Rainfall Regimes in the in Southern Mexico

An application of the Hidden Markov Method to rainfall data stations

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AREA OF STUDY

Study Area:

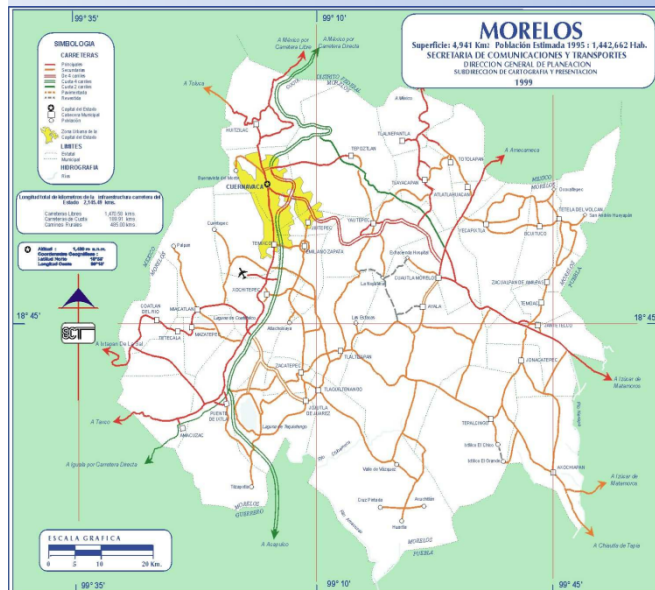Morelos state (Southern Mexico)

Data:

Daily rainfall

Number of stations:

7

Period:

1980-2000 (21 years)

AIMS AND GOALS

1. Identification of the Morelos rainfall regimes using HMM model in the different seasons.

2. Deeper understanding of the rainfall seasonal and intra-seasonal variability within the study area.

3. Detection of the corresponding weather pattern and comparison with results from SOM analysis.

METHODOLOGY

Application of the HMM model, using the HMMTool 2.1 program (Robertson et al.) to a subset of the available Morelos stations data.

Step 1:

Selection of the number of state during the whole year

Step 2:
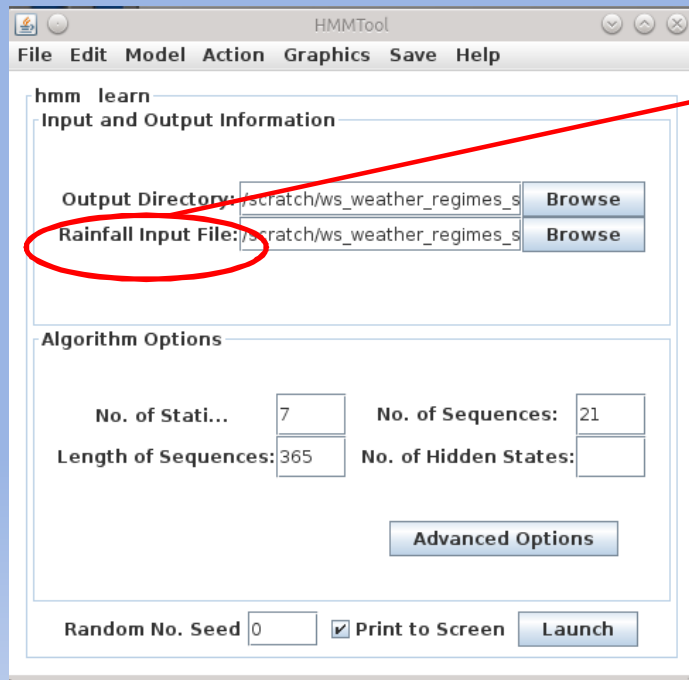
Circulation pattern analysis during summer season JJA

Step 3:

Conclusions and results

APPLICATION OF THE HMM

Step 1:

Selection of the optimal number of states

Morelos daily rainfall

APPLICATION OF THE HMM

Step 1:

Selection of the optimal number of states

7 stations

APPLICATION OF THE HMM

Step 1:

Selection of the optimal number of states

21 years
From 1980 to 2000
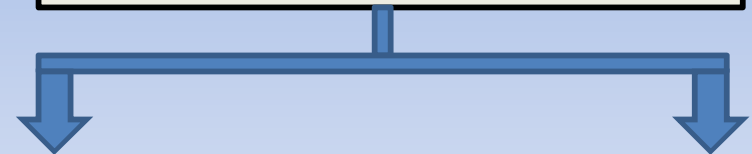
APPLICATION OF THE HMM

Step 1:

Selection of the optimal number of states
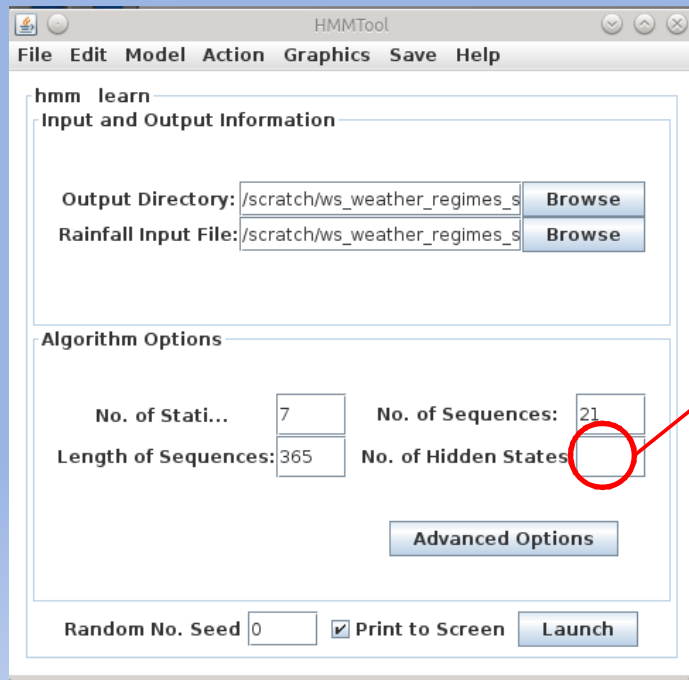
How many weather regimes ????

