



## Air

Population density, scarcity of land, narrow streets and busy traffic all affect Macao's air quality. However, this is offset to some extent by the low discharge of industrial pollutants. The air quality is therefore generally quite good.

Every winter, a comparatively high level of pollutants in the air increases the air pollution index; while in summer the air quality improves, with lower pollution index readings, as the convective precipitation of the tropical climate dispels pollutants.

During 2005, roadside monitors recorded that the air quality was "good" on 63 percent of the days, "acceptable" on 30 percent, and "poor" on only seven percent (26 days). In the high-density residential area of Macao peninsula, the air quality was "good" on 64 percent of the days, "acceptable" on 27 percent, and "poor" on nine percent (33 days). The air quality in the high-density residential area of Taipa was "good" on 59 percent of the days, "acceptable" on 35 percent, and "poor" on six percent (15 days). Ambient monitoring stations recorded that the air quality was "good" on 62 percent of the days, "acceptable" on 32 percent, and "poor" on six percent (20 days).

Compared with last year's figures, although the annual average concentration level of nitrogen dioxide recorded at general monitoring stations in 2005 was slightly higher, every pollutant concentration level recorded at other stations showed a small drop. The number of days on which "poor" air quality readings were recorded at roadside stations and stations in the high-density residential area of Macao peninsula was comparable to those of 2004. The number of days on which poor air quality was recorded at ambient monitoring stations fell by more than 50 percent compared with the previous year. These stations recorded poor air quality on just 20 days. Overall, Macao's air quality remained good. The annual average content level of every pollutant was normal, and met all relevant standards. It should be noted that the station in the high-density residential area of Taipa was relocated between June and September 2005, and monitoring records during this period were unavailable; so, data collected at that station were not taken into account in the above conclusions.



### Average Pollutant Concentrations in 2005







Monitoring Station	Respirable suspended particulates ( $\mu\text{g}/\text{m}^3$ )	Sulphur monoxide ( $\mu\text{g}/\text{m}^3$ )	Nitrogen dioxide ( $\mu\text{g}/\text{m}^3$ )	Ozone ( $\mu\text{g}/\text{m}^3$ )	Carbon monoxide ( $\text{mg}/\text{m}^3$ )
Roadside	75.2	---	70.9	---	2.19
High-density residential area of Macao peninsula	79.7	28.9	52.1	26.3	0.84
High-density residential area of Taipa island*	72.5	---	50.1	37.9	0.63
Ambient	62.0	21.6	38.1	38.4	---

\* The station in the high-density residential area of Taipa was relocated between June and September; so, no monitoring record was available.

### Comparisons between Pollutant Concentrations and the Daily Air Pollution Index

Air quality Index	Respirable suspended particulates 24-hour average ( $\mu\text{g}/\text{m}^3$ )	Sulphur dioxide 24-hour average ( $\mu\text{g}/\text{m}^3$ )	Nitrogen dioxide 24-hour average ( $\mu\text{g}/\text{m}^3$ )	Ozone dioxide 8-hour average ( $\mu\text{g}/\text{m}^3$ )	Carbon monoxide 8-hour average ( $\text{mg}/\text{m}^3$ )
0	0	0	0	0	0
50	100	60	80	80	5
100	150	150	150	160	10
200	350	800	280	350	17
300	420	1,600	565	600	34
400	500	2,100	750	800	46
500	600	2,620	940	1,000	57



Air Pollution Index						
Air quality Index	0 ~ 50	51 ~ 100	101 ~ 200	201 ~ 300	301 ~ 400	401 ~ 500
Air quality level (Macao standards)	Good	Acceptable	Poor	Bad	Severe	Harmful
Symbol						

## Climate

Macao is situated in a subtropical zone, with the Asian continent to the north and a wide tropical sea to the south. In winter, Macao experiences a north wind, cold and dry weather and low rainfall, due to a cold continental high-pressure system at medium and high latitudes. In summer, the MSAR is mainly subject to southwesterly winds, hot and wet weather and heavy rainfall, due to the influence of oceanic tropical weather systems. The reverse of wind directions in winter and summer, together with minimal temperature variations during the day, give Macao a marine monsoon climate.

