APPENDIX A

GEMPAK PARAMETERS

This appendix contains a list of the GEMPAK parameters. Algorithms used in computing these parameters are also included. The following constants are used in the computations:

KAPPA	= Poisson's constant	= 2 / 7
G	= Gravitational constant	= 9.80616 m/sec/sec
GAMUSD	= Standard atmospheric lapse rate	= 6.5 K/km
RDGAS	= Gas constant for dry air	= 287.04 J/K/kg
PI	= Circumference / diameter	= 3.14159265

References for some of the algorithms:

Bolton, D., 1980: The computation of equivalent potential temperature., Monthly Weather Review, 108, pp 1046-1053.

Miller, R.C., 1972: Notes on Severe Storm Forecasting Procedures of the Air Force Global Weather Central, AWS Tech. Report 200.

Wallace, J.M., P.V. Hobbs, 1977: Atmospheric Science, Academic Press, 467 pp.

TEMPERATURE PARAMETERS

TMPC - Temperature in Celsius

TMPF - Temperature in Fahrenheit

TMPK - Temperature in Kelvin

STHA - Surface potential temperature in Kelvin

STHK - Surface potential temperature in Kelvin

STHC - Surface potential temperature in Celsius

STHE - Surface equivalent potential temperature in Kelvin

STHS - Surface saturation equivalent pot. temperature in Kelvin

THTA - Potential temperature in Kelvin

THTK - Potential temperature in Kelvin

THTC - Potential temperature in Celsius

THTE - Equivalent potential temperature in Kelvin

THTS - Saturation equivalent pot. temperature in Kelvin

TVRK - Virtual temperature in Kelvin

TVRC - Virtual temperature in Celsius

TVRF - Virtual temperature in Fahrenheit

THTV - Virtual potential temperature in Kelvin

TDXC - Maximum 24 hour temperature in Celsius

TDNC - Minimum 24 hour temperature in Celsius

TDXF - Maximum 24 hour temperature in Fahrenheit

TDNF - Minimum 24 hour temperature in Fahrenheit

T6XC - Maximum 6 hour temperature in Celsius

T6NC - Minimum 6 hour temperature in Celsius

T6XF - Maximum 6 hour temperature in Fahrenheit

T6NF - Minimum 6 hour temperature in Fahrenheit

DMAX - Daily weather map maximum temperature in Fahrenheit

DMIN - Daily weather map minimum temperature in Fahrenheit

SSTC - Sea surface temperature in Celsius

SSTF - Sea surface temperature in Fahrenheit

LTMP - Temp. in Celsius of surface air lifted to 500 or !x mb

```
TMPC = ( TMPF - 32 ) * 5 / 9

TMPC = TMPK - 273.16

THTA = TMPK * ( 1000 / PRES ) ** KAPPA

STHA = TMPK * ( 1000 / PALT ) ** KAPPA

TVRK = TMPK * ( 1 + ( .001 * MIXR ) / .62197) ) /
                ( 1 + ( .001 * MIXR ) )

THTV = TVRK * ( 1000 / PRES ) ** KAPPA

THTE = THTM * EXP [ ( 3.376 / TLCL - .00254 ) *
                ( MIXR * ( 1 + .81 * .001 * MIXR ) ) ]
      THTM = potential temperature for moist air
           = TMPK * ( 1000 / PRES ) ** E
      E = 2.  / 7.  * ( 1 - ( .28 * .001 * MIXR ) )
      TLCL = temperature at the LCL in Kelvin
```

MOISTURE PARAMETERS

DWPC - Dewpoint in Celsius

DWPF - Dewpoint in Fahrenheit

DWPK - Dewpoint in Kelvin

DPDC - Dewpoint depression in Celsius

DPDF - Dewpoint depression in Fahrenheit

DPDK - Dewpoint depression in Kelvin

MIXR - Mixing ratio in g/kg

MIXS - Saturated mixing ratio in g/kg

SMXR - Surface mixing ratio in g/kg

SMXS - Surface saturated mixing ratio in g/kg

RELH - Relative humidity in percent

TMWK - Wet bulb temperature in Kelvin

TMWC - Wet bulb temperature in Celsius

TMWF - Wet bulb temperature in Fahrenheit

VAPR - Vapor pressure in millibars

VAPS - Saturation vapor pressure in millibars

LHVP - Latent heat of vaporization in J/kg

PWTR - Precipitable water (mm) at any given level

DPDx = TMPx - DWPx

MIXR = .62197 * (E / (PRES - E)) * 1000
E = VAPR * [1.001 + (PRES - 100) / 900 * .0034]
VAPR = 6.112 * EXP ((17.67 * DWPC) / (DWPC + 243.5))

MIXS = .62197 * (Es / (PRES - Es)) * 1000
Es= VAPS * [1.001 + (PRES - 100) / 900 * .0034]
VAPS = 6.112 * EXP ((17.67 * TMPC) /(TMPC + 243.5))

SMXR = .62197 * (E / (PALT - E)) * 1000
E = VAPR * [1.001 + (PALT - 100) / 900 * .0034]
VAPR = 6.112 * EXP ((17.67 * DWPC) /\(DWPC + 243.5))

SMXS = .62197 * (Es / (PALT - Es)) * 1000
Es= VAPS * [1.001 + (PALT - 100) / 900 * .0034]

VAPS = 6.112 * EXP ((17.67 * TMPC) / (TMPC + 243.5))

RELH = VAPR / VAPS * 100

(TMPK - TMWK) * Cp - (Rsat (TMWK) - RMIX) * LVAP = 0

Implicit equation solved by Newton's method for TMWK.
Cp - Specific heat at constant pressure
Rsat - Saturation mixing ratio at TMWK
RMIX - Mixing ratio
LVAP - Latent heat of vaporization

VAPR = 6.112 * EXP [(17.67 * DWPC) / (DWPC + 243.5)]

VAPS = 6.112 * EXP [(17.67 * TMPC) / (TMPC + 243.5)]

LHVP = (2.501 - .00237 * TMPC) * 10E6

HEIGHT PARAMETERS

HGHT - Height in meters

HGTM - Height in meters

HGTK - Height in kilometers

HGTD - Height in decameters

HGFT - Height in feet (3.28084 * HGHT)

HGFH - Height in hundreds of feet

HGFK - Height in thousands of feet

HGML - Height in miles (6.2137E-04 * HGHT)

DHGT - Dry hydrostatic height in meters

MHGT - Moist hydrostatic height in meters

STDZ - Character standard height convention used on u.-a. charts

RSTZ - Numeric standard height convention used on u.-a. charts

For data below 500 mb, the standard height is the last three digits of the height. For data at and above 500 mb, the height is the last three digits of the height in decameters.

