Report on the outcomes of a Virtual Mobility

Action number: CA21119 HARMONIA

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Virtual Mobility Details

Title: AERONET investigation of Northern high-latitude peat fires aerosols: A missing piece in estimating and interpreting Earth's energy budget (NiLFA).

Start and end date: 24/09/2024 to 10/10/2024.

Description of the work carried out during the VM

Description of the virtual collaboration and activities carried out during the VM, with focus on the work carried out by the grantee. Any deviations from the initial working plan shall also be described in this section.

(max. 500 words)

Northern high-latitude peat fires are an underexplored yet significant source of aerosol emissions. Although peatlands cover only 3% of the Earth's terrestrial surface, they play a crucial role in the global carbon cycle, storing approximately 25% of the world's soil carbon. However, rapid climate change in high latitudes is leading to more frequent and intense peat fires. These wildfires are the largest and most persistent on Earth, with profound impacts on the global carbon cycle, atmospheric composition, climate, air quality, and human health. Despite their importance in climate change, significant uncertainties remain regarding their impacts, largely due to the limited representation of peat fires in Earth System Models (ESMs).

A significant step towards addressing these uncertainties involves quantification of the contribution of peat fire emissions to the total aerosol load. Ground-based measurements are invaluable for validating ESMs, as the direct comparison between observed and simulated data is vital for determining how well models represent real-world conditions. In particular, AERONET measurements serve as a crucial reference for assessing model performance during extreme events, such as wildfires. Accurate modeling of these events is often challenging, and AERONET data provide a critical observational benchmark.

In this context, AERONET measurements before and during identified major peat fire events, such as the wildfires in Flow Country, Scotland, in May 2019, and Saddleworth Moor, north-west UK, in June 2018, were used as a solid basis to quantify aerosol emissions from wildfires. Specifically, NiLFA, by using AERONET data from stations located in the proximity of the above-mentioned peat fire events, established an AERONET-based classification record to be used as reference for supporting evaluation of the mode outputs and developments with respect to peat fire representation in ESMs. This reference and ESM support record includes classification of AERONET observations into (i) "non-observing atmospheric smoke aerosol emissions" (Case I), (ii) "medium probability of observing atmospheric smoke aerosol emissions" (Case II), and (iii) "high probability of observing atmospheric smoke aerosol emissions" (Case III).

This methodological approach will be expanded to be more broadly used as a robust framework for validating the representation of peat fire events in ESMs on the basis of AERONET observations, alongside refining their further development. In addition, by bringing together AERONET measurements and global modelling better representation of events, such as peat fires can be achieved, and models' uncertainties can be reduced. In a nutshell, an enhanced understanding of the peat fires and their impacts on climate change, air quality and human health can be accomplished.

Description of the VM main achievements and planned follow-up activities

Description and assessment of whether the VM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the VM. Agreed plans for future follow-up collaborations shall also be described in this section.

(max. 500 words)

Climate warming is occurring faster at high latitudes, heightening the vulnerability of carbon-rich peatlands to fire. Northern peatlands comprise the largest terrestrial carbon store and exert a net cooling effect on the climate. However, warmer and drier conditions due to climate change are expected to contribute substantially to increased fire severity and frequency in the northern high latitudes, potentially shifting peatlands from carbon sinks to greenhouse gas emission sources. Peat fires, considered as the largest and most persistent fires on Earth, can significantly impact the global carbon cycle, atmospheric composition, climate, air quality, and human health. Although incorporating peatland fire feedbacks to climate in ESMs is essential for accurately predicting the future of the climate system, the majority of the current ESMs do not include a representation of peat fires. Thus, quantifying peat fire emissions' contribution to the total aerosol load could be a stepping stone in reducing uncertainties in these models.

The VM addressed this challenge by utilizing AERONET observations and products as a reference for necessary validation and evaluation activities aimed at improving ESM simulations. More precisely, NiLFA examined the aerosol optical properties before and during major peat fire events with AERONET measurements from stations in the proximity of the wildfires and established an AERONET-based classification record that will significantly improve the peat fire representation in ESMs. The contribution of AERONET measurements to validating ESMs is essential as the network provides direct, high-quality observations of real-world conditions and allows for a critical comparison between observed data and model outputs, helping to identify discrepancies and improve model accuracy. Moreover, AERONET reference measurements are crucial for capturing localized, extreme events, such as the wildfires in Flow Country, Scotland, in May 2019, and Saddleworth Moor, north-west UK, in June 2018 investigated in the framework of the VM, that are often difficult for models to simulate precisely. By integrating ground-based reference data in modeling studies, model parameterizations on peat fires is feasible to be refined, uncertainties to be reduced, and the reliability of ESM predictions for climate and atmospheric processes to be enhanced. In essence, AERONET measurements are vital for validating and evaluating fire models, ensuring more accurate simulation of the aerosol emissions, smoke dispersion, and the radiative impacts of wildfires, and enhancing our understanding of wildfire impacts on climate, air quality and human health.

Overall, the main outcomes of the NiLFA VM grant are the following:

1) better understanding of the peat fire events of Flow Country, Scotland, in May 2019, and Saddleworth Moor, north-west UK, in June 201 and the way AERONET sunphotometers recorded those events.

2) AERONET measurements classified into a reference record of observations reference for validation of the representation of peat fires in ESMs.

3) transfer of knowledge with respect to AERONET observations in the short-term, new knowledge in terms of the performance of ESMs and peat fire events representation to be fostered in mid-term, and necessary support in career development interactions and networking in the long-term.

Overall, the VM NiLFA is aligned with the objectives of the COST HARMONIA action. More specifically, through the extensive implementation of the AERONET sunphotometer measurements and products, the VM enhances the value of model outputs by implementing photometry datasets, as photometry serves as a critical validation reference, and facilitates improvements in the capacity of ESMs (WG3-T3.1) to translate model outputs into information, improving our understanding on the impact of peat fire events under the ongoing climate change (WG3-T3.2). Additionally, it promotes more efficient use of existing photometry resources and builds bridges between the ground based-measurement photometry community and the scientific community of ESMs. Furthermore, VM NiLFA creates added value through links with existing ongoing projects (e.g., AXA Chair in Wildfires and Climate), accelerating the effort to translate ESM outputs into policymaking by international organisations, governments and public actors to adapt financial and social agendas accordingly.

Upon expansion and implementation of the established evaluation methodology and reference record in terms of AERONET observations and products to address the performance of ESMs in terms of peat fire representation, the conclusions will be disseminated in the form of scientific publication in a peer review journal. Moreover, the VM outputs will be presented and disseminated to the broader scientific community in a specialised conference (e.g., EGU2025, COMECAP, HARMONIA meetings) in order to increase the activity's outreach.