ATMOSPHERIC THERMODYNAMIC FUNCTIONS

This section contains the standard thermodynamic functions that can be used with a specific procedure.
Go to page 6 for the start of any specific calculations

Enter Freezing temperature and freezing band

$TFC \equiv -10$ $FB \equiv 20$

1.0 Define CONSTANTS

$CPA \equiv 1004.675$ $RA \equiv CPA \cdot KA$ $KA \equiv \frac{2}{7}$

$CPV \equiv 1846.04$ $RV \equiv CPV \cdot KV$ $KV \equiv \frac{1}{4}$

$\varepsilon \equiv \frac{RA}{RV}$

$fCPA(M) := CPA + CPV \cdot M$ $fRA(M) := RA + RV \cdot M$ $fKA(M) := \frac{fRA(M)}{fCPA(M)}$

$P0 \equiv 100$ $PV0 \equiv 0.61068$

$T0 \equiv 273.15$ $TF \equiv T0 + TFC$ $G \equiv 9.8$

$PG \equiv 70$ $TG \equiv 280$ $MG \equiv 0.01$

$LV0 \equiv 2500840$ $LF0 \equiv 333660$

$CW \equiv 4190$ $CI \equiv 2090$

$\alpha L \equiv 52.91688$ $\alpha I \equiv 25.48597$

$\beta L \equiv 6806.171$ $\beta I \equiv 6286.1912$

$\Gamma L \equiv 5.078893$ $\Gamma I \equiv 0.528613$

2.0 FUNCTIONS: Vapor pressure, mixing ratio, virtual temperature

$$fPVL(T) \equiv \exp\left(\alpha L - \frac{\beta L}{T} - \Gamma L \cdot \ln(T)\right)$$

$$fPVI(T) \equiv \exp\left(\alpha I - \frac{\beta I}{T} - \Gamma I \cdot \ln(T)\right)$$

$$fPV(T) \equiv if(T > TF, fPVL(T), fPVI(T))$$

$$fMVS(P,T) \equiv \varepsilon \cdot \left(\frac{fPV(T)}{P - fPV(T)}\right)$$

$$fMVL(P,T) \equiv \varepsilon \cdot \left(\frac{fPVL(T)}{P - fPVL(T)}\right)$$

$$fPV2(P,M) \equiv M \cdot \frac{P}{M + \varepsilon}$$

$$fMS3(P,T,M) \equiv fMVS(P,T)$$

$$fMV3(P,T,M) \equiv if(fMVS(P,T) > M, M, fMVS(P,T))$$

$$fU3(P,T,M) := 100 \cdot \left[\frac{(M)}{fMVS(P,T)}\right]$$

$$fPV3(P,T,M) \equiv fMV3(P,T,M) \cdot \frac{P}{\varepsilon + fMV3(P,T,M)}$$

$$fPA3(P,T,M) \equiv P - fPV3(P,T,M)$$

$$fMC3(P,T,M) \equiv if(fMVS(P,T) < M, M - fMVS(P,T), 0)$$

$$fMLB(P,T,M) \equiv if\left(T > TF - FB, fMC3(P,T,M) \cdot \frac{T - TF + FB}{FB}, 0\right)$$

$$fML3(P,T,M) \equiv if(T \geq TF, fMC3(P,T,M), fMLB(P,T,M))$$

$$fMIB(P,T,M) \equiv if\left(T < TF, fMC3(P,T,M) \cdot \frac{TF - T}{FB}, 0\right)$$

$$fMI3(P,T,M) \equiv if(T < TF - FB, fMC3(P,T,M), fMIB(P,T,M))$$

3.0 ENTROPY

$$fSA(P,T) \equiv CPA\cdot\ln\left(\frac{T}{T0}\right) - RA\cdot\ln\left(\frac{P}{P0}\right)$$

$$fSV(P,T) \equiv CPV\cdot\ln\left(\frac{T}{T0}\right) - RV\cdot\ln\left(\frac{P}{PV0}\right) + \frac{LV0}{T0}$$

$$fSL(T) \equiv CW\cdot\ln\left(\frac{T}{T0}\right)$$

$$fSI(T) \equiv CI\cdot\ln\left(\frac{T}{T0}\right) - \frac{LF0}{T0}$$

$$fSA3(P,T,M) \equiv fSA(fPA3(P,T,M),T)$$

$$fSV3(P,T,M) \equiv fMV3(P,T,M)\cdot fSV(fPV3(P,T,M),T)$$

$$fSL3(P,T,M) \equiv fML3(P,T,M)\cdot fSL(T)$$

$$fSI3(P,T,M) \equiv fMI3(P,T,M)\cdot fSI(T)$$

$$fST3(P,T,M) \equiv fSA3(P,T,M) + fSV3(P,T,M) + fSL3(P,T,M) + fSI3(P,T,M)$$

$$fSM3(P,T,M) := \frac{fST3(P,T,M)}{(1+M)}$$

$$fSC(T) \equiv if(T > TF, fSL(T), fSI(T))$$

$$fAA3(P,T,M) \equiv fSA(P,T) + M\cdot fSC(T)$$

$$f\theta M4(P,T,M,PC) \equiv T\cdot\left(\frac{PC}{P}\right)^{\frac{RA+M\cdot RV}{CPA+M\cdot CPV}}$$

4.0 ENTHALPY

$$fHA(T) \equiv CPA\cdot(T - T0)$$

$$fHV(T) \equiv [CPV\cdot(T - T0) + LV0]$$

$$fHL(T) \equiv [CW\cdot(T - T0)]$$

$$fHI(T) \equiv [CI\cdot(T - T0) - LF0]$$

$$fHA3(P, T, M) \equiv fHA(T)$$

$$fHV3(P, T, M) \equiv fMV3(P, T, M)\cdot fHV(T)$$

$$fHL3(P, T, M) \equiv fML3(P, T, M)\cdot fHL(T)$$

$$fHI3(P, T, M) \equiv fMI3(P, T, M)\cdot fHI(T)$$

$$fHT3(P, T, M) \equiv fHA3(P, T, M) + fHV3(P, T, M) + fHL3(P, T, M) + fHI3(P, T, M)$$

$$fHC(T) \equiv if(T > TF, fHL(T), fHI(T))$$

$$fEE3(P, T, M) \equiv fHA(T) + M\cdot fHC(T)$$

$$fHW4(P, T, M, W) \equiv fHA(T) + M\cdot fHV(T) + if(W > TF, fHL(W), fHI(W))\cdot(fMVS(P, W) - M)$$