ZMSL, Z000, Z900, Z850, Z800 - Estimated height at a pressure level

DHGT and MHGT are computed using the hypsometric equation and integrating from the surface pressure to the desired level. DHGT (MHGT) is computed without (with) the influence of moisture.

DHGT = HB + (RDGAS / G) * LN (PBOT / PTOP) * TAVE
- HB= height of the bottom of a layer
- PBOT = pressure at bottom of a layer
- PTOP = pressure at the top of a layer
- TAVE = average temperature of a layer

MHGT = HB + (RDGAS / G) * LN (PBOT / PTOP) * TVAVE
- HB = height of the bottom of a layer
- PBOT = pressure at bottom of a layer
- PTOP = pressure at the top of a layer
- TVAVE = average virtual temperature of a layer

Zxxx = [To * (1 - (PRES / ALTM) ** (RDGAS * GAMUSD / G)] / GAMUSD
- Zxxx = height at the pressure level
  - ZMSL : 1013.25 mb
  - Z000 : 1000 mb
  - Z900 : 900 mb
  - Z850 : 850 mb
  - Z800 : 800 mb
- To= sea level temperature in U.S. Std. Atmos. = 288 K

PRESSURE AND ALTIMETER PARAMETERS

PRES - Station pressure in millibars

PRES is the actual pressure at a level as reported with upper air data.

PMSL - Mean sea level pressure

PMSL is reported with surface data.

PALT - Surface pressure in millibars from ALTI

ALTI - Altimeter setting in inches of mercury

ALTI is reported with surface data.

ALTM - Altimeter setting converted to millibars

SALT - Abbreviated standard altimeter setting

SMSL - Abbreviated mean sea level pressure in millibars

SALI - Abbreviated altimeter setting in inches of mercury

RMSL - First 3 digits left of decimal of PMSL * 10

RSLI - First 3 digits left of decimal of ALTI * 100

RSLT - First 3 digits left of decimal of ALTM * 10

PTND - Pressure tendency: graphics symbol with numeric change

PTSY - Graphics symbol for pressure tendency

P03C - 3-h numeric pressure change

P03D - Pressure tendency and change group, appp

P24C - 24-h numeric pressure change

PMSL = PRES * EXP ((G * SELV) / (RDGAS * TVAVE))
SELV = station elevation
TVAVE = average virtual temperature between station and sea level
= TVRK + (DELTV / 2)
DELTV = GAMUSD * SELV / 1000

PALT = ALTM *
(1 - ((SELV / 1000) * GAMUSD / To)) **
(G / (GAMUSD * RDGAS) * 1000)
SELV = station elevation in meters
To = sea level temperature in U.S. Std. Atmos. = 288 K

ALTM = ALTI * (1013.25 / 29.921)

SALT = MOD (ALTM * 10, 1000)

WINDS

UWND - U-component of the wind in meters/second

VWND - V-component of the wind in meters/second

UKNT - U-component of the wind in knots

VKNT - V-component of the wind in knots

DRCT - Wind direction in degrees

SPED - Wind speed in meters/second

SKNT - Wind speed in knots

SMPH - Wind speed in miles/hour

PSPD - Packed direction and speed in meters/second (ddfff)

PKNT - Packed direction and speed in knots (ddfff)

GUST - Wind gusts in knots

GUMS - Wind gusts meters/second

PWDR - Peak wind direction in degrees

PWSP - Peak wind speed in meters/sec

PWHR - Hour of peak wind

PWMN - Minutes of peak wind

WNML - Wind component toward a direction 90 degrees counter-clockwise from a specified direction.

WCMP - Wind component toward a specified direction

BARB - Barb feathered in m/s

BRBM - Barb feathered in m/s

BRBK - Barb feathered in knots

BRBS - Barb feathered in mi/hr

ARRW - Arrows scaled in m/s

ARRM - Arrows scaled in m/s

ARRK - Arrows scaled in knots

DARR - Wind direction arrows of uniform length

UWND = - SIN (DRCT) * SPED

VWND = - COS (DRCT) * SPED

DRCT = ATAN2 (-UWND, -VWND) * 180 / PI

SPED = SQRT (UWND ** 2 + VWND ** 2)

SPED = SKNT / 1.9438

PSPD = JDRCT * 100 + JSPED
JDRCT = NINT (DRCT / 5)
JSPED = NINT (SPED)

PKNT = JDRCT * 100 + JSKNT
JDRCT = NINT (DRCT / 5)
JSKNT = NINT (SKNT)

WCMP = - COS (DRCT - SPCD) * SPED
SPCD is the specified direction

WNML = - COS (DRCT - (SPCD - PI/2)) * SPED
SPCD is the specified direction

LIFTED CONDENSATION LEVEL (LCL)

TLCL - Temperature in Kelvin at the LCL from the given level

PLCL - Pressure in millibars at the LCL from the given level

TLCL = [1 / (1 / (DWPK - 56) + LN (TMPK / DWPK) / 800)] + 56

PLCL = PRES * (TLCL / (TMPC + 273.15)) ** (1 / KAPPA)
Poisson's equation

STABILITY INDICES

Note: Default depths given in the definitions below are preceded by an ! and may be changed using the in-line depth specification. Negative depths reset to the default values. Zero depth will yield missing values for layer parameters. dz in the definitions below defaults to the layer thickness in the sounding.

