SYNOPTIC CLIMATOLOGY AND CHANGES IN PRECIPITATION ASSOCIATED WITH THE SOUTH ATLANTIC CONVERGENCE ZONE UTILISING A CLOUD BAND IDENTIFICATION TECHNIQUE

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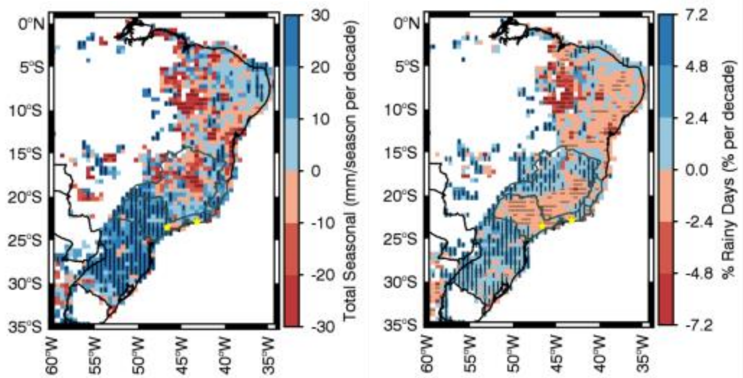
CHANGES IN PRECIPITATION ALONG THE SACZ

Observed changes in seasonal (DJF) precipitation [Zilli et al 2016]:

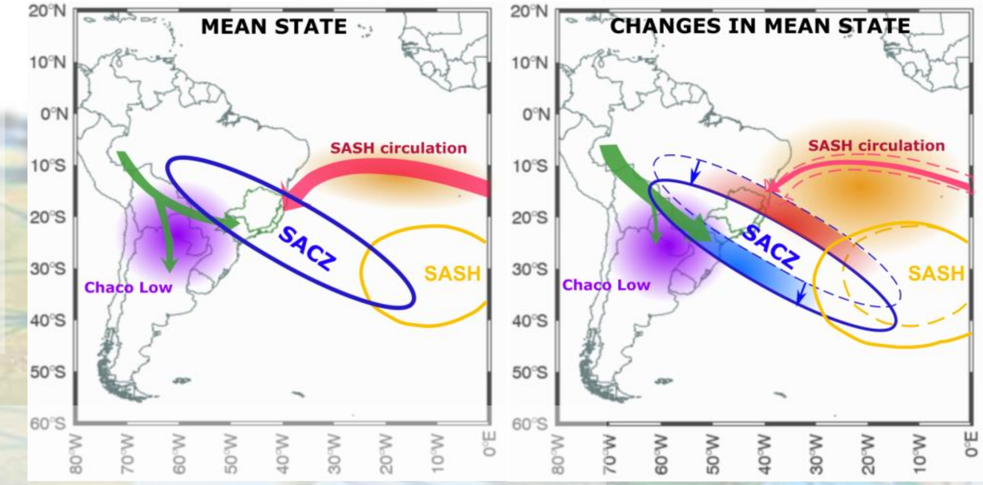
- Reduction (increase) in precipitation over eastern (southern) Brazil (left)
- Reduction (increase) in the number of rainy days over southeastern (southern) Brazil (right).



(Zilli, et al 2016)

Changes in circulation over recent decades [Zilli et al 2019]:

- Weakening of the poleward winds along the northern margin of the SACZ
- Southwestward shift of the SACZ, reducing (increasing) precipitation along its equatorward (poleward) margin.



(Zilli, et al 2019)

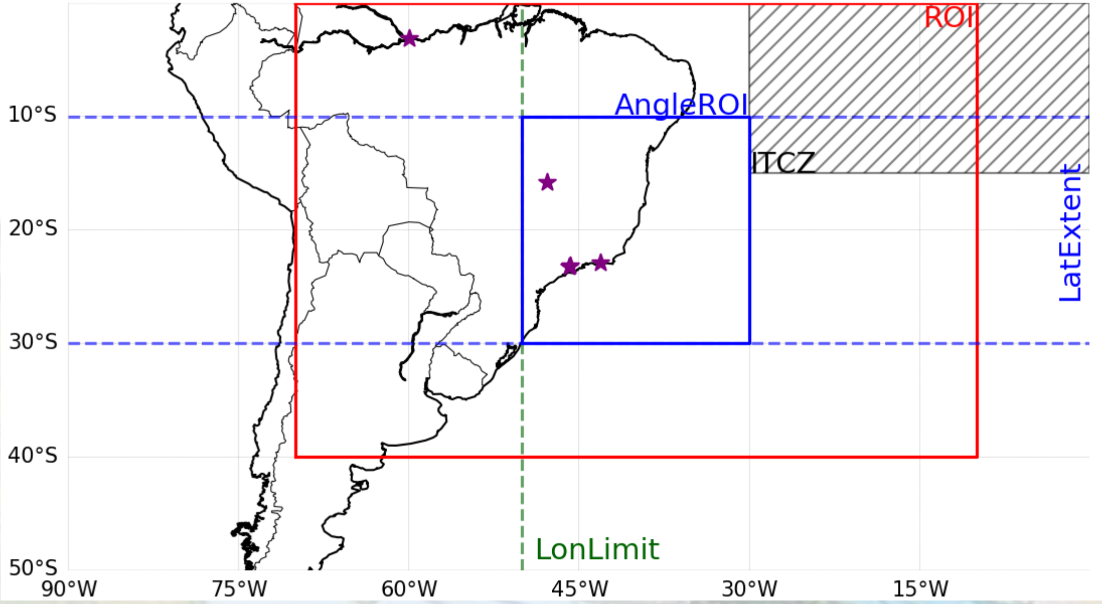
- ➢ What are the main synoptic characteristics associated with individual Tropical-Extratropical (TE) cloud band events, such as the SACZ?
- ➢ How are TE events changing over recent decades? What are their contribution to observed changes in seasonal precipitation?

