Dealing with the unpredictable: anticipation of drought and salinity stress to crops under erratic weather condition

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Knowledge for Climate

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Problem definition

- Project in the context of Knowledge for Climate on impact climate change on agriculture
- How to deal with drought and salinity?
- Weather is poorly predictable!
- How to predict sustainable agriculture under changing climate and erratic weather?
- Preferably generic, not only NL

Knowledge for Climate

Drought and Salinity

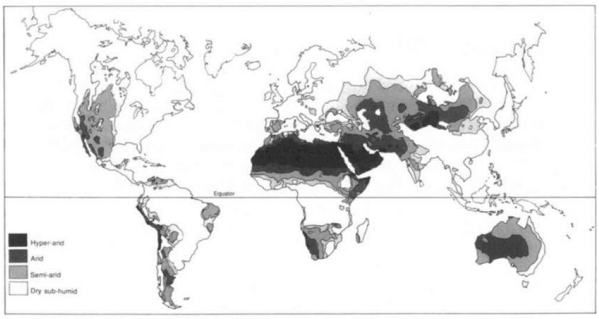
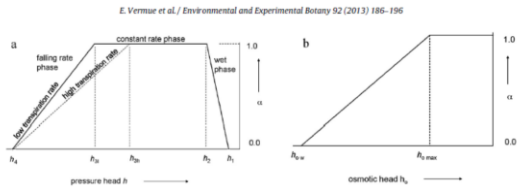


Figure 2: Drylands of the world (UNEP, 1992b).

Predict: needs a model:

Conceptual model,
analytical or numerical of:

- Water & salt dynamics in soil



- Yield response to drought and salinity
- Feddes et al. (1977) & Maas & Hoffman (1977)

These functions are challenged

Overall effect of:

- Soil
- Crop
- Climate

- Unfounded assumptions
- Permanent exposure!
- Recovery drought/salt?
- Validity to generalize?!

Re-assessment of salt tolerance functions

what do we gain with new salt tolerance functions?

Region/ Water board	Current salt tolerance return	future return	Change returns
	€	€	€
	9 041 550.-	9 127 427.-	85 877.-
Hollands Noorderkwartier	367 218 784.-	389 183 232.-	21 964 448.-
Rijnland	51 711 368.-	53 118 308.-	1 406 940.-
Zeeuwse Eilanden	57 468 320.-	65 957 620.-	8 489 300.-
Zuidhollandse Eilanden	155 279 264.-	157 212 784.-	1 933 520.-
Wetterskip Fryslan + wadden	89 125 048.-	93 484 960.-	4 359 912.-
Schieland+Krimpenerwaard	10 585 296.-	10 596 339.-	11 043.-
Zeeuws Vlaanderen	23 461 200.-	24 163 548.-	702 348.-
Brabantse Delta	312 371 840.-	319 925 792.-	7 553 952.-
Hunze en Aa's	104 091 776.-	104 093 848.-	2 072.-
Noorderzijlvest	45 889 700.-	48 580 816.-	2 691 116.-
Zuiderzeeland	471 360 608.-	480 998 272.-	9 637 664.-
Totaal	1 697 604 754.-	1 756 442 946.-	58 838 192.-

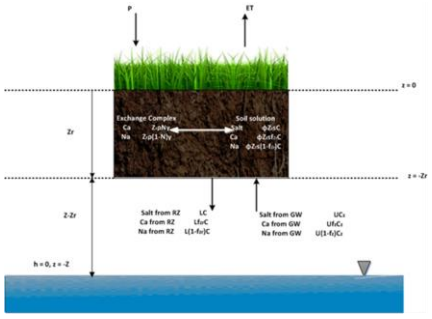
Approach of predictions

Consider a rootzone

+ all fluxes of water

+ fluxes of salt in water

- Rainfall & irrigation vary (erratically) in time
- This forces erratic behavior on water & salt dynamics

