AIRBORNE GAMMA RADIATION SNOW SURVEY PROGRAM

A User's Guide

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INTRODUCTION

The National Operational Hydrologic Remote Sensing Center (NOHRSC) maintains an Airborne Gamma Radiation Snow Survey Program to make airborne snow water equivalent (SWE) and airborne soil moisture measurements from low-flying aircraft across the country. The program maintains over 1900 flight lines covering portions of 29 states and 7 Canadian provinces. This User's Guide is intended to provide the end-user with information on:

1. How airborne SWE measurements are made,
2. What the airborne SWE measurements represent and how (and why) they differ from ground-based SWE measurements,
3. What soil moisture assumptions are made and their affect on the SWE calculations,
4. How airborne SWE measurements should be modified by end-users with more timely and realistic soil moisture estimates,
5. How and when the airborne data for each flight line are transmitted, in SHEF, to AWIPS and to the NOHRSC web site,
6. Where and when the color contour maps of airborne SWE are posted to the NOHRSC web site,

7. Where and when the SHEF messages giving the mean areal SWE, by basin, are posted to the NOHRSC web site and shipped to AWIPS and the identifiers used,
8. How to obtain from the NOHRSC web site: (a) maps of the flight line network using the NOHRSC interactive map server, (b) the national digitized flight line network for use in ArcInfo or ArcView, (c) the flight line station index database, and (d) the historic airborne SWE database, and
9. Where to look on the NOHRSC web site for details of snow survey mission scheduling and daily notification and updates of airborne survey activities and plans.

In addition, this User's Guide provides end-users with the information necessary to receive, analyze, modify, use, and understand airborne SWE measurements.

AIRBORNE SNOW WATER EQUIVALENT MEASUREMENT THEORY

Gamma rays are emitted from that high energy portion of the electromagnetic spectrum between x-rays and cosmic rays. The ability to make reliable, airborne gamma radiation SWE measurements is based on the fact that natural terrestrial gamma radiation is emitted from the potassium, uranium, and thorium radioisotopes in the upper eight inches of soil. The radiation is sensed from a low-flying aircraft flying 500 feet above the ground over established flight lines. Each flight line is approximately 10 miles long and 1,000 feet wide. Consequently, airborne SWE measurements are mean areal estimates integrated over approximately 2 square miles. Water mass (regardless of phase) in the snow cover attenuates, or blocks, the terrestrial radiation signal. Consequently, the difference between airborne radiation measurements made over bare ground and snow covered ground can be used to calculate a mean areal SWE estimate with a root mean square error of less than one-half inch. The technique measures the attenuation of the radiation signal due solely to the intervening water mass. The technique provides no information on snow depth -- only SWE. Airborne SWE measurements are made using the following relationship:

$$SWE = \frac{1}{A}\left[\ln\frac{C_0}{C} - \ln\left(\frac{100 + 1.11M}{100 + 1.11M_0}\right)\right] g/cm^2$$

(equation 1)

where:

C and Co = Uncollided terrestrial gamma count rates over snow and bare ground,

M and Mo = Percent soil moisture over snow and bare ground,

A = Radiation attenuation coefficient in water, (cm^2/g).

The inverse radiation attenuation coefficients used in equation 1 for the potassium, thorium, and total count windows are 14.34, 18.85, and 17.73, respectively. An independent SWE estimate is calculated for each of the three radioisotope photopeaks. A weighted SWE estimate is calculated by multiplying each of the three independent SWE estimates by weighting coefficients (that sum to unity) and summing the results. The potassium, thorium, and total count weighting factors are 0.346, 0.518, 0.136, respectively. Only the weighted SWE estimate is reported; the three SWE estimates are calculated for each photopeak but are not reported in NOHRSC products. Background radiation and soil moisture estimates (Co and Mo) are collected only once under snow-free conditions and used to calibrate a flight line.

