Evaluation of the utility of seasonal meteorological forecasts for Portugal

[Extended Abstract]

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Abstract: Meteorological forecast for a period of time not superior to a year, even if approximate, it may be a useful tool when its needed to plan how to manage the available hydrological resources due to the climate change.

Based on that, the goal is to appraise how the North Atlantic Oscillation can be used as forecast indicator for precipitation in Portugal. To achieve reasonable results and take supported conclusions is necessary an appropriate graphic representation of the quantitative values and their evolution through time.

The chosen methodology should include a careful choice of the meteorological stations, the optimization of the temporal data to be analyzed, their representation on the map and, at last, the graphic representation and observation of results.

The selected meteorological stations must provide continuous and long duration data of precipitation evenly distributed through Portugal mainland.

Once chosen, the following step should be the evaluation of the correlation relations between precipitation data and posterior georeferencing of meteorological stations to characterize three main regions in the country, North, Center and South.

Finally, the precipitation and North Atlantic Oscillation temporal series are compared for each geographic region and for three different time periods, annual, semiannual and quarterly.

The conclusions are supported by the graphic representation of precipitation and NAO evolution during a certain time period.

Key-words: North Atlantic Oscillation, Precipitation, time series, meteorological forecast.

1. Objective

The technological development of the last decades contributed to the expansion of human population, the improvement of quality of life conditions and, as consequence, an increasing consumption of available resources, with severe consequences to the environment.

This scenario tends to get worse when also there are significant changes in weather regimes due to climate changes that deregulates natural cycles and consequently affects the availability of natural resources such as water, which is essential for the maintenance and subsistence of wildlife, flora and human being.

Although, with a greater access to relevant information, appeared the opportunity to deepen the knowledge about meteorology and climatology phenomena which has allowed the formulation of new theories and concepts that have modified our view of certain atmospheric phenomena, how they define meteorological regimes of the globe and, also, the changes expected according to their temporal evolution and their influence in natural cycles and resources availability.

The last few years have been particularly difficult. There are changes in rainfall patterns that tend to cause serious impacts on the available reserves. This recent scenario requires a better water management and probably greater limitations in terms of use and water consumption for several sectors, with a higher weight for the agricultural sector.

These changes are the reason of the extension of periods of drought and, in the remaining months of the year, where the recharge of the existing water reserves is expected, of the decrease in the average precipitation values.

Having as trustworthy information numerous studies that categorize meteorological modifications as outcome of an irregular evolution of certain atmospheric phenomena such as North Atlantic Oscillation (Miranda et al, 2002; Mateus e Cunha, 2013; Trigo, Osborn e Corte-Real, 2002) this study aims to do a new approach to a concept already studied and analyzed, and to arrange a method of forecasting that enables an early preparation and prevention for unfavorable weather conditions.

Due to that, the objective is to verify if is there any association among precipitation values recorded in Portugal and NAO index and, if there is one, how this information can be transformed into a new meteorological forecasting tool.

Therefore, it will be made a comparison between time series of precipitation and NAO, extended over a period of 70 years, for the three main regions of the country, where is intended to verify the influence of NAO and its evolution in the precipitation of the country.

NAO and climate variability

The North Atlantic Oscillation is described as the barometric difference among two pressure poles where the low pressure center is located at high latitudes, the Icelandic depression, and the high pressure center at subtropical latitudes, over the Azores islands.

The air mass circulates between the north pole and Ferrel cells. The air cools down in the polar zone and when in contact with hot air of the Golf Stream warms up due to heat transference. Not only the air temperature rises but also the moisture content increase.

Such alterations to the air parameters will define the rainfall regime for Iberian Peninsula.

Depending on the pressure values on the dipole, the air jet stream can take two different directions. When NAO is at positive phase, the high and low pressure atmospheric centers present higher and lower than average pressure values, respectively. On this phase the jet stream is directed to the north of Europe, which means rainy and moderated meteorological conditions for that countries, and cool and dry meteorological conditions for Iberian Peninsula, particularly for winter season.

