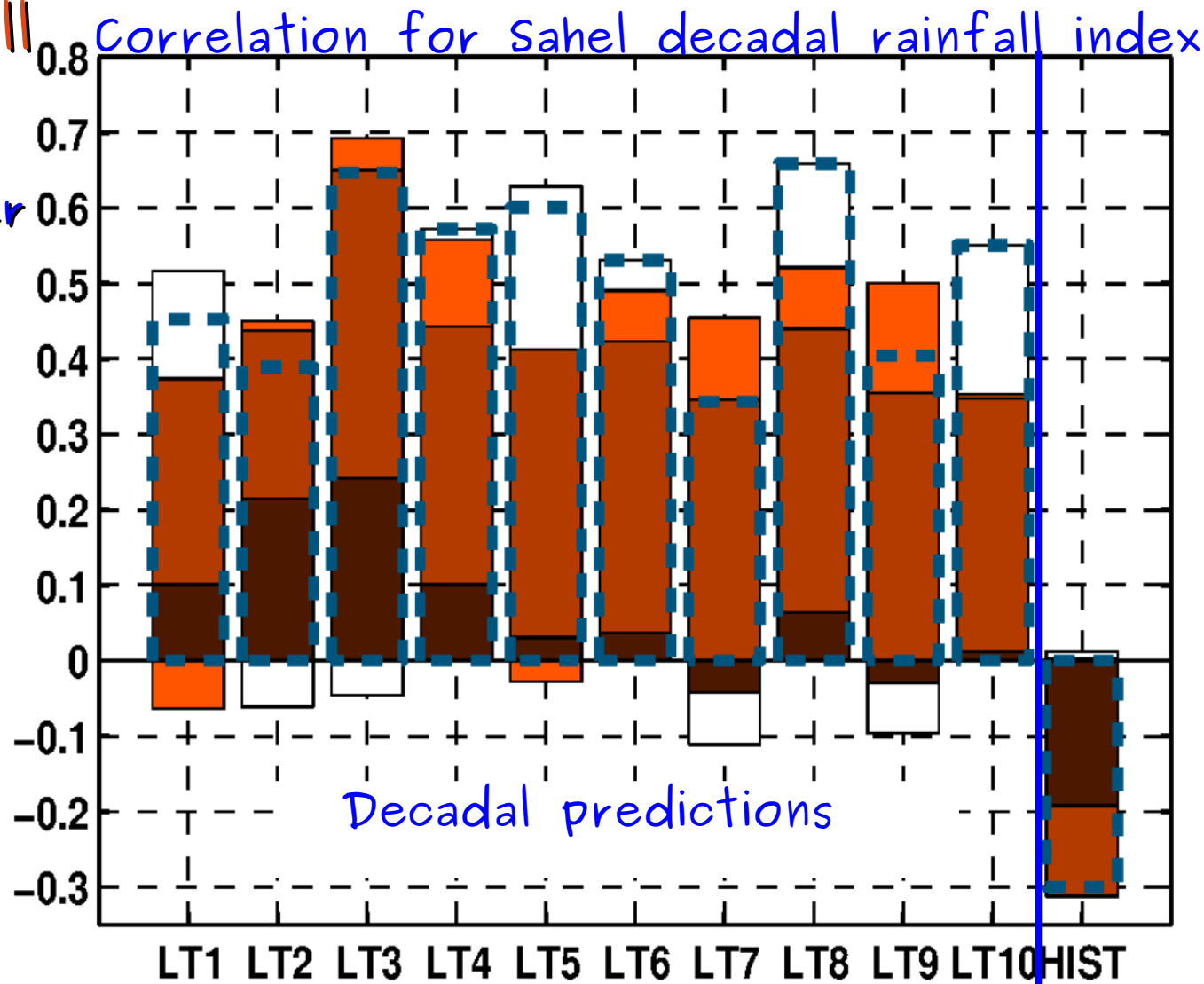


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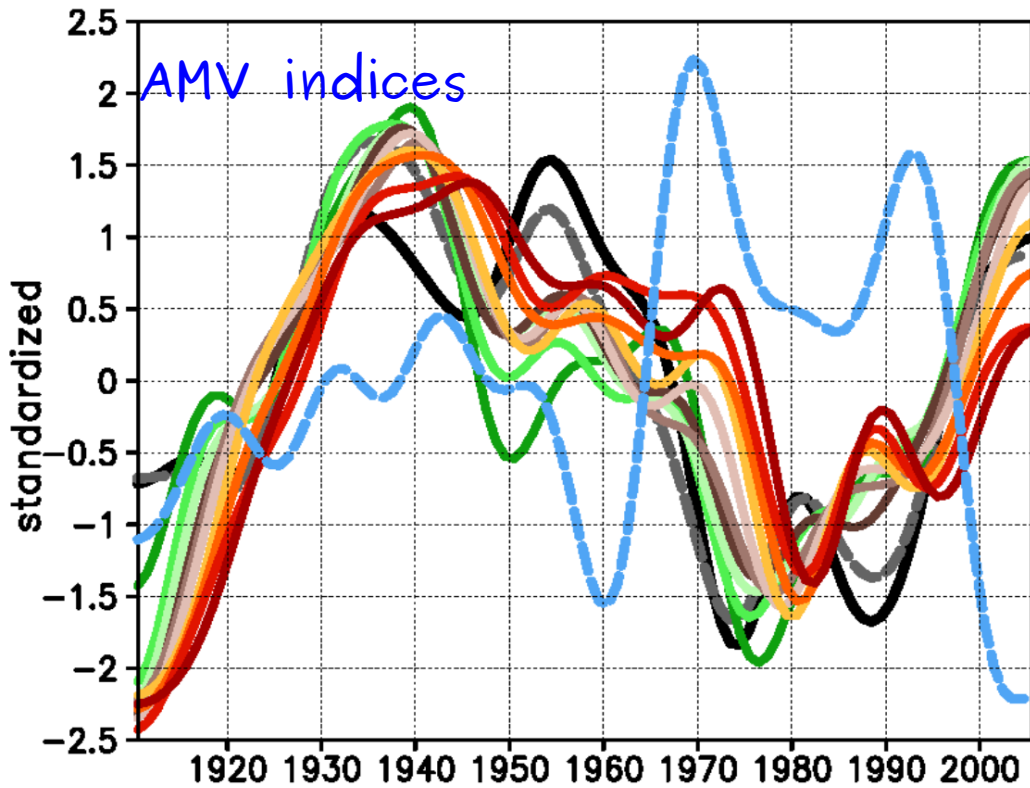
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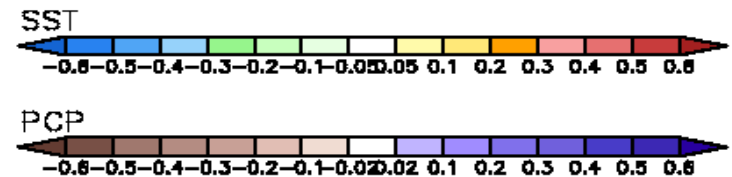
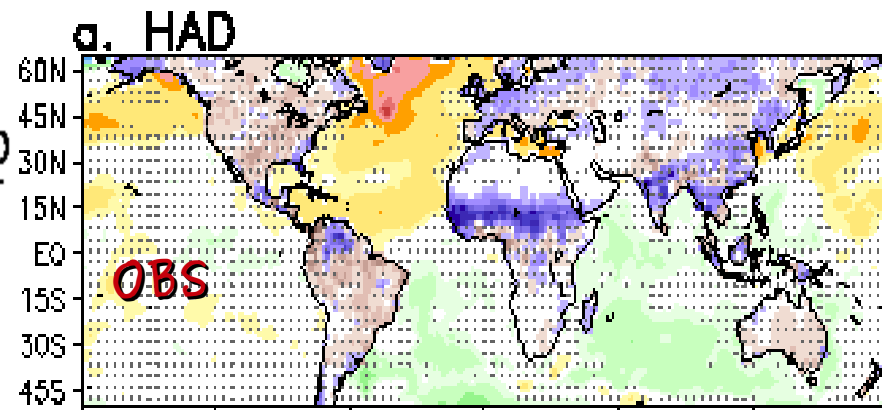
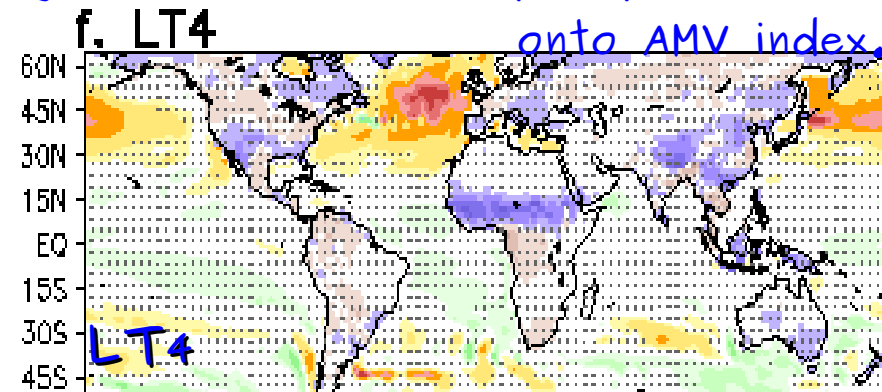
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Contribution of AMV



