Subseasonal prediction of South American monsoon rainfall: active and break episodes, extremes and the contribution of the MJO

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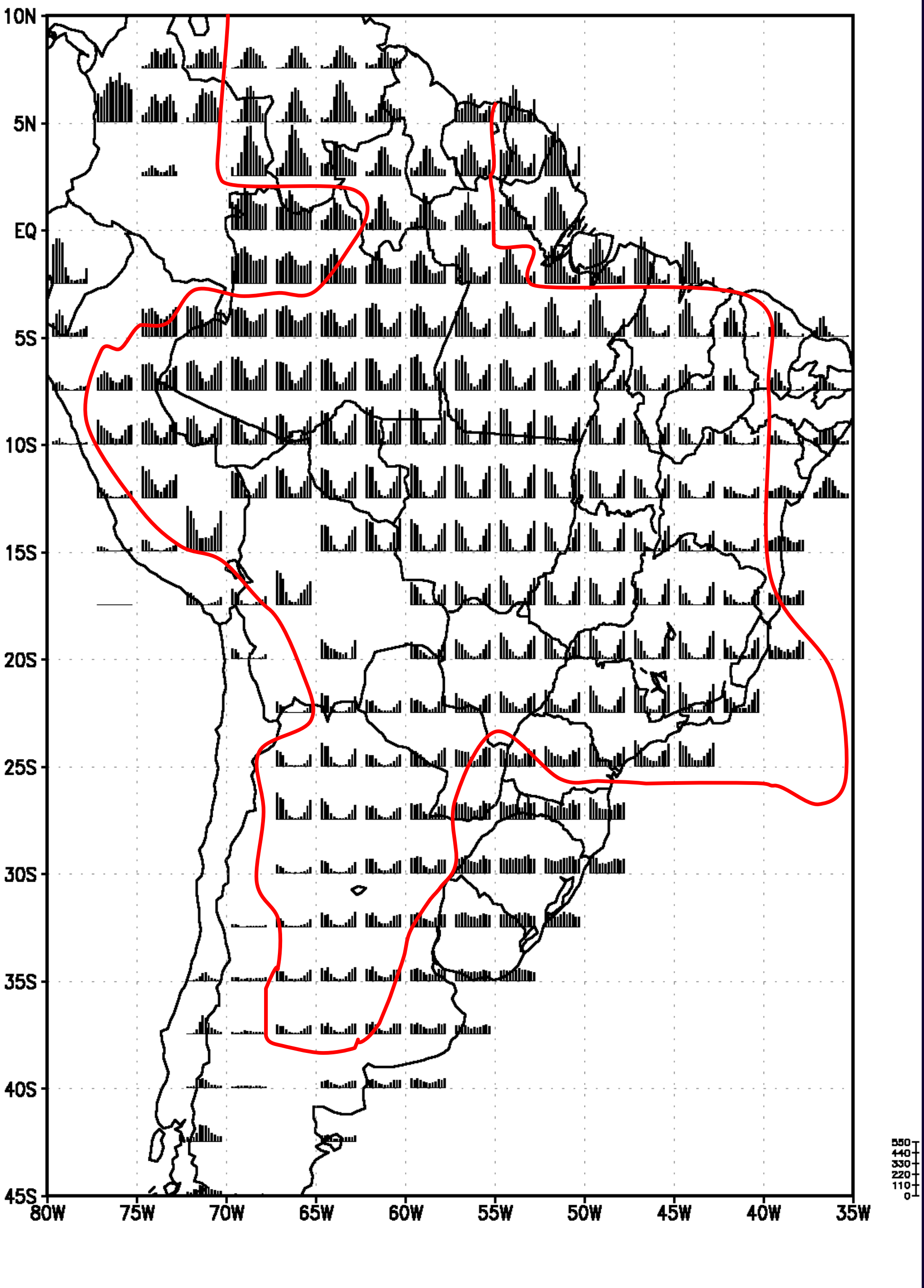
8th GEWEX Open Science Conference, Canmore, 7-11 May 2018

Outline

1) Impacts of the Madden-Julian Oscillation (MJO) on the South American monsoon (1979-2009 and 1999-2010)
2) Skill of S2S models (CFSv2 and ECMWF) in simulating the MJO and its teleconnections to South America
3) Active and break phases of the South American monsoon and the influence of the MJO in observations and models
4) Subseasonal prediction of South American summer monsoon indexes with CFSv2 and ECMWF reforecasts

Precipitation Climatology in SA Monsoon region



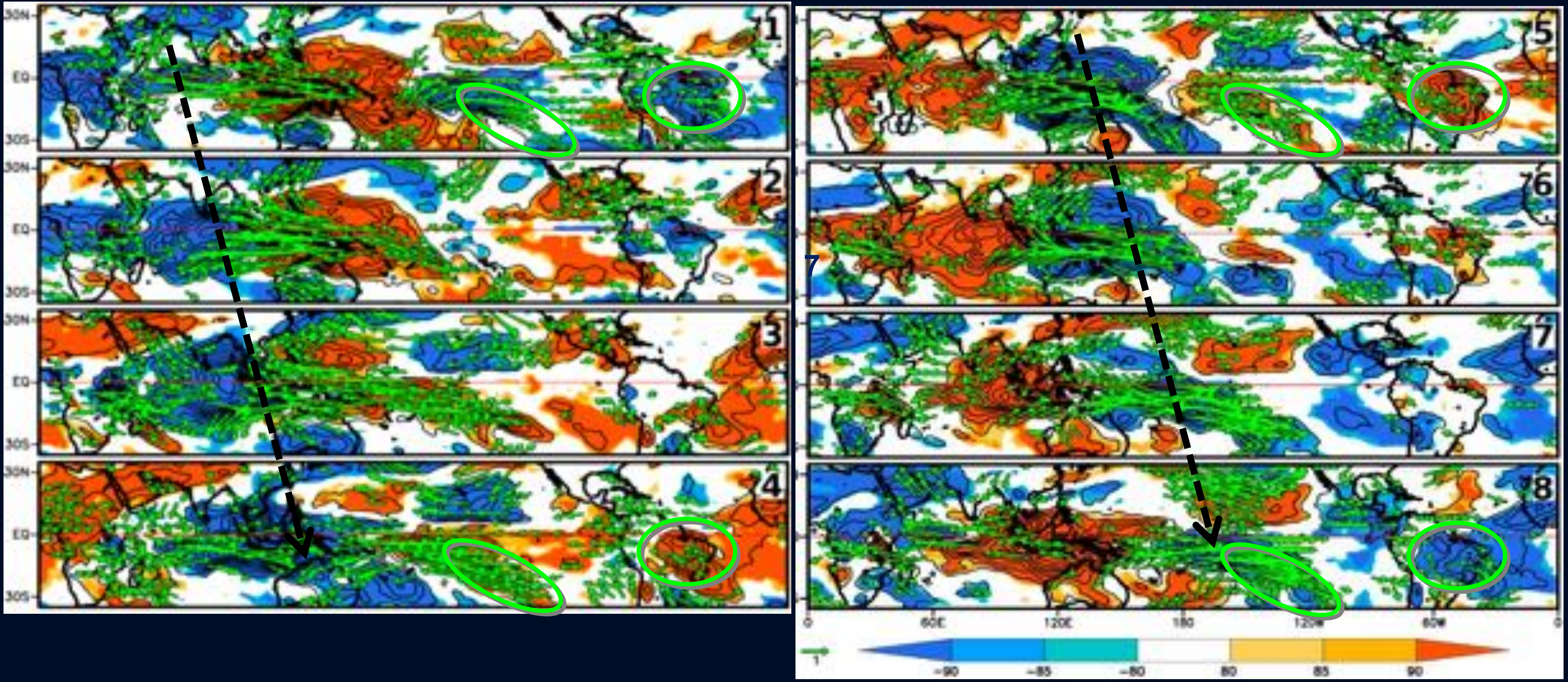
(Grimm 2011, *Stochastic Envir. Res. Risk Assessment*)

1. Impacts of the MJO on the South American Monsoon

1a. Period 1979-2009

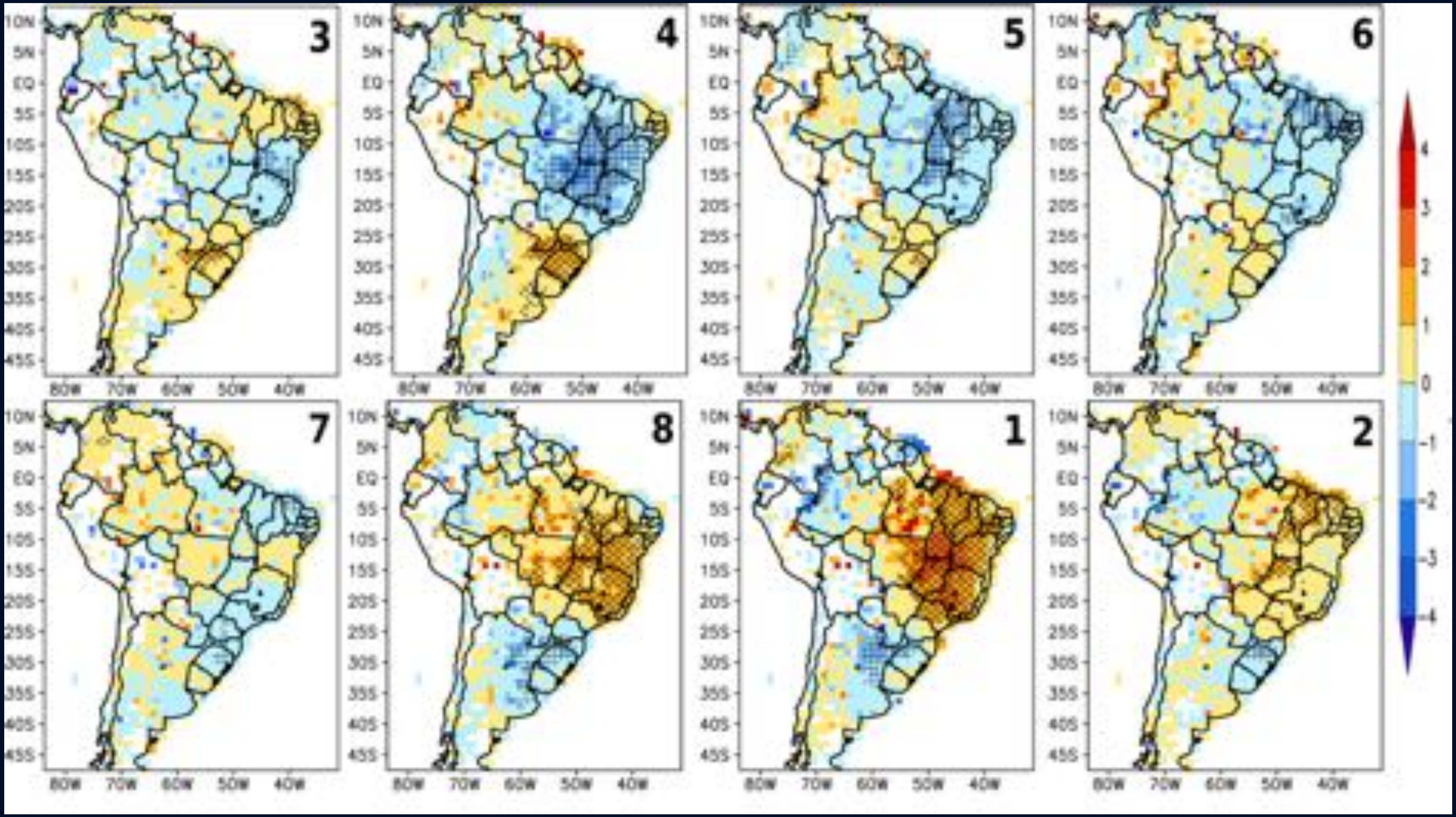
(Grimm 2018, submitted)

DJF MJO anomalies of OLR and V_{850}



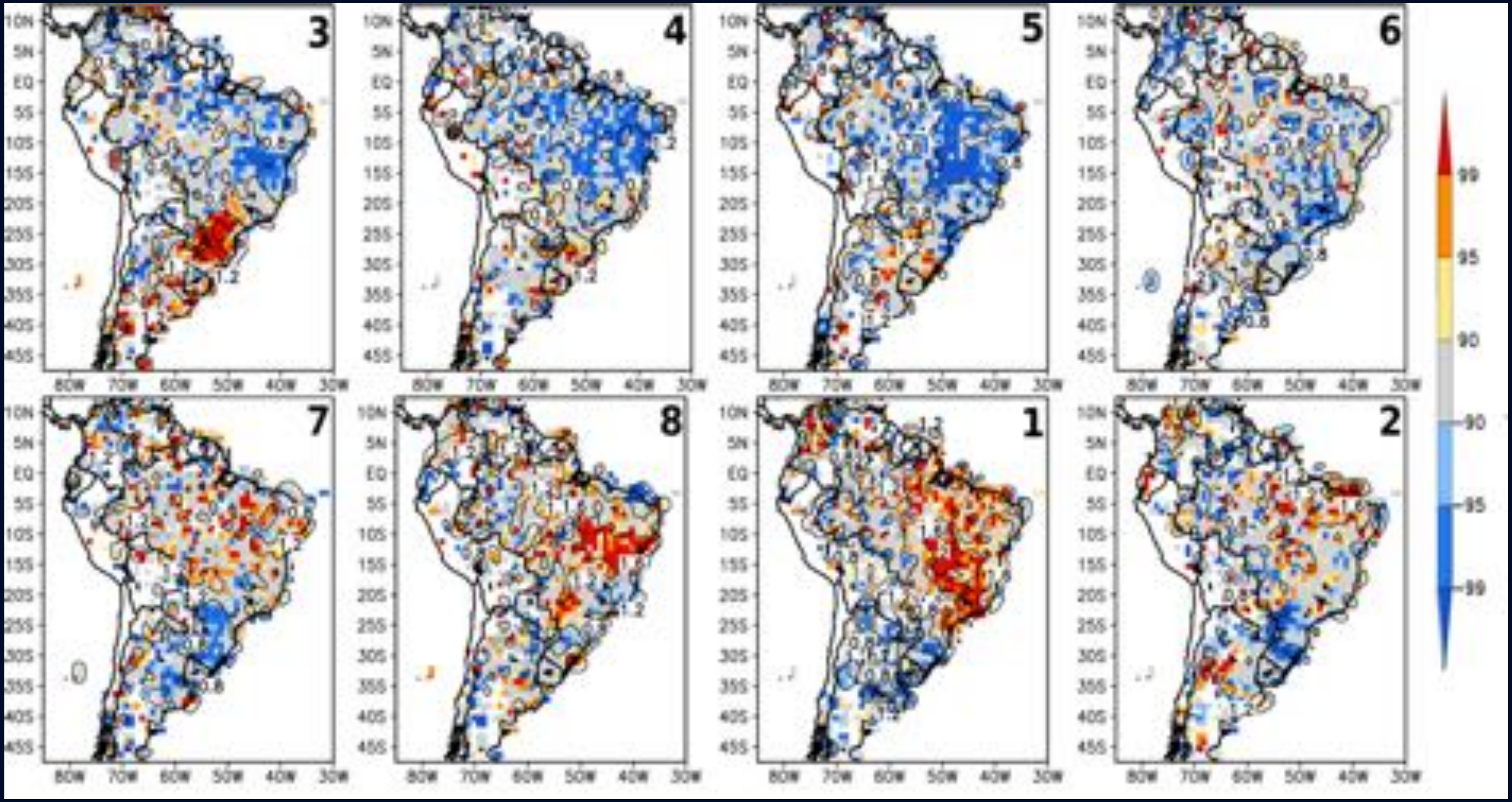
(Grimm 2018, submitted)

South America summer MJO-related daily precipitation anomalies



In central-east South America there is up to 4 mm more daily precipitation on average during phase 1 of MJO. (Grimm, 2018, submitted)

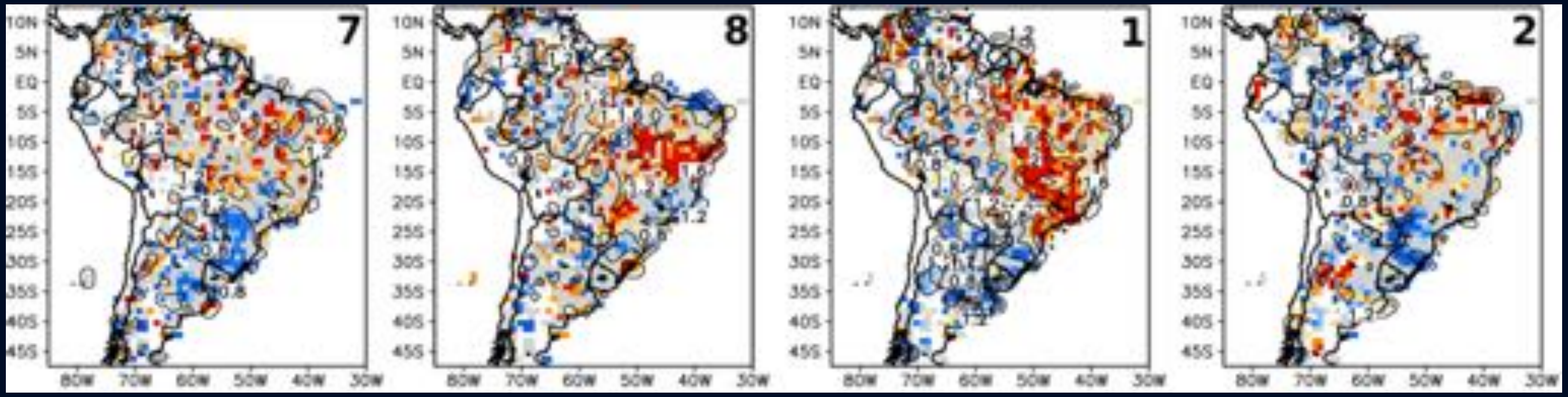
South America summer MJO-related anomalies in frequency of extreme events



In central-east South America there are twice more extreme rainfall events in MJO phase 1. In southeast South America, they increase by a factor 1.6 in phase 3.

