MEDITERRANEAN TROPICAL CYCLONE REPORT

Written by:
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Tropical Storm Andira
15-17 December 2020

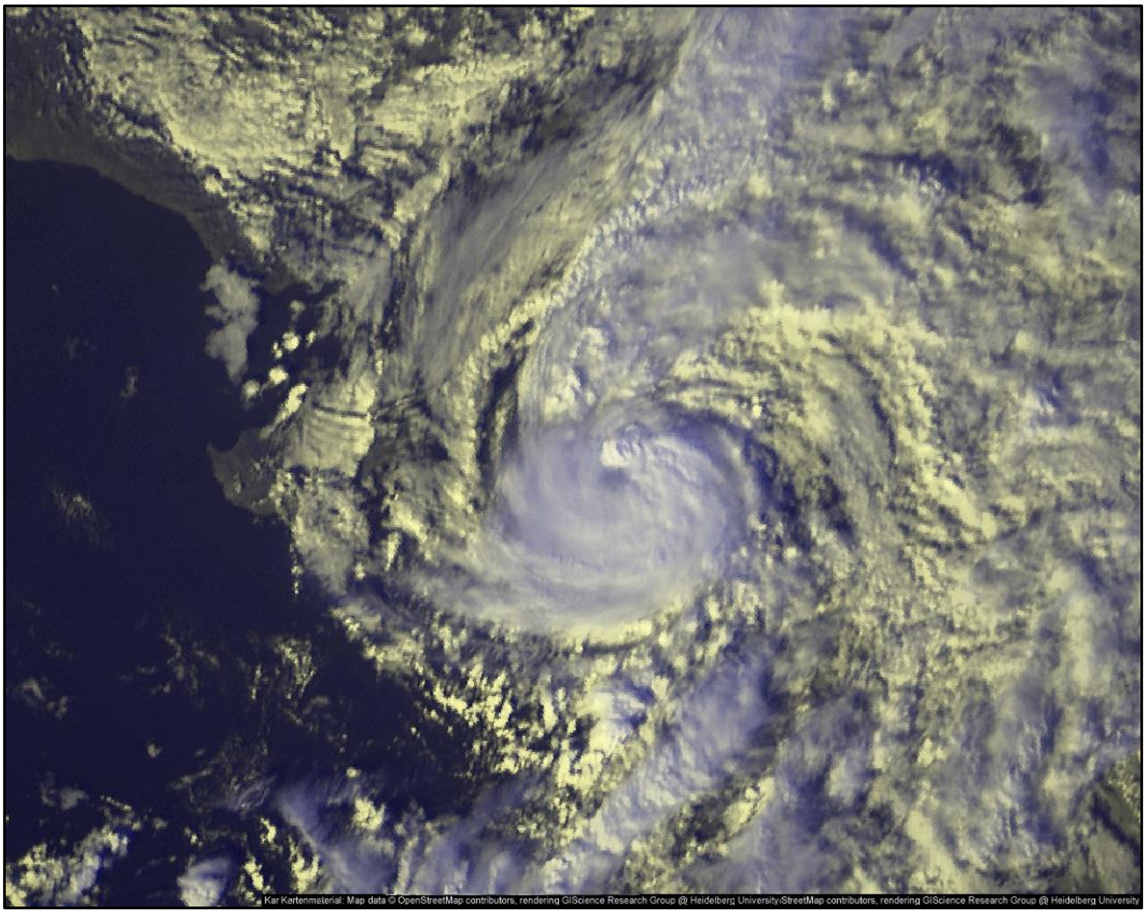

Image: EUMETSAT

Andira (named by Freie Universität - Berlin) was a very small but well-defined tropical cyclone which transitioned from an extratropical low near Cyprus and likely was a strong tropical storm on 16 December since it had a temporarily closed eye on radar and satellite images. Andira made landfall at the border of Syria and Lebanon late on that day and dissipated over the land on 17 December.

Synoptic history

In the first part of December a strong and very long-lasting blocking pattern dominated over Europe as a widespread anticyclone placed over the eastern part of the continent, while deep cyclones reached the northwestern part of Europe from the Atlantic Ocean. Thanks to the anticyclone these cyclones weakened fast, became nearly stationary, more of them even fell apart to multiple lows as moved eastward, and often generated secondary low-pressure systems over the Western and Central Mediterranean Sea along their frontal zones. The extratropical low, that the Freie Universität (Berlin) named to ‘Andira’ on 9 December – when it located east of Nova Scotia –, developed east of Florida on 7 December and quickly deepened as headed northeastward on the next days, and reach the northern parts of the British Isles on 11 December. Thereafter the cyclone fell apart to 3 low-level centers, and the northern 2 of these melted into the circulation of another deep extratropical cyclone’s which came from west, while the southernmost one became a cut-off cyclone over the Central-South Mediterranean Sea by 13 December and moved eastward then. This report follows the cyclone’s lifetime from this day.

The cyclone already had a lot of convection as it formed, especially along the cold front and near its center, where the higher instability associated with the upper-level cold airmass helped its formation. The occlusion process begun quite fast, already on 13 December, and in the night hours it seems that the cyclone had at least two separated low-level centers, but later the southernmost became the dominant which passed south of Crete and headed to east. In the afternoon and evening hours of 14 December, the convection gradually increased and became more organized around the cyclone’s center, although it still was not sustained. At night, Andira continued to gradually organizing. A larger band of sustained and deep convection with cloud top temperature around -60 °C developed on the northeast side of the cyclone, while smaller and a bit more shallow curved convective bands formed around and southeast of the cyclone’s center. Along with this, the whole cluster detached from the weakening frontal zone which moved away eastward and located over Turkey, Syria and Iraq in the morning hours of 15 December. Therefore Andira transformed into a subtropical cyclone by 0600 UTC (Fig. 3).

After 1300 UTC deep convection started to form closer to the center on the northeast side of the cyclone and a band of thunderstorms developed on its south side (Fig. 4). In addition, visible satellite images showed that the low-level circulation became more symmetrical by this time. On the north side of the cyclone, an upper-level poleward outflow channel also started to develop toward northeast, which became more apparent in the evening and night hours, when deep convection expanded and wrapped around the center, temporarily led to the formation of an eye-like feature (Fig. 5). Since the convection became sustained and according to the satellite measurements the wind field became more tropical-like then earlier, it is estimated that Andira transformed into a tropical cyclone around 1800 UTC 15 December. In the second half of the night a small but well-defined central dense overcast developed over the low-level center with cloud tops around -55, -60 °C. After 0500 UTC, a larger, partial eye-like feature formed from this, which shortly became obscured by new deep convection which started on the western and northern side of the center (Fig. 6). The convective bursts became more sustained from 1000 UTC, when a central dense overcast formed again, and the cyclone shortly developed a well-defined eye with strong, rotating convective cells in the eyewall. The eye temporarily became visible on the infrared satellite too around 1200-1300 UTC (Fig. 7). Andira likely reached its peak intensity around this time and started to weaken slowly as it nearing the coastline in the next hours. However, according to the estimates not so much weakening occurred until the landfall since deep convection periodically redeveloped around the eye (Fig. 8). The eye reached the coast around 1800 UTC, directly at the border of Syria and Lebanon, north of *Tripoli*. After the landfall, the eye quickly collapsed, but until around 0000 UTC 17 December the convection remained fairly strong, especially on the east side of Andira. Then the convection also diminished fast, so the cyclone became a remnant low by 0600 UTC, and weakened into a disorganized area of low pressure thereafter, but some mid-level spin was evident on satellite images until the night as its remnants turned to south.

Beside the satellite images, radar data from *Hatay* (Turkey) were very helpful the determinate the cyclone’s structure (Fig 9). In the developing phase between 1800 UTC 15 December and 0600 UTC 16 December initially well-defined curved bands formed on the north and east side of the cyclone, which transitioned into a larger, opened eye-like feature by the end of this period. Around 0900 UTC and after that, a more well-defined and compact eye developed which temporarily became closed, and especially between 1200 and 1500 UTC strong convection occurred in the north and east part of the eyewall, the reflectivity of the strongest cells sometimes neared or reached the 50 dBz. After that, the convection weakened somewhat, but the eye remained intact until the landfall.

Meteorological statistics

Andira was a very small cyclone, it spend its most time over water and made landfall in an area where the meteorological observations are poorly, and based on these factors the available wind and pressure (Tabl. 2) data were very limited, especially from the subtropical and tropical phase. The few available ship reports (Tabl. 3) limited mainly from the extratropical phase of the cyclone too, but the availability of the precipitation data (Tabl. 4) was a bit better. ASCAT and SCATSAT measurements (Fig. 10-11) were the only data which confirmed that Andira was a tropical storm, but these did not catch the peak of the cyclone.

Winds and pressure

Andira produced gale force, 65-75 km/h (35-40 kt) winds in a larger area during its extratropical phase, mainly on the western and southern quadrant. These values were confirmed by reports from land stations and ships as well as the satellite measurements of ASCAT and SCATSAT sensors. Based on these, it is estimated that the strength of the cyclone did not changed much until the subtropical transition. The central pressure also was good analyzable at this time, because the broad central area of the cyclone moved near the southeastern islands of Greece and the coastline of Turkey on 13-14 December. Since the cyclone formed within a former low-pressure area that located over the Central Mediterranean Sea before the precursor cut off low reached the area, the central pressure was fairly low already after the cyclogenesis but did not change very much on the first to days.

