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Singapores continuous temperature records since 19481 show that the island has warmed, notably in the mid-1970s when rapid urbanisation took place. Mean surface air temperature has risen by an average of 0.25C per decade between 1948 and 2024. The upward trend is approximately double the trend in global temperatures, which occurred at a rate of 0.12C per decade from 1951-2012. The Intergovernmental Panel on Climate Change (IPCC) in their 2013 Fifth Assessment Report state it is extremely likely that more than half of the observed global trend was caused by anthropogenic (human-activity) increase in greenhouse gas concentrations and other anthropogenic forcings. The higher trend over Singapore may have been due to the urbanisation, and could also be influenced by regional variations in the man-made global warming effect. Eight of the ten warmest years on record in Singapore have occurred in the 21st century and all the ten warmest years are since 1997. [1Temperature measurements from our climate station started in 1929. After a break due to the Second World War (1942-1947), measurements began again in Jan 1948.]Fig 1 Annual mean temperature in Singapore from 1948 to 2024(Data based on climate station)YearAnnual Average Temperature (Degree Celsius)202428.4201928.4201628.4199828.3202328.2201528.2199728.2201028.1200228.1202028.0Table 1 Top 10 warmest years based on long-term annual average temperatures records of our climate station from 1948-2024. RainfallSingapores year-to-year rainfall is highly variable; however, on a longer term basis, annual rainfall total for Singapore since 1980 has increased at an average rate of 78.1 mm per decade.* Data based on 23 rainfall stations across the island that have the most complete continuous records from 1980 onwards. (To account for the spatial variation in rainfall over Singapore, more stations were used for the trend analysis, but not all selected stations have records before 1980, resulting in the shorter period of available data.)Fig 2 Total annual rainfall in Singapore from 1980 to 2024Fig 3 Map showing the past trends of annual rainfall total at individual stations.Most stations indicate upward trends (Upward and downward trends are depicted by up-arrow and down-arrow respectively). Red arrows represent statistically significant trends.The numerical value next to each arrow indicates the annual rate of change (in mm/year) for the period 1980-2024.RainfallChange per decade (1980-2024)Annual number of days with hourly rainfall totals exceeding 40 mm (heavy rain)+ 0.3 days per decadeAnnual number of days with hourly rainfall totals exceeding 70 mm (very heavy rain) 0.2 days per decadeTable 2 Changes in heavy rainfall occurrence in Singapore from 1980 to 2024In Singapore we have observed upward trends in the average annual rainfall and in the frequency of heavy rainfall over the past few decades. However it is not scientifically possible, using the research information that is currently available, to definitively attribute these observed rainfall changes in Singapore to global warming, natural climate variability or other effects (such as urbanisation).SummaryPast climate trends over Singapore have shown an increase in surface air temperatures and the frequency of heavy rainfall over the past few decades. However, the climate system is complex and the past trends and the magnitude of the change will not necessarily continue into the future. Climate projections using tools like climate modelling is thus necessary to project the future climate for planning and adapting to climate change. --> (previously named The Year In Review)The Year In Numbers summarises Singapores key weather and climate statistics from the previous year. It is a prelude to the comprehensive Annual Climate Assessment Report which is released around March.Annual Climate AssessmentReportsThe Annual Climate Assessment Report is an annual publication that providesupdates on climate trends over Singapore, a description of the key climatic features and the notable weather events that have affected Singapore during the year. It aims to provide the necessary information to appreciate the state of the current climate of Singapore and place it within a historical perspective.Annual Climatological ReportsThe Annual Climatological Reports are the Meteorological Service Singapores official summaries of the Singapore climate. They contain detailed monthly, daily and hourly weather statistics of all stations around Singapore, as well as isohyets and wind rose, during the reporting year.2024Annual Climate Assessment ReportThe Year In Numbers 2023Annual Climate Assessment ReportThe Year In Numbers 2022Annual Climate Assessment ReportThe