R.P.O. **ATTEX** Ltd.

Research-and-production organization “Atmospheric Technologies”

MTP 5

AIR TEMPERATURE PROFILES BY MICROWAVE TECHNOLOGY

State of the art microwave radiometer
All-weather operation
Reliable performance
Fast response time
Passive measurement

Ideal for air pollution and climatology studies
Wide operating temperature range
Self-calibrating
Low operating costs
Very low environmental impact

Introduction

There are a number of applications in meteorological and environmental sciences where it is desirable to measure the temperature of the atmosphere in the 1000 m closest to the ground. This is part of the Planetary Boundary Layer (PBL). As altitude increases the air temperature falls with a theoretical 'Adiabatic Lapse Rate' of approximately 6.5 °C per 1000 m, but this rate is influenced by a number of factors.

Under Adiabatic conditions pollutant gases, aerosols and fine particulates tend to rise into the atmosphere and disperse. However, in the case of a temperature inversion a layer of warmer air can trap the pollutants close to the ground. This leads to poor air quality events that can last for many hours until the inversion breaks up.

By monitoring the atmospheric temperature profile in real-time it is possible to predict the development and break-up of inversions within a specific area and actions can be taken to minimise the environmental and health impacts. Many industries have processes which release gasses into the atmosphere, but this should not take place when an inversion is present. Temperature profiles are an essential input for accurate plume and dispersion modelling.

The MTP 5 family of instruments is specifically designed to provide real-time PBL measurements with all-weather, unattended operation and automatic self-calibration. They require no specialist knowledge to install, maintain and operate or to analyse the data, and are ideal for network use. MTP 5 uses a uniquely designed compact and rugged microwave receiver which is highly sensitive to atmospheric 'black-body' thermal radiation at 5 mm wavelength (60 GHz frequency). MTP 5 emits no radiation and does not require any operating licences.

MTP 5 is quick and simple to set up and most versions can be easily transported to different locations. Typically the instrument is mounted on a platform a few meters above ground level or on the roof of a building. The instrument is connected to a PC running the operating software, which stores the data, calculates the temperature profiles using specially developed algorithms, and displays the results graphically every 5 minutes. MTP 5 is unique, in that it requires no specialist knowledge to operate. It self-calibrates and produces the temperature profiles automatically in all conditions in real time.

Applications

MTP 5 has important applications in the monitoring of urban air quality. It offers a simple, fast and economical solution for forecasting and for aiding the process of issuing public information. Typically a small network of 2 or 3 instruments is used, one in the city centre and others in areas from which changes in atmospheric conditions originate.

MTP 5 data are useful for scheduling releases from industrial processes and as inputs to computer models that predict the dispersion of gasses deliberately or accidentally released.

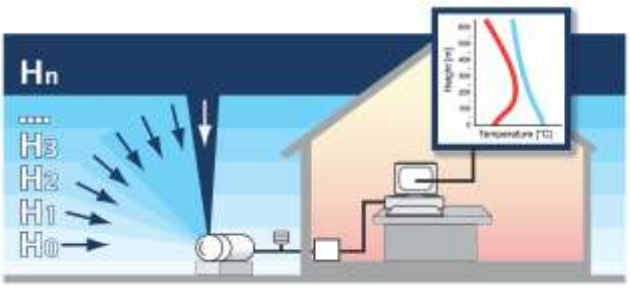
Other applications include:

- Investigation into urban heat island effects
- Monitoring of atmospheric stability at airports
- Regional and mesoscale forecasting in meteorology
- Input to emergency management systems of nuclear power stations and petrochemical facilities
- Support of energy balance studies and fog forecasting
- Research into radio wave and laser beam propagation
- Atmospheric chemistry research

Choice of Instrument

MTP 5 is a remote sensing instrument that measures microwave radiation emitted from the lower 1000 m of the atmosphere, within the Planetary Boundary Layer. The atmosphere is a strong source of radiation but the changes due to temperature are small, so a very sensitive receiver is required. Unique radiometers and specially designed antennae operating in the 5 mm waveband form the heart of MTP 5.

