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Three Decades of high-Resolution ERA5 Downscaling over the Italian domain: Validation and Applications in Hydrology, Meteorology, and Climate Analysis

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This study presents a detailed assessment of very high-resolution reanalysis data covering the entire Italian territory and the broader Alpine domain for the three-decade period 1990-2020. The dataset was generated using a dynamical downscaling of ERA5 reanalysis with the convection-permitting model **MOLOCH**, implemented at a fine grid spacing of 1.8 km.

Validation against high-resolution observational datasets (GRIPHO, ARCIS, and the ISAC-CNR precipitation and temperature dataset) and comparisons with similar downscaled reanalysis products (ERA5-LAND, CERRA, MERIDA-HRES, and SPHERA) confirm the dataset's reliability in reproducing key meteorological variables, such as temperature and precipitation. Importantly, the dataset leads in capturing higher-order statistics, including intensity and extremes.

The dataset's versatility is illustrated through multi-disciplinary applications. In hydrology, it enables high-resolution drought characterization; in meteorology, it supports the analysis of extreme weather events and orographic effects. In climate research, it provides valuable insights into long-term trends and variability.

This work underscores the importance of very high-resolution datasets in advancing our understanding of the complex interactions between natural processes and human activities, especially in regions with challenging topography like the Alps. It establishes a strong foundation for future research and practical applications, including disaster risk management, water resource planning, and climate adaptation strategies.

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