Exploring the CRCM5-LE using machine learning techniques

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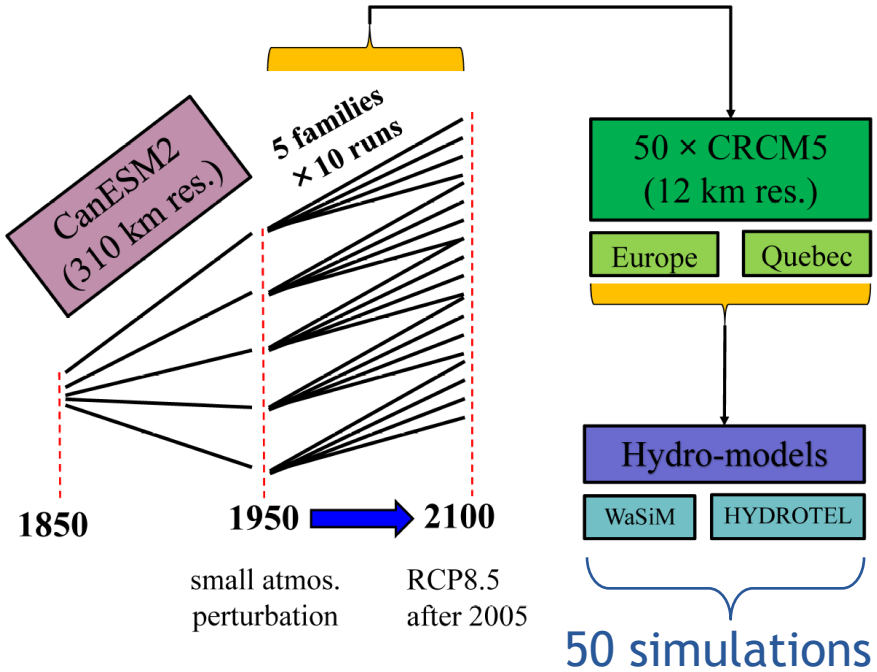
Advantages & challenges of the CRCM5-LE



+ Studying extreme events

+ Analyzing internal variability

Efficiently detecting specific extreme events in the large ensemble

Machine Learning

I. Application on Vb-cyclones (Bavaria)

II. Application on Freezing Rain (Québec)

Floods & Vb-cyclones

30 % of summer floods in Bavaria triggered by Vb-cyclones (Stahl & Hofstätter, 2018)

Climate Change?

Internal Variability?

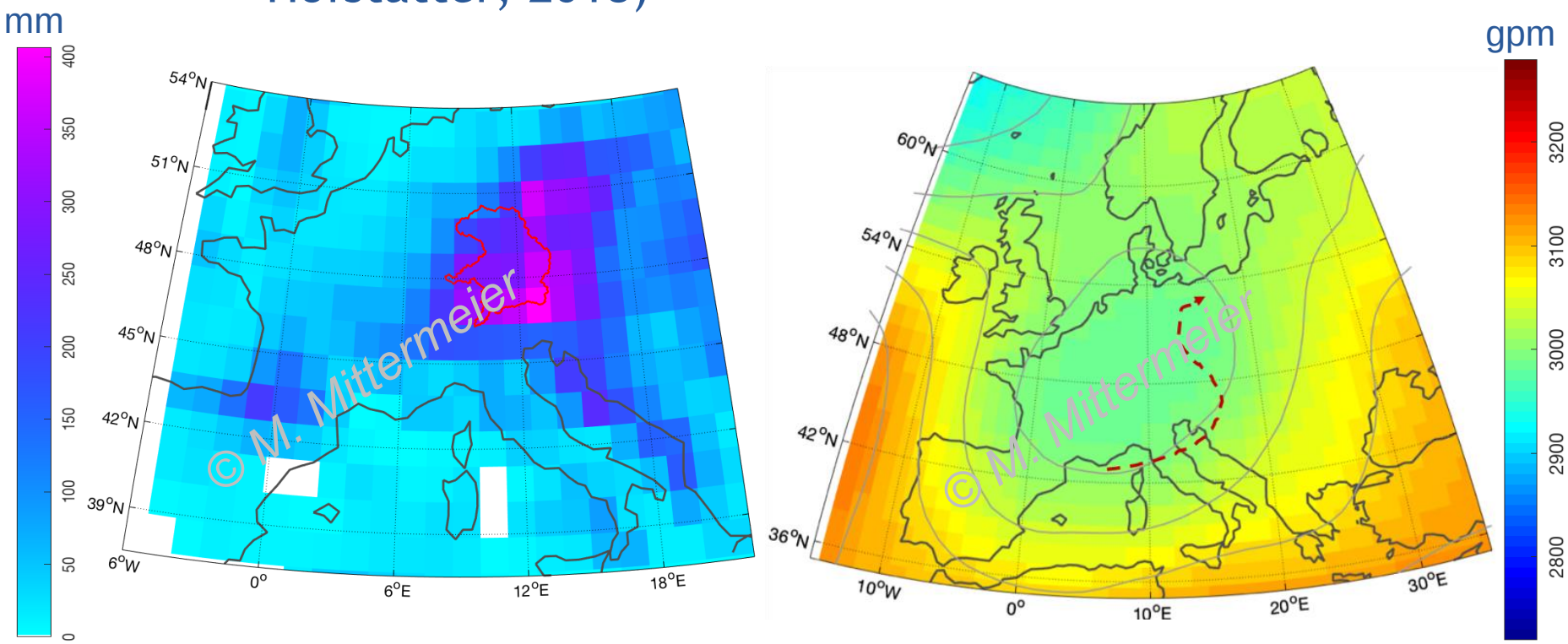
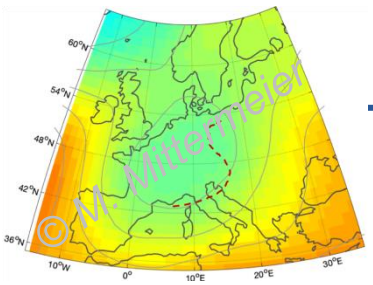


