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A deep learning approach for the identification of the synoptic-scale drivers of long-duration mixed precipitation in Montréal (Canada)

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Climate change is altering the Earth's atmospheric circulation and the dynamic drivers of extreme events. Extreme weather events pose a great potential risk to infrastructure and human security. In Montréal (Québec, Canada) long-duration mixed precipitation events (freezing rain and/or ice pellets) are high-impact cold-season hazards and an understanding of how climate change alters their occurrence is of high societal interest.

Here, we introduce a two-staged deep learning approach that uses the synoptic-scale drivers of mixed precipitation to identify these extreme events in archived climate model data. The approach is destined for the application on regional climate model (RCM) data over the Montréal area. The dominant dynamic mechanism leading to mixed precipitation in Montréal is pressure-driven channeling of winds along the St. Lawrence river valley. The identification of the synoptic-scale pressure pattern related to pressure-driven channeling is a visual image classification task that is addressed with supervised machine learning. A convolutional neural network (CNN) is trained on the classification of the synoptic-scale pressure patterns by using a large training database derived from an ensemble of the Canadian Regional Climate Model version 5 (CRCM5). The CRCM5 is to our knowledge the only RCM available so far that employs the diagnostic method by Bourgouin to simulate mixed precipitation inline and thus delivers training examples and labels for this supervised classification task.

The CNN correctly identifies 90 % of the Bourgouin mixed precipitation cases in the test set. The weak point of the approach is a high type I error, which is enhanced in a second stage by applying a temperature condition. The evaluation on an CRCM5 run driven by ERA-Interim reanalysis reveals a still low precision of 21 % and thus a Matthews correlation coefficient of 0.39. The deep learning approach can be applied to ensembles of regional climate models on the North America grid of the Coordinated Regional Downscaling Experiment (CORDEX-NA).