BRCH - Bulk Richardson number

BRCH = CAPE / (0.5 * U**2)
CAPE = Convective Available Potential Energy
U = magnitude of shear (u2 - u1, v2 - v1)
u1,v1 = average u,v in the lowest !500 m
u2,v2 = average u,v in the lowest !6000 m

BRCV - BRCH computed by using CAPV

BRCH = CAPV / (0.5 * U**2)
CAPV = CAPE computed by using virtual temperature
U = magnitude of shear (u2 - u1, v2 - v1)
u1,v1 = average u,v in the lowest !500 m
u2,v2 = average u,v in the lowest !6000 m

BVFQ - Brunt-Vaisala frequency in a layer

BVFQ = SQRT ((G / THTA) * STAB)

BVPD - Brunt-Vaisala period in a layer

BVPD = 2. * PI / BVFQ

BVSQ - Brunt-Vaisala frequency squared in a layer

BVSQ = BVFQ ** 2

CAPE - Convective Available Potential Energy

CAPE = GRAVTY * SUMP (DELZ * (TP - TE) / TE)
SUMP = sum over sounding layers from LFCT to EQLV for which (TP - TE) is greater than zero
DELZ = incremental depth
TP= temperature of a parcel from the lowest !500 m of the atmosphere, raised dry adiabatically to the LCL and moist adiabatically thereafter
TE= temperature of the environment

CAPV - CAPE computed by using virtual temperature

CAPV = GRAVTY * SUMP (DELZ * (TVP - TVE) / TVE)
SUMP = sum over sounding layers from LFCV to EQTV for which (TVP - TVE) is greater than zero
DELZ = incremental depth
TVP = virtual temperature of a parcel from the lowest !500 m of the atmosphere, raised dry adiabatically to the LCL and moist adiabatically thereafter
TVE = virtual temperature of the environment

CINS - Convective Inhibition

CINS = GRAVTY * SUMN (DELZ * (TP - TE) / TE)
SUMN = sum over sounding layers from top of the mixed layer to LFCT for which (TP - TE) is less than zero.
DELZ = incremental depth
TP= temperature of a parcel from the lowest !500 m of the atmosphere, raised dry adiabatically to the LCL and moist adiabatically thereafter
TE= temperature of the environment

CINV - CINS computed by using virtual temperature

CINV = GRAVTY * SUMN (DELZ * (TVP - TVE) / TVE)
SUMN = sum over sounding layers from top of the mixed layer to LFCV for which (TVP - TVE) is less than zero.
DELZ = incremental depth
TVP = virtual temperature of a parcel from the lowest !500 m of the atmosphere, raised dry adiabatically to the LCL and moist adiabatically thereafter
TVE = virtual temperature of the environment

CTOT - Cross Totals index

CTOT = TD850 - T500
TD850 = Dewpoint in Celsius at 850 mb
T500 = Temperature in Celsius at 500 mb

EQLV - Equilibrium level

EQLV = level at which a parcel from the lowest !500 m of the atmosphere is raised dry adiabatically to the LCL and moist adiabatically to a level above which the virtual temperature of the parcel is the same as the environment. If more than one Equilibrium Level exists, the highest one is chosen.

EQTV - EQLV computed by using virtual temperature

KINX - K index

KINX = (T850 - T500) + TD850 - (T700 - TD700)
T850 = Temperature in Celsius at 850 mb
T500 = Temperature in Celsius at 500 mb
TD850 = Dewpoint in Celsius at 850 mb
T700 = Temperature in Celsius at 700 mb
TD700 = Dewpoint in Celsius at 700 mb

LAPS - Temperature lapse rate in a layer

LAPS = d (TMPK) / dz = d (TMPC) / dz

LCLP - Pressure in millibars at the LCL from the surface

LCLP = PRES * (LCLT / (TMPC + 273.15)) ** (1 / KAPPA)
Poisson's equation

LCLT - Temperature in Kelvin at the LCL from the surface

LCLT = [1 / (1 / (DWPK - 56) +
LN (TMPK / DWPK) / 800)] + 56

LFCT - Level of Free Convection by comparing temperature between a parcel and the environment

LFCT = level at which a parcel from the lowest !500 m of the atmosphere is raised dry adiabatically to LCL and moist adiabatically to the level above which the parcel is positively buoyant. If more than one LFCT exists, the lowest level is chosen. If the parcel is positively bouyant throughout the sounding, the LFCT is set to be the same as the LCLP. If the parcel is negatively bouyant throughout the sounding, the LFCT is set to missing.

LFCV - LFCT computed by using virtual temperature

LIFT - Lifted index

LIFT = T500 - Tparcel
T500 = temperature in Celsius of the environment at 500 mb
Tparcel = 500 mb temperature in Celsius of a lifted parcel with the average pressure, temperature, and dewpoint of the layer !100 mb above the surface

LFTV - LIFT computed by using virtual temperature

MLMR - Mean mixed layer MIXR

MLMR = average MIXR in the lowest !500 m

MLTH - Mean mixed layer THTA

MLTH = average THTA in the lowest !500 m

PWAT - Precipitable water (mm) for the entire sounding

RICH - Richardson number in a layer

RICH = BFVQ ** 2 / SHRM ** 2

SEPA - Isentropic pressure thickness in a layer

SEPA = pressure difference over a isentropic layer !5 K deep

SHOW - Showalter index

SHOW = T500 - Tparcel
T500 = Temperature in Celsius at 500 mb
Tparcel = Temperature in Celsius at 500 mb of a parcel lifted from 850 mb

SHRD - Wind shear direction in a layer

SHRD = direction of [du/dz, dv/dz]

SHRM - Wind shear magnitude in a layer

SHRM = magnitude of [du/dz, dv/dz]

STAB - THTA lapse rate in a layer

STAB = d (THTA) / dz

STAP - THTA change with pressure in a layer

STAP = - d (THTA) / dp

SWET - SWEAT index

SWET = 12 * TD850 + 20 * TERM2 + 2 * SKT850 +
SKT500 + SHEAR
TD850 = Dewpoint in Celsius at 850 mb
TERM2 = MAX (TOTL - 49, 0)
TOTL= Total totals index
SKT850 = 850 mb wind speed in knots
SKT500 = 500 mb wind speed in knots
SHEAR = 125 * [SIN (DIR500 - DIR850) + .2]
DIR500 = 500 mb wind direction
DIR850 = 850 mb wind direction