In the subtropical and tropical phases, no land and ships measurements were available near the cyclone, so only the satellite measurements helped the estimation of the intensity. However, since Andira was very small and located close to the land, these data also loaded with errors. On 15 December, 3 ASCAT passes were available. The firs one at 0711 UTC, shortly after the subtropical transition still showed an asymmetric and a bit elongated wind field, and strongest winds expanded farther from the center, especially on the south and southeast side. The other 2 passes occurred at 1802 UTC and 1917 UTC, and the wind field became more symmetrical and compact by this time. The measurements also indicated quick strengthening as the first pass showed maximum winds around 55 km/h (30 kt) but the second already 75 km/h (40 kt). After that no more ASCAT measurements were available until 1809 UTC 16 December, when the cyclone already made landfall, and this pass also contained a lot of unflagged wind. 2 SCATSAT measurements were available both on 15 and 16 December too, although this equipment is more inaccurate than the ASCAT sensors. These showed a bit stronger winds compared to the ASCATs, with credible maximum wind around 85 km/h (45 kt) at 1703 UTC 15 December and 0647 UTC 16 December, and there are some, but mainly unflagged wind barbs around 95 km/h (50 kt). Based on the satellite measurement and the improvement of the cyclone's structure before the landfall, when no exact data were available, it is estimated that Andira peaks with 100 km/h (55 kt) winds around 1200 UTC, but since the satellite and radar presentation was well-defined, it cannot be ruled out that it had a bit stronger winds. There were no available pressure data from the subtropical and tropical phase of the cyclone. However, some amateur reports from *Tripoli* suggested that the pressure dropped off around 1000 hPa at the landfall, and if this data is correct, the minimum central pressure likely was around 994-995 hPa when Andira peaked in intensity.

Rainfall

Andira caused the most precipitation in the southwest parts of Turkey on 12-14 December, when it was still extratropical. The 3 days amounts reached 100-150 mm in a lot of place, and locally even more. For example, the region of *Antalya* got 250-300 mm precipitation, and it fell around 200 mm rain only on 13 December. Since the cyclone had rather convective appearance it is possible that the precipitation summary was even above of these values in some areas, especially in the mountains. The rain amount also reached about 100-150 mm in some Greek islands near Turkey. It is worth to be noting that the multiple low-pressure area before Andira already caused around 50-100 mm rain in these Greek and Turkish territories on 10-11 December. On Cyprus and the Middle East the cyclone caused mainly moderate, around 30-60 mm amount of precipitation, but the summary locally reached or exceeded 100 mm. According to the earlier mentioned radar data, Andira's curved bands and eastern eyewall caused durable rain in a smaller area on the coastline of Syria and northwest Lebanon, and it seems possible that some place got even 150-200 mm precipitation, but there was no available measurement what confirmed it.

Storm surge

There were no available wave height measurements or eyewitness videos from the storm surge associated with Andira.

Reanalysis data

Andira had been analyzed by ECMWF-ERA5 high-resolution reanalysis data. The examined parameters were 300 hPa divergence and winds (Fig. 12), 925 hPa geopotential and 850 hPa vertical speed (Fig. 13), 850 hPa equivalent potential temperature and wind (Fig. 14), 500-1000 hPa thickness and 850 hPa relative vorticity (Fig. 15), 200-1000 hPa thickness and 300 hPa potential vorticity (Fig. 16) and vertical cross-sections of potential vorticity (Fig. 17). The analysis expanded from 0000 UTC 13 December to 2100 UTC 17 December. However, only two images are listed here: the first one is at 0000 UTC 14 December, when Andira still was extratropical, and second one at 0900 UTC 16 December, when it reached its best appearance as a tropical storm on the analysis. An animation of all reanalysis maps is available here:

https://www.youtube.com/watch?v=zmyM-gIsNus

The extratropical phase of Andira was very classical according to the analyzed parameters. On 13 and 14 December a moderate jet stream located on the western and southern side of the cyclone which generated upper-level divergence above it due to the streams as an upper-level low gradually cut off and also thanks to the circulation of the yet streak. This divergence was temporarily quite strong and helped the development of the earlier mentioned intense convective systems over Greece and South Turkey, which were represented by the strong updraft areas on 850 hPa vertical velocity maps too. Before and along the cold front a warm conveyor belt reached that area that also fed the thunderstorms with warm and moist air. On 14 December the warm and moist air mass gradually wrapped into the cyclone’s center more and more extensively while an elongated cold, dry conveyor belt area developed south of this feature behind the cold front. The temperature difference also was high between the two sides of the front which was indicated by the sharp gradient in the thickness fields, and the upper-level trough/low generated widespread area of potential vorticity at 300 hPa in the cold sector.

The subtropical and tropical phase of Andira on 15 and 16 December was not so well represented, likely due to the very small size of the storm and the lack of concrete measurements. The cyclone remained under the middle of the large, weakening upper-level low, where the upper-level winds were slight, provided low-shear environment for Andira. Mainly from the afternoon hours of 15 December to the morning hours of 16 December, a smaller subvortex over Turkey generated southerly and southwesterly flow on the north and northeast side of the cyclone which contributed the formation of the earlier mentioned upper-level poleward outflow channel and strengthened the upper-level divergence over the cyclone. As the upper-level low weakened, the 300 hPa potential vorticity also became weaker and its coverage reduced, but smaller areas of stronger vorticity persisted, mostly to the west and southwest of the storm. This anomaly – that stretched downward from the typically strong stratospheric potential vorticity area – was visible on the vertical cross section too, while only a very weak and shallow PV tower appeared associated with the cyclone. The 200-1000 hPa thickness showed very little evident of warm core and its gradient remained quite high, which also indicated that the cyclone was not very deep, and still cold air dominated above and north of it. The warm core was a bit more defined on the 500-100 hPa thickness maps, and the 850 hPa relative vorticity showed more typical appearance as it become more stronger and concentrated in the cyclone’s center when it transitioned into subtropical and then tropical storm, and the earlier frontal features dissipated. In line with this process, after a short period of weakening on 15 December, the updrafts at this pressure level also became stronger near the center of Andira around and after the tropical transition, but not as strong as it occasionally was in the extratropical stage along the cold front. After the earlier frontal features like the warm and cold-dry conveyor belts dissipated on 15 December, the EPT values steadily increased as well around the cyclone’s center and remained higher until 2100 UTC 16 December.

Table 1 Best track for Andira, 13-17 December 2020

Day/Time [UTC]	Latitude [°N]	Longitude [°E]	Pressure [hPa]	Wind speed [km/h *(kt)*]	Stage
13 / 0000	37.0	16.3	998	65 *(35)*	extratropical
13 / 0600	36.8	18.0	997	65 *(35)*	”
13 / 1200	35.6	21.1	996	65 *(35)*	”
13 / 1800	36.5	22.7	995	75 *(40)*	”
14 / 0000	35.5	21.6	995	75 *(40)*	”
14 / 0600	34.4	23.1	996	75 *(40)*	”
14 / 1200	33.2	25.8	996	75 *(40)*	”
14 / 1800	33.5	28.6	997	75 *(40)*	”
15 / 0000	33.7	30.0	998	75 *(40)*	”
15 / 0600	33.9	31.7	1000	75 *(40)*	subtropical storm
15 / 1200	34.1	33.6	1000	75 *(40)*	”
15 / 1800	34.8	34.7	998	85 *(45)*	tropical storm
16 / 0000	35.3	35.3	996	95 *(50)*	”
16 / 0600	35.2	35.3	995	95 *(50)*	”
16 / 1200	34.9	35.4	994	100 *(55)*	”
16 / 1800	34.7	35.9	997	85 *(45)*	”
17 / 0000	34.6	36.3	1008	45 *(25)*	tropical depression
17 / 0600	34.4	36.9	1013	35 *(20)*	low
17 / 1200					dissipated
16 / 1200			994	100 *(55)*	minimum pressure and maximum wind
16 / 1800			997	85 *(45)*	landfall north of Tripoli (Lebanon)

Table 2 Selected surface winds and pressure observation

Location	Minimum sea level pressure		Maximum surface wind speed		
	Day/Time [UTC]	Pressure [hPa]	Day/Time [UTC]	Sustained (10-min) [km/h *(kt)*]	Gust [km/h *(kt)*]
El Khoms (Libya)			13 / 1000	56 *(30)*	
El Khoms (Libya)			13 / 1500	65 *(35)*	
Methoni (Greece)	13 / 1500	996.7			
Matera (Italy)			13 / 1600	63 *(34)*	
Kalamata Airport (Greece)	13 / 1800	996.8			
Derna (Libya)			13 / 1800	56 *(30)*	
Matera (Italy)			14 / 0200	61 *(33)*	
Astypalaia (Greece)	14 / 0300	996.0			
Skyros Airport (Greece)			14 / 0900	48 *(26)*	72 *(39)*
Tobruk (Libya)			14 / 0900	56 *(30)*	
Matera (Italy)			14 / 1000	70 *(38)*	
Datca (Turkey)	14 / 1100	997.3			
Derna (Libya)			14 / 1800	93 *(50)*	
Derna (Libya)			15 / 0900	63 *(34)*	
Sitia (Greece)			15 / 1200	48 *(26)*	70 *(38)*
Rosh Haniqra (Israel)			15 / 1900	43 *(23)*	
Basel Assad I.A. (Syria)	16 / 0300	1007.4			
Basel Assad I.A. (Syria)	16 / 1500	1011.3			

