Recommendations for Potential Uses of Climate Data Available in the Atlas

This document describes some of the potential use that the climate information in the Climate Risk Atlas for Grenada can provide in the context of decision making in agriculture and other climate-vulnerable sectors in the country. This document is not comprehensive in extent but rather a guide for users to help them visualize how the information can be used to inform adaptation within a risk management framework. When possible, we provide examples for the agriculture, water resource management, infrastructure and tourism sectors for Grenada. We highlight and differentiate the use of historical data versus scenario-driven data. For example, the 1981-2020 precipitation climatology has different uses within the sectors discussed above. For agriculture, analyzing long-term precipitation trends helps identify periods of drought or excessive rainfall that affect crop yields. Historical correlations between rainfall anomalies and harvest levels (e.g., nutmeg, cocoa, root crops) can inform drought-resilient crop planning and anticipatory actions. Naturally, for this information to be useful in this context, the users will need to get ahold of the production data for the crops of interest. In the case of water resource management, this information supports modeling of river flow and aquifer recharge, identifying dry season trends that may compromise potable water availability or irrigation systems. For the infrastructure sector, managing the risk of flooding can be very important. Here, the historical precipitation records can help locate flood-prone areas based on historical wet season intensities, informing road network design, drainage systems, and location of critical infrastructure (e.g., hospitals). Similarly, understanding seasonality of rainfall helps predict high-risk periods for landslides or road washouts affecting eco-tourism destinations, like those seen in the west-side of Grenada. A deeper analysis can also enable the participation of other sectors like NGOs and humanitarian organizations to develop parametric insurance schemes like those created recently in similar contexts in the region. The projected precipitation data in the Atlas can have other uses. For instance, in the water security and infrastructure sector, the 2030, 2050, and 2070 projections under the SSP24.5 and SSP58.5 scenarios can have divers uses including anticipating seasonal water shortages or excess precipitation risks (e.g., flash flooding, landslides) with added confidence intervals to help assess confidence in potential droughts or floods. In the agricultural sector, the projected precipitation data can help identify shifting rainy seasons, impacting sowing dates and crop calendars. These projections can be used to stress-test cropping systems under plausible futures as demonstrated in the Atlas section on Food Security. In the disaster risk management sector, these projections can help highlight months and years where extreme wet or dry events become more probable and inform dam operation, drainage design, and land-use zoning. You can easily compare projected June–August precipitation under SSP5-8.5 in 2070 against current crop water needs for nutmeg or cocoa, adjusting irrigation design accordingly. In the next sections, specific examples are presented for most of the data sets available in the Atlas.

1981-2020 Precipitation Climatology

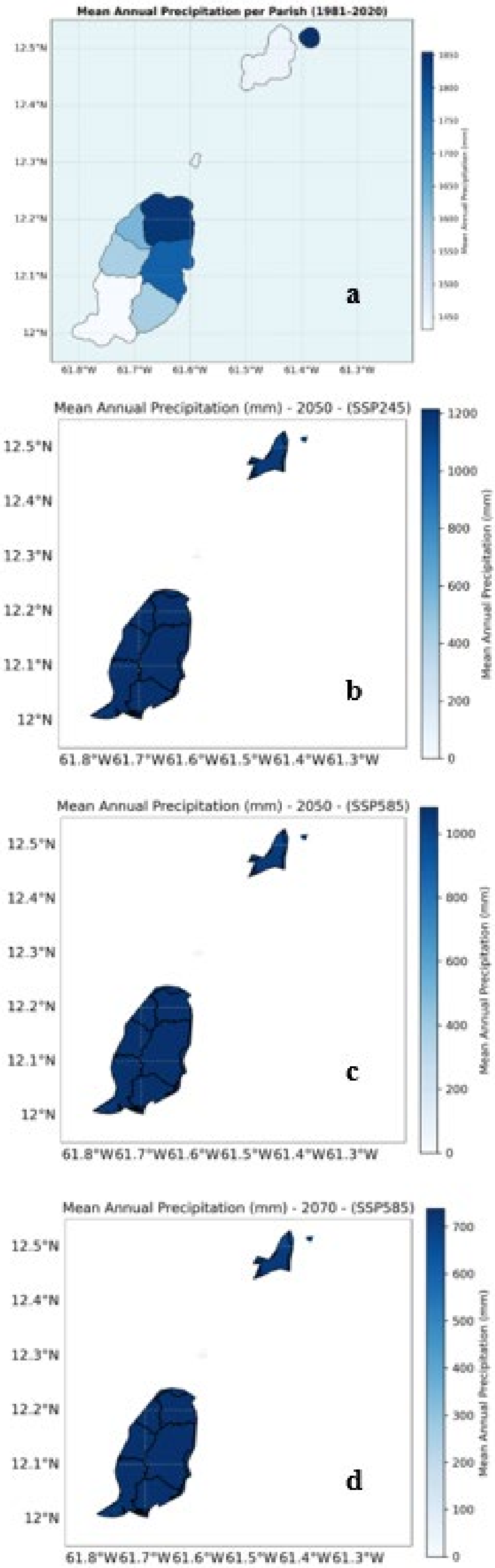
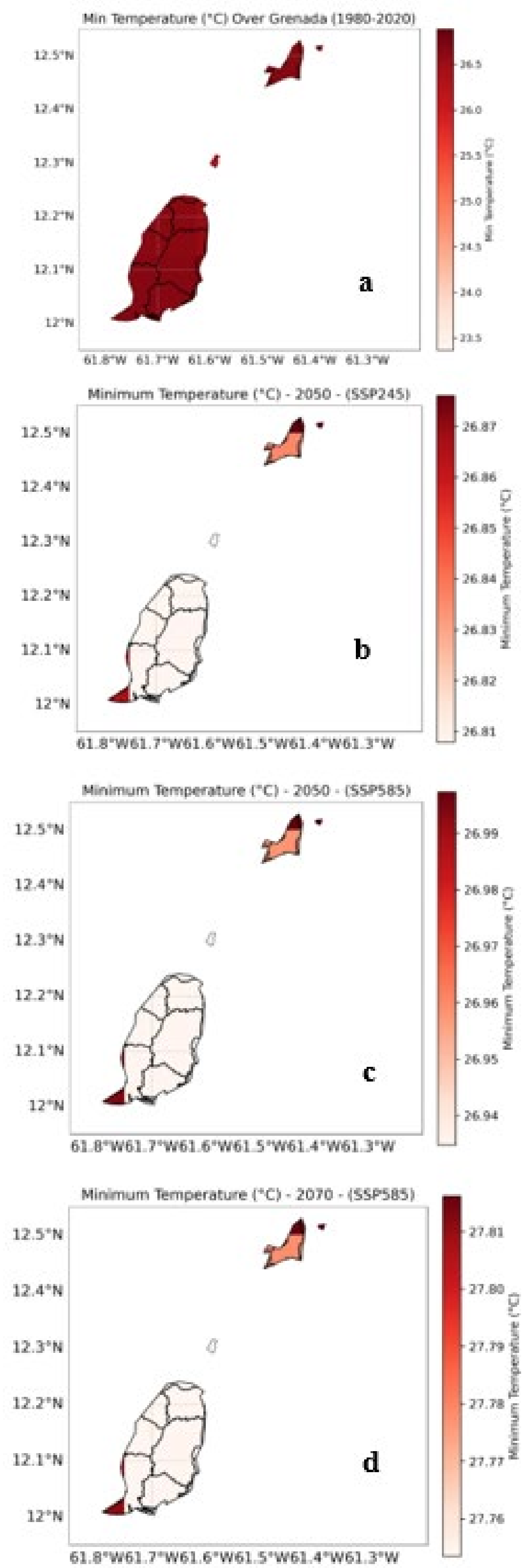


