Climate

A 30–Year Site-Level Climate Overview for Planning and Design

September 2025

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1 Introduction

This report presents a synthesis of key climate indicators based on about 30 years of data for the selected site. It is intended to support land managers, designers, and planners in understanding long-term trends and seasonal patterns relevant to agriculture, infrastructure placement, ecological restoration, and energy planning.

The report focuses on frost occurrence, solar insolation, precipitation, temperature, wind dynamics, and their trends over time. The data is presented visually, with intuitive plots that highlight variability, extremes, and long-term changes. Where applicable, guidance is provided on how each variable can inform decision-making on the ground.

This document is part of an ongoing effort to provide actionable, localized climate intelligence to support regenerative and resilient land use design.

2 Frost

The frost visualization in Figure 1 captures patterns in the timing of frost events over the past 30 years, offering insights into seasonal transitions and, by extension, the duration and boundaries of the growing season.

Two heatmaps illustrate:

- **Last Spring Frost:** Shows the weeks of the year when the final frosts most frequently occurred.
- **First Autumn Frost:** Shows the weeks when the first frosts most frequently occurred.

Together, these heatmaps define the typical frost-free window between the last spring frost and the first autumn frost, representing the core period suitable for planting and growing. The consistency or variability of this window across years signals the level of climatic reliability: a narrow, stable gap suggests a predictable growing season, while a broader or shifting gap indicates greater year-to-year uncertainty.

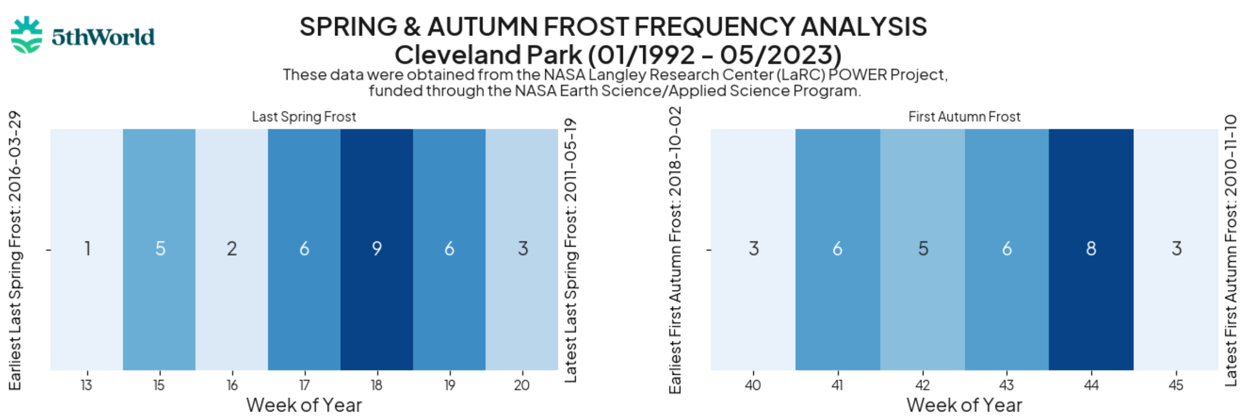

Figure 1: Weekly frequency of last spring frost (left) and first autumn frost (right) over the past 30 years. Each cell represents one week of the year. The number inside each cell indicates how many years, among those that experienced frost, had their last (spring) or first (autumn) frost in that week. Darker shades correspond to higher frequencies of frost occurrence.

3 Solar Insolation

The solar insolation visualization (Figure 2) illustrates the typical distribution of daily sky clearness over the past 30 years, highlighting which months tend to be sunnier or cloudier.

Monthly violin plots display how daily values of the clear-sky insolation index are distributed throughout the year. This index measures the relative clarity of the sky, where higher values correspond to clearer, sunnier days and lower values indicate more cloud cover. The width of each violin plot reflects the frequency of those values: wider sections represent common sky conditions, while narrower sections indicate less frequent ones.

