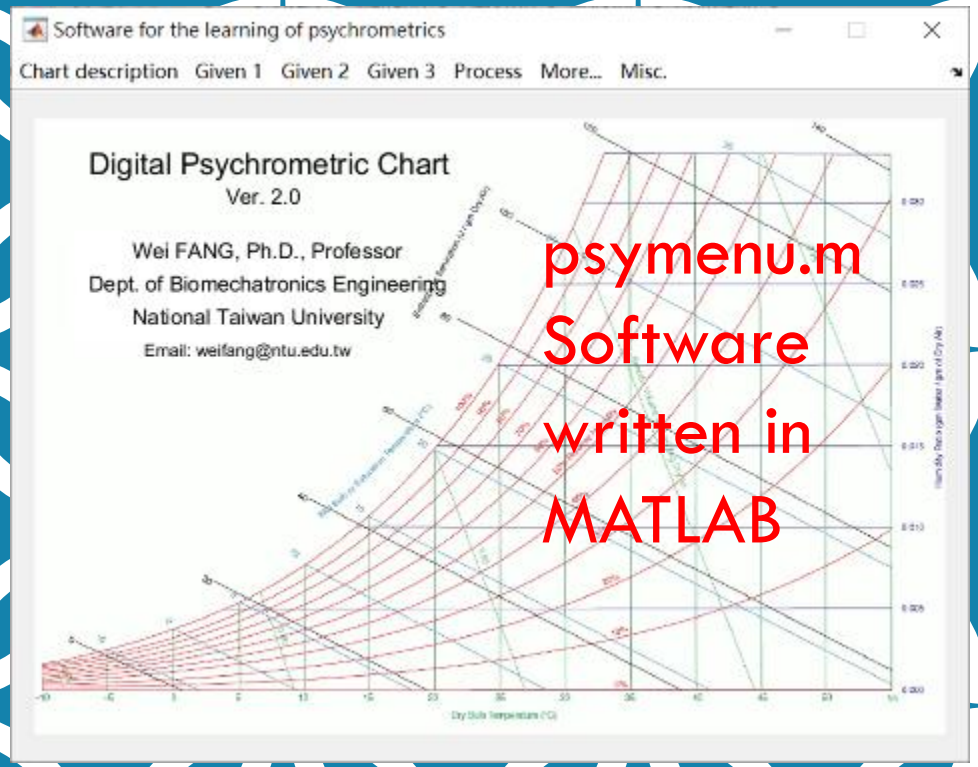
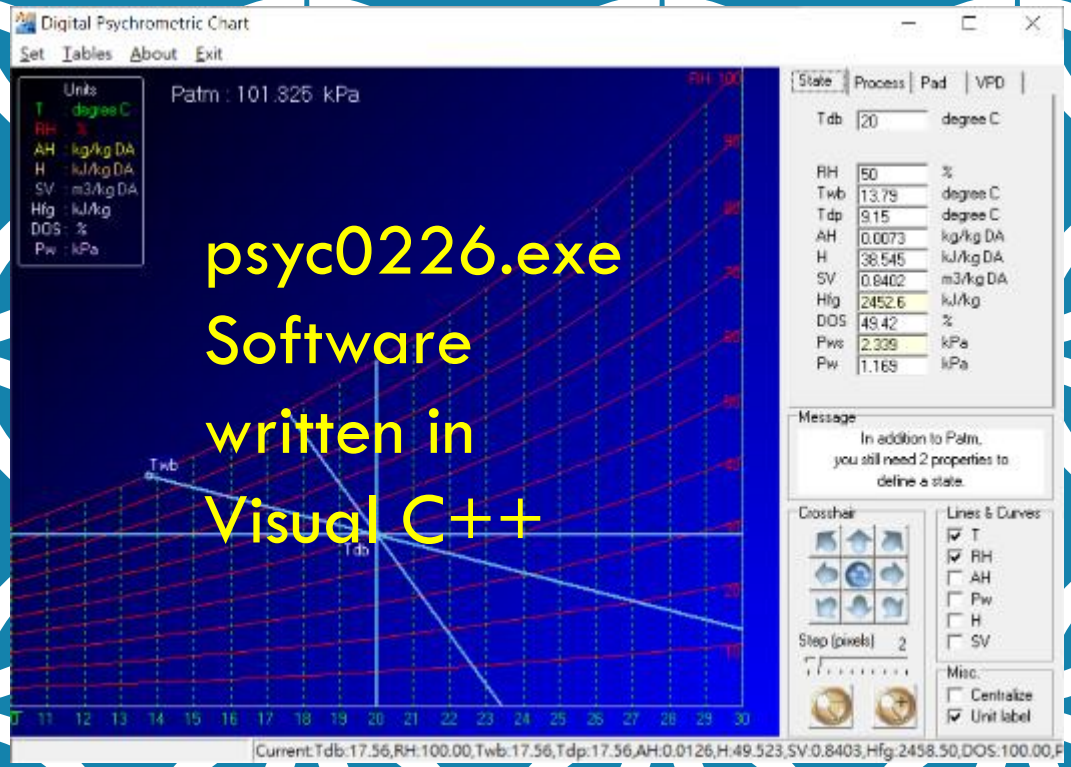
數位化溫室工程

1. 太陽軌跡與能量
2. 濕空氣熱力特性
3. 溫室通風與成本
4. 蒸發降溫系統
5. 溫室供暖
6. 二氧化碳施肥
7. 植物蒸散模式





Wei FANG, Ph.D., Professor
Dept. of Biomechatronics Engineering
National Taiwan University

MATLAB™ BASED SOFTWARE RELATED TO PSYCHROMETRICS

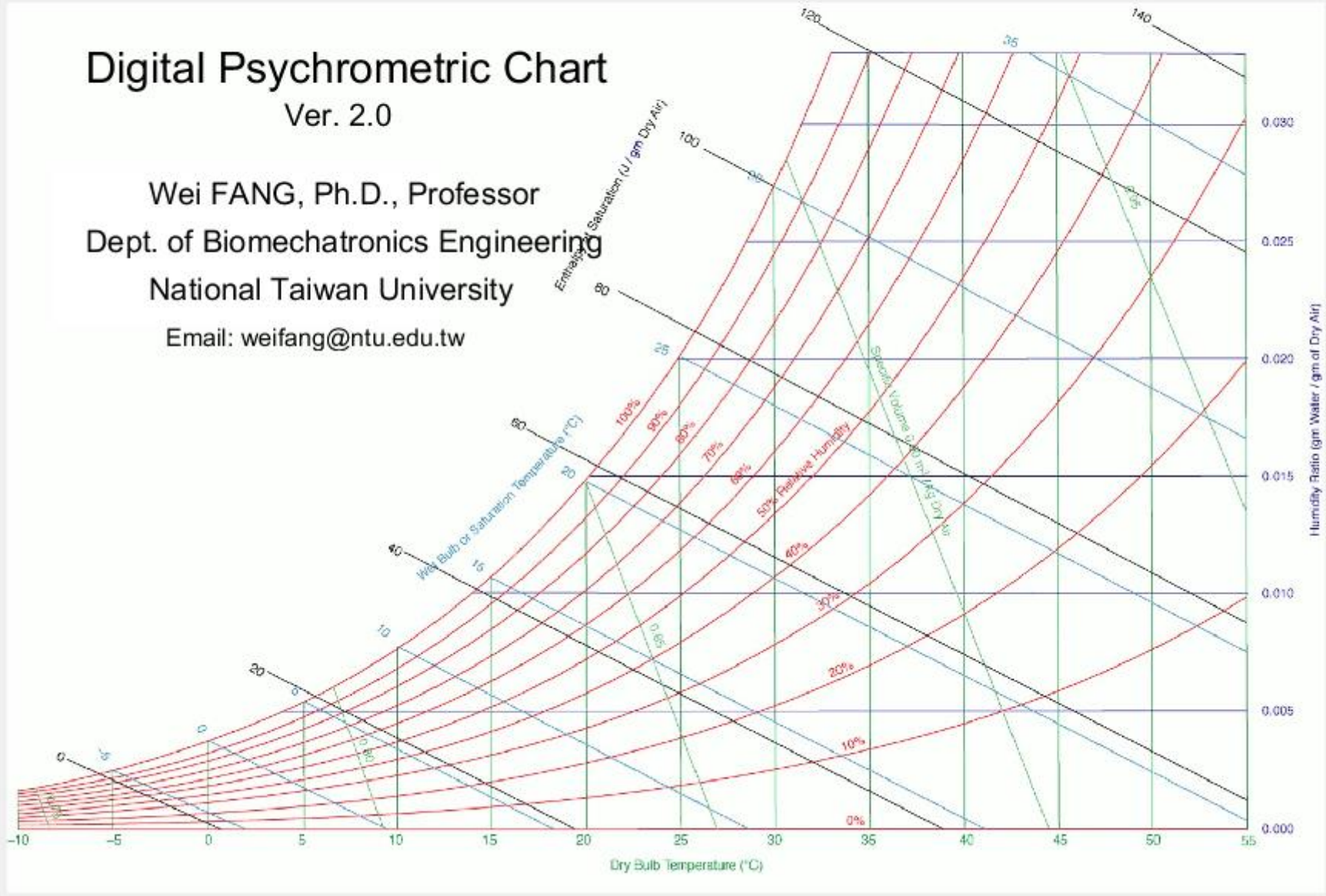
濕空氣熱力特性

How to start

- Download the psymenu.zip file
- Unzip it and copy all files to an assigned directory, say ‘psymenu’
- Run the Matlab software
- Assigned the working directory to the ‘psymenu’ directory
- Type dir, press Enter to make sure there are .m, .dat files, and a subdirectory ‘pic’ containing pictures
- Type ‘psymenu’ in the command window, press Enter.
- A window will appear as shown in the next page

Software for the learning of psychrometrics

Chart description Known 1 property 2 properties 3 properties Process More... Misc.



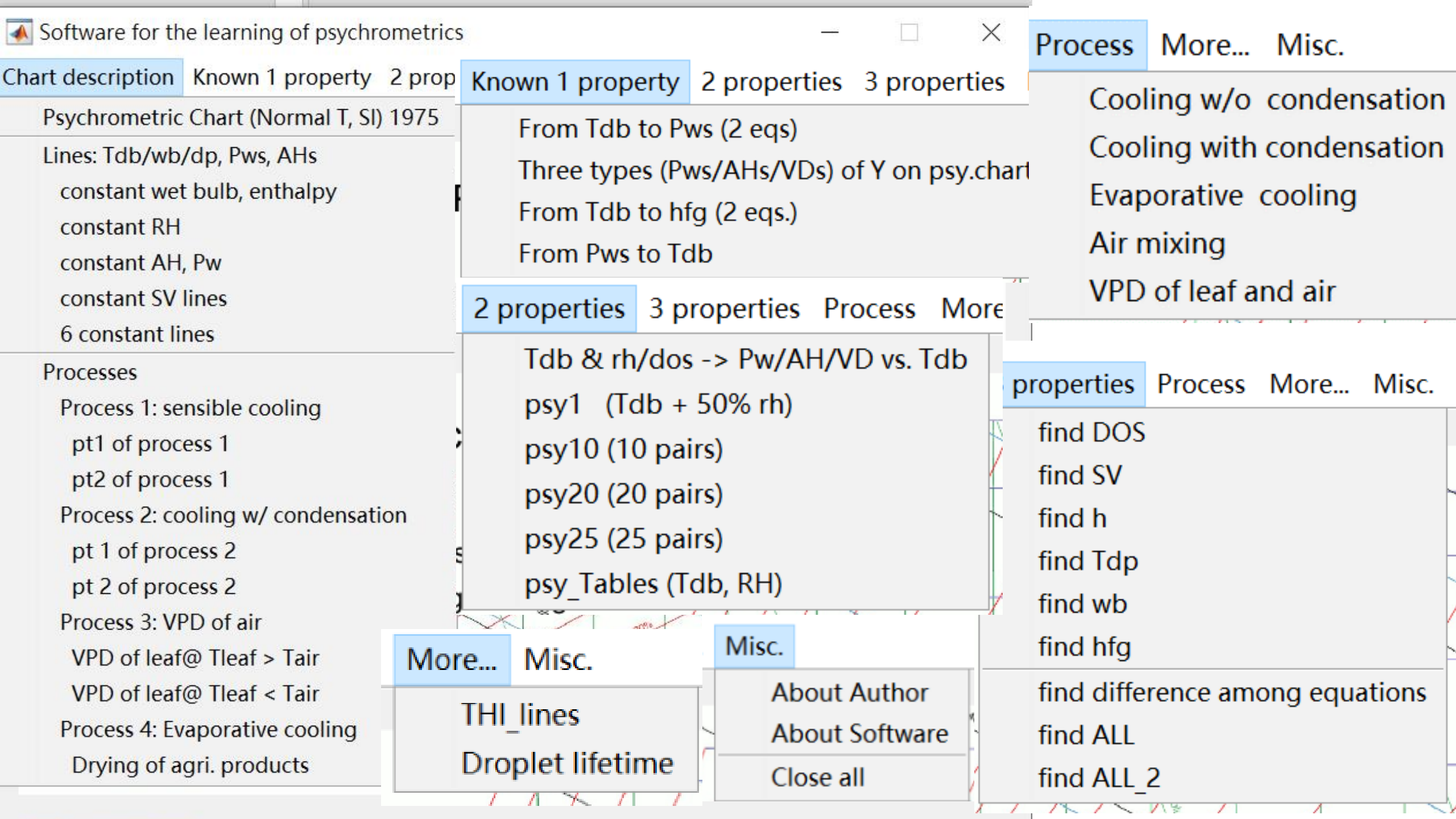
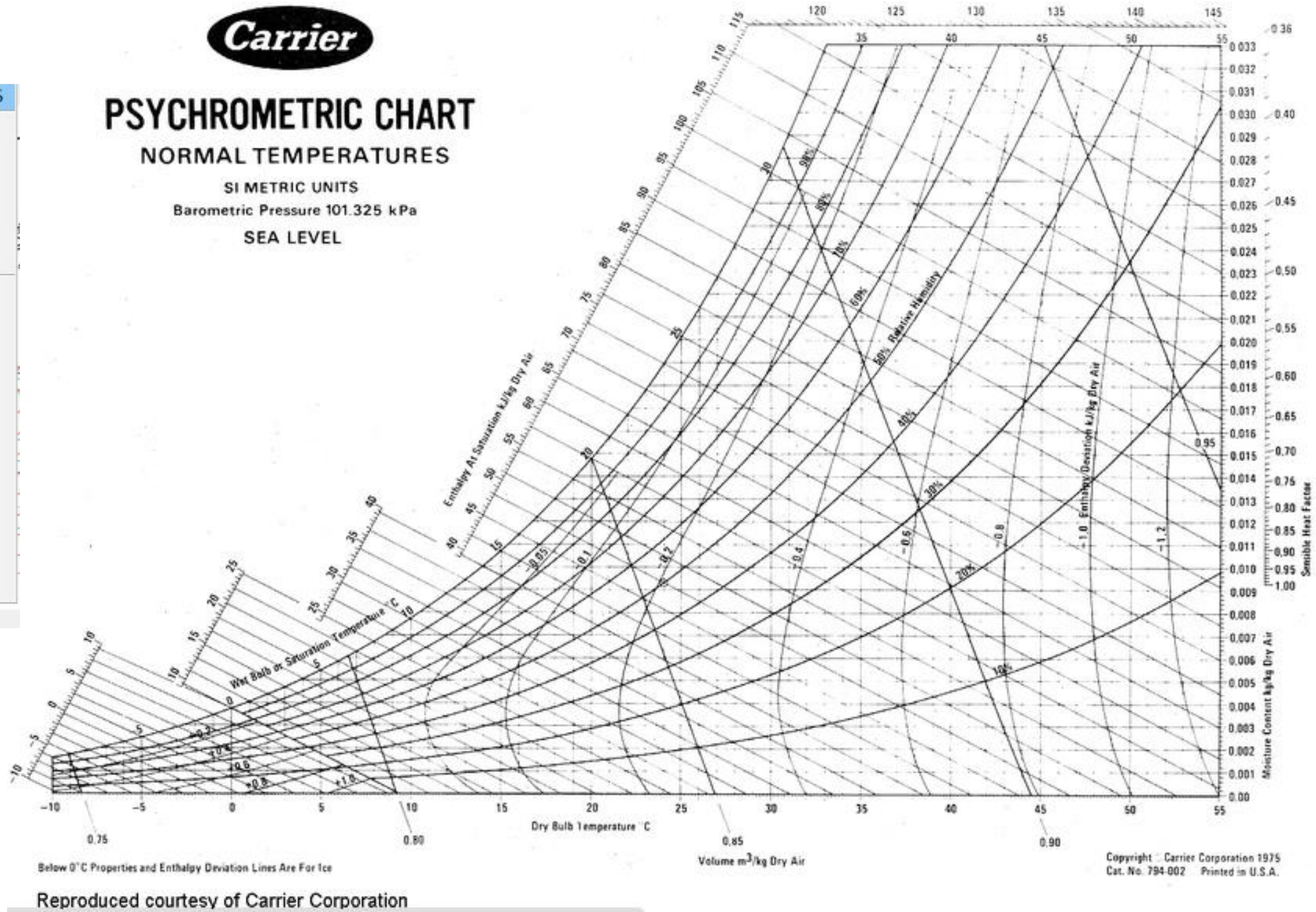
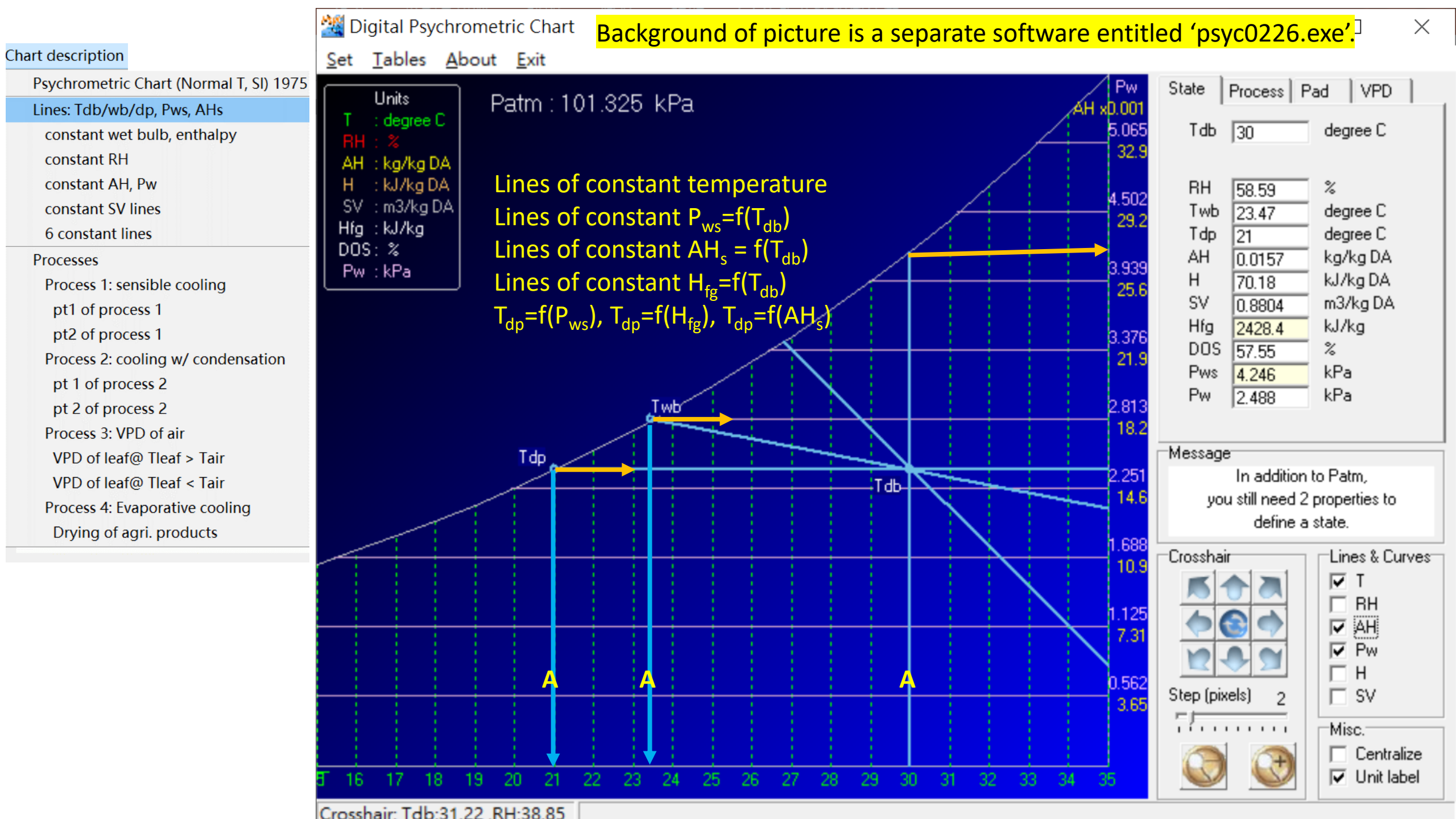

Software for the learning of psychrometrics
Chart description
Known 1 property
2 prop
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Known 1 property
2 properties
3 properties
From Tdb to Pws (2 eqs)
Three types (Pws/AHs/VDs) of Y on psy.chart
From Tdb to hfg (2 eqs.)
From Pws to Tdb
2 properties
3 properties
Process
More
Tdb & rh/dos -> Pw/AH/VD vs. Tdb
psy1 (Tdb + 50% rh)
psy10 (10 pairs)
psy20 (20 pairs)
psy25 (25 pairs)
psy_Tables (Tdb, RH)
More...
Misc.
THI_lines
Droplet lifetime
Misc.
About Author
About Software
Close all
Process
More...
Misc.
Cooling w/o condensation
Cooling with condensation
Evaporative cooling
Air mixing
VPD of leaf and air
properties
Process
More...
Misc.
find DOS
find SV
find h
find Tdp
find wb
find hfg
find difference among equations
find ALL
find ALL_2

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products



Reproduced courtesy of Carrier Corporation


Digital Psychrometric Chart
Background of picture is a separate software entitled 'psyc0226.exe'.
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
Lines of constant temperature
Lines of constant $P_{ws}=f(T_{db})$
Lines of constant $AH_s = f(T_{db})$
Lines of constant $H_{fg}=f(T_{db})$
$T_{dp}=f(P_{ws})$, $T_{dp}=f(H_{fg})$, $T_{dp}=f(AH_s)$
Twb
Tdp
Tdb
A
A
A
Pw
AH x0.001
5.065
32.9
4.502
29.2
3.939
25.6
3.376
21.9
2.813
18.2
2.251
14.6
1.688
10.9
1.125
7.31
0.562
3.65
16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
State
Process
Pad
VPD
Tdb 30 degree C
RH 58.59 %
Twb 23.47 degree C
Tdp 21 degree C
AH 0.0157 kg/kg DA
H 70.18 kJ/kg DA
SV 0.8804 m3/kg DA
Hfg 2428.4 kJ/kg
DOS 57.55 %
Pws 4.246 kPa
Pw 2.488 kPa
Message
In addition to Patm,
you still need 2 properties to
define a state.
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:31.22 RH:38.85

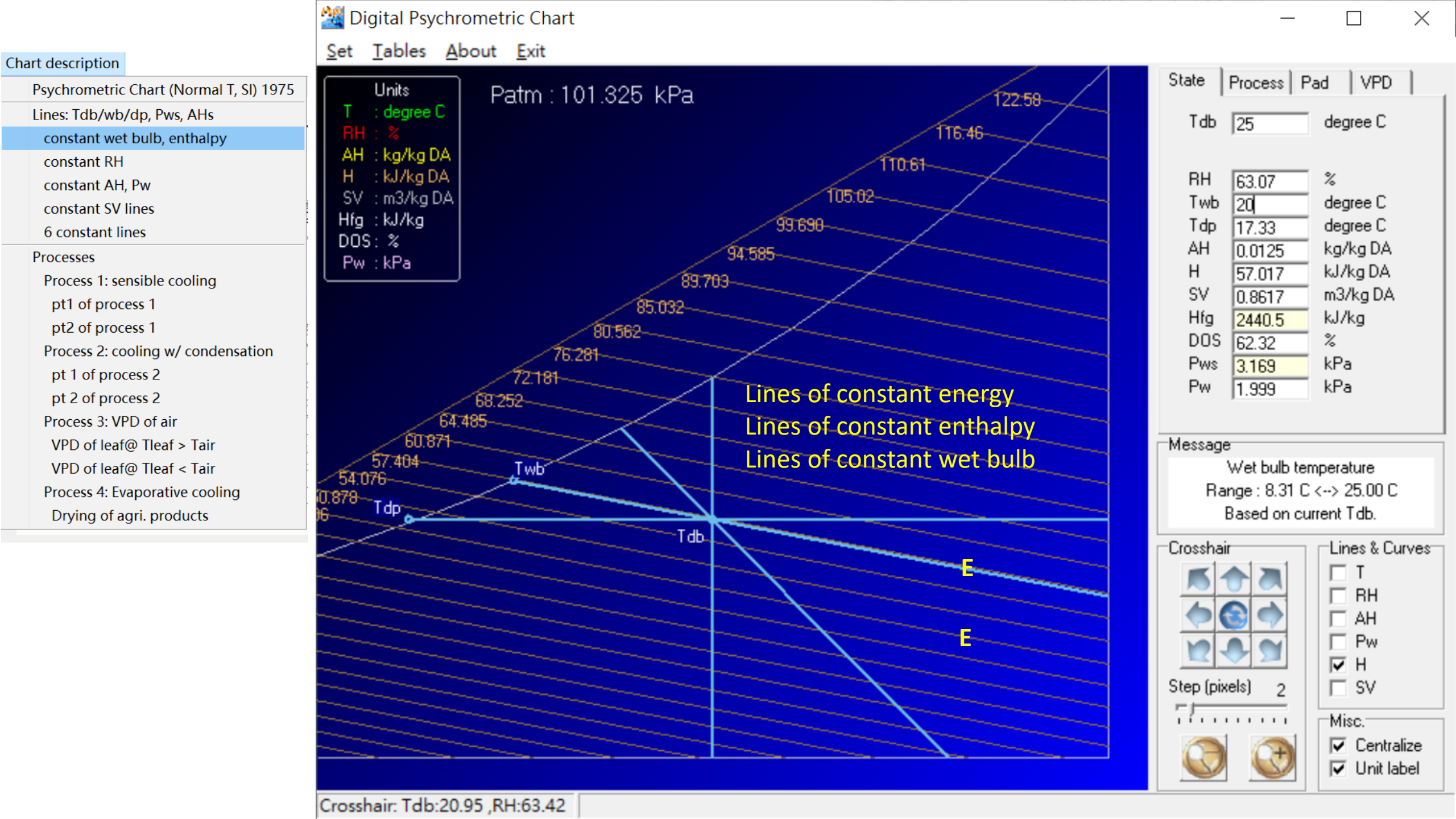
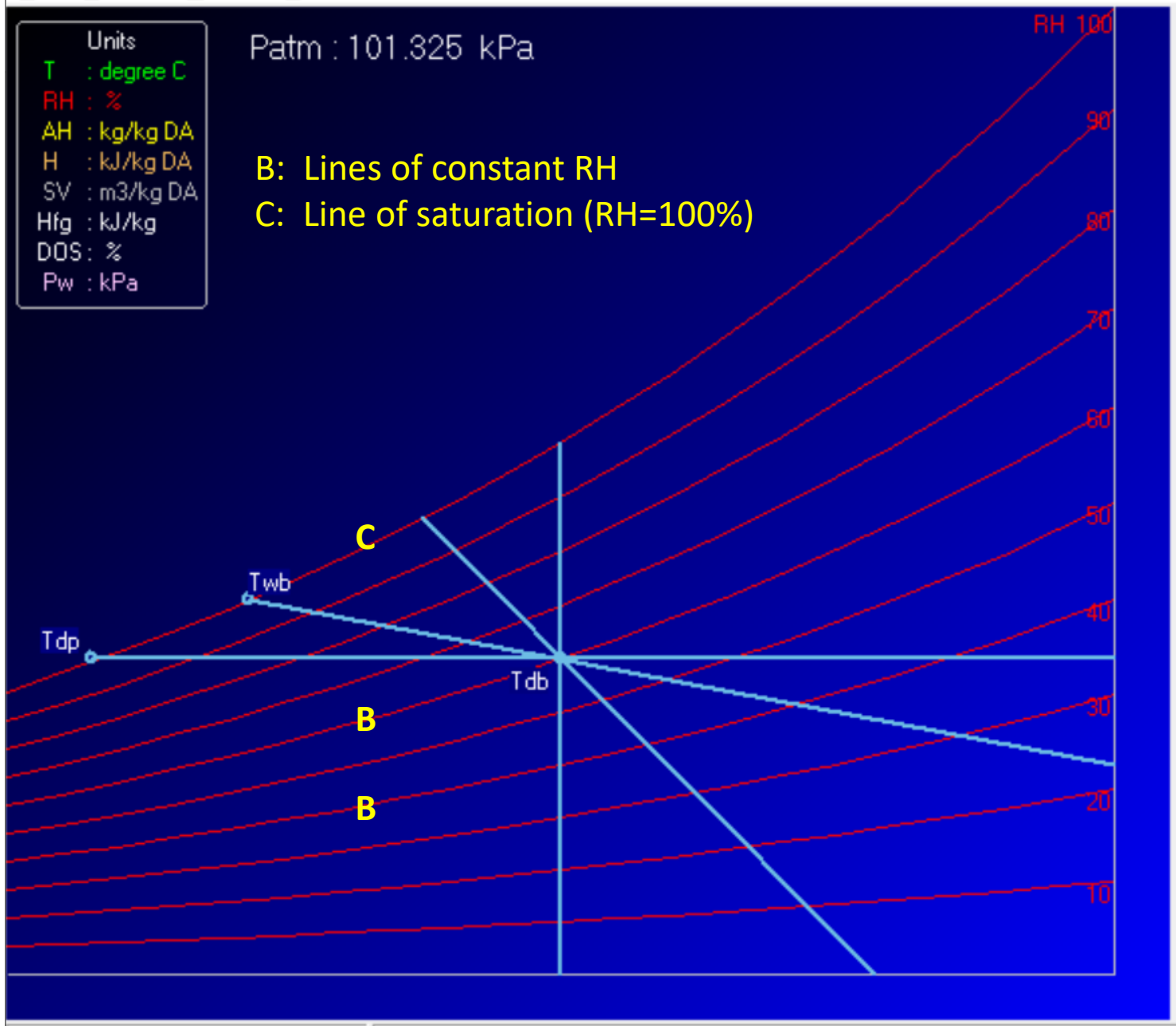

Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
122.58
116.46
110.61
105.02
99.690
94.585
89.703
85.032
80.562
76.281
72.181
68.252
64.485
60.871
57.404
54.076
Twb
Tdp
Tdb
Lines of constant energy
Lines of constant enthalpy
Lines of constant wet bulb
E
E
State
Process
Pad
VPD
Tdb 25 degree C
RH 63.07 %
Twb 20 degree C
Tdp 17.33 degree C
AH 0.0125 kg/kg DA
H 57.017 kJ/kg DA
SV 0.8617 m3/kg DA
Hfg 2440.5 kJ/kg
DOS 62.32 %
Pws 3.169 kPa
Pw 1.999 kPa
Message
Wet bulb temperature
Range : 8.31 C <--> 25.00 C
Based on current Tdb.
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:20.95 ,RH:63.42

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State | Process | Pad | VPD

Tdb	25	degree C
RH	60	%
Twb	19.38	degree C
Tdp	16.54	degree C
AH	0.0119	kg/kg DA
H	55.438	kJ/kg DA
SV	0.8608	m3/kg DA
Hfg	2440.5	kJ/kg
DOS	59.23	%
Pws	3.169	kPa
Pw	1.902	kPa

Message

Relative Humidity

Range : 0 % <--> 100 %

Crosshair

Step (pixels) 2

Lines & Curves

- [ ] T
- [x] RH
- [ ] AH
- [ ] Pw
- [ ] H
- [ ] SV

Misc.

- [x] Centralize
- [x] Unit label

Crosshair: Tdb:20.95 ,RH:63.42

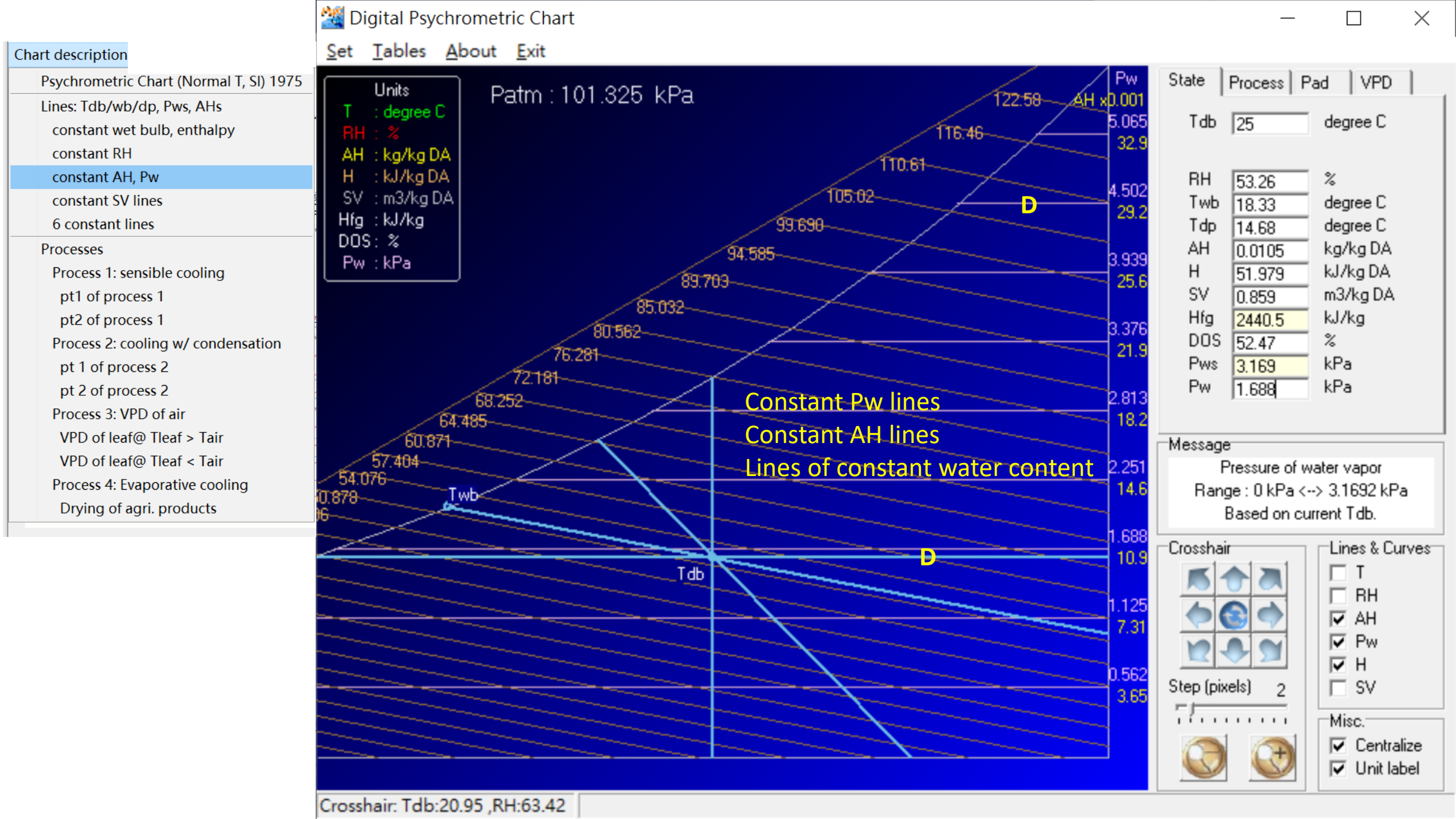
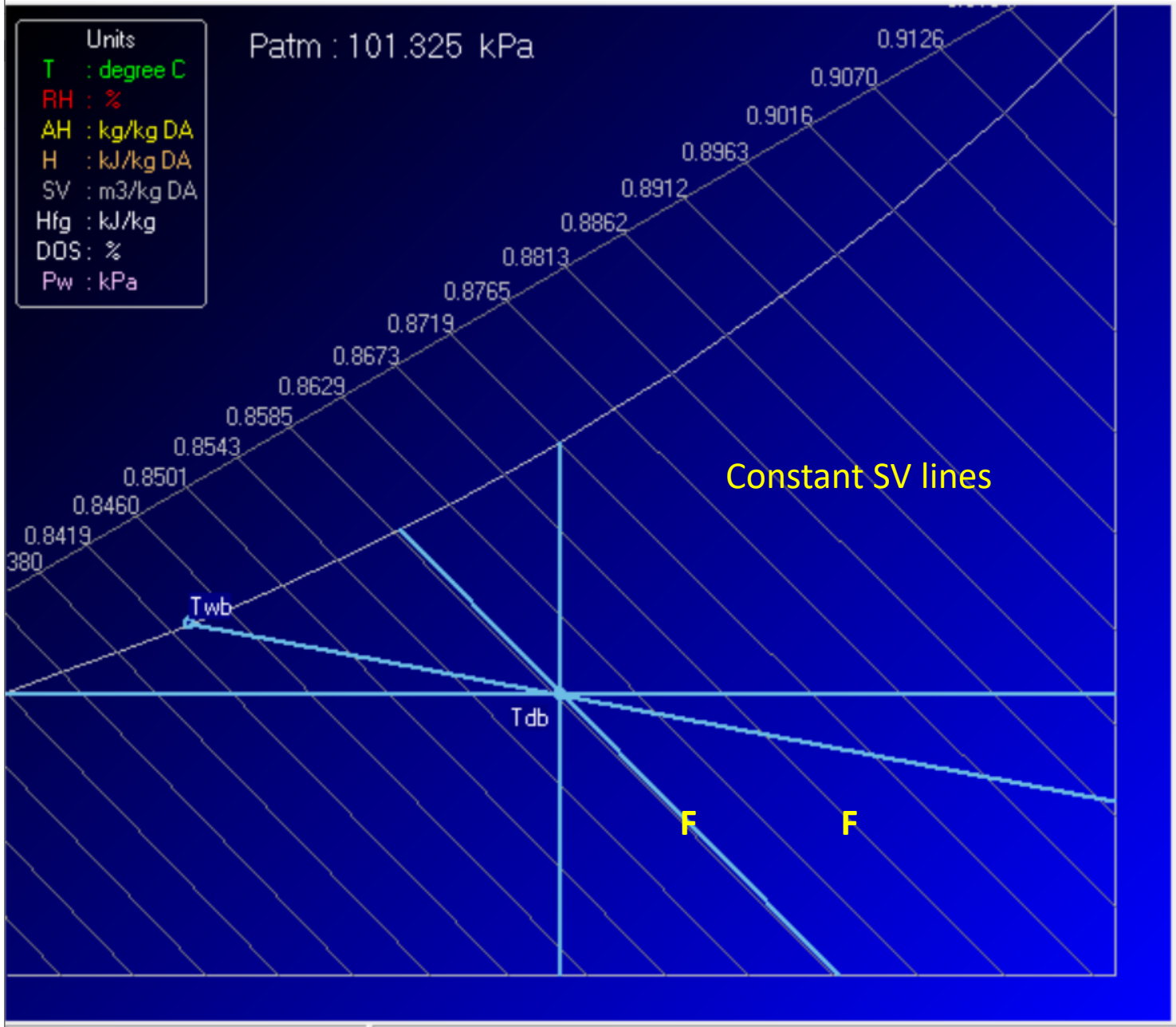

Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
Pw
AH x0.001
122.58
116.46
110.61
105.02
99.690
94.585
89.703
85.032
80.562
76.281
72.181
68.252
64.485
60.871
57.404
54.076
5.065
32.9
4.502
29.2
3.939
25.6
3.376
21.9
2.813
18.2
2.251
14.6
1.688
10.9
1.125
7.31
0.562
3.65
D
D
Twb
Tdb
Constant Pw lines
Constant AH lines
Lines of constant water content
State
Process
Pad
VPD
Tdb 25 degree C
RH 53.26 %
Twb 18.33 degree C
Tdp 14.68 degree C
AH 0.0105 kg/kg DA
H 51.979 kJ/kg DA
SV 0.859 m3/kg DA
Hfg 2440.5 kJ/kg
DOS 52.47 %
Pws 3.169 kPa
Pw 1.688 kPa
Message
Pressure of water vapor
Range : 0 kPa <--> 3.1692 kPa
Based on current Tdb.
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:20.95 ,RH:63.42

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State | Process | Pad | VPD

Tdb	25	degree C
RH	53.26	%
Twb	18.33	degree C
Tdp	14.68	degree C
AH	0.0105	kg/kg DA
H	51.979	kJ/kg DA
SV	0.859	m3/kg DA
Hfg	2440.5	kJ/kg
DOS	52.47	%
Pws	3.169	kPa
Pw	1.688	kPa

Message

In addition to Patm,
you still need 2 properties to
define a state.

Crosshair

Step (pixels) 2

Lines & Curves

- [ ] T
- [ ] RH
- [ ] AH
- [ ] Pw
- [ ] H
- [x] SV

Misc.

- [x] Centralize
- [x] Unit label

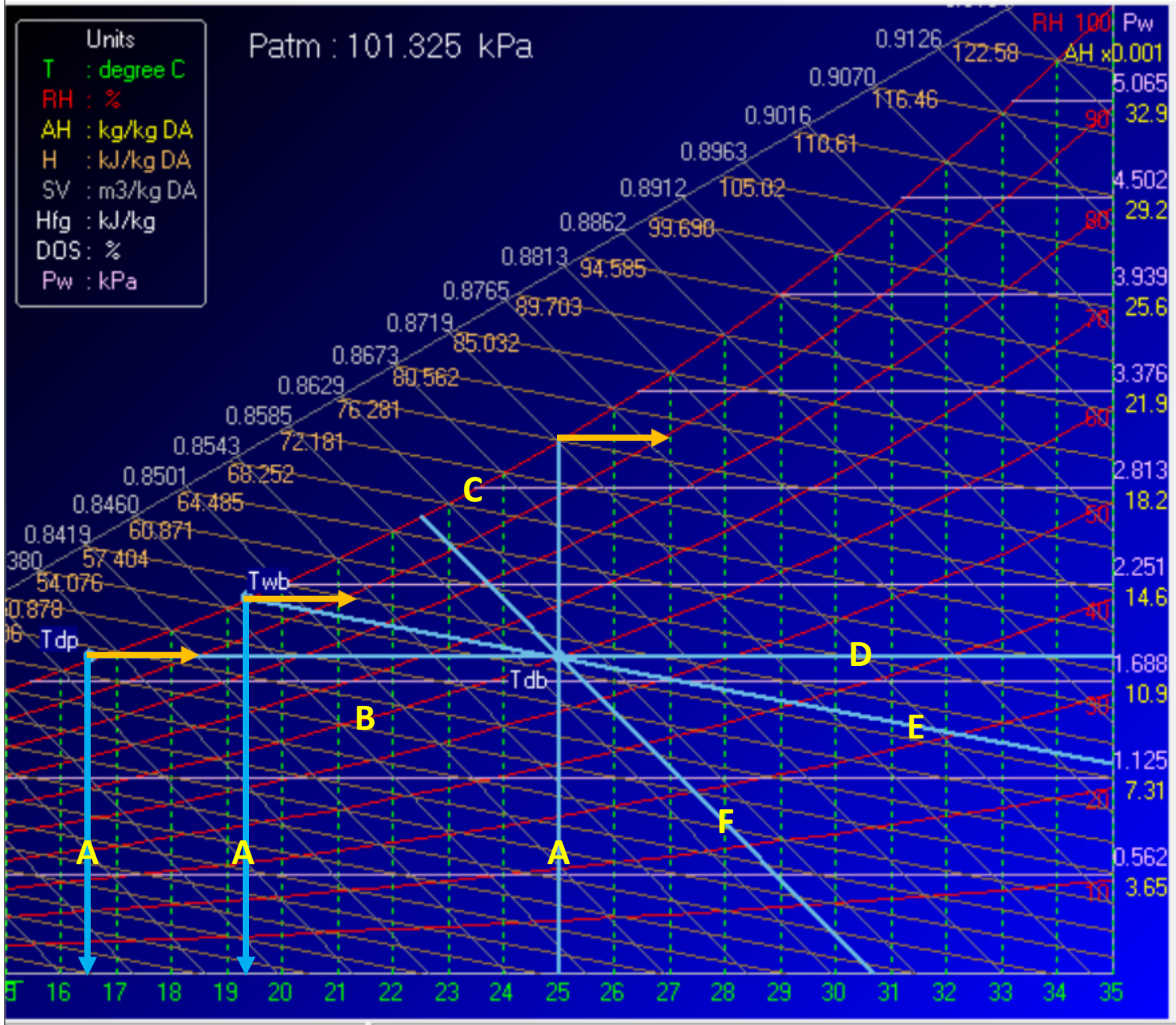
Crosshair: Tdb:20.95 ,RH:63.42

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State | Process | Pad | VPD

Tdb	25	degree C
RH	60	%
Twb	19.38	degree C
Tdp	16.54	degree C
AH	0.0119	kg/kg DA
H	55.438	kJ/kg DA
SV	0.8608	m3/kg DA
Hfg	2440.5	kJ/kg
DOS	59.23	%
Pws	3.169	kPa
Pw	1.902	kPa

Message

In addition to Patm,
you still need 2 properties to
define a state.

Crosshair

Step (pixels) 2

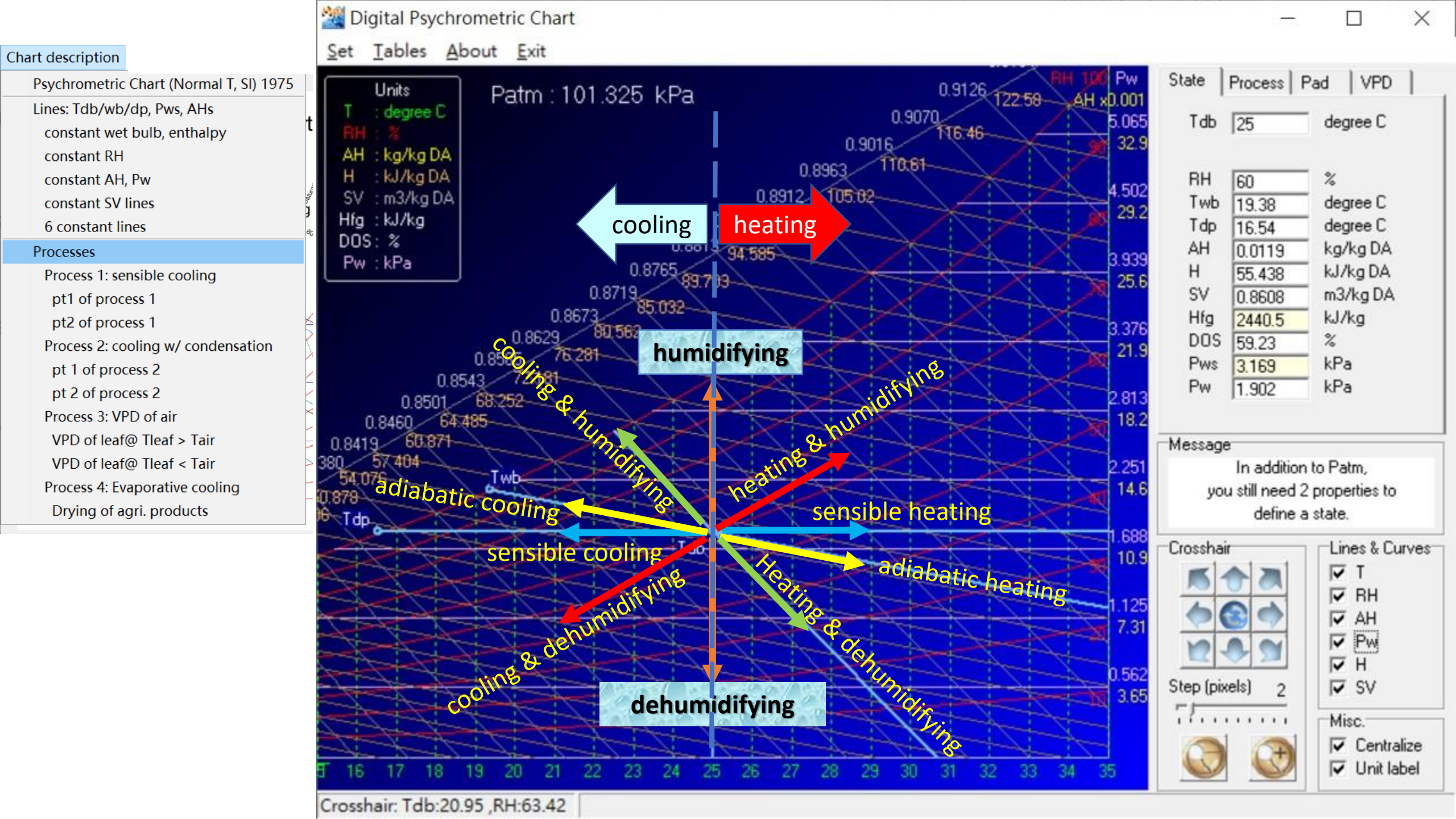
Lines & Curves

- [x] T
- [x] RH
- [x] AH
- [x] Pw
- [x] H
- [x] SV

Misc.

