Predictability of intraseasonnal pluviometric descriptors in East Africa

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Introduction – Issues & objectives

East Africa rainfall predictability ⇢ seasonal amounts ! (Mutai & al, 1998; Philippon & al, 2002 …)

Main objective

Understand linkages between regional variability of the rainy season onset and global modes of the climate system to set up efficient predictive tools based on Model Output Statistics (MOS)

Local final information → Canonical Correlation Analysis (CCA)

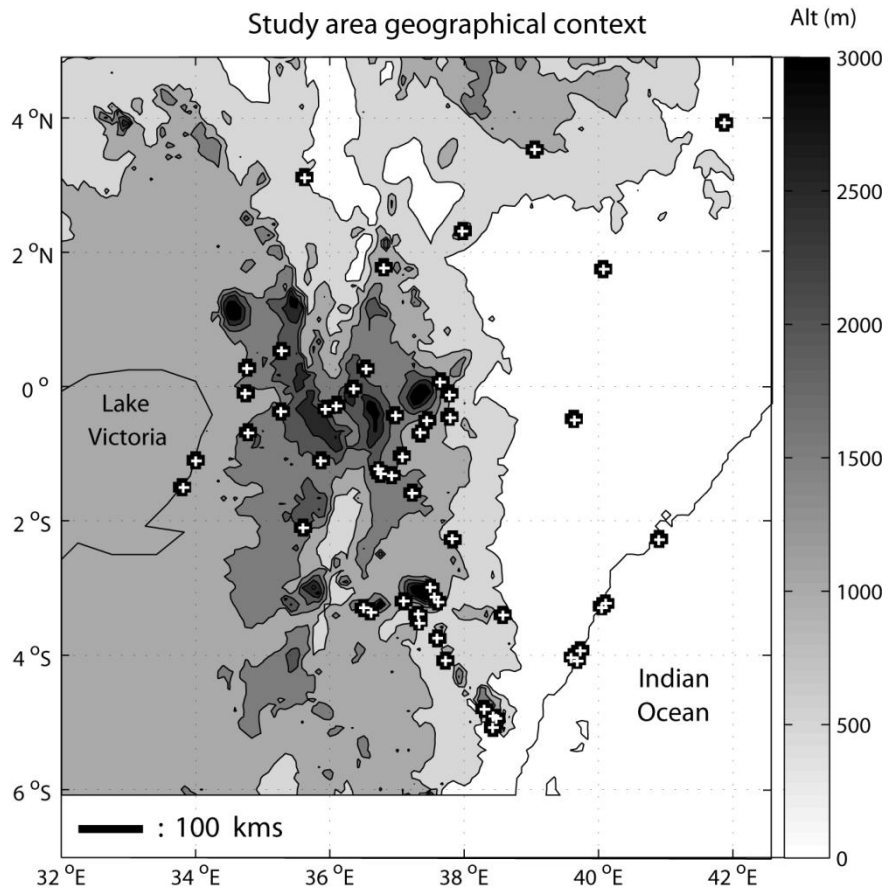
Regional final information → Multiple Linear Regression (MLR)

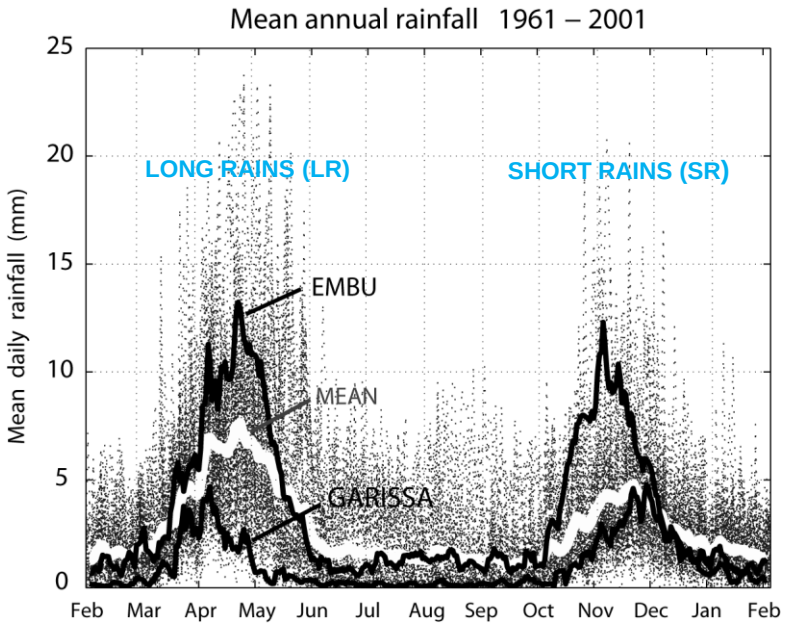
General Circulation Model - ECHAM 45 (*Atmospheric GCM; 2.8° x 2.8° spatial resolution*)

Methodology and data

→ 4 steps

1/ Predictand analysis : spatial coherence of rainy season onset over Kenya & Tanzania





DATA : - Daily rainfall
- 53 rain gauges
- 1961-2001 period

SOURCES : - Kenya Meteorological Department
- Tanzania Meteorological Agency

Methodology and data

1/ Predictand analysis : spatial coherence of rainy season onset over Kenya & Tanzania

(Local observed rainfall data)

2/ Teleconnections between onset & observed large scale atmospheric circulation : lag 0

Atmospheric fields

ERA 40 covering 1961 – 2001 period

- Zonal & Meridional wind ---> 850 / 500 / 200 hPa
- Geopotential ---> 850 / 500 / 200 hPa
- Vertical velocity ---> 500 hPa

Oceanic fields

HADISST2 covering 1961-2001 period
+ Niño 4 index, + Indian Ocean Dipole Mode Index (DMI)

Methodology and data

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(Reanalyzed data)

3/ Skill of ECHAM 4.5 to reproduce observed atmospheric fields

⟶ ECHAM4.5 retrospective 24-ensemble monthly members forced by observed SST

Methodology and data

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3/ Skill of ECHAM 4.5 to reproduce observed atmospheric fields

(Simulations forced by observed SST)

4/ Evaluation of ECHAM 4.5 predictive potential

- Local scale (CCA)