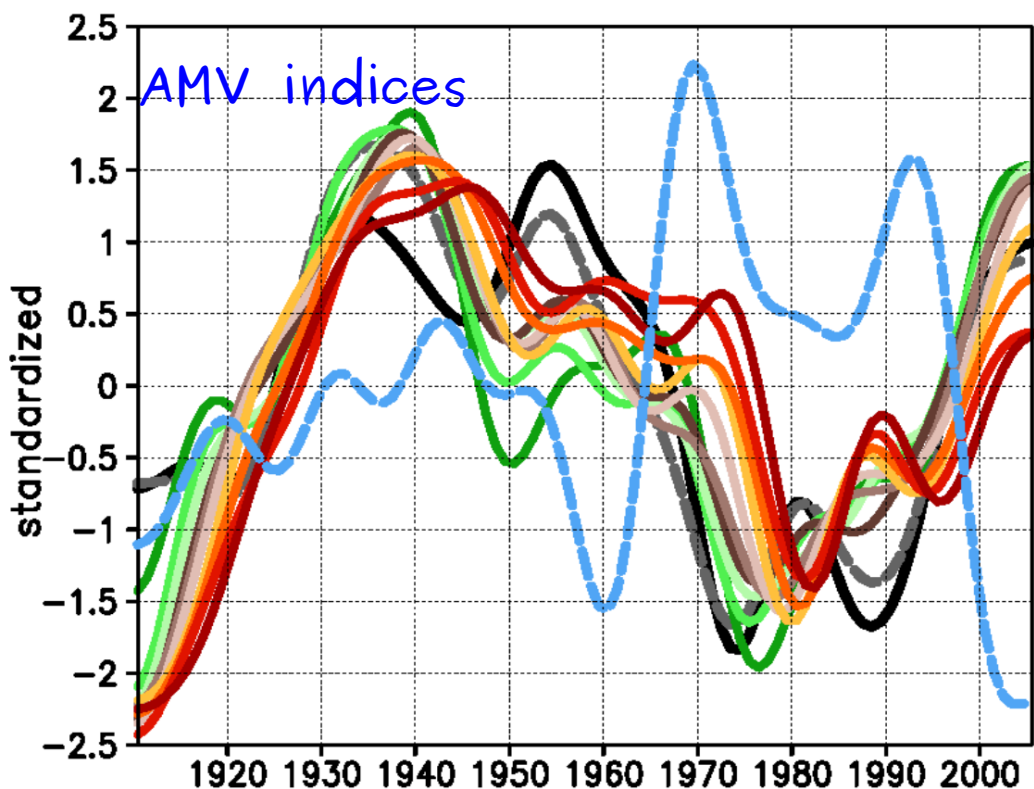
- HAD
- ERS
- LT1
- LT2
- LT3
- LT4
- LT5
- LT6
- LT7
- LT8
- LT9
- LT10
- HIST

Regression of SST and precip. anomalies onto AMV index.

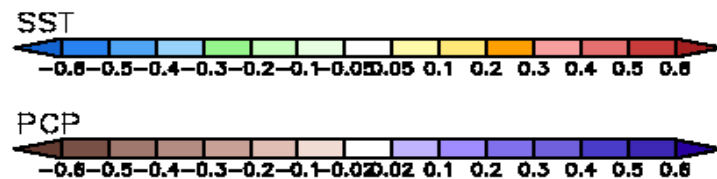
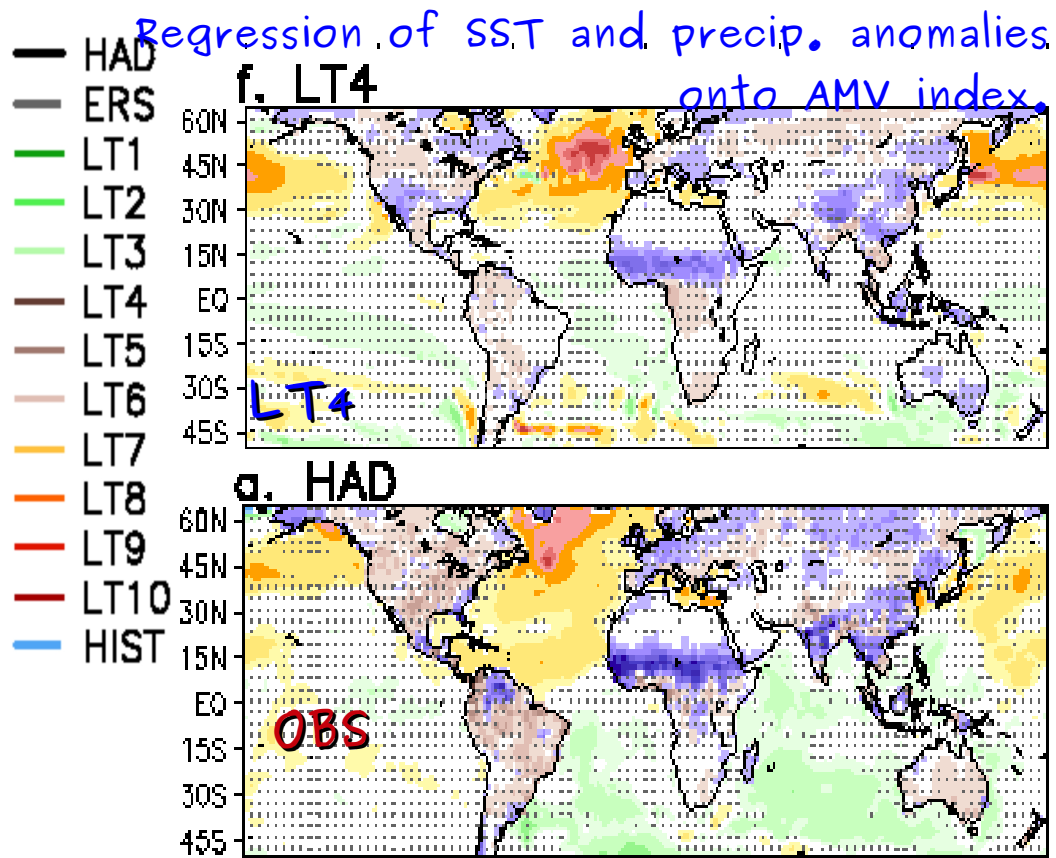