If TD850 is negative, then TD850 is set to 0.
SHEAR is set to 0 if any of the following
conditions are met:
wind direction at 850mb is < 130 or > 250
wind direction at 500mb is < 210 or > 310
DIR500 - DIR850 <= 0
SPD500 <= 15 or SPD850 <= 15

TOTL - Total Totals index

TOTL = (T850 - T500) + (TD850 - T500)
T850 = Temperature in Celsius at 850 mb
TD850 = Dewpoint in Celsius at 850 mb
T500 = Temperature in Celsius at 500 mb

VTOT - Vertical Totals index

VTOT = T850 - T500
T850 = Temperature in Celsius at 850 mb
T500 = Temperature in Celsius at 500 mb

CLOUD PARAMETERS

Cloud coverage may be defined using a cloud code, short code, fractional coverage or numeric value. The valid values of these param-

eters ordered from least to greatest cloud coverage, are:

Cloud Coverage	Cloud xCLD	Short	Fractional xCLO	Numeric CLCx	Symbol CFRT
missing		-	0.00	0	-
clear	CLR	C	0.00	1	0
thin scattered	-SCT	-S	0.25	6	2
scattered	SCT	S	0.40	2	3
thin broken	-BKN	-B	0.60	7	5
broken	BKN	B	0.75	3	6
thin overcast	-OVC	-O	0.90	8	7
overcast	OVC	O	1.00	4	8
thin obscured	-X	-X	0.00	9	0
obscured	X	X	1.00	5	9

The following lists the GEMPAK parameter definitions with an example using the sample AIRWAYS cloud report:

22SCT 80-BKN 250OVC

Note that the character x may be replaced by L, M, or H, indicating low, mid or high clouds. Also note that the character T indicates the value of the parameter at the level of maximum cloud coverage.

xCLD - Character cloud coverage code

Examples: LCLD = SCT
MCLD = -BKN
HCLD = OVC

TCLD - xCLD at maximum cloud coverage

Example: TCLD = OVC

xCLO - Fractional cloud coverage

Examples: LCLO = 0.400
MCLO = 0.600
HCLO = 1.000

TCLO - xCLO at maximum cloud coverage

Example: TCLO = 1.00

CLCx - Numeric cloud coverage

Examples: CLCL = 2
CLCM = 7
CLCH = 4

CLCT - CLCx at maximum cloud coverage

Example: CLCT = 4

The next two parameters combine cloud coverage values from the three cloud levels.

CLDS - Combined cloud coverage short code from three levels

Example: CLDS = S-BO

CMBC - Combined cloud coverage numeric from three levels

Example: CMBC = 274

The next set of parameters are combined cloud height and cloud coverage.

CLHx - Cloud height in hundreds of feet

Examples: CLHL = 22.
CLHM = 80.
CLHH = 250.

CLDx - Combined cloud height and short code

Examples: CLDL = 22S
CLDM = 80-B
CLDH = 250O

CLDT - CLDx at maximum coverage level

Example: CLDT = 250O

COMx - Numeric combined cloud height and coverage combined as

CLHx * 10 + CLCx

Examples: COML = 222.
COMM = 807.
COMH = 2504

Note: In the case when the sky is partially obscured, the value of 10000 is added on to the lowest reporting level. For example, if AIRWAYS report is -X M5 BKN 19 BKN, COML would equal 10053.

COMT - COMx at maximum coverage level

Example: COMT = 2504.

The next two parameters combine the cloud height and coverage allowing up to three reports which do not necessarily correspond to low, middle and high level clouds. These parameters allow a means of storing cloud reports where there may be more than one report at a single level.

CHCx - Numeric combined cloud height and coverage combined as
CLHx * 10 + CLCx, where x is the cloud report group number from 1 to 3.
Examples: CHC1 = 222.
CHC2 = 807.
CHC3 = 2504
Note: In the case when the sky is partially obscured, the value of 10000 is added on to the first reporting level. For example, if AIRWAYS report is -X M5 BKN 19 BKN, CHC1 would equal 10053.

CHDx - Combined cloud height and short code
Examples: CHD1 = 22S
CHD2 = 80-B
CHD3 = 250O

The next parameter is the ceiling, defined as the height above the earth's surface of the lowest cloud layer that is reported as broken or overcast, or the vertical visibility into an indefinite ceiling.

CEIL - Ceiling in hundreds of feet

The following set of cloud parameters is the numeric WMO codes which are reported by airways data.

CFRL - Fraction of celestial dome covered by all low and mid level clouds from WMO Code 2700

CTYL - Low-level cloud genera from WMO Code 0513

CTYM - Mid-level cloud genera from WMO Code 0515

CTYH - High-level cloud genera from WMO Code 0509

CBAS - Cloud base height from WMO Code 1600

CSYL - Cloud graphics symbol for CTYL

CSYM - Cloud graphics symbol for CTYM

CSYH - Cloud graphics symbol for CTYH

CSYT - Cloud graphics symbol for first level reporting clouds

CFRT - Cloud coverage number from CLCT (maximum clouds)

SKYC - Cloud coverage graphics symbol for CFRT

SKYM - Sky coverage symbol with wind barbs in m/s

SKYK - Sky coverage symbol with wind barbs in knots

XVFR - Categorical identification of flight rules
0 = Low Instrument Flight Rules (LIFR)
1 = Instrument Flight Rules (IFR)
2 = Marginal Visual Flight Rules (MVFR)
3 = Visual Flight Rules (VFR)

The flight categories and corresponding ceiling and visibility values are listed below.