IDENTIFICATION OF TROPICAL-EXTRATROPICAL (TE) CLOUD BANDS EVENTS

Algorithm developed by Hart et al. (2012, 2013) and adapted to South America

OLR: NOAA CDR OLR V1.2 [1°lat/lon; 1979-2018]

- Threshold: < $225 W/m^2$
- Location:
  - **ROI:** -70°W to -10°W; -40°S to 0°S
  - Minimum extent: -15°S and -30°S (LatExtent), across -50°W (LonLimit)
- Orientation: [-80°, -10°] in relation to east-west within **AngleROI** region: 50°W to -30°W; -30°S to -10°S
- Excluding ITCZ area: east of 30°W and north of 15°S



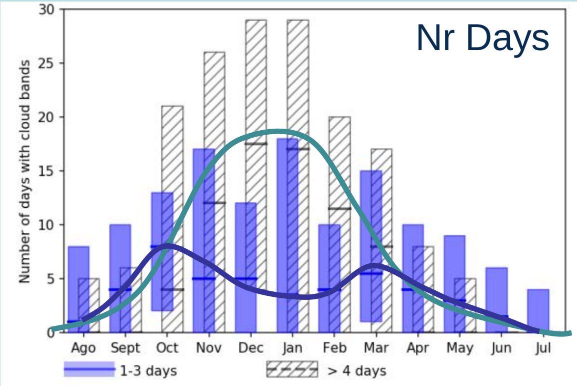
CHARACTERISTICS OF SELECTED TE CLOUD BAND EVENTS

TOTAL: 4907 days in 1769 events

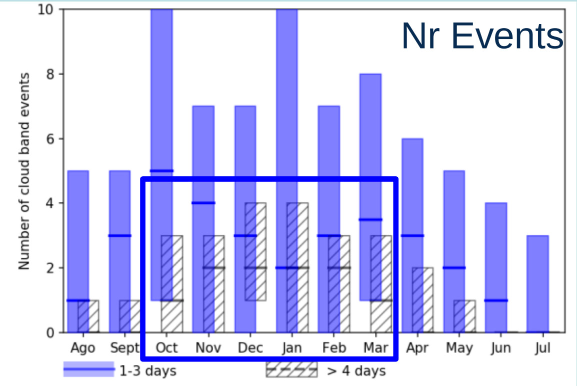
EVENTS PERSISTING 1-3 DAYS: 1993 days in 1282 events

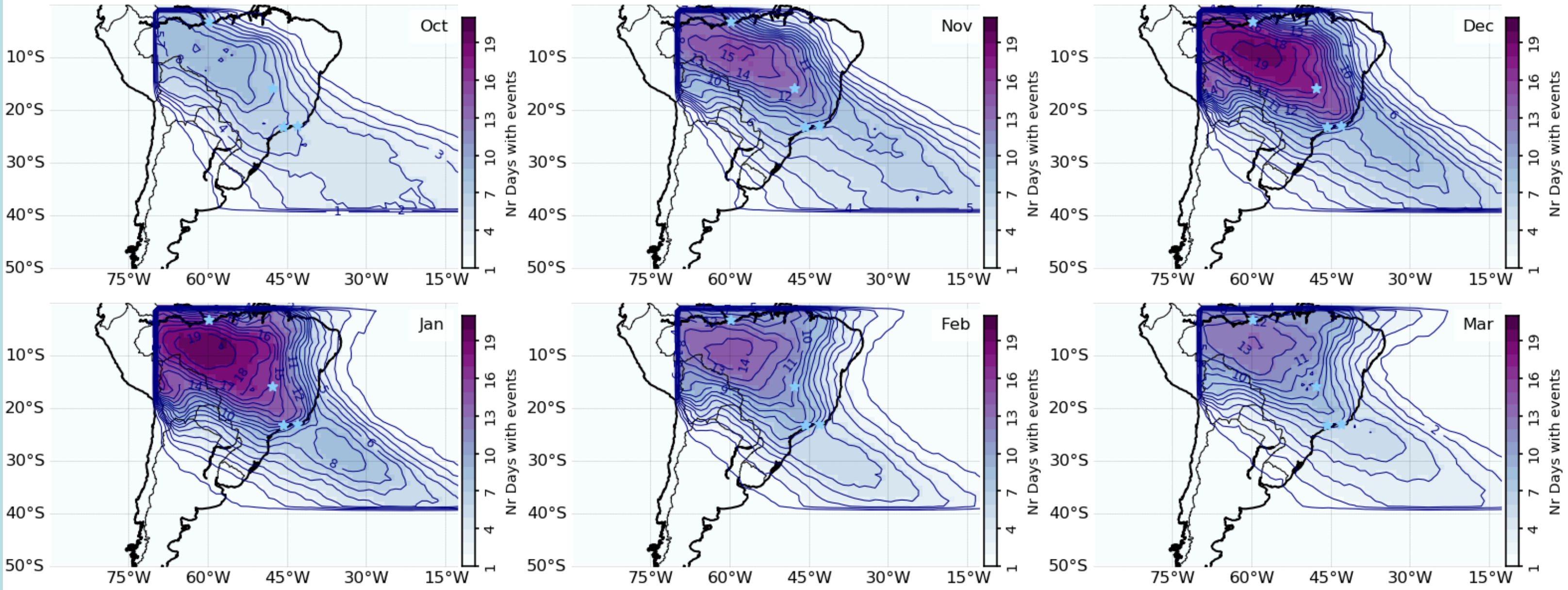
EVENTS PERSISTING 4 OR MORE DAYS: 2914 days in 514 events

- Number of TE cloud bands:
  1-3 days events: **peak in Oct and Mar**
  ≥ 4 days events: **peak in Dec-Jan**
- Events persisting 4 or more occur only in the **rainy season (Oct-Mar)**
- Spatial distribution (all days with events) depicts the migration of the SACZ during the rainy season



Median (bar), minimum and maximum (boxes) number of days with TE cloud band events (left) and number of TE events (right) lasting 1-3 days (blue) or 4 or more days (hatching).





Average number of days with TE cloud band events per month.

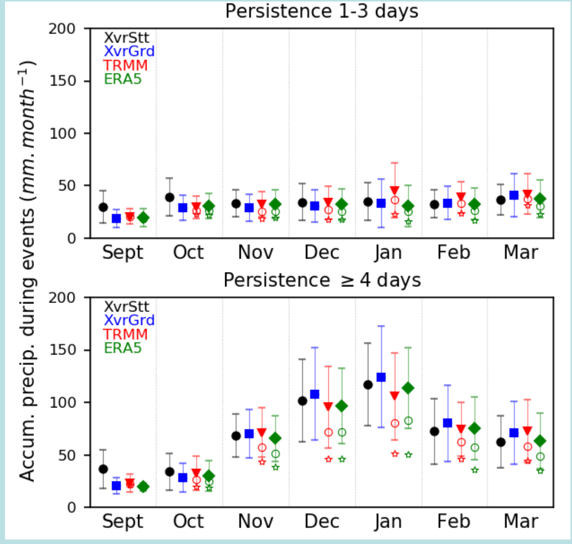
PRECIPITATION DURING TE EVENTS

- Gridded observations [1980-2016] (left) [Xavier et al 2016]
- TRMM-3B42 [1998-2016] (center)
- ERA5 [1979-2018] (right)

