Monitoring of subsidence of agricultural peatlands and impact of submerged drains in The Netherlands

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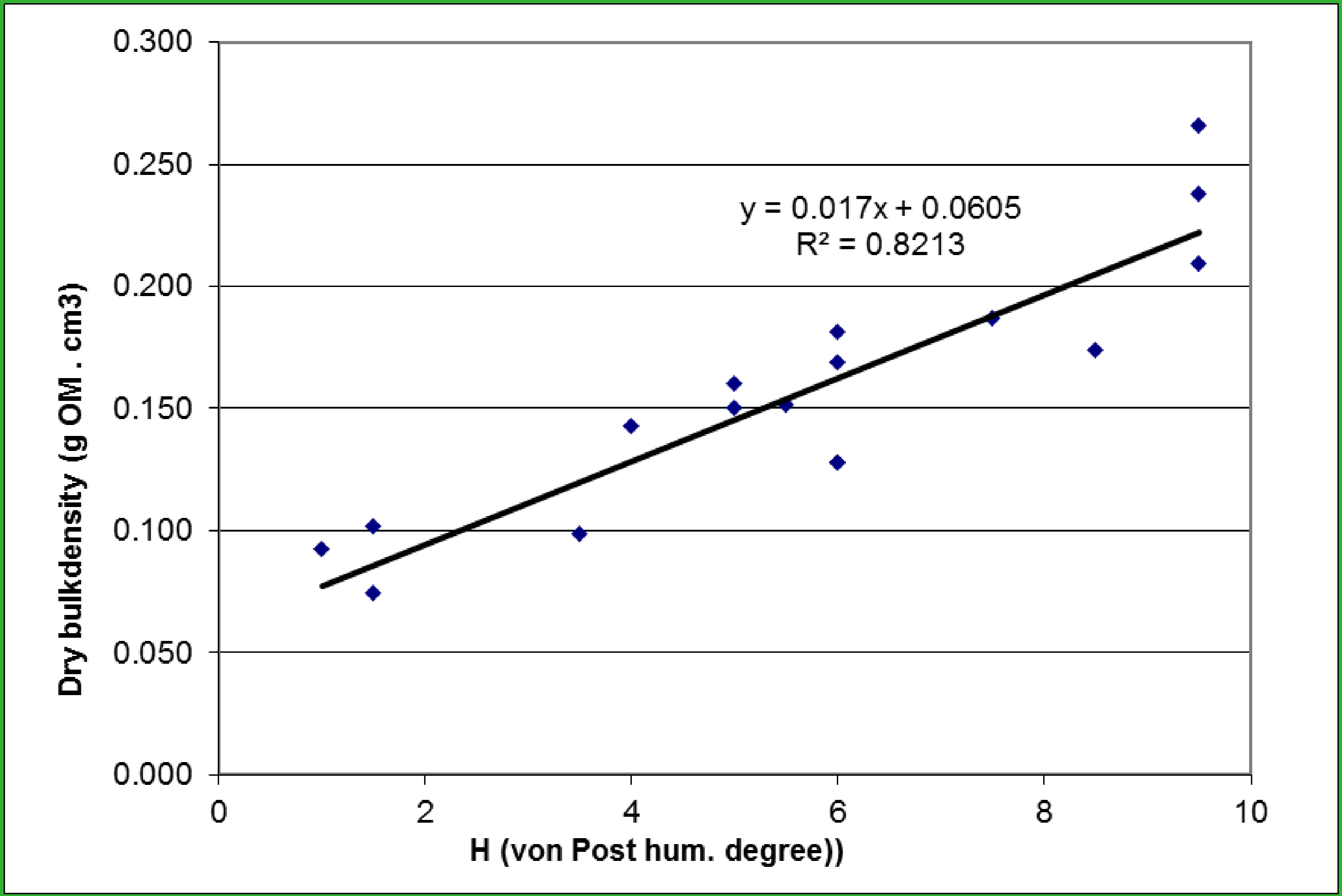
Components subsidence

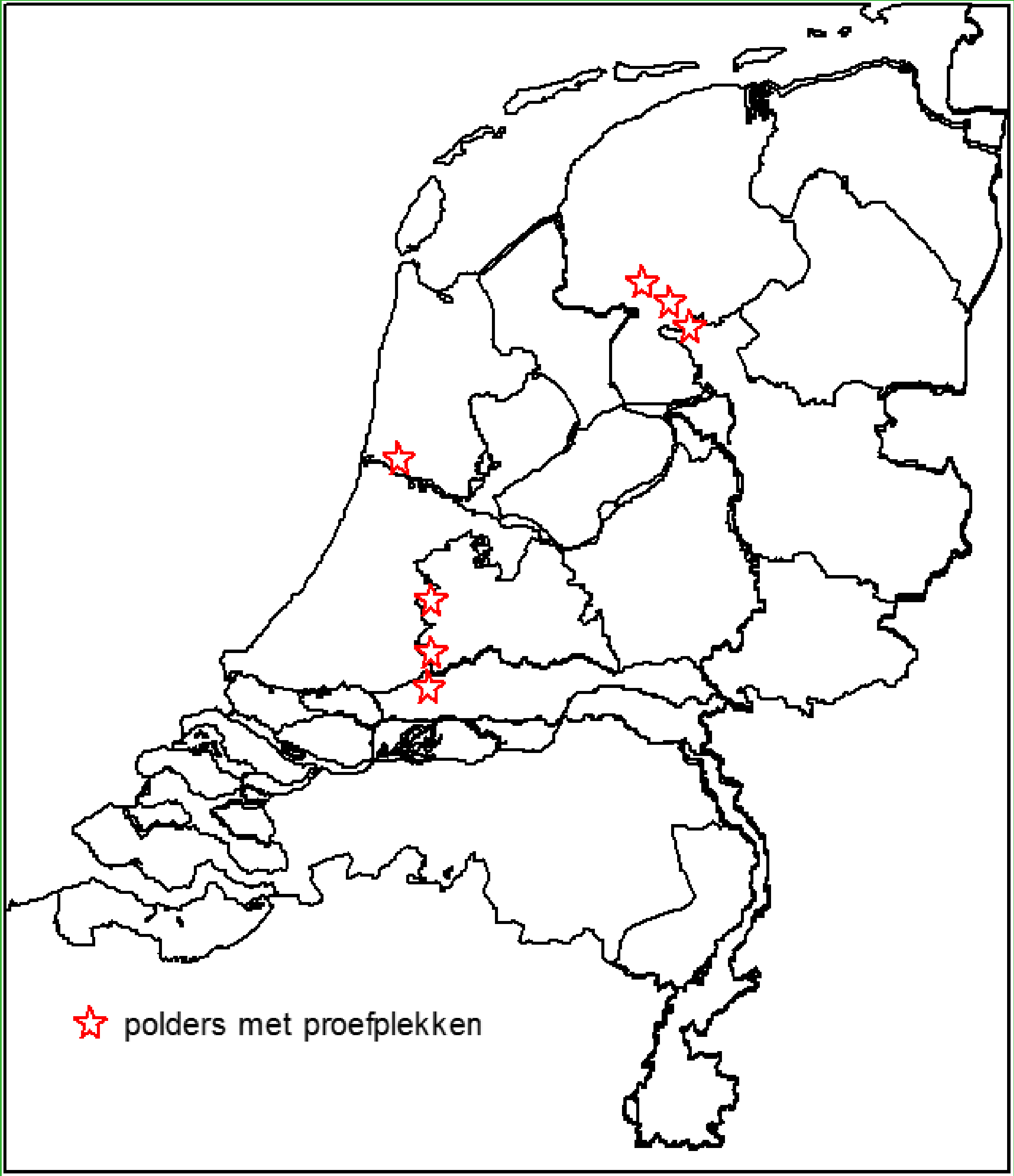
- Consolidation
- Shrinkage: reversible and irreversible
- Oxidation (biological decomposition) => CO_2

1 mm subsidence = 2.26 t CO_2 per ha

Decomposition increases dry bulkdensity and so subsidence



Locations monitoring



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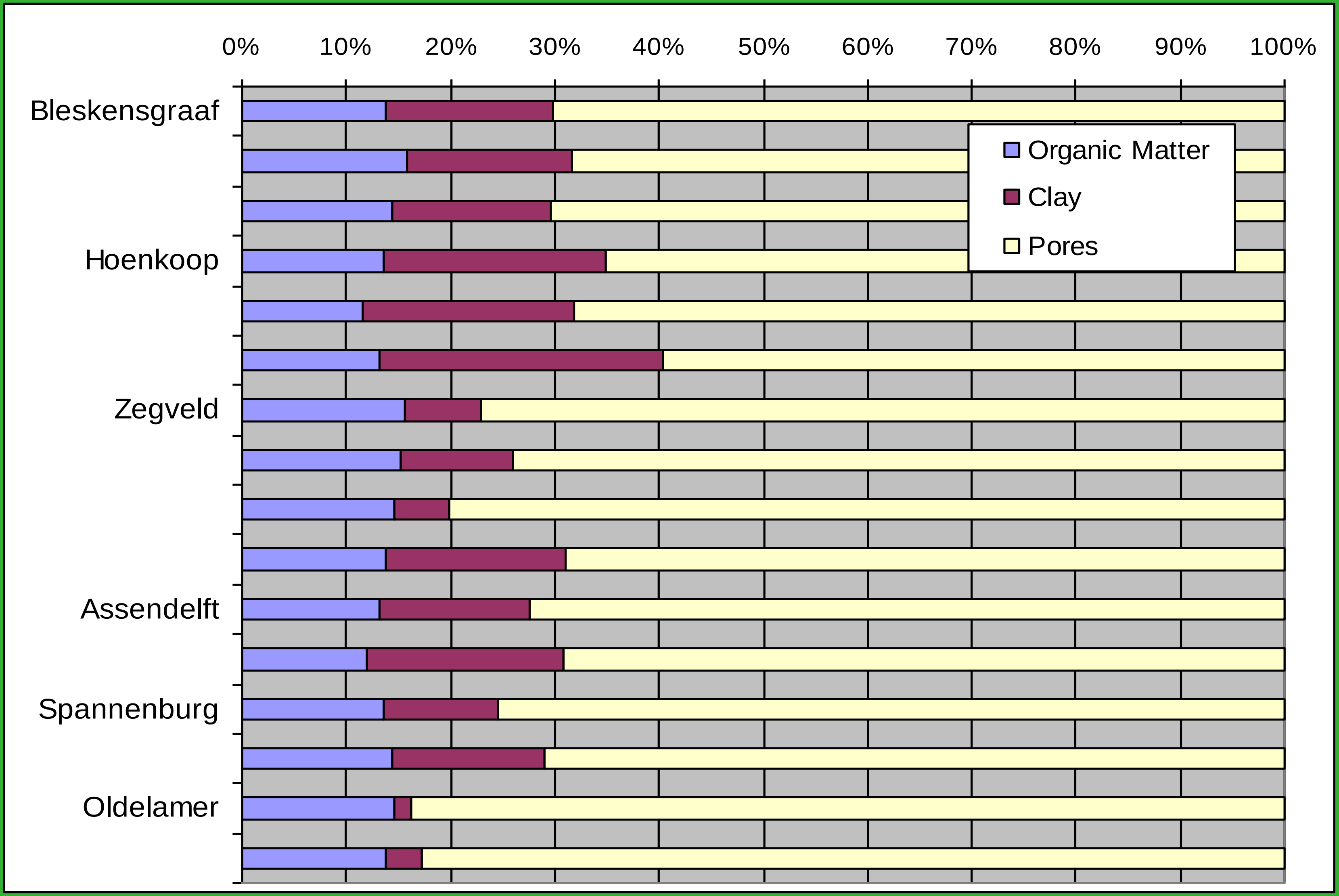
Volume Organic Matter, Clay, Pores upper 30 cm



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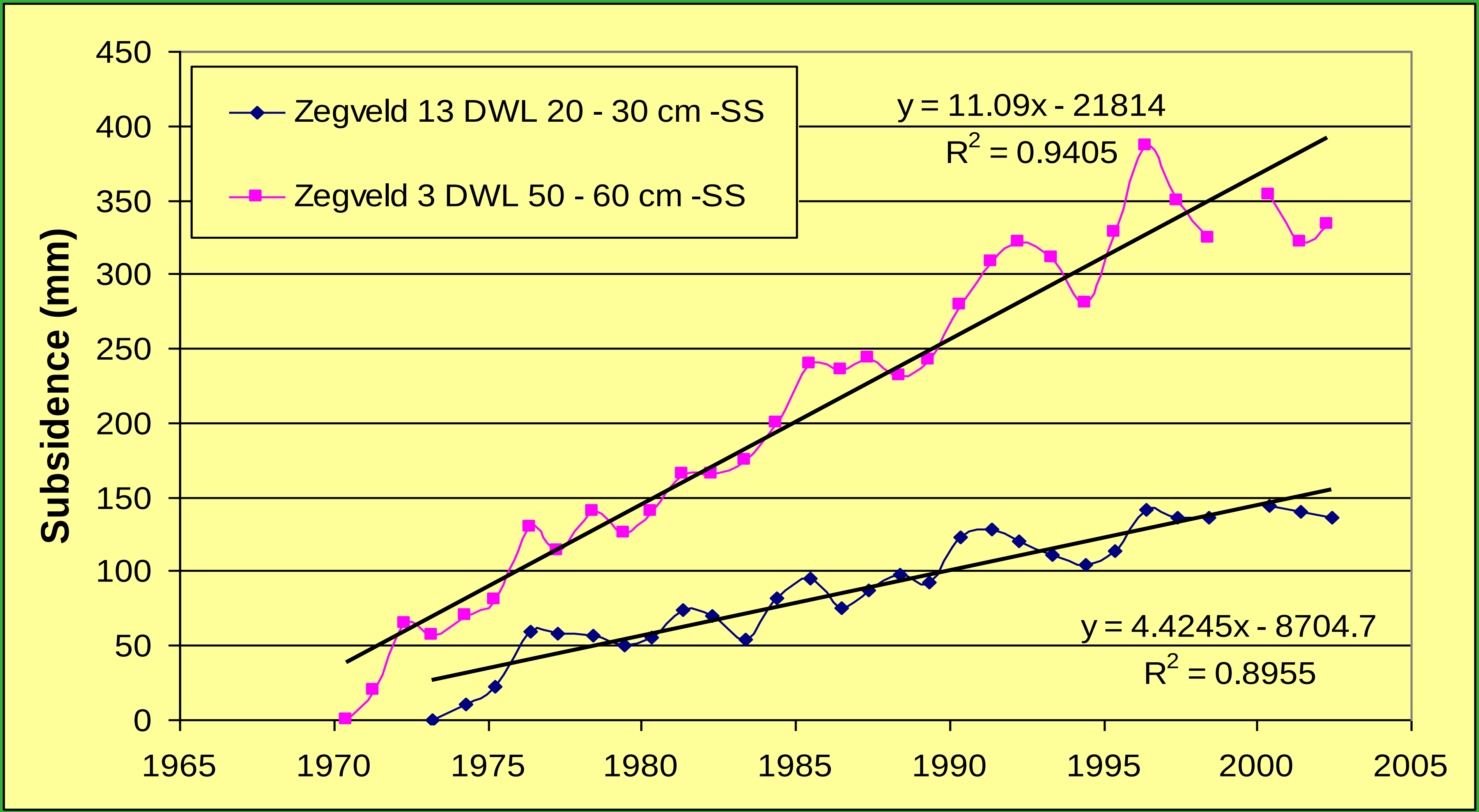
Subsidence in relation to Ditch Water Level



