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Relationship between global warming and decreasing soil moisture: short-term and long-term impacts in mediterranean regions

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Abstract. The intergovernmental panel on climate change (ipcc) released an important report in 2007, revealing evidence of A rising global average temperature. Consequently, the ecosystem of earth has already been affected by the climate change. One apparent indicator is the soil moisture. Soil moisture plays A significant role in ecosystem since it facilitates crop growth, regulates atmospheric temperature, and supplies water to plant roots, among other functions. Due to rising temperatures, the soil is becoming more arid, decreasing the soil moisture. This drop is especially obvious in mediterranean regions. This paper explores the connection between climate change and soil moisture. It demonstrates the immediate and long-term consequences resulting from climate change and the decreasing of soil moisture in mediterranean european countries through A method of literature review. This study aims to increase the awareness of the severity of climate change and the decline in soil moisture, and it attempts to promote the preservation of soil moisture.

Keywords: soil moisture, Mediterranean region, climate change.

1. Introduction

Because of the anthropogenic activities, such as industrial and agricultural practices that generate significant greenhouse gas emissions, climate change is inevitable. The growth of the human population further escalates global warming. As a result, there has been an increase in global temperature, resulting in an elevated occurrence of heat waves, a rise in sea levels, and a decline in biodiversity [1]. Climate change has led to a reduction in soil moisture, which is one of its effects. Soil moisture is indispensable in the ecosystem because it promotes the growth of vegetation and crops, while also regulating air conditions within the climate.

A study conducted by Liu et al. demonstrates that a low level of soil moisture is the dominant factor causing dryness stress on ecosystem output in over 70% of vegetated land areas with reliable data [2]. Lionello and Scarascia suggest that the Mediterranean region will see a reduction in temperature at a pace of approximately -20 mm/K or -4%/K, and the temperature in this region will increase 20% more than the global average in the twenty-first century [3]. The increase in temperature and the decrease in precipitation suggest that the soil in the Mediterranean region will experience increased aridity. These researches indicate a pressing need to address the declining soil moisture. Furthermore, it is crucial to

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prioritize the examination of the soil moisture level in the Mediterranean region and its intensifying global warming situation.

The paper will investigate on the positive feedback loop between climate change and decreasing soil moisture in the Mediterranean region through the usage of literature review, and will explore the short- and long-term implications of this relationship. It provides a perspective on the significance of soil moisture and the severity of climate change. Furthermore, it aims to raise awareness about the detrimental effects of decreasing soil moisture and climate change on Mediterranean region. The goal of this paper is to encourage the public to protect soil all over the world with practical methods and decrease the emissions of greenhouse gas in people's daily lives.

2. The Role of Soil Moisture

Though this paper mainly focuses on the Mediterranean region, the function of soil moisture is the same around the globe. As defined by the AMS Glossary of Meteorology, soil moisture is "the total amount of water, including the water vapor, in an unsaturated soil." Soil moisture, sometimes also called soil water, represents the water on land surfaces that is not in rivers, lakes, or groundwater, but instead resides in the pores of the soil [4]. Soil moisture is important for plant growth because the roots need water to grow. Figure 1 illustrates that the soil contains approximately 25% water. However, if the water proportion exceeds 25%, it will result in waterlogging. Waterlogging is harmful to plants because the oxygen content of the soil is largely decreased and, instead, it is filled with water. This hinders the respiration of soil and therefore restricts the growth of soil. However, under current climate change, the frequency of soil moisture droughts is more likely to happen. Because of the increasing temperature, the humidity of soil will decrease, causing dry soil. This presents a more serious problem because only a few species are adapted to extremely poor water conditions, and the insufficient water will negatively affect the species richness and distributions [5]. The decrease in soil moisture inhibits the growth of plants, thus decreasing biodiversity. Many vegetations cannot grow, and they cannot provide habitat for wild animals. Soil moisture, as a result, helps to maintain our ecosystem, and if there are soil moisture deficits, it will lead to the loss of biodiversity.

