Last year's El Niño brought drought to south-east Asia, creating the conditions for enormous wildfires that sent vast amounts of carbon into the atmosphere and endangered people's health across the region with terrible air pollution. Martin Wooster of King's College London and NERC NCEO reports.

The worst **air quality** in the world?

You might recall that 2015 was one of the strongest El Niño years on record. In some places, El Niño brings welcome rain. Yet elsewhere – Indonesia, for example – it typically brings drought, and this can have terrible consequences for air quality.

By the second half of 2015, Indonesia was receiving far less rainfall than usual. The country's tropical ecosystems may be able to cope with this relatively well in their natural state, but decades of deforestation and sometimes unsuccessful development policies have made many landscapes much more flammable and drought-sensitive.

Indonesia's peatlands were particularly badly affected. These cover around 200,000km^2 and represent around 65 per cent of the world's tropical peat, storing much more carbon than the country's trees. This peat is composed of semi-decayed plant material accumulated over millennia, and is typically many metres thick. More than half its mass is carbon, and when dry it burns easily.

Measuring air quality.
Martin Wooster

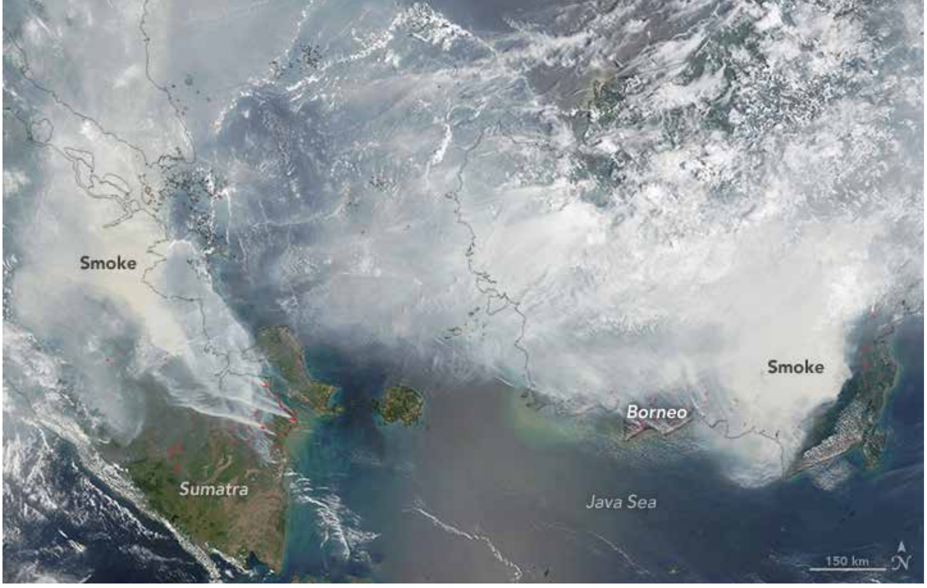
Over the decades many Indonesian peatlands have been drained for agriculture, by digging canals to carry away the water and lower the water table. When El Niño brought drought, it was not long before large areas of these degraded peatlands became dry enough to burn.

As well as fuel, fires also need an ignition source. Throughout much of SE Asia it is common to use fire to dispose of farm waste or to clear new land cheaply, so there is no shortage of fires to get things started.

Problems with fires and smoke pollution are quite common in parts of Indonesia, but in 2015 the combination of a dried landscape, multiple ignitions and plenty of carbon-rich fuel proved disastrous for air quality. By early September, large areas of Kalimantan (the Indonesian part of Borneo) and Sumatra were burning, with huge smoke plumes visible in satellite imagery.

In addition to the large areas affected, the burning peat behaved differently from most vegetation fires, where a 'flaming front' typically moves across the landscape consuming the available vegetation and leaving behind mostly ash and charred remains, mixed with plants that withstood the flames. In Indonesia the soil is so carbon-rich it can keep burning long after the surface vegetation is gone, meaning vast areas of ignited peatland continued smoking for weeks, only stopping in late October when strong rain finally came.

