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Short Cruise Report Maria S. Merian MSM121

Nuuk — Ponta Delgada September 23, 2023 — October 16, 2023 Chief Scientist: Christian Mertens Captain: Ralf Schmidt



Objectives

The Atlantic Meridional Overturning Circulation (AMOC) is a key component of the climate system, responsible for ocean heat and freshwater transport. However, the link between ocean transport and deep water formation relies on the common conceptual view of the AMOC as a 'great ocean conveyor' which was developed to explain millennial fluctuations in climate. The collaborative Horizon Europe project EPOC (Explaining and Predicting the Ocean Conveyor) aims to generate a new conceptual framework for the AMOC, to understand how it functions in the Earth system and impacts on weather and climate. The objective of the EPOC field programme is to determine physical processes that maintain or disrupt the meridional connectivity of ocean transports in the so-called Transition Zone (TZ), between the subpolar and subtropical Atlantic, where models show a breakdown of the meridional AMOC coherence. MARIA S. MERIAN cruise MSM121 marks the beginning of a 2-year field experiment that will, together with high-resolution coupled model simulations, improve the understanding of physical processes that determine transport variability. These include upstream variability of deep water masses and boundary currents, and local instabilities, eddies or flow-topography interactions of the Deep Western Boundary Current (DWBC). The scientific programme of MSM121 contributes to the EPOC field programme, that includes three cruises in the working area around Flemish Cap and the Grand Banks: a mooring and IES deployment cruise in 2023, a survey for hydrography, circulation, and turbulence in 2024, and a recovery cruise in 2025. The objective is to study physical processes along the pathway of the DWBC, that impact on the meridional connectivity of the AMOC. Specific goals are: (1) Identify mechanisms responsible for AMOC coherence across a key latitude in the Atlantic. (2) Clarify the relationship between the DWBC, AMOC and deep water ventilation. (3) Quantify the influence of the North Atlantic Current on the variability of the DWBC.

The MSM121 work programme had three major components: The deployment of tall current meter moorings along sections perpendicular to the DWBC at depths ranging from 800 m to 4200 m, the deployment of inverted echo sounders (IES) south of Flemish Cap, and supporting full-depth CTD casts along the moored arrays. Moorings and inverted echo sounders will remain in the water for a period of two years. The array is designed to identify signals of coherence along the western boundary of the Atlantic from the subpolar to subtropical gyre which are anticipated to be associated with fast boundary waves and intermediate speed advective processes. One array of four moorings was deployed north of Flemish Cap, and a second array of four moorings south of the Grand Banks. A single mooring was deployed in Flemish Pass. This arrangement allows for the observations of transport variations around Flemish Cap and the Grand Banks, with one array serving as the upstream reference and the other as the downstream reference. The moorings are equipped with temperature and conductivity recorders (SBE37 Micro-CAT) and acoustic current meters (ADCP and Aquadopp). Due to the proximity of the planned deployment to the ventilation region in the Labrador Sea and existing observations at the western boundary of the OSNAP array (53°N), it will be possible to identify the arrival of recently ventilated waters. A dense array of 14 inverted echo sounders with pressure sensors (PIES) was deployed south of Flemish Cap, five of which are equipped with an acoustic current meter (C-PIES). The array will provide time-varying estimates of surface and deep transports for diagnosing interactions of the DWBC with the nearby North Atlantic Current. Additionally, CTD casts were performed at the mooring positions and along sections across the DWBC to determine transports and to calibrate the moored instruments.

