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25 Years of Polarstern Meteorology
(1982-2006)

Gert König-Langlo, Bernd Loose, Benny Bräuer

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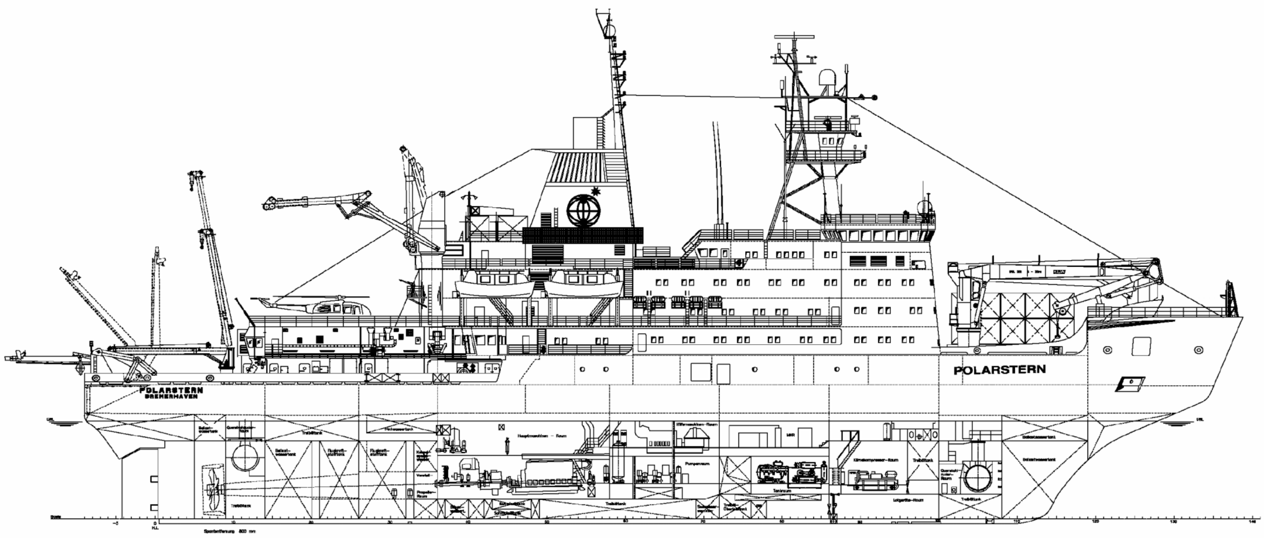

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Content

1. Introduction

The most important tool in Germany's polar research program is the research and supply vessel Polarstern. The ship was commissioned in 1982, the maiden voyage started at the end of 1982. The owner of the ship is the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. Within the last 25 years Polarstern performed a total of 44 expeditions to the Arctic and Antarctic.

The ship is well equipped for meteorological research as well as for routine meteorological services. The meteorological office is permanently manned with a weather technician/-observer from the German Weather Service (DWD) who performs the routine 3-hourly synoptic observations and the daily upper air soundings. Additionally, a weather forecaster is responsible to advice the ships captain as well as the helicopter pilots and all scientists in any weather related question. The forecaster gets assistance from the weather technician who performs the satellite picture reception and manages the near real time data flow.

2. Instrumentation

Temperature, wind and humidity are measured at portside and at starboard simultaneously. To minimize the ships influence on the measurements only the windward sensors are registered.

Air temperature

The air temperatures are measured at a height of 29 m above the waterline. Till 2002-06-25 the measurements were performed with PT100 mounted in radiation shield not ventilated artificially. Afterwards, combined humidity and temperature transmitter (HMP 233, Vaisala, Finland) – also mounted in not ventilated radiation shields - are used.

Wind

Cup anemometer (SK 565, Thies, Germany) and wind vanes (SK 566, Thies, Germany) at a height of 39 m above the waterline are used to measure the relative wind direction and wind speed. The true wind was calculated from the relative wind data using the ship speed measured relative to the water (ATLAS, DOLOG 22). From 1998-10-15 on – after GPS came into use – the true winds are calculated with respect to the ships movement over ground.

Humidity

Air humidity data are obtained at a height of 29 m above the waterline. A hair hygrometer (portside, 1.10000.01.48, Thies, Germany) and a dew point sensor (starboard, 3100.0000 BG, Friedrichs, Germany) were used. The accuracy of both instruments was rather limited. Differences in the derived relative humidity of more than 10% were frequent. When the reason for these differences could not be detected, both values were excluded from the datasets and the 3-hourly routine surface observations were performed by using a hand held psychrometer after Assmann. When the difference between both instruments were lower than 10% the average of both values were registered.
At 2001-07-11 the dew point sensor was replaced by a combined humidity and temperature transmitter (HMP 233, Vaisala, Finland). At 2002-06-25 also the hair hygrometer got replaced

by a HMP 233 sensor mounted in not ventilated radiation shields. The accuracy of these sensors can be taken to be better than 5% relative humidity in most cases. Only the windward sensor gets registered.

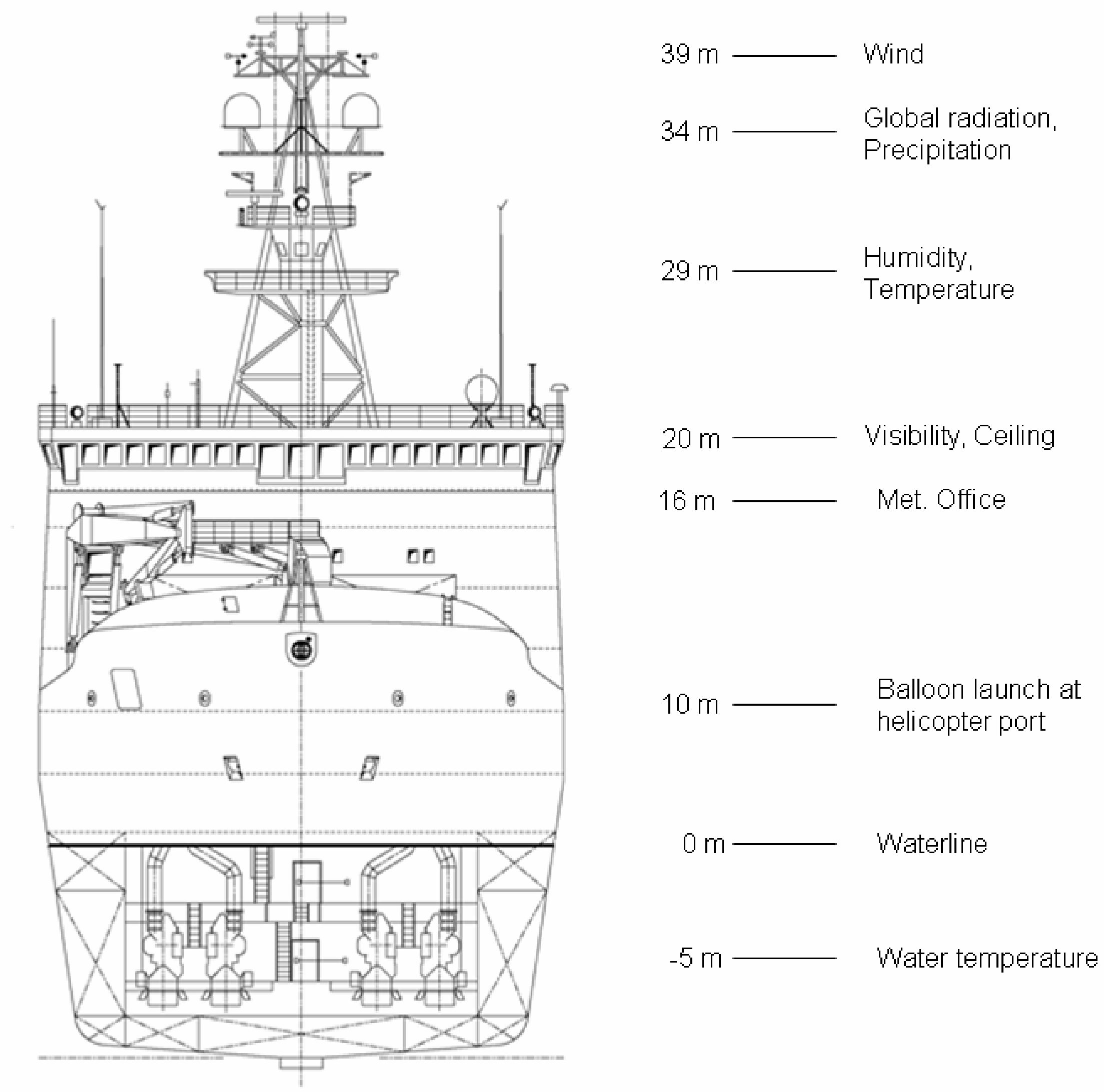

Fig. 1: Heights of the meteorological sensors with respect to the waterline

Surface air pressure

The air pressure is measured with an electronic barometer (SETRA B270, Friedrichs, Germany). Although the air pressure is measured inside the meteorological office at a height of 16 m the measurements are reduced to sea level. To avoid the influence of pressure fluctuations within the meteorological office due to air conditioning etc. the inlet of the pressure sensor is connected to a pipe leading to the outside close to the craws nest. The end of this pipe is a pressure labyrinth to reduce wind induced pressure fluctuations. Nevertheless, strong winds still influence the air pressure measurements up to 1 hPa. From 1993-05-18 to 1994-10-06 the surface pressure was sampled in hPa once a minute and stored only as integer. Thus, the 10-minute averages - taken during this time - have a rather low resolution.

Precipitation

Precipitation measurements on board of Polarstern started at 1994-10-18 (DOSA 450, Friedrichs, Germany). The sensor is unable to measure solid precipitation. Only rain events are quantified. Due to several problems with the sensor, the data should be taken with care. Data which are obviously wrong are already excluded from the datasets. Nevertheless, it is still possible that some rain events are missing, that extreme sea spray affects the measurements and that accumulated snow melts within the sensor and gets measured as liquid precipitation hours or days after the snowfall.

Global radiation

Global radiation is measured by using an artificially ventilated pyranometer (CM11, Kipp&Zonen, Netherlands). The instrument is placed at the level of the craw's nest, a position, not totally free of cast shadows. Night-time values are normally not set to zero. They vary +/-0 and can be used to quantify offsets of the instrument which also occur during daytime. Especially the older data are subject of rather huge offset problems and have to be taken with care.

Water temperature

The water temperatures are measured in a depth of 5 m below the waterline inside the box of the fin stabilizer. The average of the signals of portside and starboard mounted platinum resistance thermometers (PT-100, 2.1210.99, Thies, Germany) gets registered.

Visibility

The visibility is measured by using a Videograph 3 (Impulsphysik, Germany). The instrument generates flashes with a xenon lamp. The backscattered light of these flashes inside a control volume some meters apart from the ship gets analysed to estimate the visibility. The instrument is limited to a maximum range of 10.000 m. For the automatic synoptic observation this sensor is used to quantify the parameter VV (horizontal view distance). All measurements at the maximum range are codes as VV=97, see Tab. 1. Values with VV > 97 are given only during manmade synoptic observations.

VV – horizontal view distance

```
---------------------------------------
90 --  0.00 km <= VV <   0.05 km
91 --  0.05 km <= VV <   0.20 km
92 --  0.20 km <= VV <   0.50 km
93 --  0.50 km <= VV <   1.00 km
94 --  1.00 km <= VV <   2.00 km
95 --  2.00 km <= VV <   4.00 km
96 --  4.00 km <= VV <  10.00 km
97 -- 10.00 km <= VV <  20.00 km
98 -- 20.00 km <= VV <= 50.00 km
99 -- 50.00 km <  VV
// -- missing
```

Tab. 1: WMO-code (FM12/13) for visibility observations VV

Cloud ceiling

The height of the cloud base vertical above the ship is measured by using the cloud ceilometer LD-WHX 05 (Impulsphysik, Germany). The instrument bases on the LIDAR principle. It has a maximum range of 12000 feet (~ 3600 m). The data from this instrument are used for the automatic synoptic observation of the lowest cloud base h, see Tab. 2. Manmade observations include estimated cloud ceilings from clouds not vertical above the ship.

h – cloud base of lowest cloud (meter above ground)

```
-----------------------------------------------------------------
0 --     0 to   50 m
1 --    50 to  100 m
2 --   100 to  200 m
3 --   200 to  300 m
4 --   300 to  600 m
5 --   600 to 1000 m
6 --  1000 to 1500 m
7 --  1500 to 2000 m
8 --  2000 to 2500 m
9 --  above   2500 m
/ --  unknown
```

Tab. 2: WMO-code (FM12/13) for cloud ceiling observations h

Upper air soundings

Till 2004-10-01 the upper air soundings are carried out with RS80 radiosondes (VAISALA, Finland). They directly measure air pressure, air temperature and relative humidity. Till 1996 the wind vector was determined with the aid of the OMEGA navigation system; the height information is calculated using the hydrostatic approximation. Since 1996 a GPS-based wind-finding system is used. After some initial problems (1996/1997) the change of the wind-finding system lead to a remarkable improve of the quality of the wind data. The RS80 radiosondes were replaced for a short time by RS90 radiosondes. Since 2005-04-09 RS92-SGPW radiosondes are in use.

Helium filled balloons (TOTEX 600 g, 800 g, Japan) are taken to obtain an ascent velocity of about 5 ms^{-1}. The balloons get launched from the helicopter port at a height of 10 m above waterline. Typically, two hours later the balloons burst at heights between 25 and 37 km. All balloons were filled inside an inflation shed equipped with a sliding door 3 m towards the helicopter port. During strong wind conditions (>20 ms^{-1}), only 350 g balloons can be launched with a reasonable chance of success. Since 2004-06-16 the data reception and evaluation is carried out by a DigiCORA III MW31 (VAISALA, Finland). Before, a DigiCORA II and a MicroCora (VAISALA, Finland) were used.

During some cruises – see Tab. 4 – ozone soundings where performed to measure the vertical ozone profile through the troposphere and the lower stratosphere. For the ozone soundings an ozonesonde (ECC-6AB, Science Pump Corporation, USA) is connected via an interface to a normal radiosonde. The ozone is measured by pumping air through a chemical solution and using the principal of iodide redox reaction to release electrons. 1500 g TOTEX balloons are used for these ascents. The DigiCORA is able to handle the data reception and evaluation of both, the normal radiosonde and the ozonesonde at the same time.

Fig. 2: Balloon launch from the helicopter port of Polarstern

3. Cruises

The home harbor from Polarstern is Bremerhaven, Germany. During summer, Polarstern usually operates in the Arctic, during winter (austral summer) in the Antarctic. The Arctic cruises are named “ARK-n”, the Antarctic cruises “ANT-n” with “n” as a running number written in Roman numerals. The stopovers in Bremerhaven are typically during spring and autumn where most of the maintenance work gets performed. Usually, Polarstern is more than 300 days per year in operation.

Each cruise is separated into legs. The first and last part of an Antarctic cruise is usually a meridional cross section through the Atlantic. In seldom cases “Polarstern” stayed longer than one winter in the southern hemisphere, see e.g. ANT-IV/ANT-V ANT-X, ANT-XXIII.

Cruise	Leg	Departure	Arrival
ANT-I	1	1982-12-27 Bremerhaven	1983-01-21 Cape Town
ANT-I	2	1983-01-22 Cape Town	1983-03-24 Rio de Janeiro
ANT-I	3	1983-03-25 Rio de Janeiro	1983-04-24 Bremerhaven
ARK-I	1	1983-06-29 Bremerhaven	1983-07-20 Longyearbyen
ARK-I	2	1983-07-21 Longyearbyen	1983-07-29 Longyearbyen
ARK-I	3	1983-07-29 Longyearbyen	1983-08-25 Bremerhaven
ANT-II	1	1983-09-21 Bremerhaven	1983-10-13 Rio de Janeiro

ANT-II	2	1983-10-15	Rio de Janeiro	1983-11-12	Punta Arenas
ANT-II	3	1983-11-22	Punta Arenas	1983-12-27	Punta Arenas
ANT-II	4	1983-12-29	Punta Arenas	1984-03-10	Cape Town
ANT-II	5	1984-03-12	Cape Town	1984-04-06	Bremerhaven
ARK-II	1	1984-05-10	Bremerhaven	1984-06-11	Tromsoe
ARK-II	2	1984-06-12	Tromsoe	1984-07-19	Longyearbyen
ARK-II	3	1984-07-19	Longyearbyen	1984-08-08	Tromsoe
ARK-II	4	1984-08-09	Tromsoe	1984-08-27	Aalesund
ARK-II	5	1984-08-31	Aalesund	1984-09-21	Bremerhaven
ANT-III	1	1984-10-09	Bremerhaven	1984-11-15	Punta Arenas
ANT-III	2	1984-11-14	Punta Arenas	1984-12-09	Punta Arenas
ANT-III	3	1985-01-03	Punta Arenas	1985-03-06	Cape Town
ANT-III	4	1985-03-07	Cape Town	1985-04-03	Bremerhaven
ARK-III	1	1985-05-04	Bremerhaven	1985-06-01	Kiel
ARK-III	2	1985-07-03	Bremerhaven	1985-07-30	Longyearbyen
ARK-III	3	1985-07-30	Longyearbyen	1985-08-23	Bremerhaven
ANT-IV	1a	1985-09-03	Bremerhaven	1985-09-29	Las Palmas
ANT-IV	1b	1985-09-28	Las Palmas	1985-10-14	Dakar
ANT-IV	1c	1985-10-14	Dakar	1985-11-04	Rio de Janeiro
ANT-IV	2	1985-11-06	Rio de Janeiro	1985-12-02	Punta Arenas
ANT-IV	3	1985-12-06	Punta Arenas	1986-03-14	Cape Town
ANT-IV	4	1986-03-18	Cape Town	1986-04-30	Punta Arenas
ANT-V	1	1986-05-06	Punta Arenas	1986-06-20	Bahia Blanca
ANT-V	2	1986-06-27	Bahia Blanca	1986-09-18	Cape Town
ANT-V	3	1986-09-28	Cape Town	1986-12-15	Cape Town
ANT-V	4	1986-12-26	Cape Town	1987-03-17	Puerto Madryn
ANT-V	5	1987-03-19	Puerto Madryn	1987-04-19	Bremerhaven
ARK-IV	1	1987-05-14	Bremerhaven	1987-06-09	Longyearbyen
ARK-IV	2	1987-06-06	Longyearbyen	1987-07-02	Tromsoe
ARK-IV	3	1987-07-04	Tromsoe	1987-09-03	Hamburg
ANT-VI	1	1987-09-24	Bremerhaven	1987-10-20	Rio Gr. do Sul
ANT-VI	2	1987-10-20	Rio Grande do Sul	1987-12-20	Ushuaia
ANT-VI	3	1987-12-21	Ushuaia	1988-03-18	Cape Town
ANT-VI	4	1988-03-18	Cape Town	1988-04-11	Bremerhaven
ARK-V	1	1988-04-26	Bremerhaven	1988-06-05	Reykjavik
ARK-V	2	1988-06-06	Reykjavik	1988-07-05	Tromsoe
ARK-V	3a	1988-07-06	Tromsoe	1988-08-03	Reykjavik
ARK-V	3b	1988-08-03	Reykjavik	1988-08-29	Bremerhaven
ANT-VII	1	1988-09-15	Bremerhaven	1988-10-10	Rio Gr. do Sul
ANT-VII	2	1988-10-11	Rio Grande do Sul	1988-11-20	Punta Arenas
ANT-VII	3	1988-11-23	Punta Arenas	1989-01-10	Punta Arenas
ANT-VII	4	1989-01-13	Punta Arenas	1989-03-11	Cape Town
ANT-VII	5	1989-03-12	Cape Town	1989-04-07	Bremerhaven
ARK-VI	1	1989-04-20	Bremerhaven	1989-05-16	Tromsoe
ARK-VI	2	1989-05-16	Tromsoe	1989-06-08	Tromsoe
ARK-VI	3	1989-06-08	Tromsoe	1989-06-29	Longyearbyen
ARK-VI	4	1989-06-29	Longyearbyen	1989-07-09	Hamburg
ANT-VIII	1	1989-08-05	Bremerhaven	1989-09-06	Puerto Madryn
ANT-VIII	2	1989-09-06	Puerto Madryn	1989-10-31	Cape Town
ANT-VIII	3	1989-11-01	Cape Town	1989-12-01	Punta Arenas
ANT-VIII	4	1989-12-01	Punta Arenas	1989-12-14	Ushuaia
ANT-VIII	5	1989-12-17	Ushuaia	1990-03-13	Cape Town
ANT-VIII	6	1990-03-14	Cape Town	1990-05-01	Cape Town
ANT-VIII	7	1990-05-01	Cape Town	1990-05-23	Bremerhaven
ARK-VII	1	1990-06-07	Bremerhaven	1990-07-10	Tromsoe
ARK-VII	2	1990-07-10	Tromsoe	1990-08-15	Tromsoe
ARK-VII	3a	1990-08-16	Tromsoe	1990-08-28	Longyearbyen
ARK-VII	3b	1990-08-28	Longyearbyen	1990-10-04	Bremerhaven
ANT-IX	1	1990-10-20	Bremerhaven	1990-11-15	Punta Arenas
ANT-IX	2	1990-11-17	Punta Arenas	1990-12-31	Cape Town
ANT-IX	3	1991-01-03	Cape Town	1991-03-29	Cape Town
ANT-IX	4	1991-03-30	Cape Town	1991-05-14	Bremerhaven
ARK-VIII	1	1991-06-01	Bremerhaven	1991-06-20	Tromsoe
ARK-VIII	2	1991-06-20	Tromsoe	1991-07-31	Tromsoe
ARK-VIII	3	1991-08-01	Tromsoe	1991-10-15	Bremerhaven
ANT-X	1a	1991-11-14	Bremerhaven	1991-12-10	Puerto Madryn
ANT-X	1b	1991-12-10	Puerto Madryn	1992-01-03	Punta Arenas
ANT-X	2	1992-01-04	Punta Arenas	1992-03-26	Cape Town
ANT-X	3	1992-03-27	Cape Town	1992-05-20	Cape Town
ANT-X	4	1992-05-21	Cape Town	1992-08-06	Puerto Madryn

ANT-X	5	1992-08-08	Puerto Madryn	1992-09-27	Punta Arenas
ANT-X	6	1992-09-29	Punta Arenas	1992-11-30	Cape Town
ANT-X	7	1992-12-03	Cape Town	1993-01-23	Ushuaia
ANT-X	8	1993-01-24	Ushuaia	1993-02-23	Bremerhaven
ARK-IX	1a	1993-02-26	Bremerhaven	1993-03-24	Longyearbyen
ARK-IX	1b	1993-03-24	Longyearbyen	1993-04-18	Bremerhaven
ARK-IX	2	1993-05-16	Bremerhaven	1993-06-25	Tromsoe
ARK-IX	3	1993-06-25	Tromsoe	1993-08-05	Tromsoe
ARK-IX	4	1993-08-06	Tromsoe	1993-10-06	Bremerhaven
ANT-XI	1	1993-10-18	Bremerhaven	1993-11-27	Cape Town
ANT-XI	2	1993-12-12	Cape Town	1994-01-12	Punta Arenas
ANT-XI	3	1994-01-14	Punta Arenas	1994-03-28	Cape Town
ANT-XI	4	1994-03-29	Cape Town	1994-05-20	Cape Town
ANT-XI	5	1994-05-21	Cape Town	1994-06-18	Bremerhaven
ARK-X	1	1994-07-06	Bremerhaven	1994-08-16	Tromsoe
ARK-X	2	1994-08-17	Tromsoe	1994-10-06	Bremerhaven
ANT-XII	1	1994-10-18	Bremerhaven	1994-11-22	Punta Arenas
ANT-XII	2	1994-11-23	Punta Arenas	1995-01-04	Cape Town
ANT-XII	3	1995-01-05	Cape Town	1995-03-20	Punta Arenas
ANT-XII	4	1995-03-21	Punta Arenas	1995-05-15	Punta Arenas
ANT-XII	5	1995-05-15	Punta Arenas	1995-06-12	Bremerhaven
ARK-XI	1	1995-07-07	Bremerhaven	1995-09-21	Tromsoe
ARK-XI	2	1995-09-20	Tromsoe	1995-10-30	Bremerhaven
ANT-XIII	1	1995-11-09	Bremerhaven	1995-12-03	Cape Town
ANT-XIII	2	1995-12-04	Cape Town	1996-01-25	Cape Town
ANT-XIII	3	1996-01-26	Cape Town	1996-03-16	Cape Town
ANT-XIII	4	1996-03-17	Cape Town	1996-05-19	Punta Arenas
ANT-XIII	5	1996-05-19	Punta Arenas	1996-06-21	Bremerhaven
ARK-XII	1	1996-07-12	Bremerhaven	1996-09-24	Bremerhaven
ANT-XIV	1	1996-10-05	Bremerhaven	1996-11-09	Punta Quilla
ANT-XIV	2	1996-11-12	Punta Quilla	1997-01-01	Punta Arenas
ANT-XIV	3	1997-01-04	Punta Arenas	1997-03-20	Cape Town
ANT-XIV	4	1997-03-21	Cape Town	1997-04-26	Bremerhaven
ARK-XIII	1	1997-05-14	Bremerhaven	1997-06-23	Tromsoe
ARK-XIII	2	1997-06-24	Tromsoe	1997-08-12	Tromsoe
ARK-XIII	3	1997-08-11	Tromsoe	1997-09-30	Bremerhaven
ANT-XV	1	1997-10-15	Bremerhaven	1997-11-07	Cape Town
ANT-XV	2	1997-11-09	Cape Town	1998-01-12	Cape Town
ANT-XV	3	1998-01-13	Cape Town	1998-03-25	Punta Arenas
ANT-XV	4	1998-03-25	Punta Arenas	1998-05-23	Cape Town
ANT-XV	5	1998-05-26	Cape Town	1998-06-22	Bremerhaven
ARK-XIV	1	1998-06-27	Bremerhaven	1998-08-27	Tromsoe
ARK-XIV	2	1998-08-28	Tromsoe	1998-10-15	Bremerhaven
ANT-XVI	1	1998-12-15	Bremerhaven	1999-01-06	Cape Town
ANT-XVI	2	1999-01-08	Cape Town	1999-03-16	Cape Town
ANT-XVI	3	1999-03-16	Cape Town	1999-05-11	Cape Town
ANT-XVI	4	1999-05-11	Cape Town	1999-06-03	Bremerhaven
ARK-XV	1	1999-06-23	Bremerhaven	1999-07-19	Tromsoe
ARK-XV	2	1999-07-21	Tromsoe	1999-09-08	Tromsoe
ARK-XV	3	1999-09-08	Tromsoe	1999-10-14	Bremerhaven
ANT-XVII	1	1999-12-14	Bremerhaven	2000-01-07	Cape Town
ANT-XVII	2	2000-01-07	Cape Town	2000-03-15	Cape Town
ANT-XVII	3	2000-03-18	Cape Town	2000-05-11	Punta Arenas
ANT-XVII	4	2000-05-14	Punta Arenas	2000-06-20	Bremerhaven
ARK-XVI	1	2000-06-30	Bremerhaven	2000-07-30	Longyearbyen
ARK-XVI	2	2000-07-30	Longyearbyen	2000-08-26	Bremerhaven
ANT-XVIII	1	2000-09-29	Bremerhaven	2000-10-24	Cape Town
ANT-XVIII	2	2000-10-24	Cape Town	2000-12-04	Cape Town
ANT-XVIII	3	2000-12-07	Cape Town	2001-01-13	Cape Town
ANT-XVIII	4	2001-01-13	Cape Town	2001-02-22	Punta Arenas
ANT-XVIII	5a	2001-02-23	Punta Arenas	2001-04-13	Punta Arenas
ANT-XVIII	5b	2001-04-14	Punta Arenas	2001-05-08	Punta Arenas
ANT-XVIII	6	2001-05-08	Punta Arenas	2001-06-06	Bremerhaven
ARK-XVII	1	2001-06-19	Bremerhaven	2001-07-30	Tromsoe
ARK-XVII	2	2001-07-31	Tromsoe	2001-10-07	Bremerhaven
ANT-XIX	1	2001-11-07	Bremerhaven	2001-11-30	Cape Town
ANT-XIX	2	2001-12-01	Cape Town	2002-01-21	Punta Arenas
ANT-XIX	3	2002-01-23	Punta Arenas	2002-02-26	Punta Arenas
ANT-XIX	4	2002-03-01	Punta Arenas	2002-04-02	Punta Arenas
ANT-XIX	5	2002-04-03	Punta Arenas	2002-05-05	Punta Arenas

ANT-XIX	6	2002-05-05 Punta Arenas	2002-05-30 Bremerhaven
ARK-XVIII	1	2002-06-25 Bremerhaven	2002-08-24 Tromsoe
ARK-XVIII	2	2002-08-24 Tromsoe	2002-10-15 Bremerhaven
ANT-XX	1	2002-10-26 Bremerhaven	2002-11-22 Cape Town
ANT-XX	2	2002-11-24 Cape Town	2003-01-23 Cape Town
ANT-XX	3	2003-01-23 Cape Town	2003-02-16 Bremerhaven
ARK-XIX	1	2003-02-28 Bremerhaven	2003-04-24 Longyearbyen
ARK-XIX	2	2003-04-24 Longyearbyen	2003-05-15 Bremerhaven
ARK-XIX	3a	2003-05-23 Bremerhaven	2003-06-26 Tromsoe
ARK-XIX	3b	2003-06-26 Tromsoe	2003-07-19 Longyearbyen
ARK-XIX	3c	2003-07-19 Longyearbyen	2003-08-07 Tromsoe
ARK-XIX	4a	2003-08-07 Tromsoe	2003-09-21 Longyearbyen
ARK-XIX	4b	2003-09-21 Longearbyen	2003-10-13 Bremerhaven
ANT-XXI	1	2003-10-22 Bremerhaven	2003-11-15 Cape Town
ANT-XXI	2	2003-11-17 Cape Town	2004-01-19 Cape Town
ANT-XXI	3	2004-01-21 Cape Town	2004-03-26 Cape Town
ANT-XXI	4	2004-03-26 Cape Town	2004-05-07 Cape Town
ANT-XXI	5	2004-05-08 Cape Town	2004-06-02 Bremerhaven
ARK-XX	1	2004-06-16 Bremerhaven	2004-07-16 Longyearbyen
ARK-XX	2	2004-07-16 Longyearbyen	2004-08-30 Tromsoe
ARK-XX	3	2004-08-30 Tromsoe	2004-10-03 Bremerhaven
ANT-XXII	1	2004-10-12 Bremerhaven	2004-11-05 Cape Town
ANT-XXII	2	2004-11-04 Cape Town	2005-01-20 Cape Town
ANT-XXII	3	2005-01-20 Cape Town	2005-04-07 Punta Arenas
ANT-XXII	4	2005-04-08 Punta Arenas	2005-05-22 Bahia Blanca
ANT-XXII	5	2005-05-24 Bahia Blanca	2005-06-22 Bremerhaven
ARK-XXI	1a	2005-07-21 Bremerhaven	2005-08-13 Longyeabyen
ARK-XXI	1b	2005-08-13 Longyeabyen	2005-09-18 Bremerhaven
ANT-XXIII	1	2005-10-13 Bremerhaven	2005-11-18 Cape Town
ANT-XXIII	2	2005-11-18 Cape Town	2006-01-13 Punta Arenas
ANT-XXIII	3	2006-01-13 Punta Arenas	2006-02-09 Punta Arenas
ANT-XXIII	4	2006-02-11 Punta Arenas	2006-04-11 Punta Arenas
ANT-XXIII	5	2006-04-13 Punta Arenas	2006-06-12 Cape Town
ANT-XXIII	6	2006-06-13 Cape Town	2006-08-21 Cape Town
ANT-XXIII	7	2006-08-24 Cape Town	2006-10-29 Cape Town

Tab. 3: Cruises of Polarstern from 1982-12-27 to 2006-10-29 ordered by date

Cruise	**Leg**	**O_3-Soundings**	**Departure**	**Arrival**
ANT-V	5	26	Puerto Madryn	Bremerhaven
ANT-VII	1	40	Bremerhaven	Rio Grande do Sul
ANT-X	8	33	Ushuaia	Bremerhaven
ANT-XI	1	34	Bremerhaven	Cape Town
ANT-XI	5	17	Cape Town	Bremerhaven
ARK-X	1	34	Bremerhaven	Tromsoe
ANT-XIV	1	25	Bremerhaven	Punta Quilla
ANT-XV	1	21	Bremerhaven	Cape Town
ANT-XVII	1	18	Bremerhaven	Cape Town
ANT-XVII	2	5	Cape Town	Cape Town
ANT-XVII	4	21	Punta Arenas	Bremerhaven
ANT-XVIII	1	19	Bremerhaven	Cape Town
ANT-XX	1	23	Bremerhaven	Cape Town
ANT-XX	2	13	Cape Town	Cape Town
ANT-XX	3	23	Cape Town	Bremerhaven
ARK-XIX	1	32	Bremerhaven	Longyearbyen
ANT-XXI	1	22	Bremerhaven	Cape Town
ANT-XXIII	1	30	Bremerhaven	Cape Town

Tab. 4: Cruises performing ozone soundings

4. Datasets

Within this publication 3 different routine meteorological datasets are published. They complement one another. The routine 3-hourly observations gave the most complete datasets including many visual observations also covering basic ice information. The upper air soundings are routinely performed once a day and contain all meteorological relevant vertical profile data sometimes including ozone concentrations. The continuous meteorological surface measurement – available since 1993-05-15 - offer the only continuous dataset based on measurements averaged over 10 minutes. The geocodes ALTITUDE, DATE/TIME, LATITUDE and LONGITUDE are included in any dataset.

4.1. Routine 3-hourly meteorological observations

The observations are carried out every three hours. They include measurements and visual observations according Tab. 5. All data are 10-minute averages or instantaneous observations at the given time in UTC. During night time – when the weather observer is not on duty - the 3-hourly meteorological observations are performed automatically. Thus, no visual observations are available. All data are generally coded according the definitions of the Word Meteorological Organization WMO (FM12/13) and transferred without delay into the Global Telecommunication System GTS were they contribute for the world wide weather forecasts.

Parameter	Short Name	Unit	Method
ALTITUDE	Altitude	m	
DATE/TIME	Date/Time		
LATITUDE	Latitude		
LONGITUDE	Longitude		
High cloud	CH	code	Visual observation
Low cloud	CL	code	Visual observation
Middle cloud	CM	code	Visual observation
Mean ship´s course	Ds	code	
Height of first swell waves	Hw1Hw1	code	Visual observation
Height of second swell waves	Hw2Hw2	code	Visual observation
Height of waves	HwHw	code	Visual observation
Total cloud amount	N	code	Visual observation
Low/middle cloud amount	Nh	code	Visual observation
Pressure, atmospheric	POPOPOPO	hPa	
Periode of first swell waves	Pw1Pw1	sec	Visual observation
Periode of second swell waves	Pw2Pw2	sec	Visual observation
Wave period	PwPw	sec	Visual observation
Temperature, air	TTT	deg C	
Dew/frost point	TdTdTd	deg C	

Temperature, water	Temp	deg C	
Horizontal view distance	VV	code	
Mean ship´s speed	Vs	code	
Past weather1	W1	code	Visual observation
Past weather2	W2	code	Visual observation
Present weather	WW	code	Visual observation
Characteristic of barometric tendency	a	code	
Wind direction	dd	deg	
Direction of first swell waves	dw1dw1	code	Visual observation
Direction of second swell waves	dw2dw2	code	Visual observation
Wind velocity	ff	m/sec	
Cloud base height code	h	code	
Amount of barometric tendency	ppp	hPa	

Tab. 5: Parameter included in the 3-hourly meteorological observations

4.2. Upper air soundings

The upper air soundings are normally performed once a day to measure vertical profiles of air pressure, temperature, relative humidity and the wind vector, see Tab. 6. Whenever possible, the launches were performed about 10 UTC. The measurements were transferred without delay into the Global Telecommunication System GTS were they contribute for the world wide weather forecasts. The profile data were taken every 10 (5) seconds which result in a vertical profile resolution of about 50 (25) meter. The profiles terminate at the burst level of the balloons, normally at heights between 25 and 37 km.

Sometimes, additional soundings were performed to advice the helicopter pilots. For these soundings small balloon were used which usually reach rather low burst levels. Furthermore, all soundings of any scientific short time experiment based on the upper air sounding facilities of Polarstern are included in this publication. In this framework it is worth to mention meridional Atlantic cross sections with ozone soundings and cross sections with high spatial resolutions see Tab. 4 and chapter 6.

Parameter	Short Name	Unit
ALTITUDE	Altitude	m
LATITUDE	Latitude	
LONGITUDE	Longitude	
Pressure, at given altitude	PPPP	hPa
Humidity, relative	RH	%
Temperature, air	TTT	deg C
Wind direction	dd	deg
Wind velocity	ff	m/sec
Ozone	O3	mPa

Tab. 6: Parameter included in the upper air soundings

4.3. Continuous meteorological surface measurement

In this publication datasets from 1993-05-15 on are included. The measurements are taken automatically on board of Polarstern as a subset of the so called PODAS-System, see http://podas.awi-bremerhaven.de/. The time resolution is 10 minutes. Most of the parameters are averages. The parameter *Ceiling* contains minima. The parameter *LATITUDE, LONGITUDE*, *Course*, and *Speed* are instantaneous values taken at the end of the averaging interval. The *DATE/TIME* information represents the center of the 10-minute statistic interval. Please notice that all instantaneous values are taken about 5 minutes later. All values are post processed and quality controlled. Elderly data are available at AWI but not yet post processed.

Parameter	Short Name	Unit	Comment
ALTITUDE	Altitude	m	*Geocode*
DATE/TIME	Date/Time		*Geocode*
LATITUDE	Latitude		*Geocode*
LONGITUDE	Longitude		*Geocode*
Ceiling	Ceil	feet	10-min minimum; 20000: No clouds detected within 12000 feet
Course	Course	deg	Instantaneous value at end of interval
Global radiation	GlRad	W/m^2	10-min average
Heading	Head	deg	10-min average
Pressure, atmospheric	POPOPOPO	hPa	10-min average
Precipitation	Precip	mm/10min	10-min average
Humidity, relative, mean	RelHum	%	10-min average
Wind direction, relative	RelWindDir	deg	10-min average
Wind velocity, relative	RelWindVel	m/sec	10-min average
Speed	Speed	m/sec	Instantaneous value at end of interval
Temperature, air	TTT	deg C	10-min average
Visibility	Visib	m	10-min average (9999 denotes >= 9999)
Wind direction	dd	deg	10-min average
Wind velocity	ff	m/sec	10-min average

Tab. 7: Parameter included in the continuous meteorological surface measurement

5. Cruise tracks and time series

For any cruise listed in Tab. 3 the cruise track and time series of relevant meteorological data are presented in this chapter. These plots are made to offer only a rough overview over the huge amount of data and cannot show any details. Thus, the plots are quite busy and sometimes hardly readable. In seldom cases, when the readability of the plots gets too low one cruise is splitted up into multiple plots.

The cruise tracks base on the routine synoptic observations presented as a line. Each upper air sounding is presented as a dot. Once a day (at 12 UTC) month (mm), day (dd) and year (yyyy) information are included. Please notice that the date format in the diagrams (mm-dd-yyyy) is not ISO 8601 compatible. Although the date information are frequently plotted above each other and unreadable, they can be used to judge the duration Polarstern stays at a certain location.

The horizontal time axis of the time series are scaled variably according the duration of the depicted cruise. This fact has to be taken into account if time series of different cruises get intercompared. The time series include information about the concentration or arrangement of sea ice (ci), the visibility (VV), the present weather (ww), and the total cloud cover (N). These information are coded according to the international FM12/13 code of the Word Meteorological Organization WMO. The code is presented in Tab. 1 and Tab. 8-10.

5.1. FM12/13-code description

ci -- Concentration or arrangement of sea ice

```
----------------------------------------------------------
0 -- No ice
1 -- Ship in open lead more than 1 n. mile wide or ship in fast ice with boundary
     beyond limit of visibility
Sea ice concentration uniform
2 -- Open water or very open pack ice, < 3/8 concentration
3 -- Open pack ice 3/8 to < 6/8 concentration
4 -- Close pack ice 6/8 to < 7/8 concentration
5 -- Very close pack ice 7/8 to < 8/8 concentration
Sea ice concentration not uniform
6 -- Strips and patches of pack ice with open water between
7 -- Strips and patches of close or very close pack ice with areas of lesser
     concentration
8 -- Fast ice with open water, very open or open pack ice to seaward of the ice
     boundary
9 -- Fast ice with close or very close pack ice to seaward of the ice boundary
/ -- Unable to report, because of darkness, poor visibility or because ship is more
     than 0.5 n. mile away from ice edge
```

Tab. 8: WMO-code (FM12/13) for visual sea ice observations ci

ww -- Present weather

```
----------------------------
00 -- clear skies
01 -- clouds dissolving
02 -- state of sky unchanged
03 -- clouds developing
Haze, smoke, dust or sand
04 -- visibility reduced by smoke
05 -- haze
06 -- widespread dust in suspension not raised by wind
07 -- dust or sand raised by wind
08 -- well developed dust or sand whirls
09 -- dust or sand storm within sight but not at station
Non-precipitation events
10 -- mist
11 -- patches of shallow fog
12 -- continuous shallow fog
13 -- lightning visible, no thunder heard
14 -- precipitation within sight but not hitting ground
15 -- distANT-precipitation but not falling at station
16 -- nearby precipitation but not falling at station
17 -- thunderstorm but no precipitation falling at station
18 -- squalls within sight but no precipitation falling at station
19 -- funnel clouds within sight
Precipitation within past hour but not at observation time
20 -- drizzle
```

21 -- rain
22 -- snow
23 -- rain and snow
24 -- freezing rain
25 -- rain showers
26 -- snow showers
27 -- hail showers
28 -- fog
29 -- thunderstorms

Duststorm, sandstorm, drifting or blowing snow

30 -- slight to moderate duststorm, decreasing in intensity
31 -- slight to moderate duststorm, no change
32 -- slight to moderate duststorm, increasing in intensity
33 -- severe duststorm, decreasing in intensity
34 -- severe duststorm, no change
35 -- severe duststorm, increasing in intensity
36 -- slight to moderate drifting snow, below eye level
37 -- heavy drifting snow, below eye level
38 -- slight to moderate drifting snow, above eye level
39 -- heavy drifting snow, above eye level

Fog or ice fog

40 -- Fog at a distance
41 -- patches of fog
42 -- fog, sky visible, thinning
43 -- fog, sky not visible, thinning
44 -- fog, sky visible, no change
45 -- fog, sky not visible, no change
46 -- fog, sky visible, becoming thicker
47 -- fog, sky not visible, becoming thicker
48 -- fog, depositing rime, sky visible
49 -- fog, depositing rime, sky not visible

Drizzle

50 -- intermittent light drizzle
51 -- continuous light drizzle
52 -- intermittent moderate drizzle
53 -- continuous moderate drizzle
54 -- intermittent heavy drizzle
55 -- continuous heavy drizzle
56 -- light freezing drizzle
57 -- moderate to heavy freezing drizzle
58 -- light drizzle and rain
59 -- moderate to heavy drizzle and rain

Rain

60 -- intermittent light rain
61 -- continuous light rain
62 -- intermittent moderate rain
63 -- continuous moderate rain
64 -- intermittent heavy rain
65 -- continuous heavy rain
66 -- light freezing rain
67 -- moderate to heavy freezing rain
68 -- light rain and snow
69 -- moderate to heavy rain and snow

Snow

70 -- intermittent light snow
71 -- continuous light snow
72 -- intermittent moderate snow
73 -- continuous moderate snow
74 -- intermittent heavy snow
75 -- continuous heavy snow
76 -- diamond dust
77 -- snow grains
78 -- snow crystals
79 -- ice pellets

Showers

80 -- light rain showers
81 -- moderate to heavy rain showers
82 -- violent rain showers
83 -- light rain and snow showers
84 -- moderate to heavy rain and snow showers

```
85 -- light snow showers
86 -- moderate to heavy snow showers
87 -- light snow/ice pellet showers
88 -- moderate to heavy snow/ice pellet showers
89 -- light hail showers
90 -- moderate to heavy hail showers
```
Thunderstorms
```
91 -- thunderstorm in past hour, currently only light rain
92 -- thunderstorm in past hour, currently only moderate to heavy rain
93 -- thunderstorm in past hour, currently only light snow or rain/snow mix
94 -- thunderstorm in past hour, currently only moderate to heavy snow or rain/snow
95 -- light to moderate thunderstorm
96 -- light to moderate thunderstorm with hail
97 -- heavy thunderstorm
98 -- heavy thunderstorm with duststorm
99 -- heavy thunderstorm with hail
```

Tab. 9: WMO-code (FM12/13) for present weather observations ww

N -- Total cloud cover

```
0 -- 0 eighths (clear)
1 -- 1/8th
2 -- 2/8ths
3 -- 3/8ths
4 -- 4/8ths
5 -- 5/8ths
6 -- 6/8ths
7 -- 7/8ths
8 -- 8/8ths (overcast)
9 -- sky obscured
/ -- no observation
```

Tab. 10: WMO-code (FM12/13) for total cloud cover observations N

5.2. Antarctic cruises (ANT)

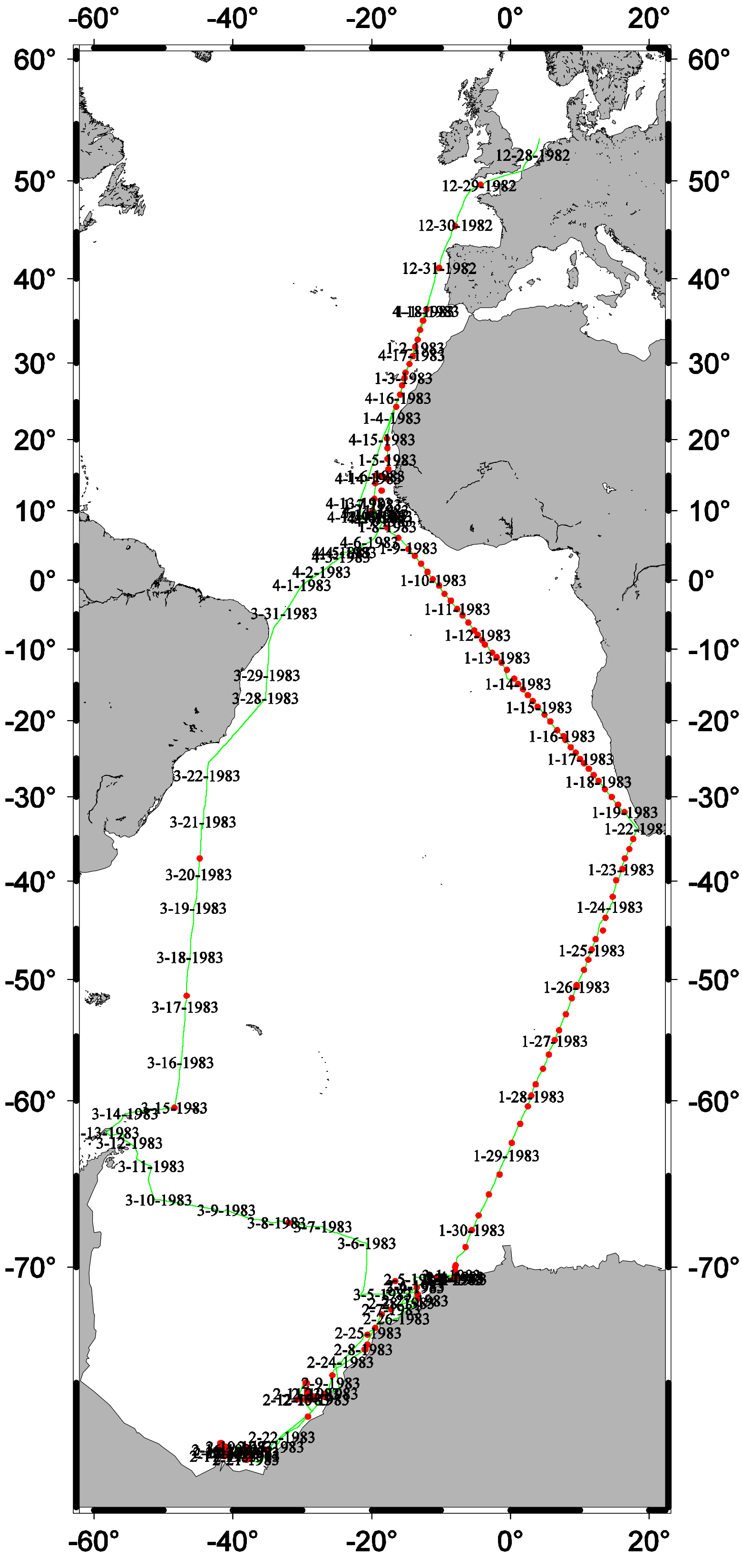

Fig. 3: Cruise track from ANT-I based on the 3-hourly synoptic observations.

Dots denote upper air soundings

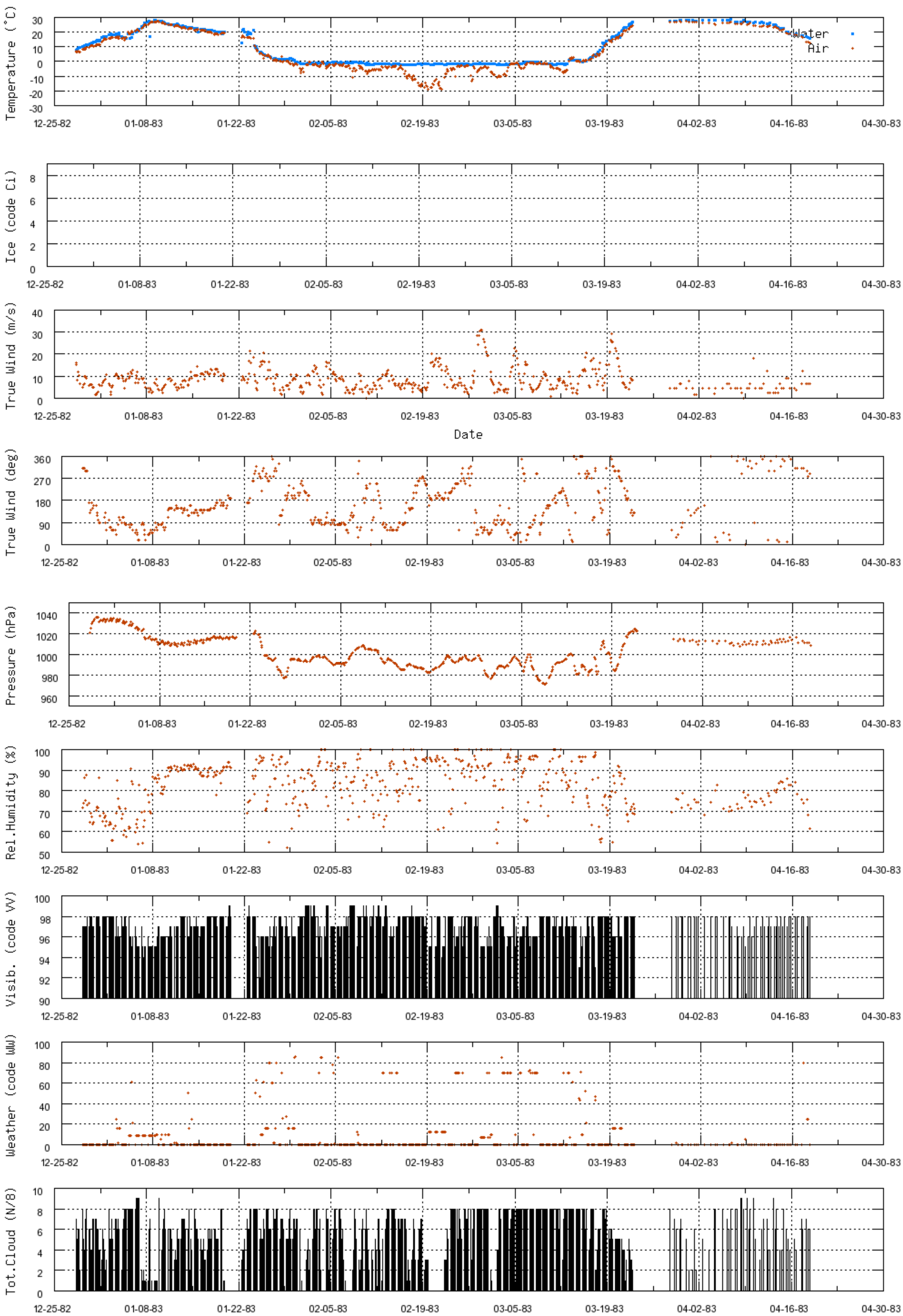

Fig. 4: Time series from ANT-I based on the 3-hourly synoptic observations

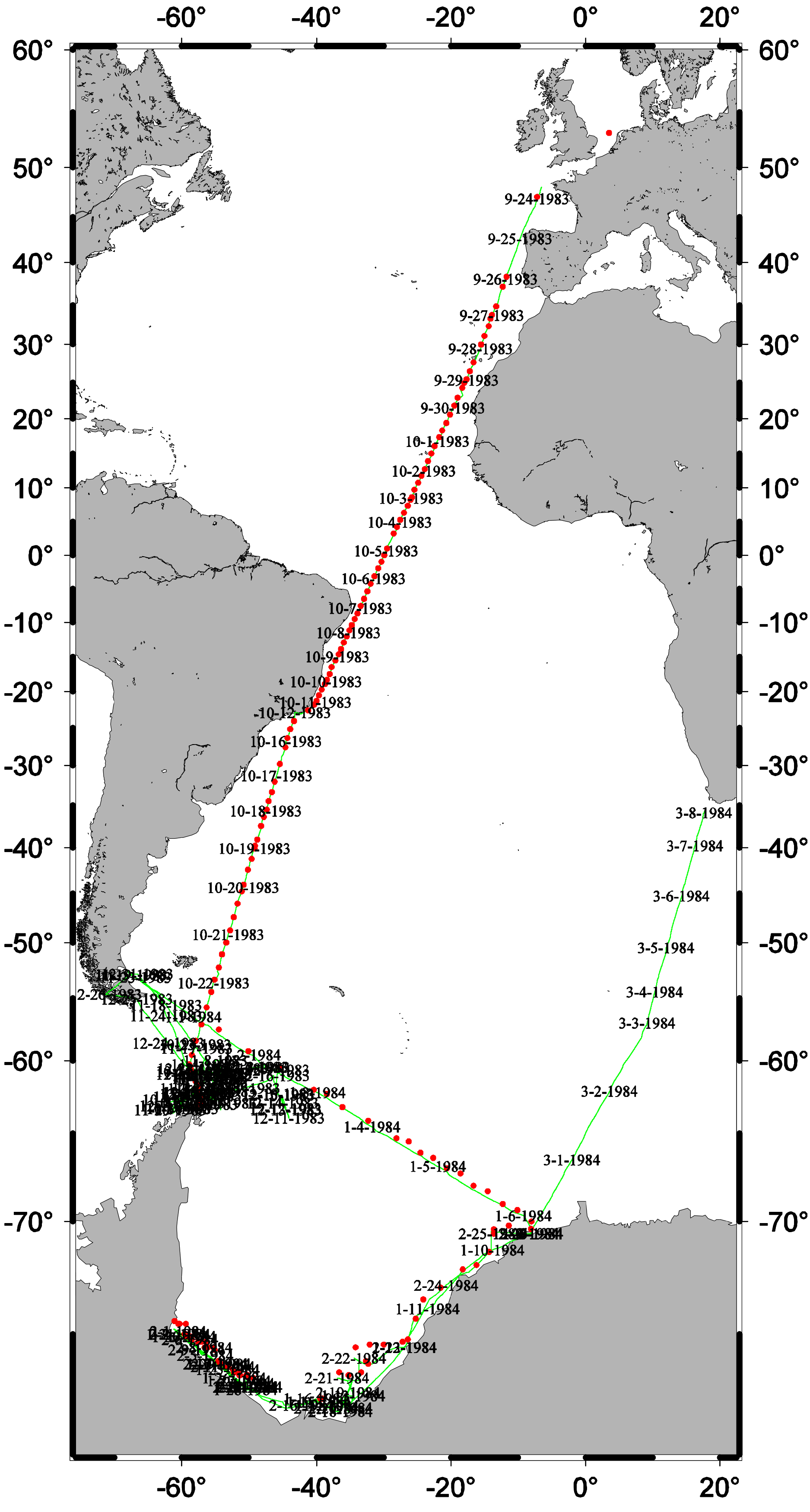

Fig. 5: Cruise track from ANT-II based on the 3-hourly synoptic observations.
Dots denote upper air soundings

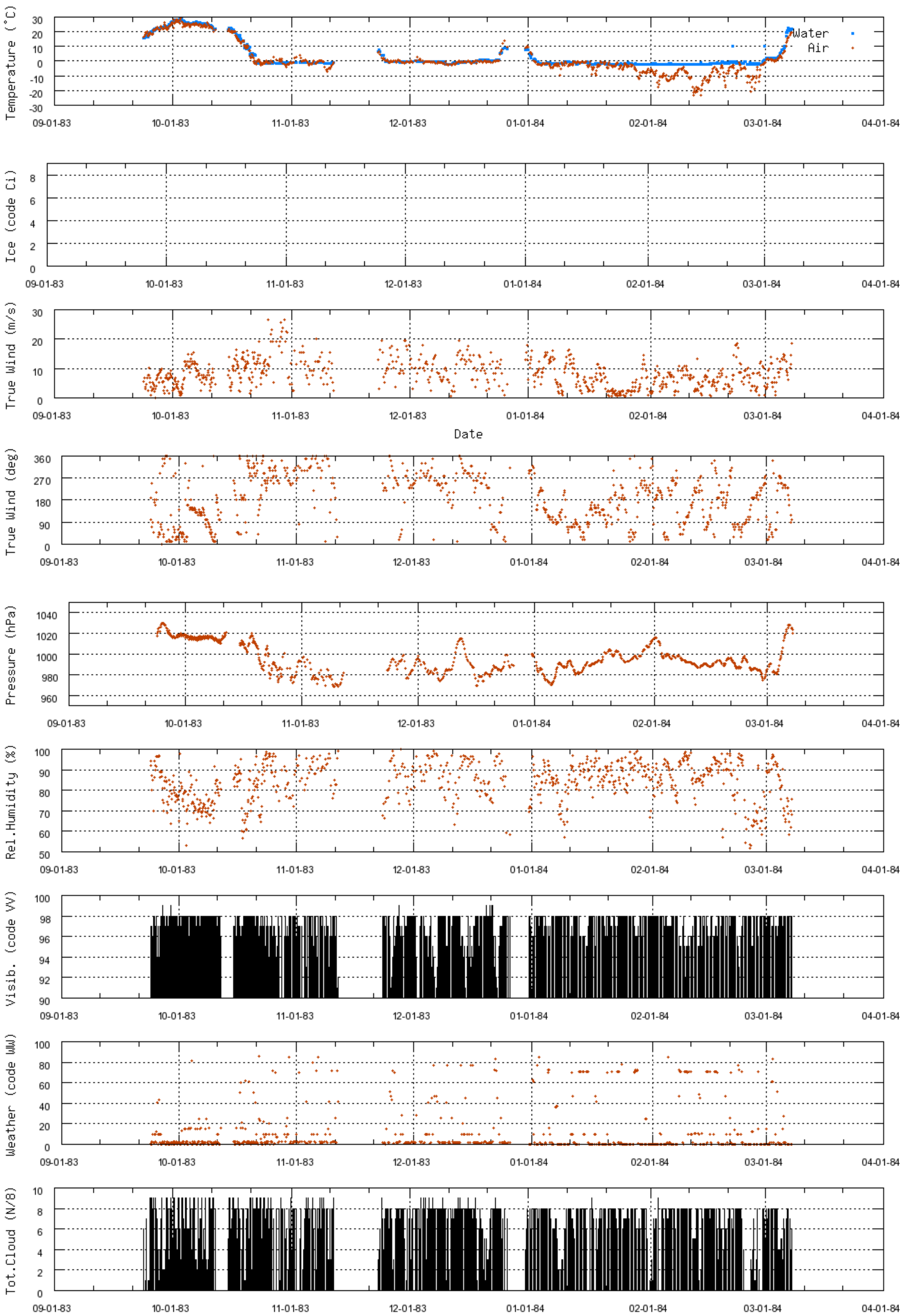

Fig. 6: Time series from ANT-II based on the 3-hourly synoptic observations

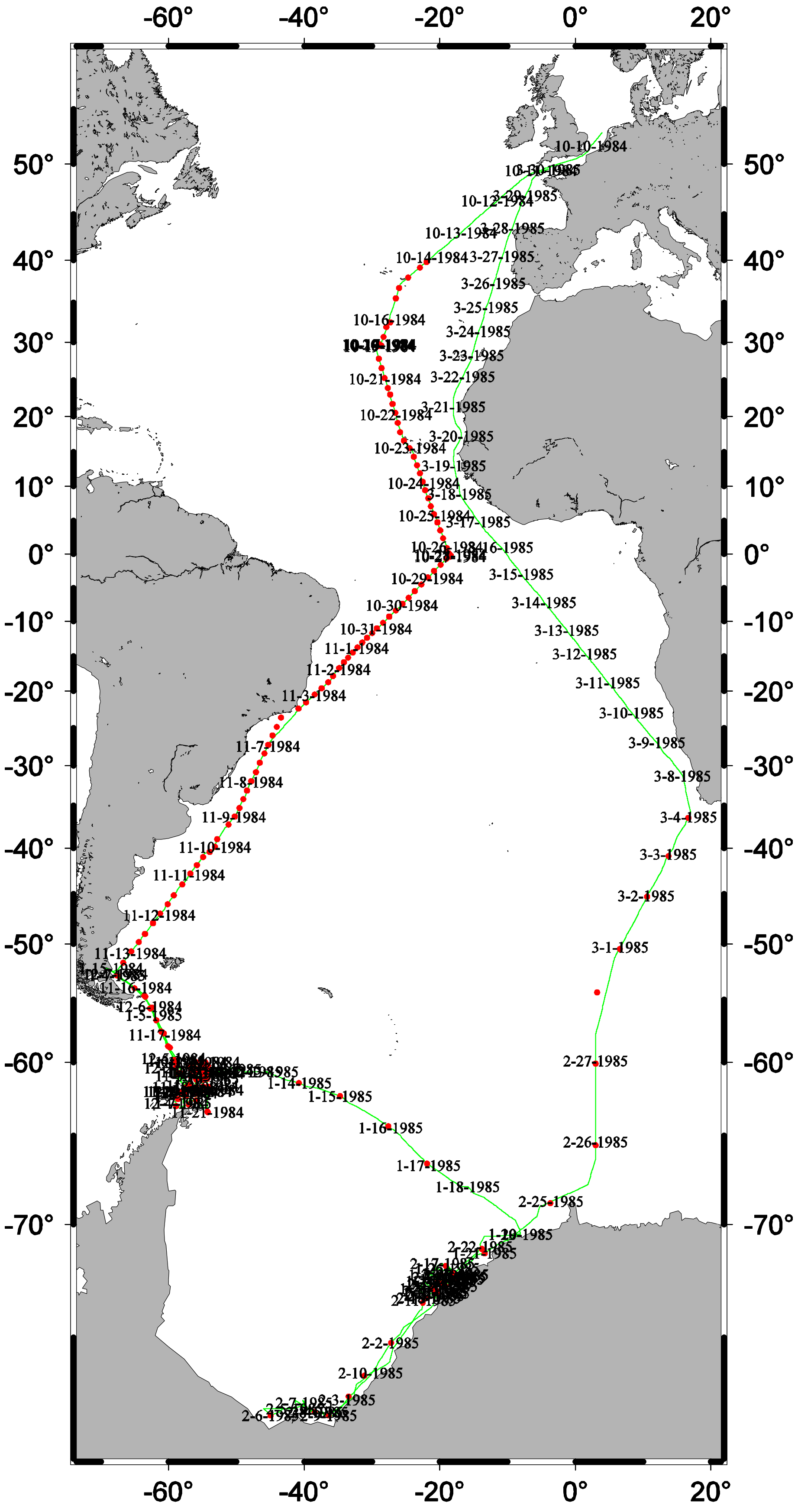

Fig. 7: Cruise track from ANT-III based on the 3-hourly synoptic observations. Dots denote upper air soundings