Satellite data on the area affected and the amount of heat being released let us rapidly estimate how much vegetation and peat was being consumed, and even on average how deep into the ground the peat was burning. But we wanted to understand the fires' effect on atmospheric greenhouse gas concentrations and air quality, so we needed to know what exactly was in the smoke.



Satellite image of smoke from Indonesian wildfires in 2015. NASA

To do that Bruce Main and I from King's College London, together with scientists from the Indonesia-based Centre for International Forestry (CIFOR), journeyed to city of Palangkaraya, the capital of Central Kalimantan and home to around 220,000 people. The local airport was often closed because of poor visibility, so we flew to the coastal city of Banjarmasin and drove the last 200km while measuring the concentration of various atmospheric gases and particles with instruments in the back of our truck.

Smoke detectives

By the time we got to Palangkaraya our noses told us the air was full of smoke, but it was past midnight and the darkness made it hard to tell how bad things were. Just before going to sleep though, I turned on one of our gas measuring instruments to download that day's data for safekeeping and was surprised when I saw a carbon monoxide concentration of 30 parts per million (ppm) in the hotel – enough to set off some European smoke alarms – even though we were many miles from the fires themselves. We wondered if sleeping in such polluted conditions was entirely safe.

The next day the view from the hotel's sixth floor showed the buildings of Palangkaraya peeking out from a fog-like layer of smoke, with visibility of just a few hundred meters. This smoke, locally called 'haze', was being caused by the huge peat fires all around the city. Unfortunately for local people, most of the particles in the 'haze' are very small – being classed as PM10, with a diameter of 10 micrometres or less. In fact PM2.5 and smaller usually dominate in smoke from burning biomass, and these particles are small enough to penetrate into the deepest part of the lungs, and so cause the most serious health problems.

Particulate measurements are typically reported in microgrammes of PM10 particles per cubic meter of air (μg/m^3). In the UK, daily mean PM10 values of 101μg/m^3 or above are considered 'very high' – the most severe level usually seen here – and the US Environmental Protection Agency (EPA) views 300μg/m^3 or more as hazardous, advising everyone to consider avoiding physical activity outdoors under such conditions.

Palangkaraya's local air quality monitoring station turned out to be frequently reporting PM10 concentrations around 2000μg/m^3, and sometimes closer to 4000μg/m^3. This was probably the worst outdoor air quality of any city on Earth at the time, and hospital admissions soared. Beijing for example has notoriously poor air, but even on its worst days it doesn't come close to these levels.

Wearing masks, we ventured out to sample the smoke itself. Different fuels produce smoke with diverse composition, and we wanted real close-to-source measurements to enable us to convert our satellite measurements of peat and vegetation burning into emissions estimates.

We easily found areas of extensive burning, and our measurements of the gases and particles in the smoke are now being used to make better calculations of the fires' true emissions. Our findings have already shown that the emissions factor of methane (the amount of CH_4 released per kg of peatland fuel burned) appears far lower in reality than it was when the peat was collected, dried and burned within laboratories, giving us a clearer idea of how the carbon the fires are releasing to the atmosphere is split between CO_2, methane and carbon monoxide. This matters because each gas has a different effect in the atmosphere, and because 2015 turned out to show the single largest increase in atmospheric CO_2 since records began in the 1950s, and we want to know what role the Indonesian fires played in that increase.

We are now analysing the data on particulates, and early results indicate PM2.5 emissions factors far higher than from landscape fires in other tropical or temperate biomes, probably because the dried peatland mostly smouldered rather than flamed, and smouldering produces more particulates. This also helps explain why the air quality decrease in Indonesia was quite so extreme, and why particle-laden air was able to reach places like southern Thailand, Cambodia and the Philippines, as well as closer countries like Malaysia and Singapore that are more often impacted by 'haze' from Indonesian fires.

The last El Niño of comparable size to 2015 was 1997-98, and recent estimates suggest the Indonesian fires that accompanied it resulted in thousands of additional deaths. It's too early to know whether the 2015 fires had a similar effect, but already its clear just how bad air quality got and so how seriously it may have harmed the health of people in southeast Asia.

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