

Evaluation of ICON model in simulating heat wave events over India

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1.2–1.4×

more heatwave days than IMDAA over Northwest and North-Central India

≈ 2×

more heatwave days than IMDAA averaged over All-India

2.4–4.6×

more heatwave days than IMDAA over South Coastal India

3–5 weeks

earlier start of the simulated heat season

1 Why it matters

Pre-monsoon heatwaves are among India's deadliest hazards, and their health impact grows with the number of hot days. Before a model is used for heat-risk work, it must get the frequency of extreme days right, not only mean temperature.

2 Model and experiments

- ICON 2024.01, NWP physics; five one-way nested domains, R3B4 → R3B8 (≈160 → 10 km grid spacing)
- Three free runs, 1 Feb – 31 Oct: 2010 (SST fixed at initial values), 2016 and 2022 (daily ERA5 SST)
- Evaluated on DOM03 (R3B6, ≈26 km effective), the finest nest covering all of India

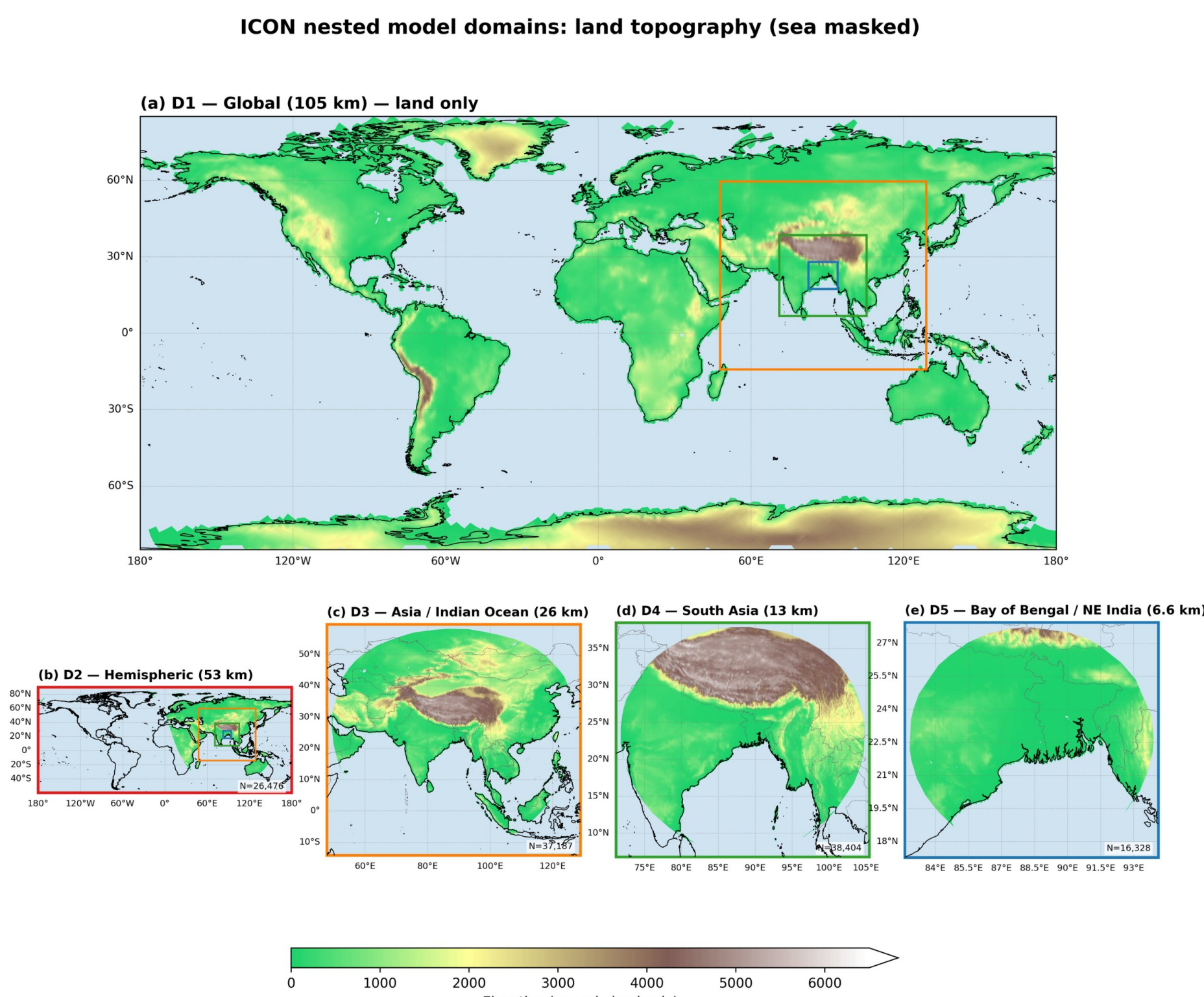


Fig. 1 Nested ICON domains (land topography). Effective spacing: 105, 53, 26, 13 and 6.6 km.

