CEE 6400 HW # 1

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1 i $I = 0.00042\,H + 0.00026\,H \cdot P$

$\Rightarrow 0.00042 \times (mm) \Rightarrow \left(0.00026 \times \frac{1}{mm}\right) \times mm \times mm$

$\Rightarrow 0.00042 \times \left(\frac{1}{25.4}\right) in \Rightarrow 0.0026 \times \frac{1 \times \cancel{25.4}}{1 \times 1} \times \frac{1}{\cancel{25.4}}\, in \times \frac{1}{25}$

$\Rightarrow 0.000016\,H + 0.00010\,HP$

ii $B = 0.00061 \cdot p \cdot \left(\frac{T_s - T_a}{e_s - e_a}\right)$

$\Rightarrow [1] = \left(0.00061 \cdot \frac{1}{mb\,(^\circ C)}\right) mm \cdot \frac{(^\circ C)}{mb}$

$\Rightarrow 0.00061 \cdot \frac{(\cancel{1}25.4)\,P_{inHg} \cdot (32 + 1 \times 1.8)^\circ F}{1 \cdot P_{inHg} \cdot (32 + (T_c \times 1.8))^\circ F \left(1/33.8639\right) P_{inHg}}$

P_{mb}

P_{mmHg}

$^\circ C$

$32 + (T_c \times$

$\Rightarrow 0.0061 \times 1.33$

$\Rightarrow 0.0081$

$B = 0.0081\, p \left(\frac{T_s - T_a}{e_s - e_a}\right)$

iii $R_n = (0.83 \cdot K_{in}) - 54$

$$\Rightarrow \frac{cal}{cm^2 d} = 0.83 \cdot \frac{cal}{cm^2 d} - 54 \cdot \frac{cal}{cm^2 d}$$

1 cal = 4.2 J
= 4.2 Ws

$$\Rightarrow \frac{W}{m^2} = 0.83 \cdot \frac{(4.2)\,W\cancel{s}}{((10^{-2})^2)\,m^2\,(24\times60\times60)\,\cancel{s}} - 54 \cdot \frac{(4.2)\,W\cancel{s}}{(10^{-2})^2\,m^2\,(24\times60\times60)\,\cancel{s}}$$

$$\Rightarrow \frac{W}{m^2} = 0.83 \times (0.0281) - 54\,(0.028)$$

$$\Rightarrow R_n = 0.023\,K_{in} - 1.5$$

iv $$E = \frac{3.64}{T_a} \cdot \frac{u_a}{\left[\ln\left(\frac{z_m}{z_0}\right)\right]^2} \left(e_a^* - e_a\right)$$

$$\frac{cm}{d} = 3.64\times\left(\frac{K}{mb}\right) \frac{1}{K} \cdot \frac{km}{d} \cdot \frac{1}{\left(\frac{cm}{cm}\right)^2} \cdot (mb)$$

$T_K = T_c + 273$
1 KPa = 10 mb

$$\frac{mm}{s} = 3.64 \frac{(T_K - 273)\,°C}{0.1\,kPa} \times \frac{1}{(T_K - 273)\,°C} \times \frac{10^6\ mm}{24\times60\times60\ s} \quad 0.1\,kPa$$

$$E = 42.13\,\frac{u_a\,(e_a^* - e_a)}{T_a\left(\ln\left[\frac{z_m}{z_0}\right]\right)^2}$$

2 a) Avg Residence time of water in land phase = $\frac{Vol}{rate}$

$$= \frac{421 \times 10^6\ km^3}{(113 \times 10^3)\ km^3\ yr^{-1}} = 3725.7\ yr$$

b) Avg residence time of water in rivers & lakes = $\frac{Vol}{rate}$

$$= \frac{178 \times 10^3\ km^3}{40 \times 10^3\ km^3\ yr^{-1}} = 4.45\ yr$$

3 i a) Consistent

$A = 20370\ km^2$, $\mu_P = 1100\ mm/yr$, $\varepsilon_P = 11\%$, $\mu_Q = 386\ m^3/s$, $\varepsilon_Q = 5\%$

$\mu_{ET} = \mu_P - \mu_Q$

$\mu_P = 1100\ mm/yr$

$$\mu_Q = \frac{386\ m^3/s}{20370\ km^2} = \frac{386 \times 10^9\ mm^3/s}{20370 \times (10^6)^2\ mm^2 \left(\frac{1}{365 \times 60 \times 24 \times 60}\right) yr}$$

$$= \frac{386}{20370} \times 31536 = 597.59 \text{ mm/yr}$$

$$M_{ET} = M_P - M_Q = 1100 - 597.59 = \underline{\underline{502.41 \text{ mm/yr}}}$$

$$\% \text{ err} = \left(\frac{(0.1 \times 1100) + (0.05 \times 597.59)}{502.41}\right) \cdot 100 = 27.64\%$$

b) <u>Yukon</u>

$A = 932400 \text{ km}^2$, $P_{Avg} = 570 \text{ mm/yr}$, $\varepsilon_P = 20\%$, $Q_{Avg} = 5100 \text{ m}^3/\text{s}$, $\varepsilon_P = 10\%$

