

ABLAQ-R05 / ENVIRONMENTAL PHYSICS / VERSION 1.0.0

When weather changes a courtyard comparison

Direct and diffuse solar access at a Jordanian model point, using PVGIS SARAH3 and ERA5 forcing for 2005-2023.

ABLAQ Studios · Published 13 October 2026
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Abstract

A geometry-only ranking need not persist when direct and diffuse solar radiation vary in time. We couple a rectangular courtyard transmission model to two public PVGIS forcing products at 32.3°N, 36.2°E. The comparison covers 27 prescribed geometries, 19 annual periods and 18 complete winters. SARAH3 instantaneous samples and ERA5 hourly means retain distinct time treatments. The primary model includes opaque walls and isotropic diffuse radiation, without reflections.

For 100 m² floors and 5 m walls, the north-south 4:1 plan exceeds a square’s aggregate winter transmission by +0.25 percentage points with SARAH3 and +1.24 with ERA5. The advantage occurs in 14 of 18 SARAH3 winters and all 18 ERA5 winters. A prescribed zenith-weighted sky reverses the small aggregate SARAH3 advantage. The result supports a qualified conclusion: a direct-sunlight advantage alone is insufficient to establish a stable total-radiation ranking.

Original forcing, calculated tables, a separate polygon-clipping audit, reproducible source and sensitivity analyses accompany the report. These are internally verified model results, not observations of courtyard performance or evidence of thermal comfort.

Primary winter result	PVGIS-SARAH3	PVGIS-ERA5
Square / 0°	29.76%	27.35%
4:1 / north-south	30.01%	28.59%
Elongated minus square	+0.25 pp	+1.24 pp

Report and research materials: ablaqstudios.com/weather-weighted-solar-access

1. Question, system and evidence

Scientific question

ABLAQ-R02 established seasonal direct-access differences; ABLAQ-R03 quantified diffuse sky access; ABLAQ-R04 showed that a prescribed diffuse fraction can reverse a ranking. This report asks whether the square-versus-elongated comparison remains stable when those fractions and direct irradiance are supplied by public historical radiation products.

Controlled geometry

Floor area is fixed at 100 m². Aspect ratios are 1, 2 and 4; uniform wall heights are 2.5, 5 and 7.5 m; long-axis bearings are 0°, 45° and 90° clockwise from north. All 27 combinations are retained. The benchmark contrast is the 4:1 north-south courtyard minus the 0° square at 5 m height. A square at 45° is a distinct solar-orientation case.

External forcing and provenance

The European Commission Joint Research Centre's PVGIS 5.3 service supplies SARA3 satellite-derived and ERA5 reanalysis-derived horizontal beam and diffuse irradiance. Requests use the same coordinates, 2005-2023 period, horizontal plane and no terrain horizon. The coordinate is a model point near Mafraq, not a claimed monitoring site, building or institutional address. The two products are alternative forcing estimates; neither is treated as ground truth.

Each product contains 166,536 hourly labels, including leap days. Source responses are retained losslessly with request parameters, acquisition dates and SHA-256 digests. Meteorological records predate this analysis; ABLAQ did not collect them. Study work and publication occurred in October 2026.

Time and period definitions

The captured SARA3 records occur at minute 09 and represent instantaneous satellite samples. They receive one-hour weights for aggregation. ERA5 records occur at minute 30 and represent hourly averages. ERA5 shading is averaged across each represented hour while conserving the supplied horizontal beam exposure. No local civil-time conversion is applied.

Annual and June-August summer summaries cover 2005-2023. Winter is the contiguous December-February interval labelled by its January year. Only complete winters 2006-2023 are retained. Aggregate ratios use sums of exposure, not averages of yearly percentages.

Data-quality finding

SARA3 contains 424 unflagged records with zero beam plus diffuse irradiance when the calculated sun exceeds 10° elevation, across 220 UTC dates. ERA5 has no such records. We preserve these provider values in the primary analysis, do not infer their cause, and separately remove the same affected dates from both products. This diagnostic screen was added after inspection; it is not a preregistered exclusion or an imputation.

2. Mathematical and numerical methods

Direct sunlight

For width $W = \sqrt{(100/r)}$, length $L = \sqrt{(100r)}$, height H , and solar direction (e', n', z) rotated into the courtyard axes, the directly illuminated floor fraction for $z > 0$ is:

$$f = \max(0, 1 - |H e' / z| / W) \times \max(0, 1 - |H n' / z| / L)$$

For $z \leq 0$, direct transmission is zero. Solar position uses pvlib's implementation of the NREL Solar Position Algorithm with geometric topocentric elevation, provider elevation above sea level, computed ΔT and no atmospheric refraction. An alternative NOAA approximation measures algorithm sensitivity; it is not the primary ephemeris.

