

# Invloed van windsleuven op regenwater, bodemvocht en grondwater



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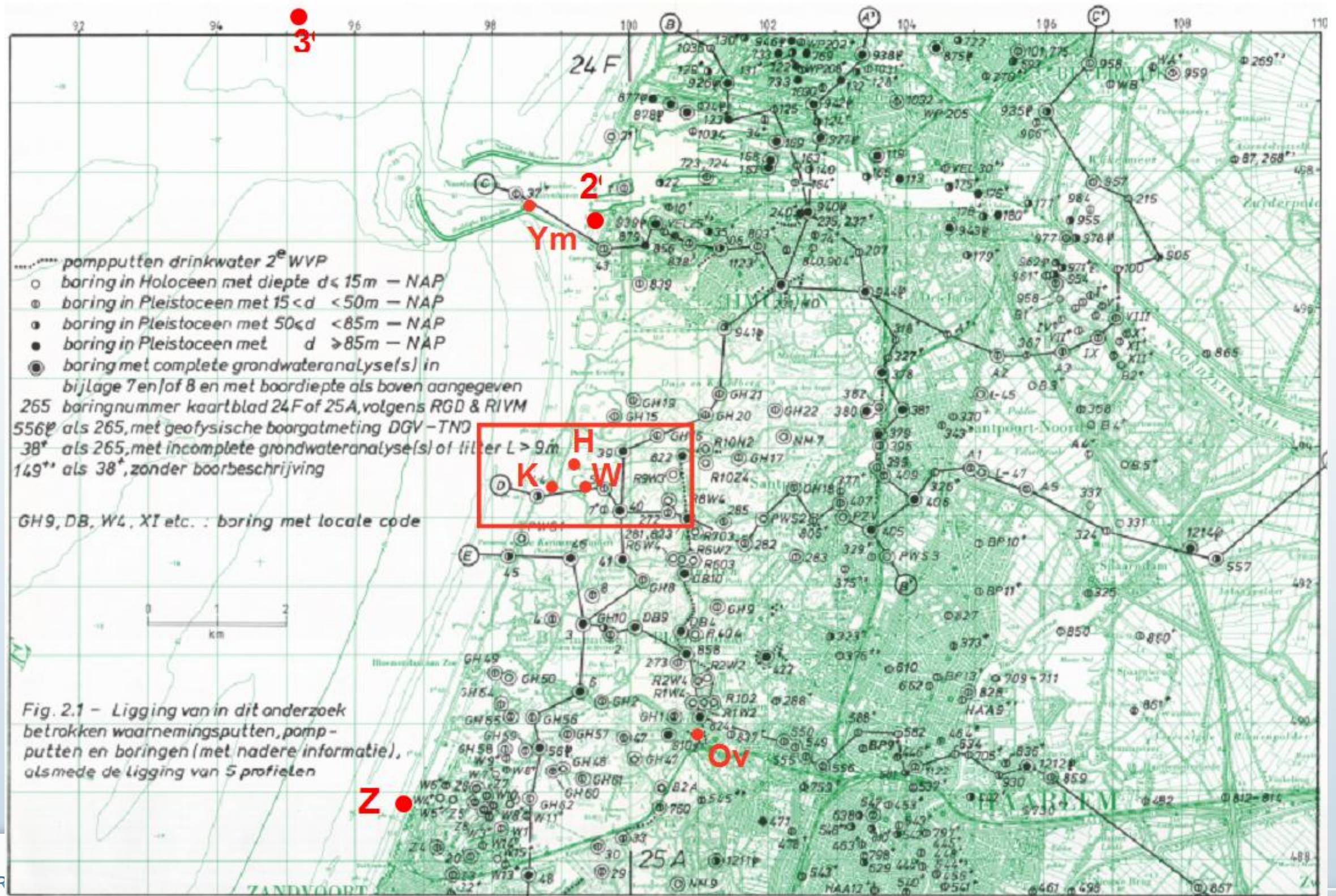


**Kattendel in:  
mei 2011,  
maart 2013,  
nov. 2013,  
april 2014,  
juli 2015.**



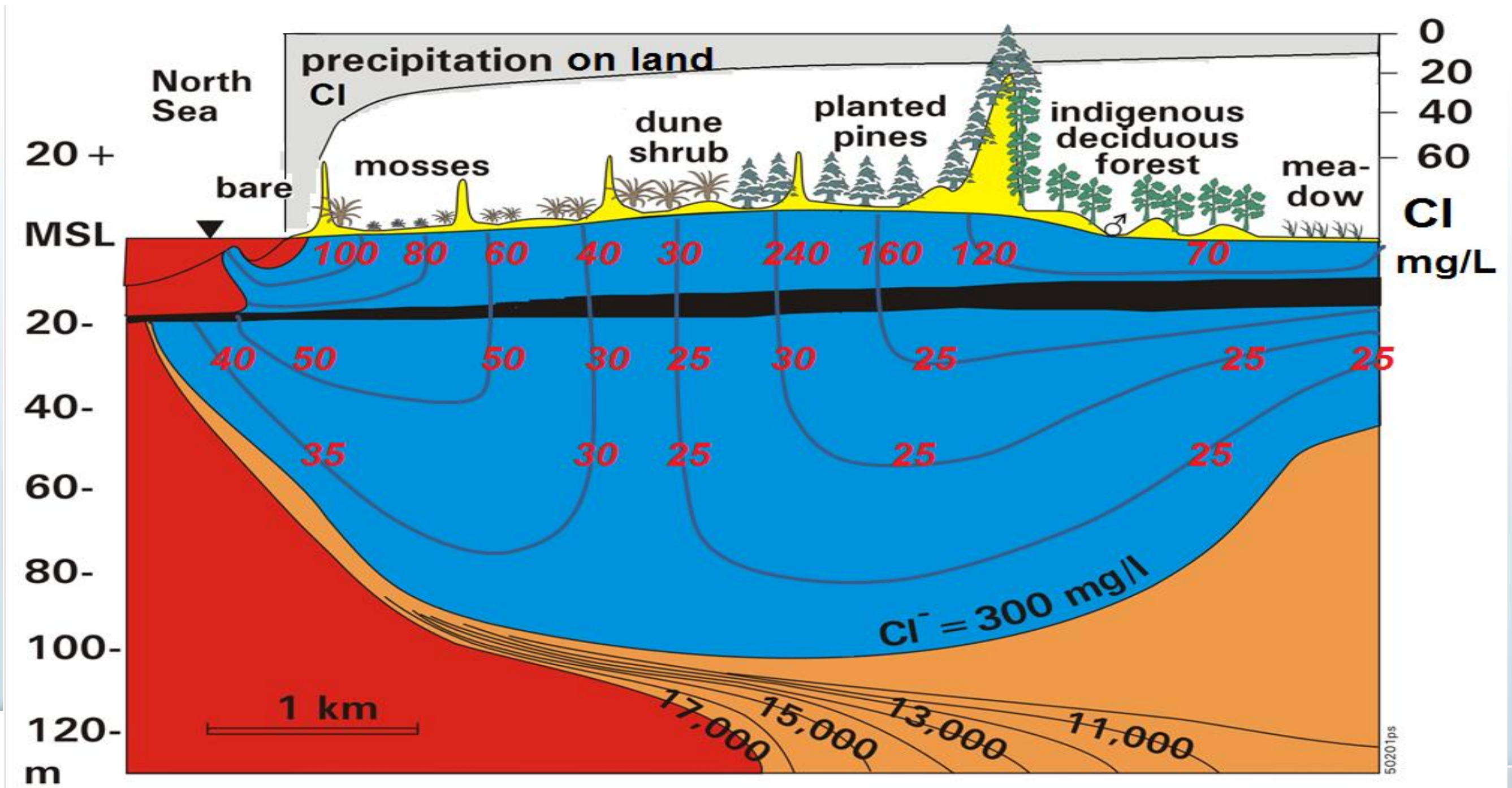


**Studiegebied**  
**+ KNMI**  
**windmast**  
**Ymuiden**  
**(Ym) +**  
**KNMI**  
**regenstation**  
**Overveen**  
**(Ov) + RWS**  
**zeewaterst.**  
**(Z, 2, 3)**





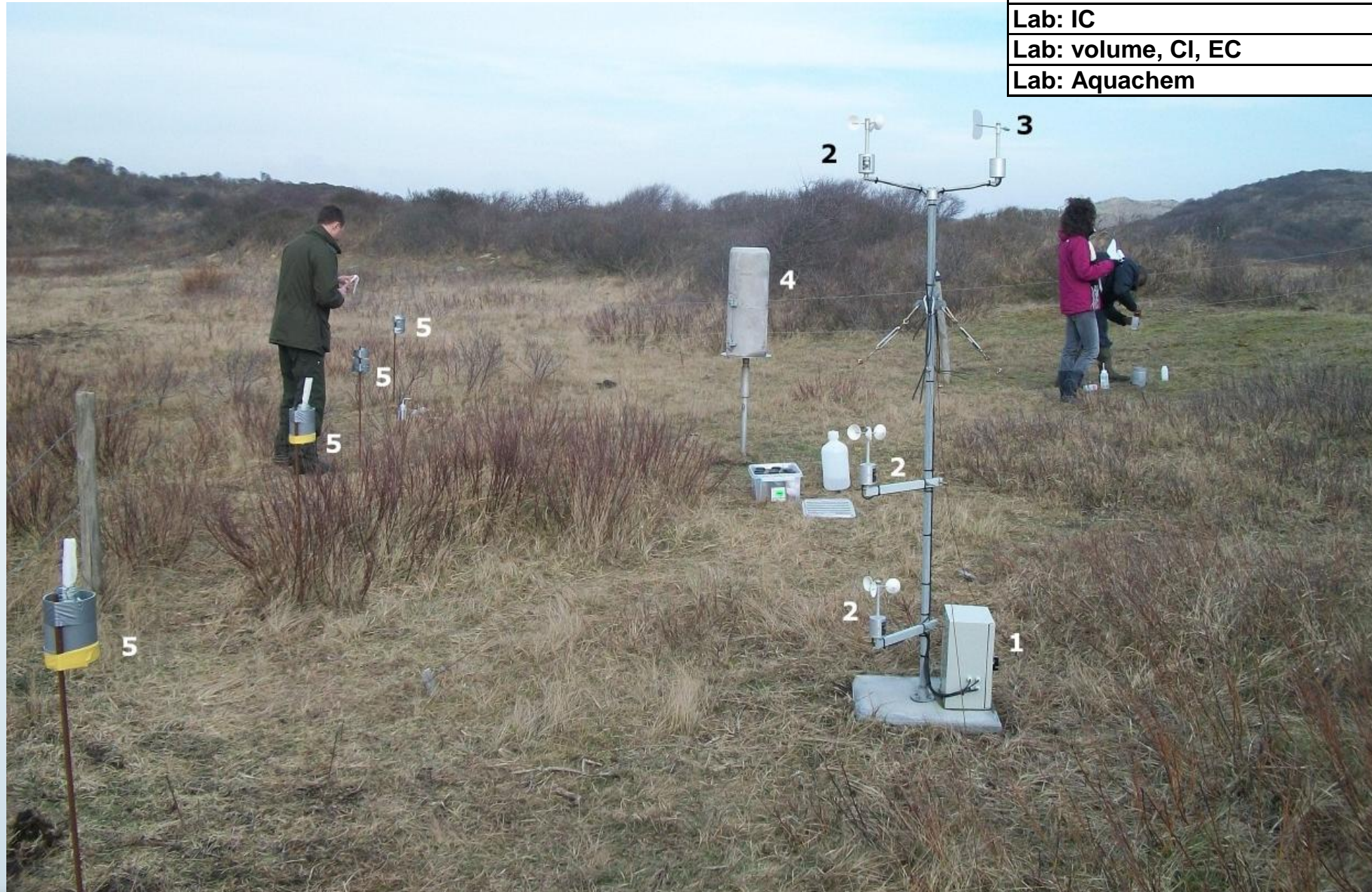
# Het grote beeld van Chloride in duin- en geïnfiltrieerd zeewater





# Er is eea gemeten

Analyses	Parameters
Field: volume	volume
Field: electrode, titration	pH, EC, HCO <sub>3</sub>
Lab: electrode, titration, weight	pH, EC, HCO <sub>3</sub> , volume
Lab: ICP-OES: major elements	Na, K, Ca, Mg, Fe, Mn, SiO <sub>2</sub> , S-tot, PO <sub>4</sub> -tot
Trace elements 1	Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, Sr, V, Zn
Trace elements 2	Ag, Eu, Ho, La, Sc, Tl, Yb
Lab: IC	Cl, SO <sub>4</sub> , NO <sub>3</sub> , NO <sub>2</sub> , PO <sub>4</sub> , F, Br
Lab: volume, Cl, EC	volume, Cl, EC
Lab: Aquachem	NH <sub>4</sub> , HCO <sub>3</sub>



**Periode sept. 2010 – juli  
2015:**

**1434 x Regenwater**

**79 x Doorval**

**950 x Bodemvocht**

**598 x Grondwater**

**m.m.v.**

**21 VU-studenten**

**hydrologie**



	<b>KB1, WB2, WA</b>	<b>Permanent VU-collector</b>
	<b>VU-X</b>	<b>Satellite VU-collector, operational since March 13, 2012</b>
	<b>VU-X.2</b>	<b>Satellite VU-collector, moved from X to X.2, operational since April 11 / May 8, 2012</b>

