

Bridging Science to Practice: Future Weather and Design Conditions

FutureWeather.co: A Web-Based Platform for Generating Future
EPW and DDY Files

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Agenda

1. An Important Challenge: From Research to Practice
2. EPW Generation: Morphing Methodology
3. Technical Approach and Architecture
4. Enhancing Realism: Tail Adjustments & Design Conditions
5. Brief Live Demonstration
6. Open Discussion: Making Outputs Useful in Practice

An Important Challenge: From Research to Practice

THE GAP

- Validated science exists (morphing, downscaling, weather generators)
- Adoption remains limited; not yet standard practice

A BARRIER

- Not only scientific: Product and distribution are key
- Requires sustainable business model and ongoing development

OUR GOAL

- Bridging research to practice
- Meeting practitioners in existing workflows
- Providing a fast, low-cost, and frictionless service

EPW Generation: Morphing Methodology

SCIENTIFIC BASIS

- Rodrigues et al. (2023)¹; peer-reviewed, ~180 citations
- CMIP6 ensemble: 23 GCMs, 4 x SSP scenarios

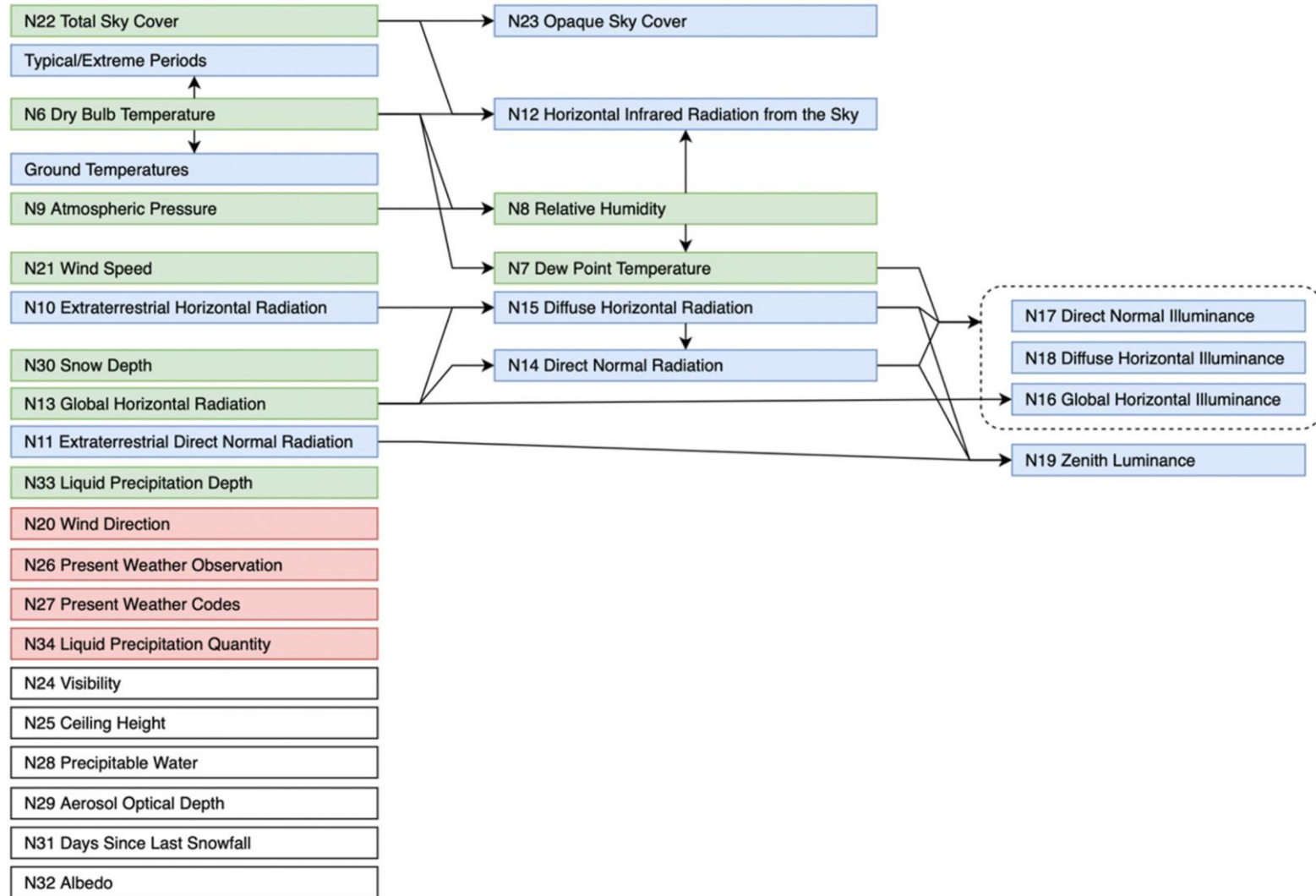
MORPHING APPROACH

- Monthly climate deltas → hourly change factors
- Preserves: Diurnal cycles, synoptic variability, correlations
- Pipeline: T → RH → Tdp → P → Radiation

