MEDITERRANEAN TROPICAL CYCLONE REPORT

Written by:
Dávid Hérincs

Tropical Storm Numa
16-19 November 2017

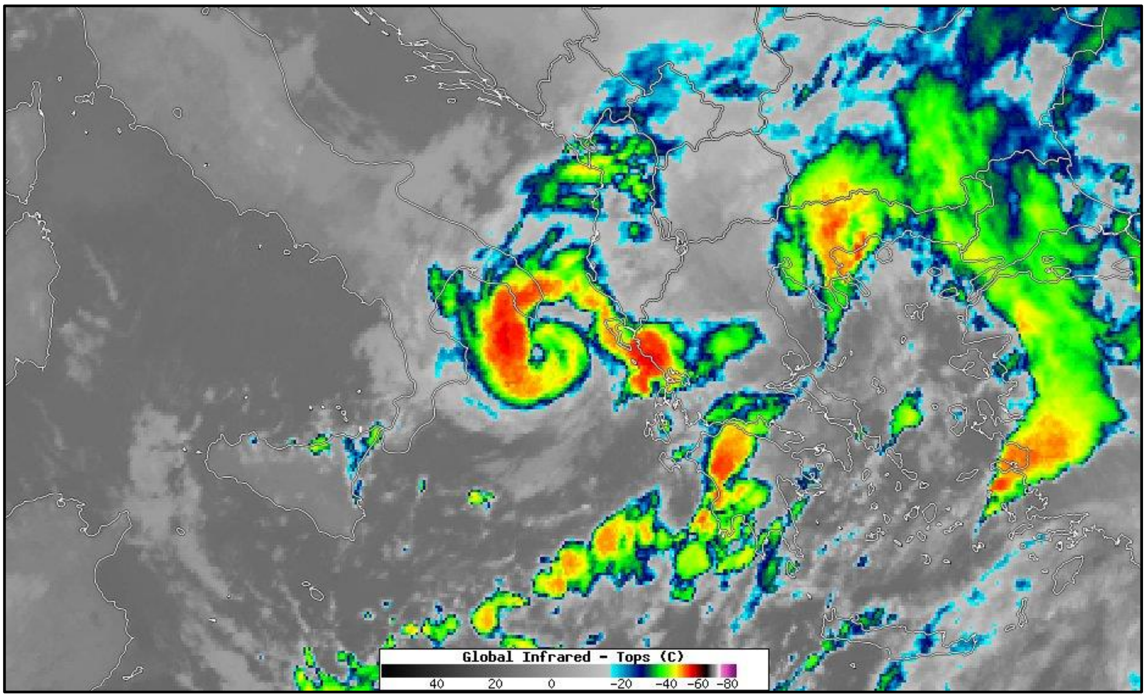

Image: EUMETSAT

Numa (named by Freie Universität - Berlin) developed over the Central Mediterranean Sea in the middle of November as a cut-off extratropical cyclone, and later it transitioned into a subtropical, then a tropical cyclone south of Italy. It peaked as a moderate tropical storm on 18 November while became a small but well-defined system with an almost fully closed eye surrounded by deep convection. The cyclone later made landfall the western part of Greece. Numa (in its all 3 phase) caused heavy rains in South Italy and West Greece.

Synoptic history

In the first days of November blocking patterns persisted over the North Atlantic Ocean that contributed the formation of Tropical Storm Rina over the Central Atlantic. On 5 November a strong extratropical cyclone reached the southern part of Greenland but in the next days it slowed down and became a larger, multi-centered cyclonic system as it moved away toward Iceland and Scandinavia. Its main, elongated cold front interacted with Rina on 9 November and thanks to this it became extratropical. On 11-13 November Ex-Rina quickly moved through the central parts of Europe from west to east as a weak secondary cyclone on the southern side of the large cyclonic system and dissipated over Russia on 14 November. Behind Ex-Rina another extratropical low developed along the frontal zone that reached the British Isles on late 11 November. At the same time an anticyclone built up over Iceland and it later displaced near to the British Isles, which indicated a strong cold outbreak from the North Atlantic region toward West Europe. The cold air reached the Alps on 12 November and the lee-cyclogenesis generated a secondary low south of the mountains by 13 November. The Freie Universität (Berlin) named this cyclone to ‘Numa’. Associated with the cyclone an upper-level cut-off low also reached that area which generated high instability, so the cyclone produced heavy convective precipitation in Italy.

On 14 November another cyclonic wave developed along the cold front over South Italy, which soon became the dominant center as the earlier one dissipated over the Tyrrhenian Sea. The new cyclone center started to detach from the weakening frontal zone on 15 November, and became frontless with increasing and organizing convection by early 16 November, indicated that Numa became a subtropical depression around 0600 UTC. By this time the cyclone made a loop around Sicily and moved over slightly warmer water with temperature around 21 °C, which also supported its transition. On the second part of the day the organization of the cyclone increased rapidly as numerous thunderstorms developed and wrapped around the center, while the low approached South Italy. Thereafter, Numa got blocked by a strong anticyclone over Central Europe and moved very little in the next 1.5 days. Around 0000 UTC 17 November the convection almost fully surrounded the center and also became deeper with cloud top temperature around -50, -55 °C, so Numa strengthened into a subtropical storm around that time (Fig. 3). However, the convection weakened temporarily thereafter, thus the intensification was short-lasting.

The thunderstorms started to redevelop closer to the cyclone's center some hours later and weak upper-level outflow also formed, which indicated that Numa transitioned into a tropical storm around 1200 UTC. After that, the intensification phase returned as more intense convection fired up around the center after sunset and these convective bursts lasted through the night. Numa had the best structure around 0000 UTC 18 November as it developed an almost close eye (Fig. 4). The temperature of the highest cloud's top reached -60, -65 °C in the western and northern part of the cyclone between 1530 UTC 17 November and 0500 UTC 18 November. The lowest values were measured around 2030 UTC 17 November and 0330 UTC 18 November. Since the cyclone moved very little in this period, it caused upwelling effect and cooled the sea surface around itself. Thanks to this, the convection weakened significantly in the morning hours and the storm lost some strength too, but its structure remained well-defined with a cloud-free eye-like feature (Fig. 5). However, another burst of deep convection occurred in the late afternoon hours (Fig. 6) and the cloud top temperature reached -60, -65 °C again around 1700 UTC. Numa made landfall on Kefalonia Island around 2300 UTC and weakened to a tropical depression after 0600 UTC 19 November. In the late morning hours, the cyclone quickly lost its organization, so it became a remnant low by 1200 UTC, and a cold front absorbed it in the end of the day.

Meteorological statistics

Since Numa spend its most time near the Italian and Greek coasts, the available wind (Tabl. 2) data were limited, however there were more precipitation data (Tabl. 4), especially from Greece. A few ship reports were available too (Tabl. 3) and some ASCAT pass (Fig. 7) also helped the wind estimation.

Winds and pressure

Before the landfall in Greece, Numa crossed *Lampedusa* and *Malta* as an extratropical cyclone. On these islands stations reported minimum pressure around 1004-1005 hPa on 15 and 16 November, but on 14 November some nearby station measured a bit lower pressure. These data were in line with the UKMet central pressure estimate, although they were a bit lower than that. After the subtropical transition, the central pressure started to decrease slowly, which also reflected in the UKMet analysis. Since the cyclone remained over water in its subtropical and tropical stage, direct pressure data were not available at this time. The nearest measurement to the cyclone was in *S. Maria Di Leuca* in South Italy, where the pressure decreased to 1004-1005 hPa on 17 and 18 November. Based on this and the estimated wind speed, the central pressure could be around 994 hPa when Numa peaked at 0000 UTC 18 November. After the peak, the pressure increased only slowly during the day since the pressure fell around 1000 hPa on some Greek stations when the cyclone made landfall in the late evening hours (Fig. 8). Thereafter, the pressure jumped upward significantly as the cyclone weakened fast and lost its tropical characteristics over Greece.

Most of the weather stations on the coastal areas never measured sustained tropical storm force winds, except 14 November, when *Capo Bellavista* in Sardinia reported 70 km/h wind and one hour later 107 km/h gust. However, *S. Maria Di Leuca* permanently measured 50-55 km/h sustained winds from early 17 November to early 18 November with many tropical storm force (70-80 km/h) wind gusts. At Numa's landfall, some Greek stations also reported tropical storm force (65-80 km/h) wind gusts (Fig. 8). In Rio, which city locates in a strait on the northern tip of the Peloponnese, the strongest sustained wind reached 57 km/h and the highest gust 92 km/h around 0630 UTC 19 November.

