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Modeling soil water content for vegetation modeling improvement

Carmen Cianfrani, Aline Buri, Barbara Zingg, Pascal Vittoz, Eric Verrecchia, and Antoine Guisan
Institute of Earth Surface Dynamics (IDYST), University of Lausanne (UNIL), 1015 Lausanne, Switzerland,
carmen.cianfrani@unil.ch

Soil water content (SWC) is known to be important for plants as it affects the physiological processes regulating plant growth. Therefore, SWC controls plant distribution over the Earth surface, ranging from deserts and grassland to rain forests. Unfortunately, only a few data on SWC are available as its measurement is very time consuming and costly and needs specific laboratory tools. The scarcity of SWC measurements in geographic space makes it difficult to model and spatially project SWC over larger areas. In particular, it prevents its inclusion in plant species distribution model (SDMs) as predictor.

The aims of this study were, first, to test a new methodology allowing problems of the scarcity of SWC measurements to be overpassed and second, to model and spatially project SWC in order to improve plant SDMs with the inclusion of SWC parameter.

The study was developed in four steps. First, SWC was modeled by measuring it at 10 different pressures (expressed in pF and ranging from pF=0 to pF=4.2). The different pF represent different degrees of soil water availability for plants. An ensemble of bivariate models was built to overpass the problem of having only a few SWC measurements (n = 24) but several predictors to include in the model. Soil texture (clay, silt, sand), organic matter (OM), topographic variables (elevation, aspect, convexity), climatic variables (precipitation) and hydrological variables (river distance, NDWI) were used as predictors. Weighted ensemble models were built using only bivariate models with adjusted-R2 > 0.5 for each SWC at different pF. The second step consisted in running plant SDMs including modeled SWC jointly with the conventional topo-climatic variable used for plant SDMs. Third, SDMs were only run using the conventional topo-climatic variables. Finally, comparing the models obtained in the second and third steps allowed assessing the additional predictive power of SWC in plant SDMs.

SWC ensemble models remained very good, with adjusted-R2 ranging from 0.55 to 0.65. Bivariate models with higher performance were the one using OM and river distance for pF < 2.7 and the one using clay content and topography (convexity) for pF > 2.7.We found that adding SWC improves vegetation models. It improves 51%-64% (depending on pF) of plant SDMs. In 6-10% of SDMs, SWC was the most important variable.

In conclusion, this study emphasized that important information is still missing in SDMs to capture all abiotic drivers of plant species distributions.