Towards the inversion of plumes from power plants and industrial sites in satellite CO2 images using deep neural networks

Joffrey Dumont Le Brazidec*[1], Pierre Vanderbecken[1], Alban Farchi[1], Marc Bocquet[1], and Grégoire Broquet[2]

[1]Centre d'Enseignement et de Recherche en Environnement Atmosphérique (CEREA) – Ecole des Ponts ParisTech, EDF RD – 6-8 Avenue Blaise Pascal, Champs sur Marne77455 Marne la Vallée Cedex 2, France

[2]Laboratoire des Sciences du Climat et de l'Environnement (LSCE) – Commissariat à l'énergie atomique et aux énergies alternatives, Université Paris-Saclay, Centre National de la Recherche Scientifique – Bât. 12,avenue de la Terrasse, F-91198 GIF-SUR-YVETTE CEDEX, France

Résumé

Carbon dioxide anthropogenic emissions are the main driver of climate change. Current emission estimates, which are needed to guide reduction policies, rely on statistical data of energy consumption and are subject to important uncertainties.
In order to assess these emissions in an independent, timely and accurate manner, the Copernicus CoCO2 project aims to build a prototype system for a CO emission monitoring service exploiting atmospheric CO measurements, and in particular the XCO images from the future CO2M mission. As part of this project, our goal is to build an inverse modelling system to quantify large local CO sources (large urban areas and industrial sites) based on the space-borne imagery of the CO atmospheric plumes from these sources.
The quantification of such sources depends on the detection of the associated plumes in the satellite images of the CO average column concentrations (XCO), which represents a significant challenge. Indeed, the signal of the XCO plumes induced by hotspots emissions rarely exceeds values of a few ppm and its extraction is perturbed by the instrumental noise and variable regional CO background signals in the images.

We explore the use of deep learning techniques to solve the problem of CO plume detection and inversion. Our dataset used to train and test such techniques includes pseudo images based on simulations of hourly XCO fields in the vicinity of various power plants, tracing plume emissions from anthropogenic and biogenic sources. Specifically, we employ convolutional neural networks (CNN) to analyse the CO plume contour and the associated emissions in a pseudo XCO image. Our findings show that the CNN model outperforms traditional plume inversion approaches such as the cross-sectional method, achieving highly accurate results with a median relative error between 15 and 30%, depending on the power plant studied. Furthermore, our estimations are only slightly affected by the absence of NO2 fields or a detection mechanism. These promising results suggest a high potential of CNNs in estimating local CO emissions from satellite XCO images.

*Intervenant

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Mots-Clés: CNN, CO2, satellite, image, GHG