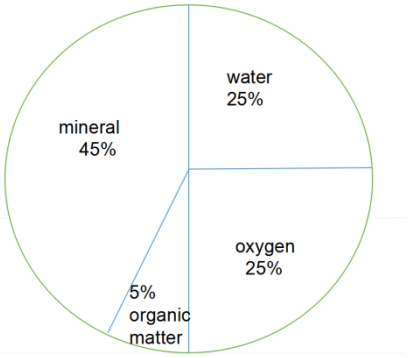

Figure 1. Major components of soil

Soil moisture is a critical factor in agriculture. Crops provide the main sustenance for people, and rely on water for proper growth and development. The soil moisture level in agriculture directly impacts the quantity of harvested crops. Maintaining adequate soil moisture is therefore essential to guarantee sufficient food production to meet the needs of diverse populations around the world.

Other than supporting the growth of vegetation and crops, soil moisture serves to maintain a stable hydrologic cycle. When there's enough soil moisture in the soil, the water will evaporate into the atmosphere, and the water vapor will be generated into precipitation. If soil humidity is reduced, there will not be enough water evaporated into the atmosphere, hindering the hydrologic cycle. If the hydrologic cycle is disrupted, there will be suppressed precipitation, resulting in drought and even heat waves, which may cause water depletion.

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Through these three functions of soil moisture, it is simple to see the necessary role of soil moisture in the ecosystem. Nevertheless, global warming is the cause of the increasing atmospheric temperature and will steadily decrease soil moisture if humans do not reduce the emissions of greenhouse gases. And unfortunately, the decrease in soil moisture will further worsen global warming.

3. The Positive Feedback Loop of Global Warming and Decreasing Soil Moisture

As stated above, the increase in atmospheric temperature resulting from global warming will make the soil drier. Accordingly, soil moisture decreases because less water in the soil suppresses the evapotranspiration process. There will be less water evaporated into the atmosphere, rendering more sensible heat flux from the land surface to the low-level atmosphere via decreasing the latent heat flux [6]. On the other hand, because of decreased evapotranspiration, there will be less water vapor forming clouds. Clouds can block some of the sunlight, maintaining a cool temperature near the surface. However, because there are fewer clouds being formed, the solar radiation will not be weakened by cloud covers, allowing the surface to receive more radiation. Both processes increase the heat received by the earth's surface, thereby increasing the global temperature. As the global temperature increases constantly, soil moisture will further decrease. As a result, this leads to the creation of a positive feedback loop. Both global warming and soil moisture deficits will escalate.

3.1. Short-Term Impacts on Mediterranean Region

The positive feedback loop of global warming and soil moisture deficits will increase the severity of both climate change and decreasing soil moisture, and it may especially pose threats to the Mediterranean region. It is because of the special climate of the Mediterranean region. In winter, the sun is directly radiating at the Tropic of Capricorn. This causes both the subtropical high-pressure belt and the subpolar low-pressure belt to move southward, making the Mediterranean region in the area between these two belts. The wind blown from the subtropical high-pressure belt to the subpolar low-pressure belt will be affected by the coriolis effect, becoming westerly. The westerly wind will bring moisture from the sea, and thus there will be enough precipitation in the Mediterranean region. However, when it is summer, the condition is different because the sun will directly radiate at the Tropic of Cancer. This causes the two belts to move northward, making the Mediterranean region lie in the area of the subtropical high-pressure belt. The high-pressure belt will cause the air in the Mediterranean region to descend, inhibiting the generation of precipitation. The high temperature and the low precipitation in the summer will induce an extreme soil moisture deficit. For example, Turkey is a country in the Mediterranean region, and its temperature and precipitation throughout the year are shown in the table.

Table 1. Izmir, Turkey temperature and precipitation around the year [7]

Month	Temperature(celsius)	Precipitation (millimeter)
1	9	141
2	9	100
3	11	72
4	15	43
5	20	39
6	25	8
7	28	3
8	27	3
9	23	11
10	19	41
11	14	93
12	10	141

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According to the statistic, during the summer, which spans from June to September, the temperature is between 23 and 28 ℃ in Izmir, but the precipitation is just 3 to 11 mm. This shows extreme dryness, and it generates intense dryness stress on the soil in the Mediterranean region. From Turkey, which is a representative country in Mediteranean countries, it is clear that the severity of the soil moisture deficit. According to the study of the response of soil moisture to climate variability in the Mediterranean region, the increase in dry days mainly impacts the summer and autumn seasons from June to October. None of the stations show an increase in extreme dry days during winter. Results of studies show that agricultural drought events in the Mediterranean region are likely to be more intense, with longer episodes extending until the months of October and November [8]. This result corresponds with the data provided about Izmir's temperature and precipitation conditions. Because of the drier climate and decreased soil moisture, there will be some short-term impacts.

