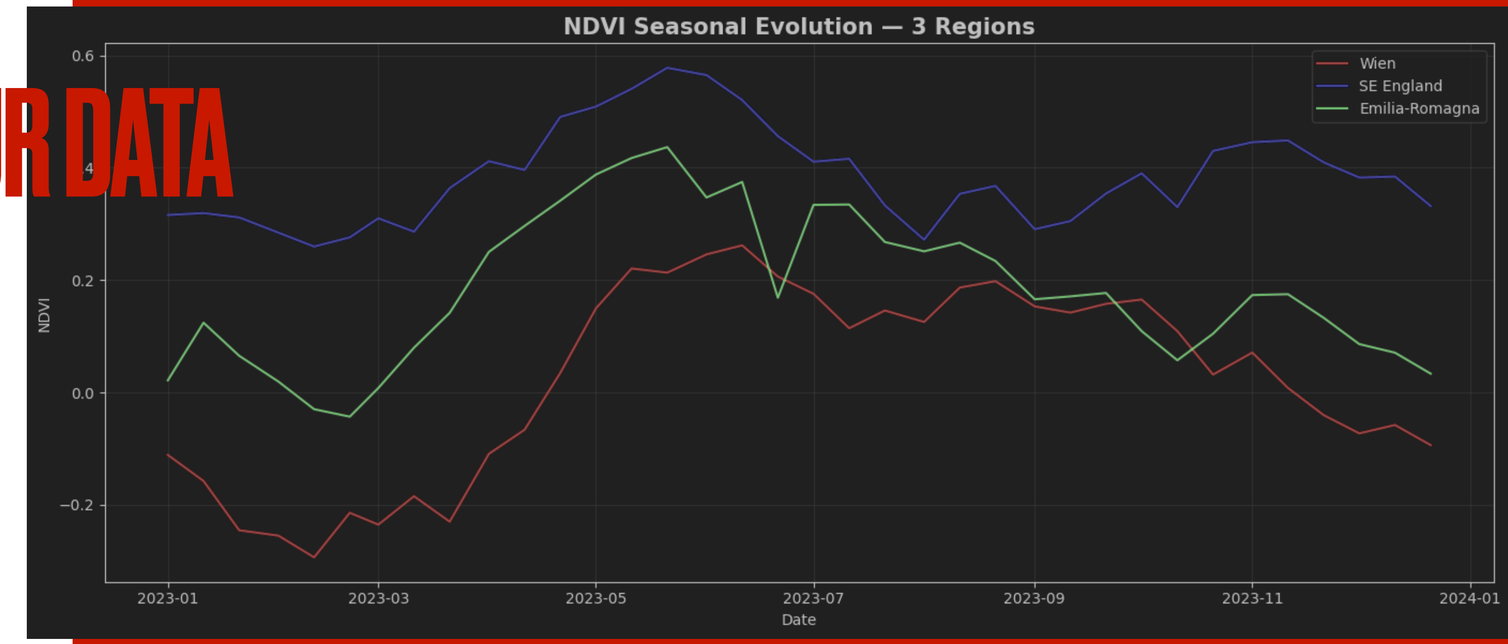
LATENT-SPACE [16]

