JAMES RENNELL CENTRE FOR OCEAN CIRCULATION

INTERNAL DOCUMENT No. 8

Meteorological data gathering during RRS *Discovery* Cruise 198

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1. Introduction

The meteorological monitoring system used on RRS *Discovery* is a modified version of the metlogger installed on RRS *James Clark Ross* in 1991 and comprises the following instruments :

an R.M.Young Instruments 05103 wind monitor, including wind vane and anemometer - this is situated on the foremast;

two Vector Instruments psychrometers, located port and starboard on the foremast (serial numbers 1072 and 1073 respectively), measuring wet and dry bulb air temperatures;

two Didcot cosine collector PAR sensors (spectral range 400-700nm) located port and starboard on the foremast (respective serial numbers 0150 and 0151);

two Kipp and Zonen total irradiance sensors (92015 and 92016 located port and starboard);

an IOSDL longwave pyrgeometer, fitted by Keith Birch prior to *Discovery*'s departure from UK waters, also on the foremast;

a hull-mounted RVS/RS Components platinum resistance thermometer, recording sea surface temperatures;

a Vaisala DPA21 aneroid barometer, located in the main lab.

The metlogger system was designed as a general purpose meteorological data package for use on cruises not requiring meteorological research standard instrumentation and therefore complements the IOSDL designed Multimet system which is geared towards a higher standard of performance. The *Discovery* metlogger system was developed as part of a joint project between British Antarctic Survey and the Instrument and Sensors Group at Research Vessel Services (RVS) and uses modular sensor packages and signal conditioning. For all sensors apart from the barometer, the conversion to digital data takes place at the module (by Rhopoint) and data are transmitted to the logger by an RS485 link (data from the barometer are transmitted by an RS232C link).

As this cruise was the first time the metlogger system had been used on *Discovery*, considerable thought was given on how best to process the data from the various instruments. Unlike most shipboard instruments that have a dedicated Level A interface, the metlogger PC emulates a standard Level A interface and transmits the data directly to the Level B in Ship Message Protocol (SMP). The data are transferred to the Level C and then reformatted from Level C to PSTAR format to allow processing under Unix, using a series of pexec scripts based on the set of scripts used for the IOSDL Multimet system. However, given the new instrument configuration on this cruise and a number of errors and inconsistencies in the Multimet scripts, a considerable degree of rewriting was necessary. Additionally, since the emlog was unavailable for the cruise, the speed of the ship over ground was calculated from GPS position fixes, averaged over one minute.

Note that all wind velocities in this document are given in meteorological convention, ie where the wind is coming **from** - this differs from the standard oceanographic convention for currents etc which are defined as where they are going to.

2. Processing

The Unix shell script *metexec0* was used to retrieve 24 hour sections of data from the Level C and convert them into PSTAR format. *Metexec1* was used to calibrate all instruments apart from the aneroid barometer and wind monitor, and histograms of the calibrated output were produced for all sensors as a range check, to allow editing of obvious spikes. Ship's navigation data were merged with the met file by *metexec2*. *Metexec3* would normally be used to merge the emlog file and was therefore not used for this cruise. Ship's heading (gyro) was merged by *metexec4* and a combination of the ship's velocity components and heading was used in *metexec5* for the conversion from relative to absolute wind velocities. *Metexec6*, an appending script was used to generate a full time series from the individual 24 hour files and 10 minute averaged data files (vector averaging for the absolute wind velocities) were created by *metexec7*, both for general use by interested scientists and to allow the production of time series and vector summary plots.

2.1 Calibration

With the exception of the aneroid barometer and wind monitor, which were calibrated by the manufacturers prior to installation and were therefore logged through to the Level B as calibrated output, all instruments were calibrated during PSTAR processing of the met. data. The calibration algorithms applied were derived either from manufacturers calibration certificates or from calibrations undertaken by RVS and IOSDL prior to the cruise. Details are given in Table 1.

2.2 Plotting

Ten minute averages were computed for all parameters, except true wind speed and direction, which were first converted to east and north components and then calculated as 10 minute vector averages. In order to plot the vectors representing the direction the wind was going to, rather than coming from, the signs of both the east and north components of the wind vectors were reversed.

The scales on the vector plots of true wind speed and direction were chosen to represent an equivalent longitudinal area map for the latitude 60°S, ie each interval on the x axis represents twice as many longitudinal units as the number of latitudinal units represented by each y axis interval. The vector plots of the two SeaSoar surveys and the 88°W transect were also designed to represent the same scale as the ADCP current vector plots.

Time series plots summarising the data from 7 day blocks were also produced - the vertical scales on these plots were simply designed to maximise the vertical separation between parameters. Sea and air temperatures were plotted on the same vertical scale throughout these plots to enable easy identification of features where sea temperature exceeded air temperature and to allow comparison of the degree of variation between the two parameters.

3. Performance

Generally, the instruments performed very well, particularly for a first cruise. The PC display was very useful and frequently consulted, particularly when crossing fronts, during storms and generally by those who resented being cut off from reality by dogged portholes ! There were, inevitably, a couple of problems which have been detailed below, but these are minor details in a system which has generally proven reliable and readily usable:

The port dry bulb sensor was very noisy throughout the majority of the cruise, particularly at near-zero and sub-zero temperatures. However; the remaining signal is strongly correlated with the port wet bulb temperature and is almost certainly worth keeping - the noise can easily be flagged out at BODC using an interactive graphical editor.

Both PAR sensors recorded negative irradiances during dark periods. At present it is not clear whether this is a calibration offset, in which case the entire PAR profiles will be consistently underestimated by approximately $5W/m^2$ or whether it is a nonlinearity near zero, as suggested by comparison at low-zero light levels with the output from the Aiken PAR sensor However, this comparison is of limited use due to the different configurations of the two types of sensor. (The Didcot instruments are cosine collectors; the Aiken sensor is hemispherical - ie 2 π). Recalibration of the sensors would be the only unequivocal way to resolve this problem.

The sea surface temperature sensor calibration only spans a range of +5° to +25°C, which is of limited use in Antarctic waters with an approximate temperature range of -2° to 7°C. Comparison with SeaSoar surface temperatures suggests that both the slope and offset of the calibration equation are inapplicable to near-zero and sub-zero temperatures.

The conversion from relative to absolute wind velocities is dependent upon a continuous record of heading from the ship's gyro. The current PSTAR processing script merges the ship's navigation file to the met file by linear interpolation- this is not suitable for a parameter such as ship's heading which "wraps around" at 360 degrees. The problem was circumvented on this cruise by going back to the original 1 second gyro file, but this is, at best, a temporary solution.

Redrawing of the LabTech display on the PC causes an unacceptable loss of data acquisition. This is exacerbated by users' impatience with the slow screen redraw, sometimes resulting in several redraw commands being issued. Separation of the screen handling and data acquisition functions of the system would be a welcome bonus - the display is an excellent one, but need not compromise data acquisition.

4. Summary

The following features emerged through the cruise.

From the wind vector plots (note that the arrowheads actually indicate where the wind is "going to" rather than "coming from") of the Drake Passage / West transect, the two SeaSoar surveys and the 88°W transect, it can be seen that the winds are predominantly northeasterlies and northwesterlies and are fairly stable in terms of direction (although a reversal does occur during leg C of the second SeaSoar survey). The second survey was generally blessed with lighter winds than the first, whereas the westward transect was more prone to strong winds (and greater swell) than the Drake Passage run, with the final part of the westward transect / start of the first SeaSoar survey being particularly hard hit by winds consistently in the range 10 - 20 m/s. The 88°W transect was notable for the consistently westerly winds, mostly in the range 8 - 15 m/s.

The solar radiation plots, although noisy are encouraging - where there is a drop in longwave radiation signalling breaks in cloud cover, total irradiance increases relative to PAR (clouds are less "transparent" to PAR). Only the port side PAR and irradiance are shown, as the starboard sensors were frequently prone to shadowing as the ship tended to be heading South before local noon and North thereafter. As all the plots are in GMT, the PAR and total irradiance profiles become increasingly shifted to the right with increasing longitude, as local midnight becomes later, reaching a lag of nearly 6 hours at 88°W. From the longwave radiation plots it is apparent that cloud cover is intermittent, but generally quite high - there are very few cloud-free periods greater than 12 hours.

The wind speed and barometric pressure plots show that the operational area was swept by rapidly changing weather systems, where wind speed was not closely related to pressure. Even when the pressure dropped to almost 950mb, the wind speed did not exceed 20m/s, while the period of 15-20m/s winds persisted for less than 12 hours. There were very few occasions when the wind speed dropped below 5m/s and these also tended to be of short duration (6 - 12 hours).