WA  
WB2

**Wieringen**

**Kattendel**



194 m

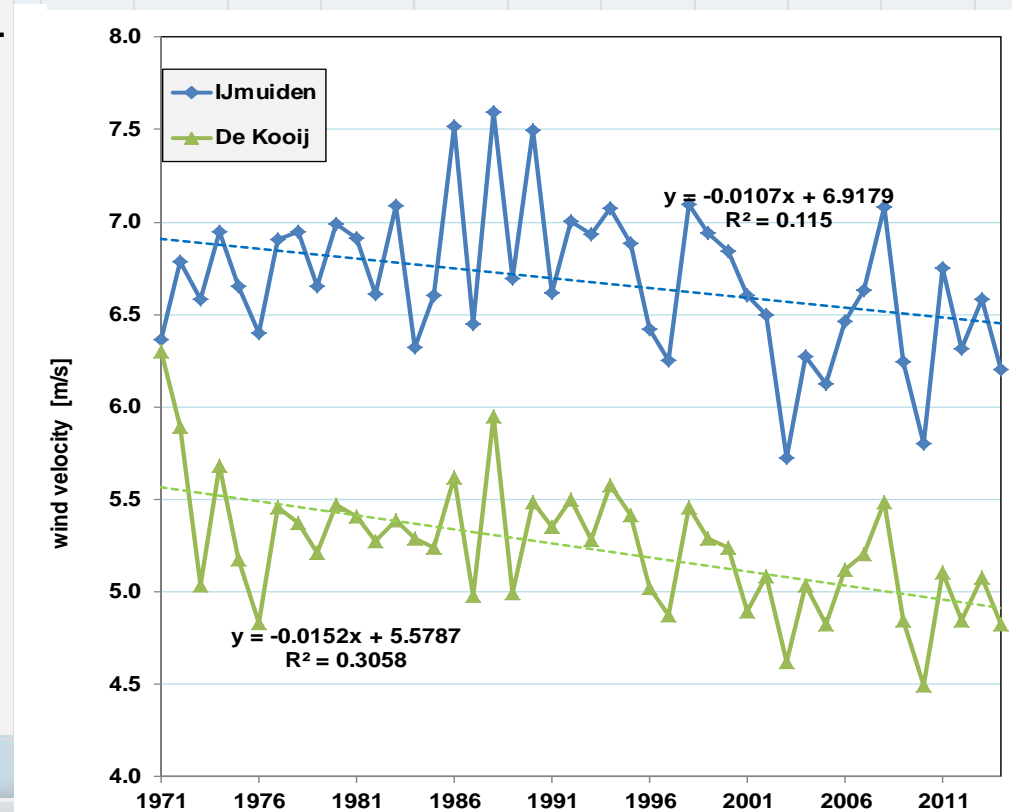
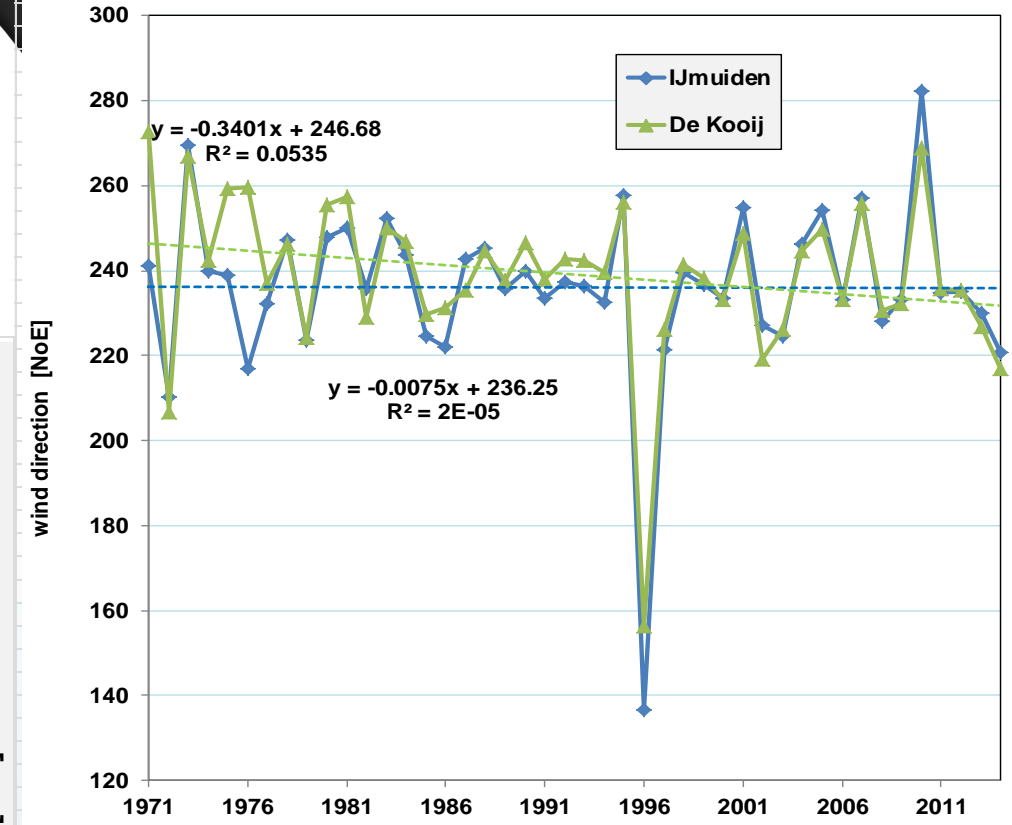
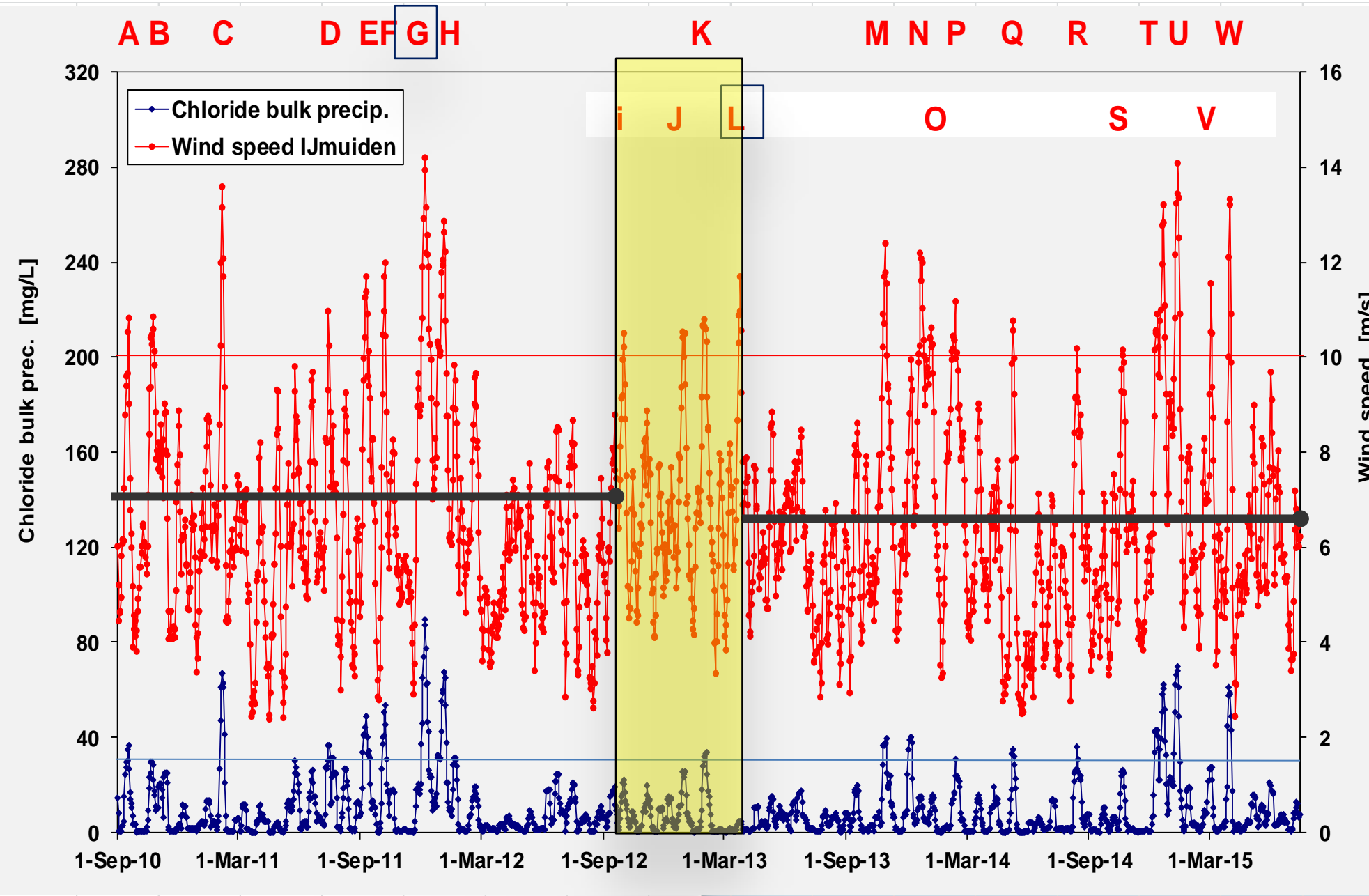
Image © 2012 Aerodata International Surveys

