Climate Analysis of Ireland

To find the best place to live on the island

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INTRODUCTION

The goal of this project is to determine the best place to live in Ireland using research and meteorological data analysis. A secondary aim is to better understand seasonal weather patterns- both as a resident and as someone who sails, surfs, and windsurfs. The project also explores the potential effects of climate change in future years. It primarily relies on data and resources from Met Éireann.

CRITERIA

Let's define what is meant by the climatically "best" place:

1. High temperature
2. High sun exposure
3. Low humidity
4. Low precipitation
5. Low wind speeds

ABSTRACT

The Polar Jet Stream is a constant current which drives air masses through Ireland from the North Atlantic with seasonal oscillation, thus delivering cold air masses during the winter and warm air masses during the summer. Because of the strong Atlantic influence, Ireland's Climate is constantly regulated temperature wise, while keeping it very moist and maritime. The mountains, mainly located at the west and southwest parts of the island, defend against the winds and cause precipitation. After analysing open source long term datasets it was found that the area of county Dublin ranks highly in most aspects, thanks to its unique position, located far from the Atlantic, yet to the north of a vast mountain range and close to the coast. Other notable spots include areas near Wexford, Cork and Carlow.

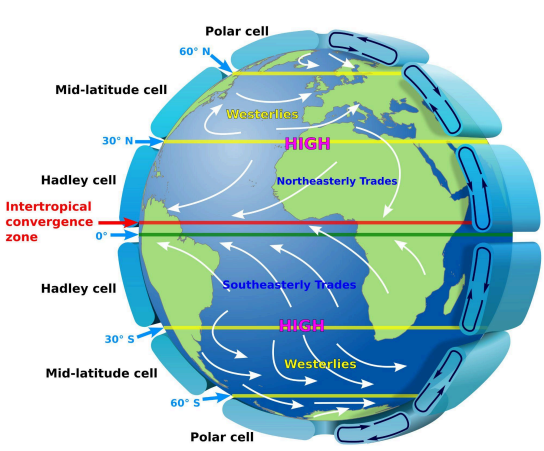
AIR AND WATER MASS MOVEMENT IN THE ATLANTIC

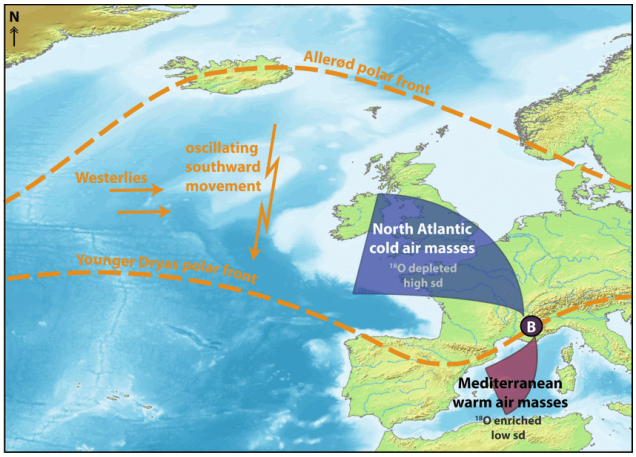
Air and water are very similar in their movement, generally flowing from areas of high pressure to low pressure. The Earth's rotation causes the Coriolis effect, leading to an additional rotational force to moving air masses, clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. The effect is strongest near the equator, where the rotational speed is greatest. In the mid-latitude cell (which includes Europe), the force of friction between warm and cold air masses combines with the pressure force, causing air to flow eastward.

Key moments:

1. Air moves from the high pressure point (local maximum near the Azores) to the low pressure point (local minimum near Iceland)
2. Diverges clockwise due to Earth's rotation
3. Is further affected by turbulences and cyclones formed because of friction between the warmer tropical air and the colder polar air

As a result we get warm moist tropical air masses as well as water currents of the same characteristics coming from the west towards Ireland with seasonal oscillation due to Earth's rotation around the Sun. This air mass current is called the Polar Jet Stream, For this reason the climate in Ireland is mild, maritime and rarely reaches extreme cold or hot temperatures.