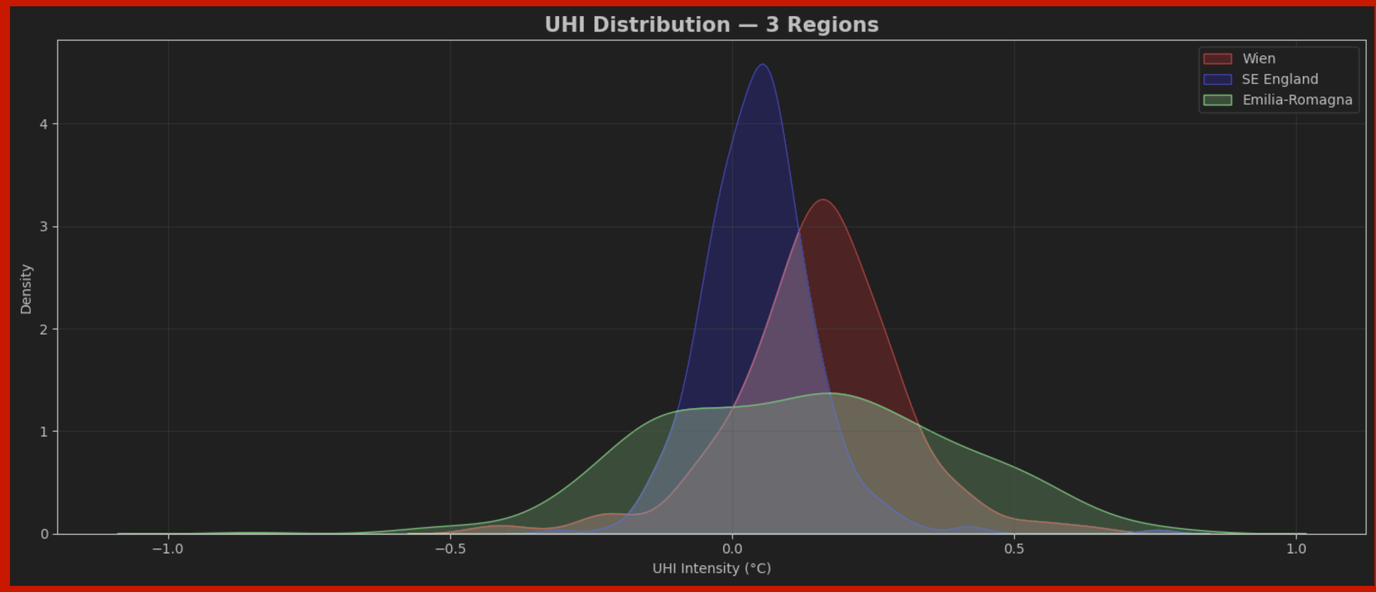
NDVI-AWARE DOWNSCALING & BIAS CORRECTION FOR URBAN CLIMATE RISK-[GENHACK]