RESULTS

Contribution of AMV

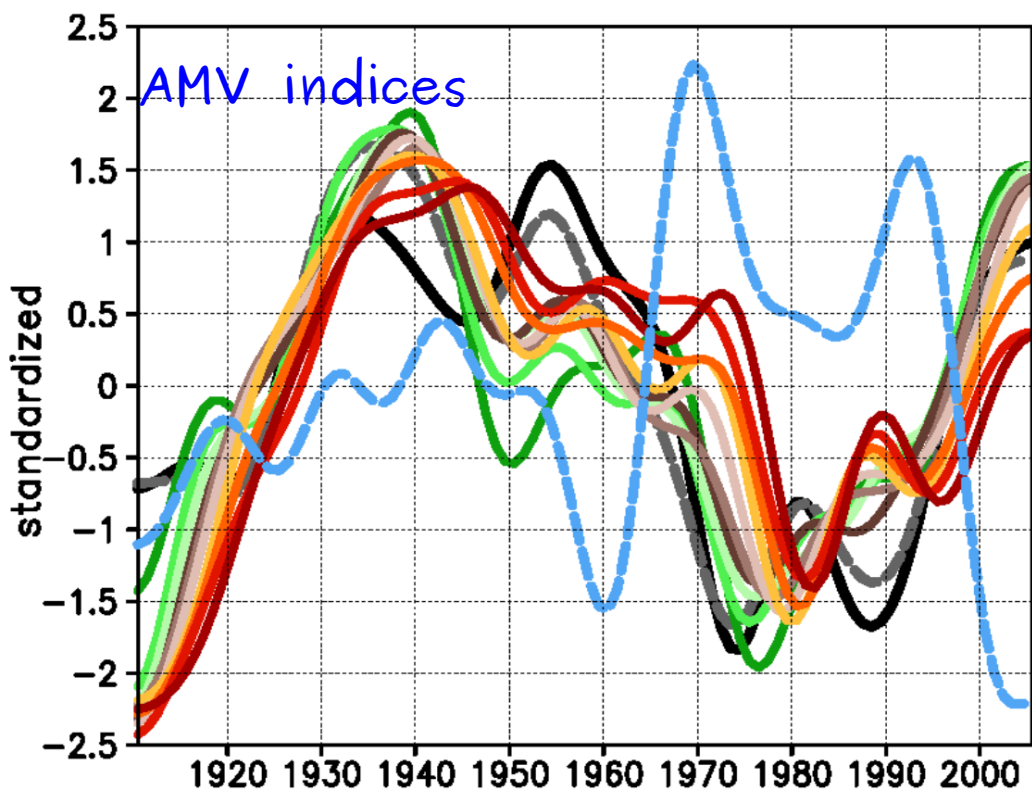


Good timing & rainfall response,
though weak



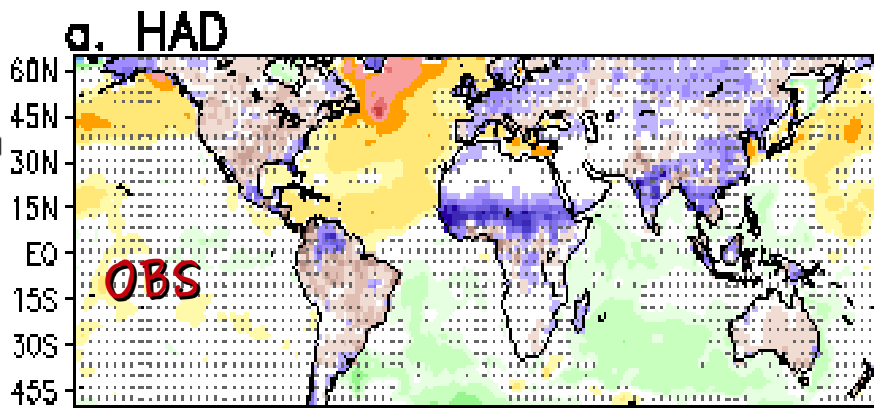
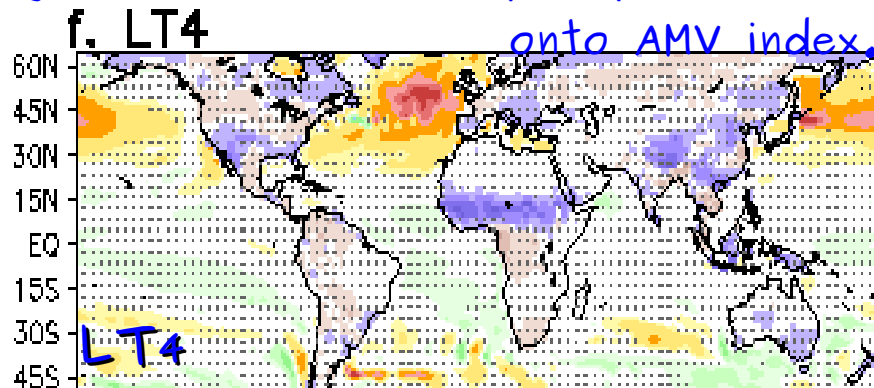
RESULTS

Contribution of AMV



- HAD
- ERS
- LT1
- LT2
- LT3
- LT4
- LT5
- LT6
- LT7
- LT8
- LT9
- LT10
- - - HIST

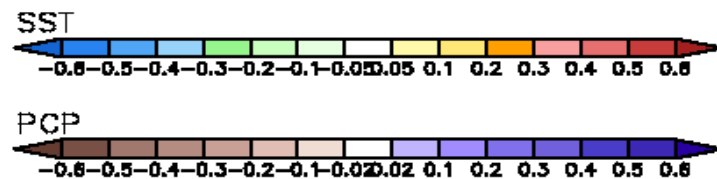
Regression of SST and precip. anomalies onto AMV index.



Good timing & rainfall response, though weak

Good ACC scores

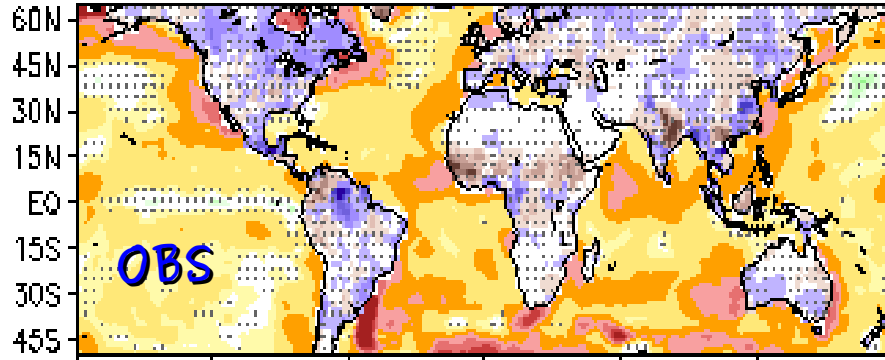
Low variance of Sahel index



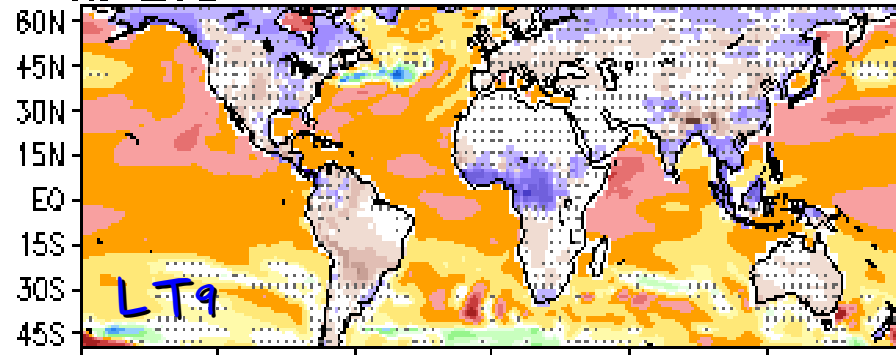
RESULTS

Contribution of GW

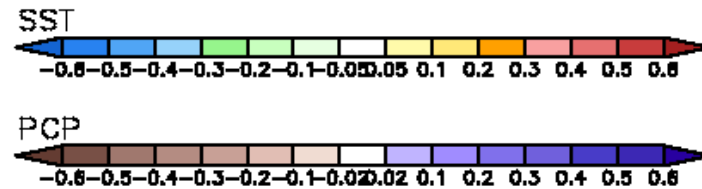
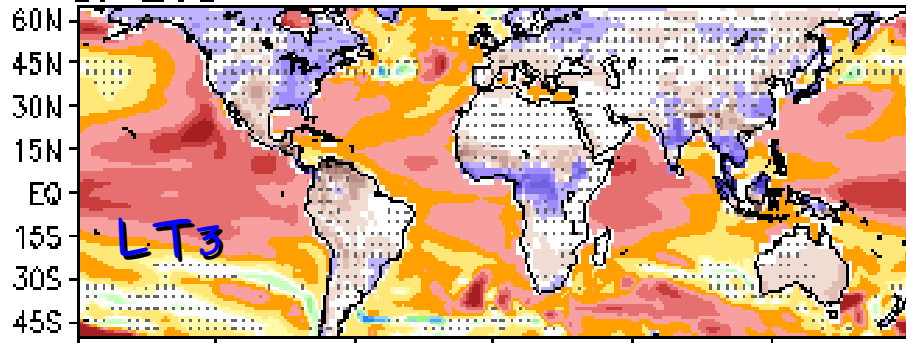
a. HAD



k. LT9



e. LT3

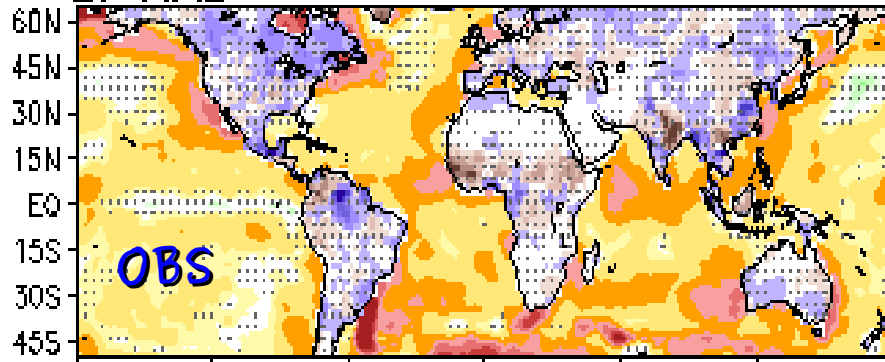


Regression of SST and precip. anomalies onto GW index.

