TESTING WATERSPOUT FORECASTING INDICES OVER THE ADRIATIC SEA USING THE ALADIN MODEL

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I. INTRODUCTION

A number of waterspout events take place in Croatia every year. This has motivated us to develop and test a waterspout forecasting tool. Forecasting waterspout events is of great importance since they can be dangerous and cause damage, especially in the case of landfall.

Two forecasting indices are most often mentioned in the literature: the Szilagyi Waterspout Index (SWI) and the Kuiper and van der Haven waterspout index (KHS). Both indices measure the risk of (water)spout development.

In the present study these two indices will be tested on several waterspout cases along the Croatian Adriatic coast.

The Szilagyi Waterspout Index (SWI) is based on the Szilagyi Waterspout Nomogram (SWN) which is an empirical method used to forecast waterspouts over the Great Lakes of North America (Szilagyi, 2005).

The KHS–Index was developed by Jacob Kuiper in cooperation with Menno van der Haven from KNMI (Kuiper and van der Haven, 2007).

II. ABOUT THE ALADIN MODEL

ALADIN (Air Limitee Adaptation Dynamique development InterNational) is a limited-area model (LAM) built on the basis of global IFS/ARPEGE model. The output surface wind fields from the 8-km resolution Croatian domain have been dynamically adapted to orography with a 2-km resolution (Fig. 2). ALADIN model data are used to compute the SWN and KHS for waterspout events in 2010.

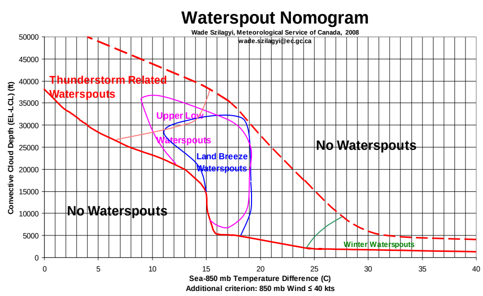

FIG. 2: The Szilagyi Waterspout Nomogram

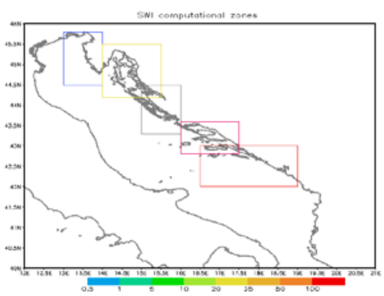

FIG. 2: ALADIN SWI computational zones

III. SWN AND KHS INDICES

The KHS index is based on four criteria: wind shear 0-3 km (wind speed only), temperature lapse-rate 0-500 m, average humidity 0-1 km and 10 m wind speed.

The Szilagyi Waterspout Index (SWI) is a stability index used to evaluate the potential for waterspout development. For the SWI the combination of three parameters correlates strongly with waterspout events: water – 850 hPa temperature difference (ΔT – instability parameter below 1500 m), convective cloud depth, EL-LCL (ΔZ) and 850 hPa wind speed (W_{850}). This three parameters are used in the Nomogram (SWN) (Fig. 1). The outer curves (red lines) on the nomogram are known as the "waterspout threshold lines". In the area bounded by these curves, conditions are favourable for the development of waterspouts. Outside this area waterspouts are not likely to occur. The SWI is a function of both ΔT and ΔZ, thus reducing a three variable (ΔT, ΔZ, W_{850}) forecast technique (the nomogram) to only two variables. The values of SWI range from -10 to $+10$. Waterspouts are likely to occur when SWI ≥ 0.

IV. WATERSPOUT CASES IN 2010

Nineteen waterspout events were recorded in 2010. These cases were gathered using the data from synoptic and climatological weather stations, as well as from eyewitness information found in newspapers and on the internet.

Seven cases took place before noon, 3 around noon, 8 in the afternoon and 1 during the night.

Analysing the synoptic and mesoscale weather conditions (4 basic synoptic types were investigated, viz. south-westerly flow (SW), long-wave trough (LW), closed low (CLOSED) and short-wave trough (SWT)), it appears that waterspouts occur most frequently when the CLOSED low is present (Fig. 3).Approximately 50% of the events were thunderstorm related, other occured in fair-weather and this was identified by the presence of lightning activity.

For 2010 waterspout cases the SWN successfully forecasted 14 out of 19 (hit rate of 73.7%) and KHS 13 out of 19 (hit rate of 68.4%).

