

PART 2
REQUIREMENT SPECIFICATIONS

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1 INTRODUCTION

1.1 Overview

- 1.1.1 Tenderers are invited to submit a proposal for the provision of a Climate Data Management System (“System” as defined in Part 1 Section B) for the Meteorological Service Singapore, National Environment Agency (“Agency” as defined in Part 1 Section B).
- 1.1.2 The Supplier shall provide a turnkey solution, inclusive of hardware and software, to supply, deliver, install, test and commission the System to fulfil the specifications in the Contract.

1.2 Objectives

- 1.2.1 The purpose of the System is to archive and manage all the climate data (point weather station observations) of the Agency, from data collection, quality control, recording of metadata, and the production of reports/products for end-users.
- 1.2.2 The aim is to have a System that is easy to access and use, to help in improving the efficiency of the Agency’s work processes in managing the data and to be able to respond faster to adhoc queries related to climatological information.
- 1.2.3 The Agency aims to enhance the quality of its climate data and to produce most of its climatological products using the System and to be able to adapt easily to changing requirements with time.

2 SUBMISSION OF TENDER PROPOSAL

- 2.1 The Tenderer shall submit their proposals for the supply, delivery, installation, testing, commissioning and maintenance of the System in accordance with the requirements as stipulated in this Invitation to Tender.
- 2.2 The Tenderer shall assess and propose the necessary hardware and storage capacity to meet the Agency’s needs for the Life-Span of the System (as defined in Part 1 Section B), based on current and projected future growth (please refer to Appendix I for estimated current data inventory and projected future expansion in our local weather observation network).
- 2.3 The Tenderer shall explain clearly how the configuration will meet the requirements specified for system availability, reliability, response time, data storage, performance and other requirements as stated in Part 2, Section 10 of this Requirement Specifications.
- 2.4 The Tenderer shall also state and justify all assumptions made in the assessment and substantiate the explanations with performance statistics from existing installations.
- 2.5 The Tenderer shall note the submission required as stated in Clause 5.1.3, 5.2.1 5.2.14, 5.5.16, 5.5.17, 10.1.3, 10.1.4 and 10.2.2 and include the required information in their Tender Proposal. Tender Offers that did not include the required information is liable to be rejected.

- 2.6** The Tenderer shall note that the Tender Proposal will be evaluated in accordance to the criteria stated in Part 4 – Evaluation Criteria.

3 SCOPE OF WORK

- 3.1** The Supplier shall be responsible for the supply, delivery, installation, configuration, testing and commissioning of the System, including one (1) year System Warranty and the followings;

- a) Provision of data migration and conversion services
- b) Provision of documentations and training ;

- 3.2** The Supplier shall grant the Agency the options to purchase the following items:

- a) Supply, delivery, installation, testing and commissioning of a Document Archiving and Cataloguing Module (Clause 5.8 of this Part 2 – Requirement Specifications), including one (1) year of System Warranty;
- b) Supply, delivery, installation, testing and commissioning of the necessary hardware and software for disaster recovery at an alternate site, including one (1) year of System Warranty;
- c) Other modules proposed by the Tenderer to better fulfil the objectives stated in Clause 1.2, including one (1) year of System Warranty;
- d) Comprehensive maintenance service of the System after the first year of warranty, up to a maximum of seven (7) years, as indicated in Part 1 Section C - Conditions of Software Support and Hardware Maintenance;
- e) Comprehensive maintenance service of the Document Archiving and Cataloguing Module after the first year of warranty, up to a maximum of seven (7) years, - as indicated in Part 1 Section C – Conditions of Software Support and Hardware Maintenance
- f) Comprehensive maintenance service of the necessary hardware and software for disaster recovery at an alternate site after the first year of warranty, up to a maximum of seven (7) years - as indicated in Part 1 Section C – Conditions of Software Support and Hardware Maintenance
- g) Comprehensive maintenance service of other module(s) proposed by the Tenderer (as stated in Clause 5.1.2 in Part 2 Requirement Specifications) after the first year of warranty, up to a maximum of seven (7) years, - as indicated in Part 1 Section C – Conditions of Software Support and Hardware Maintenance
- h) Provision of up to one hundred and sixty service request man-days, as an option to procure, for carrying out modifications and enhancements to the System during the entire contract period, including all maintenance years.

- 3.3** The options to purchase in Clause 3.2 (a), (b) and (c) shall be exercisable by written notice given by the Agency to the Supplier within 10 months of the Letter of Acceptance. The option to purchase in Clause 3.2 (d), (e), (f) and (g) shall be exercisable as indicated in Part 1 Section A - Invitation to Tender (Clause 39), Part 1 Section B - Conditions of Contract (Clause 27) and Part 1 Section C – Conditions of Software Support and Hardware Maintenance (Clause 15). The option to purchase in Clause 3.2 (h) shall be exercisable as indicated in Section 11 of this Part 2 – Requirement Specifications.

4 GENERAL REQUIREMENTS

- 4.1** The System shall support at least ten (10) concurrent users.
- 4.2** The System shall be based on a multi-tier architecture and at a minimum, the database access tier shall be physically separated from the other tiers.
- 4.3** The System is to be accessible from the Agency's offices connected via its LAN/WAN and from internet via the Agency's VPN gateway.
- 4.4** The Supplier shall lay all electrical, network and/or telecommunication cables required for the System within the Agency's data centre (power cables from distribution board to rack/servers, network cable from switch to rack/servers etc). All electrical works shall comply with all necessary regulations of the relevant authorities (such as the Energy Market Authority) and if required, shall be endorsed and approved by the relevant personnel and authorities (e.g. endorsement of electrical single line diagram by licensed electrical worker) at the cost of the Supplier. The Supplier shall be responsible for all submissions (including submission fees) to relevant authorities (building owners etc).
- 4.5** The Supplier shall supply and install the necessary server rack(s) (42U, 600mm wide, minimum 1200mm deep, including cable management arm and accessories) equipped with rack mountable KVM switch and LCD monitor, keyboard and mouse, to house all computer servers, network and other computer peripherals supplied.
- 4.6** All servers/equipment supplied shall be able to receive power supply from two (2) independent power sources (e.g. having 2 power supplies in the equipment, provision of automatic power transfer switch for single power inlet devices).
- 4.7** The rack(s) shall each be equipped with the followings:
- a. at least two (2) units of metered power distribution unit (PDU) to receive two (2) independent power sources for redundancy purpose. The PDU shall support 32A CEE form power socket connector for input.
 - b. One (1) set of temperature and humidity sensors compatible with the Agency's Environmental Monitoring System, including installation and laying of cables from rack to the Environmental Monitoring System.
- 4.8** The System shall automatically synchronize with the Agency's Network Time Server (NTS) periodically to maintain an accurate system time.

- 4.9** The System shall be equipped with software tool to monitor operating status of critical IT Infrastructure (e.g. computing systems, storage devices, power supplies) and critical system processes/services/engines.
- 4.10** Whenever a fault was detected by the software tool, a Short Message Service (SMS) notification shall be sent to the Agency and qualified service engineer, via the Agency's SMS Gateway. The message content shall include (but not limited to) the system/device where the fault was detected, the nature of failure and time of occurrence. The Application Programming Interface (API) of the SMS Gateway shall be provided by the Agency during project implementation phase.
- 4.11** The software tool shall also be capable to send fault notification via email channel using the Agency's SMTP (Simple Mail Transfer Protocol) server. The email content shall include (but not limited to) the system/device where the fault was detected, the nature of failure and the time of occurrence.

5 FUNCTIONAL REQUIREMENTS

5.1 Overview

- 5.1.1** The broad functionalities and modules of the System required are as follows:

- a) Data Ingest and Extract
- b) Observations Quality Control, Flags and Alerting
- c) Data Processing and Analysis
- d) Climate Data Presentation and Report / Product Generations
- e) Metadata Management
- f) System Administration
- g) Document Archiving and Cataloguing Module [optional]

- 5.1.2** The Tenderer may, as an option, assess and recommend additional modules for the System to better fulfil the objectives stated in Clause 1.2. The Tenderer shall list and quote for these additional functionalities and modules in Part 3, Annex I, Table 1. The Agency reserves the right to make the final decision on whether the additional items will be implemented.

- 5.1.3** The Tenderer shall indicate clearly in its tender submission, the list of proposed functionalities that are currently not available in the latest release version of its software package but will need additional application development efforts to implement.

5.2 Data Ingest and Extraction

- 5.2.1 The System shall ingest data, on a near real-time basis, from the Agency's Automatic Weather Observation System (AWOS), manned weather stations (including an upper air observation station) and regional data from the Message Switching System and World Meteorological Organization (WMO) Information System. The Agency shall provide all necessary information on these systems to the Supplier, who shall then propose and implement the optimal data ingestion method so that the data can be ingested into the System promptly. The objective is to be able to obtain the latest daily aggregation (for local Singapore data, till the latest hourly mark of the current day) as soon as possible. The Tenderer shall provide information on the possible methods and the time-delays for obtaining the latest daily aggregation in its tender submission, together with the assumptions, methods and calculations used to compute the time-delay.
- 5.2.2 The ingested data could be based on different standard times (e.g. UTC, Singapore local time, station time) and the System shall handle these accordingly so that the correct date/time is tagged to the stored data after ingest.
- 5.2.3 The System shall be able to assign priority levels to different types of data. e.g. a record that has been keyed in via a quality assurance process may be given a higher priority than a record acquired via a real-time data ingest or calculated by the System. The System shall be able to detect occurrences when the data it is ingesting or calculating are already in the System (i.e. same parameter for same time period and station), and to define the necessary rules, which could depends on the data priority of the data types involved, to handle such conflicts.
- 5.2.4 The System shall support the creation of a wide range of business rules that govern how data are ingested into the System, such as:-
- a. Action required when new phenomena are to be ingested but a record already exists in the database for that time period.
 - b. Action required when a message arrives for ingest but the message type is not appropriate according to the observations metadata on record for that station.
 - c. Action required should a message arrive containing an observed value that is outside the accepted bounds for a given phenomenon. For example, a message contains a value of 90°C for temperature, where the maximum accepted temperature is 60°C.
 - d. Action required should a message arrive that is of a lower order of precedence to one that has already been ingested for the same time period and station.
- 5.2.5 The System shall record all ingest activity and status.

Data Ingest from AWOS System

- 5.2.6 The Agency operates a network of around 66 automatic weather stations (AWS), which is estimated to increase to around 115 stations in the next few years (refer to Appendix I for the projected expansion in the weather observation network). Other than the finest 1-min resolution data, the AWS performs aggregation for different time intervals like 5-min, 1-hour etc and stream the data to the AWOS central processing system. The System shall be capable of receiving and storing all data of different time intervals from the AWOS central processing system. The Agency is using SMHI/Apertum's "Airviro" as its AWOS central processing system. Other than exporting of observational data in common formats (e.g. CSV) and sending using common file transfer protocols (e.g. sftp, ftp), the AWOS central processing system also allows other systems to pull observational data from its server via "HTTP POST" request method.

