The Observatories of the Georg-von-Neumayer Station

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Summary

The German wintering-over station in Antarctica serves among others as a basis for continuous seismic, gravity, Earth's magnetic, meteorological and air chemical observations. The technical background of the observatory functions of the Georg-von-Neumayer-Station is delineated in the subsequent report.

Zusammenfassung

Die deutsche Überwinterungsstation in der Antarktis dient unter anderem als Observatorium für kontinuierliche Aufzeichnungen seismischer, gravimetrischer, erdmagnetischer, meteorologischer und luftchemischer Größen.

Dieser Bericht erläutert die zu diesem Zweck an der Georg-von-Neumayer-Station vorhandenen technischen Einrichtungen.

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1. Introduction

The traditional task of geophysical observatories is long term recording of oceanic, atmospheric or solid earth properties which are relevant for the state of the entire Earth system.

The sampling period of the majority of Antarctic scientific stations is naturally limited to some ten years so that they are not fully adequate for this purpose. In spite of this restriction their exceptional geographical locations offer favourable opportunities to collect valuable data sets of past and actual geophysical events which control the long term physical development of the planet Earth. Therefore, Antarctic wintering-over stations which provide a rather comprehensive observational background for specific geophysical areas may be defined as research observatories. The German Georg-von-Neumayer-Station fullfils such requirements for seismic, Earth magnetic, Earth gravity, meteorological and climatological studies.

The scientific data sampling started in March 1981 with three hourly meteorological routine observations and continuous records of surface data including short and long wave radiation. The magnetic, gravity and seismic measurements as well as the sampling of trace substances in the atmosphere and in the snow cover began in April 1981/82. During the summer period 1982/83 the scientific equipment has been improved and completed. Since the beginning of 1983 principally all measurements are recorded automatically on computer compatible data logging systems.

2. Location, site and buildings

The Georg-von-Neumayer-Station (G.v.N.) is located at 70°37'S and 08°22'W on the Ekström Ice Shelf at the Atka Bay (Figure 1). It is built on floating ice of 200 m thickness in about 6.5 km distance of the ice edge. The environmental ice surface which is more or less flat, slopes gently upwards to the south.

The station complex is composed of a main building consisting of two parallel steel tubes which are linked together (Figure 2) and several shelters for vehicles, fuel and supply goods (Figure 1). The seismometers, the gravitymeter and the magnetometer are installed in two container laboratories, about 950 m south of the main building in order to avoid man made noise. For similar reasons the sampling of

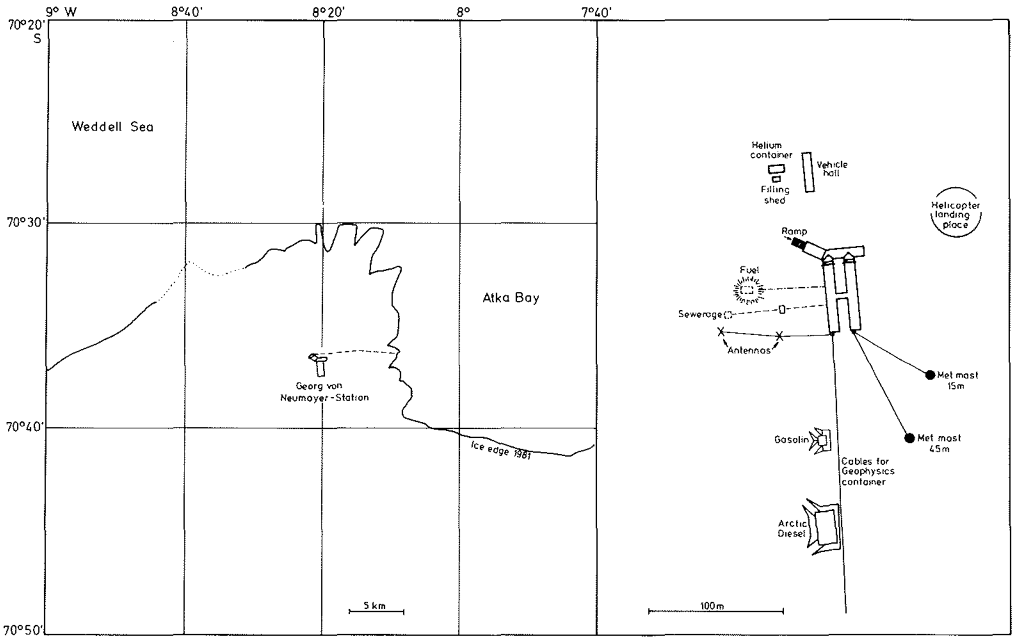


Figure 1: The geographic location of the Georg-von-Neumayer-Station (left) and the building configuration of the main station (right). The trace substance observatory and the geophysics containers lie farther south of the main buildings

