RainBench: Enabling Data-Driven Precipitation Forecasting on a Global Scale

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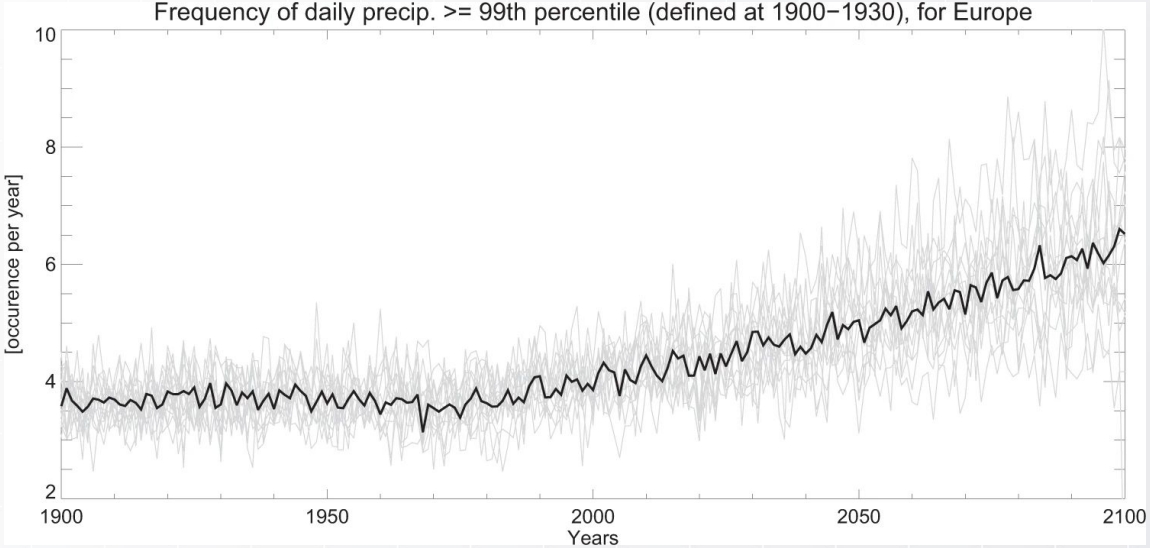
Global Precipitation Forecasting

Motivation

Climate change: rising **extreme precipitation events**



Myhre, Gunnar, et al. "Frequency of extreme precipitation increases extensively with event rareness under global warming." *Scientific reports* 9.1 (2019): 1-10.

Global Precipitation Forecasting

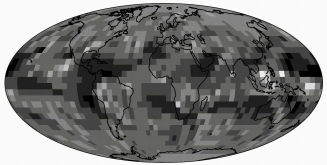
Motivation

Numerical models: heavy data and resource requirements

Recent Machine Learning models: regional nowcasting (<8 hours)

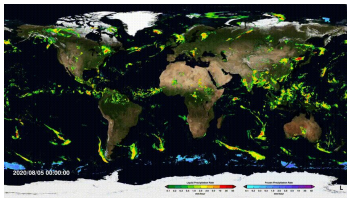
This work: introduce a **multi-modal** benchmark dataset to advance **global** precipitation forecasting in the **medium-range** (3-5 days)

Rainbench



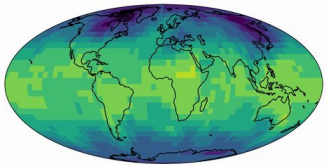
SimSat
2016-present

- Generated from ECMWF
- Emulates 3 spectral channels from the Meteosat-10 SEVIRI satellite
- Native resolution 0.1°



IMERG
2000 - present

- Global precipitation estimation product provided by NASA
- Native resolution 0.1°