Narrative

The MARIA S. MERIAN left the port of Nuuk, Greenland, on Friday, September 22 2023, at 17:30 LT heading to St. John's, Newfoundland. Underway measurements started at 21:00 LT. The scientific party comprised 18 scientists from the Universities of Bremen and Hamburg, the Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer) in Brest, and the ETH Zurich. The detour to St. John's became necessary, because one of the containers with mooring material had not arrived on the ship for reasons not yet fully clarified. The equipment that was missing were mainly the anchor weights without the moorings cannot be deployed. Replacements were unavailable in Nuuk and waiting for delivery of the container would have meant a delay of at least six days. Through the support from the ship and the German Research Fleet Coordination Centre it was possible to get the anchor weights in St. John's. The ship arrived there on September 26 at 15:00 and after about two hours everything was loaded and we left the harbour in the direction of the first work area.

The first mooring array was deployed south of the Grand Banks, at approximately 52°W. Work on this began on the afternoon of September 27 with mooring GB4 and an inverted echo sounder with pressure (PIES). Mooring GB3 was deployed on the next day together with a drift-free bottom pressure recorder close to it. Moorings GB1 and GB2 were deployed on September 29, with an additional drift-free bottom pressure recorder close to GB2. CTD/LADCP casts were made along a transect parallel to the mooring array, mostly during the nights. Work along the GB array was completed at 20:00 LT on September 30. After a transit of 21 hours we deployed a PIES at 41°N, 47°W.

Deployment of PIES south of Flemish Cap begann at 20:00 LT on October 2 along line E at the southwest end of the array. A total of four PIES were deployed along this line, two of which were C-PIES with an additional current meter 50 m above the seafloor. A total of 9 CTD casts were made along line E, at and between the PIES sites. Line E was completed on October 3 at 21:00 LT and we moved on to line D. Two PIES and one C-PIES were deployed along line D, CTD casts were made at the deployment positions. Line D was completed at 10:00 LT on October 4. Line C was started at about 12:30 LT on the same day. Two C-PIES and one PIES were deployed along this line and 11 CTD casts made. In the morning of October 4, the weather worsened and winds reached gale force with speeds of up to 23 m/s at the last CTD station of line C. We proceeded to Flemish Pass, where we arrived on October 5 at about 10:30 LT. Wind and swell had somewhat decreased overnight, but remained too strong for mooring work. Instead we proceeded with the CTD programme at Flemish Pass.

On October 7, at about 10:00 LT we started a CTD section along the planned Flemish Cap (FC) mooring array. Since the weather continued to be too unfavorable for mooring deployments, we continued the CTD work until the afternoon of October 8, when we deployed the first mooring of the array, FC4. The other three moorings of the array, FC1, FC2 and FC3, could then be deployed in much calmer weather on October 9. We were then able to deploy the mooring in Flemish Pass on October 10 and return to the PIES array south of Flemish Cap. Two PIES (line B) where deployed on October 11, followed by an 11-hour CTD tow-yo over the Flemish Cap continental slope to obtain a high-resolution section of current velocity and stratification. The scientific programme ended with the deployment of two more PIES (line A) in the night. The transit to Ponta Delgada started on 12 October at 03:30 LT. On the way we had the opportunity to recover the torn-off telemetry buoy of a GEOMAR mooring. Underway measurements were stopped on October 15, 22:00 LT. The ship docked at Ponta Delgada pier on October 16, 08:30 LT.

Acknowledgements

We thank Captain Ralf Schmidt and the entire crew of the MARIA S. MERIAN for the friendly and cooperative atmosphere and their professional technical assistance, which immensely contributed to the success of the expedition. The German Research Fleet Coordination Centre (Leitstelle Deutsche Forschungsschiffe), Markus Gehrken (LPL Projects + Logistics GmbH), and Barbara Kozák (University of Bremen) provided logistical and administrative support. The scientific work conducted during this cruise received funding by the EU Project 101059547 EPOC.

