SEVERE WEATHER PROBABILITY

ALGORITHM DESCRIPTION

NX-DR-03-015/19

1.0 PROLOGUE

1.1 FUNCTIONAL DESCRIPTION

The purpose of the SEVERE WEATHER PROBABILITY (SWP) algorithm is to determine the probability that an identified radar echo is part of a severe storm. A severe storm is defined as one with a tornado or funnel cloud, surface hail $\geq$ 3/4 inch, and/or wind gusts $\geq$ 50 knots or reported wind damage.

A multiple screening regression technique was used to determine the degree of association of vertically integrated liquid (VIL) water content predictors with subsequent observations or reports of severe weather. The approach depended on the collection of a statistically significant sample of candidate predictors and a corresponding sample of reported occurrences of severe weather. The probability of occurrence of severe weather was expressed in terms of a weighted, linear combination of the predictors selected by the screening process. The screening process for predictors was repeated until the reduction of variance by additional predictors reached a predetermined lower limit.

The data sample was from the 1972 WSR-57 digital radar archives of the National Severe Storms Laboratory. There were 109 cells defined from VIL data obtained in this experiment, of which 23 were associated with severe weather events. Only those cells containing VIL values greater than ten were considered. The sixteen predictors derived from vertically integrated liquid water content are as follows:

*1. VIL SIZE	=	Number of BOXes (4 km x 4 km Grid) with VIL values greater than or equal to 10×10^6 kg/km^2. The symbol for this value is VS.
2. maximum LIQUID WATER (Integrated-SWP)	=	the maximum integrated liquid water value in a BOX (SWP), in kg/km^2. The symbol for this value is VILSmax.
*3. VIL WEIGHT	=	(VS) x (VILSmax)
4. VIL MASS	=	$\sum_{i=2}^{I} i \times (\text{VIL SIZE}_i)$ where VIL SIZE_i is the number of BOXes (4 km x 4 km Grid) with VIL values in the interval (5i-4, 5i-3,....,5i) and I is the interval containing

maximum LIQUID WATER
(Integrated-SWP).

5.	SVG10	=	number of BOXes (4 km x 4 km Grid) with VIL values greater than 10 x 10^6 kg/km^2.
*6.	SVG15	=	number of BOXes (4 km x 4 km Grid) with VIL values greater than 15 x 10^6 kg/km^2.
*7.	SVG20	=	number of BOXes (4 km x 4 km Grid) with VIL values greater than 20 x 10^6 kg/km^2.
*8.	SVG25	=	number of BOXes (4 km x 4 km Grid) with VIL values greater than 25 x 10^6 kg/km^2.
9.	BIN15	=	1 if VILSmax is greater than 15 x 10^6 kg/km^2, 0 otherwise.
10.	BIN20	=	1 if VILSmax is greater than 20 x 10^6 kg/km^2, 0 otherwise.
11.	BIN25	=	1 if VILSmax is greater than 25 x 10^6 kg/km^2, 0 otherwise.
12.	BIN30	=	1 if VILSmax is greater than 30 x 10^6 kg/km^2, 0 otherwise.
13.	BIN35	=	1 if VILSmax is greater than 35 x 10^6 kg/km^2, 0 otherwise.
14.	BIN40	=	1 if VILSmax is greater than 40 x 10^6 kg/km^2, 0 otherwise.
15.	BIN45	=	1 if VILSmax is greater than 45 x 10^6 kg/km^2, 0 otherwise.
16.	LIFETIME	=	The number of minutes the SWP (BOX) has been defined.

Only five of the original 16 predictors are used in the final regression equation (marked with asterisks). The weights derived for each predictor are given in Section 3.2. This equation was derived for a specific set of NSSL data. Analysis of future data sets archived for NEXRAD may yield different regression equations for different parts of the country.

1.2 SOURCE

The SWP algorithm described herein has been implemented for the D/RADEX experiment conducted by the National Weather Service (NWS). Mr. Robert Saffle of the NWS Techniques Development Laboratory supplied the D/RADEX information.

REFERENCES

Alaka, M.A., R.C. Elvander, and R.E. Saffle, 1979: Nowcasts and Short-Range (0-2 Hour) Forecasts of Thunderstorms and Severe Convective Weather for Use in Air Traffic Control. Dept. of Trans. Report No. FAA-RD-79-98, 31 pp.

Elvander, R.C., 1977: Relationships between Radar Parameters Observed with Objectively Defined Echoes and Reported Severe Weather Occurrences. Preprints. 10th Conference on Severe Local Storms, Omaha, Nebraska, Amer. Meteor. Soc., 73-76.

1.3 PREPROCESSING ENVIRONMENT

This algorithm requires the output identified in the VERTICALLY-INTEGRATED LIQUID WATER [006] algorithm.

2.0 INPUTS

2.1 IDENTIFICATION

LIQUID WATER (Integrated)	=	the integrated liquid water values (per grid box), for a column within a STORM, in kg/km^2.
SEVERE WEATHER COEFFICIENTS	=	The set of coefficients (SW1...SW6) of a regression equation that determines the severe weather probability. The default values are SW1 = 6.90, SW2 = 7.39, SW3 = 0.22,SW4 = 3.67, SW5 = 0.01 and SW6 = 2.55.
Box (4 km x 4 km Grid)	=	Square grid boxes which are 4 km on a side and cover ranges from 0 to 230 km.
Box (SWP)	=	A box composed of a square array of BOXes (4 km x 4 km Grid).
SWP BOX SIZE	=	The size of the SWP analysis area, in odd numbered multiples of 4 X 4 kilometer boxes (e.g., 28 X 28, 36 X 36, 44 X 44...etc.) The default size is 44 X 44 kilometers.

