CE EN 431
Engineering Hydrology
Winter 1994
Section 1

Lab Problem no. 1: Humidity and Radiation

Submitted to:
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by
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Contents

Objectives/Procedure

For the objectives and procedure, I have included the lab handout. You can find the lab handout in the appendix.

Sample Calculations

To make my calculations, I used the following equations:

Part 1:

(b) $T_{avg} = \frac{T_{\max} + T_{\min}}{2}$

Part 2:

(a) Table A-16

(b) $e = f \times E$

(c) $r_v = \frac{0.622 \times e}{R_g \times T_a}$

(d) $r_d = \frac{p_d}{R_g \times T_a}$

(e) $r = \frac{r_v}{r_d}$

(f) $q_h = \frac{r}{1 + r}$

(g) $\Delta T = T_a - T_w$

(h) $T_w = T_a - \Delta T$

(i)Table A-16

Part 3:

(a) $L_{up} = s e_{surf} T_{surf}{}^{4}$

(b) $L_{0down} = s e_{atm} T_{atm}{}^{4}$ and $L_{down} = L_{up} - \left(L_{up} - L_{0down}\right)\left(0.2 + 0.8\left(\frac{n}{N}\right)\right)$

(c) $K_{down} = K_0\left(0.2 + 0.5\left(\frac{n}{N}\right)\right)$

(d) $K_{down} = aK_{down}$

(e) $Q_{net} = K_{down} - K_{up} + L_{down} - L_{up}$

where:

T_{max}= The maximum temperature during the day.
T_{min}= The minimum temperature during the day.
T_{avg}= The average temperature during the day.
e= Partial water vapor pressure.
E= Saturation vapor pressure.
f= Relative humidity.
ρ_v= Water vapor density (absolute humidity).
R_g= The ideal gas constant.
T_a= The temperature of the air.
ρ_d= Dry density of air.
p_d= Atmospheric pressure.
r= The mixing ratio.
q_h= The specific humidity.
T_w= The wet bulb temperature.
ΔT = Wet bulb depression.
L= Long-Wave (terrestrial) radiation.
σ= $5.67 \times 10^{-8} \frac{W}{m^2 - K^4}$.
ε= The emissivity of the atmosphere = $0.53 + 0.067 \times \sqrt{e}$.
K= Short-Wave (solar) radiation.
$\frac{n}{N}$ = Fraction of cloud cover.
and α= The albedo (fraction of solar radiation reflected).

Tables and Figures

Table 1: A comparison of my calculated humidity and radiation values with Matt Staten's values.

Parameters	*My Values (November, 1981)*	*Matt's Values (June, 1980)*
Part one: Data		
Air temperature (F)	44.3	---------------------------------
Air temperature (C)	6.833	---------------------------------
Surface temperature (F)	44.45	---------------------------------
Surface temperature (C)	6.08	---------------------------------
Relative humidity (%)	60	34
Percent of possible sunshine (%)	46	---------------------------------

Parameters	*My Values (November, 1981)*	*Matt's Values (June, 1980)*
Part two: Atmospheric Parameters		
Saturation vapor pressure (mbar)	10.1	25.03
Actual vapor pressure (mbar)	6.06	8.51
Water vapor density (g/m^3)	4.69	6.27
Dry air density (g/m^3)	1261	1199
Mixing ratio (g/kg)	3.72	5.23
Specific humidity (g/kg)	3.71	5.20
Wet bulb depression (C)	3	9
Wet bulb temperature (C)	3.83	12.1
Dewpoint temperature (C)	0	---------------------------------
Part three: Radiation Parameters		
Long wave surface emittance (W/m^2)	337.8	416.61
Long wave incident radiation (W/m^2)	283.5	330.04
Short wave irradiance (W/m^2)	150	200.48
Short wave reflected radiation (W/m^2)	30.0	40.097
Net total radiation (W/m^2)	65.7	246.95
Part four: Stuve Diagram		
LCL_{up} (mbar)	915	---------------------------------
LCL_{down} (mbar)	700	---------------------------------
Air temperature at 1000 mbar on lee side (C)	32	---------------------------------
Initial dewpoint temperature (C) at 1000 mbar	14	---------------------------------
Final dewpoint temperature (C) at 1000 mbar	6.5	---------------------------------
Wet bulb temperature (C) at 1000 mbar	17	---------------------------------

Results/Discussion

As you can see, the results are located in table one above. In general, my results seem reasonable when compared with data from June of 1980.

Data. The data was extremely useful. It was the basis of all my calculations. In calculating the average monthly soil temperature, I averaged the Fahrenheit and Celsius values from the month, instead of converting the averages Fahrenheit value to Celsius.

Atmospheric parameters. Comparing Matt's values with mine, you can see that there was a greater density of water vapor in the air during the summer. But because of the high saturation vapor pressure during June, the relative humidity during the month of June was significantly lower than in November (34% vs. 60%).

Radiation parameters. During the month of June, there was much more radiation than in November. The net total radiation in June was 246.95 W/m^2, while in November, the net total was only 65.7 W/m^2. The difference between the net total radiation values is because higher temperatures yield higher radiation values ($L = seT^4$).

Stuve diagram values. The values from using the Stuve diagram are also located in table one. As the air rises, the air pressure decreases. The air cools and condenses. Eventually, precipitation occurs. The lifting condensation level (up) is the point at which condensation and precipitation develop. 4 g/kg of water vapor was lost from the air in the lab. Then, as the air reached its maximum height, it fell at the dry-adiabatic lapse rate. The temperature of the air increased at the dry lapse rate until the air reached 1000 mbar once again.

Conclusions/Applications

Atmospheric parameters. The atmospheric parameters such as dewpoint temperature, relative humidity, water vapor density, and the mixing ratio are extremely useful. You can use this information to predict future values and to forecast when precipitation will happen.

Radiation parameters. Higher temperatures yield higher radiation values, according to the equation $L = seT^4$. Thus, a solar panel will be much more effective in the summer than in the winter.

Stuve diagram values. The Stuve diagram is important and useful. If you have the necessary weather information, you can use the Stuve diagram to find out at what altitude condensation and precipitation will occur. Also, you can determine the amount of precipitation that will occur. Finally, you can determine the temperature on the other side of the rising air and the chance of precipitation on the other side. Thus, the Stuve diagram is a powerful tool for predicting weather patterns.

<u>**Appendix**</u>

Appendix A: References

- Staten, Matt. "Lab No. 1: Humidity and Radiation". A student laboratory for CE EN 431, BYU.
- National Oceanic and Atmospheric Administration (NOAA). **Climatological Data: Utah, November 1981**. Volume 83, Number 11. Printed by the climactic center at Asheville, NC. (can be found in the C55 microfiche files in the library).

The lab handout and my calculations are located on the following pages.

Appendix B: Lab Handout

Appendix C: Calculations