© 2012 Google

GOO

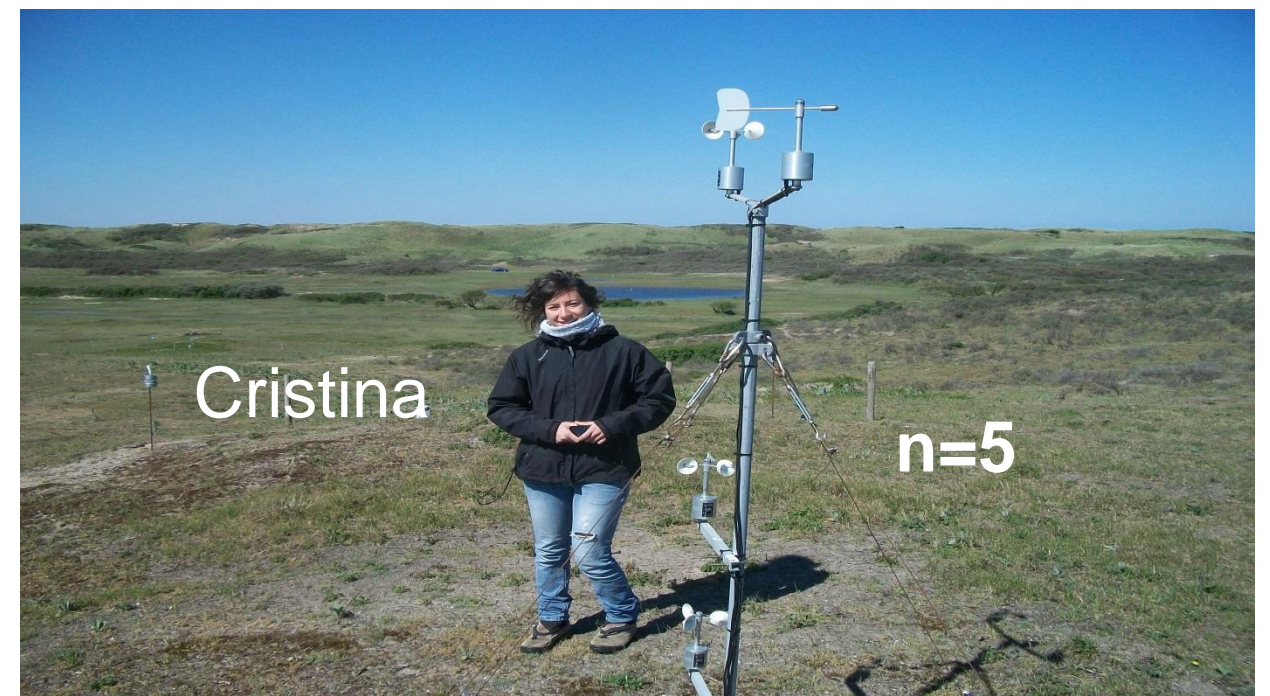


# Wind metingen





# Bovengronds: regenwater, zout en wind



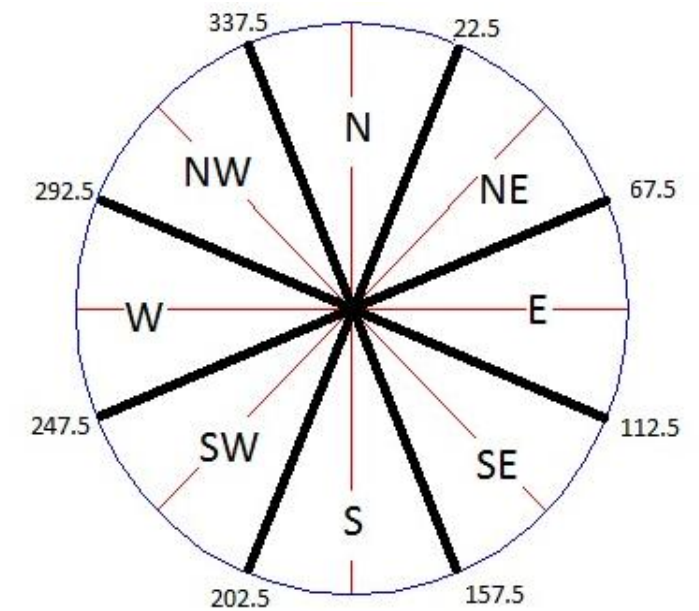


# De windrichtingafhankelijke bulk regenwater collector van VU: operationeel van sept 2011 t/m dec. 2014, Wierindaen



Hugo

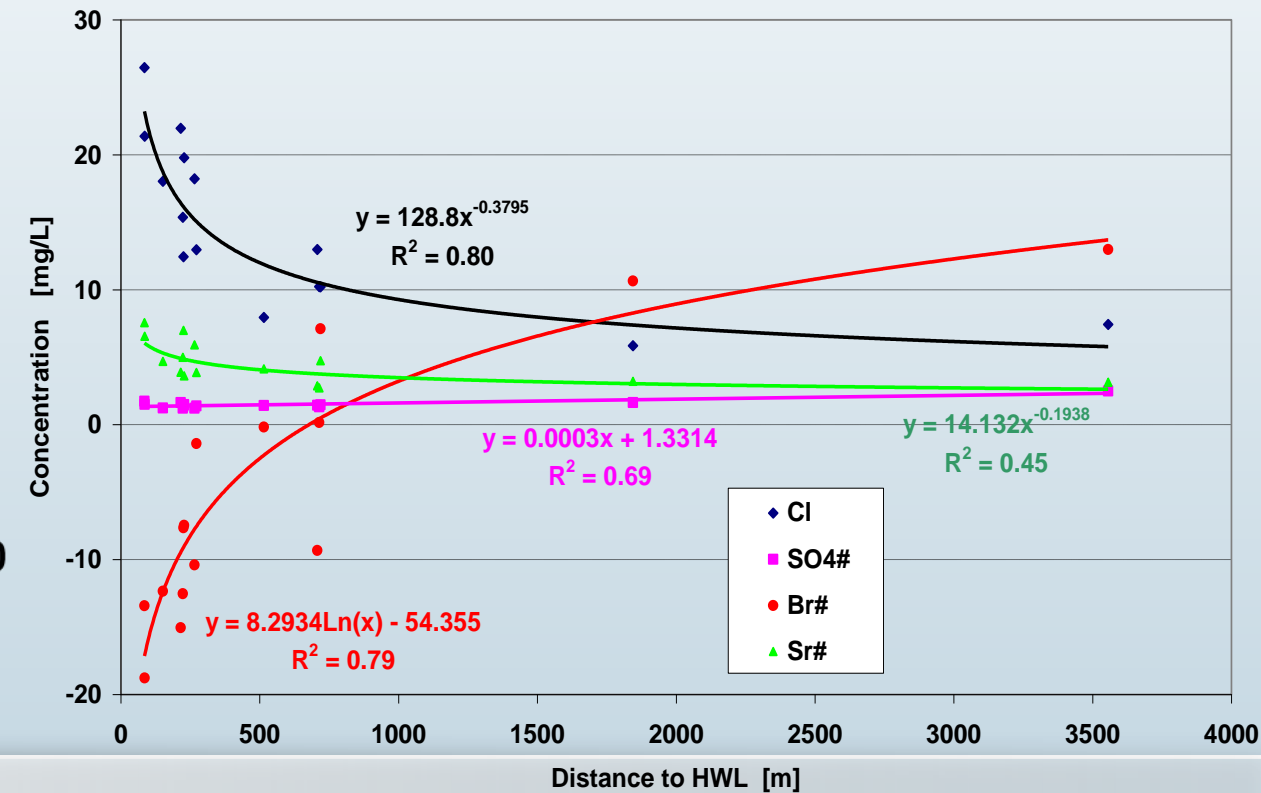
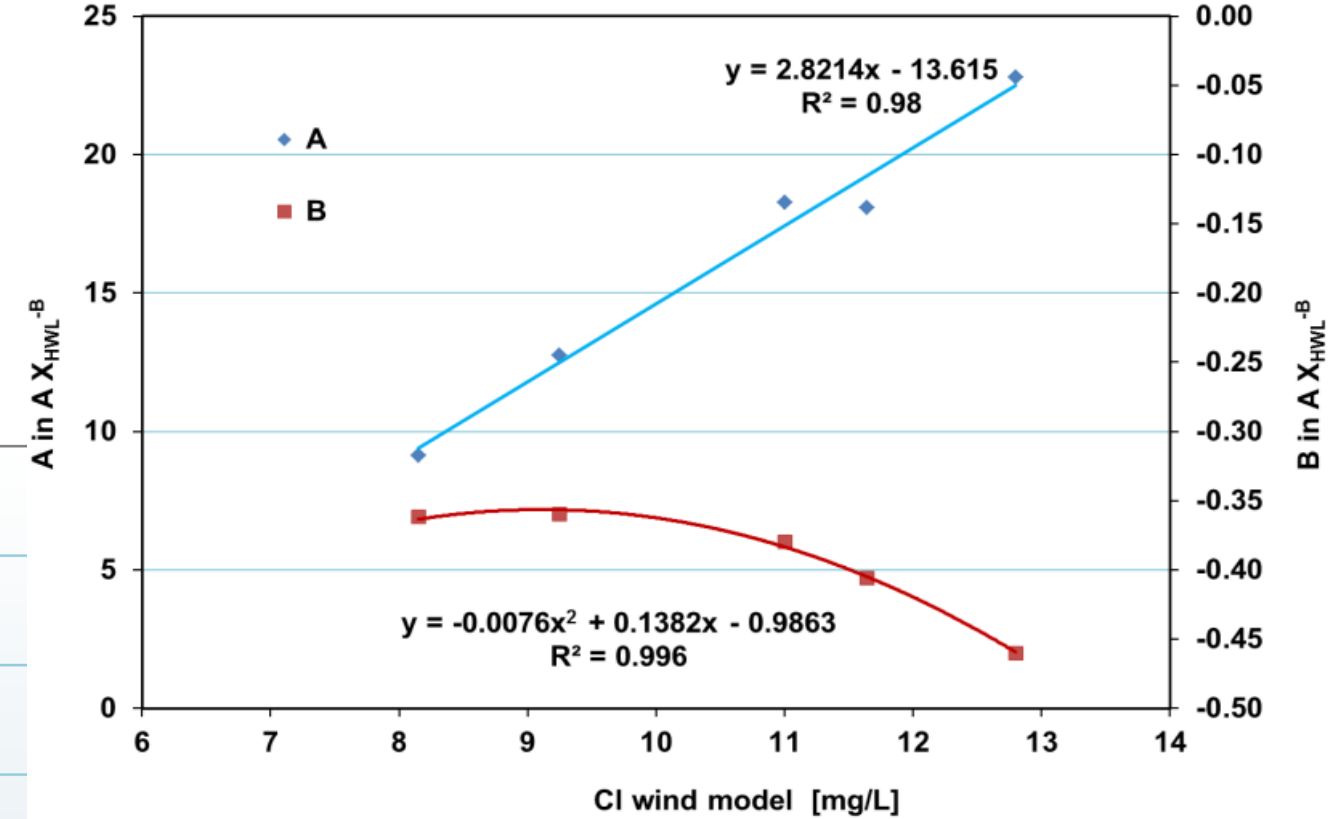
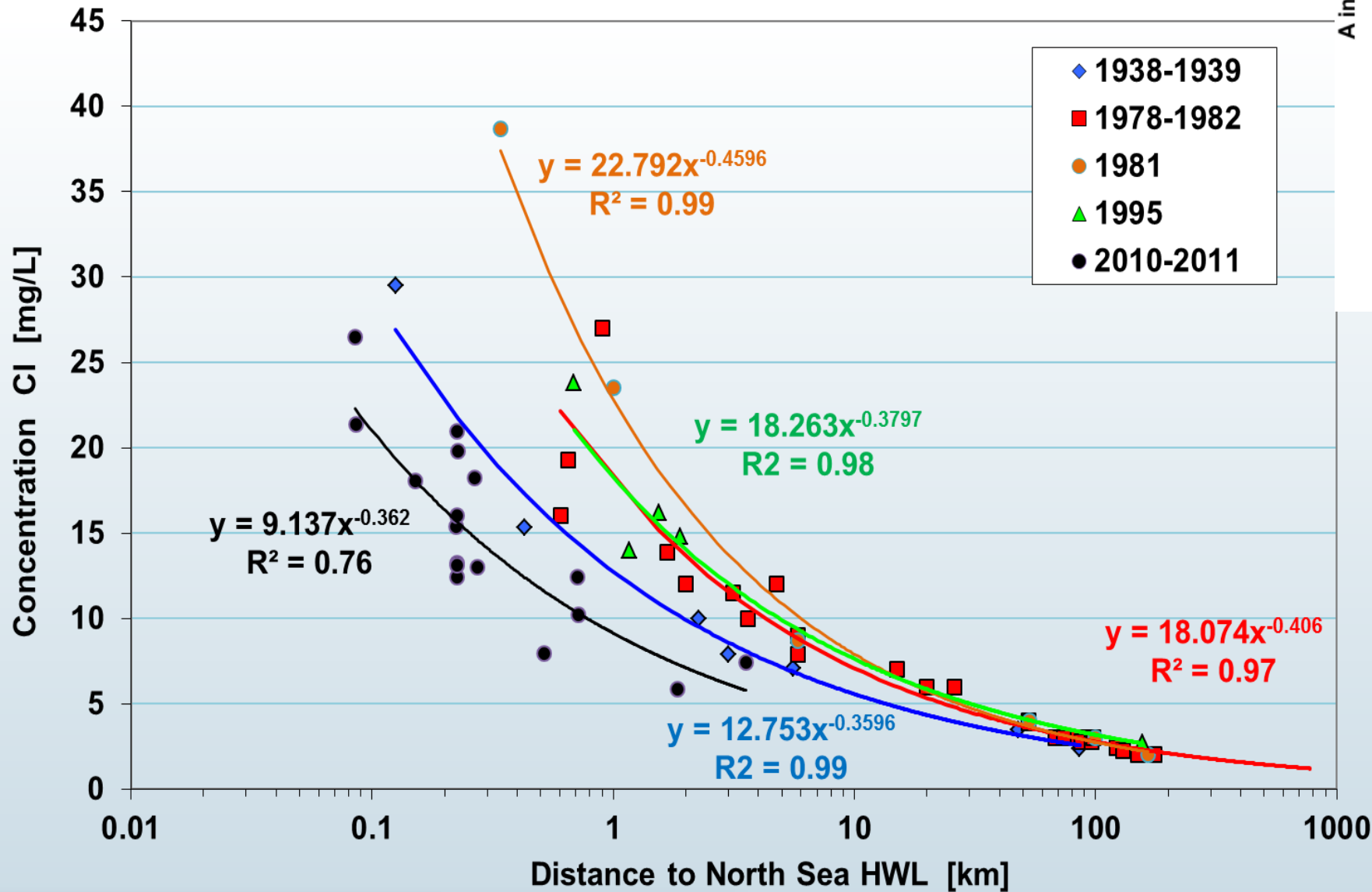
Julian





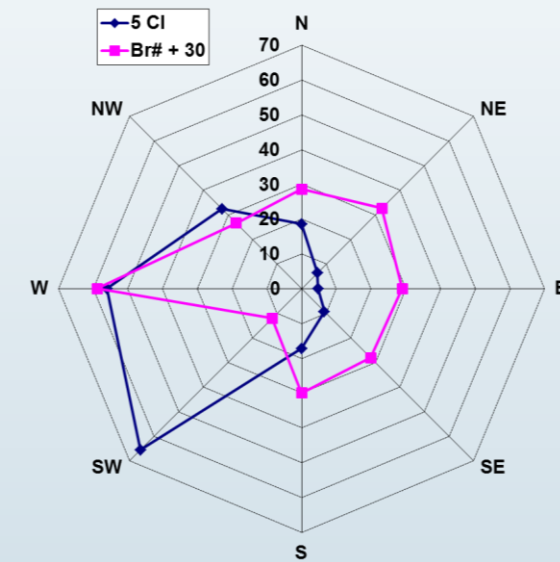
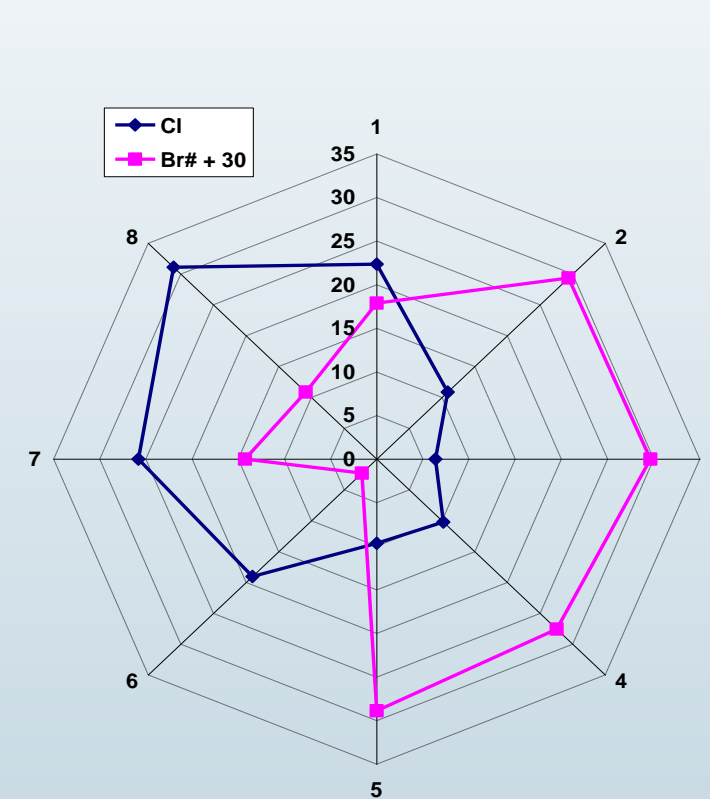
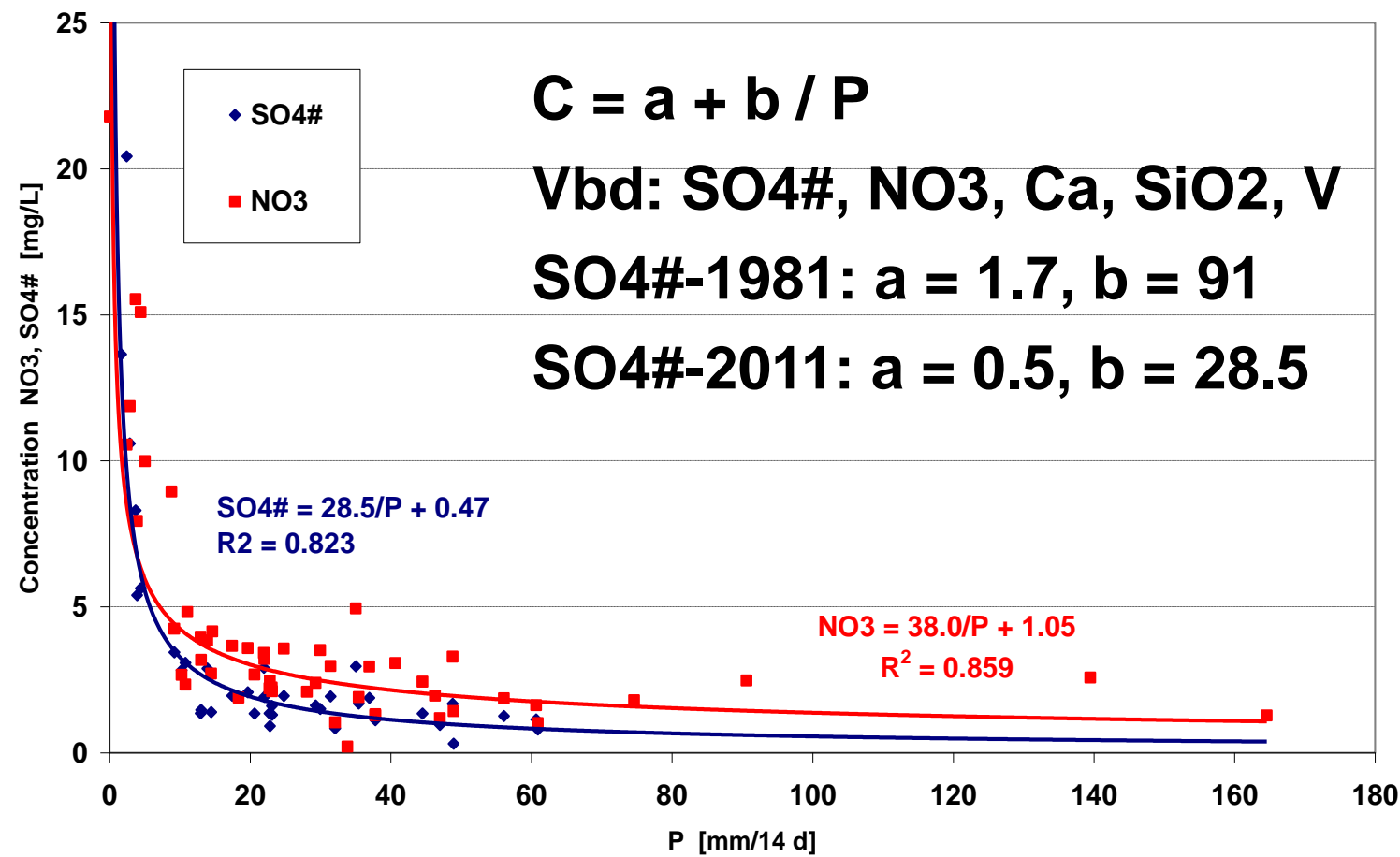
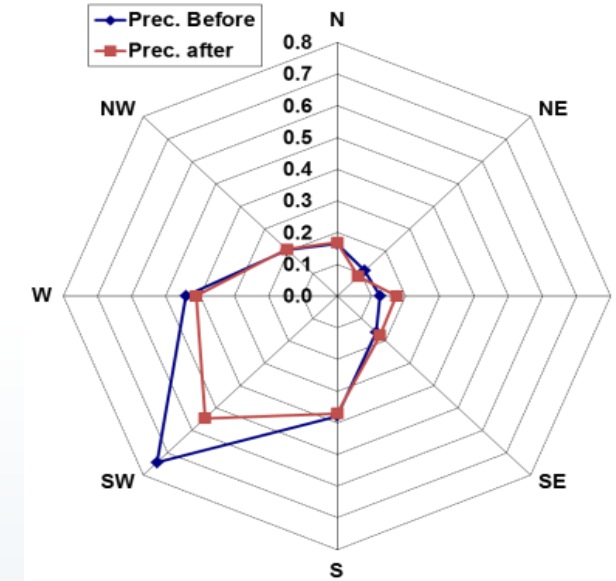
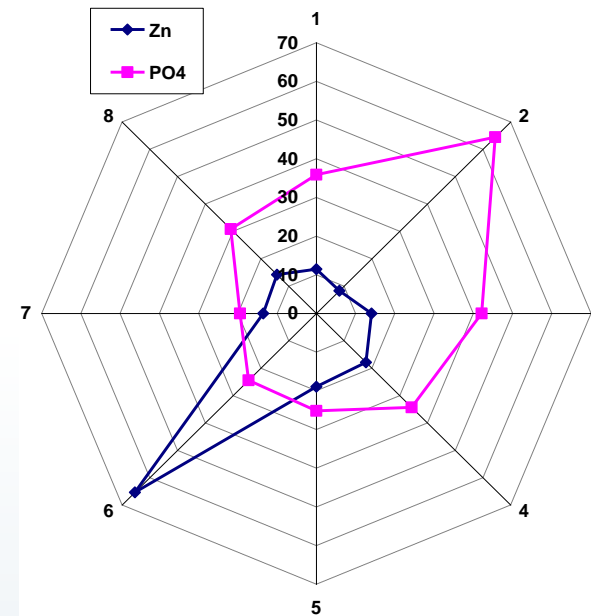
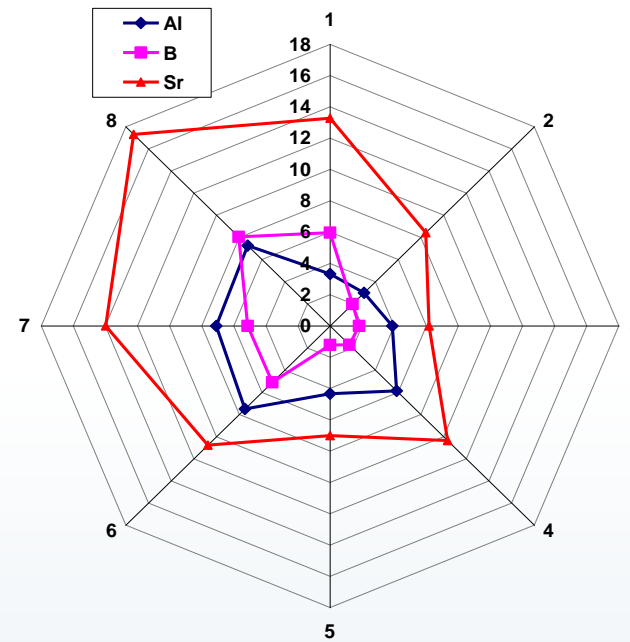
# Chloride in bulk regenval

