A case study for Unprecedented Storm in Turkey in 2012

Turkish State Meteorological Service

Dr. Levent YALCIN
lyalcin@mgm.gov.tr

Huseyin Yuksel OZALP
yozalp@mgm.gov.tr

Turkish State Meteorological Service, Department of Weather Forecasts

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INTRODUCTION

Due to Turkey's geographic location and topographic conditions Turkey is exposed severe weather at times. Turkey has a very large area with different topographic and climate conditions which makes it very difficult to observe and predict the weather. At the date of 18th April 2012, low pressure centre which is located so deep in Aegean Sea caused storm and dust transport particularly in western and central part of Turkey. Wind speed which has been measured at many meteorological stations has reached extreme or close to extreme values in the country. Losses of life, injuries, property losses occurred and everyday life such as transportation (marine, air and road) was effected negatively due to this strong wind. In the study, this extraordinary meteorological event is synoptically analyzed. Also use and interpretation of ECMWF products (deterministic, EPS, EFI) in forecasting and warnings of this event in Turkish State Meteorological Service is examined. ECMWF products served this extreme event forecasts successfully to TSMS forecasters in a suitable period of time to warn related units.

MATERIAL AND METHOD

In this study, synoptic charts, observations, ECMWF deterministic and EPS forecasts, operational forecast issued by TSMS and some press outputs are presented in a classified method. All these materials are used for everyday operational forecast issues in TSMS.

SYNOPTIC EVALUATION

1012 hPa high pressure centre over Turkey and 1008 hPa low pressure centre over Egypt, the trough of 138 gpdam low centre over Adriatic Sea at 850 hPa level extending from east of Italy to Libya (Figure 1a-1b).

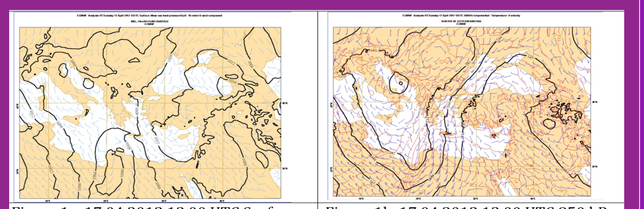

Figure 1a. 17.04.2012 12.00 UTC Surface MSLP, 10 m Wind

Figure 1b. 17.04.2012 12.00 UTC 850 hPa Geopotantial, Temperature, Wind

A deepening 996 hPa low pressure centre at the North of Egypt moves to northward at 18.00 UTC. A deepening 135 gpdam low centre at 850 hPa moves toward the south of Greece (Figure 2a-2b).

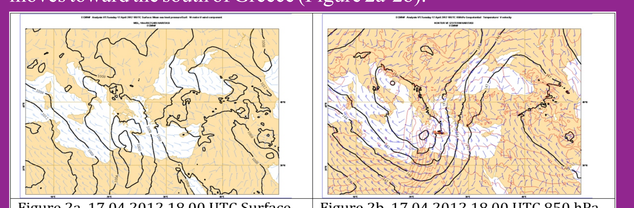

Figure 2a. 17.04.2012 18.00 UTC Surface MSLP, 10 m Wind

Figure 2b. 17.04.2012 18.00 UTC 850 hPa Geopotantial, Temperature, Wind

At 00 UTC the deepening low pressure centre that the central surface pressure lowers to 992 hPa moves toward the south of Peloponnese Peninsula. So there is isobaric gradient in the western regions of Turkey. There appears 16 hPa pressure difference along with 500 km distance between Western and Central Anatolia. The low centre at 850 hPa moves to Greece and takes the value of 132 gpdam. Contour gradient over western regions reaches 16 gpdam. It is clearly seen that there is a isotherm gradient, of which the difference reaches 15 °C, along with cold front zone (Figure 3a-3b).

