

Άσκηση 1+2:

(1) Ενεργειακό Ισοζύγιο

Για τον Ιούλιο:

$$\left. \begin{aligned} E_r &= \frac{R_n}{l_v p_w} \\ l_v &= 2500 - 2,36T = 2500 - 2,36 * 28,5 = 2432,74 \text{ kJ/kg} = 2433 \text{ kJ/kg} \\ R_n &= 185 \text{ W/m}^2 \\ p_w &= 996,3 \text{ kg/m}^3 \end{aligned} \right\} \Rightarrow E_r = 7,63 * 10^{-8} \text{ m/sec} \Rightarrow \boxed{E_r = 6,6 \text{ mm/day}}$$

Για τον Ιανουάριο:

$$\left. \begin{aligned} E_r &= \frac{R_n}{l_v p_w} \\ l_v &= 2500 - 2,36T = 2500 - 2,36 * 14 = 2466,96 \text{ kJ/kg} = 2467 \text{ kJ/kg} \\ R_n &= 40 \text{ W/m}^2 \\ p_w &= 999,2 \text{ kg/m}^3 \end{aligned} \right\} \Rightarrow E_r = 1,6 * 10^{-5} \text{ m/sec} \Rightarrow \boxed{E_r = 1,4 \text{ mm/day}}$$

(2) Αεροδυναμική Μέθοδος

Για τον Ιούλιο:

$$E_a = B(e_s - e_a)$$

$$B = \frac{0,622 k^2 R_a (u_2)^2}{p p_w \left[\ln \left(\frac{z_2}{z_0} \right) \right]^2}$$

$$e_s = 611 \exp \left(\frac{17,27 T}{237,3 + T} \right) \Rightarrow e_s = 611 \exp \left(\frac{17,27 * 28,5}{237,3 + 28,5} \right) = 3892,6 \text{ Pa} \approx 3893 \text{ Pa}$$

$$e_a = R_h e_s \Rightarrow e_a = 0,55 * 3893 \text{ Pa} = 2141,15 \text{ Pa} \approx 2141 \text{ Pa}$$

$$p_w = 996,3 \text{ kg/m}^3$$

$$p_a = \frac{P}{R_a T_a} \Rightarrow p_a = \frac{101,3 * 10^3}{287 * (28,5 + 273)} = 1,17 \text{ kg/m}^3$$

$$u_2 = 2,7 \text{ m/sec}$$

$$z_2 = 2 \text{ m} = 200 \text{ cm} \quad \& \quad z_0 = 0,03 \text{ cm} \Rightarrow \left[\ln \left(\frac{z_2}{z_0} \right) \right]^2 = 77,5$$

$$P = 101,5 \text{ kPa}$$

$$k = 0,4$$

$$\Rightarrow E_a = 6,99 * 10^{-8} \text{ m/sec} \Rightarrow$$

$$\Rightarrow E_a = 6,0\text{mm/day}$$

Για τον Ιανουάριο:

$$E_a = B(e_s - e_a)$$

$$B = \frac{0,622k^2 R_a (u_2)^2}{p p_w \left[\ln \left(\frac{z_2}{z_0} \right) \right]^2}$$

$$e_s = 611 \exp \left(\frac{17,27T}{237,3 + T} \right) \Rightarrow e_s = 611 \exp \left(\frac{17,27 * 14}{237,3 + 14} \right) \cong 1599 \text{ Pa}$$

$$e_a = R_h e_s \Rightarrow e_a = 0,65 * 1599 \text{ Pa} = 1039 \text{ Pa}$$

$$p_w = 999,2 \text{ kg/m}^3$$

$$p_a = \frac{P}{R_a T_a} \Rightarrow p_a = \frac{101,3 * 10^3}{287 * (14 + 273)} = 1,23 \text{ kg/m}^3$$

$$u_2 = 2,0 \text{ m/sec}$$

$$z_2 = 2 \text{ m} = 200 \text{ cm} \quad \& \quad z_0 = 0,03 \text{ cm} \Rightarrow \left[\ln \left(\frac{z_2}{z_0} \right) \right]^2 = 77,5$$

$$P = 101,5 \text{ kPa}$$

$$k = 0,4$$

$$\Rightarrow E_a = 1,5 \text{ mm/day}$$

(3) Συνδυαστική Μέθοδος - Pennman

Για τον Ιούλιο:

$$\left. \begin{aligned} E &= \frac{\Delta}{\Delta + \gamma} E_r + \frac{\gamma}{\Delta + \gamma} E_a \\ \Delta &= \frac{4098 e_s}{(273,3 + T)^2} \Rightarrow \Delta = \frac{4098 * 3893}{(273,3 + 28,5)^2} \Rightarrow \Delta = \frac{4098 * 3893}{(273,3 + 28,5)^2} = 225,8 \text{ Pa}/^\circ\text{C} \\ \gamma &= \frac{C_p K_h P}{0,622 * l_v K_w} \\ \frac{K_h}{K_w} &= 1 \\ C_p &= 1005 \text{ J/kg}^\circ\text{C} \\ P &= 101,3 \text{ kPa} \\ l_v &= 2433 \text{ kJ/kg} \end{aligned} \right\} \Rightarrow \gamma = 67,27 \text{ Pa}/^\circ\text{C} \cong 67,3 \text{ Pa}/^\circ\text{C}$$
$$\Rightarrow E = \left[\left(\frac{225,8}{225,8 + 67,3} \right) 6,6 + \left(\frac{67,3}{225,8 + 67,3} \right) 6,0 \right] \text{ mm/d} \Rightarrow$$

$$E = (5,084 + 1,377) \text{ mm/d} = 6,46 \text{ mm/d} \Rightarrow E \cong 6,5 \text{ mm/d}$$

