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Performance Evaluation of Marlin-Yug Drifting Buoys Deployed by INCOIS in the Indian Ocean During 2021-24

By

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Abstract

Thirty satellite-tracked surface drifters from Marlin-Yug were deployed across the North Indian Ocean to monitor sea surface temperature (SST) and atmospheric Pressure as a contribution to the Global Drifting Buoy Programme (GDP). In this report, the overall performance and the SST and barometric pressure measurements from these drifters were evaluated to assess sensor and system performance and data quality, which provides critical guidance for future procurement decisions, operational planning, and improvement of observational strategies. Of the 30 surface drifters deployed, 12 failed in the open ocean, while the remaining units either beached or were vandalized by fishermen. Among the 12 drifters that failed in the open ocean, no evidence of water intrusion or battery failure was observed, suggesting that system malfunction may not have been the primary cause. Based on the returned data, the quality of data was greater than 98.5% for all drifters, and in 27 cases, it exceeded 99.5%. Due to the scarcity of concurrent *in-situ* observations along the drifter tracks, satellite-based OISST and reanalysis data from ERA5 were used to evaluate the drifter measurements. These external datasets were first validated against available *in-situ* observations to establish a baseline accuracy. A comparison between SST from drifters and satellite observations revealed strong agreement, with correlation coefficients typically exceeding 0.9 and root mean square difference (RMSD) in the range of 0.1-0.3°C. Similarly, the comparison of barometric pressure measurements from the Drifter with ERA5 provides a correlation of magnitude 0.99 and RMSD of 1 hPa. These analyses suggest that the drifter measurements are within acceptable limits.

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Table of Abbreviations

GDP	Global Drifting Buoy Programme
GOOS	Global Ocean Observing System
SVP	Surface Velocity Program
SST	Sea Surface Temperature
GTS	Global Telecommunication System
OEM	Original Equipment Manufacturer
GPS	Global Positioning System
QC	Quality Control
STO	Stopped transmitting data in the open Ocean
REMSS	Remote Sensing Systems
MW_IR OI SST	Microwave and Infrared Optimally Interpolated SST
MSLP	Mean Sea Level Pressure
RAMA	Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
RMSD	Root Mean Square Difference

TMI SST	Tropical Rainfall Measuring Mission (TRMM) Microwave Imagers (TMI) SST

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1. Introduction

The Global Drifting Buoy Programme (GDP), a key component of the Global Ocean Observing System (GOOS), is a multinational collaborative initiative designed to maintain a global Surface Velocity Program (SVP) drifting buoys (defined as Drifter in the rest of the manuscript). The network is designed with a target of maintaining at least one buoy in every 5°x5° grid over the open ocean to collect vital environmental data [*Beal et al.,* 2020]. These buoys measure key parameters such as sea surface temperature (SST) and atmospheric Pressure, and their precise satellite-tracked positions allow us to derive ocean surface boundary layer currents [*Laurindo et al.,* 2017; *Lumpkin et al.,* 2017]. The measurements from this buoy have vital scientific and operational benefits, such as enhancing our understanding of ocean and atmospheric interactions, supporting climate research, tropical cyclone and monsoon prediction, and calibration and validation of satellite-derived products. Most importantly, these observations also serve as essential data sources for the assimilation of numerical weather prediction models used for seasonal and extended-range predictions.

As a contribution to GDP, the Indian National Centre for Ocean Information Services (INCOIS), under the Ministry of Earth Sciences (MoES) is responsible for the deployment of 30 drifters annually. As part of the annual procurement plan, INCOIS placed the order for the procurement of 30 drifters in March 2021 to M/s. Marlin-Yug and received drifters in August 2021. INCOIS started the deployment of drifters in January 2022 and completed the deployment by 2024. During the initial period, the travel restrictions imposed due to COVID-19 related protocol significantly hampered the deployment plan of these floats.

This report presents the evaluation of SST and Sea Level Pressure measurements from these drifters. In addition, the report assesses the overall performance of the drifters, including an analysis of their trajectories and battery life. Section 2 describes the data sources and methodology employed in this study. Section 3 presents the results and discussion, followed by a summary in Section 4.

2. Data and Methods

2.1. SVP-B/40H Marlin-Yug Drifter buoy

The data from the Marlin-Yug drifting buoys model SVP-B/40H is evaluated in the report. Each Drifter is equipped with a SST sensor and a barometric pressure sensor (Figure 1). The surface buoy is made of polycarbonate plastic with a diameter of 38 cm, and it houses a battery pack composed of D-size alkaline cells. The Drifter is typically activated by removing a magnet from the float hull, though a self-activating option is also available. The data collected by the Drifter was communicated to INCOIS and the Global Telecommunication System (GTS) through the Argos satellite telemetry system. Prior to deployment, all the sensors and drifters successfully passed the Factory Acceptance Tests conducted at the Original Equipment Manufacturer (OEM) premises. Additionally, after being received at INCOIS, the drifters underwent satellite communication tests to verify their performance. Preliminary analysis indicates that the intercomparison of measurements from the drifters shows reasonable agreement and fell within acceptable ranges.

A stainless steel wire rope with a 0.5 cm outer diameter, encased in plastic, connects the surface float to the Holey Sock drogue. The drogue is constructed using Cordura nylon fabric. The height and diameter of the drogue are 7.5 meters and 0.65 m, respectively, and it is centered at a depth of 15 meters below the sea surface to facilitate drifters to follow mixed layer currents. The movement of a drifter is governed by the combined effects of wind and ocean currents. When a drogue is attached, the drifter primarily follows the ocean's mixed layer currents. In contrast, undrogued drifters are more susceptible to wind forcing, which can lead to biased estimates of ocean surface currents.

The Drifter is also equipped with a submergence sensor, and it is used to detect the presence or absence of the drogue. A sudden decrease in the percentage of submergence time is indicative of drogue loss. Using Global Positioning System (GPS)/GLObalnaya NAvigatsionnaya Sputnikovaya Sistema (GLONASS) positioning system and Argos Doppler capability, the buoy provides high-accuracy location data.

The thermistor is mounted at the base of the drifter surface buoys and measures sub-skin SST at 18 cm water depth. The SST sensor is strategically positioned to minimize radiative heating effects. The buoy measures atmospheric Pressure using a barometer equipped at the top of the surface buoy, and it is protected with a specially designed self-draining port. The accuracy, resolution, and range of SST and atmospheric pressure measurements from the buoy are summarized in Table 1.

The drifter dataset underwent a series of quality control (QC) procedures, including GPS correction, spike detection and removal, and range test to ensure the reliability and accuracy of the measurements. GPS correction involved filtering out data points where the difference in latitude or longitude between consecutive samples exceeded 1 degree, which is considered physically implausible for drifter movement over short intervals. Spike detection and removal were carried out through visual inspection, allowing the identification and exclusion of abrupt, non-physical variations in the data. A range test was applied to both SST and atmospheric Pressure, with acceptable limits set between -5°C and 35.88°C for SST, and

850 to 1054.7 hPa for atmospheric Pressure (Table 1). The values outside these ranges were excluded. A specific sensor behavior observed in some buoys, where SST values jump directly from the upper limit (35.88°C) to the lower limit (−5°C), indicates that when an SST measurement reaches the upper threshold, such data are discarded from the analysis. These QC measures ensured that only high-quality, physically consistent data were used in subsequent analyses, including trajectory evaluation, sensor validation, and performance assessments.

The drifters in the dataset were classified as beached, retrieved by fishermen, and stopped transmitting data in the open ocean (STO). Beached drifters were identified based on their trajectories, where movement ceased near coastlines. Drifters that stopped transmitting in the open ocean were identified by examining the continuity of data; an abrupt termination in otherwise consistent transmissions was used to categorize them in this group. Drifters vandalized by fishermen were detected by calculating the drift speed, such as, the distance between successive positions was computed using the Haversine formula and divided by the time interval to obtain the speed [*Shijo et al.,* 2014]. Following the drifting buoys' quality control manual, a sustained and sudden increase in drift speed exceeding 3m s^{-1} was taken as an indicator of retrieval by fishermen. These classifications help to improve the interpretation and quality of the drifter dataset by distinguishing natural drifter behavior from external influences or premature data loss.

2.2. Satellite and Reanalysis data

Concurrent measurement of *in-situ* measurements along the drifter track is very scarce. Hence, we used satellite-based products and reanalysis data to evaluate the performance of SST and atmospheric pressure measurements from the Drifter, respectively. We used the optimally interpolated (OI) Remote Sensing Systems (REMSS) Version 5 SST product, derived from multi-mission microwave and infrared (MW_IR) satellite sensors with a spatial resolution of 0.09° and a daily temporal resolution, to evaluate the SST observations from the drifting buoy [*Gentemann et al.,* 2003]. The Microwave and Infrared Optimally Interpolated SST (MW_IR OI SST) product merges the cloud-penetrating capability of microwave data with the high spatial resolution and nearshore sensitivity of infrared SST data. During the daytime, solar heating can lead to the formation of a diurnal warm layer at the ocean surface, particularly under low wind and high insolation regimes [*Price et al.,* 1986]. Satellite-based SST measurements during the daytime are influenced by the diurnal warm layer effect. To ensure consistency between daytime and nighttime SST observations, this effect was removed from the daytime measurements using a simple empirical relationship based on wind speed, solar insolation, and the local time of the satellite overpass [*Gentemann et al.,* 2003].

We used hourly Mean Sea Level Pressure (MSLP) data from the European Centre for Medium-Range Weather Forecasts Reanalysis Version 5 (ERA5) reanalysis, with a spatial resolution of 0.25°, to evaluate the Drifter's barometric pressure measurements [*Hersbach et al.,* 2020]. Since satellite-derived SST and ERA5 data are not *in-situ* measurements, their quality was evaluated by comparing them against *in-situ* observations from the Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) buoys [*McPhaden et al.,* 2009]. The temperature measurements at 1m depth of RAMA are nominally considered as SST. For SST, comparisons were made at three representative locations: the Arabian Sea (8°N, 67°E), the Bay of Bengal (15°N, 90°E), and the Equatorial Indian Ocean (0°N, 67°E). For barometric Pressure, validation was conducted at different RAMA sites: the Arabian Sea (15°N, 65°E), the Bay of Bengal (15°N, 90°E), and the Equatorial Indian Ocean (0°N, 80.5°E). For that purpose, we used SST measurements at 1m depth and barometric pressure measurements at 3 meters above the sea surface with daily and hourly temporal resolution, respectively. It is found that satellite SST showed a good agreement with the measurements from the RAMA mooring with a correlation of 0.9 and RMSD of magnitude 0.4°C (Table 2). Similarly, the comparison of ERA5 atmospheric pressure data shows a good agreement with the measurements from the RAMA mooring with a correlation of 0.9, and RMSD ranges from 0.4 to 0.5 hPa (Table 2). These characteristics provide us with the confidence to use MW_IR OI SST and ERA5 atmospheric pressure data to evaluate drifter performance.

3. Results and discussion

3.1 Assessment of Drifter Data Availability and Operational Status

A total of 30 drifters were deployed in the North Indian Ocean, with 12 in the Arabian Sea and 18 in the Bay of Bengal (Figure 2). Among these, six drifters failed shortly after deployment. Subsequently, M/s. Marlin-Yug has provided a replacement for these six failed buoys, which were deployed in the Arabian Sea and the Bay of Bengal. Note that of these six re-deployed buoys, data collected after the re-deployment were only considered for the analysis.

The drifter trajectories cover a broad spatial extent of the Indian Ocean, including the Arabian Sea, Bay of Bengal, Equatorial Indian Ocean, and the eastern Indian Ocean near the Maritime Continent (Figure 2). To enhance readability, each Drifter's trajectory is displayed individually.

Of the deployed drifters, eight were beached, ten were retrieved by fishermen, and twelve ceased data transmission due to unknown reasons in the open ocean. Although the average drifter lifetime is approximately 450 days [*Lumpkin et al., 2012*], the duration of quality data recorded in this study ranged from 5 to 316 days (Figure 3). While one unit failed prematurely within 5 days, the majority remained operational for more than two months, with 7 units exceeding 200 active days (Table 3 and Figure 3). The average life cycle of 12 drifters categorized as STO was generally strong, with four units recorded more than 100 active days, demonstrating stable performance over extended periods. These drifters also maintained a high percentage of good-quality data, indicating effective operation and reliable data transmission until the communication loss.

Each Drifter in the array is programmed to transmit 24 samples per day, corresponding to an expected data return rate of 100%. However, due to various operational and environmental factors such as satellite communication gaps, the actual number of transmitted data points per day often falls short of this ideal rate. The percentage of data returned from individual drifters is calculated as the ratio of the number of actual data samples received to the number of expected data samples (based on one-hour temporal resolution) (Figure 4). The analysis indicates that more than 75% of cases returned more than 50% of data, 25% of cases returned more than 55% of data, and in a few instances, it was reduced to 30% (Figure 4). This might be due to the poor repeatability of the Argos satellite.

Figure 3 illustrates the percentage of good SST and barometric pressure measurements available from each Drifter. It is apparent from Figure 4 that after applying the quality control procedure, there is an insignificant data loss from the Drifter based on the recorded data. Notably, 27 of the 30 drifters returned more than 99.5% data based on the recorded data, while the remaining three buoys provided more than 98.5% data. These characteristics demonstrate the ability of these drifters to provide good quality measurements during their life cycle. Overall performance of the SST and barometric Pressure from these drifters were summarized in the subsequent section.

3.2 Evaluation of Sea surface temperature and Atmospheric Pressure

Due to the lack of high temporal resolution in-situ observations along drifter trajectories during their operational period, MW_IR SST data and ERA5 pressure data were used, to evaluate the performance of SST and barometric pressure measurements from the drifters, respectively. The quality of MW_IR SST and ERA5 MSLP data was evaluated against RAMA buoy SST and MSLP measurements in the Arabian Sea, Bay of Bengal, and Equatorial Indian Ocean. For that purpose, we used daily averaged SST data and hourly MSLP data from MW_IR SST and ERA5, respectively. The correlation values for SST are 0.96, 0.97, and 0.95, respectively, with RMSD values ranging from 0.24 to 0.32 °C (Figure 5). These results are consistent with previous findings by *Senan et al.* [2001], who reported a correlation of approximately 0.94 and an RMSD of ~0.4 °C between Tropical Rainfall Measuring Mission (TRMM) Microwave Imagers (TMI) SST and buoy observations, thereby reinforcing the reliability of MW_IR SST for scientific applications. The analysis of barometric Pressure also showed excellent agreement, with correlation coefficients of 0.999, 0.998, and 0.993, and

RMSD values ranging from 0.45 to 0.58 hPa (Table 2 and Figure 6). These statistics confirm the high quality of ERA5 MSLP data and support their suitability for scientific analysis.

The statistical comparison includes standard deviation, correlation, and RMSD between daily averaged drifter SST data and satellite SST measurements. The correlation coefficients of SST measurements are generally high (around 0.9) for most of the drifters, indicating good agreement between the satellite datasets (Figure 7). However, two drifters show notably lower correlations, such as drifter ID 220831 exhibits a negative correlation, while drifter ID 220832 shows a low positive correlation (Figure 7). Despite the negative correlation for 220831, visual inspection suggests reasonable agreement between these two datasets with an SST difference of magnitude of 0.1°C. These characteristics suggest that the poor correlation likely results from the short duration of data spanning only 5 days (Figure 18). The nighttime SST values from the drifters also show strong correlations with satellite SST, comparable to those observed during daytime measurements. The RMSD values for the drifters range between 0.1 and 0.35 °C, which is within acceptable limits. The standard deviation values for both drifter and satellite SSTs are also consistent.

The correlation and RMSD values between Drifter and satellite SST closely match those between satellite and RAMA buoy SST. This characteristic indicates that the drifters provided high-quality SST measurements.

ERA5 MSLP data shows excellent agreement with the drifter barometric pressure measurements, with correlation coefficients consistently above 0.95 for all drifters and approaching 1.0 in most cases (Figure 8). The RMSD values generally range between 0.9 and 1.4 hPa, indicating a good level of accuracy in the reanalysis data. The standard deviation comparison also reveals that the ERA5 data closely follows the variability observed in the drifter measurements, with both datasets showing similar magnitudes across different drifters. Although the RMSD between ERA5 and RAMA buoy pressure measurements differs from that between ERA5 and drifter data, the drifter barometric pressure sensors have a reported accuracy of ±1 hPa (Table 1), which falls within acceptable performance limits.

3.3 Air-sea interaction processes captured by Drifter

Figure 9 - Figure 38 (b-d) shows the comparison between Drifter SST and MW_IR SST for each deployed Drifter. One particular buoy (ID: 220844, Figure 31) was initially deployed in the Arabian Sea; however, it was later found to have shifted to the Bay of Bengal. This relocation was likely due to it being retrieved by fishermen and subsequently redeployed in the Bay of Bengal. Despite this unexpected relocation, the buoy continued to transmit high-quality data, confirming the robustness of its sensors. The springtime warming from March to May was consistently captured by all drifters. Additionally, the drifter trajectories appear to follow the prevailing circulation patterns in the Bay of Bengal. For instance, several drifters exhibited movement consistent with the East India Coastal Current during the pre-monsoon period (Figure 15a) and post-monsoon period (Figures 24a, 27a, and 32a). One Drifter also followed the typical winter monsoon current pattern (Figure 38a), further demonstrating the Drifter's ability to reflect seasonal ocean circulation features.

Notably, during May 2023, the drifter observations recorded a significant cooling event associated with the passage of Tropical Cyclone Mocha over Bay of Bengal (Figure 26, 28, 35, 37). A sharp drop in SST exceeding 3°C and Pressure exceeding 15 hPa was observed for two drifters (IDs: 220841, 220848 and 220850; figure 28(b-d), 35(b-d) and 37 (b-d)) which were located in close proximity (within 80 km) to the cyclone's path. Additionally, a smaller pressure (5hpa) decrease is observed during Tropical Cyclone Sitrang in October 2022 over the Bay of Bengal (Figure 26, 27, 28, 30, 32, 34). Two drifters (IDs: 220839 and 220843; Figures 26 (e-g) and 30 (e-g)) near the cyclone's track recorded a pressure decrease of approximately 8hPa. These observations highlight the Drifter's capability to effectively capture ocean-atmosphere interactions and the oceanic response to intense tropical cyclones.

4. Summary

Thirty drifters developed by Marlin-Yug were deployed in the North Indian Ocean. Of these, six drifters failed immediately after deployment and were redeployed subsequently.

Based on recorded data, most drifters returned more than 99.5% of the transmitted data. However, when compared to the expected data return (based on one-hour temporal resolution), over 75% of the drifters returned more than 50% of the expected data, with only a few exceptions. The SST and atmospheric pressure measurements from drifters were evaluated against satellite and reanalysis products. The quality of these reference datasets was assessed using RAMA buoy observations, revealing high correlation and low RMSD values, confirming their reliability. Similarly, most drifters showed strong agreement with satellite and reanalysis data, with correlation and RMSD values comparable to those observed between RAMA buoys and reanalysis datasets. The drifters effectively captured the springtime warming and clearly recorded temperature and pressure drops associated with the passage of Tropical Cyclone Mocha during May 2023 over Bay of Bengal. Additionally, the drifter trajectories aligned well with known ocean circulation patterns, such as the East India Coastal Current during the pre- and post-monsoon periods. Overall, the Marlin-Yug drifters demonstrated reliable performance in accurately measuring both SST and atmospheric Pressure. Of the deployed drifters, approximately 10 appeared to have been vandalized by fishermen. To maintain the drifter network in the Indian Ocean region, particularly in coastal areas, it is recommended that greater awareness be created among coastal communities regarding the scientific value of these instruments. The quality-controlled data in NetCDF format is available with the INCOIS data management team and is available for analysis upon request. In addition, estimation of current velocity along the track of the Drifter is in progress and will be reported in the following technical report.

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Parameter	Range	Resolution	Accuracy
Barometric Pressure (hPa)	850 to 1054.7	0.1	±1
SST (°C)	-5 to 35.88	0.08	±0.1
Submergence (%)	0 to 100	100/63	-

Table 1. The accuracy, resolution, and range of SST, barometric Pressure, and submergence sensor from the SVP-B/40H drifters from Marlin-Yug.

