International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Noun Seyad Basin Climate Change: The Register of Thermal and Rainfall Between 1901 and 2018

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Abstract

The Earth's climate was never stable in the previous millions of years. This was confirmed by the variations in temperature and precipitations, since they are considered to be the most impacted climatic parameters. The research in the field of he paleoclimatic proxies was able to identify different climatic stages of the Earth's history, as well as the natural factors responsible for these changes (the milankovic parameters).

This is the case of the Noun Seyad basin, which was well exploited by these researchers, which made it possible to have a general help on the paleoclimate of the basin in the holocene and pleistocene periods,

The objective of this study is to identify recent climate changes in our study area, between 1901 and 2018, also to highlight the role of anthropogenic activity in these changes using statistical studies of temperature and precipitation.

Keywords: climate change, rainfall, temperature, NOA, Noun Seyad basin.

Introduction:

Since the upper Pleistocene the Earth's climate has undergone changes illustrated by the alternation of the glacial and interglacial periods, likewise at the level of Morocco, these changes were marked by several paleoclimatic controls.

The Noun Seyad basin, located in the anti-western atlas, was the subject of several paleoclimatic studies, taking into account the dating of travertine deposits in order to reconstruct the evolution of river systems upstream of the basin (case of Oued Assaka) [1]. The dating of some gastropods of sultanas deposits below the basin (Taghjijt) allowed us to have a help on the paleoclimate of basin [2]. This showed that it has undergone several changes with alternation between wet and solid phases since the Pleistocene. The periods of ordinary operation of the arid and semi-arid river system seem to be around 45 ka, between 30-17 ka and during most of the Holocene [3].

Also the radiometric dating of certain fluviatile travertine at the anti-atlas allowed the detection of successive wet phases illustrated by a concretional travertine which also involved the variation of hydrological parameters, with an abundance of precipitation [4].

Most reports indicated an alternation between the wet and dry phases at the anti Atlasic zone, with a discussion surrounding the dating and the precise identification of these periods. We support the approach of Alimen [5], which supposed that the Atlasic zone has known two humid periods since the upper Pleistocene, one at the level of the upper Pleistocene about 40000 to 18000 in Bp, and another period at Holocene level about 9000 to 3370 in Bp.

The recent climate is the most impacted by climate change given the human anthropogenic activity that amplified the emissions of greenhouse gases which then introduces a global warming on the Earth.
In our study, we will try to investigate the various recent climate changes in the Noun-Seyad basin in order to show the impact of anthropogenic activity on the climate in this basin from 1901 to 2018.

Presentation of the study area:

The Noun-Seyad Basin is located in the western anti-atlas basin that is bounded by the Taissa buttonhole in the south and by the Bani mountain chain in the west, and the Akhssas limestone plateau in the north, and by the Atlantic Ocean and the Ifni massif in the east. The total area is around 6,873 km² with a perimeter of 592 km. The topography of the basin comprises high-altitude mountainous terrain with a maximum value of 1,495 m and a low pression area with values of 16 m.

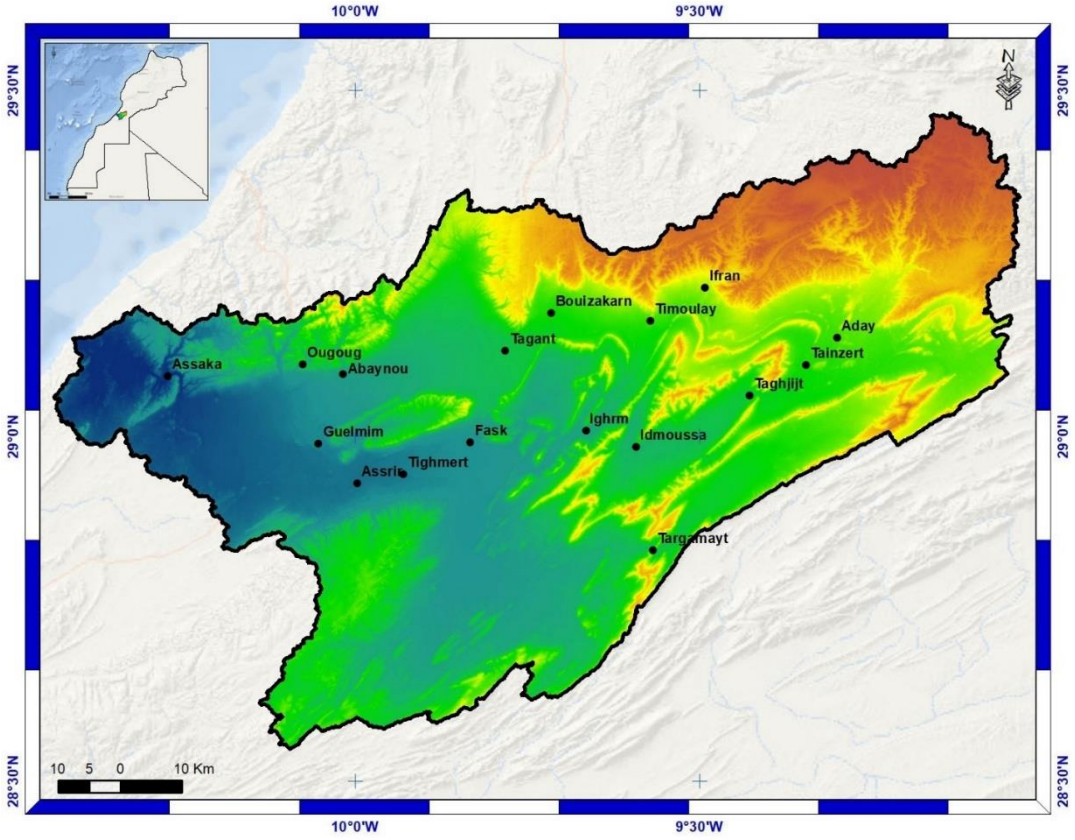

Figure 1: Geographical Situation in the Noun Seyad basin

Climate:

The climate of the basin is semi-arid, in which the interannual rainfall is between 100 mm and 200 mm. The precipitation map (Figure 2) shows a spatial irregularity of precipitation given the disposal of the anti-atlasic chain which forms a barrier against rainy pressions from the north and west (wind sheltering) [7]. We note that rainfall is very important in the mountainous zone of limestone plateau of Akhssass and north of Ifran and at the level of Ifni massif contrary to the zone of Bani where the drought has just settled. The rainy season starts from October until the end of February.
The arrangement of the anti-atlasic chain forms a barrier against rainy pressions coming from the north and west (wind sheltering) [7] and this is caused by the heterogeneity of precipitation according to three zones :

- Bani area: low rainfall.