✓ Good similarity among dataset

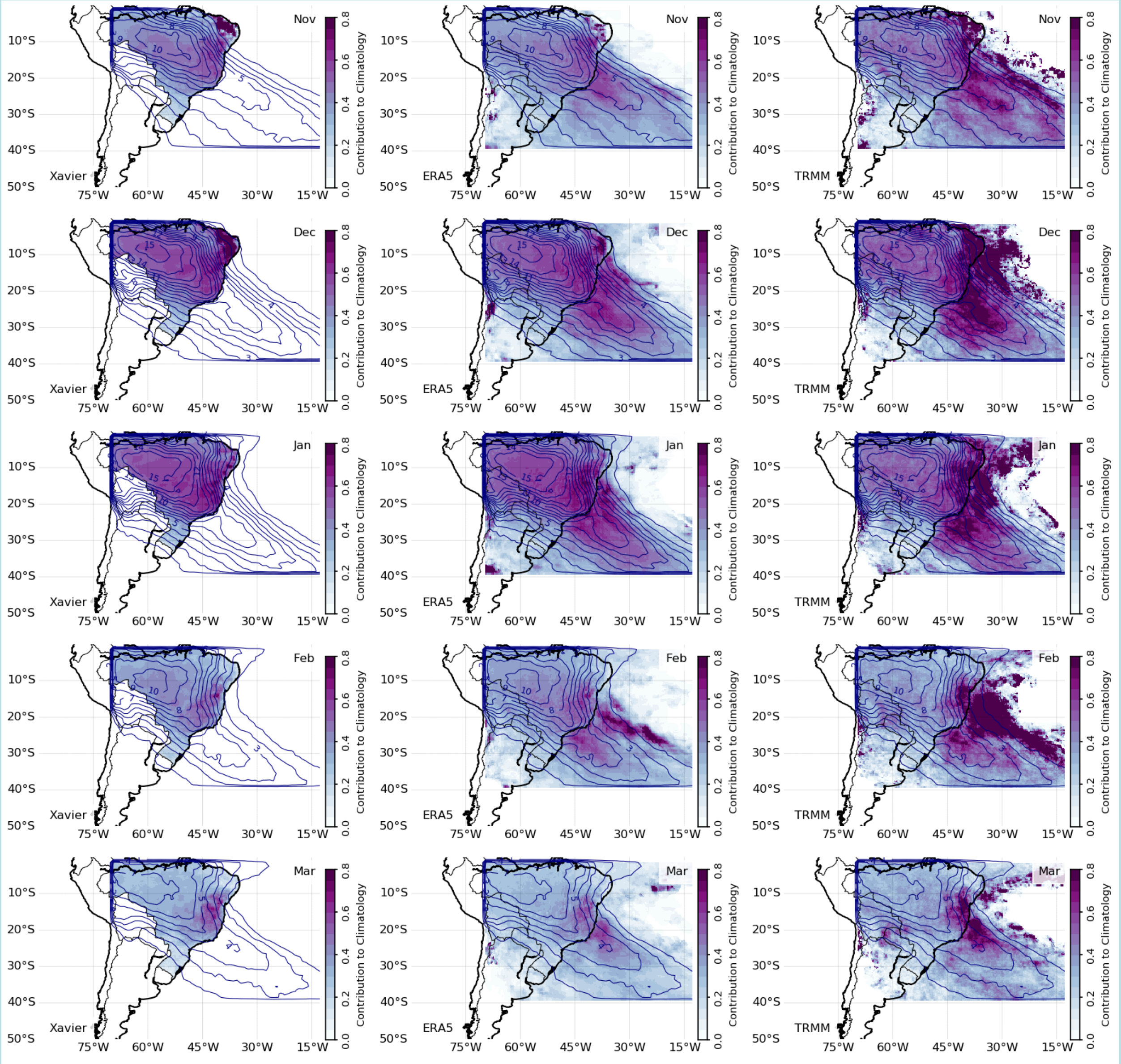
✓ Contribution to climatology (shades) ∝ number of days with events (contour)

✓ TE events account for ~ 50% of monthly precipitation



← Total precipitation during events persisting 1-3 days (top) and 4 or more days (bottom). Values spatially averaged within the signature of TE cloud bands.

Number of days with events persisting 4 or more days (contour) and their contribution to climatology. Values within the signature of TE cloud bands. →



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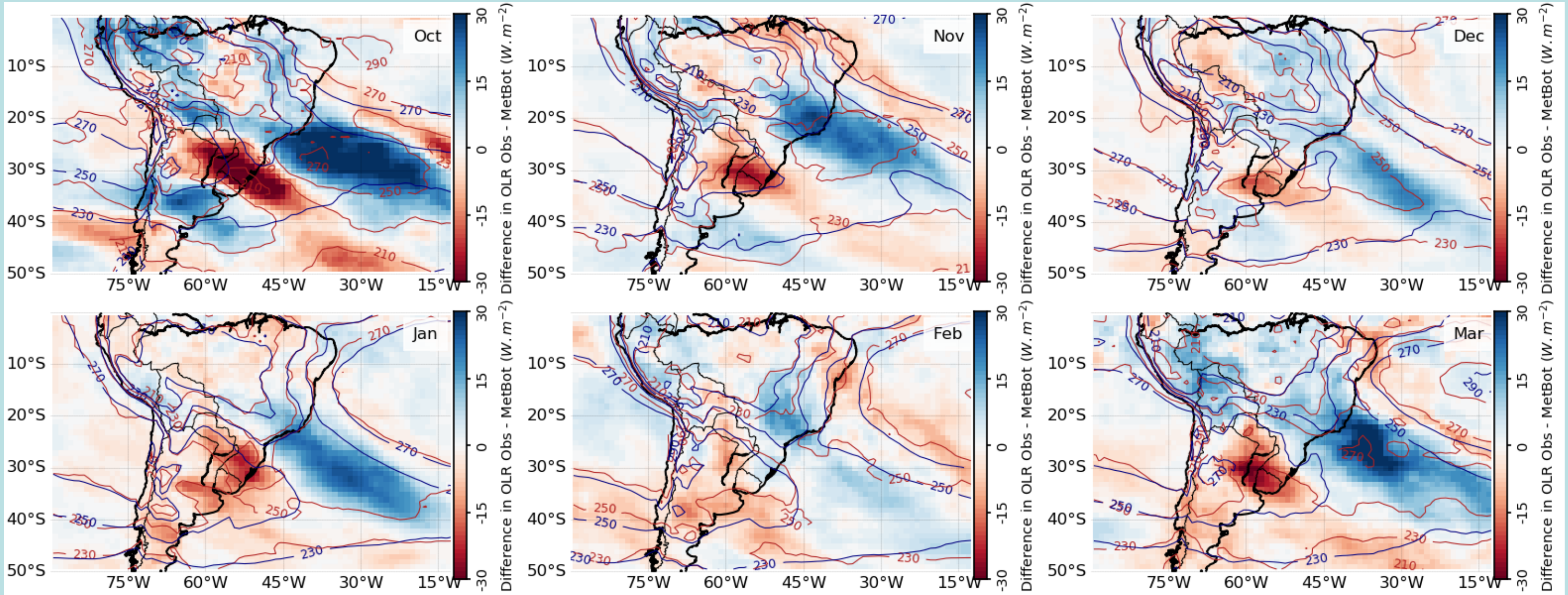
EFFICIENCY OF THE ALGORITHM

Comparison with SACZ events identified by the Brazilian Center of Weather Forecast and Climate Research, CPTEC [Rosso et al 2018]

SACZ – TE events lasting 4 or more days with specific dynamic components.