Flight Category	CEILING (feet)	VISIBILITY (statute miles)
LIFR	< 500 ft	and/or < 1 SM
IFR	>= 500 to < 1,000	and/or >= 1 to < 3
MVFR	>= 1,000 to <= 3,000	and/or >= 3 to <= 5
VFR	> 3,000 or none	and > 5

WEATHER CODES

WCOD - Character weather code

WNUM - Numeric weather code

The weather code WCOD may also be accessed as WTHR. The weather number consists of 3 parts, A, B, C where
WNUM = A * 80 * 80 + B * 80 + C.
Each part corresponds to one of the values:

0 (no value)
1 R (mod rain)
2 L (mod drizzle)
3 S (mod snow)
4 A (mod hail)
5 T (thunder)
6 H (haze)
7 K (smoke)
8 D (dust)
9 F (fog)
10 Q (squalls)
11 V (volcanic ash)
12
13 R- (lt rain)
14 R+ (hvy rain)
15 ZR (mod frz rain)
16 RW (mod rain shwr)
17 L- (lt drizzle)
18 L+ (hvy drizzle)
19 ZL (frz drizzle)
20 S- (lt snow)
21 S+ (hvy snow)
22 SW (mod snow shwr)
23 IP (mod ice pellet)
24 SG (mod snow grain)
25 SP (mod snow pellet)
26 A- (lt hail)
27 A+ (hvy hail)
28 T- (lt thunder)
29 T+ (hvy thunder)
30 IF (ice fog)
31 GF (ground fog)
32 BS (blowing snow)
33 BD (blowing dust)
34 BY (blowing spray)
35 BN (blowing sand)
36 IC (mod ice crystals)
37 IN (ice needles)
38 AP (small hail)
39 KH (smoke, haze)
40 PO (dust whirls)
41 UP(unknown prcp)
42
43
44
45
46
47
48
49 ZR- (lt frz rain)
50 ZR+ (hvy frz rain)
51 RW- (lt rain shwr)
52 RW+ (hvy rain shwr)
53 ZL- (lt freezing drizzle)
54 ZL+ (hvy freezing drizzle)
55 SW- (lt snow shwr)
56 SW+ (hvy snow shwr)
57 IP- (lt ice pellets)
58 IP+ (hvy ice pellets)
59 SG- (lt snow grains)
60 SG+ (hvy snow grains)
61 SP- (lt snow pellets)
62 SP+ (hvy snow pellets)
63 IPW (mod ice pellet shwr)
64 IC- (lt ice crystals)
65 IC+ (hvy ice crystals)
66 TRW (mod thunder shwr)
67 SPW (snow pellet shwr)
68 BD+ (hvy blowing dust)
69 BN+ (hvy blowing sand)
70 BS+ (hvy blowing snow)
71
72
73
74
75 IPW- (lt ice pellet shwr)
76 IPW+ (hvy ice pellet shwr)
77 TRW- (lt rain thunder shwr)
78 TRW+ (hvy rain thunder shwr)
79

The following correspond to a single character code:

-1 TORNA (tornado)
-2 FUNNE (funnel cloud)
-3 WATER (water spout)

WNUM - Numeric weather code, as computed from the METAR codes

The weather number consists of 3 parts, A, B, C where
WNUM = A * 80 * 80 + B * 80 + C.
Each part corresponds to one of the values:

-1	+FC (tornado or		-2 FC (funnel cloud) waterspout)
0	(no value)		
1	RA (mod rain)	41	UP (unknown prcp)
2	DZ (mod drizzle)	42	
3	SN (mod snow)	43	
4	GR (mod hail)	44	
5	TS (thunder)	45	
6	HZ (haze)	46	
7	FU (smoke)	47	
8	DU (dust)	48	
9	FG (fog)	49	-FZRA (lt frz rain)
10	SQ (squalls)	50	+FZRA (hvy frz rain)
11	VA (volcanic ash)	51	-SHRA (lt rain shwr)
12		52	+SHRA (hvy rain shwr)
13	-RA (lt rain)	53	-FZDZ (lt frz drizzle)
14	+RA (hvy rain)	54	+FZDZ (hvy frz drizzle)
15	FZRA (mod frz rain)	55	-SHSN (lt snow shwr)
16	SHRA (mod rain shwr)	56	+SHSN (hvy snow shwr)
17	-DZ (lt drizzle)	57	-PL (lt ice pellets)
18	+DZ (hvy drizzle)	58	+PL (hvy ice pellets)
19	FZDZ (frz drizzle)	59	-SG (lt snow grains)
20	-SN (lt snow)	60	+SG (hvy snow grains)
21	+SN (hvy snow)	61	-GS (lt snow pellets)
22	SHSN (mod snow shwr)	62	+GS (hvy snow pellets)
23	PL (mod ice pellet)	63	SHPL (mod ice pellet shwr)
24	SG (mod snow grain)	64	
25	GS (mod snow pellet)	65	
26		66	TSRA (mod thunder shwr)
27	SHGR (hvy hail)	67	SHGS (snow pellet shwr)
28		68	+BLDU (hvy blowing dust)
29		69	+BLSA (hvy blowing sand)
30	FZFG (ice fog)	70	+BLSN (hvy blowing snow)
31	BR (ground fog)	71	
32	BLSN (blowing snow)	72	
33	BLDU (blowing dust)	73	
34	BLPY (blowing spray)	74	
35	BLSA (blowing sand)	75	-SHPL (lt ice pellet shwr)
36	IC (mod ice crystals)	76	+SHPL (hvy ice pellet shwr)
37		77	-TSRA (lt rain thunder shwr)
38		78	+TSRA (hvy rain thunder shwr)
39		79	
40	PO (dust whirls)		

WTMO - Character WMO weather code

WWMO - Numeric WMO weather code

WSYM - Graphics weather symbol corresponding to WWMO

The transformation is:

0 =	34 = BD+	67 = ZR
1 =	35 = BD+	68 = R-S-
2 =	36 = BS	69 = RS
3 =	37 = BS+	70 = S-
4 = K	38 = BS	71 = S-
5 = H	39 = BS+	72 = S
6 = D	40 =	73 = S
7 = BD	41= F	74 = S+
8 = PO	42 = F	75 = S+
9 =	43 = F	76 = IN
10 = F	44 = F	77 = SG
11 = GF	45 = F	78 = IC
12 = GF	46 = F	79 = IP
13 =	47 = F	80 = RW-
14 =	48 = IF	81 = RW
15 =	49 = IF	82 = RW+
16 =	50 = L-	83 = RW-SW-
17 = T	51 = L-	84 = RWSW
18 = Q	52 = L	85 = SW-
19 = FUNNEL	53 = L	86 = SW
20 =	54 = L+	87 = IPW-
21 =	55 = L+	88 = IPW
22 =	56 = ZL-	89 = A-
23 =	57 = ZL	90 = A
24 =	58 = R-L-	91 = R-
25 =	59 = RL	92 = R
26 =	60 = R-	93 = RS
27 =	61 = R-	94 = R+S+
28 =	62 = R	95 = TRW-
29 =	63 = R	96 = TRW-A
30 = BD	64 = R+	97 = TRW+
31 = BD	65 = R+	98 = TD
32 = BD	66 = ZR-	99 = TRW+A
33 = BD+		

105 = TSW-	107 = TSW+	
201 = V	202 = BY	203 = UP

PWTH - Character past weather WMO code or graphics symbol for it

PWWM - Numeric past weather WMO code

The past weather WMO numeric codes are:

0 = Cloud covering less than 1/2 sky
1 = Cloud covering more than 1/2 during part of
period and less than 1/2 sky during part
2 = Cloud covering more than 1/2 sky
3 = Sandstorm, duststorm or blowing snow
4 = Fog, ice fog, thick haze or thick smoke
5 = Drizzle
6 = Rain
7 = Snow, rain and snow mixed or ice pellets
8 = Showers
9 = Thunderstorm with or without precipitation

The translation is:

0 =	5 = L
1 =	6 = R
2 =	7 = S
3 = BD	8 = RW
4 = F	9 = T

STATION PARAMETERS

STID - Character station identifier

STNM - Station number

STNM is the 5-digit WMO identifier for upper air data; 6 digits for surface data, usually the WMO identifier with a zero appended.

SLAT - Station latitude in degrees

SLON - Station longitude in degrees; West longitude is negative

SELV - Station elevation in meters

RANG - Range in kilometers (specialized use)

AZIM - Azimuth in kilometers (specialized use)

LATI - Latitude in degrees from range/azimuth

LONG - Longitude in degrees from range/azimuth

LATI and LONG are calculated from the RANG and AZIM using equations developed for AOIPS/RADPAK.

DELT - Delta time in seconds (specialized use)

MODEL OUTPUT STATISTICS

MXMN - Maximum or minimum temperature in Fahrenheit

TNTF - Night temperature fcst in Fahrenheit

TNCF - Night temperature climatology in Fahrenheit

TNAF - Night temperature anomaly in Fahrenheit

TDYF - Day temperature fcst in Fahrenheit

TDCF - Day temperature climatology in Fahrenheit

TDAF - Day temperature anomaly in Fahrenheit

TCNT - Night cloud coverage fcst

CL12 - Prevailing total sky cover fcst for a 12-hr period
1 = CL = mostly clear
4 = OV = mostly overcast
7 = PC = mixed clouds and clear skies

TCDY - Day cloud coverage fcst

SKNN - Night wind speed fcst in knots

SKND - Day wind speed fcst in knots

SK12 - Maximum sustained surface wind speed fcst for a 12-hr period
5 = light = 0 - 12 knots
15 = moderate = 13 - 21 knots
25 = strong = 22 - 33 knots
40 = high = greater than or equal to 34 knots

PP06 - Probability of precipitation fcst in a 6-hr period

PP12 - Probability of precipitation fcst in a 12-hr period

PP1C - Probability of precipitation climatology in a 12-hr period

PP1A - Probability of precipitation anomaly in a 12-hr period

PPNT - Probability of precipitation fcst for night

PPNC - Probability of precipitation climatology for night

PPNA - Probability of precipitation anomaly for night

PPDY - Probability of precipitation fcst for day

PPDC - Probability of precipitation climatology for day

PPDA - Probability of precipitation anomaly for day

PP24 - Probability of precipitation fcst in a 24-hr period

PP2C - Probability of precipitation climatology in a 24-hr period

PP2A - Probability of precipitation anomaly in a 24-hr period

QP06 - Quantitative precipitation fcst in a 6-hr period

1 = 0.01 - 0.09 inches
2 = 0.10 - 0.24 inches
3 = 0.25 - 0.49 inches
4 = 0.50 - 0.99 inches
5 = 1.00 - 1.99 inches

QPX2 - Maximum amount of precipitation in inches fcst in a 12-hr period. Values are same as QP12.

QP12 - Quantitative precipitation fcst in a 12-hr period

0 = no precipitation expected
1 through 5 same as QP06
6 = greater than or equal to 2.00 inches

QP24 - Quantitative precipitation fcst in a 24-hr period
0 through 5 same as QP12
6 = 2.00 - 2.99 inches
7 = greater than or equal to 3.00 inches

TS06 - Unconditional probability of thunderstorms occurring in a 6-hr period

TS12 - Unconditional probability of thunderstorms occurring in a 12-hr period

TS24 - Unconditional probability of thunderstorms occurring in a 24-hr period

TC06 - Conditional probability of severe weather occurring in a 6-hr period

TC12 - Conditional probability of severe weather occurring in a 12-hr period

PCPT - Categorical forecast of precipitation
0 = R = rain
1 = S = snow
2 = Z = freezing

POZP - Conditional probability of freezing precipitation
(not included during the warm season)

POSN - Conditional probability of snow
(not included during the warm season)

PSNT - Conditional probability of snow for night
(not included during the warm season)

PSDY - Conditional probability of snow for day
(not included during the warm season)

SN06 - Categorical forecast of snow amount falling in a 6-hr period
0 = no snow
1 = trace - less than 2 inches
2 = greater than or equal to 2 inches

SN12 - Categorical forecast of snow amount falling in a 12-hr period

0 and 1 same as SN06
2 = 2 to less than 4 inches
4 = 4 to less than 6 inches
6 = greater than 6 inches
(not included during the warm season)