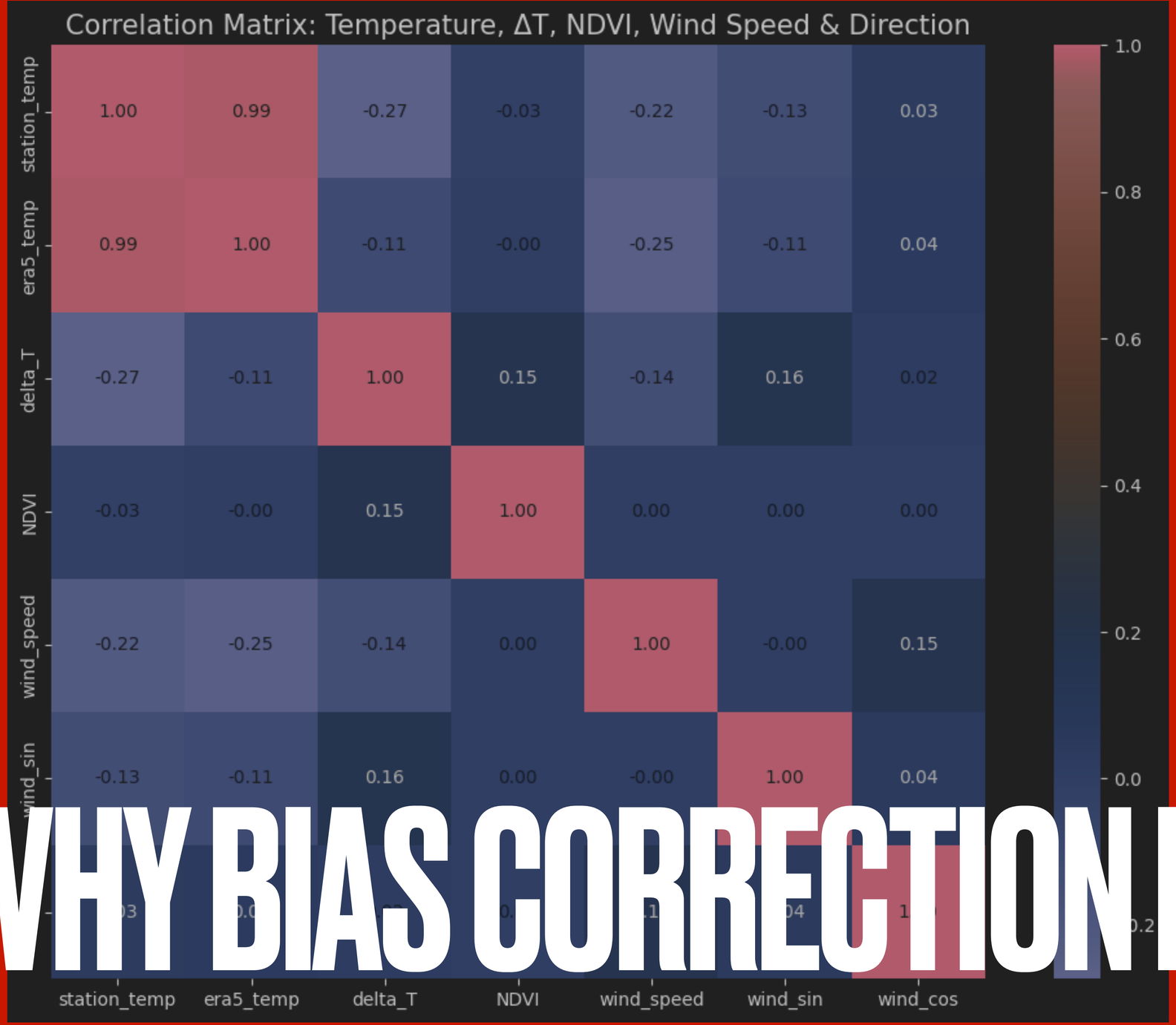
WHAT WE LEARNED FROM OUR DATA

- *NDVI is a robust proxy for vegetation ➜ tied to cooling capacity.*
- *UHI varies strongly by region type: continental > Po Valley > maritime.*
- *Wind modulates UHI: calm ➜ stronger bias; windy ➜ weaker biases.*
- *ERA5 systematically underestimates station temperatures in all regions.*

—> WE MUST CORRECT ERA5 USING PHYSICAL SURFACE INFORMATION (NDVI), METEOROLOGY (WIND), AND SEASONALITY.







A. ΔT = ERA5 – Station is *not random noise*.

B. It correlates meaningfully with:
| + NDVI → more vegetation → smaller bias | – Wind speed → calm days show larger errors

C. Temperature itself is almost perfectly correlated between ERA5 and stations → the problem is **systematic bias**, not random error.

WHY BIAS CORRECTION IS NEEDED

MODEL 1: MULTI-FACTOR LINEAR BIAS MODEL

A SIMPLE PHYSICAL PROXY MODEL ALREADY IMPROVES CLIMATE DATA QUALITY.

$$\Delta T = a + b \cdot NDVI + c \cdot wind + season\_effects$$

- ***NDVI is positively correlated with bias*** → *low vegetation → ERA5 underestimates more.*
- ***Wind reduces bias*** *(physically intuitive).*
- *Summer & spring have the largest corrections → heatwaves amplify UHI.*
- ***$R^2 = 0.13$****: modest but meaningful for climate data.*
- *Bias is reduced and distribution is more centered around 0°C.*

OLS Regression Results

Dep. Variable:	delta_T	R-squared:	0.130
Model:	OLS	Adj. R-squared:	0.129
Method:	Least Squares	F-statistic:	239.5
Date:	Thu, 04 Dec 2025	Prob (F-statistic):	3.63e-239
Time:	05:41:24	Log-Likelihood:	-14196.
No. Observations:	8028	AIC:	2.840e+04
Df Residuals:	8022	BIC:	2.845e+04
Df Model:	5		
Covariance Type:	nonrobust		

