STUDY OF THE EVOLUTION OF THE SAHELIAN CLIMATE BASED ON SATELLITE OBSERVATION AND ATOVS DATA.

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INTRODUCTION

The study of the Sahelian climate is of crucial importance, as this region is undergoing significant climate changes that affect human life and biodiversity. The Sahel is a semi-arid region between the Sahara in the north and the savannah in the south, extending over 5,000 km in West Africa. It is characterized by low and irregular rainfall, high temperatures and strong winds.

In recent decades, the Sahelian climate has undergone significant variations, with a decrease in rainfall and an increase in average temperatures. These changes have had a significant impact on agriculture, livestock and water resources, as well as on biodiversity and food security in the region.

The objective of this study is to analyse the evolution of the Sahelian climate from satellite observation and data ATOVS. The data ATOVS are remote sensing data collected by the NOAA (National Oceanic and Atmospheric Administration) satellites that measure atmospheric temperature and humidity. The methodology used includes the analysis of these data to study climate trends in the Sahel region in recent decades. The study aims to better understand climate change in the Sahel region and provide valuable information for natural resource management planning and decision-making in that region.

Objectives : General and specific

○ General objective

The general objective of the thesis is the implementation (creation) of a regional/local climate model.

This will involve the use of vertical sounders on satellites, vertical profiles characteristic of radiances, linked to climatic phenomena. In fact, in Sahelian regions, convective systems such as squall lines are the main sources of precipitation; in this climatic zone, most of the population derives its income from agro-pastoral and fishing activities.

Satellite data have significantly improved weather forecasting, partly due to the information they provide on regions where conventional data are scarce.

** Define new paradigms of atmospheric evolution using radiation balance.

** Determine radiative energy profiles for the Sahelian zone taking into account the anthropogenic effect.

○ Specific objective

The specific objectives are to :

- validate data from low earth orbit satellite transmissions;

- to set up an atmospheric and oceanic database of ATOVS microwave sensors (AMSU-A and MHS) in the Sahelian zone;

- determine the spectral signatures of convective systems;

- to provide correlations between lower atmospheric radiance anomalies and Sea Surface

Satellite Observations: Description and Methods

The satellite observations used in this study are data collected by NOAA satellites, which are meteorological satellites operated by the United States National Oceanic and Atmospheric Administration. These satellites are equipped with remote sensing instruments such as the Advanced Microwave Sounding Unit (AMSU) and the Microwave Humidity Sounder (MHS), which measure the temperature and humidity of the atmosphere.

Data ATOVS (Vertical Advanced Tiros Operational Sounder) are remote sensing data which are diverted from these instruments on board of satellites NOAA. They are available online via the data centre of the Royal Meteorological Institute of Belgium. The data ATOVS used in this study were collected over a period of several decades, from 1987 to 2019, covering a period long enough to study long-term climate trends.

Data ATOVS were pre-processed prior to analysis to ensure quality and reliability. Pre-treatment included the application of corrections for systematic errors, the elimination of missing data and outliers, and spatial and temporal interpolation to obtain regular data across the Sahel region.

Once the data were pre-processed, statistical analyses were carried out to study long-term climate trends in the region. These analyses determined changes in air temperature and humidity in the Sahel region over time, as well as possible upward or downward trends.

Data Analysis ATOVS: Methods and Results

The data ATOVS were analyzed using several statistical methods to determine climate trends in the Sahel region. The main methods used included:

Linear regression analysis: This method was used to evaluate linear trends in air temperature and humidity in the region over time. It makes it possible to determine whether the trends observed are statistically significant.

Spectral analysis: This method was used to study seasonal and interannual variations in data ATOVS. It determines the dominant cycles in the data, such as seasonal variations in temperature and precipitation.

Trend analysis: This method was used to assess long-term trends in temperature and humidity in the region. It makes it possible to determine whether the trends observed are significant over a period of several years.

Data analysis results ATOVS have shown a significant increase in air temperature in the Sahel region in recent decades. Indeed, the data showed an increase in the annual average temperature of about 0.5 ° C per decade, representing a total increase of almost 1.5 ° C over the past 30 years.

The data also showed a significant decrease in humidity in the region, with a decline of about 10% per decade. This reduction in humidity is of particular concern, as it has a significant impact on water resources and agriculture in the region.

