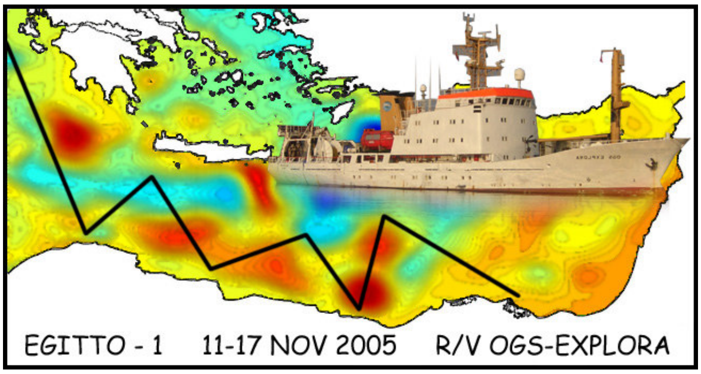
ISTITUTO NAZIONALE di Oceanografia e di Geofisica Sperimentale Trieste

Laboratoire d'Océanographie et de Biogéochimie (LOB), CNRS



OCEANOGRAPHIC CRUISE

EGITTO-1

R/V OGS- EXPLORA

11-18 November 2005

Trieste, Italy to Port Said, Egypt

CRUISE REPORT

by

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Approved for publication: ....

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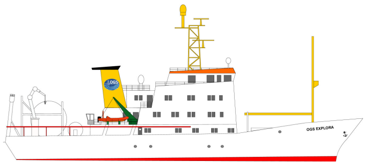


1. Introduction

The EGITTO-1 cruise is a component of the Eddies and Gyres Paths Tracking (EGYPT) and the EGITTO projects whose main goal is to assess and study the circulation and water mass distribution in the southeastern Mediterranean Sea. The campaign took place onboard R/V OGS-EXPLORA between 11 and 18 November 2005 between Trieste, Italy in the Northern Adriatic and Port Said, Egypt. Surface drifters, Argo profilers and XBT probes were launched while the ship was sailing in a zig-zag pattern in the southern Ionian and Levantine sub-basins. Contemporaneously, the shipborne ADCP, the underway thermosalinometer and the meteorological systems acquired data. The sampling strategy was tailored to study specific circulation features revealed by satellite images and numerical model products available prior to the cruise and sent to the ship in near-real time.

This cruise report contains some information on the oceanographic state-of-the-art in the southeastern Mediterranean and the scientific goals of the EGYPT and EGITTO projects (section 2). The specific objectives of the EGITTO-1 cruise are also described. The list of scientific personnel, a description of the instruments used and the sequence of cruise operations follow in sections 3, 4 and 5, respectively. In section 6, preliminary results are illustrated and discussed. Conclusions, acknowledgements and references can be found in sections 7 to 9.

2. Scientific goals and rationale

The Mediterranean Sea can be viewed as an anti- (or negative) estuarine basin, in which Atlantic water (AW) enters through the Strait of Gibraltar and flows eastward in a near-surface layer as far east as the Levantine sub-basin (Robinson and Golnaraghi, 1994). There, evaporation greatly exceeds precipitation and river runoffs (the Levantine is a “concentration” basin). As a result, the salinity increases and convection occurs down to intermediate depths. The Levantine Intermediate Water (LIW) is formed and flows typically westward in a sub-surface (200-300 m) layer where salinity is maximum, and partially exits through the strait of Gibraltar, closing the overall thermohaline “conveyer belt” circulation.

One of the classical circulation diagram in the Eastern Mediterranean is that of Lacombe and Tchernia (1972) based mainly on hydrographic data (Figure 1). This map shows an AW main pathway in the central Ionian which splits into a slope (along the African coast) and mid-basin (toward Cyprus) currents east of the Cretan Passage. Two anticyclonic gyres are present in the southern Ionian.

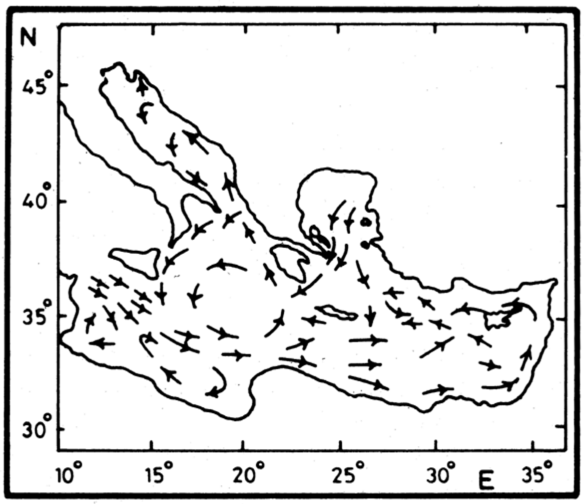


Figure 1. Schematic representation of the surface circulation in the Eastern Mediterranean according to Lacombe and Tchernia (1972).

Under the POEM (Physical Oceanography of the Eastern Mediterranean) international program (POEM Group, 1992), extensive hydrographic surveys were undertaken throughout the Northeastern Mediterranean between 1985 and 1992 by several Mediterranean countries. The results of these investigations have been synthesized by Robinson et al. (1991) and Ozsoy et al. (1993).

Robinson et al. (1991)'s (see Figure 2) circulation map introduces the Atlantic Ionian Stream or the Modified Atlantic Water Jet (MAWJ) in the Strait of Sicily and the Mid-Mediterranean Jet (MMJ) in the Levantine sub-basin as major eastward-flowing AW central cross-basin pathways. The latter splits in several branches. Some branches turn cyclonically west of Cyprus, forming the Rhodes and the West Cyprus Gyres, before forming the Asia Minor Current (AMC). Other branches turn anticyclonically to feed clockwise circulation features such as the Mersa-Matruh and the Shikmona Gyres. A cyclonic gyre is evident southwest of Crete.

A recent analysis of long time series of satellite thermal images (Hamad et al., 2005; Millot and Taupier-Letage, 2005) generated new, somewhat controversial, maps of the Eastern Mediterranean surface circulation in which the AW flows as a slope current all around the basin (Figure 3). This cyclonic basin circulation varies at seasonal and interrannual scales. In addition, eddies are generated by instability of this slope current and by the action of the winds sheared by orographic effects. The southern part of this slope current (called the Libyo-Egyptian Current) is markedly unstable and generates numerous instability features (anticyclonic vortices/eddies). According to these recent analyses, the MMJ has been confused with the northern limbs of the anticyclonic eddies that have not been completely sampled. These eddies represent a large amount of AW and play a fundamental role in spreading AW from the alongshore region to the open sea.

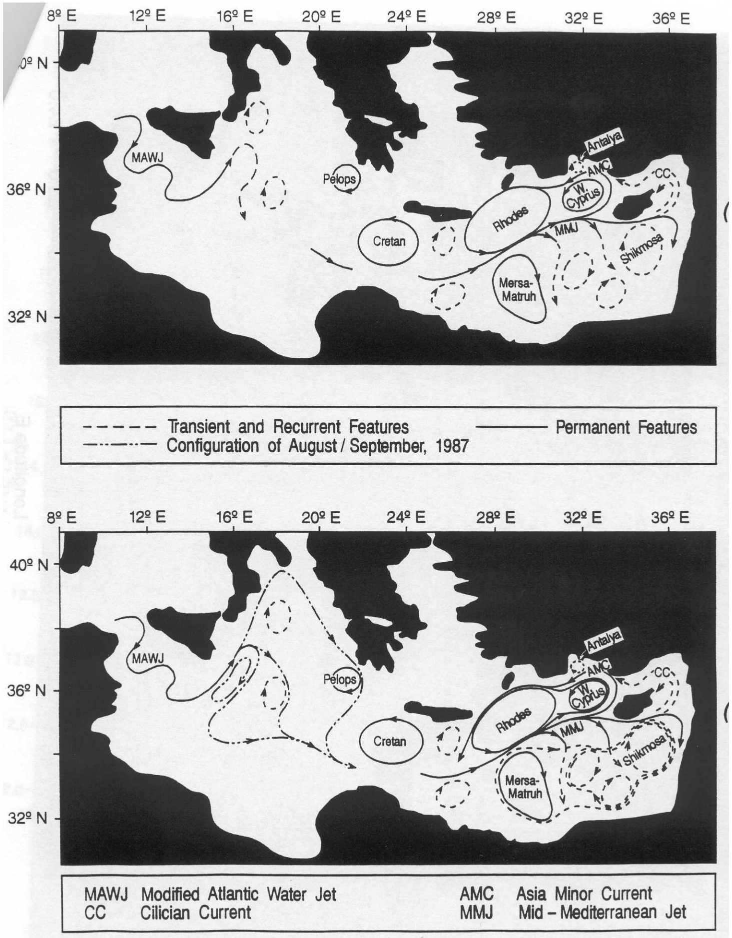


Figure 2. Maps of near-surface circulation in the Eastern Mediterranean compiled by Robinson et al. (1991; top) and by Robinson and Golnaraghi (1993; bottom).

The EGITTO project is an observational program funded by the United States Office of Naval Research (ONR) that started in 2005 to study the circulation in the southeastern Mediterranean Sea and to verify the various circulation patterns published in the literature based on in-situ observations, remote sensing data and models. The goal is to describe the surface circulation eddy and seasonal variability using low-cost satellite-tracked drifters in concert with hydrographic measurements (Argo profilers and XBT/CTD surveys) and with satellite observations of sea surface temperature, near-surface chlorophyll pigment concentration and sea surface dynamic topography. The main focus is on the AW main pathway that has recently been represented as coastal and along-slope current off the African coast, and that is extremely unstable and generates energetic meanders and anticyclonic eddy circulation features.

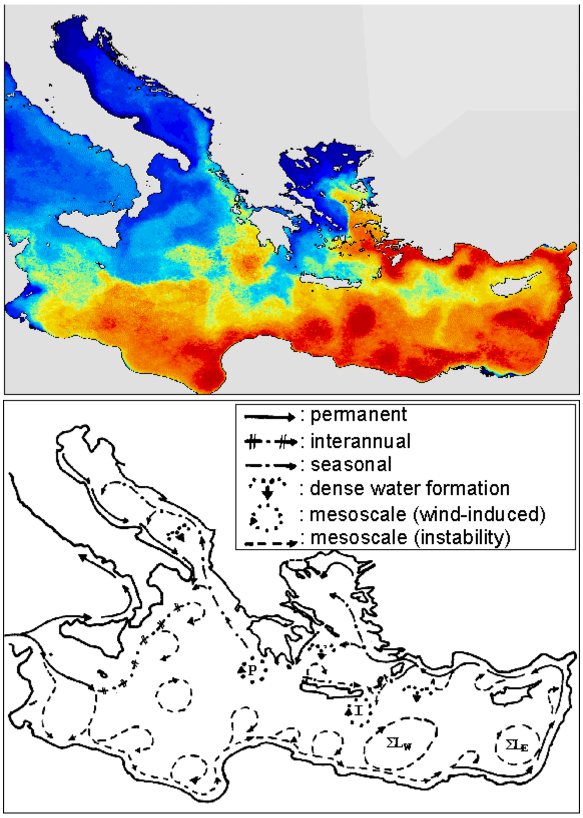


Figure 3. Top: Monthly SST composite for January 1998 in the Eastern Mediterranean. Red (blue) colors represent relatively warmer (cooler) surface waters. Bottom: New schematic representation of the mean surface circulation in the Eastern Mediterranean according to Hamad et al. (2004).

In straight collaboration with French, Tunisian and Egyptian oceanographers, the plan is to monitor the surface circulation in the southeastern Mediterranean Sea for about a year (fall 2005 – summer 2006) releasing drifters in the Strait of Sicily, in the southeastern Ionian and in the southern Levantine sub-basin on a seasonal basis. Eulerian (seasonal maps of mean currents and eddy variability) and Lagrangian (one and two-particle diffusion) statistics will be computed. Satellite data will be integrated with the drifter observations to study the circulation variations and their relations to the local wind forcing and the bottom topography.

EGYPT is a French program with similar objectives as EGITTO-1, that is, to investigate the circulation of all the water masses in the eastern basin of the Mediterranean, in order to validate the new schema of the circulation based upon the analysis of infrared satellite imagery and the few in situ data available (Hamad et al., 2005; Millot and Taupier-Letage, 2005), and backed by the results of modelling (Alhammoud *et al.*, 2005 ; Béranger *et al.*, 2005). The strategy is to combine both observations (in situ and remote sensing data) and model simulations, to be complemented by process studies for improved understanding. In particular, the in situ measurements include a cluster of seven currentmeter moorings to be operated in 2006-2008.

The EGITTO-1 oceanographic cruise was organized to initiate the surface drifter deployments in the southern Ionian and Levantine sub-basins. The specific goals of the campaign were to sample adequately the salient circulation features (mostly anticyclonic eddies) in the study area with the drifters and with ancillary measurements of water mass properties (XBT, thermosalinometer) and currents (ADCP) in the water column. Another objective was to release Argo floats in the southeastern Mediterranean Sea to provide temperature and salinity data, as well as the XBT temperature data, in near-real time to numerical models of ocean forecasting as part of the MEDARGO project (Poulain, 2005), which is a component of the Mediterranean Forecasting System Toward Environmental Predictions (MFSTEP) operational oceanography program.

3. Scientific personnel and responsibilities

The following oceanographic institutions were involved in the EGITTO-1 cruise:

Remote Sensing Group (SIRE), Department of Oceanography (OGA)
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)
Borgo Grotta Gigante, 42/c, 34010 Sgonico (Trieste), Italy

GEA and NAVE Groups, Department for the Development of Marine Technology and Research (RIMA)
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)
Borgo Grotta Gigante, 42/c, 34010 Sgonico (Trieste), Italy

Laboratoire d'Océanographie et de Biogéochimie (LOB), CNRS UMR 6535
Université de la Méditerranee, Centre d'Océanologie de Marseille
Antenne de Toulon, c/o IFREMER, BP 330, F-83507 La Seyne, France

The scientific group onboard R/V OGS-EXPLORA included :

Dr. Pierre-Marie Poulain, SIRE/OGA, OGS, Trieste, Italy

Main responsibility : Scientist-in-charge, deployments of drifters and Argo profilers.

Dr. Riccardo Gerin, SIRE/OGA, OGS, Trieste, Italy

Main responsibility : Drifter and Argo profiler deployments.