Figure **a** shows the baseline data for the 1981-2020 Precipitation Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSp58.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest. The most useful information in these images corresponds to the changes in the mean state of the variable of interest. Here, the mean annual precipitation baseline shows a high record of 1850 mm or Petite Martinique and St. Patrick, with some of the lowest average records in St. George of around 1450 mm (see Figure a) for the 1981-2020 period. However, the scenarios produced by the model ensemble for the 2050 period suggest decreasing annual accumulated precipitation for both the SSP24.5 (medium range emissions) and the SSP58.5 (high emission scenario). The SSP24.5 scenario (Figure b) suggests a maximum annual accumulated precipitation of 1200 mm – which represents 600 mm less on average under medium-range emissions. Similarly, the SSP8.5 scenario (Figure c) suggests a maximum of 1,100 mm for the same 2050 period. Additionally, we have included projections of annual accumulated precipitation for the 2070 period for both the SSP24.5 and SSP58.5 scenarios. Figure d shows the dramatic decrease of precipitation under the high-emission scenario with a total of 725 mm of total annual accumulated precipitation – a sharp decrease from the 1850 mm estimated for the baseline. This information can be used to generate awareness of the potential magnitude of expected changes in the annual accumulated precipitation in Grenada.

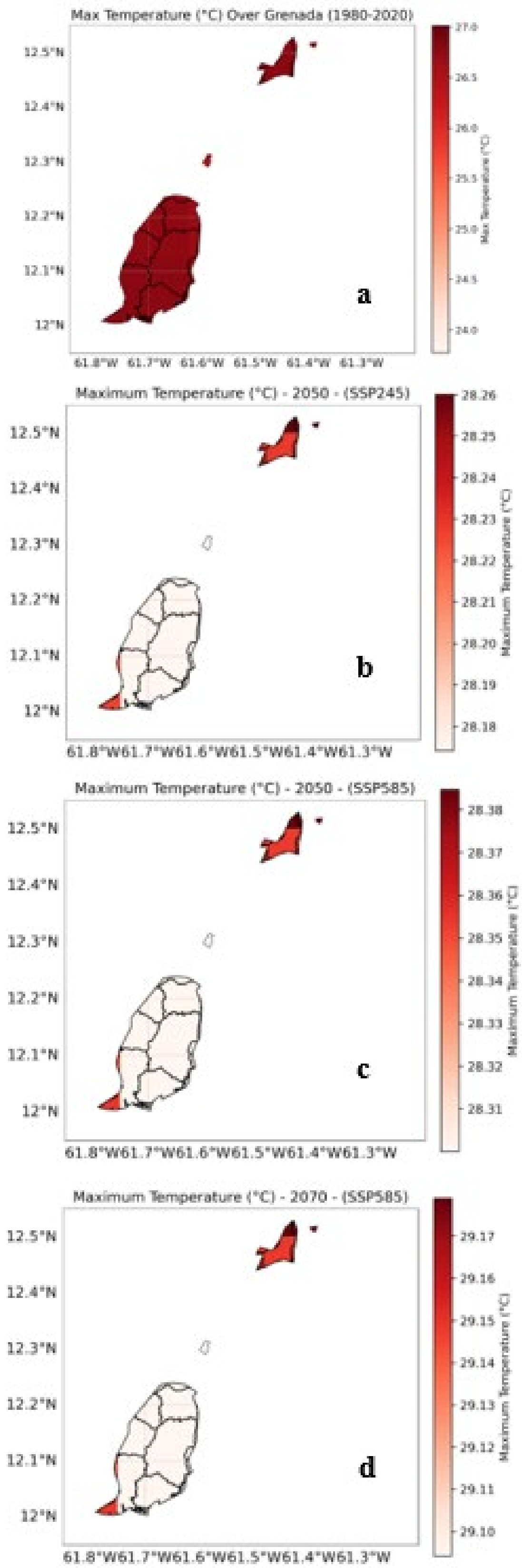
1981-2020 Minimum Temperature Climatology



Like the Annual Accumulated Precipitation, figure **a** shows the baseline data for the 1981-2020 Minimum Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSP58.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

As discussed previously, the most useful information in these images corresponds to the changes in the mean state of the variable of interest projected visually. In this case, the minimum temperature climatology baseline shows an average of 26.5 ˚C for most of Grenada (see Figure a) for the 1981-2020 period. However, the scenarios produced by the model ensemble for the 2050 period suggest an increasing minimum temperature for the entire territory with Carriacou and Petite Martinique showing the highest increases in minimum temperature for both the SSP24.5 (medium range emissions) and the SSP58.5 (high emission scenario). The SSP24.5 scenario (Figure b) suggests a minimum temperature of around 26.81 for most of Grenada, representing an increase of a third of a degree. Similarly, the SSP8.5 scenario (Figure c) suggests a minimum temperature of 26.94 for the same 2050 period. The projections of minimum temperature for the 2070 SSP58.5 scenario suggest an increase of more than a degree under the high-emission scenario.