This visualization reveals seasonal patterns in atmospheric clarity. Months with broad, elevated distributions suggest consistently clear skies, whereas those with distributions skewed toward lower values indicate frequent cloudiness or more variable weather.

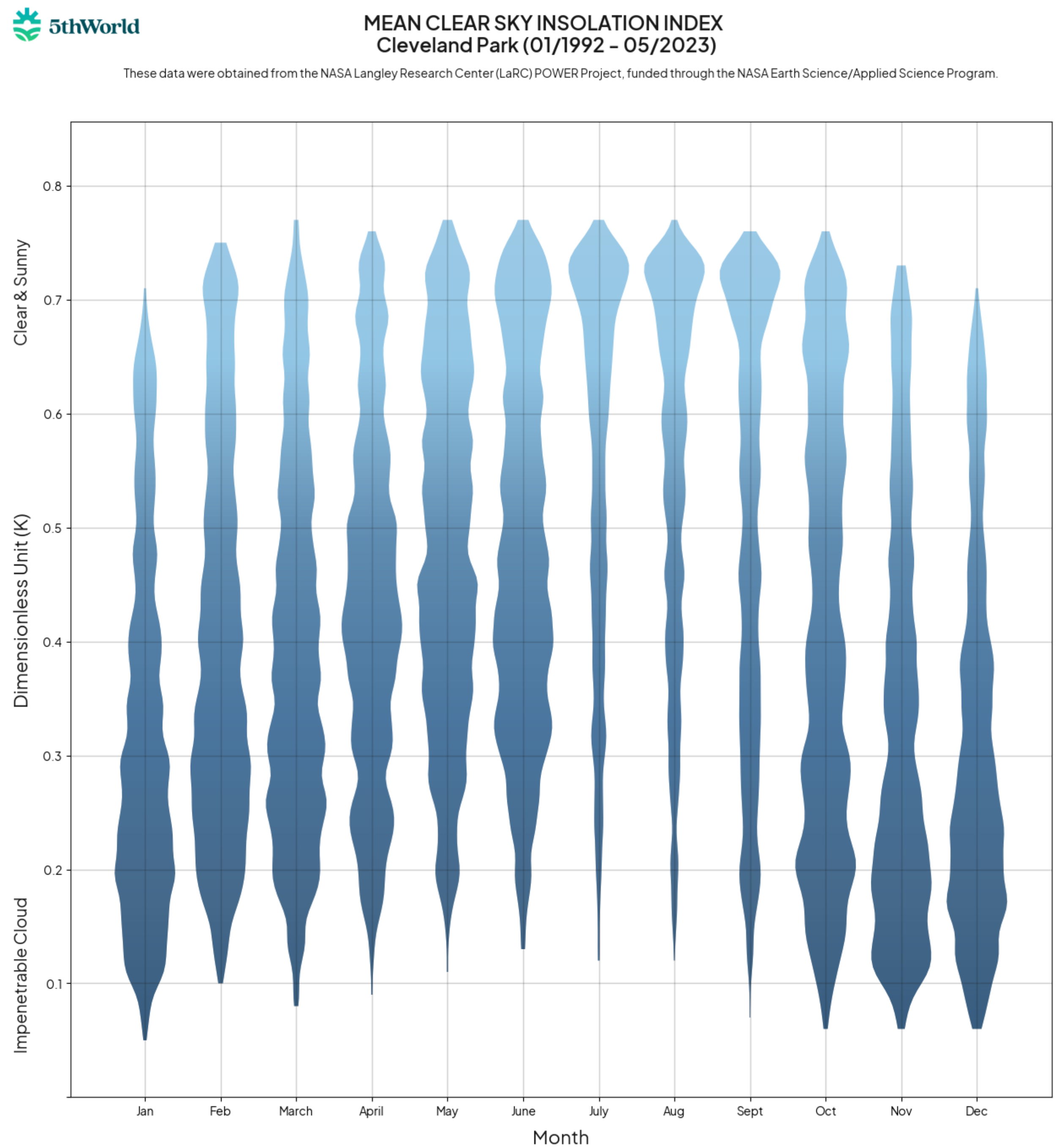

Figure 2: Monthly distribution of daily clear-sky solar insolation index values over 30 years. Each violin plot shows the frequency of daily sky clearness values for that month, with wider sections representing more frequent conditions. A color gradient from dark (low clearness, "Impenetrable Cloud") to light (high clearness, "Clear & Sunny") illustrates the scale. Note: this index reflects relative sky clarity and does not represent actual solar energy flux.

4 Precipitation

The precipitation visualization (Figure 3) offers a dual perspective on monthly rainfall patterns, capturing both typical variability and extreme events.

Monthly Precipitation Characteristics:

- The navy blue line traces the average total precipitation for each month.
- Shaded bands surrounding the mean convey variability: the darker blue region shows the interquartile range (middle 50% of monthly totals), while the lighter blue area extends from the minimum to the maximum observed values. Together, they reflect both typical fluctuations and outlier conditions.

Highest Single-Day Rainfall:

- Red bars mark the most intense rainfall events for each month, highlighting the maximum precipitation recorded on a single day.
- These peaks help identify months prone to heavy downpours, useful for assessing flood risks or planning drainage, erosion control, and water harvesting systems.

This combination of statistical range and extremes offers a practical view of precipitation behavior, supporting informed water and land management decisions.