Dr. Isabelle Taupier-Letage, LOB/CNRS, Toulon, France

Main responsibility : XBT survey, deployments of Argo profilers

Dr. Giulio Notarstefano, SIRE/OGA, OGS, Trieste, Italy

Main responsibility : Navigation system.

Dr. Emiliano Gordini, GEA/RIMA, OGS, Trieste, Italy

Main responsibility : Navigation system.

Dr. Claudio Pelos, PROS/RIMA, OGS, Trieste, Italy

Main responsibility : Navigation system.

Mr. Carmine D'amicantonio, NAVE/RIMA, OGS, Trieste, Italy

Main responsibility : Drifter and Argo profiler deployments.

4. Scientific instrumentation used onboard

4.1. Underway automatic systems

R/V OGS-EXPLORA is equipped with the following permanent scientific equipment that was used during the EGITTO-1 cruise.

4.1.1. Ship-mounted Meteorological Sensor

Two Young Meteorological systems provided air temperature and pressure, humidity, wind relative direction and speed, and ship heading with sampling interval of 1 s (Figure 4). A thermistor installed on the ship haul provided sea surface temperature (SST) data with the same sampling interval. Mean values averaged over 1 min were save on a flashcard. The raw and mean strings were saved on the computer and were sent to the PDS2000 navigation system. Numerical and graphical results were displayed in real time on a monitor in the laboratory (Figure 4).

Figure 4.Picture of the two Meteorological stations mounted on R/V OGS-EXPLORA. Insert: real-time display of the meteorological observations as it appears in the laboratory.

4.1.2. Ship-mounted T/S sensors

The Sea-Bird 21 SEACAT thermosalinometer (Figure 5) mounted on the bow of R/V OGS-EXPLORA was operated continuously during the cruise. The sea surface temperature, salinity and density were displayed versus time on a monitor in the laboratory in real-time (Figure 5). The sampling interval was 5 s. The data were saved on the acquisition computer and processed with the Sea-Bird SBE data Processing software (Win 32).

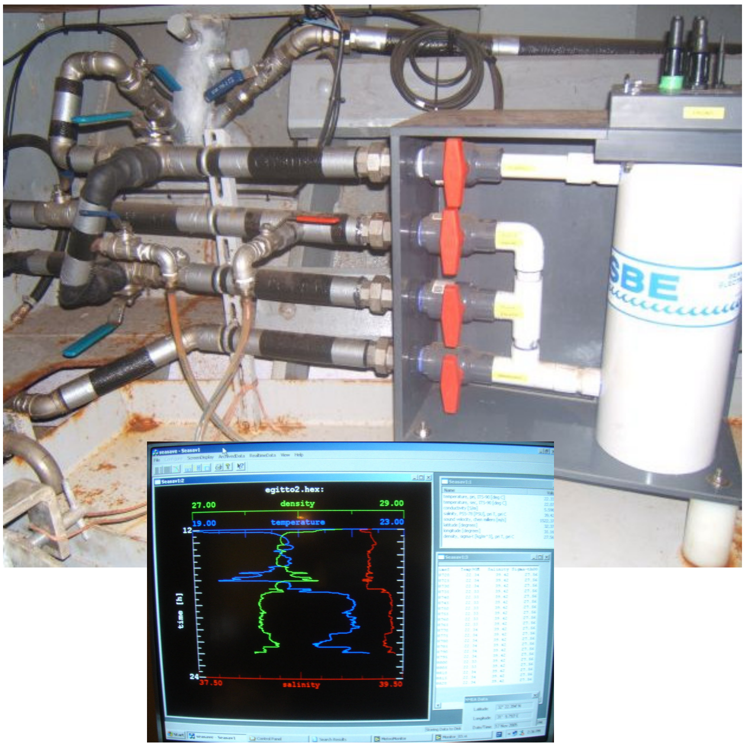


Figure 5. Top: picture of the Sea-Bird 21 SEACAT thermosalinometer and associated system of valves and tubes installed on R/V OGS-EXPLORA (bow area). Bottom: real-time display of the data collected by the thermosalinometer in the laboratory.

4.1.3. Ship-mounted ADCP

The 75 KHz RDI Ocean Surveyor ADCP mounted on the ship haul was set up to measure the horizontal currents in 60 bins of 8 m, centered at 10.5, 18.5, 26.5,…and 482.5 m. Pings were acquired every ~2 s and averaged over time intervals of 30 s. Numerical and graphical results were displayed in real-time on a monitor in the laboratory. Unfortunately, no information of gyro-compass and ship pitch and roll was fed into the ADCP system because the sensors were not available (out for maintenance). As a result, special data processing was required to obtain useful measurements of currents.

4.1.4. Navigation system

The Reson PDS2000 navigation software was operated during the entire cruise. Position data from a GPS were directly transferred to the navigation at the rate of 1 Hz. All the deployment operations (of XBT probes, drifters and Argo profilers) were coordinated using the RESON PDS2000 navigation system.

4.2. XBT probes

The following Sippican XBT probes were made available for the cruise:

1) 11 probes T-6;
2) 74 probes T-7;
3) 30 probes DB (Deep Blue);

amounting to a total 115 probes.

The Sippican (Lockheed Martin) MK21 USB oceanographic data acquisition system and a PC were installed in the "caponera" (Figure 6). This system was connected to the hand-held launcher (model LM3A). All the XBT probes were launched from the ship aft deck (near the starboard side, Figure 7) while the ship was sailing at 12-13 knts.

The XBT launch coordination and the official logging of time and position were made using the PDS2000 navigation system. In addition, the launch times and positions (latitude and longitude) were manually logged in the "caponera" using a hand-held GARMIN GEKO 201 GPS receiver.

Some XBT drops yielded non realistic (bad) temperature profiles. They are listed in Table 1. They were repeated shortly after the failed launches. Two T7 probes did not make any contact in the hand-held launcher. As a result, a total of 108 XBT stations with good temperature profiles were obtained.

The XBT launches started on 12 November 2005 at 21.32 GMT in the southern Adriatic Sea and ended on 17 November 2005 at 03.04 GMT in the southern Levantine Basin. The distance between consecutive XBT drops varied from 20 nautical miles (in the southern Adriatic and northern Ionian), to 10 or 12.5 nautical miles in the southern Levantine. When crossing circulation features of interest, this interval was reduced to 5 nautical miles.

Figure 6. Pictures of the "caponera" where the Sippican MK21 USB acquisition system and computer were installed. Left. view of the "caponera" from the aft deck; right: inside the "caponera" with monitor showing the XBT acquisition graphics and the view on the ship's stern.

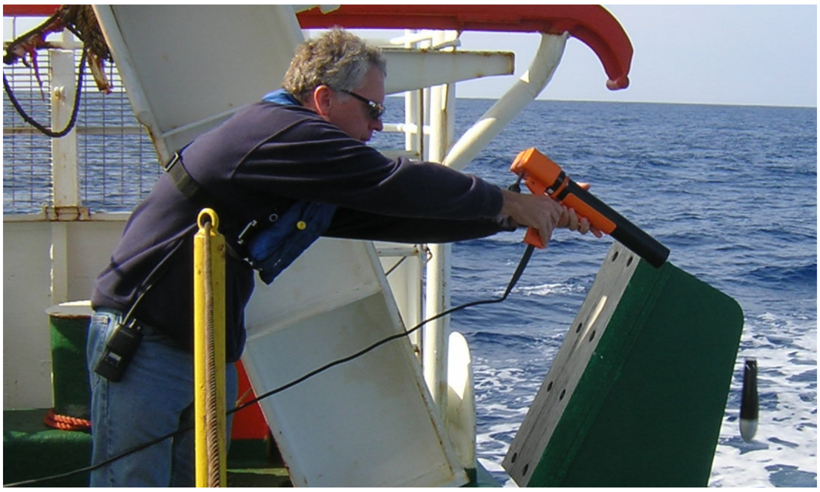


Figure 7. Picture of the launch of an XBT probe. The hand-held launcher and the probe are clearly seen.

Transect #	XBT Sta #	Probe Type	Manuf. Year
1	12	T7	1999
1	24	T7	1999
1	26	T7	1999
3	63	DB	2003
3	69	DB	2003

Table 1. List of XBT drop failures.

4.3. Surface drifters

A total of 15 surface drifters (Figure 8) manufactured by Clearwater Instrumentation were deployed during the cruise. The drifters are SVP models (ClearSat-15-III Custom Mini-Drogue) with a holey sock drogue centered at 15 m nominal depth. The drifter specifications are listed in Table 2. Before launch, the drifters were turned on by removing the magnet on the surface ball. The Argos transmission was checked using a mechanical beeper and a portable Telonics TSUR-400 receiver. All the drifters were tossed in the water from the aft deck while the ship was moving at 12-13 knts. The timing of the launches was coordinated using the PDS2000 navigation system

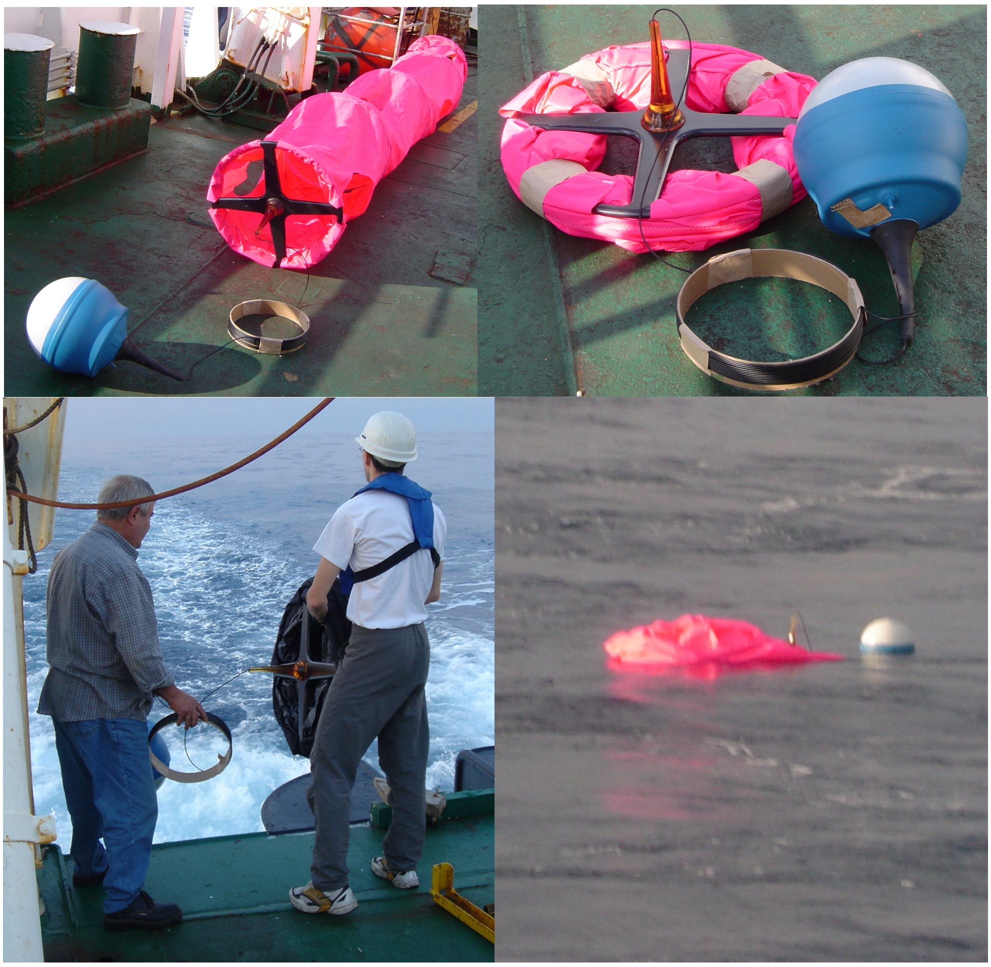


Figure 8. Pictures of the SVP drifter with mini holey sock drogue. Top: drifter on the ship deck with drogue folded and unfolded. Bottom: release of a drifter from the aft deck and drifter just deployed at sea.

Surface float	Diameter 30.5 cm, 5-mm thick ABS hull
Thether	Diameter 0.32 cm. OD polypropylene-impregnated wire rope between surface float and drogue.
Drogue	Holey sock made from Cordura nylon cloth; diameter 61 cm. Length 5 m. Centered at 15 m; drogue sensor type: tether strain
Stress reliefs	Carrot below surface float: 2-in diameter x 9-in height with flared base. Carrot above drogue: 2-in diameter x 9-in height with flared base.
Drag	Cross-sectional drag area above drogue (square cm.): 1,042 Cross-sectional drag area of the drogue (square cm.): 42,672
Stress reliefs	Carrot below surface float: 2-in diameter x 9-in height with flared base. Carrot above drogue: 2-in diameter x 9-in height with flared base.
Power supply	4 diode-protected battery packs, each consisting of 9 alkaline D-cells
Transmitter	Toyocom T-2071; repetition rate: 90 ± 9 s; frequency: 401.65 MHz
Sensors	Battery voltage, drogue sensor, SST
Sampling rate	Tether strain: 30 min; voltage: 1 h; temperature: 15 min

Table 2. Technical specific details about the SVP drifters.

Details about the drifter deployments (time and location, etc) are listed in Table 3. All drifters were assigned with Argos identification and WMO numbers. They were tracked and their data were telemetered via the Argos system onboard the polar-orbiting NOAA satellites. The WMO numbers were used to distribute the drifter data in near-real time on the GTS.

WMO	ARGOS	TURN ON Date - GMT Time	DEPLOY Date - GMT Time	Latitude	Longitude
61800	59752	14/11/2005 8.45	14/11/2005 14.28	34°00'02.9163"	21°39'05.5213"
61801	59753	14/11/2005 12.48	14/11/2005 15.06	33°52'47.3422"	21°42'08.6565"
61802	59754	14/11/2005 12.50	14/11/2005 16.07	33°40'57.8881"	21°47'05.6477"
61803	59755	14/11/2005 13.20	14/11/2005 17.09	33°29'10.4624"	21°52'01.0776"
61804	59756	14/11/2005 13.20	14/11/2005 18.08	33°17'20.2199"	21°56'57.0095"
61805	59757	15/11/2005 3.35	15/11/2005 6.49	33°41'07.5590'	23°57'15.2627"
61806	59758	15/11/2005 3.35	15/11/2005 8.19	33°23'50.2942"	24°09'18.6755"
61807	59759	15/11/2005 3.35	15/11/2005 9.52	33°06'45.5712"	24°21'10.4395"
61808	59760	15/11/2005 8.47	15/11/2005 21.47	32°51'22.1859"	26°28'12.0701"
61809	59761	15/11/2005 8.48	15/11/2005 23.44	33°01'03.8162"	26°49'05.8602"
61810	59762	15/11/2005 8.48	16/11/2005 1.25	33°10'42.8082"	27°09'55.7103"
61811	59763	16/11/2005 15.46	16/11/2005 16.29	31°49'40.8629"	28°35'40.8759"
61812	59764	16/11/2005 15.46	16/11/2005 18.24	32°11'53.0395"	28°39'57.0915"
61813	59765	16/11/2005 15.46	16/11/2005 19.44	32°29'18.4010"	28°43'28.0581"
61814	59766	16/11/2005 15.47	16/11/2005 21.22	32°49'06.6976"	28°47'09.2634"

Table 3. Deployment information for the 15 surface drifters.

