

# **Identification of weather regimes over Sudan by using Hidden Markov Model (HMM).**

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**School and Workshop on Weather Regime and Weather Types in the  
Tropics and Extra-tropics: Theory and Application to Prediction of  
Weather and Climate**

**21 – 30 October 2013**

**Trieste - Italy**



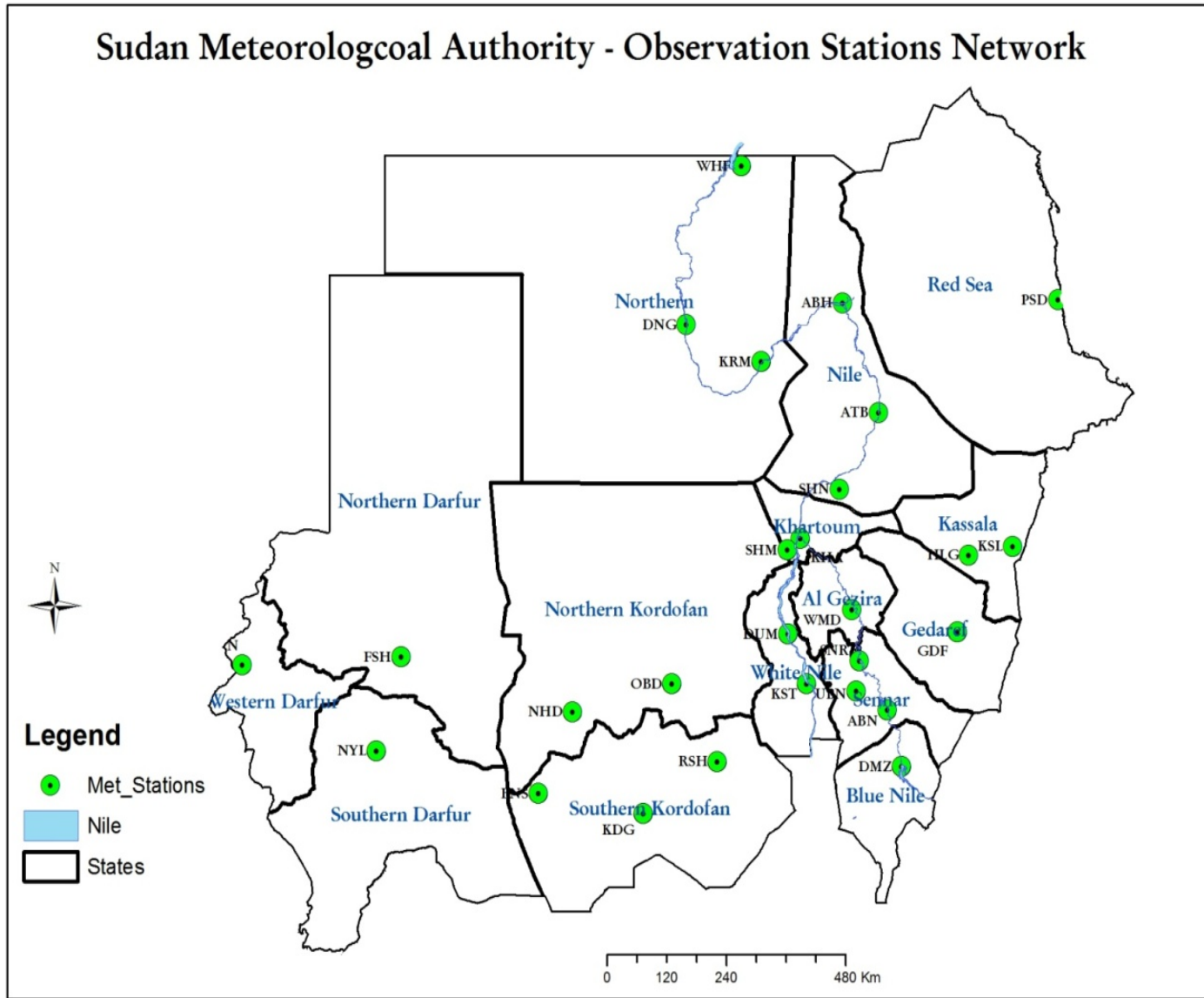
# Introduction

- Sudan is affected by 2 different sources of moisture: Indian Monsoonal flow , and Atlantic Ocean flow.
- The main goal of this study is to identify rainfall regimes over Sudan by using Hidden Markov Model (HMM).