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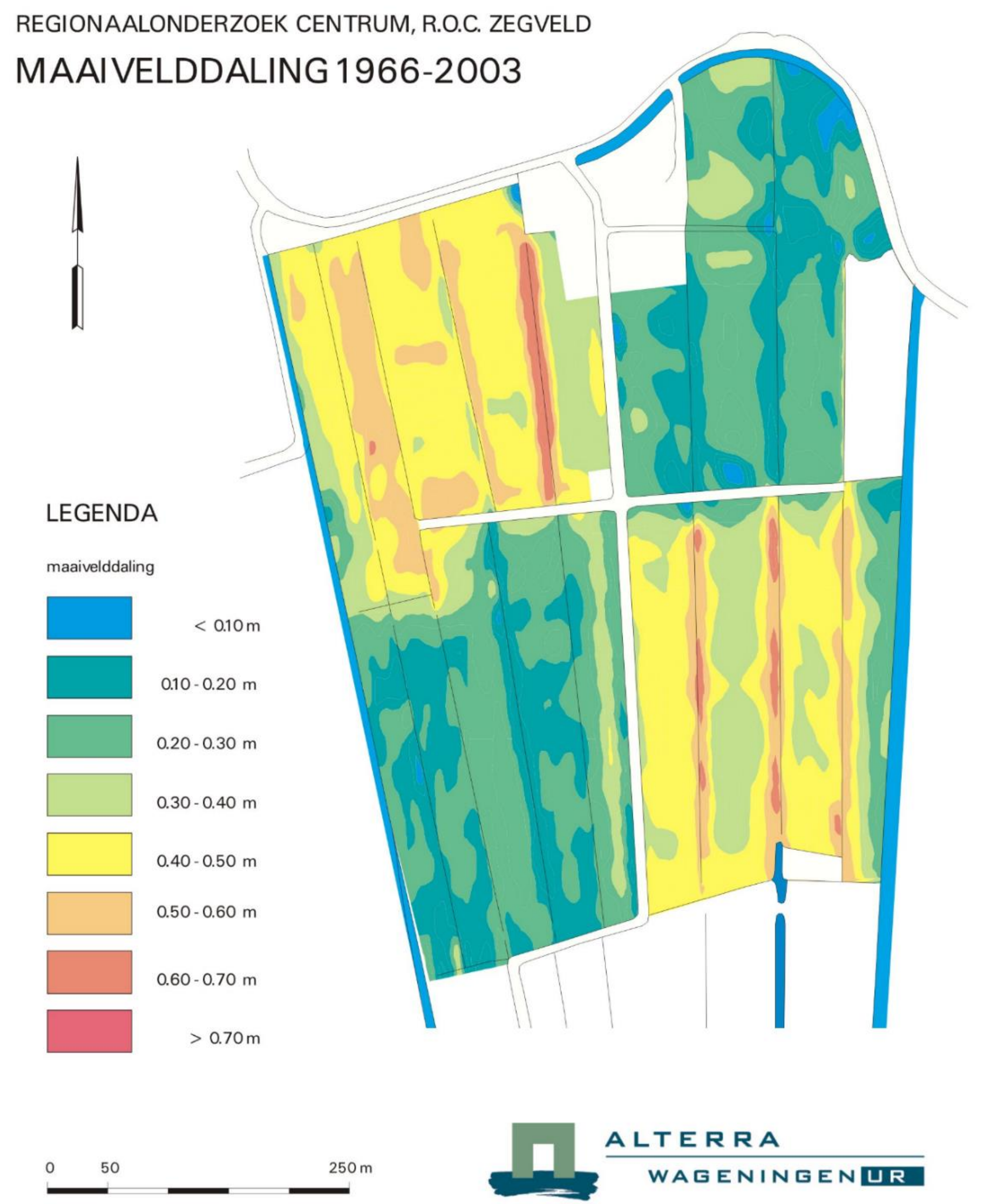
Subsidence experimental farm Zegveld
1966 – 2003

Ditchwater levels:
high: 20 – 35 cm –SS
low: 55 – 60 cm -SS



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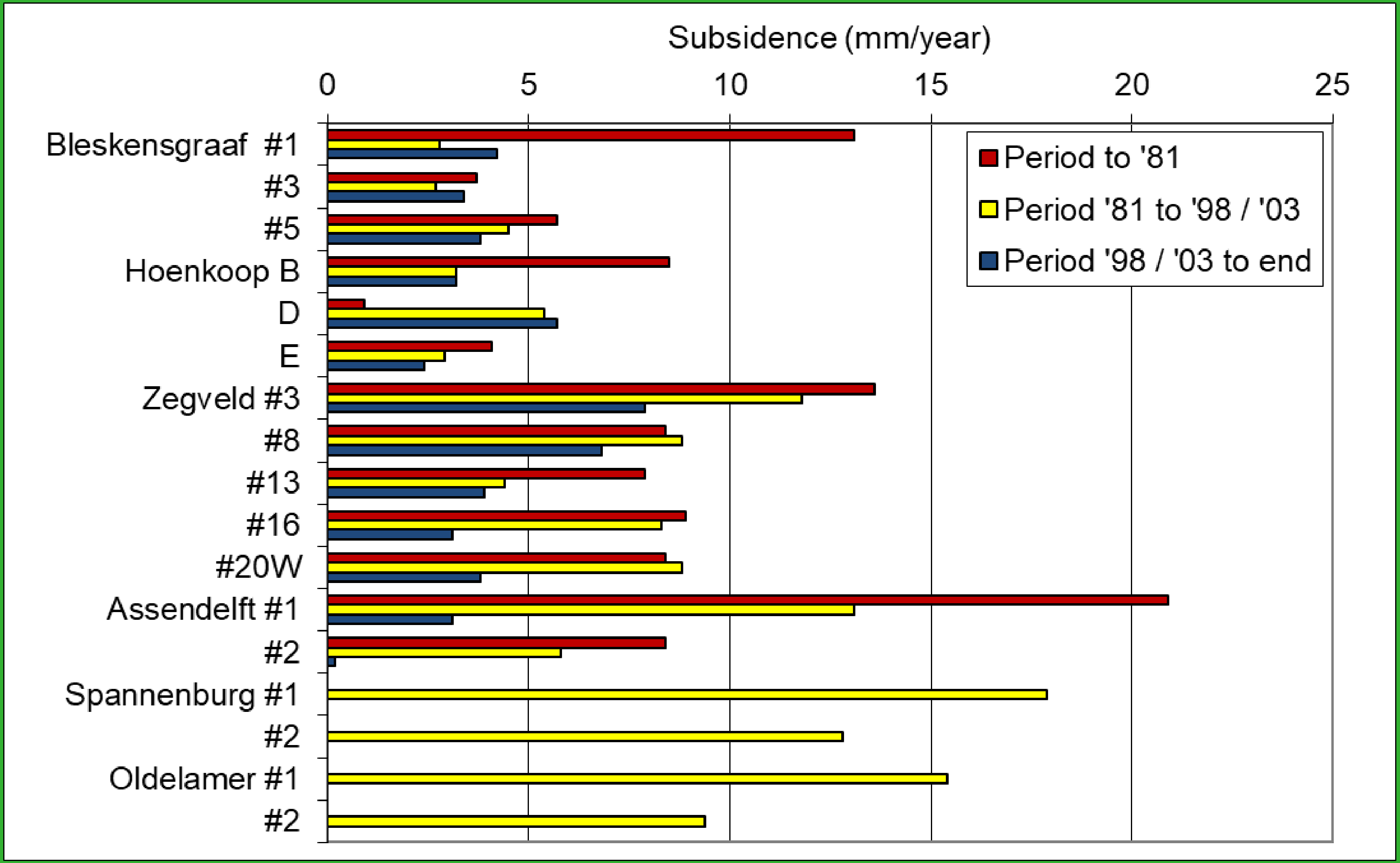
Subsidence in start, '81 – '00, '00 - now



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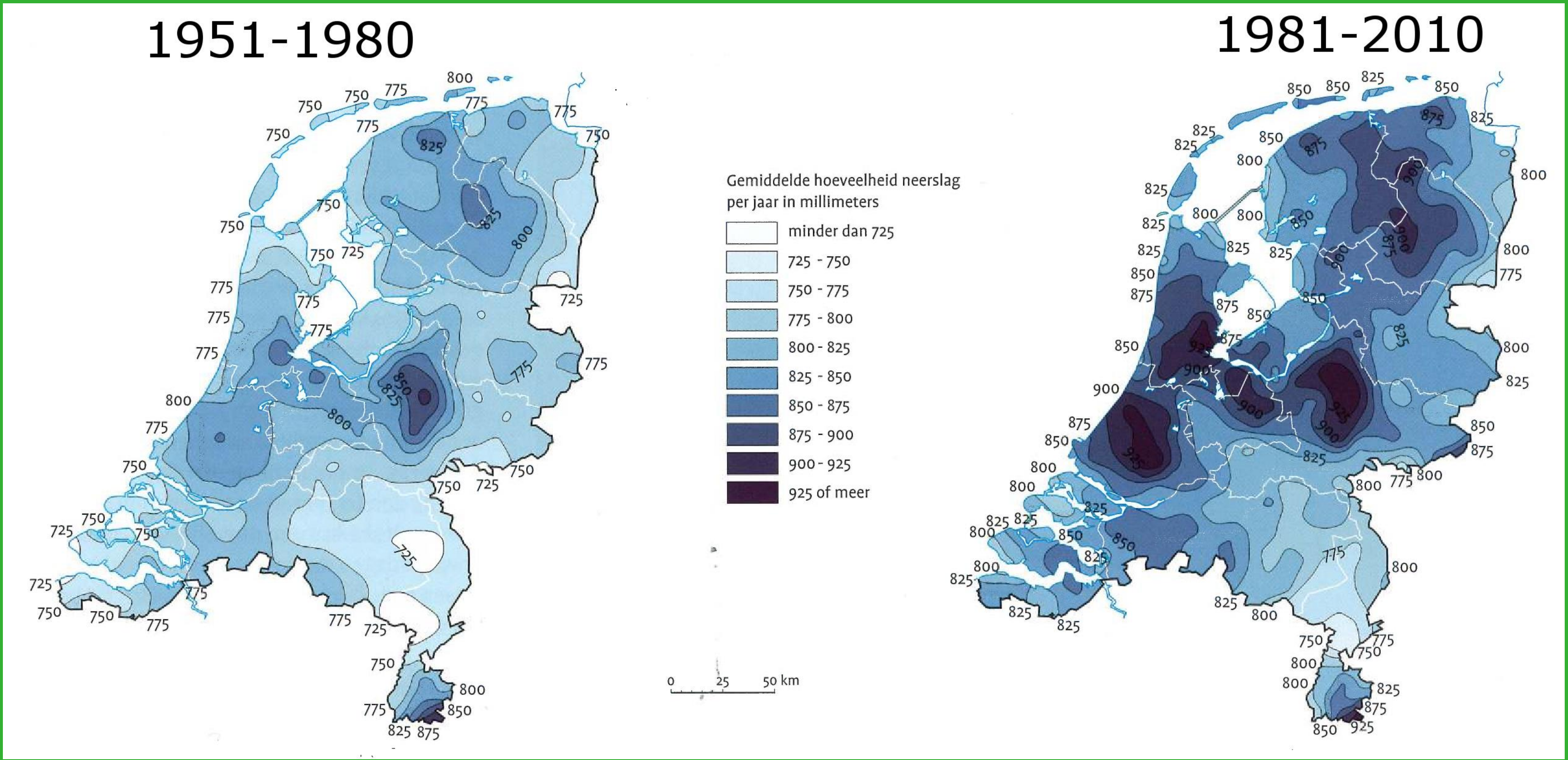
Climate is changing

Mean yearly percipitation



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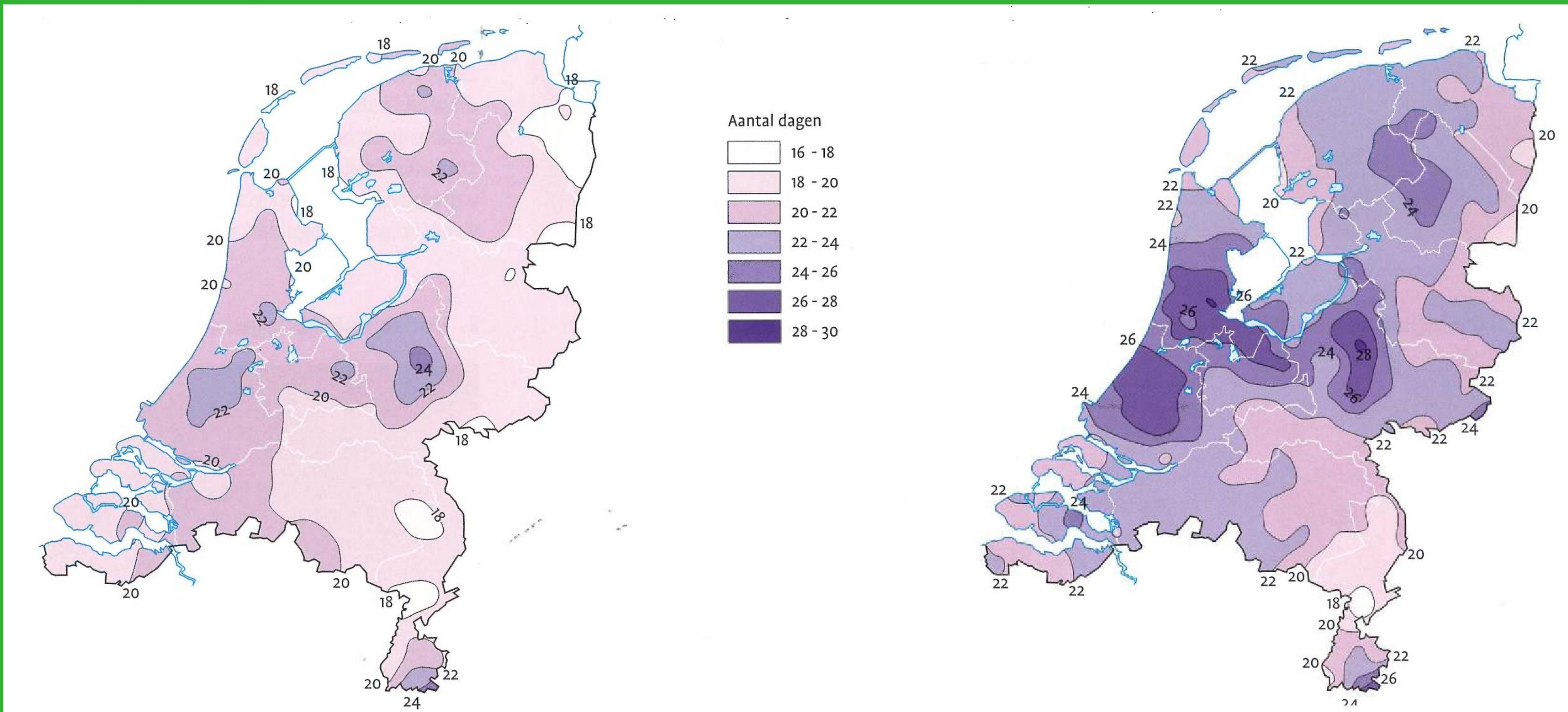
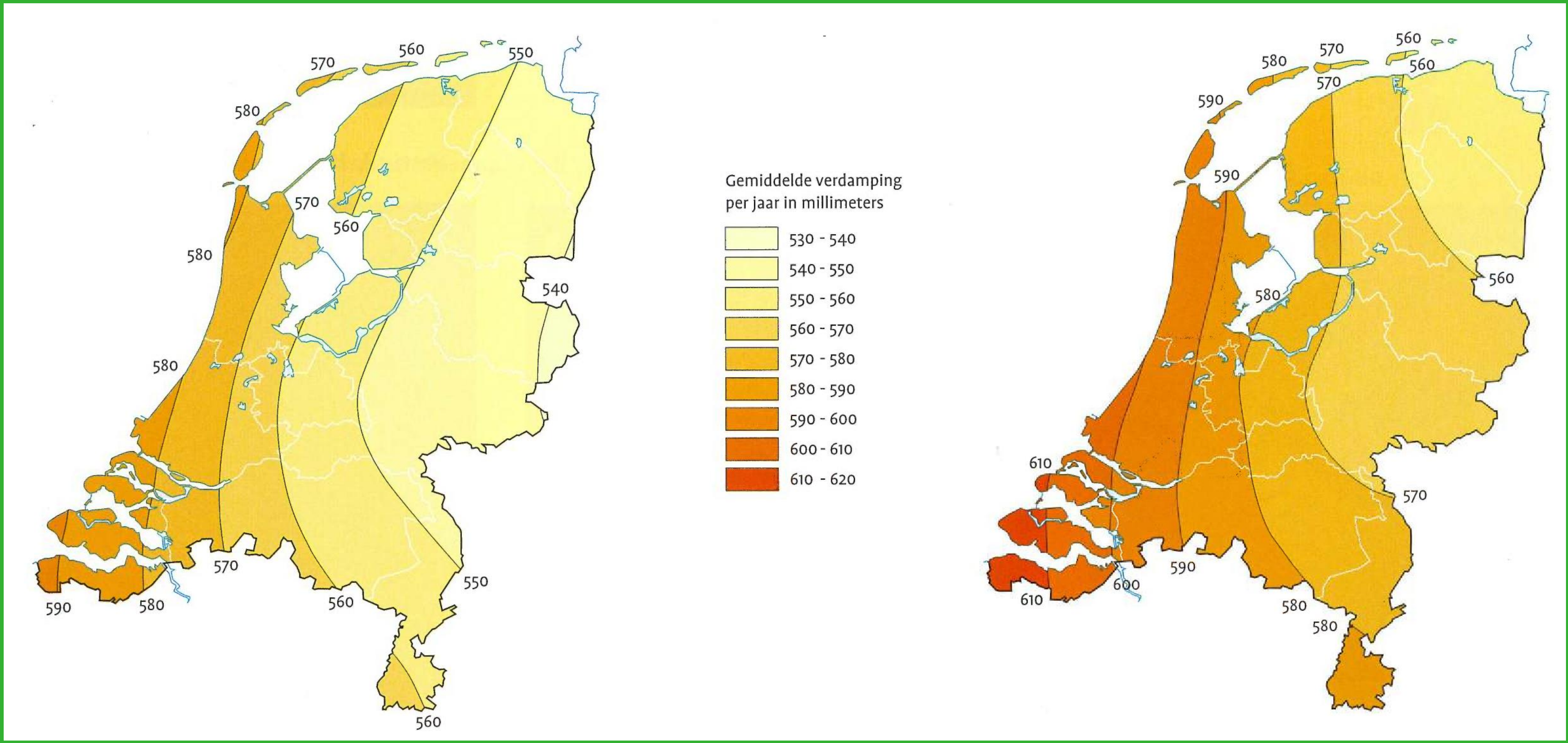
Climate is changing