Fig.: Event precipitation sum and mean synoptic pattern at 700 hPa during the 2013 flood event (29.05 – 02.06.2013) in JRA-55 reanalysis data.

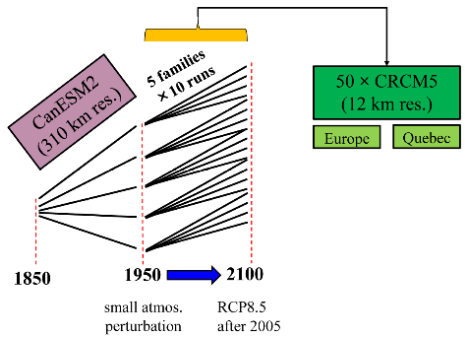
Study Concept

Floods & Large-scale driver



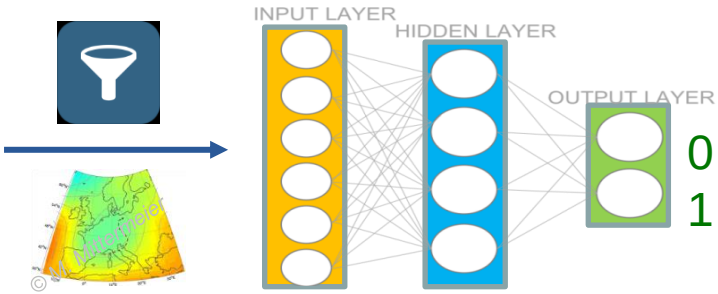
Internal Variability?

CRCM5-LE

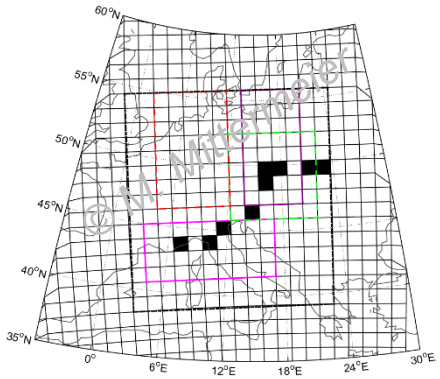


Big Data !