Left: global wind map. You can notice the aforementioned wind "rotation" clockwise in the North and counterclockwise in the South. Also due to these constant winds it is possible to sail from Europe to the Americas and back in only 2 downwind tacks.

Right: diagram showing how the Polar jet stream operates between the northern polar front (low pressure) and the southern polar front (high pressure) with oscillation due to difference in temperature/pressure through the seasons.

WIND AT THE SURFACE

Having said these simplified general ideas, it should be noted that these air mass movements are not the same as the wind we feel hitting our faces as we come out of the house. The more global wind is called geostrophic and occurs above 500-1000m and is responsible for all of the movements stated above. The wind that is near the surface diverges from the geostrophic wind due to the following chain reaction:

1. Friction force between air and the surface, which leads to:
2. Reduce in the Coriolis effect (clockwise rotation), which leads to:
3. More direct barometric gradient force (from high pressure to low), which leads to:
4. General increase in winds towards the north

So, even though the geostrophic wind usually moves above Ireland from the west and southwest, the surface wind can diverge in different directions (depending on the terrain) with the prevailing direction being towards the north.

PROPERTY	LOW PRESSURE AIR	HIGH PRESSURE AIR
TEMPERATURE	Warmer	Colder
DENSITY	Lower	Higher
MOISTURE CAPACITY	Higher	Lower
MOVEMENT	Expands and rises	Contracts and sinks
WEATHER EFFECT	Leads to clouds and storms	Leads to clear skies

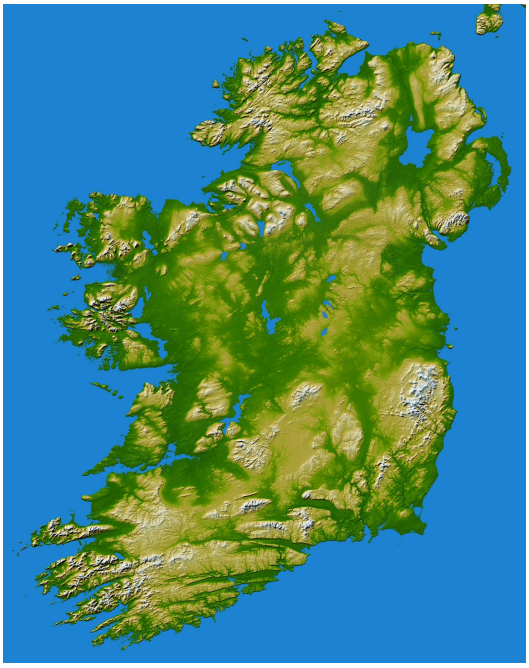
SEASONAL DIFFERENCES

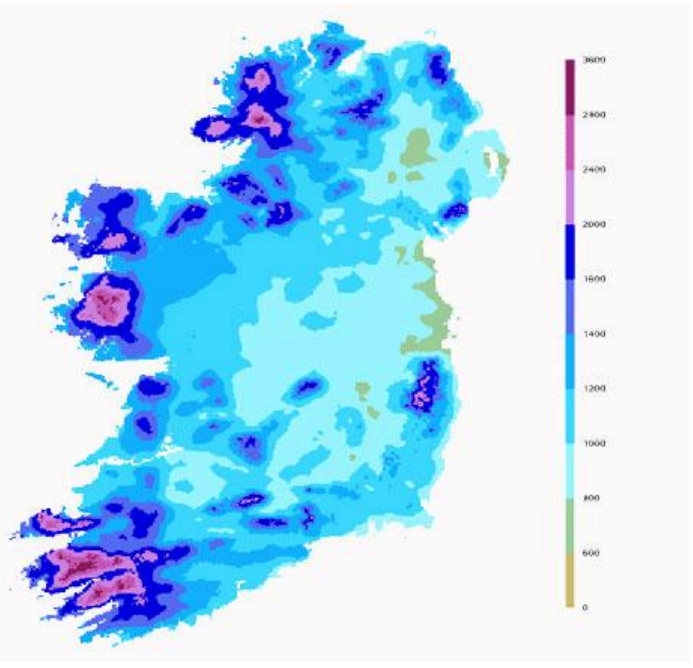
So we found that the Polar Jet Stream varies in curvature due to the different angle of Earth to the Sun. For this reason during the winter months Ireland receives air masses from the Atlantic's low-pressure systems, which means warm, moist air and high wind speeds, while during the summer the high pressure systems prevail with colder, drier air, clearer skies and lighter winds. As for the transitional seasons of spring and autumn, generally spring has more high pressure systems and autumn has more low pressure systems, both with a roughly 60/40% cut.

