6 Ship's Meteorological Station

6.1 Weather and Meteorological Conditions during Leg M 44/1

(D. Behr)

R/V METEOR left the port of Cádiz on January 22, 1998 morning steering on an easterly course to her first working position at 35°14'N/21°30'E (Urania-Basin). During her transit there were northerly winds force 4 Bft shifting to north-westerly direction soon after. A small but intense gale centre developing near Cape Finisterre followed R/V METEOR and reached her first working area at the same time. In the vicinity of Crete Island there were south-westerly winds force 8 Bft and a swell of up to 4 m making the station work troublesome. After finishing station work R/V METEOR sailed with southerly winds force 4 to 5 to the Port of Çanakkale for picking up a large group of scientists at January, 31.

R/V METEOR started in the Sea of Marmara with a bathymetric-profile-transect (see 4.1). Due to increasing north-easterly winds force 7 causing a swell of nearly 3 m the transect was hold up. Station work was done leeward of a peninsula in the meantime. After the passage of a cold front the wedge of a central European high expanded to the Sea of Marmara. Due to this there were westerly to south-westerly winds between force 3 and 5 Bft.

At February 5 a storm centre moved from Scotland to southern Finland. Its cold-front swung southwards across eastern Europe and passed the Sea of Marmara at February 6. In the vicinity of this front there were in the working area of R/V METEOR light and variable winds and poor visibility.

New lows developed at this cold-front and moved from France over the Ionian Sea and Aegean Sea to the Sea of Marmara since then up to the end of the cruise. They cause a steady change between south-westerly winds force 5 to 6 Bft. (the low was approaching to the working area of R/V METEOR), light and variable winds combined with rainy periods (the low was passing the working area), and north-westerly winds force 7 to 8 combined with showersqualls (passage of the cold-front). R/V METEOR reached Istanbul on February 13, 1999 noon.

The following short statistics of wind force in Beaufort and sea heights in m during the leg M44/1 illustrates the statements given above. They are given in % of all measurements.

Tab. 32: Statistics about wind force and sea hights during M 44/1

0	1	2	3	4	5	6	7	8	9	Windforce in Bft
0.6	2.8	7.5	18.2	22.8	16.8	19.2	10.5	1.6	-	% of all measurements

0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	Swell and sea in m
55.3	30.9	13.8	-	-	-	-	-	-	% of all measurements

Activities of the Ship's Weather Watch

a) A weather report was compiled and published twice a day. Comments on this report were given to the ship's command and the chief scientist regularly. The other participants of the cruise were informed by a bulletin or on special request. Special advice was given if necessary. The records needed for preparing the weather report were received as synoptic observations and weather maps from the wireless stations Pinneberg and Rome, as satellite pictures from METEOSAT 7, and as forecast charts from Deutscher Wetterdienst, Hamburg and Offenbach (Main).
The forecasts of weather conditions and height of sea and swell were based essentially on surface analyses charts of the Northern Atlantic Ocean (east of 30°W) and the Mediterranean Sea. Surface observations of European and Northern African weather-stations and voluntary merchant ships were compiled by hand drawing in these charts. They were analyzed by hand afterwards twice every day.
b) Meteorological parameters have been measured and recorded continuously and were transferred to the ship's data collecting system. By this every participant could retrieve the necessary data into his computer system afterwards. Sensors and meteorological equipment were maintained regularly, some repairs were done.
c) Every hour a World Meteorological Organization (WMO) standard weather observation was carried out. 8 of them were transmitted into the WMO Global Telecommunication System (GTS) including eye observations done by meteorological staff.
d) Every day at 12 UTC a radar-wind sound was launched with the ASAP-System, determining a vertical profile of pressure, temperature, moisture, and horizontal wind up to an altitude of 20 to 25 km. The evaluated data (temps) were transmitted into the GTS of the WMO.

Determination of the atmospheric turbidity at sea

Information about the spatial and temporal distribution of the net total radiation and its components at the sea surface as well as atmospheric turbidity are one of the most important parameters in resolving numerous meteorological and oceanographic questions. Therefore during the cruise the following radiation components were recorded: direct solar radiation, sunshine duration, global solar radiation and UV-B global solar radiation as well as longwave thermal radiation of the atmosphere. Additional components necessary to establish a radiation balance: reflected solar radiation and ocean surface radiation are computed using numerical models successfully tested on former research cruises in the Atlantic (BEHR, 1990).