When NAO is at negative phase, the high and low pressure centers present lower than average pressure values and the jet stream is directed to Iberian Peninsula. At this point is expected rainy and moderate conditions for this region, and the opposite for North of Europe.
Normally, we can expect a swing between phases in a space of a year, two years or one decade, but something changed in a recent past.
After a thorough analysis of NAO evolution in the last decades, it can be observed a change in the NAO pattern. Abnormally, it seems that the positive phase is persisting during longer periods of time, mainly in the second quarter of the hydrological year, with the exception of one or two years where it has changed for the negative phase.
Like so, that shift of pattern means the continuous cool and dry conditions in the spring for Portugal, which can be seen as a significant problem to water availability and management, especially for center and south of the country.
Portugal as an average precipitation of 900 mm per year, not evenly distributed during the 12 months.
The first six months of the hydrological year present the major percentage of precipitation and are crucial for the recharge of water bodies.
From the total amount of rainfall only a small part will be stored and used for the activities depending of it. However, with a decrease of precipitation in this 6 months, with the exact same structures and sectors to provide, Portugal is in hands with a major problem, lack of water to sustain them all.
This implies also, drastic economic losses. Without any preventive and correcting measures for all the end users, such as agricultural sector, are facing huge risks most of time.
In a scenario where the necessities surpasses the available quantities of water, it is common not provide the agricultural sector, in the way to guarantee the ecological and human requirements, which means lose all the investments made, such as plantation areas.
This only may be altered if gathered information about future weather conditions, like a decrease on the expected precipitation, that allow a readjust of the investments made and avoid unnecessary losses.
Considering this, it is imperative a more efficient water management, primarily in the more sensible geographic areas, and determine how they can be affected due to the noticed alterations in precipitation patterns to mitigate the inherent consequences.

3. Regionalization and description of precipitation in Portugal

Before the comparison analysis, is necessary to define three regions, the group of meteorological stations for each one of them and their individual contribute for the total precipitation for a certain region.
For that, the temporal series of precipitation for each station must be correlated to verify the level of similarity between the precipitation values using Principal Components Analysis method (Sousa, A.J, 2007). The exit parameters are vector projections representing each station.

Depending on the direction of each vector it is possible to assume the similarity relations maintained and quantify almost immediately the number of groups formed. Are giving two possible results. For the first hypothesis result two major groups, where the largest one represent North and Center regions. However, the intention is to define three groups so the biggest one will be divided also into two, achieving the primary goal.

To refine this results, is necessary a second step, that's consists in the definition of the number of clusters pretended, that return as result all the stations hierarchical aligned by group, as showned in fig.1.

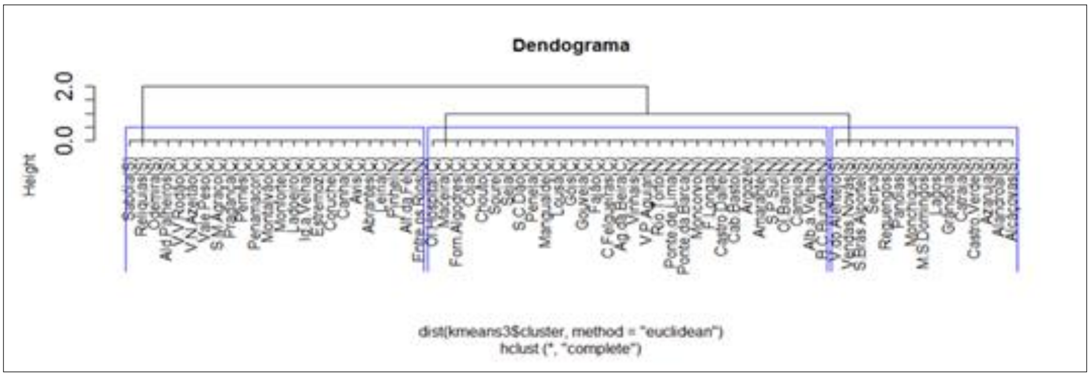

Fig. 1 - Dendogram for "K-means=3". Metereological stations aligned and grouped up by region.

After that, to understand the distribution of the stations and the groups formed, all this information will be used as input for the geographic representation on the map.

The purpose is to determine which station as a higher contribution in terms of precipitation for the region calculating the thiessen polygons. Due to this intermediate step the time series are optimized and the appreciation of the graphic representation for NAO and precipitation time series is more reliable.

4. Prediction based on NAO evolution

Finally, after compilate all the data it is possible to evaluate the evolution of the time series for precipitation and NAO and see how this information can be useful to predict the meteorological changes observed in Portugal.

Due to the extension of the time series, that will overcharge the graphic representation, it is considered to make three different approaches, annual, semiannual and quarterly time series, to verify the one that allows to understand which are the critical periods during the hydrological year.

For this analysis are considered two types of data, the precipitation average and its anomalies, and both are correlated with NAO values.

In the annual analysis we start to have an idea how the precipitation values decreased in the last decades, but at this point is just a supposition. The graphic evolution for the two parameters is not sufficiently noticeable to take a final conclusion.

Furthermore, the intention is to identify the critical periods of the year, which it is not possible with this extension of data.