Days with events		Observation	
		Y_o	N_o
Algorithm	Y_a	683	942
	N_a	343	3126

Percentage Correct = 0.75
Hit Rate = 0.67
False Rate = 0.23
Bias = 1.58

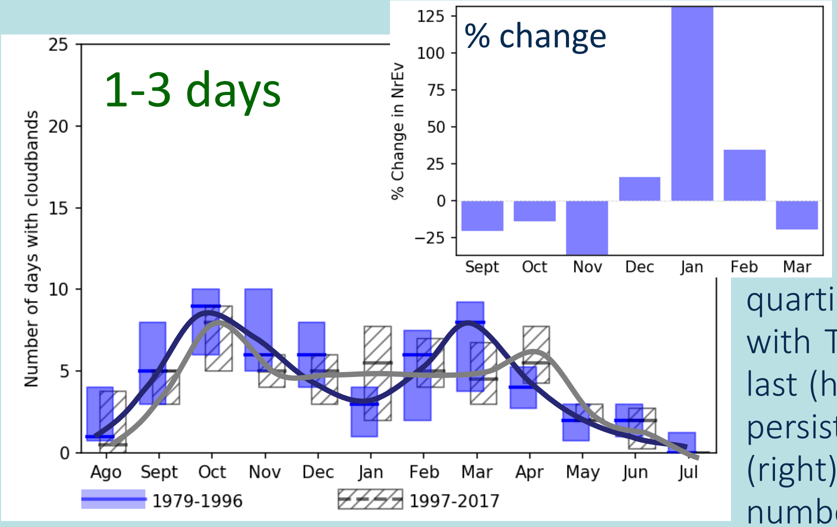


Contour: Average OLR during observed SACZ events (blue) and during TE cloud band events identified by the algorithm (red). Shades: differences in OLR (algorithm-observed).

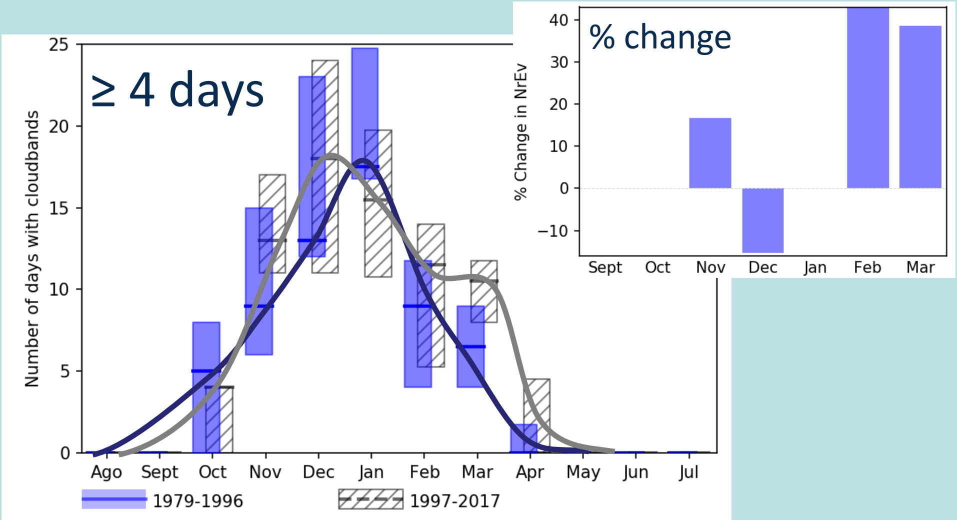
- Algorithm identified 67% of the days with observed SACZ
- Algorithm identified more (fewer) events than observed over tropical (subtropical) Brazil
- Discrepancies: algorithm focused on identifying TE cloud bands, independent of persistence and forcing.

CHANGES IN TE EVENTS OVER RECENT DECADES – FREQUENCY

- Change in the number of TE cloud band events between 1979-1996 and 1997-2017
- 9-year periods excluding ENSO years:
  - EN: 82, 86, 87, 91, 94, 97, 02, 06, 09, 15
  - LN: 83, 84, 88, 95, 98, 99, 00, 07, 10, 11, 17



Median (bar), lower, and upper quartiles (boxes) of the number of days with TE events during the first (blue) and last (hatching) periods analyzed for events persisting 1-3 days (left) or 4 or more days (right). Inset: percentage change in the number of TE events.