- [x] Centralize
- [x] Unit label

Crosshair: Tdb:20.95 ,RH:63.42


Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
cooling
heating
humidifying
dehumidifying
cooling & humidifying
heating & humidifying
adiabatic cooling
sensible cooling
sensible heating
adiabatic heating
cooling & dehumidifying
Heating & dehumidifying
Twb
Tdp
State
Process
Pad
VPD
Tdb 25 degree C
RH 60 %
Twb 19.38 degree C
Tdp 16.54 degree C
AH 0.0119 kg/kg DA
H 55.438 kJ/kg DA
SV 0.8608 m3/kg DA
Hfg 2440.5 kJ/kg
DOS 59.23 %
Pws 3.169 kPa
Pw 1.902 kPa
Message
In addition to Patm,
you still need 2 properties to
define a state.
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:20.95 ,RH:63.42

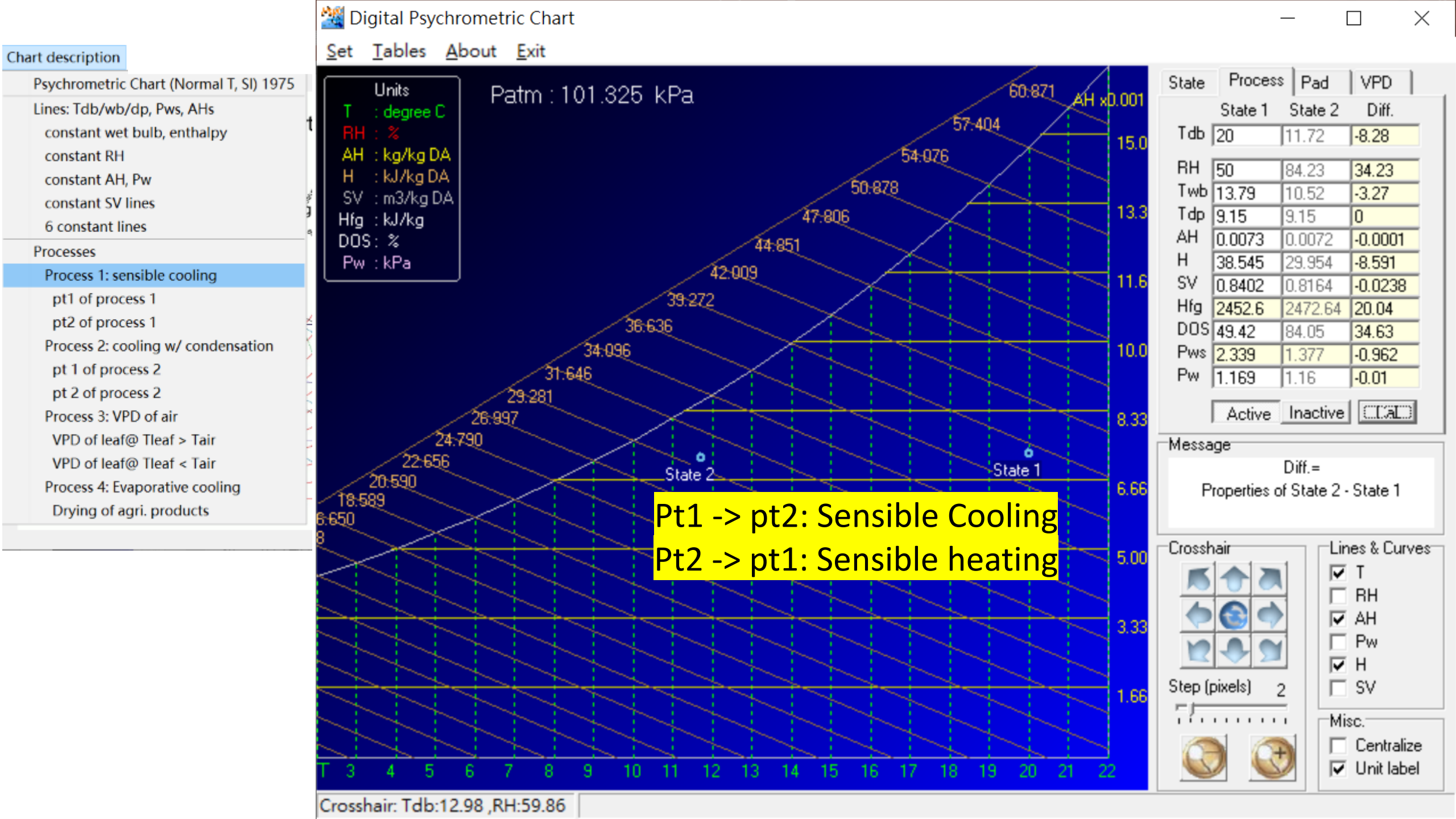
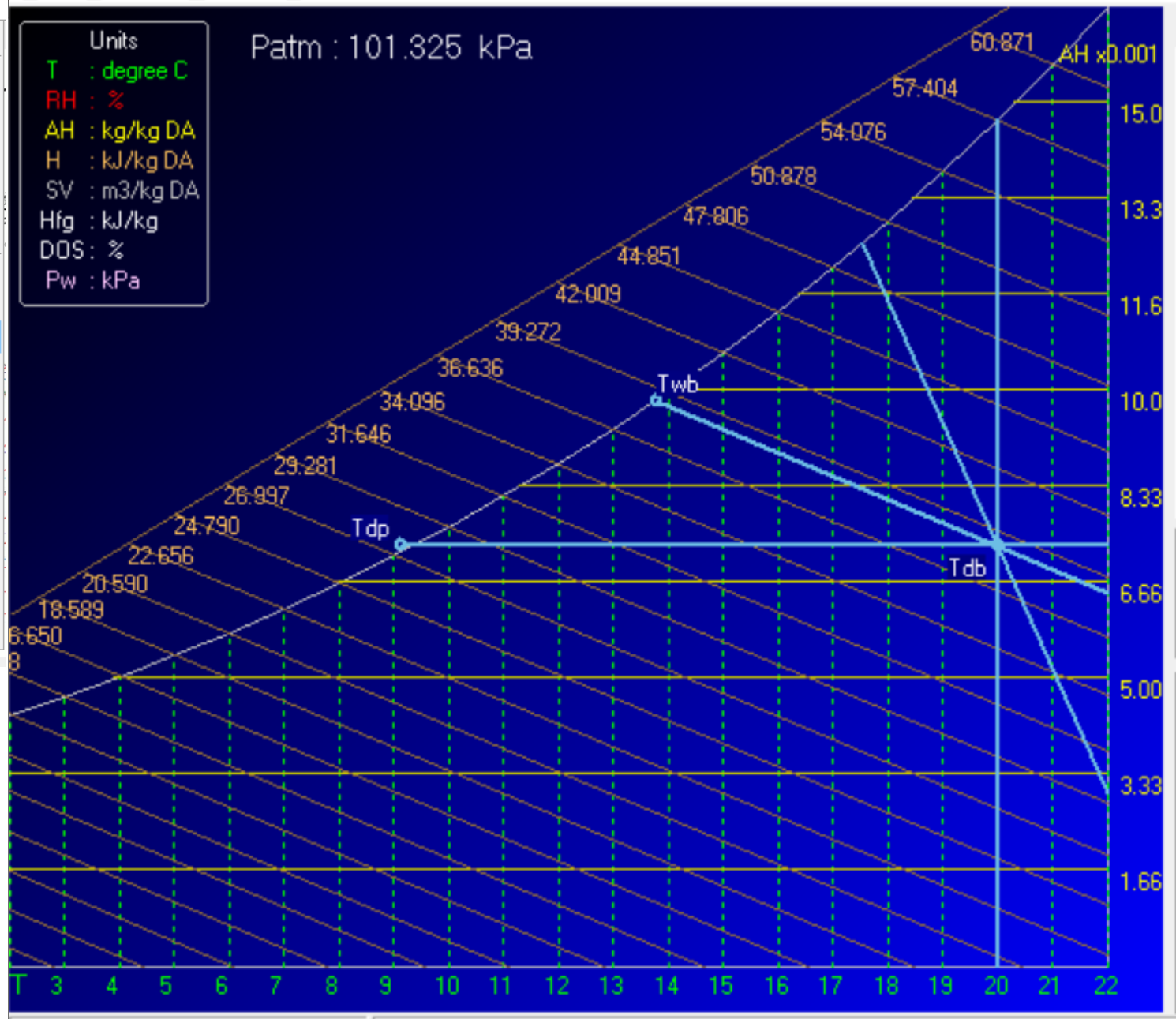

Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
AH x0.001
60.871
57.404
54.076
50.878
47.806
44.851
42.009
39.272
36.636
34.096
31.646
29.281
26.997
24.790
22.656
20.590
18.589
16.650
15.0
13.3
11.6
10.0
8.33
6.66
5.00
3.33
1.66
State 2
State 1
Pt1 -> pt2: Sensible Cooling
Pt2 -> pt1: Sensible heating
T 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
State
Process
Pad
VPD
State 1
State 2
Diff.
Tdb 20 11.72 -8.28
RH 50 84.23 34.23
Twb 13.79 10.52 -3.27
Tdp 9.15 9.15 0
AH 0.0073 0.0072 -0.0001
H 38.545 29.954 -8.591
SV 0.8402 0.8164 -0.0238
Hfg 2452.6 2472.64 20.04
DOS 49.42 84.05 34.63
Pws 2.339 1.377 -0.962
Pw 1.169 1.16 -0.01
Active
Inactive
Message
Diff.=
Properties of State 2 - State 1
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:12.98 ,RH:59.86

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State | Process | Pad | VPD

	State 1	State 2	Diff.
Tdb	20	11.72	-8.28
RH	50	84.23	34.23
Twb	13.79	10.52	-3.27
Tdp	9.15	9.15	0
AH	0.0073	0.0072	-0.0001
H	38.545	29.954	-8.591
SV	0.8402	0.8164	-0.0238
Hfg	2452.6	2472.64	20.04
DOS	49.42	84.05	34.63
Pws	2.339	1.377	-0.962
Pw	1.169	1.16	-0.01

Active Inactive CAL

Message

In addition to Patm,
you still need 2 properties to
define a state.

Crosshair

Step (pixels) 2

Lines & Curves

- [x] T
- [ ] RH
- [x] AH
- [ ] Pw
- [x] H
- [ ] SV

Misc.

- [ ] Centralize
- [x] Unit label

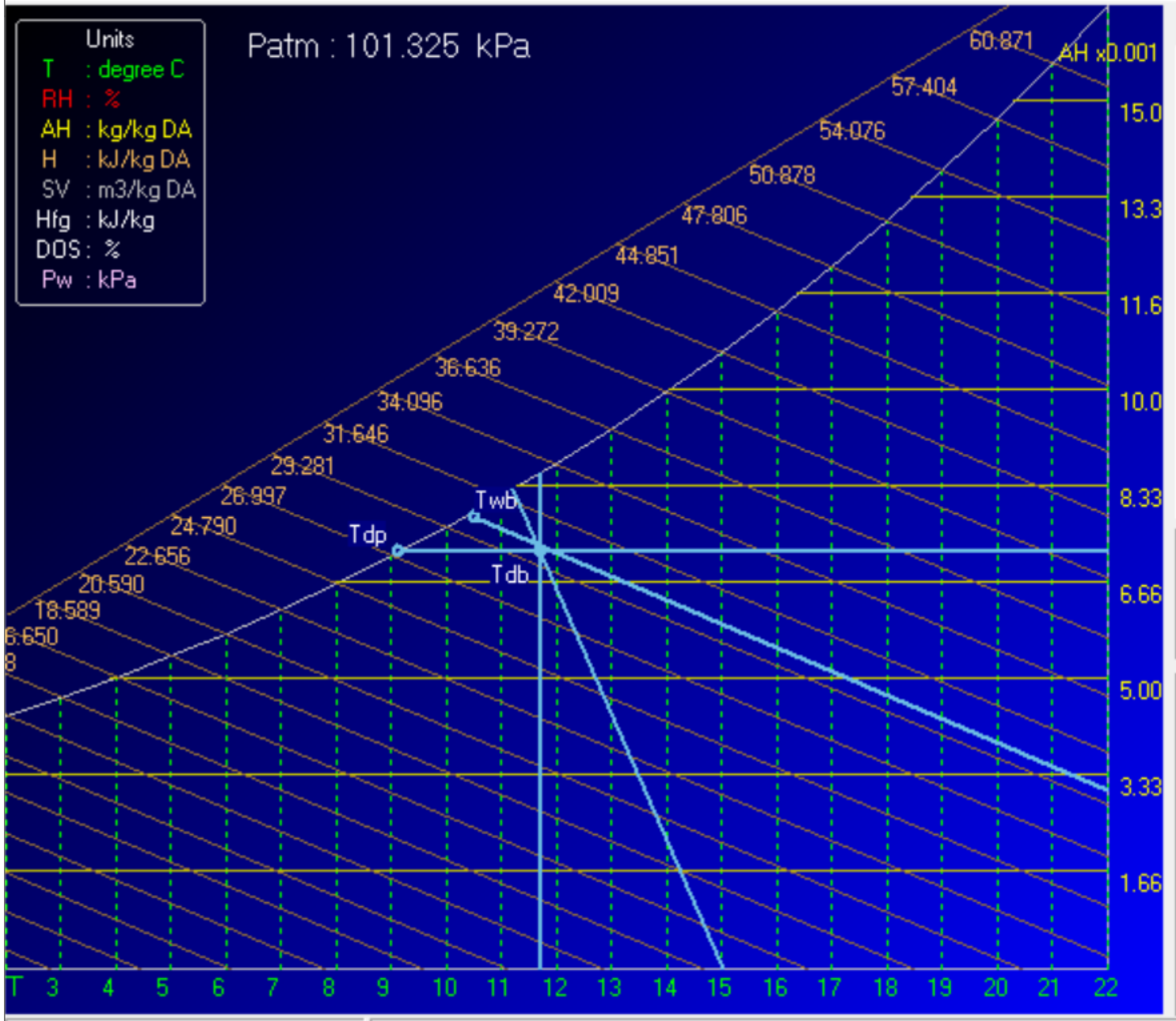
Crosshair: Tdb:12.98 ,RH:59.86

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State	Process	Pad	VPD

	State 1	State 2	Diff.
Tdb	20	11.72	-8.28
RH	50	84.23	34.23
Twb	13.79	10.52	-3.27
Tdp	9.15	9.15	0
AH	0.0073	0.0072	-0.0001
H	38.545	29.954	-8.591
SV	0.8402	0.8164	-0.0238
Hfg	2452.6	2472.64	20.04
DOS	49.42	84.05	34.63
Pws	2.339	1.377	-0.962
Pw	1.169	1.16	-0.01

Inactive Active CAL

Message

In addition to Patm,
you still need 2 properties to
define a state.

Crosshair

Step (pixels) 2

Lines & Curves

- [x] T
- [ ] RH
- [x] AH
- [ ] Pw
- [x] H
- [ ] SV

Misc.

- [ ] Centralize
- [x] Unit label

Crosshair: Tdb:12.98 ,RH:59.86

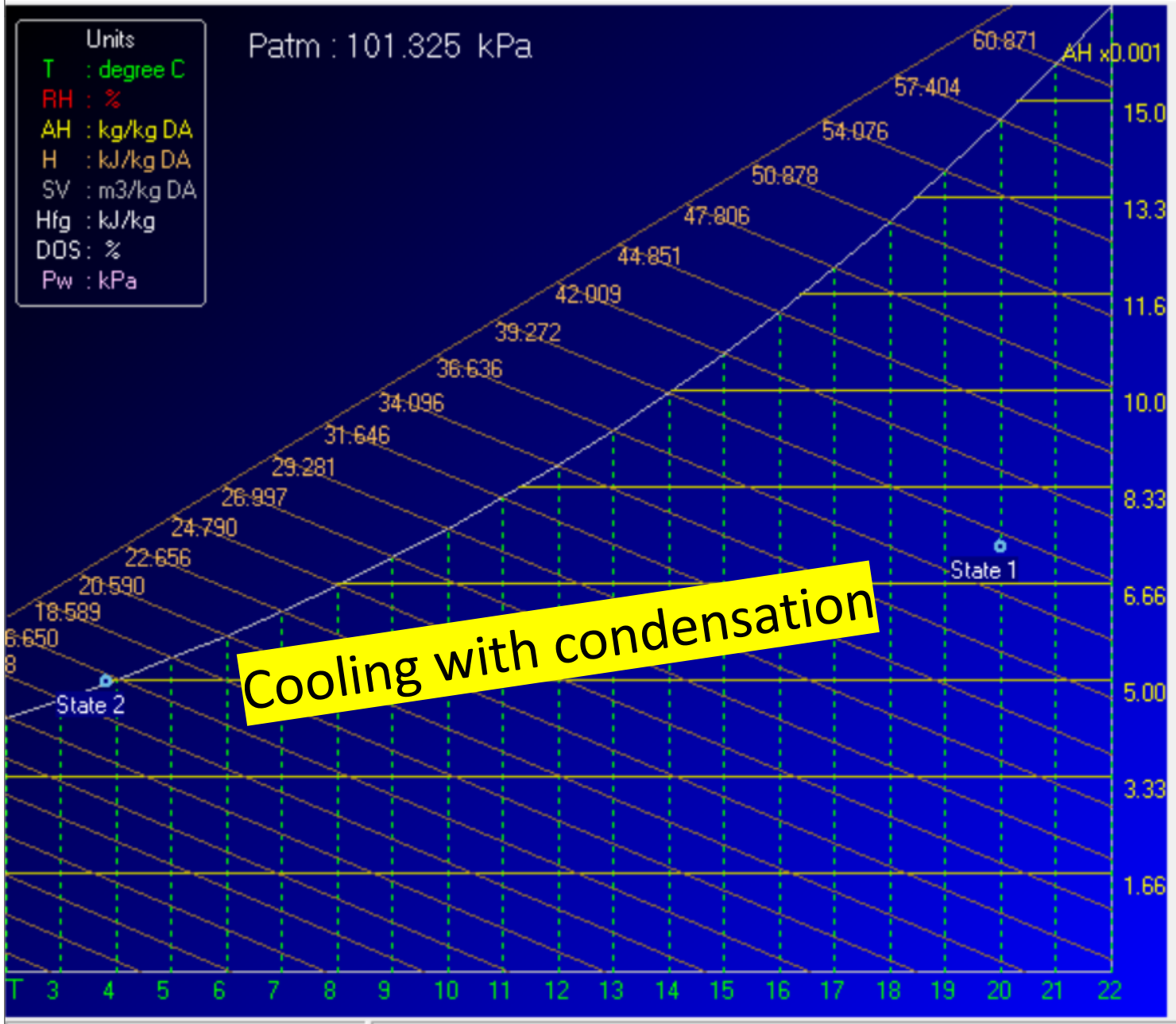
Plot family curves of selected Properties.

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products

Digital Psychrometric Chart

Set Tables About Exit



State | Process | Pad | VPD

	State 1	State 2	Diff.
Tdb	20	3.85	-16.15
RH	50	100	50
Twb	13.79	3.85	-9.94
Tdp	9.15	3.85	-5.3
AH	0.0073	0.005	-0.0023
H	38.545	16.364	-22.181
SV	0.8402	0.791	-0.0492
Hfg	2452.6	2491.68	39.08
DOS	49.42	100	50.58
Pws	2.339	0.805	-1.534
Pw	1.169	0.805	-0.36

Active | Inactive | Cal.

Message

Diff.=
Properties of State 2 - State 1

Crosshair

Step (pixels) 2

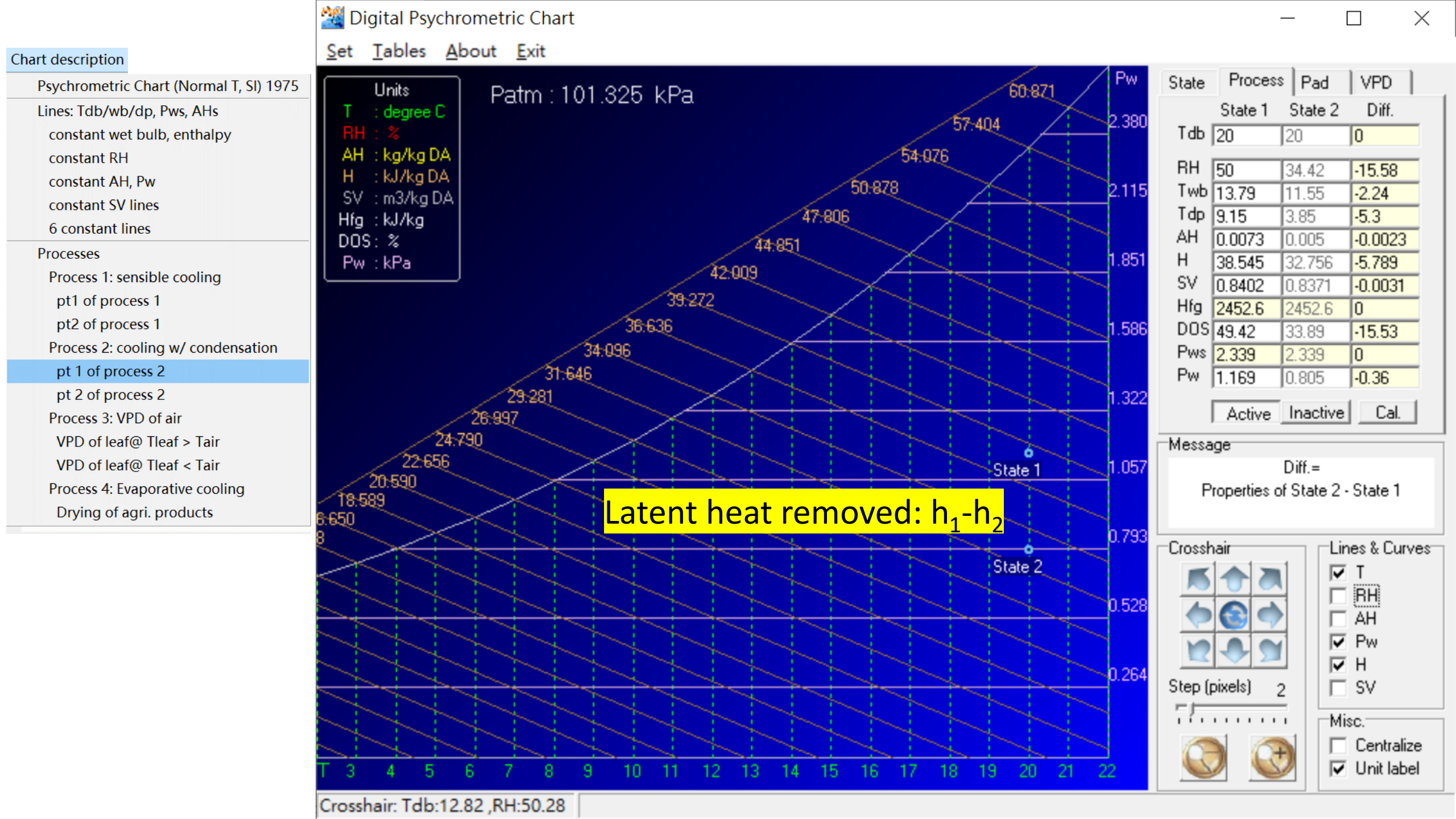
Lines & Curves

- [x] T
- [ ] RH
- [x] AH
- [ ] Pw
- [x] H
- [ ] SV

Misc.

- [ ] Centralize
- [x] Unit label

Crosshair: Tdb:12.98 ,RH:59.86


Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
Pw
2.380
2.115
1.851
1.586
1.322
1.057
0.793
0.528
0.264
60.871
57.404
54.076
50.878
47.806
44.851
42.009
39.272
36.636
34.096
31.646
29.281
26.997
24.790
22.656
20.590
18.589
16.650
State 1
State 2
Latent heat removed: h1-h2
T 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
State
Process
Pad
VPD
State 1
State 2
Diff.
Tdb 20 20 0
RH 50 34.42 -15.58
Twb 13.79 11.55 -2.24
Tdp 9.15 3.85 -5.3
AH 0.0073 0.005 -0.0023
H 38.545 32.756 -5.789
SV 0.8402 0.8371 -0.0031
Hfg 2452.6 2452.6 0
DOS 49.42 33.89 -15.53
Pws 2.339 2.339 0
Pw 1.169 0.805 -0.36
Active
Inactive
Cal.
Message
Diff.=
Properties of State 2 - State 1
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label
Crosshair: Tdb:12.82 ,RH:50.28

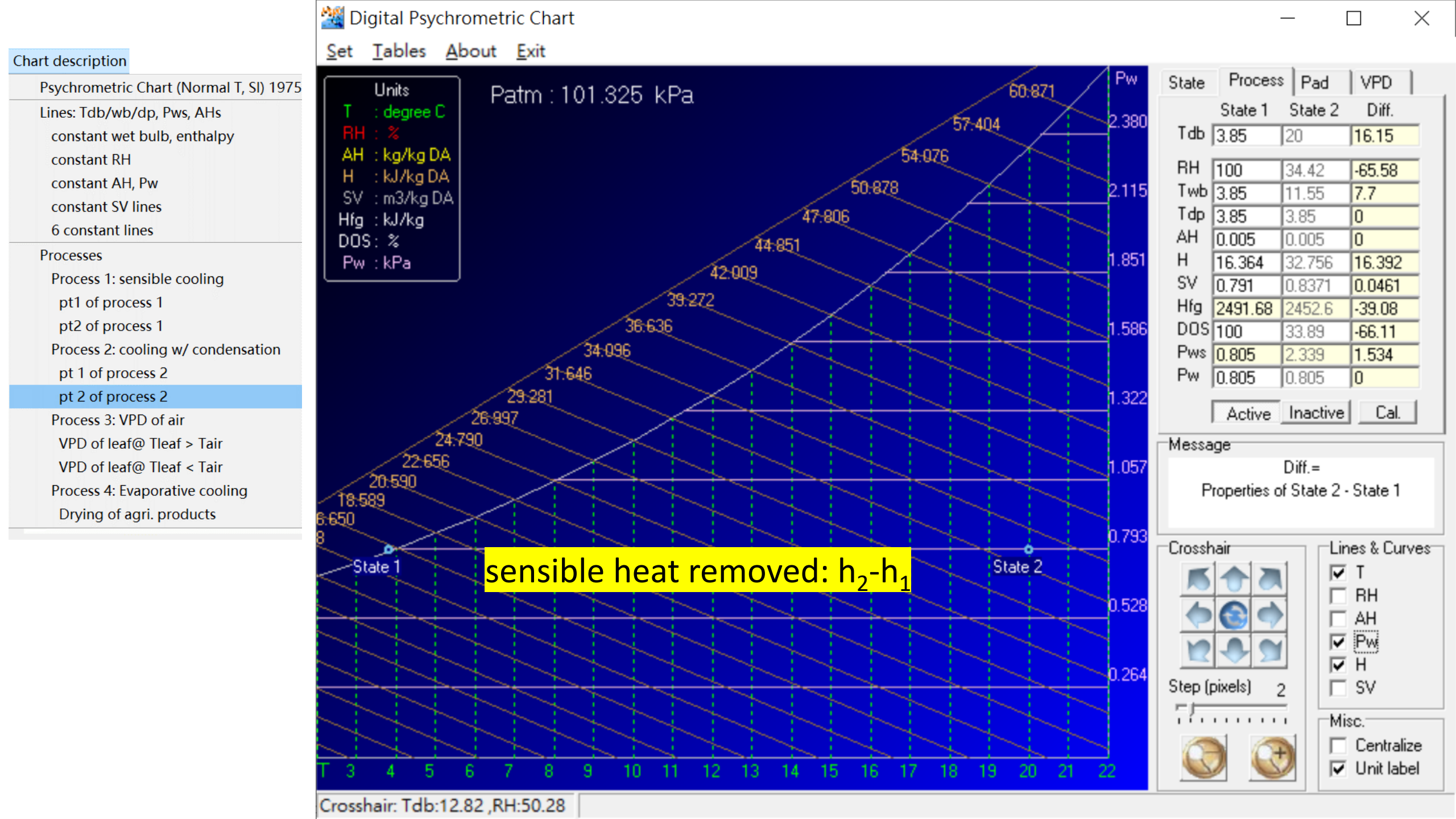


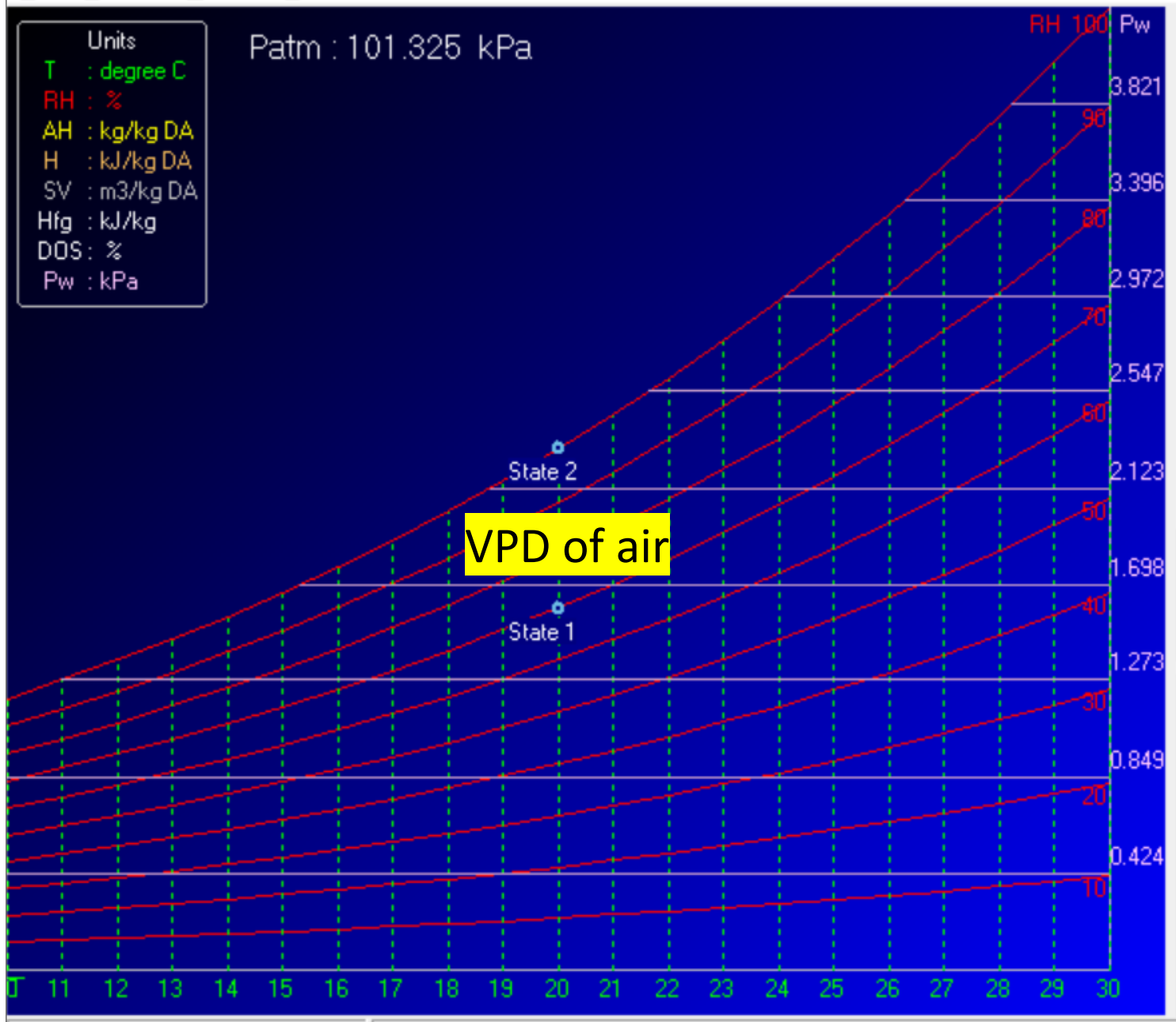
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Digital Psychrometric Chart
Set
Tables
About
Exit
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
60.871
57.404
54.076
50.878
47.806
44.851
42.009
39.272
36.636
34.096
31.646
29.281
26.997
24.790
22.656
20.590
18.589
6.650
8
Pw
2.380
2.115
1.851
1.586
1.322
1.057
0.793
0.528
0.264
State 1
State 2
sensible heat removed: h2-h1
T 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Crosshair: Tdb:12.82 ,RH:50.28
State
Process
Pad
VPD
State 1 State 2 Diff.
Tdb 3.85 20 16.15
RH 100 34.42 -65.58
Twb 3.85 11.55 7.7
Tdp 3.85 3.85 0
AH 0.005 0.005 0
H 16.364 32.756 16.392
SV 0.791 0.8371 0.0461
Hfg 2491.68 2452.6 -39.08
DOS 100 33.89 -66.11
Pws 0.805 2.339 1.534
Pw 0.805 0.805 0
Active
Inactive
Cal.
Message
Diff.=
Properties of State 2 - State 1
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label

Digital Psychrometric Chart

Set Tables About Exit

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products



State | Process | Pad | VPD

	State 1	State 2	Diff.
Tdb	20	20	0
RH	70	100	30
Twb	16.45	20	3.55
Tdp	14.21	20	5.79
AH	0.0102	0.0147	0.0045
H	46.036	57.405	11.369
SV	0.8441	0.8501	0.006
Hfg	2452.6	2452.6	0
DOS	69.51	100	30.49
Pws	2.339	2.339	0
Pw	1.637	2.339	0.7

Active | Inactive | Cal.

Message

Diff.=

Properties of State 2 - State 1

Crosshair

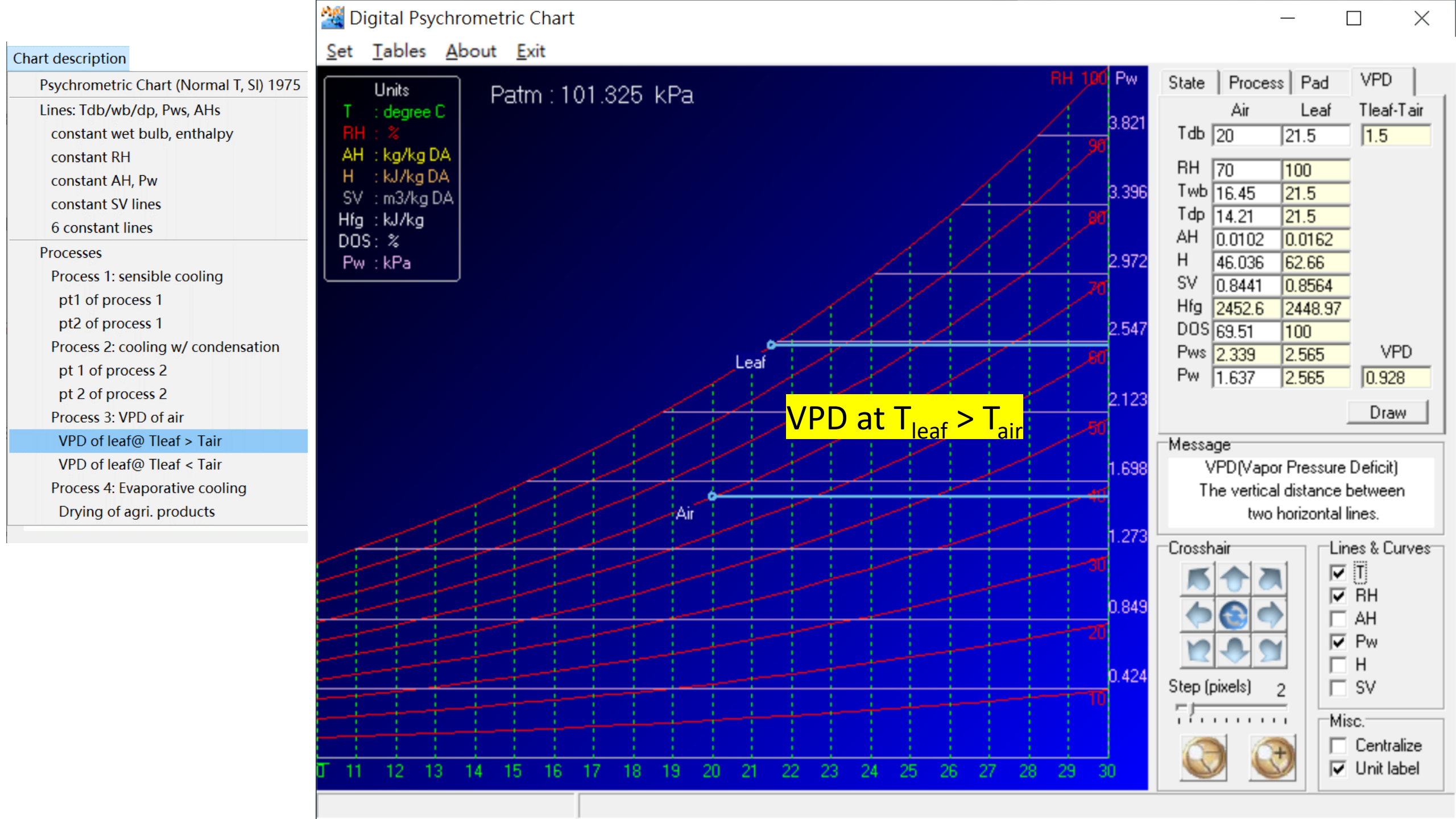
Step (pixels) 2

Lines & Curves

- [x] T
- [x] RH
- [ ] AH
- [x] Pw
- [ ] H
- [ ] SV

Misc.

- [ ] Centralize
- [x] Unit label

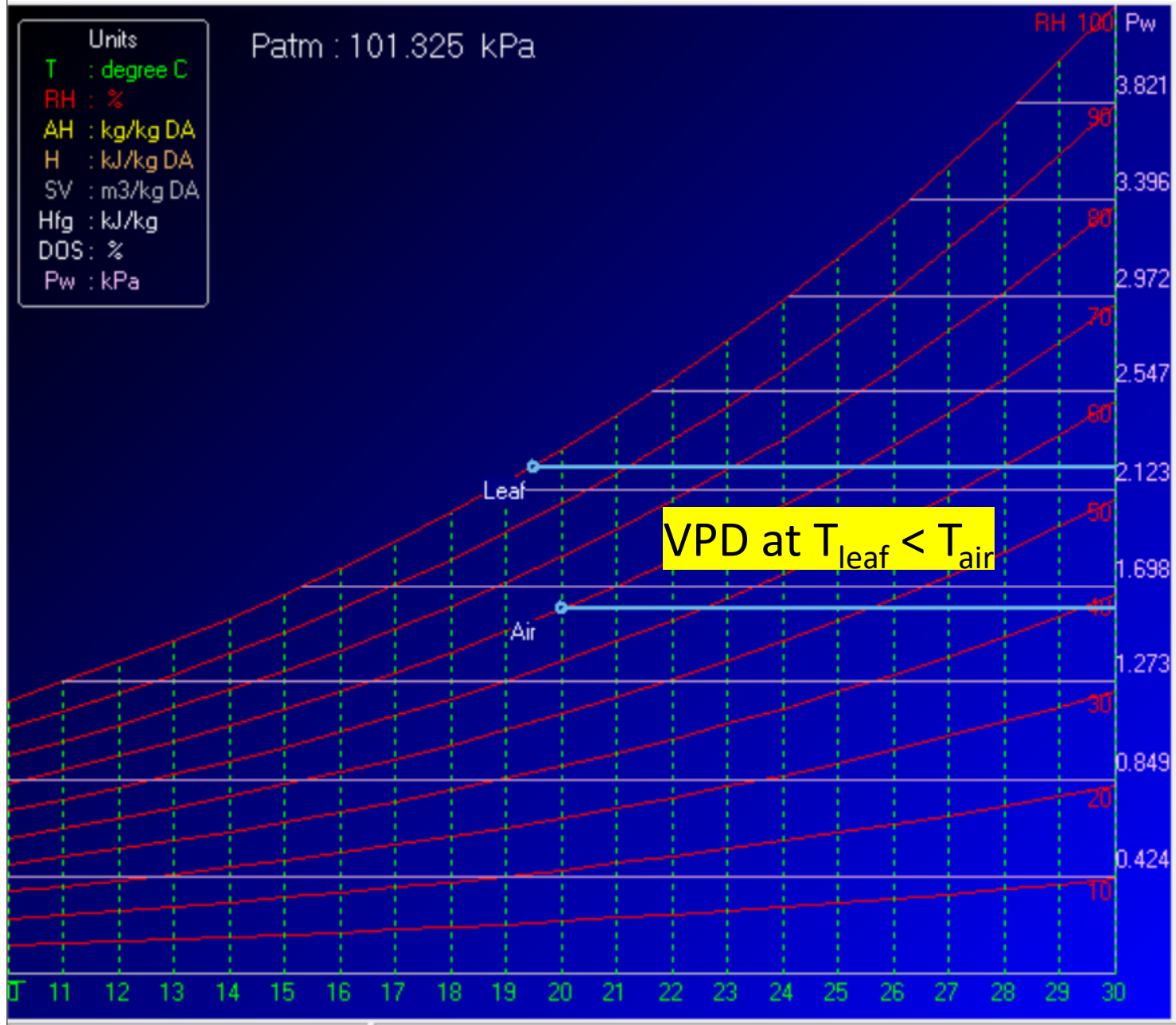

Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
RH 100
90
80
70
60
50
40
30
20
10
Pw
3.821
3.396
2.972
2.547
2.123
1.698
1.273
0.849
0.424
Leaf
Air
VPD at $T_{leaf} > T_{air}$
T 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
State
Process
Pad
VPD
Air
Leaf
Tleaf-Tair
Tdb 20 21.5 1.5
RH 70 100
Twb 16.45 21.5
Tdp 14.21 21.5
AH 0.0102 0.0162
H 46.036 62.66
SV 0.8441 0.8564
Hfg 2452.6 2448.97
DOS 69.51 100
Pws 2.339 2.565
Pw 1.637 2.565
VPD
0.928
Draw
Message
VPD(Vapor Pressure Deficit)
The vertical distance between
two horizontal lines.
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label

Digital Psychrometric Chart

Set Tables About Exit

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
    - Drying of agri. products



State	Process	Pad	VPD		
	Air	Leaf	Tleaf-Tair		
Tdb	20	19.5	-0.5		
RH	70	100			
Twb	16.45	19.5			
Tdp	14.21	19.5			
AH	0.0102	0.0142			
H	46.036	55.724			
SV	0.8441	0.8481			
Hfg	2452.6	2453.81			
DOS	69.51	100			
Pws	2.339	2.267	VPD		
Pw	1.637	2.267	0.63		

Draw

Message

VPD(Vapor Pressure Deficit)
The vertical distance between two horizontal lines.

Crosshair

Step (pixels) 2

Lines & Curves

- [x] T
- [x] RH
- [ ] AH
- [x] Pw
- [ ] H
- [ ] SV

Misc.

- [ ] Centralize
- [x] Unit label

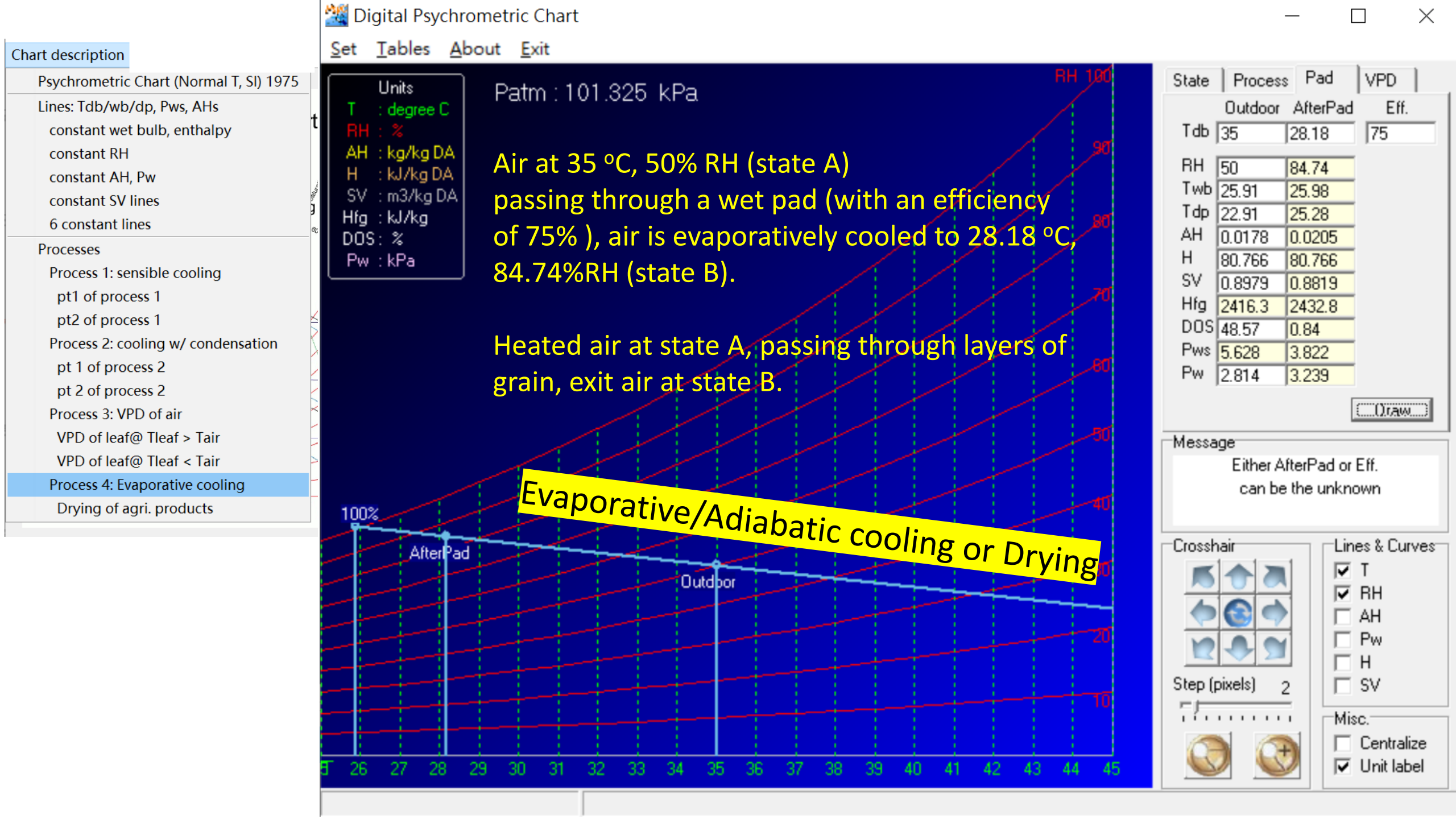
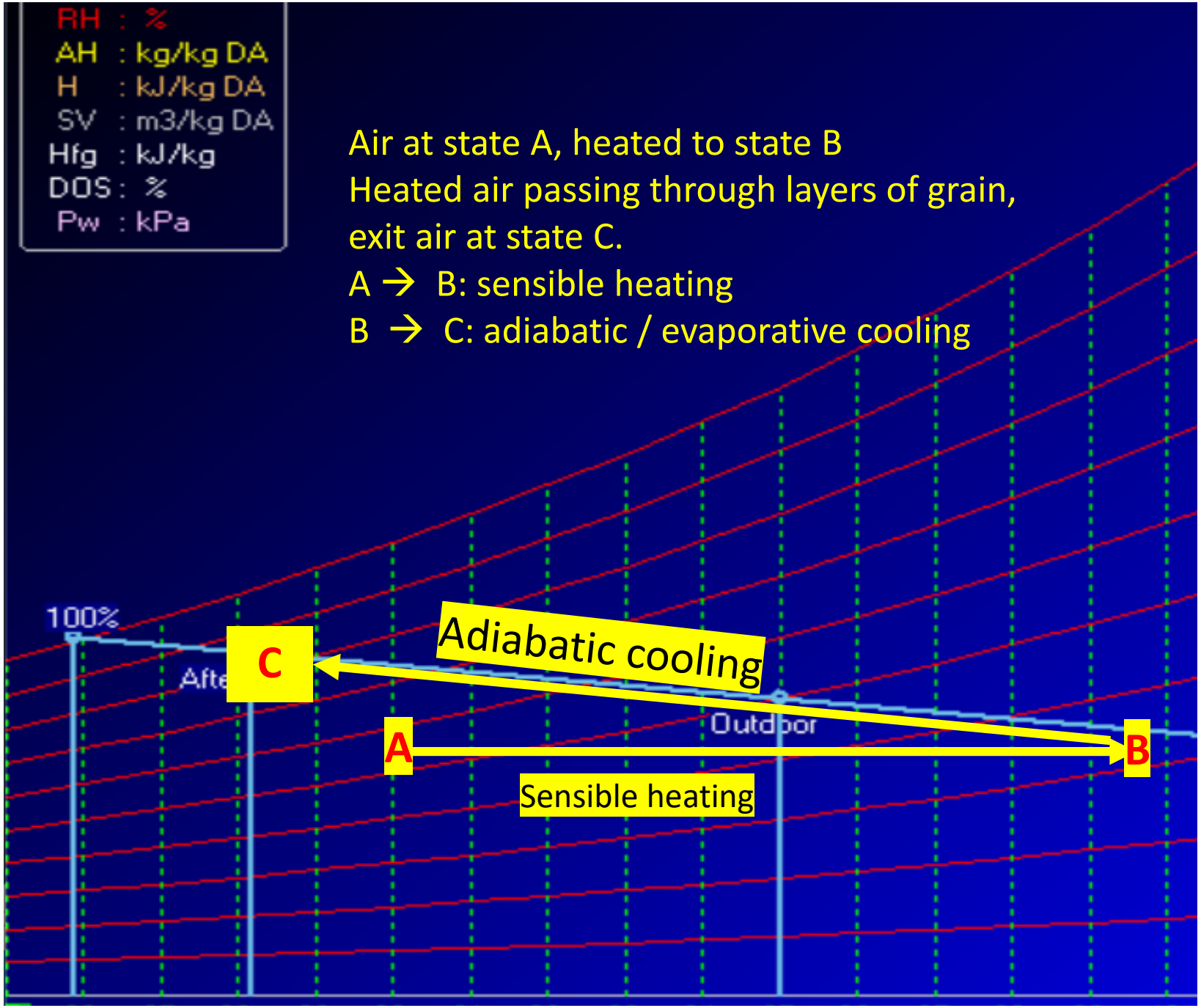

Digital Psychrometric Chart
Set
Tables
About
Exit
Chart description
Psychrometric Chart (Normal T, SI) 1975
Lines: Tdb/wb/dp, Pws, AHs
constant wet bulb, enthalpy
constant RH
constant AH, Pw
constant SV lines
6 constant lines
Processes
Process 1: sensible cooling
pt1 of process 1
pt2 of process 1
Process 2: cooling w/ condensation
pt 1 of process 2
pt 2 of process 2
Process 3: VPD of air
VPD of leaf@ Tleaf > Tair
VPD of leaf@ Tleaf < Tair
Process 4: Evaporative cooling
Drying of agri. products
Units
T : degree C
RH : %
AH : kg/kg DA
H : kJ/kg DA
SV : m3/kg DA
Hfg : kJ/kg
DOS : %
Pw : kPa
Patm : 101.325 kPa
Air at 35 °C, 50% RH (state A)
passing through a wet pad (with an efficiency of 75%), air is evaporatively cooled to 28.18 °C, 84.74%RH (state B).
Heated air at state A, passing through layers of grain, exit air at state B.
Evaporative/Adiabatic cooling or Drying
100%
AfterPad
Outdoor
RH
T
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
State
Process
Pad
VPD
Outdoor
AfterPad
Eff.
Tdb 35 28.18 75
RH 50 84.74
Twb 25.91 25.98
Tdp 22.91 25.28
AH 0.0178 0.0205
H 80.766 80.766
SV 0.8979 0.8819
Hfg 2416.3 2432.8
DOS 48.57 0.84
Pws 5.628 3.822
Pw 2.814 3.239
Draw
Message
Either AfterPad or Eff.
can be the unknown
Crosshair
Step (pixels) 2
Lines & Curves
T
RH
AH
Pw
H
SV
Misc.
Centralize
Unit label

Chart description

- Psychrometric Chart (Normal T, SI) 1975
- Lines: Tdb/wb/dp, Pws, AHs
  - constant wet bulb, enthalpy
  - constant RH
  - constant AH, Pw
  - constant SV lines
  - 6 constant lines
- Processes
  - Process 1: sensible cooling
    - pt1 of process 1
    - pt2 of process 1
  - Process 2: cooling w/ condensation
    - pt 1 of process 2
    - pt 2 of process 2
  - Process 3: VPD of air
    - VPD of leaf@ Tleaf > Tair
    - VPD of leaf@ Tleaf < Tair
  - Process 4: Evaporative cooling
  - Drying of agri. products



Software for the learning of psychrometrics

Chart description | Known 1 property | 2 properties | 3 properties | Process | More... | Misc.