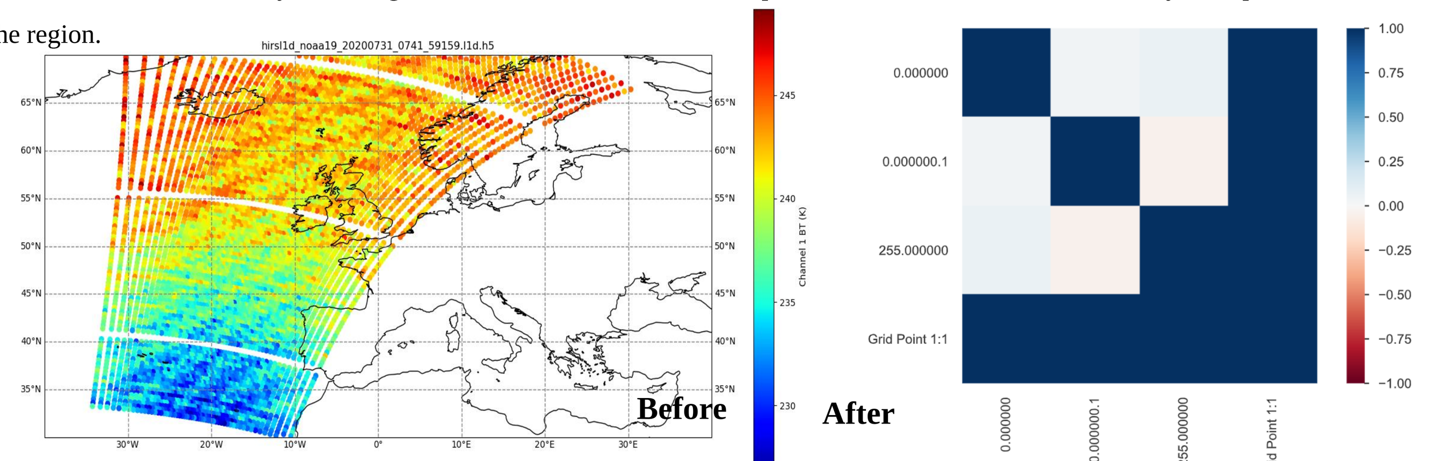

Figure 1 : Channel 1 HIRS L1d of NOAA 19

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With respect to precipitation, the results of the analysis were more mixed. Although there is no significant downward trend in precipitation in the Sahel region as a whole, there have been significant variations from year to year. This can be partly explained by weather events such as atmospheric oscillations, dust storms and strong winds, which have significant effects on precipitation in the region.

In summary, the results of the data analysis ATOVS have shown a significant increase in air temperature and a decrease in humidity in the Sahel region, with significant consequences for biodiversity, agriculture and food security in the region.

Interpretation of results: Discussion of future implications and prospects

The results of this study on Sahelian climate change based on satellite observation and data ATOVS have important implications for the understanding of climate change in the region and for the planning of adaptation measures to climate change. Indeed, the increase in temperature and the decrease in humidity in the region have important consequences for agriculture, biodiversity and food security. As precipitation is also a key component of the Sahelian ecosystem, its interannual variation must be monitored to anticipate extreme events such as droughts.

The results of this study also show the importance of satellite data for climate monitoring in areas where field data are scarce. The data ATOVS provided information on the evolution of the Sahelian climate over a period of several decades, which is particularly important for understanding long-term trends.

However, some limitations of the study should be noted. First, data ATOVS are indirect measurements of temperature and humidity and can be influenced by factors such as clouds and variations in atmospheric composition. In addition, the study focused on large-scale data analysis and did not take into account local variations in temperature and precipitation. Future prospects include exploring the impact of extreme climate events, such as heat waves and droughts, on the Sahelian region using satellite and terrain data models. It is also important to study the interactions between climate and socio-economic factors, such as agricultural practices, population growth models and public policies, in order to better understand the implications of climate change in the region.

NOAA LEVEL 1B DATABASE This section describes the NOAA-KLMNN' and Metop Polar Orbiter Level 1b NOAA datasets archived by NOAA. Also described are the formats in which NOAA distributes raw data to the users. NOAA Level 1b (following FGGE terminology) is raw data that have been quality controlled, assembled into discrete data sets, and to which Earth location and calibration information have been appended (but not applied). Please note that NASA and EUMETSAT use a different definition for Level 1b, so the following information may not apply to data sets produced by other organizations. Currently, the NOAA Level 1b data are ingested into the Comphrehensive.