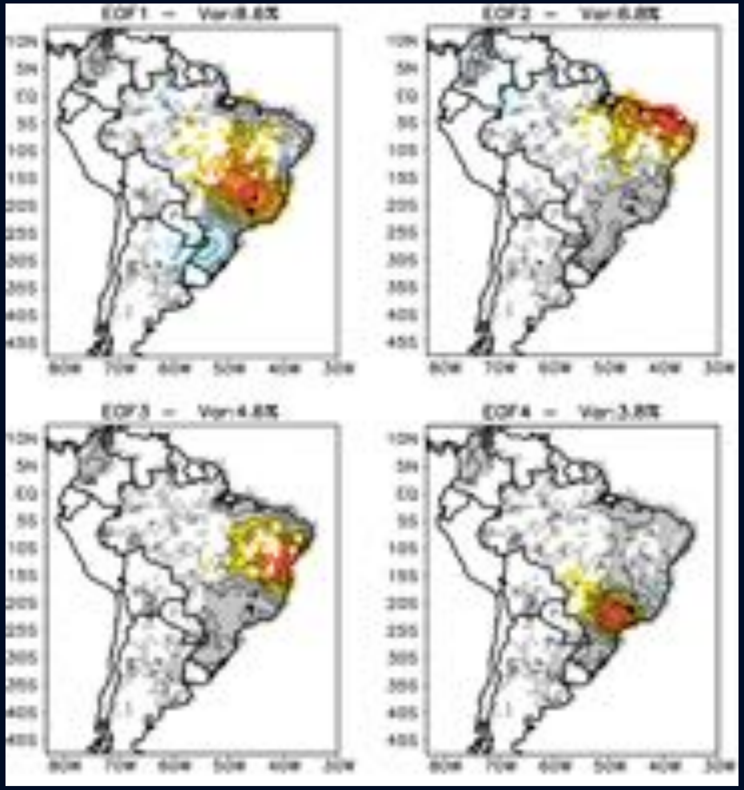
(Grimm, 2018, submitted)

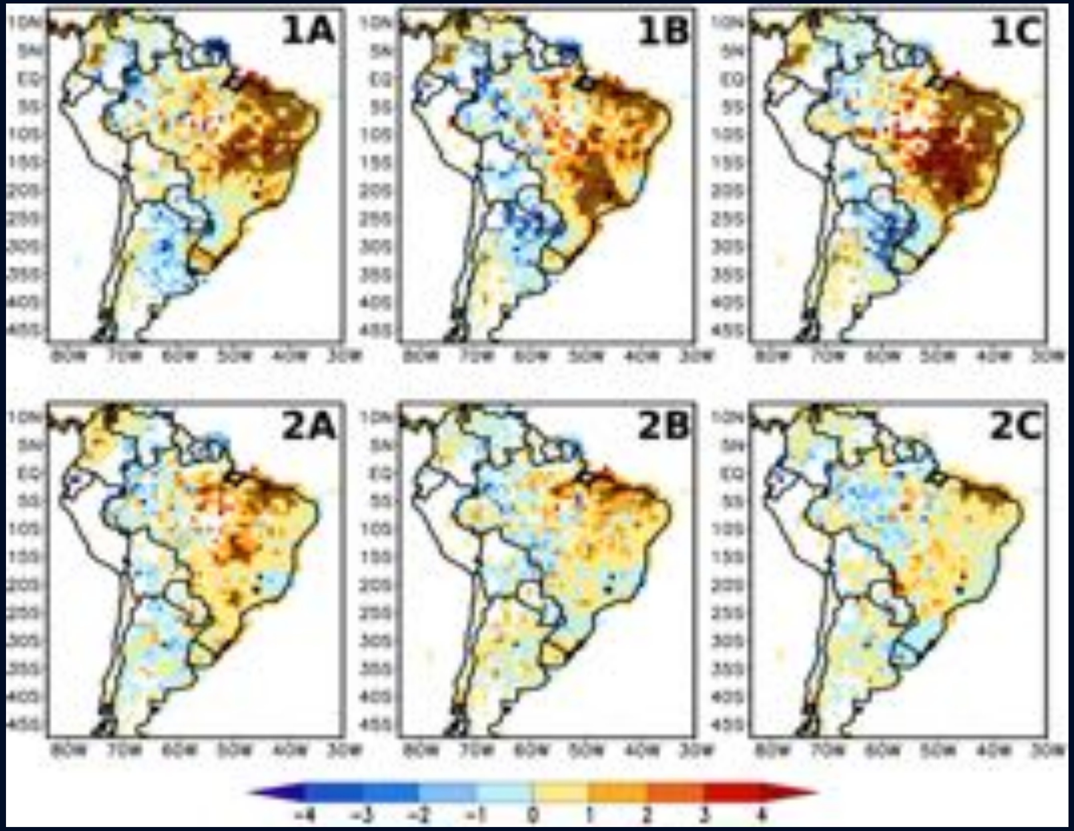
Evolution of MJO precipitation anomalies



MJO:
Frequency of extremes

Intraseasonal EOFs of precip. variability



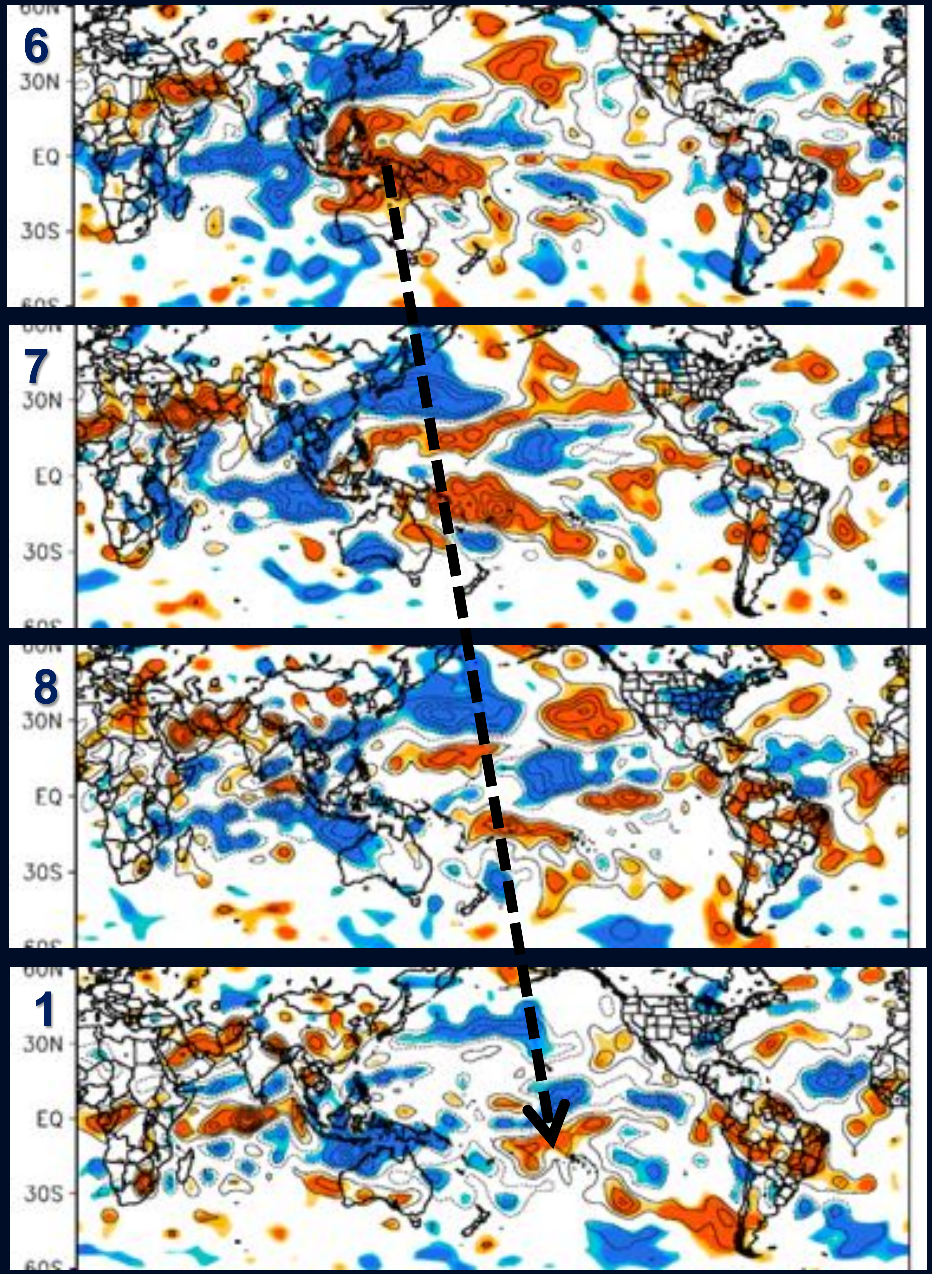


MJO:
Precipitation anomalies with higher temporal resolution during phases 1 and 2.

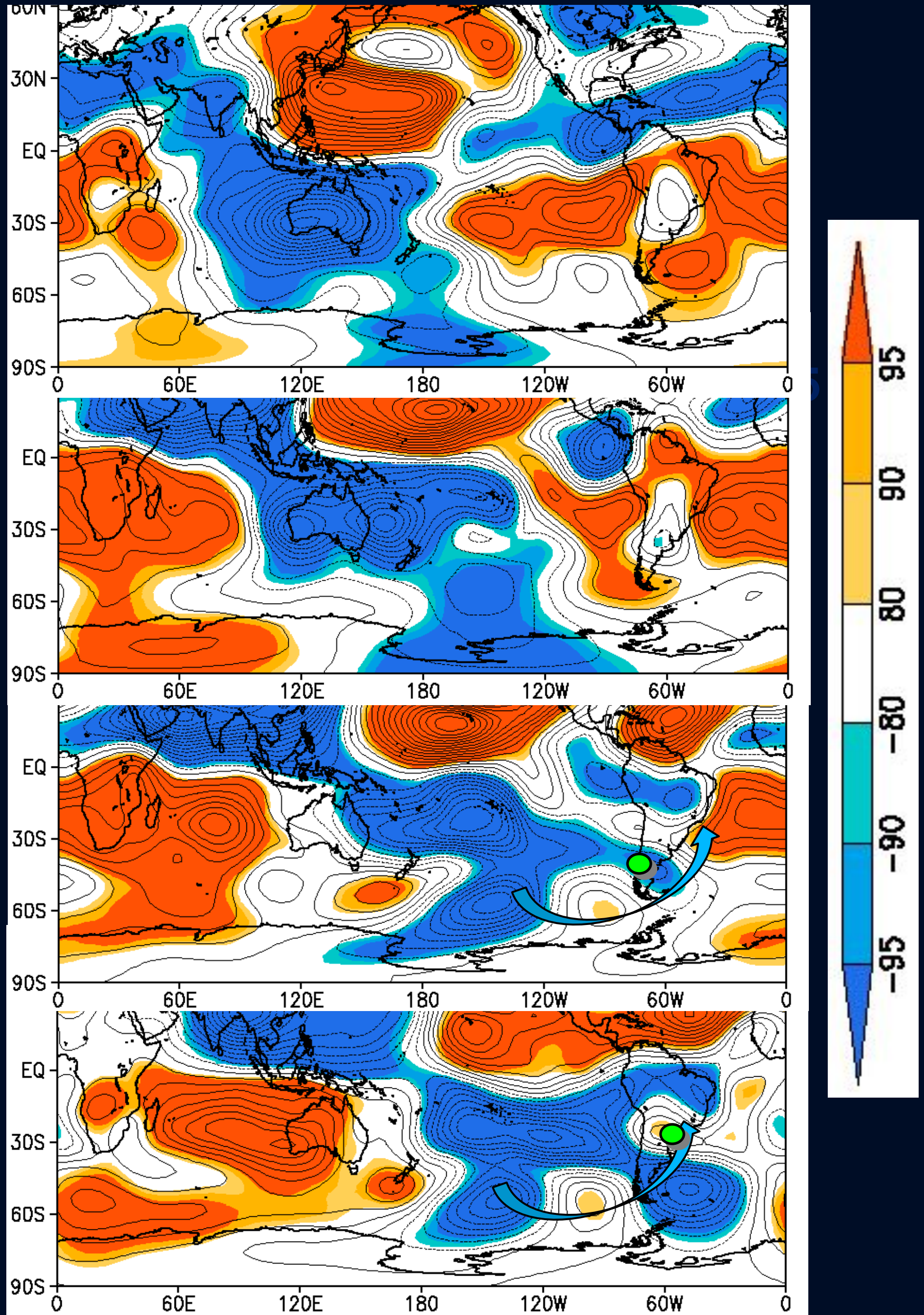
(Grimm, 2018, submitted)

Tropics-tropiccs and tropics-extratropics teleconnections to South America

MJO-related anomalies: Div$_{200hPa}$ and Ψ_{200hPa} – SH Summer

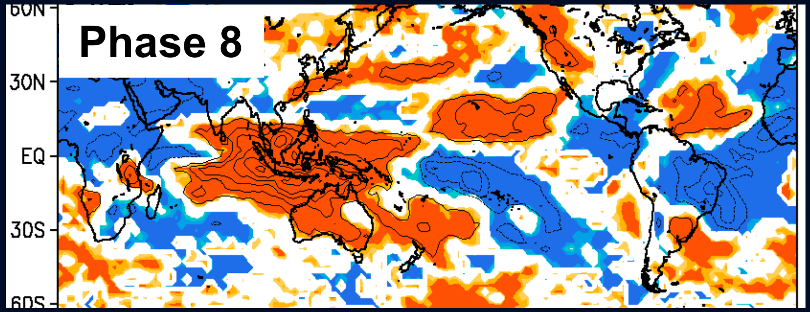


(Grimm, 2018, submitted)

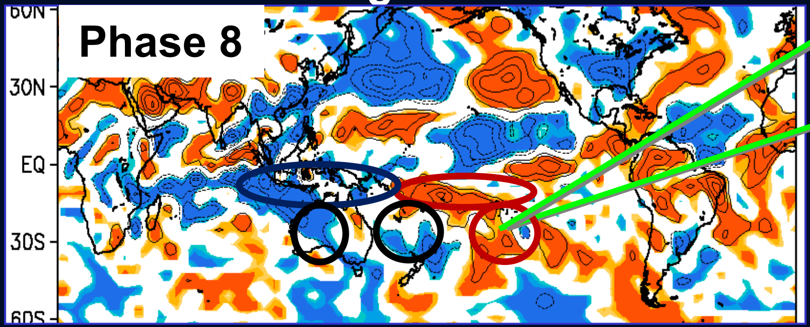


Tropics-extratropics teleconnection to South America

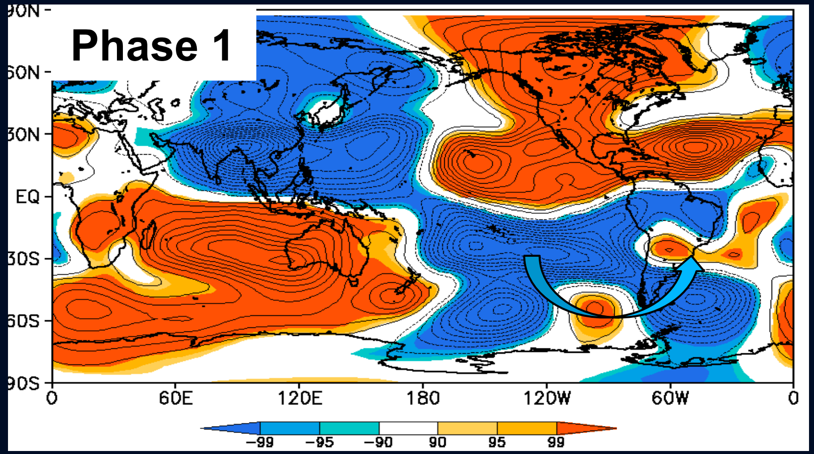
OLR anomalies



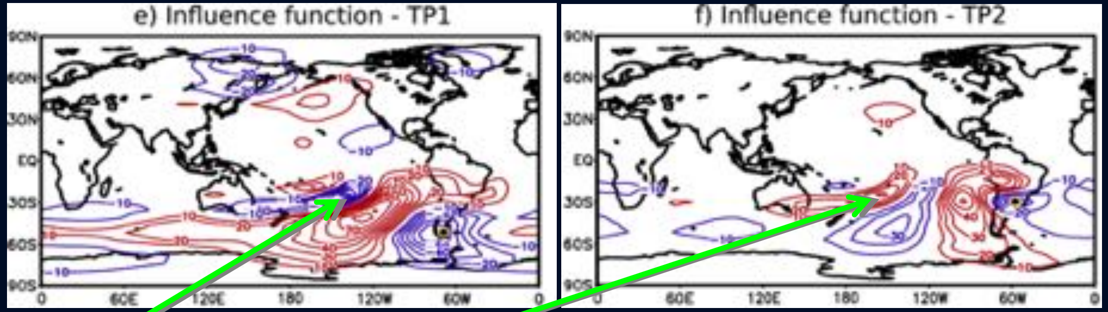
200 hPa divergence anomalies

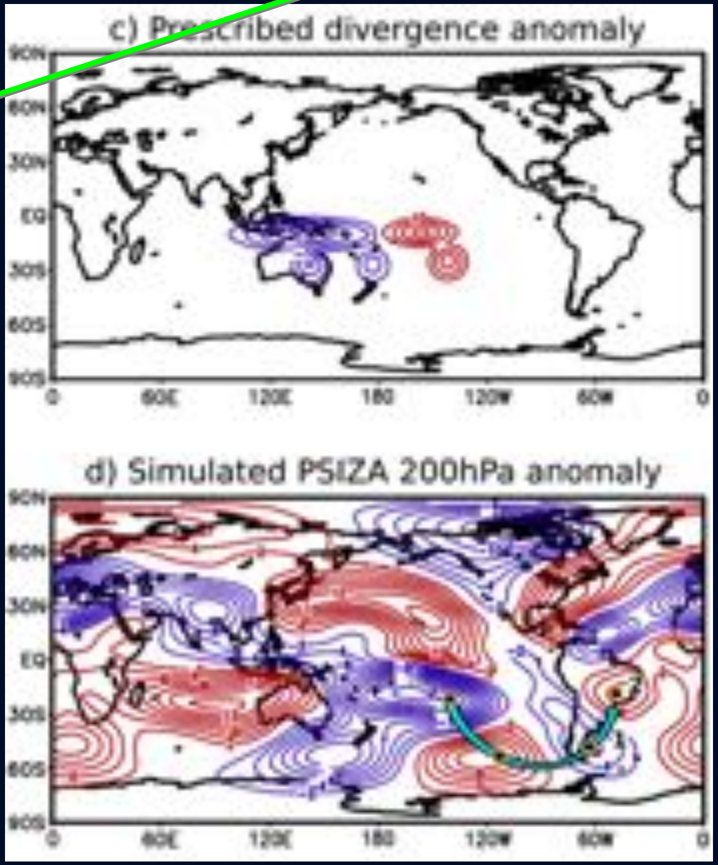


Streamfunction 200 hPa



Influence Functions

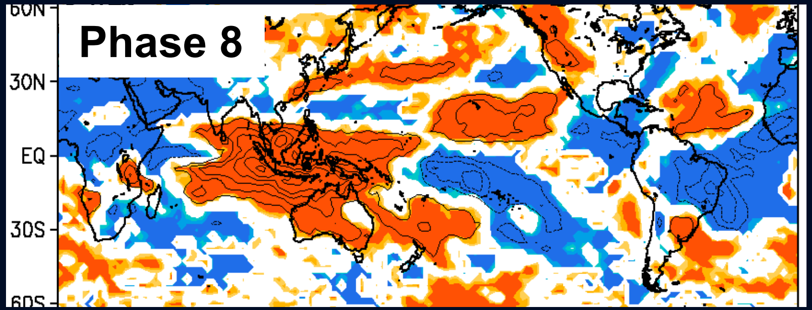




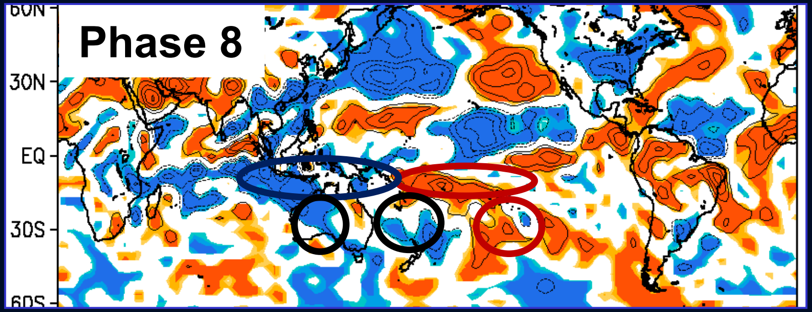
(Grimm 2018, submitted)

