

AMT RRS Discovery Cruise D371 AMT21 Underway Meteorology and Surface Hydrography Document

Cruise details

Dates	2011-09-29 to 2011-11-14
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Data supplied by	Martin Bridger (NMF-SS)

These notes refer to underway data collected during the RRS Discovery cruise (D371) AMT21, between 29th September and 14th November 2011. The cruise departed from Avonmouth (UK) and finished in Punta Arenas (Chile). All time quoted in this document are UTC.

The data provided to BODC cover the period from 29/09/2011 to 09/11/2011.

The data did not fully cover the period of the cruise as the sea surface hydrography sensor suite was not turned on until clear of land at the start of the cruise (30/09/2011 08:00) and turned off prior to entering Argentinean territorial waters (09/11/2011 14:00). The vessel then arrived into Punta Arenas two days ahead of schedule on 12th November 2011.

Content of data series

Parameter	Units	Parameter code	Comments
Latitude	Degrees (+ve N)	ALATGP01	-
Longitude	Degrees (+ve E)	ALONGP01	-
Ship's heading (Gyro)	degrees	HEADCM01	-
Ship's eastward velocity	cm s ⁻¹	APEWGP01	-
Ship's northward velocity	cm s ⁻¹	APNSGP01	-
Distance run	km	DSRNCV01	-
Bathymetric depth	m	MBANCT01	-
Atmospheric pressure	mbar	CAPHTU01	-
Air temperature	°C	CDTASS01	-
Relative humidity	%	CRELSS01	-
PAR irradiance	W m ⁻²	DWIRRXMX	-
Total irradiance	W m ⁻²	CSLRR1XS	-

Relative wind direction	Degrees	ERWDSS01	-
Relative wind speed	m s ⁻¹	ERWSSS01	-
Absolute wind direction	Degrees	EWDASS01	Corrected for ship's heading and speed
Absolute wind speed	m s ⁻¹	EWSBSS01	Corrected for ship's heading and speed
Salinity - calibrated	Dimensionless	PSALSG01	Calibrated against samples
Temperature (sea surface, remote housing at non-toxic seawater supply inlet) - calibrated	°C	TEMPHG01	Calibrated against samples
Temperature (TSG housing)	°C	TMESSG01	-
Fluorometer output: voltage	V	FVLTWS01	-
Chlorophyll fluorescence (calibrated)	mg chl_a m ⁻³	CPHLUT01	Calibrated against samples
Beam transmission	%	POPTDR01	-
Beam attenuation	m ⁻¹	ATTNDR01	-

Instrumentation

Navigation and bathymetry (HIPLAT)

Instrument	Type
Fugro Seastar 9200 G2 XP Differential	GPS
Trimble GPS 4000 DS Surveyor	GPS
ASHTECH ADU-2 Altitude Detection Unit	GPS
Ship's Gyrocompass	Gyro compass
Simrad EA500 Precision Echo Sounder	Echosounder

Meteorology (HIMET)

Sensor	Serial number	Last calibration date	Deployment
Gill Wind sonic (Option 3)	071123	-	Port
Skye Instruments SKE510	28559	2010-07-22	Starboard
Skye Instruments SKE510	28563	2011-09-02	Port
Kipp and Zonen Ltd CMB6	962276	2010-09-17	Starboard

Kipp and Zonen Ltd CMB6	962301	2011-05-12	Port
Vaisala PTB100A	S3440012	2011-03-21	Port
Vaisala HMP45A	B4950011	2011-04-10	Port

Surface hydrography (HIUWAY)

Sensor	Serial number	Last calibration date
Sea-Bird SBE38	0491	2011-06-27
Sea-Bird SBE45	229	2011-04-13
Wetlabs C-Star	CST-1131PR	2011-03-24
Wetlabs WetStar	WS3S-248	2010-12-15

Originator's Data Processing

Navigation and bathymetry (HPPLAT)

During the cruise there was a dual logging system in place on the RRS Discovery. Data from the various instruments were logged to the RVS Level-C system and also as NetCDF (binary) through the Ifremer Techsas data logging system. The following instruments were logged during the cruise:

