Geophysical Research Abstracts
Vol. 20, EGU2018-13175, 2018
EGU General Assembly 2018

Genesis of Diamond Dust, Ice Fog and Thick Cloud Episodes observed and modelled above Dome C, Antarctica

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Episodes of thick cloud and diamond dust/ice fog were observed during 15 March to 8 April 2011 and 4 to 5 March 2013 in the atmosphere above Dome C (Concordia station, Antarctica, 75°06'S, 123°21'E, 3233 m amsl). The objectives of the paper are mainly to investigate the processes that cause these episodes based on observations and to verify whether operational models can evaluate them. The measurements were obtained from the following instruments: 1) A ground-based microwave radiometer (HAMSTRAD, H_2O Antarctica Microwave Stratospheric and Tropospheric Radiometers) installed at Dome C that provided vertical profiles of tropospheric temperature and absolute humidity every 7 minutes. 2) Daily radiosoundings launched at 12:00 UTC at Dome C. 3) A tropospheric aerosol Lidar that provides aerosol depolarization ratio along the vertical at Dome C. 4) Down- and upward short- and longwave radiations as provided by the Baseline Surface Radiation Network (BSRN) facilities. 5) An ICE-CAMERA to detect at an hourly rate the size of the ice crystal grains deposited at the surface of the camera. 6) Space-borne aerosol depolarization ratio from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) Lidar aboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platform along orbits close to the Dome C station. The time evolution of the atmosphere has also been evaluated by considering the outputs from the meso-scale AROME and the global-scale ARPEGE meteorological models. Thick clouds are detected during the warm and wet periods (24-26 March 2011 and 4 March 2013) with high depolarization ratios (greater than 30%) from the surface to 5-7 km above the ground associated with precipitation of ice particles and the presence of a supercooled liquid water (depolarization less than 10%) clouds. Diamond dust and/or ice fog are detected during the cold and dry periods (5 April 2011 and 5 March 2013) with high depolarization ratios (greater than 30%) in the planetary boundary layer to a maximum altitude of 100-300 m above the ground with little trace of precipitation. Considering 5-day back trajectories, we show that the thick-cloud episodes are attributed to air masses with an oceanic origin whilst the diamond dust/ice fog episodes are attributed to air masses with continental origins. Although operational models can reproduce thick cloud episodes in the free troposphere, they cannot evaluate the diamond dust/ice fog episodes in the planetary boundary layer because they require to use more sophisticated cloud and aerosol microphysics schemes. This study is part of the Year of Polar Prediction (YOPP) project Water budget over the Dome C station (H_2O-DC).