Percent Soil Moisture by Weight

Percent soil moisture (by weight) is calculated as the weight of water divided by the weight of dry soil multiplied by 100. By this formulation, it is possible to have a percent soil moisture estimate greater than 100%. Field holding capacity is largely a function of landuse and soil type. For a typical loam soil, field holding capacity is about 35% soil moisture. Under frozen soil conditions, it is possible to accumulate interstitial ice that can raise the percent soil moisture estimate for the upper eight inches to typical values of 50% to 70%. Soil moisture conditions can generally be characterized by the relationship given in Table 1.

Table 1
Percent Soil Moisture by Weight

Percent Soil Moisture	Moisture Content
5 – 10	Extremely dry
10 – 15	Dry
15 – 25	“Normal”
25 – 35	Wet to Very wet
Above 35	Extremely wet (standing water)

AIRBORNE SNOW WATER EQUIVALENT MEASUREMENT PRACTICE

The airborne measurement technique depends on: (1) the difference between the no-snow and over-snow radiation measurements (Co and C), and (2) the effect of the soil moisture conditions (M) extant at the time of airborne SWE measurements. The technique is not sensitive to the phase of the moisture in the snow or soil and accounts for the effect of atmospheric moisture. We do not, however, collect radiation data in the rain or snow and require VFR conditions to collect airborne data at 500 feet AGL. Agricultural vegetation does not significantly affect the no-snow or over-snow radiation measurements.

Figure 1 is a schematic representation of the various factors associated with making and understanding airborne SWE measurements. It represents the airborne SWE estimate as the sum of the moisture (regardless of phase) contained in the SWE (SWE'), ice lenses (IL), liquid water in the snow pack (LW), ground ice (GI), standing water (SW), and superimposed soil moisture (M_s). It also represents the total soil moisture (M_t) in the eight inch soil zone as composed of the primary soil moisture (M) and the superimposed soil moisture (M_s). The above characterization makes it possible for an end-user to "recalculate" the reported airborne SWE estimate by changing the primary soil moisture estimate (M), used in the airborne SWE calculation, to a more representative primary soil moisture estimate (M'). NOTE: In Figure 1, the airborne SWE estimate totals *all* of the above-ground moisture plus the superimposed soil moisture:

$$SWE = SWE' + IL + LW + GI + SW + M_s.$$

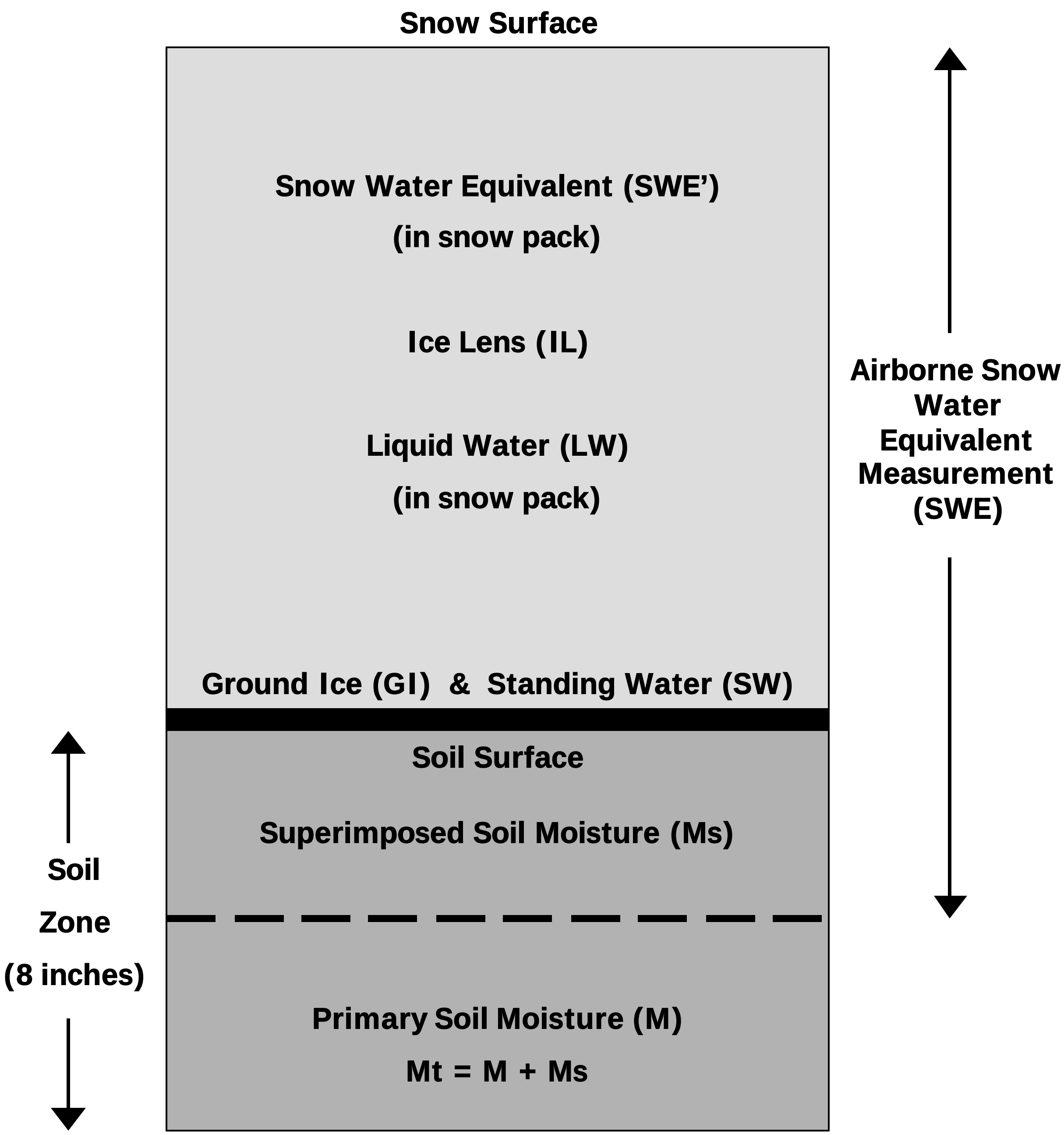
(equation 2)

M_t represents all of the soil moisture in the upper eight inches. The estimate of M is used in the SWE calculation and can be set by the user: $M = M_t - M_s$.

Using the above formulation, it is possible to estimate how much total liquid and solid moisture has accumulated since the late fall. In this case, M should be set to a estimate which represents the fall soil moisture condition. M_s will, quite likely, be significant and represent moisture from later precipitation, mid-winter snowmelt, and/or moisture transported from the lower soil zones toward the surface due to winter vapor pressure gradients near the soil surface. Consequently, the resulting airborne SWE estimate could include a significant amount of moisture in the soil (M_s) which exceeds the fall soil moisture estimate (M).

Figure 1

Factors Associated with Making and Understanding Airborne Snow Water Equivalent Measurements



Additionally, it is possible to estimate how much above-ground moisture (SWE' + IL + LW + GI + SW) and soil moisture (M_s) *above* field holding capacity is present. In this case, the primary soil moisture estimate (M) is set to field holding capacity of the local soil (typically 35%). This estimates the amount of moisture contained in the above-ground snow and ice, but also *that portion of the soil moisture above field holding capacity that acts hydrologically very much like SWE.*

It is possible also to estimate the total above-ground moisture (i.e., the traditional SWE estimate). The this case the superimposed soil moisture estimate (M_s) is set to zero and, consequently, the primary soil moisture (M) is estimated to equal the total soil moisture (M_t) – easy to say; hard to estimate. In this case, the estimate of M can easily be above field holding capacity and values of 50% to 70% soil moisture are not uncommon. If M is an accurate estimate of the total mean areal soil moisture in the upper eight inches over a flight line, then (and only then) the resulting airborne SWE will be an accurate estimate of the true, above-ground moisture content. In this case, however, the airborne SWE estimate will not account for the 15% to 30% soil moisture (1 to 2 inches of water equivalent) in the soil above field holding capacity that may exist and acts hydrologically like SWE.

