HAIL CORE ALOFT

ALGORITHM (HCAA) DESCRIPTION

NX-DR-Ø3-Ø35/Ø1

1.0 PROLOGUE

1.1 FUNCTIONAL DESCRIPTION

The purpose of the Hail Core Aloft Algorithm (HCAA) is to provide for each storm cell the following three estimates:

* the Probability of Hail (POH) of any size,

* the Probability of Severe Hail (POSH)(or hail ≥ ¾" in diameter), and

* the Maximum Expected Hail Size (MEHS).

Based on drop-size/hailstone distribution and empirical studies, the algorithm assumes that large reflectivity values observed aloft (above the freezing level (Ø°C)) are most likely hail.

This algorithm analyzes storm cell and environmental data available in a specific format. A storm cell is defined as a core of a three dimensional region of significant reflectivity values. Each storm cell is made up of two-dimensional components in horizontal proximity at adjacent elevation angles of radar observation. A component is a minimum areal extent of reflectivity values greater than or equal to a specific reflectivity threshold at one elevation. The algorithm's inputs are environmental data and storm cells components' maximum reflectivity and height above ground level (AGL)(of the mass weighted center (or centroid)). The environmental data is the height AGL of the Ø°C and -2Ø°C environmental temperatures (which is usually derived from a nearby sounding).

To determine the POH of any size for each storm cell, the height of the highest component with a large maximum reflectivity value (of at least a threshold value) which is above the freezing level is used in an empirical relationship. The higher the component is above the freezing level, the greater the POH.

To determine the POSH and MEHS for each storm cell, the algorithm uses a relationship between reflectivity and the Hailfall Kinetic Energy (Ž). Ž is the flux of kinetic energy of hailstones. Ž is calculated from components with large maximum reflectivity values (of at least a threshold value) above the freezing level. The larger the components' maximum reflectivity values, the larger their Ž. A height and reflectivity weighted vertical integration of the Ž is done for all components within a storm cell (which meet the relative height and reflectivity criteria). The vertical integration of Ž is weighted toward components with very large (of at least a threshold value) maximum reflectivity values above the height of the -2Ø°C environmental temperature. The vertical integration results in a parameter called the Severe Hail Index (SHI). The greater the collective depth of components in a storm cell with large Ž values and the higher those components are (above the freezing level), the larger a storm cell's SHI value. The POSH is calculated from SHI and a warning threshold which is a function of the height of the freezing level. The MEHS for each storm cell is computed using SHI in an empirical formula.

1.2 SOURCE

The HCAA has been implemented as part of the Hail Detection Algorithm (HDA) by the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma. The other part of the HDA is the Upper Level Divergence Algorithm (ULDA) (Witt, 1994) which provides a second estimate of the MEHS.

REFERENCES

Kessinger, C. and Brandes, E., 1994: A Comparison of Hail Detection Algorithms - Summary Project Report, National Center for Atmospheric Research, Boulder, CO.

Johnson, J. T., 1994: Enhanced WSR-88D Storm Cell Identification and Tracking Algorithm - Final Documentation Report, NSSL, Norman, OK.

NEXRAD Algorithm Report, 1985: HAIL ALGORITHM DESCRIPTION [Ø12/35], The NEXRAD Joint Systems Program Office (JSPO).

Witt, A., 1994: The NSSL Hail Detection Algorithm - Initial Documentation Report, NSSL, Norman, OK.

1.3 PROCESSING ENVIRONMENT

As stated, the HCAA analyzes and requires storm cell data. The algorithm's statistical performance was evaluated while running in conjunction with the Storm Cell Identification and Tracking (SCIT) Algorithm to provide storm cell data. The SCIT Algorithm is documented as a series of the following algorithms: STORM CELL SEGMENTS [Ø36], STORM CELL CENTROIDS [Ø37], STORM CELL TRACKING [Ø38], and STORM POSITION FORECAST [ØØ8](Version 26) algorithm descriptions. The STORM CELL CENTROIDS [Ø37] algorithm provides storm cell data as input to this algorithm. The SCIT Algorithm identifies individual cells within a convective storm instead of the entire storm (Johnson, 1994).