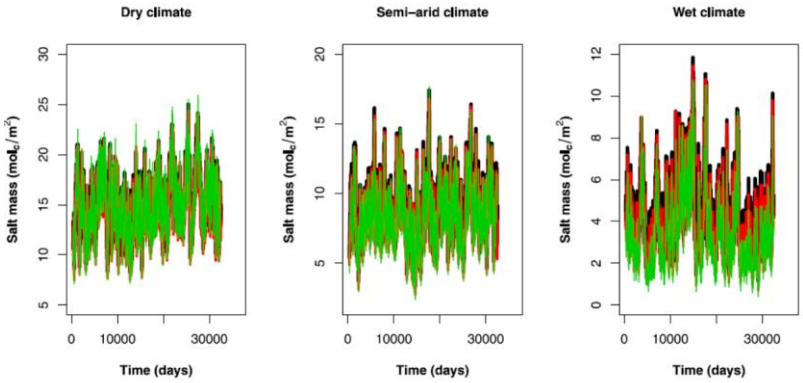


Data availability

1. Climate/weather data
2. Soil profile data
3. Geohydrology
4. Crop drought & salinity data

1. Well available (national & world)
2. Well available (soil survey inst.)
3. Well available (water inst.)
4. limited

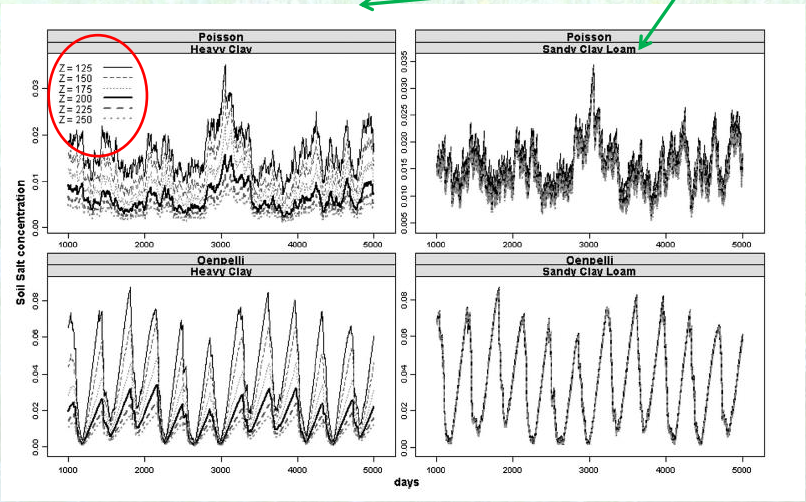
Irregular change of salt mass in rootzone under erratic weather



scenarios

- Consideration of synthetic (Poisson distributed) rainfall: for understanding
- Consideration of real rainfall records with seasonal effects: for real

Salinity; 6 groundwater levels
Poisson or seasonal climate; 2 soils



Vervoort & Van Der Zee, Ecohydr. 2013

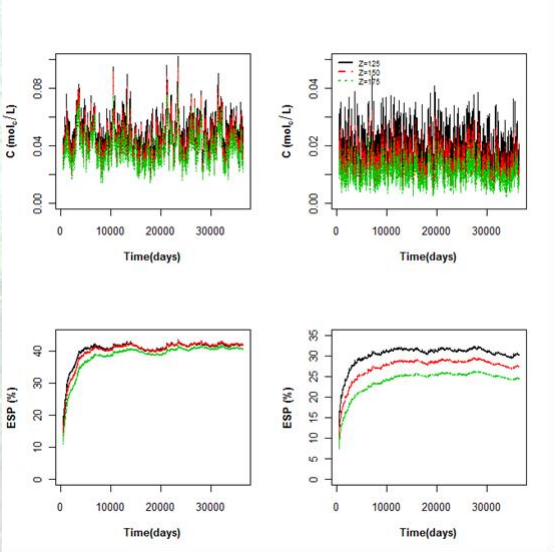
Sodicity: salinity induced soil structure deterioration!