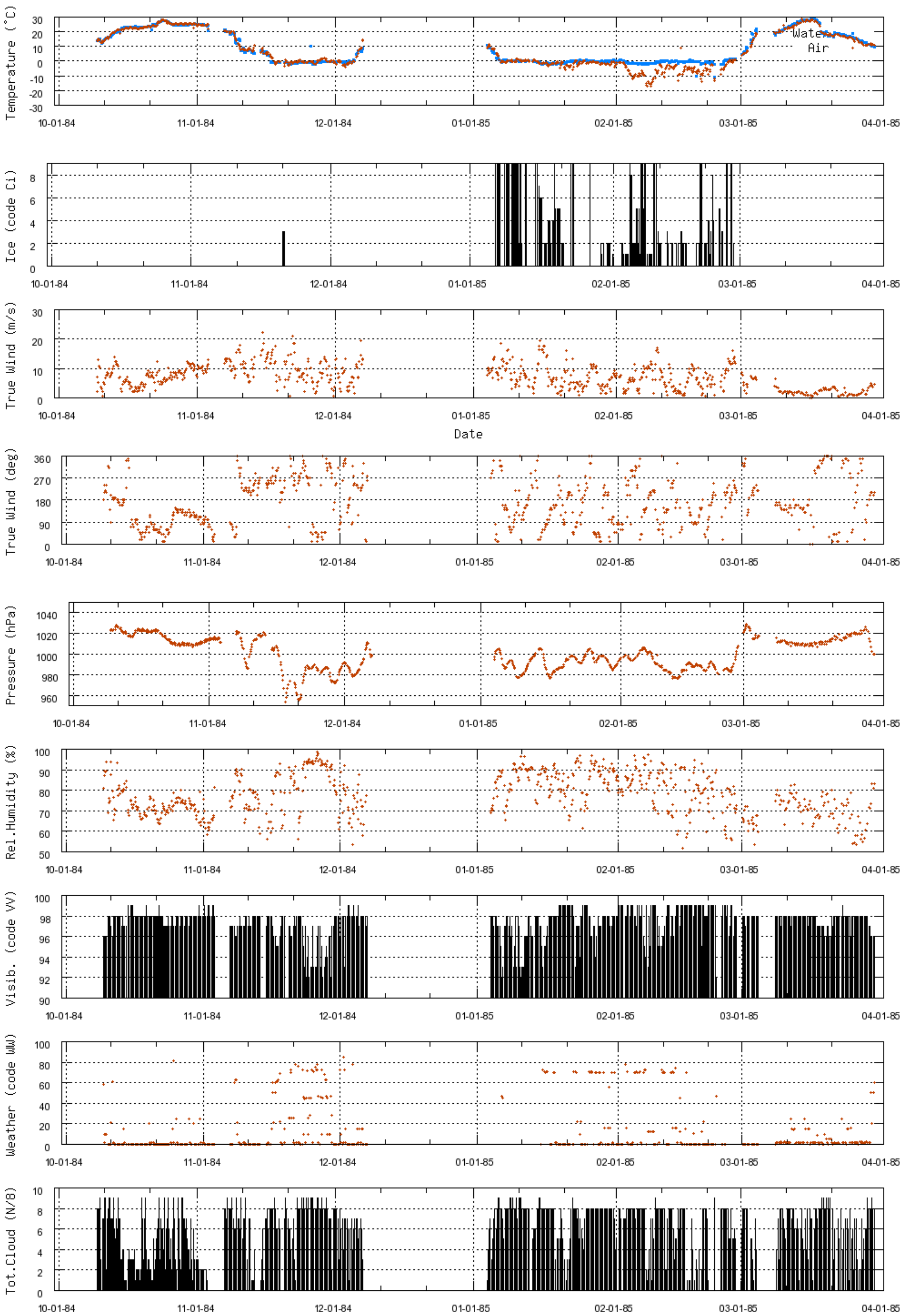

Fig. 8: Time series from ANT-III based on the 3-hourly synoptic observations

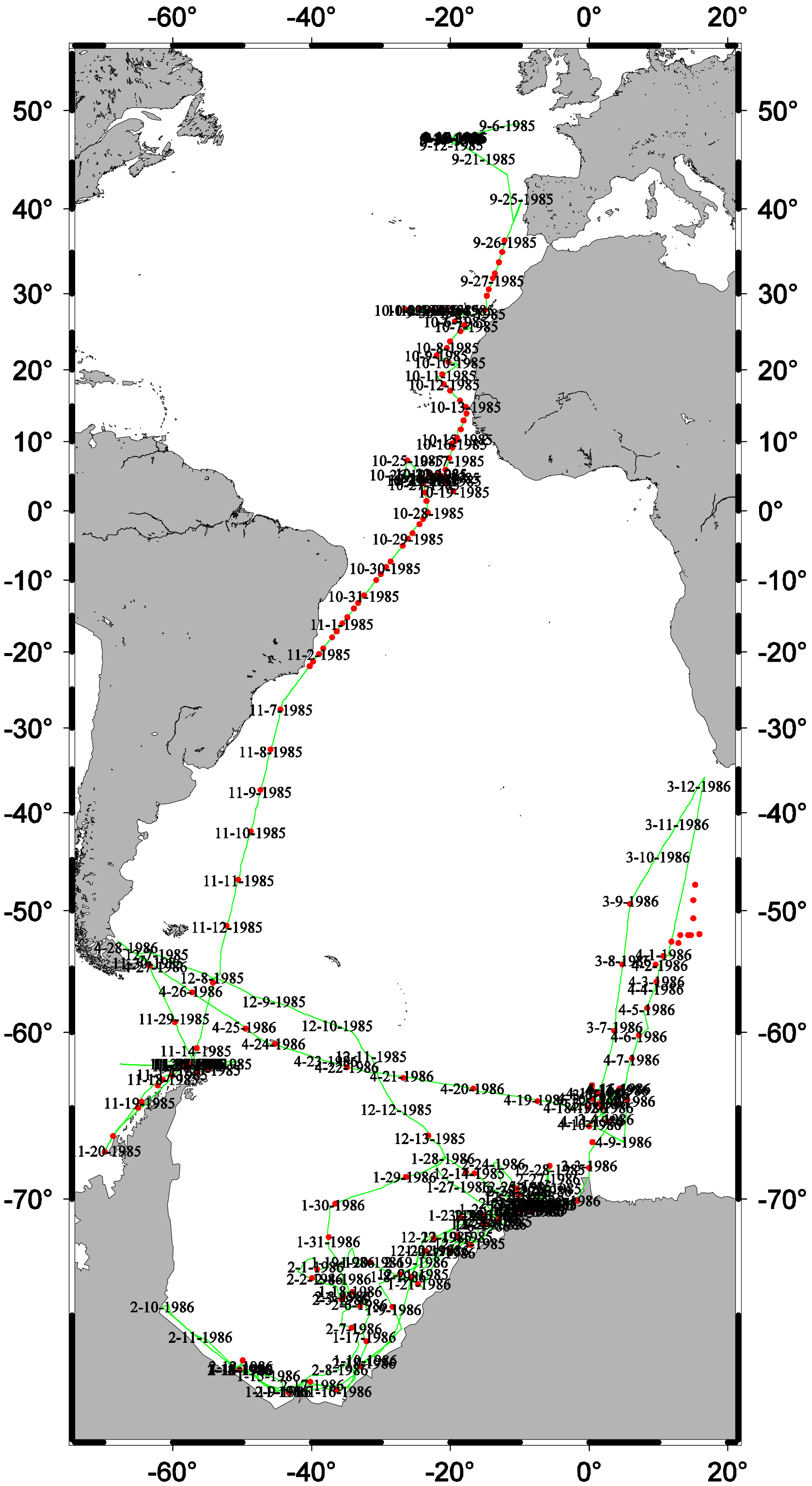

Fig. 9: Cruise track from ANT-IV based on the 3-hourly synoptic observations. Dots denote upper air soundings

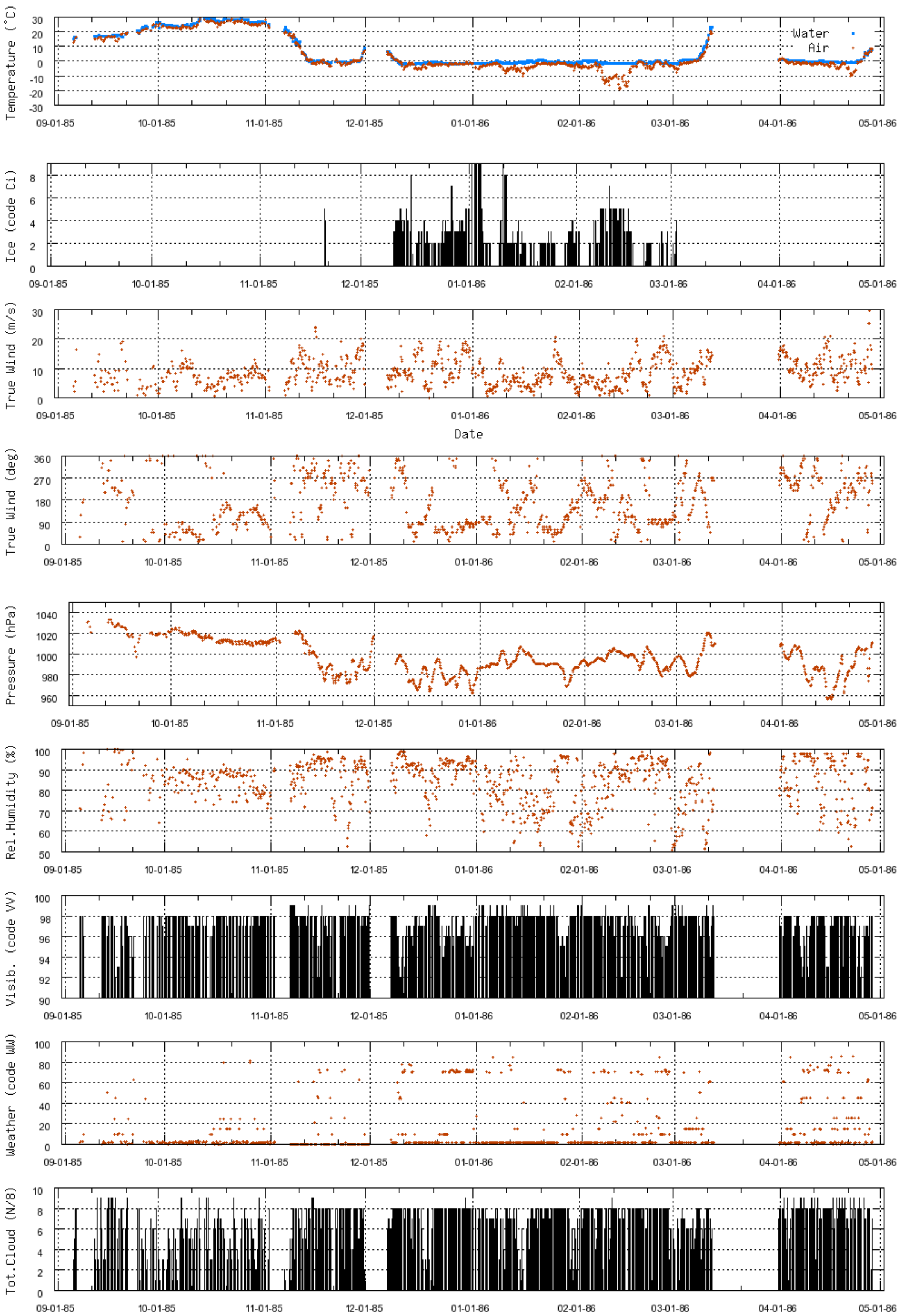

Fig. 10: Time series from ANT-IV based on the 3-hourly synoptic observations

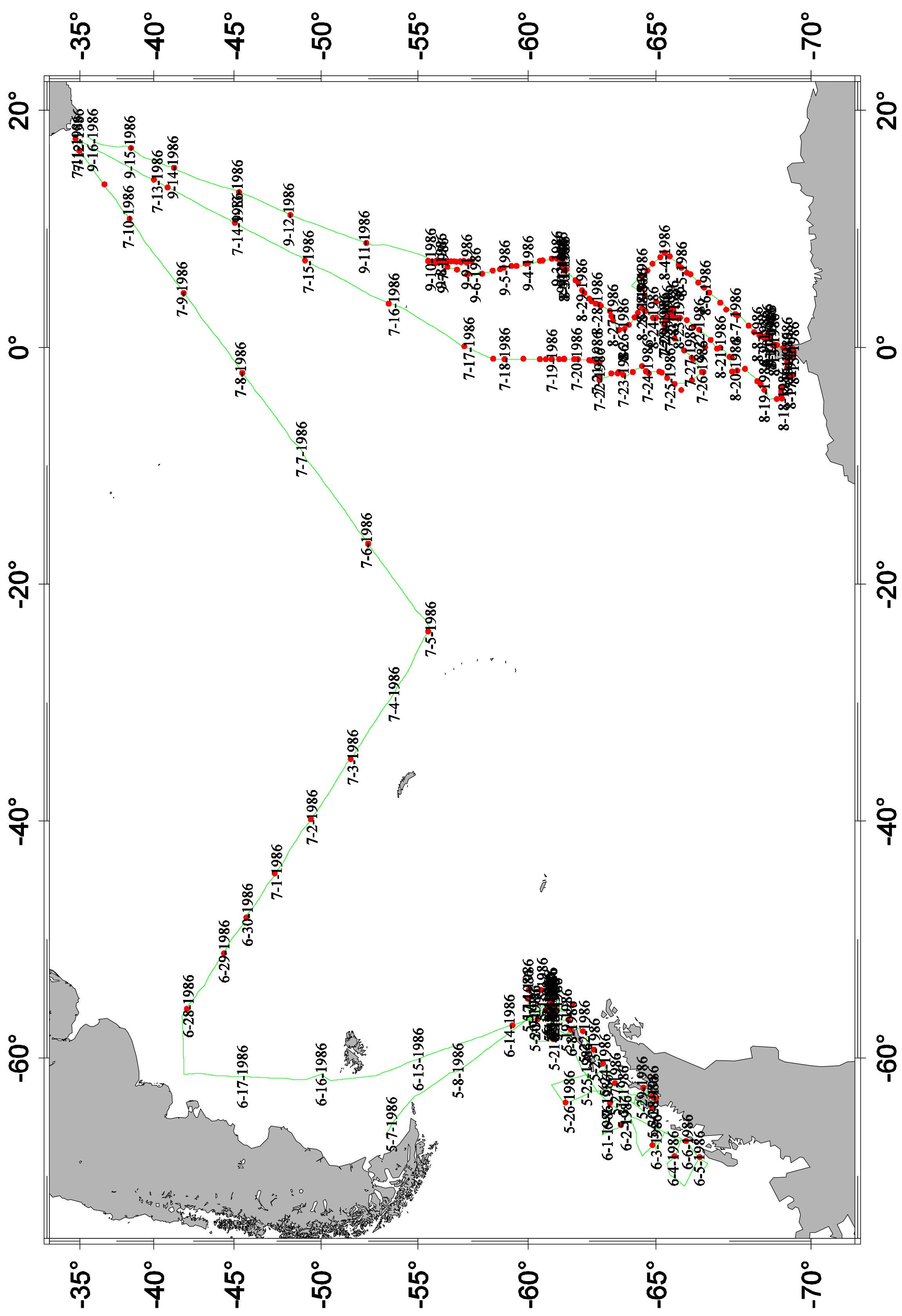

Fig. 11: Cruise track from ANT-V/1,2 based on the 3-hourly synoptic observations.
Dots denote upper air soundings

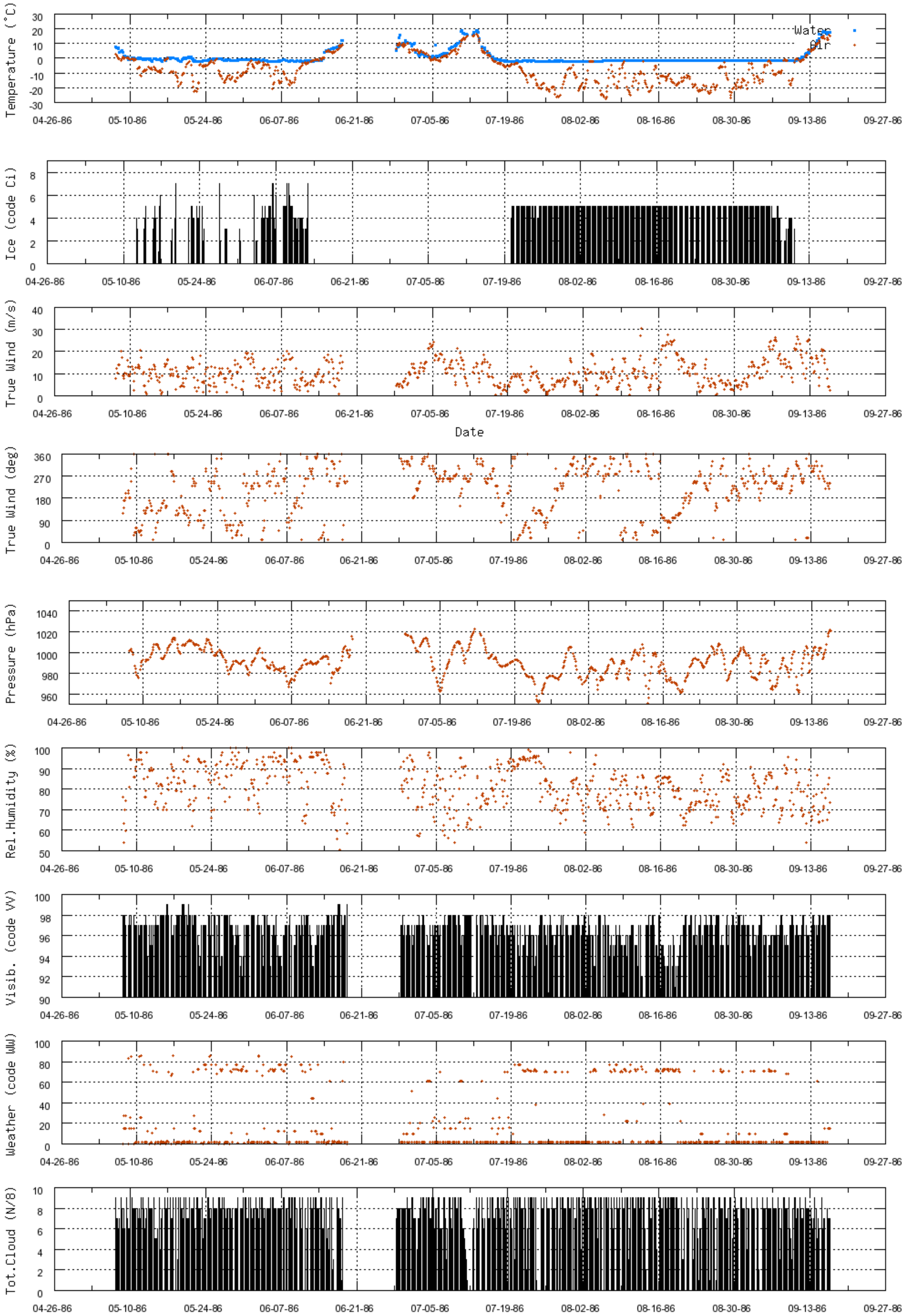

Fig. 12: Time series from ANT-V/1,2 based on the 3-hourly synoptic observations

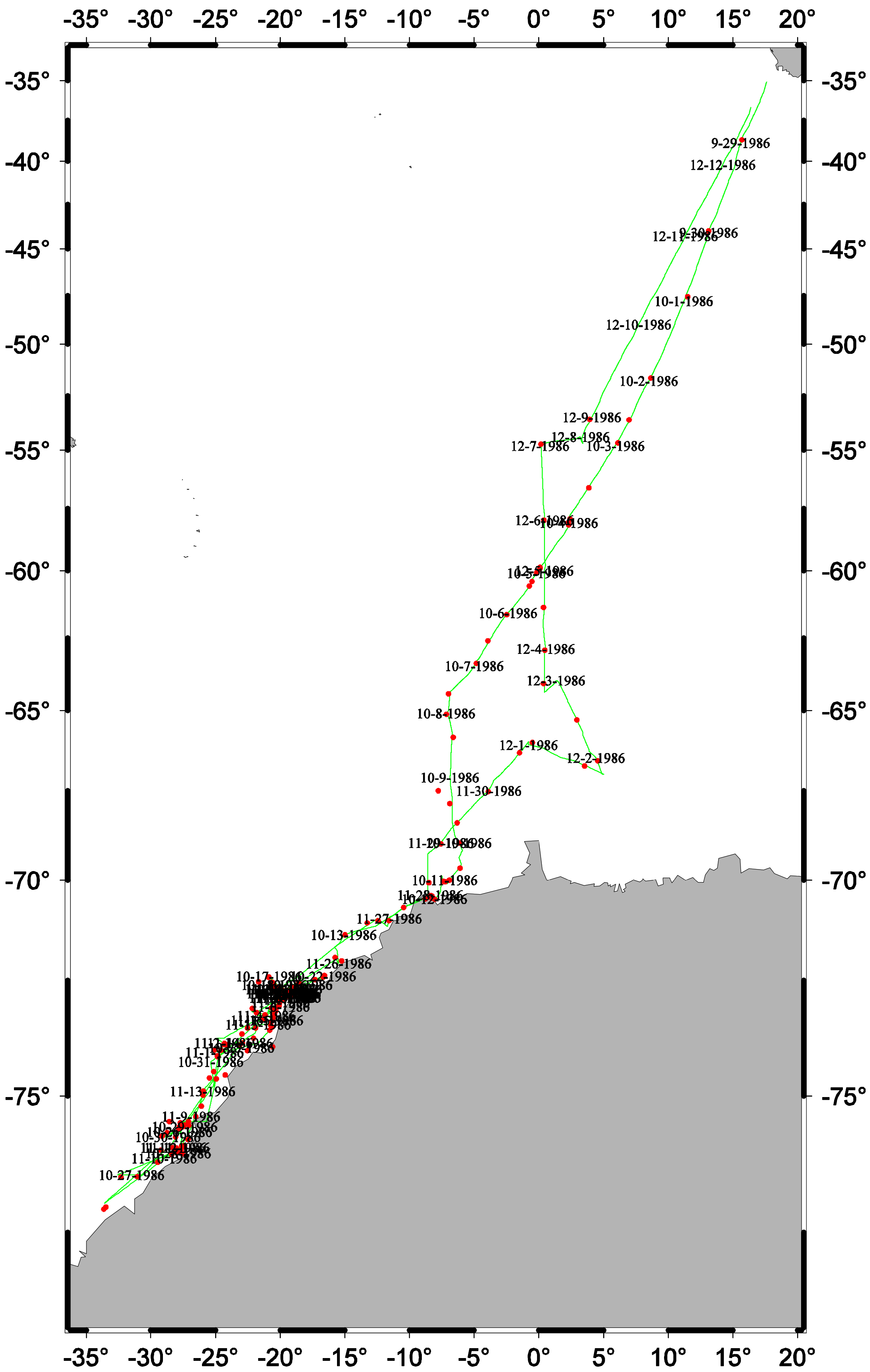

Fig. 13: Cruise track from ANT-V/3 based on the 3-hourly synoptic observations. Dots denote upper air soundings

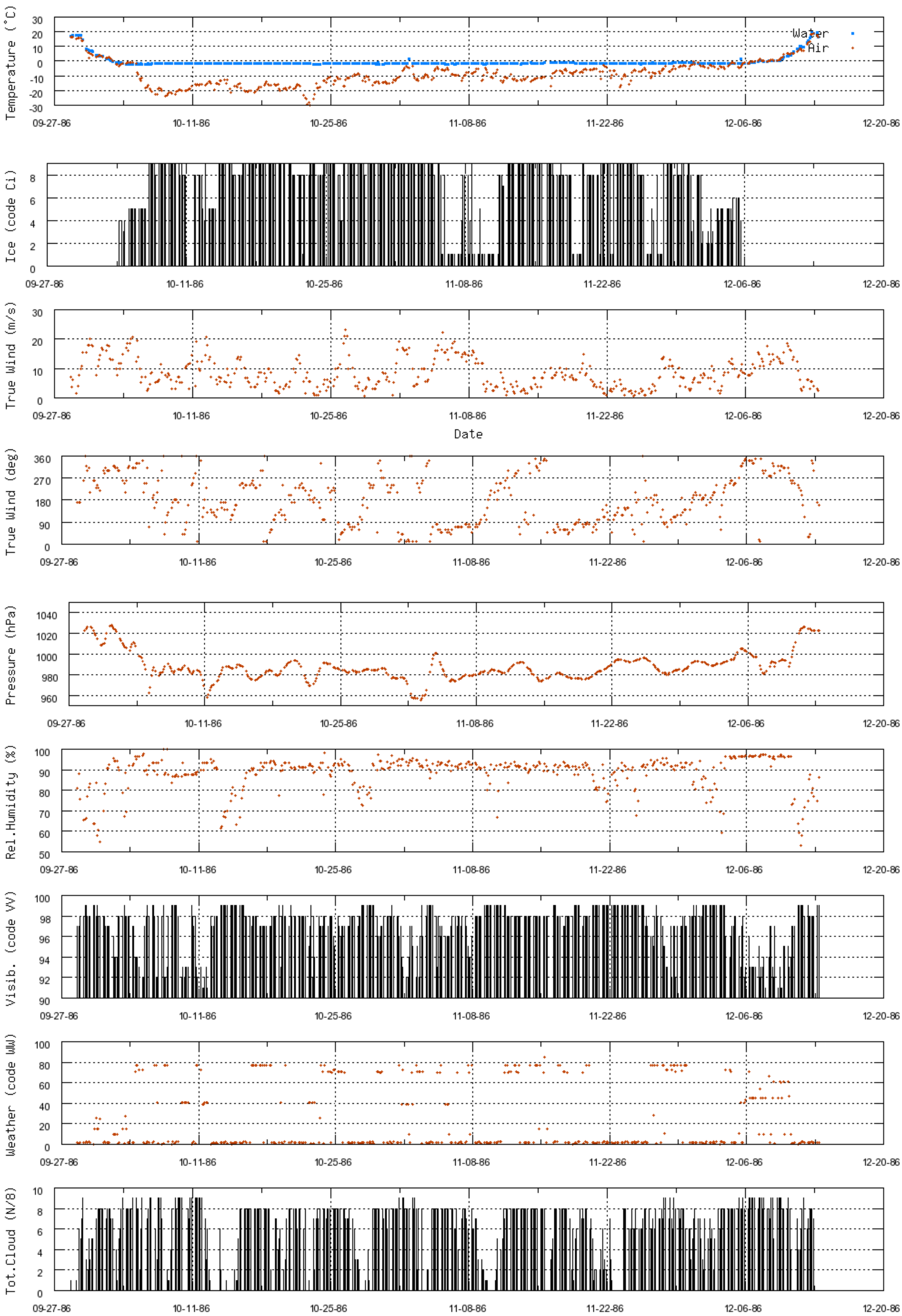

Fig. 14: Time series from ANT-V/3 based on the 3-hourly synoptic observations

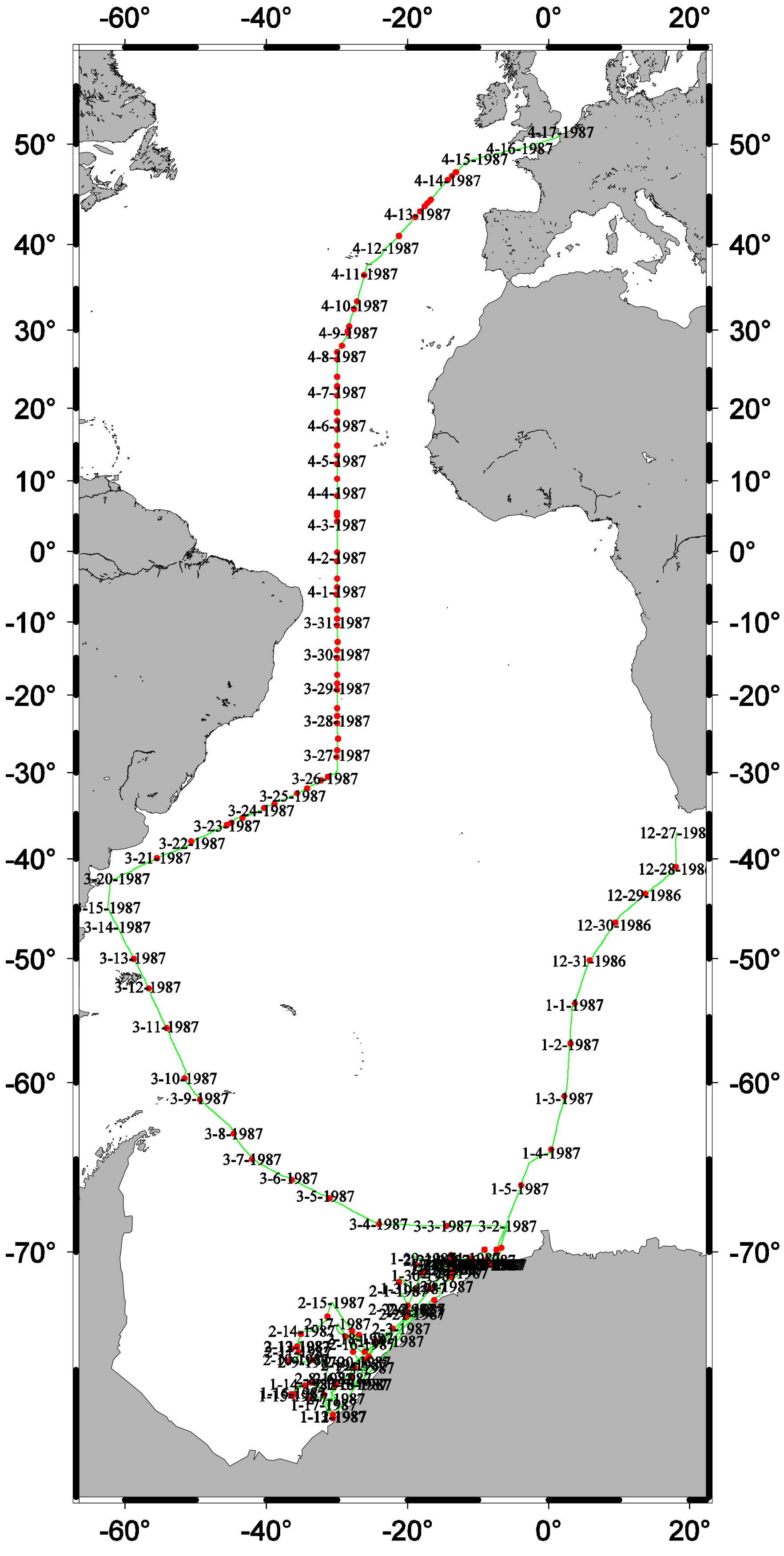

Fig. 15: Cruise track from ANT-V/4,5 based on the 3-hourly synoptic observations. Dots denote upper air soundings

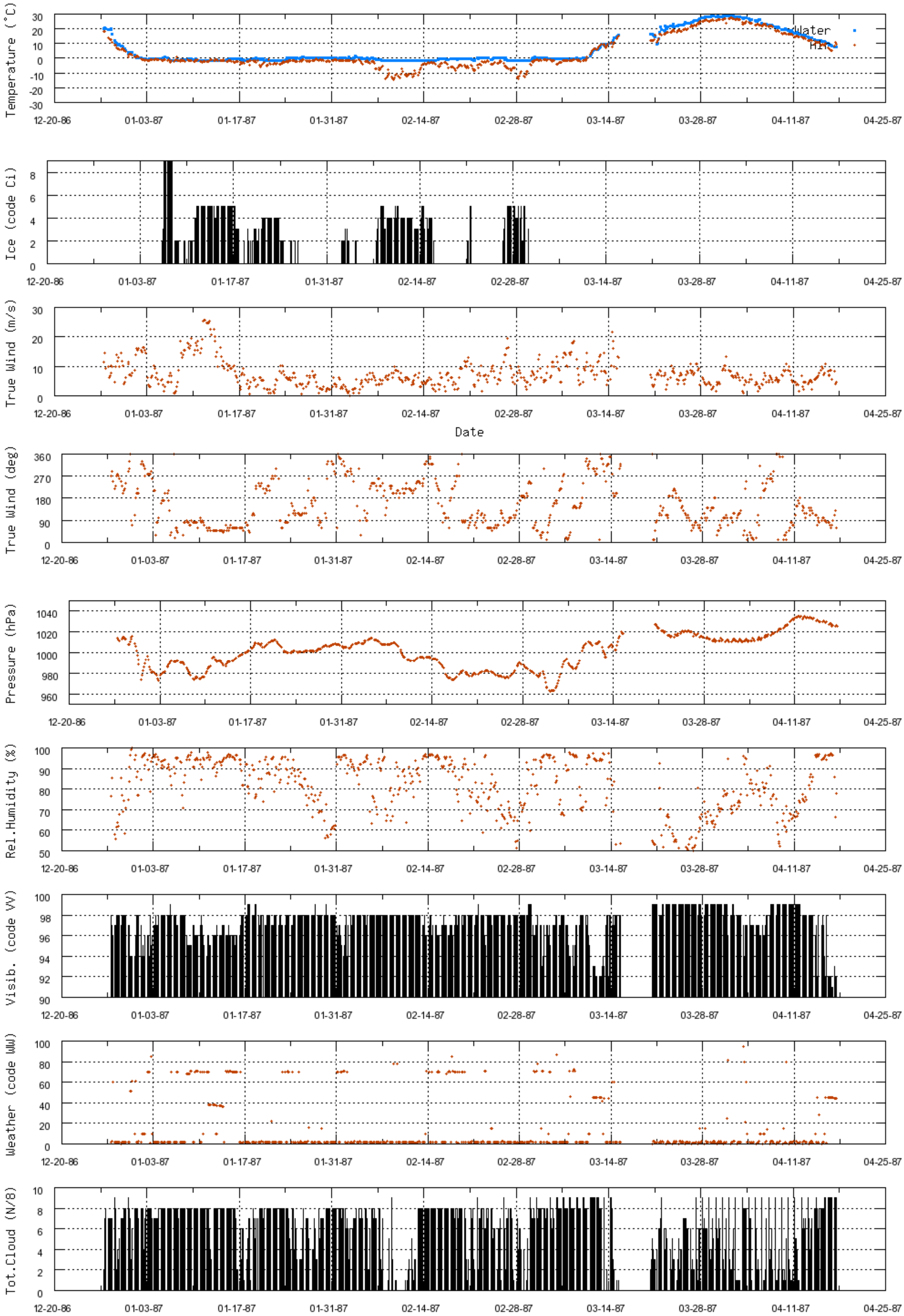

Fig. 16: Time series from ANT-V/4,5 based on the 3-hourly synoptic observations

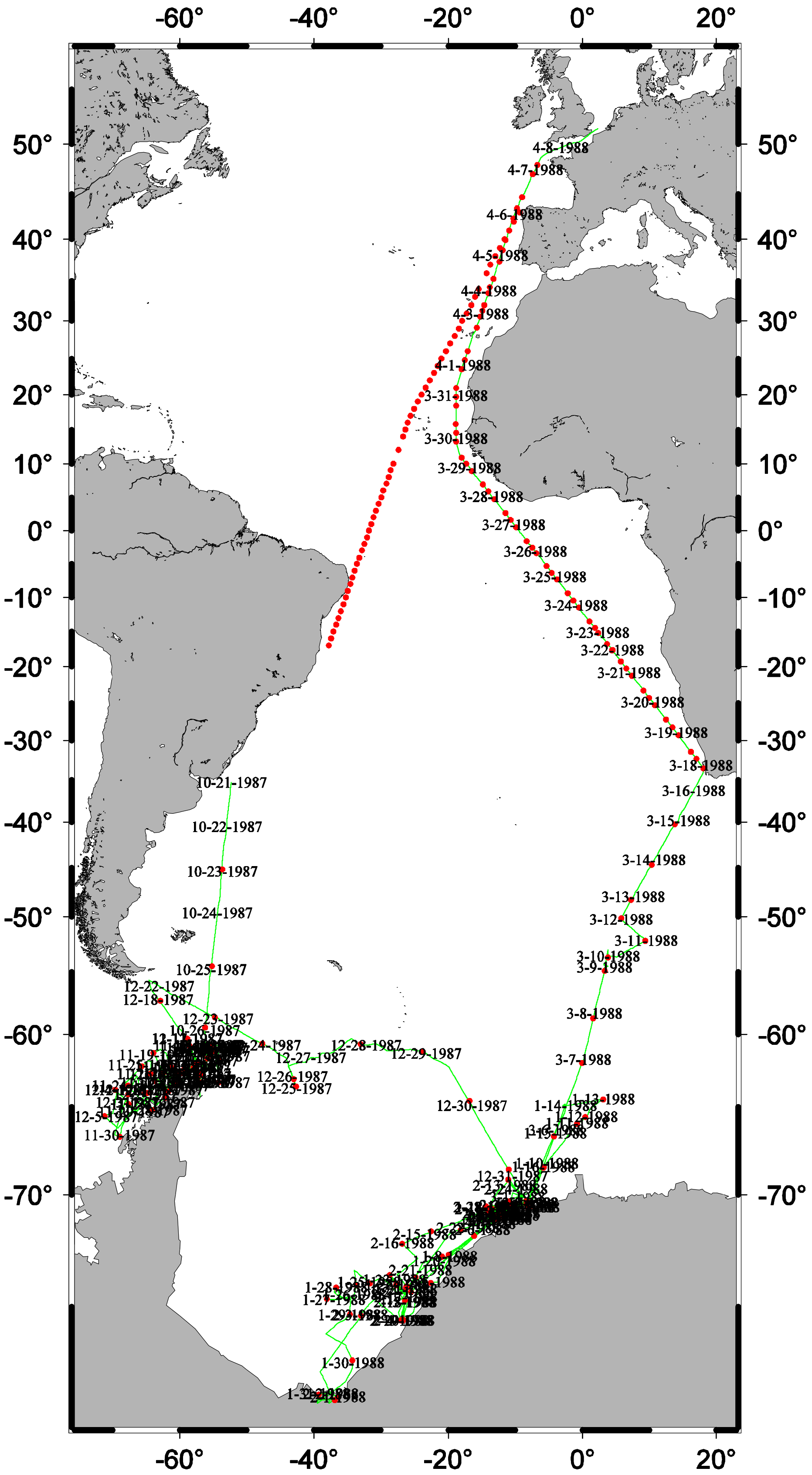

Fig. 17: Cruise track from ANT-VI based on the 3-hourly synoptic observations.
Dots denote upper air soundings

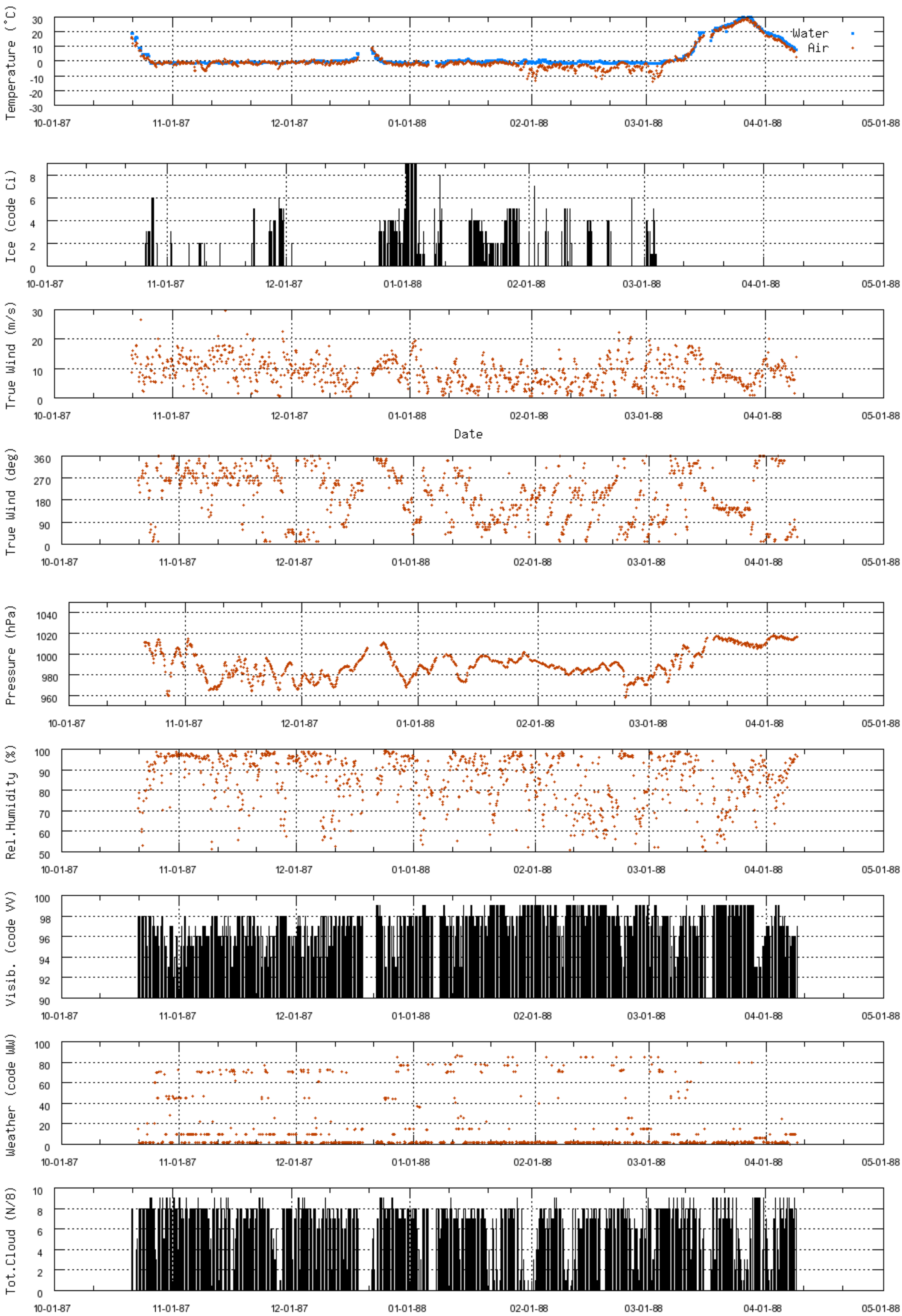

Fig. 18: Time series from ANT-VI based on the 3-hourly synoptic observations

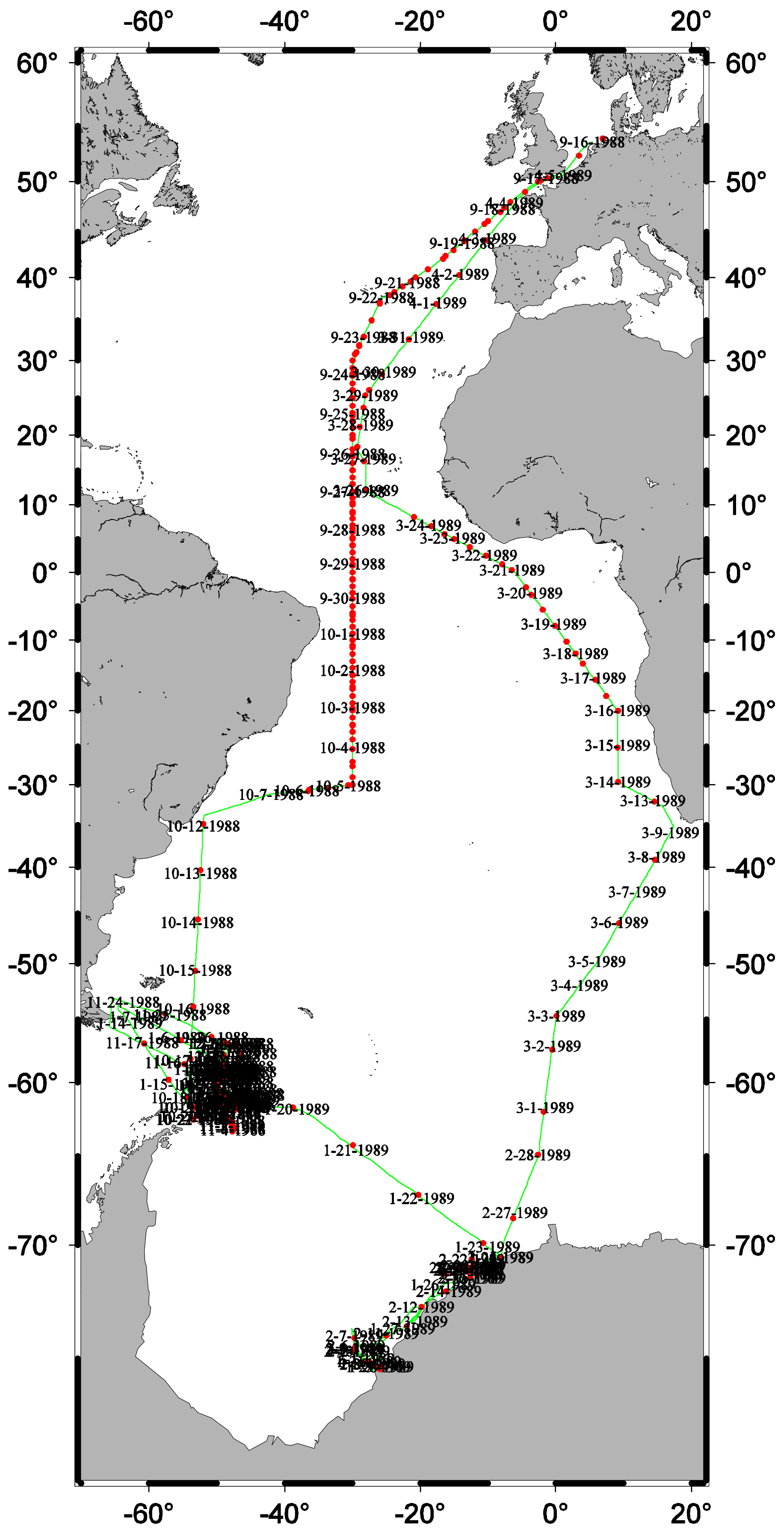

Fig. 19: Cruise track from ANT-VII based on the 3-hourly synoptic observations. Dots denote upper air soundings

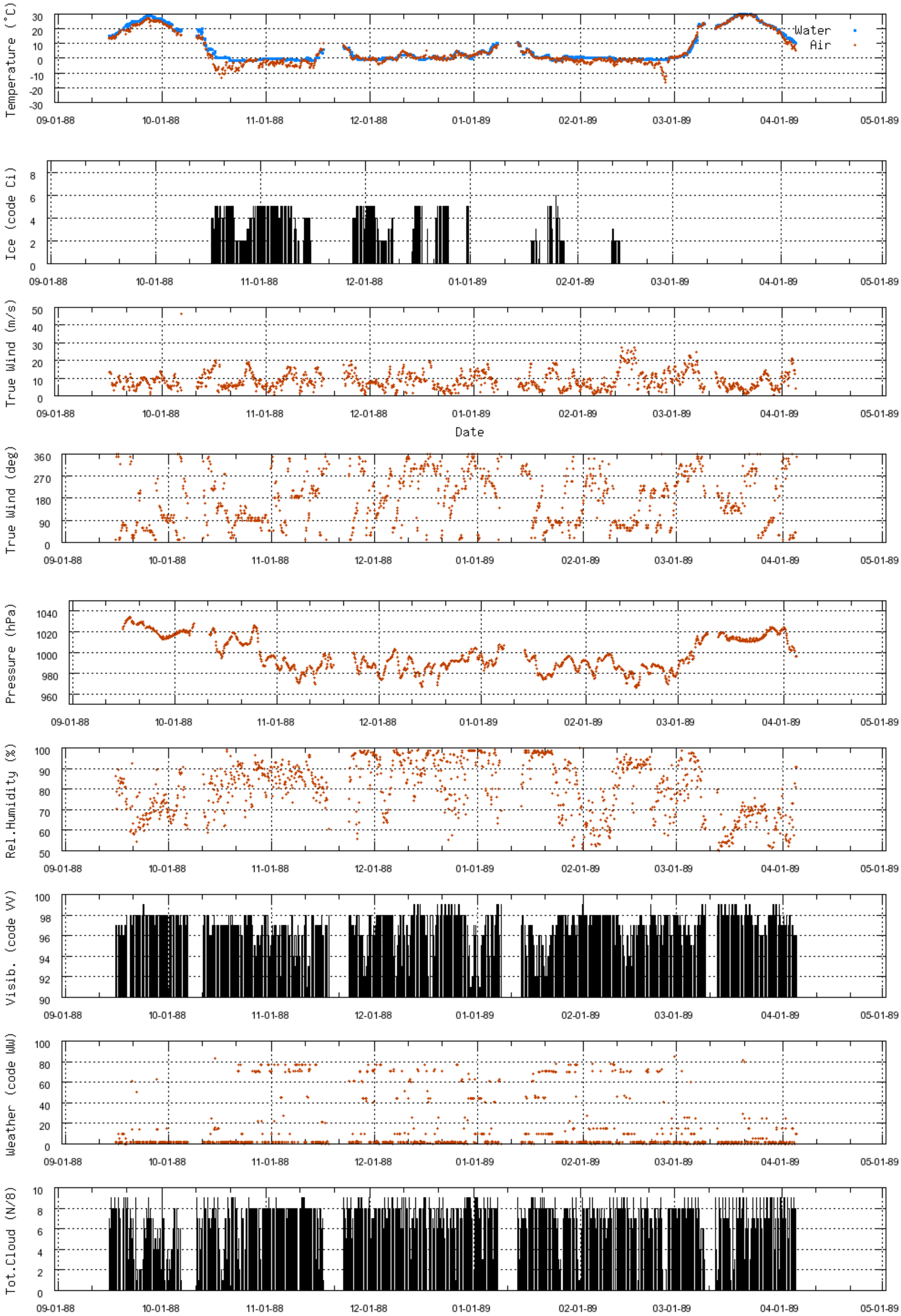

Fig. 20: Time series from ANT-VII based on the 3-hourly synoptic observations

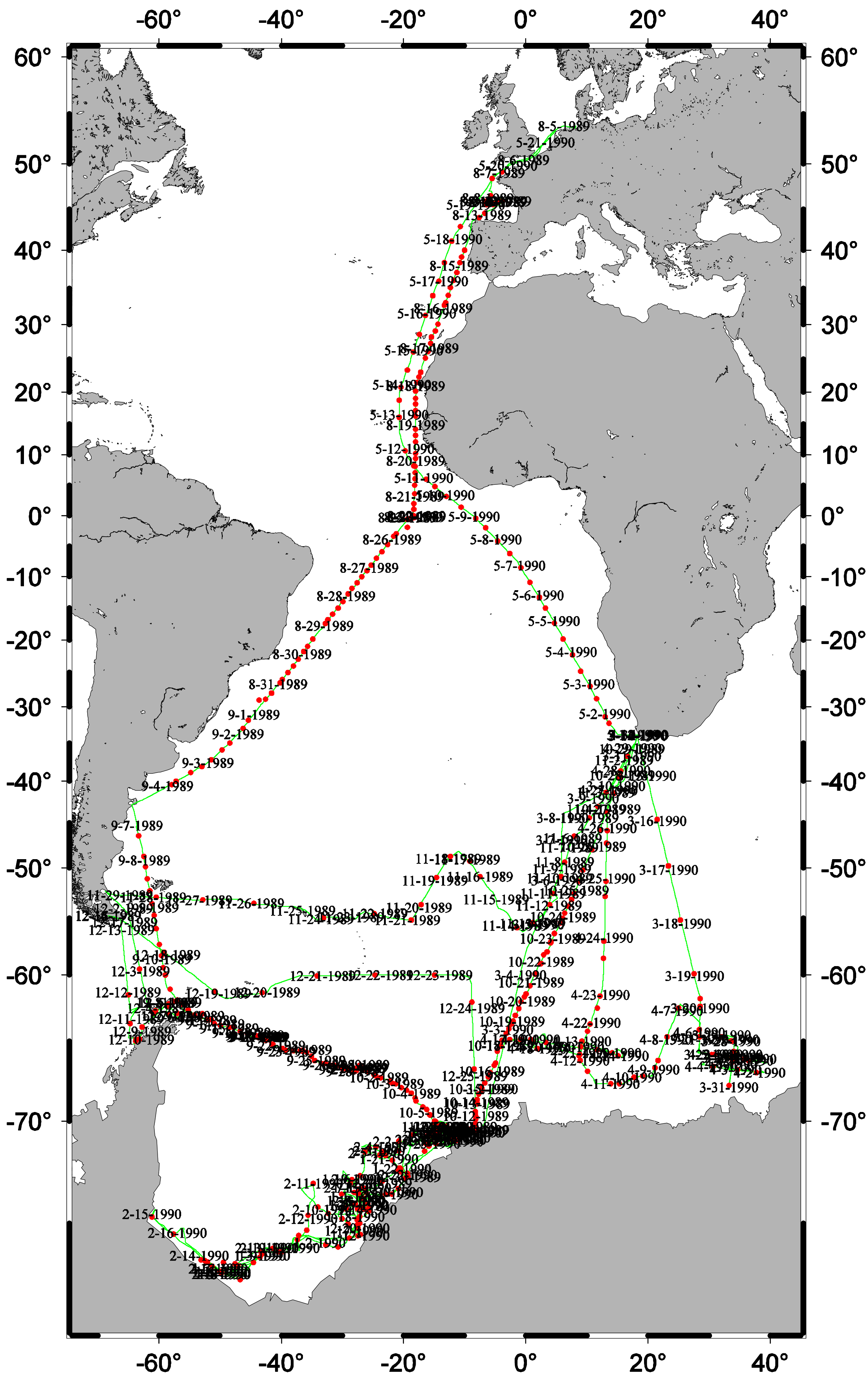

Fig. 21: Cruise track from ANT-VIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

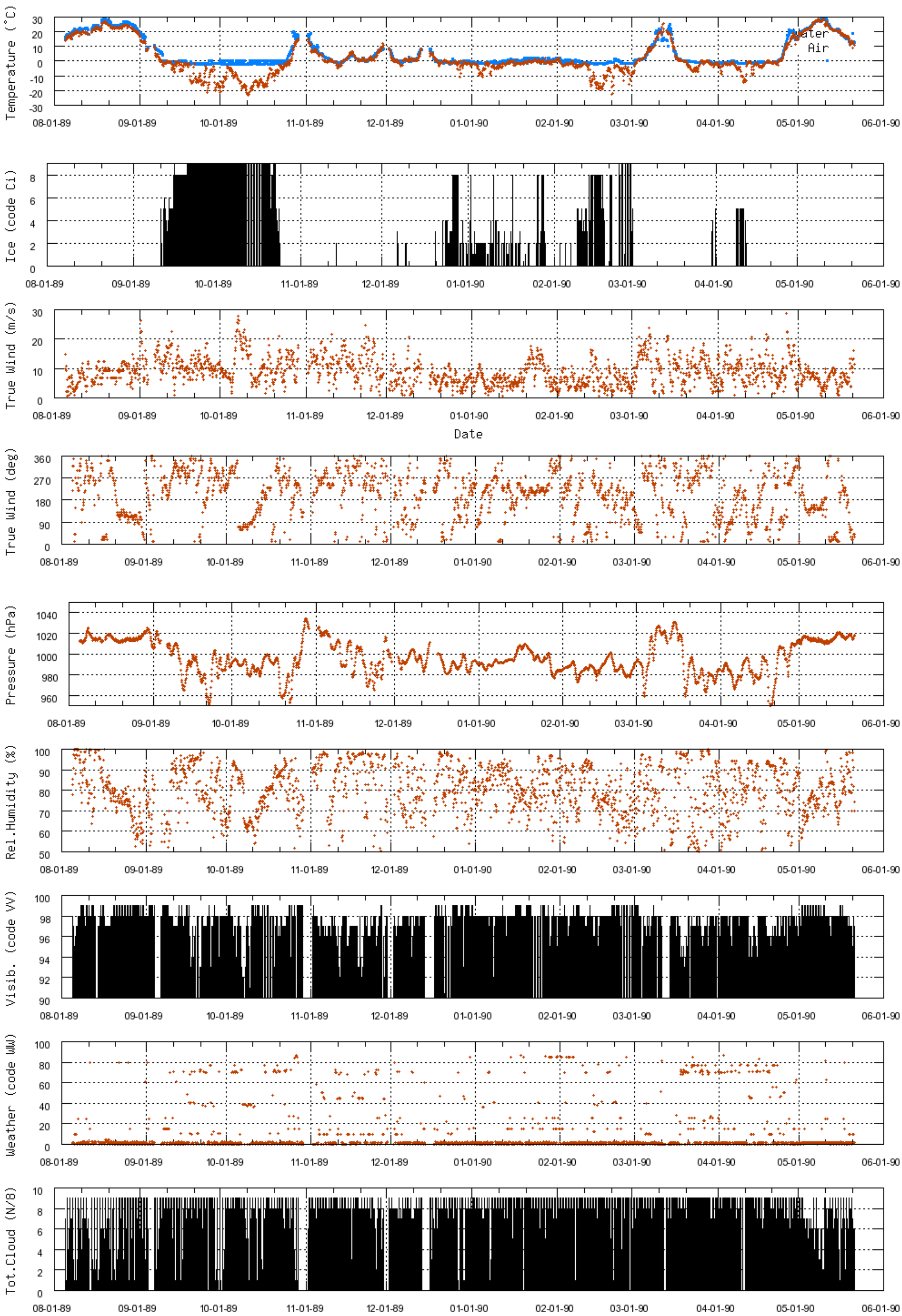

Fig. 22: Time series from ANT-VIII based on the 3-hourly synoptic observations

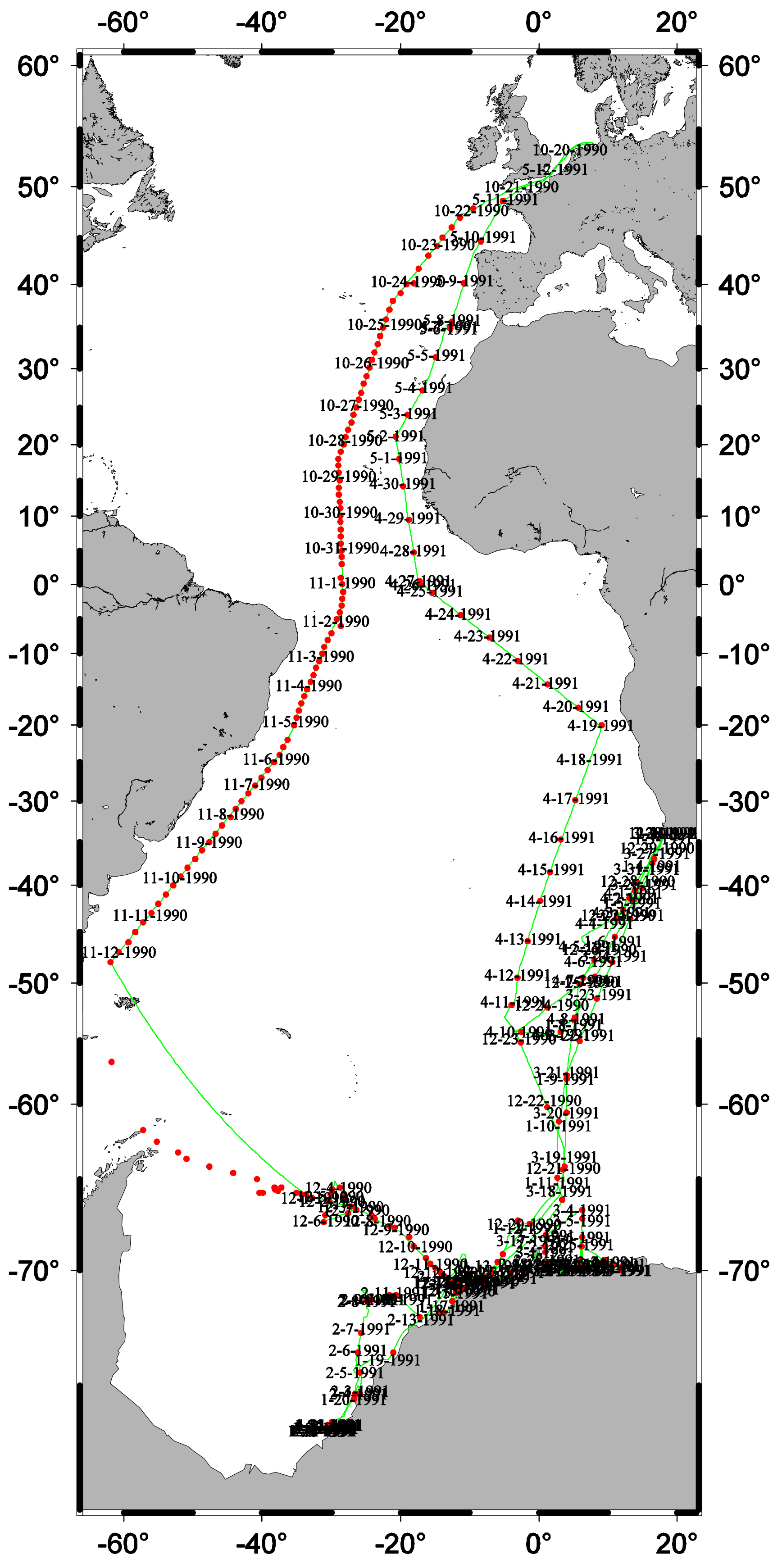

Fig. 23: Cruise track from ANT-IX based on the 3-hourly synoptic observations.
Dots denote upper air soundings