The first ASCAT passes indicated that the highest wind speeds associated with Numa were around 65 km/h after it formed, but it weakened a bit early on 15 November. The wind did not change very much in the next 1.5 days while Numa transitioned into a subtropical cyclone as a depression. The early morning pass on 16 November catch the cyclone around its transformation, and by this time the wind filed already became more symmetrical than earlier, but the strongest winds occurred on the southern part of the cyclone in a larger area, far from the center. In the next 1.5 days only a partial pass was available around 0800 UTC 17 November, which also did not show tropical storm force winds. But the cyclone's structure improved since the last pass, and likely became a subtropical storm around 0000 UTC 17 November. By midday, the cyclone transitioned into a tropical storm, and started to strengthen. This was confirmed by an ASCAT pass around 1900 UTC that measured maximum winds around 75 km/h on the western side of the cyclone, and also verified the tropical transition as the wind field became more symmetrical and compact than earlier. Another pass around 0900 UTC 18 November showed similar wind maximum and structure. Based on the satellite presentation, Numa peaked between these two passes with estimated maximum wind speed of 95 km/h, and started to weaken slowly after that. Before the landfall, the wind field became even more compact as the next, partial ASCAT pass showed around 1900 UTC. This pass missed the western part of the cyclone, where tropical storm force winds still likely existed since on the eastern side the maximum winds were around 55-60 km/h, similar to the previous passes.

Rainfall

The most devastating weather phenomena associated with Numa (as extratropical, subtropical and tropical) was the high amount of precipitation. The cyclone produced heavy thunderstorms and because the slow motion of the cyclone, these often developed over the same places. In extreme South Italy and the southwest parts of Greece 100-300 mm rain fell during 7 days. The highest precipitation amount was 246.5 mm in Italy *(S. Maria Di Leuca)* and 290.4 mm in Greece *(Gaios)*. Since the weather was rainy in Greece already before Numa, this large amount of rain caused severe floods and mudslides which destroyed a lot of homes, roads, and the electrical and drinking water network. Based on the estimations, around 100 people were injured by the floods, at least 22 died and more than 1000 left without home, but these numbers were generally related to the flooding in the middle of November in that area, not only to Numa.

Storm surge

Since Numa was only a moderate tropical storm, it did not cause very high waves. Satellite-based altimeter data (Fig. 9) showed significant wave height (SWH) around 3.5-4 m (12-14 feet) at 0708 UTC 18 November on the strongest western side of the cyclone. However, another passes measured mainly 2.5-3 m wave heights on the east side of the cyclone, near the Greece coast. The waves and coastal flooding caused only minor damage.

Reanalysis data

Numa had been analyzed by ECMWF-ERA5 high-resolution reanalysis data. The examined parameters were 300 hPa divergence and winds (Fig. 10), 925 hPa geopotential and 850 hPa vertical speed (Fig. 11), 850 hPa equivalent potential temperature and wind (Fig. 12), 500-1000 hPa thickness and 850 hPa relative vorticity (Fig. 13), 200-1000 hPa thickness and 300 hPa potential vorticity (Fig. 14) and vertical cross-sections of potential vorticity (Fig. 15). The analysis expanded from 0000 UTC 13 November to 2100 UTC 19 November. However, only two images are listed here: the first one is at 0300 UTC 17 November, when Numa was subtropical, and the second one at 0300 UTC 18 November, shortly after it reached its peak intensity as a tropical storm. An animation of all reanalysis maps is available here:

https://www.youtube.com/watch?v=Wy5XRFWqeXk

When the cyclone developed south of the Alps, it presented the typical appearance of a leeward extratropical cyclone. The cold air mass reached the area from two directions: the western branch of it bypassed the mountains from west, across South France and the Ligurian Sea, while the eastern branch came from north-northeast, across Austria, West Hungary and Slovenia. This process was well traceable on the 850 hPa equivalent potential temperature (EPT) maps on 13 November while especially the 500-1000 hPa thickness maps also showed the sharp temperature gradient along the frontal zone and the 850 hPa vorticity was strong along the fronts. Along with this, an upper-level cut-off cyclone placed above the surface low which also helped its intensification as generated moderate upper-level divergence associated with the jet stream's circulation and the 300 hPa potential vorticity became stronger too. On 14 November Numa occluded fast and started to weaken, so the temperature gradient slowly decreased and the 850 hPa vorticity also became weaker along the fronts. So the upper-level low became the dominant weather feature and generated widespread convection in the cyclone's cold sector. On 15 November the cyclone's center made a counter-clockwise loop around South Italy and Sicily while the cyclone ingested a bit warmer air into its core at 850 hPa from the weakening warm conveyor belt of the cyclone east and northeast to it. The developing warm core also appeared on the thickness maps and the 850 hPa relative vorticity started to increase in the cyclone's center in the second half of the day, and became more separated from the frontal zone at night, when the occlusion head detached from it.

On 16 November Numa continue to develop and its small core became even more separated. However, the cyclone got influenced by a jet streak which passed southwest and south of it and generated stronger divergence above the cyclone, while the 300 hPa potential vorticity also remained strong at this time. This confirmed that Numa transitioned into subtropical cyclone at the first time. On 17 November the jet streak moved away eastward and lost its strength, and Numa remained under a weak upper-level flow area with low shear. Along this, the upper-level potential vorticity also weakened and displaced from the cyclone, while the warm core became more apparent both on the thickness and the 850 hPa EPT maps, and the 850 hPa relative vorticity completely concentrated in the cyclone's center and increased further. These all indicated the tropical transition of the cyclone. The vertical cross sections of potential vorticity also showed the decreasing of the upper-level anomaly during this process, but only a weak low-level anomaly appeared in the core of the cyclone, however, it is possible that the resolution of the re-analysis could not presented well the very small cyclone. In the vertical velocity maps the updrafts started to increase after the subtropical transformation and they became the strongest in the night hours of 17-18 November, when the convection was the deepest and most organized. In this time the 925 hPa geopotential field looked quite symmetric with moderate gradient. As Numa moved closer to Greece in the second half of 18 November westerly winds stared to strengthen at 300 hPa which generated more shear over the cyclone. However, the wind field was divergent, so upper-level divergence temporarily increased and this likely contributed to the redevelopment of the deep convection before the landfall. The other parameters retained its well-defined appearance, but after the landfall, the cyclone quickly lost its organization.

Table 1 Best track for Numa, 14-20 November 2017

Day/Time [UTC]	Latitude [°N]	Longitude [°E]	Pressure [hPa]	Wind speed [km/h *(kt)*]	Stage
14 / 1200	37.6	16.3	1002	65 *(35)*	extratropical
14 / 1800	38.7	15.4	1002	65 *(35)*	”
15 / 0000	39.6	13.5	1003	65 *(35)*	”
15 / 0600	38.3	11.3	1004	55 *(30)*	”
15 / 1200	37.7	11.5	1004	55 *(30)*	”
15 / 1800	36.8	12.0	1004	55 *(30)*	”
16 / 0000	35.5	12.9	1004	55 *(30)*	”
16 / 0600	35.8	15.1	1004	55 *(30)*	subtropical depression
16 / 1200	35.9	17.1	1004	55 *(30)*	”
16 / 1800	37.3	18.5	1003	55 *(30)*	”
17 / 0000	39.0	18.6	1002	65 *(35)*	subtropical storm
17 / 0600	39.0	18.5	1002	65 *(35)*	”
17 / 1200	39.3	18.3	1001	65 *(35)*	tropical storm
17 / 1800	39.4	18.5	998	75 *(40)*	”
18 / 0000	39.3	18.4	994	95 *(50)*	”
18 / 0600	39.2	18.5	995	85 *(45)*	”
18 / 1200	39.0	18.7	997	75 *(40)*	”
18 / 1800	38.7	19.6	997	75 *(40)*	”
19 / 0000	38.4	20.7	998	75 *(40)*	”
19 / 0600	38.4	22.3	1002	65 *(35)*	
19 / 1200	38.2	24.7	1005	45 *(25)*	low
19 / 1800	39.2	26.6	1006	45 *(25)*	”
20 / 0000					absorbed by a front
18 / 0000			994	95 *(50)*	minimum pressure and maximum wind
18 / 2300			998	75 *(45)*	landfall near Ithaki