2.2 ACQUISITION

LIQUID WATER (Integrated) values are acquired from the VERTICALLY-INTEGRATED LIQUID WATER [006] algorithm.

SEVERE WEATHER COEFFICIENTS are site dependent adaptation parameters.

SWP BOX SIZE is a site dependent adaptation parameter.

BOX (4 km x 4 km Grid) and BOX (SWP) are system supplied parameters.

3.0 PROCEDURES

3.1 ALGORITHM

BEGIN ALGORITHM (SWP)

1.0 DO FOR ALL (LIQUID WATER (Integrated))
1.1 Locate the maximum LIQUID WATER (Integrated) value whose BOX (4 km x 4 km Grid) location is not part of any BOX (SWP). (NOTE: The first value will equal VILmax from the VIL algorithm. To reduce computation, this first value may be obtained directly from the VIL algorithm.)

1.1.1 IF (LIQUID WATER (Integrated) is greater than or equal to 10×10^6 kg/km^2)
THEN (Identify the SWP BOX SIZE area centered on the BOX (4 km x 4 km Grid) as a BOX (SWP))
COMPUTE (maximum LIQUID WATER (Integrated-SWP))
COMPUTE (VIL SIZE)
COMPUTE (VIL WEIGHT)
COMPUTE (NO. OF GRID BOXES WITH VIL > 15 kg/km^2)
COMPUTE (NO. OF GRID BOXES WITH VIL > 20 kg/km^2)
COMPUTE (NO. OF GRID BOXES WITH VIL > 25 kg/km^2)
COMPUTE (PROBABILITY (Severe Weather))
COMPUTE (PROBABILITY (Severe Weather))
END IF
END DO

END ALGORITHM (SWP)

3.2 COMPUTATION

3.2.1 NOTATION

VS = VIL SIZE, the number of grid boxes (n) covered by echo, i.e., with integrated liquid water values.

VWT = VIL WEIGHT, the size of the VIL cell (VS) multiplied by the maximum value of VIL (VILSmax) in the cell, in kg/km^2.

VIL = LIQUID WATER (Integrated), the integrated liquid water values (per grid box), for a column within a STORM, in kg/km^2.

VILS = LIQUID WATER (Integrated-SWP), the integrated

liquid water values in a BOX (SWP), in kg/km^2.

VILSmax = maximum LIQUID WATER (Integrated-SWP), the maximum integrated liquid water value in a BOX (SWP), in kg/km^2.

FTN = NO. OF GRID BOXES WITH VIL > 15, number of grid boxes with VIL greater than 15.

TWY = NO. OF GRID BOXES WITH VIL > 20, number of grid boxes with VIL greater than 20.

TWF = NO. OF GRID BOXES WITH VIL > 25, number of grid boxes with VIL greater than 25.

PWX = PROBABILITY (Severe Weather), the probability of severe weather, in percent.

BSP = BOX(SWP), a box composed of a square array of BOXes (4 km x 4 km Grid).

SW1-SW6 = SEVERE WEATHER COEFFICIENTS, the set of coefficients of a regression equation that determines the severe weather probability. The default values are SW1= 6.90, SW2 = 7.39 SW3 = 0.22, SW4 = 3.67, SW5 = 0.01, SW6 = 2.55.

NOTE: Precision is to the units specified unless otherwise stated.

3.2.2 SYMBOLIC FORMULAS

COMPUTE (maximum LIQUID WATER (Integrated-SWP))

Assign subscripts to all BOXes (4 km x 4 km Grid) in the BOX (SWP). Assume VILSmax = $VILS_1$. Then VILSmax = $VILS_i$ if $VILS_i$ is greater than VILSmax.

COMPUTE (VIL SIZE)

VS = Count of grid boxes within a BOX (SWP) with VIL values.

COMPUTE (VIL WEIGHT)

VWT = (VS) (VILSmax)

COMPUTE (NO. OF GRID BOXES WITH VIL > 15)

FTN = Count of grid boxes within a BOX (SWP) with VIL value greater than fifteen.

COMPUTE (NO. OF GRID BOXES WITH VIL > 20)

TWY = Count of grid boxes within a BOX (SWP) with VIL value

greater than twenty.

COMPUTE (NO. OF GRID BOXES WITH VIL > 25)

TWF = Count of grid boxes within a BOX (SWP) with VIL value greater than twenty-five.

COMPUTE (PROBABILITY (Severe Weather))

PWX = SW1 + SW2(TWY) + SW3(VS) - SW4(FTN) +
SW5(VWT) - SW6(TWF)

4.0 OUTPUTS

4.1 IDENTIFICATION

A set of PROBABILITY (Severe Weather) values is output, with each value corresponding to a BOX (SWP).

4.2 DISTRIBUTION

These values can be sent directly to an output device for display. They can also be used by other algorithms to determine which echoes should be given priority when seeking to identify areas of severe weather.

5.0 INFERENCES

5.1 LIMITATIONS

As with any empirical, statistical technique, there is the possibility that the statistical sample does not reflect the true population. How much of the variance in the true population is explained by this equation is not known; in the dependent sample, twenty-four (24) percent of the variance was explained.

The lack of earth curvature correction described in the LIMITATIONS Section of the VIL (006) algorithm apply.

5.2 FUTURE DEVELOPMENTS

No plans for change are known at this time.