$$f\sigma 4(P, T, M, Z) \equiv fHT3(P, T, M) + G\cdot(1 + M)\cdot Z$$

5.0 VIRTUAL TEMPERATURE AND HEIGHT

$$fTV(T, M) \equiv T\cdot\left(\frac{1 + \frac{M}{\varepsilon}}{1 + M}\right)$$

$$fTV3(P, T, M) \equiv if\left[M < fMVS(P, T), fTV(T, M), fTV(T, fMVS(P, T))\cdot\left(\frac{1 + fMVS(P, T)}{1 + M}\right)\right]$$

$$f\alpha(P1, P2, TV1, TV2) \equiv \frac{G}{RA}\cdot\left(\frac{\ln\left(\frac{TV2}{TV1}\right)}{\ln\left(\frac{P2}{P1}\right)}\right)$$

$$fZ(P1, P2, TV1, TV2) \equiv \frac{TV2 - TV1}{f\alpha(P1, P2, TV1, TV2)}$$

SOLVER BLOCKS

ISENTROPIC EXPANSION
TEMPERATURE

Given

$fST3(P, TG, M) = S$

$fTSOL(S, P, M) := Find(TG)$

ISENTROPIC EXPANSION
PRESSURE

Given

$fST3(PG, T, M) = S$

$fPSOL(S, T, M) := Find(PG)$

ISENTROPIC DESSICATION TEMPERATURE

Given

$fAA3(P, TG, M) = S$

$fASOL(S, P, M) := Find(TG)$

ISENTHALPIC DESSICATION TEMPERATURE, EQUIVALENT TEMPERATURE

Given

$fEE3(P, TG, M) = H$

$fESOL(H, P, M) := Find(TG)$

MIXING RATIO FROM WET BULB

Given

$fHT3(P, W, fMVS(P, W)) = fHW4(P, T, MG, W)$

$fMSOL(P, T, W) := Find(MG)$

WET BULB FROM MIXING RATIO

Given

$fHT3(P, TG, fMVS(P, TG)) = fHW4(P, T, M, TG)$

$fWSOL(P, T, M) := Find(TG)$

LIFTING CONDENSATION LEVEL

Given

$fU3(PG, f\theta M4(P, T, M, PG), M) - 100 = 0$

$fCSOL(P, T, M) := Find(PG)$

DEW POINT

Given

$fPV2(P, M) = fPV(TG)$

$fDSOL(P, T, M) := Find(TG)$

by: L.Michaud, 8 Nov 2006.

Fetch and display sounding data
Ending α denotes property of the sounding

Fetch the San Juan average sounding for 13 Sept 2003 1800Z and 0000Z 14 Sept 2003

<u>READ SOUNDING DATA</u>

SDAT := READPRN("SANJUAN.prn")

Sounding Pressure (kPa)

$$P\alpha := \frac{SDAT^{\langle 1 \rangle}}{10}$$

Sounding Level (m)

$$ZW := SDAT^{\langle 2 \rangle}$$

Sounding Temperature (C)

$$TC\alpha := SDAT^{\langle 3 \rangle}$$

Sounding Dew Point (C)

$$TD\alpha := SDAT^{\langle 4 \rangle}$$

Sounding Realtive Humidity (%)

$$UW := SDAT^{\langle 5 \rangle}$$

Sounding Mixing Ratiol (g/kg)

$$MW := SDAT^{\langle 6 \rangle}$$

$P\alpha =$

	1
1	101.1
2	100
3	92.5
4	85
5	70
6	50
7	40
8	30
9	25
10	20
11	15
12	10
13	8.96
14	7
15	5
16	3
17	2

$TC\alpha =$

	1
1	27.8
2	27.8
3	21.6
4	16.6
5	8.2
6	-7.5
7	-19.9
8	-34.1
9	-41.1
10	-54.1
11	-62.9
12	-80.1
13	-76
14	-75.3
15	-69.3
16	-61.7
17	-57.7

$TD\alpha =$

	1
1	24.1
2	23.6
3	18.4
4	12.9
5	-4.8
6	-29.5
7	-36.9
8	-39.1
9	-65.1
10	-72.1
11	-80.5
12	-94.5
13	-84.3
14	-85.3
15	-81.3
16	-76.7
17	-74.7

