SOLARNET: SOLAR FLARES PREDICTION WITH SELF-SUPERVISED LEARNING

Jonathan Donzallaz (jonathan.donzallaz@hefr.ch)
André Csillaghy (andre.csillaghy@fhnw.ch)
Jean Hennebert (jean.hennebert@hefr.ch)

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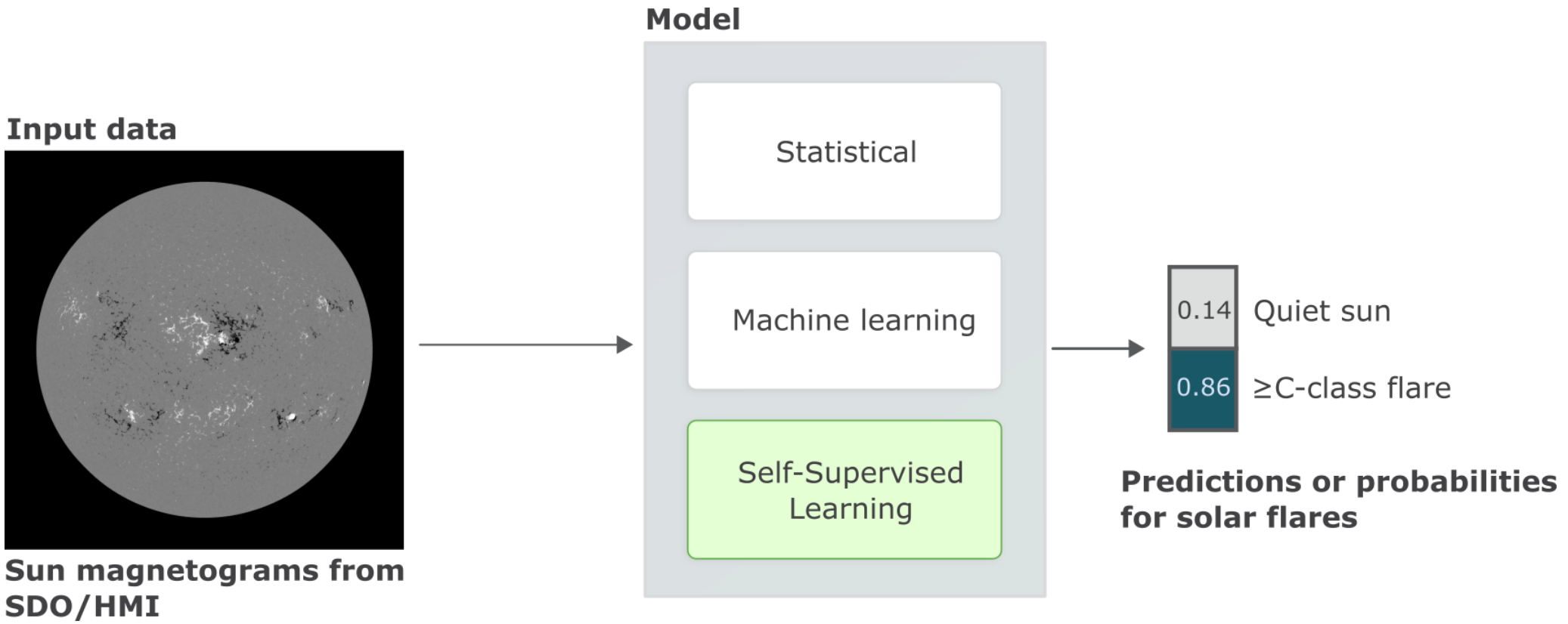
Hes·so
Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg
iCoSys
Institute of Complex Systems
n|w University of Applied Sciences and Arts Northwestern Switzerland

CONTEXT



SDO: Pesnell et al. 2012, doi: 10.1007/s11207-011-9841-3

STATE OF THE ART

Reference	Method	Data	True Skill Statistic (TSS)	
			≥C-class	≥M-class
Park et al. (2018)	CNN	SOHO/MDI, SDO/HMI	0,63	
Nishizuka et al. (2018)	MLP	SDO/HMI&AIA	0,63	0,8
Wang et al. (2019)	LSTM	SHARP	0,559	0,681
Ahmed et al. (2013)	CCNN	SOHO/MDI	0,512	
Huang et al. (2018)	CNN	SOHO/MDI, SDO/HMI AR	0,487	0,662
Bloomfield et al. (2012)	Poisson prob.	Flares & AR	0,456	
Jonas et al. (2017)	Linear classifier	SDO/HMI&AIA AR		0,814
Bobra and Couvidat (2015)	SVM	SHARP		0,761
Zheng, Li, and Wang (2019)	CNN	SDO/HMI AR		0,749
Liu et al. (2017)	Random forest	SHARP		0,532