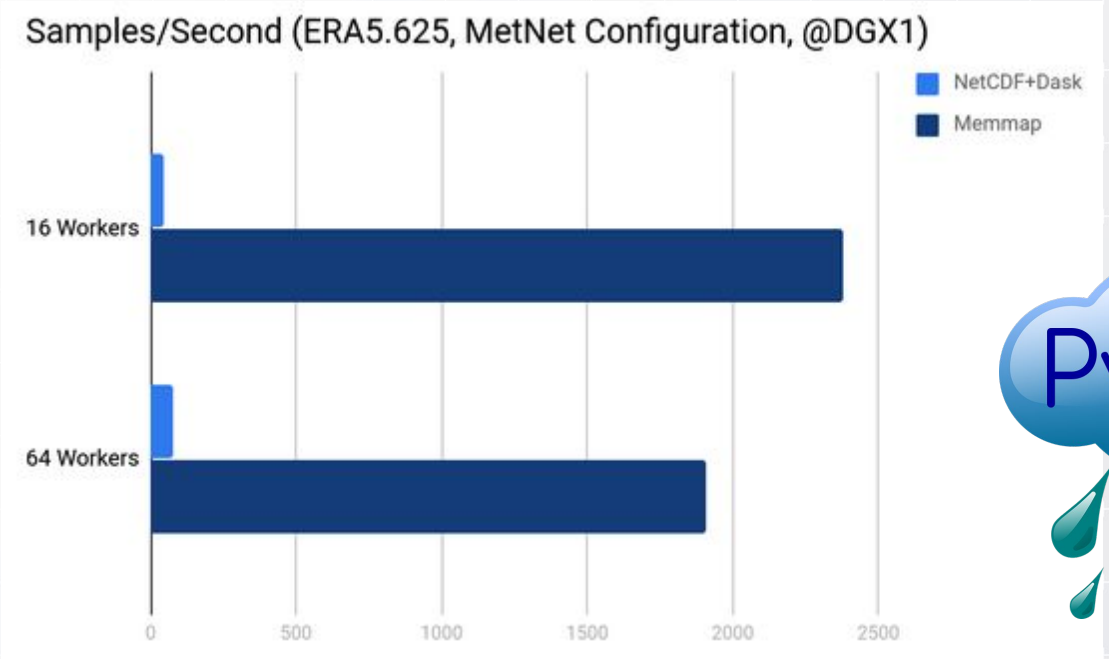


ERA5
1979-present

- ERA5 Reanalysis Product
- Broad spectrum of physical and atmospheric variables at different heights (e.g. humidity, temperature)
- Includes precipitation
- Native resolution 0.25°

PyRain

Efficient data loading pipeline



Performance Analysis

Benchmark Tasks

3 input data settings: (a) SimSat only, (b) ERA only, (c) Simsat + ERA

Forecasting precipitation values from: ERA5, or, IMERG

Model: ConvLSTM conditioned on lead-time[1]

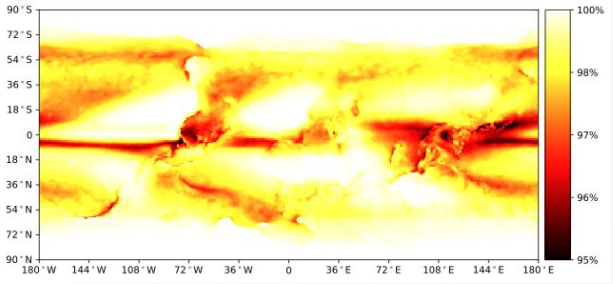
	ERA5			IMERG		
	1-day	3-day	5-day	1-day	3-day	5-day
Persistence	0.6249	0.6460	0.6492	1.1321	1.1497	1.1518
Climatology	0.4798	0.4802	0.4803	0.8244	0.8249	0.8246
SimSat	0.4610	0.4678	0.4691	0.8166	0.8201	0.8198
ERA	0.4562	0.4655	0.4677	0.8182	0.8224	0.8215
SimSat + ERA	**0.4557**	**0.4655**	**0.4675**	**0.8134**	**0.8185**	**0.8185**

[1] Sønderby, Casper Kaae, et al. "MetNet: A Neural Weather Model for Precipitation Forecasting." arXiv:2003.12140 (2020).

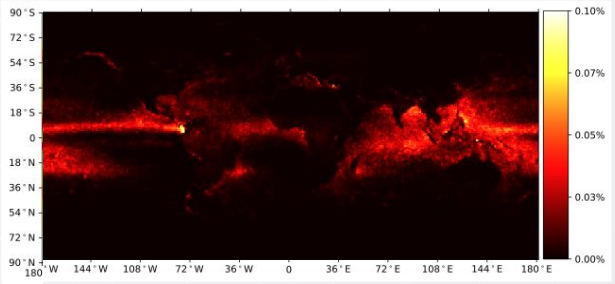
Performance Analysis

Class Imbalance

Slight Rain



Violent Rain



		Slight	Moderate	Heavy	Violent	Micro Avg.	Macro Avg.
Unbalanced	ERA	**0.20**	4.08	16.2	63.1	0.65	20.9
	SimSat	**0.20**	4.38	16.8	54.1	0.65	18.9
	SimSat + ERA	**0.20**	4.03	16.5	53.0	**0.65**	18.4
Balanced	ERA	1.05	**2.75**	12.4	58.0	1.40	18.6
	SimSat	1.17	3.10	13.3	50.1	1.26	16.9
	SimSat + ERA	1.30	3.15	**11.8**	**44.3**	1.38	**15.1**

Model: LightGBM

RainBench

Future Work

1. Limited extreme precipitation events

   class-balanced sampling

2. Modelling earth topology

   neural network architectures for spherical data

3. Using high-resolution data

   multi-fidelity approach

4. Making use of atmospheric state variables

   physics-informed ML approach

RainBench: Enabling Data-Driven Precipitation Forecasting on a Global Scale

Release expected by Dec 2020.

Thank you for listening.

Link to code:
https://github.com/FrontierDevelopmentLab/PyRain

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