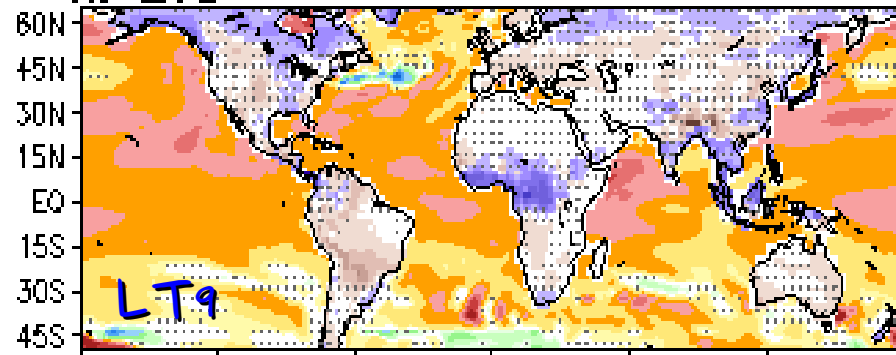
RESULTS

Contribution of GW

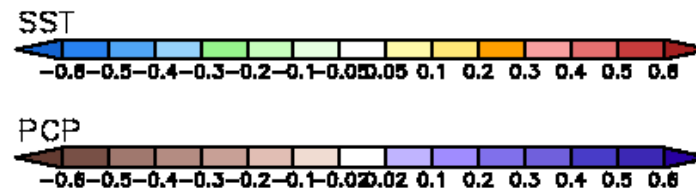
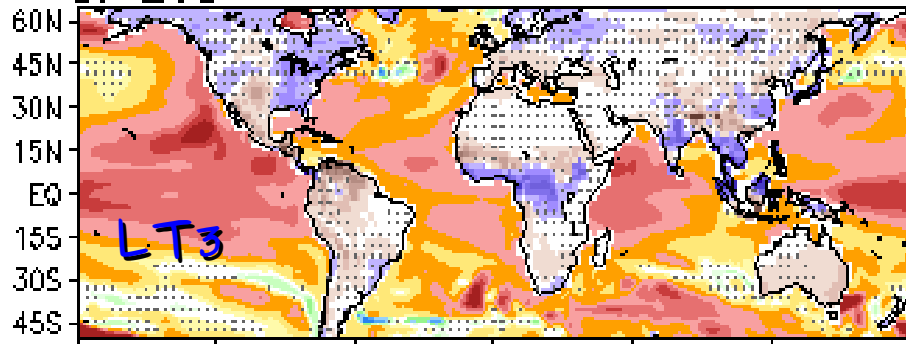
a. HAD



k. LT9



e. LT3



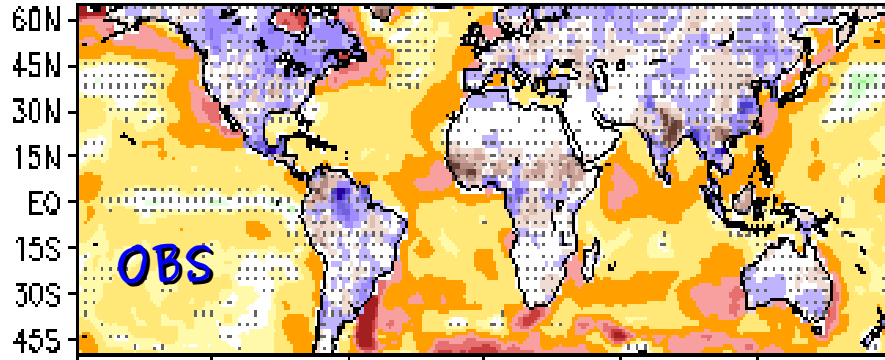
Regression of SST and precip. anomalies onto GW index.

-Good timing (trend), but reversed response in historical and some LT

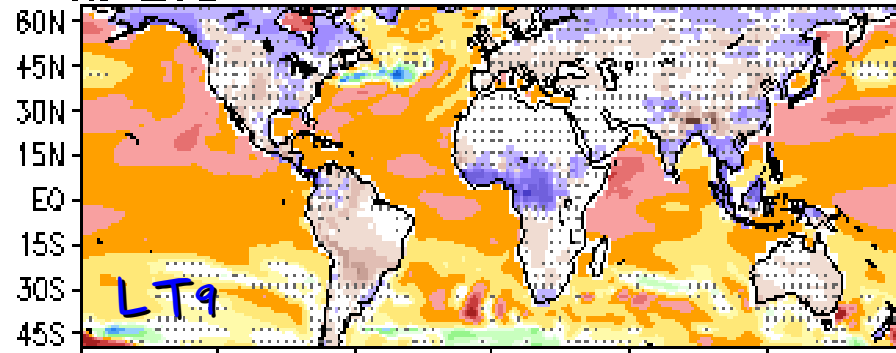
RESULTS

Contribution of GW

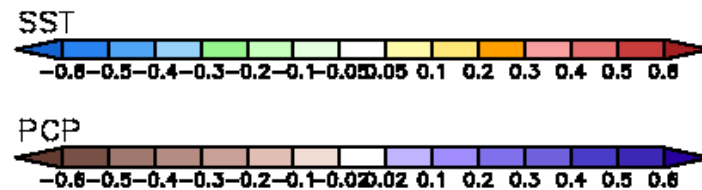
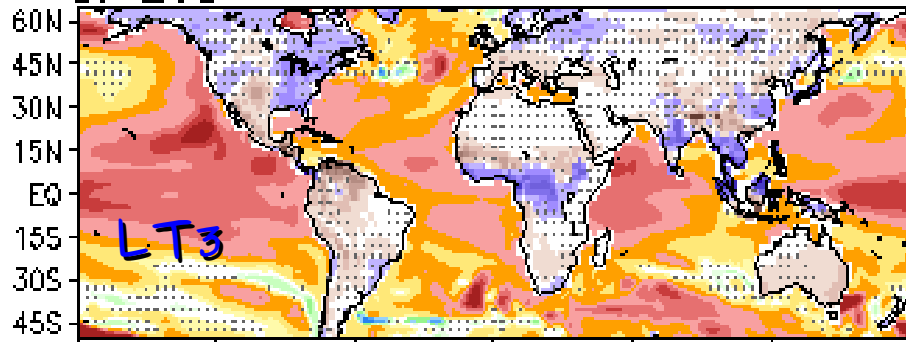
a. HAD



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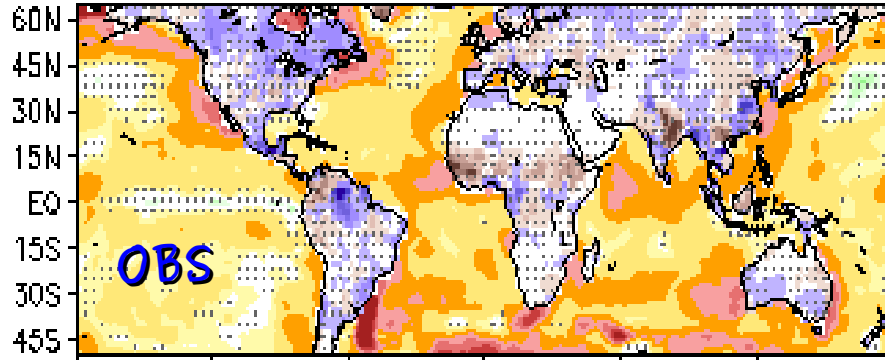
Negative ACC scores



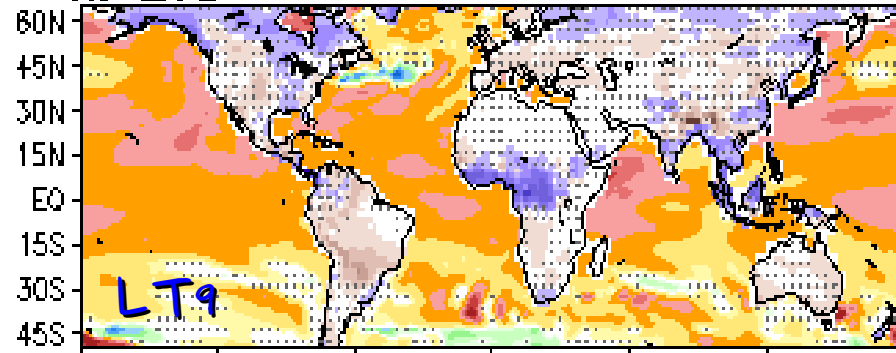
RESULTS

Contribution of GW

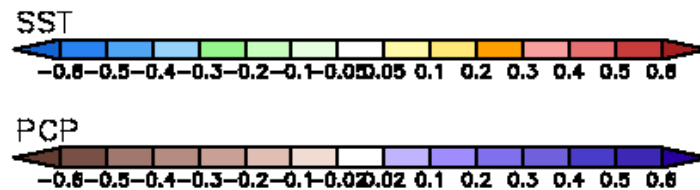
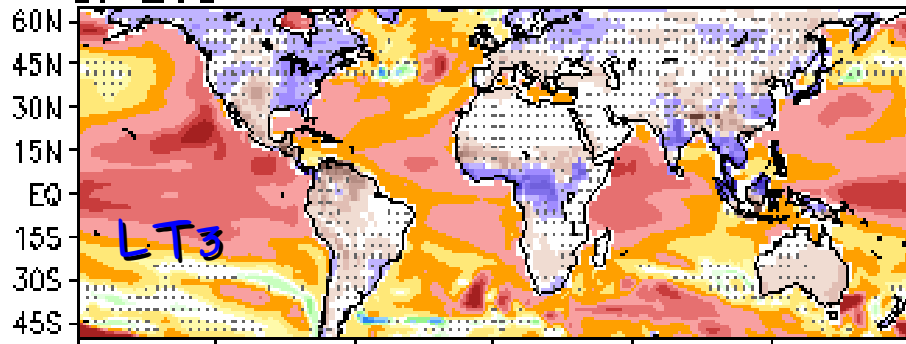
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k. LT9



e. LT3



Regression of SST and precip. anomalies onto GW index.