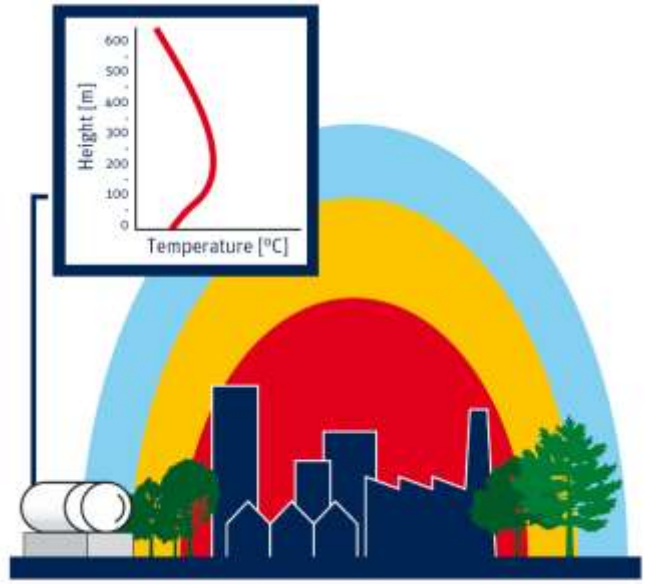
Atmospheric radiation is measured by scanning in angular steps from horizontal to vertical and the operating software processes the data into vertical height and temperature information. The data is stored and profiles are displayed graphically every 5 minutes, typically showing the temperature at 25 and 50 m height intervals.



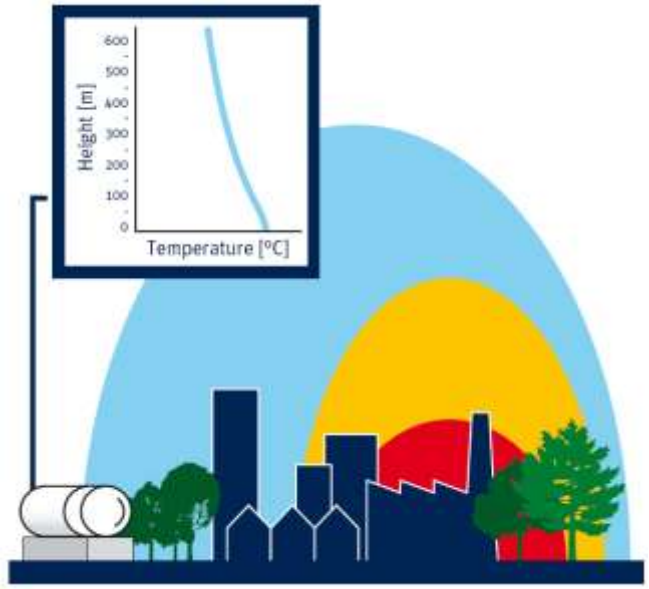
Measurement principle

Models

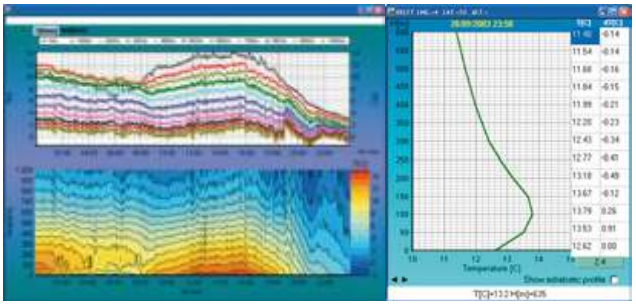
MTP 5 is a family of instruments sharing design features and components and they have common software and data formats. The choice of model depends on the application and the measurement location characteristics.



A temperature inversion, typically in the early morning, the gasses and aerosols are trapped close to the ground.



During the day the profile becomes adiabatic as the gasses and aerosols escape to higher levels.



The temperature field display and the temperature profile

MTP 5-H is the member of the family. It makes measurements up to 1000 m above the instrument and gives the same performance in all weather conditions. It is compact and operates from 12 VDC (a bench-type AC-DC power supply unit is included). The rotating scanner assembly is protected by a special cover that has very good microwave transmission. The cover sheds precipitation and allows compensation for dirt during the self-calibration. A high accuracy ambient temperature sensor forms part of the self-calibration system. A mounting frame is included, and cables for the temperature sensor, power and RS 232 data communication to a PC (not included).

