INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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CABLE: CENTRATOM - TELEX 460392-1

SMR/104-8

COLLEGE ON SOIL PHYSICS

19 September - 7 October 1983

ADDENDUM: EXAMPLES

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Calculation of the soil water pressure head, the hydraulic head and the soil water content using tensiometer data and neutron probe data

Given : The height of the mercury in the manometer of the tensiometers located at different depths for a specific time. The soil surface being the reference level. The level of the mercury reservoir above the reference level is 18 cm.
The neutron probe readings (cpm) for every 10 cm interval for a specific time.

Find :- The soil water pressure head and the hydraulic head at different depths for that specific measuring time.

- The soil water content at different depths for that specific measuring time using the calibration curves.
- Construct the hydraulic head and the soil water content profile.
- Calculate the soil water storage between 0 and 90 cm depth for that specific measuring time.

FIELD DATA

Depth "Z" (cm)	Tensiometer readings "x" (cm)	"h" (cm)	"H" (cm)	Neutron moisture readings "N" (cpm)	Moisture content "θ_p" (vol %)
10	37.8	- 448.2	- 458.2	10224	7.4
20				16046	7.6
30	23.3	- 245.5	- 275.5	20600	15.9
40				22336	15
50	17.7	- 155	- 205	23172	16.2
60				23188	16.2
70	17.5	- 132.5	- 202.5	23526	16.7
80				27378	22.1
90	17.8	- 116.2	- 206.2	28998	24.4
100				26528	20.9
110	20.7	- 132.8	- 242.8	22672	15.5

1. Soil water pressure head and hydraulic head for depth z = 10 cm . y = 18 cm

$h = -12.6\ x + y + z = -12.6\ (37.8) + 18 + 10 = -448{,}2$ cm

$H = h - z = -448.2 - 10$ cm $= -458.2$ cm

2. Determination of soil water content

Calibration curve for:

z = 10 cm	$cpm = 834.9\ \theta_p + 4077$
z = 20 cm	$cpm = 633.2\ \theta_p + 11249.1$
z = 30 cm	$cpm = 572.4\ \theta_p + 11495.7$
z = 40 - 120 cm	$cpm = 712.8\ \theta_p + 11645.9$

Example: θ_p at z = 10 cm

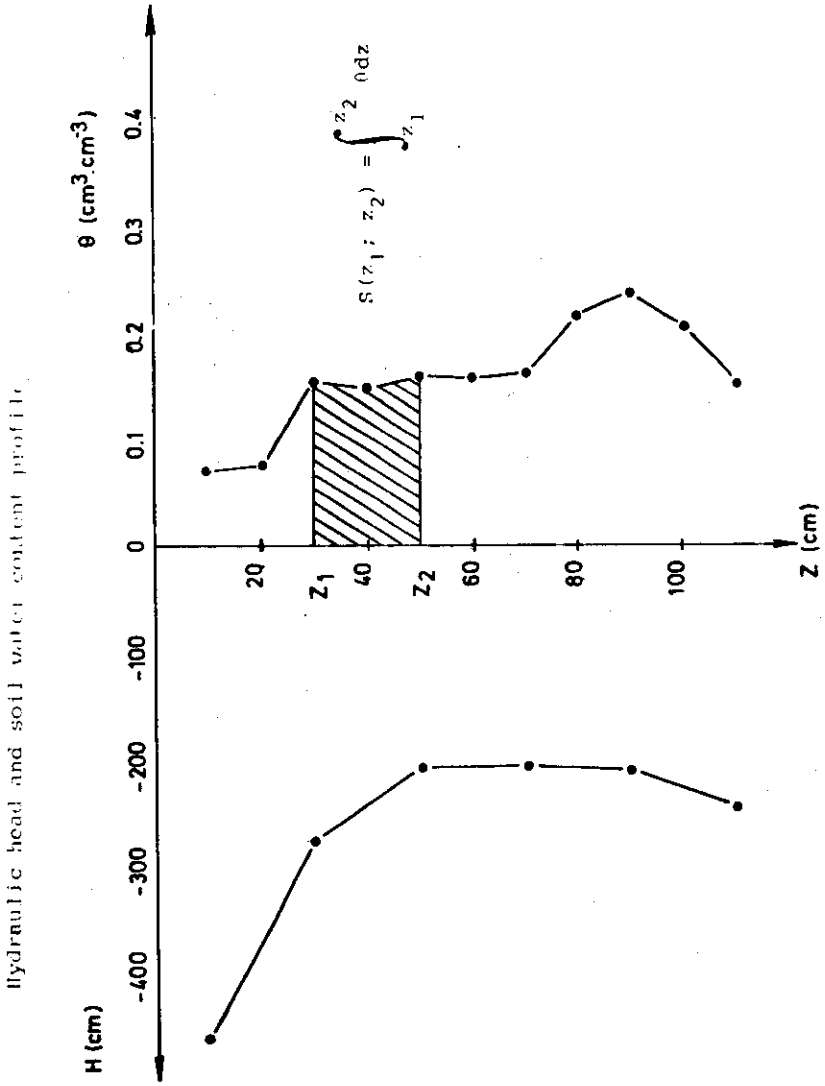
$$\theta_p = \frac{cpm - 4077}{834.9} = 7.4 \text{ Vol \%}$$