- From Tdb to Pws (2 eqs)
- Three types (Pws/AHs/VDs) of Y on psy.chart
- From Tdb to hfg (2 eqs.)
- From Pws to Tdb

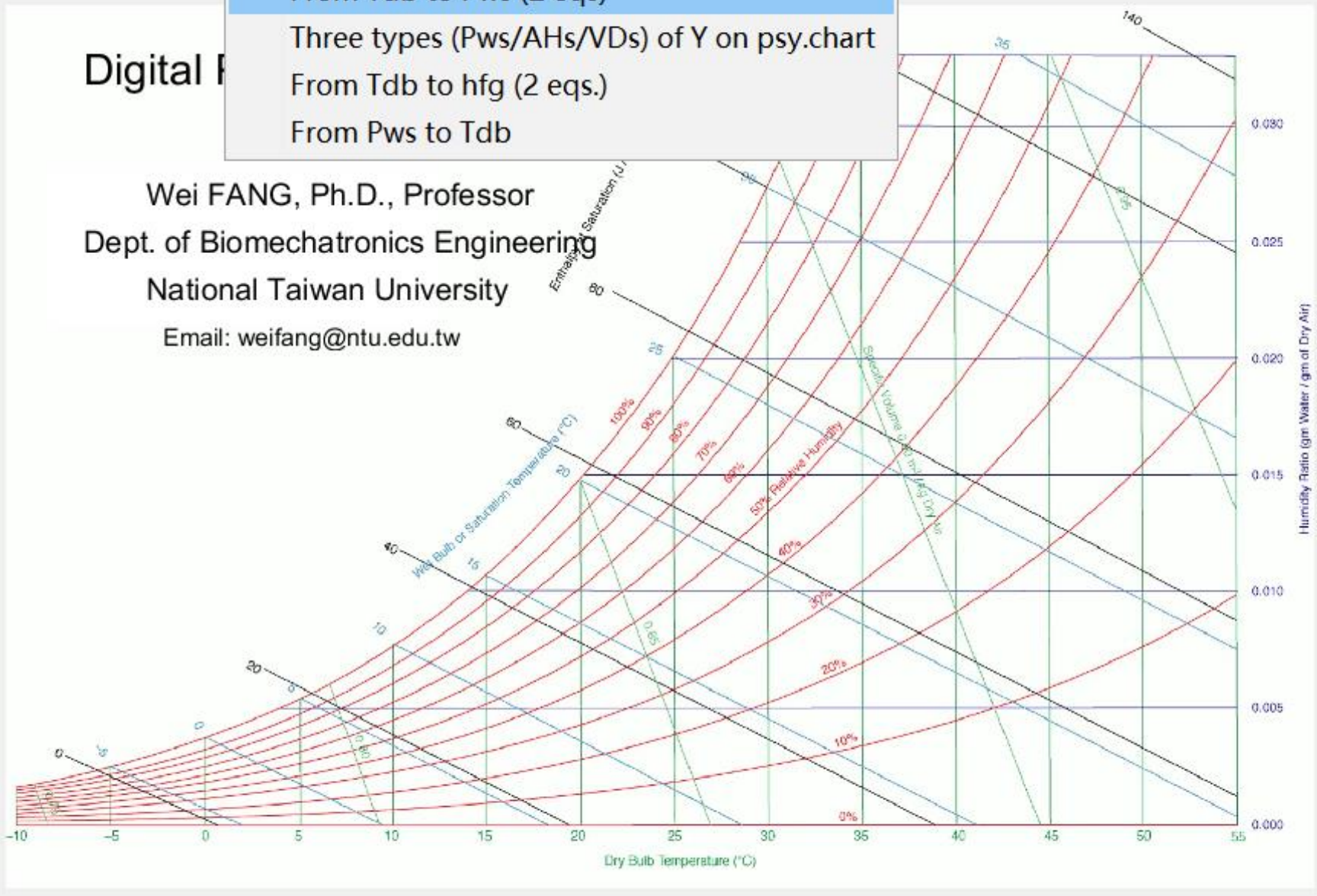
Digital P

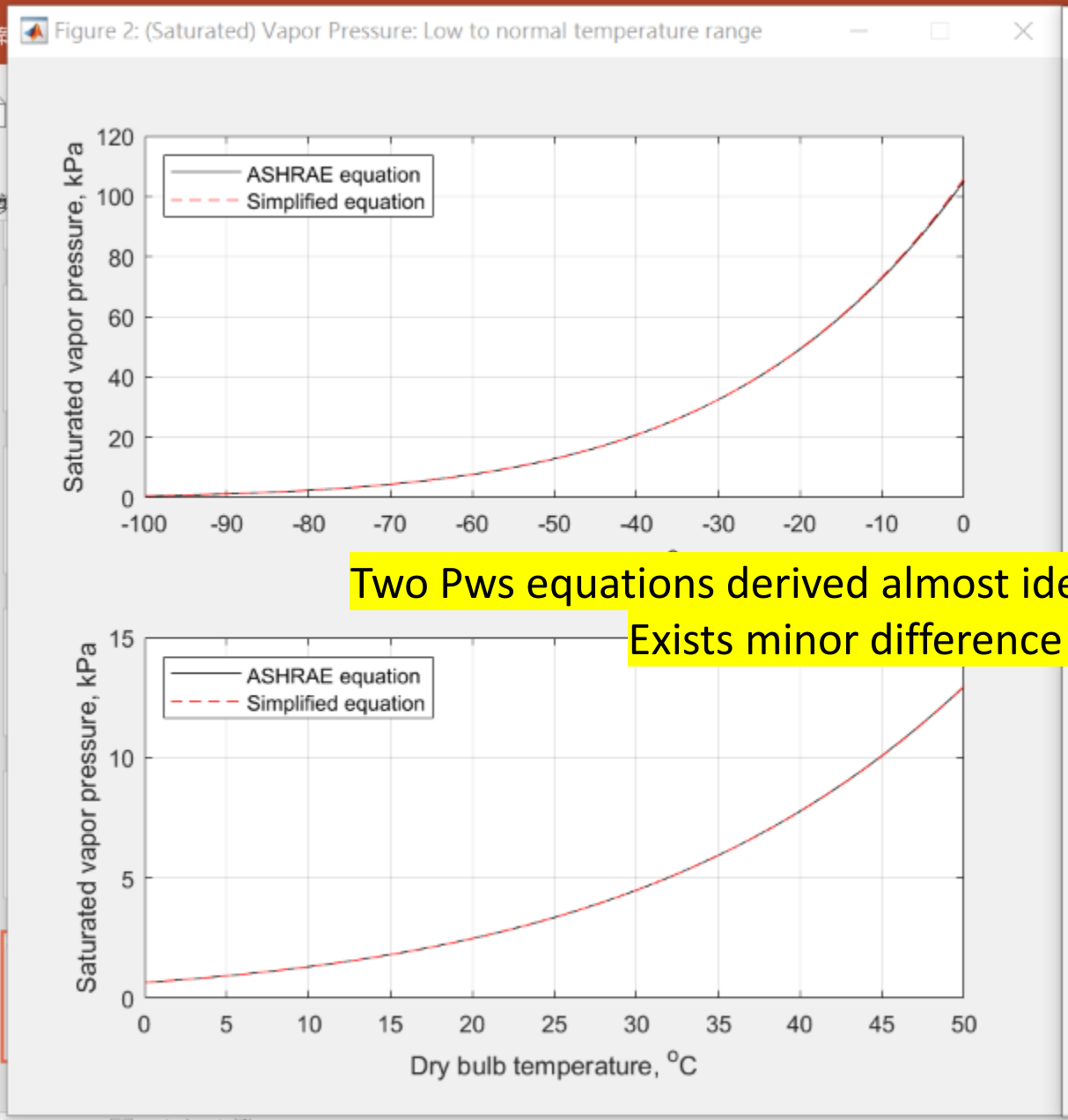
Wei FANG, Ph.D., Professor

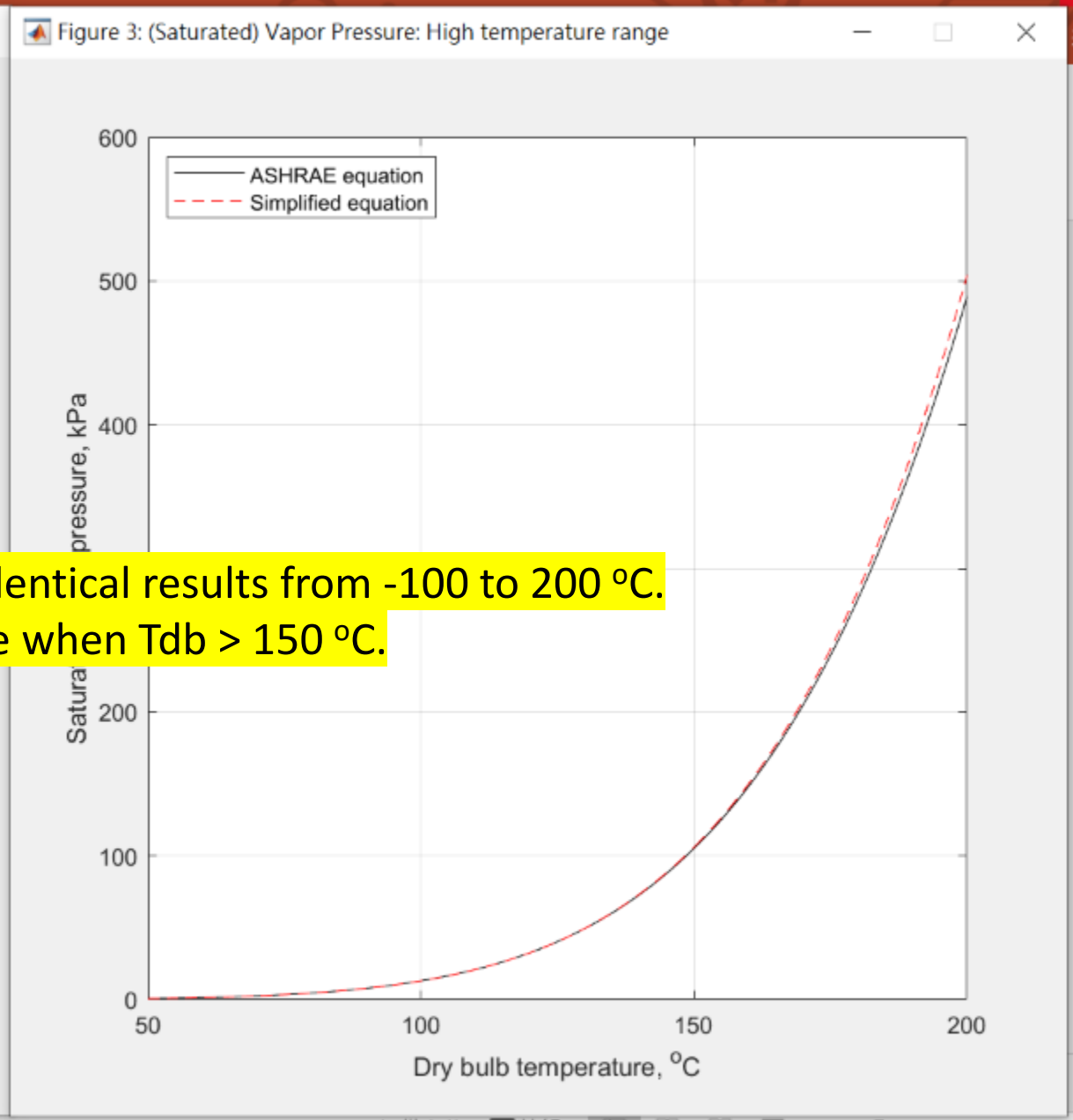
Dept. of Biomechatronics Engineering

National Taiwan University

Email: weifang@ntu.edu.tw







Two Pws equations derived almost identical results from -100 to 200 °C.
Exists minor difference when Tdb > 150 °C.

p_{ws}. The water vapor saturation partial pressure can be determined (in Pa) from the following for temperatures, T, in Kelvin:

$$\ln(p_{ws}) = A_1 / T + A_2 + A_3T + A_4T^2 + A_5T^3 + A_6T^4 + A_7\ln(T). \quad (2\text{-}1)$$

In the dry-bulb temperature range from -100 to 0 C, water vapor saturation of air is over ice and the coefficients of Equation 2-1 have the following values:

A_1 = -5.6745359 E + 03
A_2 = 6.3925247 E + 00
A_3 = -9.677843 E - 03
A_4 = 0.6221570 E - 06
A_5 = 2.0747825 E - 09
A_6 = -0.9484024 E - 12
A_7 = 4.1635019 E + 00

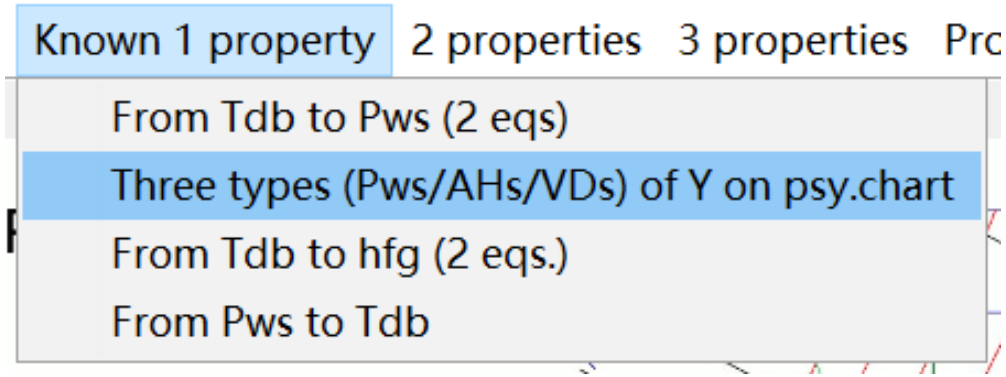
Over water, in the temperature range from 0 to 200 C, coefficients to calculate water vapor saturation partial pressure are:

A_1 = -5.8002206 E + 03
A_2 = 1.3914993 E + 00
A_3 = -48.640239 E - 03
A_4 = 41.764768 E - 06
A_5 = -14.452093 E - 09
A_6 = 0.0
A_7 = 6.5459673 E + 00

Pws = f(T) = 0.61121 exp((18.678 – (T / 234.5)) * (T / (257.14 + T))) . . . for T > 0 °C

Pw= Pws * (RH/100)

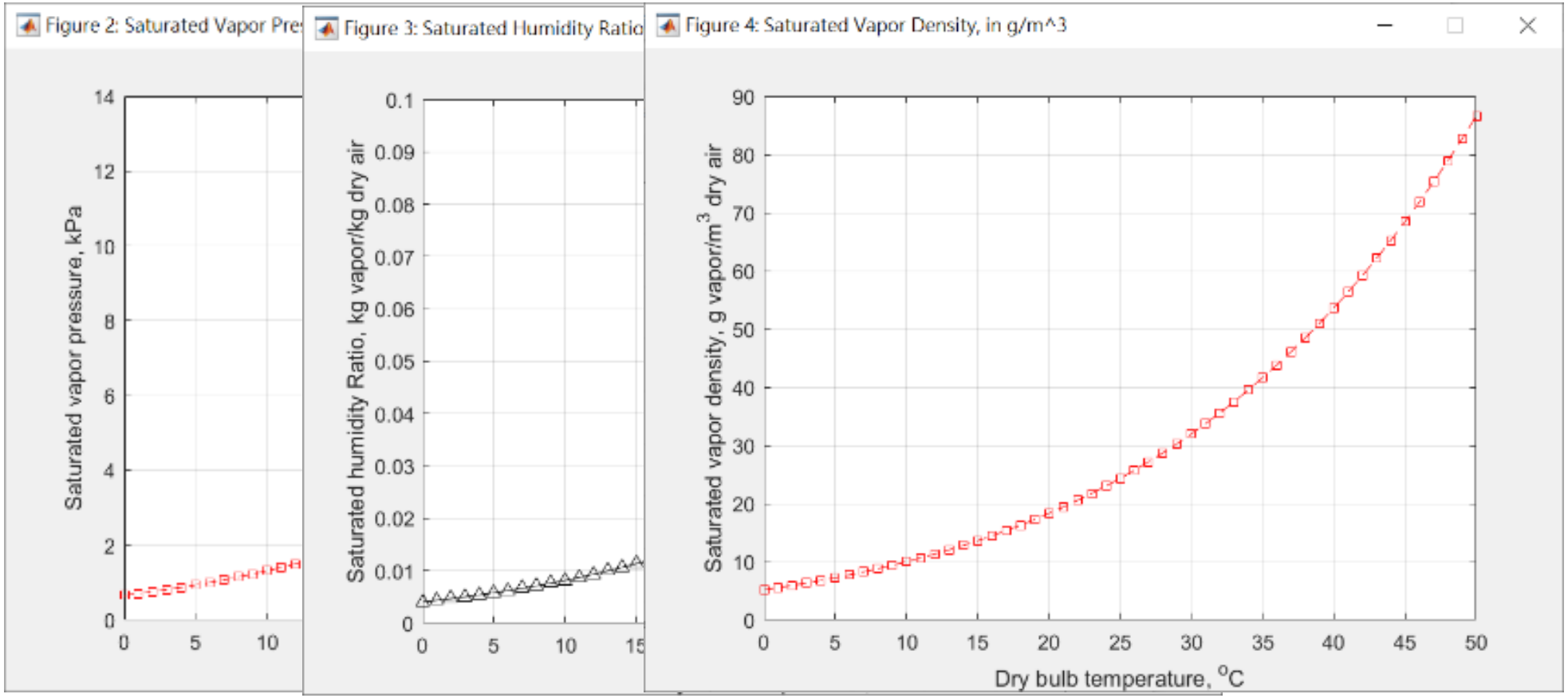
VPDa = Pws - Pw = Pws * (1-RH/100)



Pws in Pa or kPa

AHs in g or kg vapor/kg dry air

VDs in g or kg vapor/m^3 dry air



絕對溼度 $AH = 0.62198\ P_w / P_a$

$= 0.62198\ P_w / (P - P_w)$

$AH_s = 0.62198\ P_{ws} / (P - P_{ws})$

飽和度 $DOS = AH/AH_s$ $RH = P_w/P_{ws}$

飽差 $AHD = AH_s - AH$ $VPD = PW_{ws} - P_w$

比容=1/密度 $\upsilon = (1/P)\ R_a\ T\ (1+1.6078\ AH) / (1+AH)$

理想氣體的氣體常數
Ra = 287.055 J/kg.K

蒸汽密度 $VD_s = AH_s / \upsilon$

$VD = AH / \upsilon$

$DOS = VD/VD_s$

大氣壓力	Pa	101.325	kPa		
乾球溫度	T	20	deg.C		
相對溼度	RH	50	%		
飽和蒸汽壓	Pws	2.3383	kPa		
蒸汽壓	Pw	1.1692	kPa	1169.17	Pa
蒸汽壓差	**VPD**	**1.1692**	**kPa**		
飽和絕對溼度	AHs	0.0147	kg/kgDA	14.7	g/kgDA
絕對溼度	AH	0.0073	kg/kgDA	7.3	g/kgDA
飽差	**AHD**	**0.0074**	**kg/kgDA**	**7.4**	**g/kgDA**
飽和度	DOS	0.4942			

h_{fg}=2501 – 2.42 t 2452.6 kJ/kg

h=1.006 t + AH (2501 + 1.805 t) 38.541 kJ/kg

tdp=-35.957-1.8726*Ln(Pw)+1.1689*(Ln(Pw))^2 9.144 deg.C

氣體常數	Ra	287.055	J/kg.K
比容	SV	0.834	m3/kgDA
飽和蒸汽密度	VDs	17.615	g/m3
蒸汽密度	VD	8.704	g/m3
	DOS	0.4942	

Pws = f(T) = 0.61121 exp((18.678 – (T / 234.5)) * (T / (257.14 + T))) .. . for T > 0 oC

Pw= Pws * (RH/100)

VPDa = Pws - Pw = Pws * (1-RH/100)

AHs = 0.62198 * Pws / (Pa - Pws)

AH = 0.62198 * Pw / (Pa - Pw)

AHDa = AHs – AH = 0.62198 * [Pws / (Pa - Pws) - Pw / (Pa - Pw)]

RH = Pw / Pws

DOS = AH / AHs

SV=(1/P) Ra T (1+1.6078 AH) / (1+AH)

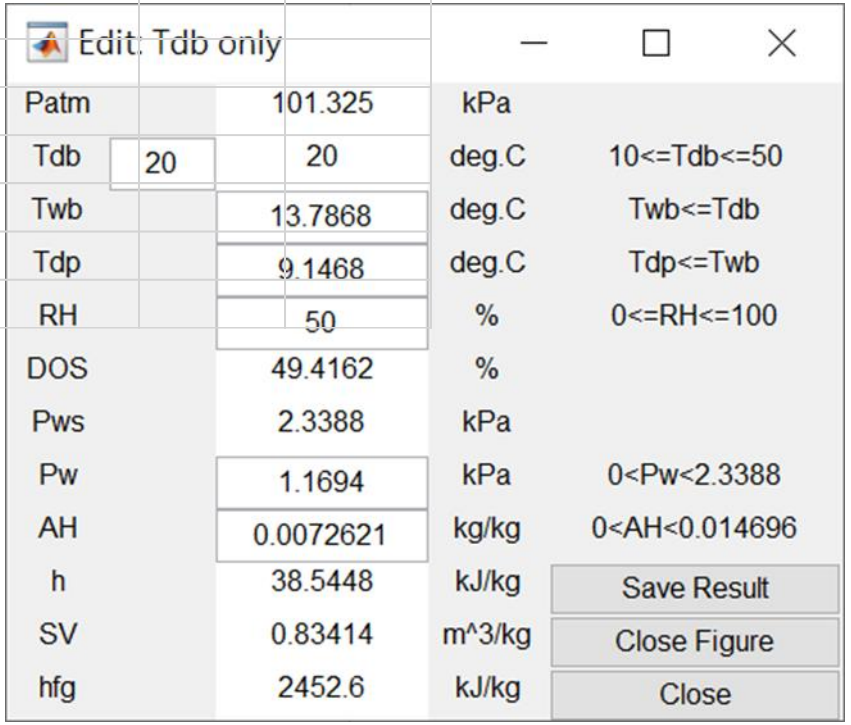
where P in Pa, T in K

VD: vapor density

VDs= AHs / SV

VD= AH / SV

DOS=VD / VDs



For conditions of frost between - 60 C and 0 C, the dew point in Celsius is

$$t_d = -60.45 + 7.03221n(p_w) + 0.3700(1n(p_w))^2.$$

For temperatures between 0 and 70 C

$$t_d = -35.957 - 1.87261n(p_w) + 1.1689(1n(p_w))^2,$$

where p_w has units of pascals.

$$P_w = \mathrm{Exp}\left(0.8801 + \sqrt{3.40302 + \frac{Td}{1.1689}}\right)$$

$$h = 1.006\ t + AH\ (2501 + 1.805\ t)$$

where t in °C, AH in kg/kg, h in kJ/kg

$$h_{fg} = 2501 - 2.42\ t$$

…簡化公式

where t in °C (0 ~ 65 °C only)

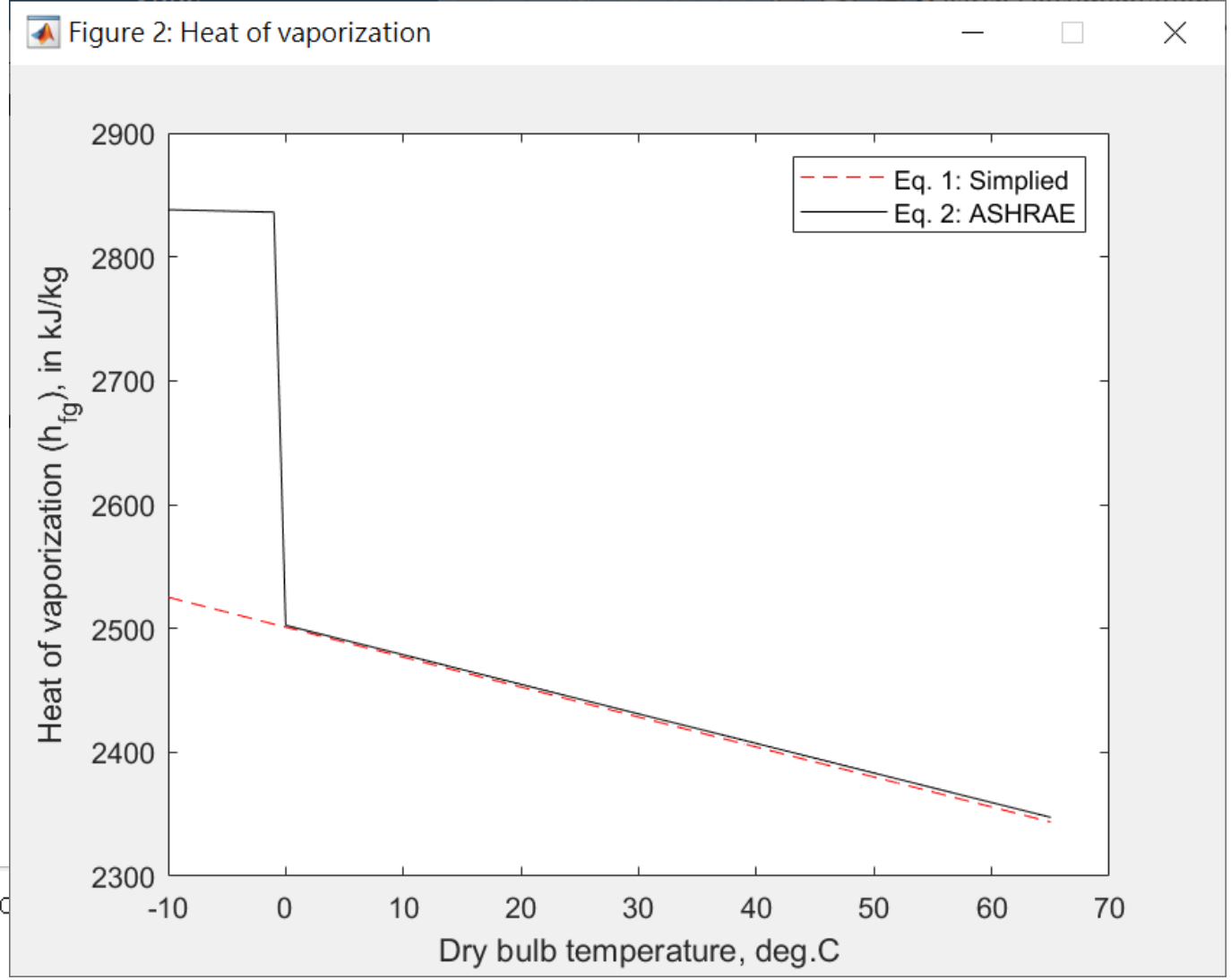
Edit: Tdb only

Patm		101.325	kPa	
Tdb	20	20	deg.C	10<=Tdb<=50
Twb		13.7868	deg.C	Twb<=Tdb
Tdp		9.1468	deg.C	Tdp<=Twb
RH		50	%	0<=RH<=100
DOS		49.4162	%	
Pws		2.3388	kPa	
Pw		1.1694	kPa	0<Pw<2.3388
AH		0.0072621	kg/kg	0<AH<0.014696
h		38.5448	kJ/kg	Save Result
SV		0.83414	m^3/kg	Close Figure
hfg		2452.6	kJ/kg	Close

Known 1 property | 2 properties | 3 properties | Pr

- From Tdb to Pws (2 eqs)
- Three types (Pws/AHs/VDs) of Y on psy.chart
- From Tdb to hfg (2 eqs.)
- From Pws to Tdb

Almost the same when Tdb > 0 °C

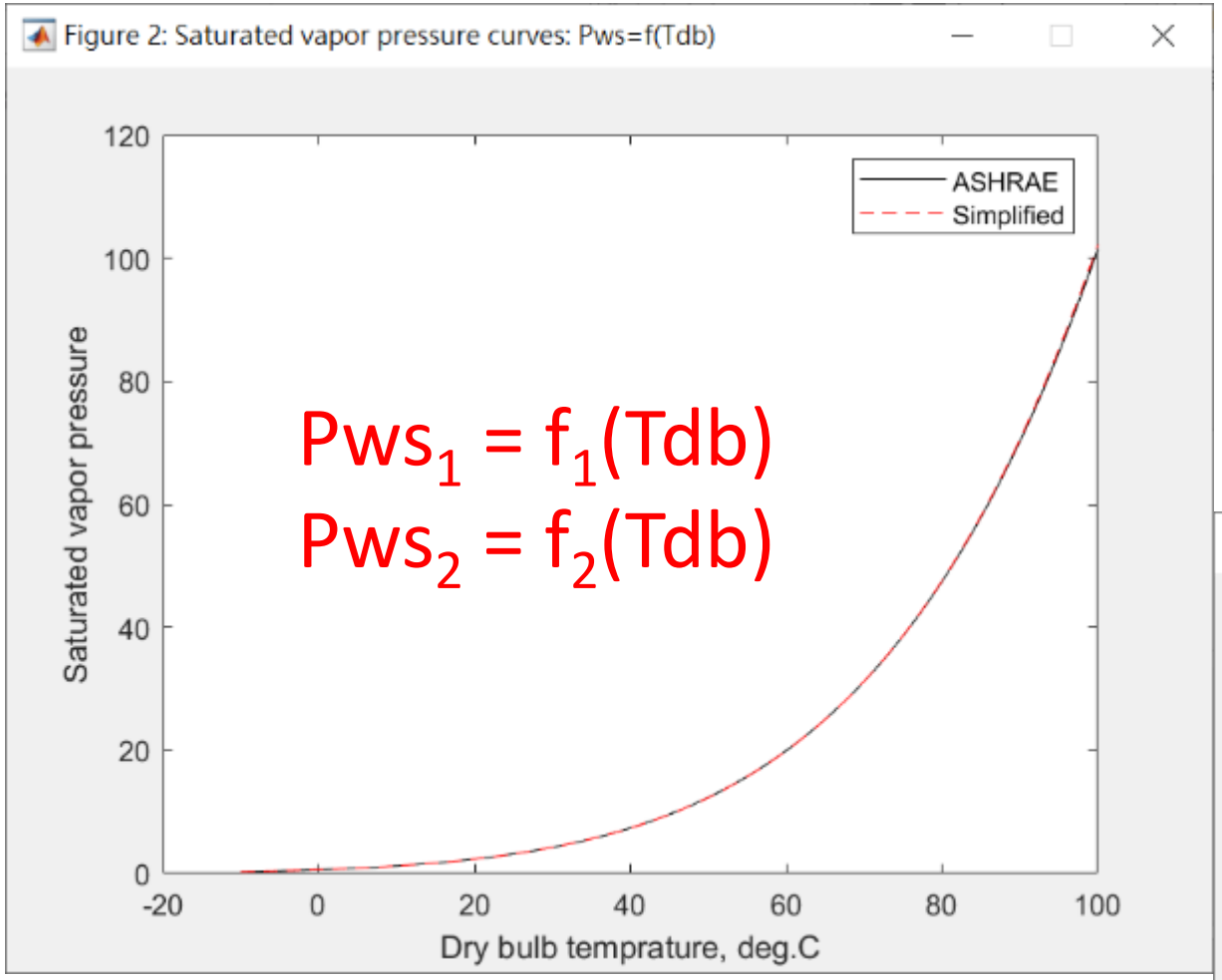



```
This program deals with the usage of the psychrometric subro
focusing on difference of two Tdb --> hfg equations

------------------------------------------------------------------------------------------
Given Tdb to derive hfg using various equations.......
Tdb                 =    -10    -5     0     10     20     30     40     50     60     70     80     90    100 deg.C
hfg (0~65 deg.C)    =   2525  2513  2501   2477   2453   2428   2404   2380   2356   2332   2307   2283   2259 kJ/kg
hfg (-18~200 deg.C) =   2838  2837  2503   2479   2455   2431   2407   2383   2359   2334   2310   2285   2259 kJ/kg
Press 'enter' to continue
```

Known 1 property | 2 properties | 3 properties | Pr

- From Tdb to Pws (2 eqs)
- Three types (Pws/AHs/VDs) of Y on psy.chart
- From Tdb to hfg (2 eqs.)
- From Pws to Tdb

```
------------------------------------------------------------------------------------------------
 This program deals with the usage of the psychrometric subroutines: psy.m
 focusing on equations to derive Pws from Tdb (Tdb --> Pws)  and vice versa (Pws --> Tdb)
------------------------------------------------------------------------------------------------
Tdb                = -10.00   0.00   1.00  10.00  20.00  30.00  40.00  50.00  60.00  80.00 100.00 deg.C
Pws_1              =   0.27   0.62   0.66   1.23   2.34   4.25   7.38  12.35  19.94  47.41 101.42 kPa
Pws_2              =   0.29   0.61   0.66   1.23   2.34   4.24   7.37  12.33  19.93  47.51 102.18 kPa
------------------------------------------------------------------------------------------------
Given Pws_1 to derived Tdb_1
            Tdb_1  =  -9.95   0.42   1.10  10.01  20.01  30.02  40.03  50.03  60.03  80.03 100.03 deg.C
    error of Tdb_1 =   0.05   0.42   0.10   0.01   0.01   0.02   0.03   0.03   0.03   0.03   0.03 deg.C
Given Pws_2 to derived Tdb_2
            Tdb_2  =  -9.17   0.12   1.10  10.01  20.00  30.01  40.00  50.00  60.01  80.08 100.24 deg.C
    error of Tdb_2 =   0.83   0.12   0.10   0.01   0.00   0.01   0.00   0.00   0.01   0.08   0.24 deg.C
------------------------------------------------------------------------------------------------
```

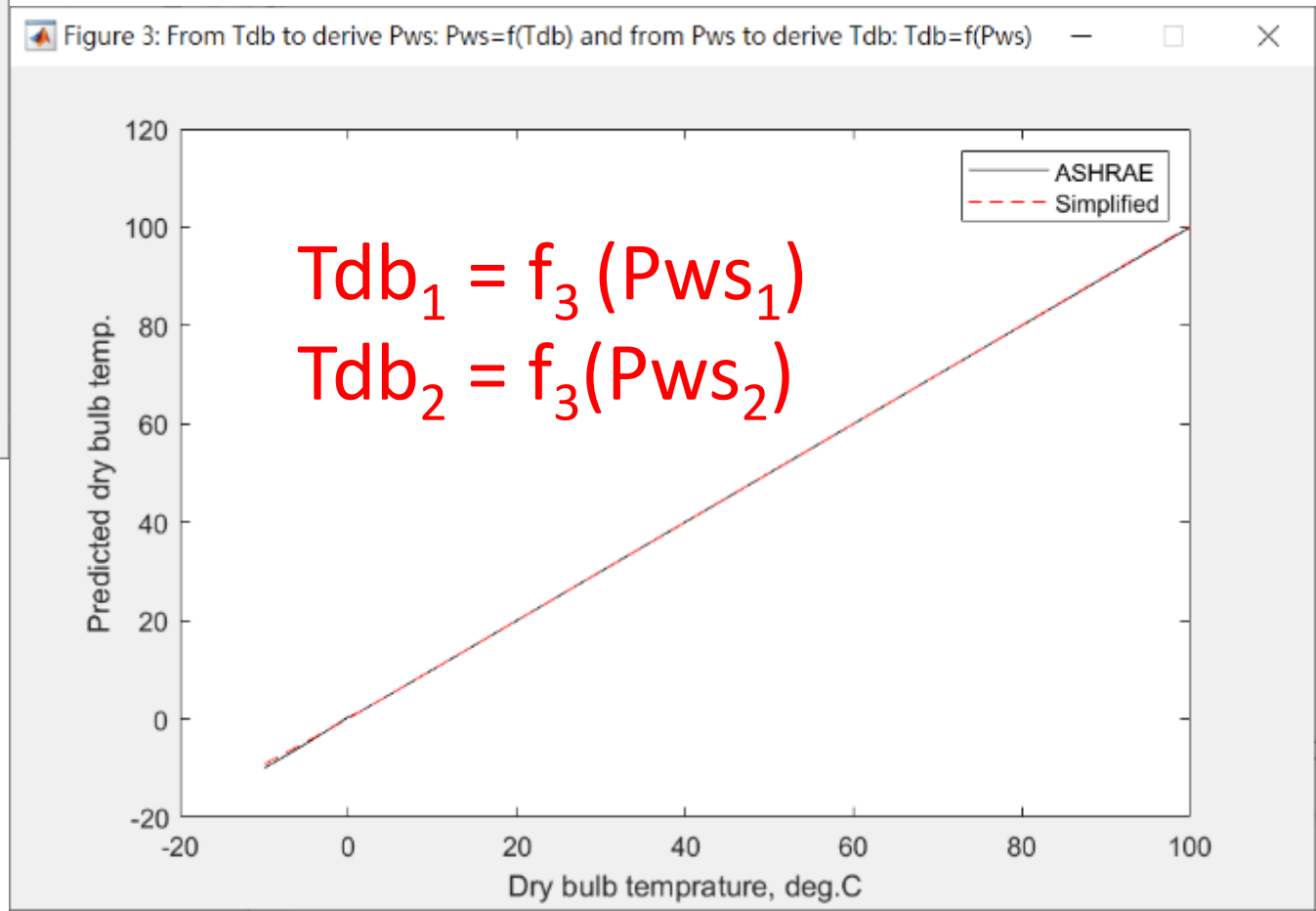


$Pws_1 = f_1(Tdb)$

$Pws_2 = f_2(Tdb)$

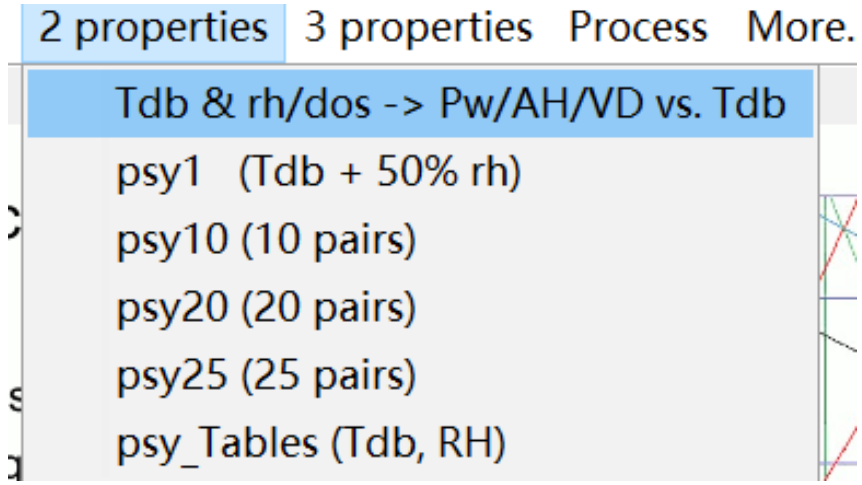
Two equations (f_1, f_2) derived same result ($Pws_1 = Pws_2$) when $Tdb \geq 0\ ^oC$

One equation (f_3) derived same result ($Tdb \geq 0\ ^oC$) when input varied (Pws_1, Pws_2)



$Tdb_1 = f_3(Pws_1)$

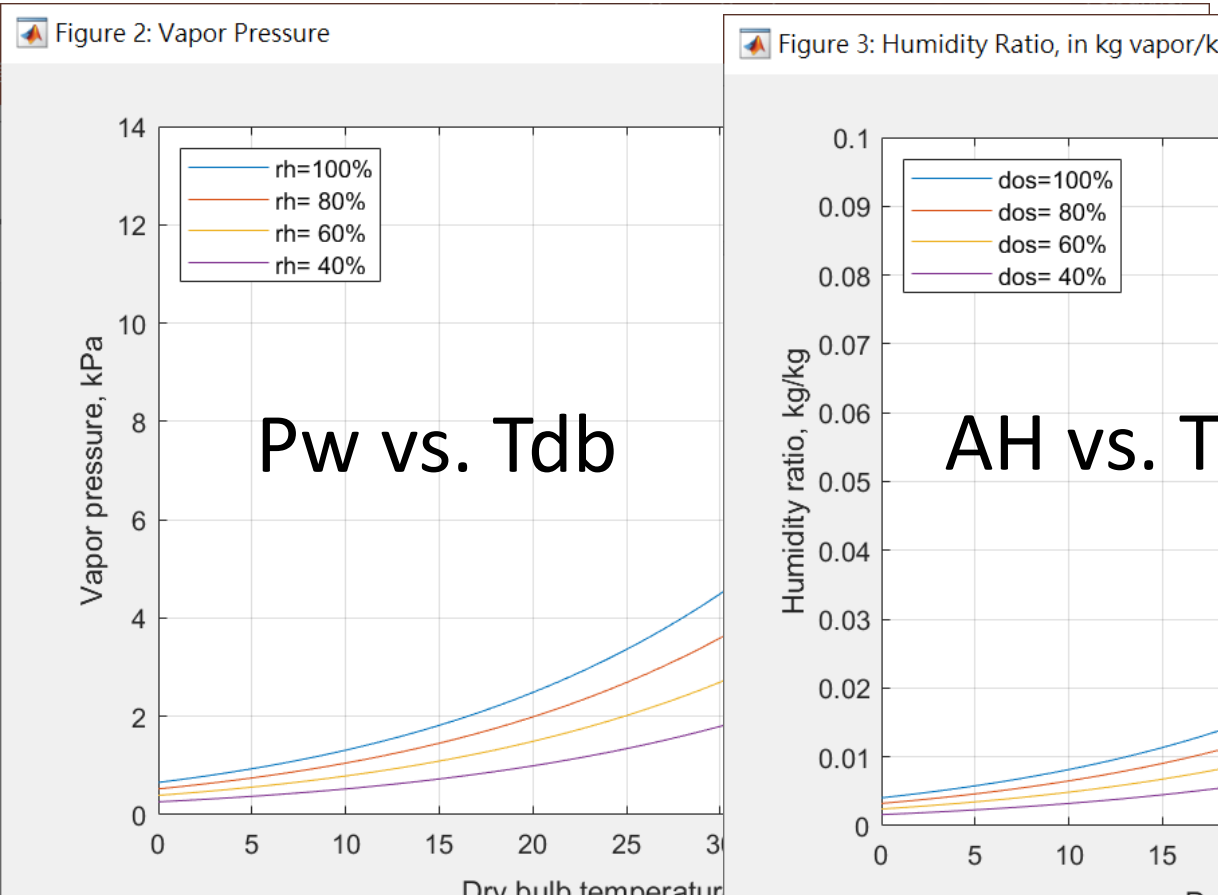
$Tdb_2 = f_3(Pws_2)$

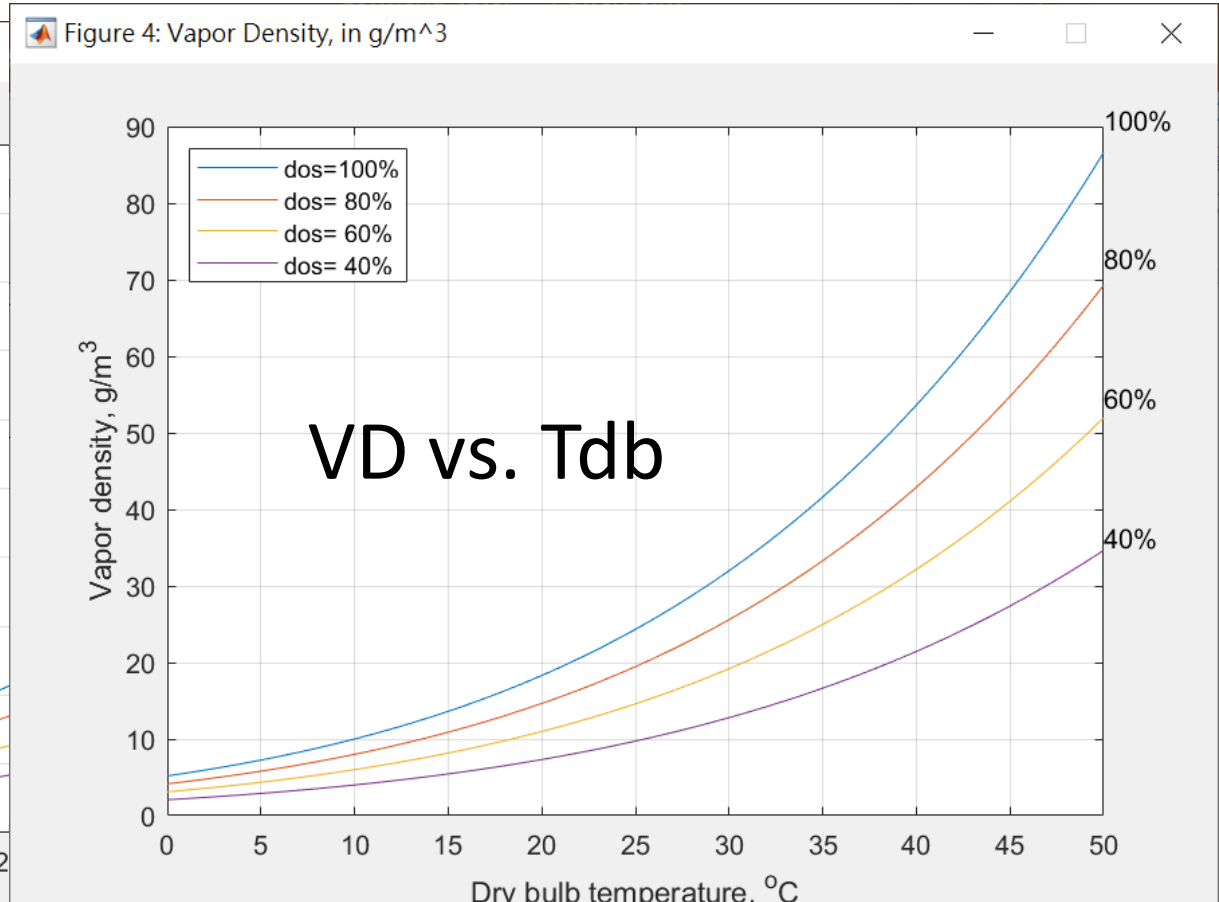


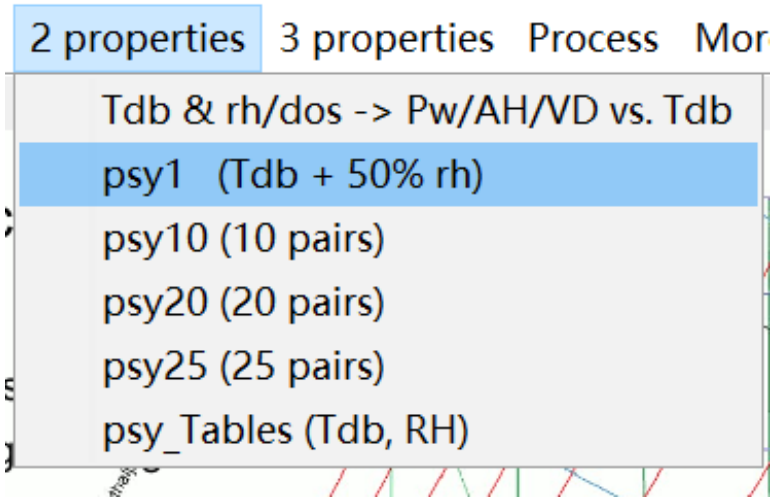
Relative humidity (rh) = Pw/Pws*100

Degree of saturation (dos) = AH/AHs*100

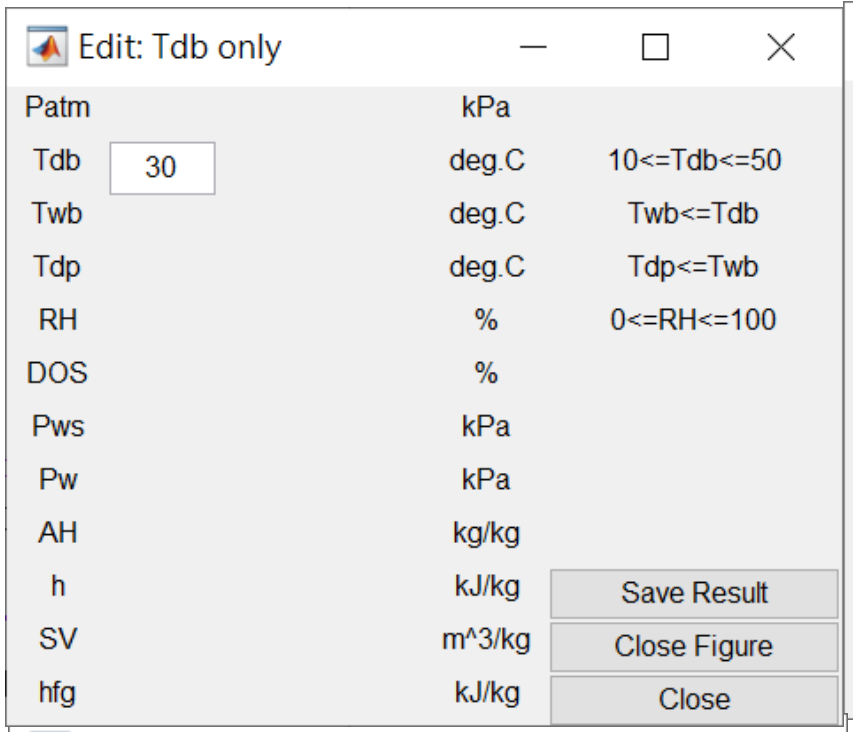
dos = VD/VDs*100

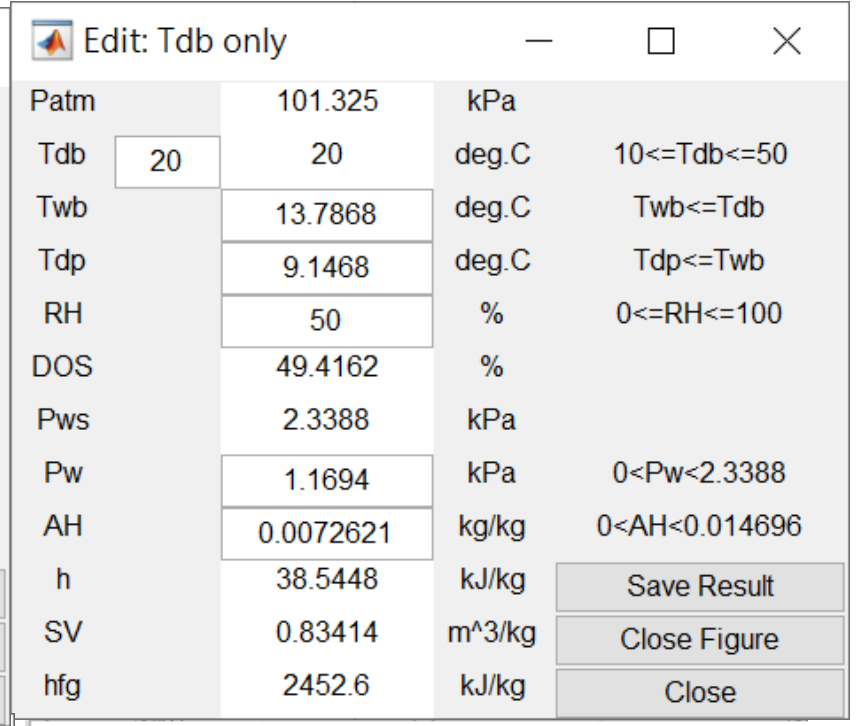


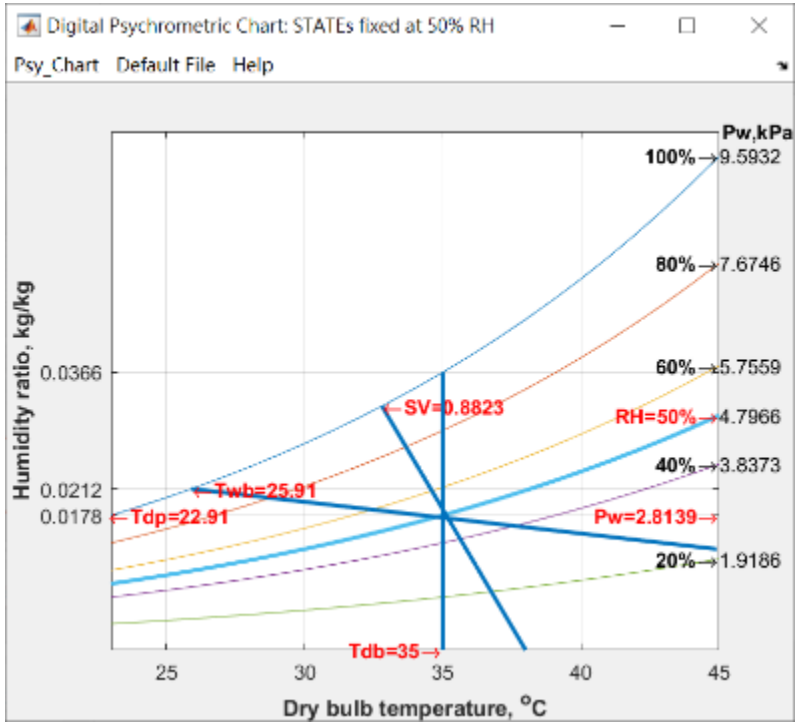


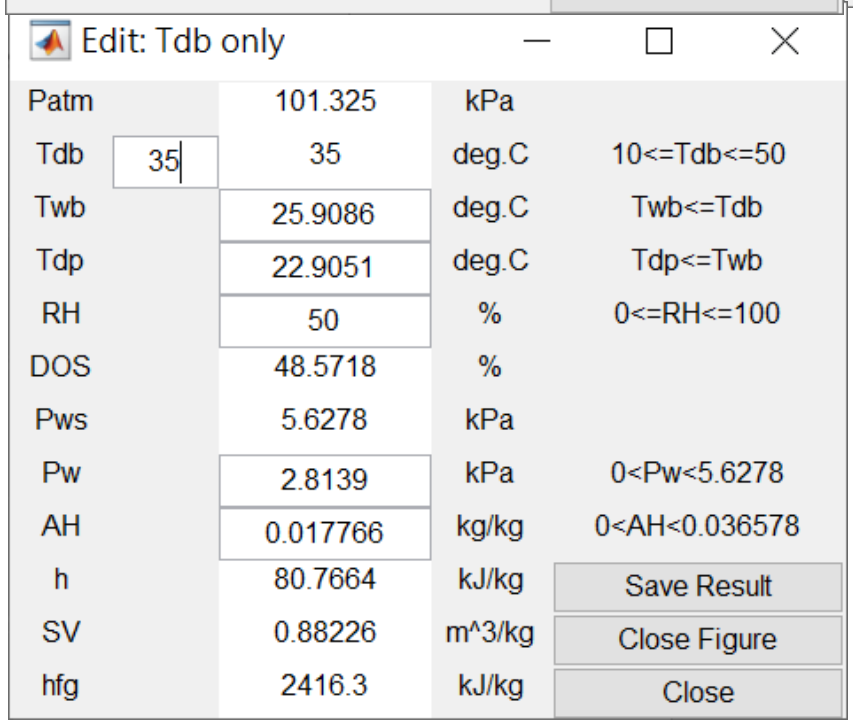

2 properties
3 properties
Process
Mor
Tdb & rh/dos -> Pw/AH/VD vs. Tdb
psy1 (Tdb + 50% rh)
psy10 (10 pairs)
psy20 (20 pairs)
psy25 (25 pairs)
psy_Tables (Tdb, RH)

