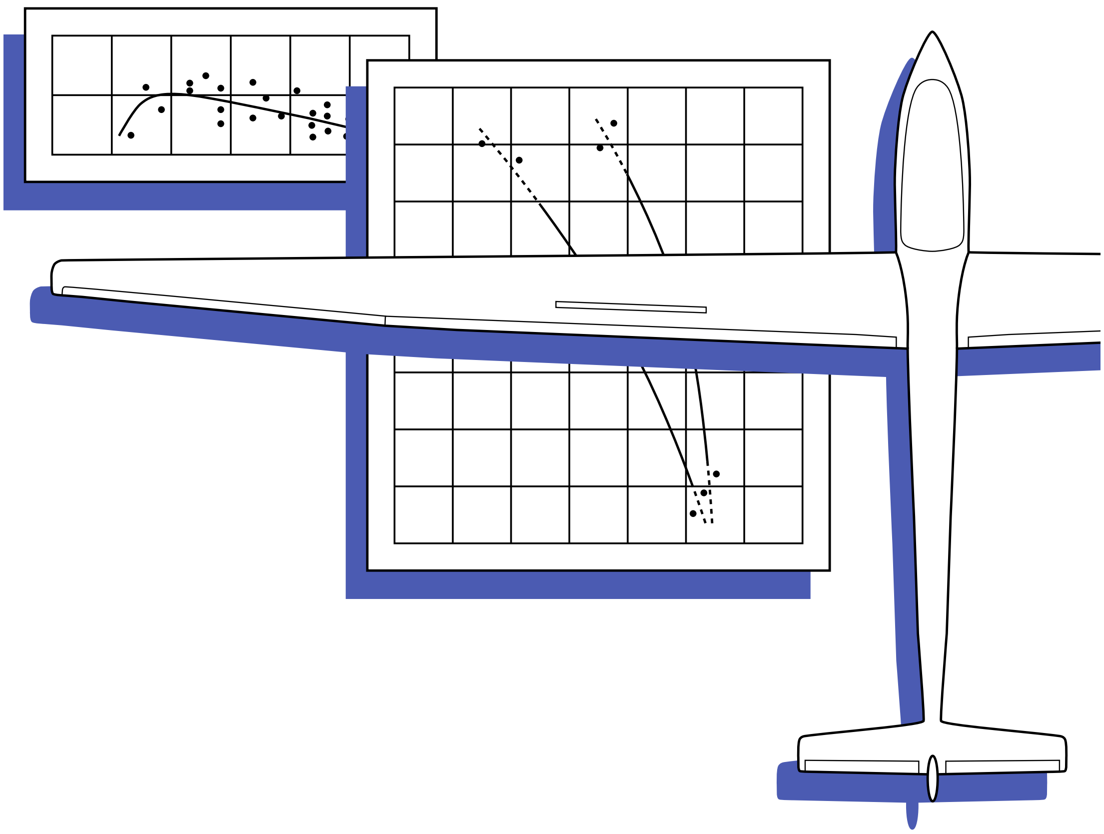
Volume 42, Number 2 April, 2018

# Technical Soaring

## An International Journal



- **Investigation of High Wind Events at the Major Airports in Turkey**

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# Technical Soaring

The Scientific, Technical and Operational Journal of
the Organisation Scientifique et Technique Internationale du Vol à Voile
(International Scientific and Technical Organization for Soaring)




ISSN 0744-8996

**Volume 42, Number 2** **April — June 2018**



*Technical Soaring* (*TS*) documents recent advances in the science, technology and operations of motorless aviation.
*TS* is published quarterly by the Organisation Scientifique et Technique Internationale du Vol à Voile (International Scientific and Technical Organization for Soaring, OSTIV), c/o TU Braunschweig, Institute of Fluid Mechanics, Hermann-Blenk Str. 37, D-38108 Braunschweig, Germany. E-mail: `president@ostiv.org`; URL: `www.ostiv.org`.
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## From the Editor

### Publication Date

This issue is the second of Volume 42 of *TS*, corresponding to April-June 2018. For the record, the issue was published in September, 2019.


### Acknowledgments

We gratefully acknowledge the invaluable work of Prof. Edward Hindman, who currently does everything to support the EIC in catching up, so *TS* should be back on schedule by the end of 2019.