SN24 - Categorical forecast of snow amount falling in a 24-hr period

0 = no snow or a trace
1 = greater than a trace to less than 2 inches
2 = 2 to less than 4 inches
4 = 4 to less than 6 inches
6 = 6 to less than 8 inches
8 = greater than 8 inches
(not included during the warm season)

PZ12 - Conditional probability of freezing precipitation in a 12-hr period

PS12 - Conditional probability of snow in a 12-hr period

PR12 - Conditional probability of mixed liquid/frozen precipitation in a 12-hr period

PC12 - Categorical forecast of precipitation type in a 12-hr period

0 = R = liquid
1 = S = frozen
2 = Z = freezing
3 = RS = mixed liquid and frozen precipitation
4 = RZ
5 = SZ
6 = RSZ

FCIG - Categorical forecast of ceiling height conditions

1 = less than 200 feet
2 = 200 - 400 feet
3 = 500 - 900 feet
4 = 1000 - 3000 feet
5 = 3100 - 6500 feet
6 = 6600 - 12,000 feet
7 = greater than 12,000 feet

FVIS - Categorical forecast of visibility conditions

1 = less than 0.5 miles
2 = 0.5 - 0.875 miles
3 = 1.0 - 2.75 miles
4 = 3.0 - 5.0 miles
5 = greater than 5.0 miles

FVSA - Categorical forecast of visibility conditions (for new MOS)

1 = less than 0.25 miles
2 = 0.25 to less than .5 mile
3 = .5 mile to less than 1.0 mile
4 = 1.0 to less than 3.0 miles
5 = 3.0 to 5.0 miles
6 = 6.0 miles
7 = greater than 6.0 miles

OVIS - Categorical forecast in plain language of obstructions to vision

0 = N = none of the following:
1 = FG or F = fog or ground fog (vis. less than .625 mile)
2 = HZ or H = haze, smoke, dust
3 = BR = mist (fog with visibility greater than .625 mile)
4 = BL = blowing dust, sand, snow

WXPB - Categorical weather precipitation probability or areal coverage determined by the precipitation parameter having the highest probability or areal coverage in WNUM.

For probability:
1 = slight chance
2 = chance
3 = likely
4 = occasional
5 = definite

For areal coverage:
1 = isolated
2 = widely scattered
3 = scattered
4 = numerous
5 = widespread

TERMINAL AERODROME FORECAST (TAF) PARAMETERS

TDRC - Temporary/probability wind direction in degrees

TSKN - Temporary/probability wind speed in knots

TGST - Temporary/probability wind gusts in knots

BRGK - Gust barb feathered in knots

TCHx - Temporary/probability numeric combined cloud height and coverage, as for CHCx

TCEL - Temporary/probability ceiling in hundreds of feet, as for CEIL

TSKC - Temporary/probability cloud coverage graphics symbol, as for SKYC

TXVF - Temporary/probability categorical identification of flight rules, as for XVFR

TWNM - Temporary/probability numeric weather code, as for WNUM

TWSY - Temporary/probability graphics weather symbol corresponding to TWNM, as for WSYM

TVSB - Temporary/probability visibility in statute miles

PPRB - Probability for TAF forecast change indicator

30 = PROB30 - 30 percent probability condition
40 = PROB40 - 40 percent probability condition
50 = TEMPO - temporary condition

VWNM - Vicinity numeric weather code, as for WNUM

VWSY - Vicinity graphics weather symbol corresponding to VWNM, as for WSYM

TVWN - Temporary/probability vicinity numeric weather code, as for WNUM

WSKC - Worst case cloud coverage graphics symbol, as for SKYC

WXVF - Worst case categorical identification of flight rules, as for XVFR

TPWN - Temporary/probability/vicinity numeric weather code, as for WNUM

TPWS - Temporary/probability/vicinity graphics weather symbol corresponding to TPWN, as for WSYM

AWNM - Prevailing/temporary/probability/vicinity numeric weather code, as for WNUM

AWSY - Prevailing/temporary/probability/vicinity graphics weather symbol corresponding to AWNM, as for WSYM

LLWS - Low level wind shear forecast flag

MOTV - Mountain obscuration threshold value in hundreds of feet

CMSL - Ceiling converted to mean sea level in hundreds of feet

MOBS - Mountain obscuration threshold met indicator

MARINE PARAMETERS

WHGT - Wave height in meters

WHFT - Wave height in feet

WPER - Wave period in seconds

HOWW - Height of wind wave in meters

POWW - Period of wind wave in seconds

HOSW - Height of predominant swell wave in meters

POSW - Period of predominant swell wave in seconds

DOSW - Direction of predominant swell wave in degrees

HOS2 - Height of secondary swell wave in meters

POS2 - Period of secondary swell wave in seconds

DOS2 - Direction of secondary swell wave in degrees

WAV2 - Combined wind wave period and height in feet ("2 group")

WAV3 - Combined predominant and secondary swell wave direction in tens of degrees ("3 group")

WAV4 - Combined predominant swell wave period and height in feet ("4 group")

WAV5 - Combined secondary swell wave period and height in feet ("5 group")

WPHM - Combined wave period and height in half meters

WVSW - Combined swell wave direction, period and height in half meters

SWEL - Character combined swell wave direction, period and height in half meters

DAWV - Swell wave direction arrows of uniform length

IDTH - Thickness of ice on ship in meters

ROIA - Rate of ice accretion on ship from WMO Code 3551

0 = Ice not building up
1 = Ice building up slowly
2 = Ice building up rapidly
3 = Ice melting or breaking up slowly
4 = Ice melting or breaking up rapidly

IGRO - Rate of ice accretion on vessel in salt water in inches per three hours

IGRO = (A*PR + B*PR*PR + C*PR*PR*PR) * CVFAC
A = 2.73 * 10E-2
B = 2.91 * 10E-4
C = 1.84 * 10E-6
PR = (SPED * (-1.7 - TMPC)) /

(1 + 0.4 * (SSTC + 1.7))
(priesendorfer regression)
CVFAC = 1.1811, to convert cm/hr to in/3hr

