Adv. Sci. Res., 4, 9–13, 2010
www.adv-sci-res.net/4/9/2010/

Advances in Science & Research
Open Access Proceedings

9th EMS Annual Meeting and 9th European Conference on Applications of Meteorology 2009

The 27 July 2002 tornado event in Athens, Greece

J. T. Matsangouras and P. T. Nastos

Laboratory of Climatology and Atmospheric Environment, Faculty of Geology and Geoenvironment,
University of Athens, Panepistimiopolis, 157 84 Athens, Greece

Received: 27 December 2009 – Revised: 23 February 2010 – Accepted: 9 March 2010 – Published: 12 March 2010

Abstract. This study analyzes the tornado event on 27 July 2002 at Athens International Airport (Eleutherios Venizelos), a suburban area located at the east of Athens. The tornado was formed approximately at 10:20 UTC and characterized as T4 (Torro Scale). A synoptic discussion of the ECMWF analysis charts from the surface up to the 500 hPa geopotential height level is presented along with the daily composite anomaly (reference period: 1968–1996) of the relative meteorological parameters from NCEP/NCAR reanalysis dataset. The vertical profile of the atmosphere is also presented, and derived from the operational sounding of the nearest upper air meteorological station to the tornado incidence site. The dynamic indices of the atmosphere revealed unstable atmospheric conditions capable for thunderstorm formation. The tornado caused injuries to a woman due to the shift of a parked airplane during the disembarkation procedure and also several damage at the airport facilities.

1 Introduction

Tornadoes, as results of extreme convective weather at local or large scale, are associated with strong winds, which cause extended damage and in many cases loss of life. The increased atmospheric moisture content due to global warming may force an increase in severe weather and tornado activity. These fury phenomena are rare in Greece and in most of the cases appear in the sea without causing significant damage, until they take place over an urban region with remarkable consequences.

Tornadoes occur in many parts of the world (Fujita, 1973) and several publications during the last two decades indicate the occurrence of tornadoes in many European countries (Dessens, 1984; Dessens and Snow, 1987; Paul, 1999; Reynolds, 1999; Dotzek, 2001; Holzer, 2001; Bechini et al., 2001; Sioutas, 2003; Bertato et al., 2003). The tornado damage path is considered to extend a few hundred meters in width causing though considerable damage in buildings and in many cases posing a serious threat for human life, especially when tornadoes develop near urban areas or hit international airports. Bech et al. (2007) analyzed a tornado outbreak on 7 September 2005 in the Llobregat delta river, affecting a densely populated and urbanised area and the Barcelona International airport (NE Spain). At least five short-lived tornadoes were confirmed, four of which were weak (F0, F1) and the other one was significant (F2 on the Fujita scale).

Greece has experienced a mean number of six tornadoes per year (Sioutas, 2003), as its complex geomorphology creates a favorable environment for the development of tornado activity. This tornado activity causes several damages in buildings and in a few cases lethal effects. During the last century whirlwind phenomena (33 events occurred in 28 days) caused the loss of 4 lifes, the injury of 40 people and numerous damage on human constructions and cultivations (Nastos and Matsangouras, 2009). Although that the number of 33 cases is greater than the number of 17 cases presented in previous research by Sioutas (2003), this database is assumed incomplete as more cases are likely to be found in the future. The tornado reporting in Greece within the 20th century revealed an increasing trend, mainly over the west and south coastal areas, while the temporal variability showed that the maximum of tornadoes activity dominated within the cold period of the year (autumn and winter) during the warm hours of the day of the day (09:00–15:00 UTC) (Nastos and Matsangouras, 2009). It should be noted that historical reviews contribute to a significant climatological information (Paul,1999; Tyrrell, 2001).

Correspondence to: P. T. Nastos
(nastos@geol.uoa.gr)

Published by Copernicus Publications.

Figure 1. Tornado at Athens International Airport "Eleftherios Venizelos" at 10:20 UTC on 27 July 2002.

This study analyzes the tornado event on 27 July 2002 at Athens International Airport (Eletherios Venizelos), a suburban area located at the east of Athens. The tornado was formed approximately at 10:20 UTC after the passage of a thunderstorm and was characterized as T4 (Torro Scale). Torro scale was developed by Meaden (1976) of the Tornado and Storm Research Organisation (TORRO), a meteorological organization in the United Kingdom, as an extension of the Beaufort scale. The International Tornado Intensity Scale categorizes wind speeds of tornadoes. The scale is directly related to the Beaufort scale and is the only true tornado intensity scale with a sound scientific base. Tornadoes of strength T0, T1, T2, T3 are termed weak tornadoes, those reaching T4, T5, T6, T7 are strong tornadoes and T8, T9, T10, T11 are violent tornadoes.

