Last Copy

NOAA Technical Memorandum NWS WR-215

WEATHERTOOLS

Tom Egger
National Weather Service
Weather Service Forecast Office
Boise, Idaho

October 1991

U.S. DEPARTMENT OF COMMERCE / National Oceanic and Atmospheric Administration / National Weather Service

NOAA TECHNICAL MEMORANDA
National Weather Service, Western Region Subseries

The National Weather Service (NWS) Western Region (WR) Subseries provides an informal medium for the documentation and quick dissemination of results not appropriate, or not yet ready, for formal publication. The series is used to report on work in progress, to describe technical procedures and practices, or to relate progress to a limited audience. These Technical Memoranda will report on investigations devoted primarily to regional and local problems of interest mainly to personnel, and hence will not be widely distributed.

Papers 1 to 25 are in the former series, ESSA Technical Memoranda, Western Region Technical Memoranda (WRTM); papers 24 to 59 are in the former series, ESSA Technical Memoranda, Weather Bureau Technical Memoranda (WBTM). Beginning with 60, the papers are part of the series, NOAA Technical Memoranda NWS. Out-of-print memoranda are not listed.

Papers 2 to 22, except for 5 (revised edition), are available from the National Weather Service Western Region, Scientific Services Division, P.O. Box 11188, Federal Building, 125 South State Street, Salt Lake City, Utah 84147. Paper 5 (revised edition), and all others beginning with 25 are available from the National Technical Information Service, U.S. Department of Commerce, Sills Building, 5285 Port Royal Road, Springfield, Virginia 22161. Prices vary for all paper copies; microfiche are $3.50. Order by accession number shown in parentheses at end of each entry.

ESSA Technical Memoranda (WRTM)

2 Climatological Precipitation Probabilities. Compiled by Lucianne Miller, December 1965.
3 Western Region Pre- and Post-FP-3 Program, December 1, 1965, to February 20, 1966. Edward D. Diemer, March 1966.
5 Station Descriptions of Local Effects on Synoptic Weather Patterns. Philip Williams, Jr., April 1966 (Revised November 1967, October 1969). (PB-17800)
8 Interpreting the RAREP. Herbert P. Benner, May 1966 (Revised January 1967).
11 Some Electrical Processes in the Atmosphere. J. Latham, June 1966.
17 A Digitalized Summary of Radar Echoes within 100 Miles of Sacramento, California. J. A. Youngberg and L. B. Overaas, December 1966.
21 An Objective Aid for Forecasting the End of East Winds in the Columbia Gorge, July through October. D. John Coparanis, April 1967.
22 Derivation of Radar Horizons in Mountainous Terrain. Roger G. Pappas, April 1967.

ESSA Technical Memoranda, Weather Bureau Technical Memoranda (WBTM)

25 Verification of Operation Probability of Precipitation Forecasts, April 1966-March 1967. W. W. Dickey, October 1967. (PB-176240)
26 A Study of Winds in the Lake Mead Recreation Area. R. P. Augulis, January 1968. (PB-177830)
28 Weather Extremes. R. J. Schmidli, April 1968 (Revised March 1986). (PB86 177672/AS)
29 Small-Scale Analysis and Prediction. Philip Williams, Jr., May 1968. (PB178425)
30 Numerical Weather Prediction and Synoptic Meteorology. CPT Thomas D. Murphy, USAF, May 1968. (AD 673365)
31 Precipitation Detection Probabilities by Salt Lake ARTC Radars. Robert K. Belesky, July 1968. (PB 179084)
32 Probability Forecasting--A Problem Analysis with Reference to the Portland Fire Weather District. Harold S. Ayer, July 1968. (PB 179289)
36 Temperature Trends in Sacramento--Another Heat Island. Anthony D. Lentini, February 1969. (PB 183055)
37 Disposal of Logging Residues Without Damage to Air Quality. Owen P. Cramer, March 1969. (PB 183057)
39 Upper-Air Lows Over Northwestern United States. A.L. Jacobson, April 1969. PB 184296)
40 The Man-Machine Mix in Applied Weather Forecasting in the 1970s. L.W. Snellman, August 1969. (PB 185068)
43 Forecasting Maximum Temperatures at Helena, Montana. David E. Olsen, October 1969. (PB 185762)
44 Estimated Return Periods for Short-Duration Precipitation in Arizona. Paul C. Kangieser, October 1969. (PB 187763)
46 Applications of the Net Radiometer to Short-Range Fog and Stratus Forecasting at Eugene, Oregon. L. Yee and E. Bates, December 1969. (PB 190476)
47 Statistical Analysis as a Flood Routing Tool. Robert J.C. Burnash, December 1969. (PB 188744)
48 Tsunami. Richard P. Augulis, February 1970. (PB 190157)
49 Predicting Precipitation Type. Robert J.C. Burnash and Floyd E. Hug, March 1970. (PB 190962)
50 Statistical Report on Aeroallergens (Pollens and Molds) Fort Huachuca, Arizona, 1969. Wayne S. Johnson, April 1970. (PB 191743)
51 Western Region Sea State and Surf Forecaster's Manual. Gordon C. Shields and Gerald B. Burdwell, July 1970. (PB 193102)
52 Sacramento Weather Radar Climatology. R.G. Pappas and C. M. Veliquette, July 1970. (PB 193347)
54 A Refinement of the Vorticity Field to Delineate Areas of Significant Precipitation. Barry B. Aronovitch, August 1970.
55 Application of the SSARR Model to a Basin without Discharge Record. Vail Schermerhorn and Donal W. Kuehl, August 1970. (PB 194394)
56 Areal Coverage of Precipitation in Northwestern Utah. Philip Williams, Jr., and Werner J. Heck, September 1970. (PB 194389)
57 Preliminary Report on Agricultural Field Burning vs. Atmospheric Visibility in the Willamette Valley of Oregon. Earl M. Bates and David O. Chilcote, September 1970. (PB 194710)
58 Air Pollution by Jet Aircraft at Seattle-Tacoma Airport. Wallace R. Donaldson, October 1970. (COM 71 00017)
59 Application of PE Model Forecast Parameters to Local-Area Forecasting. Leonard W. Snellman, October 1970. (COM 71 00016)
60 An Aid for Forecasting the Minimum Temperature at Medford, Oregon, Arthur W. Fritz, October 1970. (COM 71 00120)
63 700-mb Warm Air Advection as a Forecasting Tool for Montana and Northern Idaho. Norris E. Woerner, February 1971. (COM 71 00349)
64 Wind and Weather Regimes at Great Falls, Montana. Warren B. Price, March 1971.
65 Climate of Sacramento, California. Tony Martini, April 1990. (Fifth Revision) (PB89 207781/AS)
66 A Preliminary Report on Correlation of ARTCC Radar Echoes and Precipitation. Wilbur K. Hall, June 1971. (COM 71 00829)
69 National Weather Service Support to Soaring Activities. Ellis Burton, August 1971. (COM 71 00956)
71 Western Region Synoptic Analysis-Problems and Methods. Philip Williams, Jr., February 1972. (COM 72 10433)
74 Thunderstorms and Hail Days Probabilities in Nevada. Clarence M. Sakamoto, April 1972. (COM 72 10554)
75 A Study of the Low Level Jet Stream of the San Joaquin Valley. Ronald A. Willis and Philip Williams, Jr., May 1972. (COM 72 10707)
76 Monthly Climatological Charts of the Behavior of Fog and Low Stratus at Los Angeles International Airport. Donald M. Gales, July 1972. (COM 72 11140)
77 A Study of Radar Echo Distribution in Arizona During July and August. John E. Hales, Jr., July 1972. (COM 72 11136)
78 Forecasting Precipitation at Bakersfield, California, Using Pressure Gradient Vectors. Earl T. Riddiough, July 1972. (COM 72 11146)
79 Climate of Stockton, California. Robert C. Nelson, July 1972. (COM 72 10920)
80 Estimation of Number of Days Above or Below Selected Temperatures. Clarence M. Sakamoto, October 1972. (COM 72 10021)
81 An Aid for Forecasting Summer Maximum Temperatures at Seattle, Washington. Edgar G. Johnson, November 1972. (COM 73 10150)
82 Flash Flood Forecasting and Warning Program in the Western Region. Philip Williams, Jr., Chester L. Glenn, and Roland L. Raetz, December 1972, (Revised March 1978). (COM 73 10251)
83 A comparison of Manual and Semiautomatic Methods of Digitizing Analog Wind Records. Glenn E. Rasch, March 1973. (COM 73 10669)
86 Conditional Probabilities for Sequences of Wet Days at Phoenix, Arizona. Paul C. Kangieser, June 1973. (COM 73 11264)
87 A Refinement of the Use of K-Values in Forecasting Thunderstorms in Washington and Oregon. Robert Y.G. Lee, June 1973. (COM 73 11276)
89 Objective Forecast Precipitation Over the Western Region of the United States. Julia N. Paegle and Larry P. Kierulff, September 1973. (COM 73 11946/3AS)
91 Arizona "Eddy" Tornadoes. Robert S. Ingram, October 1973. (COM 73 10465)
92 Smoke Management in the Willamette Valley. Earl M. Bates, May 1974. (COM 74 11277/AS)
93 An Operational Evaluation of 500-mb Type Regression Equations. Alexander E. MacDonald, June 1974. (COM 74 11407/AS)
94 Conditional Probability of Visibility Less than One-Half Mile in Radiation Fog at Fresno, California. John D. Thomas, August 1974. (COM 74 11555/AS)
95 Climate of Flagstaff, Arizona. Paul W. Sorenson, and updated by Reginald W. Preston, January 1987. (PB87 143160/AS)
96 Map type Precipitation Probabilities for the Western Region. Glenn E. Rasch and Alexander E. MacDonald, February 1975. (COM 75 10428/AS)
97 Eastern Pacific Cut-Off Low of April 21-28, 1974. William J. Alder and George R. Miller, January 1976. (PB 250 711/AS)
98 Study on a Significant Precipitation Episode in Western United States. Ira S. Brenner, April 1976. (COM 75 10719/AS)
99 A Study of Flash Flood Susceptibility-A Basin in Southern Arizona. Gerald Williams, August 1975. (COM 75 11360/AS)
102 A Set of Rules for Forecasting Temperatures in Napa and Sonoma Counties. Wesley L. Tuft, October 1975. (PB 246 902/AS)
103 Application of the National Weather Service Flash-Flood Program in the Western Region. Gerald Williams, January 1976. (PB 253 053/AS)
104 Objective Aids for Forecasting Minimum Temperatures at Reno, Nevada, During the Summer Months. Christopher D. Hill, January 1976. (PB 252 866/AS)
105 Forecasting the Mono Wind. Charles P. Ruscha, Jr., February 1976. (PB 254 650)
106 Use of MOS Forecast Parameters in Temperature Forecasting. John C. Plankinton, Jr., March 1976. (PB 254 649)
107 Map Types as Aids in Using MOS PoPs in Western United States. Ira S. Brenner, August 1976. (PB 259 594)
108 Other Kinds of Wind Shear. Christopher D. Hill, August 1976. (PB 260 437/AS)
109 Forecasting North Winds in the Upper Sacramento Valley and Adjoining Forests. Christopher E. Fontana, September 1976. (PB 273 677/AS)
110 Cool Inflow as a Weakening Influence on Eastern Pacific Tropical Cyclones. William J. Denney, November 1976. (PB 264 655/AS)
112 The MAN/MOS Program. Alexander E. MacDonald, February 1977. (PB 265 941/AS)
113 Winter Season Minimum Temperature Formula for Bakersfield, California, Using Multiple Regression. Michael J. Oard, February 1977. (PB 273 694/AS)
114 Tropical Cyclone Kathleen. James R. Fors, February 1977. (PB 273 676/AS)
116 A Study of Wind Gusts on Lake Mead. Bradley Colman, April 1977. (PB 268 847)
117 The Relative Frequency of Cumulonimbus Clouds at the Nevada Test Site as a Function of K-Value. R.F. Quiring, April 1977. (PB 272 831)
118 Moisture Distribution Modification by Upward Vertical Motion. Ira S. Brenner, April 1977. (PB 268 740)
119 Relative Frequency of Occurrence of Warm Season Echo Activity as a Function of Stability Indices Computed from the Yucca Flat, Nevada, Rawinsonde. Darryl Randerson, June 1977. (PB 271 290/AS)
121 Climatological Prediction of Cumulonimbus Clouds in the Vicinity of the Yucca Flat Weather Station. R.F. Quiring, June 1977. (PB 271 704/AS)
122 A Method for Transforming Temperature Distribution to Normality. Morris S. Webb, Jr., June 1977. (PB 271 742/AS)
124 Statistical Guidance for Prediction of Eastern North Pacific Tropical Cyclone Motion - Part I. Charles J. Neumann and Preston W. Leftwich, August 1977. (PB 272 661)
125 Statistical Guidance on the Prediction of Eastern North Pacific Tropical Cyclone Motion - Part II. Preston W. Leftwich and Charles J. Neumann, August 1977. (PB 273 155/AS)
126 Climate of San Francisco. E. Jan Null, February 1978. Revised by George T. Pericht, April 1988. (PB88 208624/AS)
127 Development of a Probability Equation for Winter-Type Precipitation Patterns in Great Falls, Montana. Kenneth B. Mielke, February 1978. (PB 281 387/AS)
128 Hand Calculator Program to Compute Parcel Thermal Dynamics. Dan Gudgel, April 1978. (PB 283 080/AS)
129 Fire whirls. David W. Goens, May 1978. (PB 283 866/AS)
130 Flash-Flood Procedure. Ralph C. Hatch and Gerald Williams, May 1978. (PB 286 014/AS)
131 Automated Fire-Weather Forecasts. Mark A. Mollner and David E. Olsen, September 1978. (PB 289 916/AS)
132 Estimates of the Effects of Terrain Blocking on the Los Angeles WSR-74C Weather Radar. R.G. Pappas, R.Y. Lee, B.W. Finke, October 1978. (PB 289767/AS)
133 Spectral Techniques in Ocean Wave Forecasting. John A. Jannuzzi, October 1978. (PB291317/AS)
134 Solar Radiation. John A. Jannuzzi, November 1978. (PB291195/AS)
135 Application of a Spectrum Analyzer in Forecasting Ocean Swell in Southern California Coastal Waters. Lawrence P. Kierulff, January 1979. (PB292716/AS)
136 Basic Hydrologic Principles. Thomas L. Dietrich, January 1979. (PB292247/AS)
137 LFM 24-Hour Prediction of Eastern Pacific Cyclones Refined by Satellite Images. John R. Zimmerman and Charles P. Ruscha, Jr., January 1979. (PB294324/AS)
138 A Simple Analysis/Diagnosis System for Real Time Evaluation of Vertical Motion. Scott Heflick and James R. Fors, February 1979. (PB294216/AS)
139 Aids for Forecasting Minimum Temperature in the Wenatchee Frost District. Robert S. Robinson, April 1979. (PB298339/AS)
140 Influence of Cloudiness on Summertime Temperatures in the Eastern Washington Fire Weather district. James Holcomb, April 1979. (PB298674/AS)
141 Comparison of LFM and MFM Precipitation Guidance for Nevada During Doreen. Christopher Hill, April 1979. (PB298613/AS)

