

Supplement to
“FiLMeR (v1.0): a FiLM-conditioned machine-learning emulator
for multi-domain regional WRF-scale surface weather fields”

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S1 Domainwise Spatial Plots

S1.1 Domain - Indian Subcontinent

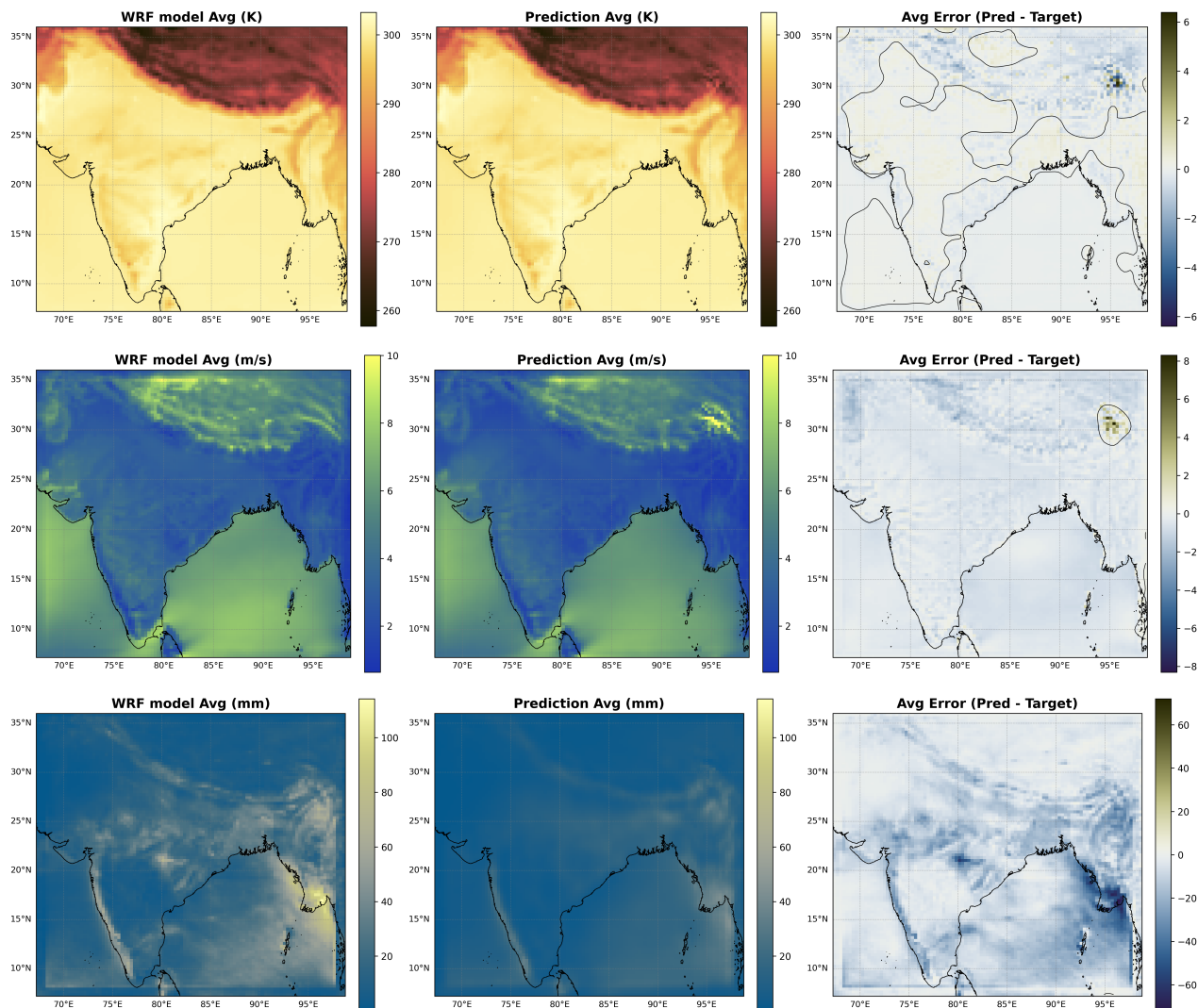


Figure S1. Spatial distributions of time-averaged forecast fields and error profiles generated by the **FiLMeR v1.0** (DF) model, averaged across 3 training seeds, for Domain D01. Rows from top to bottom correspond to: (top) 2 m Temperature, (middle) 10 m Wind Speed, and (bottom) Precipitation. Maps were generated by the authors using `matplotlib` and `cartopy` from model output data.