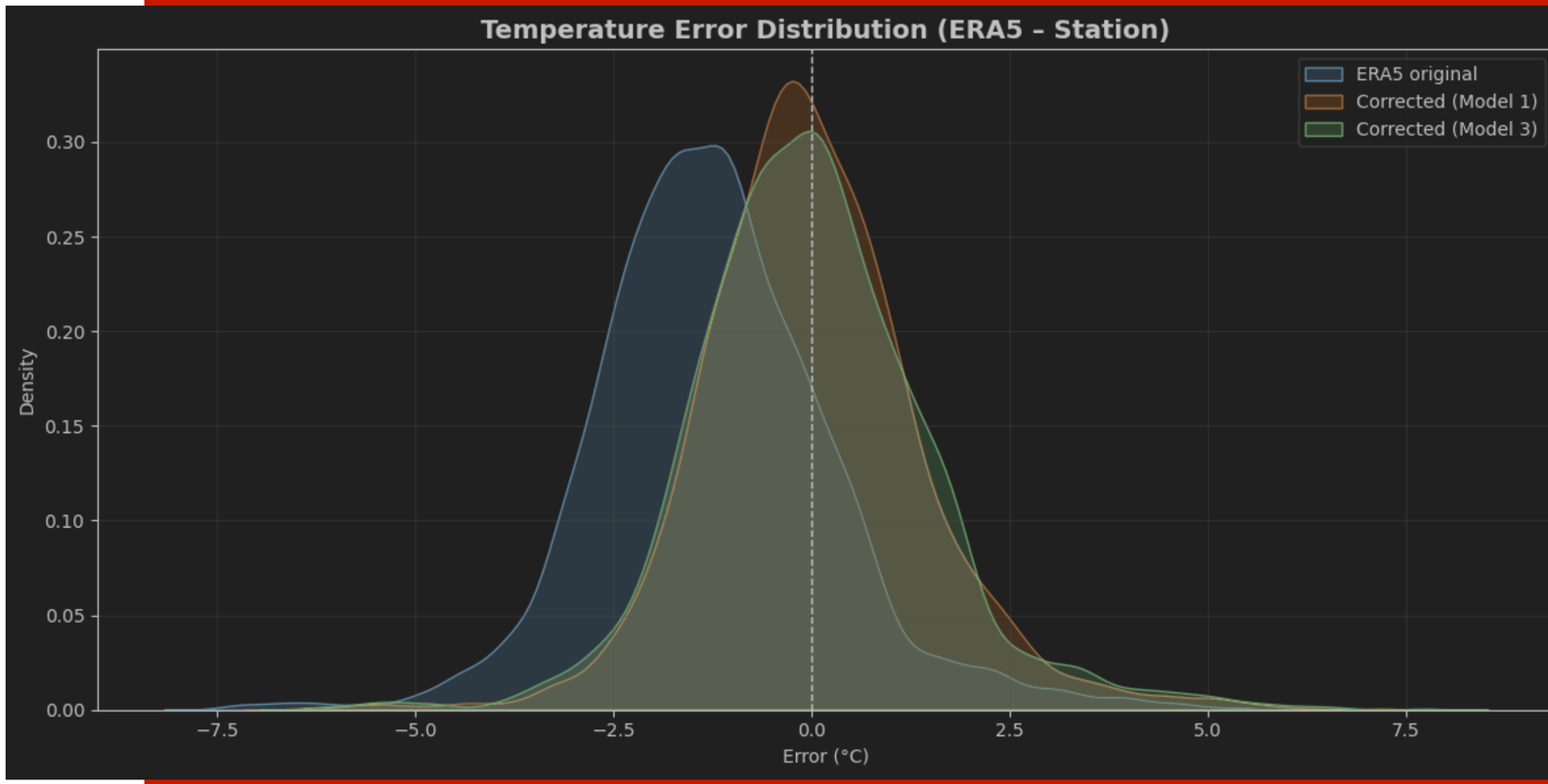
	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.7467	0.055	-13.561	0.000	-0.855	-0.639
NDVI	1.4676	0.101	14.558	0.000	1.270	1.665
wind_speed	-0.1741	0.011	-15.732	0.000	-0.196	-0.152
S_Spring	-1.0187	0.045	-22.761	0.000	-1.106	-0.931
S_Summer	-0.9141	0.045	-20.364	0.000	-1.002	-0.826
S_Winter	-0.1564	0.045	-3.459	0.001	-0.245	-0.068