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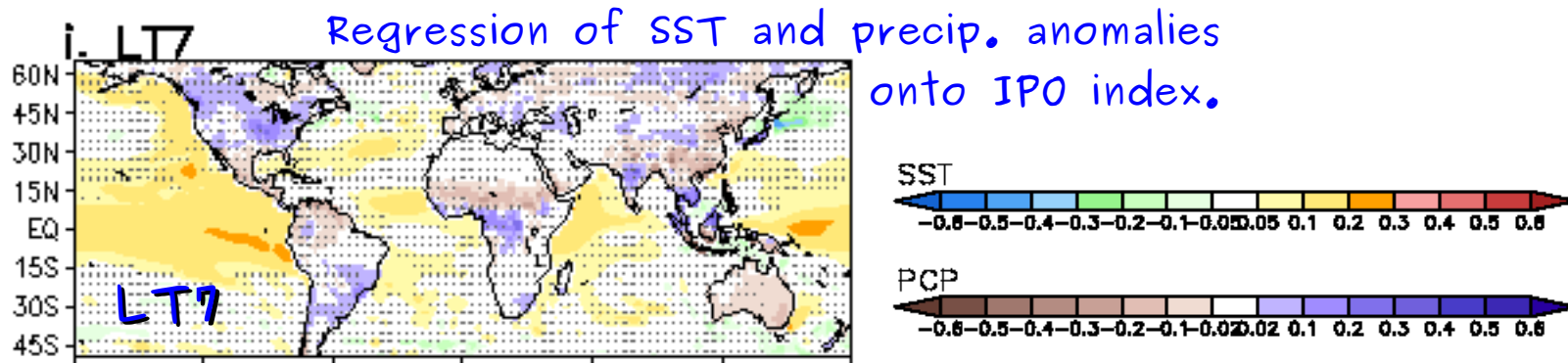
Negative ACC scores

-Spurious strong SST anomaly in tropics at short lead times leading to Sahel drought (good response for wrong reasons)

Good ACC scores only for LT1 to LT4

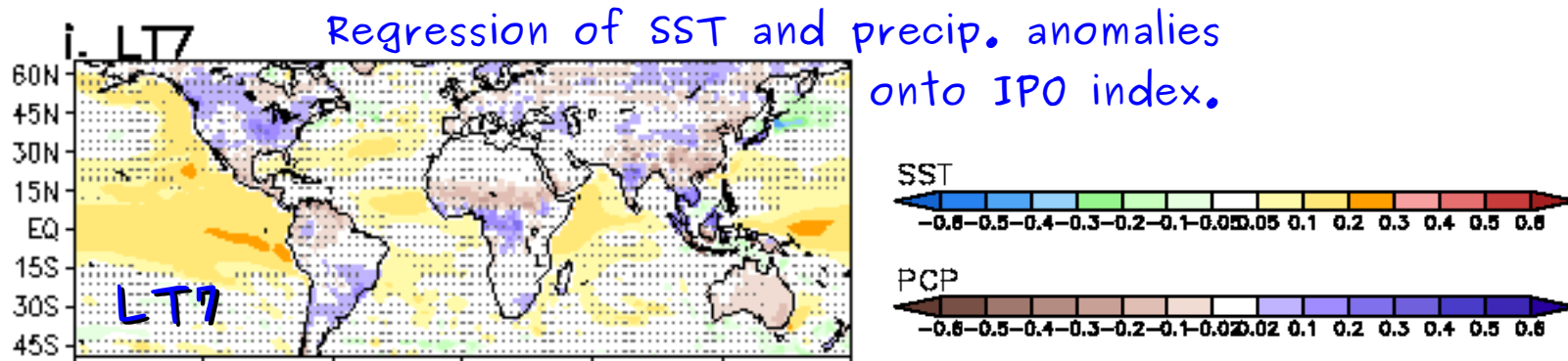
RESULTS

Contribution of IPO



RESULTS

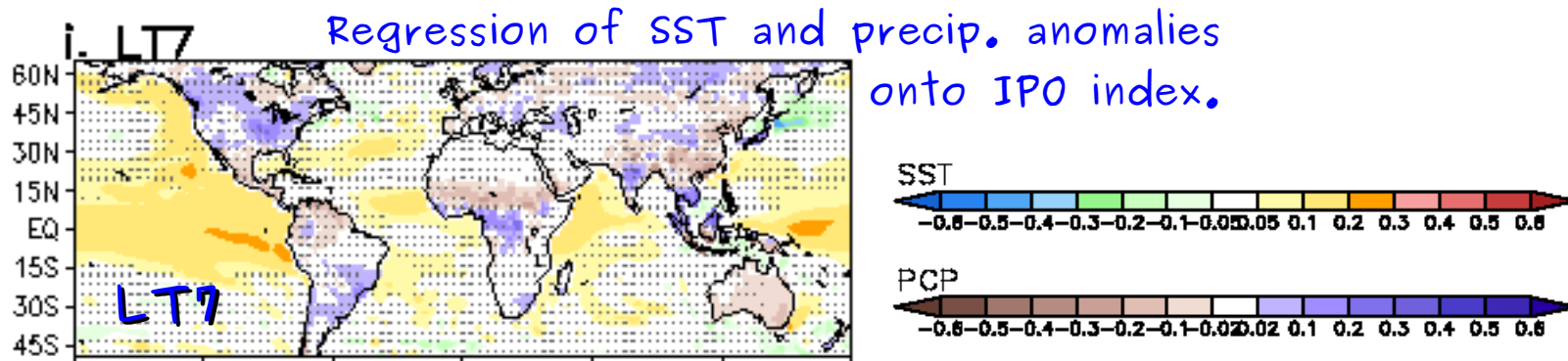
Contribution of IPO



-Typically good sign in the rainfall response to IPO

RESULTS

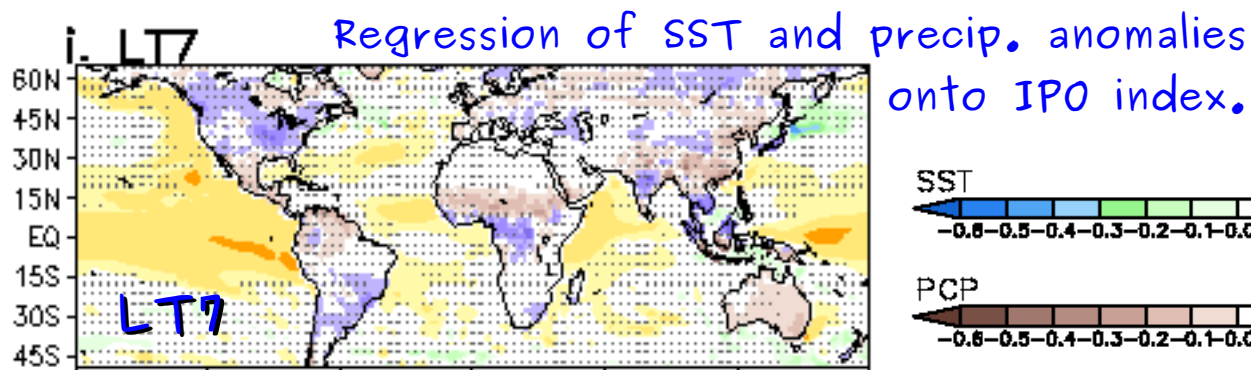
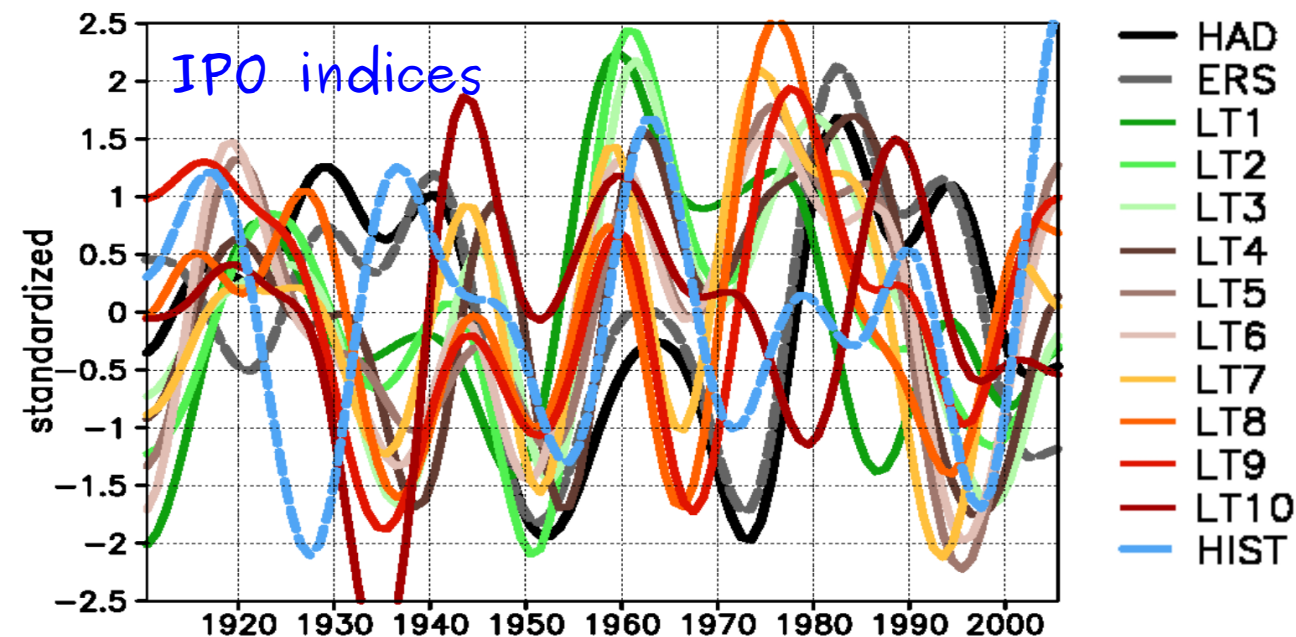
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RESULTS