Tropics-extratropics teleconnection to South America

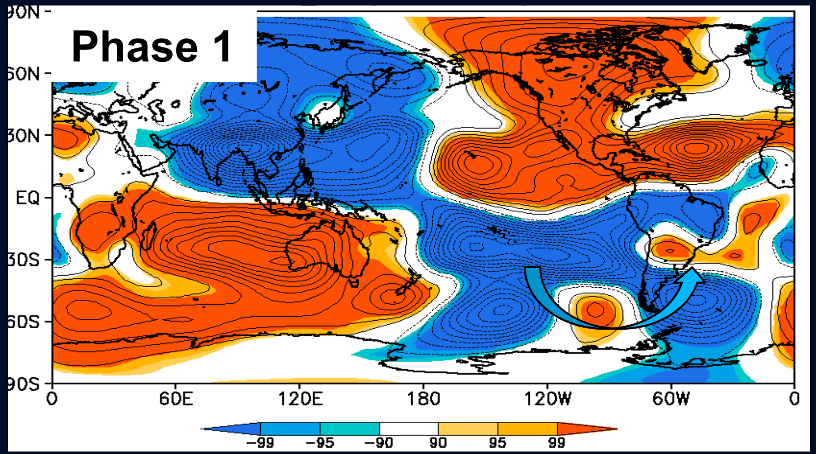
OLR anomalies

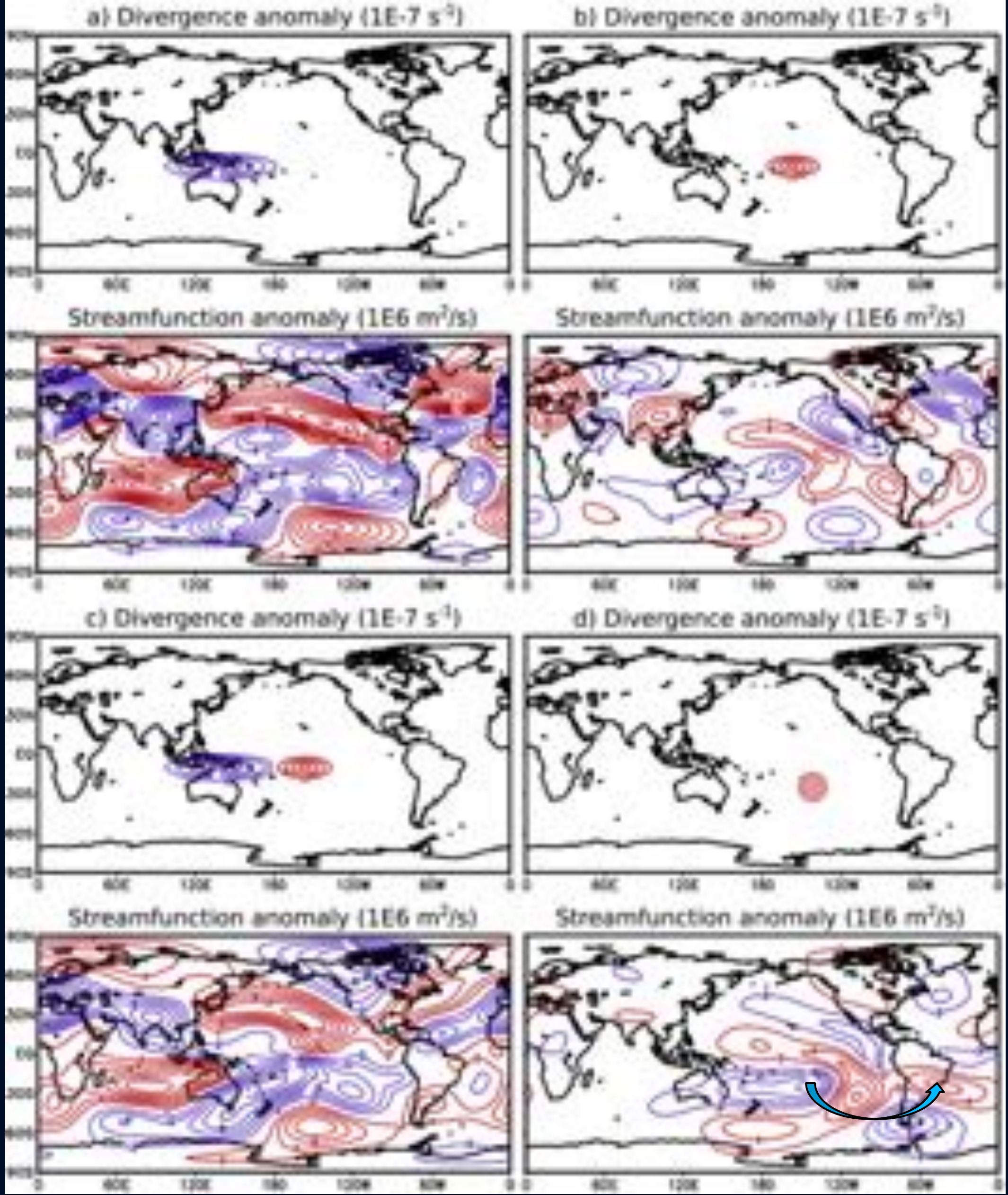


200 hPa divergence anomalies



Streamfunction 200 hPa





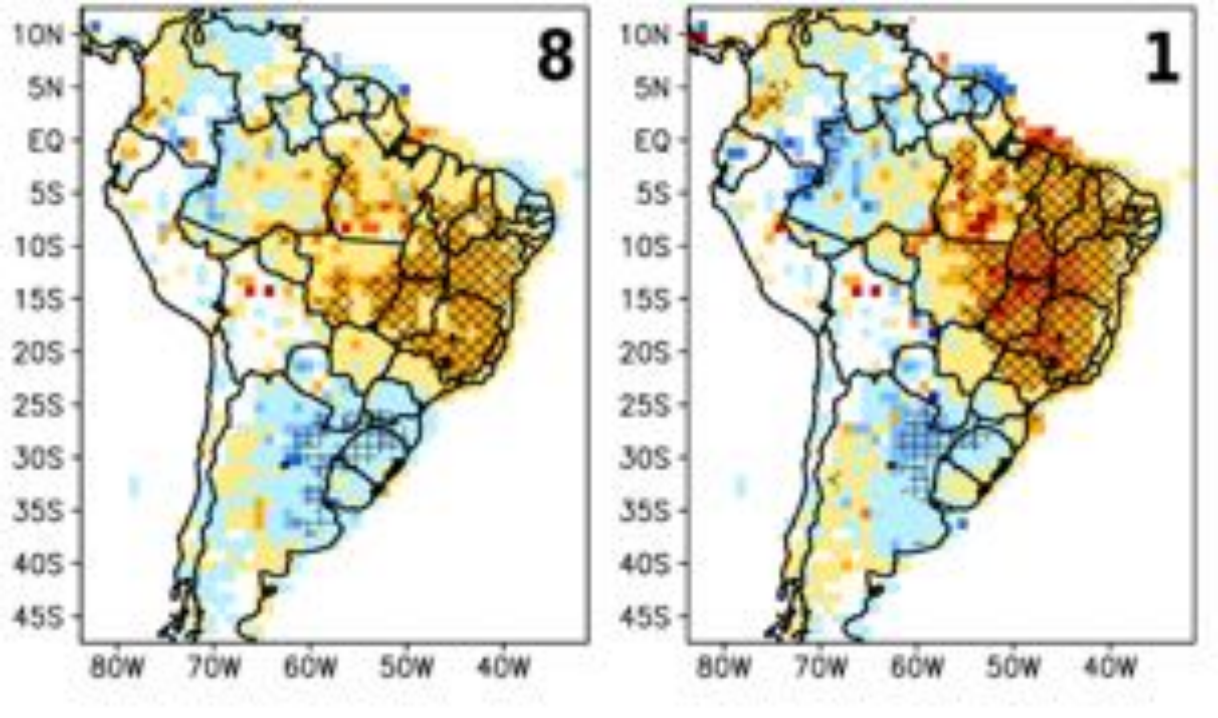
(Grimm, 2018, submitted)

1. Impacts of the MJO on the South American Monsoon

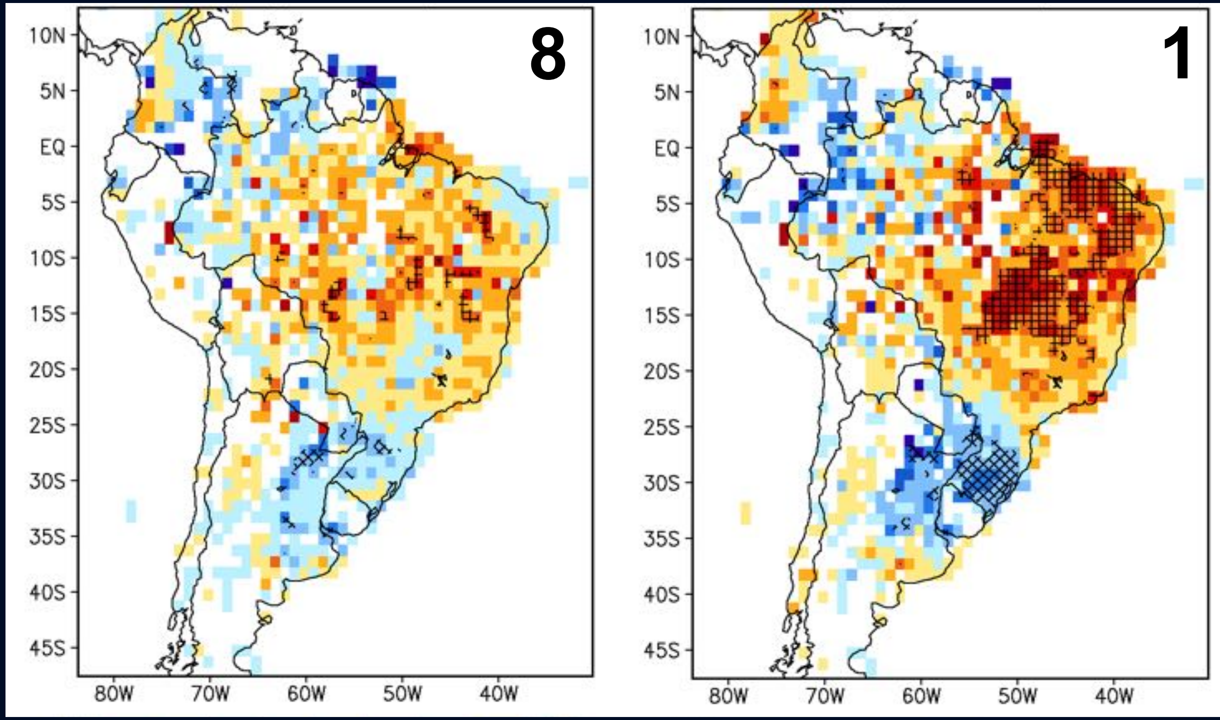
1b. More recent period 1999-2010 (S2S common period)

South America summer
MJO-related daily precipitation anomalies

1979-2009



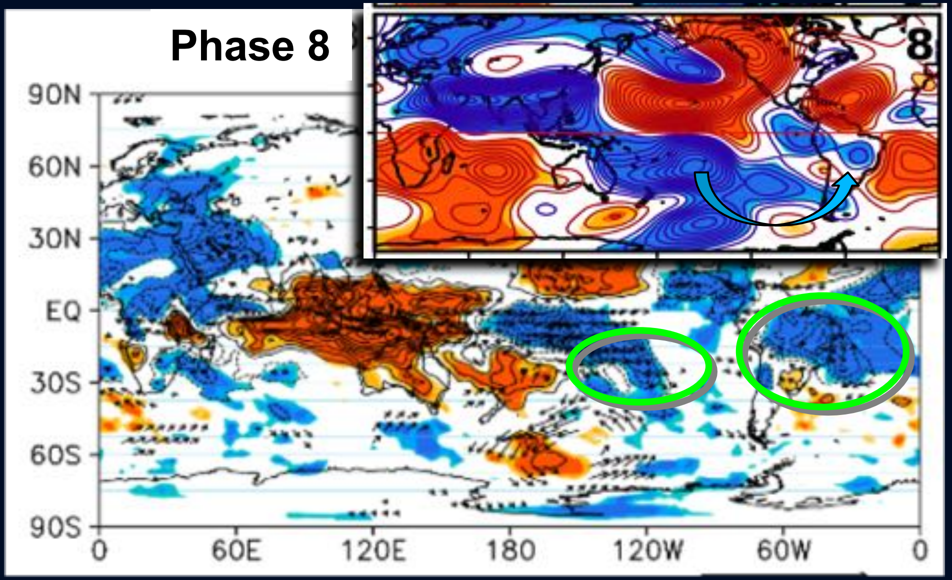
1999-2010

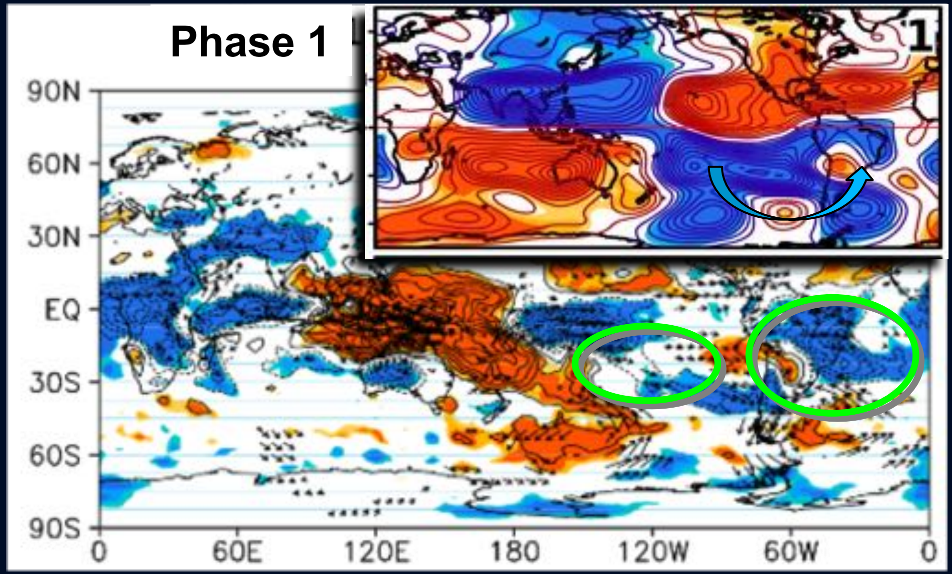


The main features of the MJO impact on SA are the same in 1979-2000 and in 1999-2010, the common period of the S2S reforecasts analized in this study.