- 1) Fugro Seastar 9200 G2 XP Differential (logged to RVS format as gps_g2)
- 2) Trimble GPS 4000 DS Surveyor (logged to RVS format as gps_4000)
- 3) ASHTECH ADU-2 Altitude Detection Unit (logged to RVS format as gps_ash)
- 4) Chernikeef EM speed log (logged to RVS format as log_chf)
- 5) Ships Gyrocompass (logged to RVS format as gyro)
- 6) Simrad EA500 Precision Echo Sounder (logged to RVS format as ea500)

Processing was carried out using the RVS software suite. The following routines were run on the navigation and bathymetry data channels to produce files named after the routine that generated them:

RELMOV - Relmov is the relative motion file for this cruise. This was generated using the ships gyro and ships Chernikeef Log data to extract a movement in a given direction. This was then used by bestnav when and where necessary to calculate fixes if GPS fixes were not available.

BESTNAV - Bestnav uses all 3 GPS Systems logged and creates a best suite stream by providing an as complete account of the ships track as possible. This is done by reading all 3 GPS streams with gps_g2 being primary, gps_4000 as secondary and gps_ash as tertiary. The system looks for gaps of a certain length in the primary and when it finds those gaps it requests that the next gps down fill in the gaps. If no GPS data is available it asks RELMOV to fill in until data is available again. Then the system calculates back over itself to ensure that the extrapolated positions are correct using the GPS data available around the gap.

BESTDRF - Bestdrf is a product of bestnav. When run bestnav uses the relmov data which contains a predicted vn and ve based upon direction and speed through the water. The Bestdrf file is the accurate drift velocity of what actually occurred based on the GPS changes between each record.

PRODEP - Prodep is an automated process that accessed the bestnav position fix data and then uses a pre programmed Carter tables of corrections and corrects the echo sounder data for that given time.

Filename	Data type	Start Calendar Day	Start Time	Finish Calendar Day	Finish Time	Data Interval
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relmov	RVS Level-C processed	2011-09-28	08:06:50	2011-11-12	14:02:40	10 seconds
bestnav	RVS Level-C processed	2011-09-28	08:06:50	2011-11-12	14:02:40	10 seconds
bestdrf	RVS Level-C processed	2011-09-28	08:06:50	2011-11-12	14:02:40	10 seconds
prodep	RVS Level-C processed	2011-09-28	14:20:16	2011-11-09	13:58:05	variable
gps_g2X	RVS Level-C raw	2011-09-28	08:06:47	2011-10-01	15:27:46	1 sec
gps_g2	RVS Level-C raw	2011-10-01	09:34:08	2011-11-11	17:58:42	1 sec
gyroX	RVS Level-C raw	2011-09-29	09:04:45	2011-10-02	09:00:06	1 sec
gyro	RVS Level-C raw	2011-10-01	09:34:09	2011-11-11	17:59:02	1 sec

Meteorology (HPMET)

During the cruise there was a dual logging system in place on the RRS Discovery. Data from the various instruments were logged to the RVS Level-C system files surfmetX and surfmet, and also as NetCDF (binary) through the Ifremer Techsas data logging system. The following instruments were logged during the cruise:

- 1) Gill Wind sonic (Option 3)
- 2) Skye Instruments SKE510 (port and starboard)
- 3) Kipp and Zonen Ltd CMB6 (port and starboard)
- 4) Vaisala PTB100A
- 5) Vaisala HMP45A

Processing was carried out using the RVS software suite only on the wind channels. The RVS processing routine PRO_WIND was run on the navigation data in the bestnav and the relative wind data in the surfmet files. This program was designed to remove the relative variables from the wind data logged by surfmet. By removing any fixed offsets in the system and removing the affect of ship motion the data in the pro_wind file is a true representation of wind data at the ship's position.