## Data Source and Study Area

- The daily rainfall data were obtained from Sudan Meteorological Authority (SMA).
- It covers 19 stations, from May to October for the period 1981 -2012.





# Methodology

- The area of study was divided into three zones (East, Center, and West) according to:
  - Different sources of moisture.
  - Different cloud formation types.
- Hidden Markov Model was used to simulate rainfall at each station location; probability and amount .



## Table of stations:

West	Center	East
FSH	KHA	KSL
GEN	WMD	HLG
OBD	DUM	GDF
NHD	KST	SNR
NYL		DMZ
RSH		UBN
KDG		ABN
BNS		

\*The Abbreviation of the station's name.



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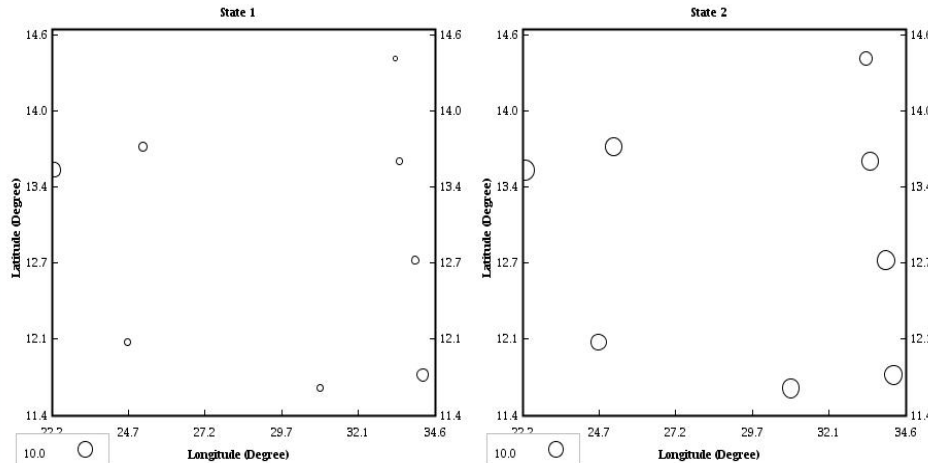
# **Results and Discussions**



# Western Zone; Rainfall Amount and Probabilities

hmm learn independent delta-exponential

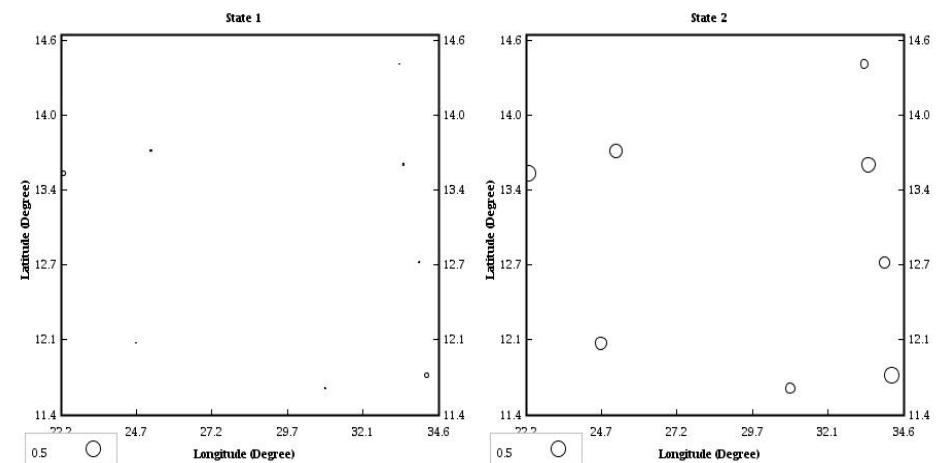
Rainfall Amount (mm)



Transition probability:  
0.964, 0.036  
First entry probabilities:  
0.781, 0.219  
Conditional probabilities:  
0.251, 0.749  
Log-likelihood of the data set: -5.643315883168e+04  
Log-posterior of the data set: -5.642207092300e+04  
Per-dimension log-posterior of the data set: -1.197819100777e+00  
Number of free (real-valued) parameters: 67  
Bayes Information Criterion score: 1.134479226646e+05  
Failure rate: 0 out of 10.

