ANALYSIS OF SYNOPTIC DATA
FOR
SELECTED HAIL DAYS IN NORTHEASTERN COLORADO, 1961

by

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ANALYSIS OF SYNOPTIC DATA
FOR
SELECTED HAIL DAYS IN NORTHEASTERN COLORADO, 1961

INTRODUCTION

The successive objectives of the research on hail being conducted at Colorado State University are:

1. To obtain the climatology of hailfalls and rainfalls in the High Plains, a region of high frequency of hail
2. To determine the environmental factors which favor the occurrence of hail
3. To design and conduct an experiment in hail modification by cloud seeding.

Work done under National Science Foundation Grant NSF G 17964 was directed at the second of these objectives. This report presents an analysis of synoptic data for selected days with hail in Northeastern Colorado during 1961. A summary of mean values of the various synoptic parameters examined and a discussion of their relative importance are given in the body of the report. The appendix includes data for case studies of six days of severe hail, six days on which hail of moderate intensity occurred, and six days on which no hail occurred during the period 1 May - 31 July 1961.

DATA AND METHODS

Selection of days for study - - Five criteria were used to classify hail intensity for each day during the 1961 hail season from 1 May to 31 July, using data from the Colorado State University network. These criteria were: 1) the number of reports of hail occurrence received from cooperative observers; 2) maximum stone size; 3) maximum energy number; 4) the largest "most common" stone size; 5) the number of damaged hail indicators.

Using these criteria, the following dates were chosen as being a representative sample of hail days of the intensities indicated: Severe--May 13, May 16, May 31, June 2, July 1, and July 14; Moderate--May 21, May 24, June 8, June 13, June 28, and July 8; None--May 22, June 21, June 26, July 3, July 17, and July 23.

Synoptic data - - For each day, the following information was obtained:

1. Surface synoptic patterns gathered from data collected at 1100 and 2300 MST. The surface weather maps for this report were taken from the Daily Weather Map prepared by the U. S. Weather Bureau
2. 500 mb contour patterns at 1700 MST, also taken from the Daily Weather Map.
3. The jet stream configuration and isotach analysis at 1700 MST, obtained from 300 mb facsimile charts.
4. A mean wind profile over the area, obtained by averaging upper wind reports from LND, DEN, BFF, LBF, GLD from the ground surface to the tropopause.
5. Wind profiles along the mean wind direction for each respective upper-air station in the vicinity, including Lander (LND), Denver (DEN), Scottsbluff (BFF), North Platte (LBF), and Goodland (GLD).
6. Vertical air mass structures, obtained from plotted raob soundings (Skew-T, log P diagrams) at 0500 and 1700 MST.
7. A precipitable water and stability index chart, taken from USWB facsimile charts.
8. A chart showing the forecast size of hailstones at stations in and near northeastern Colorado by the Fawbush-Miller method, using the 1700 MST raob soundings.
9. Diagrams showing the daily rainfall amounts and hail occurrences, compiled from reports by cooperative observers and hail indicators in the hail network.

These synoptic data are presented in the appendix for each of the 18 days selected for study.

RESULTS AND CONCLUSIONS

Mean values of synoptic parameters - - Table 1 gives average values of selected synoptic parameters for days classified as having severe, moderate and no hail.

Table 1 shows little difference in the stability index and precipitable water for the three categories of hail intensity. On the other hand, a faster mean jet stream speed and high mean wind speed are associated with the severe hail days. A further distinction between severe and moderate hail lies in the orientation and location of frontal systems with respect to the hail network.
Table I. Mean synoptic parameters for days with hail of three intensity classifications. Values given are means with six days per category.

<table>
<thead>
<tr>
<th>Hail Intensity Category</th>
<th>Showalter Stability Index, Deg. C</th>
<th>Precipitable Water, Inches</th>
<th>Jet Stream Speed, Knots</th>
<th>Mean Wind, Surface to Tropopause, Direction and Speed, Knots</th>
<th>Fronts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>0.0</td>
<td>.76</td>
<td>57</td>
<td>260/33</td>
<td>NNE-SSW 188 SE</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.5</td>
<td>.76</td>
<td>40</td>
<td>270/25</td>
<td>N-S 205 NW</td>
</tr>
<tr>
<td>None</td>
<td>0.6</td>
<td>.64</td>
<td>38</td>
<td>310/26</td>
<td>--- ---</td>
</tr>
</tbody>
</table>

These observations from Table I, based on mean values, are substantiated by examination of data from individual days.