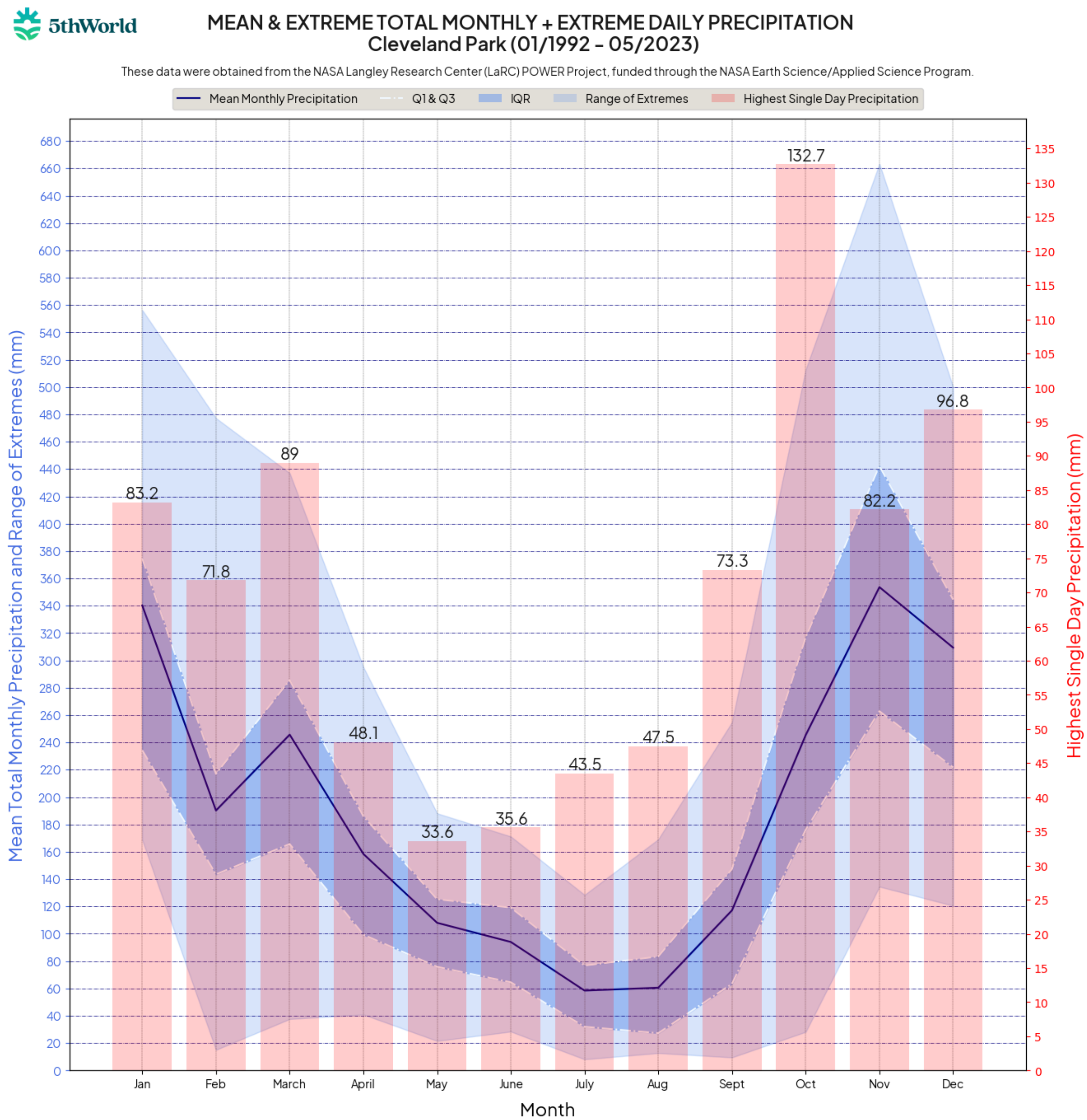

Figure 3: Monthly precipitation summary. The navy blue line represents average monthly totals, with shaded bands indicating variability: the interquartile range (darker blue) and full observed range (lighter blue). Red bars show the highest single-day rainfall recorded in each month.

5 Temperature

The Figure 4 visualization summarizes the distribution and variability of daily mean, maximum, and minimum temperatures throughout the year. Understanding these patterns is critical for assessing thermal regimes that affect plant viability, energy demand, comfort, and climate adaptation strategies.

Each month is represented by three violin plots:

- **Mean temperatures** (white) reflect average daily conditions relevant to baseline thermal comfort and vegetation growth.
- **Maximum temperatures** (red) highlight periods of potential heat stress for plants, animals, and infrastructure.
- **Minimum temperatures** (blue) indicate cold-season risks, including frost damage, freezing pipes, or limits to overwintering species.

The width of each violin shows the frequency of values, and the vertical extent captures the full observed range. Wider sections indicate more consistent temperatures; taller violins suggest higher variability or extremes.

Together, these distributions provide a nuanced picture of thermal behavior across seasons, vital for selecting species, designing passive heating/cooling strategies, and managing temperature-sensitive infrastructure.