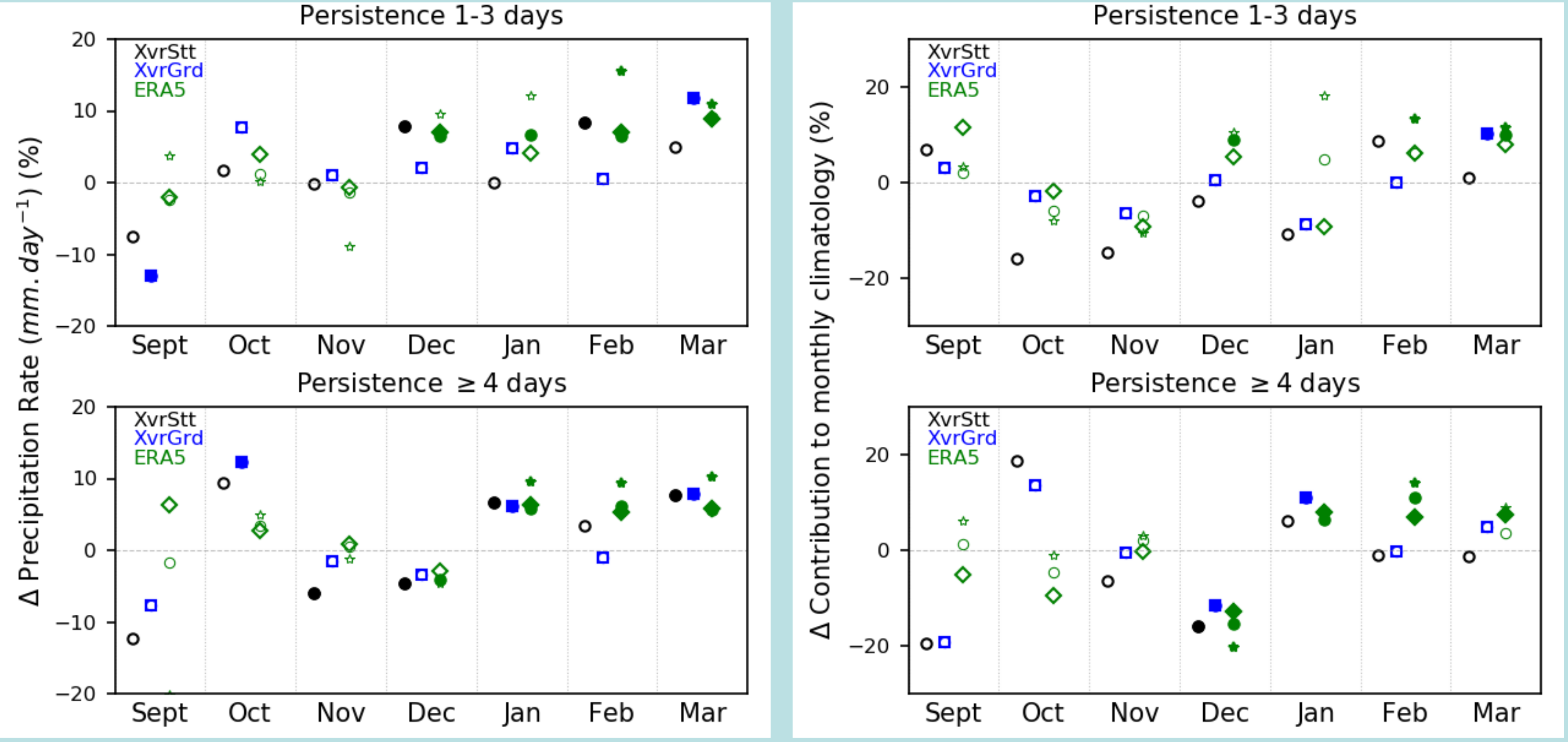


- Decrease in number of days with TE events during entire rainy season, except in Jan.
- Delay of the peak at the end of the rainy season.

- Increase in total number of TE events in the beginning (Nov) and end (Feb and Mar) of the rainy season (inset).
- Peak in median number of days with TE events anticipated to Dec, during which the variability also increased.

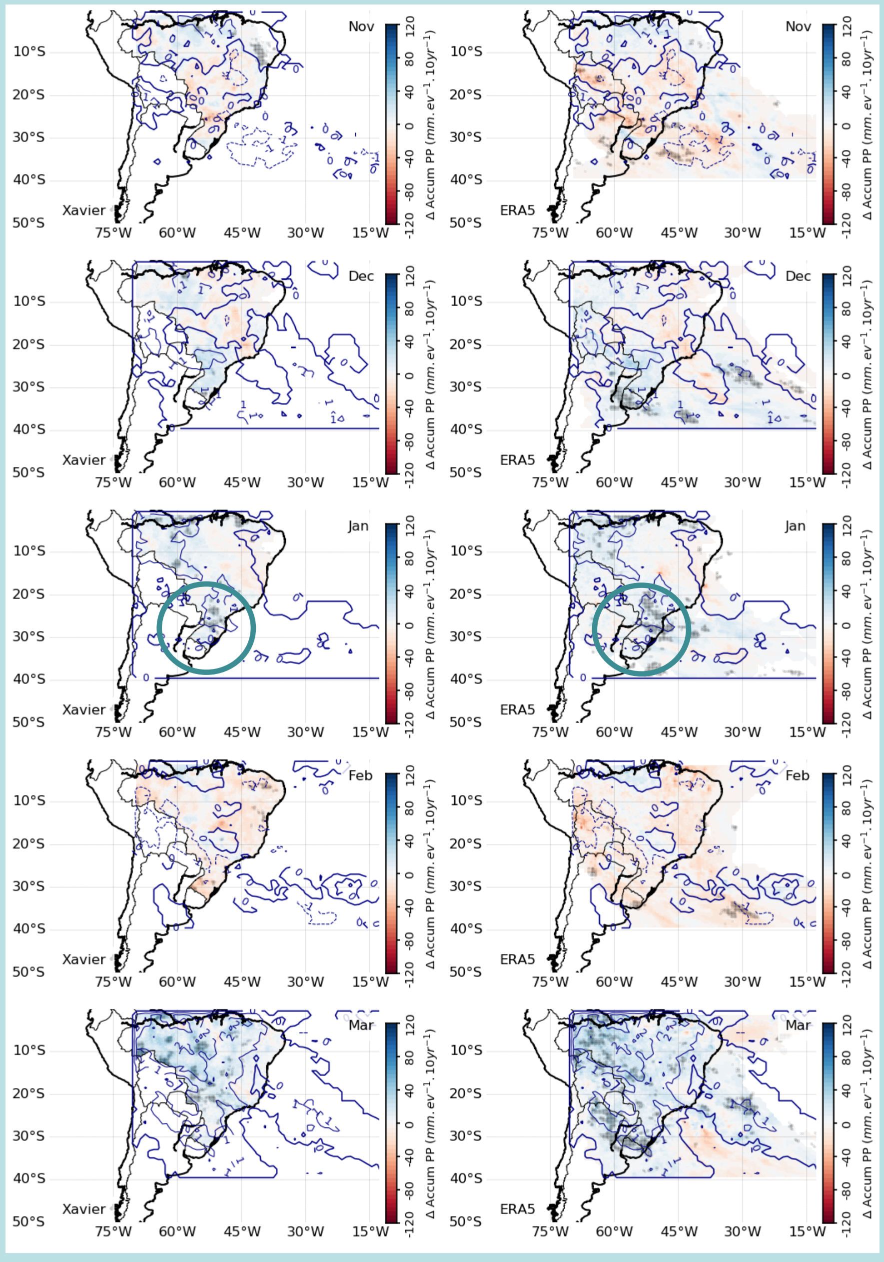
CHANGES IN PRECIPITATION DURING TE EVENTS – INTENSITY

Changes in average precipitation rate (left, in mm.day^{-1}) and in their contribution to the monthly total precipitation (right, %) considering TE events persisting 1-3 days (top) and 4 or more days (bottom). Changes are significant in months with filled symbol. Values spatially averaged within the signature of the TE cloud bands.

