Modelling plant-available soil water in Amazonia
Montpellier, France; starting date : February 15th 2022

Context and objectives:

Plant-available soil water is a major driver of species distribution and ecosystem functioning, in particular in tropical forests (e.g. Baltzer, Davies, Bunyavejchewin, & Noor, 2008; Esquivel-Muelbert et al., 2017; Ouédraogo et al., 2016; Wagner et al., 2016). Quantifying plant-available soil water and its spatio-temporal variability is thus crucially needed to understand and predict the fate of tropical forests, especially as drought intensity and frequency is predicted to increase across the Tropics (Duffy et al., 2015). To this end, most studies focusing on regional to continental scales have so far used simple indices that account for climatic variables only, such as annual precipitation or dry season length. A widely used index is the maximum cumulative water deficit (MCWD; Malhi and Wright 2004; Aragão et al. 2007; Chave et al. 2014; Ouédraogo et al. 2016; Esquivel-Muelbert et al. 2017; Esquivel-Muelbert et al. 2019). The basic principle of MCWD is to accumulate the monthly water deficit in order to quantify the maximal water stress constraining plants at one site. The monthly deficit is itself computed as the balance between water supply and demand, whereby water supply to plants is assumed to be equal to precipitation. It thus does not take into account the soil hydrologic properties nor the topographic position, that can have strong effects on water retention and drainage, and therefore on plant-available soil water and tree species distribution (Sabatier et al. 1997). One of the main difficulties to account for the effect of soil properties on water availability for plants consists in the lack of relevant soil data at large scales.

This project aims at quantifying the plant-available soil water across French Guiana by combining the concept of MCWD with the one of Relative Extractable Water (e.g. Wagner et al. 2011, 2012) or water-balance model (Nepstad et al. 2004, Ouédraogo et al. 2016) by mobilizing different types of data, and assess the possibility to expand such quantification to the whole Amazonian basin.

More specifically, the objectives are to:

(i) Leverage the soil data available in French Guiana (e.g. soil texture, organic matter content) to map soil properties across French Guiana using machine learning approaches such as Random Forest models and a set of environmental variables at various spatial scales as potential predictors, including landscape-scale geomorphological units previously mapped (Guitet et al., 2013, 2015) and local topographic variations derived from 30m-SRTM images. Results will then be compared to data or maps available at larger scales (Hengl et al., 2017; Marthews et al., 2014) whose limitations will be discussed. Model development and performance assessment will endeavour to account for spatial autocorrelation (Meyer et al., 2019; Meyer & Pebesma, 2021; Ploton et al., 2020). This task will benefit from preliminary works led by the team or collaborators.

(ii) Build an index of plant-available soil water combining the approaches of MCWD and of water-balance model, and map it across French Guiana. Different hypotheses on root depth will be discussed. Opportunities and limitations to expand such mapping of water availability to the Amazonian basin will be then assessed.

The index of plant-available soil water will be added to a dataset of climatic and environmental variables for French Guiana (https://guyaclim.cirad.fr/) under construction. In collaboration with the team, climatic and environmental variables will be used to explore changes in tree species assemblage (beta diversity) and forest structure across French Guiana, using statistical models such as species distribution models.

Required skills :

The candidate should have the following qualifications:

- PhD in ecology, sol sciences or environmental sciences.
- General knowledge in ecology.
- Knowledge of tropical soils.
- Willingness to use modelling and data analysis approaches.
- Familiarity with R and expertise in statistical analyses.
- Experience in machine learning approaches.
- Experience in using a software of spatial analysis (R, GRASS, QGIS).
- Excellent written skills in English.

Team :

The post-doc will work in close collaboration with Vincent Freycon, Isabelle Maréchaux, and Ghislain Vieilledent. V. Freycon is a soil scientist (CIRAD, UPR Forêts & Sociétés, Montpellier) working on the relationships between soils and tropical forests. He has a great field experience in French Guiana and Congo Basin, and on the spatial distributions of soils as a function of geomorphology in these areas. I. Maréchaux is an ecologist (INRAE, UMR AMAP, Montpellier), and her research aims at better understanding and predicting the dynamics of tropical forests, taking the large taxonomic and functional diversity they shelter into account. To this end, she mainly uses two complementary approaches – modelling and ecophysiology – using traits measurements in the field, mainly in French Guiana. G. Vieilledent is an ecologist (CIRAD, UMR AMAP, Montpellier) who leads research on community ecology and on the interactions between tropical forests and climate. He develops statistical, mapping and computing tools to tackle new research questions in these fields, mainly in Madagascar, French Guiana, and New-Caledonia.

The post-doc will be funded by the METRADICA ("Mechanistic traits to predict shifts in tree species abundance and distribution with climate change in the Amazonian forest") project, funded by the Labex CEBA (http://www.labex-ceba.fr/en/6337-2/). While the post-doc work is included in the first task of the project, the index he/she will develop and map will be used in other tasks of the project. He/she will thus interact with the rest of the project team, including Bruno Ferry (AgroParisTech), Stéphane Guitet (ONF Guyane), and Clément Stahl (INRAE, ECOFOG).

Location :

The post-doc will be based in Montpellier, France, within the *Forêts & Sociétés* lab (https://ur-forets-societes.cirad.fr/), on *Campus de Baillarguet* (access from Montpellier city center by buses), with regular visits to AMAP lab (https://amap.cirad.fr/en/index.php). One or two two-week missions in French Guiana, within the ECOFOG lab (http://www.ecofog.gf/ , Kourou) are planned.

Appointment time and starting date : from 12 to 17 months depending on the post-doc experience, with a starting date in February 2022.

Salary : will depend on the experience of the post-doc, 2150€ net per month for a junior post-doc (<2 years experience since PhD). In addition to salary, the contract includes social insurance, contributions to lunch fees. 45 days of holidays per year.

Application : To apply, e-mail (1) a letter of application, (2) a CV and (3) 2 letters of recommendation, in one single pdf file, to vincent.freycon@cirad.fr, isabelle.marechaux@inrae.fr and ghislain.vieilledent@cirad.fr before December 31st 2021.

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