As a result, airborne SWE measurements made using a value of 35% soil moisture (M), or less, typically, and appropriately, tend to overestimate ground-based SWE measurements that, in turn, tend to underestimate the true SWE conditions on the ground. Consequently, airborne snow measurements should be expected to be a better measure of true ground snow cover conditions than those provided by cooperative observers and others using traditional ground-based snow measurement techniques.

Adjustment of Airborne Snow Water Equivalent Measurement

Airborne SWE is calculated using an assumed, measured, estimated, or default value for M in equation 1. The value of M used in the airborne SWE calculation is reported in the SHEF message. Unfortunately, the soil moisture estimate used in the SWE calculation may not, in fact, be representative of the soil moisture conditions in the upper eight inches of soil at the time the airborne measurement is made. Consequently, it may be necessary for the end-user to change the estimate of M and "recalculate" the airborne SWE estimate based on a more realistic, or representative, estimate of M for the upper eight inches of soil at the time of the airborne measurement.

Table 2 allows an end-user to modify the reported airborne SWE estimate by changing the estimate of M used in the original SWE calculation. The table gives the original soil moisture estimate (M) (reported in the SHEF message) along the X-axis and a new, updated, estimate (M') along the Y-axis. The body of the table gives the change of SWE, in inches, from the original SWE when using a new, primary soil moisture estimate (M') entered from the Y-axis. For example, if we want to *increase* the percent soil moisture (M) on a flight line from 20% (M) to 60% (M'), we would need to *reduce* the original SWE by 2.1 inches to derive a new SWE estimate.

Table 2
Change in Airborne SWE (inches) Using Different Percent Soil Moisture Estimates (M)

Percent soil moisture (M') used in "new" SWE.

100	-5.0	-4.3	-3.7	-3.1	-2.6	-2.1	-1.6	-1.2	-0.8	-0.4	0.0
90	-4.7	-4.0	-3.3	-2.7	-2.2	-1.7	-1.2	-0.8	-0.4	0.0	0.4
80	-4.3	-3.6	-2.9	-2.3	-1.8	-1.3	-0.8	-0.4	0.0	0.4	0.8
70	-3.9	-3.2	-2.5	-1.9	-1.4	-0.9	-0.4	0.0	0.4	0.8	1.2
60	-3.4	-2.7	-2.1	-1.5	-1.0	-0.5	0.0	0.4	0.8	1.2	1.6
50	-3.0	-2.3	-1.6	-1.0	-0.5	0.0	0.5	0.9	1.3	1.7	2.1
40	-2.5	-1.8	-1.1	-0.5	0.0	0.5	1.0	1.4	1.8	2.2	2.6
30	-1.9	-1.2	-0.6	0.0	0.5	1.0	1.5	1.9	2.3	2.7	3.1
20	-1.4	-0.6	0.0	0.6	1.1	1.6	2.1	2.5	2.9	3.3	3.7
10	-0.7	0.0	0.6	1.2	1.8	2.3	2.7	3.2	3.6	4.0	4.3
0	0.0	0.7	1.4	1.9	2.5	3.0	3.4	3.9	4.3	4.7	5.0
	0	10	20	30	40	50	60	70	80	90	100

Percent soil moisture (M) used in original SWE calculation.

Alternatively, the change in airborne SWE due to a change in the primary soil moisture (M) can be calculated as:

$$SWE'' = \frac{1}{A}\left[\ln\left(\frac{100+1.11M}{100+1.11M'}\right)\right] inches$$

(equation 3)

where:

SWE" = Change in snow water equivalent (in inches)

M and M' = Original and modified primary soil moisture estimate (in percent soil moisture),

A = Radiation attenuation coefficient in water, (equal to 0. 1482).

Additionally, equation 3 and Table 2 provide a direct relationship between percent soil moisture and water equivalent in inches. If M' is set to zero, then equation 3 and Table 2 provide a direct estimate of the water equivalent for any given percent soil moisture (M).