According to the World Meteorological Organization (WMO) 30-year-average standard calculation, the average annual precipitation in the Macao SAR between 1971 and 2000 was more than 2,000 mm, with most rainfall occurring between April and October. May had the most precipitation – an average of 361.9 mm – while January had the least – an average of 32.4 mm.

Macao has an average annual temperature of 22.4°C. The coolest month is January, when it averages 14.8°C. Most years, Macao has a short, cold weather period when temperatures fall below 5°C. The average monthly temperature exceeds 22°C during seven months of the year, indicating that Macao has a short winter but a long summer.

The MSAR is frequently hit by typhoons. The typhoon season starts in May and ends in October, with July and August as its peak period.



## Weather Overview

### General Situation

Macao was slightly warmer than usual during 2005, with the average annual temperature of 22.5°C – 0.1°C higher than the climate normal. Average temperatures exceeded the climate normals during four months of the year. The average relative humidity was equal to the climate normal, while the total rainfall and evaporation levels were lower. The total amount of bright sunshine was also lower. Except during August and November, the hours of sunshine every month were also below their respective climate normals. June saw a total of 87.6 hours of sunshine, approximately half the climate normal and the lowest figure since 1952.

Four tropical cyclones affected Macao during 2005. They were tropical storm Washi on 29 and 30 July; severe tropical storm Sanvu on 12 and 13 August; tropical storm Vicente on 17 and 18 September; and typhoon Damrey between 22 and 26 September. Typhoon Damrey necessitated the hoisting of the No. 3 strong wind signal; whereas the No. 1 alert signal was required for all the other three tropical cyclones.

Three rainstorm warnings were issued during 2005.

Fifty-six thunderstorm warnings were issued during the course of the year, 16 more than in 2004. The first thunderstorm warning was issued on 3 March, and the last on 7 October.

Fifteen strong monsoon signals (black ball) were hoisted during 2005.

Summary of Severe Weather Warnings Issued in 2005			
Warning/Signal Type		Hoisted/Issued Frequency	No. of Warning Reports Issued
Tropical Cyclone Warning	No. 1 Alert Signal	4	21
	No. 3 Strong Wind Signal	1	17
	All Signals Lowered	4	4
Strong Monsoon Warning (Black Ball)		15	51
Rainstorm Warning		3	11
Thunderstorm Warning		56	152



## **Temperatures**

Macao had an average annual temperature of 22.5 °C during 2005, 0.1°C higher than the climate normal. The maximum monthly average temperature during the year was 28.5°C in July, and the minimum average was 14.4°C in January. The hottest day was 19 July, when the temperature rose to 37.4°C, the highest July figure since 1958; whereas the coldest day was 1 January, when the temperature fell to just 4.2°C.

## **Relative Humidity**

The average relative humidity during 2005 was 79 percent, which was equal to the climate normal. February, April and June saw the highest average humidity, at 87 percent; whereas the lowest was 59 percent in December, the lowest figure for that month since 1987.

## **Rainfall**

Total rainfall during 2005 was 1,898.8 mm, 234.6 mm below the climate normal. June was the wettest month, with 483.6 mm of precipitation, which was 143.9 mm more than the month's climate normal. A mere 1 mm of rainfall fell in October, considerably lower than the month's climate normal of 116.9 mm.

## **Evaporation**

The total evaporation level in 2005 was 868 mm, 203.2 mm less than the climate normal. In December, the evaporation level was 138.2 mm, the highest figure during the year, whereas the figure of 29.3 mm for February was the lowest during the year.

## **Sunshine**

Macao had 1,590.2 hours of sunshine during 2005, 237.8 hours less than the climate normal. The total amounts of bright sunshine were lower than the monthly climate normals during 10 months of the year.

