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Changes in rainfall a consequence of clean fossil fuel energy

Implementation of technology to clean the flue gases of coal-fired power plants has significantly reduced sulphur and fine particle emissions that cause environmental damage. However, recent research suggests that plants applying this technology would emit more ultrafine particles (1-10 nanometer (nm) diameter) that affect the formation of clouds, with the unintended consequence of changing the amount and intensity of rainfall downwind of fossil fuel power installations.

Fossil fuel power plants are significant sources of sulphur dioxide and nitrogen dioxide emissions. To reduce the environmental impact, particularly from the acidic sulphur aerosols (particles) that form in the atmosphere from the sulphur dioxide emissions, many coal-fired power plants have been fitted with technology to clean the flue gases before they are emitted to the atmosphere.

This has succeeded in reducing the damage caused by sulphur deposition (e.g. acid rain). However, some previous studies have suggested that certain types of flue gas cleaning technology may increase new production and emission of ultrafine particles. In the atmosphere, these ultrafine particles can grow to cloud condensation nuclei (CCN), i.e. particles of 50 nm diameter and above, around which water droplets form in clouds.

Increased numbers of CCN in clouds are considered to be beneficial in cooling the earth and modifying the impact of climate change warming by reflecting back more of the sun's radiation. However, over land, there can be other impacts that change the amount and distribution of rainfall.

This study carried out airborne measurements of ultrafine particles emitted from power plants in Germany, Inner Mongolia and Australia and over the boreal forest in Finland to determine the sources, concentration and sizes of particle emissions, and the production rates of CCN.

Modern, clean coal-fired power plants were found to be one of the main emitters of ultrafine particles found in the lower atmosphere in pristine and mildly polluted regions. In Germany, for example, plumes containing concentrations of up to 50,000 particles per cubic centimeter were found a few kilometers downwind from a coal-fired power plant and petrochemical refinery. Two hours after emission, and 40km from the source, these particles had grown into larger CCN precursors (average about 20nm diameter) with further particle growth within a few more hours resulting in thousands of CCN (over 50 nm diameter) per cubic centimeter.

Coal-fired power plants were compared with other sources of ultrafine particles. In Germany, for example, annual emissions of ultrafine particles from one clean power plant (of about 600 MW electricity production) were similar to those emitted annually from traffic on 4000km of the German highway system. This is the same amount of ultrafine emissions produced naturally by half the boreal forest area in Finland. Although the total sulphur emission of the plants applying flue gas cleaning is about 10 times lower than that of non-abated power plants, the number of CCN these "clean" plants generate is significantly higher.

The increase in ultrafine emissions from clean power plants is likely to produce a significant increase in the production of CCN with the side-effect of changing the amount and intensity of rainfall at the regional level. It is possible that this would cause a shift of rainfall patterns from low-intensity but steady rainfall to less frequent but more intense rainfall events. For example, in Australia the study found that a doubling of CCN formation was linked to a 20% regional reduction in rainfall. The construction of new clean coal-fired power plants to meet future energy requirements, particularly in semi-arid agricultural regions, could have a serious impact on the amount and pattern distribution of regional rainfall.

Source: Junkermann, W., Vogel, B., Sutton, M. A. (2011) The climate penalty for clean fossil fuel combustion. *Atmospheric Chemistry and Physics*. 11: 12917-12924. This study is free to view at: www.atmos-chem-phys-discuss.net/11/24567/2011/acpd-11-24567-2011.pdf

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