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A Hidden Markov Model of Daily Precipitation over Western Colombia.

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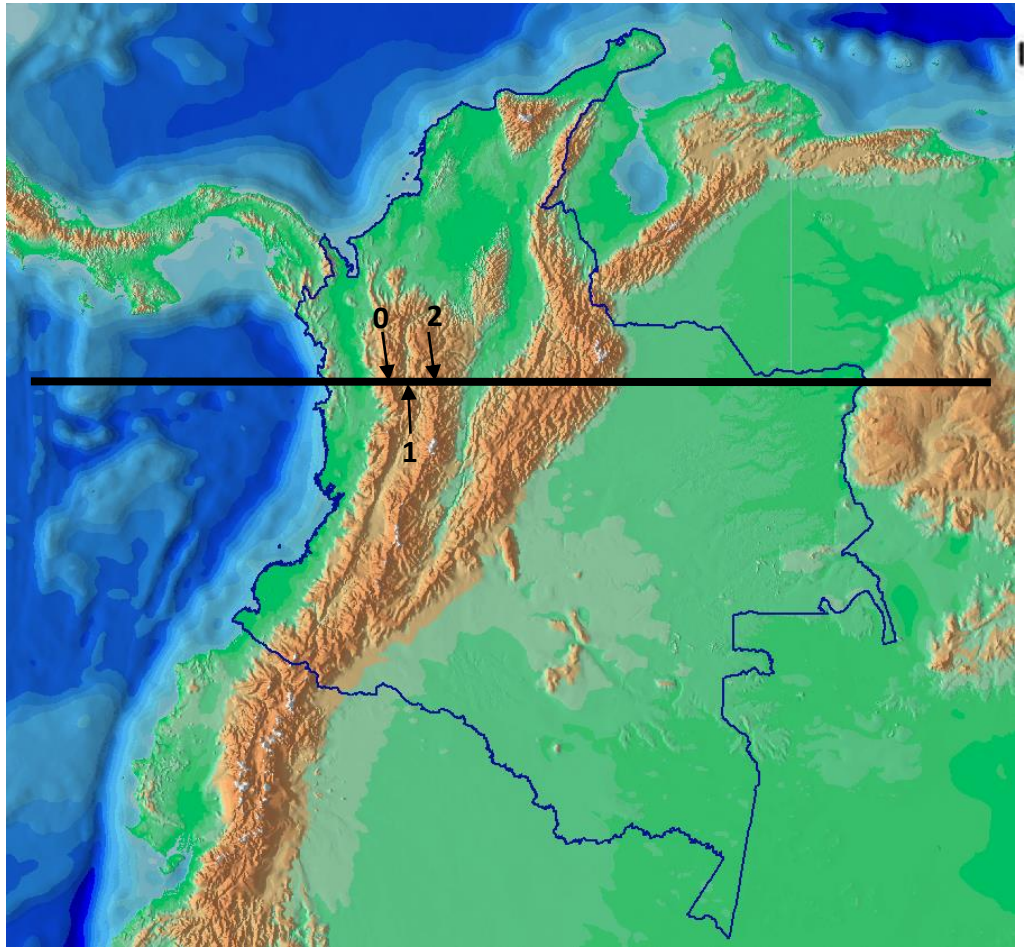
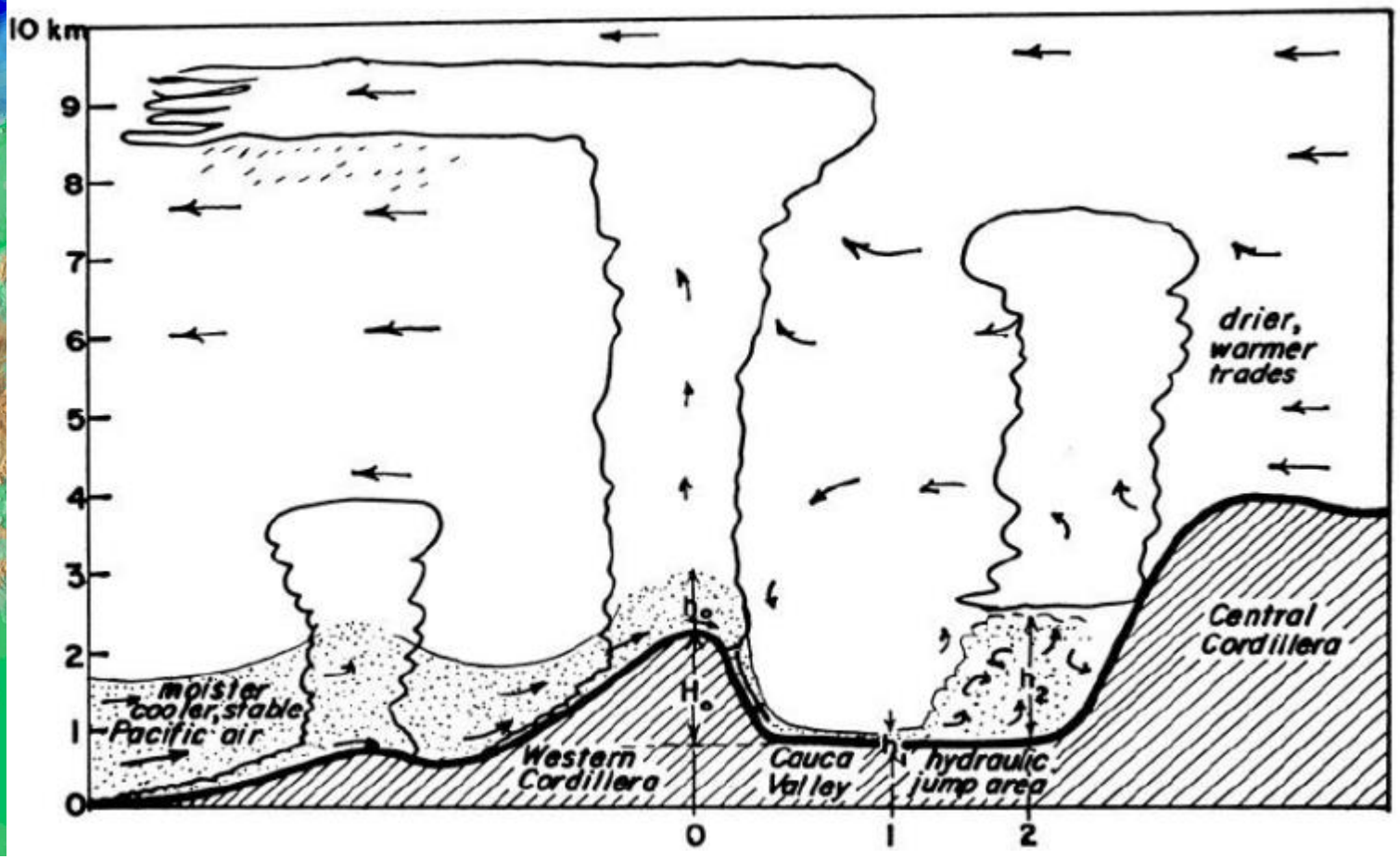
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

The western Pacific coast of Colombia (Chocó Region) is among the rainiest on earth, largely due to low level jets activity and orographic lifting along the western Andes





Lopez and Howell (1967)

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Three low level jet acts over Colombia:

- The Chocó low-level (CHOCO)

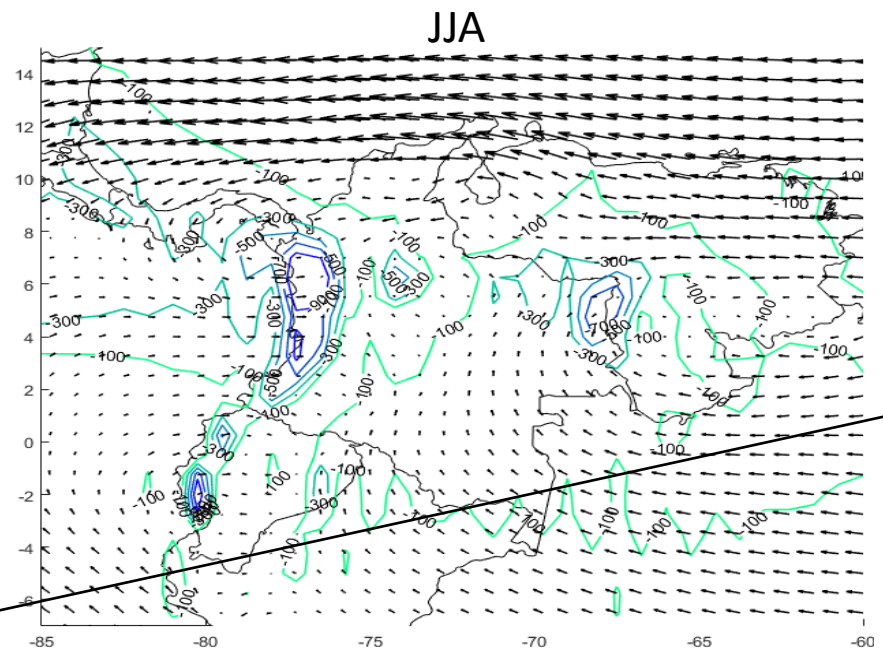
Poveda, G., & Mesa, O. (1999)