	Correlation			RMSD		
	Arabian Sea	Bay of Bengal	Equatorial Indian Ocean	Arabian Sea	Bay of Bengal	Equatorial Indian Ocean
SST	0.96	0.97	0.95	0.25	0.32	0.24
MSLP	0.99	0.99	0.99	0.57	0.58	0.46

Table 2: Correlation and RMSD between the measurements from the RAMA and OISST (ERA5) for SST (barometric Pressure) in the Arabian Sea (SST: 8°N, 67°E; MSLP: 15°N, 65°E), Bay of Bengal (15°N, 90°E), and Equatorial Indian Ocean (SST: 0°N, 67°E; MSLP: 0°N, 80.5°E).

ARGOS ID (WMO ID)	Data transmission		No. of Active Days	Status of Drifter
	Start Date	End Date		
220822 (2302613)	15/02/2022	28/12/2022	316	Beached
220823 (2302614)	15/02/2022	17/09/2022	215	Fishermen retrieval
220824 (2302615)	15/02/2022	19/09/2022	217	Fishermen retrieval
220825 (2302616)	31/01/2024	16/03/2024	46	Fishermen retrieval
220826 (2302617)	01/02/2022	27/03/2022	55	STO
220827 (2302618)	31/01/2022	21/06/2022	142	Beached
220828 (2302619)	06/02/2022	26/03/2022	49	STO
220829 (2302620)	07/02/2022	14/03/2022	36	Fishermen retrieval
220830 (2302621)	30/01/2024	19/03/2024	50	Fishermen retrieval
220831 (2302622)	06/03/2022	11/03/2022	5	Fishermen retrieval
220832 (2302623)	30/01/2024	14/02/2024	15	STO
220833 (2302624)	11/03/2022	03/05/2022	53	STO
220834 (2302625)	11/03/2022	25/03/2022	15	Fishermen retrieval

220835 (2302626)	13/03/2022	21/07/2022	129	STO
220836 (2302627)	01/02/2024	25/03/2024	54	STO
220837 (2302628)	15/09/2022	26/10/2022	42	Beached
220838 (2302629)	12/09/2022	17/10/2022	33	STO
220839 (2302630)	12/09/2022	22/05/2023	253	STO
220840 (2302631)	11/09/2022	03/01/2023	114	Fishermen retrieval
220841 (2302632)	12/09/2022	26/06/2023	288	Beached
220842 (2302633)	09/09/2022	29/11/2022	82	Beached
220843 (2302634)	09/09/2022	18/12/2022	100	Beached
220844 (2302635)	31/01/2024	03/11/2024	161	Fishermen retrieval
220845 (2302636)	06/09/2022	15/02/2023	163	STO
220846 (2302637)	28/04/2024	06/06/2024	39	STO
220847 (2302638)	04/09/2022	10/12/2022	96	STO
220848 (2302639)	30/01/2023	26/11/2023	301	Beached
220849 (2302640)	01/02/2023	22/02/2023	22	Fishermen retrieval

220850 (2302641)	04/02/2023	09/11/2023	275	STO
220851 (2302642)	14/02/2023	15/03/2023	30	Beached

Table 3: The Argos ID (WMO ID), date of deployment, and date of last transmission date were considered based on the stop transmission, beaching, or fisherman vandalism of 30 drifters deployed over the Northern Indian Ocean.

Figures with caption

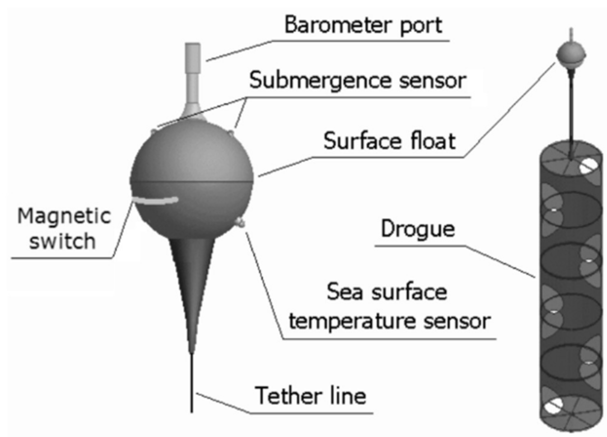

Figure 1. Schematic diagram of a drifter buoy.

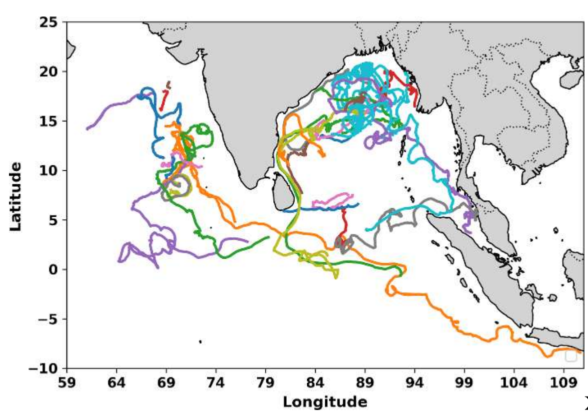

Figure 2. Tracks of 30 Marlin-Yug drifters SVP drifters deployed in the North Indian Ocean.

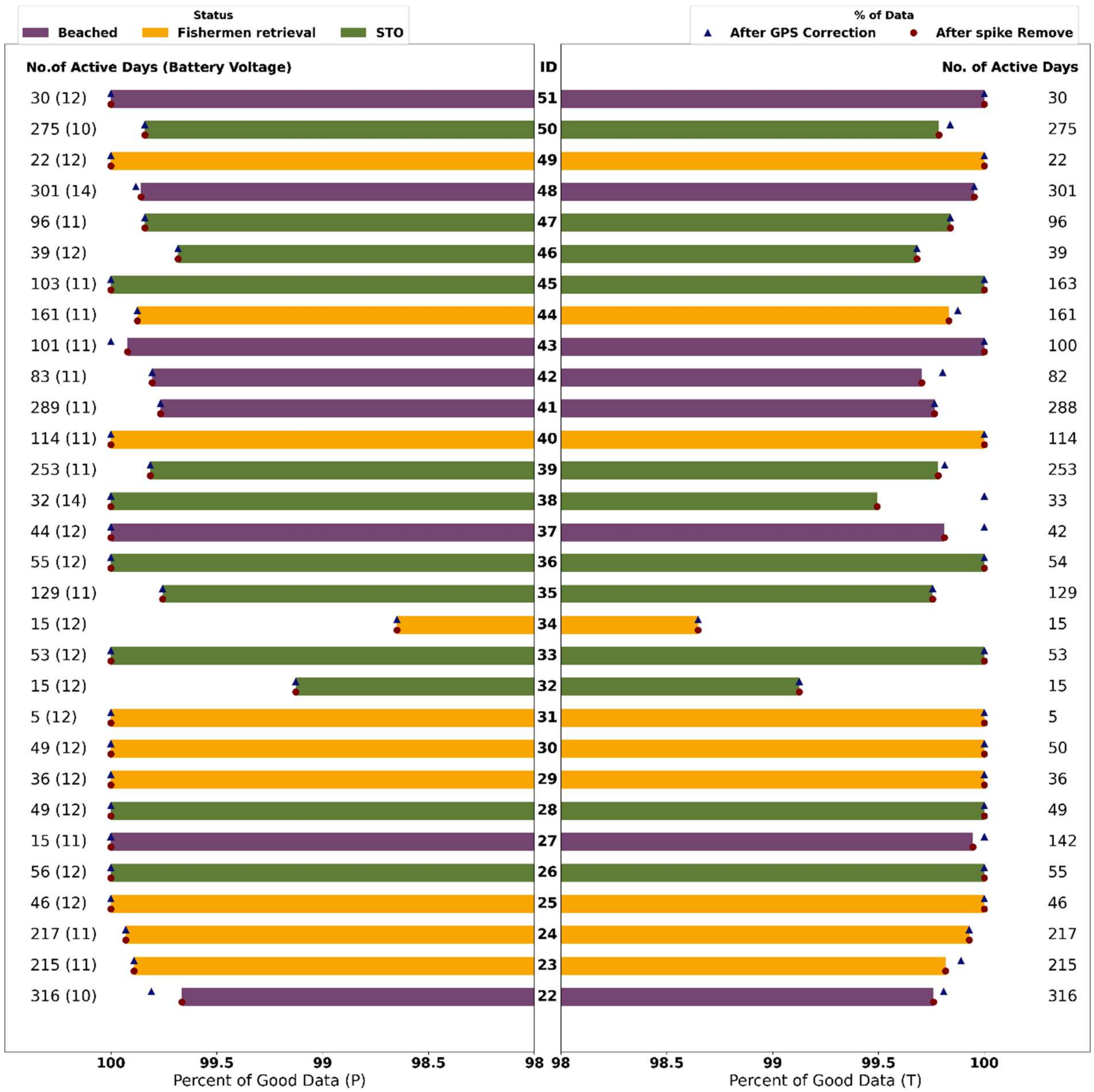

Figure 3. Data availability and status of drifters. The left side panel represents the barometric Pressure, and the right side panel represents SST. The drifter ID (last two digits of ARGOS ID of the Drifter) is presented between the left and right hand side panels. The number in the bracket on the y-axis of the left side panel indicates the battery voltage before the Drifter beached, vandalized by fishermen, or stopped transmitting data in the open ocean (STO). Numbers on the y-axis in the left side and right side panels represent the number of active days of drifters before they beached (purple), vandalized by fishermen (orange), or stopped transmitting data in the open ocean (green). The x-axis represents the percentage of good data return based on the recorded data, sequentially after applying GPS corrections (blue triangles), spike removal (red circles), and range test (the bar).

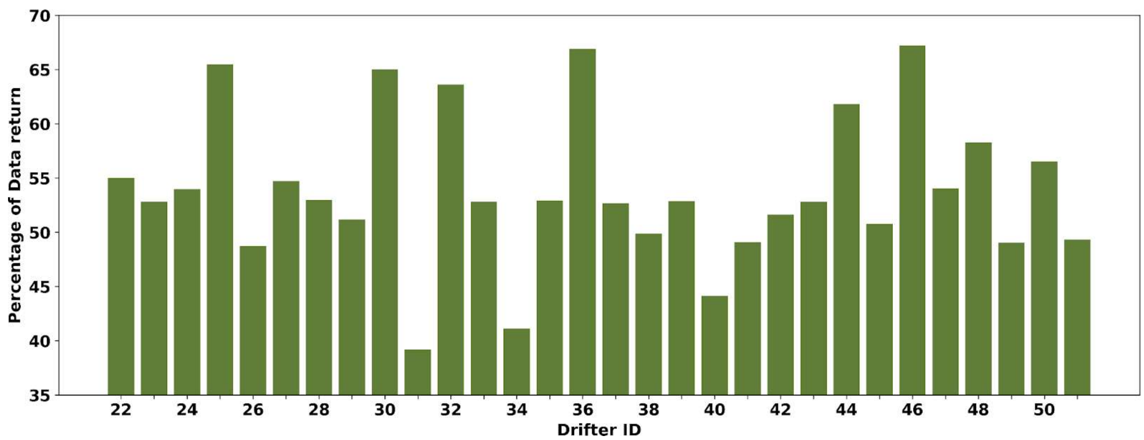

Figure 4. Percentage of data return (y-axis) from individual drifters (x-axis; last two digits of ARGOS ID of the Drifter is mentioned). The percentage is calculated as the ratio of the number of actual data samples received to the number of expected data samples (based on one-hour temporal resolution). For example, if a drifter operated for two days and returned 10 data samples, the data return percentage is calculated as $(10 / (24 \times 2)) \times 100$.

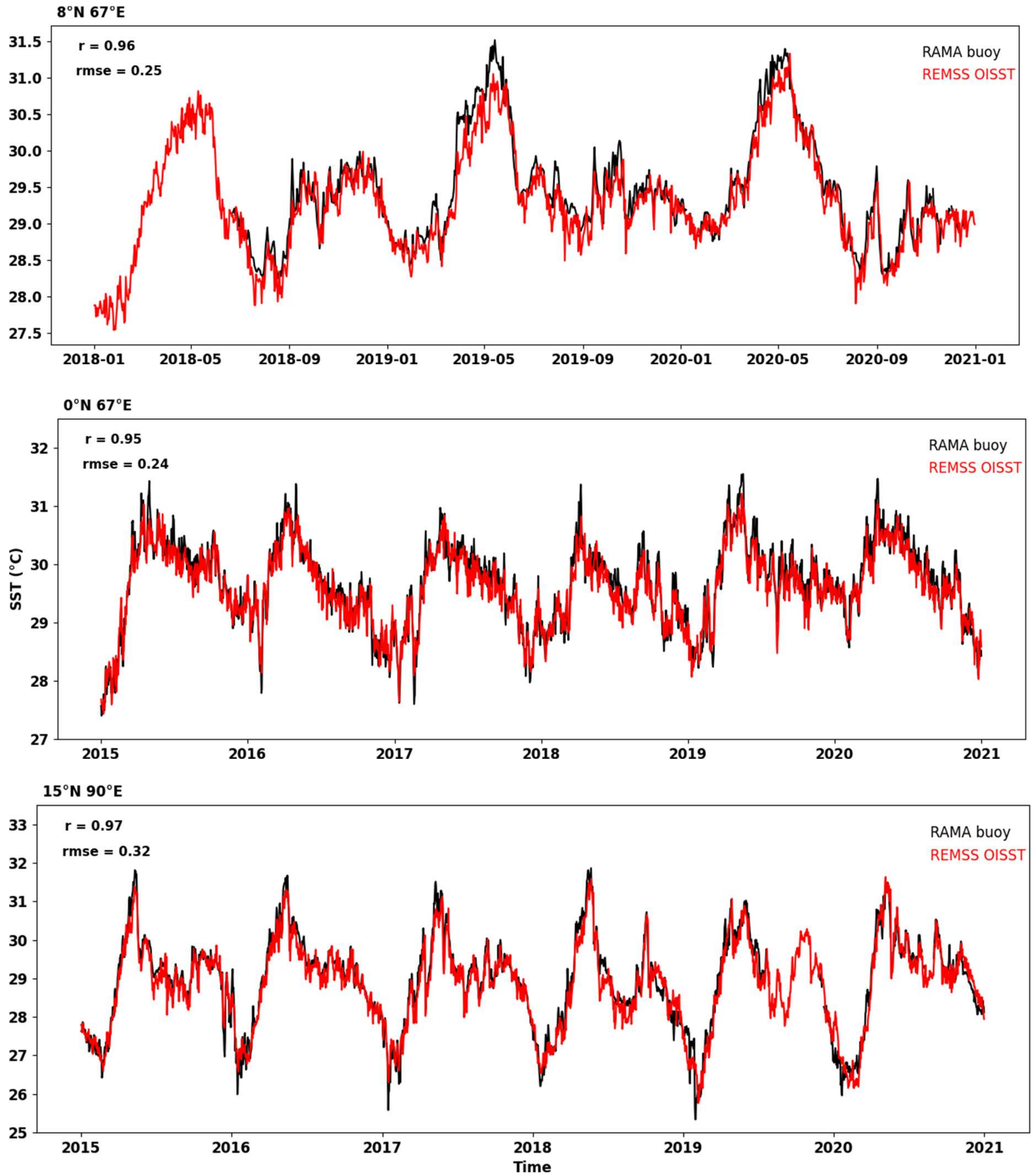

Figure 5. Comparison of daily averaged SST (°C) derived from satellite (red) and RAMA (black) buoy in the (upper panel) Arabian Sea (8°N, 67°E), (middle panel) Equatorial Indian Ocean (0°N, 67°E) and (bottom panel) Bay of Bengal (15°N, 90°E).

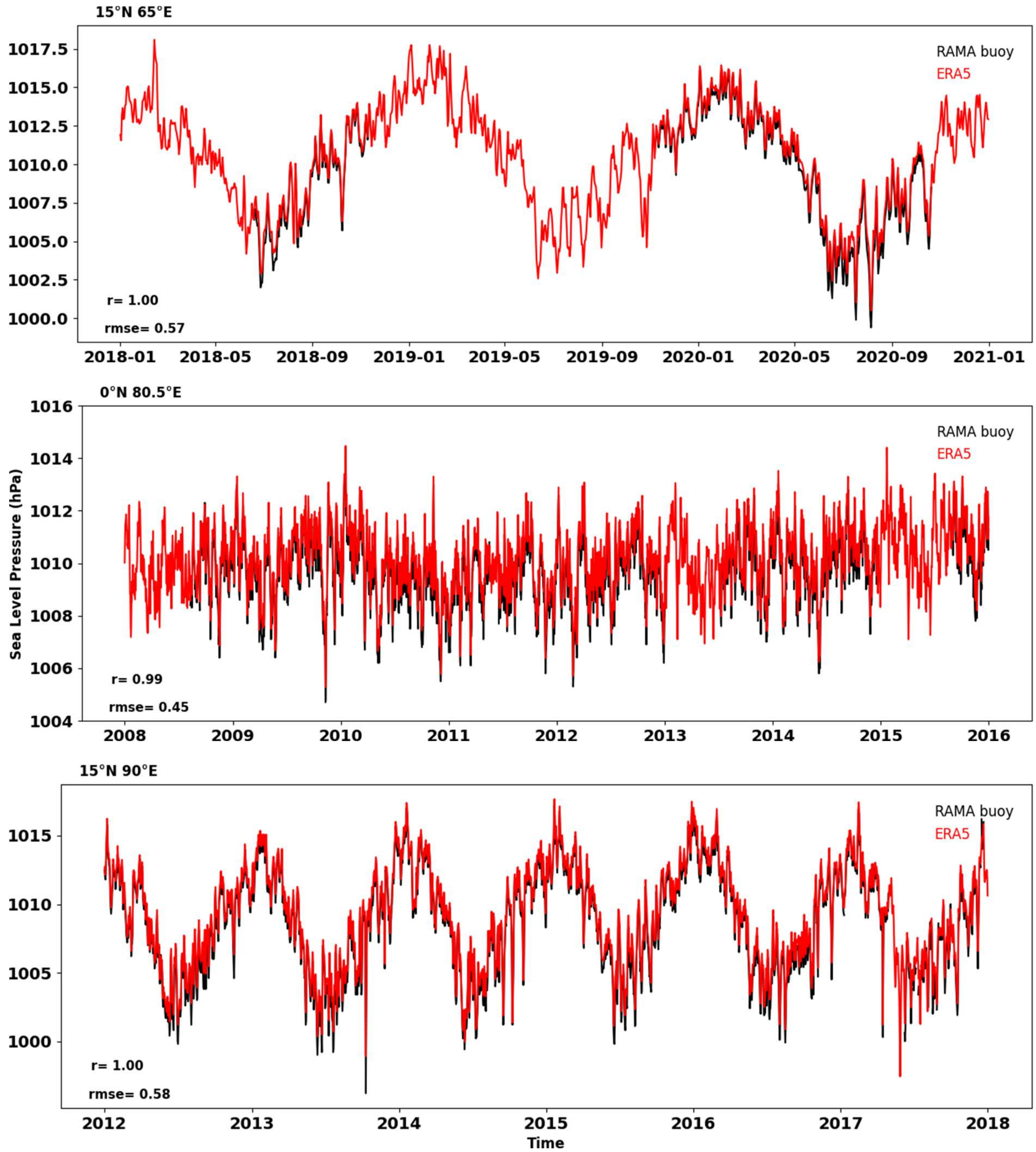

Figure 6. Comparison of daily averaged MSLP (hPa) from ERA5 (red) and RAMA (black) buoy in the (upper panel) Arabian Sea (15°N, 65°E), (middle panel) Equatorial Indian Ocean (0°N, 80.5°E) and (bottom panel) Bay of Bengal (15°N, 90°E).

Figure 7. (Upper panel) Correlation and (middle panel) RMSD between SST from Drifter (°C) and satellite. (bottom panel) Standard deviation of SST (°C) from Drifter and satellite.