Days with > 10 mm percipitation

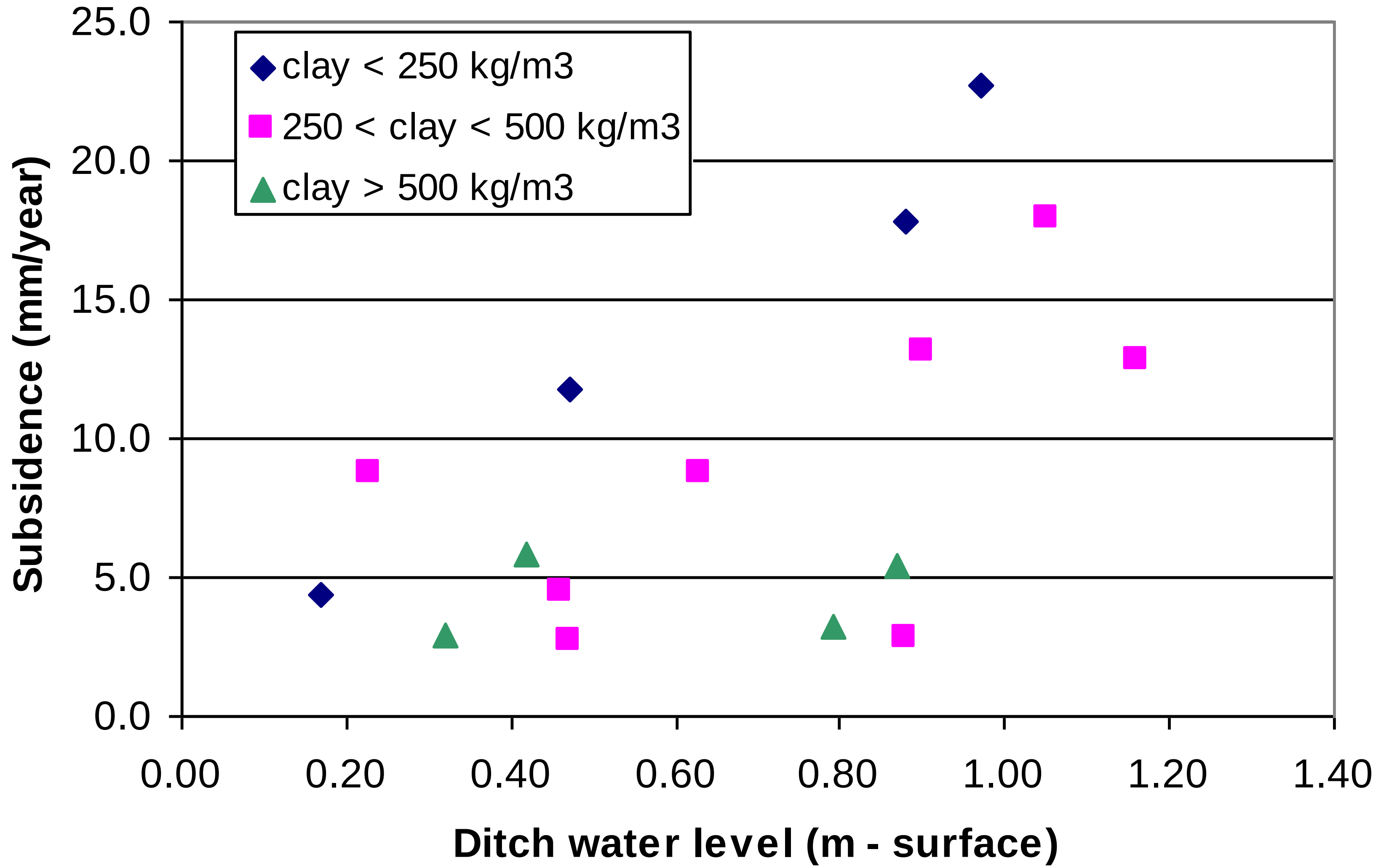


Climate is changing

Mean evapotranspiration per year in mm



Effect ditch water level on subsidence



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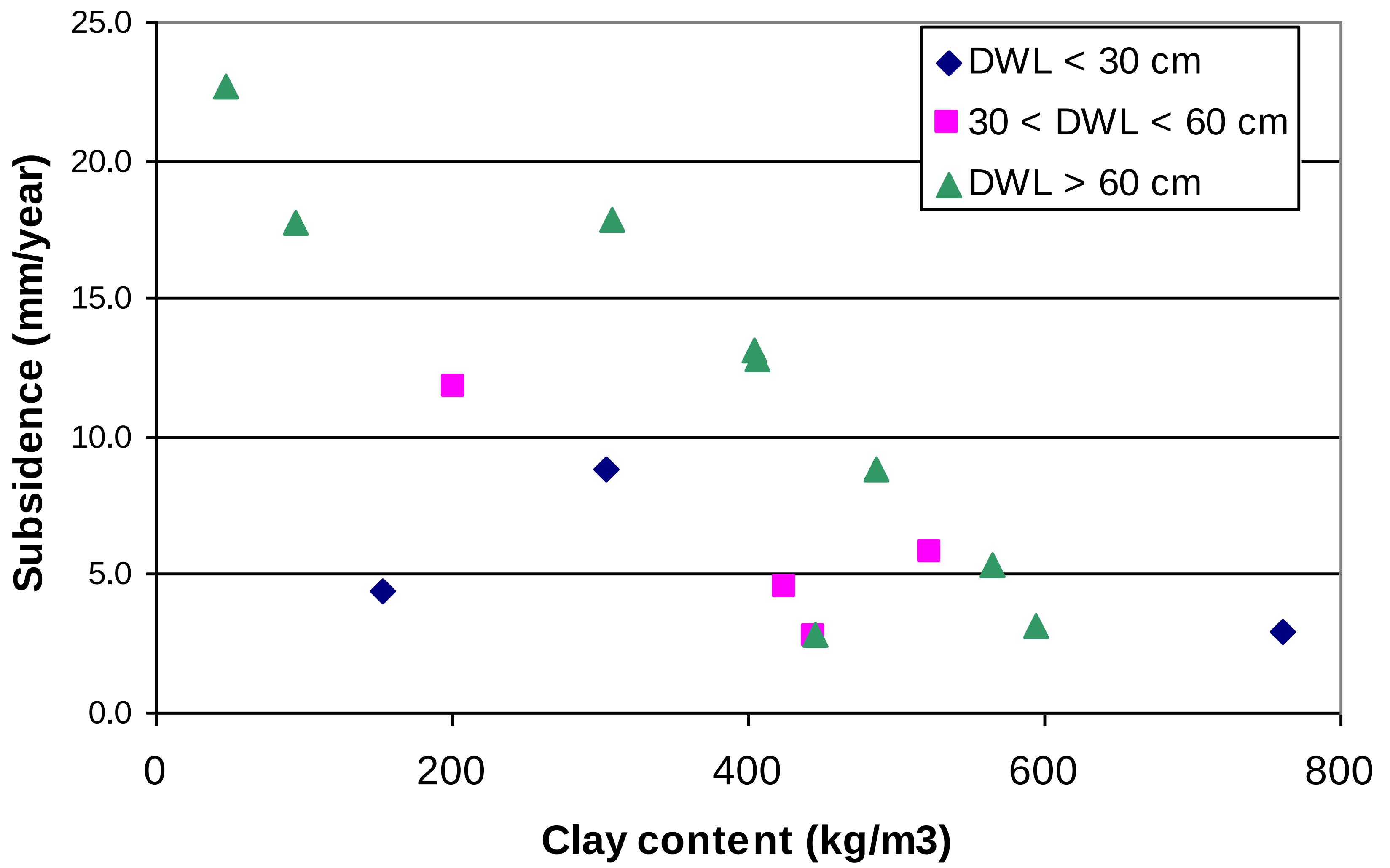
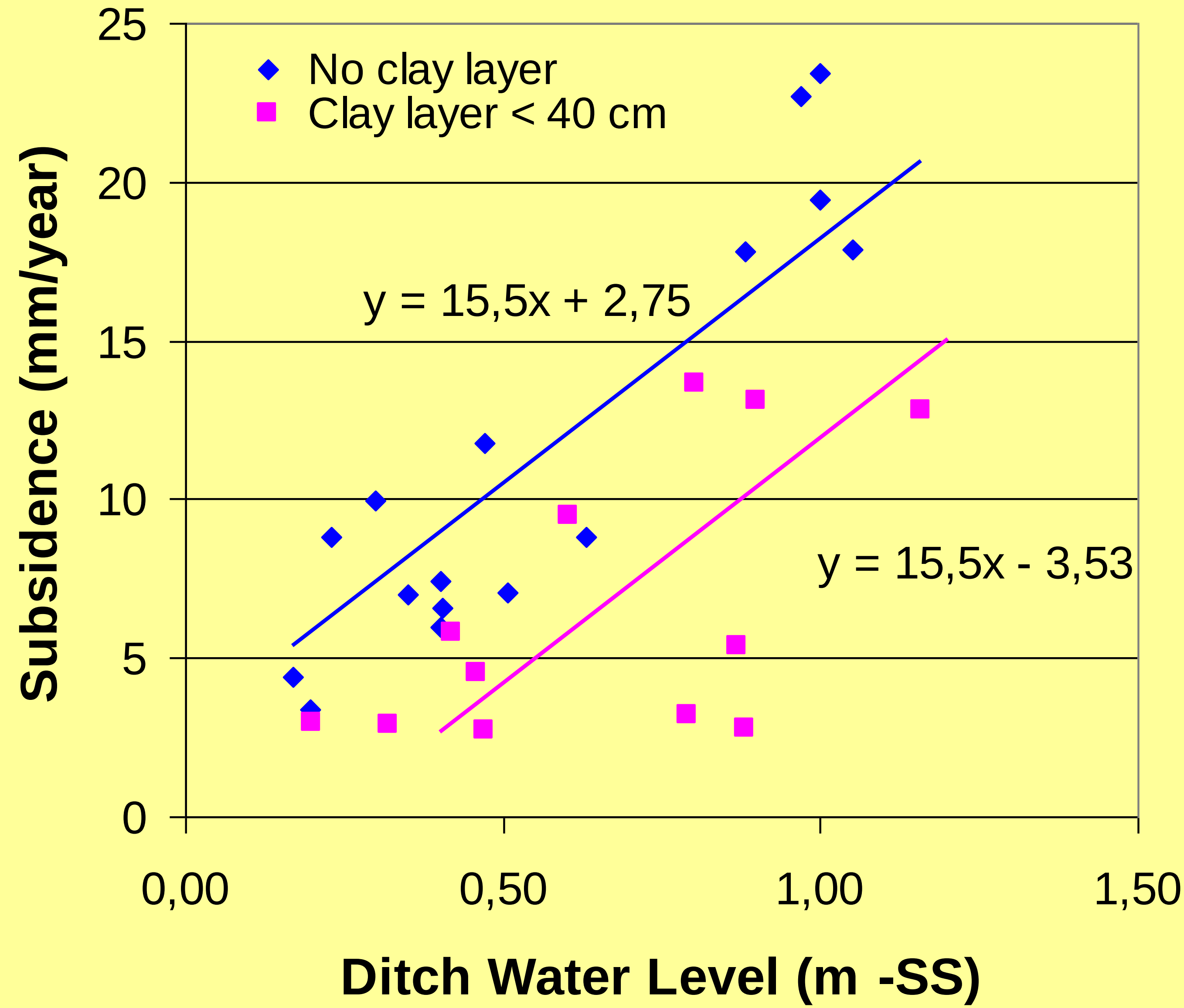
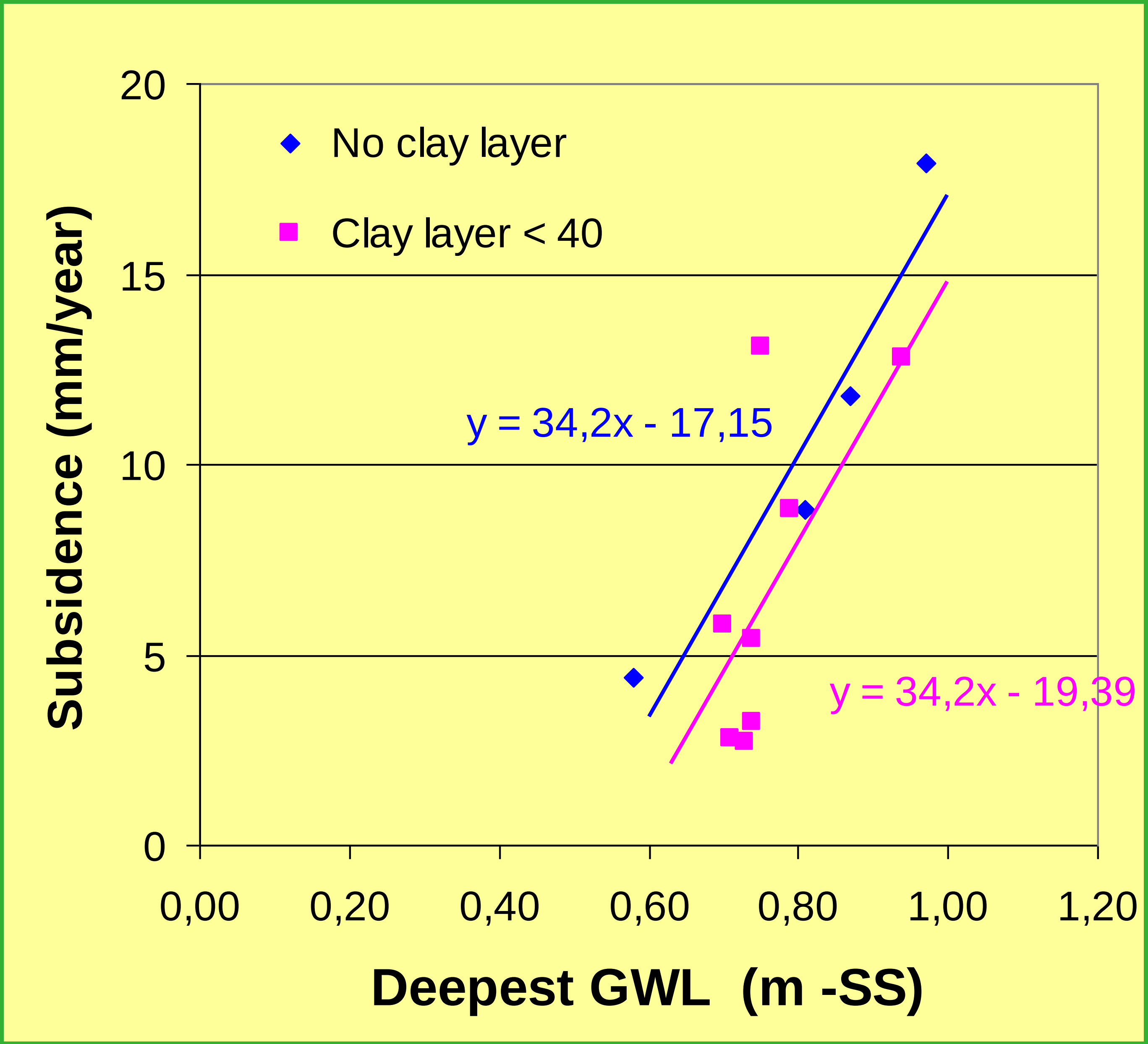
Effect clay content 0 - 30 cm on subsidence