**Severe hail days** - In examining the severe days, the existence of a jet maximum overhead of about 55-60 knots indicates a day of severe rather than moderate or no hail. Values for moderate and "none" days were approximately 35-40 knots. For severe days, the value of the jet maximum ranged between 30 and 105 knots.

One of the best correlations was found to be the position and orientation of the surface front over the region. In all six severe cases, the front was positioned to the southeast of the area. No distinction was made in this analysis between mP and cP air masses causing the fronts.

The presence of a low pressure system to the south of the area favored the occurrence of severe hail. On 5 of the 6 days studied, low pressure systems were noted to the south of the area, and three of these proved to be of substantial strength producing hail as the low pressure area moved to the east. The average position of low pressure areas was in WSW Kansas (1200Z).

**Moderate hail days** - Days with hail of moderate intensity exhibited no strong preference for any of the parameters studied. The mean frontal positions for these days was with an orientation N-S, a distance of about 205 miles to the WNW of the center of the forecast area. This might lead to the conclusion that the storms producing moderate hail were associated with pre-frontal activity. Only one out of the six days had a front which had already passed the area by 1200Z.

The idea of the dew-point front might be suggested as a cause for hailstorms of moderate intensities, since the most intense storms frequently occur after the frontal passage or as the dry denser air behind the front and aloft over the mountains displaces the residual moist air remaining behind the front. Occasionally, low pressure systems were noted SE of the forecast area, but these were static and sluggish systems.

**Days with no hail** - A primary difficulty in this study was an inability to find parameters which distinguished days of moderate hail from days of no hail occurrence. As mentioned earlier, there was little difference in the jet speeds, the value for both being 35-40 knots. Frontal and low pressure activity and centers were indefinite for the no-hail days. One positive correlation did appear, however, on the no-hail days. For days of no hail, the direction of the mean wind speed from the surface to the tropopause was from the NW (310°), while the direction for the moderate and severe days was 270° and 260°, respectively.

**Parameters with no apparent correlation with hail intensity** - Some of the parameters showed no correlation with hail intensity. The Showalter Stability Index and the Precipitable Water Amounts were such parameters. The respective values were as follows: Severe--SSI = 0, with range of -3 to +4; precipitable water = .67; Moderate--SSI = 0, with range of 0 to +2; precipitable water = .76; None--SSI = 0, with range of 0 to +4; precipitable water = .64.

**Mean soundings** - Finally, computations were made to determine mean soundings for the days in question. By grouping all the days of severe, moderate, and no hail, respectively, three average soundings for the area were constructed to demonstrate a severe hail day sounding, a moderate hail day sounding, and a "no-hail" day sounding. These soundings are given in Figures 1, 2 and 3. These average soundings were determined by taking the soundings for the individual stations of LND, BFF, LBF, DEN, and GLD, for both 1200Z (morning) and 0000Z (evening). After averaging for each station, a weighted average was determined for the six days of the study.

Figures 1 and 2 show remarkable similarity which suggests that they represent typical hail soundings without regard for intensity.
Examination of the soundings indicates no obvious features such as, for example, the typical hail and tornado soundings of the middle West, studied by Fawbush and Miller. It may be noted that the surface temperature tends to increase at 0000Z when the hail intensity decreases. This could be attributed to the fact that on the severe and moderate days a lower surface temperature may be caused by the presence of thunderstorms in and over the area, with the resulting downdrafts cooling the region.

A 10°C dew-point spread was common for all levels of the severe hail sounding, increasing to 10-15°C spread for moderate soundings, and finally to as much as 20°C spread for days of no hail. These soundings indicate that the occurrence of no hail is related to the dry soundings, but to determine whether severe or moderate hail would occur cannot be determined from the sounding. Analysis of the soundings also indicates that the mean severe sounding is some 4-5°C cooler from the surface to 400 mb than the lapse rate for the mean no-hail sounding. This can not be attributed to the presence of thunderstorms, since both the morning and evening soundings for the severe day exhibit this temperature reduction. One important conclusion is that when analyzing the soundings for the CCL (using the 1200Z for predicting purposes) and the convective temperature, Tc, which would initiate cumulus development by heating alone, the Tc lies below the reported surface temperature for the 0000Z observation. Granting that this observation may take place after the afternoon maximum temperature is realized, the meteorological events resulting in this convective activity are not caused by just reaching the Tc and then retreating. This observation leads to the conclusion that other effects must be active in causing rapid convective development.