$$Cl = A X_{HWL}^{-B} ; Cl = A e^{-B X_{HWL}}$$



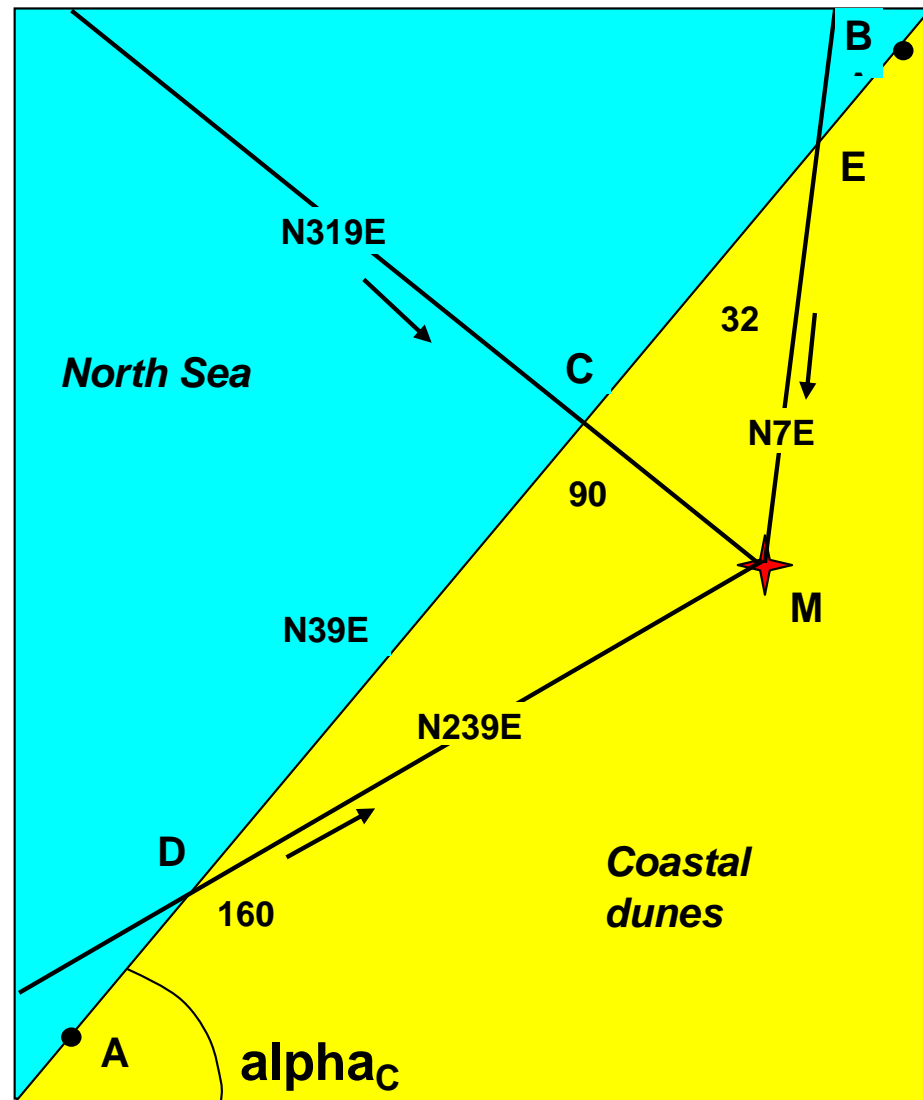


# De 2 belangrijkste factoren: regenval (P) en windrichting/windkracht





# SEA Spray Atmospheric deposition Model (SEASAM)



$$Cl_G = f_E^{1.5} Cl_P \quad \text{with } f_E = P/(P-E), \text{ incl. interception deposition}$$

$$Cl_P = f_B f_W \sqrt{(P_{AV}/P) \Sigma (v_W^{3.4} 550 [X_{WIND}]^{-0.45})/365.25 + 0.1}$$

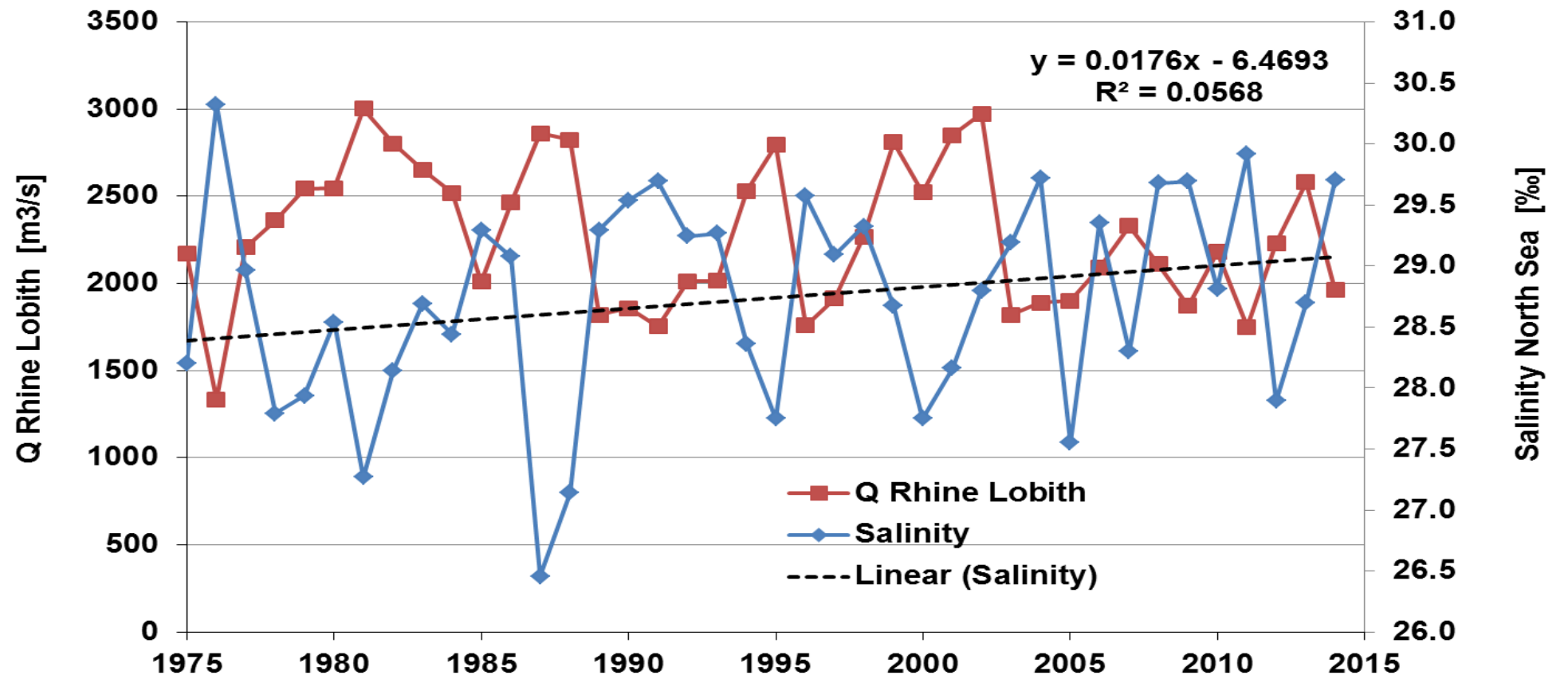
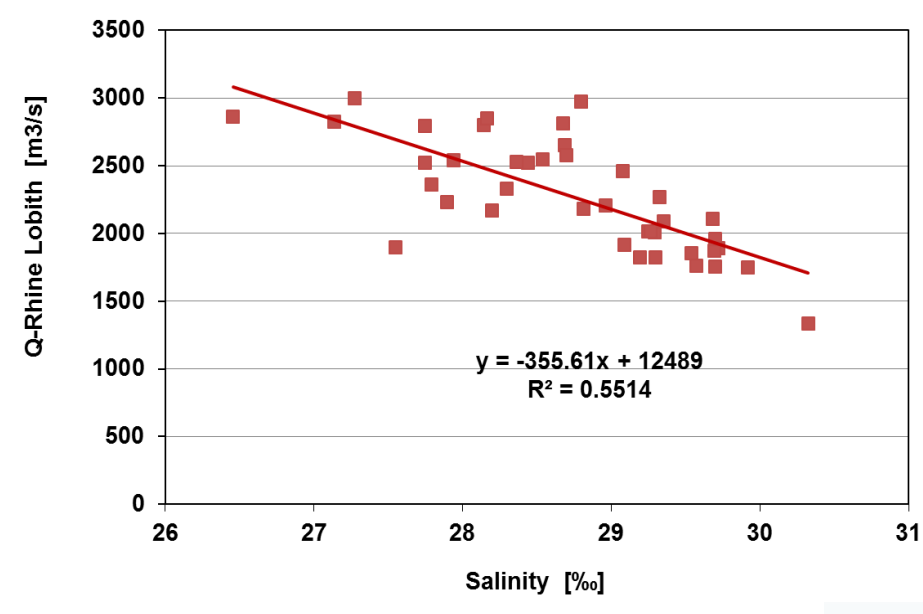
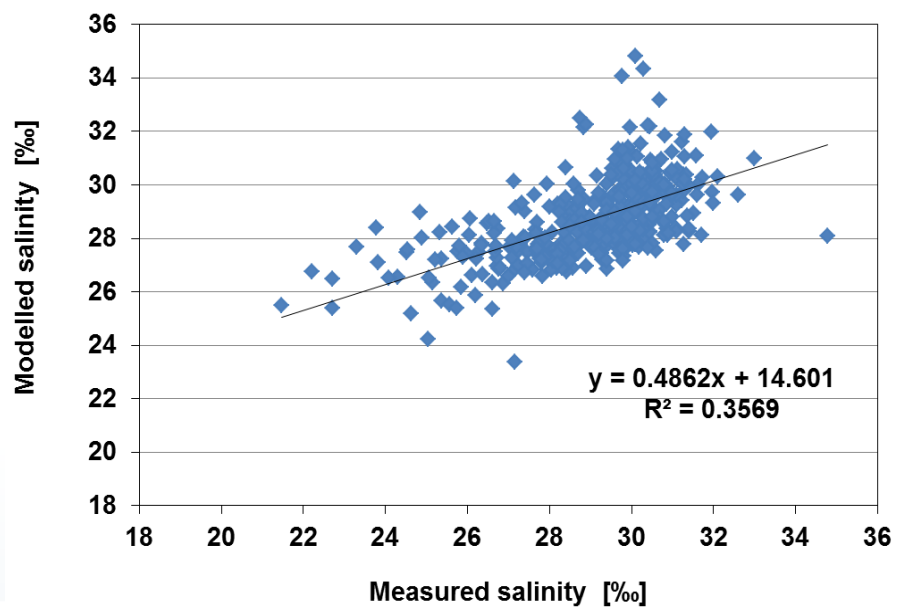
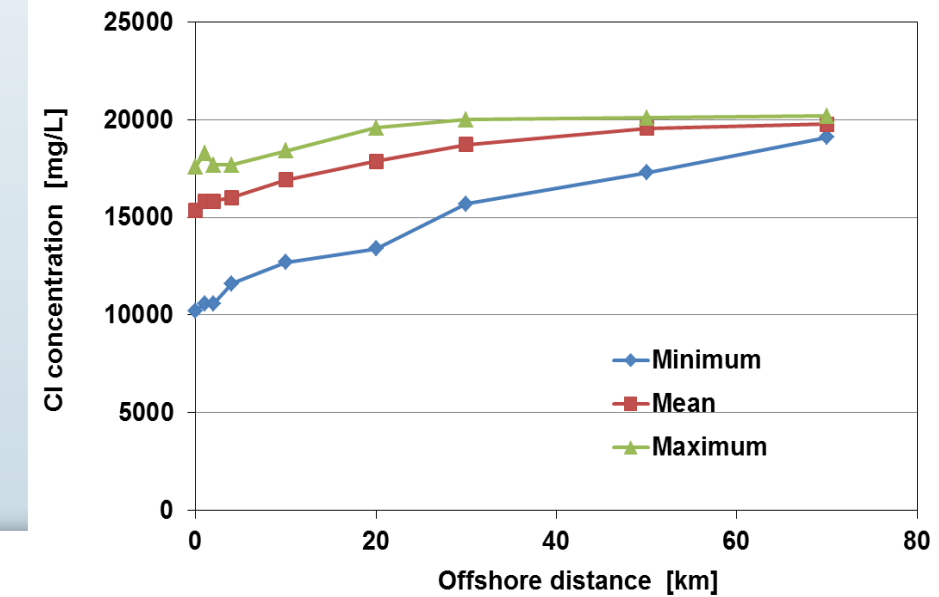
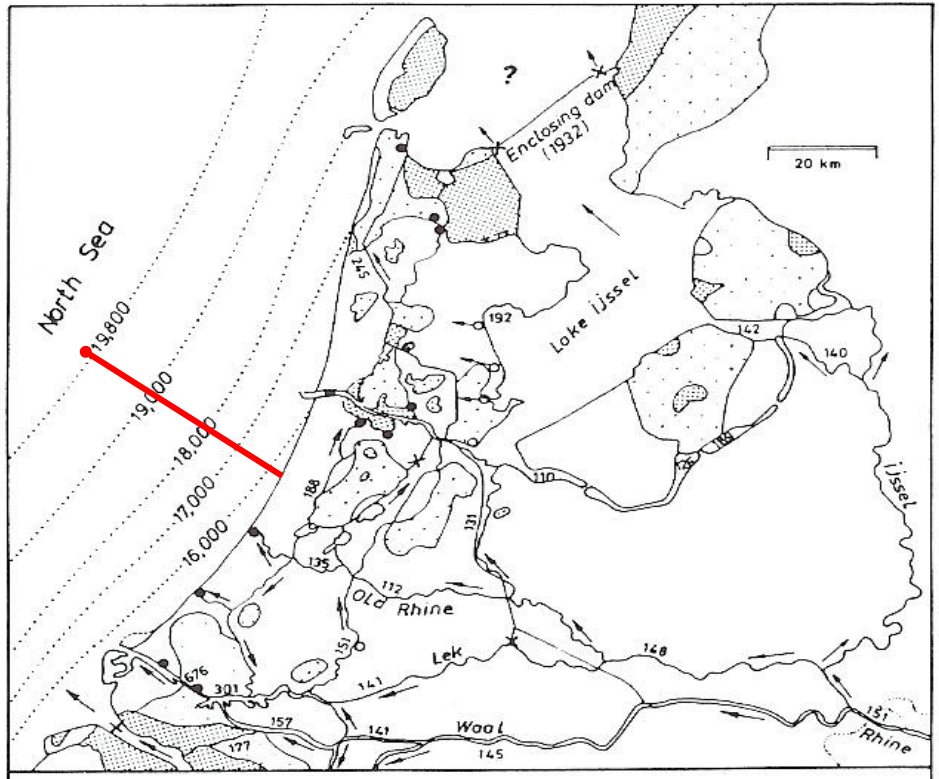
$$X_{WIND} = \text{sqrt} [\{a_C (b_C - b_M)/(a_M - a_C) + b_C - Y_M\}^2 + \{(b_C - b_M)/(a_M - a_C) - X_M\}^2]$$