hmm learn independent delta-exponential

Rainfall Probabilities

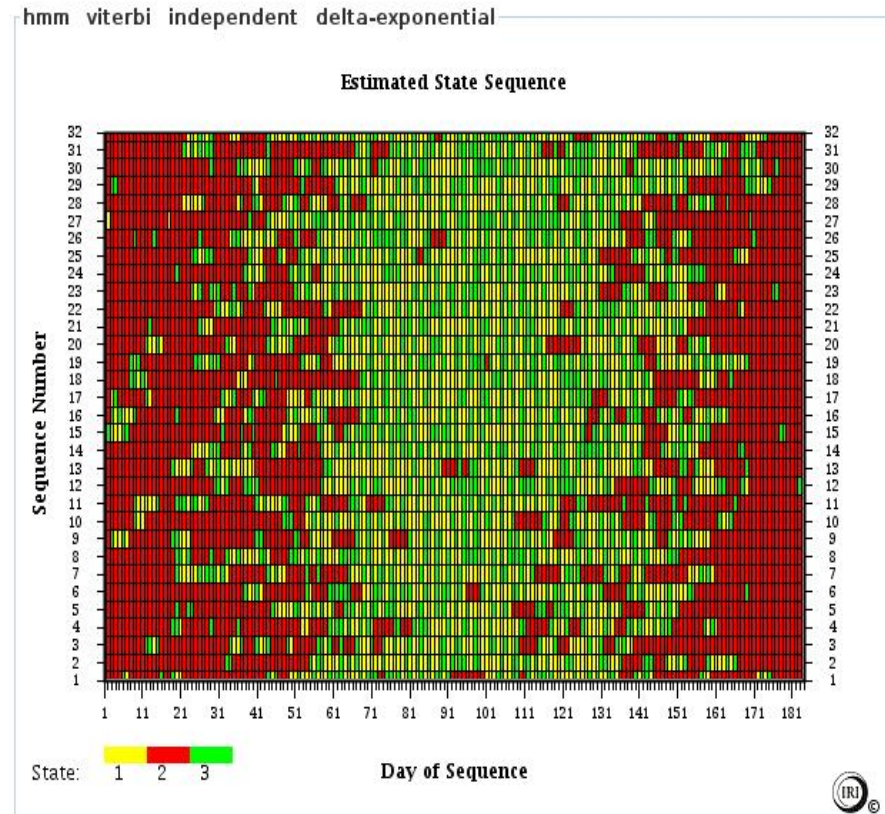
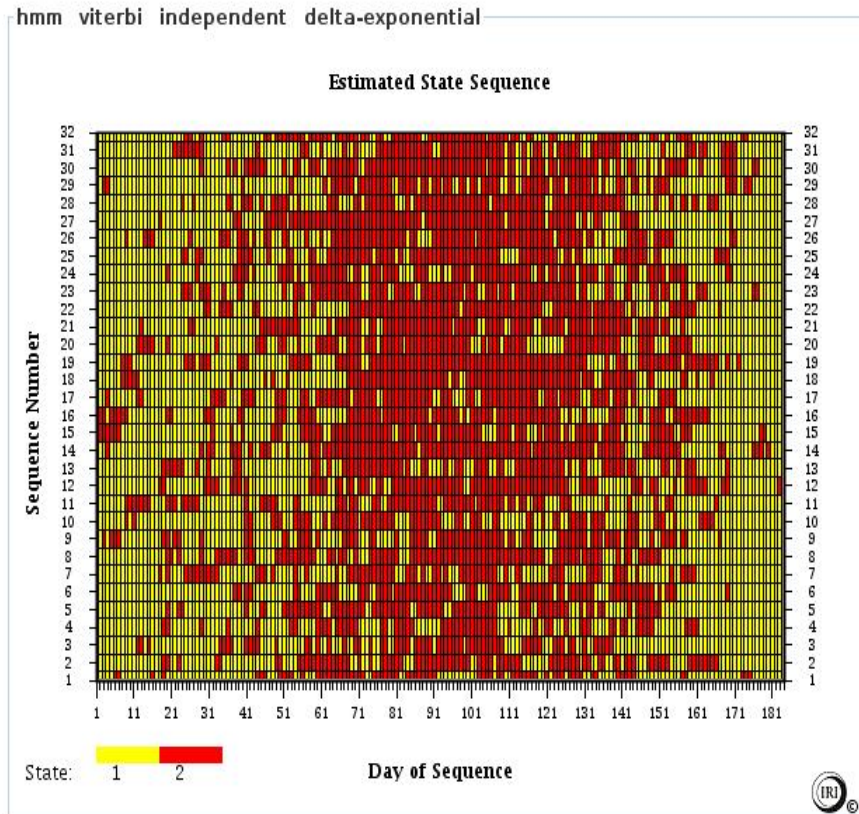