Very Respectfully,


Arne Seitz
Editor-in-Chief, *Technical Soaring*
`ts-editor@ostiv.org`

# Investigation of High Wind Events at the Major Airports in Turkey

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## Abstract

**Gust, a sudden and brief increase in wind speed, becomes important for general aviation and soaring when it exceeds threshold values. Exceeding these thresholds may lead to delaying or cancelling flights and soaring activities. One of these thresholds is defined as a high-wind event when gust speed reaches 50 knots or more. In this study, high-wind events were investigated at the major airports in Turkey for the period 2009-2013. These events were classified according to their wind direction and weather mechanism (convective and non-convective). There were 105 high-wind-event days in this investigated period. About two-thirds of these events were found from southerly directions, and one-third were from northerly directions. The occurrence frequencies of convective and non-convective events were similar, but convective high-wind events were more common in late spring and summer months.**

## Introduction

Gust forecasts have a great importance for global aviation users for strategic flight planning. Global Numerical Weather Prediction (NWP) models with turbulence forecast support the users and their flight planning. Sources of clear-air and mountain wave turbulences are defined. Indeed, convective sources are more complex and problematic. A high wind event means that sustained wind speeds of 35 knots or greater lasting for 1 hour or longer, or winds of 50 knots (wind gust) or greater for any duration [1]. In this study, wind gusts values were used recorded at airports in Turkey between 2009 to 2013. Frequency distributions of monthly and annual high wind events were analyzed in this period. The highest wind gust value was measured at 79 knots at Esenboğa International Airport (in Ankara the capital of Turkey, ICAO code: LTAC, Figure 1), on August 2, 2011. Probabilities of exceedance for selected thresholds of high winds would provide crucial information for general aviation and soaring [1], [2], [3].

Airline companies may cancel their flights following headwind and tailwind conditions: headwind blows 50 knots or more; crosswind blows 25 knots or more; and the gust of crosswind blows 35 knots or more [4]. Due to the strong wind conditions, flights can be suspended, some runways may be inactive which leads to delays in departures and landings, or planes can be diverted to other airports. From 1980 to 1996, 287 fatal airplane accidents happened during approaching and landing [5]. In another study, which investigated 76 aircraft accidents that happened during approaching and landing between 1984-1997, one third of these accidents occurred due to strong wind conditions (i.e., strong crosswinds and tailwinds) [6].

The aim of this study is to statistically analyze and to evaluate the strong wind gust, 50 knots or more, conditions at the major airports of Turkey.

## Data and Methodology

A METeorological Aerodrome Report (METAR) and/or an Aviation Special Weather Report (SPECI) are used to analyze the high-wind events occurred at the major airports in Turkey. METAR is a routine weather report issued at hourly or half-hourly intervals which includes wind direction and speed; visibility; air and dew point temperature; barometric pressure; cloud cover and height. Beside these basic atmospheric measurements and information, weather events, if any, are reported. SPECI is the same as METAR but issued between routine METAR reports in case of important changes in the meteorological parameters [4], [8].

METAR and SPECI reports which are provided by the Turkish State Meteorological Service (TSMS), issued at the major airports in Turkey for a five-year period 2009-2013, are investigated to determine the occurrence of high-wind events. The locations of these airports are shown in Fig. 1.

The National Weather Service (NWS) in the US defined a

This article was peer reviewed by two independent, anonymous reviewers.