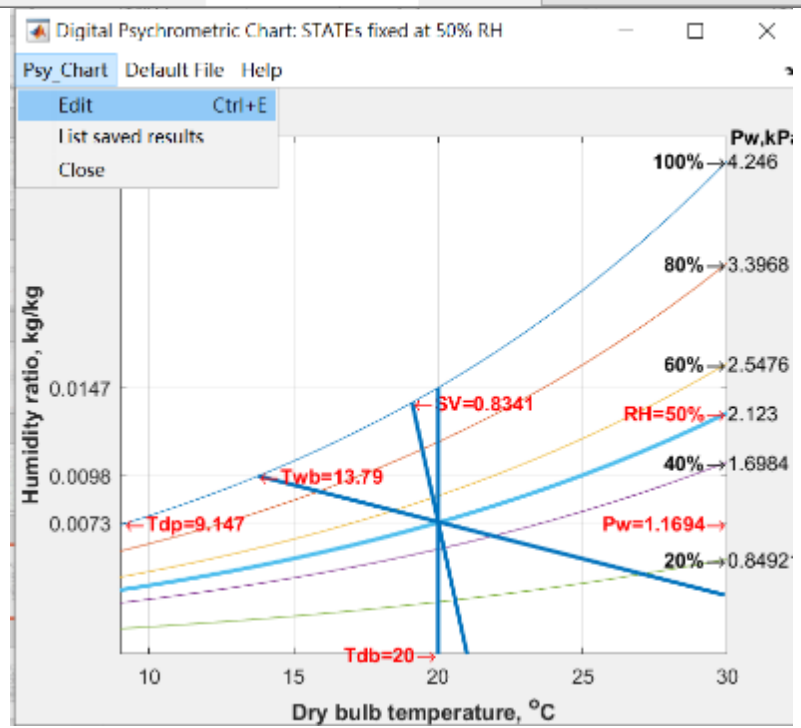
f(Tdb, rh=50%)

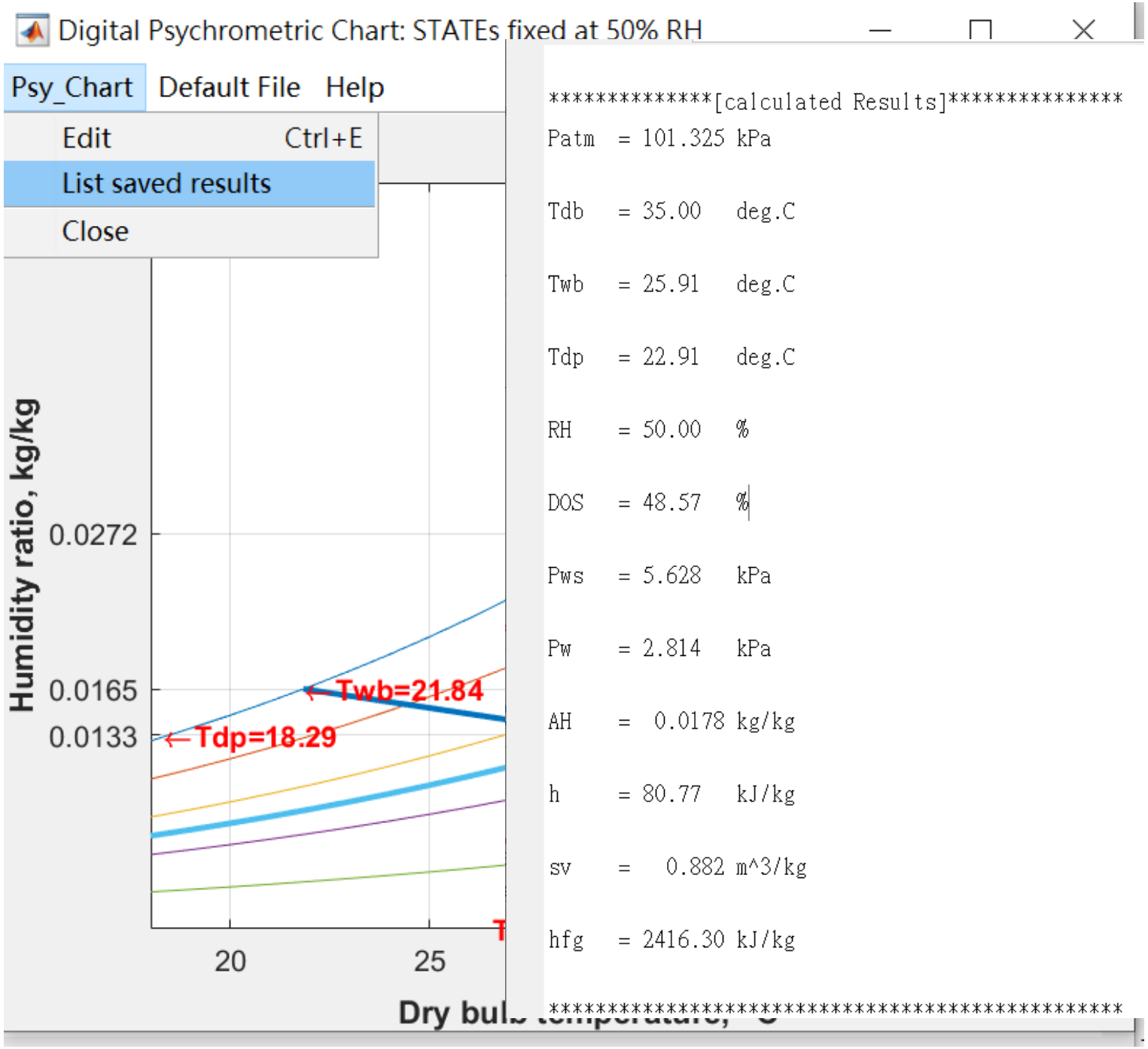

Edit: Tdb only
Patm kPa
Tdb 30 deg.C 10<=Tdb<=50
Twb deg.C Twb<=Tdb
Tdp deg.C Tdp<=Twb
RH % 0<=RH<=100
DOS %
Pws kPa
Pw kPa
AH kg/kg
h kJ/kg
SV m^3/kg
hfg kJ/kg
Save Result
Close Figure
Close


Edit: Tdb only
Patm 101.325 kPa
Tdb 20 20 deg.C 10<=Tdb<=50
Twb 13.7868 deg.C Twb<=Tdb
Tdp 9.1468 deg.C Tdp<=Twb
RH 50 % 0<=RH<=100
DOS 49.4162 %
Pws 2.3388 kPa
Pw 1.1694 kPa 0<Pw<2.3388
AH 0.0072621 kg/kg 0<AH<0.014696
h 38.5448 kJ/kg
SV 0.83414 m^3/kg
hfg 2452.6 kJ/kg
Save Result
Close Figure
Close


Digital Psychrometric Chart: STATEs fixed at 50% RH
Psy_Chart Default File Help
Pw,kPa
100%→9.5932
80%→7.6746
60%→5.7559
RH=50%→4.7966
40%→3.8373
20%→1.9186
Pw=2.8139→
SV=0.8823
Twb=25.91
Tdp=22.91
Tdb=35→
Humidity ratio, kg/kg
0.0366
0.0212
0.0178
25
30
35
40
45
Dry bulb temperature, °C

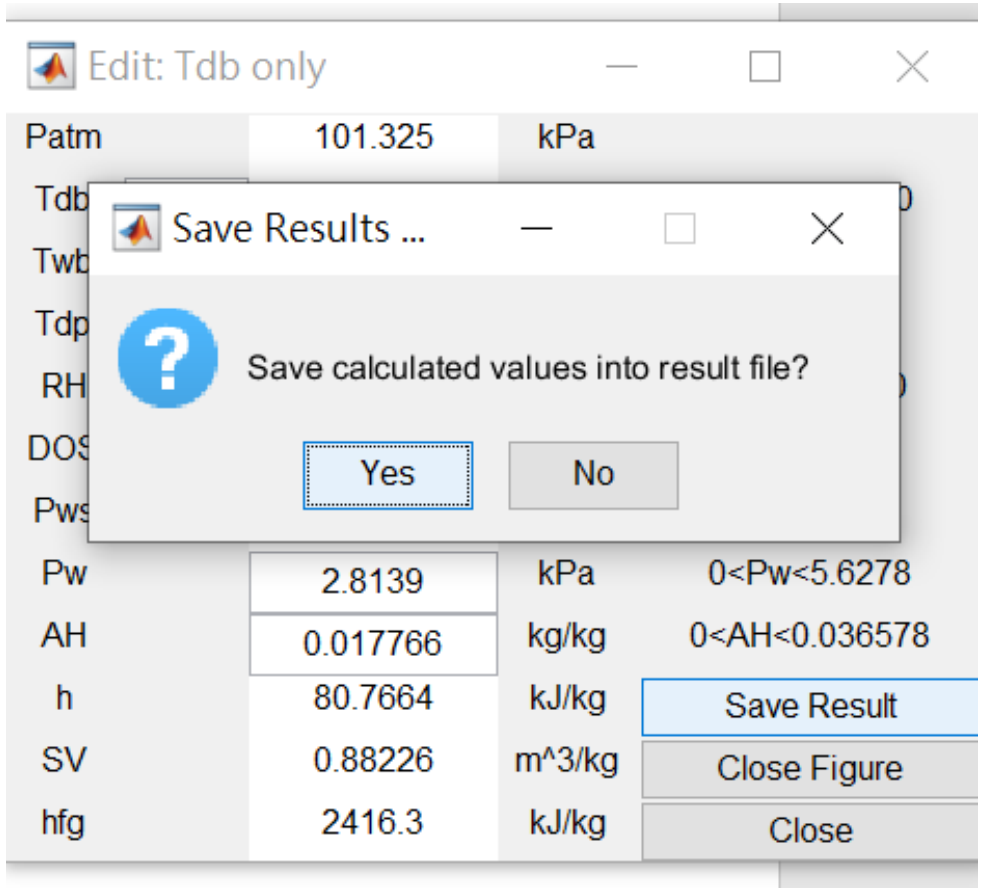

Edit: Tdb only
Patm 101.325 kPa
Tdb 35 35 deg.C 10<=Tdb<=50
Twb 25.9086 deg.C Twb<=Tdb
Tdp 22.9051 deg.C Tdp<=Twb
RH 50 % 0<=RH<=100
DOS 48.5718 %
Pws 5.6278 kPa
Pw 2.8139 kPa 0<Pw<5.6278
AH 0.017766 kg/kg 0<AH<0.036578
h 80.7664 kJ/kg
SV 0.88226 m^3/kg
hfg 2416.3 kJ/kg
Save Result
Close Figure
Close


Digital Psychrometric Chart: STATEs fixed at 50% RH
Psy_Chart Default File Help
Edit Ctrl+E
List saved results
Close
Pw,kPa
100%→4.246
80%→3.3968
60%→2.5476
RH=50%→2.123
40%→1.6984
Pw=1.1694→
20%→0.8492
SV=0.8341
Twb=13.79
Tdp=9.147
Tdb=20→
Humidity ratio, kg/kg
0.0147
0.0098
0.0073
10
15
20
25
30
Dry bulb temperature, °C



psy.dat

Psyresult.dat

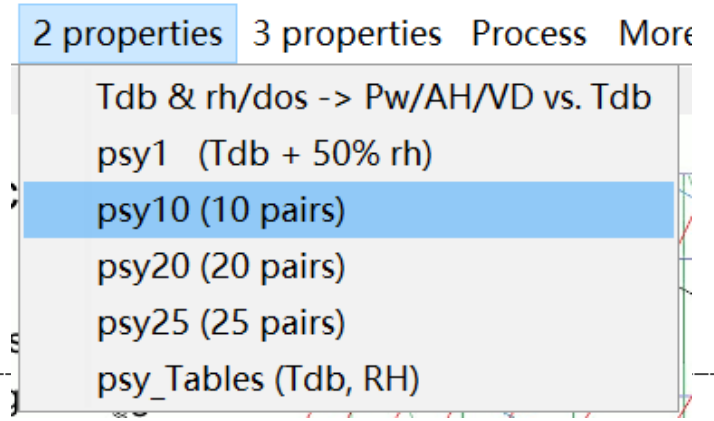


Totally, 45 Pairs of psychrometric properties
39 independent pairs (Possible to derive others)
6 dependent pairs (Impossible to derive others)

	T_{wb}	RH	T_{dp}	AH	SV	H	P_{ws}	h_{fg}	P_w
T_{db}	P	P	P	P	P	P	I	I	P
T_{wb}		P	P	P	P	I	P	P	P
Rh			P	P	P	P	P	P	P
T_{dp}				I	P	P	P	P	I
AH					P	P	P	P	I
SV						P	P	P	P
H							P	P	P
P_{ws}								P	P
h_{fg}									P

Totally, 55 Pairs of psychrometric properties
47 independent pairs (Possible to derive others)
8 dependent pairs (Impossible to derive others)

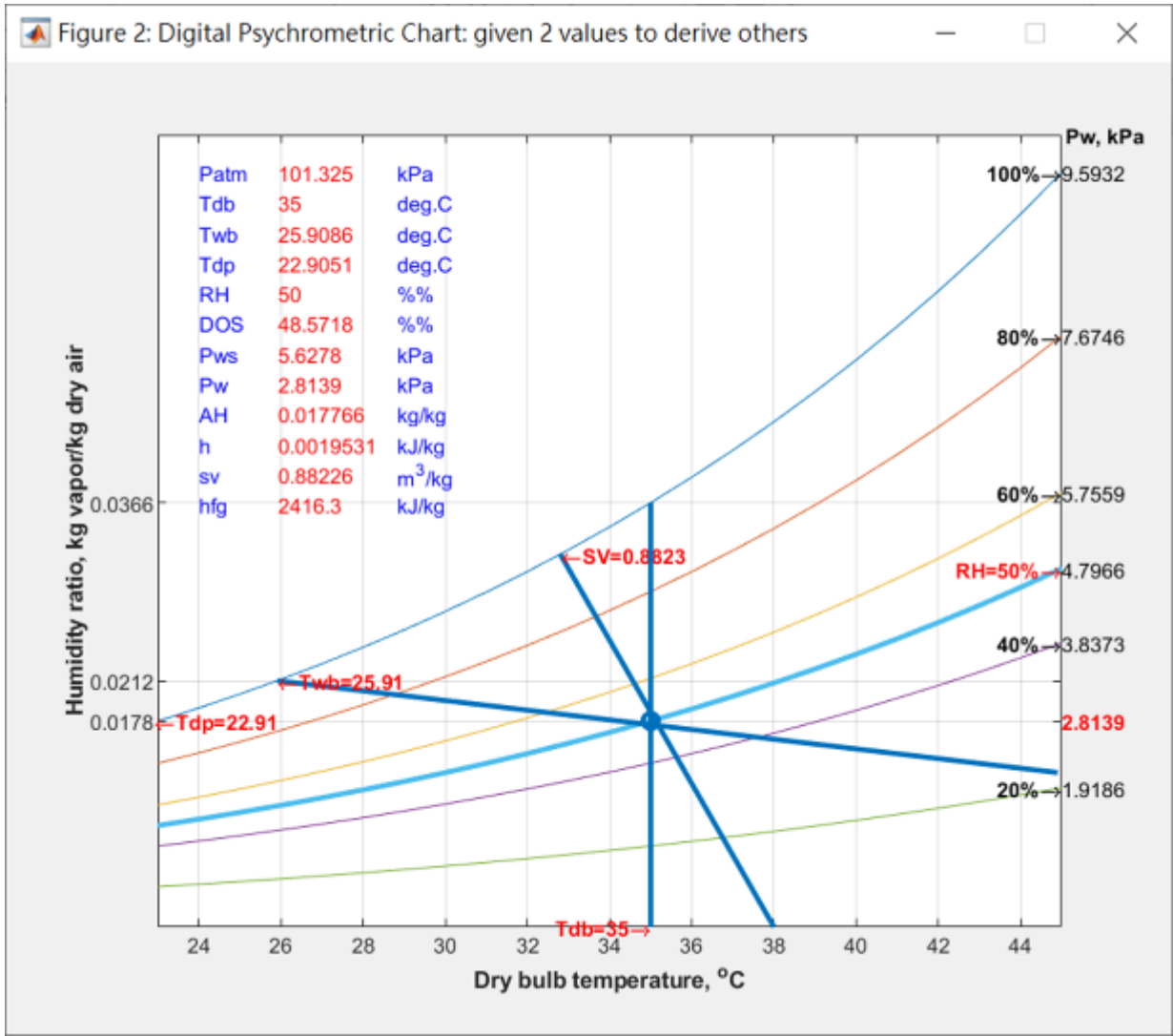
	T_{wb}	RH	T_{dp}	AH	SV	H	P_{ws}	h_{fg}	P_w	**DOS**
T_{db}	P	P	P	P	P	P	I	I	P	P
T_{wb}		P	P	P	P	I	P	P	P	P
RH			P	P	P	P	P	P	P	I
T_{dp}				I	P	P	P	P	I	P
AH					P	P	P	P	I	P
SV						P	P	P	P	P
H							P	P	P	P
P_{ws}								I	P	P
h_{fg}									P	P
P_w										**P**



10 pairs of input parameters

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah
-------------------------------------------------------------------------------

                press Enter to quit, input 1:10 to choose 1

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm             (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb (deg. C) =  35.000
 enter Rel. humidity (from 0 to 100%, press 'enter' for detail) =
 Rel. humidity (from 0 to 100%) = 50.000
```

f(Tdb, rh)



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

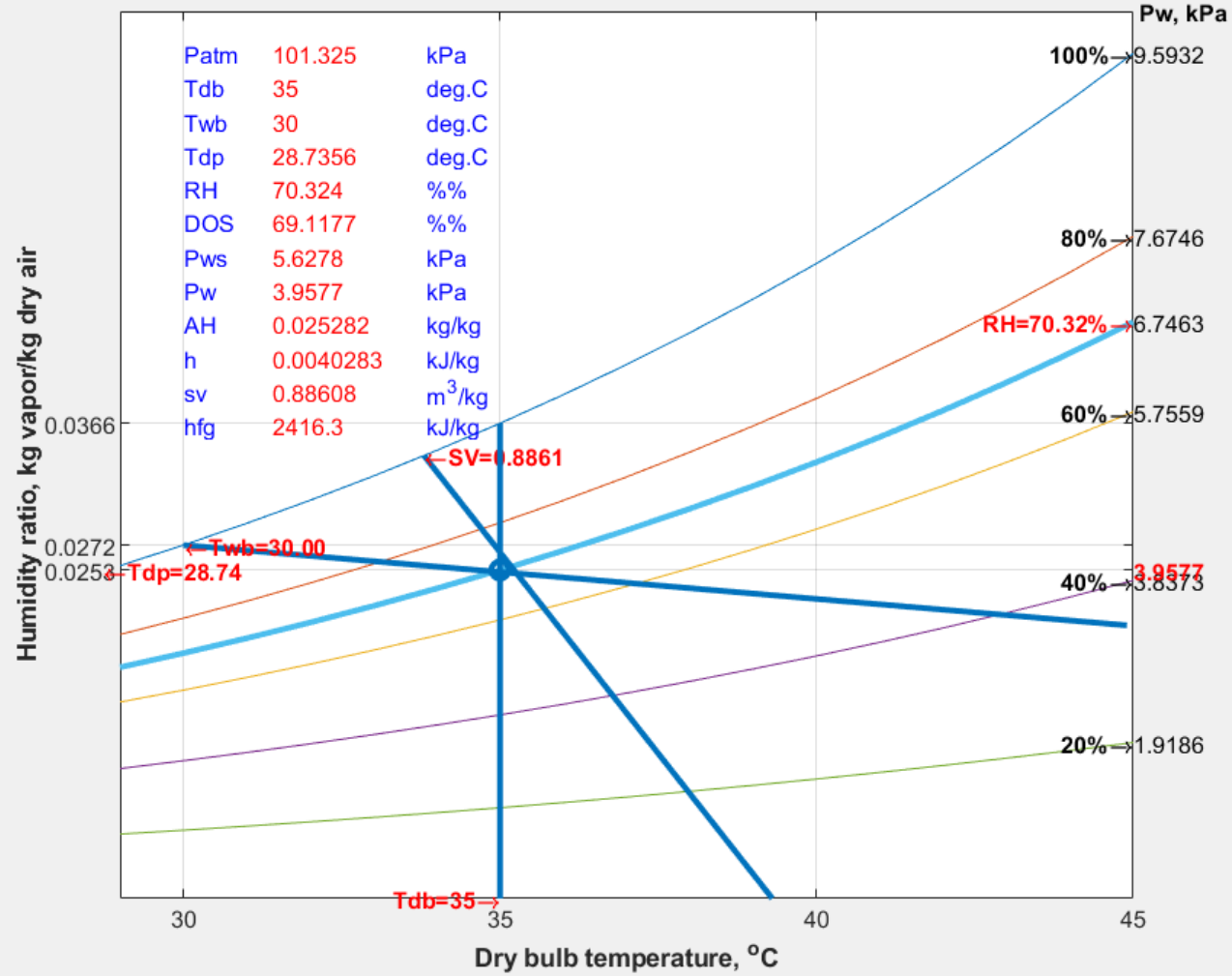
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 2

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb (deg. C) =  35.000
 enter Wet bulb T (from 12.70 to 35.00 deg.C, press 'enter' for default) =
 Wet bulb T (from 12.70 to 35.00 deg.C) = 30.000
```

f(Tdb, Twb)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

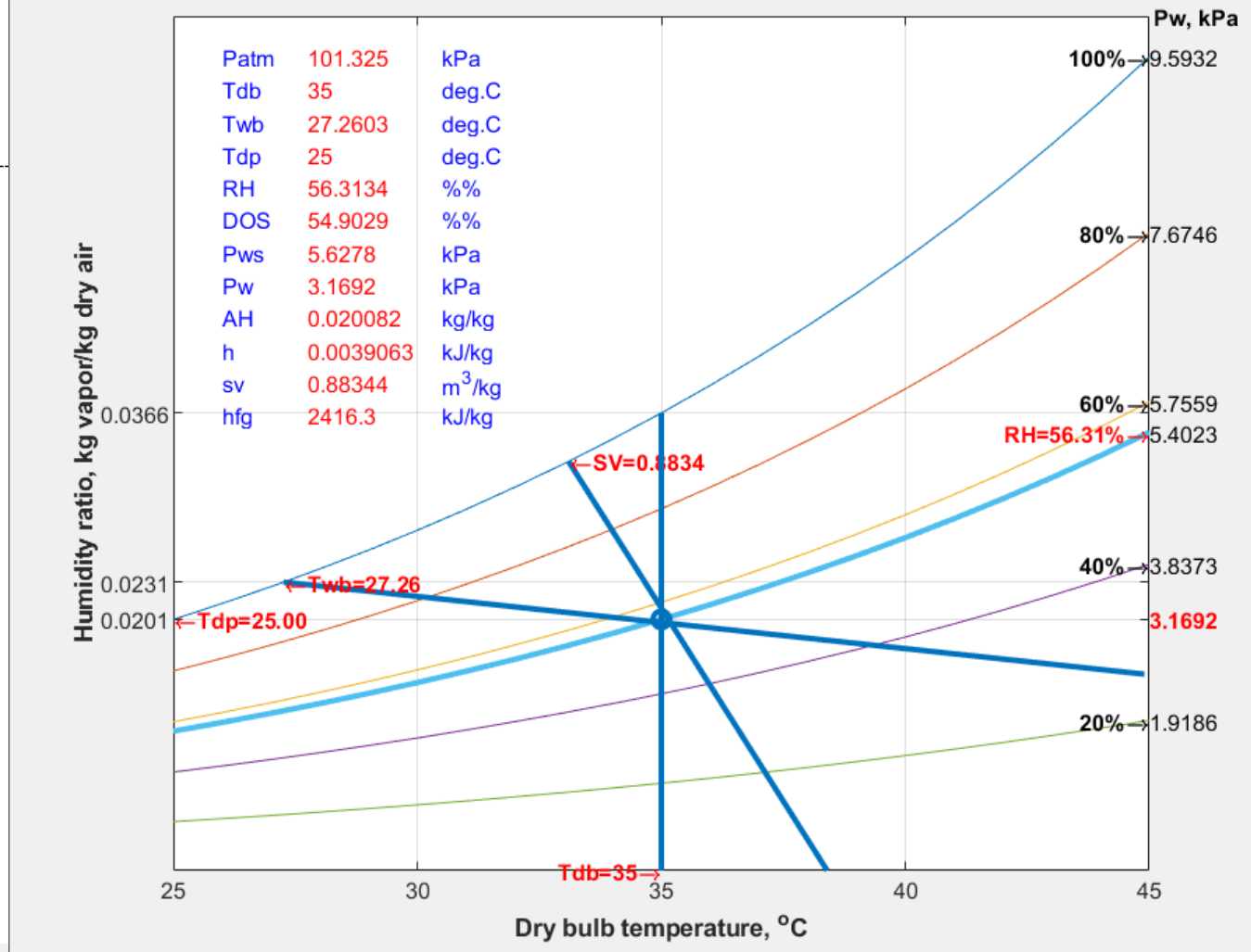
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 3

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb (deg. C) =  35.000
 enter Dew pt. T (from -34.49 to 35.00 deg.C, press 'enter' for default) =
 Dew pt. T (from -34.49 to 35.00 deg.C) = 25.000
```

f(Tdb, Tdp)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

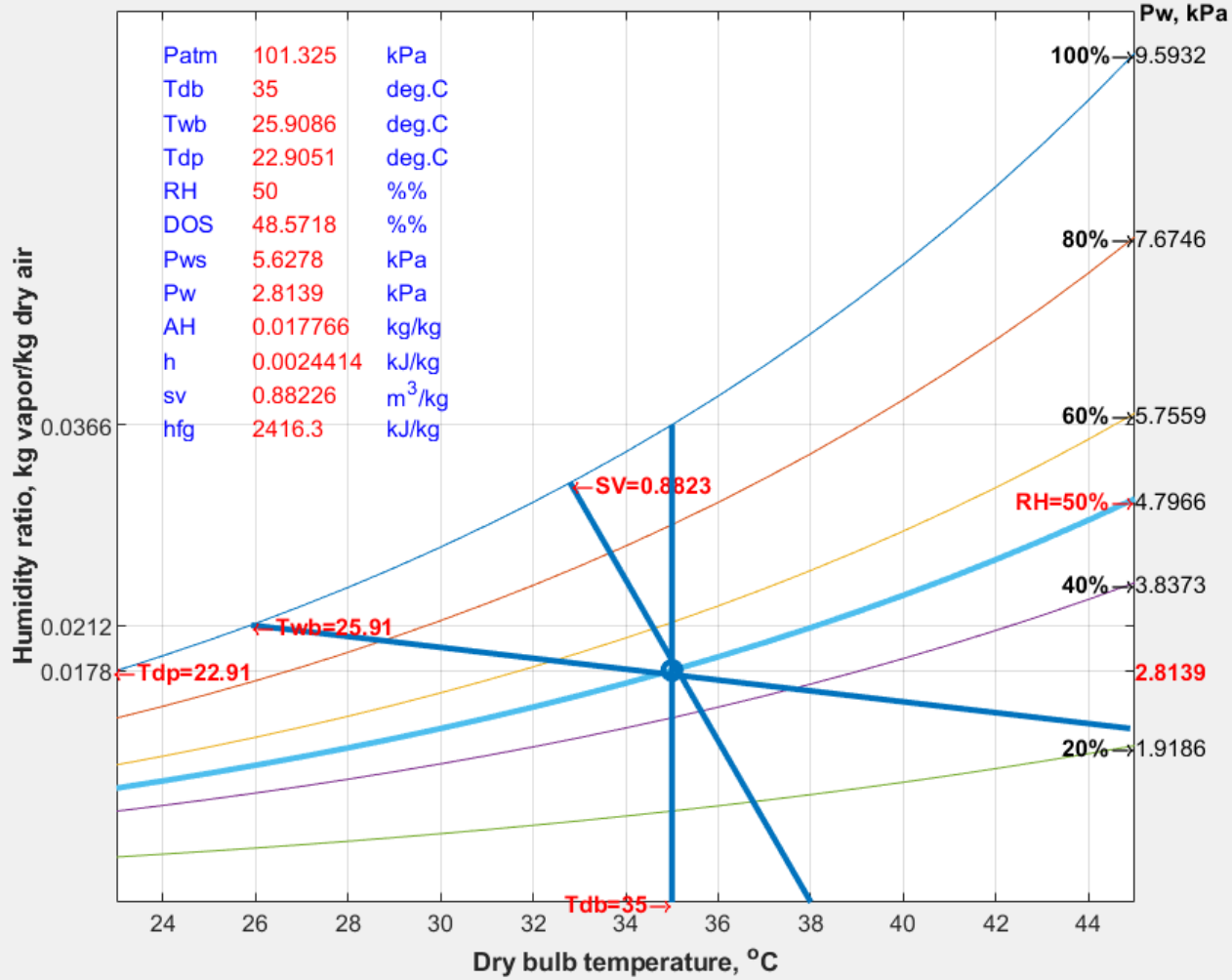
```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 4

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb (deg. C) =  35.000
 enter Vapor pressure (from 0.0006 to 5.6278 kPa, press 'enter' for default) =
 Vapor pressure (from 0.0006 to 5.6278 kPa) =  2.814
```

fx

f(Tdb, Pw)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

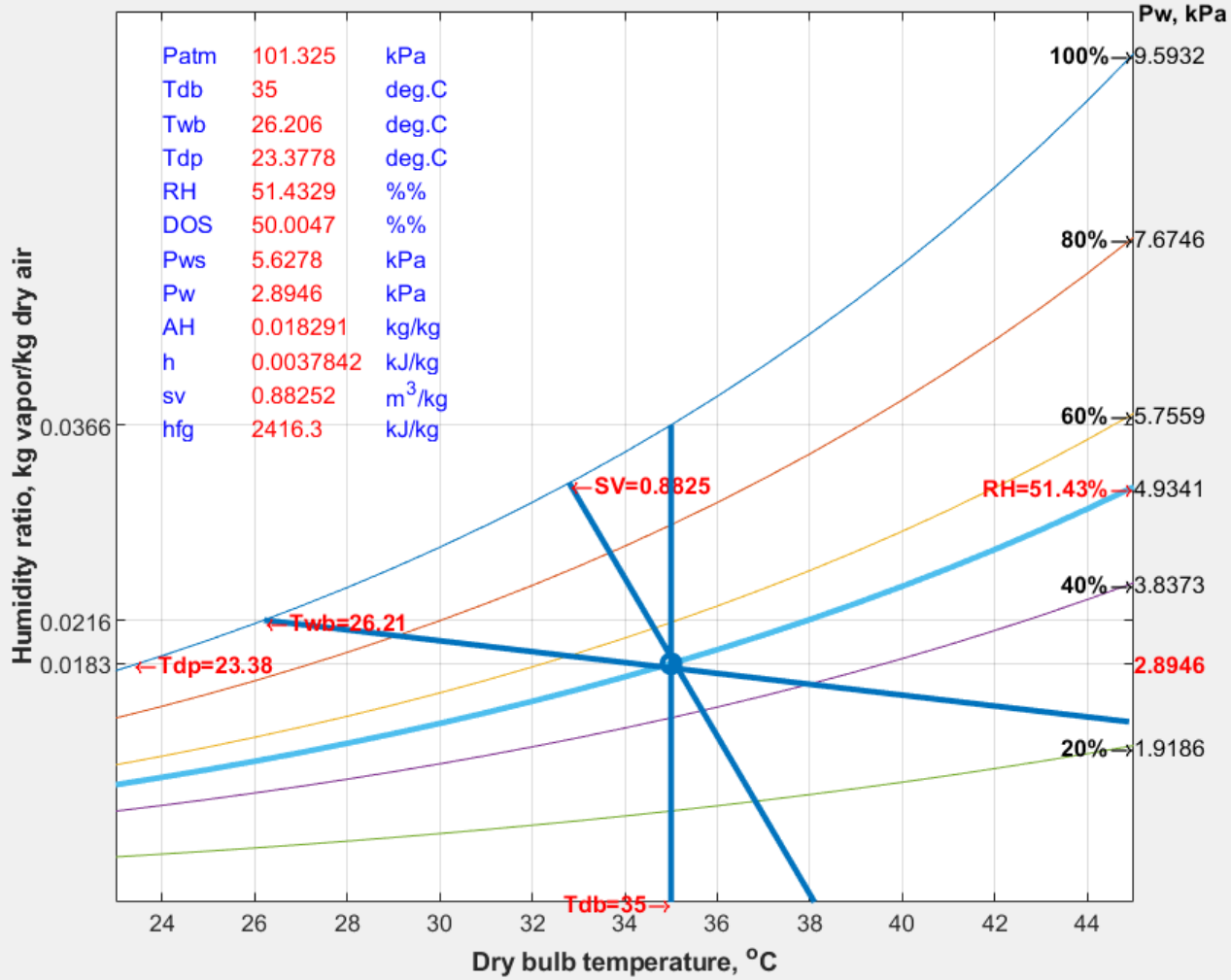
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 5

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb (deg. C) =  35.000
 enter Abs. humidity (from 0.00000 to 0.03658 kg/kg, press 'enter' for default) =
 Abs. humidity (from 0.00000 to 0.03658 kg/kg) =  0.018
```

f(Tdb, ah)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

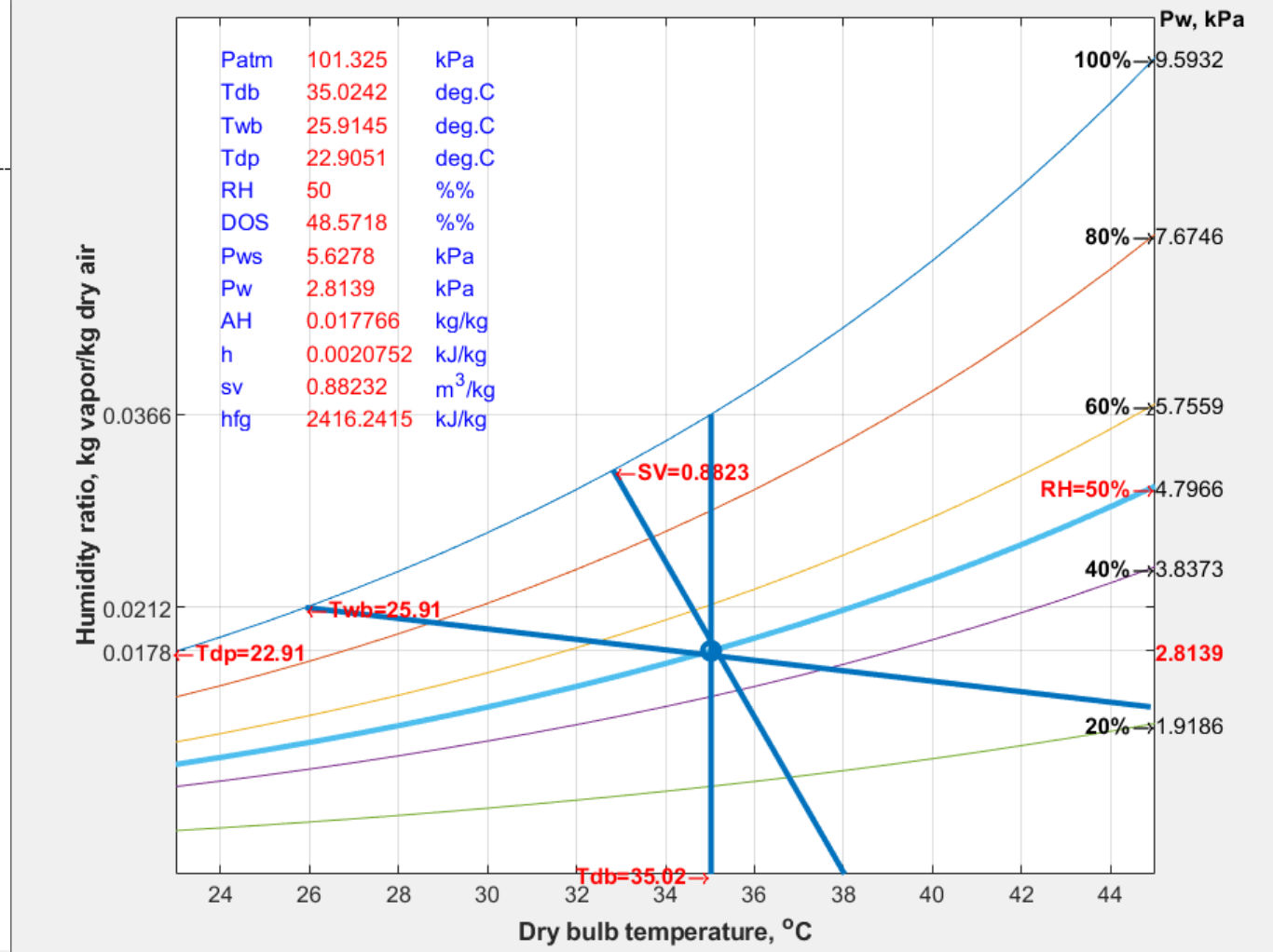
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                  press Enter to quit, input 1:10 to choose 6

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm             (in kPa) = 101.325
 enter saturated vapor pressure (Pws) in g/kg DA (press 'enter' for default)
 Pws (g/kg DA) =    5.628
 enter Rel. humidity (from 0 to 100%, press 'enter' for detail) =
 Rel. humidity (from 0 to 100%) = 50.000
```

f(Pws, rh)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

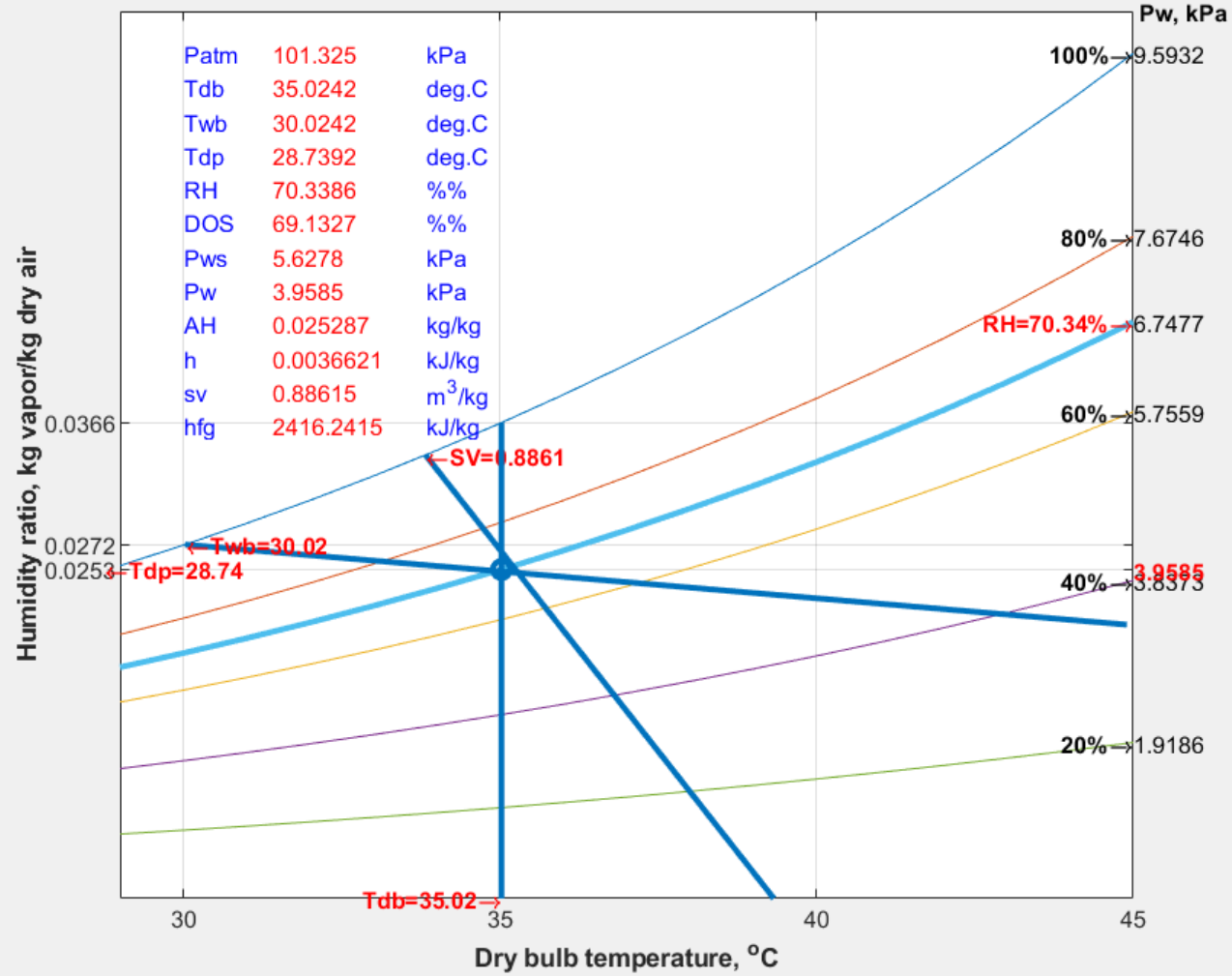
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 7

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter saturated vapor pressure (Pws) in g/kg DA (press 'enter' for default)
 Pws (g/kg DA) =   5.628
 enter Wet bulb T (Twb) from 12.71 to 35.02 deg.C, (press 'enter' for default) =
 Twb  =  30.024
```

f(Pws, Twb)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

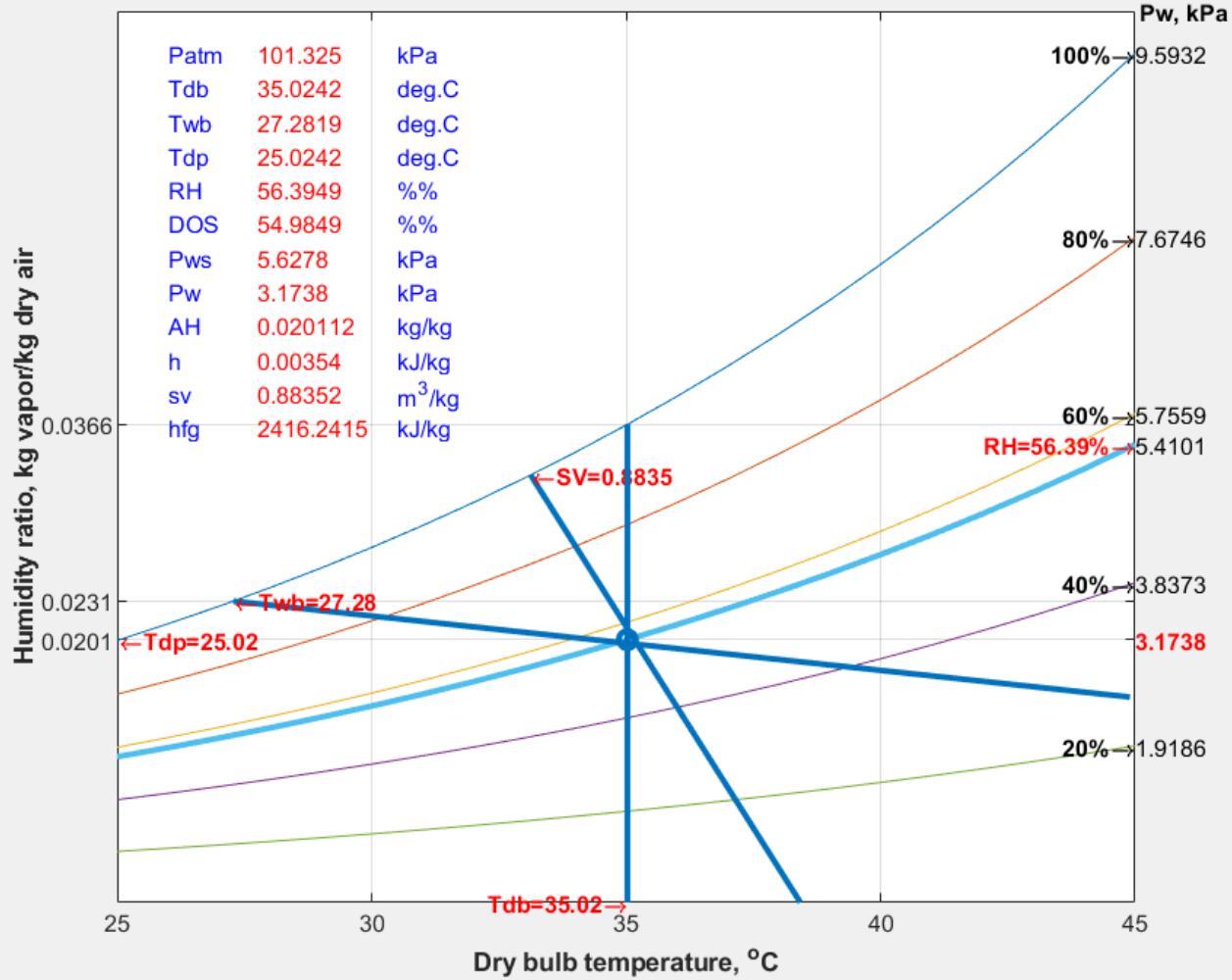
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                  press Enter to quit, input 1:10 to choose 8

