Caribou Snow Amount Tool v5.7

- Designed by Dan Cobb (NOAA/NWS/Grand Rapids MI)

- Uses BUFKIT data as input.

- Output includes:
  - Precipitation Type
  - Snow Ratio, Snowfall, Snow Accum with/without compaction
  - Precipitation Totals for Snow, Sleet, Freezing Rain
  - Percent of hydrometeors reaching the ground in the form of liquid, ice, and snow

- See output for explanation

Caribou Snow Amount Tool

- ## Snow Amount Algorithm

  - Creates the snow amount by assessing the sounding in a top-down approach. The analysis looks at vertical velocity, wet-bulb and dry-bulb temperature, and relative humidity to generate a snow ratio. This is done for every model level from hydrometeor creation down to the surface.

  - Documented in an AMS presentation
    - Weather Analysis and Forecasting/17th Conference on Numerical Weather Prediction 2005
    - Recorded online presentation:
      - http://ams.confex.com/ams/WAFNWP34BC/techprogram/paper_94815.htm

- ## Precipitation Type Algorithm

  - Algorithm was designed to use the strengths of the Top-Down Approach (Baumgardt, http://www.crh.noaa.gov/arx/micro/micrope.php), Bourgouin and Ramer algorithms.

  - Traces a hydrometeor vertically toward the surface.

The Output Explained

SRat: Snow:Water Ratio,
Snow: Snowfall during time step,
TotSF: Run Total Snow Accum,
TotSN: Run Total Snow Accum
with compaction

Site

Model precipitation during the time step (QPF), Run Total Precipitation (TotQPF)

RH to consider a layer saturated

Sleet:Water ratio

Percent of hydrometeors reaching the surface as Snow (%S), Ice (%I), and Liquid (%L). Sleet would add to %I, Freezing rain would add to %L.

Valid time of the output in YYMMDD/HHHH"Z". Time is UTC. To get local time, subtract 6h during DST, 5h otherwise.

```
StnID: klse    Model: nam       Run: 20121209/1800   Cloud RH threshold:   85%     Sleet Ratio: 2:1   || CarSnowTool 5.7

Date/hour      FHr  Wind     SfcT    Ptype    SRat|Snow||TotSF|TotSN      QPF||TotQPF Sleet||TotPL   FZRA||TotZR    S%| I%| L%
==================================================================================================================================
121209/1900Z    1  07011KT  31.9F   SNOW     15:1| 0.9||  0.9| 0.9    0.057|| 0.06   0.00|| 0.00   0.00|| 0.00    100|  0|  0
121209/2000Z    2  07013KT  32.1F   SNOW     15:1| 0.4||  1.2| 1.2    0.023|| 0.08   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             14:1| 0.1||  1.3| 1.3    0.006|| 0.09   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             16:1| 0.1||  1.4| 1.4    0.008|| 0.09   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             17:1| 0.4||  1.8| 1.7    0.024|| 0.12   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             19:1| 0.5||  2.3| 2.1    0.025|| 0.14   0.00|| 0.00   0.00|| 0.00    100|  0|  0
------+------++-----+----+-----------++--------+-----++---------+----
                                             17:1| 0.5||  2.8| 2.5    0.028|| 0.17   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             15:1| 0.4||  3.2| 2.8    0.026|| 0.20   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                             14:1| 0.4||  3.6| 3.1    0.026|| 0.22   0.00|| 0.00   0.00|| 0.00    100|  0|  0
                                              9:1| 0.2||  3.7| 3.3    0.019|| 0.24   0.00|| 0.00   0.00|| 0.00    100|  0|  0
121210/0500Z   11  02010KT  30.6F   SNOW      8:1| 0.1||  3.8| 3.3    0.009|| 0.25   0.00|| 0.00   0.00|| 0.00    100|  0|  0
121210/0600Z   12  01011KT  30.3F            0:1| 0.0||  3.8| 3.3    0.000|| 0.25   0.00|| 0.00   0.00|| 0.00      0|  0|  0
------------------------------------------------------------------------------
121210/0700Z   13  01010KT  30.1F                                        0.25
121210/0800Z   14  36009KT  29.7F                                        0.25
121210/0900Z   15  35009KT  29.2F                                        0.25
121210/1000Z   16  34009KT  29.4F                                        0.25
121210/1100Z   17  34009KT  29.2F                                        0.25
121210/1200Z   18  33009KT  28.8F            0:1| 0.0||  0.0| 0.0    0.000|| 0.00   0.00|| 0.00   0.00|| 0.00      0|  0|  0
```

Model precipitation during time step in the form of sleet or ice pellets, Run Total Precip from Sleet

Model precipitation during time step in the form of freezing rain, Run Total Precip from freezing rain

Summing Hourly Snowfall

$$SA_h = \sum_{i=0}^{h} QPF_i \times SR_i$$

Can't use SRs derived using 6-hour snow measurements on hourly data.

Reference: The 1997 Montague Report

Snow Accumulation

$$SA_h = \sum_{i=0}^{h} QPF_i \times SR_i \times e^{-a(h-i)^{1/2}}$$

$Where:$

Snow Accumulation with compaction based on studies at WFO Buffalo (Mahoney).
Does not account for: temperatures, wind, sublimation, melting, solar isolation, etc...

$SA_h = snow\ accumulation\ for\ hour\ h$

$QPF_i = QPF\ for\ hour\ i$

$SR_i = snow\ ratio\ for\ hour\ i$

$a = compression\ coefficient\ (0.08)$

Created By: NOAA NWS La Crosse, Wisconsin

The SREF Matrix

Members are run through the Cobb algorithm, then summarized for each hour

Members evaluated
21 + mean=22 possible

```
StnID: klse   Model: sref      Run: 20120227/0900
  Date/Hour    SREF Members: Probability of Measurable Precipitation Types      Total Members: 21 (of 22)  Ver:0.8
==========================================================================================================================
120227/1000Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1100Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1200Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1300Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1400Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1500Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1600Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1700Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120227/1800Z  Dry 100%  SNOW  0%  SNPL  0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
```

How are the individual precipitation types binned?

SNOW: "SNOW" or "SG"
SNPL: "SNPL"
PL: "PL"
FZMIX: "FZPL" or "FZSN" or "ZRPL" or "ZLSG"
FZRA: "FZRA"
FZDZ: "FZDZ"
RA/DZ: "RAIN" or "DZ"
OTHER: all other types not listed above (e.g., SNRA or Snow/Rain mix).

```
120228/0700Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/0800Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/0900Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1000Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1100Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1200Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1300Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1400Z  Dry 100%  SNOW   0%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat  0:1
120228/1500Z  Dry  95%  SNOW   5%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat 12:1
120228/1600Z  Dry  86%  SNOW  14%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat 12:1
120228/1700Z  Dry  76%  SNOW  24%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat 13:1
120228/1800Z  Dry  62%  SNOW  38%  SNPL   0%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat 14:1
120228/1900Z  Dry  62%  SNOW  33%  SNPL   5%  PL  0%  FZMIX  0%  FZRA  0%  FZDZ  0%  RA/DZ  0%  OTHER  0%  SRat 13:1
```

Example: On Feb 28, 2012 at 1800Z, the SREF suggests ~40% of measurable precipitation in the form of snow. About 60% of the members are dry. The average snow ratio for SNOW members is 14:1.