CONTRIBUTIONS

1. **Self-Supervised Learning** (SSL) applied to solar images

2. Prepared **datasets** for SSL pre-training and flares prediction

3. Seamless **reproducibility** of results with a **library** to use the pre-trained models

SELF-SUPERVISED LEARNING

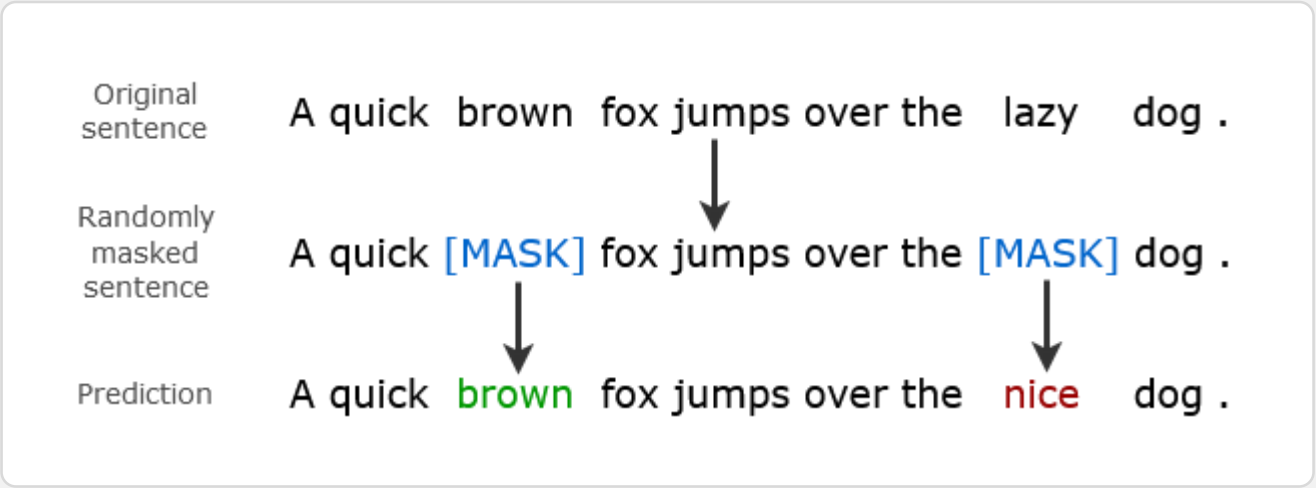
Step 1

Pretraining with unlabelled data

Pretext task

Large volume of data

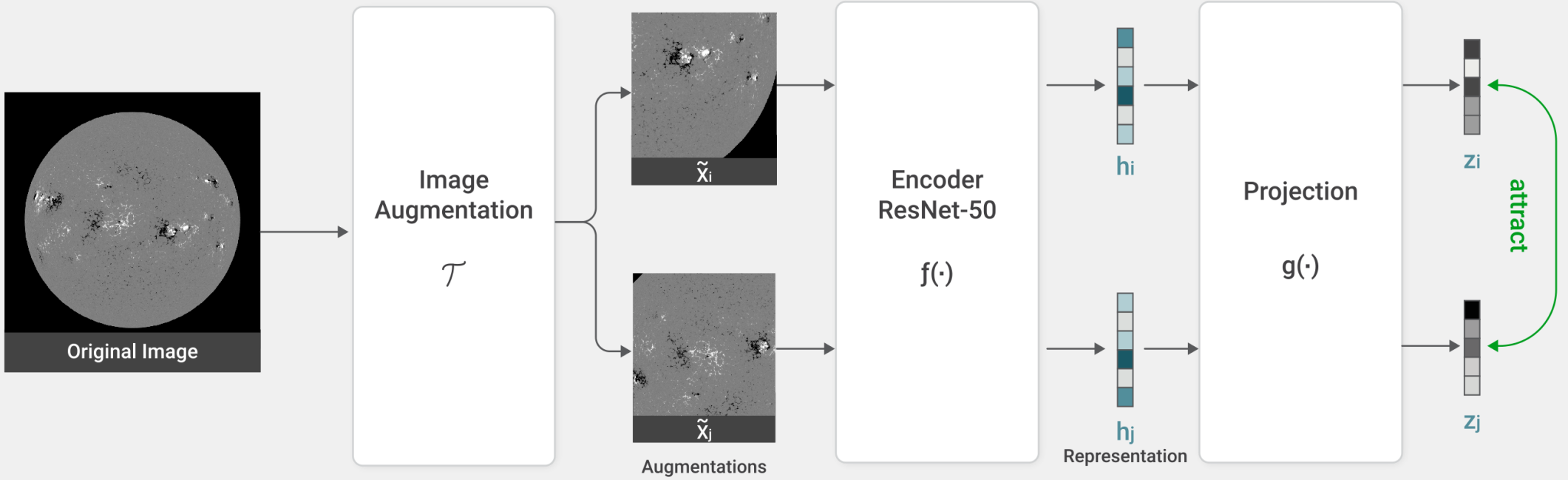
- Learns pattern in the data
- General-purpose model