Calculate sounding properties

$im := last(P\alpha)$ $i := 1 .. im$ $im = 17$

$jm := last(P\alpha) - 1$ $j := 1 .. jm$ $jm = 16$

Temperature in degree Kelvin

$T\alpha := TC\alpha + T0$

Mixing Ratio from dew point

$M\alpha := \overrightarrow{fMVL(P\alpha, TD\alpha + T0)}$

Entropy

$S\alpha := \overrightarrow{fST3(P\alpha, T\alpha, M\alpha)}$

Enthalpy

$H\alpha := \overrightarrow{fHT3(P\alpha, T\alpha, M\alpha)}$

Relative Humidity from mixing ratio-

$U\alpha := \overrightarrow{fU3(P\alpha, T\alpha, M\alpha)}$

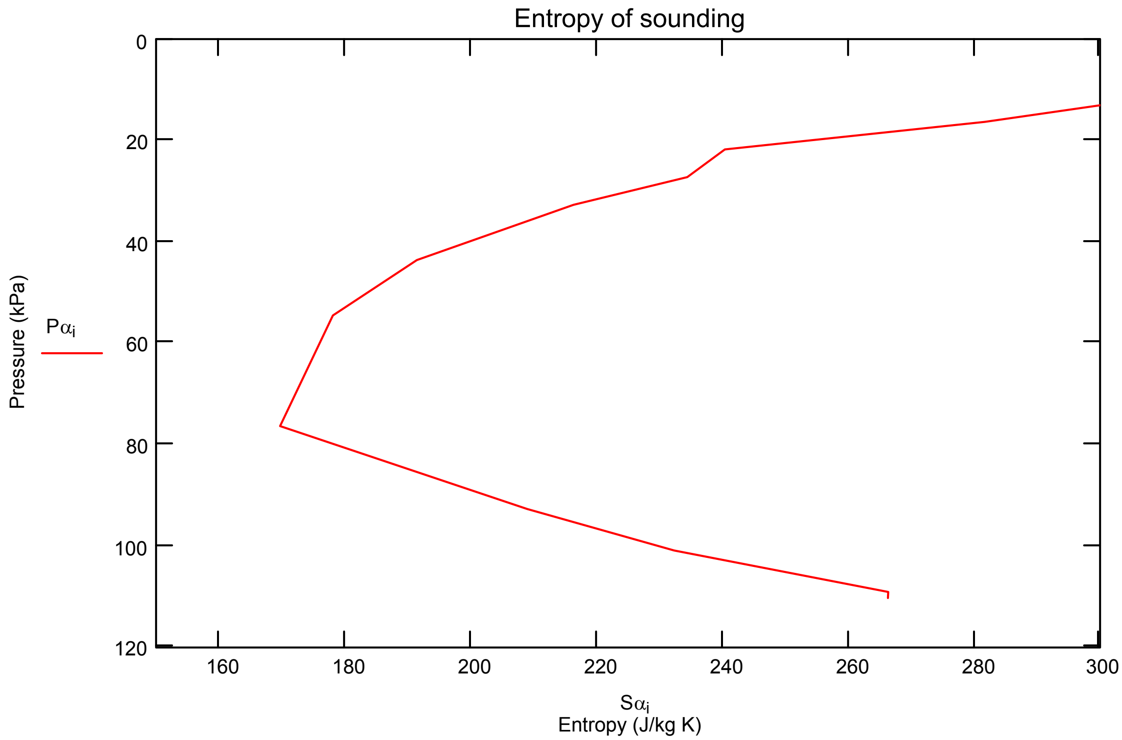
Virtual Temperature

$TV\alpha := \overrightarrow{fTV(T\alpha, M\alpha)}$

$$\rho\alpha := \overrightarrow{\left[P\alpha \cdot \frac{1000}{\frac{(RA + M\alpha \cdot RV)}{(1 + M\alpha)} \cdot T\alpha} \right]}$$

$P\alpha_i$ =	$T\alpha_i$ =	$M\alpha_i \cdot 1000$ =	MW_i =	$S\alpha_i$ =	$H\alpha_i$ =
101.1	300.95	19	19.06	266.29	76425
100	300.95	18.63	18.74	266.34	75480
92.5	294.75	14.54	14.62	232.34	58651
85	289.75	11.07	11.12	208.98	44696
70	281.35	3.83	3.84	169.72	17864
50	265.65	0.67	0.67	178.11	-5881
40	253.25	0.41	0.41	191.45	-18994
30	239.05	0.43	0.43	216.35	-33206
25	232.05	0.02	0.02	234.41	-41232
20	219.05	0.01	0.01	240.39	-54324
15	210.25	0	0	281.68	-63183
10	193.05	0	0	312.27	-80473
8.96	197.15	0	0	364.95	-76346
7	197.85	0	0	439.38	-75642
5	203.85	0.01	0.01	566.08	-69596
3	211.45	0.04	0.04	749.85	-61892
2	215.45	0.08	0.08	885.58	-57775

$P\alpha_i$ =	$U\alpha_i$ =	UW_i =	$TV\alpha_i$ =	$\rho\alpha_i$ =
101.1	79.76	80	304.36	1.157
100	77.32	78	304.3	1.145
92.5	81.62	82	297.32	1.084
85	78.4	79	291.68	1.015
70	39.02	39	282	0.865
50	15.26	15	265.76	0.655
40	24.95	21	253.31	0.55
30	84.73	60	239.11	0.437
25	8.85	6	232.05	0.375
20	16.33	9	219.05	0.318
15	15.08	19	210.25	0.249
10	19.04	27	193.05	0.18
8.96	57.76	20	197.15	0.158
7	43.83	20	197.85	0.123
5	33.43	16	203.85	0.085
3	22.89	12	211.46	0.049
2	17.92	10	215.46	0.032



Entropy of sounding
Pressure (kPa)
$P\alpha_i$
0
20
40
60
80
100
120
160
180
200
220
240
260
280
300
$S\alpha_i$
Entropy (J/kg K)

Calculate lapse rate and heights

$\alpha_1 := 0$

$\alpha_{j+1} := f\alpha\left(P\alpha_j, P\alpha_{j+1}, TV\alpha_j, TV\alpha_{j+1}\right)$

$Z_{j+1} := -fZ\left(P\alpha_j, P\alpha_{j+1}, TV\alpha_j, TV\alpha_{j+1}\right)$

$ZC_1 := ZW_1$

$ZC_{j+1} := Z_{j+1} + ZC_j$

$ZD := ZW - 0$

$\alpha \cdot (-1000) =$

	1
1	0
2	-0.669
3	-10.158
4	-7.733
5	-5.932
6	-6.02
7	-7.338
8	-6.846
9	-5.611
10	-8.822
11	-4.866
12	-7.187
13	6.534
14	0.49
15	3.032
16	2.448
17	1.58

$Z =$

	1
1	0
2	98
3	687
4	729
5	1631
6	2698
7	1696
8	2074
9	1258
10	1474
11	1808
12	2393
13	628
14	1428
15	1979
16	3107
17	2535

$ZC =$

	1
1	19
2	117
3	803
4	1533
5	3164
6	5862
7	7558
8	9632
9	10890
10	12364
11	14173
12	16566
13	17194
14	18622
15	20601
16	23708
17	26243

$ZD =$

	1
1	19
2	102
3	789
4	1518
5	3147
6	5850
7	7550
8	9630
9	10890
10	12420
11	14220
12	16570
13	17061
14	18630
15	20470
16	23590
17	26150

Calculate surface pressure reduction using the TWO GUESSES METHOD.

Define air properties at large radius - State 1

$P1 := P\alpha_1$ $\quad$ $P1 = 101.1$

$T1 := T\alpha_1$ $\quad$ $T1 - T0 = 27.8$

$M1 := \frac{MW_1}{1000}$ $\quad$ $M1 \cdot 1000 = 19.06$

$H1 := fHT3(P1, T1, M1)$ $\quad$ $H1 = 76574$

$S1 := fST3(P1, T1, M1)$ $\quad$ $S1 = 266.8$

Define P4 pressure - State 4

$n := 12$ $\quad$ $P4 := P\alpha_n$ $\quad$ $P4 = 10$

ENTER SEA SURFACE TEMPERATURE

$SSTC := 27.5$

$SST := T0 + SSTC$

ENTER TEMPERATURE AND HUMIDITY APPROACHES

$A := 2$ $\quad$ $B := 3$

Calculate T3 and U3

$T3 := SST - A$ $\quad$ $T3 = 298.65$ $\quad$ $T3 - T0 = 25.5$

$U3 := 100 - B$ $\quad$ $U3 = 97$

Enter first guess for eyewall base pressure and calculate second guess

$PC3_1 := 94$

$PC3_2 := PC3_1 - 0.5$

Calculate surface air mixing ratio

$MC3 := \overrightarrow{fMVS(PC3, T3) \cdot \frac{U3}{100}}$ $\quad$ $MC3 \cdot 1000 = \begin{pmatrix} 21.66 \\ 21.78 \end{pmatrix}$

