PhD Offer (3 years)

at the Laboratoire des Sciences du Climat et de l'Environnement (LSCE)

Unite mixte CEA-CNRS-UVSQ, Universite Paris-Saclay

What are the respective contributions of anthropogenic land cover change and global warming on rainfall amounts and variability, in rainfed agricultural regions across the world ?

Summary

Land use (switching from one land cover to another or changing land management) is known to be important for climate at both global and regional scales. It is a significant source of greenhouse gas emissions for the atmosphere and thus contributes to global warming. At smaller spatial scales it can shape the response of some regions to global warming, by either dampening or enhancing the increase in temperature during summer time (for example). It has also been shown to modulate the intensity, frequency and persistence of heat waves.

The effects of land use on climate, discussed throughout the literature, generally focus on greenhouse gas emissions and on temperature. Those are the two variables that have been assessed in the IPCC special report on Land (published August 8, 2019). Many papers however report significant effect of e.g. tropical deforestation on rainfall in the Amazon, others have looked at the effects of land cover (e.g. afforestation) or management (e.g. irrigation) on african and asian monsoon rains. But there is yet no assessment made on how land use affects the water cycle, in a changing climate, at both the global and regional scales. How are the various components of the water cycle affected by land use? How do those changes compare with the ones induced by global warming?

In addition there is evidence that deep-water resources, used for irrigated agriculture, are becoming or may become more scarce in many regions of the world with both increasing anthropogenic pressure and climate change. There is thus a need to make sure that rainfed agriculture can still be sustained across the world.

We propose, for this PhD work, to assess the respective contributions of anthropogenic land cover change and global warming on past and projected changes in rainfall, with a specific focus on present-day rainfed agriculture areas as well as on present-day irrigated areas. The student will analyze existing simulations carried out in various modeling groups around the world, within the framework of IPCC exercises. Those simulations address past and future climate changes, with and without land use changes, at both global and regional scales.

Context of the work

Land use refers to changes in land cover (e.g. deforestation to grow crops) as well as to changes in land management (e.g. irrigation). It is known to be important for climate at both global and regional scales. It is a significant source of greenhouse gas emissions for the atmosphere and thus contributes to global warming (Le Quéré et al. 2018, IPCC SRCCL 2019). At the scale of large continental regions, or at smaller spatial scales, it can shape the response of some regions to global warming, by either dampening or enhancing the increase in temperature during summer time (de Noblet-Ducoudré et al. 2012; Wang et al. 2014). It has also been shown to modulate the intensity and duration of some extreme weather events such as heat waves (Lejeune et al. 2018).

The effects of land use on climate, discussed throughout the literature, generally focus on greenhouse gas emissions and on temperature. Those are the two variables that are being assessed in the upcoming IPCC special report on Land (that has been published August 8, 2019). Many papers however report significant effect of e.g. tropical deforestation on rainfall in the Amazon (Lawrence and Vandecar 2015), others have looked at the effects of land cover (e.g. afforestation; Kemena et al. 2018) or management (e.g. irrigation; Chen and Jeong 2018) on african and asian monsoon rains. But there is yet no assessment made on how land use affects the water cycle, in a changing climate, at both the global and regional scales.

Objectives of the PhD and proposed organization of the work

There is a need to better assess how the various components of the water cycle are affected by land use. Those components include total evapotranspiration, rainfall, convection, water vapor in the atmosphere, and water vapor advected from or towards adjacent regions. There is also a need to compare the land use induced changes with those resulting from global warming. This is thus what is proposed for this PhD work.

The PhD will start with a thorough review of the literature. This review will beneficiate from two relevant IPCC[1] reports in which the list of essential papers will be listed: the special report on Land that came out August 8, 2019, and the 6th report that is in preparation within the IPCC working group I, and that has an entire chapter devoted to the water cycle.

The student will then analyze the many global climate simulations available, within the CMIP[2] framework (CMIP5 & CMIP6). For a large number of models historical and future climate simulations have been run with and without scenarios of land use change. Comparing those will allow isolate (and thus evaluate) the contribution of land use to the global water cycle. It will also make it possible to compare this contribution with that resulting from the increase in greenhouse gases in the atmosphere.

Some of those global scale climate simulations have been downscaled for many regions of the world within the CORDEX[3] framework. For example, EURO-CORDEX have launched series of simulations to evaluate how changing land cover in Europe will modify the European future climate change (project LUCAS[4]). We will use those various existing simulations to quantify the contribution of land use to the European water cycle.

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[1] IPCC – The Intergovernmental Panel of Climate Change - https://www.ipcc.ch/

[2] CMIP – Coupled Model Intercomparison Projet -

[3] CORDEX – Coordinated Regional Climate Downscaling Experiment - https://www.cordex.org/

[4] LUCAS – A CORDEX FlagShip Project 'Land Use & Climate Across Scales' - http://www.icrc-cordex2016.org/images/pdf/Programme/presentations/parallel_B2/B2_1_Rechid.pdf

Agricultural areas will be the focus of the analyses carried out as the overarching question we are interested in is whether rain will be sufficient to sustain rainfed agriculture in the future. The respective contributions of anthropogenic land cover change and global warming to the variations and variability of rainfall in those areas will be analyzed.

Requested Competences and diploma

This subject being centered around the use of climate models, the student needs to be familiar programming, data analysis, statistics. Knowledge of Linux, R and/or Python is strongly encouraged.

The candidate will need to be familiar with the theme of climate change and if possible have some knowledge in land-atmosphere interactions.

Requested diploma: Master 2 or equivalent.

Direction and Co-direction of this thesis

This PhD work will be supervised at LSCE by Nathalie de Noblet-Ducoudré, nathalie.de-noblet@lsce.ipsl.fr

This work will be co-supervised by 2 high-level international scientists who declared themselves very interested in this topic, and who can host the PhD student for some time during the thesis:

- **Andy Pitman.** Director of the ARC Centre of Excellence for Climate Extremes; The University of New South Wales, Sydney, NSW, 2052; Email.: a.pitman@unsw.edu.au

- **Elena Shevliakova.** Climate Modeler, Ecology and Evolutionary Biology, co-chair of LMDT; GFDL, New York – USA; Email.: elena.shevliakova@noaa.gov

Location of the PhD

The PhD will work at LSCE (https://www.lsce.ipsl.fr/), just outside Paris on the Plateau de Saclay. Nathalie de Noblet-Ducoudré works in the team ESTIMR (https://www.lsce.ipsl.fr/Phocea/Vie_des_labos/Ast/ast_groupe.php?id_groupe=22) and so will the PhD student.

How to apply?

CV and motivation letter to be submitted **before April 12, 2020**. Informations to be sent directly to nathalie.de-noblet@lsce.ipsl.fr

You should get a message confirming the receipt of your application within 1 week. If you do not please try again

References

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