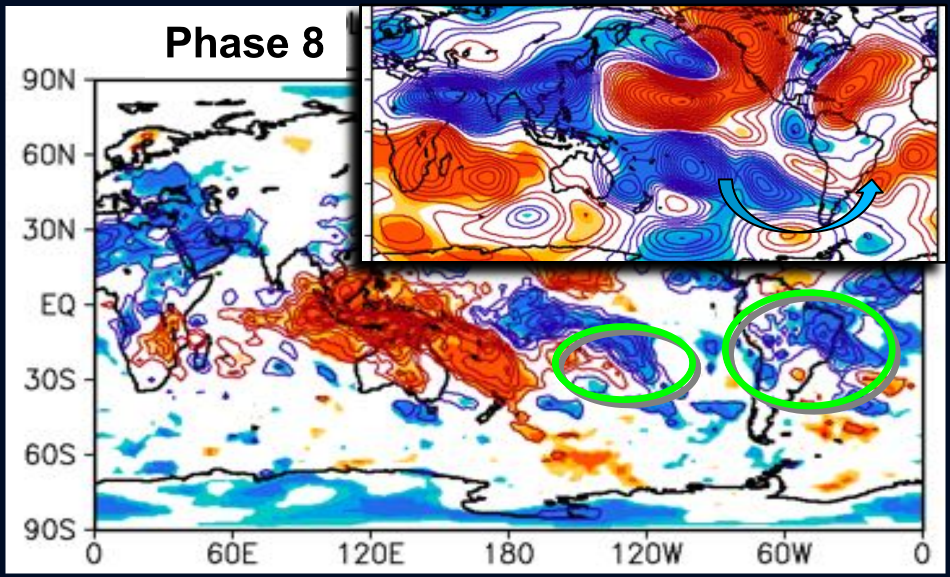
South America summer MJO-related OLR anomalies

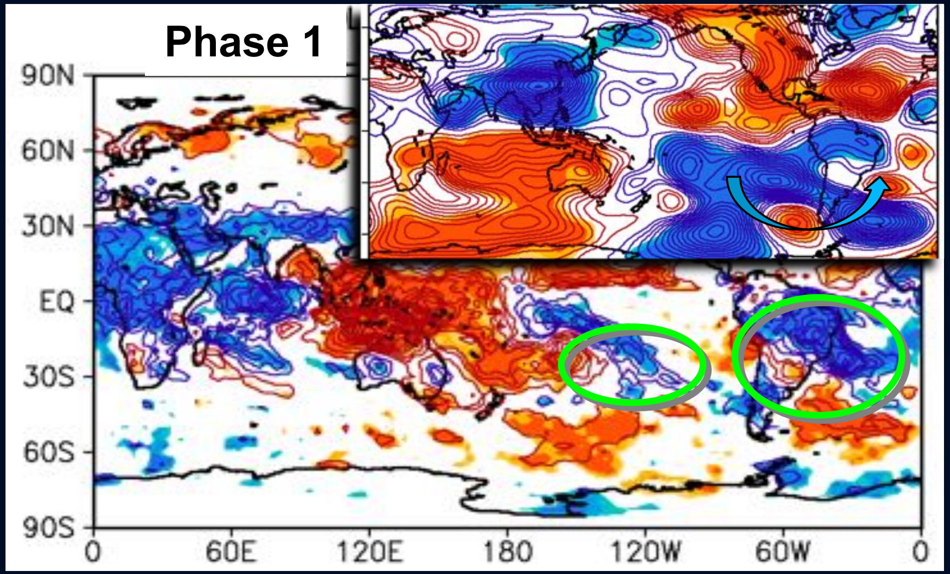
1979-2009





1999-2010





2. Skill of S2S models in simulating the MJO and its teleconnections to South America

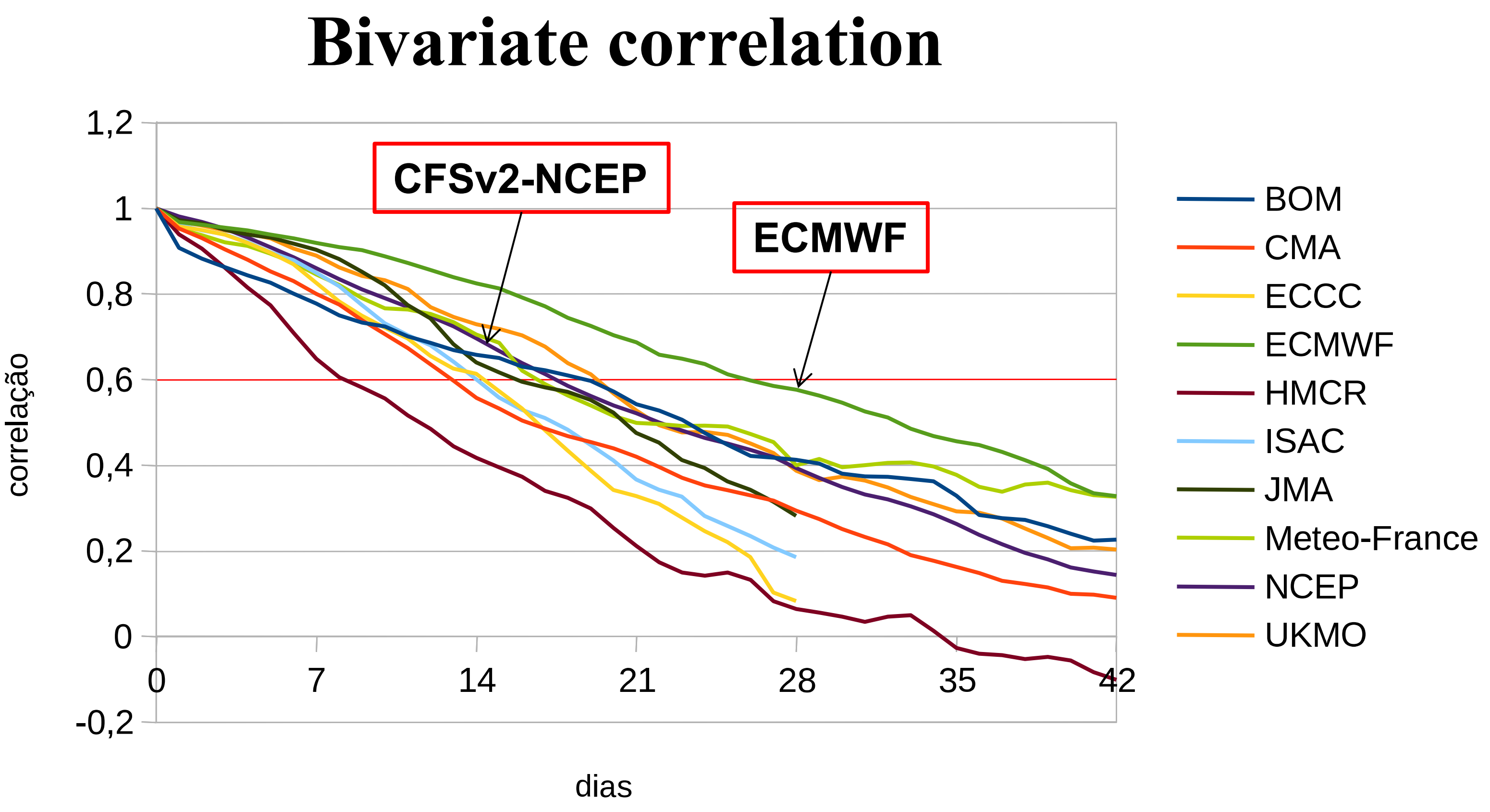
Evaluation of the skill to predict the MJO
(Lin et al., 2008):

1) Bivariate correlation between analysis and forecast RMM1 and RMM2. Consider that forecast is skilfull for values above 0.5 (Vitart et al, 2010).

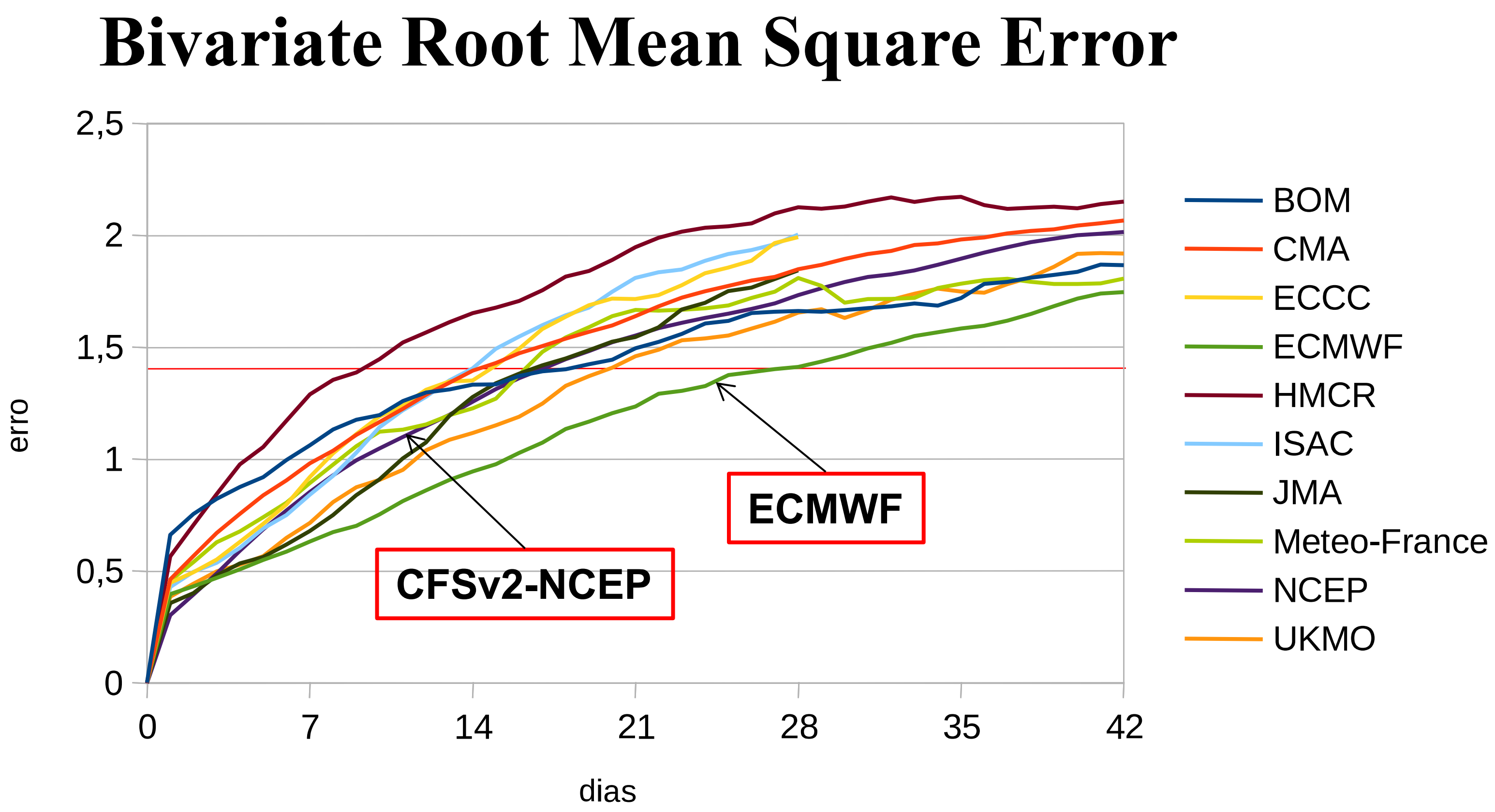
2) Bivariate Root Mean Square Error between analysis and forecast RMM1 and RMM2.

3) Common period: 1999-2010.

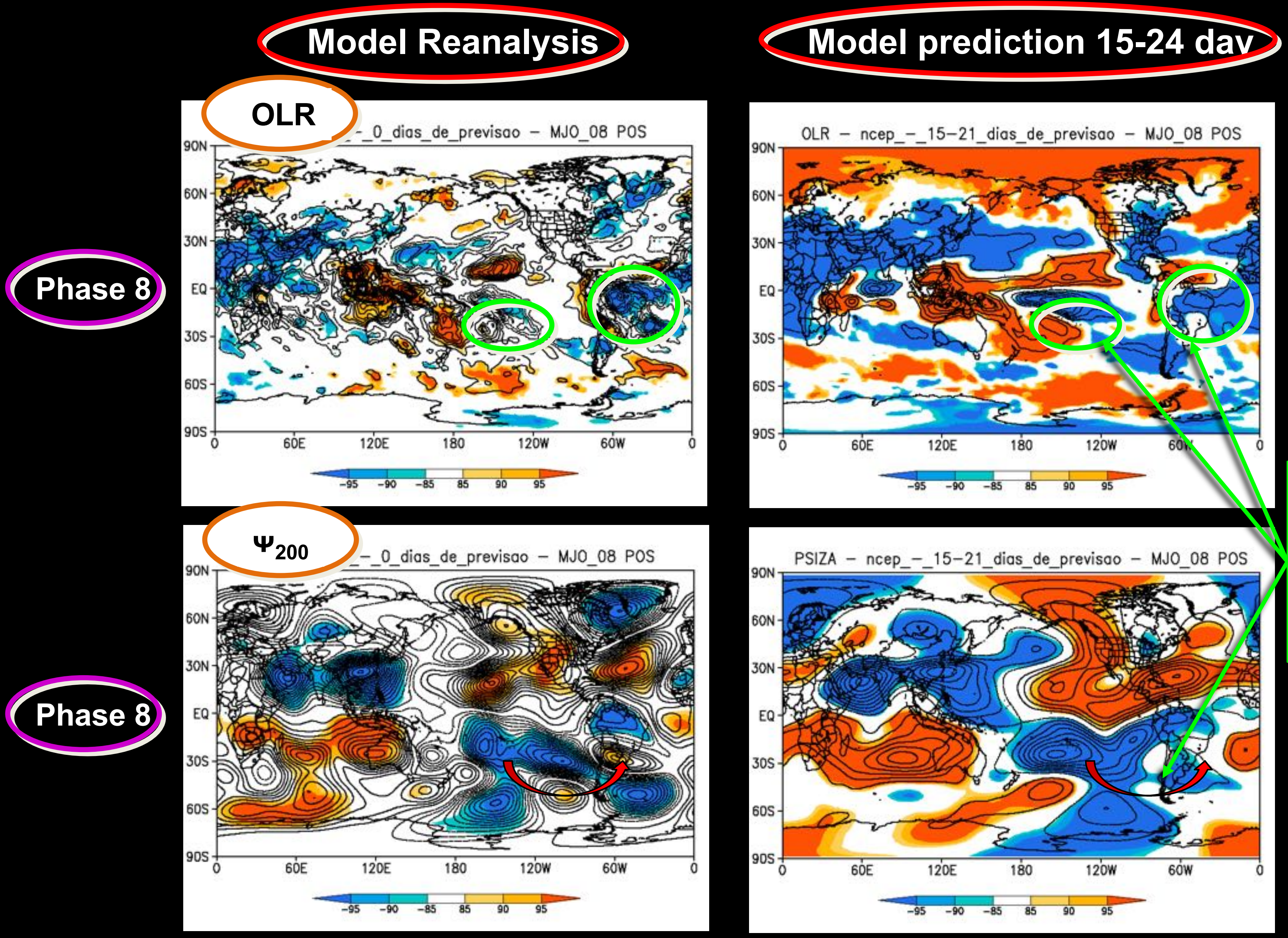
Results


Bivariate correlation
CFSv2-NCEP
ECMWF
1,2
1
0,8
0,6
0,4
0,2
0
-0,2
correlação
0
7
14
21
28
35
42
dias
BOM
CMA
ECCC
ECMWF
HMCR
ISAC
JMA
Meteo-France
NCEP
UKMO

Results


Bivariate Root Mean Square Error
2,5
2
1,5
1
0,5
0
erro
0
7
14
21
28
35
42
dias
CFSv2-NCEP
ECMWF
BOM
CMA
ECCC
ECMWF
HMCR
ISAC
JMA
Meteo-France
NCEP
UKMO

MJO - Model CFS v2



- Mixed signal in subtropical Central Pacific
- Weaker teleconnection
- Weaker or no response in SACZ