Diffuse access and total transmission

F_0 is the area-averaged view factor between a rectangular floor and its congruent opening, using the established parallel-rectangle relationship from ABLAQ-R03. For horizontal beam B and diffuse D , the primary transmission over a period is:

$$T = \Sigma(B f + D F_0) / \Sigma(B + D)$$

The same one-hour integration factor appears in numerator and denominator. Beam and diffuse values are already horizontal irradiances; no second cosine factor is applied to B . Reflected radiation from walls, ground and surrounding objects is excluded.

Conservative within-hour treatment

For ERA5, the effective f is $\Sigma(f_i z_i) / \Sigma(z_i)$ across twelve five-minute midpoint samples inside the hour. This assumes constant within-hour direct normal irradiance and preserves the supplied horizontal beam total. A 24-sample repeat tests numerical convergence. Applying an interval average to SARA3 is retained only as a time-representation sensitivity; it cannot recover missing subhourly observations.

Prescribed sky-distribution sensitivity

We use nonnegative axisymmetric radiance $L(\alpha) \propto 1 + q \sin(\alpha)$, with $q = -0.8, 0$ and 2 . All distributions are normalized to the same horizontal diffuse input. These are controlled angular stress tests, not inferred weather states or calibrated sky models.

$$Fq = (F_0 + q J_1) / (1 + 2q/3)$$

$$J_1 = (1/\pi) \int f(\alpha, \beta) \sin^2(\alpha) d\Omega$$

J_1 is computed by hemispherical quadrature and compared with a separate floor-to-opening surface integral. Negative q weights the horizon more; positive q weights the zenith more. The profile has no circumsolar component, azimuthal variation or spectral distinction.

3. Results: season and year both matter

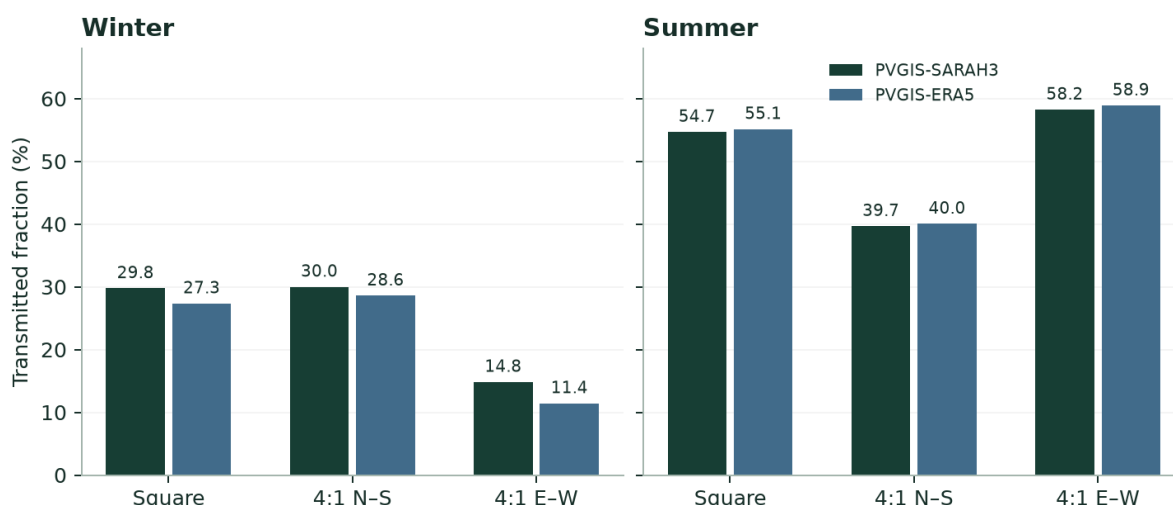


Figure 1. Exposure-weighted transmission for three selected 100 m² plans at 5 m height. Each forcing product is retained separately. Winter uses 18 complete seasons; summer uses 19.

Under the primary isotropic model, winter transmission is 29.76% for the square and 30.01% for the north-south elongated plan with SARAH3. The corresponding ERA5 values are 27.35% and 28.59%. Both aggregate comparisons favour the elongated plan, but by substantially different margins.