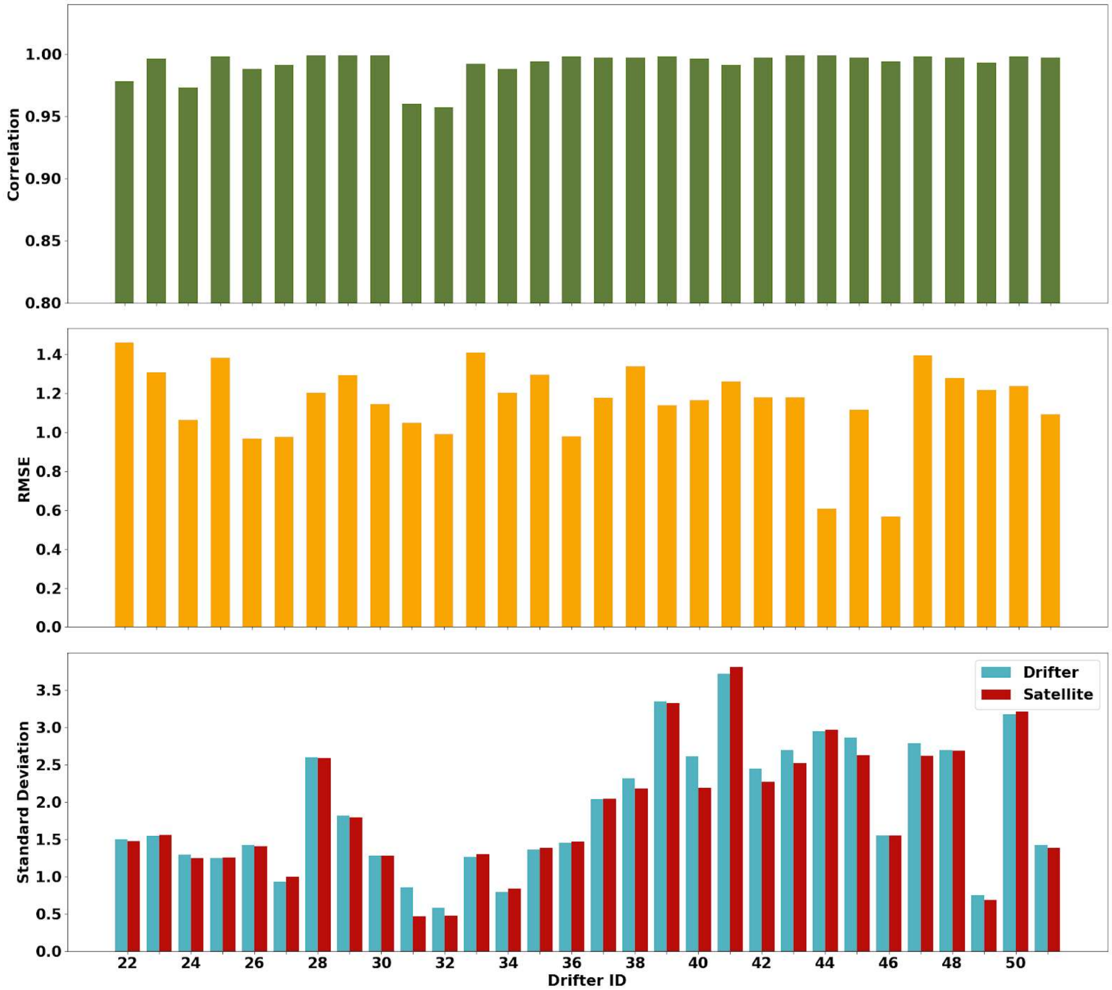

Figure 8. (upper panel) Correlation and (middle panel) RMSD between MSLP from Drifter (hPa) and ERA5. (bottom panel) Standard deviation of MSLP (hPa) from Drifter and ERA5.

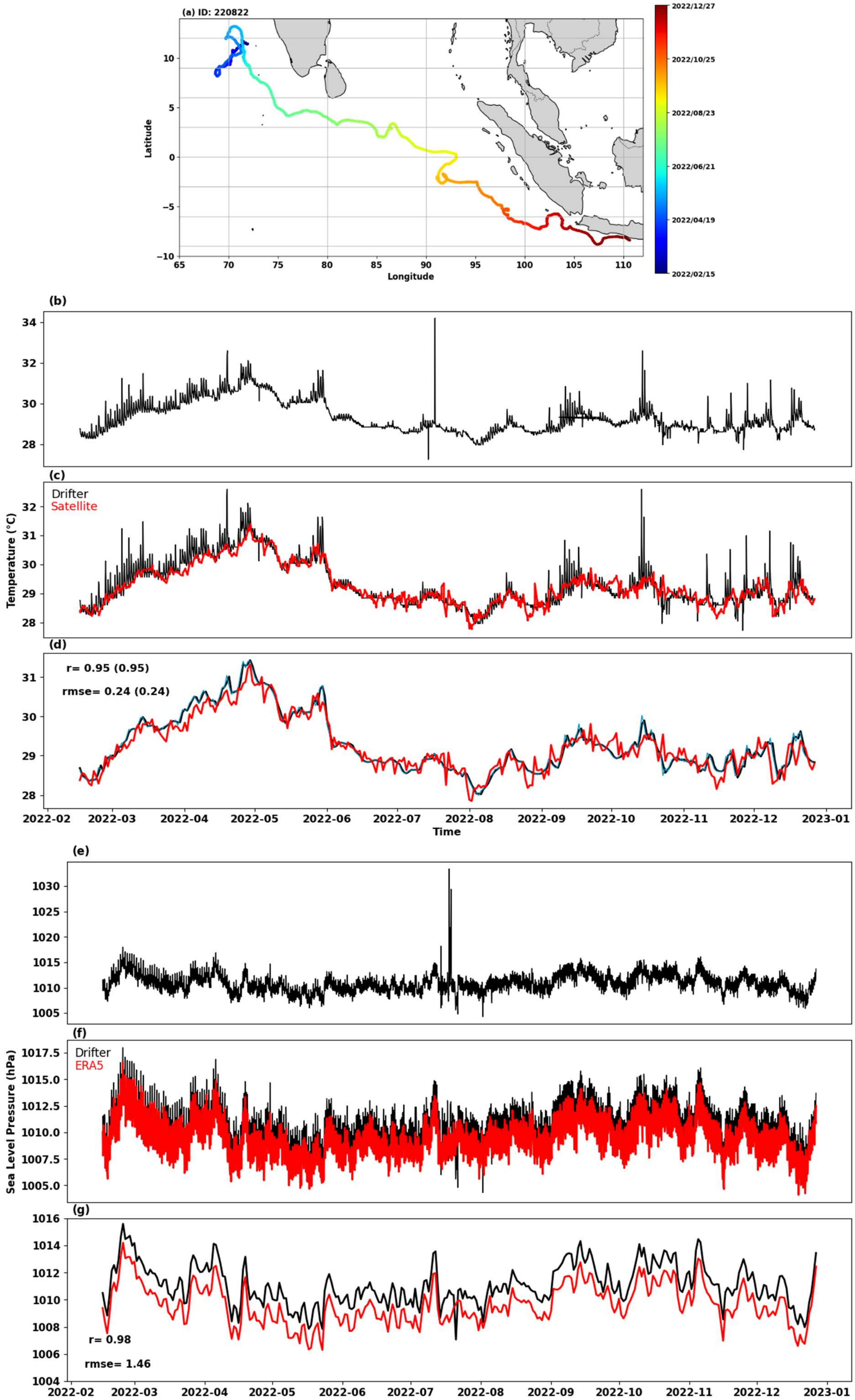
(a) ID: 220822
Latitude
Longitude
2022/12/27
2022/10/25
2022/08/23
2022/06/21
2022/04/19
2022/02/15
(b)
(c)
Drifter
Satellite
Temperature (°C)
(d)
r= 0.95 (0.95)
rmse= 0.24 (0.24)
Time
(e)
(f)
Drifter
ERA5
Sea Level Pressure (hPa)
(g)
r= 0.98
rmse= 1.46
Time

Figure 9. (a) Trajectory of the Drifter (ARGOS ID: 220822) and the color in the trajectory represents the date. Panel (b)-(d) represents SST (°C) and panels (e-f) represents barometric Pressure (hPa). (b) drifter SST data before filtering, (c) comparison of SST data from the Drifter after QC with satellite and (d) comparison of daily averaged SST from Drifter and satellite. In panel (d) thin blue line represents nighttime SST values from the Drifter. In panel (d) correlation and RMSD between daily averaged SST from Drifter and satellite is presented and values in parentheses indicate the correlation and RMSD between satellite SST and nighttime averaged values (averaged over 1800 IST 0600 IST) of SST from Drifter. (e) drifter barometric pressure before filtering, (f) comparison of barometric Pressure from Drifter after QC with reanalysis and (g) comparison of daily averaged barometric Pressure from Drifter and reanalysis.

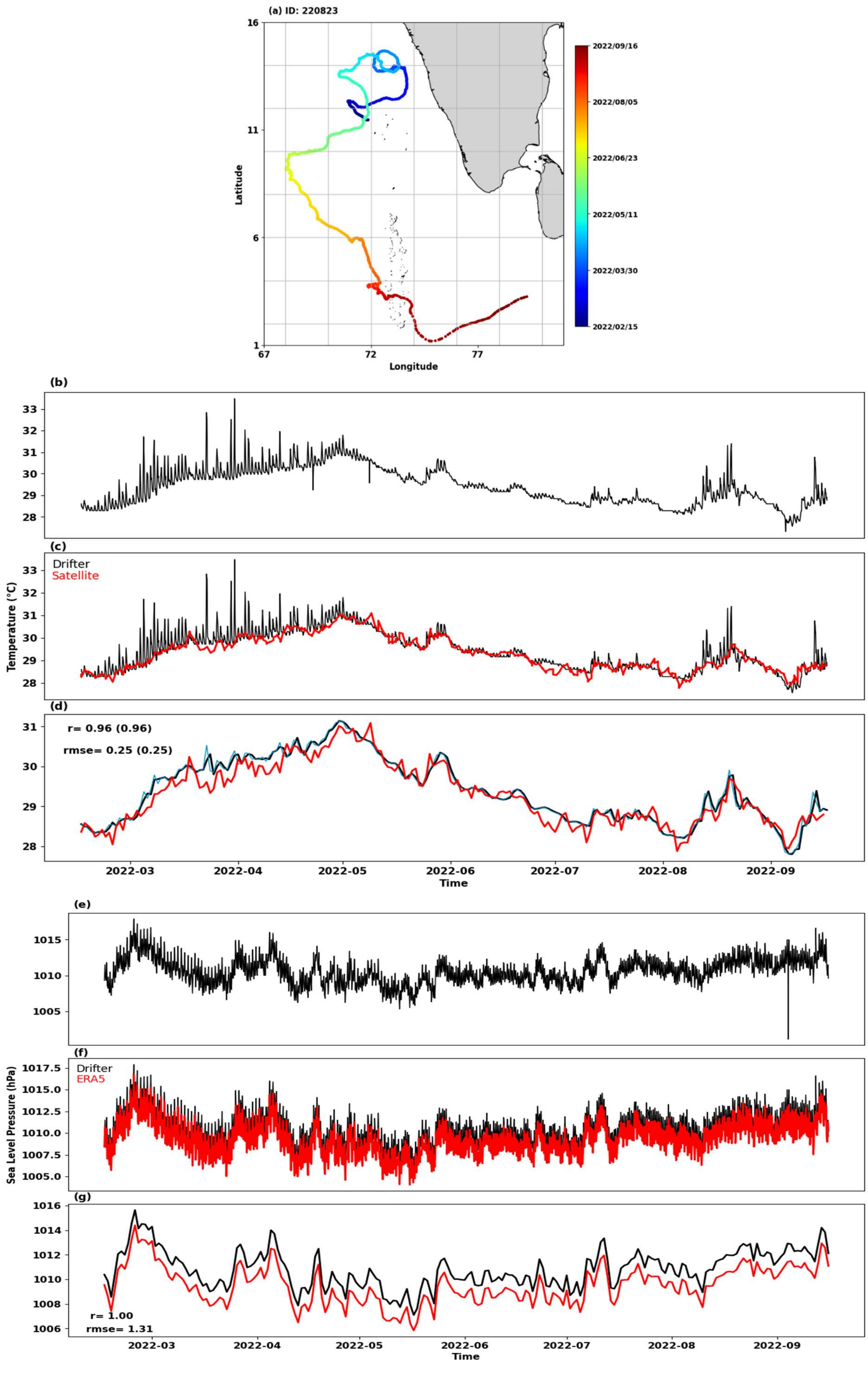

Figure 10. Same as Figure 8, but for drifter ID: 220823.

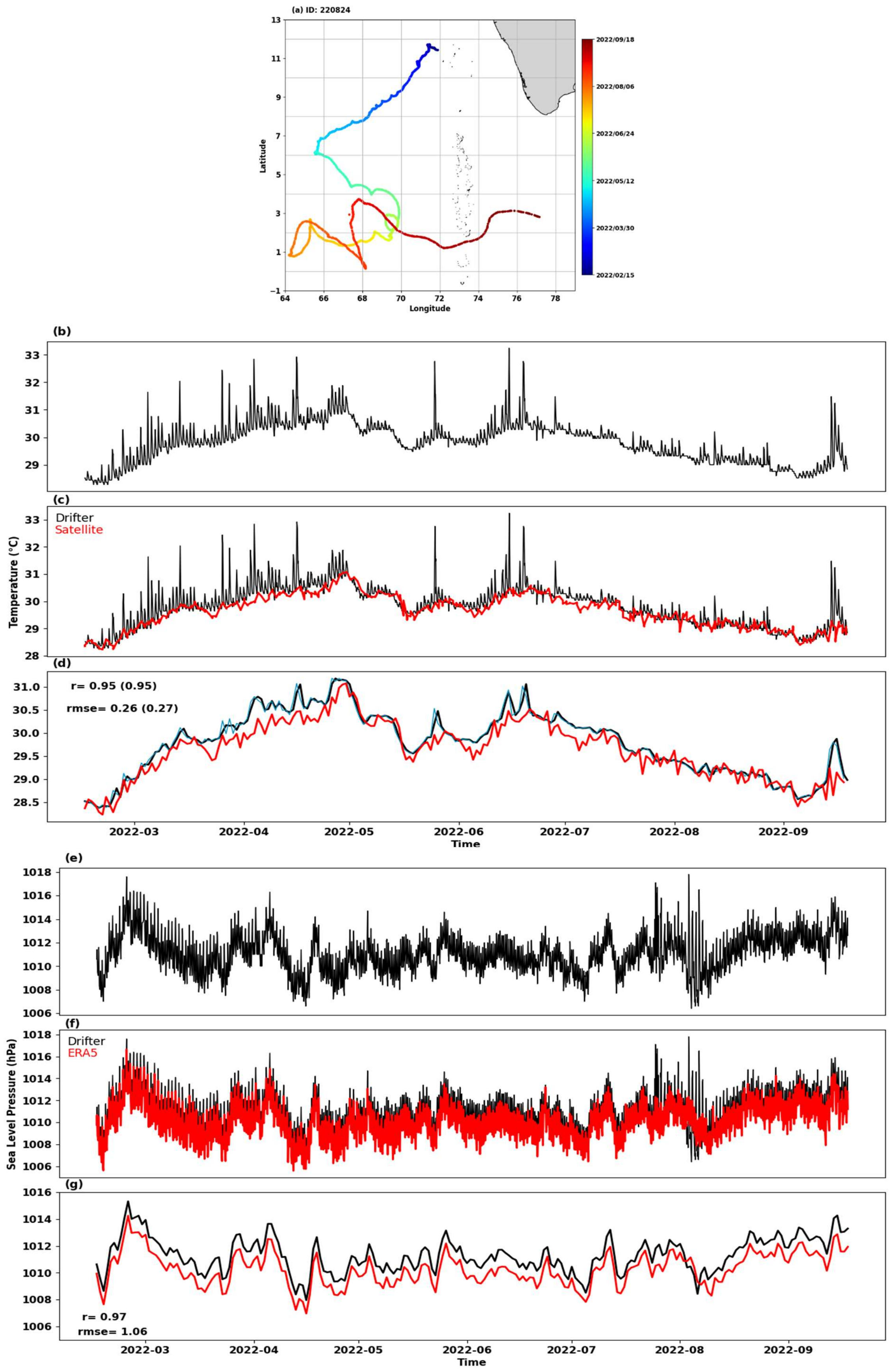

Figure 11. Same as Figure 8, but for drifter ID: 220824.

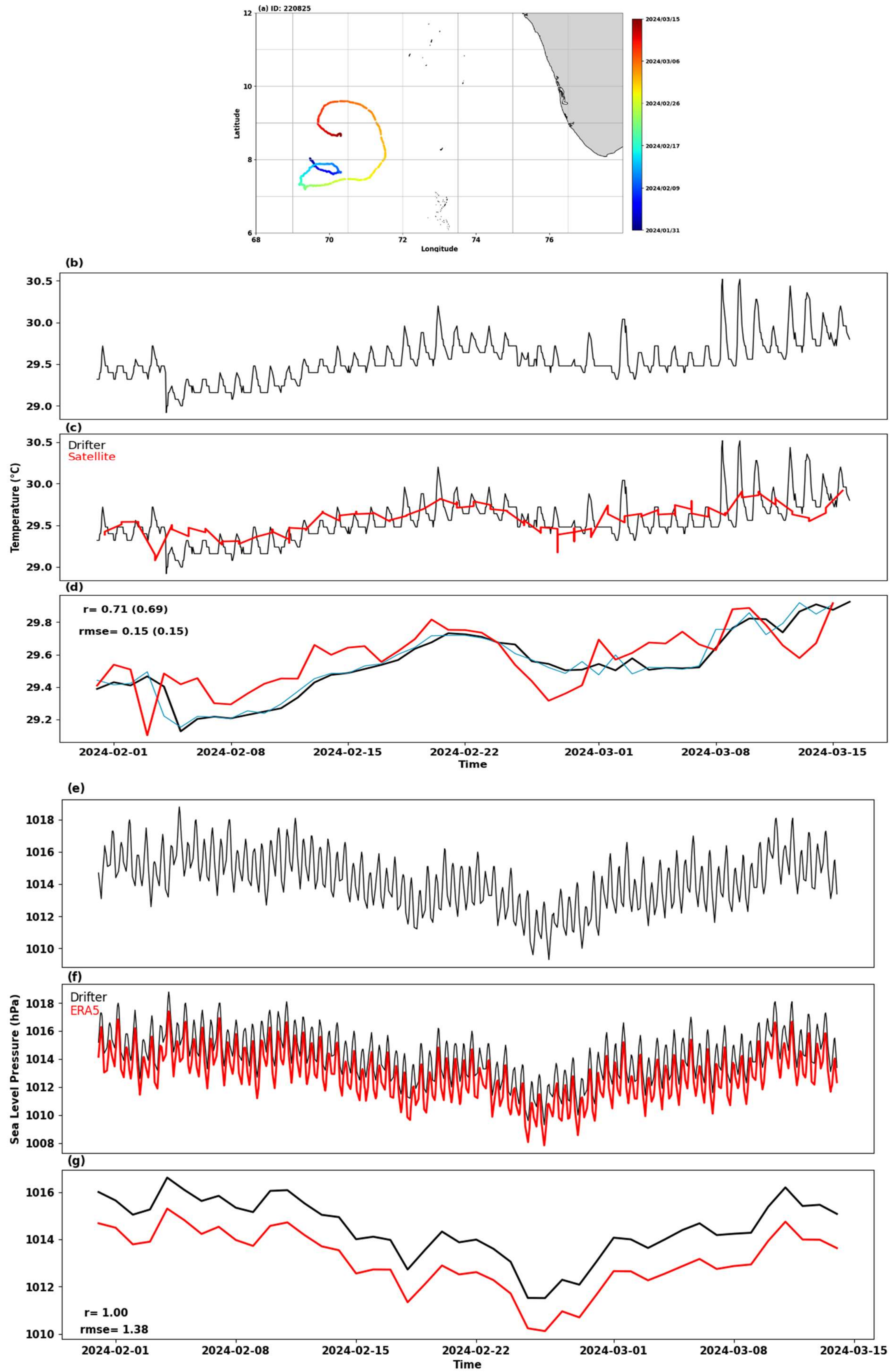

Figure 12. Same as Figure 8, but for drifter ID: 220825.