We want to choose the proper number of weather regimes that can describe at better the seasonal variability of rainfall in the study area.
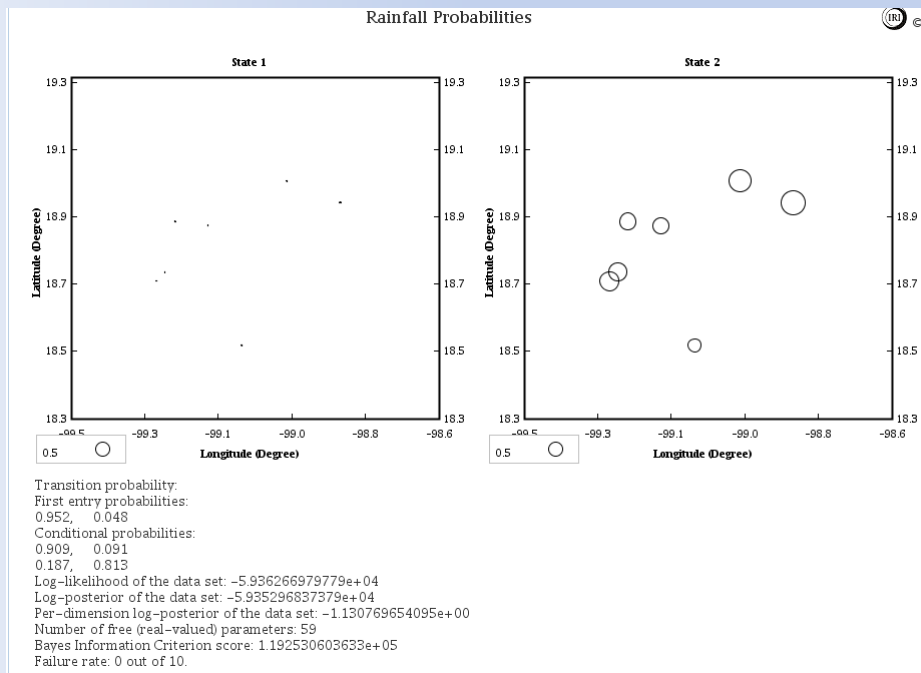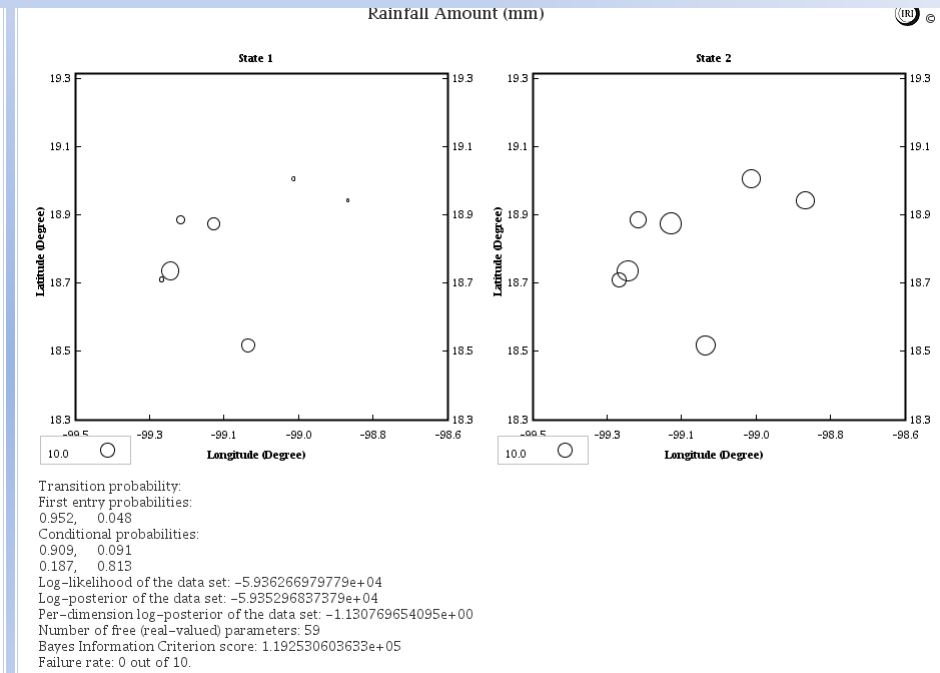
2 regimes

3 regimes

# *HMM IN THE WHOLE YEAR: 2 REGIMES*

Rainfall Probabilities

Rainfall Amounts

We have identified 2 states:

- in the **1ˢᵗstate** there is a **low rainfall probability** with average rainfall intensity around 5 mm/day with a certain local variability between the different station examined.
- In **2ⁿᵈ state** the frequency of occurrence of **rainfall is higher**, with also higher rainfall intensity with less local variability.

HMM IN THE WHOLE YEAR: 2 REGIMES
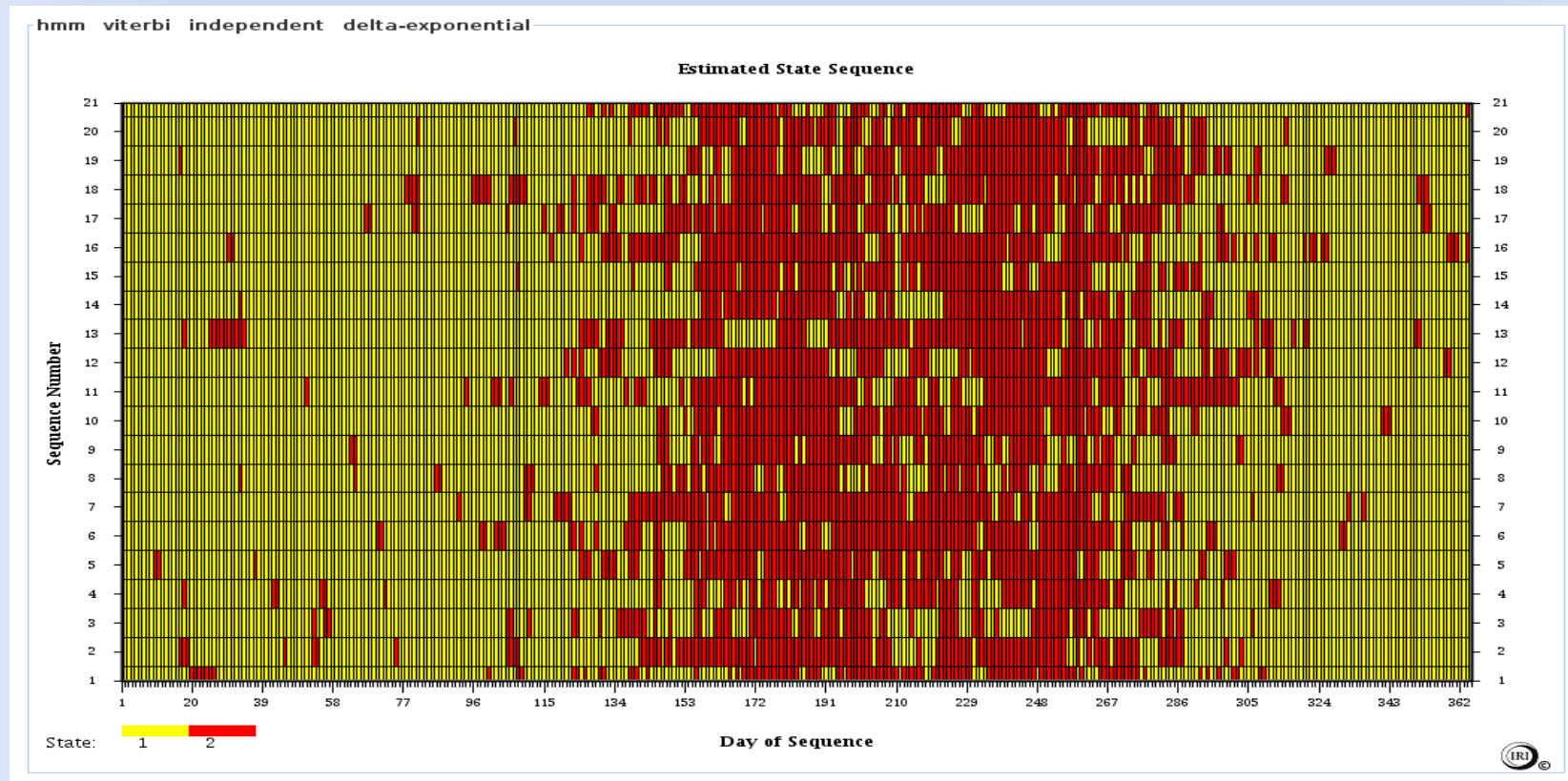
From the **Viterbi plot** it is evident that the two states identifies the **seasonal cycle**.
The season associated to state 2 starts around **May and lasts till September** and it's characterized by intense rainfall and high precipitation amounts, uniformly distributed inside the region.
The season associated to state 1 is drier than the one in state 2 and it is characterized by rare rainfall spell, less uniformly distributed inside the study area.