DIGR - Character rate of ice accretion in inches per three hours

AIRCRAFT PARAMETERS

TURB - Amount of turbulence
- 0 = No turbulence
- 2 = Light turbulence
- 3 = Light to moderate turbulence
- 4 = Moderate turbulence
- 5 = Moderate to severe turbulence
- 6 = Severe turbulence
- 8 = Extreme turbulence

TBSE - Base of turbulence in feet

TTOP - Top of turbulence in feet

HBOT - Base of turbulence in meters

HTOT - Top of turbulence in meters

FQOT - Frequency of turbulence
- 1 = Occasional
- 2 = Intermittent
- 3 = Continuous

TPOT - Type of turbulence
- 1 = Clear air turbulence
- 2 = Chop
- 3 = Low level wind shear
- 4 = Turbulence in cloud

TBSY - Graphics symbol for turbulence

ICNG - Amount of airframe icing
- 0 = No icing
- 1 = Trace icing
- 2 = Trace to light icing
- 3 = Light icing
- 4 = Light to moderate icing

5 = Moderate icing
7 = Moderate to severe icing
8 = Severe icing

IBSE - Base of icing in feet

ITOP - Top of icing in feet

HBOI - Base of icing in meters

HTOI - Top of icing in meters

TPOI - Type of icing
1 = Rime
2 = Clear
3 = Mixed
4 = Rime in cloud
5 = Clear in cloud
6 = Mixed in cloud
7 = Rime in precipitation
8 = Clear in precipitation
9 = Mixed in precipitation
10 = Frost
11 = Non-persistent contrails
12 = Persistent contrails

ICSY - Graphics symbol for icing

WBSE - Base of weather in feet

WTOP - Top of weather in feet

HBWX - Base of weather in meters

HTWX - Top of weather in meters

CLC1 - Numeric cloud coverage 1

CBS1 - Cloud base 1 in feet

CTP1 - Cloud top 1 in feet

CB1M - Cloud base 1 in meters

CT1M - Cloud top 1 in meters

CLC2 - Numeric cloud coverage 2

CBS2 - Cloud base 2 in feet

CTP2 - Cloud top 2 in feet

CB2M - Cloud base 2 in meters

CT2M - Cloud top 2 in meters

ACRT - Aircraft report type

1 = AIREP - Aircraft report
2 = PIREP - Pilot report
3 = RECCO - Reconnaissance flight report
4 = AMDAR - Aircraft report (aircraft meteorological data relay)

SELV - Flight level in meters

FELV - Flight level in hundreds of feet

ITSY - Icing type symbol

TTSY - Turbulence type symbol

TFSY - Turbulence frequency symbol

ACTP - Character aircraft type

ATP1 - Numeric aircraft type

The numeric aircraft type is a real representation of up to four characters from the character aircraft type. ATP1 = v4 * 40 * 40 * 40 + v3 * 40 * 40 + v2 * 40 + v1. Each character corresponds to one of the values:

1 = -	9 = 5	17 = D	25 = L	33 = T
2 = .	10 = 6	18 = E	26 = M	34 = U
3 = /	11 = 7	19 = F	27 = N	35 = V
4 = 0	12 = 8	20 = G	28 = O	36 = W
5 = 1	13 = 9	21 = H	29 = P	37 = X
= 2	14 = A	22 = I	30 = Q	38 = Y
7 = 3	15 = B	23 = J	31 = R	39 = Z

8 = 4 16 = C 24 = K 32 = S

Any character not defined above is treated as a /.

MISCELLANEOUS PARAMETERS

VSBY - Visibility in statute miles

VSBK - Visibility in kilometers

VSBN - Visibility in nautical miles

VSBF - Character visibility in fractions of statute miles

VSBC - Character visibility in fractions of statute miles for all visibility numbers

PnnI - Precipitation over last nn hours in inches

nn = 01, 03, 06, 09, 12, 18 or 24

PnnM - Precipitation over last nn hours in millimeters

nn = 01, 03, 06, 09, 12, 18 or 24

DPRC - Character daily weather map precipitation in inches

PR24 - Precipitation over last 24 hours in inches, as sum of four successive 6-hour precip amounts

SNOW - Snow depth in inches

SNEW - Amount of new snow in inches

SNRT - Forecast snow and ice pellet accumulation to watch threshold ratio

SI12 - Forecast snow and ice pellet 12-h accumulation in inches

SNIP - Snow and ice pellet watch threshold in inches

FZRT - Forecast freezing rain accumulation to watch threshold ratio

FZ12 - Forecast Freezing rain 12-h accumulation in inches

FZRN - Freezing rain watch threshold in inches

WEQS - Water equivalent of snow on the ground in inches

HAIL - Hail flag

HLSZ - Hail size in centimeters

DDEN - Density of dry air in kg/(m**3)

PSYM - Montgomery stream function in m**2/(100*s**2)

HEAT - Heat index in Fahrenheit

HMTR - Humiture (apparent temperature) in Fahrenheit

WCEQ - Wind chill equivalent temperature in Fahrenheit

WCHT - Revised wind chill temperature in Fahrenheit

MSUN - Duration of sunshine in minutes

FFnn - Flash flood guidance for next nn hours in inches

nn = 01, 03, 06, 12 or 24

ITSO - Indicator for type of station operation and for present and past weather

Operation	Present and past weather data
1 = manned	included
2 = manned	omitted (no significant phenomena)
3 = manned	omitted (no observation, data N/A)
4 = automatic	included, using WMO Code 4677 and 4561
5 = automatic	omitted (no significant phenomena)

6 = automatic omitted (no observation, data N/A)
7 = automatic included, using WMO Code 4680 and 4531

TOST - Type of station (manned or automatic)
0 = automatic
1 = manned

STIM - Report hour and minutes as hhmm

TEXT - Undecoded data

SPCL - Undecoded special reports

MARK - Markers

SPACING PARAMETERS

BLNK - Plot a blank, not accounted for in FILTER

SPAC - Plot a space, accounted for in FILTER