Ground-based Snow Water Equivalent Measurements

Ground-based SWE measurements are typically made by an observer using a snow tube and a scale that give a direct reading of SWE. Snow tube measurements tend to *systematically underestimate* true SWE because of the sampling difficulties associated with ice lenses, ground ice, and depth hoar. It is virtually impossible to accurately measure the water content in ice layers on the ground that can be 2 to 4 inches thick. Moreover, one point sample tends not to be representative of an area.

Airborne SWE estimates, however, include *all* the SWE, liquid water, ground ice, and standing water above the ground. In addition, they may also include some superimposed soil moisture (M_s) depending on the estimate of the primary soil moisture (M) used in the SWE calculation. As a result of the tendency for ground observations to underestimate true SWE and the possibility that the airborne SWE estimate may include some soil moisture (depending on the estimate of M used),

ground-based SWE estimates tend to underestimate airborne SWE measurements.

Additionally, the reliability of one point estimate to characterize the mean areal SWE of a two to three square mile area is limited.

Accuracy Of Airborne Snow Water Equivalent Measurements

Research over agricultural areas in the Upper Midwest and over forested areas of the Lake Superior basin and Saint John River basin suggest airborne SWE measurements can be made with the errors given in Table 3 when compared to ground-based snow measurements.

Table 3
Airborne SWE
Measurement Error (inches)

Error	Agricultural	Forest
Root Mean Square Error	0.35	0.91
Average Absolute Error	0.30	0.74
Average Bias	0.21	0.06
Percent Bias	12.10	1.28
Number of flight lines	15	70

The airborne measurement errors (Table 3) were derived by comparing airborne and ground-based SWE data collected on flight lines in both agricultural and forest environments. We typically take over 1,000 depth and density measurements on a single flight line to estimate a ground-based SWE with which to compare the airborne measurement made over a single flight line. Of course, all ground-based snow data have substantial errors. Coefficients of variation for ground-based snow measurements vary typically between 40% and 60%. A significant rub in this business comes in knowing the true SWE with which to compare the airborne SWE estimates. Ground-based snow measurements tend not to provide an accurate, mean areal SWE estimate.

Winter Airborne Snow Survey Schedule

It is the responsibility of RFC and WFO hydrologists to make requests for specific airborne snow surveys in those river basins of most interest to the respective offices. Airborne snow survey schedules and locations for data collection are determined approximately ten days before each outlook release date and are based on snow cover conditions across the country. Service Hydrologists should submit email requests to both the RFC and to the NOHRSC (Tom.Carroll@noaa.gov) with as much lead time as possible. RFCs should send an email summary of all flight line requests in their area with some estimate of priority for each group or basin.

A daily summary of the airborne snow survey schedule, recent survey activity, and future plans is posted to the NOHRSC web site Bulletin Board page under Airborne Snow Survey Schedule during the snow survey season.

AIRBORNE SNOW SURVEY PRODUCTS

The NOHRSC ships all alphanumeric products, in SHEF, to AWIPS (using the AWIPS ids given in Table 4 below) and to the NOHRSC web site. We ship all image products to our web site in gif, ArcInfo, and postscript formats. This document is not intended to be a "NOHRSC Web Site User's Guide" but will discuss the products generated by the Airborne Snow Survey Program. The primary airborne products are three:

1. Airborne SWE, by flight line, shipped to AWIPS and the NOHRSC web site once or more each day,
2. Color contour maps of SWE shipped to NOHRSC web site at the conclusion of each airborne snow survey, (in gif, ArcInfo, and postscript formats), and
3. Mean areal airborne SWE, by basin, shipped to AWIPS and the NOHRSC web site at the conclusion of each airborne snow survey (a companion product, in SHEF, to the map).

To access the above products from the NOHRSC web site (www.nohrsc.nws.gov):

1. Click on the “Operational Products Search Engine”
2. Click the Eastern USA/SWE box in the left panel,
3. Select RFC, CWA, or days, if required,
4. Click “submit”
5. Scroll down in the right panel to “East: Composite SWE Derived From Gamma”
6. Click on the appropriate gif map generated at the conclusion of each survey. (Only “zz” products contain exclusively airborne SWE data. Other SWE products (that don’t start with “zz”) may contain airborne SWE data *and* ground-based cooperative observer SWE data.)
7. To access the companion SHEF product giving the mean areal SWE, by basin, click on the associated “zz” SHEF message.
8. To access the daily SHEF messages giving the airborne SWE, by flight line, for each day’s flights, scroll to the bottom of the right panel and select the required SHEF message.