θ_p at z = 20 cm

$$\theta_p = \frac{cpm - 11249.1}{633.2} = 7.6 \text{ Vol \%}$$

3. Soil water storage

$$S_{90\ cm}^{0} = 1.5 \times 7.4 + (7.6 + 15.9 + 15 + 16.2 + 16.2 + 16.7 + 22.1) + 24.4 \times 0.5 = 11.1 + 109.7 + 12.2 = 133 \text{ mm}.$$



Calculation of evapotranspiration and drainage under rye-grass.

Given : - The height of the mercury in the manometer of the tensiometers installed at different depths under the soil surface for different measuring times. The soil surface being the reference level. The level of the mercury reservoir above the reference level is 18 cm.

- The neutron probe readings (cpm) for every 10 cm interval for different measuring times.
- Rainfall : 1,5 mm on 9 July,
  3.1 mm on 12 July.

Find : - The soil water pressure head and the hydraulic head at different depths for the different measuring times.

- Construct the hydraulic head profiles. Locate, if it occurs, the plane of zero flux for each measuring time (day).
- The soil water content at different depths for the different measuring times using the calibration curve.
- Construct the soil water content profiles.
- Calculate the soil water storages (S) up to different depths (15, 20, 30, 40, 50, 60, 70, 80, 90 and 100 cm) for the different measuring times being 1, 8, 11 and 15 July.
- Calculate the change in soil water storage above the plane of zero flux between 1 and 8 July; 8 and 11 July; 11 and 15 July.
- Calculate the change in soil water storage between the plane of zero flux and the depth of 100 cm between 1 and 8 July; 8 and 11 July; 11 and 15 July.
- Calculate the evapotranspiration (E T_{cr}) and the drainage component (D) for the periods 1 - 8 July; 8 - 11 July and 11 - 15 July.

FIELD n° 2

Date: 24/6

$h = -12.6\ x + y + z$

$H = h - z$

x = height of mercury in the manometer

y = level of mercury reservoir above reference level (= 18 cm)

z = depth of tensiometer

depth z (cm)	Tensiometer reading			Neutron probe readings (c.p.m.)	Soil water content (volume %)
	x (cm)	h (cm)	H (cm)		
10	24,3	-278,2	-288,2	15.250	13,4
20				19.848	13,6
30	17,5	-172,5	-202,5	22.126	18,6
40				22.896	15,8
50	16,2	-136,1	-186,1	24.236	17,7
60				24.594	18,2
70	16,3	-117,4	-187,4	24.304	17,8
80				27.836	22,7
90	16,6	-101,2	-191,2	28.748	24,0
100				26.860	21,4
110	20,6	-131,6	-241,6	23.170	16,2