4.4. Argo profilers

Argo profilers (Figure 9) were deployed during the cruise. Two types of floats were used: the APEX, produced by Webb Research (USA) and the PROVOR designed by Ifremer and manufactured by Metocean -Martec (France). They were programmed in the "Park and Profile" configuration with a neutral parking depth of 350 m (near the salinity maximum of the Levantine Intermediate Water - LIW) and a maximum profiling depth of 700 m, with a cycling period of 5 days. Every ten cycles, the floats were programmed to profile between 2000 m and the surface in order to sample deep water mass properties. When at surface, the floats were located by, and transmitted data, to the Argos system onboard the NOAA satellites. The sampling intervals for the vertical profiles are 5 m (above 100 m), 10 m (between 100 and 700 m) and 50 m (below 700 m). Two profilers (Apex 50761 and Provor 50772) were part of the EU-funded MFSTEP project (Work package 4 – MEDARGO) whereas the other three units were funded by France.

The deployments of the 5 profiling floats was done at reduced speed or, when needed, with the ship at full stop. The procedures provided by the float manufacturers were followed to activate the float and deploy them (Figure 10). The use of a crane (A-frame) was necessary for the Provor due to its weight and height. Profilers were assigned with WMO numbers and their data were distributed onto the GTS. Details about the Argo profiler deployments (time and location, etc) are listed in Table 4.

Similarly to the surface drifters, the Argo profilers use the Argos satellite system for location and data telemetry. While at the surface (for about 8 hours) the profilers transmit every 45 s. The Argos transmission was checked with a portable Telonics receiver and an acoustic beeper (Figure 10) before each deployment.

FLOAT TYPE	SERIAL	WMO	ARGOS	TURN ON Date - GMT Time	DEPLOY Date - GMT Time	Latitude	Longitude
PROVOR	04MSS203	1900629	50772	14/11/2005 8.57	14/11/2005 9.06	35°01'16,1655"	21°13'16,4352"
PROVOR	PV407	1900599	52112	14/11/2005 14.16	14/11/2005 14.27	34°00'04.4910"	21°39'05.0386"
PROVOR	PV411	1900600	54006	15/11/2005 9.45	15/11/2005 9.50	33°06'49.6823"	24°21'07.6018"
PROVOR	PV416	1900601	54011	15/11/2005 23.27	15/11/2005 23.44	33°01'01.7914"	26°49'01.3751"
APEX	1667	1900630	50761	16/11/2005 14.50	16/11/2005 21.21	32°49'01.5379"	28°47'08.0753"

Table 4. Deployment information for the 5 Argo profilers.

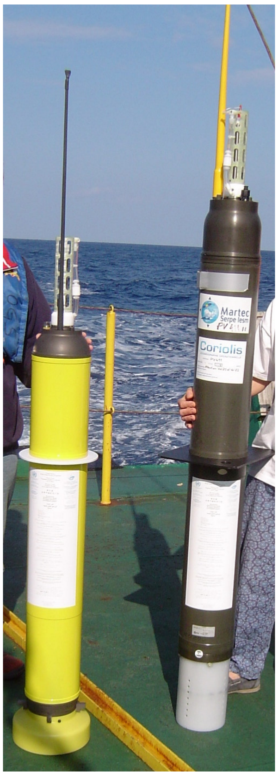


Figure 9. Picture of the APEX (left) and PROVOR (right) Argo profilers.

Figure 10. Pictures showing the deployment operations of a PROVOR profiler. Left: turning on the float. Bottom right: checking the float transmission (beeper, Telonics receiver, float antenna and CTD sensors). Center and top right: deploying the profiler using the A-frame.

5. Sequence of cruise operations

5.1. Friday 11 Nov 2005

Left Trieste harbor at 15.18 GMT with navigation system on, the meteorological system and the ADCP acquiring. Initiated the thermosalinometer in the Gulf of Trieste.

5.2. Saturday 12 Nov 2005

Start the acquisition of the navigation system at 20.52 GMT. Commenced XBT transect #1 (Figure 11) in the southern Adriatic at 21.32 GMT. Ship course made good of 138º. Starting at 14.00 GMT, winds from NW with force 2-4 and sea from NW with force 1-3.

5.3. Sunday 13 Nov 2005

Continued transect #1 in the Ionian Sea (XBT drops 3 to 17). Ship course made good of 161º. Starting at 10.00 GMT, winds from SE with force 2-5 and sea from SE with force 1-4.

5.4. Monday 14 Nov 2005

Continued transect #1 in the Ionian Sea (XBT drops 18 to 41) as far south as ~15 nm from the Libyan coast (~33°N08', see Figure 11). Deployed five drifters starting at 14.28 GMT and ending at 18.08 GMT (from XBT station 29 to XBT station 39). Deployed MEDARGO PROVOR float (WMO 1900629 Argos 50772) at 09.06 GMT (with XBT 22). Deployed French PROVOR float (WMO 1900599 Argos 52112) at 14.27 GMT (with XBT 29 and first drifter). Ship course made good of 161º. Winds from SE with force 2-5 and sea from SE with force 1-4. Commenced transect #2 with only automatic data acquisition of thermosalinograph, meteo and ADCP after 18.56 GMT. Ship course made good of 42º.

5.5. Tuesday 15 Nov 2005

Continued transect #2. Started transect #3 with XBT station 42 at 03.14 GMT. Ship course made good of 150º. Winds from E and NE with force 2-3 and sea from E and NE with force 2.

Ended transect #3 with XBT 69 at 14.34 GMT. Deployed two drifters at XBT stations 49 and 53 (at 06.49 and 08.19 GMT). Deployed one French PROVOR float (WMO 1900600 Argos 54006) at 09.50 (XBT station 57) and one drifter. Started transect #4 and launched XBT 58 to 83. Deployed one drifter at 21.47 GMT (XBT station 79). Deployed French PROVOR float (WMO 1900601 Argos 54011) at 23.44 GMT with XBT 83 and drifter. Ship course made good of 61°. Winds from NNE with force 2-3 and sea from NNE with force 2-3.

5.6. Wednesday 16 Nov 2005

Continued transect #4 until 01.49 GMT at XBT station 88. Deployed drifter at 01.25 at XBT station 87). Sailed along transect #5 with only automatic data acquisition of thermosalinograph, meteo and ADCP. Ship course made good of 157°. Winds from N with force 2-3 and sea from N with force 1-3. Started transect #6 at 13.57 GMT near the Egyptian coast with XBT station 89. Deployed drifters at 16.29 GMT (XBT 92), at 18.24 GMT (XBT 94) and 19.44 GMT (XBT 98). Deployed MEDARGO APEX float (WMO 1900630 Argos 509761) at 21.21 GMT with XBT 102 and the last drifter. Continued transect #6 until XBT 104 at 23.19 GMT. Ship course made good of 9°. Winds from N with force 2 and sea from N with force 1.

5.7. Thursday 17 Nov 2005

Finished transect #6 with XBT stations 105 to 108. Ended XBT survey at 03.04 GMT. Started last transect (#7) heading to Port Said, Egypt. Ship course made good of 133°. Winds from SW with force 2 and sea from SW with force 1-2. Interrupted ADCP, thermosalinometer, meteorological and navigation systems at about 19.20 GMT. Executed the routine standard maintenance of the thermosalinometer.. Entrance in Port Said Harbor and Suez Canal in late evening.

5.8. Friday 18 Nov 2005

EGITTO-1 scientific personnel disembarked around 1.00 GMT and stayed overnight in Port Said. The personnel was transferred to Cairo by minibus service. While waiting the plane at Cairo international airport, zipped text files with the XBT data were sent to the MFS-VOS Data Center (ENEA, La Spezia, Italy) at the following email address (vosdata@santateresa.enea.it) via terrestrial cellular phone.

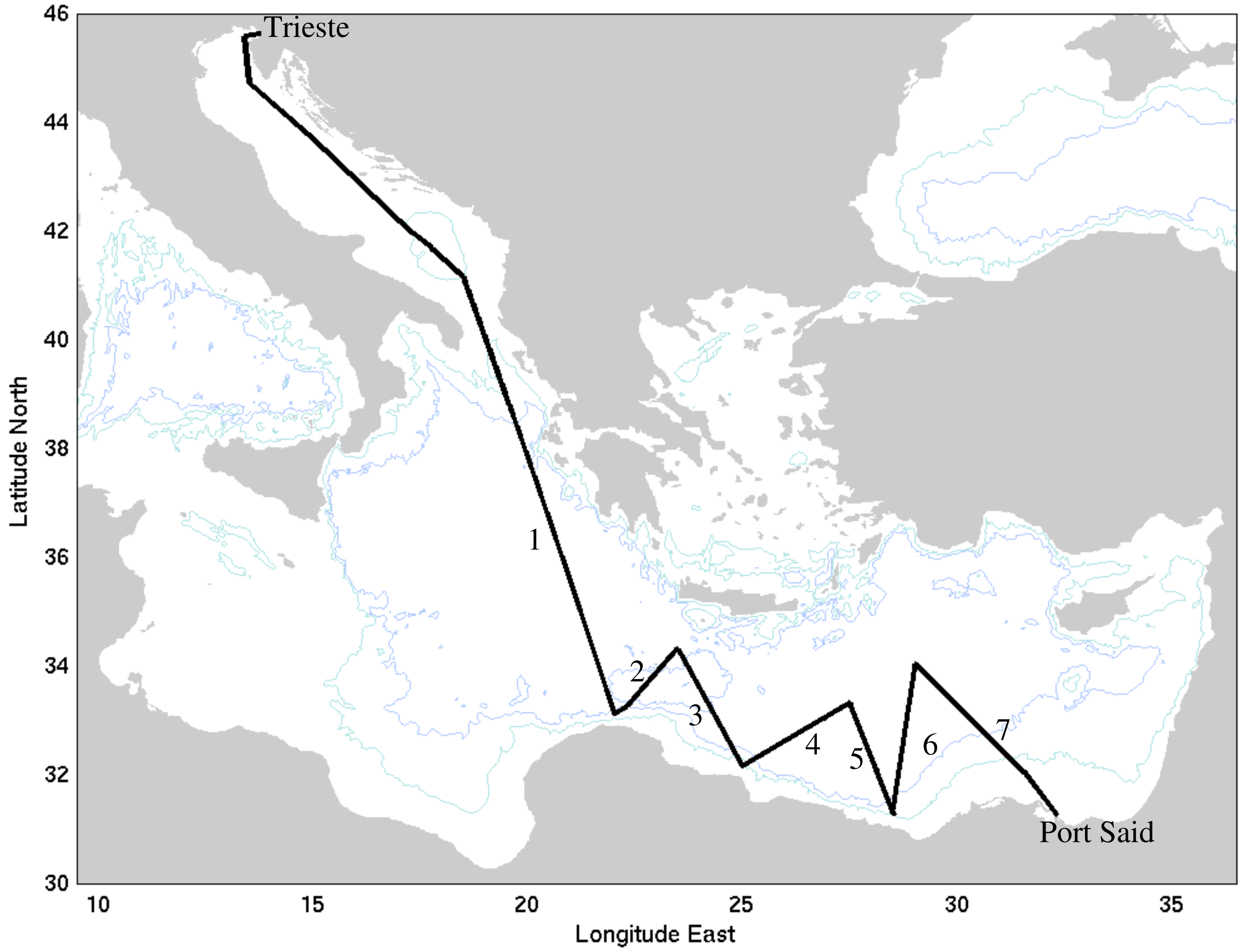


Figure 11. Track of R/V OGS-EXPLORA between Trieste, Italy and Port Said, Egypt. Numbers indicate the various transects conducted in the Ionian and Levantine Seas. Isobaths 1000 and 2000 m are shown.

6. Preliminary results

6.1. Meteorological observations

The time series of the meteorological data provided by the two stations (meteo 1 and 2) are presented in Figures 12 to 15. All the meteorological observations sampled at 1 Hz were averaged over one minute. The air temperature (Figure 12) ranges from about 12ºC (night of 11 November in northern Adriatic) to around 20ºC (in the southern Levantine basin where a diurnal cycle of ~2ºC is evident). The atmospheric pressure (Figure 12) shows a slow decreasing trend from about 1025 hPa on 11 November to 1015 hPa on 17 November. These high values are associated to a high pressure system that migrated from western to eastern Europe during the time period considered. There is a slight offset between the two pressure measurements.