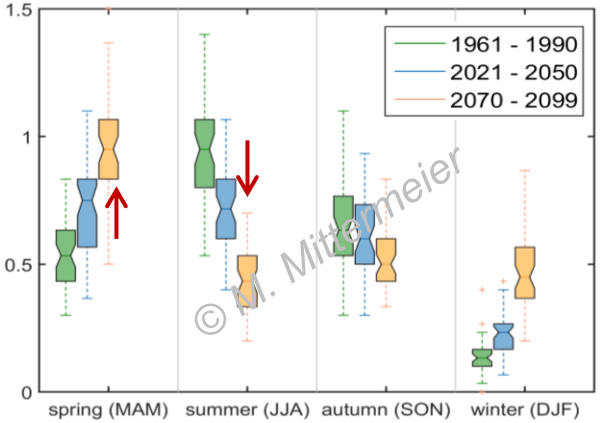
Neural Network



Tracking Procedure



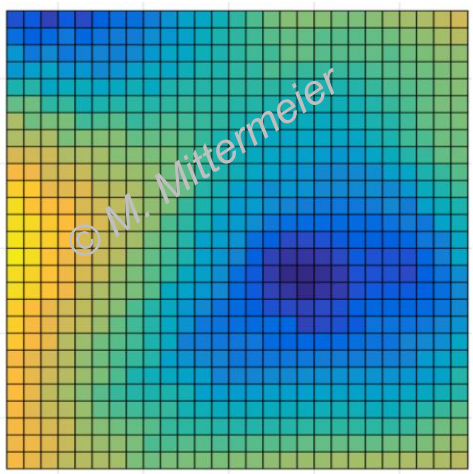
Climate Change Study



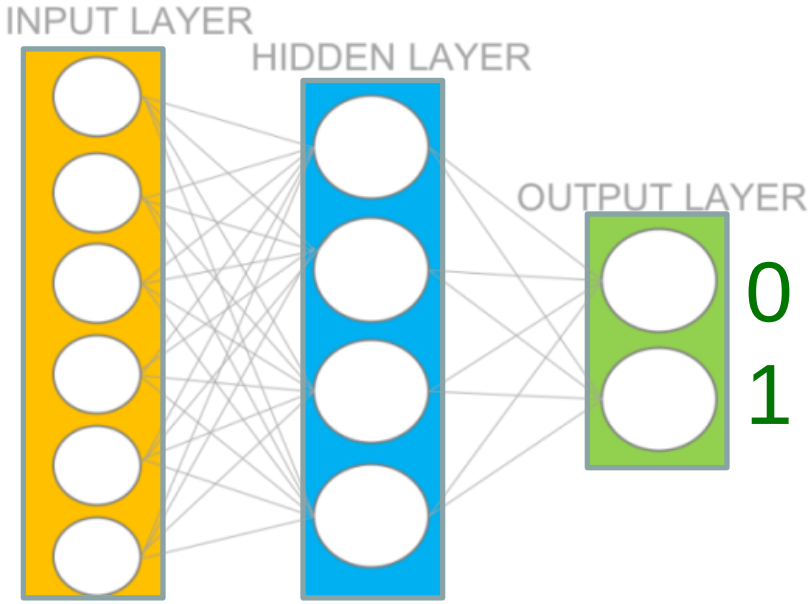
Pattern Recognition with Neural Networks

Supervised Classification Task
Training Set: examples for pattern and counter-examples (images + labels)

training example



Label: 1



Workflow

1 TRAININGSET:
historic events & reanalysis

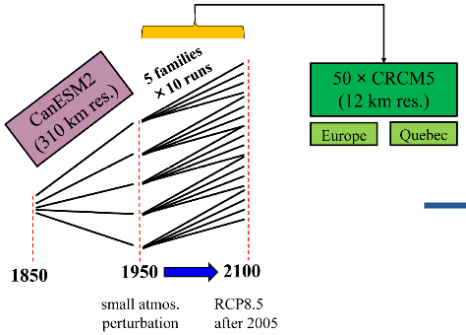
Vb- weather pattern	1
counter-examples	0

2 TRAINING OF NEURAL NETWORK

↑↓ **3 VALIDATION**

ERA-Interim driven CRCM5 Run

4 APPLICATION



5 OUTPUT:
detected events

Classification Results (cross-validation)

test set

OUTPUTS	TARGETS 1	TARGETS 0	%
1	12.3	23.8	33.22
0	9.7	3124.2	99.98
%	94.62	99.24	99.22

overall

OUTPUTS	TARGETS 1	TARGETS 0	%
1	256.1	501.5	33.8
0	8.9	62453.5	99.99
%	96.64	99.2	99.19

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INDEPENDENT TEST SET:

- Overall accuracy: 99.2 %
- Recall: 94.6 % → low type II error
- Precision: 33.2 % → High type I error

→ type I error later reduced through tracking procedure

Cyclone tracking

- position of the cyclone centre is defined as local minimum at 700 hPa geopotential height
- several conditions for the definition of a Vb-pathway