NOAA Technical Memorandum NWS WR-215

WEATHERTOOLS

Tom Egger
National Weather Service
Weather Service Forecast Office
Boise, Idaho

October 1991

UNITED STATES
DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

National Oceanic and
Atmospheric Administration
John A. Knauss, Under Secretary
and Administrator

National Weather Service
Elbert W. Friday, Jr., Assistant
Administrator for Weather Services

This publication has been reviewed
and is approved for publication by
Scientific Services Division,
Western Region

Ken Mielke

Kenneth B. Mielke, Chief
Scientific Services Division
Salt Lake City, Utah

TABLEOF CONTENTS

WEATHERTOOLS

I. INTRODUCTION

On a typical day at a busy weather office the forecaster is called upon to answer many questions. When the problems are algebraic, a spreadsheet is a perfect vehicle for solutions. Version 5.01 of WeatherTools has eleven spreadsheets combined into one toolkit to find quick answers to some complex and time-consuming problems common to many weather offices, especially those in mountainous areas.

Unlike computer programs that require enormous amounts of time to develop, debug, and refine, a spreadsheet is fast and flexible. Any of the WeatherTools sheets can be removed or changed easily.

Though WeatherTools may seem to be geared for mountain weather forecasting, more than half of the spreadsheets are generic and can be used by other offices as well. Many of the algorithms used should be familiar to most forecasters. Caution should be used in interpreting results. In some cases the answers provided are just a start of the solution. In every case, the answer is an estimate.

The author invites any user to adapt the spreadsheets for their own needs and encourages further development of WeatherTools. There is plenty of room for expansion. If you find WeatherTools useful, you may also find its companion, HydroTools (Egger 1991), equally helpful.

II. ENVIRONMENT, SETUP, AND RUNNING WEATHERTOOLS

ENVIRONMENT:

WeatherTools is driven by QUATTRO or 1-2-3 on an IBM compatible machine running DOS 2.1 or higher. The hardware required is 512K of RAM, one floppy drive, a hard drive, and a monochrome or color monitor.

The distribution floppy should contain the following files:

WXTOOLSC.WK1	- QUATTRO or 1-2-3 spreadsheet color version
WXTOOLSM.WK1	- QUATTRO or 1-2-3 spreadsheet monochrome version
WXTOOLS	- WeatherTools User's Guide

SETUP:

Copy the appropriate spreadsheet to the QUATTRO or 1-2-3 directory. For a QUATTRO user, assuming \QUAT is the QUATTRO directory and a color monitor used, put the distribution floppy in the A: drive and from the A: prompt, type,

COPY WXTOOLSC.WK1 C:\QUAT

If a monochrome monitor is used, then do the following:

COPY WXTOOLSM.WK1 C:\QUAT

Notice the M instead of C in the spelling.

RUNNING WXTOOLS:

In the Quattro directory, type Q WXTOOLSC for color systems or Q WXTOOLSM for monochrome systems. Sorry, no instructions for the 1-2-3 users. See your 1-2-3 user manual for loading and running spreadsheets.

The WeatherTools title screen should appear as below.

```
                                                        ver 4.02

                         WeatherTools:
           Spreadsheet Solutions to several meteorological problems.
              Tom Egger / WSFO-Boise, Idaho / (208) 334-9860

           Sheet 1.......Mountain Temperatures
           Sheet 2.......Forecast max temps from 850/700 temps
           Sheet 3.......Snow Avalanche Temps
           Sheet 4.......Freezing Levels from 850 temps
           Sheet 5.......Conversions
           Sheet 6-2.....Pressure/Density Altitude, Altimetry
           Sheet 7.......Windchill
           Sheet 8.......Distance/Speed on a Sphere
           Sheet 9.......Degree Days
           Sheet 10-3....Stability, Lapse Rates, Cloud Height, Haines
           Sheet 11......Forecast min temps
......................................................................
      Use Pg Up/Pg Dn keys to desired sheet.  Then use arrow cursor
      keys to position over input cell.   NEVER use the delete key.
```

If the above menu page is not displayed, then hit the Home key on the number pad (make sure the Num Lock is not engaged). Notice there are eleven spreadsheet topics. A few topics have related spreadsheets: 1.1, 1.2, 10.1, 10.2, etc. Related spreadsheets are on side pages (more on that later). Dislocation (getting lost) in the spreadsheet can be corrected by depressing the Home key.