## **Wind**

During 2005, Macao was subject mainly to northerly winds from January to March and from October to December. Southeasterly winds prevailed during April and September, while southerly winds prevailed between May and August. Wind speeds averaged 15.4 kilometres per hour.



## Weather Services

### Meteorological and Geophysical Bureau

The Meteorological and Geophysical Bureau (SMG) is supervised by the Secretary for Transport and Public Works. It provides weather reports, monitors air quality, and conducts research into climate, climate change and earthquakes.

The SMG's work has a direct influence on Macao's everyday life. Apart from hourly real-time weather information, the SMG issues various types of daily weather forecasts for the public, Government departments and private institutions. These include five weather reports and forecasts and two marine and weather forecasts for the South China coastal area, all of which are broadcast daily. The SMG provided 1,825 weather reports and 730 marine and weather forecasts for the South China coastal area during 2005.

The SMG releases four-day forecasts on a daily basis. Every day, its officers explain the day's weather conditions and the forecast for the following day in telephone reports broadcast on the Macau Broadcasting Company's (TDM) morning TV programme. These presentations explain forthcoming weather conditions and teach viewers about meteorology.

The SMG also issues timely warnings of adverse weather conditions, including tropical cyclones, strong monsoons (black ball), rainstorms, and thunderstorms.

A round-the-clock, Automatic Air Quality Monitoring Network and Ultraviolet (UV) Monitoring System enable the SMG to summarise daily air quality and UV indices, and report them to the public together with an air quality forecast for the following day. Residents can access this information by dialling 1311 - the "Hotline Weather Report" and 1313 - the "Weather Report Fax", or by visiting the SMG's website at [www.smg.gov.mo](http://www.smg.gov.mo).

In view of the ever-increasing popularity of mobile phones and personal data assistants (PDAs), the SMG launched the Mobile WebWeather Service on 23 March 2005. It also makes weather data about Macao and other places worldwide more accessible to the public via the Internet through its website at [mobile.smg.gov.mo](http://mobile.smg.gov.mo).



Real-time weather conditions, weather forecasts, and extreme weather warning information are available via SMS for registered customers of three mobile phone service providers. The SMG has also teamed up with Companhia de Telecomunicacoes de Macau (CTM) for cellular broadcasting of relevant information to its mobile phone subscribers three times a day.

The SMG Aeronautic Meteorological Center at Macau International Airport provides hourly weather observations and special reports to aviation organisations and flight crews. The center issues 24-hour and nine-hour weather forecasts for Macau International Airport every six hours and three hours, respectively. It also issues thunderstorm and typhoon warnings for the airport, and provides updated aeronautical meteorological documents for departing flights. The latter include meteorological maps for every route, as well as high-altitude air temperatures, wind maps, and weather forecasts. The centre issued about 25,000 such documents during 2005.

The SMG has acquired a caesium beam atomic clock and time device to offer the public an accurate and convenient time service. Residents may synchronise the clocks of their computers with the time provided by the bureau via the Internet.

### **Monitoring Network**

The SMG collects weather data 24 hours a day via its Automatic Weather Station Network of 12 weather-observation stations in key locations around Macao. Three of these automatically send information every 15 minutes to destinations worldwide, using the international SYNOP code and the Global Telecommunications System (GTS). This forms part of the Pearl River Delta Real-time Automatic Weather Monitoring Network, which was jointly established to exchange meteorological data by the Guangdong Provincial Meteorological Bureau, the Hong Kong Observatory and the Macao SMG. In addition, the SMG has equipped the Macau Tower with Automatic Weather Station Network installations at different altitudes of 100, 150, 241, 294 and 324 metres, to facilitate round-the-clock collection of weather information.

During 2005, the SMG also teamed up with the Hong Kong Observatory to establish a substation of the Pearl River Delta Lightning Location Network.