25
20
15
10
5
0
No clay layer
Clay layer < 40 cm
y = 15,5x + 2,75
y = 15,5x - 3,53
Subsidence (mm/year)
0,00
0,50
1,00
1,50
Ditch Water Level (m -SS)



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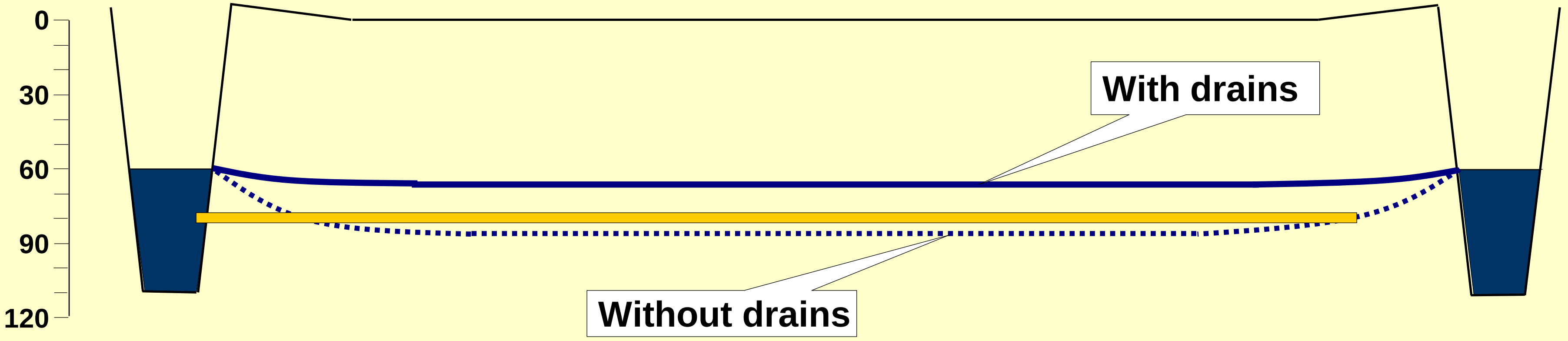
Prevention by infiltration with submerged drains

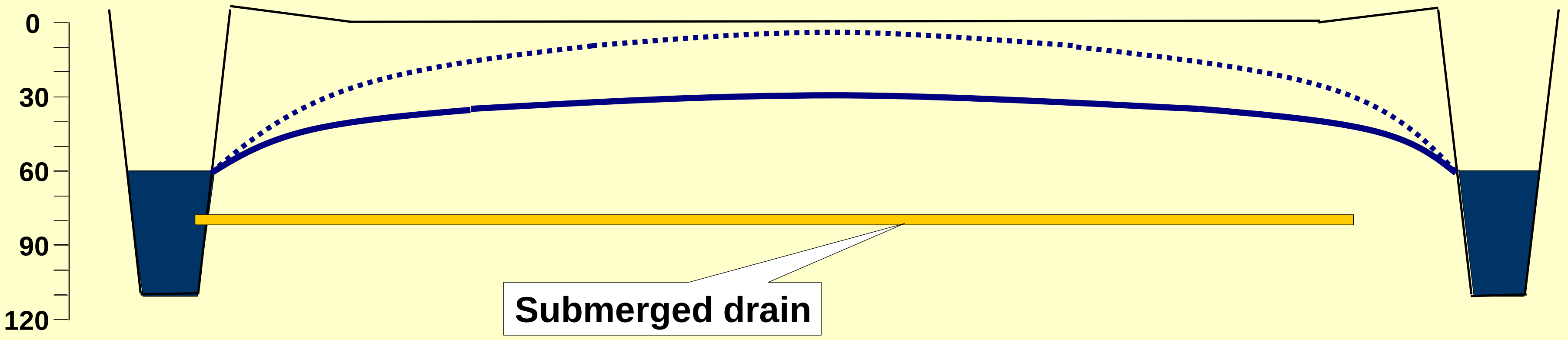
a. groundwater level in summer

cm -soil surface



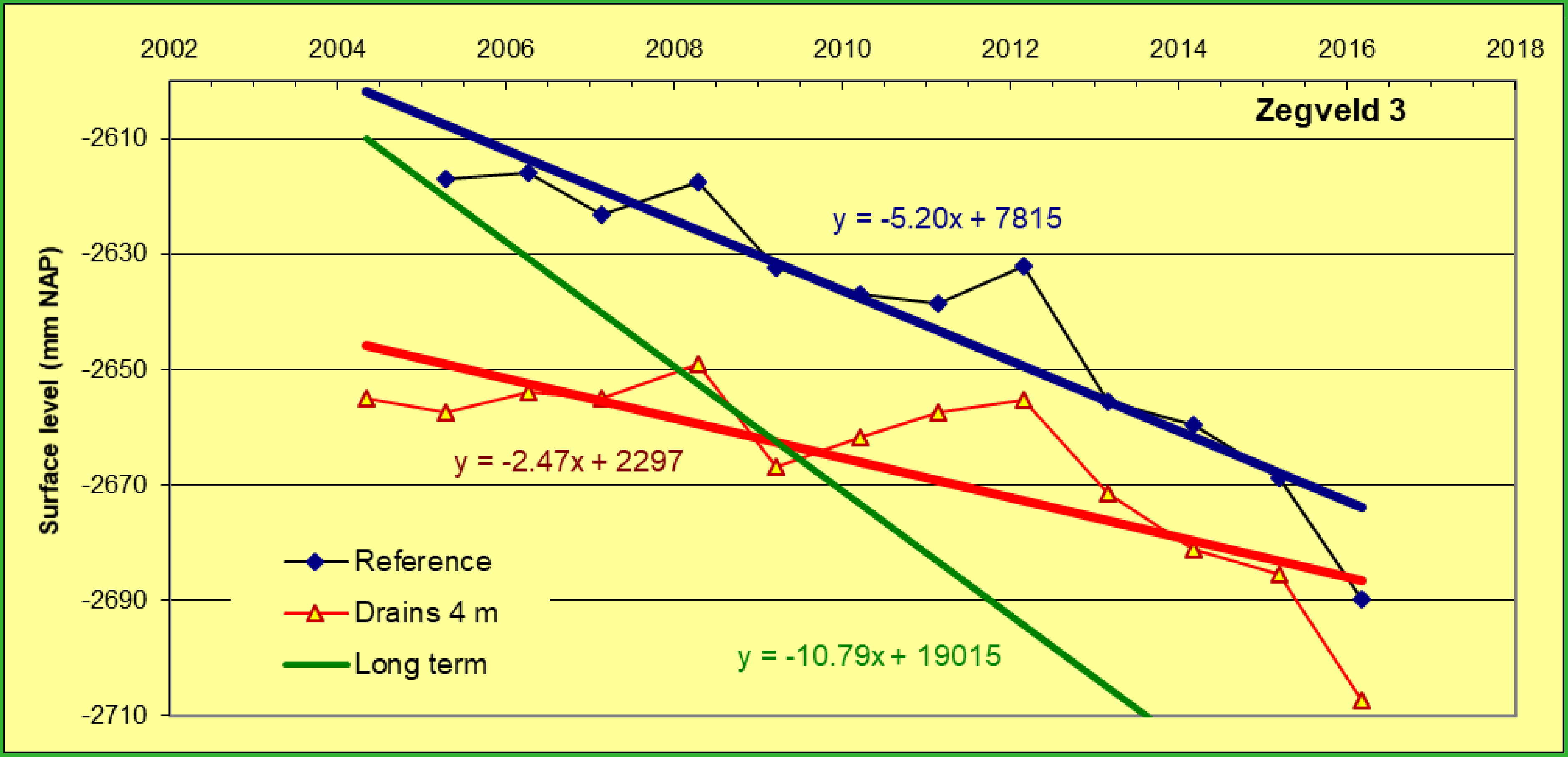
b. groundwater level in winter

cm -soil surface



Subsidence Zegveld 3, Ditch Water Level = 55 cm

(based on three cross sections)



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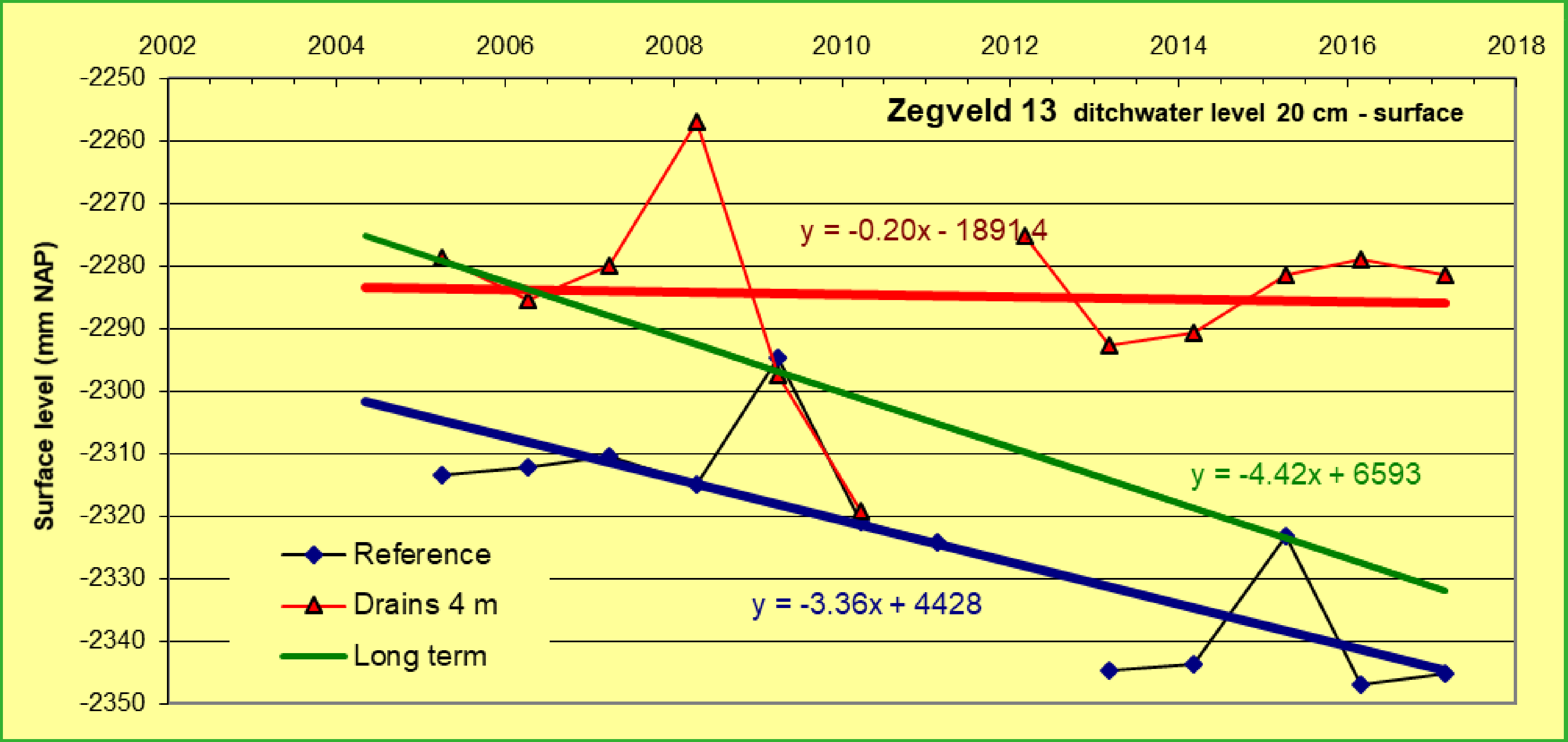
Subsidence Zegveld 13, Ditch Water Level = 20 cm (based on three cross sections)



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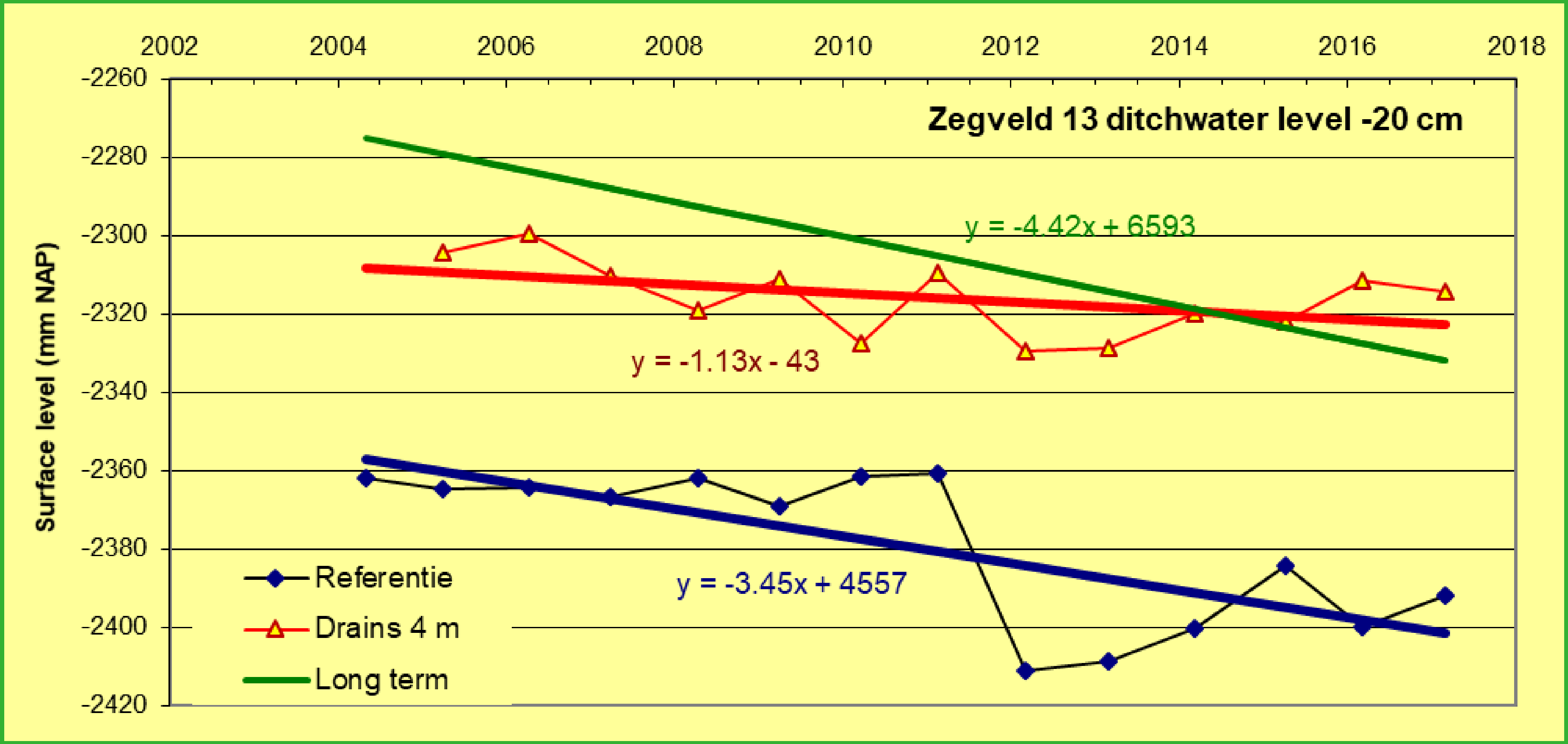
Subsidence Zegveld 13, Ditch Water Level = 20 cm (based on 8 points around reference pole)