2 Tornado event analysis

The tornado formed at 10:20 UTC (13:20 Greek Local Time) on 27 July 2002, approximately 8 km SW from Athens International Airport (Eletherios Venizelos) shortly after the passage of a thunderstorm (Fig. 1). According to the authors' interview from a weather officer, who was on duty that day, the tornado moved NE straight to the airport area and when it reached the Athens International Cargo Station it was dissipated and reformed after that point. The tornado reinforced as it was crossing the airports runways and moved another 2 km to NE causing several damage. In the process, the tornado weakened and a rope funnel cloud was formed on the sky suggesting the dissipation of tornado.

Although the tornado event lasted only 10 min, it caused several damage on light constructions which was on its path and it was characterized as a T4-tornado (Sioutas, 2003). Damage was also reported within the airport's area as debris flow and other light objects hit the planes that were parked causing significant damage to their frames. The strong winds resulted in shifting a parked airplane, hurting a passenger, who was in the disembarkation procedure, the time when she was using the landing stairs. The existence of the tornado at the airport was the reason that many departures and arrivals were cancelled because of the significant possibility of having an accident. Besides, pilots during the landing procedure experienced severe turbulence as the tornado came closer to the airport. On that day another tornado event (T3, Torro scale) was noticed in Peraia, Northen Greece (Sioutas, 2003).

3 Synoptic discussion

As the event took place at 10:20 UTC, we used the 06:00 UTC reanalysis from the European Center for Medium-Range Weather Forecasts (ECMWF) for the synoptic discussion of several levels of the atmosphere. Additionally, the daily composite anomalies (reference period: 1968–1996) for relevant meteorological parameters were calculated from the reanalysis datasets of the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR). Finally, the vertical profile of the atmosphere was presented using the available upper air data at 00:00 UTC on 27 July 2002, in Athens.

3.1 ECMWF reanalysis

The synoptic conditions of the event day were characterized by a closed low at the isobaric level of 500 hPa associated with low temperatures over the area of interest causing a SW upper air flow (Fig. 2a). This synoptic type is characterized as the dominant type for tornado formation in Greece (Sioutas, 2003). The cyclonic circulation also existed at lower levels such as 700 hPa, 850 hPa and at Mean Sea Level (MSL) causing S-SW air stream over the studied area (Fig. 2b, c, d). The reanalysis of the divergence-convergence revealed convergence values equal to $1.2\,s^{-1}$ along with vertical velocity values equal to –1.12 Pa/s at the lower levels of the atmosphere (850–925 hpa) (not shown). These values were greater than the respective mean monthly values of July 2002 (divergence at 850–925 hPa: $0.2\,s^{-1}$ and vertical velocity at 850–925 hPa: +0.06 Pa/s) (not shown).

3.2 NCEP/NCAR reanalysis

Studying the NCEP/NCAR reanalysis datasets (Kalnay et al., 1996), relevant conclusions were extracted. Daily composite anomalies (reference period: 1968–1996) of the geopotential heights occurred from the middle to the lower atmospheric levels (500 hPa – mean sea level) on 27 July 2002 (Fig. 3a–c). Moreover, a significant daily composite anomaly (reference period: 1968–1996) of the horizontal wind shear extended over the area, from 700 hpa to 925 hpa (Fig. 3d–f).