Table 3 Selected ship reports

Day/Time [UTC]	Ship call sign	Latitude [°N]	Longitude [°E]	Wind dir/speed [km/h *(kt)*]	Pressure [hPa]
13 / 0000	9VKH7	33.5	23.5	190 / 59 *(32)*	1003.7
13 / 0700	9VHK7	32.8	28.1	180 / 56 *(30)*	1006.8
14 / 0000	VRKF2	33.4	26.0	230 / 59 *(32)*	999.9
14 / 0100	C6CM8	35.7	23.7	220 / 26 *(14)*	996.2
14 / 1000	VROO5	34.4	21.7	310 / 72 *(39)*	1005.1
15 / 0000	A8KC6	33.2	30.3	230 / 31 *(17)*	1001.0
15 / 0000	KSKM	32.7	33.2	220 / 70 *(38)*	1005.6
15 / 0600	C6CS9	31.2	29.7	230 / 67 *(36)*	1008.0

Table 4 Selected surface rainfall observation

Location	Rain on 12 Dec. [mm]	Rain on 13 Dec. [mm]	Rain on 14 Dec. [mm]	Rain on 15 Dec. [mm]	Rain on 16 Dec. [mm]	Total rain [mm]
Chios Airport (Greece)	37.1	124.7	0.2	0.0	0.0	162.0
Mytilini Airport (Greece)	40.0	44.0	2.1	0.0	0.0	86.1
Samos Airport (Greece)	11.8	20.0	15.6	0.0	0.0	47.4
Zakynthos (Greece)	6.0	53.5	0.0	0.0	0.0	59.5
Souda Airport (Greece)	0.3	4.2	38.5	5.3	0.0	48.3
Rhodes Airport (Greece)	1.5	25.2	32.6	0.0	0.0	59.3
Mugla (Turkey)	118.3	96.6	0.8	0.0	0.0	215.7
Cesme (Turkey)	23.6	88.7	1.3	0.0	0.0	113.6
Izmir (Turkey)	61.7	52.0	2.5	0.0	0.0	116.2
Izmir / Adnan M. (Turkey)	61.0	42.0	1.6	0.0	0.0	104.6
Kas (Turkey)	29.2	48.2	23.4	0.0	0.0	100.8
Kusadasi (Turkey)	75.5	14.0	0.0	0.0	0.0	89.5
Bodrum Milas (Turkey)	59.6	29.8	0.0	0.0	0.0	89.4
Finike (Turkey)	32.8	96.7	27.7	0.0	0.0	157.2

Antalya (Turkey)	29.0	223.2	37.4	0.0	0.0	289.6
Antalya-Bolge (Turkey)	23.0	161.5	39.3	0.0	0.0	223.8
Alanya (Turkey)	24.3	21.8	23.0	0.0	0.0	69.1
Isparta (Turkey)	0.8	21.6	7.6	0.0	0.0	30.0
Silifke (Turkey)	0.6	7.4	60.6	0.8	0.0	69.4
Mersin (Turkey)	0.3	3.5	56.2	2.0	0.0	62.0
Anamur (Turkey)	21.5	5.6	25.5	0.2	0.0	52.8
Marmaris (Turkey)	51.2	54.3	35.3	0.0	0.0	140.8
Datca (Turkey)	20.5	7.2	25.5	0.0	0.0	53.2
Kyrenia (Cyprus)	0.0	2.5	44.0	16.5	no data	63.0
Morphou (Cyprus)	0.0	0.5	29.8	28.4	6.1	64.8
Tymbu / Nicosia (Cyprus)	0.0	0.0	5.6	15.5	2.6	23.7
Athalassa (Cyprus)	0.0	0.8	3.0	22.0	0.8	26.6
Yesilirmak (Cyprus)	0.0	4.3	30.1	no data	no data	34.4
Akrotiri (Cyprus)	0.0	0.2	22.0	10.0	0.2	32.4
Larnaca Arport (Cyprus)	0.0	0.4	14.8	21.2	0.0	36.4
Safita (Syria)	0.0	0.0	18.0	14.0	77.0	109.0
Basel Assad Int. A. (Syria)	0.0	0.0	31.0	17.5	16.3	64.8
Tripoli (Lebanon)	0.0	0.0	no data	no data	55.0	55.0
Houche-Al-Oumara (Lebanon)	0.0	0.0	11.0	29.0	29.0	69.0
Rosh Haniqra (Israel)	0.0	0.0	0.8	48.6	90.1	139.5
Hadera Port (Israel)	0.0	0.0	2.0	1.7	39.7	43.4
Bet Dagan (Israel)	0.0	0.0	5.6	23.2	37.7	66.5
Har-Knaan / Zefat (Israel)	0.0	0.0	6.4	61.9	25.5	93.8

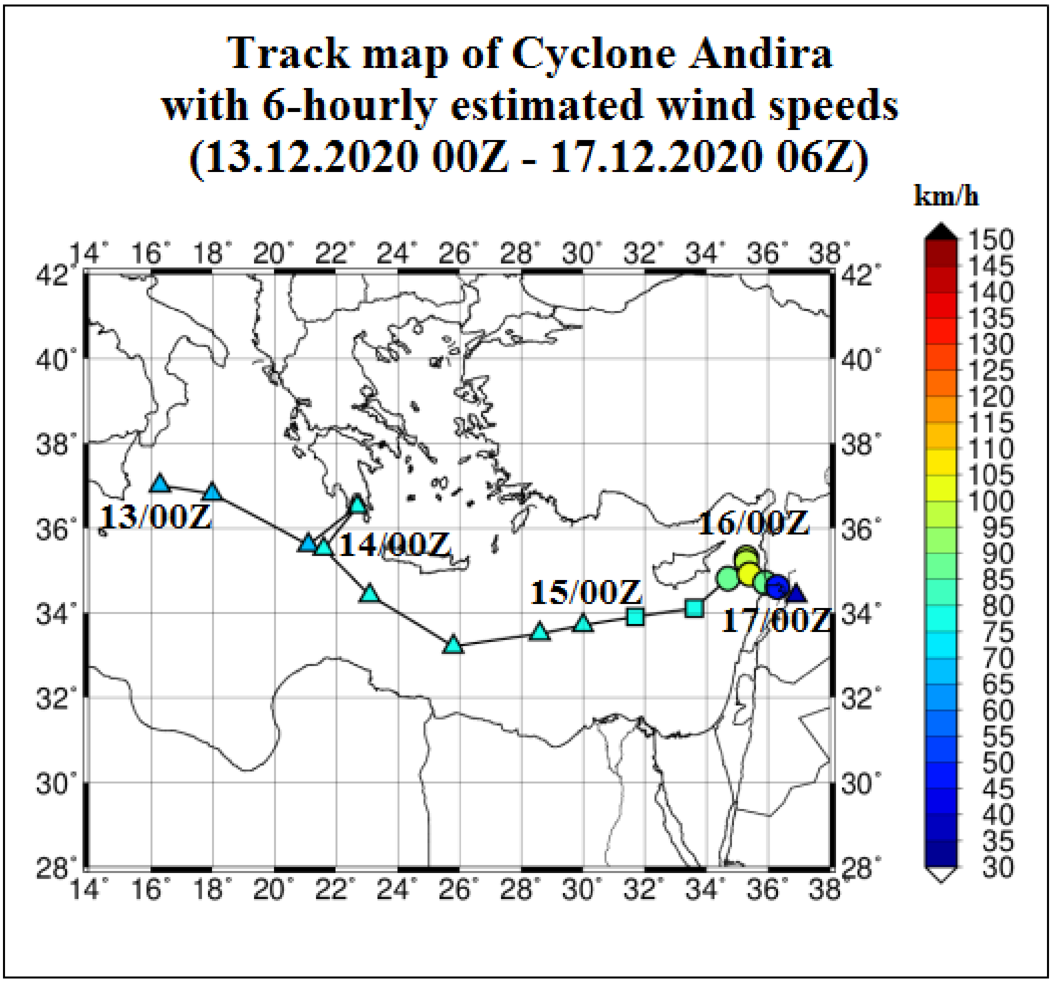

Figure 1. Best track positions for Tropical Storm Andira, 13-17 December 2020. The triangles mean extratropical, the squares subtropical and the circles tropical stage. The colors represented the estimated wind speeds (from Table 1) at the actual time. The position based on satellite images and ECMWF reanalysis.