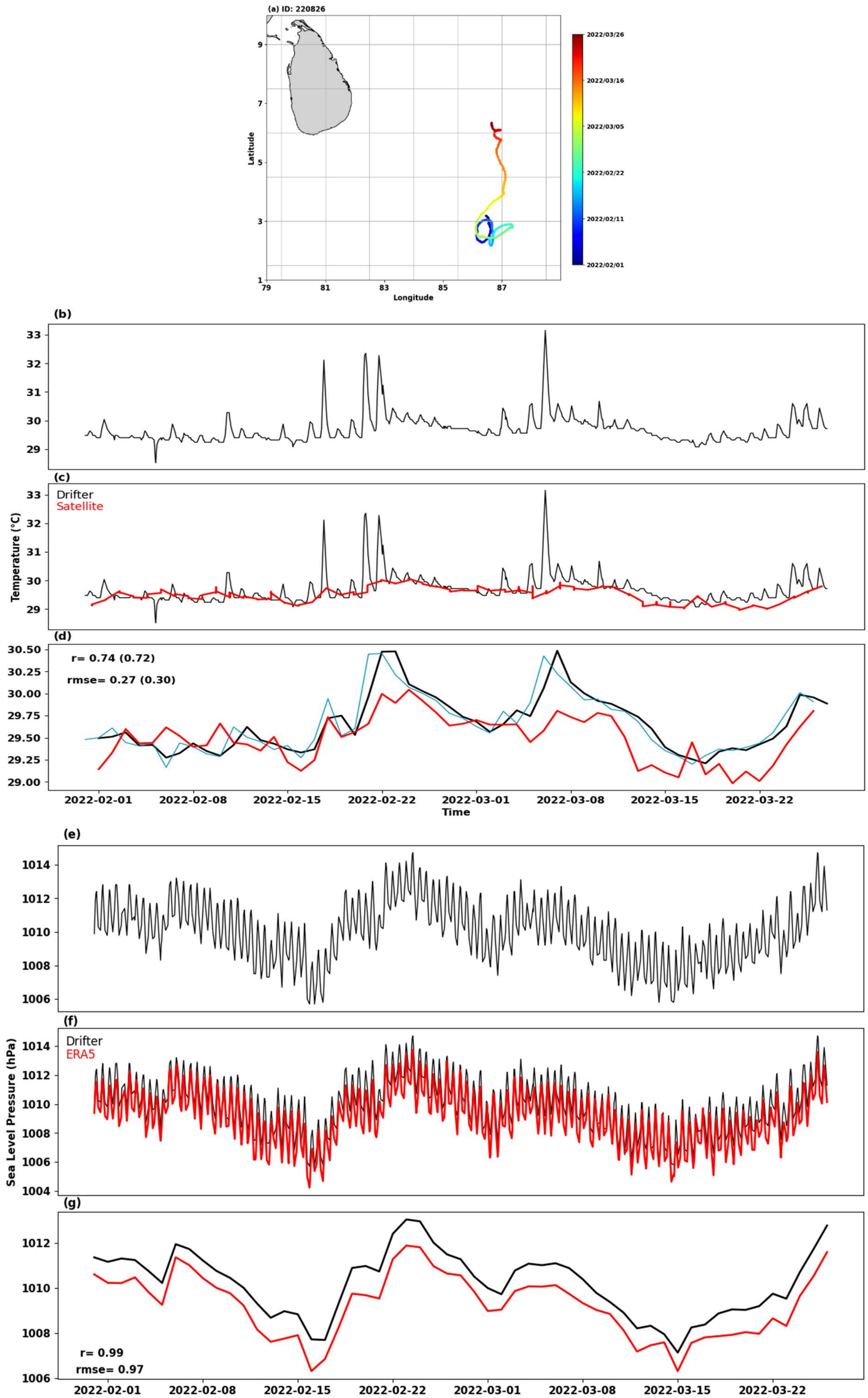

Figure 13. Same as Figure 8, but for drifter ID: 220826.

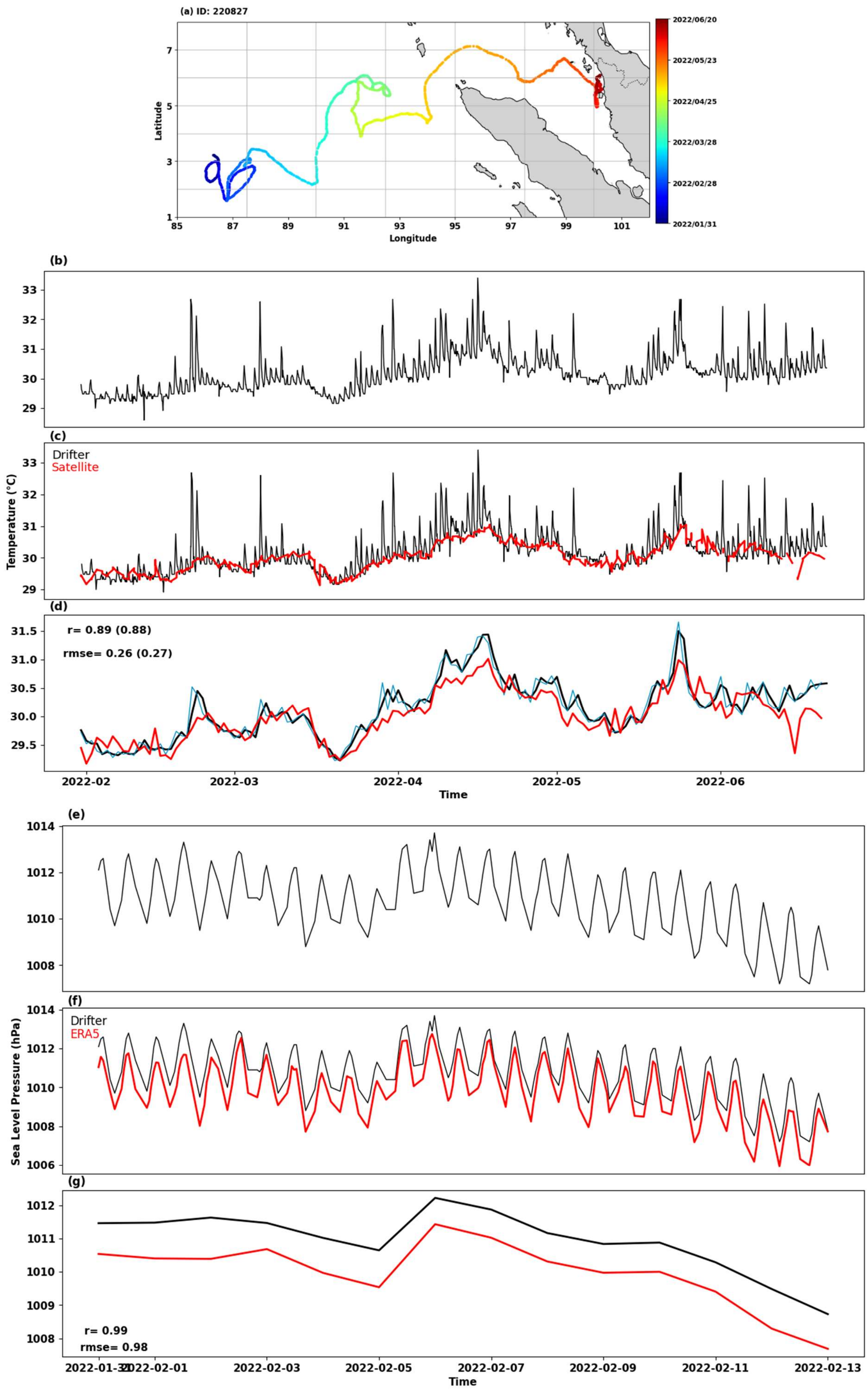

Figure 14. Same as Figure 8, but for drifter ID: 220827.

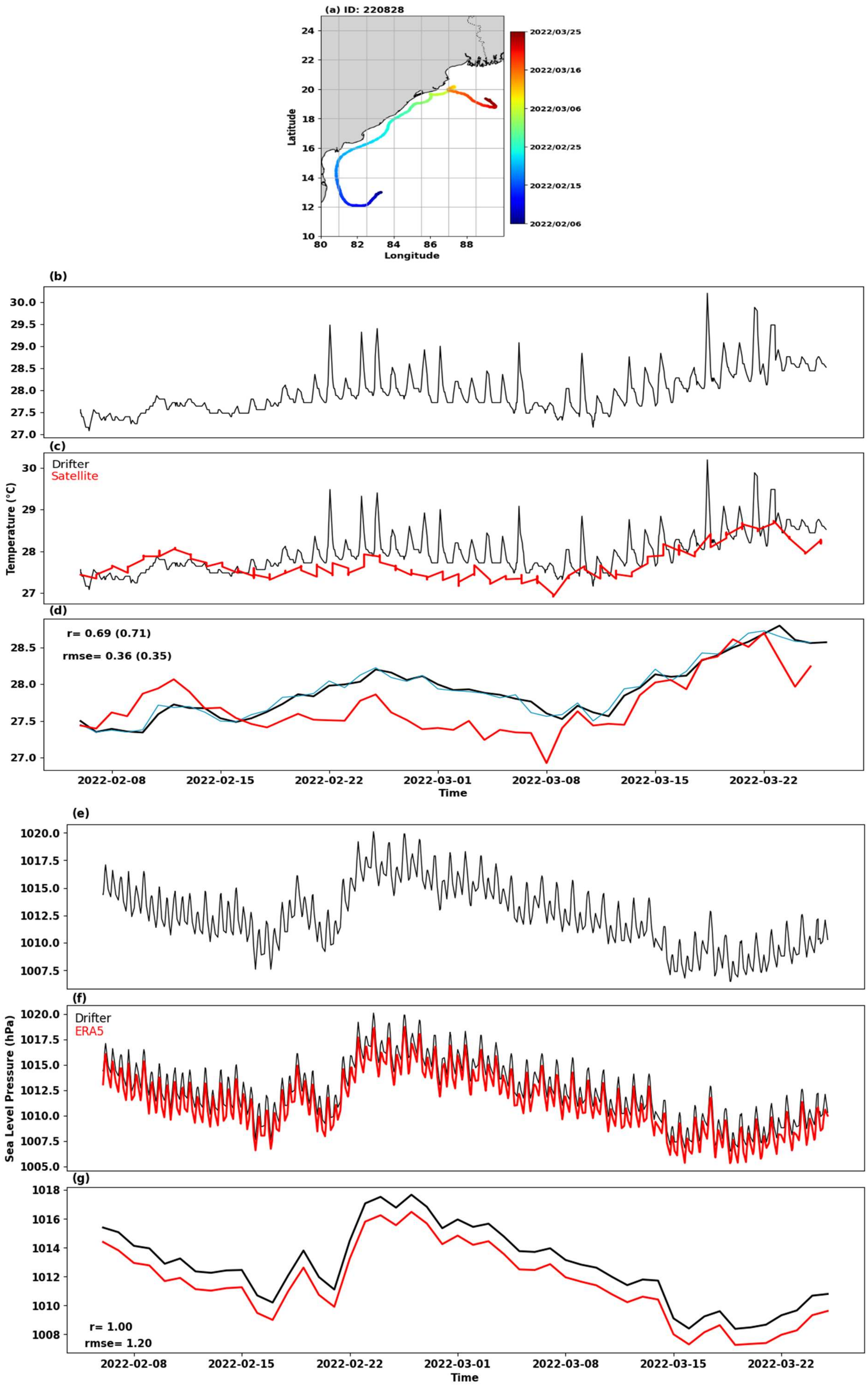

Figure 15. Same as Figure 8, but for drifter ID: 220828.

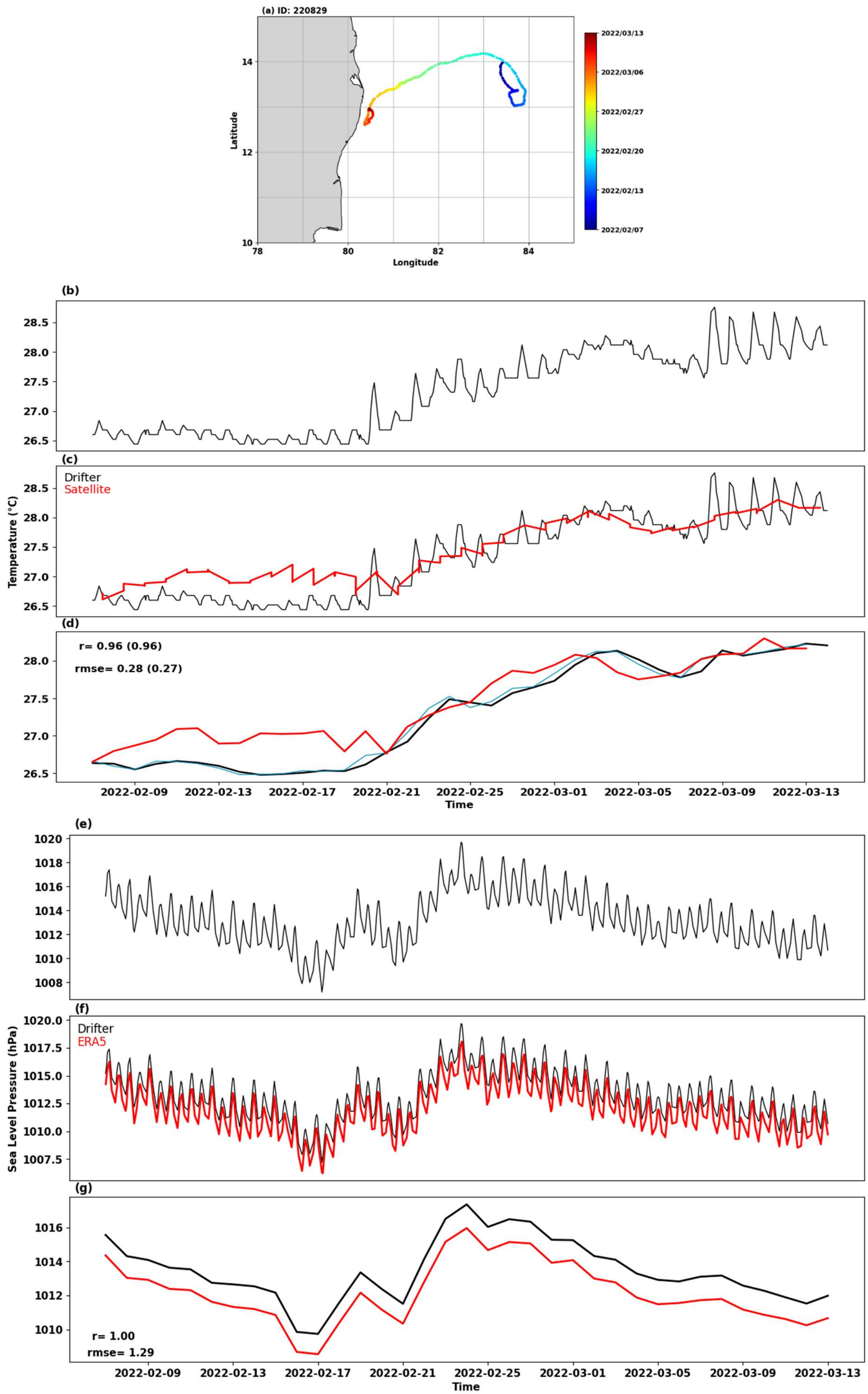

Figure 16. Same as Figure 8, but for drifter ID: 220829.

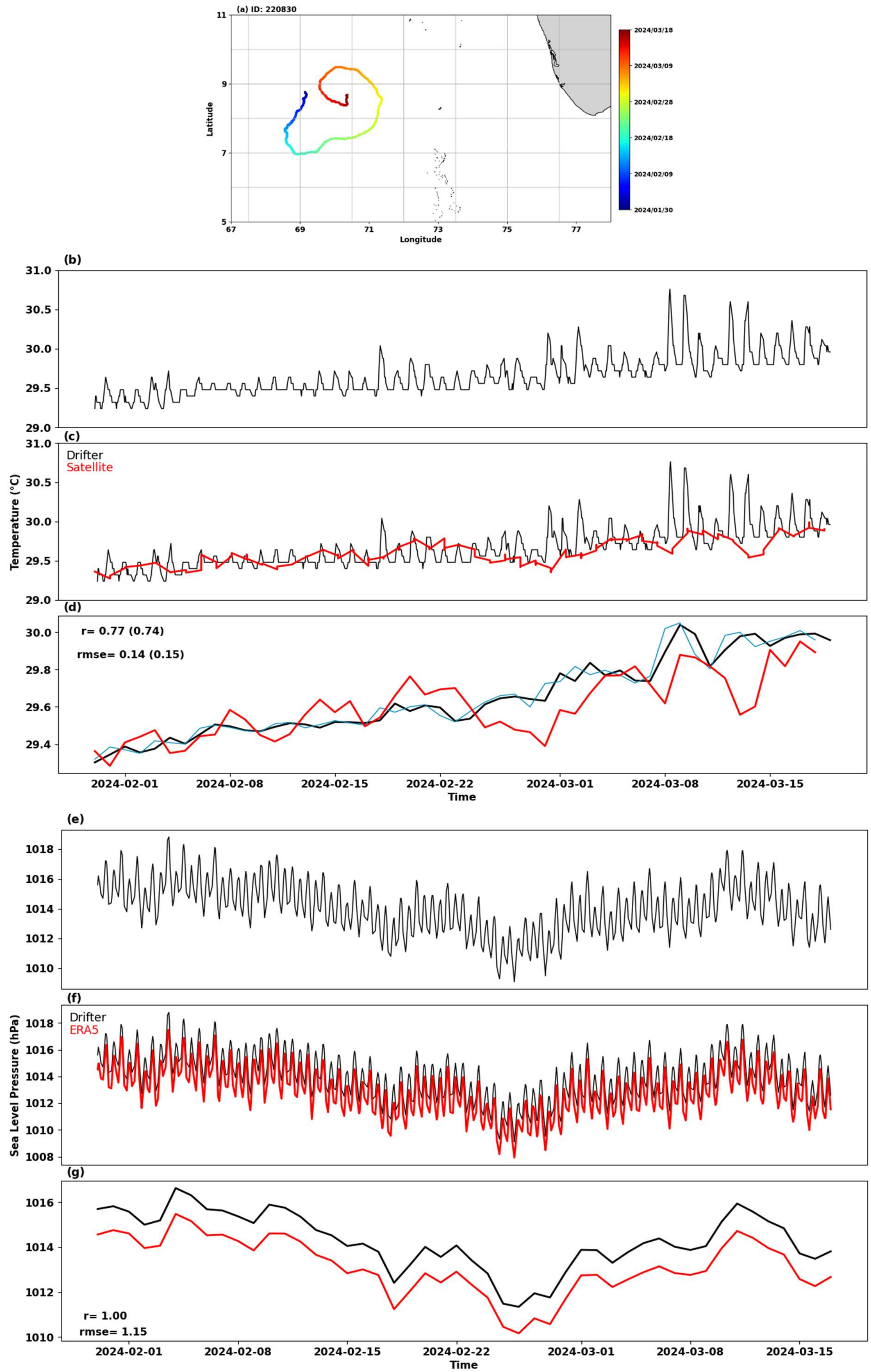

Figure 17. Same as Figure 8, but for drifter ID: 220830.