- The limestone plateau and the Ifni massif: significant rainfall.
- The plain of Guelmim and low Daraa massif: average rainfall.

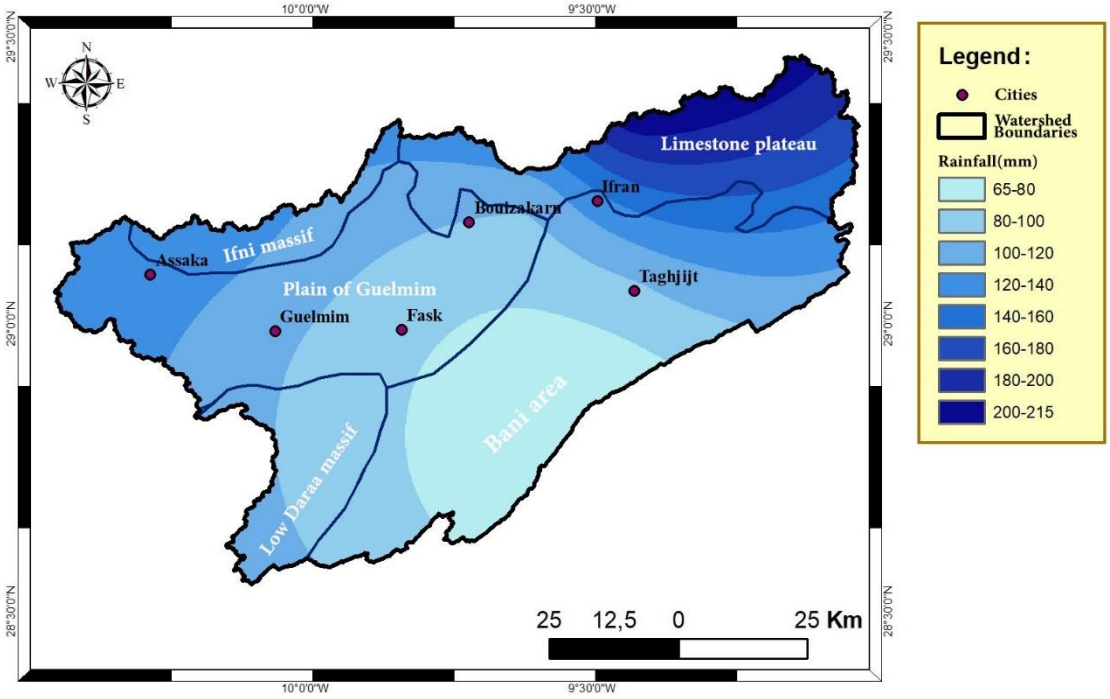

Figure 2: Noun Seyad basin rainfall map

Temperature:

The mean temperature in the Noun Seyad Basin increases from the northwest to the southwest away from the Atlantic Ocean, with a difference of 12 C°. The average annual temperature is around 21°C at Guelmim. The maximum monthly average is 35°C to 36°C in the summer, with peaks exceeding 38°C. The minimum temperature drops to 10°C in winter, sometimes to 7°C. Data on temperatures at Guelmim are presented in the following graphic:

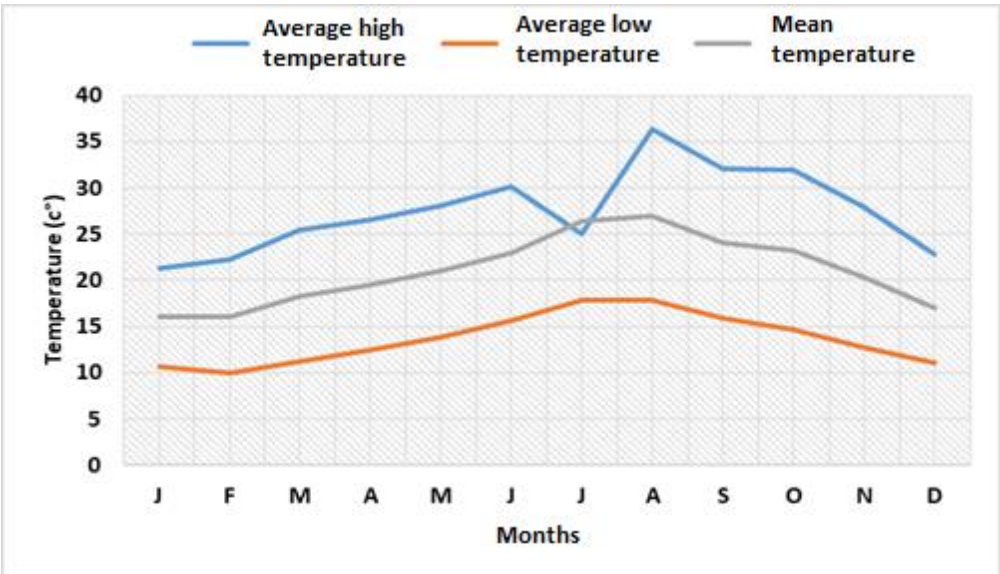

Figure 3: Monthly temperature distribution in the Guelmim station

Bioclimate:

The interference between the mountain and Mediterranean climate and the desert climate in the Noun Seyad basin reflects on the distribution of plant species. The woody plants gather in this area in the form of matorral shrubs whose vegetation is degraded by grazing [7]. This consists essentially of a stand of cedar (Tetraclinis articulata) well limited to the limestone plateau, the argan tree (Argania spinosa) is the most abundant species in the greater part of the basin. Argania spinosa forest is denser in the north of the basin and more degraded and dispersed towards the south and east (Map 3), this is generally due to the arid climatic conditions in the eastern part of the basin.