Airborne Snow Water Equivalent (by flight line)

The following discusses the SHEF products that give the airborne SWE, by flight line, using the example in Figure 2 below (note key at bottom of Figure 2). In the Figure 2 example, we made a fall soil moisture survey on November 13 and interpolated the airborne soil moisture to be 43% on flight line IA107. Making the leap-of-faith that soil moisture conditions between the fall survey date and the winter survey date did not change, we calculated SWE to be 3.6 inches for the flight line. For line IA127, we had no objective fall soil moisture estimate. Consequently, we used a subjective estimate of 25% soil moisture and calculated a SWE estimate of 4.1 inches. (We also include in the SHEF message a SWE estimate, for each flight line, using an arbitrary estimate of 35% soil moisture for reference using the rational above.) If, however, there is good reason to believe that soil moisture conditions for IA127 on the survey date are not the estimated 25% but rather, for example, 45%, it is possible for the end-user to “adjust” the calculated SWE using Table 2 above and the more realistic estimate of 45% soil moisture. In Table 2, simply enter 25% on the x-axis and 45% on the y-axis to estimate the SWE correction as –1.1 inches using the higher 45% soil moisture. Consequently, 4.1-1.1 = 3.0 inches of SWE using the higher soil moisture estimate for IA127. Note that the SWE estimates using 25% and 45% in this example are consistent with the SWE reported in the SHEF message using an arbitrary 35% soil moisture estimate.

Figure 2

SHEF Message
Airborne SWE (by flight line)