3 Right pattern, too many hot days

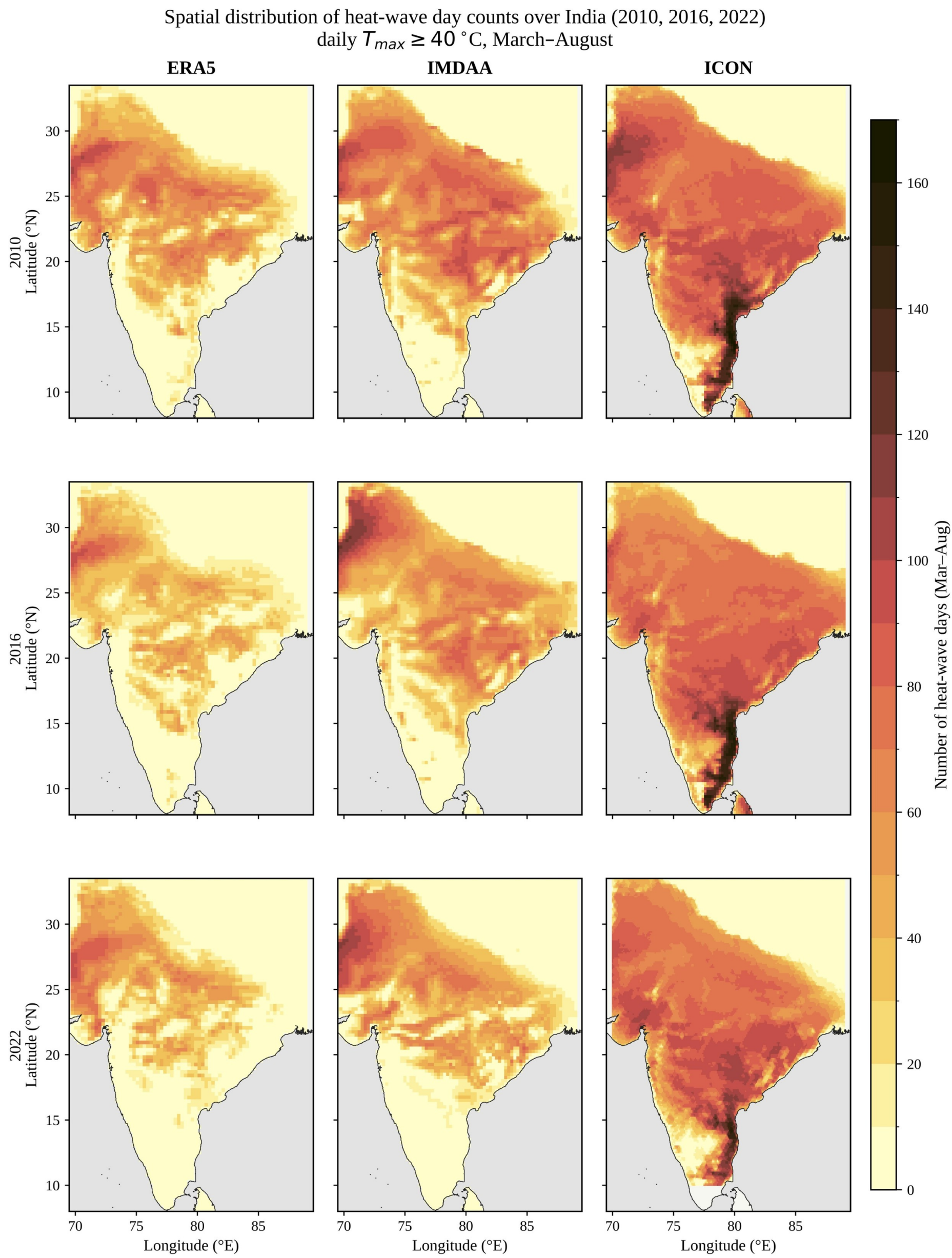


Fig. 2 Heatwave days ($T_{max} \geq 40^\circ\text{C}$), March–August: ERA5, IMDAA, ICON (left to right).