The HCAA was developed for use on a Weather Surveillance Radar - 1988 Doppler (WSR-88D). The HDA and SCIT Algorithm were developed and tested on NSSL's Radar Analysis and Display Software (RADS) on a 32 bit UNIX based SUN Workstation which ingests live (wideband) or archived (Level II) radial data from a WSR-88D.

2.0 INPUTS

2.1 IDENTIFICATION

HEIGHT(Ø°C)	=	The height of the Ø°C environmental temperature (or freezing level), in km AGL.
HEIGHT(-2Ø°C)	=	The height of the -2Ø°C environmental temperature, in km AGL.
HEIGHT(Component)	=	The height of the center of mass of a component, in km AGL.
HKE COEFFICIENT #1	=	A multiplicative factor used in computing the Hailfall Kinetic Energy (5x1Ø$^{-4}$).
HKE COEFFICIENT #2	=	A multiplicative exponential factor used in computing the Hailfall Kinetic Energy (8.4x1Ø$^{-2}$).
HKE COEFFICIENT #3	=	An operand factor used in computing the Hailfall Kinetic Energy (1Ø).
maximum REFLECTIVITY (Component)	=	Maximum (averaged) reflectivity value detected in an individual COMPONENT, in dBZe.
POSH COEFFICIENT	=	A multiplicative factor used in computing the POSH from the SHI (29).
POSH OFFSET	=	An offset used in computing the POSH from the SHI (5Ø), in percent.
SHI HAIL SIZE COEFFICIENT	=	A multiplicative factor used in calculating the Maximum Expected Hail Size from the SHI (Ø.1).
SHI HAIL SIZE EXPONENT	=	The power to which the SHI is raised in calculating the Maximum Expected Hail Size from the SHI (Ø.5).
STORM CELL	=	A STORM CELL is a three dimensional region composed of COMPONENTs characterized by reflectivity values above a given threshold.
COMPONENT(Storm Cell)	=	A COMPONENT is a two dimensional region of a STORM CELL which meets reflectivity and area thresholds, ordered from lowest to highest for each STORM CELL.

THRESHOLD (HKE Reflectivity Weighting Lower Limit)	=	The lower limit of reflectivity values used in the reflectivity weighting function for the POSH calculation (4Ø), in dBZe.
THRESHOLD (HKE Reflectivity Weighting Upper Limit)	=	The upper limit of reflectivity values used in the reflectivity weighting function for the POSH calculation (5Ø), in dBZe.
THRESHOLD (minimum Reflectivity POH)	=	Minimum maximum REFLECTIVITY (Component) used in the calculation of the POH (45), in dBZe.
THRESHOLD (POH Height Difference #1)	=	Maximum height difference which correlates to Ø% POH (1.625), in km.
THRESHOLD (POH Height Difference #2)	=	Maximum height difference which correlates to 1Ø% POH (1.875), in km.
THRESHOLD (POH Height Difference #3)	=	Maximum height difference which correlates to 2Ø% POH (2.125), in km.
THRESHOLD (POH Height Difference #4)	=	Maximum height difference which correlates to 3Ø% POH (2.375), in km.
THRESHOLD (POH Height Difference #5)	=	Maximum height difference which correlates to 4Ø% POH (2.625), in km.
THRESHOLD (POH Height Difference #6)	=	Maximum height difference which correlates to 5Ø% POH (2.925), in km.
THRESHOLD (POH Height Difference #7)	=	Maximum height difference which correlates to 6Ø% POH (3.3), in km.
THRESHOLD (POH Height Difference #8)	=	Maximum height difference which correlates to 7Ø% POH (3.75), in km.
THRESHOLD (POH Height Difference #9)	=	Maximum height difference which correlates to 8Ø% POH (4.5), in km.
THRESHOLD (POH Height Difference #1Ø)	=	Maximum height difference which correlates to 9Ø% POH (5.5), in km.
WARNING THRESHOLD SELECTION MODEL COEFFICIENT	=	A factor multiplied by the HEIGHT(Ø°C) in the Warning Threshold Selection Model ($57.5 \times 1Ø^2$), in J $m^{-2}s^{-1}$.
WARNING THRESHOLD SELECTION MODEL OFFSET	=	An offset used in the Warning Threshold Selection Model ($-121 \times 1Ø^5$), in J $m^{-1}s^{-1}$.