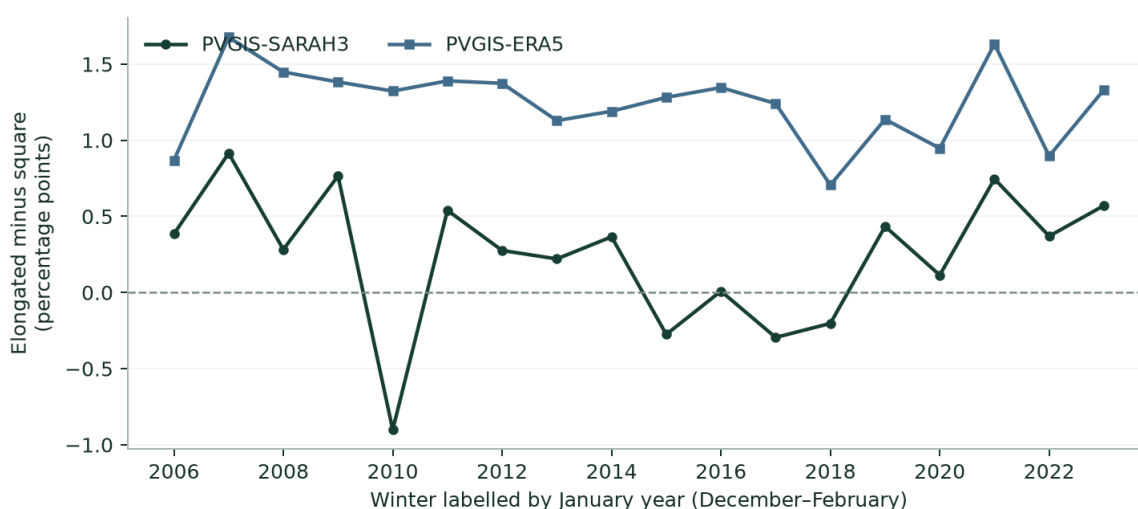


Figure 2. Paired winter differences at 5 m height. Values above zero favour the north-south elongated plan. The difference changes sign in the SARAH3 series; it remains positive in ERA5.

The elongated plan is higher in 14 of 18 SARAH3 winters and 18 of 18 ERA5 winters. SARAH3 differences range from -0.90 to +0.91 percentage points; ERA5 ranges from +0.71 to +1.68. These are descriptive year ranges, not confidence intervals or independent experimental replicates.

4. Sensitivity and robustness

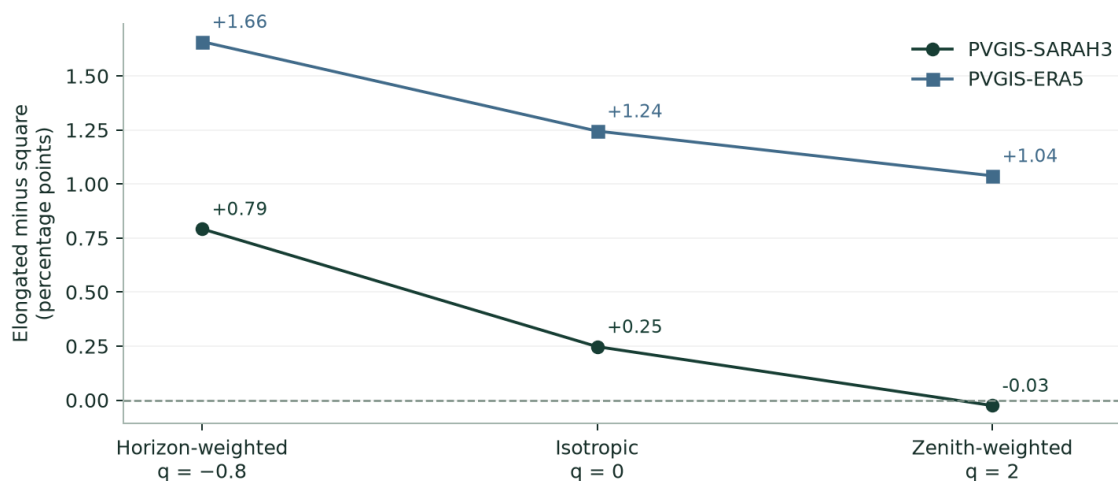


Figure 3. Aggregate winter ranking under three prescribed sky-radiance profiles, with the same external diffuse totals. The small SARAH3 ranking reverses under the zenith-weighted case.

The zenith-weighted sky gives a SARAH3 difference of -0.03 percentage points, compared with +0.25 under the isotropic sky. This sign change is small in magnitude and is evidence of assumption sensitivity, not evidence that either form is optimal.