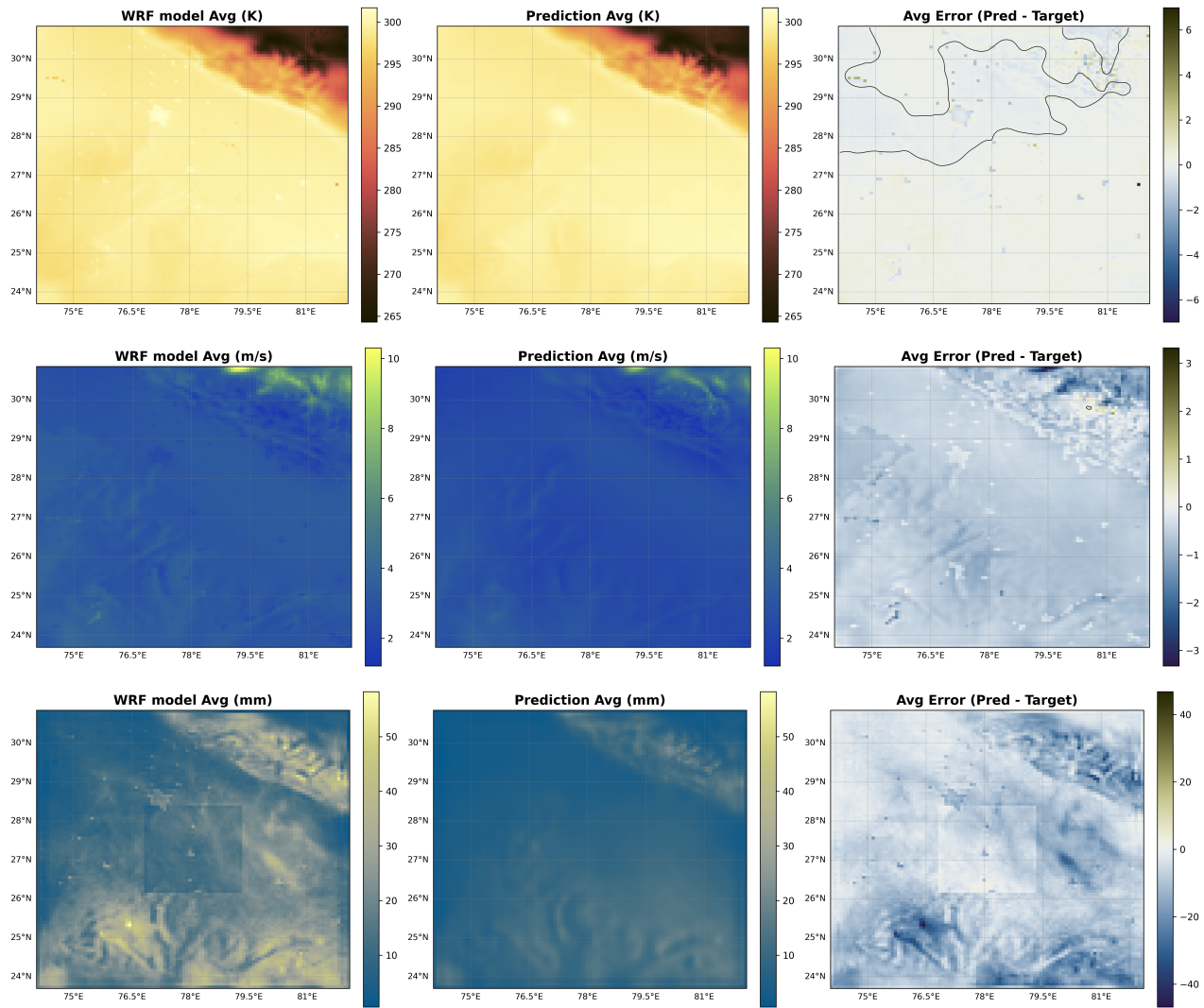


Figure S2. Spatial distributions of time-averaged forecast fields and error profiles generated by the **FiLMeR v1.0** (DF) model, averaged across 3 training seeds, for Domain D02. Rows from top to bottom correspond to: (top) 2 m Temperature, (middle) 10 m Wind Speed, and (bottom) Precipitation. Maps were generated by the authors using `matplotlib` and `cartopy` from model output data.

