CVG3120-FALL 2015 – Assignment 3

Problem One:

If the measured atmospheric pressure is 1013 mb, and the wet bulb temperature is 15^{o}C, and the calculated temperature is 22^{o}C, find the absolute and relative humidity, actual vapour pressure, vapour pressure deficit and also the dew point temperature.

Solution One:

Problem One
Assignment 3

$P_a = 1013$ mb

$T_{wb} = 15$ °C

$T = 22$ °C

$$e_s = 2.7489 \times 10^8 \exp\left(-\frac{4278.6}{T + 242.79}\right)$$

$$e_s = 2.7489 \times 10^8 \exp\left(-\frac{4278.6}{22 + 242.79}\right) = 26.40 \text{ mb}$$

$$\boxed{e_s = 26.40 \text{ mb}}$$

$$H_v = 597.3 - 0.564\,T_a = 597.3 - 0.564(22) = 584.89 \text{ cal/g}$$

$$\boxed{H_v = 584.89 \text{ cal/g}}$$

$$e = e_s - \frac{P_a C_p}{0.622 H_v}(T_a - T_w) = 26.40 - \frac{1013 \times 0.2396}{0.622 \times 584.89}(22 - 15)$$

$$\boxed{e = 21.827 \text{ mb}}$$

$$R_h = \frac{e}{e_s} = \frac{21.827}{26.40} = 0.8267 \cong 82.67\% \Rightarrow \boxed{R_h = 82.67\%}$$

$$\rho_v = 0.622 \frac{e}{RT} = 0.622 \times \frac{21.827}{2.8704 \times 10^3 \times (273 + 22)} = 1.603 \times 10^{-5} \text{ g/cm}$$

$$\boxed{\rho_v = 1.603 \times 10^{-5} \text{ g}}$$

$$\text{Vapour Pressure Deficit} = \frac{e_s - e}{e_s} = \frac{26.40 - 21.827}{26.4} = 17.32\%$$

$$T - T_d = (14.55 + 0.114T)(1 - R_h) + [(2.5 + 0.007T)(1 - R_h)]^3 + (15.9 + 0.117T)(1 - R_h)^{14}$$

$$(14.55 + 0.114 \times (22))(1 - 0.8267) + [(2.5 + 0.007(22))(1 - 0.8267)]^3 + (15.9 + 0.117 \times 22)(1 - 0.8267)^{14}$$

Problem Two:

From the following table, use the necessary information to calculate the daily evaporation rate (mm/day) during June to September in the area A (Latitude: 20) using the Penman Equation.

Temperature (C)		**Pressure (mb)**		**Wind velocity (km/hr)**		**Constant**	
Actual temperature	19.5	Total atmospheric pressure	1013	At 2-m height	10	Slope of the saturation vapor curve (mmHg/C)	0.485
Wet bulb temperature	14	Vapour pressure deficit	10	At 4-m height	15	Psychrometric constant	0.485
Dew point temperature	17			At 8-m height	18	Specific heat capacity of air at constant pressure $[{cal}/{g\ °C}]$	0.2396
						Number of hours of sunshine	14.5
						Maximum number of hours of sunshine	20
						Albedo	0.15
						Boltzman constant	11.71×10^{-8}
						Pan coefficient	0.25

Table 1: Values of Short-Wave radiation flux I_0, at the outer Limit of the Atmosphere in Calories per cm^2 per day, as a Function of the month of the Year and the Latitude

Latitude'	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
N 90	0	0	55	518	903	1,077	944	605	136	0	0	0	3,540
80	0	3	143	518	875	1,060	930	600	219	17	0	0	3,660
60	86	234	424	687	866	983	892	714	494	258	113	55	4,850
40	358	538	663	847	930	1,001	941	843	719	528	397	318	6,750
20	631	795	821	914	912	947	912	887	856	740	666	599	8,070
0	844	963	878	876	803	803	792	820	891	866	873	829	8,540

(Note* To convert unit from cal/g to cal/cm3 using the average density of water 1g/cm3)

Solution Two:

a) **The Penman Equation:** $E = \frac{\Delta}{\Delta + \alpha} H + \frac{\alpha}{\Delta + \alpha} E_a$

$E_a[mm/day] = 0.35\ (e_s - e)(0.2 + 0.55V)$

$e_s\ of\ 19.5\ C\ = \sim \mathbf{17}\ [mm\ hg]\ (from\ the\ table) = \ (17 * 1.36) = \mathbf{23.12}\ [mb]$