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SRUS43 KMSR 182106
RRMASP

.BR GAMMA 010218 /SAIRF/SWIRF
:TO ------ Service Hydrologist (Please give HARDCOPY to SH)
:FROM ---- Tom Carroll, (952) 361-6610 ext 225, Minneapolis, Minnesota
:Visit our web page at www.nohrsc.nws.gov
:SUBJECT - AIRBORNE SWE DATA              010218210638
:-----------------------------------------------------------------------
: Total No. of flight lines sent = 29
:-----------------------------------------------------------------------
:Line   Survey    %SC   SWE   SWE %SM Est Fall  %SM  Pilot
:No.    Date           (in) (35%) (M) Typ Date  (F)  Remarks
:=======================================================================
IA101  DY010218 / 100 / 4.5 : 4.6, 38 AI   1113 , 38 DRIFTING SNOW ICE UN
IA102  DY010218 / 100 / 3.4 : 3.9, 43 AI   1113 , 43 SNO DRFTS
IA106  DY010218 / 100 / 3.9 : 4.4, 43 AI   1113 , 43 WATERMAN CREEK FRZN
IA107  DY010218 / 100 / 3.6 : 4.1, 43 AI   1113 , 43 LITTLE ROCK R FRZN
IA110  DY010218 / 100 / 4.1 : 4.2, 37 AI   1113 , 37
IA127  DY010218 / 100 / 4.1 : 3.5, 25 SE      0 , 25 ICE ON SNO
IA129  DY010218 / 100 / 4.6 : 4.1, 25 SE      0 , 25 LTL SIOUX RVR FZN
IA138  DY010218 / 100 / 4.5 : 3.9, 25 SE      0 , 25 SNO DRFTS
IA139  DY010218 / 100 / 4.6 : 4.1, 25 SE      0 , 25 SNO DRFTS
IA143  DY010218 / 100 / 4.9 : 4.3, 25 SE      0 , 25 SNO DRFTS
IA144  DY010218 / 100 / 5.2 : 4.6, 25 SE      0 , 25 RVRS FZN
IA216  DY010218 / 100 / 6.2 : 5.6, 25 SE      0 , 25 OTTER CRK P-OPN
IA217  DY010218 / 100 / 5.5 : 4.9, 25 SE      0 , 25 ICE CRUSTED SNO
IA218  DY010218 / 100 / 6.1 : 5.6, 25 SE      0 , 25 BVR CRK P-OPN
IA224  DY010218 / 100 / 6.2 : 5.7, 25 SE      0 , 25 SNO DRFTS
IA233  DY010218 / 100 / 6.1 : 5.6, 25 SE      0 , 25 CDR RVR P-OPN
MN258  DY010218 / 100 / 3.3 : 3.1, 31 AI   1113 , 31 N FORK CROW R FRZN
MN315  DY010218 / 100 / 3.7 : 3.8, 37 AI   1113 , 37 ROCK RVR FZN
MN321  DY010218 / 100 / 4.7 : 4.7, 37 AM   1109 , 37 WATONWAN R FRZN
MN325  DY010218 / 100 / 4.7 : 4.6, 35 AI   1113 , 35 MINN R FRZN
MN327  DY010218 / 100 / 4.6 : 4.2, 28 AM   1109 , 28 DRIFTING SNOW
MN337  DY010218 / 100 / 3.9 : 4.0, 36 AI   1113 , 36 SPIRIT LAKE FRZN
MN341  DY010218 / 100 / 3.3 : 3.4, 36 AI   1113 , 36 W FORK DES MOINES R
MN343  DY010218 / 100 / 3.5 : 3.6, 37 AI   1113 , 37 DES MOIONES R FRZN
MN352  DY010218 / 100 / 4.1 : 4.2, 37 AI   1113 , 37 HAWK CREEK FRZN
MN504  DY010218 / 100 / 3.8 : 4.3, 43 AM   1109 , 43 DRIFTING SNOW
MN508  DY010218 / 100 / 4.6 : 4.6, 35 AI   1113 , 35 SLEEPY EYE CREEK FRZ
MN514  DY010218 / 100 / 5.0 : 5.1, 36 AI   1113 , 36 COTTONWOOD R FRZN
.END
Today's survey covered most of southwestern MN and northern IA.  Good
visibilities and high overcast conditions prevailed over the area and
winds were strong and gusty out of the south and southwest behind an
extensive high pressure system moving east out of the area.  Most
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rivers seen from the air were frozen, with the few exceptions noted
above, which were only partially open.       Heavy snow drifts were seen in
all areas surveyed today. Much of the snow was crusted with a thin
layer of ice, particularly in the open fields.
NNNN
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SHEF Message Key

```
Line No.        Flight line number,
Survey Date     Survey Date,
%SC             Visual estimate of percent snow cover over
                flight line made by pilots,
SWE(in)         SWE, in inches, made using the %SM(M) soil
                moisture estimate,
SWE(35%)        SWE, in inches, made using an assumed 35% soil
                moisture,
%SM(M)          Percent soil moisture used in SWE calculation
Est type        Type of estimate for %SM(M):
        AM      Airborne soil moisture measurement,
        AI      Interpolated from airborne measurements,
        GM      Ground-based soil moisture measurement,
        GI      Interpolated from ground measurements,
        SE      Subjective estimate,