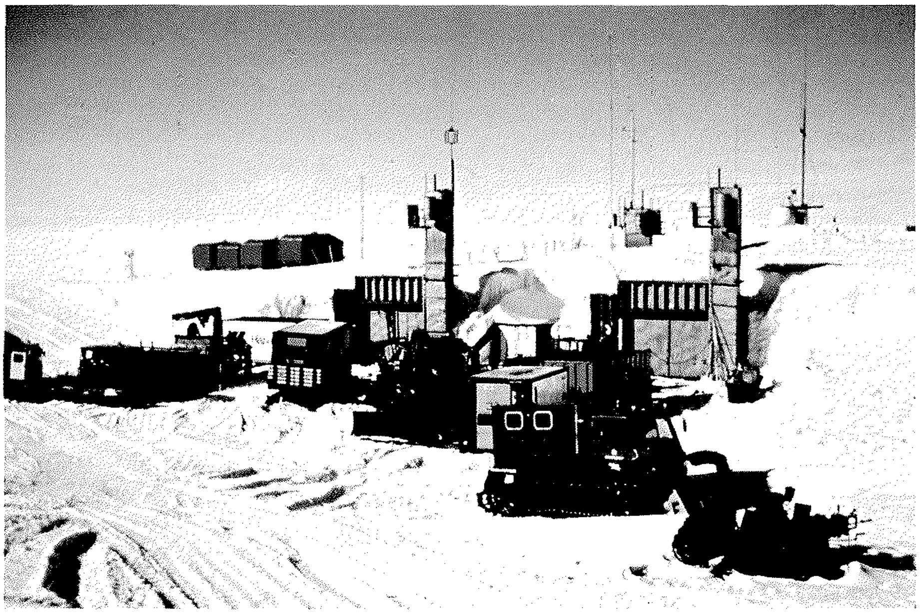


Figure 2: The front side of the tubes of the main station before the construction of the ramp

atmospheric trace constituents occurs in a movable hut about 500 m to 1500 m upstream of the central station with respect to the prevailing wind direction. During the summer season additional laboratories may be installed even in greater distances to the camp. Meteorological sensors are mounted on 15 m and 45 m high masts near the main station (Figure 3). Radiosondes are launched at the northern side of the buildings.

The two steel tubes of the main construction are each 50 m long and 7.5 m wide. The living quarters, workshops, two power stations and various laboratories are housed in 31 prefabricated 20ft containers which are mounted inside the tubes. Because of the snow deposition the tubes are totally covered with snow already. The slopes to the large doors to be seen on Figure 2 had to be cleared each summer in order to move heavy goods into or out of the station. A sloping ramp mostly covered by a steele tube has been installed in 1984 in order to simplify the supply procedure.

The station is anticipated for a life time of about 15 years. During this time it will have moved by about 2 km towards NNE. For evacuation trenches will be cut into the ice to retrieve the containers, the power station and the scientific equipment.

3. Seismic, gravity and Earth's magnetic field observations

The geophysical observatory is instrumented for seismic, gravity and magnetic measurements. The sensors and the data aquisition units are accommodated in two containers. They are mounted in two 6 m deep trenches the top of which is covered by wooden roofs.

One of the containers which is made of non-magnetic material houses the magnetic sensors only. It is linked to the second one in about 100 m distance by a DC power cable and a data transfer line. The second laboratory is equipped with the three component seismometer and a tidal gravitymeter as well as with the electronic data aquisition system. Here the three phase AC power supply of the main station terminates.

Because of the considerable heat generation by the data aquisition unit the latter laboratory has to be ventilated with the aid of three chimney tubes extending well above the snow surface.

Besides these two special establishments further equipment, e. g. for monitoring of four further seismometers which are distributed in a 5 km array around the station and for supporting atmospheric measurements, is installed in the main station.