Step 2

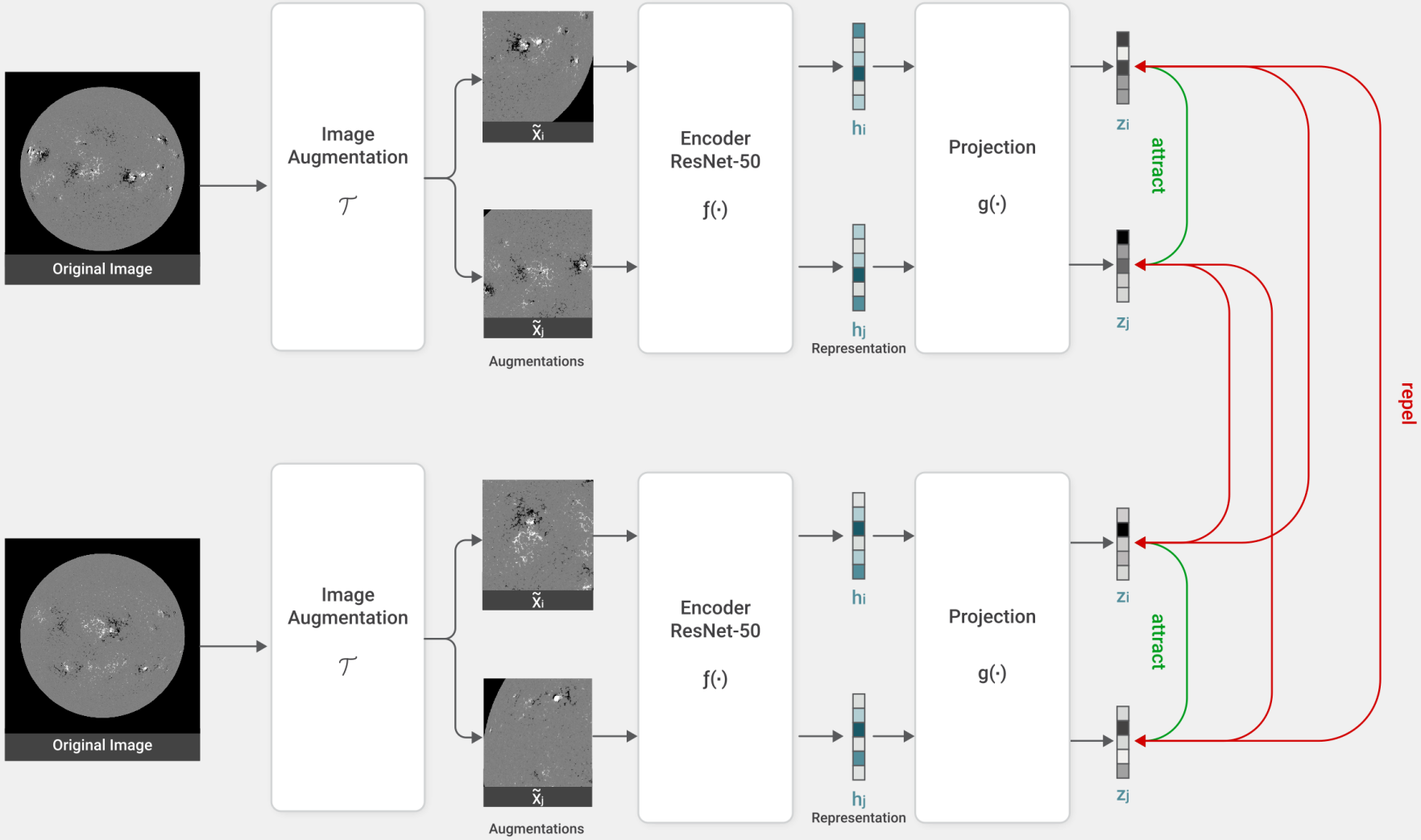
Finetuning with lower amount of data

Step 1: Self-Supervised Learning



SimCLR: Chen et al. 2020, doi:10.48550/arXiv.2002.05709