$$M_Q = \frac{5100 \text{ m}^3/\text{s}}{932400 \text{ km}^2} = \frac{5100}{932400} \times 31536 = 172.49 \text{ mm/yr}$$

$$M_{ET} = 570 - 172.49 = \underline{\underline{397.51 \text{ mm/yr}}}$$

$$\% \text{ err} = \left(\frac{0.2 \times 570 + 0.1 \times 172.49}{397.51}\right) \cdot 100 = 33.02\%$$

c) Euphrates

$A = 261100\ km^2$, $P_{avg} = 300\ mm/yr$, $\varepsilon_p = 10\%$, Q_{Avg} $911\ m^3/s$ ε_Q 10%

$$\mu_Q = \frac{911\ m^3/s}{261100\ km^2} = \frac{911 \times 31536}{261100} = 110.03\ mm/yr$$

$$\mu_{ET} = 300 - 110.03 = \underline{\underline{189.97\ mm/yr}}$$

$$\%\ err = \left(\frac{0.1 \times 300 + 0.1 \times 110.03}{189.97}\right) \cdot 100 = 21.58\%$$

d) Mekong

A $663,000\ km^2$, $P_{Avg} = 1460\ mm/yr$, $\varepsilon_p = 15\%$, Q_{Avg} 13200, ε_Q 5%

$$\mu_Q = \frac{13200\ m^3/s}{663000\ km^2} = \frac{13200}{663000} \times 31536 = 627.87\ mm/yr$$

$$\mu_{ET} = 1460 - 627.87 = \underline{\underline{832.13\ mm/yr}}$$

$$\%\ err = \left(\frac{0.15 \times 1460 + 0.05 \times 627.87}{832.13}\right) \cdot 100 = 30.09\%$$

ii a) Connecticut

μ_{ET} : 502 mm/yr : $\underline{\underline{50.2 \text{ cm/yr}}}$ Vs 40 ⇒ diff : +25%

b) Yukon

μ_{ET} 397.51 mm/yr : $\underline{\underline{39.751 \text{ cm/y}}}$ Vs 40 ⇒ diff : +0.625%

c) Euphrates

μ_{ET} : 189.97 mm/yr : $\underline{\underline{18.9 \text{ cm/y}}}$ Vs 20 ⇒ diff : -5.5%

d) Mekong

μ_{ET} 832 mm/yr : $\underline{\underline{83.2 \text{ cm/yr}}}$ Vs 80 ⇒ diff : 4%

∴ They compare reasonably well

iii 95% abs & relative uncertainties in ET

a) Connecticut

$$S_P : \frac{0.1 \times 1100}{2} : 55 \text{ mm yr}^{-1}$$

$$S_Q : \frac{0.05 \times 597.59}{2} : 14.94 \text{ mm y}^{-1}$$

$$S_{ET} : \sqrt{(55)^2 + (14.94)^2} : 56.99 \text{ mm yr}^{-1}$$

$$M_{ET} : \frac{2 \times 56.99}{502.41} : 0.23$$

$$\therefore \Pr\{502.41 - 0.23(502.41)\} \le \mu_{ET} \le \Pr\{515 + 0.23 \times 502.41\}$$

$$= \Pr\{\underline{\underline{386.86 \text{ mm y}^{-1}\} \le \mu_{ET} \le 630.55}}\} : 0.95$$

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b) Tigris

$$S_p = \frac{0.2 \times 570}{2} = 57 \text{ mm/yr}^{-1}$$

$$S_Q = \frac{0.1 \times 172.49}{2} = 8.62 \text{ mm/yr}^{-1}$$

$$S_{ET} = \sqrt{(57)^2 + (8.62)^2} = 57.65 \text{ mmyr}^{-1}$$

$$\mu_{ET} = \frac{57.65 \times 2}{397.51} = 0.29$$

$$\Pr\{282.23 \text{ mmyr}^{-1} \leq \mu_{ET} \leq 512.79 \text{ mmyr}^{-1}\} = 0.95$$

c) Euphrates

$$S_p = \frac{0.1 \times 300}{2} = 15$$

$$S_Q = \frac{0.1 \times 110.03}{2} = 5.50$$

$$S_{ET} = \sqrt{(15)^2 + (5.50)^2} = 15.98 \text{ mmyr}^{-1}$$

$$\mu_{ET} = \frac{2 \times 15.98}{189.97} = 0.17$$

$$\Pr\{157.68 \text{ mmyr}^{-1} \leq \mu_{ET} \leq 222.26 \text{ mmyr}^{-1}\} = 0.95$$

d) Mekong

$$S_P = \frac{0.15 \times 1460}{2} = 109.5 \text{ mm/yr}^{-1}$$

$$S_Q = \frac{0.05 \times 627.87}{2} = 15.7 \text{ mm/yr}$$

$$S_{ET} = \sqrt{(109.5)^2 + (15.7)^2} = 110.62 \text{ mmyr}^{-1}$$

$$M_{ET} = \frac{2 \times 110.62}{832.13} = 0.27$$

$$Pr\{607.95 \text{ mmyr}^{-1} \leq M_{ET} \leq 1056.81 \text{ mmyr}^{-1}\}$$

$$= 0.95$$