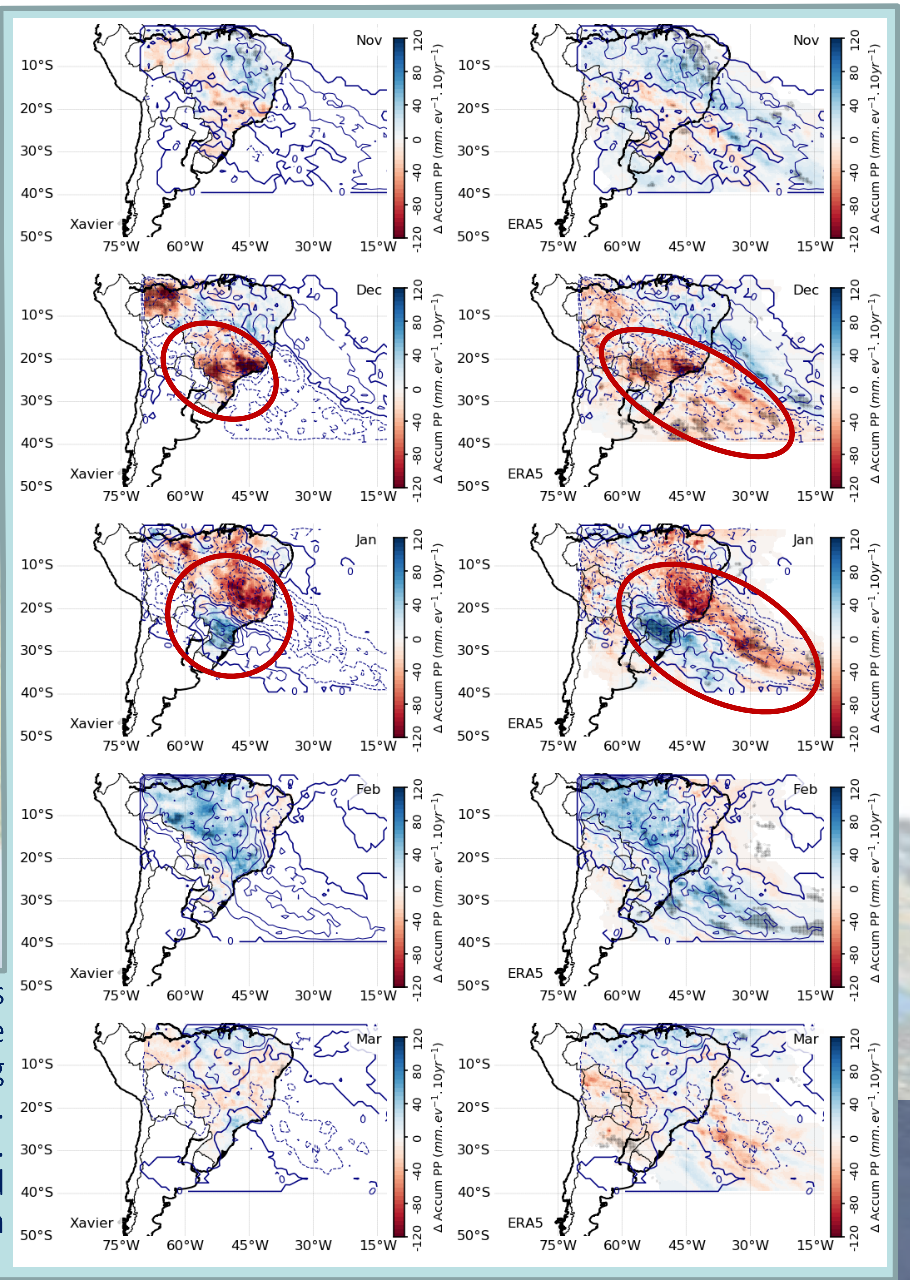


- Precipitation rate during TE events is increasing in Jan-Mar, independently of the event's persistence (left).
- Dec: precipitation rate is increasing (decreasing) during TE events persisting 1-3 (more than 4) days (left).
- Changes affect the contribution of individual days with TE events to the total precipitation only when considering TE events persisting 4 or more days (right).

SPATIAL CHANGES IN TE EVENTS OVER RECENT DECADES

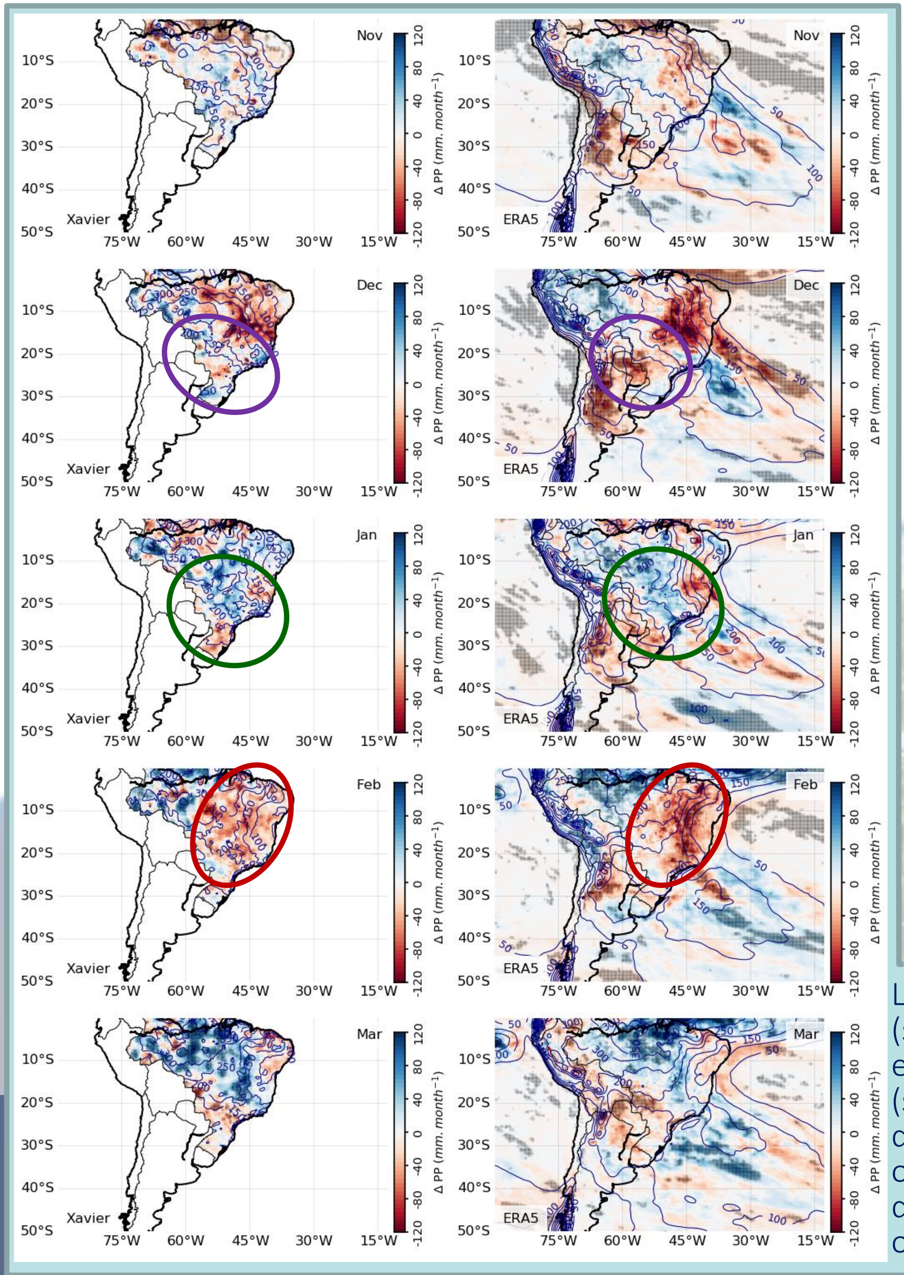


- No significant changes in total precipitation during TE events persisting 1-3 days (left), except for an increase over southern Brazil in Jan
- Changes in the number of TE events persisting 4 or more days, and consequently on their total precipitation, suggests a poleward displacement of the SACZ, specially in Dec and Jan.