# HMM IN THE WHOLE YEAR: 3 REGIMES

Rainfall Probabilities
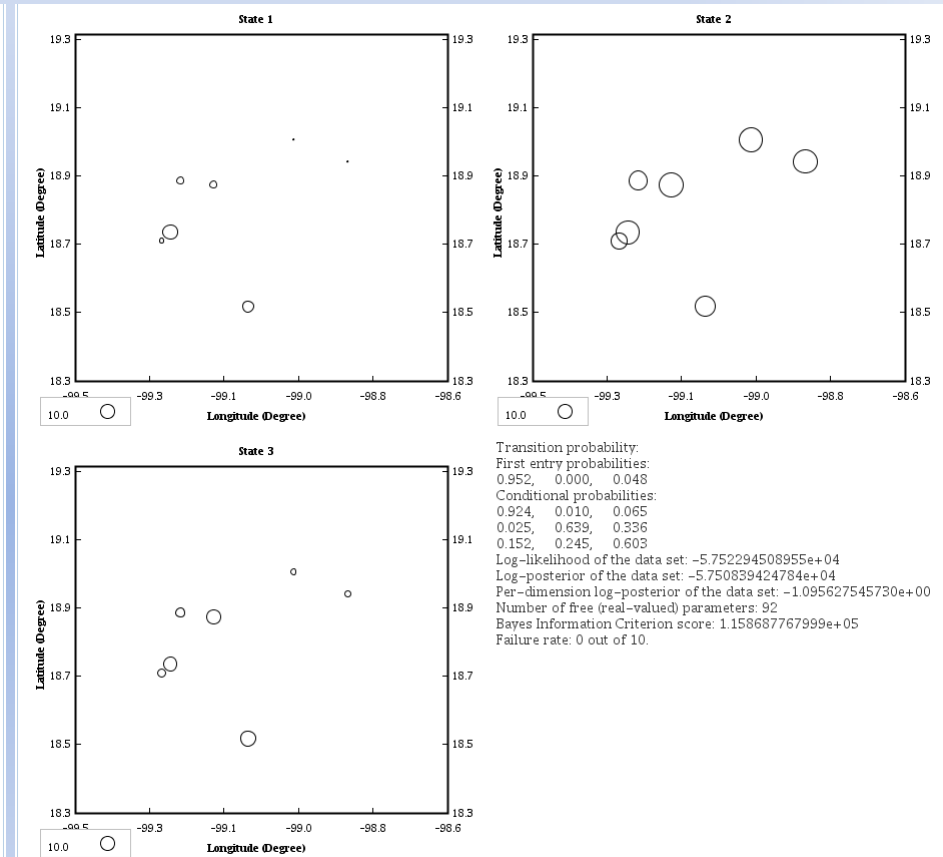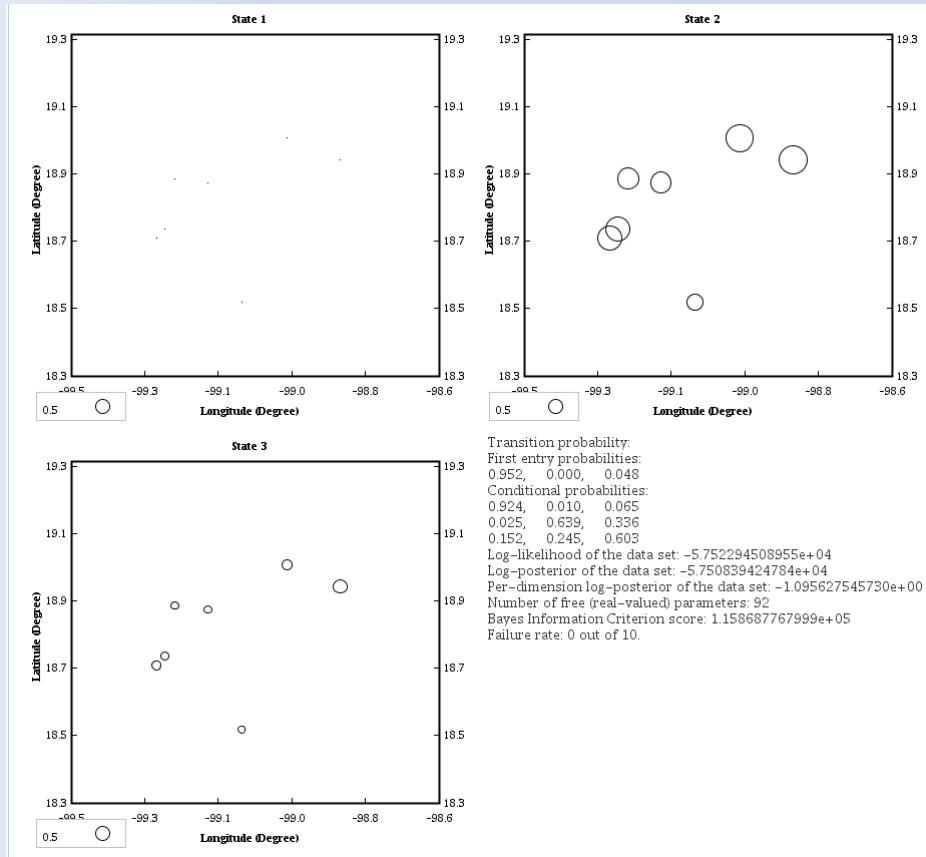
Rainfall Amounts

In the 3 states regime we noticed that:

•The first state represent the driest season, with scarce precipitation and low rainfall amounts.