Filename	Data type	Start Calendar Day	Start Time	Finish Calendar Day	Finish Time	Interval
pro_wind	RVS Level-C processed	2011-09-28	08:07:00	2011-11-12	14:01:50	10 seconds
surfmetX	RVS Level-C raw	2011-09-28	08:06:49	2011-10-02	09:00:00	1 sec
surfmet	RVS Level-C raw	2011-10-01	09:34:08	2011-11-11	18:03:53	1 sec

Sea surface hydrography (HPUWAY)

During the cruise there was a dual logging system in place on the RRS Discovery. Data from the various instruments are logged to the RVS Level-C system and also as NetCDF (binary) through the Ifremer Techsas data logging system. The following instruments were logged during the cruise:

- 1) Wetlabs C-star 25 cm pathlength transmissometer (logged to RVS format in surfmet)
- 2) Wetlabs WetStar fluorometer (logged to RVS format in surfmet)
- 3) Seabird SBE38 Temperature sensor (logged to RVS format in seabird)

4) Seabird SBE45 MicroTSG (logged to RVS format in seabird)

Filename	Data type	Start Calendar Day	Start Time	Finish Calendar Day	Finish Time	Interval
seabirdX	RVS Level-C raw	2011-09-30	08:02:38	2011-10-02	09:00:06	1 sec
seabird	RVS Level-C raw	2011-10-01	09:34:09	2011-11-09	10:26:53	1 sec
surfmetX	RVS Level-C raw	2011-09-28	08:06:49	2011-10-02	09:00:00	1 sec
surfmet	RVS Level-C raw	2011-10-01	09:34:08	2011-11-11	18:03:53	1 sec

BODC Data Processing

Navigation and bathymetry (HPPLAT)

The last ~20 days TECHSAS files (except the TSG data) were not saved to the post-cruise archive. TECHSAS files from 23 Oct 2011 to 13 Nov 2011 were missing. The RVS level-C files were confirmed complete by the originator. Since the TECHSAS file record for the cruise was incomplete the RVS Level-C files were chosen for transfer to the BODC underway file.

The bestnav data were initially transferred but over 100 gaps were found in the navigation channels, a number of them substantial (>3 hours). The originator confirmed the Fugro Seastar 9200 G2 XP Differential channels were the most reliable of the three GPS instruments on the vessel. The data streams in the gps_g2 and gyro files were checked and found to be more complete for the cruise. The navigation channels from the gps_g2 and gyro files were loaded in preference to the bestnav channels. A description of the channels present in the files, units, whether they were transferred, BODC parameter code and units, and if a unit conversion was applied during the transfer are detailed in the table below:

gps_g2	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	nbseen	number of satellites that can theoretically be seen from the current position	-	not for transfer	-	-
	nbused	number of satellites actually used to compute the position	-	not for transfer	-	-
	hdop	GPS horizontal dilution of precision	-	not for transfer	-	-
	vdop	GPS vertical dilution of precision	-	not for transfer	-	-
	pdop	GPS positional dilution of precision	-	not for transfer	-	-
	sec	time stamp applied by the GPS receiver device rather than the	-	not for transfer	-	-

		Techsas logger				
	lat	Latitude	Degrees +ve N	ALATGP01	Degrees +ve N	*1
	lon	Longitude	Degrees +ve E	ALONGP01	Degrees +ve E	*1
	alt	height of the antenna above the reference ellipsoid	-	not for transfer	-	-
	prec	horizontal position precision code	-	not for transfer	-	-
	mode	mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix	-	not for transfer	-	-
	cog	Course over ground = Course made good	Degrees True	APDAGP01	Degrees True	*1
	sog	Speed over ground = Speed made good	knots	APSAGP01	m s ⁻¹	*0.514
gyro	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	heading	Ship's heading	Degrees true	HEADCM01	Degrees true	*1
prodep	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	uncdepth	Raw depth from echosounder	m	MBANZZ01 - To be dropped after screening	m	*1
	cordepth	Depth corrected from Carter's tables	m	MBANCT01	m	*1
	cartarea	Carter's table area from position	-	not for transfer	-	-

The navigation channels were checked using BODC Matlab routine 'navcheck' and three gaps were identified. Each period was less than 10 minutes in duration and using the BODC Matlab routine 'navint' the gaps were filled by interpolation. There were no speed check failures. The latitude and longitude channels were screened by plotting the course on to a map of the Atlantic Ocean. There was no further flagging required.

