Understanding ENSO teleconnections and processes in the La Plata basin using river discharge as precipitation proxies with Regional Earth System model RegIPSL

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Region of study: La Plata basin (LPB)

Features

- 3.1 million km2
- +150 million inhabitants
- 75 dams
- +30 large hydropower plants
- varied ecosystems

Main Rivers

Paraná 17,000 m3/s
Uruguay 5,500 m3/s
Paraguay 4,300 m3/s

Motivation

- Economic activities in the LPB rely on water availability: agriculture, river navigability and hydroelectric production. Extreme events in the LPB have produced significant socio-economic impacts and these took place mainly during El Niño-Southern Oscillation (ENSO) warm and cold phases.
- Better isolating regional responses to strong El Niño events, and their impacts on society, is imperative given that strong El Niño events are projected to increase in frequency with increasing greenhouse gas concentrations

Main objective

Understand how the ENSO modulate relevant atmospheric mechanisms that produce the wet and dry extremes in the river discharges of the LPB using the IPSL regional Earth System Model (RegIPSL).

Particular case study to be discussed in this presentation

- **El Niño 2015/2016**

RegIPSL: Regional Earth System Model (RESM) of the Institute Pierre Simon Laplace

https://gitlab.in2p3.fr/ipsl/lmd/intro/regipsl/regipsl/-/wikis/home

Dynamical coupling of 3 regional models of the climate system:

- **WRF** (v 3.7.1): atmosphere
- **ORCHIDEE** (v CMIP6): land
- **NEMO** (v 3): ocean

Coupled via OASIS-MCT and I/O with XIOS

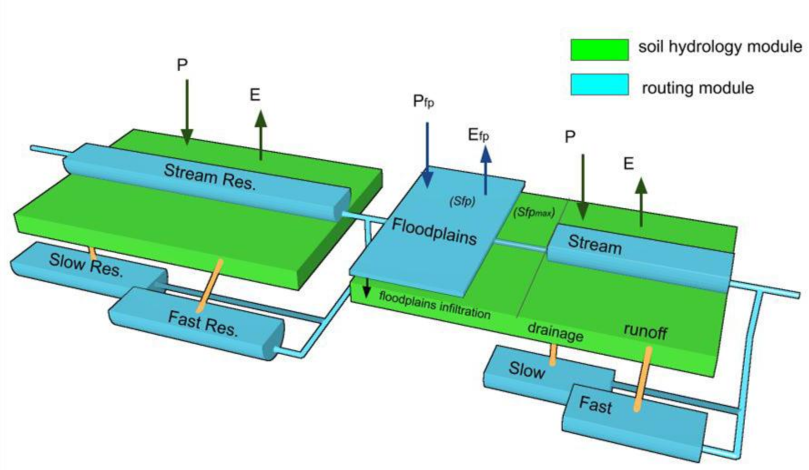
WRF

- 20 km x 20 km South American continent
- 50 vert. levels @ 10hPa
- RRTMG (sw/lw rad), MYNN-2.5 (pbl/sfc), Morrison 2-moment (mp), Grell-Freitas (cu)
- Spectral nudging to ERA5