•At the contrary in state 2 rainfall occurs more often and with the highest amounts.

•The state 3 has intermediate features between state 1 and 2.

HMM IN THE WHOLE YEAR: 3 REGIMES
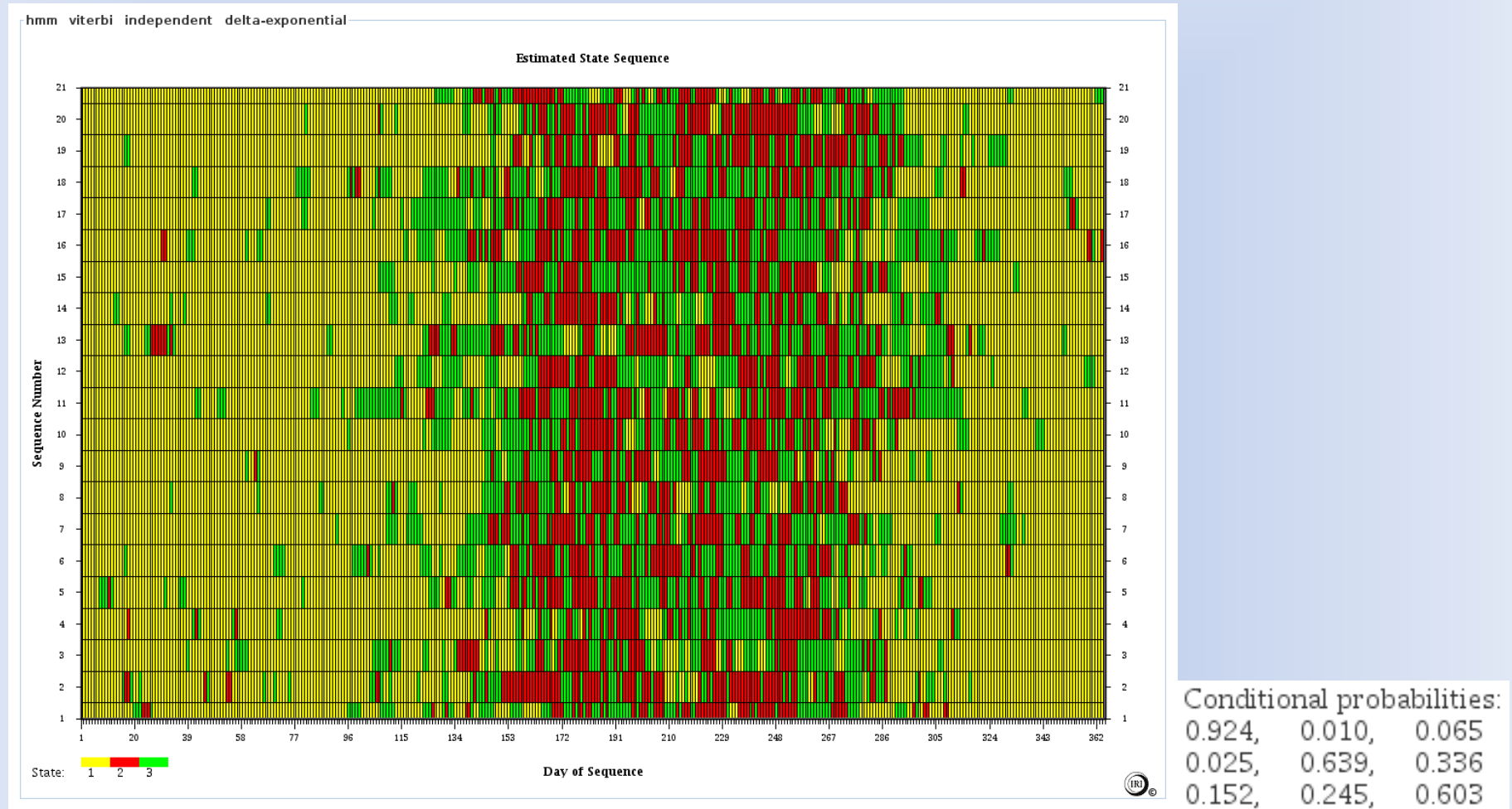
Looking at the Viterbi table, the state 1 is associated to the winter months, while the state 2 and 3 alternate