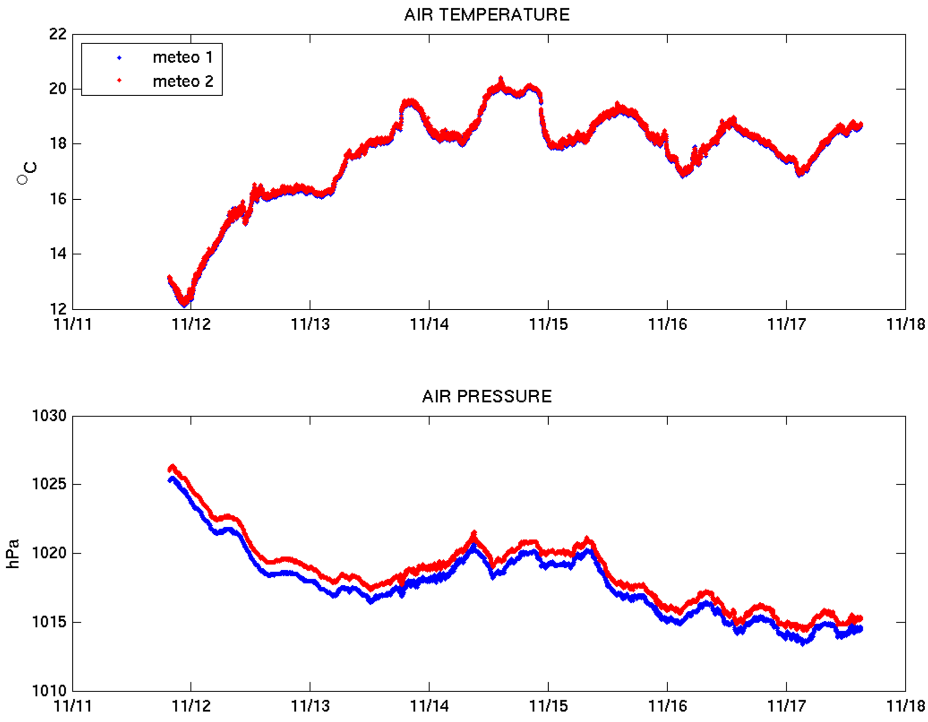


Figure 12. Air temperature and pressure as measured by the two Young meteorological stations (one-minute averaged; meteo 1: port side; meteo 2: starboard).

Relative humidity (Figure 13) was initially high in the northern Adriatic (> 80%). It generally decreased as the ship proceeded southward. On 15-16 Nov, the humidity reached its minimum value (<50%) when the ship was sampling in the southern Levantine basin.

Wind data (Figure 14) were converted from the measurements relative to the ship to absolute values using the ship motion deduced from the PDS2000 navigation system. Weather conditions were generally fair throughout the cruise, with weak northwesterly winds prevailing on 12 November, southeasterly winds blowing on 13-14 November and reaching 12 m/s on 14 November morning, and with northwesterly and westerly winds prevailing during 15-17 November with speed less than 6 m/s.

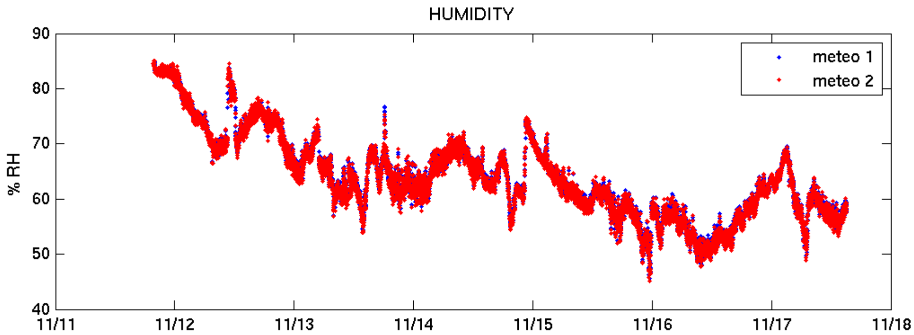


Figure 13. Relative humidity as measured by the two Young meteorological stations (one-minute averaged; meteo 1: port side; meteo 2: starboard).

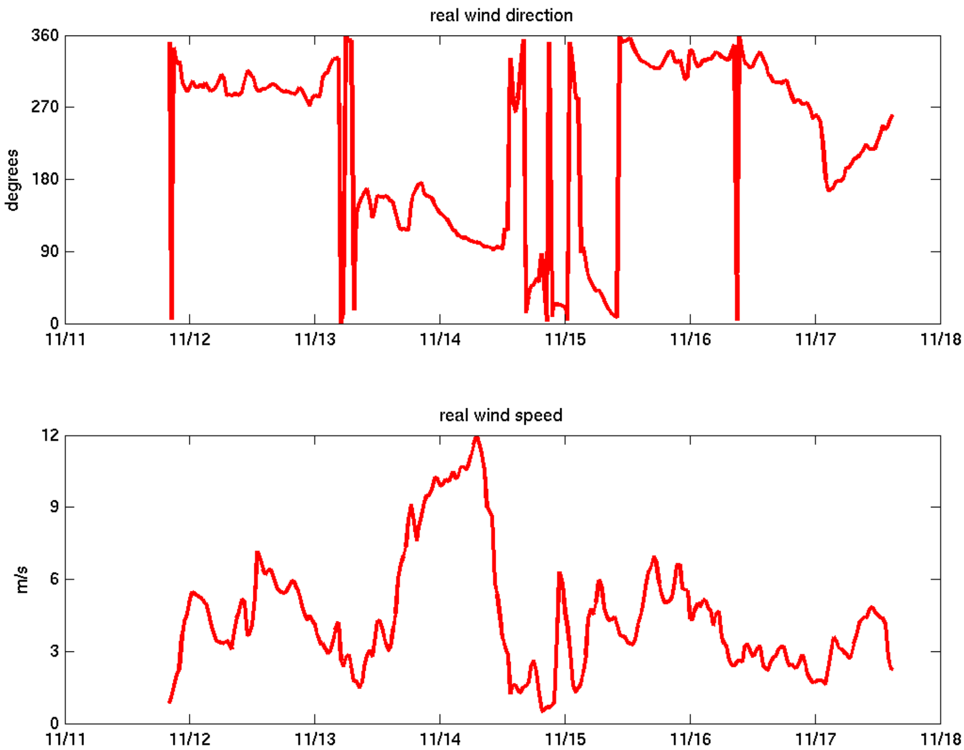


Figure 14. Wind speed and direction versus time as measured by the meteo 1 system. Data were averaged over one minute.

The SST data (Figure 15) measured by the thermistor mounted on the ship's haul show a general warming trend with minimum values (16 °C) in the northern Adriatic and maxima (>22 °C) in the southern Levantine. SST is also plotted along the ship track as color-coded dots (Figure 16).

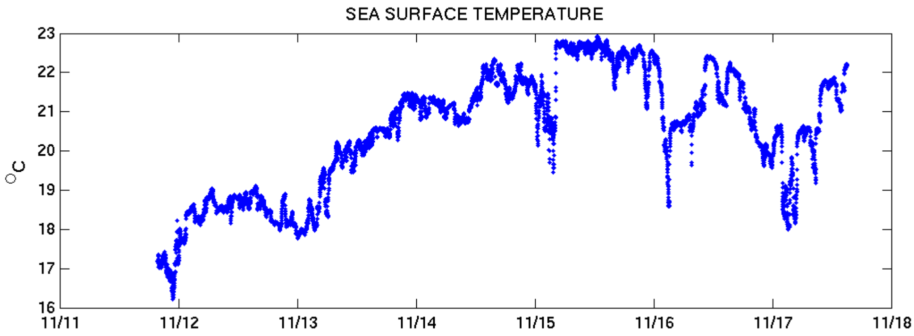


Figure 15. Sea surface temperature versus time as measured by the thermistor of the meteorological system (one-minute averages).

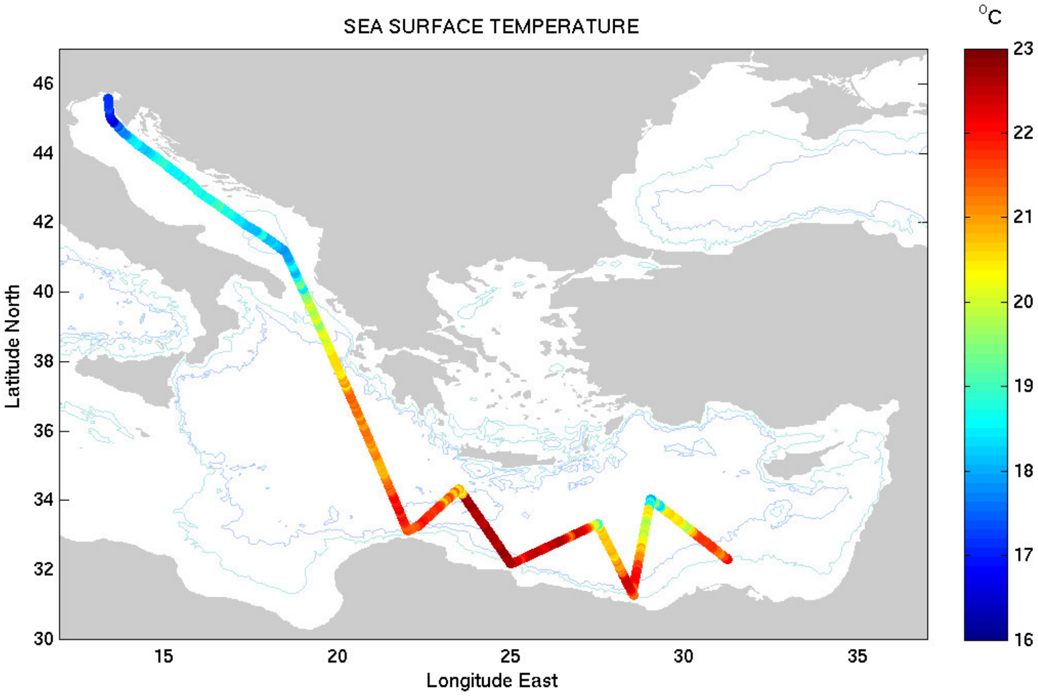


Figure 16. Color-coded sea surface temperature as measured by the thermistor of the meteorological system.

6.2. Underway thermosalinometer salinity

The temperature and conductivity data of the Sea-Bird 21 SEACAT thermosalinometer were used to calculate the surface salinity. The salinity is plotted versus time in Figure 17. It ranges from about 38 (in the Po River influenced waters in the northern Adriatic Sea) to about 39.5 in front of Port Said, Egypt at the end of the survey. Figure 18 shows the spatial variability of the surface salinity. Salinity variations in the southern Levantine are associated with the intense eddy activity under study.

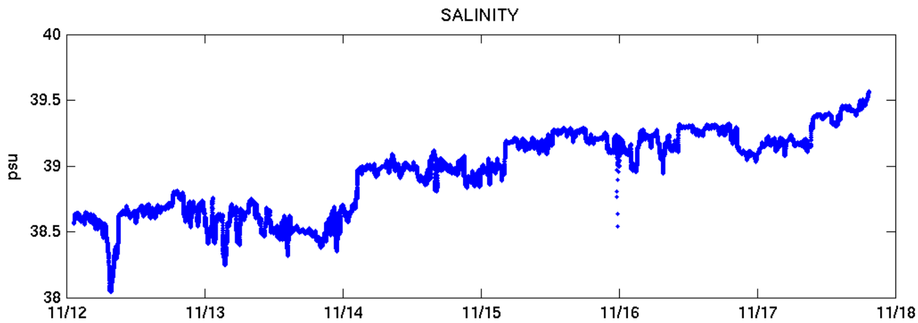


Figure 17. Sea surface salinity versus time as measured by the thermosalinometer.

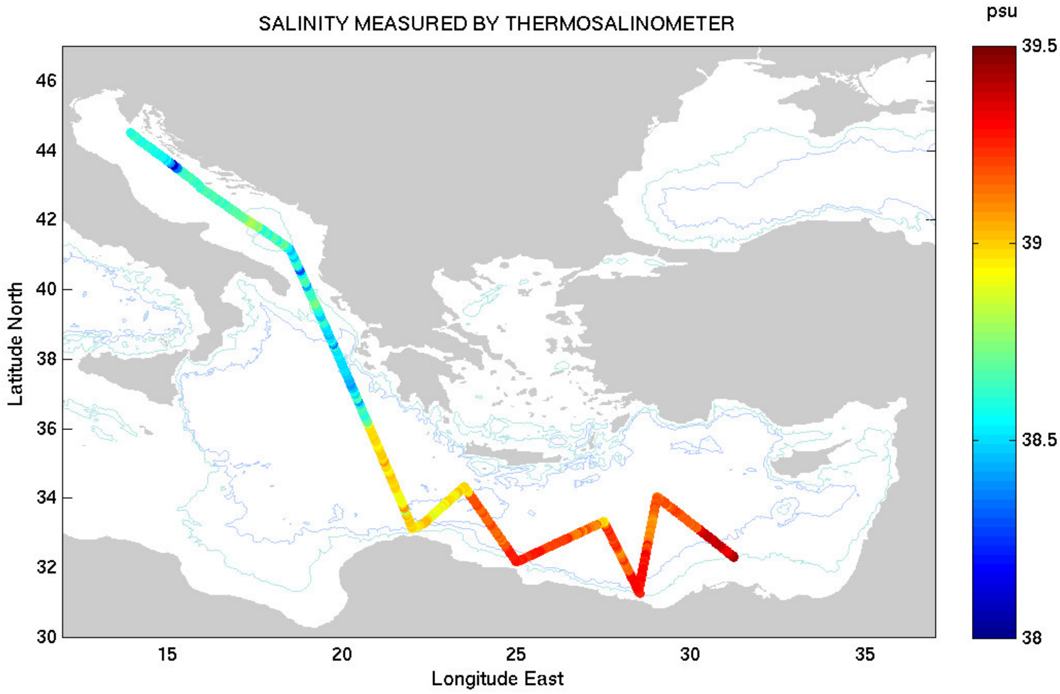


Figure 18. Color-coded sea surface salinity as measured by the thermosalinometer.

6.3. ADCP currents

The ADCP data are still being processed at the redaction time of this report. We present hereafter a few plots with a few preliminary results for the southernmost portion of transect # 1 in the southeastern Ionian Sea (Figure 19). The ADCP data in bin 1 (10.5 m) and 8 (66.5 m) about 50 km off the Libyan coast reveal an anticyclonic feature with generally westward currents to the south and weak eastward flow to the north (Figure 20). Drifter # 59755 which was deployed in the same area confirm the prevailing westward flow. The number of good ping returns in 30 s intervals is plotted versus depth and distance along ship track in Figure 21, along with the magnitude and the direction of the horizontal currents. A surface-intensified flow to the northeast is evident near the middle of the section with speeds approaching 50 cm/s. This structure might be associated with the Pelops anticyclone. A more barotropic westward current extending down to 500 m depth and with magnitude reaching 1 m/s is striking between distances 150 and 200 nautical miles. More to the south, weak northward currents appear north of eastward flow. The latter could be associated with the African coastal current.