MJO - Model CFS v2

Model Reanalysis

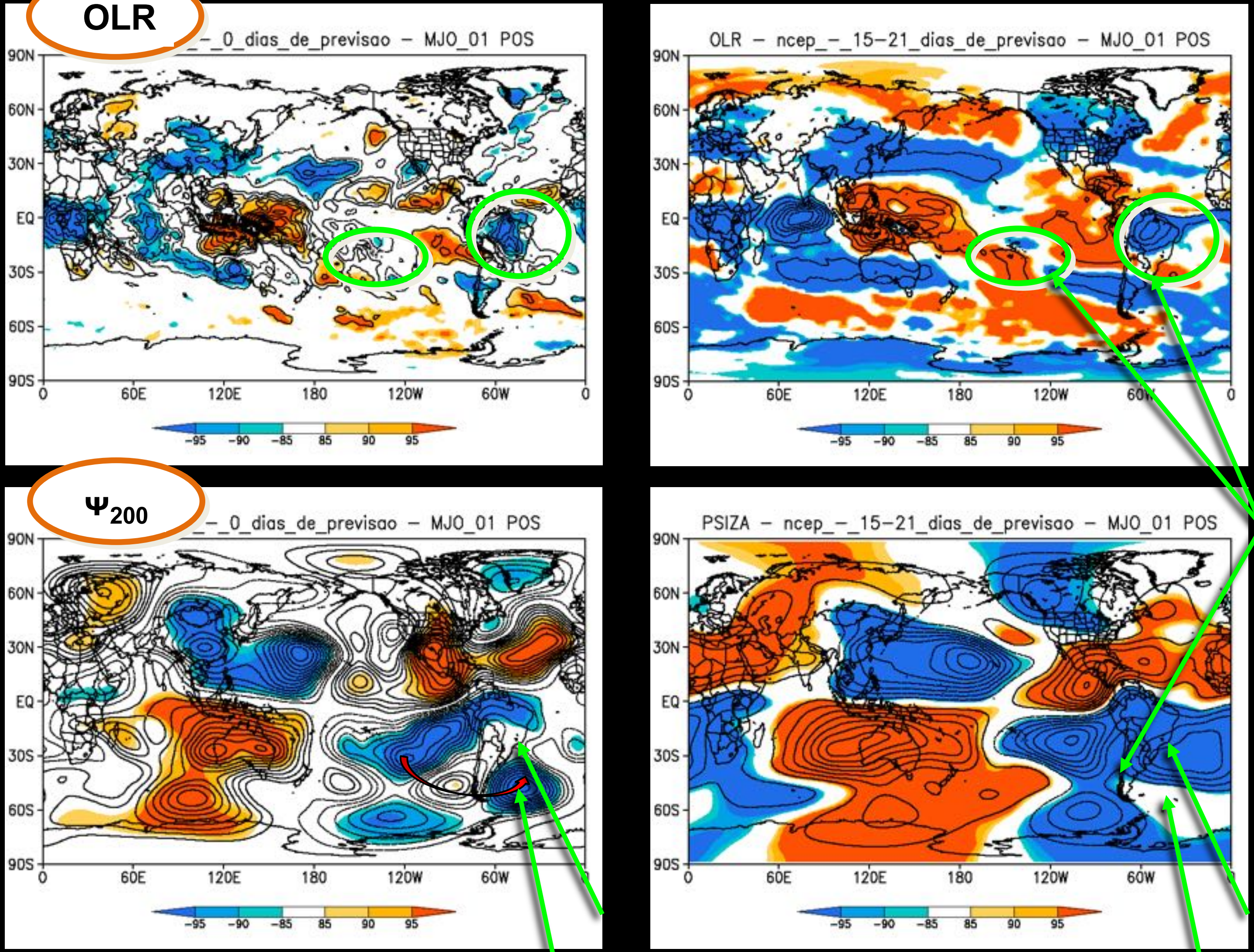
Model prediction 15-24 day

OLR

Phase 1

Ψ_{200}

Phase 1

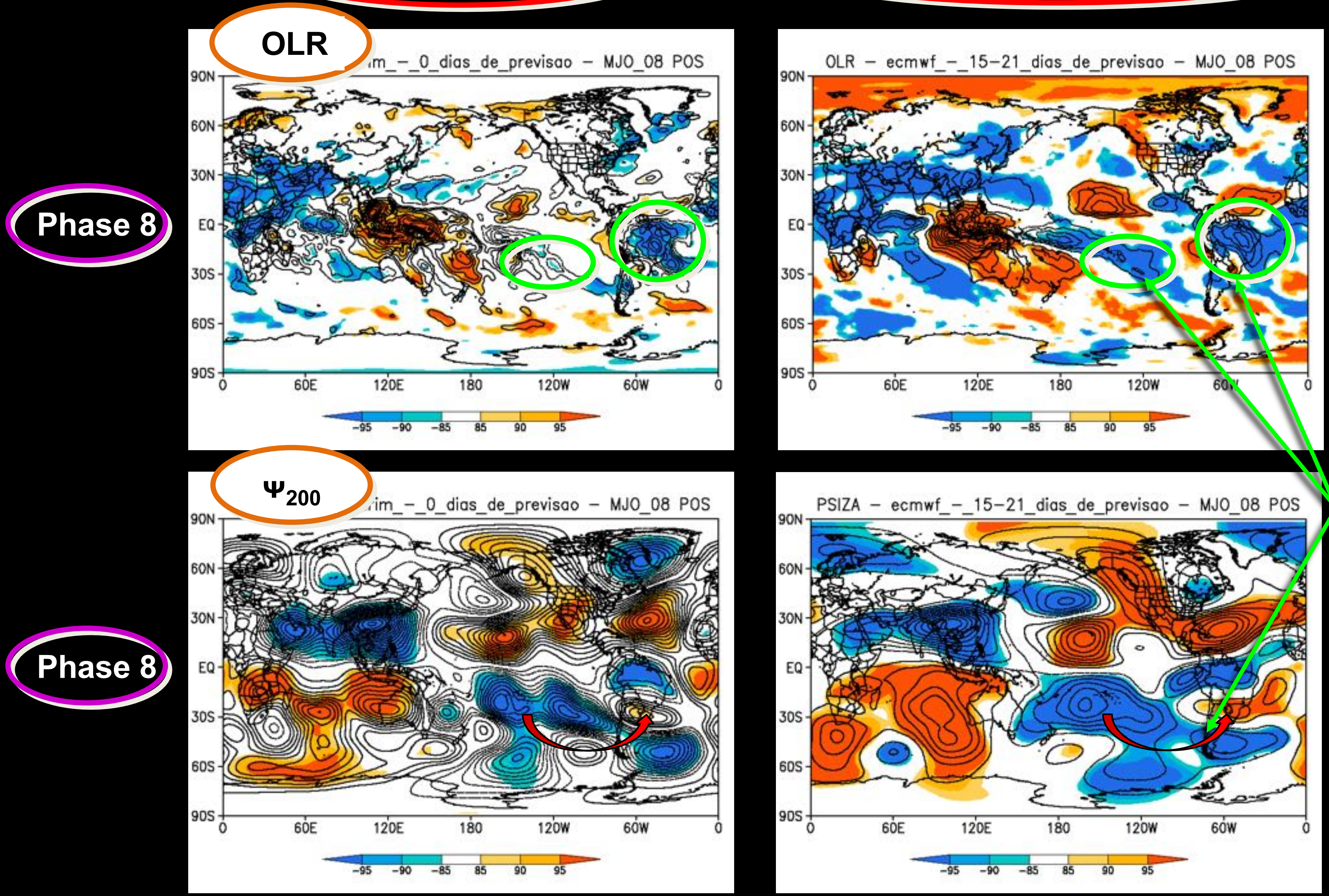


- Opposite signal in subtropical Central Pacific
- Different teleconnection
- Inverted or no response in SACZ

MJO - Model ECMWF

Model Reanalysis

Model prediction 15-21 day



- Right signal in subtropical Central Pacific
- Strong teleconnection
- Strong response in SACZ

MJO - Model ECMWF

Model Reanalysis

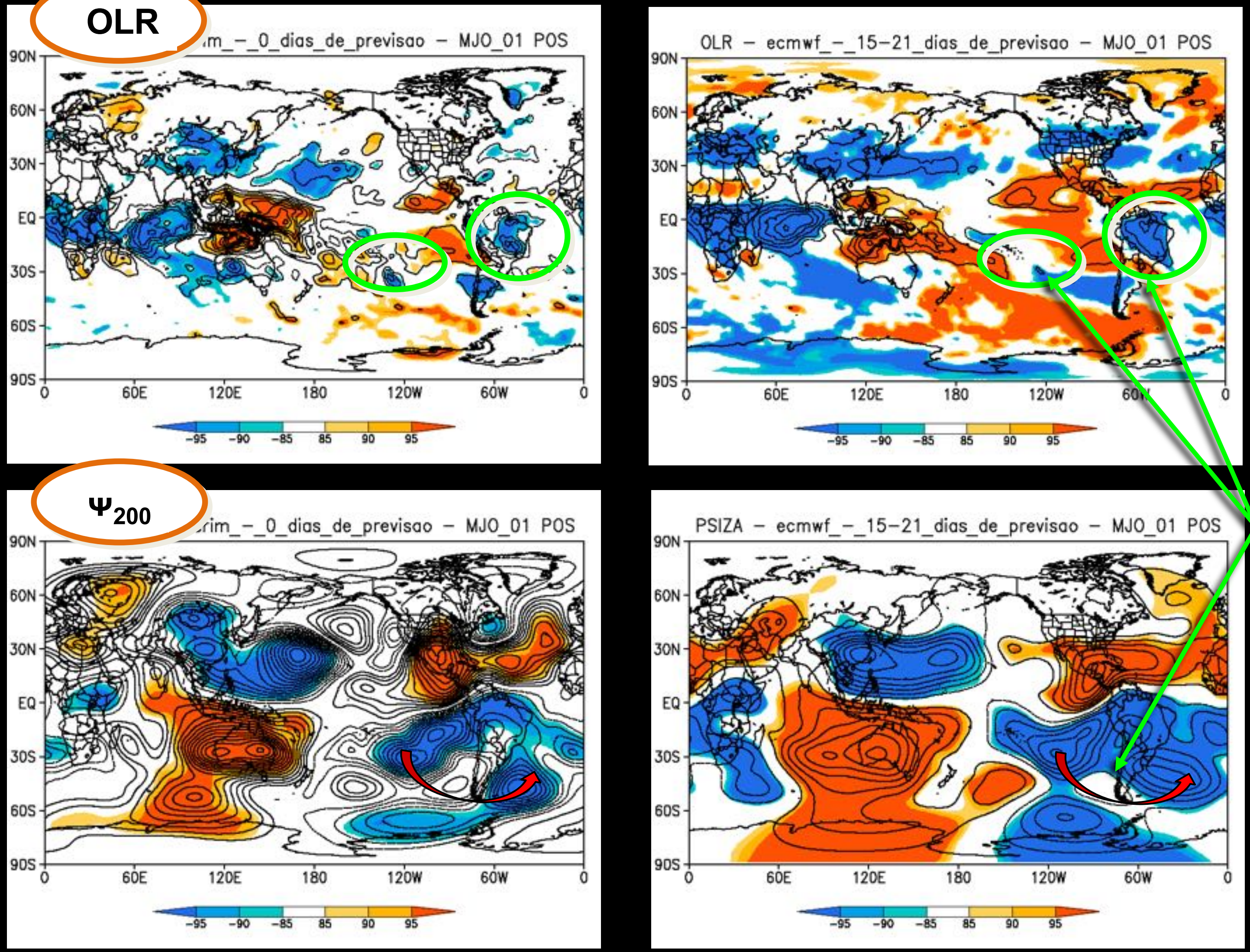
Model prediction 15-24 day

OLR

Phase 1

Ψ_{200}

Phase 1

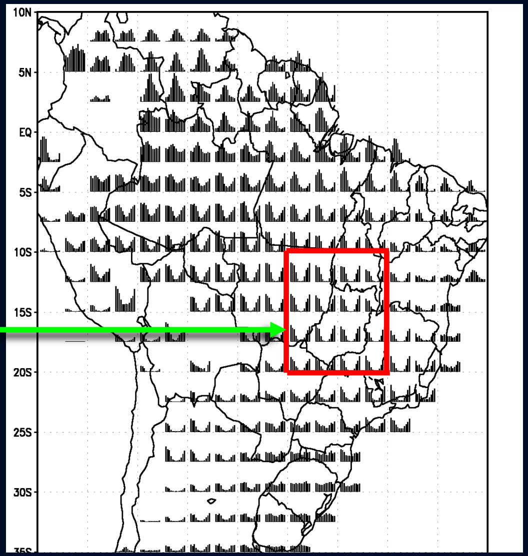


- Weak signal in subtropical Central Pacific
- Weak teleconnection
- Weak response in SACZ

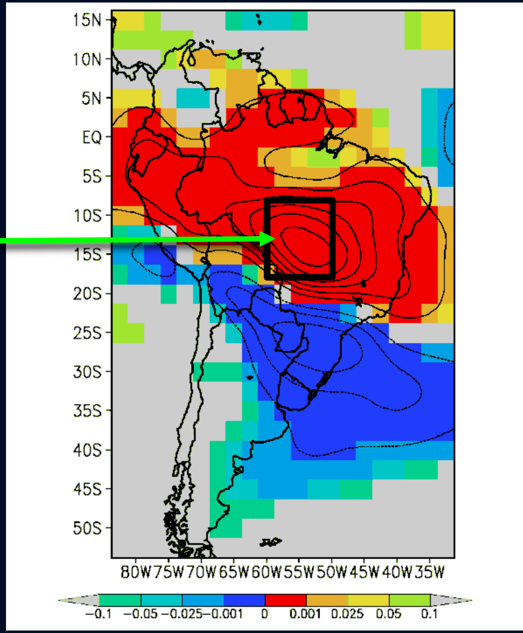
3. Active and break phases of the South American monsoon and the influence of the MJO

Monsoon variability indexes in SA

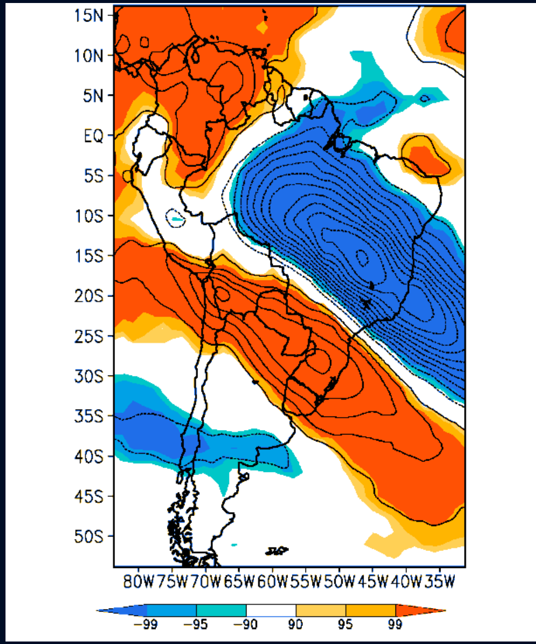
Precipitation Index



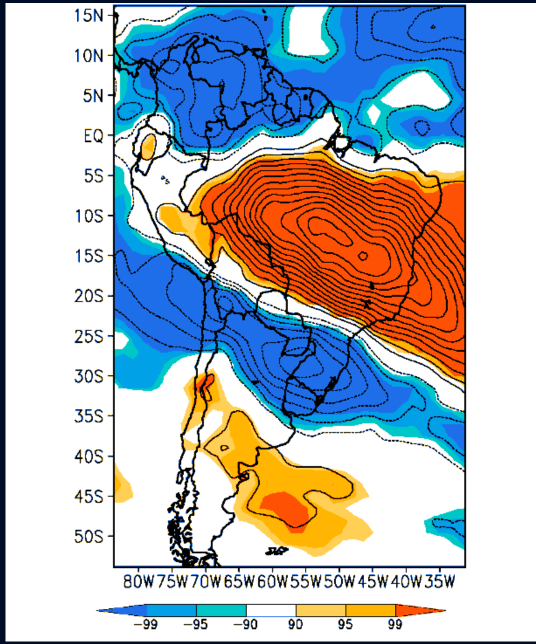
U_{850} Index



Composite OLR anomalies
Active monsoon days



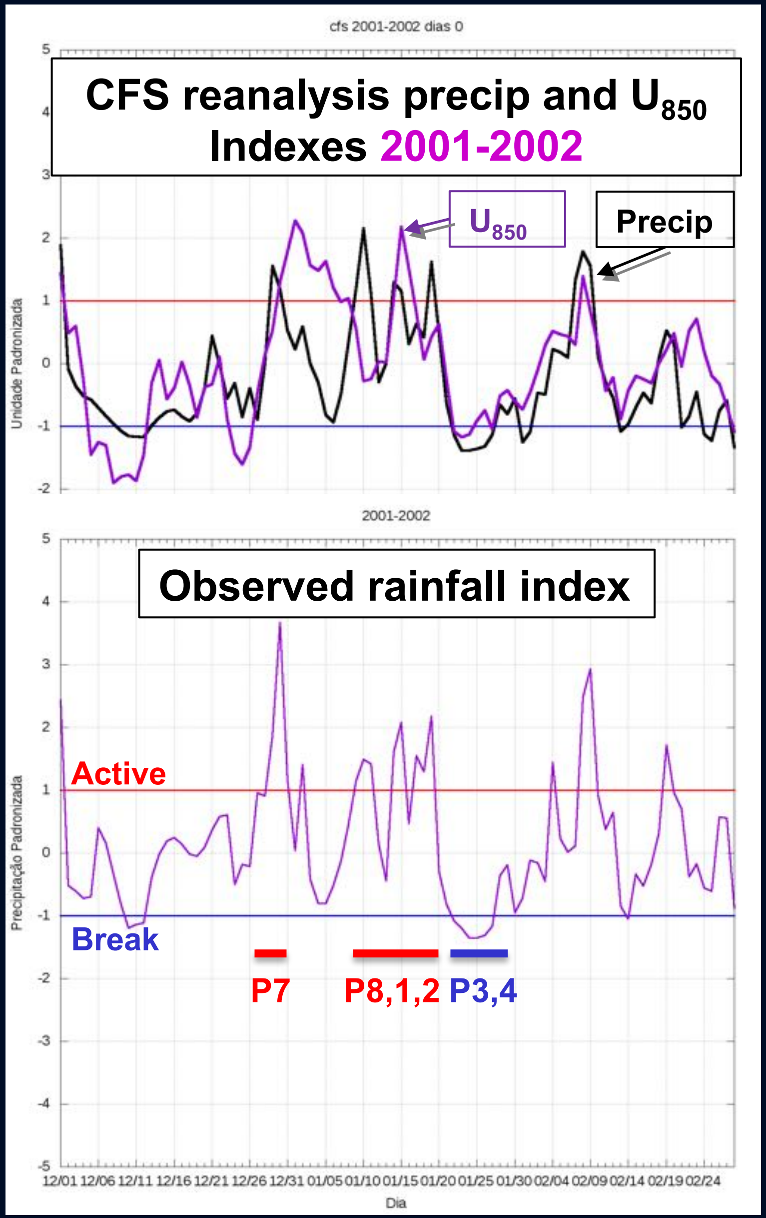
Composite OLR anomalies
Break monsoon days

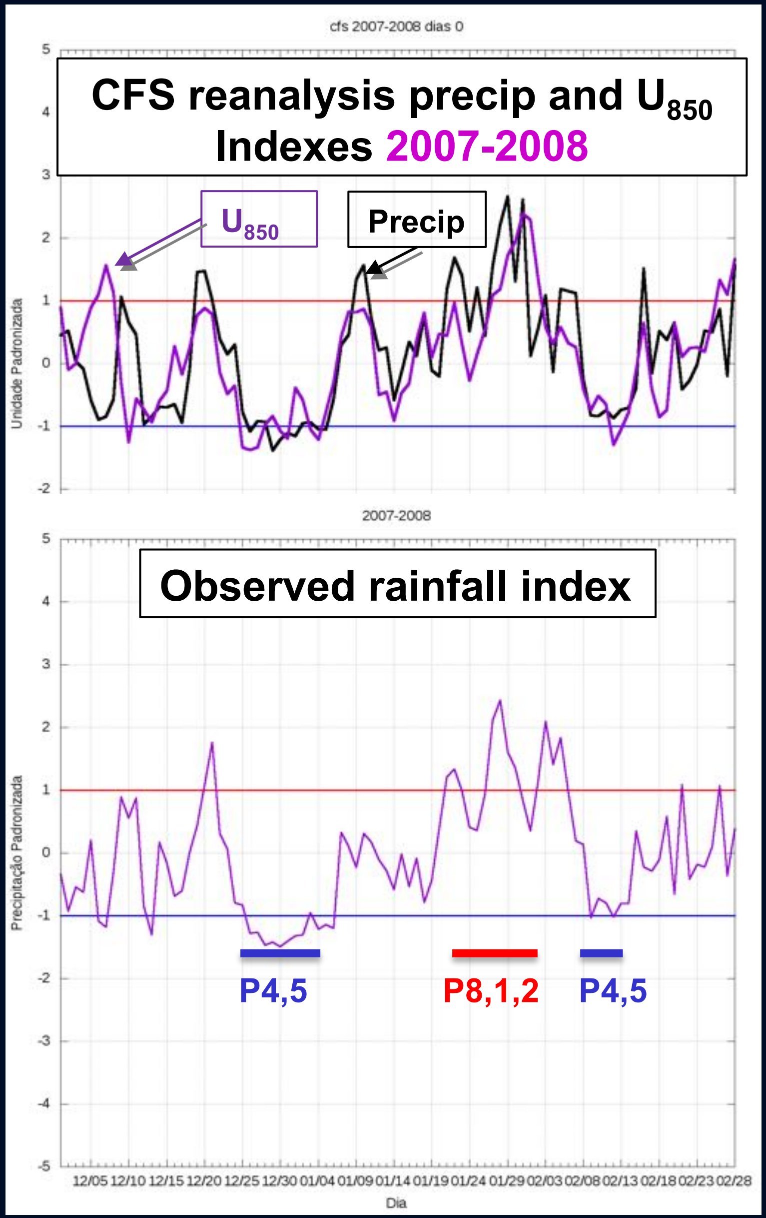


The precipitation index also represents well the first intraseasonal mode of variability during the summer

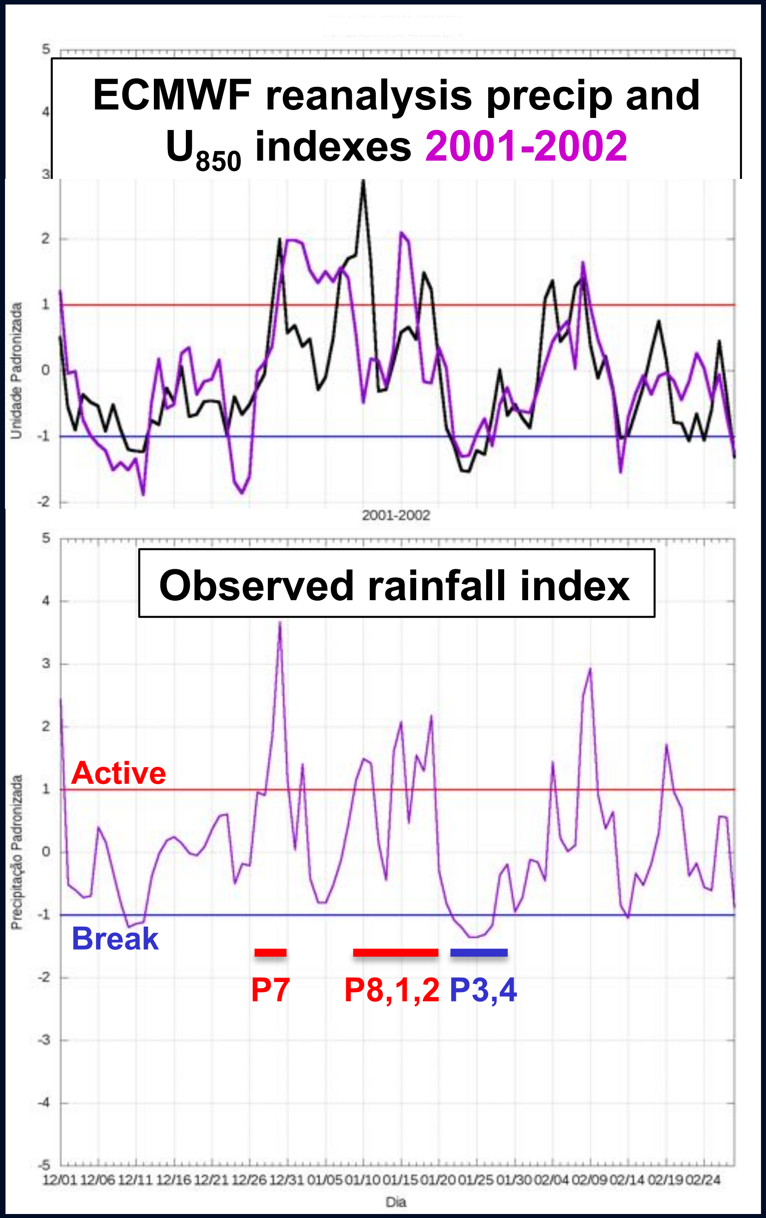
Correlation between the monsoon precipitation index and zonal wind at 850 hPa.