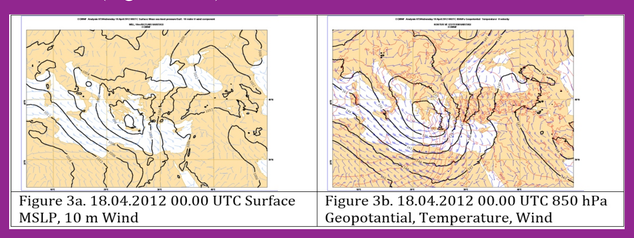

Figure 3a. 18.04.2012 00.00 UTC Surface MSLP, 10 m Wind

Figure 3b. 18.04.2012 00.00 UTC 850 hPa Geopotantial, Temperature, Wind

At 06 UTC the deepening low pressure centre that the central surface pressure lowers to 984 hPa moves toward the Aegean Sea. So there is a large isobaric gradient (7 isobars within about 500 km area) in the western and central regions of Turkey. There appears 28 hPa pressure difference between Western and Central Anatolia. The low centre at 850 hPa moves to Aegean and takes the value of 123 gpdam. There is a large contour gradient over Western and Central regions. It is also seen that there is a large isotherm gradient along with cold front zone (Figure 4a-4b).

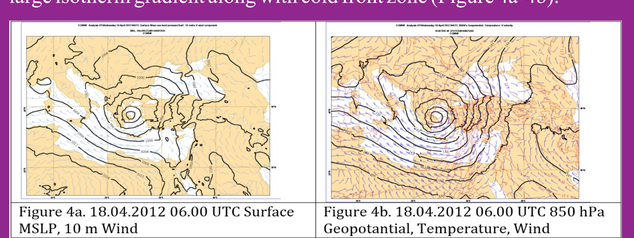

Figure 4a. 18.04.2012 06.00 UTC Surface MSLP, 10 m Wind

Figure 4b. 18.04.2012 06.00 UTC 850 hPa Geopotantial, Temperature, Wind

At 12 UTC, 984 hPa low pressure centre over Northern Aegean Sea and 988 hPa low pressure centre over Western Black Sea. There is a large isobaric gradient (6 isobars within about 500-600 km area) in the western and central regions of Turkey. There appear 16 hPa pressure differences over Central Anatolia. At 850 hPa, 123 gpdam low pressure centre moves little to eastward. And also, a cold front passes associated with a isotherm gradient over the inner part of Central Anatolia (Figure 5a-5b).

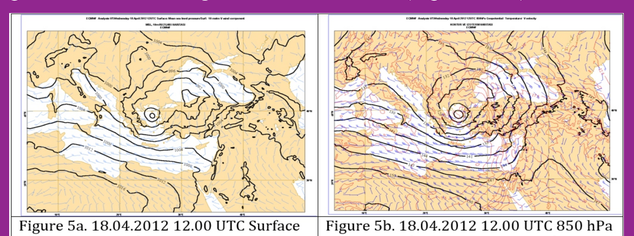

Figure 5a. 18.04.2012 12.00 UTC Surface MSLP, 10 m Wind

Figure 5b. 18.04.2012 12.00 UTC 850 hPa Geopotantial, Temperature, Wind

By 18 UTC, the filling low pressure centre moves in the direction of northeast (Figure 6a-6b and 7a-7b)