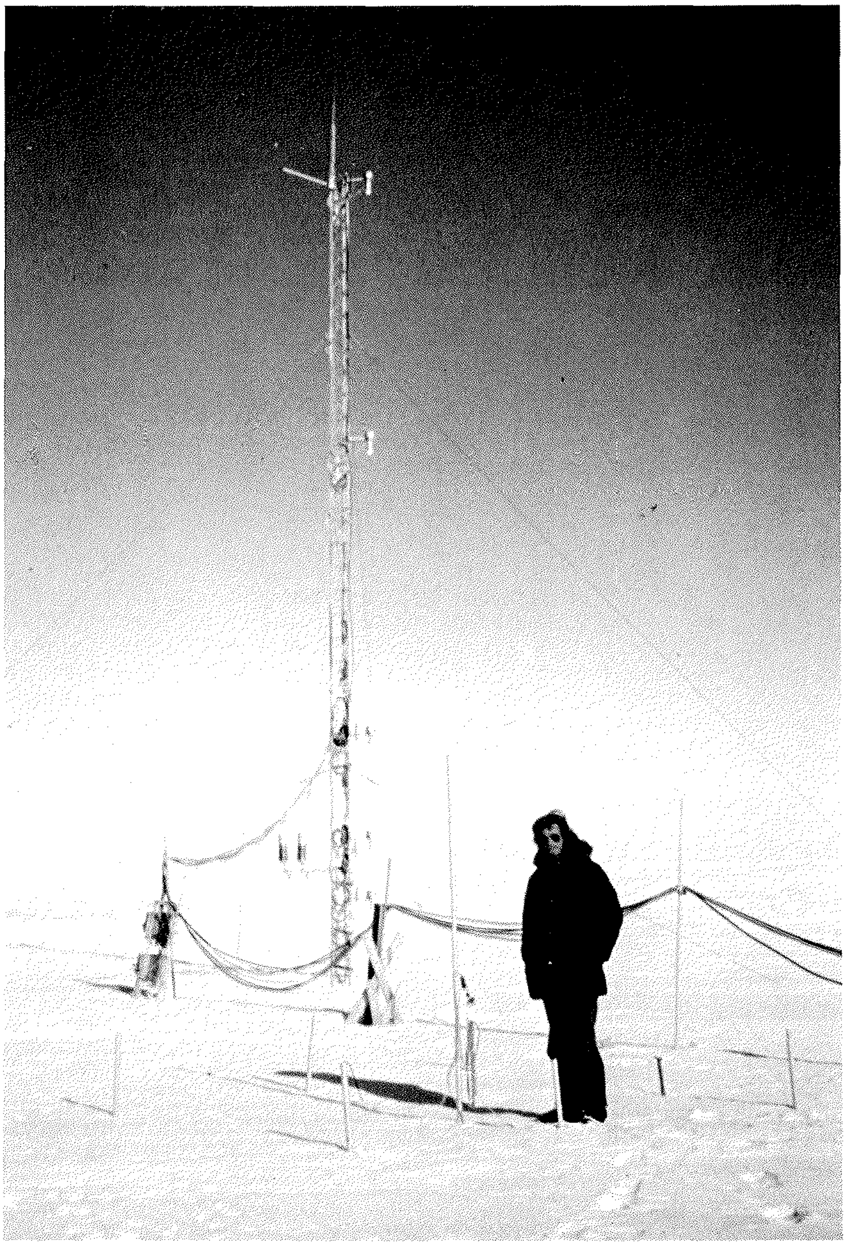


Figure 3: The small meteorological mast (height: 15 m) equipped with psychrometers

3.1 Earth's magnetics

The Earth's magnetic field is continuously recorded with the aid of a three-component flux gate sensor. The instrument is mounted on a gimbal frame oriented towards true North. Consequently the time variations of the x-, y- and z-components of the Earth's magnetic field are observed. Absolute values of the field strength are obtained by a non-magnetic theodolite combined with a one component flux gate sensor together with a precision proton magnetometer (accuracy: 0.1 n T) for the total intensity. Both, the three-component flux gate sensor and the total intensity are recorded on a strip chart recorder continuously and in one minute intervalls, respectively. In parallel the data are stored in digital form on discettes. The normal sampling interval is one minute but it can be increased to one second during intensive magnetic activities.

