



Reanalysis Datasets for Climate Services in Italy: Validation and Inter-Comparison

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Climate services increasingly rely on spatially and temporally consistent meteorological datasets to support climate-aware decision-making across many sectors. In Italy, where complex orography and strong regional climate gradients challenge weather modelling and observational representativeness, meteorological reanalyses represent a key backbone for climate services, enabling monitoring, impact assessment, and adaptation planning in areas such as water resources, renewable energy, civil protection, and urban management.

This contribution summarises a PhD work which assessed the performances of major reanalysis datasets available over Italy through systematic inter-comparison and validation. We focus on 2-m surface air temperature (t2m) and total precipitation (tp) variables. The analysis includes global products (ERA5 at ~31 km grid spacing and ERA5-Land at ~9 km) alongside a comprehensive set of regional dynamical downscalings, namely MERIDA and MERIDA-HRES (developed by RSE), MOLOCH and BOLAM (LaMMA), SPHERA (ARPAE), VHR-REA_IT (CMCC), and MORE (ISAC-CNR), with resolutions ranging from 7 km down to convection-permitting scales (~2 km). Other European products, such as CERRA (Copernicus) and COSMO-REA6 (DWD), are included. Reanalyses are evaluated against high-quality observational references, both gridded and station-based, using validation approaches that explicitly account for scale, resolution, and orography.

Temperature validation (1991–2020) uses observational data elevation-adjusted to each reanalysis grid, eliminating orographic mismatches. Regional products show systematic cold bias (-0.5 to -1°C), strongest in winter over the Alps, where climatological errors dominate. However, daily anomalies and climate indices (e.g., tropical nights) are well captured, demonstrating strong performance in weather variability and impact-relevant metrics. Precipitation validation (1995–2019) uses wavelet spectral analysis to demonstrate the added value of convection-permitting reanalyses in resolving localised (<10 km) phenomena critical for hydrological and risk services. Frequency analyses show that ERA5 underestimates extremes (>20 mm/day), while higher-resolution products better capture intensity distributions but show spatial displacements of convective events. Systematic biases emerge: +30% summer wet bias in northern Italy; -20%

winter/fall dry bias in southern regions, and product-specific differences in long-term trends, underscoring the need for bias correction in climate assessments.

The validation effort has resulted in the publication of several papers in international scientific journals (references below), where the full set of methodologies and results is documented and made available to the wider community. Overall, this work highlights how rigorous, scale-aware validation is essential to guide the informed use of reanalysis products in climate services. By identifying strengths and limitations relevant to specific variables, regions, and applications, the study supports transparent and product-specific integration of reanalysis data into operational climate services and adaptation strategies in Italy.

References:

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