Winter comparison / 5 m	SARAH3 difference	ERA5 difference
Primary, isotropic	+0.25 pp	+1.24 pp
Matched-day quality screen	+0.25 pp	+1.24 pp
Horizon-weighted sky	+0.79 pp	+1.66 pp
Zenith-weighted sky	-0.03 pp	+1.04 pp

Numerical resolution is a separate question

Across all 27 geometries and both products for the 2023 annual, summer and within-year winter-block comparisons, five-minute versus 2.5-minute integration changes total transmission by at most 0.00072 percentage points. This is numerical convergence under the same hourly forcing, not a bound on meteorological or model error.

The maximum point-sample versus interval-average difference in that diagnostic is 0.556 percentage points. Changing SPA to the NOAA approximation at the same point timestamps changes total transmission by at most 0.240 percentage points. These tests support using consistent time definitions and an explicit ephemeris.

5. Verification and reproducibility

Check	Coverage	Observed agreement
Analytical fraction vs polygon clipping	1,000 off-grid synthetic geometries and directions	2.2e-16 maximum absolute fraction error
Diffuse-sky formulations	9 width/height pairs; angular and surface integrals	7.9e-09 maximum J_1 difference
Separate end-to-end accumulation	2023 annual; 3 selected plans × 2 products	5e-13 maximum transmission difference
Published energy identities	3,024 seasonal rows and 162 aggregate rows	All within 2×10^{-11} after CSV rounding
Fresh-process reproduction	Complete source run with retained input bytes	All computational outputs byte-identical

The separate audit does not import the primary study code: it clips projected polygons and accumulates scalar exposures independently. It shares pvlib's astronomical library and the same forcing inputs. It is an internally executed implementation comparison, not replication by an external researcher.

Reproduction

The research materials include both original compressed PVGIS responses, acquisition receipts, exact dependency versions, primary software, the separate verifier, calculated CSV tables and file digests. The main calculation makes no network requests.

```
python3 -m pip install -r requirements-weather.v1.txt
python3 -B weather-study.v1.py --inputs inputs --output results
python3 -B verify-weather.v1.py --inputs inputs --results results \
  --output independent-audit.json
```

The backslash continues the final command on the next line. Use compare-weather.v1.py to compare the generated outputs with the published computation manifest. CSV values use 12 significant digits; figure labels round for readability. The data dictionary defines every field and unit.

Publication record

Version 1.0.0, first published 13 October 2026. Original reports ABLAQ-R01 to R04 retain their own versions and conclusions within their defined assumptions. R05 extends the forcing and sensitivity analysis; it does not turn the earlier idealized calculations into field observations.

Public record: ablaqstudios.com/research-record

Methods and corrections: ablaqstudios.com/open-science

6. Interpretation, responsibility and sources

What the work supports

At this model point and within the prescribed geometry, the direct-light advantage of a north-south elongated plan does not establish an invariant advantage for combined direct and diffuse exposure. Between-year variability, the forcing product and the sky distribution matter most when the ranking margin is small. The large winter disadvantage of the east-west elongated example is distinct from that near-tie.

Limits that affect use

The analysis covers one coordinate, two gridded radiation products and idealized opaque courtyards. It omits wall reflections, surrounding terrain and buildings, vegetation, variable wall height, glazing, sky azimuthal structure, thermal storage and occupant behaviour. No courtyard measurements calibrate or validate the predicted fractions. Source products are not statistically independent samples, and their disagreement is not a probability interval. Hourly sampling and unflagged source zeros remain evidence limits despite sensitivity checks.

No result establishes a universally optimal courtyard, measured energy savings, indoor daylight compliance, cooling performance or thermal comfort. Such claims require additional models and suitable observations. The primary contribution is the documented comparison and its robustness analysis using established physics.

Authorship and scientific accountability

ABLAQ Studios is the institutional author and publisher. Osama Khaled Ahmed Abdel-Qader, Scientific Research Lead and Founder & CEO, directs the research programme and holds responsibility for its scientific decisions, interpretation, publication and corrections.

Computational tools, including AI-assisted development and documentation, support implementation, numerical checks and preparation of this report. They are not authors. The work has not undergone external peer review. Questions and corrections: osama.khaled@ablaqstudios.com.

References

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- [6] ABLAQ Studios. Radiative research reports R02-R04 (2026).

PVGIS data: European Commission JRC / CM SAF SARA3 and ECMWF ERA5, retained under source usage terms. Original ABLAQ code, numerical outputs and figures: CC0 1.0. Institutional identity and third-party material are excluded.