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INSTITUT DE RECHERCHES
SUR LA CATALYSE
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Research proposal for "Contrats Doctoraux 2022"
Ecole Doctorale Chimie, Université Claude Bernard Lyon1.

Thesis Title: **Atmospheric chemical implications of Arctic permafrost thawing**

Implications sur la chimie atmosphérique du dégel du pergélisol arctique

It is now established that the strong amplification of global warming accelerates the thawing of permafrost in the Arctic. Permafrost contains approximately 50% of the global soil carbon, and when it thaws, a subsequent quantity of carbon is available for microbial degradation, which releases into the atmosphere large quantities of methane (CH_4) and carbon dioxide (CO_2). This process is expected to yield positive feedback on global warming by releasing into the atmosphere greenhouse gases, including CH_4 and CO_2. According to the Intergovernmental Panel on Climate Change (IPCC), the Arctic air temperature is anticipated to increase by up to 10◦C by 2100 compared with the temperature levels in 1986–2005. While the impact of thawing permafrost on greenhouse gas emissions has been extensively studied and evaluated, emissions from carbon-rich permafrost soils of other traces gases, including volatile organic compounds (VOCs), remain scarcely examined.

Yet VOCs play a pivotal role in climate change and air pollution by modulating tropospheric oxidation capacity and providing precursors for ozone and atmospheric particles. Of specific importance to both air quality and climate, are ultrafine particles (< 100 nm), which contribute to a major fraction of the total aerosol load. Such particles result from the gas-to-particle conversion of (highly) oxygenated VOCs (OVOCs), formed from the gas-phase oxidation of VOC emitted from both natural and anthropogenic sources. The quantitative assessment of the impact of aerosols on climate remains poorly understood due to several factors, including an incomplete understanding of the sources of OVOC. These uncertainties lead to large errors between modeled and ambient observations of aerosol loading.

In this context, we hypothesize that permafrost thawing, as a consequence of global warming, might release important quantities of VOCs and other inorganic species (e.g., amines and ammonia). This process can ultimately lead to the formation of new particles in the atmosphere and contribute greatly to aerosol loading overall.

Work description

The Ph.D. work will be carried out at the *Institut de Recherches sur la Catalyse et l'Environnement de Lyon* (IRCELYON, http://www.ircelyon.univ-lyon1.fr/).

The temperature-dependency of VOC emissions will be examined by sequentially increasing the temperature inside a climate-controlled chamber. Emissions will be characterized current state-of-the-art mass spectrometers (i.e., chemical ionization (CI) and proton transfer). CI is a highly selective and sensitive technique able to characterize organic and inorganic species. As a result, we will perform uniquely comprehensive measurements using different reagent ion schemes to map the wide variety of species emitted from permafrost thawing. VOCs and OVOCs

emitted from the permafrost will be further oxidized using an aerosol oxidation flow reactor to evaluate the potential of the emissions at forming new particles. The outcome of this work is a better description of future global warming that can greatly enhance VOC emissions from the Arctic permafrost, which may significantly impact the Arctic atmospheric chemistry and climate change.

PhD Candidates

Candidates with a background in chemistry, physical or analytical chemistry, or physics are encouraged to send their CV.

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