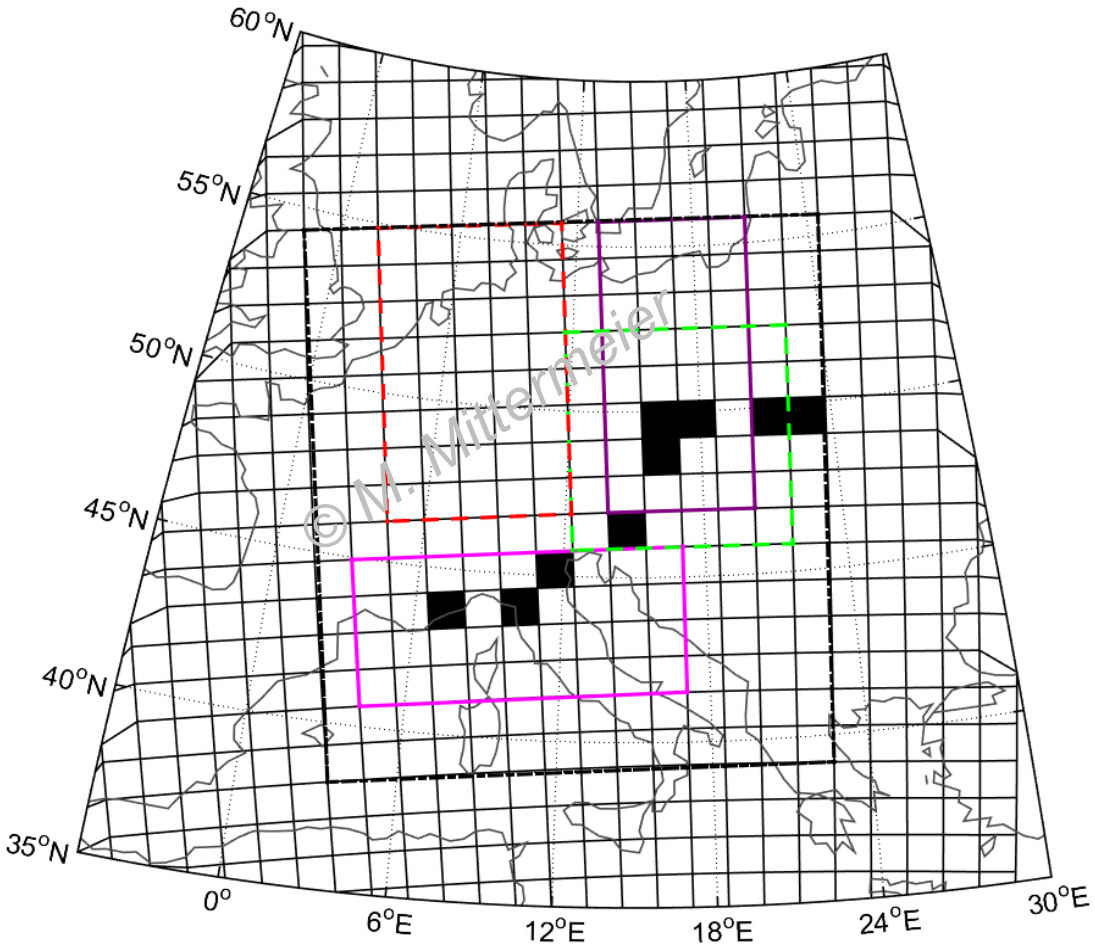


Fig. 6: Track of the Vb-cyclone on August 10th to 13th 2002 in JRA-55 reanalysis data with boxes used for the definition of a Vb-pathway.