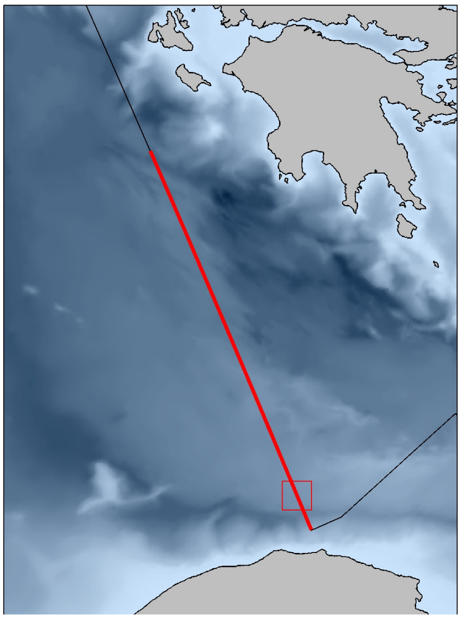


Figure 19. Ship track (black line) and location of the portion of transect #1 chosen to show the ADCP results (red line).

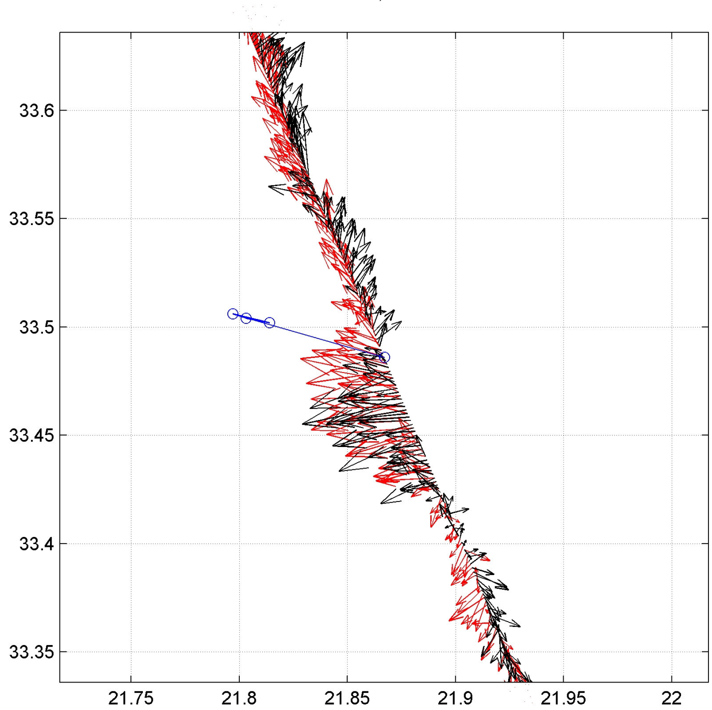


Figure 20. ADCP data for a small portion of transect #1 in the southeastern Ionian (shown as square in Figure 19): Horizontal current vectors (red: bin 1 @ 10.5 m and black: bin 8 @ 66.5 m). The first five positions of drifter 59755 are plotted with blue symbols.

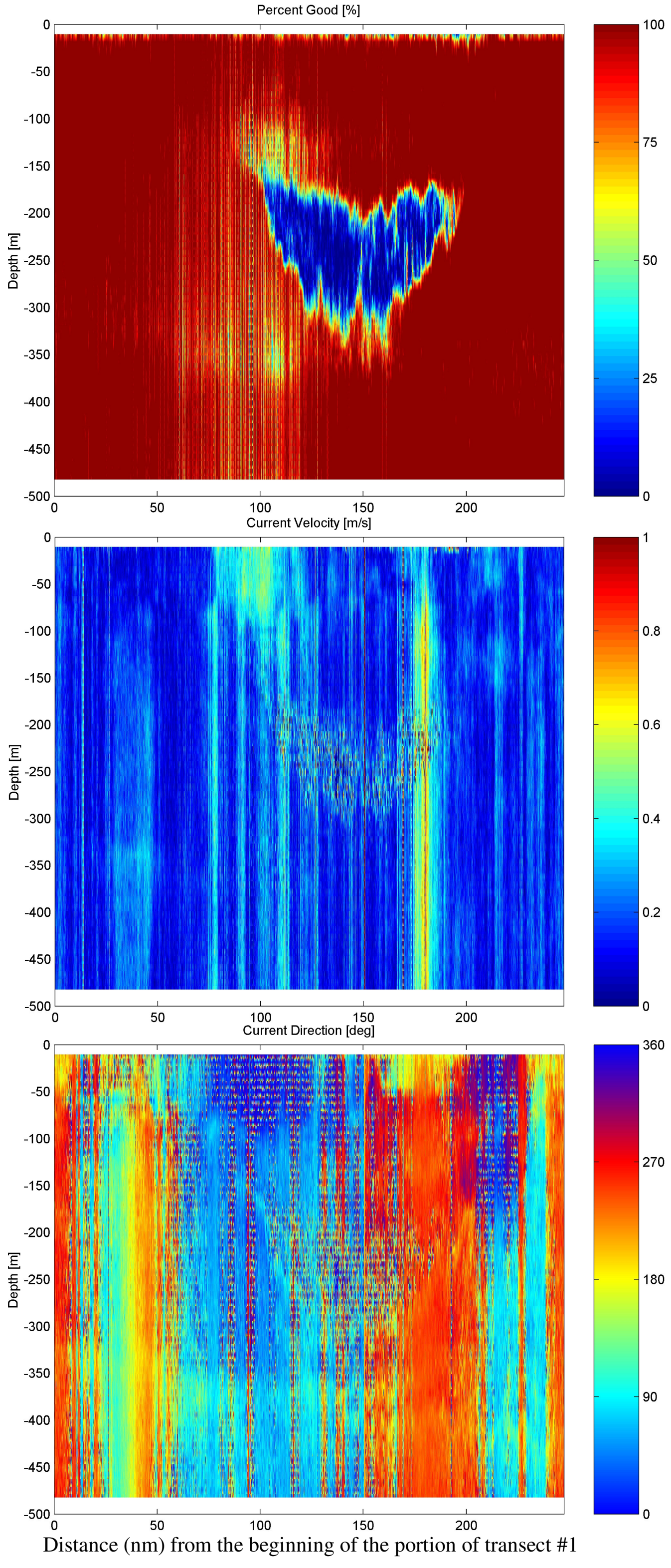


Figure 21. Color-coded ADCP data for a portion of transect #1 in the southeastern Ionian (see Figure 19): percentage of good returns (top), speed (middle) and direction (bottom).

6.4. XBT temperature data

XBT data sorted by transects are presented hereafter as composite plots of temperature profiles and as temperature contour diagrams. Considering all the XBT data, the temperature ranges between ~19-23°C near the surface, and between 13-14°C at depth (700-900 m).

Transect #1 includes the southern Adriatic, the Strait of Otranto and the eastern Ionian Sea. A near-surface mixed layer and a strong thermocline located at depths between 40 m (Adriatic and northern Ionian) and 100 m (southeastern Ionian) are striking (Figure 22).

The XBT data of transect #3 (Figure 23), located south of Crete, reveal a doming of the temperature vertical distribution corresponding to a cold-core eddy feature prevailing between 100 and 300 m. Near the surface, the mixed layer is shallow to the north (~20 m) and deepens to about 100 m to the south.

Transect #4 (see Figure 24), located off the eastern Egyptian coast, is characterized by a deep warm (>22°C) mixed layer reaching 100 m, Below the thermocline, the isotherms are doming due to the presence of a relatively warm eddy structure extending down to about 400 m.

The last XBT section (transect #6, see Figure 25) includes a warm top mixed-layer above ~80 m as far north as station #106, north of which there is a thermal front and temperatures decrease to values near 18°C. At depth, there is some signature of a warm sub-surface feature extending down to about 250 m in the southern part of the section (stations #89 to 95). In contrast, a strong and deep (~500 m) warm-core eddy is striking between stations #100 to 106. These two features correspond to the so-called Mersa-Matruh anticyclonic gyres.

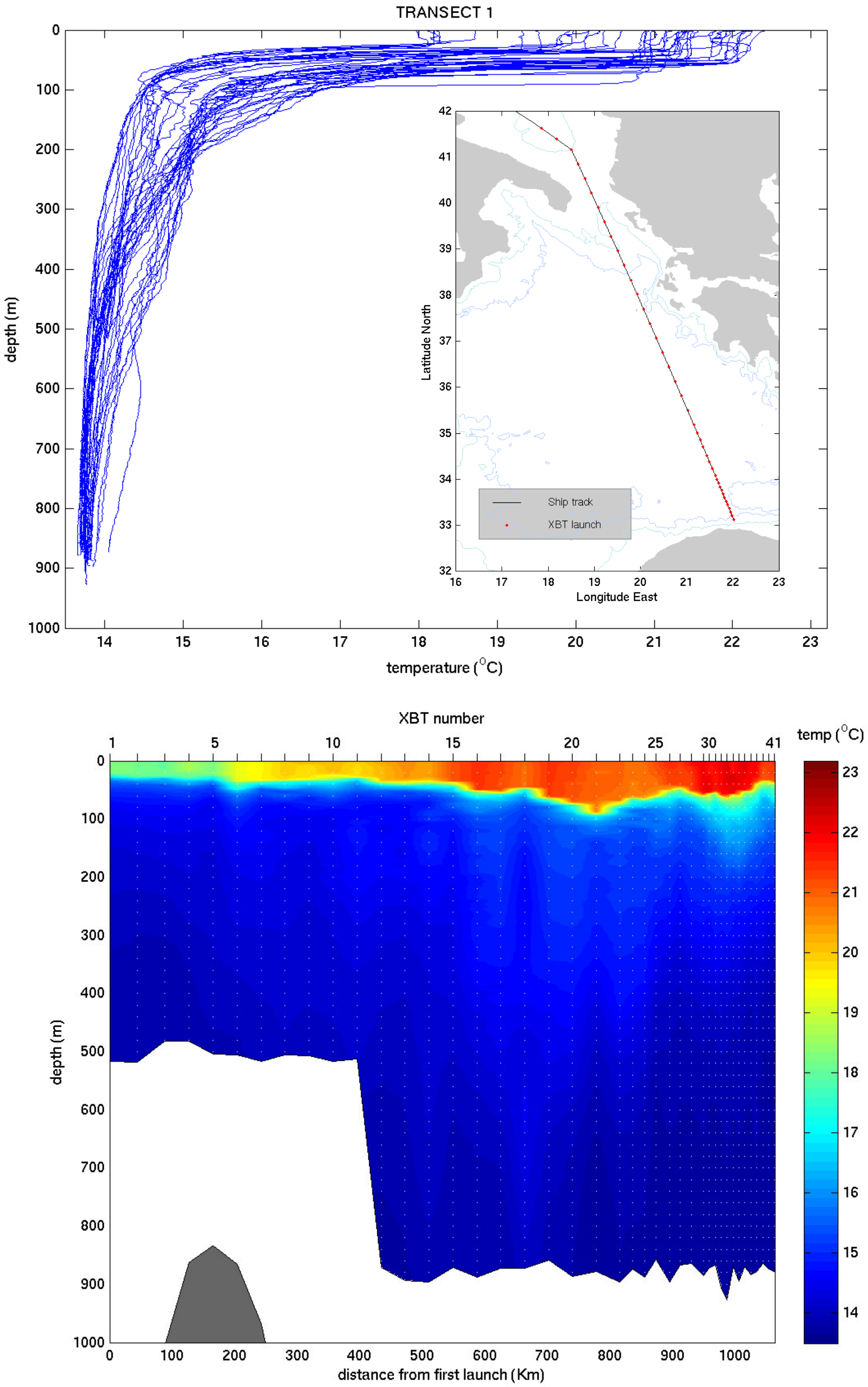


Figure 22. Temperature profiles (top) and color-coded temperature contours for transect # 1 in the southern Adriatic and Ionian Seas. The geographical locations of the XBT stations are shown in the insert.

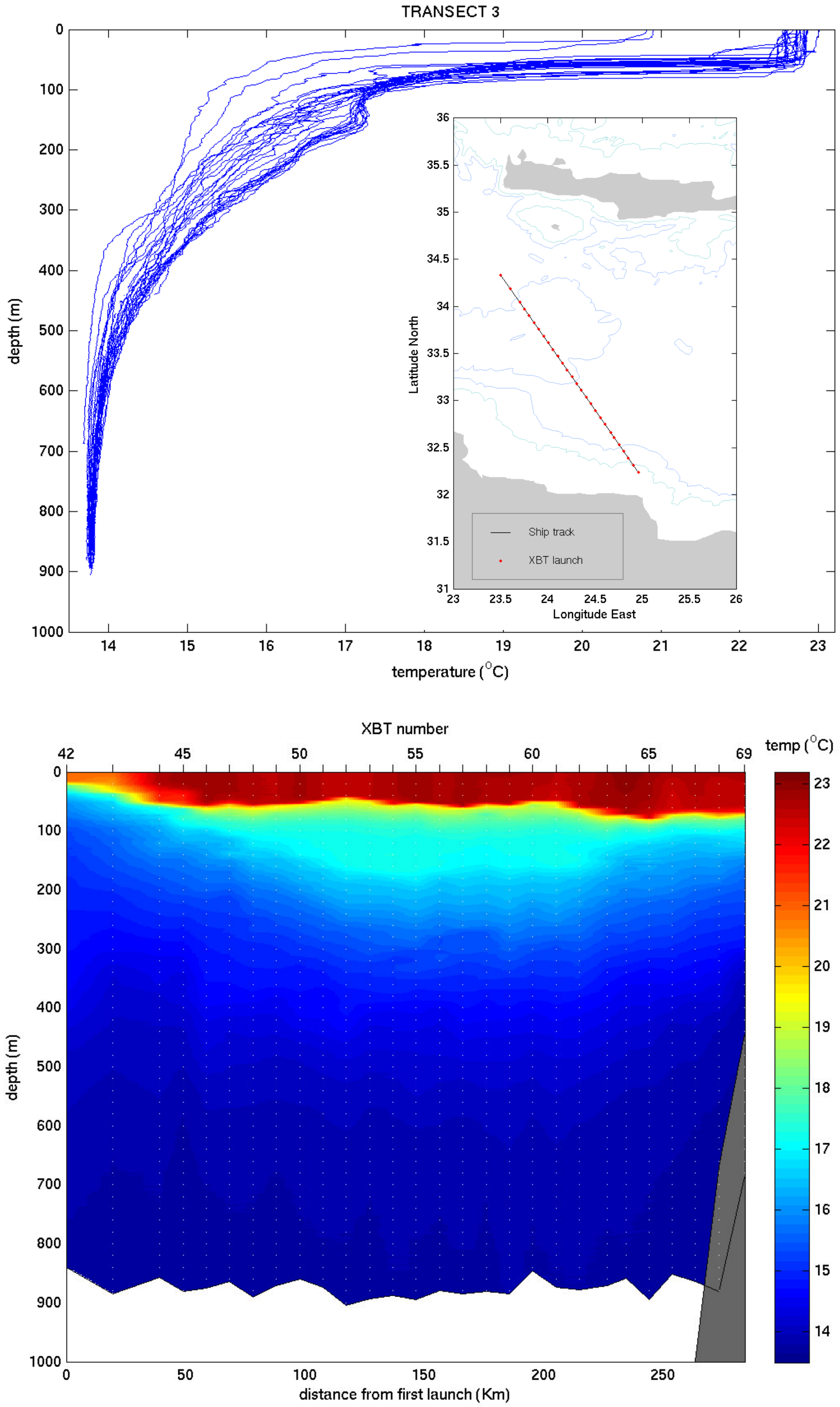


Figure 23. Same as in Figure 22 but for XBT transect #3.