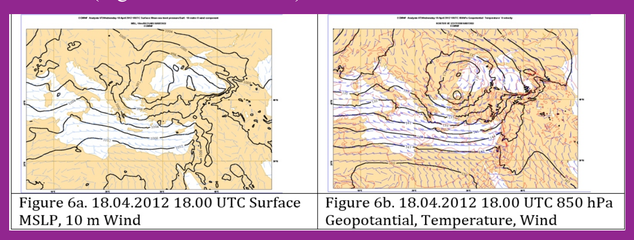

Figure 6a. 18.04.2012 18.00 UTC Surface MSLP, 10 m Wind

Figure 6b. 18.04.2012 18.00 UTC 850 hPa Geopotantial, Temperature, Wind

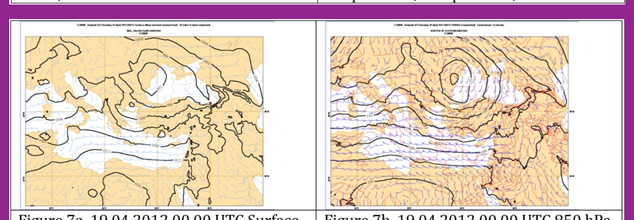

Figure 7a. 19.04.2012 00.00 UTC Surface MSLP, 10 m Wind

Figure 7b. 19.04.2012 00.00 UTC 850 hPa Geopotantial, Temperature, Wind

Dry macrobursts, produced by high based thunderstorms that generate little to no surface rainfall, occur in environments characterized by a thermodynamic profile exhibiting an inverted-V at thermal and moisture profile, as viewed on SkewT [1] presented below (Figure 8a, 9a, 9b). Figure 8a and 8b shows changing in surface wind direction from south to northwest which means cold front crossing.

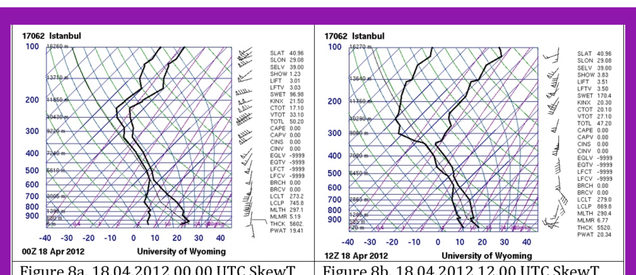

Figure 8a. 18.04.2012 00.00 UTC SkewT (Istanbul)

Figure 8b. 18.04.2012 12.00 UTC SkewT (Istanbul)

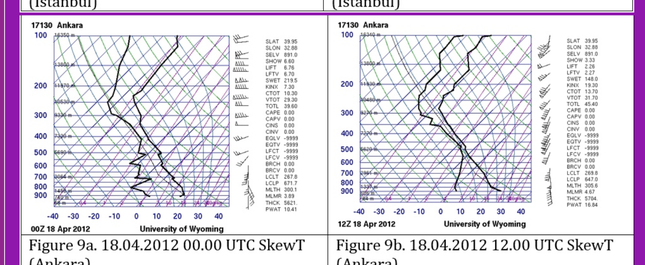

Figure 9a. 18.04.2012 00.00 UTC SkewT (Ankara)

Figure 9b. 18.04.2012 12.00 UTC SkewT (Ankara)

At 12 UTC pressure tendency chart, the cold frontal zone can be seen clearly over Western Anatolia (Figure 10).

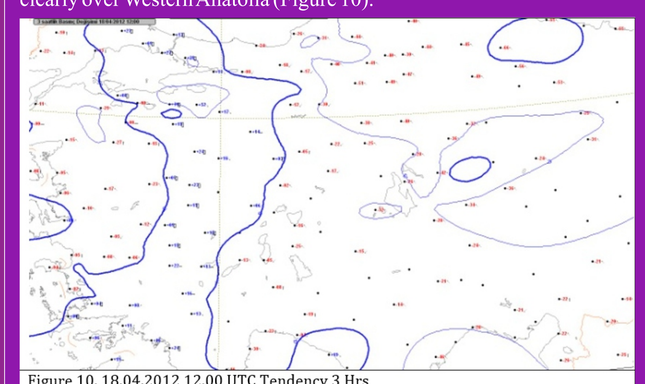

Figure 10. 18.04.2012 12.00 UTC Tendency 3 Hrs

As a result, the decreasing pressure value reaching 20-24 hPa in 24 hours, associated with pressure and isotherm gradients, resulted in wind storms. Furthermore, the 984 hPa low is rarely seen in the season [2]. This is seen in the Figure 17a-b. at the chart of ECMWF EPS anomalous map. Movement of the cold front and dry macrobursts increased severity of wind storm.