MOVING AROUND:

The cursor keys, Page Up/Down, Ctrl, and number keys on the top row are the only keys needed for entry and moving around.

1. Select a spreadsheet (topic) with the Page Up/Down keys.
2. Enter data by moving to the highlighted cursor box with the cursor keys, then use number keys for changing a value.
3. Observe the answers change in output boxes.
4. **Never use the Delete (Del) key.**

Example:

Determine the maximum temperature today using the 700 mb temperature and height from this morning's sounding. Using the coded mandatory level message CCCMANXXX, enter the following keystrokes:

1. Home
2. Page Down
3. Page Down
4. Move cursor to the 700 tmp input box.
5. Enter the 700 mb temperature in deg C from the CCCMANXXX.
6. Enter the coded 700 mb height (as is) from the MAN message.

On a color monitor the input area is blocked and highlighted. In monochrome the input area is just highlighted. If it is not, adjust the contrast and brightness until you can distinguish between the input and other areas. Keep the cursor in the input area at all times. The estimated answer is at the bottom of the screen. Change the temperature several times and notice the answers. Depress the Home key and then select a different spreadsheet.

A few macros will make some procedures easier:

ALT-E - UNPROTECT AND SET EDIT MODE
ALT-M - PROTECT AND SET MONOCHROME
ALT-C - PROTECT AND SET COLOR MODE
ALT-Q - QUIT

SPREADSHEET 1 MOUNTAIN TEMPERATURES

```
Sheet 1...Mountain Temps. (Given Temp. and lapse rate at one level)
INPUT:
      Lapse Rt.  >     4.2 < deg F/1000 ft  (5.5 dry, 3.6 std, 3.0 wet)
     Base Elev.  >    2800 < msl
     Base Temp.  >      60 < deg F        Top Elev.  >     9700 < msl
                                         Bot'm Elev.  >     6435 < msl
.....................................................................
OUTPUT:  12000 ft>      21        -6 < deg F  deg C
         11000 ft>      26        -4 <
         10000 ft>      30        -1 <        NOTE: No allowance for
          9000 ft>      34         1 <        latitude, pressure,
          8000 ft>      38         3 <        moisture, slope, snow
          7000 ft>      42         6 <        cover, wind, clouds,
          6000 ft>      47         8 <        inversions etc..
          5000 ft>      51        10 <
          4000 ft>      55        13 <        OTHER LEVELS:
          3000 ft>      59        15 <           ELEV.    deg F    deg C
          2000 ft>      63        17 <            9700      31       -1
          1000 ft>      68        20 <            6435      45        7
          MSL    >      72        22 <
```

PURPOSE:

One of the biggest challenges to a weather forecaster is predicting temperatures for complex terrain. Several techniques could be employed. One common practice associates temperatures and height data obtained from nearby soundings with the elevation in question. Since height labels on Skew-T and Pseudo-adiabatic diagrams are with respect to the standard atmosphere, the temperatures used for an elevation may be off by quite a bit. Unless the atmosphere is "unusually standard" the temperatures indicated are not really for the given elevation. When was the last time you analyzed a perfectly standard sounding? Another popular technique would be to mentally make adjustments for elevation using a standard lapse rate. Spreadsheet 1 is similar to this method.

Instead of using the standard lapse rate of 3.6 deg F for each 1000 feet, Spreadsheet 1 allows for different lapse rates. See Spreadsheet 10.1 for averaging lapse rates.

FORMULA:

$$T1 = (((H0-H1)/1000)*LR)+T0$$

where

T1 = temperature deg F at higher level
T0 = temperature deg F at surface
H1 = higher elevation
H0 = surface elevation
LR = lapse rate deg F/1000 ft

APPLICATION:

The Forest Service calls and needs a maximum temperature forecast for 6435 feet and 9700 feet at a fire site. The nearby weather station is at 2800 feet where the expected maximum temperature is 60 degrees. You already ran Spreadsheet 10.1 and determined your average lapse rate to be 4.2 deg F/1000 feet. He is in a hurry and needs an answer quickly. No other information about slope or exposure was provided. Your response?

1. Page down to Spreadsheet 1.
2. Move the cursor to the Base elevation block and enter 2800.
3. Enter 60 degrees in the base temp block.
4. Enter 4.2 in the lapse rate block.
5. Move the cursor over to the Top Elev: block and enter 9700.
6. Enter 6435 in the block just below labeled Bot'm Elev..

Response:

9700 ft max = 31
6435 ft max = 45

CAUTIONS AND RESTRICTIONS:

No allowance is made for slope, aspect, snow cover, inversions, etc. The output is limited by the input of only three parameters: elevation, temperature, and lapse rate.

Spreadsheet 1 works best on estimating maximum temperatures when no inversion is present (i.e., the morning inversion is mixed out).

SPREADSHEET 2 FORECAST MAXIMUM TEMPERATURE

```
SHEET 2...FORECAST MAX TEMP (based on 850 or 700 or 500 temp):
Get temps and heights from AFOS product CCCMANXXX:
INPUT:
         elev.  :>    2840                 |
                     deg C     hgt.        |     feet     deg F
         850 tmp:>     7.0      439        |     4721      44.6
         700 tmp:>    -1.1        6        |     9863      30.0
         500 tmp:>   -18.5      550        |    18046      -1.3
.....................................................................
OUTPUT:
                                FULL SUN             CLOUDY

           bring 850 down >     55  deg F          50  deg F
           bring 700 down >     69  deg F          51  deg F
           bring 500 down >     82  deg F          44  deg F

.....................................................................
>>>> FULL SUN uses 5.5 deg F/1000 feet       | NOTE: At Boise use 850
>>>> CLOUDY uses 3.0 deg F/1000 lapse rate   | in Winter...700 Summer.
```

PURPOSE:

Maximum temperatures are commonly estimated by "bringing down" to the surface dry-adiabatically the 850 mb temperature on a Pseudo or Skew-T diagram . During the summer in the West, the 700 mb level is used at many sites. Accomplishing this on a small diagram with finely plotted lines is difficult. You will probably find Spreadsheet 2 to be an improvement.

FORMULA:

$$Tx = (((h7 - h0) / 1000) * 5.5) + t7$$

where

Tx = maximum temperature at surface h0
h7 = 700 mb height in feet
h0 = surface elevation in feet
t7 = temperature deg F at 700 mb

APPLICATION:

1. Page down to Spreadsheet 2.
2. Move the cursor to the "elev. :>" block and enter station elevation in feet.
3. Enter 850/700/500 mb temperature and height data directly from the mandatory level message CCCMANXXX. The spreadsheet will decode the height data. (Ex: 70006 01156 would be entered as -1.1 for the temperature and 6 for the height).

4. Check the output section for results. Make allowances for warm and cold air advection (WAA and CAA) by changing the input temperature accordingly. Example: the morning 700 mb temperature is -1.1 but WAA would make the afternoon temperature closer to +2.0. Enter the 2.0 instead.

Note: It is not necessary to enter the 500 mb and 850 mb data if 700 mb is the desired level.

SPREADSHEET 3 SNOW AVALANCHE TEMPERATURES (GIVEN 850t, LAPSE RATE, 850h)

SHEET 3...Snow Avalanche Temps. (Given 850t, lapse rate, 850 ht):
Enter 850 temp, lapse rate, and 850 ht.

	850 t deg C	lapse rate	850mb hgt.	ht meters	ft
00Z aftn	12.0	4.0	120	1200	3937
12Z morn	13.0	4.0	140	1400	4593
00Z tmrw	15.0	5.0	150	1500	4922

	FAHRENHEIT			CELSIUS		
	tdy	tnt	tmrw	tdy	tnt	tmrw
10000FT TEMP: >	29	34	34	-1	1	1
9000 FT TEMP: ** >	33	38	39	1	3	4
8000 FT TEMP: >	37	42	44	3	5	6
7000 FT TEMP: ** >	41	46	49	5	8	9
6000 FT TEMP: >	45	50	54	7	10	12
5000 FT TEMP: >	54	55	59	12	13	15

PURPOSE:

Mountain snow rangers monitor snowpack conditions for signs of instabilities that lead to avalanches. Accurate temperature forecasts for several elevations are needed for planning purposes. When model output temperatures, as in the FD(1-3) messages, do not provide acceptable guidance; alternate approaches are desirable. Estimating temperatures by extrapolating 850 mb data from the NGM is sometimes used. Spreadsheet 3 using 850 mb temperature and height data can provide useful results in winter when the surface inversion does not extend above 850 mb. All conversion of units is handled automatically. This spreadsheet was originally designed to assist the Boise forecaster during the winter months in the development of snow avalanche guidance product BOISAGBOI.

