North and Central South American Low Level Jets: mechanisms and association with active and break phases of the South American Monsoon System

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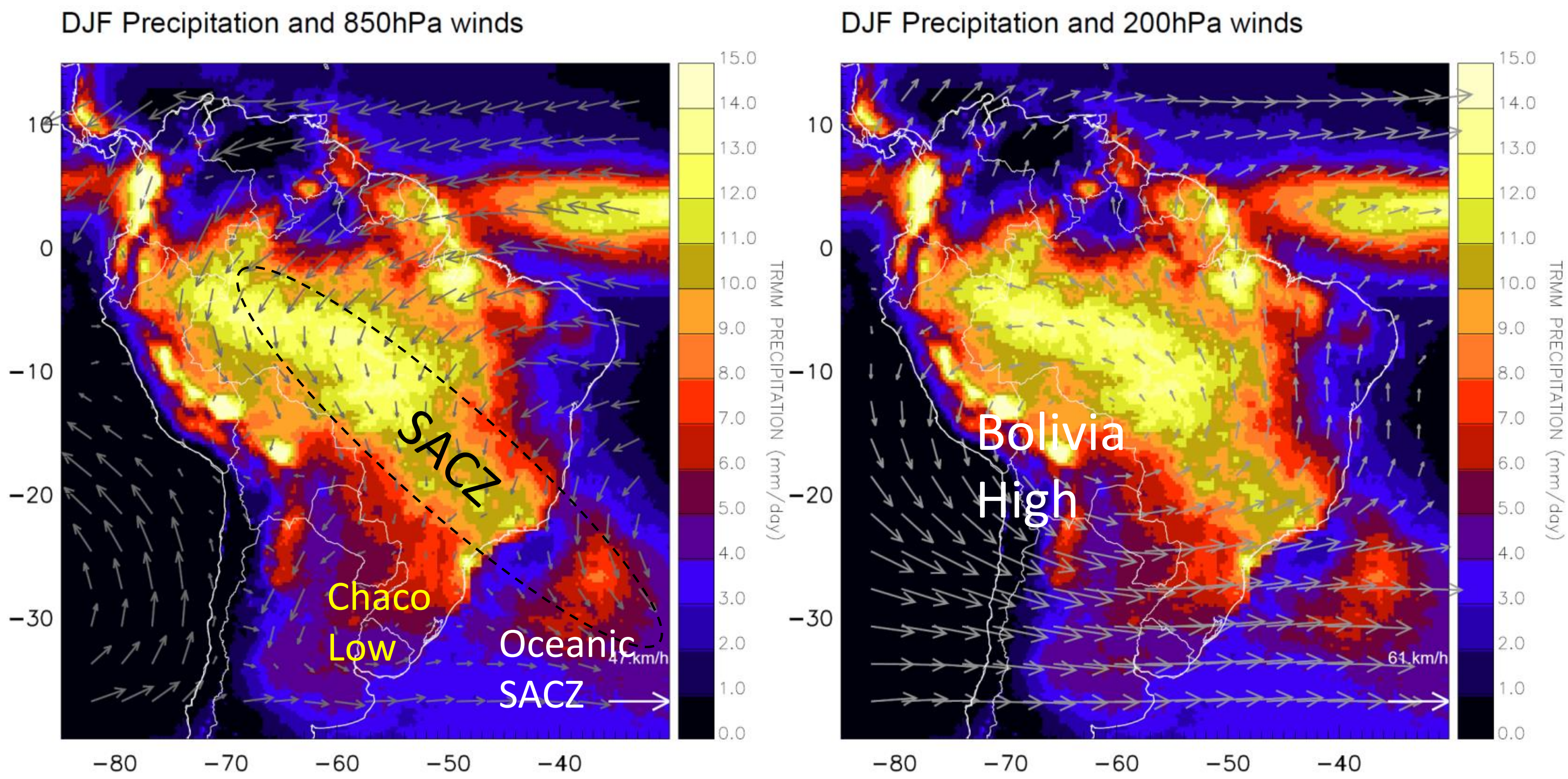
Outline

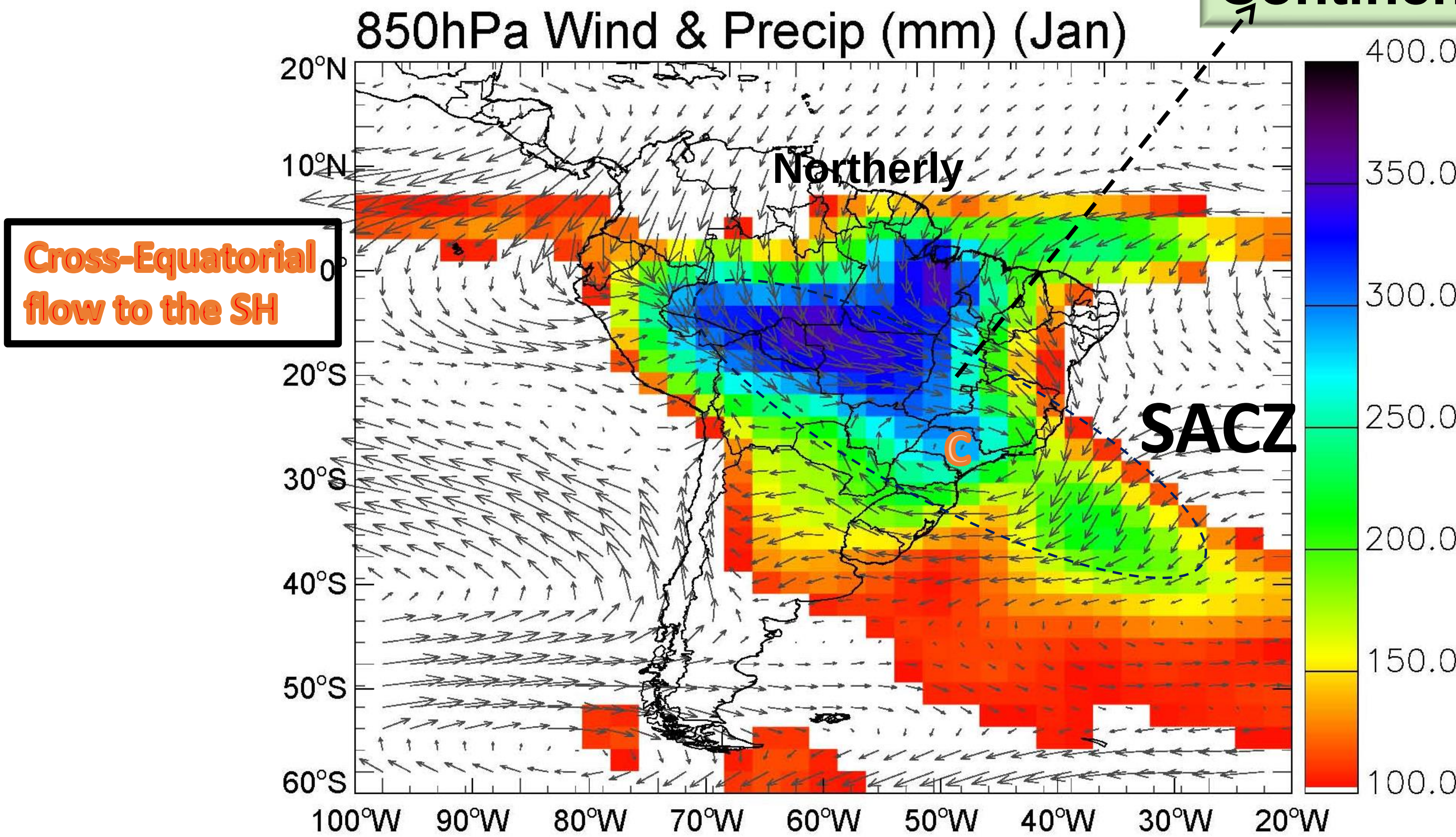
- Overview of the South American Monsoon variability
- Overview of low-level jets along the eastern Andes
- Classification and analyses of SALLJ
- Conclusions

