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A mathematical model for the estimation of stomatal conductance

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Abstract. Global climate change has significantly impacted plants in Mediterranean-type climate areas, with heatwaves and reduced rainfall leading to more frequent and severe droughts. In this context, stomatal conductance plays a fundamental role in the exchange of gases between the atmosphere and vegetation, particularly in relation to photosynthesis. This study introduces a dynamical mathematical model for estimating stomatal conductance, considering essential environmental variables that influence stomatal opening. Simulation results revealed the existence of a stable positive equilibrium point, which represents an optimal state of stomatal opening that enhances CO_2 absorption by the plant, facilitating the photosynthesis process.

1. Introduction

Global climate change (GCC) and its impact on agriculture have become a problem studied by scientists in recent years [1, 2], particularly in regions with a Mediterranean-type climate, such as California, Australia, and Chile [3, 4]. This climate type supports the growth of various plant species, many of which are vital for maintaining ecological balance and human nutrition [1]. However, GCC has considerably altered these environments, changing precipitation patterns and increasing temperatures, which exacerbate droughts and heatwaves. These changes have disrupted plant life in these regions, which now face the challenge of adapting to the changes brought about by GCC [5]. In response to these environmental changes, plants have mechanisms to regulate their temperature through transpiration, with stomata playing a crucial role in this process [6–8].

Stomata are microscopic pores located in the epidermis of leaves, stems, and other plant organs, acting as valves that facilitate gas exchange between the atmosphere and the plant. This process is essential for both photosynthesis and transpiration [9]. The degree of stomatal opening is measured by stomatal conductance (g_s), which indicates the plant's ability to transmit water vapor, primarily through its leaves. g_s is influenced by various environmental factors in the soil-plant-atmosphere continuum (SPAC), such as relative humidity, photon flux density, air temperature, and CO_2 concentration [10]. Under water stress, stomatal opening is reduced