- All datasets: heat core over the northwest; none over the Himalaya, northeast or Western Ghats.
- ICON: 60–90 days across the northern plains, higher and smoother than both reanalyses.
- A spurious belt of **120 to over 160 days** along the Eastern Ghats and the Andhra Pradesh–Tamil Nadu coast; reanalyses show under 40.

4 Method

A **heatwave day** is a day with $T_{max} \geq 40^\circ\text{C}$, counted from 1 March to 31 August against **ERA5** (0.25°) and **IMDAA** (0.12°). For each region, the daily fraction of grid points above 40°C summed over the season gives the area-mean count H.

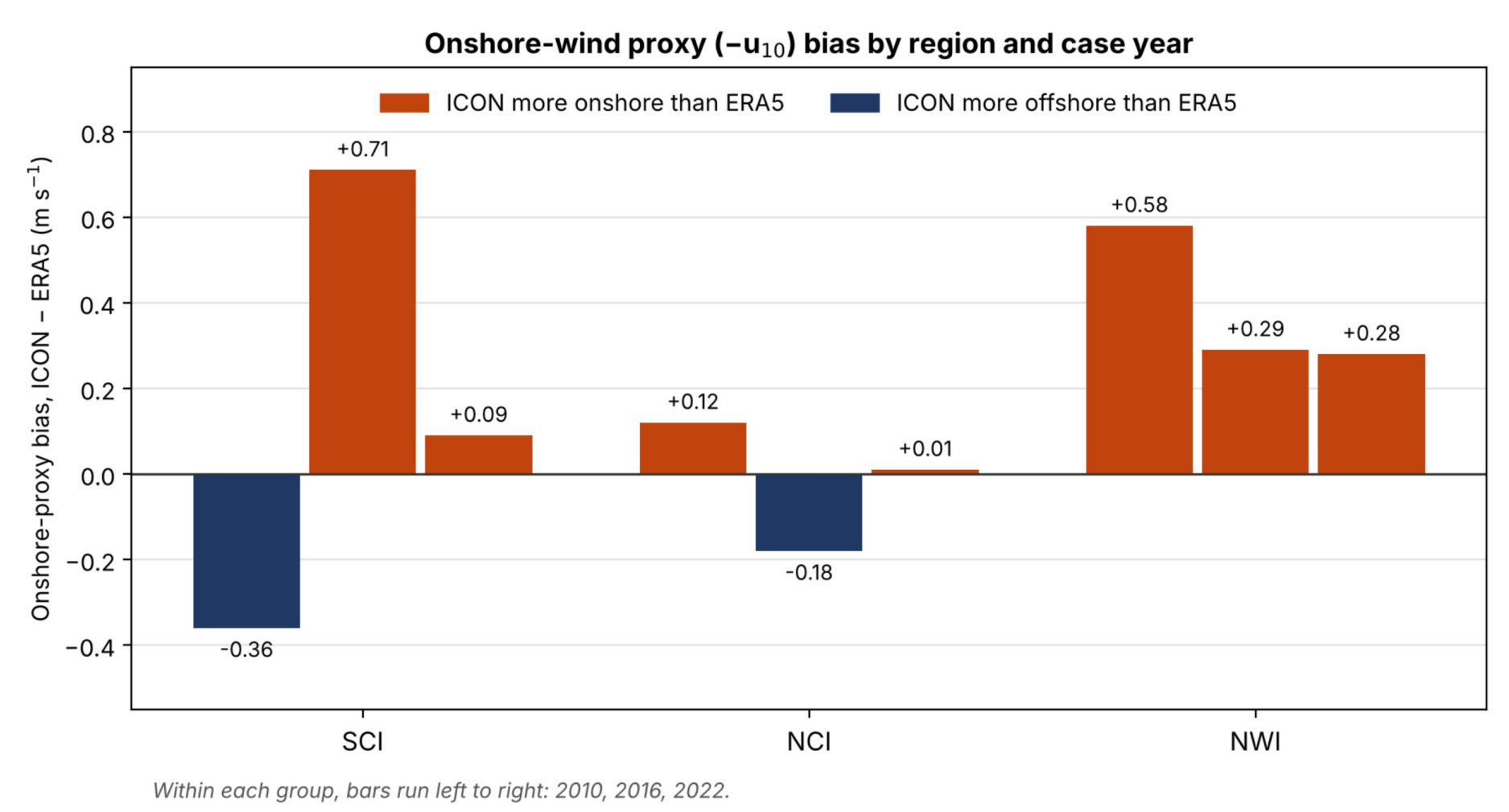
Regions: All-India (AI) · North-Central (NCI, $72\text{--}81^\circ\text{E}$, $24\text{--}30^\circ\text{N}$) · Northwest (NWI, $70\text{--}77^\circ\text{E}$, $22\text{--}31^\circ\text{N}$) · South Coastal (SCI, $79\text{--}83^\circ\text{E}$, $15\text{--}19^\circ\text{N}$)