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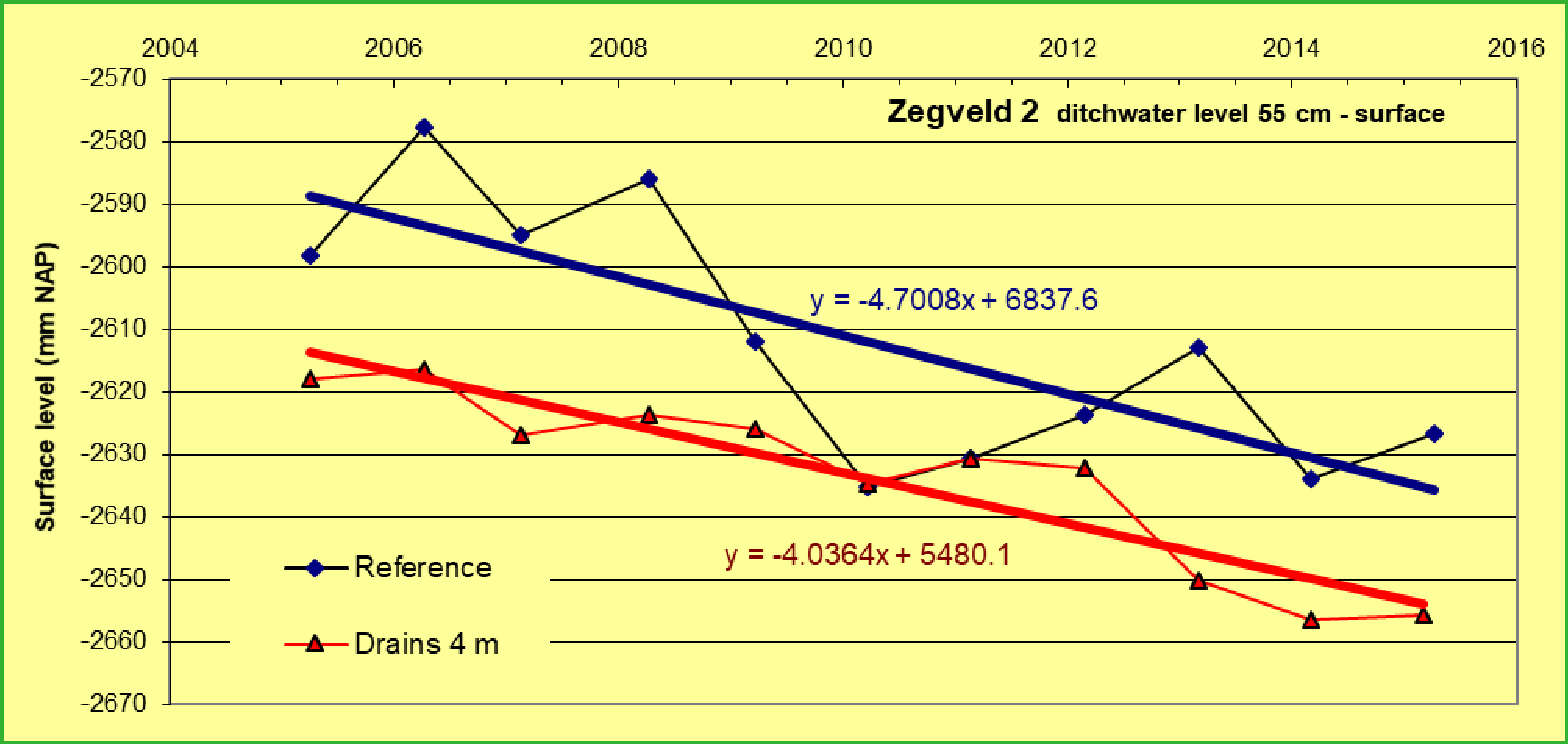
Subsidence Zegveld 2, Ditch Water Level = 55 cm



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Dairy farming (costs, yields, etc)

- Costs installation all in € 1 / m drain; € 1700 – € 2500 / ha
- Live time: 20 – 30 years
- Significant extra days with enough bearing capacity
- Yield lower due to reduced mineralization of N
- Yield higher due to better usage of manure (better nutrients efficiency)
- Less trampling of grass
- Longer grazing season
- In total a higher effective yield
- Short term: slightly cost effective. Long term: good cost effective

Results measurements and modelling

- Potentional 50% reduction of subsidence
- Measurements show 50% reduction subsidence is possible. Long periods of measurements are required (> 10 years).
- Amount of days with sufficient bearing capacity increased.
- Water quality: Nitrogen leaching the same; Phosphate leaching less; Sulphate leaching less at high ditchwater levels (40 cm) and more at low ditchwater levels (60 cm)
- Water inlet: increases per year with about 35% (= 40 mm) (reduction peat oxidation requires water!). Climate smart watermanagement can reduce this to 10%.
- Climate scenario's with models show that climate change will:
- - double the problems with peat soils at the end of this century
- - make raising ditchwater levels evermore inadequate. Infiltration via submerged drains becomes increasingly effective.

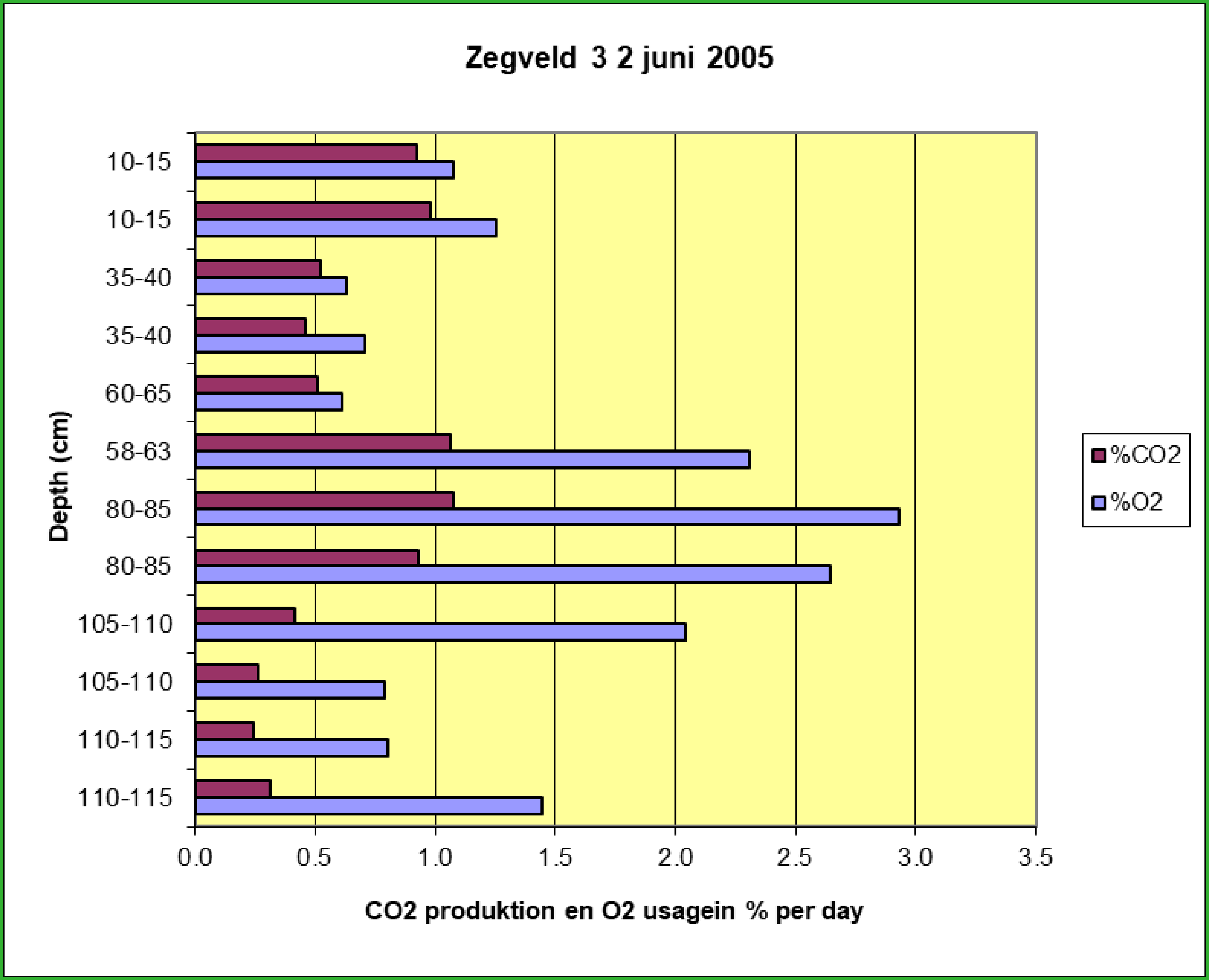
Some requirements of submerged drains:

- Highest ditchwater level farming: 30/35 cm –soil surface
- Lowest ditchwater level: 60 cm –soil surface
- Drains about 15/20 cm –ditchwater level
- Minimum diameter 6 cm; then length < 200 m
- Distance between drains 4 meters, if soil water conductivity is high, then up 6 meters
- Good installation and maintainance is very important

Conclusions

- Problems with subsidence, CO2, water quality, etc will increase in time
- Climate change will double the problems
- Adaptation and minimizing peat oxidation is urgently needed => more measurents > 3 years
- A strong reduction of subsidence and GHG emissions is potentially possible by using submerged drains
- Conservation of peat soils requires WATER
- Submerged drains are a **water** efficiënt solution to conserve peat soils
- Submerged drains can be a very **cost** efficiënt solution

Use of O2 and production of CO2 of peat samples



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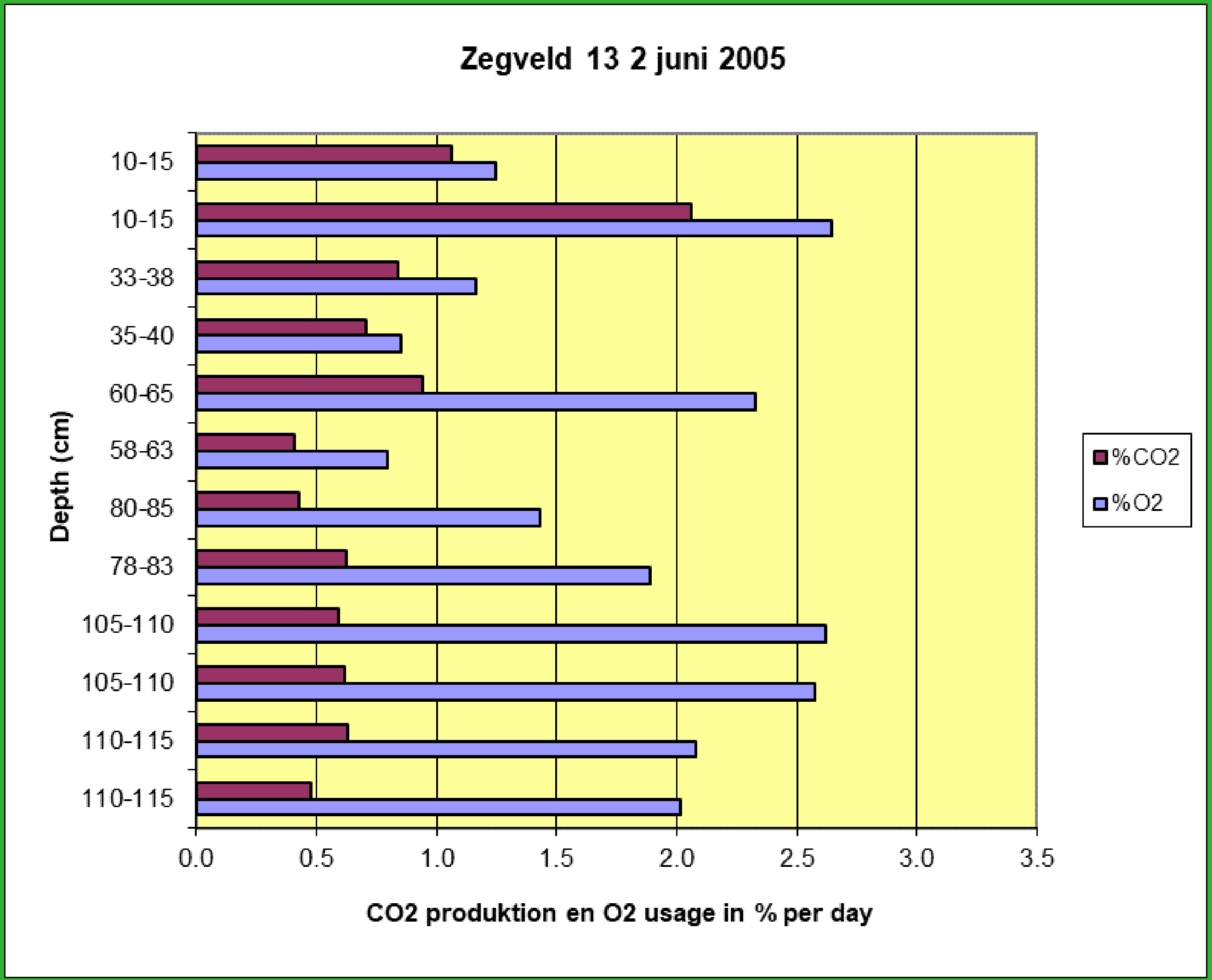
Use of O2 and production of CO2 of peat samples



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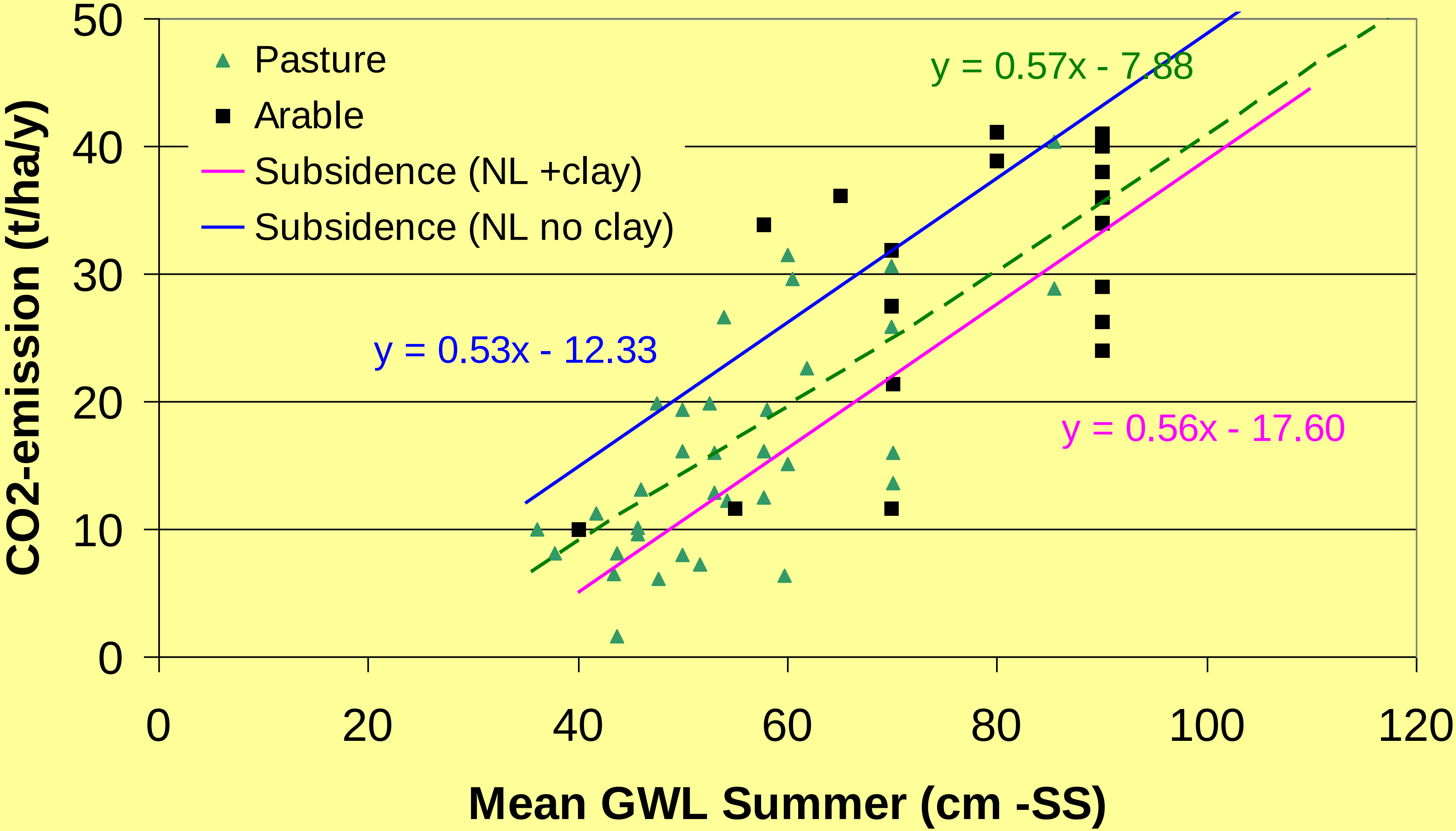
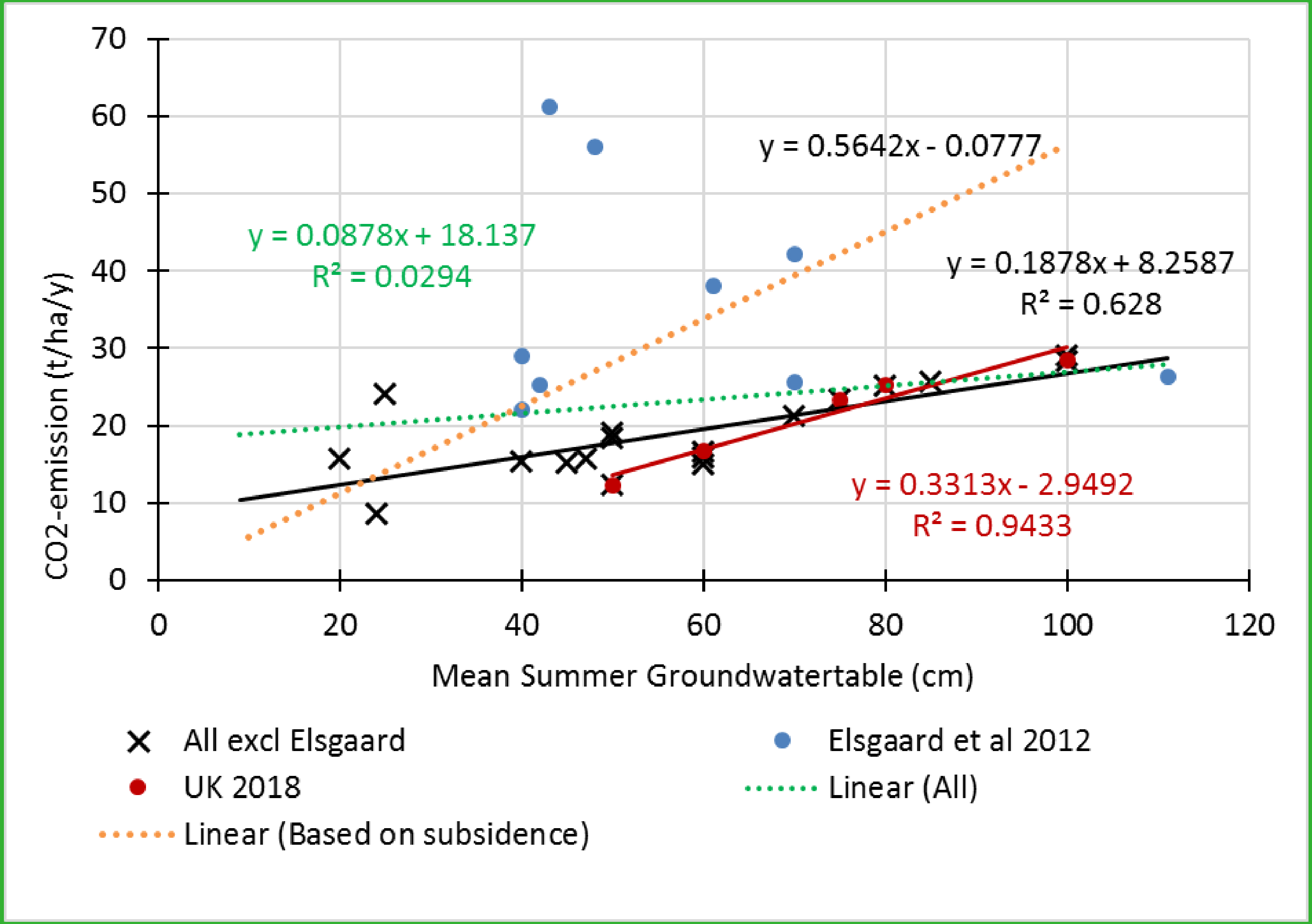
Comparison with values in literature



