#### Study of precipitation variability based on seasonality



### and entropy over the Eastern Mediterranean



European Geosciences Union General Assembly 2015 Vienna | Austria | 12 – 17 April 2015

## Introduction

- Mediterranean region has shown large climate shifts in the past
- and it has been identified as one of the most prominent "Hot-Spots"
- in future climate change projections.
  - CIMP5 multi-model mean results of projected average percent change in annual mean precipitation for (2081-2100) relative to (1986-2005).



Interannual variability of precipitation can directly or indirectly affect many hydrological, ecological and biogeochemical processes that, in turn, influence climate.

> The relative seasonality of rainfall represents the degree of variability in monthly rainfall throughout the year.

**Entropy** is a fundamental quantity in statistics and machine learning. It evaluates the amount of information contained in random signals and quantifies random signals based on their occurrence probability. It provides a measure of dispersion, uncertainty, disorder and diversity of precipitation intensity and/or precipitation amount.

Precipitation change



#### 104 series are considered for this study



Stations with daily and monthly precipitation data (70)

Stations with monthly precipitation data (34)

Lat (o)

# Mean Annual Precipitation 1961-2012





projections of future global precipitation changes from the 2007 IPCC



Trend in precipitation over the Eastern Mediterranean with altitude



ippt.com



## Relationship between latitude and CVs calculated for each station.



#### Spatial distribution of mean seasonal variability index over Eastern Mediterranean







Scatterplots of latitude and annual rainfall variability index computed over 1961-2012



The annual and
multiseasonal correlation
coefficients between rainfall
variability index and latitude

## **Relative seasonality of rainfall** refers to the degree of variability in monthly rainfall through the year. It assesses seasonal contrasts in rainfall amounts rather than whether months are "dry" or "wet" in absolute sense.

**Seasonality index** helps in identifying the rainfall regimes based on the monthly distribution of rainfall. In order to define these seasonal contrasts, the seasonality index  $\overline{SI}$  and  $\overline{SI}_i$  were computed to quantify the annual rainfall regimes. These indices can show differences in relative seasonality even in areas with 2 or 3 rainfall peaks throughout the year.









Scatter diagram and linear regression line of seasonality index  $\overline{SI}$ and latitude ( $\phi$ )

Box-whisker diagram of the ratio  $\overline{SI} / \overline{SI_i}$  in all stations over 1961-2012





About **60%** of total stations have an  $\overline{SI}$  increasing trend, which is statistically significant in 10% of them. This increasing in  $\overline{SI}$  trend reveals that the rainfall distribution in these sites has become as commetric, accompanied with\_changes in rainfall characteristics such as intensity and duration.

The **Sum of Regime Shift Indices (RSI)** calculated for each

of the 104 single stations resulted in highest cumulative values in whole 1990s. It peaked in 1989, 1995 and 2005.



Summary of all regime shift index (RSIs) in mean estimated by STARS for 103 stations during 1961–2012. (α=0.05; cut-off length= 26; Huber parameter = 1) Regime shifts in Mean Individual Seasonality Index from in selected stations 1961 to 2012 ( $\alpha$ =0.05; cut-off length= 26; Huber parameter = 1)







A discrete form of entropy H(x) is given as  $H(X) = H(p_1, p_2, \dots, p_n) = -\sum_{i=1}^n p_i log p_i$ Where X is a discrete random variable,  $P_i$  is the probability that X assumes a value  $X = x_i$ , and n is the number of values (sample size) that X can take on this Equation defining entropy in real time or space. Entropy is expressed in bits if the base of the logarithm is assumed to be equal to 2.

A corresponding R package "entropy" was deposited in the R archive CRAN and is accessible at the URL:



http://cran.r-project.org/web/packages/entropy/ under the GNU General Public License.

#### Spatial distribution for the entropy of monthly (a) and daily (b) rainfall amounts

during 1961-2012 over the Eastern Mediterranean





#### Relationship between entropies and CVs in autumn and spring