The north-south (APNSGP01) and east-west (APEWGP01) velocities were then calculated from the latitude and longitude using the BODC Matlab routine 'velcal' and the distance run (DSRNCV01) using the BODC Matlab routine 'disrun'.

Meteorology (HPMET) and Sea surface hydrography (HPUWAY)

The last ~20 days TECHSAS files (except for the TSG data) were not saved to the post-cruise archive. TECHSAS files from 23 Oct 2011 to 13 Nov 2011 were missing. The RVS level-C files were confirmed complete by the originator. Since the TECHSAS file record for the cruise was incomplete the RVS Level-C files were chosen for transfer to the BODC underway file.

The surfmetX/surfmet and seabirdX/seabird data were transferred. A description of the channels present in the files, units, whether they were transferred, BODC parameter code and units, and if a unit conversion was applied during the transfer are detailed in the table below:

surfmet	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	temp_h	TSG housing temperature	-	not for transfer - loaded from seabird file with salinity	-	-
	temp_m	Remote temperature at non-toxic inlet	-	not for transfer - loaded from seabird file with salinity	-	-
	cond	TSG conductivity	-	not for transfer - loaded from seabird file with salinity	-	-
	fluo	Raw fluorometer voltage	V	FVLTWS01	V	*1
	trans	Raw transmissometer voltage	V	TVLTDR01	V	*1
	press	Atmospheric pressure at measurement height - no sea level correction	1 hPa	CAPHTU01	1 mbar	*1
	ppar	Raw port PAR sensor voltage	10 ⁻² mV	DVLTRPSD	V	*10 ⁻⁵
	spar	Raw starboard PAR sensor voltage	10 ⁻² mV	DVLTRSSD	V	*10 ⁻⁵
	speed	Relative wind speed	m s ⁻¹	ERWSS01	m s ⁻¹	*1
	direct	Relative wind direction	Degrees	ERWDSS01	Degrees	*1
	airtemp	Air temperature	Degrees Celsius	CDTASS01	Degrees Celsius	*1
	humid	Air humidity	Percent	CRELSS01	Percent	*1
	ptir	Raw port TIR sensor voltage	10 ⁻² mV	CVLTRP01	V	*10 ⁻⁵
	stir	Raw starboard TIR	10 ⁻² mV	CVLTRS01	V	*10 ⁻⁵

seabird	Channels	Description	Units	BODC Parameter Code	Units	Conversion Factor
	temp_h	TSG housing temperature	Degrees Celsius	TMESSG01	Degrees Celsius	*1
	cond	TSG conductivity	S m ⁻¹	CNDCSG01	S m ⁻¹	*1
	salin	Salinity	PSU	PSALSU01	dimensionless	*1
	sndspeer	Velocity of sound in water	m s ⁻¹	SVELSG01	m s ⁻¹	*1
	temp_r	Remote temperature at non-toxic inlet	Degrees Celsius	TEMPHU01	Degrees Celsius	*1

* temp_h, cond, temp_m not loaded from surfmet as where present these data are identical to the seabird file data but maybe delayed in time in the surfmet file (details on page 5 of the D371 Computing and Ship Systems Report)

Wind channels - calculation of absolute values

The BODC Matlab procedure 'wincor' was run using relative wind speed and direction, the ship's north-south and east-west velocities with the vane set to 0 degrees at the bow to generate absolute wind speed (EWSASS01) and direction (EWDASS01).

