A WATERSPOUT FORECASTING TECHNIQUE

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I. INTRODUCTION

Waterspouts are a known hazard to both the marine and aviation communities. Providing accurate and timely forecasts has always been a challenge for operational meteorologists around the world. More often than not, users would be notified of a waterspout event after a report was received. No technique existed that allowed meteorologists to predict this phenomenon in advance.

Until recently, very little research has been conducted in the field of waterspout forecasting. Work by Wegener (1917), Rossmann (1961), and Golden (1974a,b, 1977) was already carried out, however, these studies concentrated on waterspout physical processes and structure, not prediction. The first known attempt at developing a forecast technique was made by Keltieka (1987). His technique was based on a very limited sample of 9 waterspout events. The geographic coverage for which the technique applied was also limited, being used only over Lake Erie (one of the Great Lakes of North America).

In 1994, Szilagyi (1994, 2004, 2009) initiated an intensive investigation on waterspout activity over the Great Lakes, which continues at present. The technique that he developed, known as the Szilagyi Waterspout Nomogram (Fig. 1), is based on a large sample of 172 waterspout events spanning over 21 years.

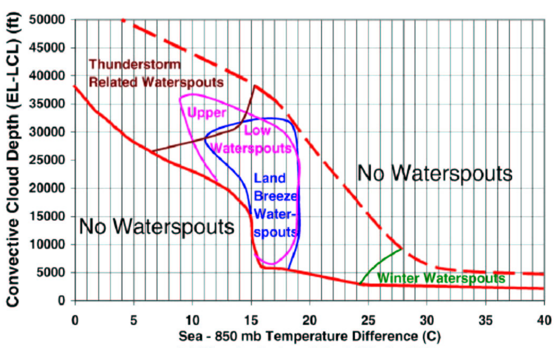

Fig. 1: The Szilagyi Waterspout Nomogram (2005).

In that same year, Choy and Spratt (1994) proposed a forecast strategy for the east central Florida coast using specific radar products to recognize precursor signatures to waterspout formation.

Brown and Rothfuss (1998) also developed an approach which applied to south Florida and Keys.

In recent years, other focused studies on waterspout forecasting have been conducted by Sioutas and Keul (2007), Kuiper and Van der Haven (2007), and Dotzek, Emeis, Lefebvre, and Gerpott (2009).

II. PRESENTATION OF PROJECT

An essential part in the development of any empirical technique is the collection of a large data sample. Meteorological data associated with waterspout events over the Great Lakes was collected from the period of 1988 to the present. During this period, a total of 263 confirmed waterspouts events occurred. This includes the sighting of an unbelievable 824 individual waterspouts! Also, numerous photographs and videos have been collected.

Fourteen parameters were investigated as possible correlators to waterspout formation. Out of these, two instability parameters (Water-850 mb temperature difference (ΔT) and convective cloud depth (ΔZ)) and one wind constraint (850 mb wind speed (W850)) were judged to be the strongest correlators.

The data set was then vetted for completeness based on recorded values of these three parameters. This reduced the total number of events that could be used from 263 to 172; meaning that out of the original 263 events recorded, only 172 events had complete ΔT, ΔZ, and W850 values.

ΔT and ΔZ, where then plotted for each of these events. The majority of the plotted data was then enclosed by two curves called "waterspout threshold lines" (lower and upper bound). In the area bounded by these curves, conditions are favourable for the development of waterspouts. Outside this area, waterspouts are not likely to occur (Fig. 1).

Additionally, a waterspout classification scheme was developed and indicated on the nomogram. It was noticed that each "waterspout type" was uniquely located on the nomogram (Fig. 1).

To quantify the likelihood of waterspout occurrence, the Szilagyi Waterspout Index (SWI) was developed (Fig. 2). The SWI is a stability index and is derived directly from the waterspout nomogram (Fig. 1). The values of SWI range from −10 to +10. Waterspouts are likely to occur when the SWI≥0.

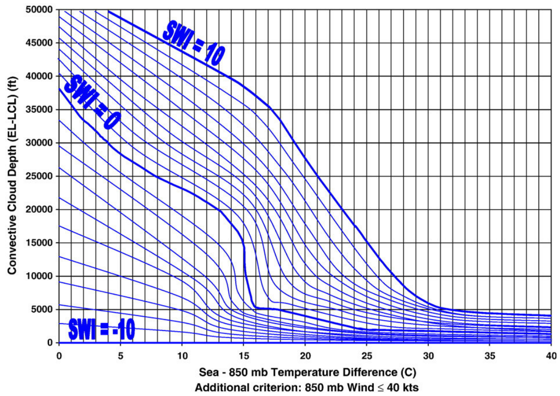

Fig. 2: Szilagyi Waterspout Index (SWI)

Another advantage of the SWI is that computer algorithms can now be developed using the combination of both SWI and W850 to produce waterspout forecasts. In 2006, an experimental waterspout forecast model was developed. Preliminary results of the computer output look favourable.

In addition to developing the nomogram and SWI, a Great Lakes Waterspout climatology was constructed. Also, a significant observation was made during the study. It was noted that waterspouts were capable of forming during windy conditions. This was contrary to the previous belief that waterspouts only occurred during light wind scenarios. Another significant point was the sighting and confirmation of the rare "winter waterspout" (Szilagyi,1994).

III. CONCLUSIONS

The waterspout nomogram has proven itself as valid prognostic tool and is continuously being refined with the addition of new data every year. Meteorologists in North America now routinely use the nomogram to forecast waterspouts up to 2 days in advance, as was the case over Lake Huron in September 9, 1999 (Fig. 3).


Fig. 3: Three watersouts over Lake Huron successfully predicted using The Szilagyi Waterspout Nomogram (September 9, 1999) (photograph by the Kincardine News).

Recently, the nomogram was tested over the Mediterranean with success (Keul, Sioutas, Szilagyi, 2009). Expanded use of the nomogram over other temperate climatic regions is now being considered.

Current work on the nomogram and SWI includes a collaborative project with NOAA in developing a diagnostic tool for meterologists to use in real-time. This will be a first step in the development of an operational waterspout forecast model.

Possible future enhancements to the nomogram include incorporating a low-level convergence parameter as well as correlators used by Kuiper and Van der Haven.

IV. ACKNOWLEDGMENTS

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