S1.2 Domain - Northern India

45 S1.3 Domain - Southern India

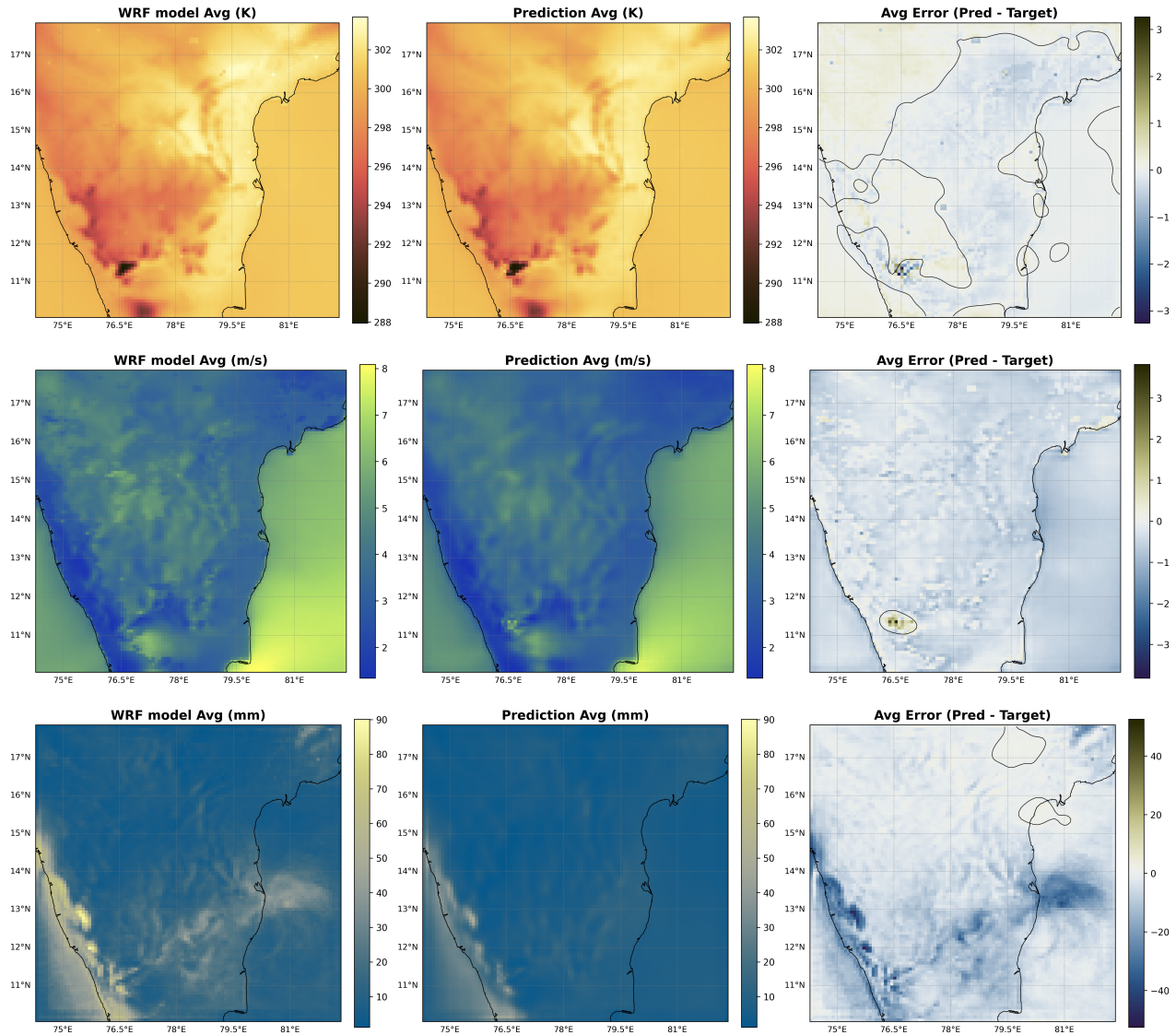


Figure S3. Spatial distributions of time-averaged forecast fields and error profiles generated by the **FiLMer v1.0** (DF) model, averaged across 3 training seeds, for Domain D03. Rows from top to bottom correspond to: (top) 2 m Temperature, (middle) 10 m Wind Speed, and (bottom) Precipitation. Maps were generated by the authors using `matplotlib` and `cartopy` from model output data.