The air and sea temperature plots are drawn to the same scale for ease of comparison, in order to highlight the occasions when sea temperature is greater than air temperature and convection becomes an important consideration. This can be seen crossing Burdwood Bank (day 316) and at the beginning of the first SeaSoar transect (day 330); this may also occur on other occasions, but is fairly equivocal, given the uncertainties surrounding the calibration of sea surface temperature. Generally, air temperature is considerably more variable than and usually exceeds, sea surface temperature, as predicted by the relatively high specific heat capacity of water.

5. Future work

Several of the data channels as they stand are fairly noisy and need to be rigorously screened on a datacycle -by-datacycle basis - this can probably be best achieved at BODC by making use of the available interactive graphical editing facilities. The port dry bulb temperature in particular needs careful attention.

The calibration uncertainties of sea surface temperature and of port and starboard PAR would ideally be resolved by a recalibration of the three instruments. Failing that, detailed comparisons of all the available, fully screened PAR and total irradiance channels will be necessary to determine and correct the calibration offsets in the port and starboard PAR. Given a relatively cloud-free day, it should be possible to predict the ratio of PAR to total irradiance, given the solar constant and knowledge of the appropriate geometries of the hemispherical and cosine collector instruments. Sea surface temperature should be recalibrated against the best measurement of underway temperature (SeaSoar, or ADCP).

Table 1 Calibration coefficients for the met. sensors installed on Cruise 198

Measurement	**Calibration**	**Source**	**Comments**
wind speed	y = 0.1x	manufacturer	cm/s to m/s
wind dir	none	manufacturer	calibrated on installation
port wet bulb temp	a = -23.71101 b = 6.84806e-3 c = 5.626587e-6 d = 1.077627e-9	IOS	equation takes the form : $y=a+x(b+x(c+dx))$
port dry bulb temp	a = -23.84735 b = 5.788879e-3 c = 5.648462e-6 d = 9.076649e-10	IOS	as above
starboard wet bulb temp	a = -21.63646 b = 2.580562e-3 c = 7.893778e-6 d = 6.608683e-10	IOS	as above
starboard dry bulb temp	a = -20.18834 b = 9.73387e-4 c = 7.835114e-6 d = 5.250384e-10	IOS	as above
sea temp	a = 2.9755e-4 b = 0.99189 c = 0.26705	RVS (range +5 - +25 °C)	equation takes form : $y=ax^2+bx+c$
port PAR	y = x / (5 * 12.86e-6)	manufacturer	5 is the signal amplification factor
starboard PAR	y = x / (5 * 12.87e-6)	manufacturer	as above
port total irradiance	y = x / (2 * 48.49e-3)	manufacturer	2 is the signal amplification factor
starboard total irradiance	y = x / (2 * 43.63e-3)	manufacturer	as above
longwave radiation	y = 0.23364486x	IOSDL	includes a *5 signal amplification factor
barometric pressure	none	manufacturer	calibrated prior to installation

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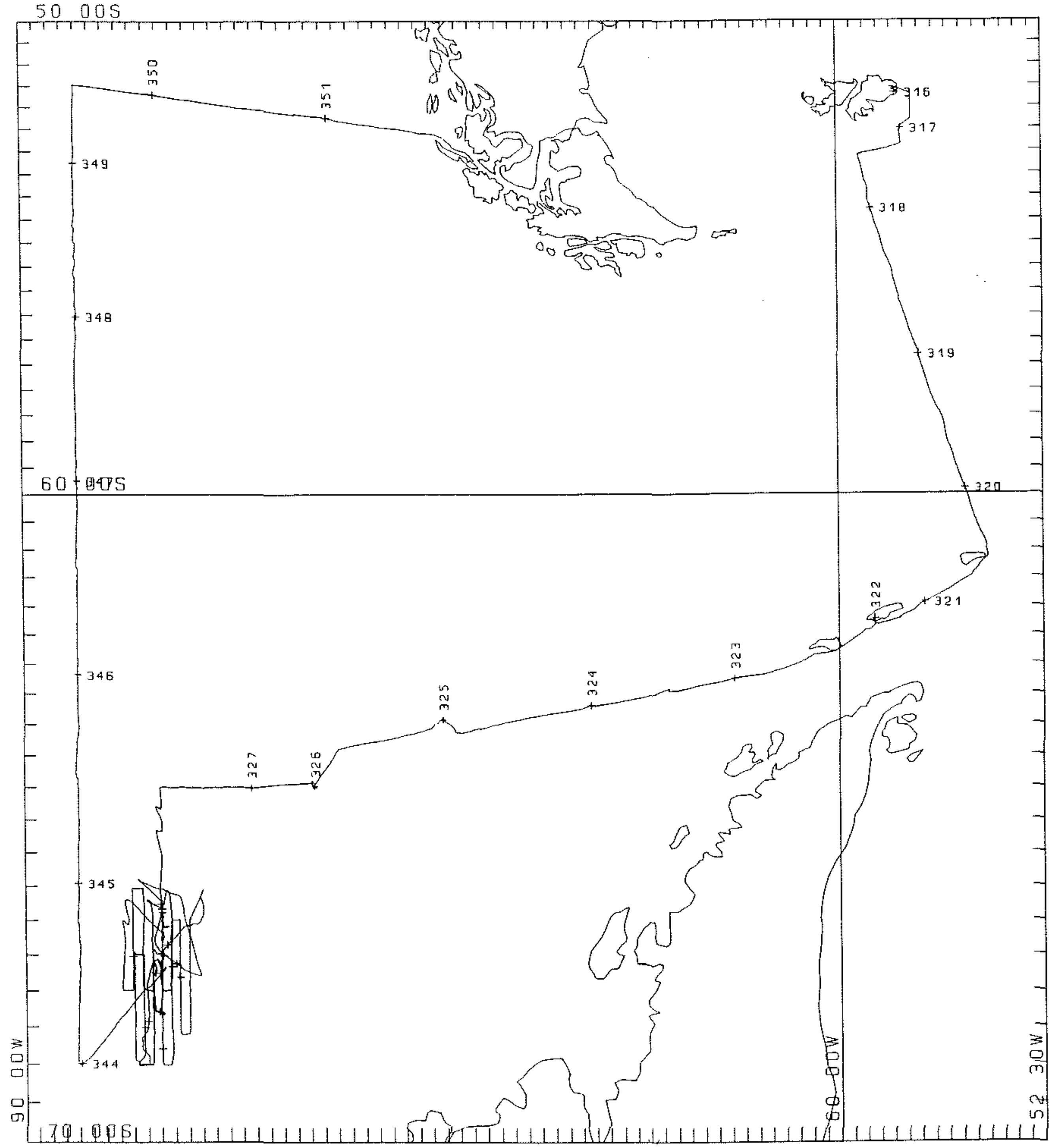

MERCATOR PROJECTION

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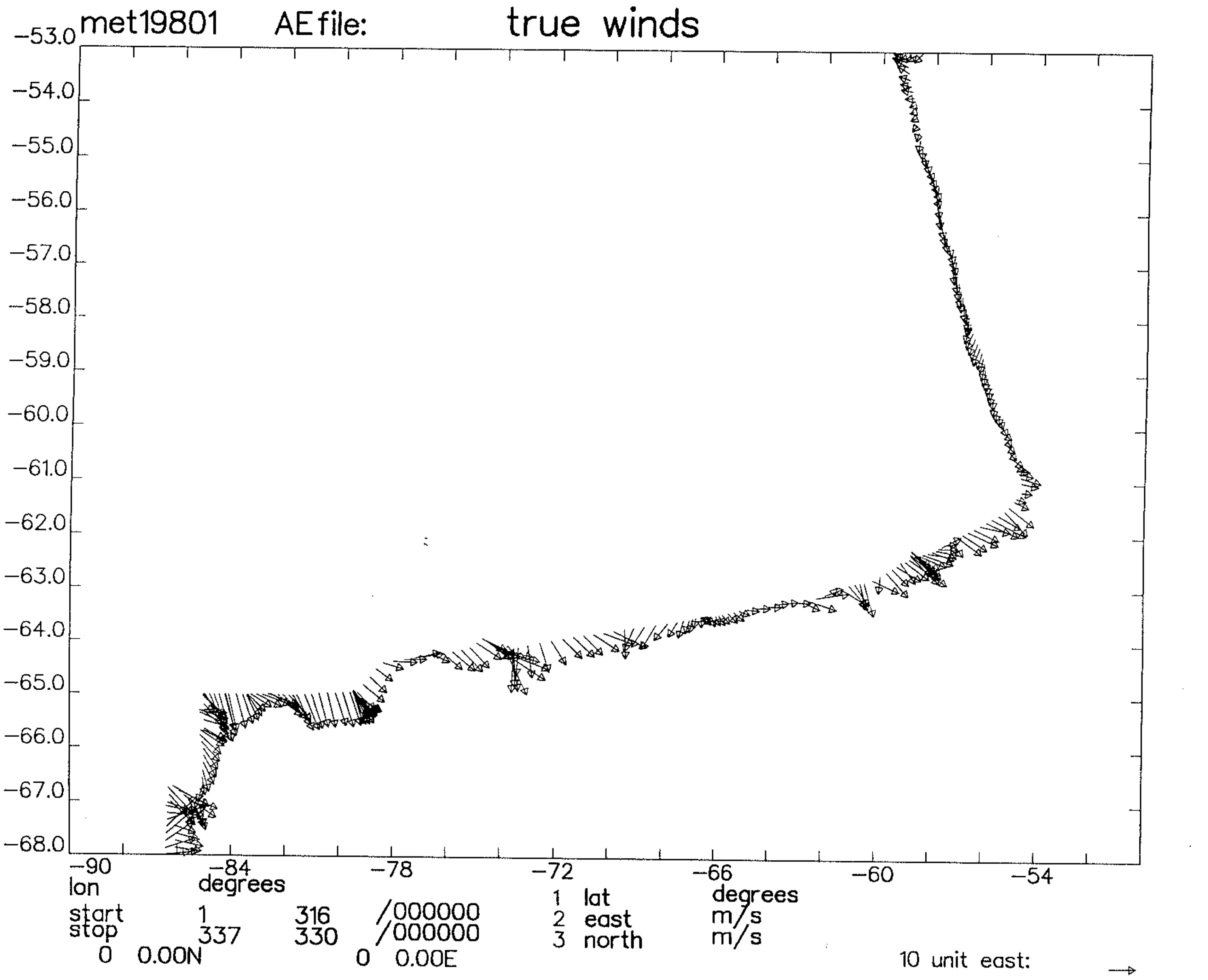
INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