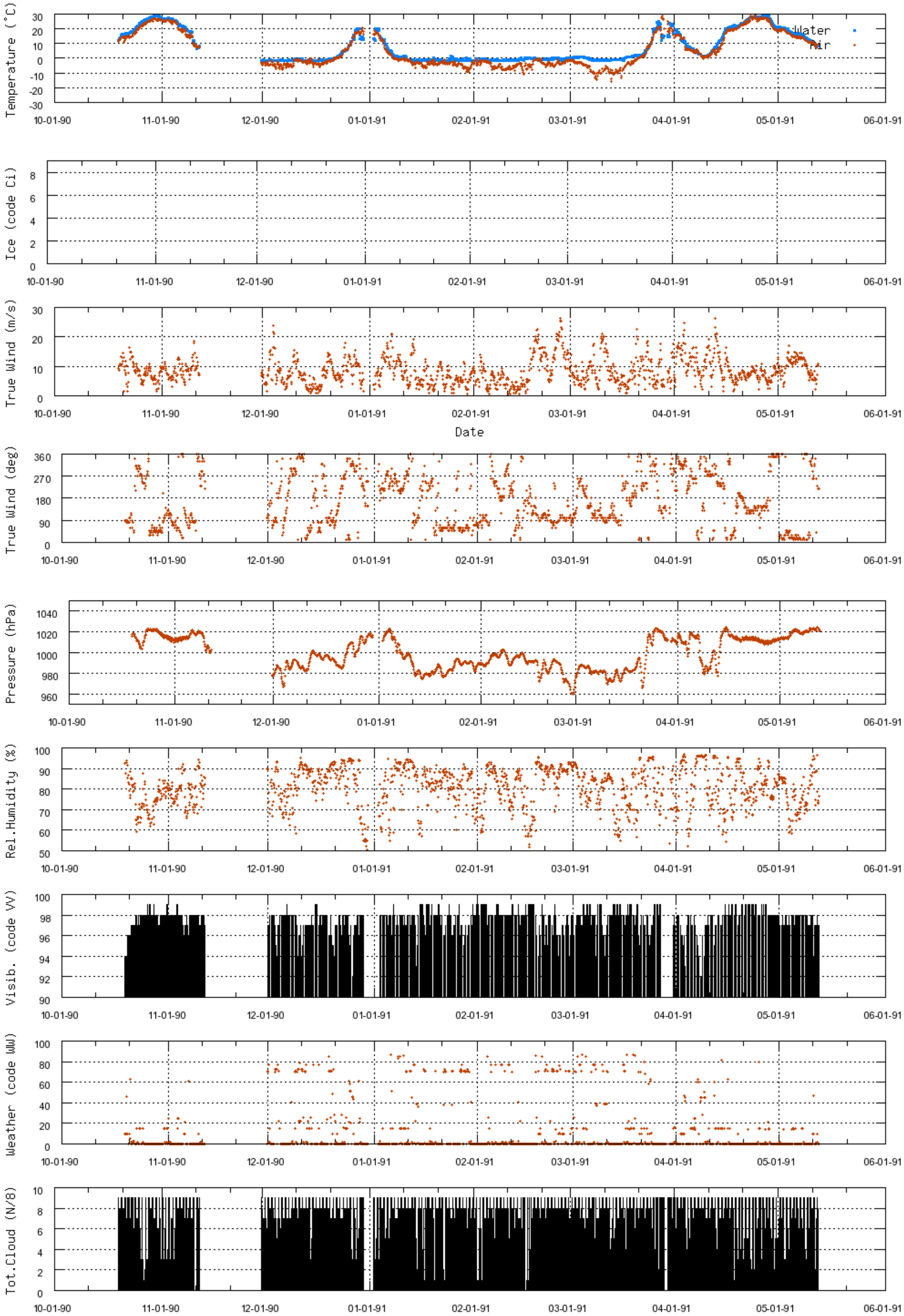

Fig. 24: Time series from ANT-IX based on the 3-hourly synoptic observations

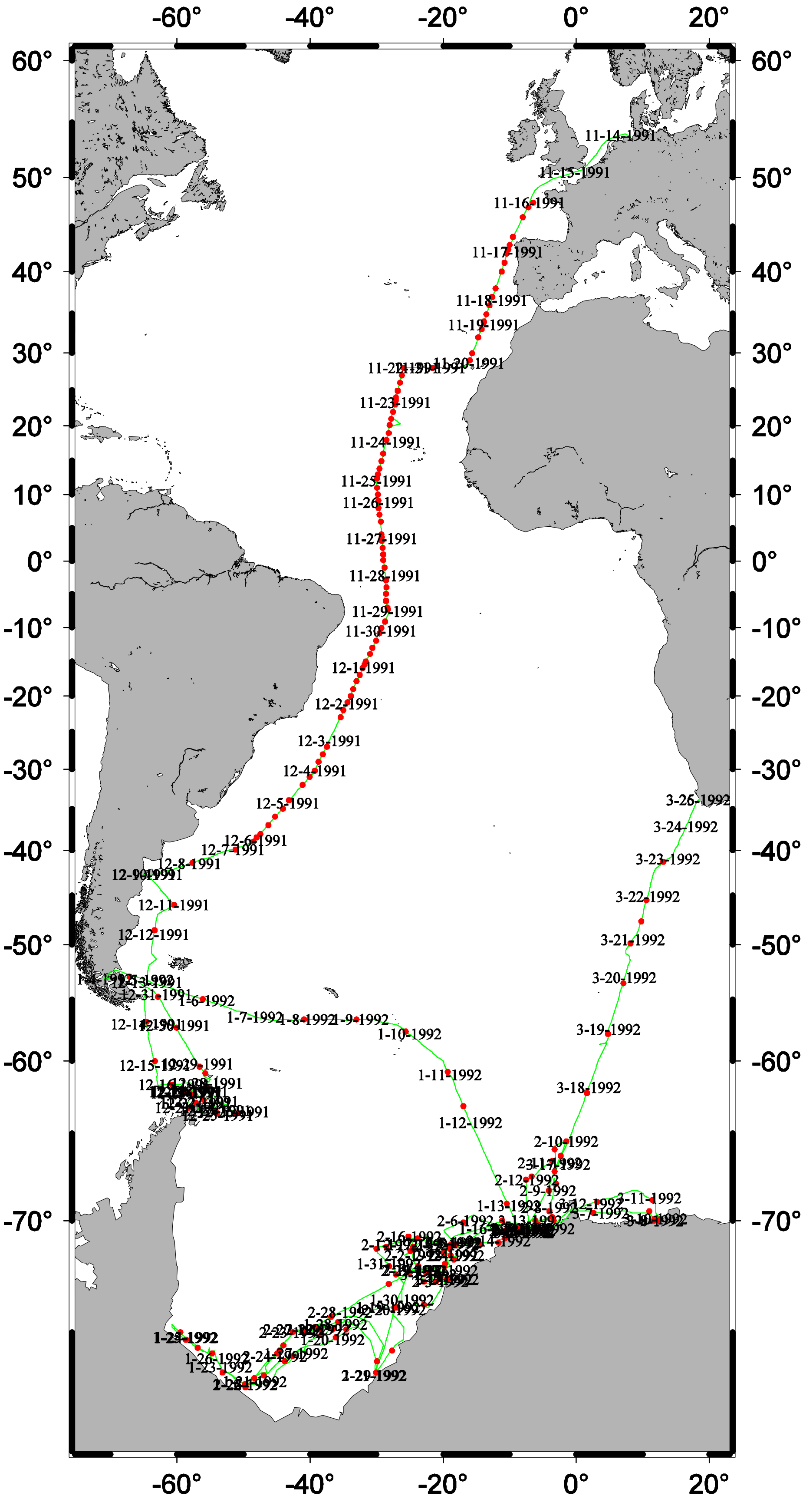

Fig. 25: Cruise track from ANT-X/1,2 based on the 3-hourly synoptic observations. Dots denote upper air soundings

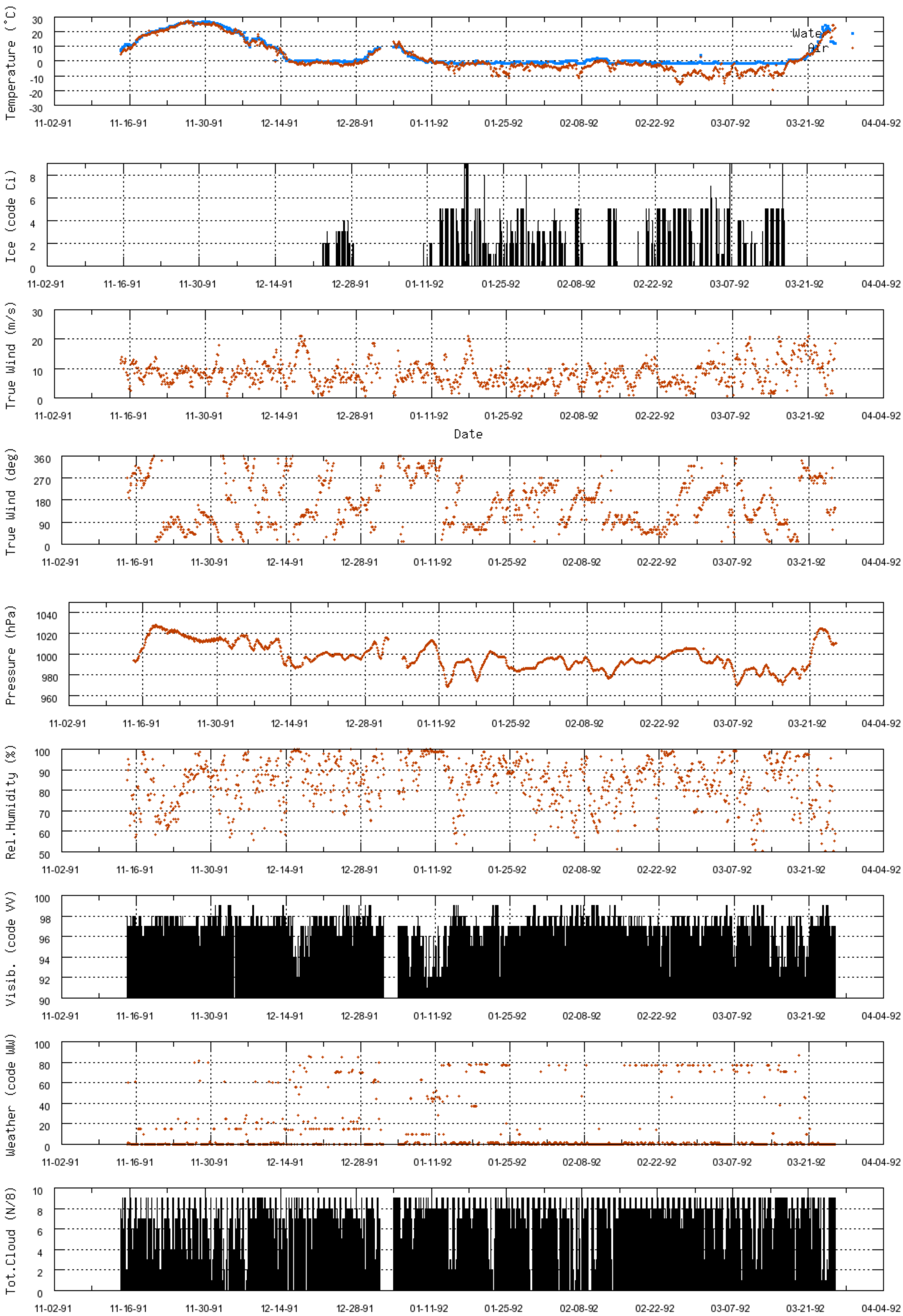

Fig. 26: Time series from ANT-X/1,2 based on the 3-hourly synoptic observations

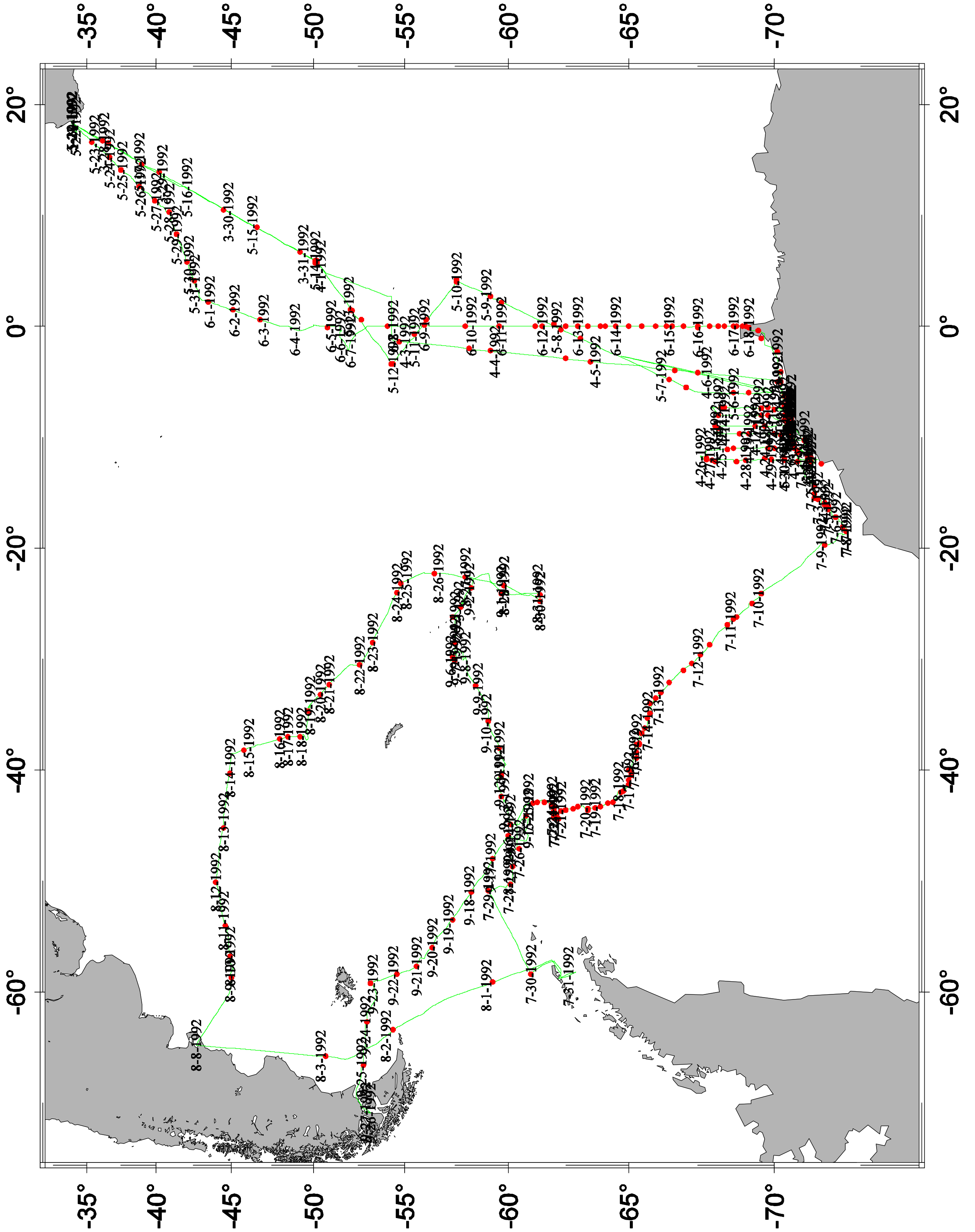

Fig. 27: Cruise track from ANT-X/3,4,5 based on the 3-hourly synoptic observations.
Dots denote upper air soundings

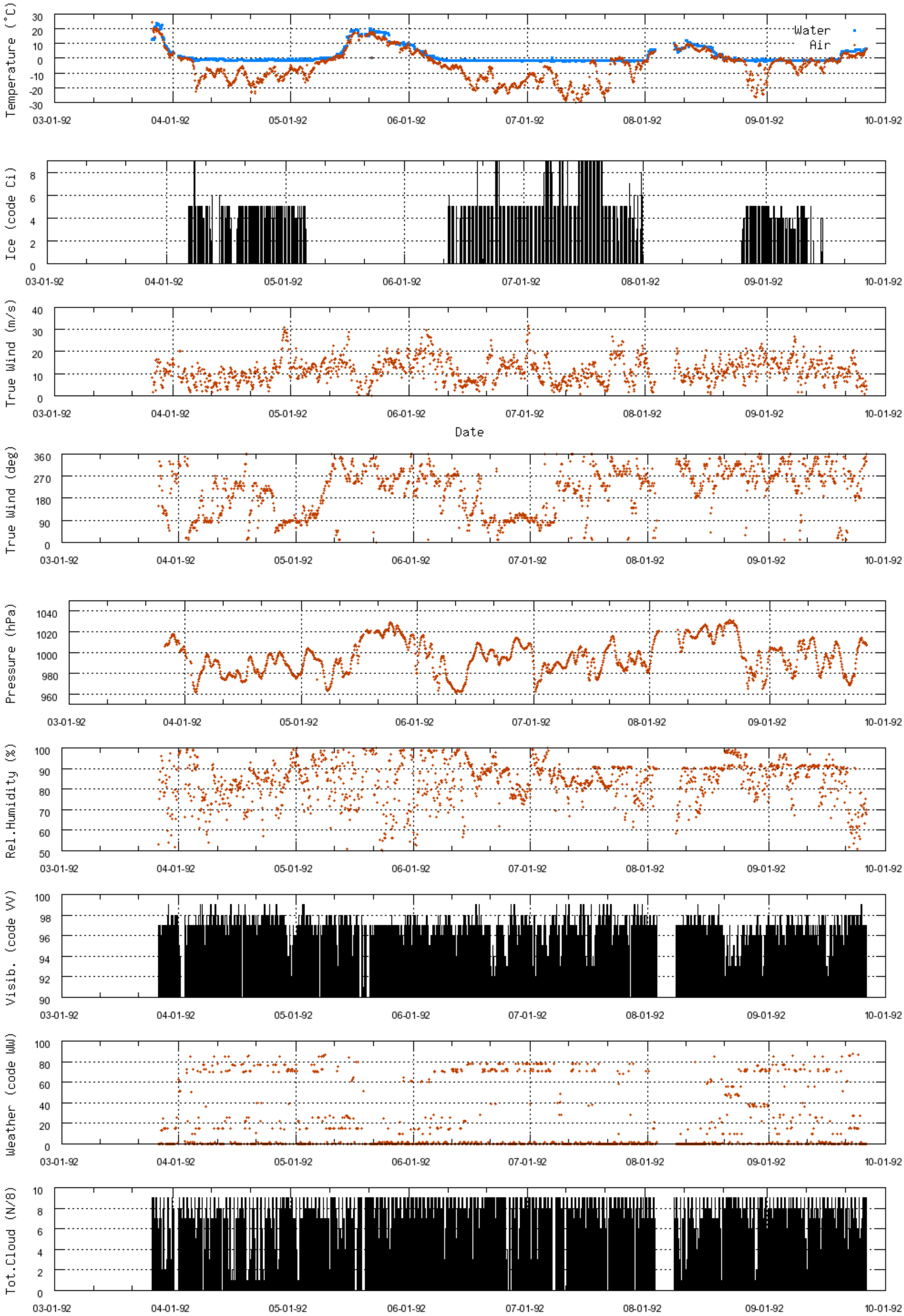

Fig. 28: Time series from ANT-ANT-X/3,4,5 based on the 3-hourly synoptic observations

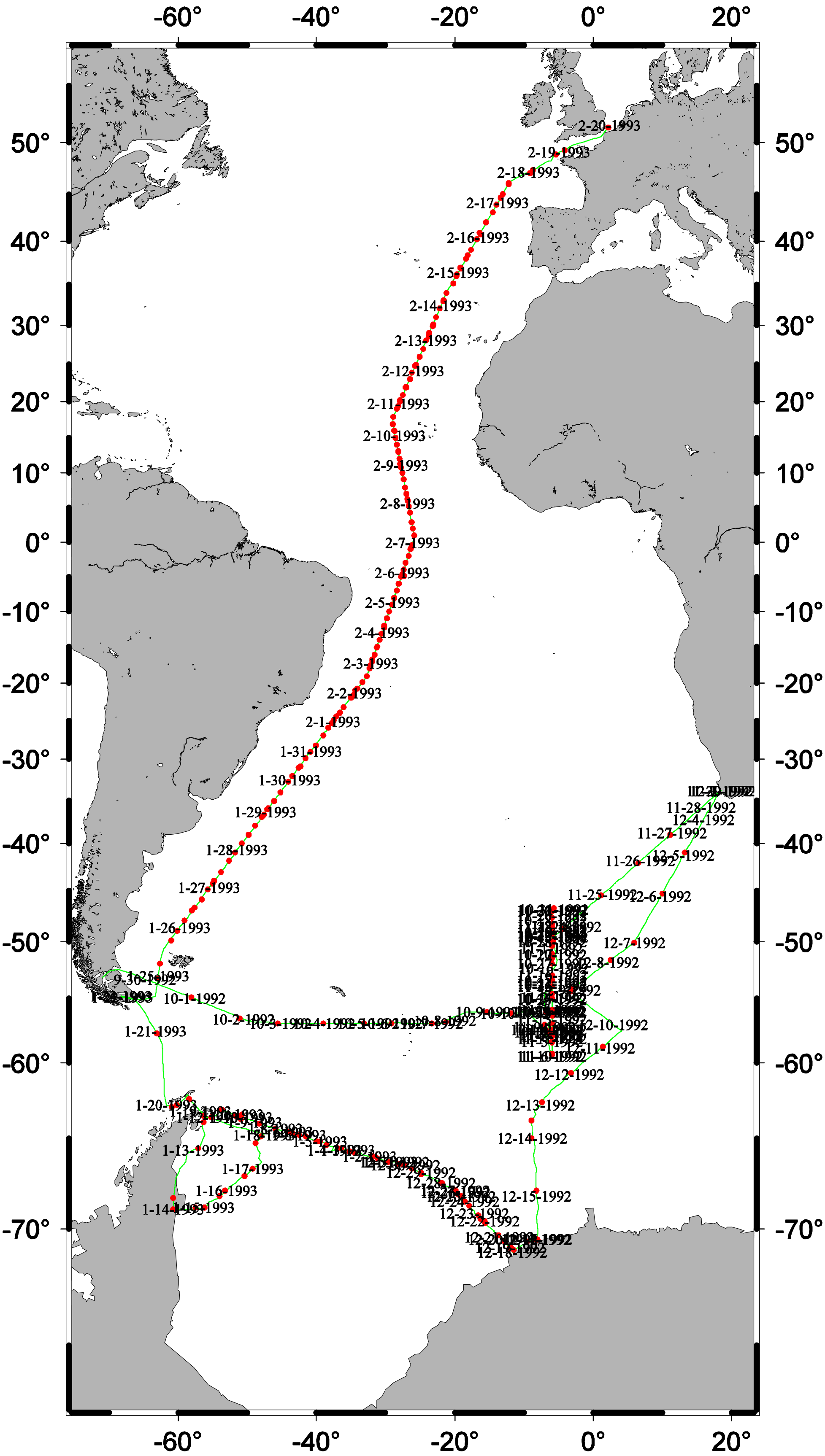

Fig. 29: Cruise track from ANT-X/6,7,8 based on the 3-hourly synoptic observations. Dots denote upper air soundings

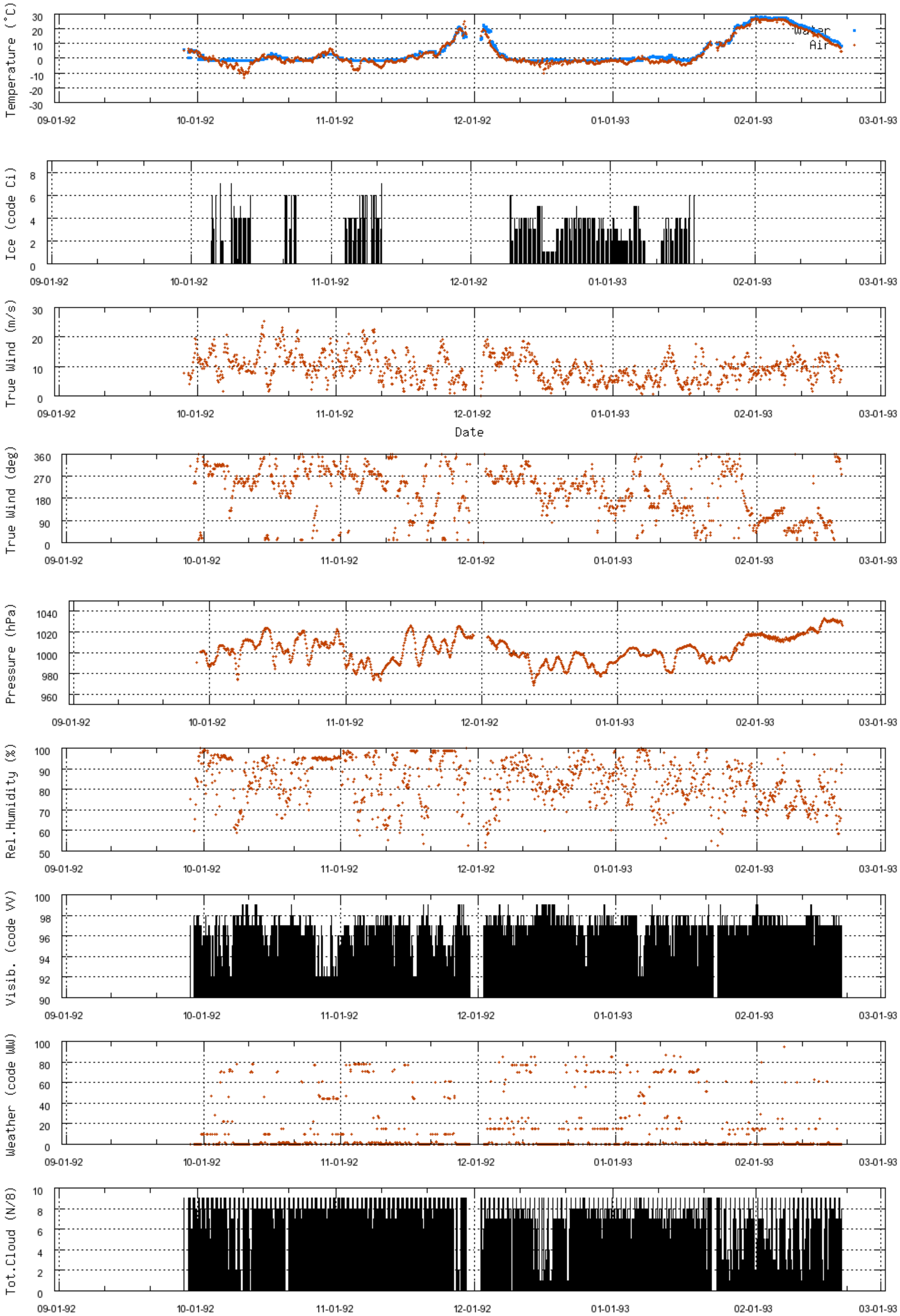

Fig. 30: Time series from ANT-ANT-X/6,7,8 based on the 3-hourly synoptic observations

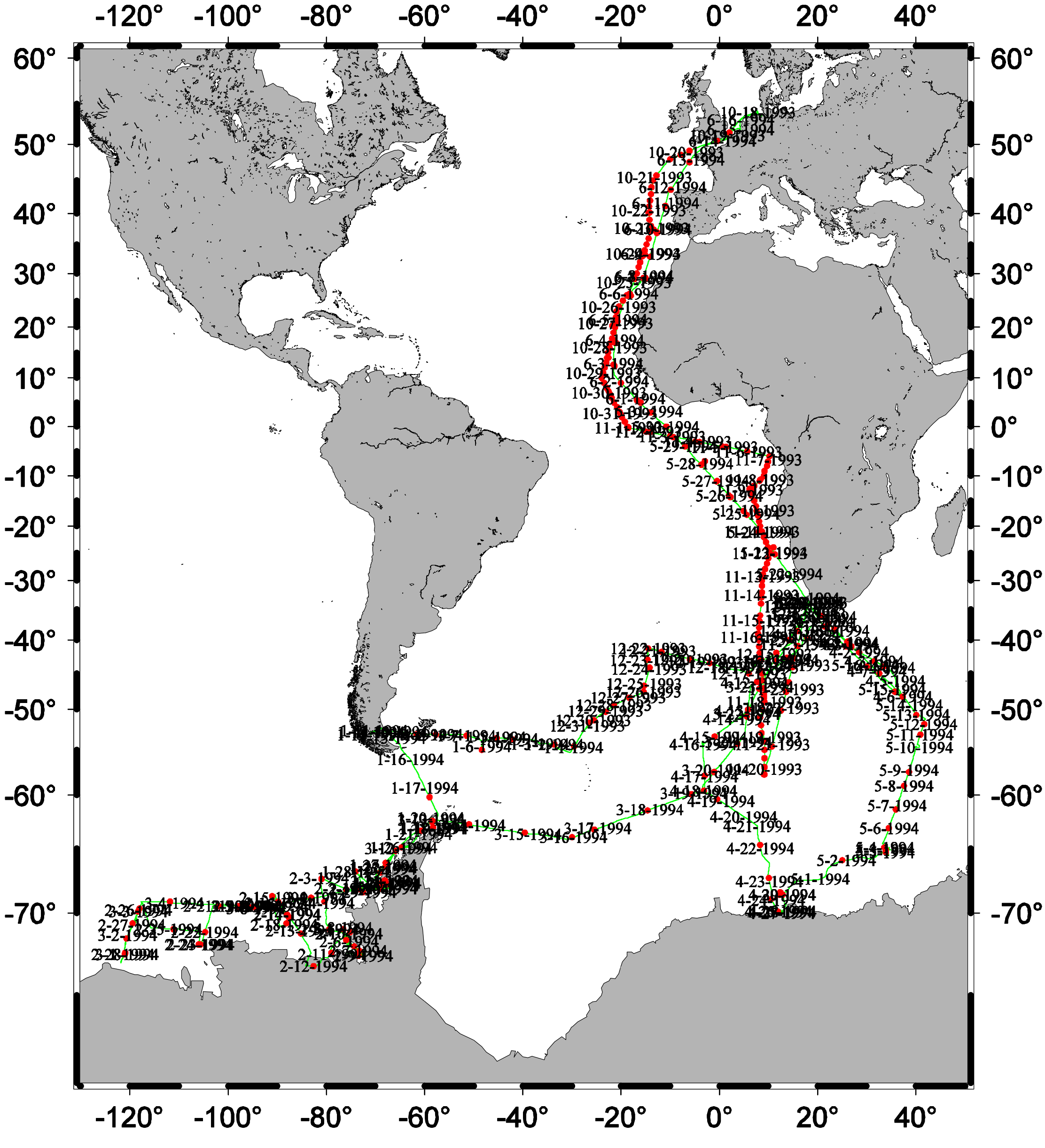

Fig. 31: Cruise track from ANT-XI based on the 3-hourly synoptic observations.
Dots denote upper air soundings

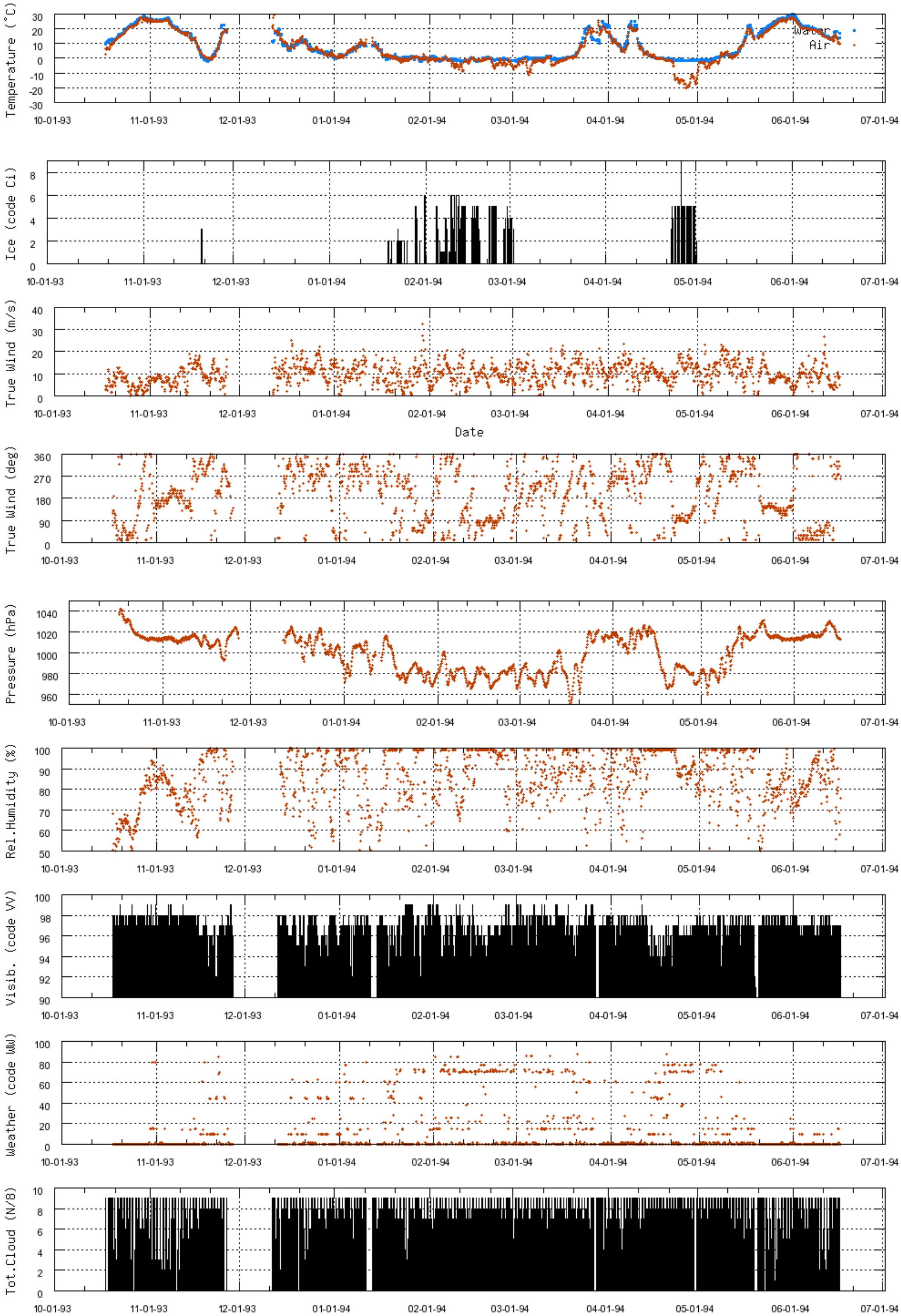

Fig. 32: Time series from ANT-XI based on the 3-hourly synoptic observations

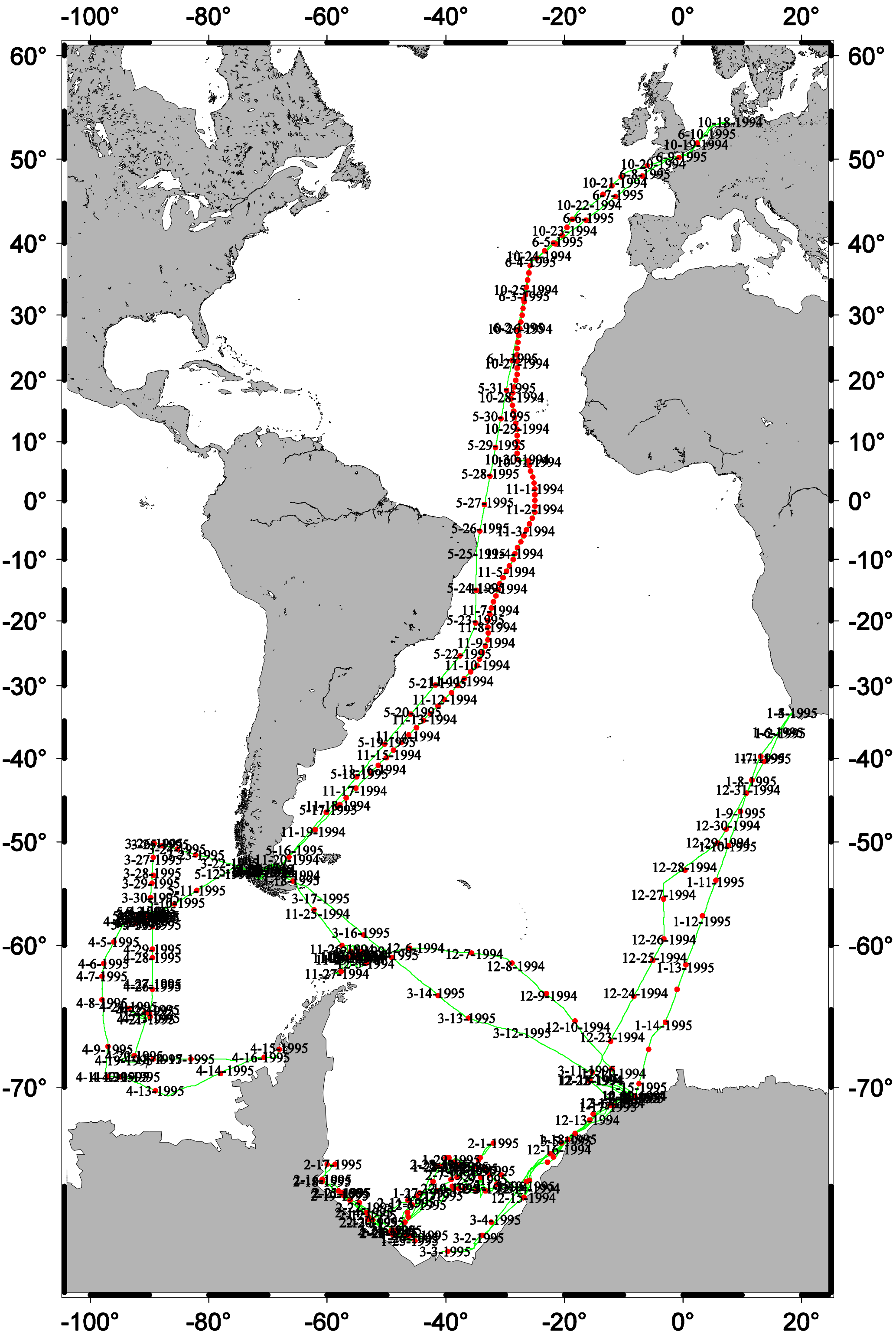

Fig. 33: Cruise track from ANT-XII based on the 3-hourly synoptic observations.
Dots denote upper air soundings

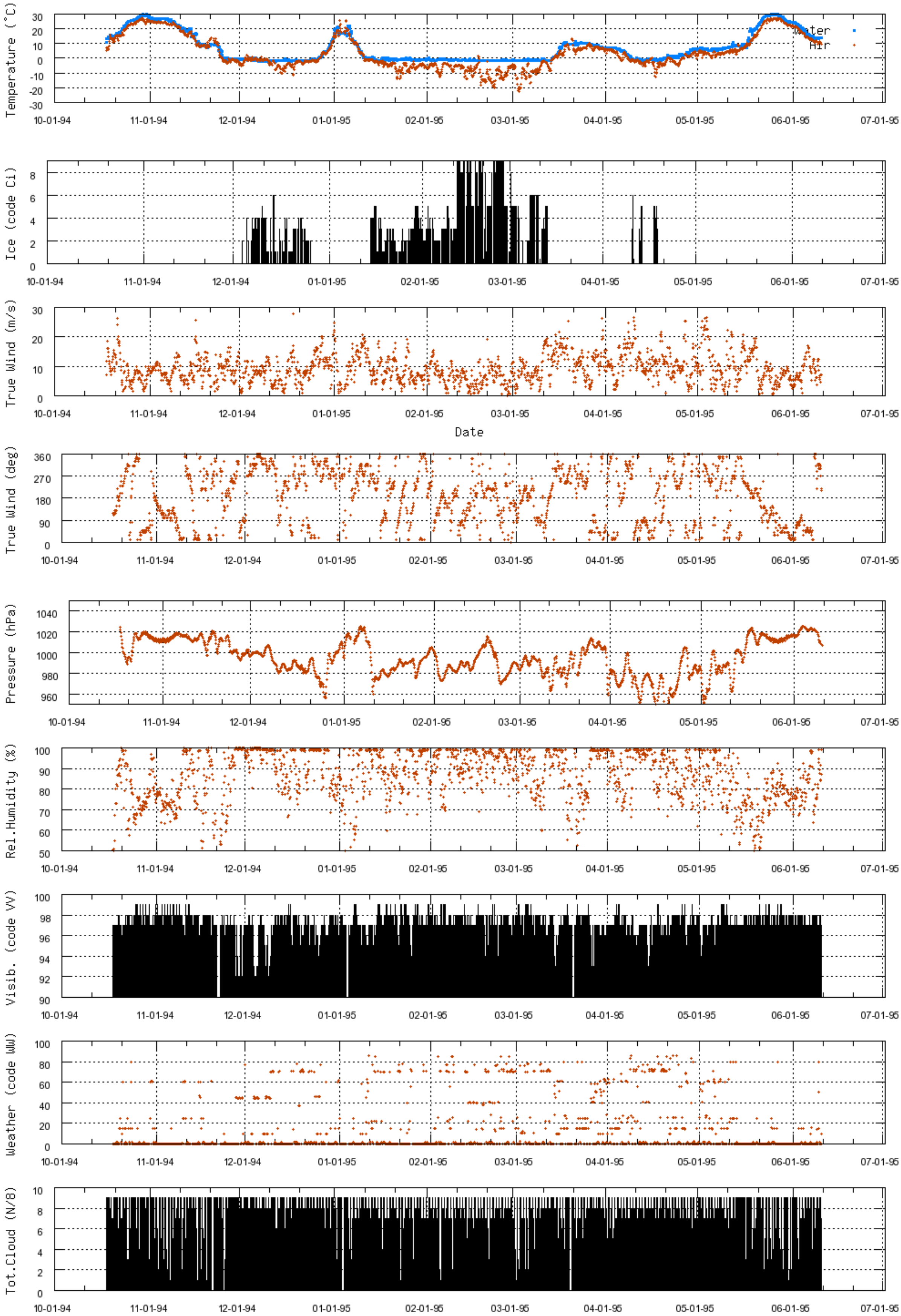

Fig. 34: Time series from ANT-XII based on the 3-hourly synoptic observations

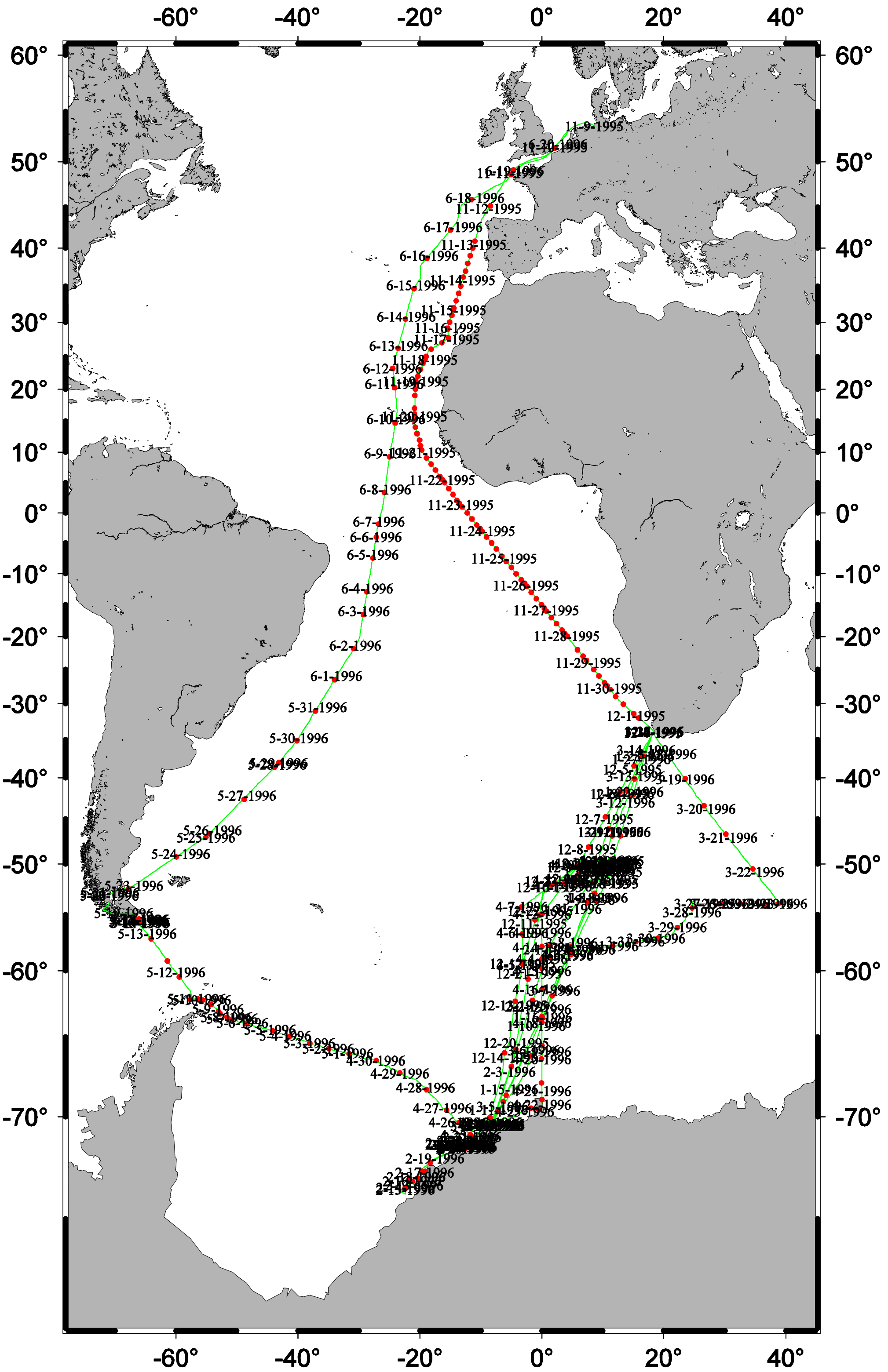

Fig. 35: Cruise track from ANT-XIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

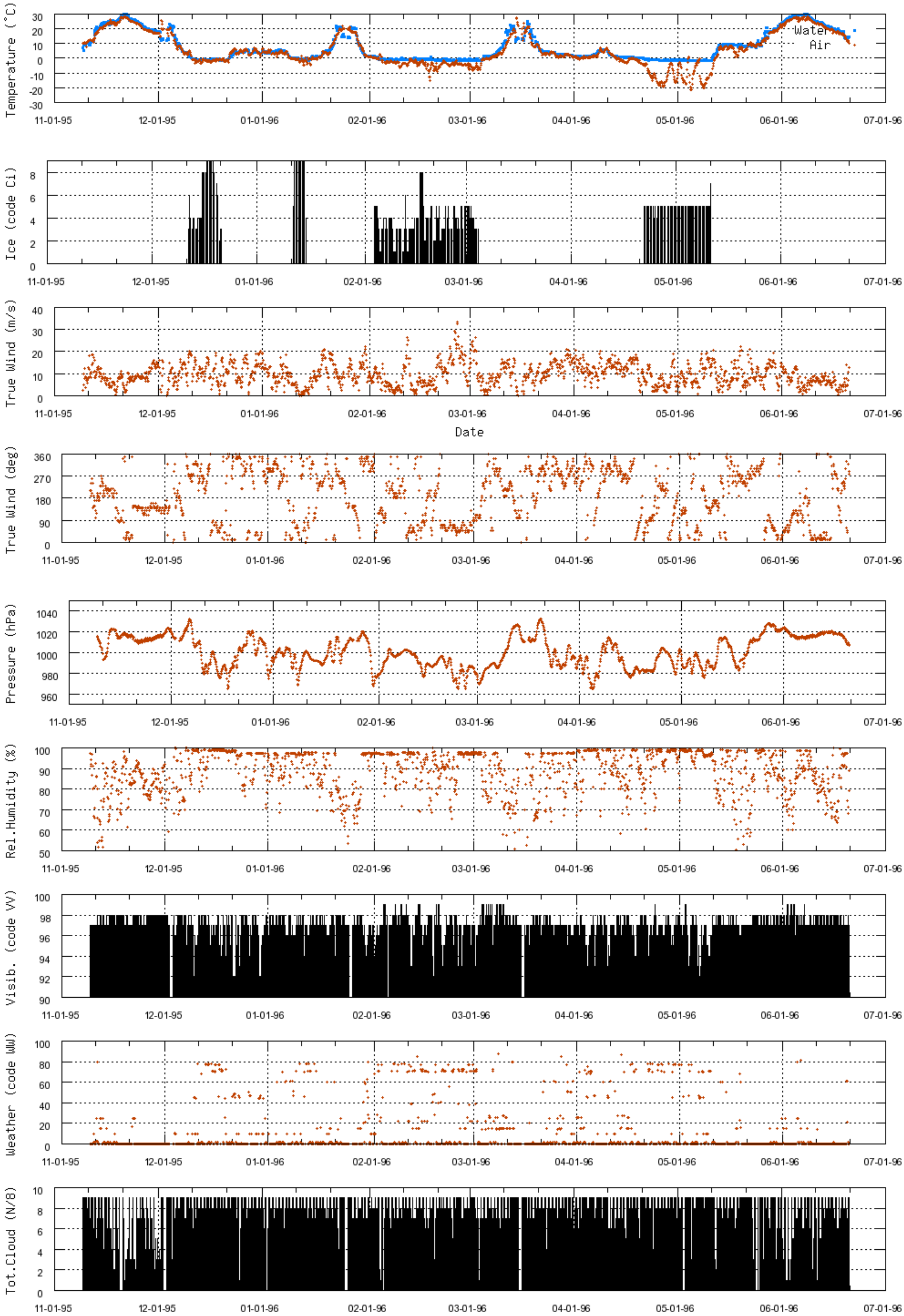

Fig. 36: Time series from ANT-XIII based on the 3-hourly synoptic observations

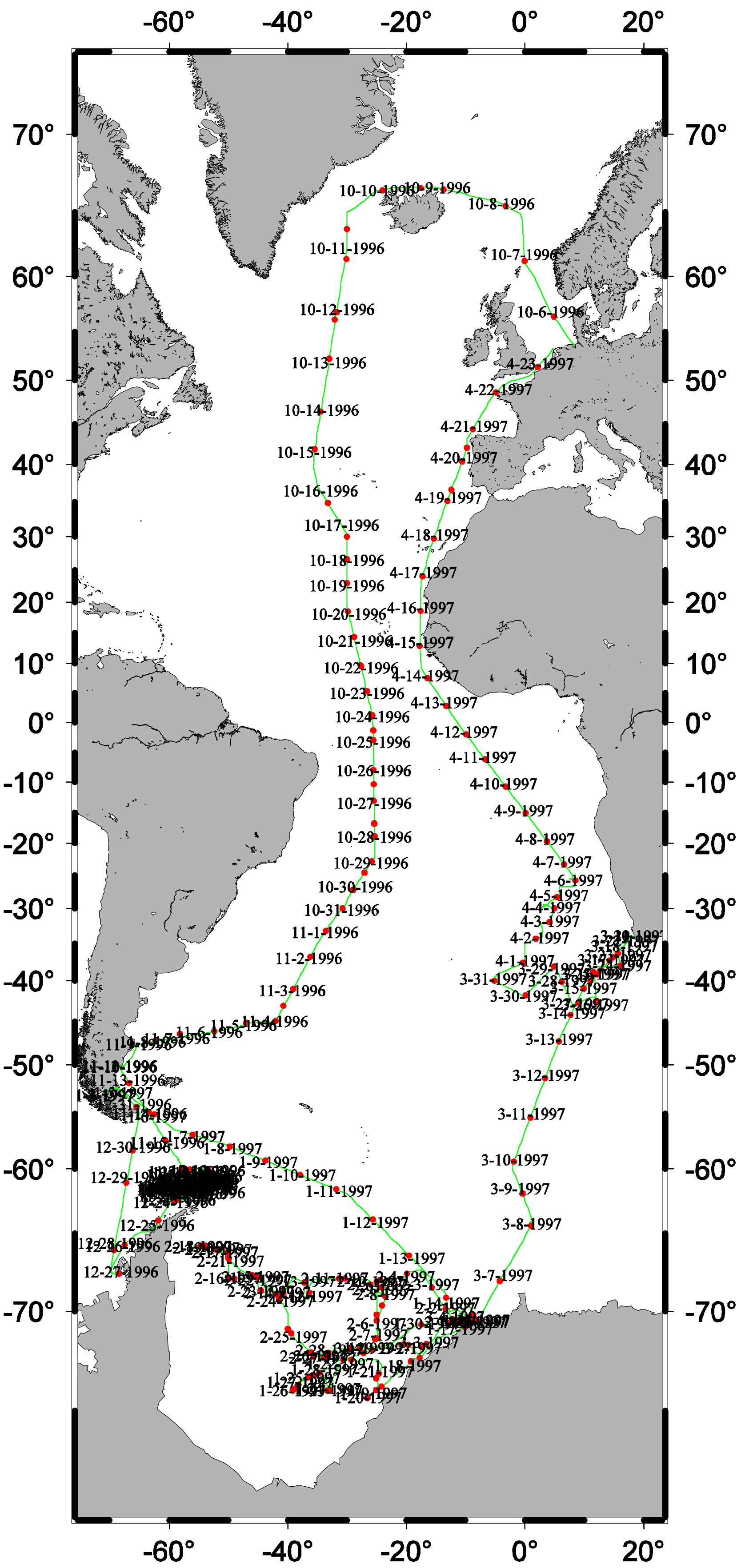

Fig. 37: Cruise track from ANT-XIV based on the 3-hourly synoptic observations. Dots denote upper air soundings

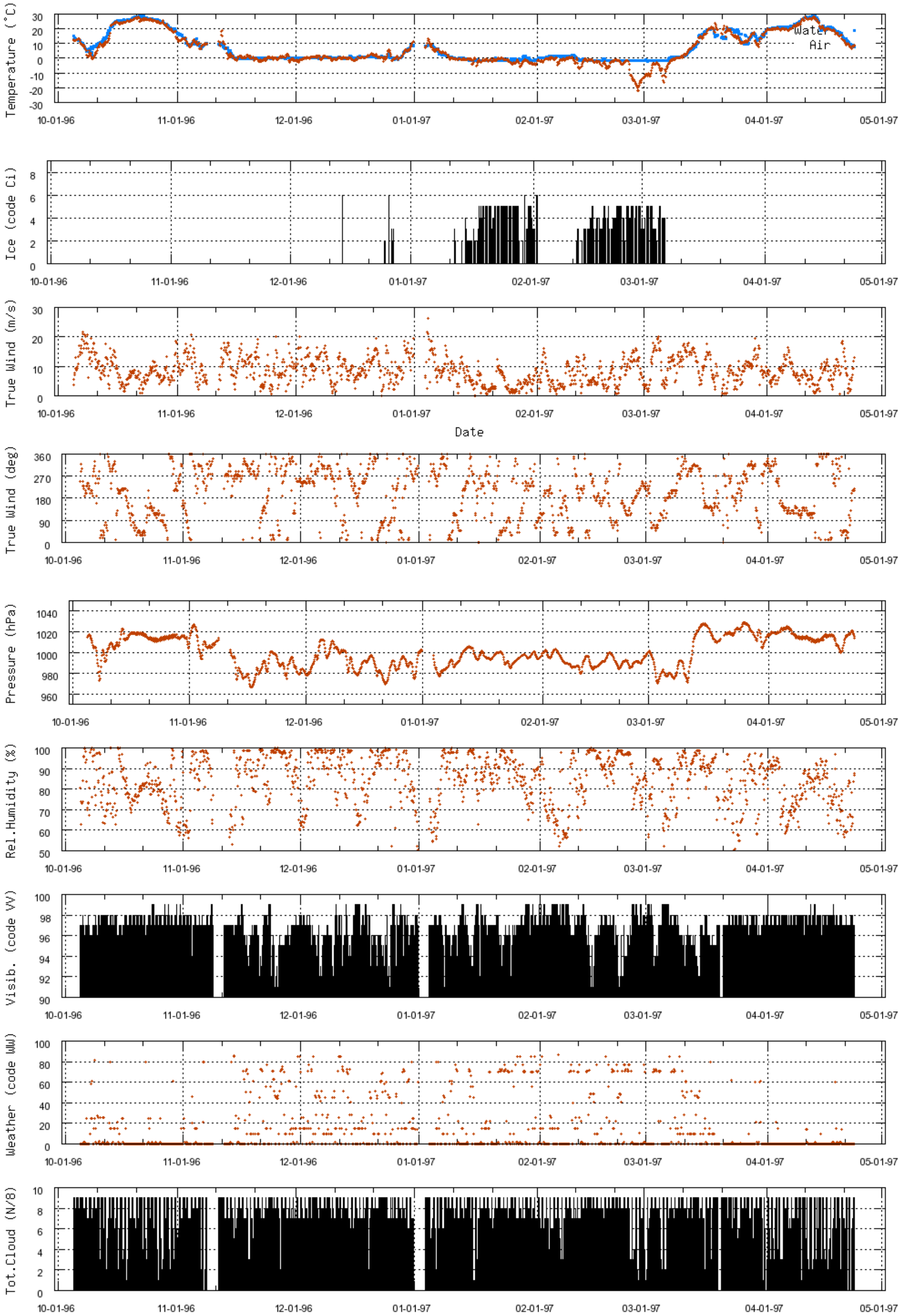

Fig. 38: Time series from ANT-XIV based on the 3-hourly synoptic observations

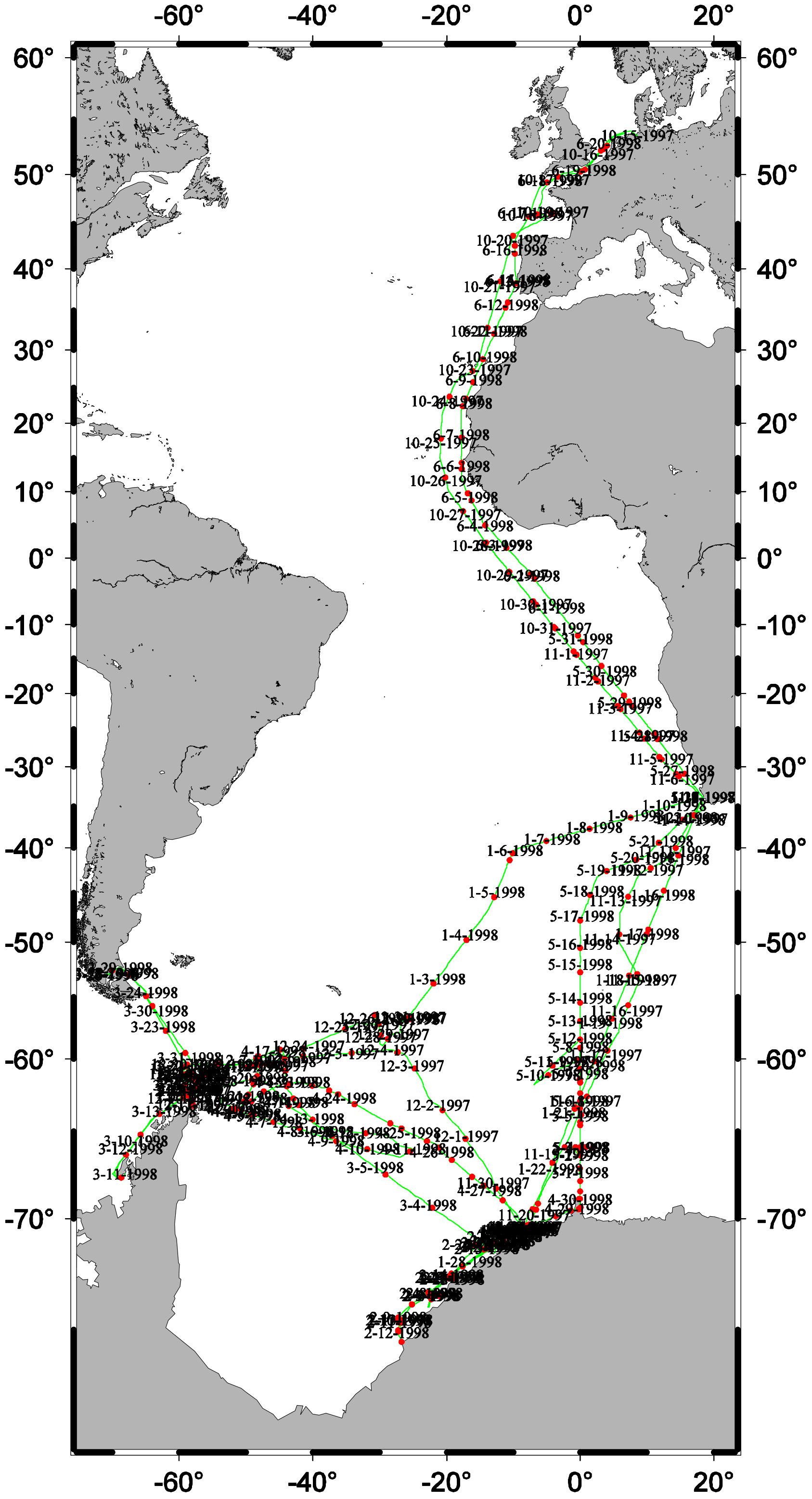

Fig. 39: Cruise track from ANT-XV based on the 3-hourly synoptic observations. Dots denote upper air soundings

