Potassium in biomass could help to improve wildfire emissions estimates

Farrer Owsley-Brown, PhD Student
@ farrerfires

Earth Observation And Wildfire Research Group
Department of Geography, King's College London

Pot-ash-ium

Potassium, or K, is an essential nutrient for many processes in plants. It's, therefore, an important component in fertilisers for growing crops.
For centuries, potassium was collected using a recipe involving fire. First, some wood would be burned, and the leftover ash was then placed in a pot with water. The solids were then strained, and the water evaporated off. What was left is called potash. It had many applications including the production of soap, glass, fireworks and gunpowder, as well as fertilisers. In 1807, a scientist born in Cornwall called Humphrey Davy isolated this metal from potash and named it potassium (or pot-ash-ium).

But there may be a new application of this relationship between potassium, biomass and fire...

Emission Lines

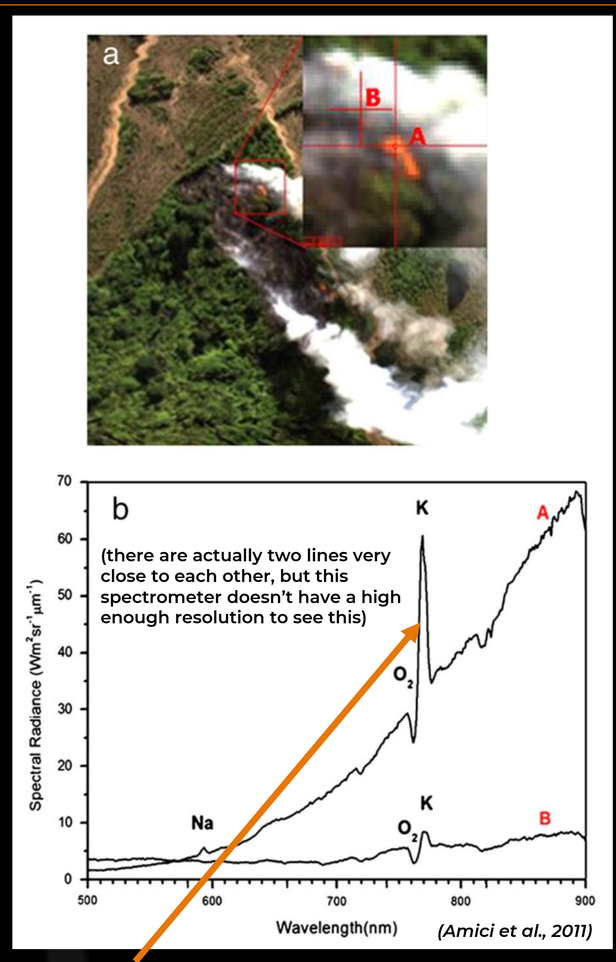
Potassium atoms emit light at specific colours (or, more accurately, wavelengths) when exposed to high temperatures. These are called emission lines. This is due to electrons in the atom jumping between energy levels.
During a Bunsen burner flame test, potassium gives off a characteristic lilac colour due to emission lines at 405 nm (indigo) and 464 nm (blue).
However, potassium atoms also produce much stronger emission lines in the near infrared (NIR) at around 767 and 770 nm, just outside of the range that is visible to humans (approx. 380 – 750 nm). This potassium emission in the NIR have been observed from flaming fires. The temperatures in smouldering combustion are not high enough. However, it has not yet been linked directly to emissions.

Relationship to Emissions

Potassium emission is produced by flaming fires, not smouldering fires.

The emissions produced a smouldering fire are very different to what is produced by a flaming fire, even for the same fuel. Per kg burned, a much higher amount of many important chemical species are produced. This includes CO, CH_4, volatile organic compounds and particulate matter.

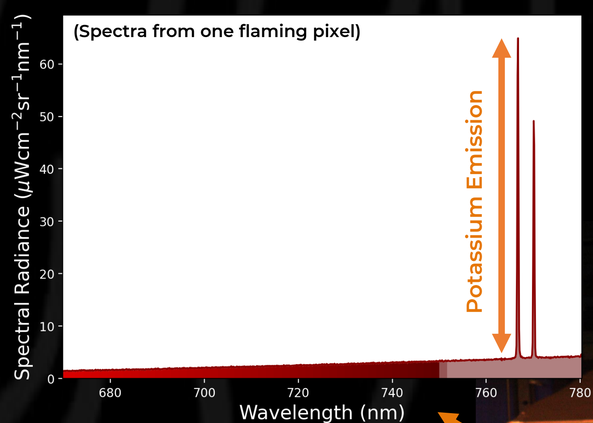
By distinguishing the flaming zone from the smouldering zone by measuring the potassium emission, you can adjust emissions estimates to make them more accurate for that specific fire.