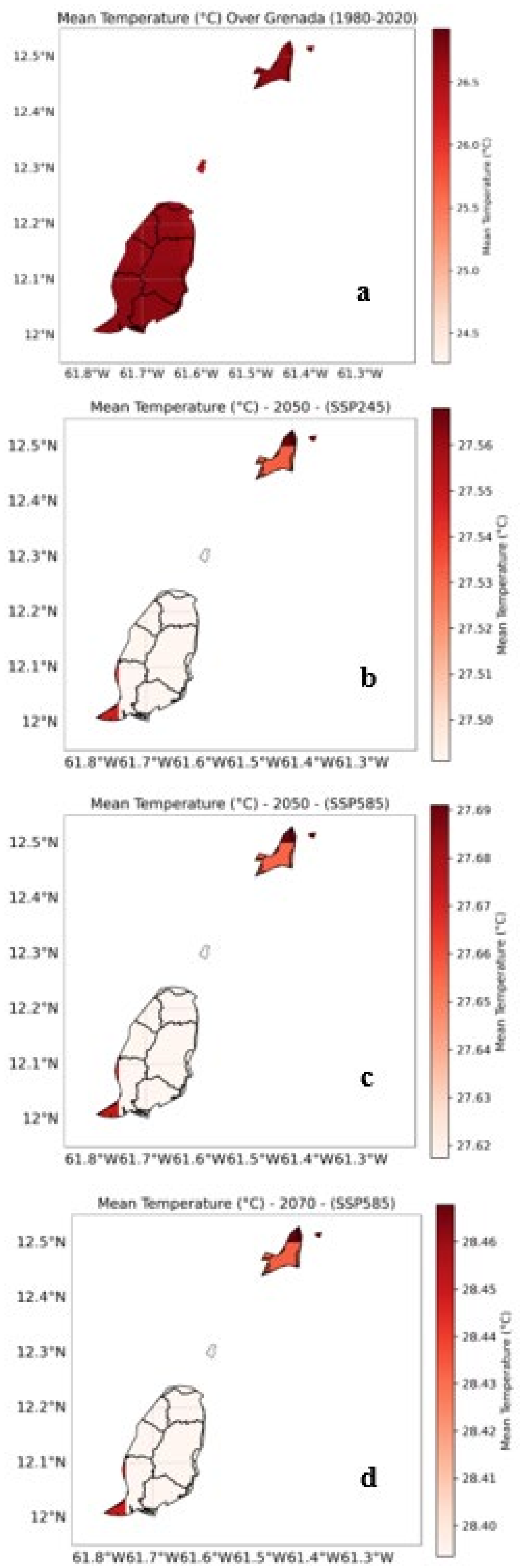
1981-2020 Maximum Temperature Climatology



This section shows in figure **a** the baseline data for the 1981-2020 Maximum Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSP58.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

The changes in the mean state of the maximum temperature among periods can inform preparedness and adaptation in the long term. In this case, the maximum temperature climatology baseline shows an average of 27 ˚C for most of Grenada (see Figure a) for the 1981-2020 period. However, the scenarios produced by the model ensemble for the 2050 period suggest an increasing maximum temperature for the entire territory with Carriacou and Petite Martinique showing the highest increases in minimum temperature for both the SSP24.5 (medium range emissions) and the SSP58.5 (high emission scenario). The SSP24.5 scenario (Figure b) suggests a maximum temperature of around 28.26 for most of Grenada, representing an increase of more than a degree. Similarly, the SSP8.5 scenario (Figure c) suggests a maximum temperature of 28.38 for the same 2050 period. The projections of maximum temperature for the 2070 SSP58.5 scenario suggest an increase of more than two degrees under the high-emission scenario.

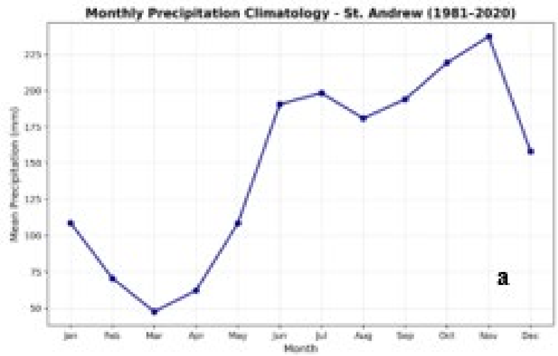
1981-2020 Mean Temperature Climatology

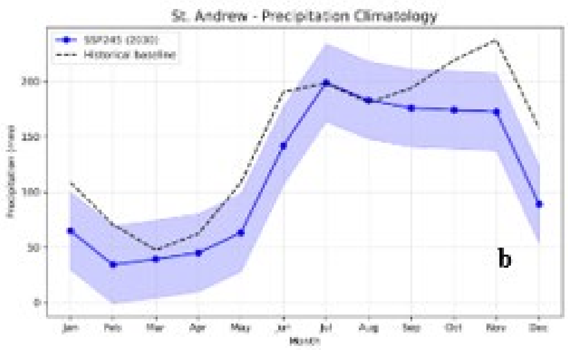


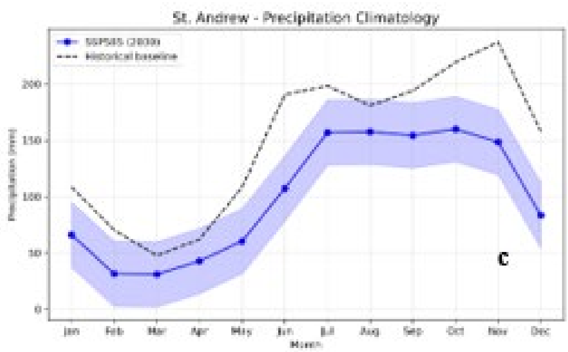
Following the comparison from the other temperature projections against the baseline, figure **a** shows the baseline data for the 1981-2020 Mean Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSP58.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest under the high-emission scenario by 2070.

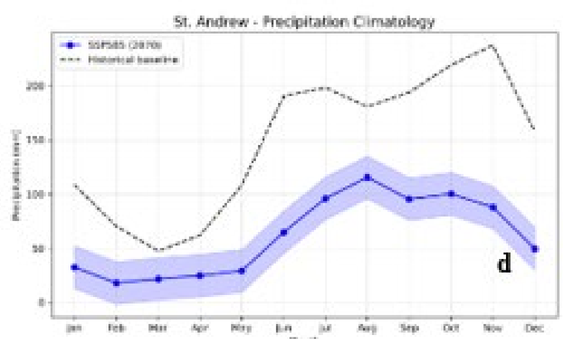
Here, the mean temperature climatology baseline shows an average of 26.57 ˚C for most of Grenada (see Figure a) for the 1981-2020 period. However, the scenarios produced by the model ensemble for the 2050 period suggest an increasing mean temperature for the entire territory with Carriacou and Petite Martinique showing the highest increases in minimum temperature for both the SSP24.5 (medium range emissions) and the SSP58.5 (high emission scenario). The SSP24.5 scenario (Figure b) suggests a mean temperature of around 27.50 ˚C for most of Grenada, representing an increase of around a degree in mean temperature for this period. Similarly, the SSP8.5 scenario (Figure c) suggests a mean temperature of 27.62 ˚C with higher increased for Carriacou, Petite Martinque and southern St. George for the same 2050 period. The projections of mean temperature for the 2070 SSP58.5 scenario suggest an increase of more than a degree under the high-emission scenario with 28.40 ˚C for most of the country.