Mean Summer Groundwatertable and CO2-emissions



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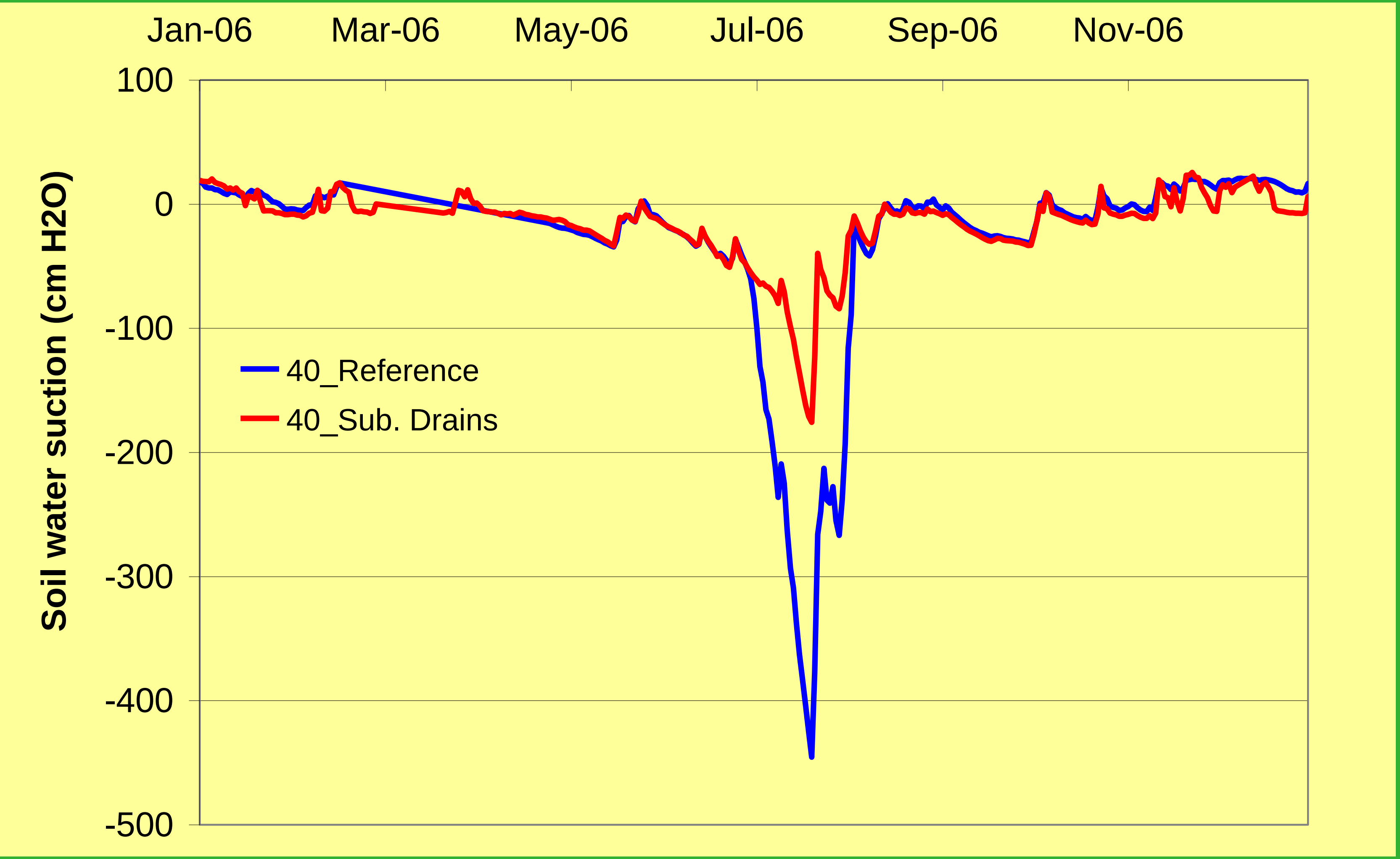
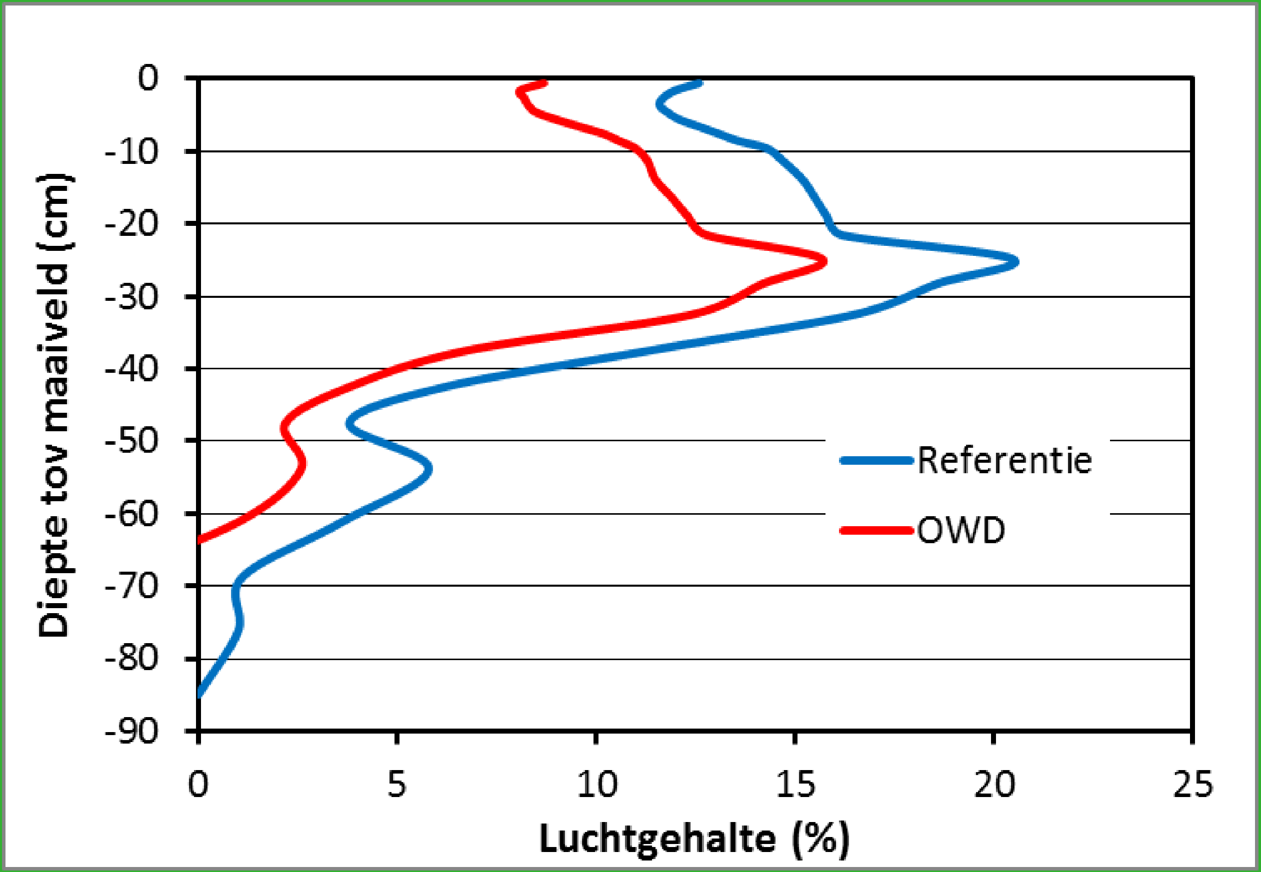
Soilwater suction at 40 cm depth Zegveld 3 (ditchwater level -55 cm)



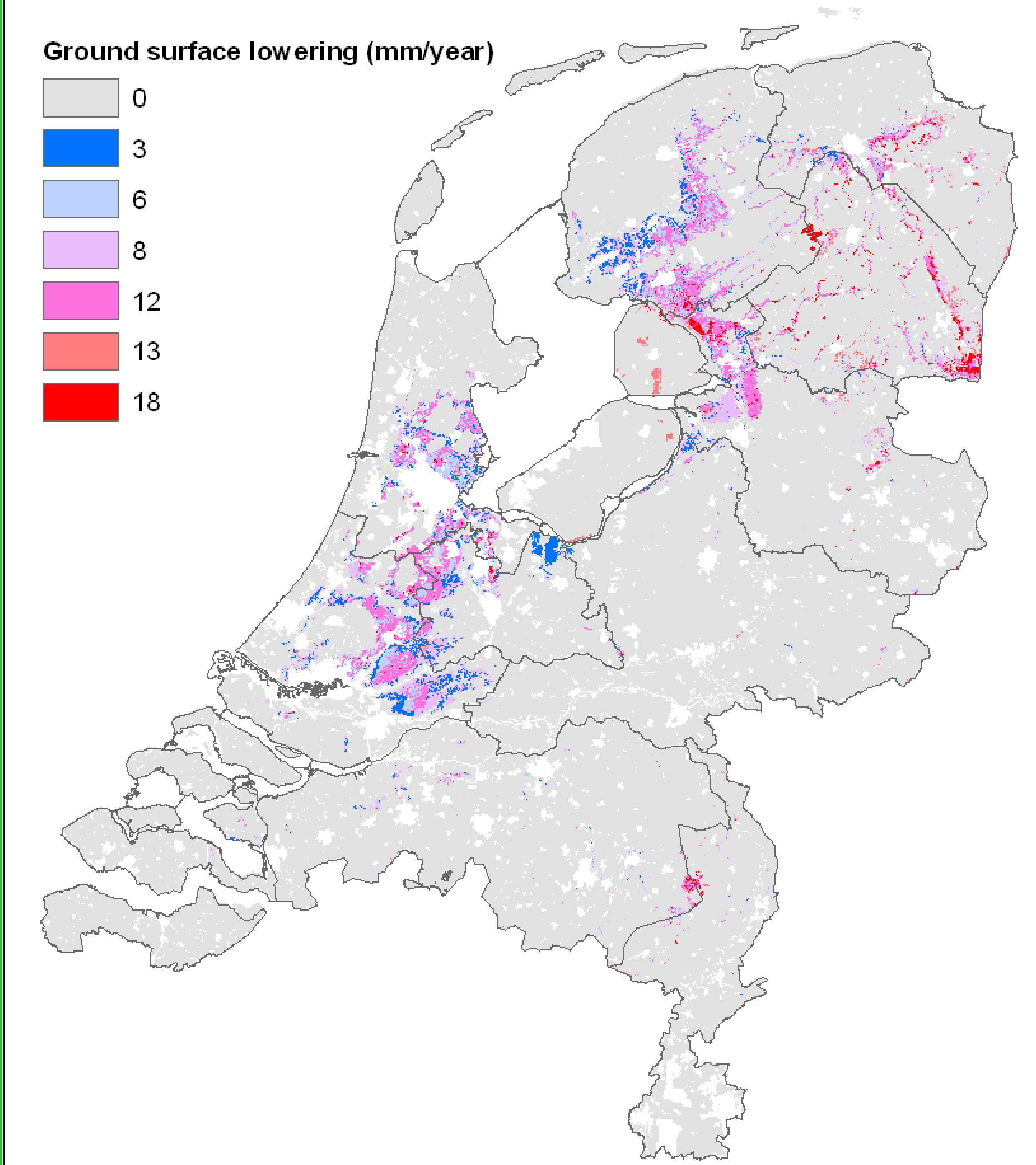
Volumepercentage luchtgevulde porien Zegveld 3 (2003)



Problem: Degradation of peat soils by oxidation

- Subsidence (NL: 0 – 2.5 cm per year)
- Damage to buildings and infra structure
- Increasing costs of water management
- Drainage of nature reserves to lowered agricultural land
- Water pollution
- Green House Gas emissions (NL: 2 – 3 % total CO_2)
- Loss of peat soils (NL: 2 % per year)

Subsidence peat soils calculated from mean deepest groundwater levels (mm/year)