Step 1: Self-Supervised Learning



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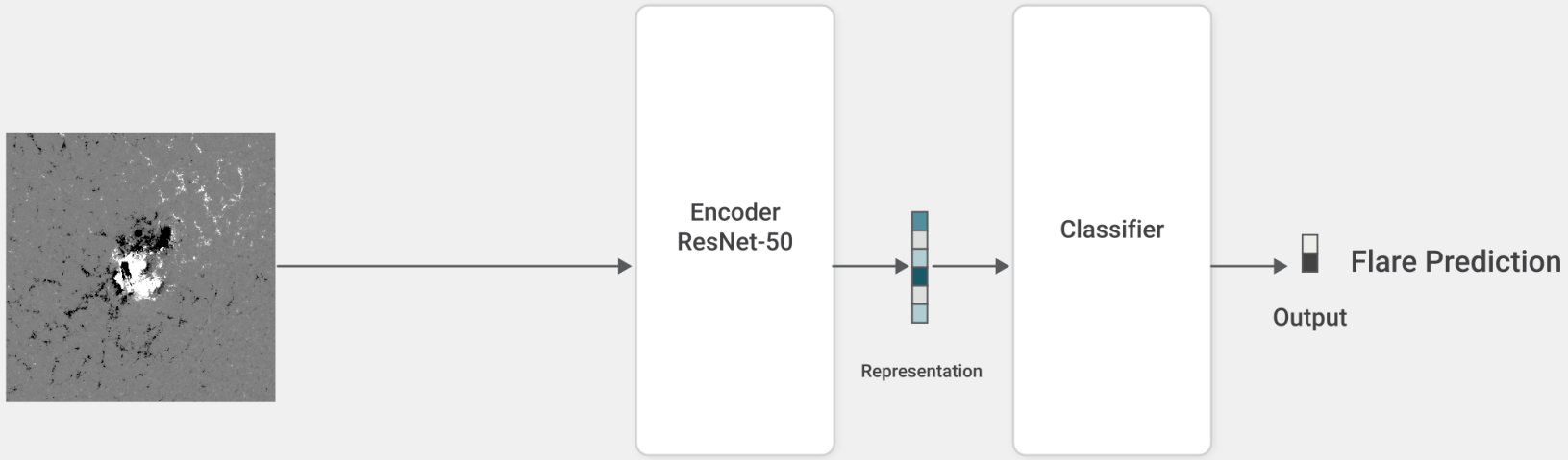
Step 2: Finetuning on supervised downstream task