ECMWF PRODUCTS

DETERMINISTIC

ECMWF/IFS 13.04.2012 00 Run shows that there is no any signal about severe wind storm and deepening low pressure centre around Turkey for 18.04.2012 12 UTC (Figure 11).

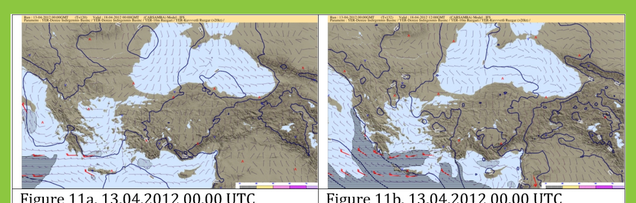

Figure 11a. 13.04.2012 00.00 UTC (VT: **18.04.2012 00.00 UTC**)

Figure 11b. 13.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 11: ECMWF / IFS Pressure MSL, 10 m Wind, Wind>20 kt

ECMWF/IFS 14.04.2012 00 Run shows 1000 hPa low pressure centre at the west part of Turkey and strong wind over south-western part of Turkey for 18.04.2012 12 UTC (Figure 12).

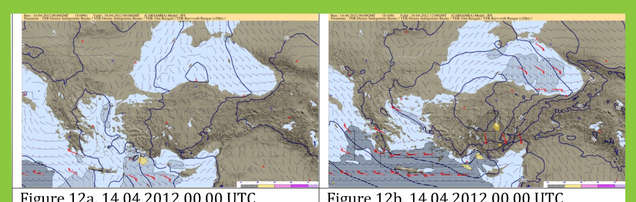

Figure 12a. 14.04.2012 00.00 UTC (**18.04.2012 00.00 UTC**)

Figure 12b. 14.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 12: ECMWF / IFS Pressure MSL, 10 m Wind, Wind>20 kt

ECMWF/IFS 15.04.2012 00 Run shows 988 hPa low pressure centre at east of Marmara Region and strong wind for Central parts of Turkey for 18.04.2012 12 UTC (Figure 13).

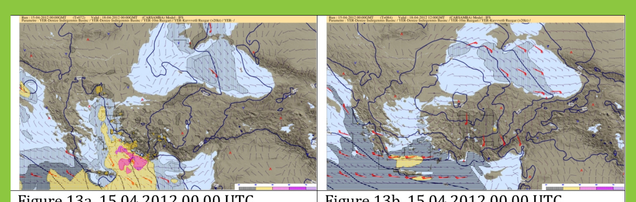

Figure 13a. 15.04.2012 00.00 UTC (**18.04.2012 00.00 UTC**)

Figure 13b. 15.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 13: ECMWF / IFS Pressure MSL, 10 m Wind, Wind>20 kt

ECMWF/IFS 16.04.2012 00 Run shows 988 hPa deep low pressure centre at east of Marmara Region and and strong wind with gust for western and central parts of Turkey for 18.04.2012 12 UTC (Figure 14).

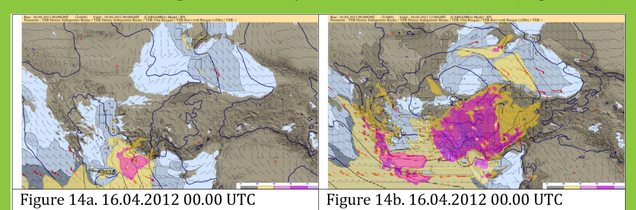

Figure 14a. 16.04.2012 00.00 UTC (**18.04.2012 00.00 UTC**)

Figure 14b. 16.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 14: ECMWF / IFS Pressure MSL, 10 m Wind, Wind>20 kt

ECMWF/IFS 17.04.2012 00 Run shows two 988 hPa low pressure centres at the Northwest part of Turkey and wind storm for western and central parts of Turkey for 18.04.2012 12 UTC. At 850 hPa chart, there is 126 hPa low centre over North of Aegean and a large isotherm gradient over western and central parts of Turkey (Figure 15-16).