$e\ [mb] = \ e_s - \frac{P_a\ C_p}{0.622 H_v}\ (T_a - \ T_w)$

$H_v\left[{}^{cal}/_{g}\right] = 597.3 - 0.564\ (T_a) = 597.3 - 0.564\ (19.5) = \mathbf{586.3}$

$e[mb] = 23.12\ [mb] - \frac{1013\ [mb] x\ 0.2396 \left[{}^{cal}/_{g\ °C}\right]}{0.622\ x\ 586.3[{}^{cal}/_{g}]}\ (19.5 - 14) = \mathbf{19.46}\ [mb]$, $=$ $\mathbf{14.32}\ [mm\ hg]$

$V\ \left[\frac{m}{s}\right] = 10\left[{}^{km}/_{hr}\right] * \frac{1000\ m}{3600\ s}\ = \ \mathbf{2.78}$

$E_a\ \left[\frac{mm}{day}\right] = 0.35\ (e_s - e)(0.2 + 0.55V)\ = \ 0.35\ (17 - 14.32)(0.2 + 0.55(2.78))$
$= \mathbf{1.622}\ [{}^{mm}/_{day}]$

$H\ \left[{}^{cal}/_{cm^2\ day}\right] = R_s\ \left[{}^{cal}/_{cm^2\ day}\right]\ (1 - r) - \ R_L\ \left[{}^{cal}/_{cm^2\ day}\right]$

$R_s\ \left[{}^{cal}/_{cm^2\ day}\right]\ = \ \left(0.18 + 0.55\ \frac{n}{N}\right)\ I_0\ \left[{}^{cal}/_{cm^2\ day}\right]$

$I_0\ \left[{}^{cal}/_{cm^2\ day}\right] = \ \frac{947+912+887+856}{4}\ = \mathbf{900.5}$

$R_s\ \left[{}^{cal}/_{cm^2\ day}\right]\ = \ \left(0.18 + 0.55\ \frac{14.5}{20}\right)\ 900.5\ \left[{}^{cal}/_{cm^2\ day}\right] = \mathbf{521.16}$

$R_L\ \left[{}^{cal}/_{cm^2\ day}\right] = \ \sigma\ (T + 273)^4\ (0.47 - 0.077\ (e_s)^{0.5})\ (0.2 + 0.8\ \frac{n}{N})$

$R_L\ \left[{}^{cal}/_{cm^2\ day}\right] = 11.71 x 10^{-8}\ (19.5 + 273)^4\ (0.47 - 0.077\ (17)^{0.5})\ \left(0.2 + 0.8\ \frac{14.5}{20}\right) = \mathbf{101.97}$

$H\ \left[{}^{cal}/_{cm^2\ day}\right] = 521.16\ \left[{}^{cal}/_{cm^2\ day}\right]\ (1 - 0.15) - \ 101.97\ \left[{}^{cal}/_{cm^2\ day}\right] = \mathbf{341.02}$

$H\ [mm.day] = \frac{H\ \left[{}^{cal}/_{cm^2\ day}\right]}{H_v\ [{}^{cal}/_{cm^3}]}$

$H_v\ \left[{}^{cal}/_{g}\right] = 586.3\ \left[{}^{cal}/_{g}\right] \text{x}\ 1\ \left[{}^{g}/_{cm^3}\right] = \mathbf{586.3}\ [{}^{\mathbf{cal}}/_{\mathbf{cm^3}}]$

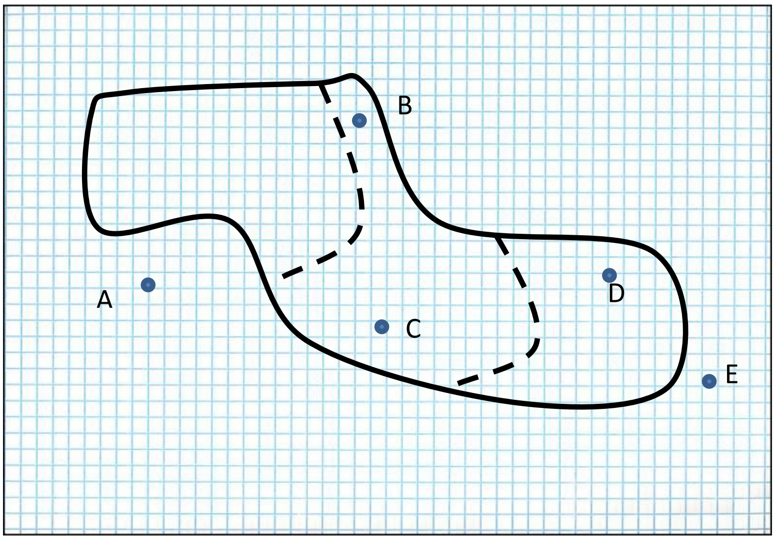
$$H\ [mm/day] = \frac{341.02\left[{}^{cal}/_{cm^2\ day}\right]}{586.3\ [{}^{cal}/_{cm^3}]} = 0.58\ cm = \mathbf{5.8\ mm/day}$$