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)*]
Capo Bellavista (Sardinia)			14 / 1000	46 *(25)*	76 *(41)*
Capo Bellavista (Sardinia)			14 / 1900	70 *(38)*	95 *(51)*
Capo Bellavista (Sardinia)			14 / 2000	61 *(33)*	107 *(58)*
Pantelleria (Italy)			15 / 1300	33 *(18)*	61 *(33)*
Lampedusa (Italy)	15 / 2200	1005.0	15 / 2200	43 *(23)*	72 *(39)*
Lampedusa e Linosa (Italy)	15 / 2330	1004.6			
Upatras (Greece)			16 / 0120		68 *(37)*
Luqa (Malta)	16 / 0400	1005.0			
Upatras (Greece)			17 / 0020		64 *(35)*
S. Maria Di Leuca (Italy)	17 / 0800	1005.7	17 / 0800	52 *(28)*	78 *(42)*
S. Maria Di Leuca (Italy)	17 / 0900	1005.7	17 / 0900	54 *(29)*	74 *(40)*
Lefkada (Greece)			17 / 2110		72 *(39)*
S. Maria Di Leuca (Italy)	18 / 0400	1004.3	18 / 0400	50 *(27)*	76 *(41)*
Lefkada (Greece)			18 / 2320		71 *(38)*

Zakynthos (Greece)			19 / 0000		66 *(36)*
Ithaki (Greece)	19 / 0154	999.7			
Ithaki (Greece)			19 /0230	36 *(19)*	66 *(36)*
Aitoliko (Greece)			19 / 0330	41 *(22)*	68 *(37)*
Aitoliko (Greece)	19 / 0410	999.6			
Patra (Greece)			19 / 0530		84 *(45)*
Upatras (Greece)			19 / 0535		64 *(35)*
Ano Kastritsi (Greece)	19 / 0550	1004.9			
Rio (Greece)	19 / 0602	1004.2			
Ano Kastritsi (Greece)			19 / 0610	47 *(25)*	90 *(49)*
Rio (Greece)			19 / 0630	57 *(31)*	92 *(50)*
Panachaiko /mount./ (Greece)			19 / 0650		79 *(43)*

Table 3 Selected ship reports

Day/Time [UTC]	Ship call sign	Latitude [°N]	Longitude [°E]	Wind dir/speed [km/h *(kt)*]	Pressure [hPa]
15 / 0300	BAREU51	39.6	12.7		1004.3
15 / 2100	C6TQ6	36.0	14.3		1008.0
16 / 0000	DFWV2	36.4	13.0		1006.5
16 / 0800	VRJL6	37.2	18.2	180 / 54 *(29)*	1010.0
16 / 1200	9V8507	36.3	19.1	170 / 30 *(16)*	1011.1
19 / 0000	ELUW8	38.2	20.0	350 / 26 *(14)*	1009.2
19 / 0600	PHEO	35.8	20.5	330 / 61 *(33)*	1011.0

Table 4 Selected surface rainfall observation

Location	Rain on 13 Nov. [mm]	Rain on 14 Nov. [mm]	Rain on 15 Nov. [mm]	Rain on 16 Nov. [mm]	Rain on 17 Nov. [mm]	Rain on 18 Nov. [mm]	Rain on 19 Nov. [mm]	Total rain [mm]
Luqa (Malta)	7.4	19.0	9.6	11.2	2.4	0.2	0.0	49.8
S. Maria Di Leuca (Italy)	0.4	53.0	20.1	20.0	99.0	54.0	0.0	246.5
Otranto (Italy)	2.0	54.0	19.0	36.0	63.0	16.0	0.0	190.0
Supersano* (Italy)	0.3	43.9	10.9	35.8	55.4	71.1	0.3	217.7
Soleto* (Italy)	1.3	30.2	20.1	22.1	30.2	16.8	0.3	121.0
Lecce (Italy)	10.0	41.0	13.0	25.0	31.0	5.0	0.0	125.0
Brindisi (Italy)	21.0	27.0	16.0	10.0	9.0	0.0	0.8	83.8
Pescara (Italy)	0.0	137.0	28.0	2.6	0.0	0.0	0.0	167.6
Kerkyra (Greece)	10.0	110.4	19.0	35.4	36.4	28.8	0.2	240.2
Gaios (Grece)	8.2	17.6	46.6	25.0	137.6	53.8	1.6	290.4
Parga (Greece)	5.2	16.6	16.8	27.4	15.4	7.8	1.0	90.2
Aktion Airp. (Greece)	11.3	27.2	23.4	9.0	33.1	13.8	0.0	117.8
Kefahlnia Airp. (Greece)	36.2	26.0	58.0	5.6	61.5	14.2	1.5	199.0
Lefkada (Greece)	3.4	35.8	28.6	32.2	121.6	48.8	6.0	276.4
Ithaki (Greece)	9.2	52.6	23.4	38.8	31.4	10.2	6.4	172.0
Zakinthos (Greece)	2.5	42.0	76.5	8.7	9.4	4.5	10.0	153.6
Vartholomio (Greece)	0.0	37.6	73.8	42.6	17.6	14.0	1.8	187.4
Zacharo (Greece)	2.6	7.4	14.0	33.0	57.6	17.8	25.0	157.4
Kalamata Airp. (Greece)	0.3	39.1	15.8	12.1	12.6	6.0	2.7	88.6
Andravida Airp. (Greece)	0.1	43.4	32.6	19.5	7.0	7.5	1.5	111.6
Ioannina Airp. (Greece)	0.0	15.2	10.1	3.1	10.0	0.5	5.9	44.8

*: *Daily rainfall data are between 0-24 UTC, elsewhere between 06-06 UTC*

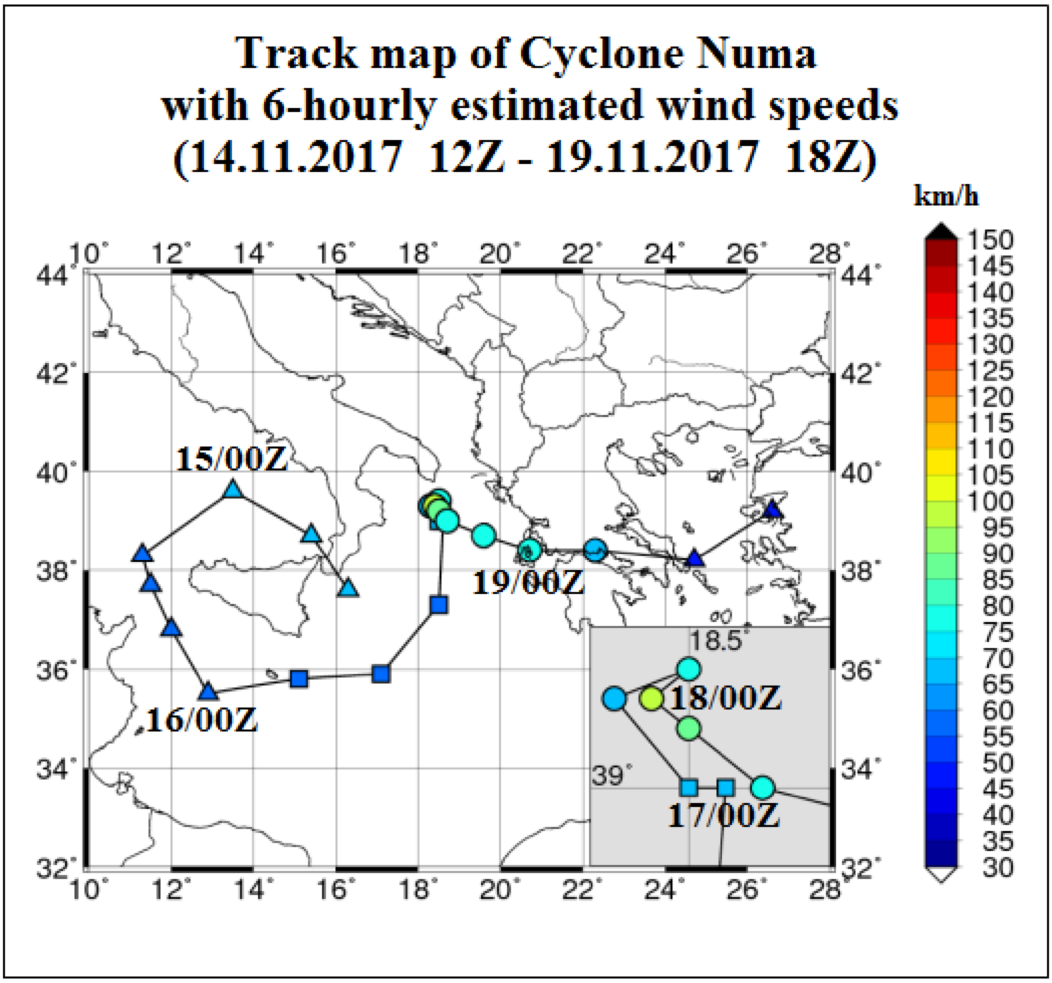

Figure 1. Best track positions for Tropical Storm Numa, 14-19 November 2017. The triangles mean extratropical, the squares subtropical and the circles tropical stage. The colors represented the estimated wind speeds (from Table 1) at the actual time. The position based on satellite images and ECMWF reanalysis.