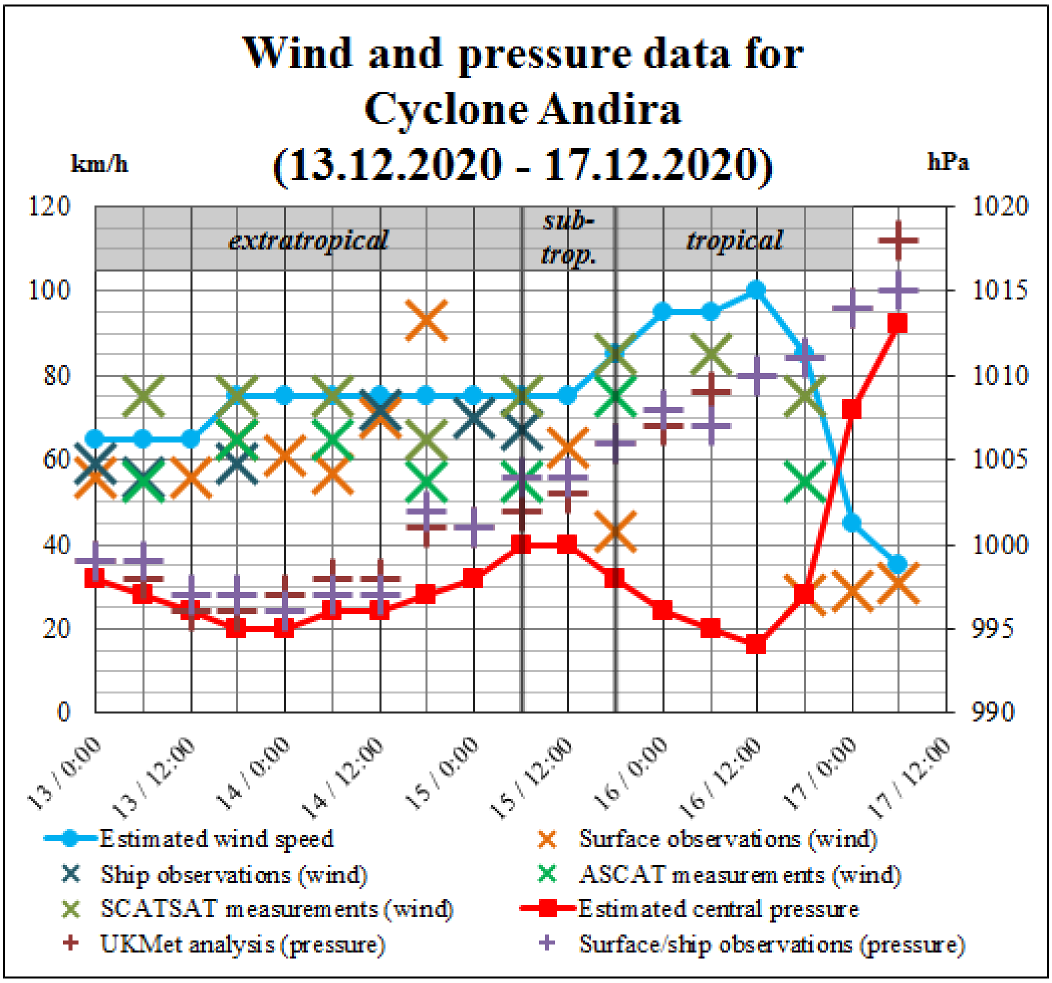

Figure 2. Selected wind and pressure observations with estimated maximum sustained wind and minimum central pressure for Tropical Storm Andira, 13-17 December 2020. The stated 6 hourly data mean the maximum sustained wind within a 3-hour interval around the marked time in case of all measurements.

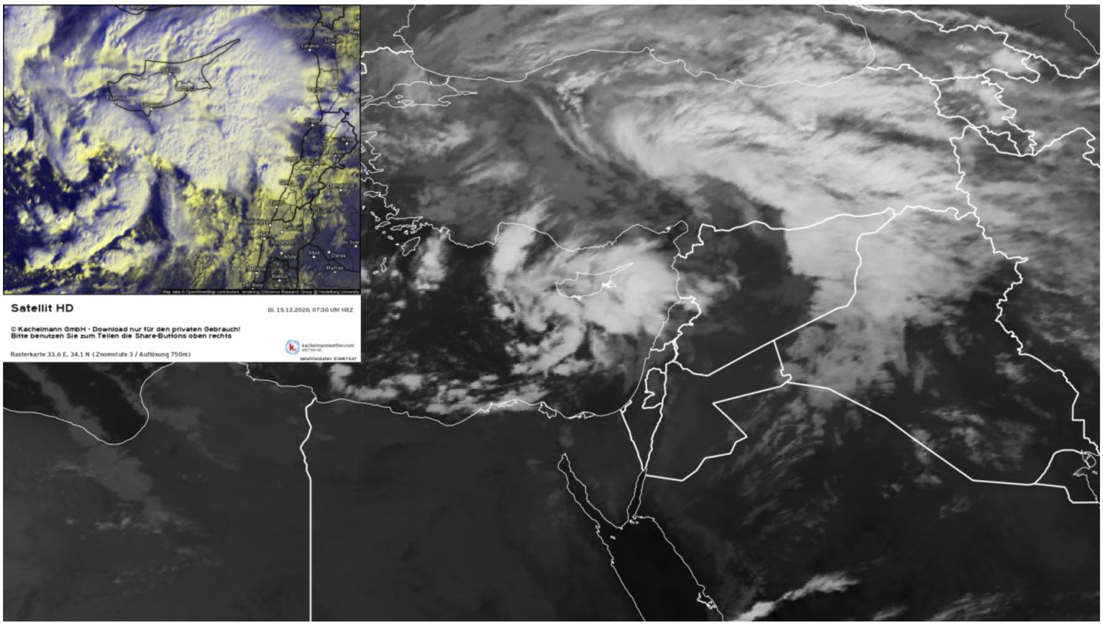

Figure 3. Infrared and visible (RGB) satellite images of Andira at 0630 UTC 15 December. The cyclone finished its transition into a subtropical storm around this time. *Source: EUMETSAT / Kachelmannwetter*

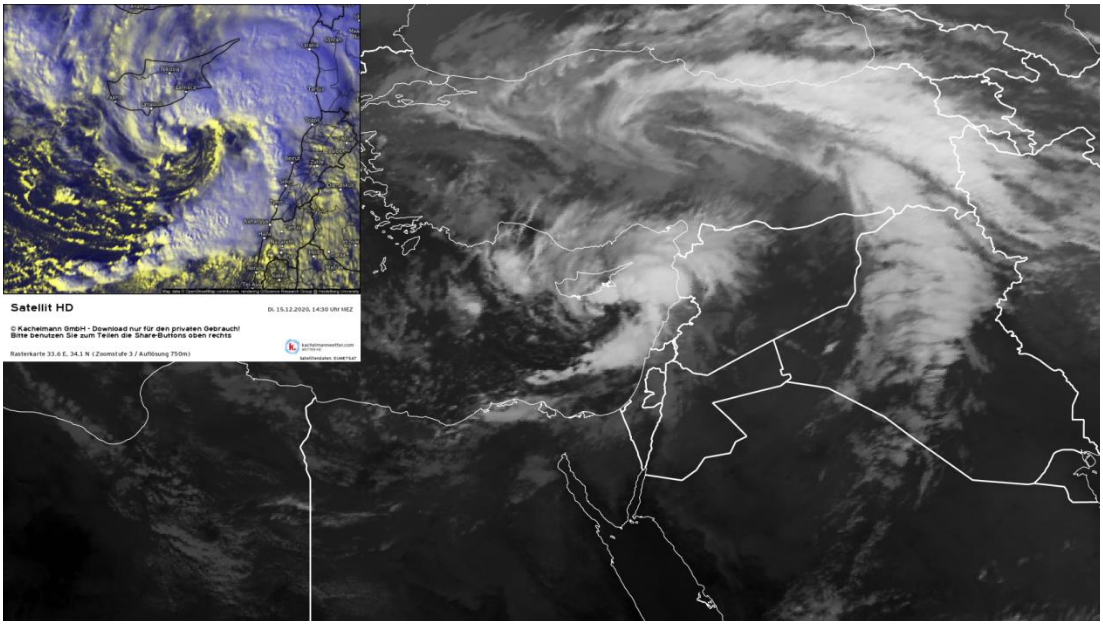

Figure 4. Infrared and visible (RGB) satellite images of Andira at 1330 UTC 15 December. Deep convection started to develop close to the center at this time, and a larger band of convection also formed on the southern side of the cyclone. *Source: EUMETSAT / Kachelmannwetter*

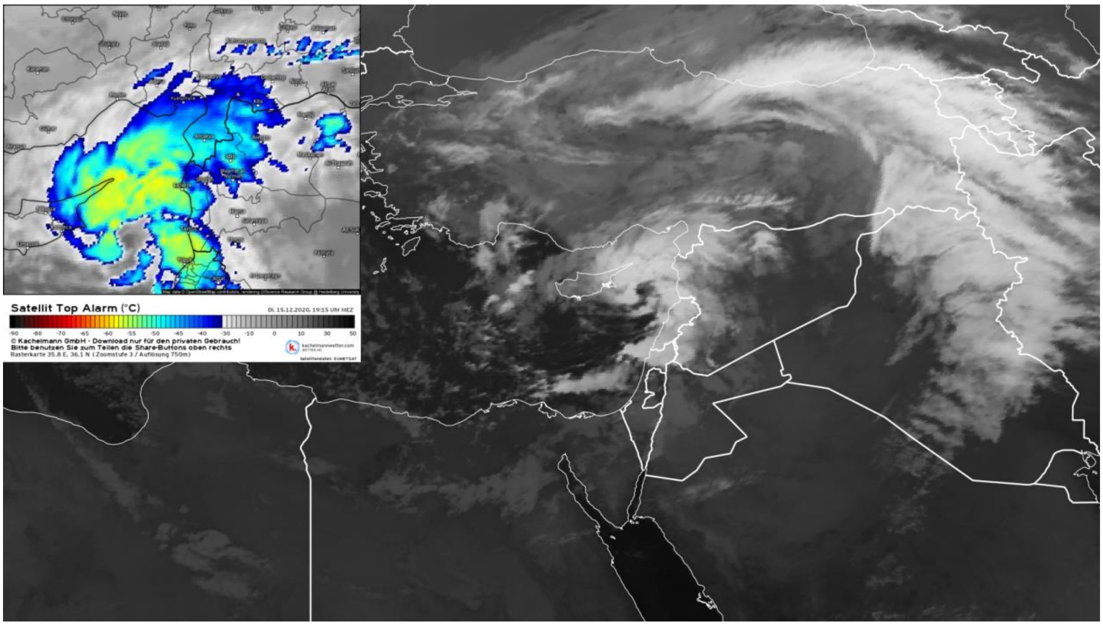

Figure 5. Infrared and cloud top temperature satellite images of Andira at 1815 UTC 15 December. Deep convection became more extensive and sustained around the center by this time, and a poleward outflow channel also formed on the northeast side of the cyclone, which indicated its transition into a tropical storm. *Source: EUMETSAT / Kachelmannwetter*