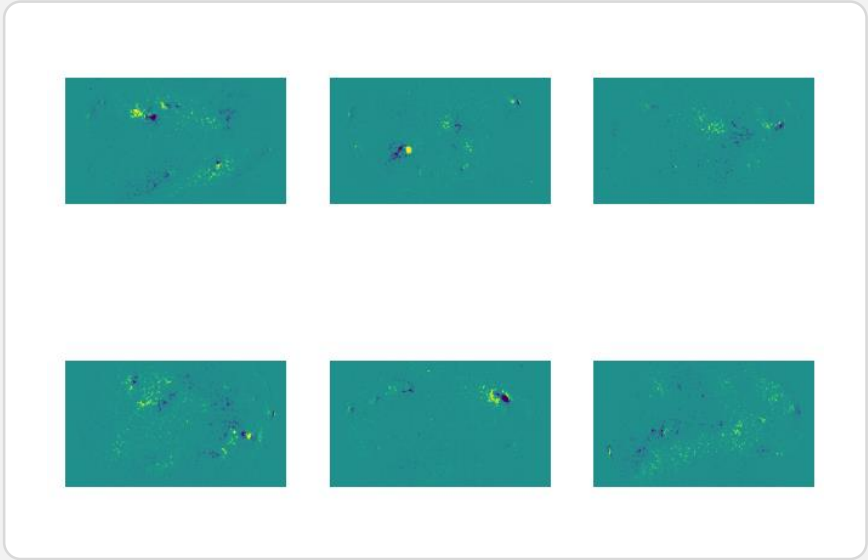


SimCLR: Chen et al. 2020, doi:10.48550/arXiv.2002.05709

DATASETS

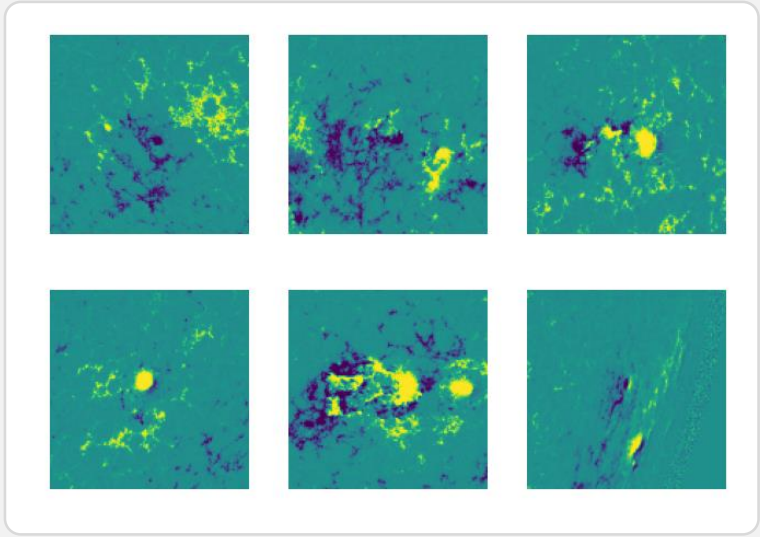
- **SDO-Dataset**
  from “A Machine Learning Dataset Prepared From the NASA Solar Dynamics Observatory Mission”
  Full-disk images 512x512, corrected
  2010-2018

Step 1: Pre-training



- **SDOBenchmark**
  images of active regions 256x256, preprocessed
  Labeled with peak flux
  2012-2018