The South American Monsoon (SAMS) summer climatology – December-February



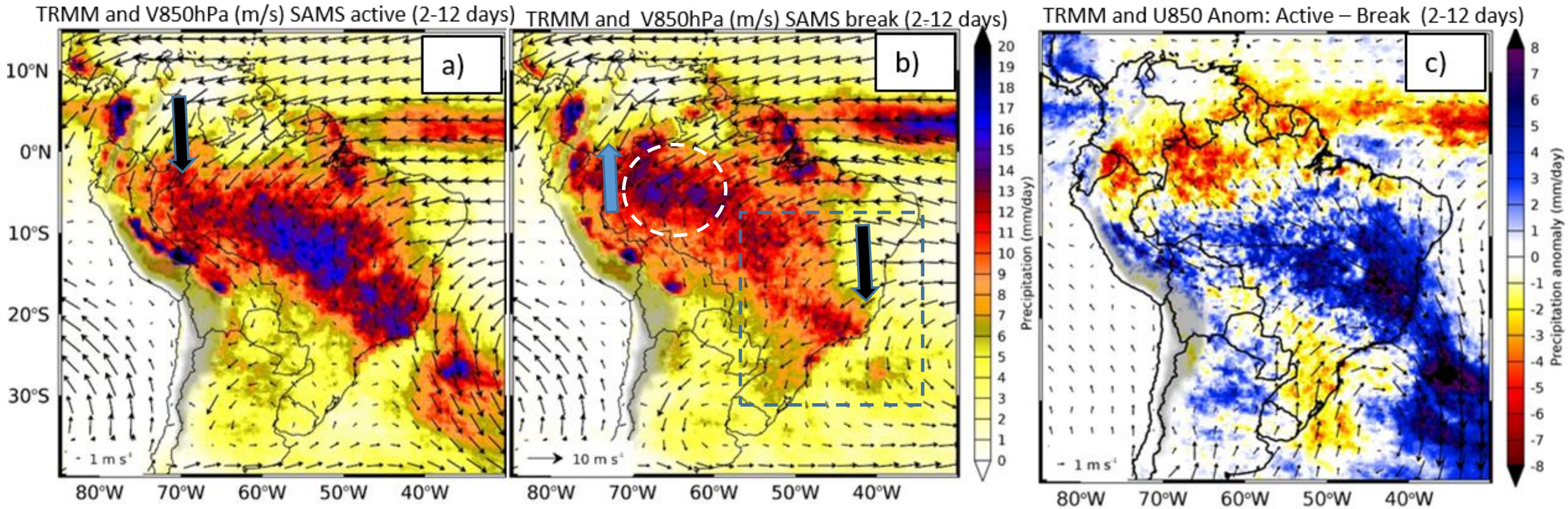
The South American Monsoon: January Precipitation and 850hPa wind anomalies relative to the annual mean

Maximum Precip Continent



SAMS variability on synoptic time scales (2-12 days)