Calculate air properties at State 3

$SC3 := \overrightarrow{fST3(PC3, T3, MC3)}$ $\quad$ $SC3 = \begin{pmatrix} 302.7 \\ 305.31 \end{pmatrix}$

$HC3 := \overrightarrow{fHT3(PC3, T3, MC3)}$ $\quad$ $HC3 = \begin{pmatrix} 80810 \\ 81116 \end{pmatrix}$

Calculate air properties at Point 4

$TC4 := \overrightarrow{fTSOL(SC3, P4, MC3)}$ $\qquad TC4 = \begin{pmatrix} 199.12 \\ 199.65 \end{pmatrix}$

$HC4 := \overrightarrow{fHT3(P4, TC4, MC3)}$ $\qquad HC4 = \begin{pmatrix} -84934 \\ -84427 \end{pmatrix}$

Calculate static energy at state 4

$\sigma C4 := \overrightarrow{f\sigma 4(P4, TC4, MC3, ZD_n)}$ $\qquad \sigma C4 = \begin{pmatrix} 80969 \\ 81496 \end{pmatrix}$

Calculate the work for the two guesses

$WC := (HC3 - \sigma C4)$ $\qquad WC = \begin{pmatrix} -159 \\ -380 \end{pmatrix}$

Calculate the pressure P3 required to make the work zero

<u>MINMUM EYEWALL PRESSURE (kPa)</u>

$$P3 := PC3_1 - (PC3_1 - PC3_2) \cdot \left[\frac{WC_1}{(WC_1 - WC_2)} \right] \qquad P3 = 94.36$$

Calculate base pressure reduction

$P13 := P1 - P3$ $\qquad P13 = 6.74$

Calculate air properties at State 3

$M3 := fMVS(P3, T3) \cdot \frac{U3}{100}$ $\qquad M3 \cdot 1000 = 21.58$

$S3 := fST3(P3, T3, M3)$ $\qquad S3 = 300.84$

$H3 := fHT3(P3, T3, M3)$ $\qquad H3 = 80592$

Calculate air properties at State 4
Check temperatures at equilibrium level

$T4 := fTSOL(S3, P4, M3)$ $\qquad T4 = 198.73 \qquad T4 - T0 = -74.42$

$TV4 := fTV3(P4, T4, M3)$ $\qquad TV4 = 194.54 \qquad TV4 - T0 = -78.61$

$TV\alpha_n = 193.05 \qquad TV\alpha_n - T0 = -80.1$

$H4 := fHT3(P4, T4, M3)$ $\qquad H4 = -85296$

Calculate air properties at State 2

$T2 := fTSOL(S1, P3, M1)$ $\qquad T2 = 295.87 \qquad T2 - T0 = 22.72$

$H2 := fHT3(P3, T2, M1)$ $\qquad H2 = 70490$

$T3 = 298.65 \qquad T3 - T0 = 25.5$

Work and Heat calculations

$W12 := H1 - H2$ $W12 = 6085$

MAXIMUM HURRICANE WIND VELOCITY (m/s)

$V2 := \sqrt{2 \cdot W12}$ $V2 = 110.31$

$Q23r := H3 - H2$ $Q23r = 10103$

$Q13i := H3 - H1$ $Q13i = 4018$

$ZD_n = 16570$

$\mu 4 := H4 + ZD_n \cdot (1 + M3) \cdot G$ $\mu 4 = 80594$

$M\_DEL := M3 - M1$ $M\_DEL \cdot 1000 = 2.52$

Calculate Updraft properties

$T\beta := \overrightarrow{fTSOL(S3, P\alpha, M3)}$

$S3 = 300.84$

$M3 = 0.02$

$$\rho\beta := \overrightarrow{\left[P\alpha \cdot \frac{1000}{\frac{(RA + M3 \cdot RV)}{(1 + M3)} \cdot T\beta} \right]}$$

$T\beta_i =$	$\rho\beta_i =$	$P\alpha_i =$
304.57	1.142	101.1
303.62	1.133	100
297.61	1.069	92.5
294.78	0.992	85
288.16	0.836	70
276.06	0.623	50
267.33	0.515	40
256.5	0.402	30
249.01	0.345	25
238.25	0.289	20
221.68	0.233	15
198.73	0.173	10
192.87	0.16	8.96
180.29	0.134	7
164.44	0.105	5
143	0.072	3
128	0.054	2

Hydrostatic Base Pressure Calculation - Air-Sea Interaction case

$q := 14$

$PK := P\alpha_q$

$PK = 7$

$M3 \cdot 1000 = 21.58$

$S3 = 300.84$

$PHK_1 := P\alpha_q$

$PHK_2 := PHK_1 + 3$

$m := 3..21$
$z := 1..21$

$PHK_m := \left[PHK_2 + 5 \cdot (m - 2) \right]$

$TK_z := \overrightarrow{fTSOL\left(S3, PHK_z, M3\right)}$

$TU_z := TK_z - T0$

$TVK_z := fTV3\left(PHK_z, TK_z, M3\right)$

$UK := \overrightarrow{fU3(PHK, TK, M3)}$

$$\rho K_z := PHK_z \cdot \frac{1000}{\frac{(RA + M3 \cdot RV)}{(1 + M3)} \cdot TK_z}$$

	PHK	TK	TVK	UK
	1	1	1	1
1	7	180.29	176.48	$4.5 \cdot 10^6$
2	10	198.73	194.54	265436
3	15	221.68	217.05	15960.6
4	20	238.25	233.48	3073.2
5	25	249.01	244.43	1255.2
6	30	256.5	252.28	730.5
7	35	262.41	258.67	495.6
8	40	267.33	264.31	346.8
9	45	272.03	269.66	273.9
10	50	276.06	274.36	226.9
11	55	279.6	278.57	194.5
12	60	282.74	282.39	170.9
13	65	285.58	285.88	153
14	70	288.16	289.11	139
15	75	290.53	292.12	127.8
16	80	292.73	294.94	118.5
17	85	294.78	297.59	110.8
18	90	296.7	300.1	104.2
19	95	299.22	303.07	94.3
20	100	303.62	307.52	76.3
21	105	307.86	311.81	62.5

$ZK_2 := ZD_n$

$PHK_{20} = 100$

$ZK_2 = 16570$

$m := 2 .. 20$

$DKZ_m := fZ\left[PHK_m, PHK_{(m+1)}, TVK_m, TVK_{(m+1)}\right]$

$ZK_{(m+1)} := ZK_m - DKZ_m$

$PHK_{16} = 80$ $ZK_{16} = 1488$

$TVK_{16} = 294.94$

$TVK0 := TVK_{16} + ZK_{16} \cdot \frac{G}{CPA}$

DKZ =

	1
1	0
2	2441.6
3	1897.3
4	1561.5
5	1326.2
6	1153.5
7	1022.7
8	921.1
9	839.4
10	771.8
11	714.8
12	666.1
13	624.1
14	587.3
15	554.9
16	526.1
17	500.3
18	477.6
19	458.7