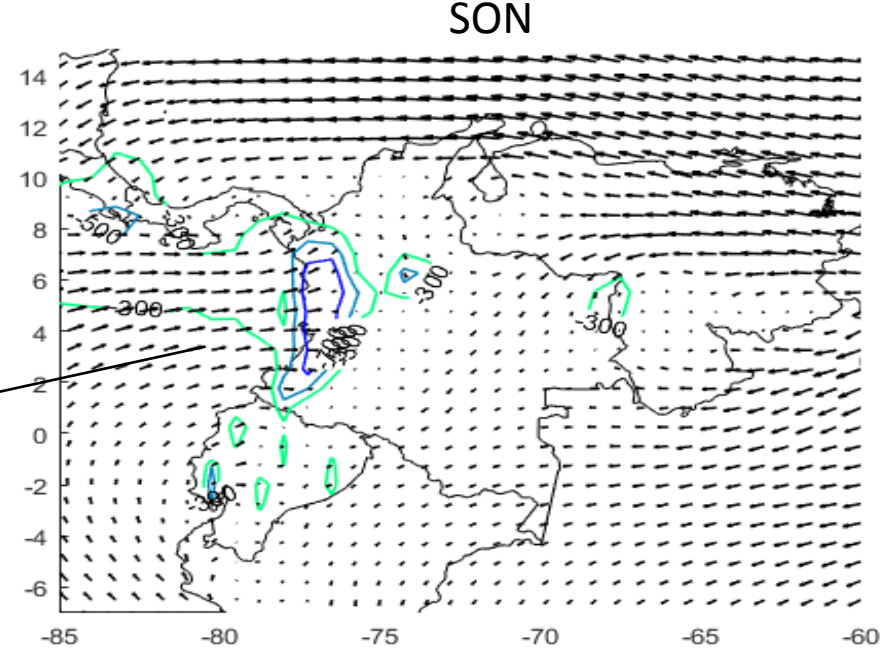
- Intra-Americas Sea low-level jet

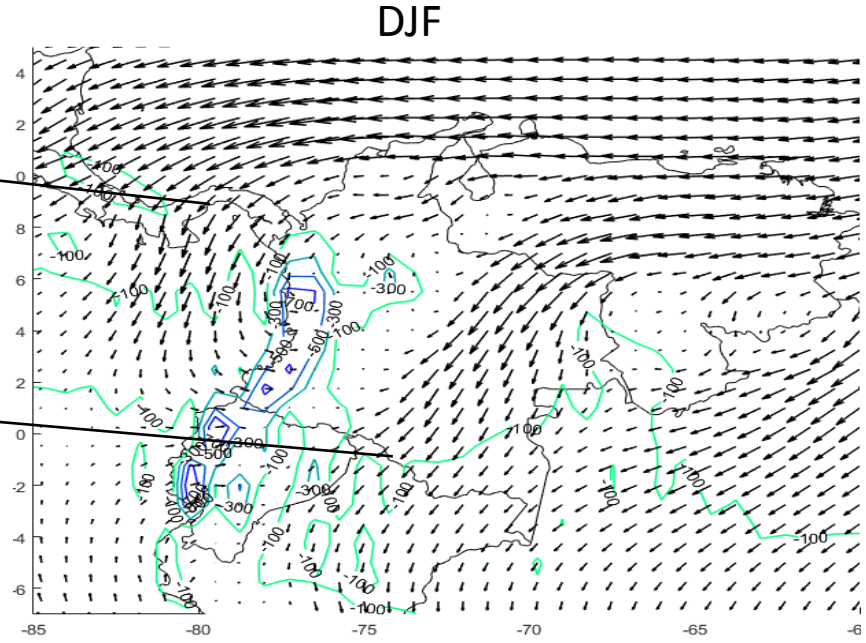
Amador (2008)

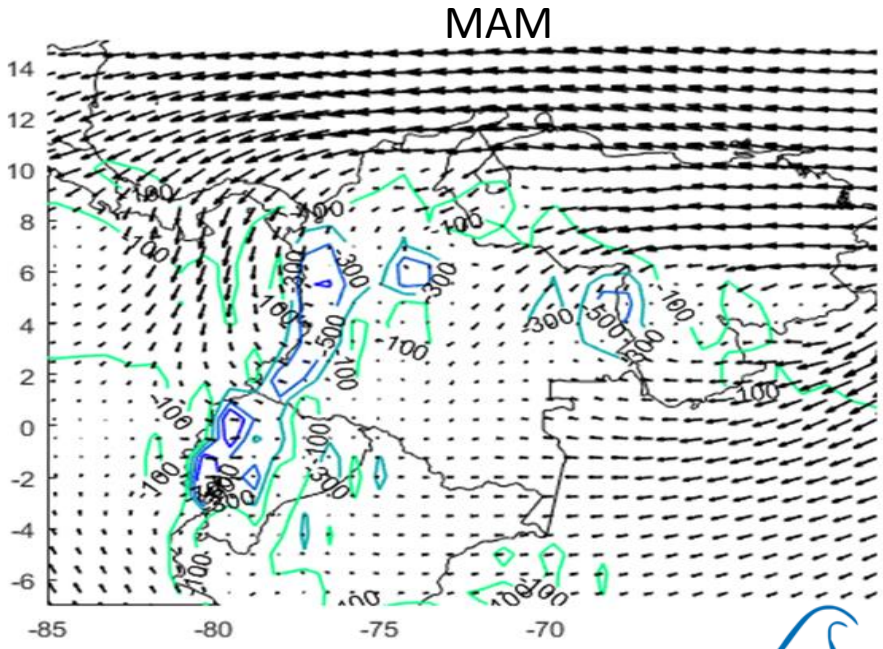
- South American low-level jet east of the Andes (SALLJ)

Marengo et al. (2004)









Vectors: Vertically integrated moisture flux (kg m-1 s-1)
Contours: Vertically integrated moisture flux Convergence (mm/month)

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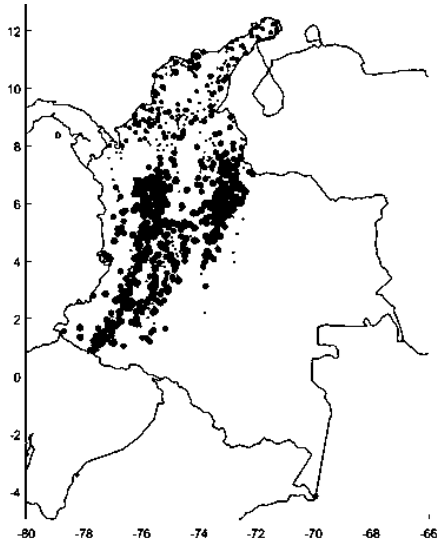
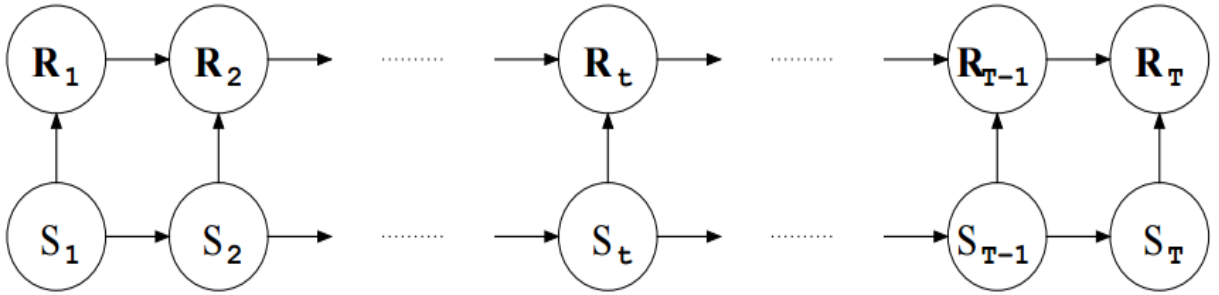
Data and Methodology (HMM)

A hidden Markov model (HMM) is used to characterize daily rainfall occurrence at 2500 gauge stations over the Western Pacific coast and Andean plateau in Colombia during the second wet season (August- December) from 1970 to 2015.