2.2 ACQUISITION

STORM CELLs, COMPONENTs, HEIGHT(Component), and maximum REFLECTIVITY(Component) are acquired from the STORM CELL CENTROIDS [Ø37] algorithm.

HEIGHT(Ø°C) and HEIGHT(-2Ø°C) are site selectable parameters which are adjustable at the Unit Control Position (UCP).

All other thresholds, coefficients, exponents, and offsets are supplied as adaptable parameters whose values have been based on theoretical and empirical hail studies (See Adaptable Parameter Table Appendix C) and are adjustable at the UCP.

3.0 PROCEDURE

3.1 ALGORITHM

```
BEGIN ALGORITHM (HAIL CORE ALOFT)

1.0  DO FOR ALL (STORM CELLs)

     1.1 DO FOR ALL (COMPONENTs)
         1.1.1 IF (maximum REFLECTIVITY(Component) is
                    greater than THRESHOLD (HKE Reflectivity Weighting
                    Lower Limit))
                    THEN
             1.1.1.1    COMPUTE (HEIGHT TOP(Component))
             1.1.1.2    IF (((HEIGHT TOP(Component) is
                            greater than HEIGHT(Ø°C)) AND
                            (HEIGHT(Ø°C) is greater than
                            HEIGHT(Component)) AND (maximum
                            REFLECTIVITY(Component) of the next higher
                            COMPONENT is greater than THRESHOLD (HKE
                            Reflectivity Weighting Lower Limit))) OR
                            (HEIGHT(Component) is greater than or
                            equal to HEIGHT(Ø°C)))
                            THEN
                    1.1.1.2.1  IF (this COMPONENT is not the
                                    lowest in the STORM CELL)
                                    THEN
                    1.1.1.2.1.1        COMPUTE (HEIGHT BOTTOM
                                           (Component))
                               END IF
                    1.1.1.2.2  COMPUTE (HEIGHT DIFFERENCE
                                       (POSH))
                    1.1.1.2.3  COMPUTE (REFLECTIVITY WEIGHTING
                                       FUNCTION(Component))
                    1.1.1.2.4  COMPUTE (HEIGHT MEDIAN
                                       (Component))
                    1.1.1.2.5  COMPUTE (VERTICAL TEMPERATURE
                                       WEIGHTING FUNCTION (Component))
                    1.1.1.2.6  COMPUTE (HAILFALL KINETIC
                                       ENERGY(Component))
                    1.1.1.2.7  COMPUTE (SEVERE HAIL INDEX
                                       (Storm Cell))
                        END IF
                END IF
         1.1.2  IF (HEIGHT(Component) is greater than
                    or equal to HEIGHT(Ø°C))
                    THEN
             1.1.2.1    IF (maximum REFLECTIVITY(Component) is
                            greater than or equal to THRESHOLD
                            (minimum Reflectivity POH))
                            THEN
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```
                    1.1.2.1.1  COMPUTE (HEIGHT(POH))
                    1.1.2.1.2  COMPUTE (HEIGHT DIFFERENCE(POH))
                        END IF
                END IF
        END DO

    1.2  COMPUTE (PROBABILITY OF HAIL(Storm Cell))
    1.3  COMPUTE (PROBABILITY OF SEVERE HAIL(Storm Cell))
    1.4  COMPUTE (MAXIMUM EXPECTED HAIL SIZE(Storm Cell))
    1.5  WRITE (PROBABILITY OF HAIL(Storm Cell))
    1.6  WRITE (PROBABILITY OF SEVERE HAIL(Storm Cell))
    1.7  WRITE (MAXIMUM EXPECTED HAIL SIZE(Storm Cell))
    END DO

END ALGORITHM (HAIL CORE ALOFT)
```