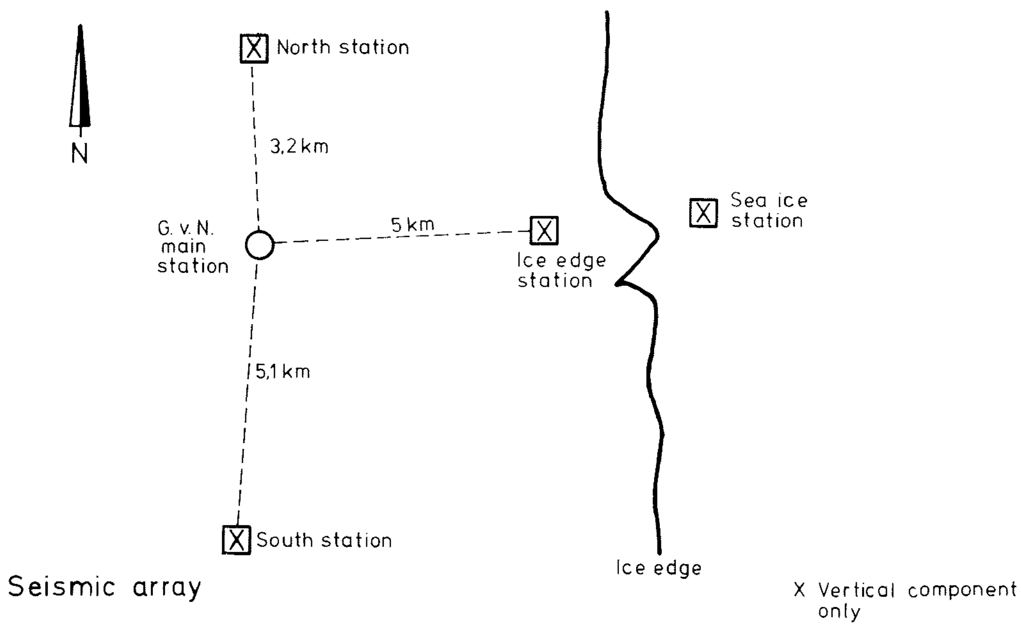
3.2 Seismology

A set of three short period seismometers is mounted on a heavy wooden platform to detect all three components of motion. The signals are stored on PCM magnetic tape as well as recorded on paper charts. For the latter purpose a drum recorder with a paper advance of 12 cm per hour has been adapted. In addition to the continously observing instruments a small array with 4 seismometers has been set up in the vicinity of the Georg-von-Neumayer-Station as portrayed in Figure 4. Data recording of the remote stations is not continuous but triggered by destinct events. In such cases the signals are transmitted by VHF radio to the main station where they are automatically recorded on PCM tape. Upper limits for the frequencies to be resolved can be chosen at 25, 50 or 100 Hz.

3.3 Gravity measurements

An Askania Gs-15 gravitymeter is installed together with the seismometers on the wooden platform. It is basically implemented to study tidal motions of the iceshelf. The signal is monitored on a strip chart recorder and stored on discettes with a sampling rate of 1 minute.

A strong tidal acceleration is observed during the summer months when the sea ice is melted away. The signal amplitude due to swell decreases by two orders of magnitude during the winter season with an extensive sea ice cover of the Antarctic Ocean.



<u>Figure 4:</u> The array of seismometers at the Georg-von-Neumayer-Station. The remote stations (squares with crosses) measure the vertical component only

3.4 Atmospherics

Since February 1983 a VLF receiver is operated to detect thunderstorm activities particulary of the Southern Hemisphere. The data are logged on magnetic tape in order to be analysed later in the home institute.

3.5 Data Processing

In March 1983 a PDP 11/23 computer with a memory of 128 KW, 20 MBYTE disk space and two magnetic tape drives has been implemented at the main station. It is linked to the data aquisition system in the seismic container. By now the seismic, gravity and magnetic field data are transferred to the central computer for real time and for off-line processing. Finally, data selection is planned for the seismic measurements. Through a combined hardware-software triggering mechanism only special events will be recorded digitally while a continuous analog signal monitoring is kept operational.