Omnibus:	539.148	Durbin-Watson:	1.472
Prob(Omnibus):	0.000	Jarque-Bera (JB):	1626.507
Skew:	0.337	Prob(JB):	0.00
Kurtosis:	5.100	Cond. No.	21.9

MODEL 2: NDVI-ONLY CORRECTION

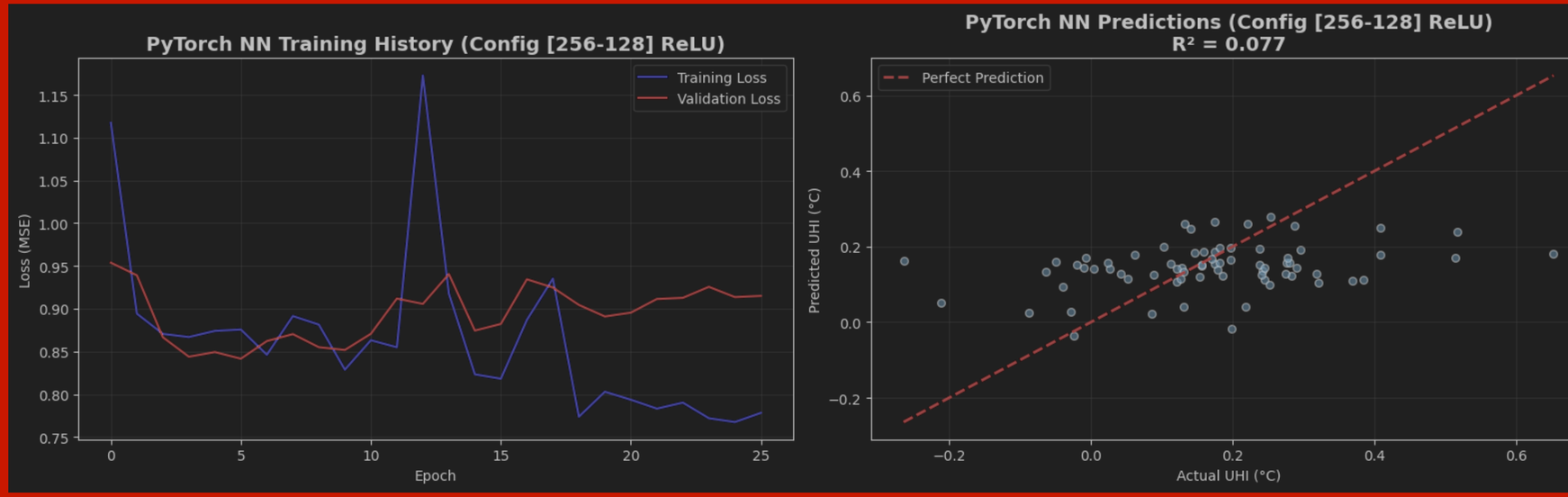
VEGETATION COVER ALONE CONTAINS VALUABLE INFORMATION ABOUT TEMPERATURE BIASES.

