Ph.D. fellowship in Satellite Remote Sensing and Climate / 2019-2021

Hosting laboratory : CNRM (University of Toulouse, Météo-France, CNRS), Toulouse, France

Ph.D. title : Deforestation and afforestation impacts on the climate of temperate regions based on 40 years of satellite observations

Starting date : From now until February 2019 (applications will be considered until November 2nd until a successful candidate is found)

Funding : Co-funded by European project and Météo-France

Ph.D. advisers : Dominique Carrer and Xavier Ceamanos (CNRM researchers)

Background and objectives

The actions of man and nature can transform forests into grasslands or crops (deforestation) or vice versa (afforestation). Forests play a key role in the climate system because of their role in the carbon cycle. They also affect the climate by modulating the exchange of energy and water vapor between the surface and the atmosphere. On the one hand, the presence of forests may warm the climate due to the low reflectivity, or albedo, of this type of surface. On the other hand, forests may cool the climate by increasing evapotranspiration in summer. Thus, the sign and magnitude of the impact of the presence (or absence) of forests on the climate often result from the competition between these two biophysical effects.

Uncertainties related to this competition are mostly found in temperate regions, where the impact on climate is more complex than for boreal or tropical forests. Some model-based studies suggest that temperate forests cool the air in comparison to grasslands and cropland, while other studies argue otherwise (Sanderson et al., 2012). Other studies point to the uncertainty about the effectiveness of afforestation efforts in Europe in the past, which have often been achieved by planting conifers instead of broadleaf trees (Naudts et al., 2016). The type of forest cover change is indeed important. For a broadleaf forest, the transition to grassland will have a different effect on climate than the transition to cropland (Bright et al., 2017). However, it is still difficult today to indicate which type of cover change would be most beneficial for the climate.

Remote sensing from space is able to investigate these questions by providing estimates of the evolution over time of these biophysical variables (albedo, evapotranspiration, etc.) and other parameters (surface temperature, vegetation type, forest cover change, etc.). During the last two decades the CNRM has developed expertise on the restitution of radiative variables including surface albedo from satellite data. Currently, the remote sensing team of the CNRM is working in two European projects aimed at generating biophysical parameters by satellite: the LSA SAF (http://lsa-saf.eumetsat.int/), using observations from EUMETSAT satellites since the 2000s, and C3S (https://climate.copernicus.eu/), which focuses on long time series since the 1980s.

The aim of the thesis is to study the effect on temperature of past changes in forest cover in temperate zones. One of the strengths and originality of the proposed work is to study the biophysical impact of forests on climate based mainly on satellite observations, and to compare the findings to the outputs of climate models.

Job description and requirements

The study will be based on the analysis of biophysical variables estimated from 40 years of satellite observations. Impacts will be differentiated as much as possible depending on the type of cover change (ie, depending on the type of forest and alternative cover). Alkama and Cescatti (2016) have developed a method to differentiate the signal related to the change of cover, and the signals corresponding to seasonal and climatic variations. This same methodology will be used to quantify the effect of the presence (or absence) of forests, and to quantify the magnitude of impacts according to the type of transition.

The impacts of these cover changes will be compared to the possible effects of slow trends on the change in vegetation properties. Over the last decades, satellite observations indicate an increase in the number of tree leaves (called greening of the vegetation; Munier et al., 2018) and therefore a greater capture of solar radiation by the surface (ie, a decrease in albedo; Planque et al., 2016). Trends will be derived based on the 40 years of satellite data available thanks to the C3S and LSA-SAF projects. Trends related to increasing of leaf quantity and albedo reduction will be compared to potential temperature trends in stationary forest areas.

Finally, in a more prospective third part, the importance of the occurrence of extreme events (fires and storms) on the modification of forest cover and climate (Teuling et al., 2017) will be discussed. The limits of the conclusions of our work will be discussed regarding potential climate feedback loops caused by forest cover changes (eg, change of cloud cover). For this, the Ph.D.

candidate will have at her/his disposal outputs of climate simulations incorporating scenarios of change of cover (Lawrence et al., 2016). This part of the thesis will be carried out in close collaboration with the CNRM climate group.

The desired candidate will have a Master of Science degree or an engineer degree. She/he will be familiar with one or more of the following topics: continental surfaces, remote sensing, biosphere, and data processing. Good programming skills are required.

Application procedure

Interested candidates/students in this Ph.D. fellowship should send the following documents by e-mail to dominique.carrer@meteo.fr, and xavier.ceamanos@meteo.fr:

- Resume/CV detailing academic background, experience in research, and technical/programming skills
- Motivation letter
- Names and contact details of two referees

Bibliography

- Sanderson et al., EC Directorate General of the Environment, 2012
- Naudts et al., Science, 2016
- Bright et al., Nature, 2017
- Alkama and Cescatti, Science, 2016
- Munier et al., Remote Sensing, 2018
- Planque et al., Remote Sensing of Environment, 2016
- Teuling et al. Nature, 2017
- Lawrence et al., GMD, 2016