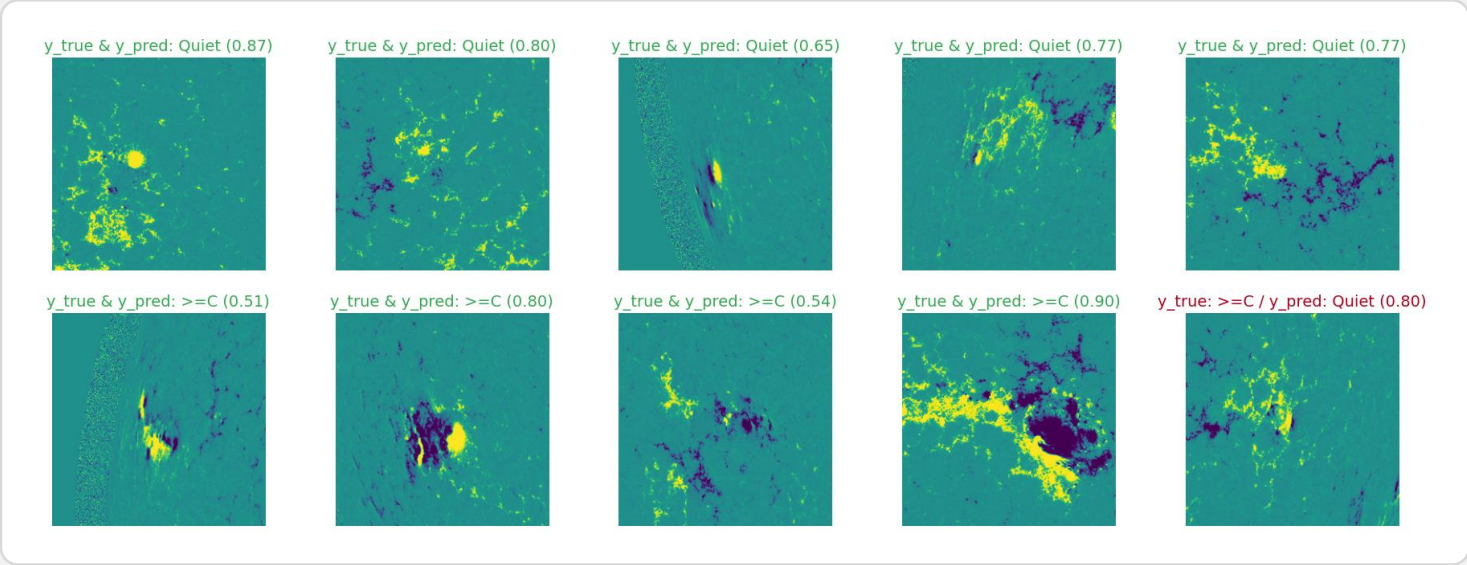
Step 2: Finetuning



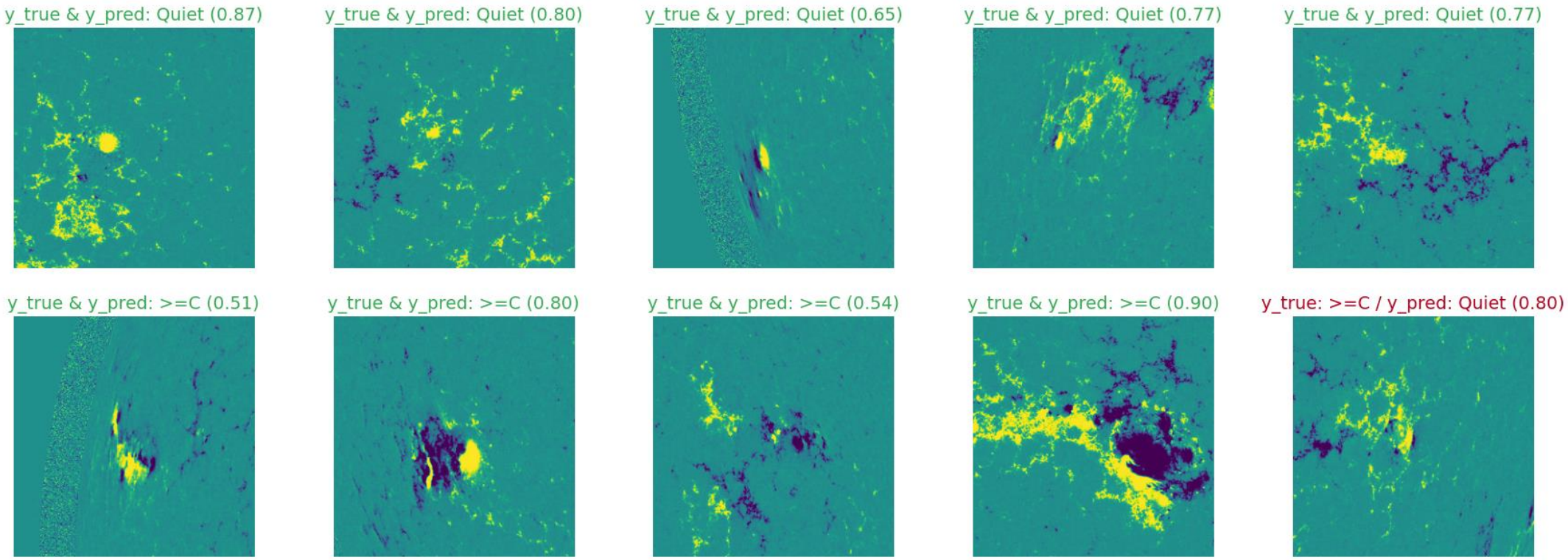
SDOML: Galvez et al. 2019, doi:10.3847/1538-4365/ab1005

RESULTS

Dataset	Model	Split	TSS	F1
	Naive (random)		0.0	0.5
SDOBenchmark (active regions)	CNN (baseline)	Train/test split: SDOBenchmark	0.607	0.803
	ResNet-50 with SSL	Pretrain: SDO-Dataset 2010-2011 Train/test split: SDOBenchmark	0.646	0.819
	Predict “Quiet sun” or “Flare ≥C-class” in next 24 hours, Data is magnetogram			



