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Tornadoes: from reality to simulations and back

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Abstract: An attempt is made to see how the Alan Davenport Wind Loading Chain can be adapted to tornadic winds. Therefore we will examine: (i) the characterization of full scale tornadoes; (ii) the simulation of tornadoes; and (iii) aspects of tornado-structure interaction.

Two very recent campaigns VORTEX2 and ROTATE2012 have gathered data related to tornado-genesis and tornado low-level wind fields, respectively. Detailed field data from these campaigns has been obtained by the Center for Severe Weather Research (CSWR) in Boulder Colorado. The WindEEE Research Institute has recently investigated the database and performed Ground-Based Velocity Track Display (GBVTD) analysis for several EF0, EF1 and EF2 tornadoes to extract the velocity field of tornadoes. WindEEE (Hangan 2014) is a unique large, hexagonal wind testing chamber, or "Wind Dome", of 25 meters inner diameter and 40 meters outer diameter. By using a system of 100 dynamic fans on the peripheral walls coupled with 6 larger fans at the ceiling level, WindEEE can produce a variety of wind systems including 4 m diameter translating tornado vortices and downbursts as well as a variety of dynamically shear flows.

A scaling relationship needs to be established between simulated and real tornadoes. In order to achieve this the two characteristics scales between real and simulated tornadoes, i.e. the scales related to the radius and the height corresponding to the maximum velocity are plotted as a function of Swirl ratio. It is expected that the two length scale ratios converge towards one value at a certain swirl ratio. That determines the geometric scale and the maximum tangential velocity is used to determine the velocity scale.

In traditional wind structure interaction where the wind field is synoptic and represented by an atmospheric boundary layer (ABL) flow field, Alan Davenport used principles of Quasi-steady theory to derive the wind loads on structures. Herein we are testing these assumptions for tornadic winds. The main assumptions of the quay-steady approach are: (i) fluctuations of surface pressures are only due to the wind inflow velocity fluctuations; (ii) stationary upstream wind velocity can be decomposed using Reynolds decomposition; (iii) velocity fluctuations are much smaller compared to the mean flow and are random.