List of participants

1.	MERTENS, Christian	Chief Scientist	IUP
2.	STAKE, Jürgen	Inverted echo sounders	IUP
3.	FRAJKA-WILLIAMS, Eleanor	Bottom pressure recorders	IFM
4.	WELSCH, Andreas	Bottom pressure recorders	IFM
5.	DESBRUYÈRES, Damien	Moorings	Ifremer
6.	LEIZOUR, Stéphane	Moorings	Ifremer
7.	PRIGENT, Sébastien	Moorings	Ifremer
8.	SELLET, Hugo	Moorings	lfremer
9.	DALE, Duncan	Tracer	ETH
10.	STEINFELDT, Rainer	Tracer, Salinometer	IUP
11.	DIRKSEN, Lukas	Oxygen	IUP
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13.	GARCIA SANTACRUZ, Dinora	CTD	IUP/MARUM
14.	HAINBUCHER, Dagmar	CTD	IFM
15.	NIKOLAUS, Viktoria	CTD	IFM
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17.	ASCHENBECK, Lara	CTD	IUP
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List of stations

Station	Date / Time UTC	Device	Latitude	Longitude	Depth (m)	Comment
MSM121_1-1	2023/09/28 02:29	CTD	42° 10.049' N	052° 09.975' W	4025	
MSM121_2-1	2023/09/28 06:51	CTD	42° 02.002' N	052° 13.998' W	4168	
MSM121_3-1	2023/09/28 11:54	CTD	41° 54.484' N	052° 17.629' W	4437	
MSM121_3-2	2023/09/28 19:25	Mooring	41° 54.661' N	052° 17.158' W	4430	GB4
MSM121_3-3	2023/09/28 21:50	PIES	41° 54.394' N	052° 17.725' W		GB4P/PIES4 (Sonardyne)
MSM121 4-1	2023/09/29 00:27	CTD	41° 45.986' N	052° 22.060' W	3730	
MSM121 5-1	2023/09/29 06:10	CTD	42° 17.927' N	052° 05.939' W	3753	
MSM121_5-2	2023/09/29 09:21	Lander	42° 18.000' N	052° 05.998' W	3751	GB3LZ Bottem Pressure
MSM121 5-3	2023/09/29 13:56	Mooring	42° 18.132' N	052° 06.439' W	3736	GB3
MSM121 6-1	2023/09/29 17:32	CTD	42° 25.923' N	052° 01.888' W	3442	
MSM121 7-1	2023/09/29 20:40	CTD	42° 33.999' N	051° 58.001' W	3091	
MSM121 8-1	2023/09/30 00:26	CTD	42° 50.005' N	051° 50.053' W	2249	
MSM121 9-1	2023/09/30 02:47	CTD	42° 58.017' N	051° 46.059' W	1863	
MSM121 10-1	2023/09/30 05:42	CTD	43° 13.991' N	051° 38.000' W	1201	
MSM121 11-1	2023/09/30 07:06	CTD	43° 18.011' N	051° 35.992' W	649	
MSM121 12-1	2023/09/30 09:04	СТД	43° 06.011' N	051° 41.991' W	1571	
MSM121 12-2	2023/09/30 12:02	Moorina	43° 06.111' N	051° 41.916' W	1576	GB1
MSM121 13-1	2023/09/30 17:57	Moorina	42° 42.223' N	051° 53.871' W	2661	GB2
MSM121 13-2	2023/09/30 18:58	Lander	42° 42.002' N	051° 53.995' W	2675	GB2LZ Bottom Pressure
MSM121 13-3	2023/09/30 20:21	CTD	42° 41.007' N	051° 54.345' W	2722	