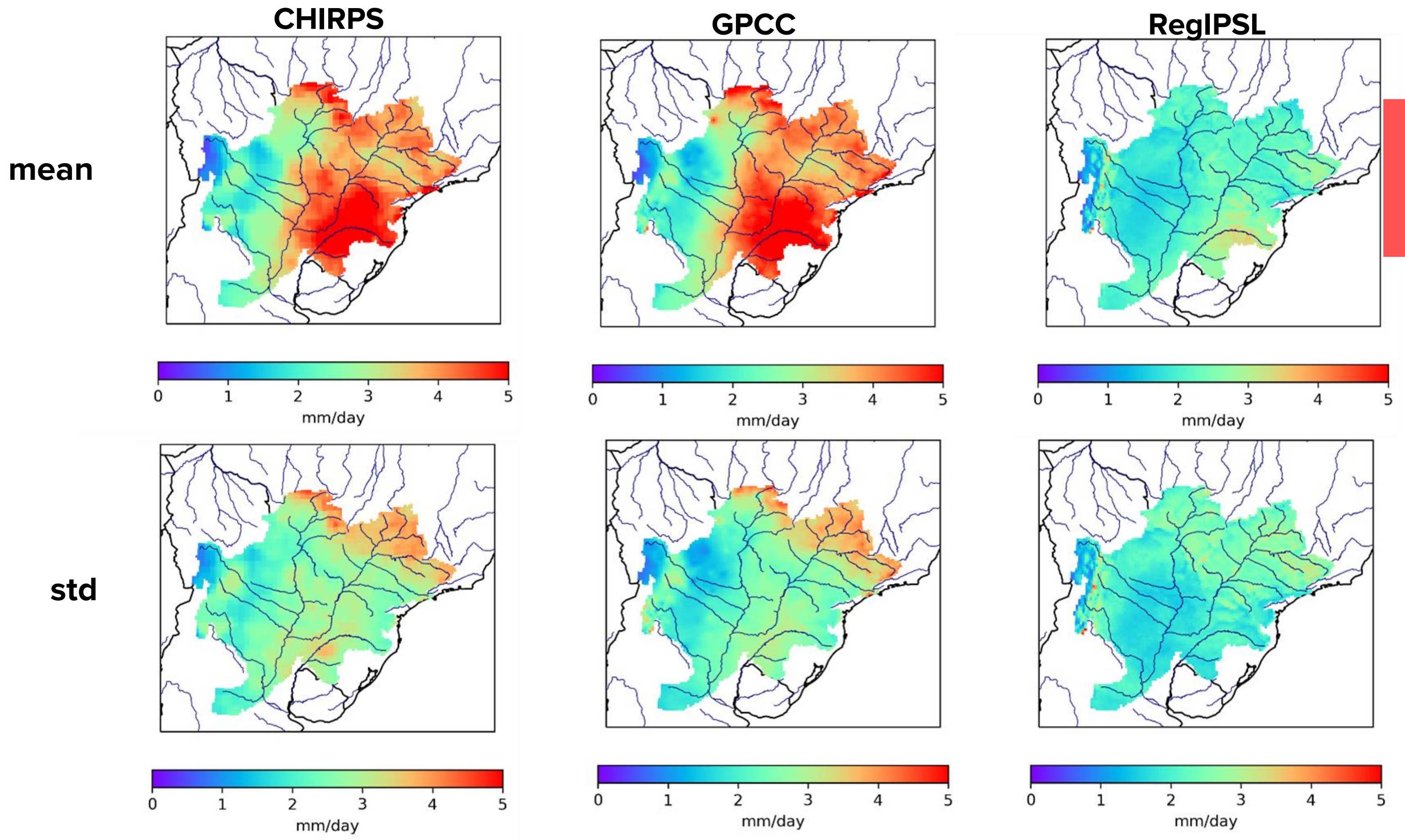
ORCHIDEE (same grid as WRF)

- 11 vertical layers
- 13 PFT (ESA-CCI-LC)
- routing scheme
- floodplains scheme
- Phenology: dynamic LAI, carbon cycle, ...
- 10 yr off-line spin-up

Illustration of the representation of the floodplains in the ORCHIDEE floodplains scheme



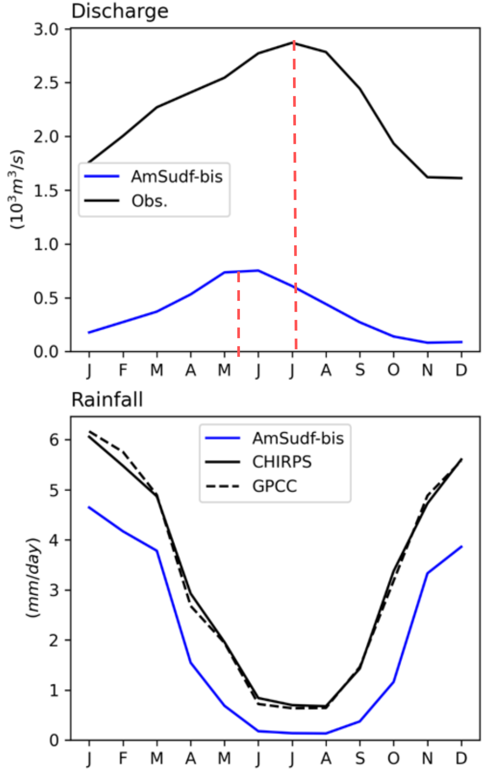
RegIPSL ability to simulate precipitation in La Plata basin



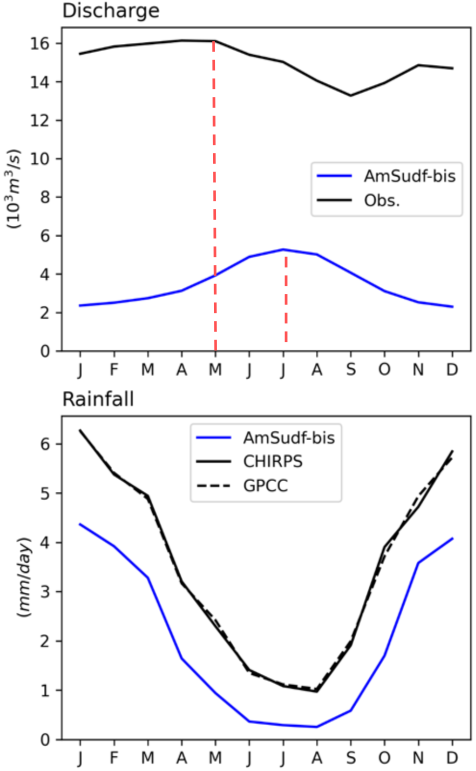
Dry bias in precip. though the spatial pattern is captured

