

ERA5

Fit for Purpose?

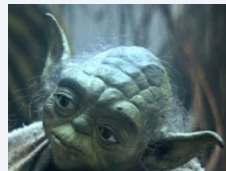
A Global Multi-Variable Evaluation of Reanalysis Strengths and Weaknesses

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- ▶ ERA5 blends numerical model output with satellite, surface, and upper-air observations
- ▶ ERA5 provides global coverage, long temporal record, no “missing data”, and huge number of useful variables
- ▶ ERA5 is very easy to access
- ▶ Widely used as proxy for observations, model initialization, and AI training
- ▶ Reanalysis quality varies by region, climate zone, variable, and time of day

...Quicker, easier, more seductive.



Data & Methods

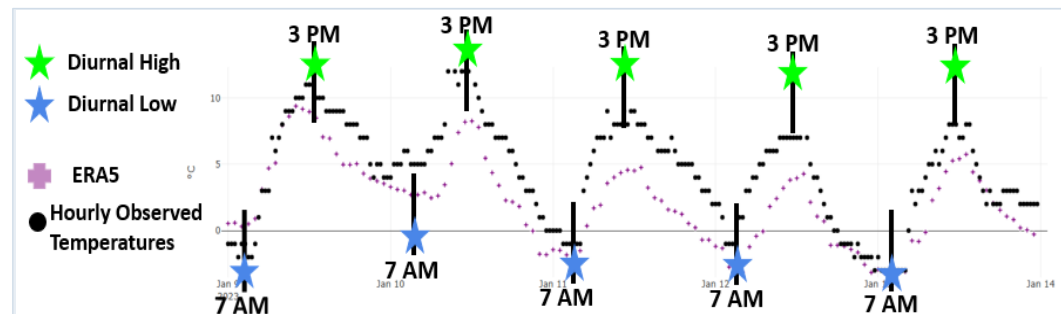
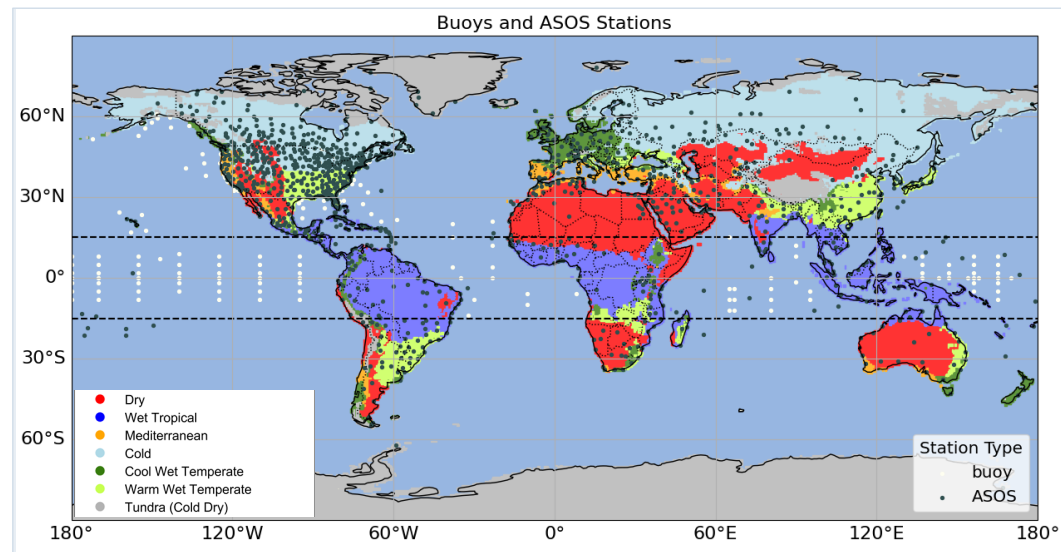
Dataset: ECMWF ERA5 reanalysis compared to surface observations at 1,200+ global airport and buoy stations

Period: 2019–2024 (6 years), with future extension to 1995 planned

Climate Zones: Simplified Köppen-Geiger classification (Tropical, Dry, Mediterranean, Warm/Cool Wet Temperate, Cold)

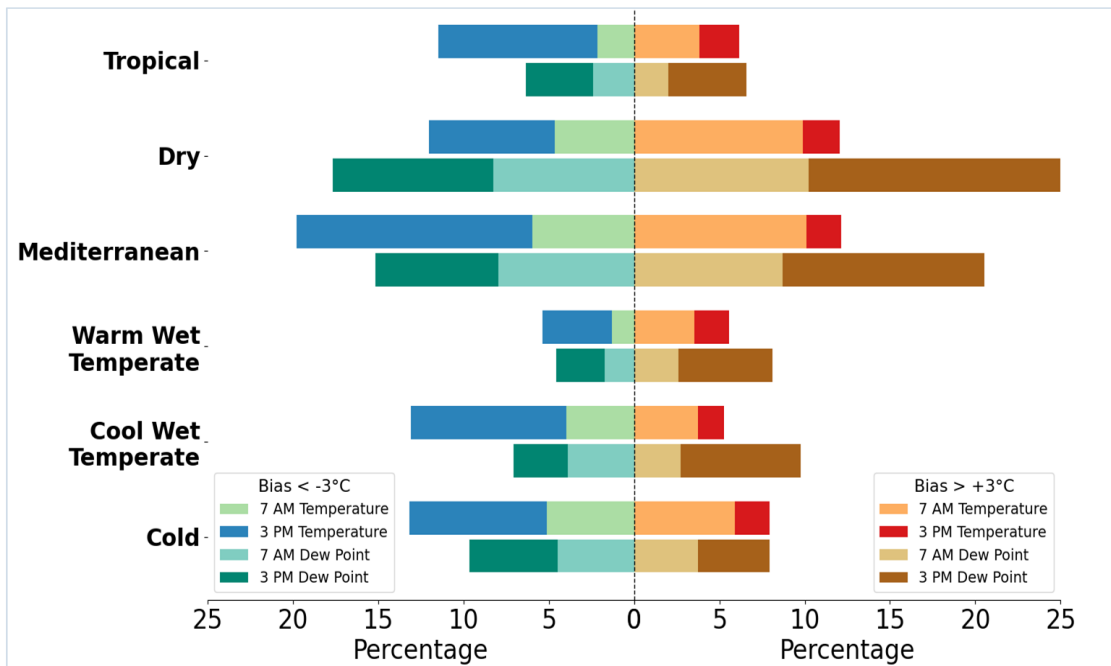
Timing: 7 AM local time (near daily minimum) and 3 PM local time (near daily maximum) to capture the diurnal cycle

Threshold: Biases $> |3^{\circ}\text{C}|$ flagged as concerning; measurement uncertainty $\sim \pm 1^{\circ}\text{C}$



Example: ERA5 vs. observed temperature, SYZ – Shiraz Airport (7 AM min & 3 PM max sampling)

Key Findings



Frequency of ERA5 biases exceeding $\pm 3^{\circ}\text{C}$ by climate zone, variable, and time of day



Temperate & Cold zones: ERA5 temperature biases are distributed near zero at both 7 AM and 3 PM



Tropical, Dry & Mediterranean: Temperature biases exceed $\pm 3^{\circ}\text{C}$ in >10% of hours



Dewpoint in arid regions: Biases exceed $\pm 3^{\circ}\text{C}$ ~18% of the time. Arid environments are systematically too moist



Extreme events: ERA5 systematically underestimates extremes — warm events too cool, dry events too moist

Future: Extend to 1995 · Gridded ERA5 reliability product for users