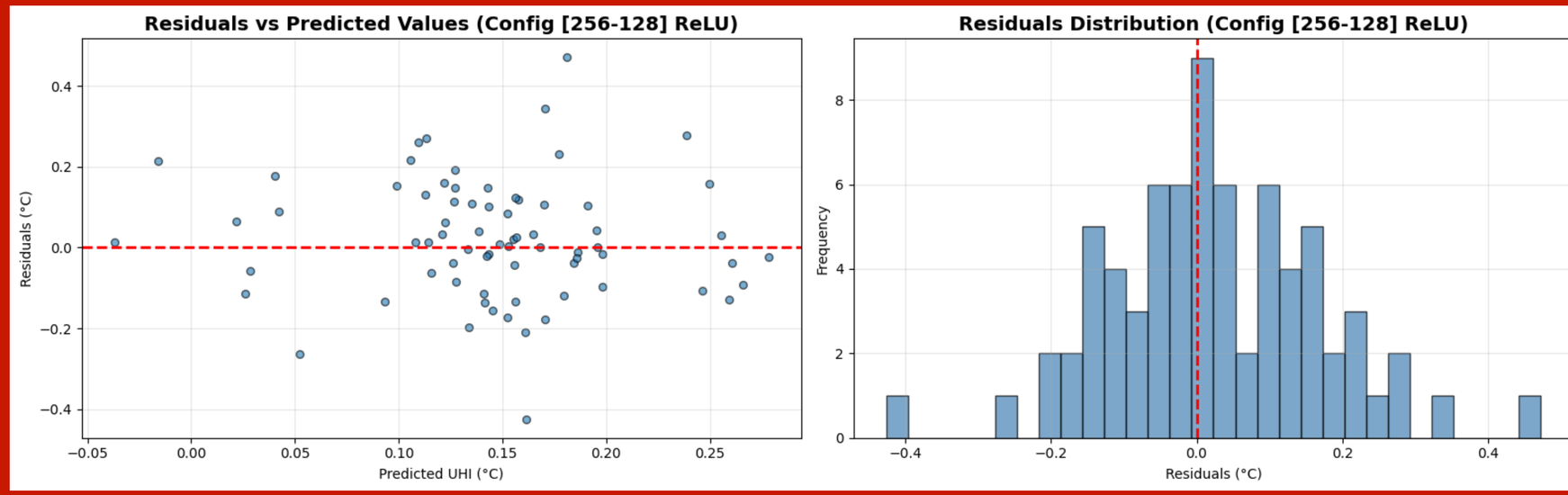
- *Even NDVI alone explains* ***~2–3%*** *of error variance.*
- ***The correction is extremely lightweight → ideal for large-scale use.***
- *Best for ESG pipelines where interpretability is essential.*



NEURAL NETWORK ATTEMPT

- *We tested a small neural regressor (256–128 ReLU).*
- ***R² ≈ 0.08** — higher capacity did not outperform the linear model.*
- *Indicates ERA5 bias is dominated by simple, physical drivers, not complex nonlinear interactions.*