The Atlantic Ocean serves as a powerful climate regulator, not allowing hot temperatures during the summer and cold temperatures during the winter by sending air masses from the north and south Atlantic.

LANDSCAPE

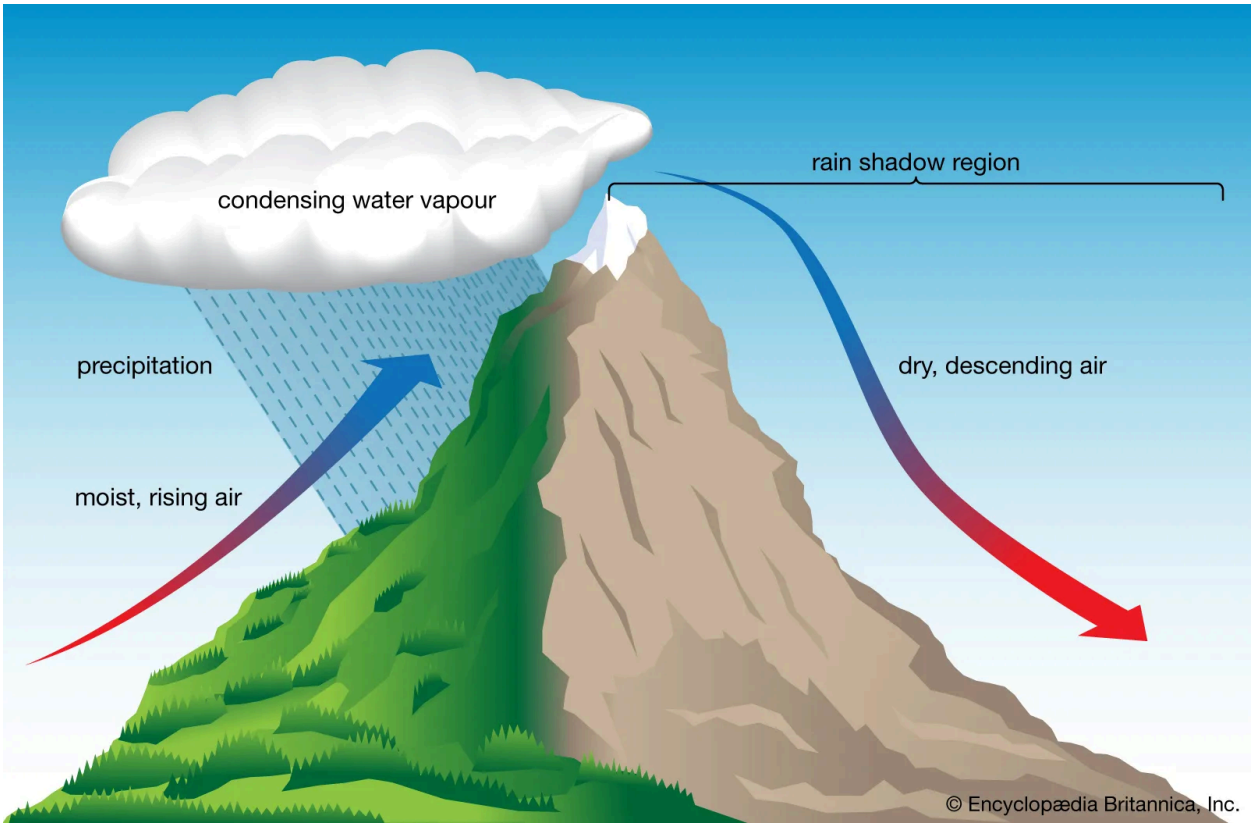
Most of Ireland's mountains are located near the coast, particularly in the west and southwest, where they act as natural barriers against prevailing western winds. As moist air encounters these elevated areas, it is forced to rise, leading to precipitation. This results in a strong correlation between rainfall and elevation near the coast:





Left: Terrain map

Right: Mean annual rainfall data map 1981-2010



Living on the northern side of a mountain range can offer protection from rain and cold winds. Dublin is a good example, situated north of the Wicklow Mountains, which block most of the "bad weather" coming from the south. Cold winds rarely pass around the range, and rainfall in Wicklow flows into the Irish Sea as the River Liffey. As altitude increases, air density and temperature decrease, making sea-level locations generally more comfortable for living.

CLOUD FORMATION

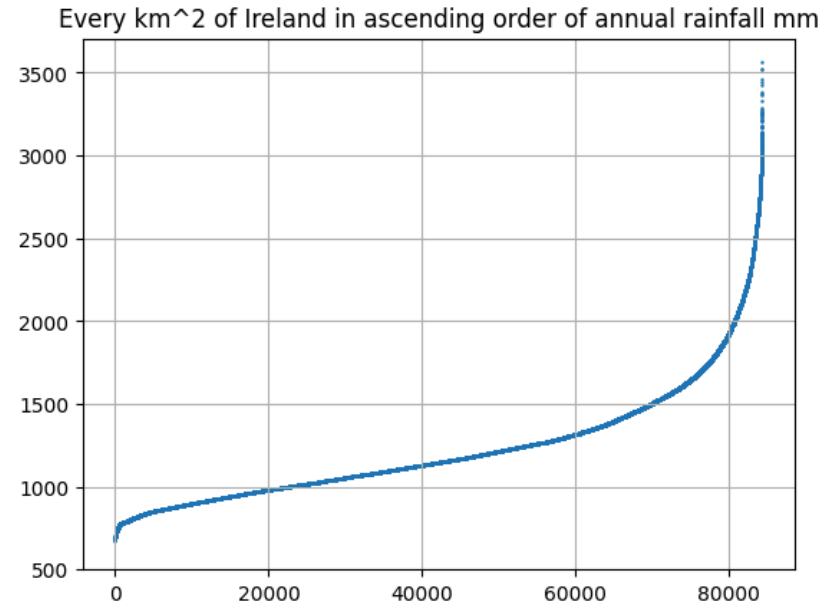
Chunky clouds form when warm, moist air rises from the surface and cools as it gains altitude. As it cools, the water vapor condenses into visible cloud droplets. The more humid and warm the surface, the more clouds are likely to form. Due to the Irish maritime climate caused by the Atlantic, the air is quite humid all across Ireland. This impacts sun exposure.