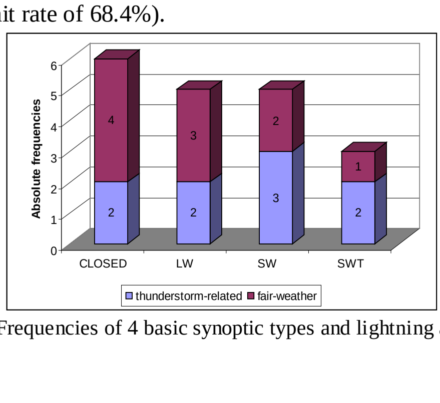

FIG. 3: Frequencies of 4 basic synoptic types and lightning activity

V. 01 JANUARY 2010

The waterspout was observed between Makarska and the island of Hvar at 12.40 UTC. There was a single well developed vortex connected to the base of a large convective cloud. Convection was associated with a strong southwesterly flow in the middle troposphere at the leading side of a trough extending from the Alpine region to Northern Africa. At the surface a cold front was passing from southwest connected to the low in the Gulf of Genoa (Fig. 4). Thermodynamical enviroment was favorable for waterspout development (KI near 30, TT over 51). In this case the KHS Index gives no values (Fig. 5) but the SWN (magenta dots) for the area of interest gives very good results (Fig. 6), indicating favorable conditions for warespout occurence.

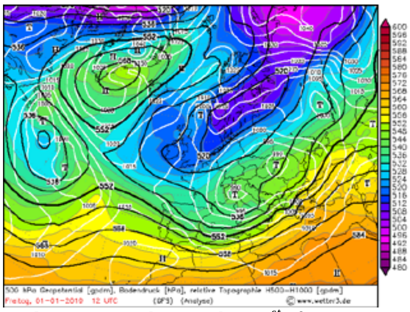

FIG. 4: SLP and Geopotential at 500 hPa, 1st of January at 12 UTC

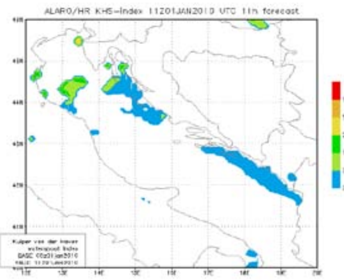

FIG. 5: KHS Index for 1st of January at 11 UTC

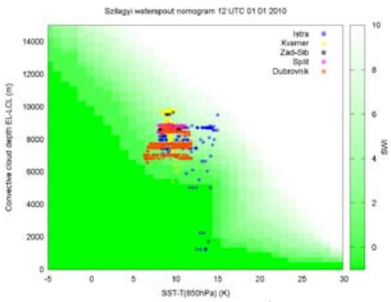

FIG. 6: Szilagyi Waterspout Nomogram, 1st of January at 12 UTC

VI. 30 MAY 2010

The waterspout activity was observed in the middle of the day in the vicinity of the town of Poreč. The interesting feature was the duration of the waterspout from which we could conclude that a multi-vortex event occurred. As in the previous case this event was also connected to a well developed deep convective cloud (Fig. 7), associated with a prefrontal cloud band of the surface cold front and the line of convergence just passing the Alpine region. The dominant flow was southwesterly due to a short wave trough in the upper levels. In the North Adriatic a vorticity advection (PVA) maximum was present, connected with the left exit region of a jet streak, which was enhancing the convection.

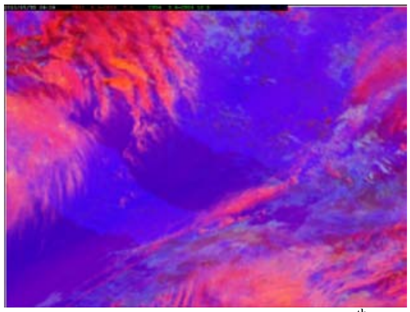

FIG. 7 Meteosat 9 Convective Storms RGB image, 30th May 9 UTC

The KHS index (Fig. 8) failed again because the values where to small in the region of interest, but the SWN (Fig. 9) gave favorable conditions for thunderstorm related waterspouts over the whole Adriatic, especially in the Istria region (blue dots).

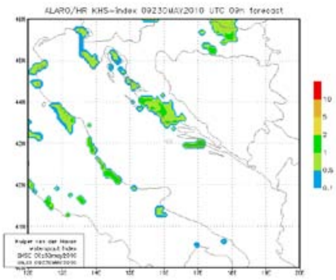

FIG. 8: KHS Index for 30th May at 09 UTC

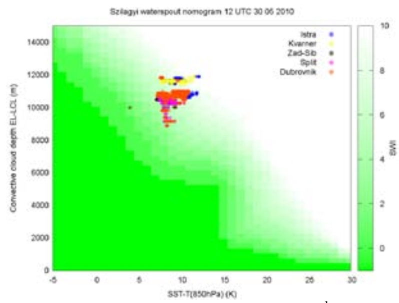

FIG. 9: Szilagyi Waterspout Nomogram for 30th May 12 UTC

VII. 21 JUNE 2010

The first day of summer 2010 was also recorded as a day with waterspout activity in the Adriatic region. This time a waterspout was observed near Dubrovnik airport in the southern Adriatic in the early afternoon hours, lasting for about 17 minutes, connected to a line of convective clouds (Fig. 10).