3.2 COMPUTATION

3.2.1 NOTATION

DBZmax	=	The maximum REFLECTIVITY(Component), in dBZe.
DH_POH	=	The HEIGHT DIFFERENCE(POH), the difference in height between the HEIGHT(Component) and HEIGHT(Ø°C) for a COMPONENT which has a maximum REFLECTIVITY(Component) greater than THRESHOLD (minimum Reflectivity POH), in km.
DH_POSH	=	The HEIGHT DIFFERENCE(POSH), the difference in height between the HEIGHT TOP(Component) and HEIGHT BOTTOM(Component), or HEIGHT TOP(Component) and HEIGHT(Ø°C) if HEIGHT(Ø°C) is higher than HEIGHT BOTTOM(Component)) for a COMPONENT which has a maximum REFLECTIVITY (Component) greater than THRESHOLD (HKE Reflectivity Weighting Lower Limit), in km.
Ž	=	The HAILFALL KINETIC ENERGY(Component), the Hailfall Kinetic Energy for each COMPONENT based on it's maximum REFLECTIVITY(Component), in 10^2 J $m^{-2}s^{-1}$.
ERW_LL	=	The THRESHOLD (HKE Reflectivity Weighting Lower Limit), the lower limit of reflectivity values used in the REFLECTIVITY WEIGHTING FUNCTION(Component) and the HAILFALL KINETIC ENERGY(Component), in dBZe.
ERW_UL	=	The THRESHOLD (HKE Reflectivity Weighting Upper Limit), the upper limit of reflectivity values used in the REFLECTIVITY WEIGHTING FUNCTION(Component), in dBZe.
H	=	HEIGHT(Component), the height of the center of mass of a component, in km AGL.
HØ	=	The HEIGHT(Ø°C), the height of the Ø°C environmental temperature (or freezing level), in km AGL.
H2Ø	=	The HEIGHT(-2Ø°C), the height of the -2Ø°C environmental temperature, in km AGL.
H_POH	=	The HEIGHT(POH); the interpolated height of the top of the hail core for each storm used in the calculation of the POH. The interpolation is done to estimate the highest height where the reflectivity equals the THRESHOLD (minimum Reflectivity POH), in km AGL.

HB	=	The HEIGHT BOTTOM(Component), the interpolated height of the bottom of the COMPONENT. It is the average of the HEIGHT(Component) for the current and the next lowest COMPONENT, in km AGL.
HKE_C1	=	The HKE COEFFICIENT #1
HKE_C2	=	The HKE COEFFICIENT #2
HKE_C3	=	The HKE COEFFICIENT #3
HM	=	The HEIGHT MEDIAN(Component), the median depth of the COMPONENT used in the VERTICAL TEMPERATURE WEIGHTING FUNCTION(Component), in km.
HS_COF	=	The SHI HAIL SIZE COEFFICIENT.
HS_EXP	=	The SHI HAIL SIZE EXPONENT.
HT	=	The HEIGHT TOP(Component), the interpolated height of the top of the COMPONENT. It is the average of the HEIGHT(Component) for the current and the next highest COMPONENT, in km AGL.
m	=	The index for COMPONENTs.
MEHS	=	The MAXIMUM EXPECTED HAIL SIZE(Storm Cell), in inches.
MR_POH_TH	=	The THRESHOLD (minimum Reflectivity POH), in dBZe.
n	=	The index for STORM CELLs.
P_COF	=	The POSH COEFFICIENT, used in the calculation of the POSH from the SHI.
P_OFS	=	The POSH OFFSET, used in the calculation of the POSH from the SHI, in percent.
POH	=	The PROBABILITY OF HAIL, Ø% to 1ØØ%.
POH_HD1	=	The THRESHOLD (POH Height Dif. #1), in km.
POH_HD2	=	The THRESHOLD (POH Height Dif. #2), in km.
POH_HD3	=	The THRESHOLD (POH Height Dif. #3), in km.
POH_HD4	=	The THRESHOLD (POH Height Dif. #4), in km.
POH_HD5	=	The THRESHOLD (POH Height Dif. #5), in km.
POH_HD6	=	The THRESHOLD (POH Height Dif. #6), in km.