simulation forced by observed SST

ECHAM 4.5 retrospective
24-ensemble forecasts based on
Constructed Analogue SST

→ Model Output Statistic

↓

skill forecast ECHAM 4.5

Methodology and data

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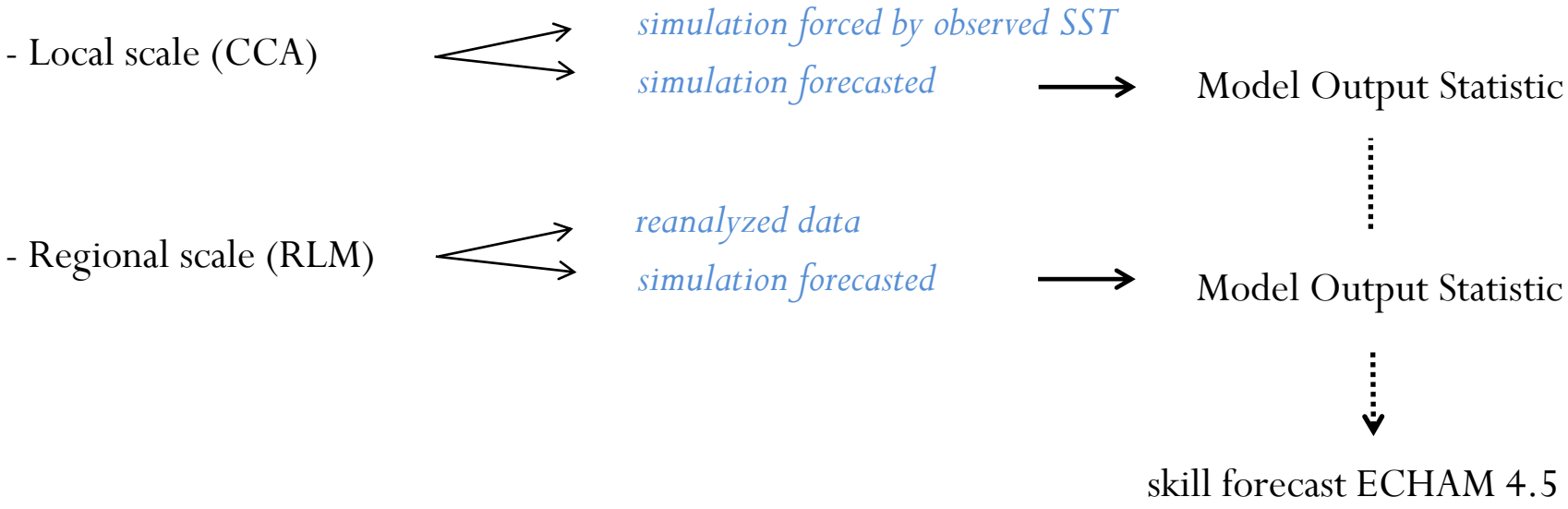


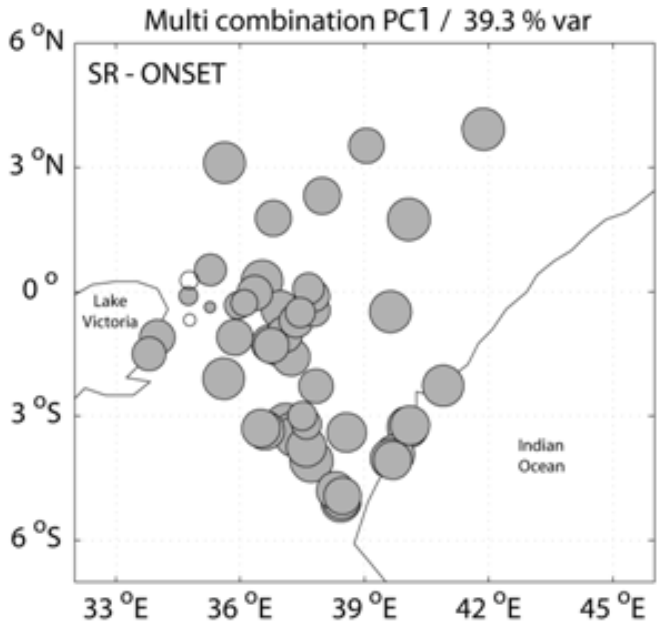
Predictand definition and analysis

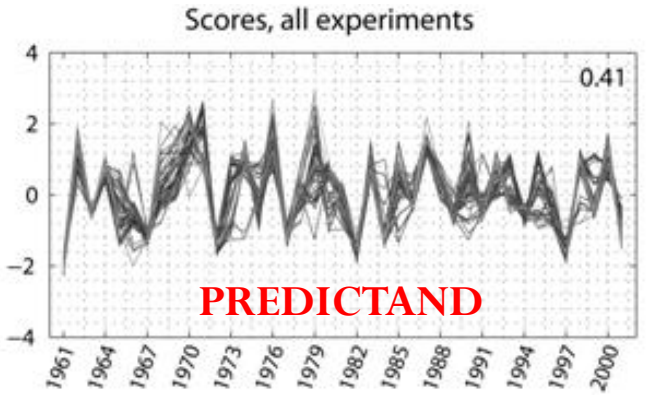
- **Rainy season ONSET** : Agro-climatologic definition (Sivakumar 1988; Ati & al, 2002)

*1st wet day (>1mm) of a wet spell (**wetseq**) of **D** consecutive days,*
*receiving at least **H** mm without to record a dry spell (**drys**)*
*of **K** days during the **T** following days (**ctrl**).*

How coherent is the onset date variability at regional scale ?

Method 1 - EOF analysis





Predictand definition and analysis

Method 2 - Spatial coherence analysis using Statistical descriptors

		Qualitative corresp.	
LR	**Onset**	**9.5**	**0.25**
	Cessation	18	0.09
	Cumul	6.8	0.31
	Njp	7.1	0.30
	Intensity	19.7	0.06
SR	**Onset**	**10.2**	**0.20**
	Cessation	10.6	0.25
	Cumul	2.8	0.57
	Njp	3.7	0.48
	Intensity	20.6	0.06

Predictand definition and analysis

Method 2 - Spatial coherence analysis using Statistical descriptors

		Qualitative corresp.
LR	**Onset**	**H I G H**
	Cessation	MODERATE
	Cumul	VERY HIGH
	Njp	VERY HIGH
	Intensity	LOW
SR	**Onset**	**H I G H**
	Cessation	H I G H
	Cumul	VERY HIGH
	Njp	VERY HIGH
	Intensity	LOW

ONSET = High spatial coherence

Predictand definition and analysis

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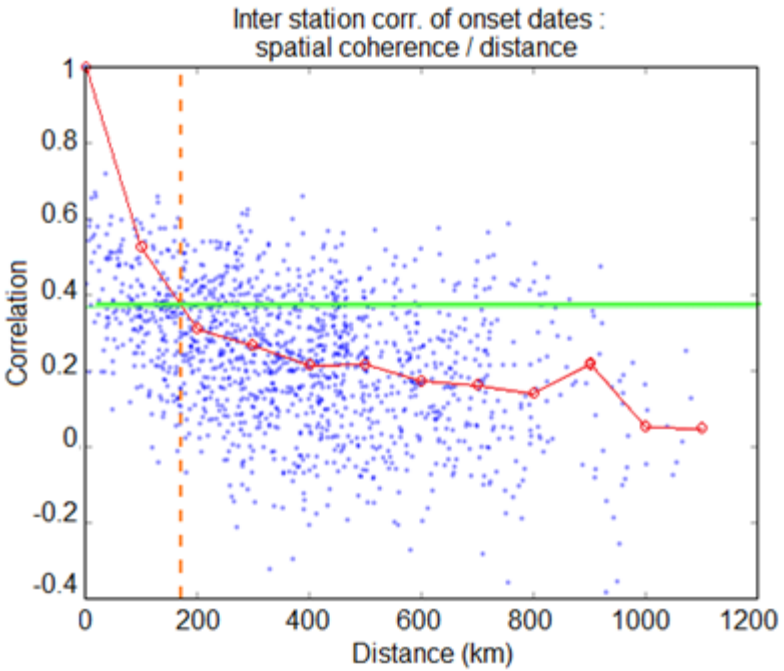

ONSET = High spatial coherence

Exponential decrease with loss of significance around 200 km

Step 1 Predictand definition and analysis

Spatial coherence analysis using Statistical descriptors

		Qualitative corresp.
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	Cessation	H I G H
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	Intensity	LOW