during the summer season (from April to November).
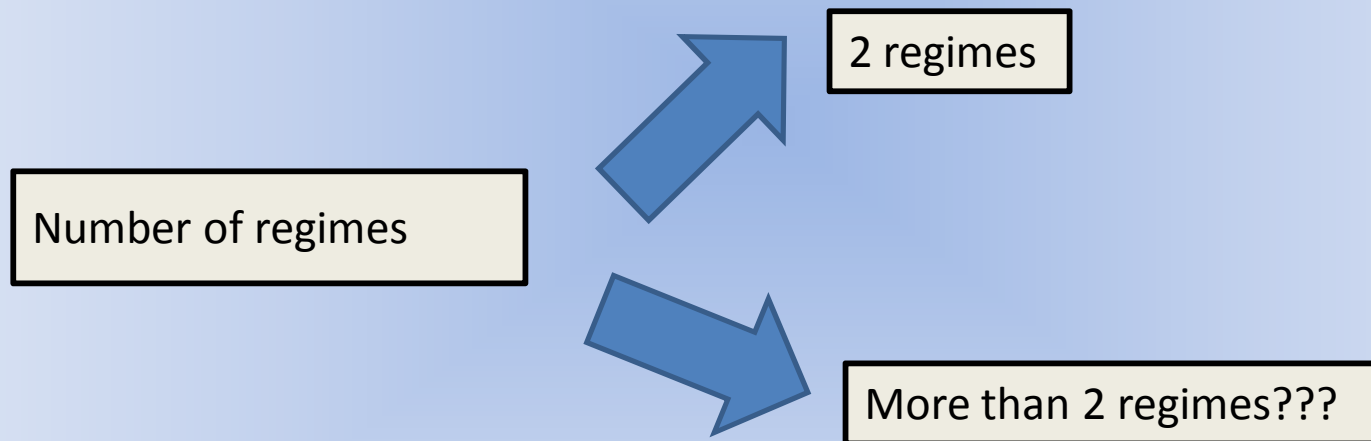**Its more likely to pass from state 2 to 3 and viceversa,** than from state 1 to the others.
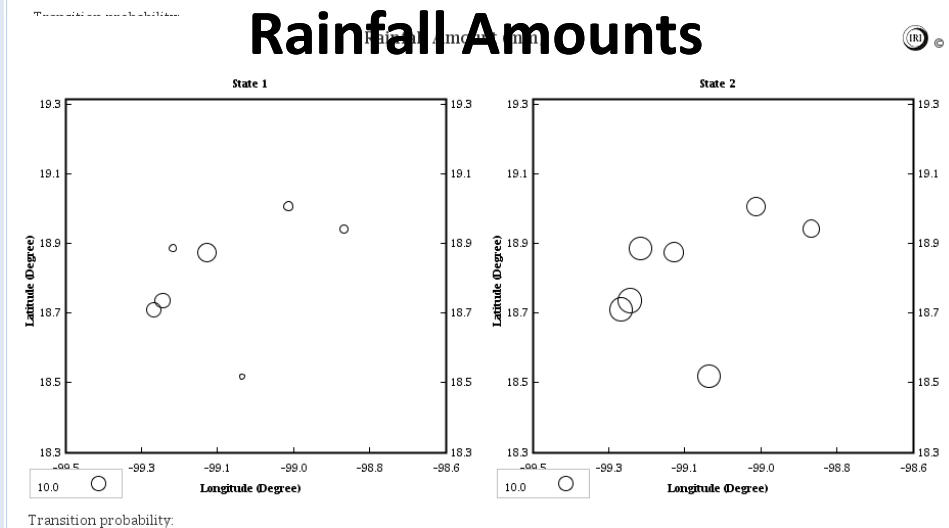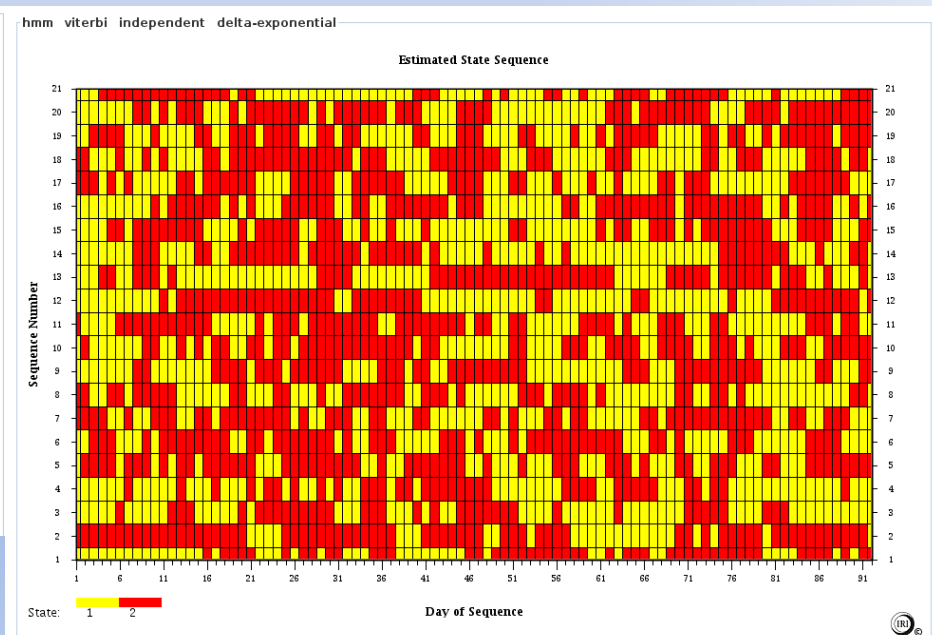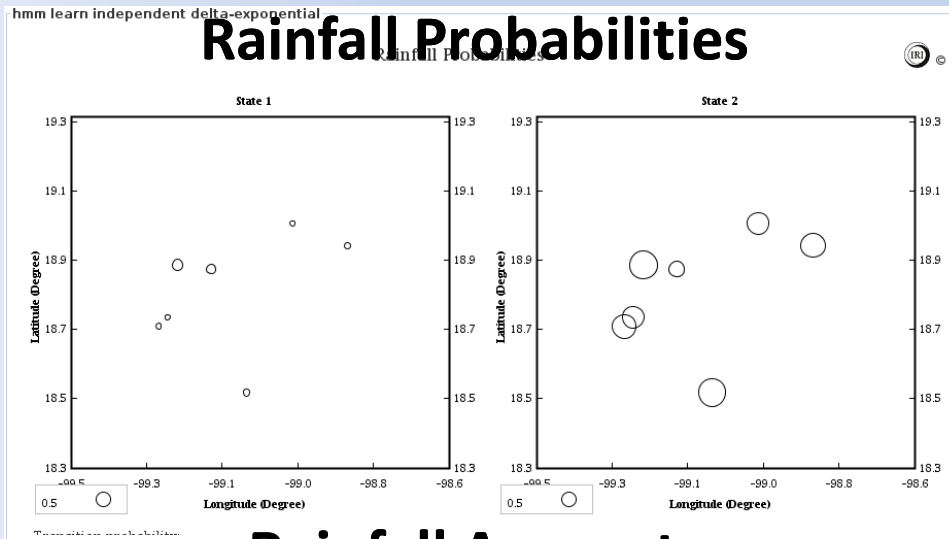
FIRST CONCLUSIONS...

