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Observational Simulation of Extreme Weather Conditions and Aviation Meteorology Applications

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Observations and prediction of extreme weather (Wx) conditions are important for land, air and sea or water transportation applications. These conditions adversely affect the economic and social life of people. Extreme Wx conditions for aviation operations for example, include, gust (Ug), wind (Uh), and turbulence (U'), low visibility (Vis), fog and frost, and icing as well as heavy precipitation. These conditions can be studied either in the natural atmosphere or in the laboratory. There have been several aircraft and balloon based in-situ studies related to extreme Wx conditions affecting aviation operations. However, studying extreme Wx conditions from aircraft observations is limited due to safety and sampling issues, instrument uncertainties, and even the possibility of the aircraft producing its own physical and dynamical effects. Remote sensing-based techniques (e.g., retrieval techniques) for studying extreme Wx conditions usually represent a volume that cannot characterize the important scales, and also represents indirect observations. Therefore, climatic wind tunnel simulations of atmospheric processes together with field observations can help us to better evaluate the interactions among microphysical and dynamical processes affecting extreme Wx conditions e.g., cold air temperatures (Ta) and low/high relative humidity with respect to water (RHw). The Climatic Wind Tunnel (CWT) in the Automotive Centre of Excellence (ACE) at the Ontario Tech University has a large semi-open jet test chamber with a flow area of 7-13 m^2 that can precisely control Ta down to -40°C, and Uh up to 250 km hr^{-1}. Ice and liquid phases of particle size distributions n the CWT are measured with optical probes such as GCIP, CDP, BCP, FMD, and LPM probes (Gultepe et al 2019, PAAG). The ACE CWT employs several modes of generating sprays, including a spray nozzle array suspended in its settling chamber and fed by heated pressurized de-ionized water to create supercooled droplets, a snow gun also located in the settling chamber, and a spray rig at the nozzle exit, to create a wide range of particle sizes from a few μm up to mm size range to create extreme Wx conditions. These set-ups, together with a range of cold Ta and RHw, plus a wide range of Uh, enabled simulation of severe Wx conditions, including icing, Vis, strong Uh and U', ice fog and frost, freezing fog, heavy snow, and blizzard conditions. Overall, the results from the CWT simulations supported by the Ontario Tech University AViation MEteorological Supersite (AVMES) observations will be

summarized for the aviation operations representing cold environments.