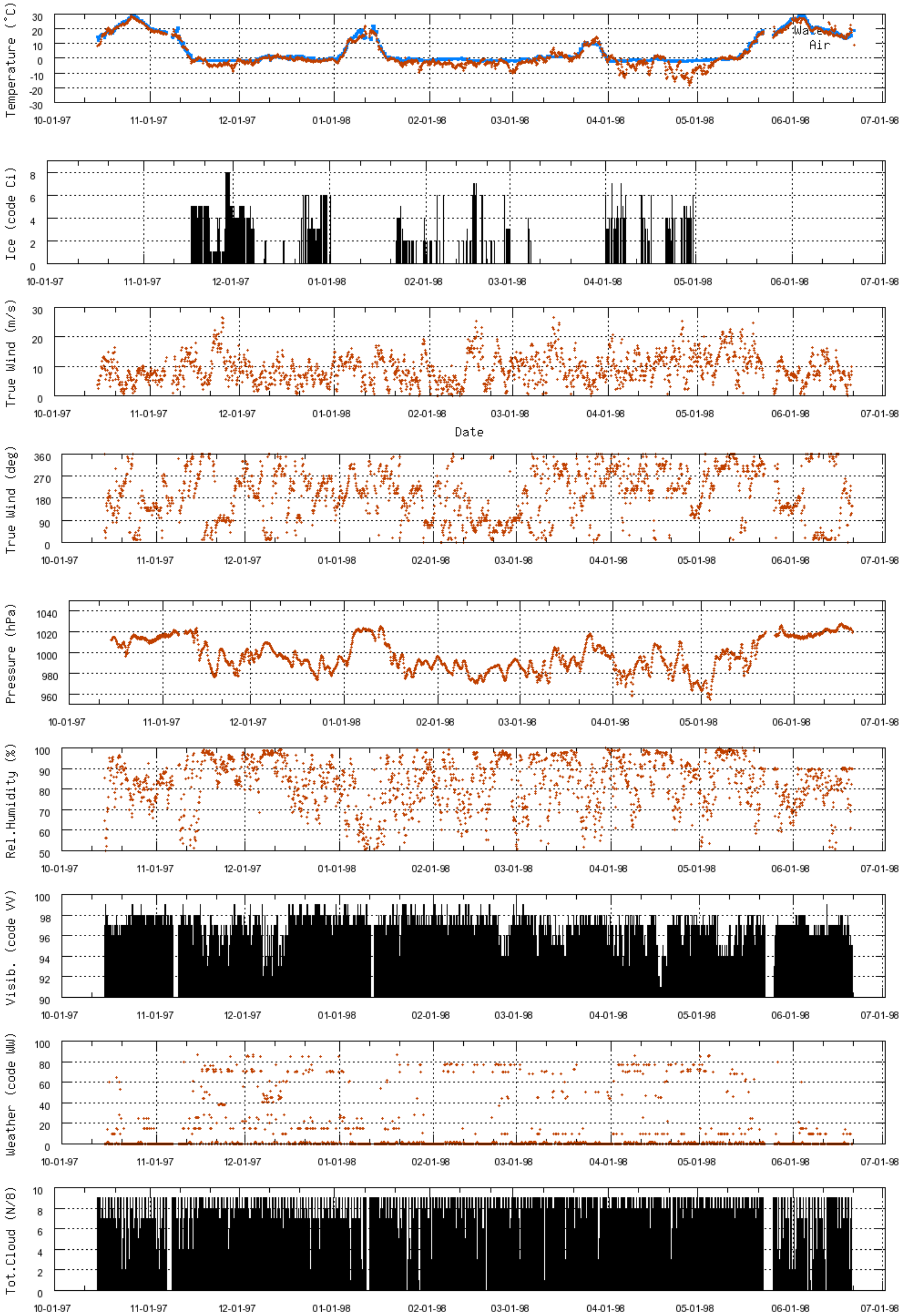

Fig. 40: Time series from ANT-XV based on the 3-hourly synoptic observations

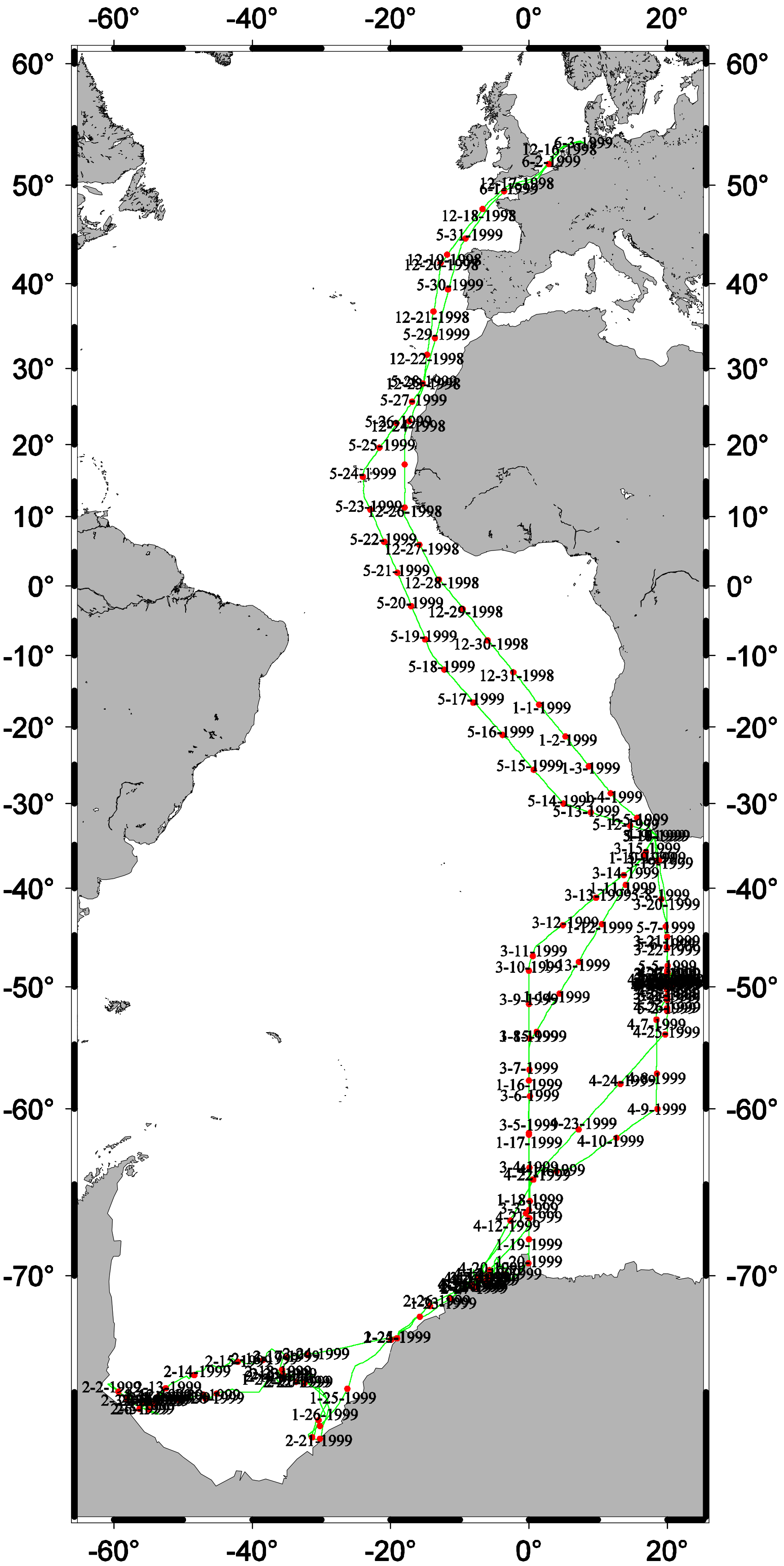

Fig. 41: Cruise track from ANT-XVI based on the 3-hourly synoptic observations.
Dots denote upper air soundings

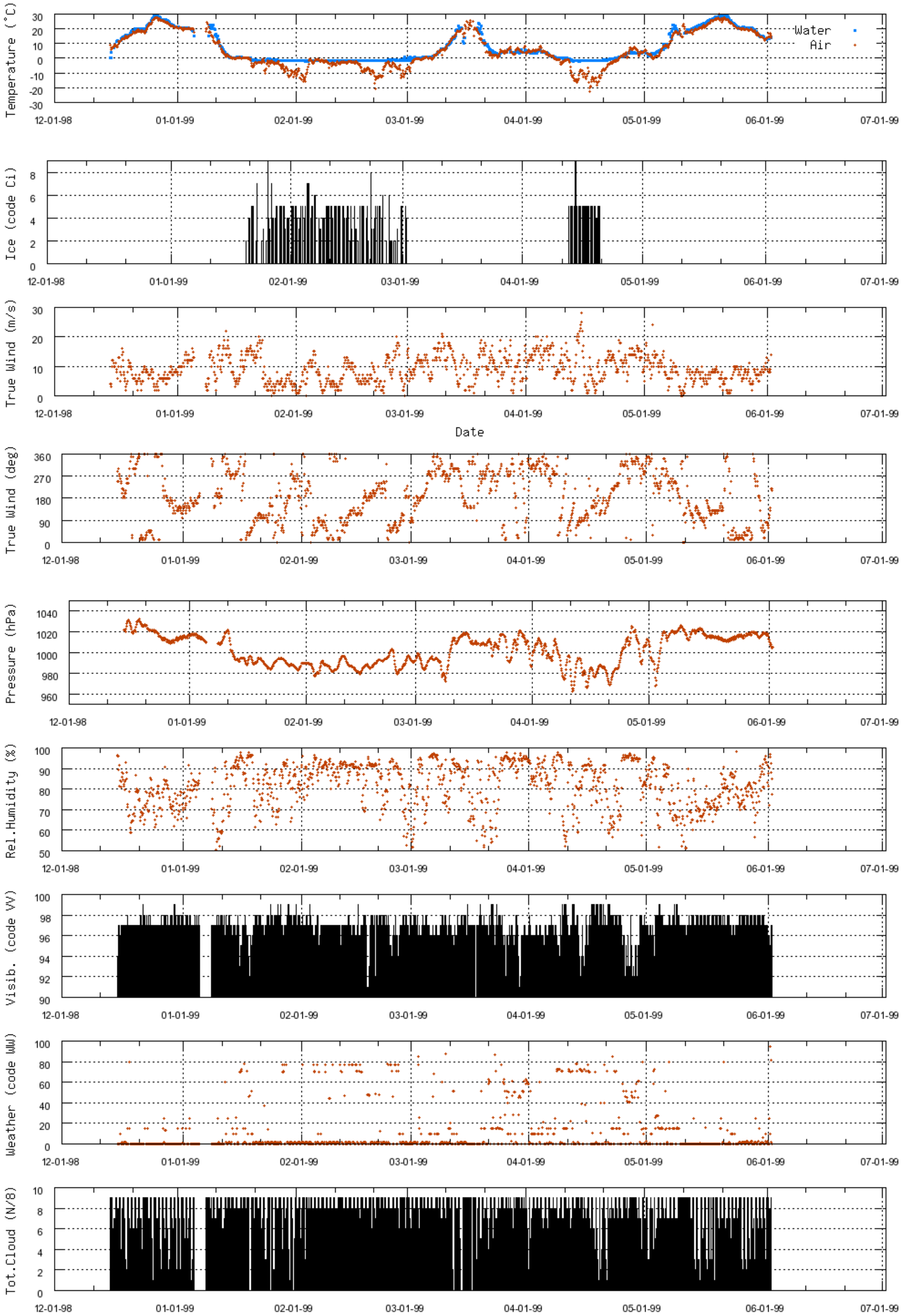

Fig. 42: Time series from ANT-XVI based on the 3-hourly synoptic observations

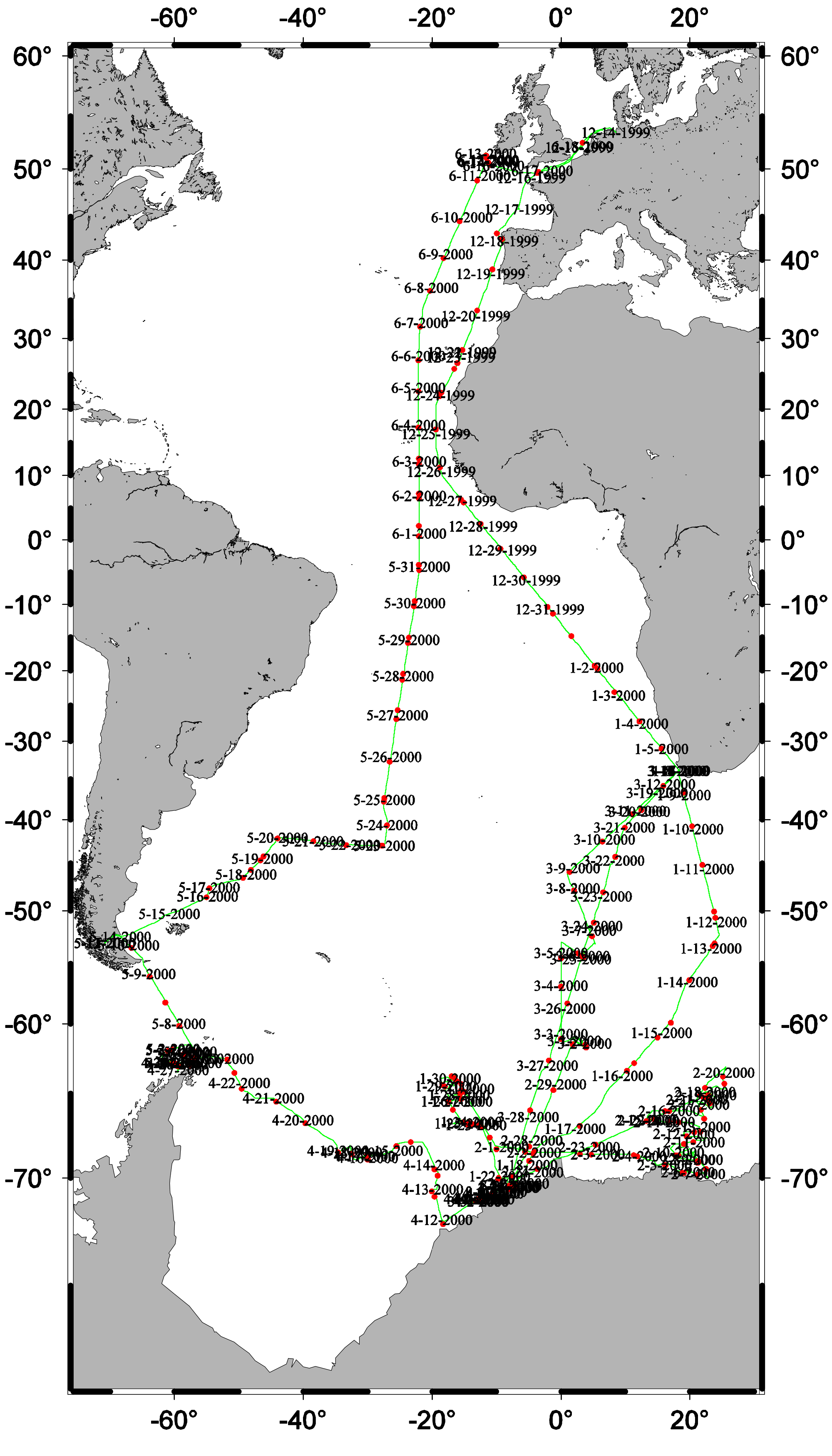

Fig. 43: Cruise track from ANT-XVII based on the 3-hourly synoptic observations. Dots denote upper air soundings

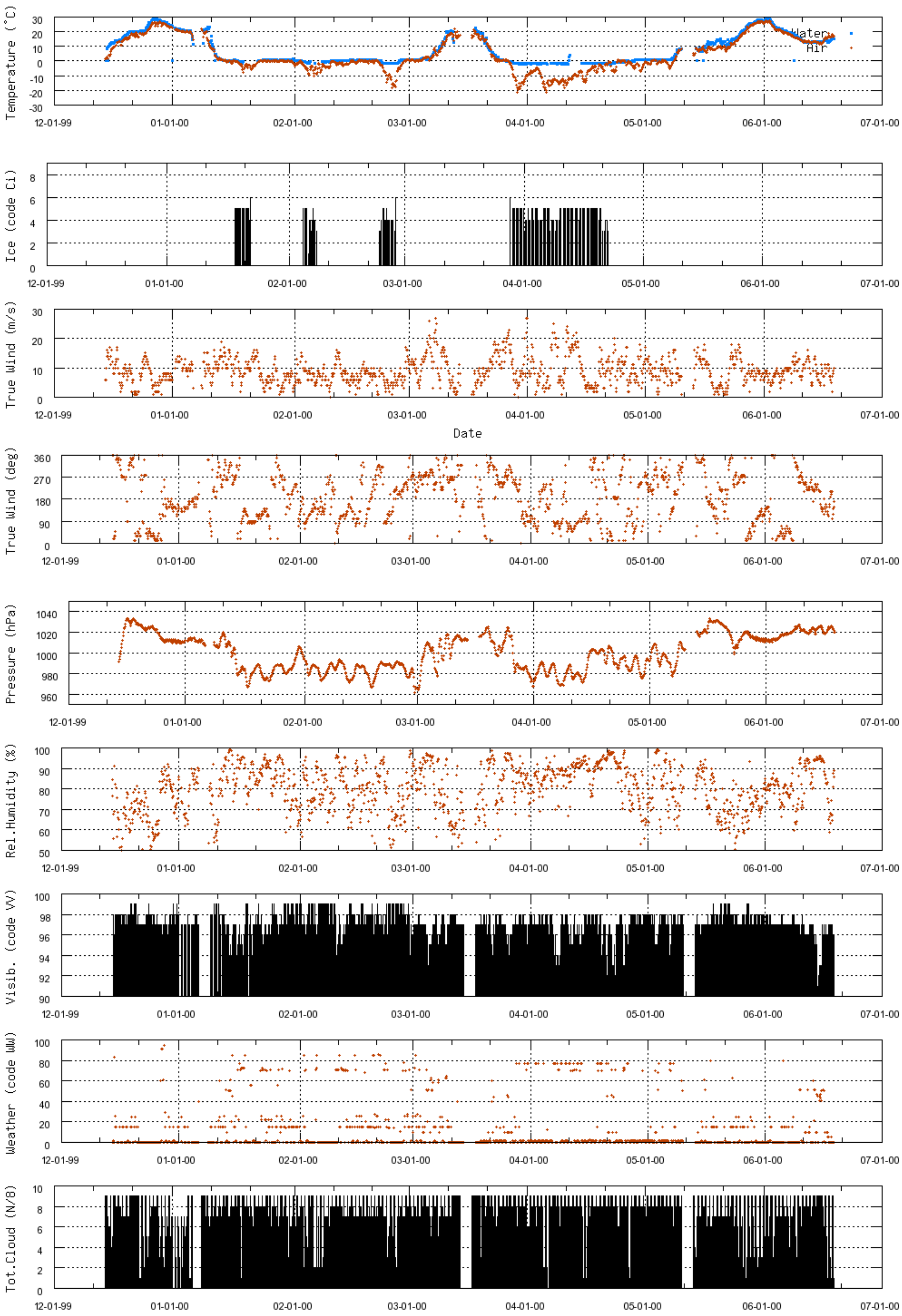

Fig. 44: Time series from ANT-XVII based on the 3-hourly synoptic observations

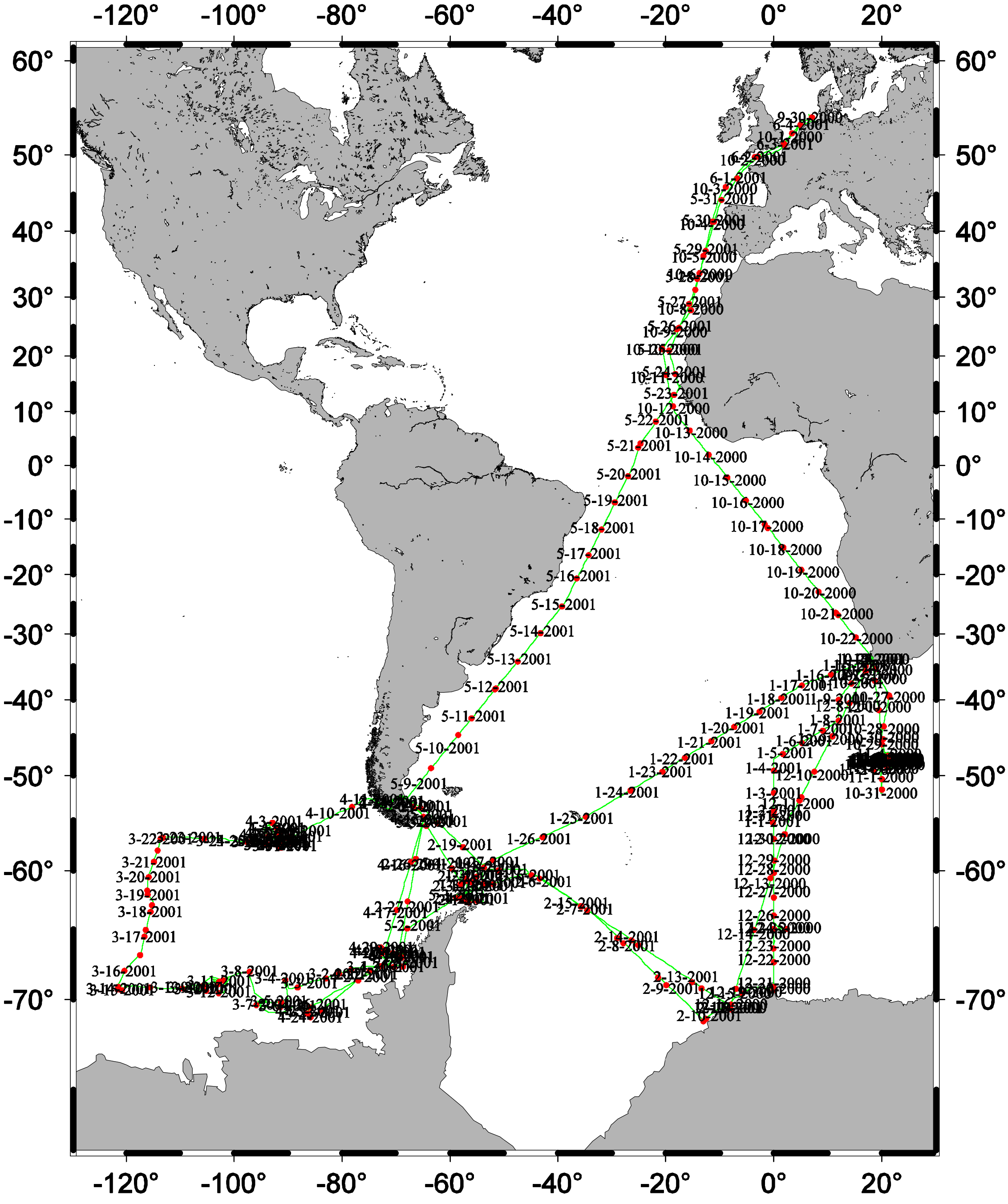

Fig. 45: Cruise track from ANT-XVIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

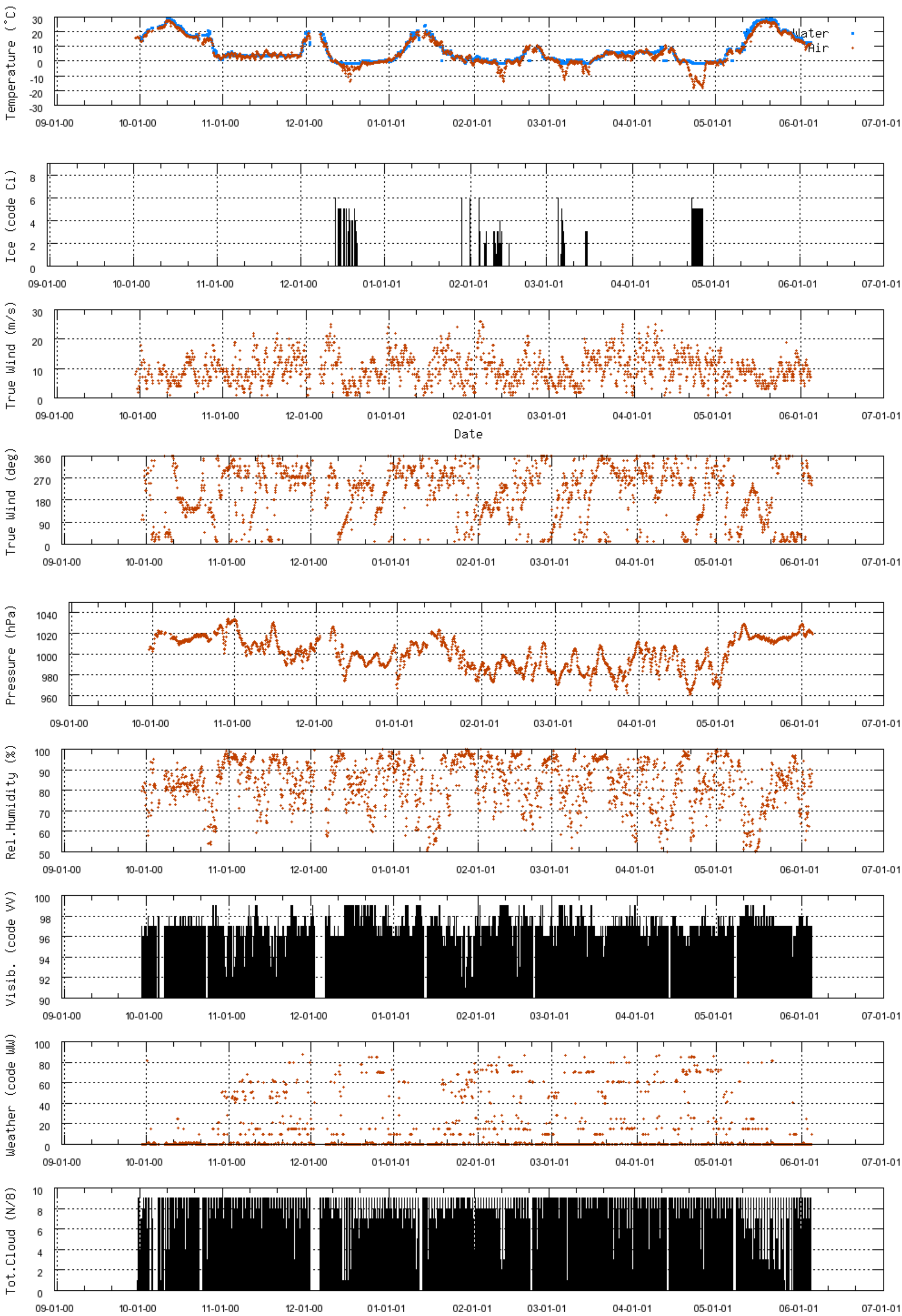

Fig. 46: Time series from ANT-XVIII based on the 3-hourly synoptic observations

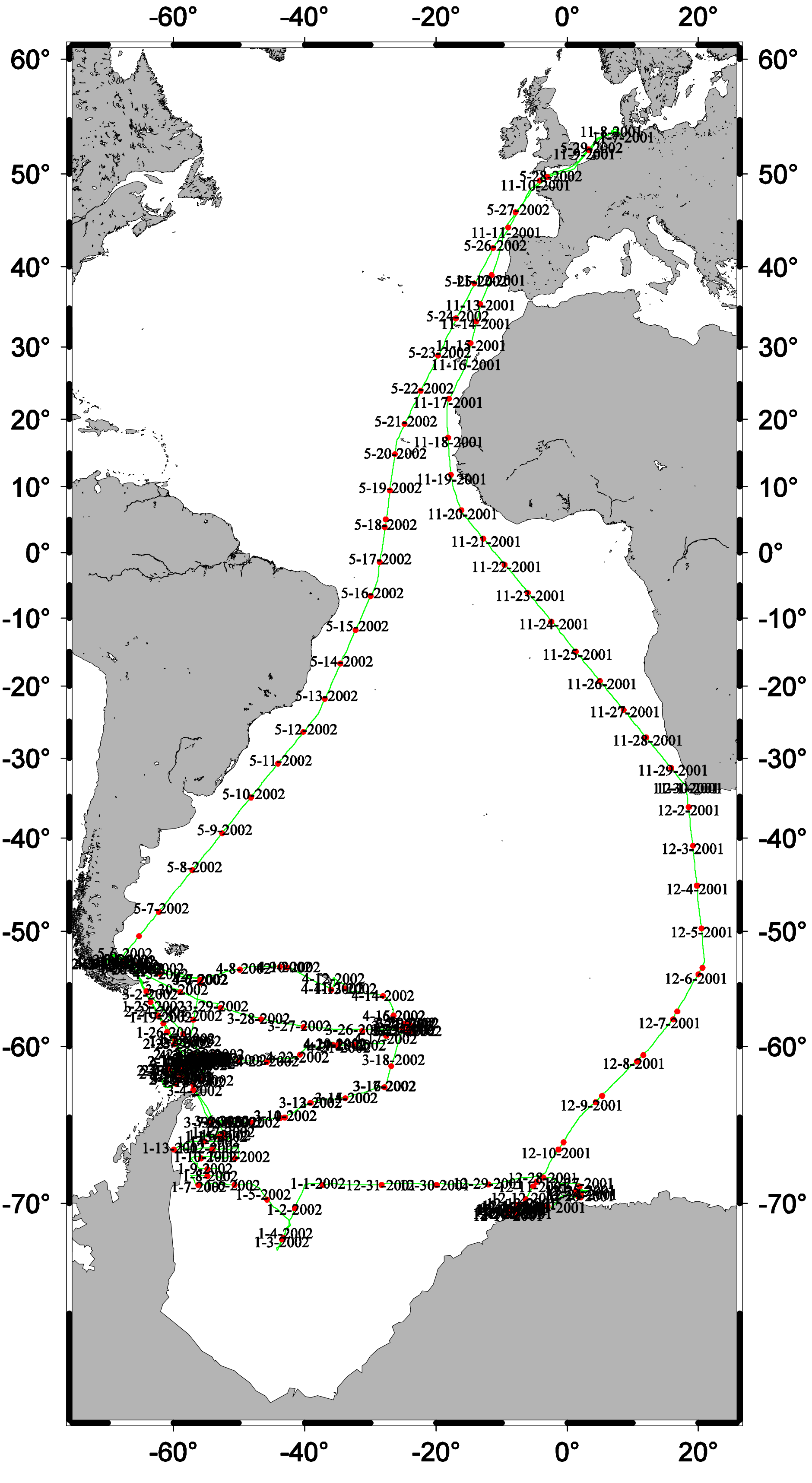

Fig. 47: Cruise track from ANT-XIX based on the 3-hourly synoptic observations. Dots denote upper air soundings

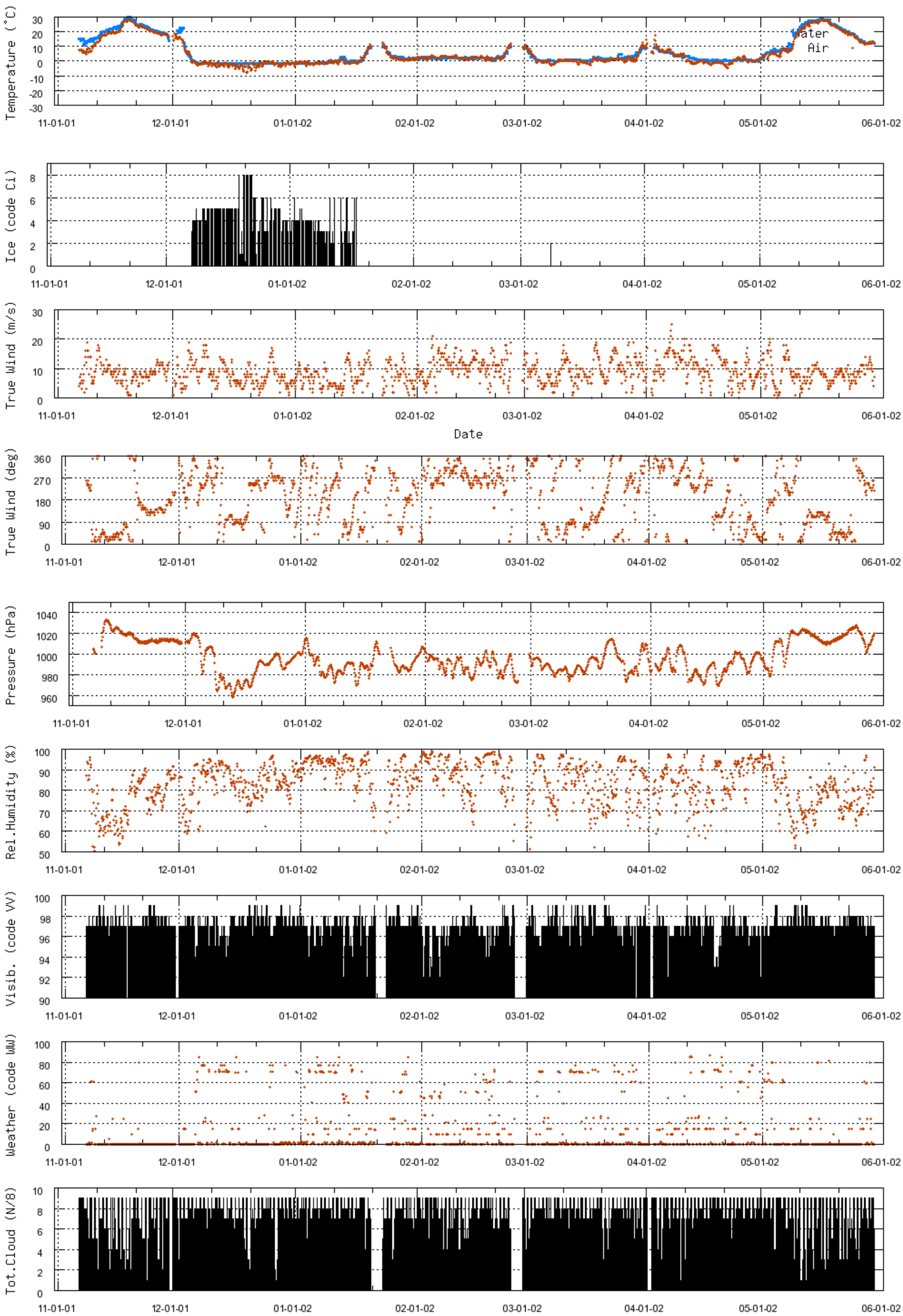

Fig. 48: Time series from ANT-XIX based on the 3-hourly synoptic observations

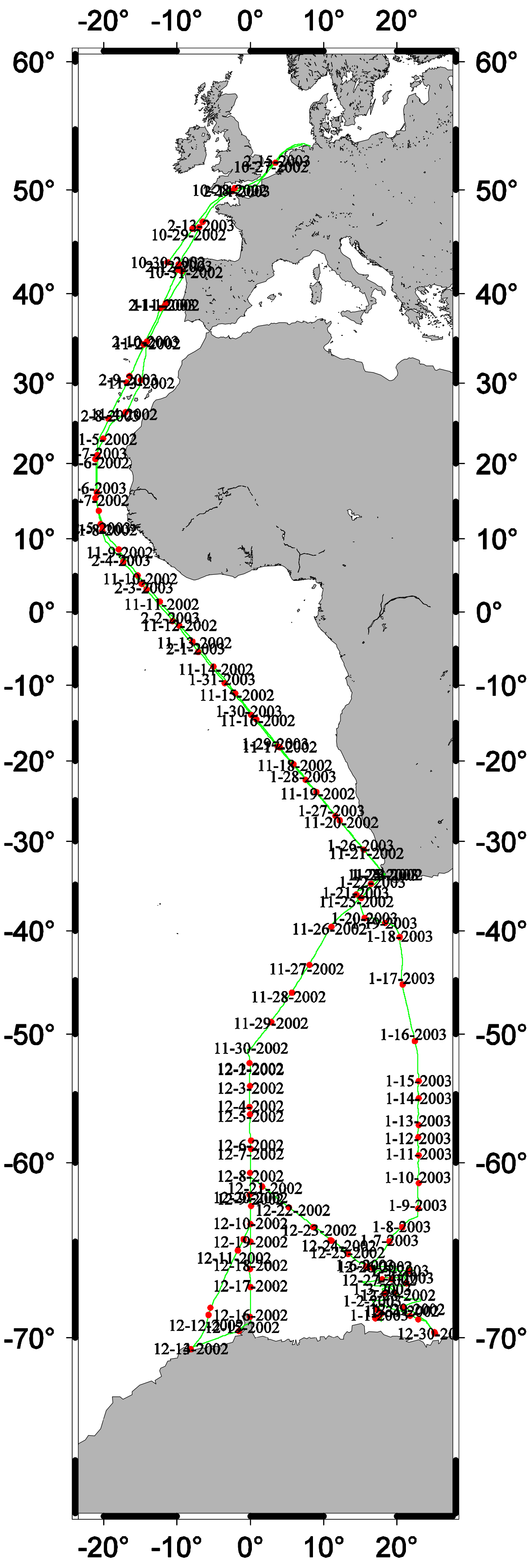

Fig. 49: Cruise track from ANT-XX based on the 3-hourly synoptic observations. Dots denote upper air soundings

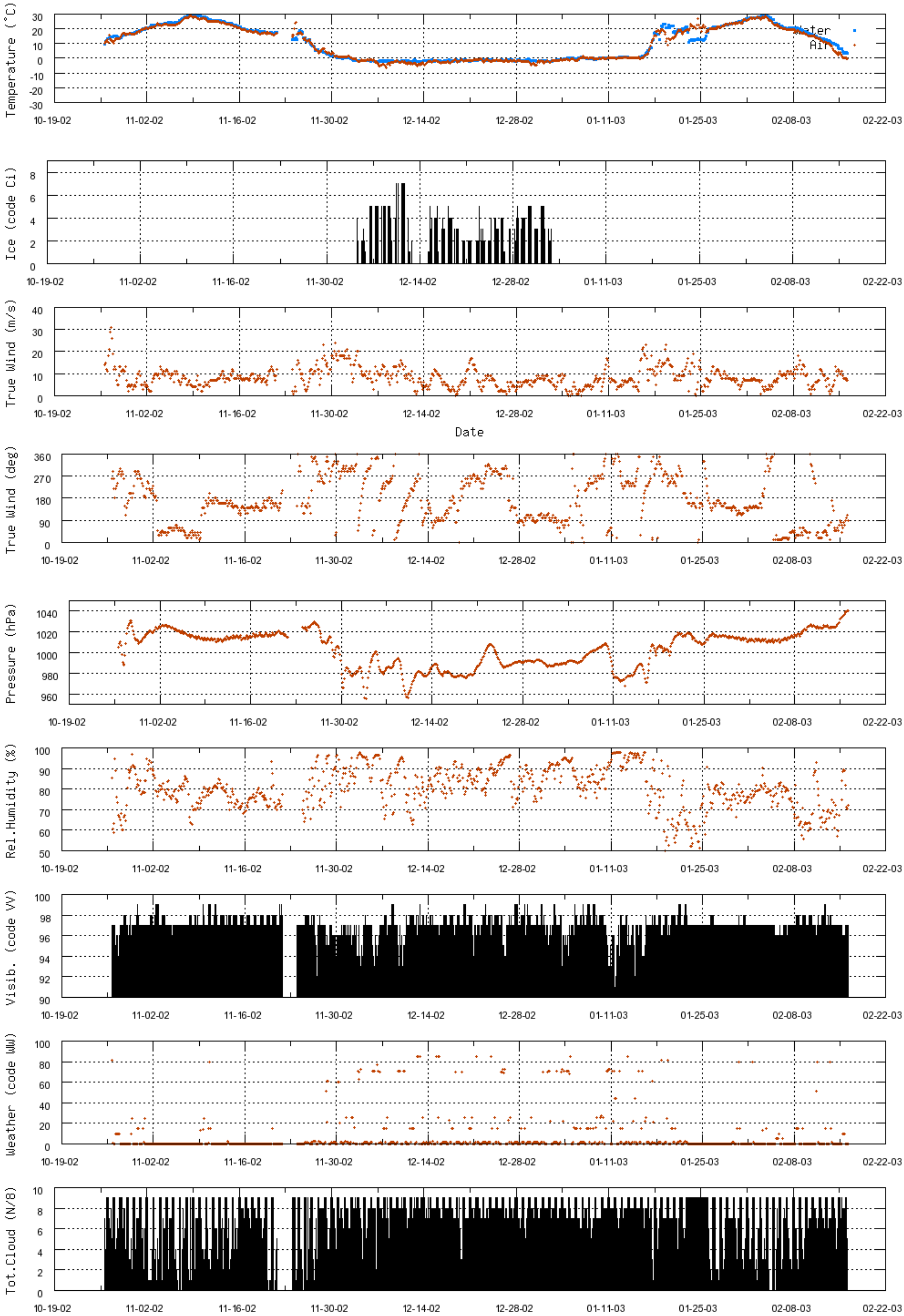

Fig 50: Time series from ANT-XX based on the 3-hourly synoptic observations

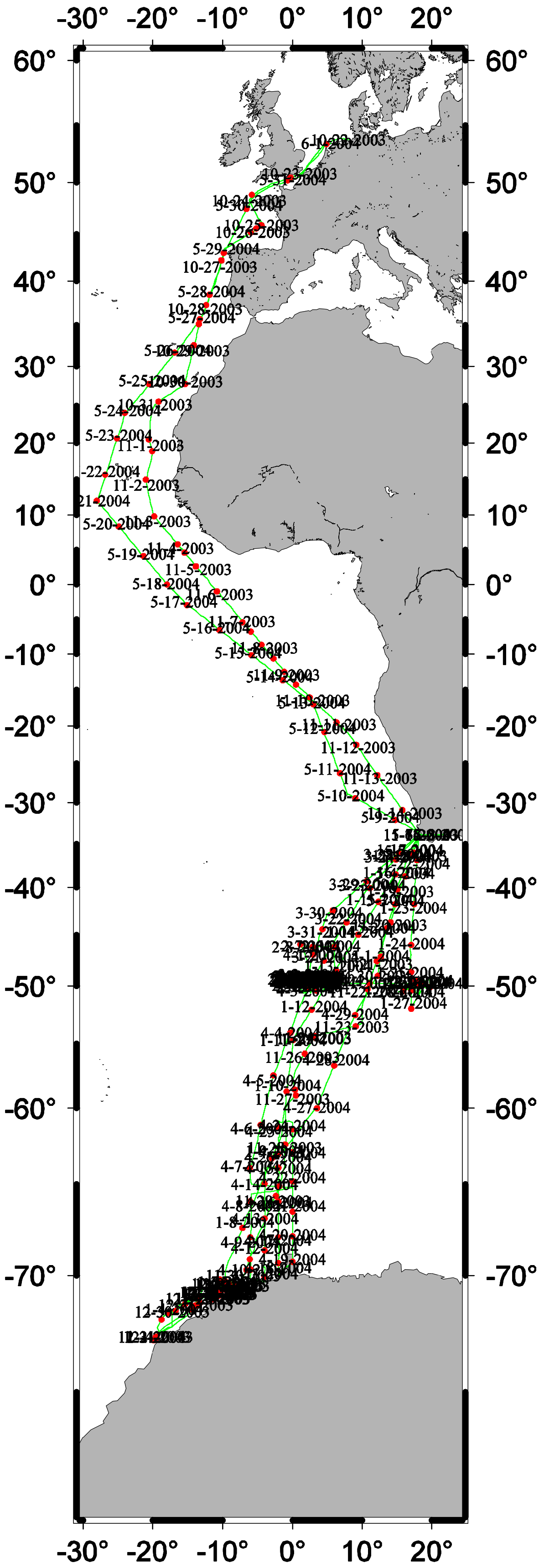

Fig. 51: Cruise track from ANT-XXI based on the 3-hourly synoptic observations. Dots denote upper air soundings

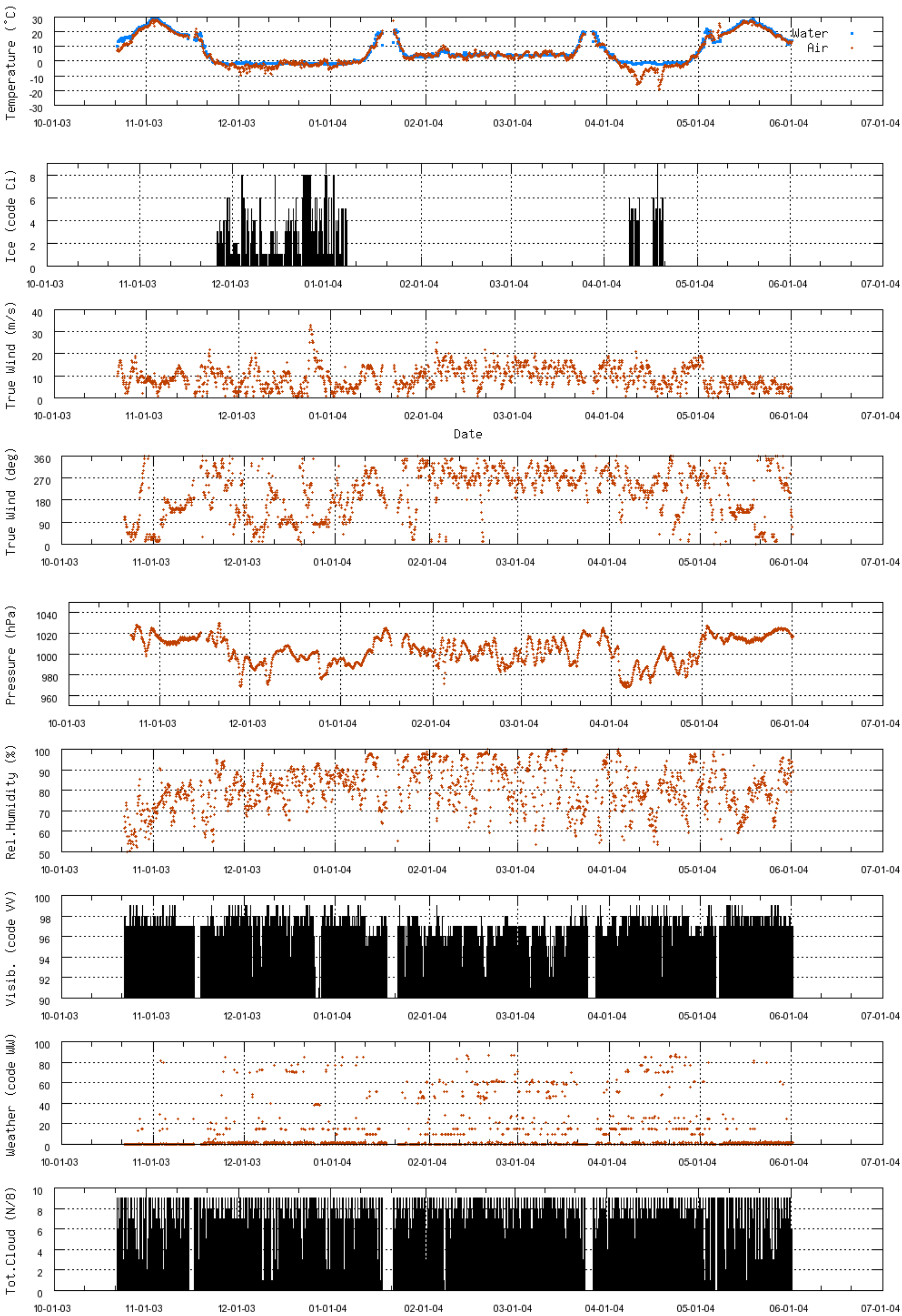

Fig. 52: Time series from ANT-XXI based on the 3-hourly synoptic observations

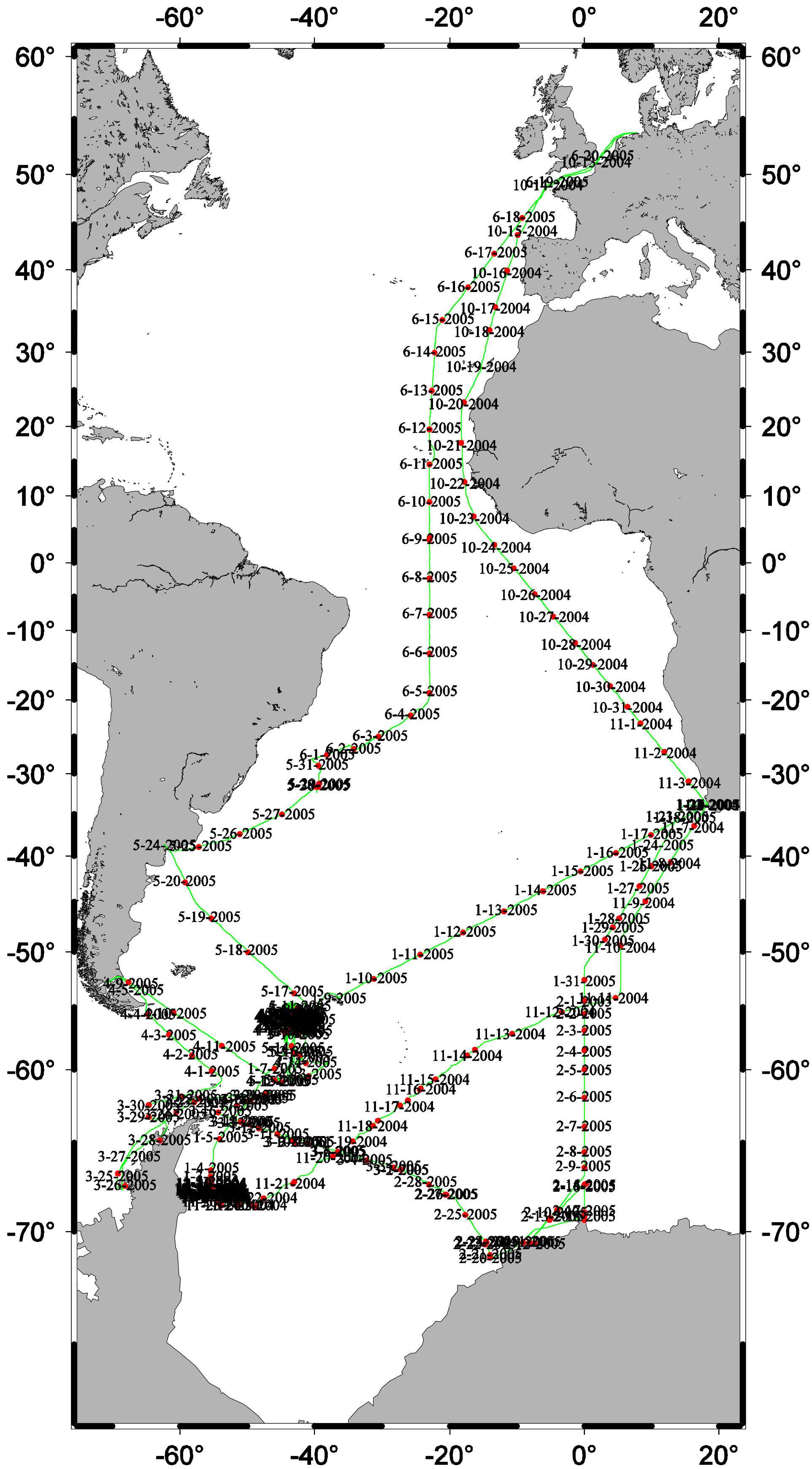

Fig. 53: Cruise track from ANT-XXII based on the 3-hourly synoptic observations. Dots denote upper air soundings

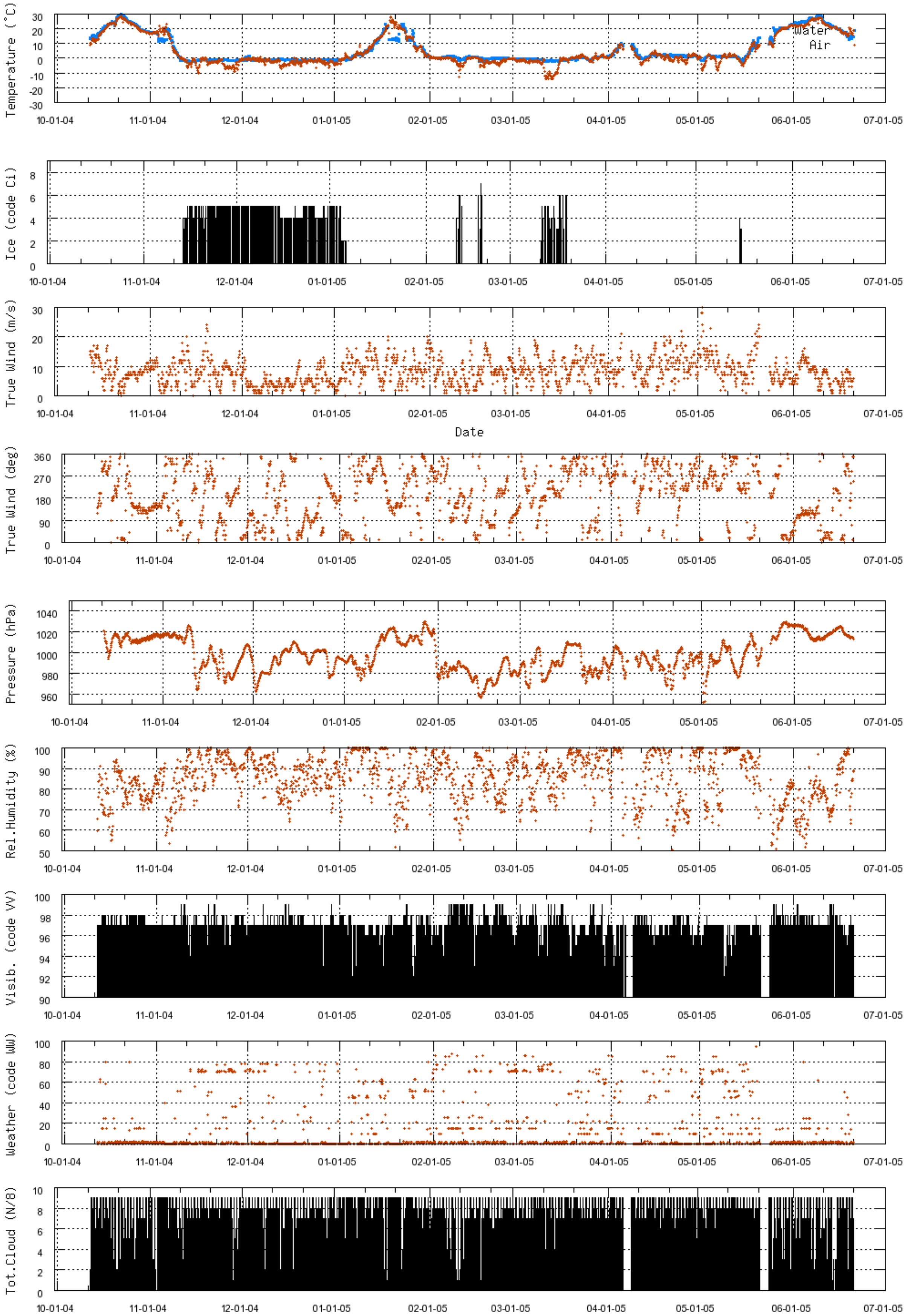

Fig. 54: Time series from ANT-XXII based on the 3-hourly synoptic observations

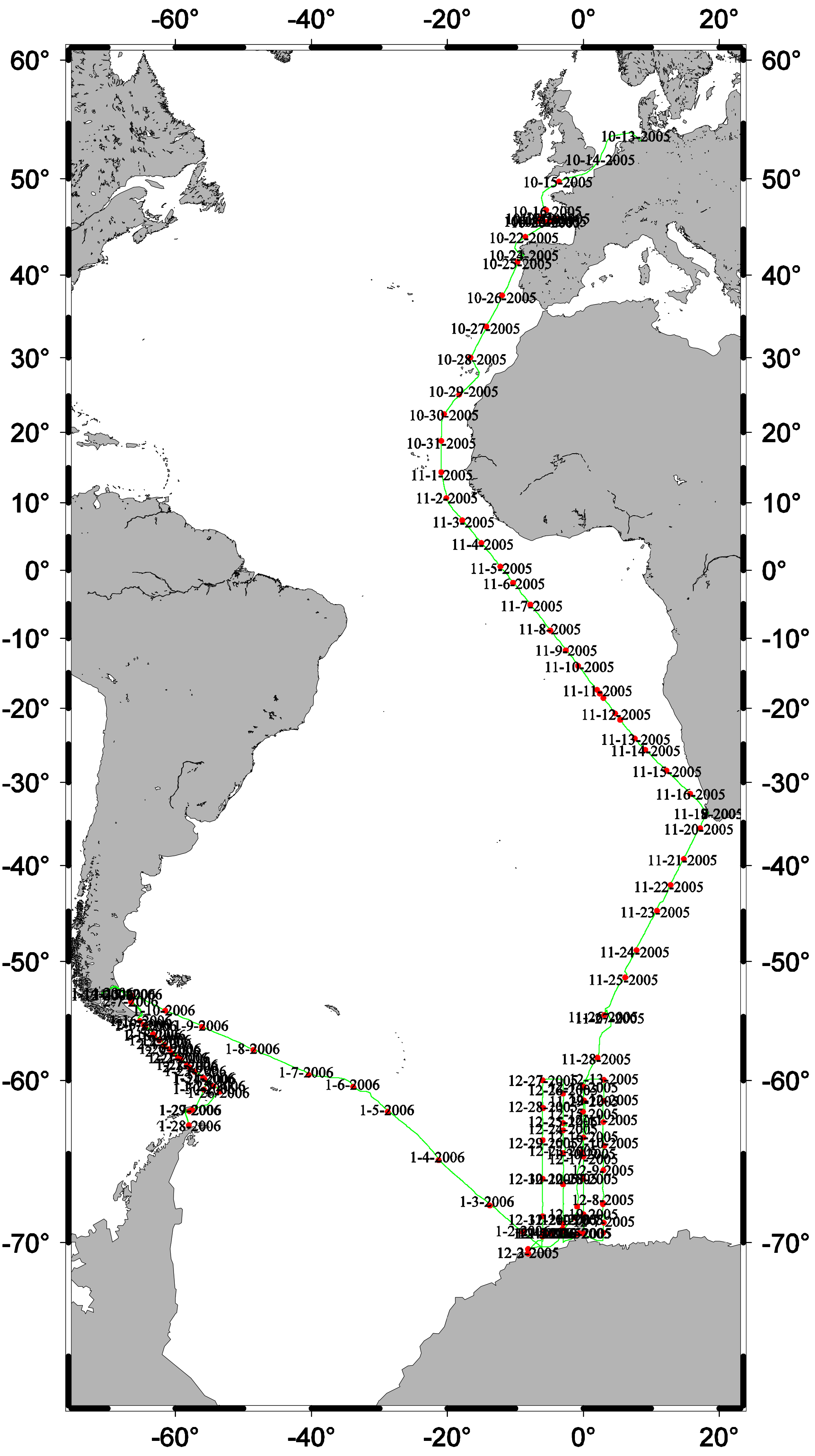

Fig. 55: Cruise track from ANT-XXIII/1,2,3 based on the 3-hourly synoptic observations. Dots denote upper air soundings