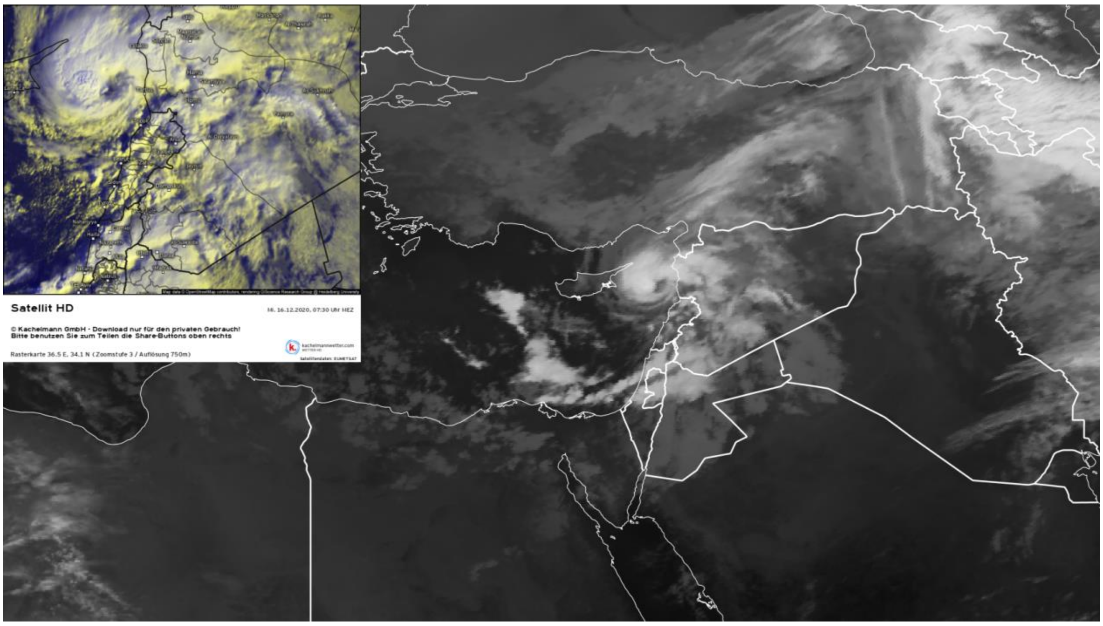

Figure 6. Infrared and visible (RGB) satellite images of Andira at 0630 UTC 16 December. The cyclone developed a larger, almost closed eye-like feature at this time. *Source: EUMETSAT / Kachelmannwetter*

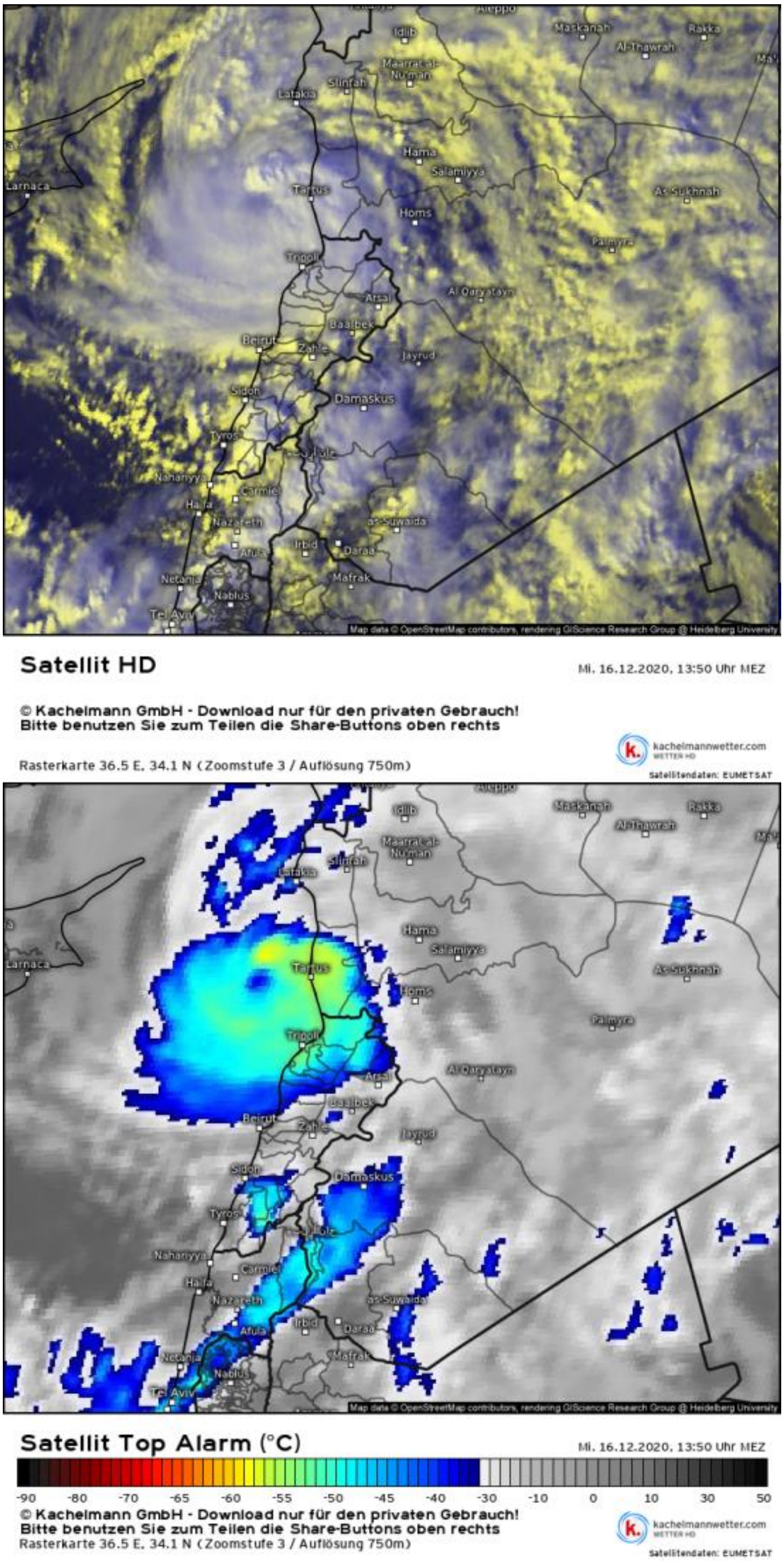

Figure 7. Visible (RGB) and cloud top temperature satellite images of Andira at 1250 UTC 16 December. The cyclone had the best structure around this time with an eye (covered by some high level clouds). *Source: EUMETSAT / Kachelmannwetter*