- We were able to extract the **seasonal cycle** from the rainfall data stations.

- We identify **three different regimes (dry, intermediate and wet)**

- Unfortunately, the **strong seasonal cycle overwhelms the signal of the different regimes,** making difficult the identification of the regimes in winds or geopotential height.

- **The method works, but it is not enough!**

HMM IN THE SUMMER SEASON

Thus we tried to investigate the intraseasonal rainfall variability during summer months, to investigate if there are preferred states of circulation.

Number of regimes

2 regimes

More than 2 regimes???

HMM IN THE SUMMER SEASON: 2 REGIMES

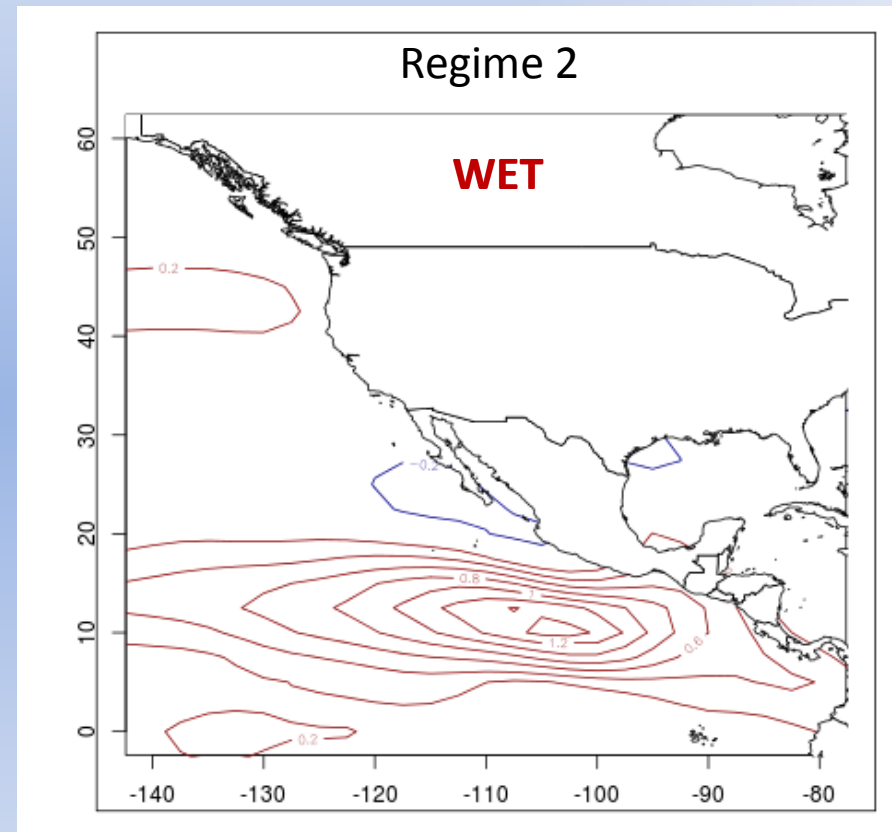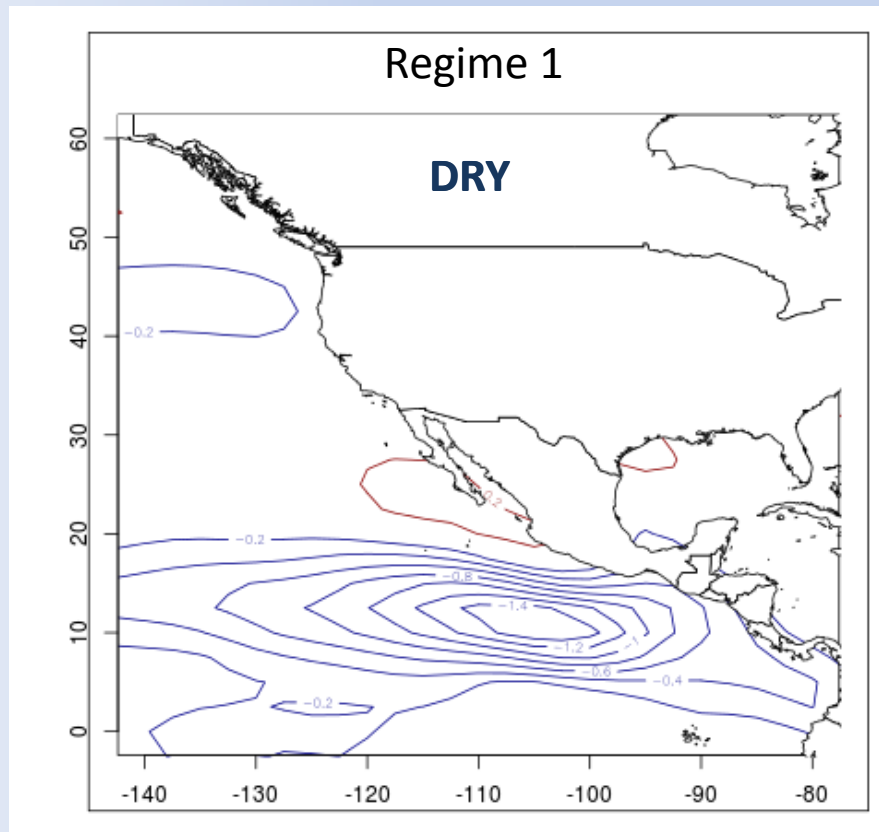**Rainfall Probabilities**

Rainfall Amounts

Conditional probabilities:
0.685,   0.315
0.291,   0.709

State 1: Dry
State 2: Wet

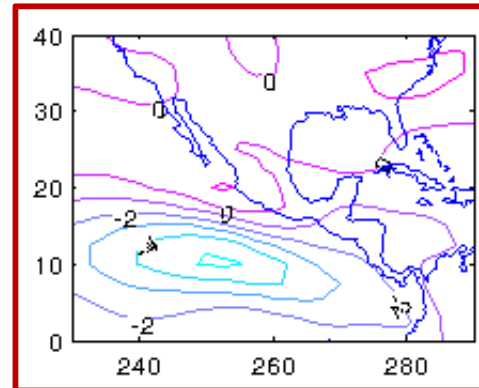# HMM IN THE SUMMER SEASON: 2 REGIMES

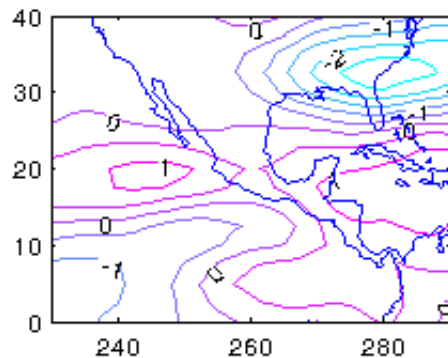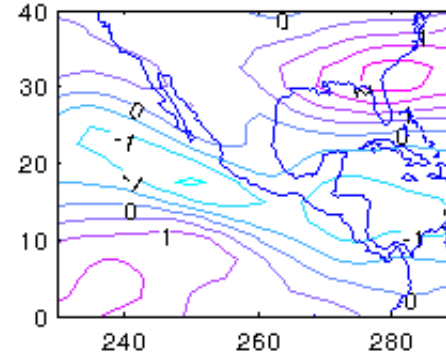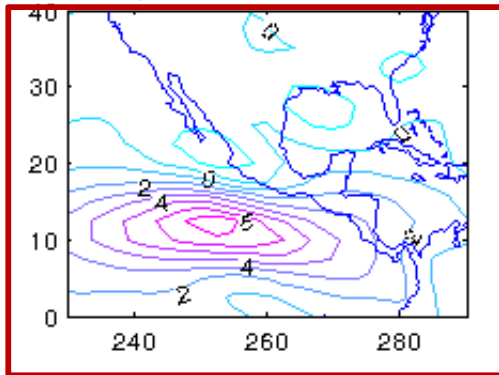## 2-Regime Composites of 850 hPa zonal wind anomalies

Two opposite circulation patterns associated with the two precipitation states: advection of moist air?