Finally,

$$E = \frac{\Delta}{\Delta + \alpha} H + \frac{\alpha}{\Delta + \alpha} E_a = \frac{0.485}{0.485 + 0.485} 5.8 \left[\frac{mm}{day}\right] + \frac{0.485}{0.485 + 0.485} (1.622) \left[\frac{mm}{day}\right]$$
$$= \mathbf{3.66\ mm/day}$$

Problem Three:

Point rainfalls due to a storm at several rain-gauge stations in a basin are shown in figure determine the mean areal depth of rainfall over the basin using Thiessen polygons and isohyetal methods.



Area of each box= 25 Km^2

Gage	Catch (in.)
A	0.7
B	1.2
C	1.3
D	1.6
E	2.1

Solution Three:

For the Thiessen Polygons

	P (in)	***Area (Km2)***	***P*Area***	***Wi***	
A	0.7	2025	1417.5	0.176087	0.123261
B	1.2	2825	3390	0.245652	0.294783
C	1.3	3425	4452.5	0.297826	0.387174
D	1.6	2500	4000	0.217391	0.347826
E	2.1	725	1522.5	0.063043	0.132391
Average	1.38	11500			1.285435
Sum	6.9	11500			

For the isohyetal Method

No.	***Isohyetal***	**Area**	**Ai/A**	
1	0.7	2050	0.17672414	0.123707
2	0.9	1625	0.14008621	0.126078
3	1.1	1625	0.14008621	0.154095
4	1.3	2825	0.24353448	0.316595
5	1.5	2050	0.17672414	0.265086
6	1.85	1425	0.12284483	0.227263
Sum		11600		1.212823

Problem Four:

In order to prepare hydrological report of a dam construction project in a location which the precipitation measurements are missing, measurements of four different gauges close the the location and also the distance of these gauges to construction location are presented in following table, calculate the missing precipitation using “inverse distance method” and normal ratio method, and explain which one is more accurate.

Quadrant	**Precipitation (in)**	**Distance (mi.)**
I	**2.9**	**12.7**
II	**1.4**	**6.3**
III	**2.1**	**8.7**
IV	**2.9**	**20.1**

Solution Four:

1. **Using the inverse distance method**

$$P_x = \sum_{i=1}^{m} P_i * \left(\frac{1/D_i^2}{\sum_{i=1}^{m} 1/D_i^2} \right)$$

$$\sum_{i=1}^{m} 1/D_i^2 = \sum_{i=1}^{4} 1/D_i^2 = \frac{1}{12.7^2} + \frac{1}{6.3^2} + \frac{1}{8.7^2} + \frac{1}{20.1^2} = 0.047082$$

$$P_x = \sum_{i=1}^{m} P_i * \left(\frac{1/D_i^2}{\sum_{i=1}^{m} 1/D_i^2} \right)$$

$$= 2.9 \left(\frac{\frac{1}{12.7^2}}{0.047082} \right) + 1.4 \left(\frac{\frac{1}{6.3^2}}{0.047082} \right) + 2.1 \left(\frac{\frac{1}{8.7^2}}{0.047082} \right) + 2.9 \left(\frac{\frac{1}{20.1^2}}{0.047082} \right)$$

= **1.87 inches**

2. **Using the normal ratio method**

In this problem, normal precipitation for all stations is considered as their monthly precipitation and for the normal precipitation of the target station; the arithmetic average will be considered as the Normal precipitation for the target station.

$$P_x = \sum_{i=1}^{m} P_i * \left(\frac{1}{m} \right) = \frac{1}{4} (2.9 + 1.4 + 2.1 + 2.9) = \mathbf{2.325} \, \boldsymbol{inches}$$

$$P_x = \sum_{i=1}^{m} P_i * \left(\frac{N_x}{mN_i} \right) = 2.9 \left(\frac{2.325}{4 \times 2.9} \right) + 1.4 \left(\frac{2.325}{4 \times 1.4} \right) + 2.1 \left(\frac{2.325}{4 \times 2.1} \right) + 2.9 \left(\frac{2.325}{4 \times 2.9} \right)$$
$$= 2.235$$

This Result shows that for locations with lower precipitation, the normal ratio method would be equal to the arithmetic average method.

The estimate made from the quadrant method is most likely the more accurate method because it gives more weight to the gauges closer to the location of the estimate.