2500 gauge stations



$$P(r_{1:T}, S_{1:T} = s_{1:T}|\Pi, \Gamma, \Upsilon) = \left[\pi_{S_1} \prod_{t=2}^{T} \gamma_{S_{t-1},S_t}\right]\left[\prod_{t=1}^{T} F_{s_t}(r_t|r_{t-1})\right]$$

- Initial probability: $\Pi = (\pi_1, \ldots, \pi_k)$
- Transition Matrix : $\Gamma = (\gamma_{1,1}, \ldots, \gamma_{k,k})$ (Rabiner, 1989)
- Emission Probability: $F_i(r) = P(r_t|S_t = i)$

http://iri.columbia.edu/our-expertise/climate/tools/hidden-markov-model-tool/

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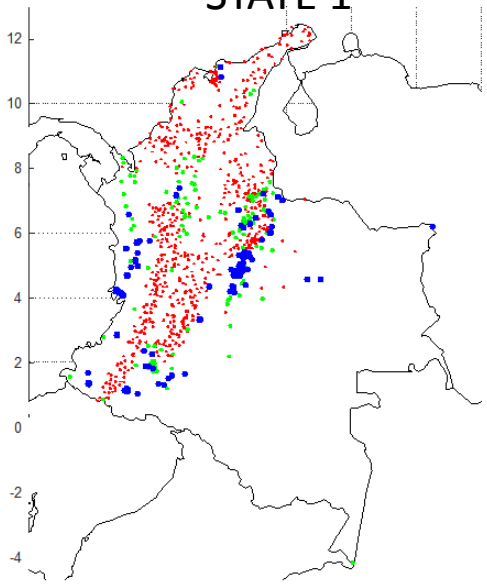
Results of HMM

STATE 1



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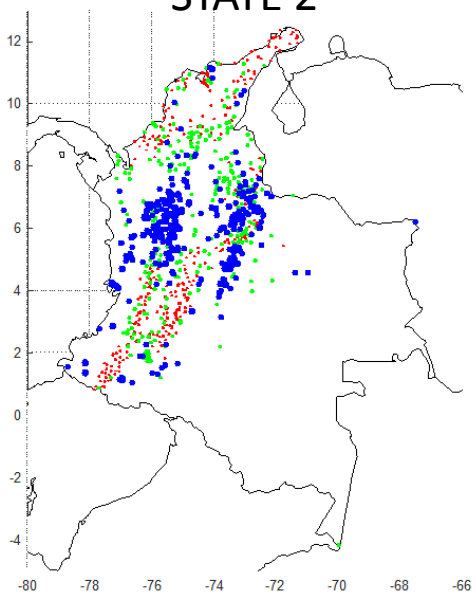

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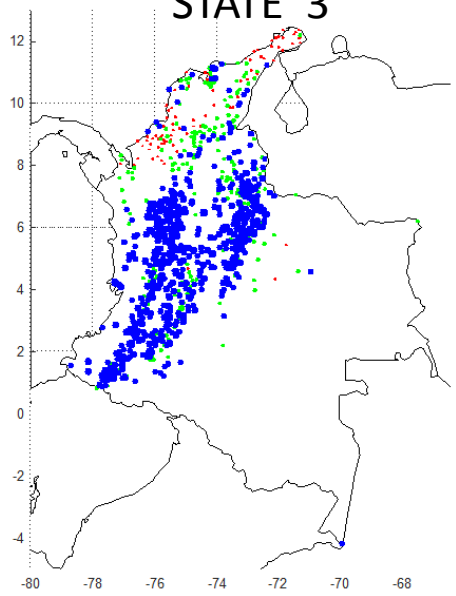

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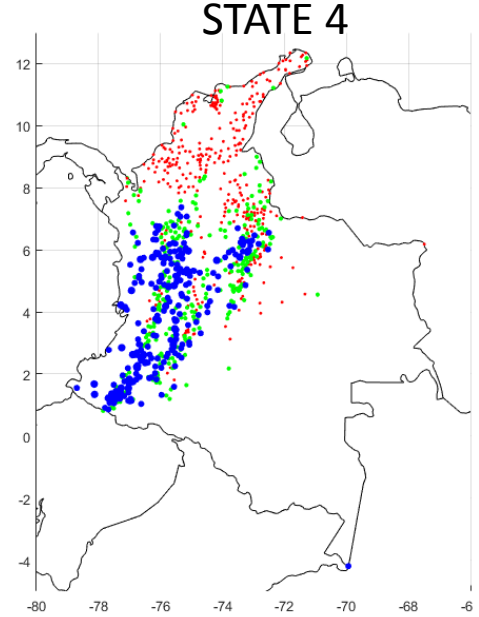

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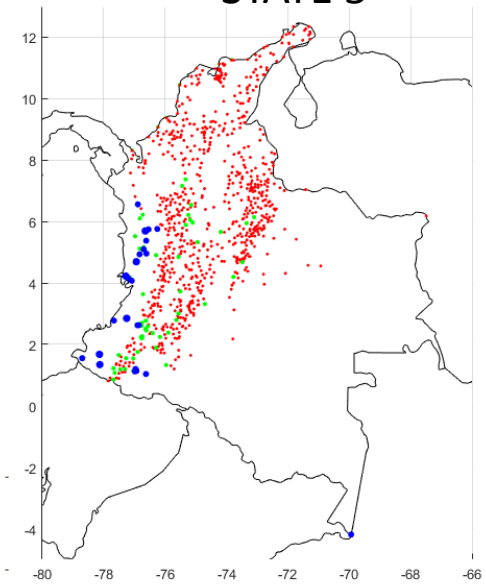

# Conditiona	1	2	3	4	5
1	66%	23%	0%	0%	11%
2	15%	53%	15%	9%	8%
3	1%	17%	66%	15%	1%
4	1%	8%	17%	56%	18%
5	11%	6%	2%	17%	65%

Transition Matrix (Probabilities)

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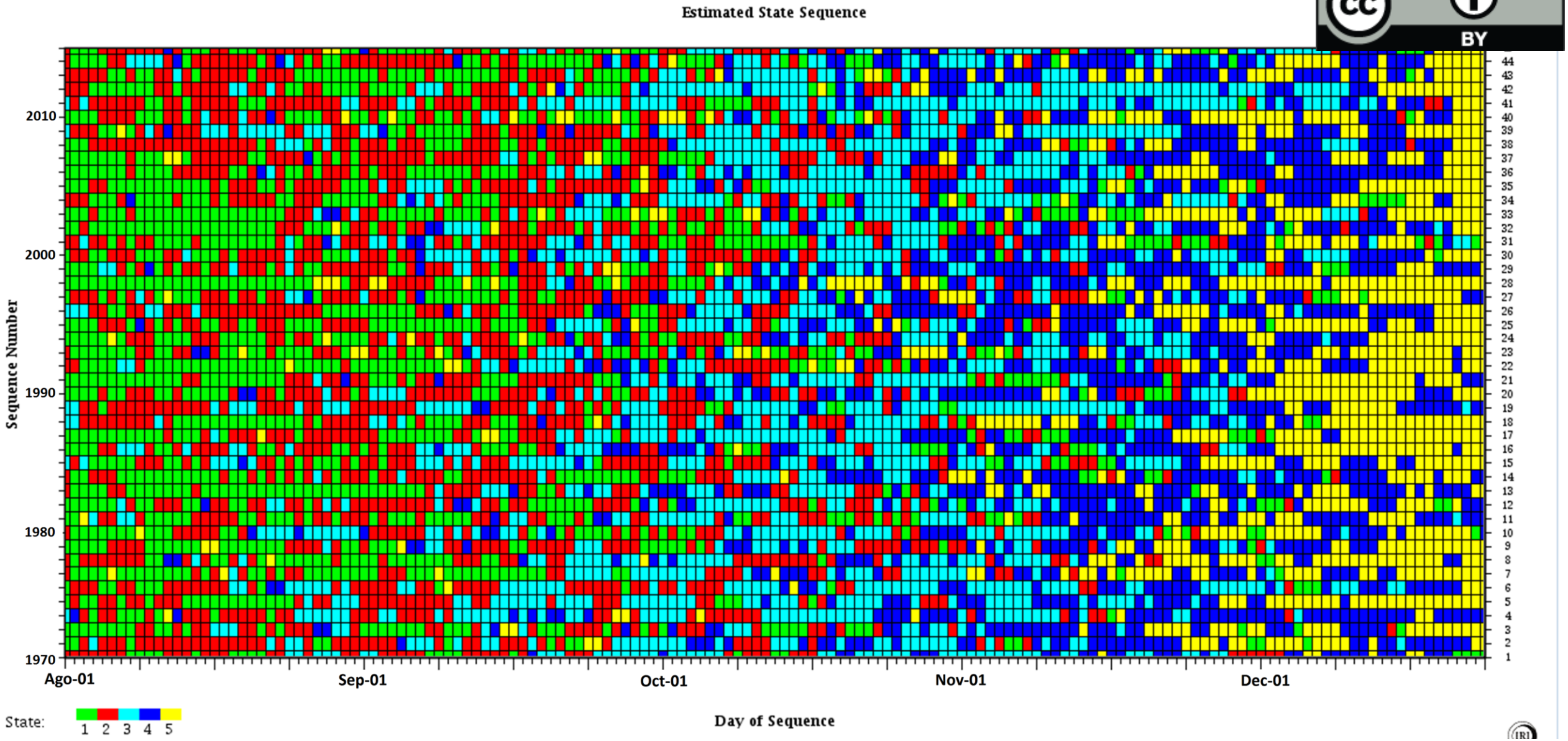
hmm viterbi independent delta-exponential