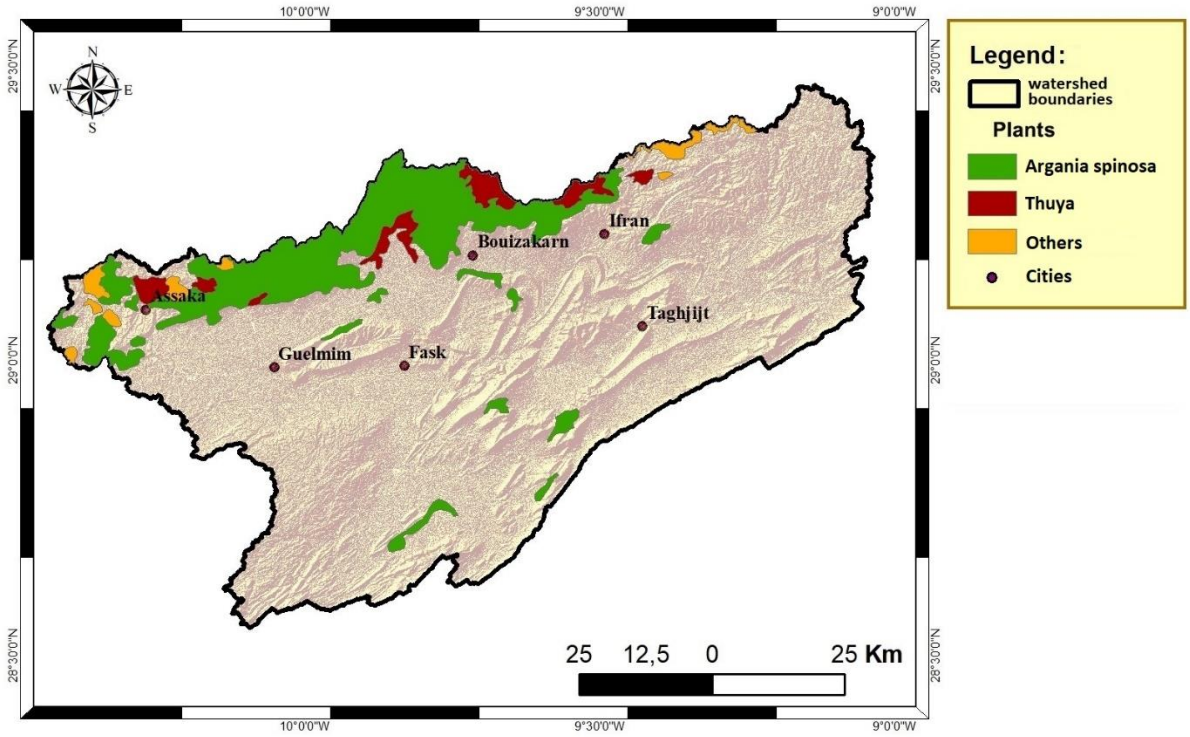

Figure 4: Noun Seyad Basin Vegetation Map

The steppes cover more than 80% of the bassin area, it is generally formed by species such as: Ephorbia beaumierara (daghmous), Euphorbia echinus (daghmous), Euphorbia regis (jugal), Senecio anteuphorbium, Wormwood (CHIH), Peganum Harmala (HARMAL) Salsola sp (Remth). The long profile from the west of the basin to the east (Figure 3) shows the different vegetative groups of the Noun Seyad basin, in fact, the vegetation is well degraded in the plain areas, because of desertification, increasing demographic pressure and pastoral activity[8].

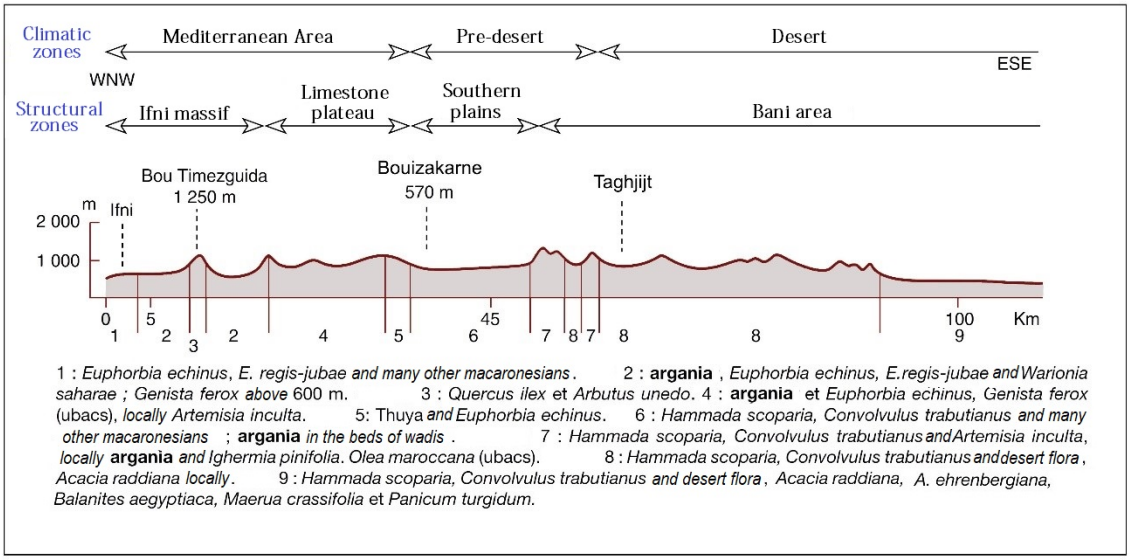

Figure 5: Distribution profile of plant species from west to east of the basin

Methodology:

We used a methodology developed by Z. NOUACEUR, which consisted in the statistical processing of rainfall and thermal data using the Chronological Information Processing Graphical Matrix (MGCTI), of the "BERTIN matrix" type [9].

In the first step, a statistical treatment of the annual precipitation of several scattered stations over the study area made it possible to calculate the dispersion parameters indicating how far the values of a distribution generally deviate from the central reference value (measures of statistical dispersion with reference to the quantiles Q1, Q2, Q3 and Q4).

Subsequently, the table of annual precipitation (Pa) was copied giving the value of 1 for a very dry year (Pa < Q1) and a value of 5 for a very wet year (Pa > Q4) Tab 1:

	Pa < Q1	Q1 < Pa < Q2	Q2 < Pa < Q3	Q3 < Pa < Q4	Pa > Q4
Code	1	2	3	4	5
Climate class	Very Dry	Dry	Normal	wet	very wet

Table 1: Annual precipitation recoding

So, the numerical table will be transformed into a graphical table with intensity classes in order to examine the relationships between rows and columns.

To determine breaks and characteristic periods, a second procedure was implemented. The sum of the numbers of all the stations for each year was centered reduced, which allowed us to obtain an index that also varies from infinity for a very wet year to less infinity for a very dry year.