STERNA 92 RRS Discovery Cruise 198 Nov/Dec 1992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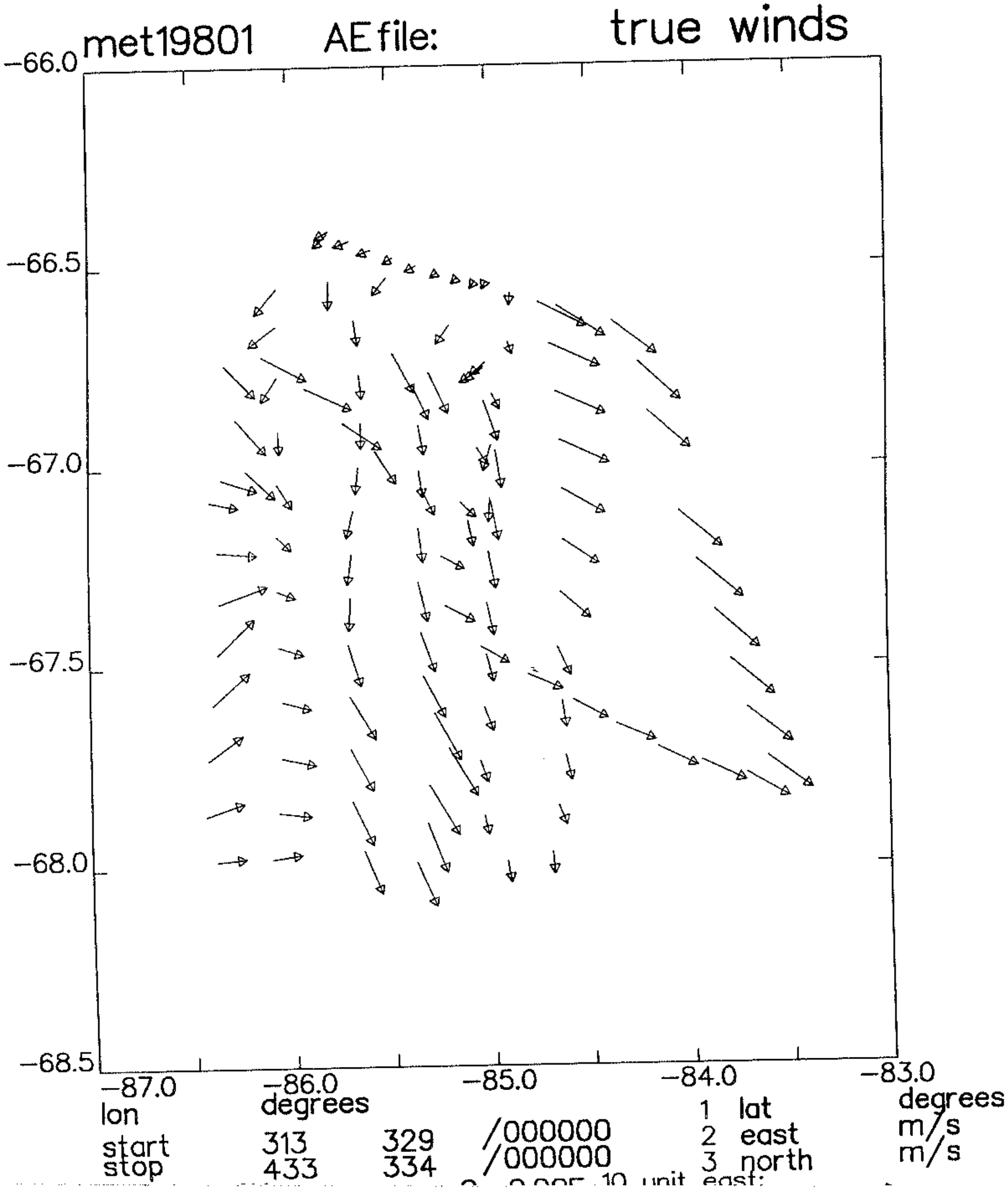
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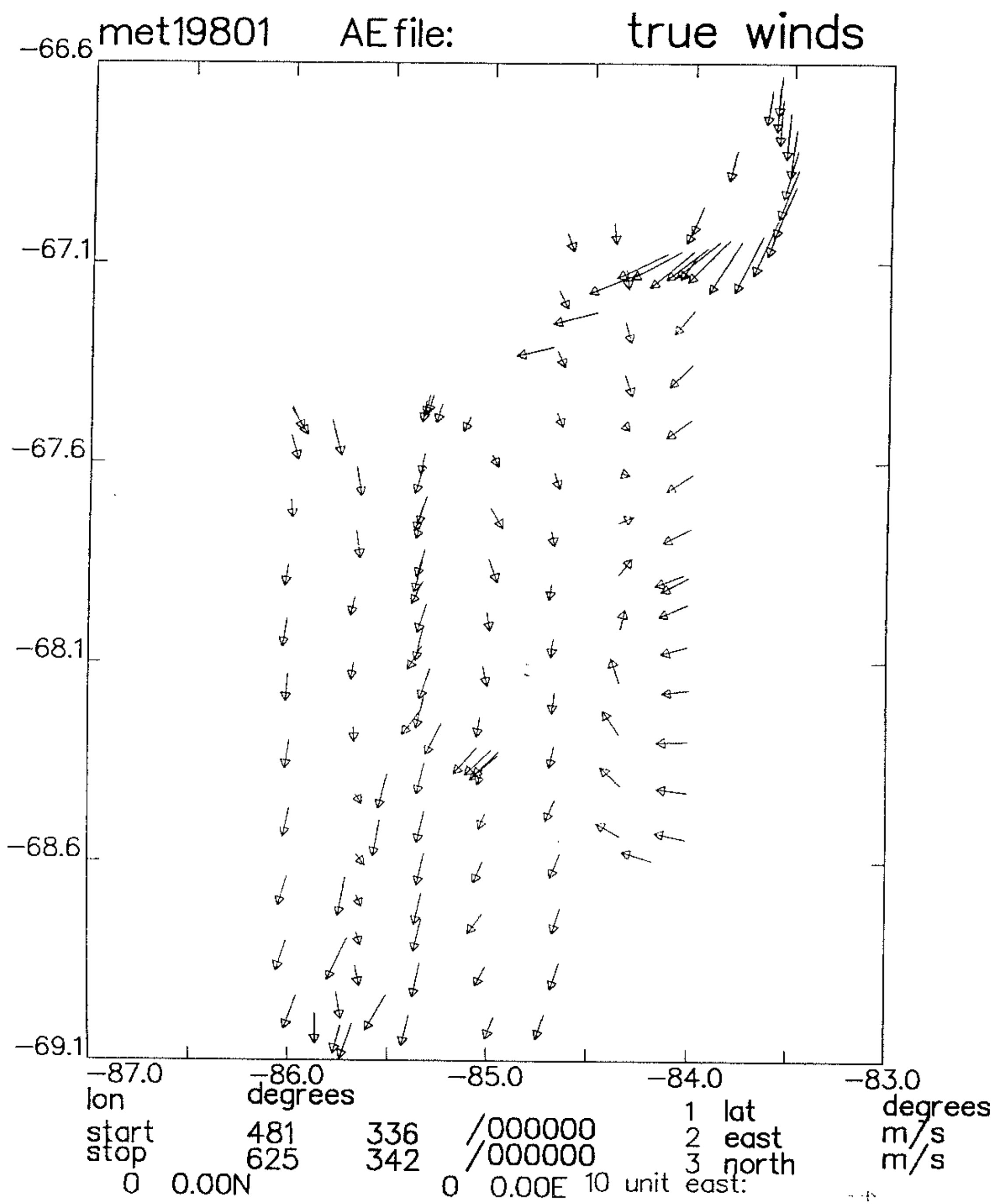