Synoptic data are presented in the appendix to permit case studies of each day.

**SUMMARY OF PROJECT**

**Period:** May 1961 - December 1962

**Personnel:**
- Richard A. Schleusener
- John D. Marwitz
- August H. Auer

**Publications (prepared in whole, or in part with sponsorship from Grant NSF G 17864):**


Fig. 1 Mean sounding for severe hail days.

Fig. 2 Mean sounding for moderate hail days.

Fig. 3 Mean sounding for "no hail" days.
APPENDIX

Data for Case Studies of Selected Hail Days in Northeastern Colorado, 1961

Hail Intensity Category

<table>
<thead>
<tr>
<th>Severe</th>
<th>Dates</th>
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<tr>
<td></td>
<td>May 13, 16, 31</td>
</tr>
<tr>
<td></td>
<td>June 2</td>
</tr>
<tr>
<td></td>
<td>July 1, 14</td>
</tr>
<tr>
<td>Moderate</td>
<td>May 21, 24</td>
</tr>
<tr>
<td></td>
<td>June 8, 13, 28</td>
</tr>
<tr>
<td></td>
<td>July 8</td>
</tr>
<tr>
<td>None</td>
<td>May 22</td>
</tr>
<tr>
<td></td>
<td>June 21, 26</td>
</tr>
<tr>
<td></td>
<td>July 3, 17, 23</td>
</tr>
</tbody>
</table>
Case of: 13 May 1961
Hail classification: Severe
Number of reports from CSU network: 72
Max stone size: 1/4"
Max E, ft-lbs per sq ft: 1552
Largest "most common" stone size: 3/4"
Number of damaged indicators, CSU network: 90

Reports of Hail
E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Case of 13 May 1961
Hail Classification: Severe

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index
0500 MST

Jet Stream 50 & 100 kt. isolochs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of: 13 May 1961
Hail Classification: Severe

Denver
SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z
Case of: 13 May 1961
Hail Classification: Severe

Legend
Day before: —?
Day of severe hail: —
Day after: —?

Hail Intensity Classification
Day before: Severe
Day of: Severe
Day after: Moderate

Wind Profiles Along Mean Wind Direction
For 1700 MST
Surface Synoptic Pattern
11 AM & 11 PM MST

Precipitable Water (inches)
& Stability Index
0500 MST

500 MB Flow
1700 MST

Jet Stream 50 & 100 kt. isotachs
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Case of 16 May 1961
Hail Classification: Severe

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of: 16 May 1961

Severe

Hail classification:

Number of reports from CSU network: 20

Max stone size: \( \frac{3}{4} \)" 

Max \( E \), ft-lbs per sq ft: 301

Largest "most common" stone size: \( \frac{3}{4} \)"

Number of damaged indicators, CSU network: 8

Hail reports:

- \( E \leq 10 \)
- \( 10 < E \leq 100 \)
- \( E > 100 \)

Reports of Hail

\( E \) = impact energy, ft-lbs per sq ft.

\( S \) = max stone size, inches.

\( M \) = missing data.

Rainfall Depth (inches)
Case of: 16 May 1961
Hail Classification: Severe

Legend
Day before: ---
Day of severe hail: ---
Day after: ---

Hail Intensity Classification
Day before: None
Day of: Severe
Day after: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 16 May 1961
Hail Classification: Severe

SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z
Hail reports •

[Diagram showing hail reports]

Case of: 31 May 1961
Hail classification: Severe
Number of reports from CSU network: 17
Max stone size: 1"
Max E, ft-lbs per sq ft: 260
Largest "most common" stone size: 3/4"
Number of damaged indicators, CSU network: 7

Reports of Hail
E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Case of:  31 May 1961
Hail Classification:  Severe

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index
1700 MST

Jet Stream 50 & 100 kt. isotachs
1700 MST

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of 31 May 1961
Hail Classification: Severe