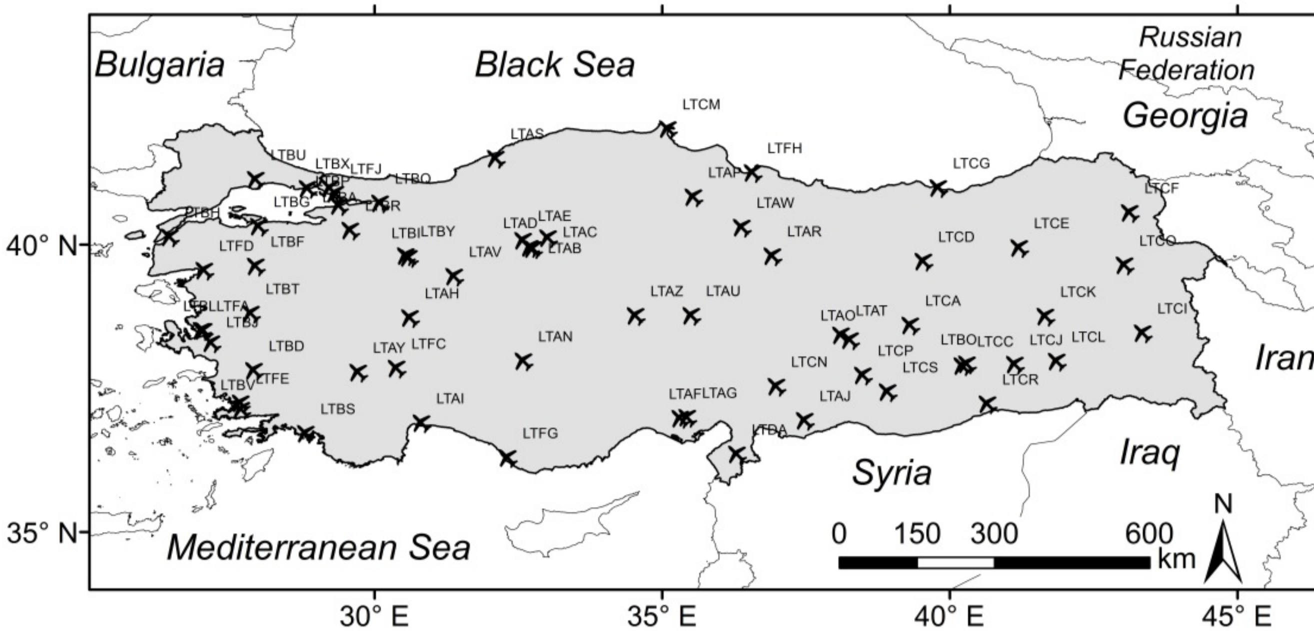


**Fig. 1: The locations of the investigated airports in Turkey (source: [7]).**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2 | 3 | 3 | - | 1 | 1 | 1 | - | - | - | - | 2 | 13 |
| 2010 | 4 | 1 | 3 | - | 2 | 2 | - | 3 | 2 | 4 | 1 | 4 | 26 |
| 2011 | 1 | 1 | 1 | 5 | 1 | 2 | 2 | 1 | - | 1 | - | 2 | 17 |
| 2012 | 2 | 2 | 2 | 2 | 5 | 2 | 2 | 2 | 1 | - | - | 4 | 24 |
| 2013 | 2 | 1 | 5 | 1 | 3 | 3 | 1 | 1 | 1 | 3 | - | 4 | 25 |
| Number of high wind events days | 11 | 8 | 14 | 8 | 12 | 10 | 6 | 7 | 4 | 8 | 1 | 16 | 105 |
| % of high wind events days | 10.5 | 7.6 | 13.3 | 7.6 | 11.4 | 9.5 | 5.7 | 6.7 | 3.8 | 7.6 | 1.0 | 15.2 | 100 |

**Table 1: Monthly and yearly distribution of high wind events days between 2009 and 2013.**

high-wind event when mean hourly wind speed is equal or greater than 35 knots or a gust is equal or greater than 50 knots [1]. Hence, in this study, we accepted 50-knot gust speed as a threshold value for a high-wind event.

The high-wind events were classified into two groups: convective and non-convective. When thunderstorm accompanies high-wind events they are classified as convective. Otherwise, they are defined as non-convective [1]. The threshold value for and the classification of the high-wind events are applied in other studies in the literature [3], [9] – [15]. Based on this threshold value, if gust speed exceeds 50 knots, the observed day is accepted as a high-wind event day. Gust is classified according to its components such as northerly or southerly. Hence, the direction of the gust is classified as southerly for 100°- 260°, purely westerly for 270°, northerly for 280°- 080°, and purely easterly for 90° [12], [16]. If the wind direction is not defined and reported as various directions, the event is assumed from variable directions.

## Analysis, Results and Discussion

Based on five-years of observations of aerodrome reports, the yearly and monthly distributions of the high-wind event days are given in Table 1. There were 105 high-wind event days observed. But the temporal frequency of these events

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Max. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 59 | 55 | 59 | - | 50 | 53 | 51 | - | - | - | - | 55 | 59 |
| 2010 | 58 | 53 | 66 | - | 56 | 50 | - | 58 | 67 | 67 | 50 | 67 | 67 |
| 2011 | 57 | 52 | 54 | 58 | 54 | 52 | 52 | 79 | - | 53 | - | 52 | 79 |
| 2012 | 53 | 57 | 51 | 65 | 55 | 55 | 53 | 52 | 56 | - | - | 54 | 65 |
| 2013 | 56 | 54 | 63 | 53 | 53 | 51 | 61 | 50 | 50 | 56 | - | 65 | 65 |