1981-2020 Monthly Precipitation Climatology





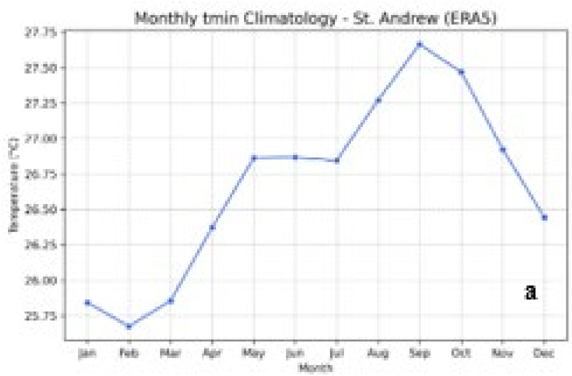


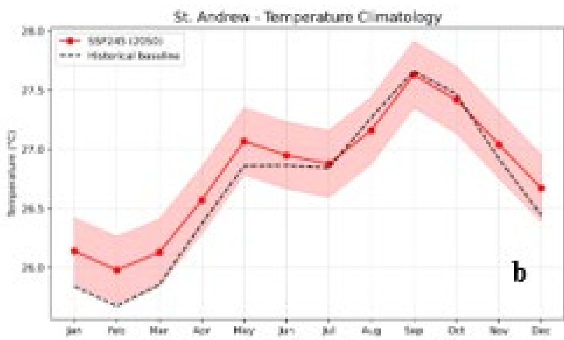


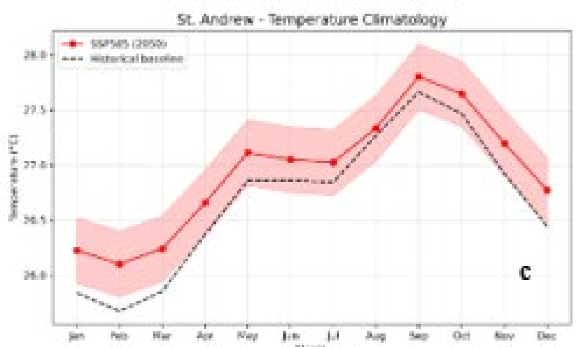
This set of images representing the monthly precipitation climatology may be very informative for decision-making around agriculture and other sectors. Change in the distribution of precipitation throughout the year can inform the selection of plant varieties for agriculture, fertilization schemes, irrigation periods, pest management, etc. Figure **a** shows the baseline data for 1981–2020 Monthly Precipitation Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSp58.5). Image **d** shows the extreme departure of monthly precipitation from the baseline conditions.

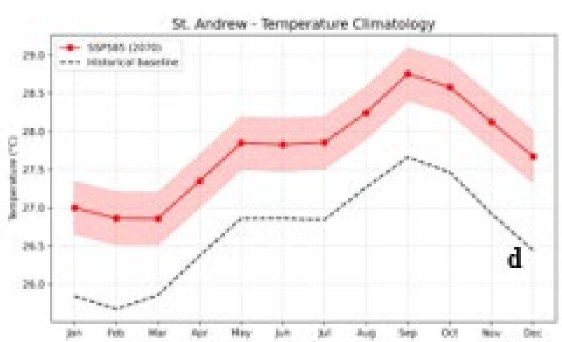
- **Uses for Climate Risk & Vulnerability Reduction:**
- Agriculture: Enables determination of the length of the rainy season, critical for planting calendars and identifying dry spells during crop-sensitive stages.
- Water Management: Assists in seasonal reservoir planning, predicting critical months of water scarcity for drinking, irrigation, or hydropower.
- Disaster Risk Management: Supports detection of seasonal flood peaks, useful for early warning systems and floodplain zoning.
- Tourism: Helps identify low-rainfall months that align with peak tourist seasons or riskier periods for outdoor activities.

1981-2020 Monthly Minimum Temperature Climatology









This set of images provides additional information for decision-making in the agricultural sector. The intersection of increasing temperatures and decreasing precipitation in critical months can create an increase in aridity arising from the soil moisture loss, impacting crops. Figure **a** shows the baseline data for 1981–2020 Monthly Minimum Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios. In the SSP58.5 scenario you can see the beginning of a departure from the baseline values. By 2070, none of the projected temperatures fall within the confidence intervals in the baseline.

• **Uses for Climate Risk & Vulnerability Reduction:**

• Agriculture: Guides timing of crop sowing and harvesting by indicating coldest months—important for tubers, vegetables, or highland crops.

• Health: Reveals months with warmest nights, linked to sleep disruption, chronic disease exacerbation, and reduced cooling relief.

• Energy: Identifies nighttime temperature patterns that affect energy demand for cooling, influencing energy security and cost planning.

Example Analysis:

• Mapping changes in nighttime thermal comfort indices over the year to inform public health outreach and infrastructure cooling strategies.

1981-2020 Monthly Maximum Temperature Climatology

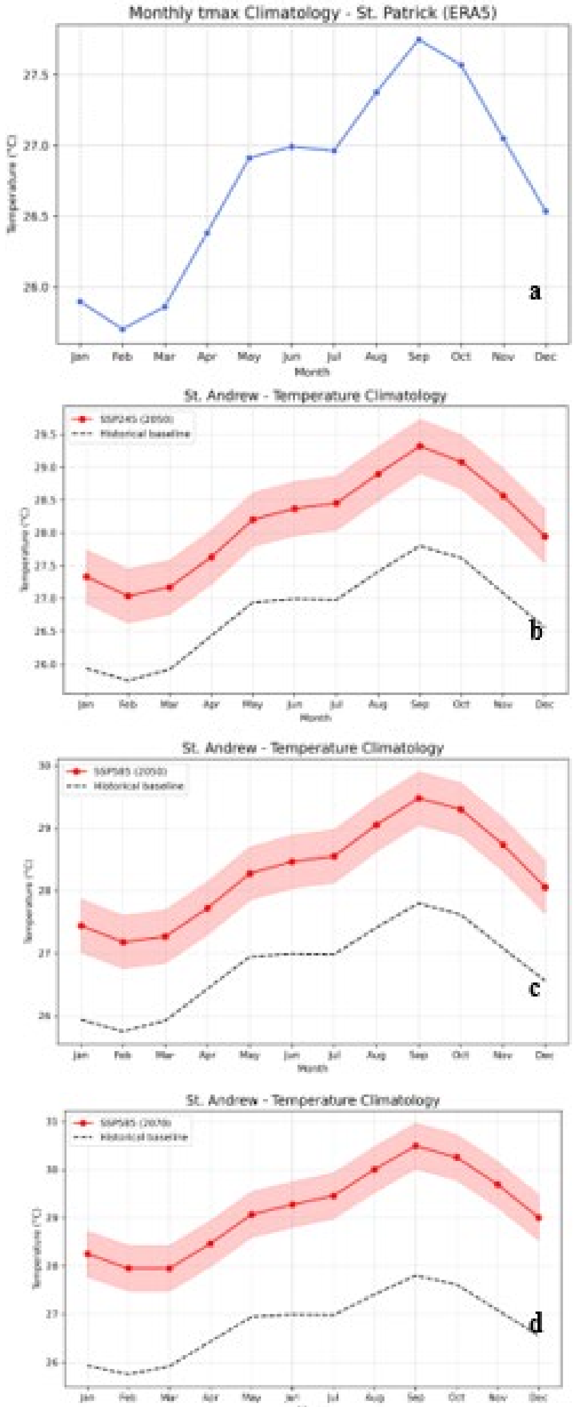


Figure **a** shows the baseline data for 1981–2020 Monthly Maximum Temperature Climatology. In contrast with the monthly minimum temperature projections, here we see a clear departure from the baseline for all the scenarios and projected periods (b,c, and d).