Active phase: **Break phase:** **Active - Break phase:**



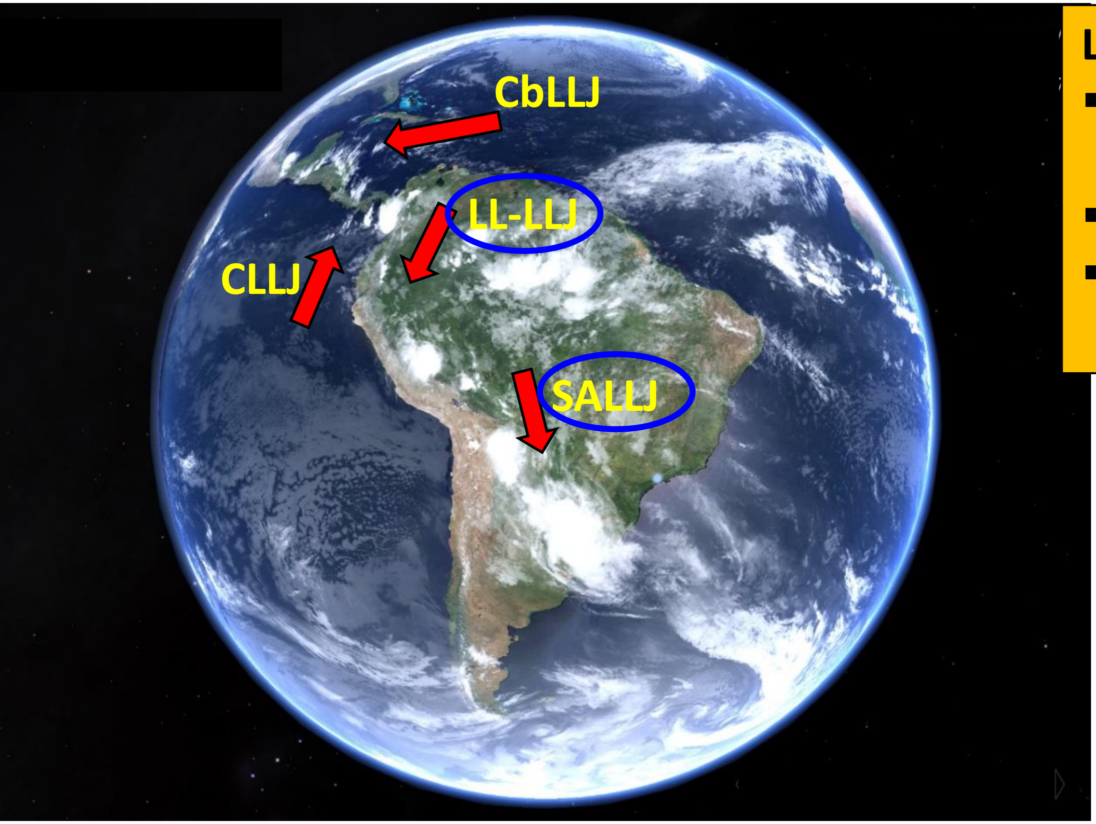
Active phase: westerly winds anomalies over central Brazil and eastern Amazon: Precipitation increases over the oceanic SACZ , and is suppressed over west Amazon

Break phase: Easterly winds anomalies: Suppressed convection over the SACZ; increased convection over western Amazon

Differences in wind anomalies and precipitation between active and Break phases

Carvalho and Silva Dias, 2020

Overview: Low-level jets affecting South America



Low-level jets:

- **Narrow region with high wind speeds; oftentimes elongated**
- **Observed in low levels (~0-1500 m agl)**
- **Large diurnal variability; oftentimes nocturnal occurrence**

- **Cb-LLJ: Caribbean LLJ**
- **CLLJ: Choco LLJ**
- **LL-LLJ: Llanos (Orinoco) LLJ**
- **SALLJ: eastern Andes LLJ**

Traditionally studied separately

- **LL-LLJ: Llanos (Orinoco) LLJ**
- **SALLJ: eastern Andes LLJ**

Are they related?

SALLJ climatology and variability:

Montini, T., C. Jones and L. M. V. Carvalho, 2019: The South American Low-Level Jet: a New Climatology, Variability, and Changes. JGR 10.1029/2018JD029634

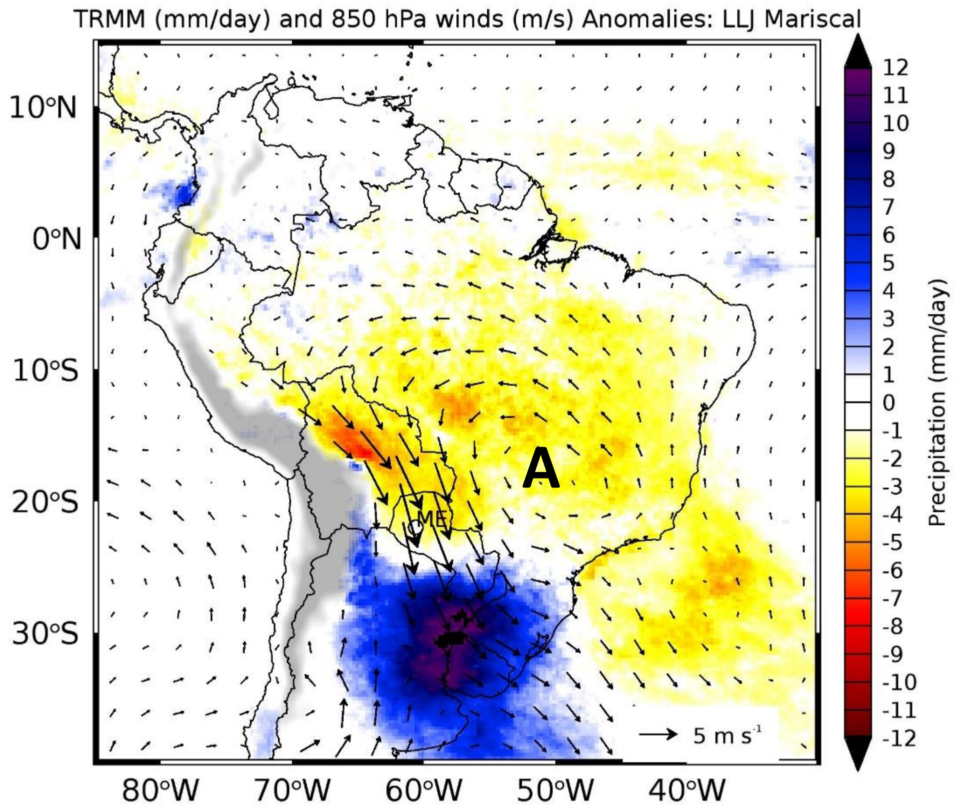
- **Modern reanalysis: CFSR, ERA-I, MERRA-2, JRA-55**
- **First generation: NCEP/NCAR reanalysis**
- **Modified Bonner criteria:**
  - **Northerly winds at 850-hPa ≥ P^{th} ms^{-1}**
  - **Vertical wind shear [850-700] hPa ≥ P^{th} ms^{-1}**
  - **v-wind < 0**
  - **v-wind > u-wind**

- **Where P^{th} are 75^{th} seasonal percentiles**
  - **6-hourly reanalysis**
  - **Determined for each location (Santa Cruz, Mariscal) separately**
  - **Determined for each season separately**

Overview: South America Low-level Jet (SALLJ)

Central Andes

- **Low-level jet: maximum winds 500-1600 m a. g.**
- **Max wind speeds near Bolivia ("Andes elbow")**
- **Nocturnal: maximum winds 8 PM- 2AM Bolivia local time**
- **Transports large amounts of moisture**
- **Formation of mesoscale convective complexes**
- **Present year round**