ZK =

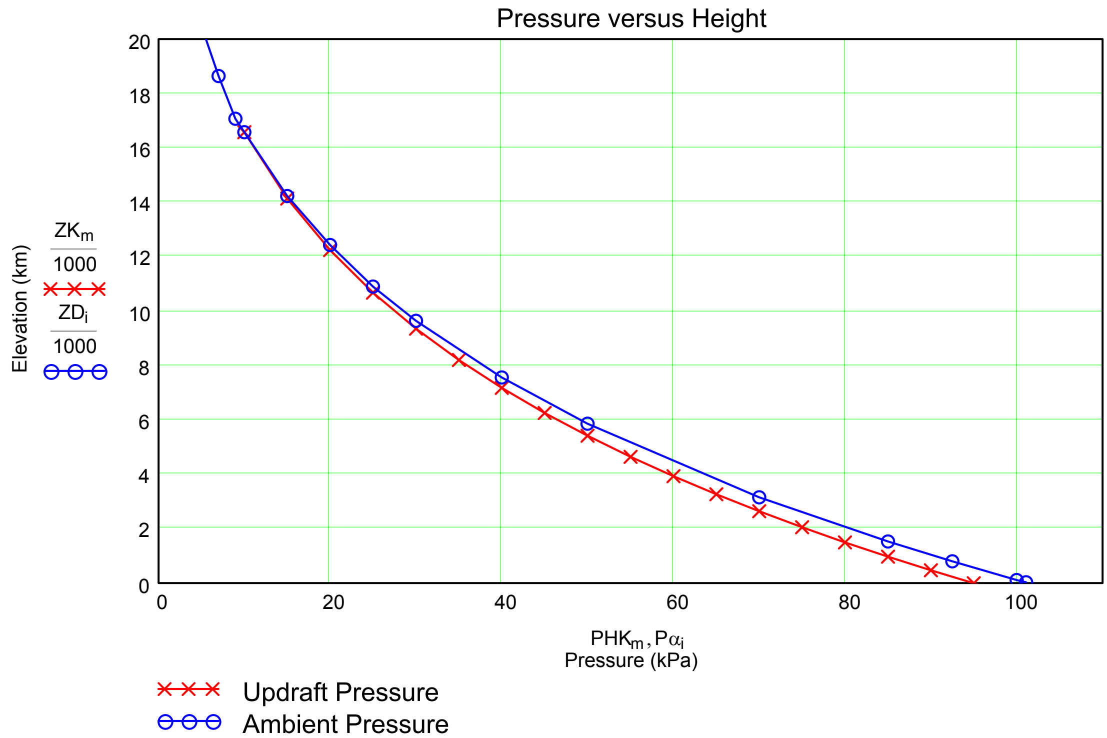
	1
1	0
2	16570
3	14128.4
4	12231
5	10669.5
6	9343.3
7	8189.8
8	7167.1
9	6246.1
10	5406.7
11	4634.9
12	3920
13	3253.9
14	2629.8
15	2042.5
16	1487.6
17	961.6
18	461.2
19	-16.4