MSM121 14-1	2023/10/01 18:49	PIES	41° 00.033' N	047° 00.167' W	4110	PIES3
MSM121 14-2	2023/10/01 18:55	CTD	41° 00.033' N	047° 00.168' W	4107	
MSM121 15-1	2023/10/02 22:07	PIES	45° 25.000' N	044° 50.006' W	4528	PIES E4
MSM121 15-2	2023/10/02 22:20	CTD	45° 25.000' N	044° 50.007' W	4525	
MSM121 16-1	2023/10/03 02:04	CTD	45° 32.546' N	044° 57.418' W	4291	
MSM121 17-1	2023/10/03 05:32	C-PIES	45° 40.027' N	045° 04.906' W	4034	C-PIES E3
MSM121 17-2	2023/10/03 05:49	CTD	45° 40.059' N	045° 04.455' W	4026	
MSM121 18-1	2023/10/03 09:11	CTD	45° 47.510' N	045° 12.481' W	3664	
MSM121 19-1	2023/10/03 12:28	C-PIES	45° 55.015' N	045° 20.015' W	3445	C-PIES E2
MSM121 19-2	2023/10/03 12:40	CTD	45° 54.738' N	045° 19.978' W	3452	
MSM121 20-1	2023/10/03 15:34	CTD	45° 59.963' N	045° 25.032' W	3171	
MSM121 21-1	2023/10/03 18:12	PIES	46° 04.986' N	045° 30.044' W	2421	PIES E1
MSM121 21-2	2023/10/03 18:22	CTD	46° 04.980' N	045° 30.106' W	2372	
MSM121 22-1	2023/10/03 20:40	CTD	46° 10.003' N	045° 35.047' W	1497	
MSM121_23-1	2023/10/03 22:28	CTD	46° 15.011' N	045° 39.943' W	876	
MSM121 24-1	2023/10/04 02:47	PIES	46° 15.026' N	044° 45.025' W	1901	PIES D1
MSM121 24-2	2023/10/04 02:54	CTD	46° 15.028' N	044° 44.982' W	1901	
MSM121 25-1	2023/10/04 05:29	C-PIES	46° 04.799' N	044° 34.843' W	3610	C-PIES D2
MSM121 25-2	2023/10/04 05:37	CTD	46° 04.578' N	044° 34.662' W	3622	
MSM121 26-1	2023/10/04 09:30	PIES	45° 50.023' N	044° 19.960' W	4327	PIES D3
MSM121 26-2	2023/10/04 09:37	CTD	45° 50.022' N	044° 19.960' W	4327	
MSM121 27-1	2023/10/04 14:25	C-PIES	46° 05.094' N	043° 44.846' W	4367	C-PIES C3
MSM121 27-2	2023/10/04 14:41	CTD	46° 05.309' N	043° 44.424' W	4360	
MSM121 28-1	2023/10/04 18:18	CTD	46° 09.988' N	043° 49.877' W	4157	
MSM121 29-1	2023/10/04 21:30	CTD	46° 15.000' N	043° 55.012' W	3991	
MSM121 30-1	2023/10/05 00:30	C-PIFS	46° 20.027' N	044° 00.015' W	3894	C-PEIS C2
MSM121_30-2	2023/10/05 00:36		46° 20 026' N	044° 00 013' W	3896	
MSM121_31-1	2023/10/05 03:39	СТЛ	46° 24 988' N	044° 04 991' W	3552	
MSM121_32-1	2023/10/05 06:13	СТР	46° 28,004' N	044° 08 002' W	3193	
MSM121 33-1	2023/10/05 08:41	СТО	46° 31 015' N	044° 11 005' W	2722	
MSM121_34_1	2023/10/05 10:48	PIFS	46° 33 002' N	044° 12 992' W	2279	PIES C1
MSM121 34-2	2023/10/05 10:58	СТО	46° 33 002' N	044° 12 992' W	2276	
MSM121 35-1	2023/10/05 12:53	CTD	46° 34,975' N	044° 15.076' W	1741	