DATA ANALYSIS INTRODUCTION

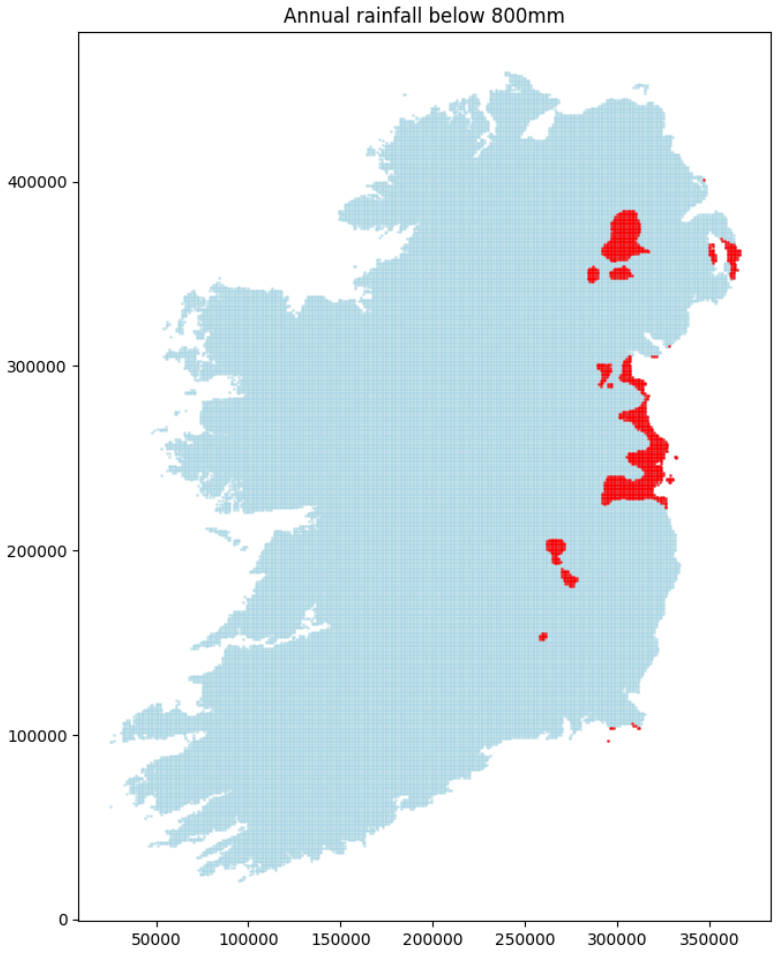
It was essential to first research and understand the Irish climate before analysing the data. Graphs or tables alone aren't enough to draw meaningful conclusions without context. This background knowledge also allows for better data selection and helps fill the gaps with hypotheses based on scientific evidence.

RAINFALL DATA

The output was pretty much the same as the one Met Éireann got in their report since the same source was used, nevertheless here are a few interesting insights:



Left: Figure 1



Right: Figure 2

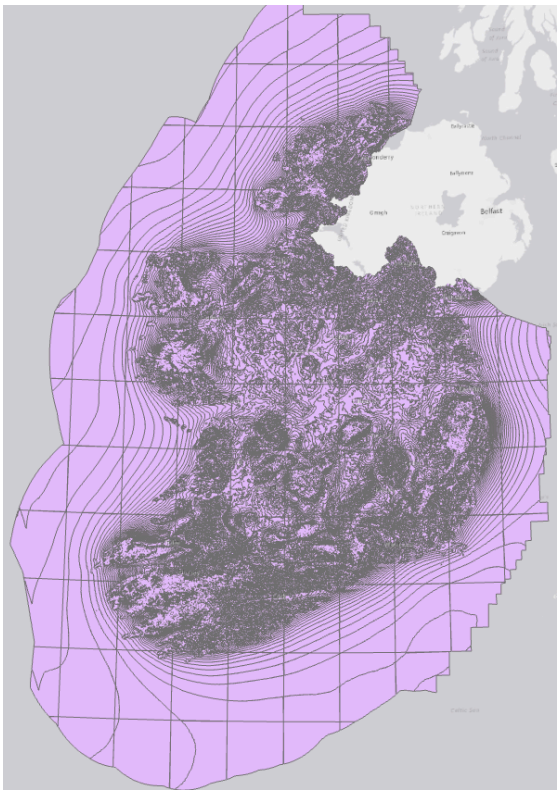
1. Distribution (see Figure 1). The major area has annual rainfall between 675 (minimum) and around 1500mm. With this graph we can easily see what percentage of the total island area we are eliminating by choosing an upper limit on annual rainfall value. For example if we set it to 800mm, we get the output as shown in Figure 2.