HYPOTHESIS

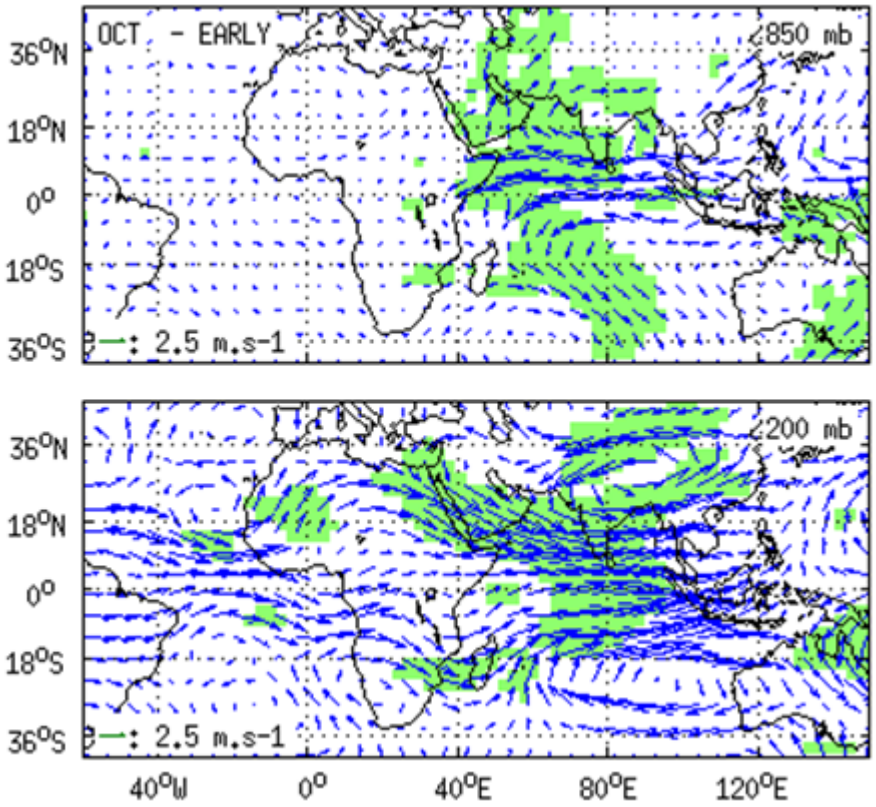
High spatial coherence
=
high predictability

We can expect some Predictability !

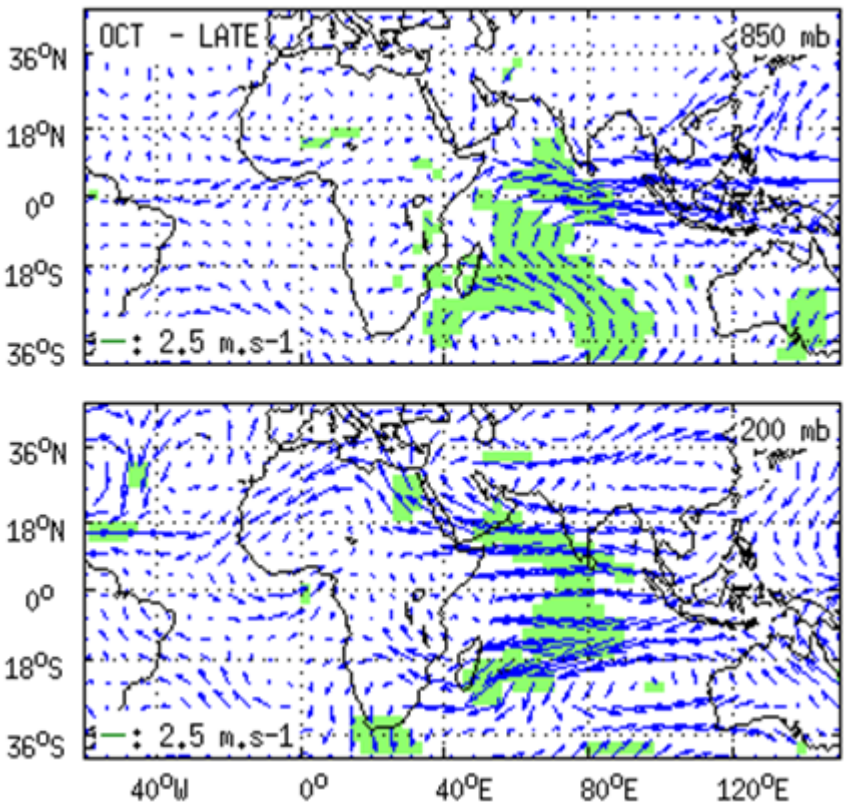
Teleconnections onset & observed atmo circulation

SHORT RAINS - Composite

EARLY ONSET



LATE ONSET



: Significant values

Lower troposphere : Easterly anomalies
Upper troposphere : Opposite anomalies

Walker cell

Lower troposphere : Westerlies anomalies
Upper troposphere : Opposite anomalies

Teleconnections onset & observed atmo circulation

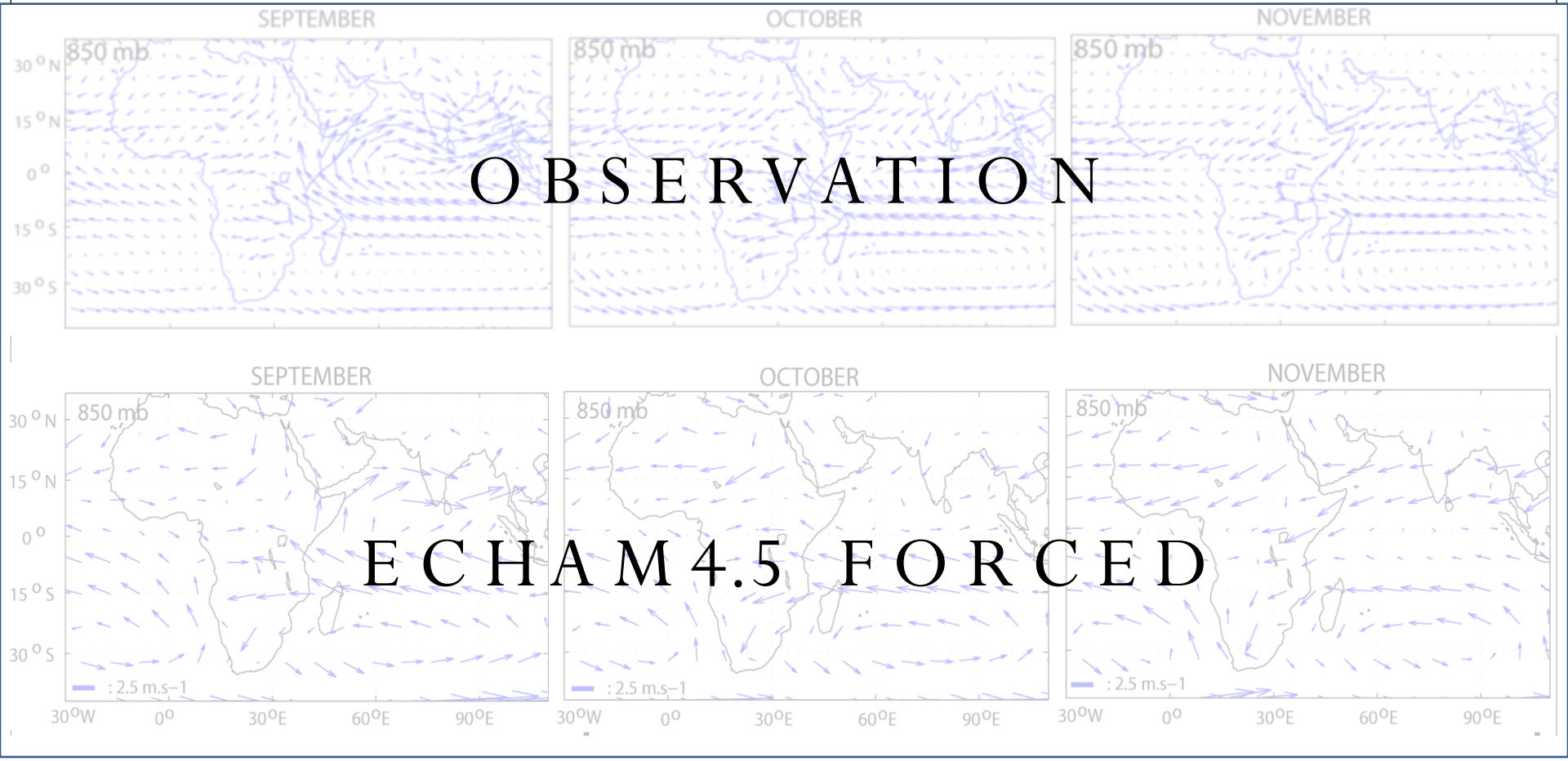
Large scale atmospheric signal associated with SR onset