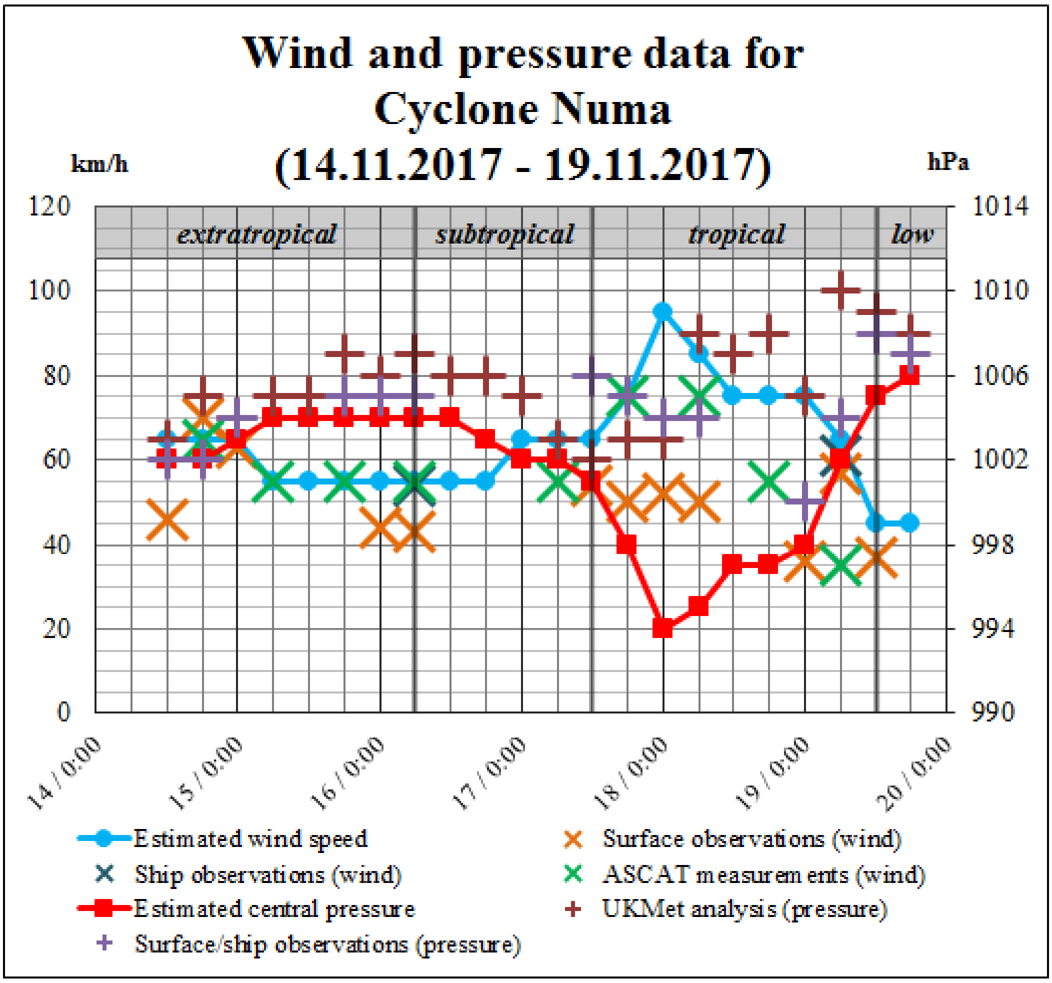

Figure 2. Selected wind and pressure observations with estimated maximum sustained wind and minimum central pressure for Tropical Storm Numa, 14-19 November 2017. The stated 6 hourly data mean the maximum sustained wind within a 3-hour interval around the marked time in case of all measurements.

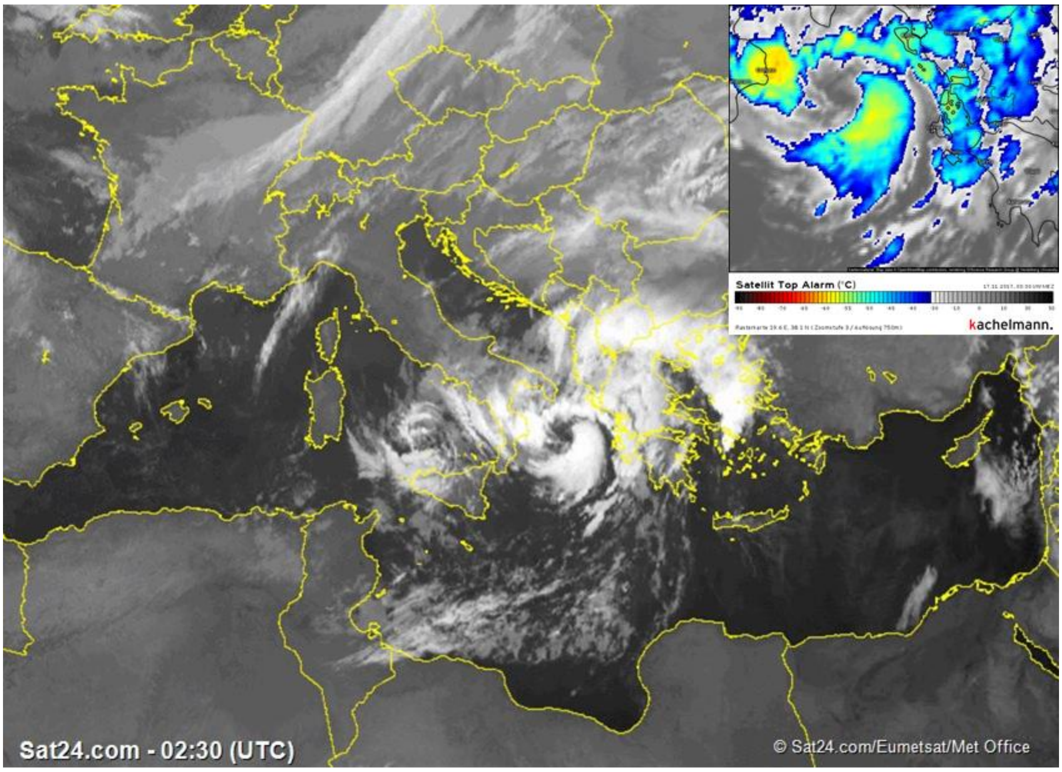

Figure 3. Infrared and cloud top temperature satellite images from Numa at 0230 UTC 17 November. The cyclone transformed into a subtropical cyclone by this time and moderate to strong convection wrapped around the cyclone's center, however still a bit far from it. *Source: EUMETSAT / Sat24.com, Kachelmannwetter*

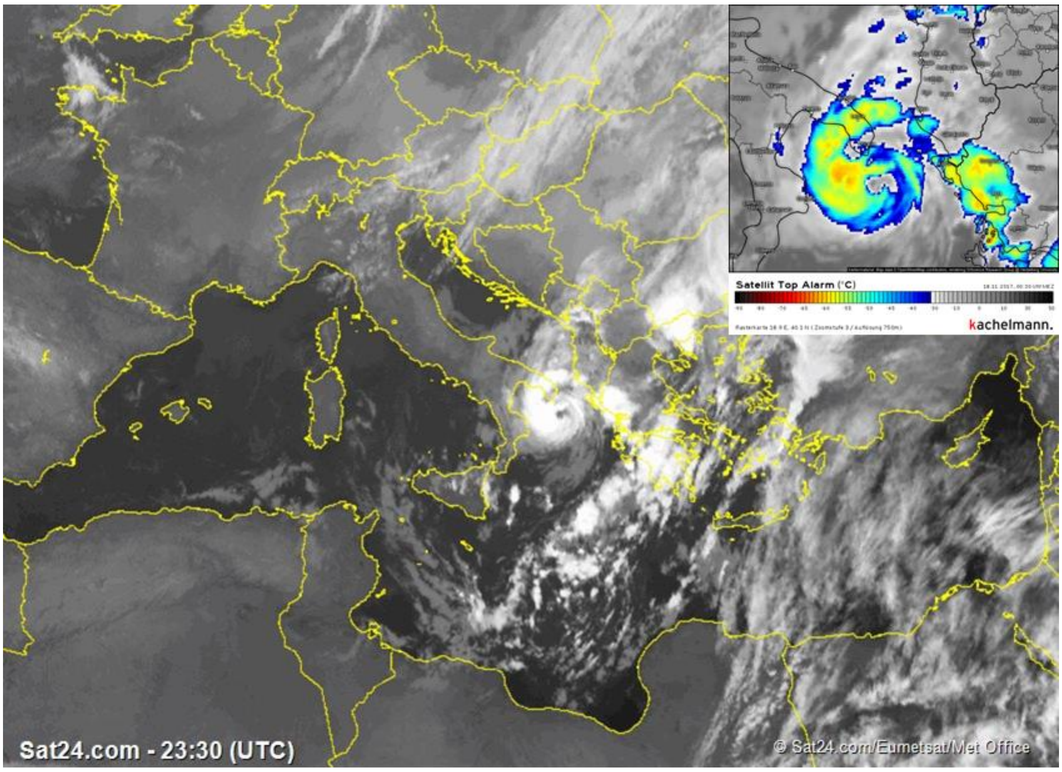

Figure 4. Infrared and cloud top temperature satellite images from Numa at 2330 UTC 17 November. The very small cyclone developed its best structure around this time with an almost fully closed eye and persisting deep convection directly near the center. Numa also developed well-defined upper-level outflow. *Source: EUMETSAT / Sat24.com, Kachelmannwetter*