•Uses for Climate Risk & Vulnerability Reduction:

•Agriculture: High daytime temperatures during flowering or fruit set stages reduce yield—this dataset identifies critical heat exposure periods.

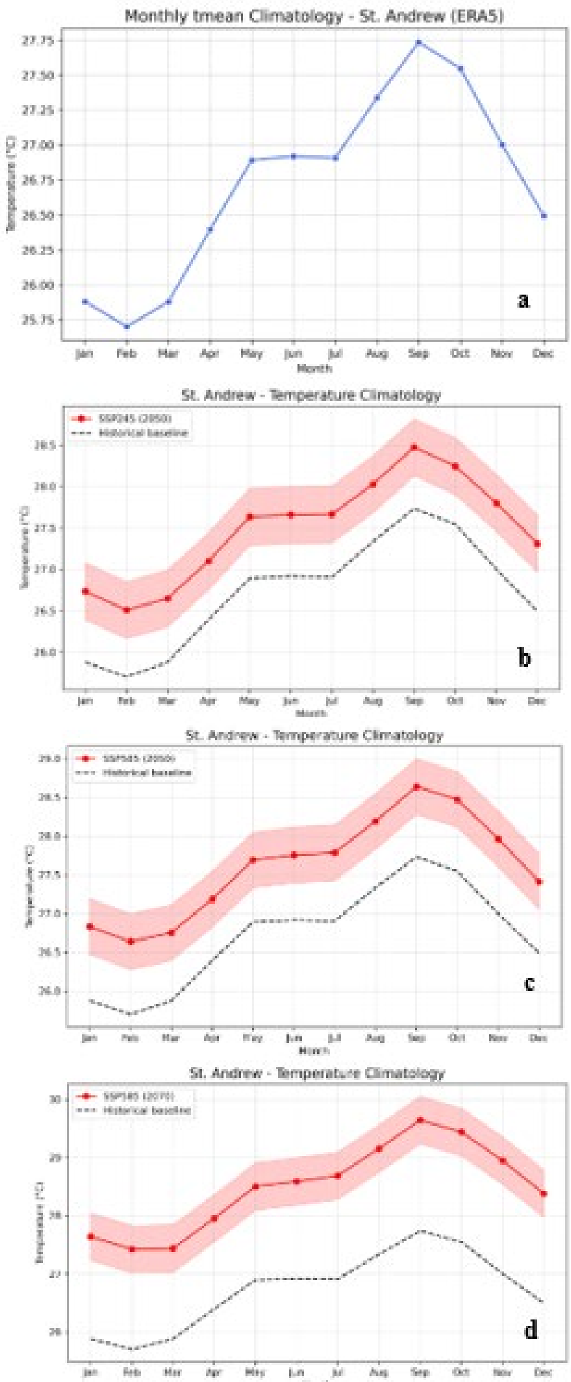
•Health & Labor Productivity: Maximum temperatures relate to heatstroke risk and reduce safe outdoor labor hours—relevant for construction and agriculture.

•Infrastructure: Extreme daytime heat accelerates pavement degradation and reduces lifespan of roads, particularly in coastal areas, which may intersect with other hazards, like mass movements and landslides on roads in mainland Grenada, particularly on the western roads of the Island already subject to extreme weather

Example Analysis:

•Monthly analysis of heat index trends to inform occupational health policies and school safety protocols, but it can also inform the tourist sector.

1981-2020 Monthly Mean Temperature Climatology



In the case of 1981–2020 Monthly Mean Temperature Climatology, it is also clear that the projections suggest a departure from the baseline conditions for the entire year for all the periods. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (SSP24.5 vs SSP28.5). In either case, the mean temperature is projected to increase, with impacts on agricultural endeavors. The largest departure from the baseline is projected in the 2070 high-emission scenario (Figure **d**).

- **Uses for Climate Risk & Vulnerability Reduction:**
- Ecosystems & Biodiversity: Monthly means provide input to species distribution models (e.g., for coral reef bleaching thresholds or pest migrations).
- Agriculture: Supports growing degree day (GDD) calculations, critical for crop growth cycle modeling.
- Tourism: Guides development of seasonal thermal comfort indices, shaping marketing and tourism strategies.

Example Analysis:

- Integration into agroclimatic zoning for crops (e.g., cacao, nutmeg) to refine land use decisions and agroforestry design as shown in the Climate Risk Atlas.

1981-2020 Interannual Precipitation Climatology

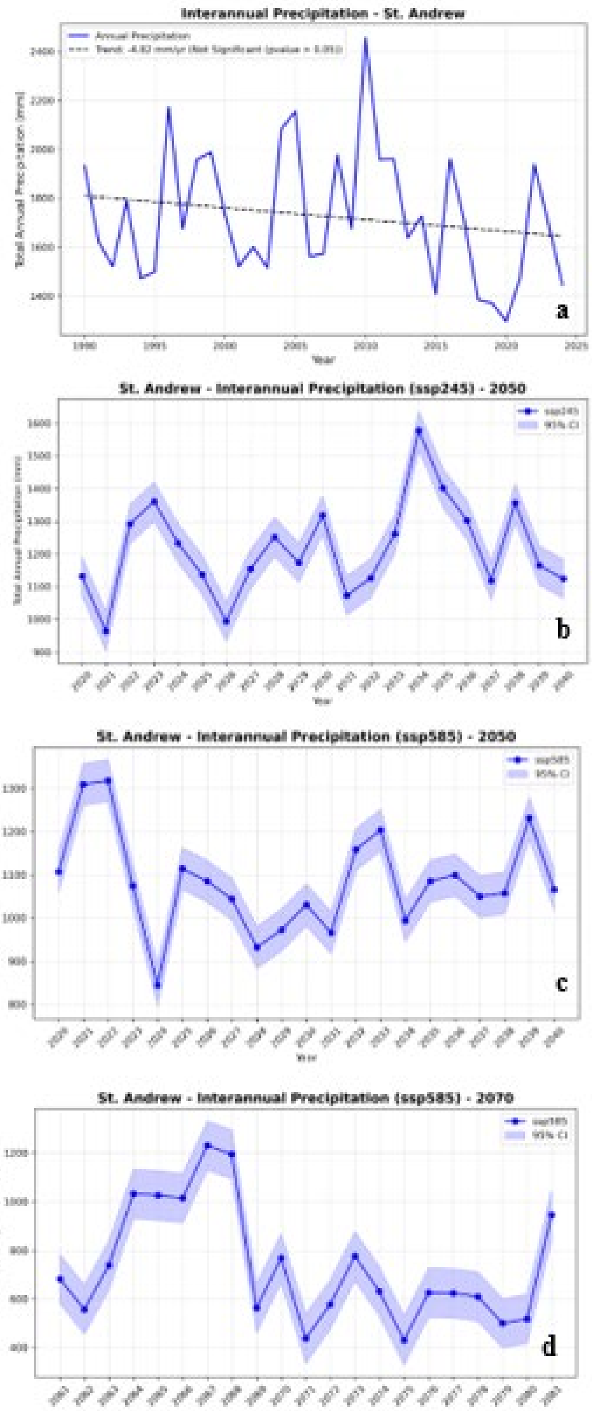


Figure **a** shows the baseline data for 1981–2020 Interannual Precipitation Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (4.5 vs 8.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

Uses for Climate Risk & Vulnerability Reduction:

Agriculture: Interannual variability affects yield stability—understanding fluctuations in annual rainfall helps guide crop selection and investment in irrigation infrastructure.