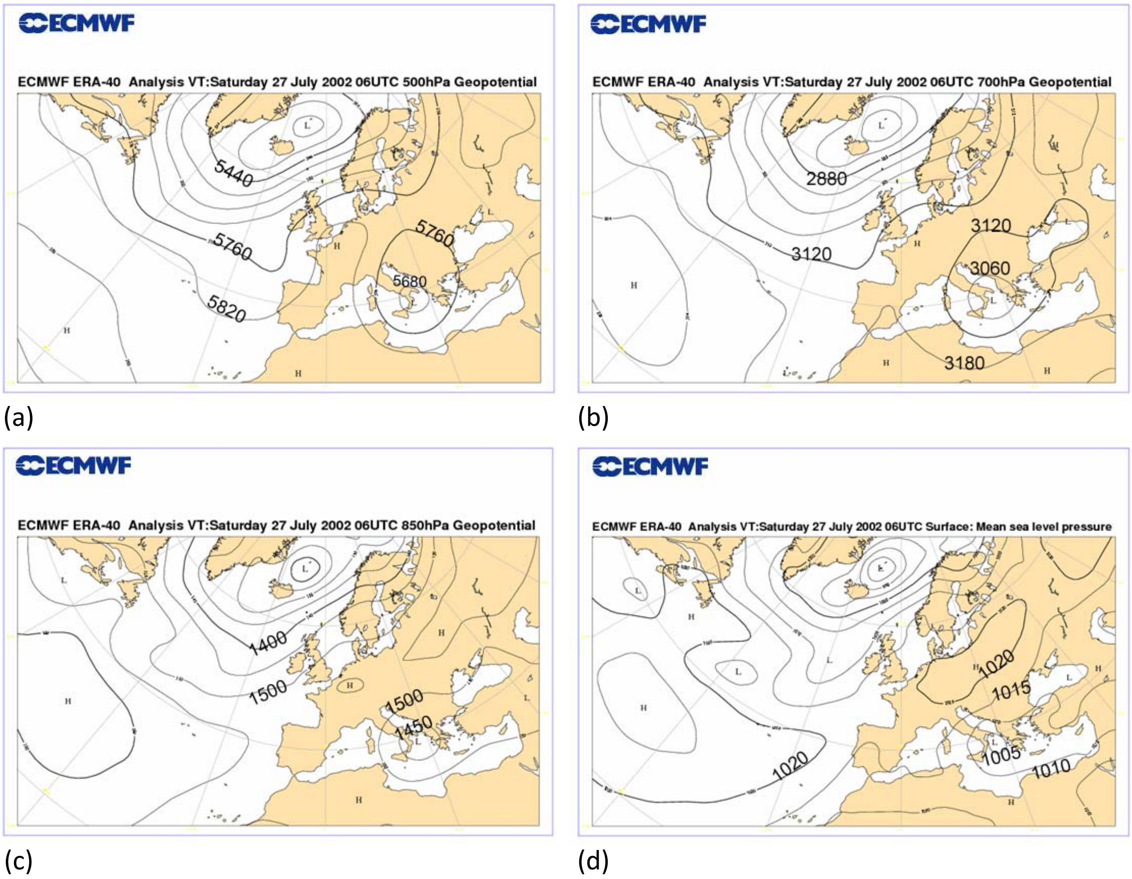

Figure 2. ECMWF reanalysis charts of geopotential heights at: **(a)** 500 hPa, **(b)** 700 hPa, **(c)** 850 hPa and **(d)** reanalysis of MSL pressure, at 06:00 UTC on 27 July 2002.

3.3 Upper air data

The vertical profile plot of the atmosphere over Athens at 00:00 UTC (Fig. 4) was a significant contribution to study the vertical dynamic structure of the atmosphere. In this point, it is useful to notify that the Upper Air Station (37°52 N, 23°44 E), from which the vertical profile of the atmosphere was taken, is located about 20km southwest from the Athens International Airport (37°56 N, 23°57 E). The Skew-T plot analysis was downloaded from Wyoming's University database (http://weather.uwyo.edu/upperair/europe.html). The dynamic indices of the atmosphere revealed unstable atmospheric conditions capable for thunderstorm formation; K Index = 23.3 °C, Showalter Index (SI) = 3.7 °C, Severe Weather Threat Index (SWEAT) = 93.6, Convective Available Potential Energy (CAPE) = 1993 ($J\,Kg^{-1}$) and Lifted Index (LIFT) = –6.5 °C. Furthermore, the above dynamic indices extracted from the Skew-T plot analysis at 12:00 UTC (1.5 h after the tornado formation-dissipation) revealed further unstable atmospheric conditions: K Index = 21.2 °C, SI = 1 °C, SWEAT = 315.6, CAPE = 1545 ($J\,Kg^{-1}$) and LI = –5.8 °C.