The projection of the result on a graph allowed us to see the evolution of the phenomenon at a regional scale and to determine the dates of breaks and change of trend.

The same method was applied to the temperature data to determine their evolution over time, and to produce the temperature matrix adopting the following statistical parameters:

	Pa < Q1	Q1 < Pa < Q2	Q2 < Pa < Q3	Q3 < Pa < Q4	Pa > Q4
Code	1	2	3	4	5
Classe de climat	Very hot	Hot	Normal	Fresh	Very fresh

Table 2: Annual average temperature recoding

The used data:

Given the inadequacy and irregularity of the rainfall and thermal data at the level of the Noun Seyed basin and in order to cover a large period of time, the CRU TS4.04 data [10] was used (https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.04/).

This database was created from monthly observations in weather stations across the world's lands. Station anomalies were interpolated into 0.5 latitude/longitude grid cells covering the Earth's surface and combined with existing climatology to obtain absolute monthly values. [6]

In our case, we used data from the six cells (zones) that cover our study area as shown in Figure 6:

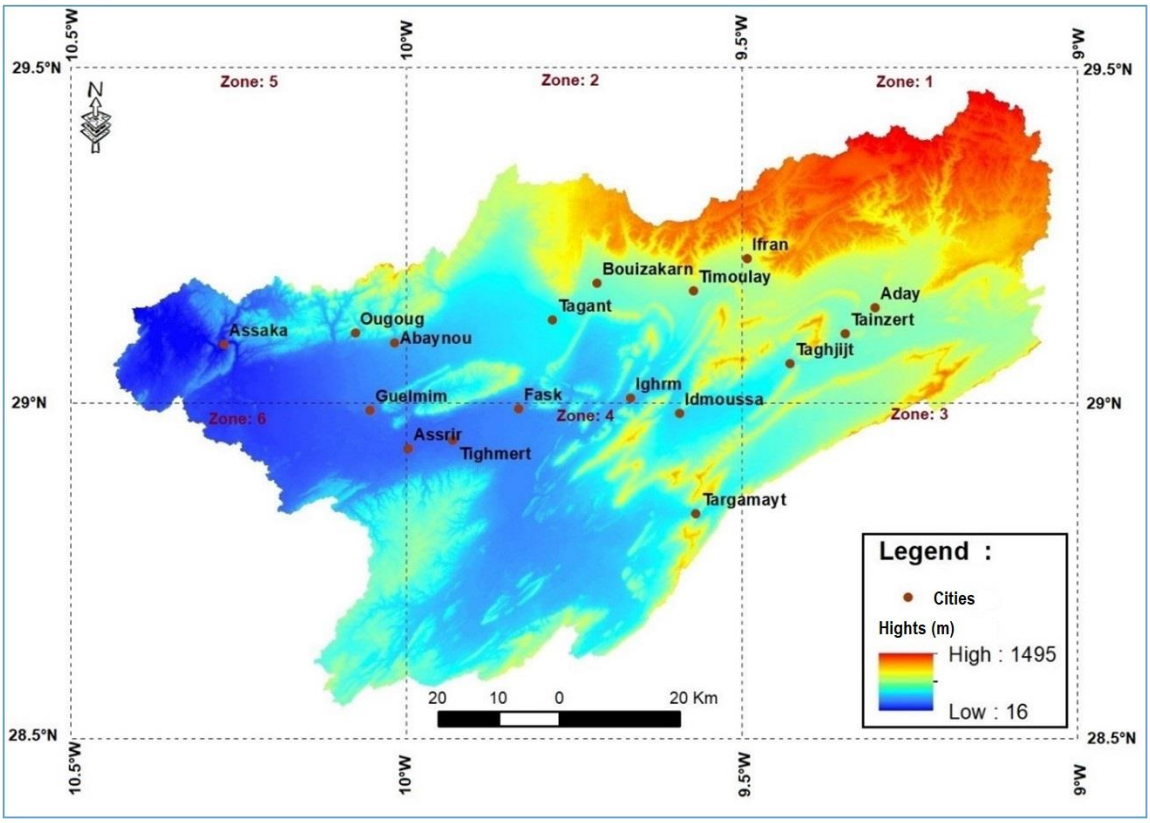

Figure 6: The division of the basin according to the areas (cells) of data used

To verify the feasibility of the data, a correlation was made between the actual measurements of the meteorological station of Taghjijt and the data estimated by the model.

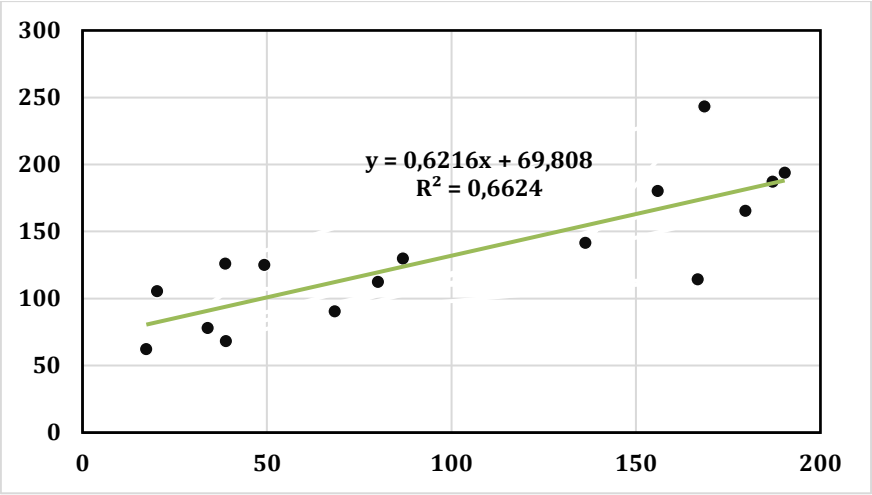

Figure 7: Correlation between actual climate data and those estimated by the CRU model

We noted that the correlation index was equal to 0.66, which showed the significance of the results, especially since we worked over a large period.