We can expect some Predictability !

Is ECHAM 4.5 able to predict these atmospheric signals ?

Step 3 Skill of ECHAM 4.5 to reproduce observation

- Mean monthly wind flow at 850 hPa during the Short Rains



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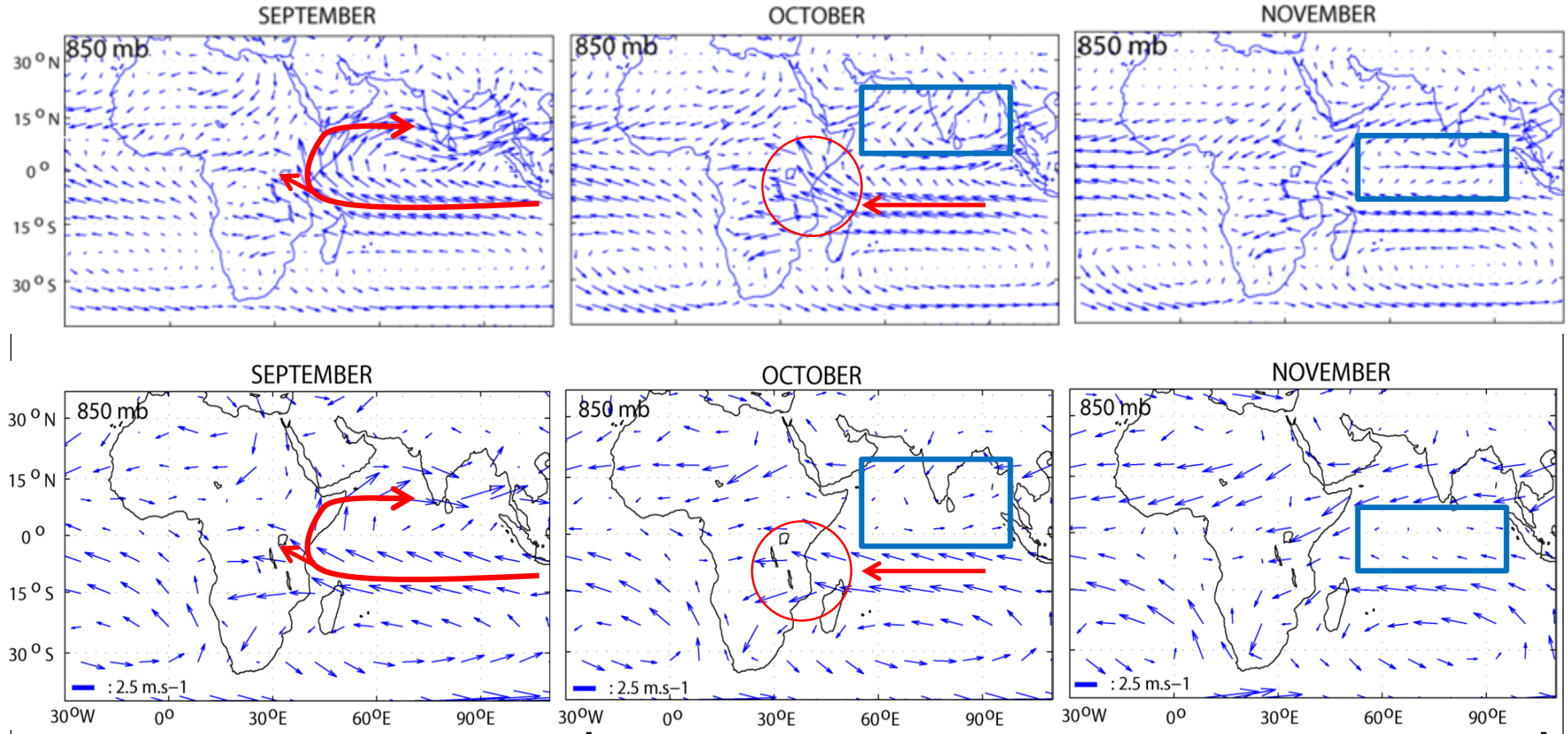
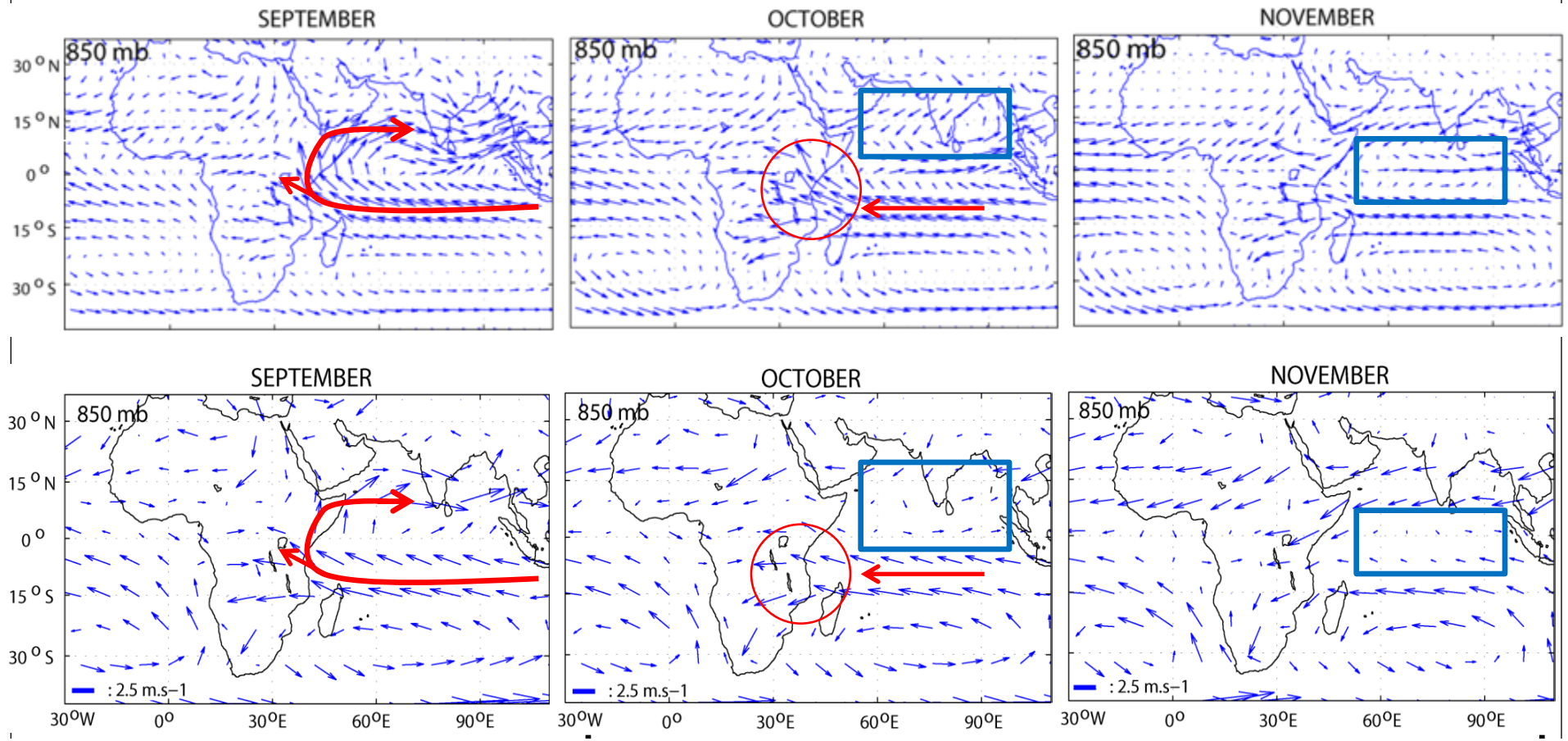