Water Security: Identifies drought years and multi-year dry spells impacting reservoir levels, aquifer recharge, and rural water systems.

Disaster Risk Management: Highlights years of excessive rainfall or drought, guiding planning for food imports or humanitarian assistance.

Food Security Planning: Supports early warning systems and contingency planning by quantifying rainfall-driven agricultural production risks.

Example Analysis:

Time-series correlation of annual rainfall with historical nutmeg or cocoa exports, identifying climate-sensitive economic years.

1981-2020 Interannual Minimum Temperature Climatology

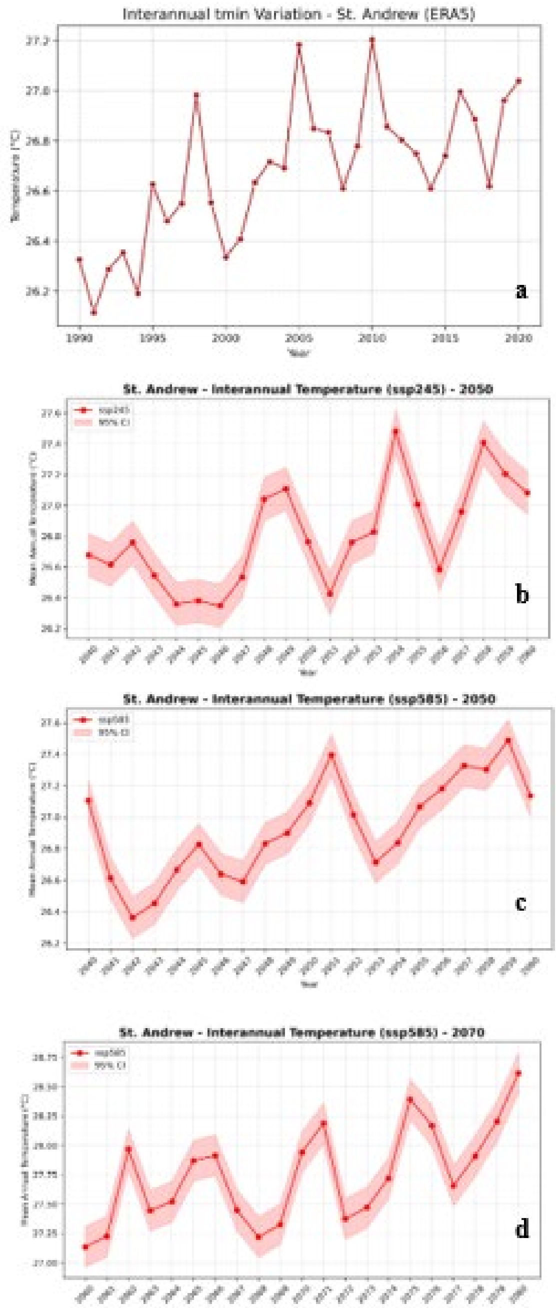


Figure **a** shows the baseline data for 1981–2020 Interannual Minimum Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (4.5 vs 8.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

Uses for Climate Risk & Vulnerability Reduction:

Agriculture: Assesses year-to-year anomalies in cold-season temperatures, which can delay flowering or promote pest outbreaks.

Health: Warmer nights in specific years may correspond with heat stress surges, especially in low-income urban zones.

Energy: Variability in nighttime temperatures affects cooling energy demand planning and informs infrastructure resilience for energy grids.

Example Analysis:

Cross-year analysis of minimum temperatures and mosquito-borne disease outbreaks, using temperature thresholds for vector breeding cycles.

Food and Agriculture Organization of the United Nations

Government of Grenada

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1981-2020 Interannual Maximum Temperature Climatology

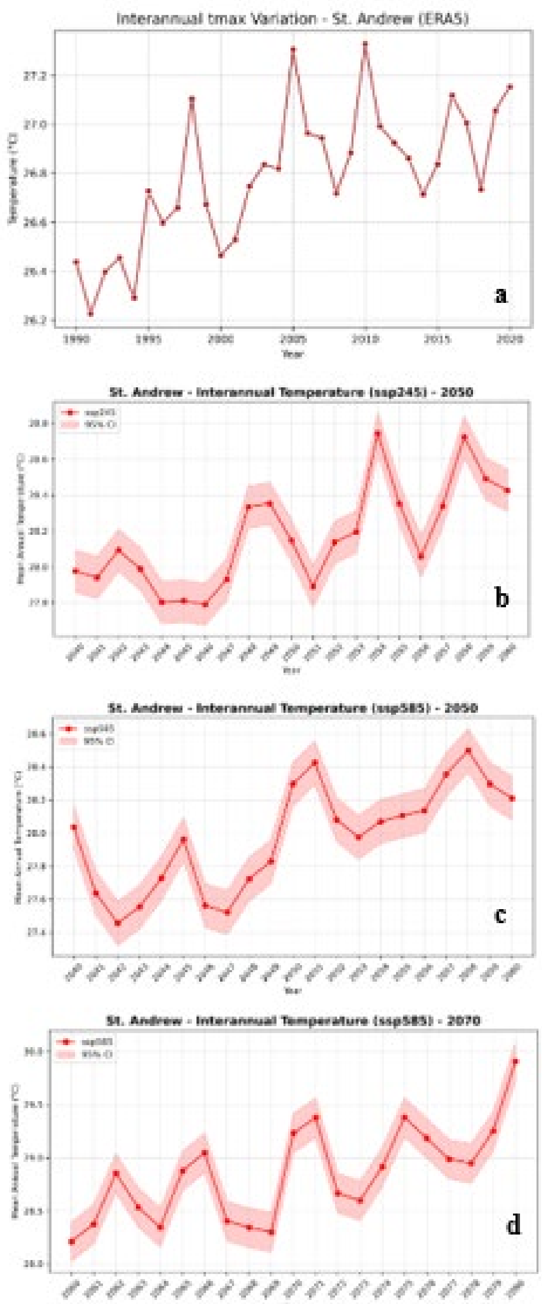


Figure **a** show the baseline data for 1981–2020 Interannual Maximum Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (4.5 vs 8.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

Uses for Climate Risk & Vulnerability Reduction:

Agriculture & Labor: Tracks years when maximum temperatures exceed agronomic heat thresholds, impacting flowering and fruit set (e.g., vegetables, bananas).