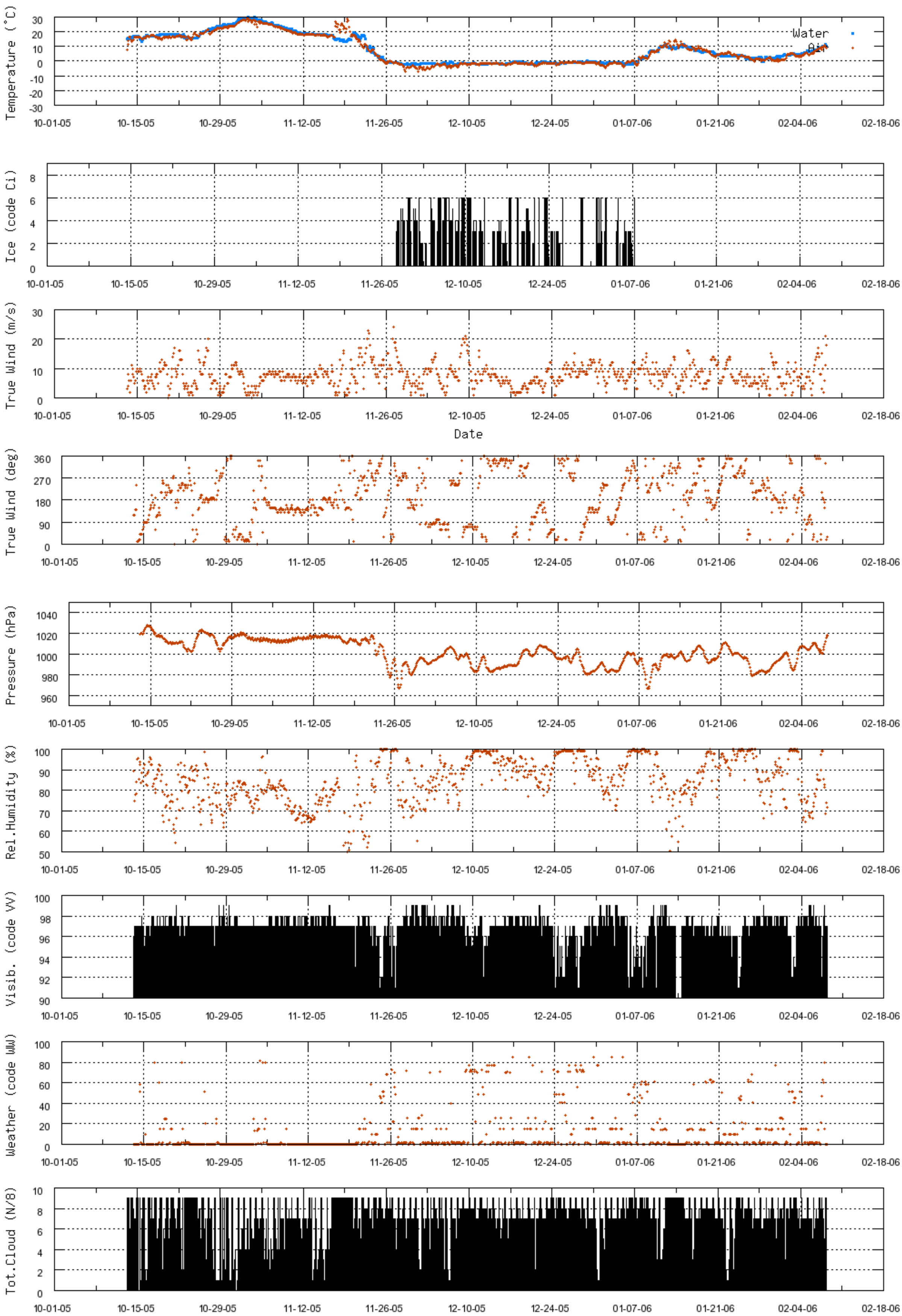

Fig. 56: Time series from ANT-XXIII/1,2,3 based on the 3-hourly synoptic observations

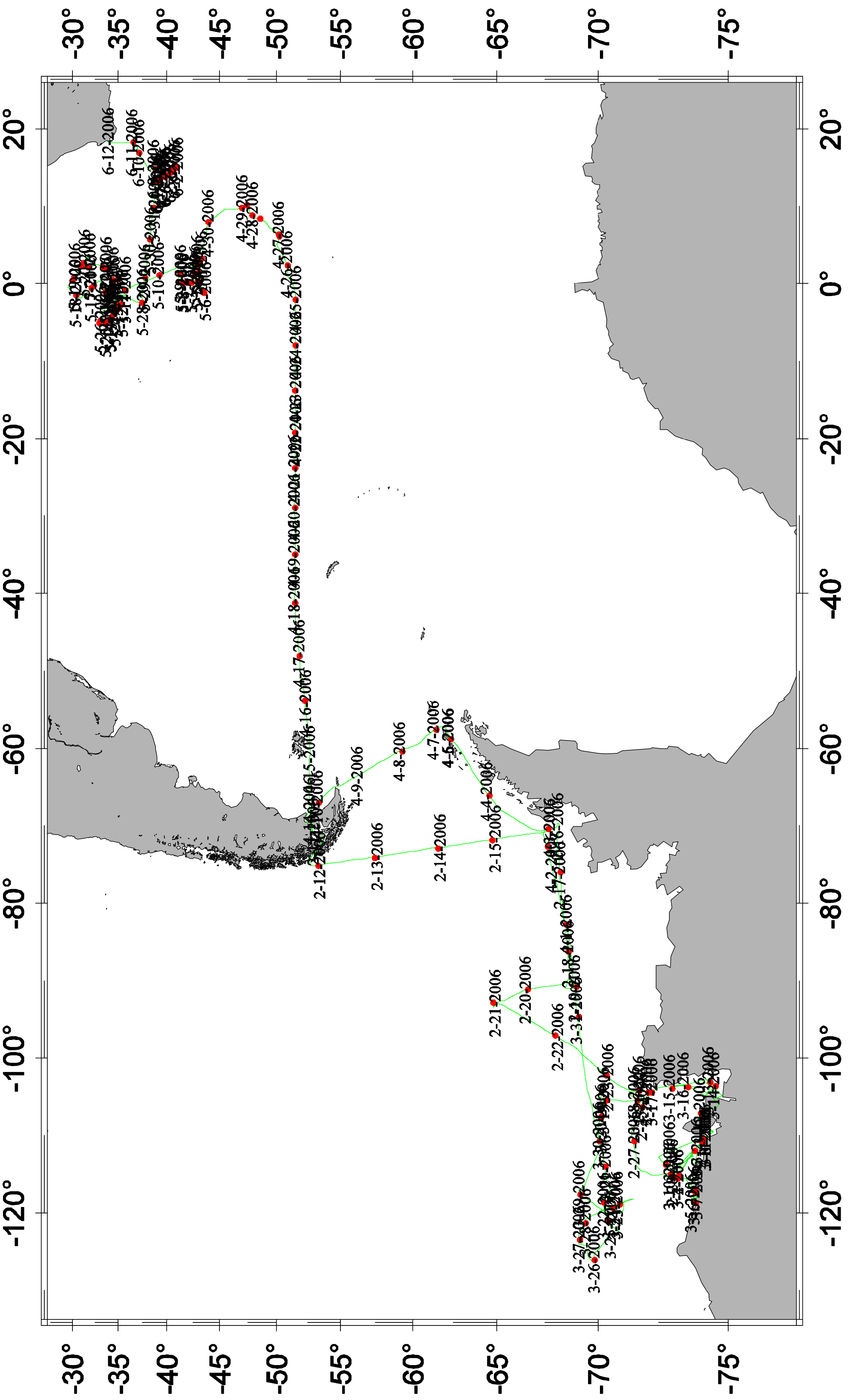

Fig. 57: Cruise track from ANT-XXIII/4,5 based on the 3-hourly synoptic observations. Dots denote upper air soundings

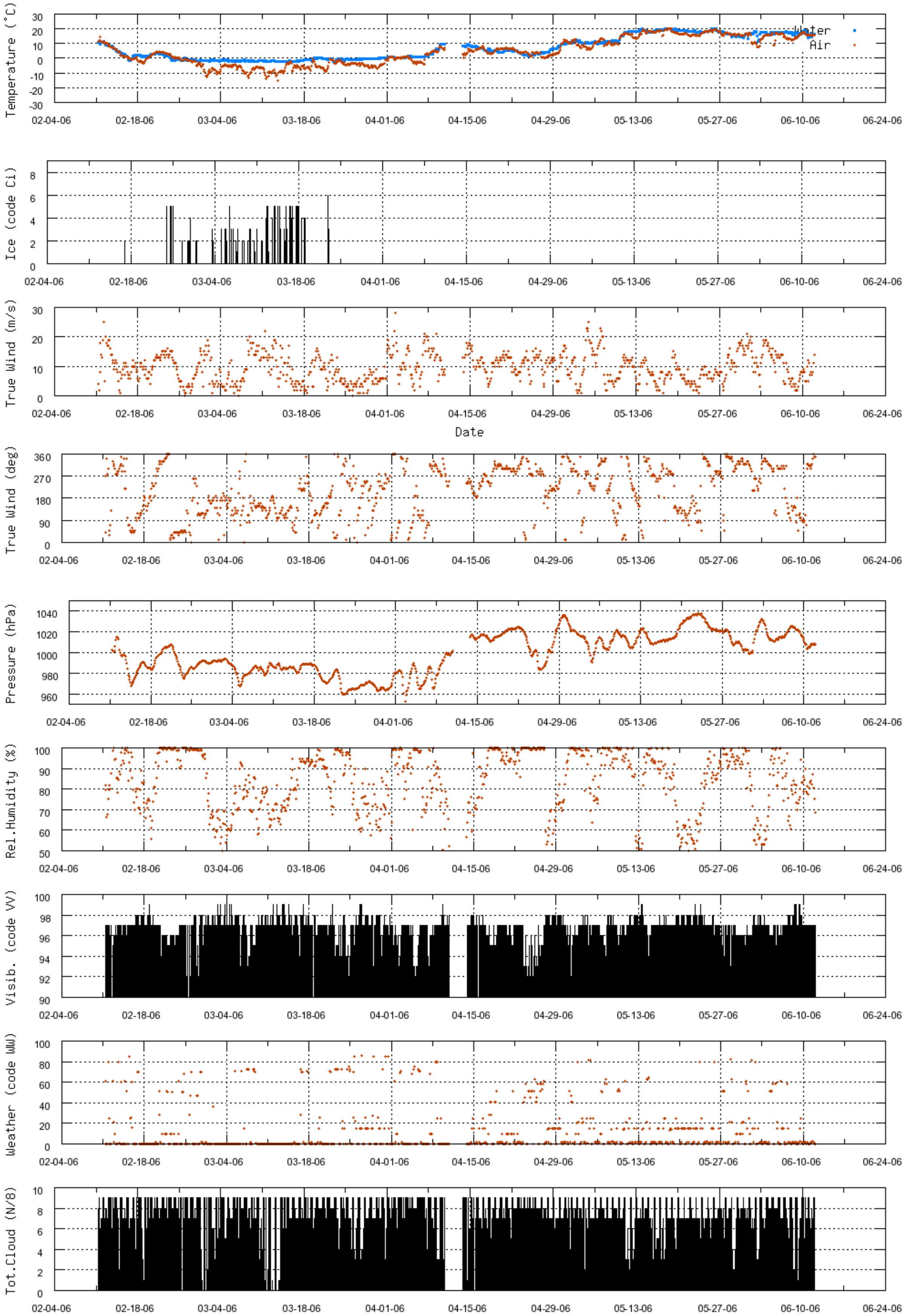

Fig. 58: Time series from ANT-XXIII/4,5 based on the 3-hourly synoptic observations

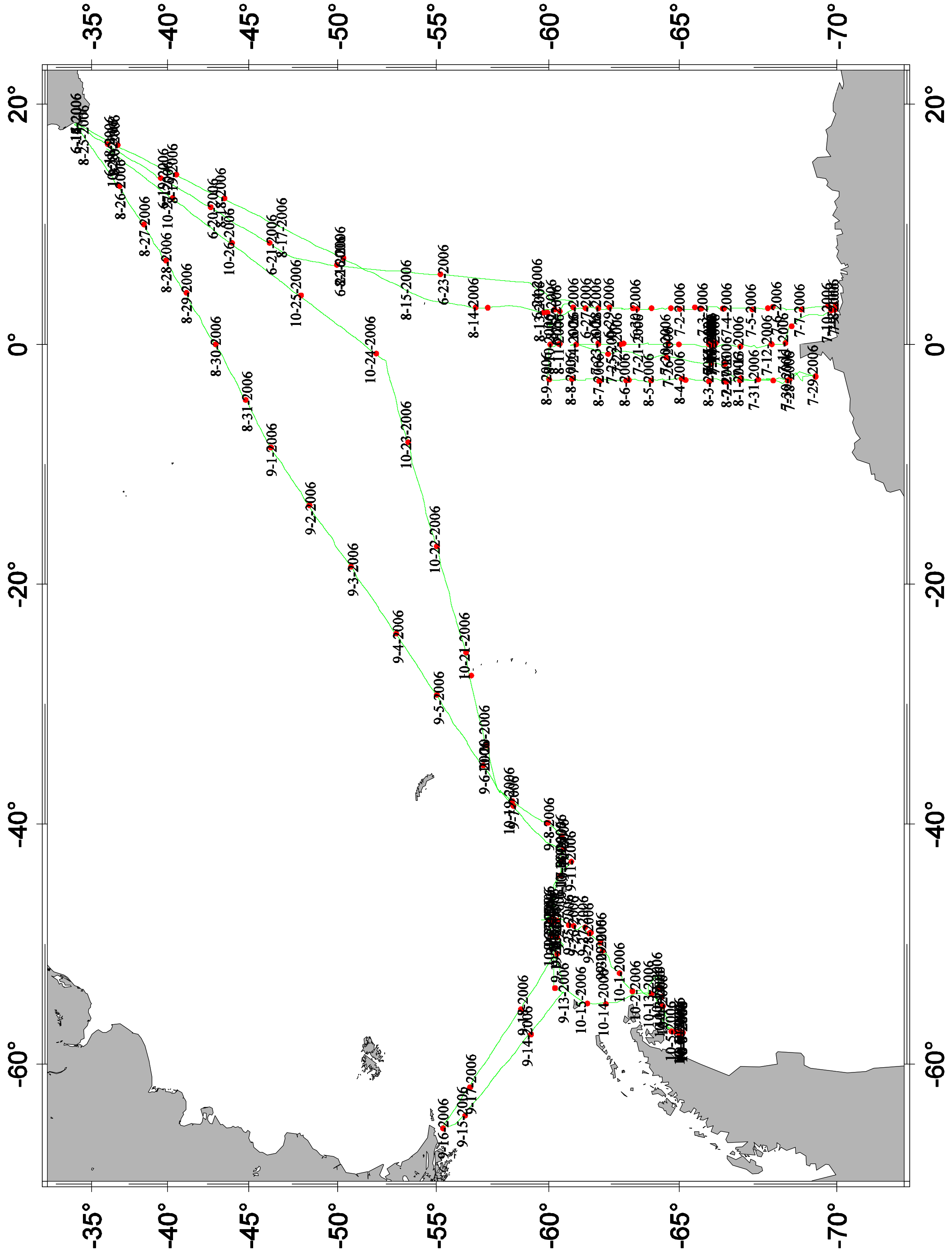

Fig. 59: Cruise track from ANT-XXIII/6,7 based on the 3-hourly synoptic observations. Dots denote upper air soundings

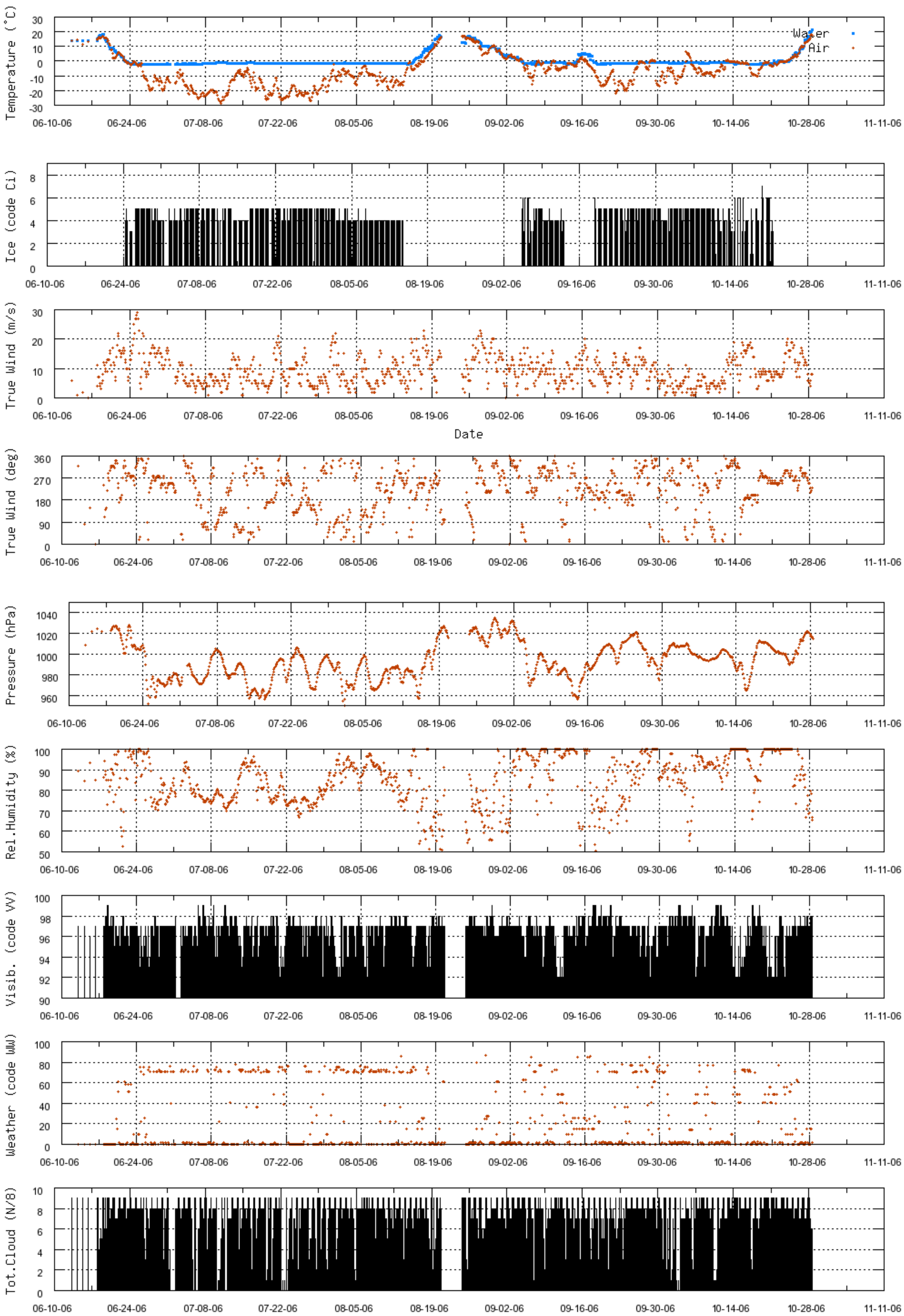

Fig. 60: Time series from ANT-XXIII/6,7 based on the 3-hourly synoptic observations

5.3. Arctic-cruises (ARK)

No synoptic observations available from ARK-I.

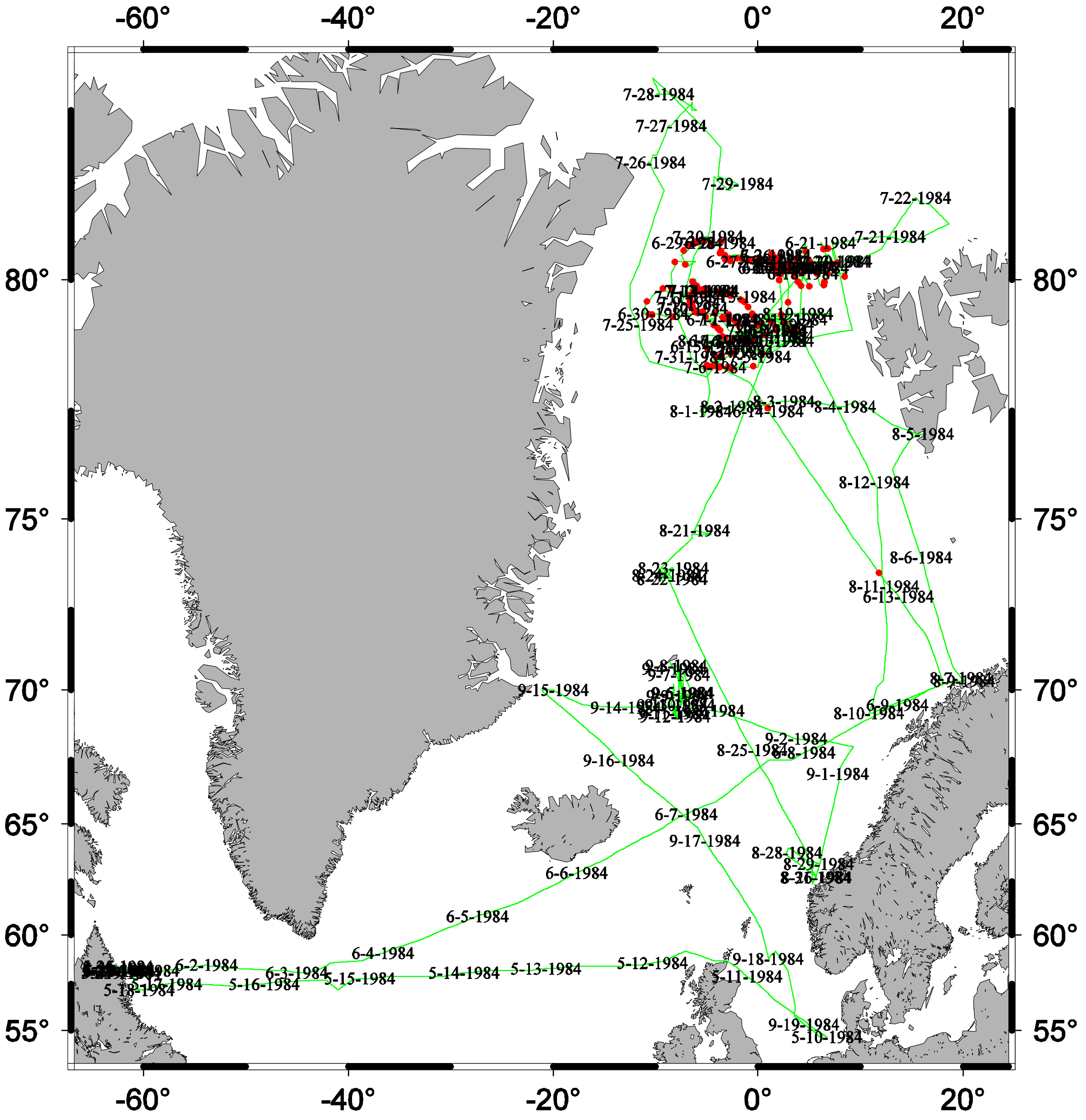

Fig. 61: Cruise track from ARK-II based on the 3-hourly synoptic observations.
Dots denote upper air soundings

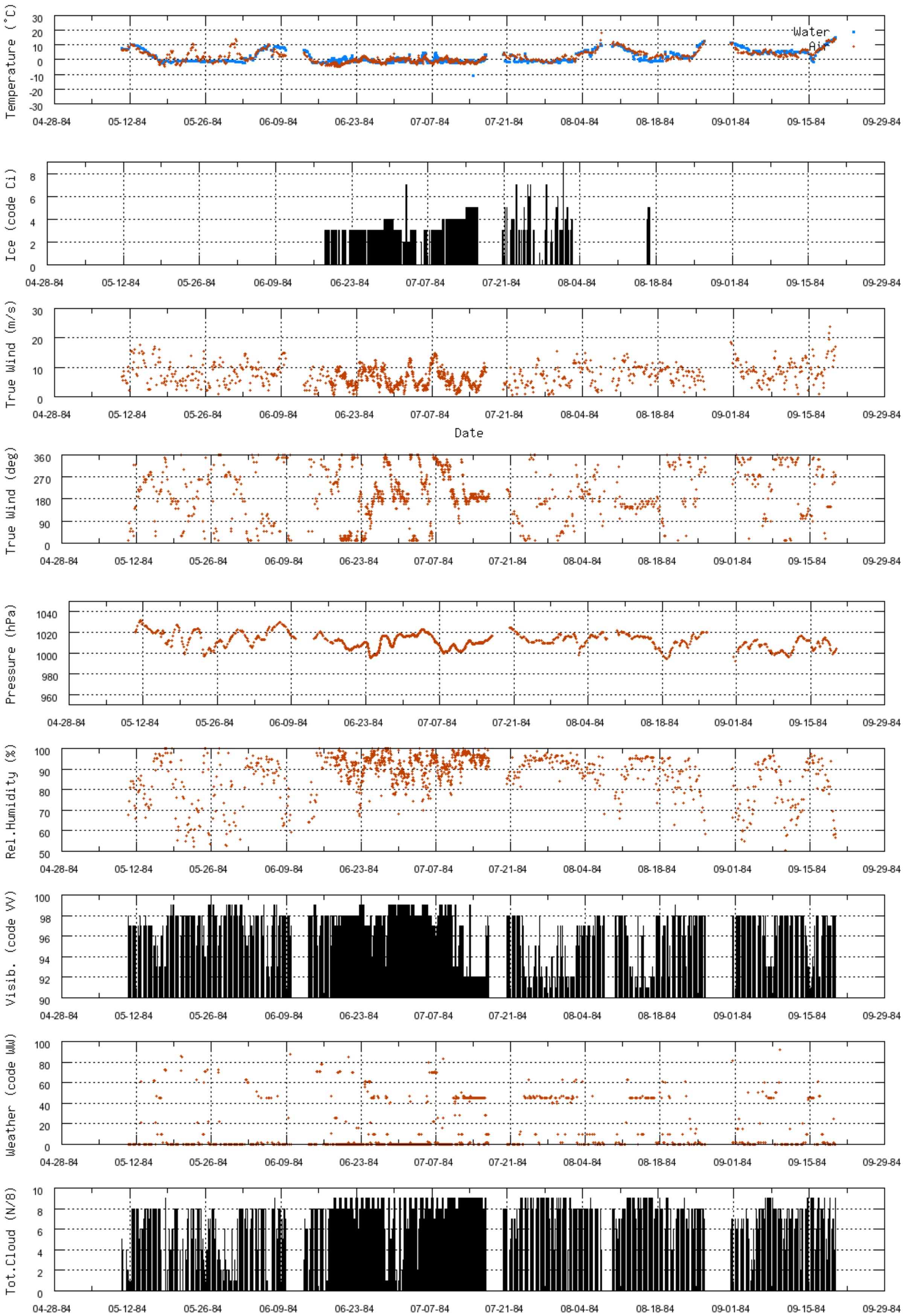

Fig. 62: Time series from ARK-II based on the 3-hourly synoptic observations

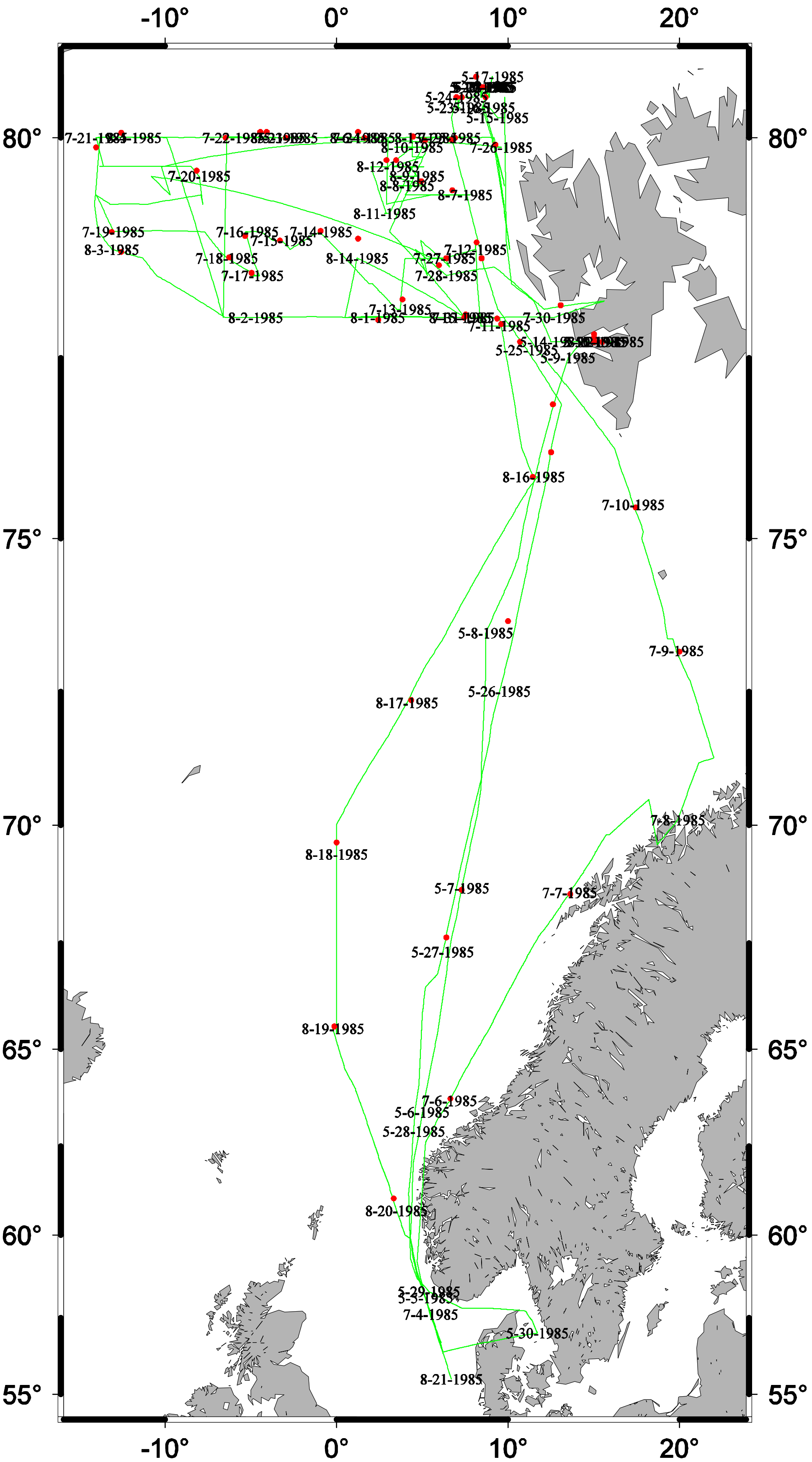

Fig. 63: Cruise track from ARK-III based on the 3-hourly synoptic observations.
Dots denote upper air soundings

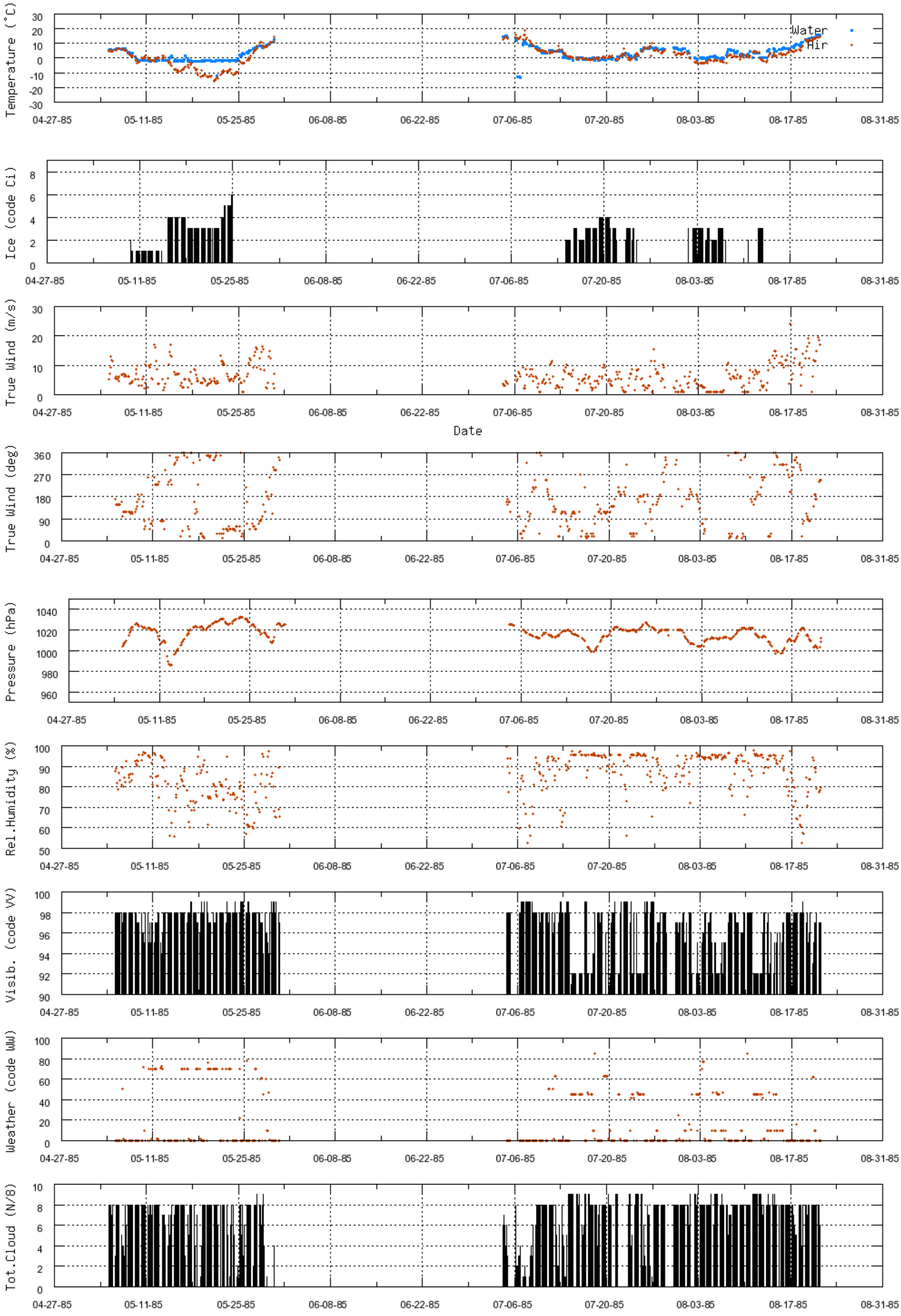

Fig. 64: Time series from ARK-III based on the 3-hourly synoptic observations

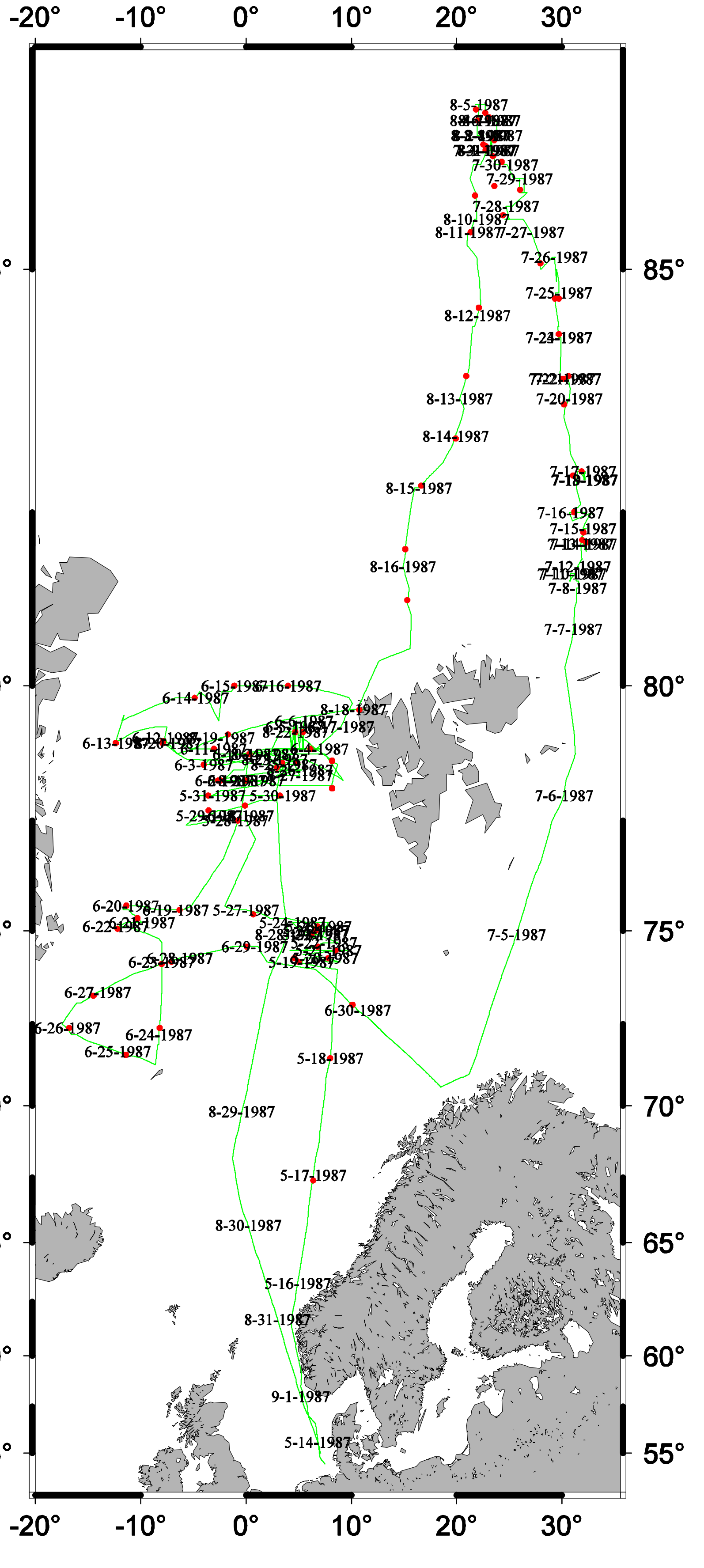

Fig. 65: Cruise track from ARK-IV based on the 3-hourly synoptic observations. Dots denote upper air soundings

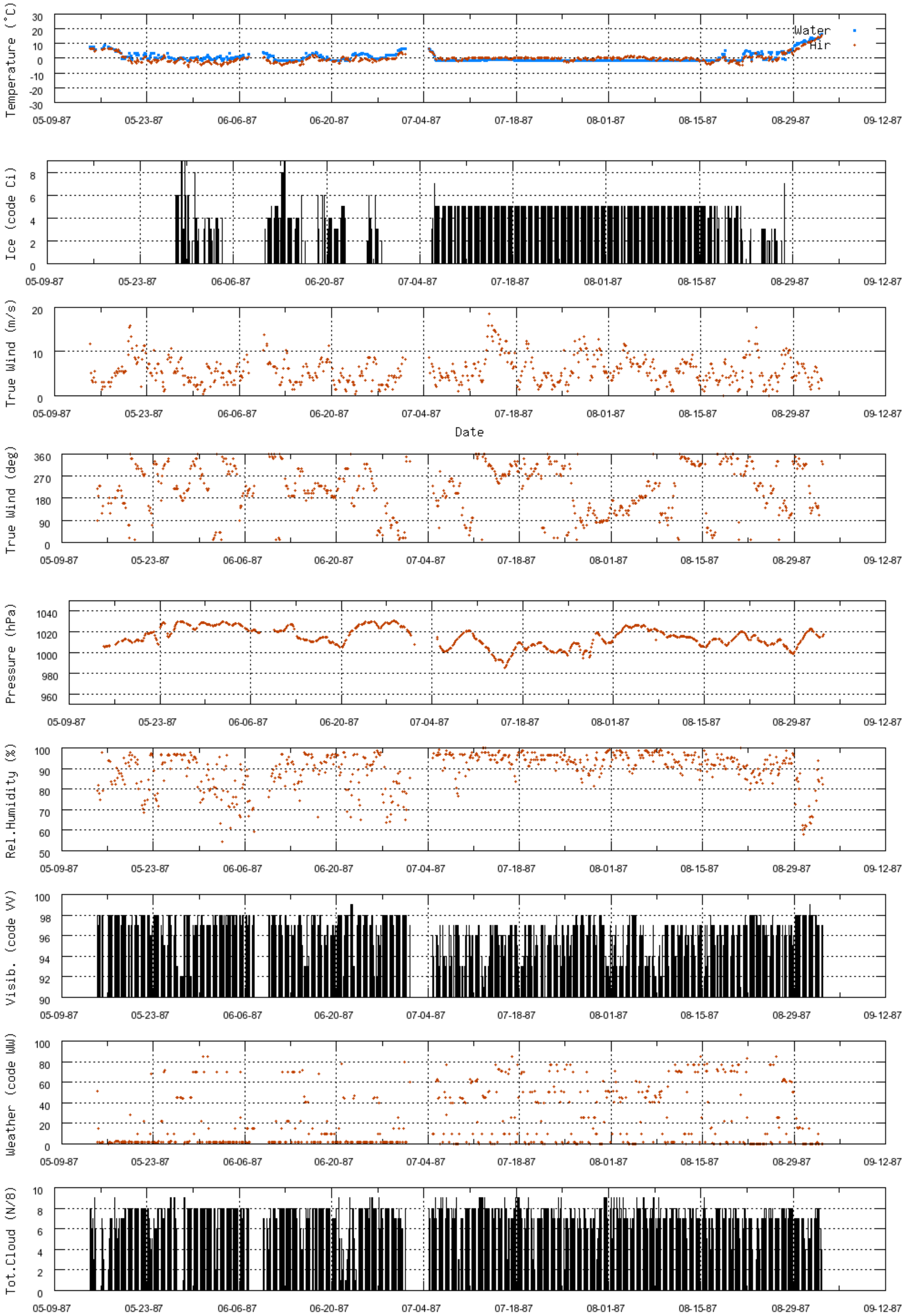

Fig. 66: Time series from ARK-IV based on the 3-hourly synoptic observations

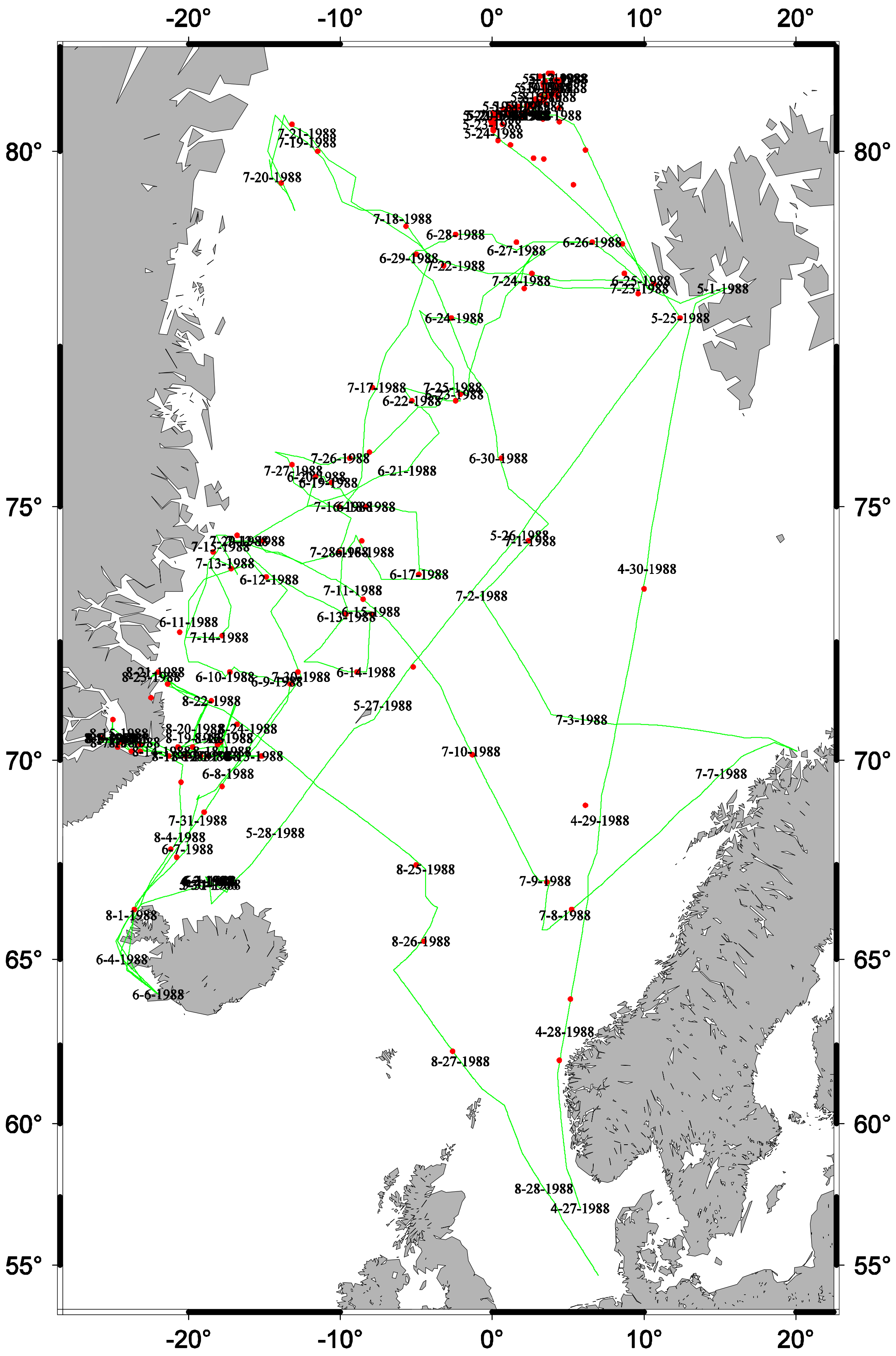

Fig. 67: Cruise track from ARK-V based on the 3-hourly synoptic observations.
Dots denote upper air soundings

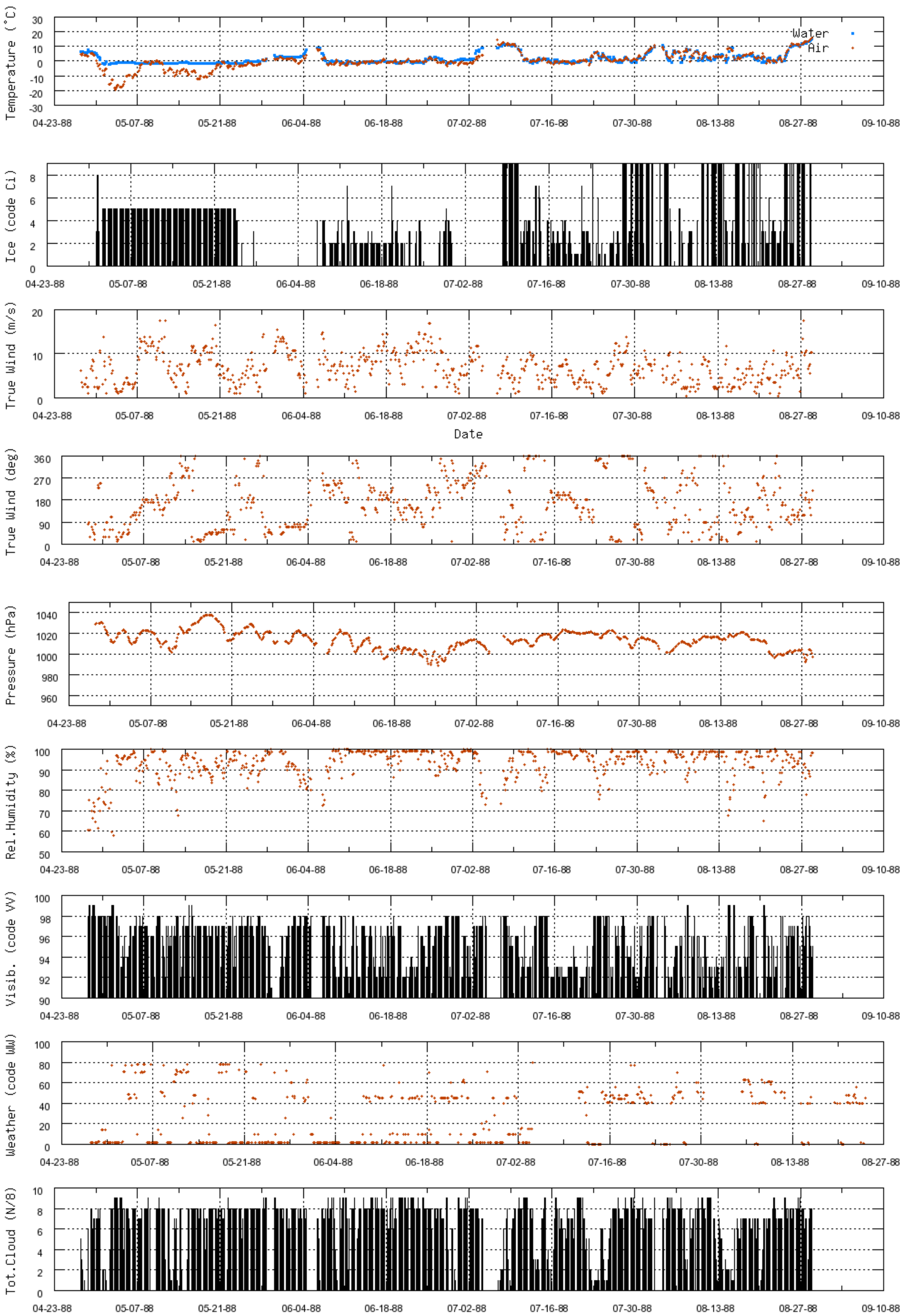

Fig. 68: Time series from ARK-V based on the 3-hourly synoptic observations

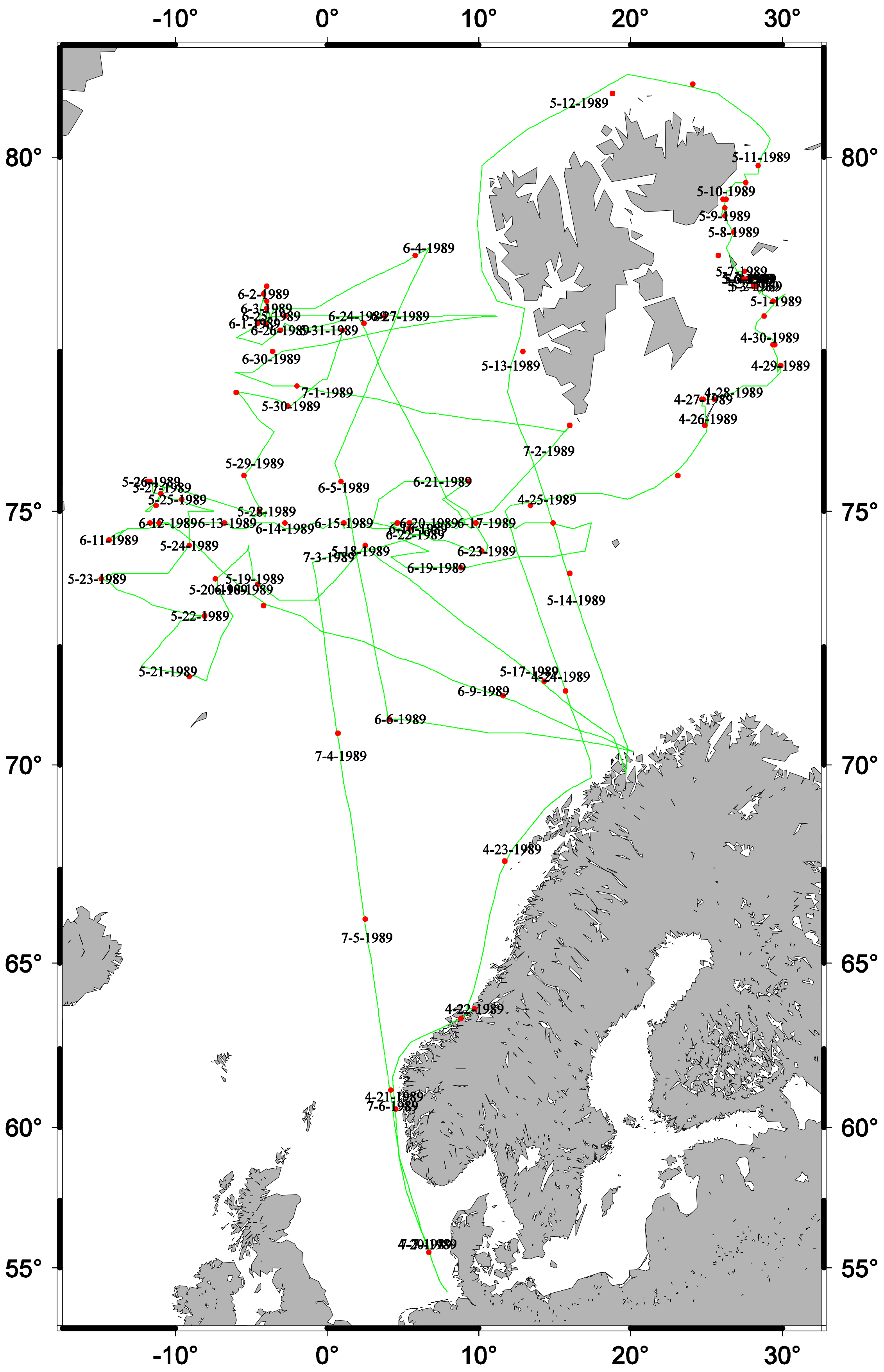

Fig. 69: Cruise track from ARK-VI based on the 3-hourly synoptic observations. Dots denote upper air soundings

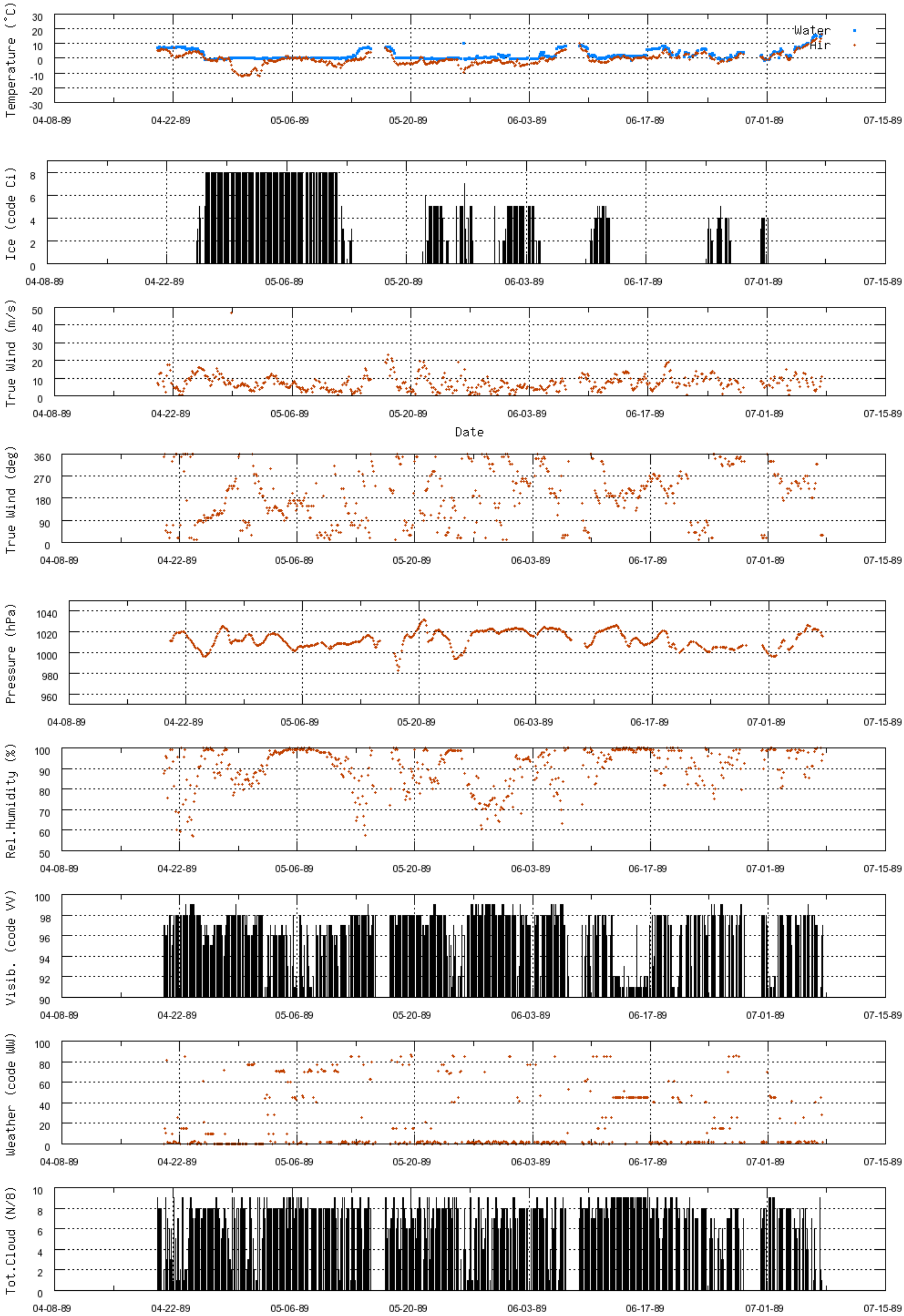

Fig. 70: Time series from ARK-VI based on the 3-hourly synoptic observations

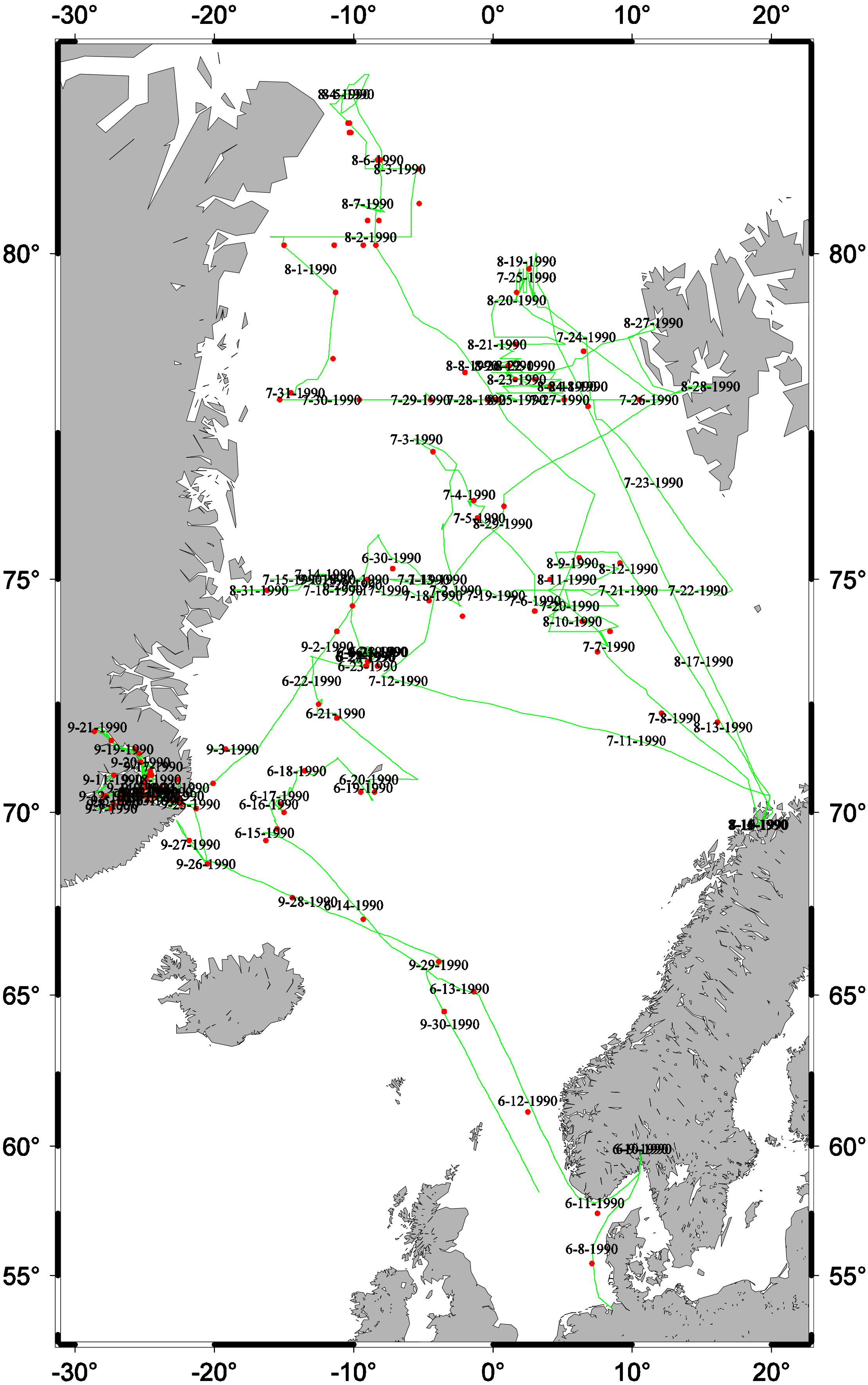

Fig. 71: Cruise track from ARK-VII based on the 3-hourly synoptic observations. Dots denote upper air soundings