**Table 2: Monthly and yearly distribution of maximum high wind events speed (knots) between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 2 | 3 | 3 | - | 1 | 1 | 1 | - | - | - | - | 1 | 12 |
| 2010 | 2 | 1 | 3 | - | 1 | - | - | 3 | 1 | 1 | 1 | 2 | 15 |
| 2011 | - | 1 | - | 4 | - | 1 | 1 | 1 | - | - | - | - | 8 |
| 2012 | 2 | 2 | - | 1 | 4 | 1 | 2 | 2 | 1 | - | - | 2 | 17 |
| 2013 | 2 | 1 | 4 | 1 | 2 | 2 | 1 | - | - | 3 | - | 1 | 17 |
| Number of southerly high wind events days | 8 | 8 | 10 | 6 | 8 | 5 | 5 | 6 | 2 | 4 | 1 | 6 | 69 |
| % of southerly high wind events days | 11.6 | 11.6 | 14.5 | 8.7 | 11.6 | 7.3 | 7.3 | 8.7 | 2.9 | 5.8 | 1.5 | 8.7 | 100 |

**Table 3: Monthly and yearly distribution of southerly high wind events days between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1 | 1 | 3 | - | - | - | - | - | - | - | - | 1 | 6 |
| 2010 | - | 1 | 3 | - | 1 | - | - | - | - | - | 1 | - | 6 |
| 2011 | - | 1 | - | 3 | - | - | - | - | - | - | - | - | 4 |
| 2012 | 2 | - | - | 1 | 1 | - | - | - | - | - | - | 2 | 6 |
| 2013 | - | - | 4 | 1 | 1 | 1 | - | - | - | 2 | - | 1 | 10 |
| Number of southerly non-convective high wind events days | 3 | 3 | 10 | 5 | 3 | 1 | - | - | - | 2 | 1 | 4 | 32 |
| % of southerly non-convective high wind events days | 9.4 | 9.4 | 31.3 | 15.6 | 9.4 | 3.1 | - | - | - | 6.3 | 3.1 | 12.5 | 100 |

**Table 4: Monthly and yearly distribution of southerly non-convective high wind events days between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1 | 2 | - | - | 1 | 1 | 1 | - | - | - | - | - | 6 |
| 2010 | 2 | - | - | - | - | - | - | 3 | 1 | 1 | - | 2 | 9 |
| 2011 | - | - | - | 1 | - | 1 | 1 | 1 | - | - | - | - | 4 |
| 2012 | - | 2 | - | - | 3 | 1 | 2 | 2 | 1 | - | - | - | 11 |
| 2013 | 2 | 1 | - | - | 1 | 1 | 1 | - | - | 1 | - | - | 7 |
| Number of southerly convective high wind events days | 5 | 5 | - | 1 | 5 | 4 | 5 | 6 | 2 | 2 | - | 2 | 37 |
| % of southerly convective high wind events days | 13.5 | 13.5 | - | 2.7 | 13.5 | 10.8 | 13.5 | 16.2 | 5.4 | 5.4 | - | 5.4 | 100 |

**Table 5: Monthly and yearly distribution of southerly convective high wind events days between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 |
| 2010 | 2 | - | - | - | 1 | 2 | - | - | 1 | 3 | - | 1 | 10 |
| 2011 | - | - | 1 | 1 | 1 | 1 | 1 | - | - | 1 | - | 2 | 8 |
| 2012 | - | - | 2 | 1 | 1 | 1 | - | - | - | - | - | 1 | 6 |
| 2013 | - | - | 1 | - | 1 | 1 | - | 1 | - | - | - | 3 | 7 |
| Number of northerly high wind events days | 2 | - | 4 | 2 | 4 | 5 | 1 | 1 | 1 | 4 | - | 8 | 32 |
| % of northerly high wind events days | 6.3 | - | 12.5 | 6.3 | 12.5 | 15.6 | 3.1 | 3.1 | 3.1 | 12.5 | - | 25.0 | 100 |

**Table 6: Monthly and yearly distribution of northerly high wind events days between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2010 | 1 | - | - | - | - | 1 | - | - | - | 1 | - | 1 | 4 |
| 2011 | - | - | 1 | 1 | 1 | - | - | - | - | - | - | 1 | 4 |
| 2012 | - | - | 2 | 1 | - | - | - | - | - | - | - | - | 3 |
| 2013 | - | - | 1 | - | - | - | - | 1 | - | - | - | 3 | 5 |
| Number of northerly non-convective high wind events days | 1 | - | 4 | 2 | 1 | 1 | - | 1 | - | 1 | - | 5 | 16 |
| % of northerly non-convective high wind events days | 6.3 | - | 25.0 | 12.5 | 6.3 | 6.3 | - | 6.3 | - | 6.3 | - | 31.3 | 100 |