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm             (in kPa) = 101.325
 enter saturated vapor pressure (Pws) in g/kg DA (press 'enter' for default)
 Pws (g/kg DA) =   5.628
 enter Dew pt. T (Tdp) from -34.49 to 35.02 deg.C, (press 'enter' for default) =
 Tdp = 25.024
```

f(Pws, Tdp)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

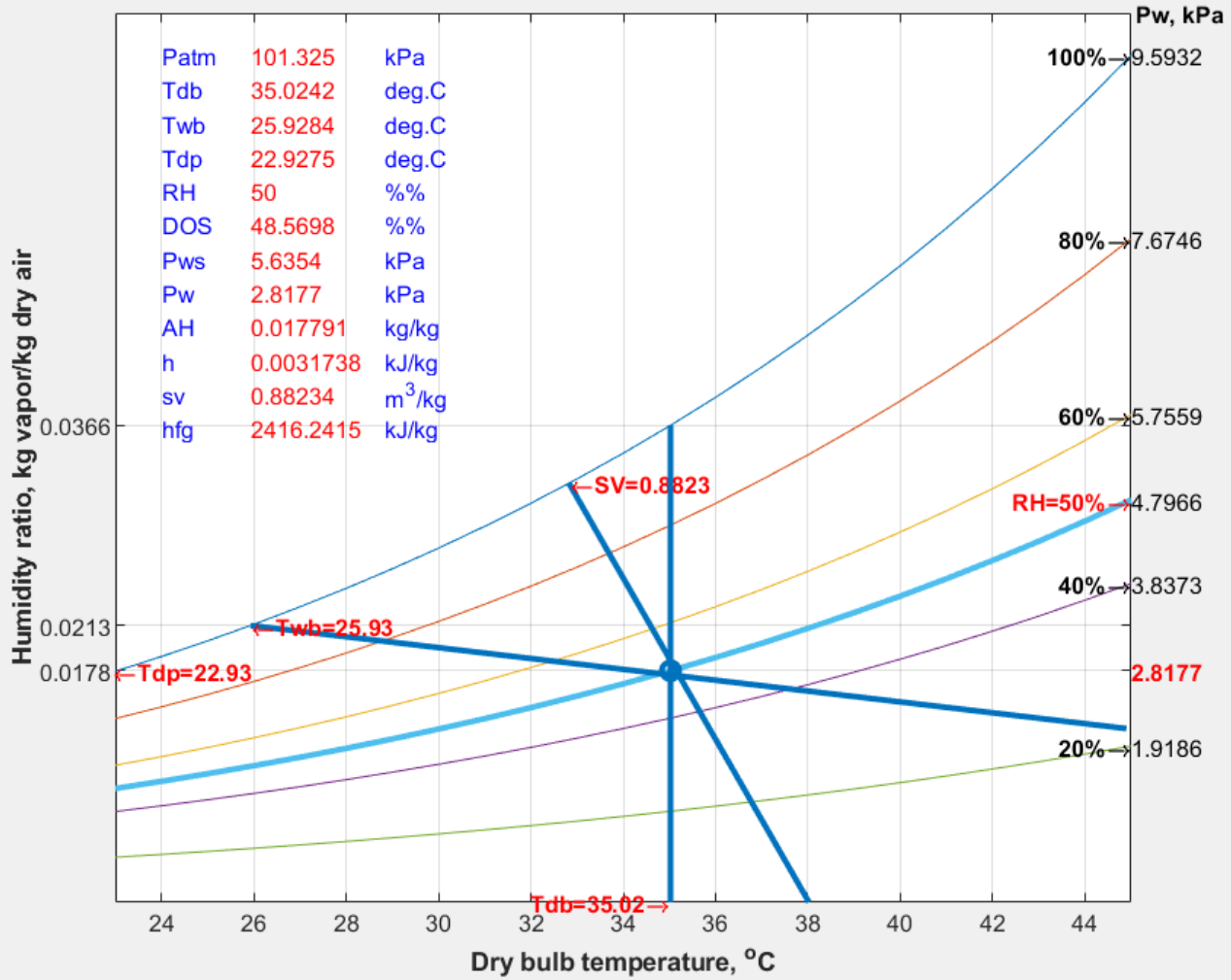
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

-------------------------------------------------------------------------------

                press Enter to quit, input 1:10 to choose 9

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter saturated vapor pressure (Pws) in g/kg DA (press 'enter' for default)
 Pws (g/kg DA) =   5.628
 enter Vapor pressure (Pw) from 0.0006 to 5.6278 kPa, (press 'enter' for default)
 Pw  =   2.818
```

f(Pws, Pw)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others



MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

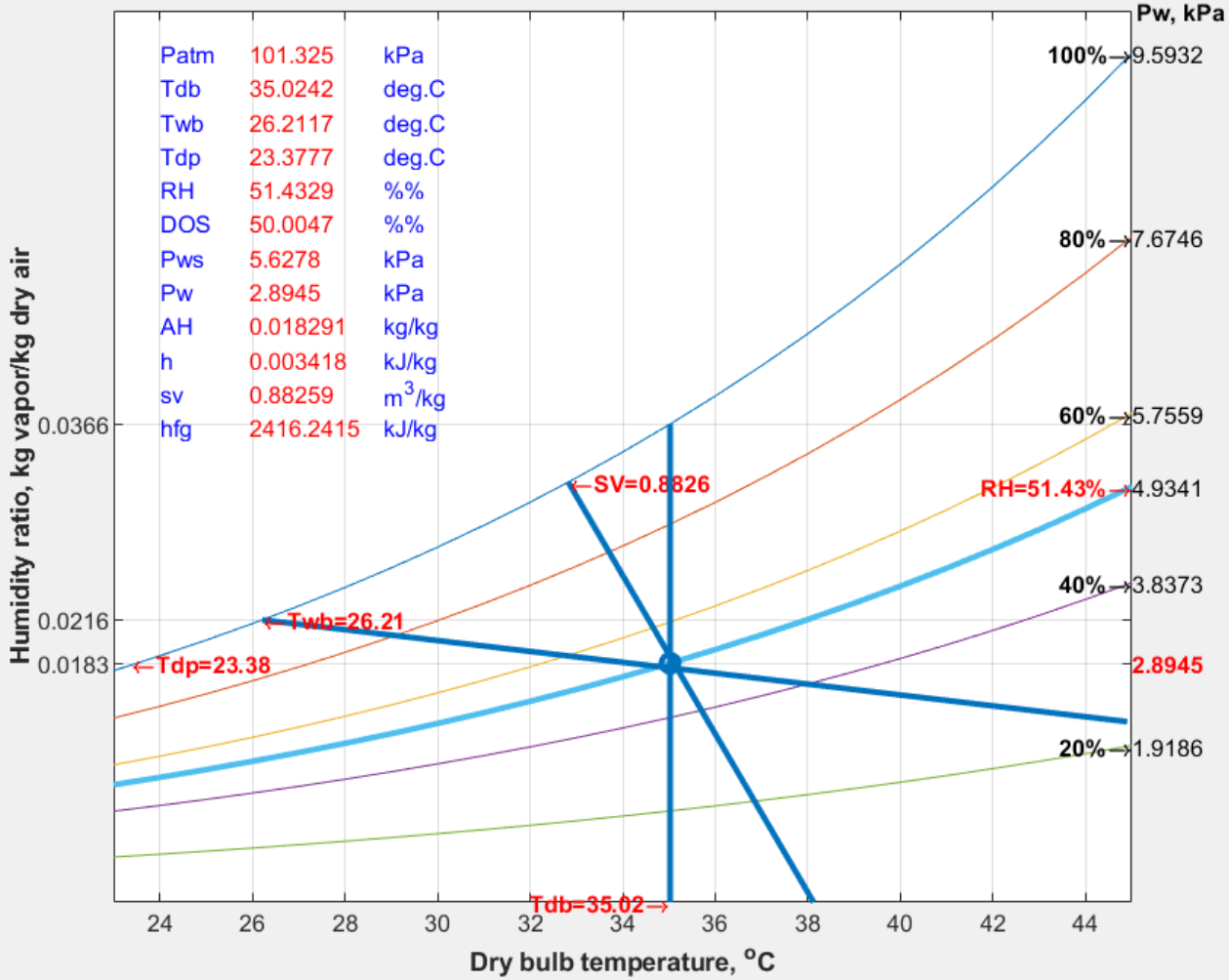
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

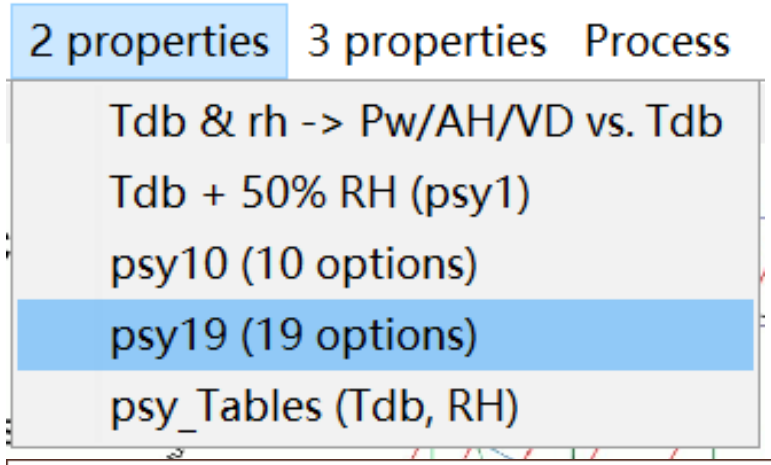
```
                    Digital Psychrometric Chart
                            ver. 2.0

  Options: (1) Tdb, rh  (2) Tdb, Twb  (3) Tdb, Tdp  (4) Tdb, Pw  (5) Tdb, ah
           (6) Pws, rh  (7) Pws, Twb  (8) Pws, Tdp  (9) Pws, Pw (10) Pws, ah

                press Enter to quit, input 1:10 to choose 10

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter saturated vapor pressure (Pws) in g/kg DA (press 'enter' for default)
 Pws (g/kg DA) =   5.628
 enter Abs. humidity (AH) from 0.00000 to 0.03658 kg/kg, press 'enter' for defaul
 AH  =  0.018
```

f(Pws, ah)

Paused: Press any key

Figure 2: Digital Psychrometric Chart: given 2 values to derive others





MATLAB R2020b - academic use

HOME PLOTS APPS Search Document

C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

Digital Psychrometric Chart

ver. 3.0

Options: (1) Tdb, rh (2) Tdb, Twb (3) Tdb, Tdp (4) Tdb, Pw (5) Tdb, ah (6) Tdb, sv
(7) Pws, rh (8) Pws, Twb (9) Pws, Tdp (10) Pws, Pw (11) Pws, ah (12) Pws, sv
(13) Twb, rh (14) Twb, Pws (15) Twb, Tdp (16) Twb, Pw (17) Twb, ah
(18) ah, rh (19) rh, Tdp

---

press 'enter' to quit, input 1:19 to choose

MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
------------------------------------------------------------------------------------------
                                Digital Psychrometric Chart
                                        ver. 3.0

  Options: ( 1) Tdb, rh  ( 2) Tdb, Twb  ( 3) Tdb, Tdp  ( 4) Tdb, Pw  ( 5) Tdb, ah   ( 6) Tdb, sv
           ( 7) Pws, rh  ( 8) Pws, Twb  ( 9) Pws, Tdp  (10) Pws, Pw  (11) Pws, ah   (12) Pws, sv
           (13) Twb, rh  (14) Twb, Pws  (15) Twb, Tdp  (16) Twb, Pw  (17) Twb, ah
           (18)  ah, rh                 (19) rh,  Tdp
------------------------------------------------------------------------------------------
                          press 'enter' to quit, input 1:19 to choose 6

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter dry bulb temperature (Tdb) in deg. C (press 'enter' for default)
 Tdb  =  35.00 deg.C
 Tdb  =  35.00 deg.C   press 'enter' to continue
 enter Specific Volume (sv) from 0.87299 to 0.89172 kg/kg, press 'enter' for default) =
 sv   =  0.882 m^3/kg
 sv   =  0.882 m^3/kg   press 'enter' to continue
```

Option 6:

A range of ‘sv’ was pre-calculated to serve as a help-tip to users.

Paused: Press any key

MATLAB R2020b - academic use

HOME PLOTS APPS Search Documentation Wei

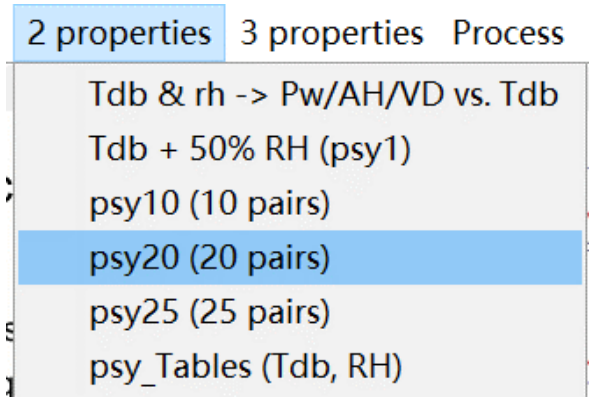
C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

```
------------------------------------------------------------------------------------------------
                                   Digital Psychrometric Chart
                                          ver. 3.0

  Options: ( 1) Tdb, rh  ( 2) Tdb, Twb  ( 3) Tdb, Tdp  ( 4) Tdb, Pw  ( 5) Tdb, ah   ( 6) Tdb, sv
           ( 7) Pws, rh  ( 8) Pws, Twb  ( 9) Pws, Tdp  (10) Pws, Pw  (11) Pws, ah   (12) Pws, sv
           (13) Twb, rh  (14) Twb, Pws  (15) Twb, Tdp  (16) Twb, Pw  (17) Twb, ah
           (18)  ah, rh                 (19) rh,  Tdp
------------------------------------------------------------------------------------------------
                              press 'enter' to quit, input 1:19 to choose 12

 enter atmospheric pressure (Patm) in kPa (press 'enter' for default)
 Patm            (in kPa) = 101.325
 enter saturated vapor pressure (Pws) from  0.624 (0 deg.C) to 12.350 (50 deg.C) g/kg DA (press 'enter' for default)
 pws  =  5.628 kPa
 pws  =  5.628 kPa   press 'enter' to continue
 enter Specific Volume (sv) from 0.87306 to 0.89179 kg/kg, press 'enter' for default) =
 sv   =  0.882 m^3/kg
 sv   =  0.882 m^3/kg   press 'enter' to continue
```

Option 12:

a range of ‘Pws’ & ‘sv’ were pre-calculated to serve as help-tip to remind users.

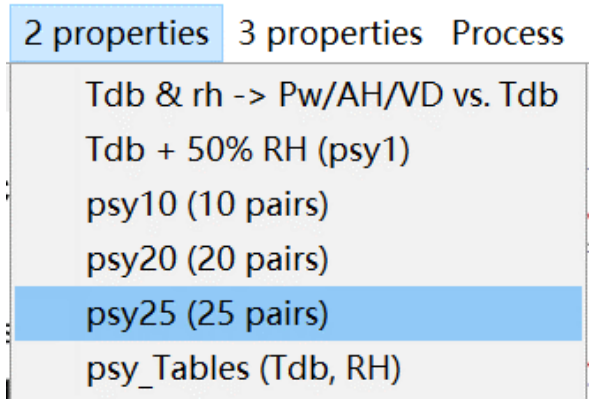
Paused: Press any key




```
                    Digital Psychrometric Chart
                            ver. 3.0

Options: ( 1) Tdb, rh  ( 2) Tdb, Twb  ( 3) Tdb, Tdp  ( 4) Tdb, Pw  ( 5) Tdb, ah   ( 6) Tdb, sv
         ( 7) Pws, rh  ( 8) Pws, Twb  ( 9) Pws, Tdp  (10) Pws, Pw  (11) Pws, ah   (12) Pws, sv
         (13) Twb, rh  (14) Twb, Pws  (15) Twb, Tdp  (16) Twb, Pw  (17) Twb, ah   (18) Twb, sv
         (19)  ah, rh                 (20) rh,  Tdp
```

1 redundant

```
press 'enter' to quit, input 1:20 to choose
```

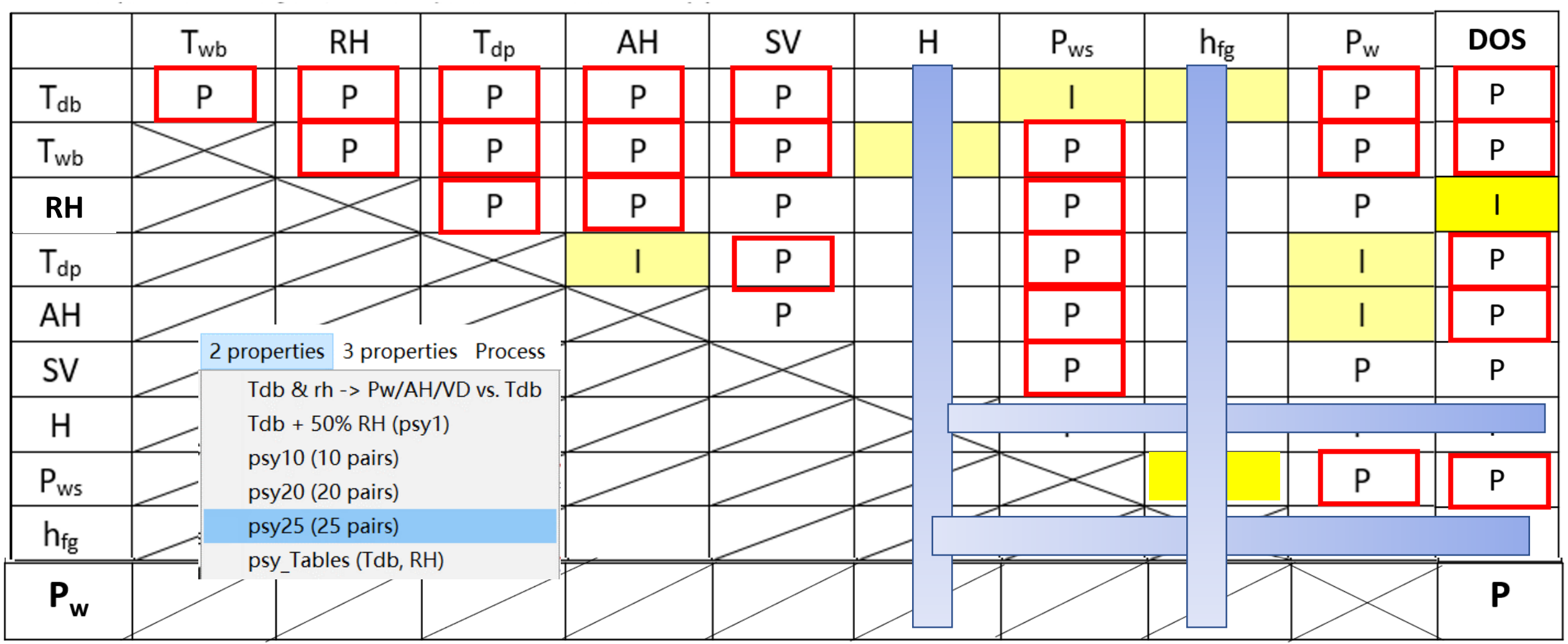



```
                    Digital Psychrometric Chart
                            ver. 4.0

Options: ( 1) Tdb, rh  ( 2) Tdb, Twb  ( 3)  Tdb, Tdp  ( 4) Tdb, Pw  ( 5) Tdb, ah   ( 6) Tdb, sv
         ( 7) Pws, rh  ( 8) Pws, Twb  ( 9)  Pws, Tdp  (10) Pws, Pw  (11) Pws, ah   (12) Pws, sv
         (13) Twb, rh  (14) Twb, Pws  (15)  Twb, Tdp  (16) Twb, Pw  (17) Twb, ah   (18) Twb, sv
         (19)  ah, rh                 (20)   rh, Tdp
         (21) Tdb, dos (22) Pws, dos  (23)  Tdp, dos  (24)  ah, dos (25) Twb, dos
```

New option

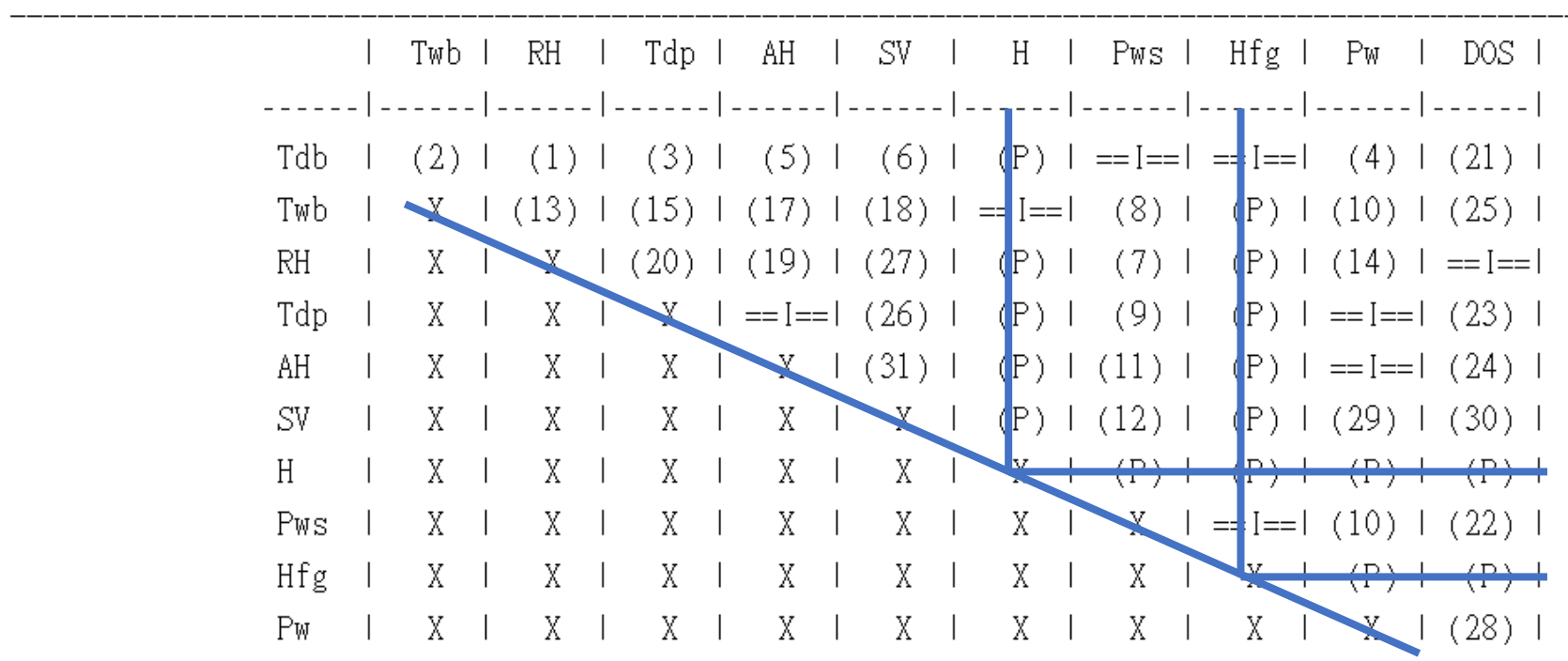
```
press 'enter' to quit, input 1:25 to choose
```

Besides H and h_{fg}, totally 31 ‘P’ pairs



Digital Psychrometric Chart ver. 5.0

```
Options: ( 1) Tdb,  rh  ( 2) Tdb,  Twb ( 3)  Tdb, Tdp  ( 4) Tdb,  Pw  ( 5) Tdb,  ah  ( 6) Tdb,  sv
         ( 7) Pws,  rh  ( 8) Pws,  Twb ( 9)  Pws, Tdp  (10) Pws,  Pw  (11) Pws,  ah  (12) Pws,  sv
         (13) Twb,  rh  (14)  Pw,   rh (15)  Twb, Tdp  (16) Twb,  Pw  (17) Twb,  ah  (18) Twb,  sv
         (19)  ah,  rh                 (20)   rh, Tdp
         (21) Tdb, dos  (22) Pws,  dos (23)  Tdp, dos  (24)  ah, dos  (25) Twb, dos  (26) Tdp,  sv
         (27)  sv,  rh  (28)  Pw,  dos (29)   sv,  Pw  (30)  sv, dos                 (31)  ah,  sv
```

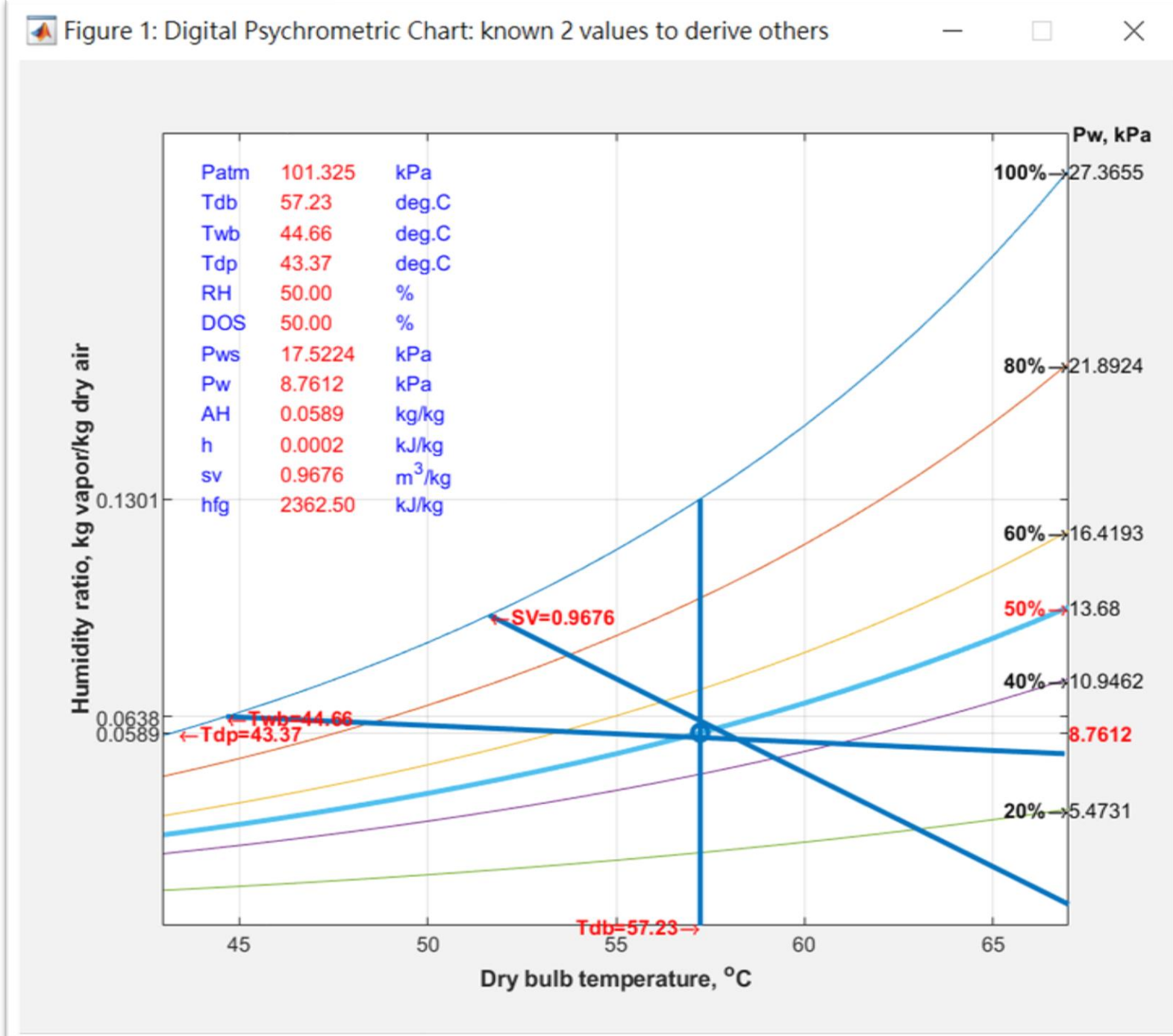


2 properties | 3 properties | Process | Mo

- Tdb & rh/dos -> Pw/AH/VD vs. Tdb
- psy1 (Tdb + 50% rh)
- psy10 (10 pairs)
- psy20 (20 pairs)
- psy25 (25 pairs)
- psy31 (31 pairs)
- psy_Tables (Tdb, RH)

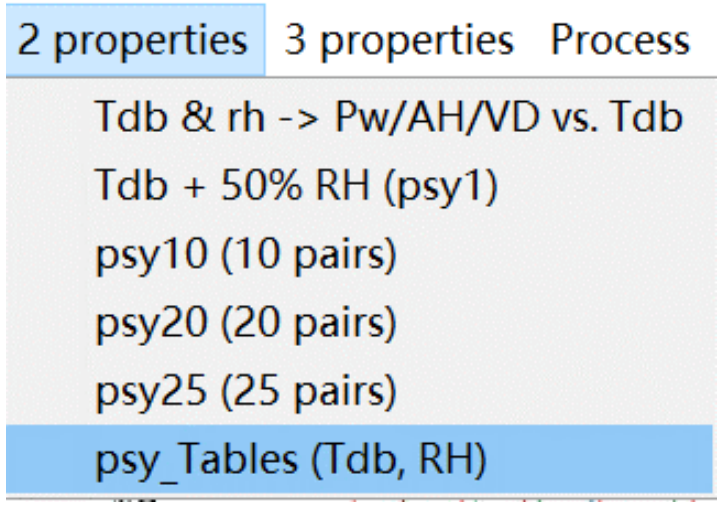
press 'enter' to quit, input 1:31 to choose

Waiting for input



ing ▸ psymenu ▸

```
Patm  =    101.325    kPa
Tdb   =     57.23     deg.C
Twb   =     44.66     deg.C
Tdp   =     43.37     deg.C
RH    =     50.00     %
DOS   =     50.00     %
Pws   =     17.5224   kPa
Pw    =      8.7612   kPa
AH    =      0.0589   kg/kg
h     =      0.0002   kJ/kg
sv    =      0.9676   m^3/kg
hfg   =   2362.50     kJ/kg

Press Enter to continue
```



12 psychrometric Tables

```
------------------------------------------------------------------------------

                        Digital Psychrometric Tables
                                ver. 2.0

  Given user assigned range of Tdb and predefined range of rh (at intevral of 10%)

------------------------------------------------------------------------------

                enter 0 to quit or press Enter to continue

 Patm             (in kPa) =
 Patm             (in kPa) = 101.325
 Min Dry bulb T (in degree C) =
 Min Dry bulb T (in degree C) =  0.000
 Max Dry bulb T (in degree C) =
 Max Dry bulb T (in degree C) = 40.000
  Interval of Dry bulb T (in degree C) =
  Interval of Dry bulb T (in degree C) =  2.000
Press 'enter'
```

	Pws __	hfg ___
Tdb = 0.0	0.611	2501.000
Tdb = 2.0	0.706	2496.160
Tdb = 4.0	0.813	2491.320
Tdb = 6.0	0.935	2486.480
Tdb = 8.0	1.073	2481.640
Tdb = 10.0	1.228	2476.800
Tdb = 12.0	1.402	2471.960
Tdb = 14.0	1.598	2467.120
Tdb = 16.0	1.818	2462.280
Tdb = 18.0	2.064	2457.440
Tdb = 20.0	2.338	2452.600
Tdb = 22.0	2.644	2447.760
Tdb = 24.0	2.984	2442.920
Tdb = 26.0	3.361	2438.080
Tdb = 28.0	3.779	2433.240
Tdb = 30.0	4.242	2428.400
Tdb = 32.0	4.754	2423.560
Tdb = 34.0	5.318	2418.720
Tdb = 36.0	5.940	2413.880
Tdb = 38.0	6.624	2409.040
Tdb = 40.0	7.374	2404.200

Pws (in kPa)=
f(Tdb=0:2:40)

Hfg (in kJ/kg) =
f(Tdb=0:2:40)

Pw	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	0.061	0.122	0.183	0.244	0.305	0.366	0.428	0.489	0.550	0.611
Tdb =	2.0	0.071	0.141	0.212	0.282	0.353	0.423	0.494	0.564	0.635	0.706
Tdb =	4.0	0.081	0.163	0.244	0.325	0.407	0.488	0.569	0.651	0.732	0.813
Tdb =	6.0	0.094	0.187	0.281	0.374	0.468	0.561	0.655	0.748	0.842	0.935
Tdb =	8.0	0.107	0.215	0.322	0.429	0.536	0.644	0.751	0.858	0.965	1.073
Tdb =	10.0	0.123	0.246	0.368	0.491	0.614	0.737	0.860	0.982	1.105	1.228
Tdb =	12.0	0.140	0.280	0.421	0.561	0.701	0.841	0.982	1.122	1.262	1.402
Tdb =	14.0	0.160	0.320	0.480	0.639	0.799	0.959	1.119	1.279	1.439	1.598
Tdb =	16.0	0.182	0.364	0.545	0.727	0.909	1.091	1.273	1.454	1.636	1.818
Tdb =	18.0	0.206	0.413	0.619	0.826	1.032	1.238	1.445	1.651	1.857	2.064
Tdb =	20.0	0.234	0.468	0.701	0.935	1.169	1.403	1.637	1.870	2.104	2.338
Tdb =	22.0	0.264	0.529	0.793	1.057	1.322	1.586	1.851	2.115	2.379	2.644
Tdb =	24.0	0.298	0.597	0.895	1.193	1.492	1.790	2.088	2.387	2.685	2.984
Tdb =	26.0	0.336	0.672	1.008	1.344	1.680	2.017	2.353	2.689	3.025	3.361
Tdb =	28.0	0.378	0.756	1.134	1.512	1.890	2.268	2.646	3.024	3.401	3.779
Tdb =	30.0	0.424	0.848	1.273	1.697	2.121	2.545	2.970	3.394	3.818	4.242
Tdb =	32.0	0.475	0.951	1.426	1.902	2.377	2.852	3.328	3.803	4.279	4.754
Tdb =	34.0	0.532	1.064	1.596	2.127	2.659	3.191	3.723	4.255	4.787	5.318
Tdb =	36.0	0.594	1.188	1.782	2.376	2.970	3.564	4.158	4.752	5.346	5.940
Tdb =	38.0	0.662	1.325	1.987	2.649	3.312	3.974	4.637	5.299	5.961	6.624
Tdb =	40.0	0.737	1.475	2.212	2.950	3.687	4.425	5.162	5.899	6.637	7.374

Pw (in kPa) =

f(Tdb=0:2:40,
rh=10:10:100)

DOS	rh =	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00%
Tdb =	0.0	9.95	19.90	29.87	39.85	49.85	59.85	69.87	79.90	89.95	100.00
Tdb =	2.0	9.94	19.89	29.85	39.83	49.83	59.83	69.85	79.89	89.94	100.00
Tdb =	4.0	9.93	19.87	29.83	39.81	49.80	59.81	69.83	79.87	89.93	100.00
Tdb =	6.0	9.92	19.85	29.81	39.78	49.77	59.78	69.80	79.85	89.92	100.00
Tdb =	8.0	9.90	19.83	29.78	39.74	49.73	59.74	69.78	79.83	89.90	100.00
Tdb =	10.0	9.89	19.81	29.74	39.71	49.70	59.71	69.74	79.80	89.89	100.00
Tdb =	12.0	9.88	19.78	29.71	39.67	49.65	59.67	69.71	79.78	89.87	100.00
Tdb =	14.0	9.86	19.75	29.67	39.62	49.60	59.62	69.67	79.74	89.86	100.00
Tdb =	16.0	9.84	19.71	29.62	39.57	49.55	59.56	69.62	79.71	89.84	100.00
Tdb =	18.0	9.82	19.67	29.57	39.51	49.49	59.51	69.57	79.67	89.81	100.00
Tdb =	20.0	9.79	19.63	29.51	39.44	49.42	59.44	69.51	79.62	89.79	100.00
Tdb =	22.0	9.76	19.58	29.45	39.37	49.34	59.36	69.44	79.57	89.76	100.00
Tdb =	24.0	9.73	19.53	29.38	39.28	49.25	59.28	69.37	79.52	89.73	100.00
Tdb =	26.0	9.70	19.47	29.30	39.19	49.16	59.19	69.29	79.45	89.69	100.00
Tdb =	28.0	9.66	19.40	29.21	39.09	49.05	59.08	69.20	79.38	89.65	100.00
Tdb =	30.0	9.62	19.32	29.11	38.98	48.93	58.97	69.09	79.31	89.61	100.00
Tdb =	32.0	9.58	19.24	29.00	38.85	48.80	58.84	68.98	79.22	89.56	100.00
Tdb =	34.0	9.53	19.15	28.88	38.71	48.65	58.70	68.86	79.12	89.50	100.00
Tdb =	36.0	9.47	19.05	28.75	38.56	48.49	58.54	68.72	79.02	89.44	100.00
Tdb =	38.0	9.41	18.94	28.60	38.39	48.31	58.37	68.56	78.90	89.37	100.00
Tdb =	40.0	9.34	18.82	28.44	38.20	48.11	58.17	68.39	78.76	89.30	100.00

DOS (in %) =

f(Tdb=0:2:40,
rh=10:10:100)

VPD	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	0.550	0.489	0.428	0.366	0.305	0.244	0.183	0.122	0.061	0.000
Tdb =	2.0	0.635	0.564	0.494	0.423	0.353	0.282	0.212	0.141	0.071	0.000
Tdb =	4.0	0.732	0.651	0.569	0.488	0.407	0.325	0.244	0.163	0.081	0.000
Tdb =	6.0	0.842	0.748	0.655	0.561	0.468	0.374	0.281	0.187	0.094	0.000
Tdb =	8.0	0.965	0.858	0.751	0.644	0.536	0.429	0.322	0.215	0.107	0.000
Tdb =	10.0	1.105	0.982	0.860	0.737	0.614	0.491	0.368	0.246	0.123	0.000
Tdb =	12.0	1.262	1.122	0.982	0.841	0.701	0.561	0.421	0.280	0.140	0.000
Tdb =	14.0	1.439	1.279	1.119	0.959	0.799	0.639	0.480	0.320	0.160	-0.000
Tdb =	16.0	1.636	1.454	1.273	1.091	0.909	0.727	0.545	0.364	0.182	0.000
Tdb =	18.0	1.857	1.651	1.445	1.238	1.032	0.826	0.619	0.413	0.206	0.000
Tdb =	20.0	2.104	1.870	1.637	1.403	1.169	0.935	0.701	0.468	0.234	0.000
Tdb =	22.0	2.379	2.115	1.851	1.586	1.322	1.057	0.793	0.529	0.264	0.000
Tdb =	24.0	2.685	2.387	2.088	1.790	1.492	1.193	0.895	0.597	0.298	0.000
Tdb =	26.0	3.025	2.689	2.353	2.017	1.680	1.344	1.008	0.672	0.336	0.000
Tdb =	28.0	3.401	3.024	2.646	2.268	1.890	1.512	1.134	0.756	0.378	0.000
Tdb =	30.0	3.818	3.394	2.970	2.545	2.121	1.697	1.273	0.848	0.424	0.000
Tdb =	32.0	4.279	3.803	3.328	2.852	2.377	1.902	1.426	0.951	0.475	0.000
Tdb =	34.0	4.787	4.255	3.723	3.191	2.659	2.127	1.596	1.064	0.532	-0.000
Tdb =	36.0	5.346	4.752	4.158	3.564	2.970	2.376	1.782	1.188	0.594	0.000
Tdb =	38.0	5.961	5.299	4.637	3.974	3.312	2.649	1.987	1.325	0.662	0.000
Tdb =	40.0	6.637	5.899	5.162	4.425	3.687	2.950	2.212	1.475	0.737	0.000

VPD (in kPa)=

f(Tdb=0:2:40,
rh=10:10:100)

AH	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	0.000	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.004
Tdb =	2.0	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.004	0.004
Tdb =	4.0	0.000	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005
Tdb =	6.0	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.005	0.005	0.006
Tdb =	8.0	0.001	0.001	0.002	0.003	0.003	0.004	0.005	0.005	0.006	0.007
Tdb =	10.0	0.001	0.002	0.002	0.003	0.004	0.005	0.005	0.006	0.007	0.008
Tdb =	12.0	0.001	0.002	0.003	0.003	0.004	0.005	0.006	0.007	0.008	0.009
Tdb =	14.0	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010
Tdb =	16.0	0.001	0.002	0.003	0.004	0.006	0.007	0.008	0.009	0.010	0.011
Tdb =	18.0	0.001	0.003	0.004	0.005	0.006	0.008	0.009	0.010	0.012	0.013
Tdb =	20.0	0.001	0.003	0.004	0.006	0.007	0.009	0.010	0.012	0.013	0.015
Tdb =	22.0	0.002	0.003	0.005	0.007	0.008	0.010	0.012	0.013	0.015	0.017
Tdb =	24.0	0.002	0.004	0.006	0.007	0.009	0.011	0.013	0.015	0.017	0.019
Tdb =	26.0	0.002	0.004	0.006	0.008	0.010	0.013	0.015	0.017	0.019	0.021
Tdb =	28.0	0.002	0.005	0.007	0.009	0.012	0.014	0.017	0.019	0.022	0.024
Tdb =	30.0	0.003	0.005	0.008	0.011	0.013	0.016	0.019	0.022	0.024	0.027
Tdb =	32.0	0.003	0.006	0.009	0.012	0.015	0.018	0.021	0.024	0.027	0.031
Tdb =	34.0	0.003	0.007	0.010	0.013	0.017	0.020	0.024	0.027	0.031	0.034
Tdb =	36.0	0.004	0.007	0.011	0.015	0.019	0.023	0.027	0.031	0.035	0.039
Tdb =	38.0	0.004	0.008	0.012	0.017	0.021	0.025	0.030	0.034	0.039	0.044
Tdb =	40.0	0.005	0.009	0.014	0.019	0.023	0.028	0.033	0.038	0.044	0.049

AH (in kg/kg)=

f(Tdb=0:2:40,
rh=10:10:100)

AHD	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	0.003	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.000	0.000
Tdb =	2.0	0.004	0.003	0.003	0.003	0.002	0.002	0.001	0.001	0.000	0.000
Tdb =	4.0	0.005	0.004	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.000
Tdb =	6.0	0.005	0.005	0.004	0.003	0.003	0.002	0.002	0.001	0.001	0.000
Tdb =	8.0	0.006	0.005	0.005	0.004	0.003	0.003	0.002	0.001	0.001	0.000
Tdb =	10.0	0.007	0.006	0.005	0.005	0.004	0.003	0.002	0.002	0.001	0.000
Tdb =	12.0	0.008	0.007	0.006	0.005	0.004	0.004	0.003	0.002	0.001	0.000
Tdb =	14.0	0.009	0.008	0.007	0.006	0.005	0.004	0.003	0.002	0.001	0.000
Tdb =	16.0	0.010	0.009	0.008	0.007	0.006	0.005	0.003	0.002	0.001	0.000
Tdb =	18.0	0.012	0.010	0.009	0.008	0.007	0.005	0.004	0.003	0.001	0.000
Tdb =	20.0	0.013	0.012	0.010	0.009	0.007	0.006	0.004	0.003	0.002	0.000
Tdb =	22.0	0.015	0.013	0.012	0.010	0.008	0.007	0.005	0.003	0.002	0.000
Tdb =	24.0	0.017	0.015	0.013	0.011	0.010	0.008	0.006	0.004	0.002	0.000
Tdb =	26.0	0.019	0.017	0.015	0.013	0.011	0.009	0.007	0.004	0.002	0.000
Tdb =	28.0	0.022	0.019	0.017	0.015	0.012	0.010	0.007	0.005	0.002	0.000
Tdb =	30.0	0.025	0.022	0.019	0.017	0.014	0.011	0.008	0.006	0.003	0.000
Tdb =	32.0	0.028	0.025	0.022	0.019	0.016	0.013	0.009	0.006	0.003	0.000
Tdb =	34.0	0.031	0.028	0.025	0.021	0.018	0.014	0.011	0.007	0.004	0.000
Tdb =	36.0	0.035	0.031	0.028	0.024	0.020	0.016	0.012	0.008	0.004	0.000
Tdb =	38.0	0.039	0.035	0.031	0.027	0.022	0.018	0.014	0.009	0.005	0.000
Tdb =	40.0	0.044	0.040	0.035	0.030	0.025	0.020	0.015	0.010	0.005	0.000

AHD (in kg/kg) =

f(Tdb=0:2:40,
rh=10:10:100)

h	rh =	10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%	90.0%	100.0%
Tdb =	0.0	0.94	1.88	2.82	3.76	4.70	5.65	6.59	7.54	8.49	9.43
Tdb =	2.0	3.10	4.18	5.27	6.36	7.46	8.55	9.64	10.74	11.84	12.94
Tdb =	4.0	5.28	6.53	7.79	9.05	10.31	11.57	12.84	14.11	15.37	16.65
Tdb =	6.0	7.48	8.92	10.37	11.82	13.28	14.73	16.19	17.66	19.12	20.59
Tdb =	8.0	9.71	11.37	13.03	14.70	16.37	18.05	19.73	21.41	23.10	24.79
Tdb =	10.0	11.96	13.87	15.78	17.69	19.61	21.54	23.46	25.40	27.34	29.28
Tdb =	12.0	14.25	16.43	18.61	20.81	23.01	25.21	27.42	29.64	31.86	34.09
Tdb =	14.0	16.57	19.06	21.56	24.06	26.58	29.10	31.63	34.17	36.71	39.27
Tdb =	16.0	18.92	21.76	24.61	27.47	30.34	33.22	36.11	39.01	41.92	44.85
Tdb =	18.0	21.32	24.55	27.80	31.05	34.32	37.60	40.90	44.21	47.53	50.87
Tdb =	20.0	23.77	27.44	31.12	34.82	38.54	42.27	46.03	49.80	53.59	57.39
Tdb =	22.0	26.27	30.42	34.60	38.80	43.02	47.26	51.53	55.82	60.13	64.47
Tdb =	24.0	28.82	33.52	38.25	43.01	47.79	52.61	57.45	62.32	67.22	72.16
Tdb =	26.0	31.43	36.74	42.08	47.47	52.88	58.34	63.83	69.36	74.92	80.53
Tdb =	28.0	34.11	40.10	46.13	52.20	58.33	64.50	70.72	76.98	83.29	89.66
Tdb =	30.0	36.86	43.60	50.40	57.25	64.16	71.13	78.17	85.26	92.41	99.63
Tdb =	32.0	39.69	47.27	54.91	62.63	70.42	78.29	86.24	94.26	102.36	110.54
Tdb =	34.0	42.61	51.11	59.70	68.38	77.16	86.03	95.00	104.06	113.23	122.49
Tdb =	36.0	45.63	55.15	64.79	74.54	84.41	94.40	104.51	114.75	125.11	135.60
Tdb =	38.0	48.74	59.40	70.20	81.14	92.23	103.47	114.87	126.42	138.13	150.01
Tdb =	40.0	51.97	63.88	75.96	88.23	100.68	113.32	126.15	139.19	152.42	165.86

h (in kJ/kg) =

f(Tdb=0:2:40, rh=10:10:100)

SV	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	0.774	0.774	0.774	0.775	0.775	0.775	0.775	0.775	0.775	0.776
Tdb =	2.0	0.780	0.780	0.780	0.780	0.781	0.781	0.781	0.781	0.781	0.782
Tdb =	4.0	0.785	0.786	0.786	0.786	0.786	0.787	0.787	0.787	0.787	0.788
Tdb =	6.0	0.791	0.791	0.792	0.792	0.792	0.792	0.793	0.793	0.793	0.794
Tdb =	8.0	0.797	0.797	0.797	0.798	0.798	0.798	0.799	0.799	0.799	0.800
Tdb =	10.0	0.803	0.803	0.803	0.804	0.804	0.804	0.805	0.805	0.805	0.806
Tdb =	12.0	0.808	0.809	0.809	0.810	0.810	0.810	0.811	0.811	0.812	0.812
Tdb =	14.0	0.814	0.814	0.815	0.815	0.816	0.816	0.817	0.817	0.818	0.818
Tdb =	16.0	0.820	0.820	0.821	0.821	0.822	0.823	0.823	0.824	0.824	0.825
Tdb =	18.0	0.825	0.826	0.827	0.827	0.828	0.829	0.829	0.830	0.831	0.831
Tdb =	20.0	0.831	0.832	0.833	0.833	0.834	0.835	0.836	0.836	0.837	0.838
Tdb =	22.0	0.837	0.838	0.839	0.839	0.840	0.841	0.842	0.843	0.844	0.844
Tdb =	24.0	0.843	0.844	0.845	0.846	0.847	0.847	0.848	0.849	0.850	0.851
Tdb =	26.0	0.849	0.850	0.851	0.852	0.853	0.854	0.855	0.856	0.857	0.858
Tdb =	28.0	0.854	0.856	0.857	0.858	0.859	0.860	0.862	0.863	0.864	0.865
Tdb =	30.0	0.860	0.862	0.863	0.864	0.866	0.867	0.868	0.870	0.871	0.873
Tdb =	32.0	0.866	0.868	0.869	0.871	0.872	0.874	0.875	0.877	0.879	0.880
Tdb =	34.0	0.872	0.874	0.875	0.877	0.879	0.881	0.882	0.884	0.886	0.888
Tdb =	36.0	0.878	0.880	0.882	0.884	0.886	0.888	0.890	0.892	0.894	0.896
Tdb =	38.0	0.884	0.886	0.888	0.890	0.893	0.895	0.897	0.899	0.902	0.904
Tdb =	40.0	0.890	0.892	0.895	0.897	0.900	0.902	0.905	0.907	0.910	0.912

SV (m^3/kg) =

f(Tdb=0:2:40, rh=10:10:100)

Tdp	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	-23.89	-17.96	-13.98	-10.91	-8.41	-6.27	-4.40	-2.74	-1.24	0.00
Tdb =	2.0	-22.75	-16.59	-12.46	-9.30	-6.72	-4.52	-2.60	-0.90	0.64	2.00
Tdb =	4.0	-21.58	-15.19	-10.93	-7.67	-5.02	-2.76	-0.79	0.96	2.54	3.98
Tdb =	6.0	-20.38	-13.77	-9.37	-6.03	-3.29	-0.98	1.04	2.84	4.46	5.93
Tdb =	8.0	-19.16	-12.32	-7.80	-4.36	-1.56	0.82	2.89	4.73	6.38	7.89
Tdb =	10.0	-17.92	-10.86	-6.21	-2.68	0.20	2.63	4.75	6.63	8.32	9.86
Tdb =	12.0	-16.65	-9.38	-4.60	-0.98	1.96	4.45	6.62	8.54	10.27	11.85
Tdb =	14.0	-15.36	-7.88	-2.98	0.73	3.74	6.29	8.50	10.47	12.23	13.84
Tdb =	16.0	-14.06	-6.36	-1.34	2.46	5.53	8.13	10.39	12.40	14.20	15.84
Tdb =	18.0	-12.73	-4.83	0.31	4.19	7.33	9.99	12.29	14.34	16.17	17.84
Tdb =	20.0	-11.39	-3.29	1.97	5.93	9.14	11.85	14.20	16.28	18.15	19.85
Tdb =	22.0	-10.04	-1.74	3.64	7.69	10.96	13.72	16.11	18.23	20.14	21.87
Tdb =	24.0	-8.67	-0.18	5.32	9.44	12.78	15.59	18.03	20.19	22.13	23.89
Tdb =	26.0	-7.29	1.40	7.00	11.21	14.61	17.47	19.95	22.15	24.12	25.91
Tdb =	28.0	-5.90	2.98	8.70	12.98	16.44	19.36	21.88	24.11	26.11	27.93
Tdb =	30.0	-4.50	4.57	10.40	14.76	18.28	21.24	23.81	26.08	28.11	29.96
Tdb =	32.0	-3.09	6.17	12.10	16.54	20.12	23.13	25.74	28.04	30.11	31.98
Tdb =	34.0	-1.66	7.77	13.81	18.33	21.96	25.02	27.67	30.01	32.10	34.00
Tdb =	36.0	-0.23	9.38	15.52	20.11	23.81	26.92	29.60	31.97	34.10	36.00
Tdb =	38.0	1.20	10.99	17.24	21.90	25.66	28.81	31.53	33.94	36.10	38.00
Tdb =	40.0	2.64	12.61	18.96	23.69	27.50	30.70	33.47	35.90	38.09	40.00

Tdp (in deg.C) =

f(Tdb=0:2:40,
rh=10:10:100)

THI	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	32.60	34.73	36.17	37.27	38.17	38.94	39.62	40.21	40.75	41.20
Tdb =	2.0	35.01	37.23	38.71	39.85	40.78	41.57	42.26	42.88	43.43	43.92
Tdb =	4.0	37.43	39.73	41.27	42.44	43.39	44.21	44.92	45.55	46.12	46.63
Tdb =	6.0	39.86	42.24	43.83	45.03	46.01	46.85	47.58	48.22	48.80	49.34
Tdb =	8.0	42.30	44.76	46.39	47.63	48.64	49.50	50.24	50.90	51.50	52.04
Tdb =	10.0	44.75	47.29	48.97	50.24	51.27	52.15	52.91	53.59	54.20	54.75
Tdb =	12.0	47.21	49.82	51.54	52.85	53.91	54.80	55.58	56.28	56.90	57.46
Tdb =	14.0	49.67	52.36	54.13	55.46	56.55	57.46	58.26	58.97	59.60	60.18
Tdb =	16.0	52.14	54.91	56.72	58.08	59.19	60.13	60.94	61.66	62.31	62.90
Tdb =	18.0	54.62	57.46	59.31	60.71	61.84	62.80	63.63	64.36	65.02	65.62
Tdb =	20.0	57.10	60.01	61.91	63.34	64.49	65.47	66.31	67.06	67.73	68.35
Tdb =	22.0	59.59	62.57	64.51	65.97	67.14	68.14	69.00	69.76	70.45	71.07
Tdb =	24.0	62.08	65.14	67.11	68.60	69.80	70.81	71.69	72.47	73.17	73.80
Tdb =	26.0	64.57	67.70	69.72	71.24	72.46	73.49	74.38	75.17	75.88	76.53
Tdb =	28.0	67.08	70.27	72.33	73.87	75.12	76.17	77.08	77.88	78.60	79.26
Tdb =	30.0	69.58	72.85	74.94	76.51	77.78	78.85	79.77	80.59	81.32	81.98
Tdb =	32.0	72.09	75.42	77.56	79.16	80.44	81.53	82.47	83.29	84.04	84.71
Tdb =	34.0	74.60	78.00	80.17	81.80	83.11	84.21	85.16	86.00	86.76	87.44
Tdb =	36.0	77.12	80.58	82.79	84.44	85.77	86.89	87.86	88.71	89.48	90.16
Tdb =	38.0	79.63	83.16	85.41	87.09	88.44	89.57	90.55	91.42	92.19	92.88
Tdb =	40.0	82.15	85.74	88.02	89.73	91.10	92.25	93.25	94.13	94.91	95.60

THI =

f(Tdb=0:2:40,
rh=10:10:100)

Twb	rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb =	0.0	-4.97	-4.49	-3.94	-3.37	-2.79	-2.20	-1.63	-1.06	-0.49	0.00
Tdb =	2.0	-3.61	-3.03	-2.39	-1.74	-1.08	-0.43	0.22	0.85	1.48	2.00
Tdb =	4.0	-2.28	-1.59	-0.86	-0.12	0.62	1.34	2.06	2.76	3.46	4.00
Tdb =	6.0	-0.97	-0.16	0.66	1.49	2.30	3.11	3.89	4.67	5.42	6.00
Tdb =	8.0	0.32	1.24	2.17	3.08	3.98	4.86	5.72	6.56	7.38	8.00
Tdb =	10.0	1.59	2.63	3.66	4.66	5.64	6.60	7.53	8.44	9.33	10.00
Tdb =	12.0	2.84	4.00	5.13	6.23	7.29	8.33	9.33	10.31	11.27	12.00
Tdb =	14.0	4.07	5.35	6.59	7.78	8.93	10.04	11.12	12.17	13.19	14.00
Tdb =	16.0	5.28	6.68	8.03	9.32	10.56	11.75	12.91	14.02	15.11	16.00
Tdb =	18.0	6.46	8.00	9.46	10.85	12.17	13.45	14.68	15.87	17.02	18.00
Tdb =	20.0	7.62	9.30	10.87	12.36	13.78	15.14	16.45	17.71	18.93	20.00
Tdb =	22.0	8.77	10.59	12.28	13.88	15.39	16.83	18.22	19.55	20.84	22.00
Tdb =	24.0	9.89	11.86	13.68	15.39	17.00	18.53	19.99	21.39	22.75	24.00
Tdb =	26.0	11.01	13.13	15.08	16.90	18.60	20.22	21.76	23.24	24.66	26.00
Tdb =	28.0	12.11	14.40	16.48	18.41	20.21	21.92	23.54	25.09	26.58	28.00
Tdb =	30.0	13.20	15.66	17.88	19.92	21.83	23.62	25.32	26.95	28.50	30.00
Tdb =	32.0	14.28	16.93	19.29	21.45	23.45	25.33	27.11	28.81	30.44	31.99
Tdb =	34.0	15.36	18.19	20.69	22.97	25.08	27.05	28.92	30.69	32.38	34.00
Tdb =	36.0	16.44	19.46	22.11	24.51	26.72	28.78	30.73	32.57	34.33	36.00
Tdb =	38.0	17.51	20.73	23.53	26.05	28.36	30.52	32.55	34.46	36.29	38.00
Tdb =	40.0	18.59	22.01	24.96	27.60	30.02	32.27	34.38	36.37	38.26	40.00

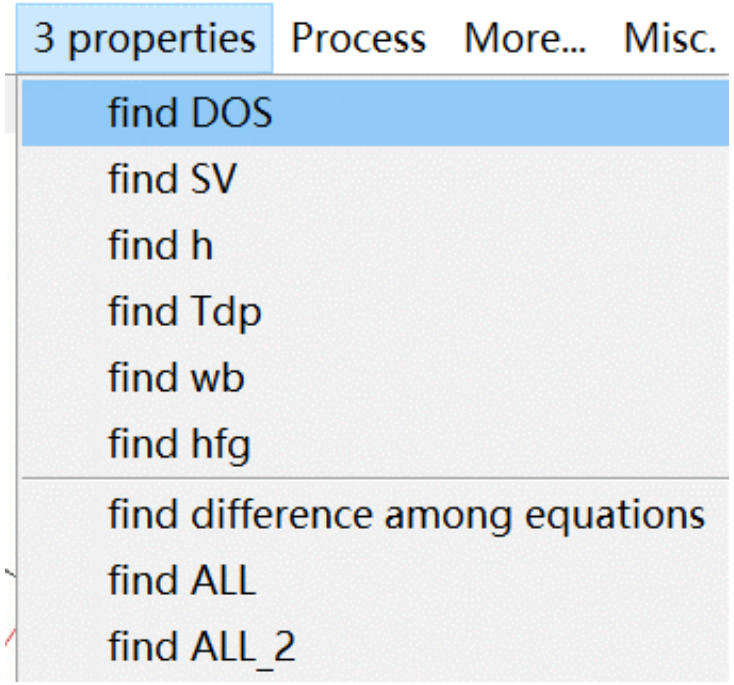
Twb (in deg.C) =

f(Tdb=0:2:40,
rh=10:10:100)

WBD rh =	10.0_	20.0_	30.0_	40.0_	50.0_	60.0_	70.0_	80.0_	90.0_	100.0%
Tdb = 0.0	4.97	4.49	3.94	3.37	2.79	2.20	1.63	1.06	0.49	0.00
Tdb = 2.0	5.61	5.03	4.39	3.74	3.08	2.43	1.78	1.15	0.52	0.00
Tdb = 4.0	6.28	5.59	4.86	4.12	3.38	2.66	1.94	1.24	0.54	0.00
Tdb = 6.0	6.97	6.16	5.34	4.51	3.70	2.89	2.11	1.33	0.58	0.00
Tdb = 8.0	7.68	6.76	5.83	4.92	4.02	3.14	2.28	1.44	0.62	0.00
Tdb = 10.0	8.41	7.37	6.34	5.34	4.36	3.40	2.47	1.56	0.67	0.00
Tdb = 12.0	9.16	8.00	6.87	5.77	4.71	3.67	2.67	1.69	0.73	0.00
Tdb = 14.0	9.93	8.65	7.41	6.22	5.07	3.96	2.88	1.83	0.81	0.00
Tdb = 16.0	10.72	9.32	7.97	6.68	5.44	4.25	3.09	1.98	0.89	0.00
Tdb = 18.0	11.54	10.00	8.54	7.15	5.83	4.55	3.32	2.13	0.98	0.00
Tdb = 20.0	12.38	10.70	9.13	7.64	6.22	4.86	3.55	2.29	1.07	0.00
Tdb = 22.0	13.23	11.41	9.72	8.12	6.61	5.17	3.78	2.45	1.16	0.00
Tdb = 24.0	14.11	12.14	10.32	8.61	7.00	5.47	4.01	2.61	1.25	0.00
Tdb = 26.0	14.99	12.87	10.92	9.10	7.40	5.78	4.24	2.76	1.34	0.00
Tdb = 28.0	15.89	13.60	11.52	9.59	7.79	6.08	4.46	2.91	1.42	0.00
Tdb = 30.0	16.80	14.34	12.12	10.08	8.17	6.38	4.68	3.05	1.50	0.00
Tdb = 32.0	17.72	15.07	12.71	10.55	8.55	6.67	4.89	3.19	1.56	0.01
Tdb = 34.0	18.64	15.81	13.31	11.03	8.92	6.95	5.08	3.31	1.62	0.00
Tdb = 36.0	19.56	16.54	13.89	11.49	9.28	7.22	5.27	3.43	1.67	0.00
Tdb = 38.0	20.49	17.27	14.47	11.95	9.64	7.48	5.45	3.54	1.71	0.00
Tdb = 40.0	21.41	17.99	15.04	12.40	9.98	7.73	5.62	3.63	1.74	0.00

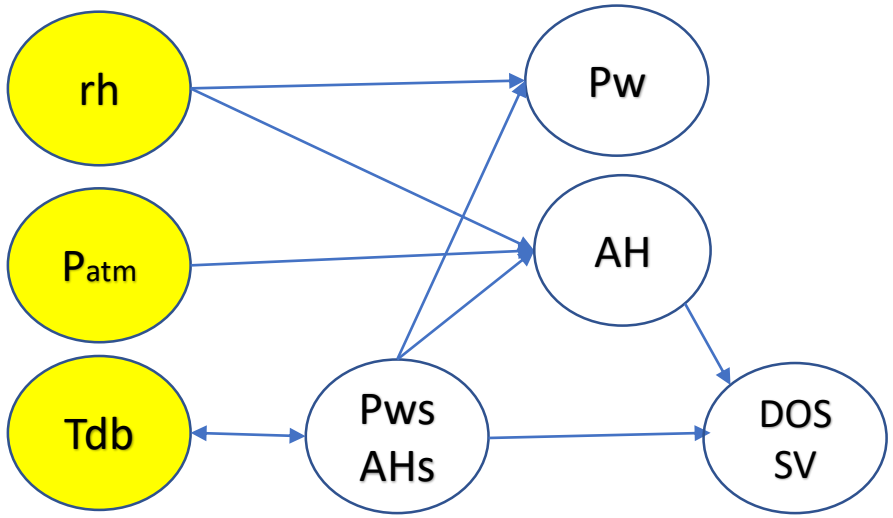
WBD (in deg.C) =

f(Tdb=0:2:40,
rh=10:10:100)