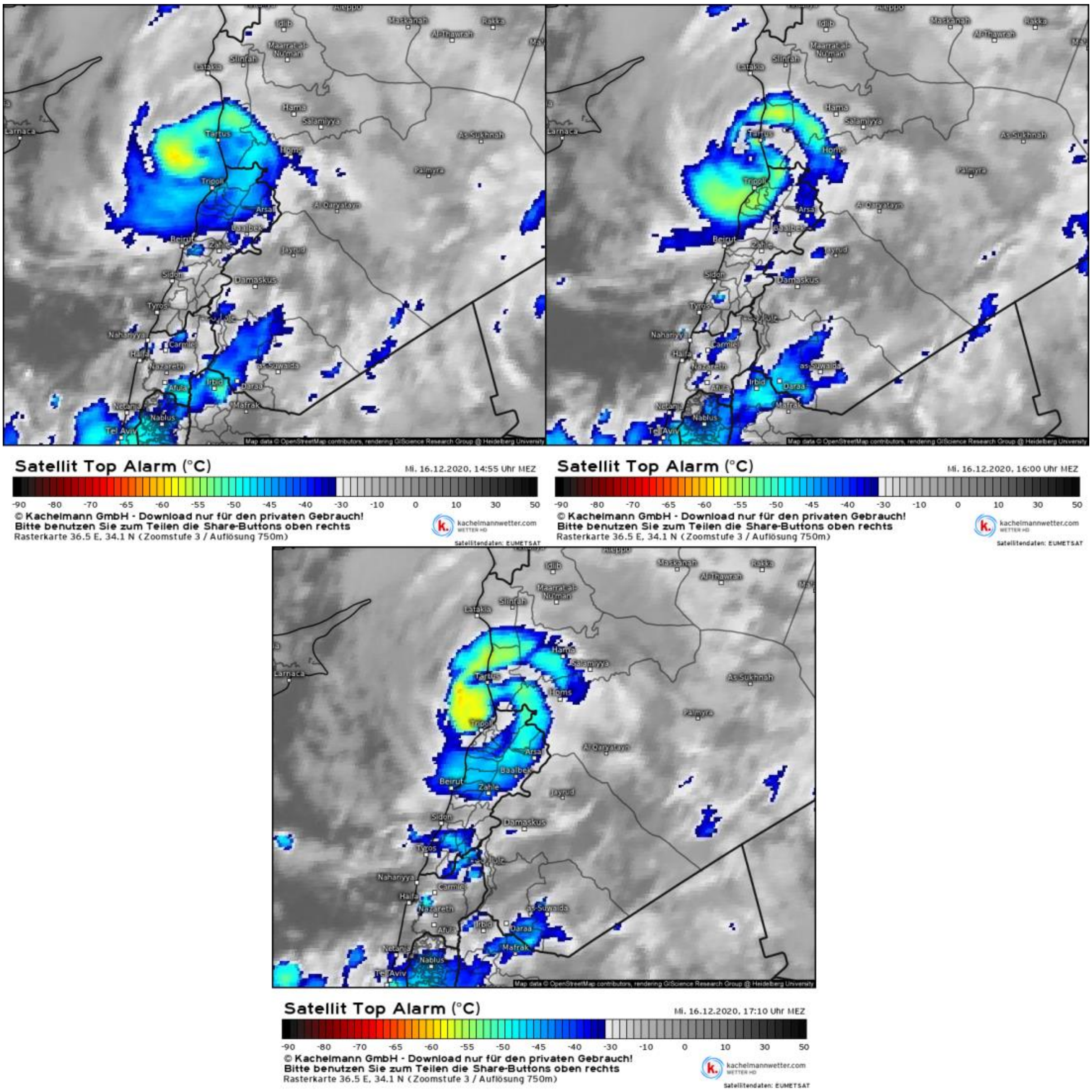

Figure 8. Cloud top temperature satellite images of Andira at 1355 UTC, 1500 UTC and 1610 UTC 16 December. The cyclone produced intermittent bursts of deep convection before the landfall and it developed small but well-defined spiral bands around the inner core, while its small eye (as warm spot) temporarily still was visible on the images. *Source: EUMETSAT / Kachelmannwetter*

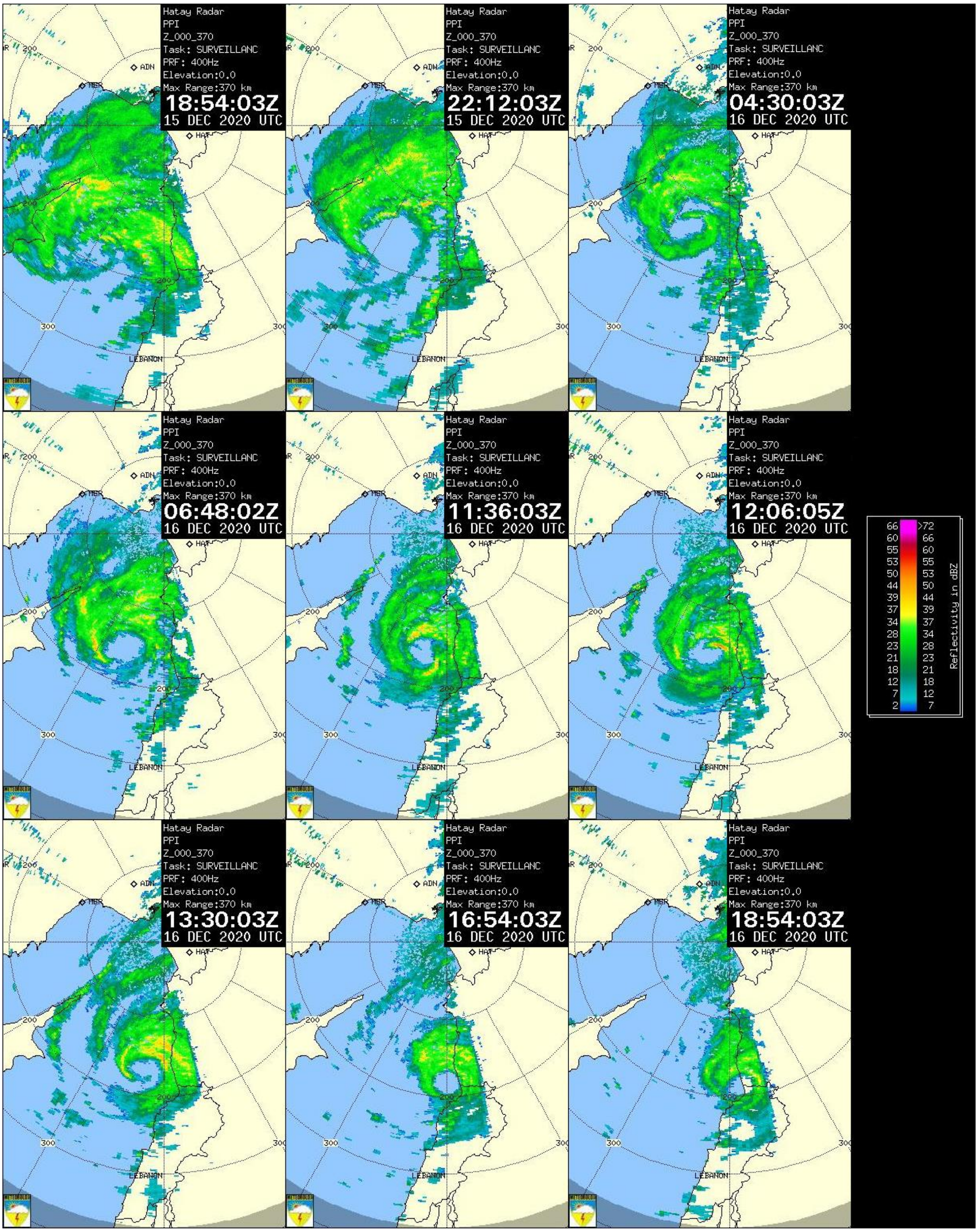

Figure 9. Selected radar data of Andira on 15-16 December. The images showed the formation of the compact, well-defined inner core and the eye of the cyclone. *Source: Turkish State Meteorological Service*

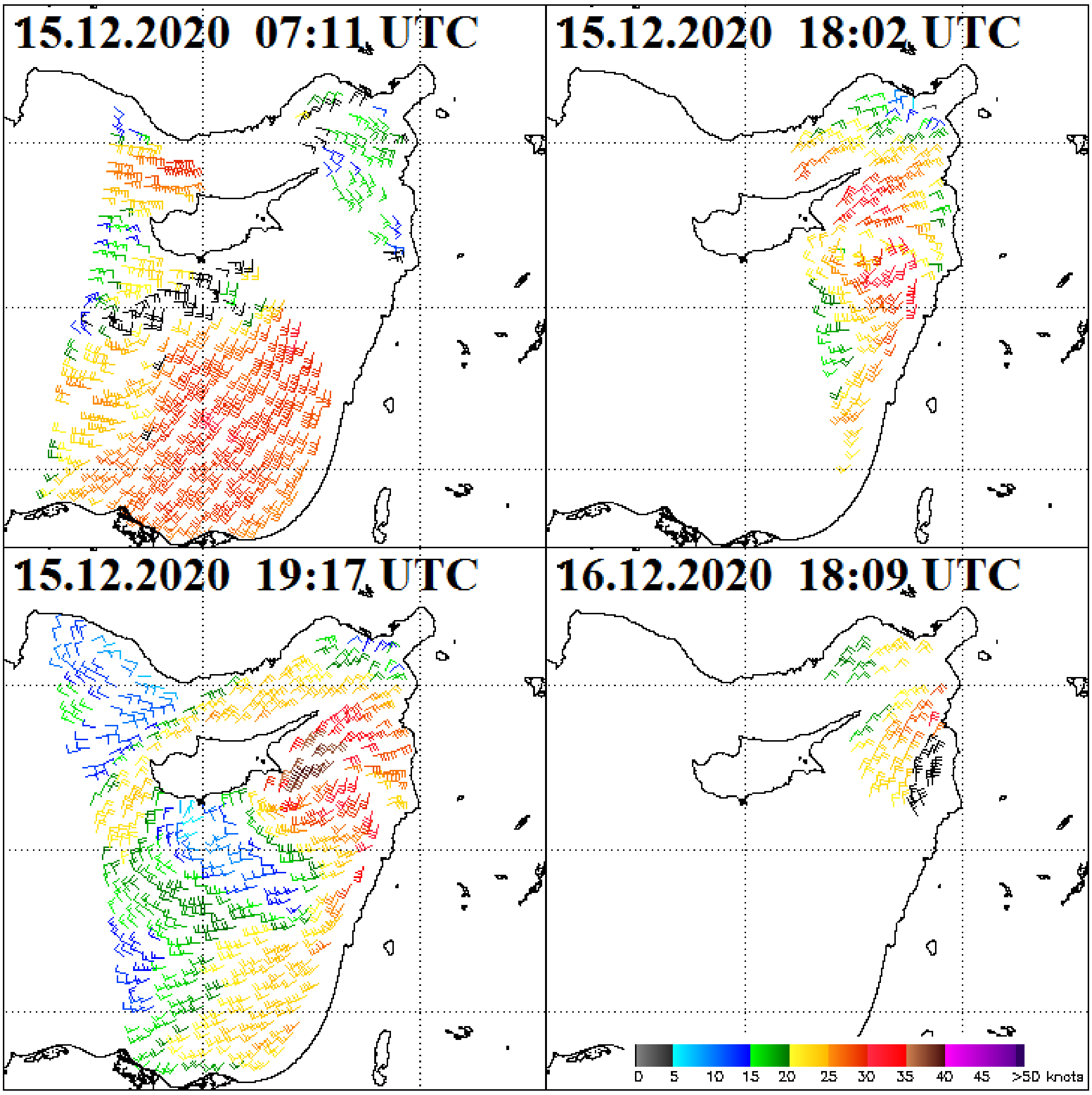

Figure 10. Satellite-based wind data of Andira on 15-16 December measured by ASCAT-A, ASCAT-B and ASCAT-C sensors. The first measurements presented the subtropical while the others the tropical transition of the cyclone, and the evening pass also showed the quick strengthening in line with the improving convective organization. *Source: NOAA NESDIS*