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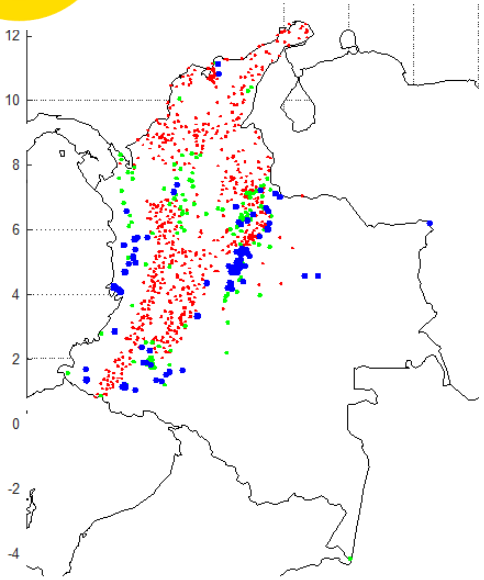
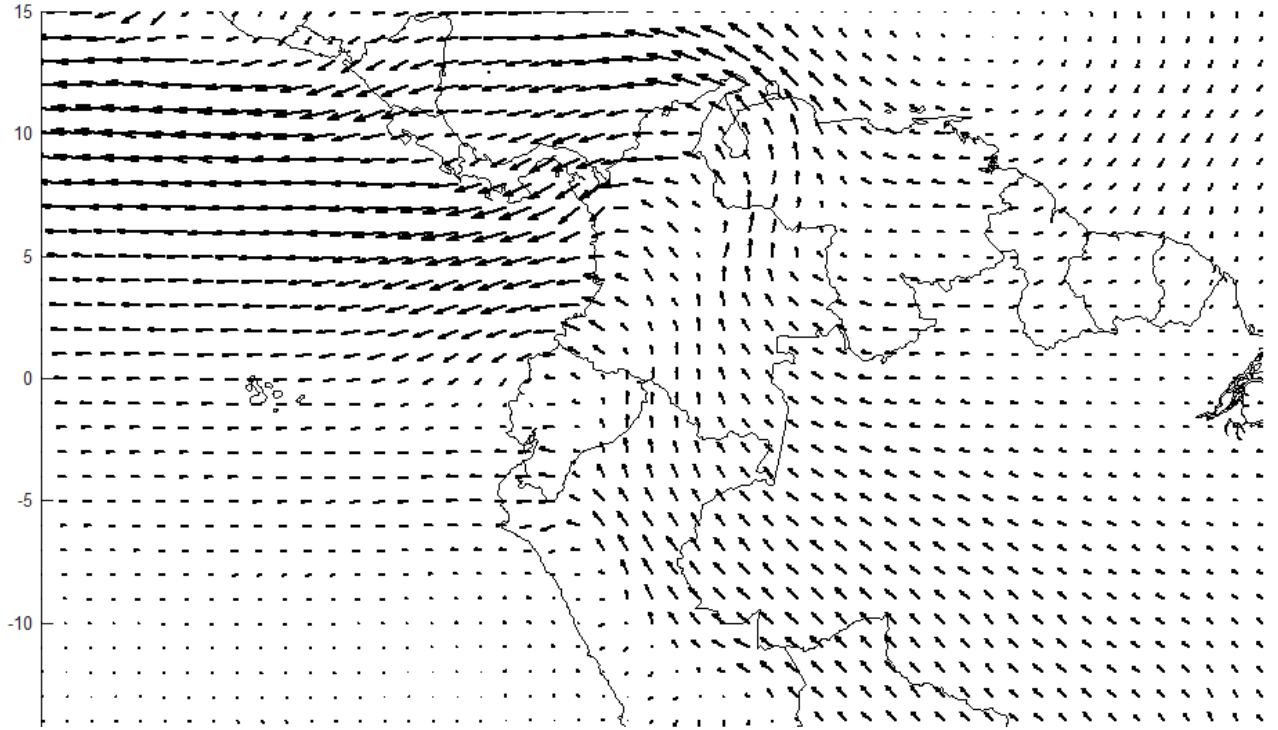
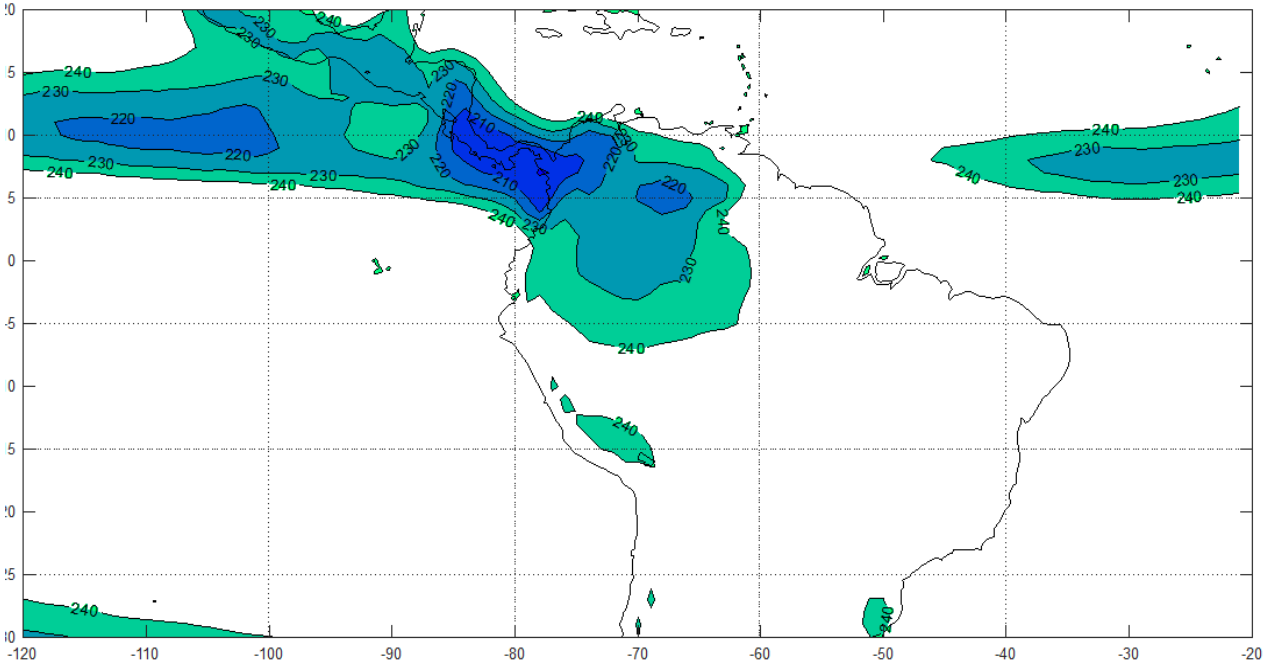
STATE 1







Anomaly composites of vertically-integrated moisture flux from the surface to 700 hPa (vectors), OLR (contours)

Pacific coast moisture divergence

Atlantic Divergence

SALLJ to north.