FORMULA:

$$Ts = ((H8 - Hs) / 1000) * LR + T8$$

where

Ts = Temperature at other surface
T8 = 850 mb temperature in deg F
LR = lapse rate deg F / 1000 feet
H8 = 850 mb height in thousands of feet
Hs = other surface elevation

APPLICATION:

Using the NGM graphic charts 8(2,4,6,8)T and 8(2,4,6,8)H, extract temperature and height values for the area under concern by reading the contours. Enter the temperature in deg C and coded height values in the input area of Spreadsheet 3 along with an appropriate lapse rate (in deg F/1000 ft). Obtain lapse rates from Spreadsheet 10.1.

Example:

1. Page down to Spreadsheet 3.
2. Move the cursor to the 00Z aftn (afternoon) block below the 850 t deg C column.
3. On AFOS, call up NGM graphics 8(4,6,8)H,T.
4. Read the 850 mb temperature contours for Sun Valley in South Central Idaho: -2.0 for 84T , -1.0 for 86T , and 3.0 for 88T.
5. Enter these values in the spreadsheet for 00Z aftn, 12z morn, and 00z tmrw (afternoon, morning, tomorrow). Include appropriate lapse rates too.
6. Read the contours for Sun Valley on the 850 mb height charts 84H, 86H, and 88H.
7. Enter these values in the appropriate cells.

Results:

Notice the output in degrees F for today, tonight, and tomorrow at the bottom of the sheet. Forecast temperatures at 7000 feet are 19, 21, and 30 degrees F for today, tonight, and tomorrow.

CAUTIONS AND RESTRICTIONS:

This technique is intended for use in the winter when a surface inversion does not rise above the 850 mb level. No allowances have been made for slope, aspect, inversions, etc.

SPREADSHEET 4.1 FREEZING LEVEL ESTIMATES (GIVEN 850 MB HEIGHT AND TEMPERATURE, LAPSE RATE) (method 1)

```
SHEET 4...FREEZING LEVEL ESTIMATES (GIVEN 850t, lapse rate, 850h):
ENTER 850mb TEMPS/HTS FROM NGM GRAPHICS 8(0,2,4,6,8)H,T:
              850 t    lapse    850ht   |       meters     ft
12Z TDY >      5.0      3.5      141    |        1410     4626
00Z DAY1>      5.0      3.5      141    |        1410     4626
12Z DAY1>      2.0      3.5      141    |        1410     4626
00Z DAY2>      6.0      3.5      141    |        1410     4626
12Z DAY2>      6.0      4.0      145    |        1450     4757
12Z DAY3>      7.0      4.0      147    |        1470     4823
****************************************
OUTPUT - FREEZING LEVELS:
                        START     ----------- DAY 1 -------------
                         12Z       18Z       00Z       06Z       12Z
          MSL           7198      7198      7198      6426      5655

                        ----------- DAY 2 -------------       DAY 3
                         18Z       00Z       06Z       12Z       12Z
          MSL           6683      7712      7572      7457      7973
```

PURPOSE:

Several users need accurate freezing level forecasts including River Forecast Centers. If it is winter or early spring and the surface inversion does not extend above 850 mb, then Spreadsheet 4 can provide estimates of freezing levels in lieu of other guidance. This spreadsheet was originally designed to assist the Boise forecaster during the winter months in the development of AFOS product BOIQPSBOI, a guidance product required by the Northwest River Forecast Center.

FORMULA:

$$FZ = ((T85 - 32) / LP) * 1000 + H8$$

where

FZ = Freezing Level
T85 = 850 mb temperature in deg F
LP = lapse rate deg F / 1000 feet
H8 = 850 mb height in thousands of feet

APPLICATION:

Obtain the 850 mb temperatures by reading the isotherms on NGM graphics 8(0,2,4,6,8)T over the site of interest. Enter these values (deg C) in the input column labelled deg C. Determine a lapse rate from Spreadsheet 10.1 and enter this value in the lapse rate block (deg F/1000 ft). Results in deg F are indicated in the lower half of the spreadsheet. Since 850 mb is a pressure surface, it is not always 5000 feet above sea level. Spreadsheet 4 makes allowances for the height vs. elevation differences. As with the AFOS 8xT charts, read the 850 mb height labels on AFOS graphics 8(0,2,4,6,8)H and place the labels "as is" in the column labelled 850ht; the sheet will compute the elevation from the height. For instance, if the 850 mb contour was 143 (1430 meters), enter 143 on the spreadsheet. For informational purposes a conversion of meters to feet is output to the right of the input area. Lapse rates are required for each time period but no guidance is available. Until a "feel" for lapse rates is developed, you may want to enter the same value for each time period.

The output form of Spreadsheet 4 suits the needs of AFOS product CCCQPSXXX; the QPF and freezing level message.

Example:

1. Page down to Spreadsheet 4.
2. Move the cursor to the first column of input blocks below 850t. Moving down the column, enter the 850 mb temperatures. Do the same for the next two columns, the lapse rates and 850 mb heights.

Assuming the lapse rates, 850 mb temperatures and heights are as indicated in the sample screen above, estimates of the freezing level for the next 10 periods are provided in the lower half of the screen. The output in the upper right are the corresponding elevations for the 850 mb surfaces.

CAUTIONS AND RESTRICTIONS:

Depending on what time of the day this procedure is run, the last one or two periods may not have any NGM guidance. Do not use this technique when a surface inversion extends above the 850 mb surface. Remember, a single lapse rate is being employed to generate the freezing level, a typical sounding will not be so "smooth".

SPREADSHEET 4.2 FREEZING LEVEL ESTIMATES (method 2)

```
SHEET 4-2...Freezing Levels (Given 850mb ht & temp and lapse rate):
INPUT:                                      |
             850 t     lapse     850mb      |       ht        ht
             deg C     rate      hgt.       |     meters      ft       deg F
period 1      5.0       3.5       141       |      1410      4626       41
period 2      2.0       3.5       141       |      1410      4626       36
.....................................
OUTPUT:
          freezing lvl pd1:>    7198 < feet msl
          freezing lvl pd2:>    5655 < feet msl
.......................................................................
Alternate Method (using sfc data):
          INPUT:              sfc elev>    2800 < feet msl
                              lapse rt>     5.0 < deg F/K ft
                              sfc temp>      52 < deg F
.......................................................................
          OUTPUT:
                      freezing level:>    6800 < feet msl
```

PURPOSE:

If the format in Spreedsheet 4.1 does not suit your needs, perhaps this alternate method will be more practical. Two approaches are offered: the first utilizes only 850 mb data while the second assumes only surface data are available.

FORMULA:

$$FZ = ((T85 - 32) / LP) * 1000 + H8$$

or

$$FZ = ((Ts - 32) / LP) * 1000 + Hs$$

where

FZ = Freezing Level
T85 = 850 mb temperature in deg F
LP = lapse rate deg F / 1000 feet
H8 = 850 mb height in thousands of feet
Ts = surface temperature in deg F.
Hs = elevation above sea level in feet.

APPLICATION:

Obtain the 850 mb temperatures and heights by reading the isogons on NGM graphics 8(0,2,4,6,8)T,H over the site of interest. Enter these values "as is" (the heights will be decoded and computed) in the input columns. Determine a lapse rate from Spreadsheet 10.1 and enter this value in the lapse rate block. Results in deg F are indicated in the lower half of the spreadsheet.

Example 1 (using 850 mb data):

1. Page down to Spreadsheet 4.1.
2. Page over to Spreadsheet 4.2 with CTRL RIGHT ARROW.
3. Move the cursor to the first column of input blocks below 850t. Moving down the column, enter the 850 mb forecast temperatures. Do the same for the next two columns, the lapse rates and 850 mb heights.

Assuming the lapse rates, 850 mb temperatures and heights are entered as in the sample screen above, estimates of the freezing level for the next 2 periods are provided in the lower half of the screen. In the upper right of the screen, the corresponding elevations for the 850 mb surfaces are output.

Example 2 (only surface data available):

1. Move the cursor to the bottom of screen - to the Alternate Method area.
2. Enter the surface elevation, an appropriate lapse rate, then your afternoon maximum in deg F.

The computed freezing level is indicated just below the dotted line.

CAUTIONS AND RESTRICTIONS:

Do not use this technique when a surface inversion is present. Remember, a single lapse rate is being employed to generate the freezing level, a typical sounding will not be so "smooth".

SPREADSHEET 5 CONVERSIONS

```
SHEET 5...CONVERSIONS (input in highlighted cross blocks ONLY)
Beware of slight round-off errors.
temps:                                length: (large units)
   deg F     deg C     deg K                sm        nm        km
   -40.0     -40.0     233.6             100.0      86.8     160.9
   -40.0     -40.0     233.6             100.0      86.8     160.8
   -40.0     -40.0     233.6             100.0      86.8     160.8

std. atmosphere: ( < 36,000 ft)      length: (small units)
   elev.     deg C      p-mb                in        cm        mm
   5,000         5       843              6.00     15.24    152.40
   2,523        10       924              6.00     15.24    152.40
   9,875        -5       700              6.00     15.24    152.40

pressure: (stnd.)                     velocity:
   in Hg     mm Hg        mb  atmos.       mph       kts       mps      km/h
    4.35     110.5     147.3   0.145      58.0      50.3      25.9      93.3
   29.92     759.9    1013.1   1.000      57.9      50.3      25.9      93.2
    2.95      75.0     100.0   0.099      57.9      50.3      25.9      93.2
   29.92     760.0    1013.2   1.000      57.9      49.8      25.9      93.2
```

PURPOSE:

Display quick conversions of popular meteorological quantities.