Typically temperature inversions that cause bad air quality events occur well below 1000 m, if they are higher than this there is not normally a problem.

Altitude resolution is **50 m** and the temperature accuracy is 0.2-1.2°C or better (depend on type of profile). The field of view is a 2.5° cone. The only routine maintenance is to periodically clean the scanner cover. MTP 5-H is ideal for use in urban environments and at airports and operates from -40 °C to +50 °C.

MTP 5-HE (Extended range) was developed for locations where the urban / industrial area lies in a valley or close to mountains and inversions up to 1000 m can cause problems. Altitude resolution is from **25 to 50 m**.
In order to measure to 1000 m a more sensitive and narrower bandwidth design of microwave radiometer is used and the frequency is slightly shifted to 'see' further in the atmosphere. A consequence of this is that the altitude resolution and the temperature accuracy are not quite as good as the MTP 5-H and there is some reduction in accuracy in heavy rain or fog.

MTP 5-PE (Polar Extended range) and **RE** uses a similar microwave radiometer to the MTP 5-HE. However, it is designed to provide much improved altitude resolution, down to 10 m in the first 100 m range. This is important for measurements over snow and ice, where temperature gradients can be very steep over small height increments. Similar effects can be observed over desert surfaces.

To achieve this improved resolution a much narrower field-of-view of 1 ° is required, and the scanner moves in smaller angular steps. A larger capture area is needed in order to maintain the signal-to-noise performance. Therefore, the scanner assembly is larger than for the other models. The radiometer and electronics have additional stabilization and modifications for operation in typical Polar conditions down to -80 °C, as encountered in the Arctic and Antarctic (PE version).

WINDOWS™ SOFTWARE runs on a PC connected to the MTP 5 and controls system configuration, measurement, data storage, processing, diagnostics and auto-calibration. The data is stored as daily ASCII files for easy export to spreadsheets. After each scan, a graph of the temperature profile is shown on-screen. Daily graphs of temperatures can also be displayed.

Specifications	MTP 5-H	MTP 5-HE	MTP 5-RE	MTP 5-PE
Altitude range	0 - 1000 m			
Displayed height interval	50 m	25m (0-100) 50 m (100-1000)	10m (0-100), 25m (100-200) and 50m (200-1000)	
Altitude accuracy	± 25%			
Measurement interval	minimum 180 seconds			
Temperature accuracy (RMS)	± 0.2 °C to ± 0.5 °C (1)	± 0.3 °C to ± 1.2 °C (1)	± 0.25 °C to ± 1.2 °C (1)	
Central measurement frequency	59.6 GHz	56.7 GHz		
Radiometer MTBF	5 years	7 years		
Receiver sensitivity (1 second integration time)	0.04 °C	0.07 °C		
Field of view, conical	3 °		1 °	
Operating temperature range	-40 °C to +50 °C			-80 °C to +45 °C
Environmental effects	No effect from rain, fog or snow	Decrease in accuracy in heavy rain		
Scanner	Rotating Teflon™ cover and parabolic reflector driven by stepping motor, conical antenna and radiometer fixed to chassis on scanner axis, rotating cover sheds precipitation. Scans from horizontal to vertical.			
Communication to PC	Serial RS 232 (2)			
Power requirements AC/DC power supply	220 VAC/ 110 VAC, 1A/ 2A, 50 - 60 Hz			
Power consumption MTP 5	Maximum 12 VDC / 120 W (60 W average)			
Self-calibration	Automatic before each measurement			
Correction for dirt or precipitation on cover	Automatic until cleaning needed due to poor signal-to-noise ratio			
Instrument dimensions, nominal	59 cm long x 25 cm diameter		81 cm long x 39 cm diameter	
Instrument weight, nominal	20 kg		25 kg	

(1) MTP 5 temperature accuracy decreases with altitude and depends upon the temperature profile shape.
(2) MTP 5 must be connected to a PC (not included) running the MTP 5 operating software in order to make measurements and store data.

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