S1.4 Domain - Eastern India

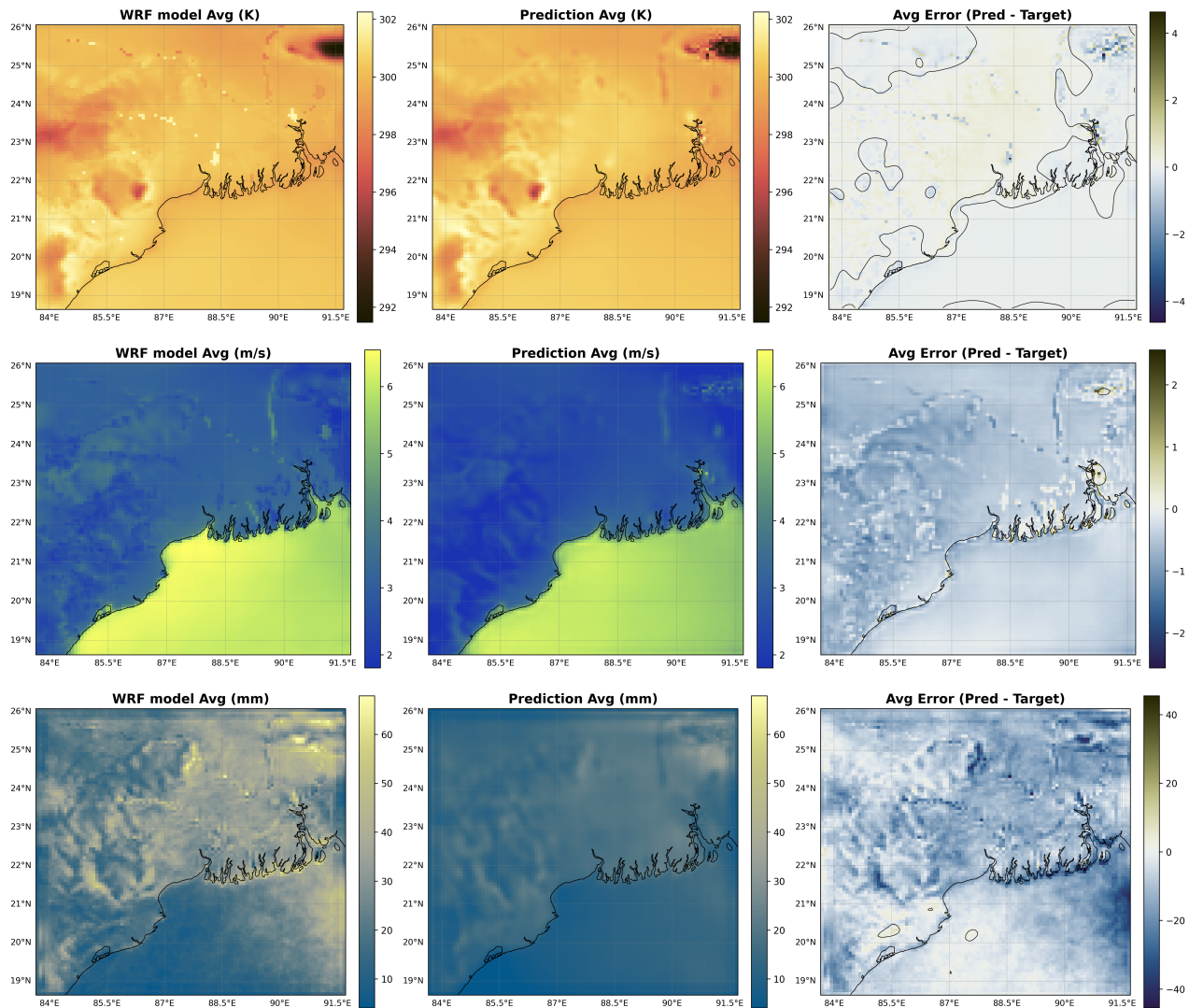


Figure S4. Spatial distributions of time-averaged forecast fields and error profiles generated by the **FiLMeR v1.0** (DF) model, averaged across 3 training seeds, for Domain D04. Rows from top to bottom correspond to: (top) 2 m Temperature, (middle) 10 m Wind Speed, and (bottom) Precipitation. Maps were generated by the authors using `matplotlib` and `cartopy` from model output data.

S2 Domainwise Metrics

This appendix provides detailed per-domain performance metrics across all four regional grids: the 27 km parent domain (**d01**) and three distinct 9 km nested configurations (**d02**, **d03**, **d04**). Metrics are reported across the full topology $\times$ conditioning design space (S0, SC, SF, D0, DC, DF, DF2) introduced in Section 3.5 of the main text, as mean $\pm$ std across 3 training seeds (42, 43, 44).

S2.1 Domain - Indian Subcontinent