FORMULA:

Temperature:
C = 5/9 (F - 32) = K - 273.16
F = 9/5C + 32 = 9/5 (K - 273.16) + 32
K = C + 273.6 = 5/9 (F - 32) + 273.16

Standard Atmosphere Estimates (T=temp, Z=elev, P=pres):
T = 15 - .0065 * Z / 32.38
Z = (T - 15) * 3.28 / -.0065
P = 1013.25 * ((288 - .0065 * Z) / 288)^5.256

Standard Pressure using Mercury (Hg):
1 mb = .750 mm Hg = .0295 in Hg
1 mm = 1.33 mb = .0394 in Hg
1 in = 33.864 mb = 25.4 mm Hg
1 atmos = 1013.25 mb = 760 mm Hg = 29.921 in Hg

Length (large units):
1 sm = .868 nm = 1.609 km
1 nm = 1.152 sm = 1.853 km
1 km = .621 sm = .54 nm
sm = statute mile   nm = nautical mile

Length (small units):
1 in = 2.54 cm = 25.4 mm
1 cm = .394 in = 10.0 mm
1 mm = .039 in = .10 cm

Velocity:
1 mps = 3.6 km/hr = 1.94 kts = 2.24 mph
1 kts = 1.15 mph = .53 mps = 1.85 km/h
1 mph = .87 kts = .45 mps = 1.61 km/h
1 km/h = .28 mps = .53 kts = .62 mph
mps = meters per second

APPLICATION:

Input procedures are a little different for this spreadsheet. Instead of entering data in vertically stacked columns, entry is made in diagonal rows. If you are using a color monitor, the input cells are blocked. For monochrome users, input cells are high intensity, output is low intensity; adjust contrast if this is not apparent.

Example 1:

Convert -12 deg C to deg F.

1. Move cursor to the second row of deg C column, enter -12.
2. Read deg F in the 2nd row first column...deg K are located in the same row column 3.

deg F	deg C	deg K
10.4	-12.0	261.6

Example 2:

Convert 58 mph to kts, mps (meters per second), km/h

1. Move cursor to first row first column of velocity section, enter 58.
2. Answers: 58.0 mph 50.3 kts 25.9 mps 93.3 km/h

SPREADSHEET 6.1 PRESSURE ALTITUDE AND DENSITY ALTITUDE

```
  SHEET 6-1...PRESSURE ALTITUDE & DENSITY ALTITUDE
INPUT:

          FIELD ELEVATION: >    5280 < FEET
          ALT. SETTING    :>   30.00 < INCHES
          Sfc. Temp:       >      90 < deg F          32.2 deg C

......................................................................
OUTPUT:

            PRESSURE ALT: >     5207 < FEET

             DENSITY ALT: >     8512 < FEET   approx.
```

PURPOSE:

Pilot briefers are accustomed to using a series of tables or a "fuzzy" chart to determine pressure and density altitude. Spreadsheet 6 displays results instantly and permits "what-ifing" to better understand the relationship of one parameter to another.

FORMULA:

Pressure Altitude:

$PA = [((Pz / 29.921)^{.190259} * 288) - 288) /$
$(-.0065 * 3.28)] + Ha$

where

PA = pressure altitude
Ha = field elevation
Pz = altimeter setting

Density Altitude:

$DA = PA + (66.67 * Vt)$

where

DA = density altitude
PA = pressure altitude
66.67 = constant (66.67 feet per 1 deg F)
Vt = actual temperature minus standard temperature at the pressure altitude (deg F) (see spreadsheet 5 for standard temps).

APPLICATION:

Enter field elevation in the block labelled FIELD ELEVATION, the current altimeter setting in the next block down, and the surface temperature in deg F next block. A conversion for deg C is provided on the right while pressure altitude and density altitude are output in the lower half of the spreadsheet.

Example:

1. Enter Field elevation of 3600 feet.
2. Altimeter setting of 30.15 inches.
3. Air Temperature 94 degrees.

PA = 3309 feet
DA = 6528 feet

What happens when the pressure falls at the same temperature? Enter a few different values in the pressure block for the answer.

SPREADSHEET 6.2 ALTIMETRY (CONVERT STATION PRESSURE TO ALTIMETER SETTING OR ALTIMETER SETTING TO STATION PRESSURE)

```
SHEET 6-2...ALTIMETRY (CONVERT STN PRES TO ALSTG OR ALSTG TO STN PRES)

Station Pres.   :>   26.00   | Altimeter Setn'g:>   30.09
Elevation ft    :>    4964   | Elevation ft    :>    4964
.........................................................
                             |
                             |
Altimeter Set'ng:>   31.15   | Station Press.  :>   25.08
```

PURPOSE:

When the pressure wheel is not handy and you must answer questions about uncorrected pressure (station pressure) Spreadsheet 6.2 should prove useful.

FORMULA:

$$A = (P - .01) * [1 + ((Po^{n})*a/To)*(Hb/P1^{n})]^{1/n}$$

where

A = altimeter in inches

P = pressure in inches

Po = standard sea level pressure 29.921 inches

P1 = pressure in inches - .01 when Po = 29.921

a = lapse rate (.0065 deg C/m)

To = standard sea level temperature 288 deg K

Hb = station elevation in meters

n = .190284

therefore

$$P = [((A^{n}-(29.921^{.190284})*.0065/288)*Hb)^{1/.190284} -.01]$$

APPLICATION:

A local laboratory is doing a chemical experiment. They need the uncorrected barometric pressure. Given the laboratory's elevation of 4964 feet and the current altimeter setting 30.09 inches: What is the station pressure?

Solution:

1. Enter 30.09 in the altimeter setting block on the right side of the spreadsheet.
2. Enter 4964 in the elevation block just below.
3. The answer is 25.08 and appears in the Station Pressure block in the lower right quarter of the spreadsheet.

SPREADSHEET 7 WINDCHILL

```
SHEET 7...WINDCHILL

INPUT:
UNITS (1=mph-deg F, 2=kts-deg F, 3=km/h-deg C, 4=mps-deg C):

 UNITS (1,2,3,4):>        1 < English
         WIND SP:>       20 < MPH
         TEMP:   >       60 < deg F

.......................................................................

         OUTPUT:

      WIND CHILL:>       47 < deg F
```

PURPOSE:

How many times have you had a request for a windchill that was beyond the range of the charts? Or, found the chart was in the wrong units. This spreadsheet handles both problems: allows for values off-the-chart and different units of measure.

FORMULA:

$$Twc = .0817 * ((3.17 * (V^{.5}) + 5.81 - .25 * V)) * (T - 91.4) + 91.4$$

where

Twc = wind chill in deg F
V = velocity in mph
T = temperature deg F

APPLICATION:

A nearby ski resort was chosen as the sight for Olympic Ski Trials. The European contestants request metric units for windchill.

1. Enter 4 in the unit selection cell.
2. Enter 25 in the wind speed cell.
3. Enter -5 in the in temperature cell.

Results:

wind chill = -27 deg C

SPREADSHEET 8 SPHERICAL DISTANCE COMPUTATION

```
Sheet 8...DISTANCE COMPUTATION (using Spherical coordinates):
Obtain coordinates from SWIS or AFOS Graphic, then determine distance.

                               decimal
                                units                DEG      MIN      SEC
ENTER LATITUDE  POINT A: >  46.0000 <                 50       30        0
ENTER LONGITUDE POINT A: > 125.0000 <                123       15        0

ENTER LATITUDE  POINT B: >  46.0000 <                 50       45        0
ENTER LONGITUDE POINT B: > 116.0000 <                116       50        0

COMPUTE? 1=TIME 2=SPEED  >        1 <
SPEED FROM A TO B:       >     20.0 < mph           >     10.0 < mph
.........................................................................
DISTANCE BETWEEN PTS.    <    433.9 > MILES         >    283.1 > MILES
                 TIME    <     21.7 < hours         >     28.3 < hours
```

PURPOSE:

Determine speed or travel time of weather systems given latitude and longitude (Egger and Fortune 1984). Computation limits are latitude 0-90 deg N and longitude 0-180 W.

FORMULA:

COS(AA) = COS(B)*COS(C) + SIN(B)*SIN(C)*COS(A)
PROP = AA/360
DIST = PROP*25000
where
A = latitude b - latitude a
B = 90 - latitude a
C = 90 - latitude b
AA = angle between a and b
PROP = proportion of Great Circle
DIST = distance between two points on Planet Earth

APPLICATION:

Satellite pictures show a fast moving cloud mass at 45N and 130W at 06Z. It was at 47N and 135N at 12Z (6 hours between positions). How fast was it moving?

Example 1 (computing speed and distance):

In the decimal units column enter:

1. Latitude for point A should read 45.
2. Longitude cell point A should read 130.
3. Latitude Point B: should read 47.
4. Longitude Point B: should read 135.
5. Enter 2 to compute the speed of the cloud mass.
6. Enter Time 6 for the elapsed time between positions.

Results:

distance = 278 miles
speed = 46 mph

Example 2 (computing travel time):

Hurricane Roseann is moving northeast at 20 mph. Current location 24N and 75W. How long will it take Hurricane Roseann to reach Jacksonville 30 deg 19 min 44 sec N and 81 deg 39 min 32 sec W?