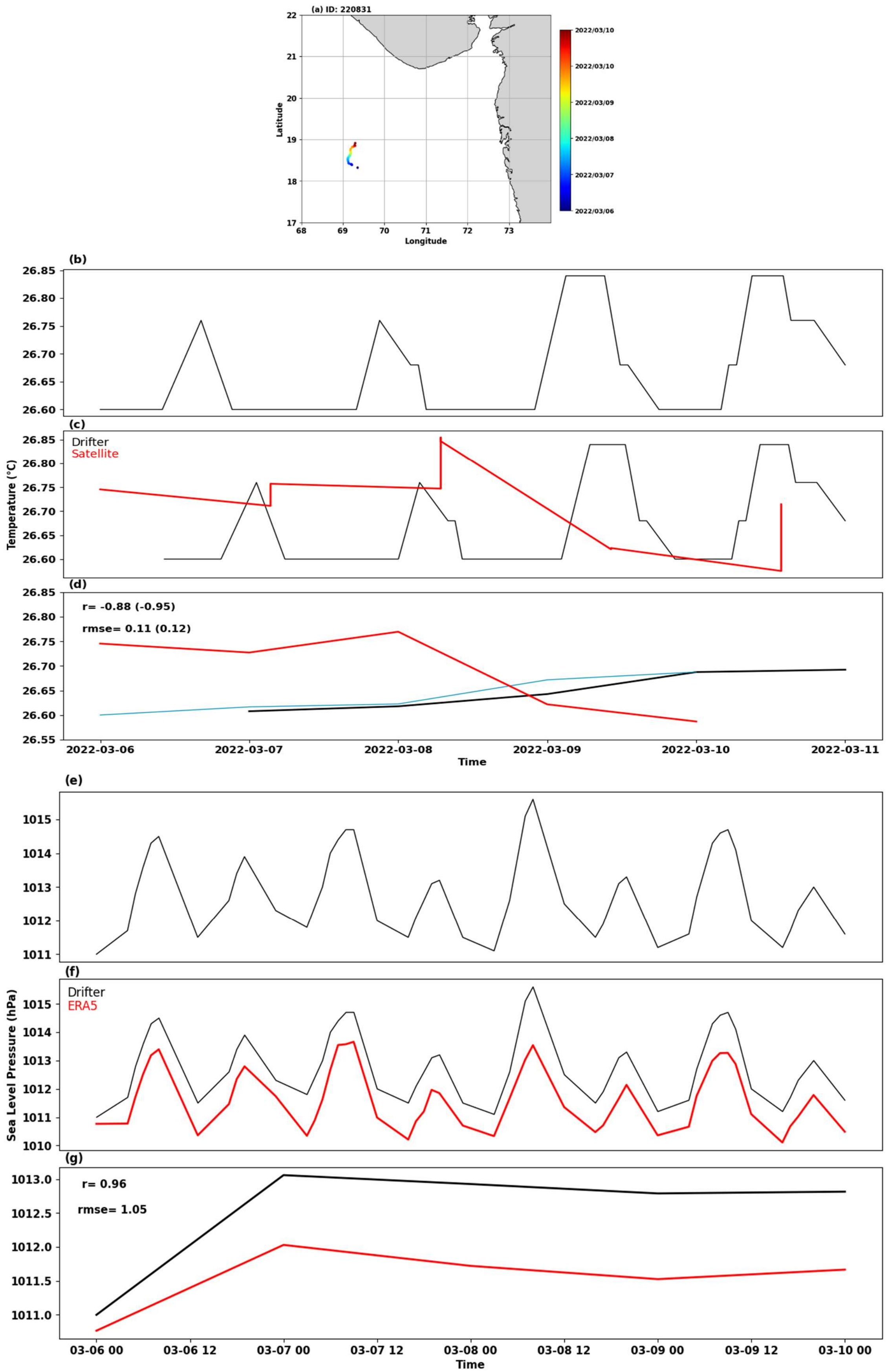

Figure 18. Same as Figure 8, but for drifter ID: 220831.

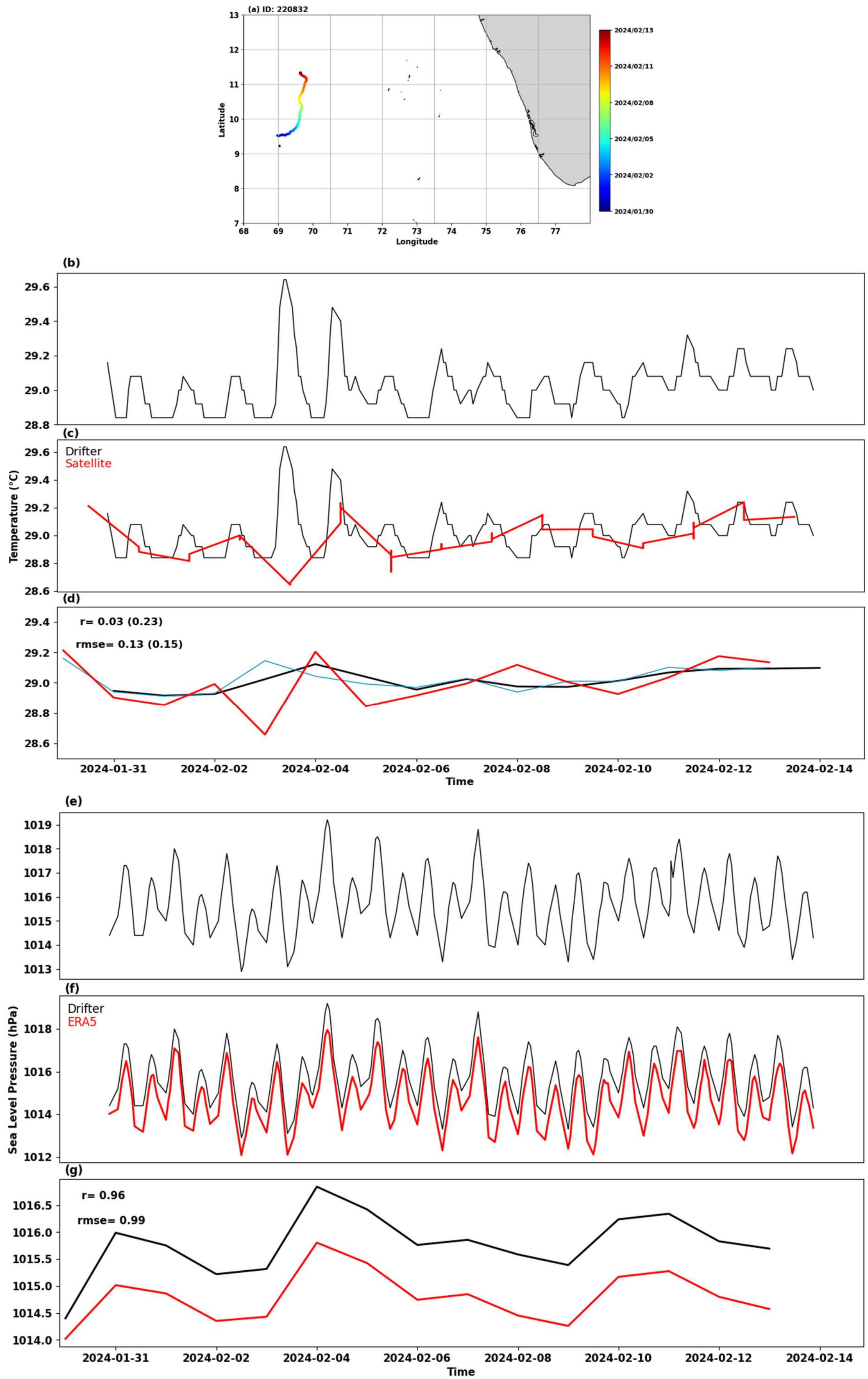

Figure 19. Same as Figure 8, but for drifter ID: 220832.

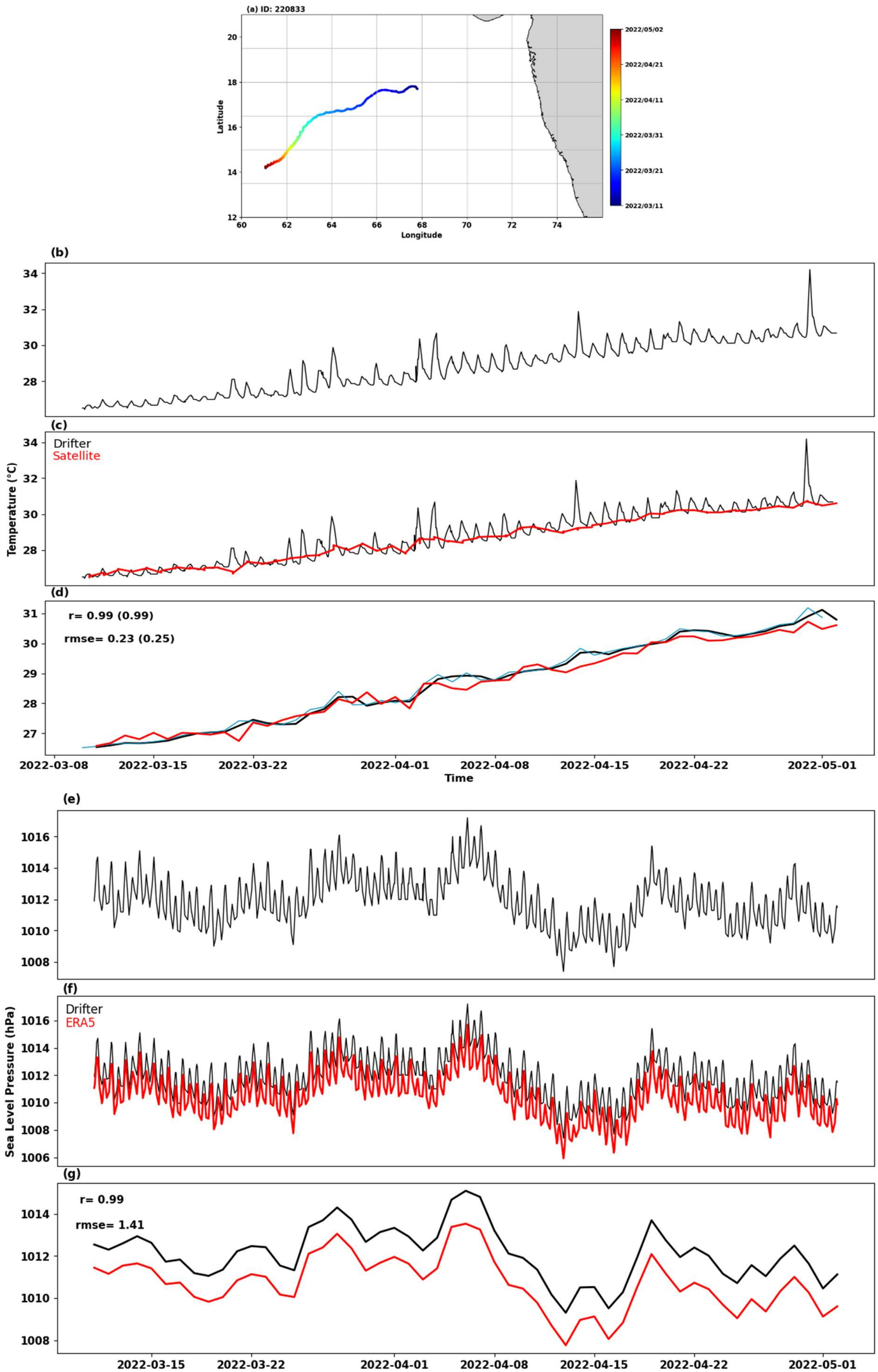

Figure 20. Same as Figure 8, but for drifter ID: 220833.

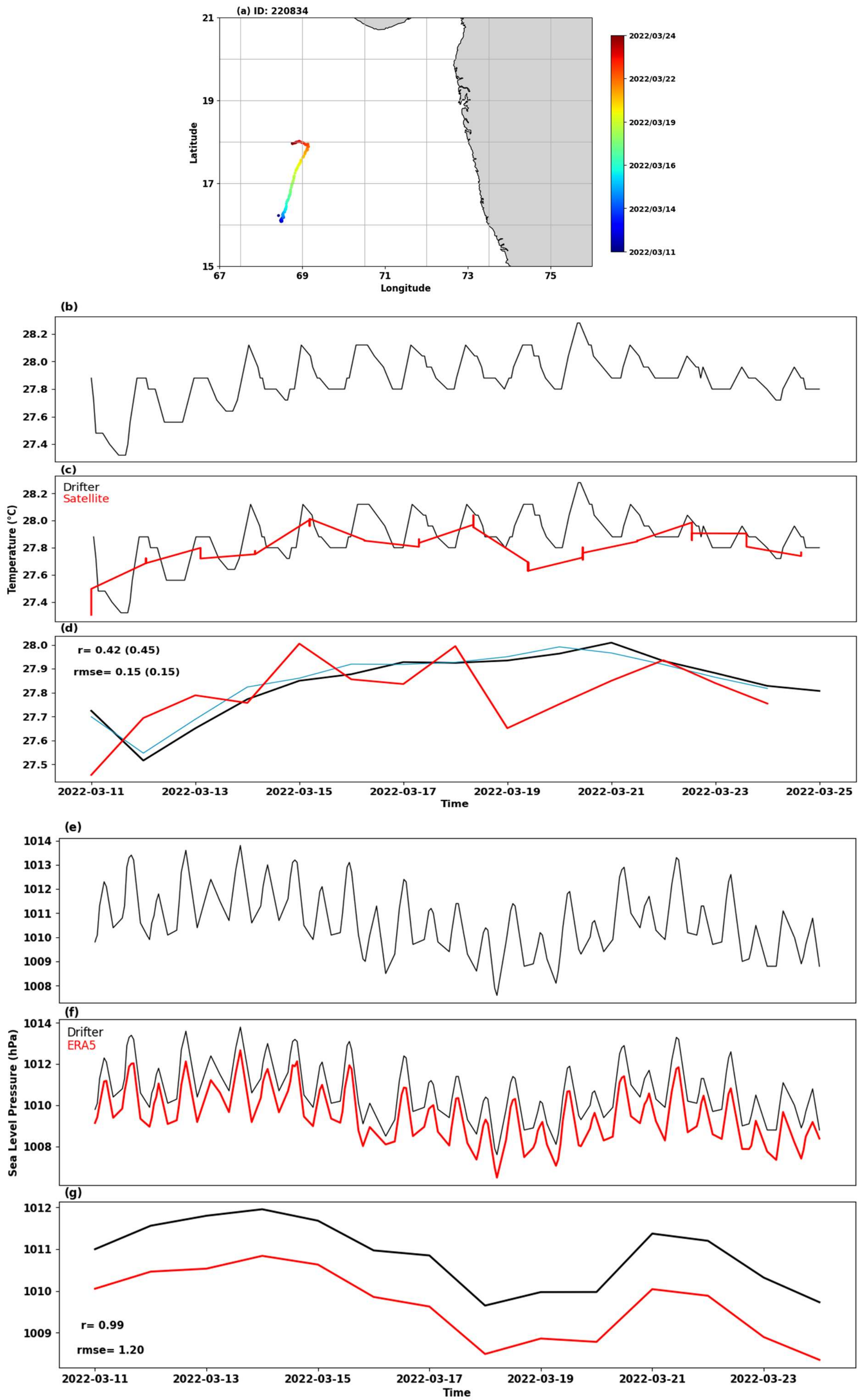

Figure 21. Same as Figure 8, but for drifter ID: 220834.

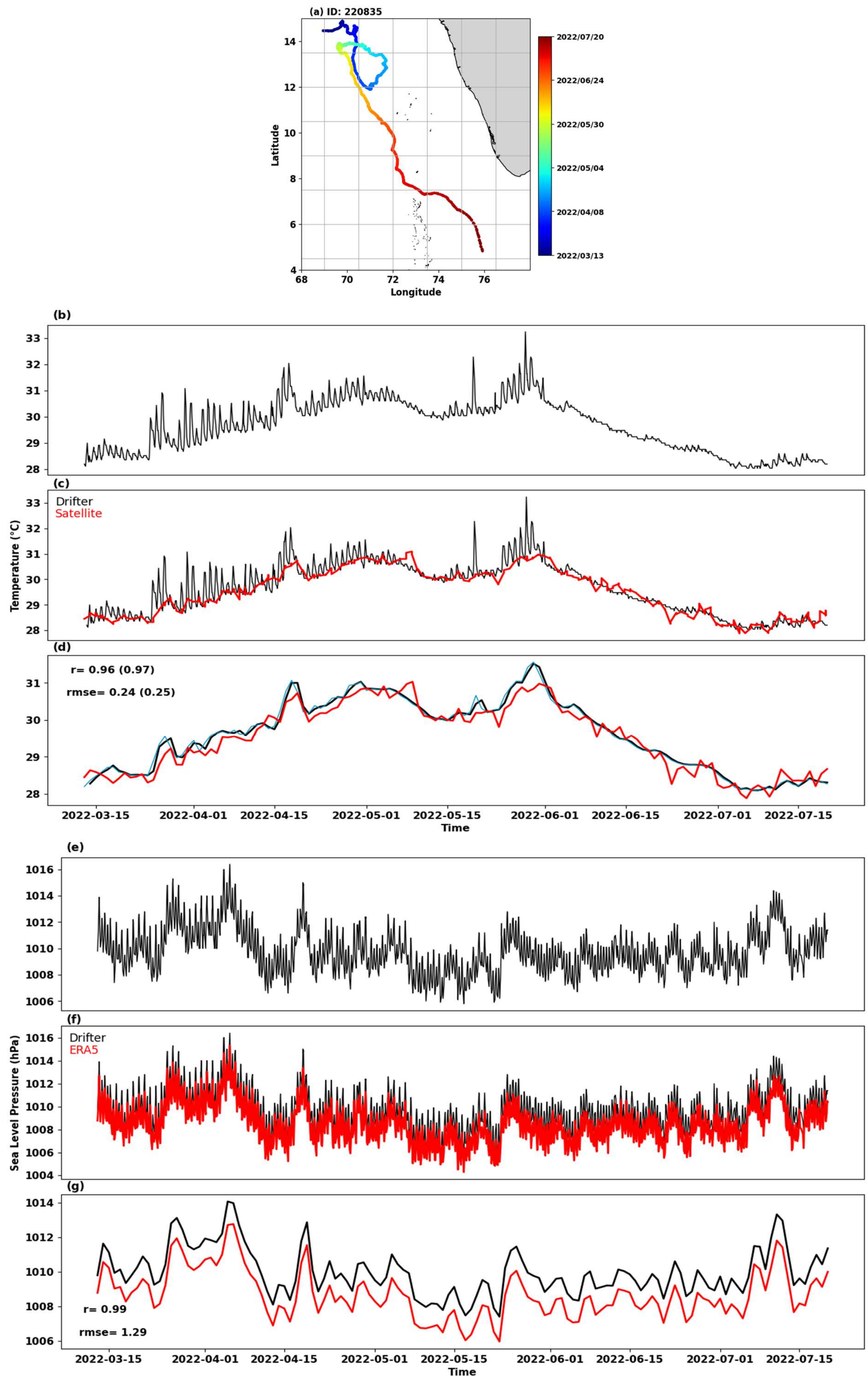

Figure 22. Same as Figure 8, but for drifter ID: 220835.

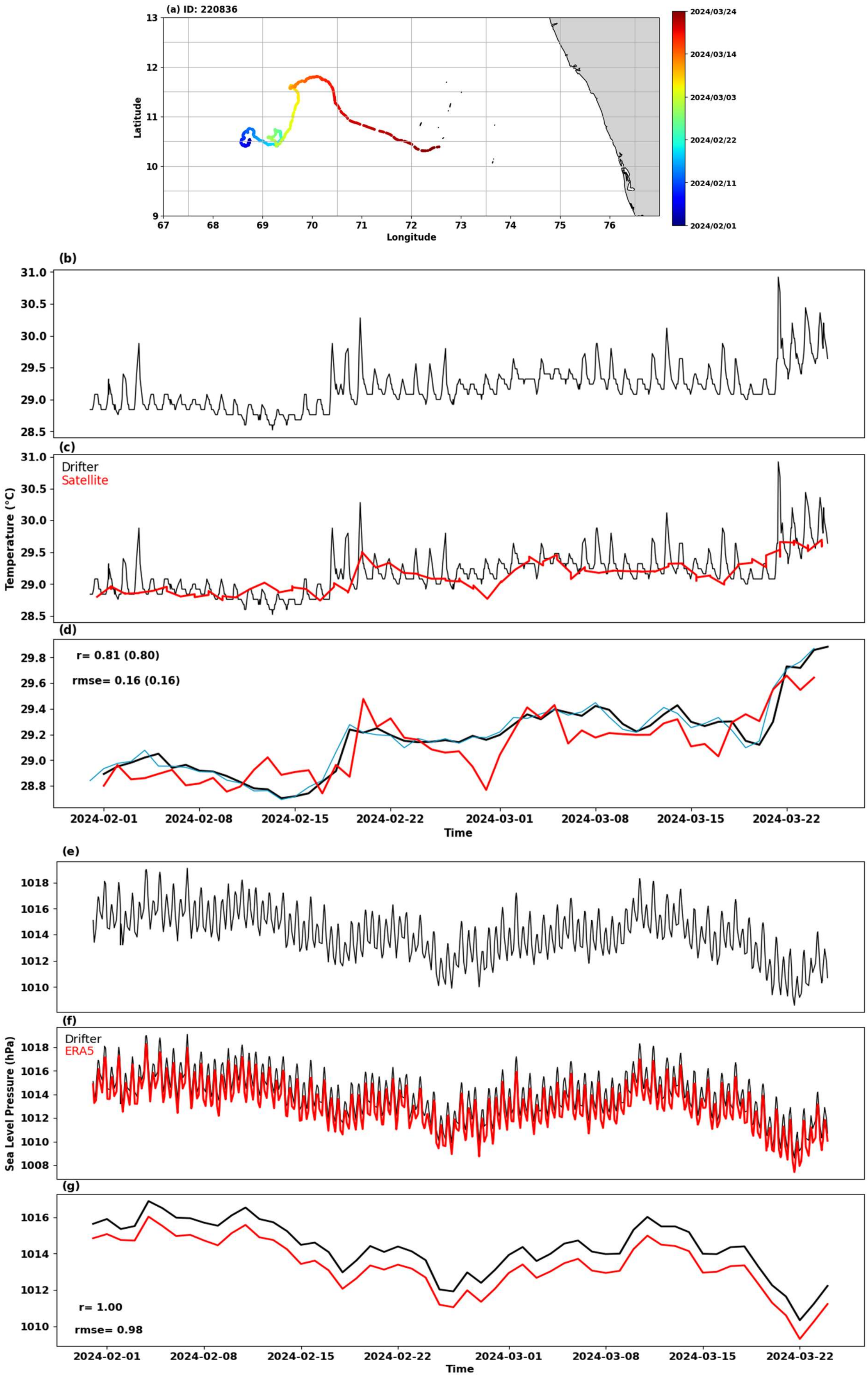

Figure 23. Same as Figure 8, but for drifter ID: 220836.