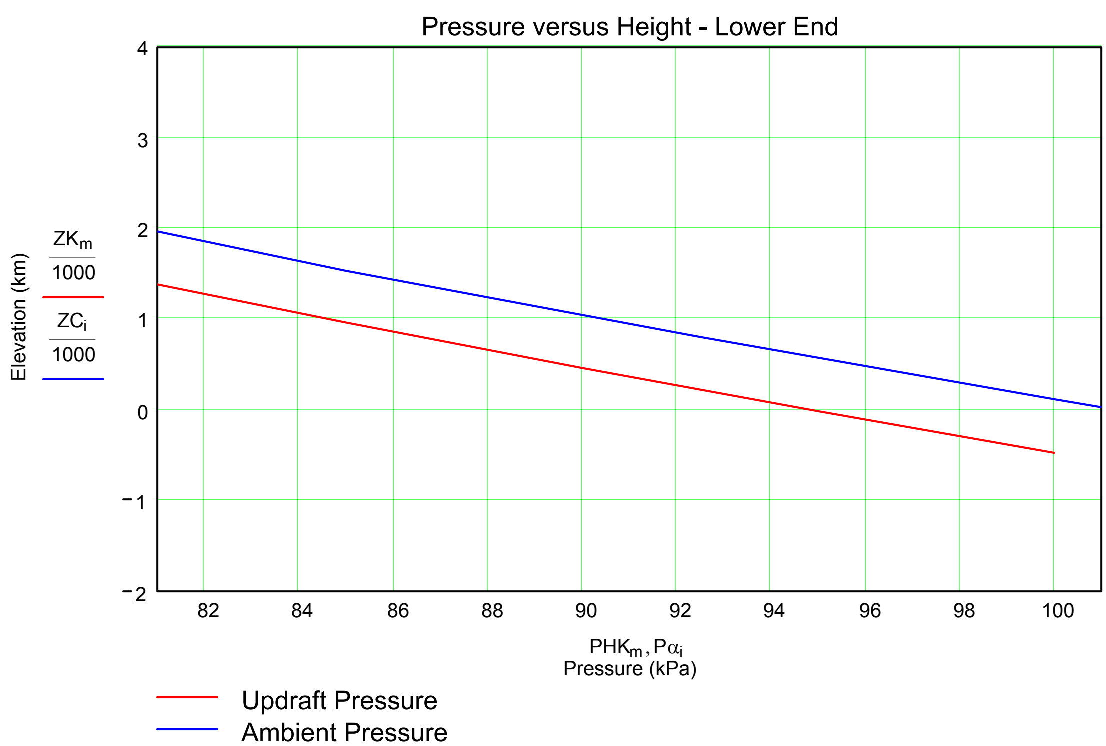
ρK =

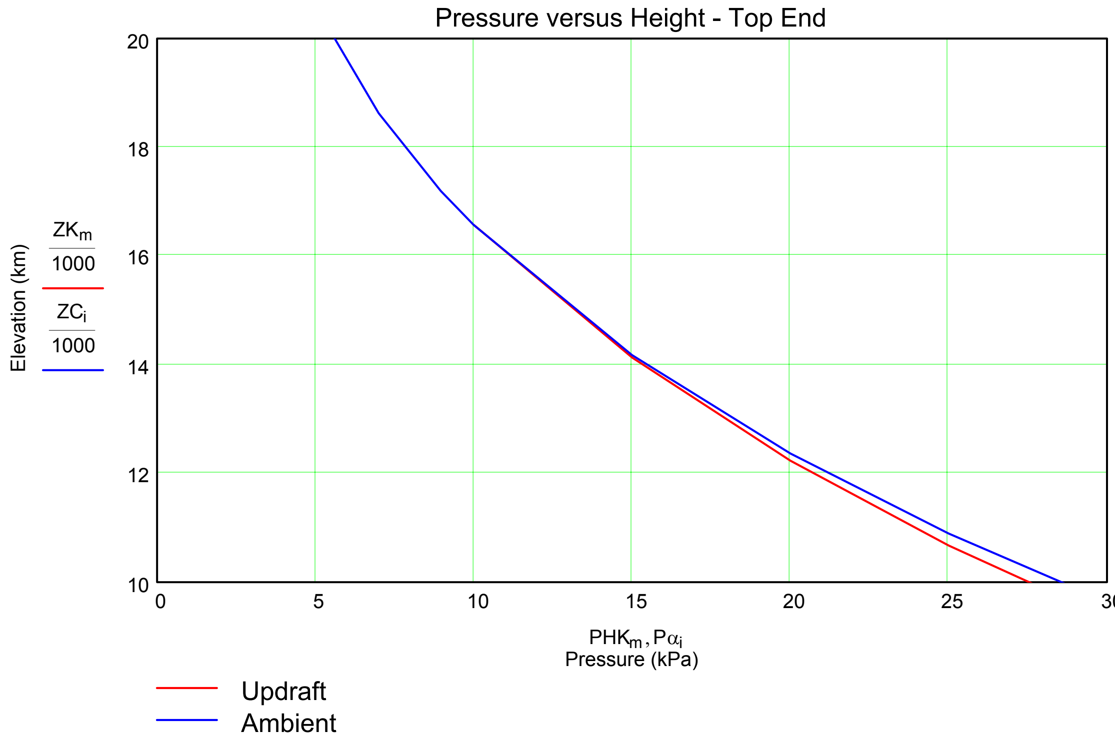
	1
1	0.134
2	0.173
3	0.233
4	0.289
5	0.345
6	0.402
7	0.459
8	0.515
9	0.569
10	0.623
11	0.677
12	0.73
13	0.783
14	0.836
15	0.888
16	0.94
17	0.992
18	1.043
19	1.092
20	1.133

PHK =

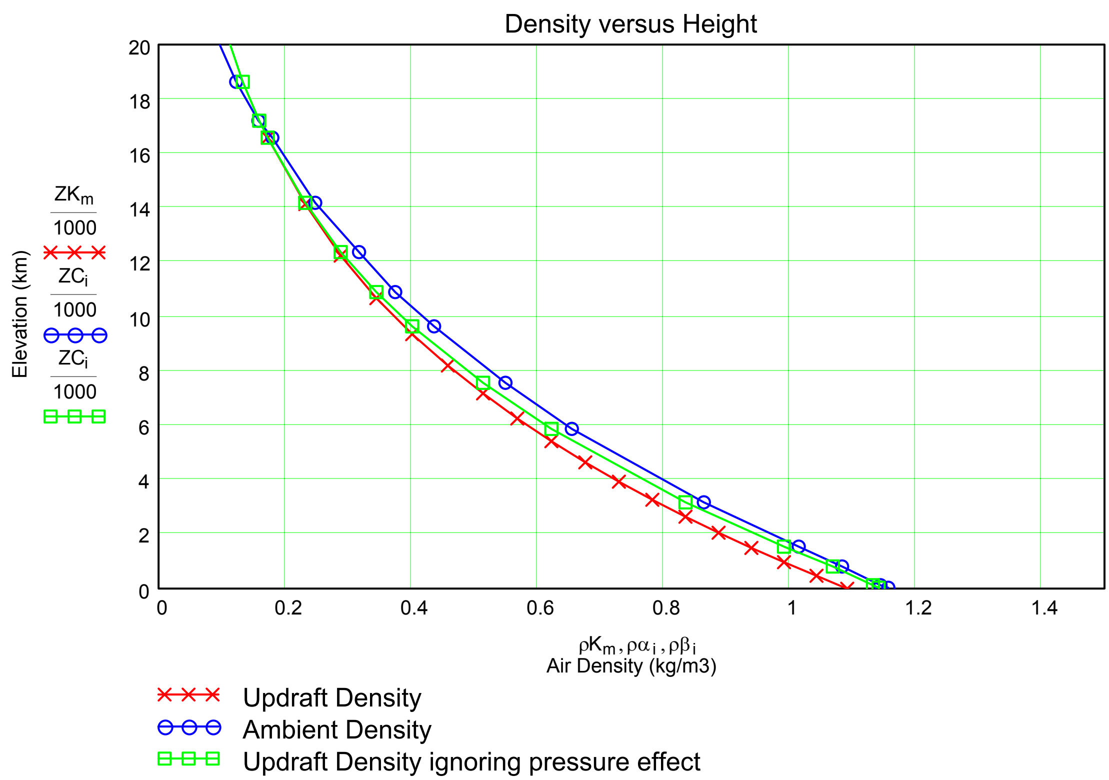
	1
1	7
2	10
3	15
4	20
5	25
6	30
7	35
8	40
9	45
10	50
11	55
12	60
13	65
14	70
15	75
16	80
17	85
18	90
19	95
20	100


Pressure versus Height
Elevation (km)
ZKm / 1000
ZDi / 1000
PHKm, Pαi
Pressure (kPa)
Updraft Pressure
Ambient Pressure

