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In-cloud atmospheric icing episodes at Mt. Zao, Northern Honshu, modeled with the WRF mesoscale numerical weather prediction system (April 2009)

Evgeny A. Podolskiy (1), Bjorn E.K. Nygaard (2), and Kouichi Nishimura (3)

(1) CEMAGREF - Centre de Grenoble, St.-Martin-d'Heres cedex, France (evgeniy.podolskiy@gmail.com), (2) Norwegian Meteorological Institute, Oslo, Norway (bjorn.e.nygaard@met.no), (3) Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan (knishi@nagoya-u.jp)

Scarcity of available data and complexity with measurements of some critically important parameters for icing models, like liquid water content or median volume diameter of the droplet size distribution, could be overcome by use of fine-grid weather forecast models. In the present paper, we would like to perform validation of the Weather Research and Forecasting (WRF) atmospheric model (Version 3.2.1) and to demonstrate how some particular atmospheric icing events of ground-based structures at high-altitude mountain area could be identified by modeling means, despite an extremely small amount of supporting in-situ measurements.

Interesting ice deposits were observed on vertical surfaces at Mount Zao (38.14º N, 140.44º E, 1841 m asl), Japan, at the end of April 2009, when cherry trees were blossoming at the bottom of the mountain. These accretion forms are called 'shrimp's tails' in Japanese (Ebi-no-shippo), due to their striking resemblance to tails, and known to be formed from supercooled water cloud droplets colliding with objects. We attempted to reconstruct meteorological icing conditions at Mount Zao by using: 10-days simulation with triple nested domains (10, 3.3 and 1.1 km grid); Thompson scheme for cloud microphysics; global analysis data from the Global Forecast System (NCEP), and terrestrial data from USGS and MODIS datasets. After comparison of model-generated results with time series from the Jizosancho ski lift station (available only for day-time) we could determine weather-related parameters of icing episodes for Mt. Zao and other high mountains of our finest domain.

Estimations produced by the model, have shown a good quantitative agreement of modeled and observed wind and temperature time series, and confirmed that a high resolution modeling (1.1 km) was much more accurate than simulations with coarser grids (10 and 3.3 km). This helped to detect two icing events 26-41 hours long, produced by passage of two low pressure systems over the Northern Honshu (996 and 986 hPa, respectively) with temperatures between -6.3° and -0.1°C, westerly winds up to 26 m s-1, and cloud water liquid content reaching as high as 0.72-1.05 g m-3. We could not be able to provide any specific details about evolution mechanism of complex 3-dimensional 'shrimp's tail' structures, but could show that joint distribution "wind speed-air temperature" for this type of rime was more similar to hard rime or glaze, than to a soft rime. Results of the present numerical experiment have demonstrated a great potential of the WRF model for studies on ground in-cloud icing in complex high mountain areas with a lack of meteorological time series.