RegIPSL discharge and precipitation annual cycles by sub-basin

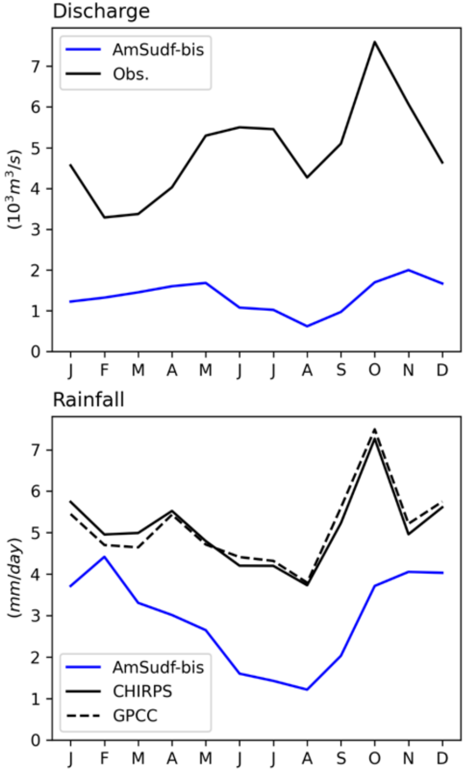
Porto Murtinho (Pantanal floodplain, Paraguay river)



Tunel Subfluvial (Paraná river)



Paso de los libres (Uruguay river)



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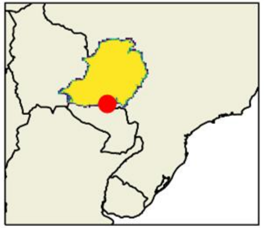

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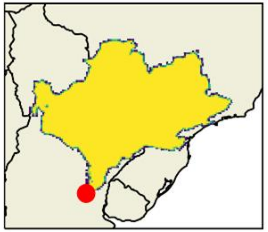

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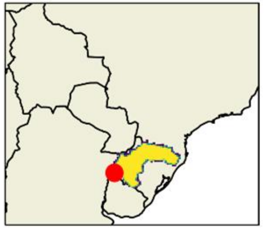