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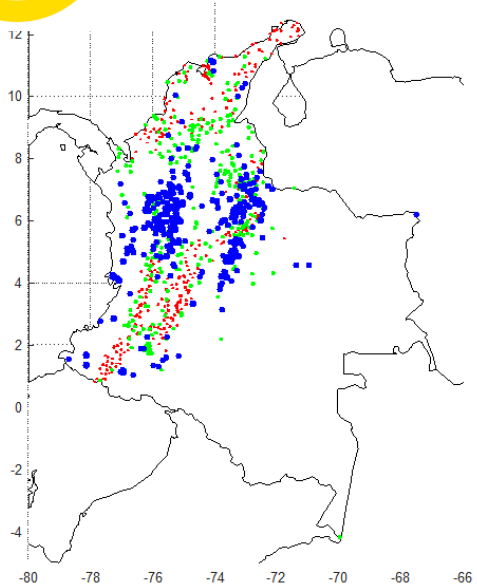
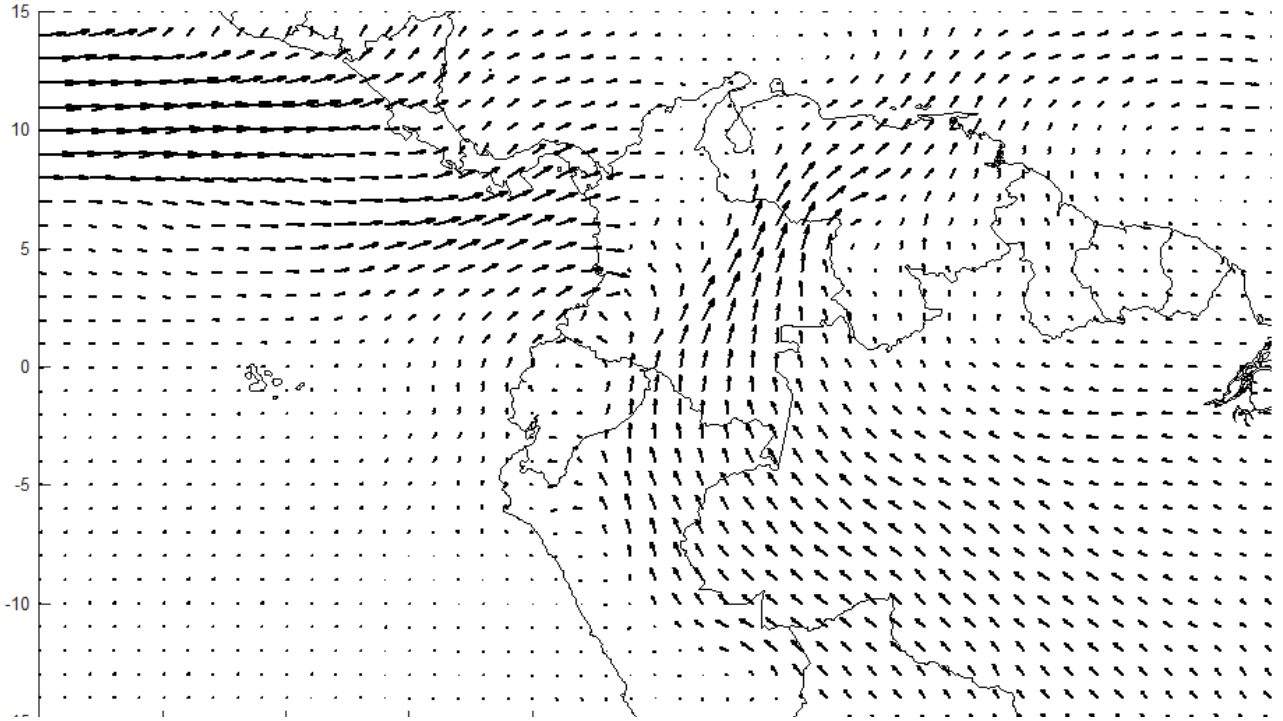
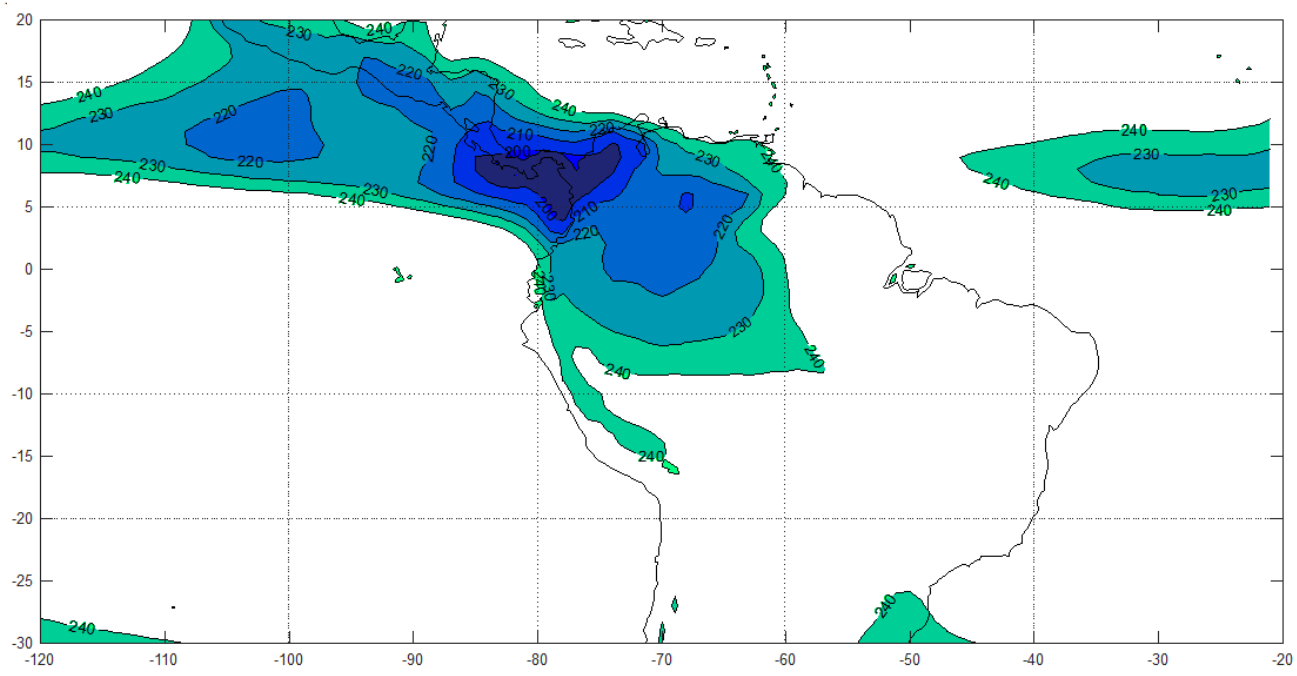
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

STATE 2







Chocó Jet intensification

SALLJ intensification To north.

Anomaly composites of vertically-integrated moisture flux from the surface to 700 hPa (vectors), OLR (contours)

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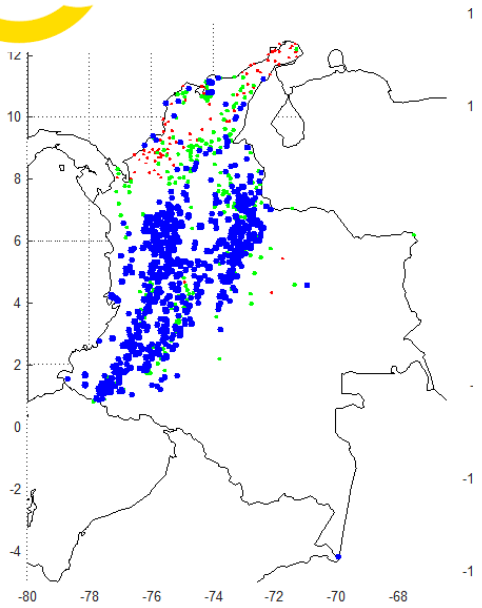
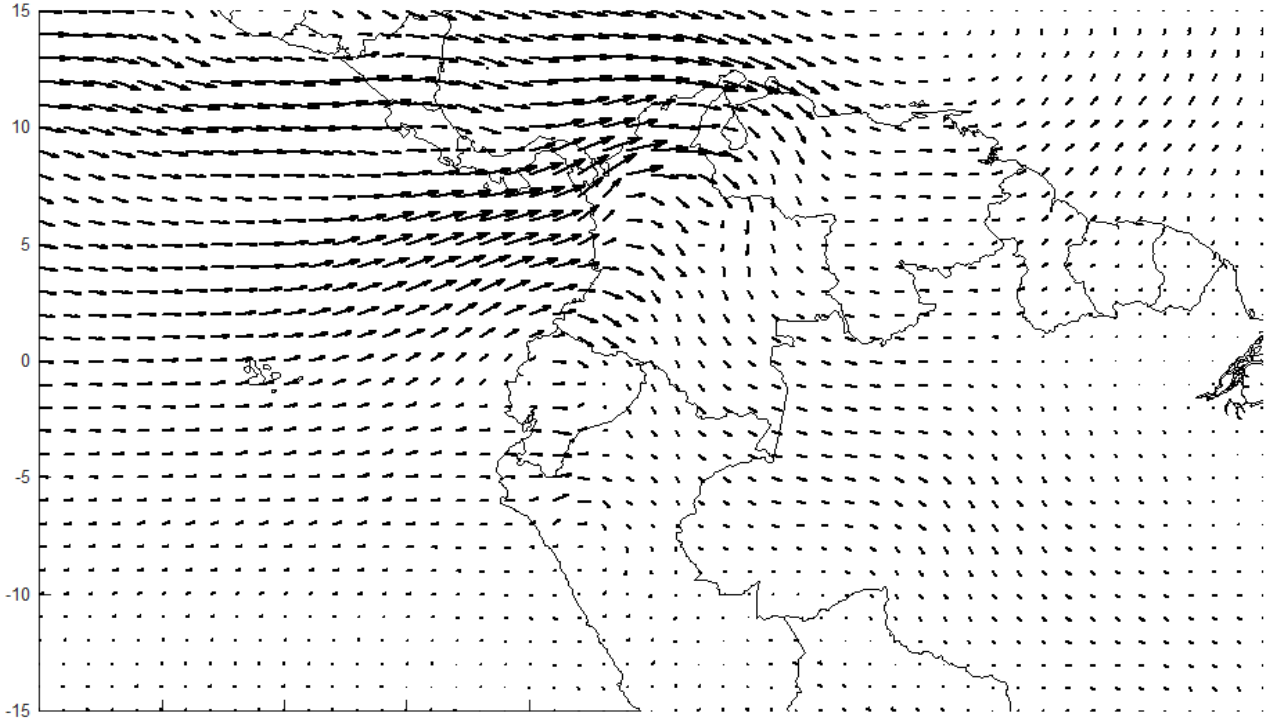
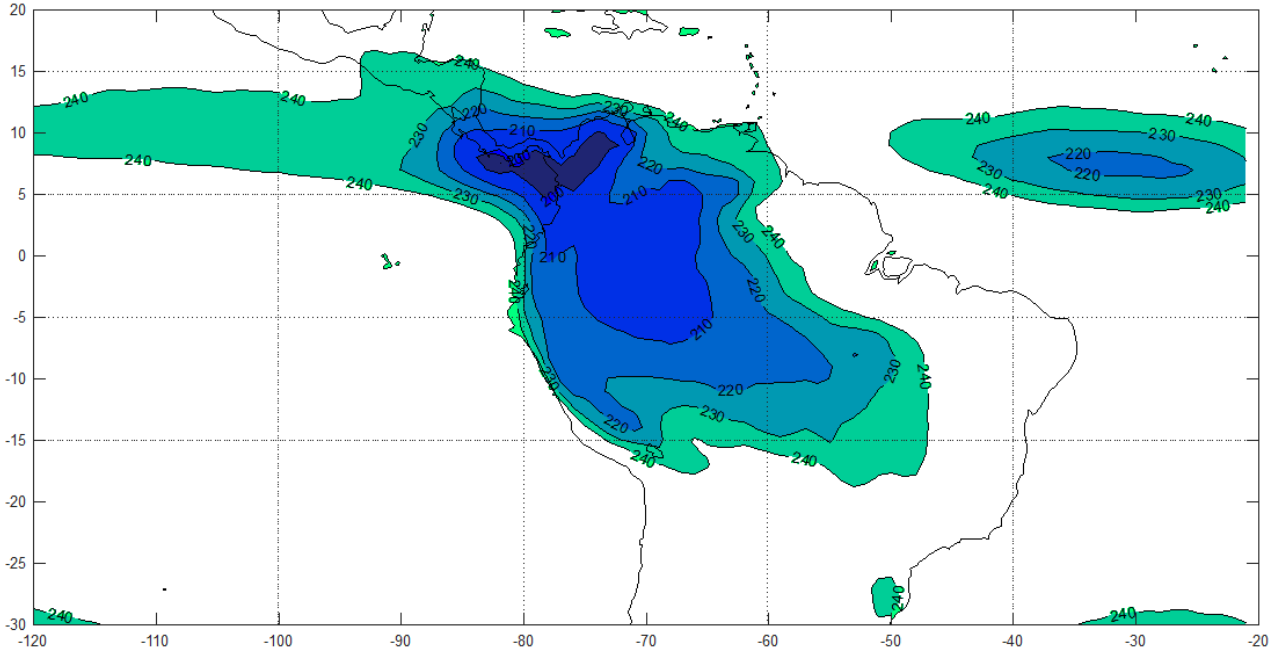
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