The SMG uses a sophisticated Doppler Meteorological Radar, and it updated this equipment's processing and display system software during 2005. It also installed a



new ground reception and processing system for the Fengyun-2 geostationary meteorological satellite, which is equipped with a low-level wind profiler. The SMG established the Air Quality Monitoring Project in partnership with other Government departments in 1987. It now employs a fully automated air-monitoring network to measure major pollutants that jeopardise Macao's air quality. Macao now has six automatic air quality monitoring stations. Two of these – located in Concordia Industrial Park and the Westin Resort Macau golf course – currently operate on a trial basis. The SMG introduced another new type of technology during 2005, when it cooperated with the City University of Hong Kong in developing and installing a laser radar system that detects respirable suspended particulates in the atmosphere.

The SMG has two seismological monitoring stations, one in Ka Ho Lighthouse on Coloane, and the other in its Taipa Grande headquarters on Taipa. A simulated seismograph and digital seismograph are installed inside the Ka Ho Lighthouse. The Taipa Grande headquarters is equipped with a deep shaft (30 metres from ground level) digital seismograph.

The SMG's headquarters is equipped with an environmental radiation monitoring station, mainly for detecting harmful Gamma radiation in the atmosphere.

### **Regional and International Cooperation**

The SMG is a member of the WMO. It actively participates in promoting technology, research, training and applications relating to meteorology. Every year, it sends delegations to meetings, seminars, workshops and training programmes arranged by the WMO, mainland and overseas meteorological agencies and academic organisations. In 2005, 44 of its delegates attended and delivered 13 papers and reports during 26 sessions and training activities.

The SMG hosted the International Workshop on Tropical Cyclone Landfall Processes in conjunction with the WMO from 21 to 25 March 2005. Part of the International Tropical Cyclone Landfall Programme (ITCLP), the workshop was an important element in the World Weather Research Programme (WWRP) and the Tropical Meteorology Research Programme (TMRP), which have been established by the WMO's Commission for Atmospheric Sciences. Sixty-three experts from 11 countries and regions attended the event, including some world-acclaimed scientists and meteorologists who are studying tropical cyclones.



Delegates from the SMG attended the 38th Session of the Typhoon Committee of the Economic and Social Commission for Asia and the Pacific and the WMO (ESCAP/WMO), which was held in Hanoi, Vietnam, from 14 to 19 November 2005. Ten of the 12 members who participated in this gathering voted to establish the Typhoon Committee Secretariat in Macao. The SMG also keenly takes part in meteorological science meetings and exchange activities conducted by its mainland and Hong Kong counterparts. Its staff visit their weather and environmental departments, and receive their personnel when they visit Macao. The annual Guangdong-Hong Kong-Macao Seminar on Meteorological Science and Technology, the Guangdong-Hong Kong-Macao Meeting on Cooperation in Meteorological Operations, and the Pearl River Delta 5 Cities Air Quality Technical Workshop are all held alternately in the three regions. All these events are forums for exchanging opinions and exploring issues about research, technical developments and the application of meteorological science and air quality monitoring. The SMG presented a total of four papers at the first two meetings, which were held in Guangdong in 2005. Macao hosted the third meeting, during which the SMG delivered three papers.

The SMG and the Department of Atmospheric Science of the Sun Yat-sen University in Guangzhou signed their first cooperation agreement in 1997. Starting with the introduction of a mesoscale model for weather forecasts, their cooperation have gradually extended to include researches and exchanges on various aspects of meteorology and the environment. This agreement has since been renewed, and the university has hailed it as a paragon of cooperation. The two organisations published 15 papers in renowned mainland and overseas scientific journals and collections of essays during 2005.

During 2005, the SMG collaborated with the China Meteorological Administration's Meteorological Press on the publication of the *MMGB (Macao Meteorological and Geophysical Bureau) Collected Papers Vol. 1 – Asia Summer Monsoon and Mesoscale Numerical Simulation*.

The SMG also participates in the European Cooperation in the Field of Scientific and Technical Research (COST), a cooperative research project on science and technology for member states of the European Union. It sent a delegate to a COST meeting during 2005.