Legend
Day before: -----
Day of severe hail: ----
Day after: ----

Hail Intensity Classification
Day before: Severe
Day of: Severe
Day after: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of Hail Classification, 31 May 1961

Severe

Lander

North Platte

Denver

SKew-T Diagrams
0500MST=1200Z
1700MST=0000Z

Goodland
Hail reports:
- $E \leq 10$
- $10 < E \leq 100$
- $E > 100$

Number of reports from CSU network: 49
Max stone size: $\frac{1}{4}$" 
Max $E$, ft-lbs per sq ft: 776 ft-lbs
Largest "most common" stone size: $\frac{3}{4}$"
Number of damaged indicators, CSU network: 65

Reports of Hail
$E =$ impact energy, ft-lbs per sq ft.
$S =$ max stone size, inches.
$M =$ missing data.

Rainfall Depth (inches)
Case of 2 June 1961
Hail Classification: Severe

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of: Severe Hail Classification: 2 June 1961

Denver

Lander

North Platte

Goodland

SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z
Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of 1 July 1961
Hail classification: Severe
Number of reports from CSU network: 13
Max stone size: 1 1/4"
Max E, ft-lbs per sq ft.: 2660
Largest "most common" stone size: 1"
Number of damaged indicators, CSU network: 6

Report of Hail
E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Surface Synoptic Pattern
II AM & II PM MST

Precipitable Water (inches) & Stability Index
1700 MST

Jet Stream 50 & 100 kt. isotachs
1700 MST

Case of 1 July 1961

Hail Classification: Severe

Mean Wind - Surface to Tropopause (knots) 1700 MST

Forecast Size of Stones (inches) (Fawbush & Miller) 1700 MST
Case of 1 July 1961
Hail Classification: Severe

Legend
Day before:
Day of severe hail:
Day after:

Hail Intensity Classification
Day before: Moderate
Day of: Severe
Day after: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of:
Hall Classification:
1 July 1961
Severe

Lander

Scottsbluff

North Platte

Denver

SK EW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z

Goodland
Case of 14 July 1961
Hail classification: Severe
Number of reports from CSU network: 18
Max stone size: $\frac{3}{4}$ in
Max E, ft-lbs per sq ft: 233
Largest "most common" stone size: $\frac{3}{4}$ in
Number of damaged indicators, CSU network: 20

Reports of Hail
E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Surface Synoptic Pattern
11 AM & 11 PM MST

Precipitable Water (inches)

& Stability Index

500 MB Flow
1700 MST

Jet Stream 50 & 100 kt. isolochs

1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST

Case of 14 July 1961
Hail Classification: Severe

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of: 14 July 1961
Hail Classification: Severe

Legend
Day before:  
Day of severe hail:  
Day after:  

Hail Intensity Classification
Day before: Moderate
Day of: Severe
Day after: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 14 July 1961
Hail Classification: Severe

Lander

Scottsbluff

North Platte

Denver

SKEW-T Diagrams
0500MST=1200Z
1700MST=0000Z

Goodland
Case of 21 May 1961

Hail classification: Moderate

Number of reports from CSU network: 1

Max stone size: 1/4"

Max E, ft-lbs per sq ft: 1

Largest "most common" stone size: > 1/4"

Number of damaged indicators, CSU network: None

Hail occurred at Fort Collins

Reports of Hail

Rainfall Depth (inches)
Case of 21 May 1961

Hall Classification: Moderate

Surface Synoptic Pattern
II AM & II PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 21 May 1961
Hail Classification: Moderate

Lander

North Platte

Denver

SKEW-T Diagrams
0500 MST - 1200Z
1700 MST - 0000Z
Case of

Hail classification:

Number of reports from CSU network: 5
Max stone size: $\frac{3}{4}$"
Max $E$, ft-lbs per sq ft.: 248
Largest "most common" stone size: $\frac{1}{2}$" 
Number of damaged indicators, CSU network: 1

Reports of Hail

$E =$ impact energy, ft-lbs per sq ft.
$S =$ max stone size, inches.
$M =$ missing data.