```
Known:
   Patm =   101.325 kPa
   Tdb =     30.00  deg.C
   RH  =     20.00  %   press 'enter' to continue
Solution:
   Pws  = f(Tdb)           =   4246.03 Pa
   AH   = f(Patm, Pws, RH) =   0.00526 kg vapor/kg DA
   AHs  = f(Patm, Pws)     =   0.02720 kg vapor/kg DA
   DOS  = f(AH,AHs)        =     19.32 %    press 'enter' to continue
```

```
case 'dos'
    header(Tdb,RH,pa);
    pws=psy(Tdb,0,0,'pws');
    AH=psy(pa,pws,RH,'ah');
    AHs=psy(pa,pws,100,'ah');
    dispresults(pws,AH,AHs,'dos');
```



不同海拔高度的大氣壓力

Table 2-1. Properties of the standard atmosphere at various elevations.

Elevation above Sea Level, m	Temperature, Celsius	Pressure, Pa
-500	18.2	107,478
0	15.0	101,325
500	11.8	95,461
1000	8.5	89,874
2000	2.0	79,495
3000	-4.5	70,108
4000	-11.0	61,640
5000	-17.5	54,020

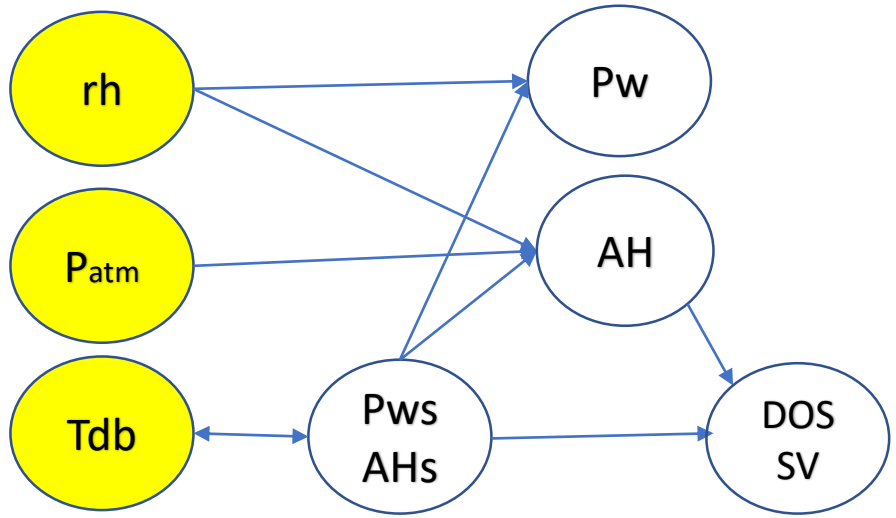
(adapted from the ASHRAE Handbook of Fundamentals, 1989)

3 properties | Process | More... | Misc.

- find DOS
- find SV
- find h
- find Tdp
- find wb
- find hfg
- find difference among equations
- find ALL
- find ALL_2

```
Given:
   Patm =   101.325 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %   Press 'enter' to continue....
Solution:
   Pws      = f(Tdb)           =     2.3388 kPa
   AH       = f(Patm, Pws, RH) =     0.0073 kg/kg
   SV       = f(Patm, Tdb, AH) =     0.8341 m^3/kg
   Density  = f(SV)            =     1.1988 kg/m^3    Press 'enter' to continue....
```

```
case 'sv'
    header(Tdb,RH,pa);
    pws=psy(Tdb,0,0,'pws');
    ah=psy(pa,pws,RH,'ah');
    sv=psy(pa,Tdb,ah,'sv');
    dispresults(pws,ah,sv,'sv');
```

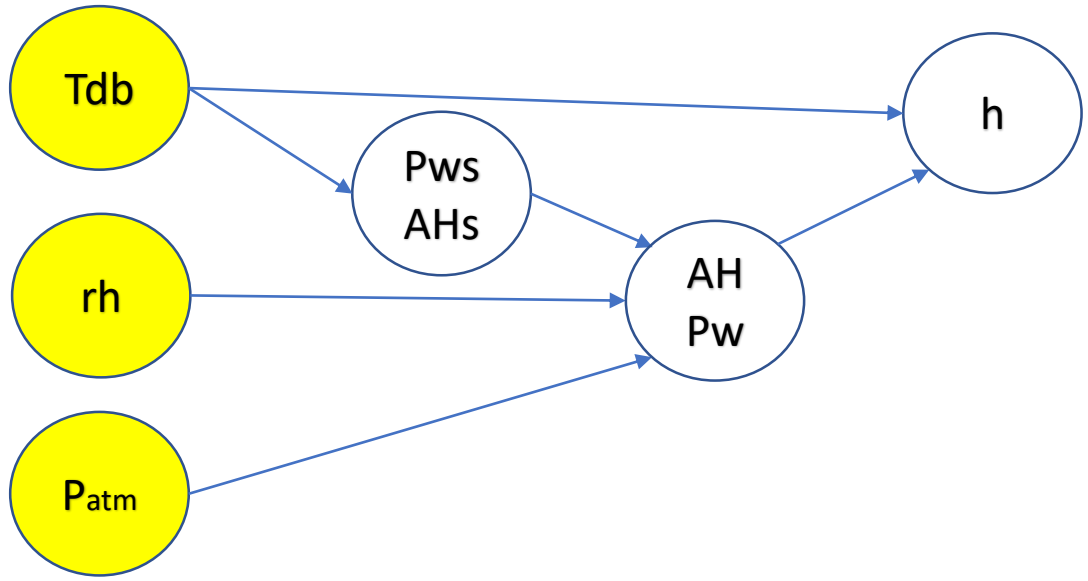


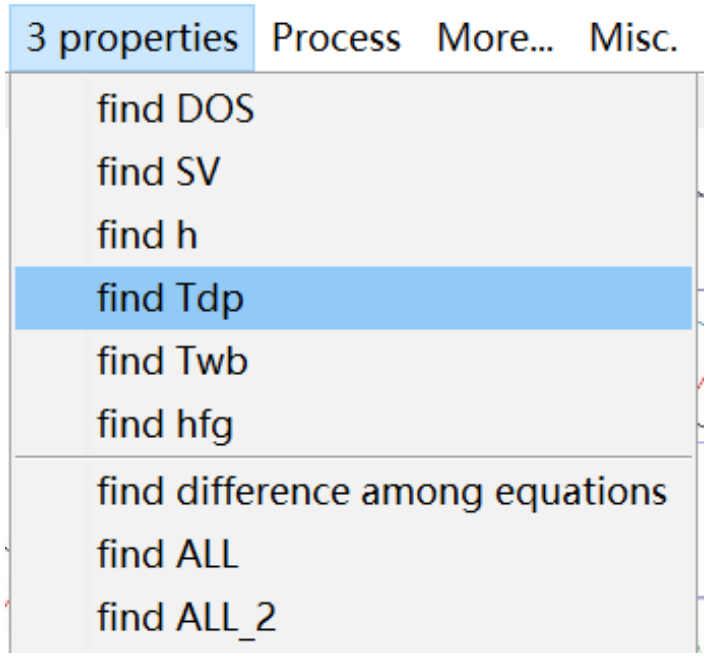
3 properties | Process | More... | Misc.

- find DOS
- find SV
- find h
- find Tdp
- find wb
- find hfg
- find difference among equations
- find ALL
- find ALL_2

```
Given:
   Patm =   101.325 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %   Press 'enter' to continue....
Solution:
   Pws = f(Tdb)          =     2.3388 kPa
   AH  = f(Patm, Pws, RH) =    0.0073 kg/kg
   h   = f(Tdb, AH)       =   38.545 kJ/kg    Press 'enter' to continue..
```

```
case 'h'
    header(Tdb,RH,pa);
    pws=psy(Tdb,0,0,'pws');
    ah=psy(pa,pws,RH,'ah');
    h=psy(Tdb,ah,0,'h');
    dispresults(pws,ah,h,'h');
```






```
case 'dp'
    tdb=[10 20 25 30 40 50];rh=[20 40 60 80 80
    for i=1:length(tdb)
        header(tdb(i),rh(i),pa);
        pws=psy(tdb(i),0,0,'pws');% in kPa
        pw=rh(i)/100*pws;              % in kPa
        tdp1=psy(tdb(i),pw,0,'tdp');
        tdp2=psy(pw,0,0,'tdp2');
        dispresults(tdp1,tdp2,tdp1-tdp2,'dp');
    end
```

```
Filename: 'find_all.m' deals with the usage of the psychrometric subroutines 'psy.m'
One parameter is needed to run. By default 'all' is used as the input parameter.

------------------------------------------------------------------------------------------

Given:
   Patm =   101.325 kPa
   Tdb =     10.00  deg.C
   RH  =     20.00  %   press 'enter' to co
Solution:
   Tdp_1 = f(Tdb, pw) =   -10.856  deg.C
   Tdp_2 = f(pw)      =   -10.635  deg.C
   difference on Tdp  =    -0.222  deg.C

Given:
   Patm =   101.325 kPa
   Tdb =     20.00  deg.C
   RH  =     40.00  %   press 'enter' to co
Solution:
   Tdp_1 = f(Tdb, pw) =     5.938  deg.C
   Tdp_2 = f(pw)      =     6.026  deg.C
   difference on Tdp  =    -0.088  deg.C

Given:
   Patm =   101.325 kPa
   Tdb =     25.00  deg.C
   RH  =     60.00  %   press 'enter' to co
Solution:
   Tdp_1 = f(Tdb, pw) =    16.542  deg.C
   Tdp_2 = f(pw)      =    16.725  deg.C
   difference on Tdp  =    -0.183  deg.C
```

```
Given:
   Patm =   101.325 kPa
   Tdb =     30.00  deg.C
   RH  =     80.00  %   press 'enter' to continue
Solution:
   Tdp_1 = f(Tdb, pw) =    26.090  deg.C
   Tdp_2 = f(pw)      =    26.164  deg.C
   difference on Tdp  =    -0.074  deg.C    press 'enter' to

Given:
   Patm =   101.325 kPa
   Tdb =     40.00  deg.C
   RH  =     80.00  %   press 'enter' to continue
Solution:
   Tdp_1 = f(Tdb, pw) =    35.928  deg.C
   Tdp_2 = f(pw)      =    35.852  deg.C
   difference on Tdp  =     0.076  deg.C    press 'enter' to

Given:
   Patm =   101.325 kPa
   Tdb =     50.00  deg.C
   RH  =    100.00  %   press 'enter' to continue
Solution:
   Tdp_1 = f(Tdb, pw) =    50.000  deg.C
   Tdp_2 = f(pw)      =    49.981  deg.C
   difference on Tdp  =     0.019  deg.C    press 'enter' to
```

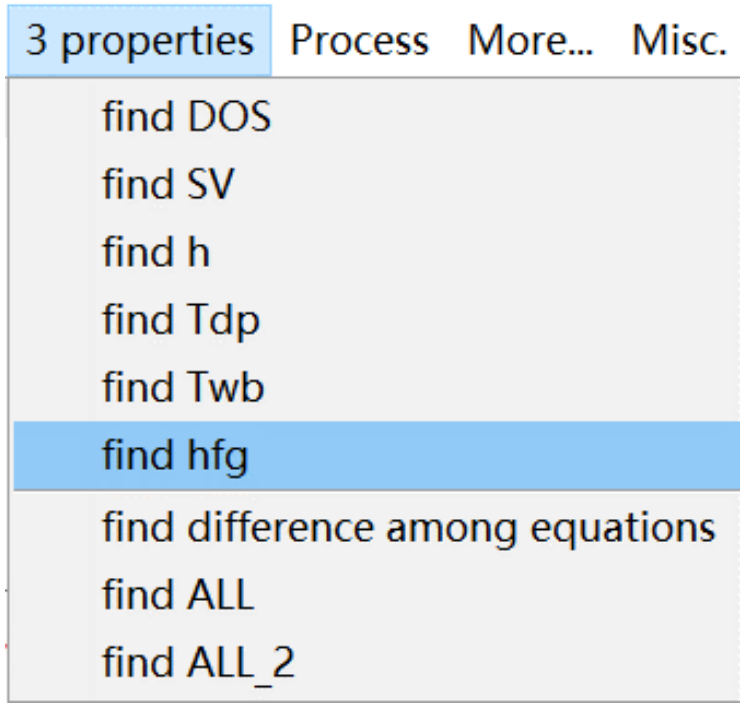
```
This program deals with the usage of the psychrometric subroutines: psy.r
Three values are needed to derive other psychrometric properties.

------------------------------------------------------------------------
 Given:
   Patm =   101.325 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %   Press 'enter' to continue....
Solution:
   Twb = f(Tdb, Pw)       =    13.787 deg.C using regression equation
   Twb = f(Tdb, Pw, Patm) =    13.803 deg.C using iterative algorithm
   difference on Twb =   -0.016 deg.C          Press 'enter' to continue

 Given:
   Patm =    89.874 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %   Press 'enter' to continue....
Solution:
   Twb = f(Tdb, Pw)       =    13.787 deg.C using regression equation
   Twb = f(Tdb, Pw, Patm) =    13.511 deg.C using iterative algorithm
   difference on Twb =    0.276 deg.C          Press 'enter' to continue

 Given:
   Patm =    79.495 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %   Press 'enter' to continue....
Solution:
   Twb = f(Tdb, Pw)       =    13.787 deg.C using regression equation
   Twb = f(Tdb, Pw, Patm) =    13.219 deg.C using iterative algorithm
   difference on Twb =    0.568 deg.C          Press 'enter' to continue
```

3 properties | Process | More... | Misc.

- find DOS
- find SV
- find h
- find Tdp
- find Twb
- find hfg
- find difference among equations
- find ALL
- find ALL_2

```
The regression equation assumed always at sea level.
It is less accurate when deals with Patm not equals 101.325 kPa.
Difference increased with reducing Patm (increased altitute).
```

```
case 'wb'
    pa=[101.325 89.874 79.495];
    % Elevation at sea level, 1000 m, 2000 m
for i=1:3
    header(Tdb,RH,pa(i));
    pws=psy(Tdb,0,0,'pws');          % in kPa
    pw=RH/100*pws;                   % in kPa
    tdp=psy(Tdb,pw,0,'tdp');         % in deg.C
    twb1=psy(Tdb,tdp,0,'twb');       % sea level only
    twb2=psy(Tdb,pw,pa(i),'twb2'); % iterative algorithm
    dispresults(twb1,twb2,twb1-twb2,'wb');
end
```




```
------------------------------------------------------------------------------------------

Given Patm, Tdb  to derive Pws and hfg using various equations
Patm               =   101.3250   101.3250    89.8740    89.8740    61.6400    61.6400 kPa
Tdb                =    50.0000    60.0000    50.0000    60.0000    50.0000    60.0000 deg.C
------------------------------------------------------------------------------ press 'enter'
Pws_1              =    12.3499    19.9438    12.3499    19.9438    12.3499    19.9438 kPa
Pws_2              =    12.3342    19.9284    12.3342    19.9284    12.3342    19.9284 kPa
hfg (0~65 deg.C)   =  2380.0000  2355.8000  2380.0000  2355.8000  2380.0000  2355.8000 kJ/kg
hfg (-18~200 deg.C) = 2383.2470  2359.3894  2383.2470  2359.3894  2383.2470  2359.3894 kJ/kg

From Pws to derived Tsat which is equals Tdb
            Tsat1  =    50.0288    60.0308    50.0288    60.0308    50.0288    60.0308 deg.C
        Tsat1-Tdb  =     0.0288     0.0308     0.0288     0.0308     0.0288     0.0308 deg.C
            Tsat2  =    50.0033    60.0142    50.0033    60.0142    50.0033    60.0142 deg.C
        Tsat2-Tdb  =     0.0033     0.0142     0.0033     0.0142     0.0033     0.0142 deg.C
fx ------------------------------------------------------------------------------ press 'enter'
```

```
case 'hfg'
    P=[101.325  101.325  89.874  89.874  61.64 61.64];
    T=[50 60 50 60 50 60];
    for i=1:1:length(P)
        tdb(i)=T(i); patm(i)=P(i);
        pws(i)=psy(tdb(i),0,0,'pws');      % in kPa
        pws2(i)=psy(tdb(i),0,0,'pws2');
        hfg(i)=psy(tdb(i),0,0,'hfg');      % in kJ/kg
        hfg2(i)=psy(tdb(i),0,0,'hfg2');
        tsat(i)=psy(pws(i),0,0,'tsat');    % in deg.C
        tsat2(i)=psy(pws2(i),0,0,'tsat');
    end
```

- Pws anf Hfg are f(Tdb).
- Both are not affected by Patm

- The Pws derived from case ‘pws2’ can derive more accurate Tdb when using case ‘tsat’.

3 properties | Process | More... | Misc

- find DOS
- find SV
- find h
- find Tdp
- find Twb
- find hfg
- find difference among equations
- find ALL
- find ALL_2

Following parameters will not varied with the change of Patm:

all Pws, all Pw, all Hfg,
Tsat, Tdp
Twb_1

MATLAB R2020b - academic use

HOME | PLOTS | APPS | Search Documentation | Wei

C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu ▸

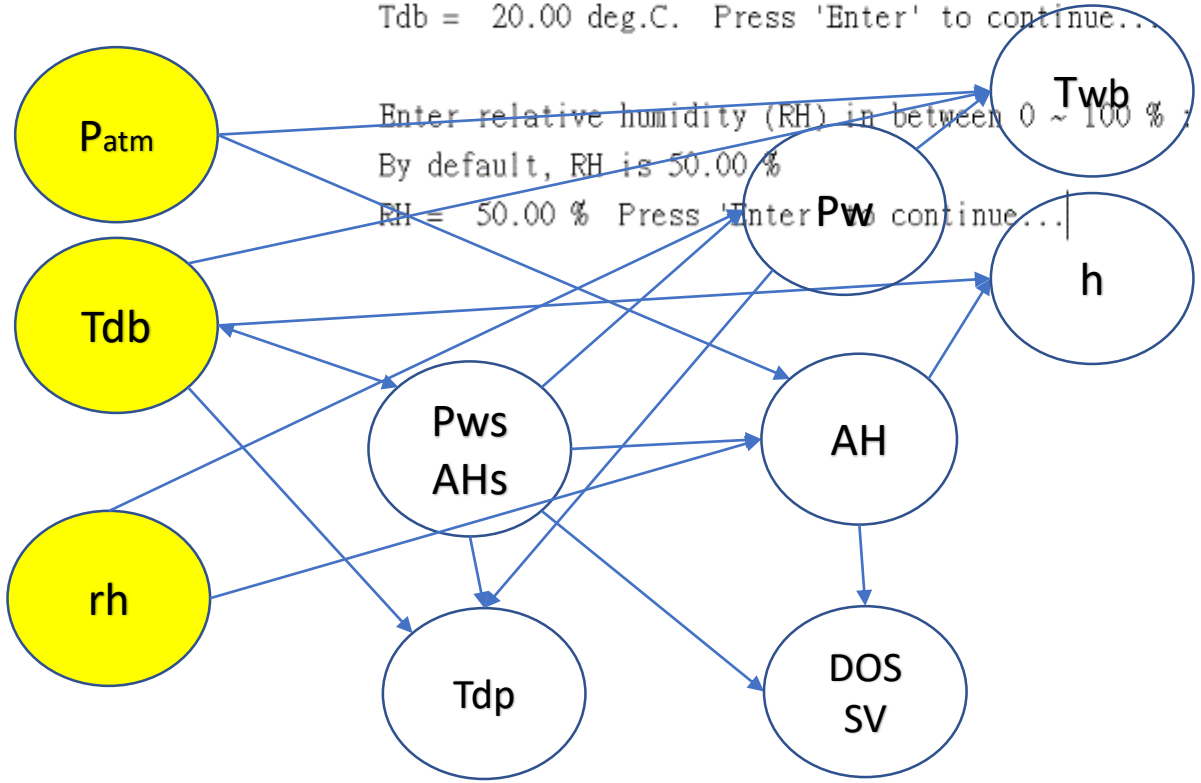
Patm	=	101.325	101.325	101.325	101.325	89.874	89.874	89.874	89.874	79.495	79.495	79.495	79.495 kPa
Tdb	=	16.000	30.000	40.000	50.000	16.000	30.000	40.000	50.000	16.000	30.000	40.000	50.000 deg.C
RH	=	20.000	50.000	80.000	80.000	20.000	50.000	80.000	80.000	20.000	50.000	80.000	80.000 %
Pws_1	=	1.818	4.246	7.383	12.350	1.818	4.246	7.383	12.350	1.818	4.246	7.383	12.350 kPa
Pws_2	=	1.818	4.242	7.374	12.334	1.818	4.242	7.374	12.334	1.818	4.242	7.374	12.334 kPa
Pws_3	=	1.817	4.240	7.371	12.328	1.817	4.240	7.371	12.328	1.817	4.240	7.371	12.328 kPa
Pws_4	=	1.818	4.246	7.383	12.350	1.818	4.246	7.383	12.350	1.818	4.246	7.383	12.350 kPa
Pw_1	=	0.364	2.123	5.907	9.880	0.364	2.123	5.907	9.880	0.364	2.123	5.907	9.880 kPa
Pw_2	=	0.364	2.121	5.899	9.867	0.364	2.121	5.899	9.867	0.364	2.121	5.899	9.867 kPa
Pw_3	=	0.363	2.120	5.897	9.862	0.363	2.120	5.897	9.862	0.363	2.120	5.897	9.862 kPa
Pw_4	=	0.364	2.123	5.907	9.880	0.364	2.123	5.907	9.880	0.364	2.123	5.907	9.880 kPa
Hfg_1	=	2462.280	2428.400	2404.200	2380.000	2462.280	2428.400	2404.200	2380.000	2462.280	2428.400	2404.200	2380.000 kJ/kg
Hfg_2	=	2464.363	2430.962	2407.105	2383.247	2464.363	2430.962	2407.105	2383.247	2464.363	2430.962	2407.105	2383.247 kJ/kg
Tdp_1	=	-6.360	18.294	35.928	45.717	-6.360	18.294	35.928	45.717	-6.360	18.294	35.928	45.717 deg.C
Tdp_2	=	-6.155	18.465	35.852	45.548	-6.155	18.465	35.852	45.548	-6.155	18.465	35.852	45.548 deg.C
Tsat_1	=	-6.432	18.455	35.902	45.602	-6.432	18.455	35.902	45.602	-6.432	18.455	35.902	45.602 deg.C
Tsat_2	=	-6.432	18.455	35.900	45.596	-6.432	18.455	35.900	45.596	-6.432	18.455	35.900	45.596 deg.C
sv_1	=	0.820	0.866	0.907	0.951	0.925	0.977	1.026	1.077	1.046	1.106	1.163	1.224 m^3/kg
sv_2	=	0.822	0.877	0.942	1.014	0.927	0.992	1.071	1.160	1.049	1.125	1.222	1.332 m^3/kg
Twb_1	=	6.684	21.837	36.388	46.063	6.684	21.837	36.388	46.063	6.684	21.837	36.388	46.063 deg.C
Twb_2	=	6.683	22.037	36.574	46.084	6.125	21.760	36.507	46.031	5.547	21.488	36.443	45.981 deg.C
h_1	=	21.782	64.251	139.473	224.735	22.508	68.694	153.001	249.699	23.347	73.857	168.900	279.421 kJ/kg
h_2	=	21.764	64.191	139.316	224.431	22.489	68.630	152.827	249.358	23.328	73.788	168.707	279.036 kJ/kg
ah_1	=	0.002	0.013	0.039	0.067	0.003	0.015	0.044	0.077	0.003	0.017	0.050	0.088 kg vapo
ah_2	=	0.002	0.013	0.039	0.067	0.003	0.015	0.044	0.077	0.003	0.017	0.050	0.088 kg vapo
ah_3	=	0.002	0.013	0.039	0.068	0.003	0.015	0.044	0.078	0.003	0.017	0.051	0.090 kg vapo

Waiting for input

3 properties | Process | More... | Misc.

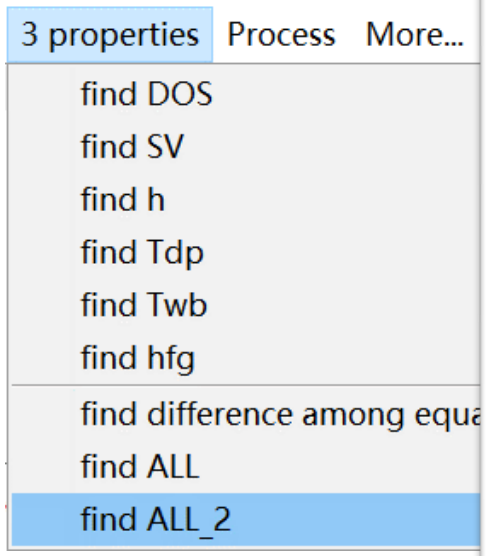
- find DOS
- find SV
- find h
- find Tdp
- find Twb
- find hfg
- find difference among equations
- find ALL
- find ALL_2

```
This program deals with the usage of the psychrometric subroutines: psy.m
Three values are needed to derive other psychrometric properties.
------------------------------------------------------------------------------------------

Select Atmospheric pressure (1. Sea level, 2. 1000 m altitude, or enter Patm value in kPa.) :
   By default, atmospheric pressure (Patm) is 101.325 kPa
   Patm =101.325 kPa.   Press 'Enter' to continue...

   Enter dry-bulb temperature (Tdb) in deg.C :
   By default, Tdb is 20.000 deg.C
   Tdb =  20.00 deg.C.  Press 'Enter' to continue...

   Enter relative humidity (RH) in between 0 ~ 100 % :
   By default, RH is 50.00 %
   RH =  50.00 %  Press 'Enter' to continue...
```




```
Given:
   Patm =   101.325 kPa
   Tdb =     20.00  deg.C
   RH  =     50.00  %
-----------------------------------------

Solution:
   Pws_1  =  2338.80 Pa =  2.33880 kPa
   Pws_2  =  2338.02 Pa =  2.33802 kPa
   Pw     =  1169.40 Pa =  1.16940 kPa
   Pws_wb =  1578.33 Pa =  1.57833 kPa
   VPD_db =  1.16940 kPa = (Pws-Pw)/1000
   VPD_wb =  0.40892 kPa = (Pswb-Pw)/1000
   AH     =  0.00726 kg vapor/kg DA
   AHs    =  0.01470 kg vapor/kg DA
   AHs_wb =  0.00984 kg vapor/kg DA
   AHD_db =  0.00743 kg vapor/kg DA = AHs-AH
   AHD_wb =  0.00258 kg vapor/kg DA = AHswb-AH
   DOS    =    49.42 %
   Twb1   =    13.80 deg.C using regression equation
   Twb2   =    13.79 deg.C using iterative algorithm
   WBD    =     6.20 deg.C = Tdb - Twb
>>
```

Given 3
to derive 15 properties.

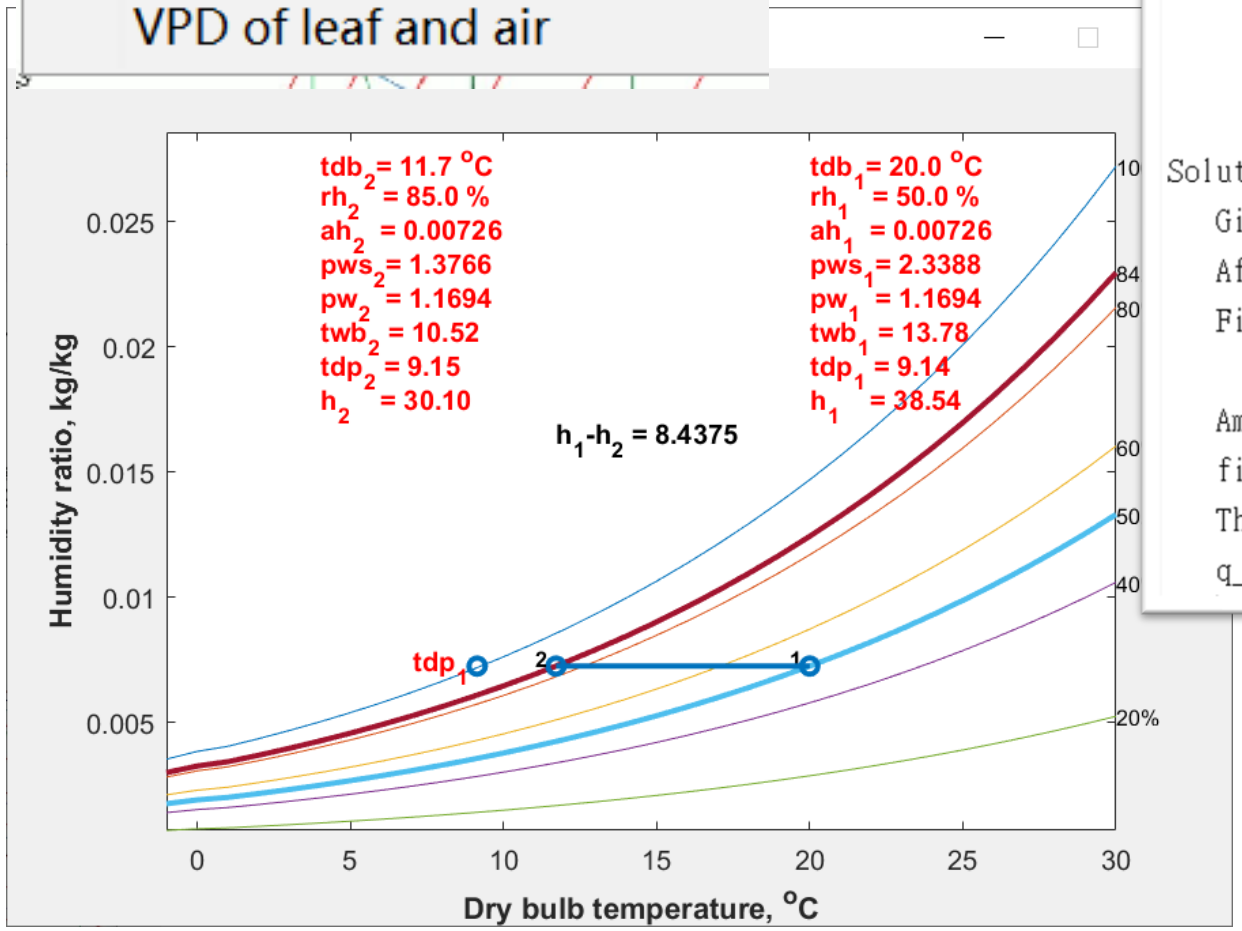


Given 3 to derive 19 properties.

```
Given Patm, Tdb and rh to derive others
Patm                = 101.3250 101.3250 101.3250 101.3250  89.8740  89.8740  89.8740  61.6400  61.6400  61.6400 kPa
Tdb                 =    10.00    20.00    20.00    30.00    10.00    20.00    30.00    10.00    20.00    30.00 deg.C
rh                  =    50.00    50.00    80.00    80.00    50.00    50.00    80.00    50.00    50.00    80.00 %
-------------------------------------------------------------------------------------------------------------------
Twb                 =     5.65    13.79    17.71    26.96     5.65    13.79    26.96     5.65    13.79    26.96 deg.C
WBD = Tdb - Twb     =     4.35     6.21     2.29     3.04     4.35     6.21     3.04     4.35     6.21     3.04 deg.C
Tdp                 =     0.20     9.15    16.29    26.09     0.20     9.15    26.09     0.20     9.15    26.09 deg.C
DOS                 =    49.70    49.42    79.62    79.31    49.66    49.34    79.21    49.50    49.03    78.83 %
Pws_1               =   1.2280   2.3388   2.3388   4.2460   1.2280   2.3388   4.2460   1.2280   2.3388   4.2460 kPa
Pws_2               =   1.2279   2.3380   2.3380   4.2424   1.2279   2.3380   4.2424   1.2279   2.3380   4.2424 kPa
Pw                  =   0.6140   1.1694   1.8710   3.3968   0.6140   1.1694   3.3968   0.6140   1.1694   3.3968 kPa
VPD=Pws-Pw          =   0.6140   1.1694   0.4678   0.8492   0.6140   1.1694   0.8492   0.6140   1.1694   0.8492 kPa
Vds=f(Vps,tdb)      =   9.3925  17.2744  17.2744  30.3112   9.3925  17.2744  30.3112   9.3925  17.2744  30.3112 g/m^3
AHs=Vds*SV          =   7.5516  14.4092  14.4472  26.3663   8.5163  16.2542  29.7743  12.4319  23.7531  43.7025 g/m^3*m^3/kg
AH                  =   3.7920   7.2621  11.7014  21.5746   4.2784   8.1996  24.4314   6.2579  12.0281  36.2748 g vapor/kg D
AHD=AHs-AH          =   3.7597   7.1471   2.7458   4.7917   4.2378   8.0546   5.3429   6.1740  11.7251   7.4278 g vapor/kg D
h                   =  19.6122  38.5448  49.8076  85.3062  20.8376  40.9233  92.6058  25.8239  50.6364 122.8674 kJ/kg
SV                  =   0.8040   0.8341   0.8363   0.8699   0.9067   0.9409   0.9823   1.3236   1.3750   1.4418 m^3/kg
Density=1/SV        =     1.24     1.20     1.20     1.15     1.10     1.06     1.02     0.76     0.73     0.69 kg/m^3
hfg (0~65 deg.C)    =  2476.80  2452.60  2452.60  2428.40  2476.80  2452.60  2428.40  2476.80  2452.60  2428.40 kJ/kg
hfg (-18~200 deg.C) =  2478.68  2454.82  2454.82  2430.96  2478.68  2454.82  2430.96  2478.68  2454.82  2430.96 kJ/kg
ASAE's THI          =    51.27    64.49    67.06    80.59    51.27    64.49    80.59    51.27    64.49    80.59 @Tdb,rh
ASHRAE's DI         =    51.47    64.59    67.16    80.59    51.47    64.59    80.59    51.47    64.59    80.59 @Tdb,Tdp
>>
```

Process More... Misc.

- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air



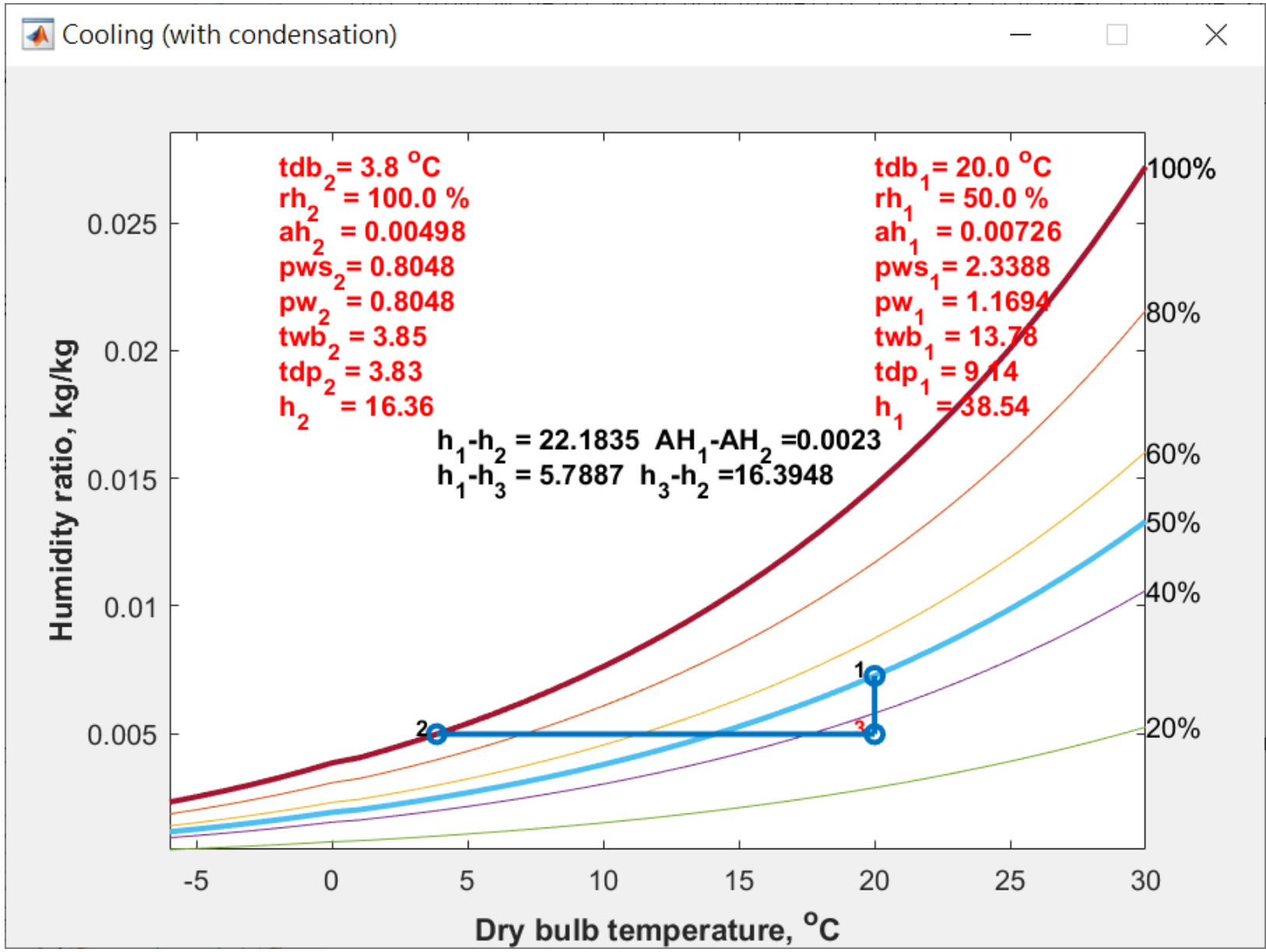

```
This program deals with cooling with or without condensation process. Assumed at Sea

   Enter dry bulb temperature (Tdb) of air in deg.C (press 'enter' for default):
   Tdb = 20.00 deg.C
   Enter relative humidity (RH) of air in % (press 'enter' for default):
   RH = 50.00 %
     Enter amount of heat removed (q_remove) in kJ (press 'enter' for default):
     q_remove = 20.000 kJ
     Enter amount of air flow (m_air) involved in kg (press 'enter' for default):
     m_air =  1.200 kg

Solution:
   Given T = 20.00 deg.C, rh=50.00 %, derived Tdp =    9.15 deg.C
   After removal of   20.00 kJ from    1.20 kg of air, ie.   16.67 kJ/kg
   Final T =  3.85 deg.C, rh = 100.00 %

   Amount of vapor removed:    2.29 g/kg DA, totally,    2.74 g removed.
   final T =  3.85 deg.C less than Tdp =  9.15 deg.C.
   This is a cooling with CONDENSATION process.
   q_sensible= 11.06 kJ/kg, q_latent=  5.61 kJ/kg
```

Process More... Misc.

- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air

C: ▸ Users ▸ weifang ▸ Desktop ▸ working ▸ psymenu

```
This program deals with cooling with or without condensation process

   Enter dry bulb temperature (Tdb) of air in deg.C (press 'enter' f
   Tdb = 20.00 deg.C
   Enter relative humidity (RH) of air in % (press 'enter' for defau
   RH = 50.00 %
     Enter amount of heat removed (q_remove) in kJ (press 'enter' fo
     q_remove = 20.000 kJ
     Enter amount of air flow (m_air) involved in kg (press 'enter'
     m_air =  1.200 kg

olution:
  Given T = 20.00 deg.C, rh=50.00 %, derived Tdp =    9.15 deg.C
  After removal of   20.00 kJ from    1.20 kg of air, ie.   16.67 kJ.
```



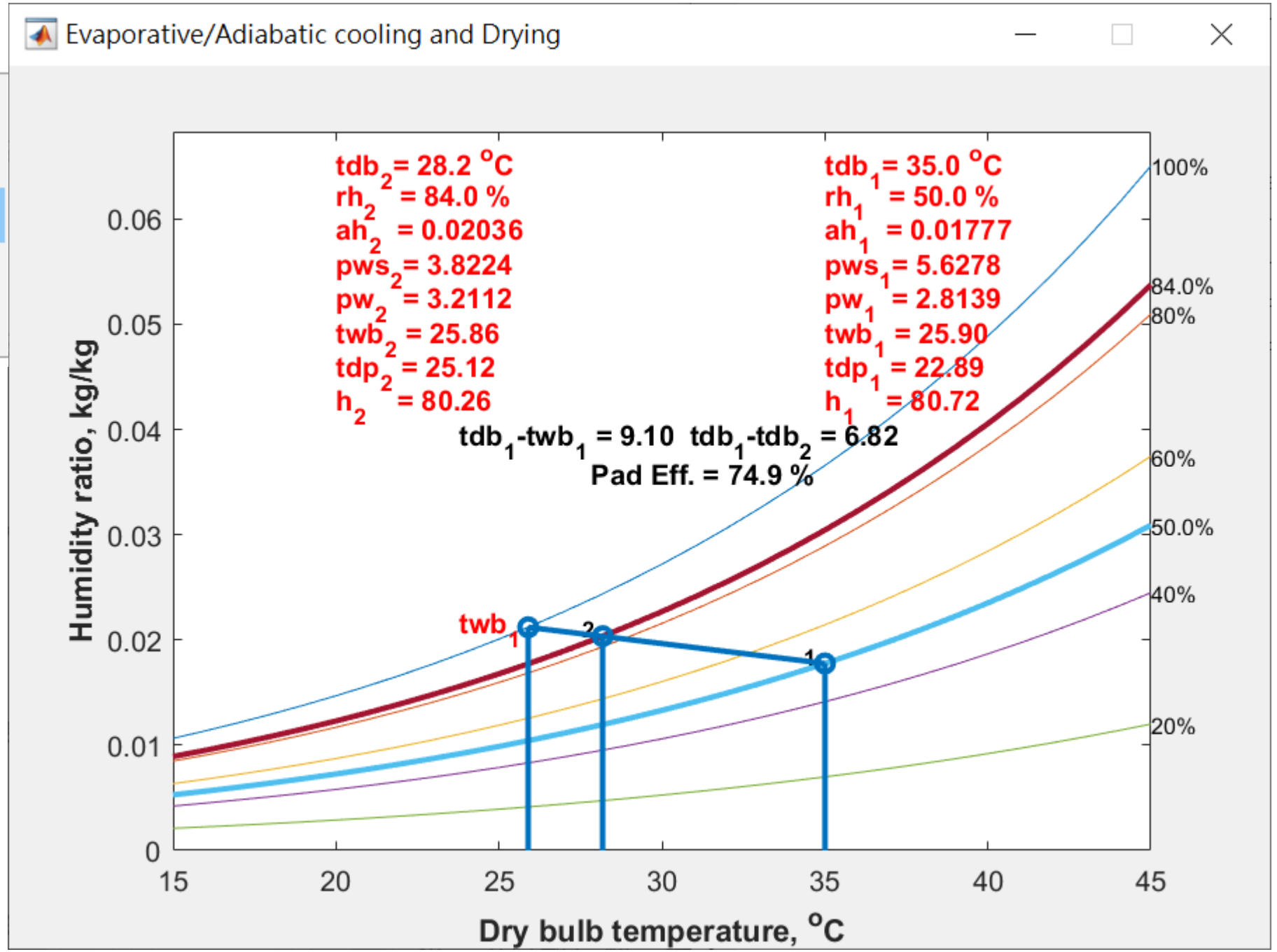
Process More... Misc.

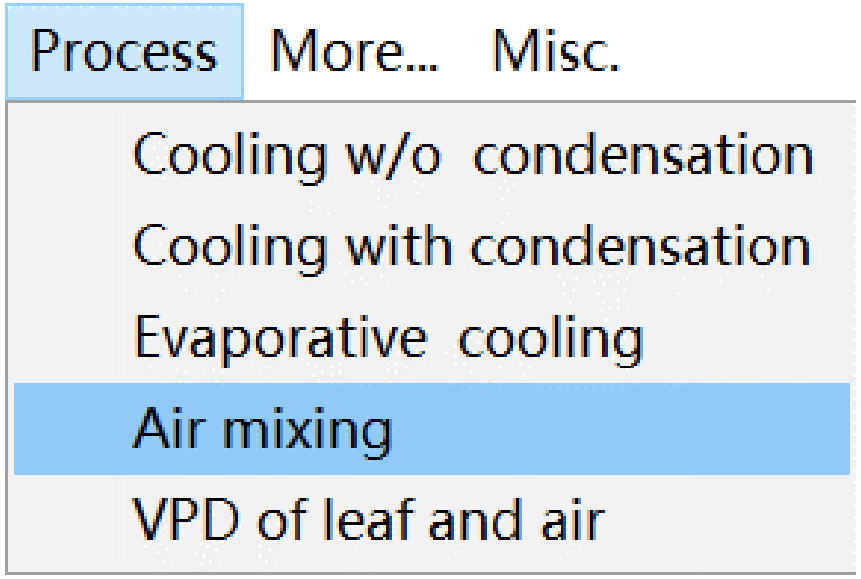
- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air

```
This program deals with evaporative cooling process. Assumed at Sea level.