Ability to reproduce monsoon flow

Under-estimated westerlies

Step 3 Skill of ECHAM 4.5 to reproduce observation

- Mean monthly wind flow at 850 hPa during the Short Rains



High similarities between ERA40 monthly wind & ECHAM4.5 monthly wind

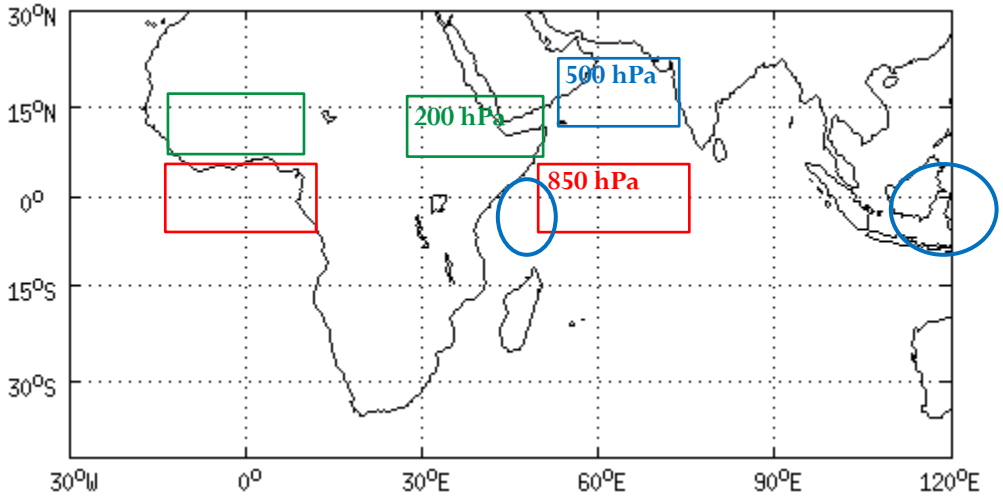
JUSTIFIES FURTHER ANALYSIS OF ECHAM 4.5 TO TEST FORECASTING SKILL

Step 4

Predictive potential of ECHAM 4.5

Statistical treatment of numerical output model = MOS

Multiple Linear Regression



24 indices --> potential predictors

. Wind
. Vertical velocity
. Geopotential
. Surface temperature
. + Niño; DMI;
. + SST modes extracted from PCA

