



## **Ph.D. position: Towards Near Real-Time Carbon Budgets over Metropolitan France with the Enhanced Vegetation Photosynthesis-Respiration Model**

ATOS are looking for a PhD candidate to be hired as a permanent position by ATOS working in an integrated team with the LSCE (Laboratoire des Sciences du Climat et de l'Environnement) and AgroParisTech on new tools to quantify regional carbon budgets using satellite imagery data.

### **Background:**

Studying the carbon cycle requires precise monitoring of the Net Ecosystem Exchange (NEE) of carbon dioxide (CO<sub>2</sub>) between the terrestrial biosphere and the atmosphere as well as of its two component fluxes, the Gross Ecosystem Exchange (GEE) and the Ecosystem Respiration (R<sub>Eco</sub>). A continuous quantification and monitoring of the Net Ecosystem Exchange (NEE) of the carbon dioxide (CO<sub>2</sub>) is essential for understanding climate impacts and detecting hotspots of carbon losses by ecosystems. Changes in the seasonal photosynthetic activity due to climate and weather alter the ecosystem productivity and net biospheric-atmospheric CO<sub>2</sub> exchange. Given the uncertainties surrounding these processes, it is essential to quantify the spatial and temporal patterns of carbon fluxes between the biosphere and atmosphere for different biomes and to understand their proximal controls.

Earth observation technique offers an ideal approach to extrapolate the CO<sub>2</sub> fluxes from single sites measurements to obtain continuous and spatial representation of the CO<sub>2</sub> fluxes. One identified and commonly used data-driven model for CO<sub>2</sub> fluxes estimations is the Vegetation Photosynthesis and Respiration Model (VPRM). The VPRM is based on the assimilation of remote sensing derived vegetation indices with climatic data with the aim to spatially extrapolate the CO<sub>2</sub> fluxes between the biosphere and the atmosphere. VPRM was calibrated for Europe and chosen as a compensation between model's complexity and estimation accuracy to upscale the CO<sub>2</sub> fluxes at large scales. It is currently used by ICOS (European Integrated Carbon Observation System) to provide hourly NEE, GEE, and RECO maps for Europe between 33° and 73° north and -15.0° to 35.0° east.

Recent research work focusing on the assessment of the current VPRM over Europe showed unsatisfactory estimations for CO<sub>2</sub> fluxes when compared to flux tower sites measurements. Main limitations included the low spatial resolution of the used optical sensor (MODIS data at 500 m spatial resolution) limiting the accurate representation of the photosynthetic activity, the unsatisfactory representation of the ecosystem respiration, the absence of a precise quantification of all the drivers of the CO<sub>2</sub> fluxes in the current VPRM equation as well as the poor capability of the current model to capture drought and water stress effect on the vegetation cover.

### **Objective**

The main objective of this thesis will concentrate on enhancing the VPRM model for a better simulation of the biosphere – atmosphere fluxes at large scale and very high resolution (100 m) with an application over France and Europe.

The improvement of the VPRM model will mainly focus on (1) Assessing the capabilities of the Sentinel-2 (S2) and/or Sentinel-3 (S3) multi-spectral data in estimating the Gross Ecosystem Exchange (GEE) across major biomes in Europe with the aim to reinforce the VPRM model with the most appropriate S2 vegetation indices for characterizing the photosynthetic activity in the GEE (2) Incorporating biophysical parameters retrieved from Sentinel-2 and/or Sentinel-3 remote sensing data which can help expand



the VPRM equation to account for more biophysical structure of the vegetation, (3) Incorporating a simple description of carbon pools dynamics (from CASA NASA model) to better link photosynthesis and respiration by providing a more complete picture of the carbon cycle considering carbon stored in different parts of the plant and soil and (4) Integrating more detailed representations of the underlying physiological processes by considering the influence of internal plant factors such as nutrient availability and water status on photosynthesis and respiration.

The expected research findings will help establish an accurate and continuous monitoring system for CO<sub>2</sub> fluxes at hourly resolution over France Metropolitan.

### **Required skills**

- Strong background in remote sensing principles with ability to utilize and deploy relevant satellite image processing tools
- Highly skilled in programming (preferably in Python/R) and machine learning, with a strong ability to implement and optimize algorithms
- Having expertise in similar climatical/ecological applications is a plus
- Satisfactory level of English proficiency (written and oral)

### **Selection Criteria**

- Master's degree in the fields of remote sensing and/or machine learning,
- Autonomy, ability to work in a team, and time management skills.
- Experienced in multidisciplinary team-based activities with the ability to effectively communicate with colleagues and with staff from the partners of a project.

### **PhD. Director:**

Philippe Ciais (LSCE)

### **PhD co-directors:**

Hassan Bazzi (Atos-France) and David Makowski (AgroParisTech)

### **Duration of the Ph.D.:**

36 months

### **Funding:**

The research is funded by ATOS and CLand a Convergence Institute performing research urgently needed on land-management solutions for managing the ecological and energy transitions of the 21st century. The successful candidate will be offered a permanent position at ATOS and will work on the PhD project for the first three years of his contract.

### **What Atos, LSCE and AgroParisTech can offer you**



### **ATOS ([www.atos.net](http://www.atos.net))**

Is a global leader in digital transformation with 105,000 employees and annual revenue of over € 11 billion. European number one in cybersecurity, cloud and high-performance computing, the Group provides tailored end-to-end solutions for all industries in 71 countries. A pioneer in decarbonization services and products, Atos is committed to a secure and decarbonized digital for its clients. The purpose of Atos is to help design the future of the information space. Its expertise and services support the development of knowledge, education and research in a multicultural approach and contribute to the development of scientific and technological excellence. Across the world, the Group enables its customers and employees, and members of societies at large to live, work and develop sustainably, in a safe and secure information space.

### **LSCE (<https://www.lsce.ipsl.fr>)**

Is a world-class research laboratory established and a collaboration between CEA, CNRS and the University of Versailles Saint-Quentin (UVSQ). It is part of the Institute Pierre Simon Laplace (IPSL). LSCE hosts approximately 300 researchers, engineers and administrative staff including many PhD and master's students. This project will provide the employee with the opportunity to work directly on advanced methods with researchers from the LSCE and other institutions.

### **AgroParisTech UMR MIA – Paris Saclay (<https://mia-ps.inrae.fr/>)**

The UMR MIA Paris-Saclay, associated with AgroParisTech, INRAE and the University of Paris Saclay, brings together statisticians and computer scientists specializing in statistical and computational modeling and learning for biology, ecology, the environment, agronomy and agri-food. Their skills cover statistical inference methods (complex models, latent variable models, Bayesian inference, learning, model selection, etc.), and algorithmic methods (generalization, domain transfer, knowledge representation). The unit develops original statistical and computational methods. Its activities are underpinned by a sound grounding in the disciplines for which it is intended: ecology, environment, agri-food, molecular biology and systems biology.

### **Starting date:**

The position is available from July 2023 and will remain open until filled. The expected start of the PhD is January 2024. A short contract before that starting time is possible

### **Salary:**

Competitive salary, full social and health benefits, commensurate with work experience.

### **How to apply:**

Applicants should submit a complete application package by email to the contacts below. The application package should include (1) a curriculum vitae including e.g., recent publications / projects, (2) statement of motivation (3) answers to the selection criteria above (4) names, addresses, phone numbers, and email addresses of at least two references.

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