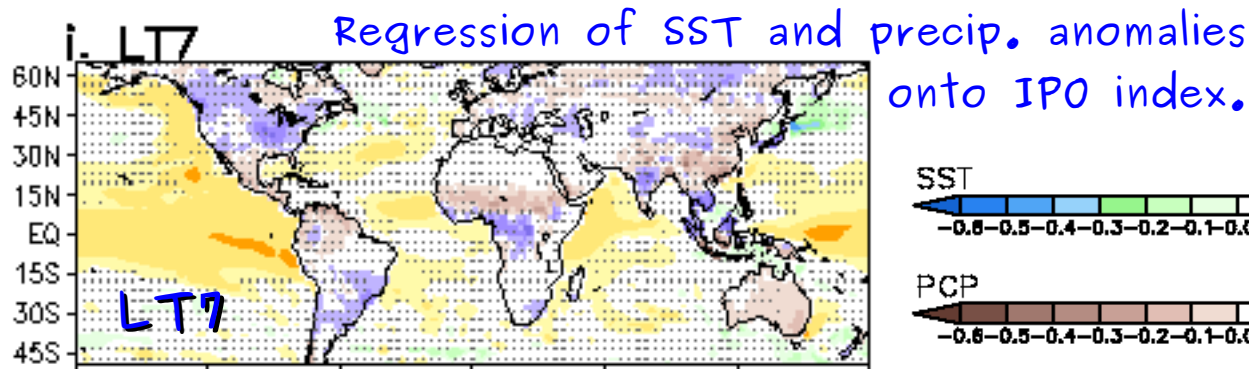
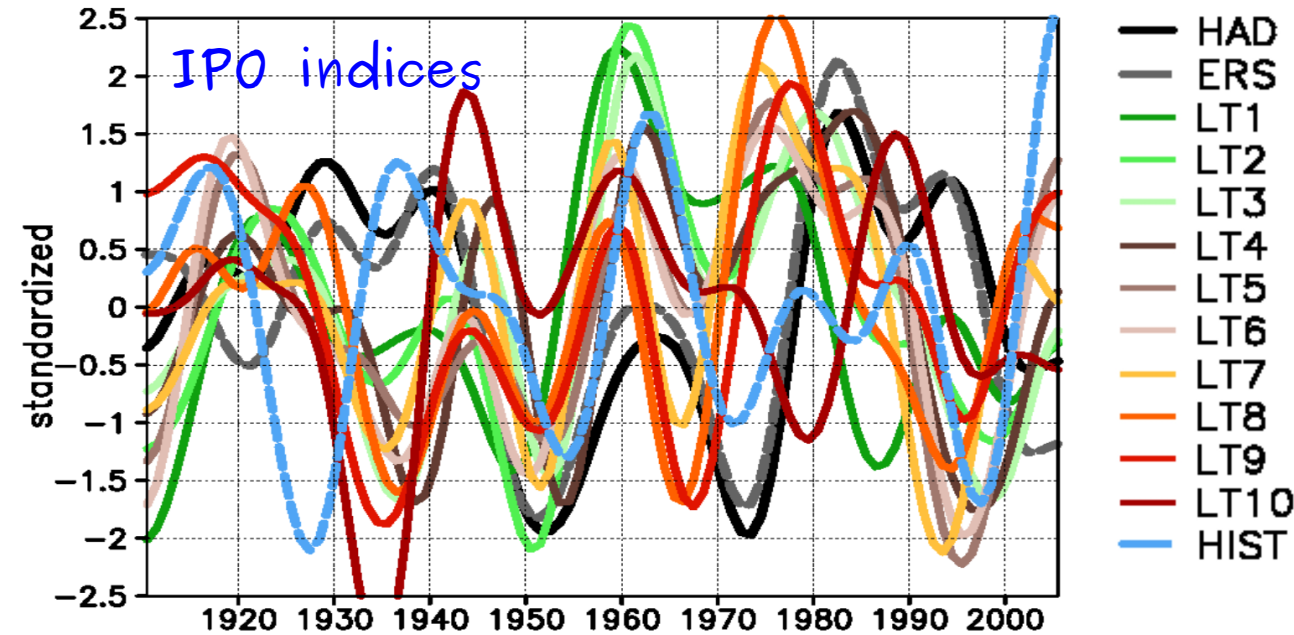
Contribution of IPO



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RESULTS

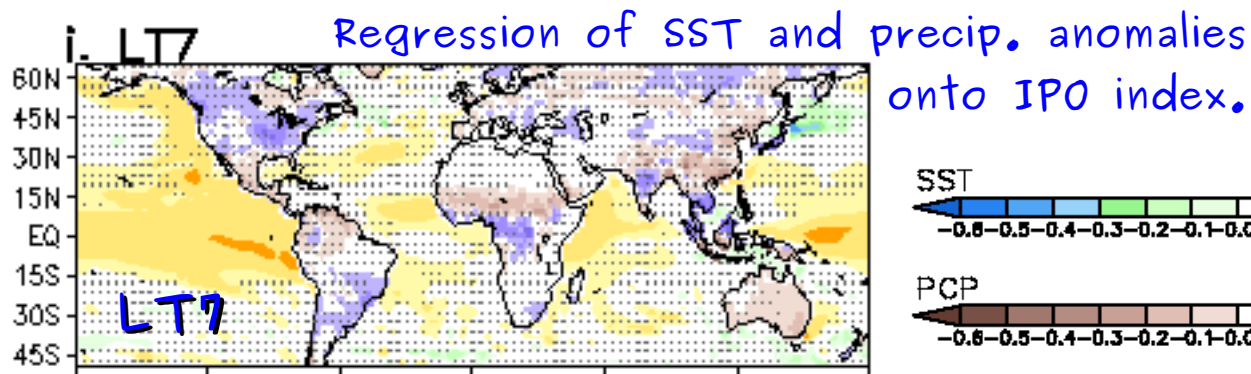
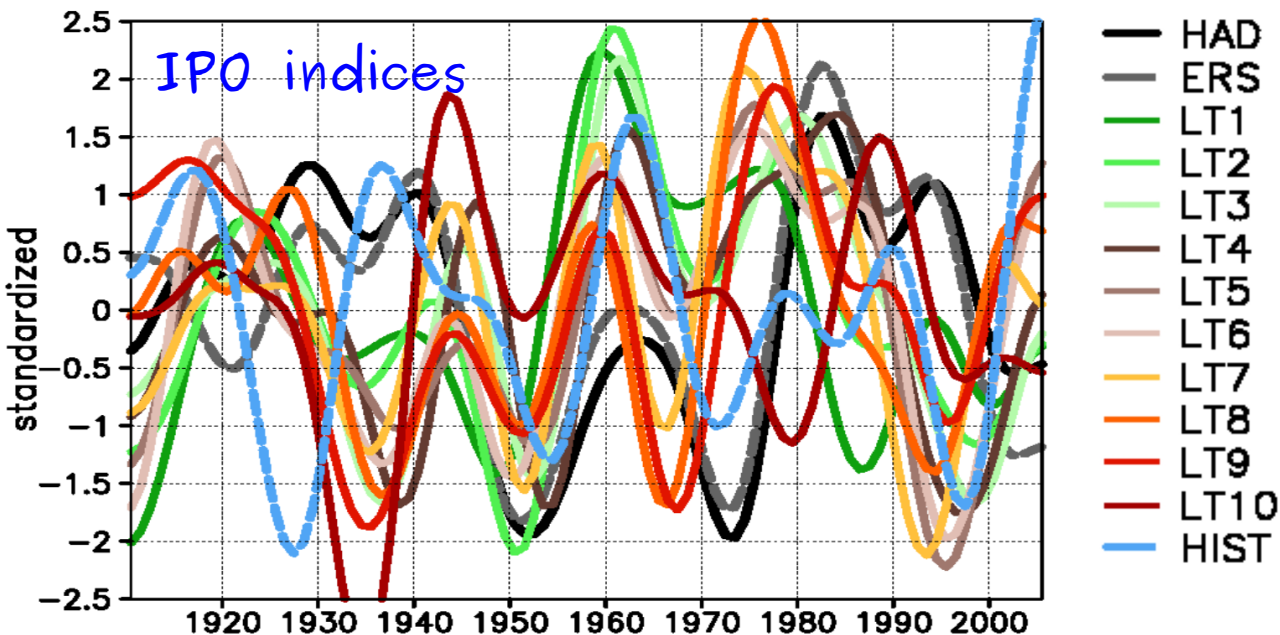
Contribution of IPO