Using DEG MIN SEC columns enter:

1. Latitude Point A: 24 00 00
   Longitude Point A: 75 00 00
   Latitude Point B: 30 19 44
   Longitude Point B: 81 39 32

2. Move cursor to Compute? block, enter 1 to compute travel time.

3. Speed A to B: enter 20 for the current speed.

Results:

Distance:> 602 miles
Travel Time:> 60 hours
2.51 days

SPREADSHEET 9 DEGREE DAYS

```
Sheet 9...DEGREE DAYS: heating, cooling, growing, freezing, ETC.
 INPUT:                          | Other base (Lower Limit):
                                 |
 MX TEMP:>      95 < deg F       |    * UPPER LIMIT:>      86 < deg F
 MN TEMP:>      77 < deg F       | BASE LOWER LIMIT:>      50 < deg F
                                 |
                                 | * Enter a number above the max
.................................   temperature, if no limit.
                                 |
          >     86 < AVG         | ...................................
                                 | OUTPUT WITH BASE:>      50
 HEATING:>       0 <             |
 COOLING:>      21 <             | no limit>        0 < below base
                                 | no limit>       36 < above base
 GROWING:>      32 < BASE 50     |
 GROWING:>      37 < BASE 40     |          >      32 < with limits
                                 |
 FREEZ'G:>       0 <             |
```

PURPOSE:

Generate a variety of degree days given maximum and minimum daily temperature.

FORMULA:

HDD.CDD = ((max+min)/2) - 65
GD50 = ((mx5+mn5)/2) - 50
GD40 = ((mx4+mn4)/2) - 40
FRZD = ((max+min)/2) - 32

where

HDD.CDD = heating/cooling degrees when negative/positive
GD50 = growing degree day base 50
GD40 = growing degree day base 40
FRZD = freezing degree day
max = daily maximum
min = daily minimum
mx5 = max temp | max $\leq$ 86 and $\geq$ 50
mn5 = min temp | min $\leq$ 86 and $\geq$ 50
mx4 = max temp | max $\leq$ 77 and $\geq$ 40
mn4 = min temp | min $\leq$ 77 and $\geq$ 40

Note: | means such that

If a maximum or minimum temperature falls outside the range, 50-86 for base 50 or 40-77 for base 40, the max/min is truncated to the nearest limit. Example: for GD50 a maximum of 89 and minimum of 43 would be changed to 86 and 50, respectively.

APPLICATION:

Enter the daily maximum temperature in the MX TEMP block, then the daily minimum in the MN TEMP block. The equivalent heating, cooling, growing and freezing days are output in the lower half of the spreadsheet. If the degree day base is not listed on the lower left of the screen, use the optional degree base portion of the spreadsheet on the right side of the screen.

Example 1 (established degree base):

A corn grower and a lettuce grower would like to know the amount of degree days for their respective crops that today's maximum and minimum temperatures generated. Today's maximum was 93 and the minimum was 48.

1. Enter 93 in the maximum temp block.
2. Enter 48 in the minimum temp block.

Results:

Average temperature was 71.
Growing degrees BASE 50 (corn grower) was 18.
Growing degrees BASE 40 (lettuce grower) was 23.

Example 2 (optional degree base with upper limit):

A hybrid corn grower uses 47 degrees as a growing degree day base. The corn becomes stressed with temperatures above 85 deg F, so he does not use temperatures above that level (upper limit) in measuring degree days. Using the same maximum and minimum as before, compute base 47 degree days that have an upper limit of 85 degrees.

1. Enter 93 in the maximum temp block.
2. Enter 48 in the minimum temp block.
3. On the right side of the screen enter 85 as the upper limit.
4. Enter 47 as the base.

Results:

The "with limits" block in the lower right of the screen contains the answer 20. Put another way, 20 degree days (base 47) were accumulated.

Example 3 (optional degree base without upper limit):

A citizen sets his thermostat at 70 degrees all year-round. Instead of a 65 degree day base, he uses a 70 degree base. Compute heating degree days for base 70.

Winter temperatures (max 25...min -5):

1. Enter 25 in the maximum temp block.
2. Enter -5 in the minimum temp block.
3. On the right side of the screen enter 100 in the upper limit block (any number above 25 would do).
4. Enter 70 in the base lower limit block.

Results:

The "no limit" blocks contain the answers. The average temperature of 10 degrees yielded 60 degrees of heating (below base). Put another way, 60 degrees of heating base 70 were accumulated. Notice on the left side of the screen, that using a base of 65, 55 heating degrees were accumulated.

SPREADSHEET 10.1 STABILITY INDICES (Western U.S.)

```
SHEET 10-1...STABILITY INDICES (Western US):
INPUT:              deg C     HGT      |     Km     feet    deg F
         850 TMP:>   23.2     543      |  1.543     5063     73.8
         700 TMP:>   11.6     202      |  3.202    10506     52.9
         500 TMP:>  -10.9     590      |  5.900    19358     12.4
  850 DEPRESSION:>   20.0              |
  700 DEPRESSION:>   17.0              |
.........................................
OUTPUT:
         K-INDEX:>     20 <====== isolated tstms
         Vert T: >     34 <====== scattered tstms
         Cross T:>     14 <====== need at least 18
         TOT TOT:>     48 <====== isolated tstms

...............................
FORMULA:                       | LAPSE RATES:  F/K ft     C/Km
>> K= (850T-500T)+850Td-700dep |    850-700:>     3.8      7.0
>> VT= (850T-500T)             |    700-500:>     4.6      8.3 <M burst?
>> CT= (850Td-500T)            |    850-500:>     4.3      7.8
>> TT= VT+CT                   |        AVG:>     4.2      7.7
```

PURPOSE:

Unlike traditional stability computer programs for AFOS that number crunch RAOB data and output several indices and leave the user to recall their meaning, Spreadsheet 10.1 displays their meaning along with several other useful bits of information. Since the atmosphere is dynamic, this interactive spreadsheet allows for advection at any level by encouraging the what-if approach to interpreting sounding data. What if the 500 mb temperature decreased another 3 degrees; what if the 850 temperature warmed another 2; or what if there was less moisture in the lower levels...? It also displays average lapse rates in deg F/1000 ft and deg C/km.

FORMULA:

See above screen clip (lower left of screen) for the stability formula. As for the lapse rate:

$$LR = (T1-T2)/(H2-H1)$$

where

LR = lapse rate
T1 = temperature at lower level
T2 = temperature at upper level
H1 = height of lower level
H2 = height of upper level

APPLICATION:

Suppose the coded groups indicated below were extracted from your latest raob message CCCMANXXX. What do they mean in terms of thunderstorms, fire danger, and lapse rates.

85474 18070 30511 70092 04062 24520 50572 16967 23018

1. Enter 18 in the 850 TMP block.
2. Enter 474 in the 850 HGT block.
3. Enter 4 in the 700 TMP block.
4. Enter 92 in the 700 HGT block.
5. Enter -16.9 in the 500 TMP block.
6. Enter 572 in the 500 HGT block.
7. Enter 20 in the 850 depression block.
8. Enter 12 in the 700 depression block.

RESULTS:

Thunderstorm Potential:

K-INDEX:	21	isolated tstms
Vert T:	35	scattered tstms
Cross T:	15	need at least 18
TOT TOT:	50	isolated tstms

Lapse Rates:

850-700 mb	4.7 F/1000 feet	8.7 C/Km	
700-500 mb	4.4 F/1000 feet	8.0 C/Km	<M burst?
850-500 mb	4.5 F/1000 feet	8.3 C/Km	

Notice the microburst remark, <M burst?, along 8.0 C/Km. Whenever the 700-500 mb lapse rate exceeds 8 deg C per kilometer, high probabilities of microbursts exist (Caplan and Bedard 1990). A flag will appear next to the lapse rate at 8.0 C/km and above. The thunderstorm potential categories are based on Western Region Technical Attachment No. 84-14.

SPREADSHEET 10.2 HAINES FIRE INDEX

```
SHEET 10-3...HAINES FIRE INDEX

 OUTPUT HAINES INDICES ARE BASED ON TEMPERATURE INPUT IN SHEET 10.1

 OUTPUT:

    HIGH TERRAIN:>          5 <====== moderate ptnl lg fire
     MED TERRAIN:>          6 <====== high ptnl lg fire
     LOW TERRAIN:>          5 <====== moderate ptnl lg fire
```

PURPOSE:

The Haines Fire Index (Ochoa and Werth 1990) is a helpful predictor of large fire potential. This spreadsheet uses input from Spreadsheet 10.1 (SS 10.1) to work up the low, mid, and high elevation large fire potential indices. Remember, **this is an output only spreadsheet.** The input is supplied by SS 10.1.

FORMULA:

HAINES INDEX = STABILITY + MOISTURE
= (Tp1-Tp2) + (Tp1-Tdp1)
= A + B

where T is the temperature at two pressure surfaces (P1,P2); and Tp1 and Tdp1 are the dry bulb temperature and dew-point temperature at a lower level. All temperatures values are in deg C.

ELEVATION	STABILITY TERM	MOISTURE TERM
LOW	950 - 850 MB TEMP A=1 when 3 or less A=2 when 4-7 A=3 when 8 or more	850 T - dew point B=1 when 5 or less B=2 when 6-9 B=3 when 10 or more
MID	850 - 700 MB TEMP A=1 when 5 or less A=2 when 6-10 A=3 when 11 or more	850 T - dew point B=1 when 5 or less B=2 when 6-12 B=3 when 13 or more
HIGH	700 - 500 MB TEMP A=1 when 17 or less A=2 when 18-21 A=3 when 22 or more	700 T - dew point B=1 when 14 or less B=2 when 15-20 B=3 when 21 or more

Add the factor values (A + b):

(A + B)	Potential for large fire
2-3	very low
4	low
5	moderate
6	high

APPLICATION:

To get to SS 10.2 from SS 10.1 hold down Ctrl and Right Arrow keys. The SS will move sideways to SS 10.2. Using the same coded data as in SS 10.1:

85474 18070 30511 70092 04062 24520 50572 16967 23018

The fire dangers are:

Elevation	Index	Meaning
HIGH	3	very low ptnl lg fire
MID	6	high ptnl lg fire
LOW	4	low ptnl lg fire

NOTE: The 950 mb temperature is computed using an algorithm similar to those employed in several of the earlier SS's.