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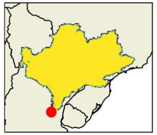
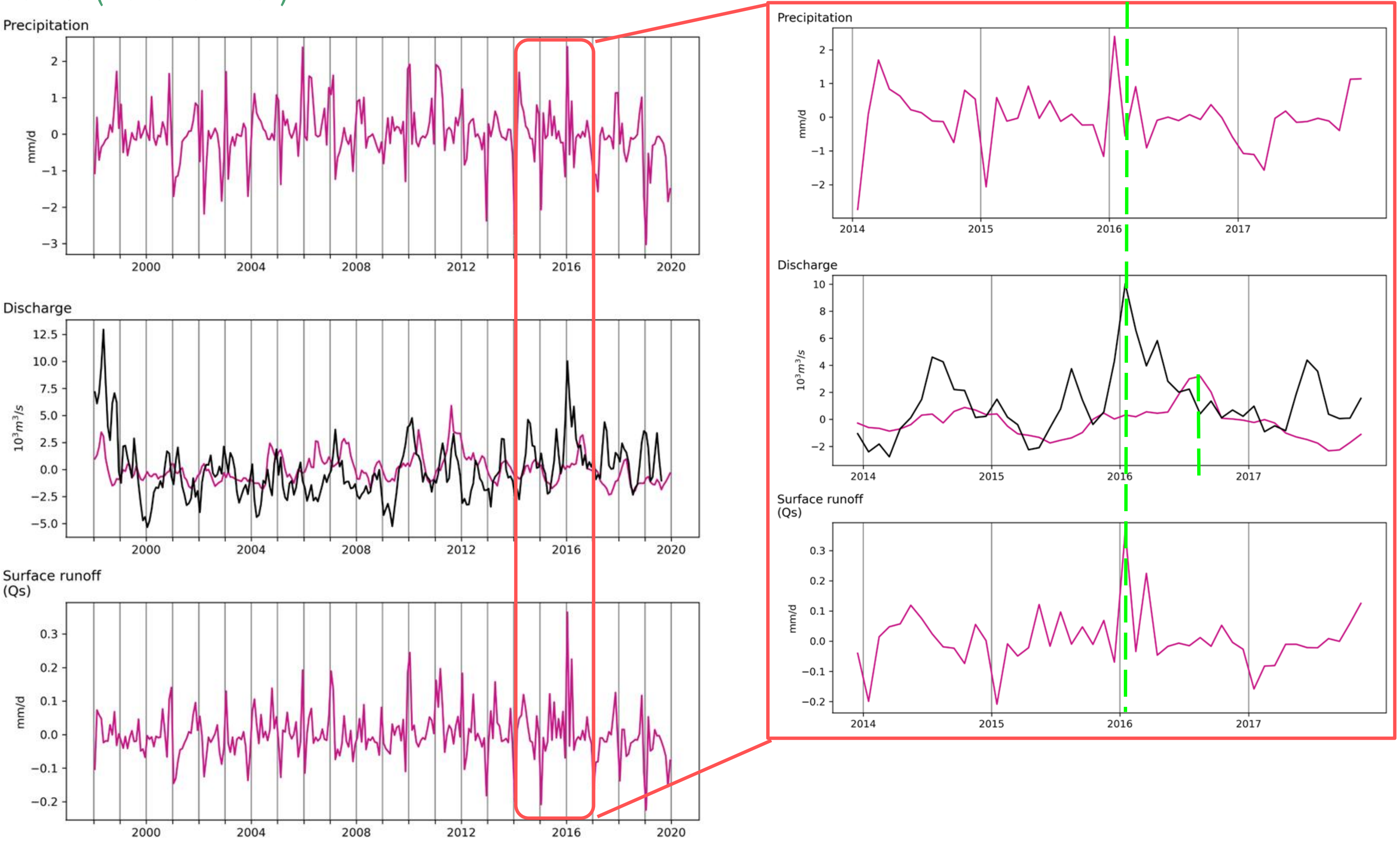
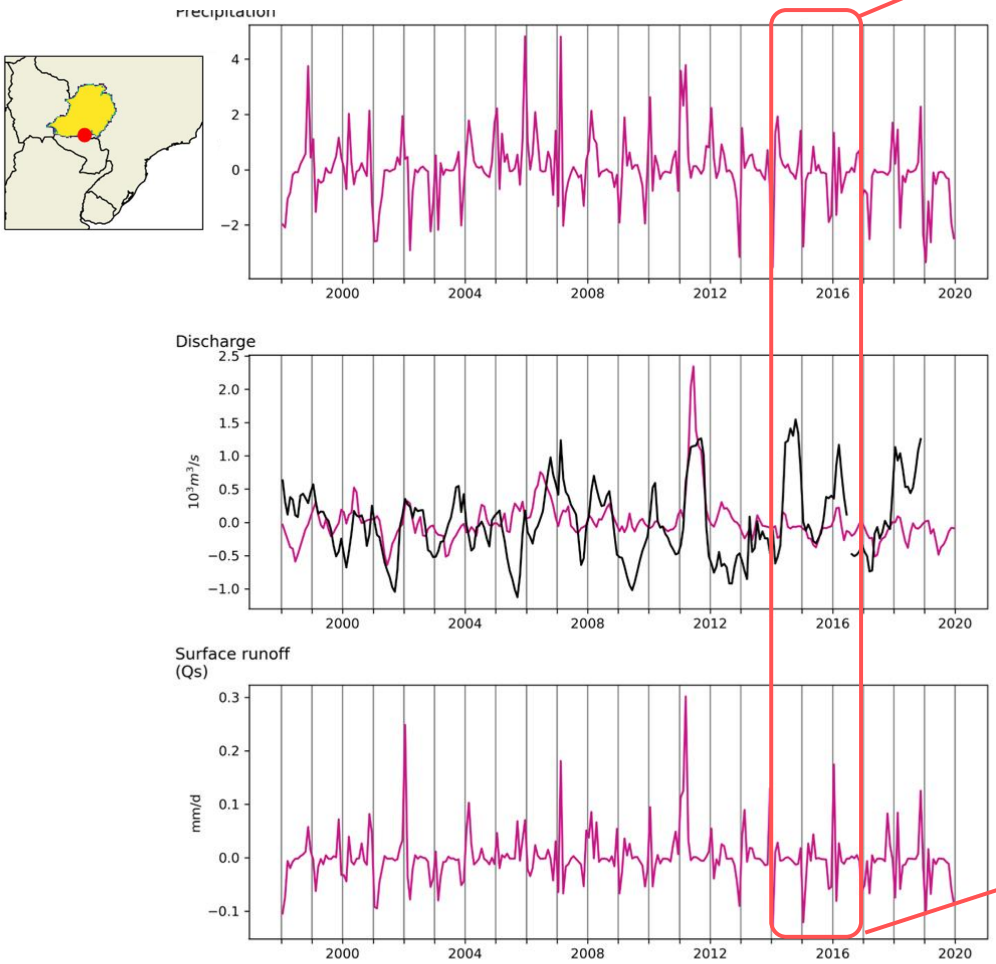
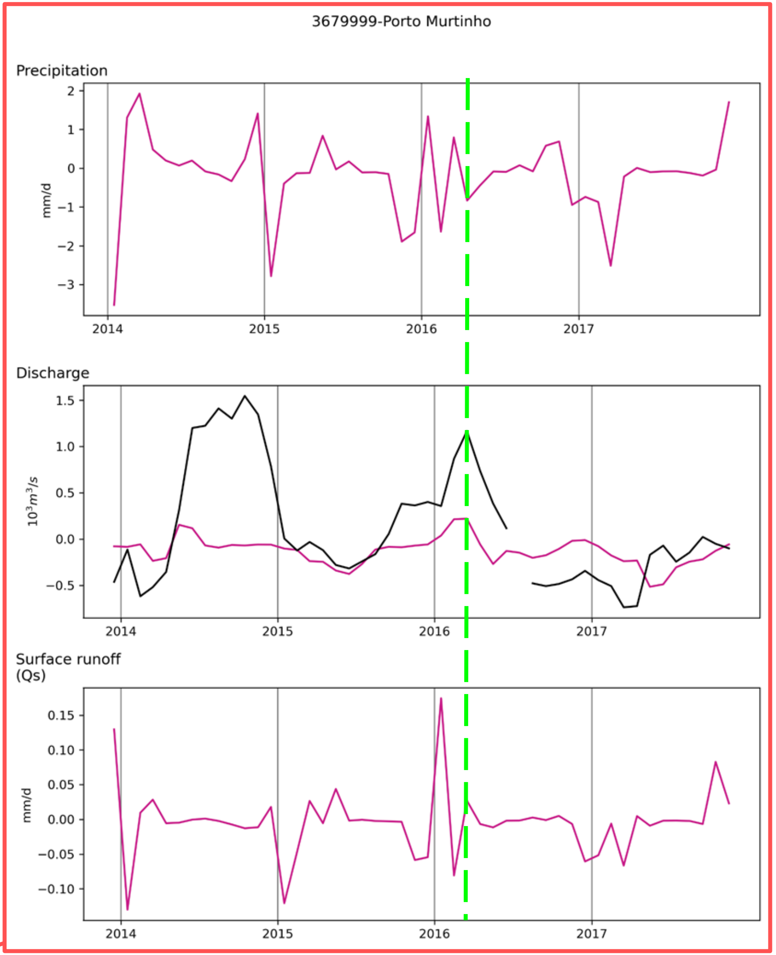