Year In Review 2021Annual Climate Assessment ReportThe Year In Review 2020Annual Climate Assessment ReportThe Year In Review 2019Annual Climate Assessment ReportThe Year In Review 2018Annual Climate Assessment ReportAnnual Climatological ReportThe Year In Review 2017Annual Climate Assessment ReportAnnual Climatological ReportThe Year In Review 2016Annual Climate Assessment ReportAnnual Climatological Report 2015Annual Climate Assessment ReportAnnual Climatological Report 2014Annual Climatological Report The purpose of our climate projections work is to develop understanding of the changing climate in the region and to generate climate scenarios to support Singapores national resilience planning.National Climate ChangeStudyThe Second National Climate Change Study (V2) was completed in 2015. The results and model output data of V2 had been utilised by public agencies for their downstream climate impact studies. The Third National Climate Change Study (V3) was carried out by scientists from the Climate Projections and Extremes (CPE) Branch of CCRS to build the next generation of climate projections for a climate-resilient Singapore. V3 results were unveiled on 5 Jan 2024 at the Symposium on V3. More information on V3 and its findings can be found on the V3 Data Visualisation Portal. Understanding and Detecting Trends in Singapore and Surrounding Regions Weather and ClimateClimate change projection research includes the detection of trends in meteorological variables and ascertaining whether they can be attributed to climate change. This is as distinct from other causes such as inter-annual and inter-decadal variability and urbanisation effects. This is known as Detection and Attribution of climate change. Several process based studies on this topic are being undertaken. The figure below shows the temperature trace at the Singapore climate station since temperature records began. The different sections are for the different locations of the climate station. Understanding the trends that are due to urbanisation, global climate change, changing frequency of El Nio events and due to other influences is a topic of future research.Figure: Time series of annual temperature at the Singapore Climate Station To further advance our understanding of tropical climate variability and change for Singapore and the Southeast Asia region, CCRS has carried out V3 for building the next generation of climate projections for a climate-resilient Singapore. Launched on 5 Jan 2024, the results of V3 are being utilised by public agencies and local institutes of higher learning for their downstream climate impact studies. Read more Two of the largest uncertainties in making climate projections for Singapore and for Southeast Asia are the limitations in our understanding of tropical convection and limitations in our ability to realistically simulate tropical convection in global climate models. Read more CCRSs SINGV numerical weather prediction (NWP) system provides high-resolution weather forecasts for Singapore and the surrounding region, with a focus on short-range prediction of localised heavy rainfall. Read more The Centre for Climate Research Singapore is a research division of the Meteorological Service Singapore. Singapore is situated near the equator and has a typically tropical climate, with abundant rainfall, high and uniform temperatures, and high humidity all year round. Many of its climate variables, such as temperature and relative humidity, do not show large month-to-month variation. However, many variables exhibit prominent diurnal (or daily) variations from hour to hour, indicating the strong influence that solar heating has on the local climate.SeasonsSingapores climate is characterised by two monsoon seasons separated by inter-monsoonal periods (see table below). The Northeast Monsoon occurs from December to early March, and the Southwest Monsoon from June to September. The major weather systems affecting Singapore that can lead to heavy rainfall are:Monsoon surges, or strong wind episodes in the Northeast Monsoon flow bringing about major rainfall events;Sumatra squalls, an organised line of thunderstorms travelling eastward across Singapore, having developed over the island of Sumatra or Straits of Malacca west of us;Afternoon and evening thunderstorms caused by strong surface heating and by the sea breeze circulation that develops in the afternoon.The occurrence of these events at different times of year is outlined in the following table.PeriodPrevailing WindsWeather FeaturesNortheast Monsoon Season (December-early March)Northerly to northeasterly windsEarly Northeast Monsoon (Wet Phase)Monsoon Surges cause widespread continuous moderate to heavy rain, at times with 25-35 km/h