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Soil hydrophobicity – relating effects at atomic, molecular, core and national scales

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The detrimental impacts of soil hydrophobicity include increased runoff, erosion and flooding, reduced biomass production, inefficient use of irrigation water and preferential leaching of pollutants. Its impacts may exacerbate flood risk associated with more extreme drought and precipitation events predicted with UK climate change scenarios. The UK's Natural Environment Research Council (NERC) has therefore funded a major research programme to investigate soil hydrophobicity over length scales ranging from atomic through molecular, core and landscape scale. This presentation gives an overview of the findings to date. The programme is predicated on the hypothesis that changes in soil protein abundance and localization, induced by variations in soil moisture and temperature, are crucial driving forces for transitions between hydrophobic and hydrophilic conditions at soil particle surfaces. Three soils were chosen based on the severity of hydrophobicity that can be achieved in the field: severe to extreme (Cefn Bryn, Gower, Wales), intermediate to severe (National Botanical Garden, Wales), and subcritical (Park Grass, Rothamsted Research near London). The latter is already highly characterised so was also used as a control. Hydrophobic/ hydrophilic transitions were measured from water droplet penetration times. Scientific advances in the following five areas will be described:
(i) the identification of these soil proteins by proteomic methods, using a novel separation method which reduces interference by humic acids, and allows identification by ESI and MALDI TOF mass spectrometry and database searches,
(ii) the examination of such proteins, which form ordered hydrophobic ridges, and measurement of their elasticity, stickiness and hydrophobicity at nano- to microscale using atomic force microscopy adapted for the rough surfaces of soil particles,
(iii) the novel use of a picoliter goniometer to show hydrophobic effects at a 1 micron diameter droplet level, which avoids the averaging over soil cores and particles evident in microliter goniometry, with which the results are compared,
(iv) measurements at core scale using water retention and wicking experiments, and
(v) the interpretation, integration and upscaling of the results using a development of the PoreXpert void network model, a significant advance on the Van Genuchten approach.
An explanation will also be given as to how the results will be incorporated into the JULES hydrological model of the UK Meteorological Office, used to predict flooding for different soil types and usage.