SOM IN THE SUMMER SEASON

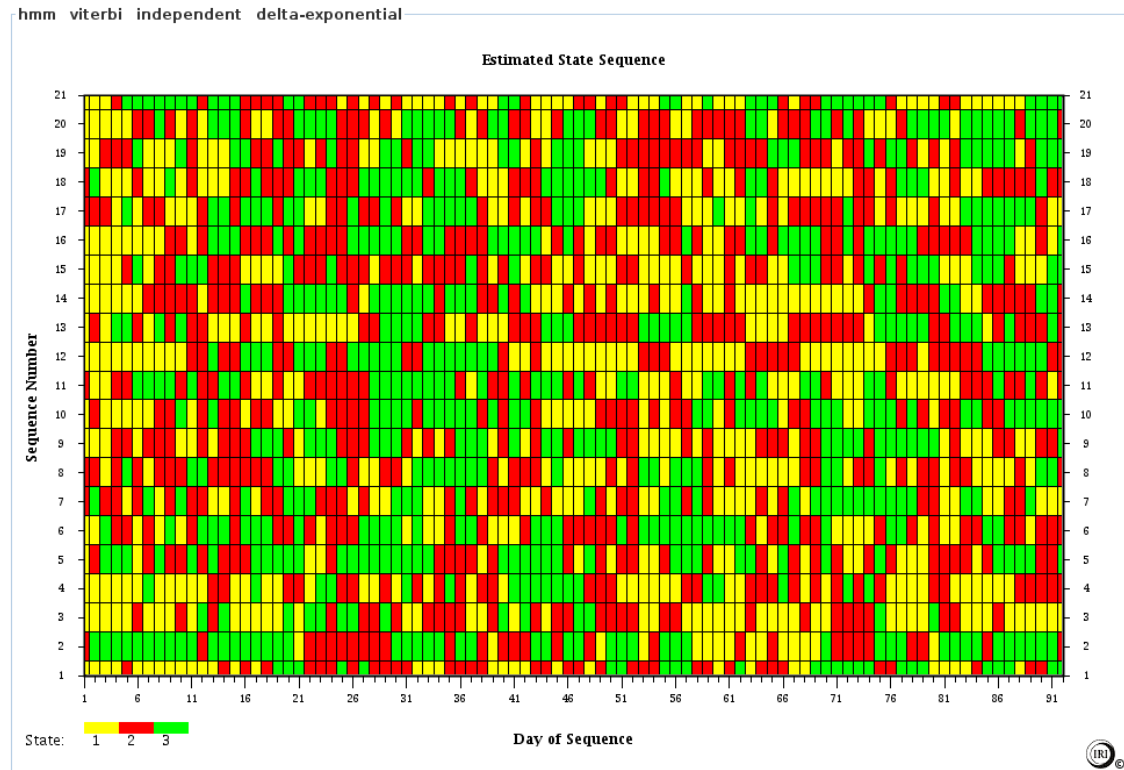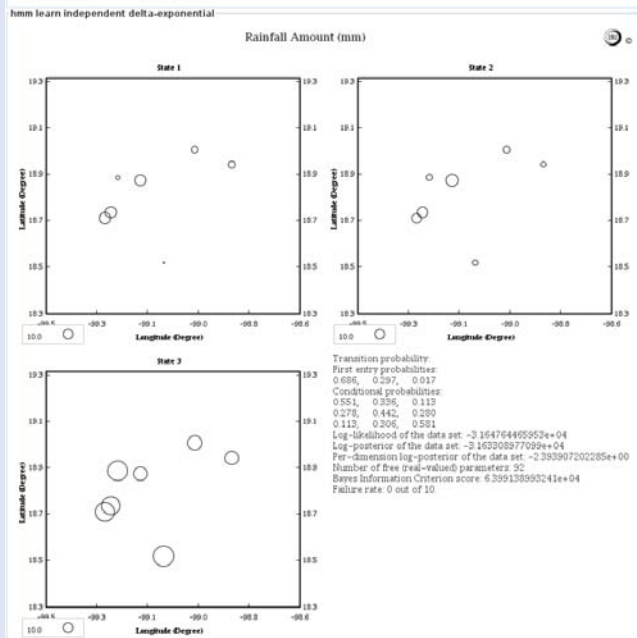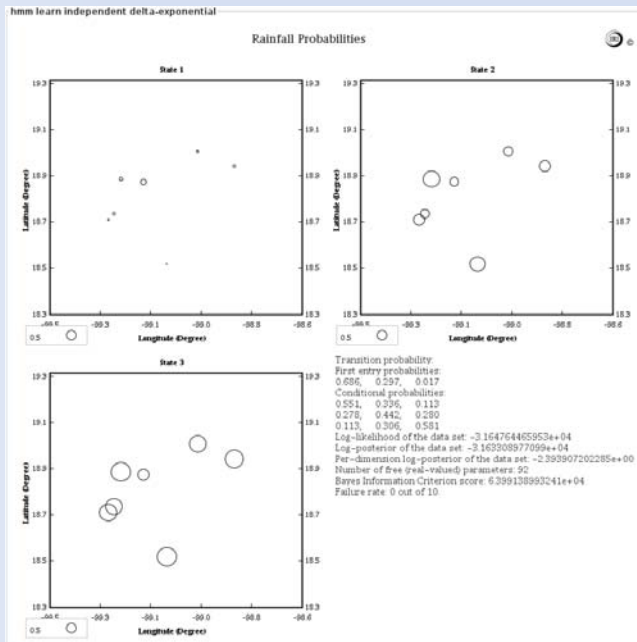## Clustering of 850 hPa zonal wind

ind SOM, 2 Anomaly Patterns, 1980 2000 0 40 230 290 850 850

The 1st and the 4th patterns found with SOM look like the Dry and Wet composites obtained with HMM.