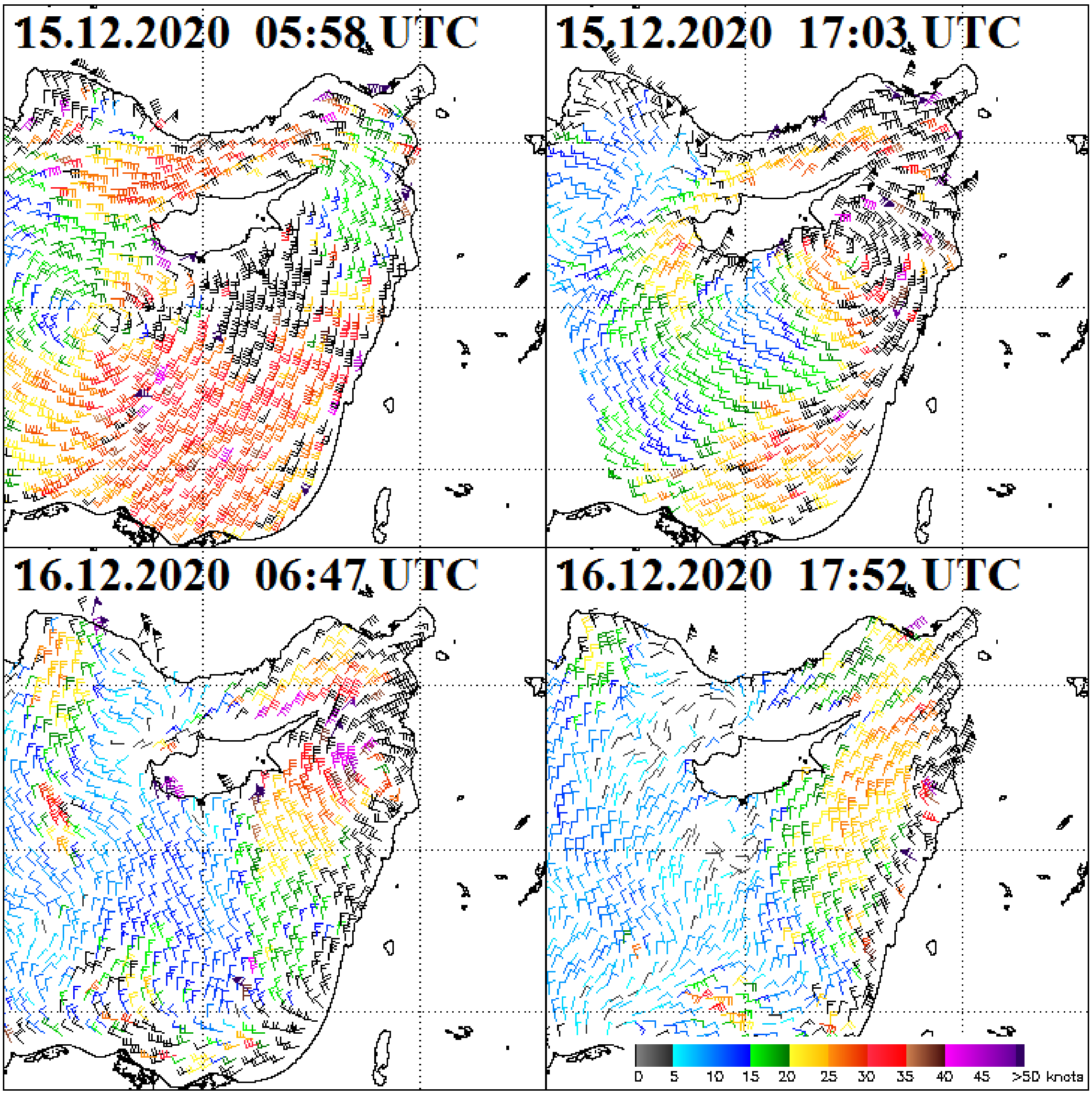

Figure 11. Satellite-based wind data of Andira on 15-16 December measured by SCATSAT sensor. These measurements showed the same structural and intensity changes as the ASCAT sensors, but with a bit stronger winds. *Source: NOAA NESDIS*

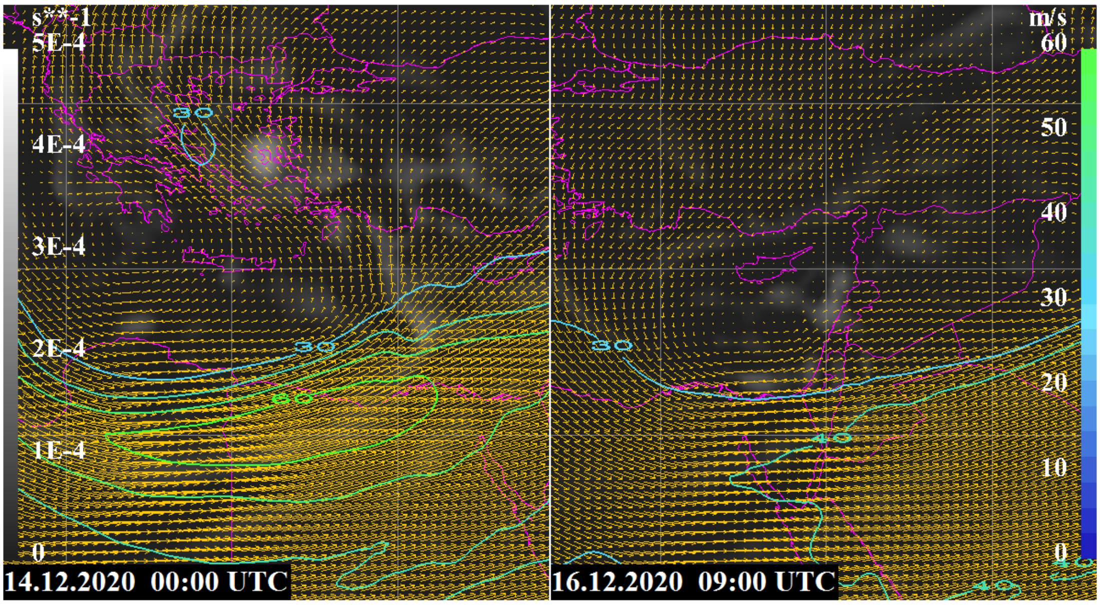

Figure 12. 300 hPa divergence (shaded) and winds (vectors and contours per 10 m/s from 30) over the Eastern Mediterranean Sea at 0000 UTC 14 December and 0900 UTC 16 December. *Data source: ECMWF/Copernicus*

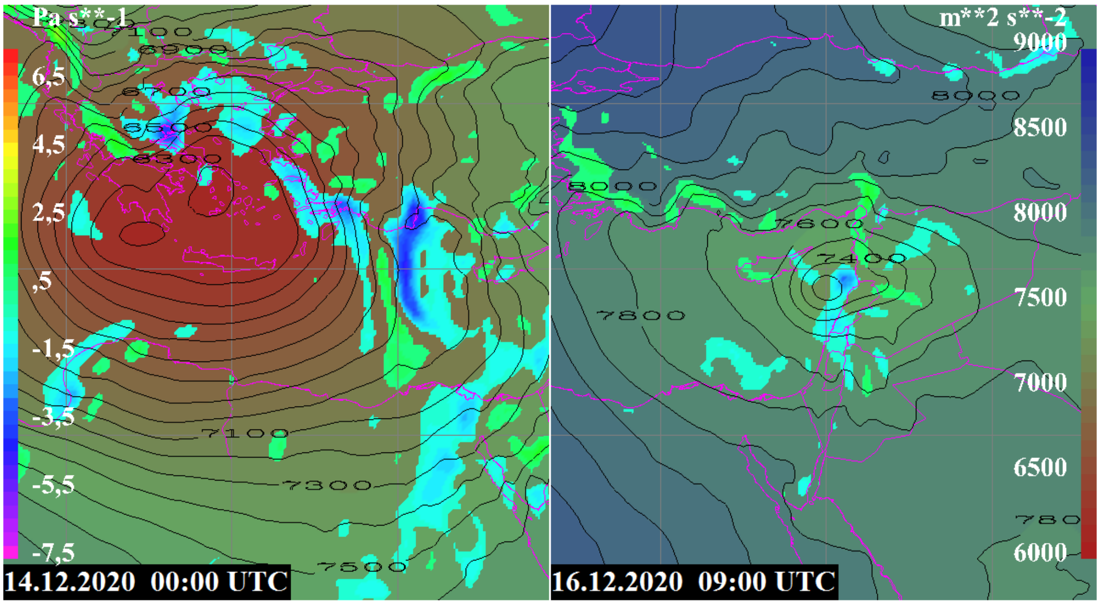

Figure 13. 925 hPa geopotential (shaded with black contours) and 850 hPa vertical speed (shaded patches, without the -0,5 to 0,5 Pa/s range) over the Eastern Mediterranean Sea at 0000 UTC 14 December and 0900 UTC 16 December. *Data source: ECMWF/Copernicus*