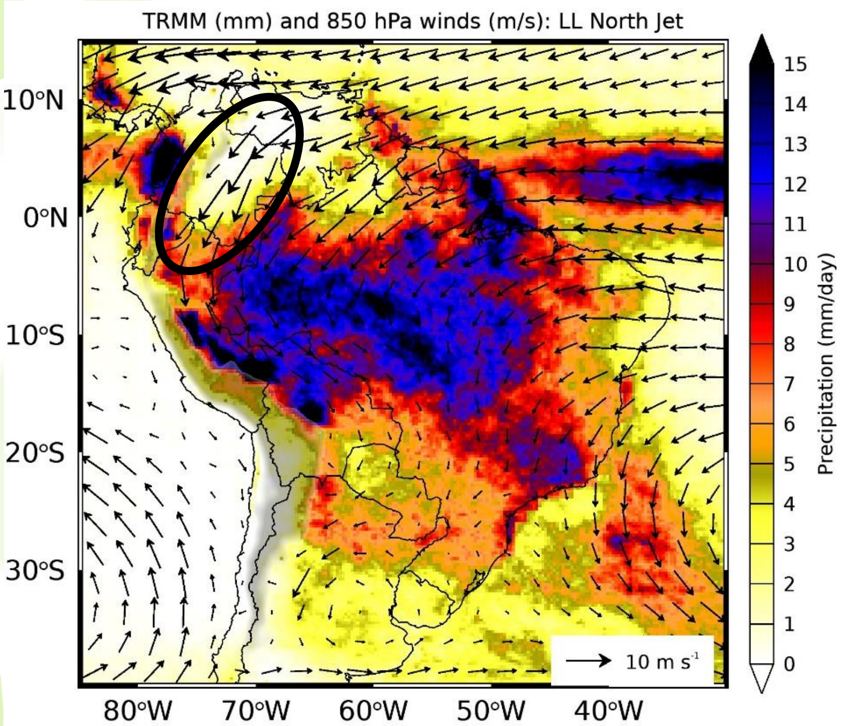


TRMM Precipitation and 850hPa wind anomalies during DJF when the jet is present at Mariscal (ME), Paraguay

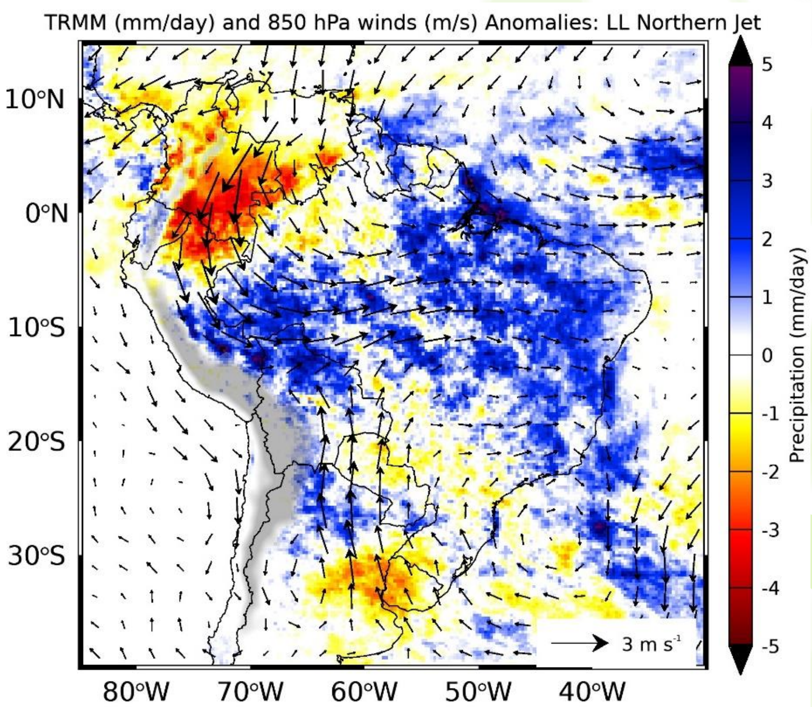
Method to identify the SALLJ discussed in Montini, T. L., C. Jones, and L. M. V. Carvalho, 2019: The South America Low-level Jet: new climatology, variability and changes. *Journal of Geophysical Research – Atmospheres* DOI:10.1029/2018JD029634