(3) Συνδυαστική Μέθοδος - Penman

Για τον Ιανουάριο:

$$\left. \begin{aligned} E &= \frac{\Delta}{\Delta + \gamma} E_r + \frac{\gamma}{\Delta + \gamma} E_a \\ \Delta &= \frac{4098 e_s}{(273,3 + T)^2} \Rightarrow \Delta = \frac{4098 * 1599}{(237,3 + 14)^2} = 103,76 \text{ Pa}/^\circ\text{C} \cong 103,7 \text{ Pa}/^\circ\text{C} \\ \gamma &= \frac{C_p K_h P}{0,622 * l_v K_w} \\ \frac{K_h}{K_w} &= 1 \\ C_p &= 1005 \text{ J/kg}^\circ\text{K} \\ P &= 101,3 \text{ kPa} \\ l_v &= 2467 \text{ kJ/kg} \end{aligned} \right\} \Rightarrow \gamma = 66,3 \text{ Pa}/^\circ\text{C}$$
$$\Rightarrow E = \left[\left(\frac{103,7}{103,7 + 66,3} \right) 1,4 + \left(\frac{66,3}{103,7 + 66,3} \right) 1,5 \right] \text{ mm/d} \Rightarrow$$

$$E = (0,854 + 0,585) \text{ mm/d} = 1,439 \text{ mm/d} \Rightarrow E \cong 1,4 \text{ mm/d}$$

(4) Μέθοδος Priestley & Taylor

Για τον Ιούλιο:

$$\left. \begin{array}{l} E_{PT} = \alpha \frac{\Delta}{\Delta + \gamma} E_r \\ \alpha = 1,3 \\ \Delta = 225,8 \text{Pa}/^{\circ}\text{C} \\ \gamma = 67,3 \text{Pa}/^{\circ}\text{C} \\ E_r = 6,6 \text{mm}/\text{d} \end{array} \right\} \Rightarrow E_{PT} = 6,6 \text{mm}/\text{d}$$

Για τον Ιανουάριο:

$$\left. \begin{aligned} E_{PT} &= \alpha \frac{\Delta}{\Delta + \gamma} E_r \\ \alpha &= 1,3 \\ \Delta &= 103,7 \text{ Pa}/^\circ\text{C} \\ \gamma &= 66,3 \text{ Pa}/^\circ\text{C} \\ E_r &= 1,4 \text{ mm/d} \end{aligned} \right\} \Rightarrow E_{PT} = 1,11 \text{ mm/d} \cong 1,1 \text{ mm/d}$$

Άσκηση 3+4:

Για τον Ιούλιο:

Αρχικά:

$$E_a = B(e_s - e_a)$$

Σύμφωνα με την εξίσωση των Doorenbos–Pruitt

$$\left. \begin{aligned} B &= 0,0027 * \left[1 + \left(\frac{u}{100} \right) \right] \\ u_2 &= 2,7 \text{ m/sec} = 86400 * 2,7 \text{ mm/day} = 233,28 \text{ Km/day} \cong 233,3 \text{ Km/day} \\ e_s &= 3893 \text{ Pa} \\ e_a &= 2141 \text{ Pa} \end{aligned} \right\} \Rightarrow B = 8,9 * 10^{-3} \text{ mmPa/day} \cong 9 * 10^{-3} \text{ mmPa/day} \Rightarrow E_a \cong 15,8 \text{ mm/day}$$

Επομένως αντικαθιστώντας στην συνδυαστική μέθοδο Penman:

$$\left. \begin{aligned}
 E &= \frac{\Delta}{\Delta + \gamma} E_r + \frac{\gamma}{\Delta + \gamma} E_a \\
 \Delta &= 225,8 \text{ Pa/}^\circ\text{C} \\
 \gamma &\cong 67,3 \text{ Pa/}^\circ\text{C} \\
 E_r &= 6,6 \text{ mm/day} \\
 E_a &= 15,8 \text{ mm/day}
 \end{aligned} \right\} \Rightarrow E = (5,084 + 3,628) \text{ mm/d} = 8,7 \text{ mm/day}$$

Για τον Ιανουάριο:

Αρχικά:

$$E_a = B(e_s - e_a)$$

Σύμφωνα με την εξίσωση των Doorenbos–Pruitt

$$\left. \begin{aligned}
 B &= 0,0027 * \left[1 + \left(\frac{u}{100} \right) \right] \\
 u_2 &= 2,0 \text{ m/sec} = 86400 * 2,0 \text{ mm/day} = 172,8 \text{ Km/day} \\
 e_s &= 1599 \text{ Pa} \\
 e_a &= 1039 \text{ Pa}
 \end{aligned} \right\} \Rightarrow B = 7,3656 * 10^{-3} \text{ mmPa/day} \cong 7,37 * 10^{-3} \text{ mmPa/day} \Rightarrow E_a \cong 4,1 \text{ mm/day}$$

Επομένως αντικαθιστώντας στην συνδυαστική μέθοδο Penman:

$$\left. \begin{aligned}
 E &= \frac{\Delta}{\Delta + \gamma} E_r + \frac{\gamma}{\Delta + \gamma} E_a \\
 \Delta &= 103,7 \text{ Pa}/^{\circ}\text{C} \\
 \gamma &\cong 66,3 \text{ Pa}/^{\circ}\text{C} \\
 E_r &= 1,4 \text{ mm/day} \\
 E_a &= 4,1 \text{ mm/day}
 \end{aligned} \right\} \Rightarrow E = (0,854 + 1,599) \text{ mm/d} = 2,453 \text{ mm/day} \cong 2,5 \text{ mm/day}$$