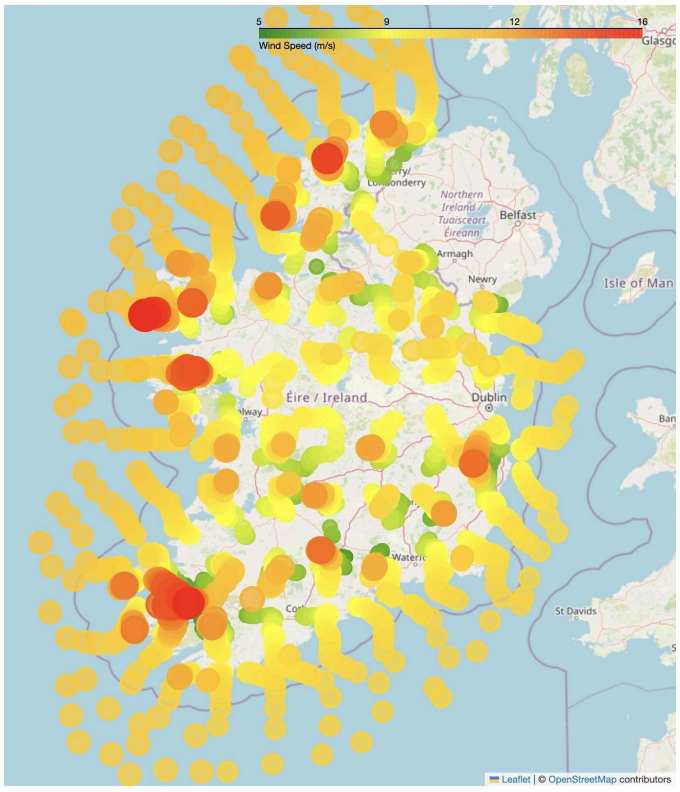
This leads us to the second highlight.

2. By choosing a lower and lower annual rainfall limit, the selected area approaches county Dublin. For Dubliners this might be disappointing, since it shows that there is no less rainy place than the city they are currently living in, being still quite wet all year round.
3. Another interesting insight is that proximity from the coast does not have any correlation with the rainfall value, it mostly depends on the elevations and wind direction (generally south-western).

WIND DATA

The wind data was quite complex:





Average wind speed at 150m above ground level. Left: Figure 3, Right: Figure 4.

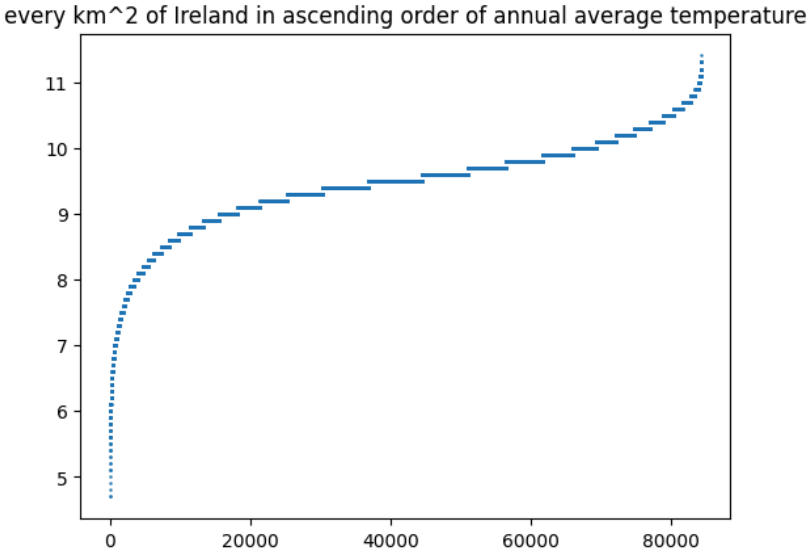
The map shown in Figure 3 is the output given by the data source office, lines show the change in wind speed with denser lines signifying a bigger difference. Translated to an easier to understand map as seen on Figure 4, we see that the average is around 10 m/s or around 20 knots (significant speed) and a distribution of green points, representing light wind and red dots, representing stronger “yellow warning” level winds. The red dots are closely aligned with the elevated terrain, however there is no obvious conclusion to make about the green dot positions. A couple of moments to consider:

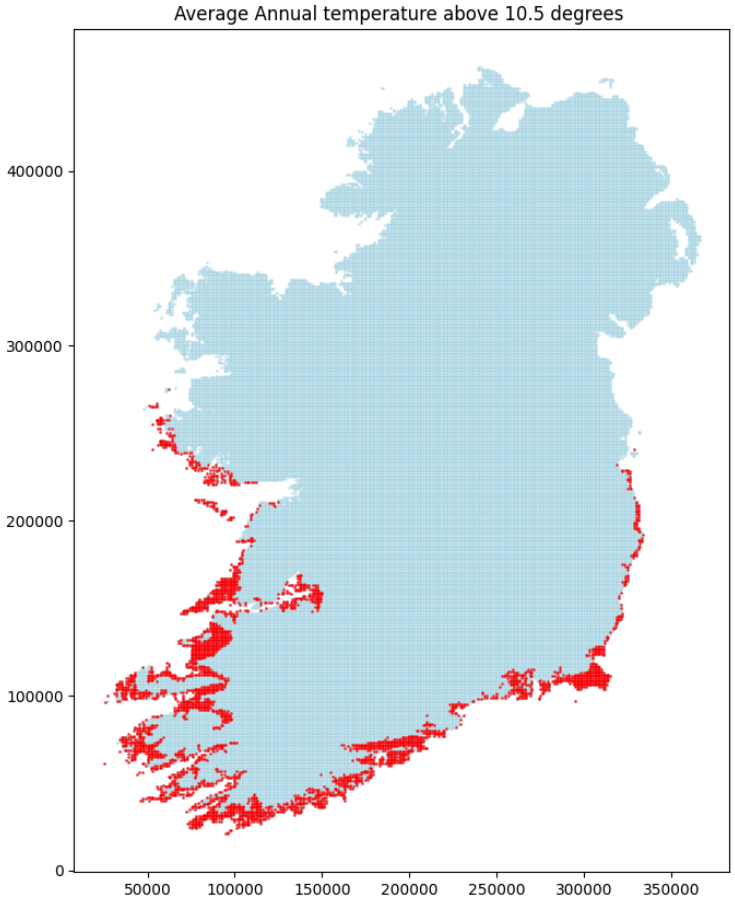
1. Winds are slower in inland areas, particularly in valleys and lowlands, which experience lower wind speeds due to terrain and obstacles.
2. Winds are slower the further away the location is from the south-western coast.

To conclude, cities located in the lowlands or flatter terrain receive weaker winds.

TEMPERATURE DATA

Following the example of rainfall data we first look at the distribution (Figure 5) of temperature values from lowest to highest, pick a lower limit and look at the map to see where the top areas by average temperature are.