Northern Orinoco LL Jet during DJF

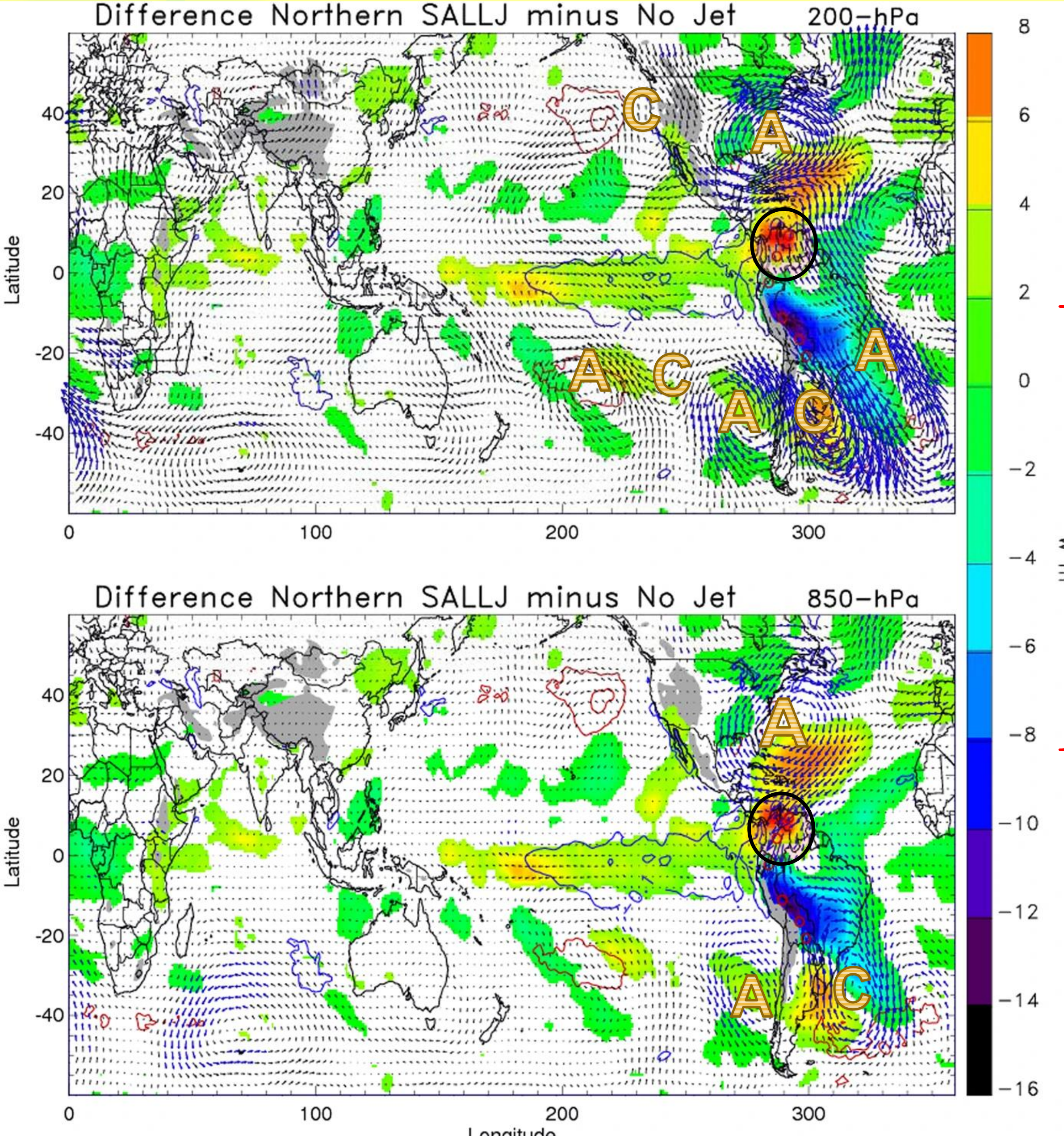
Mean precipitation and 850hPa winds



Differences LL JET- climatology



Differences Northern (Orinoco)- No jet



Color- OLR W/m^2

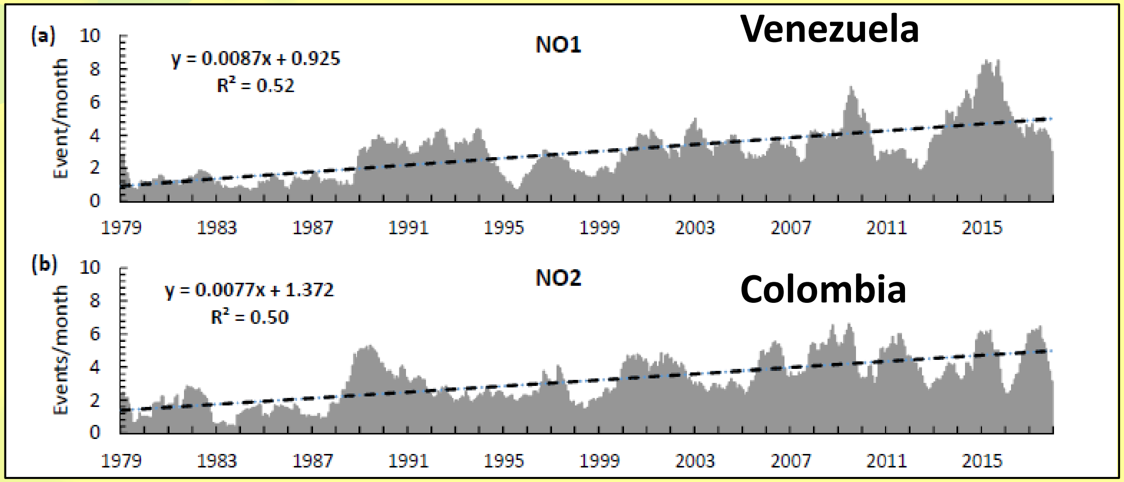
200hPa winds (vectors)
SST anomalies (contours)

850 hPa winds (vectors)
SST anomalies (contours)

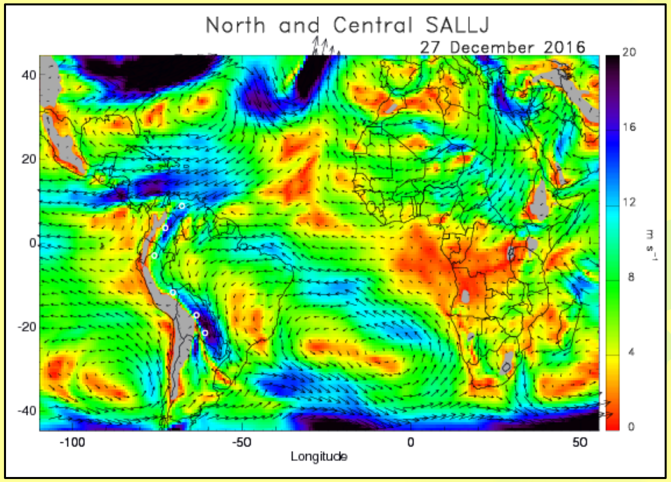
Jones, C. Recent changes in the South America low-level jet. *npj Clim Atmos Sci* **2,** 20 (2019). https://doi.org/10.1038/s41612-019-0077-5

Are there significant trends in the SALLJ?

