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Stochastic risk analysis of soil and ground water salinity in river delta areas

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Context and research questions

In deltaic areas worldwide, groundwater salinity is a problem. Replenishment of water in the rootzone (upper soil layer) by saline groundwater leads to salinity problems, that may be irreversible. Our aim is to avoid salinity problems, taking into account that weather is unpredictable from year to year.

Approach

We adopt an ecohydrological 'systems analysis' approach, using proven technology on input parameters (climate, vegetation/crop, soil, geohydrology) from consensus data bases, cast in a stochastic framework of meteorological forcing. This framework leads to a probabilistic analysis of the risk of salinity (as well as, in fact, drought), for the situation at hand.

Results

For the simple system, illustrated in Figure 1, the salinity under Poisson type rainfall shows irregular patterns, that are dictated by poorly predictable rainfall patterns.

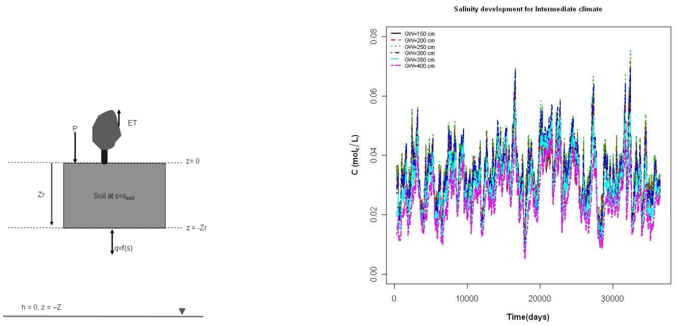

Figure 1: Illustration of the simplified soil-groundwater system (left) and the salinity development for some climate/soil/vegetation combinations (intermediate dry climate) and 6 groundwater depths (different colours, right)

The patterns may differ each year. Hence, a risk assessment requires a stochastic approach, that accounts for the variability of the weather pattern. For an erratic weather pattern the properties of interest (drought, salinity, yield depression) can be modeled and for a Poisson Process PP even a simple formula is feasible

Ref: Suweis et al., Geophys.Rev. Letters, VOL. 37, L07404, oi:10.1029/2010GL042495, 2010

Results (cont'd)

For instance, if the interest is which salinity should be expected for certain situations, a graph such as Figure 2 can be calculated. To do the same exercise for other climate, soil, geohydrology, and vegetation conditions is easy. Figure 2 tells us the risk of salt problems on a statistical basis.

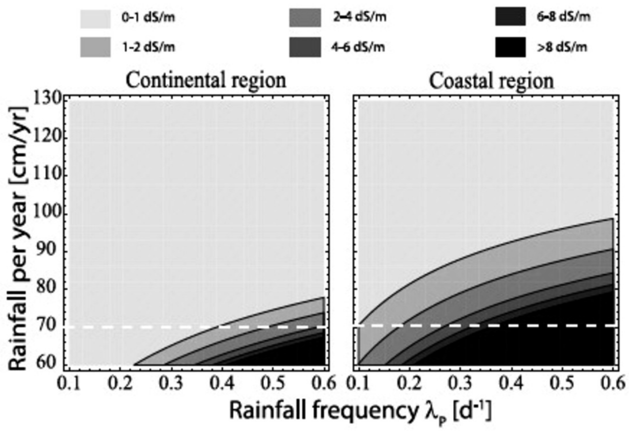

Figure 2: Topsoil salt levels as a function of rainfall quantity (vertical) and rainfall frequency (horizontal). For details, see Suweis et al. (2010)

Prospects for the future

In view of the mathematical complexity, a simple analysis may not always be feasible. However, the approach can be used in numerical assessments of risks subject to erratic and unpredictable weather patterns. Some examples of interesting risks to quantify could be: (i) probability of a particular yield loss, (ii) probability that a drought induced yield loss can be repaired by irrigation with brackish water, (iii) the risk of irreversible damage to nature areas, due to salinity of surface or ground water.

The approach does not prevent that unexpected events, e.g. the extreme drought of 2003, can occur and have devastating effects. Otherwise, insurances would not be needed. However, it quantifies the chance that certain events occur, and gives entrepeneurs the possibility to balance risks and gains. For these reasons, this line of research is pursued, integrating improved understanding of salinity induced crop yield depressions and damage to nature, as developed in the Knowledge for Climate program.

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