Max size of stone
- $0 < S \leq \frac{1}{4}$"
- $\frac{1}{4} < S \leq \frac{1}{2}$"
- $\frac{1}{2} < S \leq 1$"
- $1 < S \leq 2$"
- $S > 2$"

Rainfall Depth (inches)
Surface Synoptic Pattern
11 AM & 11 PM MST

Precipitable Water (inches)
& Stability Index

Mean Wind - Surface to Tropopause (knots) 1700 MST

500 MB Flow
1700 MST

Jet Stream 50 & 100 kt. isolochs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST

Case of: 24 May 1961
Hail Classification: Moderate
Case of: 24 May 1961
Hail Classification: Moderate

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 24 May 1961
Hail Classification: Moderate

Land er North Platte

Denver

SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z
Case of: 8 June 1961
Hail classification: Moderate
Number of reports from CSU network: 2
Max stone size: 1"
Max E, ft-lbs per sq ft.: 6
Largest "most common" stone size: >\(\frac{1}{4}\)"
Number of damaged indicators, CSU network: 1

Reports of Hail

E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Case of 8 June 1961

Hail Classification: Moderate

Surface Synoptic Pattern
11AM & 11PM MST

Precipitable Water (inches) & Stability Index
1700 MST

500 MB Flow
1700 MST

Jet Stream 50 & 100 kt. isotachs
1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of:
Hail Classification: Moderate
8 June 1961

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of Hail Classification
8 June 1961
Moderate

SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z

Lander

0000Z
1200Z

North Platte

0000Z
1200Z

Denver

0000Z
1200Z

Goodland
Case of: 13 June 1961
Hail classification: Moderate
Number of reports from CSU network: 2
Max stone size: 1/4".
Max E, ft-lbs per sq ft: 13
Largest "most common" stone size: 1/4"
Number of damaged indicators, CSU network: 1

Reports of Hail
E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.
Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isolochs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST

Case of: 13 June 1961
Hail Classification: Moderate
Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 13 June 1961
Hail Classification: Moderate

Lander
Scottsbluff
North Platte
Denver
Goodland

SKEW-T Diagrams
0500 MST = 1200Z
1700 MST = 0000Z

Moderate
Case of: 28 June 1961

Hail classification: Moderate

Number of reports from CSU network: 2
Max stone size: \( \frac{1}{2} \) in
Max E, ft-lbs per sq ft: 16

Largest "most common" stone size: \( \frac{1}{4} \) in

Number of damaged indicators, CSU network: None

Reports of Hail

E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Max size of stone:
- O \( 0 < S \leq \frac{1}{4} \) in
- \( \frac{1}{4} < S \leq \frac{1}{2} \) in
- \( \frac{1}{2} < S \leq 1 \) in
- 1 in \( < S \leq 2 \) in
- O \( S > 2 \) in

Rainfall Depth (inches)
Case of: 28 June 1961
Hail Classification: Moderate

Precipitable Water (inches) & Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches) (Fawbush & Miller) 1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST

Surface Synoptic Pattern 11 AM & 11 PM MST

500 MB Flow 1700 MST
Case of: 28 June 1961
Hail Classification: Moderate

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of:  
Hail Classification: Moderate  
28 June 1961

SKEW-T Diagrams
0600 MST = 1200Z
1700 MST = 0000Z
Hail reports, 8 July 1961

Hail classification: Moderate

Number of reports from CSU network: 1
Max stone size: >1/4"
Max E, ft-lbs per sq ft: 1
Largest "most common" stone size: >1/4"
Number of damaged indicators, CSU network: None

Reports of Hail

E = impact energy, ft-lbs per sq ft.
S = max stone size, inches.
M = missing data.

Rainfall Depth (inches)
Case of 8 July 1961

Hail Classification: Moderate

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isotherms

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 8 July 1961
Hail Classification: Moderate

SKEW-T Diagrams

Lander
Scottsbluff
North Platte
Denver
Goodland

0500 MST = 1200Z
1700 MST = 0000Z
Case of:

Hail classification: None
Number of reports from CSU network: None
Max stone size: None
Max E, ft-lbs per sq ft: None
Largest "most common" stone size: None
Number of damaged indicators, CSU network: None
Case of 22 May 1961

Hail Classification: None

Surface Synoptic Pattern
11 AM & 11 PM MST

Precipitable Water (inches) & Stability Index
0500 MST

500 MB Flow
1700 MST

Jet Stream 50 & 100 kt. isolochs
1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of: 22 May 1961
Hail Classification: None