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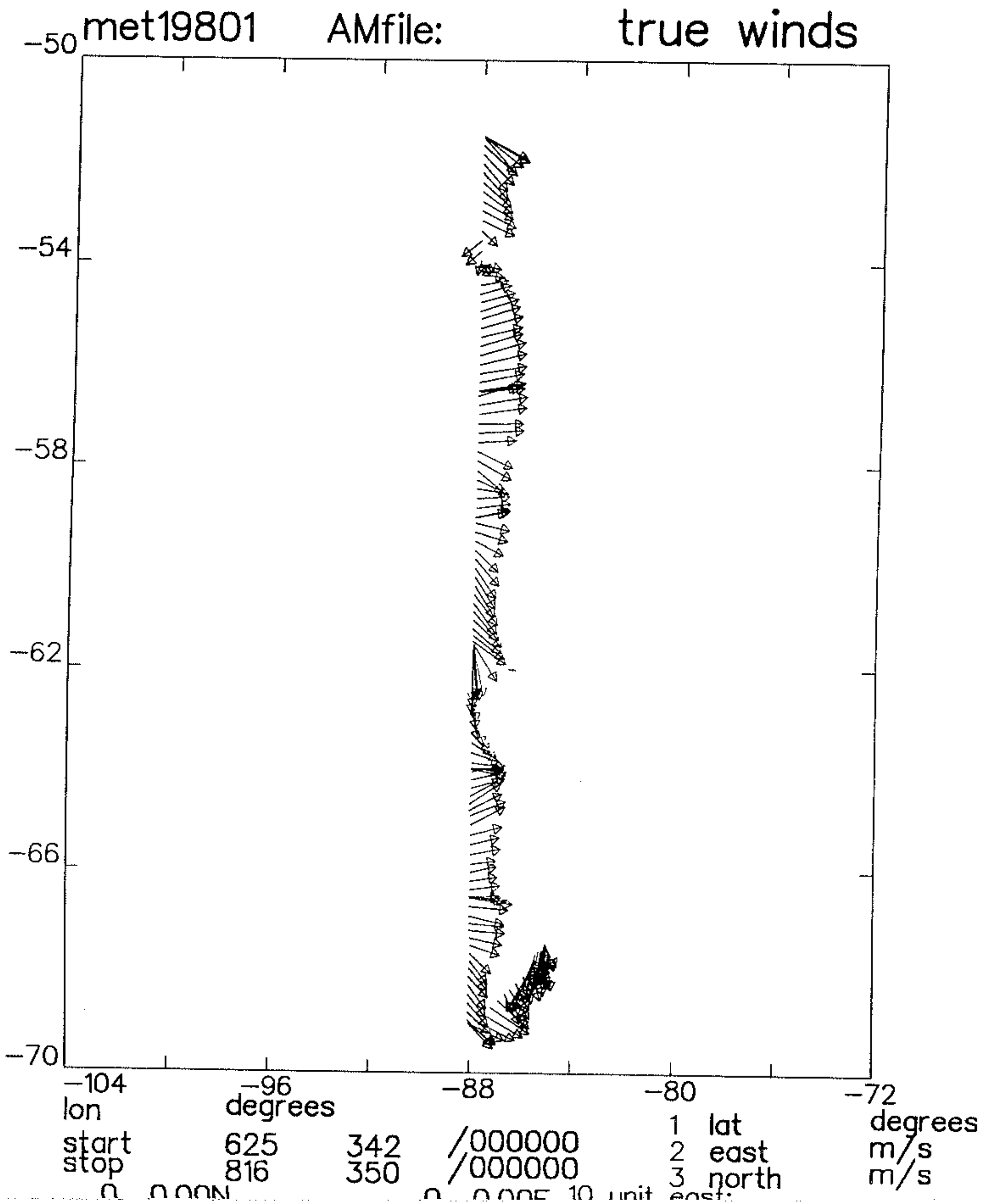
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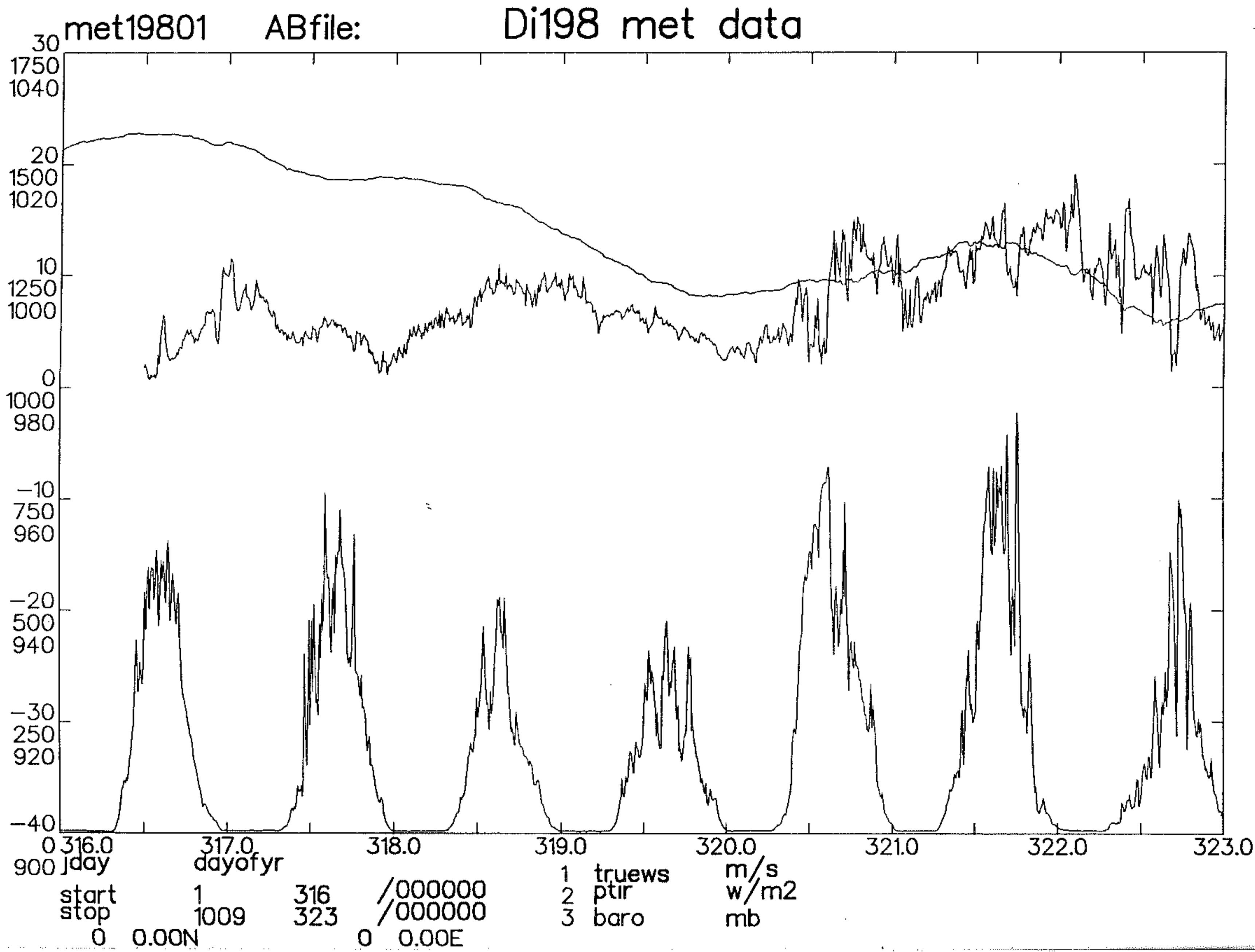
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