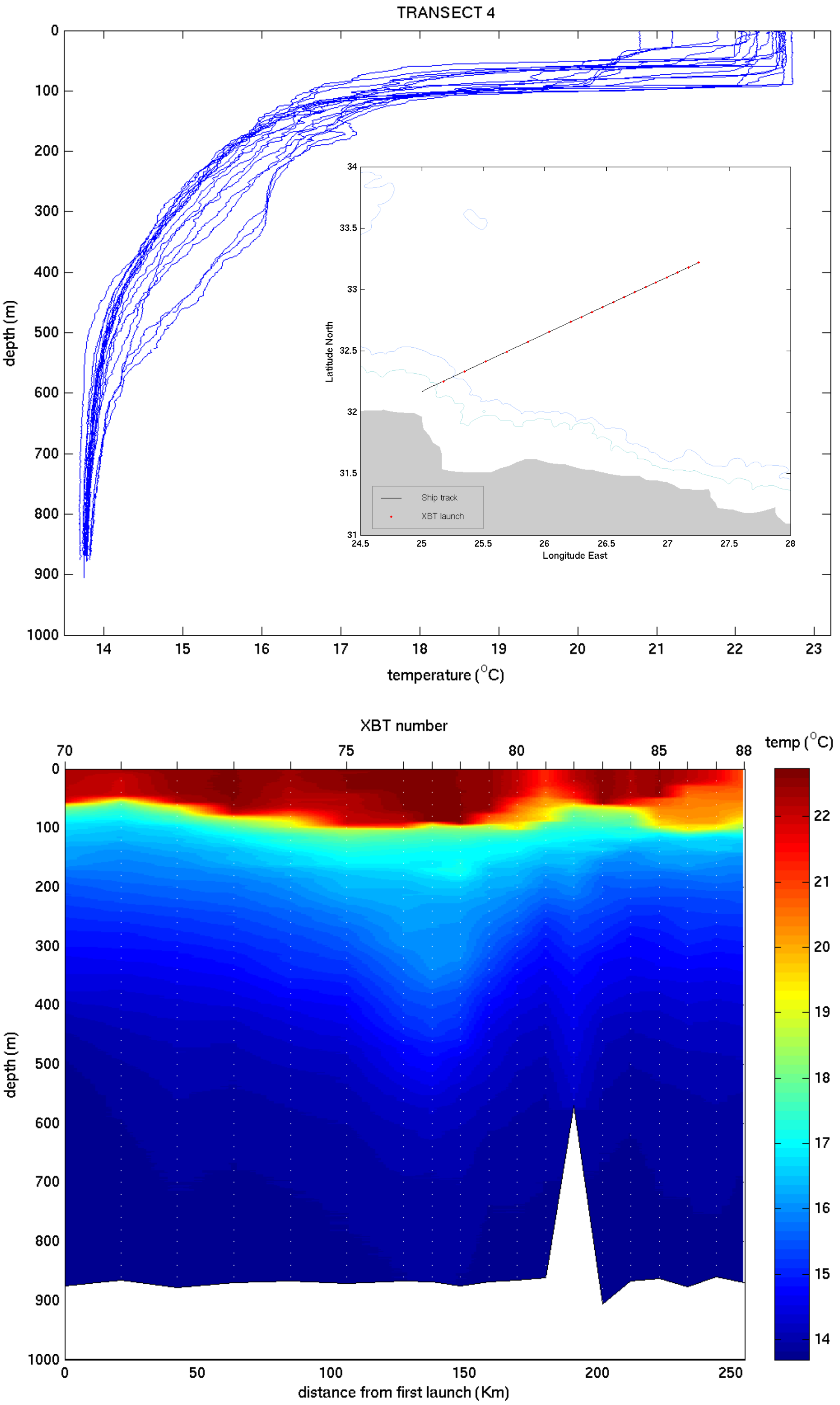
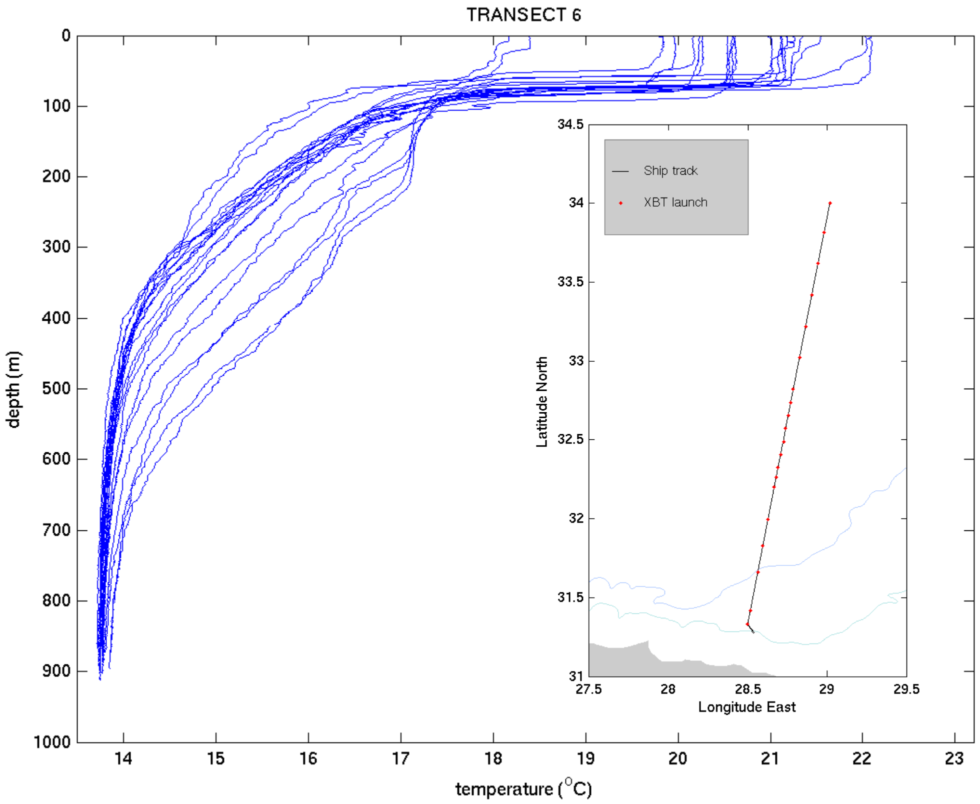


Figure 24. Same as in Figure 22 but for XBT transect #4.



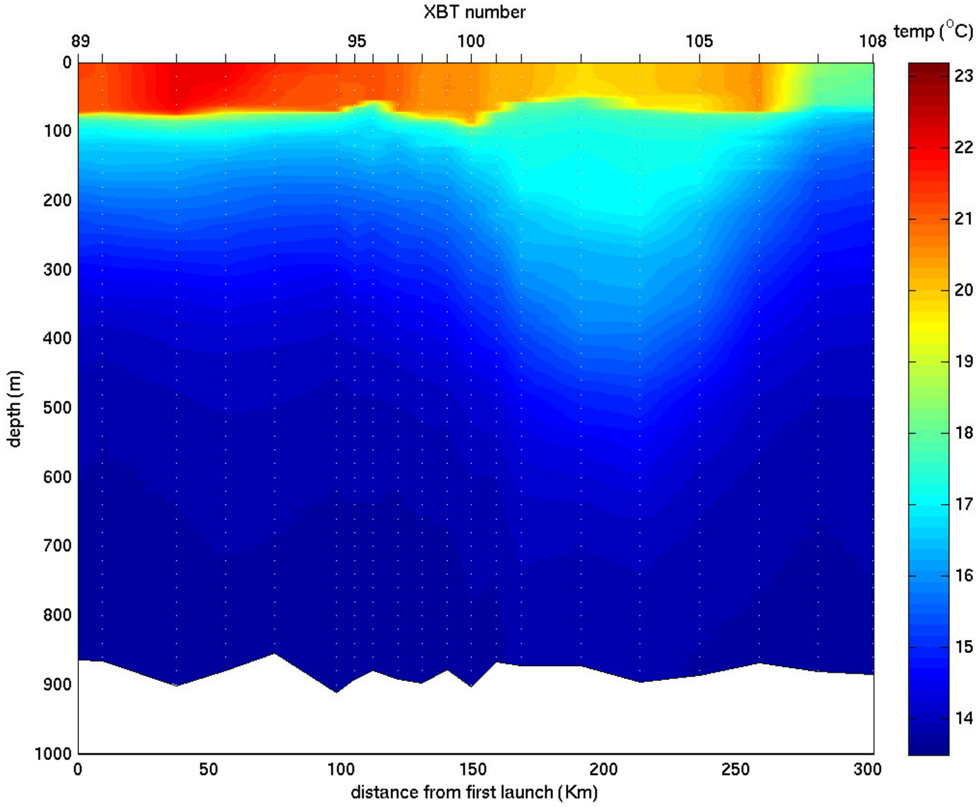


Figure 25. Same as in Figure 22 but for XBT transect #6.

6.5. Drifter tracks

The 15 SVP drifters were deployed along transect #1, 3, 4 and 6. Their release locations as well as their trajectories during the first 5 days after deployment are depicted in Figure 26. The drifters deployed in the southern part of transect #1 moved eastward in two groups, one to the north near latitude 34°N, and the other to the south over the African continental slope. The 3 drifters released along transect #3 showed a southward motion before splitting into westward and eastward branches. More to the east, along transect #4, the southernmost drifter showed a clear anticyclonic motion, whereas the other two units deployed more to the north revealed complex eastward and westward drifts. Only the northmost drifter of the four units released along transect #6 shows a strong anticyclonic movement associated with the north Mersa-Matruh gyre. To the south, the drifters moved either to the west or to the south and eventually joined the eastward coastal current off Egypt.

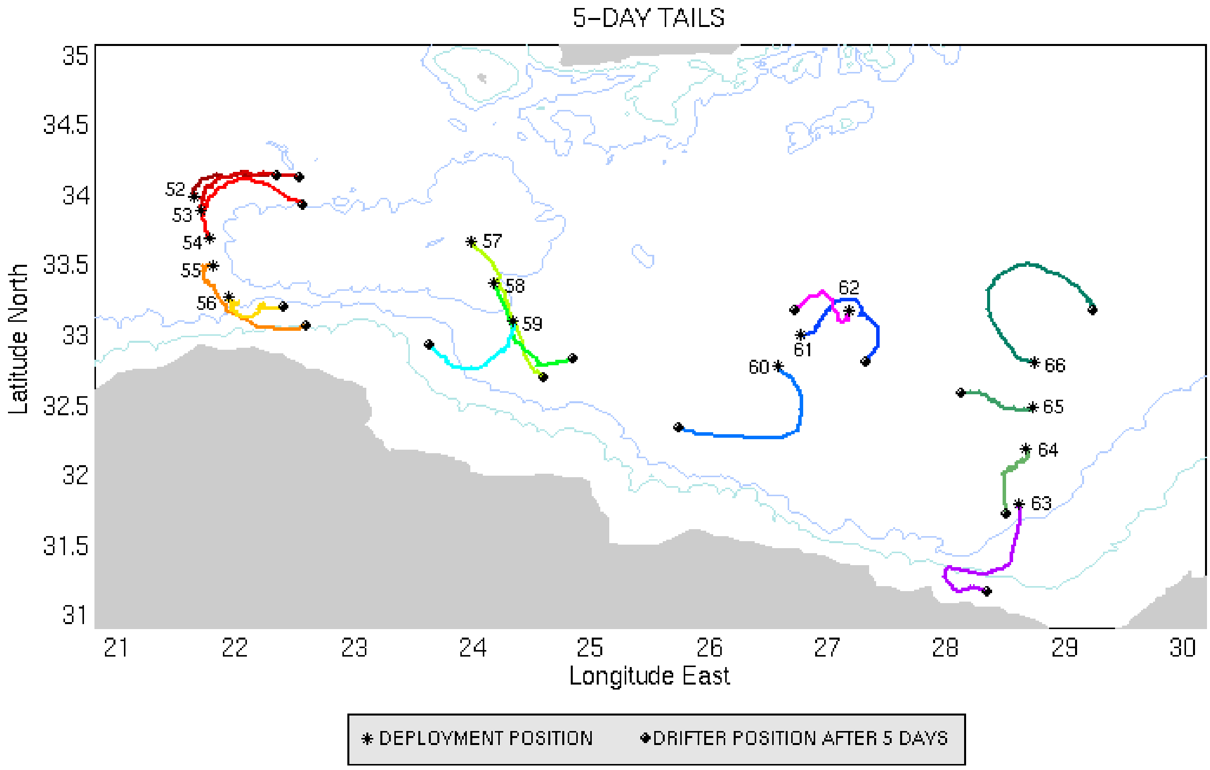


Figure 26. Drifter trajectory segments for 5 days after release. The star and dot symbols indicate the first (deployment location) and the last drifter positions, respectively. The last two digits of the Argos PTT numbers of the drifters are posted near the deployment sites.

6.6. Argo profiler data

The first sub-surface (~350 m) displacements (over about 2 and 5 days, for the PROVOR and APEX floats, respectively) of the Argo profilers are presented in Figure 27. Two profilers were deployed in the eastern Ionian Sea along transect #1. The first unit (PROVOR WMO 1900629) moved slowly to the west, maybe in the southern limb of the Pelops anticyclone. The second PROVOR (WMO 1900589) showed some indication of northeastward flow. Two other PROVOR floats were deployed more to the east on transects #3 and #4. They drifted southward and northward, respectively. The last Argo profiler, APEX WMO 1900630, was deployed south of the strong Mersa-Matruh anticyclonic gyre along transect # 6. Over 5 days, it drifted to the northwest in agreement with the expected anticyclonic circulation.