FIELD n° 2

Date: 1/7

h = -12.6 x + y + z

H = h - z

x = height of mercury in the manometer

y = level of mercury reservoir above reference level (= 18 cm)

z = depth of tensiometer

depth z (cm)	Tensiometer reading			Neutron probe readings (c.p.m.)	Soil water content (volume %)
	x (cm)	h (cm)	H (cm)		
10	13	-135,8	-145,8	18.144	16,8
20				20.912	15,3
30	16,5	-159,9	-189,9	22.104	18,6
40				23.034	16,0
50	16,9	-144,9	-194,9	23.978	17,3
60				23.996	17,4
70	17,0	-126,2	-196,2	23.598	16,8
80				27.692	22,5
90	17,3	-109,9	-199,9	28.778	24.1
100				26.230	20,5
110	20,4	-129,0	-239,0	22.484	15,2

FIELD n° 2

Date: 8/7

h = -12.6 x + y + z

H = h - z

x = height of mercury in the manometer

y = level of mercury reservoir above reference level (= 18 cm)

z = depth of tensiometer

depth z (cm)	Tensiometer reading			Neutron probe readings (c.p.m.)	Soil water content (volume %)
	x (cm)	h (cm)	H (cm)		
10	37,8	-448,2	-458,2	10.224	7,4
20				16.046	7,6
30	23,3	-245,5	-275,5	20.600	15,9
40				22.336	15,0
50	17,7	-155,0	-205,0	23.172	16,2
60				23.188	16,2
70	17,5	-132,5	-202,5	23.526	16,7
80				27.378	22,1
90	17,8	-116,2	-206,2	28.998	24,4
100				26.528	20,9
110	20,7	-132,8	-242,8	22.672	15,5

FIELD n° 2

Date: 11/7

$h = -12.6\ x + y + z$

$H = h - z$

x = height of mercury in the manometer

y = level of mercury reservoir above reference level (= 18 cm)

z = depth of tensiometer

depth z (cm)	Tensiometer reading			Neutron probe readings (c.p.m.)	Soil water content (volume %)
	x (cm)	h (cm)	H (cm)		
10	63,0	-765,8	-775,8	9.272	6,2
20				11.172	4,6
30	26,5	-285,9	-315,9	19.204	13,5
40				21.946	14,5
50	18,7	-167,6	-217,6	23.090	16,1
60				21.892	14,4
70	18,5	-145,1	-215,1	22.470	15,2
80				26.400	20,7
90	18,3	-122,5	-212,5	28.322	23,4
100				25.734	19,8
110	20,8	-134,0	-244,0	22.420	15,1

FIELD n° 2

Date: 15/7

$h = -12.6\ x + y + z$

$H = h - z$

x = height of mercury in the manometer

y = level of mercury reservoir above reference level (= 18 cm)

z = depth of tensiometer

depth z (cm)	Tensiometer reading			Neutron probe readings (c.p.m.)	Soil water content (volume %)
	x (cm)	h (cm)	H (cm)		
10	62,1	-754,4	-764,4	8.544	5,4
20				13.252	3,2
30	32,3	-358,8	-388,9	17.850	11,1
40				20.382	12,3
50	20,4	-189,0	-239,0	22.134	14,7
60				21.396	13,7
70	20,0	-164,0	-234,0	21.454	13,8
80				26.752	21,2
90	18,7	-127,6	-217,6	28.150	23,2
100				26.140	20,4
110	20,8	-134,0	-244,0	21.920	14,4

Calibration curves of the neutron probe for:

depth z = 10 cm cpm = 834.9 θ + 4077.0

z = 20 cm cpm = 633.2 θ + 11249.1

z = 30 cm cpm = 572.4 θ + 11495.7

z = 40-120 cm cpm = 712.8 θ + 11645.9

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Reference crop evapotranspiration (ET_0 - Penman), crop evapotranspiration (ET_{cr}) and deep drainage (D) at a depth of 100 cm during very dry period between 1/7 - 15/7