Data Ingest from Manned Weather Stations

- 5.2.7 The Agency operates five manned weather stations and one of them is the climate station. Four of these stations use custom developed application software for data entry and storing of the observation data and the remaining one station directly keys the data into the current Main Data Processing System (MDPS) through key-entry forms.
- 5.2.8 The System shall be able to perform automatic ingest of the data exported from the data entry software. The System shall also provide customized key entry forms for manual data entry directly into the System.
- 5.2.9 The System shall perform robust quality control and quality flags on data entered/transmitted from the manual weather stations.
- 5.2.10 For data entry via customize key-entry forms, the System shall perform checks and prompt the users if there are missing fields, before storing such data into the System.
- 5.2.11 The Agency also operates an upper air observatory. The System shall ingest and archive the upper air data.

Regional Data from Message Switching System/WMO Information System

- 5.2.12 The System shall ingest regional data from the World Meteorological Organization (WMO) Global Telecommunication System (GTS) via the Agency's Message Switching System and WMO Information System (The Agency uses Corrobor's "MESSIR-COMM" as its Message Switching System and MFI's "OpenWIS" as its WMO Information System). The data shall consist of the following:
- a) CLIMAT;
 - b) SYNOP;
 - c) METAR;
 - d) TEMP and PILOT upper air data;
- 5.2.13 The System shall be able to ingest both traditional alphanumeric codes (TAC) and table driven code form (TDCF).

- 5.2.14 The Supplier shall also import historical observational data from the WMO GTS (from 1961 and onwards) within the Southeast Asia region into the System. This shall include land surface observations of both daily and hourly resolution, as well as upper air observations. The Supplier shall be responsible for getting these data from sources such as the Global Historical Climatology Network (GHCN), Integrated Surface Database (ISD), Integrated Global Radiosonde Archive (IGRA) hosted by National Oceanic and Atmospheric Association (NOAA)'s National Centers for Environmental Information. The Supplier shall also import station metadata, if available, into the System. The Tenderer shall include in their tender submission, information on how they are going to source for such data.

Data Extraction

- 5.2.15 The System shall allow users to query and extract data and export them into common file formats like csv, xml, Excel, netCDF.
- 5.2.16 The System shall provide an Application Programming Interface (API) to allow Agency's software applications and systems to access the functionality of the System. The API shall, at the minimum, allows the Agency to extract bulk data efficiently from the System. The System should preferably also allow the Agency to utilize the data processing and product generation engine within the System using the API or expose such functionalities in ways that allow external applications to make use of these functionalities.
- 5.2.17 All extracted data, via any means, shall be geo-tagged, i.e. there shall be fields in the extracted records to indicate the location information (e.g. latitude and longitude) of each data value.
- 5.2.18 The System should preferably allow users to customize and choose the fields to be included for the data extractions.

5.3 Observation Quality Controls, Flags and Alerting

- 5.3.1 The System shall perform the following quality checks stated in the WMO Guide to Climatological Practices and Climate Data Management System Specifications on data ingested into the System:
- a) Format Checks;
 - b) Completeness Checks;
 - c) Tolerance Checks;
 - d) Consistency Checks;
 - e) Statistical Checks;
 - f) Spatial Checks.

- 5.3.2 Apart from the quality checks specified above, the Supplier should preferably also propose and implement additional quality checks to further enhance the quality of the climate data, such as heuristics check and data comparison as stated in the WMO Climate Data Management System Specifications.
- 5.3.3 The System shall support multi-layer quality flags and flag all data based on a combination of different conditions like data type (original, corrected, reconstructed or calculated etc), validation stage/results, acquisition methods and source of data.
- 5.3.4 The System should preferably be able to perform network monitoring (keeping track of data received from an observation network) and data monitoring (monitoring ingested and derived observation data for any modifications etc) as mentioned in WMO's Climate Data Management System Specifications.
- 5.3.5 The System shall allow users to query and display the results of the quality checks. e.g. presenting the amount or period of missing data in a table.
- 5.3.6 The System shall enable users to select and display data that falls into a particular flag or quality status.

Data Modification and Recovery

- 5.3.7 The System shall provide an interface for the Agency appointed users to modify the data.
- 5.3.8 The original values shall also be stored after modifications. The System shall have a function for users to undo and restore previous data.
- 5.3.9 The System shall apply quality control procedures to modified values also and flag them accordingly.
- 5.3.10 As modified values can affect calculated data (from aggregation etc), the Supplier shall propose and implement an optimal method of monitoring such modifications, performing re-calculations and updating of affected data, taking into account factors like data priority, so that the affected data can be update promptly and does not affect the normal operations of the System. The System shall store the original values of the affected parameters and log down the date/time of modifications.
- 5.3.11 As part of the documentation, the Supplier shall also develop a detailed mapping, documenting the connection between the different parameters (e.g. raw and calculated parameters).

Alerting

- 5.3.12 The System shall alert the Agency's appointed users via email and/or SMS when any data failed any quality checks to facilitate further investigation. The Agency will provide the necessary email and SMS gateways for such dissemination.

- 5.3.13 The System shall also be able to alert the Agency's appointed users when certain parameters/statistics breach a user-defined or system derived (such as 90th percentile value, highest/lowest value) thresholds. e.g. monthly mean temperature above 95th percentile value or break the highest ever record, more than 10 consecutive days of below 1.0mm average rainfall over specified stations. The System should preferably, also allows a combination of conditions (via logical operator like AND, OR) to be defined for such alerting.

5.4 Data Processing and Analysis

- 5.4.1 The System shall process and generate calculated data from the data stored in the System.
- 5.4.2 The System shall be able to perform data aggregation for the following time intervals:
- a) Minute to Hourly;
 - b) Hourly to Daily or Monthly Hourly;
 - c) Daily to Monthly and Monthly Hourly to Yearly Hourly;
 - d) Monthly to Seasonal and Yearly;
- 5.4.3 The System shall be able to generate seasonal climate statistics in rolling 3 and 4 months (e.g. DJF, SON, OND, JJAS).
- 5.4.4 For the aggregation of data, the System shall be flexible enough to allow choosing of different time intervals for performing the aggregation and to choose different point within the time interval for the time-stamp to be tagged to the final aggregated value. E.g. for aggregating minute data to hourly data, the one-hour period can be from one half hourly mark to the next half hourly mark or from one hourly mark to the next hourly mark. The time-stamp can also be at the beginning, end or middle of the interval.
- 5.4.5 For the aggregation of data, the System shall be able to sample the data at a particular time. e.g. taking the single observation data at the hourly mark to represent the hourly value and using that to calculate the daily average, instead of calculating the average of all available data for the day, which could be 1-minute data.
- 5.4.6 The System shall be able to perform the necessary unit conversion (e.g from millimetres to inches) and to output and display the data in the user-chosen unit.
- 5.4.7 The System shall be able to generate the following statistics:
- a) Average
 - b) Standard deviations;
 - c) Counts;
 - d) Sum;

- e) Maximum and Minimum;
 - f) Percentiles;
 - g) Frequencies and/or percentage of occurrence of events that falls within certain ranges
 - h) Frequencies and/or percentage of occurrence of events that falls within certain percentiles;
 - i) Ranges of observed variable over selected stations and individual stations;
- 5.4.8 The System shall be able to generate climate normal, period averages and extremes over a user specified period.
- 5.4.9 The System shall be able to generate the anomalies against any user specified climate normal/period averages.
- 5.4.10 The System shall be able to rank extreme events (e.g. top 10 warmest years, driest February).
- 5.4.11 The System shall be able to compute the consecutive missing/defective counts and total missing/defective counts, and perform appropriate flagging of the aggregated data based on these counts. The thresholds for such counts to decide the flagging shall be user configurable.
- 5.4.12 For stations with 2 or more measurements of the same weather parameter (e.g. rainfall), the System shall be able to derive a separate final value to represent the measurement for the station using simple rules. e.g. For stations with 2 rain sensors, one of the sensor can be taken as the default value to be used and measurement for the other sensor will be used if there are missing or defective readings from the first sensor. The System shall flag the final value accordingly so that user can identify the data source (i.e. from which sensor).
- 5.4.13 The System shall be able to derive a separate parameter from the parameters in the System which are related by physical laws/equations. e.g. calculating wet-bulb temperature from dry bulb temperature, relative humidity and pressure.
- 5.4.14 As methods of observation and climatological practices have changed throughout the years, the data types/sources, aggregation methods etc for the same parameter of the same station could be different during different time-periods. e.g. the daily maximum temperature for a station might have changed from a direct observation value from a maximum/minimum thermometer to a calculated value using 1-minute observations from automatic weather stations. The Supplier shall design the data structure and configure the System so that the System can:
- a) Re-calculate past data using the latest climatological practices and store these new values, while retaining past values that were computed using the old climatological practices and imported into in the System;
 - b) perform data aggregation and compute various statistics over a combination of these different data types/sources.

- 5.4.15 The System shall be able to compute wind speed and wind direction using both scalar and vector averaging methods.
- 5.4.16 The System shall be able to categorise wind direction into both 8 and 16 compass points.
- 5.4.17 The System shall be able to convert and display the data in different standard times as well as aggregate data for the different time periods (day, month, year etc) based on different standard times. The System shall also support the calculation of daily values (daily mean, maximum, minimum etc) using different definitions of day, such as 06-06hr, 0-23hr, 1-24 hr etc, which could be different for each stations.
- 5.4.18 The System shall be able to calculate and aggregate data (such as radiation data) based on local apparent time using the equation of time and the geographical coordinates of the observing station.
- 5.4.19 The System shall indicate as much as possible, the metadata that follows the data on the calculated data that is generated. Where possible, the System should tag the processing methods used to derive the calculated data.
- 5.4.20 The System shall be able to generate the ETCCDI (Joint CCI/Clivar/JCOMM Expert Team On Climate Change Detection And Indices) core indices, which shall include at least the following indices:
- a) Monthly maximum value of daily maximum temperature;
 - b) Monthly maximum value of daily minimum temperature;
 - c) Monthly minimum value of daily maximum temperature;
 - d) Monthly minimum value of daily minimum temperature;
 - e) Percentage of days when daily minimum temperature is less than the 10th percentile;
 - f) Percentage of days when daily maximum temperature is more than the 10th percentile
 - g) Percentage of days when daily minimum temperature is less than the 90th percentile;
 - h) Percentage of days when daily maximum temperature is more than the 90th percentile
 - i) Warm spell duration index- Annual count of days with at least 6 consecutive days when the percentage of days when daily maximum temperature is more than the 90th percentile;
 - j) Cold spell duration index- Annual count of days with at least 6 consecutive days when the percentage of days when daily minimum temperature is less than the 10th percentile;

- k) Daily temperature range- monthly mean difference between daily maximum and minimum temperature;
 - l) Monthly maximum 1-day precipitation;
 - m) Monthly maximum consecutive 5-day precipitation;
 - n) Simple Precipitation Intensity Index;
 - o) Annual count of days when precipitation is greater than or equal to 10mm;
 - p) Annual count of days when precipitation is greater than or equal to 20mm;
 - q) Annual count of days when precipitation is greater than or equal to user defined threshold;
 - r) Maximum number of consecutive days with precipitation smaller than 1mm;
 - s) Maximum number of consecutive days with precipitation greater than 1mm;
 - t) Annual total precipitation based on daily rainfall greater than the 95th percentile of wet days;
 - u) Annual total precipitation based on daily rainfall greater than the 99th percentile of wet days;
 - v) Annual total precipitation in wet days.
- 5.4.21 The System shall allow the relevant threshold figures (e.g. 10th percentile, 5-day, 10mm) of the ETCCDI indices to be redefined by the users and to create other sets of indices using different threshold values.