Table S1. Continuous-variable RMSE (mean $\pm$ std across 3 seeds) across the full topology $\times$ conditioning design space for Domain **D01**.

Variable	S0	SC	SF	D0	DC	DF	DF2
PSFC RMSE (hPa)	1.48 $\pm$ 0.09	1.40 $\pm$ 0.10	1.39 $\pm$ 0.04	1.56 $\pm$ 0.02	1.42 $\pm$ 0.02	1.37 $\pm$ 0.04	1.33$\pm$0.05
T2 RMSE (K)	1.71 $\pm$ 0.01	1.53 $\pm$ 0.02	1.55 $\pm$ 0.06	1.81 $\pm$ 0.07	1.55 $\pm$ 0.02	1.52$\pm$0.02	1.54 $\pm$ 0.04
Q2 RMSE (g/kg)	1.25 $\pm$ 0.01	1.23 $\pm$ 0.02	1.23$\pm$0.01	1.27 $\pm$ 0.01	1.25 $\pm$ 0.01	1.26 $\pm$ 0.01	1.24 $\pm$ 0.01
U10 RMSE (m/s)	1.76 $\pm$ 0.03	1.76 $\pm$ 0.03	1.75$\pm$0.02	1.80 $\pm$ 0.03	1.81 $\pm$ 0.03	1.76 $\pm$ 0.01	1.76 $\pm$ 0.02
V10 RMSE (m/s)	1.73 $\pm$ 0.01	1.73 $\pm$ 0.04	1.72 $\pm$ 0.05	1.76 $\pm$ 0.00	1.75 $\pm$ 0.03	1.72 $\pm$ 0.03	1.72$\pm$0.04
Wind RMSVE (m/s)	2.46 $\pm$ 0.03	2.47 $\pm$ 0.05	2.46$\pm$0.05	2.52 $\pm$ 0.02	2.52 $\pm$ 0.04	2.46 $\pm$ 0.02	2.46 $\pm$ 0.04

Table S2. Precipitation skill (mean $\pm$ std across 3 seeds) across the full design space for Domain **D01**.