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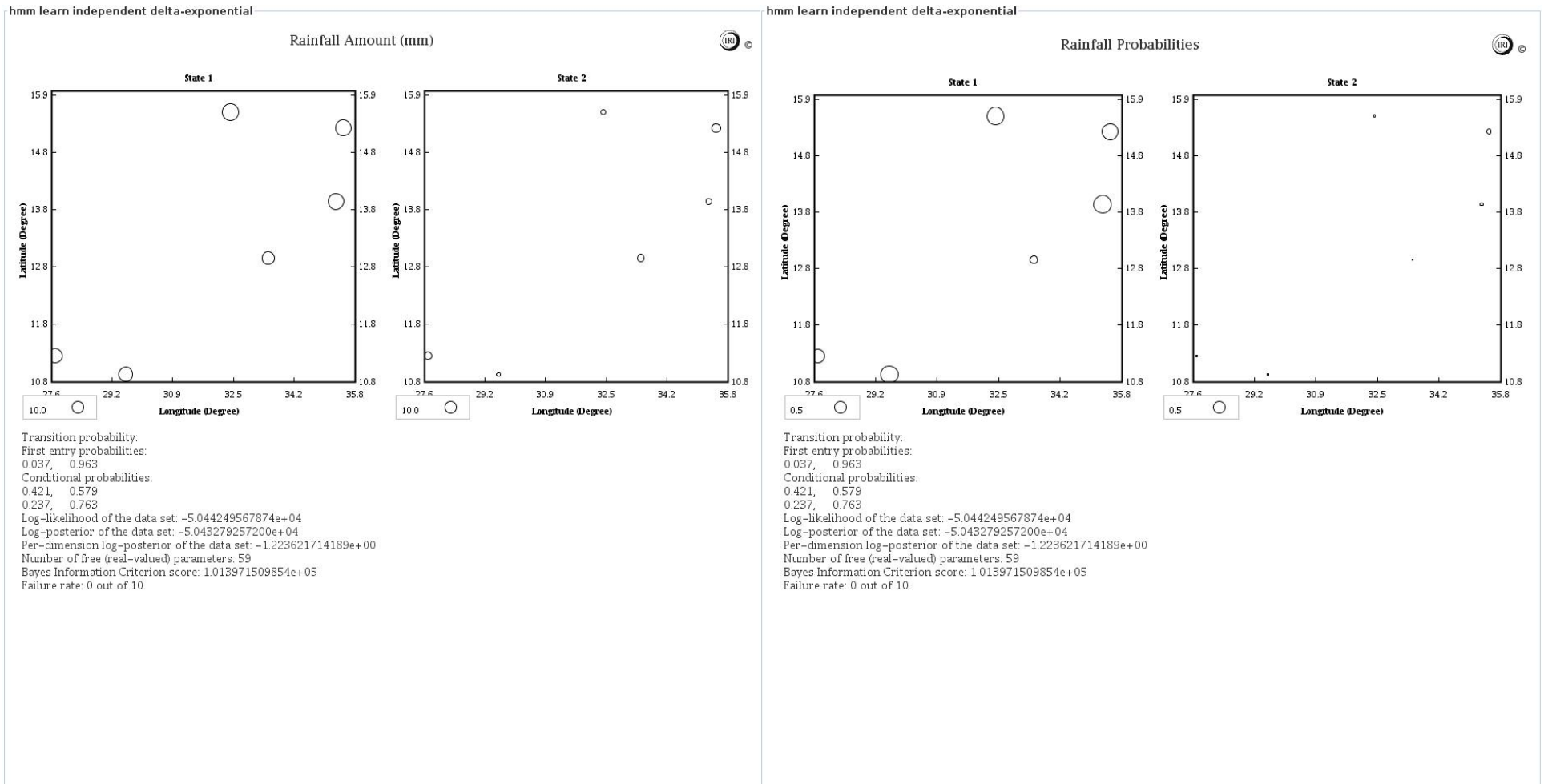