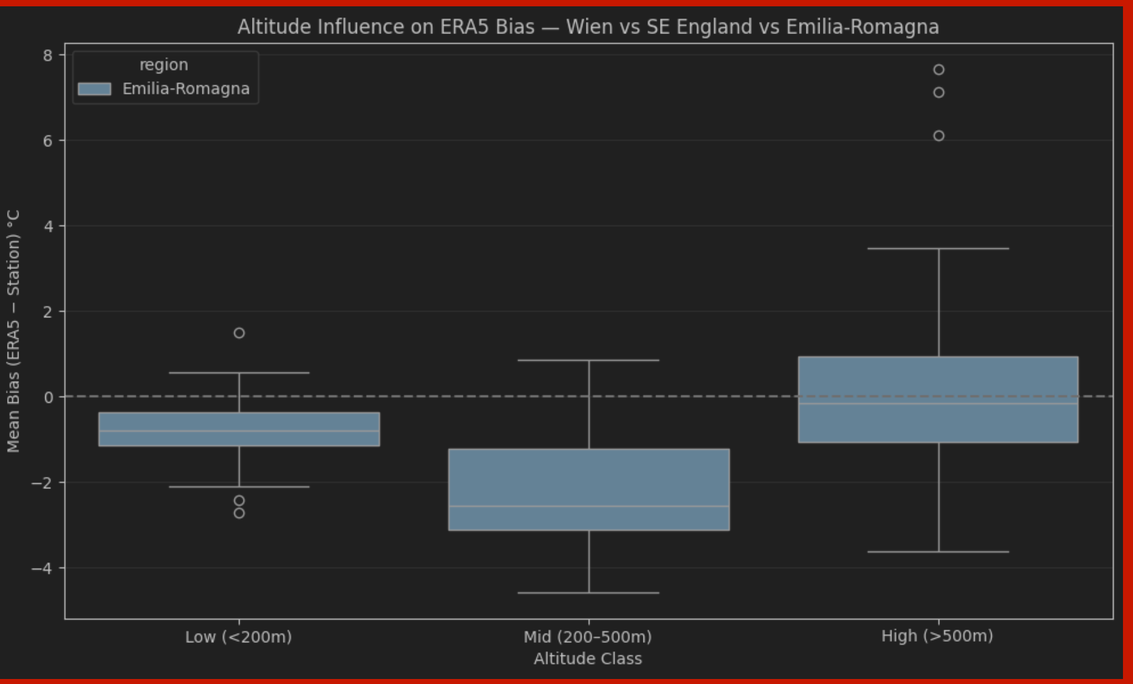


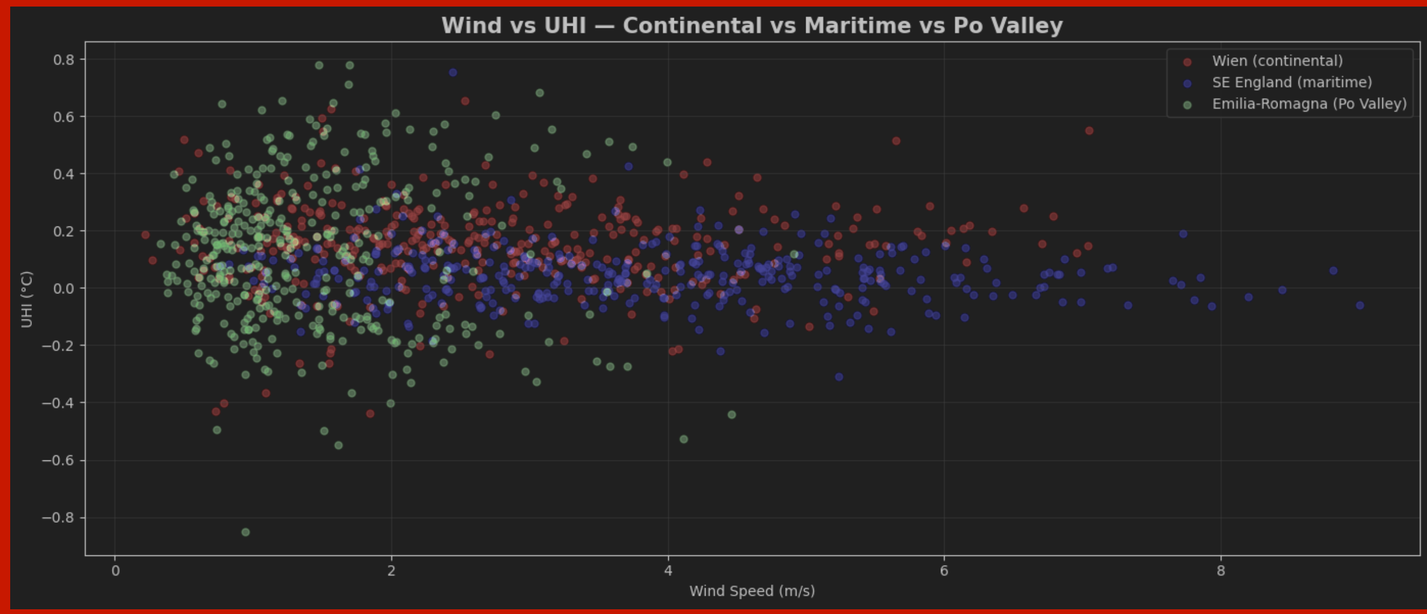


SPATIAL MODELING

- Land-surface properties (vegetation, altitude, morphology) explain spatial patterns of ERA5 errors.
- Maritime regions show smaller UHI.
- Continental regions show strong UHI amplified by low NDVI.

—> PHYSICAL GEOGRAPHY SHOULD BE INTEGRATED INTO TEMPERATURE DOWNSCALING MODELS.





1.Load ERA5 + Stations + NDVI + Wind

2.Compute ΔT (bias)

3.Fit model (linear or NDVI-only)

4.Apply correction

5.Output corrected temperature for UHI analysis or risk modelling

NDVI-AWARE BIAS CORRECTION PIPELINE

IMPROVING CLIMATE RISK ANALYTICS WITH NDVI-INFORMED TEMPERATURE CORRECTIONS

- Better estimation of *heat stress* on buildings, infrastructure, agriculture.
- More accurate *physical risk* projections and stress tests.
- Enables targeted investment in *cooling infrastructure*, *green roofs*, *urban greening*.
- Enhances ESG scoring with high-resolution land-surface intelligence.
- PRECOND → baisse PRIXVENTEP
- Supports portfolio-level climate vulnerability mapping.