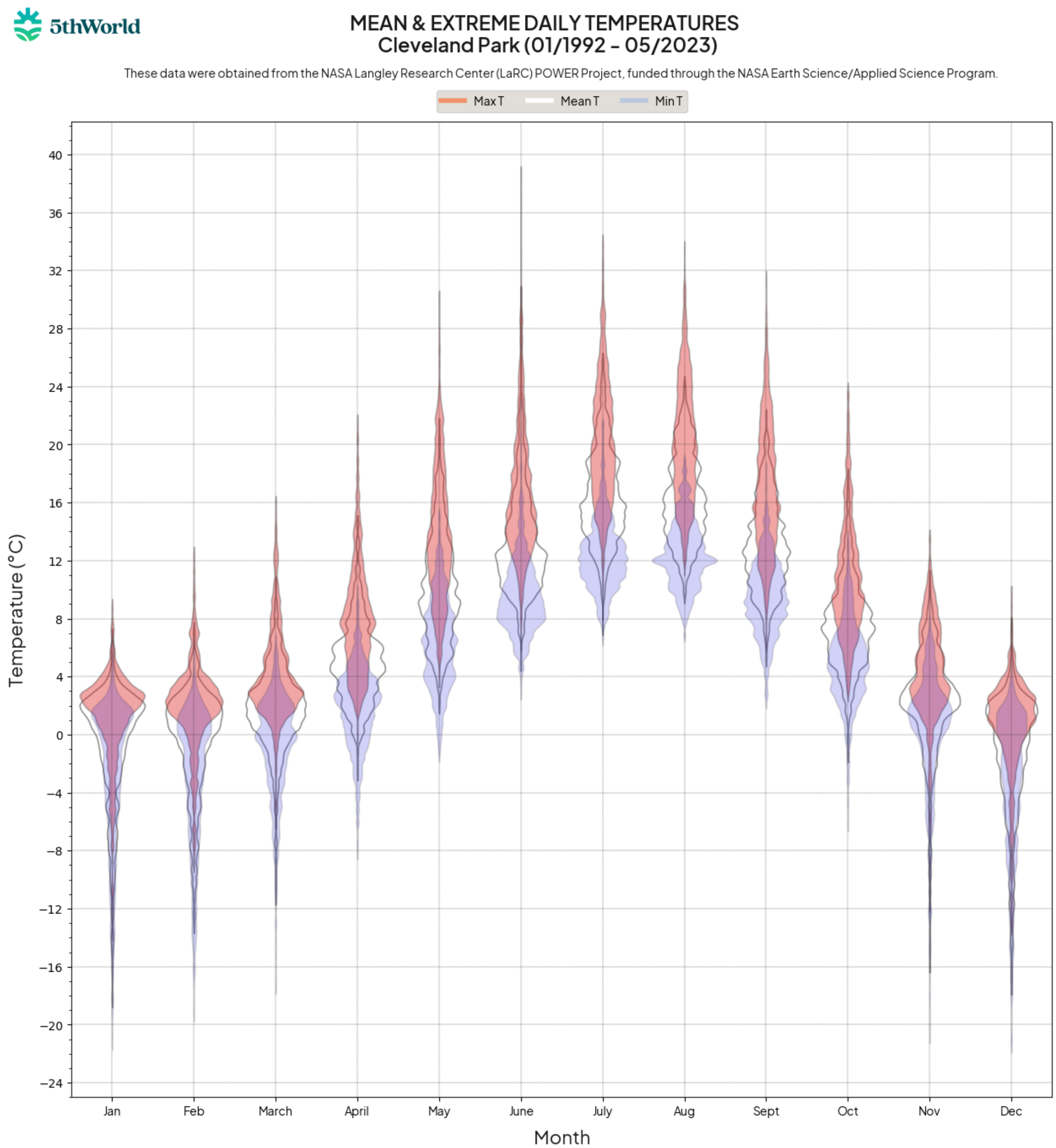

Figure 4: Monthly distribution of daily mean (white), maximum (red), and minimum (blue) temperatures. Violin plot widths reflect the frequency of values, while the vertical range represents observed extremes. This visualization captures both typical and exceptional temperature conditions throughout the year.

6 Wind

Wind patterns shape microclimates, influence evaporation and fire behavior, and guide the placement of structures, vegetation, and infrastructure. This section presents both seasonal and combined wind rose visualizations to support site-specific planning.

6.1 Seasonal Wind Patterns

Seasonal wind roses (Figure 5) illustrate how prevailing wind directions and intensities shift throughout the year. This seasonal breakdown is essential for:

- **Windbreak and shelterbelt design:** Aligning vegetation or structures with dominant seasonal winds enhances protection and improves edge microclimates.
- **Microclimate optimization:** Exposure to or shelter from winter winds, summer breezes, or drying gusts can be designed intentionally.
- **Water management:** Wind affects snow drift, evaporation, and rainfall distribution; understanding patterns supports the placement of ponds, swales, or catchment surfaces.