Public Health: High year-to-year variability in heatwaves informs extreme heat emergency response planning.

Infrastructure & Urban Planning: Identifies years of peak thermal stress to plan resilient building materials and road construction standards.

Example Analysis:

Frequency analysis of years exceeding 35°C max thresholds to guide urban heat action plans or outdoor work regulations.

1981-2020 Interannual Mean Temperature Climatology

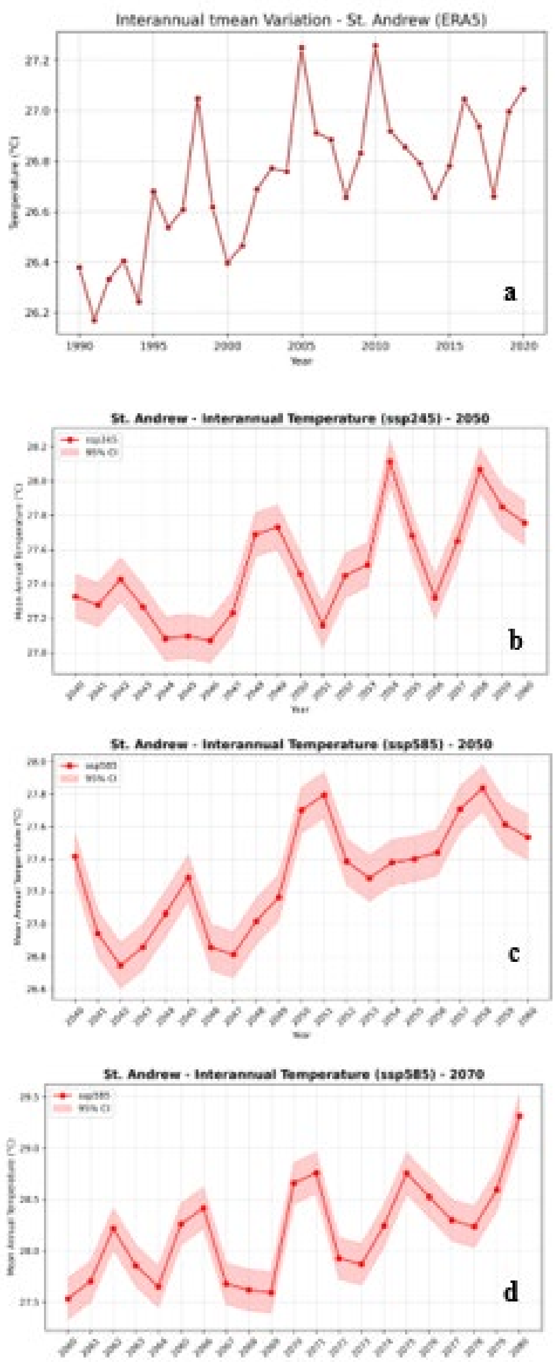


Figure **a** shows the baseline data for 1981–2020 Interannual Mean Temperature Climatology. In figure **b** and **c** you can see the difference not only between different periods (baseline vs 2050) but also between emission scenarios (4.5 vs 8.5). Additionally, in image **d** you can see the long-term changes in the specific variable of interest.

Uses for Climate Risk & Vulnerability Reduction:

Ecosystem Services: Detects long-term warming trends and climate regime shifts, influencing biodiversity, fisheries, and crop suitability.

Tourism: Interannual warming patterns can alter seasonal attractiveness of Grenada for ecotourism or beach tourism.

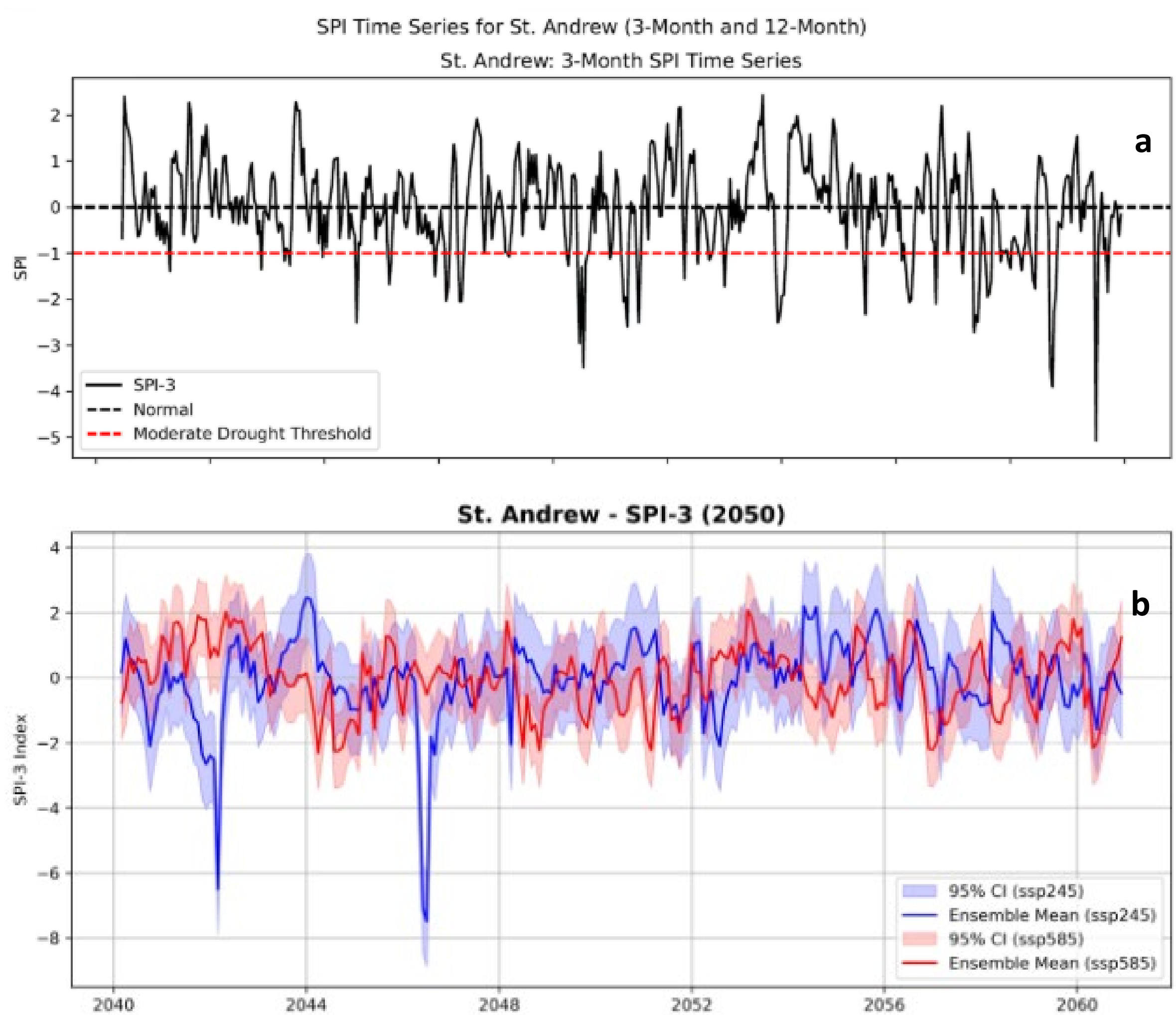
Public Services: Informs cross-sectoral planning, including climate-smart housing, education scheduling, and health system burden.