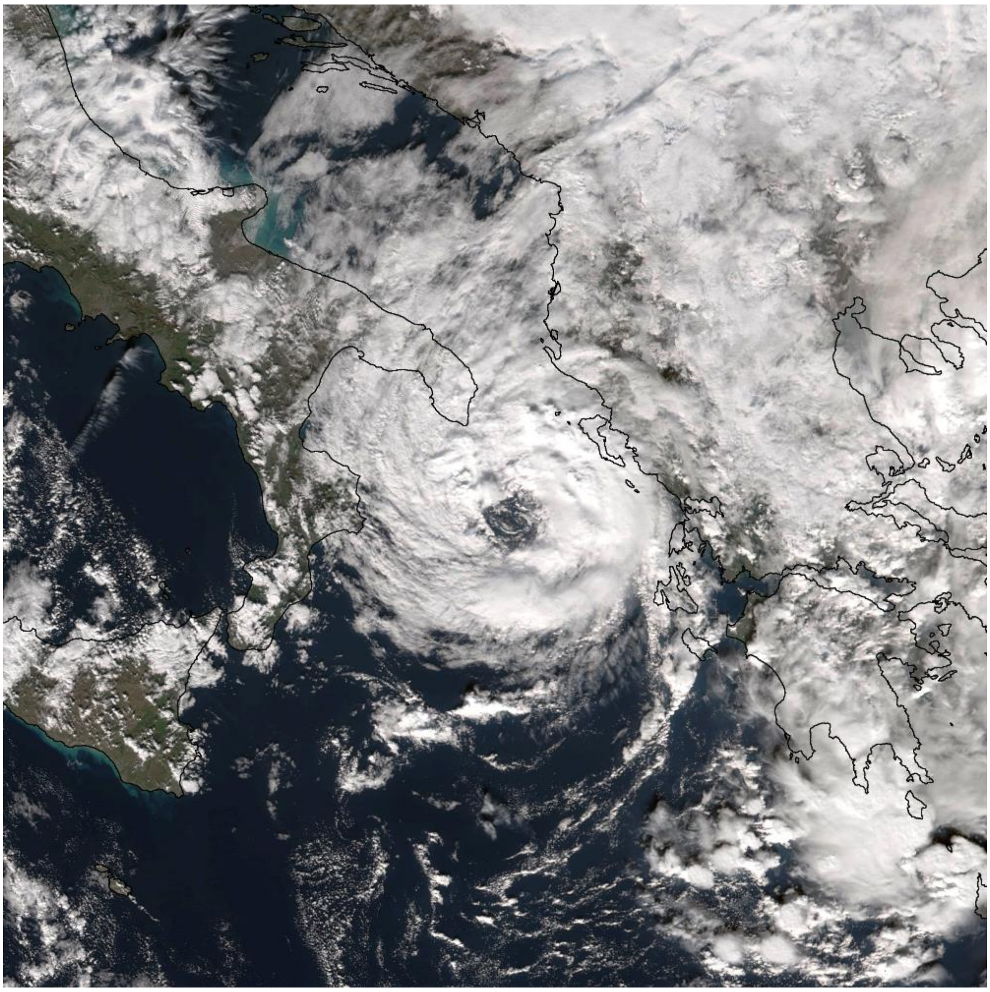

Figure 5. Daytime visible satellite images from Numa at 1224 UTC 18 November. Although the convection temporarily weakened, especially on the west side of the cyclone, Numa still had a well-defined, cloud-free eye. *Source: NASA*

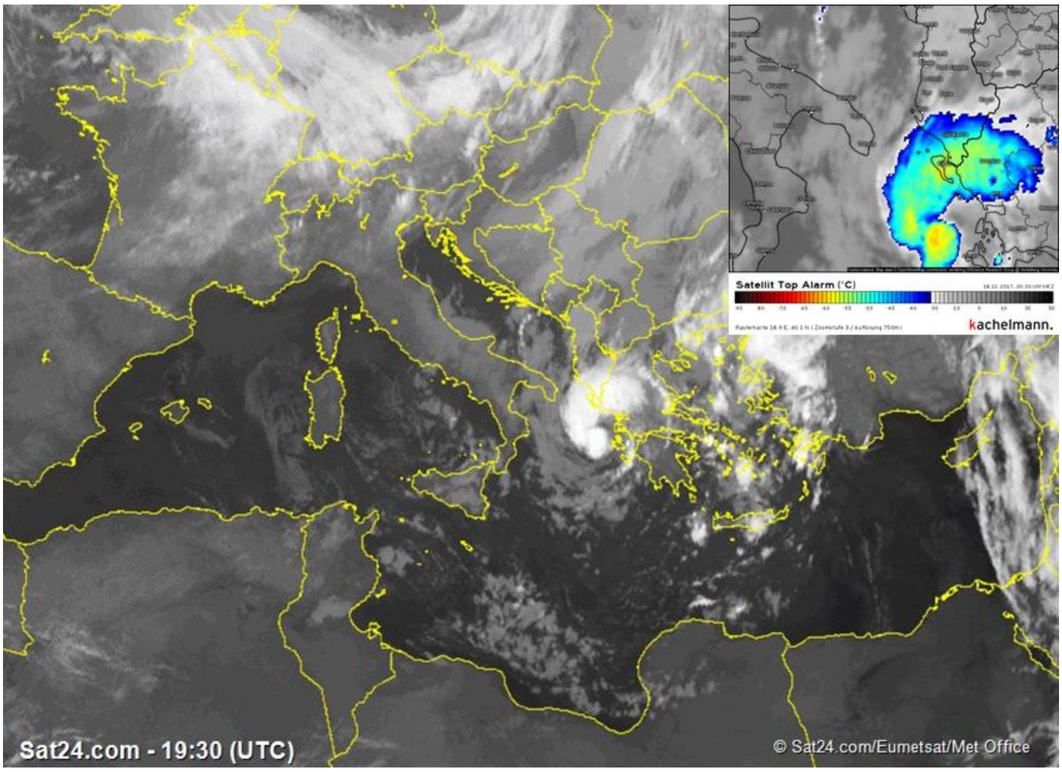

Figure 6. Infrared and cloud top temperature satellite images of Numa at 1930 UTC 18 November. Some hours before the landfall in Greece the cyclone produced another burst of deep convection while the well-defined upper-level outflow also persisted. The convection fully covered the center directly before the landfall, but the eye disappeared at this time. *Source: EUMETSAT / Sat24.com, Kachelmannwetter*