Irradiance channels (PAR and TIR) - conversion from voltages using manufacturer's calibrations

The manufacturer's calibrations from the sheets supplied by NMF-SS have been applied through the BODC Calibration database.

$$\text{BODC ICALRF 6720 DWIRRSSD} = \text{DVLTRSSD} * 89206.07 \text{ from calibration coefficient } 11.21 \mu\text{V} / \text{W m}^{-2}$$

$$\text{BODC ICALRF 6721 DWIRRPD} = \text{DVLTRPSD} * 91407.68 \text{ from calibration coefficient } 10.94 \mu\text{V} / \text{W m}^{-2}$$

$$\text{BODC ICALRF 6722 CSLRRS01} = \text{CVLTRS01} * 97276.26 \text{ from calibration coefficient } 10.28 \mu\text{V} / \text{W m}^{-2}$$

$$\text{BODC ICALRF 6737 CSLRRP01} = \text{CVLTRP01} * 101626.02 \text{ from calibration coefficient } 9.84 \mu\text{V} / \text{W m}^{-2}$$

The port and starboard channels for PAR and TIR were each merged based on the maximum value from the paired channels to give one definitive channel.

$$\text{BODC ICALRF 6135 DWIRRXMX} = \max(\text{DWIRRPD}, \text{DWIRRSSD})$$

$$\text{BODC ICALRF 6258 CSLRR1XS} = \max(\text{CSLRRS01}, \text{CSLRRP01})$$

Transmissometer - conversion from voltage using manufacturer's calibrations

The manufacturer's calibrations from the sheets supplied by NMF-SS have been applied through the BODC Calibration database.

$$\text{BODC ICALRF 6723 POPTDR01} = 100 * (\text{TVLTDR01} - 0.059) / (4.661 - 0.059) = 21.7297 * \text{TVLTDR01} - 1.2821$$

$$\text{BODC ICALRF 6724 ATTNDR01} = -(1/0.25) * \ln(\text{POPTDR01} * 0.01)$$

Sample Calibrations

Temperature

The hull temperature sensor data were calibrated against the CTD temperature sensors during the cruise. The data from the hull sensor at the CTD start time were compared with the temperature from the CTD at 7 decibars. The temperature offsets (CTD - Hull) were plotted against date/time and CTD sensor temperature and outliers identified. The relationships in the offset between sensors were then compared to the date/time and the CTD sensor temperature in separate linear regressions. There was no significant relationship with CTD sensor temperature ($R^2 = -0.01$; $n = 60$; $F = 0.376$; $p = 0.542$). There was a significant regression of offset with date/time ($R^2 = 0.08$; $n = 60$; $F = 5.82$; $p = 0.019$).

Applying the significant regression equation the offset was generated at the date/time when the non-toxic underway system was switched on (30/09/2011 08:00 offset = 0.0036) and when switched off at the end of the cruise (09/11/2011 14:00 offset = -0.0077). The offset was applied for the period in between by linear interpolation of these offsets through the BODC BUDS calibration routine (BODC ICALRF 6726).

Salinity

The SBE45 salinity data were calibrated against bench salinometer data from samples collected from the underway system during the cruise. The data from the SBE45 TSG at the discrete sampling times were compared with the bench salinometer measurements. The salinity offsets (bench - TSG) were plotted against date/time and bench salinity and outliers identified. The relationships in the offset between TSG and bench salinometer were then compared to the date/time and the bench salinity in separate linear regressions. There was a significant relationship of offset with date/time ($R^2 = 0.43$; $n = 168$; $F = 127.3$; $p < 0.001$) and also bench salinity ($R^2 = 0.18$; $n = 168$; $F = 38.0$; $p < 0.001$).

Applying the significant equation from the date/time regression with the higher R^2 , the offset was generated at the date/time when the non-toxic underway system was switched on (30/09/2011 08:00 offset = -0.0151) and when switched off at the end of the cruise (09/11/2011 14:00 offset = 0.0017). The offset was applied for the period in between by linear interpolation of these offsets through the BODC BUDS calibration routine (BODC ICALRF 6729).