Example Analysis:

Detection of long-term warming trend acceleration using interannual means to trigger sector-specific adaptation investment (e.g., resilient infrastructure).

SPI 3-month and SPI 12-month

The following figures show the history of the Standardized Precipitation Index (SPI) at 3-month and 12-month as well as the projected time series for 2050 under scenarios SSP245 and SSP585 as available in the Climate Rik Atlas. SPI-3 (short-term drought conditions) shows high variability, capturing seasonal precipitation changes in the historical period. Notice in figure a, that extreme values (below -1 & -2 standard deviations) became more prevalent since early 2000s. The future projections suggest even more extreme droughts within the possible scenarios of even -7 standard deviations – a record not seen in the instrumental historical data (figure b).



Uses for Climate Risk & Vulnerability Reduction:

- Agriculture:
    - Assesses seasonal drought stress on crops at key development stages (e.g., planting, flowering).

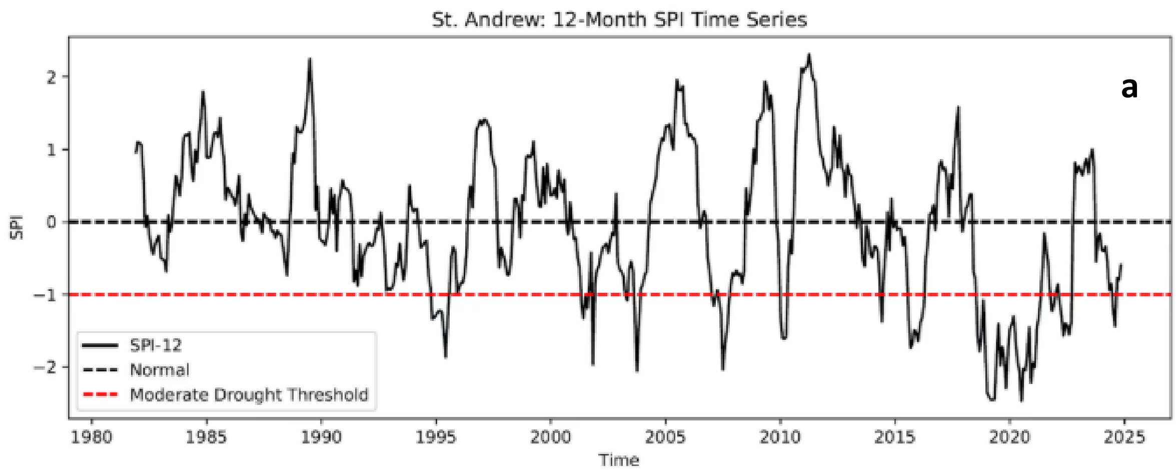
- Informs seasonal planting decisions, particularly for short-cycle crops (e.g., vegetables, maize).

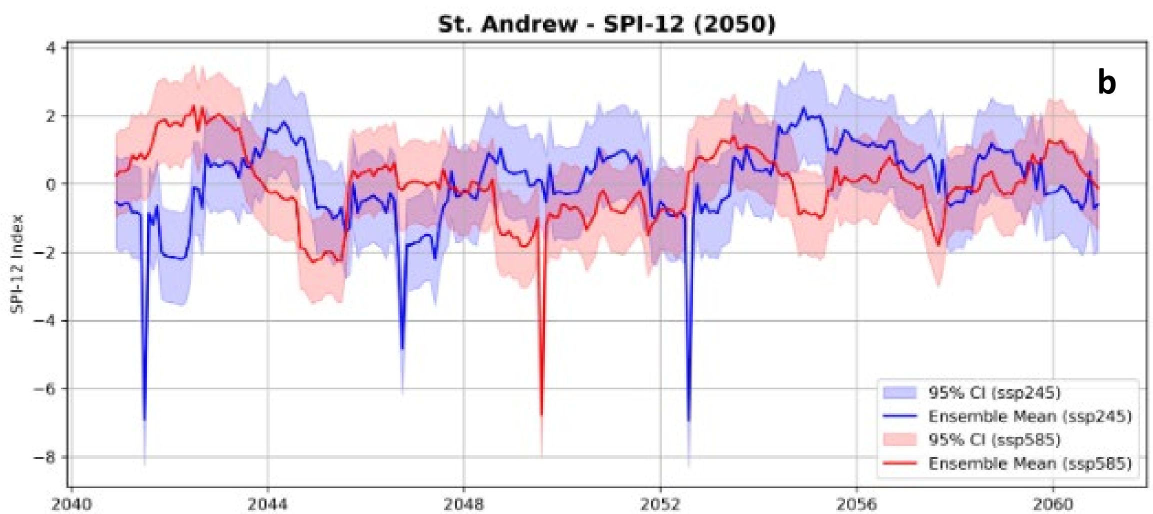
- Disaster Risk Management:
  - Supports early warning systems for meteorological drought that may evolve into agricultural or hydrological droughts.
- Food Security:
  - SPI 3-month trends are leading indicators of harvest failure risk, guiding pre-harvest interventions or food assistance planning.

Example Use:

- Triggering anticipatory cash transfers for farmers based on SPI ≤ -1.0 during the critical planting season, signaling moderate drought.

Similarly, the SPI-12 (long-term drought conditions) exhibits a smoother trend, indicative of prolonged wet or dry periods, particularly in the last 5 to 6 years (Figure a). The comparison between scenarios suggests changes in drought frequency and intensity, with SSP585 potentially leading to drier conditions (Figure b). The projections suggest potential extreme 12-month droughts, including possible scenarios where -6 standard deviations are possible.





Uses for Climate Risk & Vulnerability Reduction:

- Water Resource Management:
    - Identifies prolonged drought periods affecting reservoir levels, aquifer recharge, and streamflow.
- Forestry & Ecosystem Monitoring:
    - Supports understanding of long-term water stress in ecosystems, influencing fire risk, forest health, and biodiversity.
- Public Policy & Planning:
    - Enables identification of climate stress years that should guide infrastructure investment, insurance payouts, and social protection scaling.
- Tourism:
    - Persistent drought periods affect water availability in resorts, and landscape attractiveness (e.g., dry vegetation, lower waterfall flows).

Example Use:

- Flagging areas with SPI $\leq$ -1.5 over 12 months to prioritize water rationing strategies, dam level monitoring, or ecosystem restoration targeting.