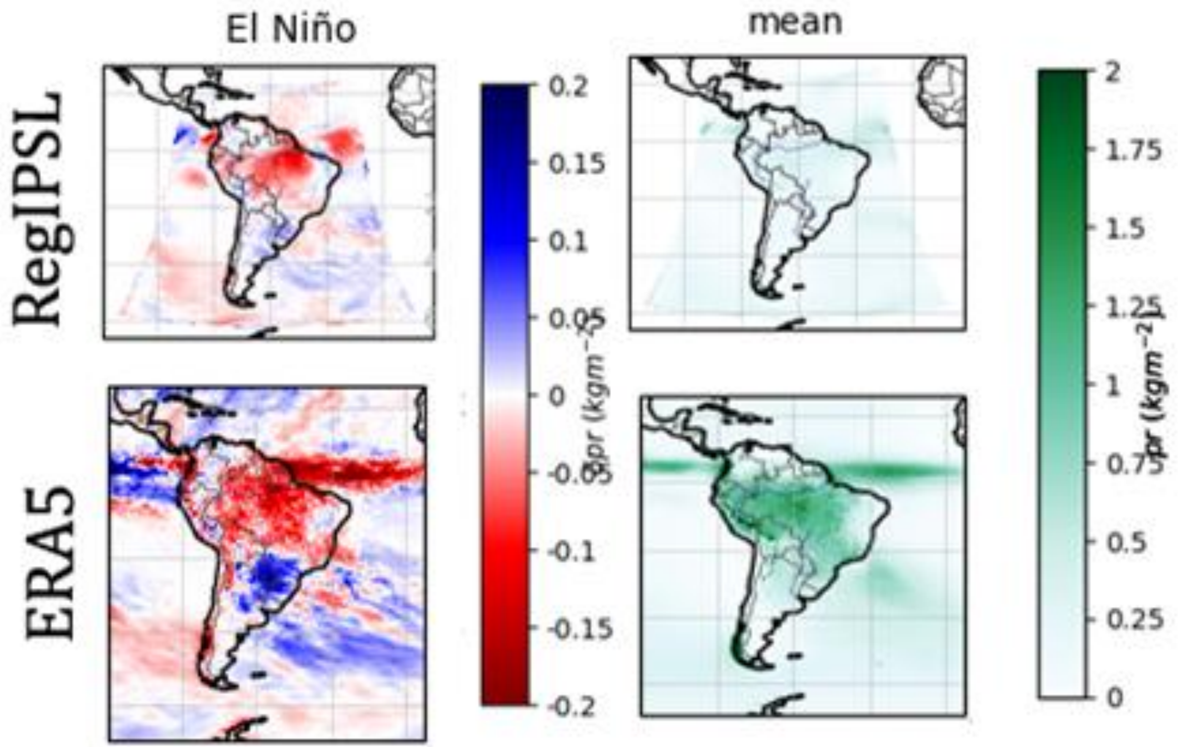


Porto Murtinho (Pantanal floodplain, Paraguay river)





ERA5 and RegIPSL precipitation anomalies for El Niño composites during austral summer (DJF) for the simulated period 1998-2019



Anomalous dry–wet rainfall dipole between the northern and SE South America . Although the RegIPSL presents a dry bias, it is able to capture the ENSO teleconnection spatial features.

Most important climate drives modulating precip in the La Plata basin

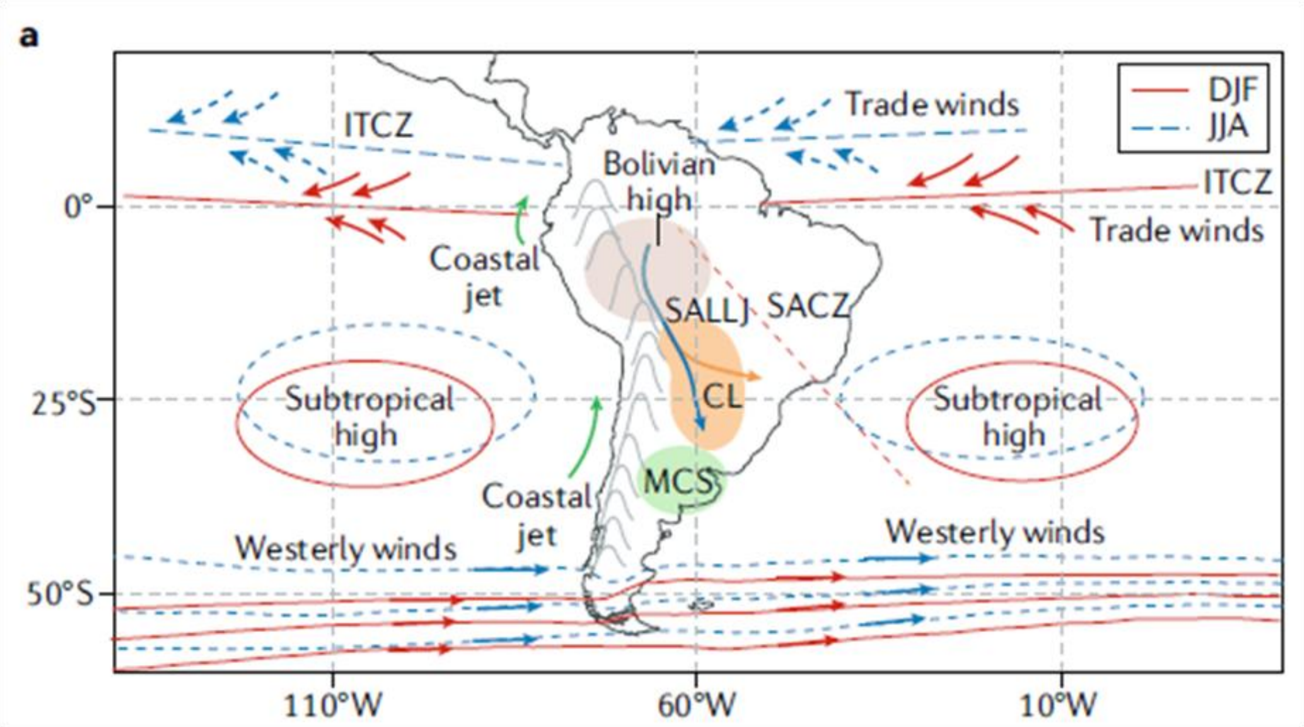


Fig. 1 | **South American meteorological and climatological features.** Schematic of the main climatological features in South America (SA) (part **a**). The blue and red lines represent features in June-July-August (JJA) and December-January-February (DJF).