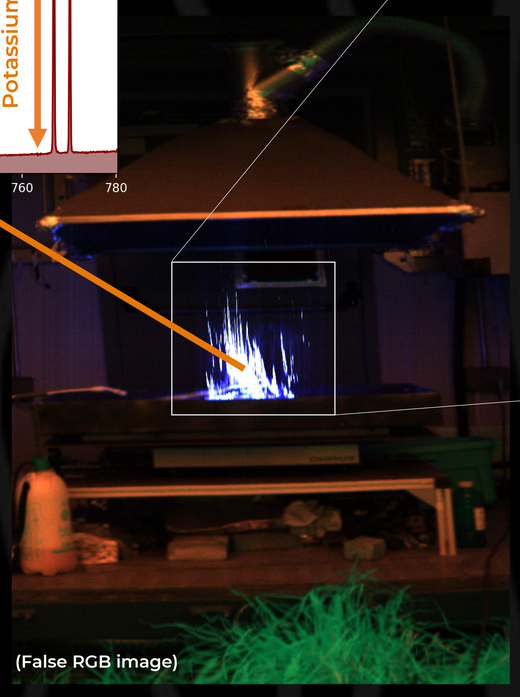


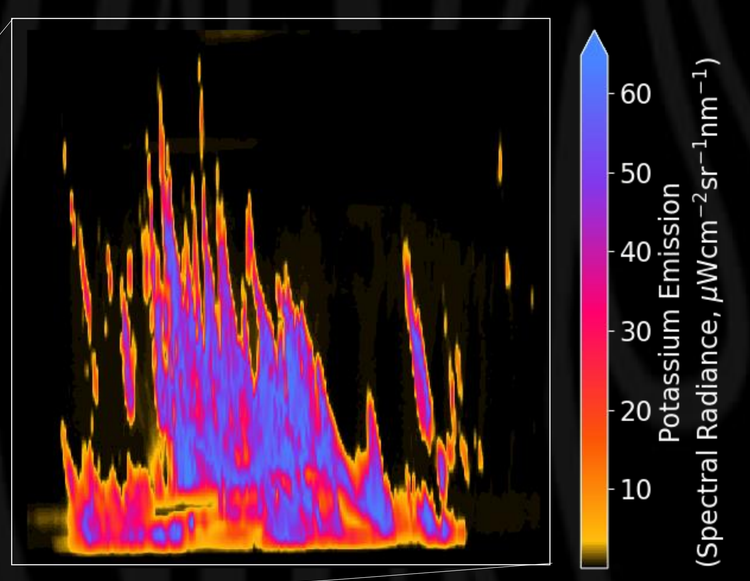
Here is an example of the potassium emission in the near infrared measured from an aircraft

Imaging the Potassium Emission from a Fire

We measured a fire from the side using a hyperspectral imager. This imager is usually used from an aircraft. For each pixel it measures light at many wavelengths with very high resolution from the red to near infrared (indicated by the colour under the curve in the spectra below).







Here is an image of the potassium emission from the flames. This may well be the first image of its kind.

By measuring the potassium emission line of laboratory fires, the errors on emissions estimates were greatly reduced. The errors were up to 53% lower for the CO_2 emission rate, 12% for CO and 26% for CH_4. As a result, we estimated Modified Combustion Efficiency (MCE) with up to 61% greater accuracy.

This approach allows one to account for the relative contribution of flaming and smouldering combustion in a fire, which is lacking in current emissions estimates.

Next Steps

ESA's new FLEX satellite, scheduled to launch in 2025, will be able to measure potassium emission lines from wildfires.

These measurements will be made simultaneously with Fire Radiative Power (FRP) measurements from Sentinel-3.

Together, these could be used to improve landscape fire emissions estimates on a global scale.

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL
LEVERHULME
Centre for Wildfires, Environment and Society
The London NERC Doctoral Training Partnership