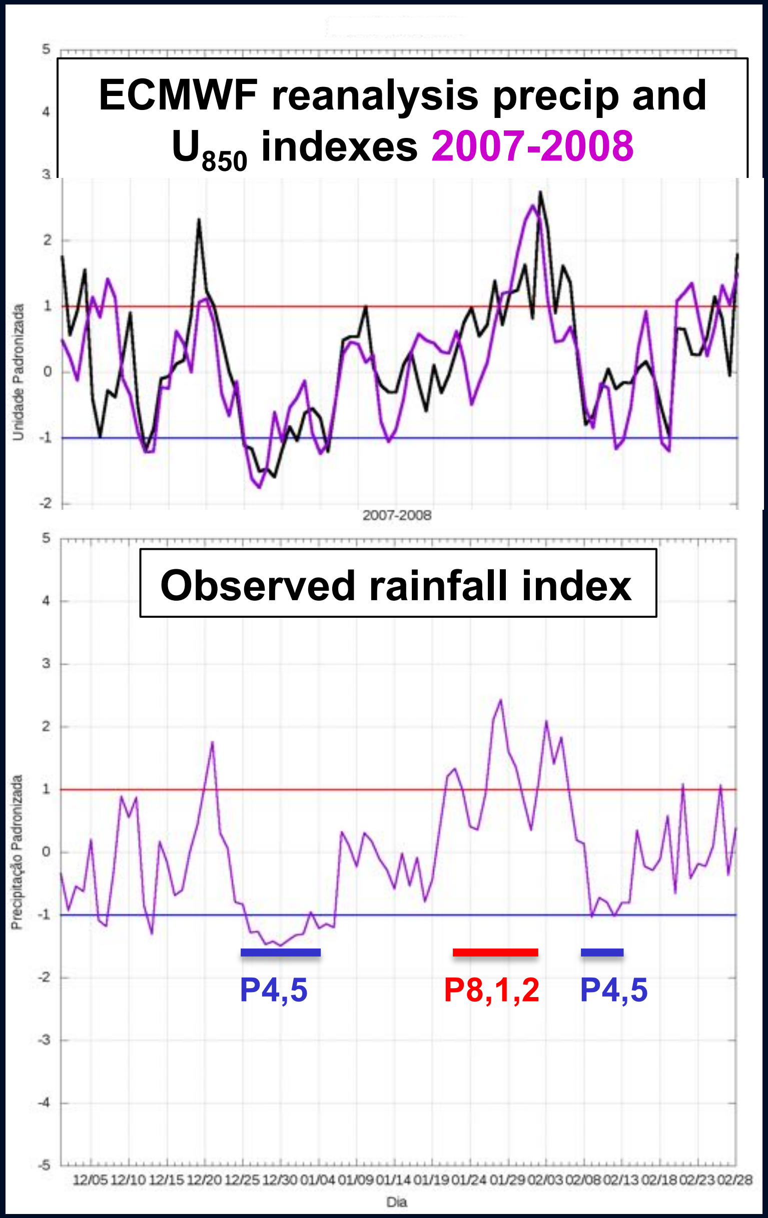
Indexes of monsoon variability in SA





Indexes of monsoon variability in SA

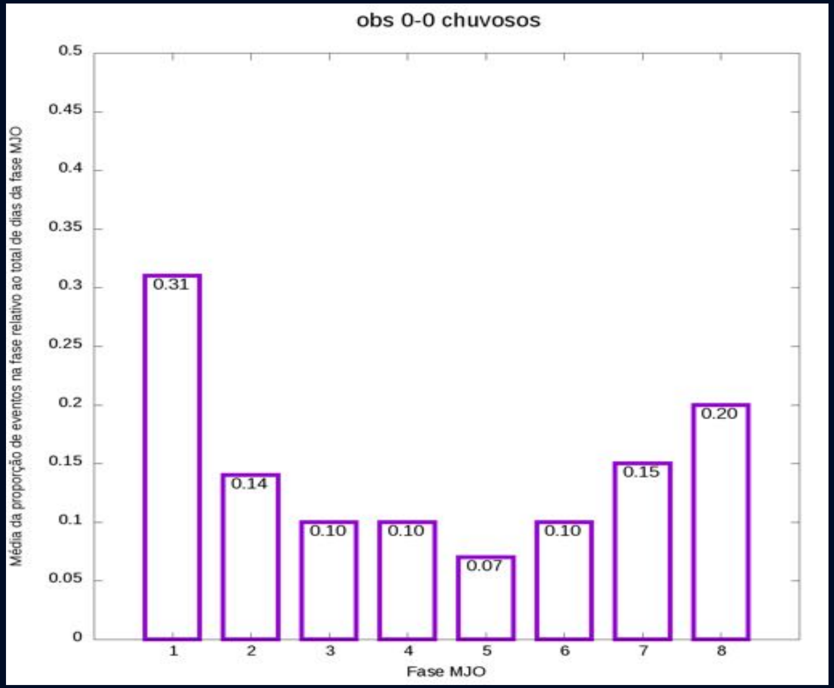


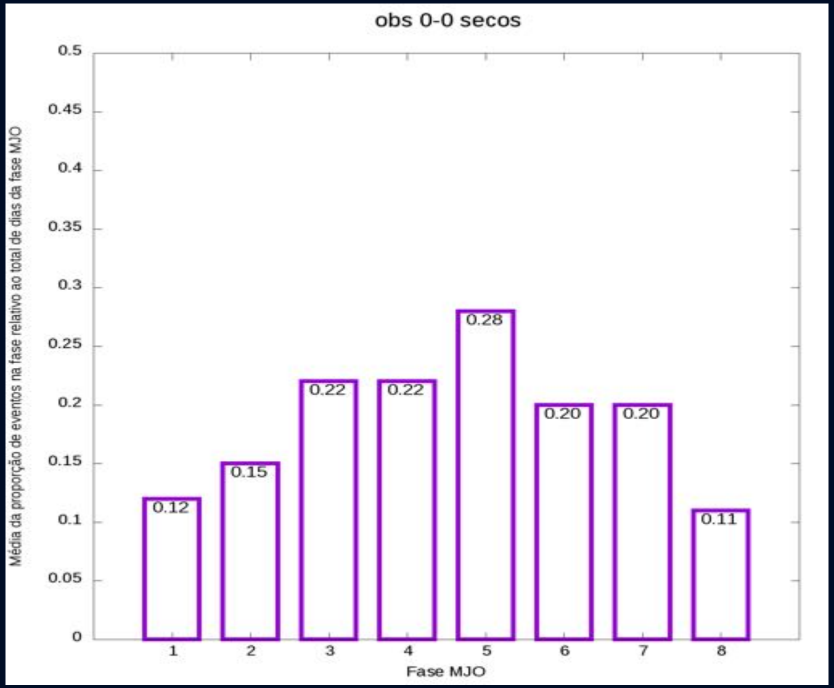


Observed association with MJO

What is the proportion of <u>active monsoon days</u> in each MJO phase?

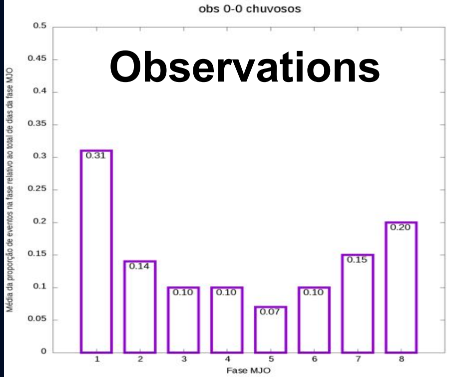
What is the proportion of <u>break monsoon days</u> in each MJO phase?



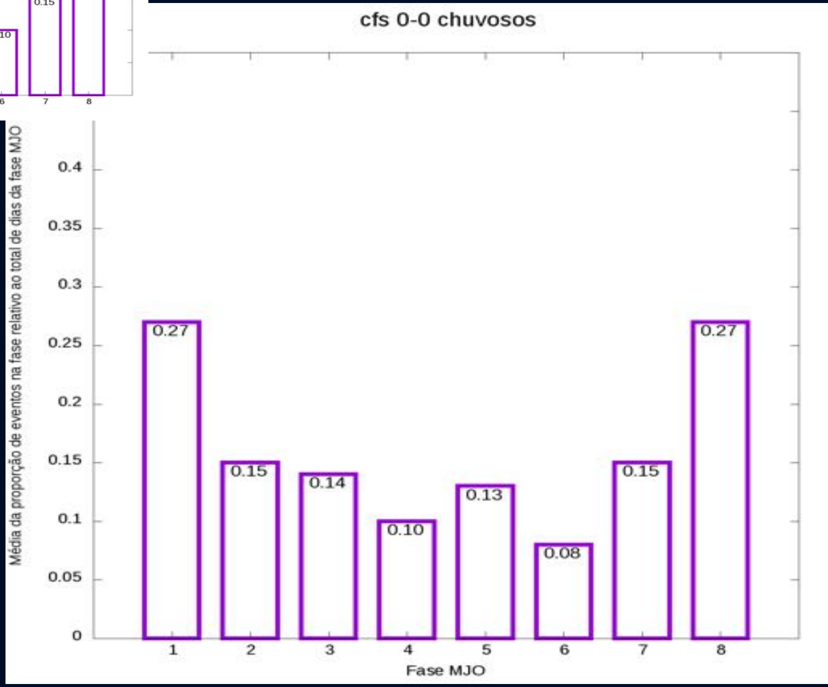


CFSv2: Reanalysis and simulated association with MJO

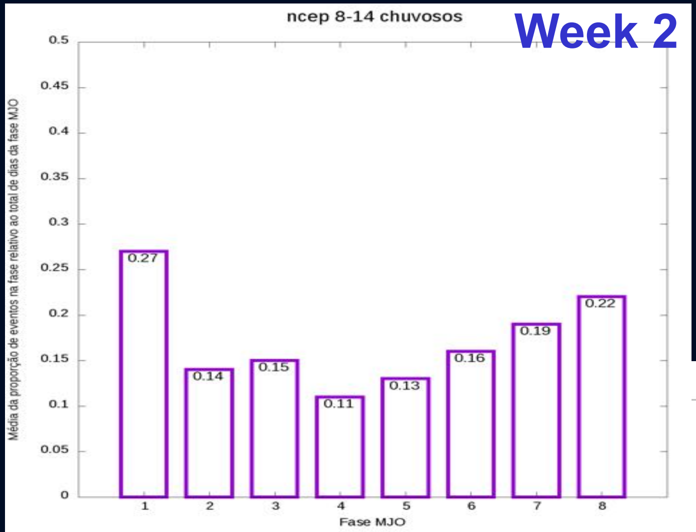
What is the proportion of <u>active monsoon days</u> in each MJO phase?

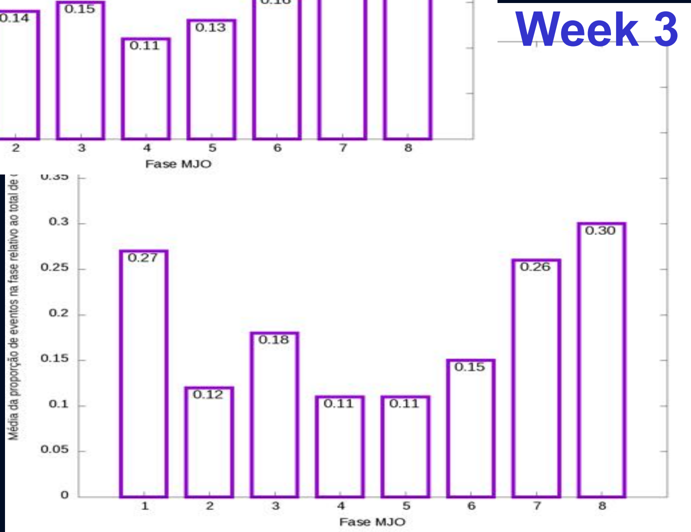


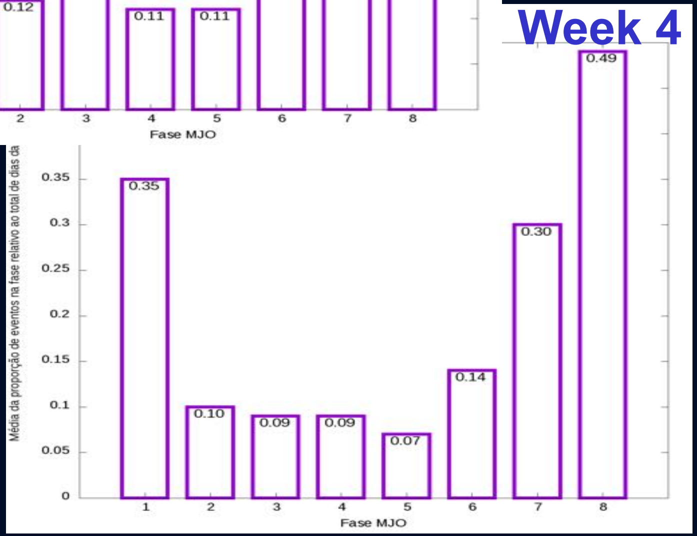
Reanalysis CFSv2



Reforecasts CFSv2

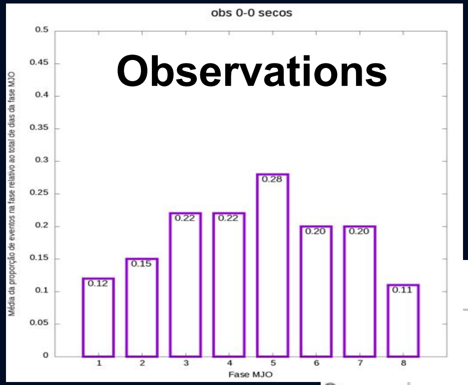




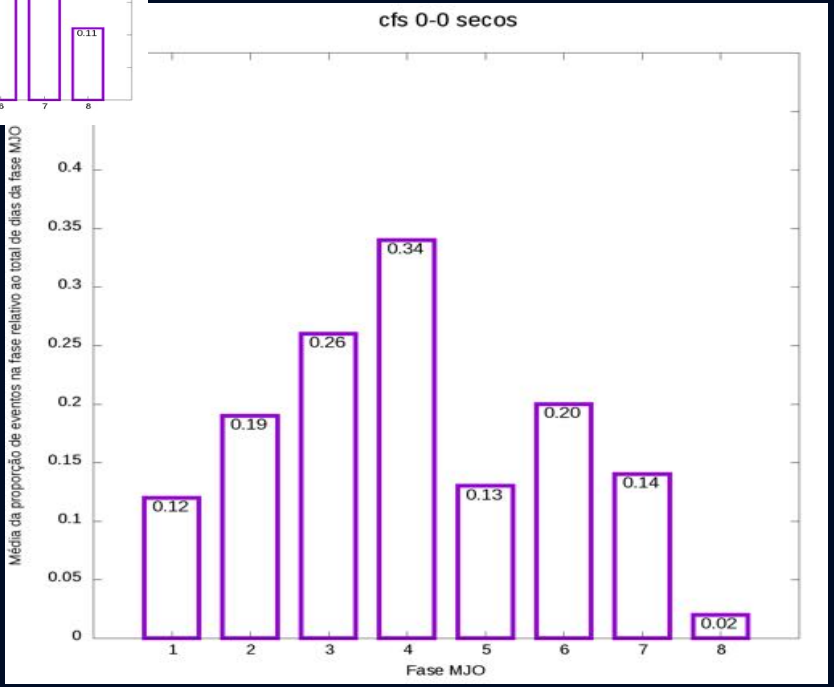


CFSv2: Reanalysis and simulated association with MJO

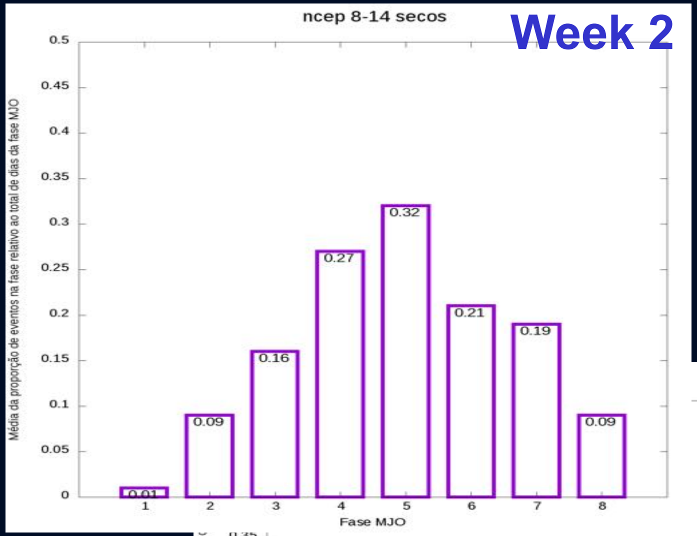
What is the proportion of <u>break monsoon days</u> in each MJO phase?