3.4 Satellite images

The tornado formed exactly after the pass of a severe thunderstorm over Athens International Airport at 10:20 UTC. The storm was spotted on the visual spectrum (VIS 0.6 μm) of Meteosat 7, at a sequence of satellite images from 09:30 UTC to 11:00 UTC (Fig. 5). Studying the sequence of the images at visual spectrum, we found out that the storm was spotted firstly at 09:30 UTC (Fig. 5a) over Saronikos Gulf (south of Athens). As the storm was propagating NE, it was further more developed on vertical structure until it was dissipated over the Southern Evoikos Gulf (eastwards of Athens international Airport) (Fig. 5d).

4 Conclusions

On 27 July 2002 at 10:20 UTC, a tornado (T4-Torro Scale) hit the Athens International Airport, a suburban area located at the east of Athens. The tornado was formed SW from the airport and propagated NE with a trajectory of approximately 10 km, causing significant damage to the airport facilities and at parked airplanes. The analysis of the ECMWF charts

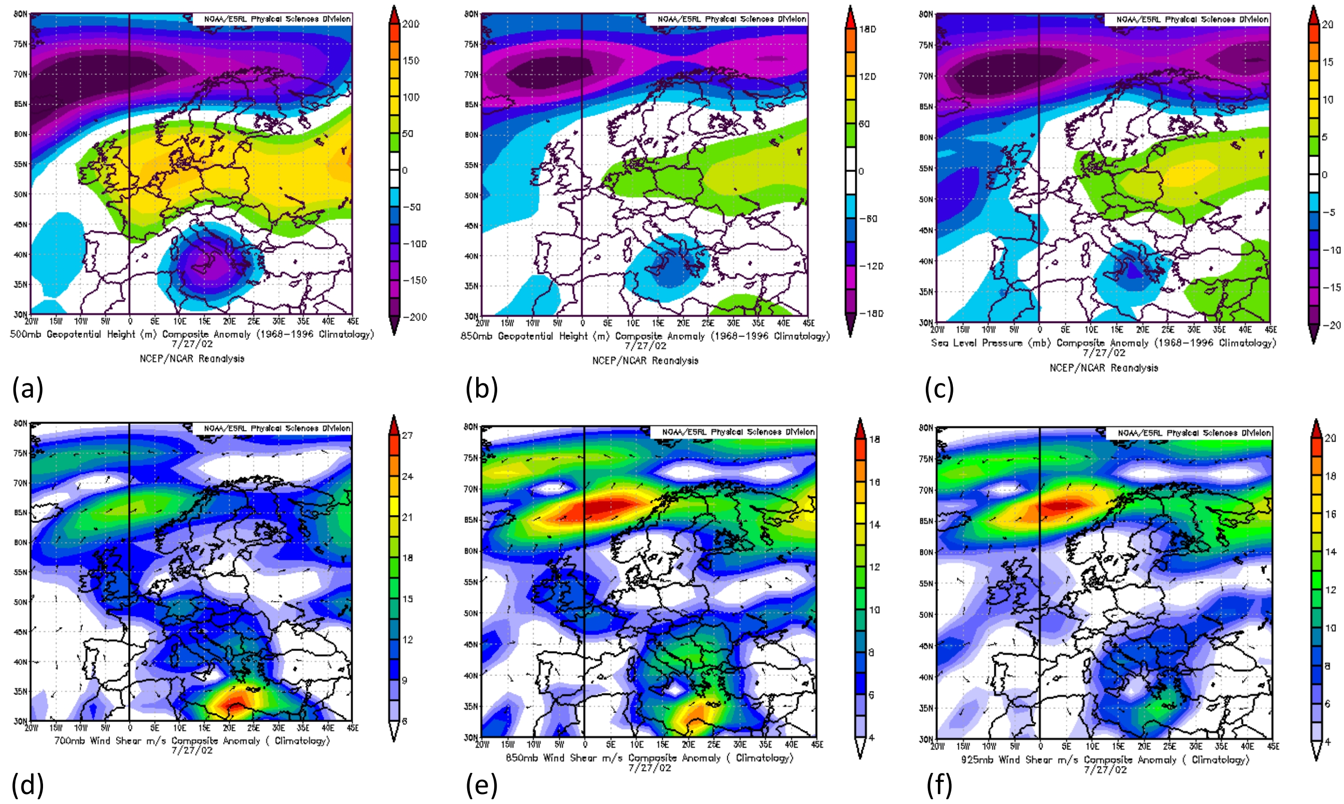

Figure 3. Daily composite anomaly (reference period: 1968-1996) of geopotential heights at the isobaric levels of 500 hPa (a) and 850 hPa (b), of sea-level pressure (c) and daily composite anomaly (reference period: 1968-1996) of wind shear at 700 hPa (d), 850 hPa (e) and 925 hPa (f), on July, 27 2002, from NCEP/NCAR reanalysis datasets.