If wind off-shore:  $X_{WIND} = 200,000$  [m]

Location	$f_B$	Location	$f_B$
	$Cl_M/16800$		$Cl_M/16800$
Schoorl	1.024	Wassenaar	0.950
Bergen	1.015	Scheveningen	0.923
Castricum	1.010	Ouddorp	0.929
Wijk aan Zee	1.005	Hilversum	1.000
Zandvoort	1.000	Veluwe	1.000
Noordwijk	0.980	Enschede	1.000



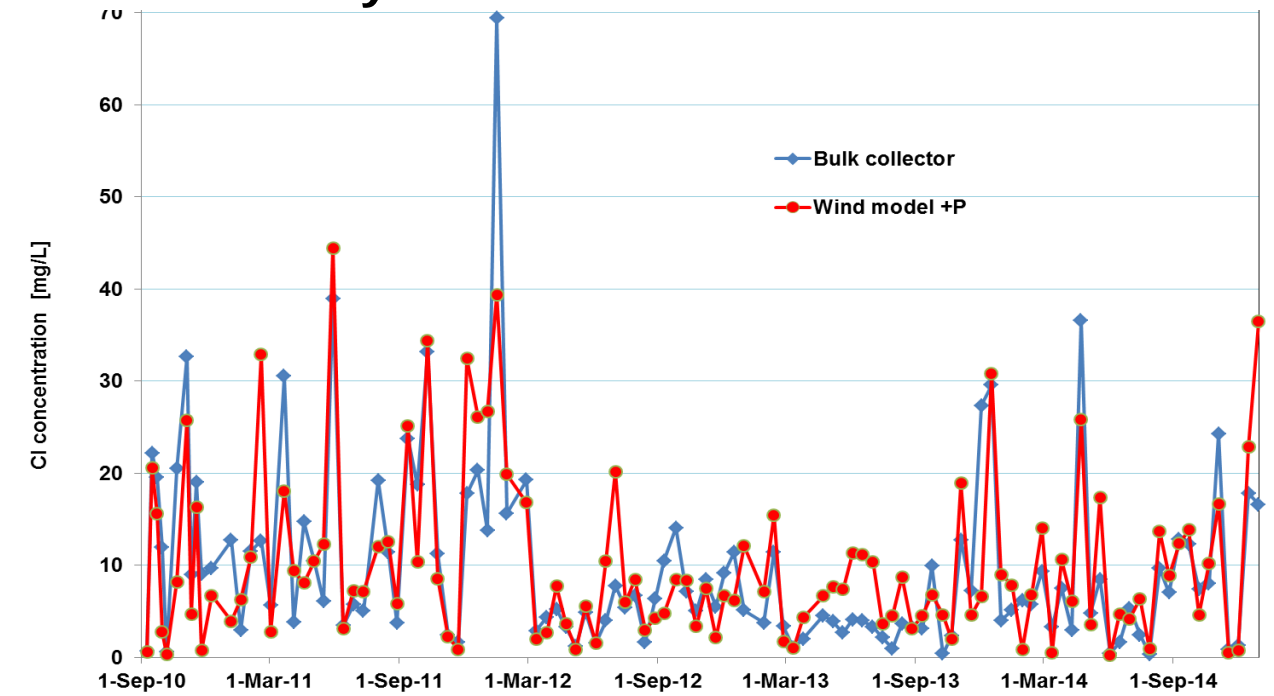
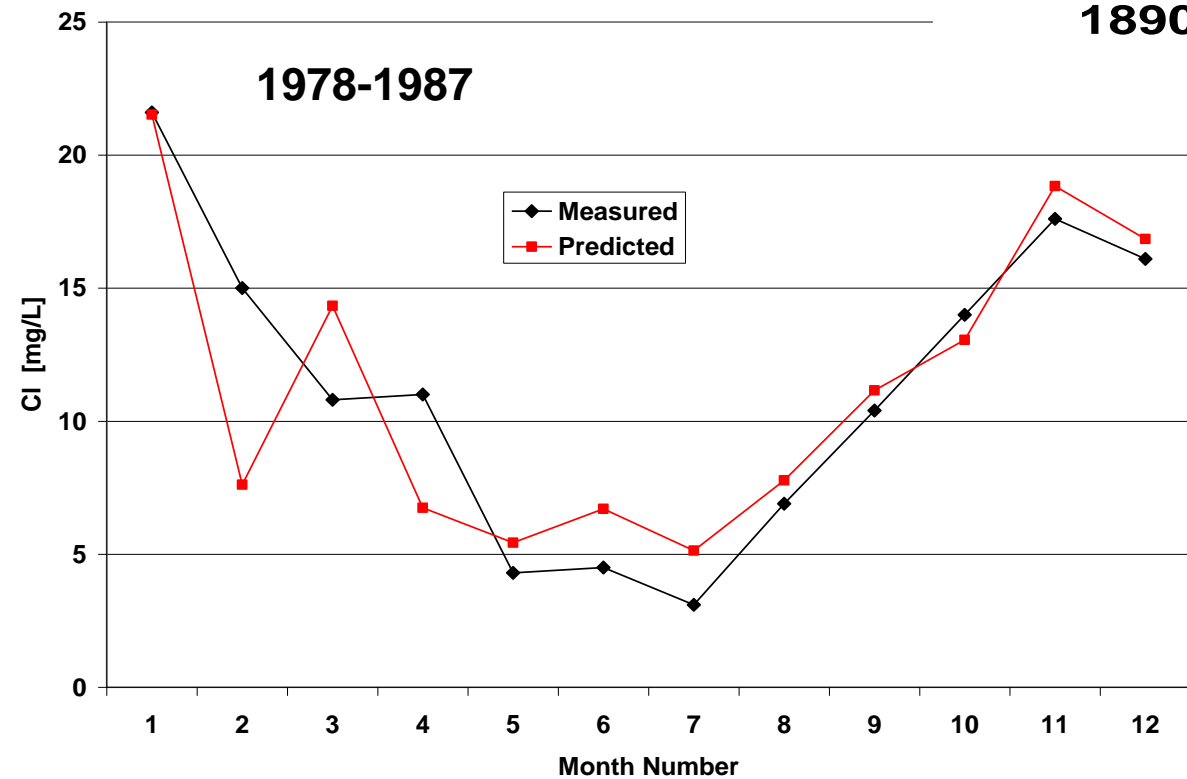
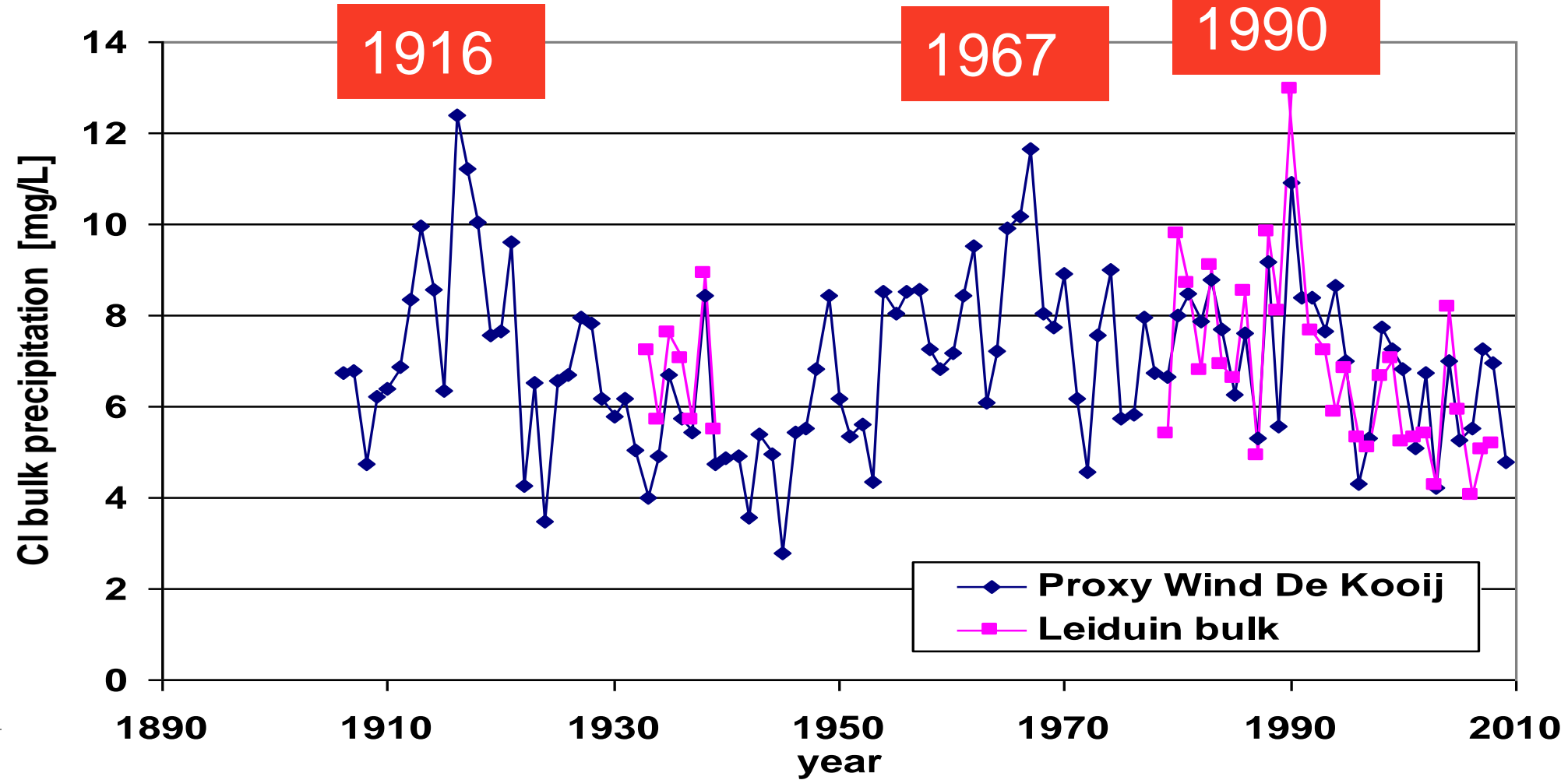
# Coastal seawater $f_B$



$$Sal_t = Sal_{AV} + 2.2 \sin(W_{D,t} - 325) (v_{W,t}/v_{W,AV})^{0.33} (Q_{L,t}/Q_{L,AV})$$



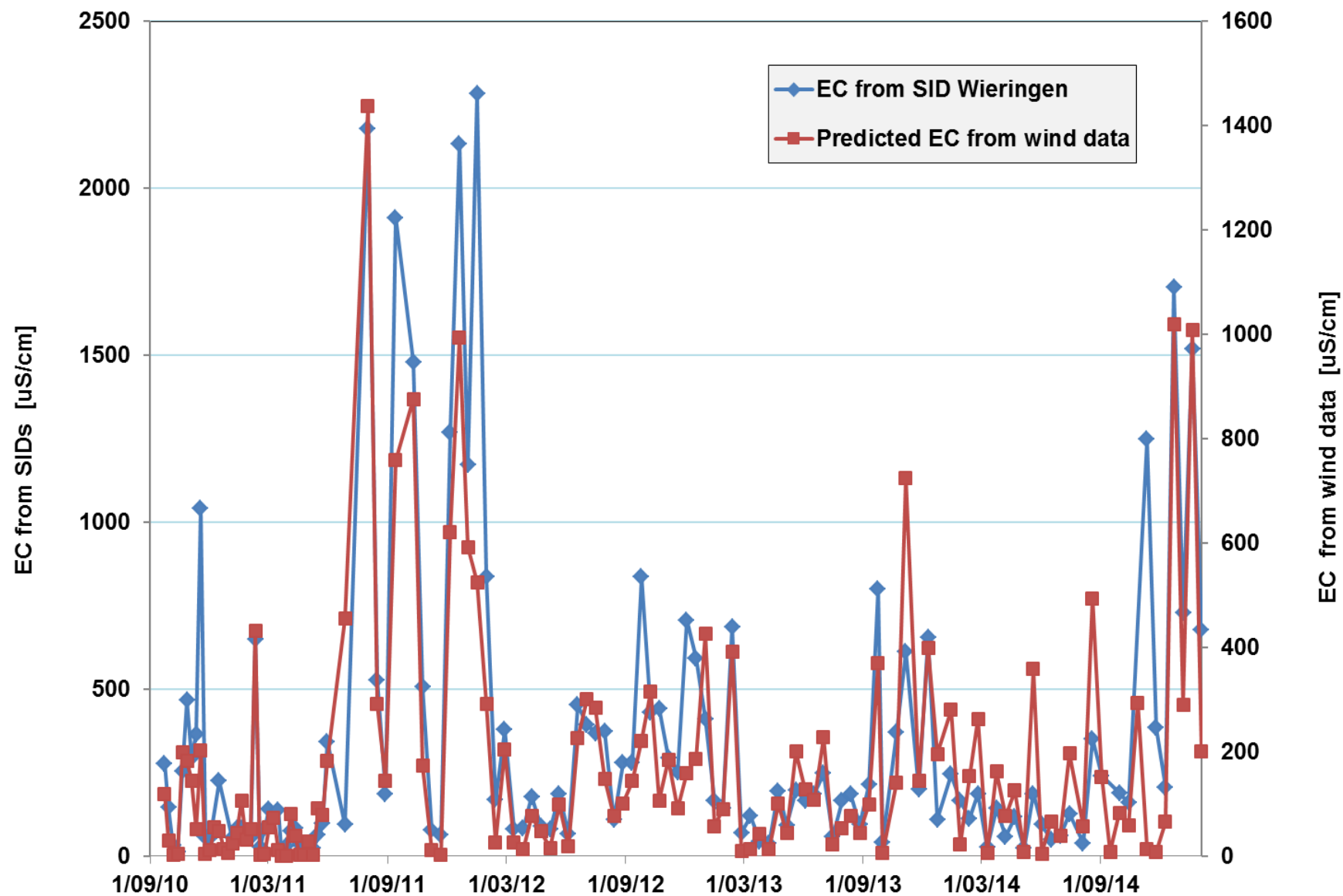
# Vergelijking gemeten Cl-conc van regenval langs Holl. kust via wind data + neerslaghoeveelh.