5 How large is the bias?

Region	ERA5	IMDAA	ICON	ICON ÷ IMDAA
NCI	32–54	51–65	69–76	1.2–1.4
NWI	39–57	53–64	71–81	1.3
AI	12–18	17–25	39–44	1.8–2.3
SCI	8–12	15–31	67–79	2.4–4.6

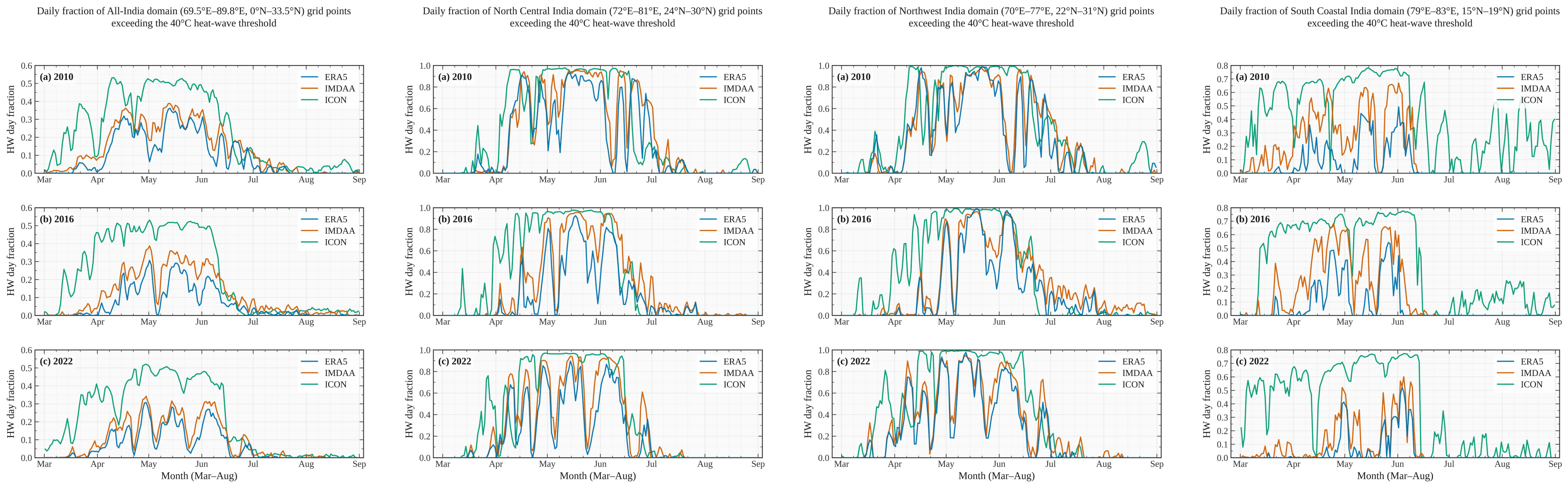
Seasonal area-mean heatwave days (range over 2010, 2016, 2022). All datasets rank 2010 most active; ICON damps the year-to-year contrast.

6 Is the coastal wind to blame?



Over SCI the onshore-wind bias changes sign (-0.36 , $+0.71$, $+0.09\text{ m s}^{-1}$) while the heat bias is large every year: land-surface drying and cloud are the likelier causes.

7 Daily evolution: earlier onset, saturated peak, late coastal heat



Figs. 3–6 Daily fraction of grid points with $T_{max} \geq 40^\circ\text{C}$ for AI, NCI, NWI and SCI (left to right); ERA5 blue, IMDAA orange, ICON green. ICON crosses a fraction of 0.2 in mid-March, against April in the reanalyses, and over SCI keeps exceeding 40°C into July–August.

Conclusions

1. ICON captures where Indian heatwaves occur, when the season ends, and which year was most active.
2. It overestimates heatwave days everywhere: modestly inland (1.2–1.4×), severely along the southeast coast (2.4–4.6×).
3. Wind biases do not explain the coastal hotspot; land-surface coupling and grey-zone convection are the prime suspects.
4. Use ICON for heatwave structure and timing; bias-adjust T_{max} before any impact or exposure estimate.

Selected references

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