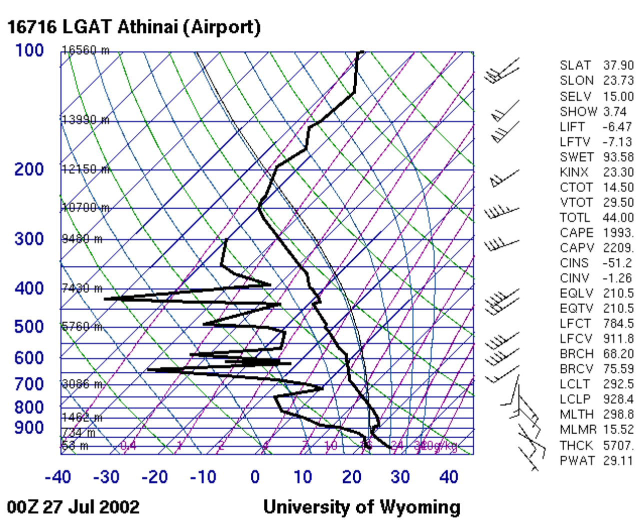

Figure 4. Skew-T plot and indices analysis for Athens at 00:00 UTC, 27 July 2002, retrieved from the database of Wyoming University USA.

revealed a cyclonic circulation from the middle to the lower levels of the atmosphere, while daily composite anomalies of the wind shear from NCEP/NCAR reanalysis datasets appeared at the lower levels of the atmosphere. The vertical profile of the atmosphere showed instability indices typical for the development of severe thunderstorm. A woman was hurt by the tornado activity due to the shift of an airplane during the disembarkation procedure, while several damage at the airport facilities was reported.

The gain of understanding the extracted results from the performed analysis is the possible use of the specific instability indices' thresholds in order to establish an early warning system for short range prognosis of tornadoes' incidence, especially in urban areas and international airports. Future work on local scale is needed in order to verify the atmospheric conditions favorable for tornadoes' development.