There was a closed low present over the Adriatic and a cold front has just passed the Dubrovnik area. In the middle troposfere cold advection connected with the presence of a cold core, together with positive vorticity advection in the region, set favorable conditions for instability.

In comparison with the previous two analysed cases, the KHS index now showed some signifcant values (higher than 1 in Fig. 11) in the upstream area, but not as high as could be expected. SWN gives positive waterspout potential, particularly in the Dubrovnik area (red dots in Fig. 12), again performing as good predictor of conditons favorable for waterspouts.

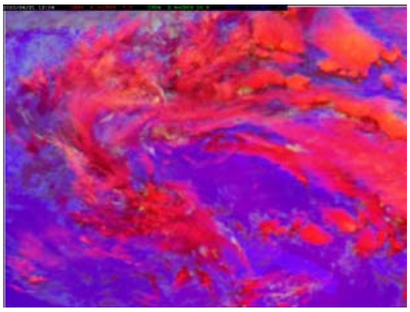

FIG. 10: Meteosat 9 Convective Storms RGB image, 21 June 12 UTC

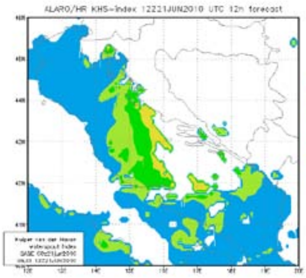

FIG. 11: KHS Index for 21 June at 12 UTC

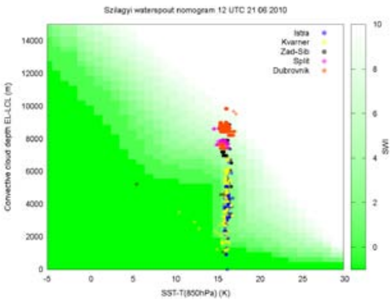

FIG. 12: SWN for 21 June at 12 UTC

VIII. 11 NOVEMBER 2010

One of the two November waterspout cases was reported near Dubrovnik around sunset, so we assume it was around 16 or 17 UTC. According to the satellite image at 17 UTC there was some cloudiness near Dubrovnik, however not deep convective clouds because there was no lightning activity around the time of observation. It seems

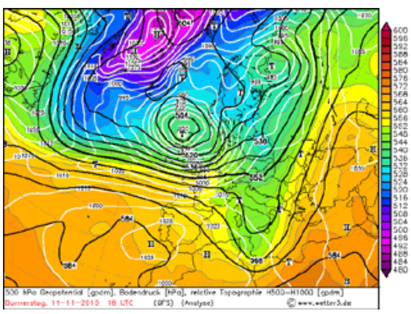

FIG. 13: SLP and Geopotential 500 hPa, 11 November, 18 UTC

that the waterspout was connected with a line of cumulus congestus clouds, so as that it could be treated as fair-weather as defined in the literature (Sioutas and Keul 2007). The 500 hPa analysis (Fig. 13) chart shows long wave trough oriented north to south with axis crossing central Adriatic. Again the KHS waterspout index (Fig. 14) shows marginal values around 1 and SWN for Dubrovnik area (Fig. 15, red dots) fulfills conditions for waterspout development, not necessary thunderstorm related, as was in this case.

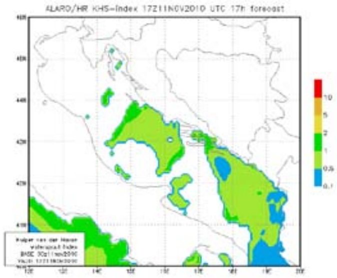

FIG. 14: KHS Index for 11 November at 17 UTC

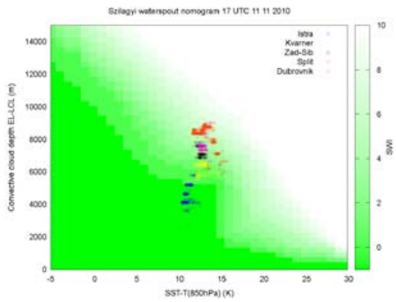

FIG. 15: SWN for 11 November at 17 UTC

IX. ACKNOWLEDGMENTS

We would like to thank all who helped us to collect the data and especially to Mr. Szilagyi who shared with us his knowledge and details about SWN and SWI. Also we are very grateful for advice and help with satellite images from our colleague Nataša Strelec Mahović.

X. REFERENCES

Keul et al., 2009. Prognosis of Central – Eastern Mediterranean waterspouts, *Atmospheric Research* 93,426-436

Szilagyi, W. 2005. Waterspout Nomogram Instruction, *Internal manuscript*. Meteorological Service of Canada, Toronto

Kuiper, J., van der Haven , M., 2007. The KHS Index, a new index to calculate risk of (water)spout development. *Poster, 4th ECSS Trieste*, 10-14 September

Sioutas, M.V., Keul, A.G., 2007. Waterspouts of the Adriatic, Ionian and Aegean Sea and their meteorological environment, *Atmospheric Research* 83,542-557