POH_HD7	=	The THRESHOLD (POH Height Dif. #7), in km.
POH_HD8	=	The THRESHOLD (POH Height Dif. #8), in km.
POH_HD9	=	The THRESHOLD (POH Height Dif. #9), in km.
POH_HD10	=	The THRESHOLD (POH Height Dif. #10), in km.
POSH	=	The PROBABILITY OF SEVERE HAIL, Ø% to 1ØØ%.
SHI	=	The SEVERE HAIL INDEX(Storm Cell), in 10^5 J $m^{-1}s^{-1}$.
VTWF	=	The VERTICAL TEMPERATURE WEIGHTING FUNCTION (Component), a weighting function based on the vertical temperature profile.
WT_COF	=	The WARNING THRESHOLD SELECTION MODEL COEFFICIENT, in 10^2 J $m^{-2}s^{-1}$.
WT_OFS	=	The WARNING THRESHOLD SELECTION MODEL OFFSET, in 10^5 J $m^{-1}s^{-1}$.
WZ	=	The REFLECTIVITY WEIGHTING FUNCTION(Component), a weighting function based on the maximum REFLECTIVITY(Component).

3.2.2 SYMBOLIC FORMULAS

<u>COMPUTE</u> (HEIGHT TOP(Component))

$HT_m = (H_{m+1} + H_m)/2$

if this is the highest COMPONENT in the STORM CELL, then

$HT_m = H_m + (H_m - H_{m-1})/2$

<u>COMPUTE</u> (HEIGHT BOTTOM(Component))

$HB_m = (H_{m-1} + H_m)/2$

if not computed, HB_m should be zero (or a small flag value)

<u>COMPUTE</u> (HEIGHT DIFFERENCE(POSH))

```
DH_POSHm = HTm - HBm
IF (HØ > HBm)
      THEN
            DH_POSHm = HTm - HØ
END IF
```

<u>COMPUTE</u> (REFLECTIVITY WEIGHTING FUNCTION(Component))

$WZ_m = (DBZmax_m - ERW\_LL)/(ERW\_UL - ERW\_LL)$

if $DBZmax_m$ is greater than or equal to ERW_UL, then

$WZ_m = 1$

<u>COMPUTE</u> (HEIGHT MEDIAN(Component))

```
HMm = (HTm + HBm)/2
IF (HØ > HBm)
      THEN
            HMm = (HTm + HØ)/2
ELSE IF ((this is .NOT. the lowest component in the STORM CELL)
      .AND.(this is .NOT. the highest COMPONENT in the STORM
      CELL).AND.(.NOT.((HØ > HBm-1).AND.(HTm-1 > HØ) .AND.
      (DBZmaxm-1 ≤ ERW_LL))))
      THEN
            HMm = (Hm-1 + Hm+1)/2
END IF
```

COMPUTE (VERTICAL TEMPERATURE WEIGHTING FUNCTION(Component))

$VTWF_m = (HM_m - H\emptyset)/(H2\emptyset - H\emptyset)$

if HM_m is greater than or equal to H2Ø, then $VTWF_m = 1$

COMPUTE (HAILFALL KINETIC ENERGY(Component))