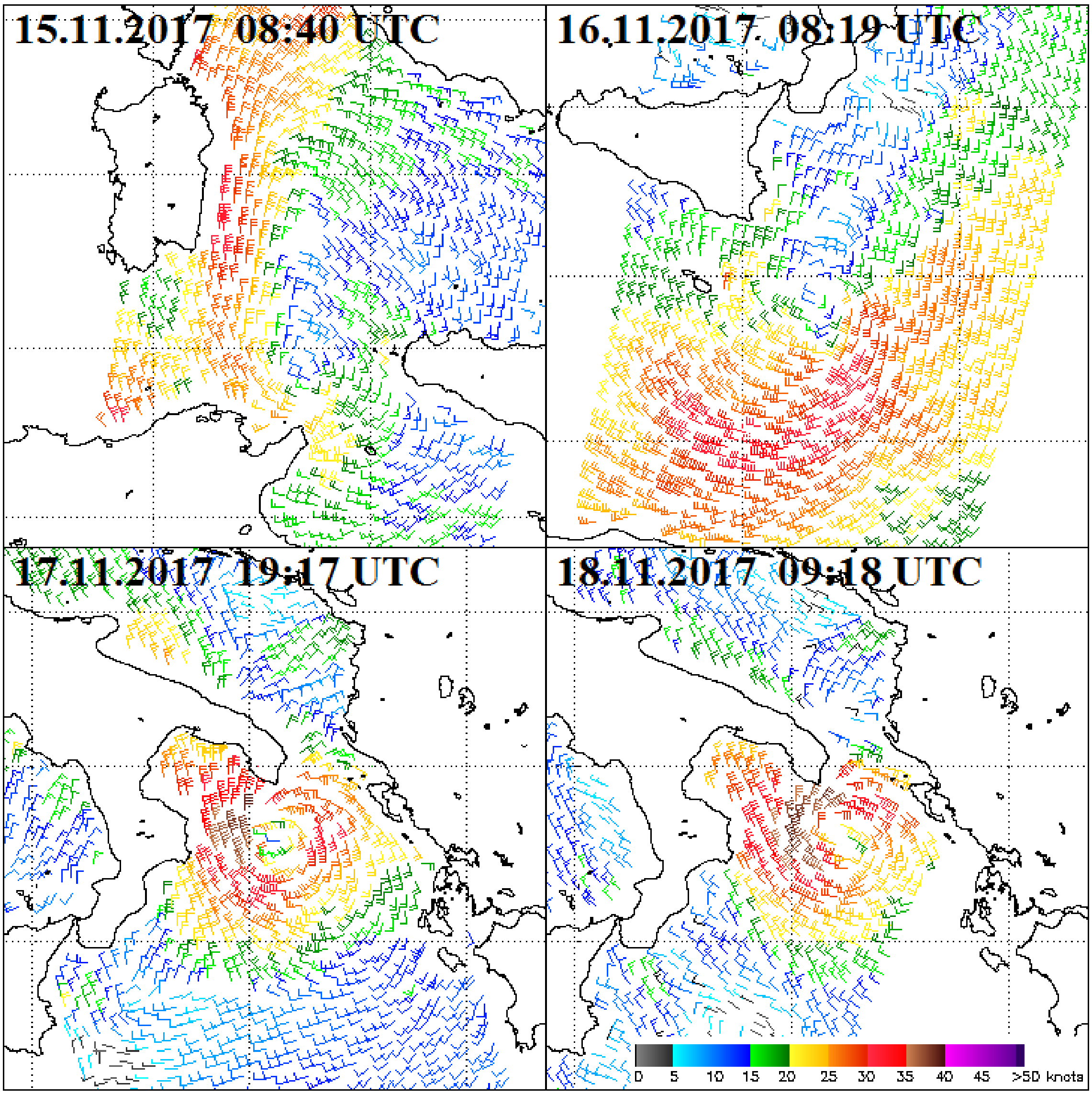

Figure 7. Satellite-based wind data of Numa between 15-18 November measured by ASCAT-A and ASCAT-B sensors. The measurements presented well the different phases of the cyclone from the extratropical via subtropical to the tropical stage, and its strengthening on 17 November. The wind field also became very tight, but symmetric by that time. *Source: NOAA NESDIS*

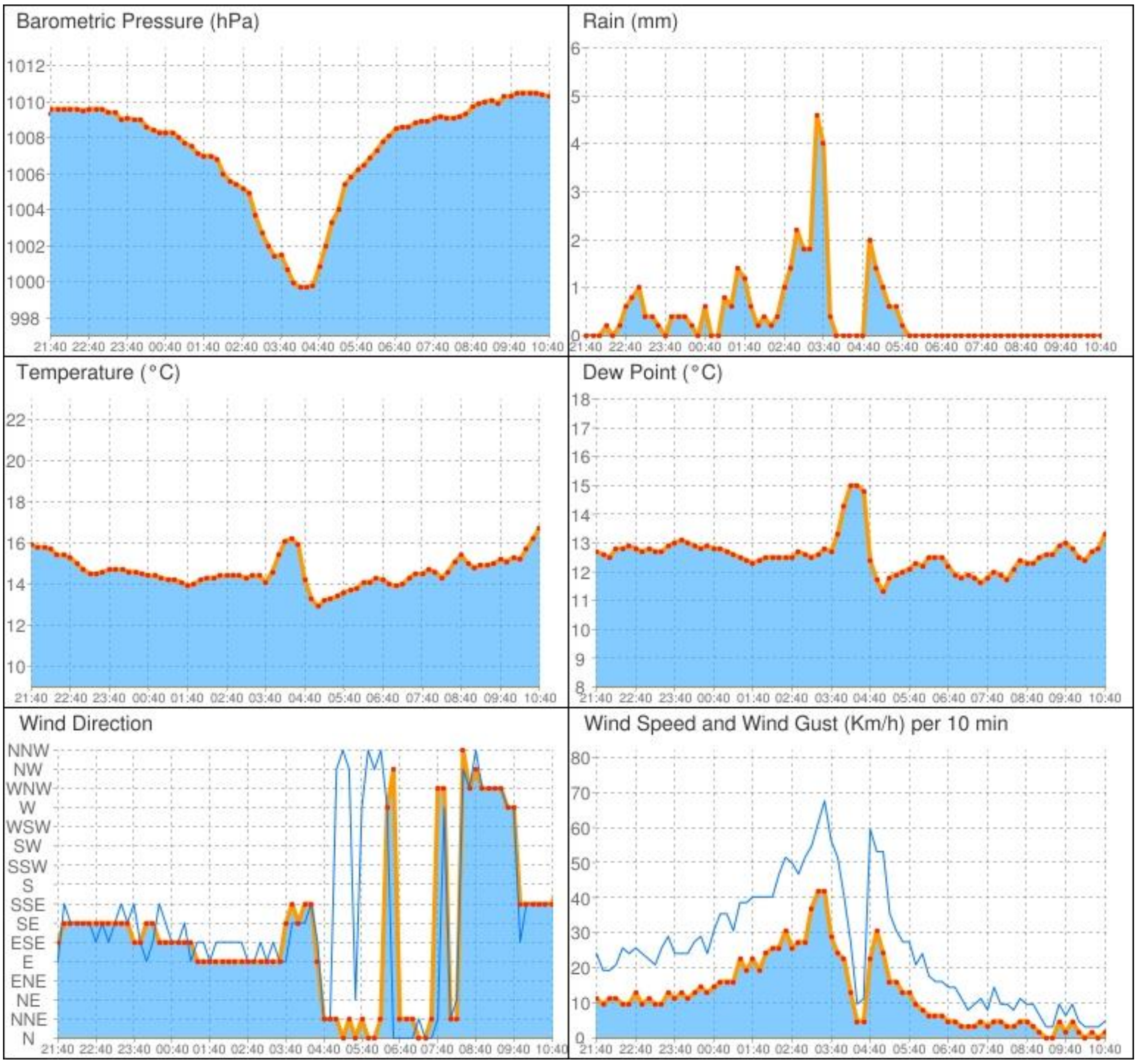

Figure 8. Meteorological data of a surface weather station in Aitoliko around the time of Numa's landfall. The measurements showed the typically double wind maximum with fast and significant change of the wind direction (from SE to NNW) when the cyclone's center passed the city. Around the landfall the temperature and dew point drop up a bit which indicated that Numa had warm core. *Source: Meteo.gr*