Agricultural practices will be largely affected. In a particular year, the soil moisture may not reach the field capacity. As a result, the farmer requires more irrigation. However, the low precipitation rate in summer decreases the amount of water that can be used by farmers to irrigate the crops. Therefore, because of the soil moisture deficit and the lack of water to irrigate, the soil will not be able to support enough crops to grow, which may generate a short-term famine to people in the Mediterranean region.

The humidity of the wetland will decrease. Wetland is a significant ecosystem that serves as habitat to maintain the growth of different plant and animal species. Because of the soil moisture deficit, through the positive feedback loop we stated before, the humidity of the wetland will keep decreasing, causing less moisture to regulate the atmospheric temperature. Therefore, the temperature may exceed the ecological tolerance of some species. This could hinder the reproduction of these species and even lead them to death.

Furthermore, the soil moisture deficit could lead to forest fires. When there is less precipitation and a higher atmospheric temperature, the soil in the forest will become drier and hotter, which increases the risk of fire. If this scenario is not relieved, there will be frequent forest fires that may destroy a large number of vegetation.

These three impacts are just parts of the short-term effects of the soil moisture deficit and global warming on the Mediterranean region, and there are still other similar negative impacts on our ecosystem. If global warming and decreased soil moisture are not suppressed, these short-term impacts will be converted into more severe long-term impacts.

3.2. Long term impacts on Mediterranean regions

If the positive feedback loop between soil moisture deficit and global warming is not controlled or even escalates, there will be serious long-term impacts on the earth.

Similar to the short-term effects, the long-term soil moisture deficits will worsen the degradation of soil, leading to severer famine. It is because the soil in the Mediterranean region allows less and less crops to grow, making food sources a shortage. More and more people do not have enough food. This could cause more children to be malnourished. More severely, there will be a large decline in population in the Mediterranean region.

The dry soil not only hinders crop growth but also adversely impacts the growth of vegetation, particularly trees. The dry soil does not contain enough water to support trees. Therefore, the number of trees in the Mediterranean region will intensely decrease. As a result, there will be more carbon dioxide remaining in the atmosphere, contributing to global warming, and because fewer trees can produce oxygen, the rate of the depletion of oxygen will be accelerated.

With the effect of the positive feedback loop and the decrease in the absorption of carbon dioxide from vegetation, global warming will be intensely escalated. In the future, because of the increase in temperature, maybe many animals in the Mediterranean region will need to migrate to colder areas. It is because these animals' ecological tolerance, as stated before, cannot bear higher temperature. Some animals may lack the ability to easily migrate to another area, and as a result, the population of them will apparently decrease, or even go into extinction.

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4. Conclusions

Because of the current condition of the global warming, the soil moisture in the Mediterranean region will decrease unavoidably, and the positive feedback loop between global warming and soil moisture deficit will make both climate change and the issue of dry soil to be more intense. Because of that, short-term and long-term impacts will be brought out to people and animals in the Mediterranean region, including the increase of temperature that hinders the living condition of wild animals, disrupting their reproductive process. More severely, those animals may die off if they do not find a new place that is suitable to live. For humans, the amount of crops will largely decrease, reducing the food source for people in this region.

There are certain shortcomings of this paper, for example, no experiment was implemented to justify the precise statistics of the soil moisture in the Mediterranean region. All the evidence and data are provided from other academic papers. In the future, the condition of the global warming and soil moisture deficit may be relieved. To achieve this goal, not only should people in the Mediterranean region raise the awareness to decrease the release of carbon dioxide and maintain the soil moisture level, people all around the world should work together to control the severeness of global warming, reducing the amount of greenhouse gas emissions. This paper aims to let more people become aware of the severity of the climatic problem, which also contributes to the understanding of global warming for the public, urging them to try their best in their daily lives to slow down the pace of global warming.

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