- Typically good sign in the rainfall response to IPO
- No skill in IPO timing

RESULTS

Contribution of IPO




-Typically good sign in the rainfall response to IPO
 -No skill in IPO timing

Small alternating contribution of IPO to ACC skill

CONCLUSIONS



CONCLUSIONS



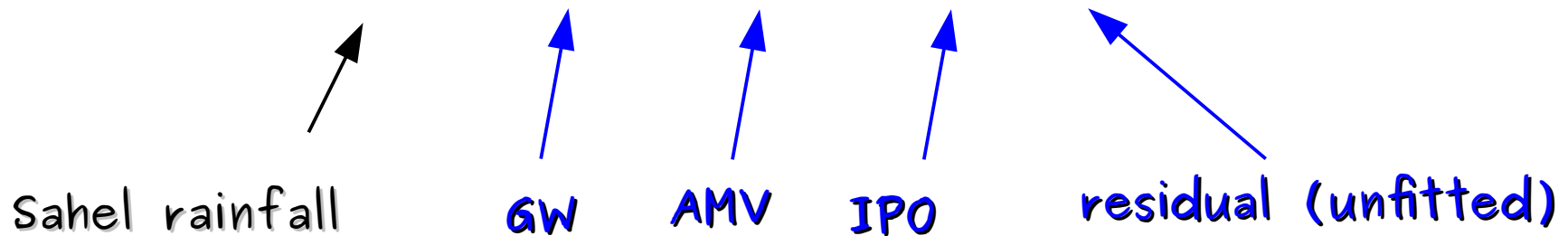
-New framework to analyse sources of skill based on multi-linear regression analysis

$$y = ax_1 + bx_2 + cx_3 + \epsilon$$

CONCLUSIONS


-New framework to analyse sources of skill based on multi-linear regression analysis

$$y = ax_1 + bx_2 + cx_3 + \epsilon$$



-Skill in predicting Sahel rainfall at decadal time scales is understood as a combination of how well the model predicts the timing of GW, AMV and IPO and on how well it simulates the rainfall response to these signals

CONCLUSIONS



-For GW, trend in timing is well captured but the rainfall response is generally not (except for the spurious tropical signal at the beginning of simulation).

CONCLUSIONS

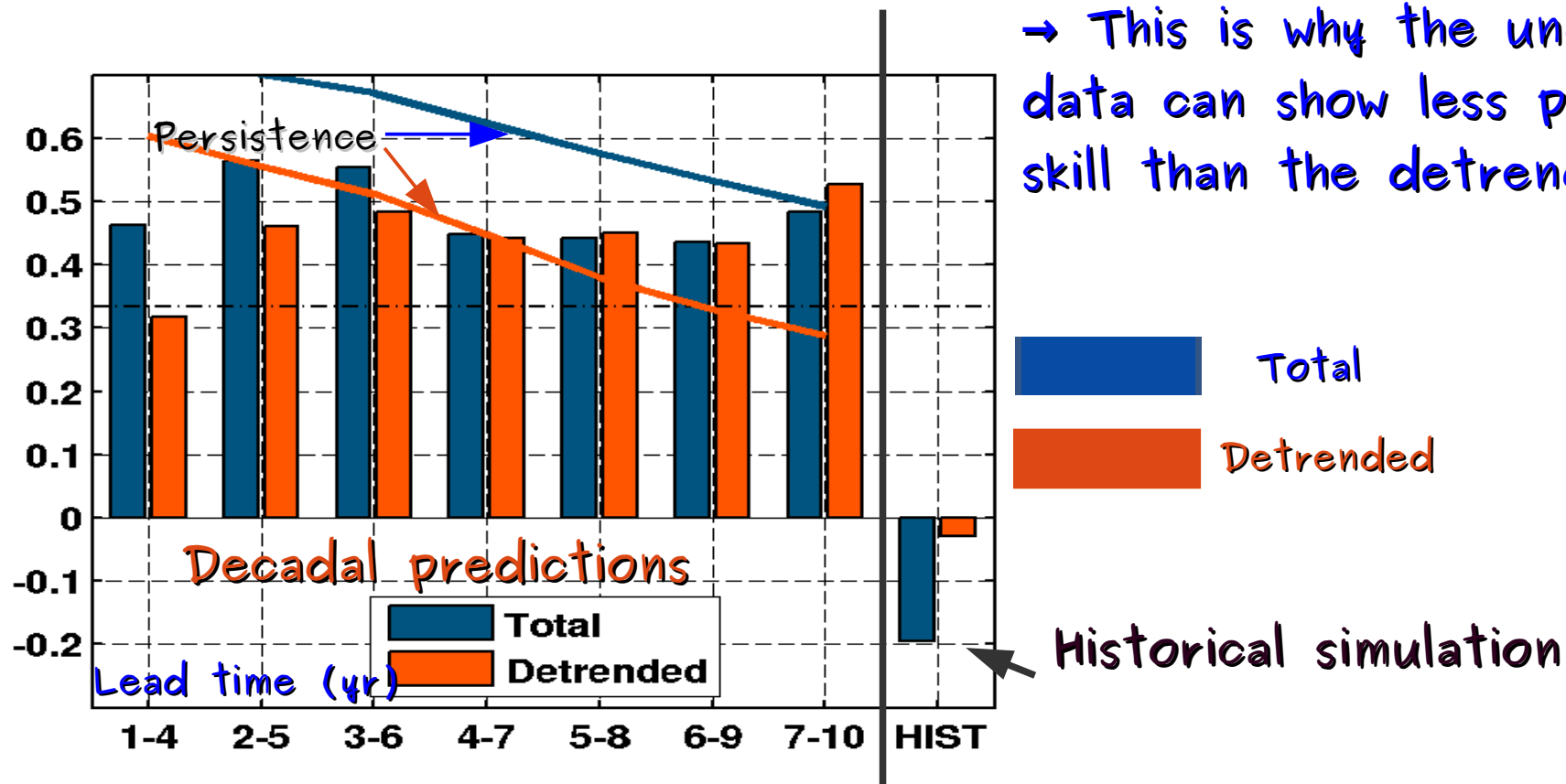


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→ This is why the undetrended data can show less prediction skill than the detrended one