5.5 Climate Data Presentation and Report/Product Generations

- 5.5.1 The System shall provide users with user-friendly and flexible tools for data presentation and generation of a wide variety of high quality reports and products, which shall allow customization according to user needs.

WMO Products

- 5.5.2 The System shall be able to generate CLIMAT report and send the report to the Agency's Message Switching System for dissemination to WMO GTS. The System shall also archive such reports.
- 5.5.3 The System shall be able to generate WMO World Weather Records in Microsoft Excel format and archive such reports. The World Weather Records contain monthly summaries of temperature, rainfall, and pressure over the past 10 years and station metadata notes, if available.
- 5.5.4 The System shall be able to generate the aerodrome climatological summary in accordance to the requirements in WMO-No.49 Technical Regulations Volume II – Meteorological Service for International Air Navigation.

Map Display

- 5.5.5 The System shall allow the users to display the observation network and the relevant status of the stations on a geographical map. Such map display shall at least support the following basic functionalities:
- a) Zoom in and out
 - b) Panning
 - c) Toggle/switch various map and layers
 - d) Printing of user-defined area
- 5.5.6 The System shall allow base maps and other map layers, in common GIS formats like shape files, to be imported and used.
- 5.5.7 The System shall be capable of displaying various climate data and statistics on the geographical map.
- 5.5.8 The map display shall also highlight any exceedance of threshold values (such as historical extremes) via means like colour codes.
- 5.5.9 The System shall also allow the relevant data and information related to the stations, such as station metadata and time series data, to be called out from the map display.

Tables and Charts

- 5.5.10 The System shall be able to generate a wide variety of tables and charts to communicate issues relating to climate data effectively. The System shall also allow users to define custom table and chart formats relevant to their uses.
- 5.5.11 The System shall, at the minimum, support the generation of the following:-
- a) Tabular Reports;
 - b) Time Series Graphs;
 - c) Scatter Plots, Histograms, Bar and Line Charts;
 - d) Wind Roses;
 - e) Wind Barbs;
 - f) Isopleth Maps;
 - g) Hovmoller Diagrams.
- 5.5.12 The System shall be able to integrate and combine tables and graphical plots under one single view.

- 5.5.13 The System shall be able to output the tables, graphical plots, or both as a PDF and common image formats (PNG, JPEG, GIF etc) without the other peripheral parts of the web environment.
- 5.5.14 The System shall, where applicable, be able to output the products in formats that common geospatial applications and platforms can easily use. e.g. generating interpolated maps in common GIS compatible formats such as GeoTIFF;
- 5.5.15 The System should preferably, where applicable, be able to output the products in NetCDF and/or GRIB format.
- 5.5.16 It is important for the System to be flexible and allow various customizations of the tables and charts/maps down to fine granular details to enable the Agency to produce the required products to cater to current and also future requirements. The Tenderer shall submit, as part of the tender proposal, a detailed list of such customization and display options available in the System. The System should preferably provide the customization and display options listed below:
- a) Selection and plotting of multiple time-series in a single chart;
 - b) Selection of font type, colors, sizes, positions etc for the chart labels, titles;
 - c) Customization of value ranges for the various plots like isopleth maps and the legend (position, size etc);
 - d) Selection of stations to be used for the isopleth maps
 - e) Customization of line thickness, colors etc for the plots;
 - f) Customization of the output dimension of images;
 - g) Plotting of multiple graph types in a single graph (e.g. lines and bar charts in a single graph);
 - h) Selection of parameters to include in tables and graphics;
 - i) Viewing quality flag/status of the data in the table and charts;
 - j) Selection of wind direction branches, wind speed intervals etc for wind rose;
 - k) Viewing of data value in the graphs via means such as mouse-over;
 - l) Zoom In/Out of graphs;
 - m) Display a summary of the number of data points, sum, mean, standard deviation, maximum, and minimum of the data viewed of the time series together with the associated charts;
 - n) Plotting of wind direction arrows together with wind speed in a time series chart;
 - o) Selection of and customization histogram bin widths;

- p) Setting of domain for geographical map;
 - q) Overlay the wind rose and wind barbs of stations over geographic map;
 - r) Setting of transparency of data, isopleths etc;
 - s) Use of mask layer to limit the isopleths to our area of interest (e.g. within coastlines of Singapore and only over land areas and not reservoirs);
 - t) Selection of page settings (page size, orientation etc) for printing and output to PDF etc.
- 5.5.17 A list of current climate related products that the Agency is generating using various different software tools is in Appendix II. The System should be able to generate most of the products listed in the list. The Tenderer shall demonstrate in its Tender Proposal, the ability of the System to meet the Agency's current production needs.
- 5.5.18 The System shall allow a combination of different products (e.g. tables and time series graphics) in a single report and page. The users shall be able to layout these combination of products according to their requirements.
- 5.5.19 The System shall have the capabilities to manage batch and scheduled jobs for the purpose of generation of reports, productions and also data processing, as well as the dissemination of such reports and products to other systems via SFTP, shared folder etc.
- 5.6 Metadata Management**
- 5.6.1 The System shall have a module to manage and archive observational metadata so that the history of the stations and the changes they have undergone are registered.
- 5.6.2 The System shall provide a user interface for the Agency appointed users to update the metadata field.
- 5.6.3 The System shall be able to record and store the observational metadata specified in the Manual on the WMO Integrated Global Observing System (latest edition as of the Tender Publication Date) and shall comply with the metadata standards specified in the manual.
- 5.7 System Administration**
- 5.7.1 The System shall have the necessary user privileges management and security features for management of user accounts and assignment of access rights.
- 5.7.2 The System shall allow granular assignment of user access rights to the different functionalities of the System and the data stored in the System, such as rights to view or edit the climate data, station metadata, different access rights to different types of data (raw, calculated etc).
- 5.7.3 The System shall have the flexibility to classify users into various groups or user roles with each group or roles having different sets of access rights.

- 5.7.4 The Supplier shall document and maintain the access control matrix on the System for administrative and review purposes.
- 5.7.5 For the duration of the System Warranty Period and Maintenance Contract (Part 1 Section C), the Supplier shall perform monthly reviews on the user accounts and access control matrix and submit to the Agency's designated user(s) for verification and endorsement.
- 5.7.6 The System shall have an administration module to allow Agency appointed user to manage the user account, groups and access rights, such as creating/deleting of user account, groups and assignment access rights.
- 5.7.7 The System shall capture detailed audit trails of transactions performed in the System. All actions on the change of contents (including both data and metadata) stored in the System shall be logged into the audit trails. The information to be logged includes user identity, action taken, date/time of action.
- 5.7.8 The contents of the audit trail shall be read-only and alteration of such information in the System shall not be allowed.

5.8 [Optional] Document Archiving and Cataloguing Module

- 5.8.1 The System shall have a document storing and cataloguing module, with a minimum storage space of 4 TB, for the archiving of the followings,
- a) Scanned Daily and Monthly Register;
 - b) Scanned Rain Charts;
 - c) Scanned Weather Charts
 - d) Scanned Paper Observation Forms;
 - e) Scanned Microfilm;
 - f) Relevant Observations Metadata Documents such as Calibration Reports;
 - g) Batch Reports from Scheduled Processes within the System
- 5.8.2 The Document Archiving and Cataloguing Module should preferably be integrated with the System but can also be a standalone system.
- 5.8.3 The System shall allow users to query and search for the documents they want by date/time of observations, document types etc.
- 5.8.4 The System shall support batch uploading and downloading of documents to facilitate fast uploading/downloading of large number of documents without manual intervention.
- 5.8.5 The Supplier shall setup the necessary batch processes for the Agency, to allow the Agency to upload existing documents into the System.

- 5.8.6 The Document Archiving and Cataloguing Module shall have the necessary user privileges management and security features for management of user accounts and assignment of access rights.
- 5.8.7 The Document Archiving and Cataloguing Module shall allow granular assignment of user access rights to the different documents stored.
- 5.8.8 The Document Archiving and Cataloguing Module shall have the flexibility to classify users into various groups or user roles with each group or roles having different sets of access rights.
- 5.8.9 The Document Archiving and Cataloguing Module shall have an administration module to allow Agency appointed user to manage the user account, groups and access rights, such as creating/deleting of user account, groups and assignment access rights.
- 5.8.10 The Document Archiving and Cataloguing Module shall also track changes made to the documents stored (changes, addition, removal of documents etc).

6 DATA MIGRATION AND CONVERSION SERVICES

- 6.1 The Supplier shall carry out migration of all data, including historical data, to the System, without any data loss.
- 6.2 The System shall apply the same business rules that govern how data are ingested into the System to the ingest of such migrated data and apply quality control procedures and flagging to these data.
- 6.3 The following data will need to be migrated or imported into the System:-
 - a) Historical records in machine readable flat file formats (such as CSV), including data digitized from the monthly and daily registers and rain charts;
 - b) Data from the AWOS system;
 - c) Data from the MDPS
 - d) Observational metadata;
- 6.4 The Supplier shall analyse users' requirements and propose a detailed Data Migration Plan for the Agency's approval. The Data Migration Plan shall include, at minimum, submissions in the following areas:
 - a) Data conversion strategy, approach, the estimated duration and activities related to conversion of existing data to the required format by the System;
 - b) Migration strategy, approach and activities related to trial and actual migration of existing data to the new environment, such as data mapping, cleaning, and data conversion;
 - c) Specify clearly the critical path and the critical success factors;

- d) Verification to ensure data integrity and completeness;
- e) Exception and error-handling process;
- f) Contingency plan for failed data migration process

6.5 The Supplier shall submit the following documents to the Agency for review and approval during the data migration process:

- a) Migration Specifications, outlining the mapping of data fields from original format to the new format required;
- b) Migration Test Plan;
- c) Migration Test Scenario and Results; and
- d) Migration Test Reports

6.6 The Supplier shall perform all data conversion where necessary or where required by the Agency. The details of the conversion shall be stated clearly in the Migration Plan.

6.7 If there is a need to convert the existing data to another format, the work shall be performed outside the existing systems' databases. The Supplier shall be responsible for successful data conversion. The Supplier shall perform any necessary programming or tasks to format the data extracted from the Agency's systems to the format required by the System.

6.8 The Supplier shall propose a validation and verification methodology and perform all necessary tests to ensure the accuracy and completeness of the migrated data.

6.9 The data migration shall be carried out, with minimal disruption to the business operation. The Agency may occasionally request the Supplier to carry out data migration work after office hours. All other additional expenses incurred for after-office hour's work shall be borne by the Supplier.

6.10 The Supplier shall ensure that the migration and conversion programs, the data migrated and converted are free of errors. The Supplier shall rectify any errors detected at no cost to the Agency.