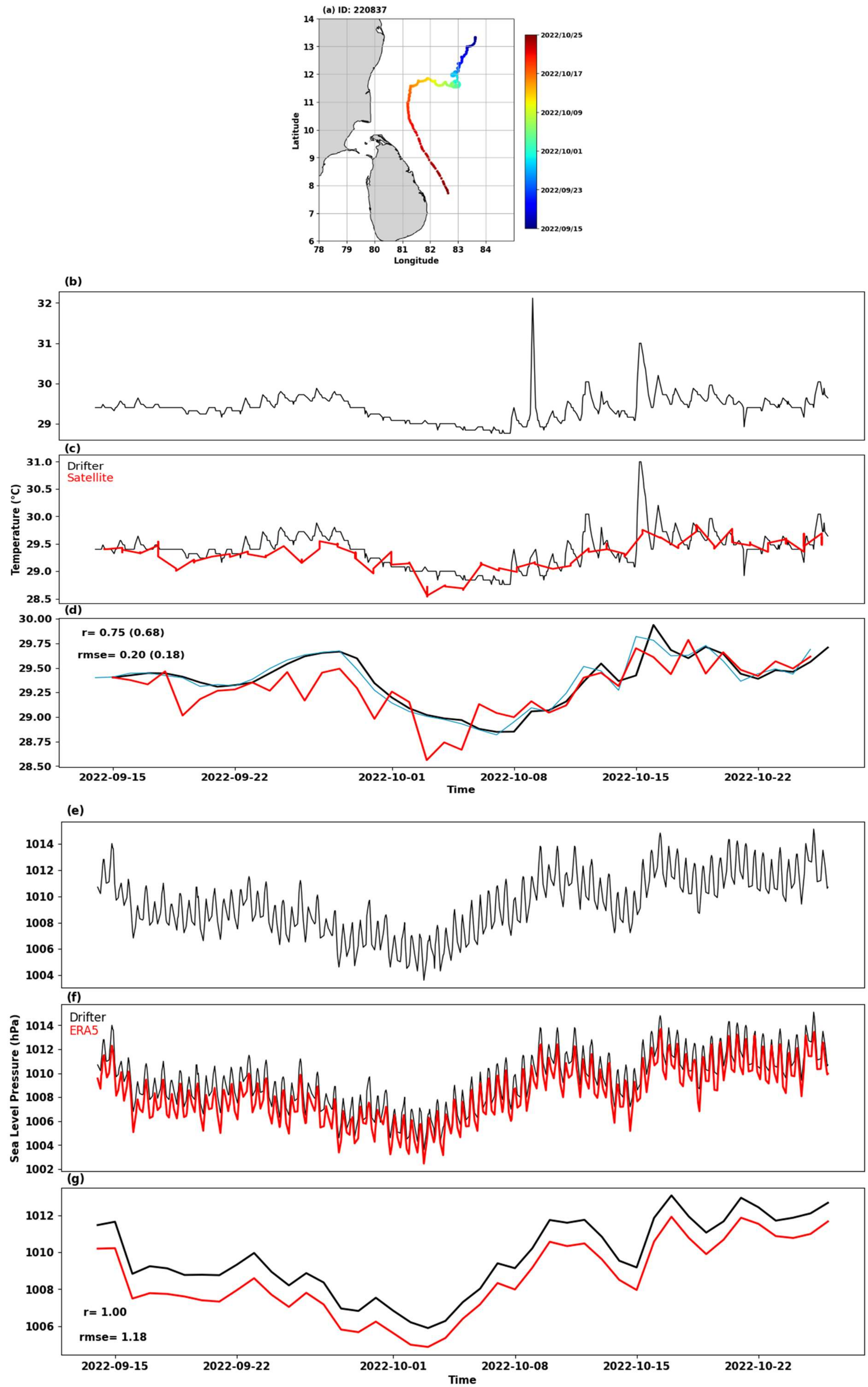

Figure 24. Same as Figure 8, but for drifter ID: 220837.

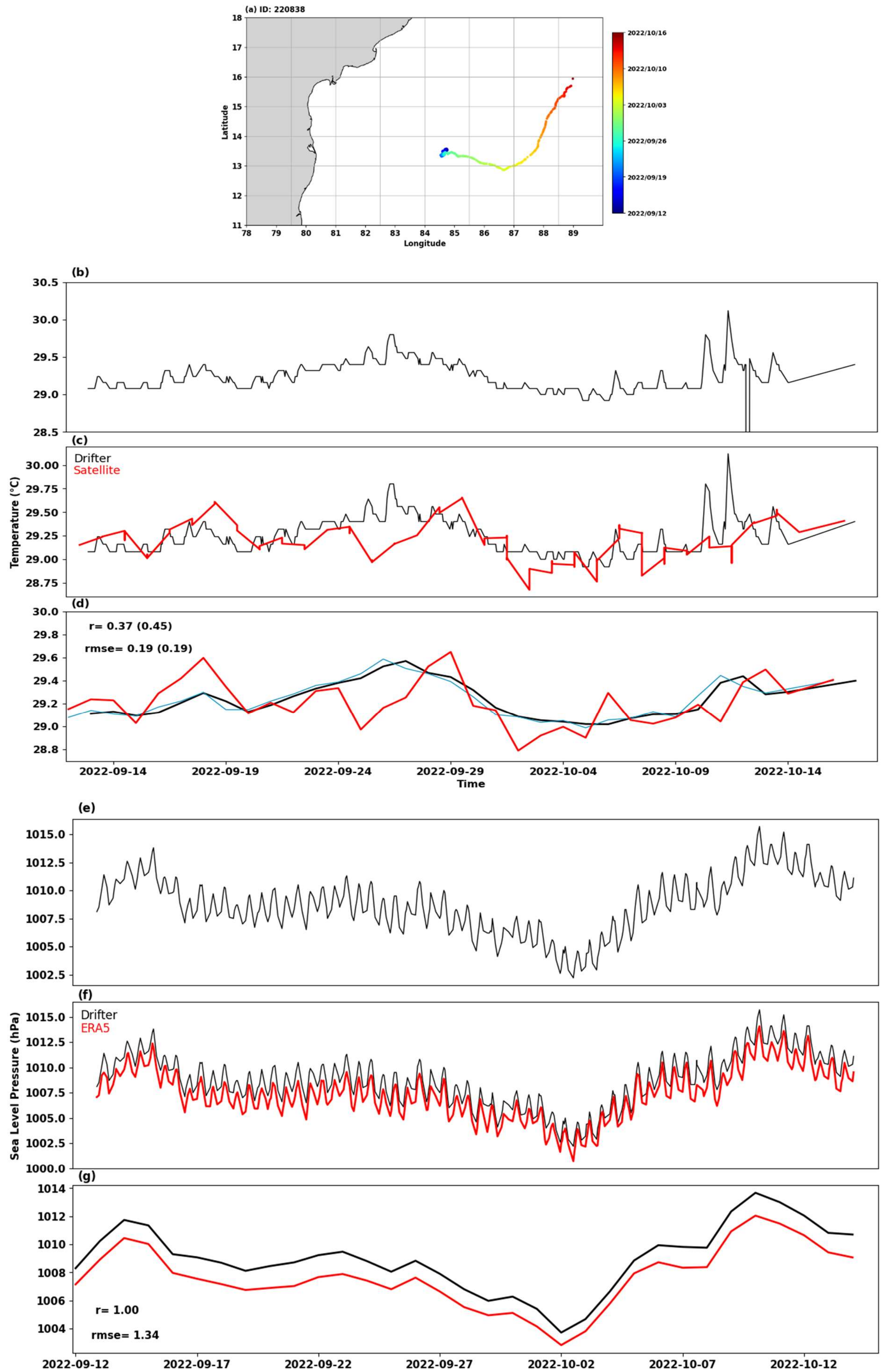

Figure 25. Same as Figure 8, but for drifter ID: 220838.

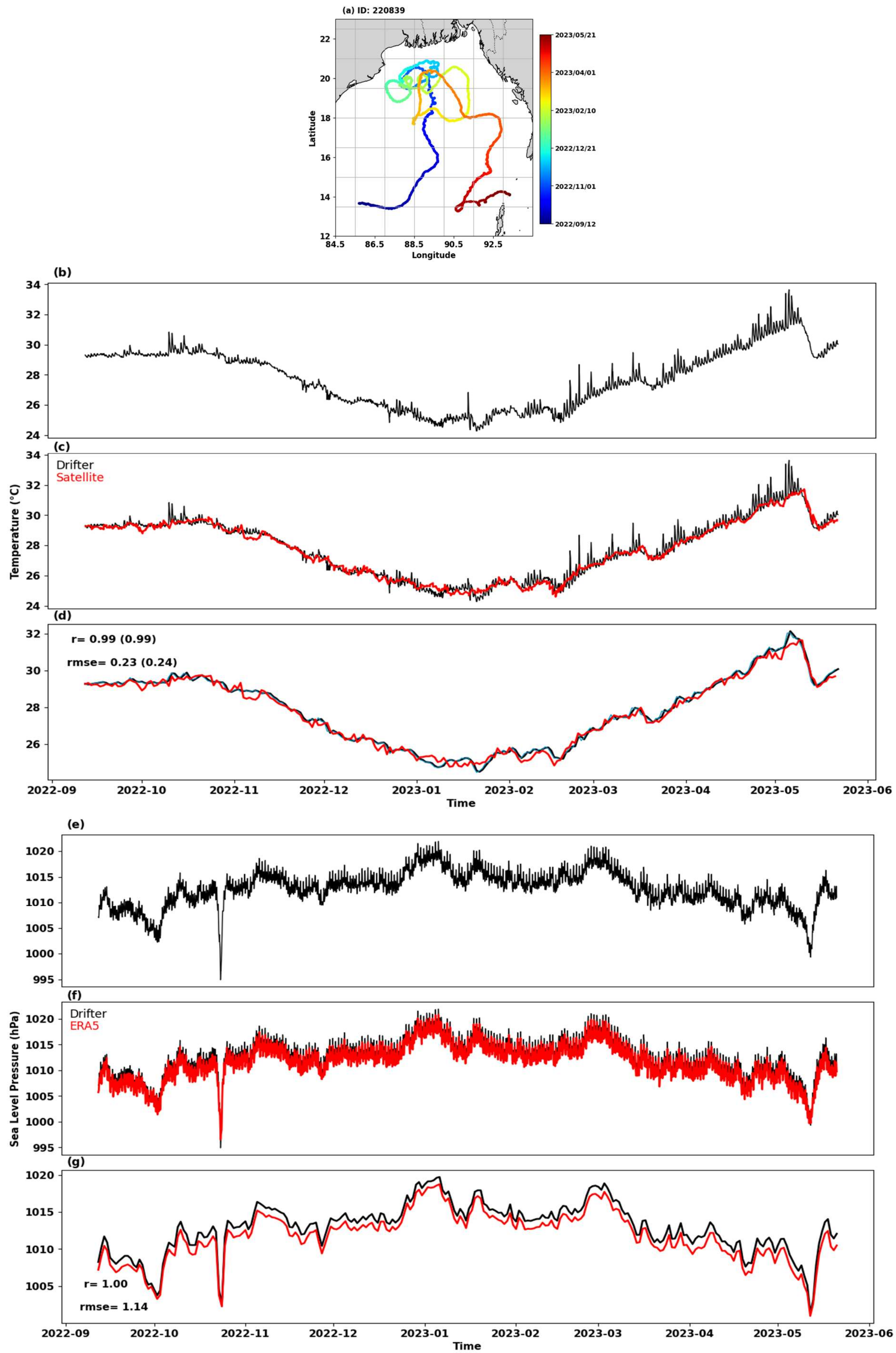

Figure 26. Same as Figure 8, but for drifter ID: 220839. SST and MSLP drop are associated with the passage of tropical cyclone *Mocha* (09-15 May 2023) over the Bay of Bengal. MSLP dip during 22-25 October 2022 is associated with tropical cyclone *Sitran*g.

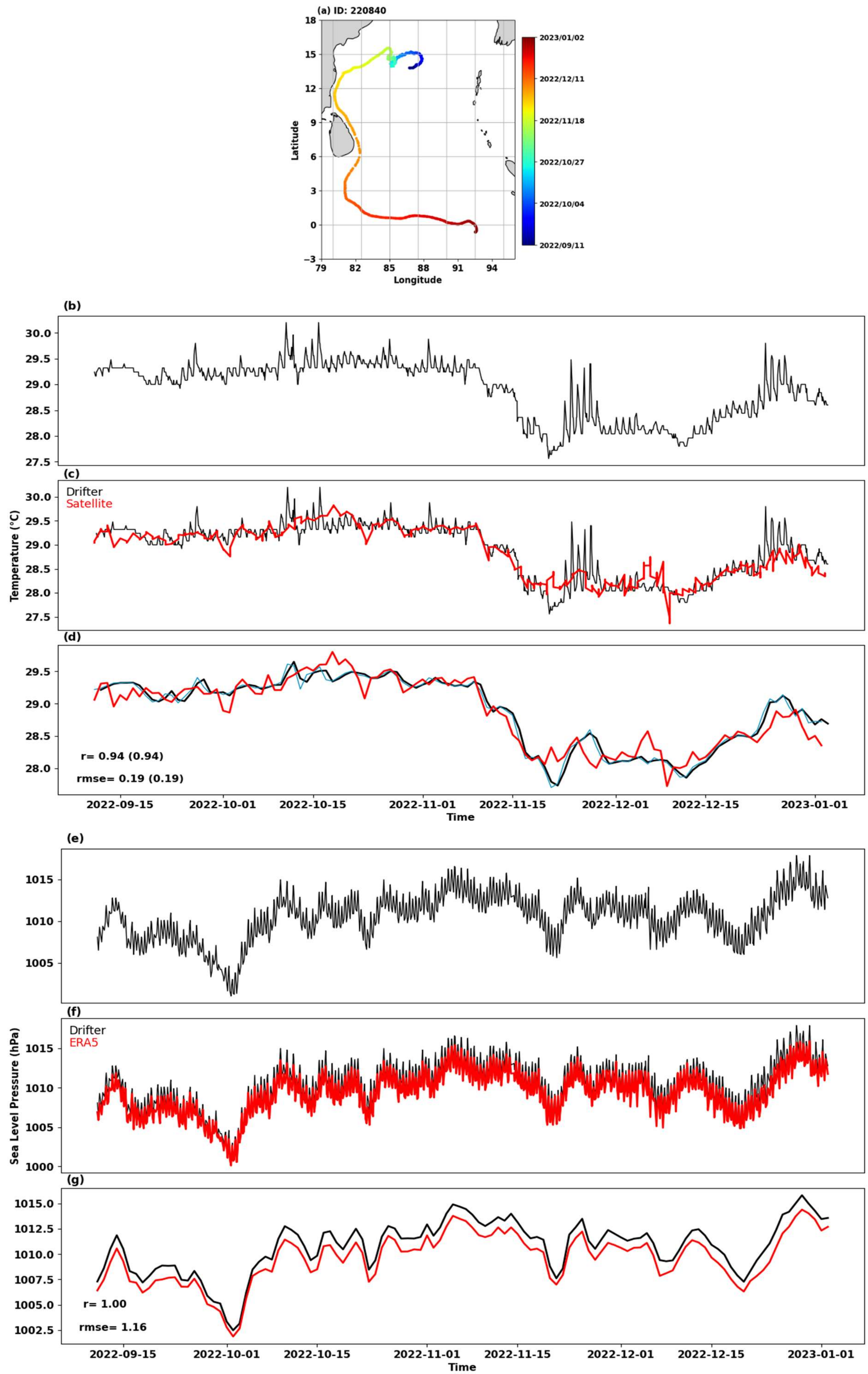

Figure 27. Same as Figure 8, but for drifter ID: 220840.

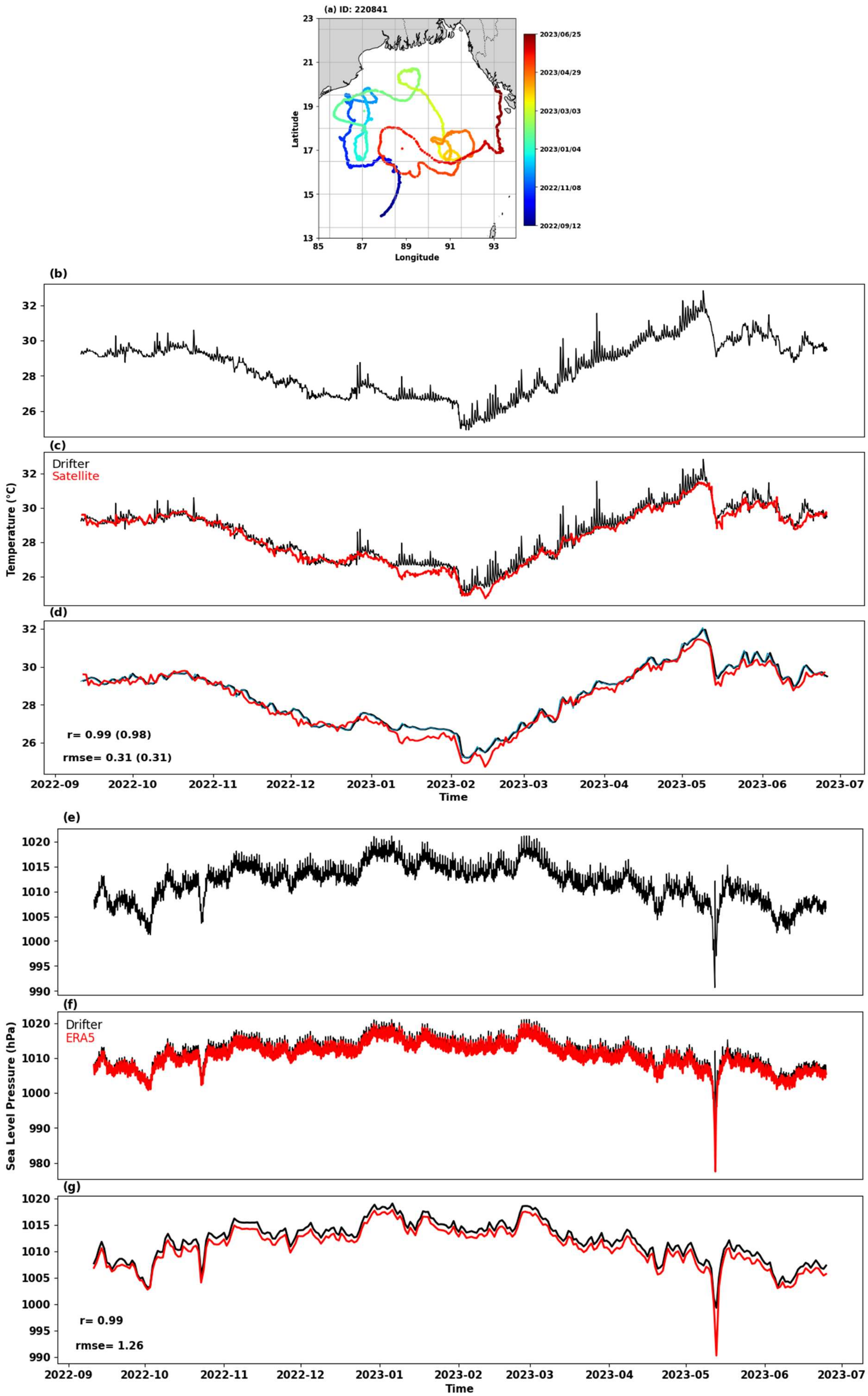

Figure 28. Same as Figure 8, but for drifter ID: 220841. SST and MSLP drop are associated with the passage of tropical cyclone *Mocha* (09-15 May 2023) over the Bay of Bengal.