Metric	S0	SC	SF	D0	DC	DF	DF2
CSI@0.1mm $\uparrow$	0.77 $\pm$ 0.01	0.77 $\pm$ 0.01	0.77 $\pm$ 0.00	0.77 $\pm$ 0.01	0.77 $\pm$ 0.02	0.77 $\pm$ 0.00	0.77$\pm$0.01
CSI@1mm $\uparrow$	0.74 $\pm$ 0.00	0.75$\pm$0.01	0.74 $\pm$ 0.01	0.74 $\pm$ 0.01	0.75 $\pm$ 0.00	0.74 $\pm$ 0.01	0.74 $\pm$ 0.01
CSI@10mm $\uparrow$	0.53$\pm$0.02	0.51 $\pm$ 0.01	0.51 $\pm$ 0.03	0.51 $\pm$ 0.04	0.51 $\pm$ 0.02	0.49 $\pm$ 0.07	0.47 $\pm$ 0.03
Masked MAE (mm) $\downarrow$	21.86 $\pm$ 0.34	21.69$\pm$0.23	21.79 $\pm$ 0.18	21.76 $\pm$ 0.38	21.86 $\pm$ 0.22	21.95 $\pm$ 0.63	21.75 $\pm$ 0.45
Masked RMSE (mm) $\downarrow$	46.60$\pm$0.41	47.61 $\pm$ 0.38	47.90 $\pm$ 1.63	48.51 $\pm$ 1.03	46.89 $\pm$ 0.42	49.19 $\pm$ 2.33	48.23 $\pm$ 1.39

S2.2 Domain - Northern India

S2.3 Domain - Southern India

55 S2.4 Domain - Eastern India

Table S3. Continuous-variable RMSE (mean $\pm$ std across 3 seeds) across the full topology $\times$ conditioning design space for Domain **D02**.

Variable	S0	SC	SF	D0	DC	DF	DF2
PSFC RMSE (hPa)	1.65 $\pm$ 0.07	1.46 $\pm$ 0.02	1.48 $\pm$ 0.06	1.62 $\pm$ 0.07	1.50 $\pm$ 0.03	1.47 $\pm$ 0.02	1.46$\pm$0.01
T2 RMSE (K)	2.24 $\pm$ 0.25	1.76$\pm$0.04	1.80 $\pm$ 0.00	2.43 $\pm$ 0.12	1.80 $\pm$ 0.04	1.77 $\pm$ 0.05	1.80 $\pm$ 0.08
Q2 RMSE (g/kg)	1.62 $\pm$ 0.00	1.60$\pm$0.01	1.61 $\pm$ 0.01	1.65 $\pm$ 0.01	1.61 $\pm$ 0.01	1.62 $\pm$ 0.01	1.61 $\pm$ 0.01
U10 RMSE (m/s)	1.77 $\pm$ 0.03	1.76 $\pm$ 0.02	1.75 $\pm$ 0.02	1.78 $\pm$ 0.01	1.78 $\pm$ 0.01	1.74 $\pm$ 0.02	1.73$\pm$0.00
V10 RMSE (m/s)	1.61 $\pm$ 0.02	1.59$\pm$0.02	1.59 $\pm$ 0.01	1.64 $\pm$ 0.01	1.61 $\pm$ 0.00	1.60 $\pm$ 0.01	1.59 $\pm$ 0.02
Wind RMSVE (m/s)	2.40 $\pm$ 0.03	2.37 $\pm$ 0.02	2.36 $\pm$ 0.01	2.42 $\pm$ 0.00	2.40 $\pm$ 0.01	2.36 $\pm$ 0.01	2.36$\pm$0.01

Table S4. Precipitation skill (mean $\pm$ std across 3 seeds) across the full design space for Domain **D02**.