RESULTS


y_true & y_pred: Quiet (0.87)
y_true & y_pred: Quiet (0.80)
y_true & y_pred: Quiet (0.65)
y_true & y_pred: Quiet (0.77)
y_true & y_pred: Quiet (0.77)
y_true & y_pred: >=C (0.51)
y_true & y_pred: >=C (0.80)
y_true & y_pred: >=C (0.54)
y_true & y_pred: >=C (0.90)
y_true: >=C / y_pred: Quiet (0.80)

RESULTS

Dataset	Model	Split	TSS	F1
	Naive (random)	-	0.0	0.5
SDO-Dataset (full-disk)	CNN (baseline)	Operational case: Train: 2010-2014 Test: 2015-2017	0.404	0.707
	ResNet-50 with SSL		0.446	0.726
	ResNet-50 with SSL	Split by months: Train: Jan.-Nov. Test: Dec.	0.783	0.891
	Predict “Quiet sun” or “Flare ≥C-class” in next 24 hours, Data is magnetogram			

REPRODUCIBILITY & LIBRARY

Links to repositories

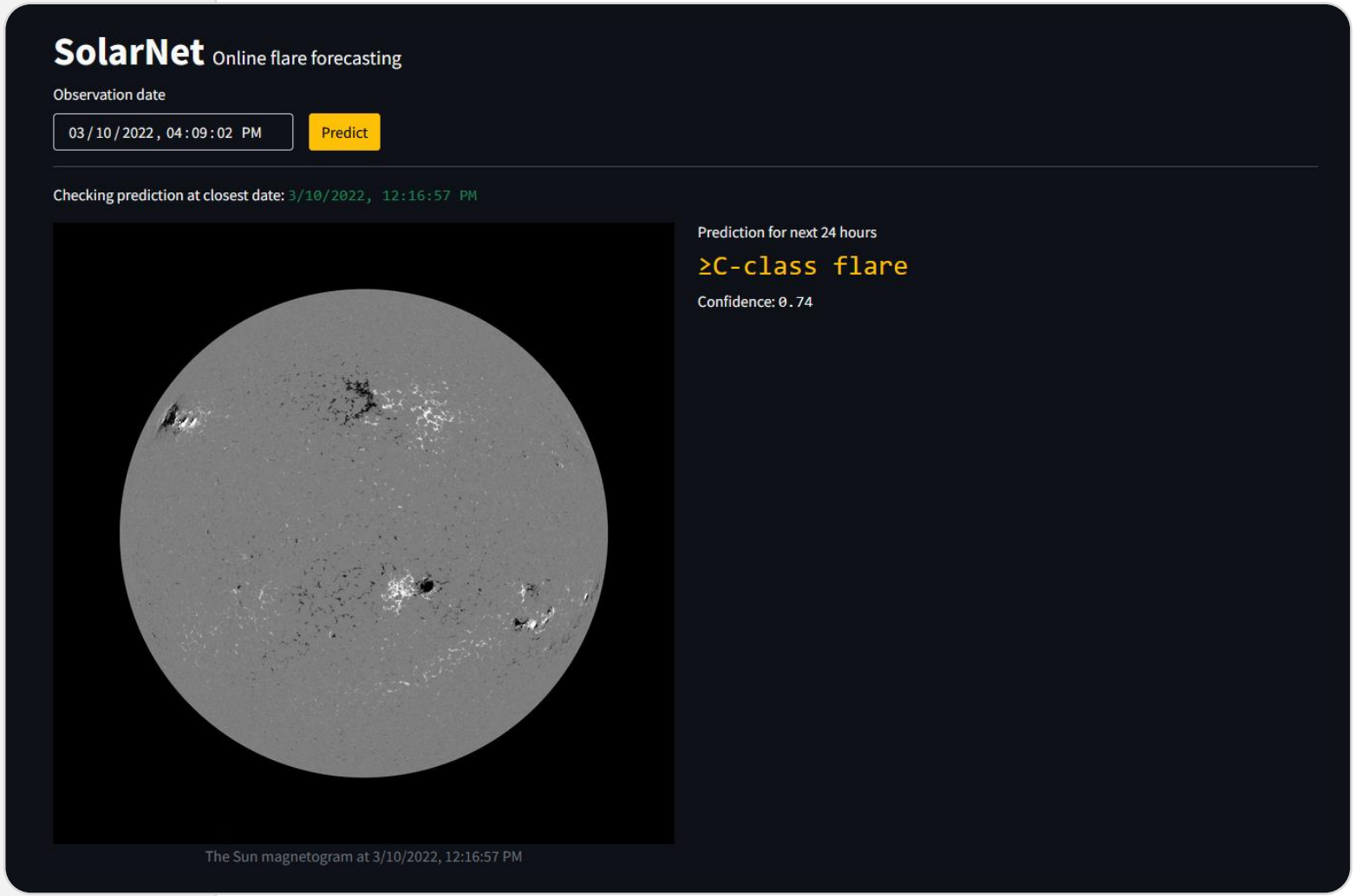
- Reproducible results: gitlab.com/jdonzallaz/solarnet-thesis
- Library: gitlab.com/jdonzallaz/solarnet