6.11 The Supplier shall also provide documentary proof to demonstrate the successful completion of data migration and conversion.

6.12 The Supplier shall design and propose a mechanism for the Agency to upload historical data into the System, without going through the Supplier, as some data are still in the process of data rescue and will take a few years to be completed. Data uploaded via this mechanism shall be subjected to the same principles and business rules as data imported previously during the set-up of the System.

7 NETWORKING AND IT SECURITY

- 7.1 The System shall sit on the Agency's network infrastructure and shall comply with all the Agency's network/IT security policies/requirements.
- 7.2 The System shall be IPv6 compliant.
- 7.3 The Supplier shall supply and install compatible antivirus software and update the latest virus signature file(s) to all computing systems supplied under this Contract. (Note: The Agency is currently using Symantec Endpoint Protection Manager to push latest anti-virus signature file(s) to computing systems connected to the LAN on a regular basis. The Supplier has the option to make use of the Agency's central server to update the anti-virus signature on a periodic basis (if the anti-virus software supplied is compatible), or manually update the anti-virus signature regularly.
- 7.4 The Supplier shall perform Operating System hardening, according to the Agency's requirements, to computing servers supplied under this Contract.
- 7.5 The Supplier shall note that the Agency's network infrastructure is color-coded. The Supplier shall lay network cables and supply patch cords according to the Agency's color code scheme (Red, Blue, Green and Yellow).
- 7.6 The Supplier is to note that the Agency's Local Area Network sits behind a firewall. While Internet connection is available, there may be restrictions to the manner in which the System is to access the Internet.
- 8 BACKUP/ARCHIVING**
- 8.1 The Supplier shall supply, deliver and install a backup/archiving solution to enable prompt system recovery and restoration of the data stored in the System.
- 8.2 The backup/archiving solution shall be based on removable storage media to facilitate the sending of the backups for off-site storage via physical transportation of the removable storage media.
- 8.3 The Supplier shall supply and deliver the necessary consumables (e.g. storage tapes) for backup/archive purpose sufficient for use during the one (1) year System Warranty Period.
- 8.4 The Supplier shall propose and implement a suitable data backup/archive strategy according to the Agency's business needs. The Agency shall agree with the backup/archive strategy plan before implementation.
- 8.5 The Agency's designated user or contractor shall be responsible for performing the routine backup and the Supplier shall provide the necessary instructions and training to enable them to perform the backup. The Supplier shall however be responsible for the system and data recovery required during the duration of the System Warranty Period and Maintenance Contract (Part 1 Section C).
- 8.6 The System shall not experience any performance degradation or downtime when the backup/archive process is running.
- 9 [OPTIONAL] DISASTER RECOVERY**

- 9.1 The Supplier shall supply and install all necessary hardware, software and licenses etc as backup at an alternate site for continued operation if the main site of the System is disrupted. The backup at the alternate site do not need to support high availability operations like the setup at the main site (Clause 10.2.2). The System at the alternate site shall also be based on a multi-tier architecture as stated in Clause 4.2.
- 9.2 The backup at the alternate site must be able to meet a Recovery Time Objective of 1 month and a Recovery Point Objective of 3 days. i.e. The System shall be able to resume operations within 1 month from the occurrence of an incident that disrupted the operations at the main site and there shall be less than 3-day worth of loss data from the time of incident.
- 9.3 For the duration of the System Warranty Period and Maintenance Contract (Part 1 Section C), the Supplier shall support the Agency's disaster recovery (DR) plan and to work with the relevant parties to carry out the DR plan. This shall include up to two (2) disaster recovery exercises per year.
- 9.4 As part of the System Documentation, the Supplier shall provide detailed instructions on how to activate the System at the alternate site and to recover the necessary data to enable operations at the alternate site.

10 SYSTEM PERFORMANCE, AVAILABILITY AND RELIABILITY

10.1 System Performance

- 10.1.1 The System shall handle most of the standard transactions within ten (10) seconds response time.
- 10.1.2 Response time shall be measured as the elapsed time between the moment a user initiates a computer process by pressing a key or clicking a mouse or to the input device and the moment the last display of the first screen of the resulting computer generated output is seen on the screen of the PC. A computer process can be a database update or any other logical unit of business transactions that involve interactive responses. Response time shall be measured at the maximum load of 10 concurrent users and executed within the Agency's operational LAN environment (a Gigabit Ethernet network) or a 100Mbps network dedicated for this purpose. For the case of data extraction, the response times shall be measured as the elapsed time between the moment a user initiates the extraction and the moment the full data is written into a storage location.
- 10.1.3 The Tenderer shall compute and provide the expected response times (as described in Clause 10.1.2) for the following transactions as part of the Tender Proposal for the Agency's evaluation and the System shall be able to meet the response times provided:
- a) Extraction of 1, 5 and 10 years of records from 10, 20 and 30 stations and for 1, 2 and 3 parameters;
 - b) Computing of 30-years normal for 1, 2 and 3 parameters and 10, 20 and 30 stations;

- c) Plotting of monthly isohyets using records from 60 stations;
- d) Averaging daily records over 60 stations and performing rankings of the averaged values.

- 10.1.4 The Tenderer shall describe the assumptions, methods and calculations used to compute the expected response times subject to the above condition.
- 10.1.5 The Supplier shall propose a performance measurement tool or suite in the Tender Proposal that will be used to measure the performance of the System.
- 10.1.6 The System will be subjected to at least a round of system performance test before commissioning.

10.2 System Availability

- 10.2.1 The System shall be required to run continuously for 24 hours a day, 7 days a week, including Saturdays, Sundays and Public Holidays.
- 10.2.2 The System shall be designed and built to support High Availability (HA) operations. The Tenderer shall elaborate on how the proposed System is able to support HA operations in the tender proposal.
- 10.2.3 The System Availability Level shall not be less than ninety-nine point five per cent (99.5%) for each calendar month as specified in Part 1 Section C – Conditions of Software Support and Hardware Maintenance.
- 10.2.4 Illustrations of “System Downtime” as specified in Part 1 Section C will include, but not be limited to the following,
- a) Any of the crucial services on any of the System becomes inaccessible (e.g. certain modules becomes inaccessible, products cannot be generated, batch/schedule jobs cannot be run);
 - b) Any of the crucial services on any of the System servers does not respond properly (e.g. error in the final calculated value when performing data aggregation, failure in generating any of the required products and reports.)
 - c) Failure in receiving and processing data from any of the sources (AWOS, Message Switching System, manned weather stations etc)
- 10.2.5 The Supplier shall size and provide a complete system configuration to meet the response time and performance requirements as specified.
- 10.2.6 The Supplier shall take into consideration the projected annual growth rate of the System data in its planning to meet the requirements.
- 10.2.7 The Supplier shall also take into consideration audit trail, transaction log, housekeeping and archival requirements etc when sizing the System.

- 10.2.8 The Supplier shall propose resource monitoring to facilitate capacity planning, maintenance and tuning. The Supplier shall provide clear illustrations on such monitoring facilities.

10.3 System Reliability

- 10.3.1 All the data in the System shall be recoverable to the last successfully completed transaction in the event of failure of the System. Comprehensive logging shall be enabled to facilitate recovery of data for the System and across other systems that have interface(s) to the System.
- 10.3.2 The Supplier shall ensure that any failure of any transaction shall not affect the integrity of the data captured / stored in the System.
- 10.3.3 The Supplier shall ensure no loss or distortion of data, interference with system functions, display of erratic information, etc, due to improper operation by maintenance personnel.

11 [OPTIONAL] SERVICE REQUEST MAN-DAYS

- 11.1 The Supplier shall quote a standard one (1) man-day rate for all Service Requests for additional work in the provision of professional services, system modifications, enhancements etc.
- 11.2 The Supplier is advised that services that require less than one man-day will be charged on a pro-rated basis.
- 11.3 The Agency shall exercise the Service Request Man-days by raising Service Requests and issuance of written notice to the Supplier.
- 11.4 The Supplier shall note that Service Request man-days procured for the initial three (3) years maintenance contract period and System Warranty period is spread across and can be carried forward during the contracted period. This shall apply also to Service Request man-days procured for the four (4) years extension of the maintenance contract after the expiry of the initial three (3) years. Any unconsumed service requests shall be omitted from the Contract at no charge to the Agency as a variation to the Contract.
- 11.5 The Supplier shall work with the Agency to prioritise the Service Requests accepted. The Agency reserves the right to re-prioritise any Service Requests given earlier and the Agency shall not be liable for any additional costs thereby incurred.
- 11.6 The Supplier shall ensure that there is proper documentation and filing of each Service Request for billing purposes as well as for audit purposes.
- 11.7 The Supplier shall discuss and ensure that there is a common understanding of the completion criteria for the service request. When the service is completed, the Supplier shall ensure that the Agency signs off the service request once completed.

12 TRAINING

- 12.1** The Supplier shall provide training to acquaint the Agency nominated officers (a minimum class size of twenty (20) officers), with basic operation of the software application of the System.
- 12.2** The Supplier shall provide training to acquaint the Agency nominated officers (a minimum class size of eight (8) officers), with advanced operation of the software application, such as administration, configurations, set-up and utilization of API.
- 12.3** The trainings indicated in Clause 12.1 and 12.2 are to be repeated in at least two separate sessions each to enable different groups of the Agency's officers to attend.
- 12.4** The Supplier shall also provide and setup equipment (such as laptop etc) if necessary, for conducting the training.
- 12.5** The medium of instruction and training document shall be in English. The Supplier shall provide each trainee with a complete set of training documents and materials for his retention.
- 12.6** For every course conducted by the Supplier, a complete set of the instruction guides and training materials shall be made available to the Agency. The Agency shall have the right to use these training materials to conduct in-house course for its personnel.

13 DOCUMENTATION

- 13.1** The Supplier shall supply and deliver full documentation and training manuals on all aspects of the System including the following:
- a) Administrator Guide;
 - b) User Guide, including Application Programming Interface (API) user manual;
 - c) Installation Manual;
 - d) System (Hardware and software) setup and configurations
 - e) Data flow between the System and other systems and details of interfaces with other systems;
 - f) List of hardware and software of the System;
 - g) Database-related information (e.g. database relationship schema, data field definition (if any))
 - h) Administrator/System account ID and password (in hardcopy)
- 13.2** In addition to the above, the Supplier shall at minimum, supply project-related documentation on the following, where applicable:
- a) System Test Plan and Report;

- b) User Acceptance Test Plan and Report;
 - c) Disaster Recovery Plan/Contingency Plan;
 - d) Disaster Recovery Test Plan and Report;
 - e) Performance Guarantee Period Report;
 - f) Problem Escalation and Resolution Management;
 - g) System Support Plan and Procedures/Operations Manual;
- 13.3** All documentation shall be in good, simple and concise English using accepted technical terms and symbols. All documents, except for the standard documentation that accompanies the appropriate hardware and system software, shall be made available in hardcopy and CD/DVD for ready reference. At least two (2) sets of hardcopy shall be given.
- 13.4** The Supplier shall also provide one (1) set of Operating System (OS) recovery/installation disk (on CD/DVD media) for each type of OS installed on the computing system supplied under this Contract.
- 13.5** The Supplier shall also provide one (1) set of installation disk (if any, on CD/DVD media) for the database software supplied under this Contract.
- 13.6** All documents produced by the Supplier in fulfilling this Contract, shall become the property of the Agency. The Agency reserves the right to reproduce, at no cost whatsoever, any documentation supplied with the System for its own use.
- 13.7** The Supplier shall also provide documentation and manuals of third party hardware, software and equipment, if there is any.
- 14 WORKPLACE SAFETY AND HEALTH**
- 14.1** The Supplier shall conduct the necessary risk assessment, propose and implement the necessary solutions and measures to ensure that all installation and maintenance work for the System are carried out safely and in compliance with the necessary workplace safety and health requirements of the relevant authority like Ministry of Manpower.