Wind Profiles Along Mean Wind Direction
For 1700 MST

Denver

Lander

North Platte
<table>
<thead>
<tr>
<th>Case of</th>
<th>21 June 1961</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hail classification</td>
<td>None</td>
</tr>
<tr>
<td>Number of reports from CSU network</td>
<td>None</td>
</tr>
<tr>
<td>Max stone size</td>
<td>None</td>
</tr>
<tr>
<td>Max $E$, ft-lbs per sq ft.</td>
<td>None</td>
</tr>
<tr>
<td>Largest &quot;most common&quot; stone size</td>
<td>None</td>
</tr>
<tr>
<td>Number of damaged indicators, CSU network</td>
<td>None</td>
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</tbody>
</table>
Case of: 21 June 1961

Hail Classification: None

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Case of:
Hail Classification:

21 June 1961
None

Lander

Scottsbluff

North Platte

Denver

Goodland

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 21 June 1961
Hail Classification: None

SKEW-T Diagrams
Q500 MST = 1200Z
1700 MST = 0000Z
<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall Depth (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidney</td>
<td>26 June 1961 None None None None None</td>
</tr>
<tr>
<td>Ft. Morgan</td>
<td>None          None</td>
</tr>
<tr>
<td>Sterling</td>
<td>None          None</td>
</tr>
<tr>
<td>Holyoke</td>
<td>None          None</td>
</tr>
<tr>
<td>Otis</td>
<td>None          None</td>
</tr>
<tr>
<td>Wray</td>
<td>None          None</td>
</tr>
</tbody>
</table>
Case of 26 June 1961

Hail Classification: None

Precipitable Water (inches) & Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches) (Fawbush & Miller) 1700 MST
Case of: 26 June 1961
Hail Classification: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of:  
Hail classification: None
Number of reports from CSU network: None
Max stone size: None
Max E, ft-lbs per sq ft: None
Largest "most common" stone size: None
Number of damaged indicators, CSU network: None

3 July 1961

Rainfall Depth (inches)
Case of: 3 July 1961
Hail Classification: None

Precipitable Water (inches) & Stability Index

Surface Synoptic Pattern 11 AM & 11 PM MST
500 MB Flow 1700 MST
Jet Stream 50 & 100 kt. isotachs 1700 MST
Forecast Size of Stones (inches) (Fawbush & Miller) 1700 MST

Mean Wind - Surface to Tropopause (knots) 1700 MST
Case of: 3 July 1961
Hail classification: None
Number of reports from CSU network: None
Max stone size: None
Max E, ft-lbs per sq ft: None
Largest "most common" stone size: None
Number of damaged indicators, CSU network: None

Rainfall Depth (inches)
Case of 3 July 1961
Hail Classification: None

Surface Synoptic Pattern
11 AM & 11 PM MST

500 MB Flow
1700 MST

Mean Wind - Surface to Tropopause
(knots) 1700 MST

Precipitable Water (inches)
& Stability Index

Jet Stream 50 & 100 kt. isotachs

Forecast Size of Stones (inches)
(Fawbush & Miller) 1700 MST
Wind Profiles Along Mean Wind Direction
For 1700 MST

Case of: 3 July 1961
Hail Classification: None

Lander

Scottsbluff

North Platte

Denver

Goodland
Case of:  
Hail classification: None  
Number of reports from CSU network: None  
Max stone size: None  
Max E, ft-lbs per sq ft: None  
Largest "most common" stone size: None  
Number of damaged indicators, CSU network: None
Case of: 17 July 1961
Hail Classification: None

Wind Profiles Along Mean Wind Direction
For 1700 MST
Case of: 23 July 1961
Hail classification: None
Number of reports from CSU network: None
Max stone size: None
Max E, ft-lbs per sq ft.: None
Largest "most common" stone size: None
Number of damaged indicators, CSU network: None
Case of 23 July 1961

Hail Classification: None

Precipitable Water (inches) & Stability Index

Jet Stream 50 & 100 kt. isolocaths

Forecast Size of Stones (inches) (Fawbush & Miller) 1700 MST
Case of: 23 July 1961
Hail Classification: None

Wind Profiles Along Mean Wind Direction
For 1700 MST