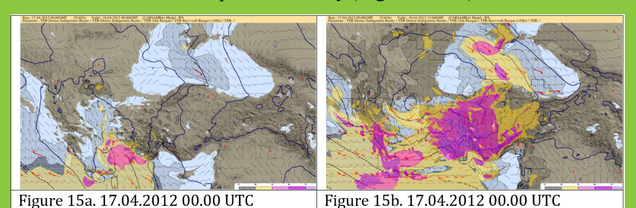

Figure 15a. 17.04.2012 00.00 UTC (**18.04.2012 00.00 UTC**)

Figure 15b. 17.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 15: ECMWF / IFS Pressure MSL, 10 m Wind, Wind>20 kt

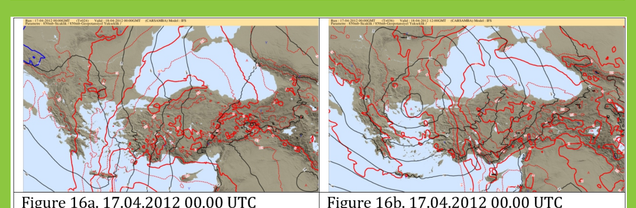

Figure 16a. 17.04.2012 00.00 UTC (**18.04.2012 00.00 UTC**)

Figure 16b. 17.04.2012 00.00 UTC (**18.04.2012 12.00 UTC**)

Figure 16: ECMWF / IFS 850 hPa Geopotantial, Temperature

EPS

EPS Anomalous map shows that MSLP is below 8 to 12 hPa than normal and extreme wind signals over western parts of Turkey (Figure 17).

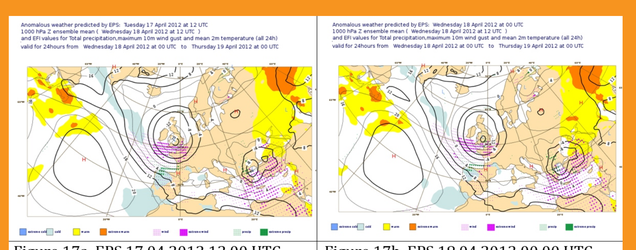

Figure 17a. EPS 17.04.2012 12.00 UTC (**18.04.2012 12.00 - 19.04.2012 00.00 UTC**)

Figure 17b. EPS 18.04.2012 00.00 UTC (**18.04.2012 12.00 - 19.04.2012 00.00 UTC**)

Figure 17: Anomalous weather prediction 1000 hPa Z Ensemble Mean

EFI wind gust index value is between 0.8 and 1.0 for 18.04.2012, that means expected wind is unusual for the region (Figure 18).

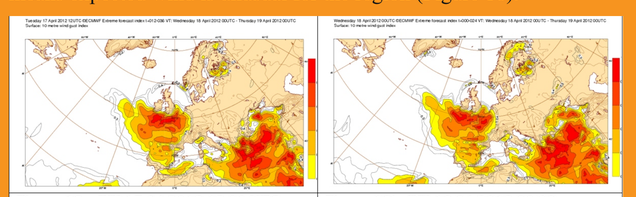

Figure 18a. EFI 17.04.2012 12.00 UTC (**18.04.2012 00.00 - 19.04.2012 00.00 UTC**)

Figure 18b. EFI 18.04.2012 00.00 (**18.04.2012 00.00 - 19.04.2012 00.00 UTC**)

Figure 18: Extreme forecast index (EFI) 10 m Wind Gust

OPERATIONAL FORECASTS

Using ECMWF deterministic and EPS product, wind storm at April 18th 2012 was forecasted and warnings were shared with public and local authorities (Figure 19-20).