# Western Zone (Viterbi)



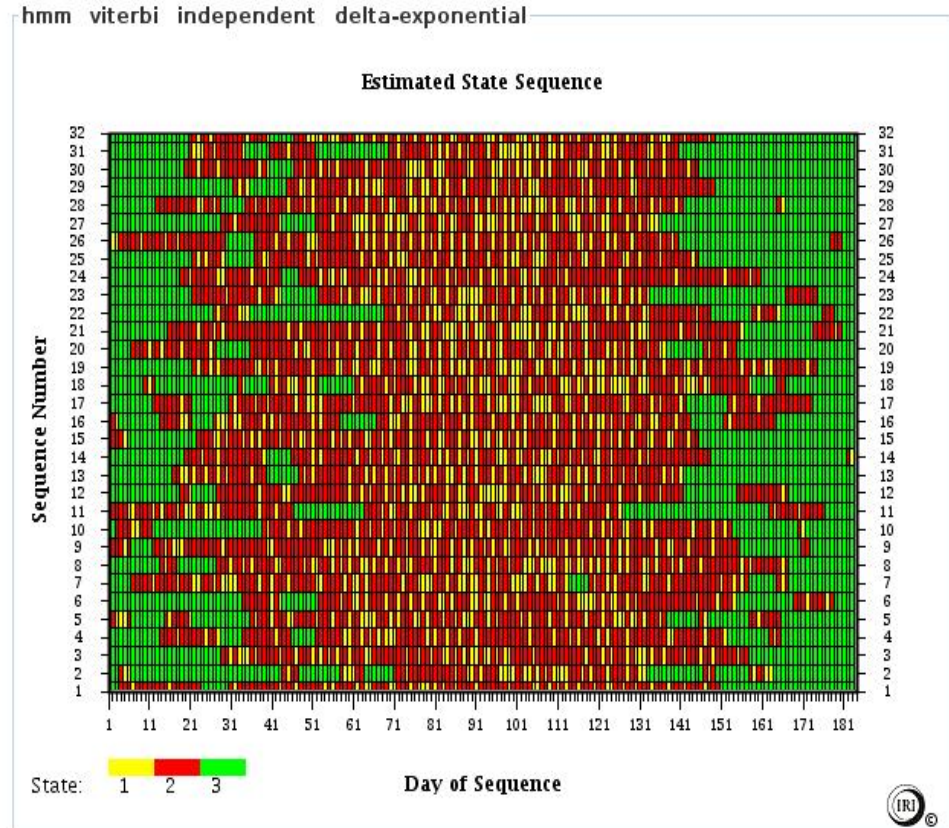
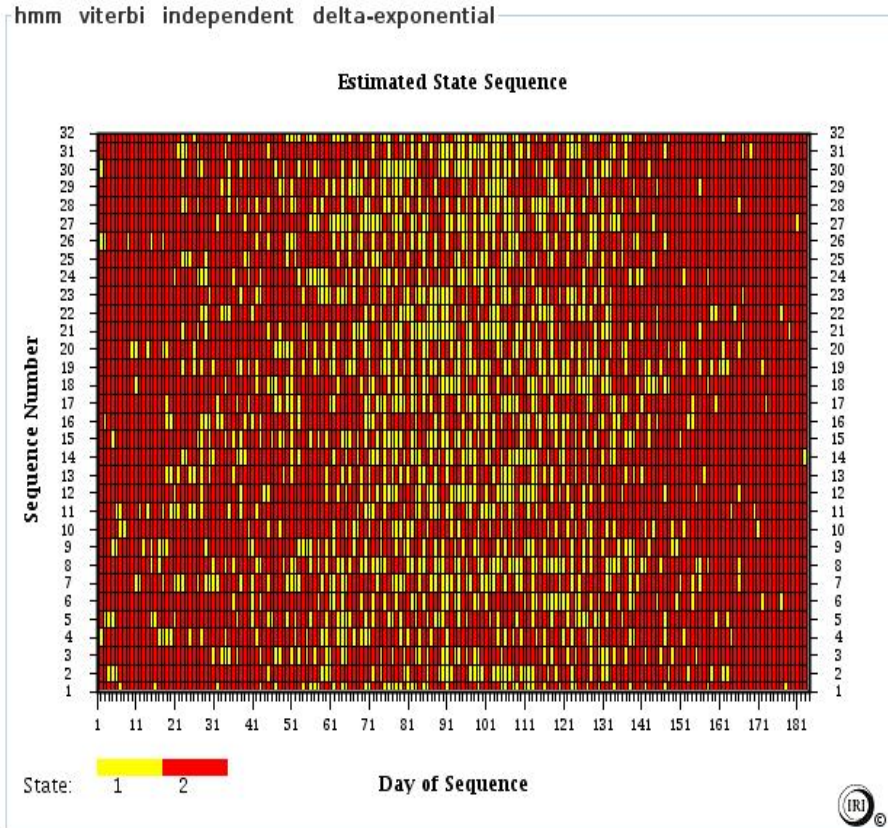