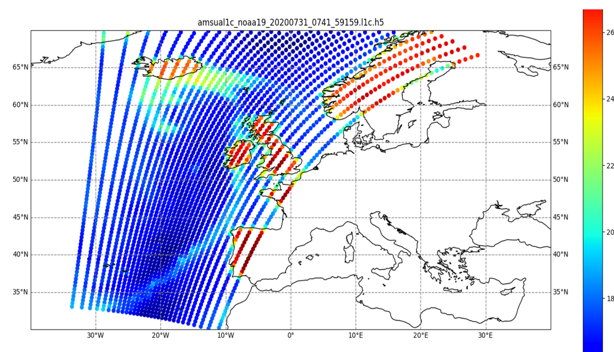


Fig 2 : Channel 2 AMSUA L1C of NOAA 19

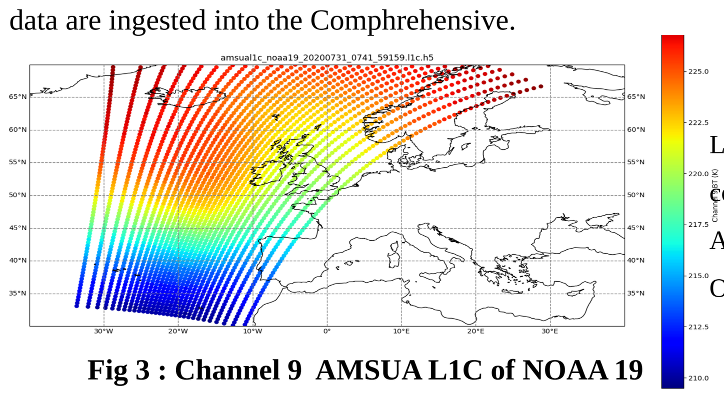
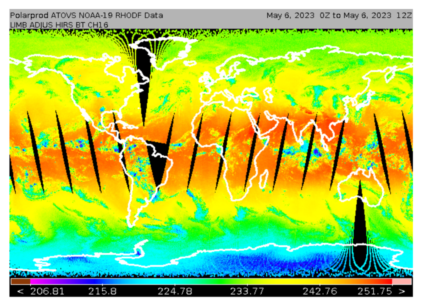


Fig 3 : Channel 9 AMSUA L1C of NOAA 19

Large Array-data Stewardship System (CLASS) from NSOF and made available to the general public within 4 hours after ingest. Each data set contains data of one type for a discrete time period. Thus, there are separate data sets for HRPT, LAC, GAC, FRAC, HIRS/3, HIRS/4, AMSU-A, AMSU-B, MHS and SEM-2.SBUV/2 data sets do not meet the NOAA Level 1b definition, and are described under Section 9.7, NESDIS Operational Products.

Results and Discussions

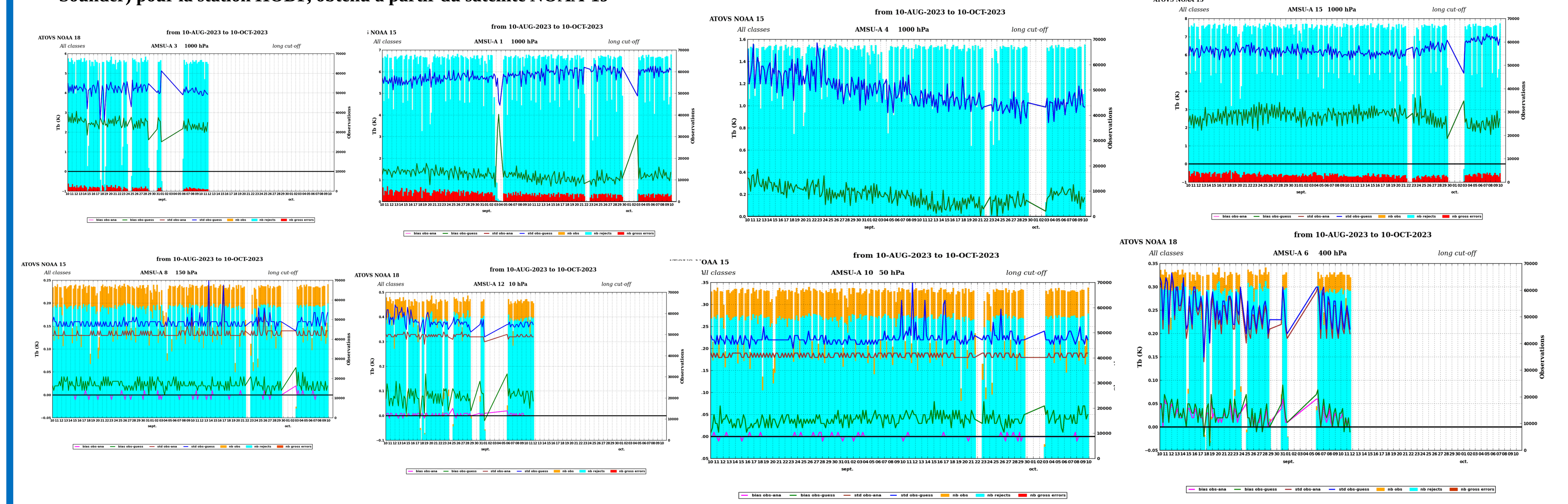


It shows the relationship between temperature and the humidity content of the atmosphere as a function of altitude, obtained from the measurement of the gloss temperature by the satellite.