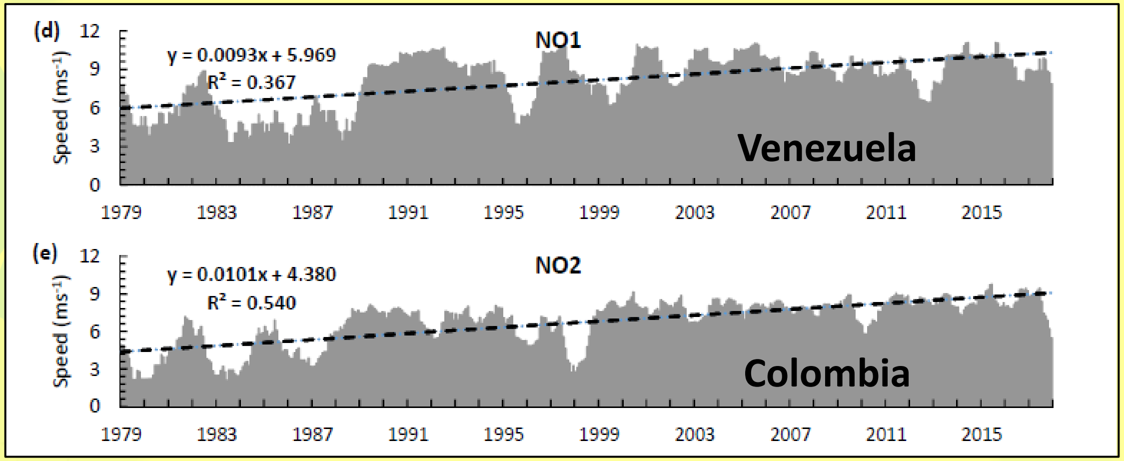
Northern SALLJ frequency



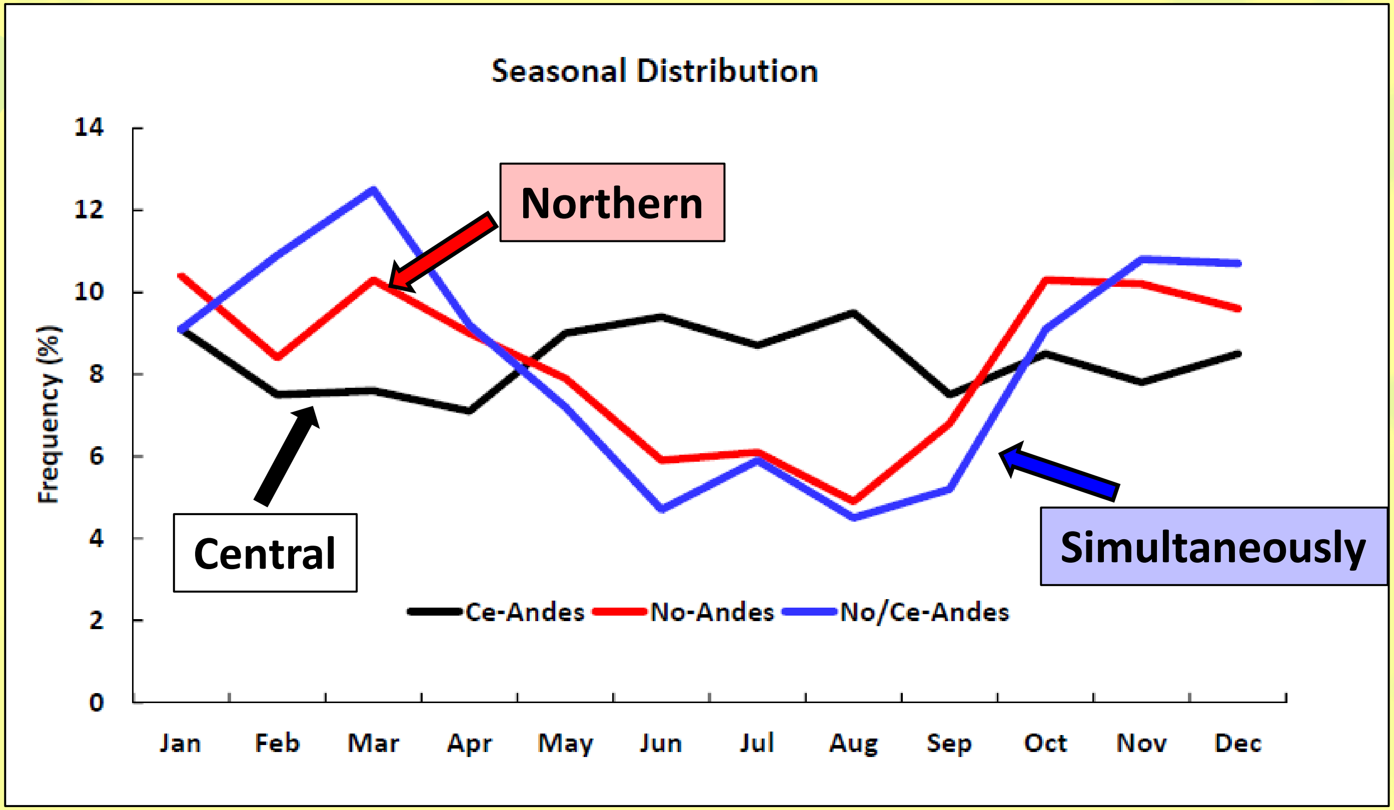
Significant increase in events and speeds in SALLJ northern Andes



Northern SALLJ speed



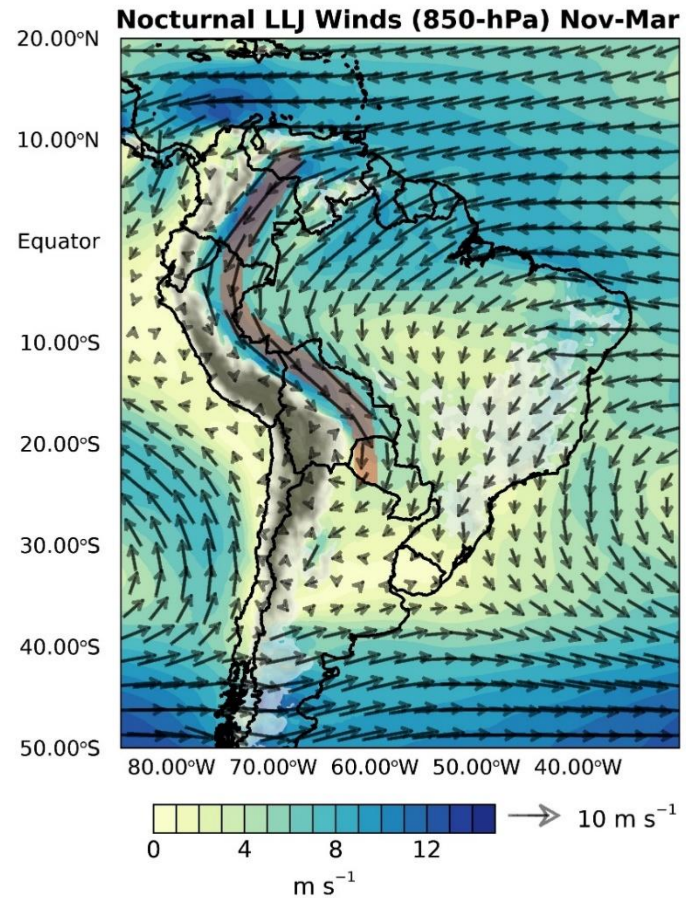
Are the northern and central Andes jets independent?