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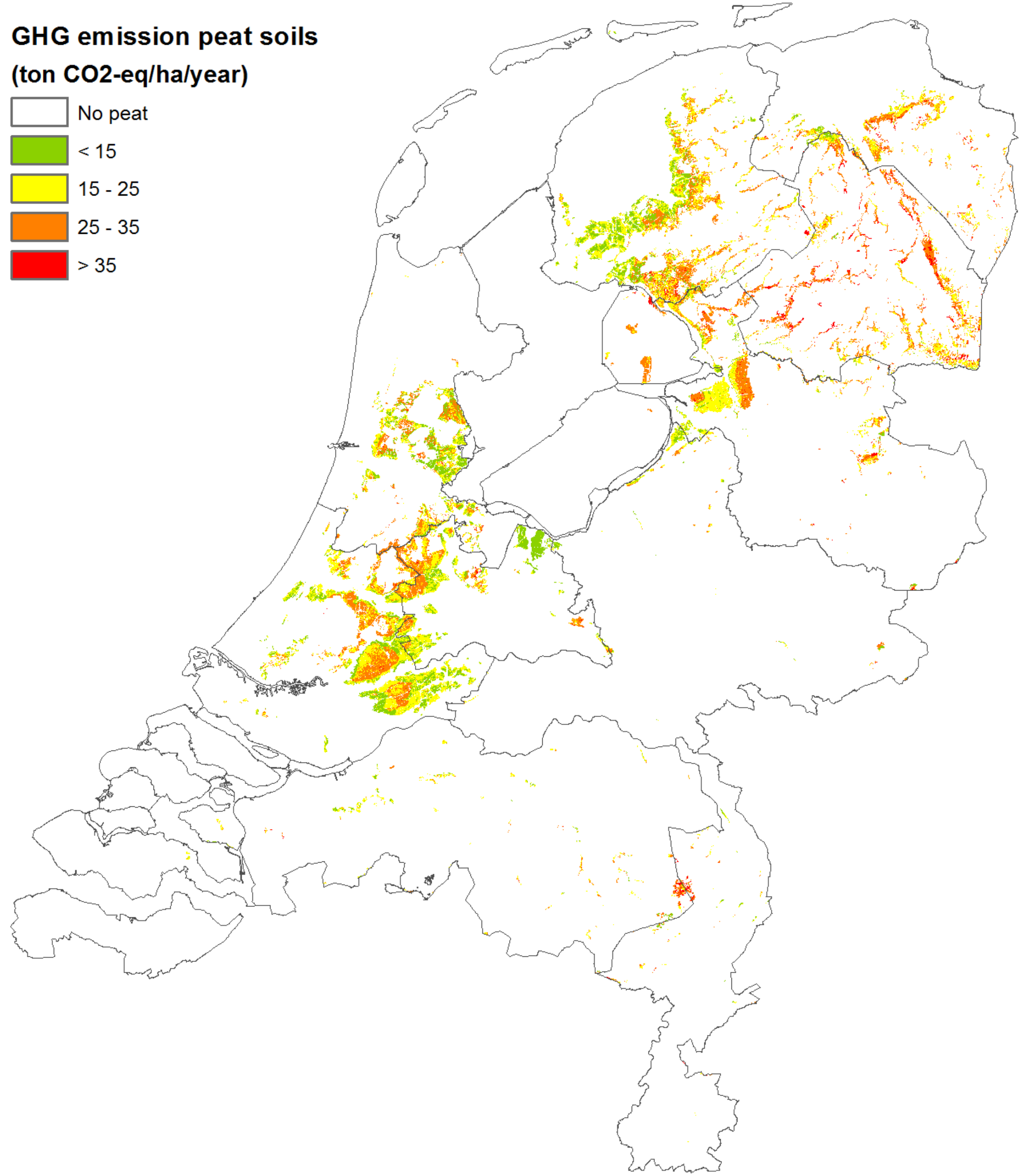
CO_2-eq emission peat soils (ton CO_2-eq per year)



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CO_2 and N_2O emissions Netherlands in CO_2 eq

CO_2 equivalents	Emission in Mton CO_2
CO_2	4.24
N_2O	0.51
Total	4.76

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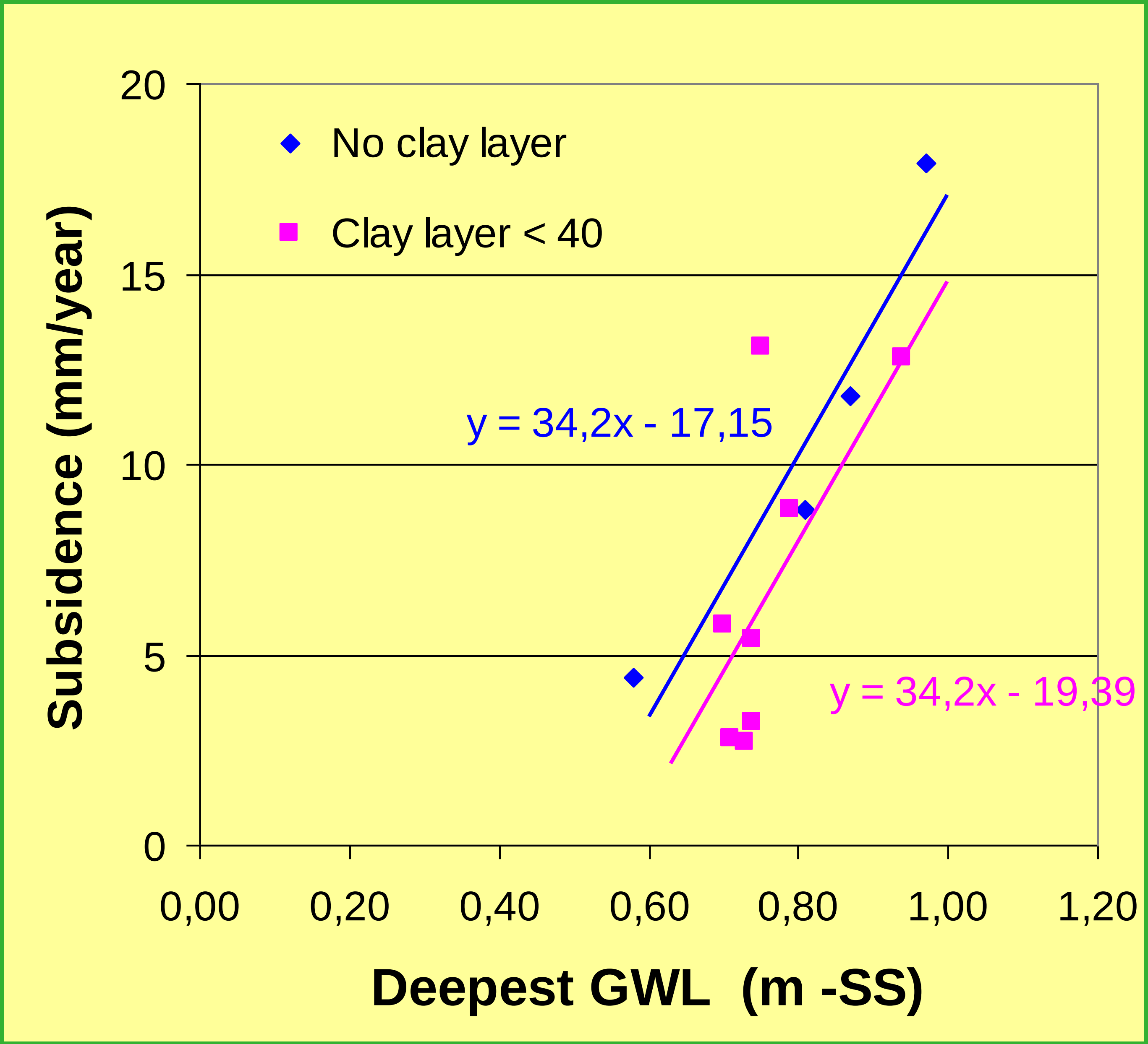

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Installation submerged drains

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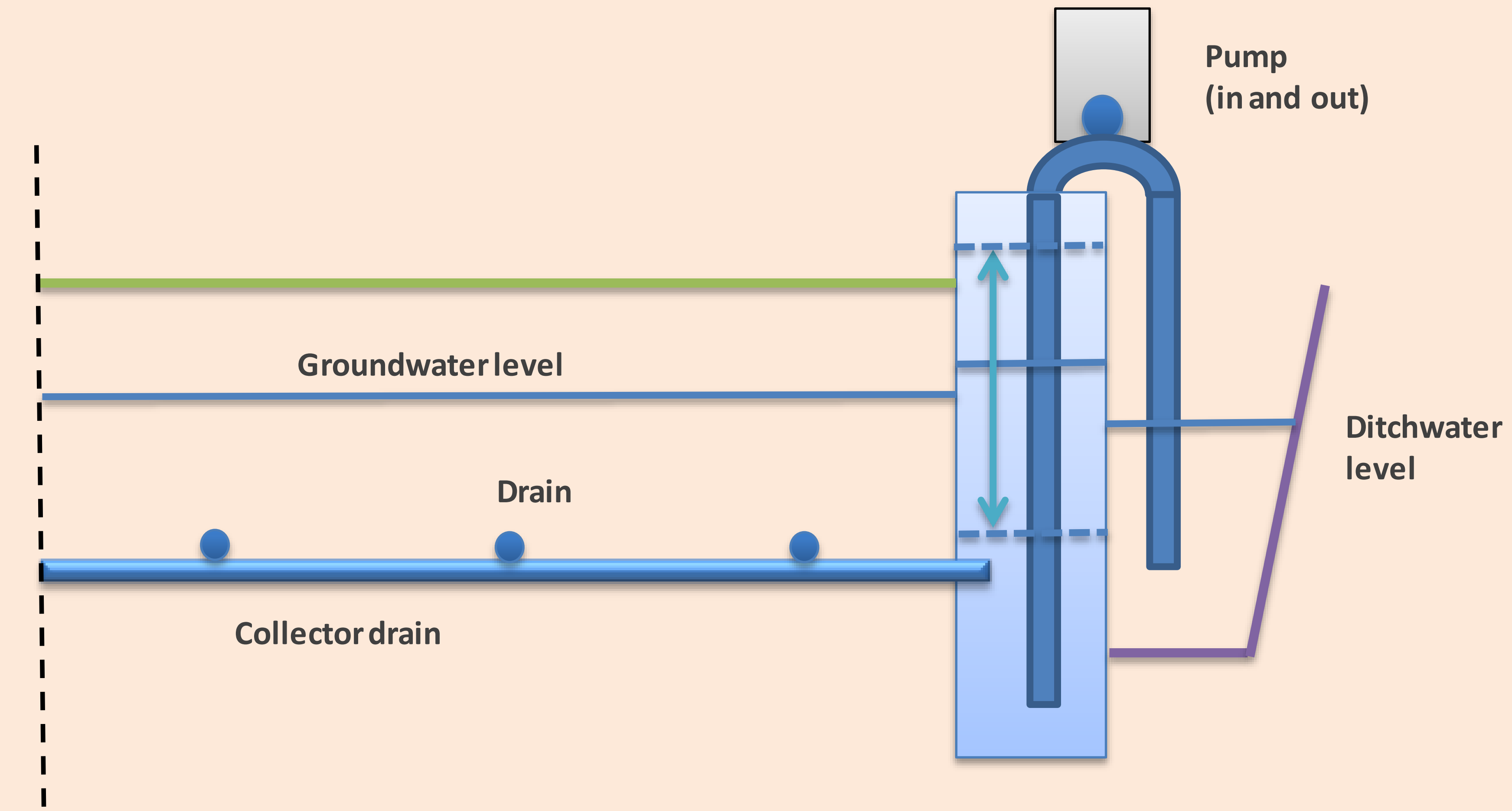
Next generation



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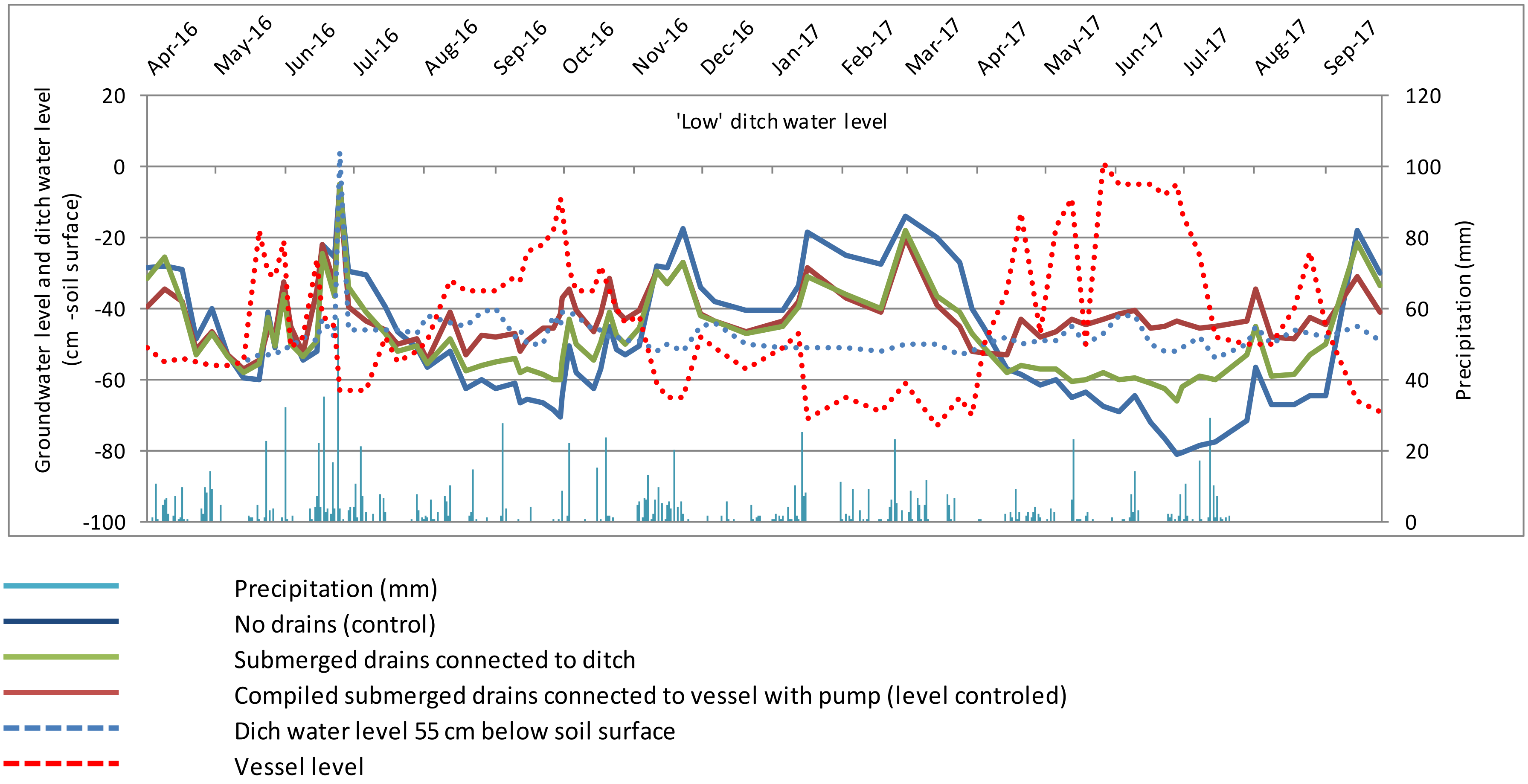
Ditch water level 55 cm below surface



Where to find:

- Van den Akker et al., 2015. Decline in organic matter in peat soils. In: *Stolte et al., 2015. Soil in Europe: Threats, functions and ecosystem services.* JRC – report.
- http://eusoils.jrc.ec.europa.eu/
- http://www.recare-project.eu/
- www.caos-project.eu/

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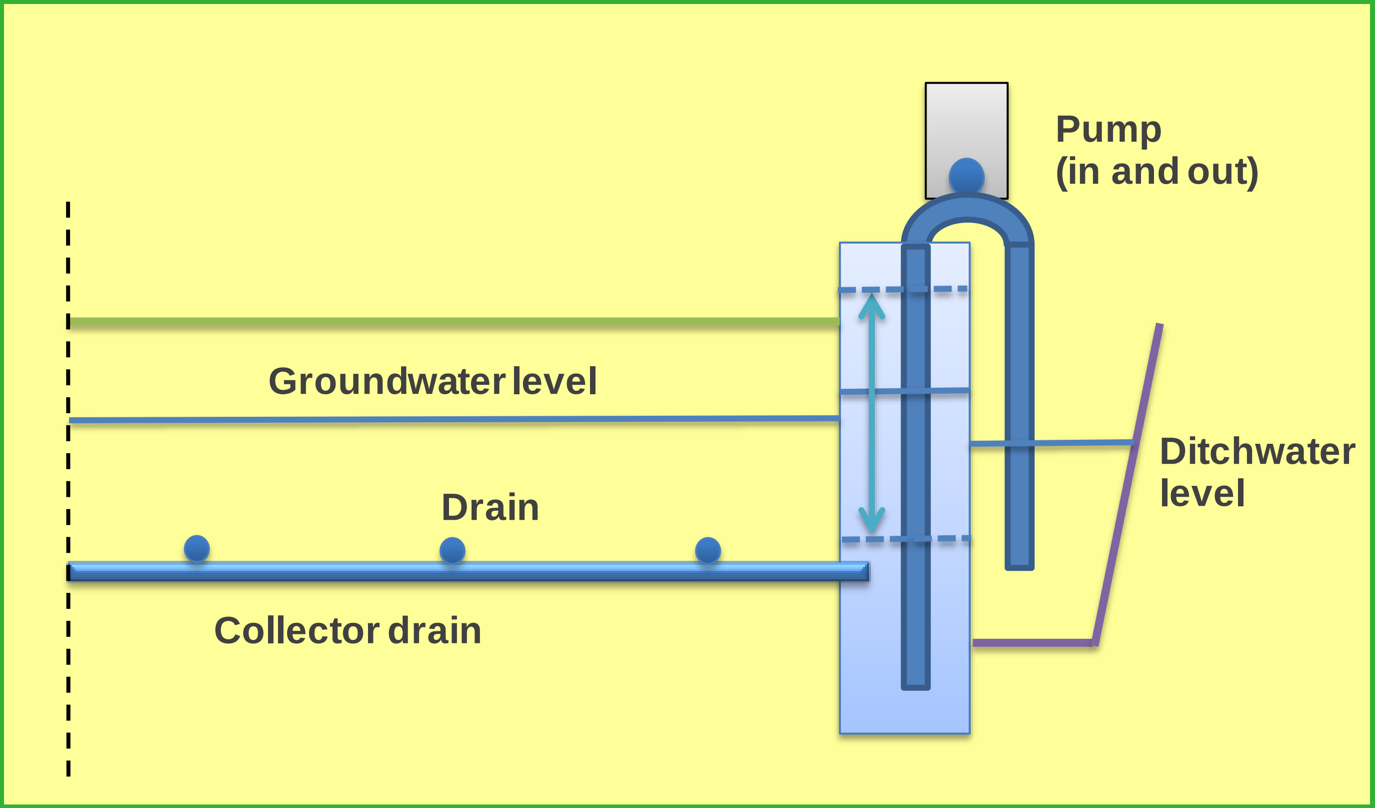
Next generation