6.2 Annual Wind Patterns

The combined wind rose summarizes overall wind behavior across the full year, useful for high-level orientation and design decisions. Key applications include:

- **Structure orientation:** Shielding greenhouses, homes, or sheds from dominant wind directions reduces heat loss and structural stress.
- **Odor and smoke management:** Wind direction informs siting of compost, toilets, or burn piles to reduce downwind impact.
- **Pollination and pest transport:** Wind-driven pollen or airborne pests follow these dominant paths, which may influence planting layout.
- **Fire safety and resilience:** In fire-prone regions, wind direction informs the design of firebreaks, fuel load zones, and emergency access.

Figure 5: Seasonal wind rose diagrams showing prevailing directions and frequencies for each quarter. These support planning of windbreaks, ventilation, snow and moisture management, and seasonal microclimate control.

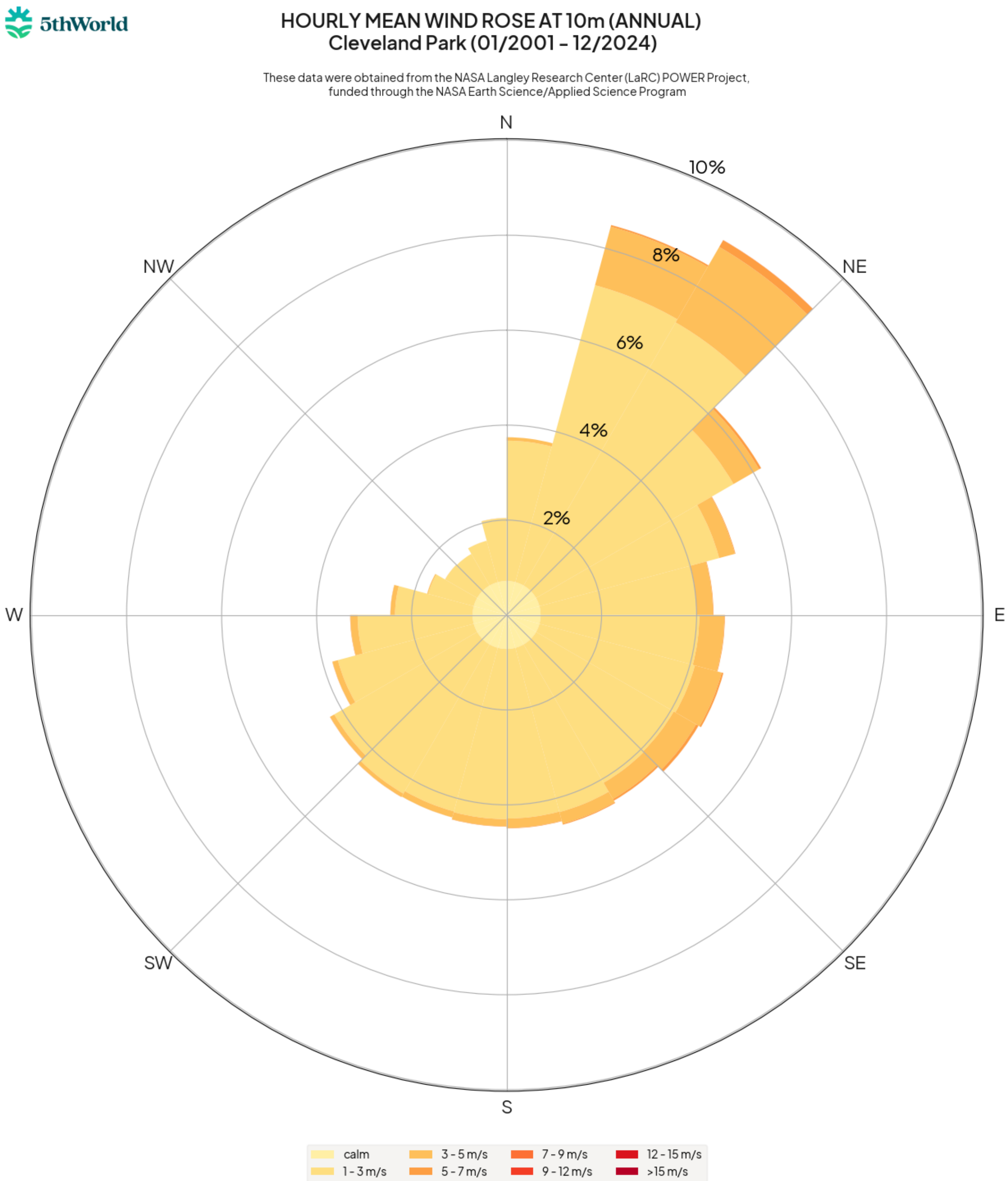

Figure 6: Annual wind rose showing the dominant wind directions and frequencies for the site. This supports general site orientation and the placement of structures, vegetation, and sensitive infrastructure.

7 Temperature Trends

The visualization of Figure 7 highlights seasonal trends in daily temperature extremes, offering a window into how local climate dynamics have shifted over time. It focuses not just on average seasonal conditions, but on the full spectrum of observed daily highs and lows within each season.

The left panel displays trends for daily **minimum temperatures**:

- **Maximum of daily minima**: the warmest night in each season.
- **Mean of daily minima**: the average of all nighttime lows in the season.
- **Minimum of daily minima**: the coldest recorded temperature each season.

The right panel shows the same metrics for daily **maximum temperatures**:

- **Maximum of daily maxima**: the hottest day in the season.
- **Mean of daily maxima**: the average of all daytime highs.
- **Minimum of daily maxima**: the coolest daytime high.

Straight lines indicate statistically significant trends:

- **Red** indicates warming.
- **Blue** indicates cooling.
- The intensity of each line reflects the significance level of the trend.

These trends provide critical insight for long-term planning. For example, rising cold-season minimums may reduce frost risk, while increasing maximums can intensify heat stress. Tracking both ends of the spectrum supports climate resilience in planting decisions, habitat design, infrastructure durability, and human comfort.