As atmospheric turbidity influences global solar radiation on its way through the atmosphere, the knowledge of this quantity is essential. Atmospheric turbidity is expressed by turbidity coefficients as follows:

T_L: Linke-turbidity-coefficient, describing all radiative processes in the whole solar spectrum,
T_s: turbidity-coefficient, describing all radiative processes in the **s**hort-range part of the solar spectrum ($0\ \mu m < \lambda < 0.63\ \mu m$), giving information about the dust in the atmosphere,
T_r: turbidity-coefficient, describing all radiative processes in the **r**ed part of the solar spectrum ($0.62\ \mu m < \lambda < 2.8\ \mu m$), giving information about the water-vapour-content in the atmosphere.

The coefficients T_L, T_s, and $T_r \equiv T_x$ can be computed by:

$$I_x = I_{0x} \exp(-T_x \cdot m \cdot \delta) \qquad (1)$$

with:
I_{0x}: extraterrestrial solar radiation received from a surface normal to the beam of the sun. Its quantity depends on the distance sun - earth only,
I_x: direct solar radiation received from a surface normal to the beam of the sun, e.g. measured with a Linke-Feussner-Actinometer,
m: optical pathlength, dependent on the solar elevation angle.
δ: optical thickness of the atmosphere.

Simply spoken T_x equals the number of clear Rayleigh-atmospheres which had to stack up one on the top of the other in order to correspond to the atmsphere in which measurements were done.

The data set of numerous measurements of direct solar radiation I done with a Linke-Feussner-Actinometer revealed the spatial and temporal variation of the atmospheric turbidity during the cruise. As a first result the daily courses of T_L, T_s, and T_r at February, 3 will be shown here. R/V METEOR worked the whole day in cold and cloudless air originating from the eastern parts of Central Europe. There were weak northerly winds with 5 to 10 knots. At this day the horizontal visibility decreased from 20 km at sunrise to 5 km after sunset remarkably (Fig. 99). The alteration of the atmospheric transparency can be explained by the measurements of atmospheric turbidity done on this day very frequently.

In Figs. 99 and 100 the time-scale used is True Solar Time (TST) in order to make the daily courses of the meteorological quantities more clear. The decrease of the horizontal visibility cannot not be explained by the daily course of the direct solar radiation (Fig. 100, thin line) as it is nearly symmetric to noon, neither by the Linke-turbidity coefficient T_L (Fig. 100, dotted line) as it is nearly constant the whole day. The value of about 4 represents a Central Europe air in spring loaded with dust particles from an larger city. But the spectral turbidity coefficients show a striking different behaviour: decreasing of T_r (Fig. 100, triangles) and an increase of T_s (Fig 100, crosses). These effects show: the drying of the atmosphere (decrease of T_r) is overcompensated by the transport of loaded air from eastern Central Europe (increase of T_s). The transport took place in the lower layers of the atmosphere (surface up to 1 km) according to the backwards-trajectories computed for this day. The new air-masses reduce the horizontal visibility as shown in Fig. 100.

These findings correspond to former results found by BEHR (1990, 1992).