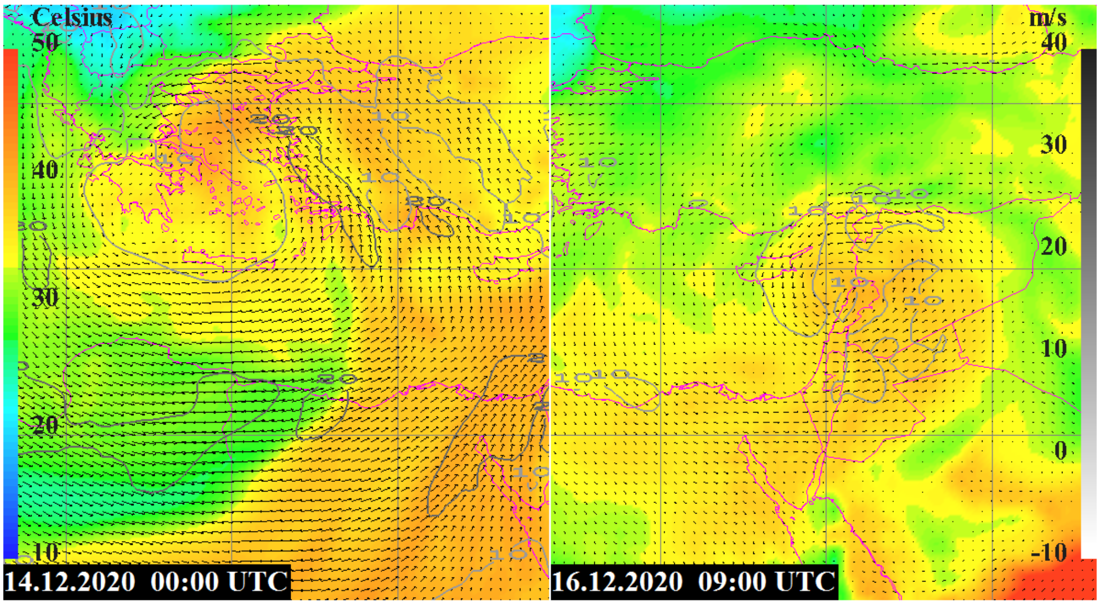

Figure 14. 850 hPa equivalent potential temperature (shaded) and winds (vectors and contours per 10 m/s) over the Eastern Mediterranean Sea at 0000 UTC 14 December and 0900 UTC 16 December. *Data source: ECMWF/Copernicus*

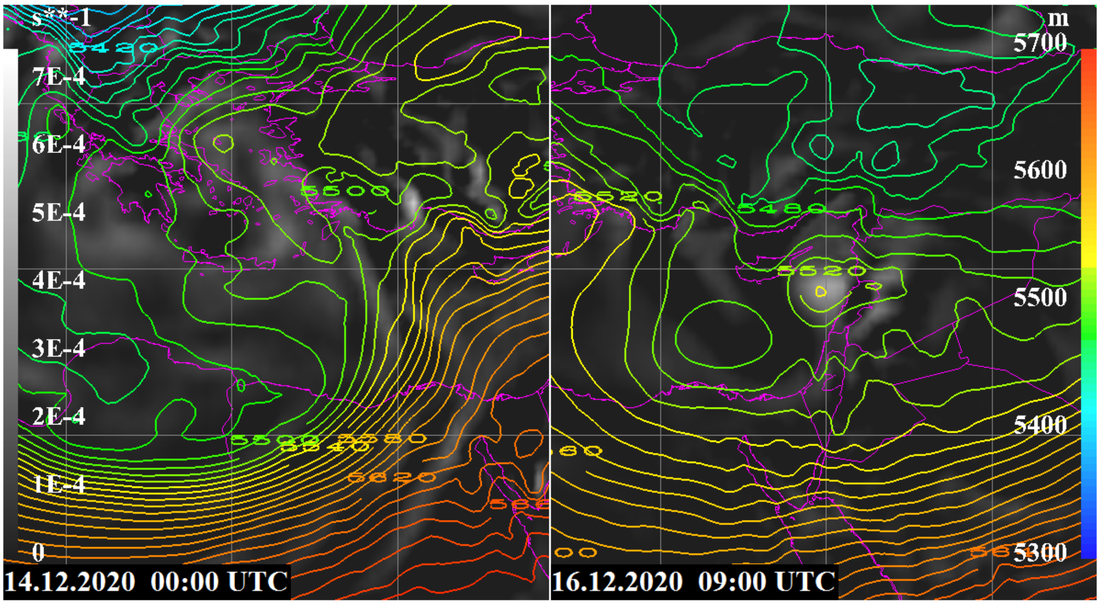

Figure 15. 500-1000 hPa thickness (contours per 10 m) and 850 hPa relative vorticity (shaded) over the Eastern Mediterranean Sea at 0000 UTC 14 December and 0900 UTC 16 December. *Data source: ECMWF/Coperncus*

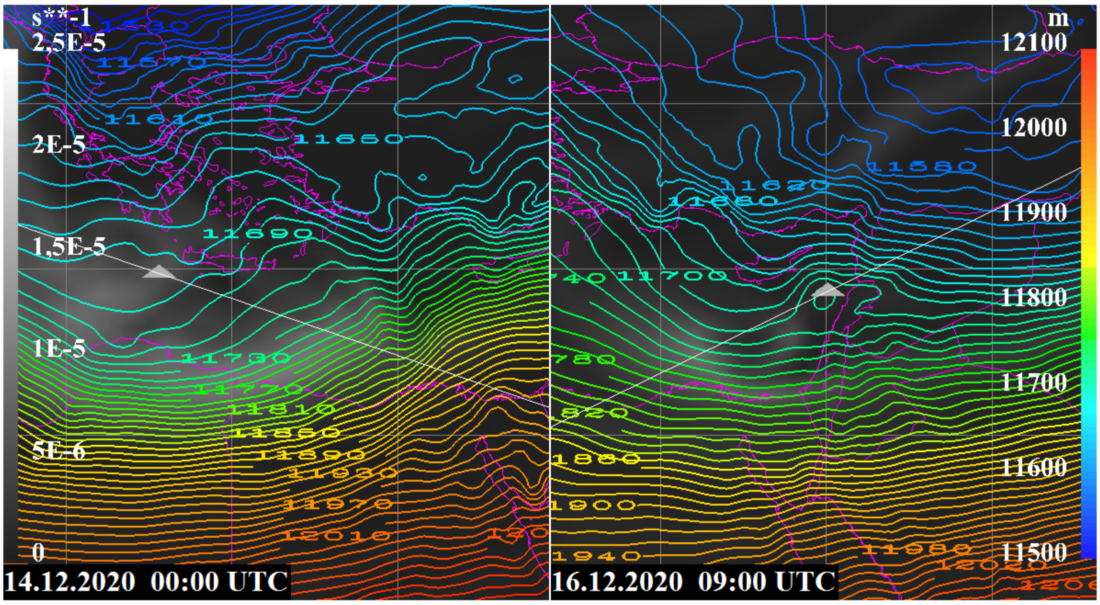

Figure 16. 200-1000 hPa thickness (contours per 10 m) and 300 hPa potential vorticity (shaded) over the Eastern Mediterranean Sea at 0000 UTC 14 December and 0900 UTC 16 December. *Data source: ECMWF/Copernicus*

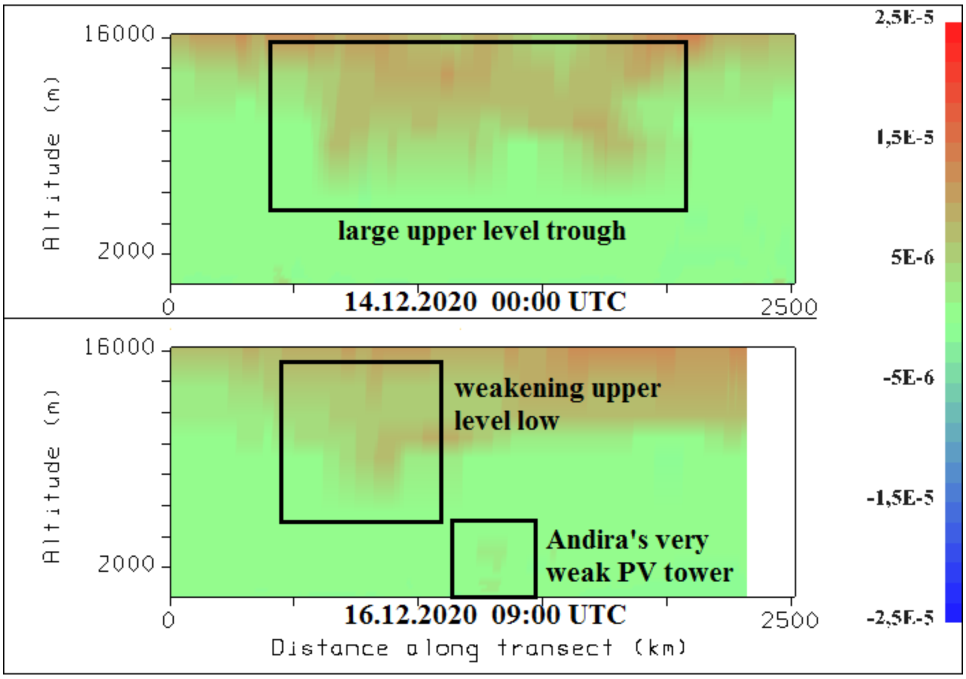

Figure 17. Potential vorticity vertical crosses through the center of Andira and its environment at 0000 UTC 14 December and 0900 UTC 16 December. The cross-sections marked with thin white lines on Figure 16. *Data source: ECMWF/Copernicus*