15 Appendix I – Estimated Inventory of Local Data from Singapore

**The list here is indicative only to facilitate sizing of the necessary hardware like storage space and does not represent the complete list of data that the System will be required to store and process. This does not include the regional data that the System is required to store and process.*

Current

(Period with an ending year indicated means that the station has stopped operations and no more data collected since then)

Manual/Manned Stations						
S/No	Number of stations	Parameter Type	Resolution	Unit	No. of parameters	Period
1	95	Rain	1 Month	mm	1	1869 to 2009
		Rain frequency	1 Month	-	3	
2	95	Rain	1 Month	mm	10	1929-2009
		Rain Frequency	1 Month		3	
		Time of occurrence of maximum intensity	1 Month	Date/Time	9	
		Rain	1 Day	mm	3	
		Rain	1 hour	mm	1	
		Rain Duration	1 hour	Minutes	1	
		Rain	5 minutes	mm	1	
3	6	Frequency of Events	1 Month	Days	7	Since 1929
		Temperature	1 Month	Deg C	8	
		Pressure	1 Month	hPa	4	
		Relative Humidity	1 Month	%	4	
		Cloud Amount	1 Month	Oktas	4	
		Sunshine Duration	1 Month	Hrs	2	
		Cloud Amount Frequency	1 Month		40	
		Temperature	1 Day	Deg C	7	
		Relative Humidity	1 Day	%	3	
		Pressure	1 Day	hPa	4	
		Cloud Amount	1 Day	Oktas	4	
		Sunshine Duration	1 Day	Hrs	1	
		Visibility	1 Day	Metre	1	
		Wind Direction and Speed	1 Day	String	1	

		Temperature	1 hour	Deg C	6	
		Relative Humidity	1 hour	%	2	
		Cloud Base	1 hour	Code	1	
		Cloud Base	1 hour	Metre	1	
		Cloud Info	1 hour	String indicating amount, type,height	4	
		Sky Conditions	1 hour	string (3 characters of low,medium, high cloud amount)	1	
		Cloud Amount	1 hour	oktas	5	
		Sunshine Duration	1 hour	Hrs	2	
		Wind Direction and Speed	1 hour	String	2	
		Pressure	1 hour	hPa	3	
		Wind Direction	1 hour	Degrees	2	
		Wind Speed	1 hour	Knots	2	
		Visibility	1 hour	Metre	1	
		Sunshine Duration	0.5 hour	Minutes	1	
		Wind Direction	1 day	Degrees	2	Since 1982
		Wind Speed	1 day	Knots	4	
		Visibility	1 day	Metre	1	
		Visibility	1 hour	Metre	1	
		Wind Direction	1 hour	Degrees	2	
		Wind Speed	1 hour	m/s	2	
		Notations	1 hour	String	4	
		Wind Direction	1 Month	Degrees	1	Since 1998
		Wind Speed	1 Month	m/s	21	
		Duration	1 Month	Hrs	20	
		Duration	1 Day	Hrs	20	
		Wind Direction	1 Day	Degrees	1	
4	1	Cloud cover days	1 Month	Days	2	Since 1929
		Temperature	1 Month	Deg C	3	
		Temperature	1 Day	Deg C	3	
		Pressure	1 hour	hPa	1	
		Codes (Weather, Visibility, cloud etc)	1 hour	String	3	
		Evaporation	1 month	mm	1	Since 1957
		Temperature	1 month	Deg C	2	
		Radiation	1 Month	MJ/m2 or	6	

				mWh/cm2		Since 1981
		Evaporation	1 Day	mm	3	
		Temperature	1 Day	Deg C	2	
		Radiation	1 Day	MJ/m2 or mWh/cm2	6	
		Radiation	1 hour	MJ/m2 or mWh/cm2	9	
		Pressure	1 month	hPa	2	
		Temperature	1 month	Deg C	7	
		Temperature	1 day	Deg C	7	
		Pressure	1 hour	hPa	2	
		Temperature	1 hour	Deg C	12	
		Codes (Weather, Visibility, cloud etc)	1 hour	string	2	
5	1 upper-air observing station	<u>Radiosonde</u> 1957 to 1983: Standard and significant levels (~ 60 levels per ascent). 1 set of observations per day 1984 to 1994: Standard and significant levels (~ 60 level per ascent). 2 sets of observations per day 1995 and onwards: Standard and significant levels, and observations every 2 seconds during the ascent of the weather balloon (~3600 levels per ascent). 2 sets of observations per day. <u>Ozonesonde</u> 1995 to 2003: Standard levels and observations every 2 seconds during the ascent of the weather balloon. 2 sets of observations every month. 2014 and onwards: Standard levels and observations every 2 seconds during the ascent of the weather balloon (~3500 levels per ascent). 1 set of observations every month.				

Automatic Weather Stations						
S/No	Number of stations	Parameter Type	Resolution	Unit	No. of parameters	Period
1	41	Rain	1 hour	mm	2	Since 2009
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
2	24	Temperature	1 hour	Deg C	10 (e.g. Apparent temperature, wet bulb	Since 2009

					temperature, dew point temperature)	
		Temperature	1 minute	Deg C	5	
		Pressure	1 hour	hPa	14	
		Pressure	1 minute	hPa	4	
		Relative Humidity	1 hour	%	2	
		Relative Humidity	1 minute	%	1	
		Rain Duration	1 hour	minutes	2	
		Rain	1 hour	mm	2	
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
		Wind Direction	1 hour	Degrees	2	
		Wind Direction	10 minute	Degrees	4	
		Wind Direction	1 minute	Degrees	7	
		Wind Speed	1 hour	Knots	2	
		Wind Speed	10 minute	Knots	4	
		Wind Speed	1 minute	knots	7	
		Wind Speed Maximum Time	1 hour	Date/time	1	
		Wind Speed Maximum Time	10 minute	Date/time	1	
		Variation	1 hour	Degrees	2	
		Variation	10 minute	Degrees	2	
		Variation	1 minute	Degrees	2	
		Radiation	1 hour	MJ/m2	2	
		Radiation	1 minute	W/m2	5	
		UV	1 hour	MJ/m2	2	
		UV	1 minute	MJ/m2	4	
3	1	Temperature	1 hour	Deg C	10+ 3+ 7x4= 4 1	Since 2009
		Temperature	10 minute	Deg C	1+ 7= 8	
		Temperature	1 minute	Deg C	5	
		Temperature Minimum/Maximum Time	1 hour	Date/Time	2+ 7x2= 16	
		Pressure	1 hour	hPa	14	
		Pressure	1 minute	hPa	4	
		Relative Humidity	1 hour	%	2	
		Relative Humidity	1 minute	%	1	
		Rain Duration	1 hour	minutes	2	
		Rain	1 hour	mm	2	
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
		Wind Direction	1 hour	Degrees	2	
		Wind Direction	10 minute	Degrees	4	
		Wind Direction	1 minute	Degrees	7	

		Wind Speed	1 hour	Knots	2	
		Wind Speed	10 minute	Knots	4	
		Wind Speed	1 minute	knots	7	
		Wind Speed Maximum Time	1 hour	Date/time	1	
		Wind Speed Maximum Time	10 minute	Date/time	1	
		Variation	1 hour	Degrees	2	
		Variation	10 minute	Degrees	2	
		Variation	1 minute	Degrees	2	
		Radiation	1 hour	MJ/m2	1	
		Radiation	1 minute	W/m2	4	
		UV	1 hour	MJ/m2	2	
		UV	1 minute	MJ/m2	4	
		Cloud Base	1 hour	Metre	2	
		Cloud Base	1 minute	metre	3	
		Cloud Base Minimum Time	1 hour	Date/time	1	
		Evaporation	1 hour	mm	1	
		Visibility	1 hour	Metre	3	
		Visibility	10 minute	metre	1	
		Visibility	1 minute	Metre	1	
		Visibility Minimum Time	1 hour	Date/time	2	
		Sky Condition	30 minute	Oktas	3	
		Sunshine duration	1 hour	Minute	1	
		Sunshine duration	30 minute	Minute	1	

Projected Future Additions

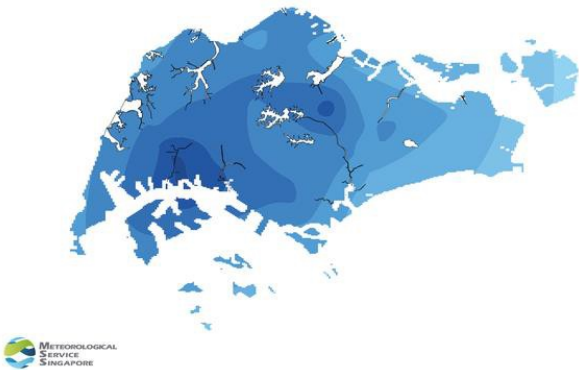
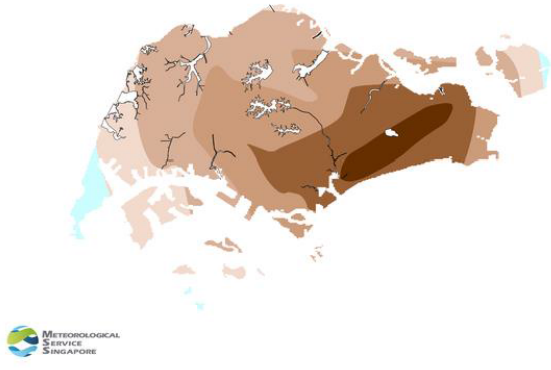