4. Meteorological observations

4.1 Surface data

The current meteorological observations at the Georg-von-Neumayer-Station consist of wind vector and temperature measurements at two masts in 8 levels in the height range from 0.5 m to 45 m. The firn temperature is obtained at 6 depths between 0.25 m and 5.25 m below the snow surface. Finally, the total and the short wave radiation from above and below and the atmospheric surface pressure are recorded.

Ten minute averages of all measurements are automatically formed and stored on magnetic tape (cassettes) as well as printed out on a paper strip. The data aquisition is controlled with the aid of a small H-P computer.

Besides these measurements three hourly routine observations are carried out at the station. The latter and the temp-message are transferred into the Global Telecommunication System via Meteosat. They are furthermore broadcasted by radio to Antarctic stations.

The meteorological measurements form the background of special research programmes which vary from time to time. Current and past work has been devoted to studies of the surface energy balance, the development of low level temperature inversions capping the atmospheric boundary layer and sea ice variations in the Atka Bay.

Several tests to measure air humidity have not been fully satisfactory. This problem will be further pursued in the future.

4.2 Upper air soundings

At the beginning of March 1983 the Georg-von-Neumayer-Station has been equipped with a combined radiosonde and OMEGA wind-finding system. The vertical profiles of air temperature, relative humidity, wind direction and wind speed are measured up to about 25 km height once daily. The height information results, as common, from pressure data.

The rate of one ascent per day will be increased during intensified observational periods which are planned for certain atmospheric flow conditions.

The ground equipment consists of a so-called Micro Cora System, manufactured by the Vaisala Company, Finland. It is basically composed of a radio receiver working in the 400 MHz band regime, a frequency demodulator, a correlator for the OMEGA signals, a small size computer, a cassette unit for data storage and a teletype. A simple strip chart recorder is availabe as a back-up for the thermodynamic quantities in case the computer or other parts of the more sophisticated instrumentation fail.

The apparatus is used together with the Vaisala RS 80 radiosonde, which measures the air pressure (aneroid), air temperature (thermistor) and relative humidity (humicap). The sonde also modulates the phase information of up to eight OMEGA transmitting stations on to the radiosonde carrier frequency. The last mentioned signals are utilized in order to determine the location of the sonde and to derive the wind vector from the change of location. The time resolution of the measurements is 10 seconds which is equivalent to 50 m in the vertical for an ascent rate of 5m/s.

The sondes are launched with the aid of 300 g-balloons inflated with helium. The gas is kept in steel cylinders which are stored in a 20ft container. A second container of half the normal size serves as an inflation shed.

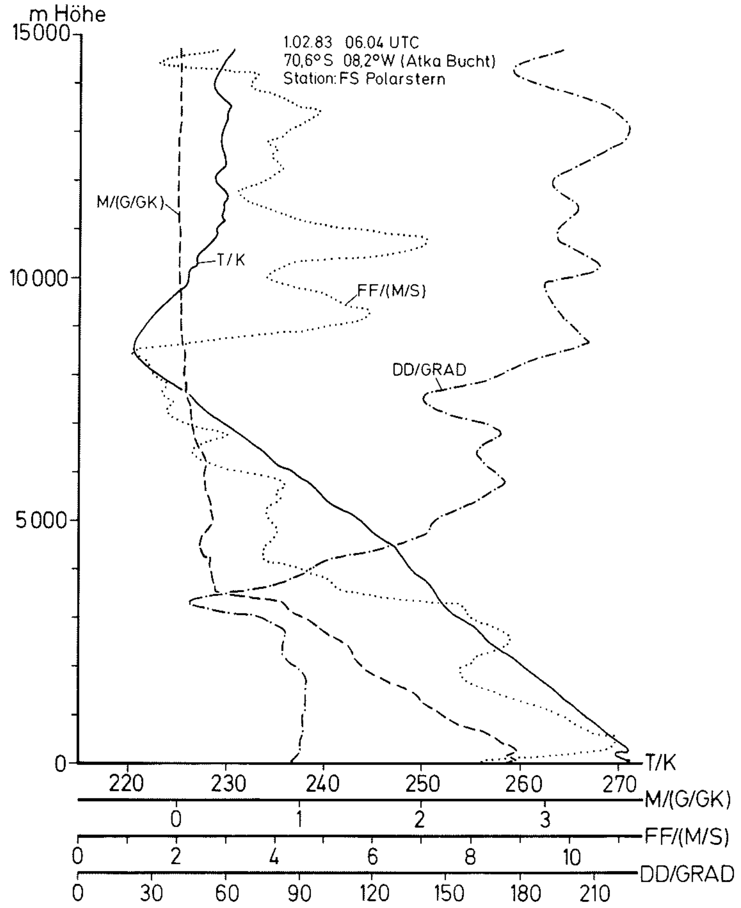


Figure 5: Radiosonde- and OMEGA-wind-sounding, observed on R. V. Polarstern at the Atka-Bay with a system equivalent to the one at the Georg-von-Neumayer-Station