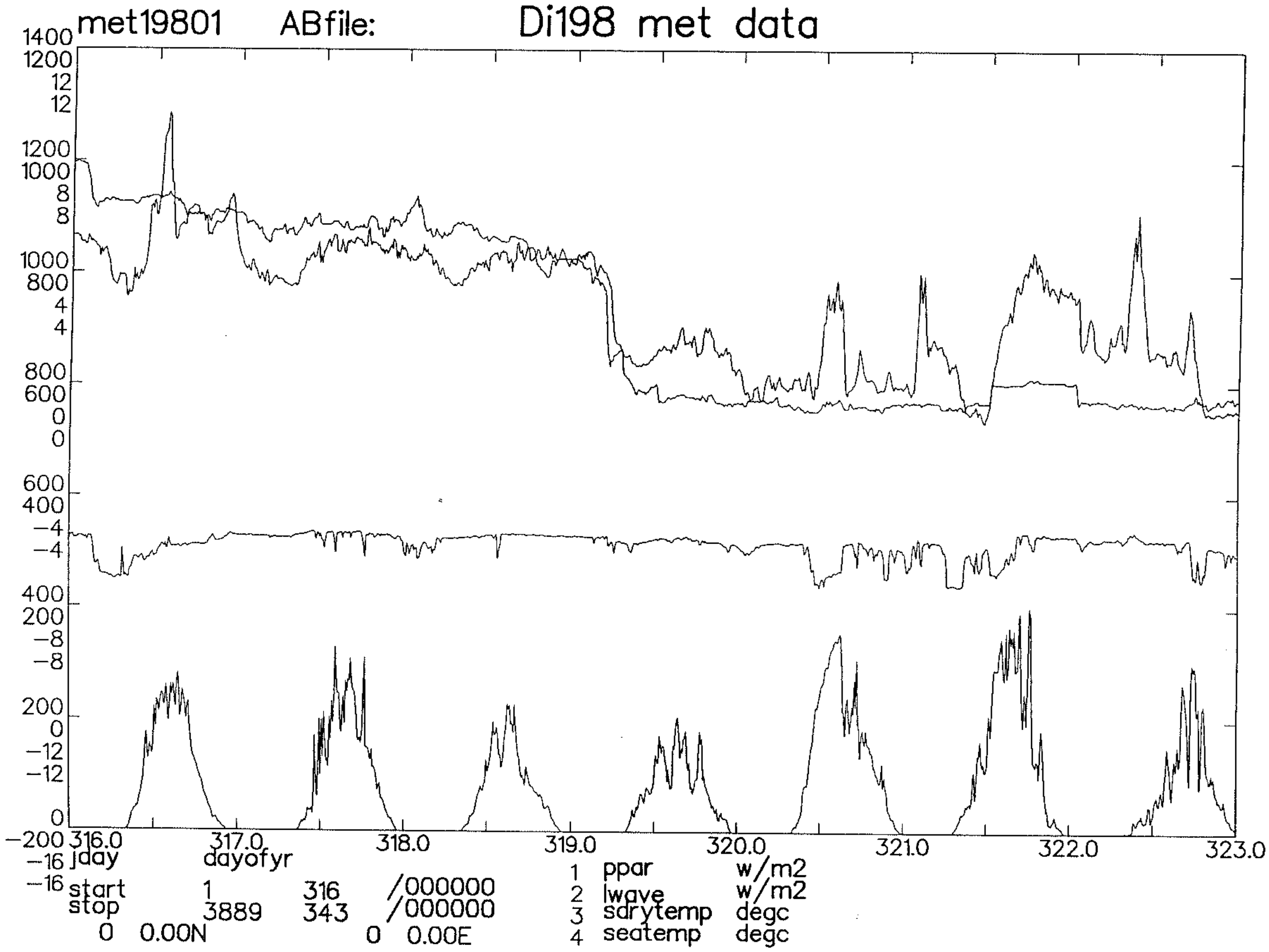
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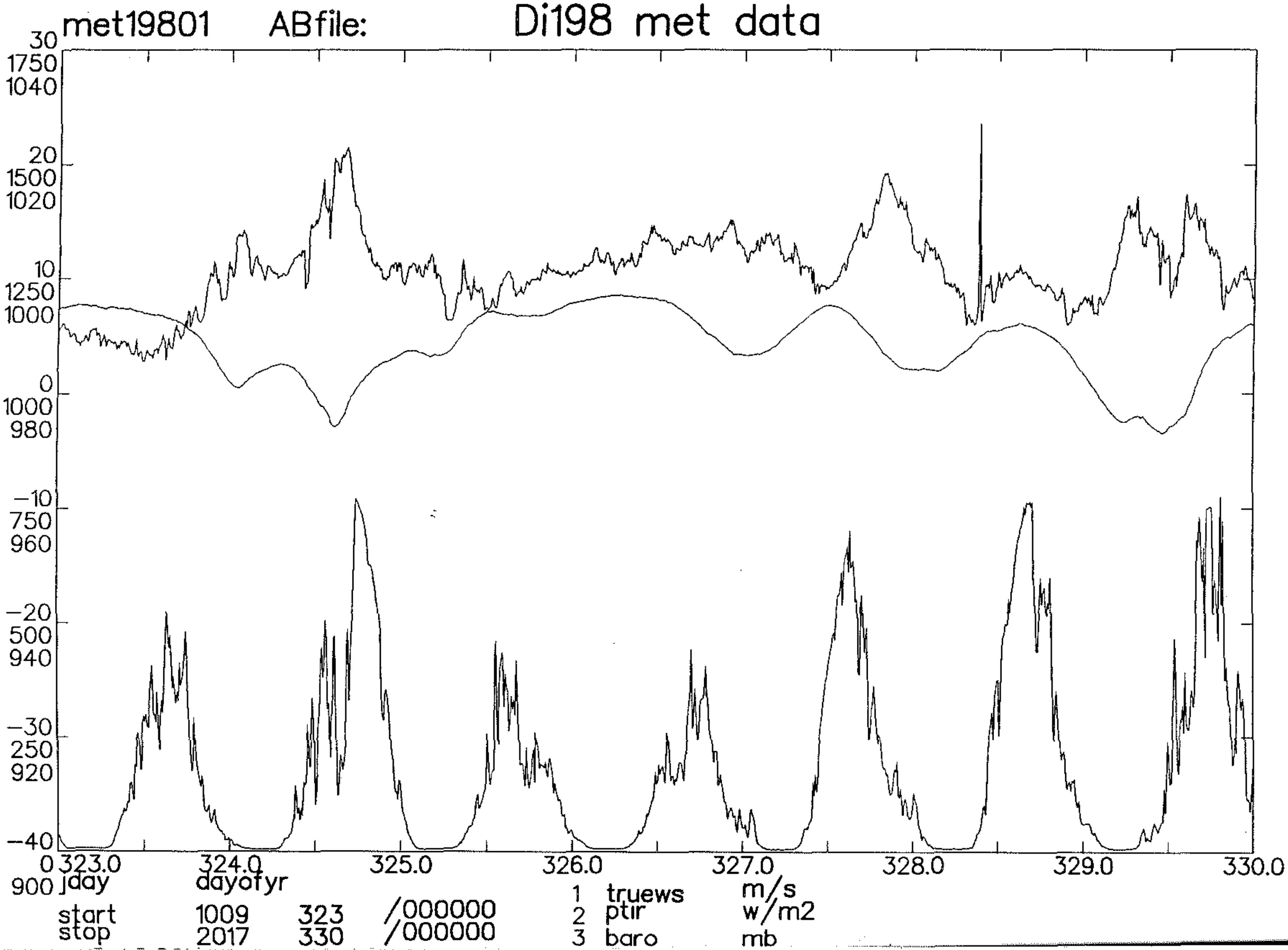
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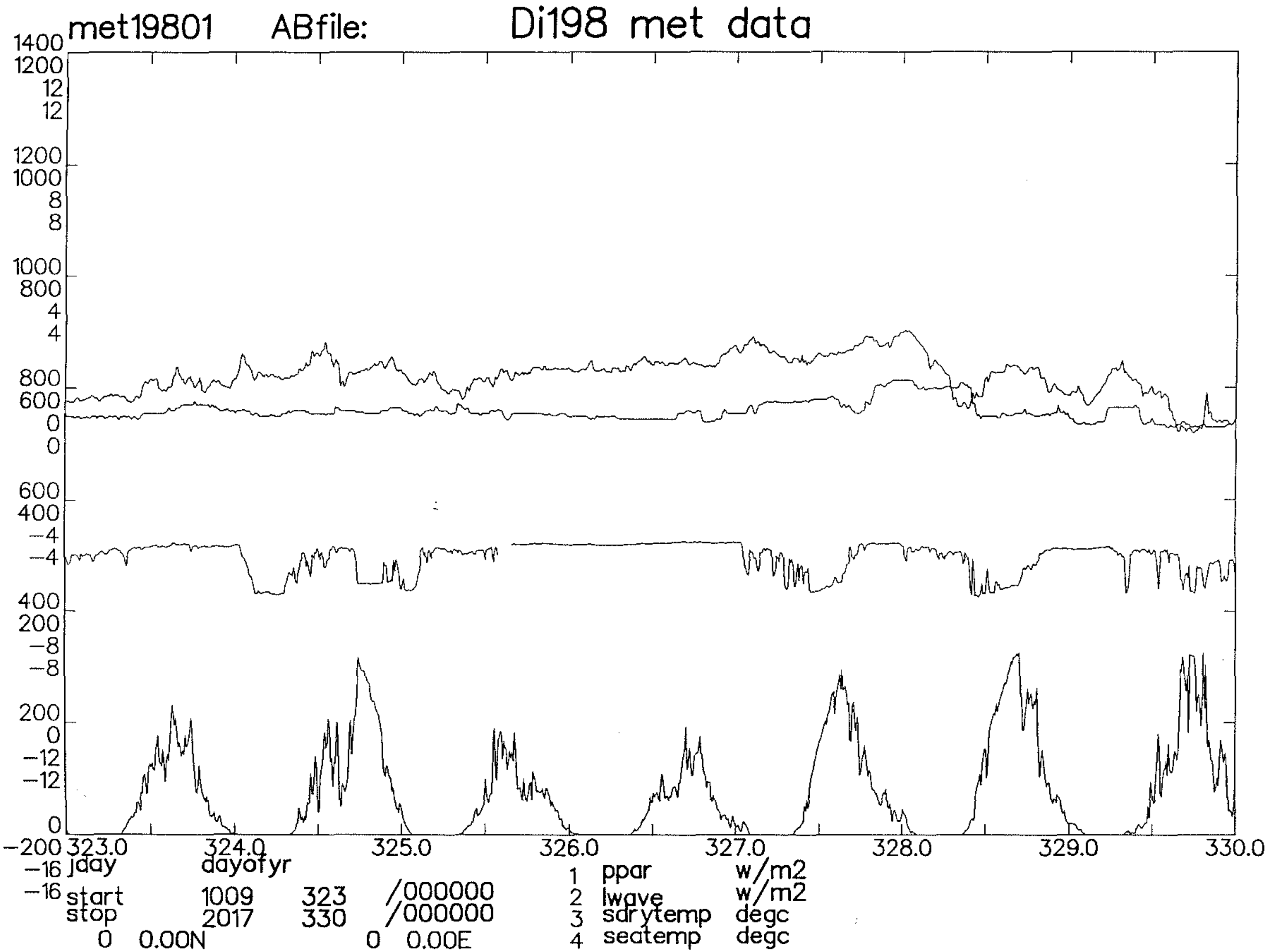