Fluorescence

The fluorometer voltage data were calibrated against extracted chlorophyll-a data from samples collected from the underway system during the cruise. Samples of seawater collected and extracted chlorophyll-a measurements made following Welschmeyer (1994). Each sample of 250 ml was filtered through a 47 mm 0.2 μm polycarbonate filter. The filters were then placed in a vial with 10 ml 90% acetone and left in a freezer for 24 hours. The samples were then analysed on a pre-calibrated Turner Designs Trilogy fluorometer with a non-acidified chl module (CHL NA #046) fitted. The bench fluorometer calibration was checked against dilutions of pure chlorophyll stock during the cruise and no modifications to the calibration were necessary. The raw voltage data from the fluorometer at the discrete sampling times were compared with the extracted chlorophyll-a measurements. The offsets (extracted chl-a - voltage) were plotted against date/time and extracted chlorophyll-a and outliers identified. Based on a preliminary calibration against extracted chl-a, which over stated the chlorophyll concentrations at the start of the cruise; it was decided to split the dataset for calibration. The calibration was split at the fluorometer cleaning event at 03/10/2011 13:04 in to two sections (1 and 2). The linear regression between the offset and extracted chlorophyll-a for each section were calculated. There was a significant relationship for both section 1 ($R^2 = 0.16$; $n = 174$; F

= 33.5; $p < 0.001$) and section 2 ($R^2 = 0.92$; $n = 174$; $F = 1880.7$; $p < 0.001$).

Applying the equation from the extracted chlorophyll-a regression for each section, the calibrated fluorescence channel data were generated through the BODC BUDS calibration routine.

Section 1: 30/09/2011 08:00 to 03/10/2011 13:04 BODC ICALRF 6727 CPHLUT01 = $1.5771 * FVLTWS01 - 0.1038$

Section 2: 03/10/2011 13:04 to 09/11/2011 14:00 BODC ICALRF 6728 CPHLUT01 = $3.3824 * FVLTWS01 - 0.1286$

References

Welschmeyer N.A., 1994. Fluorometric analysis of chlorophyll-a in the presence of chlorophyll-b and phaeopigments. *Limnology and Oceanography*, 39:1985-1992.

Data quality report

Navigation and bathymetry (HQPLAT)

The navigation data have been through BODC quality control screening. Three gaps of less than ten minutes have been filled by interpolation. Overall the data for the cruise duration appear good.

The bathymetric data have been through BODC quality control screening. There are extensive periods of large-scale noise that hide the real bathymetry in the channel. Where possible some periods have been flagged to remove the noise. Users should use caution when interpreting the bathymetric depth channel.

Meteorology (HQMET)

The meteorology data have been through BODC quality control screening. Some intermittent flagging of data have been made. Overall the data for the cruise duration appear good.

Wind channels: The relative wind speed and direction channels show natural variation and fluctuation but there were no values or trends that stood out as unrealistic. There were 'steps' in the channel but this is related to the vessel coming on to or leaving station. No additional flags were added. The absolute wind speed and direction channels were screened and a few spikes flagged suspect.

Irradiance channels: The data in the channels did not require further flagging as it is unclear whether the variation is due to changing cloud cover etc.

Sea surface hydrography (HQUWAY)

The underway log sheets were used as a guide to the times when the non-toxic flow was switched off, dropped low or was adjusted during the cruise. Where there was noise in the channel at these times the data were flagged suspect. If there was no noise or spiking the data remain unflagged.

The sample calibrations applied to the TSG salinity, hull sensor temperature and fluorometer channels appear reasonable and did not produce suspect data in the calibrated channels. The calibrated fluorometer data exhibit large amounts of variability towards the end of the cruise in the southern Atlantic Ocean. The calibration in this area is not as closely matched to the sample data for this reason and users should keep this in mind when using the sample calibrated fluorometer data.

Attenuance and transmittance: There are some periods of noise within the transmissometer data, which may be the result of bubbles accumulating at the lens. There are other periods when there are steps in the data. Users should therefore apply caution when interpreting the transmissometer data.

Problem report

Navigation and bathymetry

Not applicable.

Meteorology

Not applicable.

Sea surface hydrography

Not applicable.