Period	ET_{cr} (mm)	Rainfall (mm)	Drainage (mm)	ET_0-Penman (mm)
1/7 - 8/7	27.5	-	-0.5	30.1
8/7 - 11/7	11.6	1.5	4.0	12.9
11/7 - 15/7	13.6	3.1	- 0.4	12.5
Total	52.7	4.6	3	55.5

Soil water storage S (mm)

depth (cm)	15	20	30	40	50	60	70	80	90	100
Time										
1/7	25.2	32.9	49.8	67.1	83.8	101.1	118.2	137.9	161.2	183.5
8/7	11.1	14.9	26.7	42.1	57.7	73.9	90.4	109.8	133.0	155.7
11/7	9.3	11.6	20.7	34.7	50.0	65.2	80.0	98.0	120.0	141.6
15/7	8.1	9.7	16.9	28.6	42.1	56.3	70.0	87.5	109.7	131.5

Calculation

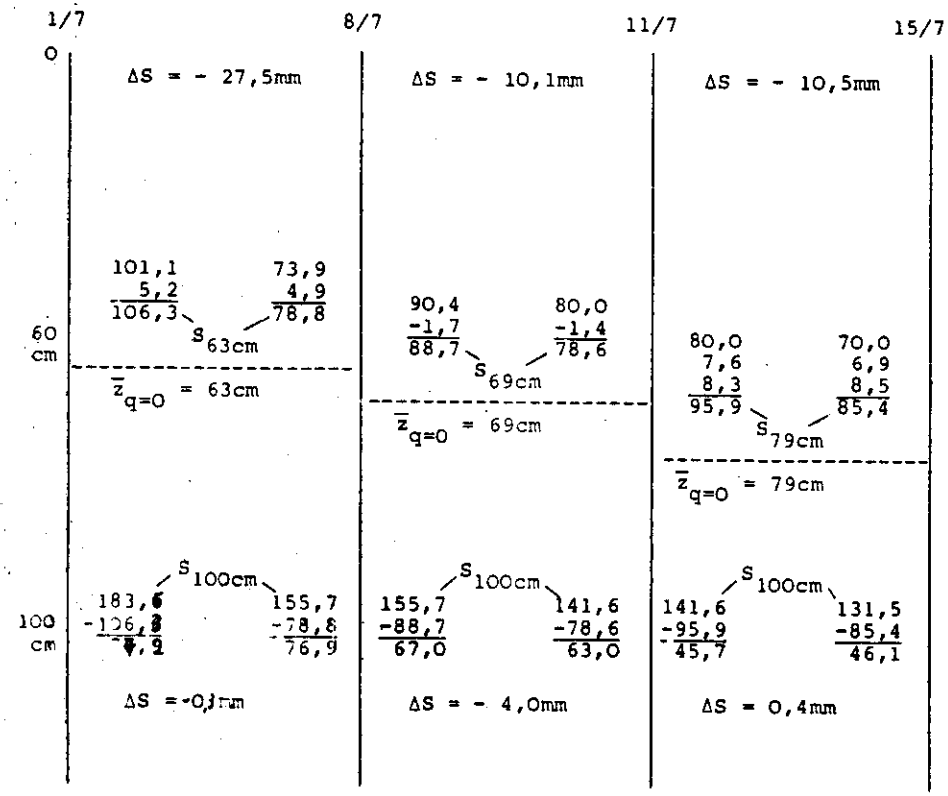
(1) $16.8 + \frac{16.8}{2} = 25.2$

(2) $25.2 + \frac{15.3}{2} = 32.9$

(3) $25.2 + 15.3 + \frac{18.6}{2} = 49.8$

(4) $25.2 + 15.3 + 18.6 + \frac{16}{2} = 67.1$

Calculation of E T_{cr} and D



For period 1/7 - 15/7

ΔS = -(27,5 + 10,1 + 10,5)mm = - 48,1 mm

P = (1,5 + 3,1) mm ≈ 4,6 mm

R = 0

Since P - E T_{cr} = ΔS + E-T_{cr} = P - ΔS

or (4,6 + 48,1)mm = 52,7 mm = E T_{cr}