STATE 3





Chocó Jet intensification



Anomaly composites of vertically-integrated moisture flux from the surface to 700 hPa (vectors), OLR (contours)

Onset of The South Atlantic Convergence Zone (ZCAS)

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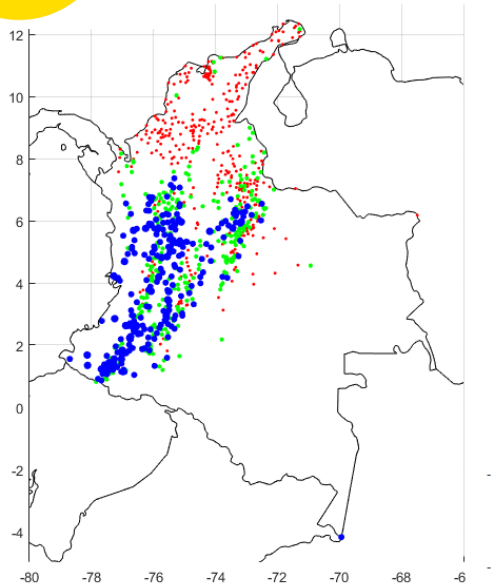
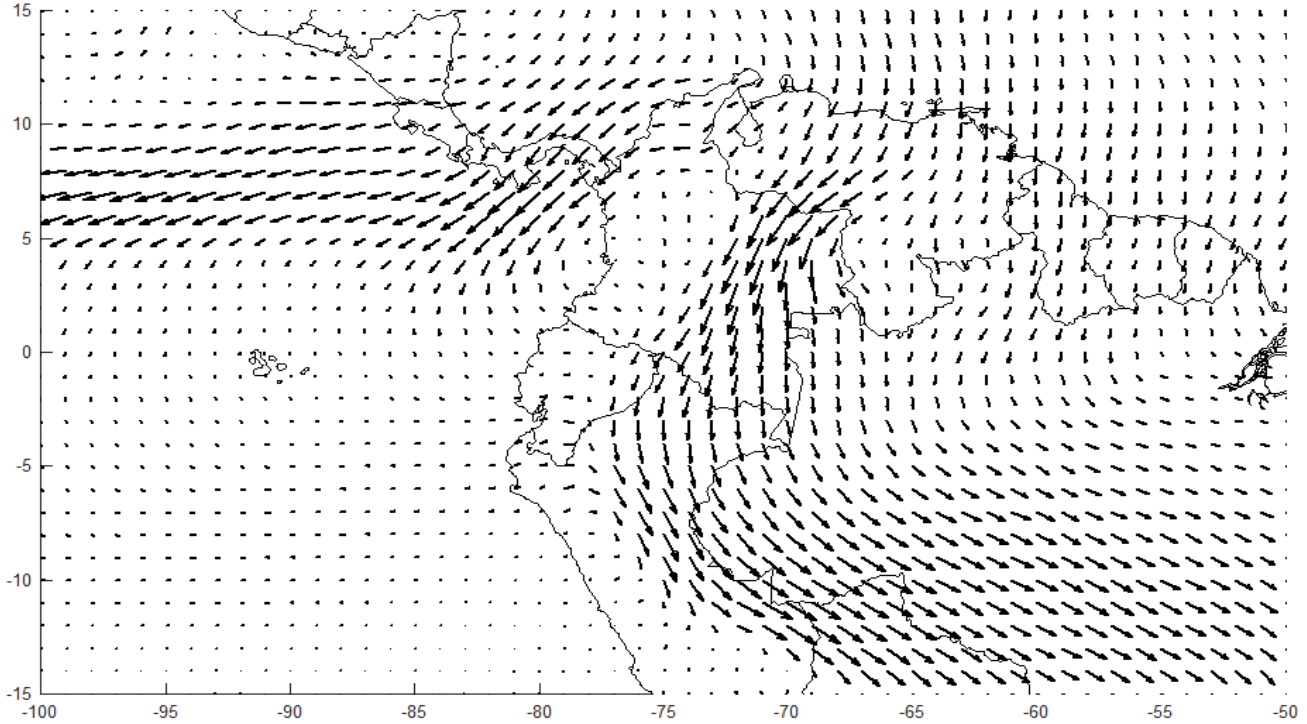
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

STATE 4

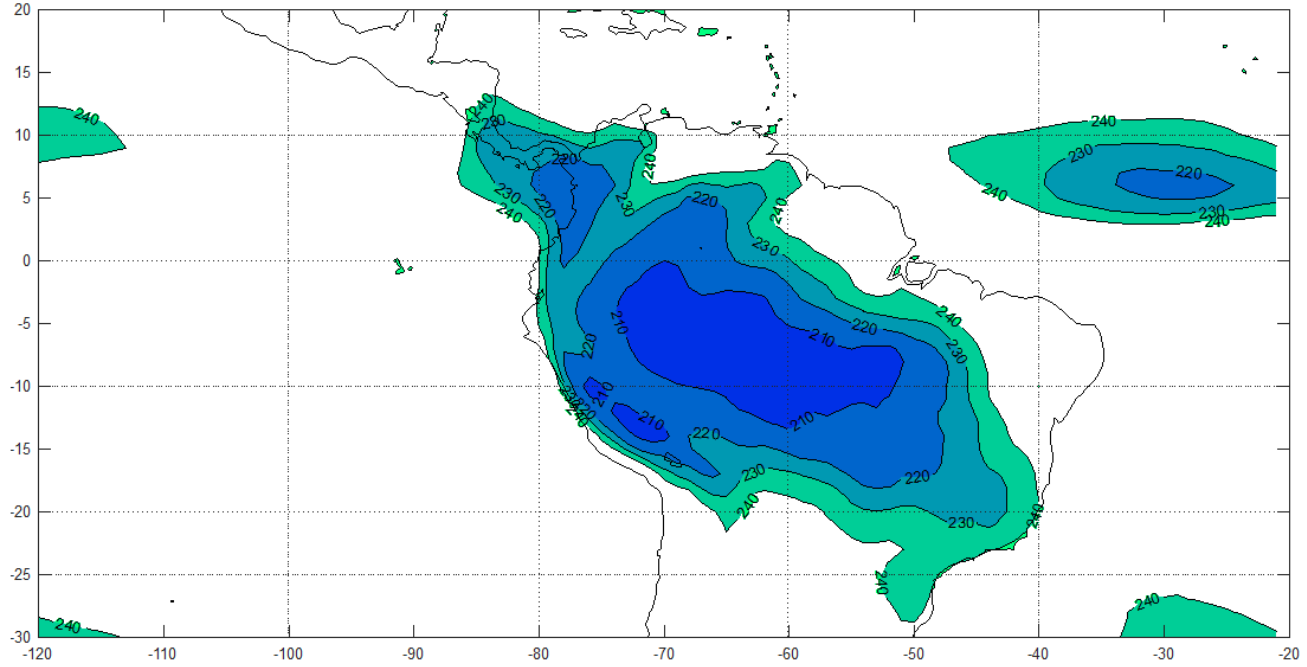




Intra-Americas Jet Intensification

SALLJ intensification To South.