# Eastern Zone; Rainfall Amount and Probabilities



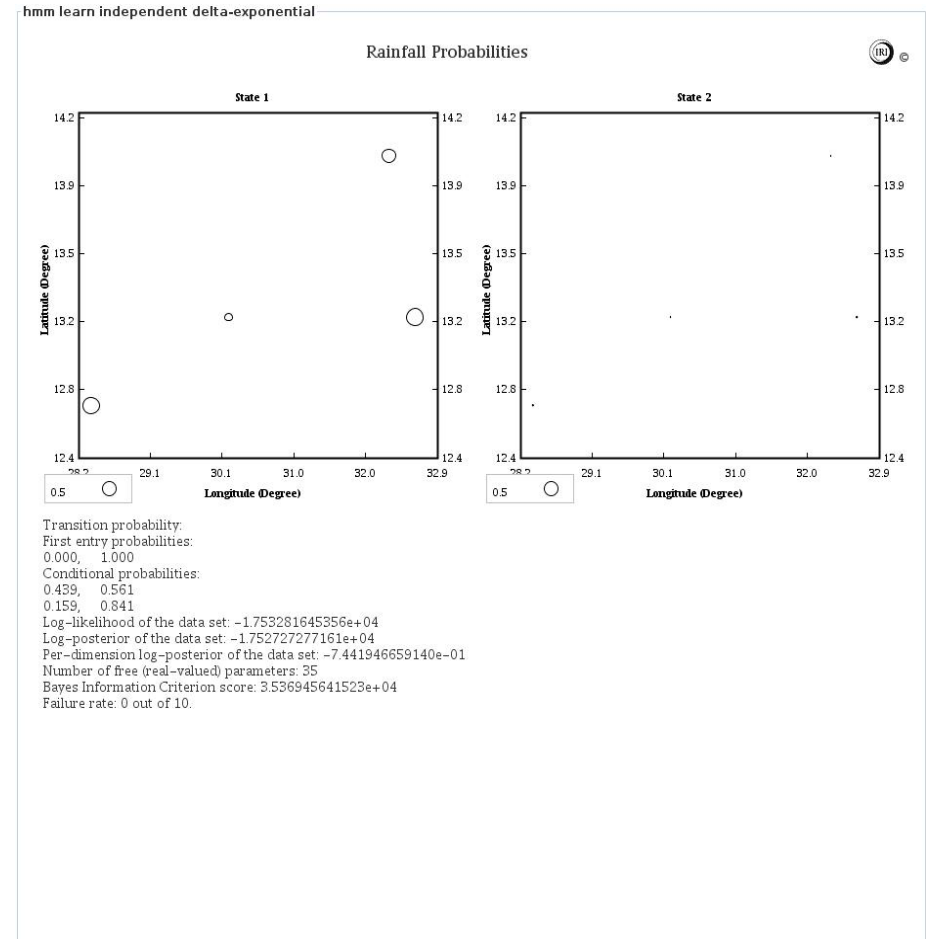
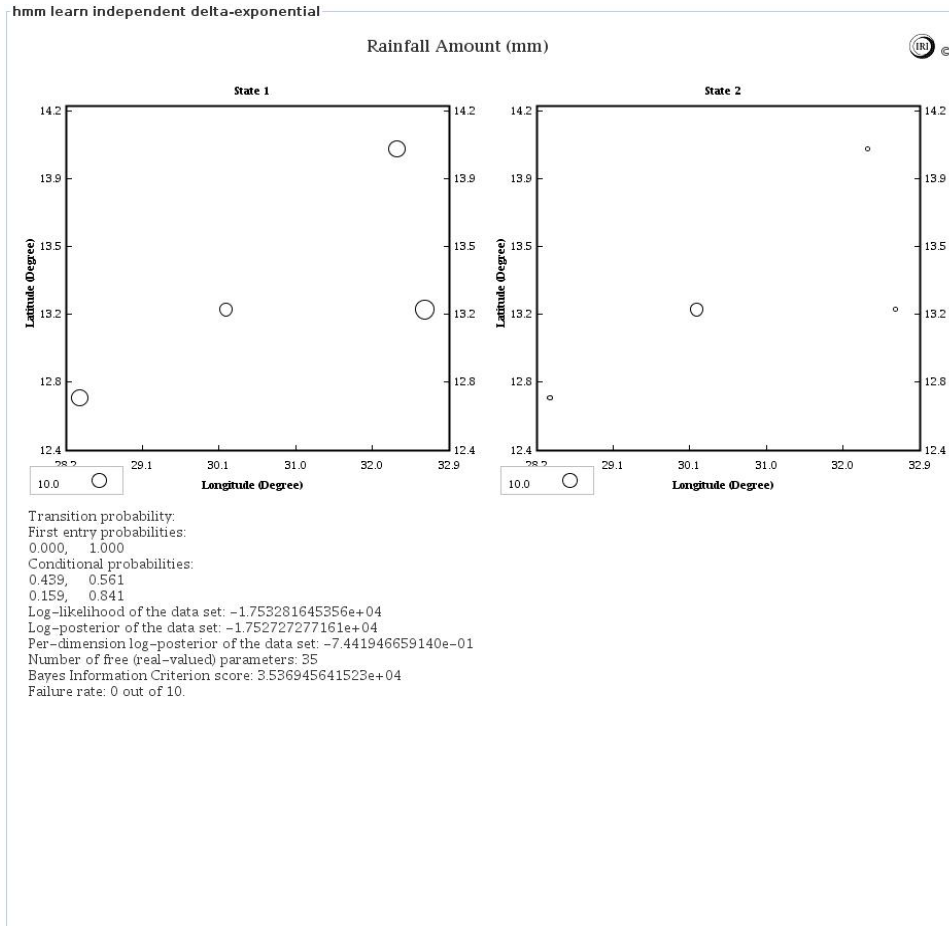