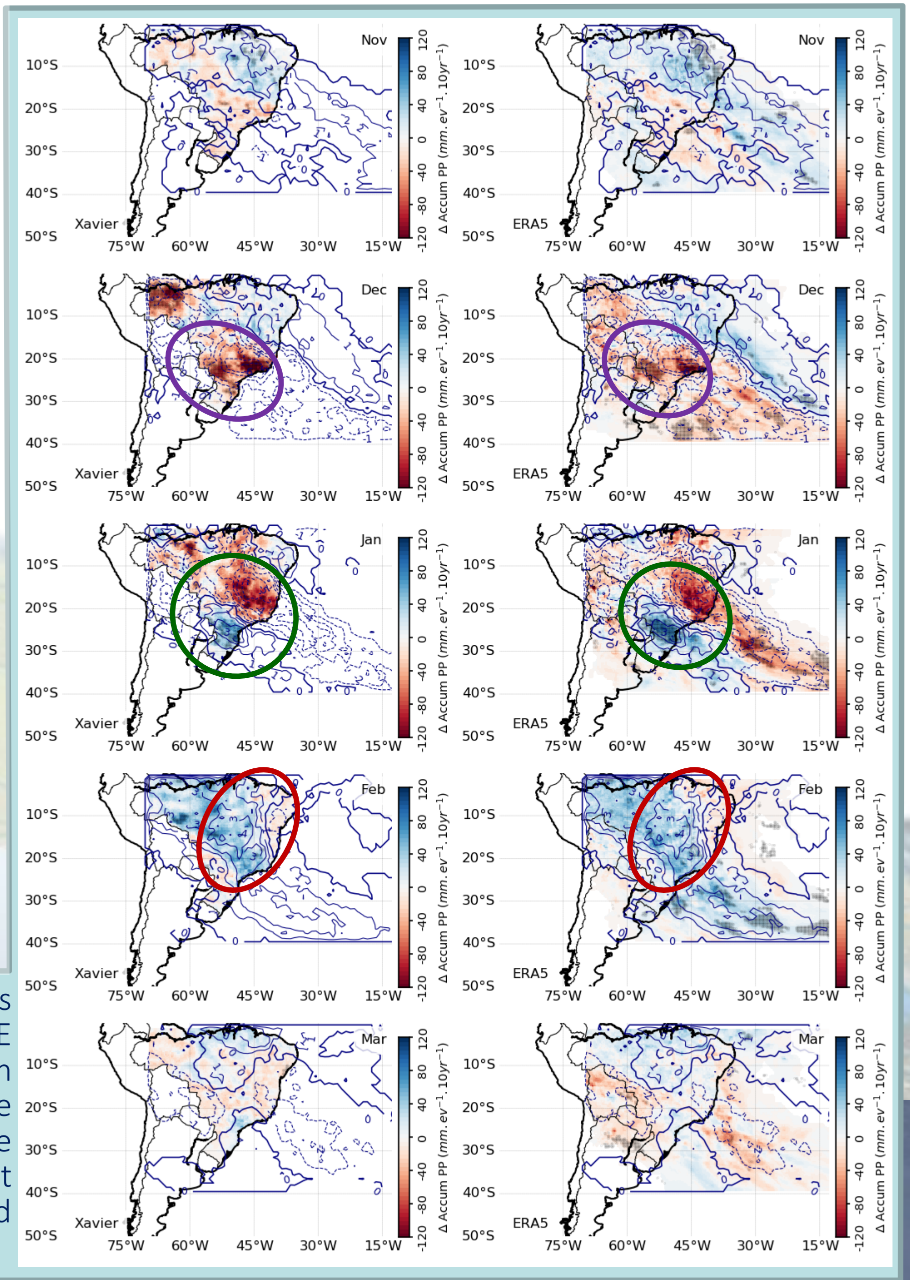


Changes in number of days with TE events (contour) and total precipitation during these events (shades), considering events persisting 1-3 days (left) and 4 or more days (right). Significant differences ($p < 0.1$) are stippled. Dataset: gridded observation (left column) and ERA5 (right column). Precipitation values within the spatial signature of TE cloud bands.

CONTRIBUTION TO CHANGES IN CLIMATOLOGY



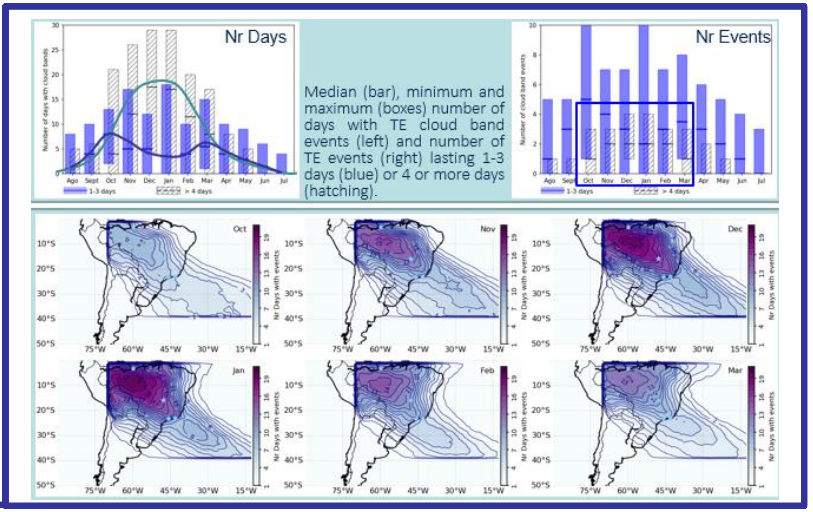
- Dec: reduction in the number of days with TE events contributes to changes in total precipitation over subtropical South America
- Jan: southward shift in the number of days with TE events partially contributes to the reduction (increase) in total precipitation over eastern Brazilian coast (SE Brazil).
- Feb: increase in the number of days with TE events offset precipitation reduction over eastern Brazil

