# PROGNOSIS OF CENTRAL-EASTERN MEDITERRANEAN WATERSPOUTS

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## I. INTRODUCTION

A first analysis of central-eastern Mediterranean waterspout cases (Sioutas and Keul, 2007) revealed several typical synoptic and thermodynamic elements. Does the scientific state-of-the-art encourage a waterspout prognosis for synoptic services although the testing is based only on the fraction of occurring waterspouts that are reported?

ESTOFEX, the European Storm Forecast Experiment (www.estofex.org), issues daily forecasts with infrequent regional waterspout warnings. The Meteorological Service of Canada, as well as the National Oceanic and Atmospheric Administration (US weather service), use a waterspout nomogram for the Great Lakes area (Szilagyi, 2006) developed by the third author. Is it a valid prognostic instrument for Mediterranean cases, too?

## II. PRESENTATION OF RESEARCH

The central-eastern Mediterranean Sea (Adriatic, Ionian, Aegean Sea) was an active region for waterspout events from 2002 to 2006. ESWD, the European Severe Weather Database (http://essl.org/ESWD) recorded 34 Adriatic reports in the five year interval, with 9 in 2005 and 18 for 2006. The first author received reports on 34 Adriatic (15 in 2002) and 8 Aegean events. The second author collected 38 Ionian and Aegean reports from the five year period (12 from 2002). All waterspout data sources used give a total of 114 cases from 2002 to 2006. Tornadic waterspouts occur in connection with thunderstorms (see Fig.1), fair-weather waterspouts near cumulus cloud(bank)s. In the first study of 28 events, about 50% were tornadic and 50% fair-weather waterspouts (Sioutas and Keul, 2007).

FIG. 1: Tornadic waterspout and cloud-ground lightning of August 4, 2006, Brac Island, Croatia (video still by Daniel Peis).

With an estimated 160 European waterspouts per year (Dotzek, 2003) and regular damage –especially from tornadic waterspouts– to life and property, the prognosis of such events is on the desiderata list of national weather services.

In 2006, ESTOFEX, the European Storm Forecast Experiment (www.estofex.org), issued 5 explicit (wording “waterspout”) and 9 implicit (tornado area warning) regional waterspout warnings in its 35 daily forecast bulletins of threat level “2” (about 10% of all bulletins). 6 of them dealt with the central-eastern Mediterranean project area, but none of them coincided with reported events.

The line of research followed by the first two authors has been to analyze reported waterspout cases with regard to synoptic and thermodynamic characteristics present (compare Sioutas, 2003) to be able to generalize “waterspout markers” for prognosis. Studying 28 tornadic and fair-weather cases from three sea regions, the frequency of four basic synoptic types associated with waterspout events – south-west flow, long-wave trough, closed low and short-wave trough – was identified as well as the role of upper and lower level jets for increased wind shear. Out of a number of thermodynamic instability indices, KI and TT were good predictors (Sioutas and Keul, 2007).

The Meteorological Service of Canada at Toronto uses a waterspout nomogram developed empirically from 150 waterspout events (Szilagyi, 2004, 2006). The nomogram is comprised of two instability parameters (Lake-850 mb temperature difference, Lake generated cloud depth (EL-LCL)) and one wind constraint (850 mb wind speed).

In order to calculate the above parameters, the following values must be determined; maximum lake temperature, 850 mb temperature over the lake, modified air temperature and dew point over the lake, equilibrium level (EL) and lifted condensation level (LCL), which are both determined from a tephigram. Once calculated, the (EL-LCL) and the lake temperature-850 mb temperature are plotted on the nomogram shown in Figure 2. Note that the 850 mb wind must be <40 kts for waterspouts to occur. Categories of tornadic, upper low, land breeze and winter waterspouts are also identified on the nomogram.

As a pre-test, 11 Adriatic waterspout events with synoptic and tephigram data were analyzed by the third author to test the applicability of the Canadian method to the Mediterranean data set. It was found that all 11 cases met the nomogram criteria, i.e. fell into the red-circled area of Fig.2, and also, with two exceptions, into the right fair-weather or tornadic nomogram segments.

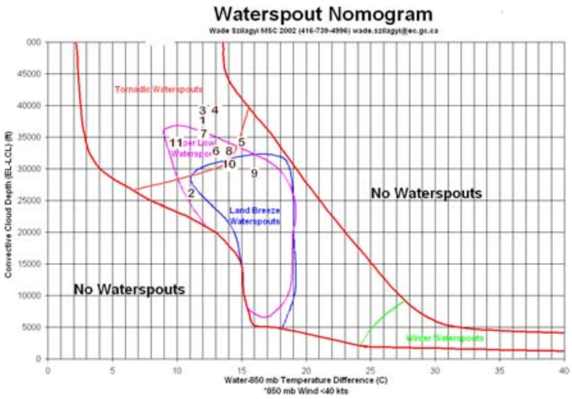


FIG. 2: Szilagyi waterspout nomogram with four types of Great Lake waterspouts and 11 inserted Adriatic pre-test cases.

| Date | 2002-07-14 | 2002-07-17 | 2002-08-28 |
|---|---|---|---|
| Tephigram used | Udine | Udine | Udine |
| Water temp ◦C | 26 | 24 | 26 |
| Air Temp over land ◦C | 29 | 20 | 27 |
| Modified air temp over water ◦C | 27 | 23 | 26 |
| Dew point temp over land ◦C | 17 | 18 | 13 |
| Mod.dew point temp over water ◦C | 23 | 22 | 22 |
| 850 mb temp | 15 | 12 | 14 |
| Modified air temp – 850 mb temp◦C | 12 | 11 | 12 |
| LCL (ft) | 2100 | 1100 | 2500 |
| EL (ft) | 39800 | 37700 | 40000 |
| EL – LCL (ft) | 37700 | 26600 | 37500 |
| Waterspout type observed | T | F | T |
| Waterspout type nomogram forecast | T | F | T |
| Case no. in nomogram | 1 | 2 | 3 |

TAB I: Three Adriatic waterspout nomogram test cases.

## III. RESULTS AND CONCLUSIONS

It has already been shown by a European waterspout project (Sioutas and Keul, 2007) that Mediterranean events follow distinct synoptic and thermodynamic “markers” with prognostic validity. The unknown ratio of reported versus non-reported waterspout events is a problem for the statistical quality test of the forecasting power of the “markers”. Consequently, a larger sample of 114 waterspout reports from the 2002-2006 five-year-interval is currently analyzed for the “markers” to make a step forward in prognosis.

The Szilagyi waterspout nomogram empirically derived from 150 waterspout events and extensively tested by the Meteorological Service of Canada in the Great Lakes area uses tephigram values, lake surface and 850 mb temperature to numerically define four waterspout types and their occurrence. A pre-test with 11 Adriatic waterspout case data already showed that the ”crossover use” of the Canadian technique for Mediterranean purposes might be fruitful. Until the ECSS 2007 meeting, the third author will finish his full study using 114 Mediterranean waterspout case and tephigram data comparing it with his 150 records.

As the European forecasters move into the direction of fast-accessible regional severe weather products with graphical solutions (www.meteoalarm.eu), our European-Canadian project group tries to develop a waterspout prognosis tool that helps current, infrequent, experimental waterspout forecasts (Estofex) to move into this direction.

## IV. ACKNOWLEDGMENTS

The authors like to thank all Mediterranean waterspout observers with an active interest, who often took photographs/videos and reported their sightings to ESWD and/or the first two authors. Without their amateur effort, this study would not have been realized. The internet databases ESWD (http://essl.org/ESWD) and ESTOFEX (www.estofex.org) have been used for research purposes.

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