These two patterns always emerge when the number of clusters in the SOM analysis is changed.
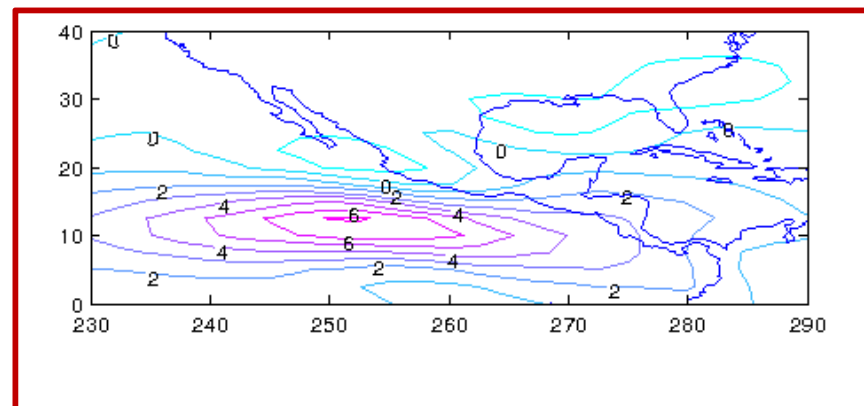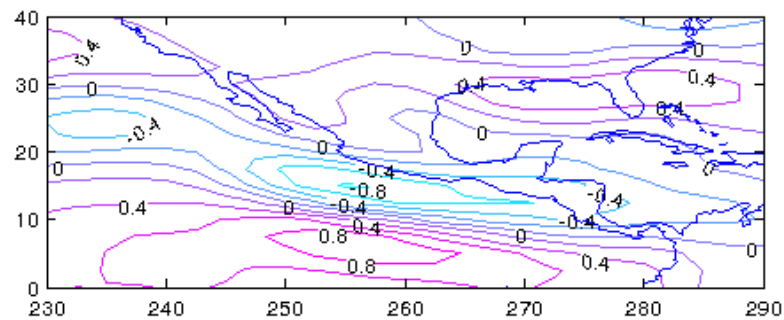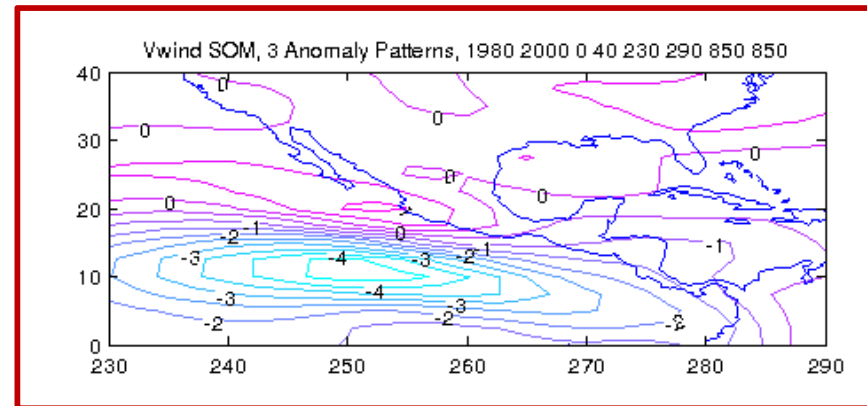
HMM IN THE SUMMER SEASON: 3 REGIMES

Conditional probabilities:
0.551, 0.336, 0.113
0.278, 0.442, 0.280
0.113, 0.306, 0.581

State 1: Dry
State 2: "Intermediate"
State 3: Wet

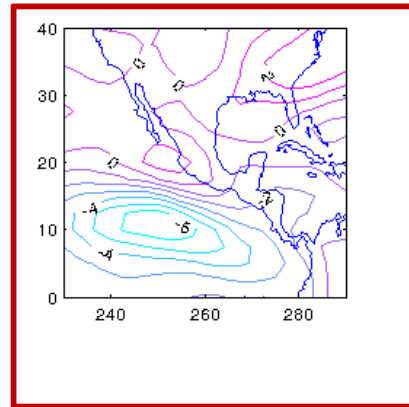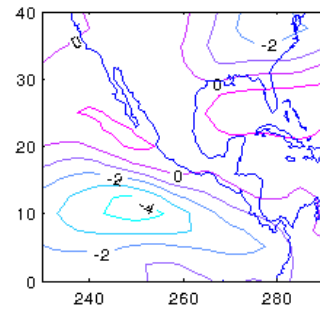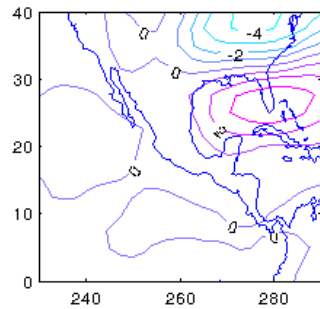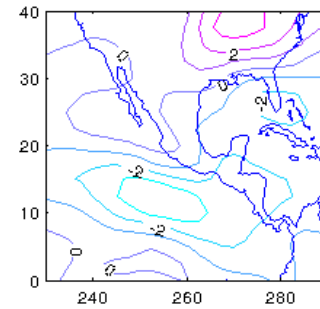Quasi-symmetric transition matrix

SOM IN THE SUMMER SEASON: 3-CLUSTER

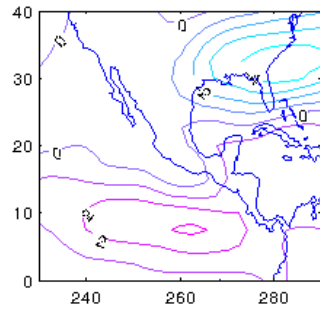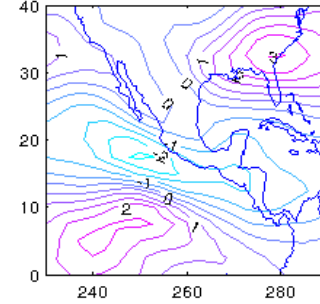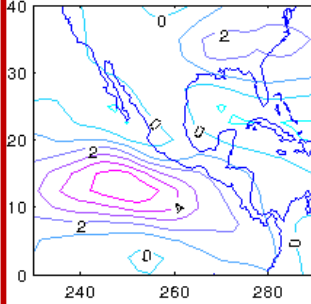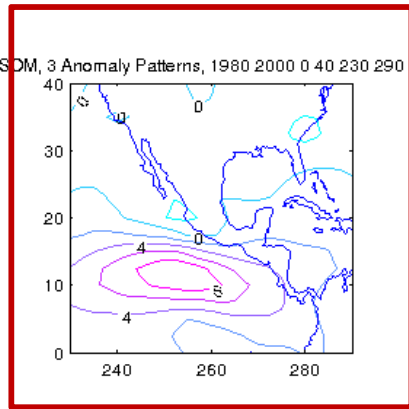Vwind SOM, 3 Anomaly Patterns, 1980 2000 0 40 230 290 850 850

SOM IN THE SUMMER SEASON: 9-CLUSTER

Vwind SOM, 3 Anomaly Patterns, 1980 2000 0 40 230 290 850 850
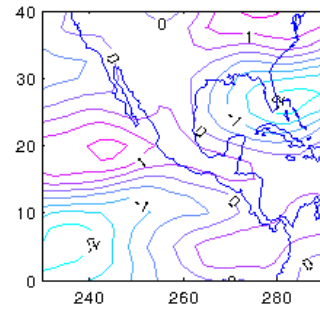
CONCLUSIONS

- Application of the Hidden Markov Method to 21 years of rainfall data from the Morelos State in Mexico.

- Trivial identification of the seasonal cycle.

- Identification of two different regimes during the summers season, with evident wind patterns that favour/reduce moist air advection from the Pacific Ocean to Mexico.

THANK YOU FOR ATTENTION!!

*Come and visit Morelos State
(although we have never been there!)*