Metric	S0	SC	SF	D0	DC	DF	DF2
CSI@0.1mm $\uparrow$	0.68 $\pm$ 0.02	0.70 $\pm$ 0.00	0.67 $\pm$ 0.01	0.67 $\pm$ 0.02	0.69 $\pm$ 0.01	0.68 $\pm$ 0.01	0.70$\pm$0.01
CSI@1mm $\uparrow$	0.61 $\pm$ 0.00	0.64$\pm$0.02	0.62 $\pm$ 0.02	0.62 $\pm$ 0.01	0.64 $\pm$ 0.02	0.63 $\pm$ 0.02	0.64 $\pm$ 0.01
CSI@10mm $\uparrow$	0.53 $\pm$ 0.02	0.56 $\pm$ 0.02	0.54 $\pm$ 0.03	0.52 $\pm$ 0.02	0.58$\pm$0.01	0.53 $\pm$ 0.05	0.52 $\pm$ 0.03
Masked MAE (mm) $\downarrow$	26.34 $\pm$ 0.70	26.74 $\pm$ 0.66	26.06$\pm$0.48	26.06 $\pm$ 0.34	26.43 $\pm$ 0.54	26.07 $\pm$ 0.47	26.33 $\pm$ 0.67
Masked RMSE (mm) $\downarrow$	54.96 $\pm$ 1.38	55.06 $\pm$ 0.85	56.65 $\pm$ 1.32	55.59 $\pm$ 2.28	54.73$\pm$1.04	56.71 $\pm$ 0.21	55.77 $\pm$ 1.00

Table S5. Continuous-variable RMSE (mean $\pm$ std across 3 seeds) across the full topology $\times$ conditioning design space for Domain **D03**.

Variable	S0	SC	SF	D0	DC	DF	DF2
PSFC RMSE (hPa)	1.32 $\pm$ 0.07	1.14 $\pm$ 0.05	1.15 $\pm$ 0.05	1.44 $\pm$ 0.01	1.19 $\pm$ 0.02	1.13 $\pm$ 0.05	1.13$\pm$0.06
T2 RMSE (K)	1.48 $\pm$ 0.03	1.27$\pm$0.01	1.30 $\pm$ 0.04	1.58 $\pm$ 0.03	1.31 $\pm$ 0.01	1.29 $\pm$ 0.01	1.28 $\pm$ 0.03
Q2 RMSE (g/kg)	1.57 $\pm$ 0.02	1.60 $\pm$ 0.01	1.54$\pm$0.02	1.60 $\pm$ 0.02	1.59 $\pm$ 0.02	1.59 $\pm$ 0.01	1.57 $\pm$ 0.02
U10 RMSE (m/s)	1.67 $\pm$ 0.05	1.65 $\pm$ 0.02	1.62$\pm$0.02	1.67 $\pm$ 0.01	1.66 $\pm$ 0.02	1.62 $\pm$ 0.01	1.62 $\pm$ 0.02
V10 RMSE (m/s)	1.60 $\pm$ 0.01	1.58$\pm$0.01	1.60 $\pm$ 0.01	1.62 $\pm$ 0.01	1.63 $\pm$ 0.02	1.60 $\pm$ 0.01	1.59 $\pm$ 0.02
Wind RMSVE (m/s)	2.31 $\pm$ 0.03	2.29 $\pm$ 0.02	2.28 $\pm$ 0.01	2.33 $\pm$ 0.01	2.33 $\pm$ 0.02	2.28 $\pm$ 0.01	2.27$\pm$0.03

Table S6. Precipitation skill (mean $\pm$ std across 3 seeds) across the full design space for Domain **D03**.

Metric	S0	SC	SF	D0	DC	DF	DF2
CSI@0.1mm $\uparrow$	0.79 $\pm$ 0.00	0.80$\pm$0.00	0.79 $\pm$ 0.01	0.79 $\pm$ 0.01	0.79 $\pm$ 0.00	0.79 $\pm$ 0.00	0.79 $\pm$ 0.00
CSI@1mm $\uparrow$	0.67 $\pm$ 0.01	0.68 $\pm$ 0.01	0.68$\pm$0.01	0.67 $\pm$ 0.01	0.67 $\pm$ 0.01	0.67 $\pm$ 0.01	0.67 $\pm$ 0.00
CSI@10mm $\uparrow$	0.44 $\pm$ 0.02	0.44$\pm$0.01	0.42 $\pm$ 0.01	0.40 $\pm$ 0.02	0.43 $\pm$ 0.01	0.41 $\pm$ 0.02	0.42 $\pm$ 0.01
Masked MAE (mm) $\downarrow$	17.17 $\pm$ 0.98	18.08 $\pm$ 0.36	16.52$\pm$0.20	16.91 $\pm$ 0.36	18.49 $\pm$ 0.60	16.87 $\pm$ 0.09	17.34 $\pm$ 0.34
Masked RMSE (mm) $\downarrow$	39.71 $\pm$ 1.04	40.80 $\pm$ 0.46	39.54$\pm$0.64	39.56 $\pm$ 0.94	40.23 $\pm$ 0.39	40.01 $\pm$ 0.78	40.09 $\pm$ 0.33

Table S7. Continuous-variable RMSE (mean $\pm$ std across 3 seeds) across the full topology $\times$ conditioning design space for Domain **D04**.

