Detecting Synoptic Patterns related to Freezing Rain in Montréal using Deep Learning

Magdalena Mittermeier[1], Émilie Bresson[2], Dominique Paquin[2], Ralf Ludwig[1]

[1] Ludwig-Maximilian University Munich
[2] Ouranos Consortium, Montréal, Canada

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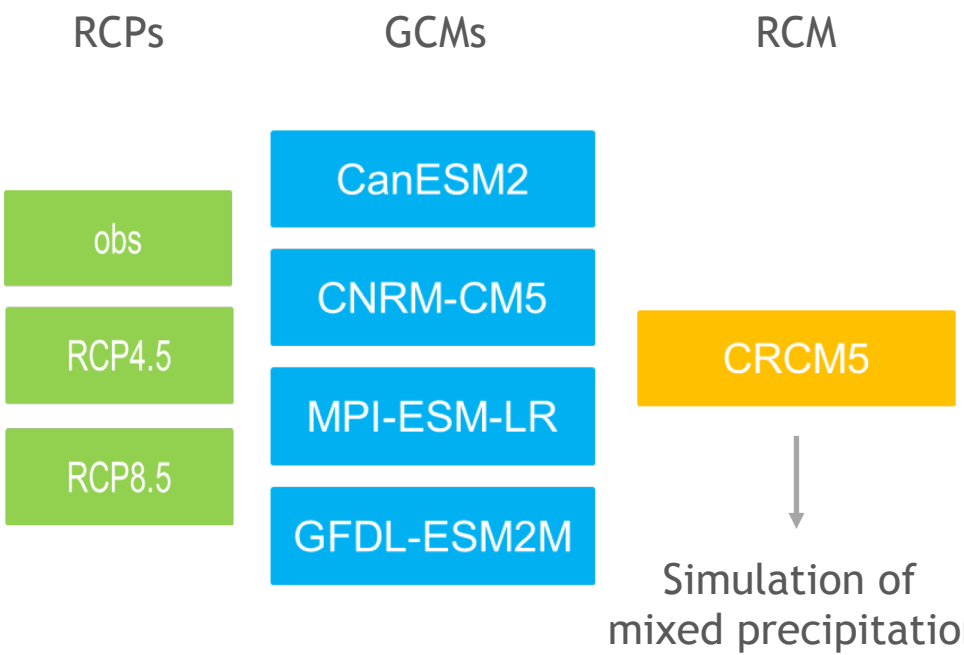
Background & Research Question: Freezing Rain in Montréal

In Southern Québec (Canada), freezing rain & ice pellets (mixed precipitation) are among the rare, yet high-impact events. The superior research question is: how does climate change affect mixed precipitation?

The goal is therefore to provide a tool to identify the synoptic drivers of mixed precipitation in large climate datasets of regional climate models (RCMs) using deep learning

Freezing Rain Event April 2019 © Hélène Côte. All rights reserved.

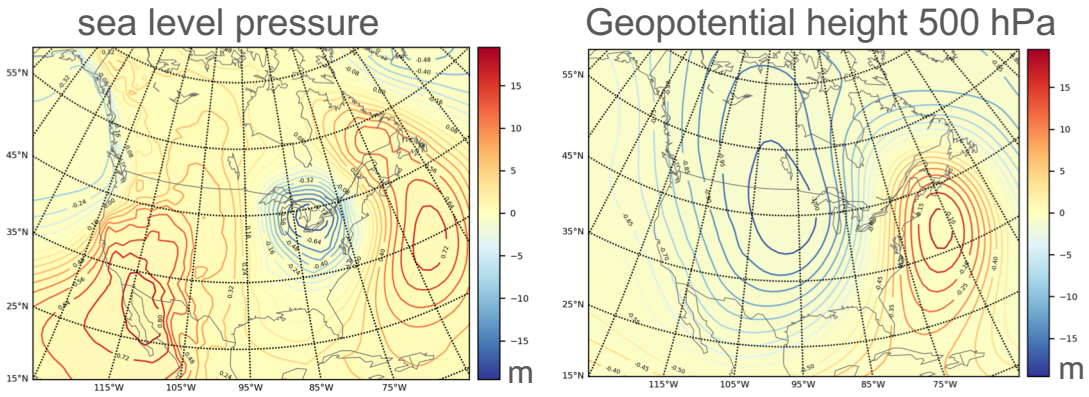
Data: ensemble of CRCM5-simulations



- The Canadian Regional Climate Model version 5 (CRCM5) is to date the only RCM, which simulates freezing rain in-line using a diagnostic method (Bourgouin´s scheme)
- An ensemble of CRCM5-simulations driven by different representative concentration pathways (RCPs) and general circulation models (GCMs) is used to derive training examples and labels to train a convolutional neural network (CNN) on the identification of mixed precipitation in the Montréal area (Québec)

Bourgouin, P. (2000). A method to determine precipitation types. *Weather and Forecasting*, *15*(5), 583-592.

