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INTRODUCING ATMOSPHERIC MONITORING, MODELING AND SIMULATION

MARIA TERESA CACCAMO [a] AND SALVATORE MAGAZÙ [a*]

ABSTRACT. Preface to the AAPP supplementary issue collecting the proceedings of the international conference on "Atmospheric Monitoring, Modeling and Simulation" (2-3 December 2019; Messina, Italy).

1. Introduction

Recent breakthroughs in Atmospheric Monitoring, Modeling, and Simulation have solidified these fields as fundamental components of environmental science, creating a self-sufficient discipline that integrates theoretical study, experimental techniques, and practical applications. This area is fundamentally based on scientific principles and is interdisciplinary, incorporating physics, chemistry, meteorology, and data analytics, while still keeping strong ties to technological innovation and policy-making.

This special issue, entitled "Atmospheric Monitoring, Modeling, and Simulation," seeks to underscore developing trends in the area, focusing on the essential contributions of both theoretical frameworks and practical implementations. It aims to confront the problems presented by the dynamic and interrelated characteristics of atmospheric systems and to emphasize the significance of interdisciplinary discourse in addressing global environmental issues. The contributions gathered here encompass a diverse array of subjects, illustrating the great scope and intricacy of atmospheric science. The comprehensive modeling of extreme weather phenomena, including the Apollo Medicane, alongside the examination of hydrogeological hazards and the influence of soil dynamics under severe climatic conditions, emphasizes the practical significance of atmospheric science in disaster mitigation. The incorporation of Artificial Intelligence in analyzing the relationship between air pollution, climate change, and human health underscores the transformative capacity of technical innovation in meeting societal demands.

Special emphasis is placed on new approaches, such as the implementation of geoelectrical monitoring in landslide-prone regions, the utilization of Raman spectroscopy for evaluating material degradation, and the mathematical-physical derivation of mesoscale atmospheric models. These methods enhance our comprehension of localized phenomena

and illustrate the scalability of these solutions to tackle global concerns. The interaction between climate and socioeconomic systems is a significant issue, illustrated by research on the economic effects of climate change on agricultural markets in Sicily. Furthermore, historical perspectives, such Late Miocene climatic alterations and their impact on biodiversity, offer insights into the enduring link between climate and ecosystems, enhancing the overarching narrative of environmental research. This issue seeks to promote a transdisciplinary approach, calling for a comprehensive and revolutionary understanding of atmospheric processes. This collection enhances atmospheric science and its applications for sustainability and resilience by restructuring knowledge within a global context and incorporating practical ideas. It aims to facilitate interdisciplinary discourse, enhance scientific dissemination, and generate effective solutions to current concerns. The issue comprises 11 chapters, each focusing on essential elements of atmospheric monitoring, modeling, and simulation via various interdisciplinary methodologies.

Chapter 1 examines the escalation of extreme weather phenomena, concentrating on Mediterranean Hurricanes (Medicanes) that have progressively affected the southern Mediterranean region. The research emphasizes the Apollo Medicane of October 2021, utilizing the Weather Research and Forecasting (WRF) model to replicate precipitation and wind patterns in southern Italy, specifically in eastern Sicily. The findings indicate a robust correlation between forecasted precipitation maps and empirical data, illustrating the model's precision and regional enhancement (Castorina *et al.* 2025).

Chapter 2 examines the environmental consequences of biomass fuel utilization, contesting the longstanding belief in its carbon neutrality. The study employs the Combined Energy and Biosphere Model (CEBM) to demonstrate how extensive biomass harvest interferes with natural carbon cycles, particularly impacting soil organic carbon reservoirs, resulting in substantial long-term ecological repercussions (Ahamer 2025).

Chapter 3 presents an interdisciplinary methodology for evaluating hydrogeological concerns. The study assesses slope vulnerability in high-risk locations due to severe rainfall by incorporating multiparametric data. A case study in the Messina Province, Italy, underscores the need of geoelectrical monitoring for early warning systems in areas susceptible to landslides (De Domenico, Rinaldi, and Caccamo 2025).

Chapter 4 concentrates on mathematical modeling in meteorology, specifically with atmospheric boundary layer research. The inquiry highlights approximation solutions and the optimization of numerical software to improve model precision and relevance (Ionescu 2025).

Chapter 5 examines the economic effects of climate change using an empirical analysis of agricultural output in Sicily. The study utilizes lemon market price data to reveal that average monthly temperatures have minimal direct effects but substantially decrease return variance, highlighting the economic dynamics influenced by climate fluctuations (Lacava *et al.* 2025).

Chapter 6 examines the evolution of biodiversity during the Late Miocene, concentrating on the Pikermian fauna of the central Mediterranean. Fossil data from Calabria indicates a distinctive animal assemblage shaped by climatic and geographic influences, offering fresh insights into biogeographic evolution (Marra and Somma 2025).

Chapter 7 introduces a novel method for assessing the deterioration of concrete structures through the utilization of a portable Raman spectrometer. The research delineates significant

chemical alterations induced by atmospheric and environmental stresses, illustrating the method's applicability for in-situ structural health assessment (Lombardo *et al.* 2025).

Chapter 8 presents a geometric Brownian motion model to examine short-term temperature fluctuations and evaluate the danger of high heat occurrences. An application to the city of Messina underscores the model's efficacy in predicting and assessing climate hazards (Lefebvre 2025).

Chapter 9 presents a comprehensive development of a mesoscale meteorological model, elucidating atmospheric dynamics inside the troposphere. The chapter presents equations that regulate fluid dynamics, thermodynamics, and phase transitions, providing a solid foundation for subsequent study and applications (Caccamo *et al.* 2025).

Chapter 10 centers on Artificial Intelligence and its applications. This research examines the relationship among climate change, air pollution, and human health. It illustrates the efficacy of machine learning algorithms in discerning cause-effect links, facilitating early diagnosis and treatment of chronic inflammatory disorders, and guiding pollutant reduction measures (Musotto *et al.* 2025).

The last chapter emphasizes the essential function of universities in combating climate change via both mitigation and adaptation strategies. Universities act as drivers for innovation and resilience by establishing carbon neutrality objectives, including sustainability into their curricula, and partnering with local communities. Their programs mitigate environmental damage and equip future generations to address climate concerns proficiently (Rinollo *et al.* 2025).

This collection unites many approaches and viewpoints, highlighting the interrelation of scientific fields and their significance in tackling global environmental issues. The problem fosters multidisciplinary conversation, scientific dissemination, and innovative solutions for a sustainable future through theoretical, experimental, and applied research.

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[a] Università degli Studi di Messina,
Dipartimento di Scienze Matematiche e Informatiche, Scienze Fisiche e Scienze della Terra,
Viale F. Stagno d'Alcontres 31, 98166 Messina, Italy

* To whom correspondence should be addressed | email: smagazu@unime.it

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