KEY PRINCIPLE

- Climate signal from GCMs + Weather structure from historical EPW

1. Rodrigues, E., Fernandes, M. S., & Carvalho, D. (2023). Future weather generator for building performance research: An open-source morphing tool and an application. *Building and Environment*, 233, 110104.



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Technical Approach and Architecture

	Future Weather Generator	FutureWeather.co
Method	Rodrigues et al. 2023	Rodrigues et al. 2023
Climate data	23 GCMs, CMIP6	23 GCMs, CMIP6
Future period	2050 or 2080	2040-2090 (inclusive)
Codebase	Java	Python
Outputs	EPW, STAT	EPW, STAT, DDY
Access modes	Desktop	Web, API
Typical runtime	~5-15 minutes	~15-30 seconds
Tail adjustment	No	Yes

Enhancing Realism: Tail Adjustments & Design Conditions

Enhancement 1: Quantile Shape Adjustment (QSA)

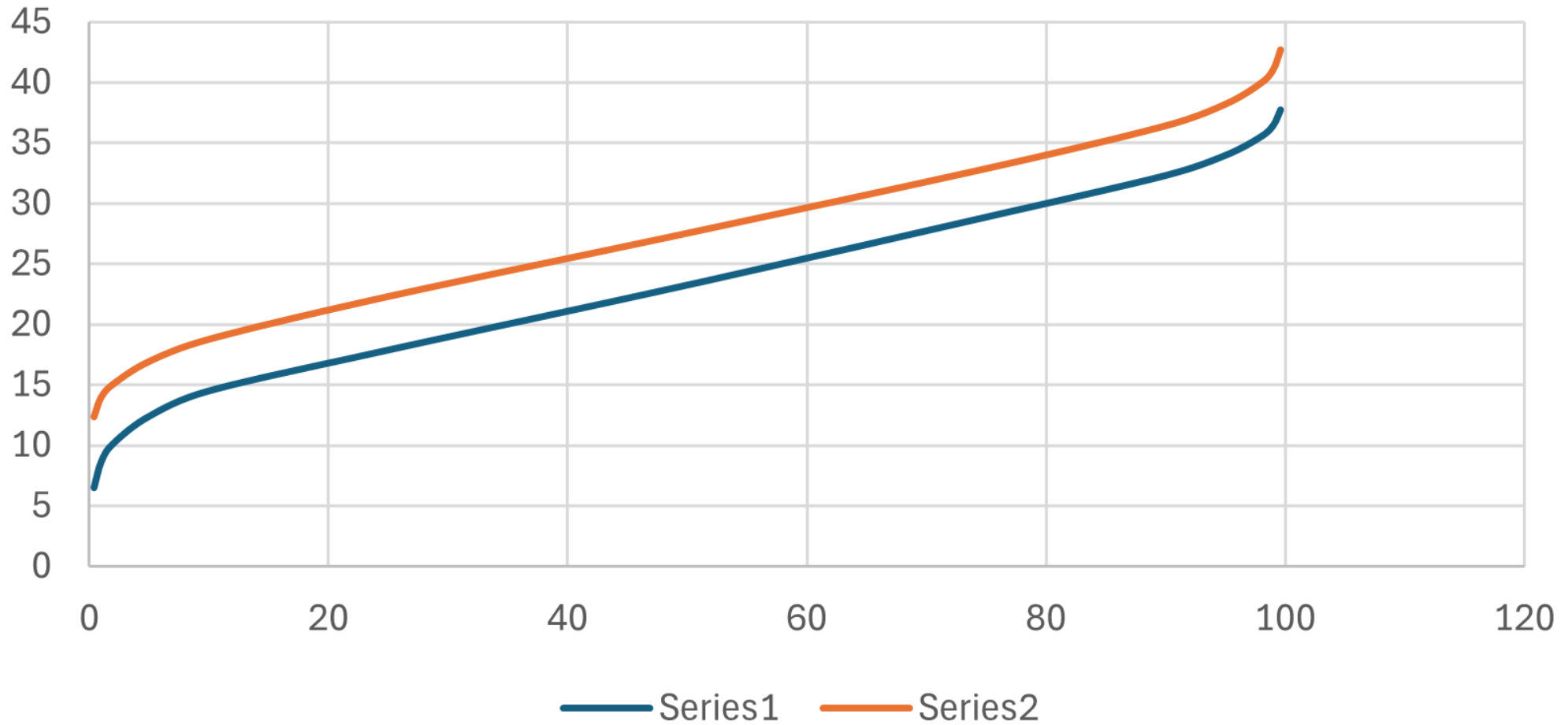
- **The Goal:** Temperature extremes may respond differently to climate change than monthly means—this lets the top 0.4% hottest hours (and coldest) change differently than the median.
- **The Method:** A residual correction applied immediately after standard temperature morphing but before humidity calculations, preserving monthly mean warming while allowing tail independence.
- **Key Detail:** Applied upstream of psychrometric processing—ensuring humidity and enthalpy remain physically valid even as peaks intensify.