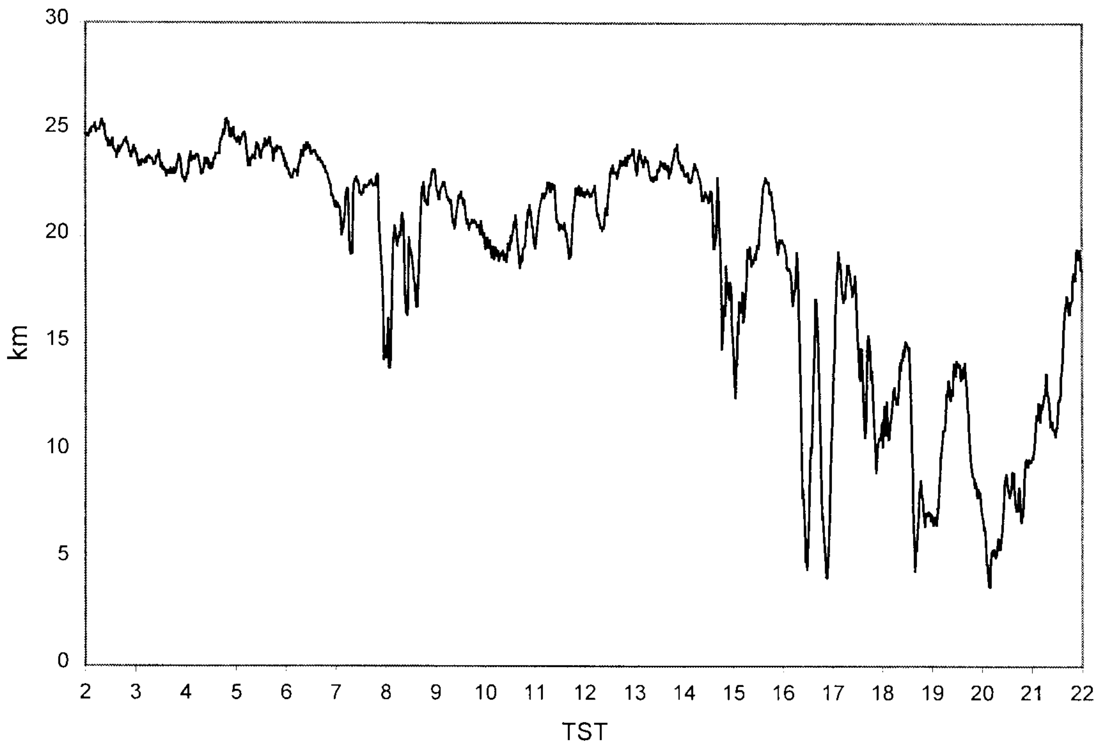

Fig. 99: Horizontal visibility on February, 3 1999. Time used is true solar time (TST).

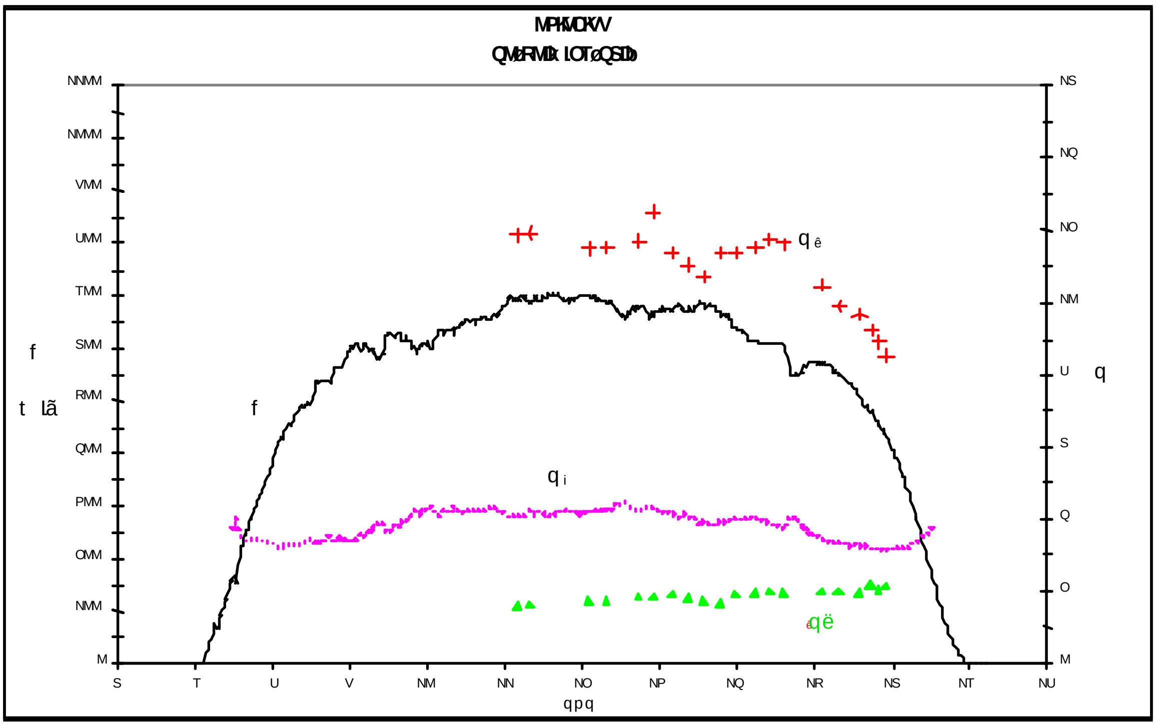

Fig. 100: Daily courses of direct solar radiation (I), Linke-Turbidity-coefficient (T_L), short-range-turbidity-coefficient (T_s), and red-part-turbidity-coefficient (T_r) on February, 3 1999. Time used is true solar time (TST).

6.2 Weather and Meteorological Conditions during Leg M 44/2
(R. Brauner)

R/V METEOR left Istanbul on the 16th of January at 19:00 hours with light southerly winds and a temperature of about 8°C. When METEOR reached the Aegean Sea northwesterly winds increased up to 28 Knots due to a low pressure system moving slowly from the Ionian Sea to thesouthwestern part of Turkey. This low pressure sytems with winds from northwest- to westerly directions dominated the weather on the cruise to Port Said. Because of the low temperature of the airmass in comparison to sea surface temperature rainshowers developed during day and night and forced the wind additionally by gusts. Due to the strong northwesterly winds windsea and swell increased to 2.5 meter.