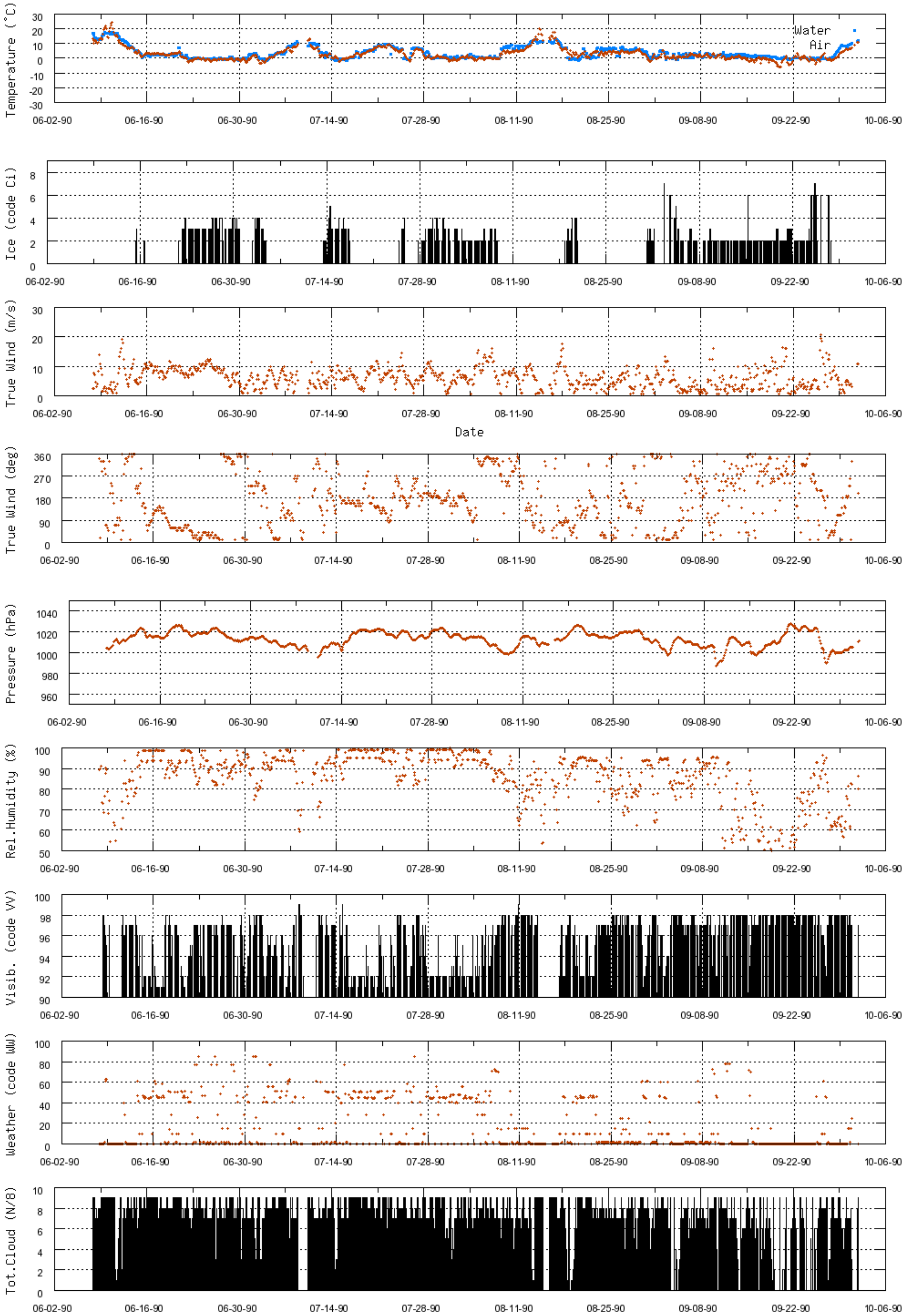

Fig. 72: Time series from ARK-VII based on the 3-hourly synoptic observations

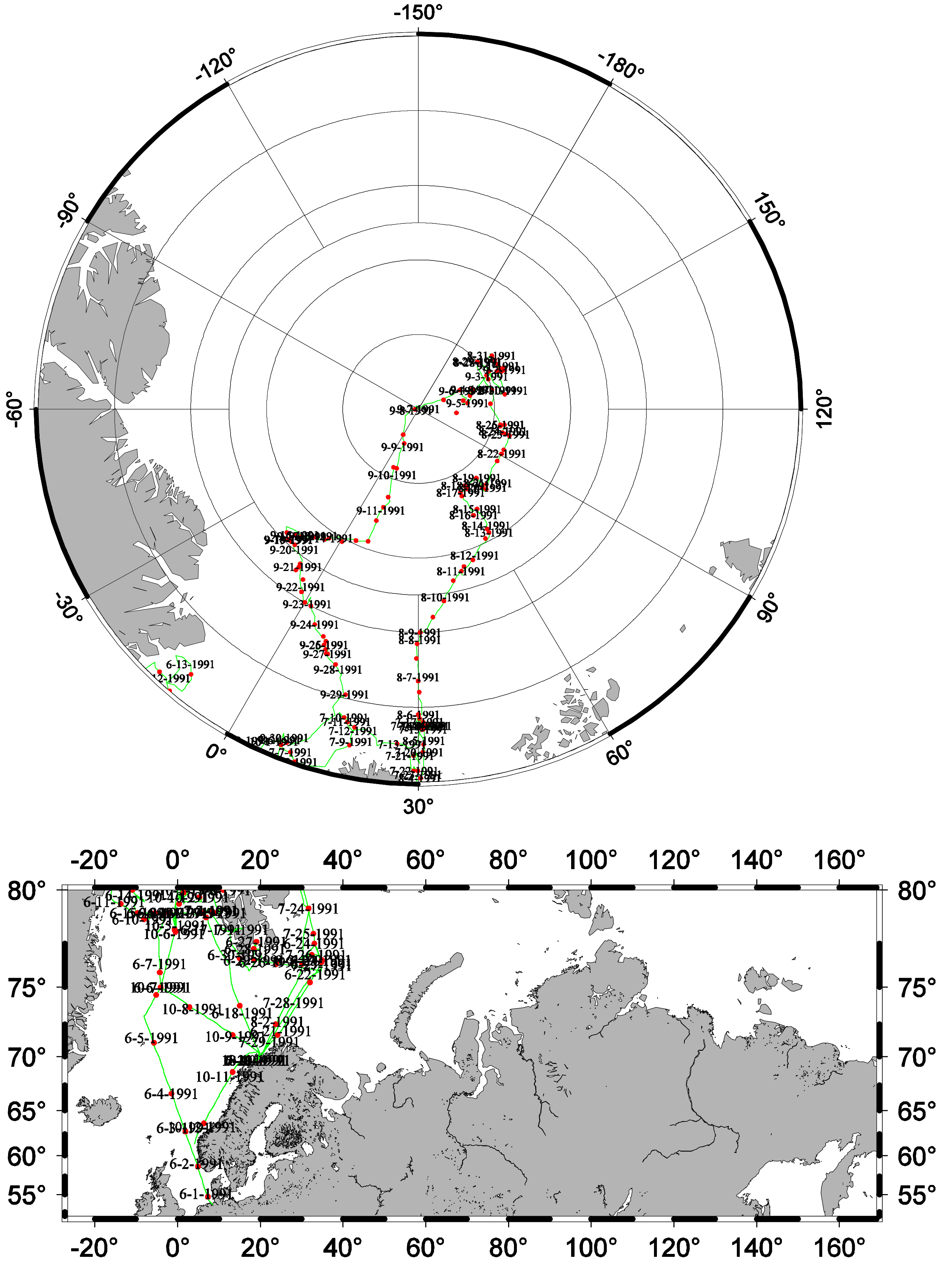

Fig. 73: Cruise track from ARK-VIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

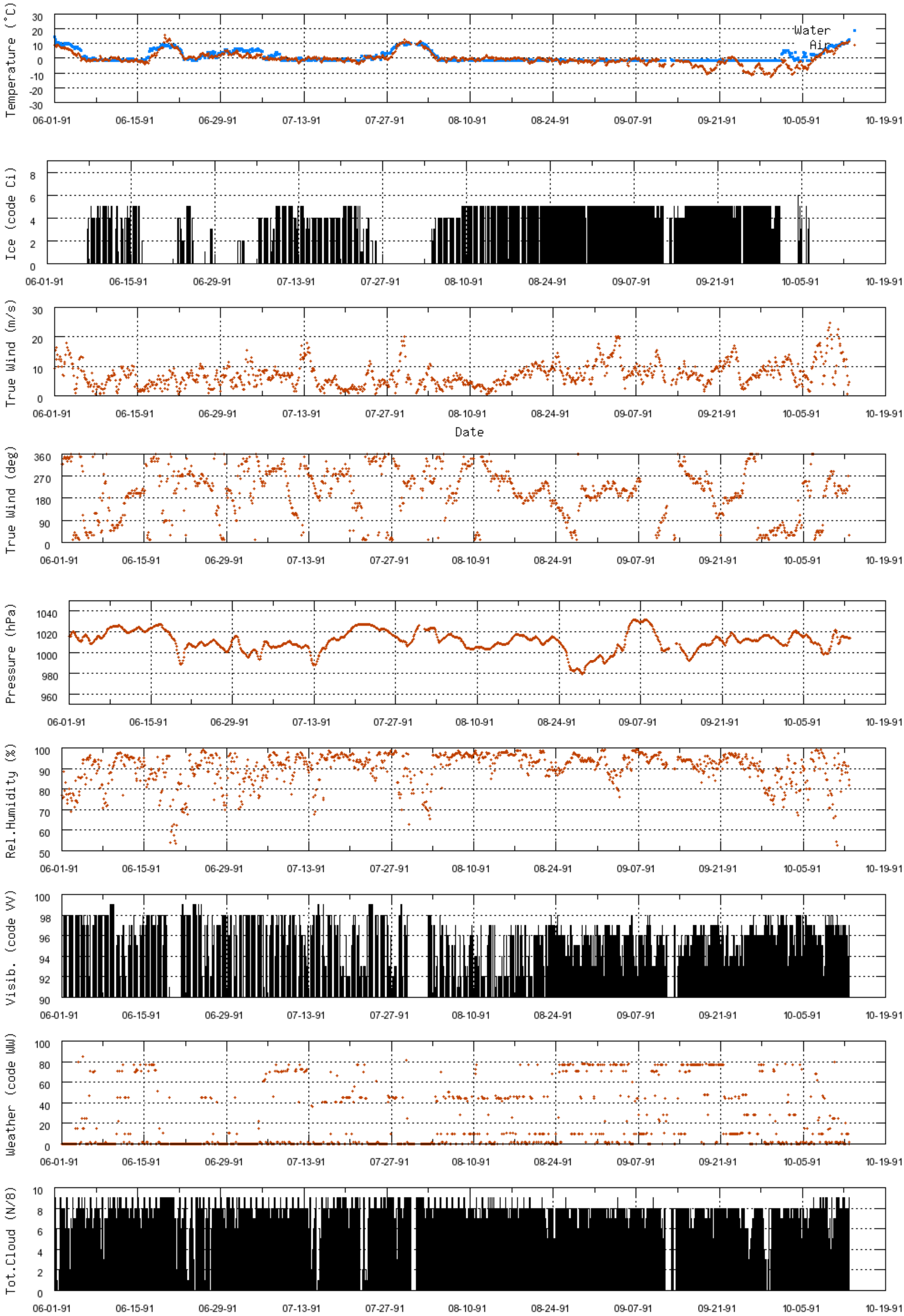

Fig. 74: Time series from ARK-VIII based on the 3-hourly synoptic observations

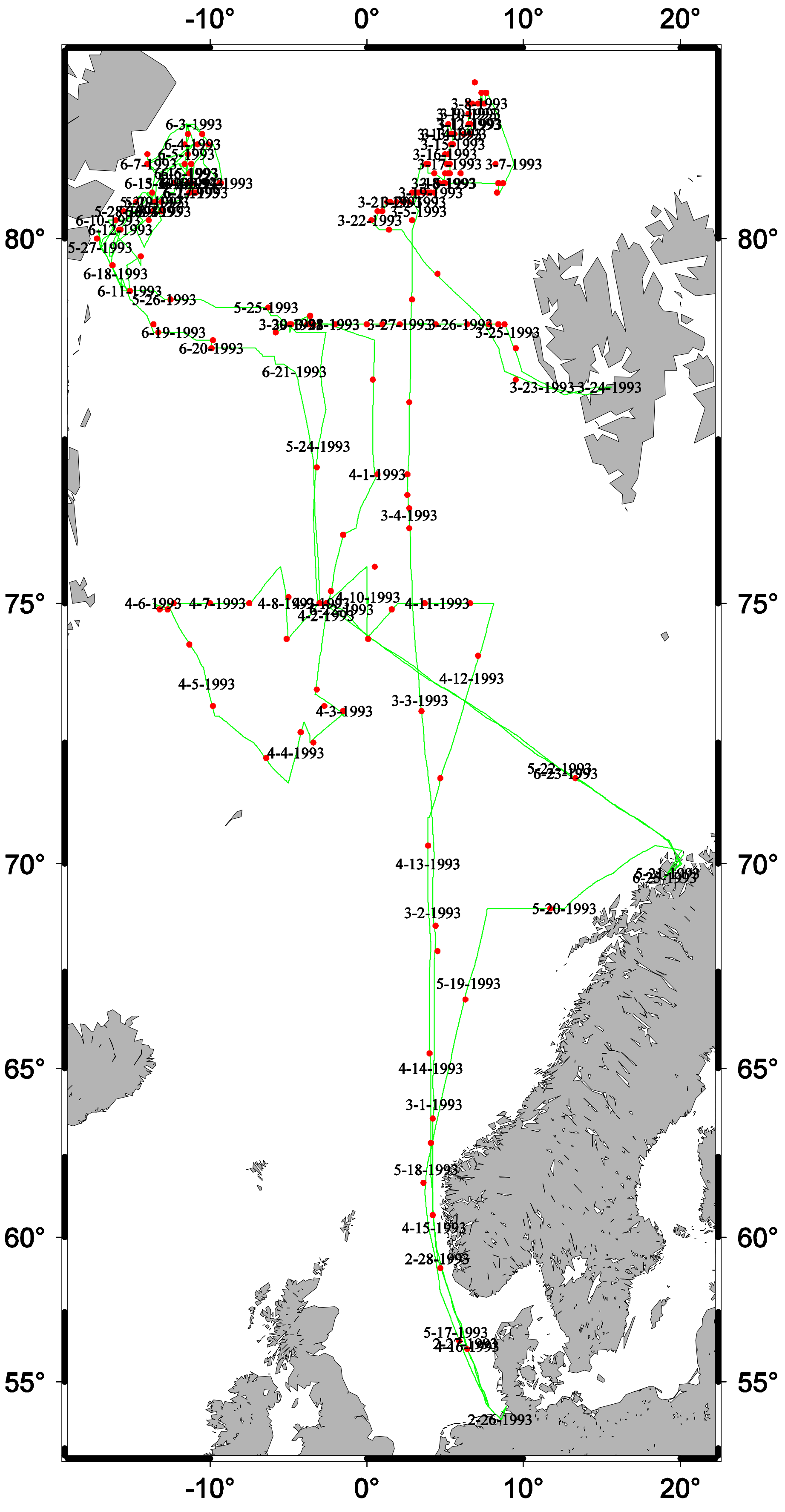

Fig. 75: Cruise track from ARK-IX/1,2 based on the 3-hourly synoptic observations.
Dots denote upper air soundings

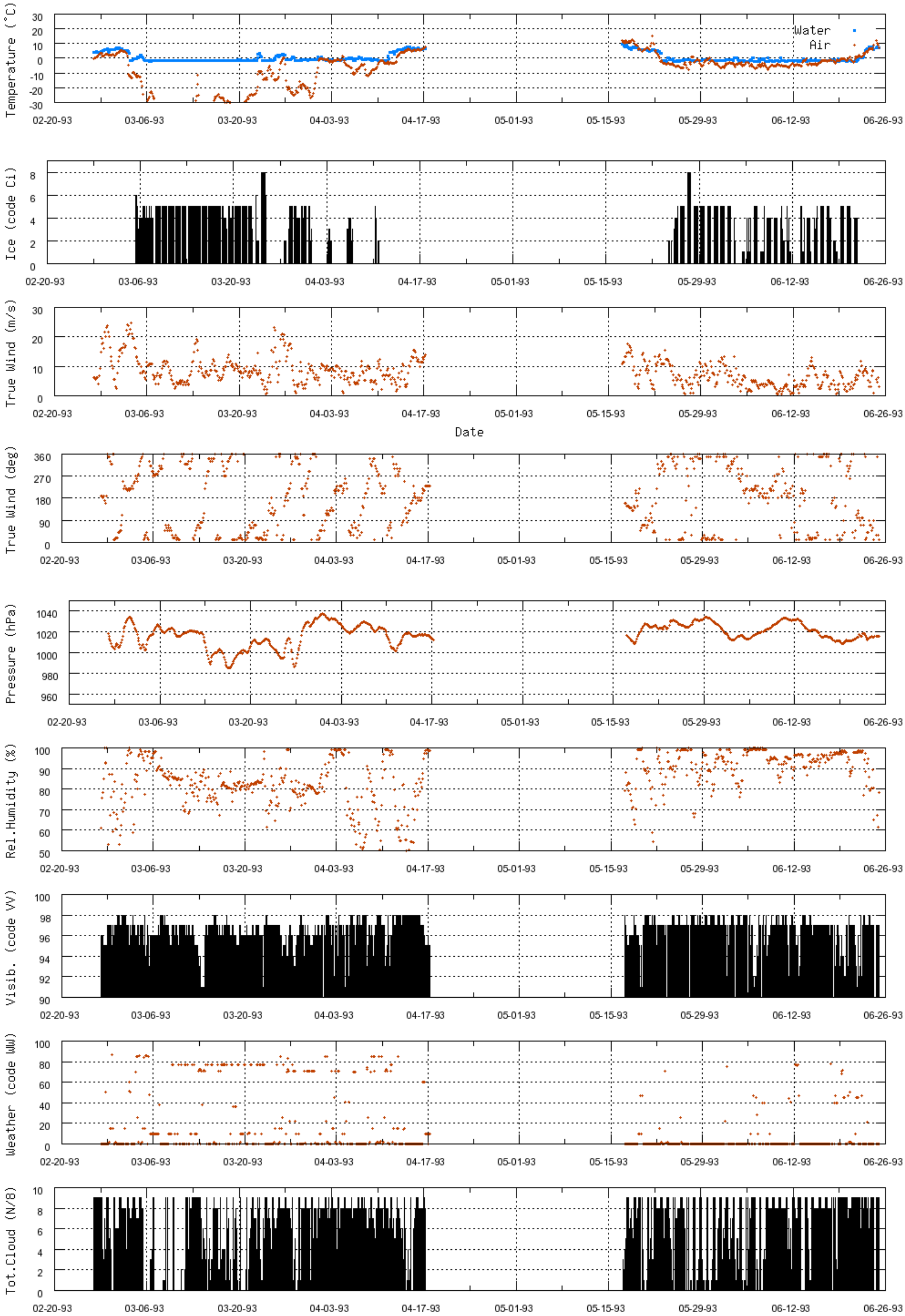

Fig. 76: Time series from ARK-IX/1,2 based on the 3-hourly synoptic observations

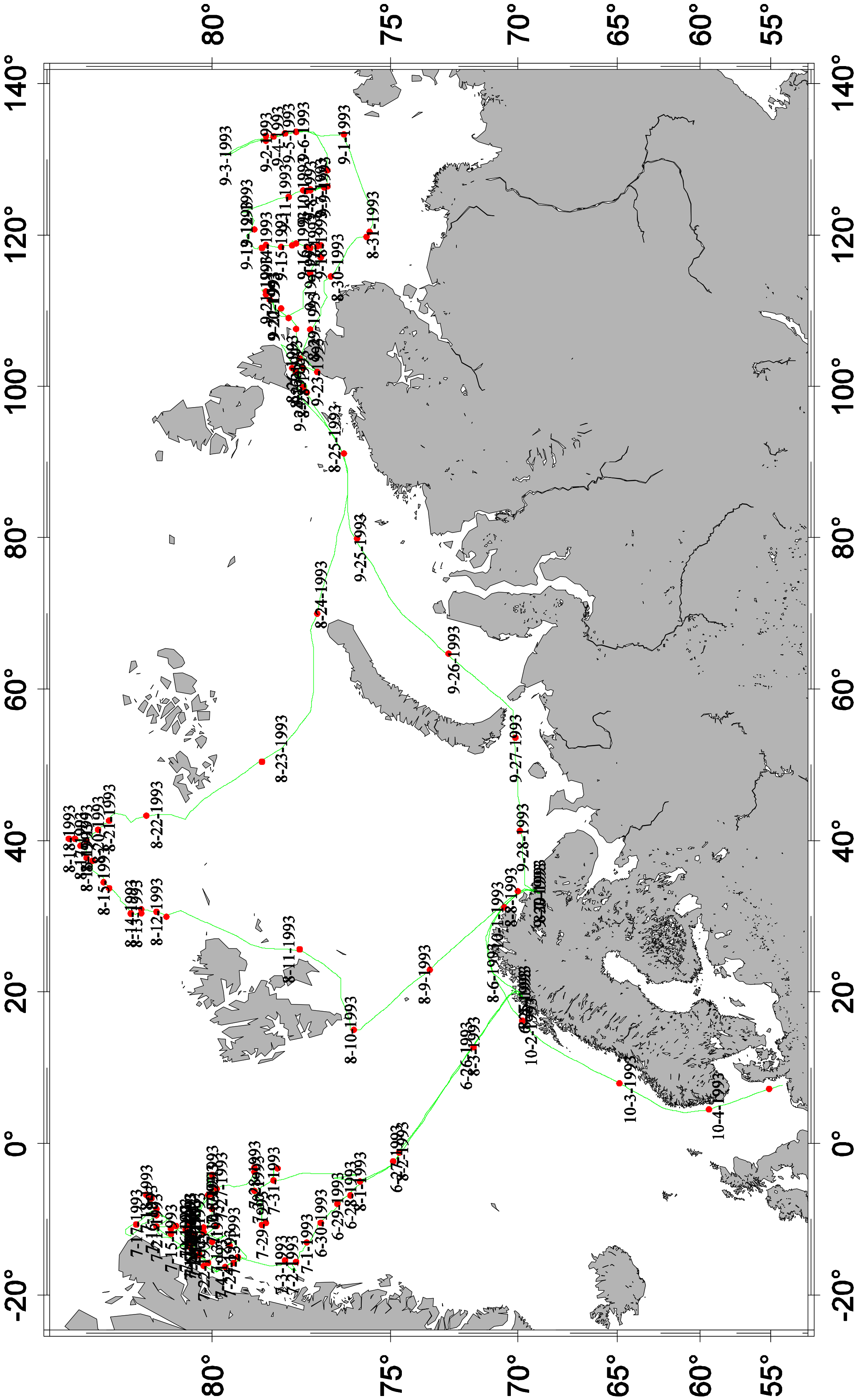

Fig. 77: Cruise track from ARK-IX/3,4 based on the 3-hourly synoptic observations. Dots denote upper air soundings

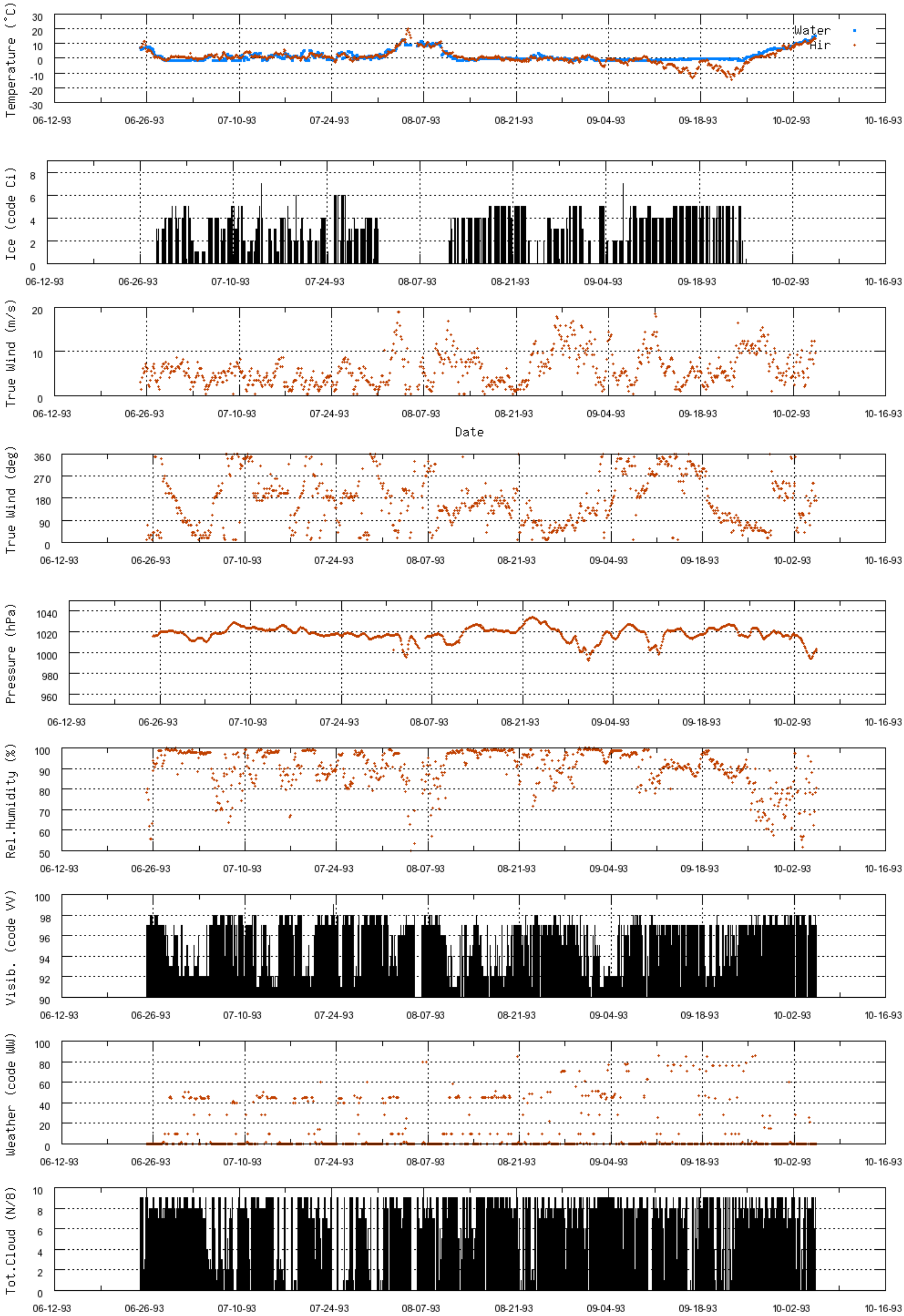

Fig. 78: Time series from ARK-IX/3,4 based on the 3-hourly synoptic observations

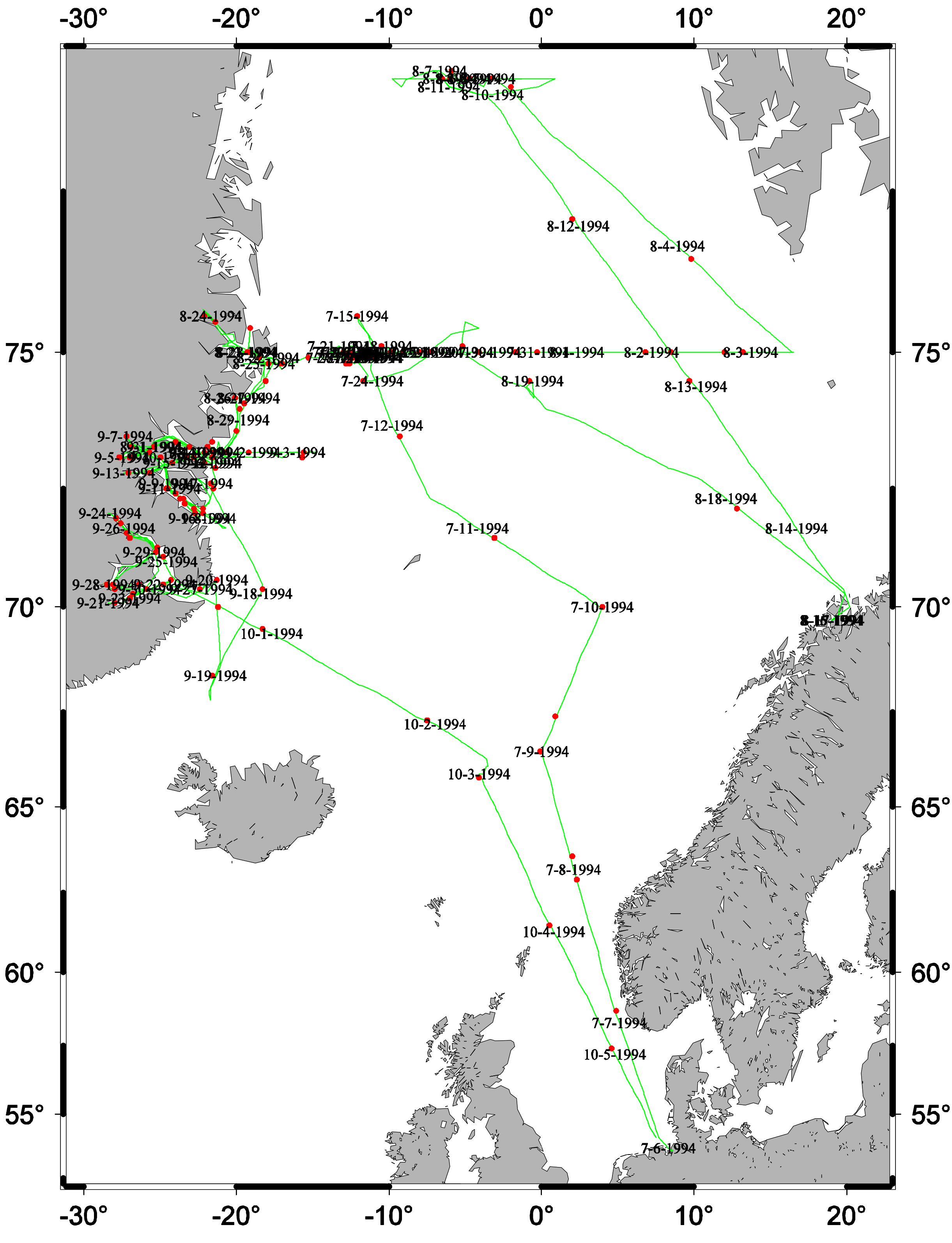

Fig. 79: Cruise track from ARK-X based on the 3-hourly synoptic observations
Dots denote upper air soundings

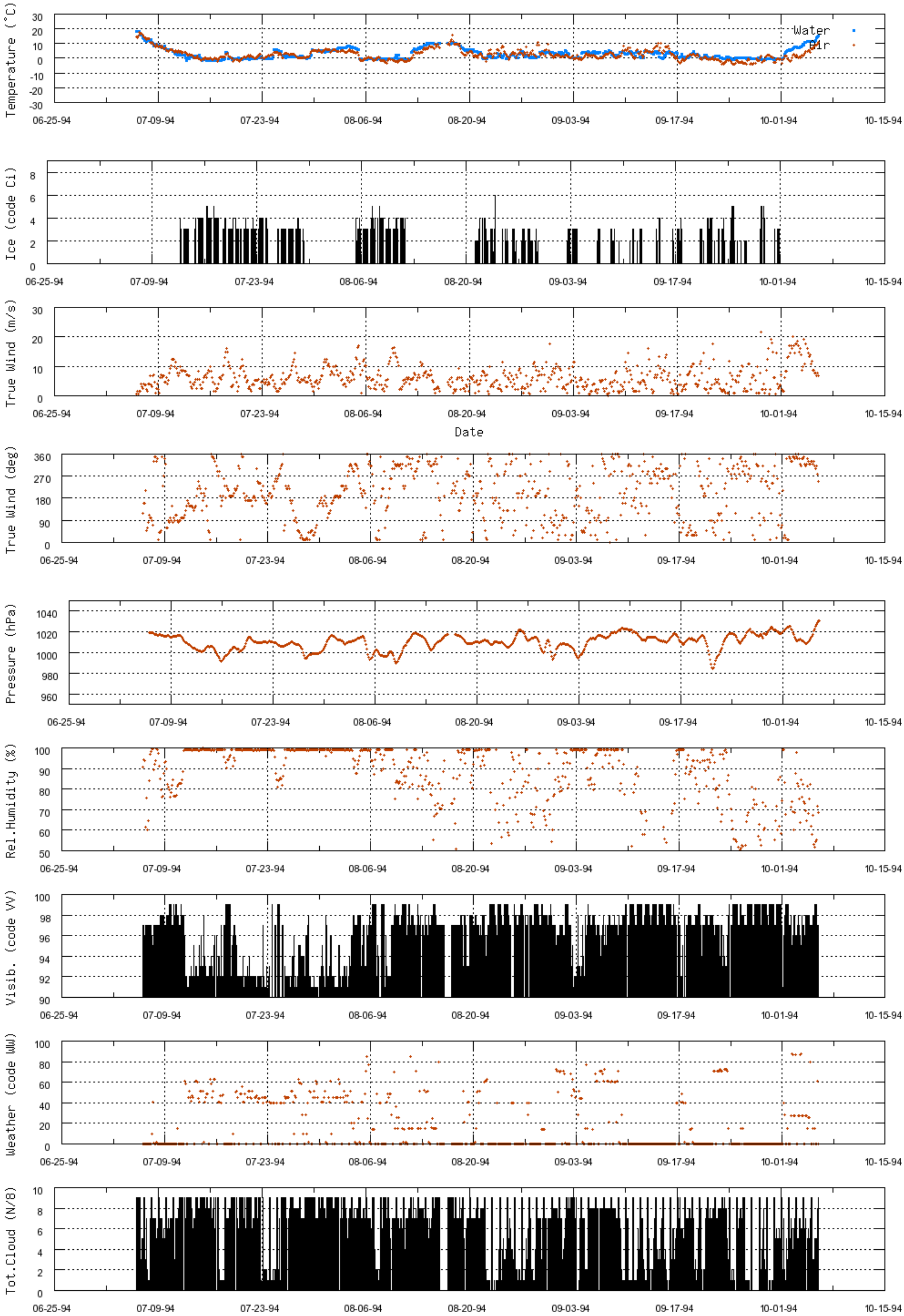

Fig. 80: Time series from ARK-X based on the 3-hourly synoptic observations

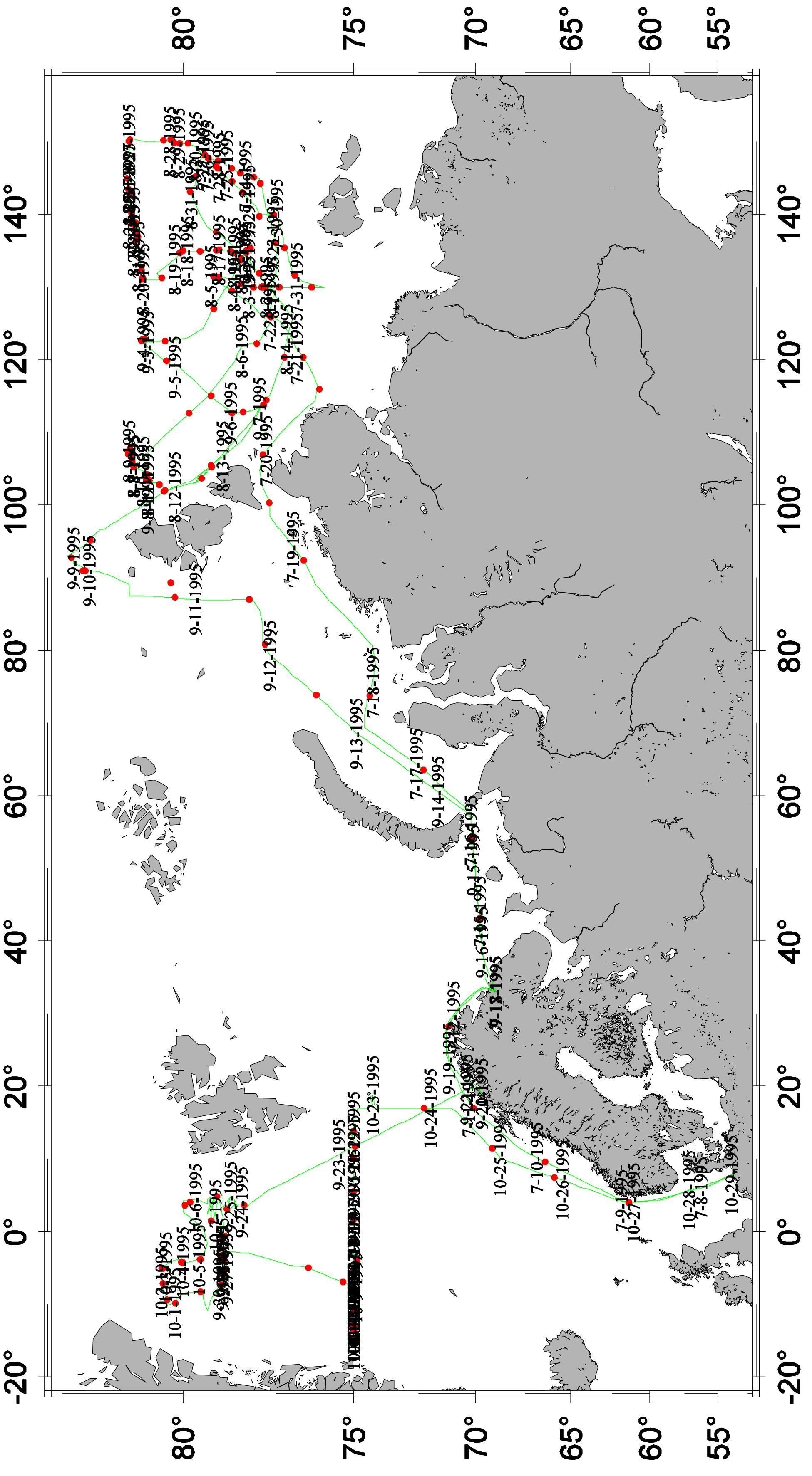

Fig. 81: Cruise track from ARK-XI based on the 3-hourly synoptic observations.

Dots denote upper air soundings

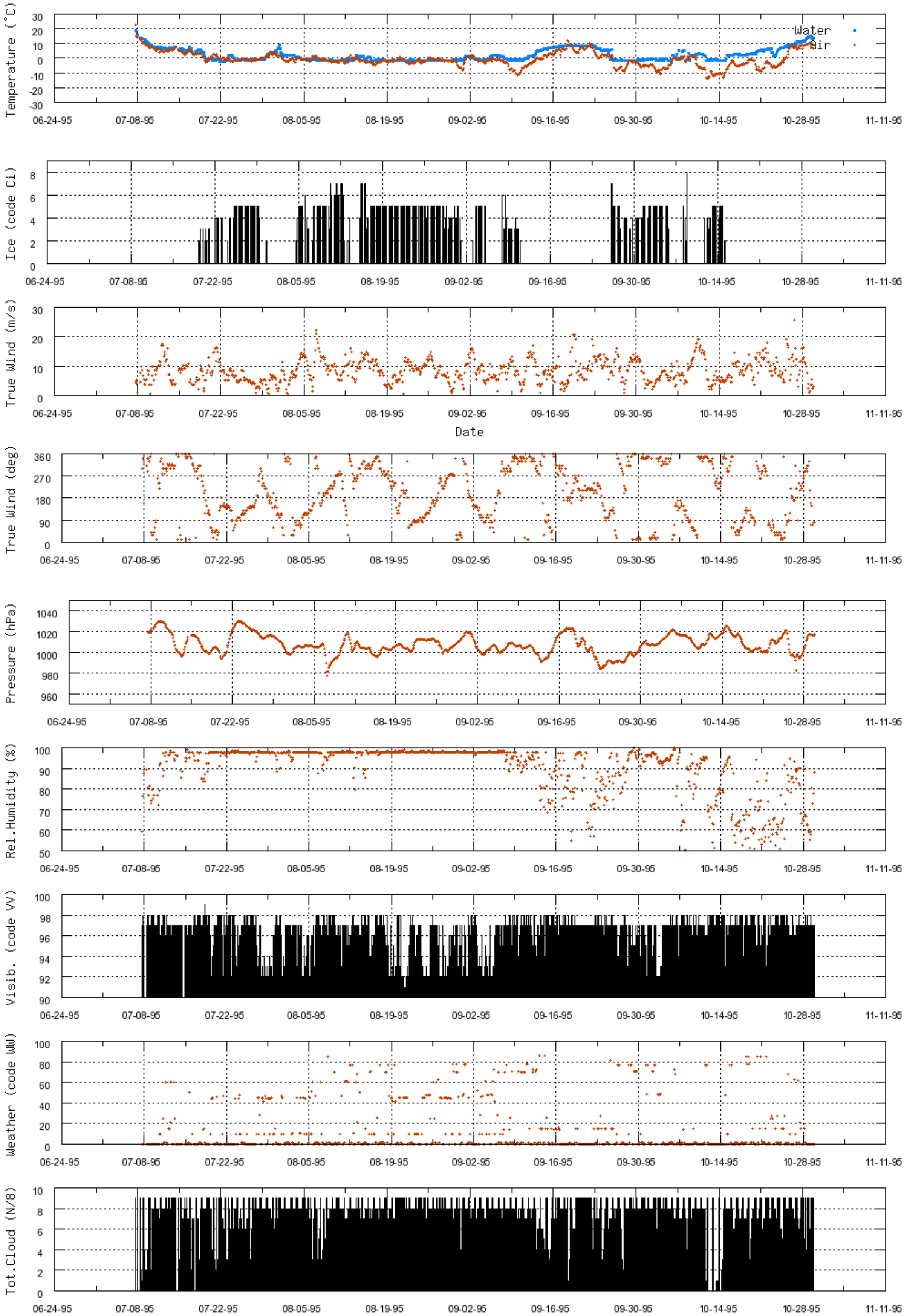

Fig. 82: Time series from ARK-XI based on the 3-hourly synoptic observations

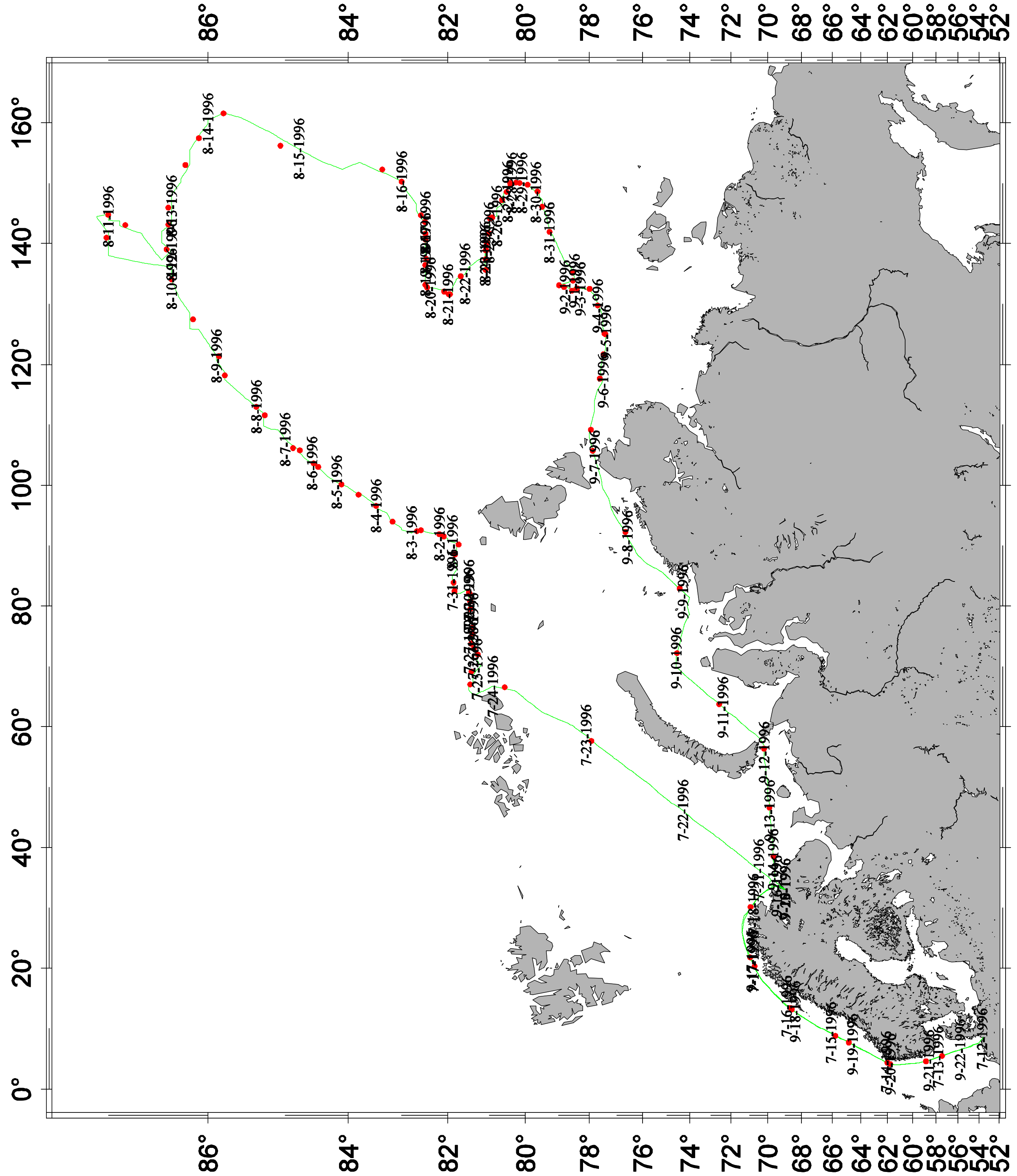

Fig. 83: Cruise track from ARK-XII based on the 3-hourly synoptic observations.
Dots denote upper air soundings

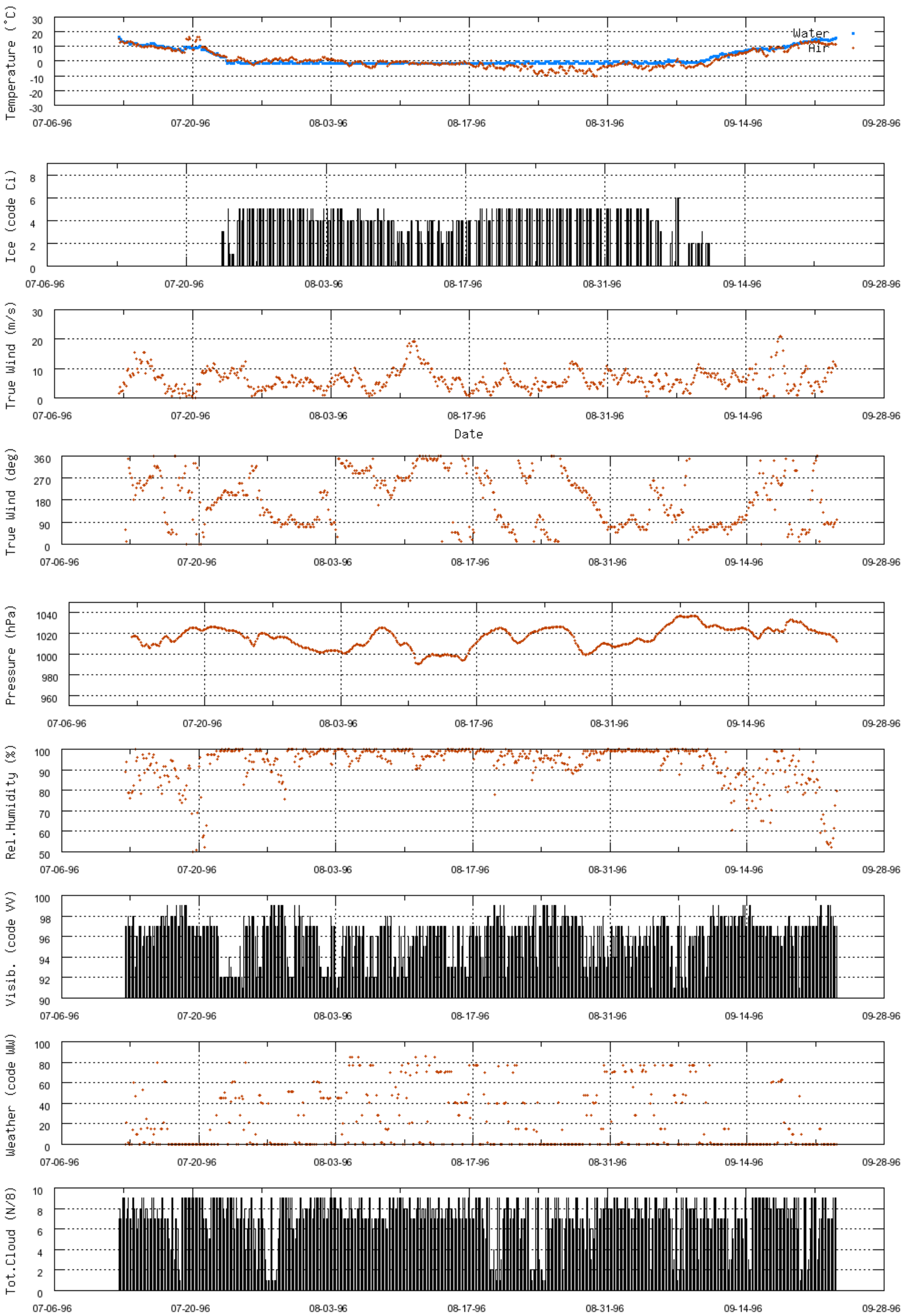

Fig. 84: Time series from ARK-XII based on the 3-hourly synoptic observations

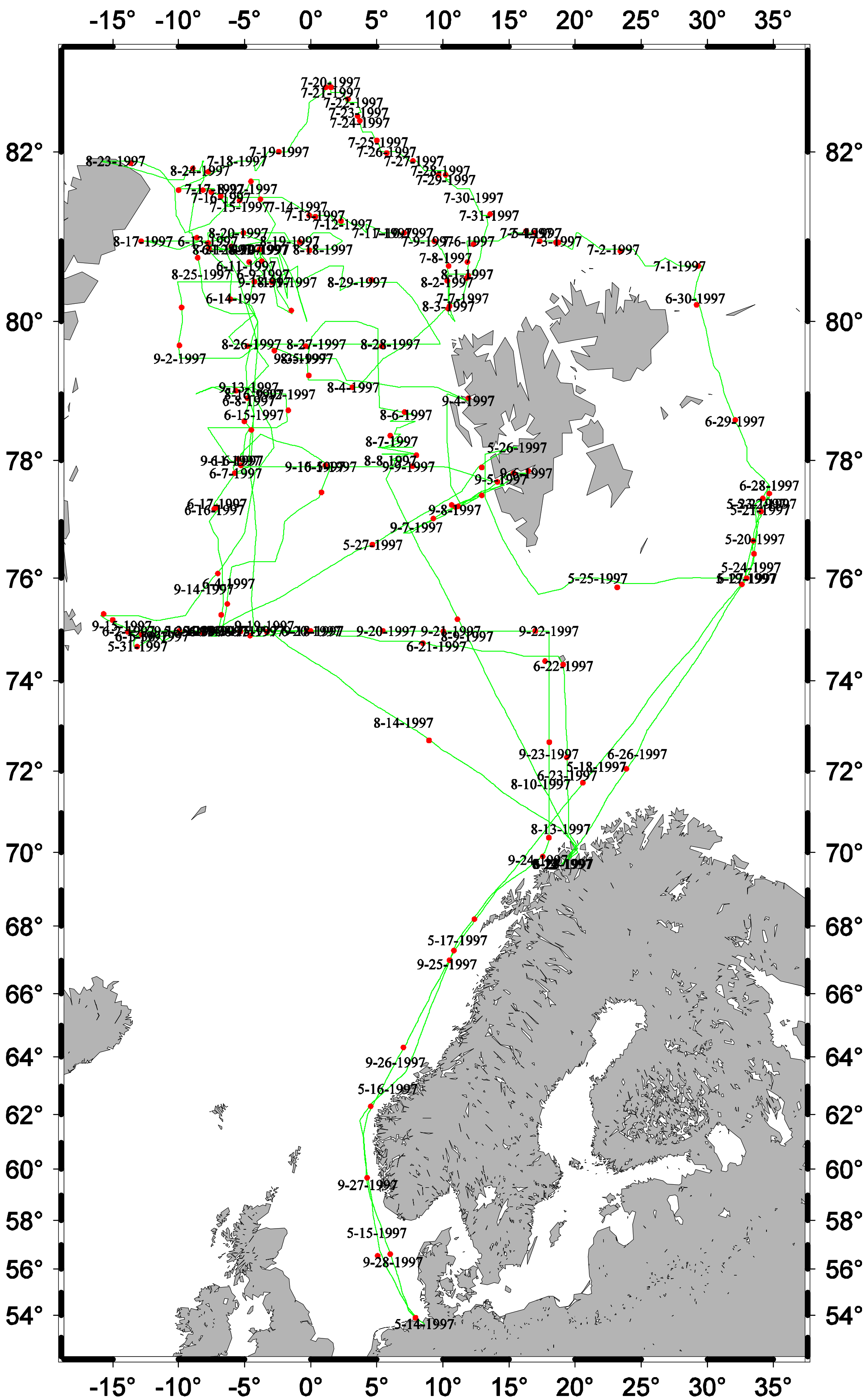

Fig. 85: Cruise track from ARK-XIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

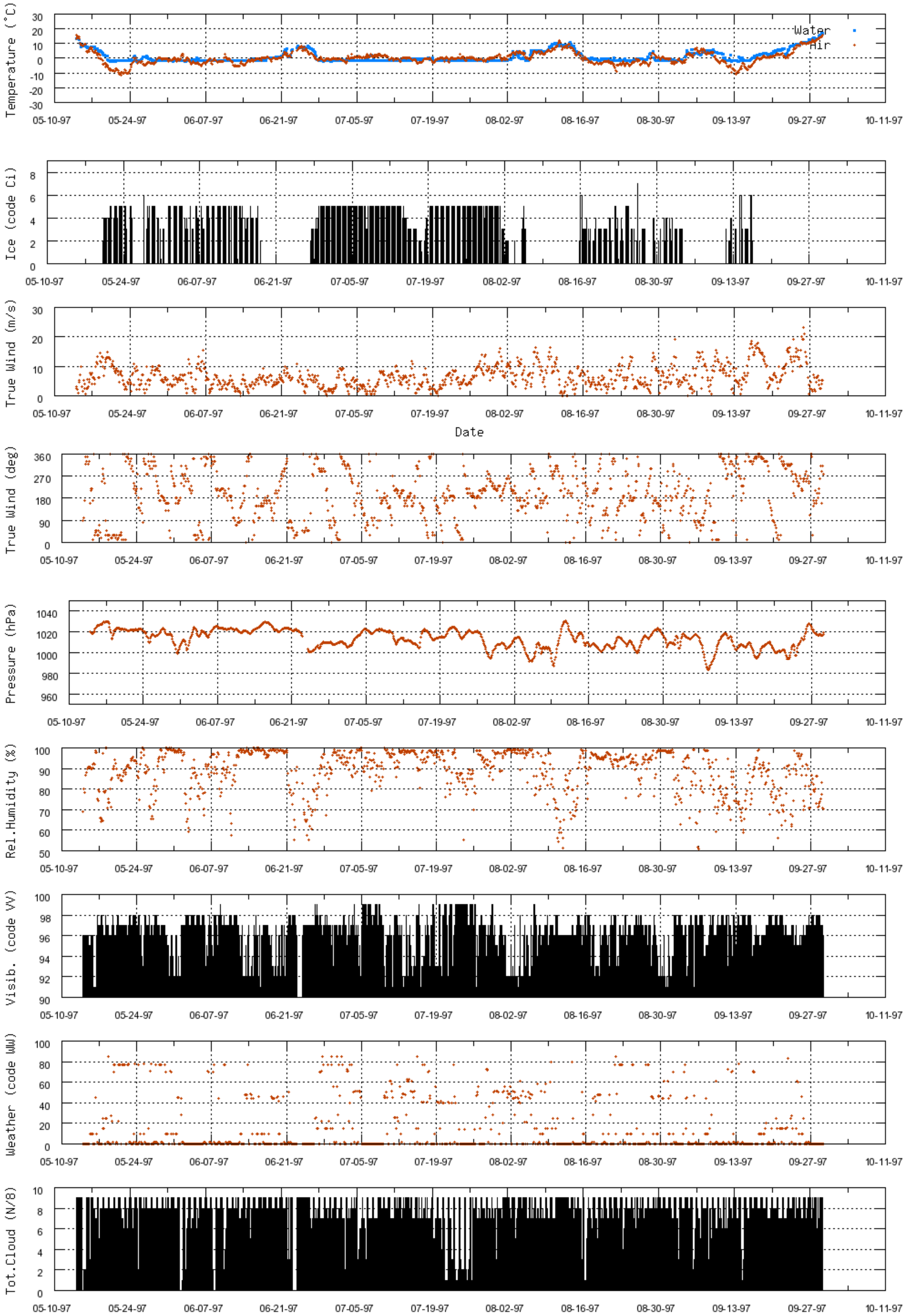

Fig. 86: Time series from ARK-XIII based on the 3-hourly synoptic observations

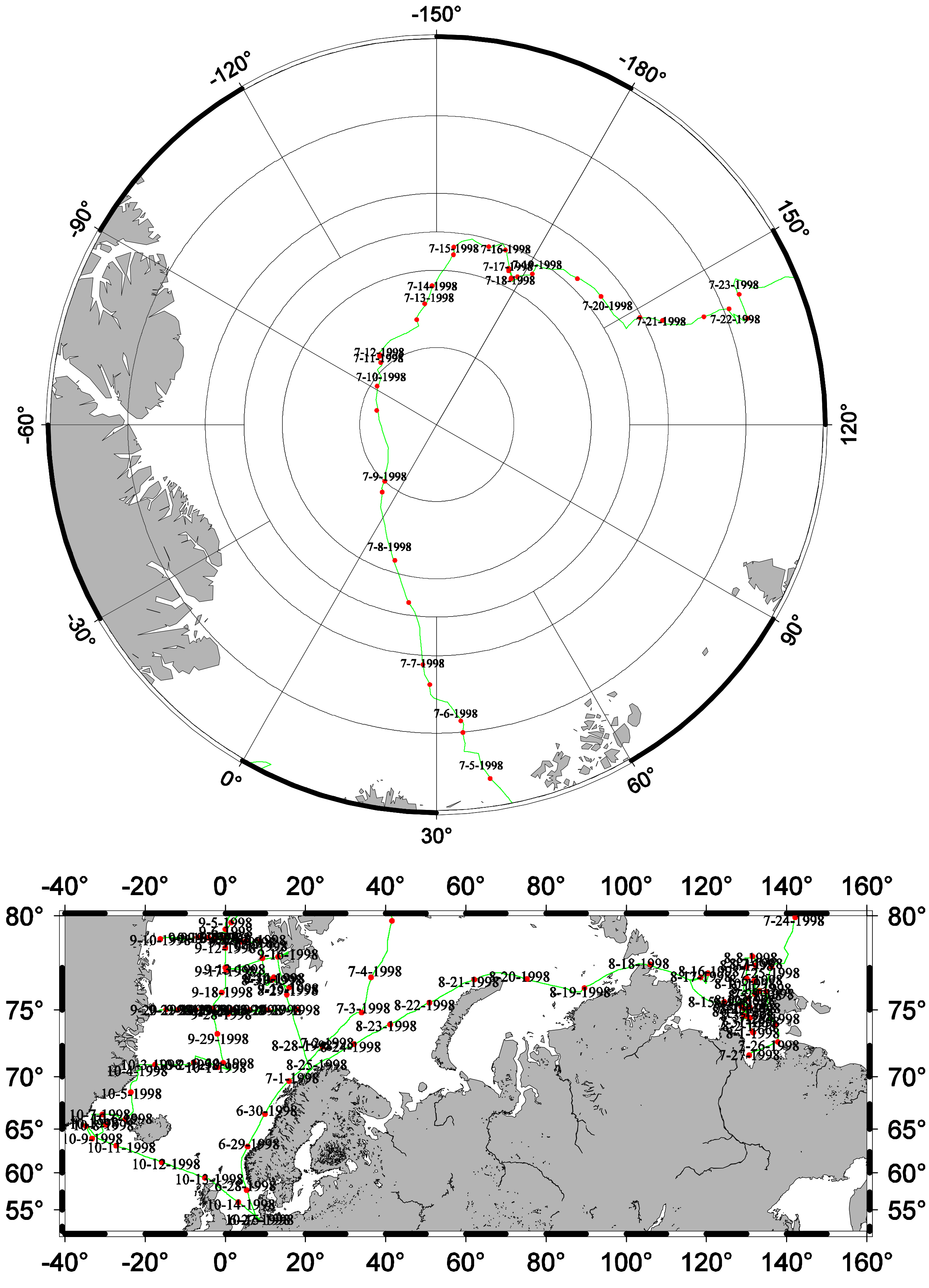

Fig. 87: Cruise track from ARK-XIV based on the 3-hourly synoptic observations. Dots denote upper air soundings