Results: Vb-cyclones in the CRCM5-LE

SHIFTING SEASONALITY OF Vb-CYCLONES WITH CLIMATE CHANGE

CRCM5-LE, RCP8.5

Peak shift from summer to spring

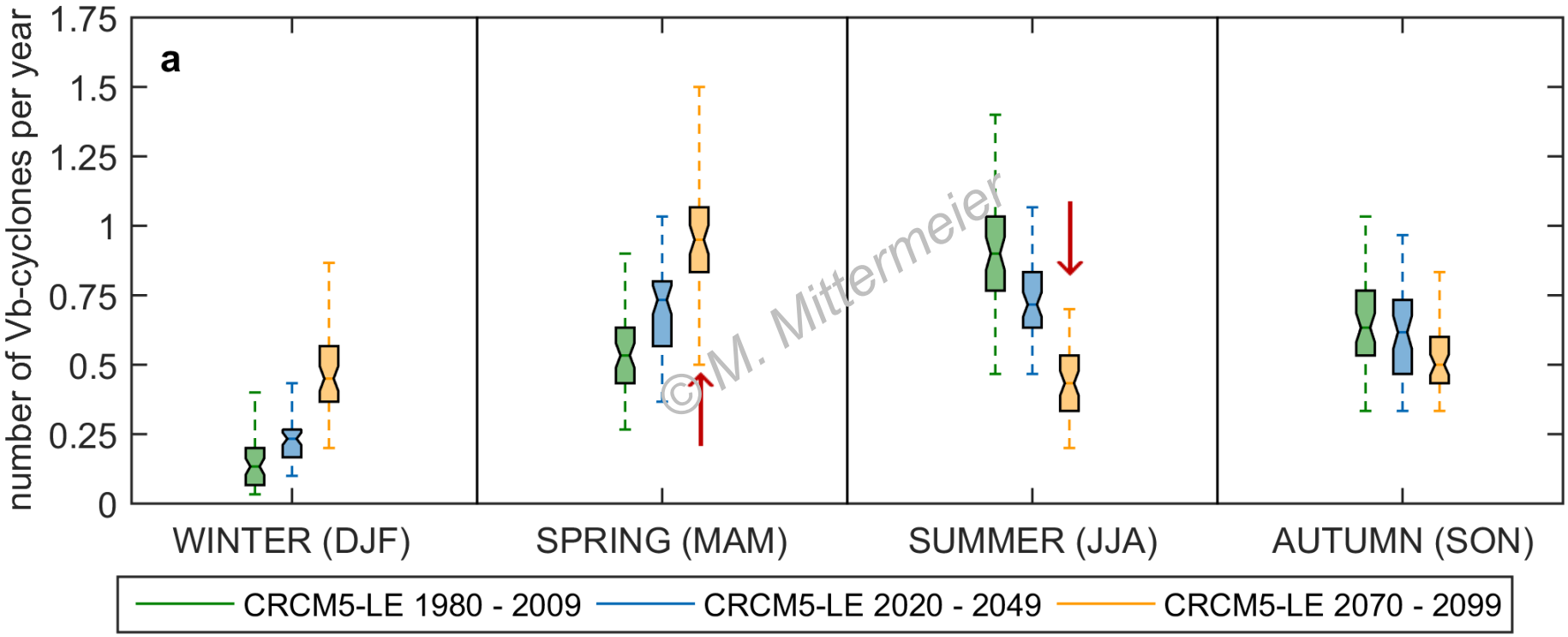


Fig. Frequency of Vb-cyclones in the CRCM5-LE in three 30-year periods (reference, near and far future) per year and season (submitted).

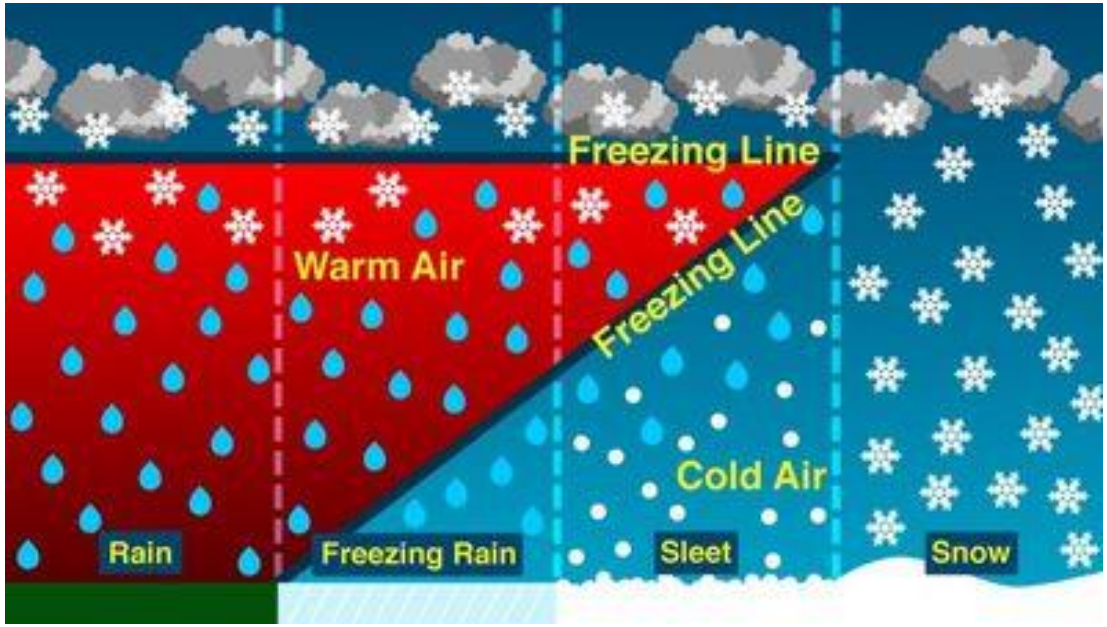
I. Application on Vb-cyclones (Bavaria)