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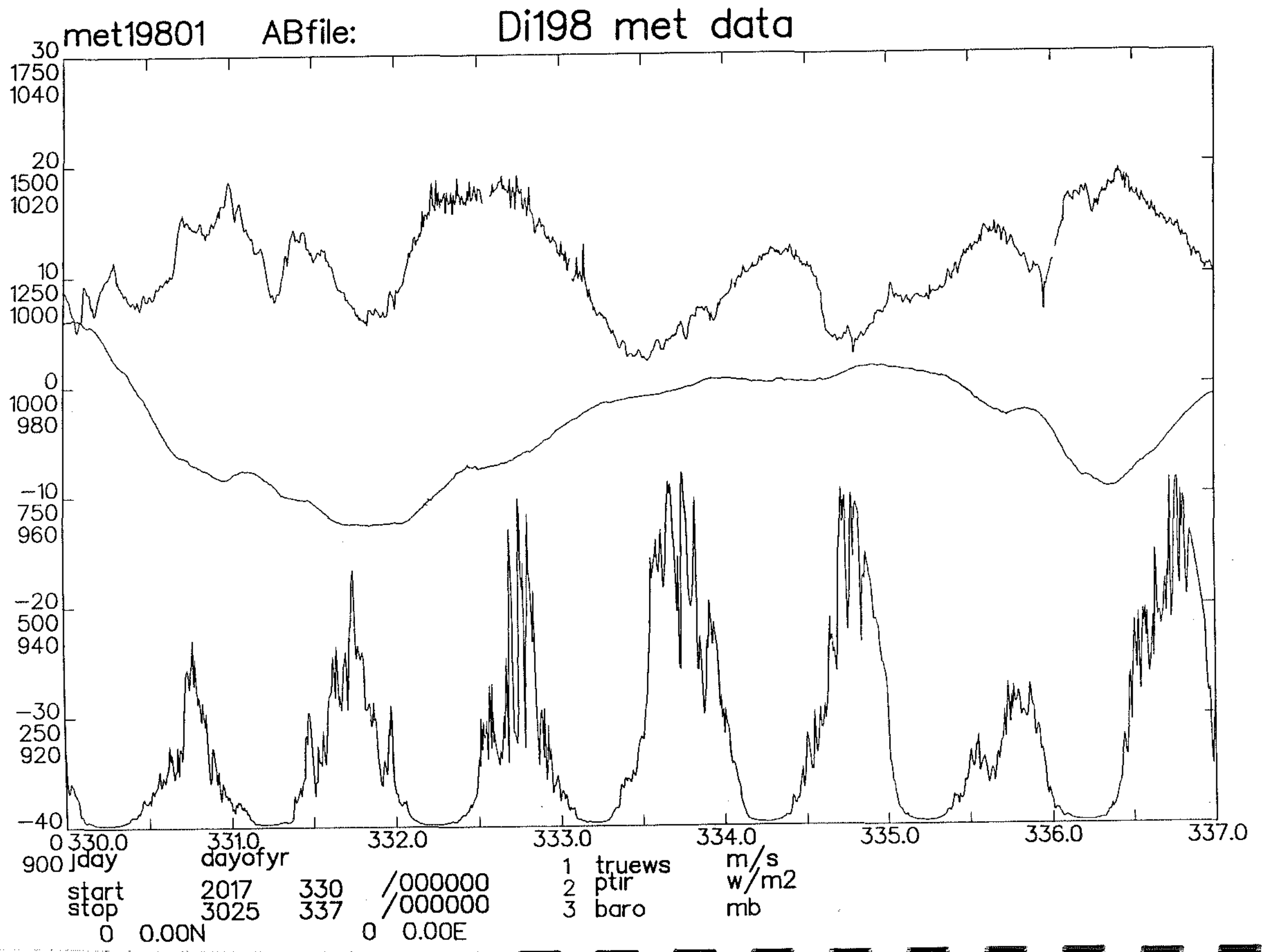
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