Training Set: Large-scale drivers of mixed precipitation



Trainings set average of standardized variables for class 1: mixed precipitation

- The CNN is trained with two variables of the CRCM5: sea level pressure and geopotential height at 500 hPa
- The input variables are standardized using a z-transformation
- The CNN is trained for a binary classification. For class 0 (no mixed precipitation) counter-examples are randomly selected

CNN: Network Architecture

Layer Type	Layer Specifications
Conv2D	window size: 5x5, #filter = 8, stride = 1
MaxPooling2D	window size: 2x2, stride = 2
Conv2D	Window size: 5x5, #filter = 16, stride = 1
MaxPooling2D	Window size: 2x2, stride = 2
Dense	50 nodes
Dropout	r-term: 0.35
Dense	2 nodes

- The model architecture is based on Liu et al., 2016
- Regularization term and learning rate are determined by hyperparameter-tuning (RandomSearch, keras-tuner)
- Batch size: 64, number of epochs: 10
- Software: tensorflow and keras (python based)

Liu, Y., Racah, E., Correa, J., Khosrowshahi, A., Lavers, D., Kunkel, K., ... & Collins, W. (2016). Application of deep convolutional neural networks for detecting extreme weather in climate datasets. *arXiv preprint arXiv:1605.01156*.

Classification Results

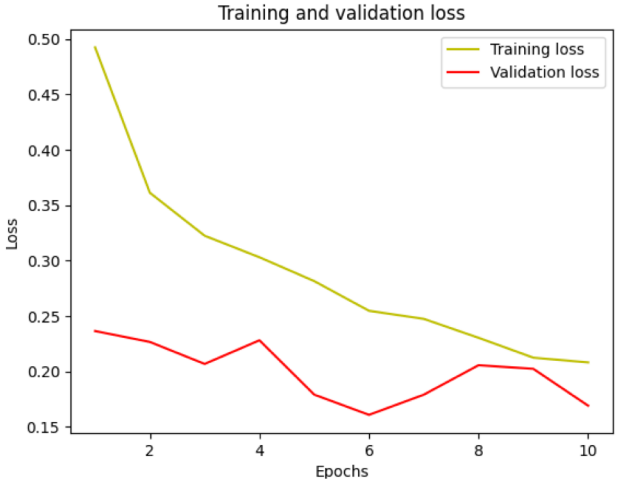
Overall accuracies:

- Training set: 94.6 %
- Development set: 93.1 %
- Test set: **94.3 %**

Test Set:

- precision: 80.9 %
- recall: 92.8 %
- F-score: **0.86**

Learning curve



Confusion matrix

TEST SET	TARGETS		
OUTPUTS	1	0	%
1	**582**	**141**	80.9
0	**45**	**2494**	98.2
%	92.8	94.7	94.3

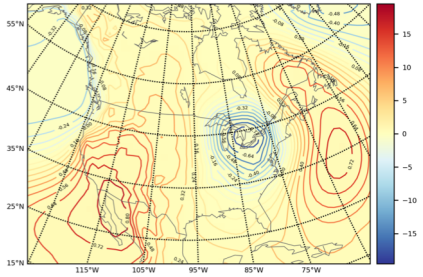
Summary

Mixed precipitation in Montréal

Important cold season hazard. Superior research question: How does climate change affect mixed precipitation?

Large-scale drivers & deep learning

Detecting mixed precipitation events through the large-scale, spatial patterns of the synoptic drivers using machine learning for pattern recognition



Goal

Deep learning based tool, which can be applied to a large ensemble of RCM-simulations over the Montréal area to efficiently identify mixed precipitation events in order to study climate change effects on them

TEST SET		TARGETS		
		1	0	%
OUTPUTS	1	595	184	76.4
	0	32	2451	98.7
	%	94.9	93.0	93.4