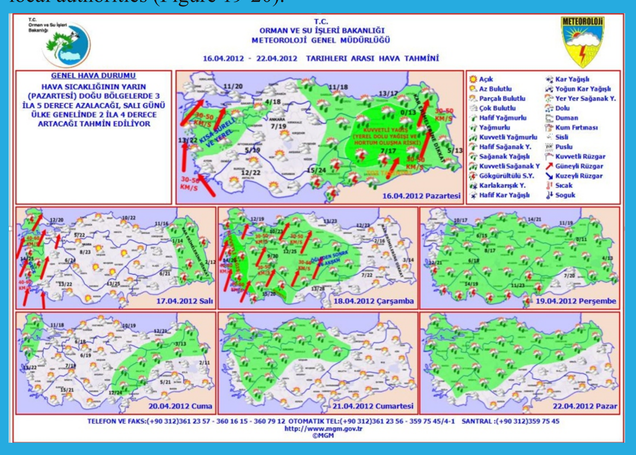

Figure 19. Weekly forecast prepared in April 15th 2012

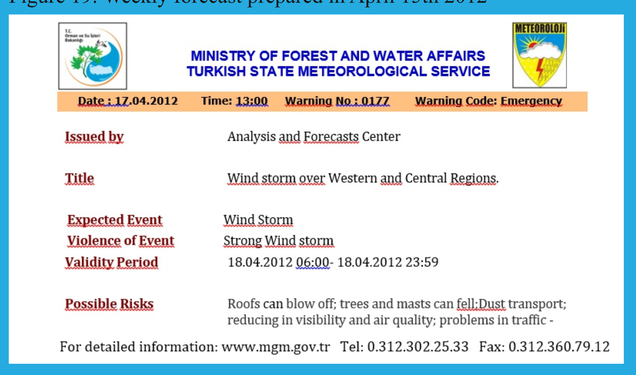

Figure 20. Warning message prepared in April 17th 2012

THE IMPLICATIONS OF EVENT

Some maximum wind speed measurements and MSG separated dust image on 18th April 2012. Many station exceeds extreme values which have ever been seen in its history (Table 1 and Figure 21).

Table 1. Some maximum wind speed measurements on 18th April 2012

Location	Wind speed	Value and date of extreme
Ankara/ (Elmadağ-Radar site)	150*	109.4 (17.02.2010)
Muğla/Datça	137	122.0 (23.01.2009)
Bartın/Amasra	125	147.6 (01.03.2001)
Uşak/Eşme	124	156.2 (10.01.2011)
Isparta/Şarkikaraağaç	124	150.8 (04.08.2007)
Konya/Cihanbeyli	120	119.8 (28.02.1970)
Bursa/Gemlik	118	145.8 (30.03.2009)
Ankara/Haymana	112	88.2 (12.02.2009)
Ankara/Nallıhan	111	142.9 (30.04.2008)
Ankara/Bala	111	102.9 (23.03.2007)
Kastamonu/Bozkurt	110	144.0 (17.05.1984)
Ankara/Polatlı	109	113.0 (17.03.1970)
İzmir/Foça	108	
İstanbul/Atatürk Airport.	105	
Isparta/Eğirdir	105	108.7 (09.01.1985)
Ankara/Esenboğa	104	125.2 (03.03.1971)
Burdur	104	171.7 (29.11.2010)
Afyon/Bayat	104	88.5 (10.06.2011)
Çifteler	103	106.9 (21.03.2008)
Ankara/Güvercinlik	102	
Afyon/Şuhut	101	118.4 (21.01.2011)
Kocaeli	98	120.9 (14.03.1973)
Afyon/Bolvadin	93	86.4 (09.08.1986)