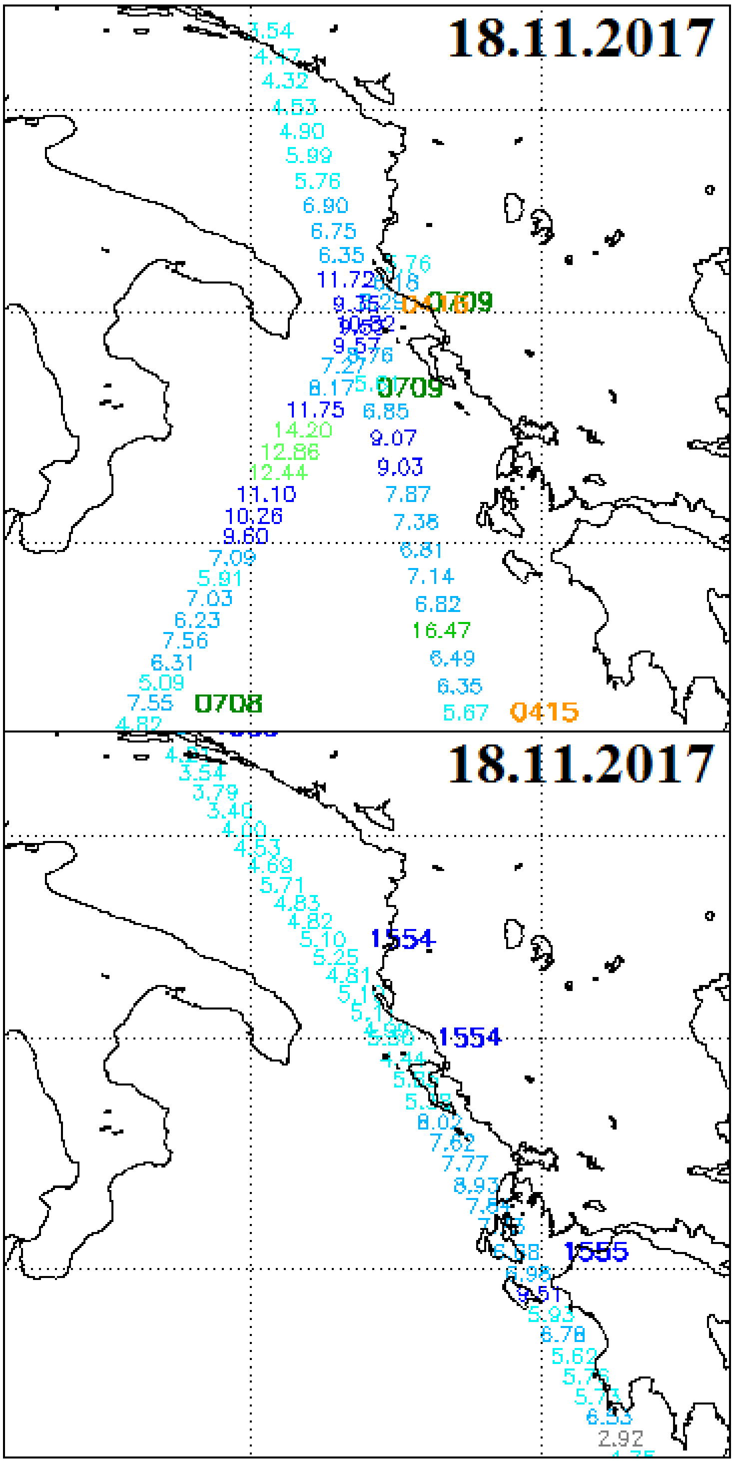

Figure 9. Satellite-based significant wave data (smaller numbers in lines, in feet) related to Numa between on 18 November The larger numbers show the time of the measurements (in UTC). *Source: NOAA NESDIS*

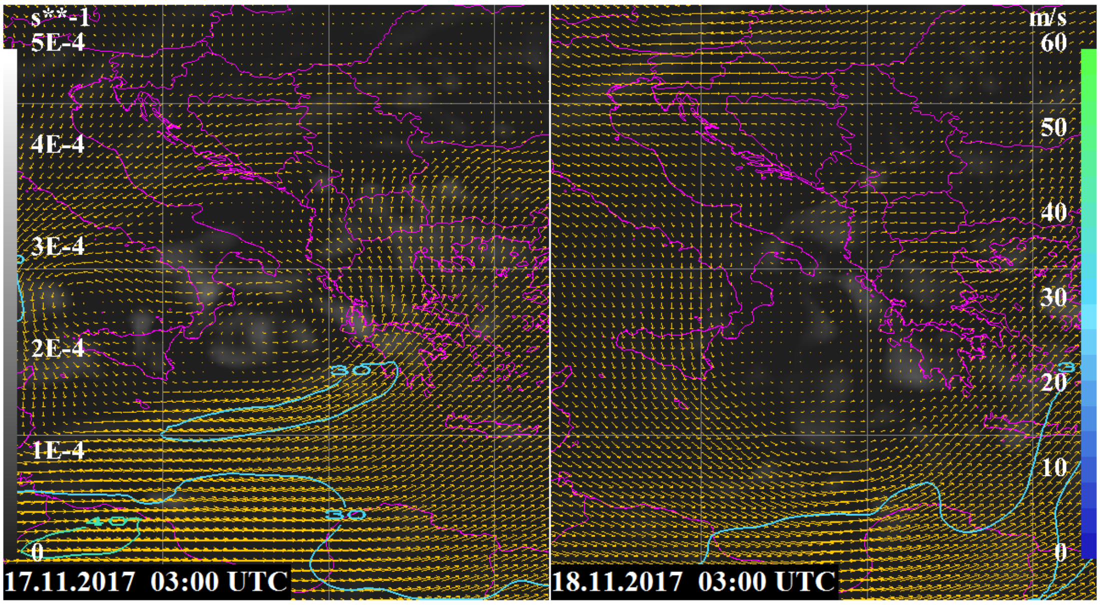

Figure 10. 300 hPa divergence (shaded) and winds (vectors and contours per 10 m/s from 30) over the Central Mediterranean Sea at 0300 UTC 17 November and 0000 UTC 18 November. *Data source: ECMWF/Copernicus*

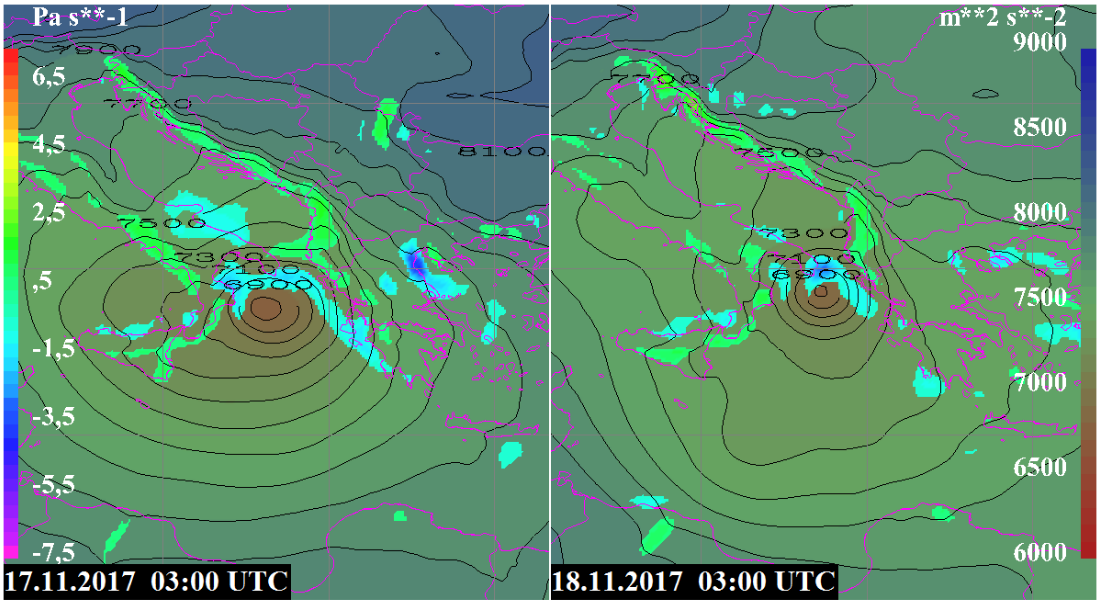

Figure 11. 925 hPa geopotential (shaded with black contours) and 850 hPa vertical speed (shaded patches, without the -0,5 to 0,5 Pa/s range) over the Central Mediterranean Sea at 0300 UTC 17 November and 0000 UTC 18 November. *Data source: ECMWF/Copernicus*