SPREADSHEET 10.3 CONVECTIVE CLOUD HEIGHT

```
SHEET 10-2...CONVECTIVE CLOUD HEIGHT LEVEL:

IF CUMULUS CLOUDS ARE JUST BEGINNING TO FORM,
USE THIS FOR CLOUD BASE   H=227*(T-Td):

          INPUT:

                    ELEV.:  >    2800  feet
                    TEMP:   >      74  deg F
                    DEW PT: >      45  deg F

.....................................................................

          OUTPUT:

                    Cloud Ht.:

                                 6438  agl

                                 9238  msl
```

PURPOSE:

Most of the previous spreadsheets involved fairly complex algorithms. The intent of WeatherTools was not only to provide a convenient toolkit but to encourage further development or new development utilizing spreadsheets. This spreadsheet's main purpose was intended to give entry level programmers a place to start; it's the simplest spreadsheet. Using the ALT-E macro to enter edit mode, move the cursor around the cells to view or change the formula. When you are done, depress ALT-C for color monitors or ALT-M for monochrome to protect your changes, then ALT-S to save the changes or ALT-Q to just quit without saving. Sorry 1-2-3 users, the ALT's will not work.

The convective cloud height formula is commonly known and widely used for determining the base of a newly forming cumulus cloud. The formula is simple and is often found or applied in the form of a diagram or table. Spreadsheet 10.3 offers another and more versatile method for determining cumulus cloud bases.

FORMULA:

$$H = 227 * (T - Td)$$

where

H = height of newly forming cumulus
T = temperature deg F
Td= dew point deg F

APPLICATION:

Skies have been clear all morning. You are far from the mountains. It is 11 am and you notice cumulus beginning to form. The temperature is 74 degrees F, the dew point 45, and your elevation is 2800 feet. How high are the bases of the cumulus?

From Spreadsheet 10.1 (SS 10.1), depress the Ctrl and right arrow keys twice to get to SS 10.3. Then,

1. Enter 2800 in the Elev block.
2. Enter 74 in the temp block.
3. Enter 45 in the dew point block.

Answer:

Cloud Ht:

6438 feet agl
9238 feet msl

SPREADSHEET 11 FORECAST MINIMUM TEMPERATURE (Olsen method)

```
SHEET 11...FORECAST MIN TEMP (UNDER CLEAR SKY- OLSEN METHOD):

ENTER:                                         GROUND CONDITIONS:
                                               INCHES:
   MAX. PREV DAY:>        76 < deg F              FRESH SNOW  :>        0
 AFTN. DEW-POINT:>        41 < deg F              DRY SNOW    :>        0
AV WD SPD 06-12Z:>         3 < kts                CRUSTY SNOW :>        0
                                                  WET SNOW    :>        0
NOTE:  Enter dates with Ctrl-D
MAR 21 CUR. YEAR:>03/21/91 < MM/DD/YY          WET GROUND (Y/N):>N
DATE TO COMPUTE: >06/16/91 < MM/DD/YY
......................................................................
OUTPUT:
   T min (deg F):>        45 < unadjusted
                >         48 < + wind adjustment
                >         48 < + ground cond adjustment
......................................................................
FORMULA:
   Tmin = 3.92*Tmax^.5 * Tdp^.25 (1+.015*SIN(Pi/180 * (Date-MAR 21))
```

PURPOSE:

Many forecast offices have objective techniques for forecasting minimum temperatures. Several years ago Dave Olsen (Area Manager, Great Falls, MT), then a forecaster at Boise, adapted an empirical formula that he developed for Helena, Montana (Olsen 1968). This technique is still used today with a few modifications made by local forecasters. The formula was utilized in a variety of ways; from nomograms and tables to careful labeling on the blank side of an anachronistic slide rule. After years of use, the slide ruler's indelible ink has faded. The technique survives time in the form of this spreadsheet. This procedure works well at many different sites in the West, perhaps with little or no modification it will work for your office.

FORMULA:

$$Tmin = 3.92 * (Tmax^{.5}) * (Tdp^{.25}) * [\, 1 + .015 * \sin(Pi/180(date-Mar\ 21))]$$

where

Tmin = forecast minimum temperature
Tmax = observed afternoon maximum temperature
Tdp = observed dew-point at maximum temperature
date = today's date

APPLICATION:

Tuesday afternoon's maximum was 72 deg F, the dew point at that time was 41 deg F while the expected average wind speed Wednesday morning between 06-12Z is 3 knots. No snow was on the ground and the ground was not wet. What is your forecast for the Wednesday morning minimum?

Enter the temperatures and wind speed in the appropriate input cells. Then move the cursor down to the "Date to Compute cell". The program automatically computes the current date. If you wish to compute a different date, procedures are a little different than entering numbers. Hold down Ctrl and D at the same time. In the lower right corner of the screen you will notice a "Date Ready" statement. Enter today's month/day. Example: enter 6/16/91 as 6/16.

Answer: 48 degrees

CONCLUSION

Version 5.01 of WeatherTools is a framework for solving problems typical to many forecast offices in the western United States. Further development at other offices is encouraged. If you are new to spreadsheeting, begin by studying your spreadsheet User Manual, then "open up" these spreadsheets to see the techniques employed. Use the Alt-E feature to view the cell formulas. Spreadsheet 10.3 is a good place to begin experimenting. Before manipulating any of the formulas, be sure to make a backup copy of WeatherTools.

REFERENCES

Caplan, S. J. and A. J. Bedard, Jr., 1990: The 700-500 mb Lapse Rate as an Index of Microburst Probability: An Application for Thermodynamic Profilers, *Journal of Applied Meteorology*, **Vol 29**, 680-687.

Egger, T. J., 1991: HydroTools, NOAA Technical Memorandum NWS WR-210, 25 pp.

Egger, T. J. and W. Fortune, 1984: Program Impact, NWS CRCP - No. 15, 19 pp.

Ochoa, R. and P. Werth, 1990: Evaluation of Idaho Wildfire Growth Using the Haines Index and Water Vapor Imagery, Fifth Conference on Mountain Meteorology. 187-193.

Olsen, D., 1968: Objective Minimum Temperature Forecasting For Helena Montana, NOAA Technical Memorandum NWS WR-27, 8 pp.

<u>Western Region Technical Attachment No. 84-14</u>: 1984, Convective Stability Indices.

ACKNOWLEDGEMENTS

Thanks to Bob McLeod for putting me onto spreadsheeting as an alternative to calculators. Had he not refused my request for an adding machine and in its place handed me a spreadsheet, WeatherTools may never have been. Also, thanks to Ken Parker for reviewing my manuscript and making many useful suggestions. Mark Mollner and Rich Ochoa also provided helpful suggestions.