winds in the first half of the season, usually from December to early January.Rapid development of afternoon and early evening showers.Late Northeast Monsoon (Dry Phase)Windy and relatively dry in the later part of the season, usually from late January to early March.Inter-monsoon Period (Late March-May)Light and variable, interacting with land and sea breezesThunderstorms, at times severe, occur in the afternoon and early evening.Hot afternoons are common (maximum temperature above 32C).Southwest Monsoon Season (June-September)Southeasterly to southerlyOccasional Sumatra Squalls with wind gusts of 40-80 km/h occurring between the predawn hours and midday.Short duration showers/thunderstorms in the afternoon are common.Inter-monsoon Period (October-November)Light and variable, interacting with land and sea breezesThunderstorms, at times severe, occur in the afternoon and early evening.Generally wetter than the Inter-monsoon Period earlier in the year. RainfallRainfall is plentiful in Singapore and it rains an average of 171 days1 of the year. Much of the rain is heavy and accompanied by thunder. The 1991-2020 long-term mean annual rainfall total is 2113.3mm.[1 A day is considered to have rained if the total rainfall for that day is 0.2mm or more.] Fig 1 Average number of rain days per month (1991-2020).* Data from Changi Climate StationFig 2 Monthly rainfall for Singapore (mm) (1991-2020)* Data from Changi Climate StationFig 3 Hourly variation of rainfall for each month (1991-2020).* Data from Changi Climate Station While there is no distinct wet or dry season in Singapore, monthly variations in rainfall do exist. Higher rainfall occurs from November to January during the wet phase of Northeast Monsoon season (Figs. 1 3), when the major tropical rain-belt (the Intertropical Convergence Zone ITCZ) is positioned near to us. The driest month is February which is during the dry phase of the Northeast Monsoon when the rain-belt has moved further south to affect Java.Rainfall in Singapore shows a marked diurnal variation (Fig 3), with rainfall occurring more frequently during the daytime, particularly in the afternoons when solar heating is strongest. In terms of spatial distribution, rainfall is higher over the central and western parts of Singapore and decreases towards the eastern part of the island (Fig 4).Fig. 4 Annual average rainfall distribution (1991-2020) TemperatureFig 5 Mean monthly temperature variation (C) (1991-2020)* Data from Changi Climate StationFig 6 Hourly variation of temperature for each month (1991-2020)* Data from Changi Climate Station Compared to countries in the temperate regions, temperatures in Singapore vary little from month to month and also from day to day. The daily temperature range has a minimum usually not falling below 23-25C during the night and maximum not rising above 31-33C during the day. May has the highest average monthly temperature (24-hour meanof 28.6C) and December and January are the coolest (24-hour mean of 26.8C). Singapore, being an island, also has a coastal climate. The proximity of the sea has a moderating influence on its climate. This is because water has a larger heat capacity than the land surface, and a greater amount of heat is required to increase the sea temperatures. During afternoons, conditions at the coast are often relieved by sea breezes. The presence of significant wind speeds, rainfall and cloud cover are the most important natural influences in mitigating the tropical heat.HumidityRelative humidity shows a fairly uniform pattern throughout the year and does not vary much from month to month (Fig 7). Its daily variation is more marked, varying from more than 90% in the morning just before sunrise and falling to around 60% in the afternoon on days when there is no rain. The mean annual relative humidity is around 82%. Relative humidity frequently reaches 100% during prolonged periods of rain.Fig 7 Hourly variation of relative humidity for each month (1991-2020)* Data from Changi Climate Station Surface WindFig 8 Annual wind rose (m/s) (1991-2020)* Data from Changi Climate Station In Singapore, winds are predominantly from the northeast and the south, indicative of the dominant monsoons that influence the region (refer to Fig 8 for the wind rose). Typically, on any given day, wind patterns align with the dominant monsoon flow, except when influenced by terrain or weather phenomena such as showers, thunderstorms, and local breezes (land or sea). During the Northeast Monsoon season (December to March), winds generally blow from the northerly to northeasterly direction, while the Southwest Monsoon (June to September) generally sees winds blowing from the southeasterly to southerly direction (Fig 9). Notably, wind strength tends to be stronger during the Northeast Monsoon. The inter-monsoon months (April, May, October, and November) serve as transitional periods between the monsoons, characterised by light and variable winds.Fig 9 Hourly variation of surface wind speed (m/s) and direction for each month (1991-2020 average). Shows a compilation of the monthly and hourly variation of surface wind over the course of the year. Arrow colours denote wind strength and arrow direction shows the direction the wind is blowing from.