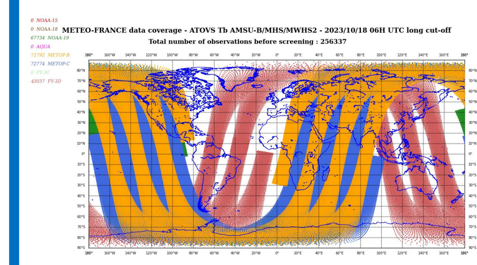
Profil sondeur ATOVS (Advanced TIROS Operational Vertical Sounder) pour la station HODF, obtenu à partir du satellite NOAA-19

The sounding profile ATOVS is obtained from an instrument on board the satellite which measures the temperature of the atmosphere in different layers of the atmosphere using the radiometry technique. In short, this figure allows us to visualize an image of a sounding profile ATOVS, which provides important information on the temperature and moisture content of the atmosphere in a specific area.

The figures present an alarming trend of increasing surface temperatures in the Sahelian region, confirming the significant impact of climate change. The implications are major, requiring immediate measures to reduce greenhouse gas emissions and mitigate the negative effects on the environment.



Accurate weather forecasts for extreme events such as sandstorms, droughts, or heavy rainfall. Climate modeling to understand regional climate trends and changes in the Sahel. Monitoring water resources and drought management. Analysis of vegetation and agricultural land to improve sustainable farming practices. Mapping of high-risk areas for emergency planning and disaster risk reduction. Development of environmental policies based on precise data to combat the negative effects of climate change. Seasonal forecasts to assist farmers in planning their crops and making informed decisions. Exploration of the influence of this information on decision-making and policies for adaptation to climate change in the Sahel. Examples include policies based on this data to mitigate the negative effects of climate change. Studying the evolution of the Sahelian climate through satellite observation and ATOVS (Advanced TIROS Operational Vertical Sounder) data is of crucial importance in understanding climate change in this region. Human activities have caused environmental disruptions, posing a threat to our planet and undermining sustainable development policies and strategies. The data ATOVS, collected by meteorological satellites, are used to measure temperature, humidity and winds at different altitudes, providing valuable information for mapping variations in surface temperature, vegetation and precipitation in the Sahelian region. These data, combined with satellite observations, provide a better understanding of the mechanisms underlying climate change, including increased surface temperature, reduced precipitation and regression of vegetation.



Cartographie de la couverture des données METEO-FRANCE pour les instruments ATOVS Tb et AMSU-A dans la région du Sahel le 19 octobre 2023 à 06h UTC

Utilisation des données pour la surveillance climatique et météorologique : Les données fournissent une couverture adéquate permettant de suivre les tendances climatiques telles que la sècheresse, les inondations, les tempêtes de sable et les sècheresses. Cela offre aux météorologues la possibilité de prévoir ces conditions et d'alerter les populations locales des risques potentiels.

Différences entre les instruments ATOVS Tb et AMSU-A : Les données des instruments AMSU-A offrent une résolution spatiale légèrement supérieure à celle des instruments ATOVS Tb, permettant ainsi une meilleure compréhension des conditions météorologiques locales. Par exemple, les données AMSU-A peuvent aider à surveiller la formation de nuages et de précipitations dans la région.

Influence des océans sur le climat du Sahel : La bonne couverture des données pour les océans est précieuse pour comprendre l'impact des courants océaniques sur les précipitations dans la région côtière du Sahel.

Conclusion and Perspectives : Summary of Key Findings and Significance of the Study

In conclusion, the study of the evolution of the Sahelian climate based on satellite observation and data ATOVS identified important trends in temperature variation and precipitation in the region. The results show an increase in the average annual temperature and a decrease in the amount of precipitation in the Sahelian region in recent decades. This trend has important implications for food security, agriculture and biodiversity in the region.

The study also showed the importance of satellite data for climate monitoring in areas where field data are scarce. The data ATOVS provided information on the evolution of the Sahelian climate over a period of several decades, which is particularly important for understanding long-term trends. Ultimately, this study contributes to a better understanding of Sahelian climate change and provides useful information for the planning of adaptation measures to climate change in the region. The results underscore the importance of monitoring the Sahelian climate and developing adaptation strategies to address the consequences of climate change in this region.

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