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A novel rain simulator for hydrological and agricultural applications in wind driven monsoonal conditions with a particular reference to India.

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India is now recognised the world over as an emerging nation with a strong economy. However, it is also largely an agrarian country where the economic growth is strongly linked to monsoon activity. Past experience has shown that with a failed monsoon the country as a whole suffers: not just from hunger and deprivation, but also from a perceptible economic melt-down. Nearly 55% of Indian droughts have occurred during the warming phase of the El Nino signal. In the recent past, the bad drought years were 1972, 1987, 2002 and 2009. The government of India experimented with artificially inducing rain through cloud seeding but that proved to be extremely expensive without much success rate.

In this paper, we elucidate the workings of a novel and economical rain simulator. The design allows for the control over water application rates particularly when there is a strong cross-wind associated with monsoon activity. Monsoon precipitations are intense (as compared to milder mid-latitude rates) and raindrops fall through stronger cross-winds. Keeping the above facts in mind, we designed a simulator that yielded the right range of droplet sizes and the showers were a reasonable proxy to natural rain falling through a gusty boundary layer. The typical size spectrum comprised of droplets with diameters between 250μm and 5mm. Since terminal velocities of rain droplets fluctuate with turbulence, it is essential to estimate the fall velocity variability in turbulent conditions. A stochastic modelling analysis was first performed to compute rain droplet trajectories in turbulence from observed raindrop size distributions. Whilst the smallest drops were easily wind driven by a cross-wind speed of 2.5 ms-1 and for modest levels of turbulence intensities, the largest drops were affected less profoundly. This preliminary model analysis enabled us to configure the working model. The simulator consists of three units-(i) a water supply unit consisting of a reservoir and a variable speed pump to regulate the flow rate to achieve the observed rainfall intensities and the correct drop size distributions (ii) a water shower unit consisting of a three-pronged mounted horizontal plate. The design is flexible and robust allowing horizontal, vertical and axial manoeuvrability of the Full Cone spray nozzles mounted on the plate (iii) a variable speed fan to simulate cross-winds of different velocities. A unique feature of this rain simulator is that this has a greatly reduced height as well as a near zero starting velocity. This unique design incorporating the combined effects of monsoon driven rain can have many uses including gauging the erosion potential and runoff dynamics over vulnerable regions of the subcontinent.