# Gemiddelde EC gemeten met de 5 SIDs in Wieringen en de voor Wieringen voorspelde EC

$$EC_{SID,CALC} = a (1 + 0.01 P) \Sigma SALT + c$$





# Bemonstering + analyse bodemvocht in duinzandmonsters





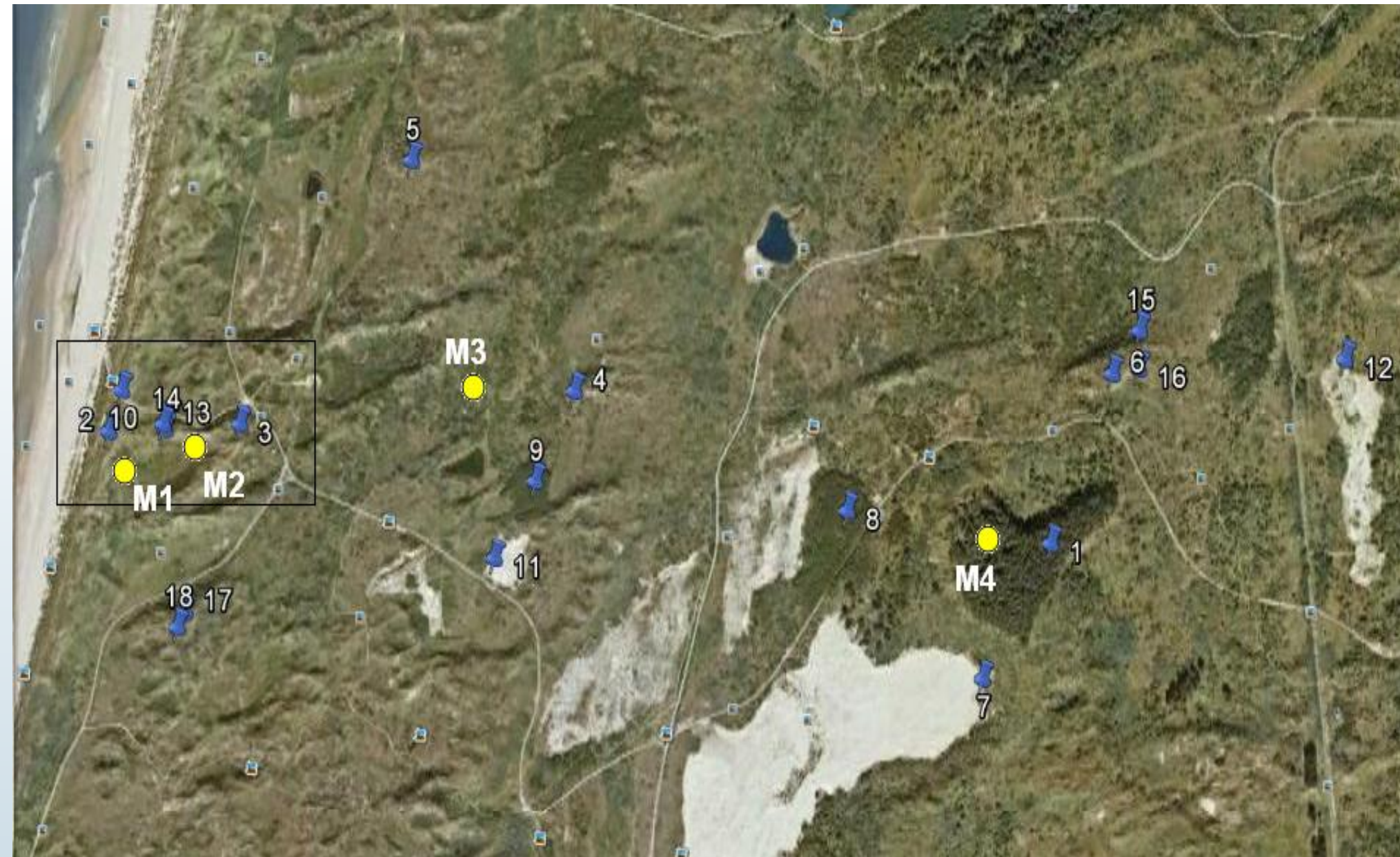
# Locatiekaart van alle bodemvochtprofielen

## CI Mass Balance (CMB):

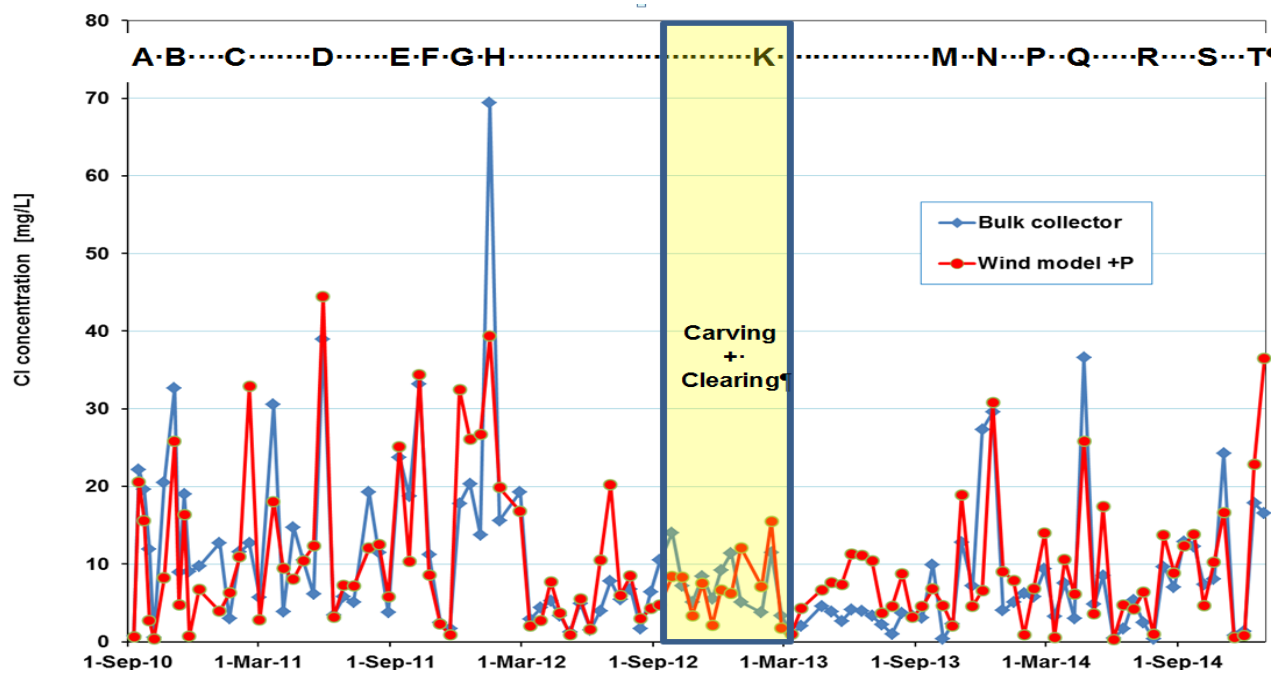
$$R = P - E = f_p f_{ID} C_{I_{BD}} P / C_{I_G}$$

## Critical Notes:

1. No surface runoff
2. In unsat zone: below root zone, take long-term averages of  $C_{I_{BD}}$  and  $C_{I_G}$  and select areas with uniform veg. + soil characteristics
3. In upper groundwater zone: be aware of seasonal and annual fluctuations
4. Correction factor  $f_{ID}$  high for tall, dense veget. & coastal sites







# Cl bodemvocht maart 2012 en april 2014

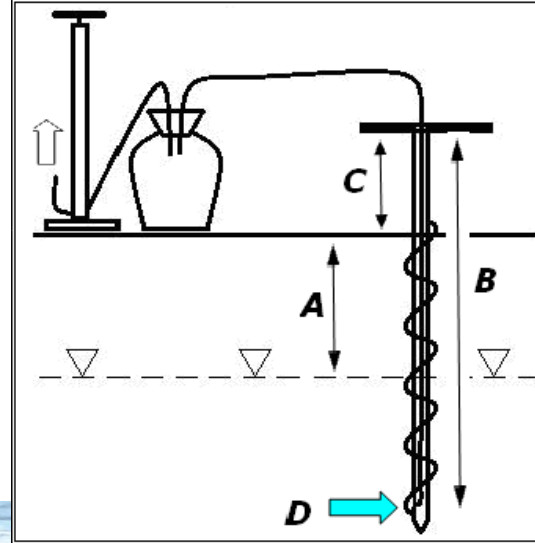
Fluct. pattern Sea spray dominated; 0.5 years moisture; E = 55%

Fluct. pattern Evap dominated; 2 years moisture; E = 85%

Obs.point Sampling year Vegetation X-HWL	1		2		3		4		5		7		8	
	2012	2014	2012	2014	2012	2014	2012	2014	2012	2014	2012	2014	2012	2014
	bare		grass	bare	grass	shrub	grass	bare	shrub	bare	shrub	bare	shrub	pinus
5	173	137	632	120	657	158	103	70	301	302	162	529	425	239
15	214	171	302	126	456	143	181	77	403	94	141	126	621	353
25	106	64	242	90	351	90	253	84	403	127	142	111	431	408
35	149	171	190	109	346		119	63	269	121	112	93	361	356
45	131	44	204	73	349		128	69	254	106	114	97	313	328
55	101	107	175	86	326	106	99	65	208	83	173	99	444	476
65	115	73	301	64	346	101	91	76	216	82	230	76	477	268
75	124	66	302	70	227	97	147	86	293	78	108	77	316	262
85	141	64	314	87	210	102	151	73	292	58	114	87	282	271
95	151	69	301	98	242	90	177	66	300	94	157	93	280	167
105	130	81	299	85	213	86	141	64	270	75	159	76	391	187
115	145	56	255	206	201	84	131	63	222	76	158	88	401	195
125	101	78	240	172	184	94	174	65	208	69	200	129	384	189
135	121	62	178	228	122	73	147	81	205	101	179	86	432	188
145	122	66	199	253	184	93	189	67	216	77	157	80	382	198
155	90	54	290	196	205	80	172	72	206	92	159	71	372	213
165	98	37	300	200	200	91	242	54	192	79	144	87	359	194
175	118	47	347	160	201	113	206	74	179	92	141	93	518	201
185	125	64	434	136	200	104	127	69	170	68	162	74	1028	202
195	161	52	530	150	185	94	132	88	179	81	237	92	707	196
205	158	62		105		85	140	55	254	87	180	85	535	225
215	146	53		102		111	199	58	256	90	196	87	484	294
225	126	83		101		116	231	70	266	97	162	106	348	256
235	119	50		154		88	269	72	189	73	161	98	490	496
245	138	62		192		117	277	79	177	115	186	150	475	625
255	174	70		202		79	186	71	233	95	198	109	569	381
265	216	72		200		108	154	73	166	100	189	104	595	618
275	188	76		187		126	155	69	194	110	174	103	613	609
285	210	87		190		139	150	65	181	102	186	103	550	640
295	264	79		203		123	212	63		112	257	101	634	555
305	271	87		171		152	201	51	224	93	164	123	613	462
315	266	125		201		152	287	61	132	77	185	118	663	429
325	320	130		182		151	240	65	182	117	145	105	636	456
335	252	115		202		117	283	42	173	139	153	99	745	434
345	219	99		204		145	239	55	217	129	134	130	640	536
355	228	118		178		132	232	63	201	142	106	88	582	643
365	240	169		178		109	235	54	194	146	116	142	774	559
375	247	171		182		121	184	71	226	125	226	142	507	538
385	229	134		206		117	250	57	210	151	178	107	415	555
395	231	147		149		89	202	75	246	149	229	93	434	501
405	236	121		165		93	353	75	233	176	262	114	513	576
415	237	129		169			282	67	338	154	245	118	490	541
425	231	129				93	252	56	293	166	188	107	470	544
435	188	123		146		117	236	59	381	187	184	119	410	513
445	175	118		166		130	281	69	315	186	159	126	423	556
455	165	112		157		137	204	78	414	216	136	100	515	565
465	150	112		148		147	274	59	365	182	172	117	514	558
475	151	103		187		152	286	75	374	261	161	93	1610	542
485	184	112		196		123	311	83	447	221	179	142	2288	656
495	201	105		222		177	341	97	363	241	225	110	3094	640
505	196						283		382		214		1594	
515							377				209		785	
525													626	
535													602	
545													458	
Weighted mean	175	93	288	159	260	113	200	68	254	119	172	105	588	381
Mean	176	94	302	158	270	114	210	68	256	124	173	112	629	412



# Grond-water via VU's hollow stem auger



## Advantages:

1. Hand drilling feasible
2. Direct sampling possible
3. No short-circuiting
4. Yields detailed hydrochemical profile (e.g. each 0.1 m)

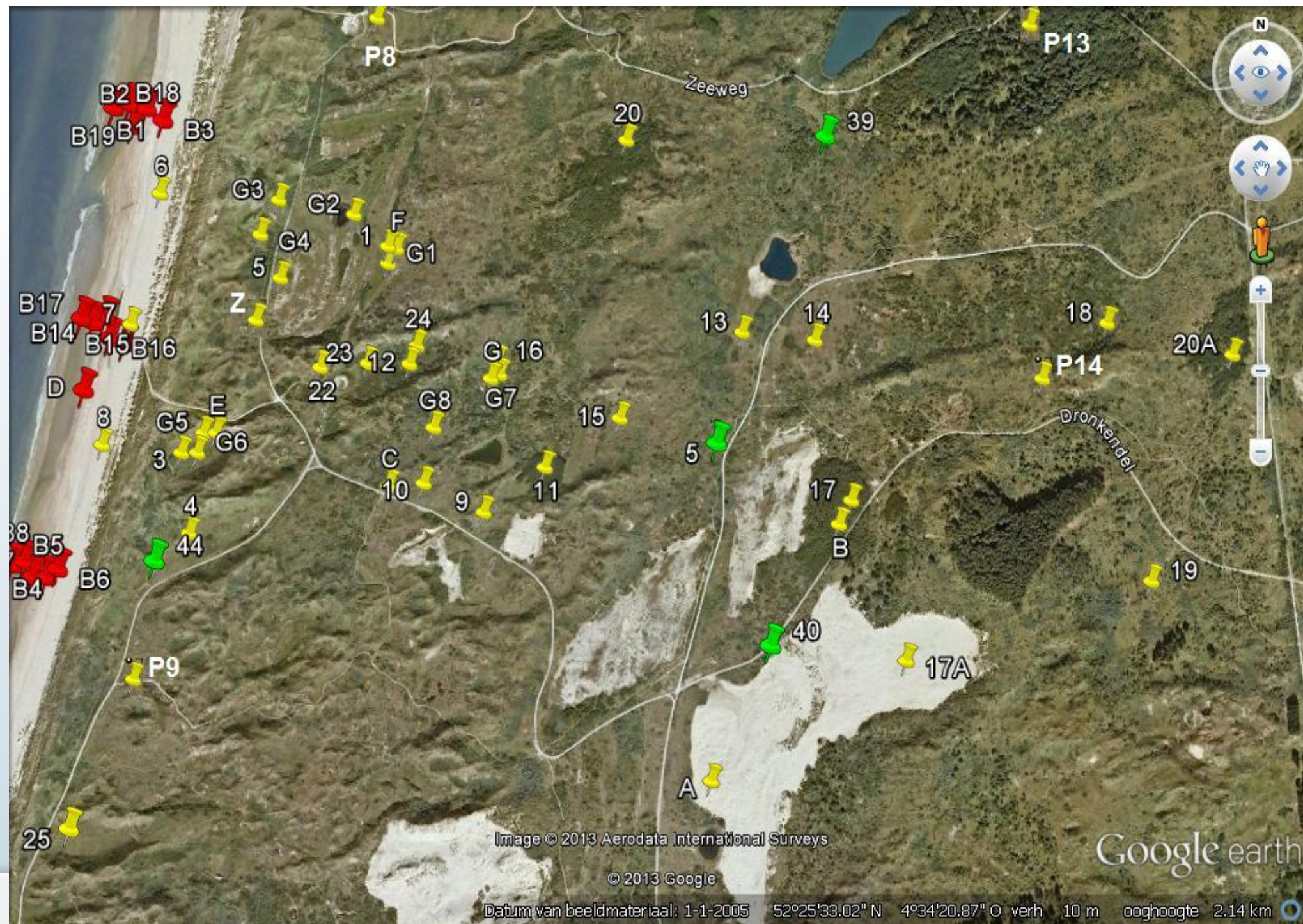
## Limitations / problems:

1. Depth <5 m BGS
2. Snap shot only (not permanent observation well)
3. Filtration of water samples can be difficult
4. Corrosion of metal parts



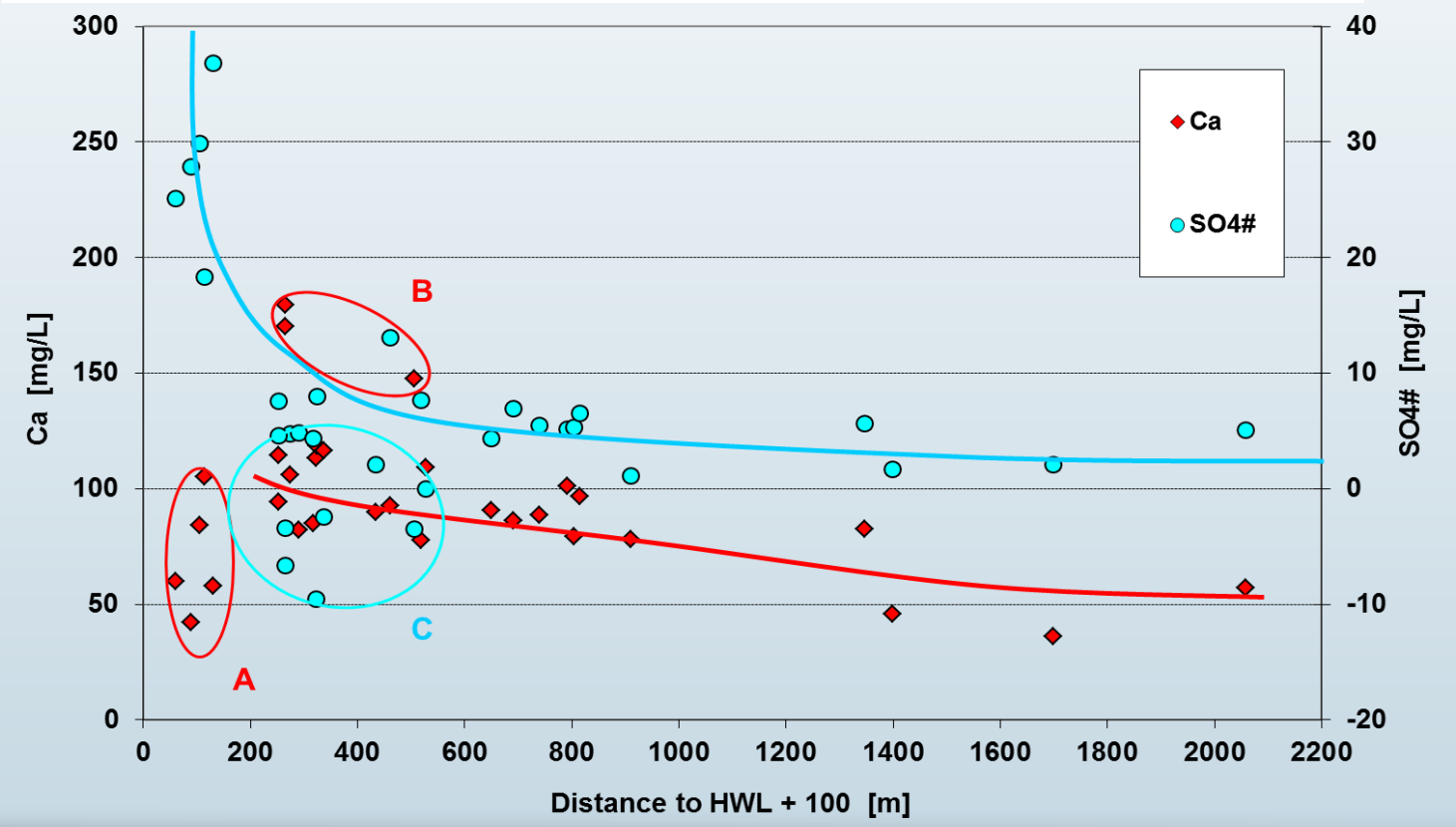
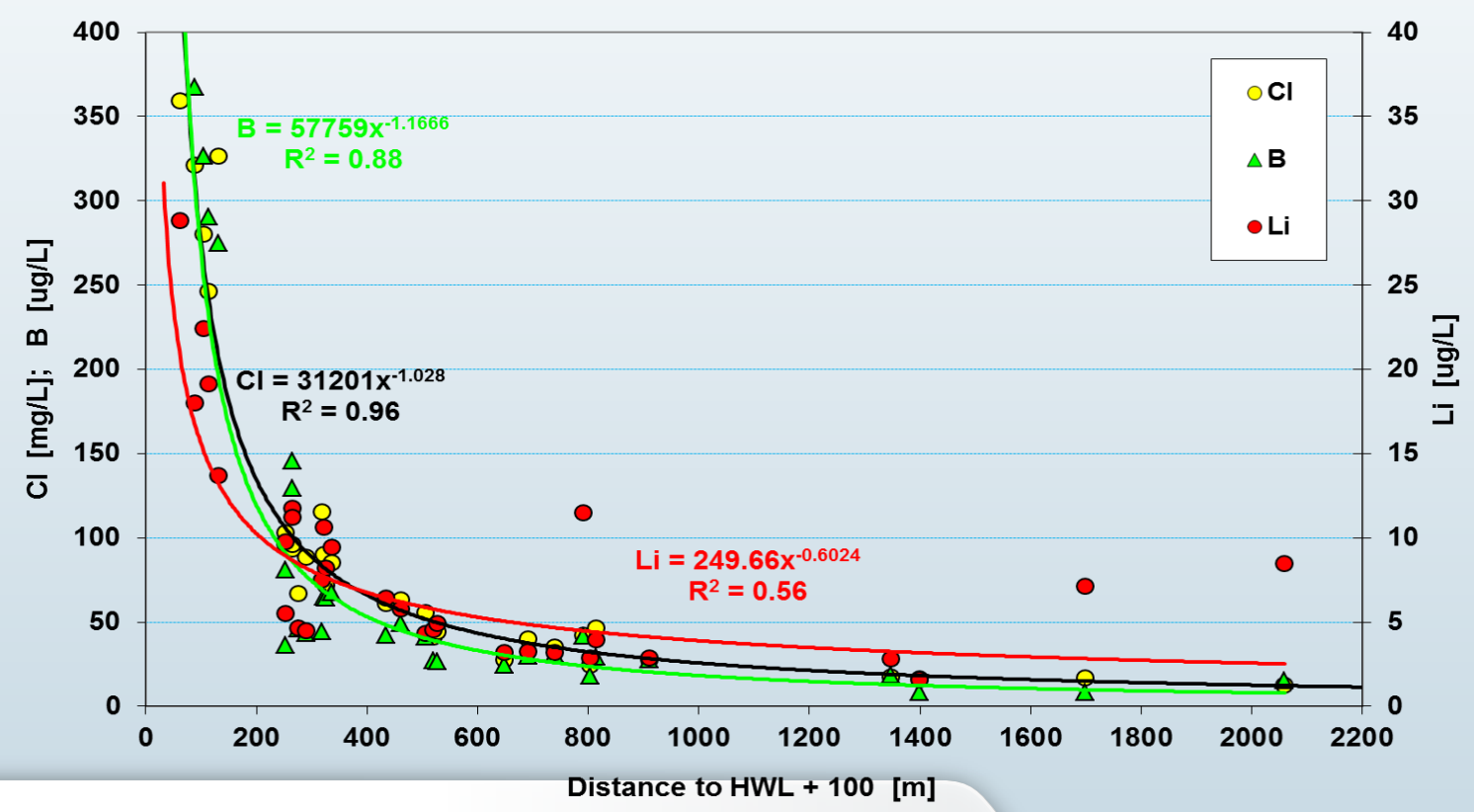
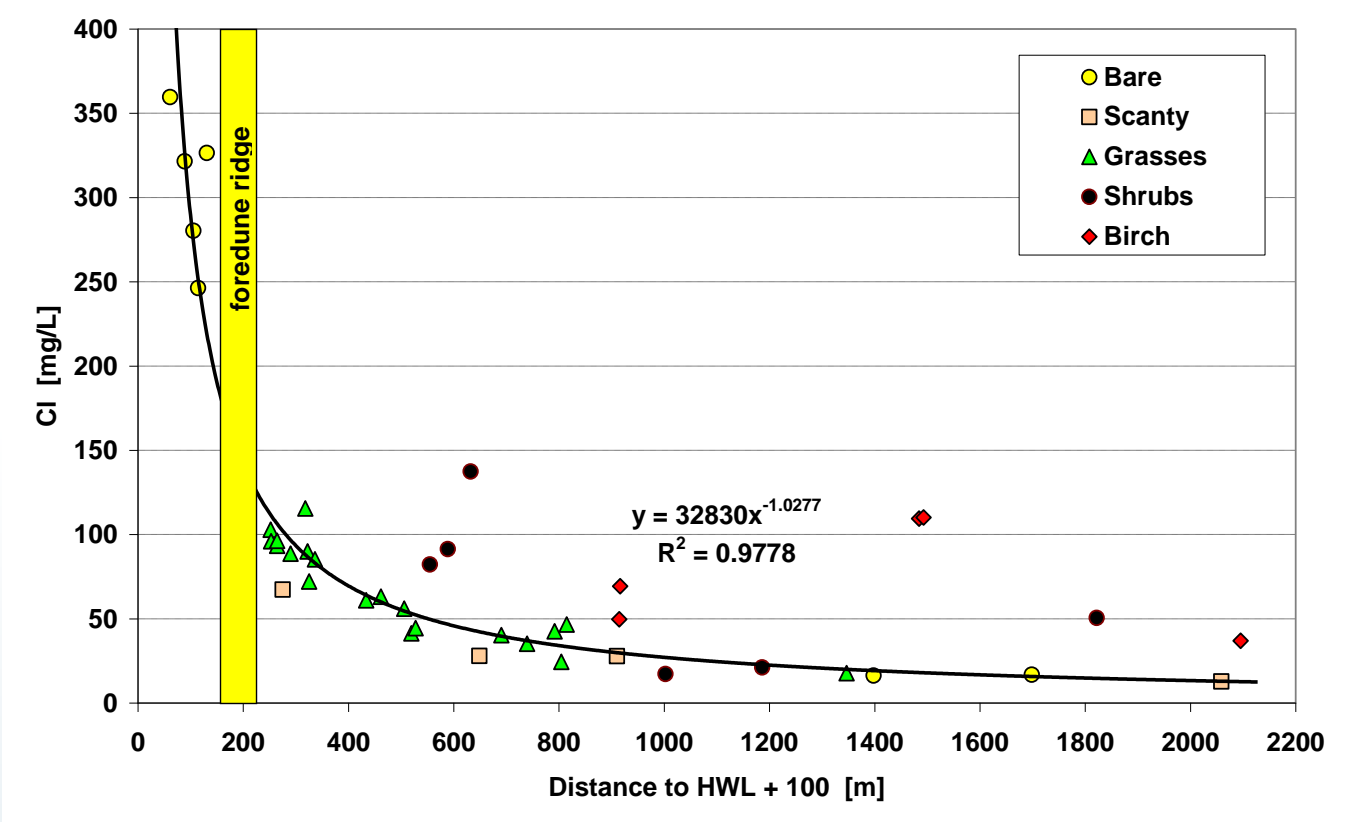
# Locaties waar grondwater bemonsterd in periode 2010-2014.

Nrs 1, 3, 4, 5, 9, 10, 12, 16, E in:  
sep/oc. 2011 +  
april 2014 +  
juli 2015.



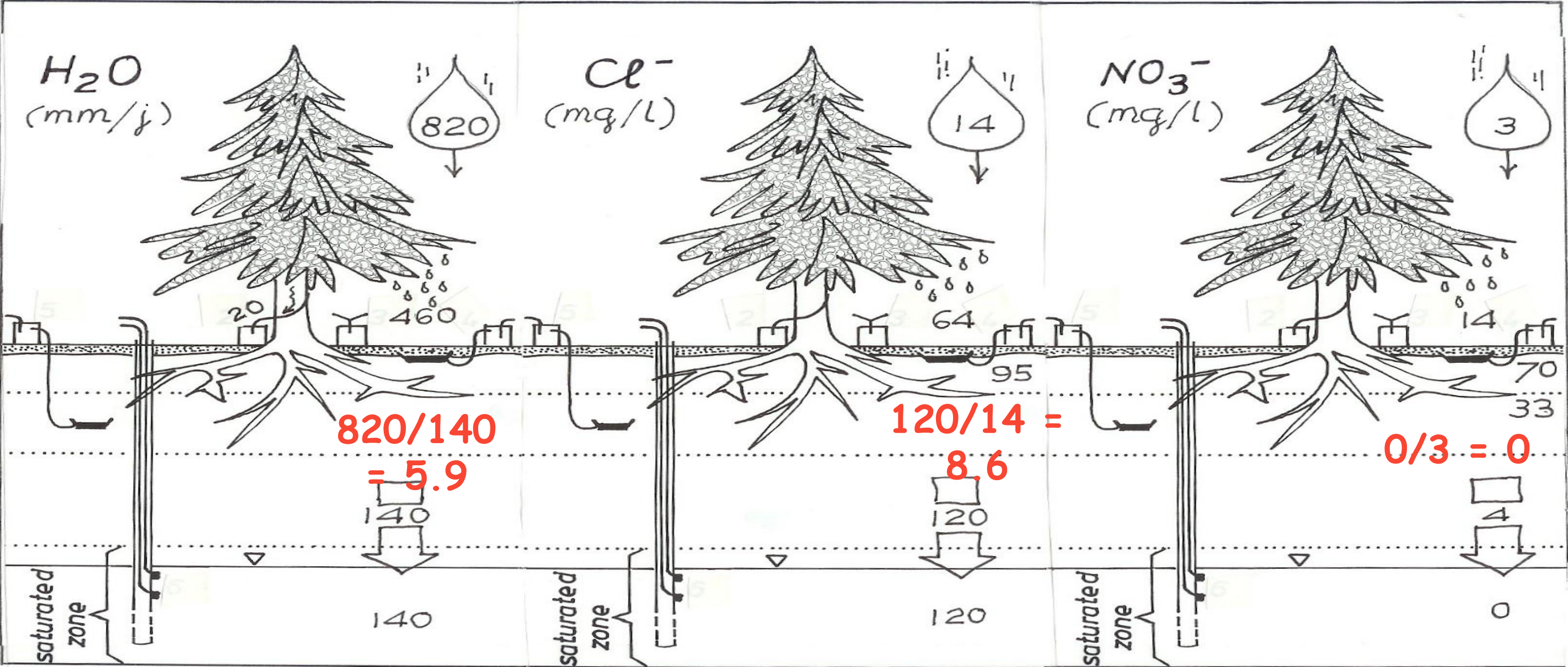


Effecten van:  
 afstand HWL (zeezout)  
 vegetatie (E, invang, CO2, opslag)  
 diepte GW (redox)  
 dynamiek (uitwisseling Na,K,Mg voor Ca)



