Abstract

The Earth's climate system is undeniably complex, necessitating an in-depth study of its changes over time. This research is fundamental for identifying climate trends that form the basis for effective climate change mitigation and adaptation strategies, which are paramount for informed decision-making and risk management. According to IPCC, (2014) climate datasets reveal a global average warming of approximately 0.85 degrees Celsius (with a range of 0.65 to 1.06 degrees Celsius) between the years 1880 and 2012.

This thesis has been developed within the framework of the PNRR NODES (Nord-Ovest Digitale e Sostenibile, "Digital and Sustainable North-West") project, focusing on Northwestern Italy. In particular the Valle d'Aosta region has been chosen as the area where to build landslide risk maps accounting for climate change. As a first step this thesis has undertaken a comprehensive literature review of climate change, including its causes and impacts. It is crucial to acknowledge that while substantial work has been conducted on climate change at a global scale, examining climate change on a regional scale introduces unique challenges. Key climate system parameters, such as precipitation and temperature, exhibit distinct behaviours in different regions, influenced by factors like longitude, latitude, altitude, and land use. These parameters can vary significantly between regions, especially in areas characterized by complex topography, such as alpine regions like Valle d'Aosta, where altitude has a significant impact on the local climate.

However, studying climate change in Valle d'Aosta is a complex endeavour, as climate variables are profoundly influenced by the region's topography and exhibit local variations. Consequently, accessing reliable datasets for the study of climate variables in this region is of paramount importance. Most publicly accessible climate datasets have limitations when employed on such a small scale, often lacking the required spatial resolution. Furthermore, the scarcity of historical observation data presents another challenge in studying climate change in this region.

The choice of an appropriate dataset depends heavily on the region's climatic characteristics. While some reanalysis datasets align well with coarser reanalysis data in global and regional scales, the complex topography of Valle d'Aosta necessitates careful consideration in choosing the suitable reanalysis dataset. After thorough experimentation with various reanalysis datasets and a rigorous comparison with observed data, ERA5-LAND, with an approximate grid size of 9 km x9 km and a minimum temporal resolution of 1 hour, offering a wide range of climate variables, including temperature and total precipitation data from 1950 to the present, was selected. This dataset is an open-access source provided by the European Centre for Medium-range Weather Forecasts (ECMWF).

In Valle d'Aosta, there are 87 weather stations, which are unevenly distributed across the region and do not consistently provide data for extended periods. To address this limitation, reanalysis datasets come, offering historical data access and consistent information for remote and challenging locations like mountainous areas. Most reanalysis datasets operate on a global scale with horizontal resolutions unsuitable for regional climate change studies. Thus, selecting a compatible reanalysis dataset for regional analysis becomes essential.

With the aim of defining a possible methodological procedure, this Thesis focuses on a smaller area of the Valle d'Aosta ranging from Pont St. Martin to Gressoney-la-Trinité. Considering the diverse behaviour of climate variables based on their location-specific characteristics, it is crucial to validate

the usability and reliability of these datasets before implementation. To validate this dataset, 13 weather stations in the previously mentioned area were chosen, and a reference period of 2014-2022 was selected due to its highest consistency in temporal and spatial data.

To validate the ERA5-LAND dataset and facilitate comparison, various statistical indicators were calculated for both in-situ parameters and simulated mean monthly temperature data for 13 weather stations during the reference period of 2014-2022. Among these stations, the Gressoney-Saint-Jean – Weissmatten station displayed strong reliability with a root mean square error (RMSE) of 0.39, indicating a high level of agreement with the ERA5-LAND dataset. Conversely, the Bard – Albard station exhibited the weakest agreement, with an RMSE of 6.73. This discrepancy is attributed to the challenges of implementing reanalysis datasets in regions strongly influenced by complex topography.

To address this challenge, further investigations identified a significant source of error associated with elevation biases. To ensure the usability of the dataset for periods lacking consistent observational data, an elevation bias correction based on the adiabatic lapse rate is considered.

A similar approach is applied to precipitation data. Since observational data is collected at specific points while reanalysis datasets provide precipitation amounts over a 9kmx9km grid, interpolation based on observed point data is conducted to enable meaningful comparisons. However, ERA5-LAND data shows discrepancies with observed precipitation data, likely due to the limitations of reanalysis models in accurately recording local precipitation events. In response, another dataset, the GPCC dataset, is chosen. This gauge-based dataset provides global spatial coverage and is used for periods with limited observational data. Comparisons between interpolated mean monthly precipitation from observed data and GPCC datasets reveal a moderate to good agreement over the Valle d'Aosta basin for the same reference period.

In summary, this study represents a fundamental step in the investigation of climate change in regions where observational data is scarce, historical data is unavailable, and environmental variables, such as precipitation and temperature, exhibit highly localized variations. These challenges are particularly prominent in areas characterized by significant altitude and complex topography.

This meticulous selection and validation of datasets ensure the credibility of research and its applicability to studying the climate change effects on landslides of Valle d'Aosta.