Left: Figure 5

Right: Figure 6

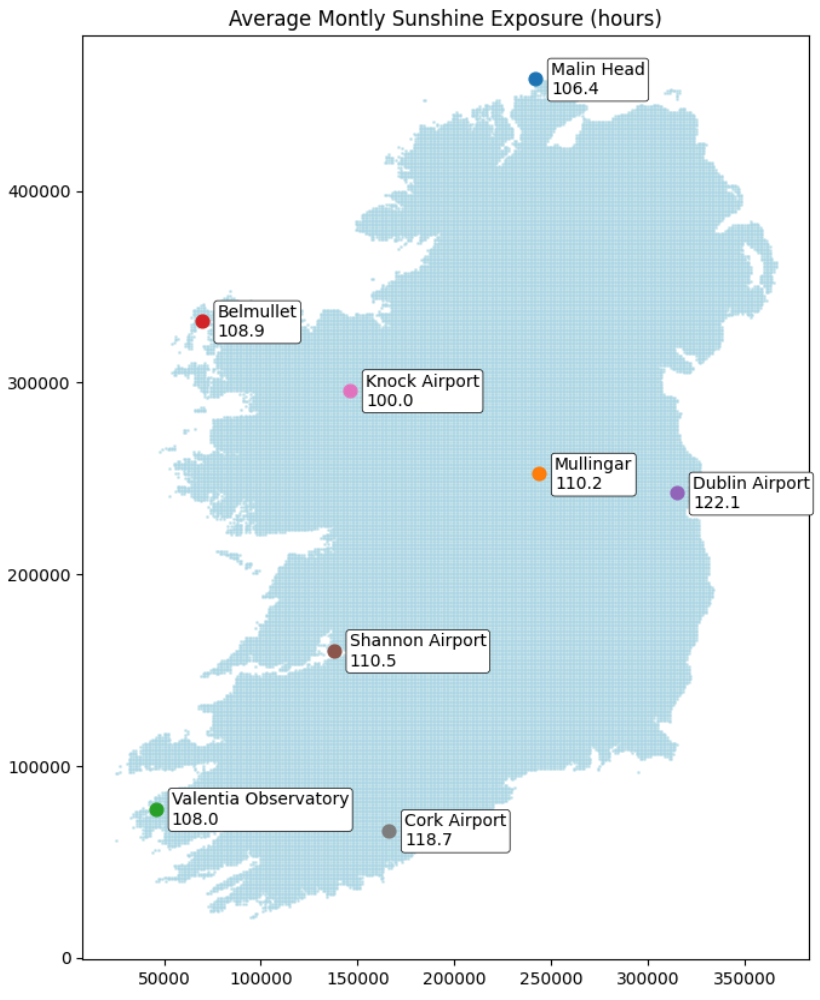
Picking a lower limit of 10.5 degrees of average annual temperature lends us the following map (See Figure 6).

And once again, the climate research is helping us decipher the data: the Atlantic winds are strong regulators of Irish climate, maintaining the temperature at a value not too high or too low. The effect of the Atlantic is strongest near the coast, even at the East coast. It should be noted that in this context a higher average temperature does not mean a higher maximum during the summer, but a lower variance in temperature values over the year.

SUN EXPOSURE

The sun exposure data is very limited and "messy", with different stations starting and ending their observation periods at different years. Therefore the diagram will have a small number of stations and will include an average of monthly averages for the duration of its observation. However, all periods are from January to December with the only difference being the years.

STATION	AVERAGE SUN EXPOSURE (HOURS)	OBSERVATION PERIOD
Malin head	106.4	1956-2010
Mullingar	110.2	1950-2006
Valentia observatory	108.0	1940-2011
Belmullet	108.9	1957-2011
Dublin airport	122.1	1942-2024
Shannon airport	110.5	1946-2024
Knock airport	100.0	1997-2019
Cork airport	118.7	1963-2024



Left: Figure 7

Right: Figure 8

The only conclusion we can make is about the individual cities and not the general areas and it is quite obvious that the Dublin Airport weather station recorded the best average monthly sunshine duration over the course of its observation (See Figure 7 and Figure 8).

CLIMATE CHANGE

Numerous reports come to the conclusion that the biggest effect will be on the extremes: hottest and coldest days will become warmer with a general ~2 degree increase measured from the 2010s until the 2050s. As a result, summers will get dryer and winters will get wetter: 14-20% alleged change.

CONCLUSION

Taking into account all of the individual results that were made from research and data analysis, it seems that county Dublin is the climatically best area to reside in as it has low precipitation, high sun exposure, high temperatures and moderate wind speeds. Being uniquely located far from the Atlantic, yet to the north of a vast mountain range and close to the coast, there is no other place like county Dublin.

Honorable mentions include areas near Wexford, Cork and Carlow, each with their own weakness but a bigger set of advantages.

REFERENCES

Research and Data

Air Mass Movement
Jet Stream
Climate of Ireland
Sun Exposure Data
Wind Speed Data
Historical Data
Rainfall Data
Temperature Data
Climate Change 1
Climate Change 2
The Feeling of Wind - Leonid Dubeykovskiy

Images

Luas Image
Jet stream 1
Jet Stream 2
Terrain Map
Rain Map
Mountain
Wind Map