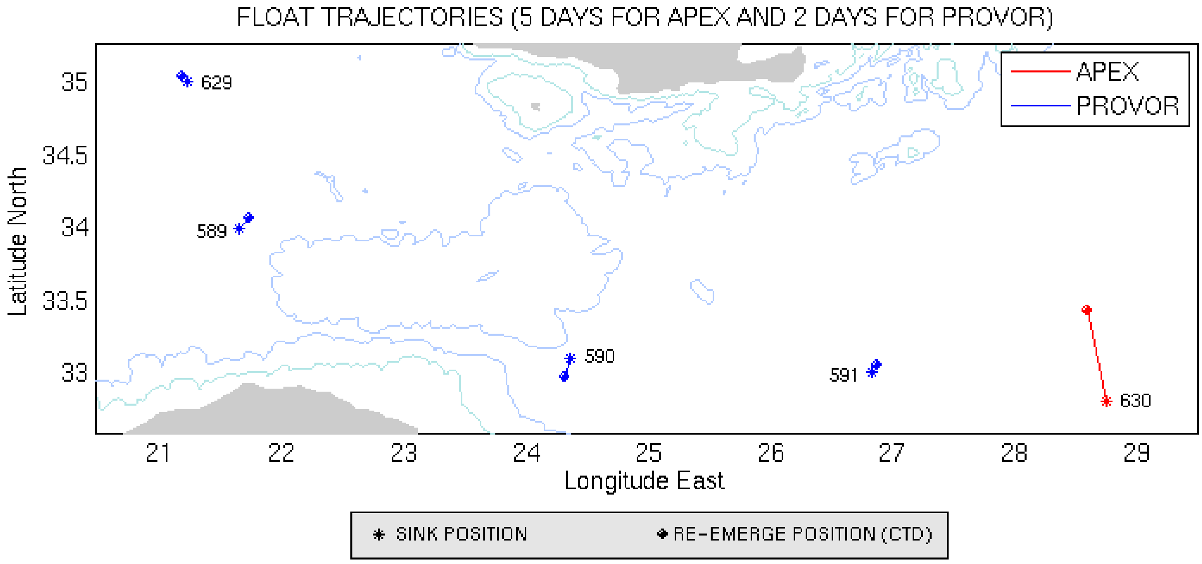


Figure 27. Sub-surface displacements between the first descent (star symbol) and the first ascent (dot symbol) of the Argo profilers deployed during the cruise. The duration of the first sub-surface displacement is about 2 and 5 days, for the PROVOR and APEX floats, respectively. The last three digits of the WMO numbers of the profilers are posted near their release sites.

The hydrological properties (potential temperature and salinity) measured by the Argo profilers during their first ascent are plotted versus depth in Figure 28. The surface mixed-layer extends to 50-70 m and some signature of warmer waters can be seen as deep as 600 m in the profile of the APEX float. A sub-surface salinity maximum is evident in all the profiles between 200 and 400 m. This is the signature of the LIW. In the deep sea, between 1000 and 2000 m, the potential temperature is quite constant and similar for all the profilers (13.5-13.65°C) whereas the salinity varies between 38.72 and 38.77. The corresponding T-S diagram (Figure 28, bottom panel) shows that the sub-surface salinity maximum has a density near 28.75-29 (sigma-t). In the deep sea near 2000 m, the maximum sigma-t is nearly the same for all the profilers and equal to 29.19.

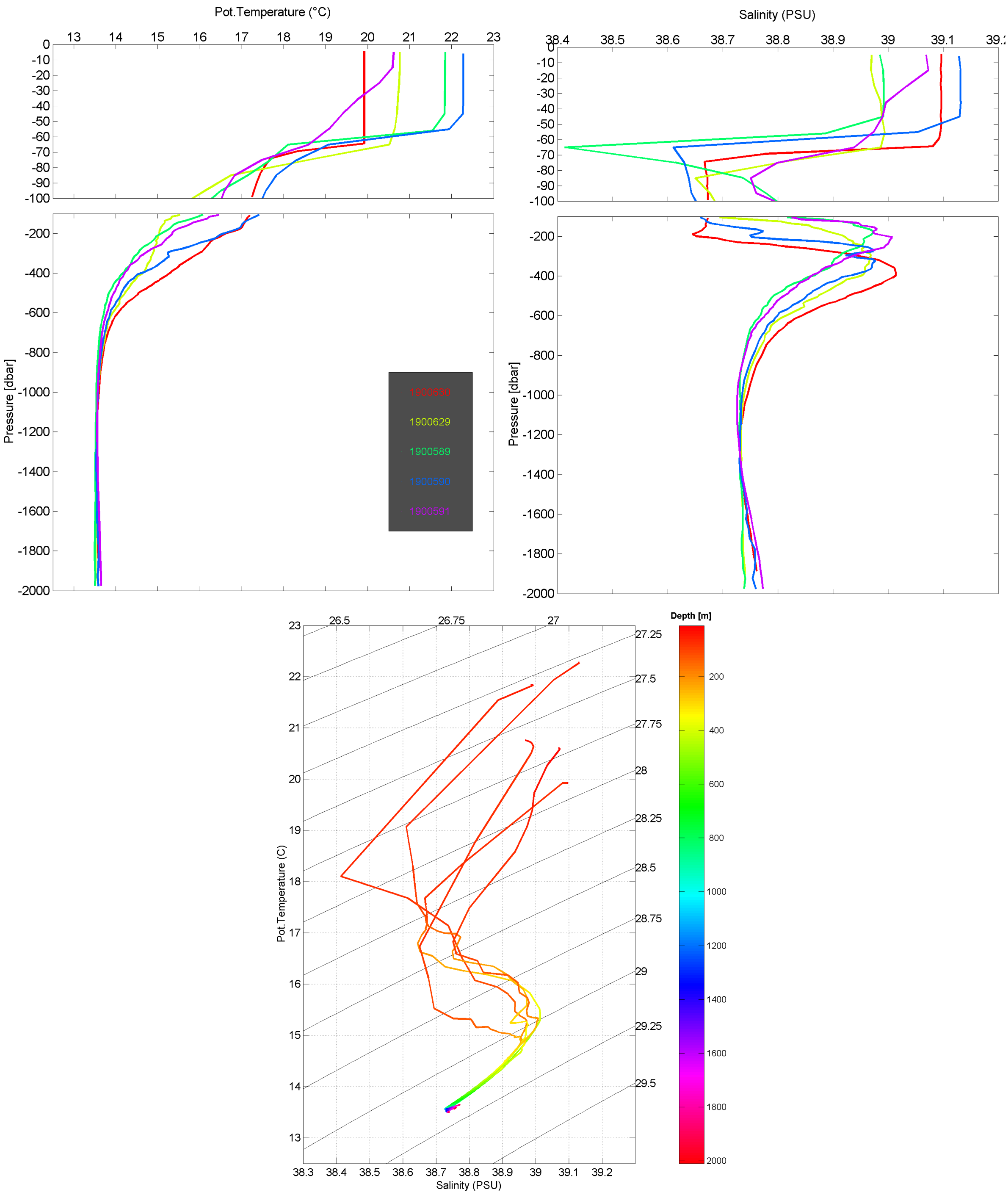


Figure 28. Potential temperature (top left panel) and salinity (top right panel) profiles sampled by the Argo floats during their first ascent . T-S diagram (bottom panel) using the same data. Isopycnals with interval of 0.25 sigma-t are overlaid.

6.7. Remote sensing images

Relatively clear AVHRR SST images of the southeastern Mediterranean produced by the SIRE Group at OGS were sent to the ship via email on a daily basis. They helped to locate the major circulation features and to plan the ship track and the XBT, drifter and Argo profiler measurements. An example of SST image is shown as Figure 29 for 13 November 2005 at 14.59 GMT. The warm (>22ºC) waters of the southern Ionian and southern Levantine are contrasting the relatively cold (<18ºC) surface waters in the northern Levantine and in the Cretan Eddy. The Ierapetra Anticyclone has a strong warm signature southeast of Crete.

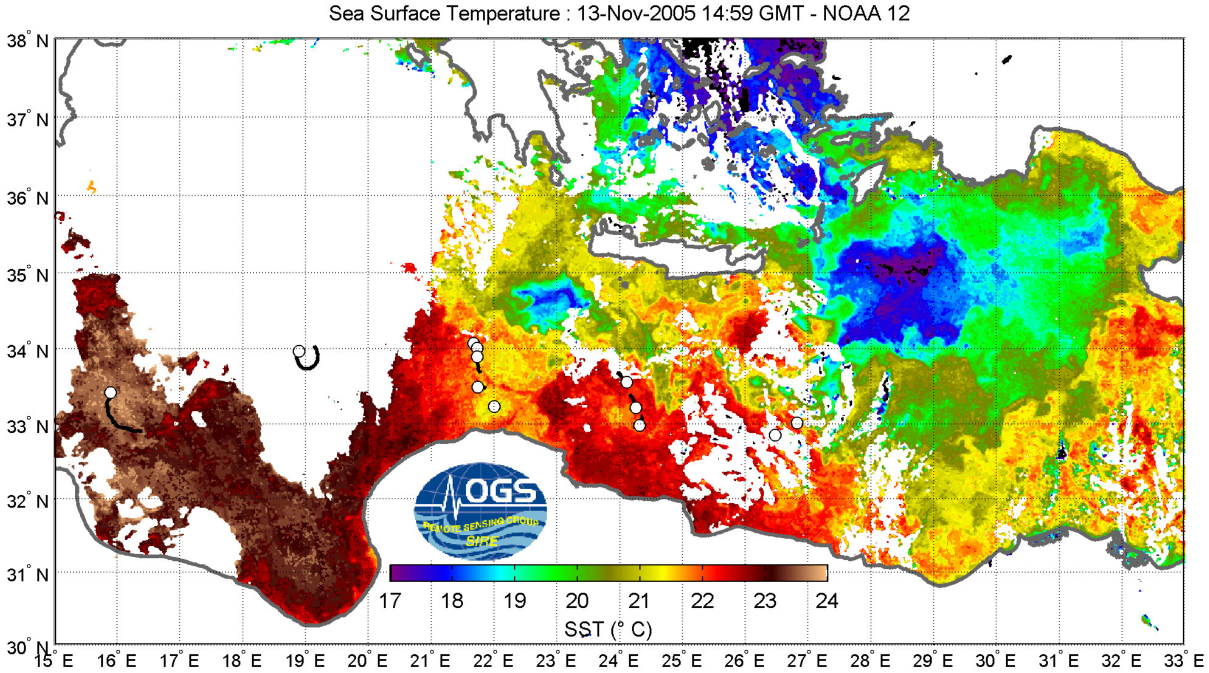


Figure 29. Color-coded AVHRR sea surface temperature image of the southern Ionian and Levantine seas on 13 November 2005 at 14.59 GMT. The drifter positions (white circles) and 5-day tracks (black tails) are overlaid.

A monthly composite SST map was obtained by averaging all the SST images (day and night passes) during the month of November 2005 (Figure 30). The averaging process has removed the cloud masking and the main sub-basin thermal structures seen in SST snapshots (like in Figure 29) still exist (e.g., the Cretan and Ierapetra Eddies, the cold area associated with Rhodes Gyre). An anticyclonic eddy is evident near 33ºN, 29ºE, in which water is entrained around a relatively cold core center.

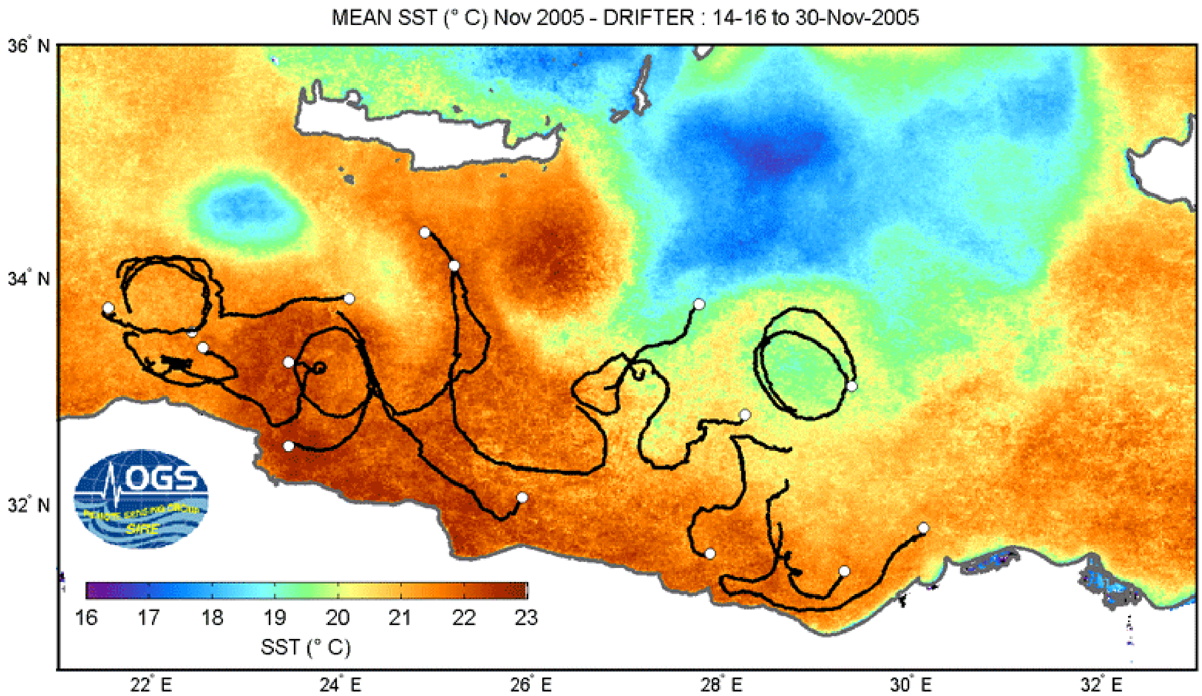


Figure 30. Color-coded mean sea surface temperature of the southern Ionian and Levantine seas for November 2005. This monthly composite includes all the AVHRR-inferred temperatures. The drifter positions (white circles) and 15-day tracks (black tails) are overlaid.