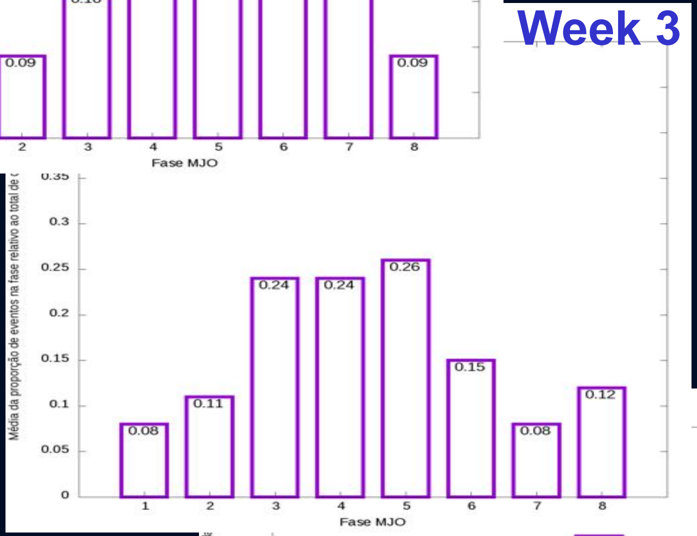


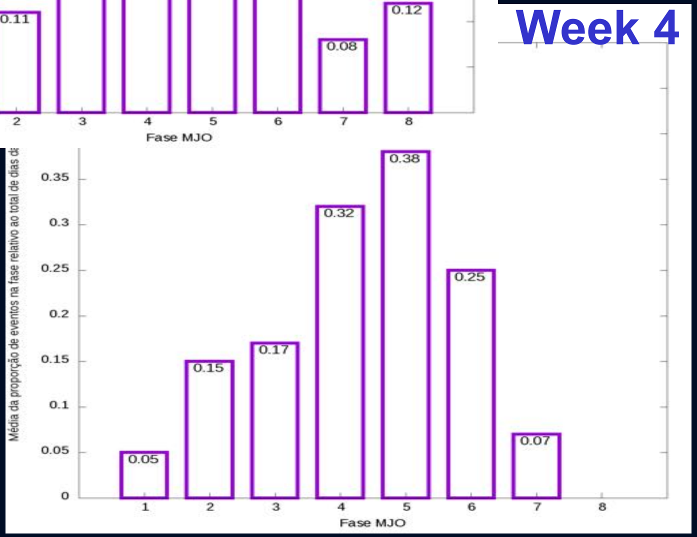
Reanalysis CFSv2



Reforecasts CFSv2

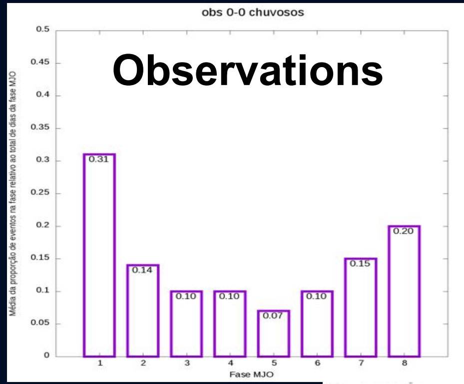




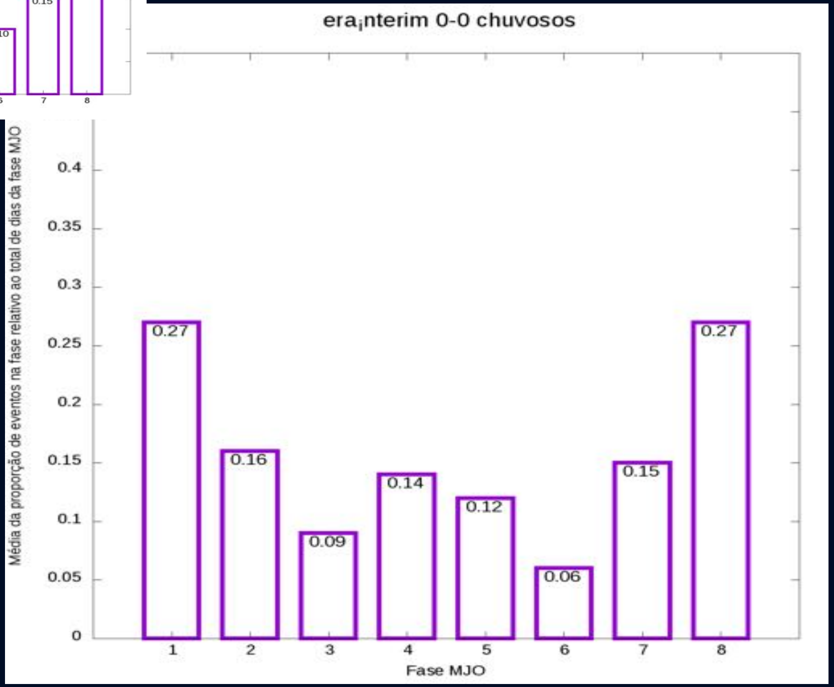


ECMWF: Reanalysis and simulated association with MJO

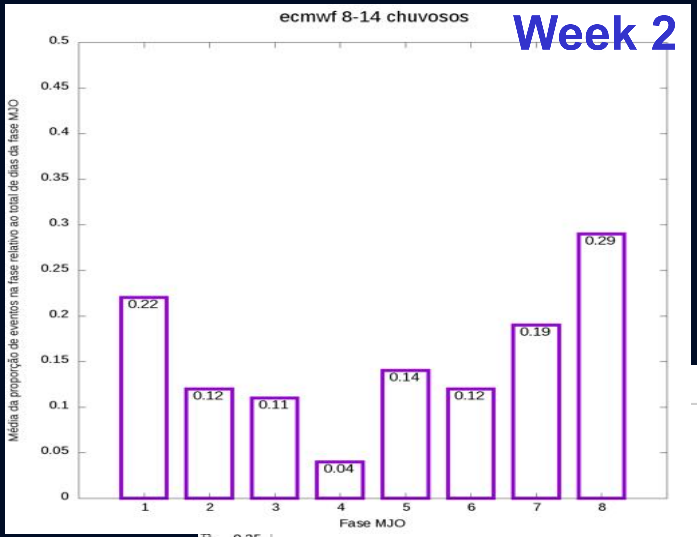
What is the proportion of <u>active monsoon days</u> in each MJO phase?

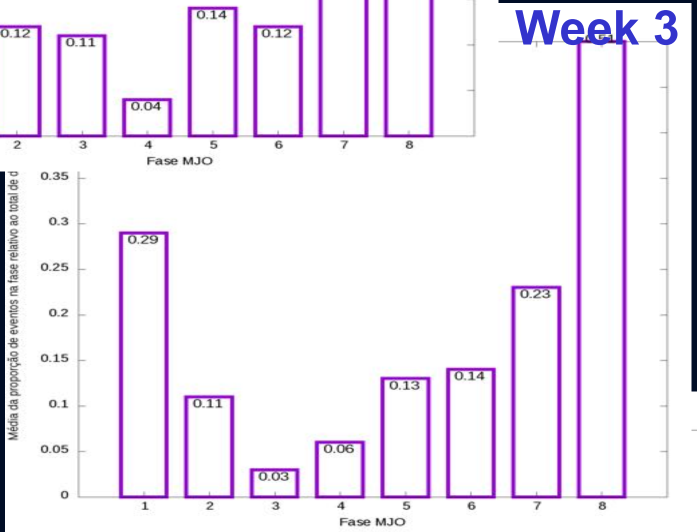


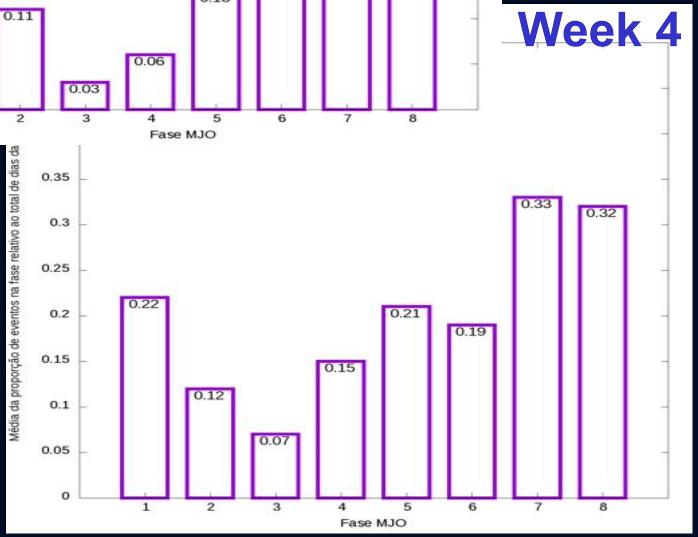
Reanalysis ECMWF



Reforecasts ECMWF

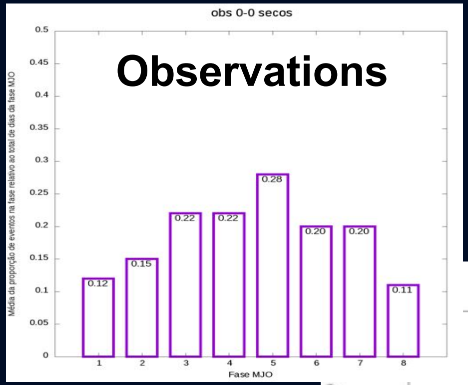




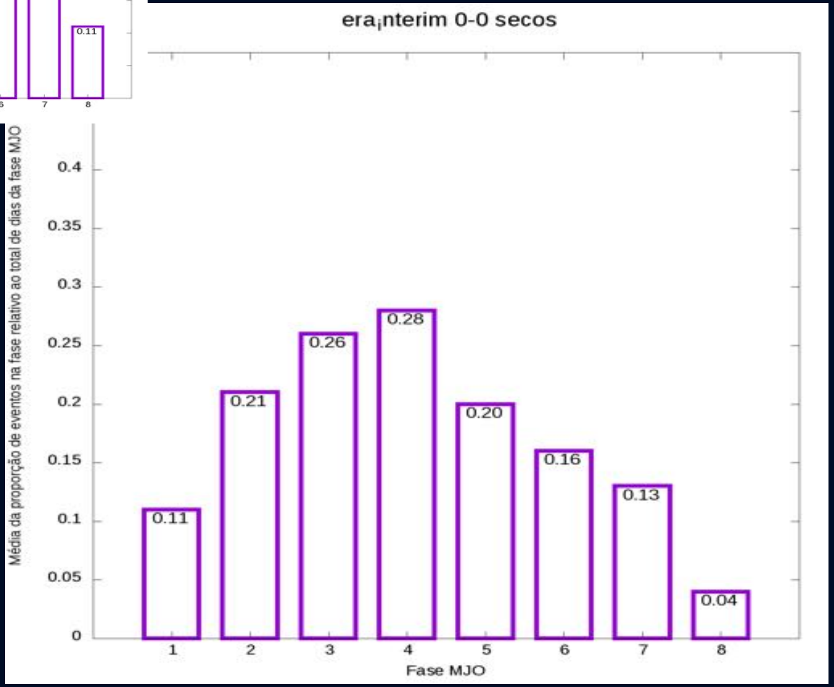


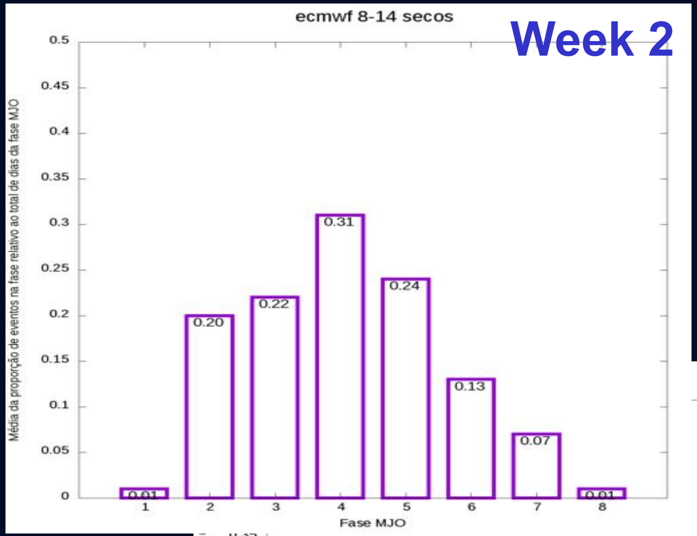
ECMWF: Reanalysis and simulated association with MJO

What is the proportion of <u>break monsoon days</u> in each MJO phase?

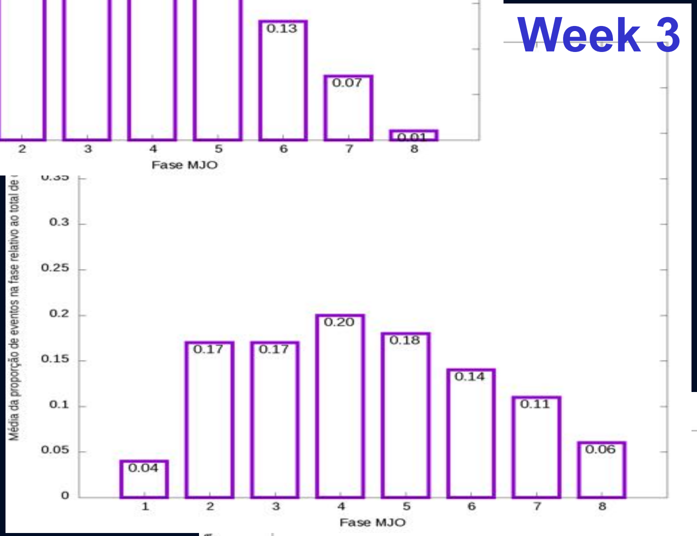


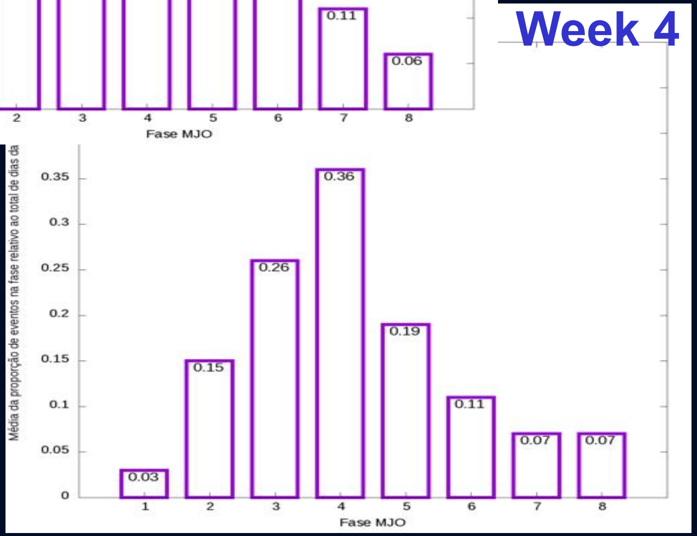
Reanalysis ECMWF





Reforecasts ECMWF





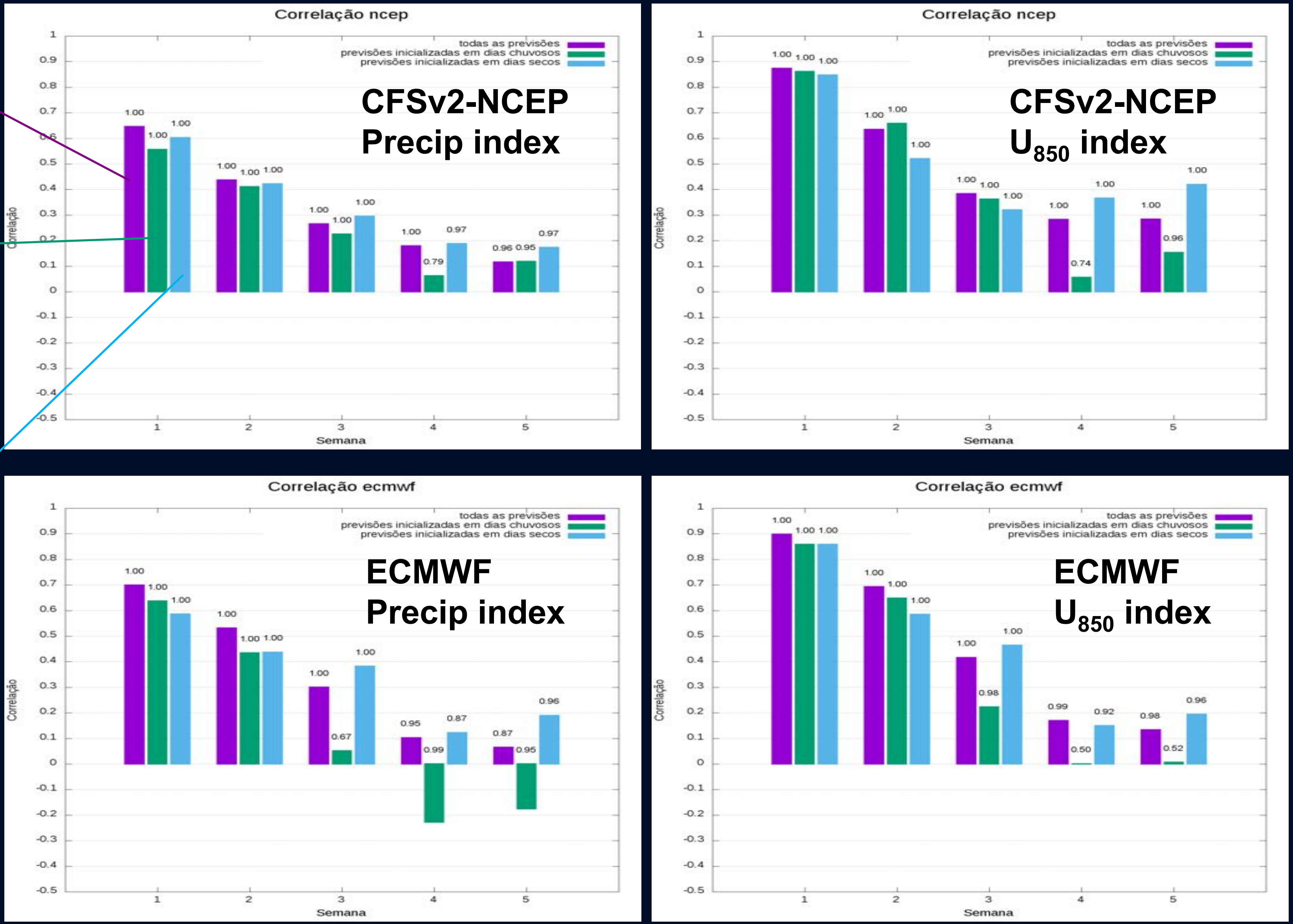
4. Subseasonal prediction of South American summer monsoon indexes