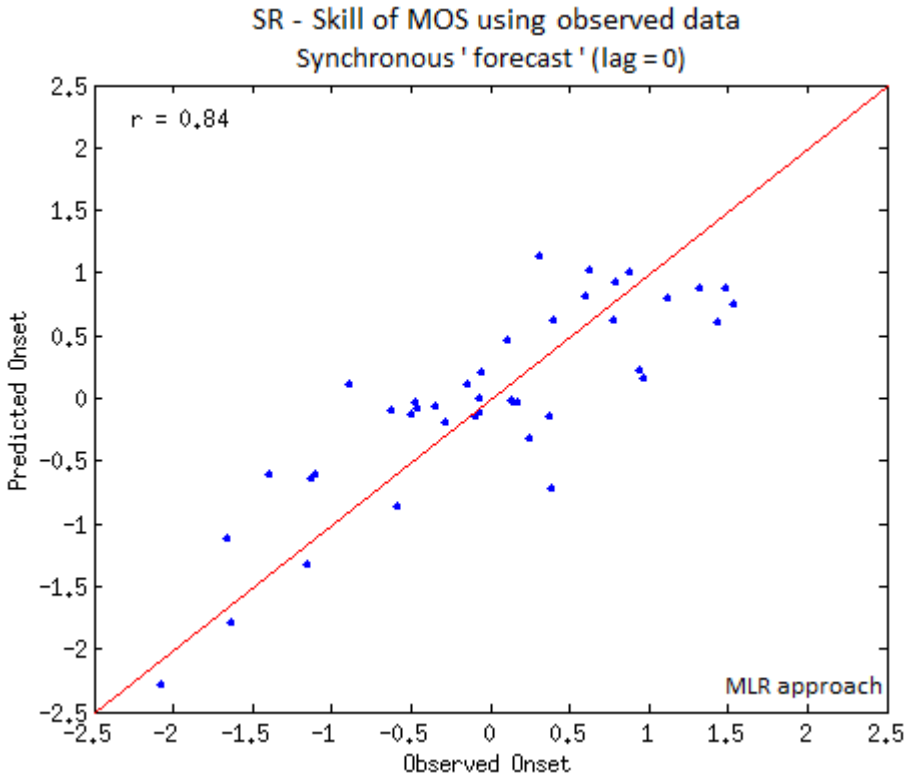
Canonical Correlation Analysis

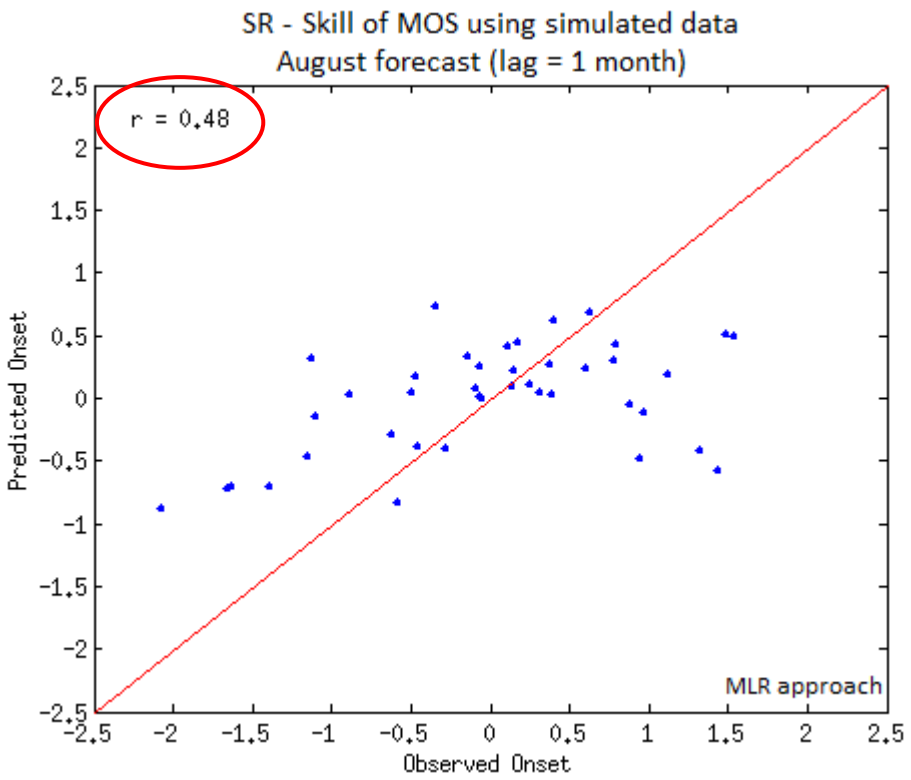
4 combined predictors : zonal wind at 850 hPa & 200 hPa
meridional wind at 850 hPa & 200 hPa

Step 4

Predictive potential of ECHAM 4.5

Regional scale



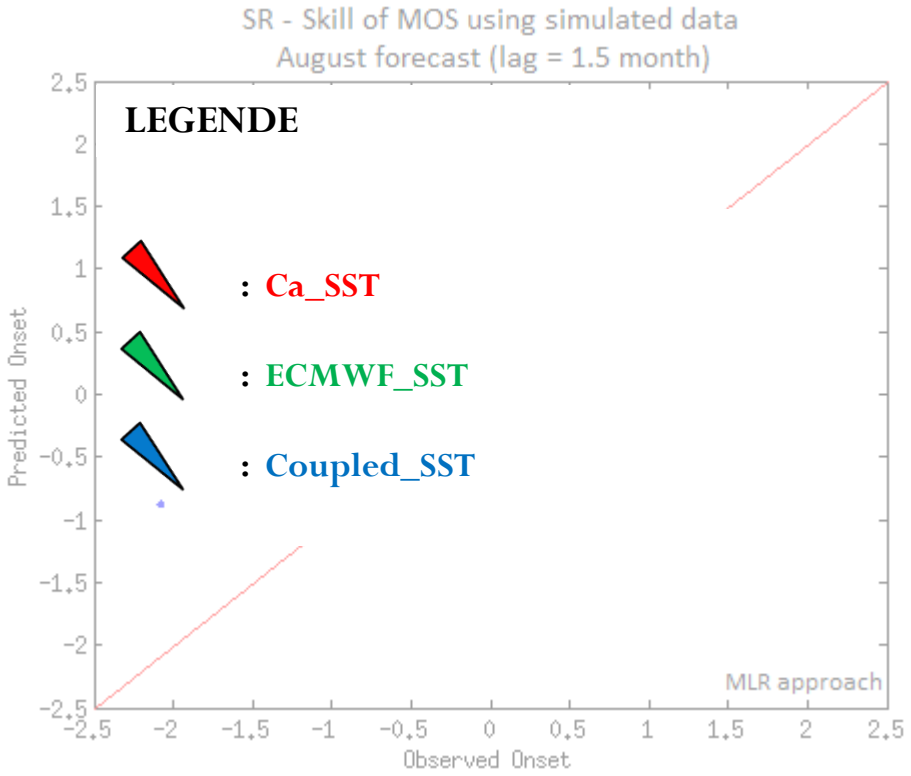


5 predictors : - U850 hPa over WIO
- U200 hPa over WIO
- V200 hPa over WIO
- Niño 4
- Mode 3 SST