Cruising from Port Said to Aqaba and also for scientific work in the Gulf of Aqaba was done under good weather conditions and a poorcloudiness. The winds blowed daily from northerly directions with windspeeds between 18 and 26 knots. Additionally orographic- and katabatic effects forced the windspeed up to 40 knots in some regions of the Gulf of Aqaba, especially in the Street of Tiran. The average wind speed during the cruise was about 20 knots from northerly directions with a frequency of 92 %. Due to the short fetch of about 100 km, the maximum windsea was about 1.5 meter. The temperatures cooled to 13°C in the morning and rised up to 22°C in the afternoon. Only in the last three days of the cruise the wind became calm because of a low pressure gradient in the area. Therefore seebreeze developed in the afternoon with windspeeds up to 8 knots from southerly directions.

The cruise M 44-2 ended in the morning of the 11th of March 1999 in Aqaba.

6.3 Weather and Meteorological Conditions during Leg M 44/3
(D. Bassek)

R/V METEOR left Aqaba on the 12th of March at 10:00 hours with moderate northerly winds and a temperature of about 20°C. The scientific work in the Gulf of Aqaba was done under good weather conditions and a poor cloudiness. The winds blowed daily from northerly directions with windspeeds between 0.5 and 26 knots. The average wind speed during the cruise in Gulf of Aqaba was about 20 knots from northerly directions. Due to the short fetch of about 100 km, the maximum windsea was about 1.5 meter. The temperatures cooled to 13°C in the morning and rose up to 22°C in the afternoon.

In the area of the Red Sea, the scientific work was also performed under good weather conditions and with windspeeds between 0 and 40 knots. The average wind speed during this cruise was about 20 knots from northwesterly to northerly directions. Only on one day did the wind reach velocities of 40 to 43 knots. The maximum wind sea was about 2 meters. To be precise, it was 16% 0 Meter, 55% 1 Meter, 29% 2 Meter. The temperatures were between 24°C and 26°C during the whole day with humidity from 30% to 90%. The visibility was good most of the time good, on other days it was dusty. Scientific work in the Eastern Mediterranean Sea onr the last 2 days was also done under weather conditions.

Synoptic situation during Leg M44/3: After starting this leg at Aqaba, the anticyclone over the eastern part of the Mediterranean Sea caused mostly northerly winds in the Gulf of Aqaba. The strongest winds were noticed in the morning hour's bft 5 to 6 with gusts up to bft 7 sometimes. Because of sunny conditions, sea breeze effects took place during the afternoon. On 18.03.99 a low passed the eastern Mediterranean Sea from west to east. Therefore winds in the Gulf of Aqaba turned right to SE but very weak in force. On 22.03.99 the anticyclone influence west of Aqaba increased again. Winds from NW to NE Bft 4 to 6 were recorded onboard. On 30.03.99 light winds were registered due to small pressure gradients in the operating area. On 31.03.99 heavy northwesterly winds were noticed enroute at the rear of a low with maximum winds near bft 9 for some hours. After leaving Port Said, winds from NW to E took place mostly moderate to strong in force.

6.3 Weather and Meteorological Conditions during Leg M 44/4

(R. Strüfing)

In spring time the weather situation over the Mediterranean Sea changes from the wintry cyclonic activities over relatively warm waters to prevailing high pressure mainly due to temperatures over sea being considerably lower than over the surrounding continents. The weather during M44/4 followed this development.

For the first three weeks an anticyclone over Crete and the Levantine Sea held the low pressure systems at bay which developed over the western parts of the Mediterranean Sea. Though these lows moved to the northeast and thus never penetrated into the Levantine Sea, the short passage of their cold fronts caused the winds to rise up to force 6. Since these few rainless weather events lasted a few hours only, the first part of M44/4 was dominated by weak winds and an abundance of sunshine.

When 'RV Meteor moved on to the Urania Basin, on 5th May a strong pressure gradient between an anticyclone over Bulgaria and a low over the asiatic parts of Turkey lead to northeasterly winds force 7 in the Agean Sea stretching out into the Ionian Sea through the Kithira Strait. This single event of strong winds persisted for 36 hours causing waves up to 3 meters. Later on high pressure over the Ionian Sea combined with weak winds ruled the weather again.

Until the beginning of May the weather over western parts of the Mediterranean Sea had been dominated by strong cyclogenisis but on 12th May hardly any pressure gradient could be found over this area. Due to the low windspeed and the relatively cold water RV Meteor experienced large fog patches on entering the Straits of Sicily (12th May).

During the transfer to Malaga westerly winds up to force 5 to 6 prevailed. Since these intervals of moderate to strong winds never lasted long the cruise M44/4 ended as smooth as it had begun. And the many hours of sunshine will be remembered as well as the lack of rain.