$\check{Z}_m = (HKE\_C1)(WZ_m)[HKE\_C3^{((HKE\_C2)(DBZmax(m)))}]$

COMPUTE (SEVERE HAIL INDEX(Storm Cell))

$$SHI_n = \sum_m [\check{Z}_m(DH\_POSH_m)(VTWF_m)]$$

COMPUTE (HEIGHT(POH))

```
IF (this COMPONENT is the last (or highest) in the STORM CELL)
      THEN
           H_POH_n = H_n,m + (H_n,m - H_n,m-1)/2
           IF (D1 ≤ Ø)
                THEN
                   IF (DBZmax_n,m = MR_POH_TH)
                      THEN
                         H_POH_n = H_n,m
                   END IF
           ELSE
                IF (H_INT < H_POH_n)
                   THEN
                      H_POH_n = H_INT
                END IF
           END IF
ELSE IF (DBZmax_m+1 < MR_POH_TH)
      THEN
           H_POH_n = (D4)(D6)/D5 + H_n,m
END IF
```

where

$D1 = DBZmax_{n,m-1} - DBZmax_{n,m}$

$D2 = DBZmax_{n,m-1} - MR\_POH\_TH$

$D3 = H_{n,m} - H_{n,m-1}$

$D4 = DBZmax_{n,m} - MR\_POH\_TH$

$D5 = MAX\ (1.0,\ DBZmax_{n,m} - DBZmax_{n,m+1})$

$D6 = H_{n,m+1} - H_{n,m}$

$H\_INT = (D2)(D3)/D1 + H_{n,m-1}$

COMPUTE (HEIGHT DIFFERENCE(POH))

$DH\_POH_n = H\_POH_n - HØ$

COMPUTE (PROBABILITY OF HAIL(Storm Cell))

```
IF (DH_POHn ≤ POH_HD1)
      THEN
           POHn = Ø
ELSE IF (DH_POHn ≤ POH_HD2)
      THEN
           POHn = 1Ø
ELSE IF (DH_POHn ≤ POH_HD3)
      THEN
           POHn = 2Ø
ELSE IF (DH_POHn ≤ POH_HD4)
      THEN
           POHn = 3Ø
ELSE IF (DH_POHn ≤ POH_HD5)
      THEN
           POHn = 4Ø
ELSE IF (DH_POHn ≤ POH_HD6)
      THEN
           POHn = 5Ø
ELSE IF (DH_POHn ≤ POH_HD7)
      THEN
           POHn = 6Ø
ELSE IF (DH_POHn ≤ POH_HD8)
      THEN
           POHn = 7Ø
ELSE IF (DH_POHn ≤ POH_HD9)
      THEN
           POHn = 8Ø
ELSE IF (DH_POHn ≤ POH_HD1Ø)
      THEN
           POHn = 9Ø
ELSE
           POHn = 1ØØ
END IF
```

The HEIGHT DIFFERENCE(POH) used here is the greatest for all the COMPONENTS for each storm. Since the COMPONENTS are sorted from lowest to highest for each storm, the last calculated HEIGHT DIFFERENCE(POH) will be the greatest.

```
COMPUTE (PROBABILITY OF SEVERE HAIL(Storm Cell))

IF (SHIn > 0)
      THEN
           POSHn = (P_COF){Ln[SHIn/(WTSM)]} + P_OFS
ELSE
           POSHn = 0
END IF

where Ln is the natural log function;

      WTSM = (WT_COF * HØ) + WT_OFS
      IF (WTSM < 20)
           THEN
                WTSM = 20
      END IF

and

      IF (POSH > 100)
           THEN
                POSH = 100
      ELSE IF (POSH < 0)
           THEN
                POSH = 0
      END IF

      IF (POH < POSH)
           THEN
                POH = POSH
      END IF


COMPUTE (MAXIMUM EXPECTED HAIL SIZE(Storm Cell))
```

$MEHS_n = (HS\_COF)(SHI_n)^{HS\_EXP}$

4.0 OUTPUTS

4.1 IDENTIFICATION

For each STORM CELL, the algorithm will output the PROBABILITY OF HAIL(Storm Cell), the PROBABILITY OF SEVERE HAIL(Storm Cell), and the MAXIMUM EXPECTED HAIL SIZE(Storm Cell).