Automatic Weather Stations						
S/No	Number of stations	Parameter Type	Resolution	Unit	No. of parameters	Period
1	31	Rain	1 hour	mm	2	Projected to be from 2016
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
2	8	Rain	1 hour	mm	2	Projected to be from 2018
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
3	2	Temperature	1 hour	Deg C	10 (e.g. Apparent temperature, wet bulb temperature,	Projected to be from 2017

					dew point temperature)	
		Temperature	1 minute	Deg C	5	
		Pressure	1 hour	hPa	14	
		Pressure	1 minute	hPa	4	
		Relative Humidity	1 hour	%	2	
		Relative Humidity	1 minute	%	1	
		Rain Duration	1 hour	minutes	2	
		Rain	1 hour	mm	2	
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
		Wind Direction	1 hour	Degrees	2	
		Wind Direction	10 minute	Degrees	4	
		Wind Direction	1 minute	Degrees	7	
		Wind Speed	1 hour	Knots	2	
		Wind Speed	10 minute	Knots	4	
		Wind Speed	1 minute	knots	7	
		Wind Speed Maximum Time	1 hour	Date/time	1	
		Wind Speed Maximum Time	10 minute	Date/time	1	
		Variation	1 hour	Degrees	2	
		Variation	10 minute	Degrees	2	
		Variation	1 minute	Degrees	2	
		Radiation	1 hour	MJ/m2	2	
		Radiation	1 minute	W/m2	5	
		UV	1 hour	MJ/m2	2	
		UV	1 minute	MJ/m2	4	
4	8	Temperature	1 hour	Deg C	10 (e.g. Apparent temperature, wet bulb temperature, dew point temperature)	Projected to be from 2018
		Temperature	1 minute	Deg C	5	
		Pressure	1 hour	hPa	14	
		Pressure	1 minute	hPa	4	
		Relative Humidity	1 hour	%	2	
		Relative Humidity	1 minute	%	1	
		Rain Duration	1 hour	minutes	2	
		Rain	1 hour	mm	2	
		Rain	5 minute	mm	14	
		Rain	1 minute	mm	2	
		Wind Direction	1 hour	Degrees	2	
		Wind Direction	10 minute	Degrees	4	
		Wind Direction	1 minute	Degrees	7	

	Wind Speed	1 hour	Knots	2
	Wind Speed	10 minute	Knots	4
	Wind Speed	1 minute	knots	7
	Wind Speed Maximum Time	1 hour	Date/time	1
	Wind Speed Maximum Time	10 minute	Date/time	1
	Variation	1 hour	Degrees	2
	Variation	10 minute	Degrees	2
	Variation	1 minute	Degrees	2
	Radiation	1 hour	MJ/m2	2
	Radiation	1 minute	W/m2	5
	UV	1 hour	MJ/m2	2
	UV	1 minute	MJ/m2	4

16 Appendix II - Climate Related Publications and Products Produced by the Agency Currently

Publications	
Description	Examples
Annual Climate Assessment Report	Refer to URL http://www.weather.gov.sg/wp-content/uploads/2016/03/Annual-Climate-Assessment-Report-2015.pdf
Annual Climatological Report	Refer to URL http://www.weather.gov.sg/wp-content/uploads/2016/03/Annual-Climatological-Report-2015.pdf

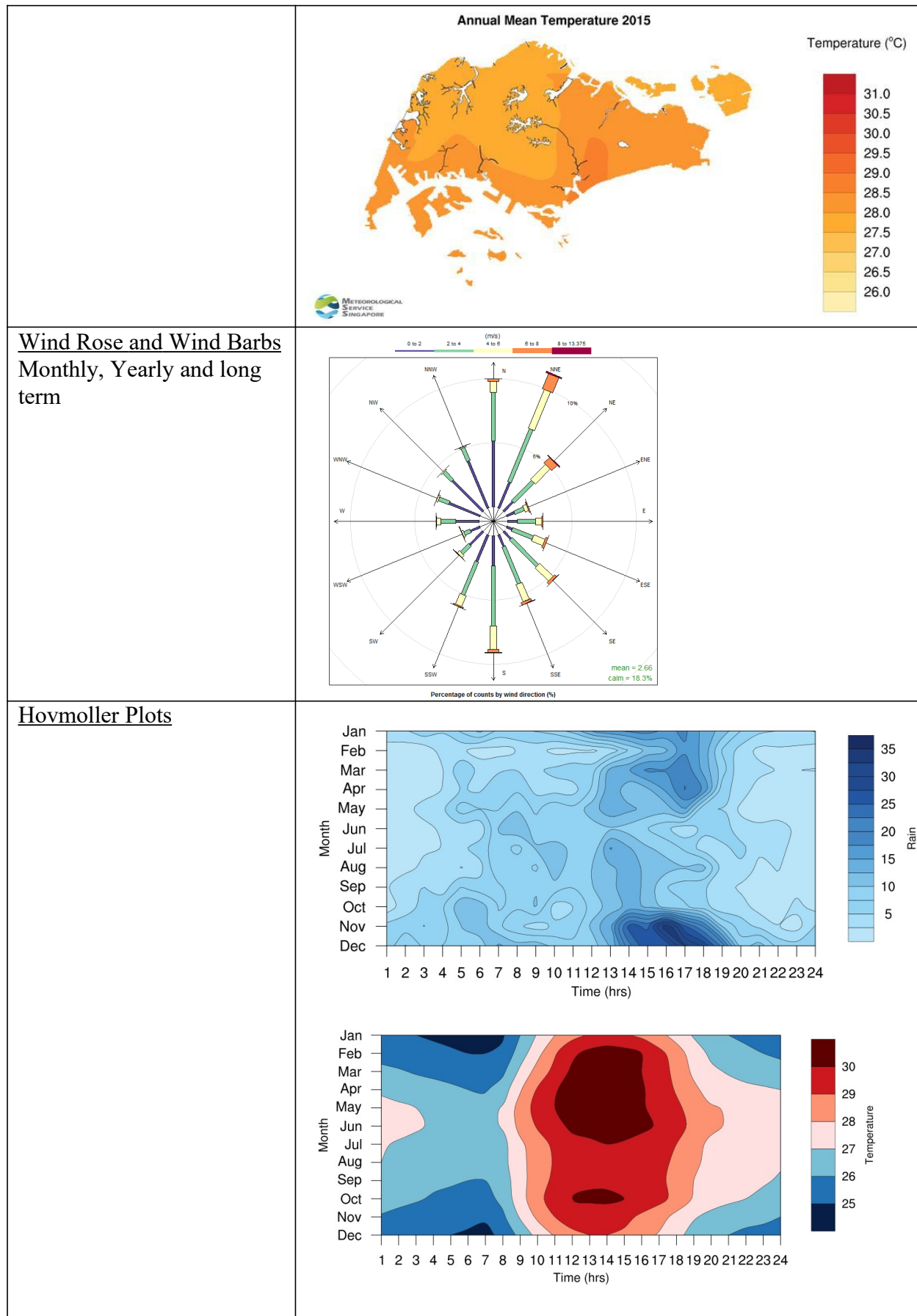
Graphical Products	
Description	Examples
<p><u>Isohyets</u></p> <p>Daily, fortnightly, monthly and yearly for total rainfall, anomalies, long term average.</p>	<p>Monthly Total Rainfall Apr 2016</p>  <p>Rainfall (mm)</p> <p>500 400 300 250 200 150 100 75 50 25 2</p> <p>Annual Rainfall Anomaly 2015</p>  <p>Rainfall Anomaly (%)</p> <p>50 40 30 20 10 0 -10 -20 -30 -40 -50</p> <p>Mean Daily Temperature Apr 2016</p>  <p>Temperature (°C)</p> <p>31.0 30.5 30.0 29.5 29.0 28.5 28.0 27.5 27.0 26.5 26.0</p>

PART 2

REQUIREMENT SPECIFICATIONS

Isotherm

Daily, monthly, yearly for
mean, minimum, maximum,
long term average
temperature.



	<p>Refer to URL http://www.weather.gov.sg/climate-climate-of-singapore/.</p>
<p><u>Trend Maps</u></p>	<p>Trend Trend significant at 5% level Trend not significant at 5% level</p>
<p><u>Various Line, bar charts</u></p>	<p>Refer to Annual Climatological Report, Annual Climate Assessment Report and URL http://www.weather.gov.sg/climate-climate-of-singapore/</p>
<p>Extremes and Records</p> <p>Refer to URL</p>	

Tabular Reports

Historical Daily Records

Refer to URL <http://www.weather.gov.sg/climate-historical-daily/> and link to CSV and PDF.

Sample of some tabular reports for various customers

METEOROLOGICAL SERVICES DIVISION JANUARY 2008

Singapore Airport (1°22'N 103°59'E)

Height above M.S.L. 14.6 m

Date	Mean Pressure at M.S.L.	Temperature			Relative Humidity			Dew Point	Mean Amount of Cloud	Sunshine Duration	Total Solar Radiation	Rainfall Amount	Surface Wind		
		Max.	Min.	Mean	Max.	Min.	Mean						Prevailing Direction	Mean Speed	No. of hours calm
	hPa	°C	°C	°C	%	%	%	°C	%	hours	mWh/cm ²	mm		m/s	hours
1	1010.1	28.0	24.6	26.0	94	70	84.5	23.1	88.75	0.20	defective	0.2	NNW	2.2	-
2	1011.3	26.2	23.6	25.3	97	84	90.1	23.5	91.25	0.10	defective	5.6	N	1.3	1
3	1012.0	27.5	23.2	25.2	98	77	90.5	23.5	93.75	0.15	defective	Trace	N	1.2	1
4	1012.2	29.9	24.3	26.2	97	73	87.6	23.9	87.50	2.65	defective	7.2	N	1.3	-
5	1012.4	30.4	24.5	26.5	93	67	85.2	23.7	88.75	5.50	defective	1.1	N	1.5	3
6	1012.6	30.9	23.8	26.2	96	65	86.5	23.7	87.50	5.85	defective	1.3	N	1	3
7	1012.4	30.3	24.2	26.1	97	72	90.0	24.3	87.50	4.55	defective	1.7	N	1.5	-
8	1011.7	27.8	23.3	25.3	100	86	95.7	24.5	91.25	0.25	defective	123.1	NNW	0.6	8
9	1011.9	27.6	23.5	25.2	100	84	95.7	24.5	92.50	0.00	defective	3.0	N	0.4	13
10	1011.5	31.3	24.3	26.9	100	71	87.0	24.4	87.50	6.95	defective	Nil	NNE	1.2	7
11	1011.1	31.5	24.1	26.2	98	66	89.9	24.3	85.00	7.05	defective	24.3	NNE	0.8	9
12	1010.6	30.4	24.1	26.3	100	73	90.4	24.5	85.00	6.15	defective	27.3	NNE	0.5	12
13	1010.2	31.7	23.5	26.3	100	67	89.5	24.3	83.75	8.10	defective	33.7	N	0.8	9
14	1010.3	30.5	24.0	26.3	99	68	88.1	24.1	87.50	6.85	defective	4.9	NNE	0.9	11
15	1011.1	30.8	22.9	26.3	99	68	87.4	24.0	83.75	7.90	defective	24.5	N	1.6	9
16	1011.2	32.4	23.9	27.5	95	60	77.5	23.0	78.75	8.60	defective	Nil	N	0.9	7
17	1010.1	33.4	25.0	28.1	93	55	79.5	23.9	83.75	9.65	defective	0.5	W	1.3	6
18	1009.2	31.7	24.3	27.0	94	62	80.7	23.3	87.50	9.25	defective	0.3	NNW	1.3	5
19	1009.7	30.2	23.4	26.2	98	69	87.0	23.8	85.00	6.10	defective	Trace	N	2	2
20	1009.3	30.9	24.5	27.3	95	67	82.7	24.0	81.25	9.75	defective	Nil	NNE	1.9	2
21	1008.5	31.6	24.2	27.5	97	65	83.3	24.2	80.00	10.65	defective	Nil	NNE	2.4	3
22	1008.2	32.6	25.1	27.6	94	68	83.3	24.4	81.25	10.85	defective	Nil	NNE	3.4	-
23	1008.8	30.7	25.2	27.2	93	71	85.0	24.4	87.50	2.25	defective	0.4	NE	2.1	1
24	1008.6	31.1	24.9	27.6	97	69	84.7	24.7	83.75	6.05	defective	1.3	NNE	3.4	-
25	1009.1	31.9	25.0	27.8	96	64	82.4	24.4	71.25	10.95	defective	Nil	NNE	2.9	-
26	1009.4	31.8	25.1	27.8	94	65	82.4	24.4	87.50	9.25	defective	Nil	NNE	2.8	-
27	1009.2	31.6	25.2	27.8	95	67	84.4	24.8	86.25	7.95	defective	1.7	NNE	3.1	1
28	1009.8	29.7	24.6	26.8	99	75	89.0	24.8	86.25	4.80	defective	0.3	NNE	2.7	1
29	1009.5	31.3	25.6	27.8	93	69	82.6	24.5	87.50	5.90	defective	Nil	NNE	2.4	-
30	1008.9	33.5	25.3	27.8	94	62	81.9	24.2	86.25	6.95	defective	Nil	NNE	2.7	2
31	1008.9	32.4	25.2	27.9	94	62	81.8	24.4	81.25	8.60	defective	Nil	NNE	3.2	-
Mean	1010.3	30.7	24.3	26.8	96.4	69.1	86.0	24.1	85.69	6.1	defective	--	NNE*	1.8	--
Total	--	--	--	--	--	--	--	--	--	189.80	--	262.4	--	--	116