The Micro Cora is an almost automatic radiosonde system. It contains several software options with different versions for the processing of the sounding and for special evalution programmes. In any case the sounding is automatically processed as shown bythe examplemeasured by R. V. "Polarstern" in the Atka Bay in Figure 5. and coded according to WMO standards with a time delay of about 5 minutes. The raw data are conserved on a digital cassette for further investigations.

At the Georg-von-Neumayer-Station the radiosonde data are evaluated to study the variations of the vertical structure of the lower troposhere, katabatic wind effects and advection of air masses within the entire troposhere.

5. Atmospheric aerosols and trace gases

5.1 General description

The particular value of observing atmospheric trace constituents in Antarctica lies in its remote geographical location with respect to natural and anthropogenic sources of atmospheric contaminants. The Georg-von-Neumayer-Station at the edge of the ice shelf furthermore offers the possibility to study annual variations which may be attributed to the seasonal changes of the sea ice cover.

Currently the following samples are taken routinely throughout the year:

a) High volumne aerosol filters are applied for studies of trace elements and of radioactive isotopes (e.g.sea salt, mineral dust, high enriched elements, ^{7}Be, ^{10}Be, ^{210}Pb, ^{137}Cs)

b) Low volumne aerosol filters serve for investigations of trace elements, microscopy, and size distribution

c) Trace gas sampling of ^{85}Kr, $^{13}CO2$, $^{14}CO2$ and flask-samples for hydrocarbons

d) Surface snow and freshly fallen snow is analysed for sea salt, trace elements, stable isotopes and radioactivity.

The trace substance observatory is accommodated in a mobile container in a distance of 500 m in winter and 1500 m in summer to the south of the central buildings (Figure 6). The position was chosen since northerly winds are extremly rare at the Georg-von-Neumayer-Station. The laboratory has a 6

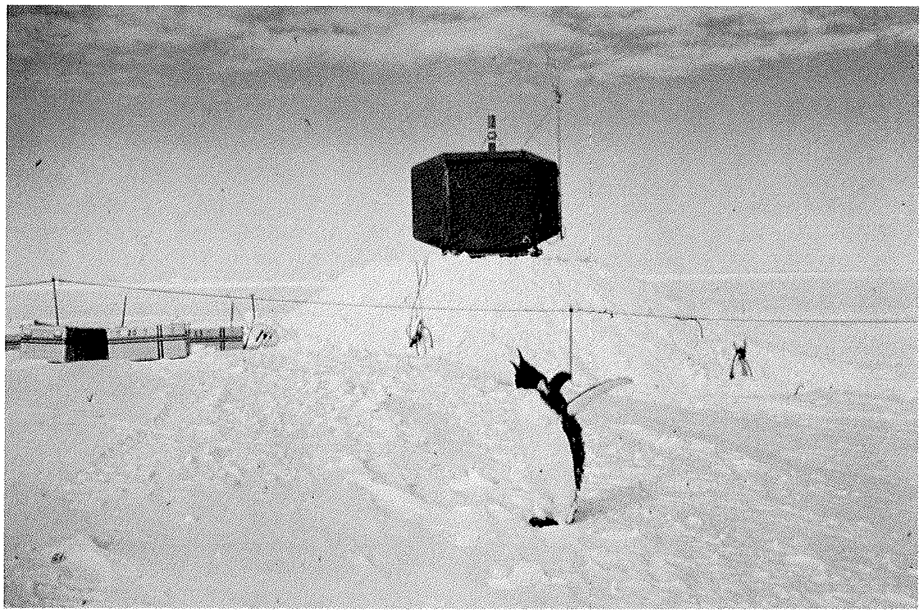


Figure 6: The trace substance observatory with meteorological sensors on the mast of the right hand side and the heated stack in the middle of the container

KVA and a 2 KVA power link to the main station for driving pumps and heaters and for the electronics, respectively. The air is sucked in through a heated stack inlet about 7 m above the snow surface. The entire system is schematically sketched in Figure 7.