Anomaly composites of vertically-integrated moisture flux from the surface to 700 hPa (vectors), OLR (contours)



The South Atlantic Convergence Zone (ZCAS)

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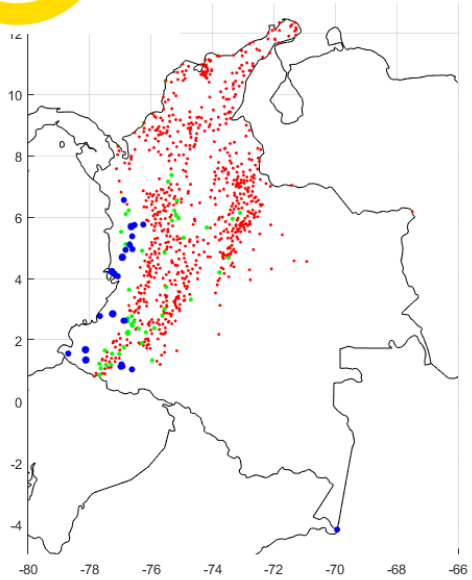
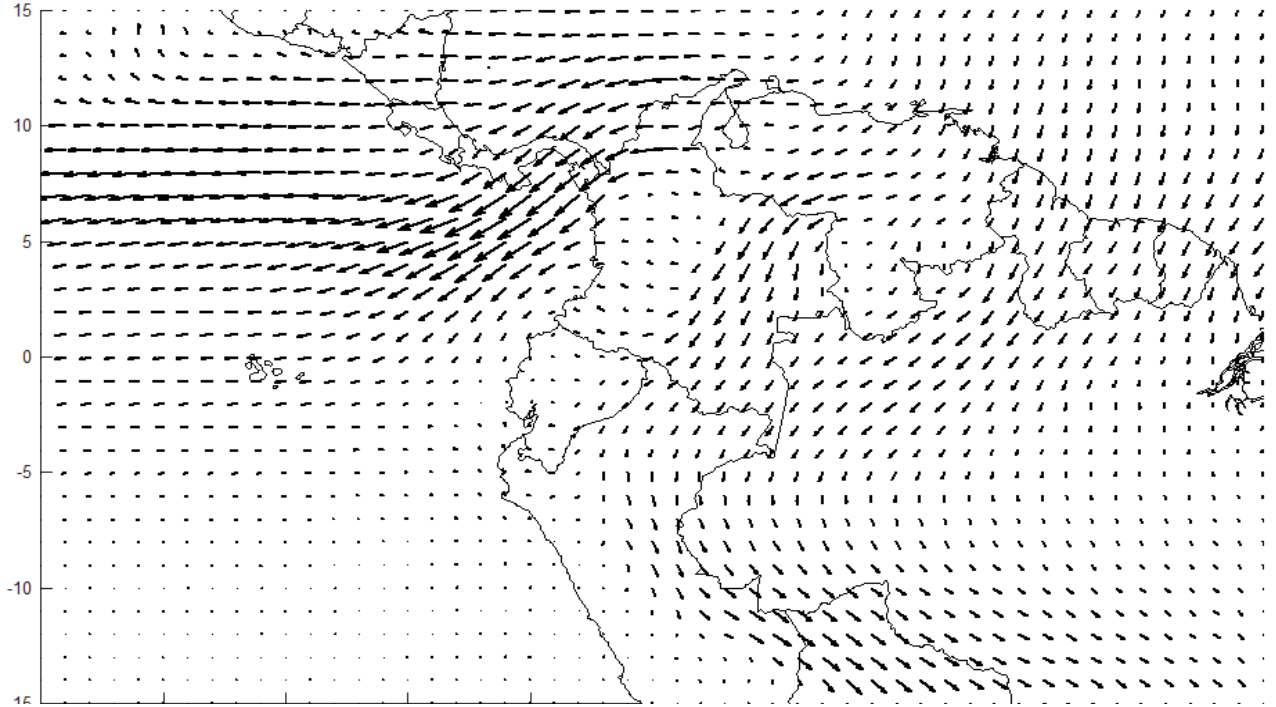
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

STATE 5

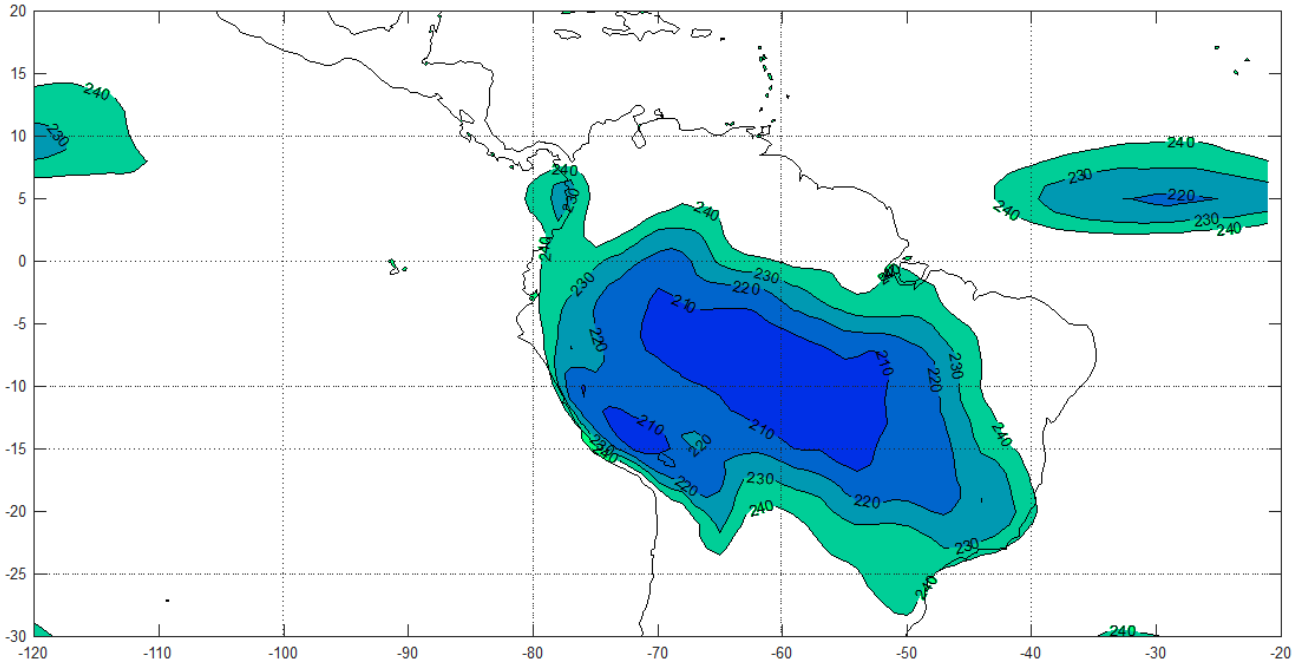




Intra-Americas Jet Intensification

SALLJ To South.

Anomaly composites of vertically-integrated moisture flux from the surface to 700 hPa (vectors), OLR (contours)



The Boreal winter Intertropical Convection over South America.

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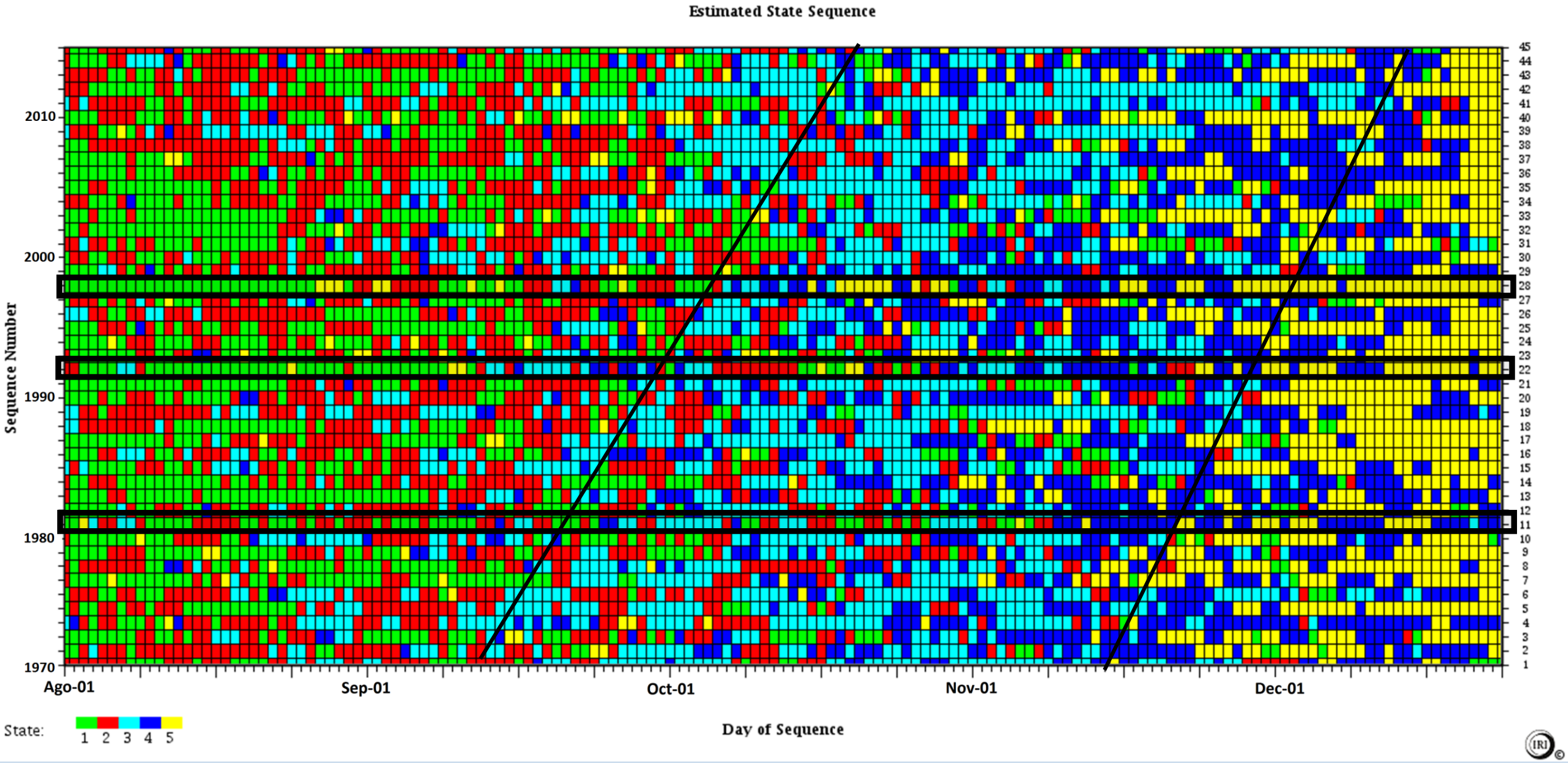
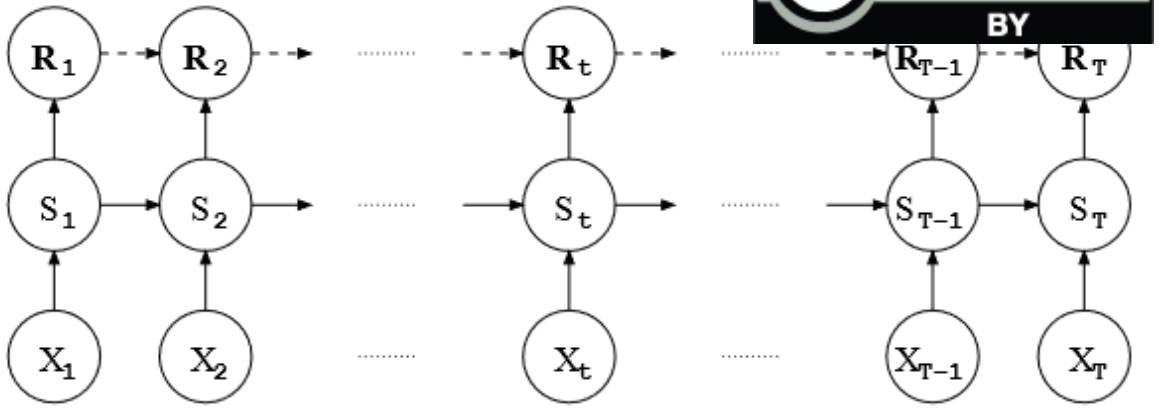
POSGRADO EN APROVECHAMIENTO DE RECURSOS HIDRÁULICOS