CONCLUSIONS

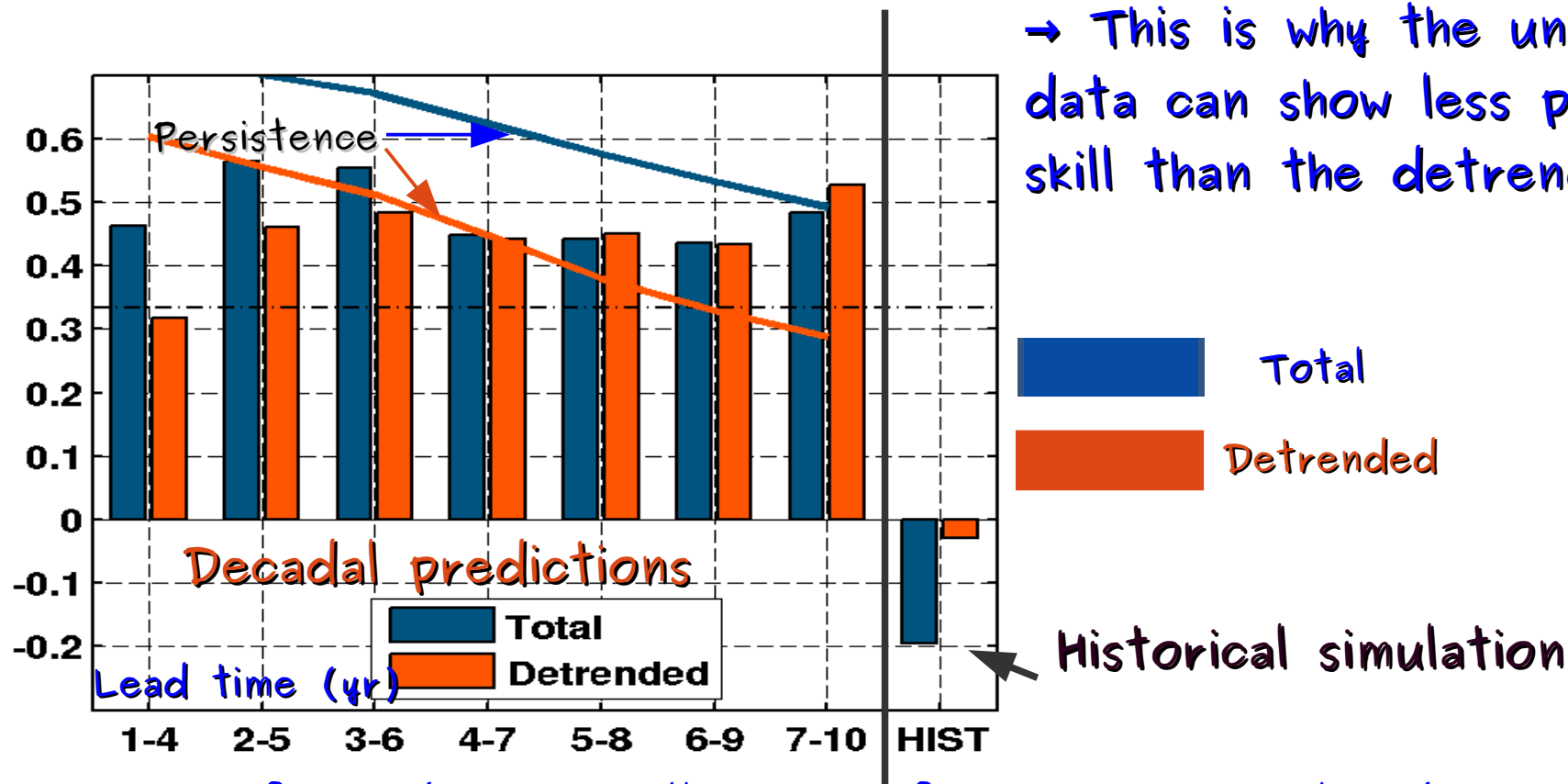
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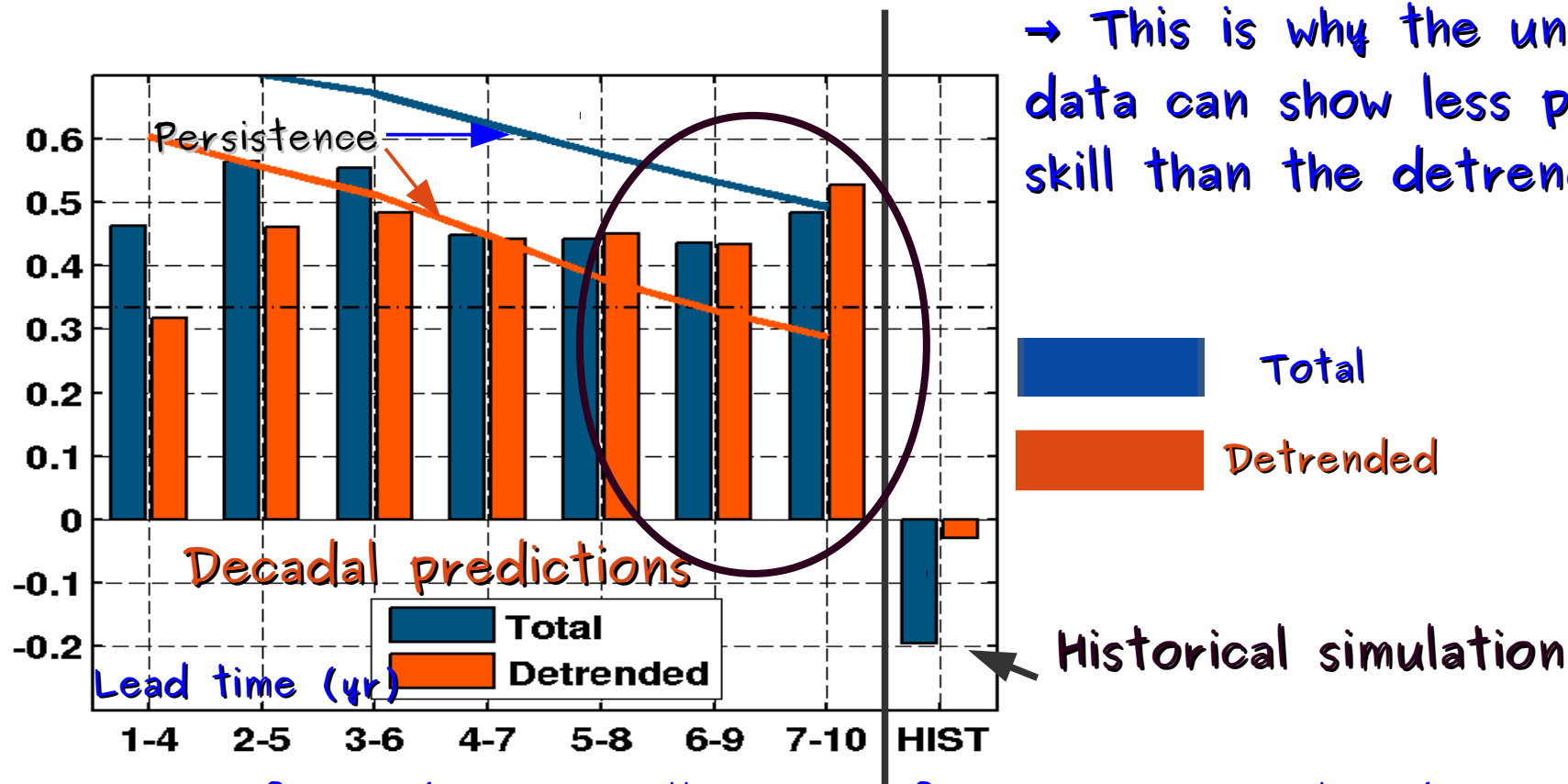


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-Most of prediction skill comes from AMV initialized component


CONCLUSIONS

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→ This is why the undetrended data can show less prediction skill than the detrended one

-Most of prediction skill comes from AMV initialized component
→ skill at long lead times DOES NOT stem from external forcing

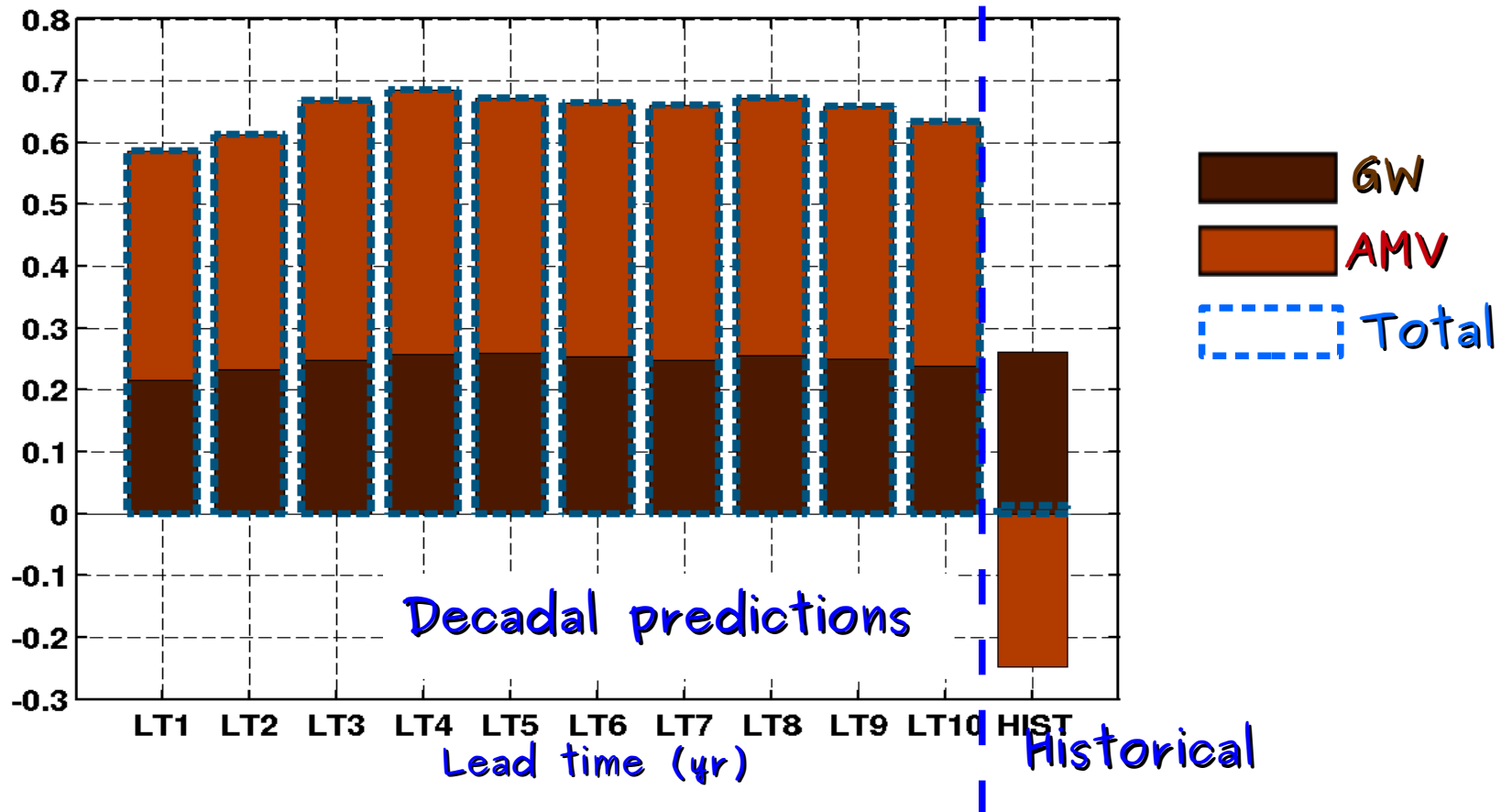


CONCLUSIONS

- There is potential in predicting Sahel rainfall at decadal time scales if the response to GW and AMV signals is well simulated

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Correlation coefficients using GW and AMV indices from model & regression coefficients from observations