MSM121_36-1	2023/10/05 14:24	CTD	46° 36.418' N	044° 16.548' W	912	
MSM121_37-1	2023/10/05 15:47	CTD	46° 37.896' N	044° 18.108' W	468	
MSM121_38-1	2023/10/06 12:36	CTD	46° 59.971' N	046° 31.977' W	395	
MSM121_39-1	2023/10/06 14:11	CTD	46° 59.980' N	046° 39.978' W	913	
MSM121_40-1	2023/10/06 16:07	CTD	46° 59.948' N	046° 50.007' W	1184	
MSM121_41-1	2023/10/06 17:53	CTD	46° 59.970' N	046° 59.957' W	1150	
MSM121_42-1	2023/10/06 19:33	CTD	46° 59.996' N	047° 09.961' W	874	
MSM121_43-1	2023/10/06 20:56	CTD	46° 59.985' N	047° 16.951' W	413	
MSM121_44-1	2023/10/07 11:48	CTD	48° 14.987' N	044° 59.924' W	630	
MSM121_45-1	2023/10/07 15:03	CTD	48° 23.724' N	045° 00.047' W	666	
MSM121_46-1	2023/10/07 16:49	CTD	48° 32.462' N	044° 59.987' W	851	
MSM121_47-1	2023/10/07 18:40	CTD	48° 41.251' N	044° 59.993' W	1156	
MSM121_48-1	2023/10/07 20:43	CTD	48° 49.972' N	044° 59.973' W	1278	
MSM121_49-1	2023/10/07 22:47	CTD	48° 58.764' N	045° 00.020' W	1572	
MSM121_50-1	2023/10/08 01:00	CTD	49° 07.490' N	044° 59.972' W	2237	
MSM121_51-1	2023/10/08 03:39	CTD	49° 16.261' N	045° 00.018' W	2566	
MSM121_52-1	2023/10/08 06:25	CTD	49° 24.996' N	045° 00.004' W	2846	
MSM121_53-1	2023/10/08 09:15	CTD	49° 33.783' N	045° 00.080' W	3225	
MSM121_54-1	2023/10/08 12:28	CTD	49° 42.501' N	045° 00.044' W	3547	
MSM121_55-1	2023/10/08 19:22	Mooring	49° 51.857' N	044° 58.742' W	3945	FC4
MSM121_55-2	2023/10/08 20:58	PIES	49° 51.950' N	044° 59.220' W	3938	PIES FC4P/PIES1
MSM121_55-3	2023/10/08 21:23	CTD	49° 52.487' N	045° 00.005' W	3927	
MSM121_56-1	2023/10/09 00:35	CTD	49° 59.998' N	044° 59.995' W	3967	
MSM121_57-1	2023/10/09 05:53	CTD	49° 29.375' N	045° 00.051' W	2992	
MSM121_58-1	2023/10/09 12:37	Mooring	49° 25.258' N	044° 59.965' W	2860	FC3
MSM121_59-1	2023/10/09 17:42	Mooring	48° 58.868' N	045° 00.037' W	1573	FC2
MSM121_60-1	2023/10/09 20:39	Mooring	48° 32.747' N	044° 59.991' W	859	FC1
MSM121_61-1	2023/10/10 11:34	Mooring	47° 00.100' N	046° 59.936' W	1149	PASS1
MSM121_62-1	2023/10/11 01:23	PIES	46° 44.996' N	043° 40.000' W	2591	PIES B1
MSM121_62-2	2023/10/11 01:28	CTD	46° 45.003' N	043° 40.009' W	2585	
MSM121_63-1	2023/10/11 06:17	PIES	46° 15.008' N	043° 09.956' W	4281	PIES B2
MSM121_63-2	2023/10/11 06:22	CTD	46° 15.008' N	043° 09.956' W	4280	
MSM121_64-1	2023/10/11 13:40	CTD	47° 04.000' N	043° 19.999' W	1620	Tow-yo Start
MSM121_64-1	2023/10/12 00:18	CTD	47° 06.896' N	043° 16.061' W	2877	Tow-yo End
MSM121_65-1	2023/10/12 00:47	PIES	47° 05.999' N	043° 18.006' W	2535	PIES A1
MSM121_66-1	2023/10/12 05:16	PIES	47° 05.987' N	041° 59.999' W	4224	PIES A2/PIES2