5.2 Technical equipment

Condensation nuclei are continuously detected with a nuclei counter, size distribution is measured by a diffusion battery. The data are plotted on a multichannel recorder and stored on magnetic tape.

High volume sampling of 180 m^3/h occurs through a high purity cellulose filter with a diameter of 24 cm. The flow volume is continuously recorded in absolute units.

Low volume sampling can be performed on different membrane filters (polycarbonate, PTFE..., 25 - 47 mm diameter). The flow rate varies between 3 and 18 m^3/h. The maximum pressure drop across the filter is 800 mb.

Hourly averages of radon are measured with a micro-processor controlled semiconductor counter.

$^{14}CO_2$ and $^{13}CO_2$ is sampled in NaOH, the sampling period is 2 weeks and 3 days, respectively.

For the analysis of ^{85}Kr, air is stored in metal cylinders at a pressure of 150 bar.

Snow samples are routinely analysed with the aid of a newly designed electric conductivity system.

Data acquisition is controlled by a computer. In case of a computer breakdown a strip chart recorder still allows data evaluation by hand as a back up. Contamination of the samples by the station is minimized by a CNC-data and wind direction air sampling control and by a class-100 clean-air bench for filter-processing.

6. Snow studies

To obtain information on the snow accumulation (amount and quality) in the vicinity of the station the following work is included into the observational programme of the station.

6.1 Snow survey

In a sufficiant distance from the station buildings a stake network is installed where readings of snow accumulation at irregular intervalls are taken. These data are compared with the accumulation measurements in snowpits. They enable us to determine the accumulation on time scales shorter than annual rates.

The observation site is extended by the geodetic markers of the deformation network and the poles of the traverse to the ice edge, both of which are also used as accumulation indicators.

6.2 Snow quality

The seasonal variation of the isotopic content of snow with respect to the stable isotopes ^{2}H and ^{18}O is studied with the aid of samples of fresh fallen snow which are prepared for laboratory analyses. The Tritium content (^{3}H) of the snow samples is analysed as well.

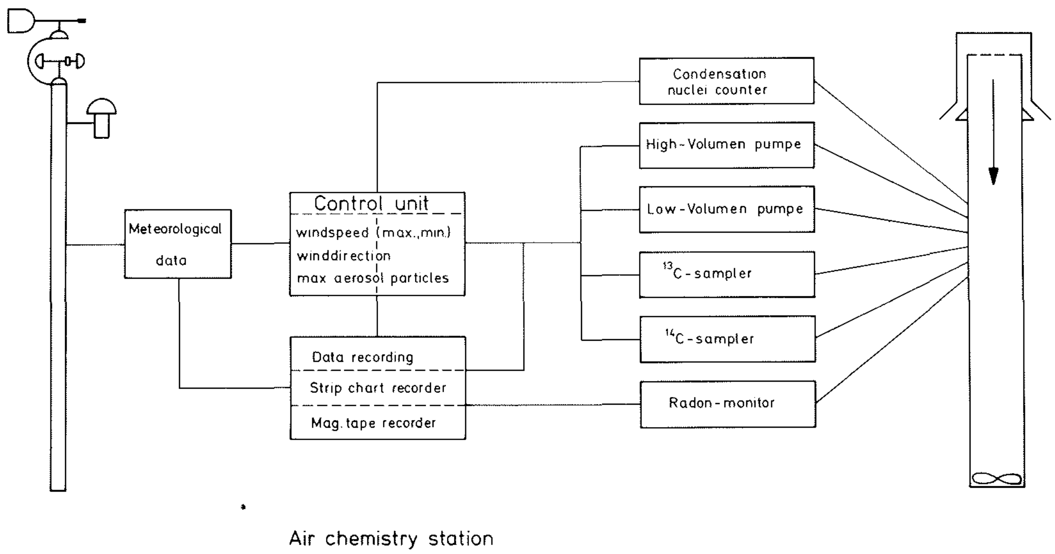


Figure 7: Schematic diagram of the trace substance observatory