142 The Usefulness of Data from Mountaintop Fire Lookout Stations in Determining Atmospheric Stability. Jonathan W. Corey, April 1979. (PB298899/AS)
143 The Depth of the Marine Layer at San Diego as Related to Subsequent Cool Season Precipitation Episodes in Arizona. Ira S. Brenner, May 1979. (PB298817/AS)
144 Arizona Cool Season Climatological Surface Wind and Pressure Gradient Study. Ira S. Brenner, May 1979. (PB298900/AS)
146 The BART Experiment. Morris S. Webb, October 1979. (PB80 155112)
147 Occurrence and Distribution of Flash Floods in the Western Region. Thomas L. Dietrich, December 1979. (PB80 160344)
149 Misinterpretations of Precipitation Probability Forecasts. Allan H. Murphy, Sarah Lichtenstein, Baruch Fischhoff, and Robert L. Winkler, February 1980. (PB80 174576)
150 Annual Data and Verification Tabulation - Eastern and Central North Pacific Tropical Storms and Hurricanes 1979. Emil B. Gunther and Staff, EPHC, April 1980. (PB80 220486)
151 NMC Model Performance in the Northeast Pacific. James E. Overland, PMEL-ERL, April 1980. (PB80 196033)
152 Climate of Salt Lake City, Utah. Wilbur E. Figgins (Retired) and Alexander R. Smith. Fourth Revision, March 1989. (PB89 180624/AS)
153 An Automatic Lightning Detection System in Northern California. James E. Rea and Chris E. Fontana, June 1980. (PB80 225592)
154 Regression Equation for the Peak Wind Gust 6 to 12 Hours in Advance at Great Falls During Strong Downslope Wind Storms. Michael J. Oard, July 1980. (PB91 108367)
155 A Raininess Index for the Arizona Monsoon. John H. Ten Harkel, July 1980. (PB81 106494)
156 The Effects of Terrain Distribution on Summer Thunderstorm Activity at Reno, Nevada. Christopher Dean Hill, July 1980. (PB81 102501)
157 An Operational Evaluation of the Scofield/Oliver Technique for Estimating Precipitation Rates from Satellite Imagery. Richard Ochoa, August 1980. (PB81 108227)
158 Hydrology Practicum. Thomas Dietrich, September 1980. (PB81 134033)
159 Tropical Cyclone Effects on California. Arnold Court, October 1980. (PB81 133779)
160 Eastern North Pacific Tropical Cyclone Occurrences During Intraseasonal Periods. Preston W. Leftwich and Gail M. Brown, February 1981. (PB81 205494)
161 Solar Radiation as a Sole Source of Energy for Photovoltaics in Las Vegas, Nevada, for July and December. Darryl Randerson, April 1981. (PB81 224503)
162 A Systems Approach to Real-Time Runoff Analysis with a Deterministic Rainfall-Runoff Model. Robert J.C. Burnash and R. Larry Ferral, April 1981. (PB81 224495)
163 A Comparison of Two Methods for Forecasting Thunderstorms at Luke Air Force Base, Arizona. LTC Keith R. Cooley, April 1981. (PB81 225393)
164 An Objective Aid for Forecasting Afternoon Relative Humidity Along the Washington Cascade East Slopes. Robert S. Robinson, April 1981. (PB81 23078)
165 Annual Data and Verification Tabulation, Eastern North Pacific Tropical Storms and Hurricanes 1980. Emil B. Gunther and Staff, May 1981. (PB82 230336)
166 Preliminary Estimates of Wind Power Potential at the Nevada Test Site. Howard G. Booth, June 1981. (PB82 127036)
167 ARAP User's Guide. Mark Mathewson, July 1981, Revised September 1981. (PB82 196783)
168 Forecasting the Onset of Coastal Gales Off Washington-Oregon. John R. Zimmerman and William D. Burton, August 1981. (PB82 127051)
169 A Statistical-Dynamical Model for Prediction of Tropical Cyclone Motion in the Eastern North Pacific Ocean. Preston W. Leftwich, Jr., October 1981. (PB82195298)
170 An Enhanced Plotter for Surface Airways Observations. Andrew J. Spry and Jeffrey L. Anderson, October 1981. (PB82 153883)
171 Verification of 72-Hour 500-MB Map-Type Predictions. R.F. Quiring, November 1981. (PB82 158098)
172 Forecasting Heavy Snow at Wenatchee, Washington. James W. Holcomb, December 1981. (PB82 177783)
173 Central San Joaquin Valley Type Maps. Thomas R. Crossan, December 1981. (PB82 196064)
174 ARAP Test Results. Mark A. Mathewson, December 1981. (PB82 198103)
176 Approximations to the Peak Surface Wind Gusts from Desert Thunderstorms. Darryl Randerson, June 1982. (PB82 253089)
177 Climate of Phoenix, Arizona. Robert J. Schmidli, April 1969 (Revised December 1986). (PB87 142063/AS)
178 Annual Data and Verification Tabulation, Eastern North Pacific Tropical Storms and Hurricanes 1982. E.B. Gunther, June 1983. (PB85 106078)
179 Stratified Maximum Temperature Relationships Between Sixteen Zone Stations in Arizona and Respective Key Stations. Ira S. Brenner, June 1983. (PB83 249904)
180 Standard Hydrologic Exchange Format (SHEF) Version I. Phillip A. Pasteris, Vernon C. Bissel, David G. Bennett, August 1983. (PB85 106052)
181 Quantitative and Spacial Distribution of Winter Precipitation along Utah's Wasatch Front. Lawrence B. Dunn, August 1983. (PB85 106912)
182 500 Millibar Sign Frequency Teleconnection Charts - Winter. Lawrence B. Dunn, December 1983. (PB85 106276)
183 500 Millibar Sign Frequency Teleconnection Charts - Spring. Lawrence B. Dunn, January 1984. (PB85 111367)
184 Collection and Use of Lightning Strike Data in the Western U.S. During Summer 1983. Glenn Rasch and Mark Mathewson, February 1984. (PB85 110534)
185 500 Millibar Sign Frequency Teleconnection Charts - Summer. Lawrence B. Dunn, March 1984. (PB85 111359)
186 Annual Data and Verification Tabulation eastern North Pacific Tropical Storms and Hurricanes 1983. E.B. Gunther, March 1984. (PB85 109635)
187 500 Millibar Sign Frequency Teleconnection Charts - Fall. Lawrence B. Dunn, May 1984. (PB85 110930)
188 The Use and Interpretation of Isentropic Analyses. Jeffrey L. Anderson, October 1984. (PB85 132694)
189 Annual Data & Verification Tabulation Eastern North Pacific Tropical Storms and Hurricanes 1984. E.B. Gunther and R.L. Cross, April 1985. (PB85 1878887AS)
190 Great Salt Lake Effect Snowfall: Some Notes and An Example. David M. Carpenter, October 1985. (PB86 119153/AS)
191 Large Scale Patterns Associated with Major Freeze Episodes in the Agricultural Southwest. Ronald S. Hamilton and Glenn R. Lussky, December 1985. (PB86 144474AS)
192 NWR Voice Synthesis Project: Phase I. Glen W. Sampson, January 1986. (PB86 145604/AS)
193 The MCC - An Overview and Case Study on Its Impact in the Western United States. Glenn R. Lussky, March 1986. (PB86 170651/AS)
194 Annual Data and Verification Tabulation Eastern North Pacific Tropical Storms and Hurricanes 1985. E.B. Gunther and R.L. Cross, March 1986. (PB86 170941/AS)
195 Radid Interpretation Guidelines. Roger G. Pappas, March 1986. (PB86 177680/AS)
196 A Mesoscale Convective Complex Type Storm over the Desert Southwest. Darryl Randerson, April 1986. (PB86 190998/AS)
197 The Effects of Eastern North Pacific Tropical Cyclones on the Southwestern United States. Walter Smith, August 1986. (PB87 106258AS)
198 Preliminary Lightning Climatology Studies for Idaho. Christopher D. Hill, Carl J. Gorski, and Michael C. Conger, April 1987. (PB87 180196/AS)
199 Heavy Rains and Flooding in Montana: A Case for Slantwise Convection. Glenn R. Lussky, April 1987. (PB87 185229/AS)
200 Annual Data and Verification Tabulation Eastern North Pacific Tropical Storms and Hurricanes 1986. Roger L. Cross and Kenneth B. Mielke, September 1987. (PB88 110895/AS)
201 An Inexpensive Solution for the Mass Distribution of Satellite Images. Glen W. Sampson and George Clark, September 1987. (PB88 114038/AS)
202 Annual Data and Verification Tabulation Eastern North Pacific Tropical Storms and Hurricanes 1987. Roger L. Cross and Kenneth B. Mielke, September 1988. (PB88 101935/AS)
203 An Investigation of the 24 September 1986 "Cold Sector" Tornado Outbreak in Northern California. John P. Monteverdi and Scott A. Braun, October 1988. (PB89 121297/AS)
204 Preliminary Analysis of Cloud-To-Ground Lightning in the Vicinity of the Nevada Test Site. Carven Scott, November 1988. (PB89 128649/AS)
205 Forecast Guidelines For Fire Weather and Forecasters -- How Nighttime Humidity Affects Wildland Fuels. David W. Goens, February 1989. (PB89 162549/AS)
206 A Collection of Papers Related to Heavy Precipitation Forecasting. Western Region Headquarters, Scientific Services Division, August 1989. (PB89 230833/AS)
207 The Las Vegas McCarran International Airport Microburst of August 8, 1989. Carven A. Scott, June 1990. (PB90-240268)
208 Meteorological Factors Contributing to the Canyon Creek Fire Blowup, September 6 and 7, 1988. David W. Goens, June 1990. (PB90-245085)
209 Stratus Surge Prediction Along the Central California Coast. Peter Felsch and Woodrow Whitlatch, December 1990. (PB91-129239)
210 Hydrotools. Tom Egger. January 1991. (PB91-151787/AS)
211 A Northern Utah Soaker. Mark E. Struthwolf, February 1991. (PB91-168716)
212 Preliminary Analysis of the San Francisco Rainfall Record: 1849-1990. Jan Null, May 1991. (PB91-208439)
213 Idaho Zone Preformat, Temperature Guidance, and Verification. Mark A. Mollner, July 1991. (PB91-227405/AS)
214 Emergency Operational Meteorological Considerations During an Accidental Relsease of Hazardous Chemicals. Peter Mueller and Jerry Galt, August 1991. (PB91-235424)

NOAA SCIENTIFIC AND TECHNICAL PUBLICATIONS

The National Oceanic and Atmospheric Administration was established as part of the Department of Commerce on October 3, 1970. The mission responsibilities of NOAA are to assess the socioeconomic impact of natural and technological changes in the environment and to monitor and predict the state of the solid Earth, the oceans and their living resources, the atmosphere, and the space environment of the Earth.

The major components of NOAA regularly produce various types of scientific and technical information in the following kinds of publications.

PROFESSIONAL PAPERS--Important definitive research results, major techniques, and special investigations.

CONTRACT AND GRANT REPORTS---Reports prepared by contractors or grantees under NOAA sponsorship.

ATLAS--Presentation of analyzed data generally in the form of maps showing distribution of rainfall, chemical and physical conditions of oceans and atmosphere, distribution of fishes and marine mammals, ionospheric conditions, etc.

TECHNICAL SERVICE PUBLICATIONS--Reports containing data, observations, instructions, etc. A partial listing includes data serials; prediction and outlook periodicals; technical manuals, training papers, planning reports, and information serials; and miscellaneous technical publications.

TECHNICAL REPORTS--Journal quality with extensive details, mathematical developments, or data listings.

TECHNICAL MEMORANDUMS--Reports of preliminary, partial, or negative research or technology results, interim instructions, and the like.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

Information on availability of NOAA publications can be obtained from:

NATIONAL TECHNICAL INFORMATION SERVICE

U. S. DEPARTMENT OF COMMERCE

5285 PORT ROYAL ROAD

SPRINGFIELD, VA 22161