NORMAL FOR JANUARY

1010.4	30.1	23.2	25.9	95.9	65.6	84.8	23.1	82.50	5.35	459.9	243.9	--	2.4	58.5
--------	------	------	------	------	------	------	------	-------	------	-------	-------	----	-----	------

HIGHEST WIND GUST: 290 deg 12.0 m/s on 15th

HIGHEST M.S.L. PRESSURE: 1015.0 hPa on 6th

LOWEST M.S.L. PRESSURE: 1005.8 hPa on 21st, 22th

TOTAL EVAPORATION: 139.5 mm

NOTE: MEAN VALUES FOR EACH DAY COMPUTED FROM 24 HOURLY OBSERVATIONS

* PREVAILING WIND DIRECTION FOR THE MONTH

HIGHEST TEMPERATURE: 33.5 °C on 30th

LOWEST TEMPERATURE: 22.9 °C on 15th

HIGHEST RELATIVE HUMIDITY: 100 % several

LOWEST RELATIVE HUMIDITY: 55 % on 17th

1996 to 2015

METEOROLOGICAL SERVICE SINGAPORE
MONTHLY TOTAL RAINFALL DAYS(>=1MM)(LOCAL TIME(00-24))
STATION 24:CHANGI MET STATION

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	11	7	7	14	14	15	7	15	13	17	13	14
1997	2	7	6	10	3	7	5	4	3	5	12	20
1998	12	5	8	11	16	12	12	17	14	18	9	22
1999	17	7	16	8	9	11	11	14	10	17	13	14
2000	13	17	13	15	7	12	9	11	9	10	19	13
2001	20	9	18	12	8	11	8	11	8	16	11	20
2002	8	1	5	9	10	7	10	8	7	5	15	19
2003	16	11	9	14	10	6	13	14	12	15	15	15
2004	12	3	12	6	8	7	13	7	10	12	10	13
2005	8	1	7	6	17	12	11	11	13	15	18	17
2006	13	8	5	18	12	14	11	14	8	6	16	20
2007	16	3	16	12	11	10	15	16	10	13	19	15
2008	15	5	14	8	8	9	11	14	14	16	16	12
2009	2	7	16	11	14	6	13	9	11	12	18	13
2010	8	3	10	16	14	14	12	11	12	12	20	13
2011	12	3	16	10	13	13	7	7	12	18	20	17
2012	12	9	14	13	15	7	12	10	10	13	15	19
2013	9	17	7	14	13	12	13	13	12	11	20	16
2014	5	-	4	12	14	11	11	16	8	10	16	12
2015	3	3	5	9	11	9	9	11	6	5	8	16
MEAN	10	6	10	11	11	10	10	11	10	12	15	16

"" = DEFECTIVE DATA

"-" = NO RAINDAYS

Issued by Meteorological Service Singapore

DEC 1999

METEOROLOGICAL SERVICE SINGAPORE
DAILY RAINFALL TABULATION (08-08)

NOTE: "" : REPRESENTS DEFECTIVE

DAILY RAINFALL FIGURES ARE IN MM

RAINDAY IS DEFINED AS A DAY WITH 0.2 MM OR MORE OF RAIN

STATION CODES				
DATE	23	24	25	
1	1.3	8.6	8.5	
2	0.7	21.9	12.9	
3	82.0	44.7	60.1	
4	-	-	-	
5	38.8	44.8	36.2	
6	0.7	0.1	1.7	
7	-	-	-	
8	-	-	-	
9	-	8.0	20.7	
10	-	-	-	
11	6.7	76.9	39.5	
12	-	2.1	0.9	
13	-	-	-	
14	-	-	-	
15	-	-	0.1	
16	-	-	-	
17	20.5	3.3	10.2	
18	42.7	34.4	74.8	
19	6.9	64.6	15.3	
20	1.2	16.6	9.9	
21	1.8	3.5	7.3	
22	0.6	1.4	6.4	
23	0.3	4.7	-	
24	0.4	3.5	-	
25	0.3	0.3	0.5	
26	-	-	-	
27	-	-	-	
28	9.8	-	-	
29	-	-	-	
30	2.2	1.1	-	
31	14.8	-	-	
Total Amount	*	*	*	
No. of Rainydays	*	*	*	

23 TENGAH MET. STN

24 CHANGI MET STATION

25 SELETAR MET. STN

Issued by Meteorological Service Singapore

METEOROLOGICAL SERVICE SINGAPORE
HOURLY RAINFALL (STATION TIME)
STATION 24:CHANGI MET STATION

JAN 2016

D: Represents Duration (mins)

A: Represents Amount (mm)

HOUR	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
DATE	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	D	A	DUR AMT
1	-	5	5	-	-	-	-	-	5	-	5	5	-	-	10	-	-	-	-	-	-	-	-	-	35
	-	0.4	0.2	-	-	-	-	-	0.2	-	0.2	0.4	-	-	0.4	-	-	-	-	-	-	-	-	-	1.8
2	-	-	-	-	-	-	5	-	-	5	-	25	60	20	10	-	-	-	-	-	-	-	5	55	185
	-	-	-	-	-	-	0.2	-	-	0.2	-	6.6	31.0	1.0	0.4	-	-	-	-	-	-	-	0.2	4.0	43.6
3	55	20	-	60	25	5	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	170
	5.0	0.8	-	5.2	1.2	0.2	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	12.6
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	10	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
	1.6	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	5
	-	-	-	-	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	0.2
15	-	-	-	-	-	-	-	5	-	-	-	-	-	-	30	-	-	-	-	-	-	-	-	-	35
	-	-	-	-	-	-	-	0.2	-	-	-	-	-	-	5.4	-	-	-	-	-	-	-	-	-	5.6
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	20	-	-	-	-	-	-	-	-	55
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.8	1.4	-	-	-	-	-	-	-	-	12.2
17	-	-	-	-	-	-	-	-	-	-	-	15	15	55	-	-	-	-	-	-	-	-	-	-	85
	-	-	-	-	-	-	-	-	-	-	-	1.8	2.0	29.4	-	-	-	-	-	-	-	-	-	-	33.2

"" = DEFECTIVE DATA

Page 1 of 2

"-" = NO RAINFALL

Issued by Meteorological Service Singapore

2016

METEOROLOGICAL SERVICE SINGAPORE
DAILY MEAN - DRY BULB TEMPERATURE (°C) (STATION TIME)
CHANGI MET STATION(24) (1°22.1' N 103°59' E)

DATE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	27.5	28.8	28.6	29.6	29.7	-	-	-	-	-	-	-
2	25.6	27.7	28.2	29.8	29.4	-	-	-	-	-	-	-
3	25.4	28.6	28.5	28.8	30.1	-	-	-	-	-	-	-
4	27.9	28.2	28.4	29.2	30.7	-	-	-	-	-	-	-
5	28.7	28.4	28.5	29.0	29.5	-	-	-	-	-	-	-
6	28.5	28.7	29.0	29.3	29.8	-	-	-	-	-	-	-
7	28.7	27.0	28.5	29.3	29.8	-	-	-	-	-	-	-
8	28.6	27.7	28.4	29.7	29.7	-	-	-	-	-	-	-
9	28.5	26.8	29.2	28.7	30.0	-	-	-	-	-	-	-
10	28.7	26.7	29.0	29.7	30.7	-	-	-	-	-	-	-
11	28.8	27.4	29.4	29.8	29.3	-	-	-	-	-	-	-
12	29.0	27.6	28.9	29.9	29.7	-	-	-	-	-	-	-
13	29.0	28.6	29.0	29.6	28.8	-	-	-	-	-	-	-
14	28.7	28.5	29.2	29.4	27.7	-	-	-	-	-	-	-
15	27.9	28.9	29.1	28.8	28.8	-	-	-	-	-	-	-
16	28.0	28.7	28.6	30.0	28.5	-	-	-	-	-	-	-
17	27.3	28.1	29.0	30.0	29.3	-	-	-	-	-	-	-
18	28.7	27.9	28.8	30.3	28.4	-	-	-	-	-	-	-
19	28.5	25.0	28.9	30.5	35.4	-	-	-	-	-	-	-
20	28.3	26.7	29.4	29.4	*	-	-	-	-	-	-	-
21	28.3	27.5	29.1	30.4	*	-	-	-	-	-	-	-
22	28.5	28.1	28.3	29.7	*	-	-	-	-	-	-	-
23	28.7	28.0	28.8	29.8	*	-	-	-	-	-	-	-
24	28.9	25.8	29.5	29.2	*	-	-	-	-	-	-	-
25	28.3	27.8	29.0	28.7	*	-	-	-	-	-	-	-
26	27.9	28.4	29.5	28.9	*	-	-	-	-	-	-	-
27	28.8	28.3	29.6	28.9	*	-	-	-	-	-	-	-
28	29.0	28.5	29.6	29.0	*	-	-	-	-	-	-	-
29	28.7	28.7	29.3	28.9	*	-	-	-	-	-	-	-
30	28.7	-	29.4	28.5	*	-	-	-	-	-	-	-
31	28.8	-	29.6	-	*	-	-	-	-	-	-	-

1997 to 2016

METEOROLOGICAL SERVICE SINGAPORE
MONTHLY MEAN(24 HOURS MEAN) - DRY BULB TEMPERATURE (STATION TIME)
CHANGI MET STATION(24) (1°22.1' N 103°59' E)