Correlation skill for prediction of the weekly mean monsoon indexes

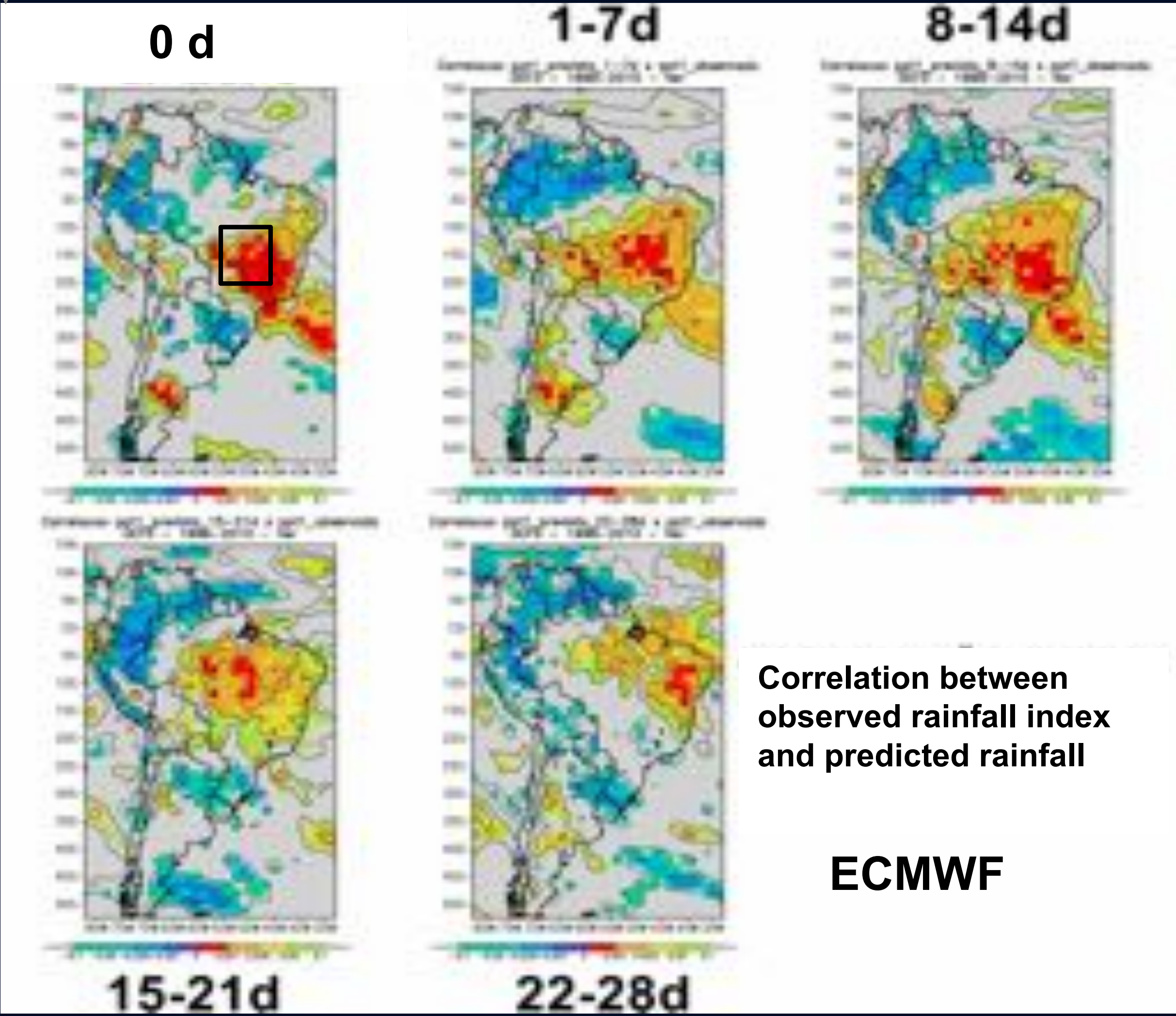
All Forecasts

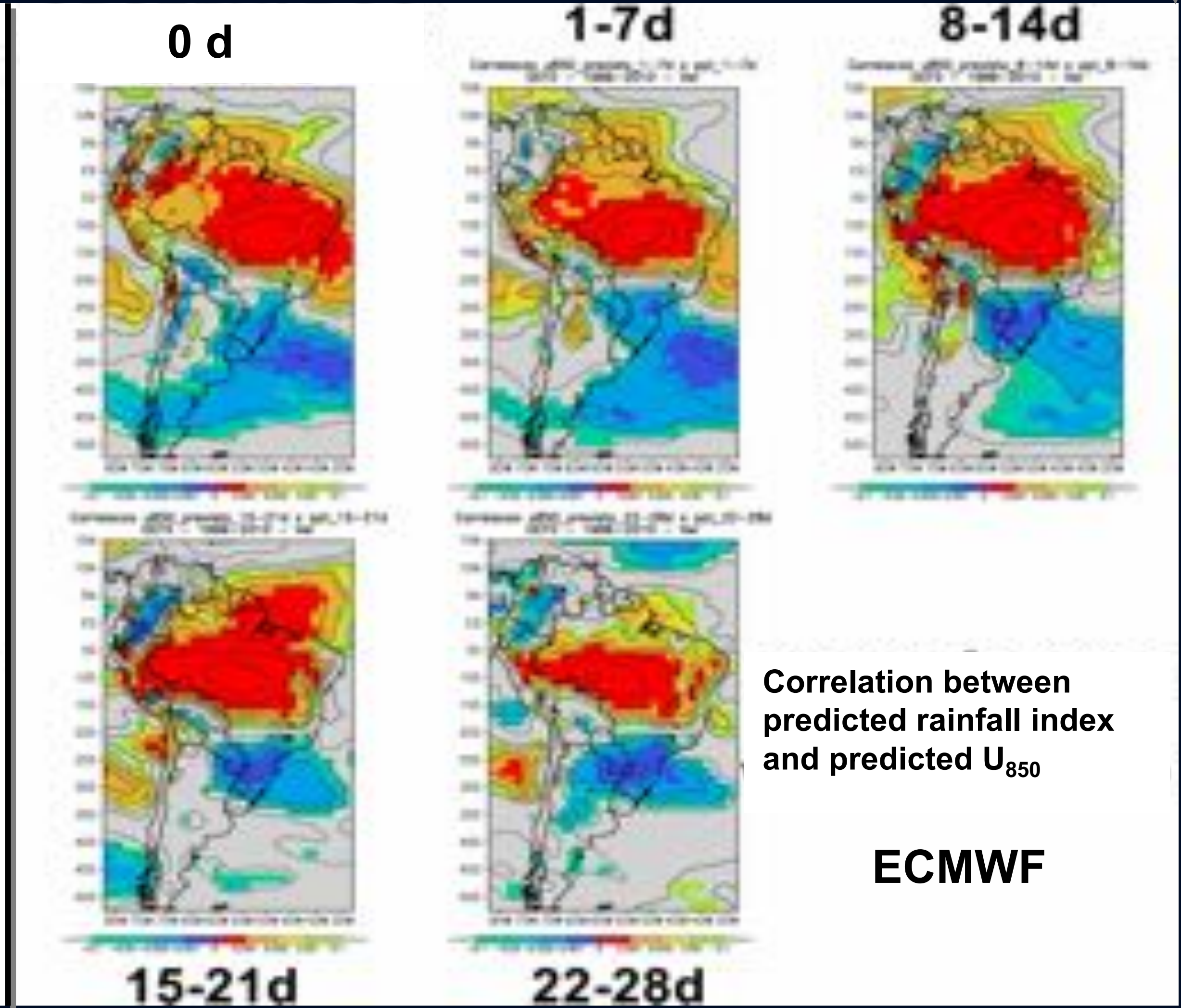
Forecasts initialized only on monsoon active days

Forecasts initialized only on monsoon break days



Correlation between observed rainfall index and predicted rainfall
Correlation between predicted rainfall index and predicted zonal wind





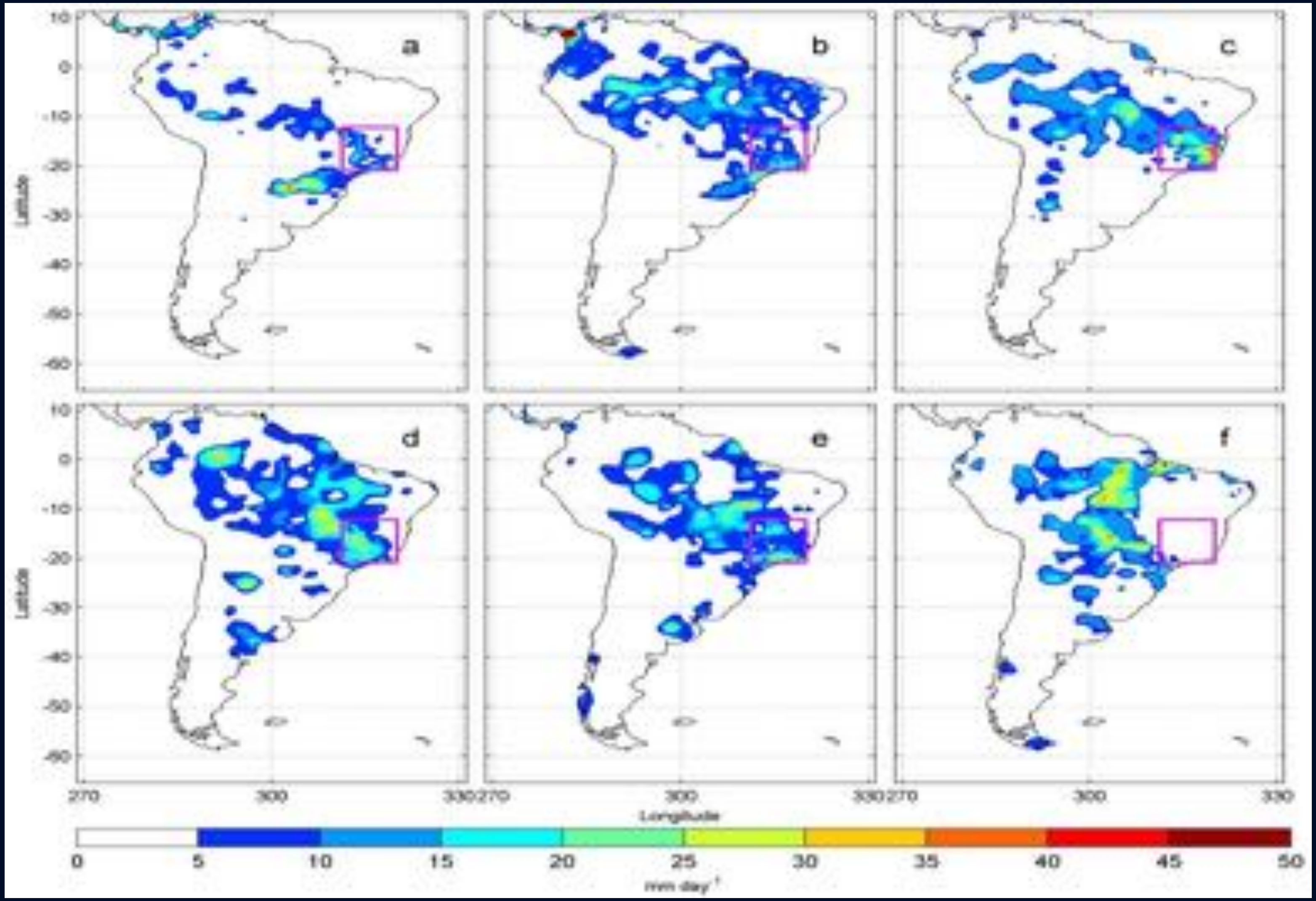
Conclusions

1) The Madden-Julian Oscillation has strong and significant impact on the South American monsoon precipitation.
2) The models are able to predict the MJO and partially its teleconnections to South America (especially tropics-tropics) but they tend to produce in MJO phase 8 what is observed in phase 1.
3) The models reproduce reasonably the proportion of active and break monsoon days in each MJO phase up to week 4 in advance, but they tend to produce in MJO phase 8 what is observed in phase 1.
4) The skilfull prediction of the monsoon rainfall for a longer lead time is associated with the skilfull reproduction of the extratropical teleconnection.
5) Better results could most probably be obtained by calibrated model results.

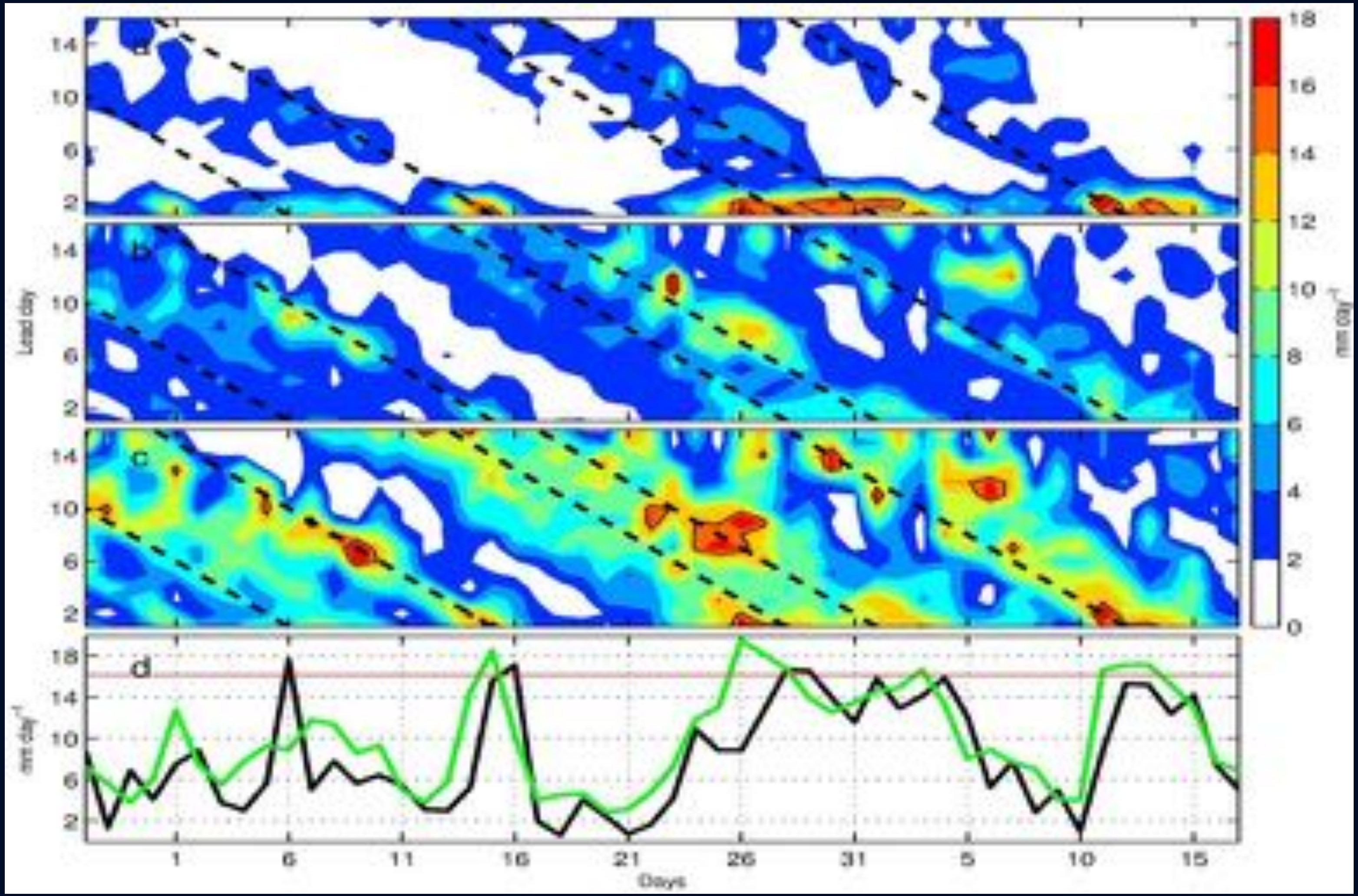
Extended-Range prediction of SACZ rainfall with calibrated CFSv2 reforecasts

(Hirata and Grimm, 2017, Climate Dynamics)

During the 2010-2011 wet season in Brazil, widespread landslides triggered by heavy rainfall killed more than 900 people and displaced nearly 35,000. The extreme precipitation was associated with the formation of the South Atlantic Convergence Zone (SACZ). We demonstrate that early predictions of heavy rainfall in the SACZ region are possible. Precipitation rate hindcasts from the NCEP Climate Forecast System version 2 are calibrated with the aid of a gridded precipitation dataset. When the calibration was applied to the 2010-2011 events, the hindcasts were able to depict both active and break phases of the SACZ with up to two weeks in advance during a period of relatively weak intraseasonal variability associated with the MJO.



Average precipitation rate during the six SACZ events in December 2010 and January 2011. The average was calculated for the duration of each event.



Hindcast lead time diagrams of area-averaged precipitation rate in the SACZ region. (a) Raw hindcast, (b) hindcast data after the quantile mapping correction, and (c) fully corrected hindcast. (d) CPC daily area-averaged rainfall rate for the SACZ region (black) and the 0h lead time corrected hindcast (green). The black dashed lines in (a-c) track the first day of each SACZ event discussed in the text. Days in (d) from December 2010 and January 2011.