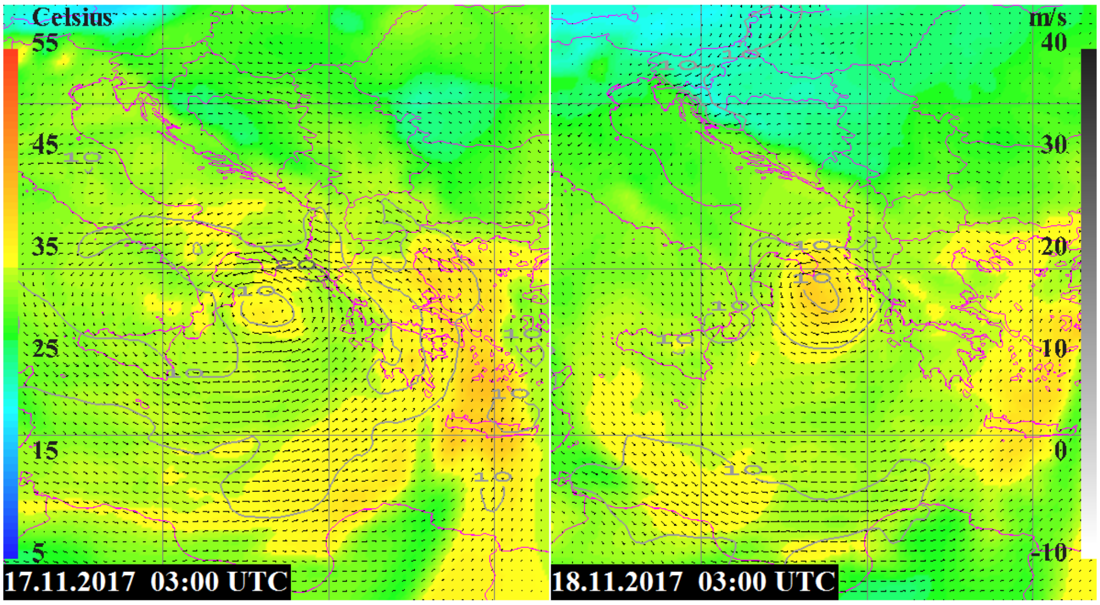

Figure 12. 850 hPa equivalent potential temperature (shaded) and winds (vectors and contours per 10 m/s) over the Central Mediterranean Sea at 0300 UTC 17 November and 0000 UTC 18 November. *Data source: ECMWF/Copernicus*

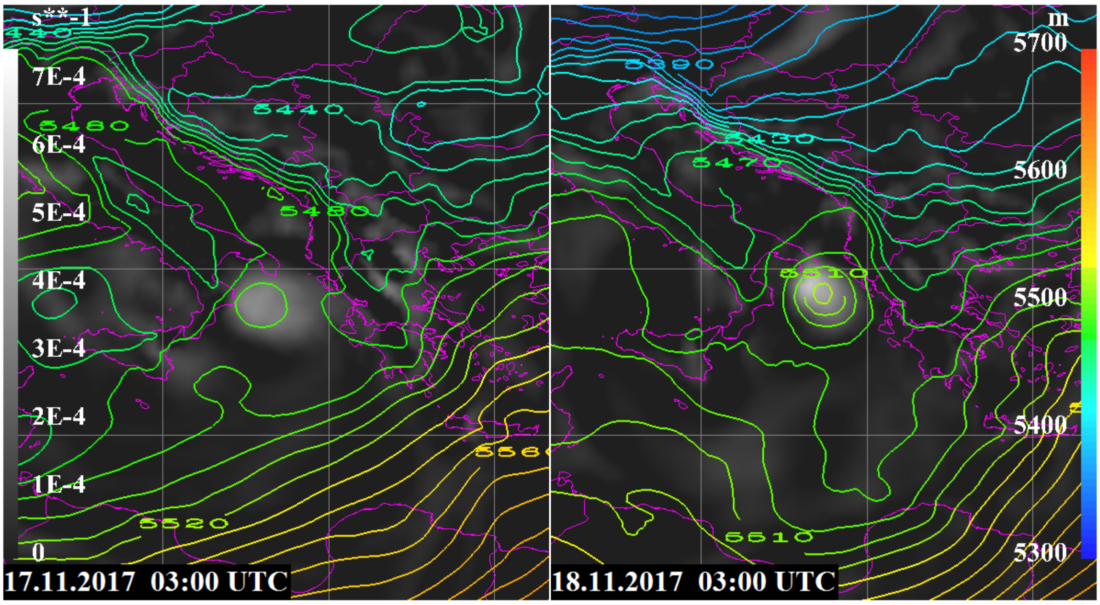

Figure 13. 500-1000 hPa thickness (contours per 10 m) and 850 hPa relative vorticity (shaded) over the Central Mediterranean Sea at 0300 UTC 17 November and 0000 UTC 18 November. *Data source: ECMWF/Coperncus*

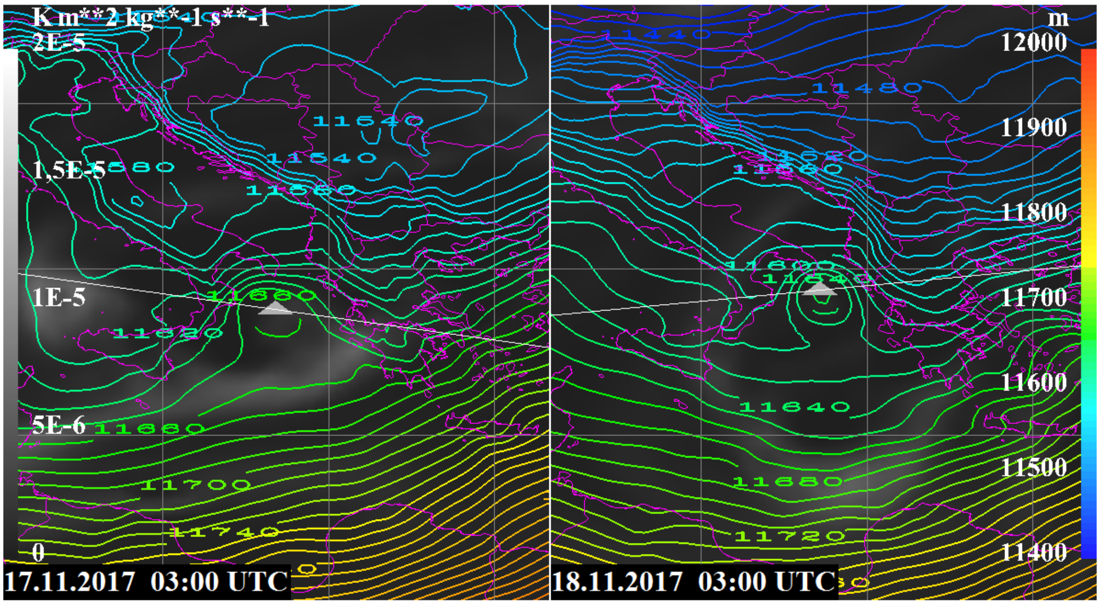

Figure 14. 200-1000 hPa thickness (contours per 10 m) and 300 hPa potential vorticity (shaded) over the Central Mediterranean Sea at 0300 UTC 17 November and 0000 UTC 18 November. *Data source: ECMWF/Copernicus*

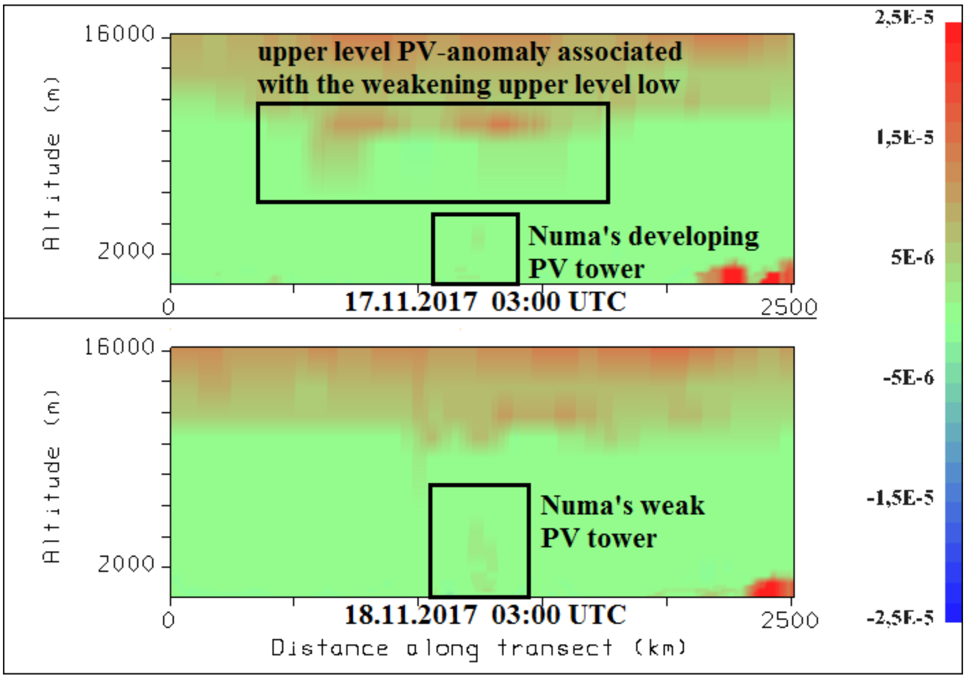

Figure 15. Potential vorticity vertical crosses through the center of Numa and its environment at 0300 UTC 17 November and 0000 UTC 18 November. The cross-sections marked with thin white lines on Figure 14. *Data source: ECMWF/Copernicus*