- Quantified by
- ESP = sodicity
- ESP = percentage of CEC occupied by Na^+
- Gapon (nonlinear) exchange

Salinity & Sodicity: numerical results

Poisson climate

- Different rate of approach new equilibrium
- Different short term variation (buffering)
- Rate & level depend on many properties

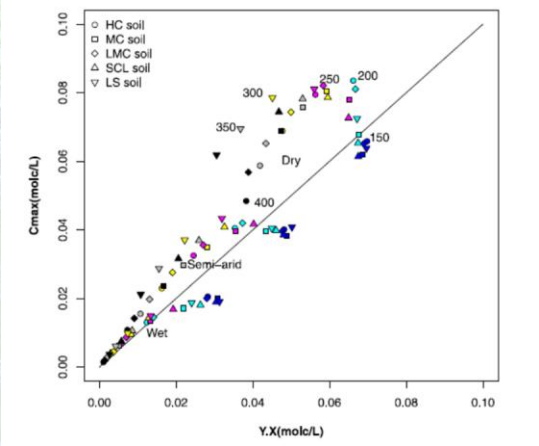


Mathematical analysis for C and ESP

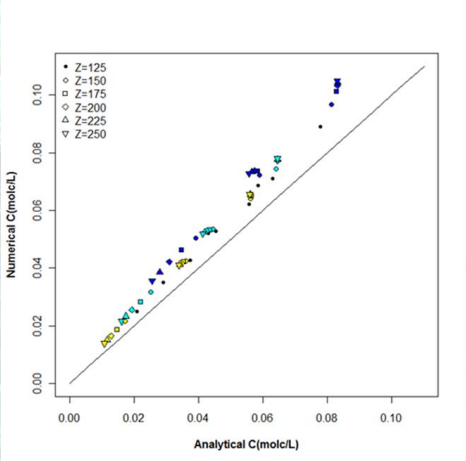
- 1st order reservoir
- $Y(t) = Y(\infty)[1 - exp(-t/\tau)]$
- τ for C: pore volu
  root zone, <
- ameters +
- $\langle E \rangle, \langle L \rangle, \langle U \rangle$ fr
  Vervoort
- $= \langle U \rangle C_Z / \langle L \rangle$
- $ESP(\infty) = ESP(\langle C \rangle, f_Z)$

Never mind the details:
Message: the math is very simple

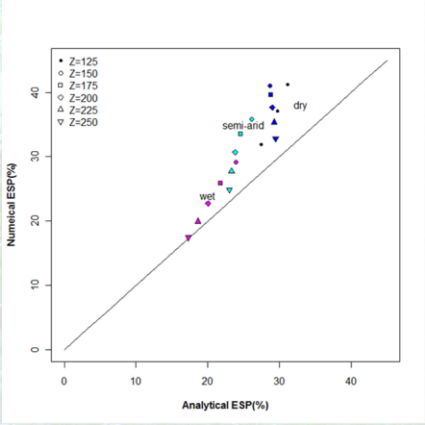
$C\langle\infty\rangle$
numerical vs simple, analytical
different soils, climates



$C\langle\infty\rangle$
numerical vs simple, analytical
one soil, climate, different Z



Long term $\langle ESP(\infty) \rangle$ numerical vs analytical one soil, climate, different Z



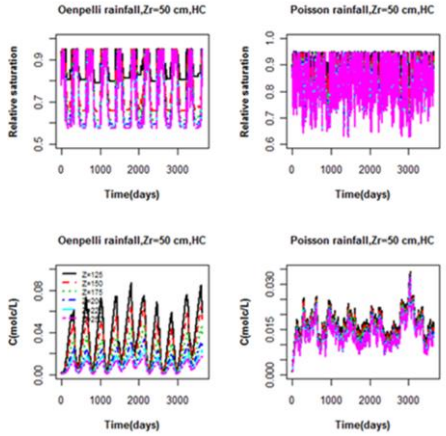
Conclusions

- Some properties, e.g. $\langle C(\infty) \rangle$, $\langle ESP(\infty) \rangle$ reasonably predicted with very (!) simple equations
- Unexplained patterns: gaps in current understanding
- Currently: confront with data & experiments & advanced models

Thank you

Seasonal effects are profound!

Strong periodicity of soil water content and on salt concentration



Which long term root zone concentration $\langle C(\infty) \rangle$