Variable	S0	SC	SF	D0	DC	DF	DF2
PSFC RMSE (hPa)	1.71 $\pm$ 0.03	1.50 $\pm$ 0.02	1.55 $\pm$ 0.07	1.76 $\pm$ 0.01	1.53 $\pm$ 0.01	1.49$\pm$0.03	1.51 $\pm$ 0.03
T2 RMSE (K)	1.80 $\pm$ 0.09	1.46 $\pm$ 0.01	1.47 $\pm$ 0.04	1.91 $\pm$ 0.02	1.48 $\pm$ 0.02	1.45$\pm$0.03	1.45 $\pm$ 0.04
Q2 RMSE (g/kg)	1.78 $\pm$ 0.03	1.74 $\pm$ 0.04	1.74 $\pm$ 0.04	1.76 $\pm$ 0.02	1.76 $\pm$ 0.02	1.76 $\pm$ 0.02	1.72$\pm$0.03
U10 RMSE (m/s)	1.93 $\pm$ 0.05	1.91 $\pm$ 0.05	1.90 $\pm$ 0.02	1.89 $\pm$ 0.01	1.90 $\pm$ 0.01	1.88$\pm$0.01	1.89 $\pm$ 0.01
V10 RMSE (m/s)	2.01 $\pm$ 0.06	1.97 $\pm$ 0.04	1.98 $\pm$ 0.07	1.99 $\pm$ 0.01	1.97$\pm$0.04	1.98 $\pm$ 0.04	2.00 $\pm$ 0.03
Wind RMSVE (m/s)	2.79 $\pm$ 0.06	2.75 $\pm$ 0.04	2.75 $\pm$ 0.06	2.74 $\pm$ 0.01	2.74 $\pm$ 0.02	2.73$\pm$0.04	2.75 $\pm$ 0.02

Table S8. Precipitation skill (mean $\pm$ std across 3 seeds) across the full design space for Domain **D04**.

Metric	S0	SC	SF	D0	DC	DF	DF2
CSI@0.1mm $\uparrow$	0.73 $\pm$ 0.02	0.74 $\pm$ 0.00	0.73 $\pm$ 0.01	0.73 $\pm$ 0.02	0.74$\pm$0.01	0.72 $\pm$ 0.01	0.72 $\pm$ 0.01
CSI@1mm $\uparrow$	0.72 $\pm$ 0.01	0.74 $\pm$ 0.00	0.72 $\pm$ 0.03	0.74 $\pm$ 0.01	0.74$\pm$0.00	0.72 $\pm$ 0.01	0.74 $\pm$ 0.00
CSI@10mm $\uparrow$	0.62 $\pm$ 0.00	0.63 $\pm$ 0.01	0.62 $\pm$ 0.01	0.64 $\pm$ 0.01	0.64$\pm$0.01	0.63 $\pm$ 0.01	0.63 $\pm$ 0.00
Masked MAE (mm) $\downarrow$	36.30 $\pm$ 0.50	34.55 $\pm$ 0.48	35.14 $\pm$ 0.52	34.10 $\pm$ 0.72	34.04$\pm$1.08	34.51 $\pm$ 0.20	34.31 $\pm$ 0.49
Masked RMSE (mm) $\downarrow$	66.26 $\pm$ 1.06	65.69 $\pm$ 1.07	67.15 $\pm$ 0.79	65.35 $\pm$ 1.00	65.61 $\pm$ 1.81	66.42 $\pm$ 1.00	64.80$\pm$0.98