Enhancing Realism: Tail Adjustments & Design Conditions

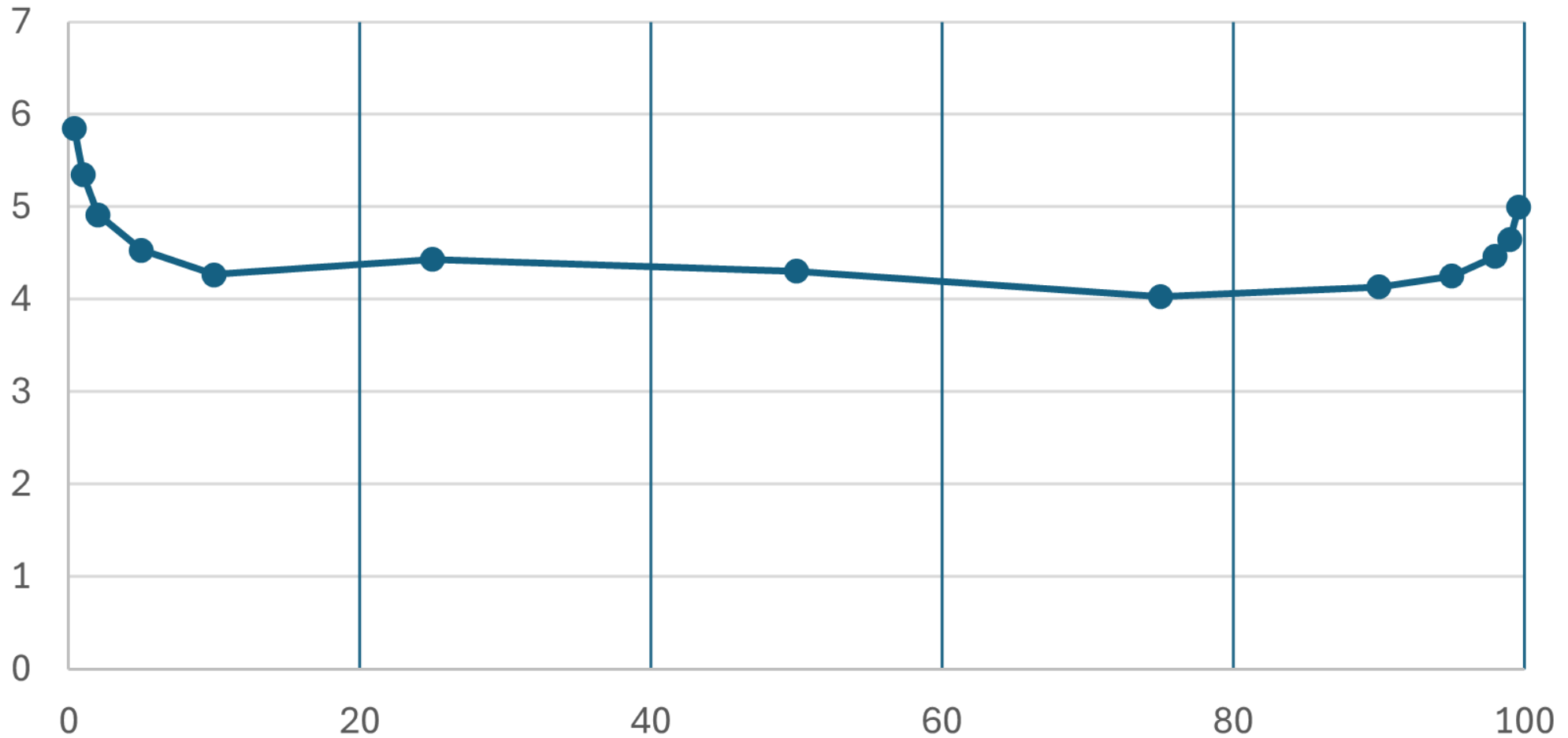
Enhancement 2: Integrated Future DDY Generation

