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Future Impacts of the Reforestation Policy on the atmospheric parameters: a sensitivity study over Ireland

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Abstract

The increase of temperature attributed to anthropogenic emissions is projected to continue in future climate scenarios. Several protocols and policies are being put in place in several European countries to reduce both emissions and impact of human activities. The Irish Reforestation policy is a good example of such protocols. Nevertheless often contemplated policies do not take into account their potential effects on the atmospheric variables. This study aims to assess the influence of the increase of vegetation cover over Ireland, with respect to the surface temperature and the livestock heat comfort, using the Weather Research Forecast (WRF) model. Two main multi-scale numerical simulations are performed: (i) a control scenario with no change in vegetation cover and (ii) a scenario with increased tree cover based on the suggested Irish Reforestation policy. The vegetation change increases the temperature over the simulated domain and moreover, it enhances the livestock heat discomfort during the day-time, with different magnitude all over the domain. It is concluded that the reforestation policy, which is introduced to mitigate the greenhouse emissions, causes a further increase in the temperature and livestock heat discomfort.

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1. Introduction

The continued emissions of greenhouse gases cause a continuous increase in the temperature, even considering the intrinsic interannual variability, as it leads further warming and changes in all components of the climate system¹. To limit climate change, many policies for greenhouse emission reduction have been applied to different levels, i.e. from the European scale, as the 2020 package and the EU climate action, to country one, as the Forestry programme² in Ireland. This is an afforestation policy which aims to increase the forest cover from 10.7% to 18% in 2020². The introduced policy is planned to positively affect different aspects of the environment as carbon sequestration, increase in biodiversity, and it should have no impacts on the water quality, as well as social aspects³.

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Vegetation cover and vegetative canopies strongly influence both energy and moisture surface-atmosphere fluxes⁴. Interaction with the atmosphere is fundamentally caused by: vegetations response to the incoming radiation and its emission in the longwave portion of the spectrum; the modification of the aerodynamics roughness length; plant transpiration and photosynthesis processes⁴.

The impact of climate change on the landuse has been well studied^{5,6,7,8}, an example being the forced migration of crop species in Europe due to variation in both temperature and precipitation patterns⁷. However, the opposite feedback effect, less considered in the past, has seen an increase in the recent studies^{9,10,5}. Previous literature has provided evidence that conversion of all land types to agriculture resulted in cooling impacts^{5,9}. Furthermore, local changes in the landuse impact beyond their scale and affect the weather and climate of a wider area⁵.

Climate change impacts also on livestock through direct and indirect effects¹¹. In fact, a high confidence of accruing a reduction in animal feeding and growing rate is reported in the literature¹¹. In a study for the impact of the UK changing climate on dairy cow production, it is found that milk yields will be reduced and the mortality rates will increase due to the heat stress throughout the current century^{12,11}. This will lead to an annual total losses amounting to around £40 million by the 2080s under a medium-high greenhouse gasses emission scenario¹². Most of the recent studies related to climate change and livestock are focused on the impact in the developing countries, as is possible to see from Thorton et al.¹³. Developed areas have less studies, such as Central and Northern Europe¹², which are still affected by climate change in the next decades¹⁷ and have almost half of the total European beef production¹⁴.

This work aims to assess, through a sensitivity approach, the effect of the reforestation policy in Ireland on the meteorological parameters, since the vegetation highly affects the climate system through atmospheric dynamics⁴ and not only as a sink for greenhouses gasses, as suggested by the policy^{2,15}. Therefore, this study considers the effect of the policy on their wellbeing, which is assessed through a developed index to quantify the thermal comfort of the livestock.

2. Method

2.1. Study area and period

The study focuses on most of the land that the reforestation policy targets, as can be seen in figure 1 from the centering of the domains. In fact, the domains are designed to have the smaller domain (D04) over the Republic of Ireland, even if excluding Northern Ireland and County Donegal, due to computational costs. Ireland has a population of 4.6 milion, 62% of it lives in urban areas that cover 2.4% of the total land area¹⁶. In the rural areas, there is a

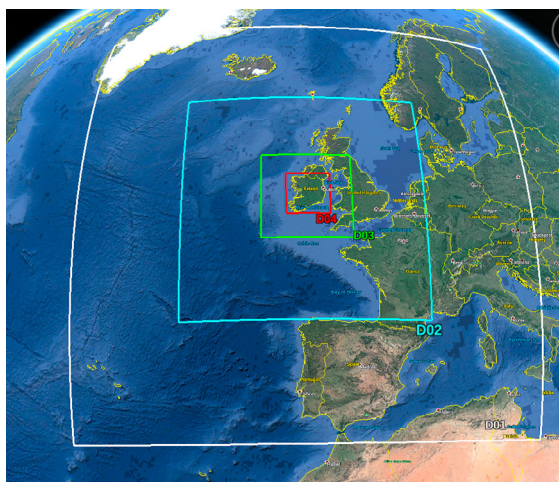


Fig. 1. Two-way nested simulation's domain centered over Ireland.

national average of 26 persons per km^2 .

On the other hand, there is a high population of livestock: 6.3 millions of cattle¹⁷, 3.3 millions of sheep³ and 1.5

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