**Table 7: Monthly and yearly distribution of northerly non-convective high wind events days between 2009 and 2013.**

| Years\Months | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 |
| 2010 | 1 | - | - | - | 1 | 1 | - | - | 1 | 2 | - | - | 6 |
| 2011 | - | - | - | - | - | 1 | 1 | - | - | 1 | - | 1 | 4 |
| 2012 | - | - | - | - | 1 | 1 | - | - | - | - | - | 1 | 3 |
| 2013 | - | - | - | - | 1 | 1 | - | - | - | - | - | - | 2 |
| Number of northerly convective high wind events days | 1 | - | - | - | 3 | 4 | 1 | - | 1 | 3 | - | 3 | 16 |
| % of northerly convective high wind events days | 6.3 | - | - | - | 18.8 | 25.0 | 6.3 | - | 6.3 | 18.8 | - | 18.8 | 100 |

**Table 8: Monthly and yearly distribution of northerly convective high wind events days between 2009 and 2013.**

is not evenly distributed. Interannual variations in the event-occurrences highlight this temporal variability. Interannual variations in the occurrences also is reflected in the seasonality of the occurrences. Winter (DJF) is the most common season to observe these events, especially December, about 15% of the occurrences happen in this month. On the other hand, fall (SON) is the least common season to observe this event.

Within the occurrence classification, Table 2 shows the monthly and yearly distributions of the maximum wind speeds for high-event days. For the investigated period, among all airports, the recorded greatest wind-speed value was 79 knots which was reported on August 2, 2011 at the Esenboğa International Airport in Ankara [2], [17]. This event caused damage not only on the infrastructure, a collapse of part of the terminal roof, but also on an aircraft which was parked on the apron, its wing hit the ground.

When event days are classified based on the direction, about two-thirds of the events (69 out of 105) were from southerly directions (Table 3). However, each month did not contain the same number. Whereas all events (eight out of eight) in February were southerly, about half of the events (six out of sixteen) in December were southerly. Hence, the direction of the high-wind events brings another level of complexity to the interannual variability in the distribution of the high-wind event days.

Within the directional classification, southerly high-wind events were classified as whether generated from non-convective or convective weather mechanism. The temporal distributions for non-convective and convective high-wind event days are given in Table 4 and Table 5, respectively. The number of non-convective high-wind event days (32) was slightly less than the number of convective ones (37). All events in March originated from non-convective weather mechanisms. The relative increase in convective high-wind events in late spring and summer can be attributed to an increase in convective activity as a result of enhanced solar insolation.

After analyzing southerly high-wind events, similar analysis was done for northerly events. The monthly and yearly distributions of northerly high-wind events are given in Table 6. In comparison to southerly events, about one third of the high-wind events are from northerly directions. These events are evenly distributed between non-convective (Table 7) and convective weather mechanisms (Table 8). Similar to southerly events, convective high-wind events are more common late spring and summer months.

## Conclusions

This study investigates high-wind-event days observed at major airports in Turkey for the period 2009–2013. Most of the events, 69 out of 105, were from southerly directions, 32 were from northerly directions, one of them was from purely easterly direction, and three events were from variable directions. Winter (33%) and spring (32%) are the most common seasons that experience high-wind events. They are followed by summer (22%) and fall (12%) seasons. December (15%) is the most common month that experiences high-wind events. The highest reported gust of 79 knots was observed in the Esenboğa International Airport during the passage of thunderstorm.

The majority of the high-wind events was from southerly directions which was about two times more than occurred from northerly directions. The occurrence frequencies of convective and non-convective events are more or less similar regardless of the wind direction. Temporal distribution of the occurrences revealed late spring and summer months experience convective high-wind events more frequently than non-convective events.

This is the first study for major airports in Turkey that investigates and reports the high-wind event occurrences, directions, and their weather mechanism. Predictability of these severe events are very important for aviation to mitigate their impacts on planes, infrastructures, and flights. Non-convective high-wind storms have greater spatial and temporal scales than convective counterparts [18] which makes them relatively more predictable than convective high-wind storms. Beside the small spatial extent, the chaotic nature of convection and relatively fast development of thunderstorm cells within a short period make these predictions much harder. Special software programs are needed to predict/forecast these events because of their importance for aviation.


## Acknowledgements

The authors would like to thank TSMS for providing the meteorological data. E.T. Özdemir acknowledges the support of the Scientific and Technological Research council of Turkey. The poster version of this study was presented at the OSTIV Meteorological Panel in 2018 [19].


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