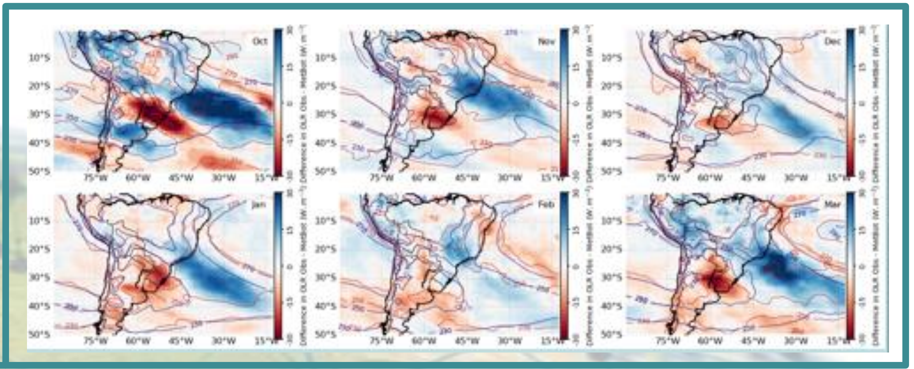


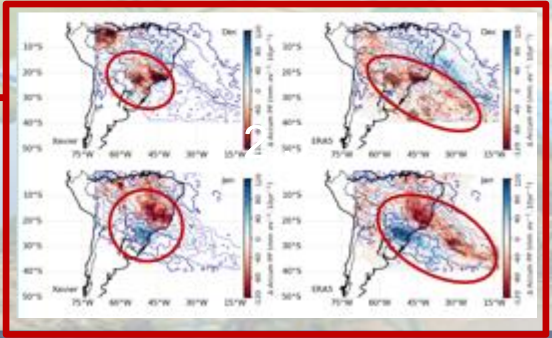
Left: total precipitation (contour) and its changes (shades). Right: Changes in number of days with TE events (contour) and their total precipitation (shades), considering events persisting 4 or more days. Precipitation only within the spatial signature of TE cloud bands. For both panels: significant differences ($p<0.1$) are stippled; dataset: gridded observation (left column) and ERA5 (right column).

FINAL REMARKS

- TE cloud detection algorithm:
  - Synoptic aspects associated to location, frequency, and persistency of cloud band events
  - Identified TE cloud band events are responsible for more than 60% of the monthly precipitation during the austral rainy season.
  - Efficient in identifying SACZ events
- Changes in TE cloud bands events: poleward shift of the SACZ in recent decades.

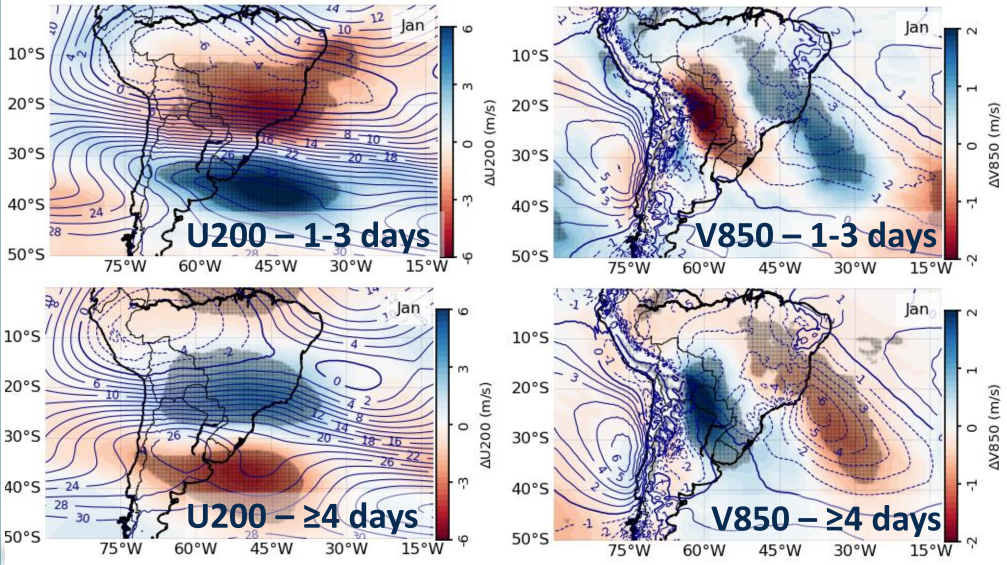




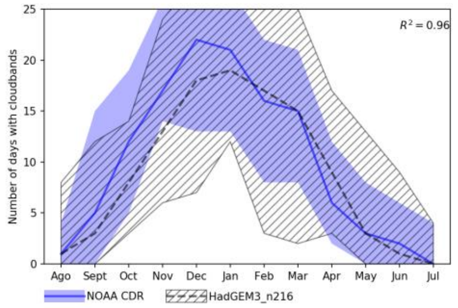


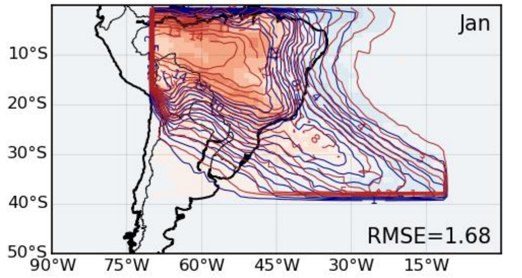
NEXT STEPS

- Synoptic climatology of TE events: circulation associated with formation and persistency TE cloud bands over coastal South America
- Interannual variability in frequency of TE events and mechanisms associated
- Evaluation of CMIP6 archive simulation of TE cloud bands



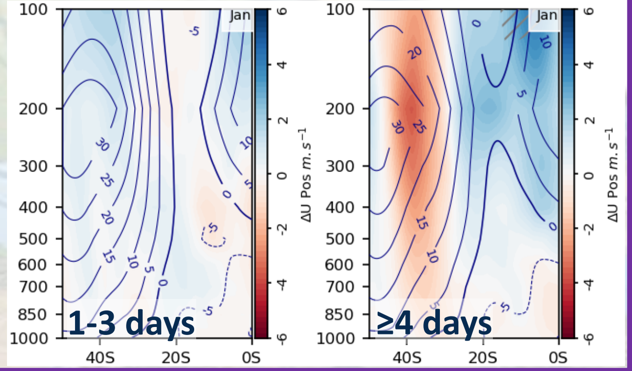
Composites of zonal winds at 200hPa (left) and meridional winds at 850 hPa (right) during January TE cloud band events persisting 1-3 days (left) and 4 or more days (right). Contours: average during events; shades: anomalies.





Left: median (line) and interquartile range (envelope) of the number of days with TE events identified using NOAA CDR (blue) and HadGEM3 n216 (hatching) OLR data. Right: Spatial representation of the number of days with TE events (contour) in NOAA CDR (blue) and HadGEM3 n216 (red) and the difference between the sources (shades, with red shades indicating fewer events in the model).

Composite of the vertical profile of zonal winds zonally averaged over South Atlantic (-40°W to -20°W) during Jan with large number of TE cloud band events persisting 1-3 days (left) and 4 or more days (right). Contour: monthly average; shades: monthly anomalies.



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THANK YOU!

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