Get started

1.
```
>> pip install solarnet-lib
```

2.
```
model = ImageClassification.from_pretrained("solarnet-ssl-bz-ft-month")
with torch.no_grad():
    y_pred = model(tensor)
```

WORKING WITH REAL-TIME DATA



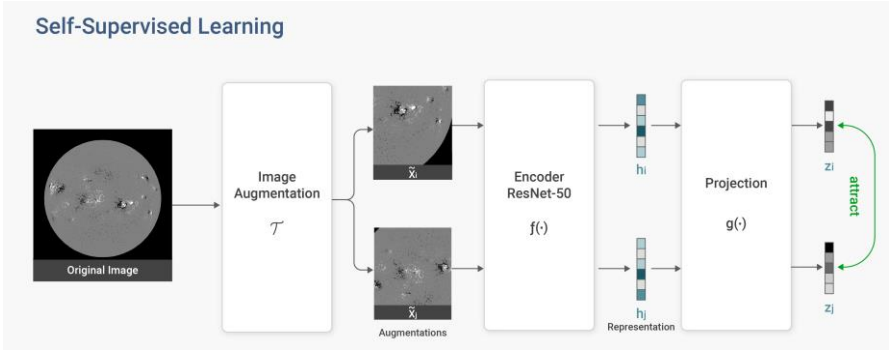
solarnet.kube.isc.heia-fr.ch

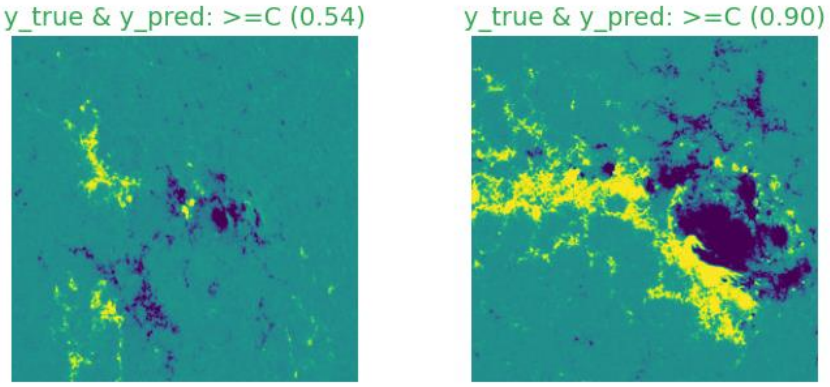
POTENTIAL DEVELOPMENTS

- Use of multi-channel images (see Yana Shtyk’s poster)
- Evaluate other architectures & SSL approaches
- In-depth operational testing
- Extend pre-training dataset to 1996-2022

SUMMING UP

- Self-Supervised Learning – provides good representation of data
- Consistently improving results
- Great reproducibility and reusability





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AUTHORS

Jonathan Donzallaz (jonathan.donzallaz@hefr.ch)
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LINKS

Library: gitlab.com/jdonzallaz/solarnet
Docs: jdonzallaz.gitlab.io/solarnet
Application: solarnet.kube.isc.heia-fr.ch

REFERENCES

Source of images: SDOML, SDOBenchmark & Helioviewer

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Haute école d'ingénierie et d'architecture Fribourg
Hochschule für Technik und Architektur Freiburg
iCoSys
Institute of Complex Systems
n|w University of Applied Sciences and Arts Northwestern Switzerland