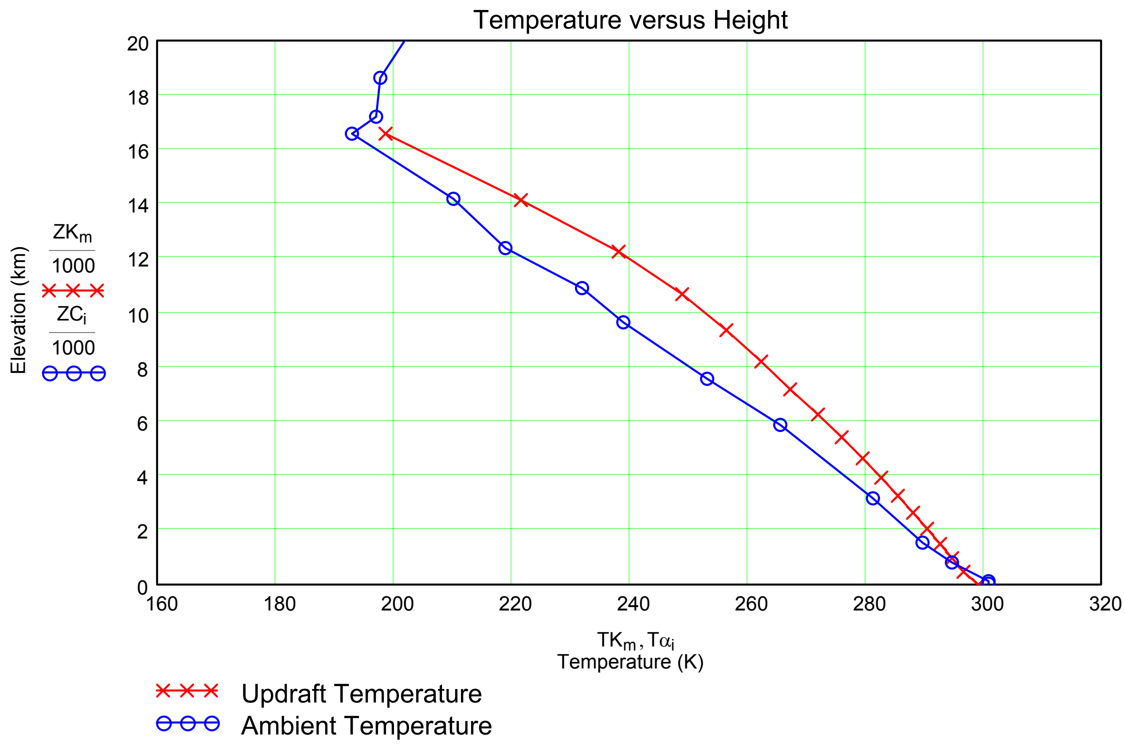

Pressure versus Height - Lower End
Elevation (km)
ZKm / 1000
ZCi / 1000
PHKm, Pαi
Pressure (kPa)
Updraft Pressure
Ambient Pressure



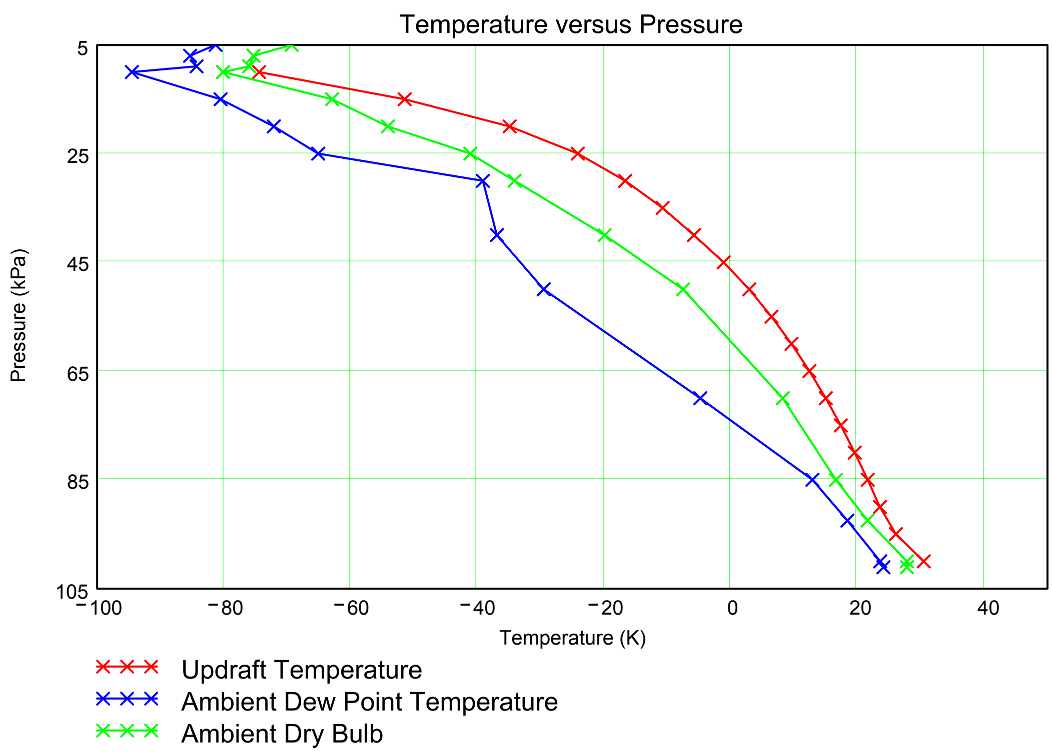
Pressure versus Height - Top End
Elevation (km)
ZKm / 1000
ZCi / 1000
20
18
16
14
12
10
0
5
10
15
20
25
30
PHKm, Pαi
Pressure (kPa)
Updraft
Ambient



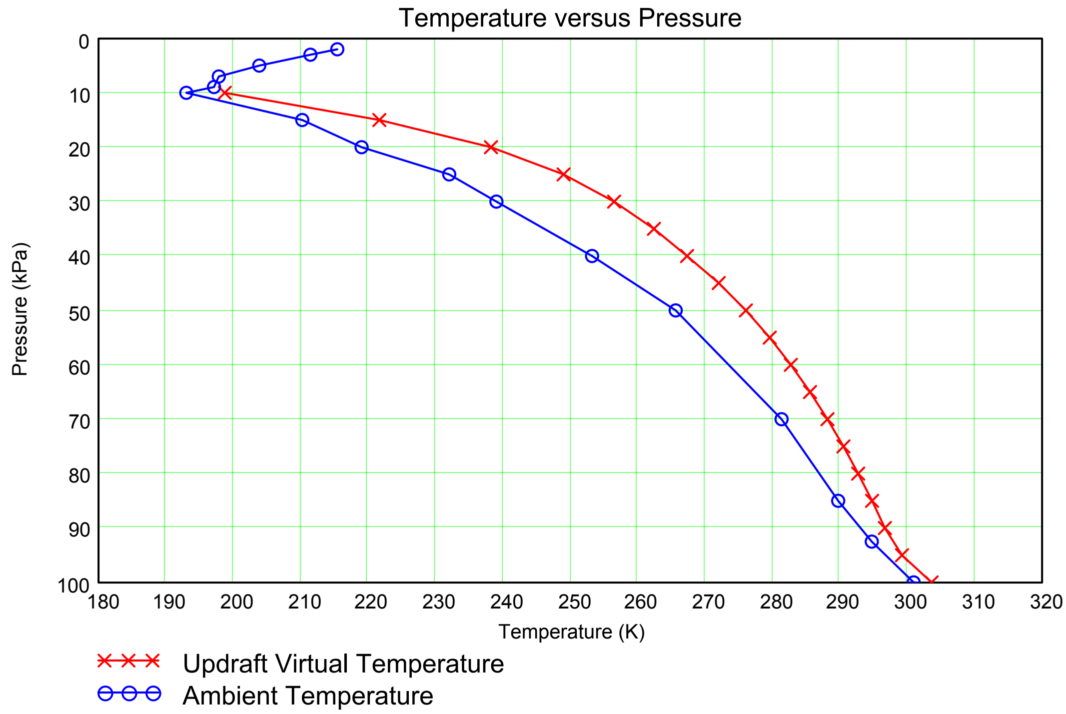
Density versus Height
Elevation (km)
ZKm / 1000
ZCi / 1000
ZCi / 1000
20
18
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
ρKm, ραi, ρβi
Air Density (kg/m3)
Updraft Density
Ambient Density
Updraft Density ignoring pressure effect