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MEAN
1997	27.1	27.4	28.1	28.1	29.4	29.3	28.8	28.8	28.8	28.2	27.8	27.3	28.25
1998	28.0	28.9	29.5	29.2	29.4	28.6	28.1	27.5	27.9	28.0	28.0	26.6	28.30
1999	26.6	27.2	27.1	28.3	28.0	28.2	27.8	27.5	27.9	27.2	27.3	26.8	27.49
2000	26.4	26.6	27.2	27.5	28.6	27.6	28.1	27.6	28.0	27.8	27.3	27.0	27.47
2001	26.5	27.0	27.4	27.8	28.5	28.2	28.4	28.0	28.0	27.6	27.2	26.7	27.60
2002	27.0	27.3	28.2	28.6	28.9	28.7	28.4	28.5	28.1	28.7	27.4	27.2	28.08
2003	26.7	27.1	28.1	27.9	29.2	29.0	28.1	28.2	27.6	27.6	27.1	26.6	27.76
2004	26.9	27.6	27.7	28.9	28.9	29.0	27.4	28.2	27.8	27.8	27.3	26.8	27.85
2005	26.6	28.5	28.5	28.7	28.5	28.8	28.0	28.2	28.2	27.6	27.3	27.3	28.01
2006	26.5	27.6	28.3	27.6	28.1	27.8	28.4	28.3	28.0	28.3	27.3	26.6	27.73
2007	26.5	27.2	27.5	28.1	28.3	28.4	27.7	27.7	27.8	27.8	26.9	26.5	27.53
2008	26.8	26.7	26.5	28.1	28.8	28.2	27.8	27.5	27.7	27.6	27.3	26.9	27.49
2009	26.8	27.3	27.2	28.5	28.7	29.1	28.3	28.3	28.3	28.3	27.2	27.1	27.92
2010	27.5	28.9	28.6	28.6	29.2	28.3	27.7	27.9	28.0	28.3	27.4	26.8	28.10
2011	26.3	27.3	27.0	27.9	28.5	28.4	28.7	27.9	27.8	27.3	27.1	26.6	27.56
2012	26.7	27.2	27.0	27.6	28.2	28.7	27.7	28.0	27.9	27.7	27.1	26.7	27.54
2013	27.0	26.5	28.3	28.2	28.2	29.0	27.8	27.9	27.5	27.7	27.1	26.5	27.64
2014	26.2	27.2	27.9	28.2	28.6	29.0	28.7	27.7	28.5	28.4	27.5	27.0	27.90
2015	26.9	27.0	28.2	28.6	28.7	29.0	29.1	28.4	28.7	28.7	28.0	27.7	28.25
2016	28.3	27.8	29.0	29.4	*	-	-	-	-	-	-	-	28.62
MEAN	26.8	27.4	27.8	28.2	28.6	28.5	28.1	28.0	28.0	27.9	27.3	26.8	27.85

** = DEFECTIVE DATA

'- ' = DATA NOT AVAILABLE

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DATE	REQUIREMENT																							
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JAN 2016

METEOROLOGICAL SERVICE SINGAPORE
HOURLY DRY BULB TEMPERATURE (°C) (STATION TIME)
CHANGI MET STATION(24) (1°22.1' N 103°59' E)

DATE	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	MEAN
1	25.4	25.5	25.5	25.5	26.1	25.9	26.3	28.0	27.7	29.5	28.0	29.3	29.1	28.7	28.6	29.0	28.7	28.5	28.2	28.0	27.8	27.2	27.2	27.1	27.5
2	27.0	27.3	26.7	26.7	26.5	26.5	26.0	26.1	26.8	26.8	27.9	23.4	23.2	24.1	24.5	24.6	24.7	25.1	24.9	24.7	25.1	25.3	25.7	25.2	25.6
3	24.6	24.8	25.0	24.7	24.9	25.1	25.4	25.4	25.9	26.1	26.1	25.7	25.8	26.1	26.6	26.2	25.8	25.3	25.1	25.0	25.1	25.0	25.0	24.7	25.4
4	25.5	25.3	25.3	25.0	25.0	25.5	25.9	27.3	28.5	28.7	30.5	31.0	30.6	30.9	31.5	29.9	29.5	29.1	28.5	28.1	27.8	27.2	27.0	27.0	27.9
5	26.9	27.0	26.8	26.7	26.5	26.3	26.8	27.9	29.3	29.6	31.0	31.6	30.5	31.4	31.8	31.5	30.6	29.0	28.2	28.1	27.8	27.8	27.4	27.2	28.7
6	27.3	27.1	27.1	26.7	26.6	26.7	27.5	28.8	29.0	30.1	30.5	30.8	28.8	30.5	30.4	30.3	30.0	29.0	28.1	27.9	27.7	27.5	27.3	27.3	28.5
7	27.2	27.1	27.0	26.8	26.9	26.8	27.3	28.3	29.2	29.9	30.5	31.5	31.6	31.7	31.3	31.1	30.2	28.8	28.3	28.0	27.7	27.5	27.1	26.9	28.7
8	26.8	26.5	26.1	25.9	25.8	25.9	26.6	28.1	29.2	30.1	31.2	31.5	32.4	32.1	31.7	31.6	29.7	28.9	28.2	28.0	27.8	27.6	27.5	27.5	28.6
9	26.9	26.4	26.3	26.2	26.1	26.1	26.8	28.3	28.9	30.2	30.6	31.4	31.6	31.9	31.6	30.8	29.7	29.0	27.9	27.7	27.5	27.3	27.5	27.3	28.5
10	27.3	26.9	26.9	26.8	26.9	26.8	27.4	28.7	29.2	30.8	31.1	30.9	31.8	32.1	31.8	30.2	29.9	28.6	27.9	27.8	27.7	27.4	27.3	27.3	28.7
11	27.0	26.9	26.7	26.8	26.0	26.3	27.6	28.6	29.3	30.0	31.4	31.2	31.9	32.1	31.6	31.5	29.9	29.1	28.4	28.3	28.0	27.9	27.8	27.7	28.8
12	27.7	27.6	27.4	27.3	27.1	27.2	27.4	28.3	29.7	30.2	30.3	31.5	31.6	31.8	32.1	31.1	30.4	29.2	28.5	28.1	27.8	27.8	27.7	27.6	29.0
13	27.5	27.3	26.9	27.0	26.9	27.1	27.9	29.2	29.6	30.6	31.5	31.1	31.2	32.2	32.0	31.3	30.6	28.8	28.2	28.0	27.9	27.7	27.7	27.7	29.0
14	27.6	27.4	27.0	26.8	26.7	26.8	27.4	29.0	29.8	30.8	30.5	28.9	31.3	30.9	31.4	30.8	29.8	29.0	28.6	28.2	28.0	27.7	27.7	27.5	28.7
15	27.3	27.2	26.9	26.6	26.4	26.5	26.8	27.9	29.0	30.1	30.3	31.2	30.6	31.3	27.0	27.3	27.4	27.5	27.4	27.2	27.2	27.1	27.0	27.1	27.9
16	26.9	26.7	26.5	26.3	26.1	26.1	26.6	28.1	28.7	30.5	31.0	32.0	32.3	28.5	26.5	27.1	28.4	28.0	27.4	27.4	27.5	27.7	27.5	27.4	28.0
17	27.0	27.2	26.7	26.6	26.4	26.1	26.2	26.9	28.2	30.5	31.2	28.9	28.1	23.9	27.0	27.8	28.4	28.0	27.5	26.9	27.0	26.8	26.5	26.5	27.3
18	26.5	26.5	26.5	26.1	25.8	25.8	26.6	28.2	29.2	30.3	31.5	32.0	31.3	29.8	31.4	31.7	30.2	29.3	28.8	28.7	28.3	28.1	27.9	27.8	28.7
19	27.7	27.4	27.2	26.8	26.7	26.5	26.8	27.9	28.9	29.7	31.1	32.0	28.8	30.2	30.2	29.8	29.5	28.9	28.7	28.3	28.1	27.8	27.7	27.5	28.5
20	27.5	27.3	27.3	27.2	27.0	27.0	27.1	28.1	29.2	29.6	30.8	31.1	31.3	29.5	30.0	29.6	28.2	28.3	27.0	27.1	27.0	26.9	26.9	27.2	28.3
21	27.3	27.3	27.2	27.1	27.1	27.2	27.4	27.5	27.6	28.7	29.3	29.8	30.1	30.9	30.4	29.9	29.5	29.0	28.5	27.9	27.7	27.7	27.6	27.5	28.3
22	27.2	26.9	26.8	26.8	26.5	26.3	26.7	27.6	28.4	29.8	30.7	31.1	30.2	30.8	30.6	30.3	29.6	29.1	28.7	28.3	27.9	27.8	27.5	27.3	28.5
23	26.9	26.7	26.6	26.8	26.7	26.6	26.8	28.0	28.3	30.5	29.6	31.8	32.0	31.7	32.4	30.9	30.0	29.2	28.7	28.5	28.1	27.7	27.5	27.4	28.7
24	27.2	27.1	27.1	26.9	26.8	26.9	27.1	28.9	29.5	31.0	31.0	32.0	29.9	30.9	30.6	31.0	30.4	29.3	28.7	28.3	28.2	28.0	28.0	27.6	28.9
25	27.7	27.2	27.0	27.1	27.1	27.0	27.5	28.1	29.9	27.6	30.9	31.1	30.6	31.7	29.1	29.0	29.1	28.5	27.5	27.0	27.0	27.6	27.4	27.4	28.3
26	27.4	27.6	27.5	26.8	25.9	26.3	26.6	28.1	27.1	29.2	27.8	27.9	27.5	29.2	30.2	29.3	29.1	28.6	28.2	28.0	27.8	27.8	27.7	27.3	27.9
27	27.4	27.4	26.9	27.0	26.8	26.5	26.6	27.5	29.2	30.4	30.8	31.4	30.8	31.8	31.9	31.0	30.3	29.0	28.4	28.2	28.0	27.8	27.7	27.5	28.8
28	27.5	27.1	27.1	26.8	26.8	27.0	27.2	28.8	29.5	30.5	30.9	31.7	32.0	32.8	32.1	31.8	30.6	29.7	29.0	27.4	27.6	27.2	27.2	26.9	29.0
29	26.7	26.5	26.4	26.4	26.3	26.4	26.7	27.7	29.4	30.2	31.1	31.7	31.5	31.8	30.9	30.7	29.6	29.1	28.9	28.5	28.1	28.0	27.7	27.3	28.7
30	27.0	26.8	26.6	26.6	26.6	26.5	26.7	27.1	29.0	30.3	31.2	31.7	31.9	32.0	32.0	31.3	30.9	29.5	28.8	28.3	27.9	27.4	27.0	26.7	28.7
31	26.9	26.8	26.7	26.8	26.7	26.7	26.9	27.5	28.7	30.6	31.5	31.9	32.0	32.0	31.9	30.9	30.2	29.3	28.8	28.4	28.1	27.9	27.8	27.2	28.8
MEAN	27.0	26.9	26.7	26.6	26.4	26.5	26.9	27.9	28.8	29.8	30.4	30.6	30.4	30.5	30.4	30.0	29.4	28.6	28.1	27.8	27.6	27.4	27.3	27.1	28.3
S.D.	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.8	0.9	1.1	1.3	1.9	2.0	2.2	2.0	1.7	1.4	1.0	1.0	0.9	0.7	0.7	0.6	0.7	0.9

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