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Distributed Temperature Sensing in the Atmosphere

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Over the past ten years, Distributed Temperature Sensing (DTS) has been applied for monitoring many different environmental processes, from groundwater movement, to seepage into streams and canals, to soil moisture, and internal waves in lakes. DTS uses optical fibres, along which temperatures are determined by measuring Raman shifts in light that scatters back after a laser pulse has been sent into the fiber. Over the past decade, performance of DTS equipment has dramatically improved. It is now possible to determine fiber temperatures with 0.05 K accuracy, for each 25 cm along a fiber optic cable. With typical spatial resolutions of 1 m, cable lengths can run up to 5 km. Accuracy improves with integration over longer sampling intervals, but measurements over 60 s can give 0.1 K accuracy with proper in-field calibration.

DTS can also be used for atmospheric properties such as air temperature, vapor pressure, and wind speed. This presentation provides a complete overview of recent advances in atmospheric DTS observations. Air temperature is the simplest, as one simply has to suspend a fiber optic cable along the profile of interest. This can be from a balloon or along poles. Care has to be taken to correct for radiative heating of the cable. Using a thin white cable minimalizes radiative effects and normally brings the measured temperature to within 1 K of actual air temperature, sufficient for studies on effects of shading in natural and urban landscapes. It is also possible to correct for radiative heating by modeling in some detail the cable's thermal behavior or by using two cables of different diameters. Supporting structures may also have an effect on cable temperatures, which should be minimized or corrected for.

Water vapor can be measured by comparing the temperatures of wet and dry cables. These wet and dry bulb temperatures allow derivation of humidity profiles, which, in turn, allows for Bowen-ratio type of calculations of latent and sensible heat fluxes. This has proven especially useful in otherwise difficult to measure profiles such as through forest canopies.

Wind speed can be measured by including a conductive element in the fiber optic cable and heating the cable actively by sending a current through that element. In effect, the cable then acts as a hot wire anemometer but then over long lengths of cable and with high spatial resolutions. When carefully executed, experiments with heated cables give very detailed insight into turbulent processes in the lower boundary. It is even possible to resolve bigger individual turbulent and sub-meso-scale eddies for studying fast evolving fluid flows (orders of seconds).

A comprehensive overview of atmospheric applications will be presented, together with pitfalls, common errors, and practical tips to avoid those in the field.