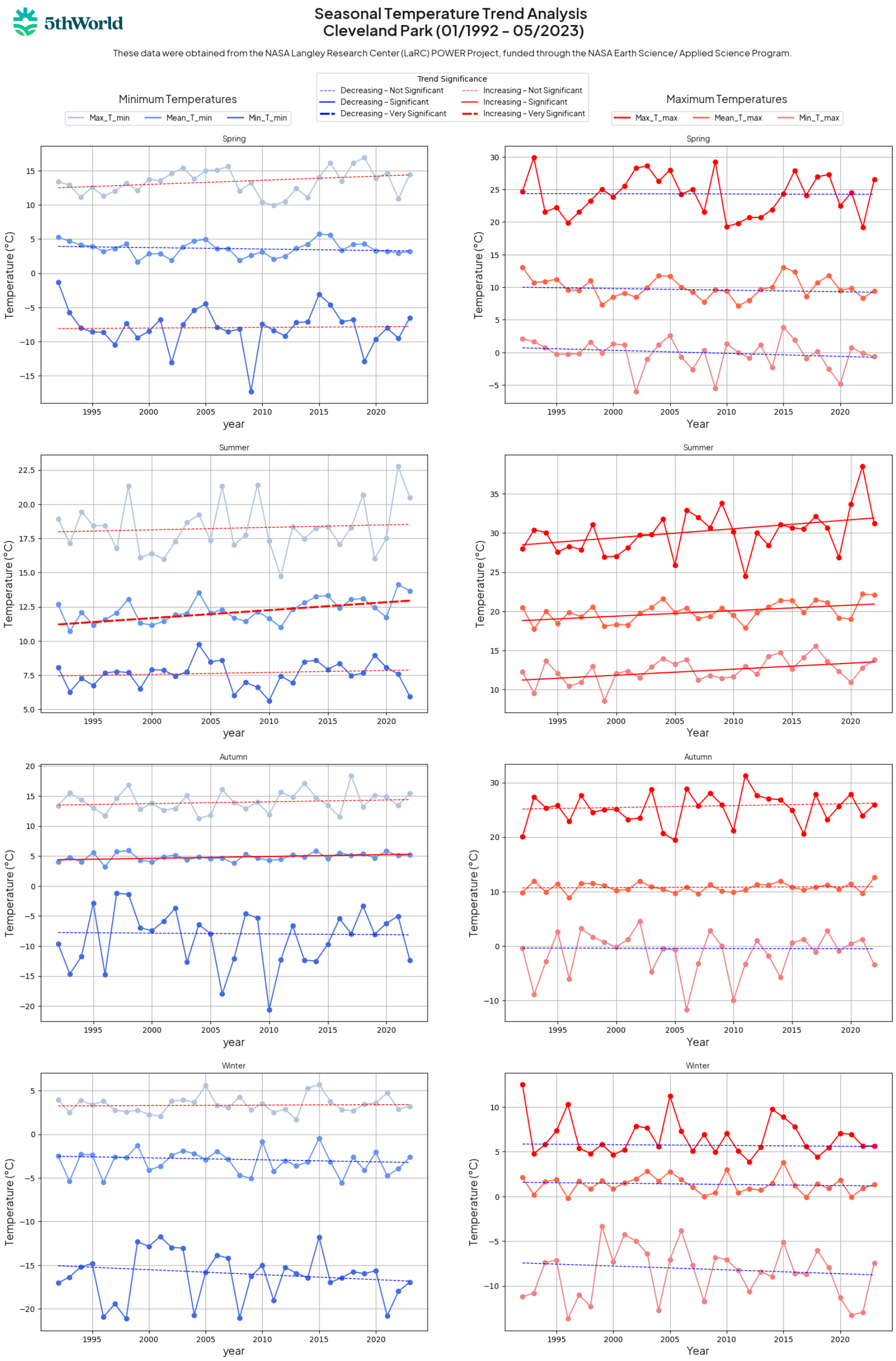

Figure 7: Seasonal temperature extremes over time. The left panel shows trends in the minimum, mean, and maximum values of daily minimum temperatures; the right panel presents the same for daily maximum temperatures. Straight lines indicate statistically significant warming (red) or cooling (blue), with line width reflecting the level of statistical confidence. This visualization highlights how the full range of daily temperature extremes has evolved across seasons.

8 Next Steps and How We Can Help

This report provides a foundational climate overview to support informed decision-making on your land. But it's only the beginning. Our team offers a suite of specialized tools and services to help you turn climate intelligence into effective, site-specific design, management, and regenerative outcomes.

Topography-Based Solar and Microclimate Analysis: Beyond sky clearness, we deliver high-resolution solar radiation modeling that accounts for topography, climate, and shadow effects. Outputs include shortwave radiation (for energy harvesting, heating, and microclimate tuning) and PAR (for evaluating potential vegetation growth and productivity).

Precipitation-Informed Water Harvesting Design: We generate terrain-sensitive strategies for rainwater harvesting, infiltration, and storage—tailored to your seasonal rainfall patterns and landform—to strengthen water resilience and landscape health.

Wind Exposure and Shelter Mapping: Our analysis identifies wind-exposed and wind-sheltered areas across your site, guiding the placement of buildings, windbreaks, wind-energy systems, and shelter-sensitive infrastructure.

Expert-Led Regenerative Design Support: Our team can help you interpret climate data in the context of your land's ecology and vision. We offer design consulting, strategy development, and co-creation of regenerative systems across climate zones and bioregions.

For more about our mission and full service offerings, visit: `www.5thworld.com`