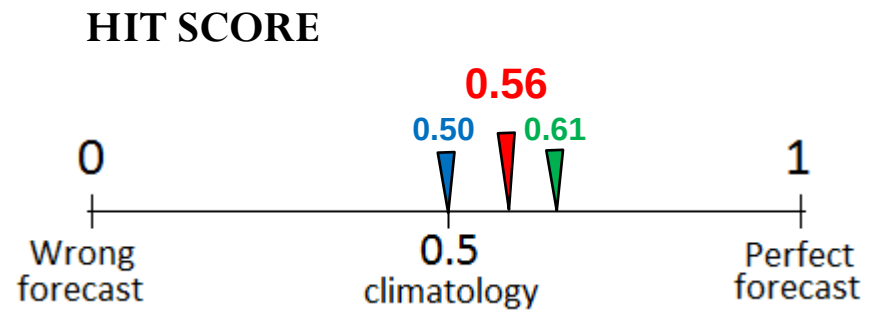
1 predictor : - DMI

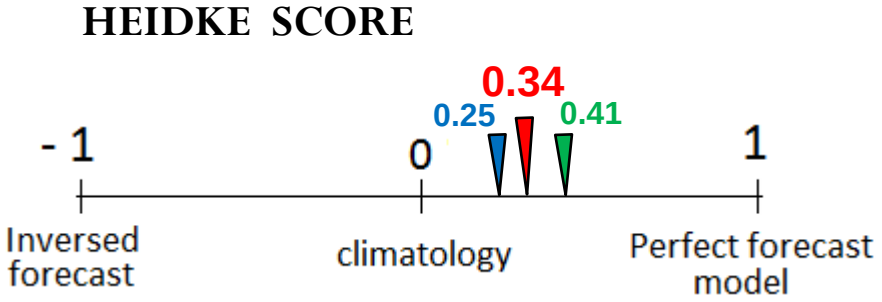
Predictive potential of ECHAM 4.5

Regional scale



1 predictor : - DMI index



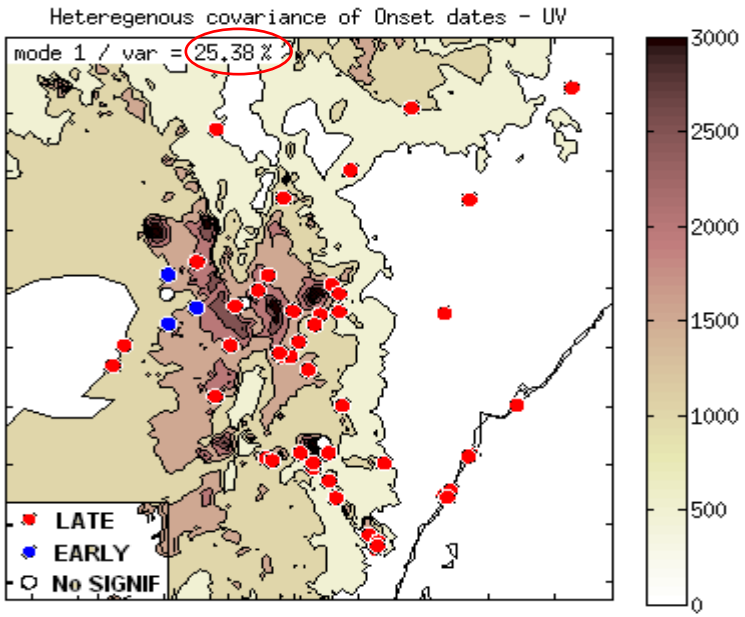


Skill of regional MOS : low to moderate

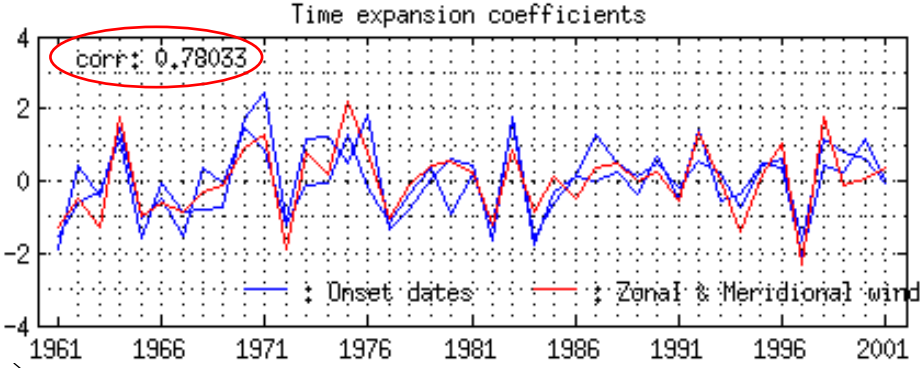
Step 4

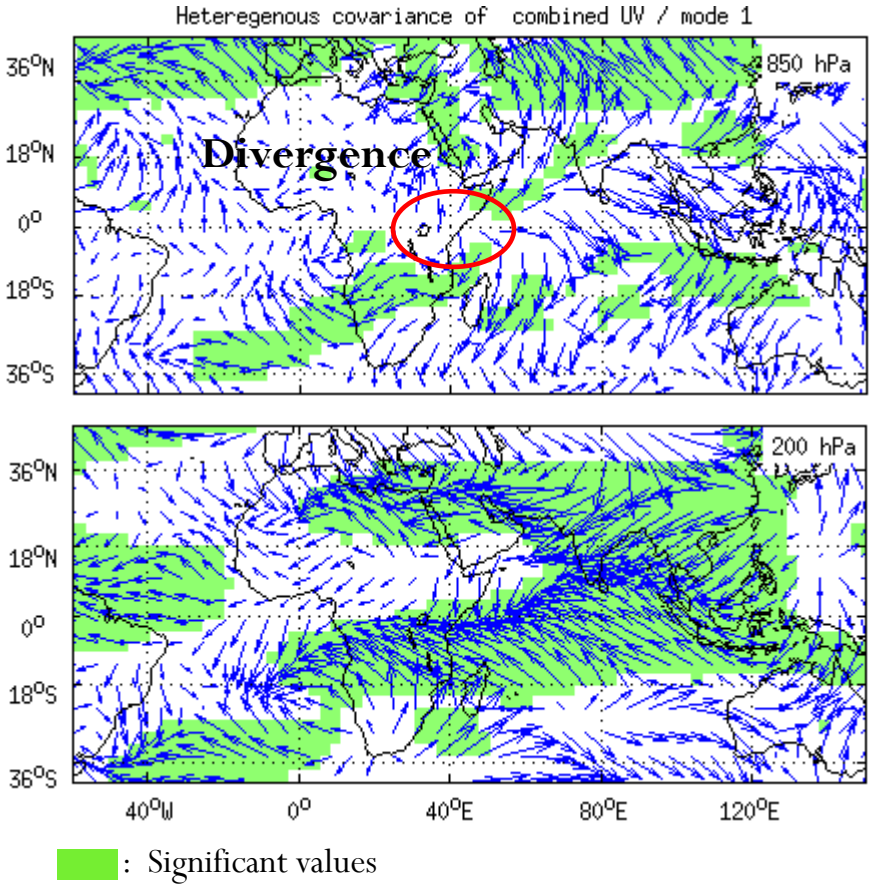
Predictive potential of ECHAM 4.5

Local scale - SR forced mode 1



Homogeneous Onset field





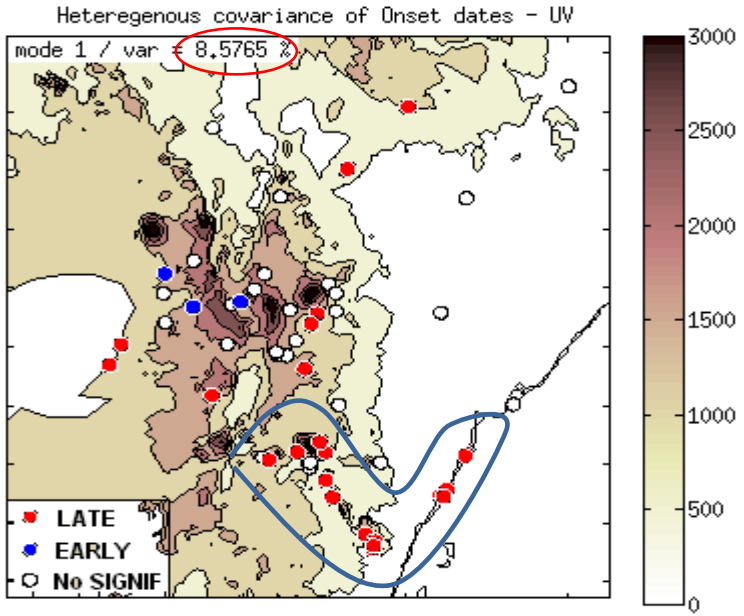
: Significant values

LATE ONSET = low level divergence
upper level convergence

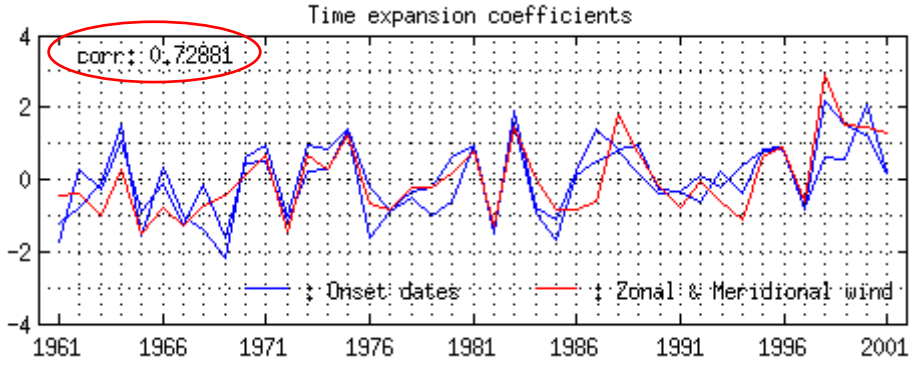
Step 4

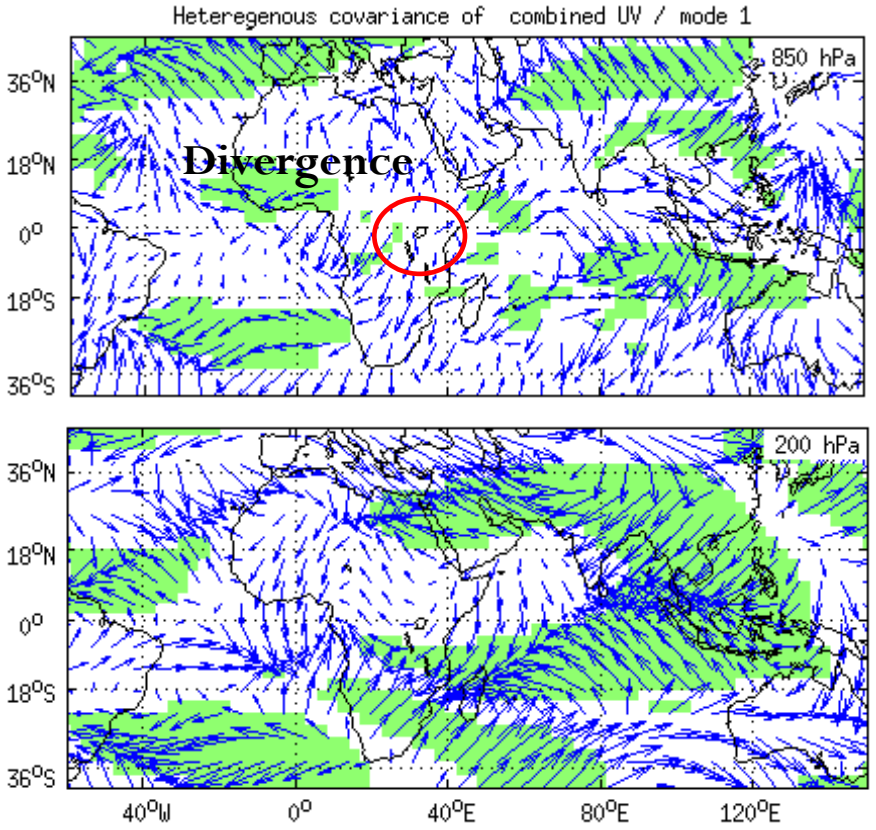
Predictive potential of ECHAM 4.5

Local scale - SR forecast mode 1



Heterogeneous Onset field
Southern stations





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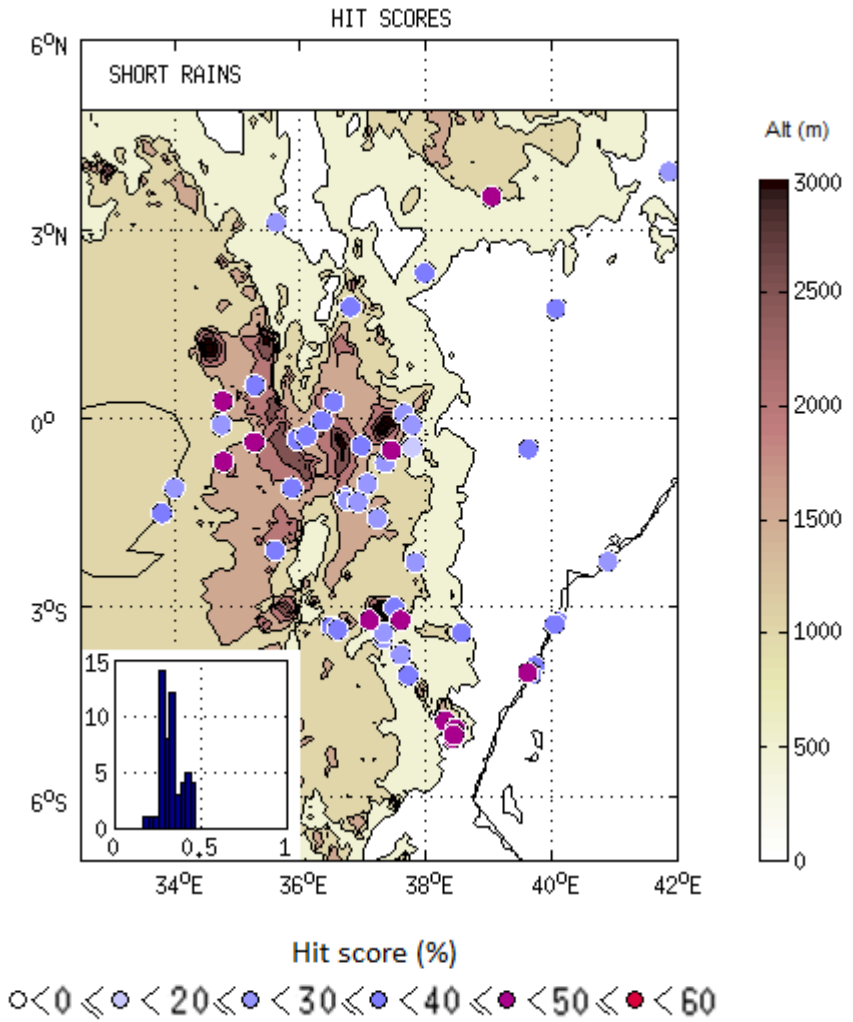

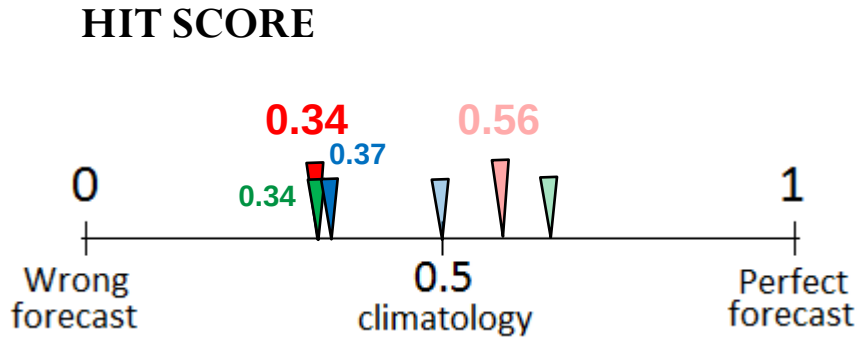

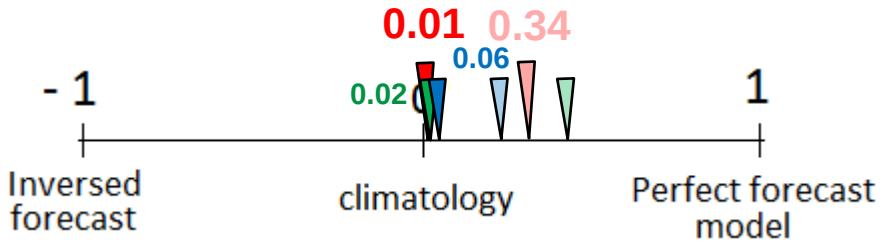

Skill of local MOS : very low !

Conclusions

1/ Rainy season onset behaviour ?

+ Relatively high spatial coherence
+ Large atmospheric signal linked to **rainy season onset.**

THE ONSET IS POTENTIALLY PREDICTABLE

2/ Skill of ECHAM 4.5 to reproduce observed atmospheric fields ?

+ Ability to reproduce large scale atmospheric signal (mean monthly)
- Difficulties to reproduce equatorial flow *(not shown)*

ECHAM 4.5 = GOOD CANDIDATE MODEL TO TEST PREDICTABILITY

3/ Evaluation of predictive potential of ECHAM 4.5 ?

- At local scale low predictive skill
+ At regional scale moderate predictive skill

Issues

Why is the skill low ?

GCM

- Difficulties to reproduce Intra seasonal mode as MJO
- Prediction of Indian Ocean temperatures inaccurate ?

PREDICTAND

- Local scale onset is partly controlled by meso scale circulation not reproduced by ECHAM 4.5

What alternative to improve forecast skill ?

- use of multi-model forecast
- add supplementary MJO information …

Issues

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PREDICTAND

- Local scale onset is partly controlled by meso scale circulation not reproduced by ECHAM 4.5

What alternative to improve forecast skill ?

- use of coupled models
- use of multi-model forecast
- add supplementary MJO information

THANK YOU …