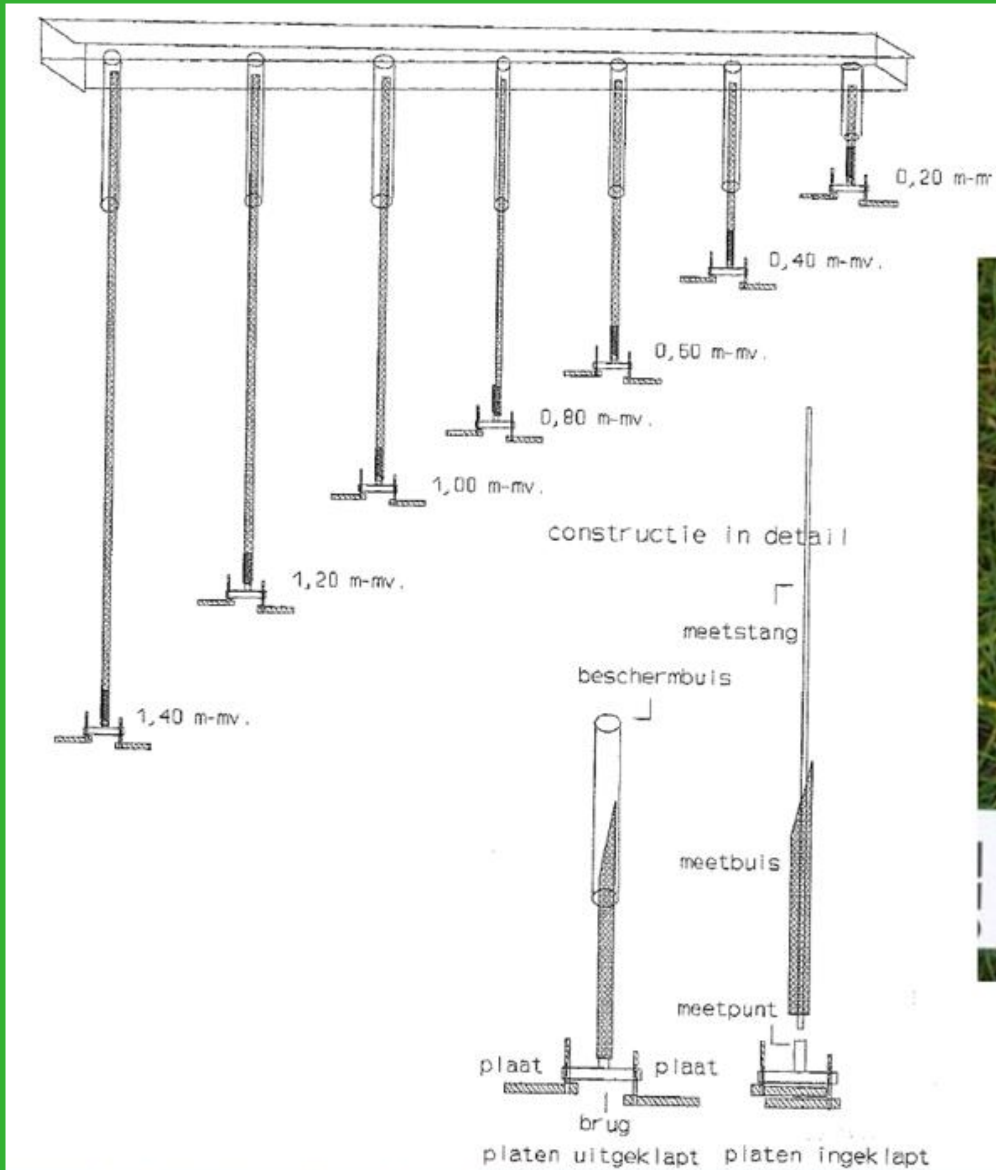


Field experiment Zegveld

Period: 2004 - 2009

Treatments:

- High (20 cm –surface) and low (55 cm -surface) ditchwater level
- Tube drainage diameter 6 cm
- Drain distances: 4, 8 and 12 m


0,20 m-mv
0,40 m-mv.
0,60 m-mv.
0,80 m-mv.
1,00 m-mv.
1,20 m-mv.
1,40 m-mv.
constructie in detail
meetstang
beschermbuis
meetbuis
meetpunt
plaat
plaat
brug
platen uitgeklapt
platen ingeklapt

Country	Agricultural area km^2	Crop area km^2	Grass area km^2	CO_2 - C Mt / a	CO_2 Mt / a	N_2O CO_2 eq Mt / a	Total CO_2 eq Mt / a
Member states of the EU							
Belgium	252	25	227	0.15	0.55	0.05	0.60
Denmark	184	0	184	0.10	0.37	0.03	0.40
Estonia	840	0	840	0.46	1.68	0.14	1.82
Finland	2930	0	2930	1.60	5.86	0.49	6.35
Germany	14133	4947	9186	10.41	38.16	3.18	41.33
Ireland	2136 [a]	896	1240	1.65	6.06	0.50	6.57
Italy	90	90	0	0.10	0.36	0.03	0.39
Latvia	1000 [a]	1000	0	1.09	4.00	0.33	4.33
Lithuania	1900 [b]	1357	543	1.78	6.51	0.54	7.06
Netherlands	2050 [c]	75	1975	1.16	4.25	0.35	4.60
Poland	7600	55	7545	4.18	15.31	1.27	16.58
Sweden	2500 [d]	630	1870	1.71	6.26	0.52	6.78
UK	392	392	0	0.43	1.57	0.13	1.70
Total EU	36007	9467	26540	24.80	90.95	7.57	98.51

Schils et al. 2008

From subsidence to CO_2 emission

$$CO_{2,em} = F * S_{mv} \cdot \rho_{so} \cdot fr_{OS} \cdot fr_C \cdot \frac{44}{12} \cdot 10^4$$

where:

$CO_{2,em}$ = CO_2 emission (kg CO_2 ha yr^{-1})

F = fraction subsidence oxidation

S_{mv} = subsidence (m yr^{-1})

ρ_{so} = bulk density peat (kg m^{-3})

fr_{OS} = organic matter fraction peat (-)

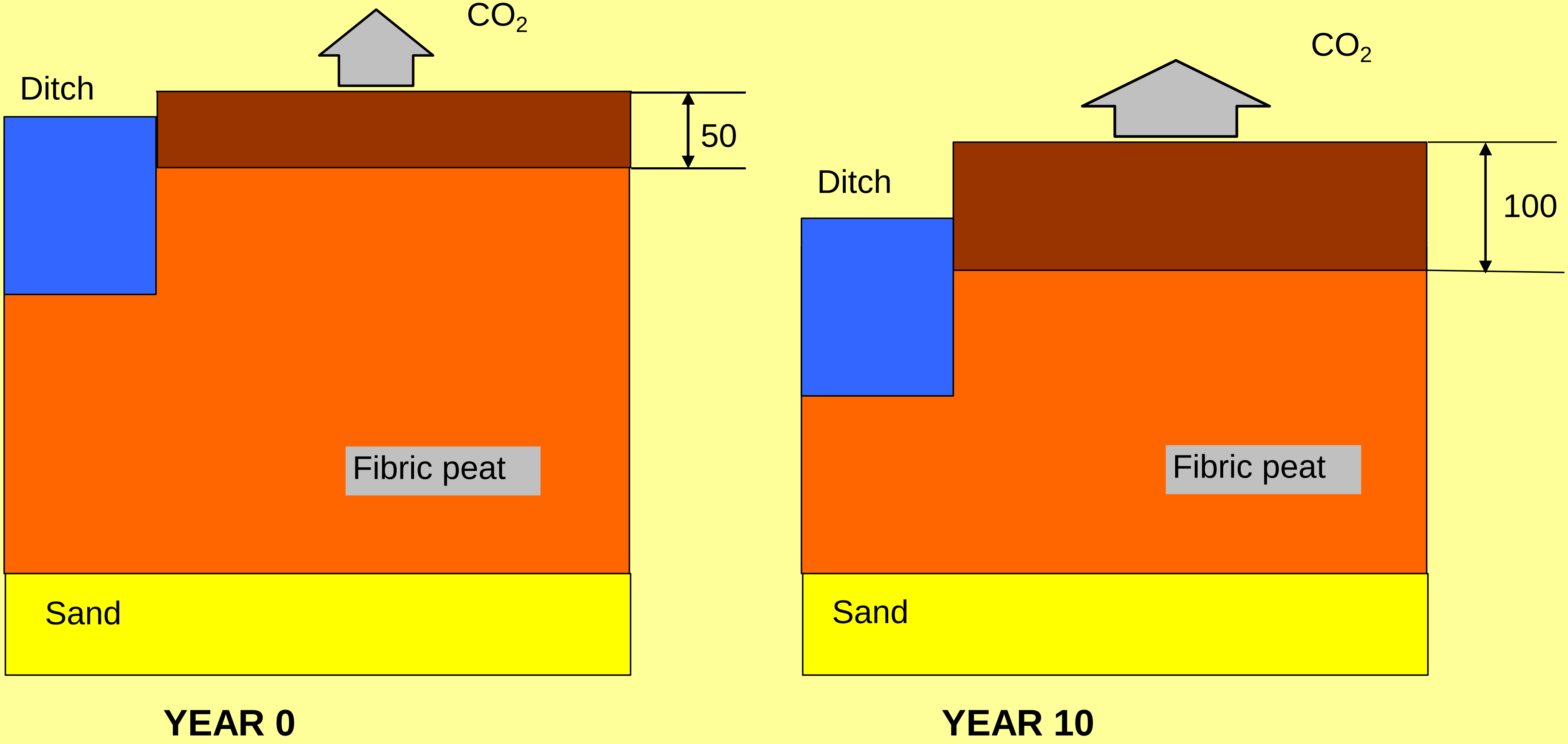
fr_C = carbon fraction organic matter (-)

From subsidence to CO_2 emission (in literature)

The upper 20 – 30 cm peat is considered

$CO_{2,em}$	= CO_2 emission (kg CO_2 ha yr^{-1})	
F	= fraction subsidence oxidation	= 0.33 – 0.67
S_{mv}	= subsidence (m yr^{-1})	
ρ_{so}	= bulk density peat (kg m^{-3})	= 200 - 400
fr_{OS}	= organic matter fraction peat (-)	= 0.6 – 0.85
fr_C	= carbon fraction organic matter (-)	= 0.5 - 0.55

From subsidence to CO_2 emission (own approach)



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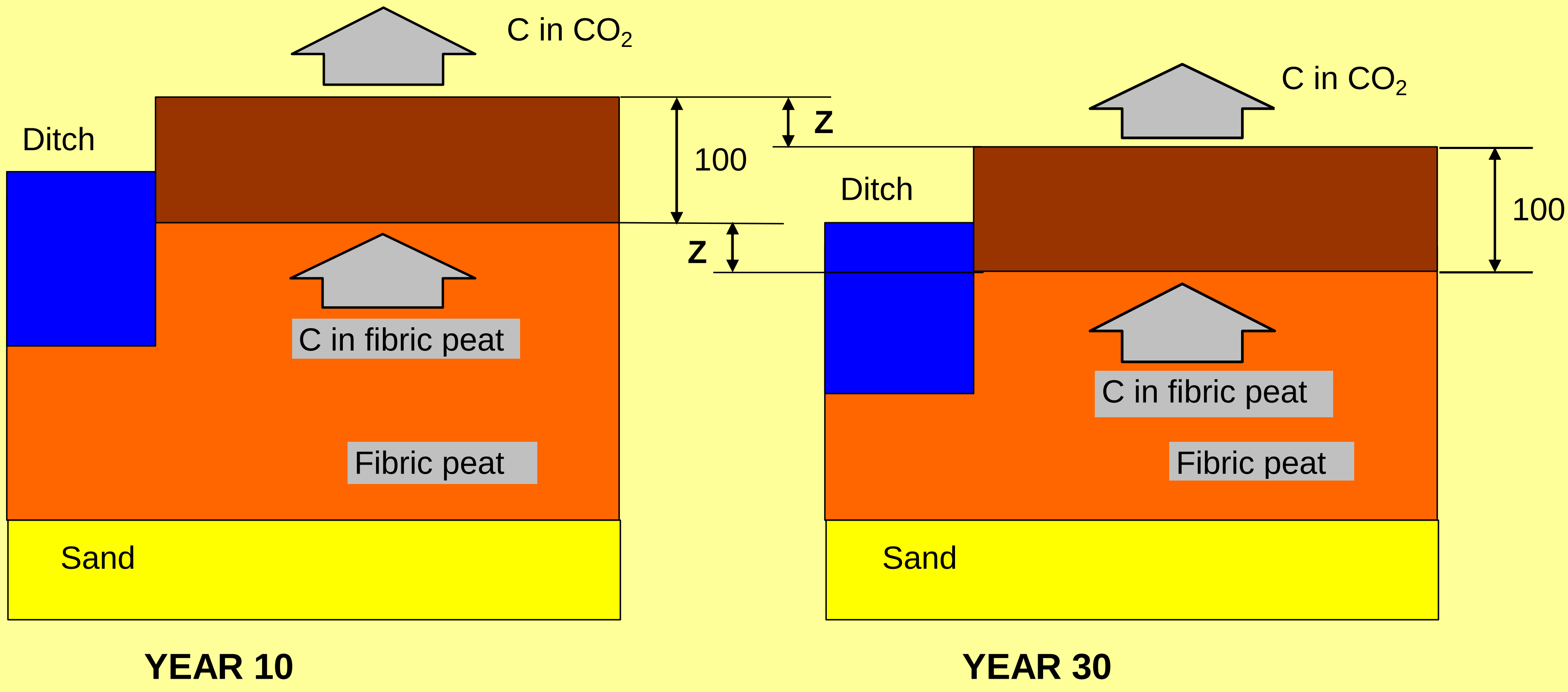
Mass balance: C_in = C_out



From subsidence to CO_2 emission (own approach)

$$CO_{2,em} = F * S_{mv} \cdot \rho_{so} \cdot fr_{OS} \cdot fr_C \cdot \frac{44}{12} \cdot 10^4$$

<u>The fabric peat at app. 100 cm depth is considered</u>

$CO_{2,em}$	= CO_2 emission (kg CO_2 ha yr^{-1})	
F	= fraction subsidence oxidation	= 1
S_{mv}	= subsidence (m yr^{-1})	
ρ_{so}	= bulk density fibric peat (kg m^{-3})	= 140
fr_{OS}	= organic matter fraction peat (-)	= 0.8
fr_C	= carbon fraction organic matter (-)	= 0.55

Comparison (example Zegveld)

		Fabric	Toplayer
$CO_{2,em}$	= CO_2 emission (kg CO_2 ha yr^{-1})	= 2259	2259
F	= fraction subsidence oxidation	= 1	0.53
S_{mv}	= subsidence (m yr^{-1})	= 0.001	0.001
ρ_{so}	= bulk density peat (kg m^{-3})	= 140	358
fr_{OS}	= organic matter fraction peat (-)	= 0.8	0.58
fr_C	= carbon fraction organic matter (-)	= 0.55	0.55

1 mm subsidence = 2259 kg CO_2 ha yr^{-1}

Comparison with values in literature