Cai et al. (2020)

Anomalies for D(0)JF(+) El Niño 2015/2016 event

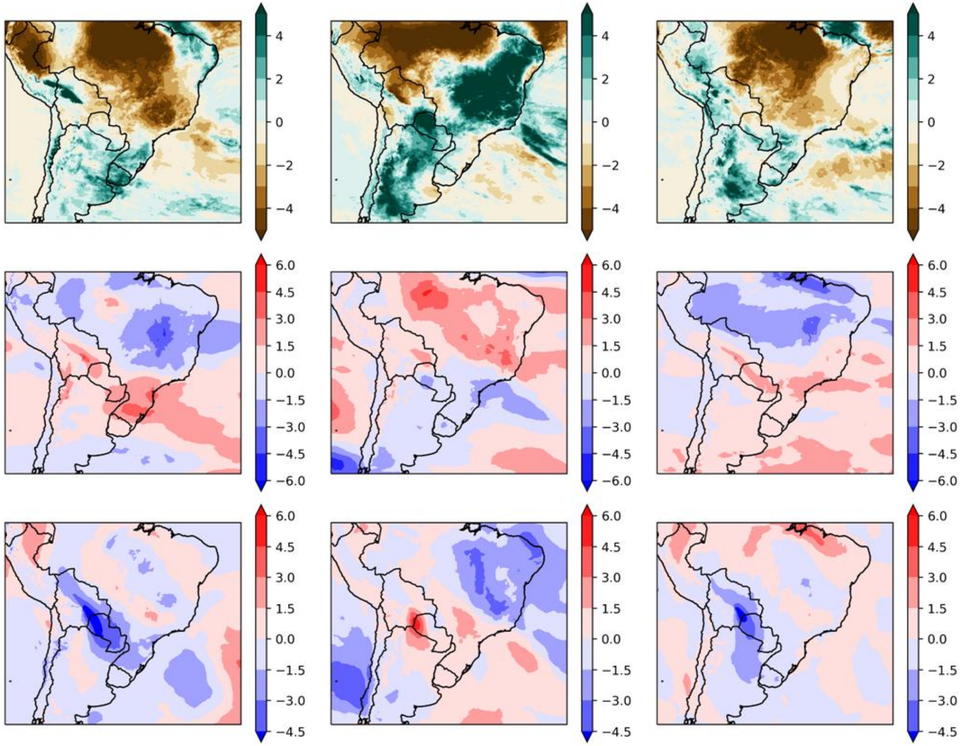
Regional indicators related to the Low Level Jet

December 2015 | **January 2016** | **February 2016**

Precipitation [mm/day]

Zonal wind 850hPa [ms^{-1}]

Meridional wind 850hPa [ms^{-1}]