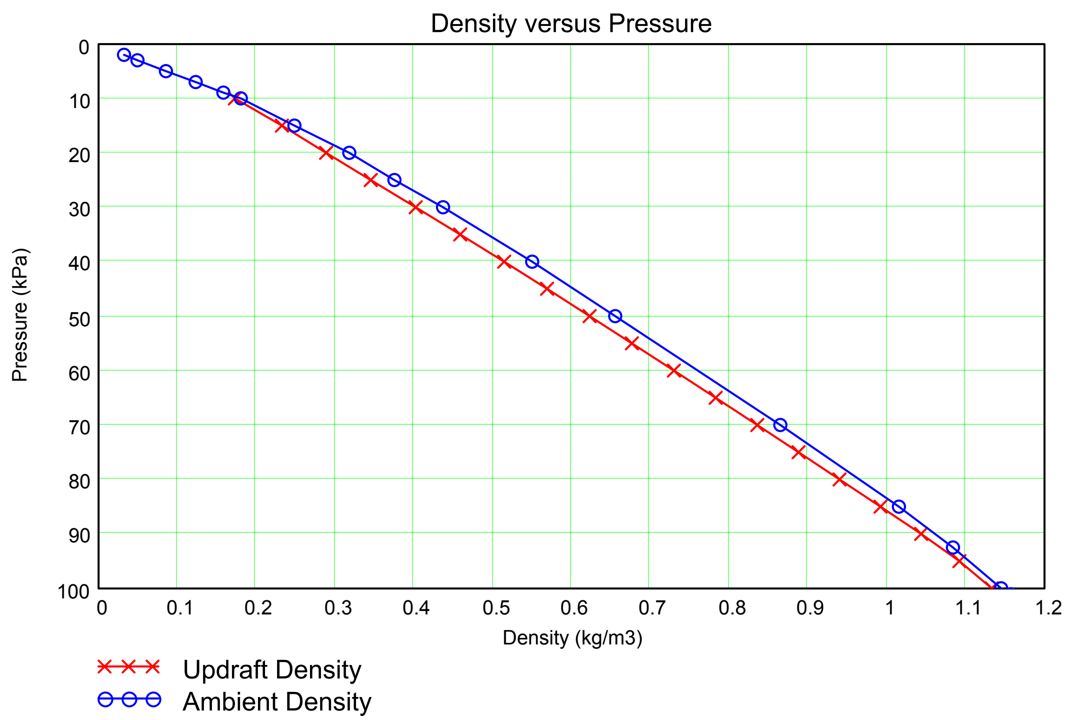


Temperature versus Height
Elevation (km)
$\frac{ZK_m}{1000}$
$\frac{ZC_i}{1000}$
$TK_m, T\alpha_i$
Temperature (K)
Updraft Temperature
Ambient Temperature



Temperature versus Pressure
Pressure (kPa)
Temperature (K)
Updraft Temperature
Ambient Dew Point Temperature
Ambient Dry Bulb


Temperature versus Pressure
Pressure (kPa)
Temperature (K)
Updraft Virtual Temperature
Ambient Temperature


Density versus Pressure
Pressure (kPa)
Density (kg/m3)
Updraft Density
Ambient Density

$$ZPPLOT^{\langle 1 \rangle} := \frac{ZC}{1000}$$

$$ZPPLOT^{\langle 2 \rangle} := \frac{ZK}{1000}$$

$$ZPPLOT^{\langle 3 \rangle} := \rho K$$

$$ZPPLOT^{\langle 4 \rangle} := \rho \alpha$$

$$ZPPLOT^{\langle 5 \rangle} := TK$$

$$ZPPLOT^{\langle 6 \rangle} := T\alpha$$

$$ZPPLOT = \begin{pmatrix} 0.02 & 0 & 0.13 & 1.16 & 180.29 & 300.95 \\ 0.12 & 16.57 & 0.17 & 1.14 & 198.73 & 300.95 \\ 0.8 & 14.13 & 0.23 & 1.08 & 221.68 & 294.75 \\ 1.53 & 12.23 & 0.29 & 1.02 & 238.25 & 289.75 \\ 3.16 & 10.67 & 0.35 & 0.86 & 249.01 & 281.35 \\ 5.86 & 9.34 & 0.4 & 0.66 & 256.5 & 265.65 \\ 7.56 & 8.19 & 0.46 & 0.55 & 262.41 & 253.25 \\ 9.63 & 7.17 & 0.51 & 0.44 & 267.33 & 239.05 \\ 10.89 & 6.25 & 0.57 & 0.38 & 272.03 & 232.05 \\ 12.36 & 5.41 & 0.62 & 0.32 & 276.06 & 219.05 \\ 14.17 & 4.63 & 0.68 & 0.25 & 279.6 & 210.25 \\ 16.57 & 3.92 & 0.73 & 0.18 & 282.74 & 193.05 \\ 17.19 & 3.25 & 0.78 & 0.16 & 285.58 & 197.15 \\ 18.62 & 2.63 & 0.84 & 0.12 & 288.16 & 197.85 \\ 20.6 & 2.04 & 0.89 & 0.09 & 290.53 & 203.85 \\ 23.71 & 1.49 & 0.94 & 0.05 & 292.73 & 211.45 \\ 26.24 & 0.96 & 0.99 & 0.03 & 294.78 & 215.45 \\ 0 & 0.46 & 1.04 & 0 & 296.7 & 0 \\ 0 & -0.02 & 1.09 & 0 & 299.22 & 0 \\ 0 & -0.48 & 1.13 & 0 & 303.62 & 0 \\ 0 & -0.92 & 1.17 & 0 & 307.86 & 0 \end{pmatrix}$$

WRITEPRN("ISABEL_PLOT.prn") := ZPPLOT