*The values in red shows wind speed exceeds extreme value

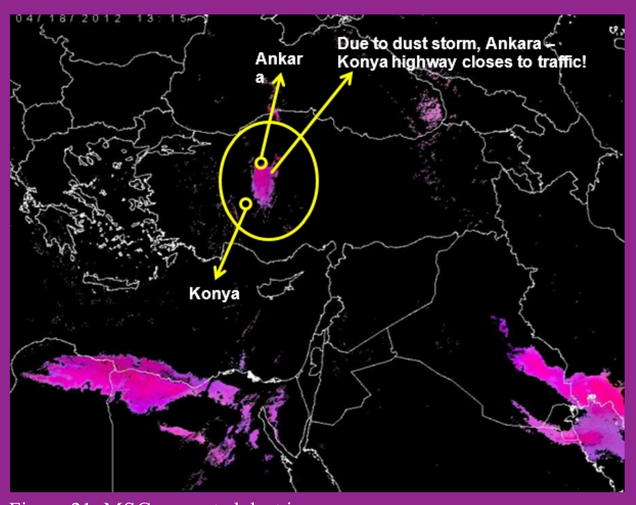

Figure 21. MSG separated dust image

RESULTS OF THE EVENT

Here is some news from national and international press agencies. There are both lose of people and goods in different life areas (Figure 21). The highlights summary briefly what people faced at the date of windstorm.

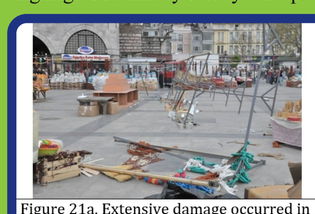

Figure 21a. Extensive damage occurred in the set of James Bond film "Skyfall" during a rain and windstorm in the Eminonu district of Istanbul [3].

Figure 21b. CNN sister network CNN Turk showed video of film and set equipment in Eminonu's main square scattered and damaged by the storm [4].

Figure 21c. A boat sailing in Istanbul caught fire after a suspected engine failure, going up in flames with passengers on board. Fishing boats rescued the 10 people on board. DHA photos

Figure 21d. Traffic was disrupted along the Ankara-Konya highway, which was affected by a sandstorm, with several traffic accidents occurring along the highway due to high-speed winds. Two people were killed and 20 others were injured in traffic accidents caused by the sandstorm.

HIGHLIGHTS

- **Roofs are ripped off and trees are felled**
- **The lodos is a strong southwesterly wind**
- **The winds measured at 100 kph ripped the roofs from some 350 buildings, downed more than 100 trees.**
- **High winds reaching 100 kilometers an hour killed six person and left numerous injured**
- **Justice and Development Party deputy Gülay Dalyan also fell in the Parliament's garden due to the storm.**
- **Bridges and the Trans European Motorway partly closed after storm tipped over in Istanbul.**
- **Turkish Airlines has cancelled 43 domestic and international flights .**
- **The Istanbul Gas Distribution Industry and Trade inc. (İGDAŞ) warned its users to be very careful of possible gas leaks due to the ongoing storms.**
- **All sea transportation has been cancelled in Istanbul.**
- **At least four dead as storm batters western, central Turkey (Todays Zaman)**
- **The storm also forced the İstanbul Ferry Lines (İDO) to cancel ferries.**

CONCLUSION

Weather hazards and related events such as hurricanes, heat waves, cold waves, windstorms, floods, and droughts jointly cause more economic damage and loss of life than other natural disasters. In recent decades such damage has shown a growing trend, and climate change may make such events even more dangerous.

Due to Turkey's geographic location and topographic conditions Turkey is exposed to severe weather at times. So early warnings help to reduce economic losses and mitigate the number of injuries or deaths from a disaster, by providing information that allows individuals, local authorities and communities to protect lives and property.

Forecasts and early warnings are prepared using both ECMWF deterministic and ECMWF EPS products effectively. Especially, It is experienced that for D+3 and later, EPS products are more useful than deterministic forecasts.

The Extreme Forecast Index (EFI) is used to forecast anomalous or extreme events.

Forecasts and warnings should be based on a careful study of probabilistic and deterministic products in addition to the EFI.

REFERENCES

[1] http://en.wikipedia.org/wiki/Microburst

[2] Coleri, M. and et al. Weather Analysis and Forecasting Techniques. 2007.

[3] www.demotix.com

[4] http://edition.cnn.com/2012/04/18/world/europe/turkey-freak-storm/

We would like to thank all our colleagues for their contribution in TSMS.