- **The Goal:** In current practice, design conditions remain at historical values even when the EPW is morphed, creating an inconsistency between annual simulation weather and sizing conditions.
- **The Method:** Calculate design statistics from both historical and future EPW files (using percentile analysis and mean coincident values), compute the climate-driven deltas, then apply those deltas to the original DDY file.
- **Key Detail:** This preserves the original DDY structure while ensuring coincident states reflect the full psychrometric response—not just temperature shifts.

Change in temperature (C) by percentile Baseline vs. 2080, September, ssp585, Las Vegas



Change in temperature (C) by percentile
Baseline vs. 2080, September, ssp585, Las Vegas



name			percentile	delta_max_ db	delta_wb_at _max_db	delta_dp_at _max_db	delta_enth_ at_max_db	delta_wind_ speed
Denver Centennial	Golden	N Ann Htg 99.6% Condns DB	99.6	6.4				
Denver Centennial	Golden	N Ann Htg 99% Condns DB	99	5.84				
Denver Centennial	Golden	N Ann Hum_n 99.6% Condns DP=>MCDB	99.6	10.18		10.1		
Denver Centennial	Golden	N Ann Hum_n 99% Condns DP=>MCDB	99	9.52		9.98		
Denver Centennial	Golden	N Ann Htg Wind 99.6% Condns WS=>MCD	99.6	0.05				0
Denver Centennial	Golden	N Ann Htg Wind 99% Condns WS=>MCDB	99	0.05				0
Denver Centennial	Golden	N Ann Clg .4% Condns DB=>MWB	0.4	5.7	nan			
Denver Centennial	Golden	N Ann Clg 1% Condns DB=>MWB	1	6	nan			
Denver Centennial	Golden	N Ann Clg 2% Condns DB=>MWB	2	5.2	nan			
Denver Centennial	Golden	N Ann Clg .4% Condns WB=>MDB	0.4	3.4	3.47			
Denver Centennial	Golden	N Ann Clg 1% Condns WB=>MDB	1	3.08	3.41			
Denver Centennial	Golden	N Ann Clg 2% Condns WB=>MDB	2	3.42	3.52			
Denver Centennial	Golden	N Ann Clg .4% Condns DP=>MDB	0.4	2.94		2.9		
Denver Centennial	Golden	N Ann Clg 1% Condns DP=>MDB	1	2.89		2.8		
Denver Centennial	Golden	N Ann Clg 2% Condns DP=>MDB	2	3.12		2.96		
Denver Centennial	Golden	N Ann Clg .4% Condns Enth=>MDB	0.4	nan			11979.44	
Denver Centennial	Golden	N Ann Clg 1% Condns Enth=>MDB	1	nan			11848.24	
Denver Centennial	Golden	N Ann Clg 2% Condns Enth=>MDB	2	nan			11922.02	

Future Enhancements - Examples

- **GCMEval:** Regional “best model” identification to support model selection/weighting strategies
- **QSA expansion:** Use multiple sub-daily models for tail behavior (currently testing with one; expand to others with sub-daily tas)
- **Downscaled CMIP6:** Integrate regional downscaled products
- **CMIP7:** Add CMIP7 scenarios/models when available
- **Urban Heat Island:** Optional UHI layer (CURA Lab model) to address urban station bias and future UHI signal

Brief Demonstration



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Open Questions for TC 4.2: Making Outputs Useful in Practice

- **Scenario/time packaging:** What's most useful for client conversations? Bundle by scenario, time horizon, or warming level framing?
- **Uncertainty communication:** What representation is defensible and understandable to non-technical stakeholders?
- **Client-ready artifacts:** What should accompany EPW/DDY to support practitioner-to-client communication (1-page summary, plots, standardized language, assumptions/limitations)?
- **Provenance/auditability:** What minimum metadata is required to defend results (data version, model list/weights, parameters, checksums, references)?
- **Workflow accessibility:** What is the most valuable default workflow? Batch generation, API integration into existing tools, or a streamlined UI?
- **Defaults vs controls:** Which parameters must be explicit vs safe defaults to reduce friction while preserving transparency?