* Data from Changi Climate StationFig 10 Average monthly surface wind speed (m/s) (1991-2020).* Data from Changi Climate Station Generally, daytime winds tend to be stronger compared to nighttime winds (Fig 9). In Singapore, winds are generally light, with mean surface wind speed of around 2 m/s. The strongest winds occur during the Northeast Monsoon, specifically in January and February (Fig 10).During the Northeast Monsoon surge, mean wind speeds can reach up to 10 m/s or more. Another occurrence of heightened wind activity is associated with thunderstorms, where surface wind gusts are commonly triggered by either the downdrafts of the thunderstorm or the passage of Sumatra squall lines. VisibilityVisibility is generally good during the Northeast Monsoon months from December to March except during rainfall or showers. Slight to moderate haze, which is common during the Southwest Monsoon and in light wind conditions during the inter-monsoon months, can reduce the visibility to below 10 kilometres. During severe episodes of transboundary smoke haze, visibilities below 1 km have been recorded. Poor visibility is also often observed between 0500hr and 0900hr in light to calm wind conditions when mist forms. Visibility, however, usually improves quickly within a few hours after sunrise when the mist dissipates. Following a few hours of rain, poor visibility is also sometimes observed, particularly in almost calm wind conditions. Sunshine DurationSunshine duration refers to the cumulative time during which an area receives direct irradiance from the sun of at least 120 Watts/m2. Since Singapore is near the equator, the length of its day is relatively constant throughout the year, and thus so is the amount of sunshine it receives. Daily sunshine hours are mainly influenced by the presence or absence of cloud cover. February and March have the highest sunshine hours, while November and December have the lowest (Figs 11 12).Fig 11 Average monthly sunshine hours (1991-2020).* Data from Changi Climate StationFig 12 Hourly variation of sunshine hours for each month (1991-2020).* Data from Changi Climate Station Cloud CoverCumulus, stratocumulus and cumulonimbus clouds are the most common low cloud types in Singapore. On an average day, cumulus clouds start to develop in the mid-morning, increasing to about 3-4 oktas (one okta is one eighth of the sky) by midday with bases of around 2,000 ft (0.6 km) and tops from 8,000 to 12,000 ft (~ 2.5 3.5 km). During the afternoon and early evening, these cumulus clouds may develop into cumulonimbus clouds with tops reaching between 30,000 and 40,000 ft (9 12 km).The clouds diminish and begin to flatten into stratiform layers by dusk and slowly disperse during the night. Weather systems act to intensify or reduce this diurnal cycle of cloud development. Overcast conditions caused by extensive middle to high layer clouds together with active cumulus and cumulonimbus clouds are often experienced during the passage of a Sumatra squall lineDuring a Northeast Monsoon surge, broken to overcast medium layer clouds occur together with large cumulus clouds producing prolonged widespread rain and intermittent bouts of heavy rain. Low stratus clouds with bases below 1,000 ft (0.3 km) are frequently observed following the passage of Sumatra squall lines and during Northeast Monsoon surges. Records of Climate Station Means(Climatological Reference Period: 1991-2020)JanFebMarAprMayJunJulAugSepOctNovDecRainfallMean Monthly/Annual Total (mm)221.6105.1151.7164.3164.3135.3146.6146.9124.9168.3252.3331.9MeanRaindays13912151513141413151919Temperature (C)MeanDaily Maximum30.631.532.232.432.331.931.431.431.631.831.230.5MeanDaily Minimum24.324.624.925.325.725.725.425.325.225.024.624.324-hrMean26.827.327.828.228.628.528.228.128.027.927.226.8Relative Humidity (%)MeanDaily Maximum94.793.794.595.695.293.793.393.093.895.296.596.0MeanDaily Minimum66.062.161.462.363.763.464.163.662.261.465.568.024-hrMean83.581.281.782.682.380.980.980.780.781.584.985.5Wind Speed (m/s)MeanMonthly/Annual2.62.82.21.61.72.02.42.52.11.61.41.9Thunderstormand LightningMeanThunderstorm Days651220191513131417191 4MeanLightning Days74132121161312121821 6

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