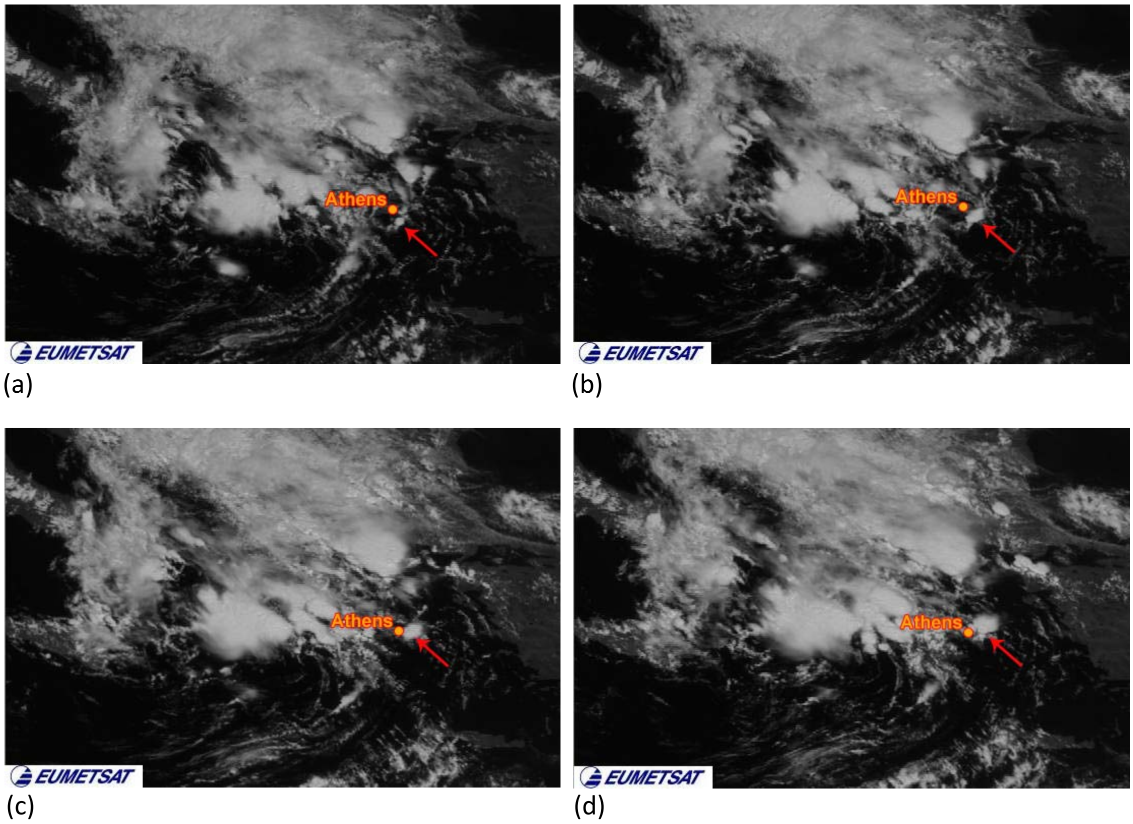

Figure 5. Sequence of satellite images at: **(a)** 09:30 UTC, **(b)** 10:00 UTC, **(c)** 10:30 UTC and **(d)** 11:00 UTC on 27 July 2002 from visual spectrum (VIS 0.6 μm) of Meteosat 7 (Eumetsat). Red arrow indicates the associated storm that formed the tornado over the Athens International Airport.

Acknowledgements. The authors are grateful to the European Center for Medium range Weather Forecasts for the use of reanalysis archive datasets at several levels. Moreover, we thank the National Centers for Environmental Prediction/National Center for Atmospheric Research, the Eumetsat and the Hellenic National Meteorological Service. Special thanks to the HNMS Meteo Officer 1st Lieutenant Mr. Litras for the detailed information about the tornado event.

Edited by: D. Giaiotti
Reviewed by: I. Pytharoulis and another anonymous referee

References

Bech, J., Pascual, R., Rigo, T., Pineda, N., López, J. M., Arús, J., and Gayà, M.: An observational study of the 7 September 2005 Barcelona tornado outbreak, Nat. Hazards Earth Syst. Sci., 7, 129–139, 2007, http://www.nat-hazards-earth-syst-sci.net/7/129/2007/.

Bechini, R., Giaiotti, D., Manzato, A., Stel, F. and Micheletti, S.: The June 4th 1999 severe weather episode in san Quirino, Italy: a tornado event?, Atmos. Res., 56, 213–232, 2001.

Bertato, M., Giaiotti, D. B., Manzato, A., and Stel, F.: An interesting case of tornado in Friuli-Norteastern Italy, Atmos. Res., 67–68, 3–21, 2003.

Dessens, J.: Les Trombes en France. Climatologie et Caracteristiques Physiques, Lannemezan, France, 1984..

Dessens, J. and Snow, J. T.: Tornadoes in France, Weather Forecast., 4, 110–132, 1987.

Dotzek, N.: Tornadoes in Germany, Atmos. Res., 56, 233–251, 2001.

Fujita, T. T.: Tornadoes around the world, Weatherwise, 26, 56–83, 1973.

Holzer, A. M.: Tornado climatology of Austria, Atmos. Res., 56, 203–211, 2001.

Kalnay, E. and Coauthors: The NCEP/NCAR 40-Year Reanalysis Project, B. Am. Meteorol. Soc., 77, 437–471, 1996.

Meaden, G. T.: Tornadoes in Britain: Their intensities and distribution in space and time, J. Meteorol., 1(8), 242–251, 1976.

Nastos, P. T. and Matsangouras J. T.: Tornado activity in Greece within the 20th Century, 11th Plinius Conference on Mediterranean storms, 7–11 September, Barcelona, Spain, Plinius Conference Abstracts, Vol. 11, 11–57, 2009.

Paul, J. F.: An inventory of tornadoes in France, Weather, 54, 217–219, 1999.

Reynolds, D. J.: European tornado climatology 1960–1989, J. Meteorol., 24, 376–403, 1999.

Sioutas, M. V.: Tornadoes and waterspouts in Greece, Atmos. Res., 67–68, 645–656, 2003.

Tyrrell, J.: Tornadoes in Ireland: an historical and empirical approach, Atmos. Res., 56, 281–290, 2001.