Velocity of Simulated Raindrops in a Wind Tunnel Measured by Different Technologies

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The wind tunnel rainfall simulator at the International Center for Eremology (ICE) in Ghent, Belgium, has been intensively used for erosion studies. Described by Gabriels et al. (1997), the tunnel is 12 meters long and 1.2 meters wide. The rain is generated by 8 spray nozzles (Teejet TG SS 14) spaced one meter from each other, attached to its ceiling at 1.85 meters height. The wind is generated by an axial fan propelled by a 200 HP electric motor.

This research is part of a large group of tests carried out to evaluate the velocity of raindrops. Results presented are restricted to the position located at 1.25 meters below the nozzles. Two different types of equipment were used to measure raindrop velocity: the UFLA DRGS (Dynamic Rain Gage System) and the PARSIVEL II laser disdrometer that was set either perpendicular (PP) or longitudinal to wind direction (PL). The water pressure at the nozzles was set to 1.5 bars to generate the simulated rainfall described in this research. The tests were carried out with a 6.4 m/s wind speed and also with no wind conditions. The measurement instruments were both installed under the fourth nozzle and also in-between the fourth and fifth nozzles. Treatments were replicated three times, and statistical evaluations included analysis of variance (ANOVA) with a 5% significance level.

While the DRGS is a moving set of pluviometers rotating at approximately 120 rpm, the PARSIVEL disdrometer is static and emits laser beams that are intercepted by the raindrops. According to the number of beams intercepted, the drop diameter is measured; and from the time the drop starts intercepting the beam to when it no longer intercepts it, the velocity is measured. Pictures taken of the rainfall with and without wind reveal that drops did not fall vertically. In fact under the wind conditions, their trajectory deviated as much as 45 degrees from vertical. With such variation and the laser beams positioned perpendicular to the vertical trajectory, it is expected that the time to cross the beams can vary significantly. Considering the cosine laws, such variation can be as high as 30%.

Results reported in Tables 1 and 2 are in agreement with data reported by Erpul et al. (1998), and indicate that the wind affected the raindrops, generally increasing their velocity, regardless of their positions under or between the nozzles. It can also be seen that the equipment tended to quantify velocities statistically different in most cases, although when tested with other water pressure values and heights, the velocities measured either with the laser disdrometer or the DRGS were not statistically different.

Table 3 indicates that the raindrop velocity varied along the tunnel, and was different when measured under the fourth nozzle, when compared to in-between the fourth and fifth nozzles. These differences can promote variations in the kinetic energy of the raindrops along the tunnel, despite the small distance between the nozzles (one meter).

In conclusion, simulated rainfall at the ICE Wind Tunnel had its drop velocity affected by the position in relation to the nozzles and velocity also increased with wind. In addition, the drop trajectory was not vertical, reaching angle variation as much as 45 degrees. Considering

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observed variations in the drop velocities, additional research should be carried out to further validate measurements obtained when using the two kinds of equipment examined in this study.

Table 1. Average raindrop velocity (m/s) under the fourth nozzle.

	No wind	With wind
UFLA - DRGS	3.12 aB*	3.50 aA
Laser - PP	2.63 bB	2.81 bA
Laser - PL	3.05 aA	2.83 bB

* The same lower case letter in the same column indicates no significant difference using a Tukey test at α=0.05. The same upper case letter in the same row indicates no significant difference using a Tukey test at α=0.05.

Table 2. Average raindrop velocity (m/s) between the fourth and fifth nozzles.

	No wind	With wind
UFLA - DRGS	2.50 aB	3.31 aA
Laser - PP	2.34 bB	2.58 cA
Laser - PL	2.37 bB	2.75 bA

* The same lower case letter in the same column indicates no significant difference using a Tukey test at α=0.05. The same upper case letter in the same row indicates no significant difference using a Tukey test at α=0.05.

Table 3. Average raindrop velocity (m/s) at different positions.

		Under 4th nozzle	Between 4th and 5th nozzles
No wind	UFLA - DRGS	3.12 aA	2.50 aB
	Laser - PP	2.63 bA	2.34 bA
	Laser - PL	3.05 aA	2.37 bB
With wind	UFLA - DRGS	3.50 aA	3.31 aB
	Laser - PP	2.81 bA	2.58 cB
	Laser - PL	2.83 bA	2.75 bB

* The same lower case letter in the same column within a wind treatment indicates no significant difference using a Tukey test at α=0.05. The same upper case letter in the same row indicates no significant difference using a Tukey test at α=0.05.

References

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