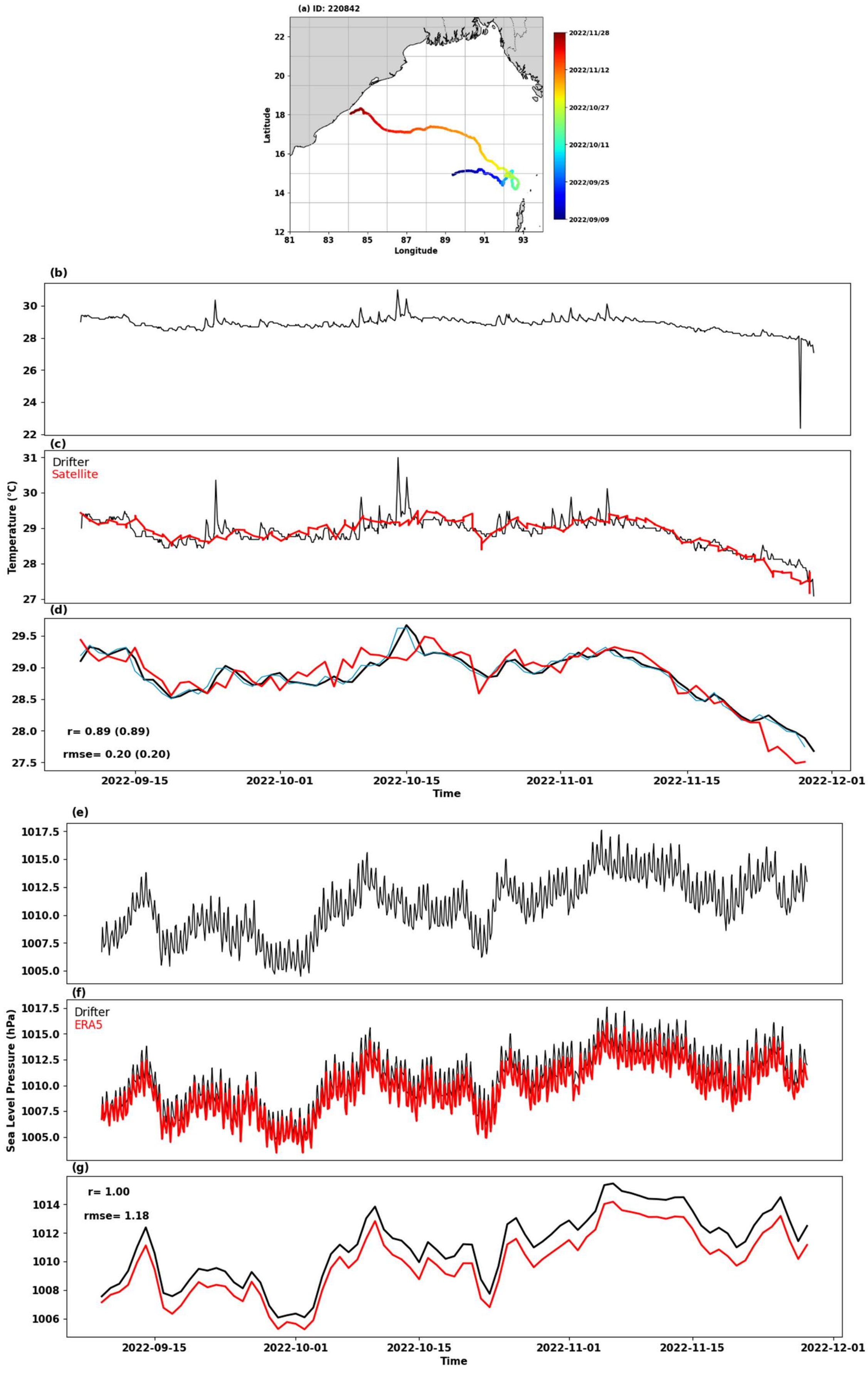

Figure 29. Same as Figure 8, but for drifter ID: 220842.

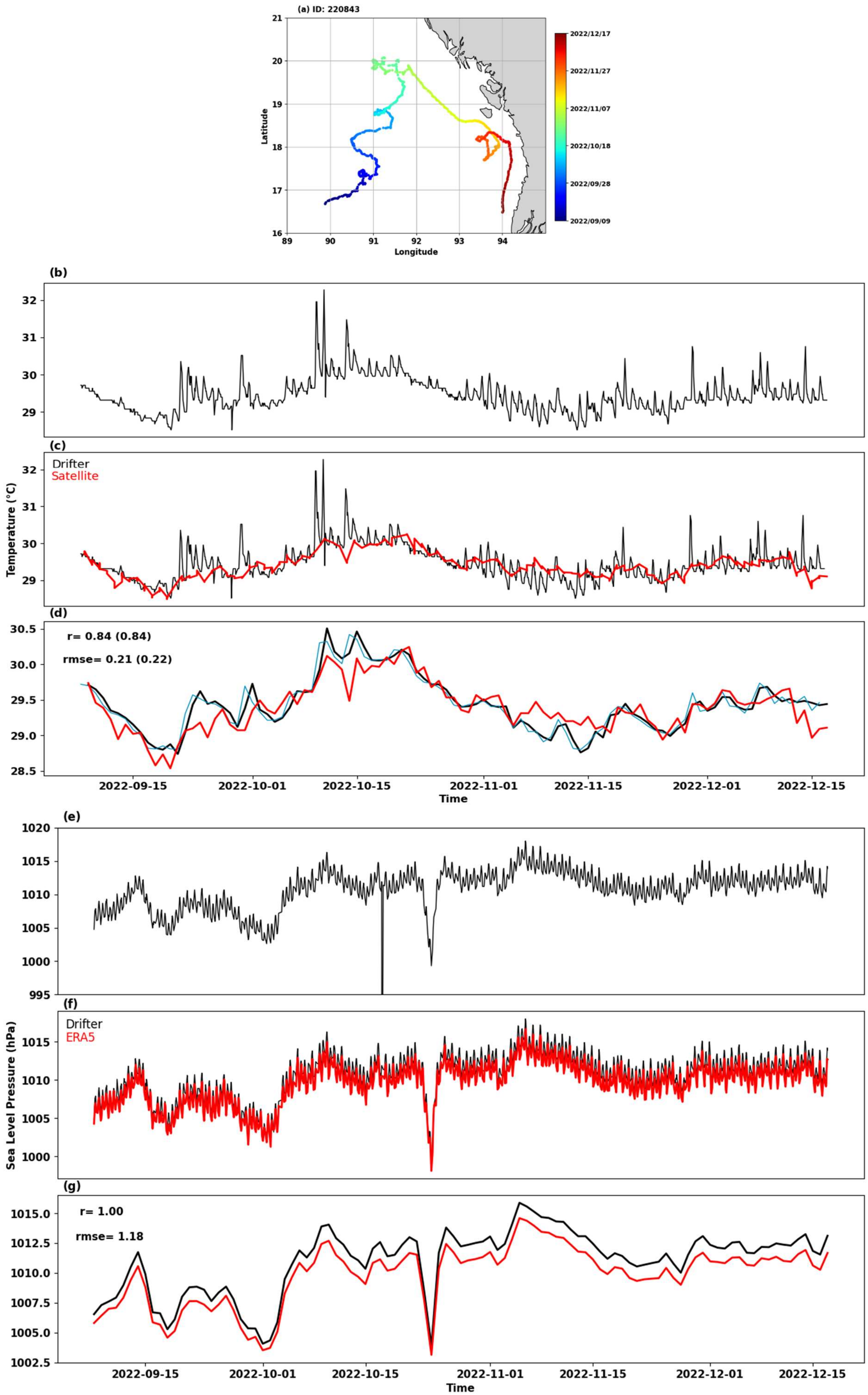

Figure 30. Same as Figure 8, but for drifter ID: 220843. MSLP drop is associated with the passage of tropical cyclone *Sitrang* (22-25 October 2022) over the Bay of Bengal.

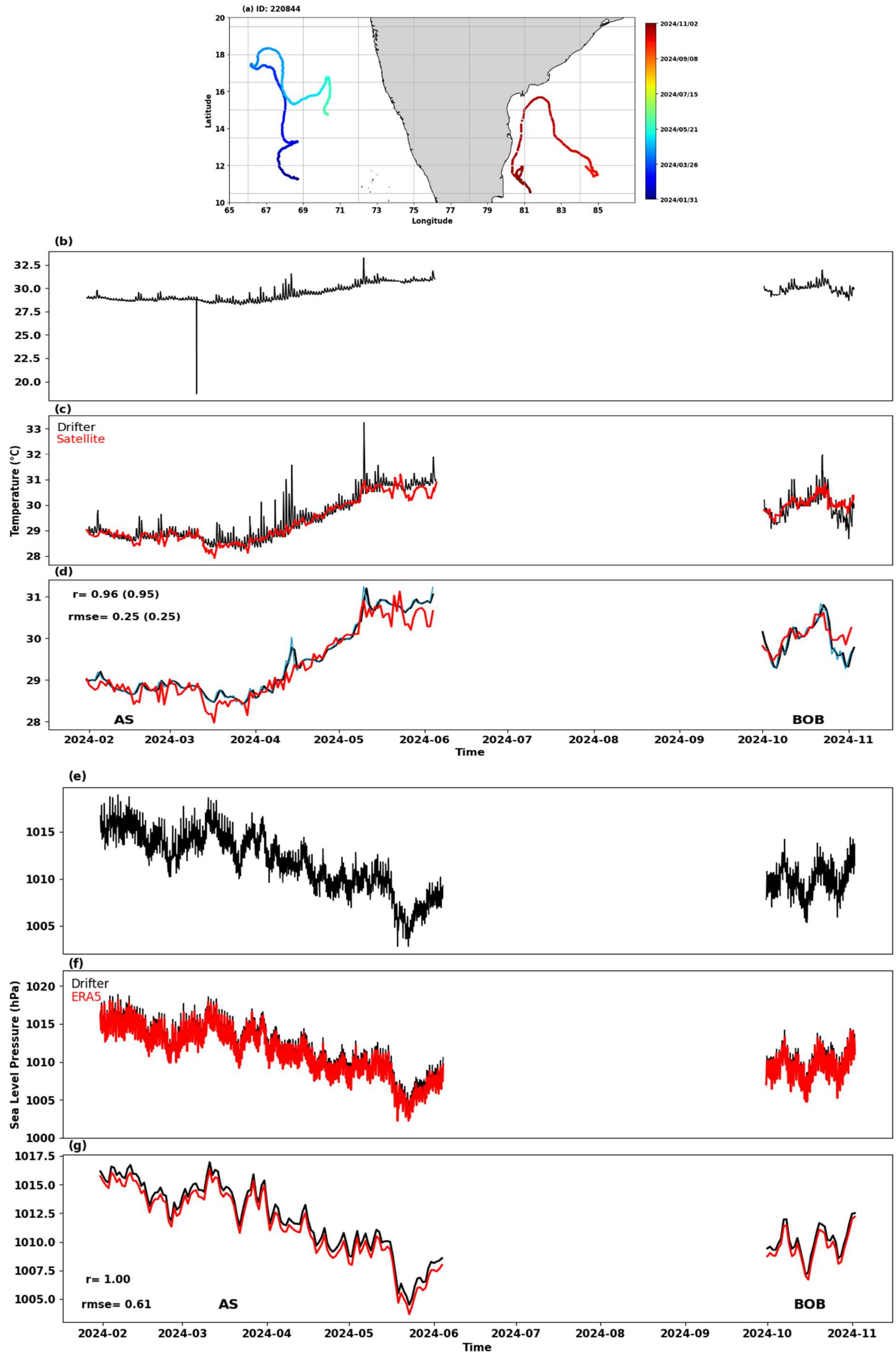

Figure 31. Same as Figure 8, but for drifter ID: 220844. Although the buoy was originally deployed in the Arabian Sea, it was later observed in the Bay of Bengal, likely as a result of being retrieved by fishermen and redeployed at Bay of Bengal.

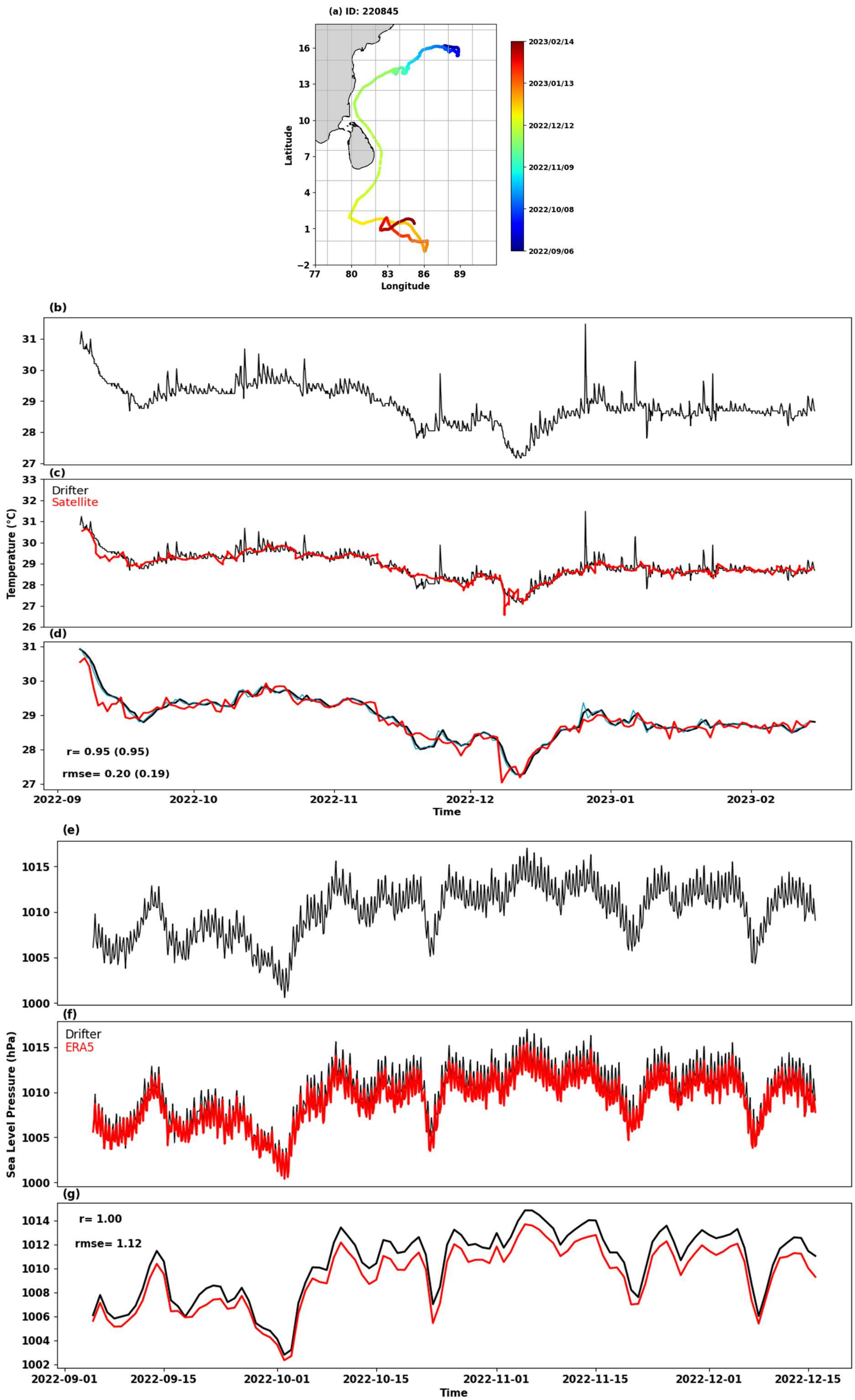

Figure 32. Same as Figure 8, but for drifter ID: 220845.

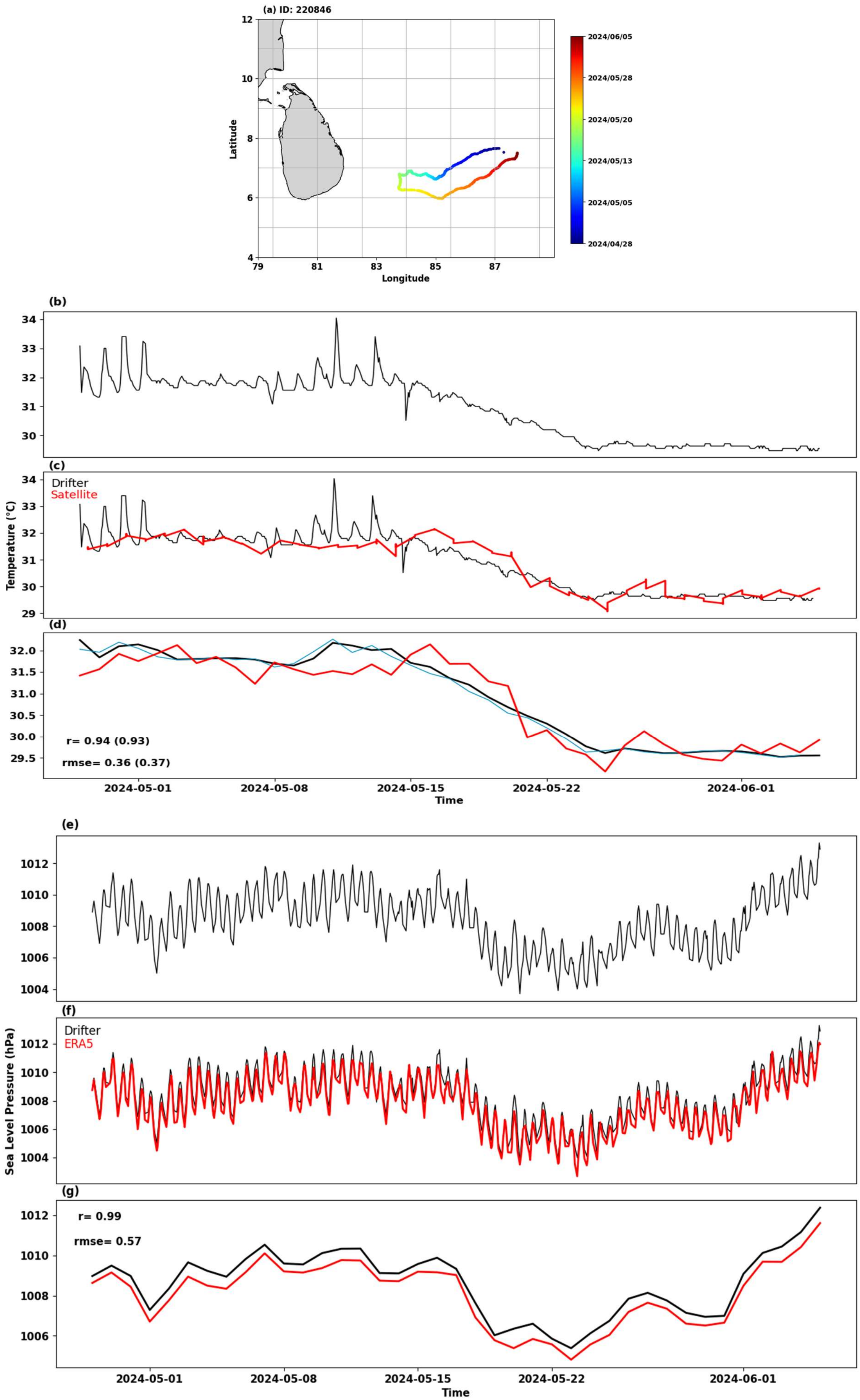

Figure 33. Same as Figure 8, but for drifter ID: 220846.