Presentation of results:

After completing the various steps, the results are presented by the following figure:

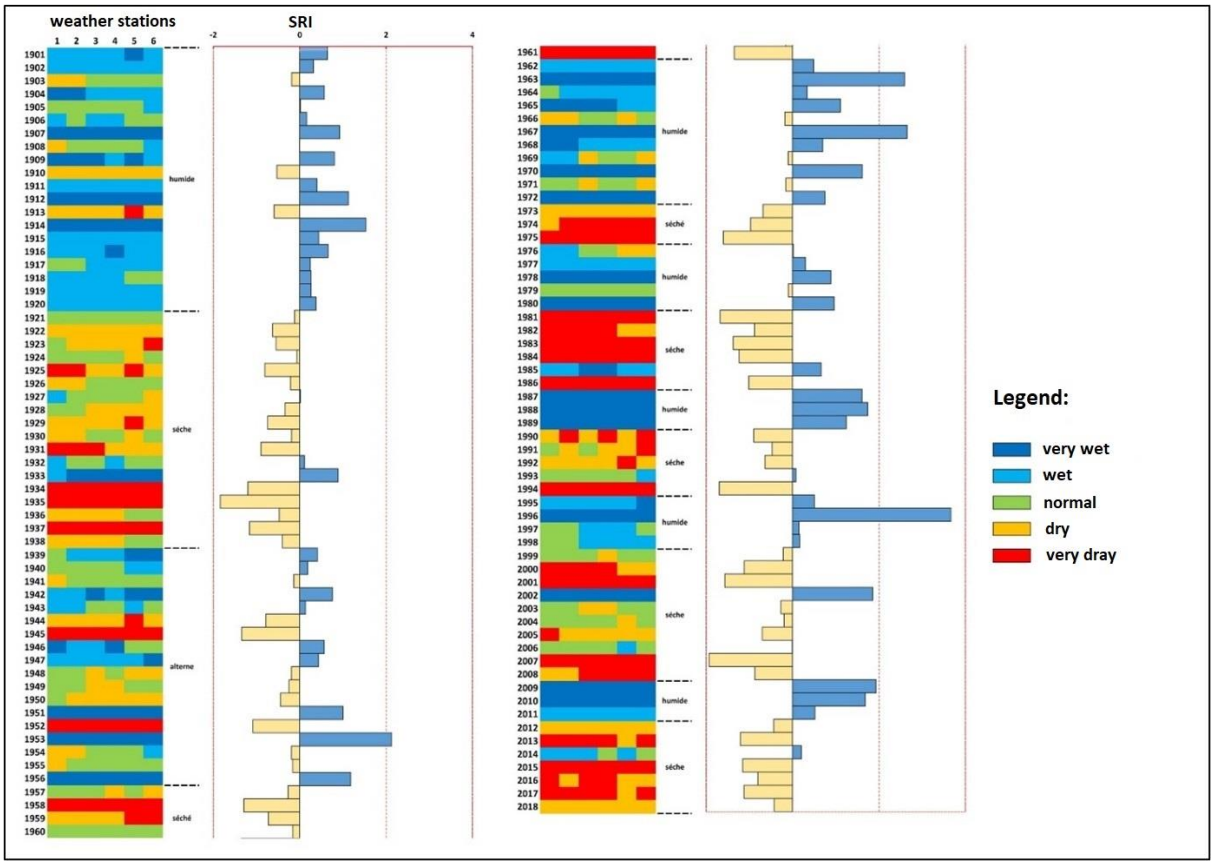

Figure 8: the MGCTI matrix and the standard rainfall index between 1901 and 2018

Based on the MGCTI matrix, the alternation between wet and dry phases was clearly marked in the Noun Seyad basin. This pattern allowed the current climate to be divided into the following periods:

From 1901 to 1920, there was a wet period with three exceptional years (1903, 1910, and 1913) that experienced low rainfall. This was followed by a dry period from 1921 to 1938. Then, from 1939 to 1956, there was an unstable period characterized by the interaction between rainy and dry years. From 1957 to 1961, the region experienced a strictly dry period.

Between 1962 and 1972, there was a wet period with very heavy rains. This was followed by a short dry period from 1973 to 1975, after which a wet period occurred from 1976 to 1980. The region then experienced another dry period from 1981 to 1986, followed by a wet period from 1987 to 1989.

From 1990 to 1994, dry conditions prevailed again, followed by a wet period from 1995 to 1998. From 1999 to 2008, there was a dry period with only one rainy year. Between 2009 and 2011, the region experienced a wet period once more, followed by a dry period from 2012 to 2018, except for the year 2014, which saw very heavy precipitation.

This detailed analysis of climatic phases in the Noun Seyad basin highlights the significant fluctuations in precipitation over more than a century, demonstrating the complex interplay of wet and dry periods that have shaped the region's climate.

In the light of these results, we concluded that the impact of short-term climate change is well demonstrated in this basin by the heterogeneity of precipitation. The MGCTI matrix showed that the distribution of the wet and dry phases during the 117 years study was irregular. Whereas before 1981, the rate of the wet years was almost equal to the rate of the dry years. This situation was no longer the same from 1981 onwards, when we noted that the rate of dry years increases to 59% (Figure 9), so the drought began to settle strictly in this basin from 1981.