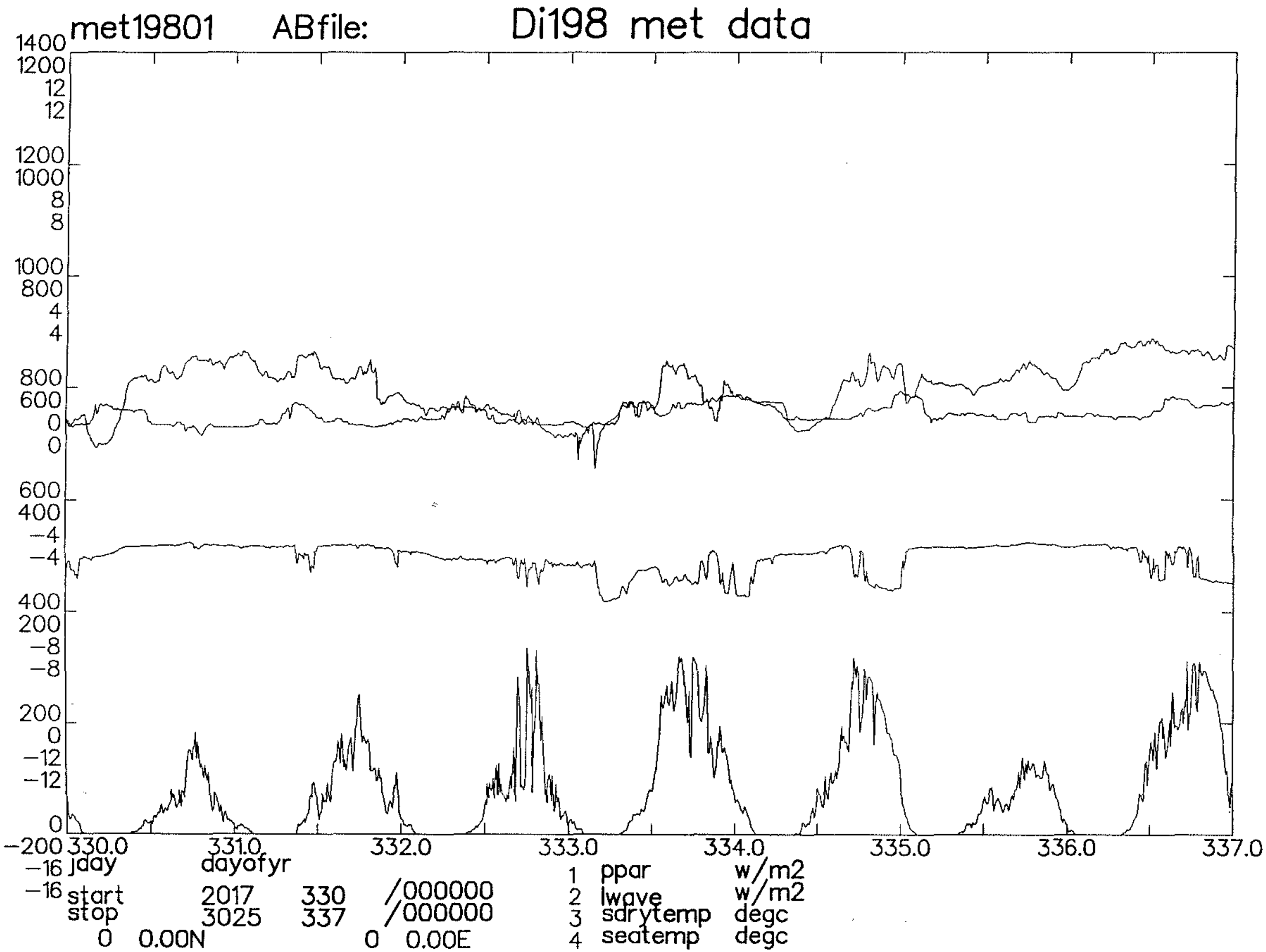
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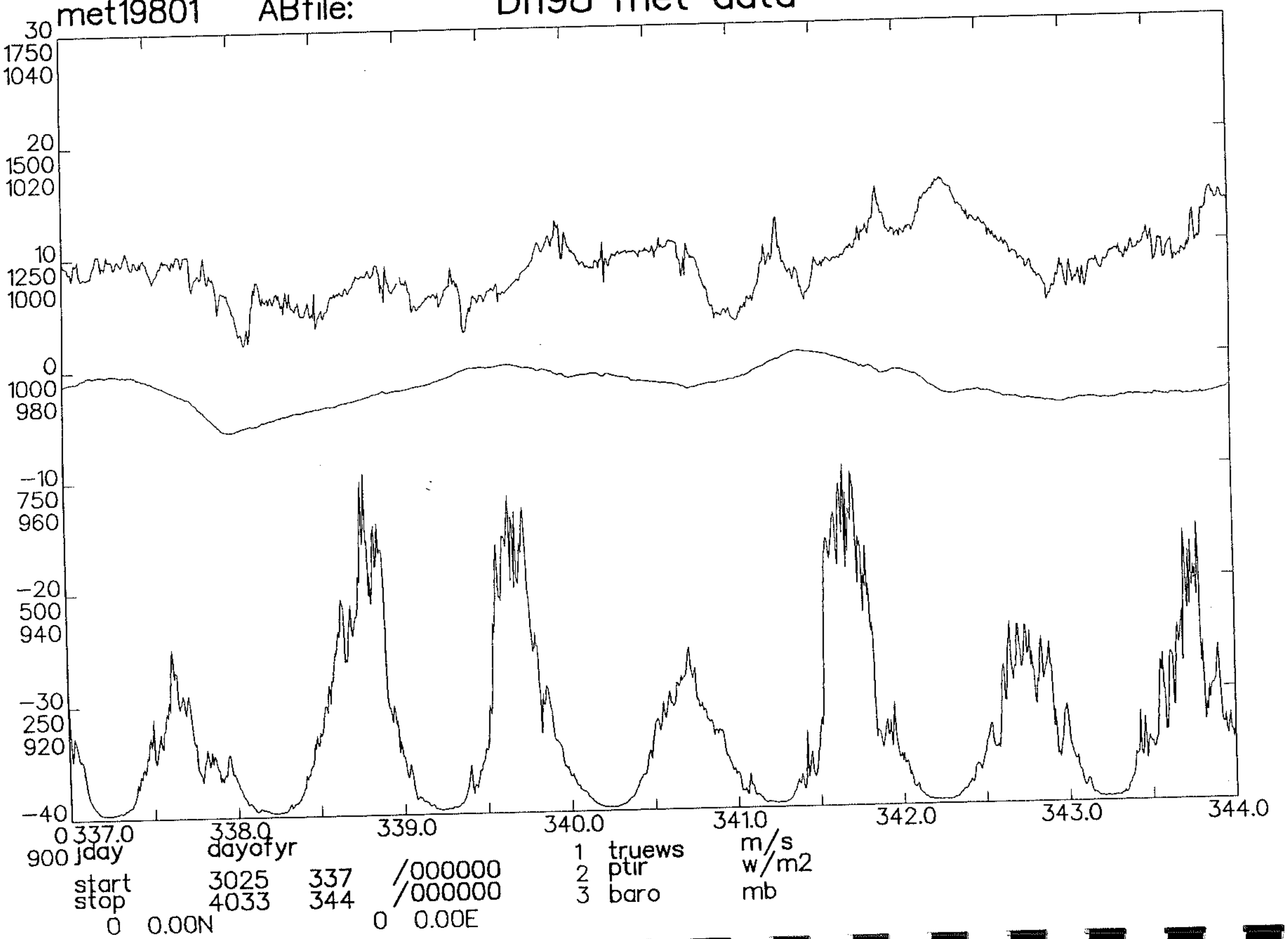