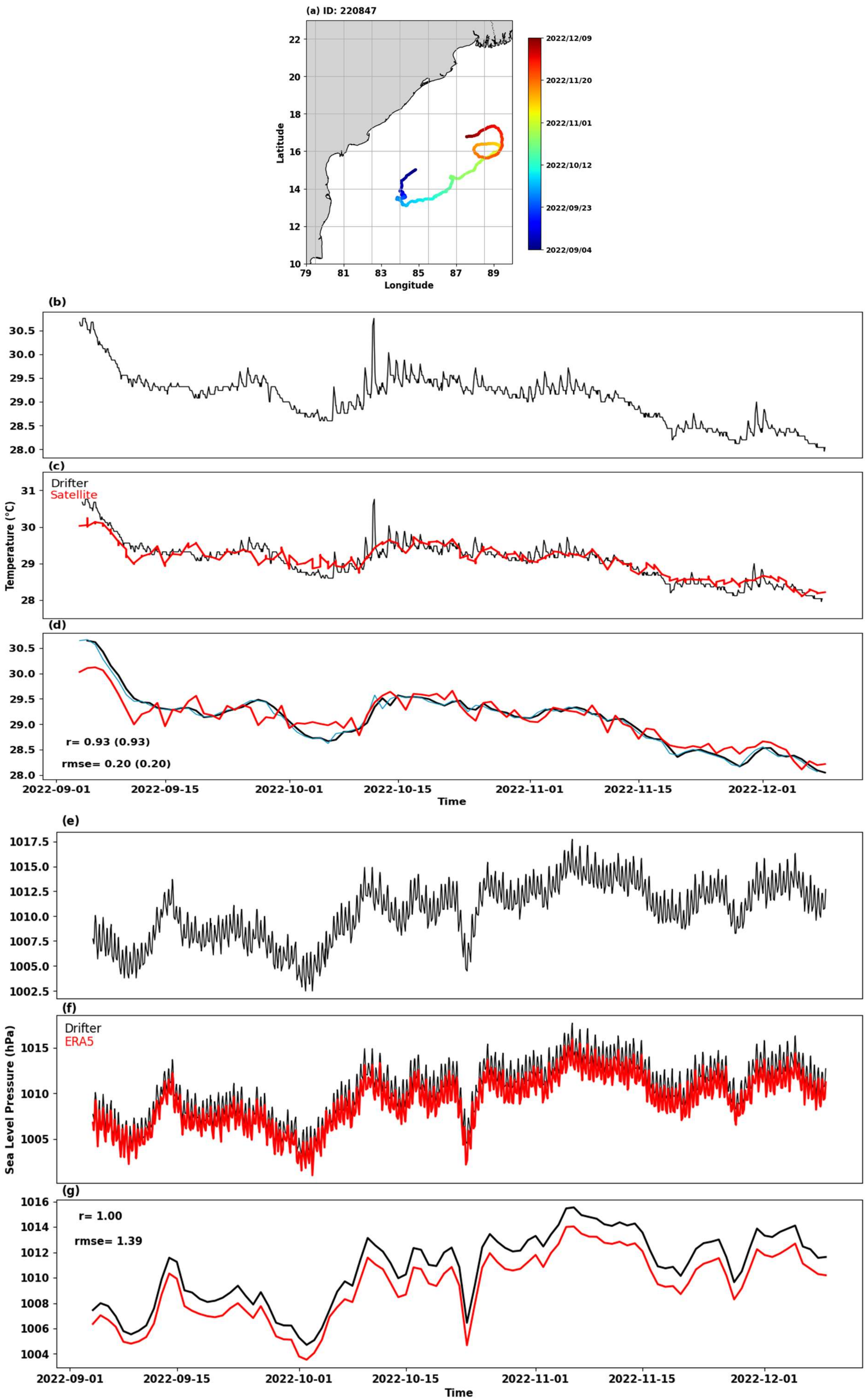

Figure 34. Same as Figure 8, but for drifter ID: 220847.

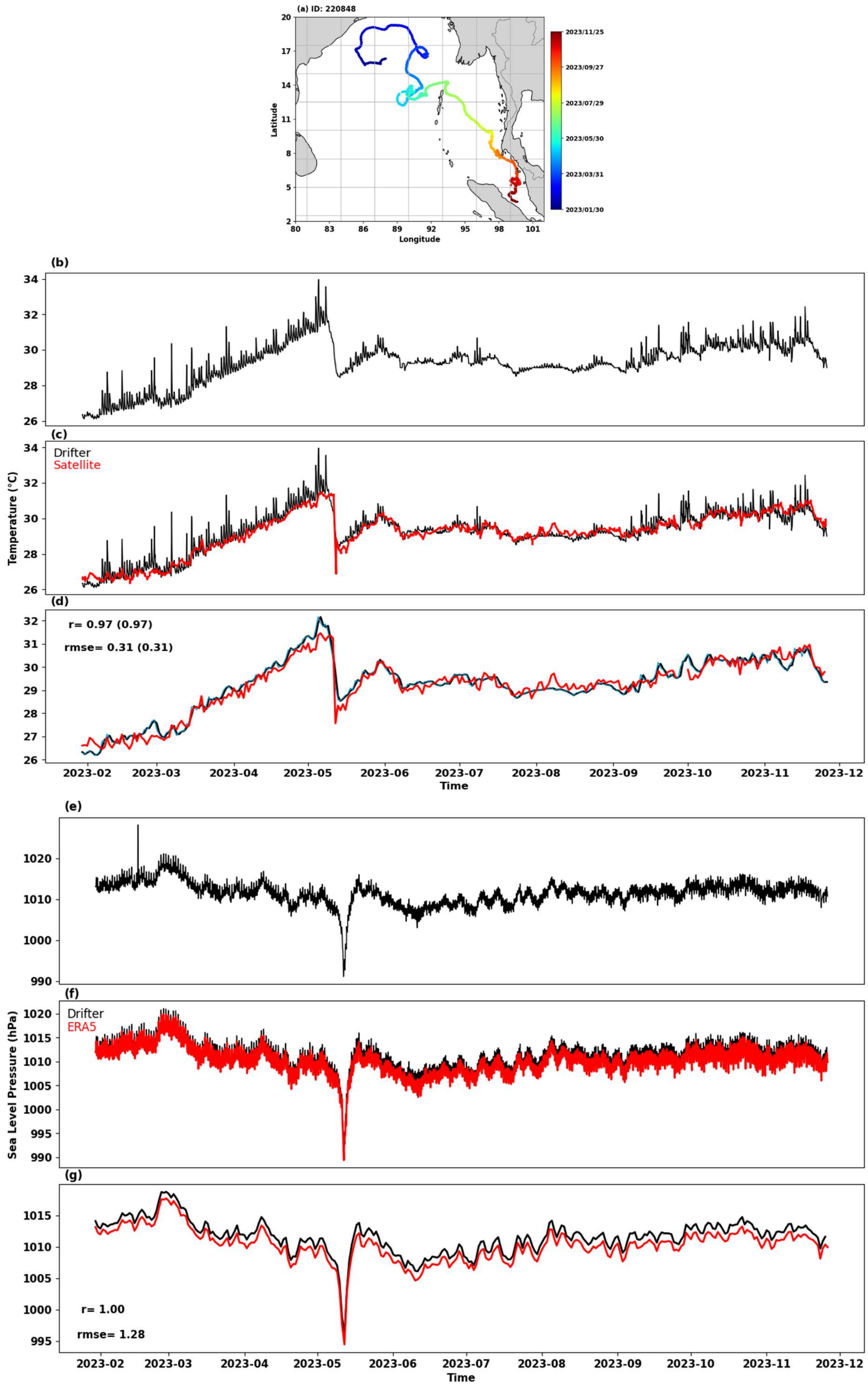

Figure 35. Same as Figure 8, but for drifter ID: 220848. SST and MSLP drop are associated with the passage of tropical cyclone *Mocha* (09-15 May 2023) over the Bay of Bengal.

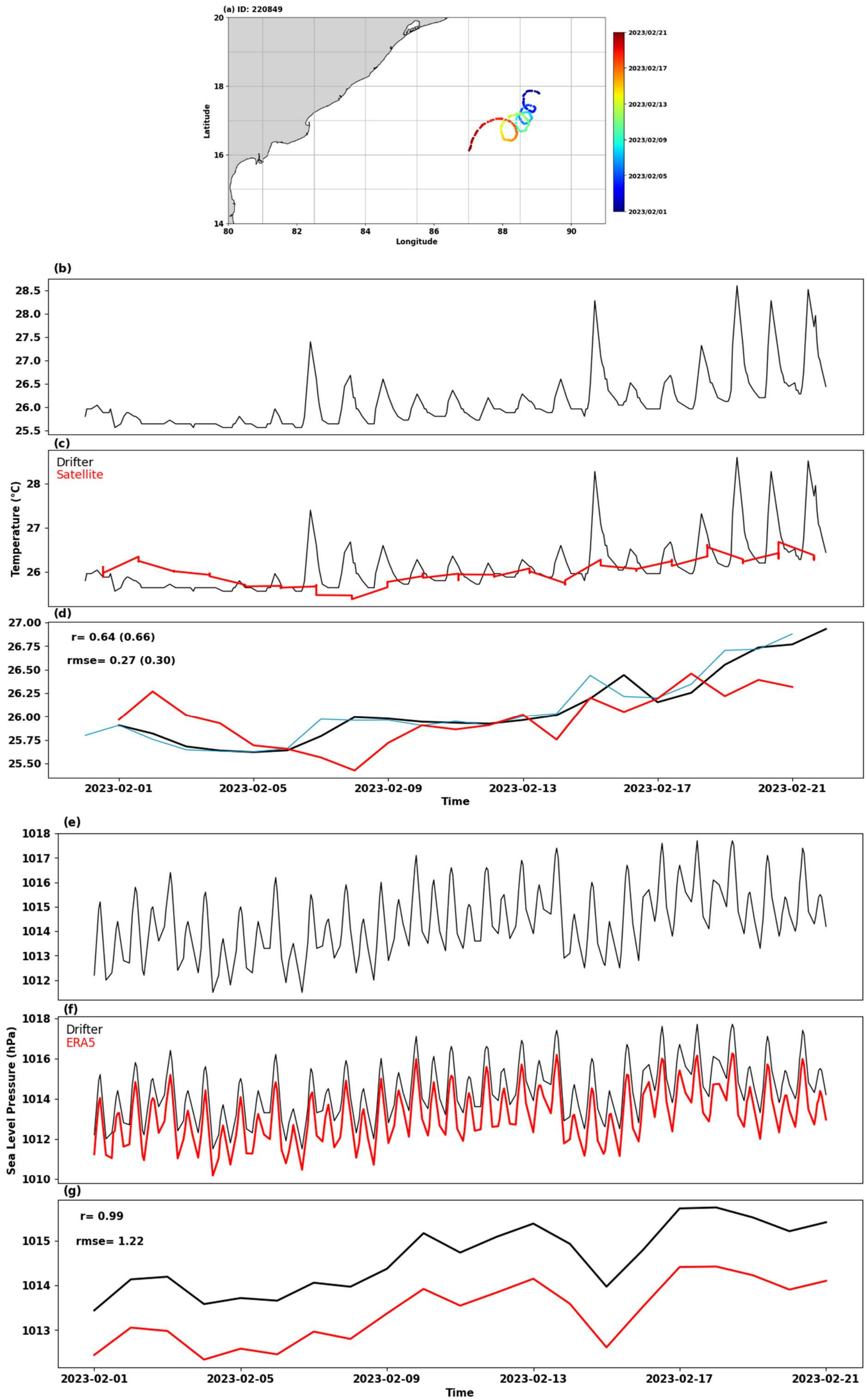

Figure 36. Same as Figure 8, but for drifter ID: 220849.

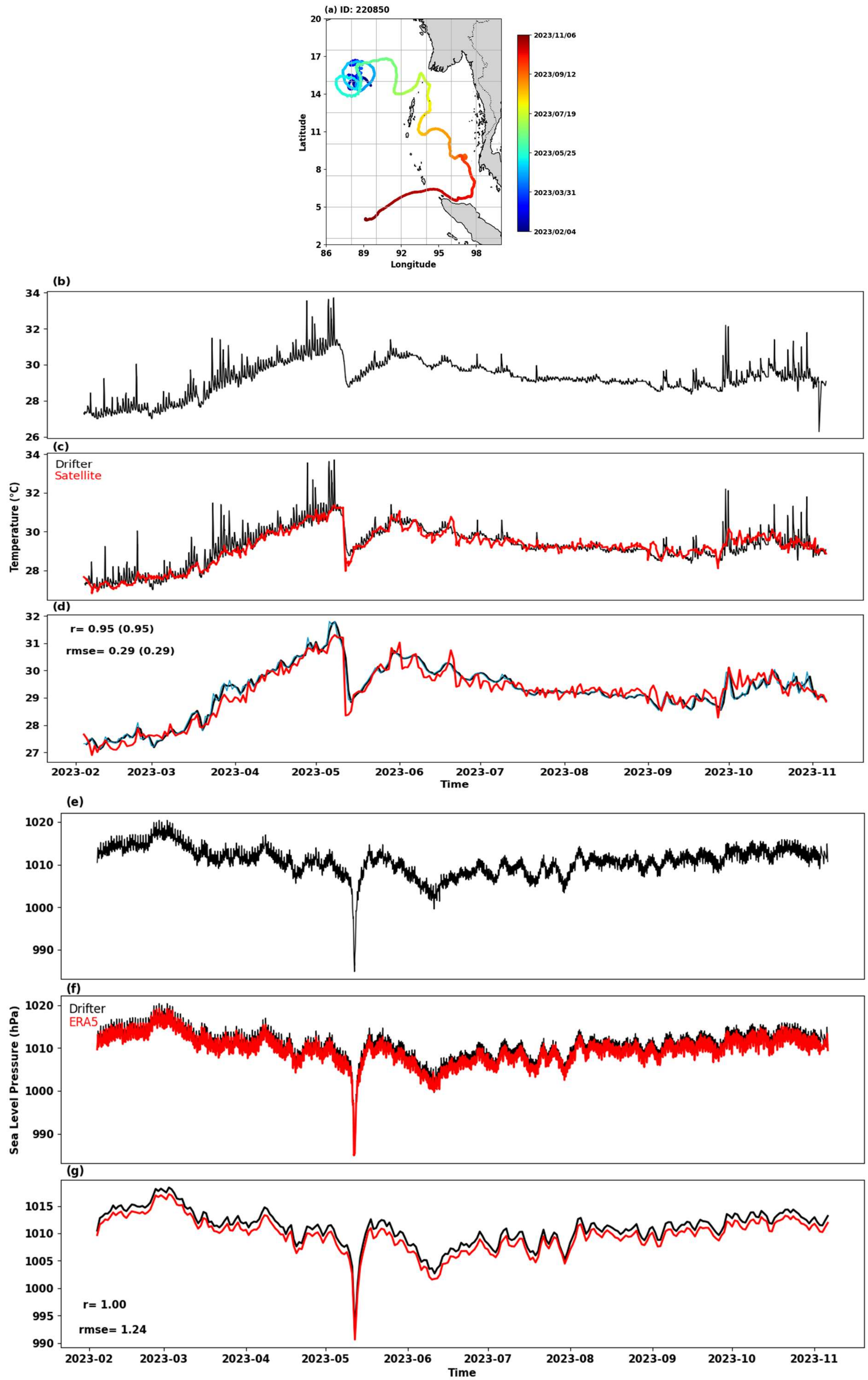

Figure 37. Same as Figure 8, but for drifter ID: 220850. SST and MSLP drop are associated with the passage of tropical cyclone *Mocha* (09-15 May 2023) over the Bay of Bengal.

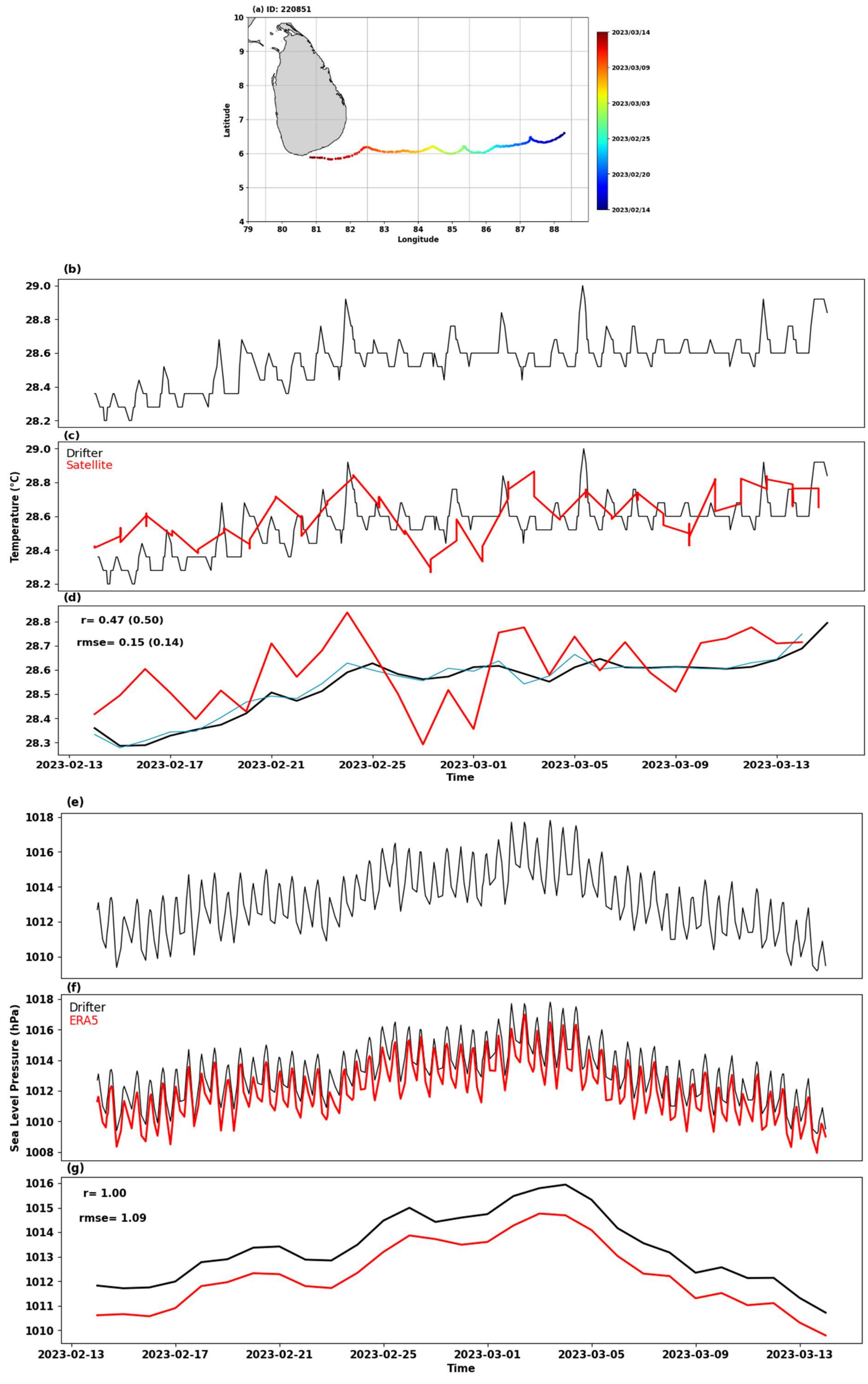

Figure 38. Same as Figure 8, but for drifter ID: 220851.