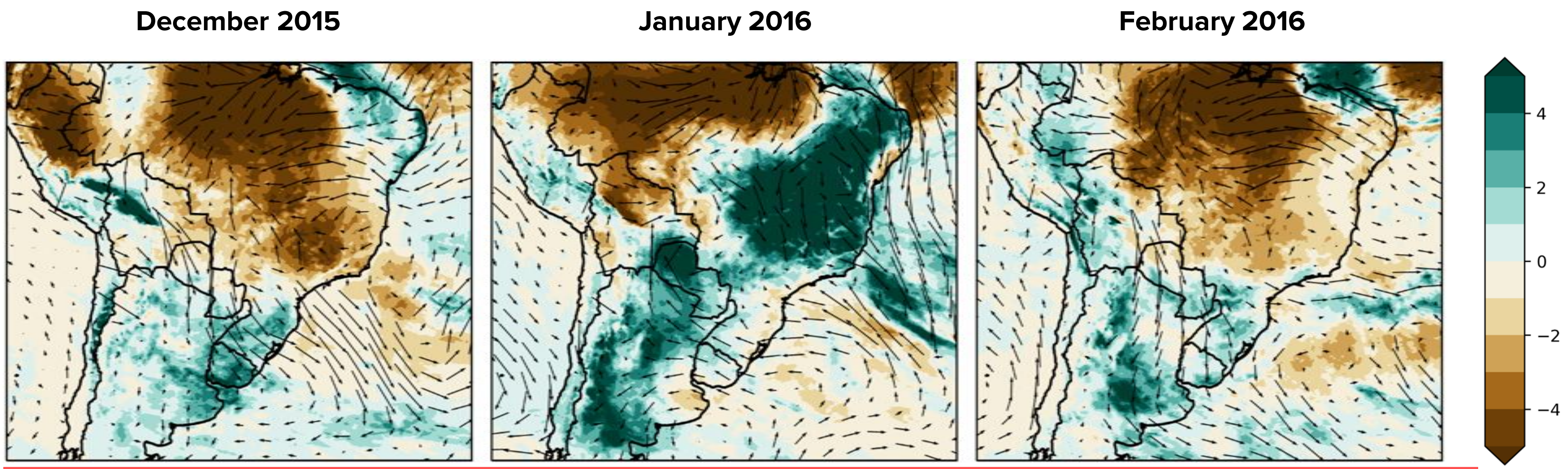


We have 40 atmospheric and land variables ready to analyse which are not shown here

Anomalies for D(0)JF(+) El Niño 2015/2016 event

Precipitation [mm/day] (shaded)

Vertically integrated moisture transport up to 850 hPa [m/s] (vectors)

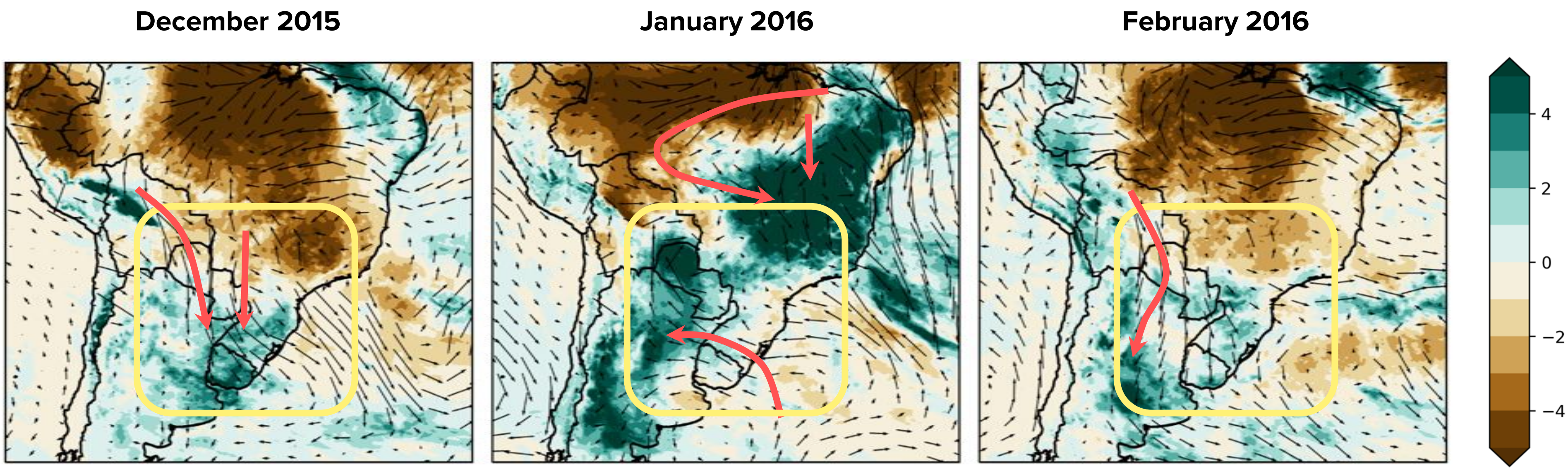


South American LLJ play a role in establishing moisture corridors that produce rainfall in subtropical and midlatitudes during the summer and this is intensified during El Niño events

Anomalies for D(0)JF(+) El Niño 2015/2016 event

Precipitation [mm/day] (shaded)

Vertically integrated moisture transport up to 850 hPa [m/s] (vectors)



Detailed consideration of the role of MJO–ENSO interaction with circulation patterns over the study region, though currently beyond scope, can help to better understand this intraseasonal fluctuations

Conclusions

- The evaluation of the performance of the **RegIPSL** in simulating precipitation showed a **dry bias** in the model and consequently there is a generalized **underestimation** of the **river discharges**.
- Nevertheless, these simulations have a potential to better **understanding ENSO teleconnections**, since **physics are adequately represented** and the atmosphere and land **climate** system **components** are **dynamically coupled**.
- RegIPSL presented **similar spatial patterns** of the El Niño years composites than those derived from **ERA5**.
- The RegIPSL was able to capture observed intaseasonal variations in precipitation pattern as well as the **stronger SALLJ** and enhanced **poleward moisture transport** to southeastern South America during El Niño 2015/2016 that produced the subtropical rainfall anomalies and thus the peak in the river discharges over LPB

Acknowledgements: GENCI-IDRIS, INSU LEFE, MINCYT-ECOS Sud, CLIMAT AMSUD