  Enter Tdb of outdoor air in deg.C (press 'enter' for default):
  tdb = 35.000 deg.C
  Enter rh of outdoor air in % (press 'enter' for default):
  rh = 50.000 %
  Enter Pad Efficiency in % (press 'enter' for default):
  Pad efficiency = 75.000 %

define point 1: outdoor environment
       point 2: after pad point
       point 3: outdoor wet bulb point

Given:
   patm   =  101.325 kPa
   tdb_1  =  35.00 deg.C
   rh_1   =  50.00 %
   eff.   =  75.00 % (pad efficiency)

Derive
__ Outdoor environmwnt ____ Saturated outdoor__
   Tdb_1  =  35.00       Tdb_3  =  25.91  deg.C
   Twb_1  =  25.91       Twb_3  =  25.91  deg.C (using regression eq.)
   Twb_1  =  26.18       Twb_3  =  26.18  deg.C (using iteration algorithm)
   Tdp_1  =  22.91       Tdp_3  =  25.91  deg.C
   rh_1   =  50.00       rh_3   =  100.00  %
   pw_1   =  2.8139      pw_3   =  3.3429  kPa
   ah_1   =  0.0178      ah_3   =  0.0212  kg/kg
-------------------------------------------------------------------------------

After pad:
   Tdb_2  =  28.18  deg.C
   Twb_2  =  25.91  deg.C (using regression eq.), 26.18 deg.C
   pw_2a  =  3.2106  kPa (calculated from efficiency)
   pw_2b  =  3.2112  kPa (calculated from equations)
   Tdp_2a =  25.16  deg.C (calculated from efficiency)
   Tdp_2b =  25.13  deg.C (calculated from equations)
   rh_2   =  84.01  %
   ah_2   =  0.0204  kg/kg (calculated from efficiency)
   sv_2   =  0.8640  m^3/kg DA
   dsty_2 =   1.16  kg DA/m^3
   h_2    =  80.2985  kJ/kg

Amount of water added:
   delta_ah     =  0.0026 kg/kg DA = 0.0030 kg/m^3 DA
Amount of temperature decreased:
   delta_Tdb    =   6.82  deg.C
   WBD          =   9.09  deg.C  Efficiency = 0.75
Amount of rel. humidity increased:
   delta_rh     =  34.01  %
```

Process More... Misc.

- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air



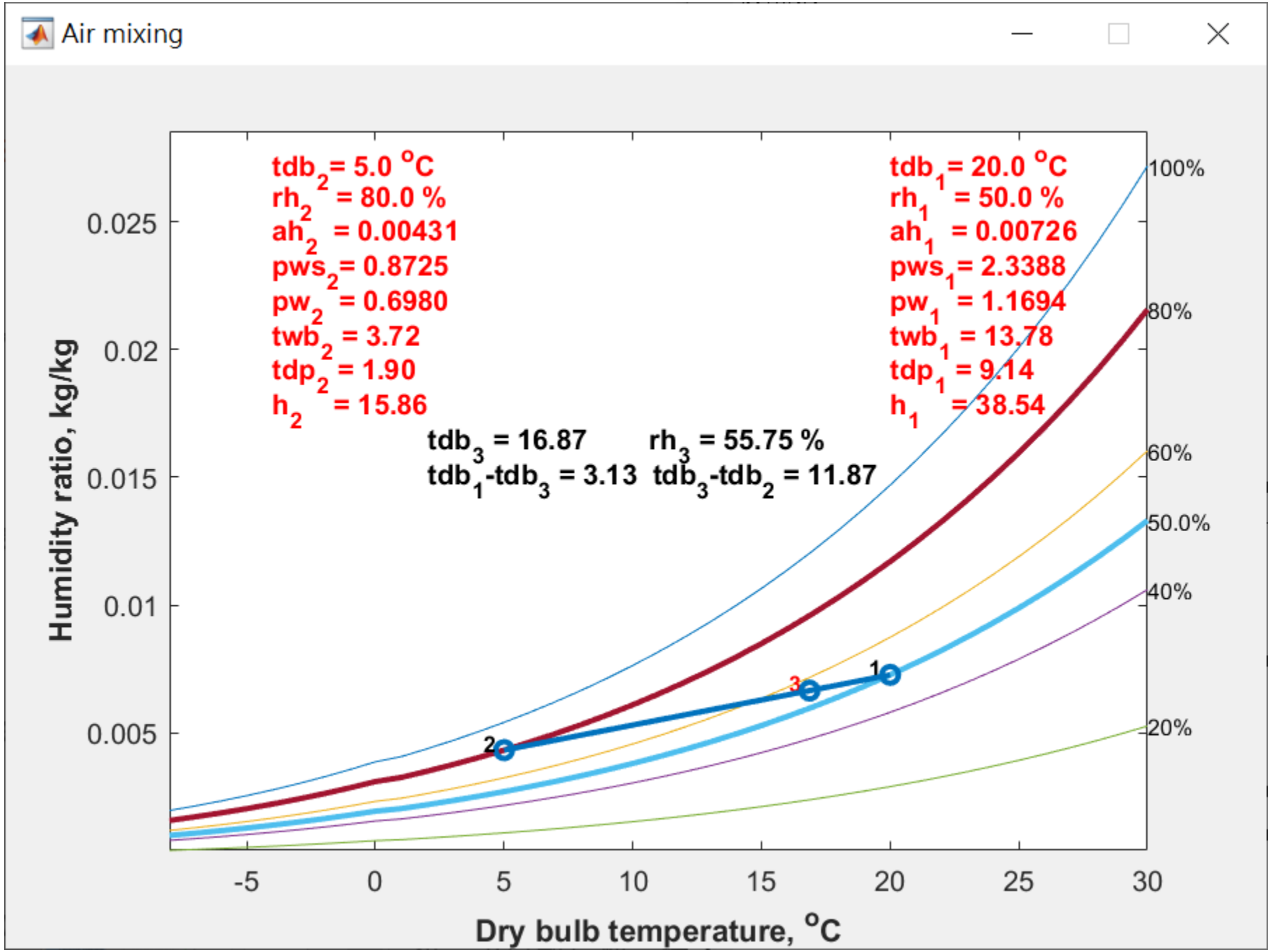


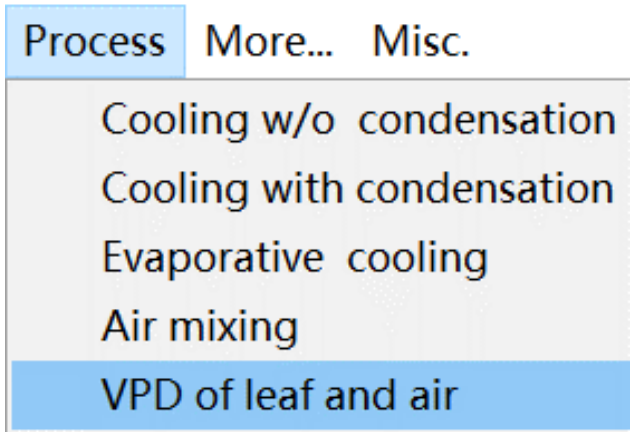

```
This program deals with the mixing of two air streams with various states and mass flow rat
Assumed at Sea level.

Air flow 1:
   enter dry bulb temperature (tdb) in deg.C (press 'enter' for default):
   tdb = 20.00 deg.C
   enter relative humidity (rh) in % (press 'enter' for default):
   rh = 50.00 %
   enter air mass flow rate in m^3/s (press 'enter' for default):
   mass flow rate =  0.80
 Air flow 2:
   enter dry bulb temperature (tdb) in deg.C (press 'enter' for default):
   tdb =  5.00 deg.C
   enter relative humidity (rh) in % (press 'enter' for default):
   rh = 80.00 %
   enter air mass flow rate in m^3/s (press 'enter' for default):
   mass flow rate =  0.20
```

```
Air mixing problem:
given:
  tdb_1   =  20.00        tdb_2   =    5.00    deg.C
  rh_1    =  50.00        rh_2    =   80.00    %
  vol_1   =  0.800        vol_2   =   0.200    m^3/s
Derive:
  ah_1    =      0.0073   ah_2    =      0.0043   kg/kgDA
  h_1     =     38.5448   h_2     =     15.8590   kJ/kgDA
  sv_1    =      0.8341   sv_2    =      0.7901   m^3/kgDA
  mflow_1 =      0.9591   mflow_2 =      0.2531   kg/s

After mixing:
  tdb_3  =       16.87  deg.C (calculated from mixing)
  twb_3  =       11.97  deg.C (using regression eq.), 11.93 deg.C
  tdp_3  =        7.87  deg.C
  rh_3   =       55.75  %
  ah_3   =     0.00665  kg/kg (calculated from mixing)
  sv_3   =     0.82492  m^3/kgDA
  dsty_3 =     1.21224  kgDA/m^3
  h_3a   =    33.80737  kJ/kg (calculated from mixing)
  h_3b   =    33.79418  kJ/kg (calculated from equations)
  vol_3  =     0.99999  m^3/s
```

Process More... Misc.

- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air





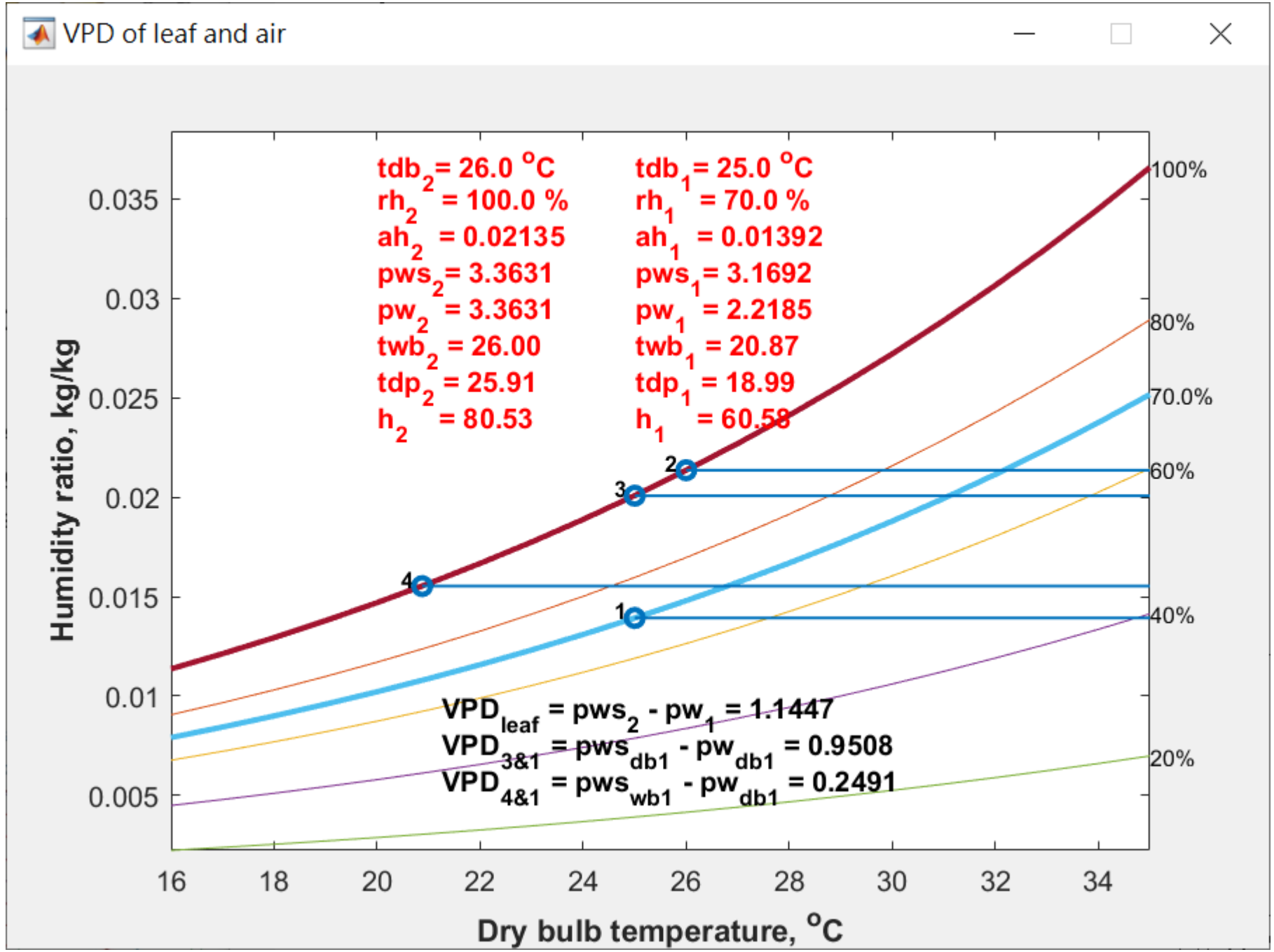

```
This program calculates WBD of air, VPD of leaf and air and VPD of air and saturated air. Assumed at sea level.

   Enter dry bulb temperature (Tdb) in deg.C (press 'enter' for default):
   tdb = 25.000 deg.C
   Enter relative humidity (rh) of air in % (press 'enter' for default):
   rh = 70.000 %
   Enter leaf temperature (Tleaf) in deg.C (press 'enter' for default):
   Tleaf = 26.000 deg.C
```

```
define point 1: environment
       point 2: leaf
       point 3: wet bulb of point 1

Given
  patm   =  101.325 kPa
  tdb_1  =  25.00 deg.C
  rh_1   =  70.00 %
  tleaf  =  26.00 deg.C
```

```
Derive
___ Air (pt 1)__ ___ Saturated (pt 3)__ Leaf (pt 2)___
  Tdb  =  25.00      Tdb  =  20.97      Tdb =  26.00  deg.C
  Twb  =  20.97      Twb  =  20.98      Twb =  26.01  deg.C
  rh   =  70.00      rh   =  100.00     rh  = 100.00  %
  pws  =  3.1674     pws  =  2.4827     pws =  3.3610  kPa
  pw   =  2.2172     pw   =  2.4827     pw  =  3.3610  kPa

------------------------------------------------------------
  VPDair  =  pws1 - pw1 = 0.9502  kPa
  VPD'air  = pws3 - pw1 = 0.2655  kPa
  VPDleaf =  pws2 - pw1 = 1.1438  kPa
  WBD of air  = tdb1 - twb1 =  4.03 deg.C
  Tdif of air to leaf = tdb1 - tdb2 = -1.00 deg.C