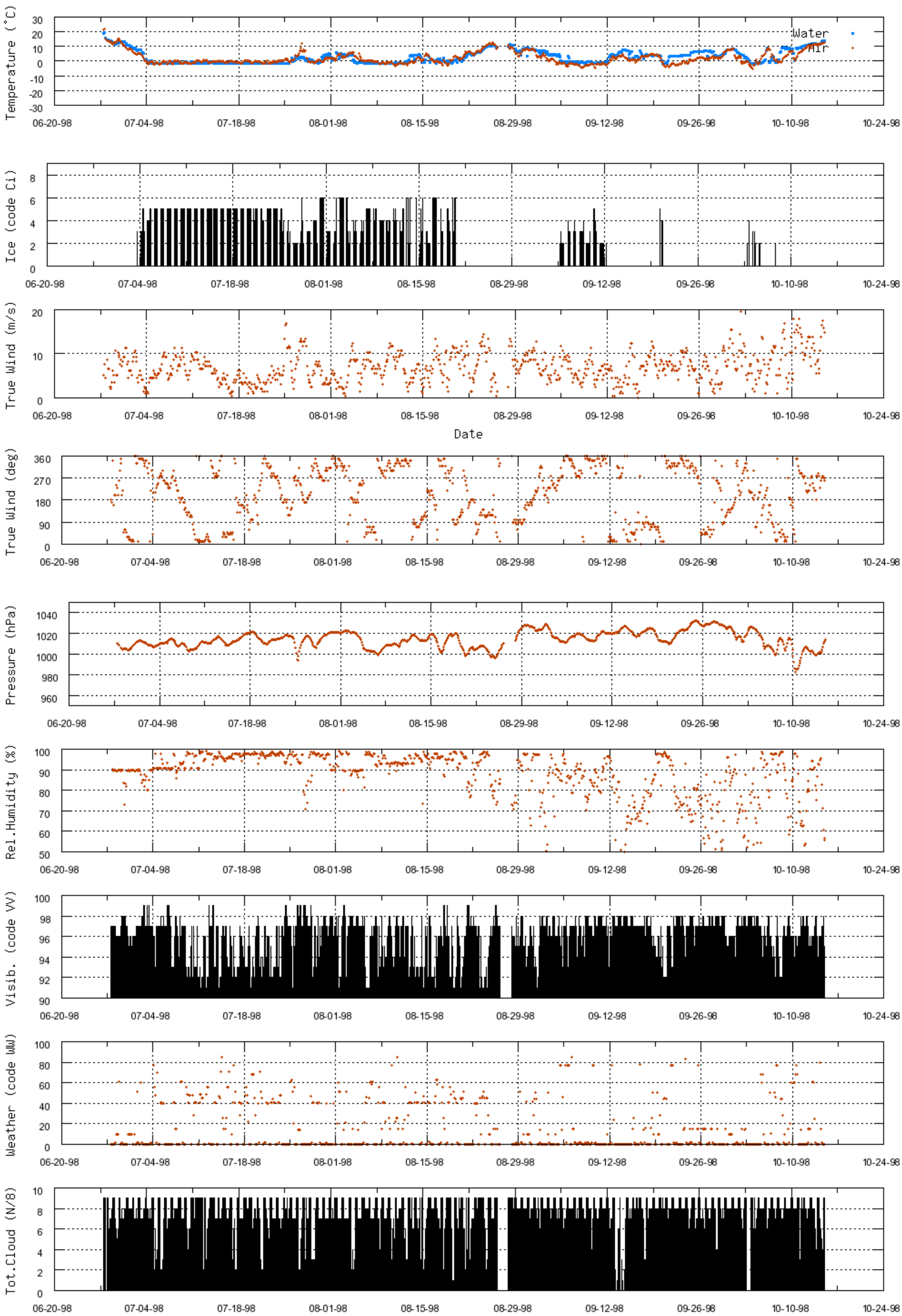

Fig. 88: Time series from ARK-XIV based on the 3-hourly synoptic observations

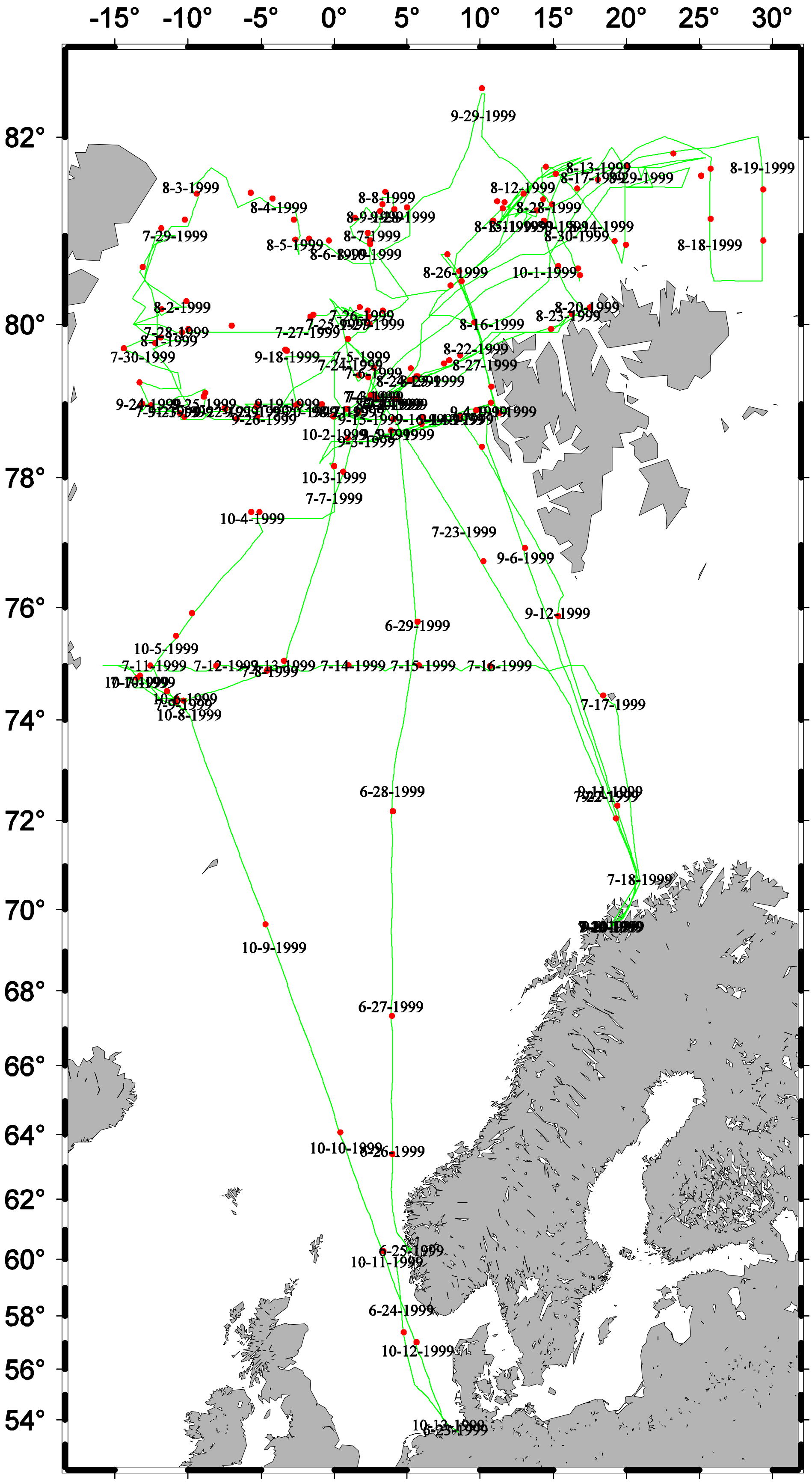

Fig. 89: Cruise track from ARK-XV based on the 3-hourly synoptic observations. Dots denote upper air soundings

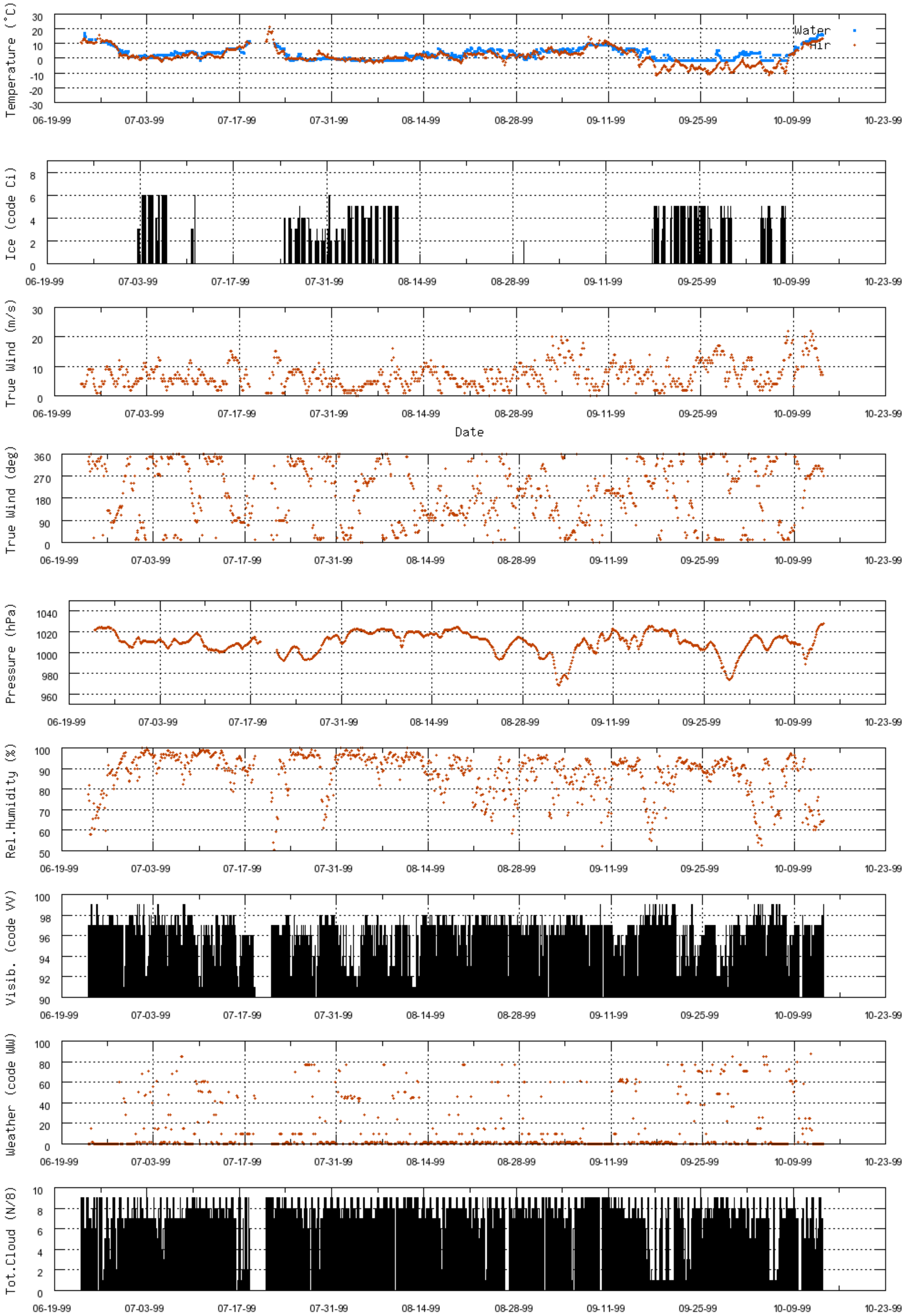

Fig. 90: Time series from ARK-XV based on the 3-hourly synoptic observations

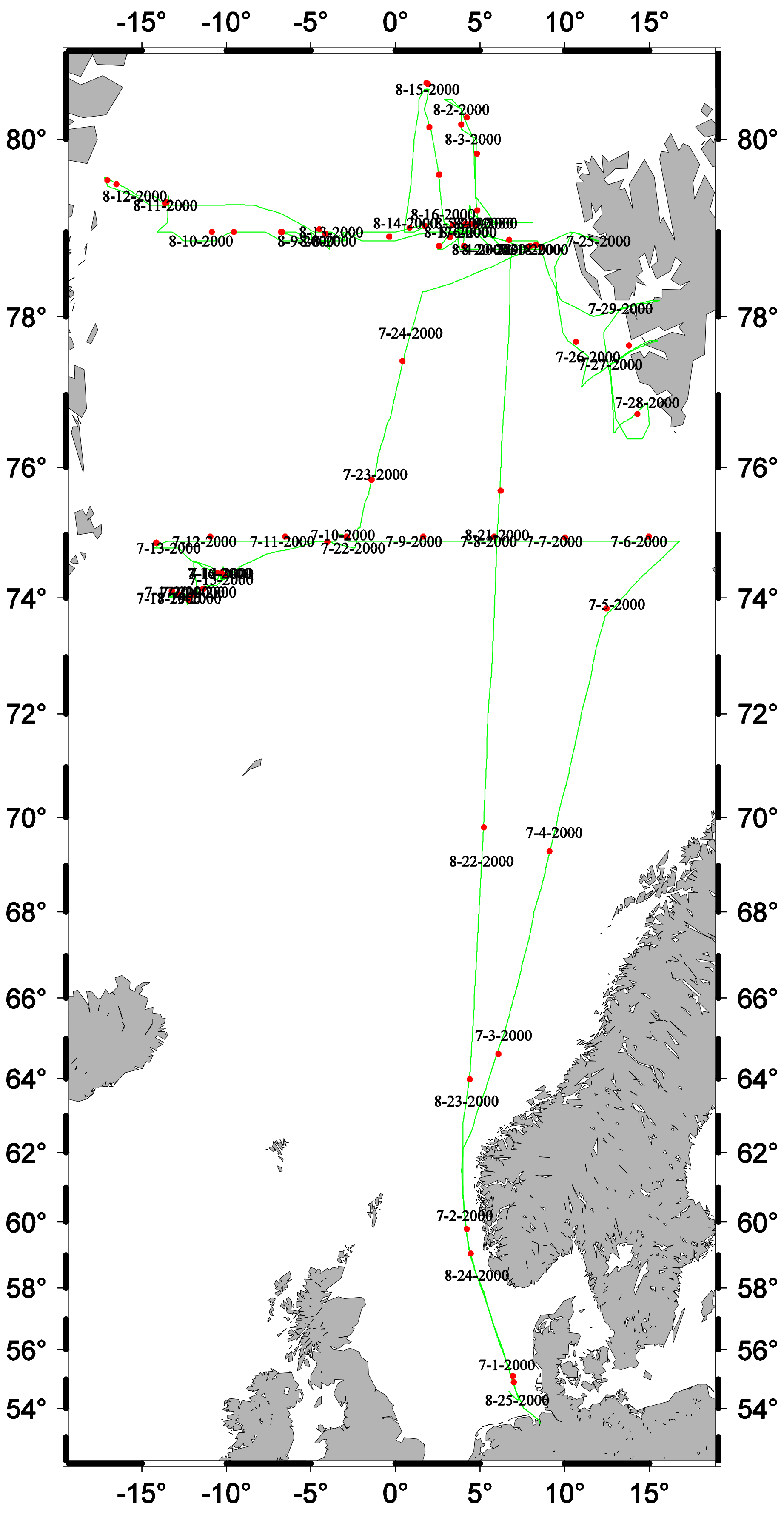

Fig. 91: Cruise track from ARK-XVI based on the 3-hourly synoptic observations.
Dots denote upper air soundings

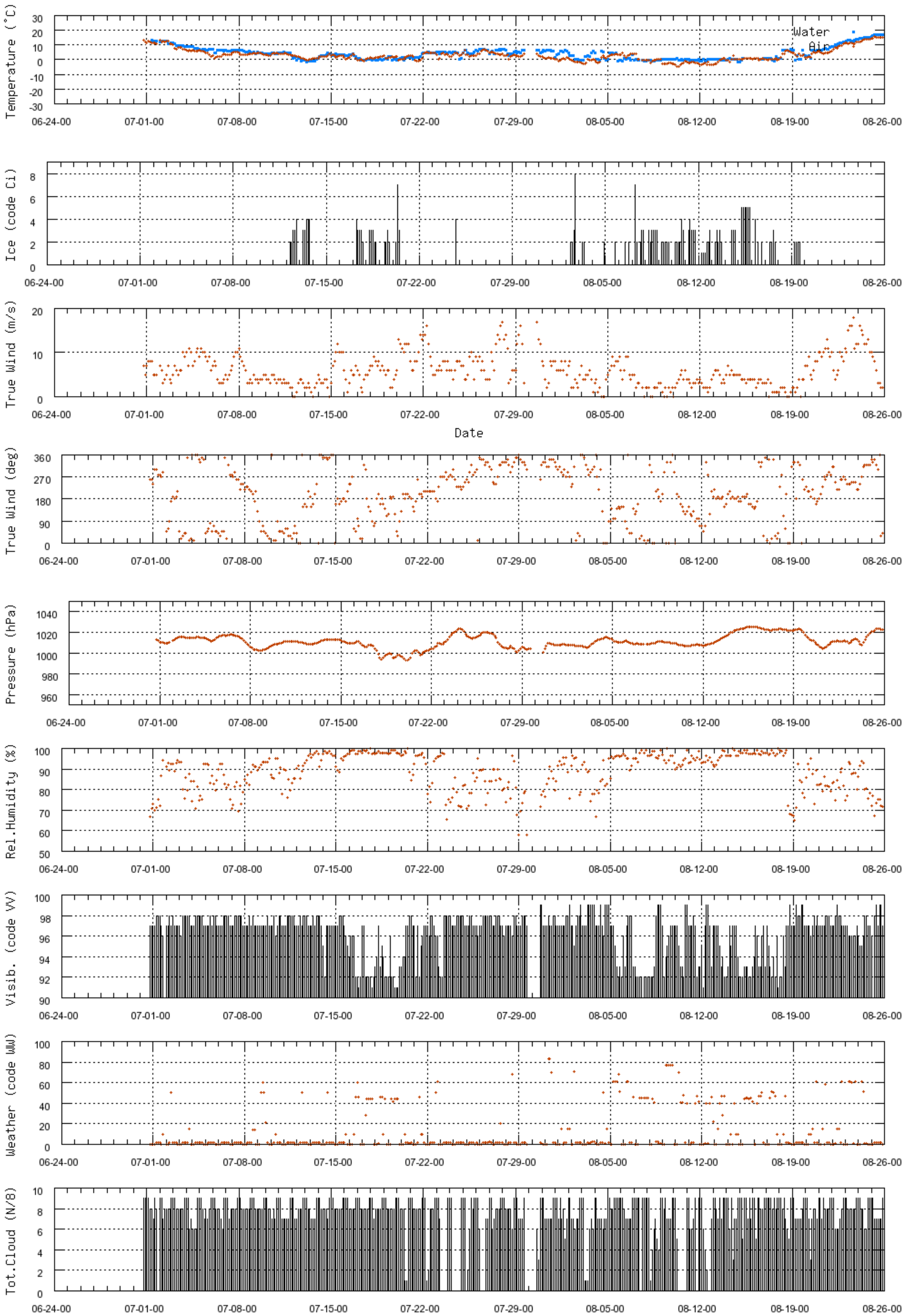

Fig. 92: Time series from ARK-XVI based on the 3-hourly synoptic observations

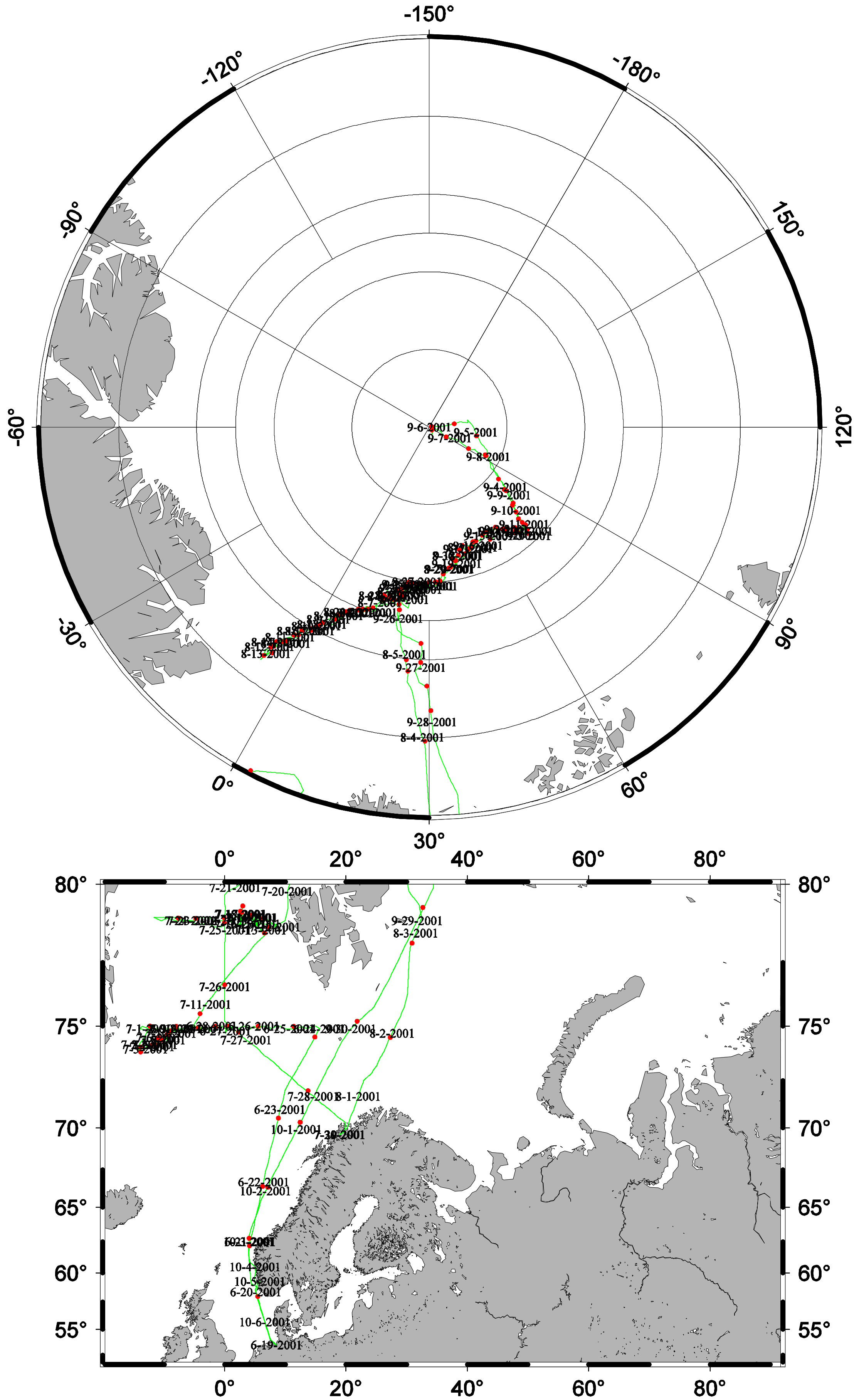

Fig. 93: Cruise track from ARK-XVII based on the 3-hourly synoptic observations. Dots denote upper air soundings

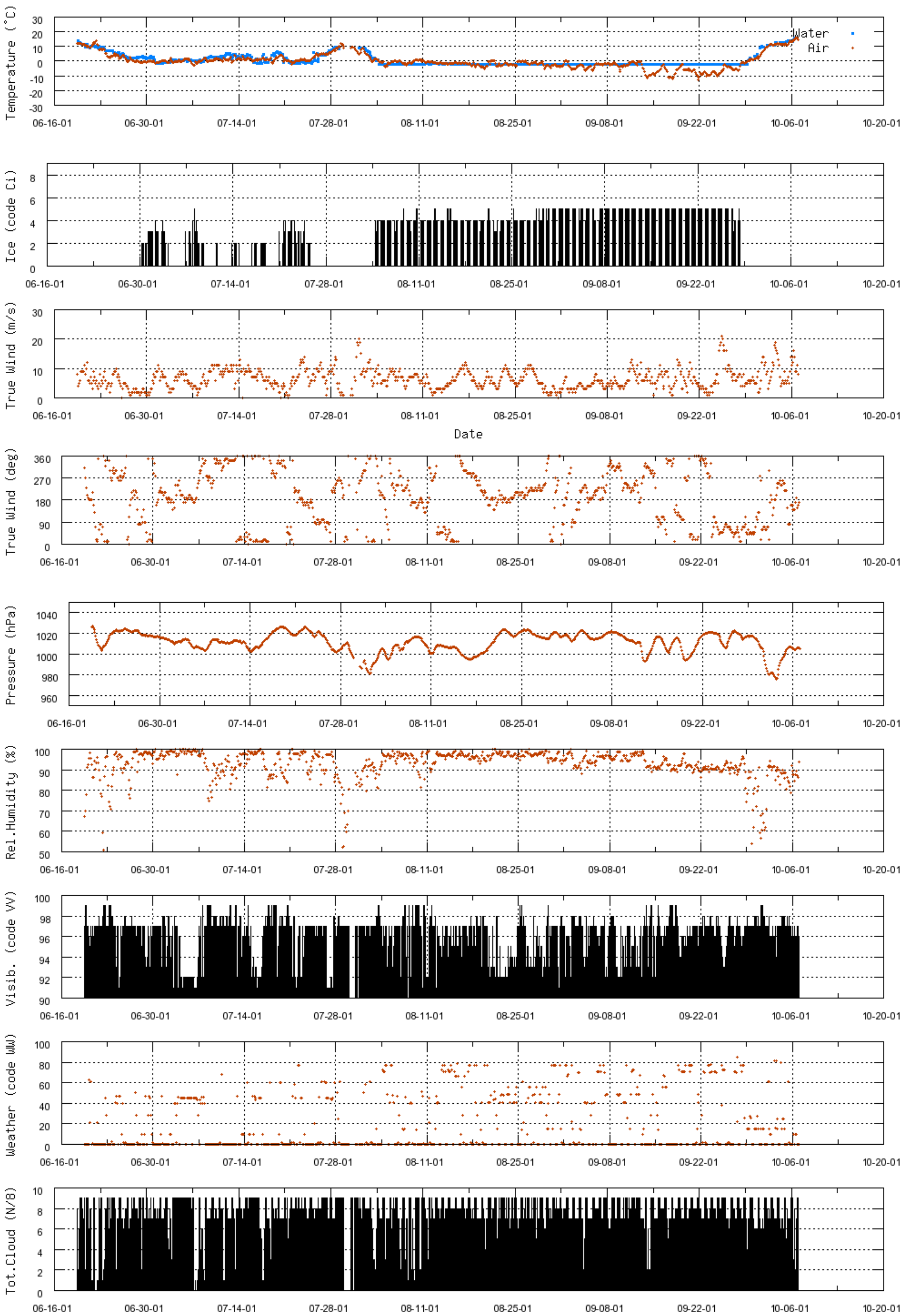

Fig. 94: Time series from ARK-XVII based on the 3-hourly synoptic observations

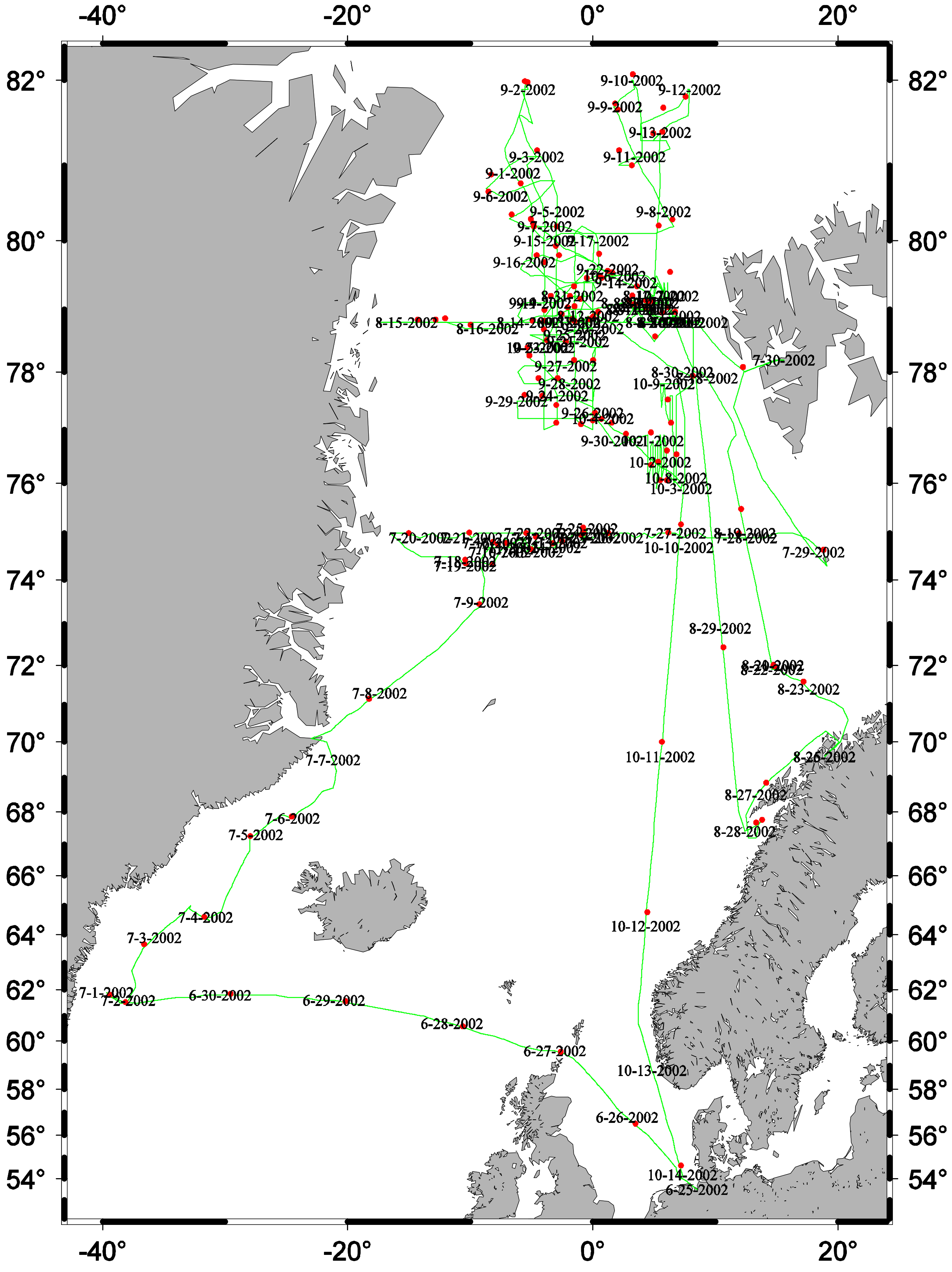

Fig. 95: Cruise track from ARK-XVIII based on the 3-hourly synoptic observations. Dots denote upper air soundings

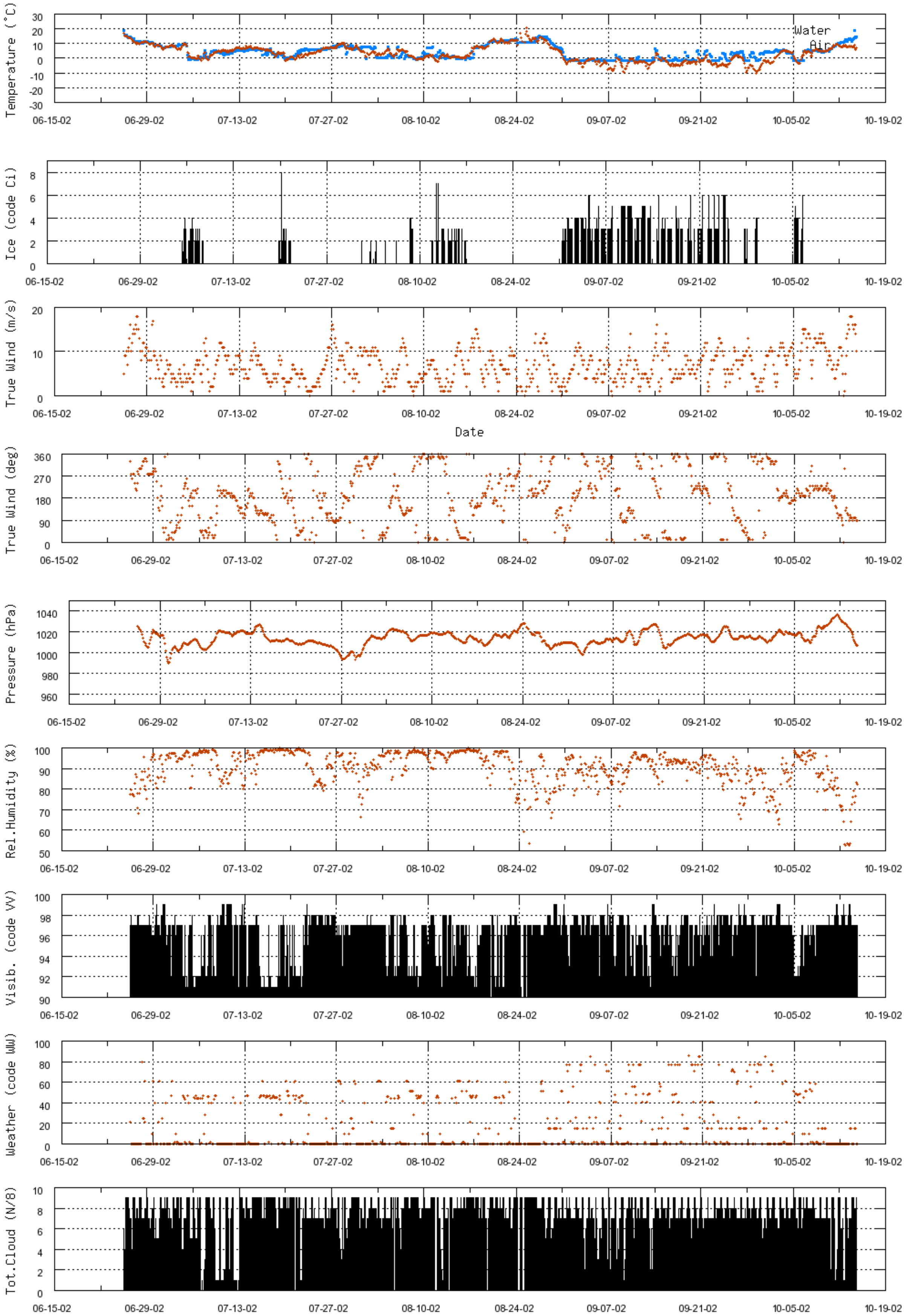

Fig. 96: Time series from ARK-XVIII based on the 3-hourly synoptic observations

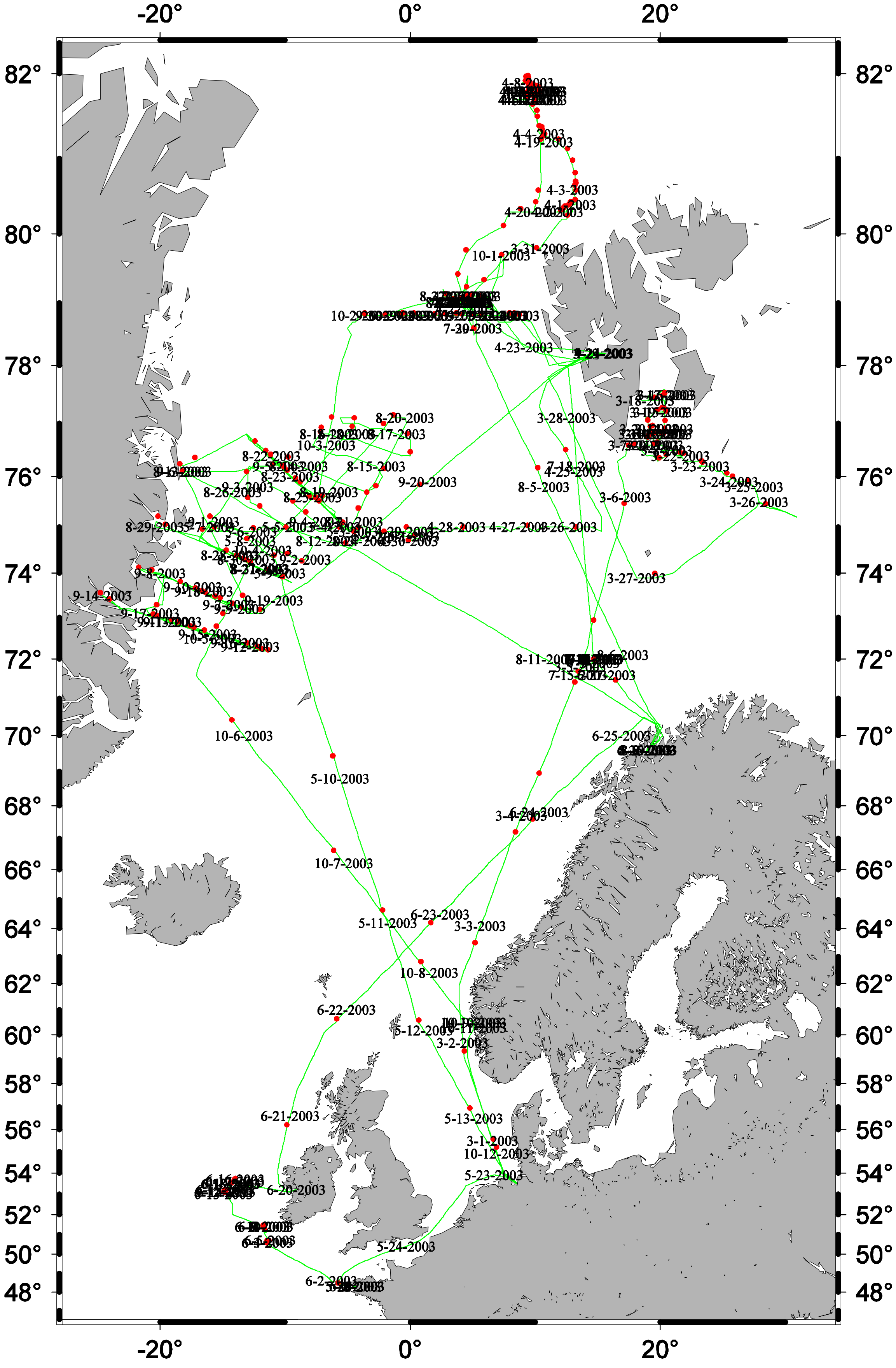

Fig. 97: Cruise track from ARK-XIX based on the 3-hourly synoptic observations. Dots denote upper air soundings

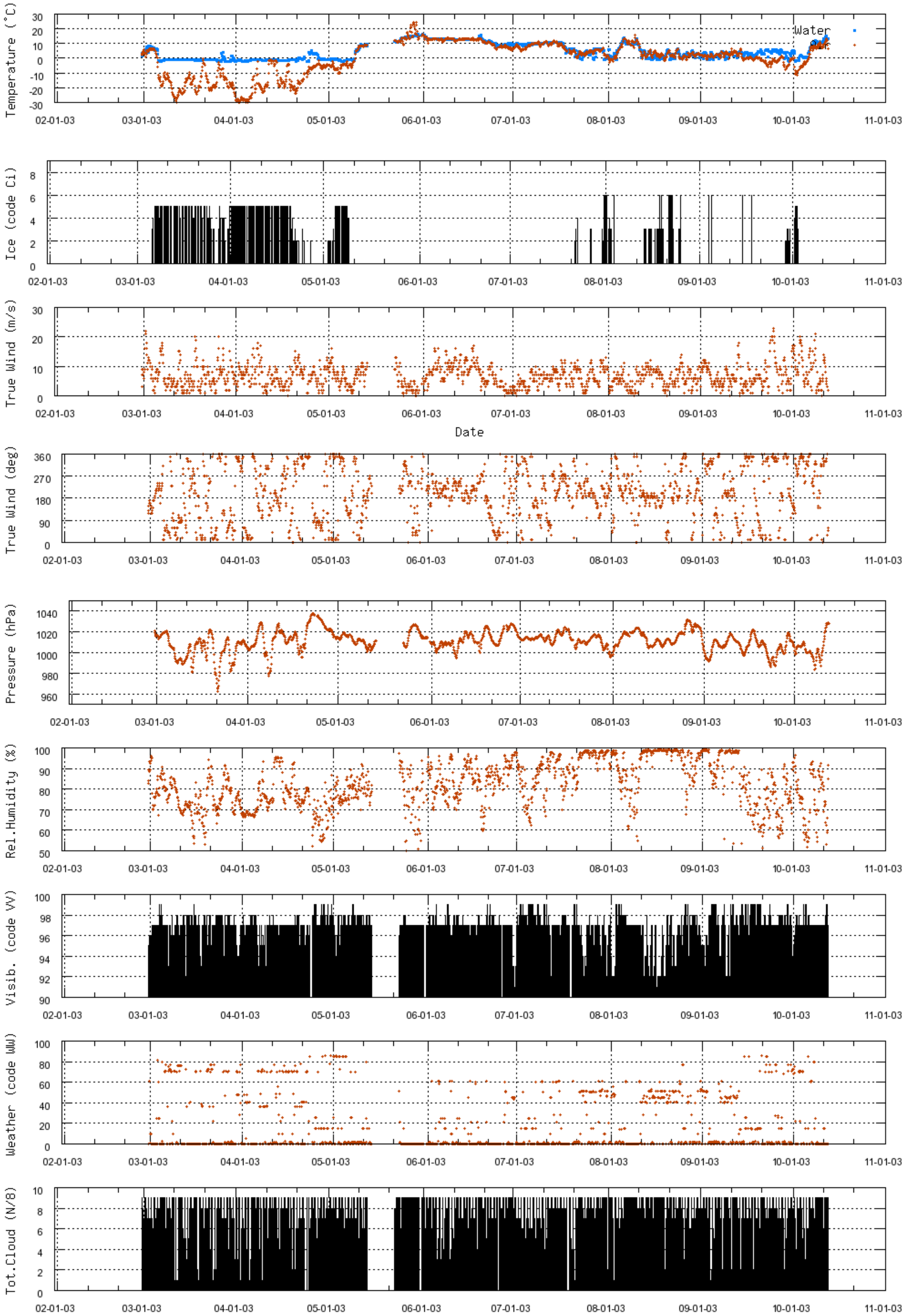

Fig. 98: Time series from ARK-XIX based on the 3-hourly synoptic observations

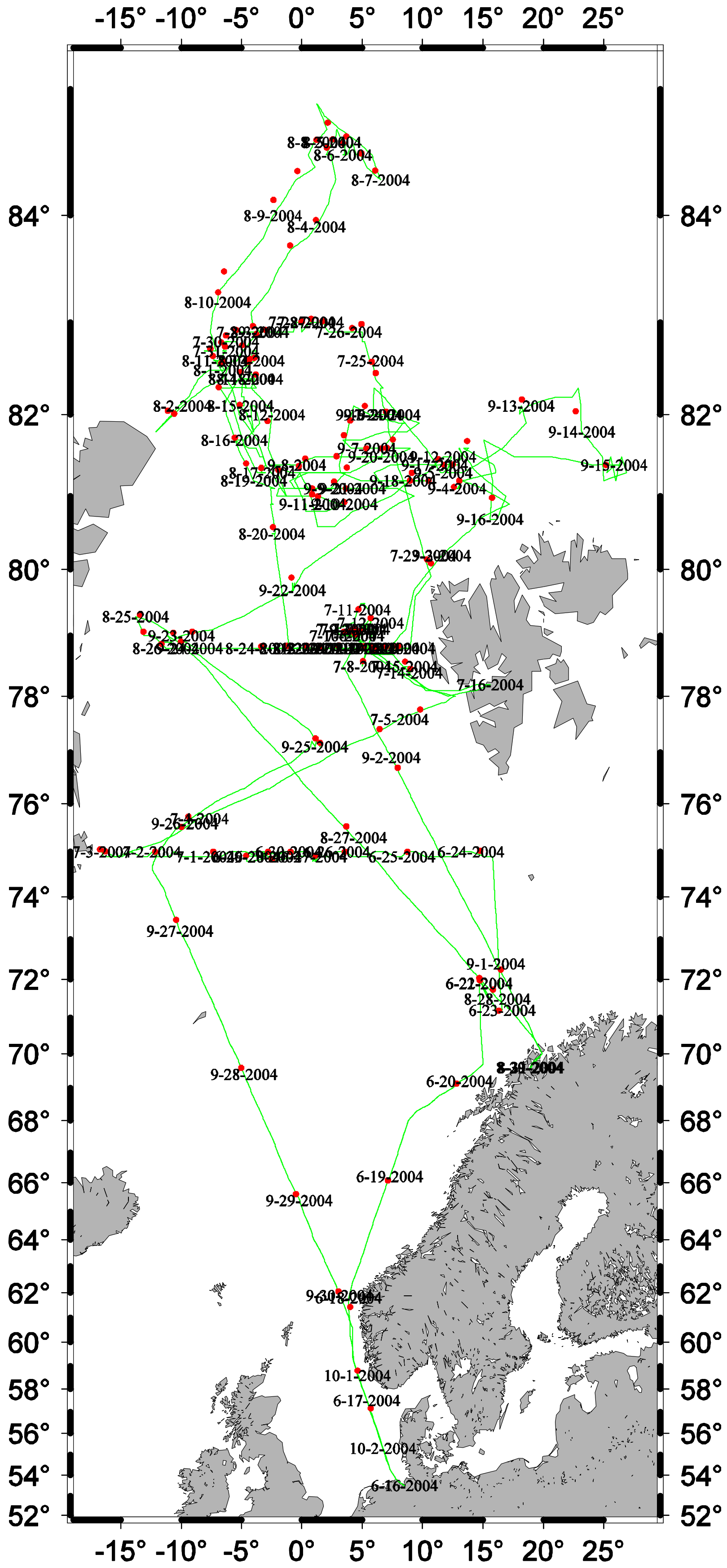

Fig. 99: Cruise track from ARK-XX based on the 3-hourly synoptic observations.
Dots denote upper air soundings

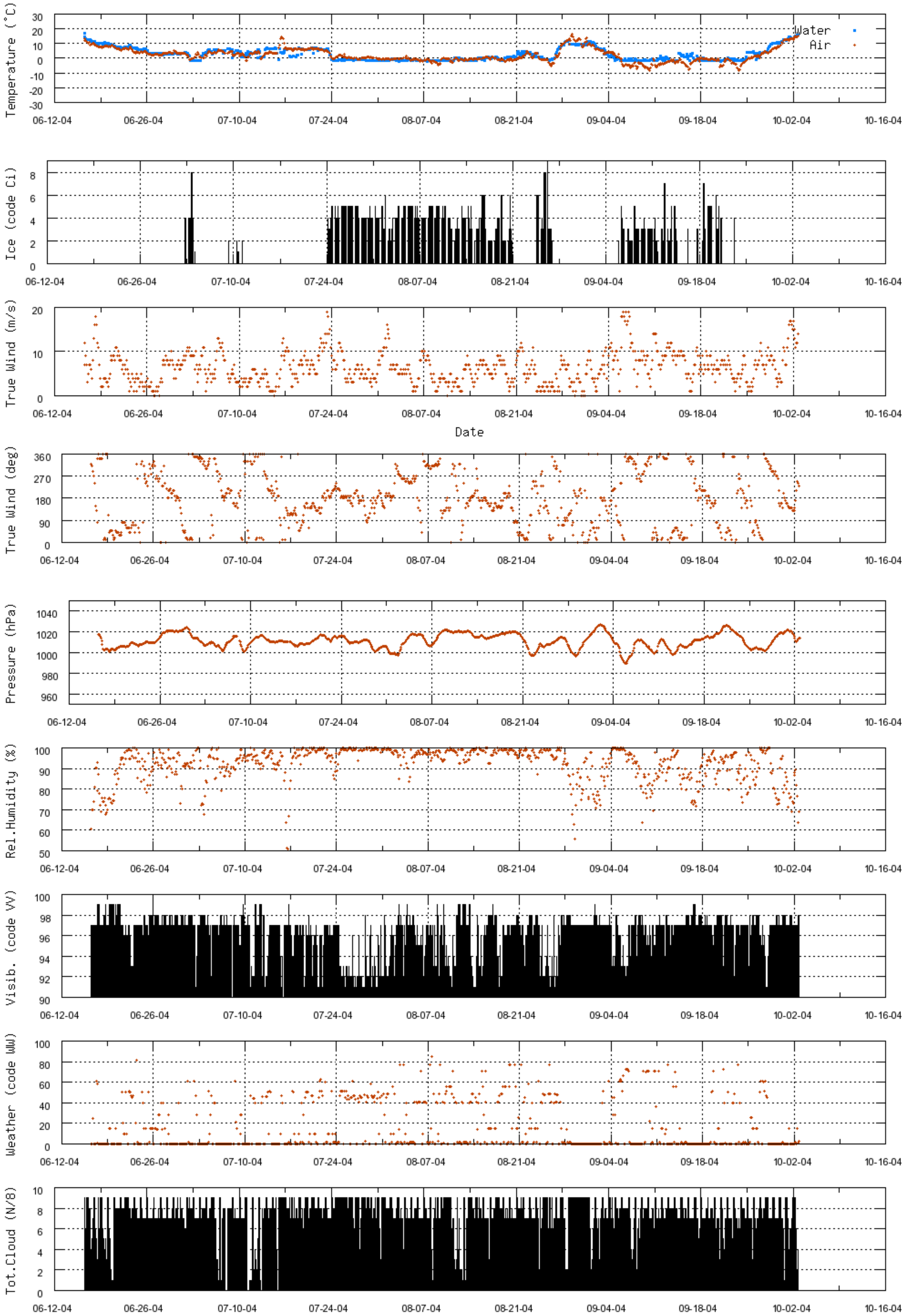

Fig. 100: Time series from ARK-XX based on the 3-hourly synoptic observations

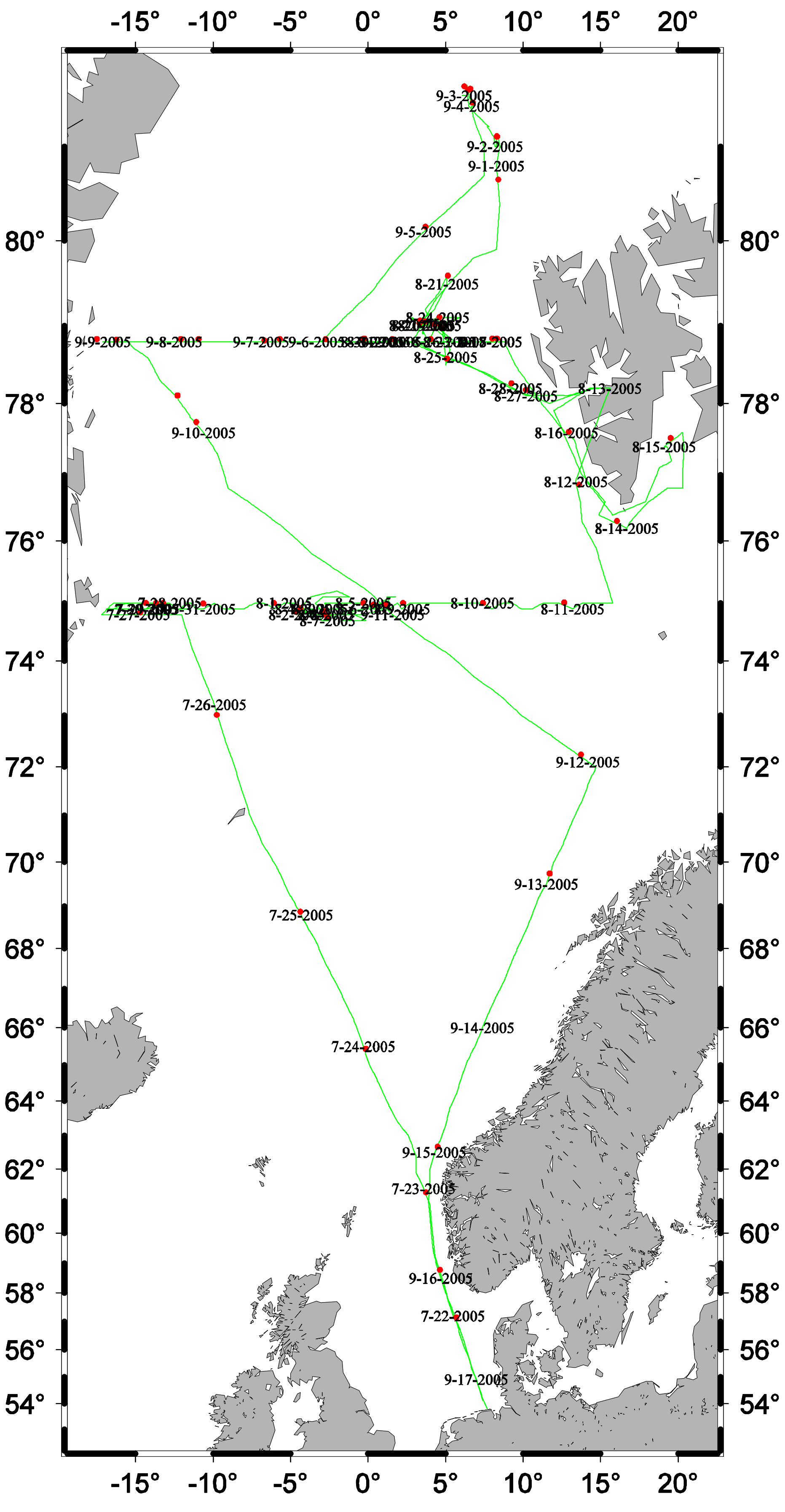

Fig. 101: Cruise track from ARK-XXI based on the 3-hourly synoptic observations.
Dots denote upper air soundings

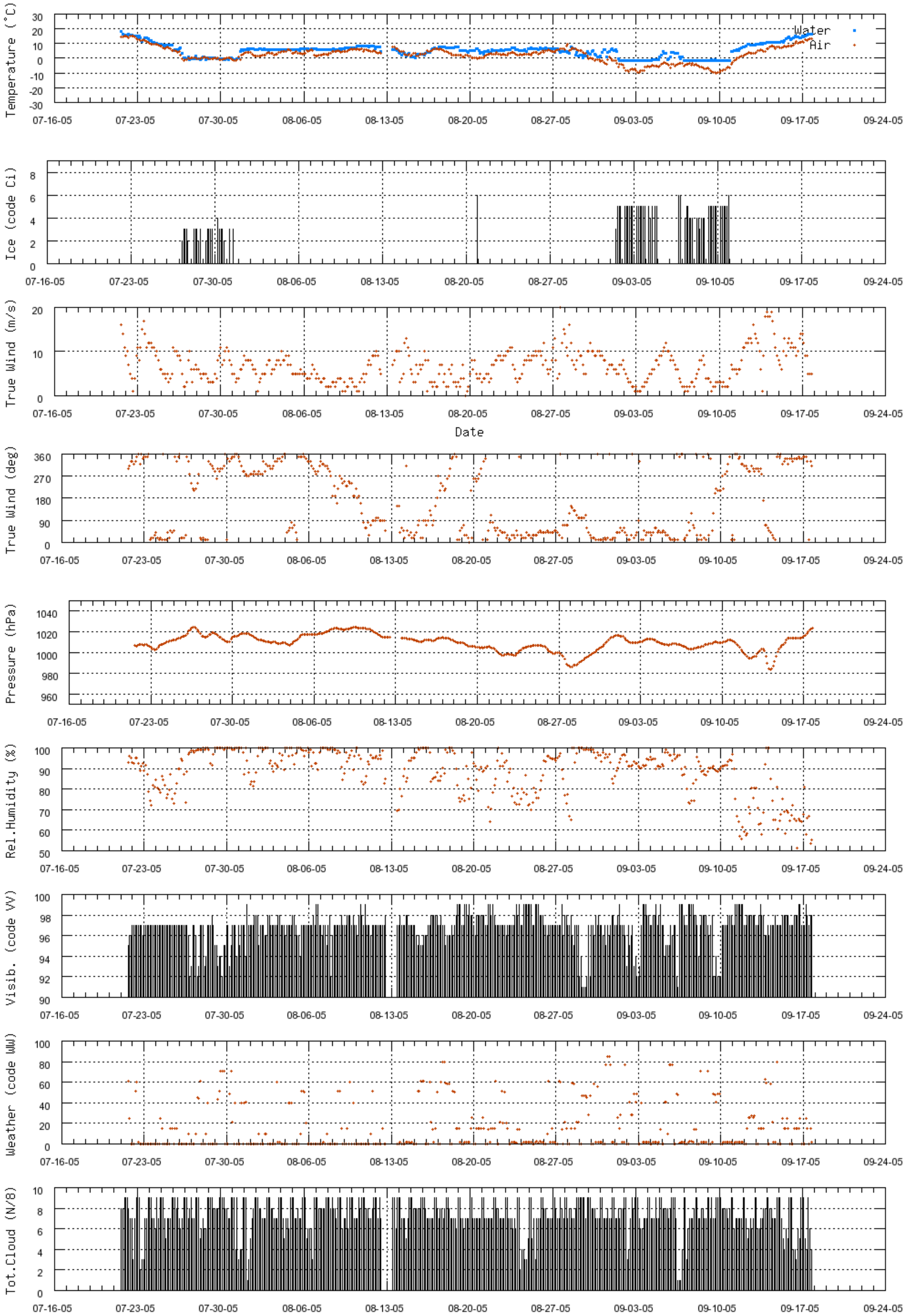

Fig. 102: Time series from ARK-XXI based on the 3-hourly synoptic observations

6. Meridional-height sections

During summer, Polarstern usually operates in the Arctic, during winter (austral summer) in the Antarctic. Thus, a huge number of meridional Atlantic cross-sections have been performed with lead to a unique meteorological dataset outside the Polar Regions. Till ANT-XIII (1995) during many meridional Atlantic cross-sections the upper air sounding programs were intensified.

The meridional Atlantic cross-sections covering the meridional range from Bremerhaven to Antarctica without major stopovers in between are listed in Tab. 11.

Cruise	**Departure**	**Arrival**
ANT-I	1982-12-28 Bremerhaven	1983-01-31 Neumayer
ANT-II	1983-09-21 Bremerhaven	1983-10-26 Antarctic Peninsular
ANT-III	1984-10-09 Bremerhaven	1984-11-18 Antarctic Peninsular
ANT-IV	1985-09-03 Bremerhaven	1985-11-15 Antarctic Peninsular
ANT-V	1987-03-01 Neumayer	1987-04-19 Bremerhaven
ANT-VI	1988-03-01 Neumayer	1988-04-11 Bremerhaven
ANT-VII	1989-02-28 Neumayer	1989-04-07 Bremerhaven
ANT-VIII	1989-08-05 Bremerhaven	1989-09-11 Antarctic Peninsular
ANT-IX	1990-10-20 Bremerhaven	1990-11-22 Antarctic Peninsular
ANT-X	1991-11-14 Bremerhaven	1991-12-17 Antarctic Peninsular
ANT-X	1993-01-18 Ant. Peninsular	1993-02-23 Bremerhaven
ANT-XII	1994-10-18 Bremerhaven	1994-11-27 Antarctic Peninsular
ANT-XIII	1995-11-09 Bremerhaven	1995-12-15 Neumayer
ANT-XIV	1997-03-06 Neumayer	1997-04-26 Bremerhaven
ANT-XV	1997-10-15 Bremerhaven	1997-11-21 Neumayer
ANT-XVI	1998-12-15 Bremerhaven	1999-01-20 Neumayer
ANT-XVII	1999-12-14 Bremerhaven	2000-01-20 Neumayer
ANT-XIX	2001-11-07 Bremerhaven	2001-12-18 Neumayer
ANT-XX	2002-10-26 Bremerhaven	2002-12-13 Neumayer
ANT-XXI	2003-10-22 Bremerhaven	2003-12-01 Neumayer
ANT-XXIII	2005-10-13 Bremerhaven	2005-12-03 Neumayer

Tab. 11: Meridional Atlantic cruises from (to) Bremerhaven to (from) Antarctica

The following figures will depict exemplarily the meridional-height sections obtained during ANT-XVII and ANT-XXI. The cruises were chosen, because they include ozone soundings from Bremerhaven till Neumayer (ANT-XVII) and from Bremerhaven till Cape Town (ANTXXI).