6.8. MFSTEP and MERCATOR model products

Graphical products of operational oceanography programs such as the French MERCATOR, the Greek ALERMO and the EU-funded MFSTEP were also sent to the ship on a daily basis. They include maps of SST, sea surface salinity, currents and sea surface height that were used to locate the main circulation features of interest and to plan the cruise.

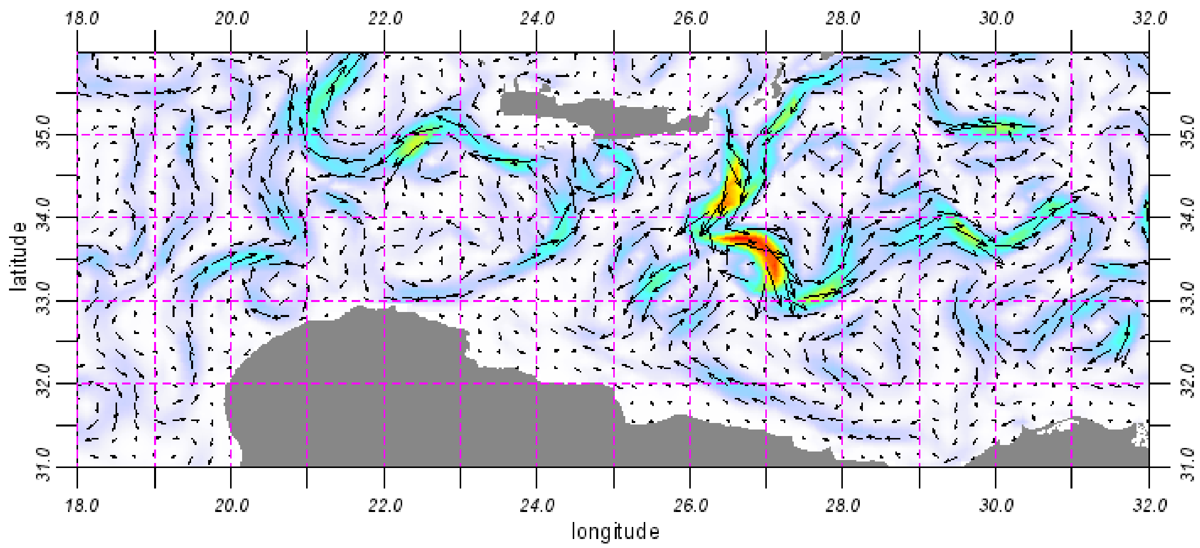
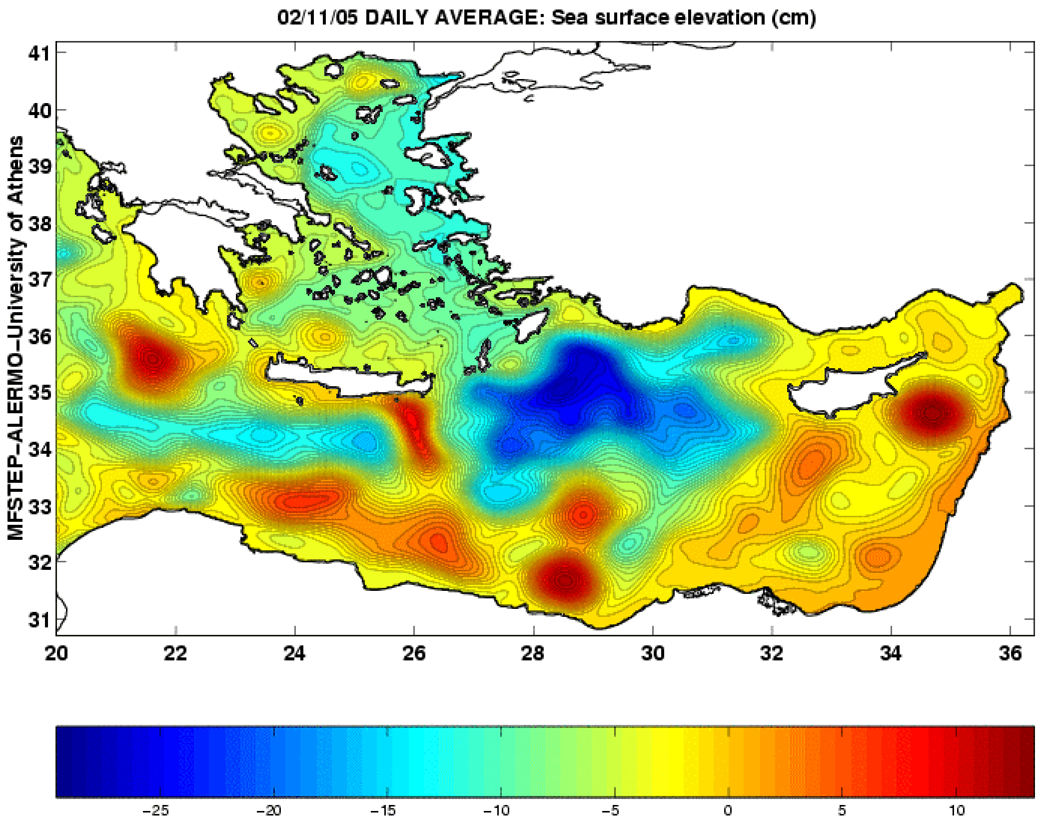


Figure 31. Analysis (nowcast) map of near-surface currents on 10 November 2005 provided by the MERCATOR program.

The near-surface circulation obtained from MERCATOR for 10 November 2005 (Figure 31) shows a meandering Libyo-Egyptian Current that is blocked near 25ºE and re-circulates into a westward current south of Crete. The Ierapetra anticyclone is weak compared to the strong and extended cyclonic Rhodes Gyre. Off Egypt, the coastal current is surprisingly westward.

Maps of sea surface height produced by the ALERMO model are depicted in Figure 32 for 2 and 13 November 2005. In addition to strong Pelops, Ierapetra and Rhodes gyres, several anticyclones are evident in the southern Levantine Sea. Two gyres are located near 24ºE and 25ºE. More to the east, what can be called the Mersa-Matruh eddy system is composed of two anticyclones. The southernmost gyre extends practically as far as the Egyptian coast. The other anticyclone, with slightly reduced strength and size, is located approximately to the north of the coastal gyre. The two maps illustrate the temporal evolution of the gyres in 11 days, with the intensification of the Rhodes Gyre and the slight waning and displacement of the anticyclones.

The sea surface height map produced by the MFSTEP model (Figure 33) on 5 November 2005 shows similar features as the ALERMO model in the Levantine sub-basin. Besides, it provides information on the circulation in the Ionian Sea. In particular, a meandering eastward and southward current is striking in the central Ionian, eventually connecting to the Libyo-Egyptian Current near 20ºE. Strong anticyclonic gyres are evident south of this central jet.



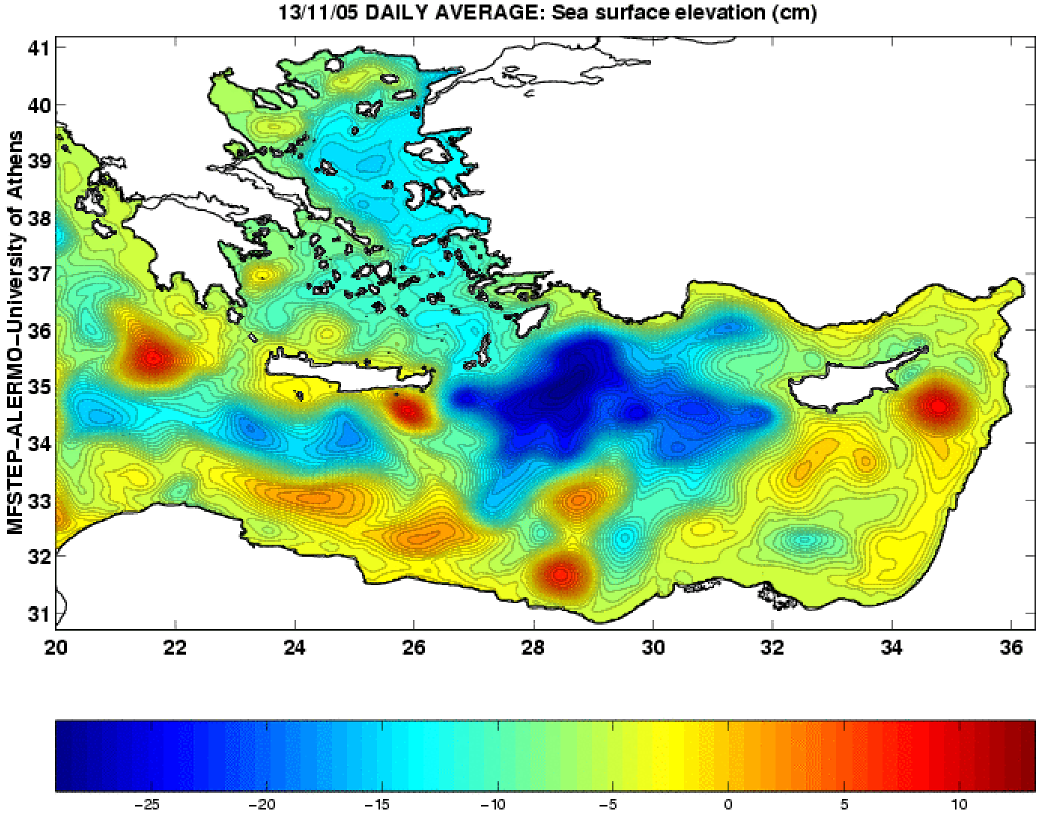


Figure 32. Sea surface height maps as a nowcast and forecast products of the MFSTEP/ALERMO numerical model showing the evolution of the main circulation features in the Levantine sub- basin between 2 and 13 November 2005.

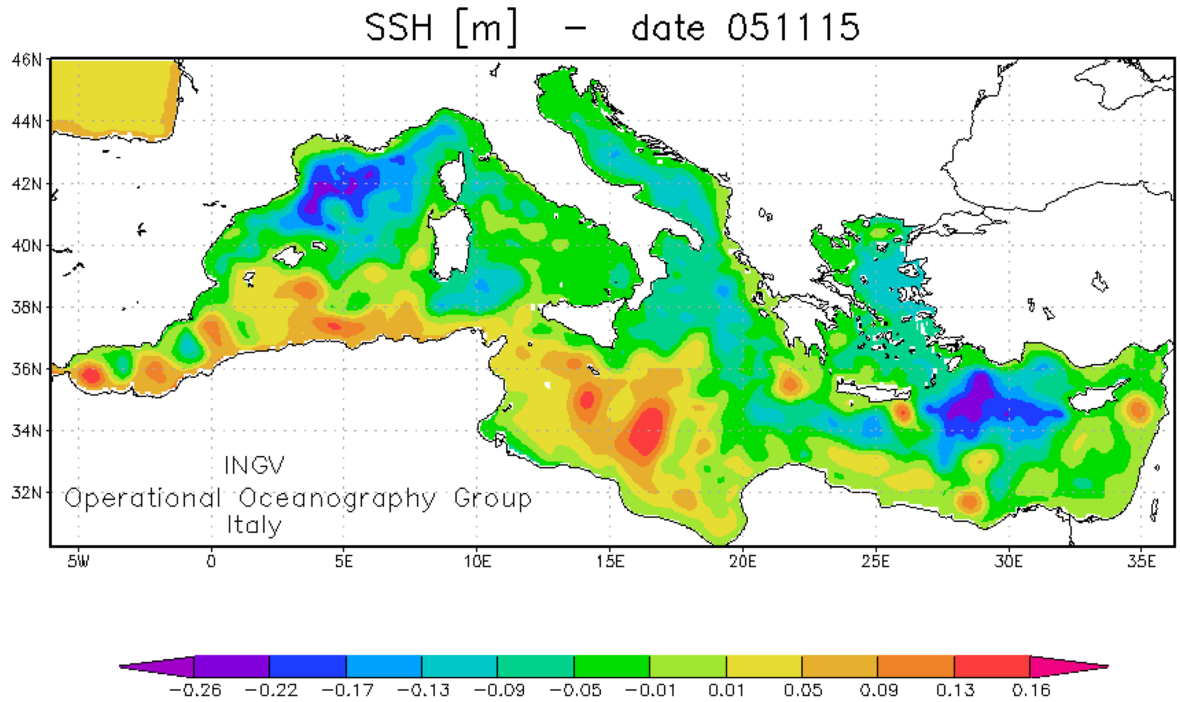


Figure 33. Sea surface height as a nowcast product of the MFSTEP numerical model showing the main circulation features in the whole Mediterranean Sea on 5 November 2005.

7. Conclusions

The EGITTO-1 oceanographic campaign which took place between 11 and 18 November 2005 onboard R/V OGS-EXPLORA is a perfect example of valorization of a transit of a research vessel. In a little more than 6 days, oceanographic operations were conducted very successfully to sample effectively salient circulation features in the Ionian and Levantine sub-basins. A total of 15 surface drifters and 5 Argo profilers were deployed, more than hundred XBT probes were launched and the ship underway automatic systems (meteorological sensors, thermosalinomer and ADCP) were operated continuously. The ship track and sampling strategy were defined using satellite images and simulations of numerical models sent to the ship in near-real time. The data collected as part of the EGITTO-1 cruise will contribute significantly to advance knowledge on the circulation in the southeastern Mediterranean Sea.

8. Acknowledgments

The drifters deployed during the EGITTO-1 oceanographic cruise were financed by the Office of Naval Research (ONR) as part of the EGITTO project (award # N000140510281). Out of the five Argo profilers deployed, two floats were part of the MFS/MEDARGO program funded by the European Commission under contract number EVK3-CT-2002-00075 and three PROVOR floats were provided to the French EGYPT project by the Groupe Mission MERCATOR CORIOLIS (GMMC). The EGYPT project is funded by CNRS/INSU, GMMC, PATOM and the Region Provence - Alpes - Cote d'Azur. The ship time for R/V OGS-EXPLORA was kindly provided by OGS. Thank you to R. Ramella, RIMA Director, and A. Crise, OGA Director, for supporting this activity. The help of G. Constantini and E. Mauri was greatly appreciated to resolve numerous logistic problems. We thank Captain Lo Presti, E. Gordini, C. Pelos, C. D'Amicantonio and the crew of OGS-EXPLORA for their excellent and enthusiastic cooperation during the campaign. Thanks are also extended to G. Rougier (LOB) and J.-L. Fuda (COM) for their assistance.

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