How to objectively identify the SALL Jets?

Processing outline:

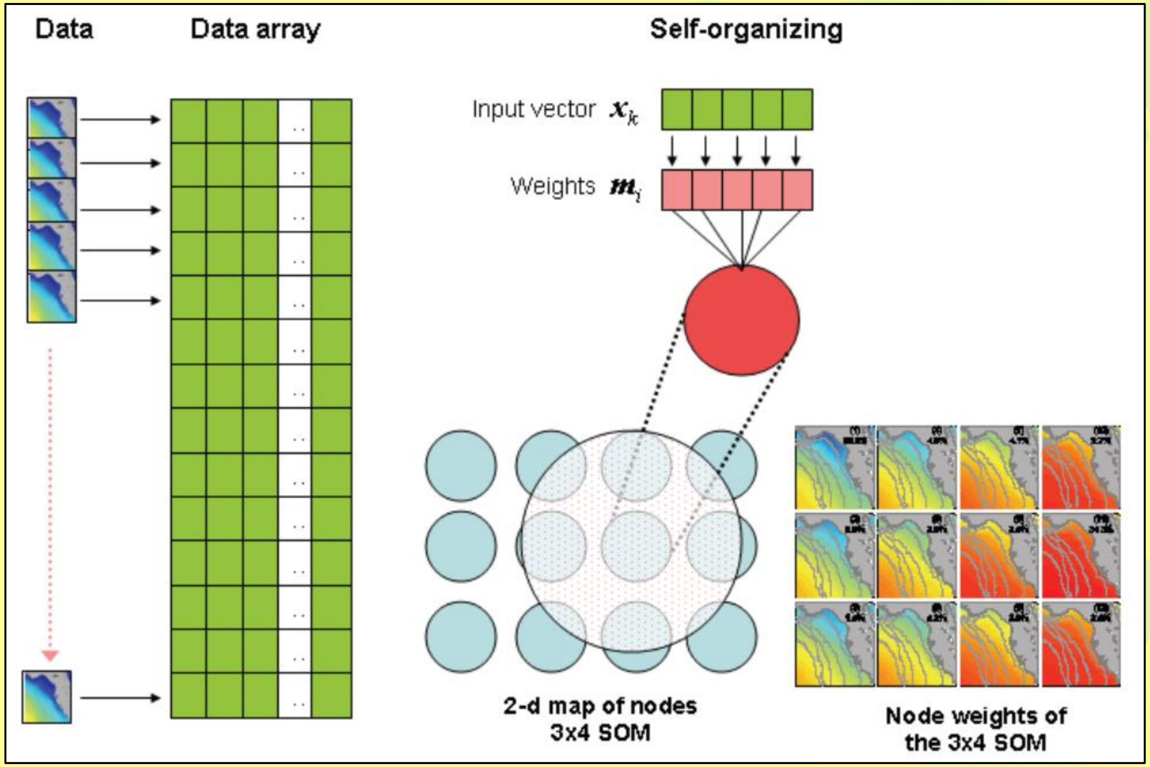
- ❑ ERA5 reanalysis:
  - ○ [u, v] 850-hPa and 700-hPa
  - ○ 1 Jan 1979 – 31 Dec 2019, hourly
- ❑ Define mask along the eastern Andes
- ❑ Adopt the criteria for defining jets along the Andes
- ❑ Use all maps of u,v classified as jets.



Self-Organizing Maps (SOM)

An unsupervised neural network tool to sort geospatial data considering non-linear relationships.

SOMs is frequently used to classify synoptic (or large scale) patterns in meteorology.



Liu, Y., and R. H., 2011: A Review of Self-Organizing Map Applications in Meteorology and Oceanography. *Self Organ. Maps - Appl. Nov. Algorithm Des.*, https://doi.org/10.5772/13146.

Configuring SOM to classify the SALLJ over South America

We use meridional nocturnal winds at 850 hPa between November and March to find non-linear spatial continental patterns