4.2 DISTRIBUTION

It is anticipated that the outputs are for display only.

5.0 INFERENCES

5.1 LIMITATIONS

The HCAA needs as input accurate and timely measurements of the heights of the Ø° C and −2Ø° C levels above ground. Failure to update this information will degrade the algorithm's performance.

During algorithm validation testing, the HCAA's statistical performance was based on the identification of storm cells by the NSSL SCIT algorithm within 230 km of the radar. Outside of 230 km, the statistical performance is unknown. The use of other storm cell identification algorithms (e.g. the Storm Series Algorithms) to provide storm cell information may degrade the HCAA performance. Also, if the storm cell identification algorithm fails to properly identify the full 3D structure of a storm cell, statistical performance will likely be degraded.

Both the POH and POSH estimates from the algorithm have shown significant improvement in statistical (and operational) performance over (the Positive Hail Index and Positive + Probable Hail Indices of) the HAIL ALGORITHM [Ø12/35] (Witt, 1993; Kessinger and Brandes, 1994). However, the POH parameter has only been tested in a High Plains environment.

Witt compared the POSH (50%) with the HAIL ALGORITHM [Ø12/35] on many cases from different regions of the country including Florida, the Southern Plains, the High Plains, Northern U.S., and the Mid-Mississippi Valley. His results show that the POSH parameter performs best in the Southern Plains region, with somewhat poorer performance (higher False Alarm Ratio (FAR)) in other regions. However, the decrease in performance may be a result of poorer verification efforts in those areas. His results also show that the POSH parameter performs best for isolated storms. Even though the POSH parameter's improvement in performance versus the HAIL ALGORITHM [Ø12/35] is due to the decrease in the FAR for non-isolated storms. In addition, the theory on which the POSH is based has been applied as a hail predictor with good results in other regions of the world.

Kessinger and Brandes compared the POH and POSH with Hail Indices from the HAIL ALGORITHM [Ø12/35] during a two year field study in Eastern Colorado. They found that for very small hail (< ½"), the POH is a significant improvement over the HAIL ALGORITHM [Ø12/35] (and the POSH). The POH has good reliability at small hail sizes and over-forecasts severe sizes. For severe sized hail, the POSH outperformed the HAIL ALGORITHM [Ø12/35] (and the POH). The POSH tends to under-forecast very small hail (< ½") and over-forecast severe sized hail or larger.

The MEHS is an estimate of the size of the largest hail expected anywhere in a storm cell. In a storm cell, the area covered by the largest hail stones is usually a very small percentage of the total area covered by hail. The MEHS parameter was developed such that statistically, 75% of hail reports are smaller. Therefore, on average, a majority of hail reports from a storm will be of smaller hail than the MEHS.

In it's limited operational use, the MEHS parameter has provided a useful rough estimate of the maximum hail size. But, in weak wind and tropical environments the POSH and MEHS parameter tends to overforecast hail and hail size (relative to all environments).

5.2 FUTURE DEVELOPMENTS

Adaptable parameter studies should be done to optimize performance for different meteorological conditions and geographical locations. The ultimate goal is to optimize the algorithm for each climatological region and each storm type.

Also, a technique to account for mid-level environmental relative humidity has been applied to this algorithm and has shown a nominal increase statistical performance. This technique applies the premise that evaporative cooling in drier conditions has been shown to increase the probability of small hail.

A method should be developed to provide automatically provide the algorithm with the latest thermodynamic (sounding) data.