Fall date       Survey date for fall soil moisture survey,
%SM(F)          Percent soil moisture measured/estimated in the
                fall,
Pilot Remarks   Pilot remarks for flight line.
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NOHRSC Product Identifiers, Descriptions, and Distribution

The NOHRSC distributes a number of SWE and satellite areal extent of snow cover products, in SHEF, over AWIPS using the AWIPS identifiers and WMO headers given in Table 4. All SHEF products sent to AWIPS are also posted to the NOHRSC web site. For a fuller description, see the document on the NOHRSC web site under the NOHRSC Technology page titled NOHRSC Product Identifiers, Descriptions, and Distribution.

Table 4
AWIPS IDS AND WMO HEADER PRODUCT IDENTIFIERS

AWIPS ID	WMO HEADER	DESCRIPTION
MSPRRMASB	SRUS43 KMSR	Airborne Soil Moisture by Basin
MSPRRMASF	SRUS43 KMSR	Airborne Soil Moisture by Flight Line
MSPRRMASP	SRUS43 KMSR	Airborne Snow Water Eq by Flight Line
MSPRRMASW	SRUS43 KMSR	Airborne Snow Water Eq by Basin
MSPSCVACR	SRUS43 KMSR	Satellite Areal Extent of SCV for APRFC
MSPSCVALR	SRUS43 KMSR	Satellite Areal Extent of SCV for SERFC
MSPSCVFWR	SRUS43 KMSR	Satellite Areal Extent of SCV for WGRFC

MSPSCVKRF	SRUS43 KMSR	Satellite Areal Extent of SCV for MBRFC
MSPSCVMSR	SRUS43 KMSR	Satellite Areal Extent of SCV for NCRFC
MSPSCVORN	SRUS43 KMSR	Satellite Areal Extent of SCV for LMRFC
MSPSCVPTR	SRUS43 KMSR	Satellite Areal Extent of SCV for NWRFC
MSPSCVRHA	SRUS43 KMSR	Satellite Areal Extent of SCV for MARFC
MSPSCVRSA	SRUS43 KMSR	Satellite Areal Extent of SCV for CNRFC
MSPSCVSTR	SRUS43 KMSR	Satellite Areal Extent of SCV for CBRFC
MSPSCVTAR	SRUS43 KMSR	Satellite Areal Extent of SCV for NERFC
MSPSCVTIR	SRUS43 KMSR	Satellite Areal Extent of SCV for OHRFC
MSPSCVTUA	SRUS43 KMSR	Satellite Areal Extent of SCV for ABRFC
MSPSWEACR	SRUS43 KMSR	Estimated SWE by Basin for APRFC
MSPSWEALR	SRUS43 KMSR	Estimated SWE by Basin for SERFC
MSPSWEFWR	SRUS43 KMSR	Estimated SWE by Basin for WGRFC
MSPSWEKRF	SRUS43 KMSR	Estimated SWE by Basin for MBRFC
MSPSWEMSR	SRUS43 KMSR	Estimated SWE by Basin for NCRFC
MSPSWEORN	SRUS43 KMSR	Estimated SWE by Basin for LMRFC
MSPSWEPTR	SRUS43 KMSR	Estimated SWE by Basin for NWRFC
MSPSWERHA	SRUS43 KMSR	Estimated SWE by Basin for MARFC
MSPSWERSA	SRUS43 KMSR	Estimated SWE by Basin for CNRFC
MSPSWESTR	SRUS43 KMSR	Estimated SWE by Basin for CBRFC
MSPSWETAR	SRUS43 KMSR	Estimated SWE by Basin for NERFC
MSPSWETIR	SRUS43 KMSR	Estimated SWE by Basin for OHRFC
MSPSWETUA	SRUS43 KMSR	Estimated SWE by Basin for ABRFC

NOTE: In the above headers:

1. **RRM** is used for NOHRSC airborne survey gamma products that are generated for the surveyed area, using only airborne gamma data, and released during, or immediately after, airborne snow or soil moisture survey missions,
2. **SCV** is used for Satellite Areal Extent of Snow Cover products which are generated for each RFC and released daily at approximately 15z, and
3. **SWE** is used for Estimated SWE by Basin products that are generated for each RFC and released daily at approximately 15z. These products include data from only the previous 24-hour period and are derived using all available SWE data, including airborne SWE data and ground-based observations, for the previous 24-hour period..

AIRBORNE PROGRAM GIS DATA SETS AND FLIGHT LINE STATION INDEX DATABASE

An ArcInfo coverage of the digitized, national airborne flight line network is available from the NOHRSC web site on the NOHRSC GIS Data Sets page. Additionally, web-based, interactive, reference maps (using user-selected options including flight lines, basin boundaries, rivers, roads, etc), the historic airborne SWE database, and the airborne station index are available on the NOHRSC web site. Click on the Operational Products Search Engine and scroll to the bottom of left panel for access.

SUMMARY

If you have any questions or require any additional information, give me a call.

Tom Carroll
(952) 361-6610 ex 225