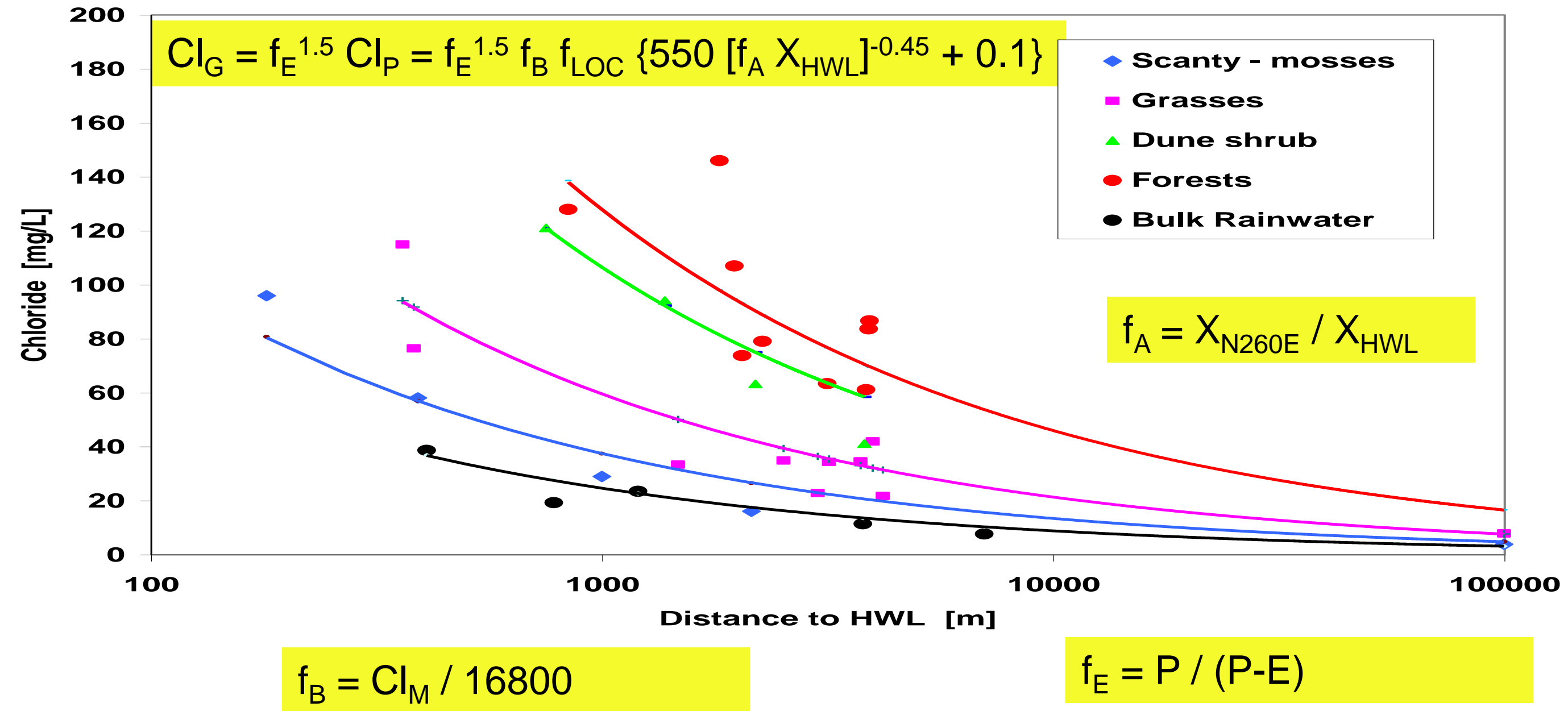


# Invoed van dennen op natuurlijke grondwateraanvulling





# Relations chloride<sub>G</sub> – X-HWL for vegetation types → estimates of effects of coastal extension / erosion and vegetation changes





# Invloed emissie IJmond industrie



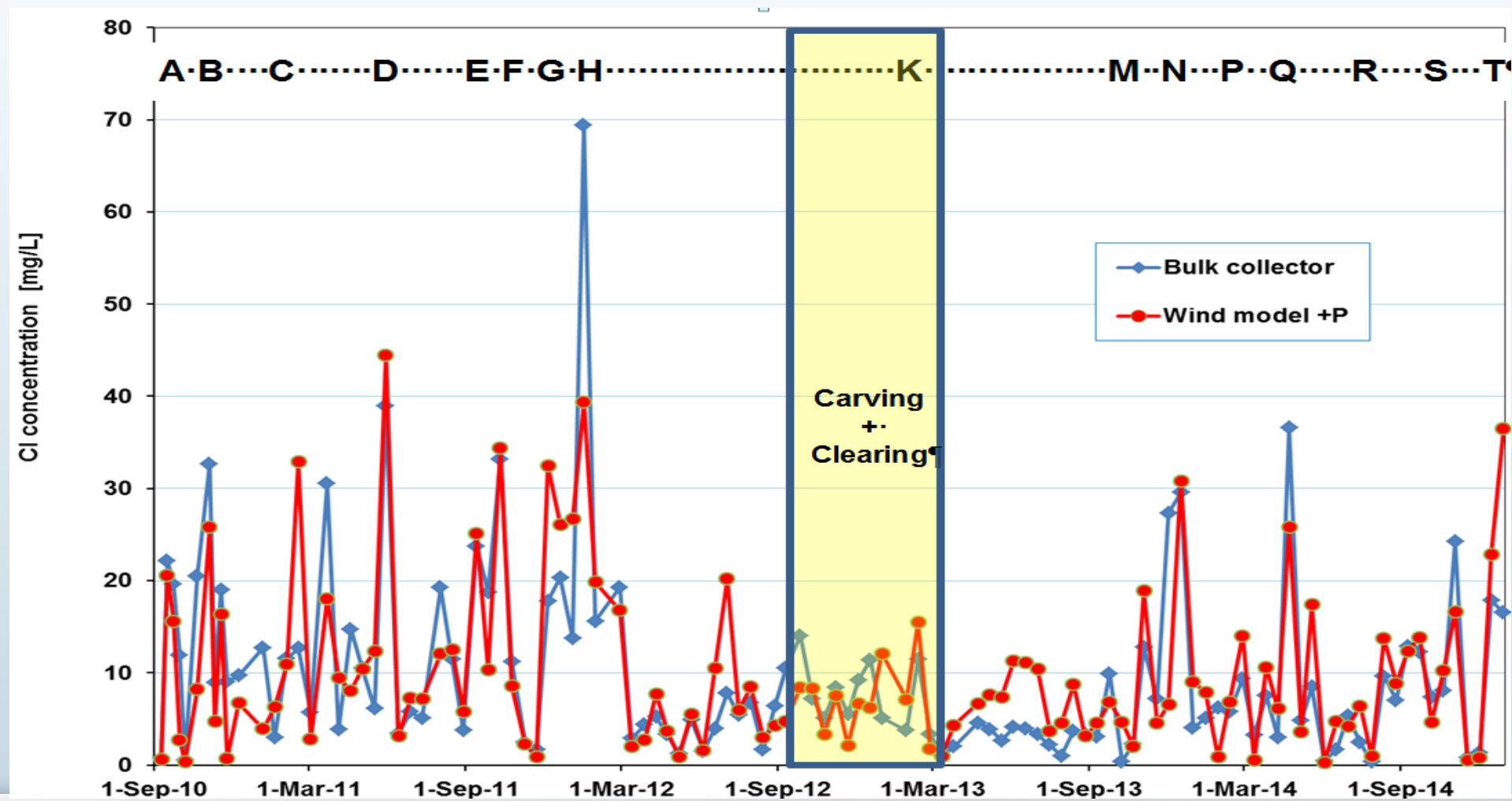


# Vergelijking zeezout meetresultaten vóór (sep.2010 – sep. 2012), en na kerven + kaalscheren zeereepzone (mrt 2013 – juli 2015)

→ zeezoutdepositie overal afgenomen met ca. 25%: zoutvangers, regenvangers, bodemvocht, ondiep grondwater

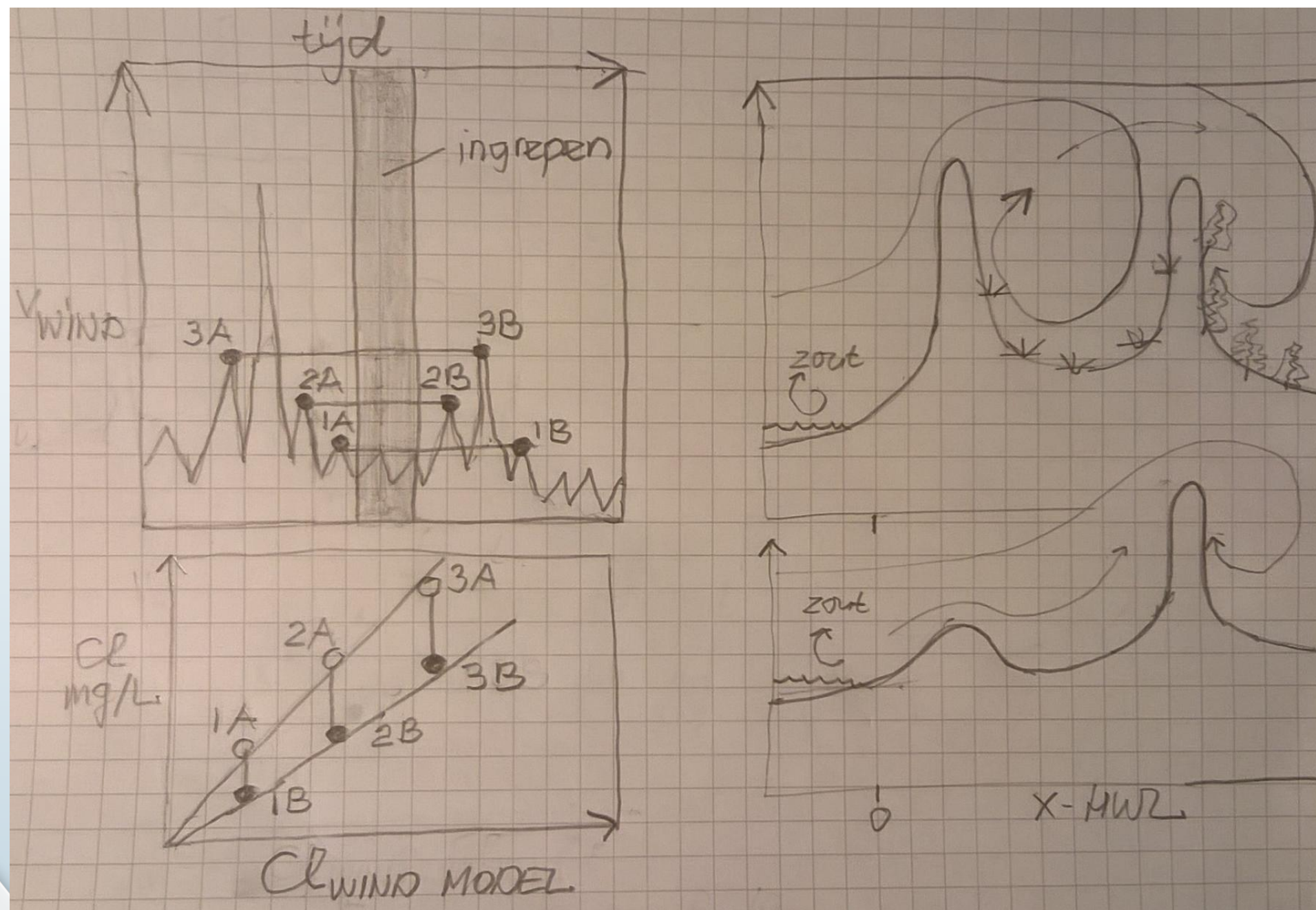
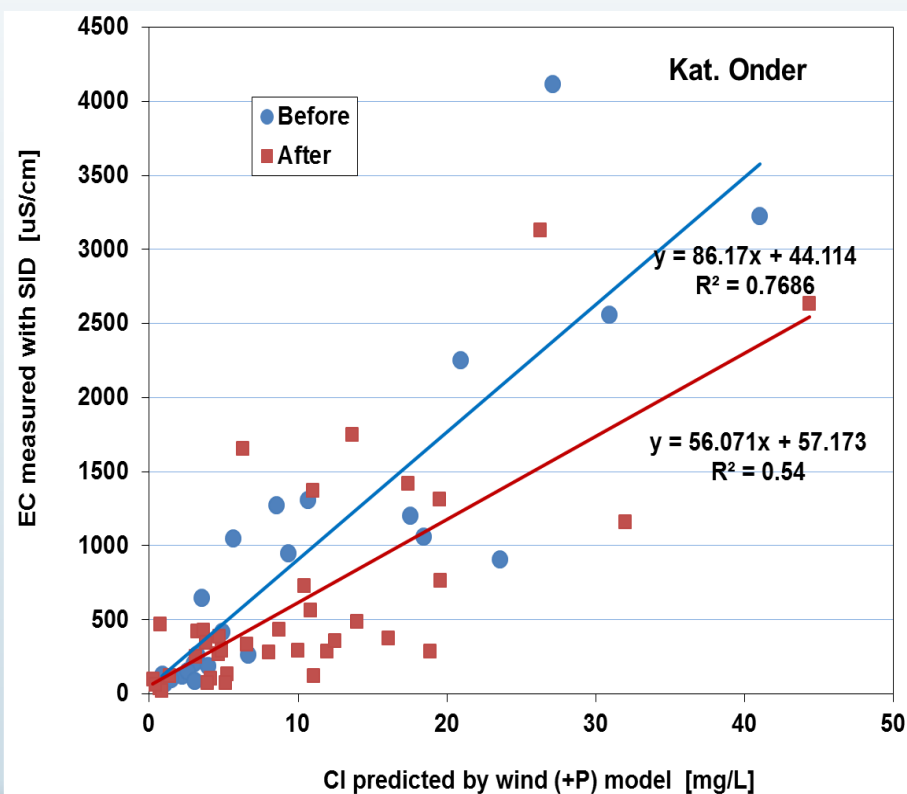
Dit lag onvoldoende aan veranderingen in:

- regenval (na 0.1 mm/d hoger)
- $v_{WIND}$  (0.09 m/s lager)
- $W_{DIR}$  (13 N°E minder)
- zeewater saliniteit (2 % minder)





# Steilere helling blauwe regressielijn → condities voor zeezoutdepositie na ingrepen ongunstiger dan ervoor.





# Enkele conclusies

- Ondanks kerven toch 25% minder zeezout, waarschijnlijk tgv veranderd depositiemilieu (ruwheid terrein minder)
- Kaalscheren en zandoverstuiving minder begroeiing, minder E, minder bodem CO<sub>2</sub>, betere grw kwal.
- Strateg. grondwatervoorraden in zoetwaterlens van gekerfde kustduinen geen gevaar door verzilting (↓↑)
- **Natuurbeheerders:** combinatie van zeereepkerven met kaalscheren van achterliggende paraboolduinen is hydrogeochemisch gunstig: (i) kwaliteit van ondiepe duingrondwater verbetert vanuit drinkwaterperspectief, (ii) verhoging grondwaterstand, en (iii) vertraging bodemontkalking



Effecten van meteorologische condities, het kerven en kaalscheren van de zeereepzone op de samenstelling van regenwater, bodemvocht en grondwater in de Kennemerduinen



ontwikkeling-beheer natuurkwaliteit  
o+bn

vereniging van bos- en natuurterreineigenaren  
VBNE