------------------------------------------------------------
```

Process More... Misc.

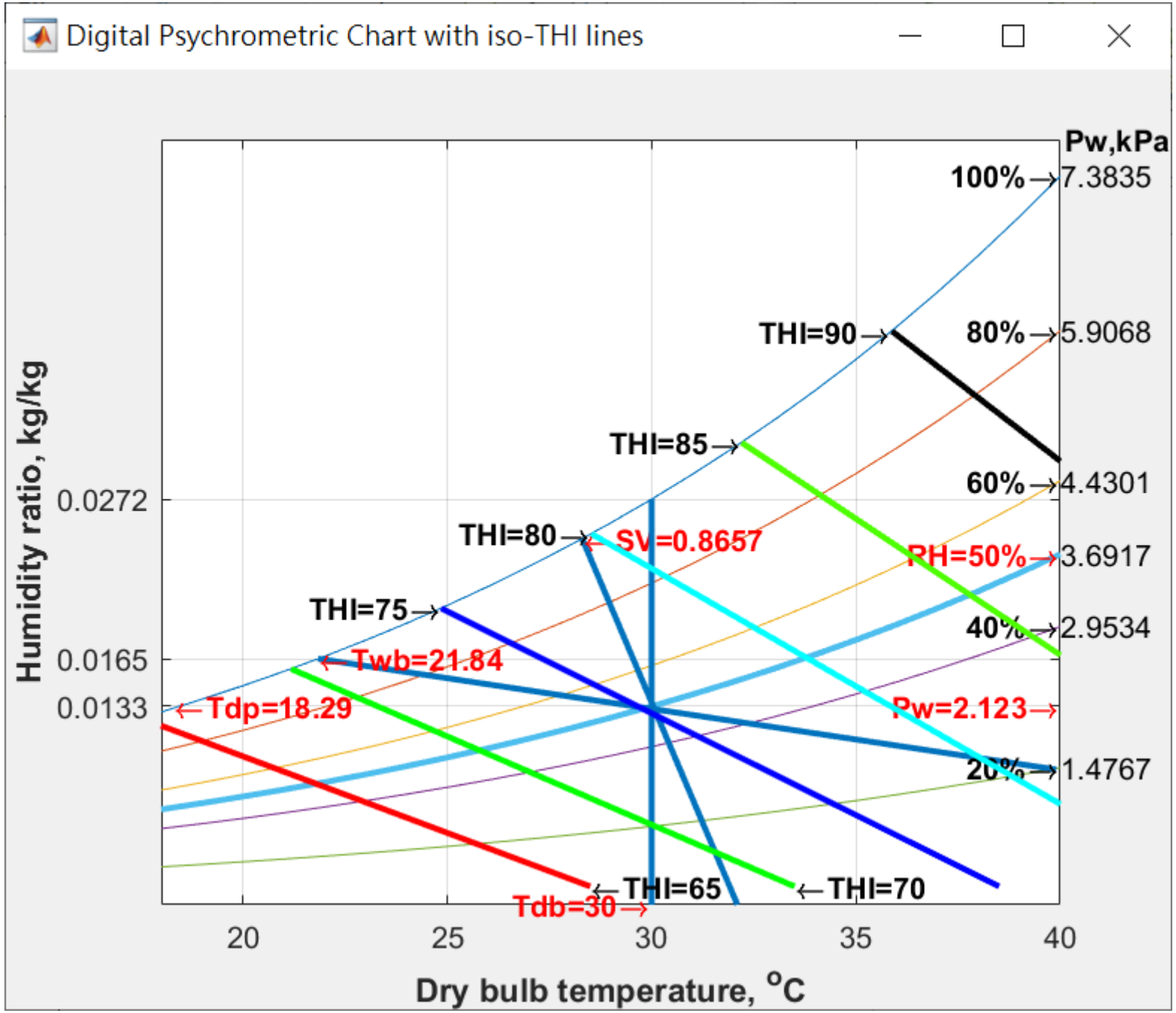
- Cooling w/o condensation
- Cooling with condensation
- Evaporative cooling
- Air mixing
- VPD of leaf and air



More... Misc.

THI_lines

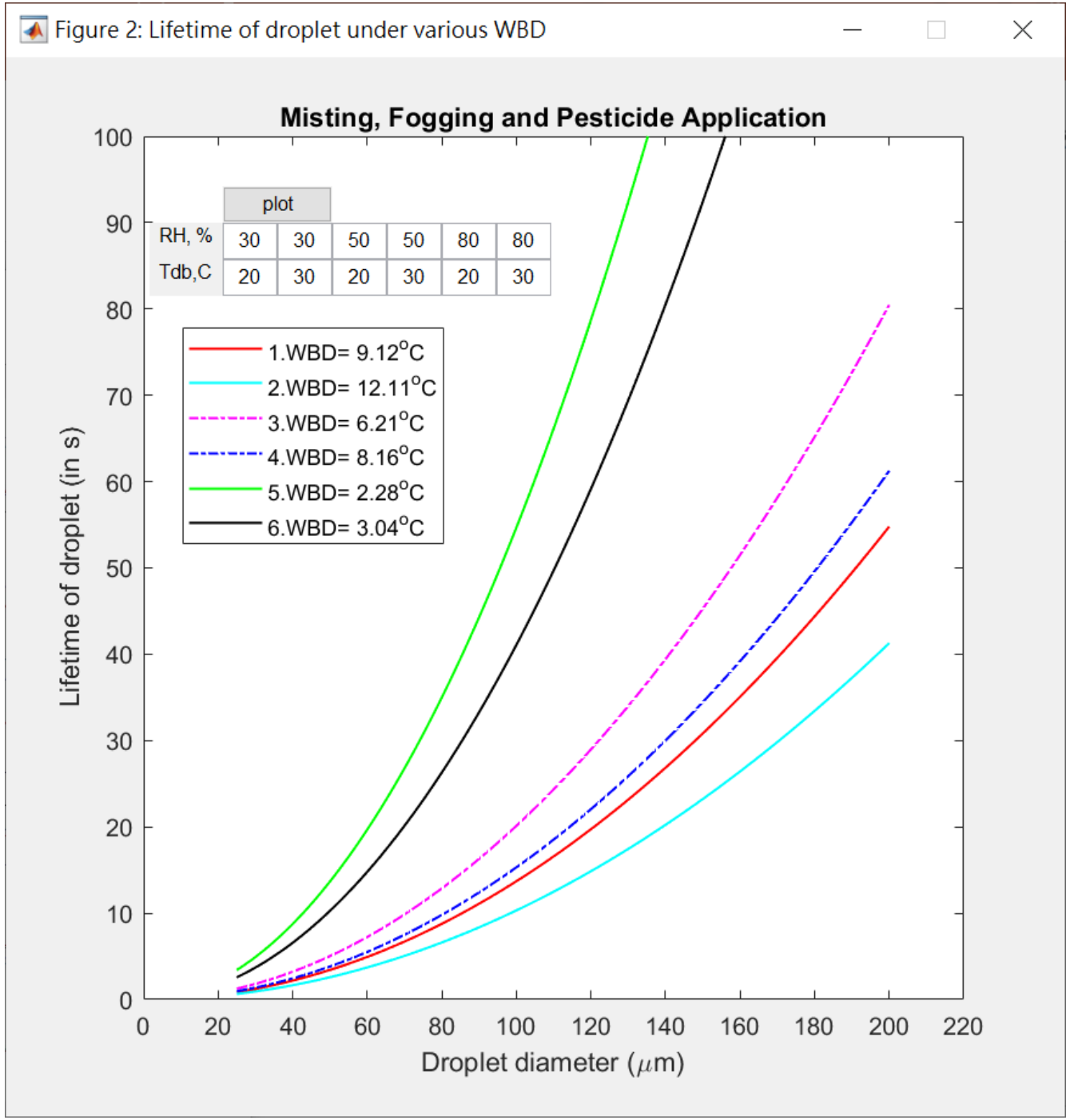
Droplet lifetime

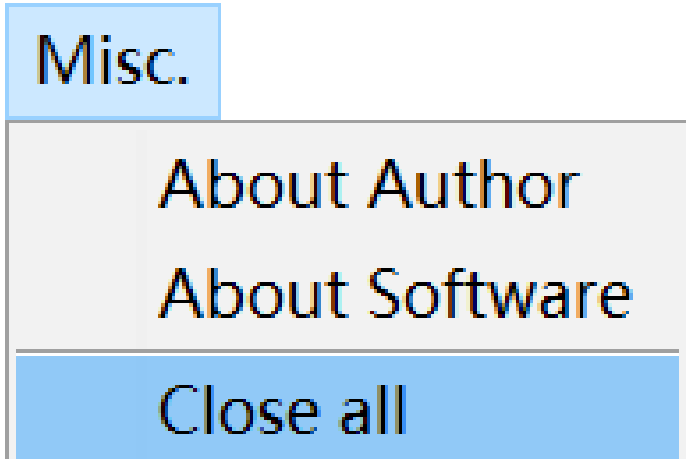


More... Misc.

THI_lines

Droplet lifetime





Thank you for using
Software for the learning of psychrometrics
ver. 2.0

Software developed by
Wei Fang, Ph.D., Professor
Dept. of Biomechatronics Engineering
National Taiwan University

Email: weifang@ntu.edu.tw
Line/Wechat ID: weifang0257

Press 'enter' to continue

Notes for people interested in MATLAB programming and psychrometric related equations

- All the psychrometric related equations can be found in ‘psy.m’
- The ‘psy.m’ contains 4 inputs, the first 3 are values for later calculation. If number of inputs less than 3, enter 0. The 4th parameter is a string works as the switch for the selection of equations.
- Following codes show examples of using the subroutine.
- To derive pws using 2 separate equations
  - pws1=psy(tdb,0,0,’pws’); % only 1 parameter is needed
  - pws2=psy(tdb,0,0,’pws2’);
- To derive pw using 1 equation with different inputs
  - pw1=psy(pws1,rh,0,’pw’); % only 2 parameters are needed
  - Pw2=psy(pws2,rh,0,’pw’);
- You can create your own subroutine, for example
  - AH=psy(patm, pws, rh, ’ah’); % all 3 parameters are needed
  - AH=psy(patm, pw, 0, ‘ah_your_version’); % due to prior calculation of pw=pws*rh/100;

Notes for people interested in MATLAB program and psychrometric related equations

- Some parameters have multiple ways to derive the value, such as :
  - Hfg1 and Hfg2; AHs1 and AHs2; Tdp1 and Tdp2
  - Twb1 (sea level only) and Twb2 (generic suitable for various Patm)
  - Tdp1 (=f(Pws)) and Tdp2(=f(AHs))
    - Tdb=Twb=Tdp=f(Pws), when rh=100
    - Tdb =Twb=Tdp=f(Ahs), when rh=100
- Most of the equations published were collected.
- If you find any psychrometric related equations not included in the ‘psy.m’ file, please forward a message to the author.

溼空氣熱力特性在溫室環控的應用

- 應用於所有層面：通風、加溫、降溫、除溼、空調等
  - 通風速率：質、能量平衡
  - 冷凝：涉及露點溫度 (Tdp)
  - 除溼：涉及絕對溼度 (AH)
  - 空調負荷：涉及焓值(H)
  - 加濕、除溼：涉及 AH、蒸發潛熱 (Hfg)
  - 蒸散：涉及蒸氣壓 (VP)、蒸氣壓差 (VPD)
  - …

達到能量平衡所需的通風速率

$$Vr = \text{Energy input} / \Delta\text{Enthalpy} \ [m^3/m^2.h]$$

Where:

ΔEnthalpy = Enthalpy difference between inside and outside air [kJ/m^3]

Vr = ventilation rate [$m^3/m^2.h$]

Energy input = net energy input from the sun and other sources [$kJ/m^2.h$]

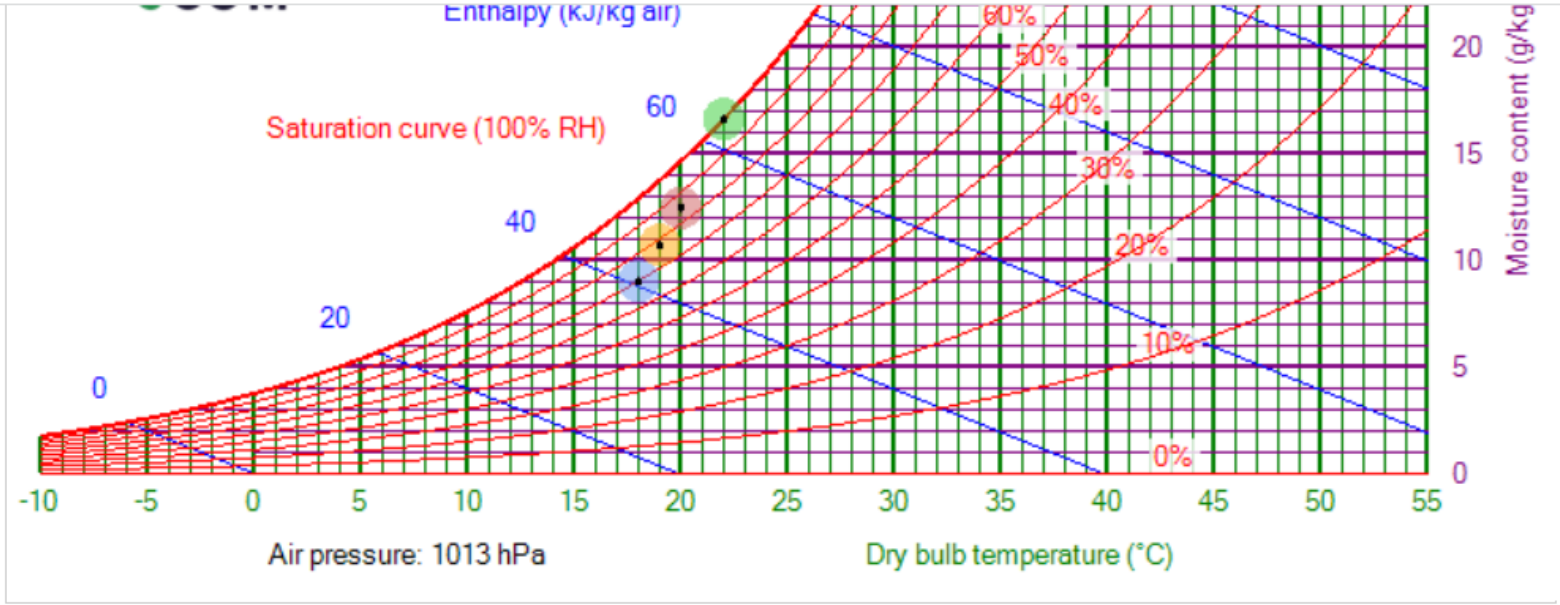
排濕量與通風速率

$$\text{Moisture exhaust} = Vr \times \Delta AH \quad [g/m^2.h]$$

Where:

Vr = ventilation rate [$m^3/m^2.h$]

Δ AH = difference between AH inside and outside [g/m^3]

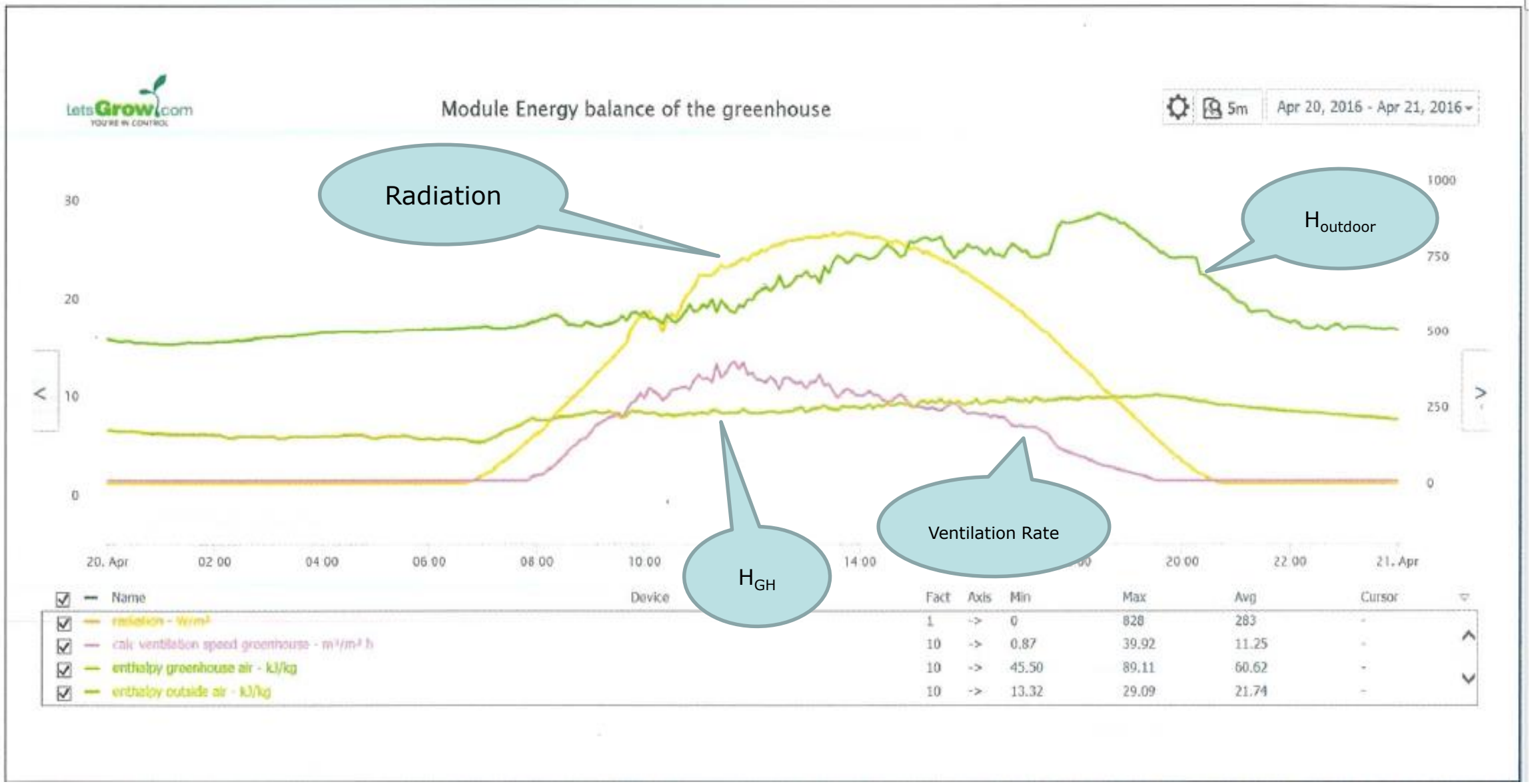


Hide Psychro diagram | More info | Air pressure 1013 hPa

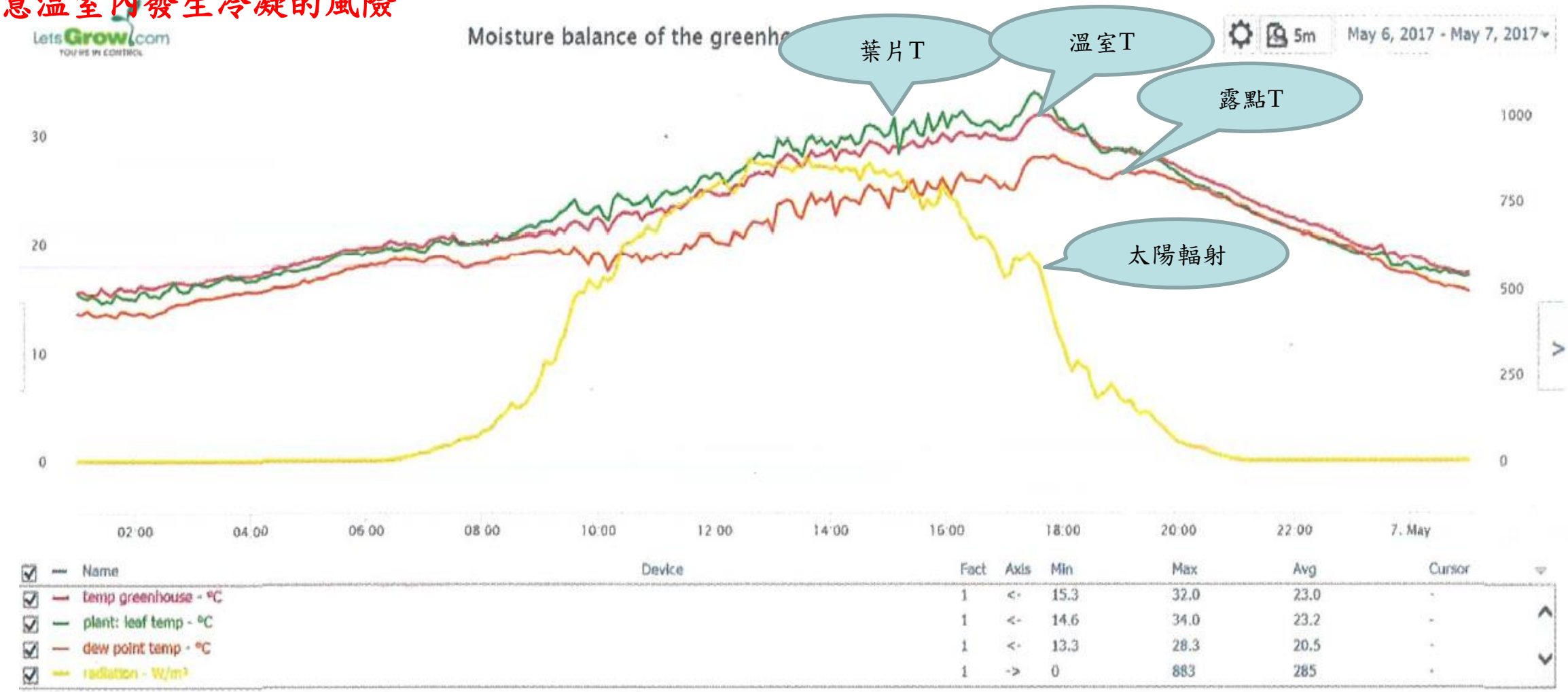
Outside		Difference	Above screen		Difference	Inside		Difference	Plant		
Temp	18 °C	1.00	Temp	19 °C	1.00	Temp	20 °C	2.00	Temp	22 °C	
RH	70 %	8.00	RH	78 %	7.00	RH	85 %	15.00	RH	100 %	
Absolute Humidity AH	9.04 g/kg	1.70	Absolute Humidity AH	10.73 g/kg	1.73	Absolute Humidity AH	12.47 g/kg	4.17	Absolute Humidity AH	16.64 g/kg	
Absolute Humidity AH	10.87 g/m³	1.99	Absolute Humidity AH	12.85 g/m³	2.01	Absolute Humidity AH	14.86 g/m³	4.79	Absolute Humidity AH	19.65 g/m³	
Humidity Deficit HD	3.87 g/kg	-0.85	Humidity Deficit HD	3.03 g/kg	-0.83	Humidity Deficit HD	2.20 g/kg	-2.20	Humidity Deficit HD	0.00 g/kg	
Humidity Deficit HD	4.66 g/m³	-1.03	Humidity Deficit HD	3.63 g/m³	-1.00	Humidity Deficit HD	2.62 g/m³	-2.62	Humidity Deficit HD	0.00 g/m³	
Enthalpy	40.61 kJ/kg	5.23	Enthalpy	45.85 kJ/kg	5.31	Enthalpy	51.16 kJ/kg	12.38	Enthalpy	63.55 kJ/kg	
Enthalpy	48.85 kJ/m³	6.05	Enthalpy	54.90 kJ/m³	6.09	Enthalpy	60.99 kJ/m³	14.06	Enthalpy	75.05 kJ/m³	
VPD	0.62 kPa	-0.14	VPD	0.48 kPa	-0.13	VPD	0.35 kPa	-0.35	VPD	0.00 kPa	
VP	1.44 kPa	0.27	VP	1.71 kPa	0.27	VP	1.99 kPa	0.66	VP	2.64 kPa	
VPsat	2.06 kPa	0.13	VPsat	2.20 kPa	0.14	VPsat	2.34 kPa	0.31	VPsat	2.64 kPa	
Dewpoint	12.4 °C	2.6	Dewpoint	15.1 °C	2.3	Dewpoint	17.4 °C	4.6	Dewpoint	22.0 °C	

依照太陽輻射量、溫室內外的焓值來設定通風速率

Figure 4.4.2.-2 Ventilation rate of the greenhouse.

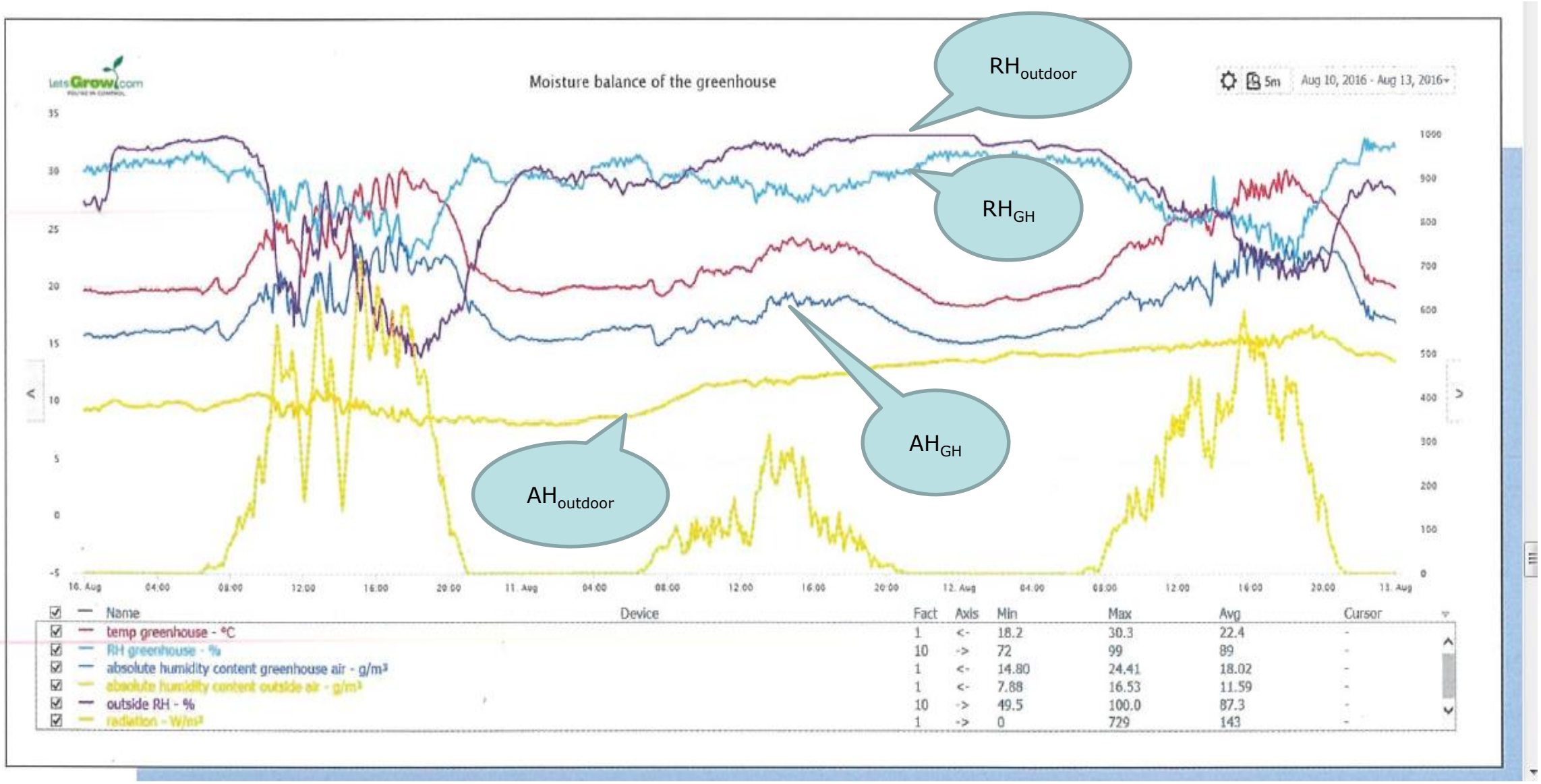


要留意溫室內發生冷凝的風險



- 夜間的葉片T、溫室T與露點T值頗接近，看似前二者均高於露點T，但要注意的是溫室內水平及垂直方向可能存在 1~1.5 ºC 的溫差，仍要留意局部位置發生冷凝的狀況。
- 日出時最易發生冷凝。上方空氣T上升較快，上方葉片蒸散較旺，下方果實及莖部溫度上升慢，當表面T低於空氣的露點T時，就會有冷凝發生在果實及莖部表面 (番茄溫室)。
- 露點溫度與 AH 有關，提高室內T無法處理冷凝，需要排濕才能避免。

當室外 RH > 室內 RH時，透過通風能夠幫助排除室內的水分嗎?

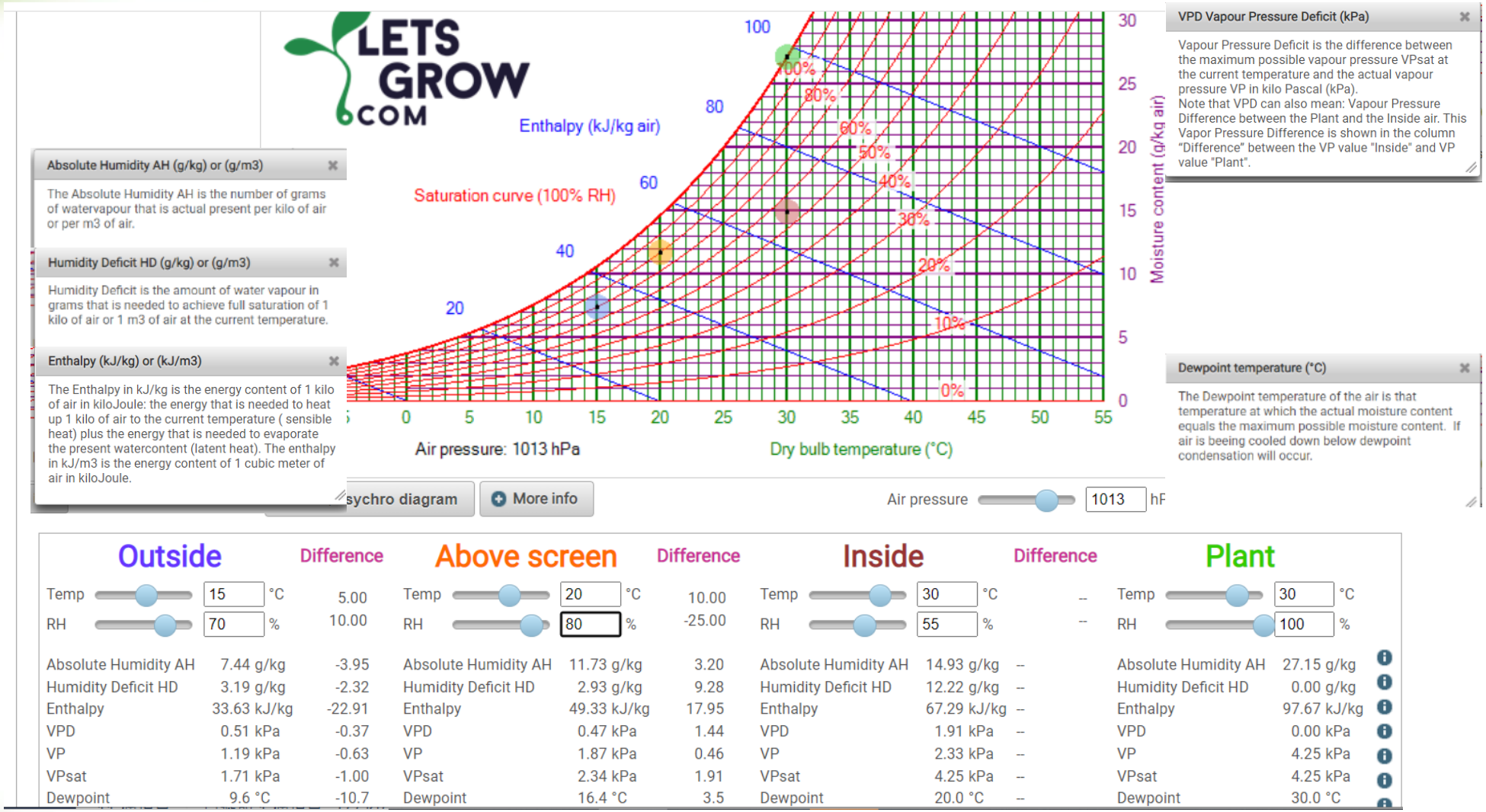


LetsGrow

A psychrometric software

https://gpe.letsgrow.com/psychro

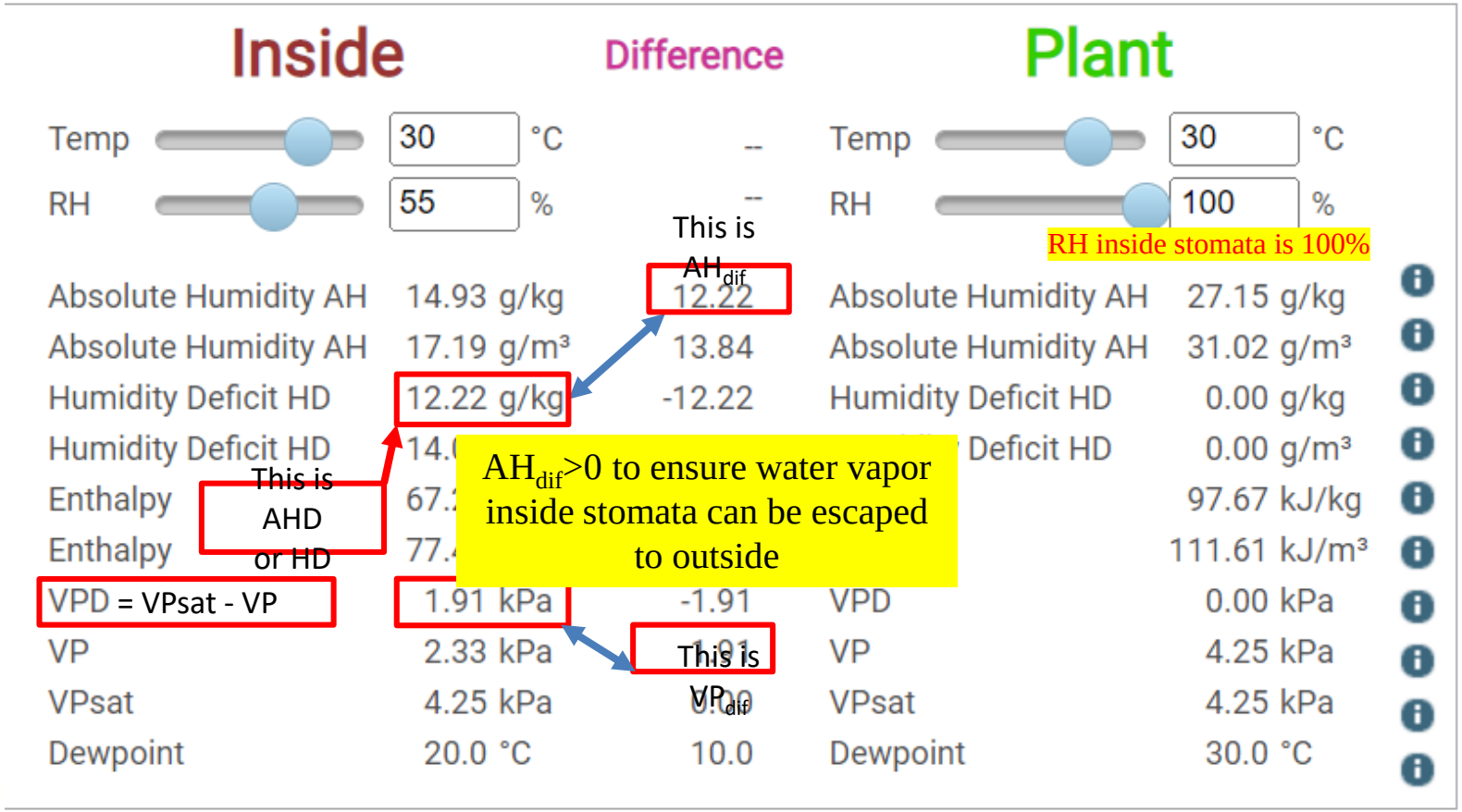
Wei FANG
NTU_BME and Global ATGS
National Taiwan University
2022/03/16



	Outside	Difference	Above screen	Difference	Inside	Difference	Plant
Temp	15 °C	5.00	20 °C	10.00	30 °C	--	30 °C
RH	70 %	10.00	80 %	-25.00	55 %	--	100 %
Absolute Humidity AH	7.44 g/kg	-3.95	11.73 g/kg	3.20	14.93 g/kg	--	27.15 g/kg
Humidity Deficit HD	3.19 g/kg	-2.32	2.93 g/kg	9.28	12.22 g/kg	--	0.00 g/kg
Enthalpy	33.63 kJ/kg	-22.91	49.33 kJ/kg	17.95	67.29 kJ/kg	--	97.67 kJ/kg
VPD	0.51 kPa	-0.37	0.47 kPa	1.44	1.91 kPa	--	0.00 kPa
VP	1.19 kPa	-0.63	1.87 kPa	0.46	2.33 kPa	--	4.25 kPa
VPsat	1.71 kPa	-1.00	2.34 kPa	1.91	4.25 kPa	--	4.25 kPa
Dewpoint	9.6 °C	-10.7	16.4 °C	3.5	20.0 °C	--	30.0 °C

Air pressure 1013 hPa

1 ATM = sea level, altitude = 0 m



Micro-climate

Inside		Difference	Plant	
Temp	30 °C	-1.00	Temp	29 °C
RH	80 %	10.00	RH	90 %
Absolute Humidity AH	21.72 g/kg	1.29	Absolute Humidity AH	23.01 g/kg
Absolute Humidity AH	24.90 g/m³	1.55	Absolute Humidity AH	26.44 g/m³
Humidity Deficit HD	5.43 g/kg	-2.87	Humidity Deficit HD	2.56 g/kg
Humidity Deficit HD	6.22 g/		HD	2.94 g/m³
Enthalpy	84.16 kJ/			86.38 kJ/kg
Enthalpy	96.49 kJ/m³	2.79	Enthalpy	99.28 kJ/m³
VPD = VPsat - VP	0.85 kPa	-0.45	VPD	0.40 kPa
VP	3.40 kPa	0.21	VP	3.61 kPa
VPsat	4.25 kPa	-0.24	VPsat	4.01 kPa
Dewpoint	26.2 °C	1.0	Dewpoint	27.2 °C

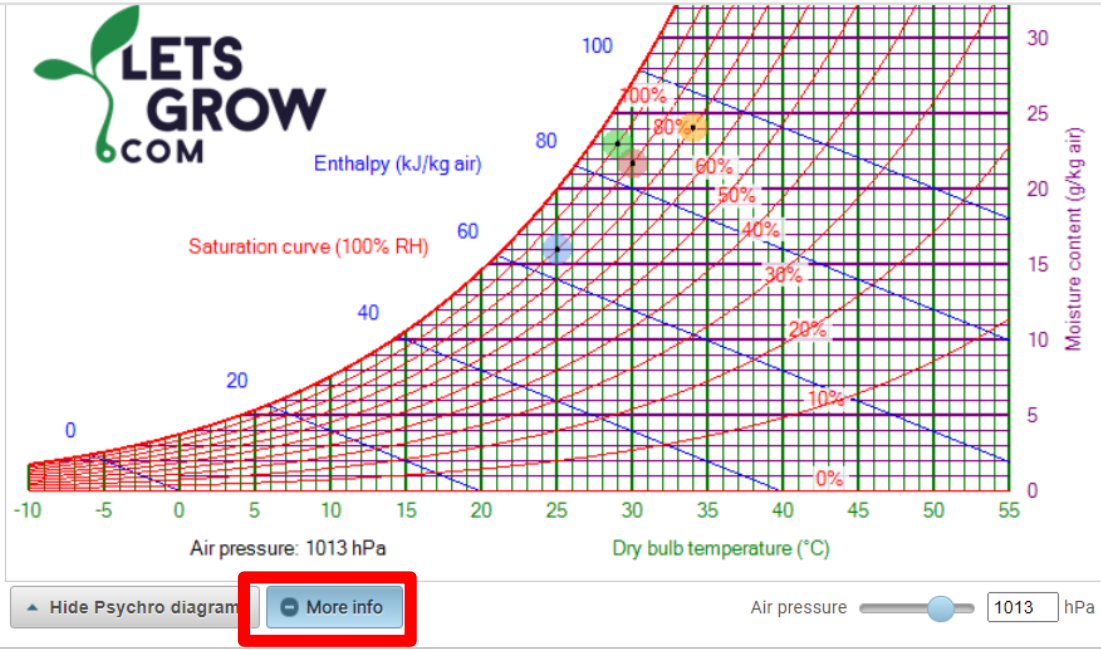
This is AH_{dif}

AH_{dif}>0 to ensure water vapor move away from crop canopy

This is VP_{dif}

AHD is not equal to AH_{dif}, AHD is the AH@Tsat – AH@Tdb
VPD is not equal to VP_{dif}, VPD is the VP@Tsat – VP@Tdb

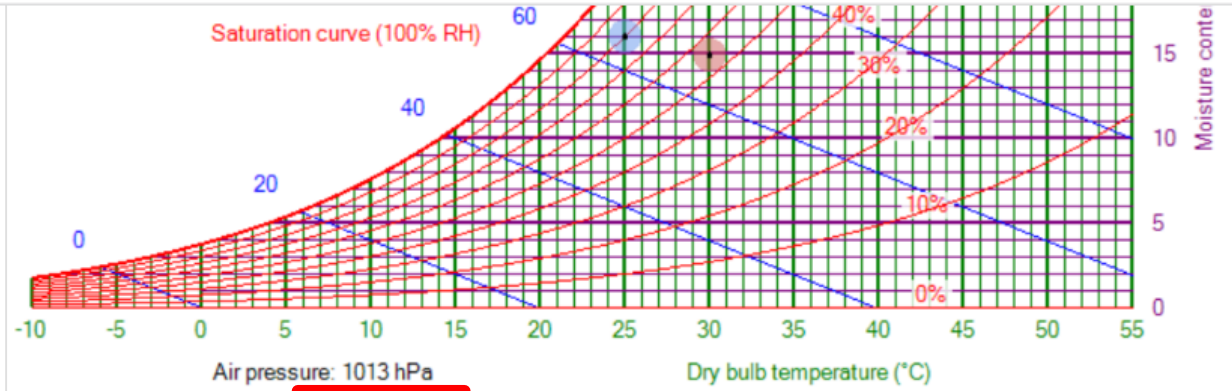
Detail version



Hide Psychro diagram | More info | Air pressure 1013 hPa

Outside		Difference	Above screen		Difference	Inside		Difference	Plant	
Temp	25 °C	9.00	Temp	34 °C	-4.00	Temp	30 °C	-1.00	Temp	29 °C
RH	80 %	-10.00	RH	70 %	10.00	RH	80 %	10.00	RH	90 %
Absolute Humidity AH	16.03 g/kg	8.06	Absolute Humidity AH	24.10 g/kg	-2.38	Absolute Humidity AH	21.72 g/kg	1.29	Absolute Humidity AH	23.01 g/kg
Absolute Humidity AH	18.75 g/m³	8.47	Absolute Humidity AH	27.23 g/m³	-2.33	Absolute Humidity AH	24.90 g/m³	1.55	Absolute Humidity AH	26.44 g/m³
Humidity Deficit HD	4.01 g/kg	6.32	Humidity Deficit HD	10.33 g/kg	-4.90	Humidity Deficit HD	5.43 g/kg	-2.87	Humidity Deficit HD	2.56 g/kg
Humidity Deficit HD	4.69 g/m³	6.98	Humidity Deficit HD	11.67 g/m³	-5.44	Humidity Deficit HD	6.22 g/m³	-3.29	Humidity Deficit HD	2.94 g/m³
Enthalpy	65.04 kJ/kg	29.02	Enthalpy	94.05 kJ/kg	-9.89	Enthalpy	84.16 kJ/kg	2.21	Enthalpy	86.38 kJ/kg
Enthalpy	76.07 kJ/m³	30.20	Enthalpy	106.27 kJ/m³	-9.78	Enthalpy	96.49 kJ/m³	2.79	Enthalpy	99.28 kJ/m³
VPD	0.63 kPa	0.96	VPD	1.60 kPa	-0.75	VPD	0.85 kPa	-0.45	VPD	0.40 kPa
VP	2.53 kPa	1.19	VP	3.73 kPa	-0.33	VP	3.40 kPa	0.21	VP	3.61 kPa
VPsat	3.17 kPa	2.15	VPsat	5.32 kPa	-1.08	VPsat	4.25 kPa	-0.24	VPsat	4.01 kPa
Dewpoint	21.3 °C	6.4	Dewpoint	27.8 °C	-1.6	Dewpoint	26.2 °C	1.0	Dewpoint	27.2 °C

Simplify version

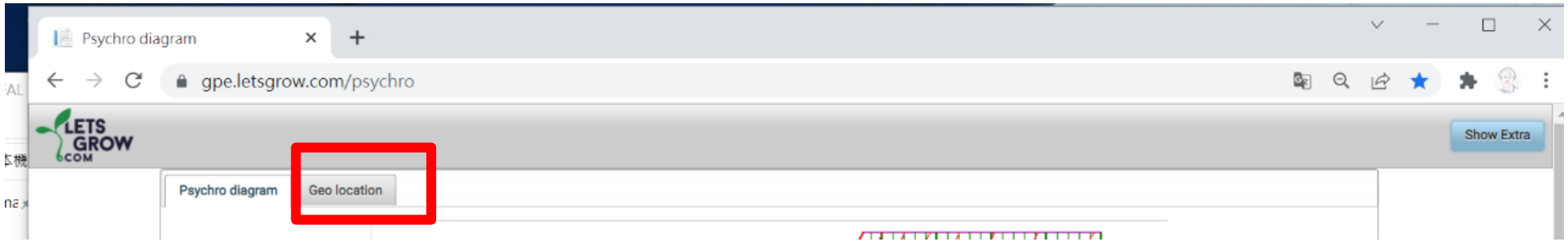


Hide Psychro diagram | More info

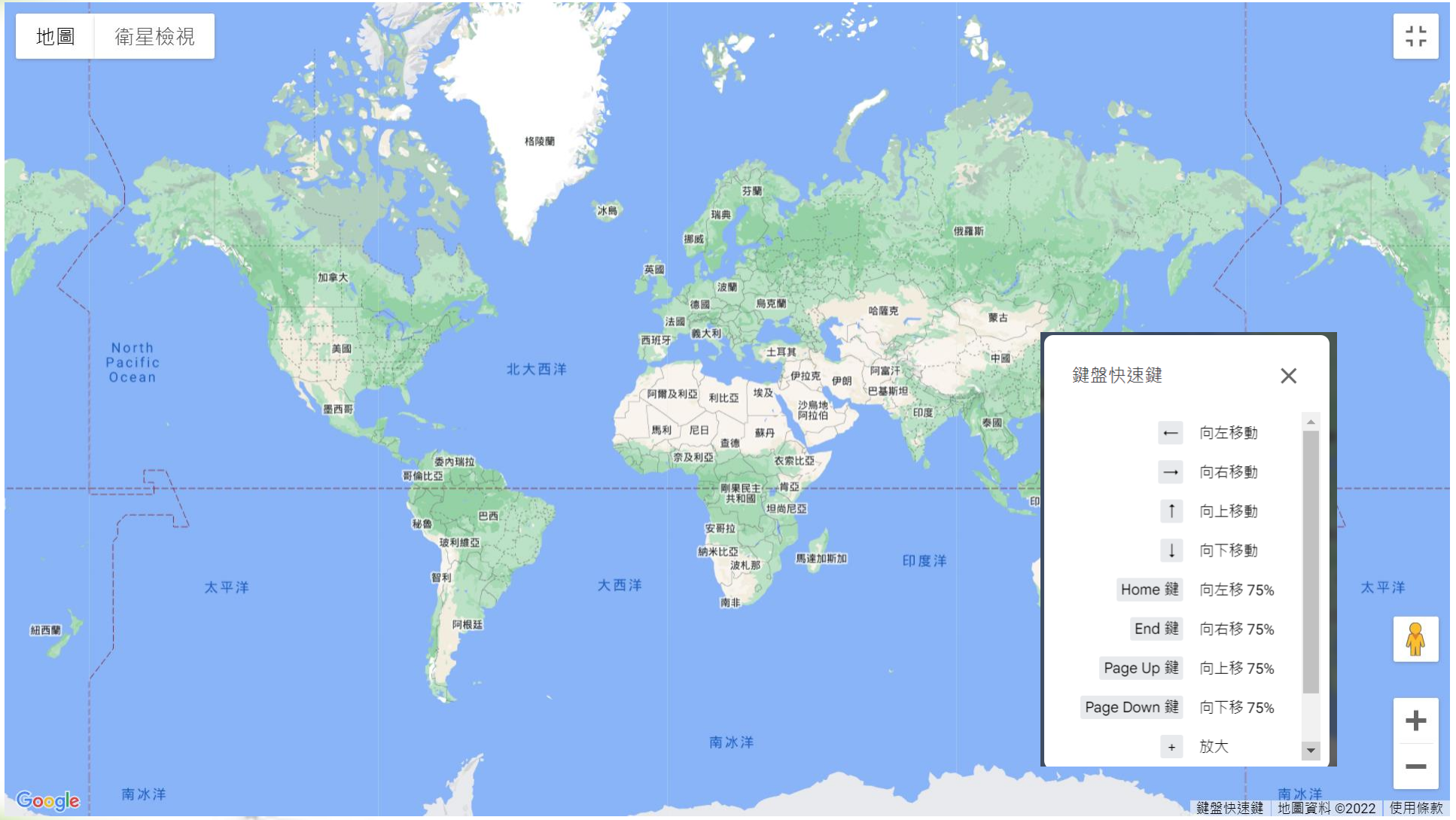
Air pressure 1013 hPa

Outside		Difference	Above screen		Difference	Inside		Difference	Plant	
Temp	25 °C	9.00	Temp	34 °C	-4.00	Temp	30 °C	0.00	Temp	30 °C
RH	80 %	-10.00	RH	70 %	-15.00	RH	55 %	45.00	RH	100 %
Absolute Humidity AH	16.03 g/kg	8.06	Absolute Humidity AH	24.10 g/kg	-9.16	Absolute Humidity AH	14.93 g/kg	12.22	Absolute Humidity AH	27.15 g/kg
Humidity Deficit HD	4.01 g/kg	6.32	Humidity Deficit HD	10.33 g/kg	1.89	Humidity Deficit HD	12.22 g/kg	-12.22	Humidity Deficit HD	0.00 g/kg
Enthalpy	65.04 kJ/kg	29.02	Enthalpy	94.05 kJ/kg	-26.77	Enthalpy	67.29 kJ/kg	30.38	Enthalpy	97.67 kJ/kg
VPD	0.63 kPa	0.96	VPD	1.60 kPa	0.31	VPD	1.91 kPa	-1.91	VPD	0.00 kPa
VP	2.53 kPa	1.19	VP	3.73 kPa	-1.39	VP	2.33 kPa	1.91	VP	4.25 kPa
VPsat	3.17 kPa	2.15	VPsat	5.32 kPa	-1.08	VPsat	4.25 kPa	0.00	VPsat	4.25 kPa
Dewpoint	21.3 °C	6.4	Dewpoint	27.8 °C	-7.8	Dewpoint	20.0 °C	10.0	Dewpoint	30.0 °C

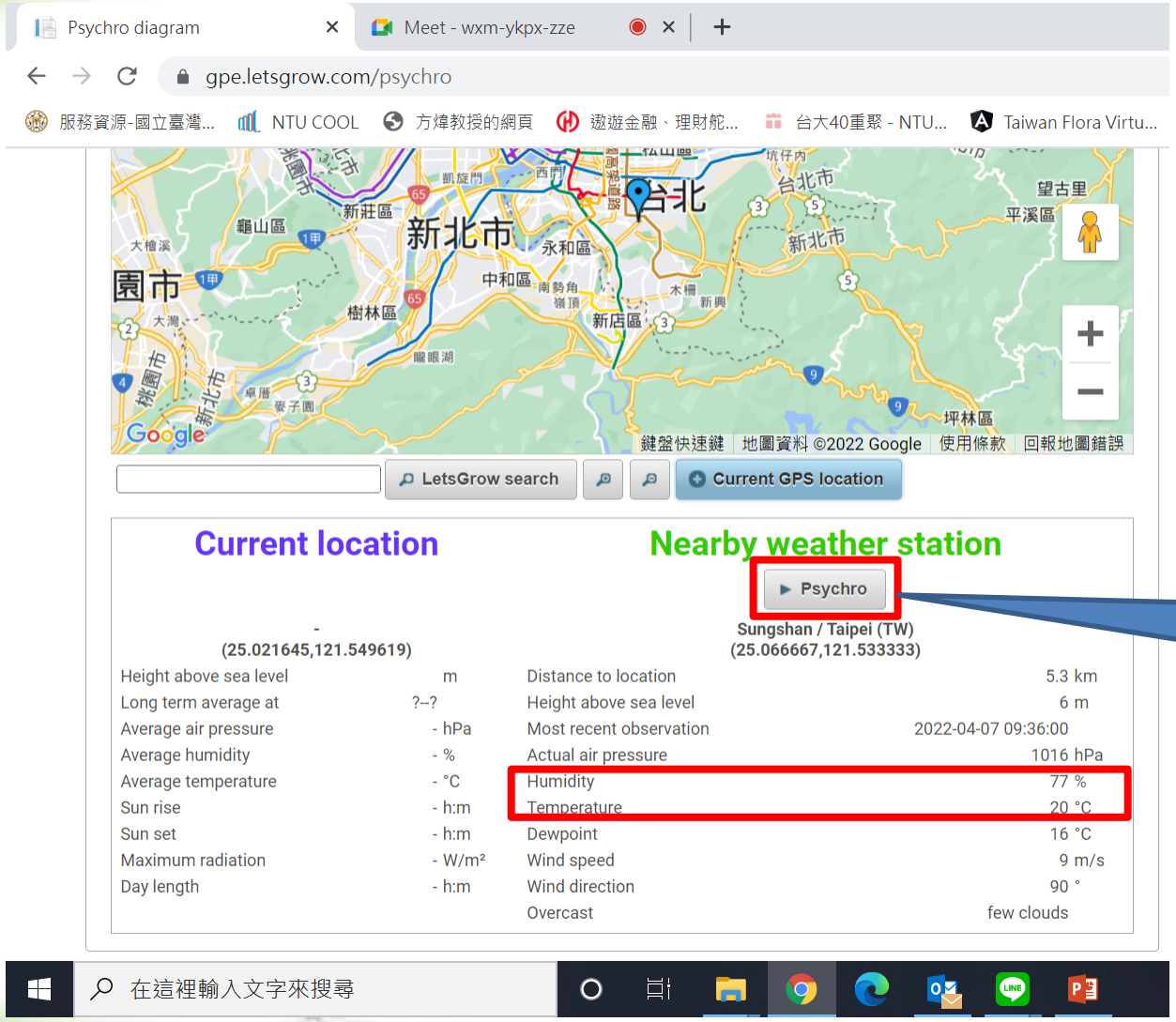
Geo location



Bring in the outdoor T and RH info from worldwide weather station into the psychrometric software


地圖
衛星檢視
格陵蘭
冰島
芬蘭
瑞典
挪威
俄羅斯
加拿大
英國
波蘭
德國
烏克蘭
哈薩克
蒙古
法國
義大利
西班牙
美國
土耳其
中國
North Pacific Ocean
北大西洋
伊拉克
伊朗
阿富汗
巴基斯坦
阿爾及利亞
利比亞
埃及
沙烏地阿拉伯
墨西哥
印度
泰國
馬利
尼日
蘇丹
查德
奈及利亞
衣索比亞
委內瑞拉
哥倫比亞
剛果民主共和國
肯亞
坦尚尼亞
巴西
秘魯
安哥拉
玻利維亞
納米比亞
馬達加斯加
智利
波札那
印度洋
太平洋
大西洋
南非
阿根廷
紐西蘭
南冰洋
鍵盤快速鍵
向左移動
向右移動
向上移動
向下移動
Home 鍵 向左移 75%
End 鍵 向右移 75%
Page Up 鍵 向上移 75%
Page Down 鍵 向下移 75%
+ 放大
Google
鍵盤快速鍵
地圖資料 ©2022
使用條款


地圖
衛星檢視
地形圖
地名
台北
桃園市
新竹市
宜蘭縣
苗栗縣
台中市
彰化縣
花蓮縣
嘉義市
玉山國家公園
台南市
台東縣
高雄市
屏東
太麻里
Google



Click on this icon can bring the weather condition to the Psychro software

Meet - wxm-ykpx-zze | Psychro diagram

gpe.letsgrow.com/psychro

服務資源-國立臺灣... | NTU COOL | 方煒教授的網頁 | 遨遊金融、理財舵... | 台大40重聚 - NTU... | Taiwan Flora Virt

LetsGrow search | Current GPS location

Current location

-
(51.915473,4.339428)

Height above sea level	m	
Long term average at	?--?	
Average air pressure	- hPa	
Average humidity	- %	
Average temperature	- °C	
Sun rise	- h:m	
Sun set	- h:m	
Maximum radiation	- W/m²	
Day length	- h:m	

Nearby weather station

Psychro

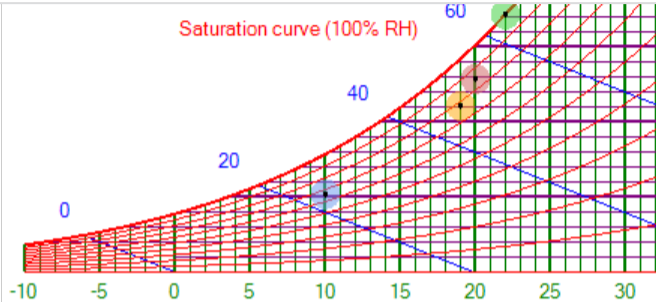
Rotterdam Airport Zestienhoven (NL)
(51.950000,4.450000)

Distance to location	8.5 km
Height above sea level	-5 m
Most recent observation	2022-04-07 09:55:00
Actual air pressure	982 hPa
Humidity	66 %
Temperature	10 °C
Dewpoint	4 °C
Wind speed	24 m/s
Wind direction	250 °
Overcast	scattered clouds

Meet - wxm-ykpx-zze | Psychro diagram

gpe.letsgrow.com/psychro

服務資源-國立臺灣... | NTU COOL | 方煒教授的網頁 | 遨遊金融、理財舵... | 台大40重聚 - NTU...



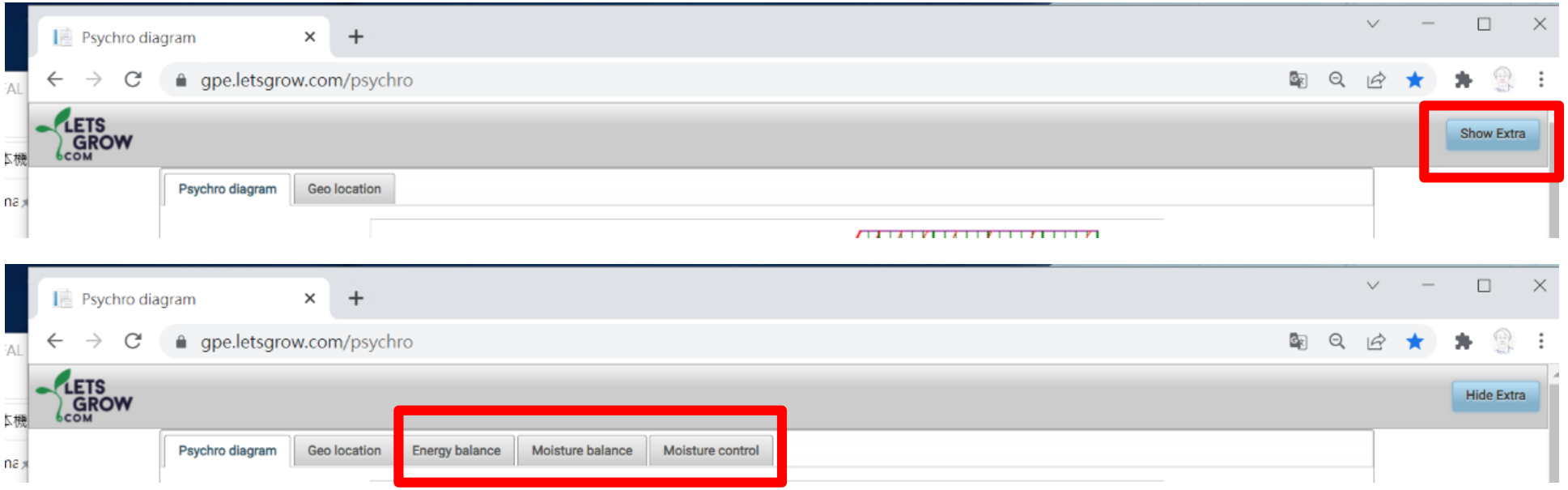
Hide Psychro diagram | More info

Outside		Difference	Above screen		Difference		
Temp	10 °C	9.00	Temp	19 °C	1.00	Temp	
RH	66 %	12.00	RH	78 %	7.00	RH	
Absolute Humidity AH	5.19 g/kg	5.89	Absolute Humidity AH	11.08 g/kg	1.79	Absolut	
Humidity Deficit HD	2.67 g/kg	0.45	Humidity Deficit HD	3.13 g/kg	-0.85	Humidit	
Enthalpy	23.00 kJ/kg	23.71	Enthalpy	46.71 kJ/kg	5.46	Enthalpy	
VPD	0.42 kPa	0.07	VPD	0.48 kPa	-0.13	VPD	
VP	0.81 kPa	0.90	VP	1.71 kPa	0.27	VP	
VPsat	1.23 kPa	0.97	VPsat	2.20 kPa	0.14	VPsat	
Dewpoint	3.9 °C	11.1	Dewpoint	15.1 °C	2.3	Dewpoi	

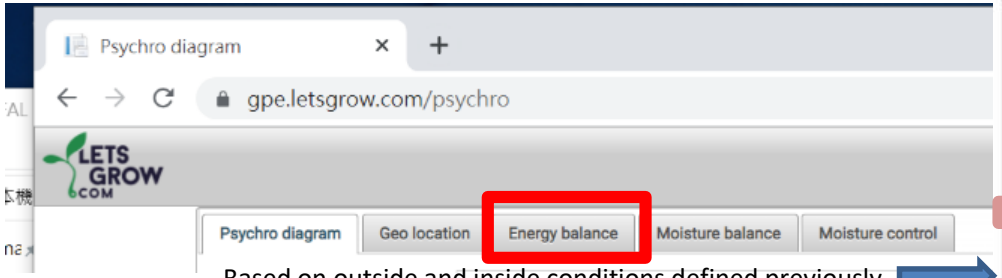
在這裡輸入文字來搜尋

在這裡輸入文字來搜尋

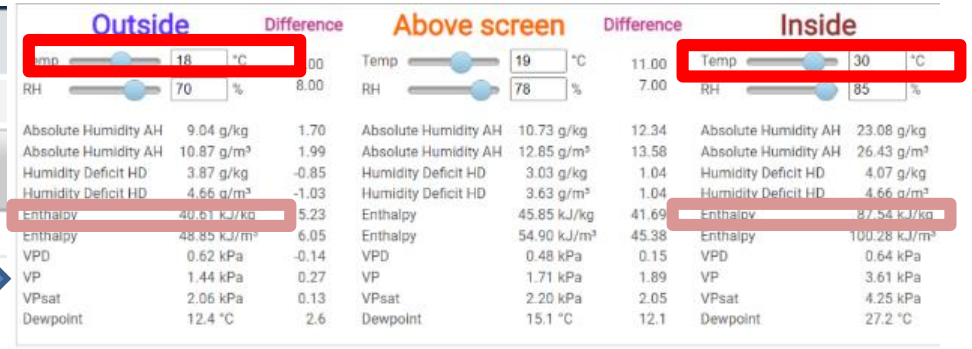
Three Extra Analysis

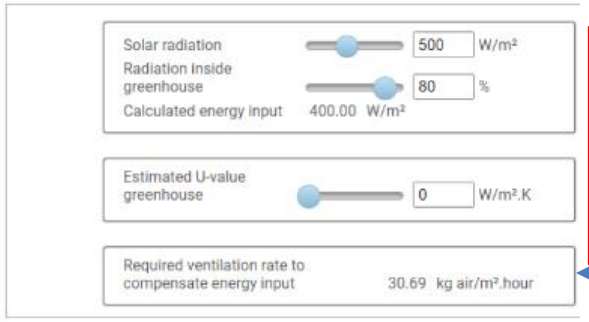


Energy Balance

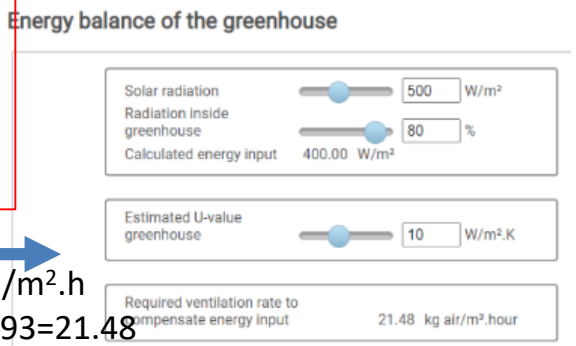


Based on outside and inside conditions defined previously



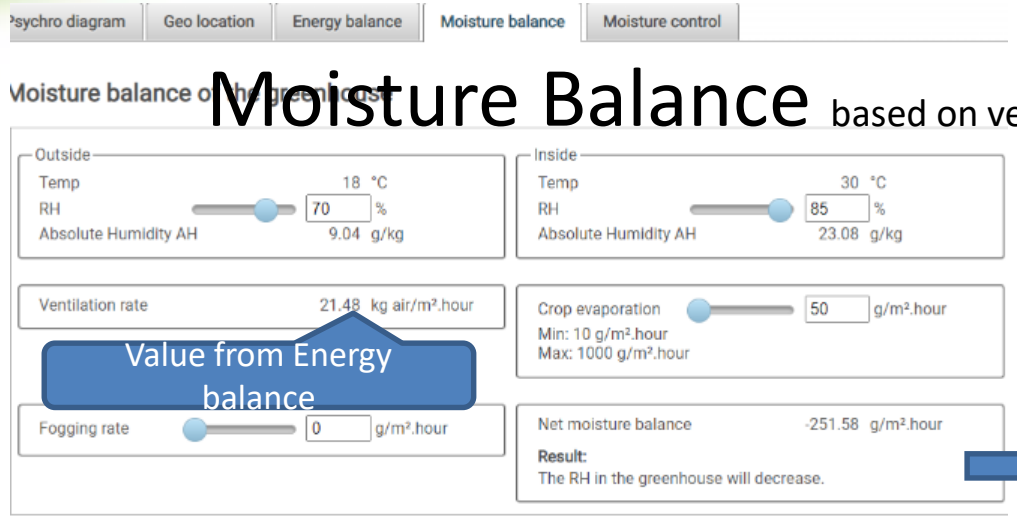


ExtraHeat = (Radiation*Transmittance) – (U*dT)
=[500*0.8 - **0*(30-18)**]*3600/1000 kJ/m^2.h
ΔEnthalpy=**87.54-40.61=46.93** kJ/kg
Ventilation=ExtraHeat/ΔEnthalpy
=400*3.6/46.93=30.69 kg/m^2.h



ExtraHeat=[500*0.8 - **10*(30-18)**]*3600/1000 kJ/m^2.h
Ventilation=ExtraHeat/ΔEnthalpy=(400-**120**)/46.93=21.48

Moisture Balance based on ventilation rate derived from energy balance



AH_{dif} = 23.08 - 9.04 = 14.04 g/kg air

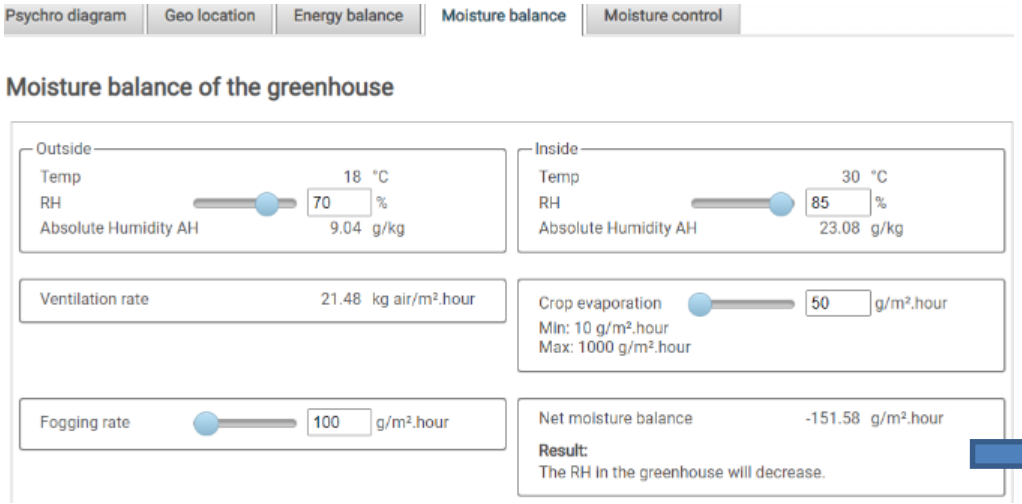
Moisture removed @given ventilation rate

= 21.48 * 14.04 = 301.58 g/m^2.h

Net moisture balance =

Moisture removed – Crop evaporation – fogging rate

= 301.58 – 50 - 0 = 251.58 g/ m^2.h

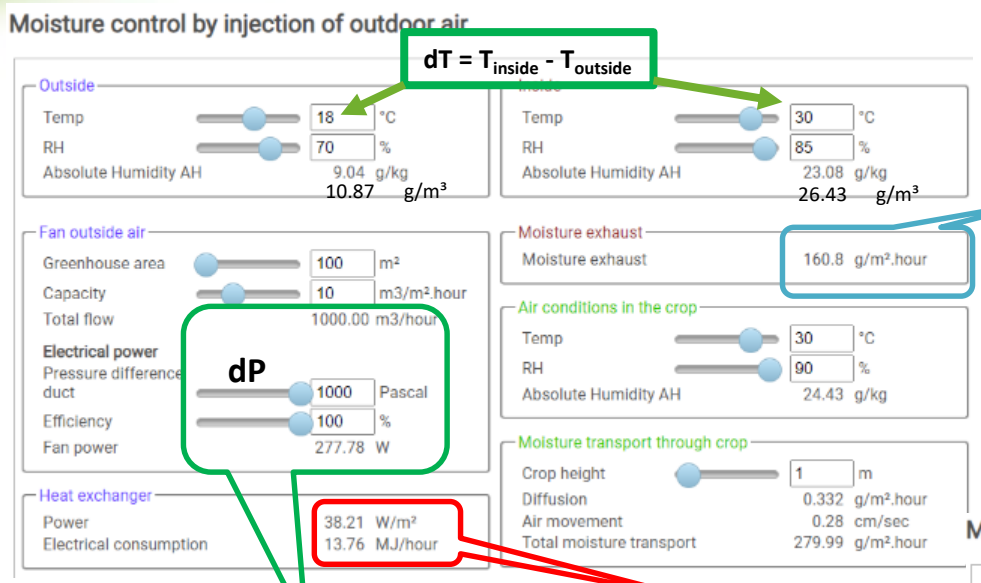


Net moisture balance =

Moisture removed – Crop evaporation – fogging rate

= 301.58 – 50 - 100 = 151.58 g/ m^2.h

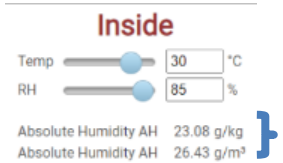
Moisture Control



$dT = T_{inside} - T_{outside}$

Moisture exhaust= Fan capacity x AH_{dif} (g/m^3)
= 10 $m^3/m^2.h$ * (26.43 – 10.87) g/m^3 = 155.6 $g/m^2.h$

Moisture exhaust= Fan capacity x AH_{dif} (g/kg) x $density_{insideAir}$
= 10 $m^3/m^2.h$ x (23.08 – 9.04) g/kg x (26.43/23.08) kg/m^3 = 160.778 $g/m^2.h$



Air density
= (26.43/23.08) = 1.1451473

Fan power = dP x (total flow/3600) / Efficiency
= 1000 x (1000/3600) /1 = 277.78 W

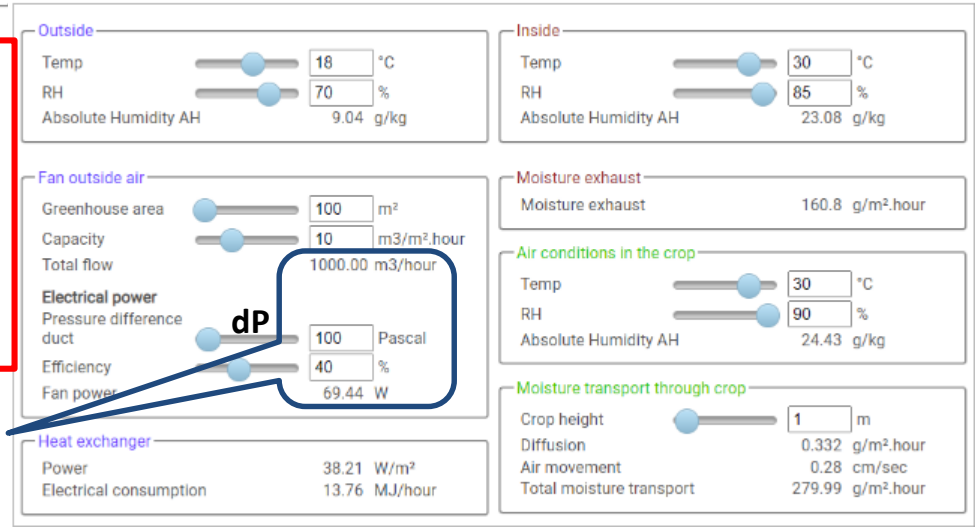
Heat Exchanger (HX) Power = f(dT, fan capacity)
If dT or fan capacity = 0, HXPower=0

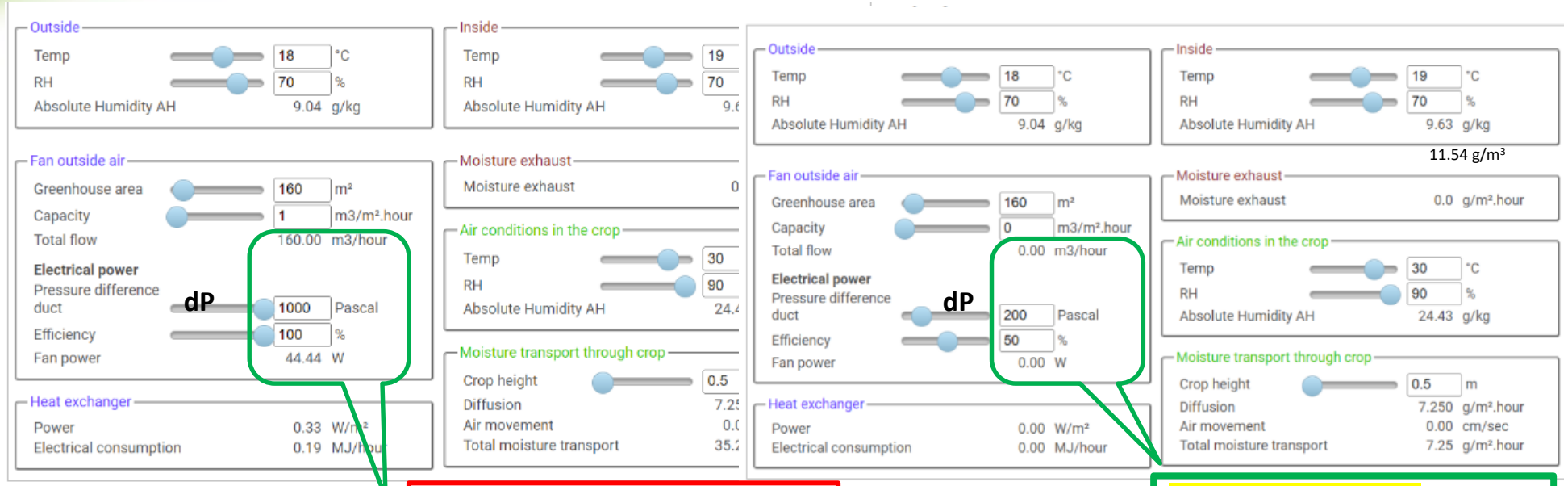
$HXPower=Cp*dT*(capacity/3.60)*density_{in}$
= 1.001 * 12 * 10 /3.6* (26.43/23.08)
= 38.2 W/m^2

Elec. Consumption = HXPower *GHarea
= 38.21*100 = 3821 W
= $3821*3600/10^6$ MJ/h
= 3.821*3.6 = 13.7556 MJ/h

Fan power = = 100 x (1000/3600) /0.4 = 69.444 W

Moisture control by injection of outdoor air





Fan power = dP x (Total flow/3600)/ Efficiency

= 1000 x (160/3600) /1 = 44.44 W

HXPower = Cp * dT * capacity/3.6 * density

= 1.001 * 1 * 1/3.6 * (11.54/9.63) = 0.333 W/m²

Elec.Consumption = HXPower *Gharea * 3.6/1000

= 0.3184*160 = 50.944 W= 50.944*3600/10^6

= 0.18336 MJ/h

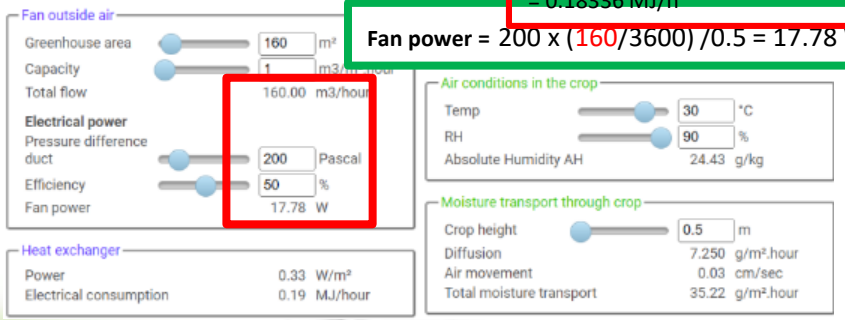
Total flow = Capacity * GH area

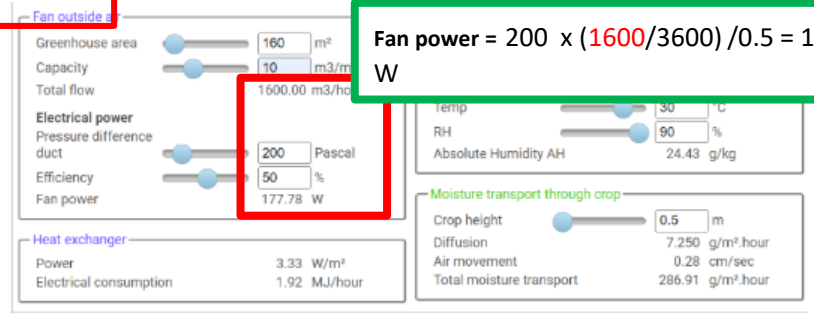
Fan power = dP x (Total flow/3600)/ Efficiency

= 1000 x (0/3600) /1 = 0 W

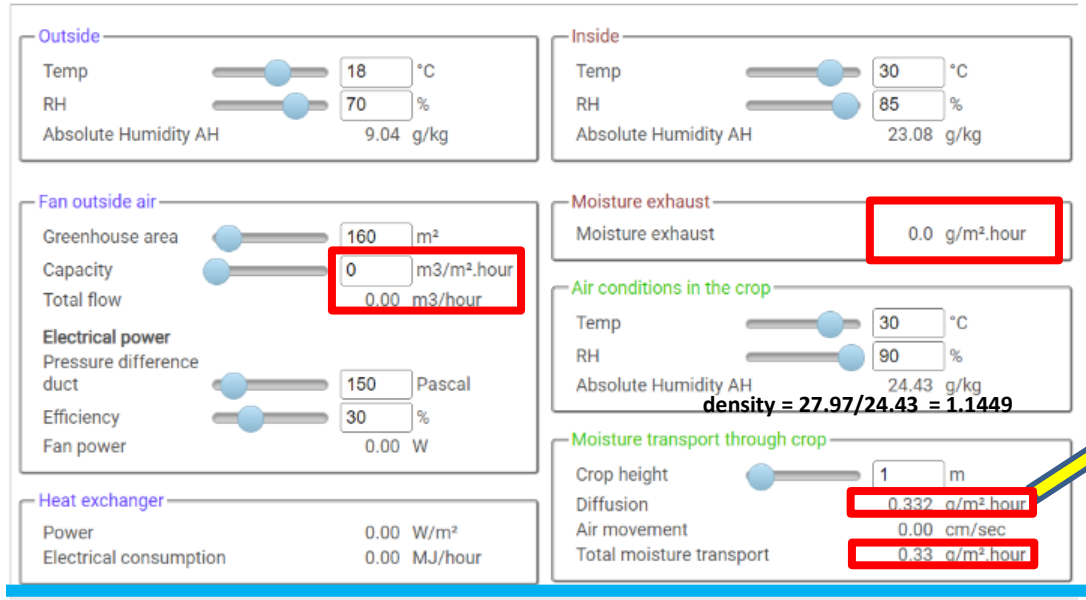
Fan power = 200 x (160/3600) /0.5 = 17.78 W

Fan power = 200 x (1600/3600) /0.5 = 177.78 W





Moisture control by injection of outdoor air



When fan capacity = 0 $m^3/m^2.h$,
There is no air exchange between in & outdoor,
thus, Moisture exhaust = 0

However, there still exist AH difference between indoor and micro-climate around crop

AH_{dif} = 24.43 – 23.08 = 1.35 g/kg

When Crop height =1 m, Air volume around crop per unit area (1 m^2) = 1 m^3

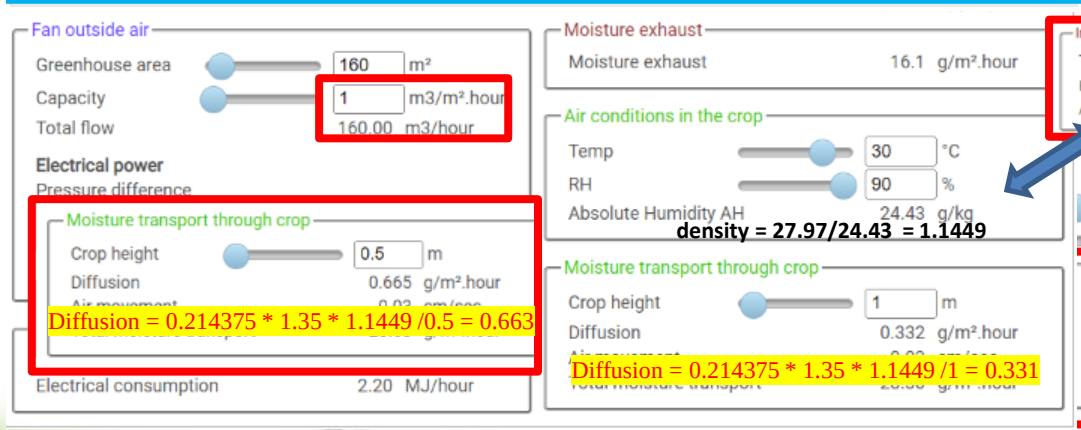
An empirical equation to derive Diffusion:

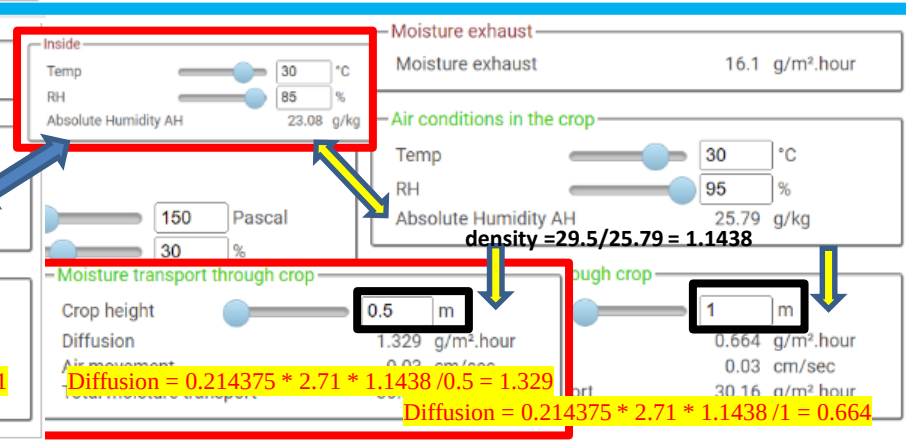
Diffusion = 0.214375 * AH_{dif} * density /crop height

= 0.214375* 1.35 * 1.1449 /1 = 0.331 $g/m^2.h$

Fan capacity = 0, air movement through crop = 0 cm/s

Total moisture transport (TMT) = Diffuse





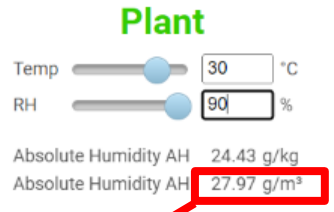
Air movement = f(fan capacity)

Total moisture transport (TmT)

= $moistureTransport_{fan}$ + $moistureTransport_{diffuse}$

= Fan capacity * AH + Diffusion

in $m^3/m^2.h$ * g/m^3 + $g/m^2.h$



1 $m^3/m^2.h$ = 100 cm/3600 s = air movement 0.0277 cm/s

TmT = 1 * 27.9658 + 0.332 = 28.2978 ≈ 28.30 $g/m^2.h$

10 $m^3/m^2.h$ = 10 * 100/3600 = 1/3.6 = 0.2777 cm/s

TmT = 10 * 27.9658 + 0.332 = 279.99 $g/m^2.h$

30 $m^3/m^2.h$ = 30 * 100/3600 = 0.8333 cm/s

TmT = 30 * 27.9658 + 0.332 = 839.306 ≈ 839.31 $g/m^2.h$