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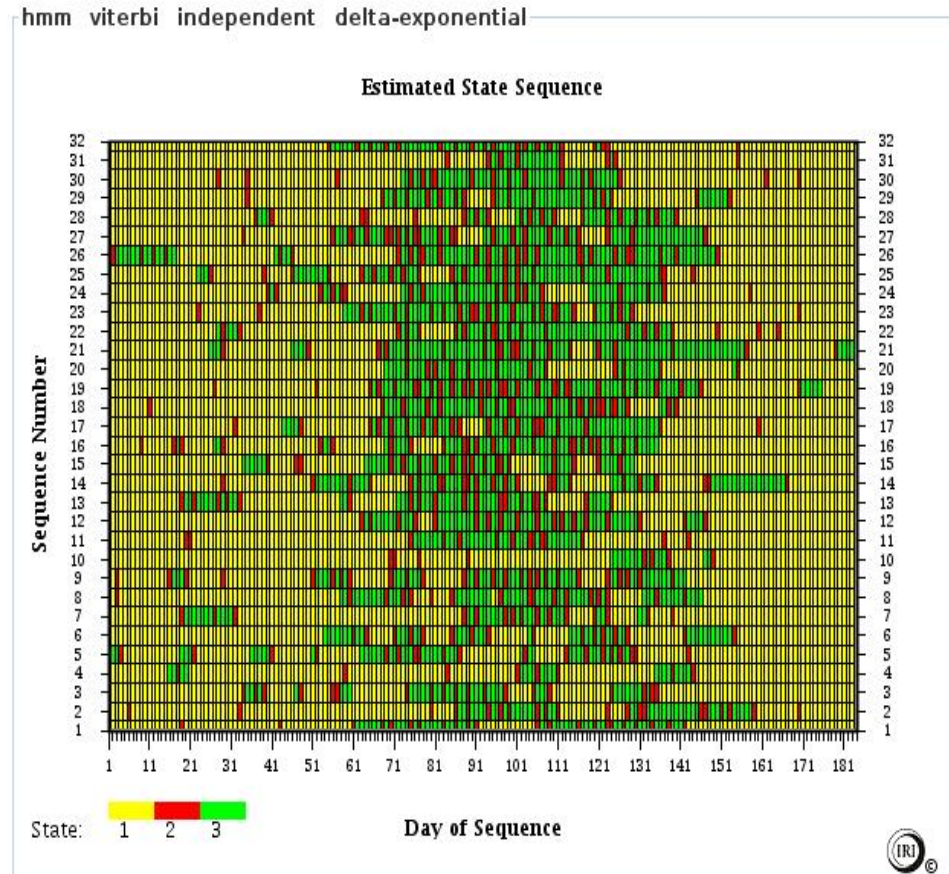
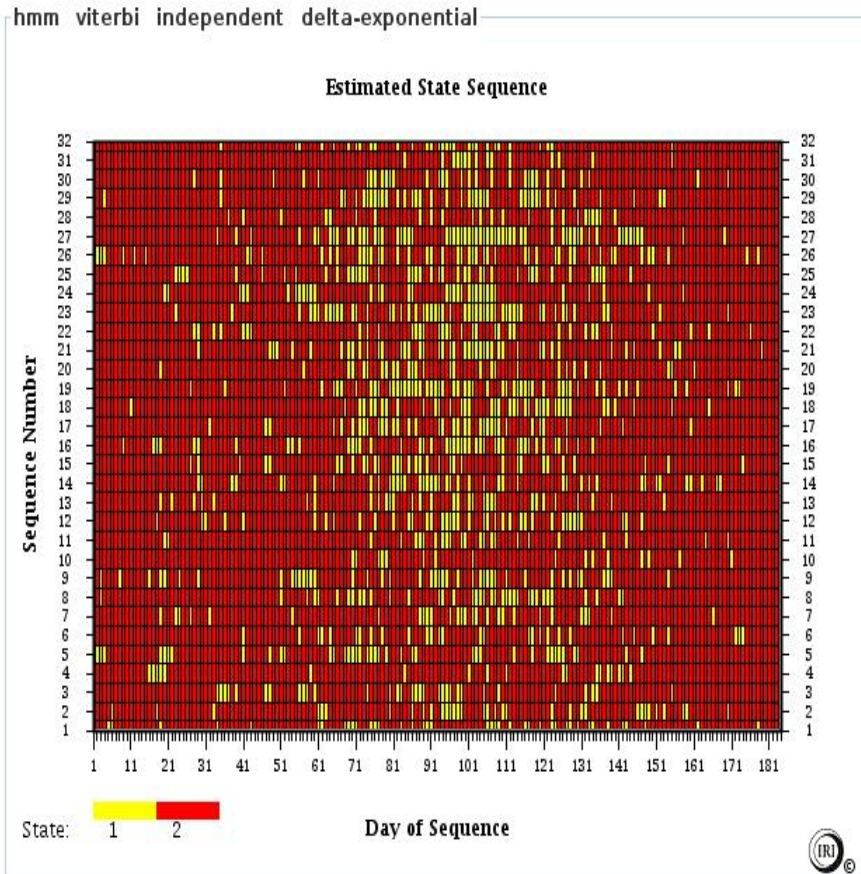


# Central Zone; Rainfall Amount and Probabilities





# Central Zone (Viterbi)



# Conclusion

- There are two main regimes controlling the rainfall over Sudan as shown from figures.
- Rainy seasons start from the beginning of July to the middle of September in the western part.
- Also the eastern and central regions August and September are the rainy months, but in the central region it shrinks to one month.
- This results indicate that the difference in the source of moisture flux, and cloud formation types may play the main role in the spatial and temporal variation of precipitation over Sudan.

**Thank you**