II. Application on Freezing Rain (Québec)

Freezing rain in Québec

Loss & damage through strong freezing rain events in Québec

Research Question:
How does climate change affect the frequency and intensity of freezing rain events?



Formation of various types of winter precipitation
© civilengineersforum

Freezing Rain Event April 2019
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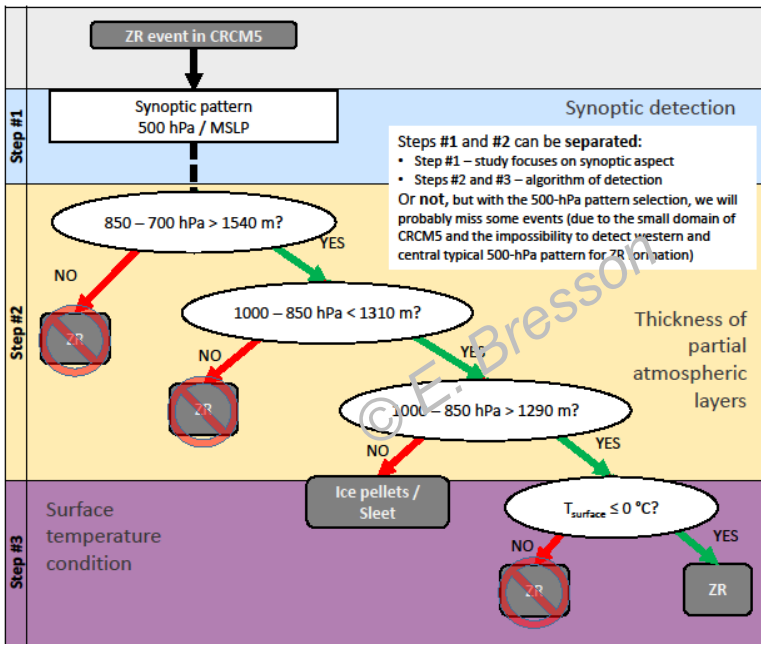
Deriving freezing rain from climate models

most models: usage of diagnostic methods on archived data

Diagnostic scheme: e.g. Cantin & Bachand

Computationally expensive!

Detecting freezing rain events in the CRCM5-LE using Machine Learning for pattern recognition - *Overview of necessary data*



Variables	Levels	Frequency	Resolu-tion
ZR (prfr)	-	24 h	High
Geopot. (zg500)	500 hPa	3 h	Low
MSLP*	-	3 h	Low
Geopot. (zg700, zg850, zg1000)	700 hPa 850 hPa 1000 hPa	3 h	Low
T (tas)	surface	3 h	High

*(derived from ps)

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CRCM5: only RCM with freezing rain as an output variable

CRCM5-LE as training data

Relationship between synoptic pattern and the occurrence of freezing rain in the Montréal area

→ CRCM5-LE as big dataset for training a DNN on the detection of synoptic pattern leading to freezing rain

→ Application to other models: Filtering of large climate datasets for synoptic pattern leading to freezing rain