ENSO PATTERNS AND TRENDS

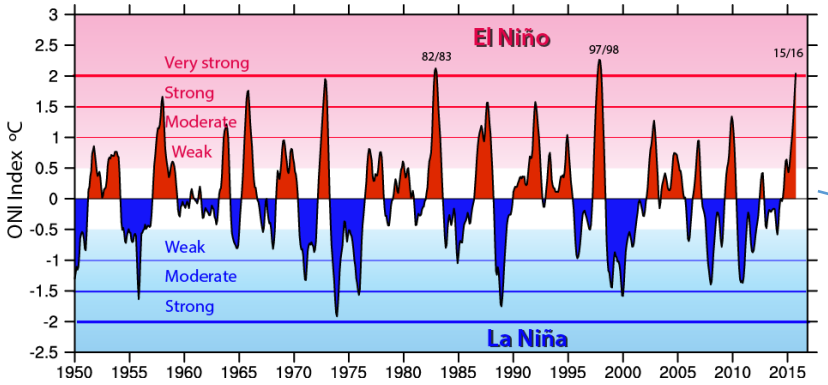


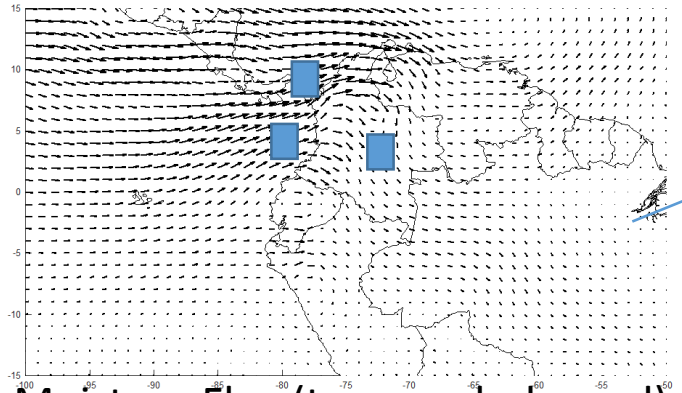
NHMM

$$P(r_{1:T}, s_{1:T} | x_{1:T}, \Theta) = \left[\pi_{S_1}(x_1) \prod_{t=2}^{T} \gamma_{S_{t-1}, S_t}(x_1) \right] \left[\prod_{t=1}^{T} F_{S_t}(r_t | r_{t-1}) \right]$$

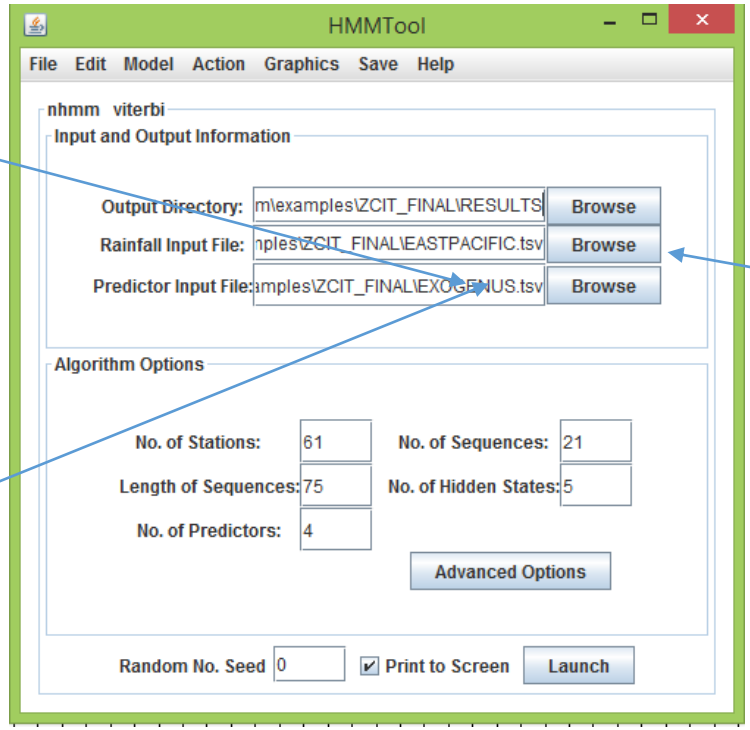


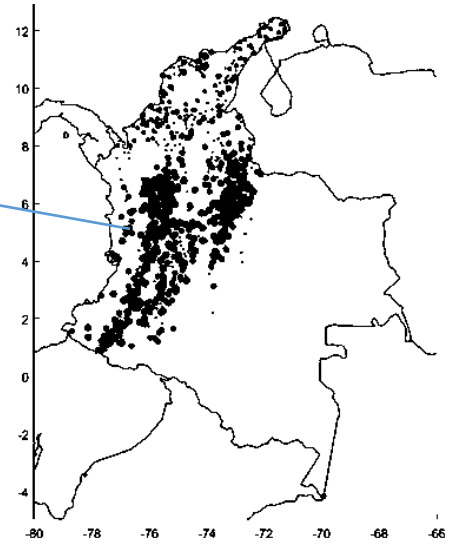
(ONI one month lagged)





Moisture Flux (two weeks lagged)





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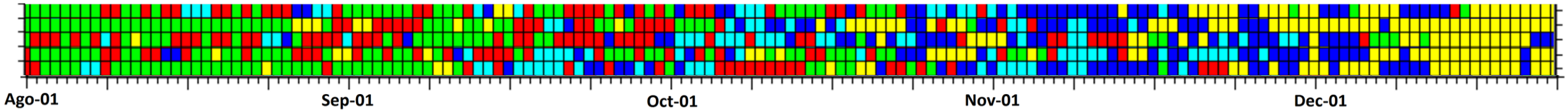
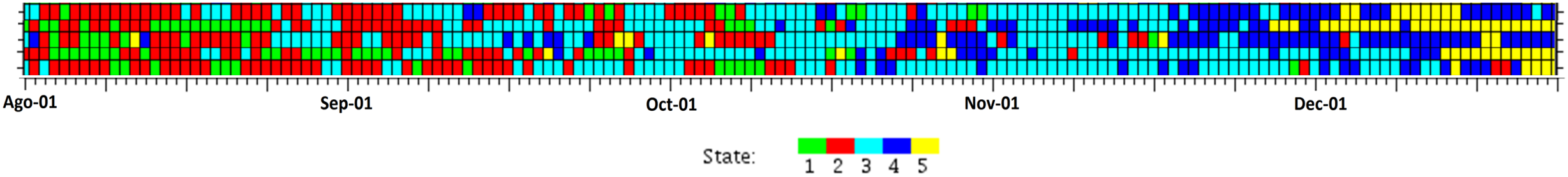
Results of NHMM for 5 years simulations

EL Niño Events simulations



La Niña Events simulations



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Conclusions

- The estimated daily state-sequence is characterized by a systematic seasonal evolution, together with considerable variability on intraseasonal and interannual time scales, exhibiting a strong relationship with ENSO.

- Simulations from the NHMM are found to reproduce the relationship between the ENSO and the western Colombian precipitation. The NHMM simulations are also able to capture interannual changes in daily rainfall occurrence and dry-wet frequencies at some individual stations.

- HMM provides a useful tool that contributes to characterizing the Colombian's Hydro-Meteorology and it's anomalies during the ENSO.

References

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