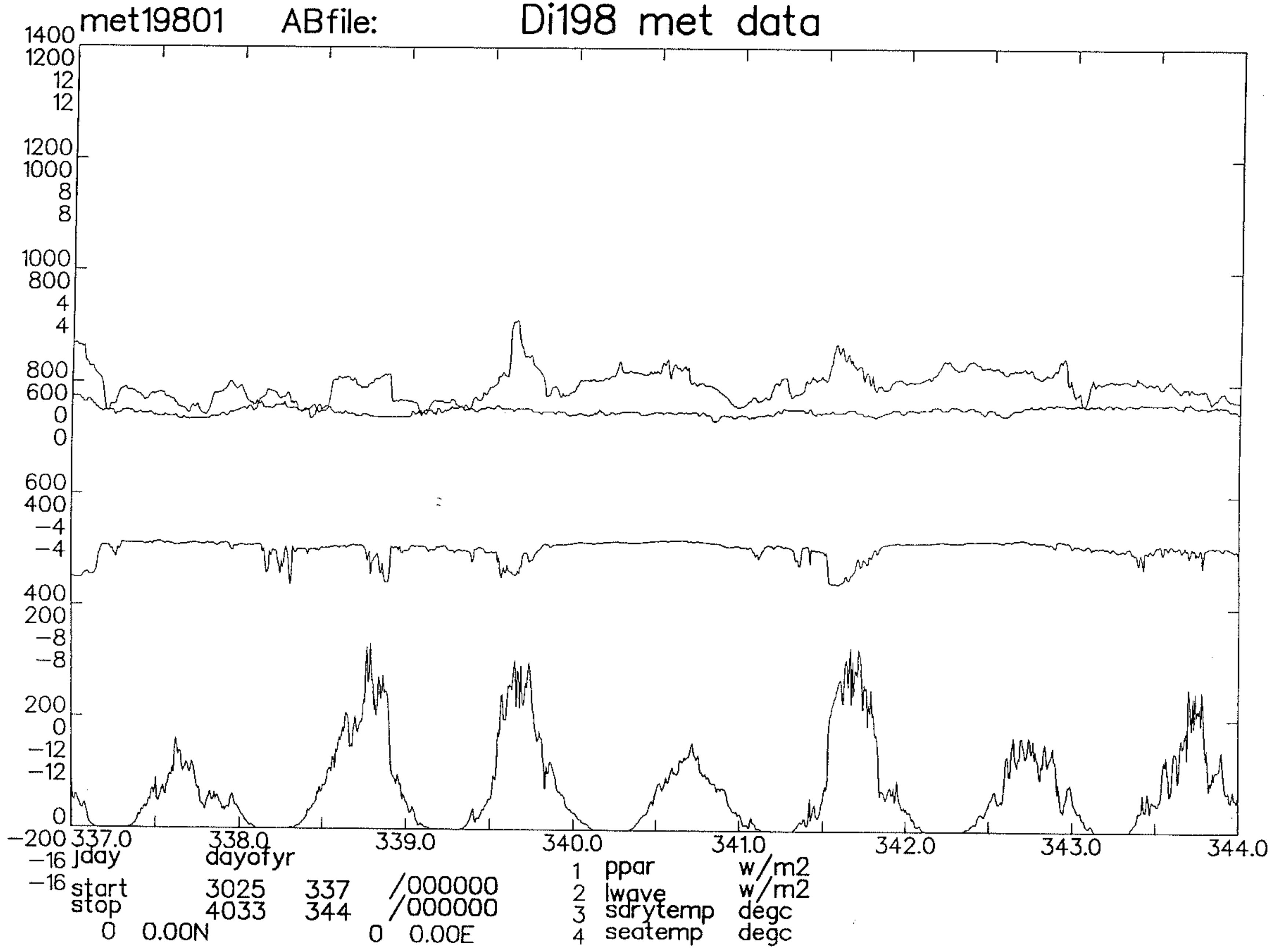
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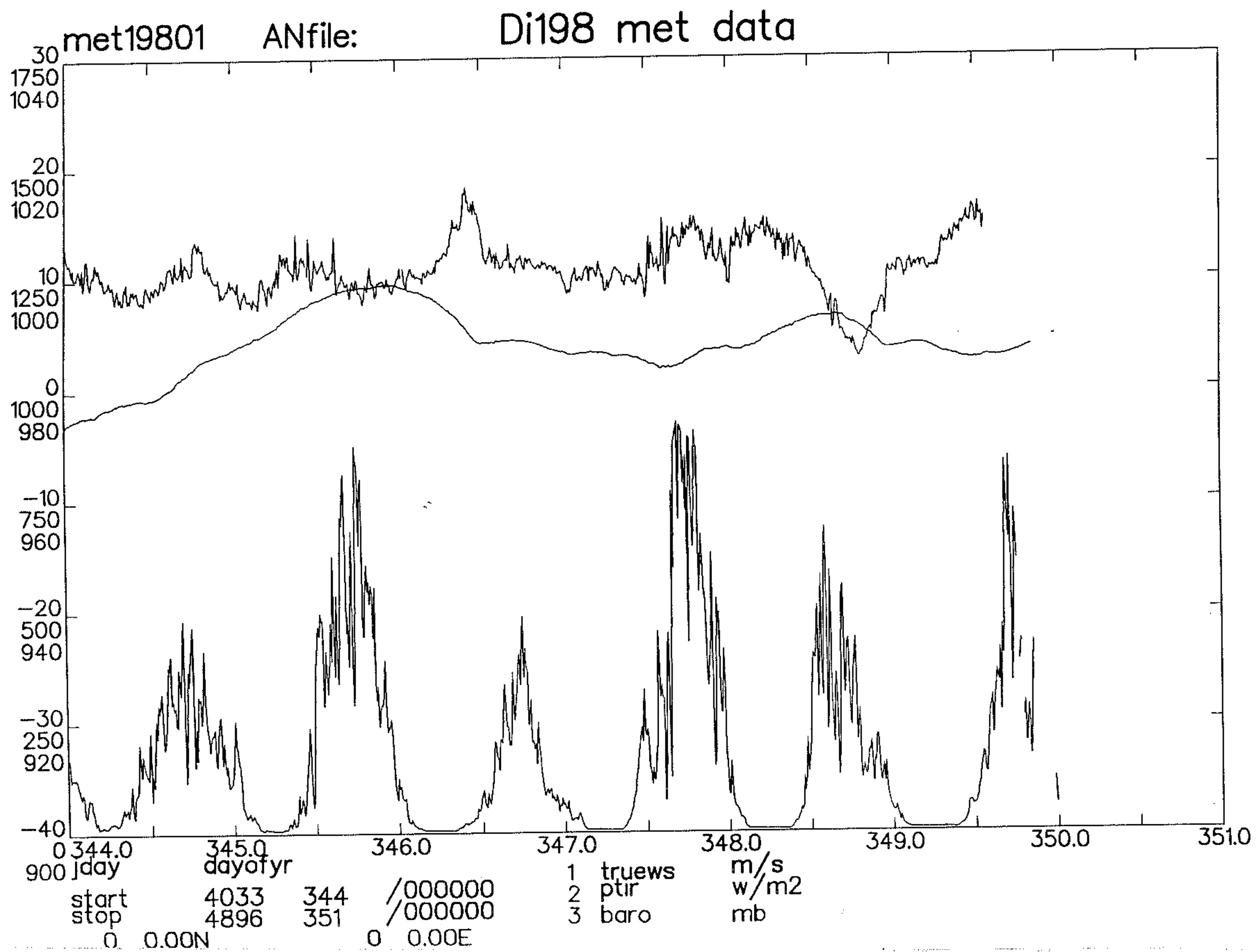
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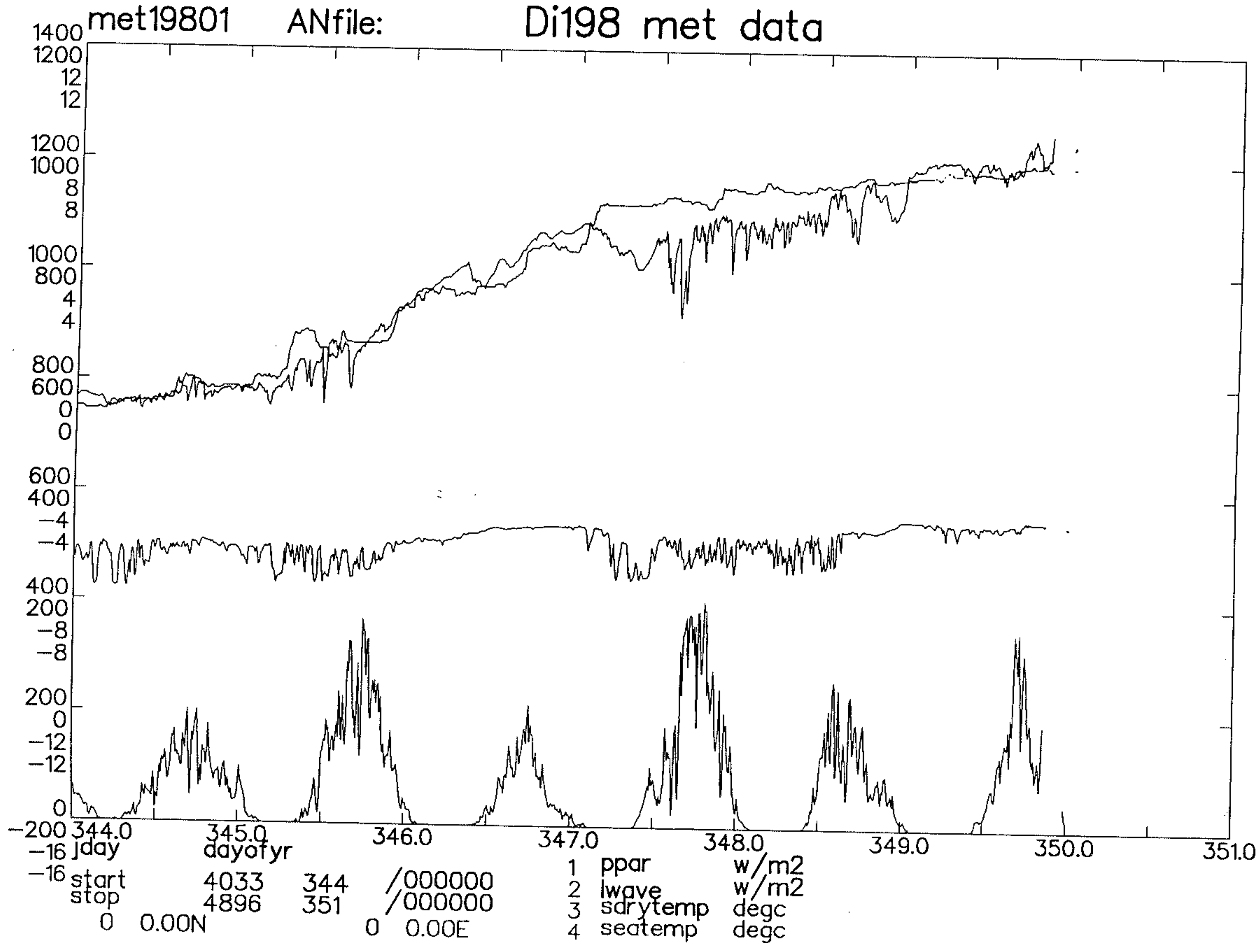

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