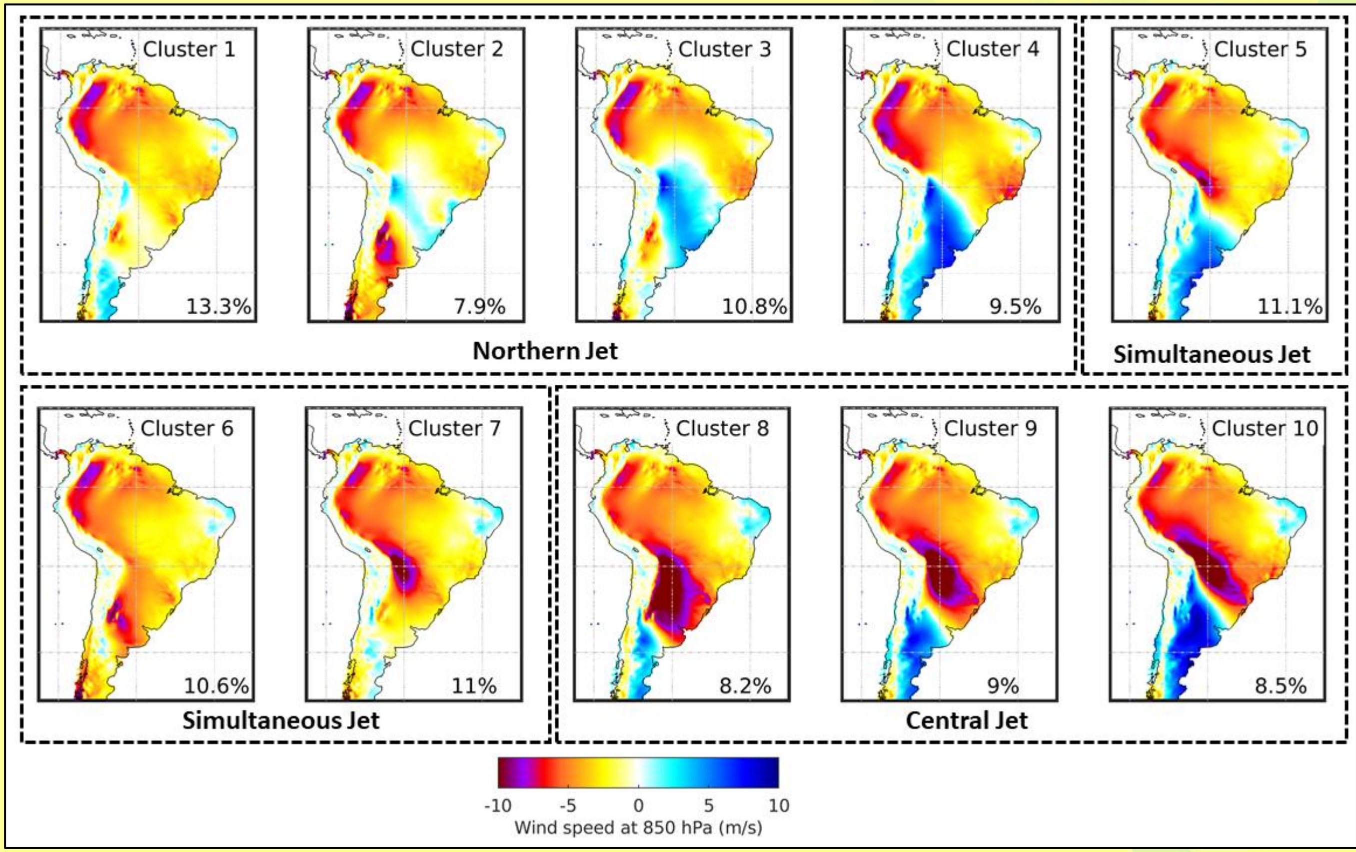
1- SOM technique

Without any preset initialization, we found **208 SOM nodes**

2 - K-mean clustering method

10 clusters cover the spatial variability of the SALLJ

We define **the northern, simultaneous and Central SALLJ**

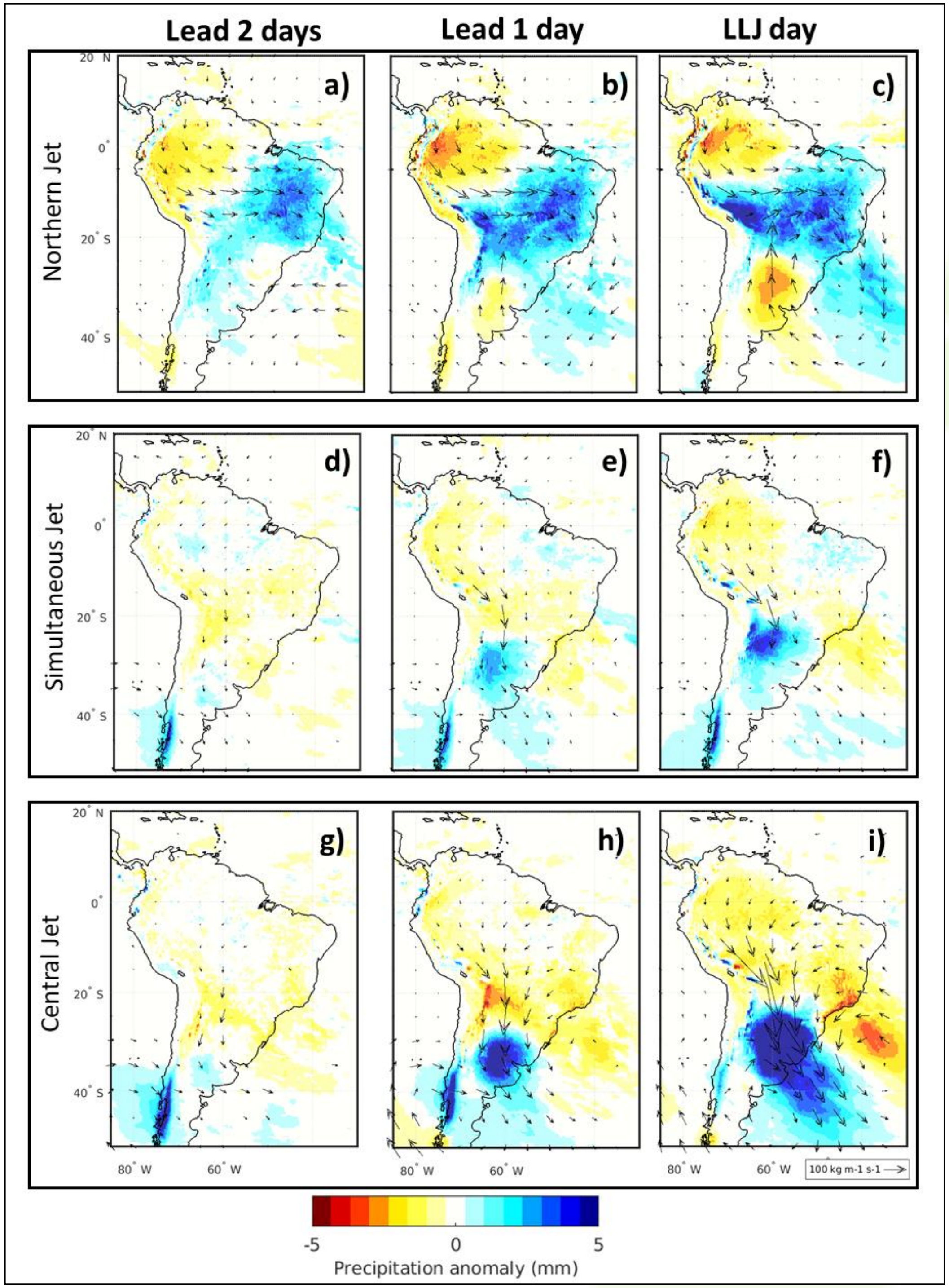


Northern

Simultaneous

Central

Integrated water vapor (arrows) Precipitation anomalies



Conclusions

- The South American Monsoon is strongly influenced by the behavior of low-level jets
- This research point out that the North and Central LLJs play a distinct role in modulating the SAMS
- The Nothern Jet is important in the active phase of the monsoon.
- There is evidence that the frequency and intensity of the Northern Jet is increasing.
- SOM is useful to less arbitrarily identify LLJs