6.1. ANT-XVII

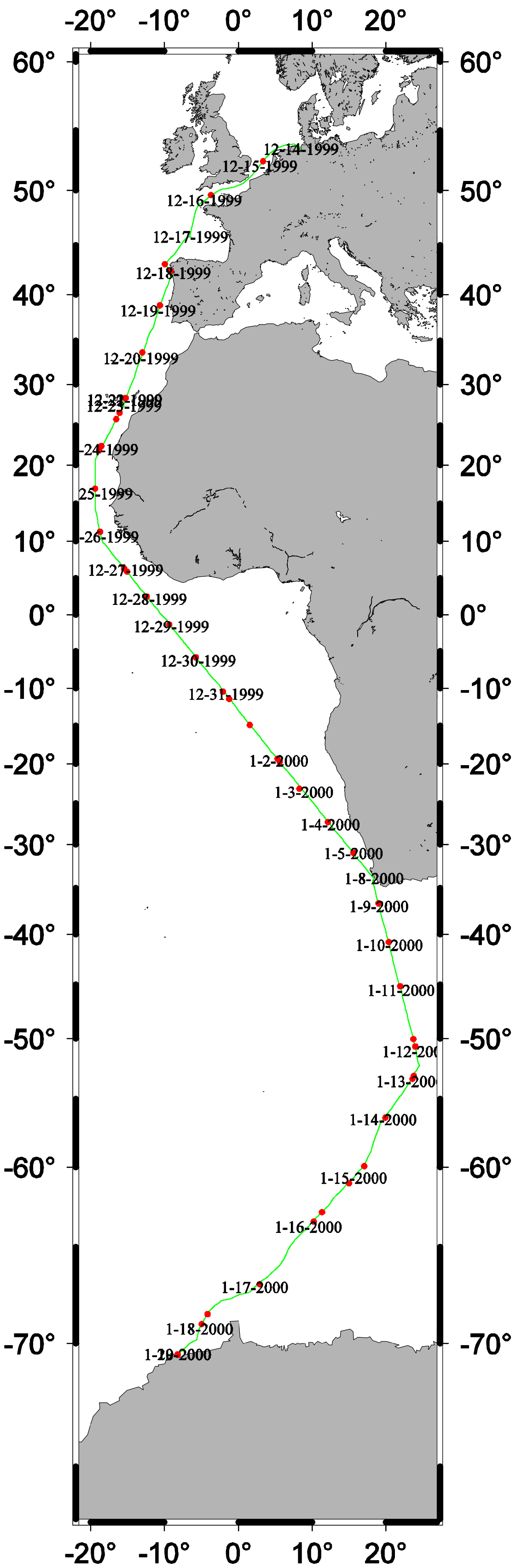

Fig. 103: Cruise track from ANT-XVII from Bremerhaven till Neumayer based on the 3-hourly synoptic observations. Dots denote upper air soundings

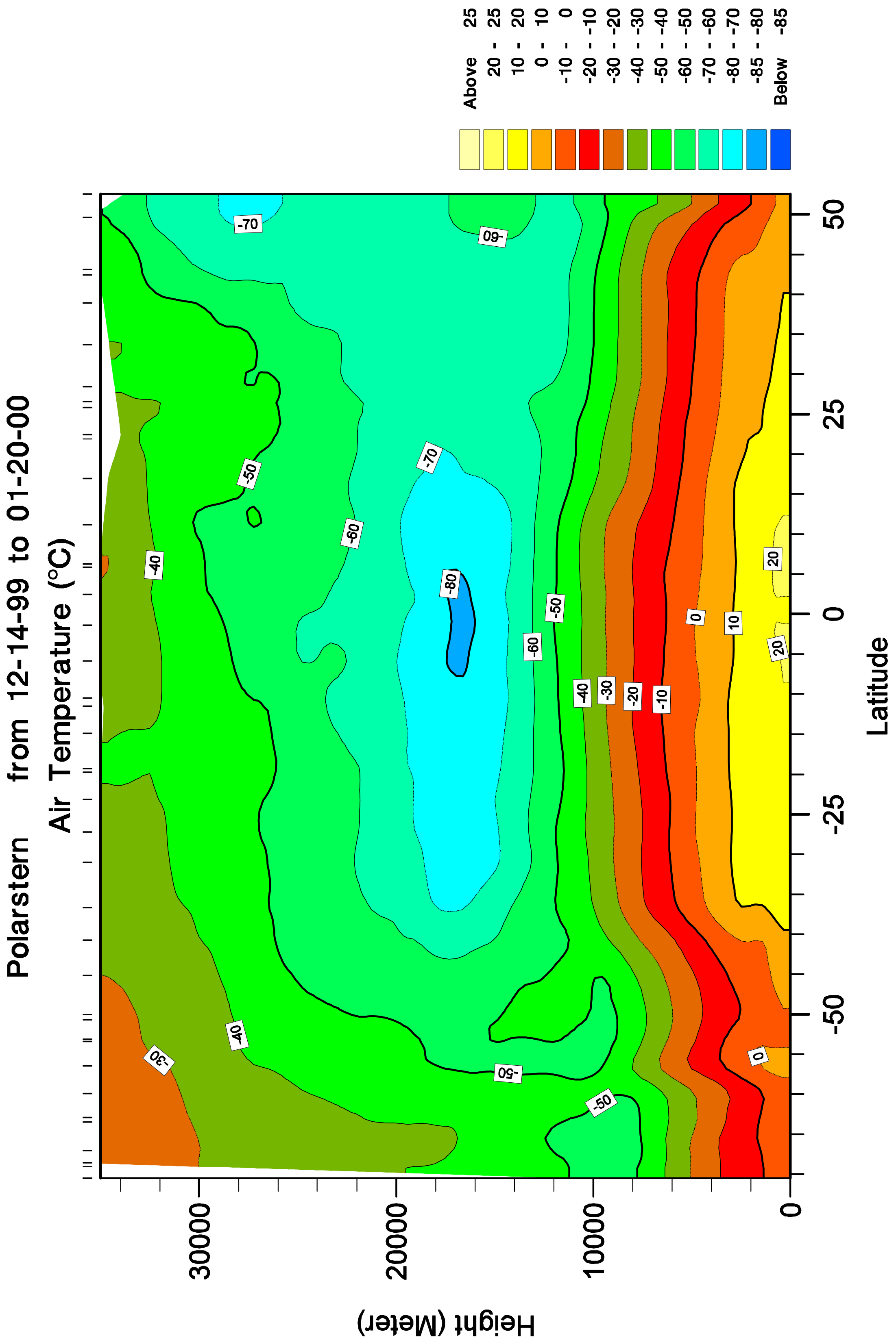

Fig. 104: Meridional-height section of temperature during ANT-XVII based on upper air soundings

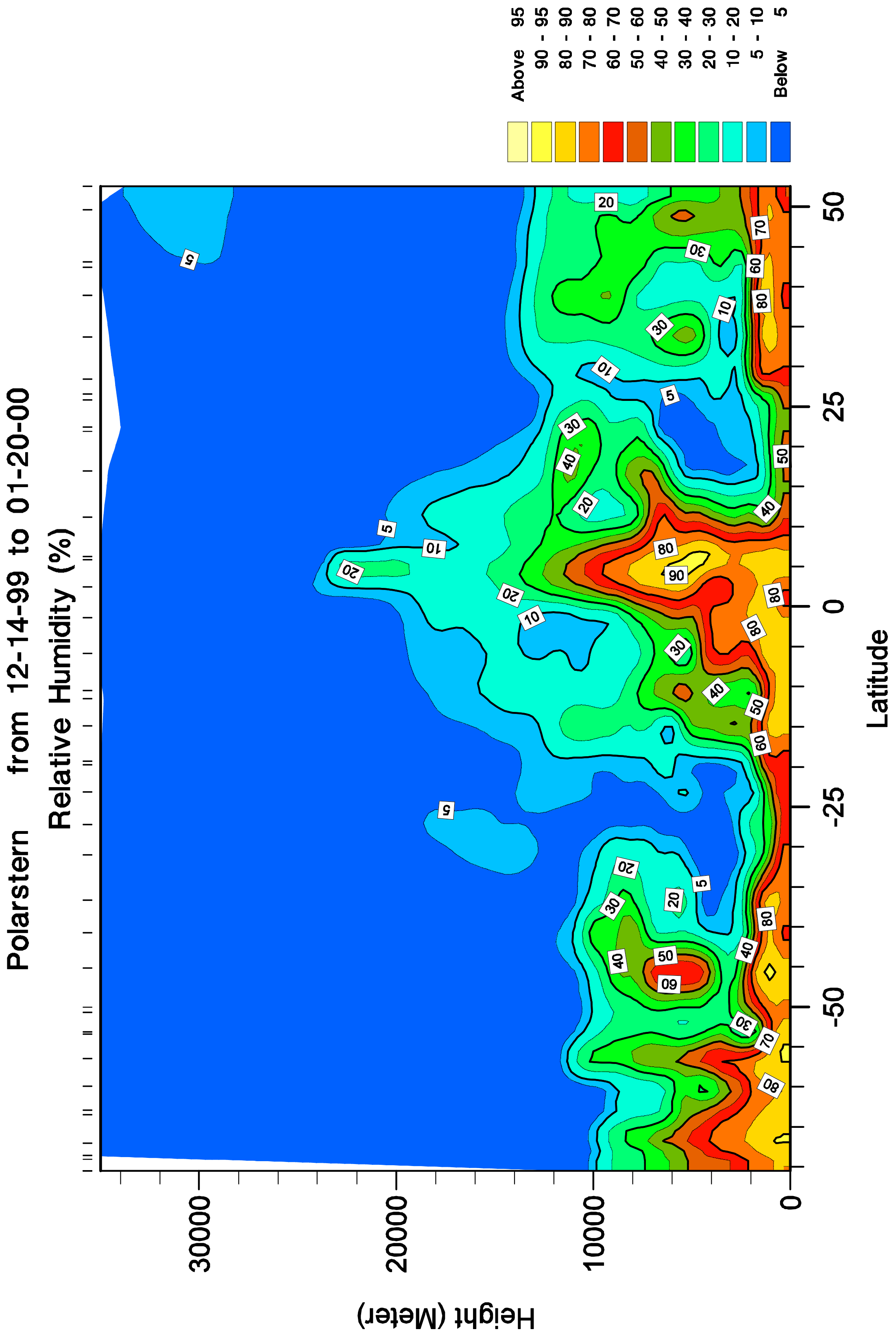

Fig. 105: Meridional-height section of relative humidity during ANT-XVII based on upper air soundings

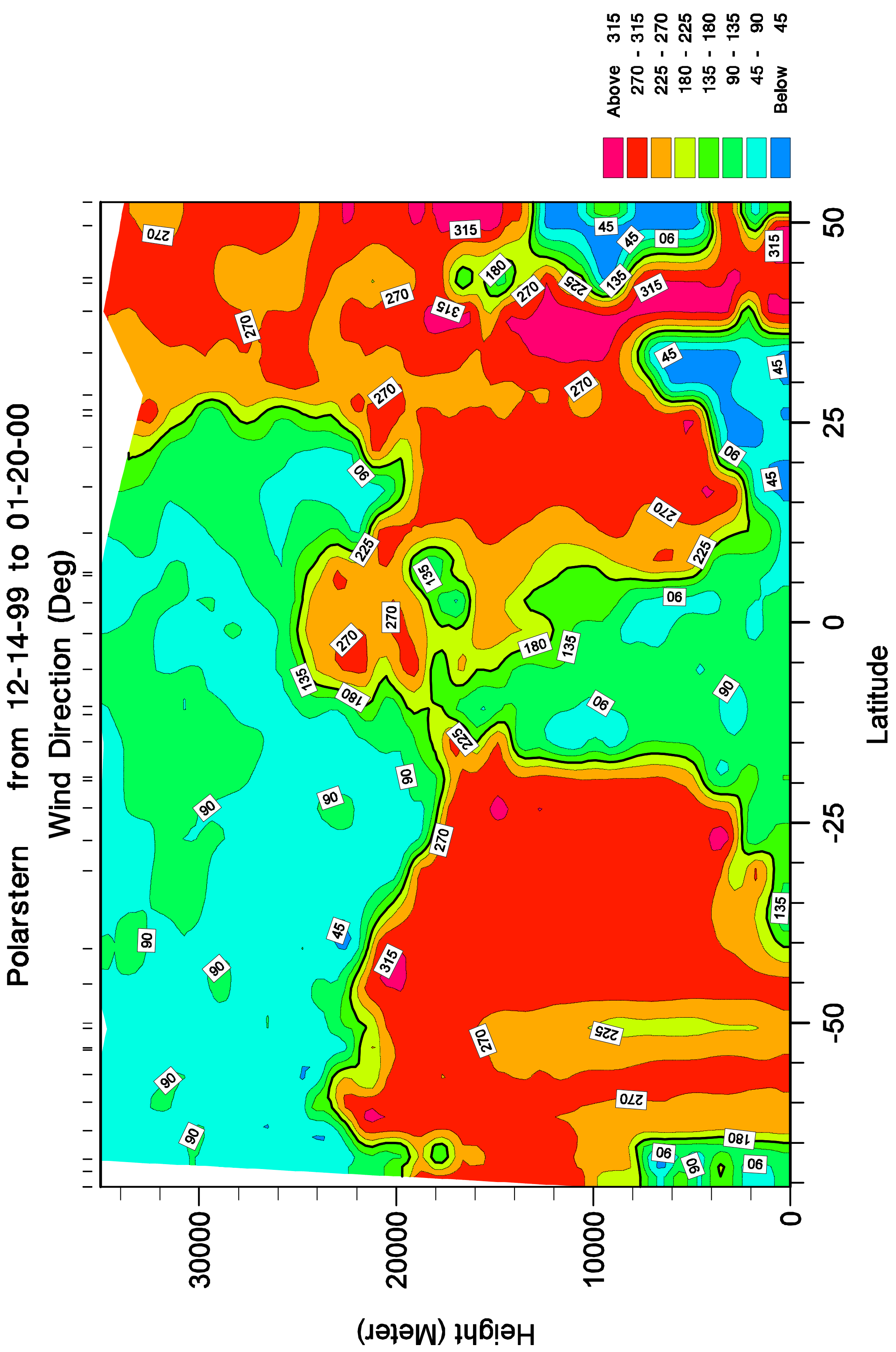

Fig. 106: Meridional-height section of wind direction during ANT-XVII based on upper air soundings

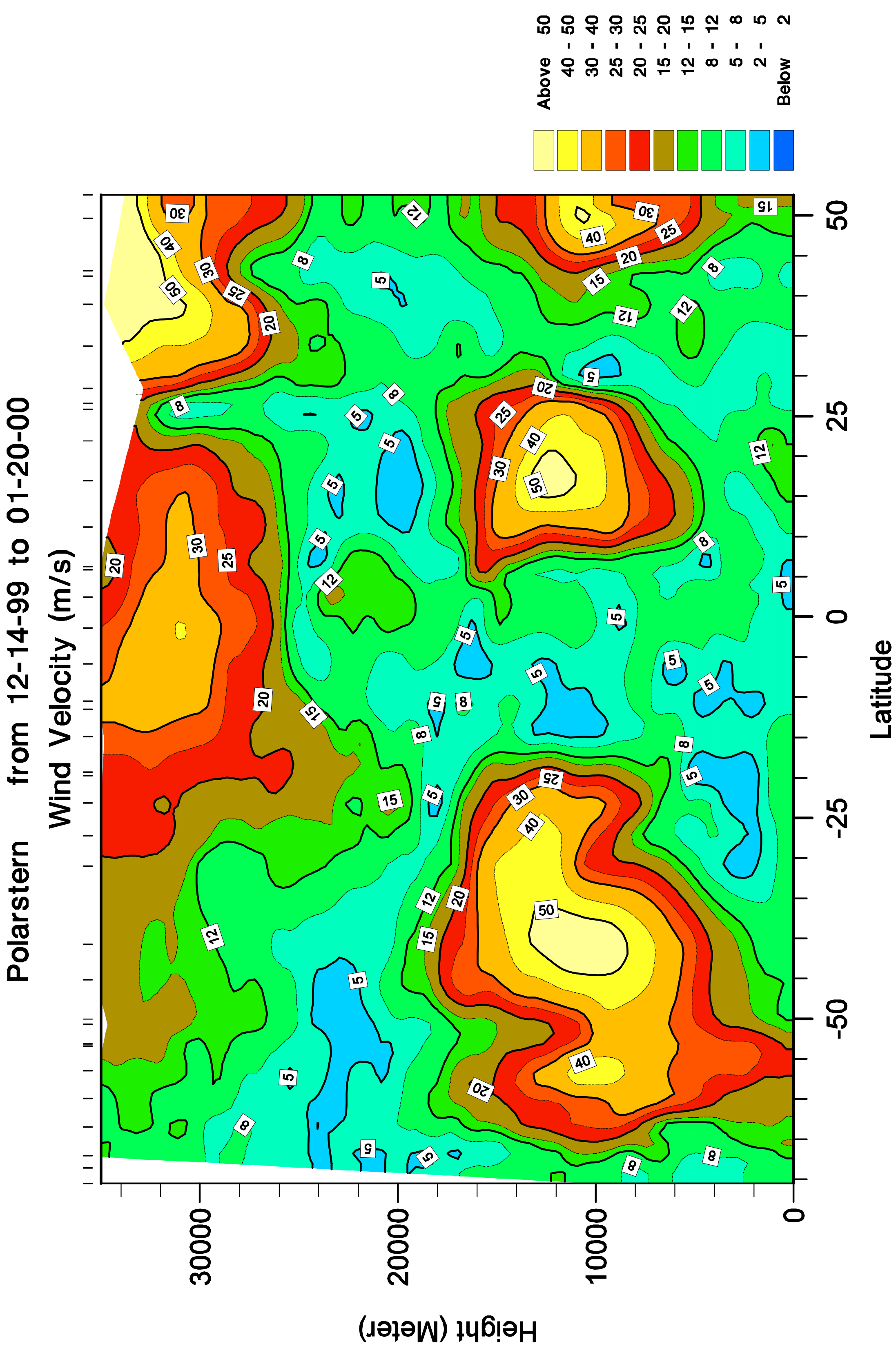

Fig. 107: Meridional-height section of wind velocity during ANT-XVII based on upper air soundings

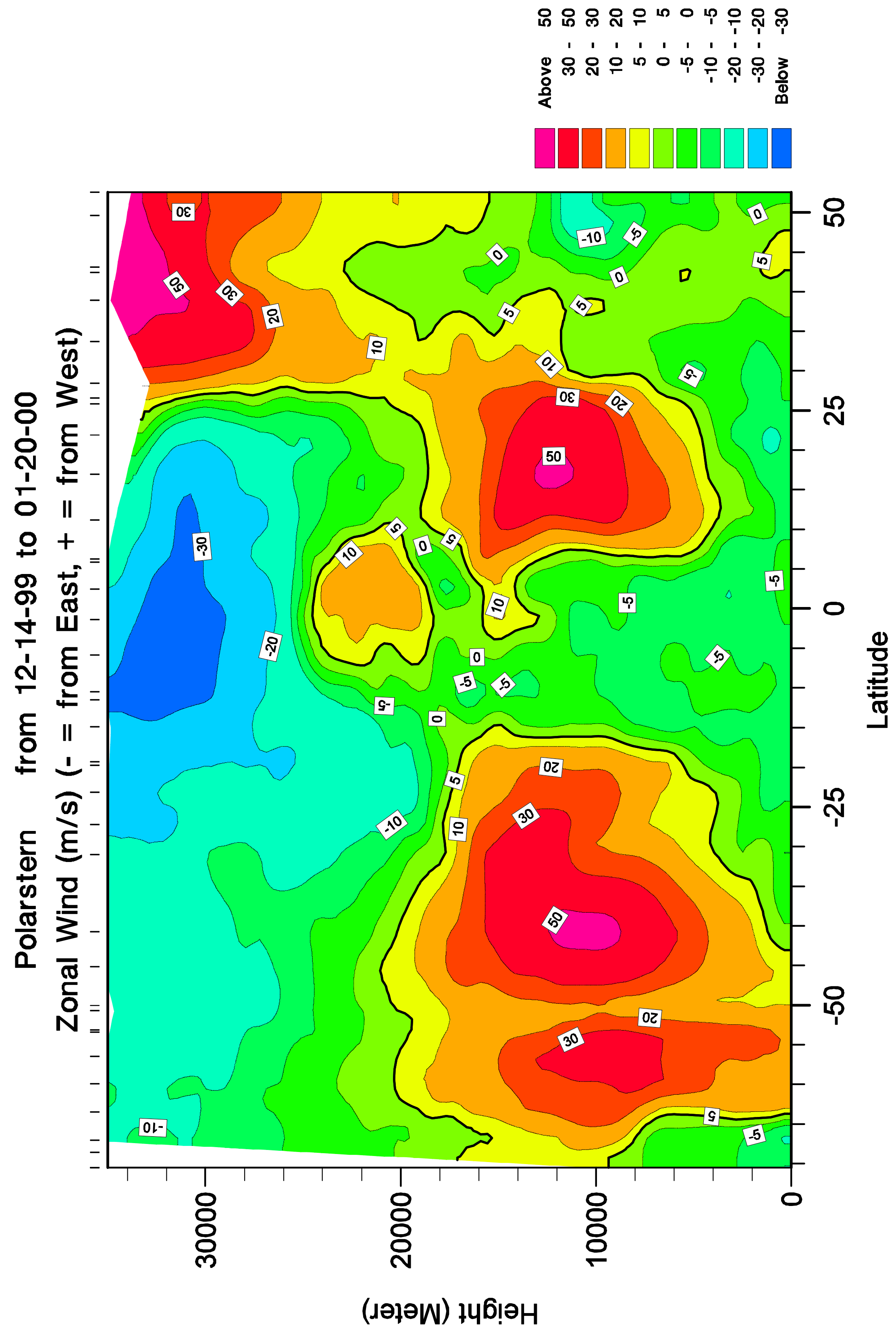

Fig. 108: Meridional-height section of zonal wind during ANT-XVII based on upper air soundings

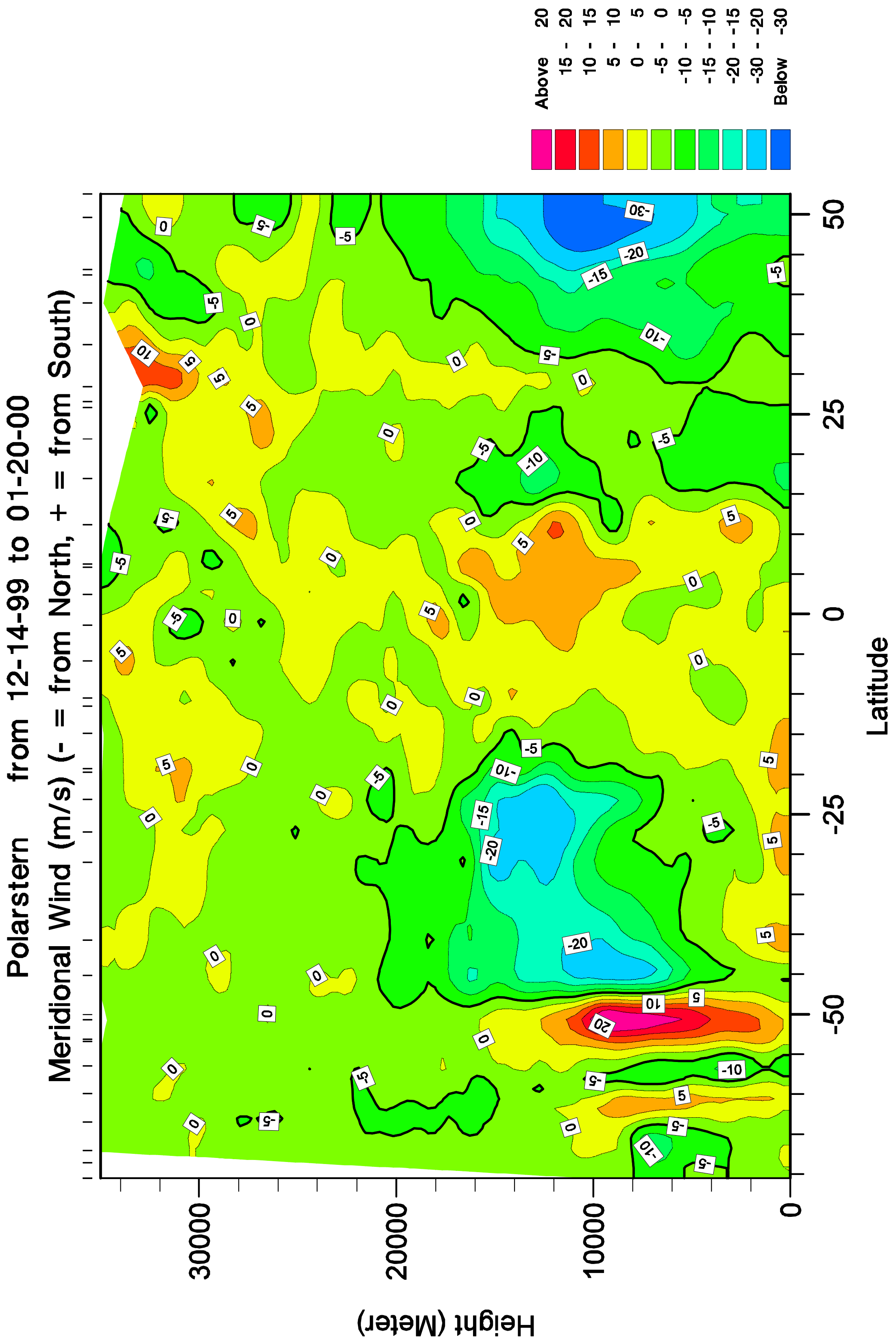

Fig. 109: Meridional-height section of meridional wind during ANT-XVII based on upper air soundings

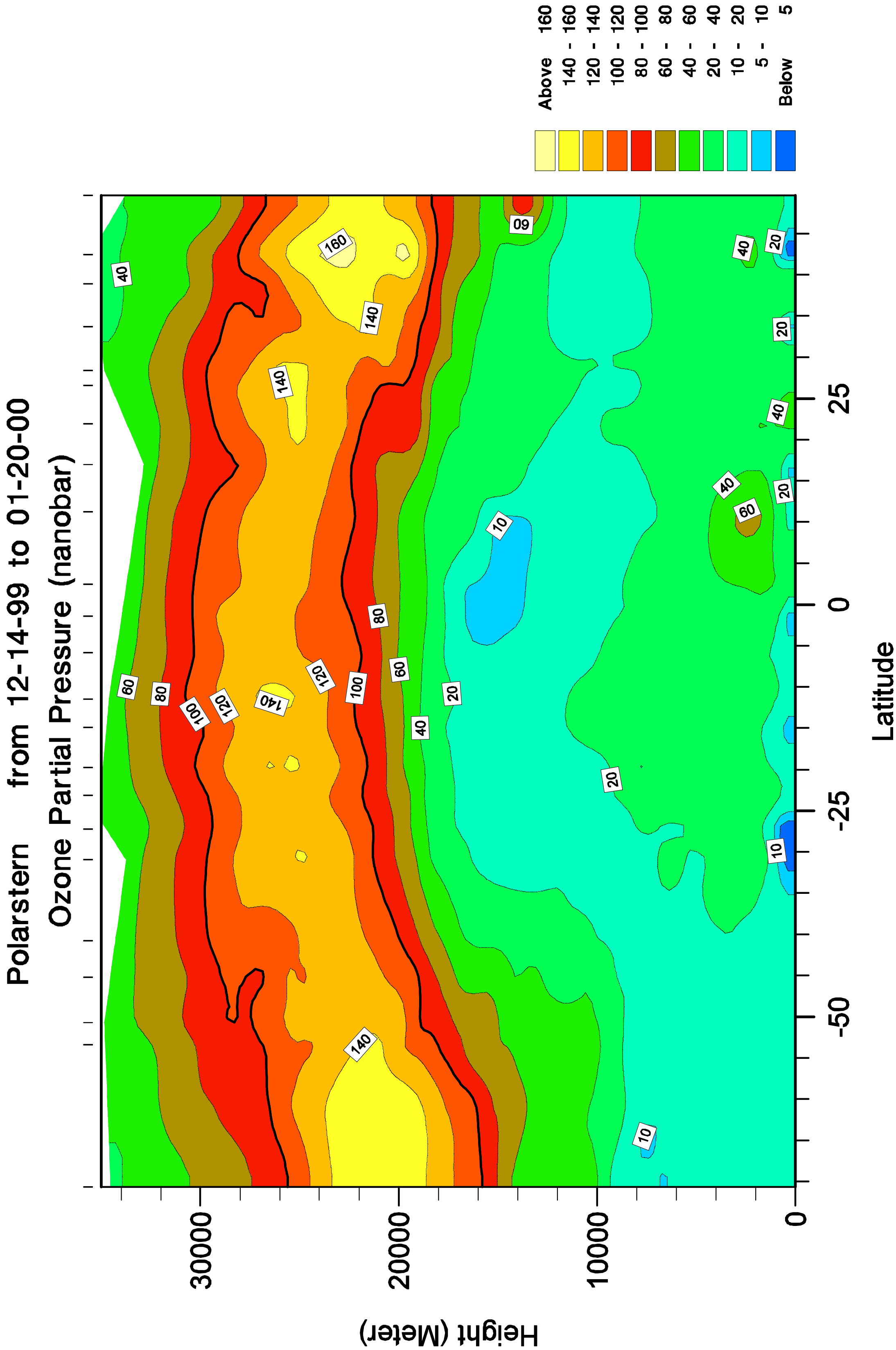

Fig. 110: Meridional-height section of ozone during ANT-XVII based on upper air soundings

6.2. ANT-XXI

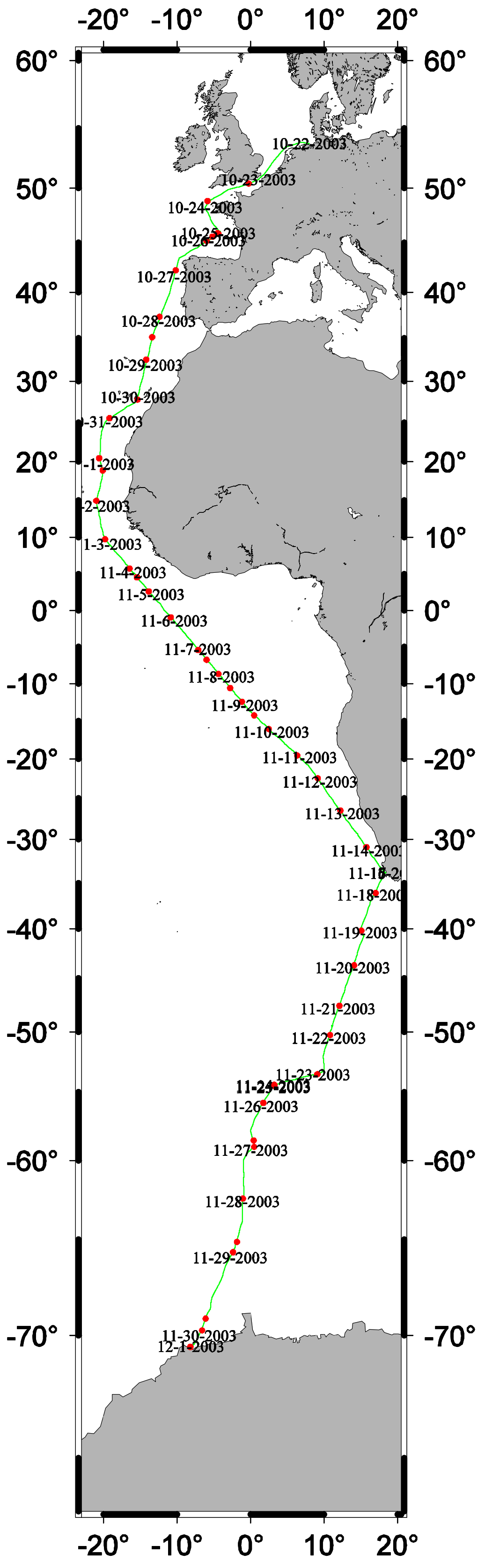

Fig. 111: Cruise track from ANT-XXI from Bremerhaven till Neumayer based on the 3-hourly synoptic observations. Dots denote upper air soundings

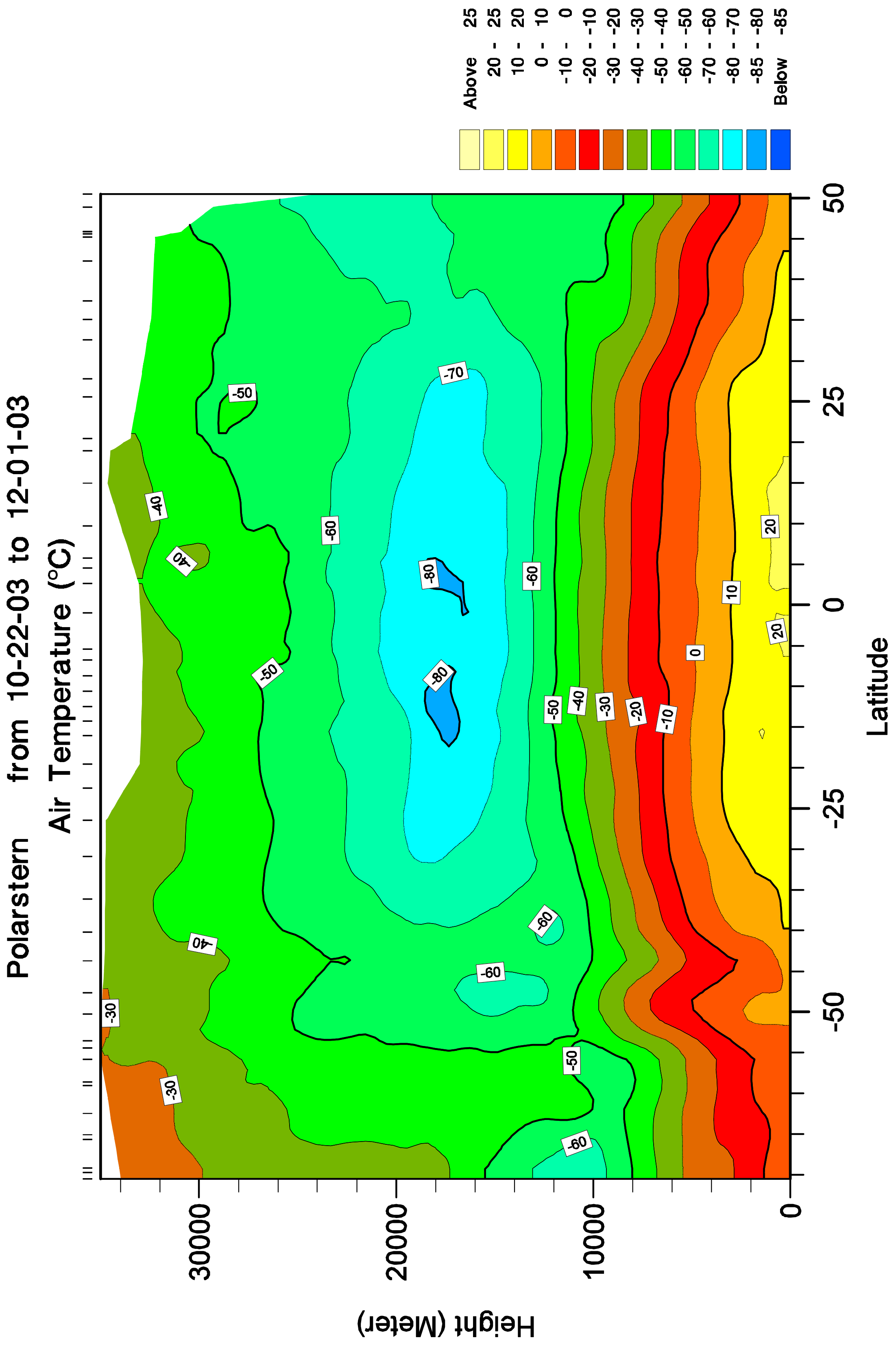

Fig. 112: Meridional-height section of temperature during ANT-XXI based on upper air soundings

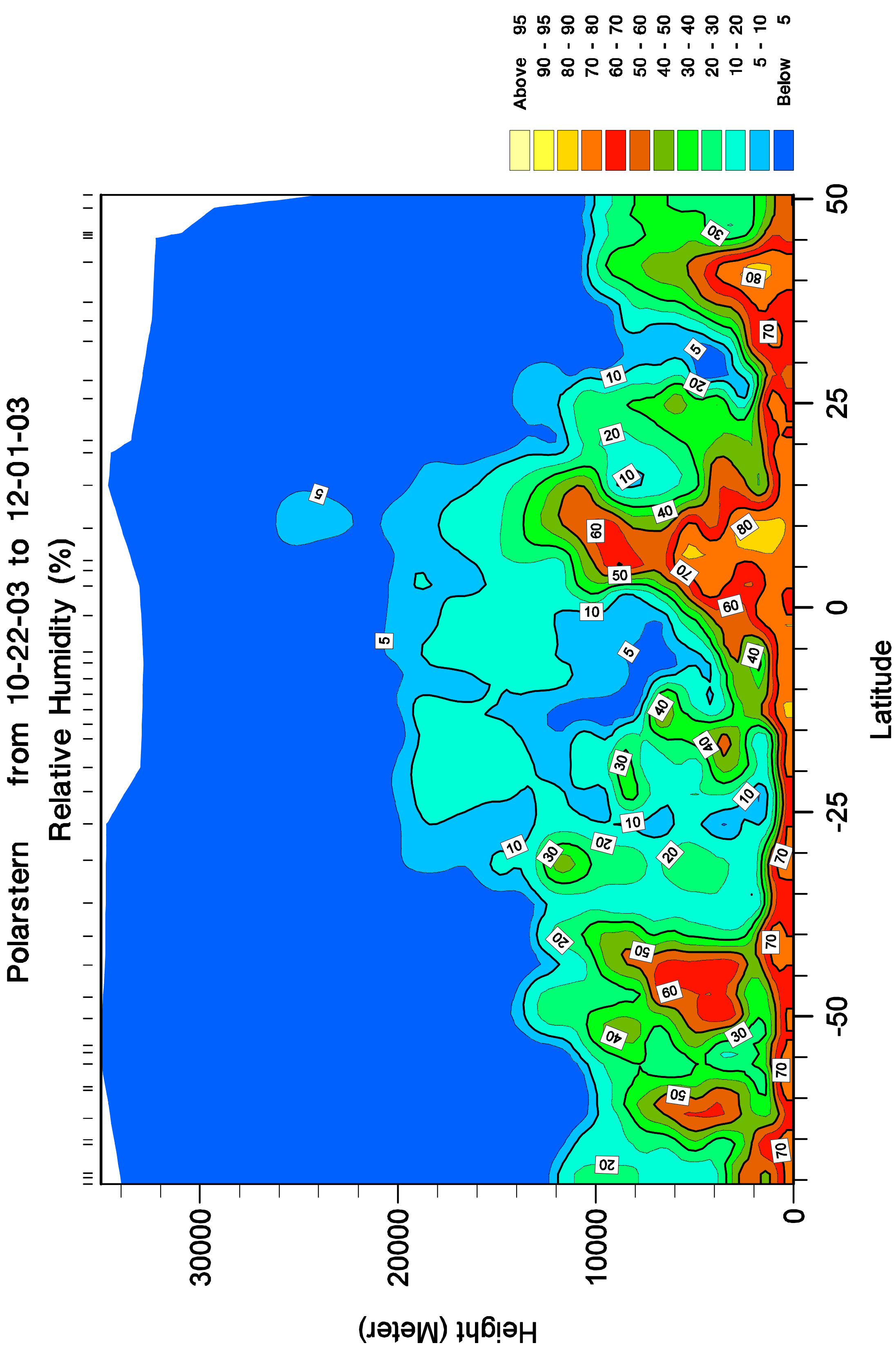

Fig. 113: Meridional-height section of relative humidity during ANT-XXI based on upper air soundings

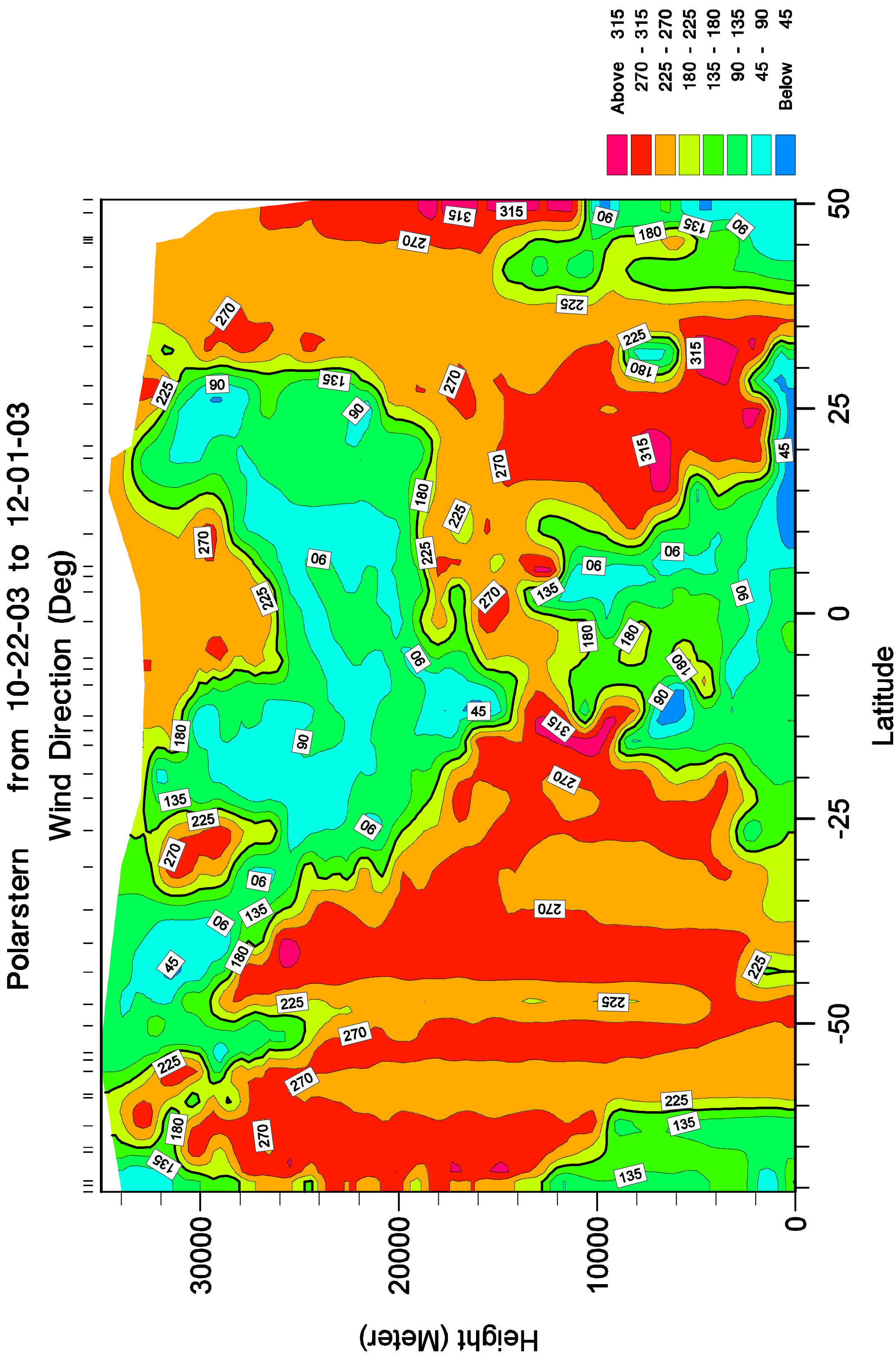

Fig. 114: Meridional-height section of wind direction during ANT-XXI based on upper air soundings

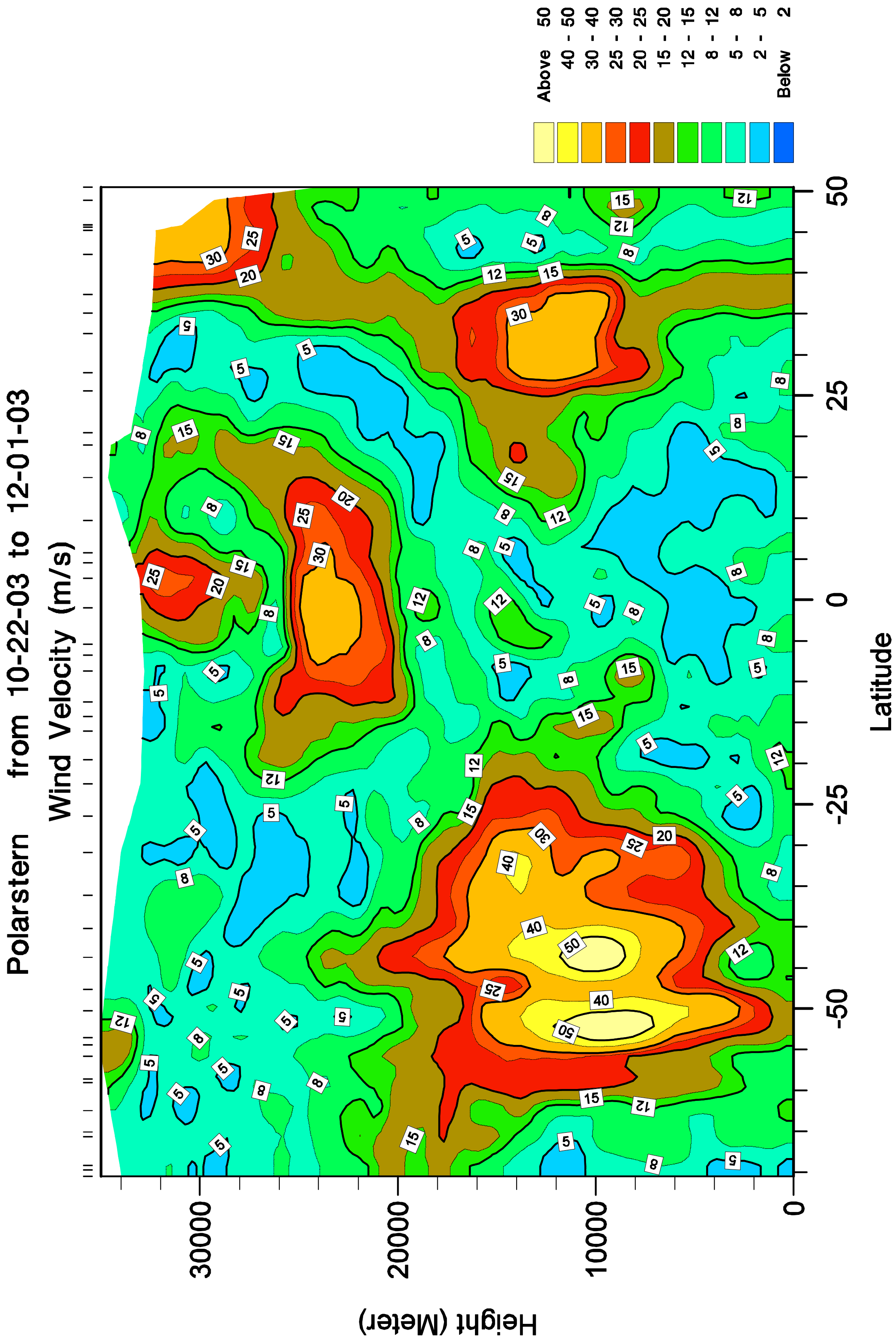

Fig. 115: Meridional-height section of wind velocity during ANT-XXI based on upper air soundings

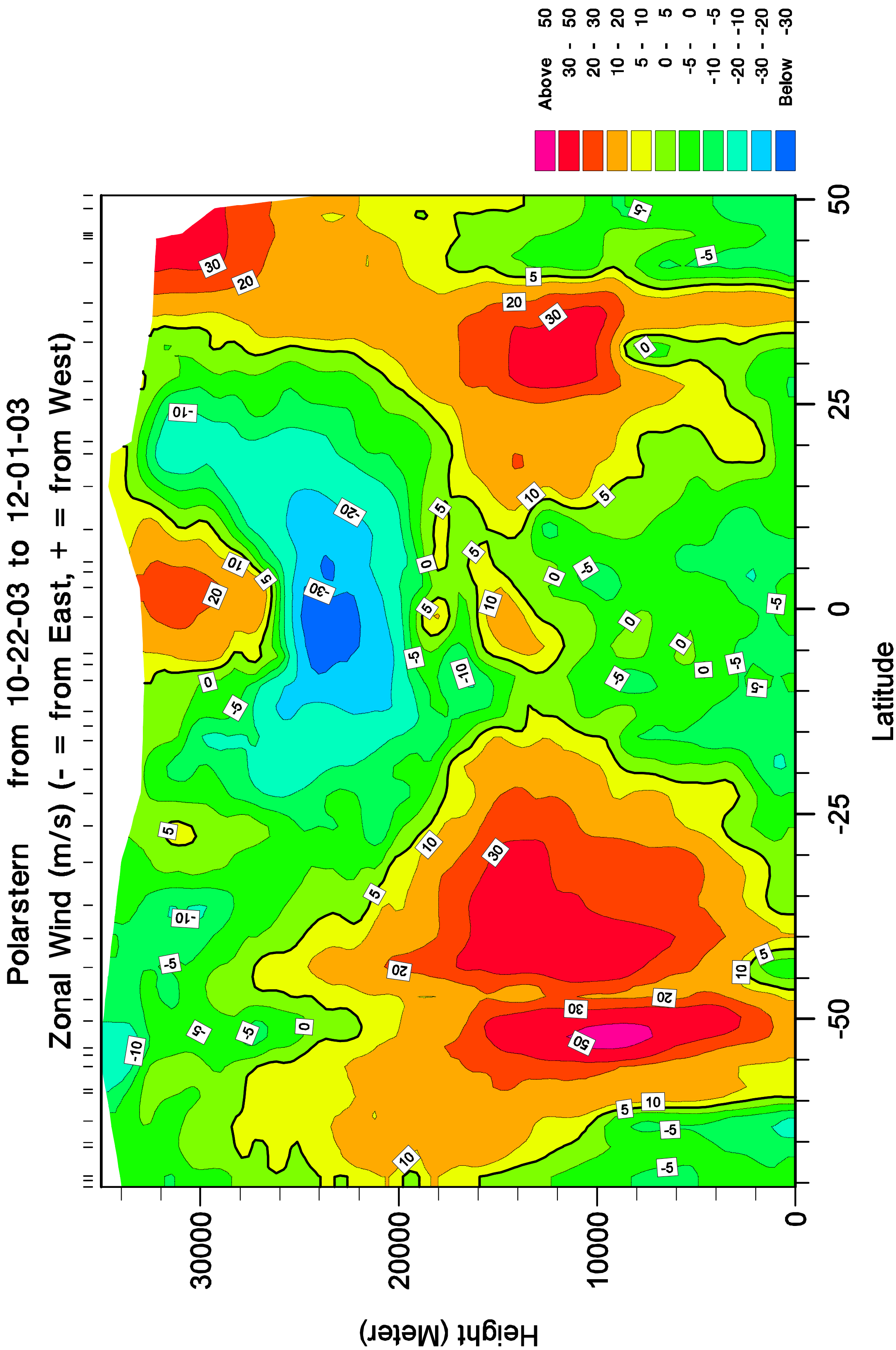

Fig. 116: Meridional-height section of zonal wind during ANT-XXI based on upper air soundings

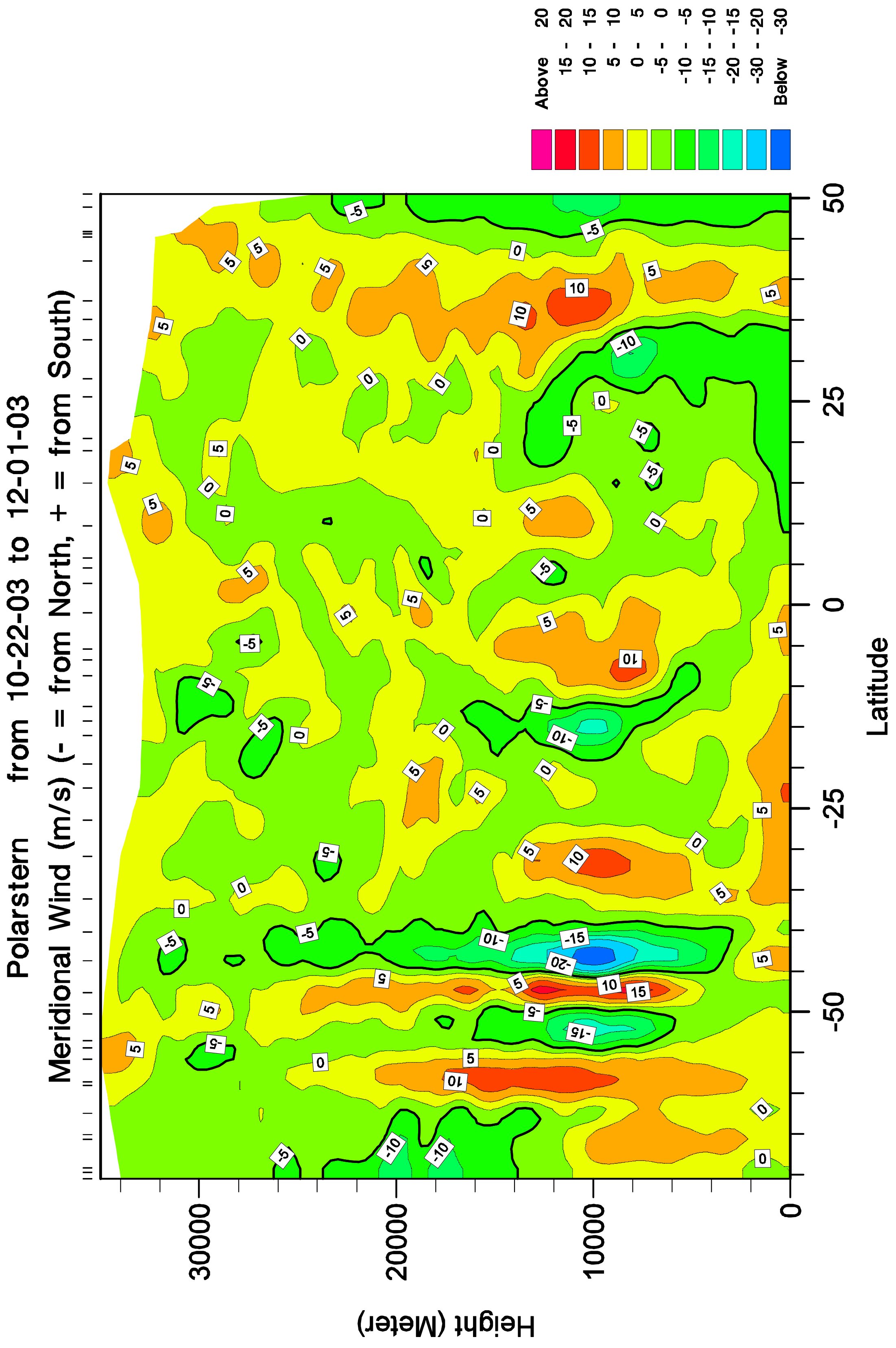

Fig. 117: Meridional-height section of meridional wind during ANT-XXI based on upper air soundings

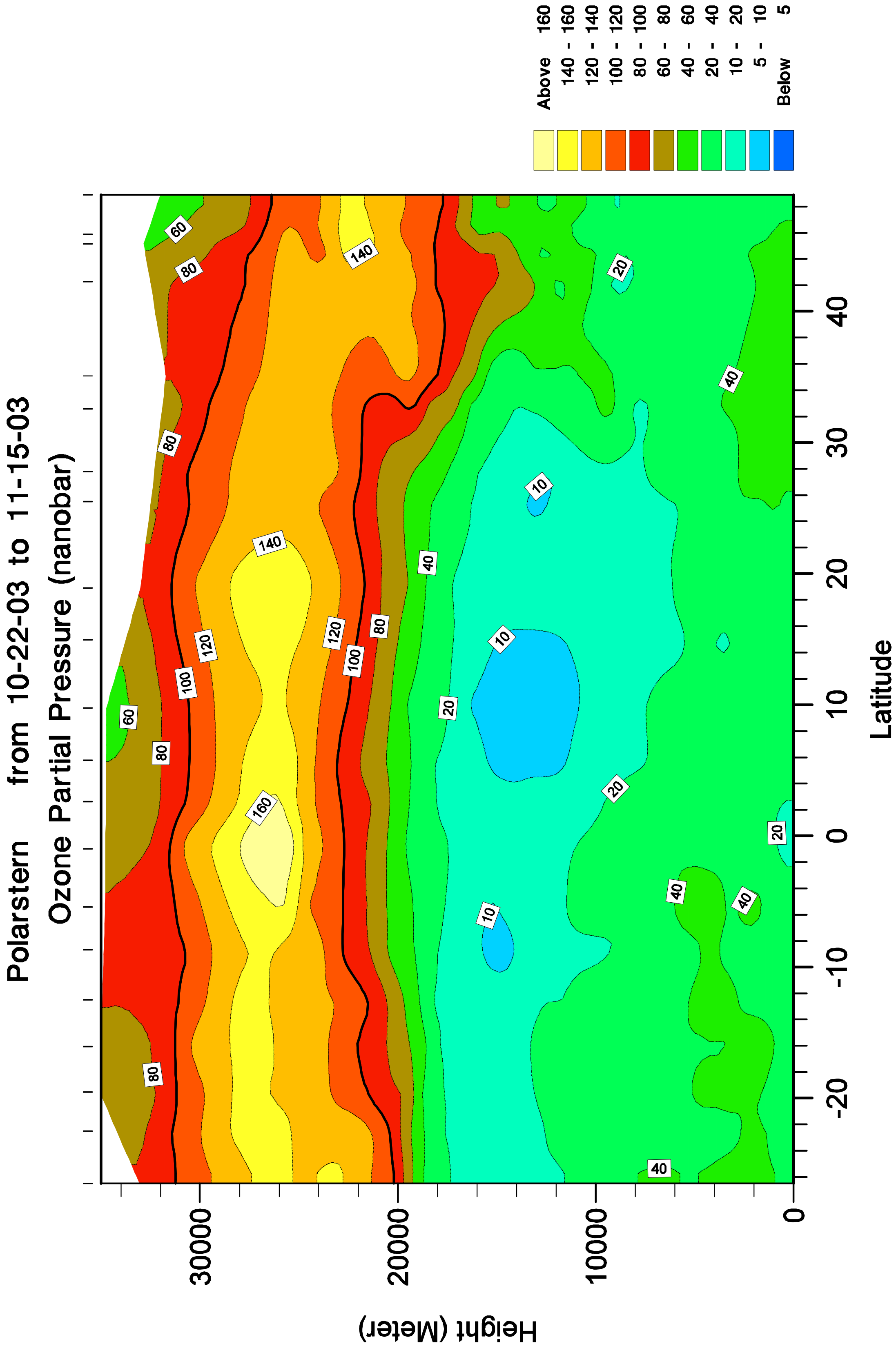

Fig. 118: Meridional-height section of ozone during ANT-XXI based on upper air soundings

7. Data Access

This report is accompanied by a CD-ROM that contains the project related datasets. The content of the medium represents the information as stored in the information system for Publishing Network for Geoscientific & Environmental Data **PANGAEA** at the time of publication. All data are also available online through http://www.pangaea.de.

Via the homepage from the Alfred Wegener Institute for Polar and Marine Research (http://www.awi.de) data subsets can be selected online from the Meteorological Information System at AWI **MISAWI.** The data archiving is ongoing and includes the most recent data.

8. Acknowledgements

This report is based on the data obtained from the weather technician/observers from Polarstern, who performed the routine 3-hourly synoptic observations and the daily upper air soundings. Thus, special thanks are expressed to Hans Ohlendorf, Dieter Bassek, Wolf-Thilo Ochsenhirt, Hans-Peter Lambert, Herbert Köhler, Hartmut Sonnabend, Klaus Bult, and last but not least to Edmund Knuth from the German Weather Service (DWD) who managed the cooperation between the Alfred Wegener Institute and the DWD.

The continuous datasets are taken from the **PO**larstern **D**ata **A**cquisition **S**ystem called **PODAS**. Special thanks go to Peter Gerchow and Jörg Hofmann from the company FIELAX, Bremerhaven who developed and maintained this powerful system.

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