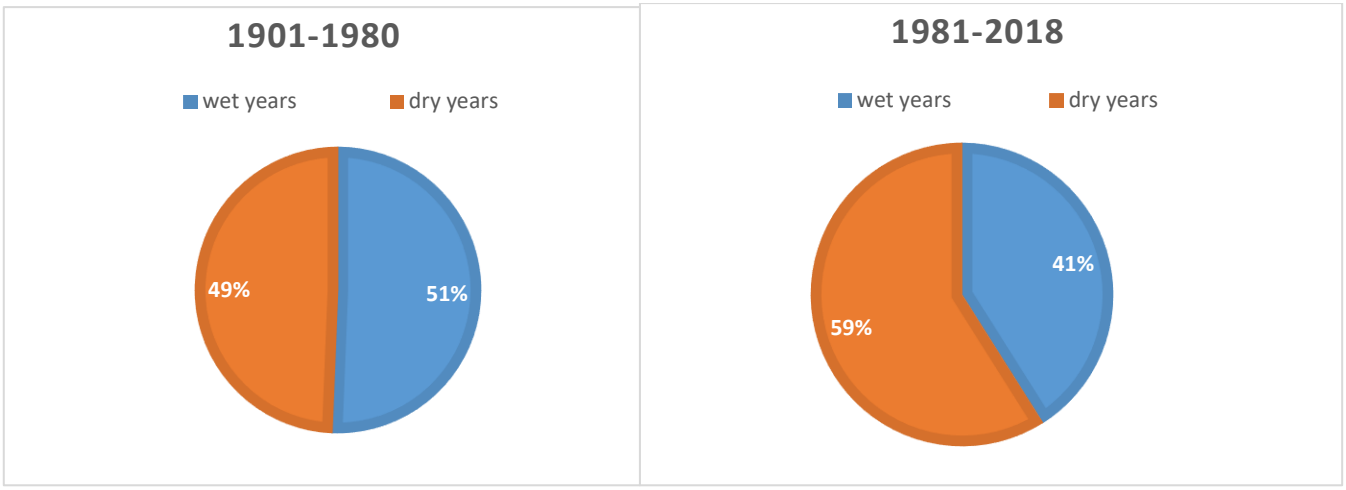

Figure 9: Comparison between wet and dry years

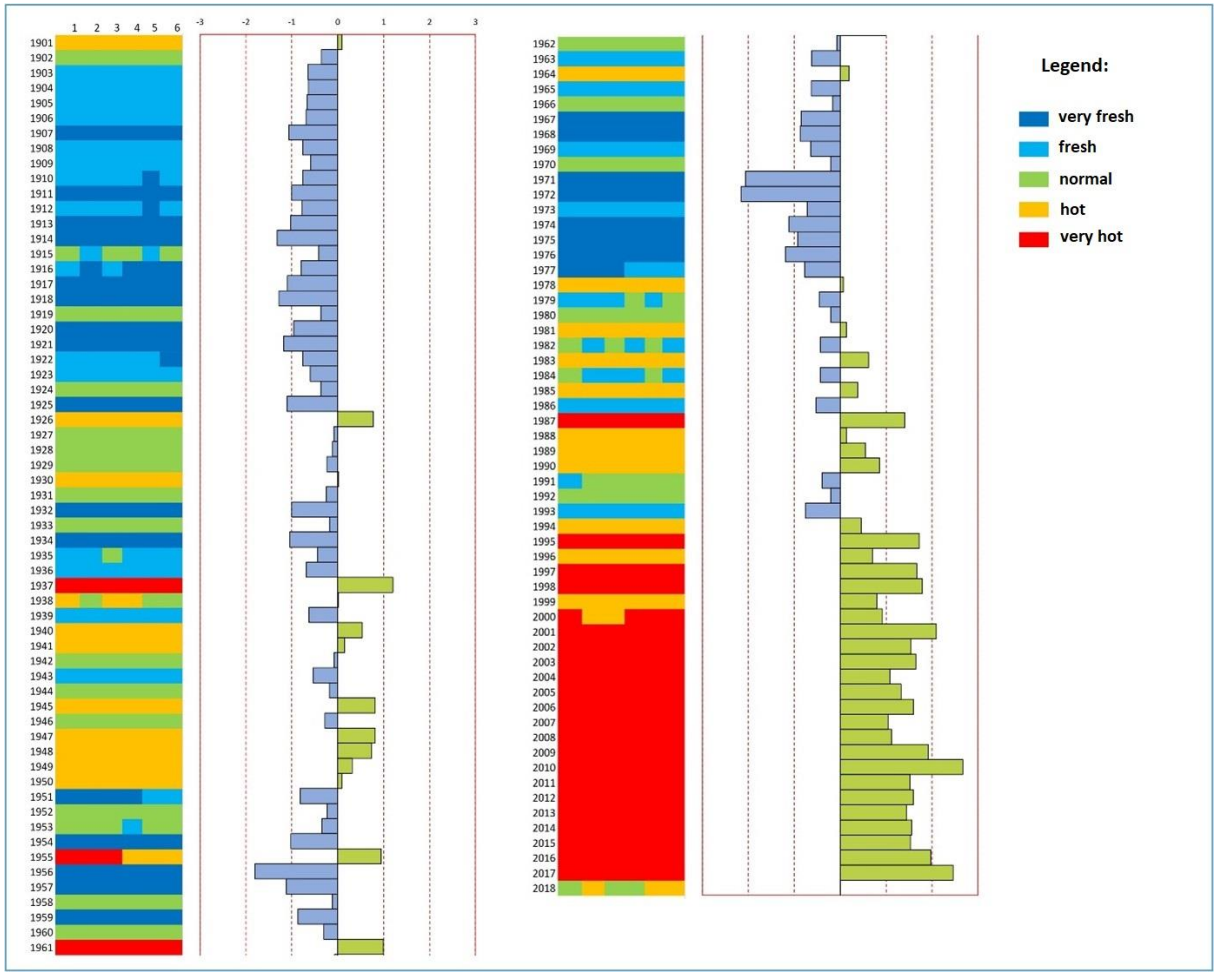

Figure 10: the MGCTI matrix and the standardized thermal index between 1901 and 2018

The climate has been cold since 1901 until 1936 and then a warm period has settled from 1937 until 1950, then the cold climate returns from 1950 to 1980, and from 1981 the warming begins in this region at first with an intermediate period between the years 1981 and 1993, and from 1993 until present the climate was strictly warm. This was well marked in the graphic (Figure 11), which showed that 81% of the years between 1901 and 1980 are cold and 19% of the years were warm. The cold climate was the most dominant until 1980. By contrast, from 1981 until 2018 the warm climate was dominant. Indeed, 84% of the years was warm and only 16% of the years was cold compared to the average annual temperatures.

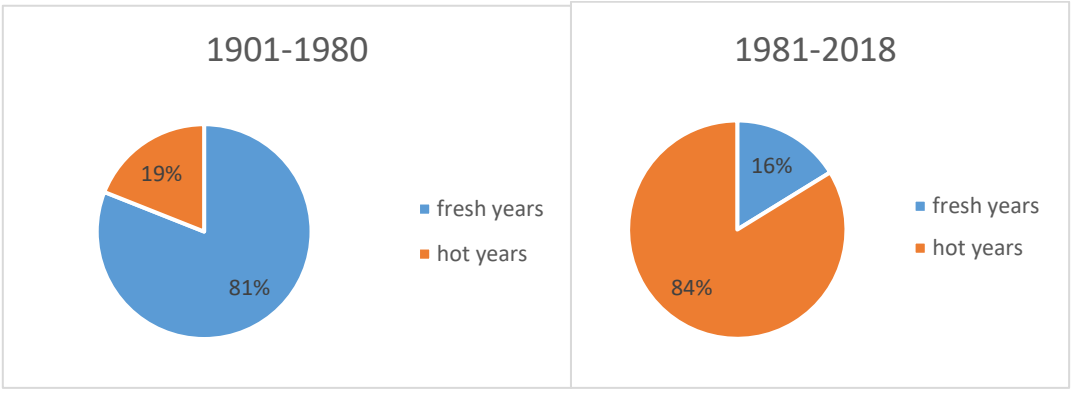

Figure 11: Comparison between cold and warm years

Discussion:

The climate of the Noun Seyad basin is very particular because of its geographical situation, which includes mountain and sub-network zones. The analysis of precipitation by the MGCTI matrix showed the presence of rain breaks, this raises the question of the origin of these ruptures. In order to remedy the problem, considering that atmospheric pressure was the agent responsible for the rainy conditions, we compared the North Atlantic Oscillation Index (NAO) and the SRI (Standard Rainfall Index) of our study area (graphic 1):

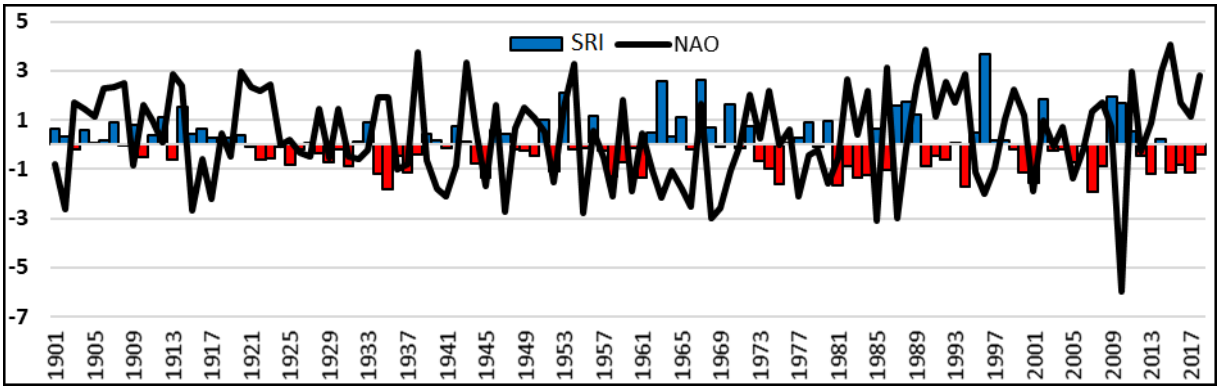

Figure 12: SRI and NAO Index Graph

We noted that there was an oppositional relationship between the SRI and ONA, while precipitation increased when the ONA and negative index and this implies a shift of depurations from north to south of the Atlantic Ocean. It is the general state of Morocco in the North Atlantic Oscillation and the main influencer of climate [11].

After presenting the thermal results we noticed that the basin was entering a period of warming from 1981 as indicated in the Figure 13.

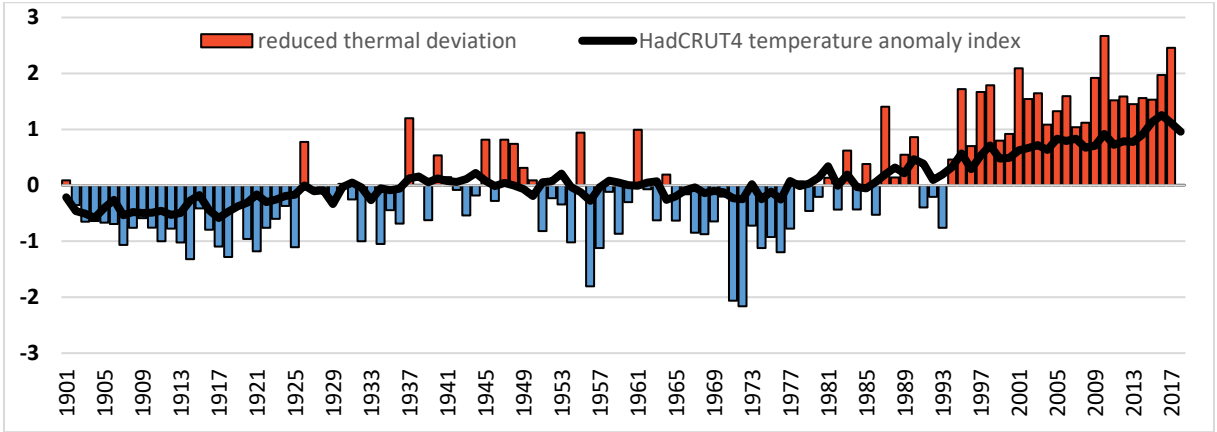

Figure 13: the graph of the reduced thermal deviation and the thermal anomaly

We noticed that the centered deviation that was reduced of the annual temperature in the Noun-Seyad basin vary in the same way as the HadCRUT4 temperature anomaly index [12] of the Earth's northern hemisphere. This showed that in our study area the cause of global warming was generally similar to that of the northern hemisphere.

The earth in the present time has undergone a natural warming related to the parameters of Milankovic, since we are in an interglacial period, and is also related to anthropogenic conditions that give rise to the

greenhouse effect [13] , while the emission of greenhouse gases is bringing the planet into a worrying situation, and this is well presented by the various predictive studies in which it is announced that the warming will continue in the future according to several scenarios as indicated in the following figure [14]:

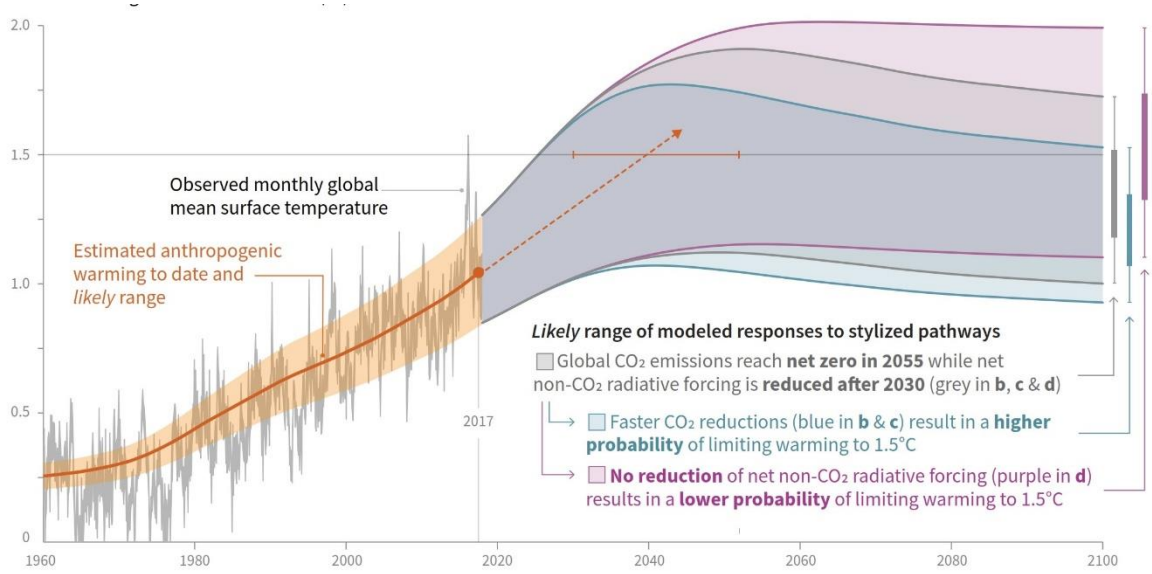

Figure 14: Observed Global Temperature Variation and Modelled Responses to Stylized Trajectories of Anthropogenic Emissions and Forcing [14]

Conclusion:

The Noun Seyad basin is a basin characterized by its particular situation, which has made it under the effect of climate change on the spatial-temporal scale. Currently, precipitation is decreasing from the West to the South-East, and the temperature increases as it moves away from the Atlantic Ocean towards the Southeast.

In addition, the current climate over the past decade has seen a decrease in the rate of rainy years and an increase in the rate of dry years, which makes it possible to say that this basin has entered a stage of warming marked by the increase in annual temperature from 1981. It is likely that anthropogenic activity and the industrial revolution on the earth's surface have had a negative effect on the climate of this region, as the duration of the dry periods will increase in the future. Likewise the temperature will continue to rise under the influence of global warming.

Bibliography:

1. L. Wengler *et al.*, "Upper Pleistocene fluvial record and palaeoenvironments on the Atlantic border of Anti-Atlas (Wadi Assaka, S-W Morocco)," *Quaternaire*, vol. 13, no. 3–4, pp. 179–192, 2002, doi: 10.3406/quate.2002.1710.
2. M. Thorp, P. Glanville, S. Stokes, and R. Bailey, "Preliminary optical and radiocarbon age determinations for Upper Pleistocene alluvial sediments in the southern Anti Atlas Mountains, Morocco," *Comptes Rendus Geosci.*, vol. 334, no. 12, pp. 903–908, 2002, doi: 10.1016/s1631-0713(02)01831-x.
3. A. Weisrock, L. Wahl, A. Ouammou, and L. Chakir, "Systèmes fluviaux du Sud-Ouest marocain et

leur évolution depuis le Pléistocène supérieur.," *Géomorphologie Reli. Process. Environ.*, vol. 12, no. 4, pp. 229–248, Dec. 2006, doi: 10.4000/geomorphologie.11119.

4. L. Rousseau *et al.*, "Premiers résultats d'une étude pluridisciplinaire sur des travertins quaternaires du MarocFirst results of an interdisciplinary study of Quaternary travertines of Morocco," *Quaternaire*, no. vol. 17/4, pp. 343–350, 2006, doi: 10.4000/quaternaire.913.
5. H. Alimen, "Evolution du climat et des civilisations depuis 40 000 ans du nord au sud du Sahara Occidental (premières conceptions confrontées aux données rerentes)," *Bull. l'Association française pour l'étude du Quat.*, vol. 24, no. 4, pp. 215–227, 1987, doi: 10.3406/quate.1987.1851.
6. M. Aouragh and A. Haissoune, "Mapping of soil degradation and vulnerability in the Noun Syed watershed by water erosion : What impacts of climate change: Remote sensing and GIS approach Cartographie de la dégradation et de la vulnérabilité des sols dans le bassin versant de l'oued Sye," *Public Heal. Territ. Intell. Env.Wat. Sci. pub. H. Ter. Int. J. EWASH TI J.*, vol. 4, pp. 442–450, 2020, [Online]. Available: https://revues.imist.ma/index.php/ewash-ti/article/view/22464.
7. R. DIJON, *Reconnaissance hydrogéologique et ressources en eau du bassin des Oueds Seyad - Ouarg-Noun*, Editions d. 1966.
8. J. Peltier, "Biodiversité et biogéographie de l ' arganeraie marocaine," *Cah. Agric. vol. 14, n° 4*, no. January, 2005.
9. Z. Nouaceur, B. Laignel, and I. Turki, "Changements climatiques au Maghreb : vers des conditions plus humides et plus chaudes sur le littoral algérien ?," *Physio-Géo*, vol. 7, no. Volume 7, pp. 307–323, 2013, doi: 10.4000/physio-geo.3686.
10. I. Harris, P. D. Jones, T. J. Osborn, and D. H. Lister, "Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset," *Int. J. Climatol.*, vol. 34, no. 3, pp. 623–642, 2014, doi: 10.1002/joc.3711.
11. A. SEBBAR, W. BADRI, H. FOUGRACH, M. HSAINE, and A. SALOUI, "Étude de la variabilité du régime pluviométrique au Maroc septentrional (1935-2004)," *Sécheresse (Montrouge)*, vol. 22, no. 3, pp. 139–148, 2011, doi: 10.1684/sec.2011.0313.
12. C. P. Morice, J. J. Kennedy, N. A. Rayner, and P. D. Jones, "Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 data set," *J. Geophys. Res. Atmos.*, vol. 117, no. 8, pp. 1–22, 2012, doi: 10.1029/2011JD017187.
13. B. Seguin and J.-F. Soussana, "Le réchauffement climatique (prédictions futures et observations récentes) en lien avec les émissions de GES," *Fourrages*, no. 190, pp. 147–162, 2007.
14. GIEC, "Rapport spécial du GIEC sur les conséquences d'un réchauffement planétaire de 1,5 °C par rapport aux niveaux préindustriels et les trajectoires associées d'émissions mondiales de gaz à effet de serre, dans le contexte du renforcement de la parade mondiale," 2018. [Online]. Available: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/09/IPCC-Special-Report-1.5-SPM_fr.pdf.