→ Costly analysis only for timesteps of interest

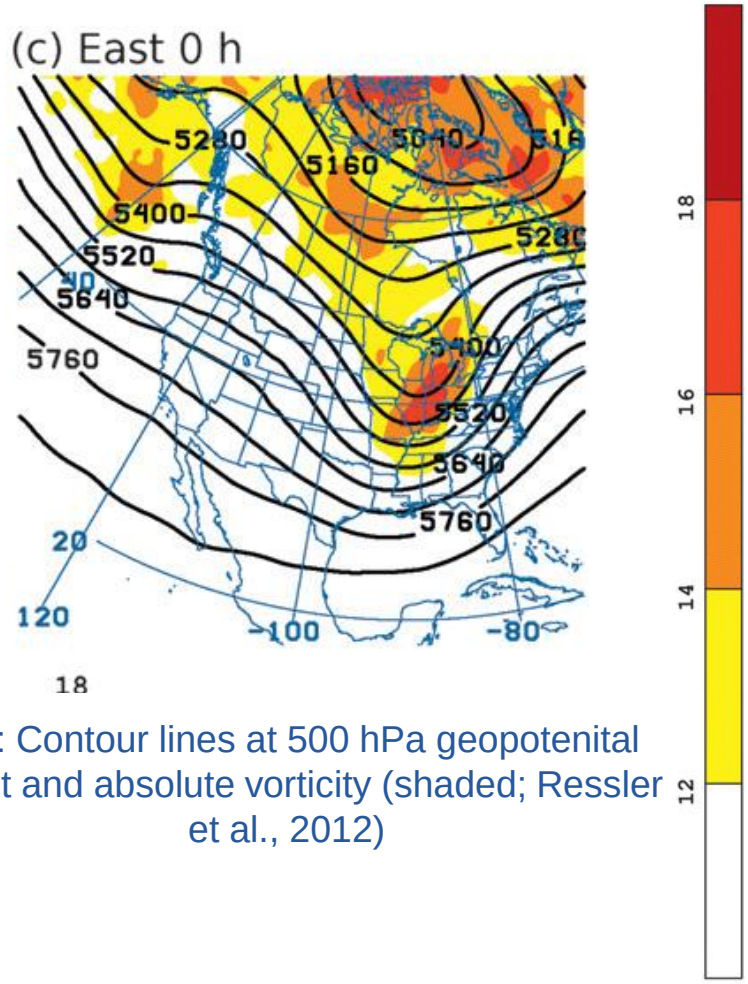
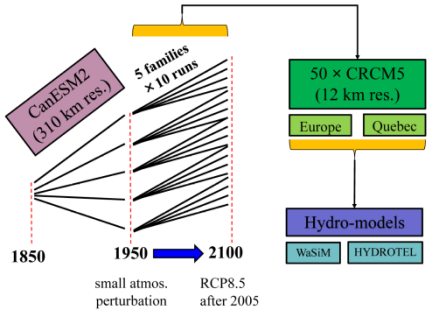


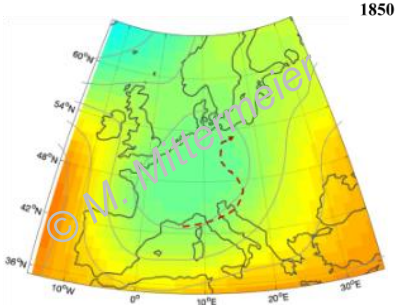
Fig.: Contour lines at 500 hPa geopotenital height and absolute vorticity (shaded; Ressler et al., 2012)

Take-home messages

CRCM5-LE & Machine Learning

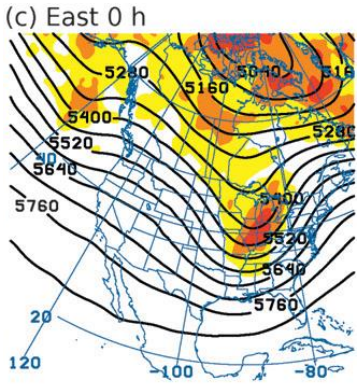
- new opportunities & challenges with high number of simulations
- Machine Learning can provide efficient analyzing tools

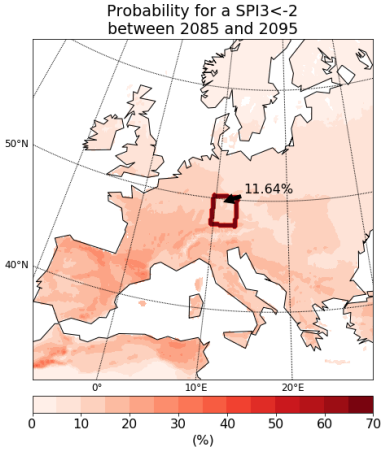




Pattern Recognition with Neural Networks:

- Vb-cyclones: filtering CRCM5-LE
- Freezing Rain: using CRCM5-LE as large training database



Outlook: exploring CRCM5-LE for droughts

Employing CRCM5-LE to predict drought index