When advancing to the semiannual analysis are expected some changes, and maybe start to recognize some kind of pattern that may lead to valuable information.

From the dispersion graphs can be observed a more condensed cloud of points when NAO is in its positive phase. It is also made an effort to compare the precipitation values with the NAO values from the past semester but it isn't found any kind of correlation between the both parameters.

From the linear graphs it is slightly perceptible a certain decrease of precipitation values for the first semester of the year. The most affected areas to these meteorological changes are the Center and South of the country.

To the second semester weren't find any concerning alterations so this evaluation will be focused on the winter months.

At last, in the quarterly analysis the data series are shorter and at this stage important conclusions are taken.

The major decrease on precipitation in parallel with the permanency of the positive phase of NAO is noticed between January and March, a crucial moment for flora growth and agricultural sustain, especially for Center (Fig.2) and South (Fig.3).

Now that the critical periods were identified, the preventive measures to deal with the climate changes can be planned, delineated and applied.

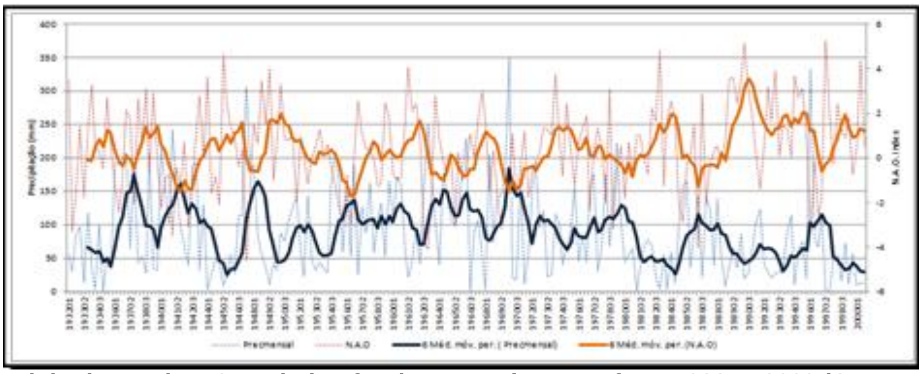

Fig. 2 - Precipitation and NAO evolution for the second quarter from 1932 to 2000 (Center Region).

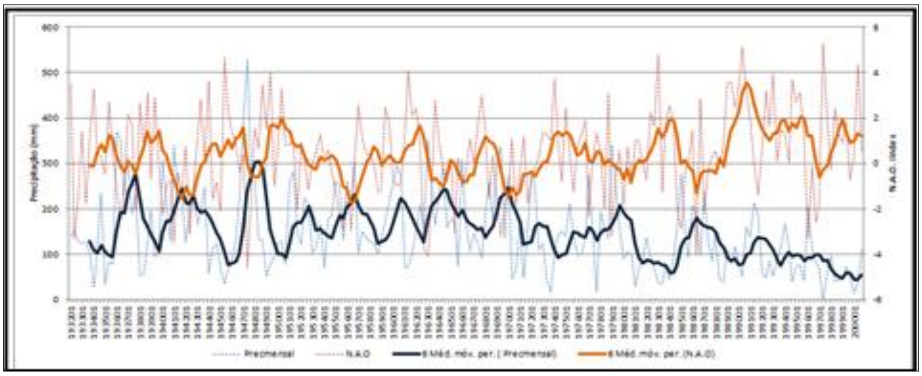

Fig. 3 . Precipitation and NAO evolution for the second quarter from 1932 to 2000 (South Region).

6. Conclusions

The objective of study was to verify the existence of some pattern able to describe the evolution of NAO through time, that allows to predict the rainfall regime for a near future.

It is not possible to determine a certain numeric value for NAO for a certain period of the year, however when considered a larger scale and its average values it's easier to formulate some prediction theory.

From the three comparison analysis made, the quarterly analysis is the one that prove a tendency for NAO's evolution that is directly correlated with a decrease in precipitation.

From January to May it is obvious the persistence of NAO's positive phase and smaller values for precipitation.

Admitting that this atmospheric conditions will persist in the next years, and considering the consequences for several sectors, mainly the agricultural, the output information should be shared with all the concerned parts.

With the possibility of a reduction of the available water for use and consumption, a proper solution is to adapt and reduce from the beginning some of the investments made in the agricultural sector, especially in sensible areas to climate change.

The agricultural development should adapt to the available water reserves and not the opposite.

To do so it is important the frequent communication of the state of water bodies and possible meteorological changes to elaborate a preventive plan for future adverse conditions.

7. Bibliography

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